LUCI & NTE

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Generic Infrared Software – Installation and User's Manual

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1 OVERVIEW

1.1 Design

The Generic Infrared Software (GEIRS) is a software layer which

- assembles parameter lists and commands received from its own graphical interface or other supervisor software,
- translates these into the firmware language ("patterns") of the MPIA readout electronics (ROE)
- initializes the readout cycles
- and accumulates the frames received from the ADC's of the electronics as FITS files or screen images.

GEIRS is

- *neither* a data pipeline or data reduction tool for an type of infrared images or detectors,
- *nor* a FITS display tool.

The *generic* attribute of the name illustrates that the core part of the software has been adapted to generations of the MPIA electronics which controlled various infrared detector chips in the past 20 years. In consequence, the command library is a superset of functionality released for a set of cameras in the past, and currently operating or under commissioning for

1. LUCI1 and LUCI2 at the Large Binocular Telescope under CentOS 7,[1]
2. PANIC upgrade to Hawaii-4RG on the Calar Alto under openSUSE 15.5,
3. CARMENES on the Calar Alto under openSUSE 13.1 [1],
4. LN at the Large Binocular Telescope under CentOS 7.
5. a test camera with the older PANIC mosaic at the AIP, presumbably under openSUSE 15.1 or higher,
6. the NTEimg and NTEisp upgrades at the NOT, presumbably under Ubuntu 22.04 or higher.

It also is used as a data acquisition and display tool in an experimental setup for Sidecar development.[2] The development platform is currently openSUSE Leap 15.5.

The software comprises pieces of instrument and telescope control software, as will become obvious and will be discussed at the subsection affected. Graphical user interfaces slavishly reflect—following established paradigms of good software practise—underlying batch processing capabilities, so some of the buttons or menus are either dead-ended, wiped out or set to invariable constants.

This document summarizes

[1] attempts to use Alma Linux 9.1 – 9.3 require patches introduced in GEIRS version trunk-r804M-1.

[2] In short, this Sidecar setup never forwards commands to any ROE and awaits (with explicitly extended timeouts) 16bit data via the OPTPCI fibers in a strict row-by-row sequential order...

- the system setup (installation, compilation);
- the graphical user interface for the standalone setup, that is, the system running without supervision or interference by any camera control software [2]. This might be the least important part during production (after commissioning);
- the command interface;
- meaning of FITS keywords.

A recent version of this document is in this PDF,the subversion system of the source code, and the `GEIRS`/*version*/`doc` subdirectory of the source code on the computers where GEIRS is installed. It describes the GEIRS release with the version imprinted on the footers of the man-pages in Section 5.5. Where instrument teams decided not to upgrade GEIRS, one should not consult this documentation but the documentation of the installed release.[3]

The software is currently developed under openSUSE Leap 15.5 with gcc version 7.5, perl 5 (version 26) and PLX SDK 8.23. It does not need SW constrained by licenses: there is no IDL, Matlab, Mathematica, NAG or others.

1.2 Interfaces

The document complements the documents on the camera control software [2], LUCI control software simulator,LUCI Management Console,readout patterns [3], installation and pattern generator [4, 5].

Note that GEIRS is just a detector control system, usually governed by some higher instrument control software. That supervisor software may at any time modify, add or delete files or programs such that the information in this manual may appear to be invalid. In case of doubt, try to contact someone or to find some manual which describes these modifications for the particular instrument.

1.3 Operation

GEIRS is installed by adding drivers of the PLX board at standard places to the Operating System, configuring the allowable shared memory parameters, retrieving the source code from a SVN repository or the MPIA public `ftp` server, and compiling the source code with the GNU C/C++ and Java compilers.

GEIRS is started with a one-line command to the Operating System with an option to start with or without interactive GUI support. The configuration of essentially permanent parameters (TCP interfaces to the ROE, the location of files concerning patterns, sound control, etc.) is done in the very same startup-script. This needs of the order of ten seconds, most of which is spent to upload default patterns to the ROE via the ethernet.

Health of the GEIRS command interface and shared memory manager may then and at any latter time be checked by querying parameters with the `status` command. More tests by scanning the log files for prototypical answers from the ROE are possible if initialization tests are needed.

[3] With the exception of Linc-Nirvana, MPIA has no control over instrument groups' decisions to work with any particular GEIRS release...

The standard operation of generating the images (that is, generating the FITS files) is to send a sequence of commands to the GEIRS "shell." There are configurational commands that specify ROE parameters like integration times, integration/readout types, repetition factors, location and size of windows in the geometry, and names of the FITS files. After such preparational step, the two commands `read` (start ADC conversion and data transfer between ROE and the host computer), and `save` (convert RAM-data to FITS file(s)) define the fundamental cycle of generating the images. The configuration may be changed after each read-save cycle. This allows the higher level control software to examine (the quality of) the FITS images before starting another exposure with the same or modified parameters.

To simplify operations, any sub-sequence of these commands may be packed into macros (ASCII files in a subdirectory) which are callable by a single command.

GEIRS is shut down by sending a `quit` command to the command interpreter.[4] This leaves the ROE in its most recently selected idle-mode (until powered off). Instruments specific aspects will probably be bundled in a set of macro files related to scenarios like calibration/flat- fielding and/or star magnitudes once the details of the windowing and timing patterns are fixed.

1.4 Acronyms

ADC analog-to-digit conversion

ADU analog-to-digital unit

AIP Leibniz-Institut für Astrophysik Potsdam https://www.aip.de

ASCII American Standard Code for Information Interchange https://en.wikipedia.org/wiki/American_Standard_Code_for_Information_Interchange

CAHA Calar Alto Astronomical Observatory http://www.caha.es

CARMENES Calar Alto High-Resolution Search for M Dwarfs with Exoearths with Near-infrared and Optical Echelle Spectrographs carmenes.caha.es

ccw counter clock wise

CPU Central Processing Unit

DAC digit-to-analog converter

DCS Detector Control System

DEC declination coordinate of the ICRF

DHCP Dynamic Host Configuration Protocol

DICOM Digital Imaging and Communications in Medicine https://www.dicomstandard.org/

DMA Direct Memory Access

DNS Domain Name Service

FIFO first in first out https://en.wikipedia.org/wiki/FIFO

FITS Flexible Image Transport System http://fits.gsfc.nasa.gov

FPGA Field programmable gate array

[4] The various ways are to click the `shutdown` button in the `controls` GUI, to type in `quit` in the GEIRS shell, or to use `quit` as the argument to the `geirsCmd` or to the `cmd_*` Linux executables.

FWHM Full width at Half Maximum

GEIRS Generic Infrared Software

GNU www.gnu.org

GUI Graphical User Interface

HDU header-data unit (of FITS)

HTML Hypertext Markup Language https://en.wikipedia.org/wiki/HTML

ICE Internet Communications Engine
https://en.wikipedia.org/wiki/Internet_Communications_Engine
https://doc.zeroc.com/

IDL Interactive Data Language http://www.uni-giessen.de/hrz/software/idl/

IIF Instrument Interface of the LBT
http://wiki.lbto.org/twiki/bin/view/SoftwareProducts/TCSsoftware

IP Internet Protocol

ISO International Organization for Standardization
https://en.wikipedia.org/wiki/ISO

LBT Large Binocular Telescope http://www.lbto.org/

LED Light Emitting Diode

LINC-NIRVANA LBT Interferometric Camera and Near-Infrared / Visible Adaptive Interferometer for Astronomy

LN liquid nitrogen

LN LINC-NIRVANA

LSB Least significant bit

LTCS Linc-Nirvana Telescope Control System

LUCI LBT NIR spectroscopic Utility with Camera and Integral-Field Unit for Extragalactic Research http://www.mpe.mpg.de/ir/lucifer

MEF Multi-extension FITS

MER Multi-endpoint Read

MPIA Max-Planck Institut für Astronomie, Heidelberg https://www.mpia.de

MPIfR Max-Planck Institut für Radioastronomie, Bonn http://www.mpifr-bonn.mpg.de

NAG Numerical Algorithms Group http://www.nag.com/nag-content/library

NIR near infrared

NOT Nordic Optical Telescope http://www.not.iac.es/

NTE NOT Transit Explorer https://nte.nbi.ku.dk/

NTP Network Time Protocol https://en.wikipedia.org/wiki/Network_Time_Protocol

PANIC Panoramic Near-Infrared Camera https://panic.iaa.es

PCI Peripheral Component Interconnect

PCIe Peripheral Component Interconnect Express
https://en.wikipedia.org/wiki/PCI_Express

PCI-X Peripheral Component Interconnect eXtended
https://en.wikipedia.org/wiki/PCI-X

PDF Portable Document Format
https://en.wikipedia.org/wiki/Portable_Document_Format

PLX PLX Technology,
http://www.broadcom.com/products/pcie-switches-bridges/software-dev-kit

PSF point spread function

RA Right Ascension

RAM Random Access Memory

RGB Red-Green-Blue

RoCon Readout Controller

ROE Readout Electronics

SVN Subversion http://subversion.apache.org

SW software

TCP Transmission Control Protocol
https://en.wikipedia.org/wiki/Transmission_Control_Protocol

TCS Telescope Control System

URI Universal Resource Identifier
https://en.wikipedia.org/wiki/Uniform_resource_identifier

UTC Universal Time Coordinated

VPN Virtual Private Network
https://en.wikipedia.org/wiki/Virtual_private_network

WCS World Coordinate System https://www.atnf.csiro.au/people/mcalabre/WCS/

XML Extensible Markup language https://en.wikipedia.org/wiki/XML

1.5 References

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2 INSTALLATION

Sections 2.1 and 2.4–2.5 discuss the setup for a first-time GEIRS installation or aspects related to upgrades of the operating system. Section 2.2 describes the installation and compilation of the GEIRS tar ball. The `unxz`, `cd` and `INSTALL` commands is all that is needed to upgrade to another GEIRS version!

2.1 External Software

2.1.1 Compilers

In case the person to install the operating system did not have have software development in mind and just went on with the standard distribution, various developer packages will probably be missing.

2.1.1.1 make

If

```
which make
```

indicates that the command is not found, install it:

```
zypper in make # openSUSE
apt install make # Ubuntu
```

2.1.1.2 patch

If

```
which patch
```

indicates that the command is not found, install it:

```
zypper in patch # openSUSE
```

2.1.1.3 c++ The GNU C++ compiler is not distributed with the default layout of openSUSE. If

```
which g++
```

reveals that this is the case, post-install the packages with

```
zypper in gcc gcc-fortran gcc-c++ cpp # openSUSE
apt install g++ gfortran make # Ubuntu
dnf install gcc-c++ gcc-gfortran # Alma Linux
```

and the equivalent `yum` under CentOS or `dnf` under Fedora.

Upgrade of the compiler under CentOS is done as specified in the https://access.redhat.com/documentation/de-de/red_hat_developer_toolset and https://centos.pkgs.org/7/centos-sclo-rh-x86_64/

```
yum install centos-release-scl
yum install devtoolset-9
```

or at least

```
yum install devtoolset-9-gcc-c++
```

Note that old compiler collections with gcc 4.8 cannot compile the GEIRS bundle, because support of C++14 is needed at least in the auxiliary `CCfits` package![5] Testing the version is done with

```
g++ --version
```

respectively

```
scl enable devtoolset-9 bash
g++ --version
exit
```

2.1.1.4 libtool, autoconf The `libtool` or `autoconf` developpers environments may be missing. If

```
which libtool
which autoconf
```

reveals that this is the case, use

```
zypper in libtool autoconf automake # openSUSE
apt install libtool autoconf automake # Ubuntu
dnf group install "Development Tools" # Alma Linux
```

to post-install them.

[5] There is an ugly patch in `INSTALL.sh` concerning this when GEIRS is installed on CentOS 7 computers...

2.1.1.5 unzip If

```
which unzip
```

reveals that `unzip` is not available, install it:

```
zypper in unzip # openSUSE
apt install unzip zlib1g-dev # Ubuntu
```

2.1.1.6 flex The `flex` compiler is not distributed with the default layout of openSUSE 13.1. If

```
which flex
```

revals that this is the case, use

```
zypper in flex # openSUSE
apt install flex # Ubuntu
```

to post-install it.

2.1.1.7 Java The `Java` compiler is not distributed with the standard software bundle of most Linuxes. If

```
which javac
```

revals that this is the case, get the currently installed JVM version with

```
java -version
```

Install the associated JDK bundle

```
zypper in java-17-openjdk-devel # openSUSE
apt install openjdk-18-jdk # Ubuntu
dnf install java-17-openjdk-devel # Alma Linux
```

to post-install it, then

```
update-alternatives --config javac
update-alternatives --config java
```

to select consistent versions of compiler and JVM.[6].

2.1.2 readline

If `/usr/include/readline/readline.h` is missing, post-install the package with

```
zypper in readline-devel # openSUSE
yum install readline-devel # CentOS
dnf install readline-devel # Alma Linux
apt install libreadline-dev # Ubuntu
```

[6]Mismatch of `javac` during compilation and `java` at runtime will lead to ugly version errors while starting the GEIRS GUIs

2.1.3 boost

GEIRS uses the `regex` package of the `boost` library. If the library is not found under openSUSE it suffices to run `/sbin/yast2` the `Software management` submenue, to search for `boost` and to install the subpackage:

```
zypper install libboost_regex1_79_0-devel  # openSUSE tumbleweed
zypper install libboost_regex1_75_0-devel  # openSUSE Leap 15.4
yum install boost boost-devel # CentOS
dnf install boost boost-devel # Alma Linux
apt install libboost-regex-dev # Ubuntu
```

2.1.4 texinfo

The online documentation of the commands (Section 5.3) is maintained in texinfo files. If

```
which makeinfo
```

shows that this is not installed in your operating system, use

```
zypper install makeinfo  # openSUSE
yum install texinfo  # CentOS
apt install texinfo # Ubuntu
dnf --enablerepo=crb  install texinfo-tex # Alma Linux
```

to install the package. Instead one can go to www.rpmfind.net, download

2.1.5 xpath

`xpath(1)` is used to parse some XML configuration files. If

```
which xpath
```

shows that this is not installed in your operating system, use

```
zypper install perl-XML-XPath  # openSUSE
yum install perl-XML-XPath  # CentOS
dnf install perl-XML-XPath  # Alma Linux
apt install libxml-xpath-perl # Ubuntu
```

to install the package.

2.1.6 cfitsio

cfitsio is used to deal with FITS files, and installed with

```
zypper install cfitsio-devel  # openSUSE
yum install cfitsio-devel  # CentOS
apt install libcfitsio-dev # Ubuntu
```

For Alma Linux the package and its devel version are downloaded from `https://repo.almalinux.`

org/development/almalinux/9/devel/x86_64/Packages/ or https://rhel.pkgs.org/9/epel-x86_64/ (because apparently it is not available from one of the standard repositories in https://almalinux.pkgs.org/) and installed with `rpm install cfitsio-devel*el9.x86_64.rpm`. This might (?) be called from within `dnf` as

```
dnf --repofrompath devel,https://repo.almalinux.org/development/almalinux/9/devel/x86_64 instal
devel # Alma Linux 9
```

2.1.7 Terminal Library

GEIRS uses texinfo which needs a terminal library. If it does not find any, it will compile its own local copy of `ncurses`, which is a waste of time. To avoid this, install at least one suitable package with

```
zypper in ncurses-devel # openSuse
yum install ncurses-devel.x86_64 # CentOS
dnf install ncurses-devel # Alma Linux
apt install texinfo # Ubuntu
```

Under Ubuntu and Alma Linux apparently only `gnome-terminal` is installed by default which seems to be tricky to start without patching some settings related to the locale/language settings. For that reason `gnome-terminal` is not used by GEIRS and either `apt install xterm` or `apt install konsole` are required on Ubuntu.

2.1.8 xerces

GEIRS uses the Xerces library for XML-related formatting. Use

```
zypper in xerces-c libxerces-c-devel xerces-j2 # openSuse
yum install xerces-c libxerces-c-devel xerces-j2 # CentOS
apt install -c libxerces-c-dev # Ubuntu
```

to install the library into the standard directories. For Alma Linux the package (including the devel version) is downloaded from https://repo.almalinux.org/development/almalinux/9/devel/x86_64/Packages/ or https://rhel.pkgs.org/9/epel-x86_64/ (because apparently it is not available from one of the standard repositories in https://almalinux.pkgs.org/) and installed with `rpm install xerces-c-3.2.3*.rpm xerces-c-devel-3.2.3-*.rpm`.

2.1.9 Other

2.1.9.1 gnuplot. If the executable gnuplot is not found when GEIRS is compiled, all associated graphing functionality will be disabled. The recommendation is: if

```
which gnuplot
```

does not find the executable, install the package

```
zypper install gnuplot # openSUSE
yum install gnuplot # CentOS
apt install gnuplot # Ubuntu
```

2.1.9.2 Within GEIRS. Further external packages (CCfits, and sofa, in the `GEIRS/`*branch*`/extern` subdirectory are compiled later with the main source code.

2.1.10 Plx

Section 2.1.10 can be ignored if the software is installed on computers without OPTPCI boards, that is, computers that run GEIRS only in simulation mode or act only as clients to exchange commands with other computers that have GEIRS installed.

The Linux driver for the PCI bus delivered by the manufacturer (PLX) of the main chip on the OPTPCI board (board designed by MPIA) is expected to be installed in `/usr/src`, which needs root privileges. We are exclusively using the `.zip` Linux version, never the much larger `.exe` package. If these header files and driver libraries are not found at GEIRS compile time, the software will always run in ROE software simulation.

The following instructions are a summary of the documentation found in the directory `Documentation/PLX_Linux_Release_Notes.htm` of the driver. You are strongly advised to recompile the driver each time a kernel update was installed in `/usr/src`—which happens a few times per year under a well-maintained operating system.[7]

Details may differ. In particular, the version will change as time progresses. The symbolic link installed below ensures that the header files are always found in `/usr/src/PlxLinux/PlxSdk/Include` and that `admin/plxload` finds the driver to install. We build only the drivers for the two PLX chips that have been in use by the MPIA electronics: 8311 (newer, PCIe, OPTPCI-e, the relevant one for LUCI, LN, PANIC, NTE, CARMENES and the MPIA king telescope) and 9656 (older, PCI-X, OPTPCI, still on duty on one MPIA computer). The manufacturer's imprint on the fattest chip onboard the OPTPCI shows immediately which of the two types is in use.

The PLX drivers are currently not under SVN control. This is third party software and distribution of the complete SDK package is explicitly *not* covered by the license, but may be available for example in `https://github.com/xiallc/broadcom_pci_pcie_sdk` .

1. If this follows a fresh installation of the operating system, the kernel drivers in the directory `/usr/src/linux-?.?.?` (`openSUSE`) or `/usr/src/kernels/` (`CentOS`) may be missing. This will lead to complaints of the form

   ```
   make: *** /lib/modules/3.11.6-4-desktop/build: No such file or directory.  Stop.
   make: *** [BuildDriver] Error 2
   ```

   when the PLX driver is installed further down. This is the case if the following test does not find the `build` directory of the Linux distribution of the current system:

   ```
   unamer=`uname -r`
   cd /lib/modules/${unamer}/build
   ls -l include
   ```

   This usually means that openSUSE was installed without the "developer" version of the kernel—which is one of the options while installing the OS but not included by default. This

[7] Beware that for Alma Linux 9.3 the software packages are automatically updated each time while the computer is shut down. Apparently related to `/lib/systemd/system/packagekit*` services.

is basically cured by running `/sbin/yast2`, selecting the `Software Management`, the `Repositories`, and post-installing the `kernel-devel` package (alternatively `Software Management`, `view`, `Pattern`, `Linux Kernel development`, `Accept` and `Continue`). The equivalent package install instruction is

```
zypper install kernel-devel # openSUSE
dnf install kernel-devel # Alma linux
```

On a freshly installed CentOS 7 the error message was triggered by an incorrect symbolic link to a non-existing `build` directory in `/lib/modules/3.10.0-123.6.3.el7.x86_64`, which had to be repaired. On a freshly installed Ubuntu 19.04 this obstacle does not appear.

2. We start from the Linux version distributed by PLX, log into the machine as `root`, and copy the `Broadcom_*Linux_v*.tar.gz` or `PLX_SDK_Linux_v*.zip` file into `/usr/src`. Only installations with major number > 7.1 are supported. Then move into the GEIRS source directory and call

```
./INSTALL.plx |& tee installplx.log
```

to compile the PLX driver. Error messages concerning unavailability of vmlinux (BTF generation) can be ignored.

3. To load the driver each time the computer is (re)booted copy the `admin/plxload8311.service` (or for old PCI-X computers `admin/plxload9656.service`) of the GEIRS source boundle into the directory `/etc/systemd/system` and enable this service with

```
systemctl enable plxload8311
systemctl list-units | fgrep -i plx
systemctl start plxload8311
```

This mechanism is implemented in the `INSTALL.plx` script, but note that we are not signing the compiled PLX bundles, so on SELinux systems (in particular the default of Alma Linux 9) one needs to edit `/etc/selinux/config` to `SELINUX=disabled` to support this `systemctl` automatism.

These steps are not needed and actually fail if no PLX device (read: no OPTPCI board) is found on the local bus system. Caveat: if this is automatism is not added, each invocation of GEIRS or any of the tests involving the OPTPCI board (i.e., everything beyond running GEIRS with ROE in simulation) needs to call either the wrapper script

```
plxstartup
```

or

```
systemctl restart plxload8311
```

at least once (which needs `root` privileges). `plxstartup` tries to load two different device drivers for OPTPCI-X and OPTPCI-e boards, but it is highly unlikely that both types of boards are plugged into a computer, so the command will usually emit an error

```
Install: Plx9656
  Load module......... ERROR: Load error or no supported devices found
```

This error should be ignored, because it refers to the type of board that is not applicable to the particular computer.

4. A simple check of successful loading of the driver is that

   ```
   lsmod | fgrep -i Plx
   ```

   contains the `Plx8311` entry and that

   ```
   /sbin/service --status-all | fgrep -i plx
   ```

   contains a line which mentions `loaded active (openSUSE) or loaded (CentOS) or [ + ] plx (Ubuntu)`.

   Call

   ```
   /sbin/lspci -v | grep -E 'Plx(8311|9656)' # CentOS openSUSE
   lspci -v | grep -E 'Plx(8311|9656)' # Ubuntu
   ```

   so see which boards are plugged into the computer.

   If you have root permissions,

   ```
   cat /proc/vmallocinfo | fgrep Plx
   ```

   should show three lines for each OPTPCI board plugged into the computer. Starting `yast2`, moving into the `Security center and hardening` menu, selecting the `Configure` of `Enable basic system services` should also indicate the Plx drivers enabled. If `lsmod` does not show the driver, scan the system logs:

   ```
   journalctl | fgrep plxload
   ```

   Note that this activates driver loading at computer run level changes; you won't see the driver in the services until the next reboot or a manual interaction as in the previous bullet.

Each time the driver is recompiled, *all* GEIRS versions which will be used in the future need to be recompiled—because they are linked with the binaries in the `/usr/src` directory, Section 2.2.2.[8] If `zypper up` installs a new Linux kernel, the steps are (as root)

```
zypper up                   # update /usr/src kernels
reboot now                  # ensure that new kernel is active
INSTALL.plx                 # recompile PLX driver
reboot now                  # test that PLX driver will become loaded
```

[8]The step that dives into the `extern` directory of the GEIRS source code can be skipped to save some time, because none of the external packages links with the PLX driver. The `configure`, `make` and `make install` steps in the top source need to be redone.

Running `zypper up` with the source files installed will sooner or later fill the partition with the `/usr/src` directory. You may remove the directories of the patterns `/usr/src/linux-[0-9].*-lp15*` for openSUSE Leap installations that are no longer active. It also helps to clean journal files with something like

```
journaltcl --vacuum-time=3d
```

to wipe some disk space, and

```
zypper clean
```

2.2 GEIRS Compilation

2.2.1 Obtaining the Source Code

- With subversion (SVN), the current (read: potentially unreliable) source is extracted with a script like

  ```
  export CAMHOME=${HOME}/GEIRS
  mkdir -p $CAMHOME
  rev=$(svn info --show-item revision https://svn.mpia.de/gulli/geirs/src/trunk)
  cd $CAMHOME ; svn checkout https://svn.mpia.de/gulli/geirs/src/trunk trunk-r${rev}-
  0
  ```

  If the `KWallet` system asks annoying additional questions, you might disable it entirely by using the KDE application menue, `System`→ `KWalletManager` →`Settings`→`Configure KWallet`.

  There is no public read accesss to this repository. Requests to obtain rights on the repository need to be directed to Florian Briegel at the MPIA. The standard way of distributing the source code is that the GEIRS maintainer (currently the same as the author of this manual) obtains full access to the computer on which GEIRS is run, and installs the software there.

- If otherwise the source code is taken in a compressed tar ball from the anonymous ftp server or GWDG server, move this into the `CAMHOME` subdirectory of the observer (Linux account) who will start and run GEIRS and eventually generate the FITS files with the data.

  In most modern browers the ftp-protokoll is disabled, so one must access the ftp server by the standard command line:

  ```
  ftp -A -a ftp.mpia-hd.mpg.de
  cd pub/mathar
  dir
  get trunk-r802M-144.tar.xz
  quit
  ```

  or

  ```
  wget --no-passive-ftp ftp://ftp.mpia.de/pub/mathar/trunk-r802M-144.tar.xz
  ```

The actual version of the tar bundle will increase in the course of time. The `ftp` directory is a scratch directory where files older than 10 days are erased; if I did not upload a version in the past 10 days, the directory may be empty. The alternative link above for the GWDG server is less volatile.

This tar ball is the same for all instruments supported by GEIRS. If this is a first installation for an account, configure the environment as explained in Section 2.5, and re-login to activate these changes. Prepare for the compilation by unbundling it:

```
cd $CAMHOME
unxz -c *_r*.tar.xz | tar x
```

The `MACROS` and `scripts` directories are not under SVN and cannot be obtained that way (and do not need to be obtained that way).

2.2.2 Compilation

There is only installation support based on the GNU autotools. This works as described in the file `$CAMHOME/`*branch*`/INSTALL` in the source code, which is particularly designed to be executed. This is in general the only thing that needs to be done to upgrade the GEIRS version. If this is a first installation for an account, configure the environment as explained in Section 2.5, and re-login to activate these changes.

There will be a `sudo` at the end of the compilation. If the account is not the sudoers file, one ought to add it for example with `usermod -aG wheel` *geirsuser* `id` *geirsuser* because usually the `wheel` group is (uncommented) in `/etc/sudoers`.[9] Compile the source code:

```
cd $CAMHOME/... # move into the new _r*M-* source directory to be compiled

./INSTALL
```

If this emits errors of the kind

```
INSTALL.sh not found
```

add the current working directory to your path (in `/.bashrc` preferably):

```
export PATH=${PATH}:.
```

This is all done under a generic non-privileged Unix/Linux account. The `INSTALL` script will ask with a sudo(1) command for permissions to modify two binaries just compiled.[10] For test environments where GEIRS runs the data acquistion in simulation mode this is superfluous (and the `INSTALL` request may be cancelled with `CTRL-C`). For production code at the telescope, however, it is recommended to set the permissions to stabilize the real-time behaviour of the data acquistion.[11]

There will be `Error 2 (ignored)` and `failed` messages related to packages mentioned in Section 2.1.9 which GEIRS will not install if equivalent packages are found in system libraries. Which system libraries are found depends on the operating systems, and even more on the attitudes of

[9] A reboot will be likely needed to reload that new permission; ...

[10] see `/etc/sudoers`. Typically uncomment the `wheel` entry and use `usermod -aG wheel` *GEIRscompiler* to add the account to the `wheel` groupd.

[11] These `root` permissions can of course also be set by someone else in the `bin` subdirectory after the `INSTALL`.

the individual system administrators to deal with software upgrades in general and the recommendations of Section 2.1 in particular. So `failed` messages are generally good because they indicate that GEIRS skipped (failed) compilation of packages because the system administrator maintained the standard libraries.

A second `./INSTALL` may run faster than the first because usually the libraries that were compiled in the first run are not recompiled.

This needs of the order of ten minutes. (This means there is no reason to cheat the installation by copying binaries or setting links or symbolic links between various Unix/Linux accounts.)

To recompile a package, remove the entire `_r*M-*` versioned source directory, and call the `unxz` on the `*.xz` and the `./INSTALL` again. So after any changes to system libraries, upgrades of the compiler and so on, we recommend to run the entire `./INSTALL`, not just a `make -f Makefile distclean ; make -f Makefile install` in the source directory.

Starting from GEIRS version 759 or newer,

```
cd ${CAMHOME}/...._r*M-..
make distclean
./INSTALL
```

should have the same effect. Note that `make -f Makefile install` in the source directory would only recompile GEIRS but not the external packages.

This tar ball and the compilation step is the same for all instruments supported by GEIRS. Note that many links to the `scripts` directory are not installed by this step of the compilation/installation, but at the time when GEIRS is started. The simple reason is that the scripts that are available should be those depending on the GEIRS version that is run, not on the most recently compiled version. The decision on which instrument is started/configured is not done at compile time but later at startup time.

The installation should not be upgraded while GEIRS is running, because some files at common places will be replaced by the versions of the release that is compiled—for the same reason as the one mentioned in Sect. 4.1.

Compile GEIRS separately for each user. *Never* (!) cross-link or copy binaries from one account to another. The source code uses static variables and these would be shared if the binaries would be run by the different accounts at the same time (leading to interference effects between the concurrent GEIRS sessions).

The subdirectories `admin` and `devel` are not compiled with a standard installation.

By design, there are GEIRS features that depend on whether the source code is compiled on a computer with a MPIA IP address or not, for example

- The standard logging level is reduced outside MPIA;
- Default IP addresses change;
- Support of handling temperatures and pressures is reduced outside MPIA for instruments other than PANIC;
- Standard sets of operators (Figure 7) change.

If the account is set up properly (Section 2.5), you should be able to start GEIRS as indicated at

the beginning of Section 3 —at least putting all components in simulation mode—and to get some images by pressing on the `Read` button of the controls GUI, Figure 9.

2.3 De-Installation

Any single GEIRS version suffices to run the instrument.

As with any other software old bugs are removed and occasionally new bugs appear as new versions are developped.

To de-install a GEIRS version remove the entire subdirectory of `$CAMHOME` with the subversioned name, which will be of the format `trunk-r*`. If you never want to see it again also remove the associated compressed tar ball.[12] There are no GEIRS specific remnants in the standard system's directories like `/usr`. Versions that are removed disappear from the options for the `geirs_start_*` and `geirs_start` startup methods.

This cleanup is recommended for all versions that have never been used for real-data acquisition at a telescope—to save disk space. This cleanup is almost mandatory each time the kernel of the operating system and the PLX driver have been upgraded—to avoid that operators start the old binaries that link to incompatible new PLX libraries.

2.4 Configuration of the Operating System

2.4.1 Shared Memory

The following paragraph is only of interest if the GEIRS computer is also running competitive programs that use shared memory for their databases and similar purposes.

Under openSUSE or CentOS, the available amount of shared memory is indicated by

```
cat /proc/sys/kernel/shmall
```

or

```
/sbin/sysctl -a | fgrep shm
```

or

```
ipcs -lm
```

As root, this may be momentarily changed by (`sysctl(8)`)

```
sysctl -w kernel.shmall=...
```

To allow this configuration to persist through rebooting the computer, it is recommended to modify `/etc/sysctl.conf` like

```
kernel.shmall = ...
kernel.shmmax = ...
```

`shmmax` is the maximum memory of a single allocatable chunk of shared memory in bytes, and `shmall` is the total allocatable shared memory in units of pages (where a page is typically 4096 bytes as indicated by the output of `getconf PAGE_SIZE` or the number of `shmni` generated above).

[12] This is not recommended for versions that have actually been run in production because one might want to roll back and to recompile if for instance the operating system and the drivers or the compiler have been updated.

A full frame of a $2k \times 2k$ chip comprises $4 \times 1024^2 = 4,194,304$ pixels, which amount to $2 \times 4,194,304 = 8,388,608$ bytes with a 16-bit ADC (LUCI,LINC-NIRVANA,NTE) or $4 \times 8,388,608 = 33,554,432$ bytes for a mosaic of 4 chips or a single Hawaii-4RG (PANIC,AIP) or $2 \times 8,388,608 = 16,777,216$ bytes for a mosaic of 2 chips (CARMENES).

The minimum requirements for the allocatable shared memory is roughly twice these numbers, because the software uses a scheme of two alternating buffers to implement parallel read and save procedures.[13] These values may be taken from the `shmmanager:wanted` lines in the standard output created during startup (Section 3).

A guideline of the shared memory for production where GEIRS runs at most two instruments on the computer at the same time would be half of the total memory available on the machine. These numbers are obtained with

```
cat /proc/meminfo
free
```

under openSUSE or CentOS. The effect is basically a cap on the number of frames that can be swallowed at one time, so it puts limits on the "length" of the sample-up-the ramp modes, on the repetition factors of most modes and the number of pairs of Fowler modes.

The shared memory used by GEIRS is actually set in the `geirs_start_gen` bash script in the function `configCAMSHMSZ` by dividing the RAM through constant integers depending on host name and instrument. So for intermediate tests one can edit these denominators prior to GEIRS startup. The default is obviously set by the SVN source code.

People who like to use the suspend mode of their computer need to ensure that (as long as they want to suspend while GEIRS is running) the swap partition has been set up large enough to include these shared memory pages.[14]

2.4.2 Subnet

This subsection is obviously not GEIRS specific but a generic hint to configuration of the host workstation.

If the rack of the ROE electronics are given IP addresses on local networks, the file `/etc/sysconfig/network/ifcfg-eth0` (typically for openSUSE) on the GEIRS workstation needs to be augmented with the additional subnet(s) and mask(s) by lines of the format[15]

```
IPADDR_ir2='192.*.*.*/*'
# LABEL_...='...'
```

Details depend on how the GEIRS workstation is known to the subnet. This is tested by powering the devices up and `ping`ing the devices from the GEIRS workstation (`ping(1)`). On behalf of GEIRS there is no need to add a nameserver for these devices; working with the 4-byte numerical addresses in the startup-script suffices.

[13] In the C++ source code these alternating buffers are disabled for CARMENES via a `SHM_BUFS` flag to increase the effective number of frames by a factor two. This requires a `sync` after each read and each write. In the era of `SSD`'s it's debatable whether the alternating buffers are actually needed...

[14] While configuring the operating system, some installers assume that swap partitions can be much smaller than the RAM...

[15] For PANIC at CAHA this is 192.168.70.1

If such entries are missing, GEIRS cannot communicate via Ethernet with these devices.

2.4.3 journaling

It is recommended to enable access of GEIRS to the system journaling as detailed in Section 10.2 because GEIRS uses the syslog(3) to log informal and error messages. This is not strictly needed for a well-debugged GEIRS version, and the casual GEIRS user will not know what to do with that information. But the installation is necessary to work with the error and debug monitors of the controls GUI.

Once enabled, the log lines are read with the shell-command

```
journalctl SYSLOG_IDENTIFIER=GEIRS
```

2.5 User Configuration

2.5.1 Directory Layout

The standard directory layout of the GEIRS installation in the observers file system is a directory named `GEIRS` with subdirectories `INFO`, `MACROS`, `log` and `scripts` and a selection of GEIRS versions which have file names that start with `trunk` and end with a SVN revision number and perhaps a subrevision number.

```
GEIRS
   -> INFO/
   -> MACROS/
   -> log/
   -> scripts/
   -> trunk_r694/
   -> trunk_r779M-50/
```

The `MACROS` directory is a default search directory for command sequences for the `macro` command (see Section 5.3). If the `macro` command is not used or used with full path names, the `MACROS` may be absent or empty.

Each of the GEIRS versions contains a bundle of C/C++/perl/Java source files and binaries, and directories for the documentation and so on, after the step of Section 2.2.1 is finished:

```
GEIRS/trunk-r779M-50
        -> admin/
        -> bin/
        -> caha/
        -> de/
        -> devel/
        -> doc/
        -> share/
        -> test/
        -> *.cxx
        -> *.h
        -> *.pl
```

```
        -> Makefile.am
        -> INSTALL
        -> configure.ac
```

Some of the files in such a version are linked back to the `scripts` directory either when the version is compiled or when GEIRS is started. This concept keeps the mandatory executables at a single place (the `scripts` directory) for the benefit of a simple `PATH` variable, but also keeps them synchronized with the operators decision to launch a particular version.

2.5.2 Path

It is well advised to add `${CAMHOME}/scripts` to the path at the standard location; this would be

```
export CAMHOME=$HOME/GEIRS
export PATH=${CAMHOME}/scripts:${PATH}
export MANPATH=${CAMHOME}/man:${MANPATH}
```

in `$HOME/.bash_login` or `$HOME/.bash_profile` (but not both) for the bash(1), for example. Unfortunately there are users who let the environment ignore that setting because they chose their shells not to be login shells—as revealed by the `shopt` command.[16] In these cases the `PATH` must be set in `$HOME/.bashrc` with constructions like

```
if [[ $BASH_SUBSHELL -eq 0 ]] ; then
    export CAMHOME=$HOME/GEIRS ;
    export PATH=${CAMHOME}/scripts:${PATH} ;
    export MANPATH=${CAMHOME}/man:${MANPATH}
fi
```

To enforce `konsole` to launch a login shell use

```
konsole -e bash -l &
```

or run in the menu bar of the `konsole settings` -¿ `edit current profile` and add the option `-l` to the `bash` command.

2.5.3 Standard Scripts

If a certain class of users should better not start some of the instruments, delete the associated symbolic link in the `scripts` directory of the user's GEIRS installation; this removes the command from the set of executables of the Linux/Unix account because it disappears from the search list of the `PATH`. There is no basic mechanism that prevents a user like `readout2` to start an instrument like `Luci_1` or vice versa,because the same GEIRS version is installed for all users,and because there is no strict association between Linux/Unix accounts and instruments. Each user decides by choice of command name and startup method which instrument is started. One could even start Linc-Nirvana from the Luci computers and vice versa if the Internet routing between the subnets allows to connect to the other instrument's ROEs. A similar argument works for the pair

[16] One reason is that the application launcher of openSUSE ignores the files `.Xresources` or `.xinitrc` where one would set the `Xterm*.loginShell` variable. A simple way to improve this is to add the `-ls` option to the `System->Terminal->Xterm` command when editing the openSUSE application launcher with a right-click, and to add that xterm to the Panel.

of CARMENES and PANIC on Calar Alto.

The simplest way to make it difficult for users (like `readout2`) to start instruments (like `Luci_1`) is to remove the symbolic links of the instrument in the users's `script` directory.[17]

The file `geirs_start_gen` is not just a startup script but a configuration script that defines many of the variables listed in Section 3.2. These defaults *must* be edited at least at one place:

1. If a ROE is to be used such that it is not simulated, `CAMPORT` must be changed to the address of the ROE. Once the instrument is run in a stable environment, the default address is known and ought to be compiled into the scripts of the SVN repository. For transient setups, one may also set the environment variable in the Linux shell before starting GEIRS, see Section 3.2.

2.5.4 Hooked Scripts

GEIRS has 4 points of the command loop where programs (scripts in some interpreter or binaries. . . , executables in the Linux sense) are started. This serves to adapt GEIRS on a per-instrument basis to requirements that are not actually in the realm of a detector controller, and allows to synchronize the detector readout with other mechanisms of the telescope or instrument. These executables are in the `scripts` subdirectory and re-installed at startup with the script of the current GEIRS version. The executable may put itself into a background program to run asynchronously with GEIRS; GEIRS waits until the executable returns.

- `QueueAFiles` is called when the `save` command is executed and before the FITS files are created.

  A common action here is to assemble the files with the complementary FITS keywords in the associated file, i.e., to modify/edit the files described in Section 7.2. (But this is usually bad design, because GEIRS is a DCS, and adding that information is the task of a supervisor software, not of the DCS. So actions of modifying the FITS files would better be implemented in the `QueueFiles`.)

- `QueueEFiles` is called when the `read` command is received, and before the detector readout actually starts. This may be used to adjust some optics of the instrument before the exposure.

  `QueueEFiles` is actually only called when the 3rd bit (0bit=LSB) of the `GEIRS_FLAGS` integer in the shared memory data base is set, so it can be changed through supervisor programs on the fly with the `put` command (see Section 5.3). This bit can also be toggled with the `-Q` check box in the controls window (Section 4.3.1).

  PANIC uses it to gather ambient and CAVEX Data for the FITS files.[18]

  The script for Linc-Nirvana moves the derotation stage of the detector to a start position in an attempt to keep the instruments infrared background constant on the detector surface. Note that for Linc-Nirvana this is not enabled when GEIRS starts up because that would require that the rotator stage of the detector is powered on, and cause infinite delays (apparent "hang-ups") if that motor is not powered.[19]

[17] . . . of course the `geirs_start` GUI still allows everbody to start every instrument. . .
[18] because the data are slowly varying, an alternative could add a `crontab(1)` entry. . .
[19] and the standard operator is not aware of that sort of interdependencies. . .

Another plausible application is to set the readout mode to `continuous` and `autosave` such that GEIRS reads detectors autonomously without operator intervention. Because that fills disks rapidly, the `QueueEFiles` may contain a trivial script which pauses while some lock file (say, `~/.geirs/nogo`) exists,

```
#!/usr/bin/env bash

while [ -a  ~/.geirs/nogo ] ; do
        sleep 5
done
exit 0
```

and the observation software could create that file with `touch ~/.geirs/nogo` during the periods where reading the detector is useless—for example while the telescope is slewing, the dome closed, the optics not ready or at the end of the night—and remove that file during clear-skys.[20]

Note that implementing `QueueEFiles` is usually bad design, because GEIRS is a DCS, and the synchronization of that kind is the task of a supervisor software, not of the DCS.

- `QueueFiles` is called when the `save` command has been completed. It might be used to display the new FITS file with ds9(1), to trigger some action related to data archival, or to start some data pipeline, see Section 3.3.
- `QueueZFiles` is called when the `quit` command is received. It may be used to add symbolic links in the data directory such that the FITS files are available under standard names of the observatory, or to extract some database from these FITS files.

These scripts may do nothing: a 2-liner like

```
#!/usr/bin/env bash
exit 0
```

or a 1-liner like

```
#!/usr/bin/env python3
```

—made executable with `chmod(1)`—would implement that.

2.5.5 Shared Memory

Whereas the setup in Section 2.4 allows some maximum of the memory (real and virtual) to be dedicated to shared memory blocks by any applications on the computer, GEIRS needs also to be configured to request some (or all) of this when started. This is done by editing the size of the variable `CAMSHMSZ` in `$CAMHOME/scripts/geirs_start_gen`, likely by setting it to some default of approximately `2048` depending on the name of the workstation. Typically this will be the integer obtained from

```
cat /proc/meminfo | fgrep MemTotal
```

[20] sending the command `pause` serves the same purpose...

divided by 2000—a factor of thousand to transcribe the number of megabytes and a factor of two to respect the needs of other programs with the thread of swapping.

The main effect of this number is to limit the number of frames that can be held in memory for the standard non-continuous readout modes before releasing that space at the time of a `save`.

The `geirs_start_gen` file uses defaults which are slightly dependend on the name of the workstation on which GEIRS is run. For LUCI there is a deliberate further divisor of 2 assuming that the two LUCI instruments may be run on the same computer.

2.5.6 Disk Allocation

There is no automated removal of administrative files by the software. Users need to look into the `$CAMHOME/DATA` directory, the `$TMPDIR` and in particular in `$CAMHOME/log` for obsolete and large log files left behind.

The amount of space required by various log-files depends in particular on the value assigned to `LOG_LEVEL` in `configure.ac` in the source directory. That default level depends on whether the source code is compiled on a computer with MPIA IP address or elsewhere.

Some files grow without bounds, so it is useful to split them into subfiles in regular intervals (with `crontab(1)` for example) one time per day when the instrument is *not* used. A shell script to automate this is proposed in `GEIRS/<branch>/admin/glogRotate.sh` and installed with `INSTALL` if missing. If

1. `glogRotate.sh` is copied to `$CAMLOG`—where `CAMLOG` is usually `$CAMHOME/log`—,
2. this is made executable with `chmod +x glogRotate.sh`, and if
3. the associated entry as proposed in `glogRotate.sh` is added with `crontab -e` into the schedule of the usual account that runs GEIRS,

this infinite growth of files is limited by the daily growth.

Since GEIRS version 769M-27, the logs of the main program are written with `syslog(3)` to the journal files, no longer to `$CAMLOG`. Only (i) the PANIC temperature logs, (ii) the lists of the commands recieved by the command manager and (iii) the messages exchanged with the ROE remain in CAMLOG.

2.5.7 info

The info file `camera.info` is available which is basically supported by adding also

```
export $CAMHOME=$HOME/GEIRS # assumes default directory layout
export INFOPATH=${INFOPATH}:$(geirs_build)
```

into the `$HOME/.bash_login` such that

```
info camera
```

of `info(1)` will also find the help file of Section 5.3.

2.5.8 Sound Configuration

GEIRS generates sound by playing the audio files in `$CAMHOME/<branch>/admin/*.au` at certain events unless

1. the sound level within GEIRS is set to zero in the `Options` submenue in Figure 9 or with the `sound` command (Section 5.3).
2. the sound is muted with the sound/mixer application on the user's desktop,
3. GEIRS runs on a remote computer and sound is not forwarded to the user's desktop (Section A.3),
4. the environment variable `CAMAUDIOPLAY` was not set (in the startup scripts).

History shows that the people who install GEIRS usually fail to test and install their (remote) sound configuration on the GEIRS workstation, so the sound volume is initially switched to zero for new users to avoid any followup problems.[21] If the setup is not installed properly and sound is switched on (measured according to the criteria listed above), it will likely happen that at the first time a sound is configured to be played, the system call to play that sound will crash, which will trigger a followup error because this will attempt to play `crash.au`, which will not succeed and eventually turn into a recursive endless cascade of sound errors.

The sounds may be changed by replacing the audio files in the GEIRS file system in that directory.

Sound File	triggered by...
doorbell.au	readout finished
cuckoo.au	macro finished
bong.au	backup or the 'shift-and-add' calculation finished
crash.au	general error
fastbusy.au	warning (at changing user level to engineer or if near saturation)
whistle.au	`save` completed
sorrydave.au	unrecognized command
touchtone.0.au	disk full

The executables charged with the sound creation are weakly configurable with the two `CAMAUDIO` environment variables of Section 3.2.

2.5.9 baloo

Because indexing all the FITS files is useless and may reduce system performance, we recommend to add

```
balooctl disable
```

somewhere in the `$HOME/.bashrc` file of users who may run GEIRS, or to unistall `baloo` altogether.

[21] Those problems can be re-introduced if software-engineers just copy GEIRS from one user account to the other; this practise is very bad and entirely discouraged.

3 INVOCATION

3.1 From workstation or remotely

Call the `$CAMHOME/scripts/geirs_start_*` that matches the instrument name,

`$CAMHOME/scripts/geirs_start_`*instru*

where *instru* is one of `nirvana`, `luci1`, `luci2`, `nteimg`, `nteisp`, `panic`, `carmenes`, `aip` or `sidecar` The full path name is not needed, of course, if the environment has been set up as proposed in Section 2.5.

This will create directories and files like `$HOME/tmp` and `$HOME/DATA` and `$HOME/*.log` if these do not exist. It will also add symbolic links in the `pttrns` directory if needed. To relocate source, data and logging directories, edit the associated environment variables in `$CAMHOME/scripts/geirs_start_gen` or set them before starting GEIRS.

The principal ways to control the electronics via GEIRS are

1. Interactive manipulation of parameters and exposures with the GUI;
2. Interactive submission of commands with a text interface to the GEIRS "shell" (Figure 13). This interface is richer than the set of GUI buttons because many commands do not have a perfectly equivalent button.
3. Commands sent from the computer on which GEIRS is running from the UNIX/Linux shell with

   `geirs_cmd_`*instru cmd arguments [; cmd arguments...]*

   `geirs_snd_`*instru cmd arguments [; cmd arguments...]*

   where *instru* is one of `nirvana`, `luci1`, `luci2`, `nteimg`, `nteisp`, `panic`, `carmenes`, `aip` or `sidecar`

   or

   `geirs_cmdClient [-s` *server*`[:`*port*`]] [-p` *port* `] [-v] [-fi|fc]` *cmd arguments [; cmd arguments...]*

   The `geirs_cmd_` versions connect to the shared memory database of a GEIRS command interpreter running on the local machine; no TCP socket is used—as one may guess from the absence of the corresponding command line options. To this effect it uses the shared memory socket created by the same user in `$HOME/.geirs` when GEIRS was started; this basically avoids interferences if multiple users are running multiple GEIRS instances on the same computer. For the Luci instruments the standard installation in Section 2.5.3 will create indexed versions `geirs_cmd_luci1` and `geirs_cmd_luci2` of the command, and this may lead to confusion: because `cmd_` looks up in the user's `~/tmp/shmsocket` to which port to connect, the index of either `geirs_cmd_luci1` or `geirs_cmd_luci2` does *not* select the instrument. The instrument is the instrument the Linux/Unix user calling the `geirs_cmd_` actually started most recently.

   The `geirs_snd_` interfaces and `geirs_cmdClient` are essentially the same, where `geirs_snd_` calls `geirs_cmdClient` which is based on TCP sockets. `geirs_snd_` are shell scripts and supposedly a little slower, but they offer a slightly finer control of which shell variables and GEIRS versions are used while executing a command.

4. Commands sent from a remote computer from the UNIX/Linux shell with

   `geirsCmd [-t` *timeoutCntSeconds[:timeoutRplySeconds]*`] [-s` *server*`[:`*port*`]] [-p` *port* `]` *cmd arguments [; cmd arguments. . .]*

   The standard port is 8501 for `geirsCmd` on older systems and taken from the port entry in the user's shared memory socket on the *server* for `geirs_cmdClient`.[22]

   Using another port—for example for running multiple instances on the same computer—is supported by starting the `cmdClient` in `geirs_start_gen` either with the switch `-s` *server:port* or with the switch `-p` *port* or modifying the `CAMSERVERPORT` before starting.

   The `-t` specifies one or two timeouts measured in seconds, positive integer numbers.

   - The first timeout is by default 10 seconds if the `-t` option is not used. It specifies a maximum duration to get into contact with the command server and to deliver the actual command and its arguments; the parameter does *not* relate to the time the execution of the command itself would need on the server side. If the timeout expires, it typically indicates that either the server has not been started, or that the port number is wrong or has been blocked by firewalls, or that the command server has been overloaded with a workload by previous commands in a typical *denial-of-service* condition.
   - The second timeout is by default half an hour, i.e. 1800, if the `-t` option is not used. It specifies a maximum duration to wait for a reply of the command server and is by default much longer in particular because a `sync` command for long integration times on spectographs may not return earlier.[23]

   The syntax supports specifying either one or both of these timeouts depending on where the colon (if any) is: `-t 1seconds` overrides only the first, `-t 1seconds:2seconds` overrides both, and `-t :2seconds` overrides only the second. In the last case the colon and number typically needs to be put in single quotes to avoid interpretation by the Linux shell.

   The *server* is typically the name of the GEIRS server resolved by the local name servers. If only a bare dotted IPv4 address is known, the usual protocol type should be included: `-s tcp://`*xxx.yyy.zzz.vvv*`:`*port*.

   `geirsCmd` uses a TCP socket interface which recognizes the same set of commands as the other interfaces. On the GEIRS computer, the sockets are managed by the `cmdServer`, which is started by either one of the `start*` commands or checking the `-cmd` option in the engineering GUI (Figure 8). `geirsCmd` is indeed just a wrapper which uses that socket interface to submit commands to the `cmdServer`.

   The syntax of separating multiple GEIRS commands by semicolons (as indicated by the line above) usually requires that the commands and arguments are packed into single quotes to prevent the Linux shell from interpreting the semicolons based on its own syntax.

   The `geirs_snd_` versions and the `geirsCmd` both use a socket interface for the command and answer. `snd_` needs an active (=started) GEIRS sessions on the local computer to hook into and uses the port number registered with the shared memory socket at GEIRS startup as

[22] The port number was also printed to `stdout` when GEIRS was started and is also in the lists of `CMDIPPORT` in the XML file of `~/.geirs/` On newer Linux systems the first 10 thousand ports are reserved and should be avoided. It is particularly import for LN with its massive use of ICE ports to check that the GEIRS ports are not in use already for other services.

[23] disadvantage: a long timeout here means that the program would not notice if the GEIRS process on the remote machine has been terminated in the meantime.

a default, whereas `geirsCmd` can contact a GEIRS session running on any remote computer reachable via the network.

5. Any other fundamental socket connection. A `telnet(1)` example looks like

```
mathar@mathar:~> telnet irws2 8501
Trying 149.217.42.24...
Connected to irws2.
Escape character is '^]'.
status
GEIRS_reply_2.0 694
itime: 2.7399310505
cycle-type: lir
cycle-repeat: 1
coadds: 1
ctime: 5.4812006566
last-filename: <unknown_not_yet_saved>
next-filename: trash_0001
autosave: off
...
error: NONE
version: carmenes@irws2: trunk-r737M-7 (May 20 2015, 17:48:39) (SINGLE) (/home/carmenes/GEIRS/t
r737M-7/bin, Carmenes_r9M)
status itime
GEIRS_reply_2.0 20
itime: 2.7399310505
ctype srr
GEIRS_reply_2.0 3
OK
quit
GEIRS_reply_2.0 56
Command return of 'quit' terminates the camera software
Connection closed by foreign host.
```

The replies contain a header line starting with `GEIRS_reply_` (a version number, a blank, and the number of bytes in the main body, including any line feeds), plus one or more lines in the main body.

If you wish to talk to GEIRS via that socket interface, be aware on fundamental Linux design issues, in particular the timeout parameters shown with

```
cd /proc/sys/net/ipv4
cat tcp_keepalive_time
cat tcp_keepalive_probes
cat tcp_keepalive_intvl
cat tcp_retries2
```

If your client interface does not get answers from GEIRS, your client may have been idle too long, and this is *not* an error of the GEIRS server, see RFC 1122.

Brackets indicate that switches and/or multiple command-argument lists are optional. Quotation marks around the command lists are usually required to avoid that the shell of the operating system splits the lists.

The *server* argument is either a simple name of the workstation on which GEIRS is running (if supported by a DNS) or a plain *tcp://x.y.z.w* IP specification.

If GEIRS has been started without opening the GUIs, inserting `quit` for *cmd* above is the recommended way of shutting GEIRS down.

Note that at GEIRS startup a single (one and only one) command port is activated to which the server listens. The `snd` and `geirsCmd` methods open and close their (client) ports for the duration of their isolated commands. This ensures (to some degree) proper sequentialization of commands and answers. The variety of other possible socket connections to that port will become very confused if a mix of these access methods is used. A standard indicator of that murky situation is that commands do not receive replies because the port is kept open by another client. In short: do *not* open the port if it is already used by another client.

3.2 Environment Variables

The configuration if GEIRS is steered primarily by setting environment variables (in the standard Unix/Linux sense of the shell) during the startup phase and later on by communication of the subprocesses via a shared memory data base.

The fundamental values of environment variables may have been set outside GEIRS with the standard mechanisms

- during login (the files `.bashrc`, `.bash_login` in the home directory and equivalent locations),
- with the `export` command.

A refined set of variables is then established in a second step within either

- the `start_*`, `snd_*` or `cmd_*` scripts or
- the `geirs_start` GUI.

In a third level, the shared memory manager starts with an internal set of default values, and overrides these with values set during the second step. As a side effect of that procedure, changing these fundamental parameters channeled trough environment variables requires a GEIRS shutdown and restart.

The following shell environment variables may be set in the `start_*` scripts to configure defaults of the behavior of the software:

CAMAUDIOMIX The name of the mixer of the audio files, for example `aumix`. If the variable is not set, no mixer will be used.

CAMAUDIOPLAY The name and options of the executable that plays the sound files, for example `paplay`, `aplay -d 5 -N -q`, `auplay` or `audioplay`. This specifies the full command stripped off its final parameter (the file name), such that attaching the name of the sound file and redirecting the standard output is a valid system call. See also [6].

CAMBIN The name of the subdirectory of `$CAMHOME` with the compiled code. This is the `bin` subdirectory of a subversion branch name, like `~/GEIRS/trunk_r713M/bin`. Whereas the variable `CAMHOME` usually remains fixed for the operator, `CAMBIN` is chosen as one of these subdirectories when GEIRS is started; this allows switching between different releases of the software.

CAMBROWSER Full path name to a HTML browser. Only used if the online help is called with the button as in Section 5.3 or for the air mass plotting in the GUI of Figure **??**.

CAMDATAPORT IP port number of the data server that submits data to the real-time display. The startup script defines the standard port and echoes its value to the standard output. After GEIRS is started one can send

```
get DATAIPPORT
```

to the GEIRS server to ask what its current port is.

CAMDPORTS The number of PCIe channels and fibers set up for the transfer of the ADC data from the ROE. This is 1 for all cameras with a single chip (LINC-NIRVANA, LUCI and NTE), 2 for PANIC, AIP and for CARMENES. The basic advantage of using two channels (which at the same time implies using both fibers of the connection from the ROE to the computer) is that the data transfer is more stable.[24]

CAMERA The master configuration label, which is either `Nirvana`, `Panic`, `Carmenes`, `Luci2`, `Luci1`, `NTEimg`, `NTEisp`, `Aip` or `SIDECAR`. Other names are not supported and obsolete.

CAMHOME The top level directory of GEIRS. It contains at least one `INFO` subdirectory and one `log` subdirectory.

CAMICEPORT IP port number of the ICE server. Only relevant if GEIRS is integrated in the LN operation, and that server may be queried by other servers. For LN any change of that number must be reflected in the listing for the `geirs-svr` in the `lnsw/config/alias-lbt.cfg` and `lnsw/config/alias-lbto.cfg` files so the clients will find that server.

CAMINFO A subdirectory for configuration purposes, typically `$CAMHOME/INFO`. It also contains bad pixel masks, and `gnuplot` command sequences.

CAMMOTSERDELAY Delay between transmission of individual bytes on serial lines connected directly (through a line connected to the GEIRS computer) to motors.

CAMPORT IP port of the ROE as a string of the tcp://xxx.xxx.xx.xx:4000 format. Empty or not set if there is no ROE rack such that this interface will be used in software simulation. The modification of this address on the ROE side via its interfaces is described in [7, Sec. 4.1.2][8] and Section A.1. The port number (4000) cannot be changed—there is no scenario where one would have to change it.[25]

[24]. . . related to the existance of a 128 kB FIFO on the OPTPCI at the end of each channel/fiber that feeds into the PLX. At a standard readout frame period of 1.3 seconds, the net 16-bit data stream from the ROE to the computer is $4 \times 2 \times 2048^2/1.3$ bytes per second, or 26 MB/sec accumulated by the 4 PANIC chips. With a single 128 kB buffer, the maximum latency of the DMA transfer to the Linux kernel is $128 \times 1024/(26 \times 1024^2)$ sec, or 5 ms. If the data are distributed over both channels, the effective FIFO capacity is 2×128 kB, and the latency allowance is doubled to 10 ms.

[25]unless communication to the ROE is mediated by an interface similar to Figure 27.

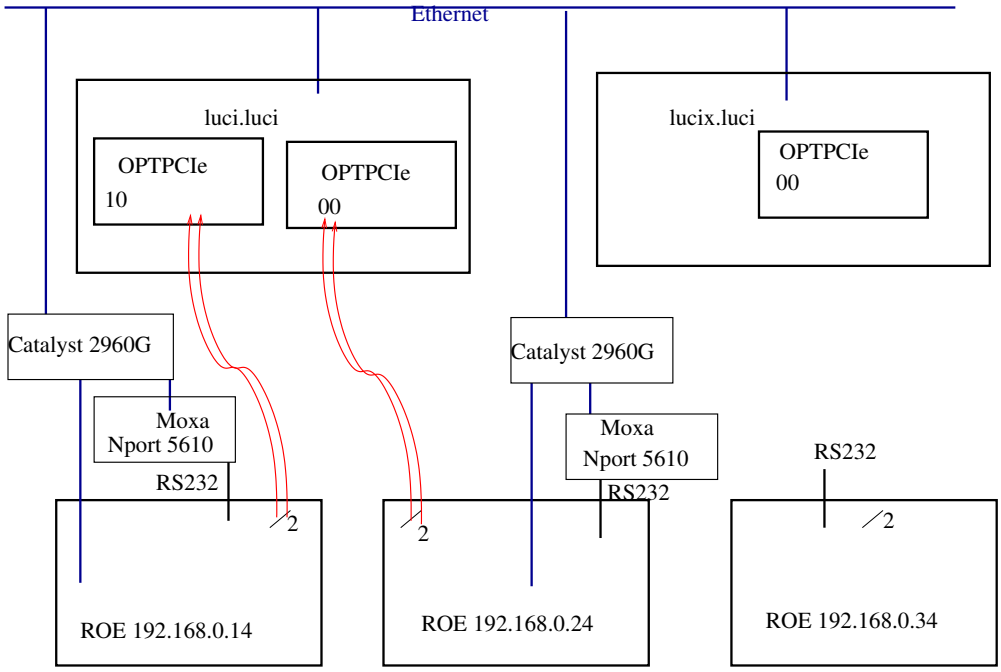


Figure 1: LUCI configuration: The ROE sends the digitized pixel data of the detector chip through one fiber of the fiber pair; the other fiber is not used and transmits zeros. Each of the two LUCI computers may receive data from any of the ROE's if GEIRS is configured with the `CAMPORT` variable to talk to the ROE that generates the data and if the fiber that streams the digitized data ends up at the correct OPTPCIe board configured with the `DATAINPORT1` variable.

Wherever GEIRS is run in normal mode (i.e., not as a software simulation), it *must* be able to connect to the ROE that controls the detector via the Internet; for testing purposes only, a control through the RS232 serial interface is possible (Section 10.1). The fiber pair from that ROE *must* lead back to the expected OPTPCIe board without swapping the two fiber heads. The fiber connection does not use any sort of network protocol but bare 16-bit data, so it *cannot* work through any type of hubs, routers or switches; it must be *direct* in the physical layer in that sense, permitting only patch panels, ST connectors and so on to cross between laboratories. Note that the `DATAINPORT1` assignments are dynamic: if any OPTPCIe board is removed from the computer, the remaining one is always addressed as `00`.

If for example the OPTPCIe from `lucix.luci` is moved into a free slot of `luci.luci`,the three boards there are called `00`,`01` and `02`,but the boards now addressed as `00` and `01` are *not necessarily* the same as those before the board transfer.[26] This has the unwelcome side effect that one may need to re-assign in the software (startup scripts and environment variables) which instrument gets its data from which `OPTPCIe` board,or alternatively to exchange fiber pairs. If the environment variable is not set otherwise,`start_luci1`,`start_luci2` and the variants with `new` or `old` take the following by default:

instrument	OPTPCIe	workstation	ROE
LUCI1	10	luci.luci	192.168.0.14
LUCI2	00	luci.luci	192.168.0.24
spare	00	lucix.luci	192.168.0.34

[26] because GEIRS scans the bus and assigns numbers in the order of finding boards with the PLX chips...

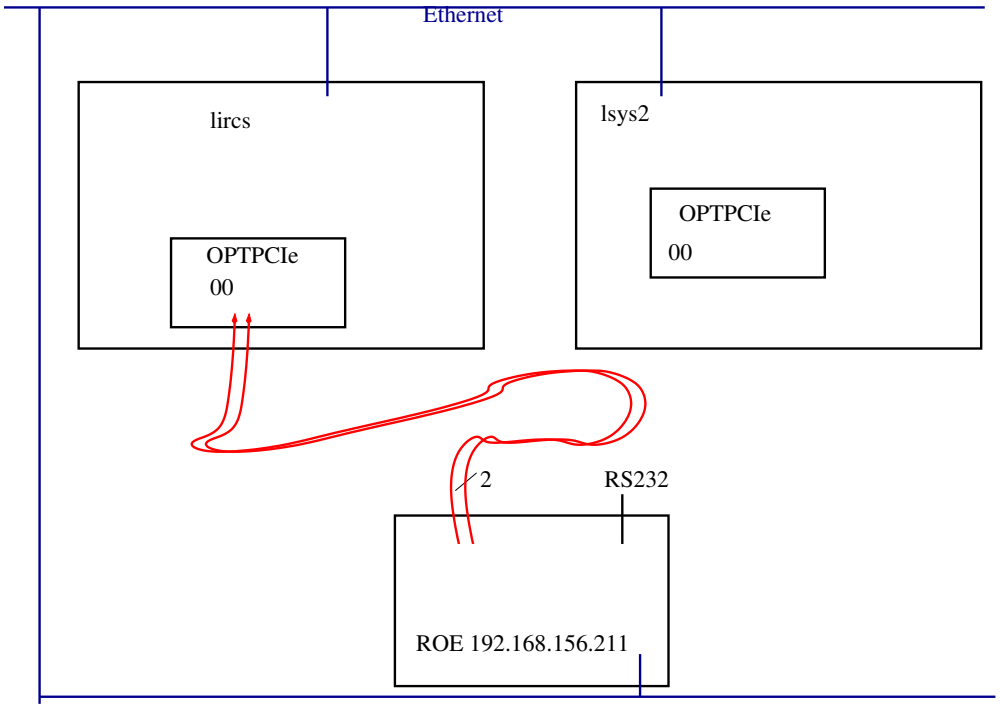


Figure 2: LN configuration: The ROE sends the digitized pixel data of the detector chip through one fiber of the fiber pair; the other fiber is not used and transmits zeros. The computer may receive data from any ROE if GEIRS is configured with the `CAMPORT` variable to talk to the ROE that generates the data and if the fiber that streams the digitized data ends up at the correct OPTPCIe board configured with the `DATAINPORT1` variable. `lsys2` is also equipped with an OPTPCI board and serves as a backup detector workstation.

If a spare ROE rack is available, there are various options to swap it in:

1. remove the old ROE (switch off, at least disconnect from the Ethernet to avoid duplicate use of the IP address), modify the IP address of the spare to match the default IP address as instructed in Section A.1, put the spare into the network,
2. or modify the `CAMPORT` shell environment variable of the account that starts GEIRS to match the new ROE's IP address before starting GEIRS, for example

   ```
   export CAMPORT="tcp://192.168.0.34:4000"
   start_luci1_new
   ```

   The `export` command can be inserted into the `~/.bashrc` or `~/.bash_login` of the account. This is the recommended variant because it needs the least amount of human interaction and is easily reverted;
3. edit the IP-address in the `geirs_start_gen` script by an ASCII editor before starting GEIRS,[27]
4. start each time with `geirs_start` and edit the `CAMPORT` entry before continuing.

Replacement of the ROE rack always requires shutting down and re-starting GEIRS.

[27] if this is a permanent change, make sure that the GEIRS maintainer also modifies the SVN source code so upcoming GEIRS versions know about this...

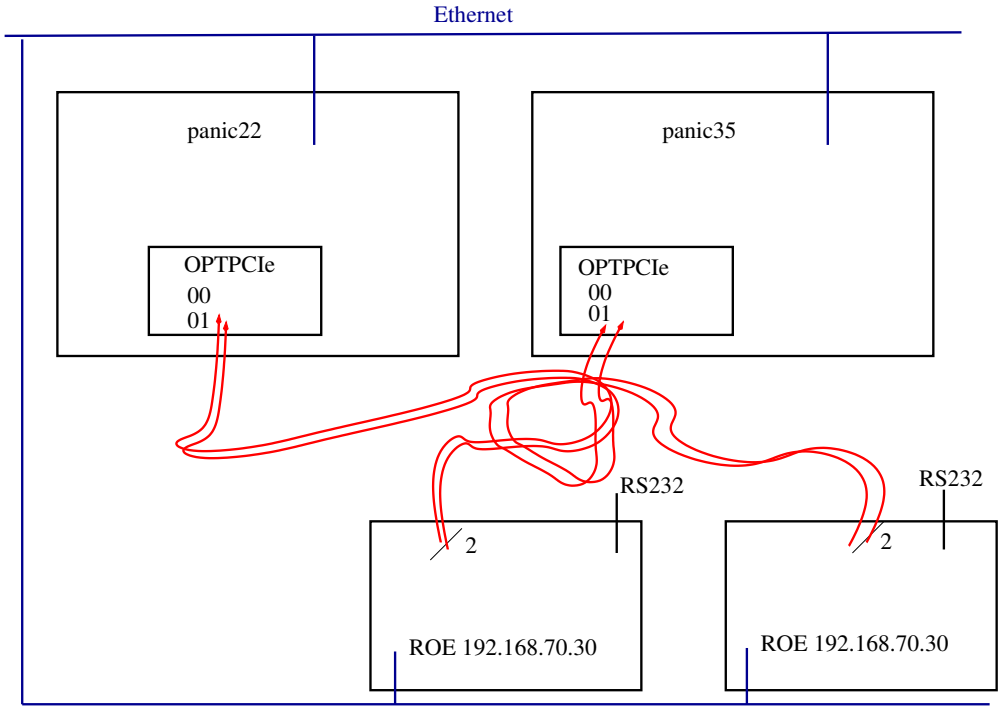


Figure 3: PANIC configuration: The ROE sends the digitized pixel data of the channels 0–31 of the H4RG through one of the fibers and of the channels 32–63 through the other fiber of a fiber pair. Each of the two PANIC computers may receive data from any of the ROE's if GEIRS is configured with the `CAMPORT` variable to talk to the ROE that generates the data and if the fiber that streams the digitized data ends up at the correct OPTPCIe board configured with the `DATAINPORT1` and `DATAINPORT2` variables. The two PANIC ROE's have the same IP addresses, which means they must not be used at the same time on the subnet of the same telescope.

CAMROE_REV The name of a subdirectory of `$CAMBIN/../pttrns` with the patterns to be applied. If the variable is not set, a default is used which is equivalent to the name of the camera, either `Panic`, `Carmenes`, `Luci2`, `Nirvana`, `Luci1` or `Aip`. There may be more than one of these subdirectories to allow switching between different pattern versions. Examples: `Panic` or `Panic_r74` or `Panic_r76` for PANIC. `Carmenes` or `Carmenes_r5` for CARMENES. `Nirvana` or `Nirvana_r98` for LINC-NIRVANA. `Luci1_r19M` or `Luci2_r20` for LUCI.

CAMSHMSZ Shared memory (in MBytes) reserved for use by GEIRS, see Section 2.5.5. This is roughly aligned with the total available RAM of the host computer via

```
setenv CAMSHMSZ `cat /proc/meminfo | fgrep MemTotal | awk '{printf "%d",$2/2048}'`
```

in `scripts/geirs_start_gen`. The divisor is basically 1024 (to convert KiB to MiB) multiplied by some rather arbitrary small factor of the order of 1 or 2. It might be adjusted if concurrent data acquisitions (more than one GEIRS session) are run by multiple users or for multiple ROEs at the same time. This sets an upper limit of the number of frames and images that can be acquired without intermediate `save` operations.

CAMSERVERPORT IP port number of the command server. The startup script defines the standard port and echoes its value to the standard output. Two distinct ports allow two

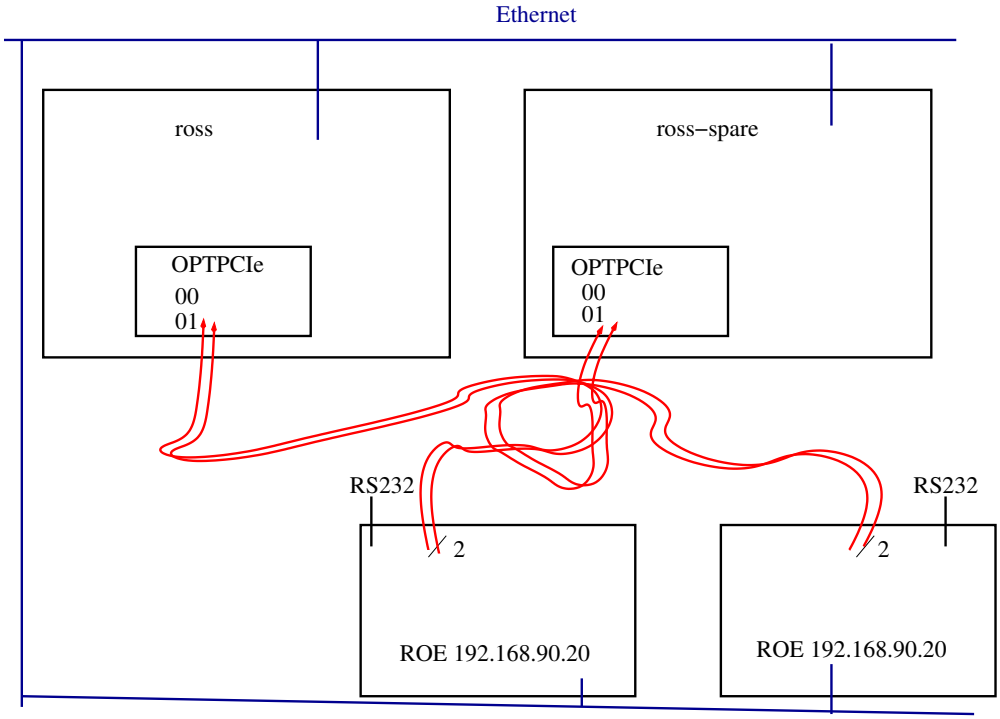


Figure 4: CARMENES configuration: The ROE sends the digitized pixel data of one of the two detector chips through one and the digitized pixel data of the other detector chip through the other fiber of a fiber pair. Each of the two CARMENES computers may receive data from any of the ROE's if GEIRS is configured with the `CAMPORT` variable to talk to the ROE that generates the data and if the fiber that streams the digitized data ends up at the correct OPTPCIe board configured with the `DATAINPORT1` and `DATAINPORT2` variables. The two CARMENES ROE's have the same IP address, which means they must not be used at the same time on the same subnet.

GEIRS command servers to be run in parallel independently for the two instruments on the same computer. After GEIRS startup one can test with a command in the style of

`nc -v -z` *server port*

from the Unix/Linux shell whether GEIRS is actually using that port. One can send

```
get CMDIPPORT
```

to the GEIRS server to ask what its current port is—this may not be useful because to submit the `get` to the correct server implies that one already knows the port. . . .

CAMSERIALDELAY Delay between transmission of individual bytes on serial lines. Usually irrelevant because commands are send to the ROE via Ethernet.

CAMSERIALEOL_RD Number of end-of-line characters for serial communication with the ROE (reading). Usually irrelevant because commands are send to the ROE via Ethernet.

CAMSERIALEOL_WR Number of end-of-line characters for serial communication with the ROE (writing). Usually irrelevant because commands are send to the ROE via Ethernet.

CAMSERIALSPEED Baud rate of serial communications with the ROE. Usually irrelevant because commands are send to the ROE via Ethernet.

CAMWWW The full path name of the HTML help file for use as in Figure 10.

CAM_CHIPGAPX Size of the vertical gap between the Hawaii2 RG chips in the mosaic in units of pixels. If not set, a default of 167 is assumed. Only relevant for the AIP detector hardware.

CAM_CHIPGAPY Size of the horizontal gap between the Hawaii2 RG chips in the mosaic in units of pixels. If not set, a default of 167 is assumed. The two chip gaps are used to span a WCS coordinate system across all four chips in MEF headers. Only relevant for the AIP detector hardware.

CAM_DETROT90 A number from 0 up to 3 (inclusive) to trigger rotations of the detector image by a multiple of 90 degrees to the right. (The fact that these rotations are clockwise is a consequence of GEIRS using a left-handed X11-type coordinate system acting on some internal index tables.) Defining a value of zero is equivalent to not setting the variable at all such that GEIRS falls back to the default of a non-rotated output. This effects both, the views within the engineering GUI's described in this manuscript as well as the pixel distribution in the FITS files. For AIP,the entire 4096×4096 image is rotated around the center of the mosaic—not the individual four images of the four chips around their centers.

Exchange of the images (without changing angles/orientation) is achieved by permutation of the four cables SG1–SG4 that start outside the dewar and enter the ROE rack fastened to the dewar. The variable should be set to 1 for LUCI2 to align the optics with the default N–E orientation on the sky.

CAM_DETXYFLIP If set to 1, this commands a left/right reflection of the images along the vertical axis. If set to 2, this commands a up/down reflection of the images along the horizontal axis. If not set or set to zero, there is no flip. If set to 3, the two flips are combined and replaced by a rotation of 180 degrees.

In combination with the previous keyword, this supports eight orientations of detector images—the basic mean to obtain a (rough) standard image orientation along N and E in the images (Sect. A.2). Rotations and reflections are not commutative: the rotation will be executed first.

The combined action of `CAM_DETXYFLIP` and `CAM_DETROT90` on the default orientation of the chip—as displayed in the manufacturer's manuals—is shown in Figures 5–6. A posteriori these two integer values can be read from the FITS header of the data files. Warning: there are earlier LUCI detector reports with other image orientations [9, Fig. 6]. The one in Fig. 6 is the orientation chosen after the actual orientation of the standard equatorial coordinates through the optics was settled—see the e-mail by Seifert on 2013-11-10. In Fig. 6 the $+\delta$ axis points upwards and the $+\alpha$ axis to the left—if the derotators are set to undo the $\approx \pm 70°$ offset of image rotation induced by the M3 reflection to the Gregorian foci.

Note that swap of the two fibers that transport the data from the ROE rack to the GEIRS computer (on any of the two sides) *cannot* be replaced or undone by any combination of the **CAM_DETROT90** and/or **CAM_DETXYFLIP** keywords.

CAM_HINVDIR The bits in this non-negative integer value indicate the left-right directions in the horizontal scanner. For the HAWAII-2RG the least-significant 8 bits are relevant, for the HAWAII-4RG the least-significant 2 bits are relevant (equivalent to HINVDIR[8..9] after left-shift), and for the HAWAII-2 the value is irrelevant. More specifically, the relevant bits for HAWAII-2RG depend on the number of outputs (see the Teledyne manuals for details):

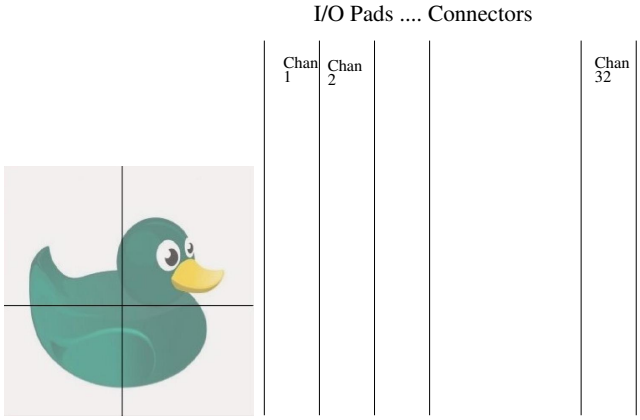


Figure 5: Reference position for rotation and flip parameter of the image: Here `CAM_DETROT90=CAM_DETXYFLIP`=0 (no rotation or flip). The top of the H2-RG chip with its I/O pads is above the duck's head. Each of the 32 channels runs from top to bottom.

- 32 outputs: all 8 bits are relevant.
- 4 outputs: bits 0, 3, 4 and 7 are relevant.
- 1 output: only bit 0 is relevant.

If not set, a value of 0 is assumed, meaning all channels are read left-to-right. Note that, depending on `CAMA_DETROT90` and `CAM_DETXYFLIP`, the channels in the real-time display and the FITS files are not necessarily at the places shown in the manufacturer's documentation.

CAM_VINVDIR This is an integer value of either 0 or 1 indicating the top-bottom direction of the vertical scanner for HAWAII-2RG or HAWAII-4RG chips. For the HAWAII-2 the value is irrelevant. If not set, a value of 0 is assumed, meaning all channels are read top-to-bottom.

CAM_IDSTR A string generally used in frames of GUIs. Useful if one switches between two similar instruments both run by GEIRS at potentially the same time, like LUCI or NTE.

CAM_MAX_EDTBUFSIZE Defines the size of a single buffer in the ring buffer in units of kilobytes.

CAM_NADC36 Number of ADC36 boards in the ROE rack. By default this is 4 for AIP, 2 for CARMENES and PANIC, and 1 for the other configurations.

CAM_NDET Number of infrared chips controlled by the ROE, and—with the exception of AIP and CARMENES—always 1. If the parameter is set to 1 for CARMENES, the GEIRS software will treat the entire readout system as if only the `SCA1` detector were present, triggering only the ADCs on one of the two ROE boards, receiving data only through one of the two fibers, showing only a 2048×2048 image and so on.

CAM_NQCHAN Number of output ports of each detector chip. By default this is 64 for Hawaii-4RG configurations, and 32 for the Hawaii-2 and Hawaii-2RG cases. There is preliminary support for 32 for Hawaii-4RG, 16 for Hawaii-4RG, 4 for Hawaii-2RG, and 4 for Hawaii-2.

Not using the maximum number of available channel causes a prolongation of the minimum integration time, see Section 8.1.

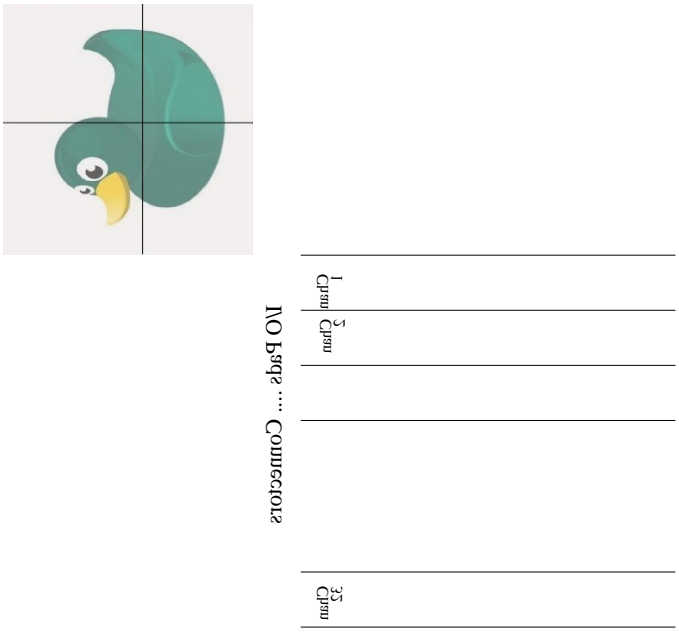


Figure 6: Illustration of the action of the rotation and flip parameters on the image: `CAM_DETROT90`=1 and `CAM_DETXYFLIP`=1 (90° followed by right-left flip) or `CAM_DETROT90`=3 and `CAM_DETXYFLIP`=2 (270° followed by up-down flip). The image displayed by GEIRS and in the FITS files is effectively mirrored along a diagonal. Each of the 32 channels runs from left to right.

The standard reason of not using the maximum number of channels is to inhibit influences of corrupt channels on the chip, on the pre-amplifiers or the ADCs. It also may help to reduce inter-channel crosstalk.

CAM_NORTH North direction in the images in the FITS files measured in degrees ccw from $+x$. If not set, a default of 90 is used. The number is used to construct/predict a WCS coordinate system across PANIC's MEF headers.

CONTRLX, CONTRLY Horizontal and vertical X11 coordinate of the preferred startup position of the Controls GUI. Here *X11* means that the upper left corner of the screen is at (0,0).

DATAINPORT1 Board and channel-number used by GEIRS to indicate on which of the OPTPCI board(s) and on which fiber the 16-bit pixel data arrive. Almost always `00` and `01` unless more than one OPTPCI board are plugged into the computer. The first (left) of the two digits enumerates the OPTPCI boards on the GEIRS worstation starting at 0. The second (the right) of the two digits enumerates the two fibers/DMA channels, 0 or 1. (The physical layer of the data/fiber connections from the ROE to the computer comes always with fiber pairs. If we say an instrument *uses* only one fiber it means that series of zeros are sent through the other, and that swapping the fibers the wrong way yields no-stars ,all-black images.) For instruments that use only one fiber/DMA channel (Luci, Linc-Nirvana, or CARMENES with `CAM_NDET`=1), the second (right) number is always 0, and `DATAINPORT1=?0`. For instruments with two fiber/DMA channels (AIP with `CAM_NDET=4` , PANIC with `CAM_NDET=1`, and CARMENES with `CAM_NDET=2`), `DATAINPORT1=?0` and `DATAINPORT2=?1`.[28] The software does

[28]That is actually, only `DATAINPORT1` needs to be specified, and `DATAINPORT2` is derived by toggling the least-significant digit $0 \leftrightarrow 1$.

not support feeding the two fibers of one instrument into two different OPTPCI boards, so the first (left) of the two digits of `DATAINPORT1` and `DATAINPORT2`, represented by the question mark above, must be the same. If the environment variable is not set otherwise,`geirs_start_luci1` takes `10` by default,whereas `geirs_start_luci2` and its variants take `00` by default. If the startup scripts detects that the first (left) of the digits is larger than what is supported by the number of OPTPCI boards currently plugged into the computer, it patches the `DATAINPORT` variables to match that reality.[29]

The two digits of this pseudo-device name are *not* related to the MPIA serial number on small stickers on each board.

The practical aspect is that one may insert any number of spare OPTPCI boards into a computer, and switching between the boards is done by re-plugging the two fibers, modifying the left/leading digit of the `DATAINPORT1` environment variable, and restarting GEIRS.

DISPLYX, DISPLYY Horizontal and vertical X11 coordinate of the preferred startup position of the Realtime Display.

MOTPORT Ports for direct communication with the motors (filter wheels etc.). This is a comma-separated list of values, one per MoCon board under GEIRS control. The parameter should be left blank if GEIRS does not control motors. This means it is only relevant to PANIC, which addresses the four filter wheels and the cold stop shutter through the first in this address list.[30]

TELESCOPE The label of the observatory, which is used to set the geographic coordinates and to convert from equatorial to topocentric coordinates. Only a few fixed strings are supported: `LBT`, `CA3.5m`, `CA2.2m`, `NOT`, `Lab`, and some obsolete others.

TEMPORT Port for direct communication with the temperature and pressure sensors. This is only relevant as a default for the crontab job (i.e., the executable `panictempress`) that reads PANIC temperatures and pressures if the command line option `-i` is missing and if the default IP address of CAHA is not to be used. Only relevant to PANIC.

TMOUT If the variable is set and larger than zero, it indicates that GEIRS should shut down if it is idle for that many seconds, which means if no read command is received for that duration. Note that this is deliberately the same variable as in the bash(1).

This list is mentioned for documentation purposes. Not all combinations of cameras and variables are supported or meaningful. In case of doubt it is recommended not to set a variable.

These variables are set in the startup script and exported, so they are defined in the child suprocesses; they are *not* exported "up" to the calling operator's shell—there is no mechanism in Unices for such modification in the other direction.

Editing the actual startup script is not recommended because any new GEIRS version will overwrite `scripts/geirs_start_gen` with its current version. If long-term changes are required, contact the GEIRS maintainer to have these added to `geirs_start_gen`, and use exported shell variables in the meantime.

The generic strategy in the `geirs_start_gen` script is to honor (not to change) variables which are already set when the script is called. This allows users with lesser knowlege of shell scripting to

[29] This counts `lscpi` lines and is currently only relevant if LUCI is started on `lucix.luci` which only has one board.
[30] At MPIA, the address is found with `nslookup elotest`.

configure/set the variables at other places, for example immediately before calling the script or in the standard files like `.bashrc` or `.bash_login`. Another use of this feature is that one can call GEIRS versions that are older than the most recently installed one. Here is an example in the case of LN started from a `bash(1)` shell:

```
export CAMBIN=${HOME}/GEIRS/trunk-r784M-17/bin
geirs_start_nirvana
```

A further aspect is that one can run GEIRS sessions in parallel on the same computer by different Unix/Linux accounts without interference, *if* the communication channels from the observer tool to the GEIRS server and from the GEIRS server to the ROE are kept separate, and *if* the computer is equipped with at least as many OPTPCI boards as active (=non-simulated) ROE's:

```
export CAMSERVERPORT=10501
export CAMPORT=tcp://192.168.0.14:4000
export DATAINPORT1="00"
geirs_start_luci2
export CAMSERVERPORT=9501
export CAMPORT=tcp://192.168.0.24:4000
export DATAINPORT1="10"
geirs_start_luci1
```

(Note that this is *just* an example. Variables will differ for the real instrument depending on hardware configurations!)

In summary: all major parameters are equipped with defaults (which depend on the instrument). If the defaults do not represent the current hardware configuration—because someone changed ROE IP addresses, re-plugged fibers and so on—the GEIRS parameters should be changed either with the Linux shell `export` commands as illustrated above before calling the start script or by modifying them through the startup GUI (Section 4.2.)

The parameters of the GEIRS server are a combination of

1. exported shell environment variables;
2. modifications of the environment variables by the engineering GUI in Figure 8;
3. modifications of the environment variables by the startup scripts;
4. modifications of the availability of subsystems (simulation) defined in the GUI in Figure 7;
5. defaults stored in the `$HOME/.geirs` directory at a previous shutdown.

3.3 Postprocessing

An infinitely rich interface to post-processing the data, starting pipelines or archival systems is offered by the script or executable located in `QueueFiles` on the GEIRS computer. (The file `QueueFiles` may be anywhere in the `$PATH` but is usually in `$CAMHOME/scripts/QueueFiles`.) It is called at the very end of every `save` command (but not at the end of saving the intermediate frames configured by the `sfdump` command). It receives two parameters, the file name of the file created by that `save` command, and a number indicating the number of files expected to be created by that `save` command. (The latter offers some means to postpone actions in that script

for example if GEIRS constructs a series of files with one window per file.) These two parameters are available in the script as `$1` and `$2` in the common Unix/Linux shells, or in the `argv` vector of higher programming languages if one would replace the shell script by any binaries.

The features of that architecture are:

- At the point in time when `QueueFiles` is called, the FITS files are already closed. So instead of polling the status of the crep counter or any similar status variable, or polling the file system for any new files that arrive, it is safer and less disruptive to trigger pipeline actions by adding them to the script.
- The `save` command is finished when `QueueFiles` terminates. If foreground commands in `QueueFiles` hang, `save` does not terminate—which might lead to the wrong conclusion that GEIRS hangs whereas it actually waits.
- As already said, `QueueFiles` is called synchronously with the `save`. Within this script, however, further actions may be pushed into background processes such that they are effectively becoming asynchronous to the GEIRS processing.
- The `sync` and `sync save` command wait on the `save` command, so the delay depends implicitly on the timing chosen within the `QueueFiles`.
- The `QueueFiles` must be a valid script and of course be executable as usual in the Unix/Linux sense. It may be empty—aside from comments etc.—if there is nothing to be done.
- There is only one `QueueFiles`. If instrument pipelines or monitors need variable actions depending on other than the two variables forwarded as command line arguments, they either need to edit/move/remove the `QueueFiles` dynamically—cautiously synchronized with the `save`—, or gather more information from the shell or user environment and use standard branching/switching statements of the shell.

Examples of actions in the `QueueFiles` are ds9 calls (Section 4.3.3) or examination of test files with the script in `test/QueueFiles` of the source directory. PANIC uses this file to add CAHA ambient data to the place where forthcoming `save` processes pick up additional FITS information.

This interface is a specialized (by time and by place of the invocation) call to the operating system. The `system` command (Section 5) to the shell offers the more flexible and general interface.

3.4 Concurrent Sessions

Section 3.4 is mainly of interest for LUCI in binocular mode and potentially for the NTE cameras.

Multiple GEIRS sessions may in principle be run at the same time on a single computer.[31] In that and many other respects a GEIRS session is not a server but a user program. Because

1. each session maintains the user's shared memory contents in a socket (special) file,
2. each session's command interpreter listens to a specific socket (port) fixed at the start of the session,

[31] Each session is typically represented by five programs `geirs_shmmanager`, `geirs_cmdServer`, `geirs_control`, `geirs_disp` and `geirs_dataServer` on the computer; see the output of `ps -elf geirs` in the Linux shell.

3. each session connects to one ROE represented by a network address and an OPTPCI board (unless in simulation)
4. each session grabs by default almost all of the available memory for its image storage (unless this is LUCI which requests only half of it)

there are some constraints as follows

1. A Linux user can only run one GEIRS session at a time.
2. Hardware is not shareable. Therefore the maximum number of sessions not run in simulation is limited to the number of independent pairs of ROE's and OPTPCI boards. So each Linux user can only use a ROE and an OPTPCI board that is not already in use by another session.
3. Users starting sessions of the same instrument on the same computer need to change their command server port away from the default port (from the second user on).

Users ignoring these constraints will observe strange and undocumented cross-talks and interferences between commands and images as a result.

Note that each session's command server listens to all commands that appear at its port. There is no protection by any type of firewall or password or user id, so every Linux user may send commands to any GEIRS session. This is for example needed because the prototypical observer never `quit`s a session and every other user that needs to restart GEIRS for that instrument needs to send the `quit` to that abandondend session to shut it down properly before restarting it.

4 GRAPHICAL USER INTERFACE (GUI)

The software handles all infrared cameras at Calar Alto. Therefore the observer, once having used one system, will easily feel at home with the other cameras. Changes are introduced only due to different hardware.

4.1 Start-up (Standard)

It is useful to check with

```
ps -C geirs_shmmanager
ps -elf | fgrep geirs
```

whether someone else is already running GEIRS on the machine. Then the command

`geirs_start_`*instru [-iwin] [-gui] [-disp] [-cmd] [-data]*

where *instru* is one of `nirvana`, `luci1`, `luci2`, `nteimg`, `nteisp`, `panic`, `carmenes`, `aip` or `sidecar` starts GEIRS.

[32] If no command line option is used,`-gui` is implicitly activated. If the `-iwin` option was present (explicitly or implicitly), it commences with the start-up screen of Figure 7. The controls and/or the image GUI will be opened depending on the presence of the options `-gui` and/or `-disp`. The command server is started depending on the presence of the option `-cmd`. The `-gui` option works only if the command server is either started here or already running. The data server is started depending on the presence of the option `-data`. The real-time display requires that the data server is run.

Error messages of the "Command not found" class indicate that the software may not have been compiled, installed or simply not integrated into the `PATH` of the operating system.

The start commands refuse to start GEIRS if the associated TCP port is already in use.

The startup script may replace some files at common places (like in the `scripts` or `INFO` directories) by versions that depend on the GEIRS version that just has been called. It generally does this by managing symbolic links. The only reason for this breaking of the rules of versioning is that some other softwares (drivers that access GEIRS from the outside) expect to find them at fixed locations in the directories.

In the associated shell script, a set of configuration decisions have already been made.

The startup script shows the remaining disk file capacity on the initial FITS file directory. The guideline is that readout electronics, detectors and fiber channels inbound via the OPTPCI boards are *not* shareable resources. The number of GEIRS instances running in simulation is not limited (apart from details mentioned elsewhere), but the number of GEIRS instances handling any real ROE or OPTPCI board at a time must never be larger than one. To that purpose, the startup script runs once `geirs_cleanup` with a test flag, which detects GEIRS processes already running by this or other users on this computer (see Section 5.5). On a system similar to LUCI or NTE with two GEIRS instances possibly running in parallel, don't be alarmed if some GEIRS linux processes pop up here, because this may be the handler of the other arm of the telescope! In the standard

[32] The only difference between the luci1 and luci2 options for now is that some DX and SX symbols appear in prompts or FITS keywords and that the noise and gains reported in the FITS headers differ.

case of running GEIRS for PANIC, CARMENES or LN with a telescope, GEIRS processes should not appear in the list—anything else means that either

1. local policies of properly shutting down GEIRS have not been communicated well between observers, or
2. observers erroneously believe that closing some of the main GUIs terminates GEIRS, or
3. the previous shutdown of GEIRS did not run smoothly. In that case running `geirs_cleanup`—without the `-t` option—may be useful to clean up these residuals, before trying again to start GEIRS.

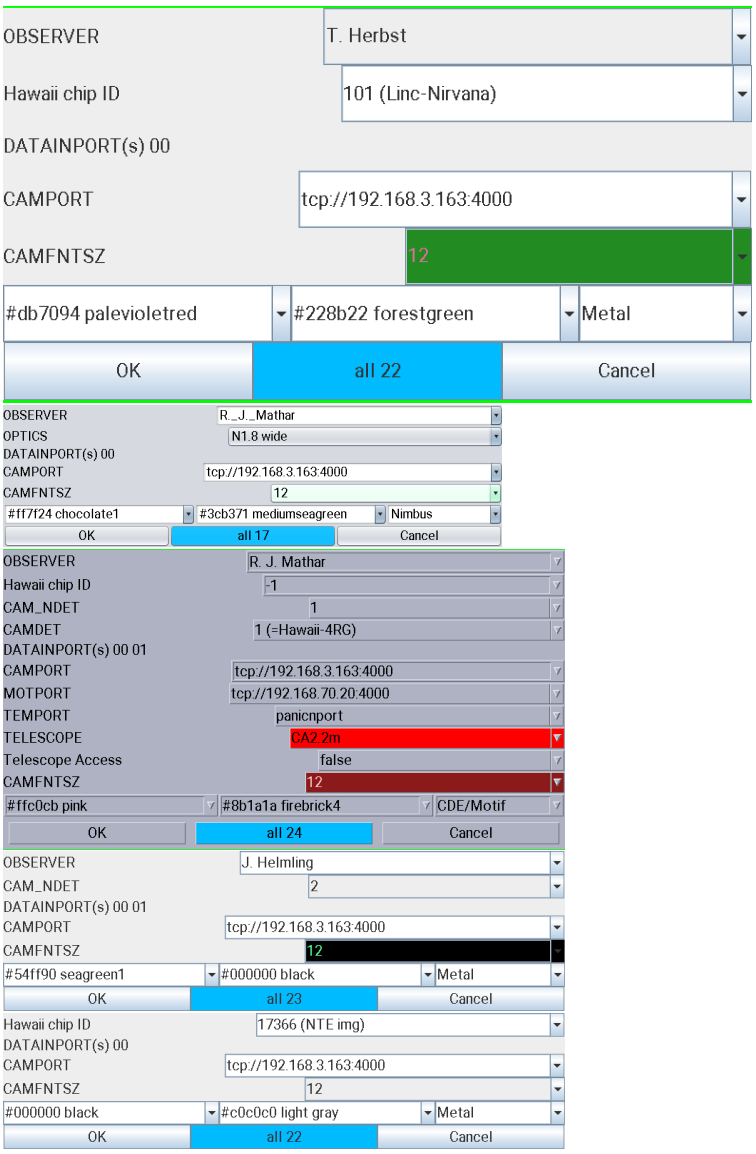


Figure 7: Startup screen to start GEIRS. Which of these layouts appears depends on the instrument.

Some parameters may be edited in Figure 7 at this time:

- **OBSERVER** Enter your name as observer. This will appear in the FITS files. (See Section 5).
- **OPTICS** The only effect of each of the three resolutions is that LUCI pixel scales of 0.25,0.12 or 0.015 arcseconds respectively are computed into the exposure frames if the ROE is used in simulation. Apart from that GEIRS does not have any clue on which of the three cameras is used during real observations,and all associated parameters and FITS keywords are determined by the observation software which controls those optical elements. In short: the wrong choice here would not have any impact on the quality of the data products.
- **CAM_NDET** The number of detector infrared chips is fixed here, see Section 3.2.
- **DATAINPORT(s)** Defines through which bus of the operating system the software expects data. Operation through as many different PCIe boards as the computer hardware allows interfacing to a set of different ROE electronic boxes. Details depend on the slot assignment on the host computer. The first placeholder in the name is `0`, maybe larger if more than one OPTPCI board is installed. The second placeholder is `0`, and may be also `1` if the ADC data from the ROE are also sent in parallel via the second data port (i.e. the other fiber).
- **CAMPORT** Selecting the empty string will start the software in a simulation mode for detector data. Otherwise it is the TCP socket and port for the internet communication with the ROE.

  If the data generator of the `OPTPCI` board in the computer will be used for test purposes described in [4], but if no ROE rack is available or if this rack is switched off, some fake address of a non-responding computer should be inserted here. This allows to set up some half-way simulation where the `rotype dgen` command followed by a `read` lets the `OPTPCI` feed data into GEIRS which are reduced and displayed as if they were streaming in through the fibers.

  In *simulation* mode, GEIRS produces fake images and FITS files by placing spots at randomized positions across all detector chips in the field mimicking a seeing close to one arcsecond. It does *not* try to communicate with the ROE via the network or to receive image data through the fibers. The positions are randomly selected for each of the images; they are not drawn from any star catalog. The time stamps produced in the simulation mode are rough software simulations; they have much larger variances than the time stamps of modes that are fed with data via OPTPCI boards.
- **MOTPORT** Absent,because GEIRS does not control motors.
- **TEMPORT** Irrelevant,because temperatures are neither controlled nor monitored by GEIRS for this instrument.
- **TELESCOPE** This entry is absent.
- **Telescope Access** This is always `false`,because GEIRS does not communicate with the telescope controls. The virtual pointing and catalog operations described further down are nevertheless enabled.
- **Fore- and Background color** The penultimate line allows to manipulate the colors for foreground (i.e., text) in the left entry and background in the middle entry which will effect the controls, display and (for PANIC) telescope GUI's. The Look-and-Feel is selectable in the right entry, which for typical OpenSuse Java installations for example offers 4 choices

(Metal, GTK,. . .). Many default colors are selectable by scrolling down, but any other color may be created by modifying the 6 hex characters in the range 0..f after the hash. (The rest of the line after white space — some standard color name — is just a comment and does not need to be preserved.) The 6 hex digits are 3 groups in the range 00..ff, the leftmost for the red component, the middle for the green component, and the right for the blue component. The letters a..f for the digits 10..15 can also be entered uppercase, A..F. Attempts to edit the values such that they don't start with `#` and are not followed by 6 consecutive hex-digits will be rejected. It is *not* wise to select color pairs with little contrast, for example black for the background and mignight blue for the foreground. To illustrate the result, the field with the font size selector will be recolored.

If the selected foreground and background colors are the defaults, `#000000` and `#c0c0c0`, the GUI's will stay with the default "metal" color scheme of the UI manager.

The colors selected here do not affect the color lookup table within the display GUI, Figure 16.

The GUI in Figure 7 allows essentially to move subsystems into simulation mode. If you are not satisfied with some of the selectable parameters, you need to start from scratch, either with Figure 8 or by explicitly setting the shell variables before using the start-commands of Section 4.1.

The GUI in Figure 7 uses a countdown of 20 seconds, where the remaining time is indicated in the label of the `all` button. If no button is pressed to change the configuration within that time interval, it will continue to start (or fail to start) GEIRS with the currently selected set of parameters.[33]

[33]That countdown was added in response to the fact that some people seem to start GEIRS without ever pressing one of the three buttons at the bottom, so we ended up with some of these GUI's hanging around for indefinite periods of time. This also supports in principle batch-type start-up from scripts.

After you press `all` in Figure 7, the subsystems (most noticably the ROE) are initialized and the GEIRS window of Figure 9 will appear. At that time all (recent) instrument patterns send commands to the ROE which switch most of the ROE's LED's off. The LED's of the network card of the ROE cannot manipulated by these software means (and must be taped to shield their light).

The button `OK` compares the current parameters of the command server with the parameters proposed in the GUI and skips the initialization if the two sets are the same.

Actually both the "Controls" window (Figure 9) and the main display window (Figure 16) may be suppressed by removing the `-gui` and the `-disp` options, respectively, from the call of the `shell` in the `$CAMHOME/scripts/geirs_start_gen` script. These changes in the configuration are available if the instrument is run in a stable production mode where the pipeline investigates the FITS files that are produced, such that the quick look at the frames is not needed or replaced by the more common ds9 viewer.

If some subsystems of GEIRS, like the ROE, the Motors or the Telescope are set to the simulation state in Figure 7, some parts of the GUIs described in this manual display yellow backgrounds in menus to provide a visual warning that the corresponding section of the action or information is in some state of software emulation/simulation.

4.2 Start-up (Engineering)

Alternatively there is an engineering GUI called by

```
geirs_start
```

which pops up similar to Figure 8. This allows *experienced* users to edit many parameters on a finer level without editing the `geirs_start_gen` script, but at a higher risk of starting GEIRS with modes that are not supported.

The entries with a white background can be fully edited (after left-mouse-click into the GUI or through selection of fixed entries by clicking on the down-triangle); the entries with a gray background can be changed to a limited degree by chosing from a finite set with the down-triangle. Down-triangles turn gray if the selection is fixed (not editable).

The program scans (pings) a list of fixed ROE IP addresses and puts those that seem to be online into the selector for the `CAMPORT`. It puts subdirectories of `CAMHOME` that look like compiled GEIRS versions into the `CAMBIN` selector. If the `Continue/Start` button is pressed, the program sets some of the environment variables mentioned in Section 3; labels in the GUI and environment variables correspond to each other. Then it calls the shell script `scripts/geirs_start_gen` with the options set in the third but last line of Figure 8. See Section 5.5 for the meaning of the `geirs_start_gen` options. The principal rationale for having this GUI is that one can

1. mix hybrid instrument configurations as they frequently occur in the MPIA development process.
2. swich temporarily to a configuration without editing the `geirs_start_gen` script, to narrow down connectivity problems (Section 10).
3. start other than the newest GEIRS versions by fishing for compiled versions in the `CAMHOME` directory.

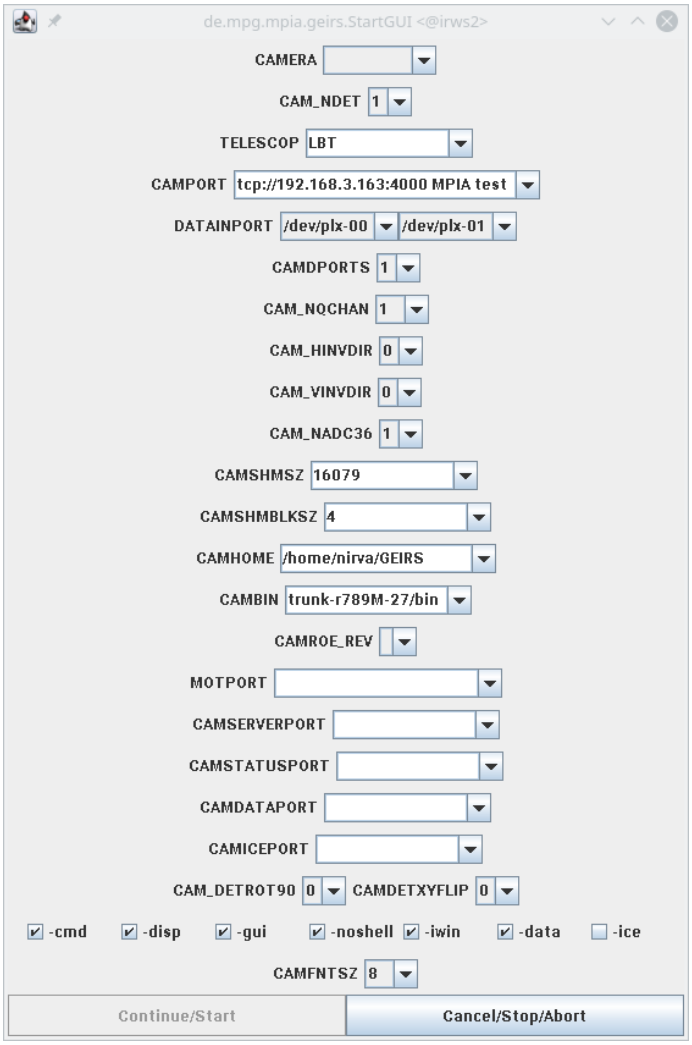


Figure 8: Engineering startup with `geirs_start`.

The major drawback of starting with this GUI is that none of the confirming messages do appear on standard output as they do with the `start*` scripts mentioned above.

4.3 The GUI's windows

4.3.1 Camera control window

The control window of Figure 9 is the interactive interface to the camera.

In the top row three pull-down menus provide further options:

- File Menu
  - **Init/reboot ROE** reboots the read-out electronics, which means, sends a set of standard readout and idle patterns to the ROE. This will transmit roughly 2,000 "words"

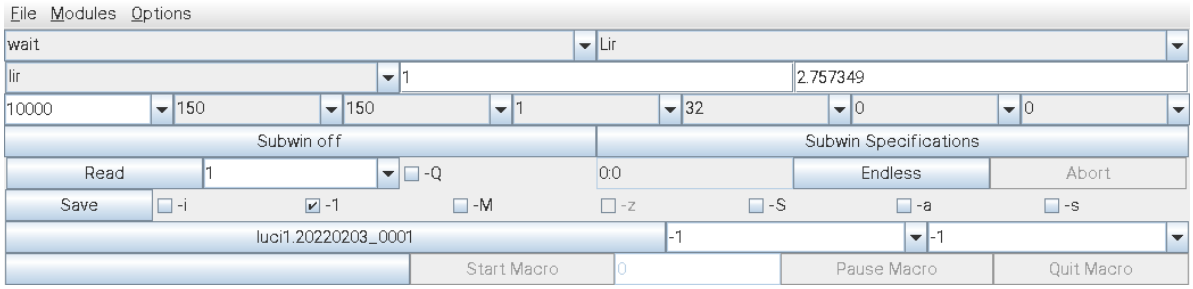


Figure 9: The camera control window with its drop-down menus. The menus can be reached by clicking on the buttons or with `<Alt>F`, `<Alt>M` or `<Alt>O`. Most submenus can be called pressing `<Ctrl>` and a letter.

to the two FPGA chips on the ROE.[34] Accounting for a few milliseconds per "word" that is transferred via the Ethernet to the ROE, this will need up to 10 or 20 seconds, depending on Ethernet speed. (You may watch that progress with the `Modules`→ `ROE Log Monitor` menue.) It is futile to attempt a readout during that intermediate period.

– **Help** Opens a web browser which shows a HTML version of the command list, similar to Figure 10, equivalent to the contents of Section 5.3. This will fail if the environment

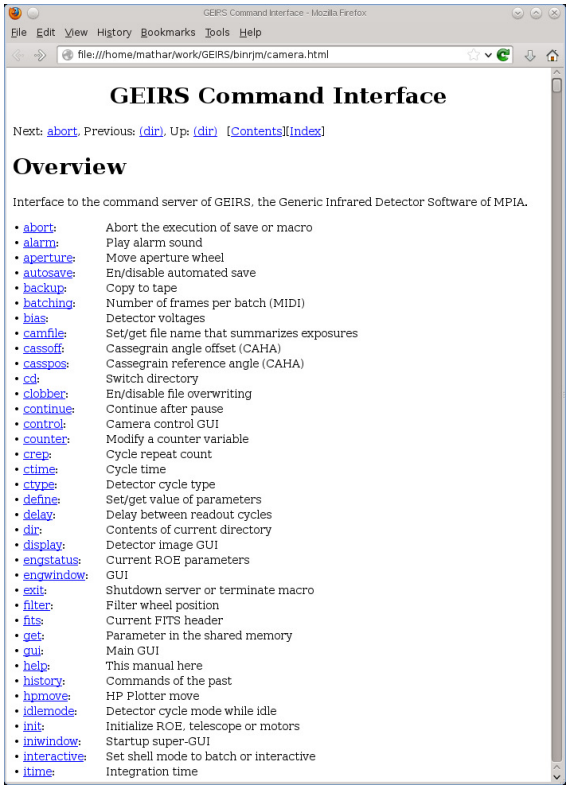


Figure 10: The web browser called by the `Help` button in Figure 9.

variables `CAMWWW` and/or `CAMBROWSER` of Section 3.2 are not configured correctly.

[34] The lowest level of these has a maximum of 1024 "words" and the second level a maximum of 512. Not all of them are used, depending on the complexity of the patterns.

  - **Shutdown GEIRS** will close GUI's related to the session and terminate the command server, shared memory manager, data server and ICE server (if applicable). It is equivalent to the `quit` command (Section 5.3). This is a swift and recommended way of terminating GEIRS. *Just closing the window does not shut down GEIRS!* To keep GEIRS running and to close GUIs press the close button of the window manager, which is usually a cross symbol in the surrounding frame. [Most people would push the iconize button of the window manager to the advantage that the GUI can be reopened conveniently by clicking on the GEIRS icon in the task bar.]

  The background of the menu is yellow if the ROE is simulated, which means that all the images are faked in software and not actually generated by interaction with a ROE rack.

- Modules Menu The modules menu starts the different modules, each of which has its own description section.
  - **Display**: Toggles the status of the image display, Figure 16, i.e., starts it if not shown and closes it if shown.
  - **Telescope** Telescope control. *Only available for PANIC.*
  - **TempControl** *Only available for PANIC.* Displays a graph with the pressure and various temperatures inside the dewar This button is only present if the `CAMWOTPCTRL` is not set in the environment (that is, in the shell script to start the instrument). The display is passive in the sense that they show a scan of lines in a special format taken from a log file that is typically fed by a `cron(5)` job which reads the sensors . GEIRS does not need to be online to store these. The plot may even be displayed with

    ```
    cd GEIRS/INFO ; xterm -e gnuplot tmp_gp.panic
    ```

    if GEIRS is not started.

    Irrelevant in the case of LBT instruments or CARMENES which have dedicated subsystems to deal with these house keeping data.
  - **New InstrShell** Opens a instrument shell window similar to Figure 13.
  - **DebugLog-Mon.** Opens a debug log monitor
  - **ErrorLog-Mon.** Opens an error log monitor
  - **ROE-Log-Mon.** Opens a log monitor similar to Figure 14 showing a history of command exchange with the ROE.
  - **Cmd-Log-Mon.** Opens a log monitor similar to Figure 15.

- Options Menu
  - **Sound** calls up a sound menu like in Figure 11, where a specific sound file can be associated with a variety of different events (such as telescope moves, completion of a read ...). To "activate" sounds played by GEIRS,
    1. the sound system must be configured as in Appendix A.3 such that it is forwarded over the network from the GEIRS workstation to the operator's computer,
    2. the volume must be set to a value larger than zero,
    3. the sound flag for `Sound On` must be checked
    4. the volumes on the operator's workstation must not be muted by the means of the operating system on that workstation.

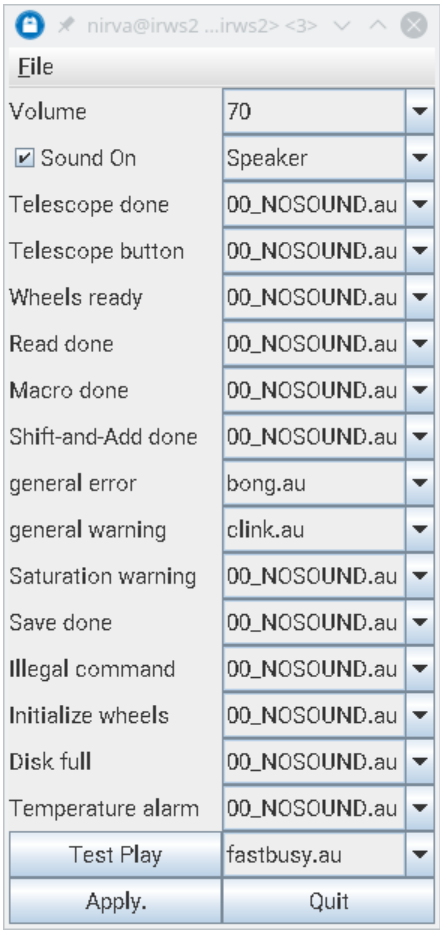


Figure 11: Popup after Selecting `Options`→`Sound` in the Controls GUI of Figure 9. The events concerning telescope, wheels or temperatures are only triggered by the PANIC version of GEIRS, so selecting a sound file here for other instruments is futile.

- **Savepath** and `Macropath` are directories that tell GEIRS where to save FITS data and where to look for macro files.

  `Macropath`, the default search path for GEIRS macros, is usually set to the `MACROS` subdirectory in `$CAMHOME`.

  A default for the `CAMPATH` is proposed which is derived from the current value of the directory by replacing the lowest component with the instrument name and an ISO time stamp of the current date. Pressing `cancel` keeps the current value—which is shown in the title bar of the GUI. Editing the path name and pressing `Save` or carriage-return accepts the new directory (and creates it if needed).

  At the time when GEIRS is shut down, the values are stored in the file `geirs.xml` in the `$HOME/.geirs` directory, and retrieved from there at the next startup.
- **Logfile** specifies where the log file is kept.

Below the drop-down menus various fields display the status of the camera and allow the setup to be changed:

- **First row: Idle Loop setup**

- **Idle** This parameter defines whether the transition from the idle mode to the read mode is done
  - abruptly (`break`, with a sort of immediate termination or break of the idle cycle) or
  - whether the currently running idle cycle is completed before the `read` starts (`wait`, reaching first a type of break point at the end of the idle cycle before switching to the read mode).

  Using `break` has the advantage of starting the reading with the least possible overhead, but it usually leads to visible edge effects in the next frames because the clocking through the detector was interrupted at some position along the "slow" direction. For this reason this parameter defaults to `wait` for all instruments. There is an intermediate type called `auto` which is equivalent to `wait` for integration times shorter than some configurable threshold and to `break` for longer integration times. The associated command is `idlemode` in Section 5.3.

- **Idle Type** The idle mode is the (usually periodic) pattern of voltages applied to the detector lines (reading and resetting) while the ROE's ADC's are switched off such that no data are actually transferred via the fibers to the workstation. The resets avoid detector saturation. GEIRS supports four choices:
  1. `ReadWoConv` (Read with conversion) Reads and resets the same timing pattern as in the current read mode, including ADC conversion (although the workstation ignores this because it has not switched the data transfers on). The cycle time of these idle cycles is the same as the main mode, including the prolongations by any integration times; this aspect plays a major role if the `Idle` button has been switched to `wait`.
  2. `Lir` (Line interlaced read) A cyclic repetition of the read-reset-read pattern at the minimum integration time (which means, the integration time implied by clocking once through the detector at the current pixel time).
  3. `Rlr` (Reset level read) Resets then clocks through the detector line by line. There is a single read of each pixel in this idle pattern, so this is basically clocking once through the chips in half the time relative to the `Lir` idle mode.
  4. `Reset` (Reset only) Executes a series of resets.[35] No reads are involved and therefore these idle mode cycles are the quickest available.

  With the exception of PANIC the default is `Lir` for all instruments. The idle patterns are unaware of any of the three possible subwindow sets of the current read mode (Section 5.6.1), which means timing and resets in the idle cycles are equivalent to full frame handling of all chips. The associated command is `idlemode` in Section 5.3. Details of the idle patterns are discussed in [4].

- **Second and third row: Read mode/pattern setup**
  - **Read Mode** The different read modes available are described in detail elsewhere [5]. For standard broad band observing this should normally be left at the initial default of the instrument (which is `lir` for LN). The GUI sends a `ctype` command of Section 5 to the command/interpreter shell.
  - is the number of reads and resets executed in the current read cycle. This is only editable for the multi-correlated modes.

[35] full frame or line by line, I cannot tell... RJM 2015-08-03

- **IT(s)** is the integration time in seconds, see Section 8.1. The detector is clocked with a rate of 100 kHz, resulting in a minimum integration time of

$$\frac{2048 \times 2048\,\text{pixels}}{32\,\text{channels}} \times \frac{2\,\text{frames}}{100\,\text{kHz}} = 2.7\,\text{sec} \tag{1}$$

  for single or multiple Hawaii-2 and Hawaii-2RG detectors in full-frame mode that reads two frames, this accumulates 2.7 sec like in Figure 9. For Hawaii-4RG detectors read out by two MPIA ROE boards this is

$$\frac{4096 \times 4096\,\text{pixels}}{64\,\text{channels}} \times \frac{2\,\text{frames}}{100\,\text{kHz}} = 5.2\,\text{sec}. \tag{2}$$

  The impact on LN detector saturation is discussed elsewhere [10].
- **prd** The pixel read time in nanoseconds. The standard is 10 μs equivalent to 100 kHz. See the `roe` command in Section 5.3 and also Section 8.9.
- **pskp** The pixel skip time in nanoseconds.
- **lskp** The line skip time in nanoseconds.
- **ems** The electronic multisampling factor.
- **nqchan** The number of output channels of each detector. The maximum is 64 for Hawaii-4 RG detectors and 32 for Hawaii-2 or Hawaii-2 RG. Changing the parameter esentially uploads entirely new command tables to the ROE, puts the camera into a busy state for that time, and modifies the integration time.
- **hinvdir** The integer representation of the two (Hawaii-4 RG) or eight (Hawaii-2 RG) bits of the horizontal readout direction in the channels. If the Hawaii-2 RG is used with less than 32 channels, not all bits are relevant. Because the Hawaii-2 detector does not support such configuration, the button is absent for Linc-Nirvana.
- **vinvdir** The integer representation of the single bit of the vertical readout direction in the channels. Because the Hawaii-2 detector does not support such configuration, the button is absent for Linc-Nirvana.

• **Fourth row: Subwins** There is one button `On/Off` to switch between full-frame mode and subwindow mode. The button does not respond if no active subwindows exist.

  The other button opens a GUI similar to Figure 12 with options to edit the index and the four parameters of the subwindows. Each row in the GUI represents one software window. Click on a checkmark to remove a window from the set, and click on the empty square of a new line to start adding another window. The five integer numbers per line have the same meaning as the arguments of the `subwin` command (Section 5.3): (i) an index ≥ 1, distinct for each window, (ii) the x and y pixel coordinate of the lower left corner of the window in the range from 1 up to a multiple of 2048 depending on the number of chips in the detector, and (iii) the width and height (≥ 1) of the subwindow again in units of pixels. The two buttons at the bottom either activate the set of windows by using a chain of `subwin` commands, or leave the subwindow coordinates as they are; If the `Set` is pressed, the windows that are not check-marked in the GUI are forgotten by GEIRS—meaning to re-active them you will have to type them in with another round of editing. Editing entries in the GUI does not have any effect until the `Set` buttom is clicked.

  `Set` and `Cancel` close the GUI. The `Subwin-Selections` and `OnOff` button indicate which configuration is left behind and effects subsequent `read`'s.

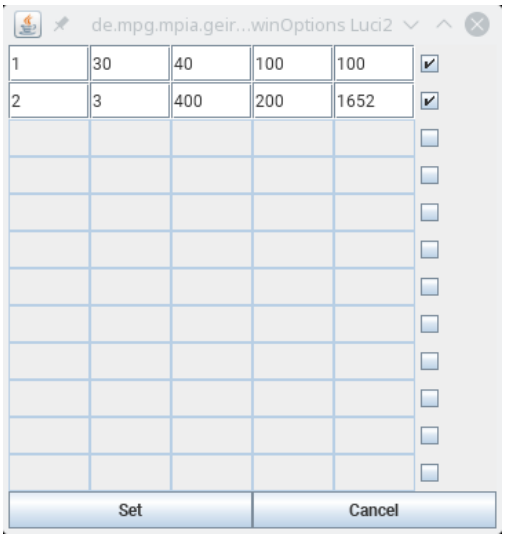


Figure 12: Subwindow selections GUI opened with the `Subwin-Selections` window of Fig. 9.

- Fifth row: Read
  - **Read** The read button executes a read using the current exposure time and number of repeats. On completion of a read, the images are not saved unless `autosave` is selected under the save option. The button turns green while an exposure is executed; but it is yellow —as a warning—if the entire startup simulates the ROE in software.
  - **-Q** If this flag is activated, the `scripts/QueueEFiles` script is executed *before* the exposure is started, see Section 2.5.4.
  - **Repeat** is the number of images N with the specified exposure time T which will be taken each time a read is executed (read-cycle). The total exposure time will then be $N \times T$ seconds. The maximum number of images depends on the computer shared memory set up in Section 2.4 and the setting of `CAMSHMSZ` in `scripts/geirs_start_gen`.
  - The current progress of the `reads` is displayed to the right of the `Read` button. The format shows two numbers separated by a colon, the current frame number and the current image number.
  - **Endless** may be pressed to start an endless loop of reads. The images are read out with the current integration time and readout mode and dumped to the display. They are not saved unless the `autosave` option has been activated via the GUI or `autosave` command (Section 5.3). This is useful for positioning the telescope. Pressing the button again lets the button return to a gray background and back to the one-time action of the `read` and `save` buttons.

    The endless mode still includes the `Repeat` factor of the pattern blocks, which means for example that in a `lir` mode with `Repeat` set to 5, the natural $2\frac{1}{2}$ seconds gap after each 5 reads is observed.
  - **Abort** Kills the read process —immediately, without regard of the current position of the address registers in the detector — and returns to the idle mode.
- **Sixth and seventh row: Save**

- **Save** The save button saves the most recent image(s) obtained using the currently defined save options. It turns green while files are saved to disk. At the end of a readout it turns blue to indicate that the current data have not yet been saved.
- **Save-Options** The check marks define the default way in which to save images. The file name to be created next is defaulted. The range of frames to be saved follows in the next line of options. The main choices are whether
  - to save individual exposures as separate disk files, equivalent not to activating any of the push buttons;
  - **-i/integrated** to integrate them (add them up arithmetically) and save only a single image;
  - **-1/FITS-cube** to store the individual frames as layers following the 3-dimensional FITS cube standard;
  - **-M/MEF** to add the `-M` option to the `save` command and end up with the multi-extension FITS format, were images and subwindows are stored as FITS extensions, one extension per window (see Section 7.5)
  - **-z/FITS compr.** to use the "internal" tile compression registered as a convention of the FITS standard [11, 12]. The current implementation allows this only if also the `MEF` is activated.
  - **-S/sngle frms** to add the `-S` option to the save command, which puts the individual frames into the FITS files, not the pre-correlated/preprocessed images.
  - **-a/auto-save** to save the data automatically (without waiting for a request through a `save` via command shell or GUI)
  - **-s/immed.-save** to save the data as soon as reading a frame is completed. (The difference to the `auto-save` is not waiting for macro termination and even starting the disk transfer before saving the previous frame has finished.

  Note that the save options are overridden by any options specified in observing macros. For example `save -f 2 -i` in a macro will integrate from image 2 to the end of the series, and save only a single file, even if the save options specify saving images separately. Turning on auto-save will execute a save after every read, without clicking on the save button.
- **Filename** The name of the next file to be saved by pressing the `Save` button at the beginning of this line or by issuing a save-command from a script. One can either specify a name or a root. In the latter case the filename is the root plus a four- or five-digit integer, which will be automatically increment by one each time a save is executed. By specifying the root, the system looks for the highest free filename. If a filename ends with a number this number will be increased; if the filename ends on a letter, this will be also "increased" to the next ASCII letter.[36]

  Clicking on the name with the current FITS file allows to change the name for the next `save` command.

  The default file name convention for most instruments is essentially a time stamp. The NTE convention is a condensed time stamp plus an (increasing) 4-digit integer. [The condensed time stamp starts with the letters `TI` or `TS` for the imager or spectograph, respectively. The next letter represents the year, where `D`=2020, `E`=2021 and so on according to the ASCII table. The next letter represents the month where `a` is January,

[36] E.g., a file name set to `fullf` will generate `fullf.fits`, then `fullg.fits` and so on...

`b` is February and so on. The next two digits is the day of the month in the range `01`–`31`. The remaining digits are sequential decimal integers.]

- The two fields to the right of the FITS file name define the range of the first and last frame or image to be included in the output. Whether the count means frames or images depends on the readout mode and whether the `-S` option was selected further above. The two indices are generally ≥ 1, but values of -1 are supported to indicate that the smallest respectively largest range of the images in the buffer should be saved to disk.

- **Last row: Macros**
  - **Macro** Specifies a macro (file with a list of GEIRS shell commands) to be executed by the macro parser. If the filename has the (recommended) suffix `.mac`, the filename may be specified without the `.mac` extension. The macro file must be in the `MACROS` directory specified under the macro path in the options menu (see above) or otherwise be specified by the full path name. Please refer to Section 5 for the macro syntax and commands. Specification of the macro just provides the file name; the macro is not started yet but with the button right to the entry field.
  - **Start**, **Pause**, and **Quit Macro** control the execution of observing macros, reads and running programs. Note, that if a pause or abort is issued, the macro will continue executing until the current command is completed! Check in the command window to be sure that the pause is in effect. Clicking again on `Pause` will continue executing the macro after the pause.

    While the macro runs, the `Start` button turns green and the field right from it indicates which line in the macro file is currently executed.

If the GUI of Figure 9 disappeared, it can be reconstructed with the `control` command to the GEIRS shell (Section 5) or using the equivalent forwarding with `cmd*` or `snd*` (Section 3.1) from the Linux shell.

4.3.2 Command Shell and Log Monitors

The `Modules`→`New InstrShell` menu starts the interactive command shell interpreter of Figure 13.

After the prompt, the GEIRS command shell expects commands from the list reproduced in Section 5, and the terminal echos the responses. The commands send from this window and the commands created by pushing buttons in Figure 9 are received by the same command manager and effect only one single set of state variables. Both channels may be used at the same time.

Two additional log monitors may be opened with the `Modules` menu, illustrated in Figures 14–15. These are passive displays: they filter lines from the `$CAMHOME/log/*.log` files; the logging parameters and amount of information that is stored in these files does not depend on whether the associated GUI is open or not. (The logging information *does* depend on the `LOG_LEVEL` definition in the `GNUmakefile` while compiling and further on the adjustments by any `log` commands send to the GEIRS shell.)

To retrieve the debugging logs use `journalctl(1)` with `GEIRS` as the identifier, for example

```
journalctl SYSLOG_IDENTIFIER=GEIRS
```

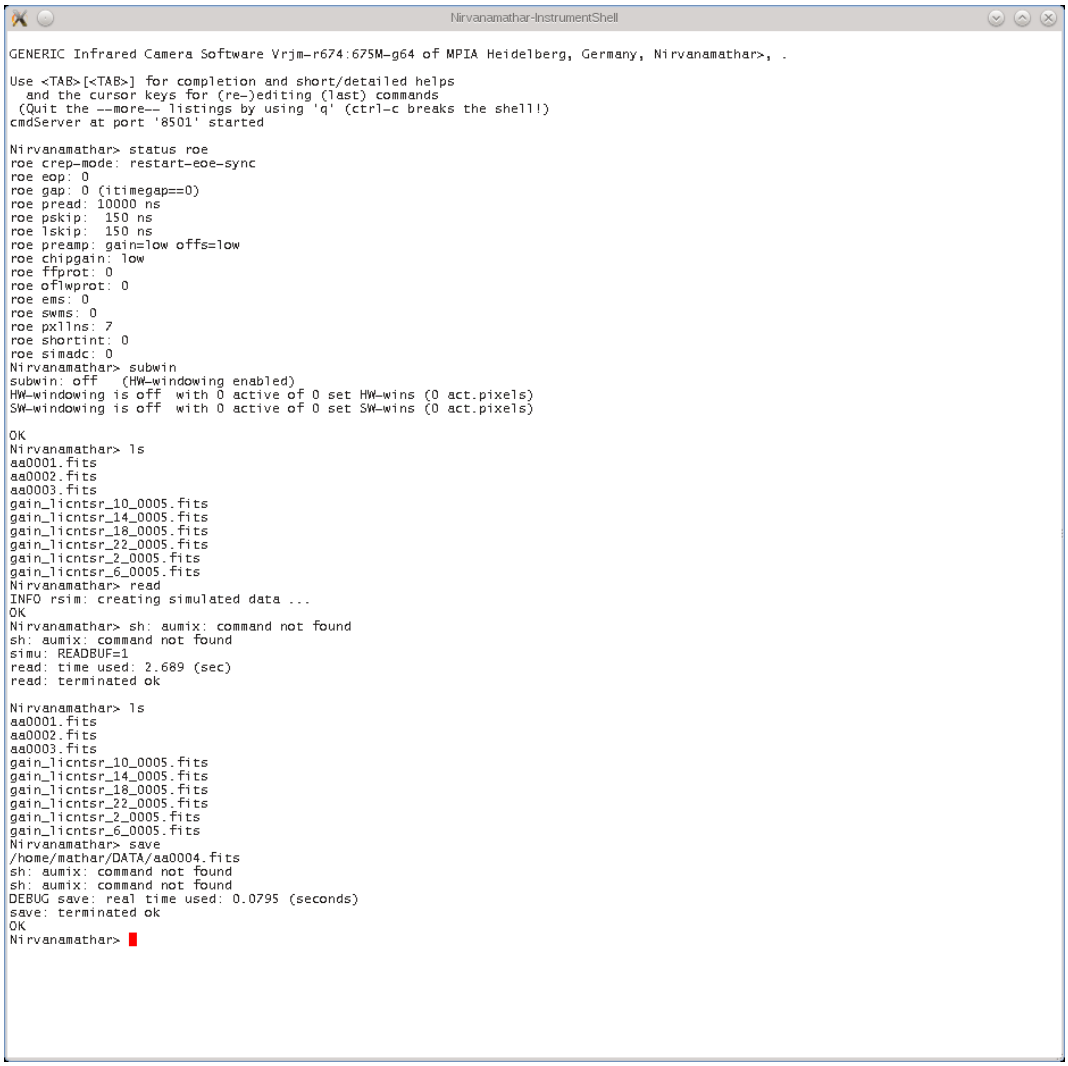


Figure 13: The command interpreter started with the `Module`→`New Instrument Shell` menu of Figure 9.

or to obtain the logs from the critical up to the warning level, filtering with an explicit user ID if different Linux accounts may be using GEIRS,

```
uid=$(id -u)
journalctl _UID=$uid SYSLOG_IDENTIFIER=GEIRS -p crit..warning
```

The monitor of the ROE logs, Figure 14, tracks `log/roe*.log`, and shows a time stamp, the user name on the host machine, the camera name, and two kinds of lines:

1. Entry and exit from one of the functions that accumulate (compute) the duration of patterns and loops over patterns,
2. Patterns submitted to the ROE. The `tout` shows the timeout (in seconds) for waiting for an answer.

The monitor of the command logs, Figure 15, tracks `log/cmd*.log`. The `inter` flags that the line

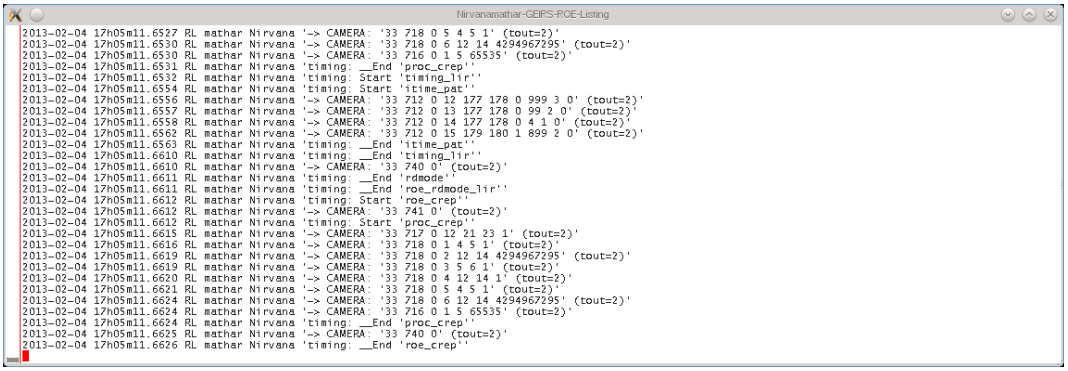


Figure 14: The monitor opened with the `Module`→`RoeLog-Mon` menu of Figure 9.

was generated by a shell script assembled by the command shell with `sh -c`, and the following `i`, `c` or `s` means the caller was the interactive gui, a command, or the shell, respectively.

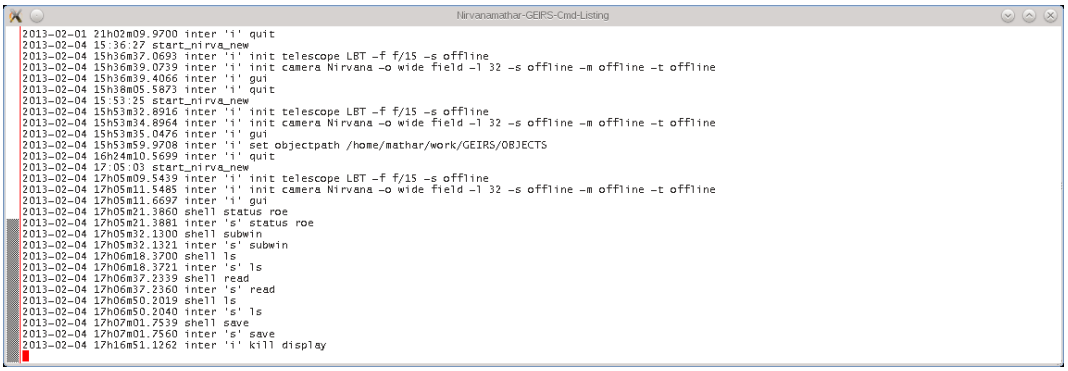


Figure 15: The monitor opened with the `Module`→`CmdLog-Mon` menu of Figure 9.

4.3.3 Real-time Display

4.3.3.1 Introduction The display tool, Figure 16 works similar to `ds9` or `fv` tools with some display options and similar statistics. The GEIRS display, however, is completely unaware of world coordinate systems standards. Some online data processing techniques are available. These interactive operations (magnifying, scrolling forward and backward through the frames, setting ADU cut levels,. . .) affect only the displayed data but do not manipulate the raw data that have been or will be saved to disk.

If `xpa` available, users can send a duplicate of each new FITS file that is generated by the `save` command to an online ds9 application by adding two lines like

```
Xpaset=`type xpaset | awk '{print $3}'`
cat $1 | $Xpaset ds9 fits
 %NOT_PANIC_END
% ONLY_PANIC_END
```

to the `QueueFiles` shell script (Sec. 3.3). As an alternative to using the `type` command one may use the full path of `xpaset` or make sure by symbolic links that the `path` contains the executable.

Note that `ds9` sometimes needs to read `ds9-64` depending on how this was compiled. With that setup, opening the GUI in Figure 16 may be superfluous.

The main difference against saving the image as a FITS file and then calling these standard displays is that one can address any picture in the current memory buffer rather quickly by its index.

The pixels in the display are all those received from the ROE; this means if windows have been used, the area covered by the pixels in the display is generally larger than the set of pixels saved into the FITS files.

The real-time display polls the shared-memory database (with a combination of `get INT_STOP_SEC`, `get READBUF` and `get NIMAGE`) each $1\frac{1}{2}$ seconds to check whether a new image is available.[37] It then requests the recent image from the data server. If the image frequency of the pattern/ROE is higher, some images/frames may not be displayed in the GUI by default; they can still be selected through the *current image* button. This deliberate throttle does *not* indicate that frames have been lost.

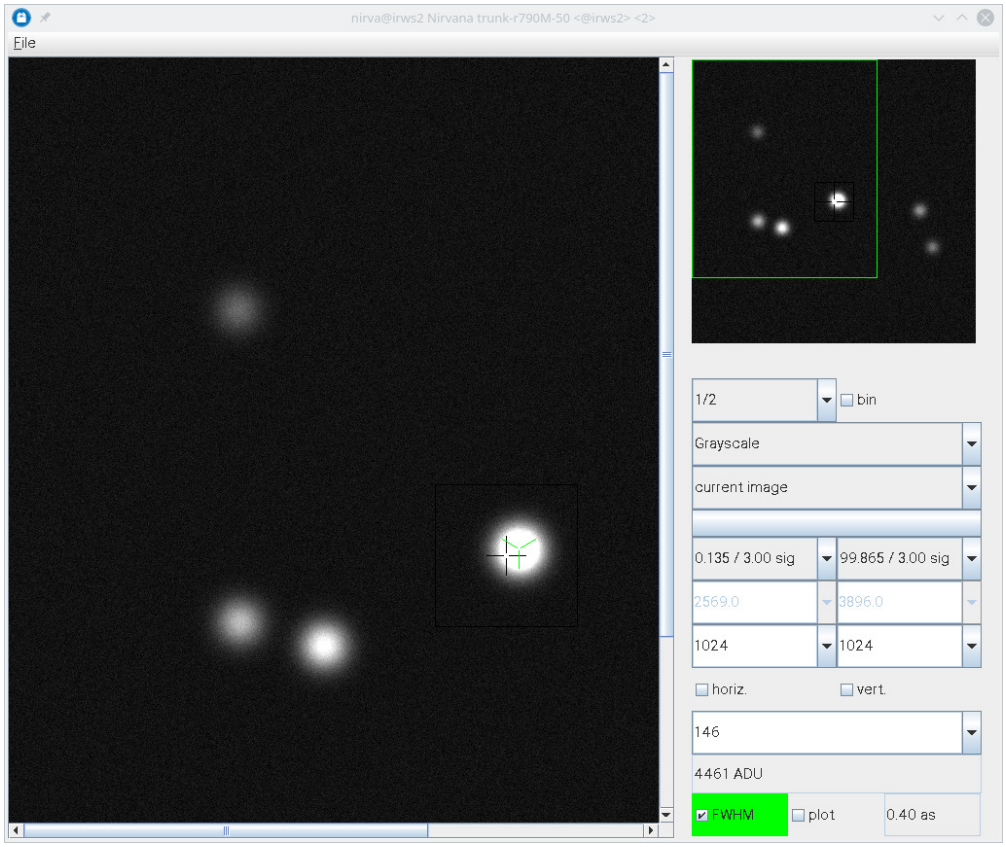


Figure 16: Current Exposure Display. Right after GEIRS startup this shows the white-on-blue logo of the MPIA.

[37] That interval can be changed by modifying the 1500 milliseconds of the `pollTmr` in `de/m*/m*/g*/DisplayGUI.java`.

The pixel display that covers most of the area is the most recent detector image. One or two scroll bars appear if the pixels of the detector(s) don't fit into the operators window depending on the zoom factor.

The menu on the right hand side of Figure 16 has a number of fields, which are described from top to bottom in the subsequent paragraphs.

Hoovering with the mouse for approximately 2 seconds shows a short description of what these fields mean. To keep the space consumption of the fields low, labels have been abandoned because these "tool tips" provide the same functionality.

There are some standard types of fields:

- Down-triangles decorate scroll-down menus. They either offer a fixed set of options (with a scroll bar if the list of options is long), or offer selections that can in addition be edited. The latter is a frequent standard for numerical fields.
- Fields with gray background are outputs for information only.
- Fields with variable background are either buttons that toggle a state or open another menu.

4.3.3.2 Thumb Nail Pixel Image. This is the detector image downscaled by a fixed factor 9 (if the detector area is 2048×2048) or 19 (if the detector area is 4096×4096), independent of the scale factor of the main display.

The rectangular frame indicates which portion of the detector(s) is currently visible in the main display. Clicking with the left mouse in this small image is equivalent to centering the main (big) image around that point, i.e., could as well be achieved by moving the scroll bars in the main image.

4.3.3.3 Zoom factor. There is a selector with fractions ranging from approximately 1/32 to 4/1 that specify a zoom factor. Each detector pixel is replaced by that many pixels in the operator's display. One may either click on the down-triangle to modify the factor or press `-` or `+` while the focus is in the pixel image to decrease or increase the factor.

The fractions from 1/32 to 1/2 are not binning groups of pixels but simply skip a fraction of rows and columns (sub-sampling) for the sake of speed. So note that for small fractions (large denominators) some of the stars—of any magnitude—may virtually disappear in the viewer if the detector pixel scale does not well resolve the Strehl width.

However, there is a flag to activate a software binning of pixel tiles to the right of the scale factor, which will replace each pixel in the GUI by the arithmetic average of a square tile in the neighbourhood if the zoom factor is < 1.[38] This is computationally more expensive and may lead to false impressions of background noise, but avoids that stars just disappear because they are not hit by a finitely subsampled grid of rows and columns.

If the zoom factor is > 1, each detector pixel value is expanded in a small square tile by copying its value to the display pixels. There is no interpolation then akin to some smoothing image processing known to other software packages.

[38] It does not just add the pixel values in the tiles because that would require adjustement of the cut levels each time the zoom factor is changed.

4.3.3.4 Color. There is a selector for the color lookup table. Some of the color tables are from the Part 6 of the DICOM book, and the others from ImageJ. All color tables—with the exception of the `Grayscale`—quantize the pixel values with 256 different RGB colors.

The display uses a linear map for the translation of ADU's to brightness by default (i.e., after GEIRS has been started). A γ-correction with a power law scaling is available by setting the `DISP_GAMMA` value of the shared memory database to some different value in the range $0 \leq \gamma \leq 100$ with the `put` command (Section 5.3), for example

```
put DISP_GAMMA 1.4
```

The default after GEIRS startup is $\gamma = 1$.

4.3.3.5 Image Stack. The image display maintains a finite circular buffer of images and frames, so one can step backwards through a limited number of previous images or frames. The choice `current image` lets the viewer collect new images arriving on the workstation, and `current frame` lets the viewer collect new frames on the workstation. This means

- The image display does not have arithmetic functions to split images into frames or to combine frames to images. It adds either new images or new frames to its stack, but not both at the same time. It is just a viewer for pixel arrays, not a calculator nor a data pipeline.
- The image display does not change if one toggles from `current image` to `current frame` or vice versa. One needs at least one further read to let the image display become aware of new data.

One of the small negative indices selects an earlier one in that circular buffer, so `-1` means the penultimate image and so forth. The negative labels are just indicating that one steps backwards—similar to the semantics of negative indices in Python or Maple lists.

If one tries to select an index which does not yet exist, the GUI corrects that index to an existing one. If you have clicked for example three times on the `Read` with a default repetition factor of 1 after starting the GUI, and select `-8` here, the GUI knows only 3 images whereas `-8` requires at least 9, so the GUI will change that selection to `-2`, the oldest image it knows about.

The circular buffer of image is private to the GUI. It does not depend on how many images fit into the main GEIRS buffer in shared memory or on how many images are created in a single `read` cycle.

Selecting anything else but `current` means that the main display freezes an earlier image, but still active read-outs will enter the GUI's buffer of images and old images are discarded. If the index in the stack is re-selected afterwards without halting the readout, the negative lables will not refer to the same images.

As a warning to the user, selection of anything but `current` paints the button in blue to indicate that one must select `current` to return to the life display.

4.3.3.6 Sky Background. There is a file name chooser for a FITS file that must contain a sky (background) image with the same full frame resolution as the current instrument. Clicking on the button allows to select a file that exists on the local file system. To disable sky subtraction, click on the `Cancel` option in the file chooser, not on the `Save` button. The button shows the

filename without the `.fits` suffix. If the name is empty or is not a compliant FITS file, no sky image subtraction occurs. *Compliant* means:

- The FITS file must contain a `EXPTIME` keyword in the primary header for an exposure time (in seconds) such its image can be linearly rescaled to the exposure time of the current display.
- The FITS file must contain an image or a cube in the primary or secondary header data unit with the same horizontal and vertical `NAXIS` dimensions as in the current full frame scenario. If the FITS file contains an at least 2-dimensional image in the primary HDU, it reads this, otherwise it tries to look for an at least 2-dimensional image in the next HDU, but it does not look into latter HDU. Even if the current exposures use subwindows, that file with the sky/background image must have the full frame dimension, including all detector chips.

  If the sky image is in a cube, all slices in the cube are added up, and its effective exposure time is set to the `EXPTIME` of the primary header multiplied by the number of slices, in compliance with Section 7.4.
- The image in the FITS file must be of `BITPIX` type 16, 32, -32 or -64, the usual short, integer and floating point types.

If the selected file is not compliant, the software will clear the file name in the GUI and resume the mode without sky subtraction. The simplest way of creating a compliant file is to save a sky exposure in Figure 9 with `-i` checked and all other options unchecked.

If that sky subtraction is activated, the derived data like cut levels, FWHM estimators, and horizontal and vertical cuts through the images are all derived from the differential/subtracted total pixel brightnesses.

The task of subtracting two FITS images is usually left to more advanced programs. if the `FTOOLS` are installed, save the first image to disk, for example the file `tst1.fits`, save the second image to disk, for example the file `tst2.fits`. Let the images be in the extension named `WIN1`, for example, then the difference is created with the `SUB` operator of farith

```
farith tst1.fits[WIN1] tst2.fits[WIN1] tst3.fits SUB
```

on the Linux shell.

4.3.3.7 Brightness Cut Levels (Parameters).

There are two cut levels selectors which offer

- `fixed`: the cut levels are not dynamically adapted to the current image but stay fixed as new images arrive. The cut levels may be edited by changing the lower and upper limit in the two number fields underneath.
- or a set of percentages of the pixels below/above which pixels are shown to be effectively zero/black or saturated/white.

If left number (lower limit) is larger than the right number (upper limit) levels are reverted; then stars appear dark on a brigher (sky) background.

4.3.3.8 Brightness Cut Levels (Values).

There are two numbers that are computed pixel cut levels based on the methodology selected higher up. These cannot be edited unless `fixed` is

selected. If editable, these entries also accept floating point notation like 2.5e3 (for 2500). The internal handling of these cut levels is quantized in integers: using accuraries better than 1 is futile.

4.3.3.9 Hot Pixel Coordinate. There are two integer numbers which represent the x and y coordinate of a "hot pixel" in the detector frame in FITS coordinates, so $(1, 1)$ is the lower left pixel. The numbers can be changed by typing in other coordinates, or by clicking with the mouse at a place in the main image (*not* in the thumbnail image) or by using the 4 cursor keys. To disable their definition, insert a negative number. If enabled, that point is marked with a cross in the display.

4.3.3.10 Horizontal/vertical Slice. In the next row the `horiz.` and `vert.` buttons open plots that show the pixel values along two straight lines that cut horizontally and/or vertically through the image at the "hot pixel" marked by the center of the cross (Figure 17).[39] The plots are updated if new images arrive or if the hot pixel is moved. The titles of the plots indicate the FITS x and y coordinates of the common crossing of the two cuts. The buttons are green while the plots are active. The two graphs should be closed by clicking again on the buttons; their color will switch back to gray if de-activated.

The width of the horizontal or vertical pixel interval that is shown in the slices becomes smaller or wider as a fucntion of the zoom factor of the main display. At zoom factors < 1, the entire detector is scanned, at zoom factors > 1, the scans show smaller sections, which means higher resolutions.

4.3.3.11 Radius of Interest. The next field defines a radius in units of detector pixels. If chosen positive, it is also inradius of the square box painted around the "hot pixel" in the pixel image; if negative, the radius is undefined, no square box is drawn, and the FWHM computation is de-activated. In the example shown the value is 146, which means the box covers 293×293 detector pixels. (Detector pixels means that the *apparent* size of the box changes if the zoom factor is changed, whereas the size on the detector does not change.) The initial value is computed from a FWHM of 0.9 arcsec, the imager's pixel scale and setting the boxes half edge to 2σ.

4.3.3.12 Hot Pixel Value. The next single integer number is the pixel value at the place of the "hot pixel." It cannot be edited.

4.3.3.13 FWHM Estimate. The next row contains two buttons and a number related to FWHM guesses. The row does not exist for CARMENES and the spectroscopic camera of NTE because the width is computed with a 2-dimensional isotropic fit to the pixel values which does not make sense if one of the axes in the image is not a direction on the sky.

The `FWHM` button can be pushed to activate FWHM monitoring in new images that arrive. `FWHM` is green while active and gray while not. Note that

1. the FWHM fit does not make any sense for the LUCI spectroscopy. But GEIRS does not have any clue whether it is currently used for imaging or spectroscopy in that case.
2. values are wrong if GEIRS does not know the correct pixel scale, in particular for instruments with variable pixel scales if started with the wrong resolution in Figure 7 and/or not getting

[39] They are *not* cutting through the location where the additional FWHM centroid may appear.

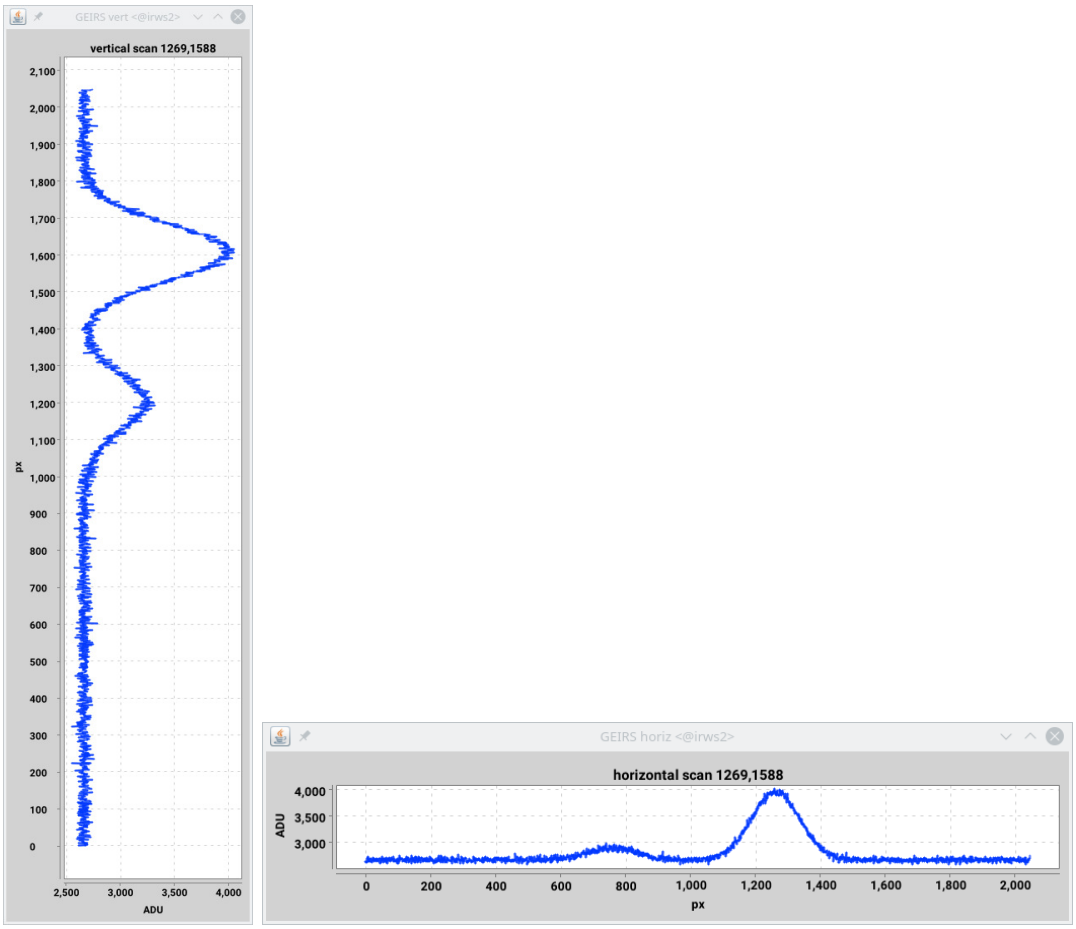


Figure 17: Examples of cut plots activated with the `horiz.` or `vert.` buttons of Fig. 16.

updates. So in particular for LUCI it is recommended to check that the pixel scale reprinted in the title of the GUI is correct.

The history of these FWHM estimates contains up to 128 measurements; older values are forgotten if that stack size limit is reached. This ensures that the graph with the plotted values does not get too crowded.

The algorithm searches for a bright center in the square frame defined by the region of interest furhter up, and fits a Gaussian (background plus amplitude with variable width) there. The computation is disabled if the radius is negative. The fitted full-width-at-half-maximum printed to the right of the button in units of arcseconds.

A cursor with three green rotor blade lines is inserted into the pixel image where the algorithm located the center of the Gaussian. This gives a visual feed back to check that the centroid search ran wild. The algorithm considers an area equivalent to the black box around the cross for fitting; for optimum performance and quality, that box should roughly cover the center of the star and 2σ of the expected Gaussian around it.

The computational load may be massive; do not activate the button unless needed. The algorithm starts by computing at 5 points (center, East, North, West, South) around the center median values of pixels, selecting the largest of these 5 points, and continuing this recursively on a shrunk subarea

taking the largest of the 5 pointas as the new center. The points in a virtual square box around that centroid are then binned by distance from the center, and a low-resolution fit to these binned data is generated using the first few components of a 1-dimensional Fourier transform to reduce noise. In the smooth approximation by that Fourier transform the zero of the second derivative (equivalent to the 1σ distance from the center) is searched, and multiplied by $2\sqrt{2\ln 2}$ and the pixel scale to create the FWHM.

The algorithm does not fit a Gaussian if the amplitude appears to be less than 10^{-3} of the background. In these cases it sets the standard deviation of the Gaussian to the square box edge length as some sort of lower estimate, and the green cursor in the pixel display disappears.

The `plot` button pops up an auxiliary window similar to Figure 18, which shows a horizontal time axis and FWHM values on the vertical axis. FWHM values above 2 arcsec/px are not included

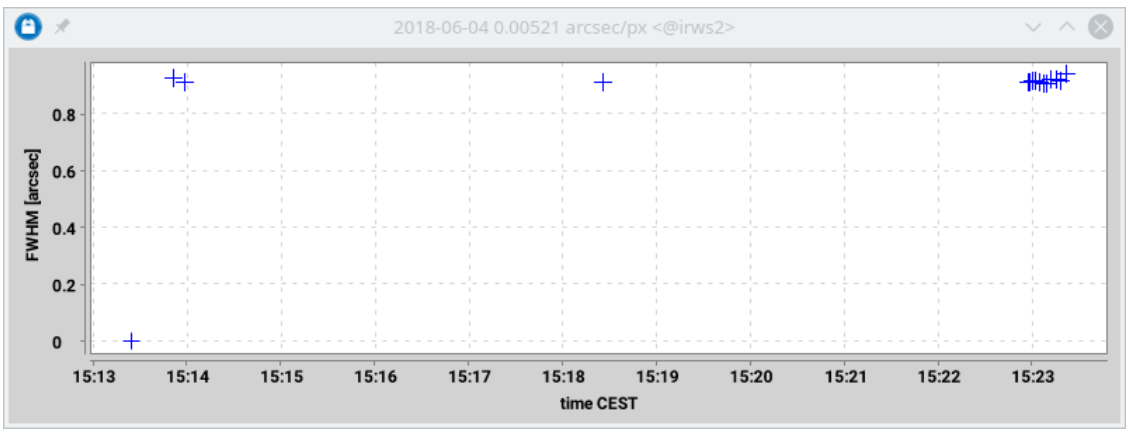


Figure 18: Intermediate FWHM history while the FWHM button of Figure 16 is active.

(for the benefit of a supporting automated scaling of the vertical axis). The time axis is the time when the snapshot of the image was drawn from the GEIRS data server. Note that this time may be off by a full integration time in comparison to the end of the exposure that actually contributed to the image! If one skips backwards through the image stack as mentioned above, and if the `FWHM` button is active, this will add points to the `FWHM` stack at these times of the past.

The button is green while that plot is displayed. Pressing the `plot` button again removes the plot. The two buttons are slightly correlated: One can push `FWHM` to collect values without plotting them; but `plot` shows only those measurements that have been collected.

4.3.3.14 Main Display. The main display (with up to two scroll bars) shows a (optionally zoomed) version of the pixels.

A mouse click in this display moves the hot pixel location to that pixel.

A drag with the left mouse (press-hold-release) selects a rectangular subsection of the pixels, copies these values into a temporary FITS file, and opens a gnuplot display with a histogram of the pixel values rendered with fitsImg2Asc(1), see Section 5.5.

4.4 Taking data

The windows introduced thus far are the environment in which one takes data manually (including the use of GEIRS macros, see Section 5). This is useful for tests or special calibrations.

4.4.1 Setting up the camera for an exposure

Before you start, make sure you have selected the proper paths for your data etc., see Figure 9 at upper right. You should also set the root name of the files to be stored on disk, which is also done in the camera control window. The instrument is completely setup in the camera control window. Here you select the read-out mode and the exposure times, to name the most important.

4.4.2 Taking exposures

An exposure is taken by pressing the `Read` button (below centre in the camera control window). Although this exposes the image, it is only read into the memory of the instrument computer. There you can use it to take a look at it on the real-time display, measure background level, seeing etc. there. If you decide to keep the image, you also may modify the format of the data (e.g. as a FITS cube, individual images, stacked images). Once set you save the data by pressing the `Save` button. Due to the double buffering, an image may be saved while the next one is already being taken. (For CARMENES, that alternating buffering scheme has been disabled to halve the RAM requirements. This works because CARMENES is only used in a batch type of environment where `read` and `save` are used only in sequential order without temporal overlap.)

4.5 Saving data

The data are stored on one of the disks of the instrument computer under the path you have specified under `SavePath` in the Options Menu of the camera control window, Fig. 9. The initial default is `$HOME/DATA` set at start-up time in Section 4.1. The files are stored as FITS files and are not write protected in the standard sense of the file system (!).

Each `save`—either explicit or implicit with the `autosave` or `sfdump` mechanisms–creates FITS files which are cached by Linuces. This incrementally reduces the amount of free RAM displayed by commands like `top(1)` or `free(1)`. (People may errneously interpret this as memory leaks or some sort of defect within GEIRS; there is even one instrument where the local system administrator restarts GEIRS periodically because he believes that memory is "lost.") This effect is obviously very pronounced on computers that produce astronomical images, and in particular where GEIRS in its standard configuration can generate FITS files half as large as the total computer's RAM in a single exposure. The caching mechanism basically does not harm but is often useless, because data reduction is rarely done on the GEIRS computer so the speed-up of reading the cached FITS files instead of their disk copies is never felt. An obvious exception here is the CARMENES first stage pipeline which uses these FITS files right at the end of each exposure.

5 COMMAND INTERFACE

5.1 Double buffering

It takes a some amount of time to transfer the data from the camera and save it to the hard-drive on the workstation. To reclaim some of this otherwise lost time, GEIRS has been configured with two image buffers. Thus, a new image can be read out while the previous image is being written to disk. To implement this feature, the commands should be written as in the examples (Section 5.7), with a `sync tele` after the telescope offset and `save` commands. The GUI will then only wait until the telescope move is completed before starting the next read (the save command may still be in progress).

5.2 Parser

5.2.1 Syntax

Commands and their arguments are usually submitted one per line, separated by line feeds. If two or more commands are to be send at once, they need to be separated by a semicolon. This makes for example sense for the commands that are almost always followed by the `sync`, for example:

```
save -M ; sync
```

Note that this format generates only a single answer from the interface, not separate answers from the individual commands in the list.

There is one command, `save`, which uses commas to bundle groups of options.

Note that command options cannot be sequeezed into short forms and cannot be swapped with non-optional arguments nor be clumpped without spaces, as some Unices allow in their shells or some higher programming languages support with some getopt(3) libraries. Example:

```
save -zC # wrong syntax !
save -z -C  # valid syntax
```

As a guideline, trailing arguments or options in commands are silently ignored.

5.2.2 Timing

The GEIRS command interpreter does not have a command stack; so one cannot type ahead an arbitrary number of commands assuming that they will be executed in order. Proper timing is achieved if and only if each command waits for the reply from GEIRS before the next command is submitted. There is no reason to implement convoluted timeout data bases on the client side: GEIRS has its own internal timeout values for the various tasks. The reply will carry an error message if GEIRS has run into one of these timeouts. It would be an even worse design of the client to set some arbitrary constant timeout on the client side.

GEIRS maintains a busy state after it received many of the commands. To relax these requirements, GEIRS actually puts a single (!) command on hold if GEIRS currently is in its busy state, and waits for up to 5 seconds for the removal of the busy flag, i.e., for the termination of the previous command. This means in practise that the client side can type ahead one single command if the

previous command is handled within 5 seconds.

5.3 Command List

In this section a complete list of commands is given. The order is lexicographically, not by functionality. These commands and syntax can be used in macros or typed directly into the command window or submitted with the interfaces of Section 3.1. Use with caution some commands are better left out of macros! For example, `quit` will exit a macro at the point it occurs, no further instructions in the macro will be executed. Also, if interactive is on, and `ls`, `dir`, or `history` are used in a macro, the macro could stop executing and wait for a carriage return.

The subsequent pages are a PDF reproduction of the "help" page generated by texinfo in various formats. The intend is to demonstrate to reviewers that this information is indeed available, not to provide a reference that is anyway accessible with the online software. [For this reason, two pages of the PDF document have been packed on a single page of the manual; this also helps to realize that they carry their own internal pagination.]

The options to read this informations are:

1. the `File`→`Help` button in the controls menu, Figure 9, if the *full* path name of a browser has been set in environment variable `CAMBROWSER` in the startup file `scripts/geirs_start_gen`. This is the same as calling

   ```
   setenv CAMBIN=${CAMHOME}/<branch>/share
   firefox ${CAMBIN}/camera.html
   ```

   offline.

2. the `info(1)` command

   ```
   info -f $CAMHOME/<branch>/share/info/camera.info
   ```

   opening the screen similar to Figure 19. This may be simplified as described in Section 2.5.7.

3. as a PDF document

   ```
   cd $CAMHOME/<branch>
   texi2dvi --clean --pdf --expand camera.texi
   evince camera.pdf
   ```

4. the `help` command entered in the command shell.

This is a generic account of the command interface, and again many of these do not apply to LUCI1,LUCI2 and NTE,in particular the commands that interface with the telescope or motor and other controllers. The commands are either in the category `type:USER` or `type:ENG` or `type:SUPER`; the commands in the latter two categories are rejected unless one is using the instrument under one of the engineering observer ID's or the observer ID `master`. (The observer ID is configured in the top field in the GUI of Figure 7.)

GEIRS Command Interface

Generic Infrared Detector Software
Max-Planck Institute of Astronomy, Heidelberg 30 March 2024

Richard J. Mathar mathar@mpia.de, **Clemens Storz**

Table of Contents

abort

type: USER
syntax: `abort [-r [-k [#]]] [-m] [-s] [-t] [-a] [-b]`

Aborts the execution of `read` and/or macros.

- `-r`: abort `read` only. See [read], page 26. Causes sends a command to the patterns on the ROE to leave the readout loop immediately and return to the idle loop. *Immediately* means that the pattern freezes independently how far it has read through the detector, so the ADCs do no longer digitize data, and starts to execute the idle loop. This is for example useful if the `read` was started in the endless mode.
- `-m`: abort `macro` only. See [macro], page 20.
- `-s`: shorten the initial wait time of the `sync` command and abort the `saad` command. Note that the meaning is *not* that the `sync` waiting state is prematurely left. It only means that the optional additional time delay that is an argument of the `sync` command is cut to zero and that the `sync` starts to wait on the termination of its processes without any artificial further delays. In particular this means that you *cannot* prematurely abort a `read` by an `abort` if a the `sync` has already been send to the interpreter. See [sync], page 38.
- `-t`: abort `test` only. See [test], page 44.
- `-a`: abort all processes above here
- -k [#]: kill the read after waiting for # seconds (default is 2s). This tries first a "smooth" kill via a catchable signal, then enforces the kill.

The default, if no options are used, is to abort everything except `save`.

If the `abort` command has been finished, the number of frames that have been received on the workstation may be too small to create images based on that number of frames, depending on read mode (correlation type, subsampling frequency, ...) and time between starting the read and the abort.

In consequence the `save` may in general fail after `abort`. A typical example of this situation is a `lir` or `srr` mode with only two reads, where any `abort` results in only a single remaining frame (the reset frame), from which no useful information (i.e., image) can be extracted.

Special note to CARMENES programmers: Note that a command sequence like `read`, `sync` cannot be shortcut by sending `abort`, because `sync` includes a `sync read` which enters a wait state that waits until all the images of the regular integration time have arrived. This means that effectively the `abort` would be recognized *after* the `sync` returns, and at that time there is nothing left to abort. This means if you are not sure at some time whether you would like to wait for the regular passing of the full integration time or perhaps use a `abort` later, *do not* send a `sync` until you really mean it.

Note that a 'PLX ApiError 533' will generally be emitted by the PLX driver because the `abort` cancels a wait status for further frames (if the `abort` occurs before the readout is terminated regularly when the integration time is exhausted). This is a fairly common scenario for CARMENES, where the client program often sets up a long maximum integration time, figures out during the observation when the integration time meets some critera on the S/N ratio, and then sends `abort`. It is no reason to conclude that GEIRS is faulty or has run out of control.

alarm

type: USER
syntax: alarm [sound] [volume]

Plays a 'General Error' sound. The 'sound' is an optional file name, where the file must reside in the `admin` subdirectory of `$CAMHOME/<version>`. 'volume' is in the range from 1 up to 100.

Note that alarm sounds cannot be blocked by setting the volume in the Options->Sound menu of the controls.

Note: On problems with the audio driver the sound may be switched off in the Options->Sound menu of the controls.

aperture

type: USER
syntax: aperture [name]

Move the aperture wheel to position 'name'. Actually this is only relevant to PANIC and moves the cold stop wheel (unless disabled). The named positions are defined in the files `$CAMINFO/wheel#.ext`. The available wheel indices '#' and the file extension `.ext` depend on the actual camera system in use.

If called without a parameter, `aperture` prints all possible aperture-positions and the current one.

Warning: `aperture` launches a background process and should be followed by a `sync` when used in a macro or when called externally.

autosave

type: USER
syntax: autosave {yes,on/no,off} [-s] [-f n] [-l n] [-r n1 n2] [-1] [-i] [-d] [-c] [-t] [[-b] or [-g]] [-p] [filename/devname] , . . .]

Enables/disables automatic `save`-operation after/during a `read`. The switches are explained with the `save`-command. If the command is used with arguments, the first one must be one of {yes,on/no,off}

If called without parameters, the current status of `autosave` is returned.

bias

type: ENG
syntax: bias [detN] biasname|biasindex [(DACdigits| -V voltage) [(DACdigits| -V voltage)] . . .]

For the MPIA ROE, the detector biases may be set via the detector control board by use of DAC's. Changing settings via this command is restricted to the ENG class of operators.

The HAWAII-2 (i.e., Nirvana) detector uses 3 biases (DSub, VReset, VBiasGate) and 1 external bias (extbias).

For HAWAII-2RG or HAWAII-4RG (Panic, Luci, CARMENES, AIP) detectors, each detector is controlled by 10 biases (DSub, VReset, VBiasGate, VnBias, VpBias, VnCasc, VpCasc, VBiasOutBuf, RefSample, RefColBuf) and 1 external bias (extbias).

These names of the biases can be written in mixed upper/lowercase characters.

The argument 'detN' is 'det1' up to 'det4', depending on the number of detectors in the camera. If 'detN' is given, the biasindex is between 1 and 10 (inclusive); If 'detN' is not given, the formula ('biasindex(1..40)'/10+1) defines the detector number. If neither 'detN' nor 'biasindex' are given, det1 or the explicit 'biasname' are used to set the destination.

If the arguments 'DACdigits' or 'Voltages' appear more than once, the first bias is addressed as shown above, and the subsequent values are written to the subsequent biases in order.

Each DACdigits is an integer between 0 and 4095.

The `-V` may also be written in lowercase `-v`.

Note that the *external* bias, one per detector, is set with `extbias`.

Examples:

```
bias det3 4 100 3248 280  #set 3 ADC-values for bias indices 24 to 26.
bias 4 100 3248 280       #set 3 ADC-values for bias indices 4 to 6.
bias 24 100 3248 280      #set 3 ADC-values for bias indices 24 to 26.
bias Vreset 3248 444      #set 2 ADC-values for bias indices 2 and 3.
bias det4 Vreset -V 2.8 3248 -V 0.5   #set 3 values for indic. 32 to 34
bias 33                   # returns status of det4 (bias indices 31..40)
bias Vreset               # returns status of det1
bias det3                 # returns status of det3
bias extbias 2300         # sets the extbias for detector1
bias det4 extbias 0       # sets the extbias for detector4
```

If called without argument, the current setting of all detectors is shown.

Note that for two of the 10 voltages, slightly different factors convert the voltages to their 12-bit digital counterpart depending on which version of the bias-board is in use (and for the Hawaii-4RG of PANIC this factor is not yet known...), as reflected in the roe3_bias_maxvolt() function in the source code. If GEIRS is compiled on a computer under a MPIA IP address, these factors can be modified (without recompilation) by adjusting the parameters in the TMPDIR directory in the file named by the IP address of the ROE.

cassoff

type: USER
syntax: cassoff [angle]

Sets the zero-point 'angle' as the cassegrain angle for the NSEW (North-South- East-West) orientation.

The command is only relevant for PANIC. The arithmetic difference of the cassegrain angle that is provided by the telescope (TECS) and that offset angle is stored as a FITS header keyword. So the sign convention and units must be compatible to those of the `casspos` command, whatever that actually might be.

Note that this value is not used to modify the WCS values of the FITS header: to rotate the WCS matrix set the CAM_NORTH environment variable, measured in degrees, to an angle, which differs from the default, before starting GEIRS. (The implicit default of CAM_NORTH is `+90`, measured counter-clock-wise from the horizontal `+x` coordinate in the FITS images. This means to instruct GEIRS that north of PANIC images is not up but sligthly more to the left, use a value of CAM_NORTH that is slightly larger than 90.)

casspos

type: USER
syntax: casspos [angle]

Sets 'angle' to be the actual cassegrain angle. The default value of the angle when GEIRS starts is the one obtained from the EPICS interface of the telescope. The Cassegrain angle of the telescope is apparently measured in degrees with some undocumented offset and sign conventions.

This CASSPOS FITS header line reports the difference of this cassegrain angle minus cassoff.

If called without parameter, the actual cassegrain-angle relative to NSEW will be returned.

The command is only relevant for PANIC.

cd

type: USER
syntax: cd [directory]

Changes the directory for `save` operations, reminiscent of the UNIX `cd(1)`.

The command checks the capacity of the filesystem of the new directory. If the capacity is below some value, the command issues a warning.

If the current default filename for the save operations was given as basename ending *not* with a digit (see [next], page 21), and that directory already contains files with that basename, the number part in the default filename will be increased if this is necessary to avoid name conflicts. If there is no such file in the new directory, the default filename stays as it is.

Warning: If used without an argument, the new directory is set to the home directory of the user. The directory of the 'save-path' and the free disk space in that directory are returned.

That means, to determine and check capacity of the current directory, execute `cd` or even better `pwd`. Alternatively, use `set` or `set savepath` to obtain more information on the paths.

The command may fail if someone else created the directory but did not give sufficient rights to the Unix group or others to switch to that directory.

clobber

type: USER
syntax: clobber {yes,no,on,off}

Enables/disables overwriting existing FITS files generated with the common `save`. The default is 'no'. The `sfdump` mechanism always overwrites files, independent of the `clobber` flag value.

If called without parameters, the current setting will be printed.

continue

type: USER
syntax: continue

Continues a macro and other processing of commands if paused.

control

type: USER
syntax: control

Opens the main camera control window (with the selection of readout parameters, the 'read' and 'save' buttons, etc).

counter

type: USER
syntax: counter [name [action [set-value/incr-count]]]

Changes the named counter 'name' according to some 'action', where actions are:

- clear: or 'clr': sets the counter 'name' to 0
- incr : increments the counter (default 1)
- decr : decrements the counter (default 1)
- set : sets counter to 'set-value'

Examples: (note that the counter EXPO_NO is automatically incremented after each 'read')

```
counter    # lists the current counters and their values.
counter EXPO_NO  # shows the value of counter EXPO_NO
counter EXPO_NO clear   # sets the counter EXPO_NO to 0
```

```
counter EXPO_NO incr    # increments counter EXPO_NO
counter EXPO_NO decr 2  # decrements counter EXPO_NO by 2
counter EXPO_NO set 99  # sets the counter EXPO_NO to 99
```

Note: The next `read` will activate and increment that value to avoid interference with any concurrent and ongoing `save`. Saving the current image before a `read` will use the **old** EXPO_NO value.

crep

type: USER
syntax: crep [n]
syntax: crep [n [#subrep [#subrepskip]]]

Sets the cycle repeat count. This defines the number of images that will be read in a single `read` command.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see [sync], page 38, .

Options not specified remain unchanged.

If called without parameters, the current status will be printed and no values will be changed. If the parameter is larger than supported by the memory allocation, it will be reduced to the count that is actually available.

If used with CARMENES note that the first pipeline stage generates at most one image for each `read`, independent of the value of `n`. Values larger than n=1 will lead to an apparent loss of data, because only the last of the read cycles will be fed into the first pipeline stage.

ctime

type: USER
syntax: ctime [time-val]

Returns the cycle time.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see [sync], page 38, .

ctype

type: USER
syntax: ctype name [parameter(s)]

Sets the type of readout cycles of the ROE. The available names and options depend on the camera.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see [sync], page 38, .

- Valid cycle types for Linc-Nirvana, PANIC, LUCI, NTE and AIP are: (see Standard modes of MPIA's current H2/H2RG RO-systems (`http://dx.doi.org/10.1117/12.927170`)
  - `rr-mpia` single correlated read (like 'rr', but fast/line-rst-rd)
  - `rrr-mpia` double correlated read (like 'rrr', but fast/line-rst-rd.rd)
  - `lir` line interlaced read - a double.correlated read, (like "rrr-fmpia')
  - `msr` multiple correlated sampling read (similar 'sample-up-the-ramp'). The parameter is the number of reads on the ramp. NOTE: With 'msr,' the effective number of images is one less than the number of reads/frames on the ramp. (all other cycle types produce a single image)
  - `lir` line.interlaced.read - recommended double.correlated read, (like "rrr-fmpia')
  - `scr` single.correlated.read (similar to 'rr' (first full frame rst))
  - `dcr` double.correlated.read (similar to 'rrr' (first full frame rst))
  - `fcr` double.correlated.read (similar to 'rrr-mpia' (fast-line-rst))
  - `mer` multiple-endpoint sampling read, Fowler sampling. The parameter is the number_of_reads_per_edge
  - `srr` sample-up-the-ramp read. The parameter is the number of reads on the ramp, with a default of 2 if the parameter is not provided. If the current integration time is too short to accomodate the number of reads (for the current number of pixels, depending on the subwindow areas), the integration time may be increased by GEIRS such that the number of reads fit into the integration time (!)

    Also note that GEIRS will effectively decrease the number of samples along the ramp if the number of frames (product of the crep and the number of samples here) does not fit into the shared memory buffers as defined by the CAMSHMSZ environment variable at startup time (!)
  - `spr` single-pixel-read, stays on the pixel and clocks as often as the field size of the channel. Parameters are the x-pos and y-pos.
  - `rlr` reset-level-read; reads the (line-)reset-level by resetting and reading the array without additional integration time.
  - `mcr` multi.correlated.read (cf. 'multi', but uses coadder) The parameter is the number of reads before/after integration
- An additional cycle type for Luci1, Luci2 and Carmenes is:
  - `srre` sample-up-the-ramp with embedded resets. The first parameter is the number of reads on the ramp and needs to be >=2. In the same manner as for the `srr` mode, the integration time may be increased by GEIRS if the number of reads does not fit into the integration time that was valid before selecting that mode (!) or the number of samples along the ramp may be decreased if the frames do not fit into the RAM buffers (!).

    The (optional) second parameter is the name of the ASCII configuration file that defines the geometry of the reset windows; this file name should preferably be

the full path name. It plays the same role as the argument of the `-i` of `geirs_srreConfig`. (An argument equivalent to the `-p` of `geirs_srreConfig` does not exist because `ctype srre` always writes the patterns into the currently active pattern directory.) There is a modest shell-type expansion mechanism applied to the name of the configuration file, which means wild cards like the tilde (for the home directory) or $CAMBIN etc. will be recognized/expanded.

Note that switching to this srre mode may trigger a full download of an entirely new pattern to the ROE which typically takes 18 seconds to complete and takes the same time before the command returns. GEIRS compares the age of configuration file in the file system with the last time it has updated the pattern in the ROE to decide whether such a full download is executed. External monitors need to maintain an appropriate command's timeout in the interface to GEIRS.

The set of supported modes may change with time. This set is immediately revealed in the menue after clicking on the `Read Mode` button of the controls GUI. Examples:

```
ctype srre
ctype srre 3
ctype srre 7 /home/staff/GEIRS/trunk-r731M/test/srreMask08.carmenes
ctype srre 5 $CAMBIN/../test/srreMask08.carmenes
ctype lir
ctype sfr
ctype srr 12
ctype mer 7  # GEIRS will round this up to an even number...
```

Note that instruments use only a small subset of these modes in reality.

define

type: USER
syntax: define [<parameter> [<specifier>]]

The `define` sets parameters. The only parameter currently implemented is 'optics'.

If GEIRS is controlled by some higher-level SW, the command is used to forward parameter values (for example concerning an optics wheel) that are not controlled by GEIRS, but still needed by GEIRS (e.g. to know the pixelscale).

The optics resolution names currently used are 'wide', 'high' and 'very-high'.

Examples:

```
define optics [ wide | high | very-high ]  # selects a resolution
define optics very           # selects the very-high resolution
define                           # prints the current parameters
define optics                # prints the optics status
```

To make impact in the FITS header, parameters need to be set before the associated `read`.

delay

type: ENG
syntax: delay [crep #]

Set 'delay crep x.x' before crep read. The final argument is a floating point number in milliseconds (exact to three fractional digits, ie., microseconds).

The command without argument returns the current status.

dir

type: USER
syntax: dir [filenames]

Executes 'ls -l' in the current directory. The output stops after each page; to proceed with the next page, enter: `<RET>`; to abort the output, enter: `q<RET>`

display

type: USER
syntax: display

Opens a GUI with the display of the detector readouts, some detector engineerig capabilities (data visualisation) and some kind of statistics of ADU variances.

engstatus

type: ENG
syntax: engstatus

Requests and returns the engineering status from the camera.

There is no useful information returned if the ROE is in simulation mode. Otherwise this shows the a version stamp of the firmware (FPGA program version)

```
INFO Seen ROE3 rocon 'DETFPGA' version '3 1 7 5'
DEBUG ROE-Electronic version: 33 750 0 2 3 1 7 5;33 750 0 1 ('33 750 0 2')
INFO ROE-Electronic version: 33 750 0 2 3 1 7 5;33 750 0 1 ('33 750 0 2')
INFO ROE-Electronic version: 33 750 0 2 3 1 7 5 ('33 750 0 2')
33 750 0 2 3 1 7 5
```

exit

type: ENG
syntax: exit [macro]

Synonymous to the `quit` command. See [quit], page 26. Shuts down GEIRS, its GUI's and servers of the camera software.

If the command is used in a macro and the argument `macro` is added, the effect is just to exit (leave) the macro at that point, but without shutting down the other parts of GEIRS. This is merely a means of type saving because it allows to ignore all the trailing lines in a macro script from some point on.

filter

type: USER
syntax: filter [position]

Where `position` is one of the filter macro names defined in `$CAMINFO/fmacros.instr` and the suffix .instr is actually .panic because this is the only instrument where (this version of) GEIRS steers wheels.

The macros in this file define the position of all wheels following:

- '-' means: leave this wheel wherever it is.

Syntax: In a fmacros-file, comments are started with either the semicolon (;) or with the sharp (#) and extend to the rest of the line in which they occur. Empty lines are ignored. In each line, a name (label) characterizing the compound filter set and the individual wheel positions are separated by any amount of white space (blanks). If there are more names than wheels in the instrument, the trailing names are ignored.

Each position (other than the star and the dash mentioned above) refers to a name in `$CAMINFO/elements.instr` and to a name in a file `$CAMINFO/wheel[0-].instr`, a set of files that enumerate wheels starting at index 0, again with the instrument's name as the suffix.

Without arguments `filter` shows all available filter macros and the current one.

`filter` starts as background process and should be followed by a `sync` when used in a macro. The `sync filter` is generally insufficient here because the recomputation of the focus offset on the telescope may cause GEIRS to emit a slave `tele pos` command which also should be waited on.

fits

type: USER

specified header card

syntax: fits fits_header_card

Adds the FITS header card `fits_header_card` to a volatile local stack in the shared memory manager. This will be added in the FITS files created with the `save` command of the future.

Generally cards that have keywords that already exist in the stack are replaced. If the card starts with `COMMENT` or `HISTORY`, however, the new card will be added without replacement.

Header cards with the HIERARCH convention must be at least 2 levels deep. If they appear to have only a simple key, the HIERARCH prefix will be dropped:

```
fits HIERARCH HUGO = 1  / this will become a simple HUGO=1
fits HIERARCH HUGO SANDERS = w  / this will become a simple HIERARCH HUGO SANDERS = 'w
```

Attempts to add cards with organizational FITS information like `BUNIT` or `END` or `CHECKSUM` will be rejected. It's believed that this could interfere with the file layout decision that are in the hands of GEIRS.

The stack of cards runs in addition to the mechanism to add FITS keywords with the `TMPDIR/geirsPhduAdd.*` files. All information in the local stack will be forgotten when GEIRS is terminated.

purge stack of information

syntax: fits clr

If the argument is the simple 3-letter word `clr`, all keywords and comments that have been added earlier with the `fits` command are deleted. This is like starting from a fresh empty local header card stack, equivalent to the situation when GEIRS is started.

get

type: USER
syntax: get varname[element] [. . .]

Reads one or more variables of the shared memory info database. When the 'varname' is an array, the entire array is listed. Alternatively, specifying an array-element in [index] reads only that single array element.

Warning: If the varname is shorted, only the first match in some internal table is returned.

In the instrument shell, a *TAB* in the command line will autocomplete or list the available arguments.

Examples:

```
get CAMERA
get ITIME
get NWHEELS
get AIRMASS
get ROTYPE
get READBUF
get CAMBUSY
get CPAR1
get CREP
get CAMPATH
get CTIME_TOT
get CMDIPPORT
get CTYPE
get DETROT90 DETXYFLIP
get FS_FCAP
get FRAMESPERIMG
get HWAWINS
get LASTFILE
get MACRONAME
get MAXIMAGES
get NIMAGE
get NPIXEL
get OBSERVER
```

```
get OBSGEO-H
get TELESCOPE
get WMACROS
get XDIM YDIM
```

The start of the current or previous exposure, the number of frames received (up to now) and the distance between nondestructive reads in the srr or srre modes can be read with

```
get INT_START_SEC
get NFRAME
get INT_DELTA_SEC
```

gui

type: USER
syntax: gui [-x xserver] [-f font]

Starts the graphical user interface (GUI) for the camera. For the description of the options, see [control], page 5.

help

type: USER
syntax: help

Prints the list of commands allowed to the current class of the user.

syntax help command

prints information about the specified 'command', where

- 'syntax' describes the (various) parameters and switches.
- 'type'
  - USER: normal user command
  - ENG: engineering command, not needed for standard operations
  - SUPER: system safety critical commands. A password is required to use such a command. The observer's name is used as the password.

Parameters in '[]' are optional. List of exclusive values are enclosed in '{}'.

history

type: USER

history

syntax: history
syntax !?

Print the GEIRS shell command history.

previous

syntax !!

Repeats the last GEIRS shell command.

previous search

syntax !abc

Repeats the last GEIRS shell command that starts with 'abc'.

idlemode

type: USER
syntax: idlemode [action] [threshold]
syntax: idlemode type [typeName]

Selects the detector's idlemode. The usual default is 'wait' with 'Lir', but that depends on the instrument/camera.

Without parameters it returns the current idle mode, which shows how the `read` would terminate the idle mode and what pattern the ROE runs on the detector while the idle mode is active.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros.

Parameter `action`

- `break` interrupts clocking of the idle mode to start the next read immediately
- `wait` completes full idle cycles and transits seamlessly from idle clocking to clocking of the readout-pattern.
- `auto` uses an integration time threshold to switch between the 'break' and 'wait' mode.

If the action is set to `auto` and a number of a `threshold` follows, the threshold should be a floating point value representing an integration time. If the integration time is shorter than the threshold, the idle mode `wait` is used, otherwise the idle mode `break`.

If the parameter `action` is set to `default`, the default idle mode of the instrument is set.

The parameter `typeName` sets the idle type. The available choices depend on the camera.

Valid idle types are:

- `default` sets the instrument default idletype
- `ReadWoConv` uses the current read-out-mode without transfer to the workstation (this was the default with previous software releases)
- `Reset` fast-reset cycles
- `Rlr` reset-level-read cycles
- `Lir` interleaved read-reset-read cycles

Examples:

```
idlemode default
idlemode type Rlr
idlemode wait
idlemode break
```

init

type: USER

(Re)initializes one of the three subsystems. The command will be rejected while the camera (i.e., what the readout electronics is frequently called in this manual) or the telescope subsystem are in their busy states.

camera

syntax: init camera [name] [-r] [-l #chans] [-o optics] [-s status] [-m status] [-t status]

Initialize the camera. Valid camera names and optics are defined in `$CAMHOME/src/cameratypes.h`. Camera names are not case sensitive and one of {Panic, Nirvana, Luci1, Luci2, Carmenes, Aip, NTEimg and NTEisp}.

If no `name` is given, the current settings are used and checked.

Examples:

```
init camera -r [..]  re-initializes the camera settings
       and the specified options.
init camera [..]     initializes the camera implementing/setting the defaults
```

Without the option `-r`, all options which are not set with this init command are set to default values of this camera.

With the option `-r`, all current settings of the camera remain as they are, unless they are overwritten with another option of this command.

- -l: # = {64,32,4,1} number of ADC-channels used to read a single detector chip. To get the total number of ADC's of the ROE multiply by the number of chips. For all MPIA systems in use, this is 32 for the Hawaii-2 and Hawaii-2RG. For the Hawaii-4RG this can be 64 (if 2 ADC36 boards are in the ROE), or 32.
- -o: optics = {wide,high,very,no}
- -s: status = {offline,online} (access to ROE hardware)
- -m: motors = {offline,camera,direct}
- -t: temperature-controller = {offline,camera,direct}
- -r: 'init camera name -r' does re-init but also re-setting all important last camera settings.

`Init` without parameters returns the states of the instrument parts.TBD

telescope

syntax init telescope name [-f number] [-s status]

Initialize the telescope. Valid telescope-names and focal-ratios are defined in `$CAMHOME/src/cameratypes.h`

telescope: = {lab,ca3.5m,ca2.2m,ca1.23m,lbt,not,none}

- -f: focal-ratio = {3,8,10,11,15,25,35,45,88} The value of 88 matches the Linc-Nirvana instrument camera. The instrument focal ratio for Luci and Linc-Nirvana after M3 is 1/15. The 11 is a nominal value for the NOT, but needs to be confirmed. The 8 is typical for the CAHA 2.5m and the 10 for the CAHA 3.5m, after the primary (i.e. without considering the secondary).
- -s: status = {offline,EPICS}

wheels

syntax init wheels

Read the filter/aperture/wheel database and move all wheels to their ZERO (home) position.

iniwindow

type: USER
syntax: iniwin

Opens a window to setup the camera/telescope configuration. If you leave the window using the OK-button, the camera, the telescope and the wheels will be initialized if their setup was changed. The all-button forces a complete new initialization whether or not anything was changed.

interactive

type: ENG
syntax: interactive [{on,off,yes,no}]

If you use the interactive-mode, the outputs in the shell are blocked after 19 lines, until you enter `<RET>`. Default is 'yes'. (All shell outputs are blocking if you use interactive=yes, and you may loose messages in the shell output ring buffer, if you set interactive=no.)

itime

type: USER
syntax: itime [time] [-stdout / -stderr] [-o[ffset] #sec] [-m[ultiple] #sec]

Set the integration time to `time` seconds. Without any argument it prints the actual integration-time status.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see [sync], page 38, .

If either the option `-stdout` or `-stderr` is added, the value is additionally printed to the associated output stream – only useful if called as `cmd_xxx itime -stdout` .

The options [-o] and [-m] are setting adjusting-factor and offset, which are used (until the value(s) are set to 0.0) according to formula: used itime = '-m'ultiple-adjustment + '-o'ffset

```
-o 0.0313  sets adding of constant offset of 0.0313 seconds
-m 0.020   sets adjusting itime to a multiple of 0.020 seconds
```

Rule: adjusted itime always >= given itime,

Exception: (adjusted-time value <= minimal integration time) will always set the minimal integration time.

Note: These values can be configured by the user staff via the environment variables `CAMITIME_MULT` and `CAMITIME_PLUS`, else the defaults are set to 'no adjustments', but may always be changed via this itime command from the user.

kill

type: USER
syntax: kill name [-w #.#]

If `name` is one of the set {display, satcheck, sdisp, gui, control, telgui, tempcon, shminfo, iniwin} then a software-terminate flag is set to the named process. All other `name` result in syntax errors.

However, setting this flag does not necessarily mean that the process is able to recognize it since the mechanism works passively (sets a flag).

If `name` is one of the set {read, save, shell, tele, wheel, filter, lyot, aperture, optics} then first a 'soft-kill' signal is sent to the process. If after timeout (default 10 seconds) the process is still alive, a 'kill -9' signal is sent to the process.

The option `-w #.#` following the process name overwrites defaulted timeout to wait for the process to terminate. The units of the parameter are seconds.

Additionally, PID-entries and serial line flags are cleared, and maybe some other flags that need a reset.

Note: If `name` is {macro}, it does not terminate the macro process, but reports only values of the macro status. If no macro process is alive, it cleans the macro status.

Warning: `kill read` should hardly ever been used in favor of `abort`.

lamp

type: USER
syntax: lamp ALLOFF

syntax: lamp L{1|2|3|4|5} OFF

syntax: lamp L{1|2|3|4} ON

syntax: lamp L5 ON {1|2|3|...9}

The command is only available if GEIRS is started for PANIC.

Controls the calibration lamps by executing `geirs_lamp.sh` with the syntax of the common `rflat` CAHA command. The `rflat` is executed on ultra3 if GEIRS is started with `TELESCOPE` set to `CA2.2m`, and on ultra1 if set to `3.5m`.

It seems that the `rflat` does not trigger any telescope motion.

The `geirs_lamp.sh` also writes the lamp status into a file which is scanned by GEIRS each time a new FITS file header is created.

All lamps can be switched off at once with the argument `ALLOFF`. Lamps 1 to 5 can be individually switched on or off. Lamp 5 can be switched on to a specific power which is indicated by small integer numbers in the range 1 to 9.

Examples:

```
lamp ALLOFF
lamp L3 OFF
lamp L4 ON
lamp L5 ON 3
```

last

type: USER
syntax: last [destfile]

Returns the filename of the most recent image that was saved and stores the filename into 'destfile'. (Relative path names are interpreted relative to the GEIRS start directory. This is considered a bug and may change in the future.)

Without the parameter, the filename is added to the file 'geirsLstFile' in the directory `$TMPDIR` (which often is `~/tmp`).

load

type: USER
syntax: load filename [#n] [#incr]

Loads `n` single FITS files into the shared memory, starting with the filename given. Only data in the primary header-data-unit can be read, not image extensions. To avoid garbage, the number of pixels along the horizontal and vertical coordinate in the FITS file should be the same as the full-frame format of the (mosaic of) detector chips currently in use.

The `filename` is a FITS file on disk. If the name is a relative name (not a full path name), it is interpreted relative to the `CAMPATH` environment variable.

If option `incr` is given this value is added to the filename-numbering for loading the next FITS file.

The command has only been used to load a sky/background image that is subtracted from the master image in the display.

The command treats the FITS data in the file as single frames, not images, to be pushed onto the buffer of frames as if they were just read. So to see that new frame in the online display, you need to toggle the online display from the `current image` to the `current frame` view, or to switch to a single frame mode like `sfr` or `rr-mpia` in the controls GUI.

Since the shared memory frame-buffers are unsigned short integers, the image will not be correct if the FITS file is encoded with a different `BITPIX` value. (This basically means that most of the FITS files saved by GEIRS should not be read that way to avoid misinterpretation, because they have been stored as correlated output with 32 bits per pixel, not as single frames.)

On negative `n`: file is added to shm.

log

type: USER, ENG
syntax: log [[module-] | [switch-] option(s)] [modulename | 'all' | 'MSG'] [value-str [value-str] [..]]

Controls the log-level of the software.

Only the ENG class of users is allowed to increase logging levels. The standard USER is limited to change bits in the loglevel and to switch to lower levels (but not below INFO).

Each UNIX sub-process can be set individually. Additionally most source files can be set independently.

The effective log level is the 'or'ed combination of the 'main'-process module and the 'object'/source-file module in the process.

A '-' (minus) sign in front of value removes that value from the setting of the selected log switch. A '+' (plus) sign in front of value adds that value to the setting of the selected log switch. Without any of the two signs in front, that value is set as the new switch. For -level, all lower loglevel are activated.

options:

- -m[main] // selects a sub-process
- -o[bject] // selects a source object (file)
- -l[evel] // controls the logging levels
- -b[its] // controls the switches inside a level
- -h[help] // prints the supported modules or objects (or use tab in shell)

If the module name is 'MSG': without any options sets the bits that control verbosity of what is written to the GEIRS shell. (same bit-definitions like the logbits)

Module names for the option -main:

- all - all processes are changed with the new parameter set
- read - only the read process is changed
- save - only the save process ...

Modules names for the option -object are:

- all - all modules are changed with the new parameter set
- nutil - only the nutil module is changed
- cstxlib - only the cstxlib module is changed
- rdbase - only the rdbase module is changed
- ...

Values should be given by their strings. It is also possible to use a numerical value, which will be filtered according to the level/bits options. If the number starts with `0x`, it is intepreted as a hexadecimal number, if it starts `0` followed by digits as octal.

String values the for option -level (all in capitals):

- (F[ATAL],E[RROR],W[ARNING] always active loglevel 0).
- I[NFO] - log level 1
- V[ERBOSE] - log level 2
- D[EBUG] - log level 3
- T[RACE] - log level 4
- L[OWLEVEL] - log level 5

String values for the option -bits (all in capitals):

- NONE
- ALL
- STD - the standard initialisation value of the sw-switches
- DFLT - the default log switch (normal user cannot remove it)

With the option -help the supported values and module names are printed.

Without additional parameters `log save` gives the current state of the 'save'-modules settings. Without additional parameters, `log` alone lists all current states.

Examples:

```
log all STD              -sets all main/object levels to init-values
log all DEBUG            -sets all main/object levels to log level 3
log all INFO            -sets all main/object levels to log level 1
log -m -l read VERBOSE   -sets for process read the log level to 2
log -o -b rdbase VERB1   -sets fpr object rdbase the VERB1 bits
log -o -l rdbase +TRACE  -adds for object rdbase the TRACE level
log -o -l rdbase -LOWL   -removes for object rdbase the LOWL level

log MSG +TRACE        -adds shell reports for all TRACE level logs
log MSG STD           -sets shell reports to init-state.
```

ls

type: USER
syntax: ls [switches] [filename]

Executes `ls` (UNIX style with options)

syntax: ls

Print contents of current `save`-directory. see [dir], page 9.

The command may fail if someone else created the directory but did not give sufficient rights to the Unix group or others to switch to that directory.

```
ls aa0010.fits
ls -l aa0010.fits
ls
ls *.fits
```

macro

type: USER
syntax: macro [[-c[lear] | [filename]]

Executes the macro defined in the file `filename`.

If the `-c[clear]` option is given alone, the last macroname is just cleared in the parameter variable (and therefore in GUI).

The file `filename` contains command lists like any of the command shell. Be careful when invoking commands like `read`, `telescope` or `filter` that run in the background. Make sure that the next command does not conflict with the previous or use the `sync` command. The default search directory for the macros is defined in the controls-GUI by the Options–>MacroPath... or by `set macropath`.

If the filename starts with a slash '/', the directory of the `MacroPath` is not used, else the `filename` is appended to the contents of the MacroPath: If the macro `test.mac` resides in a subdirectory relative to `MacroPath`, the syntax is `macro subdir/test`.

If the given filename does not exist, the software tries to open the file after adding the extension `.mac`, and eventually also with the extension `.macro`.

If the macro file is still not found, the two default paths `$CAMHOME/MACROS/filename[.mac]` are tried thereafter. This search hierarchy allows to call standard GEIRS macros, but also to overwrite them by other macros with the same name in different directories specified by an explicit macro path.

A macro file length is currently limited to 10.000 lines and the line length limited to 255 characters.

It is possible to add comments to macros starting at a '#'. Everything from the first '#' up to the end of line is chopped before the line is executed. If the first character in a line is a '#', the entire line will be ignored.

Macros refuse to start if any motor motion, read, save or telescope command are currently active.

median

type: ENG
syntax: median [-r[aw]] [[-stdout] or [-stderr]] [n1 n2] [x1 y1 x2 y2]

Calculates the median of images `n1` through `n2`. Default is all images.

The options, starting with '-', must be the first parameters, i.e, must follow right after the command and before the indices of the images n[12] or the FITS coordinate specification of the rectangle, xy[12]. The four parameters of the rectangle coordinates may be given with or without the two parameters of the frame range. If the corner coordinates of the rectangle are not provided, all pixels of the image are covered.

Results are appended to the file `$TMPDIR/median.log`. The difference relative to the output in the message buffer and in the standard output or standard error output is that the file contains also the integration time [sec] in front of the median value.

Options

- `-stdout`, `-stderr` : prints the medians also to the standard output or the standard error output of the shell of the operating system. Note that this forking of the numbers to the linux shell is disabled for GEIRS running on computers with MPIA IP addresses, because printing to standard (error) output may lead to blocking channel behaviour (hangup of the entire GEIRS processing) if GEIRS has been called from the `start_geirs` Java GUI.
- `-r[aw]` : computes medians on a frame-by-frame basis for all frames in the range of the images n1 to n2. If the option is missing, images are calculated according to the type of correlation implied by the readout type that is currently active, then the medians are defined for these (correlated) images. If the option is given, the medians are computed for each of the frames that contribute to the images, so the offsets of the reset frames for example are well visible in the statistics.

Example: 'median' of 2 images in the buffer

```
median(1): 2004
median(2): 2003
ave(medians): 2003.50
```

Example: 'median -raw' of 2 double-corr. images in the buffer

```
median(1): 1004 2007
median(2): 1003     2001
ave(medians): 1003.50 2004.00
```

With the -stdout or -stderr only the resulting

```
2003.50
```

or

```
1003.50,2004.00
```

is delivered to the data streams.

Note that a richer set of information (median, minimum, maximum, standard deviation) is also obtained from FITS files on disk by calling fimgstat (`https://heasarc.gsfc.nasa.gov/lheasoft/ftools/fhelp/fimgstat.txt`) of the HEASoft (`https://heasarc.gsfc.nasa.gov/lheasoft/`) package.

next

type: USER
syntax: next [-t or -n] [filename]

Sets `filename` as the default filename for the subsequent FITS files. This filename is used if the subsequent `save` commands are issued without their optional file name argument.

Automated numbering scheme of FITS files: A file name with an alphabetic letter at the end (basename) will be extended by a pattern with 4 digits. Basically a single `next` creates a name space for up to 9999 FITS files. During each `save`, GEIRS scans the current output (save) directory for files which match the pattern of the `filename` followed by four digits

and the extensions .fits, _win....fits, .dump, and increases the largest 4-digit number found by 1 to create the default file name of the FITS file.

```
next hugo_
read ...
save ... # no filename, creates hugo_0001.fits if no hugo_????.fits present
read ...
save ... # no filename, creates hugo_0002.fits, because hugo_0001.fits present
read ...
save ... bastian3.fits # creates  file bastian3.fits
read ...
save ... # no filename, creates hugo_0003.fits, because hugo_0002.fits present
```

Option `-t` (with or without a file name) tells GEIRS that the next `save` command should not use the default file name, but a temporary test file name. After the next `save` command the default file name is automatically reactivated, also if there was an error or problem with the `save` command. (Multiple sets of options in a single `save` command are treated as a single `save` command. This may lead to cases where the `save` cannot succeed if that implies using the same FITS file name multiple times.)

If option `-t` is given without a filename, the special name 'test' is used, else it uses the given filename. Attention: The testfile-filename is not used, if the next `save` command is given with a filename; it is only used if save is given without a filename.

To deactivate the previously commanded temporary test filename, you might either just call

```
next -n  #   without filename argument,  or
next -n filename # , where filename will be handled like above, or
next filename # , where filename will be handled like above.
```

`next` tests if the 'filename' already exists in the current path and issues a warning if this is the case. (The next `save` will then fail, if the file already exists in the current path, unless an option for overwriting (**Dangerous!**) is given.)

If `next` is used without argument, the command returns the next default and next test file names, where the one which would be used at the next `save` command is marked as 'next:'. (The 'test-filename' shows you also the starting string of the saved files, which are not queued to automatic storing to tape, etc).

object

type: USER

text

syntax: object text

Sets 'text' as OBJECTS in the FITS-header (truncated to 39 chars).

no option

syntax object

Prints the current object.

observer

type: USER

name

syntax: observer name

Sets `name` as observer in the FITS headers (truncated to 39 chars). This name is also used as the password for the privileged commands.

no option

syntax observer

Prints the current observer's name.

optics

type: USER
syntax: optics [wheel-position]

Moves a wheel of the camera optics.

Without parameter all possible positions and the actual positions are printed.

`optics` starts a background process and should be followed by a `sync` when used in a macro.

pause

type: USER
syntax: pause [macro]

Stops any command execution; only continue or kill will be executed. With option `macro`, pause will only get active if a macro is found running.

Commands/macro will be continued by entering the `continue` command or may be aborted by `abort`.

pipe

type: SUPER
syntax: pipe [-nowait] [-list] [-timeout #secs] command [par1] [par2] [...]

Send `command` and `parameters` directly to the camera-electonics. In the simple format, no interpreation or limit checking is performed.

- -n[owait] just send command but do not wait for any answer.
- -l[ist] interprets the `command` and optionally any of the further parameters as the name of files with a command list. These file names are attached here without their instrument suffixes. The search path is the `CAMBUILD/pttrns` subdirectory. In this format with the `-list`, the usual expansion of lines in the files happens: removal of comments, expansion of the multipliers, substiution of variables and so on. See the pattern constructor manual for details.
- -t[timeout] followed by an integer increases the timeout for the communication to the ROE to that number of seconds.

To turn off the front LED's of the 3 ROE boards that are under software control, for example, use the three commands

```
pipe 33 509 0
pipe 33 911 0 0x0
pipe 33 903 0 0xf
```

or to turn them on use

```
pipe 33 508 0
pipe 33 911 0 0x1
pipe 33 903 0 0x1f
```

In newer pattern versions, there are files `ledoff.*` and `ledon.*`, so to the same effect we may use

```
pipe -list ledoff
pipe -list ledon
```

ptime

type: ENG
syntax: ptime [#]

Sets the base time for the pixel time (which is $ptime in the roe interface).

- for observers ptime [default | slow] # sets the configured base-times for $ptime
- for engineers ptime #val # value >=0 as base-time

put

type: USER

numerical

syntax: put [{-i,-f,-d,-s}] offset value

Write 'value' at 'offset' into the shared-memory infopage (database).

- -i: 'value' is an (int) (default)
- -f: 'value' is a (float)
- -d: 'value' is a (double)
- -s: 'value' is a (char*)

named

syntax: put varname[element] value [varname2[element2] value [...]]

A set of variables held in the shared memory data base may be `put` (set). The names have to match the names in the data base in full; abbreviating names is not supported.

When varname is an array, all array elements are set to value. In this case it is almost always better to adress a single element of the array with the [element] index.

In the instrument shell, a *`TAB`* will autocomplete or list the applicable varnames.

See [get], page 11.

To keep GEIRS informed about LUCI changes of the pixel scale, one would use for example

```
put PIXSCALE 0.016
```

where the numerical value is in arcseconds per pixel.

pwd

type: USER
syntax: pwd

Prints the current directory for the `save` operation (UNIX style) and the free space in Mbytes.

quit

type: USER
syntax: quit [macro]

If used without argument, the server leaves the GEIRS command shell and terminates all subprocesses (the image display, the control GUI, telescope GUIs, read and save processes ...). All the subprocesses and GEIRS services detach from the shared memory such that this memory will be released in the course of shutting down. Obviously all sockets of the command manager close.

This shutdown of the Linux services does not have major consequences for the ROE. In particular any idle loop or continuous readout loop that is probably running on the ROE at that time continues (until the ROE is powered off or a subsequence GEIRS session re-initializes the ROE).

The command is synonymous to `exit`.

The effect of adding the argument `macro` within a macro is to leave the macro, but not to terminate GEIRS.

read

type: USER
syntax: read [-c]

Read 'crep' images according to the current cycle type, which means start the program on the ROE and read the data into the two buffers on the workstation. (If the ROE is in simulation, create some fake images instead.)

The option `-c` triggers a continuous read of `crep` images until the `abort` command is sent. In that case it may be useful to reduce logging with a command like `log all INFO` so the log files do not grow in size as rapidly as usual.

`read` is a "background" process and should be paired with a `sync` when used in a macro or from a batch control program.

If `read` detects that a `read` is already running, it refuses to start, and shows (on behalf of the process that is already busy) the cycle time, repetition factor and current number of frames in the two alternating buffers in the error message.

In case that smooth termination of that `read` is not desired, one should consider sending `abort`. see [abort], page 1,

repeat

type: USER
syntax: repeat # "command arg ..."

Repeat the `command` as often as given by the integer at the hash (sharp) position. The `command` is always executed as a foreground process inside `repeat`. Background calls are not possible.

Compound commands delimited with the semicolon are not possible.

Example:

```
repeat 2 macro xyz
repeat 2 test
repeat 5 "read ; sync " # ERROR
repeat 5 read ; sync # gives 5 reads with only one final sync, hazardous
```

roe

type: USER
syntax: roe [[command] or [parameter value/string]] [-last]

Control or status of ROE and pattern parameters.

- 'default' - sets all parameters controlled by this command to the instrument default
- General options:
  - pread 3000 - sets pixel read time to the value nearest to 3000 ns. Values smaller than 10000 will also reset the ems (electronic multisampling) value to 1 to make sure that the samples fit into the half-samples of the read time.

    Caution i) values smaller than 2000 may lead to pixel drops and readout errors because half of that time approaches the 1 MHz limiting frequency of the standard ADC of the ROE.

    Caution ii) possibly resubmit the `itime 0` command to force a recalculation of the fastest frame rate after changing the `pread` parameter.
  - pskip 200 - sets pixel skip time to 200 ns
  - lskip 300 - sets line skip time to 300 ns
- options
  - crep restart - crep loop ROE-macro is doing the cycle-restart.
  - crep count - ROE-macro only counts down the cycles seen but the cycle-loop is done by pattern-endless
  - crep endless - The ROE-macro only the pattern as an endless loop and the software will top the ROE.
  - eop N - N is 0 or 1, 0==continuous/1==countdown
  - gap - status of $gap, (used to exclude itimegap-pattern)
  - pxllns - status of pixel-pat-table -lines
  - ffprot N - N=1: ff-pers.protection (0: faster subwindowing)
  - oflwprot N - N=1: overflow-persistence protection at ctype end
- commands:
  - verify - checks the SW-state against the HW-state of the ROE. Output to $TMPDIR/verify_roe3states.log.
  - eval - evaluates the timing of the pattern and puts it into $TMPDIR/timing_evals.log.
- parameters:
  - shortint 1 - parameter 1 activates, paramaeter 0 de-activates the short subfield integration type

- ems 4 - ROE multisampling with 1, 2, or 4 samples. This means the electronics may build the average over 2 or 4 ADC values measured quickly in a row, instead of converting only once.
- simadc 1 - activates ROE data simulation by FPGA's.
- hinvdir N - horizontal scanner direction in terms of the 2 (Hawaii-4 RG) or 8 (Hawii-2RG) bits of the register. So N is in the range 0-3 for Hawaii-4RG and 0-255 for Hawaii-2RG. Not using the argument N returns the current value. The Hawaii-2 detector does not implement that option.
- vinvdir N - vertical scanner direction in terms of the bit of the register. N is either 0 or 1, where N=0 is the top-bottom and N=1 the bottom-up readout direction. Not using the argument N returns the current value. The Hawaii-2 detector does not implement that option.
- nqchan N - number of outputs/channels for each detector. Can be 4 or 32 for Hawaii-2, 1, 4 or 32 for Hawaii-2 RG, up to 64 for Hawaii-4 RG Not using the argument N returns the current value.

If the additional option '-last' in option 'crep <string> -last' is set, the CTIME-dependent cycle sync auto-switch is not overwriting the LAST-SYNC state for the larger cycle-times.

If used without options, the status of the ROE parameters is shown.

rotype

type: USER
syntax: rotype [g(eirs) or fa(st) or fu(ll) or [plx] or [dgen [#dgendelayVal]]

Read-Out type of the datainterface.

The plx-type defines that data are received via the MPIA PLX-board.

The dgen-type is using the MPIA PLX-board in data-generator mode. The argument dgendelayVal is a 16-bit value: 1 selects the fastest generation and 65535 the slowest generation. (2-channel-PLX-board in 32bit/PCI-slot: 3 is max. 100Mbytes/sec, 2-channel-PLX-board in 64bit/PCI-slot: 1 is max. 167 Mbytes/sec) 4-channel-PLX-boards in 64bit/PCI-slot: 1 is max. 335 Mbytes/sec)

If the `dgendelay` is 20 and `crep` is 30, 24.8 seconds will be needed for one CARMENES read. If the `dgendelay` is 30 and `crep` is 30, 35.3 seconds will be needed for one CARMENES read. For simulation of CARMENES one should use a dgendelayVal of at least around 100, because otherwise the data arrive faster than roughly one frame per 1.5 seconds, and the CARMENES name scheme of generating the frame files will not end up with unique file names, which means, some frames will be lost.

Without arguments `rotype` shows the current status.

rtime

type: ENG
syntax: rtime [#]

Set the reset time, which is the number of clock tics at the beginning of each cycle-line. (MPIA electronics only.) This is not yet implemented and does nothing.

This command is rejected while the camera is busy (i.e., while readout or wheel motions are in progress) unless it is only a query of the current parameters. Hence a previous call to `sync` may be needed in non-interactive modes, for example in macros. see [sync], page 38, .

saad

type: ENG
syntax: saad x y d

Shift and add images #2 through #n. Find peak pixel around `(x,y)` in a box of size `d`. Overwrite image#1 with the result of the shift-and-add procedure.

save

type: USER
syntax: save [-s] [[-f n] [-l n] [-r n1 n2] [-i | -S] [-1] [-d] [-c] [-g] [-p] [-M] [-z] [-C] [filename] [, ...]]

Save frames in the shared memory formatting them according to the current readout mode / cycle type (ctype).

A comma delimits saving sets, dumping actually copies of the same data frames.

- `-s`: save immediately after image completion. Do not wait until the cycles are all completed but start saving as soon as the correlated frames have arrived.
- `-f`: save from frame 'n' (= 'first frame is')
- `-l`: save upto frame 'n' (= 'last frame is')
- `-r`: save only frames from 'n1' through 'n2'. Default is all.
- `-i`: save the arithmetic sum of the selected frames. Only the sum of the pixel values over all the cycle repetitions is saved, associated with an adjustment of the integration time in the FITS header. This option is ignored for CARMENES.
- `-1`: stack all images into FITS cubes. This option has no effect if there is only one image, which means a single image still leads to the standard 2D image format.
- `-g`: split the data into single DCR-images and write to dest. The variable PKGOUTPORT provides the file name and needs to have `dif` as a substring.
- `-d`: do not create FITS-files. Just dump the shared-memory framebuffer.
- `-c`: overwrite existing files (for this save-operation only).
- `-p`: save not the actual sequence but the previous one.

  Option -p is only meant for interactive usage. It is not a good idea to use it in a macro!

- `-M`: Create images in the MEF (multi-extension FITS) format. Each subwindow is placed into an image extension of the FITS files. The primary HDU does not contain any images, only a header. The option has an additional effect for cameras with more than one detector chip: subwindows that cross chip borders are further divided along the chip borders. So for the AIP mosaic of detectors this switch is convenient to separate the full image into images of the individual detectors, stored as separate image extensions.

  The default (not using `-M`) yields separate files with enumerating suffix _win*i*.fits. For CARMENES and NTE, however, the `-M` is always (implicitly) activated.

  If this option is combined with the `-1` option, the extensions are FITS cubes and each of these contains layers with the sucession of exposures in that subwindow.

  Note for LBT instruments: This option is always switched on if windowing is active because the archive system on the mountain derives archive file names from the time stamp of the exposure, but this is obviously the same for all FITS files from a single, windowed exposure. See [subwin], page 35.

- `-S`: Save the individual frames of what has been read, without regard of the cycle type (correlation type) that was active during the exposure. The option essentially unbundles all the implicit associations between the frames; it may be used to implement pipeline stages that act on these FITS files with refined correction methods beyond the simple add or fit schemes implemented in GEIRS.

  The SAVEMODE keyword will then be set to single.frame.read and will differ from the value of the READMODE keyword. Also, the NFRAMES will refer to the single frame count, not the number of (correlating) images.

  This option cannot be combined with `-i`, because `-i` explicitly requests to combine all frames into images. The option can be combined with `-M` and/or with `-1`.

  Example: If

  ```
  save -1 -S
  ```

  is used with the lir mode and `crep` was 3, a PANIC full frame FITS file contains a data cube of 1:4096,1:4096,1:6 pixels in the primary HDU.

  ```
  ftcopy 'aa_0001.fits[*,*,4:5]' out.fits
  ```

  would extract slices 4 to 5 of the cube and put them into the file `out.fits` (which is created).

- `-z`: Store images as tile compressed data of the FITS standard. Only enabled if either the `-M` is also given, or if `-1` is both absent. Otherwise (`-1` without `-M`) is has has no effect.

- `-C`: Add CHECKSUM keywords to the header-data units. This is not yet implemented for all combinations of the other options. Actually the option is currently only making a difference if `-M` is also in use.

  The option is only available in the command interface, not through the submenue of the control-GUI.

  Note that use of this option assumes that all further handling of FITS files by other programs, including those triggered by the scripts in the `scripts/QueueFiles`, are checksum aware, which means, they either update the value or delete the keyword once they change keywords or data of the HDU.

  Note that the checksum is aware of the keyword notifications scheduled through the `TMPDIR/geirsPhduAdd.*` mechanism; so from this point of view it is safe to use the `geirsPhduAdd.*` files in conjunction with the `-C`.

- `,` : space-comma-space: delimiter for a next complete save-set. (The comma is handled like a parameter-token!)

If no filename is given, the default filename is used. If the filename is given, it is advised to let that file name end on a group of digits, because default files names of files created after this one are basically chosen by incrementing the ASCII letters with some wrap around after the 9. This is fine as long as one wants to move from files A upwards to Z and from a to z and from 0 to 9, but becomes ugly if this sort of extrapolation enters the region of file names with special characters. See [next], page 21.

With option `-b` the filename might be a device `/dev/pcd1`.

Example:

```
save -p -1 , -p -i , -1 , -i
```

which saves the previous images as FITS cubes, as an integrated (summed) single fits image, the current images as FITS cubes, and the current images as integrated images.

After a save the filesystem will be checked. If the capacity is below a certain value you will get a warning from the system.

Examples:

```
save -b -s          immediately batch-stream to PKGOUTPORT-intf.
save -b -s filename immediatelay writes the batch-stream to a file
save -t filename    wirtes as a single FITS-table file

save -g -s          immediately DCR-img-stream to PKGOUTPORT-intf.
save -g -s filename immediately DCR-img-stream to a file
```

Current PKGOUTPORT interfaces: 'dif', '/dev/PCDxx'.

`save` initiates a "background" process and should be followed by a `sync` when used in a macro. Even within a sequence of multiple `save` following each other, each individual of them ought to be followed by a `sync`, because GEIRS maintains at most one set of parameters at a time and rejects a second `save` while another one is still on its way.

`save` fails if the current save directory offers insufficient write permission for the account that runs GEIRS. See [set], page 32. A typical side effect of this is that the `save` button in the control GUI stays yellow and that the `save` does not return. Use `set savepath` then to switch to a writeable directory.

If the number of frames is insufficient to create the images, `save` returns an error:

```
Carmenescarmenes@irws2> save
save: error: framebuffer is empty (read not yet done?)
ERROR error: framebuffer is empty (read not yet done?)
ERROR analyse_wait4pid: exit-status: 62 (if geirs-error: (E_noframe=62) frame-/
ERROR 62 Command 'save' returned errorcode = 62: (E_noframe=62) frame-/img-buffe
ERROR analyse_wait4pid: exit-status: 62 (if geirs-error: (E_noframe=62) frame-/
```

This happens for example in all multi-correlated image modes if the exposure was `aborted` before a sufficient number of frames were created to combine them into an image.

set

type: USER

savepath

syntax: set savepath [-u] [-s] [dirname]

Echo or set the directory (path) for saving files.

If the directory does not exist, it is created.

- -u append the string of the date-format _YYYYMMDD_hhmmss to pathname
- -s create pathname as subdirectory of the current savepath `CAMPATH`

If an option is present but no pathname, the default pathname will be `data`.

The effect of defining the new directory is seen in all subsequent commands that are executed relative to the save path, for example `cd .` or `pwd` .

The command may fail if the account running GEIRS does not have sufficient rights to create this directory or any of its parent directories.

The command may fail if someone else created the directory but did not give sufficient rights to the GEIRS processes (i.e., to the account that starts GEIRS) to switch to that directory.

The command will return a warning if the account running GEIRS is not the owner of the directory and the group of the account does not have write access to the directory. This will lead to problems as soon as GEIRS tries to create the FITS files in the directory.

If GEIRS is shut down smoothly with `quit` as it should, the directory is stored in the file `$HOME/.geirs/geirs.xml` such that the next GEIRS session reads it from this file to provide the new default. Note that this mechanism of resuming the path name of the previous session does not notice if the path name contains some indications of a formatted date. So if the path name is luci2.20131110 for example during a session in Nov. 10th, GEIRS is shut down and restarted a month later, the path name still is initially luci2.20131110 in December.

Note that for CARMENES the command `set savepath` must not be placed after the `read` and before the `save`, but before the `read`. Otherwise the single frame FITS files are created in the wrong (old) directory and will not be found by `save`, such that also the first-stage pipeline will not find them.

macropath

syntax: set macropath [pathname]

Echo or set the directory path for macros.

sfdump

type: USER
syntax: sfdump [pathname | off]

Specifies a configuration file with instructions to dump a set of windows of each single frame to a directory while in any multi-correlated or doubly-correlated read mode. The command merely configures the action; GEIRS actually dumps the files if is notices that it runs in one of the applicable read modes, that at least one window is defined in the file, and that new frames from the ROE arrive.

If the command is used without argument, it just returns the current name of the configuration file. This is an empty string if the dumping is not active.

If the command argument is a three-letter lower-case `off`, dumping is de-activated and the previous configuration file name is forgotten. This state is also the initial status at GEIRS startup for most instruments; for CARMENES however, the default are full frame dumps on behalf of the first-stage pipeline executed by GEIRS.

Any other argument is interpreted as a file name of a an existing, readable ASCII file with the configuration parameters. If the `pathname` starts with a slash, it is interpreted as a full path name on the GEIRS computer, otherwise as a file relative to `$TMPDIR`, and if `TMPDIR` is not defined either, relative to `$HOME/tmp`.

The syntax of the configuration style is described in the GEIRS manual.

sky

type: USER
syntax: sky filename

Writes the filename at keyword SKYFRAME into the FITS-header. This is merely an indicator for pipelines where an associated suitable sky background file may be. It does *not* indicate that the \FITS file contains pixel values that have been already subtracted such background.

sleep

type: ENG
syntax: sleep #.#

Suspend execution of shell/macro for '#.#' seconds. This is the same as with 'sync none #.#'. (default about 2 seconds)

sndwin

type: USER
syntax: sndwin

Opens the sound selector-window. You may also set the volume and the output-channel.

sound

type: USER
syntax: sound [on|off] [-o {speaker|headphone}] [-v {0..100}]

Enables/disables sound after some operations like `read`, `filter`, `aperture`, `telescope`, `macro`, or as a warning if the saturation check is on. Default is 'off'.

- -o: output = {headphone,speaker}
- -v: volume = {1..100}

With some audio-players only the default volume and speaker is available. See the environemnt `CAMAUDIOPLAY` (e.g. aplay for linux) and `CAMAUDIOMIX` (e.g. aumix for linux to control main-volume).

Without parameters, `sound` prints the sound status.

status

type: USER
syntax: status
syntax: status -a
syntax: status -f cfg-name
syntax: status sub-status-str[;sub-status-str]...

Only one of the three listed alternatives is allowed.

Without options, `status` returns the instrument specific status list of file `status_cfg.instr`. If this file does not exist it returns all possible status information of GEIRS (like `status -a`).

- Option: [-a] returns all available parameters of GEIRS
- Option: [-f file] returns all statusses listed in file. The instrument's extension, e.g. `.lucifer`, is appended to the name if no dot '.' appears in the name.
- Option: [sub-status-string] only that specific status information

Examples:

```
status             returns parameter set defined in $CAMINFO/status_cfg.<instru>
status -a          returns all available status information of GEIRS
status -f my.cfg   returns the status set defined in file my.cfg
status subwin      returns coordinates of the 3 sets of subwindows
status roe preamp  returns only that specific status of the pre-amplifiers
status state read  tells us idle or busy (useful for monitoring)
status opmode      NORMAL (assuming ROE availabble) or ROE-SIM (software simul)
status rotype      plx (the standard online PLX data mode) or dgen etc.
status frame       plx (the standard online PLX data mode) or dgen etc.
status next        returns FITS file name to be generated next
status ctype       returns the cycle (readout type) like lir, srre etc
status crep        returns the currently active repetition factor
status itime       returns current integration time (seconds)
```

The status returned by some commands (if sent without option) may differ from the response of `status <command>` and may depend on the current context. The `subwin` command alone returns the current command status, for example!

The status information depends on the SW mode SINGLE/MAIN/INTERFACE.

The `status` command offers standardized information which is thought to be scanned by higher-level drivers.

subwin

type: USER
syntax: subwin clear [SW|HW]
syntax subwin [SW|auto|HW] [#wid xlstart ylstart xsize ysize]
syntax subwin HW #wid regIdx regNo
syntax subwin on|off [SW|auto|HW] [#wid]
syntax subwin [HW|SW|DET]

Clears, enables/disables, and sets the software (SW) and/or hardware (HW) subwindows and translates them to pattern windows.

The union of the harware windows are the data send from the ROE to the GEIRS workstation via the fibers. Hardware means that the patterns run on the firmware of the ROE determine which pixels or lines of pixels are either skipped or converted while reading the detector; one of the major side effects of skipping regions is that the shortest integration time becomes shorter. Pattern windows are the sub-regions of the hardware windows repeated in each of the readout channels on each detector.

The GEIRS software on the workstation can in addition cut through regions of these hardware windows it received; this post-processing we call SW windowing. (This has no further essential effect on the integration times.) The result of the hardware clipping are basically the pixels displayed in the GUI. The result of this 2-stage clipping (hardware, then software) are basically the pixels displayed in the GUI and saved to the FITS files.

Instead of the intricate manual SW and HW window setup there is the `auto` option, where GEIRS assumes that the SW windows are to be acquired from HW windows of minimum envelopes/areas. So the astronomer defines the result of the geometry of the software windows, and the GEIRS software converts these windows to (larger) HW windows and loads the associated pattern windows to the ROE.

Most subwin commands dealing immediately with HW windows are only meant for use with detector engineering.

The order of the non-numerical parameters (clear, on, off, SW, auto, HW) can be swapped: the `on`, `off` or `clear` may also be placed after the `SW`, `auto` or `HW`.

(For performance reasons it is recommended to define first the list of SW windows, then to activate the windows via a single `subwin on auto`. Background: computation of the pattern windows and the communication with the ROE is inactive as long as the subwins remain "off." So one can delay that computation by defining the geometries in the "off" state to switch them "on" only once at the end.)

`subwin on auto` will clear all HW windows and then redefine the HW windows for the instrument via the currently defined list of SW windows.

If the instrument has no HW windows defined/enabled, full frames are read out and windows are generated by SW windowing.

Subwindows are only added, if the list of subwindows is not yet full and '#wid' number is not yet used for a subwindow, where '#wid' of SW windows are overwriting any '#wid' of HW window definition. But if only HW windowing is used the '#wid' of the HW-window definition is used.

Currently the max. subwindows count per list (SW/HW/DET/PAT) is fixed in GEIRS and is at least a multiple (>2) of the data channels of the detector, currently >= 5*128.

xlstart and ylstart are the Cartesian coordinates in FITS style, i.e., each >=1 and with (1,1) addressing the lower left pixel in the full frame image. The four coordinates refer to the natural global FITS coordinate system, which stretches from the lower left corner of the lower left chip in the detector mosaic to the upper right corner of the upper right chip.

xsize and ysize are width (>=1) and height (>=1) of the window in units of pixels. Because there is a block buffer size of 512 Bytes configured in the OPTPCIe setup, GEIRS rounds the two sizes up such that the product is a multiple of 8 pixels, therefore a multiple of 16 bytes, such that the total over all 32 readout channels of each chip is a multiple of 512 bytes. This means the windows shown in the FITS files may be sligthly larger than the parameters `xsize` and `ysize` submitted by the observer.

For the specification of hardware windows there is a shortcut option with the keywords HW, a window number and only two integer parameters, regIdx (region index) and regNo (number of regions). The main use is where windows are used to decrement the minimum integration time and where nevertheless the windows are modified in turn to cover the entire detector. The regNo should be a small power of 2 (2, 4, 8, 16, 32) which specifies the number of regions into which the detector area should be split. The regIdx is a number from 0 up to one less than this regNo that selects one of these regions. So valid pairs of these parameters are for example (regIdx, regNo) = (0,2), (1,2), (0,4), (1,4), (2,4), (3,4), (0,8), (1,8), ..., (7,8). Selecting regNo=1 is useless and should be replaced by "subwin off".

If the region of a user window stretches beyond the current detector area (2048x2048 for LN or Luci, 4096x4096 for PANIC or AIP, and 4096x2048 for CARMENES), the software issues a warning and chops off the pixels that fall outside that detector area.

The software windows with different #wid indices may overlap.

There are two variants of handling subwindows that by the operator's layout stretch across different detector chips:

- If the code has been compiled with the preprocessor variable GEIRS_FITS_KEEP_SWWIN_ENUM defined in `Makefile.am`, GEIRS refuses to accept windows that have pixels on different chips. Also the operator's integer enumeration of the software windows here in the `subwin` command is carried over to the name convention of FITS files and the EXTNAME definition in MEF files. (This is the default for all instruments.)
- If otherwise the code has been compiled without the preprocessor variable GEIRS_FITS_KEEP_SWWIN_ENUM defined in `Makefile.am`, GEIRS splits and re-enumerates windows that have pixels on different chips. The windows are then enumerated contiguously from 1 upwards in the FITS file name and EXTNAME values.

The software windows are independent of (not shared with) the window set of the `sfdump` command and/or the set of the "reset" windows associated with the srre mode.

The command `subwin` without any parameter shows how many windows of which kind are currently defined and activated.

If the `subwin` command changes the set of window geometries, the main GUI with the images usually shows intermediate garbage until new data have been generated with `read` (because the `subwin` commands modify the index tables which translate the positions of data in the serial frame buffer of the detector frames of the past into positions of data in the serialized 2D geometry in the GUI, and these do not match until the new detector frames have been generated.)

Examples:

- activation control:

```
subwin off   Any windowing is switched off, resumes full frame
subwin on    HW and SW windowing with current subwindow geometries activated
subwin on SW     SW windowing will be used
subwin off HW    HW windowing will not be used
subwin off SW 1  Deactivate SW window number 1
subwin on  SW 2  Activate a previously deactived SW window number 2
```

- definition of window geometries:

```
subwin SW 12 1 1 100 100   define geometry of SW window number 12 of dimensi
                  100 by 100 starting at the left lower edge 1,1 and append
                  it to the list of SW windows, according to unique
                  #wid=12 and available window definition free space.
subwin HW 12 1 1 320 10        HW window with #wid=12
```

- clearance of window geometries:

```
subwin clear     Clear all windowing definitions
subwin clear HW  Clear all HW windowing definitions
subwin clear SW  Clear all SW windowing definitions
```

Important:

- Just setting the windows coordinates does not activate windowing. An explicit `subwin on` is still needed.
- Removing a single subwindow from the list of known subwindows is not possible. It is only possible to deactive all of them. Still the deactivation needs to be followed by a `subwin auto on`.

AND: If subwindowing is switched on, each subwin command needs to recalculate all the subwin mapping. Therefore it is always a good idea to execute first `subwin off` before changing subwin properties.

Recommended command sequences:

```
subwin off     # Deactivates subwindowing. The rationale is that
               # if subwin is on, each command has to recalculate
               # all windows. So with the "off" we avoid that the next
               # two "subwin" each recalculate windows before the full
               # set of windows has been defined.
```

```
[subwin clear    # clears/forgets all tables of previous windows]
subwin SW 1 100 100 200 300  # define/add first subwindow with coordinates
subwin SW 2 300 300 200 300  # define/add second subwindow with coordinates
subwin auto on  # recalculate and activate the HW/DET windows
[subwin SW off] # display/save/use all hardware windows
```

Example: Splitting the full area of the AIP mosaic into four windows such that they appear as four different images (even if the MEF option of the `save` is not used):

```
subwin off
subwin clear
subwin SW 1 1 1 2048 2048
subwin SW 2 2049 1 2048 2048
subwin SW 3 1 2049 2048 2048
subwin SW 4 2049 2049 2048 2048
subwin SW on
```

A quick way of switching to full frame mode, generating images, and returning to the previous set of subwindows is implemented with the following scheme:

```
subwin off      # deactivates all subwindows (now fullframe)
...
subwin on       # re-activates the previous subwindows
(or: subwin auto on # recalculates the HW/DET windows
```

Disable a single software window that was defined earlier:

```
subwin off
subwin SW 99 off   # disables the softweare windwo with id=99
subwin auto on  # activates the windows; window id=99 is now absent
```

Enable a single disabled SW window:

```
subwin off
subwin SW 99 on    # enables the SW win of id=99
subwin auto on  # activates the HW/DET wins, including id=99
```

`subwin` without any parameters or with HW or SW or DET as parameters prints the current settings.

sync

type: USER
syntax: sync [[read] [tele] [filter] [save] [test]] [[none] [all] [macro]] [#.#time]
syntax: sync -e

Waits until the background processes named by the arguments have terminated.

The model of the command execution means that these background processes reply with an early response to their command. These processes `read`, `tele` and so on are in some sort of common group because they need some time until they finish. After starting any of these processes, commands like `status` and `get` could be used to monitor how far which of these processes have proceeded. The `sync` finally is actually waiting until these processes have finished (in some cases triggered by individual timeouts), and responds which the information collected by the processes during their execution as parallel background processes.

Think of the `sync` as blocking/delaying all followup commands (even `abort`!) until `sync` itself returns. In practise this means do *not* send a `sync` if you may wish to `abort` the `read` at some time in the future.

It returns the last errors of the background processes. If no name or `all` are specified, these are all errors, otherwise the errors of the process specified by the command. This allows to watch immediately the error of a background process.

At each start of a background process it clears its last error.

To clear all last errors of any background process use `sync -e`.

`sync -e [#.#time]` waits like `sync all [#.#time]` but clears on return all previous errors of the background processes.

#.#time: int/float-value as last argument:
sync waits at least '#.#' seconds, before checking on any process to synchronize with. This is a mean to ensure that even on a busy system a just scheduled command has indeed started (which may need some time).

If the argument `none` is present, it does *not* sync with processes, *even if* process names are in the argument list.

If no process parameter is given, `sync` waits for the termination of all five background processes listed above and currently running in the system, but not on the `macro` process.

Without the `#time` specification the sync waits at least 2 seconds. The signature `#.#` indicates that this duration may be specified in a floating point format.

Examples

```
sync    - synchronizes with all background processes after
          waiting a default time .
sync 1.5   - synchronizes with all background processes after
             waiting 1.5 seconds.
sync none 0.5   - just waiting 0.5 seconds (no syncs at all!)
```

This command is needed for writing macros, since commands like `read` do not block the execution of the next command. A typical sequence could look like this:

```
sync -e 0.1          # start of sequence clears last errors
read                 # read data
sync                 # wait for all still running processes
tele rel 10 10       # move telescope 10" north, 10" east
save -f 2 -i         # save data
sync tele            # wait for the telecope movement
read                 # next 2nd read
sync read            # wait for read process
tele rel -10 -10     # move telescope -10" north, -10" east
sync save            # wait for 1st save end
save -f 2 -i         # save next data of 2nd read
sync tele            # wait for tele-movement done
read                 # next 3rd read
```

...

If a parameter of `sync` is `macro` or `all` and the `sync` is started from inside of a macro, this `macro` or `all` string is just removed.

`sync macro` waits only as a command outside of a macro on the termination of the main macro-level.

`sync all` waits on all processes including the `macro` process. `sync none` waits on neither process, only waits for the given time (or 2 seconds for default).

A note on the instruments where GEIRS steers motors: Motor movements may in general result in a decision to update the CAHA telescope offset if the wheels' configuration files indicate that the total contribution to the focal shift is larger than some minimum. In these cases `sync wheel` pauses until the motor motion is finished but does not wait until the telescope command is finished. It is therefore good practise not to use an isolated `sync wheel` but either `sync` or a combined `sync wheel` and `sync tele`.

Note: If a background process hangs or died in an unexpected way, it might be necessary to use a `kill [background-process]` command to let the `sync` command return.

system

type: USER
syntax: system ['']cmd['']

Executes any system command, where `cmd` might be any combination of arguments. On problems with special characters surround the cmd with the character `'`. Example

```
system 'tvgcmd 0 "\033"'   to send escape to tv-guider.
system tvgcmd              to get information about tvgcmd.
```

Waits for termination of the system call.

tdebug

type: USER
syntax: tdebug [text [anytext [anytext[]]

Writes an entry in the format '2004-05-28 11:23:41.3794 ZD account (logentry) alltext" to the log stream, where it can be retrieved via journalctl(1).

Alltext (limited to roughly 2048-8192 chars) is the concatenation of all the arguments.

telescope

type: USER

Only relevant for Calar Alto instruments that control telescope pointing via GEIRS (i.e., PANIC). For the other instruments the command only has the effect of setting the sky coordinates in GEIRS's internal data base such that they appear in FITS headers (unless removed by the `geirsPhduAdd` files).

Besides the specific errors listed below, the telescope interface may return the following error codes:

- 1 TELESCOPE environment variable incorrect.
- 2 Cannot communicate with EPICS
- 3 Wrong t_script command
- 4 Bad number of arguments
- 5 TELESCOPE environment variable not set.
- 20 Tracking is OFF.

Warning: These error codes are copied from a file distributed to a private list of users by the head of the Calar Alto computer department in 10/2014. They are not under GEIRS control and may change at any time if Calar Alto changes the associated Tcl scripts.

The time out durations are set within the subcommands of the `t_command` and in that sense not controled by GEIRS.

absolute

syntax: tele[scope] abs[solute] hr min sec deg min sec [equinox]

Moves the telescope to an absolute RA/DEC position. `hr`, `min` and `sec` are the alpha coordinate. `deg`, `min` and `sec` are the delta coordinate.

GEIRS does not check validity or ranges of any of the 6 or 7 numerical parameters, but forwards them to the `t_command t_posit` after rounding `hr`, `min` and `deg` down to integer. If at least one of the `deg`, `min` or `sec` parameters has a negative sign, the sign is moved to the `deg` parameter before submitting it to `t_command`.

If the `equinox` is not provided, GEIRS inserts a value equivalent to now (when the command is executed). This may not be not what the astronomer wants, but is compatible with the software run on CAHA for earlier Omega cameras. It has been argued that the telescope control software uses the `equinox` to correct for some Earth polar motions; the author of this manual here has no opinion on this.

The telescope interface may return the following error codes:

- 40 Incorrect alpha value.
- 41 Incorrect delta value.
- 42 Incorrect epoch.
- 43 Position not reached.
- 44 Telescope keeps on moving.
- 45 Timeout when moving the telescope.

relative

syntax tele[scope] rel[ative] [[zero] or [dalpha ddelta]]

Moves the telescope by `dalpha` and `ddelta` arc-seconds. The numerical value of `dalpha` is supposed to include the factor cos(delta) of the current position. (It is removed by GEIRS by division through the cosine before presenting the value to the `t_command t_offset`, which expects a number in the pure right ascension.) *The supposed advantage of this manoevre is that the dithering motions of the instrument can use essentially fixed strides all over the sky. Again, this appears to be mainly for compatibility with earlier cameras.*

```
'tele rel zero': sets the relative offset sum to zero
'tele rel':      shows the relative offset sum.
```

The telescope interface may return the following error codes:

- 50 Incorrect value in the alpha offset
- 51 Incorrect value in the delta offset
- 52 Alpha and delta positions not reached
- 53 Alpha position not reached
- 54 Delta position not reached
- 55 Timeout while moving to position

`tele` is a "background" process and should have a `sync` after it.

focus

syntax tele[scope] focus [#]

Move the telescope focus by # units (i.e., microns) by sending `t_command t_dfocus` to the telescope.

Note that it is impossible (due to some intrinsics of the t_dfocus interface in the CAHA scripting) to move to a focus position that has a negative value on the absolute focus scale. Example: If the focus position is at 5 units before the move request, and if the argument `focus` to this command is -7, the desired final focus position would be -2, and that negative value cannot be accomplished.

The telescope interface may return the following error codes:

- 30 Incorrect value for the relative focus motion.
- 31 Position not reached.
- 32 Timeout while moving to focus.

At the final stage of each motor motion (individually or in groups via the `filter`), the telescope focus is changed from within the motor procedure (unless disabled or the sum of the focus corrections of the previous and new filters are too small and so on.) It is therefore **not** recommended to issue a `tele focus` while motors are still in motion.

query

syntax tele[scope] pos[ition]

Reports the telescope coordinates (alpha, delta, hour angle and air mass) by sending `t_command t_request` to the telescope.

extended query

syntax tele[scope] get[allpositions]

Requests `tele pos` and `tele focus` combined.

TECS

syntax tele[scope]

Return telescope name and TECS status read from SW database, which means it might not be up-to-date/the current one.

The following command series returns a more reliable/up-to-date status information:

```
'tele get; sync tele 0.5; status tele [get]'
```

The `tele` command in this form without argument and the `status tele` do not need a `sync`, as they are only reading a status and do not call a 'tele' function.

temphistory

type: USER
syntax: temph file [-x time1 time2] [-f time1] [-y temp1 temp2] [-d xserver]

Same syntax and actions as for `tempp`. see [tempplot], page 43,

tempplot

type: USER
syntax: tempp file {[-x time1 time2],[-f time]} [-y temp1 temp2] [-d xserver]

Creates a X11 window plotting temperatures from the log file (that was created by `tempcon`). Only relevant to some Calar Alto instruments that have log files in the GEIRS format.

The horizontal axis are minutes, the vertical axis are temperatures [Kelvin].

- -x: time1/time2 = begin/end time on the horizonal axis.
- -f: time= begin time on the horizontal axis
- -y: temp1/temp2 = cuts of lower/upper temperatures in the graph
- -d: display on which the window is opened (e.g. xt28:0)

This window will *not* be closed when the software is shut-down with the `quit` command.

test

type: ENG
syntax: test {std,med,var} [-q #] [[-r n1 n2] or [-r1 n1]]

Computes pixel statistics and appends the result to the file `chiptest.log` either in `$TMPDIR` (if that environment variable does not exist, `~/tmp`) or in the current directory:

- std: prints averages and deviations over all pixels in all images of each channel and the same for the full image (with additional stdv of channels-stdv). This is the default option if neither `med` nor `var` are used.
- med: prints the median of all channels of each image
- var: prints the median of all pixel-averages as a function of time, and the median of all pixel-variances as a function of time. (Note: this throws an error if less than 2 images are available!)

Default: the log file shows results channel-by-channel. The channel order follows the default orientation of each detector, independent on the user's flips or rotations. That means the channel enumeration is usually not trivially related to the display and FITS orientation.

Options:

- -m: for 'test var' : de-activates median of variances independent of median-pixel of averages (takes it from the average-pixel) Default: variance is taken as independent median value.
- -r n1 n2 : use images `n1` through `n2` (e.g. 'test var -r 2 11')
- -r1 n1 : use images `n1` through the last (e.g. 'test var -r1 2')
- -s : use the software subwins for the tests if activated. Instead of the default statistics looking at the quadrants, the statistics is done by subwindow.
- -q # : use only quadrant or output-channel or SW-subwindow number '#', where the numbering starts at 1 (e.g. 'test var -q 1'). This option is only available with the `var` parameter.

Warning: the combination `-s -q` is not allowed.

If the `-s` option is not used, all HW-read data are accumulated to get the statistics. With the -s option, statitics is calculated in SW-subwindows, ignoring in which HW channels these are located.

The defaulted output of the command 'std' for PYRAMIR (4 channels) for example is:

```
test std          mean & stdv & n ( 4 outputs, 10 images, \
            ctype rrr-mpia, camera Pyramir, itime 1.000000, \
            ctime 1.186678, FULL-frame 1, npixel 1048576)
   output#1:        2004.20  3.839          2621440
   ...
   output#4:        2004.32  3.921          2621440
   output##:        2004.31  3.947  0.121         4
```

which shows for each ADC-channel the mean, standard devtion and pixel count. The final line in the output on the GEIRS shell is the 'output##' line with the 'mean of means', the 'mean of stddevs' over the channels, and the 'stddev of the channel-stddevs'.

use

type: USER
syntax: use [[ctype] or [<ctype> [corrupted, atleast, skip] [#frames]]

`use ctype` sets some parameters for the calculation of the given cycle type, given in units of single frame readouts. Currently this is only used for the mcr (multi-correlated) types, srr(e)/cntsr, lisrr/licntsr.

Examples:

```
use ctype              # list the parameters of all ctypes
use cntsr corrupted 3  # do not use the last 3 frames before ABORT
use cntsr atleast 10   # use the aborted image if at least
                         # 10 frames (default at least 2) are usable
use cntsr skip 2  # drop the first 2 frames of any cntsr cycle

Usable frames are only checked for an aborted image. It is:
     (#_of_read_frames - #_of_corrupted_frames - #_of_skip_frames)
```

The syntax without argument just returns the current status.

ustatus

type: ENG
syntax: ustatus

Returns the user status, one of {astronomer,engineering,superuser}

verbose

type: USER
syntax: verbose {on,off,yes,no}

`verbose yes` increases the amount of output to the shell.

While executing a macro, for example, the system will print every command (and its line number), so the operator always knows which marco line is being executed. Default is `yes`. If no parameter is provided, `verbose` prints the value of the verbose flag.

version

type: USER
syntax: version [-p]

Returns the version string of the GEIRS software. This includes the user account and workstation name, the revision number of GEIRS, the time it was compiled, and the location of the binary files.

The `-p` means that merely the current patterns directory is returned.

wheel

type: USER

Basic use

syntax: wheel [#wheel [[position-name]

Only relevant to some Calar Alto instruments that control motorized wheels by GEIRS.

Move wheel number '#' to the named position or return the status information. The '#' is the wheel number from 0 up to n (inclusive), as shown by the answer of the command `wheel` if used without arguments. Examples:.

```
wheel                   Returns overview of all wheels;
                 reads and displays current wheel-positions.
wheel 2                 Returns information on wheel 2.
wheel 2 wollaston45     Moves wheel2 to the wollaston45 position.
```

If the wheel number is replaced by the string `aperture`, the command addresses the first wheel that is in the `aper` class in the `INFO/wheel?.*` files. For PANIC this is actually the cold-stop wheel.

`wheel` becomes a background process and should be followed by a `sync` if called from within a macro.

focus

syntax: wheel focus [on,off,new]

`wheel focus [on/off/new]` controls the relative focus adjustment for the selected combination of elements. Example:

```
'wheel focus off'   deactivates the focus correction of all
       filter-wheels for the subsequent wheel/filter commands,
       until it is reactivated.
```

Example:

```
'wheel focus on'  (re-)activates the focus correction for
         the subsequent filter wheel commands, which are tagged
         for CHKFOCUS-correction in the wheelN.<instrument>
         configuration files.
```

Example:

```
'wheel focus new'  updates the relative focus correction
         information to the current wheel positions, for all filters
         which are tagged via CHKFOCUS correction in the
         wheelN.<instrument> configuration files. Note that this
         call does *not* change the on/off state!
```

Focus correction is always done relative to the last filter combination which was saved at the last filter-correction action.

Application note: Focus settings beyond the wheel focus control through the program will remain correct and will lead to correct relative focus corrections, as long as neither wheel/filter exchanges nor manual focus-changes occur while the GEIRS state is 'wheel focus off':

- To enable the correction of the relative wheel focus, after wheel changes *and* manual focus settings had been done in 'off' state, use `wheel focus new` to discard the previous information on the relative focus correction that was remembered by the server, and to update it with the current focus.
- initialisation of wheels does not change focus, but activates the focus correction for the next wheel usage. (At initialisation time the focus correction is correct.)

relative

syntax: wheel [#wheel relative #offsetsteps]

```
wheel 2 rel -25         Moves wheel2 25 steps backwards.
```

init

syntax: wheel init

warminit

syntax: wheel initwarm

dialog

syntax wheel dialog [on,off]

The syntax with `dialog on` or `dialog off` enables or disables warning and error GUI's. Dialogs are usually shut off if GEIRS is driven by an external handler and there is no operator that could click on the buttons.

rdb

syntax: wheel rdb

`wheel rdb` re-reads the wheel and wheel-macro database files.

aperture

syntax: wheel aperture

Yields a list of wheels in the aperture class. For PANIC this is the cold stop wheel.

filter

syntax: wheel filter

Provides a list of filter macro positions.

Index

(index is nonexistent)

```
mathar@mathar:...nk/extern/readline
File: camera.info,  Node: Top,  Next: abort,  Prev: (dir),  Up: (dir)

Overview
********

Interface to the command server of GEIRS, the Generic Infrared Detector
Software of MPIA.

* Menu:

* abort::                       Abort the execution of save or macro
* alarm::                       Play alarm sound
* aperture::                    Move aperture wheel
* autosave::                    En/disable automated save
* bias::                        Detector voltages
* camfile::                     Set/get file name that summarizes exposures
* cd::                          Switch directory
* clobber::                     En/disable file overwriting
* continue::                    Continue after pause
* control::                     Camera control GUI
* counter::                     Modify a counter variable
* crep::                        Cycle repeat count
* ctime::                       Cycle time
* ctype::                       Detector cycle type (readout mode)
* define::                      Set/get value of parameters
* delay::                       Delay between readout cycles
* dir::                         Contents of current directory
* display::                     Detector image GUI
* engstatus::                   Current ROE parameters
* engwindow::                   GUI
* exit::                        Shutdown server or terminate macro
* filter::                      Parallel filter wheel positions
* fits::                        Current FITS header
* get::                         Parameter in the shared memory
* gui::                         Main GUI
* help::                        This manual of commands here
* history::                     Command history of the GEIRS shell
* idlemode::                    Detector cycle mode while idle
* init::                        Initialize ROE, telescope or motors
* iniwindow::                   Startup configuration GUI
* interactive::                 Set shell mode to batch or interactive
* itime::                       Integration time
* kill::                        Kill a GEIRS subprocess
* lamp::                        Power of calibration lamp (CAHA)
* last::                        Most recently saved file name
* load::                        Read a FITS file into shared memory
* log::                         Change software log level
* ls::                          Contents of current FITS image directory
* macro::                       Execute macro
* median::                      Median statistics of buffered images
* next::                        Next FITS file name
* object::                      Name of the OBJECTS in FITS header
* observer::                    Set FITS OBSERVER keyword
* optics::                      Move an optics wheel
* pause::                       Pause command
* pipe ::                       Direct command to ROE
* pkginp ::                     Start input data stream
* ptime::                       ROE base time value
* put::                         Write to shared-memory data base
* pwd::                         Current directory for FITS images
* quit::                        Shutdown server or terminate macro
* read::                        Starting reading data from ROE interface
* repeat::                      Execute command repeatedly
* roe::                         Set parameter of ROE mode
* rotype::                      Readout type of ROE
* rtime::                       Set reset time
* saad::                        Shift and add image stack
* satcheck::                    Pixel saturation check on or off
* save::                        Save data to FITS files
* set::                         Set search directories (save, macro, catalogue)
* sfdump::                      Dump each frame's subwindows to FITS file
* sky::                         SKYFRAME FITS header keyword
* sleep::                       Suspend shell/macro execution
* sndwin::                      Sound GUI
* sound::                       Enable/disable sounds
* status::                      Report status information
* subwin::                      Define hard and software windows
* sync::                        Wait for termination
* system::                      Execute generic OS command
* tdebug::                      Write log text
* telescope::                   Telescope motion commands
* telgui::                      Telescope GUI (CAHA)
* tempcontrol::                 LakeShoe temperature controller
* temphistory::                 Temperature history
* tempplot::                    Temperature X11 plot
* test::                        Pixel statistics (mean, variances) on frames
* use::                         Specify range of frame indices for save
* ustatus::                     Current user rank
* verbose::                     Verbosity of macro
-----Info: (camera.info)Top, 95 lines --Top-----------------------------------------------------------------------------------
Welcome to Info version 5.2. Type h for help, m for menu item.
```

Figure 19: Example of the window appearing if `info camera` is called from the Linux shell.

5.4 Macros

5.4.1 Aim and Configuration

Macro files are prepared to carry out specific, normally reoccurring, tasks in the spirit of batch processing. The macro utility is sequentially oriented; each line in the macro file is a command of the set of Section 5.3.

Empty lines in the macro file are ignored/skipped. The part of lines starting at a hash (`#`) up to the end of the line is chopped—and serves to add comments to the macro files. The maximum line length in the macro files is 256 bytes.

The syntax does not provide conditional and loop capabilities beyond the `repeat` command of the GEIRS shell itself. In that respect it does not extend the command interface.

Macros can be nested 5 levels deep; the `macro` command may appear in a macro file. The most economic way to loop through a set of fixed commands a fixed number of times is to write this set into a macro file, then to call this macro from another "higher level" macro as many times as wished. In any way, these techniques are based on working with copy-n-paste on the ASCII files of the macros.

Macro files are started from the camera control window (lower part, see Figure 9) or with the `macro` command to the instrument shell. As a matter of orderly book-keeping, it is recommended to use the file suffix `.mac` for all macro files. GEIRS searches first for the macro file with the exact name provided by the user, and then searches in addition (as a fallback) for that exact name augmented by `.mac`. So one may lazily use the file name without suffix in the GUI of Figure 9 and after the `macro` command if file names in the directories do have the `.mac` suffix.

The "macro path" plays the role of a search path for these `*.mac` files. It is set/changed with the third pull-down menue of Figure 9 or the associated `set macropath` GEIRS shell command. If a macro file is not found in that directory defined by the search path, GEIRS also searches thereafter through `$CAMHOME/MACROS` by default. If users store their macros in that `MACROS` subdirectory anyway, the "macro path" is not that relevant.

The macro files support DOS-style end-of-line markers of the composite carriage-return and line-feed bytes. In that respect one can copy these files from older Microsoft operating systems without using `dos2unix(1)`. UTF-16 encoding of the newer Microsoft OS's is not supported and supposed to be converted by tools like `recode(1)` before feeding them into GEIRS.

5.4.2 Syntax Checker

A basic syntax checker for a macro file is called with

`geirs_MChk` *macrofilename.mac*

which tests many (but not all) lines in the macro file for syntactical correctness. `geirs_MChk` prints the lines that appear to be suspicious to standard output. It checks only the most common commands that appear in macros. Commands like `status`, `ls` and other commands that produce detailed output or open windows that needs interpretation by some listening program and do not make much sense in macros are also reported. Numerical parameter ranges are only checked by order of magnitude, or even not at all.

Checking all macros in a subdirectory is done with a loop in some bash shell similar to

```
cd $CAMHOME/MACROS
for f in *.mac ; do
    echo $f"..."
    $CAMBIN/geirs_MChk $f
done
```

The main benefit of using the checker is that typographic errors may be detected early, just after editing the macro file. The GEIRS macro interpreter reads one macro line at a time and executes it. If the total real time of executing the macro is long, errors in its late parts may lead to much delayed abortion of the macro. A syntax checker adds some safety and time savings in that type of scenario.

5.4.3 Total Integration Time

The total integration time in a macro is a sum over all products of the `crep` arguments and the `itime` arguments that are active at the `read`. It can be calculated by calling

`geirs_MItime.pl` *[-q] macrofilename.mac*

Using the *-q* option gives a more quiet output, where the partial sums are not printed. The *macrofilename.mac* is either a full path name or the name in the current working directory. If that file is not found and the CAMHOME environment variable is set, the program tries to locate the file also in the directory $CAMHOME/MACROS.

This scanner looks for lines of the format

`itime` *seconds*

`crep` *count*

`read`

`quit`

`exit`

`repeat` *count* `read`

`macro` *othermacrofile*

`repeat` *count* `macro` *othermacrofile*

and accumulates the sum over the products. If the `itime` argument is zero, it is replaced by (an estimate of) 1.3 seconds.

5.4.4 Macro Generators

Lengthy macros can essentially be created by any other high level language with loop control. We provide some examples based on languages that are available on Unices.

5.4.4.1 Shell Here is an example of a bash-shell executable with a double loop which generates 18 read-save cycles—three different values of the `ems` parameter and six different subframe coordinates. The bash-script would be put in a file like `tst.sh`, and generate the macro with `chmod +x tst.sh; tst.sh > tst.mac`:

```
#!/bin/bash
for e in 1 2 4 ; do
    echo "roe" ems $e ;
    for w in 0 1 2 3 4 5 ; do
        echo "subwin auto 1 " $(( w * 128)) $((w * 128)) 128 128 ;
        echo "read" ;
        echo "sync" ;
        echo "save -i -f 2" ;
        echo "subwin clear" ;
    done ;
done
```

5.4.4.2 awk Another example of a double loop put into a file `tst.awk` and then generating a macro calling awk as `awk -F tst.awk > tst.mac`:

```
BEGIN {
    emsarr[1] = 1 ;
    emsarr[2] = 2 ;
    emsarr[3] = 4 ;
    wxy[1] = 0 ;
    wxy[2] = 2;
    wxy[3] = 3;
    wxy[4] = 4;
    wxy[5] = 5 ;
    for (e in emsarr ) {
        printf("roe ems %d\n",emsarr[e]) ;
        for ( w in wxy ) {
            printf("subwin auto 1 %d %d 128 128\n", wxy[w]*128,wxy[w]*128) ;
            printf("read\n sync\n save -i -f 2\n subwin clear\n") ;
            }
    }
}
```

5.4.4.3 m4 A third variant is to save some typing by expansion of m4 macros. If a file `tst.m4` contains

```
#define a m4 macro expo with a roe-subwin-read-sync-save-sync atomic operation
define(expo,
# interpret the first argument as an ems paramter
roe ems $1
# interpret the second and third parameter as the lower left coordinates
# of a window divided by 128
subwin ‘auto 1 eval(’$2‘ * 128) eval(’$3 ‘* 128) 128 128’
read
sync
save
sync
subwin clear
)

# run one exposure with ems=1, then one with ems=2 and another with ems=1
expo(1,1,1)
```

```
expo(2,2,2)
expo(1,3,4)
```

then `m4 mloop.m4 > tst.mac` generates a file with three exposures.

The same "macro generator" variants could be worked out in many other programming languages.

5.4.4.4 Driver Loops An alternative is to drive the instrument through the `geirs_cmd_-` *extension* interfaces of the `scripts` directory (here: for example) from other programs/interpreters (bash, perl, python, tcl, MIDAS,...). Macros are not needed in such case.

A python script would do this by its `os.system` calls. An example with three outer loops over a variable `e` which feeds the `ems` setting and five inner loops over a variable `w` which implements a marching square subwindow might look as follows:

```
import os
for e in [1,2,4]:
    os.system('cmd_nirvana_new roe ems '+str(e))
    for w in [1,2,3,4,5]:
        os.system('geirs_cmd_nirvana subwin SW 1 ' + str(w*128) + ' ' + str(w*128) + ' 128 128' )
        os.system('geirs_cmd_nirvana subwin on auto' )
        os.system('geirs_cmd_nirvana read' )
        os.system('geirs_cmd_nirvana sync' )
        os.system('geirs_cmd_nirvana save -i' )
        os.system('geirs_cmd_nirvana sync' )
        os.system('geirs_cmd_nirvana subwin clear' )
        os.system('geirs_cmd_nirvana subwin off' )
```

In the more familiar bash shell an example might look like

```
#!/bin/bash

for (( j = 1 ; $j <= 10 ; j++ )) ; do
    echo starting exposure $j ;
    geirs_snd_panic read ;
    geirs_snd_panic sync ;
    geirs_snd_panic save ;
    sleep 10 ;
    geirs_snd_panic sync ;
    echo done exposure $j ;
done
```

5.5 Shell Commands

After installation of the manual pages (Section 2.5.2), the following documents of programs in the Linux shell are available by calling man(1), of which we show the first pages:

NAME

dfits − list headers of FITS header-data units

SYNOPSIS

dfits [-x *extnum*] *fitsinfile1.fits* [*fitsinfile2.fits* ...]

OPTIONS

-x followed by a 0-based integer specifies which extension header should be printed. If the option is missing, only the primary header is printed. If the *extnum* is an integer >=1, the header of that extension is printed. If *extnum* is zero, all headers (primary and extensions) are printed.

EXAMPLES

dfits -x 0 *

NAME

ds9loop − starts ds9 in a loop over all fitsfiles in directories

SYNOPSIS

ds9loop [*ds9option* ...] *directory* [*directory* ...]

DESCRIPTION

The command interprets all arguments that start with a dash as ds9(1) options, and all others as directories. It calls ds9(1) with the options sequencing through all files with suffix .fits .

The user must close (or exit) the ds9 GUI to move on to the next FITS file.

EXAMPLES

ds9loop .
ds9loop /data1/Panic
ds9loop -multiframe .
ds9loop -mosaicimage /disk-d/carmenes/DATA/2015-02*

NAME

fedithead − batch FITS primary header keyword editor

SYNOPSIS

fedithead [-v] *fitsfilename templatehdrfilename* [*templatehdrfilename* ...]

OPTIONS

An optional argument -v triggers a detailed message of the program for each keyword changed.

DESCRIPTION

Fedithead edits FITS header data following directions from a configuration file.

The first command line argument is the file name of an existing FITS file which is to be modified, i.e., rewritten on return.

The second argument and optionally further arguments are ASCII files structured very similar to the template files used with http://heasarc.gsfc.nasa.gov/fitsio/fitsio.html/ and https://heasarc.gsfc.nasa.gov/ftools/caldb/help/fmodhead.txt/.

TEMPLATE FILE SYNTAX

Each of these may contain empty lines and comment lines (starting with #) that have no effect.

It may contain lines starting with the dash (-) that demand removal of the keyword from the FITS header. (If that keyword does not exist this does not have any effect.) The keyword may have regex expressions to deal with a group of keywords at once.

It man contain lines that embed two keyword names between colons (:) or between exclamation marks (!), so there are three of these delimiters in that type of line. (This is a syntactical extension to template files of fmodhead, fthedit and the cfitsio templates). Fits header cards with names matching the regular expression delimited by the first two colons have their names substituted by the substitutional expression between the 2nd and third colon. (Values and comments remain as they are).

It may contain lines that start with at least 8 blanks. The rest of these lines is turned into COMMENT lines that are appended to the FITS header.

Finally, all other lines are interpreted as keyword-value-comment triples in FITS header style (with = and / as delimiters), that trigger adding that card to the header. (Existing keywords with the same name are removed).

Due to inherent limitations of the cfitsio parser (at least up to version 3.420), lines in the template files should not be longer than 140 characters.

EXAMPLE TEMPLATE FILE

delete CHOP_A and CHOP_B
-CHOP_[AB]

replace RHUM by a hierarchical version
:RHUM:HIERARCH LN AMBI RHUM:

rename enumerated wheels to filters
:WHEEL(\1):HIERARCH LN ICS FILT\1:

add a OBSERVAT keyword
OBSERVAT = 'LBT' / on the mountain

add a comment
Nice observation conditions. Dry with occasional snowflakes.

SEE ALSO

fthedit(1) fmodhead(1)

NAME

fitsImg2Asc − convert primary HDU of a FITS file to ASCII

SYNOPSIS

fitsImg2Asc *fitsIn.fits > fitsout.plt*

fitsImg2Asc -r [*xstrt*:*xend*,*ystrt*:*yend*] *fitsIn.fits > fitsout.plt*

fitsImg2Asc -h [-s] [-d] [-l] [-N *bins*] [-m *minvalue*] [-M *maxvalue*] [-a [*xmin*:*xmax*,*ymin*:*ymax*]] [-t *out.txt*] [-o *out.eps*] *fitsIn.fits* [*fitsIn.fits* ...]

fitsImg2Asc -b [-i] [-a [*xmin*:*xmax*,*ymin*:*ymax*]] -m *minvalue* -M *maxvalue* [-X] [-Y] *fitsIn.fits fitsOut.fits*

DESCRIPTION

The program fitsImg2Asc converts the image in the primary HDU of a FITS file to an ASCII format. The input file is an image in the FITS file, of which only the first slice is taken if this is a FITS cube. It often is necessary to delete the enviroment variable LD_LIBRARY_PATH with export LD_LIBRARY_PATH=" to avoid core dumps of the program!

3D view

The standard syntax is

fitsImg2Asc fitsIn.fits > fitsout.plt

or

fitsImg2Asc -r '[xstrt:xend,ystrt:yend]' fitsIn.fits > fitsout.plt

which means that the command line argument is the name of the FITS file with the image, and the output is redirected into some other file. This output file will be roughly a factor of 4 larger than the input file, and the program will run slowlier than some people would expect. In almost all cases the field will be too crowded to get useful response times from gnuplot while rotating the image, so the option -r allows to take only a rectangular subarea of the image, where the 4 arguments are 0-based ranges for the two pixel axes (different from the FITS convention).

The output contains lines with three values, which is the x coordinate of the pixel, the y coordinate of the pixel, and the value in the image at this pixel.

This ASCII file has been targeted for use with a gnuplot(1) session e.g. like:

gnuplot gnuplot> set xlabel 'x pixel' gnuplot> set ylabel 'y pixel' gnuplot> set zlabel 'adu' gnuplot> splot '....' wi li # insert the fitsout.plt file data name here gnuplot> set grid gnuplot> set contour base gnuplot> replot gnuplot> set logscale z gnuplot> replot

Example: fitsImg2Asc -r '[200:800,1200:1800]' fitsIn.fits > fitsout.plt

Histogram

The syntax to generate a gnuplot X11 window or EPS file with a histogram of pixel ADU values is triggered by the -h option as follows:

fitsImg2Asc -h [-s] [-d] [-l] [-N bins] [-m min] [-M max] [-a [xmin:xmax,ymin:ymax]] [-o fitsout.eps] fitsIn.fits [fitsIn.fits ...]

The option -N followed by a positive integer number can be used to specify the number of bins to be generated. If not provided, the program uses a default.

The option -m followed by a number is the minimum number on the horizontal axis which delimits the range of ADU's to be shown.

The option -M followed by a number is the maximum number on the horizontal axis which delimits the range of ADU's to be shown.

The option -l means a logarithmic scale is used on the vertical axis.

The option -d means the fitsIn.fits files are removed (!) when the program terminates

The option -a followed by four positive integer numbers in brackets selects a quadrangular region (of FITS coordinates) in the image to be scanned. The default is to scan all pixels in the image.

The option -o followed by a file name causes the plot to be moved to a EPS file, not to the screen.

The option -t followed by a file name causes the histogram to be dumped into the named ASCII file.

The option -s means that no gnuplot window will be opened. Effectively this is a batch-script way of printing some statistics into files and to show the mean in the standard output that avoids the need to close the gnuplot windows.

The other command line arguments are existing fits files which will be read. The gnuplot display shows the count of pixels on a per-file basis which fall into a range of ADU's. There are two variants of showing the result, one with a logarithmic scale for the counts in the bins, one with a linear scale.

Example (which uses the shell's expansion mechanism of file names):

fitsImg2Asc -h -m 0 -M 200 aa000[1-8].fits fitsImg2Asc -h -m '-50' -M 50 -N 100 -a '[5:2044,5:2044]' aa000[1-8].fits

Example (which shows the selection mechanism of moving to a named extension HDU to locate the image):

fitsImg2Asc -h -m '-50' -M 50 -N 100 -a '[5:2044,5:2044]' aa0001.fits'[WIN1]'

Bad pixel mask

The syntax to generate a bad pixel mask is:

fitsImg2Asc -b [-i] [-a '[xstrt:xend,ystrt:yend]'] [-t textout] [-X] [-Y] -m minADU -M maxADU fitsIn.fits fitsOut.fits

The mask is defined by investigating the 2D image provided in the input file fitsIn.fits and writing the bad pixel mask to fitsOut.fits.

The option -a defines a subwindow of pixel ranges to be scanned for out-of-range values. The pixels inside the original window but outside that internal window are a frame which is also regarded of containing only bad pixels. So usually for a single Hawaii-2 RG image one would declare the 4-pixel frame to be bad with -a '[5:2044,5:2044]' .

The option -t followed by the name of a file lets the program generate that file where the bad pixels are listed (one by a line) with their 1-based integer x and y coordinates. (This is also the convention of the fixpix routine of the IRAF reduction. It does not produce the generalized format with four parameters equivalent to xstrt, xend, ystrt, yend to define bad pixel blocks.)

The option -X and similarly the option -Y trigger that the bad pixel mask is generated after flipping the image of fitsIn.fits left-right along x or up-down along y. This helps to generate the mask for images that had another WCS orientation convention than the images the bad pixel mask will be generated for.

The option -m (quasi mandatory) defines the minimum ADU value and the option -M (quasi mandatory) defines the maximum ADU value of pixels in fitsIn.fits supposed to be good. To use negative values for minADU and/or maxADU surround the option plus the value with single quotes, like this: '-m -100' -M 350.

The option -i causes the bad pixel mask to be written with values of 0 for good pixels and values of 1 for bad pixels (as in some IRAF conventions). The default (without the option) is to write 1's for good values and NaN for bad values, so it could be used for multiplicative application for generic pictures.

The two final arguments are the file names of the input image and of the bad pixel image to be created.

NAME

fitsort − tabulate selected FITS header values from a set of FITS files

SYNOPSIS

dfits ... | fitsort [-d] *KEY1* [*KEY2* ...]

OPTIONS

-d means that fitsort does not print the header line with the FITS keywords.

DESCRIPTION

The standard input of fitsort must be the output of the dfits(1) command. The program prints a spreadsheet table with tab-separated columns which shows for each of the FITS files (row by row) lines with the values of the specified keywords listed side-by-side.

This answers quickly a question like *what have been the integration times for the exposures in the FITS files ?*

EXAMPLES

dfits *.fits | fitsort ITIME RA

NAME

geirsCmd − send a GEIRS command to a GEIRS command server

SYNOPSIS

geirsCmd [-v] [-h] [-p port] [-s server:port] cmd [cmdarg ...]

OPTIONS

The option -v increase the verbosity of the output

The option -h prints the usage/help message.

The option -p specifies the port number on which the GEIRS command server is running. This is either a number and should be the same as what is shown as the GEIRS start messages, or it is an instrument name (like Nirvana, Luci1, Luci2, Panic,...) and the associated port number is searched in ~/.geirs/geirsCnf.xml .

The option -s is the tcp server name and port number of the command server on which a remote GEIRS server is running.

DESCRIPTION

This command forwards the cmd and the optional followup arguments to the server at the specified port. If the server is not specified, this tries to contact the GEIRS server running on the local machine.

EXAMPLES

NAME

geirs_carmen_pip − execute the CARMENES first stage pipeline

SYNOPSIS

geirs_carmen_pip *fitsfile.fits*

OPTIONS

none

DESCRIPTION

This is the start of the first stage pipeline which calls in succession

- pipFits_ls (to collect the names of the raw FITS frames that are the main input with some Fowler-type of selection criterion),
- pipFits_nonl (to apply a nonlinearity correction to the raw frames that are selected),
- and pipFits_ols to merge the corrected frames into a single image.

The command line argument must be the full path name of one of the raw FITS frames of the two LIR or many SRR(E) reads of the finished exposure. This is usually done by putting the script into the **QueueFiles** script of GEIRS and forwarding the argument received by the **QueueFiles**. The pipeline creates one additional full-frame FITS file in the same directory with a name of the form car*_P.fits if successful.

This will fail for any of the following reasons:

- The nonlinearity calibration file is not found (see below under ENVIRONMENT)
- The command line argument is not a readable FITS file
- The exposure did not create at least 2 FITS frames.

Logs are created in the file $CAMLOG/*QueueFiles.log, which usually is the same as $CAMHOME/log/*QueueFiles.log . This contains information on timing and on the files used in the various steps. No logs are created if the script is not called (!), as for example if the GEIRS **save** command does not succeed.

Note that this pipeline script is a bash(1) script, so editing the parameters that are used for the sub steps is a trivial matter of editing that ASCII file.

ENVIRONMENT

$CAMHOME/scripts contains scripts used by the pipeline. Therefore this should be in the PATH variable.

$TMPDIR must contain the file pipNonl.fits which is the specification of the nonlinearity correction coefficients for the full frame. The subdirectory $TMPDIR/pip will be used for scratch files and cleaned mercilessly by the pipeline script according to its own needs.

EXAMPLES

geirs_carmen_pip ~/DATA/2015-06-11/car-20150612T16h34m07s-gtoc-nir.fits

NAME

geirs_cleanup − remove residual GEIRS components left over by a previous run

SYNOPSIS

geirs_cleanup [-v] [t] [-a] [-p *catmpdir*]

OPTIONS

-v leads to more verbose output of the actions

-t tests whether any actions would be taken, without actually executing them. This is a dry run.

-a Removes also temporary files. The set of files that are concerned are the files that store parameters like save paths, IP addresses, telescopes and so on that are saved at shutdown time to re-appear in the next startup GUI.

-p Allows to specify the path name of the temporary files. The default is the caller's $TMPDIR, and then ~/tmp directory.

DESCRIPTION

The script shuts down a GEIRS run by sending signals to the four components (the two GUI's, the command manager and the shared memory manager) and removing the shared memory blocks and shared memory socket.

It is used within the GENERIC script to test whether GEIRS is already running for this or another user.

The script is an emergency script to be used in case a previous GEIRS run was shut down inappropriately (for example caused by power outages) or another user is running GEIRS under the same account and left the GUI's in some unreachable state.

ENVIRONMENT VARIABLES

The variable TMPDIR (with a default backup of $HOME/tmp) is used to locate the shared memory socket to be removed.

EXAMPLES

geirs_cleanup -v -t

NAME

geirs_controlJ − open the Java based control GUI

SYNOPSIS

geirs_controlJ [*instrument*]

OPTIONS

If the CAMERA environment variable is set, the associated instrument is taken from there. If the variable is not set, the instrument (Panic, Nirvana, Luci1, Luci2, NTEimg and so on) must be the command line parameter.

DESCRIPTION

The control GUI is usually either started by default when GEIRS is started or sometimes not started at all if any client takes full control of the exposures. This means the *geirs_controlJ* command is mainly useful to operators who have closed the GUI with the X-button of the window manager and want to get it back.

For a detailed description of the layout and use consult the GEIRS manual.

Options submenu

Allows to specify the directories that contain

- the *Save path* where the FITS files or raw dumps will end up,
- *Macro path* where the software will search for macro files,

Some fine control of the files with the sounds (volume, on/off) is avialable in the *Sounds* submenu.

NAME

geirs_dataServer − start the server that delivers images in a raw format

SYNOPSIS

geirs_dataServer [-h] [-p *portnumber*]

OPTIONS

-h Prints a usage help line

-p specifies the port number on the GEIRS hosts for the server's socket. The server should be started on the GEIRS workstation after the shared memory manager has already started. It connects to the shared memory interface and reads the port number from there, so it essentially falls back to the CAMDATAPORT environment variable that was valid when GEIRS started. So the specification fo the port number is generally superfluous.

-P the same as -p .

DESCRIPTION

The server responds to queries of clients to obtain data frames. It is started by default in the startup script because the real-time display actually receives its pixel data by polling the data server. Headless GEIRS sessions that do not open the real-time display probably don't need to start the server.

The server is a thread-less server, which means it listens for a new request (command) on the port, sends back an answer (usually a data frame), and closes the port, ready for another request.

Commands

The server knows three commands, containg just a few letters:

- d (short for dimension) lets the server return the number of horizontal pixels and vertical pixels of the full frame and the count of available images in the read buffer, separated by blanks, in ASCII format. If one uses this for CARMENES, a typical answer would be

  4096 2048 0

  while the data in the first ramp are not yet completed.
- q (short for quit) Terminates the data server.
- i *imagenumber*
- iy *imagenumber* Requests to receive the pixels of the image number given by the additional argument. Here frames are counted from 1 upwards, and may be as large as the cycle repetition number of the active or terminated readout. If the *imagenumber* is missing, the server assumes that the highest available image number (most recent image) must be composed.

The image is returned in binary format, 4 bytes for each pixel, in the endianess of the GEIRS workstation. It contains a full frame image, which is 4 bytes x 4096 x 4096 for PANIC or AIP, 4 bytes x 4096 x 2048 for CARMENES, and 4 bytes x 2048 x 2048 for the other instruments. If the current readout mode uses windowing, the pixels that are not read out have numerical values of zero. If the y is in the command, the serialization of the data is that the pixels start at the top row of the image, left-to-right, then the next lower row of the image, left-to-right (which is the convention for most graphics libraries of placing the origin of coordinates at the upper left corner). If the y is absent, the serial order starts at the bottom row and works upwards (which is the FITS order).

- f *framenumber*
- fy *framenumber* Requests to receive the pixels of the data frame enumerated by frame number. The first frame is 1. The difference to the iy command is that the frames are returned in an unsigned short (2 byte) format of the pixels. The variant which includes the y in the command is again introducing a flip along the y-coordinate such that the order is the natural for windowing applications, and otherrwise the FITS order. *Not yet implemented*

The image and frame orientation pays attention to the CAM_DETROT90 and CAM_DETXYFLIP modifiers of the configuration, so it is compatible with the orientation of the real-time display and FITS files.

If the frame or image number of the request are out of range (less than 1 or larger than the currently available data set), an error message (in ASCII format) is returned.

NAME

geirs_displayJ − open the GEIRS real-time display

SYNOPSIS

geirs_displayJ [*instrument*]

OPTIONS

If the environment variable CAMERA is set to the active instrument (Panic, Nirvana,...) no command line argument is needed. Otherwise the *instrument* must be the online instrument where the ROE is governed by GEIRS.

DESCRIPTION

The window is opened which shows the infrared detector data which are updated as new images arrive in the memory of the computer. The main use of the command is to open another display on a terminal of a secondary observer. (One display is generally opened already on the operator who called start_<instrument>_new . Depending on which command line arguments were used there, this may not have happened.)

Various displays opened at the same time are not independent, because they share parameters of the unique (shared memory) parameter set held by the command server; if some operator clicks on some buttons that may effect the copies of the real-time display on other screens as well.

EXAMPLE

ssh -X lneng@lircs geirs_displayJ Nirvana

ssh -X lneng@lircs 'bash -lc 'geirs_displayJ Nirvana''

ssh -X lneng@lircs 'GEIRS/scripts/geirs_displayJ Nirvana'

ENVIRONMENT

The environment variabl CAMBIN must be set and point to a valid GEIRS directory of compiled binaries.

NAME

geirs_dropcaches − drop the cache used and memory not kept in memory

SYNOPSIS

geirs_dropcaches [-m *MiB*] [-c] [-f *frac*]

OPTIONS

-m The threshold that triggers executing the dropping in units of MiB. If not used, the default is 4096 for the standalone program, but GEIRS takes more than half of the RAM instead (depending on the GEIRS version).

-c Triggers a (explicit) compactification (de-fragmentation) of the memory tables.

DESCRIPTION

The program executes effectively a

sync; echo 3 > /proc/sys/vm/drop_caches

when the free amount of memory drops below the threshold (which lets the Linux OS clear the current caches in the virtual memory).

This is called by GEIRS at the start of every read that involves the PLX driver. The current threshold is obtained by sending the command

get DROPCACHE

to the GEIRS interpreter. It can be changed using the put command of the GEIRS interpreter while GEIRS is running, for example

put DROPCACHE 1024

to use 1024 MiB in the future. Note that all values defined by *put* are forgotten when GEIRS is shut down; so the effect of such a modification would only last for the current GEIRS session.

The command will fail with an error message if the associated permissions of the last lines in the INSTALL have not been set.

NAME

geirs_lamp.sh − status of the CAHA calibration lamp state for PANIC

SYNOPSIS

geirs_lamp.sh ALLOFF

geirs_lamp.sh L1 {ON | OFF}

geirs_lamp.sh L2 {ON | OFF}

geirs_lamp.sh L3 {ON | OFF}

geirs_lamp.sh L4 {ON | OFF}

geirs_lamp.sh L5 ON {1|2|3|4|5|...9}

geirs_lamp.sh L5 OFF

geirs_lamp.sh STATUS

DESCRIPTION

The command is called by using the **lamp** command in the GEIRS shell.

It executes a **rflats** command (for switching calibrations lamp on or off) followed by a **rflats status** command which

- leaves a FITS line at a standard place searched by GEIRS for add-on FITS lines, and
- echos a string suitable for storage in the GEIRS online data base.

Warning: no timeout is currently implemented. If the **ssh** hangs for any reason, this will cause an indefinite pausing of GEIRS (because there is no timeout currently enacted on the GEIRS side.)

This file has no use beyond GEIRS implementing PANIC at the Calar Alto.

ENVIRONMENT VARIABLES

The variable TELESCOPE determines which of the CAHA computers is consulted to execute the **rflats** command.

FILES

The output of the command is registered in $TMPDIR/geirsPhduAdd.panic_1 . If TMPDIR is not defined, it is replaced by $HOME/tmp .

EXAMPLES

geirs_lamp.sh L5 ON 4

NAME

geirs_patterns − find the directory currently used by GEIRS for the patterns

SYNOPSIS

geirs_patterns *instrument*

DESCRIPTION

The patterns of the readout electronics are controlled by separate svn repositories than the main code, so the name of the directory that keeps the patterns slowly changes in time as new features are build into the readout.

The command helps to find the version (the directory) that will be automatically selected by GEIRS at startup time. The command line argument should be the name of the instrument (in relaxed upper- or lowercase writing). The command requires at least that the $CAMHOME environment variable is set correctly and that the directory layout is a standard one as used for all installations as described in the GEIRS manual.

EXAMPLES

geirs_patterns luci1

geirs_patterns luci2

geirs_patterns carmenes

geirs_patterns Nirvana

geirs_patterns Panic

NAME

geirs_quitXterm.sh − closes open auxiliary GEIRS xterm windows with log monitors

SYNOPSIS

geirs_quitXterm.sh

OPTIONS

none

DESCRIPTION

The command closes the auxiliary x-terminals that show aspects of the GEIRS logging. These might have been opened by selecting some of the monitors of the controls GUI.

The script is called for example when a quit command is received by the GEIRS command (shell) interpreter.

EXIT VALUE

Always 0 (success)

NAME

geirs_roeDump.pl − dump the most recent contents of the ROE log file to standard output

SYNOPSIS

geirs_roeDump.pl [-t] geirs_roeDump.pl [-t] *instrument*

OPTIONS

The option -t suppresses the output of the time stamps at which the command was forwarded to the ROE, which provides a slightly more readable table.

instrument is the argument which is a string like Luci1, Luci2, Panic, Carmenes or Nirvana referring to the instrument. It is case-sensitive. If the argument is missing, the program reads from standard input.

DESCRIPTION

The command is a debugging aid for ROE pattern developers in the devel subdirectory of the source code. It prints the most recent contents of the entries downloaded to the ROE to standard output.

It does this by filtering the ROE log file for commands of the 7xx and 5xx family, not by actually reading the content of some online ROE. Therefore the command can also be used if the ROE is run in simulation.

Note that the script is not generally placed into the scripts directory of CAMHOME; therefore using a full path name or changing into the devel subdirectory is required to call it.

ENVIRONMENT VARIABLES

The variable CAMHOME must point to the top directory of the installation. The log file to be scanned is in $CAMHOME/log/ .

EXIT VALUE

Always 0 (success)

EXAMPLES

geirs_roeDump Luci1

geirs_roeDump -t Luci2

geirs_roeDump Panic

geirs_roeDump Nirvana

geirs_roeDump Carmenes

roelog=$(ls -1 $CAMHOME/log/*roe_Luc* | tail -1) geirs_roeDump.pl -t < ${roelog}

NAME

geirs_sndwinJ − open a sound configuration GUI

SYNOPSIS

geirs_sndwinJ [*instrument*]

OPTIONS

The command line argument is the name of the currently active instrument, like Nirvana, Luci1, Panic and so on. If the environment variable CAMERA is set, the command line argument is not needed.

DESCRIPTION

The GUI allows to enable or disable sounds for the GEIRS processing, to set the volume, and to assign sound files of the admin subdirectory to the set of distinct events that may trigger sounds.

The $HOME/.geirs/geirs.xml file saves the configuration when GEIRS is shut down and is read to initialize it when GEIRS is restarted.

SYNOPSIS

geirs_start

OPTIONS

The call does not have any arguments or options.

DESCRIPTION

This opens the JAVA GUI shown in the manual. The GUI should basically be filled in from top to bottom, starting with the camera for which GEIRS should be started. Most fields are entries that can either be selected or even edited after being selected.

The JAVA program scans a fixed predefined list of IP addresses and offers those that seem to be online for the ROE's Ethernet selection.

NAME

geirs_start_gen − GEIRS startup script

SYNOPSIS

geirs_start_nirvana [-iwin] [-gui] [-disp] [-cmd] [-data] [-ice]

geirs_start_luci2 [-iwin] [-gui] [-disp] [-cmd] [-data]

geirs_start_luci1 [-iwin] [-gui] [-disp] [-cmd] [-data]

geirs_start_panic [-iwin] [-gui] [-disp] [-cmd] [-data]

geirs_start_aip [-iwin] [-gui] [-disp] [-cmd] [-data]

geirs_start_carmenes [-iwin] [-gui] [-disp] [-cmd] [-data]

geirs_start_nteimg [-iwin] [-gui] [-disp] [-cmd] [-data]

geirs_start_nteisp [-iwin] [-gui] [-disp] [-cmd] [-data]

geirs_start_sc [-iwin] [-gui] [-disp] [-cmd] [-data]

OPTIONS

-iwin Opens the auxiliary intialization window

-gui Opens the controls GUI. This only makes sense for interactive use of GEIRS.

-disp Opens the GUI with the real-time image display of the pixels. Makes only sense for interactive use of GEIRS.

-cmd Starts the command server. Utterly important to run GEIRS, because this is the core command dispatcher.

-data Starts the data server. This is required if the real-time display is used or if data are requested via the ICE server.

-ice Starts the ICE server. Linc-Nirvana is the only instrument where ICE is installed on the mountain (and on nirva@irws2). In other environments ICE is probably not installed and the server not even compiled/available.

If the commands are used without option, the first five options are activated, and for Linc-Nirvana also the ICE server.

DESCRIPTION

Starts GEIRS for either LINC-NIRVANA, LUCI1, LUCI2, PANIC, AIP, CARMENES, one of the two NOT instruments or an (experimental) SIDECAR setup.

SEE ALSO

geirs_cleanup(1)

geirs_tempplot(1) General Commands Manual geirs_tempplot(1)

NAME
geirs_tempplot − Plot recent PANIC pressures and temperatures

SYNOPSIS
geirs_tempplot

OPTIONS
The call does not have any arguments or options.

DESCRIPTION
This command is only relevant to PANIC.

It opens a gnuplot(1) window and shows the approximately three last days of temperatures and pressures that have been collected with the crontab job installed with regular GEIRS installations of PANIC.

ENVIRONMENT
The enviroment variable CAMLOG should be the full path name of the directory with the panictemp.log file. If the variable is not set, the log file must be in CAMHOME/log.

GEIRS 1

geirs_wheelJ(1) General Commands Manual geirs_wheelJ(1)

NAME
geirs_wheelJ − PANIC filter wheel control GUI

SYNOPSIS
geirs_wheelJ *instrument*

OPTIONS
The mandatory command line option is the name of the instrument. This is always Panic here, because there is no other instrument where GEIRS controls motors.

DESCRIPTION
This opens the JAVA GUI shown in the manual, and is by default activated for PANIC. The GUI needs a running shared memory server to work with the motor configuration.

Each of the motor elements (filter wheels) can be moved individually to one of the named positions. The final line of the GUI allows to activate a parallel motion of all elements by selecting a name of a macro that has been configured in the **filter** file of the **admin** directory.

ENVIRONMENT
The enviroment variable CAMBIN must have a name of an existing subdirectory of one of the GEIRS installations. It usually has the format /home/user/GEIRS/trunk-rXXXM-YY/bin .

GEIRS 1

glogRotate.sh(1) General Commands Manual glogRotate.sh(1)

NAME
glogRotate.sh − Compress and remove old GEIRS log files

SYNOPSIS
glogRotate.sh

OPTIONS
none

DESCRIPTION
The files in the working directory which start with the ISO day indicator (format YYYY-MM-DD....log) and are older than 14 days are compressed with xz(1). In detail this concerns files with the format ????-??-??[cdrsQ]*.log and ????-??-??jitter_*.log which are the names used by GEIRS.

In addition, files with template names save_CA*.log and [pl]*temp.log, as they are still in use for PANIC's tracking of created FITS files and temperature/pressure log files, are spliced into files that start with the YYYY-MM-DD format to control growth of these log files. These are not compressed.

Files of the format ????-??-??*.log.xz, presumably created by earlier calls of the program, which are older than 2 years, are deleted.

The program is usually called from a crontab(1) entry with a syntax like

10 11 * * * export CAMHOME=${HOME}/GEIRS ; cd $CAMHOME/log ; ./glogRotate.sh 1>/dev/null 2>/dev/null

EXAMPLE
cd ${CAMHOME}/log ./glogRotate.sh

GEIRS 1

md_man(1) General Commands Manual md_man(1)

NAME
md_man − man

GEIRS 1

NAME

pipFits_bad − convert a bad pixel mask from ASCII to FITS format

SYNOPSIS

pipFits_bad [-4] [-v] [-R] *infile.txt outfile.fits*

OPTIONS

The option -v increases verbosity of the progress.

The option -R flags also pixels inside the reference pixel frames of H2RG or H4RG detectors as bad pixels. Without this option, reference pixels are not considered bad pixels.

The option -4 indicates that for the purpose of flagging reference pixels the detector is assumed to contain Hawaii-4RG chips. Without this option, reference pixels are arranged for Hawaii-2RG chips. The option is irrelevant if the option -R is not used.

DESCRIPTION

The file *infile.txt* specifies bad pixels in the ASCII format used by GEIRS as detailed in the GEIRS manual. The file *outfile.fits* is a FITS file that must not exist when the program is started and which will contain images equivalent to the bad pixels after the program is finished. A value of 0 denotes good pixels, a value of 1 bad pixels.

ENVIRONMENT

If the variable CAMINFO is set and if the *infile.txt* does not start with a slash, the file is assumed to be in $CAMINFO/ *infile.txt* .

EXAMPLE

rm badpix.fits ; pipFits_bad -R ~/GEIRS/INFO/badpixels.carmenes badpix.fits

NAME

pipFits_cube − computes difference of slices of a FITS cube

SYNOPSIS

pipFits_cube *infile.fits outfile.fits*

OPTIONS

DESCRIPTION

There are two mandatory command line arguments: The file *infile.fits* specifies an existing FITS file which contains an image cube in the primary header with at least two slices. The file *outfile.fits* specifies the name of a non-existing file that will be produced by the program.

The program computes *outfile.fits* which contains an image cube with the same dimensions as the *infile.fits* but one slice less than the *infile.fits*. The i'th slice of *outfile.fits* is the pixel-by-pixel difference of the (i+1)st and i'th slice of *infile.fits* .

ENVIRONMENT

EXAMPLE

rm diff.fits ; pipFits_cube inputf.fits diff.fits

NAME

pipFits_flat − subtract a polynomial fit from the CARMENES FITS images

SYNOPSIS

pipFits_flat [-l *lowpercent*] [-h *highercernt*] [-p *porder*] *fitsin.fits fitsout.fits*

OPTIONS

lowPercent is the lower percentile of the pixel data to contribute to the fit. If the value is not provided, 10 is used.

highPercent is the lower percentile of the pixel data to contribute to the fit If the value is not provided, 20 is used.

porder is the mixed order of the polynomial along the two image coordinates. If the value is not provided, a default of 2 is used, which means a fit to a polynomial of the form ..+..*x+..*y+..*xy+..*x^2+...*y^2 with 6 unknowns coefficients is computed. If the parameter is set to 0, a constant value is subtracted. If the parameter is set to 1 only a tip-tilt type of background is subtracted.

DESCRIPTION

The program reads the pixel values in *fitsin.fits*, computes for each of the two chips (i.e., image extensions) separately a histogram of these values, and discards the pixels that are not in the percent bracket of the two percentiles. The lower percentile should be large enough to discard the reset pixel regions; the upper percentile should be small enough to discard hot pixels and the pixels that are actually in the regions of the spectra.

A least squares fit of a bivariate polynomial of mixed order *porder* is adapted to the pixel in the percentile bracket separately for each chip spanning the two FITS axes. The value of the fit function is subtracted from each pixel across the chip independent of its original value. The resulting image has a flat (nearly homogeneous) field (bias) effectively removed. It is written to *fitsout.fits* (which must not exist when the program is called).

Note that using a large value of the -h option (larger than 50) will effectively disrupt photometry in the *fitsout.fits* image, because that means that the coefficient in the constant term of the fit is catching most of the average flux in the original image.

Note that using large values of *porder* is not recommended, because the result will show all the known ringing artifacts of polynomial fits.

EXAMPLES

rm tf.fits ; pipFits_flat -v -l 10 -h 90 -p 1 Linrty_No_six0087.fits tf.fits

NAME

pipFits_ls − collect FITS file names associated with a single exposure

SYNOPSIS

pipFits_ls [-M *Npairs*] [-s *skipct*] [-v] *fitsin.fits*

OPTIONS

-M specifies that in the list of time-ordered files only the first *Npairs* and the last *Npairs* are to be printed.

-s specifies that the first *skipct* files are not taken into account (skipped)

-v specifies that the set of files that is printed is the complement of the full file set with the common start time stamp, i.e., the files that are **not** taken into account.

DESCRIPTION

The exposure number is extracted from the header of the file *fitsin.fits* and all files in the same directory created with the same **read** are listed in a single line.

In detail, the *fitsin.fits* file is scanned for its START_INT header line. All files in the same directory created with the same start time and with a BITPIX=16 value in the first extension header (selecting GEIRS raw FITS frames) are listed in a single line.

If the option -M is used and sufficiently small, only the first *Npairs* and the last *Npairs* of the files are printed, and the file list contains an even number of files. The option therefore selects pairs of files out of a larger set in the manner of multi-end-point (Fowler) sampling of nondestructive infrared detector readout.

The value of the option hard-coded into geirs_carmen_pip is 10, which means a maximum of 20 raw frames will be considered for any further processing for nonlinearity and merger into a single image.

EXAMPLES

pipFits_ls ~/DATA/rrr0009.fits

pipFits_ls -M 4 ~/DATA/rrr0009.fits

NAME

pipFits_noise − Compute noise estimate from dark exposure images

SYNOPSIS

pipFits_noise [-m] [-v] *infile1.fits infile2.fits* [*infile3.fits* ...] *outfile.fits*

pipFits_noise -a [-m] [-v] *infile1.fits infile2.fits* [*infile3.fits* ...]

OPTIONS

-a indicates that the name of the output file should be derived from the name of the last input file in the argument list by adding a _N in front of the .fits .

-m indicates that not the noise but the mean of the input files should be computed. This is useful to estimate dark currents if the input files are dark exposures with variable sets of integration times.

-v indicates that some progress of the calculation should be verbosely printed to stdout.

DESCRIPTION

For each pixel *i* in the input files root mean squared noise parameter is computed (in ADU units). This means by 'peeking' at that pixel through the 'cube' of data of the k images, a mean(i)=sum_f pix[f]/k is derived, then a variance sum_f (pix[f]-mean)^2/(k-1), and then the square root of the variance. The pixel value in the output FITS file is set to that root mean squared value.

If the option -m was used, the pixel value in the output FITS file is set to the mean value of the pixel measured over the k files.

Note that the output is in ADU units and needs to be multiplied by the gain to derive a noise image or mean in the standard units of electrons.

A quick estimate of the median noise (over all pixels on the chip) is given by reading the PERCT500 keyword (50 percentile, median) from the primary header or extension header of the output file:

dfits -x 1 *outfile.fits* | grep -F PERCT500

NAME

pipFits_nonl − nonlinearity correction sequence of FITS images

SYNOPSIS

pipFits_nonl -c [-M *16bitcut*] *infile1.fits infile2.fits infile3.fits* [*infile4.fits* ...] *pipNonl.fits*

pipFits_nonl *infile1.fits pipNonl.fits outfile.fits*

OPTIONS

The option -c triggers creation of the output file from the sequence of input files.

The option -M defines an upper limit for 16bit raw ADU values to be admitted to the fit. If the option is absent, the default value is 65000. Only values smaller than 65535 are meaningful.

DESCRIPTION

The two different synopses refer to the tasks of (i) converting a sequence of calibration exposures with linear increase of integrated flux to a nonlinearity curve on one hand (very few times per year), or (ii) of **applying** such a nonlinearity curve to a science exposure on the other hand (essentially each time GEIRS is run with a best data reduction in mind).

Calibration

The call with the -c option creates the file *pipNonl.fits* by fitting the input files *infilei.fits* to a quadratic

polynomial over time. Since the fits have three unknown coefficients, the minimum number of input images is three and the minimum number of files in the command line is four. The *pipNonl.fits* will later on be used to correct nonlinearities of other exposures (without the -c option) and is therefore to be stored at some quasi-permanent place accessible by the pipeline.

Only input files with images with bitpix=16 (raw files) are admitted to the fit; the others are skipped to avoid mixing FITS files into the fit that appear already reduced (for example by a previous save command).

Application

The call without the -c option reads *infile1.fits* with images and uses the calibration file *pipNonl.fits* (which implies a nonlinearity model) to correct all pixels and to write the linearized values to *outfile.fits* .

EXAMPLE

The first example shows how a nonlinearity file n.fits is created from all fits in the current directory. For ten of them the nonlinearity is corrected and new files 001.fits up to 009.fits are created. The program fitsImg2Asc is then used to show the pixel value at pixel (400,400) in the first extension of the original file and in the corrected file.

```
rm pipNonl.fits pipFits_nonl -c -v *.fits pipNonl.fits
for (( f = 1 ; $f < 10 ; f++ )) ; do
   rm 00${f}1.fits ; pipFits_nonl Linrty_No_six00${f}1.fits pipNonl.fits 00${f}1.fits

   fitsImg2Asc -r '[400:401,400:401]' Linrty_No_six00${f}1.fits'[1]' | sed '/^$/d' ;

   fitsImg2Asc -r '[400:401,400:401]' 00${f}1.fits'[1]' | sed '/^$/d' ;

done
```

The second example takes all FITS files with even indices up to 0150 in some subdirectory and generates a nonlinearity file pipNonl.fits :

```
flist=`ls -1 2015-03-02/Linrty_No_six*.fits | grep -F -v 'six02' | grep -v '_six01[6789]' | grep '[02468].fits`'
rm pipNonl.fits
pipFits_nonl -c $flist pipNonl.fits
```


NAME

pipFits_ols − Ordinary least squares fit through a set of images

SYNOPSIS

pipFits_ols [-F] *infile1.fits infile2.fits* [*infile3.fits* ...] *outfile.fits*

pipFits_ols -a [-F] *infile1.fits infile2.fits* [*infile3.fits* ...]

OPTIONS

-a indicates that the name of the output file should be derived from the name of the last input file in the argument list by adding a _P in front of the .fits .

-F indicates that the FITS files should be ordered not by looking at the STOP_INT value in the primary header but at the FRAMENUM value.

DESCRIPTION

For each pixel in the input files an ordinary least squares fit is constructed using the time axis as the abscissa and the ADU file as the ordinate. Multiplying the slope with the integration time for that pixel and putting this value into an image, a single output file in a BITPIX=32 format is generated. The time stamps of the reads are taken from the STOP_INT keywords in the primary headers. The grid of these time stamps may be irregular; the function can fit data that are taken in clumps with Fowler-type selections, for example. (The function takes care of wrapping around time stamps if the exposure crossed UTC midnight where STOP_INT receives a kink of minus 86400 seconds.)

This fitted slope is meant to have an error (noise) which is roughly inverse proportional to the square root of the number of data on the time axis (i.e., of the number of input files).

Note that the minimum number of input files is 2. This means the program would work as well for data generated with the GEIRS lir readout pattern. (In this case, the fit becomes degenerate and is the exact linear interpolation between the two data points.)

Most of the FITS keywords in the output file are copied from the last input file, which is supposed to be the last one created in the bunch and therefore to have the most complete history of keywords. The keywords CREATOR, BSCALE, EXPTIME and so on are modified in the integrated image.

There is one case where sorting the input files by the STOP_INT values in the primary header does not work. This happens if the frames have been created with the **save -S** option, which puts the same STOP_INT time into each file's header. The linear fit for this arrangement would use the same abscissa for all pixel data; mathematically speaking this is equivalent to an attempt to fit a slope to a vertical data set and the user will see errors in the library that say that the data are linearly dependent. In this case, one can use the option -F to tell the program to arrange the files using the FRAMENUM value in the primary headers as the abscissa coordinate. The option -F is not needed for the frames generated as frame dumps while GEIRS runs, because these got individual STOP_INT data in their primary FITS headers.

5.6 Windows

5.6.1 Window Classifications and Nomenclature

GEIRS uses three basic types of windowing for a variety of different purposes:

1. Sets of sub-areas of the full frame detector images which are read from the detector and saved to the FITS files. The geometry is configured by the `subwin` commands to the command interpreter (Section 5.3). The underlying actions are that only sub-areas of the detector are read out, followed by some clipping of the resulting information by the GEIRS software. (What is created by the detector and readout hardware is called hardware windows and what is left in by the further reduction within GEIRS called software windows.) *This is what is usually meant by an infrared astronomer talking about subwindows!* This appears to be implausible: instruments with bigger and bigger cameras are assembled, why would one discard some of the information in the images? The dominant reasons are that

   - one can increase the frequency of image generation (Section 8.7), if the object quivers on some fast time scales, and/or
   - reduce the disk space consumption of the FITS data by discarding large empty areas of the detector that are of no interest.

2. Resetting some areas of the frames after each `read` while the (otherwise non-destructive) reads of multi-correlated readout modes are ongoing. This is only supported by Hawaii-2 RG detectors in conjunction with some of the MPIA ROE's (actually those of LUCI and CARMENES but not of PANIC) and will be called the subwindow reset mode. The interface deals with two aspects: First telling GEIRS where these windows are located in the FITS coordinate system in the detector plane,second telling GEIRS that the subsequent readouts should use the mode (command `ctype srre`, Section 5.6.2).

   In a vague sense this results in some opposite of the windows in the first item: the selected areas remain dark(er) than the rest of the images, whereas in the bullet above only the areas inside the windows remain visible.

   The main objective of this mode is to subdue brightly illuminated parts on the detector. One can prolong the integration time such that the (nondestructive) readout values of most of the pixels increases, but at the same time the pixels in the reset windows are often reset and do not saturate as they would otherwise. Overall this helps to increase the accessible contrast, and is typically used for spectroscopic modes (read: LUCI and CARMENES) with a small number of bright lines that can be sacrificed for the benefit of the others.

3. Saving some areas of the frames into scratch files while the non-destructive reads of multi-correlated readout modes are ongoing. This is implemented in GEIRS as a "software trigger" and shall be called the guide mode. This is configured with the `sfdump` command (Section 7.7).

   GEIRS started for CARMENES uses this to create snapshots of each read during the multi-correlated non-destrucive reads in preparation of its pipeline step that reduced these frames to a single image.

The general setup is that any mix of these three window clipping features with three different sets of windows is active/enabled. The current GEIRS patterns however do not support concurrent

operation with windows of the first two types, which means the corresponding pattern is not implemented.[40]

GEIRS does *not* provide what is commonly called the guide mode in the literature— where sub-regions of the detector are read out at a higher frequency than the full frame by interrupting the full frame readout a few times, reading the sub-area, and resuming the full frame readout—.

5.6.2 srre Readout Mode

Section 5.6.2 is of no relevance to PANIC or LINC-NIRVANA because either the detector or the ROE does not support this mode.

5.6.2.1 Principle of Operation On some MPIA readout electronics that control Hawaii2-RG detectors [13]— that is actually only CARMENES and LUCI now—the `srre` readout mode has been introduced. It is characterized by reading frames of the detector "non-destructively" while the detector is integrating, and resetting some of the pixels after each of these reads. This readout mode is activated with the `ctype srre` command (Section 5.3) and has the same global behaviour as the `srr` timing. The parameter of the `ctype srre` has the same meaning as for the `srr`; it is the number of reads and therefore also the number of resets distributed over the integration time at the end of the "ramp." If the integration time is 120 seconds, and the command is `ctype srre 7`, for example, every 20 seconds a frame is read and every 20 seconds the pixels inside the reset windows are reset.[41]

The difference between the `srr` and the `srre` (with resets) is that after each readout a finite subset of the pixels (called reset windows here) on the detector is reset. Consequences of this extended mode are that

- these reset windows never accumulate more light than equivalent to the time between two readouts, whereas the other pixels have much longer integration times that linearly rise from frame to frame. This points at the principal application of the mode: protection against pixel saturation, plus the beneficial side effects of less cross-talk and less persistence between exposures.
- in the standard linear fit of ADC value as a function of frame number through the samples within GEIRS that combine all the frame samples to a single image when calling `save`, the brightness of pixels inside the rectangles of the reset windows is essentially zero (because this is the slope through a time series of pixels that appear in each frame with approximately the same ADC values). An equivalent set of rather dark rectangular shapes of the reset windows is also visible if the frames are saved individually with `save -S...` or online with the `sfdump` configuration.
- The (minimum) integration time of the exposure increases roughly linear to the number of reset windows, needed for downloading and executing the resets sequentially. This prolongation is negligible in practise.

[40] As noted under 1. above, this is not useful for CARMENES. For LUCI it would make sense if the orientation of the slits would be predicted, but other factors like not considering disk space as a cost factor and not considering file transfer times across networks.

[41] Note the simple arithmetics: $N = 7$ reads corresonds to $N - 1 = 6$ intervals.

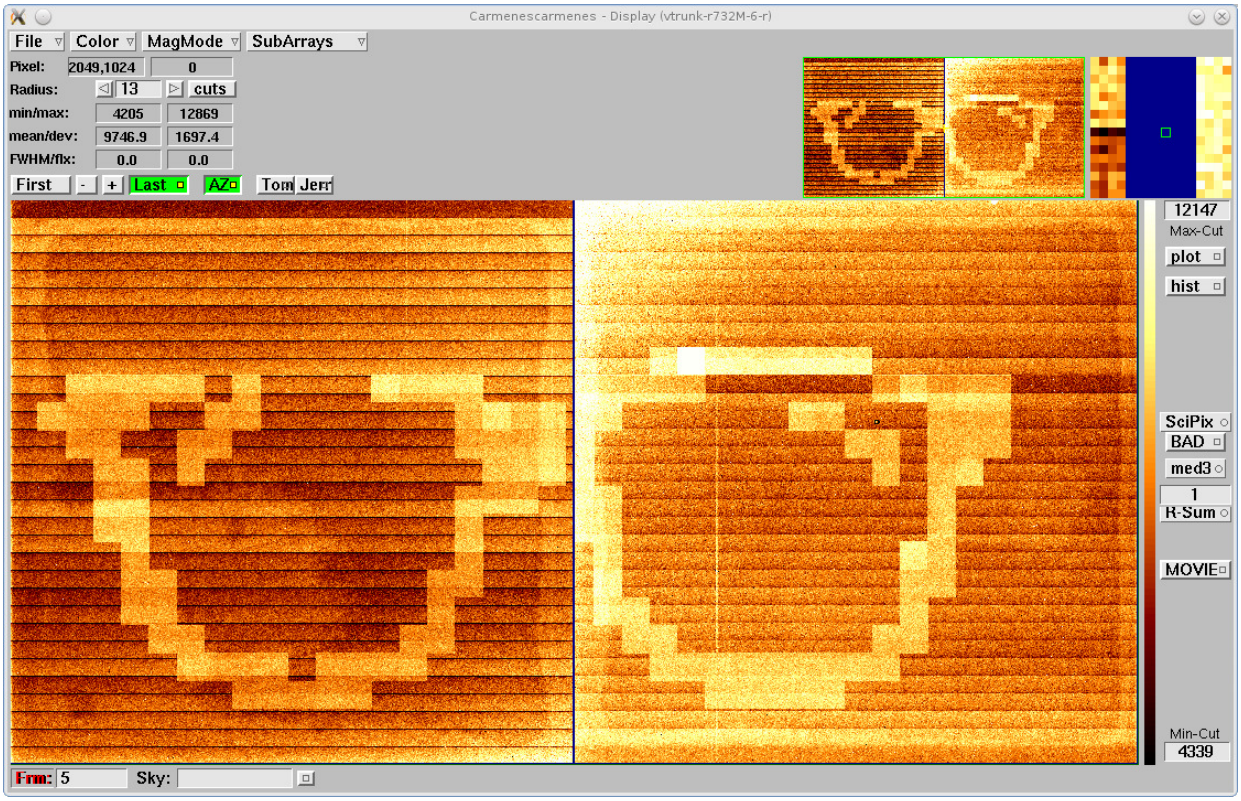


Figure 20: Example of a CARMENES exposure with 74 reset windows on the left and 68 reset windows on the right detector chip, each 102 × 102 pixels. This is the fifth frame in a ramp of five. Note that for dark exposures like this the pixels *inside* the reset windows are brighter than those *outside* due to the reset anomaly. This effect is ignored in the method, because the main effect is that the pixels *inside* the reset windows stay at that constant level and don't saturate —as explained in the main text.

5.6.2.2 Reads Parameter

The number of samples along the "ramp" is an integer

$$N \geq 2 \tag{3}$$

and a free parameter which is to be specified by the operator with the `ctype` command. There are some technical constraints, however, which set limits on N, and some interrelations with other parameters of the exposure:

- With the standard full-frame readout and at the standard pixel time of 10 μs (command `ptime`), reading once the detectors in the `srr(e)` modes needs slightly less than 1.4 seconds, a hard limit to the full-frame sampling frequency. Supposed the integration time I as specified with the `itime` command (Section 5.3) is set from the usual considerations on fluxes, readout-noise and so on, this trivially leads to

$$N - 1 \leq I/(1.4\mathrm{s}). \tag{4}$$

  A maximum of I in spectroscopic modes is defined by the allowable shift of the radial velocity (i.e., line wandering on the detector) due to Earth rotation-nutation, due to Earth ecliptic motion, changes in air mass and so on while integrating.

Figure 21: The CARMENES image generated by the linear fit through 4 frames (see Section 5.6.2.3) associated with Figure 20.

- The parameter N defines the number of frames that will be stored on the workstation which runs GEIRS. There is a finite amount of RAM R and an alternating buffer scheme in GEIRS which leads to a maximum amount of available memory of $R/2$ for a single exposure started with the `read`. [In fact this is set with the `CAMSHMSZ` parameter at startup (Section 3.2).] Let $N_d = 1$ or $N_d = 2$ be the number of chips in the camera for LUCI or CARMENES, respectively. Each frame demands $2 \times N_d \times 2048^2$ bytes in memory, and the obvious constraint is

$$N \leq \frac{R}{2 \times 2 \times N_d \times 2048^2}. \tag{5}$$

  Note that this number needs in addition to be divided by the cycle repetition parameter (`crep` in Section 5.3), if exposures are scheduled to follow immediately on each other.[42] For the CARMENES workstation we have $R \approx 32$ GB, and each raw frame needs $2 \times 2 \times 2048^2$ B $= 16$ MB. So a maximum of $32,000/2/16 \approx 1,000$ frames can be stored

$$N \leq 1000. \tag{6}$$

  Note that this is just a guess. The actual upper limit is usually smaller because GEIRS is hardly ever configured to require the entire RAM of the computer for the purpose of its own buffers. Because GEIRS automatically reduces a number of samples to the maximum supported by the configuration (see the `ctype` in Section 5.3), it is trivial to figure out that upper limit as follows: Either

[42] This is not relevant for the standard CARMENES operation because the `abort` command would terminate the entire sequence of exposures. So `crep` is almost always 1 here.

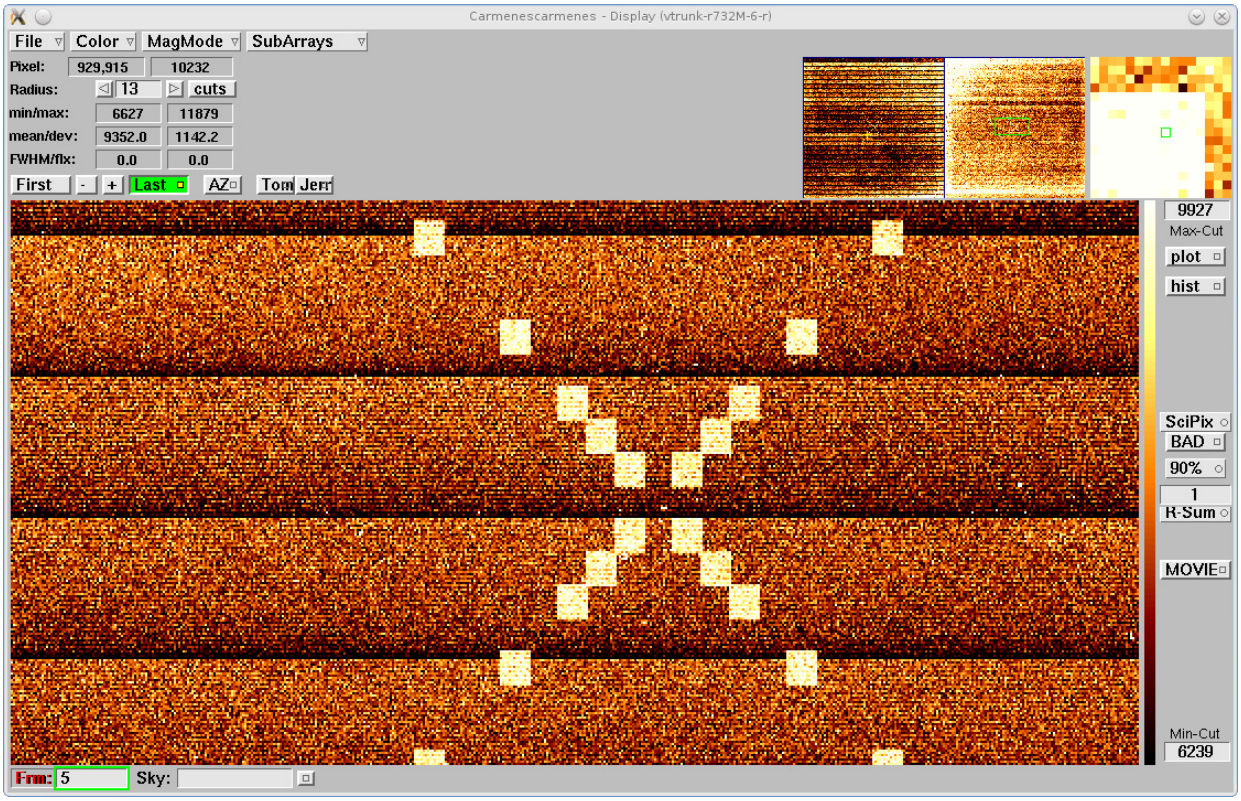


Figure 22: Zoomed view of an example of a CARMENES exposure with 14×16 reset windows on the right detector chip, This is the fifth frame in a ramp of five.

1. Send a `ctype` request with much larger number to the shell and read the result

   ```
   linux> geirs_cmd_carmenes ctype srr 10000
   Attention: Reads per cycle reduced from 10000 to 804 to fit into RAM buffer
   ```

2. or select the `srr` or `srre` mode and enter a much larger into the `#Reads` field in the controls GUI (Figure 9) and observe how that number is reduced within a second or two to the actual maximum.

- The fundamental idea of the `srre` mode is to clamp bright pixel regions. The parameter N defines not only the number of reads along the ramp; because the number of resets equals the number of reads, it also defines the number of resets along the ramp. Let I_s denote some estimated maximum integration time that can be tolerated for saturation and memory effects in the reset regions, then
$$N - 1 \geq I/I_s. \tag{7}$$

- Monitoring variations in flux, supposedly variable sky transmission due to cloud coverage, cosmics and so on proposes to set a maximum time difference between samples of the order of $T_c \approx 1$ minute. On that ground
$$N - 1 \geq I/T_c. \tag{8}$$

- The parameter N is implemented as some sort of delay between two scans of the ROE through the detector. From the point of view of the software on the workstation it leads to an arrival of N frames (less if `aborted`) at regular time intervals $I/(N-1)$ during the ramp. This gives

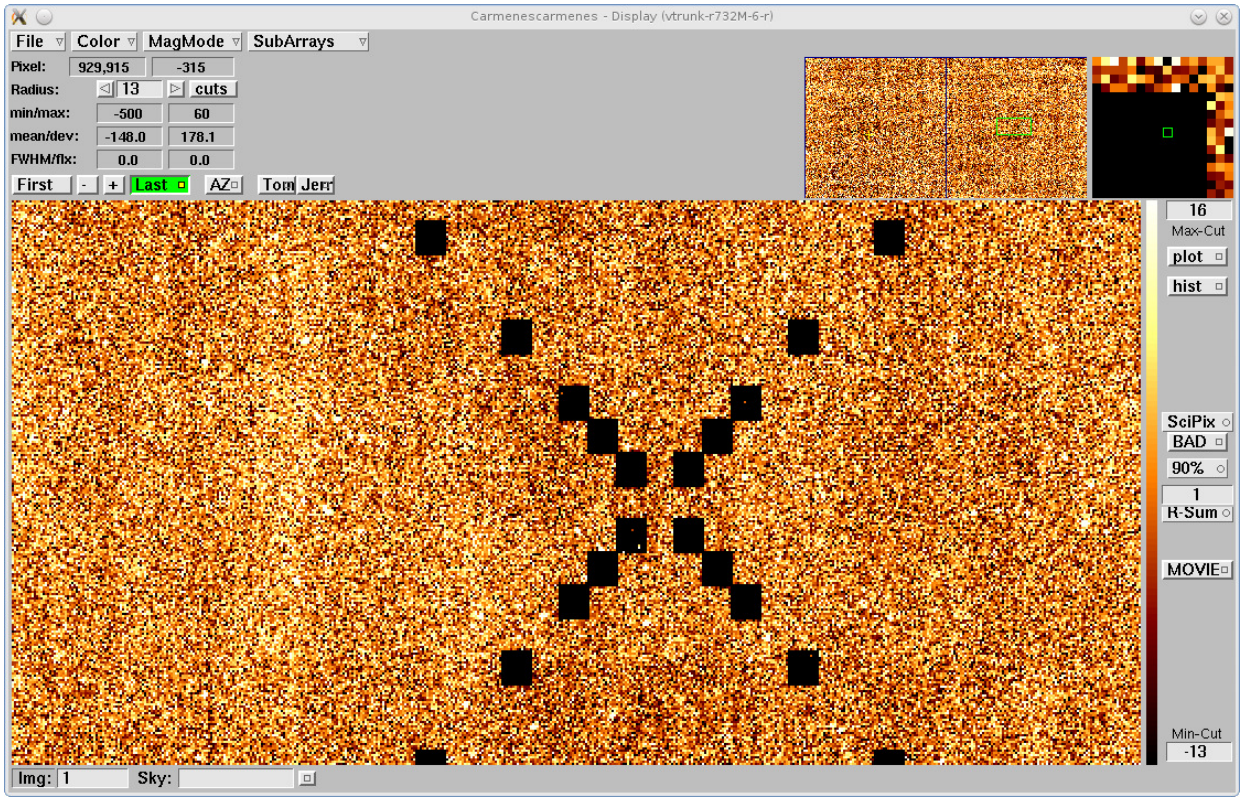


Figure 23: Image generated by the linear fit through 4 frames associated with the CARMENES Figure 22.

a strict constraint on the FITS data files that can be created, because data that did not arrive on the workstation cannot be `saved`. There is an explicit and an implicit method of saving the frames (which means, generating FITS files):

- The command `save` generates a single FITS file by calculating a least squares linear fit through (almost) all N frames of each pixel. The command has a parameter `-S` which allows also to save individually each of the N raw frames, and the command may be repeated to generate both, the "correlated" image and the set of raw frames (Section 5.3.) Note that the parameter N impacts both (i) the time that is needed for the `save` due to calculating the fits, and (ii) the disk space that is required for the `save -S`. If one would save for example all CARMENES raw frames obtained at the minimum period of the aforementioned 1.4 s, equivalent to a data rate of 16 MB /1.4 s$\approx$ 11 MB/s, the CARMENES disk space of 180 GB would be exhausted after $180,000/11$ s $\approx 16,000$ s ≈ 4.5 hours.

  Note that the command `save` has a functionality to trigger any type of pipeline code that may deal with the FITS files (*not* the raw frames!) in more detail than just fitting a straight line through the time.

- Because saving the probably large number of "fast" N frames is usally not needed and has some disadvantages detailed above, there is an online GEIRS mechanism (command `sfdump` in Section 5.3 and Section 7.7) which stores the frames on disk while the exposure continues. The configuration options explained in Section 7.7 allow to subsample the raw frames, i.e., to store only each second or each third etc. frame. This helps to avoid

the time and disk space overhead mentioned above, but does not support irregular frame subset picks.

Figure 24 illustrates how the integration time and the parameter N fix a time $I/(N-1)$ between the raw frames that are stored in the computer's RAM, and how a subset of these frames is dumped into FITS files for online monitoring.

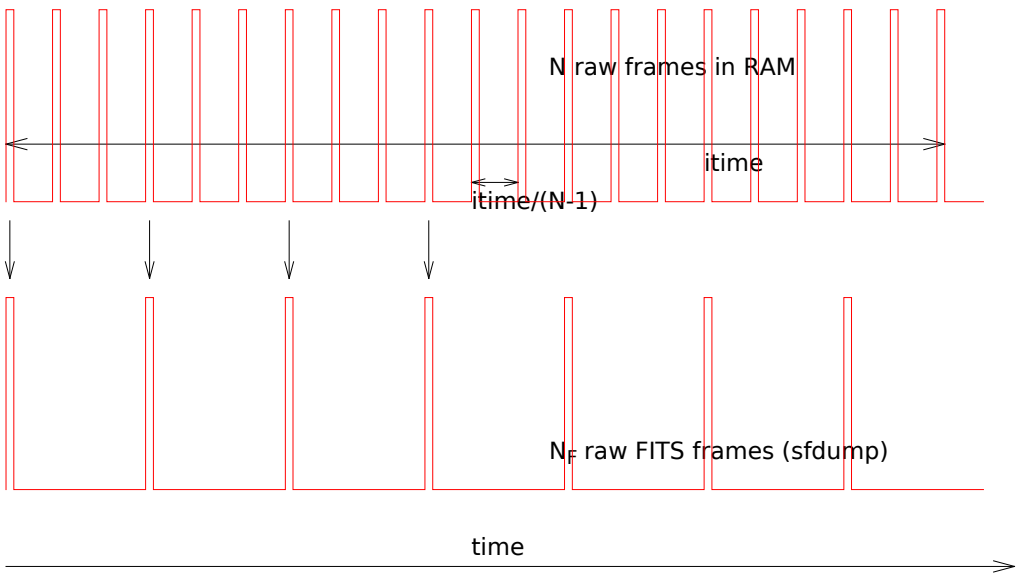


Figure 24: Upper plot: N raw frames at intervals $I/(N-1)$ in the computer's RAM. Lower plot: N_F FITS files generated from raw frames sub-sampled with `sfdump`, here with a sub-sampling factor of $s = 3$ in eq. (9).

5.6.2.3 Correlated Image The construction of a correlated image from the set of the frames is the same for `srr` and `srre`: An optional number N_d of first frames out of the N frames that have been read is ignored/dropped. For each pixel the standard linear least squares fit is generated individually through the $N - N_d$ frames that have not been dropped. (Such a fit needs at least two points on the time axis to draw a line, because one cannot fit a line through a single point to get a slope. Accordingly, if the number of frames that would remain is $N - N_d < 2$, these frames are not actually dropped but used to define the fit.) The slope of that fit is multiplied by the number of time slots along the ramp, which is $N - 1$, to calculate the count equivalent to the full integration time along the ramp. This number is stored in the FITS file for that pixel.[43]

The number of dropped frames is by default $N_d = 1$ with the current release of the software. It can be changed online with the `use` command; `use srr skip 0` for example would set $N_d = 0$ and hence incorporate all N frames in the fit for all subsequent exposures. `status use` shows the current parameters for all readout modes. The choice to ignore the first frame (the frame just after the reset) to define the ramp is a matter of experience with the frames for most of the detectors at the current mix of idle and read modes. Broadly speaking the reset frame is often too bright, even

[43] Actually the raw number is multiplied by N and the `BSCALE` keyword in the associated header is set to $1/N$ to compensate for that. This sort of adminstration improves the resolution of the integer data representation.

brighter than the second frame, although it represents a state of essentially zero integration time: there is some sort of memory persisting through the line resets. Since the primary application of the `srr(e)` modes comes with long integration times and values of N typically of the order of tens, ignoring one "bad" out of the these frames is basically no loss integration efficiency.[44]

The raw 16-bit sequential frames are storing the pixels data as they are (no further interpretation or nulling). This gives a pipeline (smart enough to deal with the noise and the shifting effective integration time as discussed in Section 8.8) opportunity to extract line shape information even at these places within the reset windows.

5.6.2.4 Configuration The number of these reset windows is limited to 128 per chip, which is a limit resulting from the number of reserved registers in the RoCon firmware (not the H2-RG). There is in addition an effective maximum of the total number of reset windows (i) on both chips of CARMENES of currently 137, and (ii) on the single chip of LUCI of currently 83, which are limits set by some "line length" of 256 words in the RoCon firmware and in the layout of the patterns. The current maximum is therefore set to 63 per chip if the source code is compiled outside the MPIA, but will not be more than 128 in the future.

The configuration of the number and location of these reset windows is done with GEIRS by modifying the readout pattern files associated with the `srre` mode in the `pttrns` subdirectory of the instrument currently in use. It is the operator's responsibility to

- define the pattern subdirectory that will be used. These are typically names like `Carmenes_-r6`, `Luci2_r42` and so on combining an instrument name and svn revision number. Because the information of the directory name to be used is actually hidden inside the startup script, and this is not scanned easily, the current procedure demands explicit knowledge of that directory's name.
- fill an ASCII file with the `srre` configuration (windows and auxiliary parameters) prior to the next call of a `read` in `srre` mode if this is different from the previous exposure. The set of windows in this file replaces any previously defined set of windows; old windows are forgotten. GEIRS does not remember the previous setup; in practise only the headers of old FITS files reveal old window sets via the `RESWN` keywords (Section 7). In that sense the new file contains a *complete* set for the next exposures. (There is no interface for an incremental replacement, deletion or increment of individual windows.)
- transform that ASCII file to five associated pattern files in the aforementioned `pttrns` directory with a call to `geirs_srreConfig` prior to calling the `read`. Note that the next `read` in the `srre` mode will then trigger an upload of a new pattern to the ROE and therefore need roughly 10 to 20 seconds (depending on network latencies, number of windows and so on) before the actual read process starts.

  Alternatively, one can append the configuration file name to the argument list of the `ctype srre` (after the number of reads) each time it has been changed. This generates the pattern files *and* loads them to the ROE.[45]

The configuration file looks like a FITS template file and contains lines of the following format:

[44] We plan to drop the first pair for the Fowler-Type of interpretations somewhen in the future for the same reason.

[45] This additional parameter makes possibly sense for LUCI where resolutions and masks are frequently changed. For CARMENES this is not supposed to happen because the window locations would change rarely, after earth-quakes or after exchange of the calibration sources.

- WIN[idx] = '[xstrt:xend,ystrt:yend]' A set of 1-based reset window specifications in the standard FITS syntax with ranges along the horizontal and vertical axis in the user's standard view of the images (i.e., including any optional modifications introduced by the `CAM_DETROT90` and `CAM_DETXYFLIP`, Section 3.2). 1-based means that the index of the pixel in the lower left corner of the coordinate system is at $(x, y) = (1, 1)$, as in FITS. The upper limits of the number for xend and yend in the coordinates are multiples of 2048, depending on how many chips are in the detector, and for non-square configurations like `CARMENES` again depending on `CAM_DETROT90` and `CAM_DETXYFLIP`. Ill-formatted specifications, like those where the quotation marks are missing or the xend is smaller than xstart or yend is smaller than ystrt or the entire window is outside the pixel coordinates of the chips, will be silently dropped.

  If a window stretches across more than one chip, it will only be recorded for the chip with the smaller x and y FITS coordinates—which in fact means that for CARMENES a window definition with `xstrt` ≤ 2048 and `xend` ≥ 2049 will define only a window on `SCA2`.

  GEIRS will also reduce the windows to fit into the active 2040×2040 inner region of the chips; reset pixels covering the reference pixels are filtered by the software.

  The letters after the `WIN` (shown as *idx* above) should be non-negative integer numbers, and each *idx* should occur only once (outside comments) in the configuration file. There may be holes in the index list. (So you might insert a `COMMENT` in front of the `WIN` to disable that window and do not need to edit the indices in the other lines in the configuration file.) You can fill these indices with zeros for readability: keywords like `WIN00`, `WIN0100` or `WIN8` are alright. Leading zeros in the *idx* are ignored, so `WIN09` and `WIN9` refer to the same window and override each other if they are in the same file.

  The numbers of reset windows on the different CARMENES chips may differ. For example there may be 4 windows WIN01, WIN08, WIN12 and WIN13 on either SCA1 or SCA2, and for example 6 windows WIN02, WIN03, WIN07, WIN11, WIN10 and WIN20 on the other.

  The FITS-style comments in the lines are *not* copied to the corresponding FITS header keywords in the images—at least not by GEIRS.

- DETROT90 = [integer] The same integer as used inside the startup script to initiate image rotations. If no such line exists in the configuration file, the default is taken from the shell environment variable `CAM_DETROT90` of the user who calls `geirs_srreConfig`. If this is also not set, the default is 1 for CARMENES and 1 for both LUCI's.

- DETXYFLI = [integer] The same integer as used inside the startup script to initiate image rotations. If no such line exists in the configuration file, the default is taken from the shell environment variable `CAM_DETXYFLIP` of the user who calls `geirs_srreConfig`. If this is also not set, the default is 2 for CARMENES and 1 for both LUCI's.

- NDET = [integer] Number of chips in the detector. If such a line is missing, the default is 2 for CARMENES and 1 for both LUCI's. This keyword supports tests where the software is not run with the full number of boards or chips; for the same reason the `NDET` environment variable may be set in the startup script and selected in the GUI of Figure 7.

- LINRES = [bool] If true, the implementation uses line resets for the reset windows. If false, the implementation uses resets in the global window mode. If this is not set (which is recommended), the default is true.

- KEYWOOD = blabla Any keyword like this one which is not in the list shown above is ignored.

- COMMENT blabla Lines to be ignored and merely serving as comments to the configuration. There may be more than one of these comment lines.
- # blabbla Lines starting with the hash are also ignored. This is a lazy version of COMMENT.
- ␣␣␣␣␣␣␣blabla Lines started with 8 spaces are also treated as comments.

All lines of these formats may be extended by a slash and further comments, which will be ignored by the parser build into `geirs_srreConfig`.

The keywords in the template header lines are converted to upper case before being checked. The interface is case-insensitive with respect to the keywords. This means for example that `Win81=...`, `wIn81=..` and `WIN81=...` are all specifying the same window; if that type of multiple re-definition happens in the configuration file, the coordinates in the latest lines (down in the file) survive.

The main differences between these FITS template files and real FITS header files are

1. FITS header lines are exactly 80 bytes long, whereas FITS template lines may be longer or shorter
2. FITS header lines are *not* terminated by line feeds or carriage returns, whereas FITS template lines *must* be terminated by line feeds
3. In the template files, the equal sign separating keyword and value is optional.
4. FITS header lines contain mandatory keywords, whereas that category does not exist in the template lines.

Examples of these files with names like `srreMask*` are in the `GEIRS`/*version*/`test` subdirectory of the GEIRS distribution.

The syntax of this configuration file is the same as the format of the configuration file of the `sfdump` command to the GEIRS shell (Section 5.3). Both files contain (i) a set of rectangular window geometries in the full-frame coordinate system, (ii) a small set of other keyword-value pairs and (iii) comments. Because the `sfump` and the `geirs_srreConfig` parsers ignore keywords that are not on their individual parameter lists, one may use a single, merged common configuration file at both places *if* one whishes to reset a set of windows after each `srre` read *and* to dump exactly the same set of windows after each read for monitoring purposes.

`geirs_srreConfig` is an executable in the Linux binaries, not a command of the GEIRS shell (!). It can actually be used even if GEIRS is not running, and it generally does not know which of the instruments supported by GEIRS (see Section 1.1) will be started by the Linux user. The syntax is

geirs_srreConfig -i *configfile* -p *infodir*

to translate an existing *configfile* to the five pattern files

1. *infodir*/`multi_win_res_coordinates`.*instru*,
2. *infodir*/`multi_win_res_init`.*instru*,
3. *infodir*/`multi_win_res_lay1`.*instru*,
4. *infodir*/`multi_win_res_lay2`.*instru*, and

5. *infodir*/`multi_win_res_pat`.*instru*

in the directory *infodir*. These five files are replaced/overwritten. *Never call this command before the current readout is finished and GEIRS has written the FITS files.*

Caution: while GEIRS is running there is one active pattern subdirectory selected at startup time—by default the subdirectory with the highest version number (see `CAMROE_REV` in Section 3.2). If the *infodir* parameter provided here is different, you will see no effect on the window coordinates in subsequent readouts, because the pattern files have been updated in a directory which is not used by the active GEIRS session. If GEIRS is actually running, one might ask it for its current pattern directory and feed this into the option:[46]

```
pdir=$(geirsCmd version -p)
geirs_srreConfig -i configfile -p ${pdir}
```

If GEIRS is not running, and your environment variables are correctly configured, the current directory is also available via the `geirs_patterns` command, for example

```
pdir=$(geirs_patterns luci1)
geirs_srreConfig -i configfile -p ${pdir}
```

There is a limit set to the number of windows within the software to ignore windows that would not fit into some layers of the detector FPGA of the ROE. `geirs_srreConfig` ignores the abundant ones (i.e., drops those that are late in the file) and says something like `imposing a ... limit ...` if it does this.

If *configfile* does not start with a slash, the full path name is `$TEMPDIR`/*configfile* if the environment variable `TMPDIR` is set, otherwise `$TMP`/*configfile* if either `$TMPDIR` or `$TMP` are set, and eventually just *configfile* (praying that this makes sense relative to the current working directory of the caller).

If *infodir* does not start with a slash, the full path name is `$CAMINFO`/*infodir* if the environment variable `$CAMINFO` is set, otherwise `$CAMHOME/INFO`/*infodir* if `$CAMHOME` is set, then `$HOME/GEIRS/INFO`/*infodir* if `$HOME` is set, and eventually just *infodir* (praying that this makes sense relative to the current working directory of the caller).

The maintenance of the `srre` configuration is quasi static:

1. As seen above, the configuration *is* represented by an existing set of files in the (active) pattern directory in the computer's file system. As long as nobody changes these files by either calling `geirs_srreConfig` or running the `ctype srre` command with a file argument or switching to a different version of the pattern directory or editing the files by any other method, the places and size of the reset windows remain frozen. Any `read` with the `srre` mode uses the windows defined through these pattern files at that time. There are differences regarding which `srre` windows are defined when GEIRS starts up:

   - For GEIRS versions up to 751M-14, one of the test patterns was loaded
   - For GEIRS versions from 751M-18 on, shutting down GEIRS saves the current pattern in the $TMPDIR directory and reloads it at the next startup.

   This persistence was introduced when it became obvious that the CARMENES NIR software often did not configure the reset windows before using the `srre` mode.

[46] This option is new since trunk-r752

2. The requirement to change these windows depends on (i) drifts in the optical setup of the instrument that may cause slow wandering of the spectral lines, (ii) on the necessity to subdue different line sets as a function of the different calibration lamps, (iii) modifications of the parameters for rotations and flips at GEIRS startup. All that is definitely not in the scope of the software manual.

3. The reset frequency is tight to the readout frequency and a consequence of the integration time and number of readouts of the ramp. Changing integration times or the number of readouts with the commands send to GEIRS does not require changing these pattern files. [Indeed the configuration file does not have timing parameters.]

5.6.2.5 Example From a driver's point of view, the scheme is

```
# create contents of srre.cfg by any means (shell, other programs,..., support routines)
echo "WIN1 = '[100:100,200:200]'" > $TMPDIR/srre.cfg
echo "WIN2 = '[700:710,200:200]'" >> $TMPDIR/srre.cfg
echo "DETROT90 = 2" >> $TMPDIR/srre.cfg
echo "DETXYFLI = 1" >> $TMPDIR/srre.cfg
...
```

and then use either

```
# update the pattern files in the pattern subdirectory
%geirs_srreConfig -i $TMPDIR/srre.cfg -p $CAMINFO/Carmenes_r9
cambuild=$(geirs_build)
geirs_srreConfig -i $TMPDIR/srre.cfg -p $cambuild/pttrns/Carmenes
# start exposure in srre mode
geirs_cmd_carmenes ctype srre 10
geirs_cmd_carmenes read
geirs_cmd_carmenes sync
geirs_cmd_carmenes save
```

or

```
# configure and start exposure in srre mode
geirs_cmd_carmenes ctype srre 10 $TMPDIR/srre.cfg
geirs_cmd_carmenes read
geirs_cmd_carmenes sync
geirs_cmd_carmenes save
```

5.6.2.6 Programming Model The following facts should be considered for software that uses GEIRS:

- The ROE keeps a single set of reset window (coordinates) at a time. Switching to another set of windows (with one of the two methods described above) costs typically 15 seconds, because this is implies constructing a new pattern and downloading it to the ROE.

- GEIRS optimizes downloading sets of reset windows as follows to minimize the aforementioned overhead:

  - a set of new windows is only downloaded if the source file on the computer has a modification date that is newer than the previous download time. If GEIRS starts up it downloads a default `srre` pattern — at the same time memorizing that as the previous download time.
  - a set of new windows is only downloaded if the next `read` is in `srre` mode.
  - the download is triggered with the `read` and with the `ctype srre` command. In particular the `read` will effectively start later (by the download time) if it observes that the current readout mode is `srre` and that the file in the operating system is newer than the recent download time.

  This conditions are all to be met at the same time to trigger a substitution of the reset window set.

- The ROE skips the actions related to the `srre` resets if the readmode mode is any other mode, like `srr` or `lir`. The ROE does not need to replace the reset windows in that case but has means to skip in a sort of subroutine manner the loop over the window resets. The set of reset window coordinates that resides on the ROE remains there in that case but stays idle/dormant until the readout mode is switched back to `srre`—which may trigger a replacement (new download) according to the conditions shown above.

In a typical use scenario of a spectroscopic camera, the reset window coordinates rarely need modification. So one needs to trigger a download of the reset window set only once (by replacing the configuration file with a newer file or at least using `touch(1)` to give it the appearance to be newer), and then one can efficiently switch these resets on and off by switching between the `srre` and `srr` modes. In that case there are no intermediate downloads, because the one in the ROE is always up-to-date with the time stamp of the file in the operating system.

If the reset window masks need a change for the next exposure, there is always that penalty of up to 15 seconds.[47]

In summary: it is useless and a waste of time to create and to maintain `srre` configuration files with zero windows.

5.6.2.7 Support Routines There is also an option to extract the brightest regions from a FITS image with the syntax

geirs_srreConfig -f *fitsfile* [-N wincnt] [-w width] [-h height] [-v] [-M] [[-r] -o *fitsofile*] > *configfile*

that reads the FITS image in the file of the `-f` option, employs a set of windows each as many pixels wide and high as specified by the `-w` and `-h` options, and extracts the brightest regions by a count delimited by the `-N` option, and dumps the coordinates of these windows to the standard output.

This call expects the image to be in the primary HDU of *fitsfile*; use the recipe of Section A.5.1 to prepare that format from other files.

The idea is that one can create the mask file for the reset windows in that semi-automated way in an enviroment where prediction of the bright spots is difficult because the optics configuration changes often and in hyperconvex parameter spaces. This primarily aims to deal with variable slit

[47] the timing depends on the load on the network that connects the workstation with the ROE, the number of reset windows and so on.

positions for LUCI, but clearly not spectral line positions for CARMENES. The program can also be used for semi-automated location of bright regions in some kind of simple astrometry for the other instruments,[48] if the *width* and *height* are chosen to match the typical FWHM of the PSF.

The option `-v` increases verbosity and lets the program report also the average ADU's in the computed subwidows. If the options `width` and `height` are missing, they default to 20. If one of the two width or height options is present and the other absent, the missing value will be set to the existing, resulting in square windows. If the option `-N` is missing, a default of 10 is substituted.

The option `-o` followed by the name of a FITS file (which must not yet exist, which means you need to remove it beforehand if the intent is to replace it) creates the *fitsofile* with a copy of the image in *fitsfile*, but with the regions of the windows wiped out by setting the values to zero inside the bright regions that are detected. This is basically a debugging option but may also be useful to remove bright regions in FITS images for example in search of ghosts. One may set in addition the `-r` flag which reverses/complements the set of pixels in *fitsofile*, which means, *fitsofile* shows only the pixels of *fitsfile* that are inside the bright regions.

The option `-M` uses not the integrated flux in rectangular regions but the median to sort them along brightness. This will slow down the calculation tremendously–the *wincnt* needs to be kept small—but has the advantage of sidelining hot or cold pixels to some degree.

Note that the coordinates may be off by factors of 2048 if single-chip images are evaluated in that way and used to configure multi-chip detectors like CARMENES. If a `DETSEC` specification is found in *fitsfile*, it will be used to shift the coordinates; `DETROT90` and/or `DETXYFLI` keywords in *fitsfile* will also be evaluated.

Also note that `geirs_srreConfig -f ...` just prepares the configuration file. It does *not* construct the pattern files that act on the forthcoming exposures. Therefore, in practise, a semiautomated application of the reset windows will always call pairs of `geirs_srreConfig`, the first with `-f` analysing a previous image, the second with `-i` and `-p` installing the new patterns. For CARMENES and for spectroscopy in general, there will at most be a handful of probably pre-selected reset window sets, because the location of bright spots on the detector depends only on a few parameters of the optical setup (the choice of calibration lamps, the option to rotate the entire detector by 180°,...)

In almost all cases the *fitsfile* will contain a full image, which means, not an image with darkened areas of the data by production with a previous `srre`. (There may be rare circumstances where deriving the reset window set recursively makes sense, starting with a full image, patching it with a finite cover of reset windows, deriving from that image the bright areas and patching this again...)

On a side note, this way of extracting the brightest pieces of an image could also be used to generate the configuration files of the `sfdump` command.

This invocation can only scan images in the primary HDU of the *fitsfile*;[49] if the image is in FITS extensions, it may be copied to a temporary file with that format through the `ftcopy` command of the heatools in the style of

```
ftcopy 'origfile.fits[SCA1_1]' tmp.fits copyall=no
```

or using the `pipFits_zech(1)` program with its `-P` option to merge the images in the extensions into a single image in the primary HDU, for example

[48] The disadvantage of the program to that purpose is that this will preferentially flag all the hot pixel regions because no support for bad pixel masks exists in the current version.

[49] this may change in the future

```
pipFits_zech -P car_measured.fits carTmp.fits
geirs_srreConfig -f carTmp.fits -N 70 -w 20 -h 40 -v > srreMask.cfg
```

Note that this does *not* upload any reset windows to anywhere, it just helps to get a first draft of the reset window coordinates into a file (here `srreMask.cfg`) of the correct format.

5.6.2.8 Disabling As a support for intermediate ROE versions that may not have firmware support of the reset window patterns, GEIRS runs through a set of decisions to consider the `srre` type supported or unsupported. If supported, the `srre` appears in the `Read Mode` submenue in Figure 9.

1. `srre` is not supported on Hawaii-2 detectors and not supported for PANIC.
2. `srre` is supported in all other cases unless all of the following is correct
   - The file `$TMPDIR`/*ip-address* exists, where the IP-address is the currently agitated readout-electronics.
   - There is a line in that file that sets the keyword `CANSRRE` to the value `F`. Note that this uses the FITS syntax for boolean values; in particular the `F` is *not* enclosed with quote marks.

In short that means that one can temporarily switch off the mode within GEIRS running LUC1 or LUCI2 on a ROE with the early firmware by adding the line `CANSRRE = F` with a text editor to the configuration file `$TMPDIR/192.168.0.24`.

5.6.2.9 Common SRRE Errors The most common errors using the `srre` mode encountered while GEIRS is used by external software or human operators are:

1. The syntax of the configuration file is wrong, for example the quotation marks are missing in the coordinate specification.
2. Warnings and errors reported by `geirs_srreConfig` are ignored.
3. `geirs_srreConfig` writes files that are read-protected from the account that runs GEIRS.
4. The files in the `INFO` directory are write-protected from the account that runs GEIRS, so `ctype srre` cannot update them.
5. The pattern directory specified through the `-p` option of the `geirs_srreConfig` is not the one used by the current GEIRS version. The result of such error is that GEIRS will not register that the configuration changed and will keep the old one.
6. The driver does not wait for the reply after the subsequent call of `ctype srre` or `read`. That means the driver ignores that `ctype` or `read`—whichever comes next—will need typically 10 to 20 seconds to complete. See Section 5.2.2.
7. `geirs_srreConfig` is called while `read` is executing, trying to reconfigure GEIRS during an exposure.
8. Too many windows are configured and the errors from the next `ctype srre` or `read` concerning the unavailable FPGA registers are ignored.

9. There is a misconception that calling `geirs_srreConfig` ensures proper configuration. In fact `geirs_srreConfig` just prepares some files on the Linux workstation; configuration of the ROE happens later during the next `read` or `ctype srre`.

10. The `subwin` command is used in conjunction with `ctype srre`. This is not supported with the current GEIRS version.

5.7 Tutorial

Basically GEIRS is commanded by a base set of about 10 commands: the read-save pairs and parameters that define integration time, number of repetitions of the readout cycle and the directory of the FITS files. Definitely all these simple tasks can be executed also with the controls GUI, Figure 9.

5.7.1 read, sync, save

If GEIRS has just been started up, some default values for the readout mode, integration time, output directory and FITS file name have already been set up. Here is the probably shortest command sequence to generate a single FITS file, which reads out the detector once if no `crep` as used earlier, waits until the frame data have arrived on the workstation, and saves the data (i.e., creates the FITS file):

```
read
sync
save
```

5.7.2 itime, ctype

The basic properties of the exposures are the integration time set with the `itime` and the readout mode (cycle type) set with the `ctype` command prior to one or more reads. The parameters do generally only need to be re-send if they should change; GEIRS remembers the current parameter set and applies it until parameters are modified. An exposure with a single-frame-read of 5 seconds (which is not saved) followed by an exposure of 5 seconds in the line-interlaced-read mode—which is saved in a FITS file— and then an exposure of 10 seconds in the sample-up-the-ramp mode with the default of 2 reads —which is saved in a FITS file—are induced by

```
ctype sfr
itime 5
read
sync
ctype lir
read
sync
save
sync
itime 10
ctype srr
read
```

```
sync
save
sync
```

5.7.3 crep, set savepath, next

The cycle repetition `crep` parameter triggers that the subsequent read commands are not creating a single image by reading the detector once (the default) but do this as often as the parameter says. The save path is the directory where new FITS files are created, and the `next` specifies a base name for creating indexed FITS files in the future.

The following sets the read mode to fowler pairs with 4 frames combined into a single image. The integration time (time between associated frames) is set to 5 seconds, and these quad-frames are read 6 times. The resulting 6 images are stored in the files `/dataA/2015-04-01/hah_0001.fits` to `/dataA/2015-04-01/hah_0006.fits` (if the directory exists or permissions allow to generate the directory):

```
ctype mer 4
itime 5
crep 6
read
sync
set savepath /dataA/2015-04-01
next hah_
save
sync
```

5.7.4 save multiple times, sample-up-the-ramp

The `srr` mode is used with an argument which sets the number of reads along a non-destructive read. The integration time which is set independently then defines implicitly the duration between two reads. In infrared astronomy, usually all frames along the time axis are also saved (for a later independent correction for nonlinearities, dark currents and so on). A total integration time of 60 seconds with 13 reads (therefore $60/12 = 5$ seconds between each read pair) saved into a file srr60_0001.fits with the linearly fitted image and the single frames saved into `srr60_0002.fits` up to `srr60_0014.fits` is executed by the sequence

```
ctype srr 13
itime 60
read
sync
next srr60_
save
sync
save -S
sync
```

If the `srr 13` at the start of this sequence is replaced by `srre 13`,the currently active set of reset windows is applied to each of the frames. So the 12 of the frames in `srr60_0003.fits` to

`srr60_0014.fits` have visible dark patterns where the reset windows have been placed. The first frame,`srr60_0002.fits`,is the one read immediately after the initial reset and does not have such an imprinted pattern.

5.7.5 subwindows,multi-extension FITS files

Three subareas of the detector are selected as windows to be read (the other pixels are discarded). 14 correlated double samples are put into stacks (FITS cubes) in each of the extensions in the next FITS file. Finally we create a another 14 images with the same integration time but reading the full detector and store it in the primary header of another file:

```
ctype lir
crep 14
itime 9
subwin sw 1 90 150 90 160
subwin sw 2 900 150 90 160
subwin sw 3 500 500 20 20
subwin auto on
read
sync
save -1 -M
sync
subwin off
read
sync
save -1
sync
```

6 LEVELS OF DEVICE SIMULATION

During the stages of instrument commisioning, or on computers which test aspects of interaction with the GEIRS servers or on computers where the ROE is already in use, GEIRS may be run in several levels of simulating parts of the hardware. Hardware in this context includes (i) the MPIA OPTCI board plugged into the computer, (ii) the small rack of the MPIA ROE in the warm but not far from the detector, (iii) a detector or some multiplexer (in the cold). For PANIC there is in addition a simulation of the telescope control interface, which is not explained here.

6.1 No Hardware

GEIRS may be run on a bare Linux computer without any of these pieces of hardware, usually called "full simulation." That is also applicable if any part of the hardware is already in use by other users, and shutting down their GEIRS sessions is not an option.

This is a typical scenario in early commissioning where communication of instrument control software with the GEIRS servers can be explored, and where (dis)agreement of the GEIRS FITS format with the local patterns of the home observatory is settled.

This environment is activated by using blank lines for all TCP parameters in the initalization GUI and any associated shell variables, and setting the detector ID to zero such that it is a-posteriori obvious in any FITS file headers that data do not refer to a real detector.

GEIRS will indicate that level of simulation by using yellow instead of green buttons at some places in the Controls GUI. The images are generated by using randomized star distributions with unrealistic photometry and basically randomized pointing coordinates. The timing will be slower in some cases than with the other levels of simulation, because GEIRS produces these images by computation, which puts additional burden on the computer's processors.

6.2 OPTPCI Present

This is the setup where at least one OPTPCI board is plugged into the computer, which is not in use by another user, and where GEIRS has been compiled including the PLX driver, and the driver has been loaded (Section 2.1.10). This includes the scenarious where no fibers are plugged into the OPTPCI board(s), or where the fibers are connected to a ROE which is switched off.

This setup is useful for basic tests of the OPTPCI integrity and to test that the PLX driver communicates with the board as expected.

This environment is started by using a fake `CAMPORT` IP address during startup; fake meaning there ought be no ethernet device there responding to `ping`. You may select for example the address of a ROE which is switched off, and/or should use an exotic port number in the range above 50000 where it's unlikely that any service is using that port.

The first command then send to GEIRS should be

```
rotype dgen 40
ctype sfr # to avoid getting computed correlated results
```

(usually typed into the interactive shell from the Controls GUI). The speed factor of 40 can be modified to mimick variable speeds of the data arrival. The followup `read` will generate images

with very characteristic patterns of stripes derived from the data generator (dgen) on board the OPTPCI. Typical examples are shown in [4].

To return from there to the level where a ROE is present and connected by fiber and properly responding to the IP address and port used at setup, you need to leave the data generator with

```
rotype plx
```

6.3 OPTPCI And ROE Present

This is a scenario where OPTPCI is present as in the level of simulation above, but also a MPIA ROE is plugged into the Ethernet reachable by the computer through valid setup of the computer's routing tables, and powered on (and therefore responding to `ping`), and connected via a non-swapped fiber-pair to (one of) the OPTPCI boards on the computer.

The startup ought use the correct full IP address of the ROE and correct pseudo-device names of the 2-digit `[012][01]` format for the fiber connectors of the OPTPCI.

There are two sub-scenarios:

- If the ROE (clocking, bias, video) cables are not connected, the images are basically responding to the low-level noise of the ADC's of the ROE. The *frames* are noisy homogeneous areas in the range of 32700 ADU's (but cuts in directions vertical to the channels ought to display clearly the 32 or 64 channels of the type of ROE in use), and with multi-correlated reads only images with noise levels of ±3 ADU's result.

  This is the most beneficial setup for DCS software development, because all the timing is the timing of the real instrument, all readout patterns are executed on the ROE, and there is no risk of mis-treatment of a valuable detector.

- If some cabling of the video channels to some flex-board with pre-amplifiers exist, flat homogeneous zeros will prevail, perhaps with the exception of a few pre-amplifier channels.

  This is a typical setup with test dewars without detector.

6.4 Hardware Complete

This is a scenario where OPTPCI and ROE are present as above, and the ROE's clocking, bias and video cables are connected to a detector (or multiplexer).[50] This is the instrument after commissioning.

In addition to the other levels of simulation it shows

- the characteristics of the detector (or multiplexer), including bad pixels, non-linearity, channel borders, cross-talk and so forth,
- any (infrared) background of the instrument or dewar,
- the choice of flipping and/or rotating the images in (dis)agreement with the predicted alignment of the detector axis with the rest of the optics and telescope by the optical and hardware engineers.

[50] This here is a software manual; we do not comment on risks of operating infrared detectors under various environmental conditions.

7 FITS OUTPUT

7.1 Illustrative Example

The primary FITS header generated by the stand-alone GEIRS is illustrated by the following example (extracted with dfits):

```
SIMPLE  =                    T
BITPIX  =                   16
NAXIS   =                    2 / 2
NAXIS1  =                 2048
NAXIS2  =                 2048
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
BSCALE  =                   1.
BZERO   =               32768. / [adu] real = bzero + bscale*value
BUNIT   = 'adu     '           / [adu]
MJD-OBS =         56610.398151 / [d] Modified julian date (TT) of DATE-OBS
DATE-OBS= '2013-11-14T09:33:20.2482' / [d] UTC date of end of first frame read
DATE    = '2013-11-14T09:40:59.0409' / [d] UT-date of file creation
UT      =         34400.248236 / [s] 09:33:20.2482 UTC at EOread
LST     =           46667.9276 / [s] local sidereal time: 12:57:47.928 (EOread)
ORIGIN  = 'Centro Astronomica Hispano Aleman (CAHA)'
OBSERVER= 'master  '
TELESCOP= 'CA-2.2  '
FRATIO  = 'F/08    '           / [1]
OBSGEO-L=            -2.546135 / [deg] telescope geograph. longit.
OBSGEO-B=            37.223037 / [deg] telescope geograph. latit.
OBSGEO-H=                2168. / [m] above sea level
LAMPSTS = '        '           / calib. lamp
INSTRUME= 'Panic   '
CAMERA  = 'HgCdTe (4096x4096) IR-Camera (4 H2RGs)'
PIXSCALE=                 0.45 / [arcsec/px]
ELECGAIN=                 2.01 / [ct] electrons/DN
ENOISE  =                  12. / [ct] electrons/read
ROVER   = 'MPIA IR-ROelectronic Vers. 3' / Version det. electronics
WPOS    =                    5 / [ct] number of GEIRS wheels
W1POS   = 'COLDSTOP22'
W2POS   = 'KS      '
W3POS   = 'OPEN    '
W4POS   = 'OPEN    '
W5POS   = 'OPEN    '
FILTER  = 'NO      '           / filter macro name of filter combinations
FILTERS = 'OPEN    '           / combination of all filters used (single OPEN)
STRT_INT=         33398.779494 / [s] '09:16:38.7795' start integration (UT)
STOP_INT=         34400.185113 / [s] '09:33:20.1851' stop integration (UT)
RA      =           216.863294 / [deg] R.A.: 14:27:27.2
DEC     =            42.714232 / [deg] Dec.: +42:42:51
EQUINOX =                2000. / [a] Julian Epoch
OBSEPOCH=          2013.866673 / [a] Julian Epoch
AIRMASS =             1.051181 / [1] airmass
HA      =           337.594738 / [deg] H.A. '22:30:22.74'
```

```
T_FOCUS =                  30. / [mm] telescope focus
CASSPOS =                   0. / [deg] cassegrain position rel. to NSEW
OBJECT  = 'no object'
FILENAME= 'Illum_srr30_300s_0214.fits'
DITH_NO =                    0 / [ct] dither step
EXPO_NO =                  235 / [ct] exposure/read counter
TPLNAME = '        '           / macro/template name
TIMER0  =                67145 / [ms]
TIMER1  =               932855 / [ms]
TIMER2  =            865710408 / [us]
PTIME   =                    2 / pixel-time-base index
PREAD   =                10000 / [ns] pixel read selection
PSKIP   =                  150 / [ns] pixel skip selection
LSKIP   =                  150 / [ns] line skip selection
READMODE= 'sample.ramp.read'   / read cycle-type
IDLEMODE= 'break   '           / idle to read transition
IDLETYPE= 'ReadWoConv'         / idle cyle-type
SAVEMODE= 'o2.single.corr.read' / save cycle-type
CPAR1   =                   50 / cycle type parameter
ITIME   =                1000. / [s] (on chip) integration time
CTIME   =          1001.370302 / [s] read-mode cycle time
CRATE   =             0.000999 / [Hz] read-mode cycle rate
EMSAMP  =                    1 / [ct] electronic multi-sampling
FRAMENUM=                   47 / of 50 saved
NCOADDS =                    1 / [ct] # of software coadds
DETSEC  = '[1:2048,2049:4096]' / [px] xrange and yrange of window
DATASEC = '[5:2044,5:2044]' / [px] xrange and yrange of science data
FRAMENUM=                    1 / of 1 saved
SKYFRAME= 'unknown '
DETSIZE = '[1:4096,1:4096]'    / [px] x-range, yrange of full frame
CHIPSIZX=                 2048 / [px] single chip pixels in x
CHIPSIZY=                 2048 / [px] single chip pixels in y
B_EXT1  =             2.299805 / [V] external bias 2355
B_EXT2  =             2.685547 / [V] external bias 2750
B_EXT3  =             2.685547 / [V] external bias 2750
B_EXT4  =             2.685547 / [V] external bias 2750
B_DSUB1 =             1.199785 / [V] det. bias voltage DSUB 2614
B_DSUB2 =             1.744141 / [V] det. bias voltage DSUB 3800
B_DSUB3 =             1.744141 / [V] det. bias voltage DSUB 3800
B_DSUB4 =             1.744141 / [V] det. bias voltage DSUB 3800
B_VREST1=             0.699951 / [V] det. bias voltage VRESET 1525
B_VREST2=             1.193359 / [V] det. bias voltage VRESET 2600
B_VREST3=             1.193359 / [V] det. bias voltage VRESET 2600
B_VREST4=             1.193359 / [V] det. bias voltage VRESET 2600
B_VBIAG1=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG2=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG3=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG4=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VNBIA1=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA2=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA3=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA4=                   0. / [V] det. bias voltage VNBIAS 0
B_VPBIA1=                   0. / [V] det. bias voltage VPBIAS 0
B_VPBIA2=                   0. / [V] det. bias voltage VPBIAS 0
```

```
B_VPBIA3=                  0. / [V] det. bias voltage VPBIAS 0
B_VPBIA4=                  0. / [V] det. bias voltage VPBIAS 0
B_VNCAS1=                  0. / [V] det. bias voltage VNCASC 0
B_VNCAS2=                  0. / [V] det. bias voltage VNCASC 0
B_VNCAS3=                  0. / [V] det. bias voltage VNCASC 0
B_VNCAS4=                  0. / [V] det. bias voltage VNCASC 0
B_VPCAS1=                  0. / [V] det. bias voltage VPCASC 0
B_VPCAS2=                  0. / [V] det. bias voltage VPCASC 0
B_VPCAS3=                  0. / [V] det. bias voltage VPCASC 0
B_VPCAS4=                  0. / [V] det. bias voltage VPCASC 0
B_VBOUB1=                  0. / [V] det. bias voltage VBIASOUTBUF 0
B_VBOUB2=                  0. / [V] det. bias voltage VBIASOUTBUF 0
B_VBOUB3=                  0. / [V] det. bias voltage VBIASOUTBUF 0
B_VBOUB4=                  0. / [V] det. bias voltage VBIASOUTBUF 0
B_REFSA1=                  0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA2=                  0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA3=                  0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA4=                  0. / [V] det. bias voltage REFSAMPLE 0
B_REFCB1=                  0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB2=                  0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB3=                  0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB4=                  0. / [V] det. bias voltage REFCOLBUF 0
TEMP_A  =               -9999. / [K] sensor A (-10272.15 C)
TEMP_B  =               -9999. / [K] sensor B (-10272 C)
PRESS1  =             0.000372 / [Pa] (3.720e-09 bar)
TEMPMON =                    8 / [ct] # of temp. 2013-11-14 09:00 monitrd loc. t
TEMPMON1=            73.740997 / [K] (-199.41 C) 2013-11-14 10:32 Sensor 1
TEMPMON2=            74.575996 / [K] (-198.57 C) 2013-11-14 10:32 Sensor 2
TEMPMON3=               74.069 / [K] (-199.08 C) 2013-11-14 10:32 Sensor 3
TEMPMON4=            73.061996 / [K] (-200.09 C) 2013-11-14 10:32 Sensor 4
TEMPMON5=           125.110001 / [K] (-148.04 C) 2013-11-14 10:32 Sensor 5
TEMPMON6=            76.603996 / [K] (-196.55 C) 2013-11-14 10:32 Sensor 6
TEMPMON7=            86.221001 / [K] (-186.93 C) 2013-11-14 10:32 Sensor 7
TEMPMON8=           123.300003 / [K] (-149.85 C) 2013-11-14 10:32 Sensor 8
CREATOR = 'GEIRS : rjm-r709M-s64 (Nov  8 2013, 17:33:58), Panic_r73M'
COMMENT = 'no comment'
OTKEYWRD=    'text'  / example of add. PANIC keyword
END
```

This is generated by running PANIC, because the number of keywords is roughly a maximum for this instrument . The outcome *is* different for other instruments.

Timestamps in GEIRS are time-zone aware, which means that the UTC timestamps of its FITS output are correct for any time zone activated on the computer.

GEIRS generates FITS images with 2 bytes per pixel when storing single frame data (created either through some single-frame read cycle type or by using the `-S` switch of the `save` command or from the single frame dumps of the guide mode), and images with 4 bytes per pixel for all the others (created by correlated cycle types). So the simplest filter for fishing for FITS files with correlated images in the local directories of CARMENES—assuming no data cubes were stored—is to select FITS files larger then 30 MB, for example:

```
find . -name "*.fits" -size +30M
```

because the single full frame files are slightly larger than 16 MB and the correlated full frame files

are sligthly larger than 33 MB.

7.2 Online Keyword Modification

Section 7.2 is irrelevant for CARMENES because there are no auxiliary FITS data on the NIR computer.

7.2.1 File-based Subscriptions

Instrument control software can funnel primary header keyword lines into the new FITS files by writing them into the `$TMPDIR/geirsPhduAdd.`*instrument* file before the FITS file is generated with the `save` command. The meaning of `TMPDIR` is the environment variable of the observer that started GEIRS, and if not defined `$HOME/tmp`.

(For the two LUCI branches the *instrument* is already ending on either *1* or *2*. This number is not the index i used here.)

Here i is a small integer from 1 to 6. The effective line set is the concatenation of the lines in these files in the natural order, as if first `geirsPhduAdd.`*instrument*, then `geirsPhduAdd.`*instrument*_1, etc and finally `geirsPhduAdd.`*instrument*_6 was acting on the raw default FITS headers. Having a range of six files at the disposal allows multiple subsystems to update or to erase these files with different frequencies.

Instrument control software has at least 3 different options to modify the FITS keywords:

- the letterbox variant of Section 7.2,
- sending `fits` commands to the command interpreter, see Section 5.3
- triggering its own FITS merger tools in any pipeline script, see Section 3.3.

7.2.1.1 PANIC convention

The current convention is that

1. `$TMPDIR/geirsPhduAdd.`*instrument* is manipulated by online tools, [14]
2. `$TMPDIR/geirsPhduAdd.`*instrument*`_1` is reserved for the `geirs_lamp.sh` output (Section **??**),
3. `$TMPDIR/geirsPhduAdd.panic_2` for any further generic cleanup within GEIRS;
4. `$TMPDIR/geirsPhduAdd.panic_3` is reserved for infrequent long-term logging and event data [15].
5. `$TMPDIR/geirsPhduAdd.panic_5` is reserved for logging of meteo data with `geirs_ambiPhdu.sh`.

7.2.1.2 Linc-Nirvana convention

1. `$TMPDIR/geirsPhduAdd.nirvana_1` is used to adapt the GEIRS conventions to some quasi-conventions of the LBTO;
2. `$TMPDIR/geirsPhduAdd.nirvana_2` are keywords collected by the Python BASDA script on `lircs`;

3. `$TMPDIR/geirsPhduAdd.nirvana_3` is constructed by the initialization window filled in at startup time, Figure 7.

4. `$TMPDIR/geirsPhduAdd.nirvana_4` contains IIF keywords. It contains snapshots of a subset of the values of the IIF dictionary and some entries of the `config/ltcs/lts.iif-dev.cfg` configuration file with telescope operator names and the like. The file is created by the `iif` instance—which usually runs on `lsys.linc`—, which polls the keywords controlled by the configuration `lnsw/config/lbcs/lbcs.iif-fits.xml`.

5. `$TMPDIR/geirsPhduAdd.nirvana_5` duplicates RA and DEC as equivalent WCS keywords.

7.2.1.3 LUCI convention

1. `$TMPDIR/geirsPhduAdd.luci2_1` and `$TMPDIR/geirsPhduAdd.luci1_1` clean up superfluous GEIRS keywords and boost them to hierarchical keywords, and

2. `$TMPDIR/geirsPhduAdd.luci2_2` and `$TMPDIR/geirsPhduAdd.luci1_2` are manipulated by online tools to add the telescope, motor, temperature and optics configuration. These two files are linked to `fitsheader_lucifer.txt` for backward compatibility of older configurations at GEIRS startup time.

7.2.1.4 CARMENES convention `$TMPDIR/geirsPhduAdd.carmenes_5` is used by GEIRS to push its keywords to the hierarchical format and to clean up keywords related to instrument control software.

7.2.1.5 NTE convention `$TMPDIR/geirsPhduAdd.`*instrument*`_1` is used by GEIRS to clean up keywords related to instrument control software.

7.2.1.6 Timing In general GEIRS cleans up these files each time it is started up, because some online tools forget to erase their associated files when they are shut down; this would leave obsolete contents in these files if GEIRS is afterwards started as a standalone program which then erroneously pile up in FITS headers.

For PANIC, however, the files `$TMPDIR/geirsPhduAdd.panic_3`, `$TMPDIR/geirsPhduAdd.panic_4`, and `$TMPDIR/geirsPhduAdd.panic_5` are preserved during startup.

This mechanism is not synchronized; GEIRS reads the contents of the `geirsPhduAdd` configurations and edits the FITS header according to their instructions just before composing the FITS file. It does not care which software created the files and how old they are.[51] Obviously there is some risk of loosing information if the frame rate exceeds 1 Hz and the supervisor software updates that `geirsPhduAdd` file at a similar frequency. If the instruments needs more precise control which additional header lines are merged into the FITS files, these are the choices of synchronization:

1. Create the `geirsPhduAdd.*` files within one of the hook scripts associated with the `start` or `save` (Section 2.5.4); [LN for example uses `scripts/QueueAFiles`, "triggered" at the start of each `save` command, to create `$TMPDIR/geirsPhduAdd.nirvana_2`. The mechanism

[51] It is advisable that the generators of these files add UTC time stamps into the comment fields of these header lines so one can decipher a-posteriori whether the services that generated them have died, for example!

assumes that at GEIRS startup a `basdard` has been activated which writes (unsupervised, asynchronously) temperature and pressure data from the various cabinets into a file set in `$TMPDIR`.]

2. Create the `geirsPhduAdd.*` files by the observation software between sending `start` and `sync ; save` to GEIRS;

3. Install an archiver script in `QueueFiles` which takes the FITS file just produced by GEIRS, and adds more information by modifying that FITS file to define its "archived" form. The advantage of this methodology is that the information may be gathered by retrieving it from online databases or freely formatted file types which may be entirely independent of the ASCII format of the `geirsPhduAdd.*` files.

   Obviously this should to be the standard: A detector control software like GEIRS should *not* be in charge of feeding telescope or environmental or motor positions information into the final FITS files.

The functionality with the fedithead syntax (see Section 5.5) is available: The `geirsPhduAdd` files can remove, replace and add keywords of the forthcoming FITS header all in one step. A set of proposals for such configuration files on a per-instrument basis is in `$CAMHOME/`*branch*`/admin/geirsPhduAdd.*` in the source code. A use case example for LUCI is the keyword `PIXSCALE` that is in the standard list of GEIRS header keywords (Section 7.4). Because GEIRS never knows the position of the camera wheel, it cannot fill in that value reliably; consequently the `geirsPhduAdd.luci1_1` and `geirsPhduAdd.luci2_1` contain a line that deletes the `PIXSCALE` keyword—and leave it to any of the other `geirsPhduAdd` files to refill the keyword and value.

7.2.2 `fits` Command

The keywords added with the `fits` command of Section 5.3 are piped through the same file-based mechanism by using the file `$TMPDIR/geirsPhduAdd.`*instrument*`_6`. So that file with index 6 is reserved for that purpose and not to be used by any other software. It is effectively rewritten just before each `save`. Because it is the last in the list, these keywords are not rewritten with the methods in the files with the smaller indices. (This does not harm because the individual instruments are supposed to know which local conventions are in place when using the `fits` command.)

7.3 Optional Cleanup

The most important aspect of this list of keywords is that, although GEIRS has no information on the telescope pointing and status in the LBT, CARMENES, AIP or NTE environment, it has inserted information on the primary star coordinates (`RA`, `DEC`) and a set of derived information, including `ALT`, `AZ`, `PARANG`, `HA`, `AIRMASS`, and `OBJECT`. This behavior is actually triggered by starting the software setting the telescope control system to the `offline` mode (Figure 7). All of this information is a consistent but randomly simulated and invalid set of data and needs to be removed/replaced by a software that has this information. For LN, this layer of the software would use the IIF of the TCS.

A second set of telescope and optics related variables which is not useful in the LBT context consists of `WPOS`, `FILTER`, `FILTERS`, `T_FOCUS`, `TEMP_A`, `TEMP_B`, `PRESS1`, `PRESS2`, all of which stem from CAHA methods *and all of which should also be deleted unless the instrument is PANIC.*

Another set of potentially useless data are the detector voltages set to 9999 V which are templates created for cameras with Hawaii2-RG or Hawaii-4RG detectors, and also to be removed/ignored for the LN case.

Another task is to translate the remaining keywords to match any particular FITS dictionary applicable to the instrument or observatory.

This cleanup and translation is typically done by putting the keywords to be deleted and to be translated into a configuration file and calling a translator like fedithead in some sort of pipeline stage. This may be customized by calling the translator from within the shell script `$CAMHOME/scripts/QueueFiles` that is called by GEIRS for each new FITS file that is created. If the keyword-value pairs are already known at the end of the exposure, the method of Section 7.2 is also applicable (and more efficient) to modify the primary header keywords.

7.4 GEIRS Core Keywords

Some keywords remain after the purging mentioned above; there are FITS mandatory keywords concerning the image dimensions and bits-per-pixel format [11], plus the following:

- `MJD-OBS =  56433.495665 / [d] Modified julian date (TT) of DATE-OBS`

  This time refers to the same time as the DATE-OBS. For CAHA instruments it is converted from the UTC to terrestrial time (TT); for LBT instruments is remains a UTC time because another keyword is used which flags that times are in UTC [16]. Accuracy of this value depends on running a reasonably recent GEIRS such that the leap seconds are known in the (external) SOFA library.

  Note that the CARMENES ICS overwrites this keyword such that it gets a different meaning unrelated to GEIRS.

- `DATE-OBS= '2013-05-21T11:53:45.4834' / [d] UTC date of end of first frame read`

  This rephrases `STRT_INT` and is a close approximation to the start of integration.

- `DATE    = '2013-05-21T11:54:17.5317' / [d] UT-date of file creation`

  `DATE` is just mentioned for completion. Following the FITS standards, this time stamp will be updated and overwritten each time some other layer of the software modifies the images or keywords, so it has essentially no significance to astrometric data reduction.

- `UT      =  42825.483405 / [s] 11:53:45.4834 UTC end of first frame read`

- `LST     =  73883.640000 / [s] local sidereal time: 20:31:23.640 (EOread)`

  The value of the local sidereal time is to be considered an estimate based on the observatory coordinates at the end of the readout. Effects of nutation and so on are completely neglected [17, 18].

  For LN, the keywords **UTC**, **LST**, **HA** and so on are just copies from the TCS polled by the LTCS subsystem at times that are not correlated with the GEIRS exposures; this explains jitters between their time scales and internal sky-related data emitted by GEIRS.

- `ORIGIN  = 'Mount Graham, MGIO, Arizona'`
  `TELESCOP= 'LBT'`
  `FRATIO  = 'F/15'  / [1]`

```
OBSGEO-L=          -109.889000 / [deg] telescope geograph. longit.
OBSGEO-B=            32.701300 / [deg] telescope geograph. latit.
OBSGEO-H=          3221.000000 / [m] above sea level
OBSCOD  = 'G39'                / Minor Planet Center Observatory code
```

These keywords related to the name and location of the observatory are hardcoded in the software. The `OBSGEO` keywords comply with the proposal on WCS coordinates [19]. Three additional keywords `OBSGEO-X`, `OBSGEO-Y`, and `OBSGEO-Z` will be created if the preprocessor variable `GEIRS_FITS_OBSGEOKW` is defined at compile time. This is switched off by default.

- `OBSERVER= 'mathar'`

  This is equivalent to the most recent `observer` command received by GEIRS (Section 5.3) or submitted with the start-up GUI, Figure 7.

- ```
  INSTRUME= 'Nirvana'
  CAMERA  = 'HgCdTe (2048x2048) IR-Camera'
  OPTIC   = 'very high res.'
  PIXSCALE=             0.005110 / [arcsec/px]
  ```

  These keywords are constants hardcoded in the software.

- ```
  EGAIN=             2.010000 / [ct] electrons/DN
  ENOISE  =            14.000000 / [ct] electrons/read
  ```

  Electronic gain and noise are hardcoded constants. This noise generally refers to the `lir` read mode . For PANIC's `rrr-mpia` mode however, a separate set of these 2 parameters for each of the 4 chips has been measured, so these 8 parameters are copied into the header cards when PANIC is in fact using that readout mode. The noise in the actual FITS images is a function of (amongst others) the readout modes, electronic sampling etc as surveyed in [20]. For instruments with more than one detector chip, both keywords are adorned with 1-based integers: `EGAIN1`, `EGAIN2` and so on.

  For LN these keywords are those of the original Hawaii-2 detector, not the ones of the previous LUCI detector that was installed during COM-6. (That detector has never been calibrated with the suite of detector voltages that are used. . .)

- `ROVER   = 'MPIA IR-ROelectronic Vers. 3' / Version det. electronics`

  A (rough) characterization of the MPIA readout electronics. The FPGA program versions are not reported in the header.

- ```
  STRT_INT=         42822.774880 / [s] '11:53:42.7749' start integration (UT)
  STOP_INT=         42825.483222 / [s] '11:53:45.4832' stop integration (UT)
  ```

  These two UTC time stamps are the most accurate timing information available for astrometry in any follow-up pipeline. `STRT_INT` measures time when the first frame has arrived on the workstation, and is very close to when reading the first frame was completed on the ROE, see Section 8.8. The `STOP_INT` is slightly earlier than the end-of-read time stamp in `UT`.

- `EQUINOX =                 2000. / [a]`

  Julian year of the RA and DEC information and of the data acquisition.

  Note that the precision of 1×10^{-6} years in the numerical value of a year is only equivalent to ≈ 30 seconds.
  ```

- `POINT_NO=  0 / [ct] pointing counter`
  `DITH_NO =  0 / [ct] dither step`
  `EXPO_NO =  1 / [ct] exposure/read counter`

  The three numbers are modified by the `counter` command (Section 5.3). The intent of the `POINT_NO` and `DITH_NO` variables is to keep track of dithered (nodding) imaging with imaging optics. It is entirely up to the software/operator that drives GEIRS whether these two may differ from zero.

  The regular update of `EXPO_NO` if not intervened by such commands is to start at one as GEIRS is started, then to increase by one for each `read`—where it does not matter if the FITS file name is changed in between. If the cycle repetition factor is chosen larger than one (`Repeat` in Figure 9 or command `crep` in Section 5.3), the `EXPO_NO` is the same in all the individual files that are created.

- `FILENAME= 'normal0003.fits'`

  The filename of the FITS file in the local file system of the detector workstation as requested by the observer.

  If the source file `geirs_save.cxx` is compiled with the preprocessor option `GEIRS_CREA_SAVE_LINK` defined, a link from the file given by `FILENAME` to a file with canonical name derived from `STRT_INT` is created at run time. This may facilitate robotic archival software and even be a trivial form of overwrite protection, but has been disabled by default because —in the eyes of the principal GEIRS developer–links may confuse operators with little knowledge of UNIX-type operating systems.

- `TPLNAME = ''  / macro/template name`

  Name of the macro file (Section 5.4) if applicable. Empty if the observation was driven on a command-by-command basis.

- `TIMER0  =  2667 / [ms]`
  `TIMER1  =  2667 / [ms]`
  `TIMER2  =  0 / [us]`

  Three time intervals that help debugging the GEIRS timing.

- `PTIME  =  1 / pixel-time-base index`
  `PREAD  =  10000 / [ns] pixel read selection`
  `PSKIP  =  150 / [ns] pixel skip selection`
  `LSKIP  =  150 / [ns] line skip selection`

  Four parameters that detail in which way the fundamental clock of the ROE was subdivided to drive some basic actions on the detector chip.

- `READMODE= 'line.interlaced.read' / read cycle-type`
  `IDLEMODE= 'wait'  / idle to read transition`
  `IDLETYPE= 'ReadWoConv'  / idle to read transition`
  `SAVEMODE= 'line.interlaced.read' / save cycle-type`

  These four parameters define the reset-read pattern of gathering the frames, how the read-out electronics clocks the detector while no data are taken, and in which way the frames send from the ROE are packed into FITS images (by averaging, subtracting, fitting. . .) by GEIRS. See [5, 20].

The `READMODE` defines the scheme of patterns and timings in use while the frames were generated by the detector and ROE and arrived on the workstation. The value of `SAVEMODE` may be different if the mode was changed (either via the button labeled `Read Mode` in Figure 9 or with the `ctype` command or by using the `-S` option of the `save` command) before executing `save`. In this case the packaging of frames into files of FITS images (by subtraction, averaging...) is modified by the `save` procedure and departs from the "standard" associated with the read mode. [The software allows to save the same set of frames more than once and switching the mode without any intermediate `read`. This is helpful if one wants to store correlated images but also the bare frames for debugging purposes.]

- `CPAR1 = 1 / cycle type parameter`

  This is the integer parameter given to the `ctype` command (Section 5.3), basically the number of frames that are correlated in the multi-correlated modes (Fowler, sample up the ramp...) [21, 22]. The value is actually a filtered version of the command in case that the associated `save`-mode does not support a variable parameter.

  If the integration along the ramp was disrupted with the `abort` command, the value is still the one that was scheduled when the `read` started, not the (smaller) number of frames that were actually read.

- `ITIME = 2.667059 / [s] (on chip) integration time`

  The scheduled integration time. The actual integration time may have been shorter if the exposure was aborted (see `EXPTIME`). If the `read` obtained more than one image (as set by the `crep` command), the integration time is still the integration time of the individual readout, not the accumulated sum over all exposures triggered by that `read`.

  For multiple-endpoint readout modes, the integration time is the time between each correlated pair. The actual time between the first and the last frame is longer by a time proportional to the number of pairs (see `CPAR1`)—but this is obviously not relevant to the photometry.

  For sample-up-the ram modes the integration time is the time difference between the readout of the first and the readout of the last frame.

- `CTIME = 5.345815 / [s] read-mode cycle time`

  The cycle time is the shortest time between starting repeated exposures. This is longer than the integration time because all relevant readout modes read the detector line-by-line, and that time appears as an overhead to be added to the integration time. So the cycle time is not relevant for photometric interpretation of the images, but an indicator of how much time is "lost" due to incomplete overlap between line resets and reads. The value is a function of readout mode and integration time, and therefore not an input in some operator's menu or command.

- `CRATE = 0.187062 / [Hz] read-mode cycle rate`

  The value is basically superfluous because it just shows the inverse of the cycle time.

- `EMSAMP = 0 / [ct] electronic multi-sampling`

  The electronic multi-sampling correlated with the `roe` command (Section 5.3). Values of 0 or 1 mean sampling once with the ADCs, otherwise the value may be 2 or 4 with the benefit of noise reduction

- `NCOADDS =  1 / [ct] effective coadds (total)`

  Software coadding is selected by the option `-i` of the `save` command (Section 5.3) and indicates how many frames have been added to generate one image.

- `EXPTIME =  2.667059 / [s] total integ. time`

  The exposure time spent creating an image. The total time that was spent integrating the flux that defined the value of an individual pixel of the FITS file. Usually this equals the integration time. If the data have been created using a repetition factor larger than one (command `crep` and keyword `NEXP`), `EXPTIME` still is the time for the single image, in case of saving the images in a FITS cube the time for each individual slice in the cube.

  If the data have been saved with the `-i` option of the `save` command, `EXPTIME` is the product of `NEXP` and `ITIME`, because each pixel in the image represents the arithmetic sum of the pixels in the individual exposures. To calculate the mean contribution of each exposure to the image then, one must divide `EXPTIME` and each pixel value through `NCOADDS`.

  If the exposure was aborted, `ITIME` is the scheduled integration time, but `EXPTIME` the (shorter) exposure time derived from the arrival time of the frames on the GEIRS computer.

  For multi-correlated modes `EXPTIME` is still the exposure time that went into the pixel, not any sort of difference between the non-destructive reads.

  If GEIRS has dropped one or more initial frames to improve the image quality in multi-correlated modes (Section 5.6.2.3), the `EXPTIME` is still the time that went effectively into the pixel values.

  Note that GEIRS may use non-integral `BSCALE` values in FITS image headers.[52]

- `FRAMENUM=  1 / OF 1 as save range`

  1-based enumeration of the images or of the frames (if single frames are stored). For images this is only relevant if the `Repeat` option was used to generate a series exposures with a constant set of parameters (`Repeat` entry in Figure 9 and `crep` in Section 5.3).

- `FRAME=`

  The 1-based enumeration of the frame in FITS files that were created with the single-frame-dump method of Section 7.7.

- `SKYFRAME= '(tmp-img)'`

  Generally an empty string, but a file name if some other FITS image has been subtracted to obtain the current FITS image, and a string in parentheses if this image was taken from another frame in the online image buffer.

- `DETSEC  = '[1:2048,1:2048]'  / [px] xrange and yrange of window`

  Coordinates of the detector window in the FITS image. The value is the same as `DETSIZE` if the full window has been read out.

- `DATASEC = '[5:2044,5:2044]'  / [px] xrange and yrange of science data`

  Coordinates of the detector window in the FITS image. This is basically the same as `DETSEC` but smaller for the case of Hawaii-2 RG detectors if some pixels fall into the 4-pixels frame along the edges.

[52] which means: do not use software which is partially FITS unaware...

- ```
  DETSIZE = '[1:2048,1:2048]'    / [px] x-range, yrange of full frame
  CHIPSIZX=                 2048 / [px] single chip pixels in x
  CHIPSIZY=                 2048 / [px] single chip pixels in y
  ```

  Three values that describe the geometry of the detector and which are always the same because all instruments use Hawaii-2 or Hawaii-2 RG detectors.

- ```
  B_EXT1  =             2.530273 / [V] external bias
  B_DSUB1 =             0.000000 / [V] det. bias voltage DSUB
  B_VREST1=             0.500000 / [V] det. bias voltage VRESET
  B_VBIAG1=             3.222656 / [V] det. bias voltage VBIASGATE
  ```

  Four values per chip (Hawaii-2) or 10 values per chip (Hawaii-2 RG) that show the voltages applied to the detector chip, which are set by DAC's and are defined by keywords in the GEIRS patterns (and potentially modified by the `bias` command). The comments show the DAC inputs in the range 0–4095 for the most recent GEIRS version.

- `CREATOR = 'GEIRS : trunk-r700M-13 (May 16 2013, 15:51:59)'`

  GEIRS SVN branch, version, and timestamp in parentheses. The timestamp is the time when GEIRS was compiled on the local computer, and does not reflect the issue date of the GEIRS version—which may be much earlier.

- ```
  EOF00000 = ...
  EOF00001 = ...
  EOF00002 = ...
  ```

  These keywords denote end-of-frame time of arrival of the last byte of the frames in the GEIRS DMA buffers. The units are the same as the `STRT_INT` and `STOP_INT` units, i.e., UT seconds in the range from 0 to $24 \times 3600 = 86400$ (the number of seconds per day). Details:

  - More precisely: the keyword `EOF00000` is not a time that marks the end of a frame but a start of triggering the read; therefore the time difference between `EOF00000` and `EOF00001` depends on the idle modes. The number of values with postive index is the product of `CPAR1` and `NEXP`, covering the entire set of frames. If the exposure was aborted, the number of values is smaller.
  - For the correlated double-sampling modes, the arrival of the reset-frame is not measured and the even indices (with the exception of 000) are absent.
  - Where `CAMDPORTS` equals 2 (Section 3.2), each time is the mean of the two arrival times of the parallel streaming through both fibers.
  - The first differences are added in the comments and ought to be basically the same on the milliseconds level. The jitter in these first differences indicates the standard deviation of the time accuracies, as sampled on the Linux workstation. The actual jitter of the timing on the ROE is much smaller.
  - In simulation mode the jitter is larger than collecting OPTPCI data, because simulated images are calculated in a non-privileged user process on the workstation. In simulation mode the `EOF` timing differences are basically always larger than one second because the simulation always computes full-frame images and is unaware of any of the speed-up methods (Section 8.9). So these keywords may not match `EXPTIME` or `ITIME` but may just indicate a maximum speed at which the software generated some diffused star images.
  ```

- `PERCT025 = ...`
  `PERCT050 = ...`
  `...`
  `PERCT500 = ...`
  `...`
  `PERCT975 = ...`

  provide the ADU levels of 2.5%, 5%,... 97.5% percentiles. The value of `PERCT500`, for example, is the median ADU in the corresponding image or frame. The data allow a quick look at the saturation level inside the image. If the keywords are generated, a quick extraction of the median for example of a sequence of FITS files can be generated with a script like

```
#!/bin/bash

cd .../2015-03-02 # move to the data directory
for j in Linr*.fits ; do   # loop over the FITS files of interest
        # extract PERCT500 (the 50.0 percentile) from extension 1
        dfits -x 1 $j.fits | fgrep PERCT500  | awk '{print $6}' ;
done
```

  or for named extensions

```
#!/bin/bash

cd .../2015-03-02 # move to the data directory
for j in Linr*.fits ; do   # loop over the FITS files of interest
# copy the extension of interest to the primary header of tmp.fits
        rm tmp.fits
        ftcopy "$j[SCA1]" tmp.fits copyall=no ;
        # extract PERCT500 (the 50.0 percentile) from primary header of tmp.fits
        dfits tmp.fits | fgrep PERCT500  | awk '{print $6}' ;
done
```

- `RESWN001 = ...`
  `RESWN002 = ...`

  indicate the location and dimension of reset windows in the `srre` mode. The indices in the keywords are generally *not* the same as in the operator's initial files. The format is the same as with the `DETSEC` and `DATASEC` keywords above: the 1-based x and y FITS coordinate system spanning all detector chips,the x range before the comma and the y-range after the comma. For LUCI1 and LUCI2 the maximum of the both ranges is 2048. For CARMENES,the y-ranges are up to 2048,the x ranges on `SCA2` are subranges of 1–2048,and the x ranges on `SCA1` are subranges of 2049–4096. (This means that the indices continue across the chips as if there was no gap.)

- `NRESWN = ...`

  The number of `srre` reset windows on this chip. This counts the number of `RESWN`i header cards in this image extension. The value may be zero.[53]

[53] There is an unfortunate and irritating practise inside the CARMENES ICS client to use the `srre` mode with

- `ABRT = ...`

  The time when GEIRS last received an `abort` command. This is only relevant if that time is later than `DATE-OBS`, because otherwise this happend before the exposure of this FITS file. It mainly serves to track and debug the behavior of client software which has unpredictable or undocumented itches of sending `abort`.

- `UUID =`

  A version 1 Universally Unique Identifier. May be decomposed into time stamp and MAC for example here, here, or here.

The keywords `CHECKSUM` and `DATASUM` appear if the associated `save` option is used.

A warning to ds9 users for PANIC: the all-mosaic composite image created by GEIRS (for example if `-M` is not used) does *not* contain any filler pixels to represent the gap between the chips. The ds9 display of these images shows nevertheless a grid of astronomical coordinates which cannot be aware of this—presumably derived from the pixel scale and assuming that the α/δ pointing refers to the center of the image. Obviously, that grid is typically wrong by roughly half of the gap, ≈ 80 pixels or the order of 40 arcseconds.

To simplify looking at the images with `ds9`, GEIRS places a WCS coordinate system on the two CARMENES FITS extensions. This has its origin at the middle of the detector plane in the gap between the two chips, and measures millimeters along the right (X) and up (Y) direction in the optical plane (i.e., ignoring the rotations and flips of the image).

7.5 Image Location

For Hawaii-2 RG detectors (AIP, CARMENES, Luci1, Luci2), GEIRS copies the four reference pixels along each of the four edges into the FITS images (if they are inside any of the subwindows). Postprocessing programs ought be aware of the fact that these pieces of the images do *not* contain regular data, and that the usable region is only a maximum of 2040×2040 pixels per chip.[54]

Using (or not using) the `save` options `-1` (requesting FITS cubes) and/or `-M` (requesting the multiple extension FITS format) leads to four different layouts of the FITS files:

- Without the two options, each window of each image is stored in the first (primary) HDU of a single file. This leads to the largest number of files and the smallest individual sizes of the files. In the extended syntax of the form `filename[..extname..]`, where the piece in brackets is the name of the extension as shown in the `EXTNAME` keyword of the HDU, this is:

  ```
  fname_0001_win1.fits # 1st window, first image/frame
  fname_0001_win2.fits # 2nd window, first image/frame
  ...
  fname_0002_win1.fits # 1st window, second image/frame
  fname_0002_win2.fits # 2nd window, second image/frame
  ```

zero reset windows configured. So one cannot rely on the `READMODE` card to differentiate `srr` and `srre` mode but must scan the `NRESWN` in both image extensions to figure this out. Newer GEIRS versions try to patch the `READMODE` keyword in the FITS files to correct for that error. These cases ought of course be replaced by using the plain `srr` mode.

[54] These are the current defaults. To in/exclude these reference pixels the `REFPIXEN` flags in the `pttrns/registers_-H*` configurations may be edited.

The first part of the file name is under user control with the standard mechanisms (Section 5.3), but not the trailing part of the underscore, `win`*i* and suffix.

- With `-1`, each window is stored in a separate file. Each image is a slice in a FITS cube of the primary HDU.

  ```
  fname_0001_win1.fits # first window, all frames as a cube in primary HDU
  fname_0001_win2.fits # second window, all frames as a cube in primary HDU
  ```

  The first part of the file name is under user control with the standard mechanisms (Section 5.3), but not the trailing part of the underscore, `win`*i* and suffix.

- With `-M`, each image is stored in a single file; the second, third HDU and so on contain the various windows of the image.

  ```
  fname_0001[win1_1].fits # 1st image/frame, first window on first chip
  fname_0001[win1_2].fits # 1st image/frame, second window on first chip
  fname_0001[win2_1].fits # 1st image/frame, first window on second chip
  ...
  fname_0002[win1_1].fits # 2nd image/frame, first window on first chip
  fname_0002[win1_2].fits # 2nd image/frame, second window on first chip
  fname_0002[win2_1].fits # 2nd image/frame, first window on second chip
  ```

  In general, the extension name starts with `win`, attaches a number (starting at 1) for the infrared chip, an underscore, and a another number (starting again at 1) as the index of the window in the set of all windows on that chip. For detectors with a single chip (LUCI1, LUCI2, LN, NTE),the first number is always 1.

- With `-1` *and* `-M`, all images of an exposure are stored in a single file. Individual windows are stored as a FITS cube in the first, second HDU and so on, where the layers in the cube are formed by the consecutive images. (If there is only one exposure, the format is automatically reduced to the standard 2D image format, which means the `NAXIS` keyword becomes 2.) This is the best organized display for multi-exposures with more than one window, but yields the largest files.

  ```
  fname_0001[win1_1].fits # first window on first chip, all frames as cubes
  fname_0001[win1_2].fits # second window on first chip, all frames as cubes
  fname_0001[win2_1].fits # first window on second chip, all frames as cubes
  ...
  ```

In summary, without `-M` all images are in the primary HDU, with `-M` no images are in the primary HDU.

Any postprocessing software knows from the `DATASEC` value which region of the full detector is covered by the window of any particular HDU, and retrieves the number of frames or images from the `NAXIS` and `NAXIS3` values.

Single-frame output from GEIRS uses 16-bit data types in the images; correlated output uses 32-bit data types. Converting all images to 32-bit data can be implemented by calling chimgtyp from within `QueueFiles`. The current name convention for the extensions (`EXTNAME`) is `Q`*d_w* for PANIC,

`SCA1|SCA2_`w for CARMENES, and `win`d`_`w for the other instruments, where d is the chip number from 1 to 4 and $w \geq 1$ is a window number. If the operator did not use subwindows, w is always 1. The index w is not necessarily the same as used in the `subwin` command; exceptions occur if

1. the operator skipped numbers,
2. defined but disabled some of the intermediate subwindows,
3. or let some windows stretch over multiple chips.

The physical order of the MEF extensions is by window number w, which just reflects the operator's liking for the order of enumeration in the `subwin` command. If a window has been split because it covers more than one detector, the split windows stay close together huddled in a group, so there is an "inner" or "fast" loop over the chips then.

7.6 Image Construction With `srr(e)`

If GEIRS has obtained a sequence of frames in the "sample-up-the-ramp" modes, it generates by default an image with the following procedure, pixel by pixel:

1. The ADU values are (virtually) plotted along the time axis.
2. The first datum — the one of the reset frame — is discarded to eliminate the reset frame anomaly. (This elimination happens only if there are at least three reads along the ramp, as a protection against having only a single point left in the plot.) Basically all instruments have a reset value that is a few ADU's higher than what would be obtained by interpolating the later values backward in time; this measure considers the first datum to be worse than the others and better be ignored if possible.

   The number of frames that are discarded can be changed by the operator with the `use srr skip` command, see Section 5.3. The current value is obtained with the `status use` command.
3. Other points in that plot exceeding a threshold ADU value are also discarded. Because the MPIA electronics uses 16-bit ADC's, the range for these thresholds is somewhere smaller 65535 (which equals saturation). So this is a single number parameter with the intent to ignore values that are near saturation or not appropriate for a standard linear fit because they are too high up in the nonlinear regime.[55]

   That value is the `ADC_SATUR` parameter in the shared memory data base, so it can be changed and read by the operator with the `put` and `get` commands of Section 5.3.[56]

   Because ADC ramps that reach saturation are chopped and linearized/extrapolated based on the first (unsaturated) values, the effective FITS values in the images (but not in the raw frames) may be larger than the unsigned 16-bit values.

[55] If that parameter is set too high, the slope (!) of the linear fit to the data computed along the ramps will be dominated by these saturated values and be small (!) such that the saturated values will be rendered darker than their non-saturated surrounding.

[56] Changing the *default* that applies after starting GEIRS needs a change in the source code that initializes these data.

4. A simple linear least-squares fit through the remaining points of the plot follows. The slope of that straight line is multiplied with the exposure time and that product becomes the ADU value for that pixel in the image. "Image" refers to the display in the GUI, Figure 16, and to the FITS image stored on disk with `save`[57].

For CARMENES a dedicated postprocessing procedure has been added that mainly (i) applies a non-lineary-correction based on quadratic fitting coefficients and (ii) narrows the number of frames that contribute to the fit to a small number of frames at the start and at the end of the procedure [23]. That sort of pipeline is not integrated into the other instruments. All these efforts are considered part of the data reduction pipeline and not part of GEIRS, the detector control software.

In summary, GEIRS does not have a build-in nonlinearity correction nor a cosmics suppression scheme that is applied when it reduces the raw frame data of successive non-destructive reads to an image. All instruments which need these improvements must save the individual frames to disk with one of the methods offered by GEIRS, apply their corrections to each frame, and re-correlate the frames to obtain the images.

7.7 Single Frame Dumps

This operative software mode refers to saving *uncorrelated single* frame snapshots to FITS or to a raw binary files in a scratch directory—while the packages of the 16-bit data of the (nondestructive) readouts arrive in the kernel buffers. If activated, this software on the GEIRS workstation considers each frame as soon as it has been read out by the detector, cuts out rectangular regions of interest, and dumps these pixels to an interface where the information is available to other (online) pipeline procedures.

The information extracted this way from an incremental read-while-integrate exposure may be used to steer other optical elements of the telescope looking at jitters and shifts/drifts in these images. The aim is that one does not need to terminate the readout cycle with `abort` or wait for the end of the integration time to get hands on the images. The profit is that any online tool may analyze the frames. In principle another profit may be that one can skip a `save -S` command at the end of the exposure which saves some time if there are hundreds of frames in long exposures—supposed the dumped frames are moved to their final destination during the exposure by some other mechanisms to avoid that they are overwritten by the next exposure.

The principle of operation is that these image data are stored with the frame arrival frequency to individual files without effecting otherwise the mixes of resets, readout patterns and windows without waiting for the end of the exposure. This almost always implies that the operation is bestowed with its local definition of data sections (windows) so the GEIRS data interface may cut out only those data essential to monitoring the data quality such that

1. the computational load due to the additional disk transfer (including the load by the reading application) is kept low.

2. the risk of stalling the main data processing task enforced by additional locking mechanisms with these buffers remains small. (The data interface works by drawing local copies of the standard shared memory data buffers parallel to the `read` process; if it is too slow, the

[57] Of course the reduction does not apply to the the single-frame formats described elsewhere in the manual.

standard procedure may fall behind its schedules working through the "read" and the "save" pairs of buffers.)

To stabilize the operation/mechanism against overloading by too frequent or too large window files, the implementation skips frames that are scheduled to be created while a previous frame is still being worked on. So depending on disk write speed, any disk activities of other processes running on the same computer, CPU speed, number of pixels in the dumped images, and of course frame frequency (depending for example on the delay used with the data generator), some of the files might *not* be created. Even nowadays, computer speed is not infinite. If you entertain the system with stupid tasks (like asking GEIRS ten times a second about the current status), the probability of not observing the intended number of FITS files on disk grows.

Note that FITS header keyword `NFRAME` relates to the sequential enumeration of frames in the shared memory buffer. If the FITS files have `NFRAME=30`, `NFRAME=31`, `NFRAME=32`, `NFRAME=34`, `NFRAME=35`, for example, frame number 33 has not been dumped because the operating system was too busy at that time. That scenario can be uncovered with a command like

```
dfits *.fits | fgrep ' FRAME '
```

in the current save directory and looking for gaps.

The operator may in addition slow down the dumping frequency below once per read with two keywords in the configuration file: The relation between the number of created FITS files N_F, the integer subsampling factor s and the number of frames N (effective, optionally after `abort`ion) in the RAM is

$$N_F = 1 + \lfloor \frac{N-1}{s} \rfloor. \tag{9}$$

Also note that this final `save` is not flagged as done at the end of the exposure (because obviously that computes a correlated image from all the previous frames and is of a very different kind of quality, depending on the `save` mode).

There requirements to install/activate this concurrent eaves-dropping mechanism are:

1. The `sfdump` (single frame dump) command (Section 5.3) is called to tell GEIRS which sections of the windows (or full frame) are to be written where. The creation of these pixel data files happens up to the time it is switched off with `sfdump off` or until GEIRS is shut down. The `sfdump` command actually points to a configuration file that contains the bounding boxes of the windows' geometries, and auxiliary parameters.

2. The readout mode is the LIR mode or one of the multi-correlated modes (Fowler, sample-up-the ramp,...). The single-frame dumps are not created for other types, because the reset frame is supposedly useless and the next frame anyway to be saved in these cases. (One does not need to call `sfdump off` if a sequence of different readout modes is started that mixes double and multi-correlated modes. The creation of the intermediate files will simply pause if the current mode is not a multi-correlated one.)

The ADC data within the windows specified in the configuration file named in the `sfdump` are written either in

- a MEF format with `BITPIX=16` and one window per extension if the `RAWF` flag in the configuration file is `F` or not given.

- or a binary stream with two bytes per pixel in the endianess of the GEIRS computer window-after-window if the `RAWF` flag in the configuration file is `T`.[58]

The intended scenario is that the monitoring programs are using the commands like `sfdump sfdump.cfg` once, and edit the file `sfdump.cfg` after a `save` and prior to the next `read` if the window number or geometry needs to be adjusted. GEIRS re-reads the configuration file (that was `sfdump.cfg` in the example above) for each frame arriving from the detector, so editing the file while a `read` is ongoing may lead to unpredictable results.

The regions/windows specified in the configuration file do not need to aligned in any particular way with the hardware and software windows specified by the `subwin` command. The windows in specified in the `sfdump.cfg` may overlap. Any pixels of the regions that fall outside the subwindows which actually are covered by the detector data are filled with zeros.[59]

The implementation is by default dumping data into a directory without any overwrite protection (!)[60] and iterating over the same base file names during every new read. We assume that these windows contain scratch data for online processing and do not have any lasting value, and in this way avoid that an extra monitor on available disk space in this part of the file system is needed. We assume that the lasting files are written explicitly with the `save` command to a different (!) directory.

The configuration file contains parameters, one per line, following a FITS-style template syntax as described in the cfitsio manual:

- COMMENT [anything...] lines to be ignored, only for documentation purposes
- WIN*idx* = '[*xstrt*:*xend*,*ystrt*:*yend*]' A portion of the detector image in the standard 1-based FITS syntax. On the right hand side, the two brackets, two colons and comma must be present as single-letters and the entire string on the right hand side *must* be encapsulated by quotes. The *idx* are distinct positive integers enumerating the windows.

  There must be at least one WIN*idx* keyword in the configuration file—otherwise no files are produced.

  This window set defined by the WIN keywords usually differs from any of the sets that are specified with the `subwin`. The regions of the detector that are copied with the `sfdump.cfg` mechanism are fixed by a 2-step process: (i) The detector is read out in the regions configured with the `subwin` command. In most instruments that command is not used, which means actually all detector pixels are read (full-frame hardware windows). (ii) This is followed by another cut-out process by the GEIRS *software* that virtually lays out these hardware windows and extracts sub-regions with the geometries defined by the WIN*idx* parameters. Think of this as stacking two sets of masks (harware and software windows) on top of each other.

  The portions of the areas defined by the WIN keywords that lie outside the regions that are read out will be filled with zeros. The windows may overlap; this leads to replicated shared pixel values inside intersections in the output.

  If there are two WIN keywords with the same index *idx*, only the latter one (further down in the file) will be used.

[58] This file format can for example be read with `od -d ...`.

[59] The current implementation also copies reference pixels of Hawaii2-RG detectors into the regions, which may change in the future.

[60] i.e., the definition of the `clobber` command are ignored

The indices do not need to be in consecutive integer order; there may be holes. (Actually all keywords that start with WIN and have a value string with the syntax of the four corner coordinates will be included in the window list.) If these indices are integers, they are copied into the EXTNAME of the FITS extensions for cross-identification.

In the case of an instrument with a single Hawaii-2 or Hawaii-2RG detector, one may for example copy all pixels to the file with the specification `WIN1 = '[1:2048,1:2048]'`.

- RAWF = T or F (boolean) Use a bare unsigned 16-bit binary format in the endianess of the GEIRS host, if true, otherwise a FITS format. The default is F (i.e., output file format is FITS, not raw, if this keyword is missing. The bare format has as many bytes as the number of pixels in all windows (defined above) multiplied by 2, where 2 is the number of bytes per pixel. The order of the pixels is first a block for the first window, then a block for the next window, in the order implied by the WIN keywords. In each window, pixels of the bottom line (smaller y-coordinates) come first, pixels of the top line last. Within each line of pixels the order is left-to-right (smaller x-coordinates first).

- VERB = T or F (boolean) If true, pack a standard (more complete) list of keywords into the FITS headers. This means that the GEIRS standard FITS keyword list is produced, and that keywords are also modified according to the rules of the geirsPhduAdd files. If false, include only a minimum set of keywords. Writing the minimum set is faster, and usually sufficient if the files are anyway only scratch image files. The default (if the VERB specification is missing) is F.

- PERCT = float. If > 0 and < 0.9, calculate a histogram of values and add these as PERCT keywords in the assocated headers. This is the difference of percentiles; a value of 0.05 means for example that 19 values are effectively calculated at 0.05, 0.1, 0.15 and so forth. The default (if the PERCT specification is missing) is -1, so this is disabled for performance reasons.

- FDIR = 'string' The name of a directory to which the files are written. If the keyword is missing, the default directory is `$TMPDIR/fits` . If the string is empty, the directory is the same directory (dynamically) as where the other FITS files go.[61] Of course this should be a directory which is cleaned up with a cron tab entry on a regular basis. The directory will be created with standard permission mask 022 if it does not exist. Of course this will fail if the GEIRS operator has insufficient write permission on any of the parent directories.

- FNAM = 'string' The base name of the files to be written. If missing, the default is an empty string. The full name of the files will be `<FDIR>/<FNAME><4digitFrameNo>.fits` if they are FITS files, otherwise `<FDIR>/<FNAME><4digitFrameNo>`. These files are overwritten if existing, independent of what has been specified with the `clobber` command.

- TSTMP = 'string' The name of a file in the FDIR which is touched after each dump. This is another passive form of signalling to monitoring processes, which might poll that file's content. If missing, no such time stamp files are created. The file contains the most recently created FITS or binary file name, a time stamp, and the number of subwindows (extensions) in that file.

- SUBSAMP = integer Subsampling of the frames such that not all frames collected by the computer are dumped but only a regular subset. The number of frames skipped in between

[61] Again: this is *definitely not* recommended because the files there are considered permanent data and the `sfdump` subroutine may erase files there...

(not dumped) is one less than the integer. If not specified a number of 1 (effectively no sub-sampling) is used. If the integer is 2, for example, the first, third, fifth,... frame is copied to the file.

- MAXSAMP = integer The maximum number of files to be created for the exposure. This is another way of defining the subsampling factor through a more dynamic interface than with the SUBSAMP keyword. If the number of frames predicted by the integer parameter of `ctype` is larger than the product of MAXSAMP by SUBSAMP, SUBSAMP will implicitly be increased such at most MAXSAMP files will be created by the single frame dumps.

  If not specified a number of 99999 (effectively no limit) is used.

- CALLB = 'string' The name of an executable (callback) to be called after the file is created. If missing or empty, no action is induced. There are two optional placeholders %s and %d in the string. The first is replaced by the name of the new file, the second by the increasing number of the frame. This string should be ending on a & to put the callback in the background. Otherwise, if the callback needs more computation time, it might block the next round of the callback to be executed. The implementation is based on system(2) calls, so redirection of its stderr and stdout need some embedding into sh calls.

Each of these configuration lines may be followed by a slash and a comment. This trailing part does not matter to GEIRS.

Header cards with other keywords than those listed above are ignored.

The line lengths in the configuration file do not matter much, but the keyword and value part must not surpass the standard 80 bytes of FITS header lines. (This effectively puts a limit on the length of the `FDIR`.)

A rough check that the configuration file is readable is made at the time `sfdump` is used. GEIRS attempts to open and read the configuration file are done later with the next `read`.

Example of a well-formed configuration file:

```
 COMMENT xample file like sfdump.cfg
WIN2 = '[40:100,700:900]' / first window, EXTNAME WIN2 size 61 x 201
FDIR = '/tmp/mathar/fits' / directory of FITS SFR files
FNAM = 'sf' / the FITS files will be sf0001.fits, sf0002.fits..
WIN5 = '[80:110,700:900]' / second window, EXTNAME WIN5; overlaps with WIN2
COMMENT PIDSGL = -1
TSTMP = '/home/mathar/tmp/last' / updated with each new frame
RAWF = F / create FITS files
VERB = T / include full FITS information
SUBSAMP = 3 / dump not all but each 3rd frame (skip 2)
CALLB = 'touch /tmp/mathar/cb%d &' / shallow log trace of callbacks
COMMENT end of xample file
```

If the keyword above were changed to `RAWF = T`, files of $2 \times (61 \times 201 + 31 \times 201) = 36984$ bytes would be created.

The frame dumping mechanism is permanently switched on for CARMENES by default with a line of the type

```
ln -s -t ${TMPDIR} ${cambuild}/admin/sfdump.carmenes
```

in the startup script. One can disable that all-frame dumping by commenting this line with a hash (#). In this case the first-stage pipeline will realize that the configuration file is not at its standard place and dump the (few) frames it is configured to use when the `save` command arrives [23].

8 EXPOSURE TIME

8.1 Readout Time

The exposure time is the readout time spent on reading the detector(s) plus optional delays between reading the frames; during the delays the ROE counts down and does not communicate with the detector, so the detector is basically collecting light without any further interference from the electronics.

The standard readout modes for infrared detectors demand at least one readout before and after an exposure [24]. The arithmetics of the single-frame readout time (and hence the minimum exposure time) is as follows:

(i) The number of pixels per detector is 2048×2048 for Hawaii-2 and Hawaii-2RG detectors and 4096×4096 for Hawaii-4RG Detetors. If hardware windowing is used, one of the two factors should be replaced by the number of rows in the hardware windows [24]. The number of ADC channels per detector is 32 for Hawaii-2 and Hawaii-2RG detectors and 64 for Hawaii-4 detectors (unless some lower power of 2 has been initialised for example with the `CAM_NQCHAN` value in the engineering GUI, Figure 8). The number of pixels per channel is the ratio: the number of pixels per detector divided by the number of channels per detector.[62]

(ii) The pixel clock (time) is the time needed to convert the detector current of one pixel by an ADC; this dominates the readout time because other times of clocking the detector need much less time and because the data transfer through the fibers to the computer happens in parallel and has enough bandwidth to keep pace with the ADCs.

The default pixel clock time in the patterns is 10 000 nanoseconds,[63] but can be changed before each read in the GUI (Figure 9) or by sending a `roe pread` to the command interpreter. The inverse of that time is therefore 100 kHz by default, which matches the recommendations for our Hawaii-type of detectors (and is overall related to the capacitor-resistance model of the detector circuits).

The minimum pixel clock time is approximately 1300 nanoseconds times the electronic multisampling factor[64] The electronic multipsampling factor is 1, 2 or 4 and can be changed either in the GUI (Figure 9) or by sending `roe ems` to the command interpreter. (Electronic multisampling means to digitize the detector current multiple times by its ADC at the end of the pixel clock interval to improve noise statistics. The ROE calculates the arithmetic mean of these samples, so from the point of view of the downstream software there is no need to divide the 16-bit values a posteriori by that factor to obtain coherent brightnesses in the pictures.)

(iii) The readout time is the number of pixels per channel multiplied by the pixel clock time.

8.2 Nomenclature

The expected time that expires between the `start` command and the receipt of the last pixel values of the last frame is of interest to exposure time calculators. It is a function of readout mode parameters and is estimated by the formulas summarized below.

[62] Because all MPIA systems built so far have been equipped with a number of boards proportional to the number of detectors, the number of detectors in the system cancels during that division and does not play a role any further.

[63] compile-time defaults which may be changed to something else on request...

[64] enforced by the use of 800 kHz ADC's in all currently built MPIA ROEs.

The overhead of (i) additional computations if the frames are to be averaged/integrated with special options of the `save` command and the overhead of (ii) actually writing the FITS frames to disk is not included here. These are functions of number and types of CPUs and disk speeds of the computer on which GEIRS is run, and depend also on any post-processing tasks added to the `QueueFiles` .

The number of frames still to be read may be monitored by sending the `status frame read` to the server, which responds by counting upwards as a function of time. This is equivalent to looking at the numbers that appear at the `Read` label in Figure 9 which turns yellow after the `start` is received. The two dominant parameters are the repeat factor (which is available by sending `status crep`) and the cycle time (which is available by sending `status ctime`). For any supervisor script it is much easier to deduce the real time of exposures by taking the cycle time as the base unit than taking the integration time, because the influence of parameters like `EMSAMP`, `PREAD`, `PSKIP`, the pair count of the multi-correlated (Fowler-type) samplings, and any form of hardware windowing (first type in Section 5.6.1) has already been incorporated then. The composition of the cycle time by interlaced execution of resets, reads, and idle waits is described elsewhere (see Section 1.2).

Note that the precision of this prediction is generally not better than the cycle time for all modes that use (or are coupled with) the ROE idle mode named `wait`. The reason is basic and simple: the `start` command is generally not synchronized with the idle cycles of the detector readout. The first pixel read waits (as the name says) for the end of the present idle cycle. (The need to read the detector even if no data are emitted by the electronics is a fundamental aspect of infrared detector exposure management and not discussed in this software manual.) The mean value of the time is the value expected for the `break` idle mode plus half of the cycle time. (One can mitigate this effect by adding a sort of dummy `sfr` exposure with minimum short integration time at the end of all long exposures—which will be adjusted upwards by GEIRS to the shortest manageable value—. The next exposure will then find the detector in a short cycle mode and react with predictable latency. The associated waste of disk space and overhead time can be kept low by saving these with the `-d` option.)

The formulas below contain small fudge factors that have been obtained by fitting a small number of exposures. They realize some overhead caused by the data transfer chain from the ROE via DMA control to the GEIRS buffers on the server.

8.3 Lir with idle break

If the readout mode is `line.interlaced.read` with idle mode `break` the time is

$$t[\mathrm{sec}] \approx 0.3 \times N_f + t_{\mathrm{cyc}}[\mathrm{sec}] \times N_f \tag{10}$$

where the number of frames N_f has been set by the application with the `crep` command and where t_{cyc} is the cycle time.

8.4 frr with idle break

If the readout mode is `fast-reset-read.read` with idle mode `break` the time is

$$t[\mathrm{sec}] \approx N_f \times t_{\mathrm{cyc}}[\mathrm{sec}] + 0.03 \times N_f. \tag{11}$$

8.5 mer with idle break

If the readout mode is `multiple.endpoints` with idle mode `break` the time is

$$t[\text{sec}] \approx N_f \times t_{\text{cyc}}[\text{sec}] + 0.003 \times t_{\text{cyc}}[\text{sec}] + 0.005 \times N_f. \tag{12}$$

There is no explicit dependence on the `CPAR1` parameter (number of Fowler pairs) which is already incorporated in the cycle time.

8.6 sfr with idle break

If the readout mode is `single.frame.read` with idle mode `break` the time is

$$t[\text{sec}] \approx N_f \times t_{\text{cyc}}[\text{sec}] + 0.06 \times N_f. \tag{13}$$

8.7 Hardware Windowing

The action of hardware windowing (Section 5.6.1) skips line set blocks along the "slow" readout direction of each of the detector chips. The slow direction is parallel to the stripes of the 32 or 64 readout channels. For Hawaii2 RG or Hawaii4 RG chips run with an odd `CAM_DETROT90` parameter (LUCI, CARMENES, NTE), the slow direction is left-right in the images. For Hawaii2 or Hawaii4 RG RG chips run with an even `CAM_DETROT90` parameter (PANIC), the slow direction is up-down. For Hawaii2 chips (LN) the slow direction depends in which of the four quadrants the subwindow is placed.[65]

Neglecting details, the time is shortened proportional to the number of pixels that are not fed into the 32, 64 or 128 ADC's, because the conversion takes the lion's share of the readout time. An estimate of the maximum speedup (and associated shortest integration time) relative to the full-frame readout is obtained by projecting all hardware windows (on a per-chip basis for the Hawaii2/4 RG and per-quadrant basis for the Hawaii2) as "shadows" onto their slow directions, which defines a set of one-dimensional pixel intervals (overlaps merged where occurring). Due to the back-to-back mounts of Hawaii2 RG's for PANIC and CARMENES, the orientation of interval must be chosen different for half of the chips, from a corner of the mosaic into the direction of the midpoint of an edge of the mosaic.

The total number of pixels in that set of intervals relative to 2048 is the relative speedup and reduction in integration time that can be achieved. This is not proportional to the ratio of the pixel-sum in the windows over the pixel-sum in any of the detectors, but proportional to some kind of edge-length sum along the slow readout direction. An example with three subwindows placed over a LUCI or NTE detector with a full frame width of 2048 pixels is given in Figure 25: the ratio $(x_1 + x_{23})/2048$ of the projected pixel widths is the expected reduction in cycle time (inverse of the speedup factor), where x_1 and x_{23} are the number of projected pixels of the windows measured along the slow (horizontal) readout direction.

The GUI in Figure 9 can be used as a pocket calculator for these times. Once the subwindow is defined and enabled, so the associated `Subwins` button is green, one can enter an integration time of zero into the `IT`; GEIRS sums up the pixel clocks in its patterns according to the selected readout mode, and inserts this minimum time back into the GUI. (This works also in simulation mode.)

[65] The `subwin auto on` command dissects windows that cross chip or quadrant boundaries so the observer does not need to be fully aware of details.

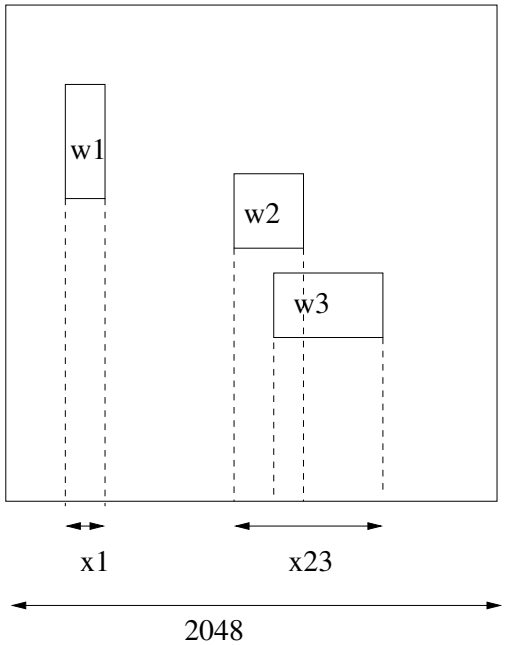


Figure 25: Illustration of the relevant dimensions that govern timing with three hardware subwindows w_1, w_2 and w_3 in the LUCI or NTE case.

A numerical example for the Hawaii2 4-quadrant case of LN: If the width of an isolated window is increased by one pixel along the slow direction, the total number of pixels read out increases by $4 \times 1 \times 1024$. The number of pixels channeled through a single ADC increases by $4 \times 1 \times 1024/32 = 128$. At a pace of the (standard) pixel read time of 10,000 ns (`prd` time in Figure 9), the increase in time is 128×10 ms $= 0.00013$ s. This number is for a single read; for an `lir` double read this becomes 0.0025 s (which will usually be announced in the controls GUI of Figure 9 as twice as that as long as the repetition factor is kept at 1 because the group of the first read-reset-read and the second read-reset-read is added all up).

A more detailed timing analysis of the most recently enabled pattern is kept in `$TMPDIR/timing_cmds.log`, and `status subwin` shows some of the window geometries that are involved [4]. A coarser measured timing of frame arrival times on the workstation is found in the `EOF` keywords in the FITS headers.

As a practical result of this analysis, one does not "lose" time if windows are stretched along their maximum extension along the fast direction. So for LUCI an assignment of the format

`subwin SW` i x y w h

can always be replaced by

`subwin SW` i x `1` w `2048`

expanding the window up-down. For PANIC, the assignment can be replaced by

`subwin SW` i `1` y `4096` h

expanding the window right-left over both detectors. This will keep the integration times almost constant, but lead to larger detector regions in the FITS files.

8.8 Higher resolutions

8.8.1 Readout times across the detector surface

The fact that the MPIA electronics reads 32 channels of 4 quadrants of the Hawaii-2 detector chip in parallel leads to a characteristic pattern of 32 time ramps of pixel reads across the detector. Figure 26 illustrates for a single full-frame reset-read at which time the individual pixels are reset and read. The first 32 pixels are read at time 0; the last pixels are read at time $2048^2/32 = 131,072$, which is scales to ≈ 1.4 seconds—half of (1)—for the standard `PSKIP`, `LSKIP` etc. parameters.

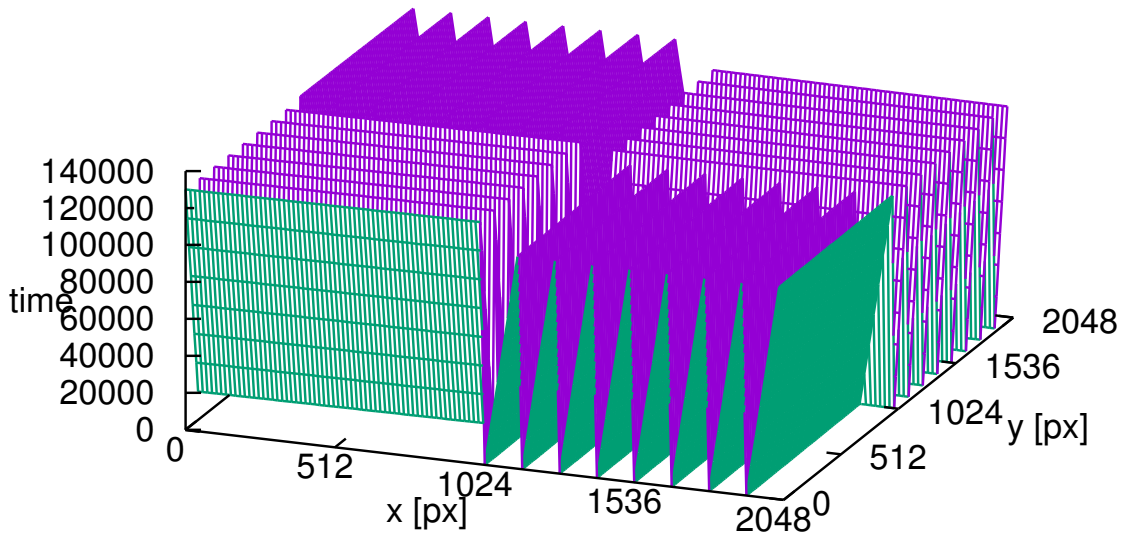


Figure 26: Pattern/distribution of effective pixel time as a function of Hawaii-2 pixel position. The transformation of the two axes directions to the FITS and image coordinates depends on the currently active `CAM_DETROT90` and `CAM_DETXYFLIP` parameters (Section 3.2).

For Hawaii-2 RG detectors (not relevant to LN) there are not 32 ramps in quadrants but 32 ramps with tops and valleys stretching over each chip. Otherwise the time scales are the same as above,because the number of channels per chip,the number of pixels per chip,the pixel read base times and ADC conversion times are the same as for the Hawaii-2 types. (The "fast" direction along the 64 pixels of each channel of Hawaii-2 RG detectors is alternating by default after the detector is powered on; 16 of them are oriented left-right and 16 of them right-left. The GEIRS patterns, however, use the chip's registers to toggle the direction of each second channel such that the actual readout direction is the same for all 32 channels. This aims to simplify a lot the arithmetics of mapping the serial 16-bit datastreams after arrival on the computer to two-dimensional images.)

For all relevant readout modes, the times of the pixel reset and the times of their readout are coordinated such that both have the same type of "offset" on absolute time scales [5]. In consequence,

- the differences (the exposure time) between reset and readout are constant across all pixels and all detector chips (with the exception of the reset windows in the `srre` mode);

- the mean (center) time of the photon flux has the same, predictable offset as a function of pixel location in the detector.

Note that if hardware subwindowing is used, these time axes can be squeezed considerably and become a more complicated function of placement and size of the windows on the chips. (If instead the windows are only established by slicing the images by software on the GEIRS computer, the pixel timing is the same as for the full-frame readout. This way of obtaining the information in windows by pure software postprocessing is not much relevant in practise.)

To visualise the timing across the detector chips one may actually take an exposure in the single frame read mode (sfr) under rather strong illumination with the default (=shortest) exposure time. Because this readout mode resets all chips of the detector at (almost) the same time and then starts reading the pixels in their "channeled" order, the actual exposure time is zero for the pixels read out early and longest for the pixels read out last. Just looking at the FITS image at sufficient contrast then displays "bars" of brightness variations along each readout channel.

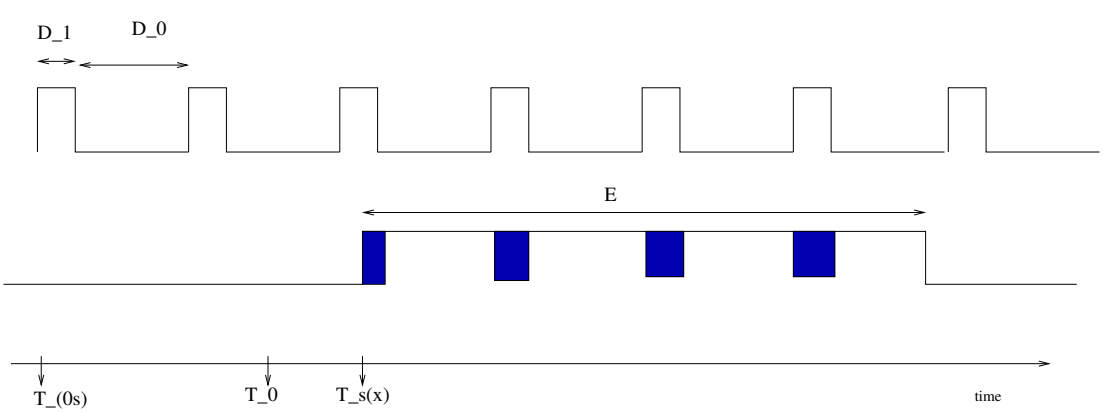
8.8.2 Chopped illumination

As explained above, the start time of the exposure is a function of the position on the detector. With CARMENES for example, the first rows of the two detectors are actually the outermost vertical columns in the FITS system. Let T_0 be some exposure start time of the readout and

$$T_s(x) \equiv T_0 + \frac{1}{2048} T_c \times \begin{cases} (x-1), & \text{SCA2} \\ (4096-x), & \text{SCA1} \end{cases} \tag{14}$$

the start time as a function of FITS `x` coordinate. For the `srr(e)` mode the ramp time is $T_c \approx 1.4$ seconds and depends in detail on parameters like the electronic multisampling. The exposure ends at $T_s(x) + E$, where E is the scheduled exposure time.

A model of a chopped illumination with an interception of the light path before the detector has three parameters, the time T_{s0} when the shutter opens, the duration D_1 during which it is open, and the duration D_0 when it is closed. We assume the shutter opens and closes with a period of $D_1 + D_0$. The fraction $D_1/(D_0 + D_1)$ is the average attenuation due to the shutter. The effective exposure time of a pixel is the sum of all times in the interval $[T_s(x), T_s(x)+E]$ where the shutter is open; in the diagram which shows the shutter periods in the upper part and the detector exposure time in the lower part these are the blue intervals:



The effective time includes a number c (possibly none, $c = 0$) of full open times D_1 and potentially two fractions of D_1 that depend on whether $T_s(x)$ and/or $T_s(x) + E$ fall into the periods where

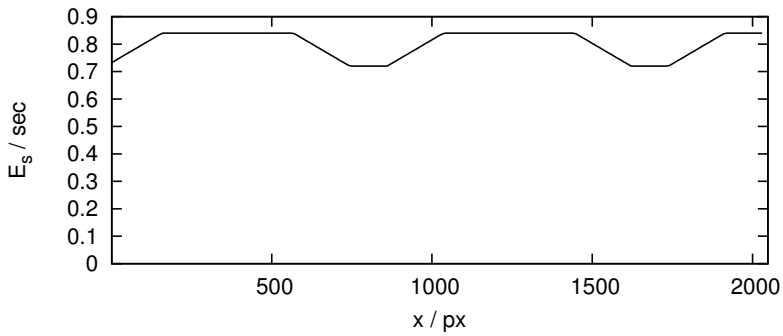
the shutter is open. Because the start of the integration time is not synchronized with the shutter open time T_{0s}—see Section 9.1—, the effective time is a basically random function of the difference $T_0 - T_{0s}$ (modulo $D_1 + D_0$). The integer number of shutter periods is the floor function

$$c \equiv \lfloor \frac{E}{D_0 + D_1} \rfloor. \tag{15}$$

The effective integration time is

$$E_s(x) = (c + \epsilon(x))D_1 \tag{16}$$

where $0 \leq \epsilon(x) \leq 1$ is the sum of two potential fractional pieces of D_1 covered at the start and/or end of the exposure. E_s is a periodic trapezoidal function of x with a randomized offset depending on $T_0 - T_{0s}$. An example with $D_1 = 0.12$s, $D_0 = 4D_1$, $E = 4$ s and $T_c = 1.4$ s looks as follows:



Here $c = \lfloor 4/(5 \times 0.12) \rfloor = 6$ and $E_s(x)$ switches between $6D_1$ and $7D_1$. For long exposures, $E \gg D_0 + D_1$, $c \gg 1$ and the wiggles introduced by a lack of interlock between shutter open and exposure start times become unimportant.

The influence of the shutter can be corrected (as a correction factor for photometry) in a pipeline if the shutter phases are logged in a fashion similar to the GEIRS readout time stamps.

8.9 Bright Sources, High Speed

If the illumination on the detector is faint, the fundamental means to adjust to the basially fixed detector gain is prolongation of the integration time. If on the contrary the illumination on the detector is too strong, there is only a limited set of tools to avoid detector saturation and the associated memory/persistence effects—because the minimum integration time is rigidly limited by the fixed number of channels that are read in parallel and by the maximum 800 kHz speed of ADC conversions [66]—. From the point of view of the GEIRS control model, these are the prospective tuning parameters:

1. Roughly a factor of 5 in speed is available by clocking faster, which means decreasing the default pixel read time (typically 10,000 ns) by roughly a factor of 5, see the `prd` button in Figure 9 and the `ptime` and `roe pread` commands in section 5.3. This is merely restating that the chip's reference design is at 100 kHz pixel frequencies whereas MPIA's ADC's are capable of 800 kHz sampling. This implies that electronic multi-sampling is not used (see the `roe` command).

[66] For the AIP setup where the 64 channels of two Hawaii-2RG are fed into each fiber the limit is actually 590 kHz set by the clocking of the serialization [4].

2. Skipping pixel lines in the slow direction by hardware windowing (Section 8.7) offers speedup factors of the order of 10 or 30 depending on how much coverage of the detector is needed.

3. Roughly a factor of 2 is gained if not the `lir` mode with two reads per scan but only a mode with one read per scan is used, for example the `srr` with only two reads in total. If relative photometry across the detector is not important but only identification of positions on the detector, one might consider the `sfr` mode which has the advantage of a full-frame reset (avoiding saturation in all areas of the detector) but reads all pixels only once.

4. The voltage of the external bias may be increased (Section 10.1).

5. Taking an idle mode with the most frequent resets is also advantageous to avoid persistence effects (button in Figure 9 and the `idlemode` command). Note that for a `srr` mode with two reads the `ReadWoConv` may be faster than the default `Lir` idle mode, because the associated cycle time may be slower if the integration times are short anyway. The `Reset` idle mode is the fastest one offered.

6. If the saturating regions on the detector are a few, and the problem at hand is rather a problem of large contrast through the areal regions, some detector types and instruments offer to mask these (i.e., reset them frequently) with the `srre` mode (Section 5.6.2).

In summary, *going high-speed* means primarily using subwindowing with small windows, but perhaps also increasing the pixel rate (at the cost of higher noise), disabling all on-line FITS activities, using sample-up-the-ramp modes[67] or even reducing logging. That sort of package options of commands looks like:

```
sfdump off
autosave off
satcheck off
subwin clear
subwin SW 1 777 999 64 64
subwin auto on
log all 1
roe ems 1
roe pread 2000
# disable intermediate image calculation: show single frames
# (actuate the lower left button in the image GUI...)
put DISP_FRAMEFLAG 1
# ensure fastest frame rate is used...
itime 0
read
sync
# save the individual frames as a fits cube...
save -1 -S
```

Note that the display (Section 4.3.3) is artificially slowed down to roughly one update each second, skipping intermediate frames if they arrive faster. Saving the frames as an image cube and reviewing these slices with other tools may be useful, or clicking through the single frames with the `-` and `+` buttons of the GUI after the exposure ended.

[67] with the disadvantage that one needs a pipeline that subtracts consecutive pairs of frames

Examples with integration times of 0.16 seconds (6 Hz) taking 128 × 128 subwindows in the LIR mode are in the runs of 2016-06-03 and 2016-06-04 of LUCI1.

Table 1 shows image cycle times for the `lir` mode and frame cycle times for the `srr 10` mode measured with a spare LUCI-ROE with GEIRS 756M-48.

- If pixel read cycle times less than 2000 ns are chosen, the ROE chain may start to drop pixels (because the ADC's start to drop end-of-conversion signals), and this type of instability is indicated with the ∼ signs in the column of the time differences.
- If the user's window size falls below 64 pixels (the channel widths) also in the horizontal direction (horizontal in the Hawaii chip's standard coordinate system), the frame rate starts to become proportional to the window's area, not just the projected edge length—because the patterns are designed to start skipping pixels also in the horizontal direction if they can.
- In all cases the predicted/calculated cycle times are well within a percent of the jitter in the frame arrival times measured on the workstation.
- The image rates of the correlated double read (`lir`) are half the frame rates of the non-destructive reads (`srr`,...).

All these measurements are using the 32-channel standard readout mode, which means that the number of pixel data forwarded from the ROE to the workstation is actually larger than product of the pixel counts of the window's edges [4]. As a guideline we can say that for a 128 × 128 area image rates of 30 Hz are achievable by tuning the pixel clock to 2000 ns, but frame rates of 800 Hz are achievable in small 16 × 16 subwindows.

8.10 Time between Reset and First Read

The internal analysis of the timing is dumped by GEIRS into the file `$TMPDIR/timing_cmds.log`. This file is overwritten each time the clocking patterns are changed,which means,the current contents reflects whatever was the most recent readout/idle mode used by the operator. This is the primary source of what GEIRS accumulates while adding its patterns.

GEIRS basic pattern modes use a line reset followed by clocking through the 64 pixels of each channel (along the "fast" direction, "fast" aligns with the vertical in the LUCI and CARMENES images, with the horizontal in PANIC images). So the distance between reset and readout is a linear function of pixel distance to the line of its channel border. Whether that border is up,down,left or right from the pixel depends on the image flip/rotation parameters (Section 3.2),and for multi-chip cameras also on the detector number in the mosaic.

As an estimate,take the cycle time of the LIR mode (5.01 secs for LUCI) as shown in the `cycT` of the `controls` GUI; it consists of 2 "ramps" (each a read-reset-read),which gives 2.5 secs for each ramp. Divide through 2048 lines along the slow direction to get 1.22 ms for each detector line,and divide through the 64 pixels of the channel to get 19 μs per pixel. (We don't divide through $2048 = 32 \times 64$ pixels along the fast direction because the 32 channels are handled concurrently by the 32 ADC's.) Because the 19 μs correspond to 2 reads and one reset,the distance between the reset and the read is only half of this,9.5 μs.

The standard timing currently uses 800 kHz ADC's,with a 4-fold sampling (FITS keyword `EMSAMP`, Section 7.4),which is 200 kHz effectively for each value submitted; that is packed into the second

`ctype`	`ems`	subwin corner	subwin size	`pread` (ns)	ΔT (sec)
lir	4	700×700	128×128	10000	0.157
lir	1	700×700	128×128	10000	0.171
lir	1	700×700	128×128	9000	0.155
lir	1	700×700	128×128	8000	0.139
lir	1	700×700	128×128	6000	0.103
lir	1	700×700	128×128	4000	0.0710
lir	1	700×700	128×128	2000	0.03535
lir	1	700×700	128×128	1500	$\sim$
lir	1	700×700	16×16	6000	0.00434
srr 10	1	700×700	128×128	10000	0.0858
srr 10	1	700×700	128×128	8000	0.0696
srr 10	1	700×700	128×128	4000	0.03555
srr 10	1	700×700	128×128	2000	0.0177
srr 10	1	700×700	128×128	1500	$\sim$
srr 10	1	700×700	64×64	10000	0.0430
srr 10	1	700×700	64×64	8000	0.0348
srr 10	1	700×700	64×64	7000	0.0300
srr 10	1	700×700	64×64	6000	0.0259
srr 10	1	700×700	64×64	4000	0.0178
srr 10	1	700×700	64×64	2000	$\sim$ 0.0089
srr 10	1	700×700	32×32	4000	0.00515
srr 10	1	700×700	32×32	2000	0.00271
srr 10	1	700×700	16×16	6000	0.00222
srr 10	1	700×700	16×16	3000	0.00123

Table 1: Image and frame rates as a function of window size and pixel read parameter measured with a Hawaii2 RG LUCI setup.

phase of a base clock,which gives an observed 100 kHz pixel speed,10 μs. That is the 10000 ns reported in the `prd:` (pixel read) field of the `controls` GUI,Figure 9. Note that there is a discrepancy of 0.5 μs per pixel between this timing and the estimate of the previous paragraph.

In summary: the delay between (line) reset and pixel read start is roughly 10 μs $\times[(2048 - y) mod 64]$,from 0 up to 640 μs.

This ought to be the same for the MER,which also uses line resets. Of course these delays between reset and read cancel in the base modes,as the two frame reads are subtracted pixel-by-pixel to define the image. So the exposure time does not depend on the distance to the channel boundary.

Note that there are also full-frame reset modes,SRR modes... [4].

9 COORDINATE SYSTEMS

9.1 Exposure Start

We summarize the causes of delays between sending the `start` command and receiving data with GEIRS:

1. The standard idle mode loops through the detector lines, resets them, but does not trigger ADC's. The start command does not interrupt this idle mode but uses a well-defined break point at the "'last" detector lines to leave these loops. [The "break" idle modes do not wait until the pattern program reaches the break point, but they lead to well known biases (steps) at the lines where the loops are exited.] Because the start command is basically uncorrelated in time with the phases in the idle loop, a delay of typically up to the full frame readout will occur.

2. If some `srre` reset windows are modified, an entirely new pattern will be downloaded to the ROE, which (as a function of internet latencies, number of reset windows etc.) will typically lead to a delay of 10 to 20 seconds.

3. The `geirs_dropcaches(1)` automatism will be invoked if the start of the readout realizes that the free memory has dropped below half of the full RAM[68]. Experience with a 32 GB computer shows that this will lead to a delay of a few seconds.

4. Before each readout, GEIRS allocates "kernel" memory[69] with the aid of the PLX library, 8 MB for each $2k \times 2k$ detector chip, in chuncks which are some fraction of the maximum of 4 MB. If this does not succeed right away (usually caused by fragmentation of the slub tables, which unfortunately is correlated with the file caching mechanism), GEIRS attemps this multiple times with intermediate waits of the order of half a second. This adds an essentially unpredictable delay to each start. This behaviour can to some degree be manipulated by changing default value of the `geirs_dropcaches(1)` and with the `put` command the subdivision factor `KMALLOC_SPLIT` in the shared memory database.

   Note that a static single allocation of that memory is not implemented because the daisy chain of the DMA depends on the size and number of subwindows used by the observer, and this set of parameters can change prior to each `read`, and is basically unpredictable.

[68] a slightly higher mark is chosen for CARMENES

[69] which actually does not exist under Linuxes...

10 TROUBLE-SHOOTING

10.1 ROE Interface

1. Problem: No data appear and the main screen of Figure 16 remains gray after a `read` has been initiated and the associated exposure time is over. GEIRS emits errors of the sort that `init` returns error codes equivalent to timeouts while trying to connect to the camera. Check list: First check that the rack of the readout electronics and all intermediate switches, hubs & c are powered on. Check that the yellowish LED of the ROE board flickers at least once or twice when the ROE is powered on. Then ensure that the shell variable `CAMPORT` (Section 3.2) in the `scripts/geirs_start_gen` is correct, including the `TCP` marker and the port number, that the readout electronics has actually been set up to listen to that address [25], and that a `ping` command with that (numerical) address from the GEIRS computer gets an answer from the readout electronics. In the standard LUCI binocular setup without the spare the first two of these should respond:

   ```
   ping 192.168.0.14
   ping 192.168.0.24
   ping 192.168.0.34
   ```

   The ROE cannot negotiate dynamic IP addresses, so the subnet in which the ROE resides must either use a static protocol (*no* DHCP) or the computer that configures the network must reserve in a quasi-static way the address range of the ROEs.

   If messages of the sort

   ```
   INFO MPIA-ROE3 reset - '33 8 0 1'
   INFO Seen ROE3 rocon 'DETFPGA' version '3 1 7 5'
   INFO Seen ROE3 rocon 'ADCFPGA' version '3 0 2 2'
   ```

   appear when GEIRS is started up, the network interface between the host computer and the ROE is working.[70]

   If you powered the ROE on *after* starting GEIRS, GEIRS will be unaware of the presence of the ROE[71], and the ROE will not host any patterns. The options are

   (a) quit GEIRS and restart it while the ROE is on.

   (b) load a standard pattern to the ROE with the `File→Init/Reboot ROE` menue of the controls menue (Figure 9).

   If it is impossible to build up an Ethernet connection to the ROE, and if no spare ROE is available, an alternative connection is available if the RS232 connection still works, as sketched up in Figure 27. The command exchange via the RS232 serial interface is estimated to be a factor one hundred or one thousand slower than via the Ethernet, and therefore impractical for standard operation.

2. Problem: No data appear and the main screen of Figure 16 remains gray. Solution: If messages of the

[70] Unfortunately starting GEIRS with the Java GUI Figure 8 never generates output on the Linux standard output, so that test is not available if that method of starting is used.

[71] GEIRS does not poll the ROE status

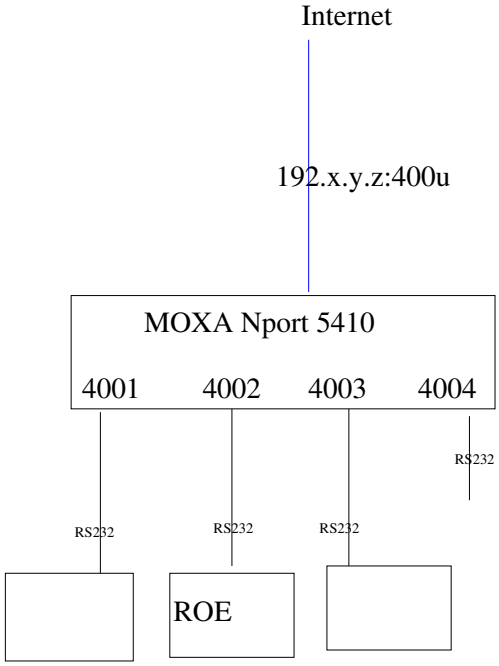


Figure 27: An engineering configuration where the ROE is not reached by its Ethernet port as in Figure 1 but by its serial port mediated through some server. In this case the `CAMPORT` variable in the software needs to be set to the Ethernet address of the intermediate server—in the MOXA case the port numbers are from 4001 upwards, $u \geq 1$.

```
(E_ptimeout=21) timeout on OPTPCI interface
```

kind appear in the GEIRS logs because GEIRS waits longer than expected for the video data, the fiber connections are disrupted, or the more fundamental problem of communication failure of the command channel to the ROE of the previous item exists.

3. Problem: The main screen of Figure 16 turns black, i.e., the ADU values received via the fibers are zero. For instruments with single chips (LN, LUCI, NTE) check that the two fiber heads have not been swapped on the OPTPCI side where they enter the workstation (or to the same effect, on the ROE side where they enter the ROE rack). The OPTPCI board offers plugs for two fiber pairs on the rear side of the workstation that receives the detector data. The basic industrial application of this type of hardware/connector is bi-directional network data transfer, but the MPIA ROE uses them only for one-way detector image data transport of the 16-bit data from the ROE into the workstation, so two of the plugs are never used and usually covered by some dust cover (Figure 28) [26]. Effectively one fiber pair connects an ROE and an OPTPCI at the workstation. On the computer/OPTPCI side only receiving ports are used, on the ROE side only sending ports. Both fiber cores are used for data transfer for PANIC and CARMENES, but only one core for data transfer for LN, LUCI and NTE. Because the equivalent selection of plugs is to be made on the ROE side, this gives a probably of 3/4 for LN, LUCI and NTE to get no data and a probably of 1/2 for PANIC and CARMENES to get swapped images if fibers are plugged in at random.

   A red LED on the OPTPCIe board indicates that the fiber on that port is disrupted. Instruments like LN, LUCI and NTE can live with one working fiber–if that is the one configured–but the other two instruments need both.

Ensure that the OPTPCI driver is compiled and installed (`lsmod` as in Section 2.1.10).

Run any of the tests in the appendix of the pattern manual [4] to ensure that data from that board's data generator generate stripes in the GEIRS display.

If more than one OPTPCI is plugged into the computer, check the correct `DATAINPORT1/DATAINPORT2` setup in `scripts/geirs_start_gen`, and with `printenv | fgrep DATA` in your `bash` shell. [72] If there is only one OPTPCI, this ought to be the `00/01` pair.

4. Problem: GEIRS says

   ```
   ERROR (91) opening line: '(E_camline=91)'
   ```

   Solution: GEIRS cannot open a socket via the Internet to the readout electronics. This indicates errors as already discussed above. Either the ROE is not powered on, or the GEIRS configuration of the `CAMPORT` (in the `geirs_start_gen` startup script) does not match the ROE's actual IP. For debugging note that GEIRS displays the current value at startup with a line of the format

   ```
   Setting ROE port to tcp://192.168.3.xxx:4000
   ```

   on the Linux shell and also in the `RO-Electronic` field of the GUI in Figure 7. For a quick temporary check whether the IP address is the culprit, one can either use the engineering GUI in Figure 8, or set the environment variable `CAMPORT` *before* starting GEIRS (because, as mentioned in Section 3.2, the startup script does not override an existing value).

5. Problem: The cycle time stays at zero seconds in the GUI. Potential causes:

   (a) GEIRS never got the `init camera` command (Section 5.3). This command is actually submitted by clicking `all` or `OK` in the startup GUI, Figure 7. However, if the two main processes (`shmmanager` and `cmdServer`) and/or the other processes (`geirs_controlJ`, `geirs_displayJ`) are called directly from the UNIX/Linux command line without using this interface, the command may not have been issued. This can be submitted for example with the `Re-init ROElec` submenue of Figure 9.

   (b) The internet connection to the ROE does not work (see above). Occasionally this is caused by temporary congestion (and the error log monitor will display timeouts) and sending the patterns again to the ROE—with the `Re-init ROElec` button of Figure 9 or the `init camera` command of Section 5.3—will remove the problem.

   (c) GEIRS was not started in simulation mode but the ROE does not respond—for any of the reasons described in Section 10.1.

   (d) The `rotype` has been set to `dgen` (the OPTPCI data generator). Execute

   ```
   status rotype
   ```

   in the GEIRS shell to see whether this is the case and set it back with

   ```
   rotype plx
   ```

   (e) The environment variable `CAMERA` was set to a string before starting the instrument and the `start_*` command used a different name. In this case delete the environment variable before using the `start_*` command:

[72] This is currently the case on one of the two LUCI computers at the LBT and on `elablx01` and `irws2` at the MPIA.

```
export CAMERA=
```

6. Problem: The detector images appear to be basically flat zeros, because the raw single frames (prior to the subtraction/correlation) are highly saturated close to the maximum of 65,535 counts. (Switch to single frame display with the *current* button in the display in Figure 16 to look at these counts.) Solution: This has been observed if the CARMENES detector is operated at rather warm or ambient temperatures. This can be improved by rising the external bias voltage applied to the chip(s) from the default value ($\approx$ 2.2 V) to values near 2.5 or 2.6 V. The current value is revealed by the command

   ```
   bias
   ```

   The value would be altered with the `bias` command (Section 5.3) in the style of

   ```
   bias det1 extbias -V 2.55
   ```

   and if there is more than one Hawaii-chip in the instrument for the others by increasing the index up to 2 for CARMENES and up to 4 for AIP:

   ```
   bias det2 extbias -V 2.55
   bias det3 extbias -V 2.55
   bias det4 extbias -V 2.55
   ```

   The same effect with the opposite sign has been observed with the LN detector after cooling down the entire optics and just switching on the ROE: the single frames may have pixel values close to zero ADU's. The effect vanished slowly within hours afterwards when the ROE was switched on[73]. During Com-3 of LN for example, this needed of the order of $4\frac{1}{2}$ hours before reasonable images were received from the ROE. In this case one could lower temporarily the external bias in steps of 0.05 to a value near 0 Volt for a first visual check of the LN detector image,

   ```
   bias det1 extbias -V 1.0
   ```

   each time followed by a `read` to see whether some noisy image appears.

   The voltages remain until they are either overwritten with another `bias` command or until GEIRS resets the electronics (Button `Re-init ROElec` in Figure 9) or is shut down and restarted.

   For instruments which use only one of the fibers (LUCI, LN or both NTE), zeros may also mean that the fibers are crossed and GEIRS scans data from the wrong fiber of the pair. As a first debugging aid in this case, shut down and re-start GEIRS with `geirs_start` and change the last, rightmost digit in the `plx` number in the `DATAINPORT` in the GUI (Figure 8). If this allows to get images, swap the fibers at the source (ROE at the dewar) or the destination (OPTPCI board of the workstation) and return to the normal operation where the last digit is zero.

   For instruments which use both fibers (AIP and CARMENES), swapped fibers mean that the associated sub-images are swapped, which is checked by verifying that the characteristic bad-pixel patterns are at their expected places.

[73] which warms up the pre-amplifiers that have some minimum operating temperature

7. Problem: starting GEIRS generates error messages that the current PLX SDK has a version mismatch with the kernel version, and `lsmod` does not have a plx line.

   Solution: You probably have updated the Linux operating system without recompiling the PLX driver. (Systems like CentOS, Ubuntu and Alma Linux in particular are known to generate rapidly changing microversions of their kernels...). Recompile the PLX SDK with `INSTALL.plx` following Section 2.1.10.

8. Error messages of the form

   ```
   libplxmpia.c:233: [plx_find_device] ERROR)  Error in Plx device found (u=2/chan=0): ffff
   ```

   or

   ```
   ERROR Error: plx_find_device: 'PLX ApiError 516 - ApiNoActiveDriver'
   ```

   mean that the driver for the board that interfaces with the RoCon fiber optics has died or not been installed. This should be fixed by loading the driver at boot time—see Section 2.1.10. One can temporarily fix this by by executing

   ```
   cd $CAMHOME/scripts
   sudo plxstartup
   ```

   but this means the same problem reappears each time the workstation is rebooted. If

   ```
   ls -l /dev/plx/Plx*
   ```

   does not show any character special devices and the loading of the driver has been activated, the simplest way to generate these devices is to reboot the computer and to check again that these special files are in that directory. Then

   ```
   cat /proc/devices | fgrep -i Plx
   ```

   ought to have a plx-line in the list of character devices. [See e.g. the `init_module` function in https://linux-kernel-labs.github.io/refs/heads/master/labs/device_drivers.html which typically generates with the `MKDEV` macro these character special devices and also the call of `register_chrdev` in `Driver.c` of the PlxSdk source code.]

9. Problem: Error messages of the form

   ```
   Unable to allocate Memory for Buffer...
   ```

   appear and no frames are read. Workaround: This indicates that the driver is not capable of allocating the kernel memory for the next exposure. This typically arises if the last lines in the `INSTALL` script (Section 2.2.1) were not executed, for example because the user installing GEIRS had insufficient rights or was a user who was unaware of memory allocation strategies in Linux systems. The only known solution for unprivileged users is to shut down GEIRS and to reboot the computer. The advice is to use only the standard tools for shutting down GEIRS as documented in this manual, never to kill the `geirs_rdbase` process from the operating system while is uses kernel buffers for reading (i.e., while a `read` command is active).

10. Problem: Communication with the ROE times out with messages like `ERROR 23 Command 'ctype srr 4' returned errorcode = 23: (E_ctimeout=23) timeout from camera (control line)`. This is occasionally caused by very high traffic in the network. The associated timeout is set to 5 seconds generally and to 10 seconds at the MPIA network in `camsend.h` and can be increased (followed by recompilation with `make install`) if this is a permanent problem.

11. Problem: The ROE LEDs die after a while. Solution: When GEIRS is started, a first action in the patterns downloaded to the ROE is to switch off as many of the ROE's LEDs as possible. The reason is that the standard operation of the ROE is in telescope domes where permanent light polution near the telescopes is undesirable. If you need this blinking for debugging purposes, put the `include ledoff` in the file `registers.*` in the `pttrns` directory into a comment, which means, insert a sharp (#) at the front of the line. Some of the ROE LEDs, the Ethernet RJ45 connector and the power unit, are not under that type of remote software control; these need to be taped to mute them.

10.2 Software

1. Problem: The commands

   ```
   plxshutdown
   plxstartup
   ```

   don't load the PLX driver relevant to the chip that is on the OPTPCI board.

   Solution: apparently the driver was not compiled. Each time the operating system has been patched with

   ```
   zypper up
   ```

   and a new kernel appears in `/usr/src`, recompile the driver in the following order as `root`:

   ```
   reboot now # reboot the computer so the new kernel so the new kernel version is recognized
   cd /home/.../GEIRS/trunk-r.... # move into the GEIRS directory  with the installation script
   ./INSTALL.plx # recompile and install the driver
   cd ../scripts ; ./plxstartup # load the new driver
   ```

   Then recompile all GEIRS versions to link with the new driver under the usual login account:

   ```
   reboot now # reboot the computer so the new kernel so the new kernel version is recognized
   cd ${HOME}/GEIRS/trunk-r.... # move into the GEIRS directory  with the installation script
   make -f Makefile clean
   make -f Makefile install
   ```

2. Problem: the startup command does not produce the GUI of Figure 7.

   Solution: you may have modified your window manager such that new windows are not popping up in the front layer of the window stack. Search through the stack of windows to detect it if hidden/covered by other windows.

3. Problem: An attempt to start GEIRS does not open the GUI of Figure 7, but instead it just shows some process list of the operating system with processes like `geirs_shmmanager`, `geirs_cmdServer` and says that some `shmsocket` exists. There is some output that says `cannot attach info page`.

   Solution: This means that GEIRS is already/still running, which means you or someone else with access to the user account has started it and did not shut it down correctly. [For example you logged out or powered down the computer without terminating the GEIRS sessions or killed the GEIRS servers in any other ways, so dangling shared memory sockets are left over.] Ring up all people in that user class and ask them whether they are still operating the readout electronics, and figure out with

   ```
   journalctl
   ```

   when the last action of this session took place. If you are sure that there is no harm done by forcing that application to quit, you may call

   ```
   ps -elf | fgrep geirs
   geirs_cleanup
   ps -elf | fgrep geirs
   ```

   on the Linux shell to kill that GEIRS session and then try again to start a new one. Because there is a subset of users who almost never shut down GEIRS in orderly ways, the `geirs_cleanup` is always called by default for each new `geirs_start` in some distributions.

4. GEIRS does not start, and some logs with the operator's name and some process names appear. Solution: the previous GEIRS session was not closed and remains active under the same Unix account. Run `geirs_cleanup -a`, then `ps -u $USER | fgrep geirs` to ensure all GEIRS processes have died, and restart again.

   It seems that this situation may arise if some process send a command to the GEIRS shell and terminated or was killed before it received the answer.

5. Problem: GUI's close at random times although neither the `Shutdown GEIRS` button was pressed in the display GUI nor the `quit` command was entered in the interactive command interpreter. Solution: The reason is probably equivalent to the above: someone else (or some script) is restarting GEIRS without taking care whether it's already in use or not.

6. Problem: GEIRS does not start and messages of the type `PlxInvalidDeviceInfo` appear. Solution: check that the environment variable(s) `DATAINPORT1` and/or `DATAINPORT2` match the number of OPTPCI boards plugged into the computer.

7. Problem: The GUI does not open, and there is a message like `can't allocate info page`. Solution: Type `geirs_cleanup -a` before you start the GUI. This program deletes shared memory pages left over by the same Linux/Unix user from a previous session and shared memory sockets `tmp/shmsocket`. The underlying problem is often that GEIRS was not properly shutdown, for example because the computer rebooted due to power failures. On some computers running openSUSE 13.2 this rebooting happens when sleep (suspend to RAM) does not wake up as intended.

8. Problem: Anything seems to work well but there are no stars. Solution: Check the third button in the display window Figure 16 for the image selection back to `current` so the images are updated.

9. Problem: The GUI in Figure 9 and the associated commands `crep` and `ctype` accept only small numbers; the GUI sets values back to smaller ones, and the status shown by the commands (without parameters) also shows smaller counts than requested. Pseudo-Solution: Increase the `CAMSHMSZ` parameter in `scripts/geirs_start_gen` (section 3.2) and/or the limit set by the operating system (section 2.5.5) before starting GEIRS. This will usually not work because the standard parameters are already set limits measured with respect to the available RAM.[74] The general solution is to split the exposures into smaller packets so each of them fits into the margins.

10. Problem: When `save`ing, a FITS filename and a message of the form `save: (E_fopen=48) could not open file` appear. Solution: Either

    - the disk is full (tested with `df -h`) or
    - the GEIRS user does not have write permission on the current data directory. This is revealed for example if one attempts to create an empty dummy test file in the style of `touch junk.txt` in that directory. A workaround then is to create a new directory with the `SavePath` button of Figure 9 for future use, which will by default be created with the corresponding write+executable permissions, or to use `mkdir` of the Linux shell in conjunction with a `set savepath` of the GEIRS shell, or to obtain modifying privileges of the intended data directory and execute `chmod g+wx` on this if owned by another user.

    Keep in mind that GEIRS does not overwrite existing FITS files (with the exception of those created via the `sfdump` command or if explicitly permitted via the `clobber` command or with the `-c` of the `save` command). This is important if operators set explicit file names with each `save` command instead of relying on the automated file selection.

11. From time to time it can happen that a process hangs. Mostly you can simply kill the hanging process. Some commands are prepared for this, as documented in the command list (Section 5.3):

    - `kill read` terminates a read command
    - `kill save` terminates a save command

    Type these commands in the interpreter window where you have started the GUI, not into the UNIX/Linux shell (where it refers to processes of the operating system).

12. Problem: `geirs_cleanup` responds with a message of the from `If 'cleanup' is not a typo....` Solution: expand the `PATH` variable as described in Section 2.5.2.

13. Problem: After the read process finished the `save` button in the controls GUI in Figure 9 stays yellow. Solution: This happens for example if automated save processes fail due to a disk full state. This is in particular a thread on the CARMENES computer with only 180 GB of disk where single frames saving with the `sfdump` interface is on by default. (This is equivalent to less than 4 hours observing time at a maximum speed of 1 frame each 1.3 seconds.)

14. Problem: Some of the FITS keyword values of the LUCI FITS files are wrong. Solution: This happens regularly when the online tool which generates the additional keywords as described in Section 7.2 is left alone and further FITS files are generated using GEIRS as

[74] The exception is the two LUCI's and perhaps also the two NOTs where the assumption is made that binocular mode requires two GEIRS sessions; so there is room by a factor of two then.

a standalone reader. The FITS keywords generated by the online tool take priority over keywords (of the same name) generated by GEIRS,but soon they become obsolete when they are no longer refreshed by the online tool. GEIRS can not do much about this because it does not know by which means it receives its commands and how often the online tool updates this information. Operators who set aside the online tool should clean the file with `echo > ~/tmp/geirsPhduAdd.luci?_2` before continuing taking data with GEIRS standalone.

15. Problem: After calling `read`, GEIRS and other processes seem to hang for up to 30 seconds. Solution: Ensure that the installation is complete, including the last lines of the `INSTALL` file concerning file owners and permissions.

16. Problem: The single frame dumps of CARMENES seem to miss some frames in `LIR` mode. Solution: Operate GEIRS in accordance with standard parameter ranges. In detail:

    - Avoid disk full states.
    - Do not abort the reads in correlated double sampling modes before the second frame is read. The first stage pipeline will reject processing output of that kind with error messages.
    - Do not impose heavy disk I/O loads besides GEIRS's own automated guide mode dumps unless you are sure that your disk writing speed exceeds the throughput of the 16 MB per frame by at least a factor or two. GEIRS drops single frame dumps if it cannot keep up with the frame rate.[75]
    - Avoid `crep` parameters larger than one in conjunction with the `ctype lir`. This will generate the raw frames but the first stage pipeline (and further processing) will discard any images but the last one.
    - Because the FITS name convention for CARMENES uses time stamps rounded to full seconds, GEIRS starts to drop frames if the frame frequency becomes larger than one frame per second. This happens for example if subwindowing is used or the pixel read time is reduced. To store all frames anyway, use an explicit `save` with the single frame option (although these will not be recognized by the first stage pipeline).

17. Problem: Macros with `crep 30` and `ctype srr 45` miss frames with CARMENES. GEIRS stores only 33 but not the expected 45 frames. Solution: The RAM requirement for the frames would be $30 \times 45 \times 16$ MB, which is larger than then 16 GB of (half of the total RAM) on the NIR computer, see Section 2.5.5 and the `CAMSHMSZ` parameter in Section 3.2. Make sure that the arithmetic product of the repetition value by the number of frames along the ramp is less than 800; if needed split exposures into multiple `read`s to stay below that limit for each single `read`.

18. It has been reported for LUCI that one can press the `Endless` button of the control GUI (Figure 9) and that the other LUCI control GUI reacts synchronously, although such a cross-talk is obviously not desired or expected. The most likely cause is that different people are using the instrument at the same time (under the same Linux account) and are just watching each other's actions on the local displays. This is supported because the number of control GUI's is not limited and everybody can join a GEIRS session for example by opening another GUI with `geirs_snd_luci{12} control`, can open further shells or can send one-shot commands (Section 3.1). It is recommended to scan the command logs (drop-down menu

[75] This is a deliberate design choice to support smooth processing with the first stage pipeline.

in Figure 9) and figure out whether all the commands appearing there are actually yours, and if not check who else might be operating the DCS. We realize that *stealing* sessions is a quite common operator pattern and that adding limits on session counts would lead to restrictions which are not desired.

19. Problem: Decreasing the subwindow size leads to missed frames and in turn timeouts while GEIRS reads the detector data. Solution: If the time to read the detector one is becoming less than approximatey 10 ms, the readout process (although configured with the real-time parameters) may become too slow for the process swaps needed to rerun the 4 real-time threads that acquire the data. Some tuning may help to reduce (but not to remove) the problem: closing/iconising the GUI with the real-time display and not sending any commands (not even `sync`) to the command handler before the readout is finished.[76]

20. Problem: pressing the `Modules`→`debug log monitor` does not open anything or just shows a GUI for a split second that closes immediately. Solution: check that

    ```
    journalctl
    ```

    shows at least a few log lines. If this responds with `...due to insufficient permissions`, check that the directory `/var/log/journal` exists. If not, switch to persistent (and per-user) journaling. by changing

    ```
    #Storage=auto
    ```

    to

    ```
    Storage=persistent
    ```

    in `/etc/systemd/journald.conf` and reboot or restart the journal with

    ```
    systemctl restart systemd-journald
    ```

    as superuser.

21. Problem: after pressing `read` one can save the exposure to files and there are no complaints in the log monitor, but the real-time display is not updated. Solution: If the range of the actual pixel (frame or image) data is narrow, the cut levels may be too narrow to let any of the new pixels pass, and the algorithm in the real-time display does not take them as a trigger to update the display. This may for example happen if a warm detector is read out, where the image is "flat." In this case switch to the `100 min-max` selection in the menu of the display, Figure 16.

10.3 Operating System

1. Problem: After `start* -gui` time GEIRS complains that `DISPLAY` is not set.[77] Solution: For all steps of establishing tunnels and using `ssh` to login to the GEIRS workstation, use the `-X` option as documented `ssh(1)`.

   In addition, if commands are run through a `sudo`,

[76] Because GEIRS is not ment to be used within AO controllers, improving on this has absolutely no priority.
[77] Of course this has nothing to do with GEIRS.

- the `env_keep` list of variables in `/etc/sudoers` ought include the `DISPLAY` variable to forward the variable from the user who runs the `sudo` to the effective user after the `sudo`.
- the effective new user needs to be authenticated with the information of (basically) `.Xdefaults` of the user who runs `sudo`, see [6].

2. Problem: the startup scripts prints some dots and then says `Cannot connect to shmmanager`. Solution: The shared memory allowances set in Section 2.4.1 are too small, so the shared memory manager does not start.

3. Problem: the command `geirs_cleanup` is not found. Solution: Add `$CAMHOME/scripts` to the `PATH` as described in Section 2.5.2.

4. Problem: the compilation of the GEIRS source enters an infinite loop with `recheck` messages. Solution: this may happen if the time stamps of the source code bundle (which has been created on another computer) are severely out-of-sync with the clock on the computer where GEIRS is compiled. Use `date` to check that the system clock is reasonable on the GEIRS computer and connect the computer with a NTP server if it is not.

5. Problem: the environment variable `CAMSERVERPORT` reported on start is not set to any integer number. Solution: either set the variable explicity on the shell before starting GEIRS as explained in Section 3.2 or complete the `xpath` installation of Section 2.1 to use the defaults.

6. Problem: error messages containing `attach received shm-page` appear after starting GEIRS at irregular times, typically at the first or second attempt to `read` the detector, followed by segmentation faults. Solution: This problem has been observed using openSUSE Tumbleweed as the operating system in the versions of July 2022. It has not yet appeared on other operating systems or on the openSUSE Leap distributions. This is a bug which may or may not have been solved in the Tumbleweed variants since then and means that attaching and detaching from the shared memory pages (which are heavily used within GEIRS) soon loses them, which can be monitored with `ipcs(1)`. There is no known patch to this but *not* to use openSUSE Tumbleweed.

10.4 External Software

(Of course, these things have nothing to do with GEIRS.)

1. If `fv` displays in `pow` a transparent image, the `kde4` allows to change this behavior by either `<Shift><Alt><F12>` momentarily, or by disabling these effects in the Application Launcher Menu in `Personal Settings (Configure Desktop)` → `Workspace Appearance and Behavior` → `Desktop Effects` and unchecking `Enable desktop effects at startup`.

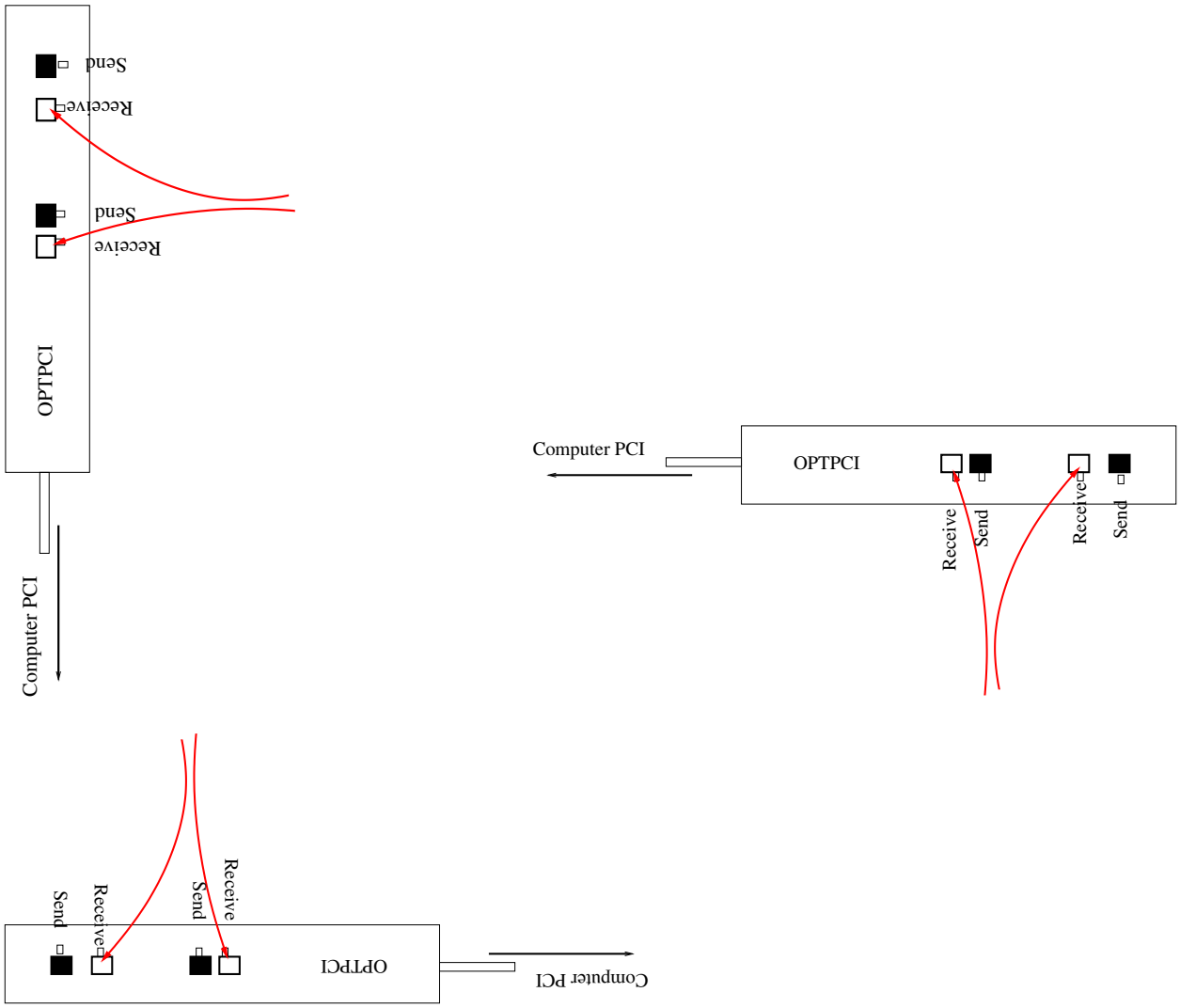


Figure 28: Fiber connectors of the OPTPCI board on the rear side of the workstation. Note that depending on which riser board is used on the computer–typically on racks of 2U height—, the entire configuration is rotated. At the upper left we sketch the vertical LUCI, MPIA and AIP installation (host: Transtec Opteron with 2 Opteron-8C 6220, Opteron-4C 2382, Tower PC respectively), in the lower left the horizontal LN or 70cm-KING installation (host: Dell R515 or PicoSYS 2614), at the right the Figure 30 of the ROE manual [26] or PANIC (host: PowerEdge R720 or Sharkoon A10-7850K).

Figure 29: Example of two OPTPCI-X boards vertically installed in a Transtec Workstation (2 Opteron-4C, 2382).

Figure 30: Example of a OPTPCI-e board horizontally installed in a PicoSys 2614.

Figure 31: Example of a OPTPCI-e #015 board horizontally installed in a Dell PowerEdge R720.

Figure 32: Example of a OPTPCI-e board horizontally installed in a Dell PowerEdge R515. The two fibers are likely at the wrong places in this photo, which means they are plugged in the "send" ports of the two OPTPCI-e ports, but should be plugged into the "receive" ports to get a working system.

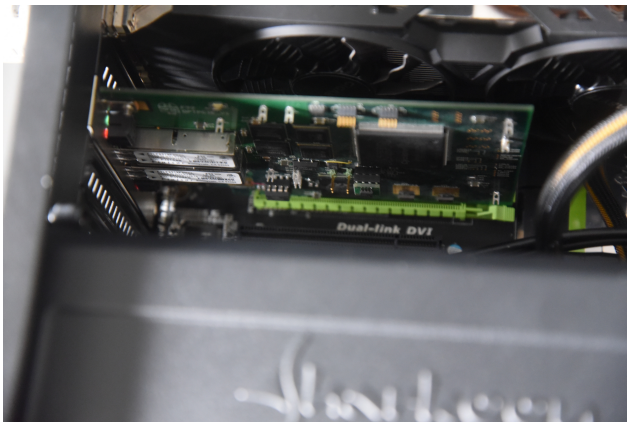


Figure 33: Example of a OPTPCI-e board vertically installed in a Sharkoon A10-7850K.

Figure 34: Example of a OPTPCI-e board horizontally installed in a Fujitsu Siemens Esprimo P7935. The board was de-installed in Oct 2020.

10.5 Recent Changes

```
Return-Path: <mathar@mpia-hd.mpg.de>
Date: Thu, 13 Jul 2023 13:51:46 +0200
From: "Richard J. Mathar" <mathar@xxx>
To: Ulrich Mall <mall@xxx>, "Jacob W. Clasen" <jclasen@xxx>,
    Vianak Naranjo <naranjo@xxx>,
    David Thompson <dthompson@xxx>,
    Glenn Eychaner <geychaner@xxx>,
    Florian Briegel <briegel@xxx>,
    Eloy Hernandez <ehernandez@xxx>,
    Matilde Fernandez_Hernadez <matilde@xxx>,
Cc: "Richard J. Mathar" <mathar@xxx>,
Subject: GEIRS version 803M-4

A summary of the GEIRS changes between version 800M-11
(as described in my e-mail of 4 Jul 2022) and the current
version 803M-4 from the application and operator point
of view is summarized here:

- chkconfig scripts to load the PLX drivers have been upgraded
  to systemctl to adapt to modern Linuxes.

- m4 macros of the autotools have been updated to the newer
  Linux distributions

- The IP address of the ROE is now editable in the (late)
  initialization GUI, not just early via shell parameters.

- Java GUI: added 8/1 and 10/1 magnification factors.
  Removed a BACKING_STORE flag in the library to avoid
  dithered frames in the display.

- Manual: removed the SRRE setup (never used anywhere, although
  in principle implemented in Luci and Carmenes ROE's)

- Allocate only half of the standard shared memory for NTE
  (assuming both ROE's are running on the same computer...)

- Changed the NTE spectrograph acronym from NTEspec to NTEisp to
  avoid name collisions with a future second (UV) spectrograph

- Some patch/back-port of the startup script that reads
  the XML configuration file to support old CentOS7 (of
  Linc-Nirvana or the elablx01 MPIA computer)

- The GUI's now use mainly the data server to request status
  information from the shared memory (relief to
```

```
  the concurrent stream of commands of some observation software).

- The controls GUI now allows to modify the readout directions
  (of the H2RG, H4RG). Obviously there is no such thing
  for the H2/Linc-nirvana.

- Upgrades of cfitsio, CCfits. In consequence C++ compilers supporting
  C++14 are now needed. Related: devtoolset installations that
  are needed to push up obsolete CentOS compiler bundles are better
  supported in the INSTALL script.

- Backport of some threshold in a data buffer for PLX transfer (as a result
  of experiments on the  elablx01 MPIA computer)

- Some more reasonable default for the expected board configuration
  of the incoming fiber data.

- Reduce computational load on the GEIRS computer while display GUIs are
  iconified.

- In the interactive controls GUI and outputs of the debugging
  windows xterm is by default replaced by konsole. X11 (including
  xterm) are no longer installed by default under concurrent
  Linuxes.

- If the number of digits reserved for the automated FITS
  file name scheme is exhausted, the "next lexicographic" lookup
  avoids incrementing the dash and underscore in file names to avoid strange
  FILE names. (Result of some involuntary PANIC experiments
  during commissioning.)

- There is an even stronger warning about GEIRS sessions already
  run on the same computer. (Results of some operator stealing
  sessions experiments during PANIC commissioning).

- As a result from LUCI statistics, some switches to the MER
  mode retry now 2 times to get their contents uploaded to the
  ROE.

- For Hawaii-2RG the default readout  directions are now
  the factory defaults (i.e. alternating left-right in horizontal
  directions).

- With experience from Linux kernels 6.x (i.e. Tumbleweed)
  some more patching of the PLX compilation in the INSTALL.plx
  scripts adapts to changes in the vm_flags of these kernels.

- The NOT ROE default IP address changed from the 193.163.3.x
```

```
  subclass to what is currently in actual use by the developers.

- for PANIC:
  - The 90deg rotations in FITS files have been adapted to the
    new H4RG mounting for PANIC
  - now rejects commands to move the wheels if the motor
    is still busy.
  - Changed the default configuration of the harmonic drive
    for the PANIC wheels to "disabled." A safety measure
    in response to the prediction that PANIC will never
    be used on the 3.5m telescope.
  - Allowed a larger jitter of motor wheels. Increased
    timeout from 60 to 70 seconds
  - Adapted pixel scale to 0.3752 from astrometry.net outputs
  - Standard North angle is 90.8 degrees (ie 0.8 off ideal
    geometric setup) derived from astrometry.net outputs
  - The default order of PANIC wheels is now that the
    total range of movements to run through all filters is
    minimized. (Result of some questions that arose during
    PANIC commissioning.)
  - The URL for the Swarthmore air mass plotter was patched.

- PLX SDK patches:
  - expanded search for header files (to support Ubuntu layout)
  - Some patch to support ALMA Linux (potentially for Luci upgrade)
  - Better count of existing number of boards on the computer bus
    (result of supporting Ubuntu....)

- Upgrade of the Xerces library to 3.2.4.

- A patch concerning commands submitted in a sequence without
  closing the socket (e.g telnet, reported by J Clasen) was added.

- The cmdGeirs for sending commands from remote computers has
  another secondary timeout flag (to support sending e.g. sync
  to the command interpreter). Likely only relevant to NOT.

- The TwoMassCnvrt was removed in geirs2Panic and
  other dead code was also removed, apparently not used by anyone (and
  obviously not a task for a detector readout controller anyway).

- As a result of a request from PANIC commissioners, the initialization
  GUI allows to modify fore- and background colors of the GEIRS
  GUI's, overriding the standard Java "metal" theme.

- In consequence of the prolonged default minimum integration times
  of the H4RG, some shortcut of the subwin commands are introduced
  (that simplify gathering the full frame contents by running
```

```
  multiple subwindows with split integration times in sucession...)

The relevant manuals are updated.
As always, all this is irrelevant to detector systems where the GEIRS
software is not upgraded.
```

The detailed changes can be reviewed with the source code browser in https://svn.mpia.de/trac/gulli/geirs/browser/src/trunk.

A BEYOND GEIRS

This section adds information on processes, other programs or aspects of the operating system that are not under GEIRS control nor part of the source distributed by the MPIA.

A.1 Installment of a new ROE IP address

How to change the IP address of the MPIA ReadOutElectronics[78]

A.1.1 Using RS232

Uninstall the ROCon board and set the configuration DIP switches 5 and 7 to ON. Start a terminal program like `PuTTY`. Reinstall ROCon board and connect it to your computer using a null modem cable. The serial settings are: 9600N81. Power on ReadOutEelctronics. You should see a message like this:

```
33 6 0 4 COS_XC161 V2.16, Jul 11 2007
33 6 0 4 ReadOut Controller V3.00beta, Jan 10 2013
33 6 0 4 System ready...
```

Now set the IP address (192.168.3.160 for example):

```
33 30 0 192 168 3 160
```

Note that there are blanks instead of dots separating the four numbers of the IP address. The new address can be read back after a soft reset (33 8 0), a pushbutton reset or a power on reset:

```
33 31 0
```

The ROCon boards responds:

```
33 31 0 2 192.168.3.160
33 31 0 1
```

If necessary the subnet mask can be set with:

```
33 34 0 255 255 255 0
```

The Subnet mask can be read back after a reset(see above):

[78] Contribution by U. Mall, 29 Feb 2015

```
33 35 0
```

Don't forget to set switch 5 to OFF for regular operation with new IP address.

A.1.2 Using ethernet

In case of configuring via ethernet your computers network adapter has to have an IP address in the same subnet as the ReadOutElectronics. Then you can `telnet` the ReadOutElectronics on port 4000:

```
>telnet 192.168.3.167 4000
Trying 192.168.3.167...
Connected to 192.168.3.167.
Escape character is '^]'.
```

The ROCon board responds with a message like this:

```
33 6 0 4 COS_XC161 V2.16, Jul 11 2007
33 6 0 4 ReadOut Controller V3.00beta, Jan 10 2013
33 6 0 4 System ready...
```

The next step is to login and reserve a module number:

```
33 21 0 user
33 22 0 mpia
33 23 0
```

For every command the ROCon board sends acknowledge:

```
33 21 0 1
33 22 0 1
33 23 0 1
```

Now setup new IP address (192.168.3.160 for example):

```
33 30 0 192 168 3 160
```

Note that there are blanks instead of dots seperating the four numbers of the IP address. The new IP address is activated after a soft reset(33 8 0), a pushbutton reset or a power on reset. After reset your telnet connection is lost. Ensure that your computers network adapter is in the same subnet as the new IP address and reconnect:

```
>telnet 192.168.3.160 4000
Trying 192.168.3.160...
Connected to 192.168.3.160.
Escape character is '^]'.
```

If you have done everything right you will see this message:

```
33 6 0 4 COS_XC161 V2.16, Jul 11 2007
33 6 0 4 ReadOut Controller V3.00beta, Jan 10 2013
33 6 0 4 System ready...
```

If necessary the subnet mask can be set with:

```
33 34 0 255 255 255 0
```

The Subnet mask can be read back after a reset(see above):

```
33 35 0
```

A.2 Image Rotation

The two configuration parameters `CAM_DETROT90`= r and `CAM_DETXYFLIP`= f specify an image transformation (r, f) defined by a rotation by a multiple of 90° ($r = 0, 1, 2, 3$) followed by an optional image flip of $f = 0$ (none), $f = 1$ (right-left) or $f = 2$ (up-down).

The four choices for `CAM_DETROT90` combined with the three choices for `CAM_DETXYFLIP` supply $4 \times 3 = 12$ combinations. This is only half of the $4! = 24$ possible permutations of all 4 corners, because only one of the orders of the two operations is implemented/supported.[79] A closer look shows that each of the rotations followed by a right-left flip can be replaced by a rotation through another 180° and a up-down flip: $(3, 2) = (1, 1)$, $(2, 2) = (0, 1)$, $(1, 2) = (3, 1)$, and $(0, 2) = (2, 1)$. So there are not 12 but only 8 image operations available. Those of the 24 that appear to be missing are group operations which would try to generate images where North and South remain not opposite to each other but end up at right angles. The transformation (r, f) is an element of a non-abelian group of order 8, isomorphic to D_8, the dihedral group with 8 elements. The group multiplication table is shown in Table 2.

	(0,0)	(1,0)	(2,0)	(3,0)	(0,1)	(1,1)	(0,2)	(1,2)
(0,0)	(0,0)	(1,0)	(2,0)	(3,0)	(0,1)	(1,1)	(0,2)	(1,2)
(1,0)	(1,0)	(2,0)	(3,0)	(0,0)	(1,1)	(0,2)	(1,2)	(0,1)
(2,0)	(2,0)	(3,0)	(0,0)	(1,0)	(0,2)	(1,2)	(0,1)	(1,1)
(3,0)	(3,0)	(0,0)	(1,0)	(2,0)	(1,2)	(0,1)	(1,1)	(0,2)
(0,1)	(0,1)	(1,2)	(0,2)	(1,1)	(0,0)	(3,0)	(2,0)	(1,0)
(1,1)	(1,1)	(0,1)	(1,2)	(0,2)	(1,0)	(0,0)	(3,0)	(2,0)
(0,2)	(0,2)	(1,1)	(0,1)	(1,2)	(2,0)	(1,0)	(0,0)	(3,0)
(1,2)	(1,2)	(0,2)	(1,1)	(0,1)	(3,0)	(2,0)	(1,0)	(0,0)

Table 2: Cayley multiplication table of the group of order 8 constructed with the `CAM_DETROT90` and `CAM_FLIPXY` keywords. The operation on the left is executed before the operation on the top.

The 8 group elements are

- the unit element (no change of the image),
- the three pure rotations $(r, 0)$ with $r = 1, 2, 3$—generated by the group element $(1, 0)$ of order 4—,
- the two pure flips $(0, 1)$ and $(0, 2)$—each of order 2—,
- and the two flips along the two diagonals, $(1, 1)$ and $(1, 2)$—each of order 2.

[79] You cannot twist the images by swapping two adjacent corners and keeping the opposing two where they are...

A.3 Remote Sound

This is a user's note that has nothing to do with GEIRS; any other means of the local computer network may be implemented as well. It is only of interest if operators need to hear GEIRS sound effects.

The computer that runs GEIRS may or may not have a sound card—see the output of any of the commands

```
cat /proc/asound/cards
amidi -l
/usr/sbin/alsa-info.sh
```

Usually GEIRS will be run on a remote server in the catacombs of the observatory, whereas the sound is supposed to be trumpeted on some controller's desktop. In that case the GEIRS computer does not need a sound card.

There is at least one technique to forward the sound to the operator under openSUSE, which feeds the digitized pulse modulation into a PulseAudio channel on the GEIRS (=remote) computer, and forwards this as an RTP package to the `pulseaudio` channel on the operator's (=local) machine, Figure 35. This is configured basically as follows:

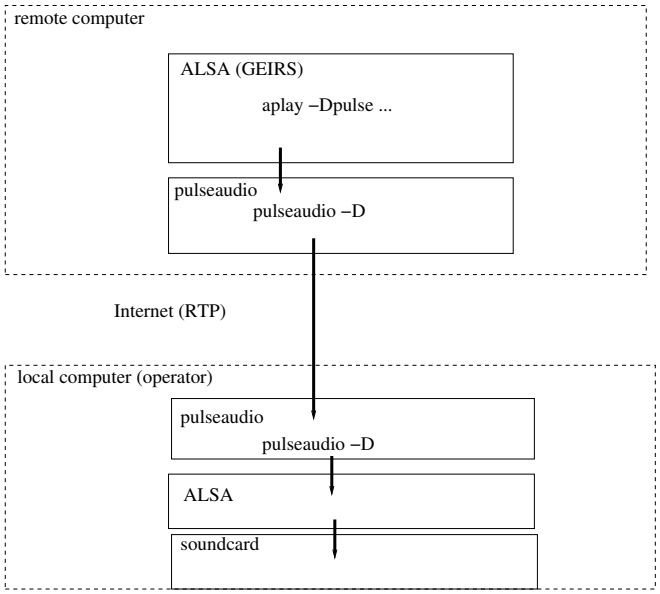


Figure 35: Potential of sound forwarding

1. Install the `paprefs` (pulseaudio preferences) openSUSE module on the remote and also on the local computer.

   If

   ```
   which paprefs
   ```

   does not show anything, this is essentially done by calling `sudo /sbin/yast2`, selecting the `Software management` submenue, searching for `paprefs` and downloading and installing it.

   There are two variants to configure the forwarding.

- `paprefs` is then called on the local computer, setting the `Network Access` to *Make... PulseAudio network... available locally*, setting the `Network Server` to *Enable network access to local sound devices*, setting the `Multicast/RTP` to *Enable Multicast/RTP receiver*. Again `paprefs` is called on the remote workstation, but setting `Multicast/RTP` to *Enable Multicast/RTP sender* and *Create separate audio device for....*

  `paprefs` can alternatively be called from the Desktop menue via `System` → `Configuration` → `PulseAudio Preferences`.

  The disadvantage of this setup is that the remote computer broadcasts continously the local audio stream to every other computer on the network, which eats bandwidth and is a waste of resources.
- An equivalent setup can be reached by enabling the TCP related modules in `/etc/pulse/default.pa` on the two machines by removing the hash marks before the two `tcp` lines and the `zeroconf` line. `paprefs` is then called on the local computer, setting the `Network Access` to *Make... PulseAudio network... available locally*, setting the `Network Server` to *Enable network access to local sound devices* and *Don't require authentication*, and not checking any of the *Multicast/RTP* buttons. Again `paprefs` is called on the remote workstation, but not enabling any of the options in the submenues.

  `paprefs` can alternatively be called from the Desktop menue via `System` → `Configuration` → `PulseAudio Preferences`.

These calls modify the `$HOME/.gconf/system/pulseaudio` files on the two computers and "called" from there with the aid of the `module-gconf` in `/etc/sound/default.pa`.

2. Enable pulseaudio either with

   ```
   setup-pulseaudio --enable
   ```

   or with `sbin/yast2` under `System` → `/etc/sysconfig Editor` → `Hardware` → `Soundcard` → `PulseAudio` such that the `PULSEAUDIO_ENABLE="yes"` appears in `/etc/sysconfig/sound`.

3. On the remote computer the `pulseaudio` server needs to run. This can be checked with

   ```
   ps -C pulseaudio
   ```

   and is generally implemented by a non-comment line of the format

   ```
   autospawn = yes
   ```

   in `/etc/pulse/client.conf`. If this does not work, start the `pulseaudio` server on the remote computer manually:

   ```
   pulseaudio --start
   ```

   and if this is refused with

   ```
   pulseaudio -D
   ```

   (This might be included in the `scripts/geirs_start_gen` of the GEIRS startup because the call is harmless if the server is already running.) On the local computer it probably is running already, because this would have detected the sound card:

```
pactl info
```

If one of the `pulseaudio` is not running, `aplay` or `paplay` will show (misleading) error messages of the form "connection refused."

4. An intermediate test of the functionality is that pulseaudio works on the local machine, to be tested by copying a sound file to that machine and playing it with

```
paplay *.au
```

5. Tell the server on the local workstation to accept the stream from the remote workstation. The least fuzzy way is to forward that information by accessing the remote computer with the `-X` switch of the `ssh`, such that the cookie appears on the remote computer, which can be checked with

```
xprop -root | fgrep PULSE
```

on the remote computer. If this information does not show up on the remote machine, either

```
start-pulseaudio-X11
```

or (more painfully) uncommenting the `load-module module-x11-publish` in `/etc/pulse/default.pa` on the local machine—before calling the `ssh`—may be needed.

The files `$HOME/.pulse-cookie` in the home directories of the two computers seem to be no longer in use.

6. If alsa is used on the remote workstation, tell it to feed the output into its `pulseaudio`. The appropriate configuration is probably already in `/etc/asound-pulse.conf` on the remote workstation.

```
# PulseAudio plugin configuration

pcm.!default {
    type pulse
    hint {
        show on
        description "Default ALSA Output (currently PulseAudio Sound Server)"
    }
    fallback "sysdefault"
}

ctl.!default {
    type pulse
    fallback "sysdefault"
}
```

Since the (reverse) feeding of the pulseaudio channel to the alsa channel is likely also needed on the local workstation, an equivalent file is likely also needed on the local file system.

7. On the remote workstation, tell the `pulseaudio` server which machine ought to receive its output by setting the `PULSE_SERVER` variable to the local host:

   ```
   RMHOST=`who -m | awk '{print $6}' | sed 's/[()]//g'`
   # RMHOST=`echo $SSH_CLIENT | awk '{print $1}'`  # alternative
   export PULSE_SERVER=$RMHOST
   ```

   This might be inserted in the `$CAMHOME/scripts/geirs_start_gen` file on the remote workstation. If this forwarding service is also needed for other programs, it is a good idea to add these few lines also to the user's `.bash_login`. Whether the numerical IP-address is needed depends on the avialability of a DNS server from the remote computer.

8. Set the environment variable `CAMAUDIOPLAY` (in the `scripts/geirs_start_gen`) on the remote machine to `paplay`, such that `aplay` on the GEIRS workstation feeds its output of the audio file to its local `pulseaudio` daemon.

The installation is working once the command

```
cd $CAMHOME/SOUNDS
aplay -Dpulse rooster.au
paplay rooster.au
```

on the remote (GEIRS) workstation plays sound on the local workstation. If the call

```
cd $CAMHOME/SOUNDS
paplay rooster.au
```

on the remote workstation still says "connection refused," this may be caused by a firewall on the local workstation—as for example enabled by default on fresh openSUSE 13.1 installations. The firewall must then be weakend (or just shut down) via `/sbin/yast2`, allowing the TCP packages from the remote computer with port 4713: `system`→`Security and Users`→`Firewall`.

A.4 X11

A.4.1 Forwarding

Under newer versions of openSUSE X11 forwarding with `ssh -X` may fail because the `DISPLAY` variable is not forwarded, although the forwarding is enabled in `/etc/ssh/sshd_config`. The solution of the problem is to enable `IPv6` in the network configuration of the remote workstation, or to set the `AddressFamily` explicitly to `inet` (thus replacing the default, which is `any`).

Remote login from another place to a workstation may fail if the ssh daemon is not enabled on the remote site. To enable it, use `/sbin/yast2` on `openSUSE`, the submenue `Security and Hardening`, then the submenue `Enable extra services in runlevel 5` and switch the entry for the `sshd` to `Yes`. On `Ubuntu` use `apt install openssh-server`.

It may happen that the remote server is configured like a laptop to enter a sleep mode after some timeout, and becomes non-reachable for that effect. In that case entering that state may be avoided with

```
sudo systemctl mask sleep.target suspend.target hibernate.target hybrid-sleep.target
```

If the GEIRS workstation is hidden in a remote local network, the usual mechanism with port matching and X11 forwarding may be used. The example is

```
verdi9> ssh -X yoursshname@ssh.lbto.org
```

and then in that new shell on the intermediate machine

```
ssh> ssh -X geirsusername@Luci.luci.lbto.org
```

to log into a remote machine on the LBT network. We showed the prompts to illustrate on which computer's shell these commands are entered. Note that incomplete names like `luci.luci` do no longer work since changes in the DNS in the network in 2014.

If one needs to work on the remote machine with `sudo(8)` mechanisms, permissions to use the X11 interface need also to be added before trying to open GEIRS or other windows `xauth(1)`.

```
xauth list
sudo -u effnewuser /bin/bash -i
# touch ~/.Xauthority # usually only needed for new users here
echo $DISPLAY
# Below add the full line after the 'add' that was the output of the
# previous xauth command. The correct line is the one which (almost)
# matches the current setting of DISPLAY. If DISPLAY is for example
# 'localhost:13', take the line from the 'list' that has 'somehost/unix:13'.
xauth add ... MIT-MAGIC-COOKIE-1 ...
```

A.4.2 Tunneling

Supposed one whishes to exchange files with a remote computer on the LBT network, this can basically be done by copying them first to `ssh.lbto.org` and from there to the destination. There are two possible directions of such a transfer. The example to copy a file `tst.txt` is

1. From the local computer named `verdi9` to the remote computer named `luci.luci.lbto.org`:

   ```
   verdi9> scp -p tst.txt yoursshname@ssh.lbto.org:.   # copy from local computer to ssh
   verdi9> ssh -X yoursshname@ssh.lbto.org           # log into the ssh
   ssh> scp -p tst.txt geirsname@luci.luci.lbto.org:.  # transfer file to luci
   ssh> rm tst.txt   # clean up file on ssh
   ssh> ~.     # log out from ssh
   ```

2. From the remote computer to the local computer:

   ```
   verdi9> ssh -X yoursshname@ssh.lbto.org           # log into the ssh
   ssh> scp -p geirsname@luci.luci.lbto.org:tst.txt .   # copy from remote computer to ssh
   ssh> ~.     # log out from ssh
   verdi9> scp -p yoursshname@ssh.lbto.org:. .  # transfer file from ssh to local
   verdi9> ssh -X yoursshname@ssh.lbto.org           # log agin into the ssh
   ssh> rm tst.txt    # clean up ssh intermediate copy
   ```

This chain of copying is complicated, and needs local disk space on the `ssh` intermediate computer that ought to be cleaned up. The more elegant alternative is to set up a tunnel that passes the

data from the local computer to the remote computer, such that no intermediate files are created. There are again two directions. The most common task is to copy the FITS files from a remote disk to your local disk as follows. First set up a tunnel through the intermediate computer calling

```
verdi9> ssh -X -N -L 2022:xxx.yyy.www.zzz:22 yourssshname@ssh.lbto.org
```

on your local computer. (This command will respond nothing, so the output seems to hang after the password was typed in. Close the tunnel with `CTRL-C` after the connection is no longer needed, to return to the Linux shell prompt.) The `xxx.yyy.www.zzz` should be the IP address of the remote computer, for example `192.168.60.12` for `luci.luci`. Then pull the files with

```
verdi9> scp -p -r -P 2022 geirsname@localhost:/dir/full/path/on/luci  /full/path/on/verdi9
```

to the local disk or push them to the remote disk with

```
verdi9> scp -p -r -P 2022 /full/path/on/verdi9 geirsname@localhost:/dir/full/path/on/luci
```

using the same number after the `-P` as the first port number in the previous tunneling setup. It is useful to move first into the target directory on the local computer, so the dot (.) can be used as the destination address. To use wild cards in the remote file names, surround the URI with simple quotation marks:

```
verdi9> cd /full/path/on/verdi9
verdi9> scp -p -r -P 2022 'geirsname@localhost:/dir/full/path/on/luci/*.fits'  .
```

If one is logged into a computer outside the MPIA network, one can log into a computer inside the MPIA network. The new approach is to use a VPN. The start of the VPN on the external machine depends on the operating system. For Fedora this is

```
extr> su
extr> openvpn --config mpia-vpn.ovpn --daemon # use the file mpia-vpn.ovpn of MPIA
mpiaitusername  # enter the user name of your MPIA account here
mpiaituserpassw  # enter the password of your MPIA account here
extr> exit
```

Then log into the MPIA computer with the particular user and password on that one:

```
extr> ssh -X mpiacompusrname@mpiacomp.mpia-hd.mpg.de
mpiacompusrpassw
```

A.4.3 vnc client

Since X11 over ssh is an extremely slow setup for working with overseas computers, the standard Linux tool to open remote displays is the `vncviewer(1)`. Installation:

```
zypper install libXvnc1 libvncclient1 libvncserver1 tigervnc vncmanager xorg-x11-Xvnc # openSUS
yum install tigervnc-server # CentOS
dnf install tigervnc-server # Fedora
apt-get install tigervnc-common tivervnc-standalone-server # Ubuntu
```

Log into the remote computer via `ssh` and start the vnc server there:

```
verdi9> ssh -X lneng@lircs.linc.lbto.org
```

`extr> vncserver -autokill`

Remember the password just entered and the display number *extr:N*, and start the client on the local machine:

`verdi9> vncviewer` *extr:N*

In practise this is combined with tunneling to the remote X11 session, using the fact that the display number N reported by the server is port $5900 + N$ on the remote machine. To run a X11 session on the local computer `verdi9` connected to the remote computer `ln-lircs`, for example:

```
verdi9> ssh -X lneng@lircs.linc.lbto.org
ln-lircs> vncserver -autokill # example response: lircs:2
verdi9> ssh -N -L 5922:localhost:5902 lneng@lircs.linc.lbto.org # select 5922 because smaller probal
verdi9> # this will appear to hang, keep the window open and open another one
verdi9> vncviewer localhost:22
```

Logout from the remote session as usual by clicking with the right-most button in a free part of the window manager of the remote screen (but do *not* shutdown the computer).

The `vncviewer` may also be run over a VPN connection: first the VPN tunnel from your external computer to the MPIA network is set up as described in Section A.4.2. Then one logs into the MPIA computer with `ssh -X` and starts `vncserver` as shown above (and optionally logs out). The one uses the `ssh -N -L` on your external computer to open the tunnel to the MPIA computer, and finally one uses the `vncviewer` (with your MPIA VPN password) on your external computer to get a login screen on the MPIA computer.

A.5 FITS

A.5.1 Chopping MEF

If images have been stored in the extensions and we wish to create versions with images in the primary header, the `ftcopy` command of the heatools is one way to create copies of that simpler format.[80] Example: the four images extensions `win1_1`–`win2_2` of the FITS file `dcrsave0007.fits` are restored in four new FITS files `tmp_win`*i*`.fits` with the four Linux commands

```
heainit # not necessary if already in ~/.bash_login
ftcopy 'dcrsave0007.fits[win1_1]' tmp_win1.fits copyall=no
ftcopy 'dcrsave0007.fits[win1_2]' tmp_win2.fits copyall=no
ftcopy 'dcrsave0007.fits[win2_1]' tmp_win3.fits copyall=no
ftcopy 'dcrsave0007.fits[win2_2]' tmp_win4.fits copyall=no
```

A note to CARMENES observers: The usual way to open both detector images at the same time with `ds9` is

`ds9 -multiframe -cmap bb` *file.fits*

Since March 2015 a 2D WCS coordinate system in units of millimeters has been added to the FITS headers, so one can also use for example

`ds9 -mosaicimage -cmap bb -zoom 0.5` *file.fits*

[80] This is a user's note that has nothing to do with GEIRS.

to render the image with an approximately correct gap between the two chips.