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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 any 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,
2. PANIC upgrade to Hawaii-4RG at the MPIA under openSUSE 15.1 or higher,
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, presumably under openSUSE 15.1 or higher,
6. the NTEimg and NTEspec upgrades at the NOT, presumably under Ubuntu 19.04 or higher.

It also is used as a data acquisition and display tool in an experimental setup for Sidecar development. The development platform is openSUSE Leap 15.1 currently.

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

- 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 any longer, one should not consult this documentation but the documentation of the applicable release.¹

The software is currently developed under openSUSE Leap 15.1 with gcc version 7.4, perl 5 (version 26) and PLX SDK 8.00. It does not contain parts constrained by (re)licensing: 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.² There is no “initialization sequence” because essentially all parameters concerning exposures are forwarded later.

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.

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

¹With the exception of Linc-Nirvana, MPIA has no control over instrument groups’ decisions to work with any particular GEIRS release. . .
²most of which is spent to upload default patterns to the ROE via the internet.
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.\(^3\) 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

2MASS  \(\text{http://www.ipac.caltech.edu/2mass/releases/allsky/index.html}\)

ADC  analog-to-digit conversion

ADU  analog-to-digital unit

AIP  Leibniz-Institut für Astrophysik Potsdam \(\text{https://www.aip.de}\)

API  Application Programmer Interface


CAHA  Calar Alto Astronomical Observatory \(\text{http://www.caha.es}\)

CARMENES  Calar Alto High-Resolution Search for M Dwarfs with Exoearths with Near-infrared and Optical Echelle Spectrographs \(\text{carmenes.caha.es}\)

ccw  counter clock wise

CPU  Central Processing Unit

DAC  digit-to-analog converter

DCS  Detector Control System

DEC  declination coordinate of the ICRF

DICOM  Digital Imaging and Communications in Medicine  
\(\text{https://www.dicomstandard.org/}\)

DMA  Direct Memory Access

DNS  Domain Name Service

\(^3\)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.
EPICS  www.aps.anl.gov/epics
FIFO first in first out http://en.wikipedia.org/wiki/FIFO
FITS  Flexible Image Transport System http://fits.gsfc.nasa.gov
FPGA  Field programmable gate array
FWHM Full width at Half Maximum
GEIRS  Generic Infrared Software
GNU  www.gnu.org
GUI  Graphical User Interface
HDU  header-data unit (of FITS)
HEASARC  High Energy Astrophysics Science Archive Research Center
          https://heasarc.gsfc.nasa.gov/
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
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  Line-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
<table>
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<tr>
<td>MER</td>
<td>Multi-endpoint Read</td>
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<tr>
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<td>Max-Planck Institut für Astronomie, Heidelberg&lt;br&gt;<a href="http://www.mpia.de">http://www.mpia.de</a></td>
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<td>NIR</td>
<td>near infrared</td>
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<td>PCI</td>
<td>Peripheral Component Interconnect</td>
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<tr>
<td>PSF</td>
<td>point spread function</td>
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<tr>
<td>RA</td>
<td>Right Ascension</td>
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<tr>
<td>RAM</td>
<td>Random Access Memory</td>
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<td>Red-Green-Blue</td>
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<td>Readout Electronics</td>
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TCS  Telescope Control System

URI  Universal Resource Identifier

UT  Universal Time

UTC  Universal Time Coordinated

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

1.5 References

References


URL webdavs://sk1/geirs/roe3MPIA/Roconv3-Draft.pdf


URL https://svn.mpia.de/trac/gulli/ln/archive/Archive/LN%20Team%20Meetings/Project%20Team%20Meeting%20-%20Consortium%20Meeting/2013

URL http://fits.gsfc.nasa.gov/iaufwg


URL http://abell.as.arizona.edu/~hill/xlbt/cgi/ican.cgi?690


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 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
```

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


```
yum install centos-release-scl
yum install devtoolset-7
scl entable devtoolset-7 bash
```

2.1.1.2 flex

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

```
which flex
```

reveals that this is the case, use

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

to post-install it.
2.1.1.3 Java  The Java compiler is not distributed with the default layout of openSUSE 15.1 or Ubuntu 19.04. If

which javac

revals that this is the case, use

zypper in java-1_8_0-openjdk-devel # openSUSE
apt install openjdk-11-jdk # Ubuntu

to post-install it.

2.1.1.4 readline  The readline library is not distributed with the default layout of openSUSE 13.1. If the GEIRS installation does not find the header files, it compiles and installs its own copy of the library in its local directory; this is a waste of time. So it is recommended, if /usr/include/readline/readline.h is missing, to post-install the package with

zypper in readline-devel # openSUSE
yum install readline-devel # CentOS
apt install libreadline-dev # Ubuntu

2.1.2 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_66_0-devel # openSUSE
yum install boost boost-devel # CentOS
apt install libboost-regex-dev # Ubuntu

2.1.3 gsl  

GEIRS uses the Gnu Scientific Library for some parts of the CARMENES pipeline. If /usr/include/gsl is missing, you need to install the developer's version, gsl-devel:

zypper in gsl-devel gsl # openSUSE
yum install gsl-devel $ CentOS

If the library is not installed, GEIRS will not provide the functions that need the library.

2.1.4 libtiff  

GEIRS uses the libtiff Library for its program fits2tiff. If the library is missing, you need to install

zypper in libtiff tiff # openSUSE
apt-get install libtiff-tools # Ubuntu

otherwise GEIRS will not provide the fits2tiff command.
2.1.5 TwiceAsNice

*This section is only relevant to Linc-Nirvana.* If the environment variable `INSROOT` is set at compile time and the header file `Ice/Ice.h` is found, the GEIRS installation assumes that TwiceAsNice is available \[6\] and additional LN programs are compiled. In practise this means that GEIRS should be compiled *after* compiling TwiceAsNice.

2.1.6 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
apt install texinfo # Ubuntu
```

2.1.7 xterm Library

If

```
which xterm
```

indicates that xterm is not available (as apparently under newer CentOS), get it with

```
zypper in xterm-devel # openSuse
yum install xterm # CentOS
apt install xterm # Ubuntu
```

Otherwise GEIRS will try to use konsole instead, with limited flexibility. If the include file `X11/Xlib.h` is missing,

```
zypper in xorg-x11-devel # openSuse
```

Under Ubuntu 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 Other

2.1.8.1 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
```
2.1.8.2 Within GEIRS. Further external packages (cfitsio, CCFits, texinfo, sofa, xercesc, and parallel) in the GEIRS/branch/extern subdirectory are compiled later with the main source code. If the compilation of cfitsio does not succeed because no acceptable Fortran compiler is found, this may mean that /usr/bin/gfortran is missing. Use

zypper search fortran
zypper install gcc-fortran gcc48-fortran

to install the packages, or the equivalent yum on CentOS.

If the linker complains about missing libicui libraries, you need to install the dependency packages

zypper in libicu-devel libicu60_2 libicu60_2-ldedata # openSuse

2.1.9 Plx

Section 2.1.9 can be ignored if the software is installed on computers without OPTPCI boards, that is, computers that run GEIRS only in simulation mode.

The Linux driver for the PCI bus delivered by the manufacturer (PLX) of the main chip on the OPTPCI board (which is designed by MPIA) is expected to be installed in /usr/src, which needs root privileges. 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.

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 LUCI1/2, LN, PANIC, NTE and CARMENES) and 9656 (older, PCI-X, OPTPCI, still on duty on some MPIA computers). 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.

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 is basically cured by running /sbin/yast2, selecting the Software Management, the Repositories, and post-installing the kernel-deskop-* packages. 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

to compile the PLX driver.

3. To load the driver each time the computer is (re)booted plxload* is copied in the “old-fashioned” way to /etc/init.d/, then

chkconfig --add plxload8311
chkconfig --list

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

/sbin/service plxload8311 restart

at least once (which needs root privileges). plxstartup tries to load two different device drivers for OPTPCI-X and OPTPCI-e boards, but only one type of boards is used for any type of 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 the chkconfig 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 need to be recompiled—starting with the oldest—because they are linked with the binaries in the /usr/src directory, Section 2.2.2. If zypper up has installed a new Linux kernel, the steps are (as root)

chkconfig --del plxload8311 # remove (temporarily) to avoid boot problems with old driver
reboot now # ensure that new kernel is active
INSTALL.plx # recompile PLX driver
chkconfig --add plxload8311 # add new driver to forthcoming reboots

2.2 GEIRS Compilation

2.2.1 Obtaining the Source Code and Patterns

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

    export CAMHOME=${HOME}/GEIRS
    mkdir -p $CAMHOME
    cd $CAMHOME ; svn checkout https://svn.mpia.de/gulli/geirs/src/trunk trunk

4The 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.
If the KWallet system asks annoying additional questions, you might disable it entirely by using the KDE application menu, System → KWalletManager → Settings → Configure KWallet.

There is no public read access 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 available in a compressed tar ball, 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. 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. Compile the source code:

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

If you are an inexperienced user or are installing GEIRS on unsupported Linux flavors, save the output so the installation process can be inspected later on:

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

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. For test environments where GEIRS runs the data acquisition 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 acquisition.\(^5\)

There will be Error 2 (ignored) and failed messages related to packages mentioned in Section 2.1.8 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 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

---

\(^5\) These root permissions can of course also be set by someone else in the bin subdirectory after the INSTALL.
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-..
mak 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 compila-
tion/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 4) 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 6.
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. There are no GEIRS specific remnants in the standard system’s directories like /usr. Versions that are removed disappear from the options for the 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).

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 $2 \times 8,388,608 =$

---

6This is not recommended for versions that have actually been run in production because one might want to rollback and recompile if for instance the operating system and the drivers or the compiler have been updated.
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. 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

```bash
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.

### 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\(^7\)

```bash
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 `pinging` 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.

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 9.2 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.

### 2.4.4 Shutdown

To terminate all GEIRS sessions gracefully when the computer is shut down normally,\(^8\) it is recommended to install the `admin/geirsStop` script in the manner of the PLX load script of Section

---

\(^7\) For PANIC at CAHA this is 192.168.70.1

\(^8\) not with `shutdown now` or from power outages...
2.1 into /etc/init.d. (For efficiency, the list of commands in that script may be adapted to the instruments of the computer.)

```
cp admin/geirsStop /etc/init.d
chkconfig --level 016 geirsStop off
chkconfig --level 235 geirsStop on
```

To remove this recognition of GEIRS for start/stop use

```
chkconfig --del geirsStop
```

### 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, OBJECTS, 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/
```

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

```bash
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. In these cases the `PATH` must be set in `$HOME/.bashrc` with constructions like

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

### 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` 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 of CARMENES and PANIC on Calar Alto.

The simplest way to make it difficult for users (like `readout2`) to start instruments (like `Luci`) is to remove the symbolic links of the instrument in the user’s `scripts` directory.

The file `GENERIC` 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 two places:

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.

---

9One 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.

10...of course the `geirs_start` GUI still allows everybody to start every instrument...
2. The CAMROE_REV must be set to the existing pattern directory. This must be done even if the software is used in ROE simulation mode. The default is to use the pattern directory of the active GEIRS version.

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 executed. 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. The usual action here is to assemble the files with the complementary FITS keywords in the associated file.

- **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. Linc-Nirvana uses this to move the derotator. **QueueEFiles** is actually only called when the 3rd bit (0=LSB) of the GEIRS_FLAGS integer in the shared memory data base is set, so it can be changed through supervisor programs 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).

- **QueueFiles** is called when the `save` command has been completed. It might be used to display the new FITS file with ds9(1), trigger some action related to data archival, or start some data pipeline.

- **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.

Such a script may be not doing anything: a 2-liner like

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

or a 1-liner like

```
#!/usr/bin/env python
```

—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/Generic`, 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

\texttt{cat /proc/meminfo | fgrep MemTotal}

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 \texttt{GENERIC} file uses defaults which are slightly dependent 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 $\texttt{CAMHOME/DATA}$ directory, the $\texttt{CAMTMP}$ and in particular in $\texttt{CAMHOME/log}$ 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 \texttt{LOG\_LEVEL} in \texttt{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 \texttt{crontab(1)} for example) one time per day when the instrument is not used. A shell script to automate this is proposed in \texttt{GEIRS/\textless branch\textgreater/admin/glogRotate.sh} and installed with \texttt{INSTALL} if missing. If

1. \texttt{glogRotate.sh} is copied to $\texttt{CAMLOG}$—where \texttt{CAMLOG} is usually $\texttt{CAMHOME/log}$—,
2. this is made executable with \texttt{chmod +x glogRotate.sh}, and if
3. the associated entry as proposed in \texttt{glogRotate.sh} is added with \texttt{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 \texttt{syslog(3)} to the journal files, no longer to $\texttt{CAMLOG}$. Only (i) the PANIC temperature logs, (ii) the lists of the commands received by the command manager and (iii) the messages exchanged with the ROE remain in \texttt{CAMLOG}.

### 2.5.7 info

The \texttt{info} file \texttt{camera.info} is available which is basically supported by adding also

\begin{verbatim}
export $CAMHOME=$HOME/GEIRS # assumes default directory layout
export INFOPATH=${INFOPATH}:$(geirs_build)
\end{verbatim}

into the $\texttt{HOME/.bash_login}$ 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 submenu in Figure 6 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.\footnote{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.} 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.

<table>
<thead>
<tr>
<th>Sound File</th>
<th>triggered by...</th>
</tr>
</thead>
<tbody>
<tr>
<td>doorbell.au</td>
<td>readout finished</td>
</tr>
<tr>
<td>cuckoo.au</td>
<td>macro finished</td>
</tr>
<tr>
<td>bong.au</td>
<td>backup or the ‘shift-and-add’ calculation finished</td>
</tr>
<tr>
<td>crash.au</td>
<td>general error</td>
</tr>
<tr>
<td>fastbusy.au</td>
<td>warning (at changing user level to engineer or if near saturation)</td>
</tr>
<tr>
<td>whistle.au</td>
<td>save completed</td>
</tr>
<tr>
<td>sorrydave.au</td>
<td>unrecognized command</td>
</tr>
<tr>
<td>touchtone.0.au</td>
<td>disk full</td>
</tr>
</tbody>
</table>

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

3 INVOCATION

3.1 From workstation or remotely

Call the $CAMHOME/scripts/start.*_new that matches the instrument name, which is $CAMHOME/scripts/-start_luc12_new or $CAMHOME/scripts/start_luc11_new for LUCI. $CAMHOME/scripts/start-
nteimg_new or $CAMHOME/scripts/start_ntespec_new for NTE. 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 ptttrs directory if needed. To relocate source, data and logging directories, edit the associated environment variables in $CAMHOME/scripts/Generic 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 10). 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

   cmd_luci1 cmd arguments []; cmd arguments...
   cmd_luci2 cmd arguments []; cmd arguments...
   snd_luci1 [-s server[:port]] [-p port] cmd arguments []; cmd arguments...
   snd_luci2 [-s server[:port]] [-p port] cmd arguments []; cmd arguments...
   cmd_nnteimg cmd arguments []; cmd arguments...
   cmd_ntespec cmd arguments []; cmd arguments...
   snd_nnteimg [-s server[:port]] [-p port] cmd arguments []; cmd arguments...
   snd_ntespec [-s server[:port]] [-p port] cmd arguments []; cmd arguments...

or

   cmd_luci1_new cmd arguments []; cmd arguments...
   cmd_luci2_new cmd arguments []; cmd arguments...
   snd_luci1_new [-s server[:port]] [-p port] cmd arguments []; cmd arguments...
   snd_luci2_new [-s server[:port]] [-p port] cmd arguments []; cmd arguments...
   cmd_nnteimg_new cmd arguments []; cmd arguments...
   cmd_ntespec_new cmd arguments []; cmd arguments...
   snd_nnteimg_new [-s server[:port]] [-p port] cmd arguments []; cmd arguments...
   snd_ntespec_new [-s server[:port]] [-p port] cmd arguments []; cmd arguments...

or

   cmd_luci1_old cmd arguments []; cmd arguments...
   cmd_luci2_old cmd arguments []; cmd arguments...
   snd_luci1_old [-s server[:port]] [-p port] cmd arguments []; cmd arguments...
   snd_luci2_old [-s server[:port]] [-p port] cmd arguments []; cmd arguments...
   cmd_nnteimg_old cmd arguments []; cmd arguments...
   cmd_ntespec_old cmd arguments []; cmd arguments...
snd_nteimg_old [-s server[:port]] [-p port] cmd arguments [: cmd arguments...]  
snd_ntespec_old [-s server[:port]] [-p port] cmd arguments [: cmd arguments...]  
or  
geirs_cmdClient [-s server[:port]] [-p port ] [-v] [-fi|fc] cmd arguments [: cmd arguments...]

The difference between using or not using the _new_ and _old_ suffixes is that the start script sets the CAMBIN environment variable to different subdirectories of CAMHOME so one can conveniently keep a set of different GEIRS versions in the CAMHOME subdirectory.

The _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 $CAMTMP 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 cmd_luci1 and 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 cmd_luci1 or cmd_luci2 does not select the instrument. The instrument is the instrument the Linux/Unix user calling the _cmd_ actually started most recently.

The _snd_ interfaces and _geirs_cmdClient_ are essentially the same, where _snd_ calls _geirs_cmdClient_ which is based on TCP sockets. _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 timeoutSeconds] [-s server[:port]] [-p port ] cmd arguments [: cmd arguments...]  

The standard port is 8501 for _geirsCmd_ and taken from the port entry in the user's shared memory socket on the _server_ for _geirs_cmdClient_.

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

_geirsCmd_ uses a TCP socket interface which “represents” 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 5). _geirsCmd_ is indeed just a wrapper which uses that socket interface to submit commands to the _cmdServer_.

The _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 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/r737M-7/bin, Carmenes_r9M)
status itime
GEIRS_reply_2.0 20
itime: 2.7399310505
cycle-type 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 \texttt{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

\begin{verbatim}
cd /proc/sys/net/ipv4
cat tcp_keepalive_time
cat tcp_keepalive_probes
cat tcp_keepalive_intvl
cat tcp_retries2
\end{verbatim}

If your client interface does not get answers from GEIRS, your client may have been idle too long, and this is \textit{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 \textit{server} argument is either a simple name of the workstation on which GEIRS is running (if supported by a DNS) or a plain \texttt{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`, `aufplay` 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 [7].

**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 16.

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.12

CAMERA The master configuration label, which is either Nirvana, Panic, Carmenes, Luci2, Luci1, NTEimg, NTEspec, 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 [8, Sec. 4.1.2][9] and Section A.1. The port number (4000) cannot be changed—there is no scenario where one would have to change it.13

Wherever GEIRS is run, 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 9.1). 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

12...related to the existence 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 $128 \times 1024/(2 \times 1024^2)$ sec, or 5 ms. If the data are distributed over both channels, the effective FIFO capacity is $2 \times 128$ kB, and the latency allowance is doubled to 10 ms.

13unless communication to the ROE is mediated by an interface similar to Figure 25.
Figure 1: 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 \texttt{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 \texttt{DATAINPORT1} variable.

switches; it must be \emph{direct} in the physical layer in that sense, permitting only patch panels, ST connectors and so on to cross between laboratories. Note that the \texttt{DATAINPORT1} assignments are dynamic: if any OPTPCIe board is removed from the computer, the remaining one is always addressed as \texttt{/dev/plx00}.

If for example the OPTPCIe from \texttt{lucix.luci} is moved into a free slot of \texttt{luci.luci}, the three boards there are called \texttt{/dev/plx00}, \texttt{/dev/plx01} and \texttt{/dev/plx02}, but the boards now addressed as \texttt{/dev/plx00} and \texttt{/dev/plx01} are \emph{not necessarily} the same as those before the board transfer.\footnote{because GEIRS scans the bus and assigns numbers in the order of finding boards with the PLX chips…} 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, \texttt{start\_lucil}, \texttt{start\_luci2} and the variants with \texttt{new} or \texttt{old} take the following by default:

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{instrument} & \textbf{OPTPCIe} & \textbf{workstation} & \textbf{ROE} \\
\hline
LUCI1 & /dev/plx10 & luci.luci & 192.168.0.14 \\
LUCI2 & /dev/plx00 & luci.luci & 192.168.0.24 \\
spare & /dev/plx00 & lucix.luci & 192.168.0.34 \\
\hline
\end{tabular}
\end{table}

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

```bash
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 GENERIC script by an ASCII editor before starting GEIRS,

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.

**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, Lucii 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. Lucii_r19M or Lucii_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

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

in scripts/Generic. 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 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

```bash
nc -v -z server port
```

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

```bash
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.

---

15 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...
**CAMSERIAL_EOL_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.

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

**CAM_TMP** The name of the directory for temporary files. If not set explicitly, set to $TMPDIR$, $TMP$ or $HOME/tmp$ in that order, depending on whether the environment variables TMPDIR or TMP are set.

**CAMWWW** The full path name of the HTML help file for use as in Figure 7.

**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 PANIC’s 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. 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 2–3. 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 [10, Fig. 6]. The one in Fig. 3 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. 3 the $+\delta$ axis points upwards and the $+\alpha$ axis to the left—if the derotators are set to undo the $\approx \pm 70^\circ$ 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.
Figure 2: Reference position for rotation and flip parameter of the image: Here $\text{CAM} \_ \text{DETR90=} \text{CAM} \_ \text{DETYFLIP}=0$ (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.

**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 $\text{HINVDIR}[8..9]$ 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 channels (see the Teledyne manuals for details):

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

If not set, a value of 0 is assumed, meaning all channels are read left-to-right.

**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 types. 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, 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 $2048 \times 2048$ 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 experimental support for 32 for Hawaii-4RG, 16 for Hawaii-2RG and 4 for Hawaii-2.
Figure 3: 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.

**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 all four chips in 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** Pseudo-device name in the Unices sense used by GEIRS to indicate on which of the OPTPCI board(s) and which fiber the 16-bit pixel data arrive. Almost always plx-00 and plx-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 workstation 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.) For instruments with only one fiber/DMA channel (Luci, Linc-Nirvana, PANIC or CARMENES with CAM_NDET=1, NTE), the second (right) number is always 0, and DATAINPORT1=/dev/plx?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=/dev/plx?0 and DATAINPORT2=/dev/plx?1. The software does 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, needs to be the same. If the environment variable is not set otherwise, start_luci1 and the variants with new or old take /dev/plx10 by default, whereas start_luci2 and its variants take /dev/plx00 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.\footnote{This is currently only relevant if LUCI is started on lucix.luci which only has one board.}

The two digits of this pseudo-device name are \textit{not} related to the MPIA serial number on a small sticker on the board.

**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.\footnote{At MPIA, the address is found with \texttt{nslookup elotest}.}

**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, GENERIC 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 \texttt{panictempress} that reads PANIC temperatures and pressures if the command line option \texttt{-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 subprocesses; they are \textit{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 \texttt{scripts/Generic} with its current version. If long-term changes are required, contact the GEIRS maintainer to have these added to \texttt{GENERIC}, and use exported shell variables in the meantime.

The generic strategy in the \texttt{GENERIC} script is to honor (not to change) variables which are already set when the script is called. This allows users with lesser knowledge of shell scripting to configure/set the variables at other places, for example immediately before calling the script or in the standard files like \texttt{.bashrc} or \texttt{.bash_login}. Another use of this feature is that one can call GEIRS versions that are older than the most recent three ones or one can invoke pattern versions that are older than the most recent one. Here is an example in the case of LN started from a bash(1) shell:

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

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=/dev/plx00
start_luci2_new
export CAMSERVERPORT=9501
export CAMPORT=tcp://192.168.0.24:4000
export DATAINPORT1=/dev/plx10
start_luci1_new

(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 5;
3. modifications of the environment variables by the startup scripts;
4. modifications of the availability of subsystems (simulation) defined in the GUI in Figure 4;
5. defaults stored in the CAMTMP 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 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. 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,

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 to that guideline 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.

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18Each 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. 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 quits a session and every other user that needs to restart GEIRS for that instrument needs to send the quit to that abandoned 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

```
```

respectively

```
start_luci1 [-iwin] [-gui] [-disp] [-cmd] [-data]
```

```
```

respectively

```
```

respectively

```
```

respectively

```
start_luci1_old [-iwin] [-gui] [-disp] [-cmd] [-data]
```

```
```

respectively

```
```

or for the most recent version of the software

```
start_luci1_new [-iwin] [-gui] [-disp] [-cmd] [-data]
```

respectively

```
```

```
```

respectively

```
```

starts GEIRS. 19 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 4. The controls and/or the image GUI will be opened depending on the presence of the options -gui

---

19 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.
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 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. Most of the screen shots of this manuscript show the result of setting CAMFONT to helvetica in scripts/GENERIC, for example.

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 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.

Some parameters may be edited in Figure 4 at this time:

- **OBSERVER** Enter your name as observer. This will (i) appear in the FITS files and (ii) toggle allowances for some commands reserved for engineering purposes. (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.

• **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 names `/dev/plx-??` are used for historical reasons. They do not correspond to UNIX/Linux devices in the file system (which appear as `/dev/plx/Plx*` if installed as described above). The first placeholder in the name is 0 or 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.

• **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 the 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.

The GUI in Figure 4 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 5 or by explicitly setting the shell variables before using the start-commands of Section 4.1.

The GUI in Figure 4 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 GEIRS with the currently selected set of parameters.\(^{20}\)

\(^{20}\)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 may end up with some of these GUI’s hanging around for indefinite periods of time.
Figure 4: Startup screen to start GEIRS. Which of these layouts appears depends on the instrument.
After you press all in Figure 4, the subsystems (most noticeably the ROE) are initialized and the GEIRS window of Figure 6 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 be 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 6) and the main display window (Figure 13) may be suppressed by removing the `-gui` and the `-disp` options, respectively, from the call of the `shell` in the `$CAMHOME/scripts/GENERIC` 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 4, some parts of the GUIs described in this manual display yellow diagonal crosses or 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 5. This allows *experienced* users to edit many parameters on a finer level without editing the `GENERIC` 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 choosing from a pre-selected 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/GENERIC` with the options set in the third but last line of Figure 5. See Section 5.5 for the meaning of the `GENERIC` 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. switch temporarily to a configuration without editing the `GENERIC` script, to narrow down connectivity problems (Section 9).

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 6 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” to the two FPGA chips on the ROE.\(^{21}\) 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,

\(^{21}\)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.
Figure 6: 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.

- Help Opens a web browser which shows a HTML version of the command list, similar to Figure 7, equivalent to the contents of Section 5.3. This will fail if the environment variables `CAMWWW` and/or `CAMBROWSER` of Section 3.2 are not configured correctly.
- Shutdown GEIRS will close GUIs related to the session and terminate the command server, shared memory manager 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!*

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 13, 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

    ```bash
    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 sub-systems to deal with these house keeping data.
  - New InstrShell Opens a instrument shell window similar to Figure 10.
  - DebugLog-Mon. Opens a debug log monitor
Figure 7: The web browser called by the Help button in Figure 6.

- **ErrorLog-Mon.** Opens an error log monitor
- **ROE-Log-Mon.** Opens a log monitor similar to Figure 11 showing a history of command exchange with the ROE.
- **Cmd-Log-Mon.** Opens a log monitor similar to Figure 12.

- **Options Menu**
  - **Sound** calls up a sound menu like in Figure 8, 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.

- **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.
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.\(^{22}\) 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.

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

\[
\frac{2048 \times 2048 \text{ pixels}}{32 \text{ channels}} \times \frac{2 \text{ frames}}{100 \text{ kHz}} = 2.7 \text{ sec} \quad (1)
\]

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 6. For Hawaii-4RG detectors read

\(^{22}\text{full frame or line by line, I cannot tell... RJM 2015-08-03}\)
out by two MPIA ROE boards this is
\[
\frac{4096 \times 4096 \text{ pixels}}{64 \text{ channels}} \times \frac{2 \text{ frames}}{100 \text{ kHz}} = 5.2 \text{ sec.}
\] (2)

The impact on LN detector saturation is discussed elsewhere [11].

- **prd** The pixel read time in nanoseconds. The standard is 10 \( \mu \text{s} \) equivalent to 100 kHz. See the **roe** command in Section 5.3 and also Section 7.8.

- **pskp** The pixel skip time in nanoseconds.

- **lskp** The line skip time in nanoseconds.

- **ems** The electronic multisampling factor.

**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 9 with options to edit the index and the four parameters of the subwindows. Each row in the GUI represents one software window.

![Figure 9: Subwindow selections GUI opened with the Subwin-Selections window of Fig. 6.](image)

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 \( \geq 1 \), 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 \( \geq 1 \) 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** button is clicked.

**Set** and **Cancel** close the GUI. The **Subwin-Selections** and **On/Off** button indicate which configuration is left behind and effects subsequent read’s.
- **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. For most instruments that script does nothing, so the status of this flag is irrelevant.

  For LN this script actually moves the derotation stage of the detector to the start position remembered from the previous exposure (in an attempt to keep the instruments infrared background constant on the detector surface).

- **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/Generic`.

- 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 6.5)
* **-z/FITS compr.** to use the “internal” tile compression registered as a convention of the FITS standard [12, 13]. The current implementation allows this only if also the MEF is activated.

* **-S/single 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—used for the diff.intf.)

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 digit integer, which will be automatically incremented 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. Clicking on the name with the current FITS file allows to change the name for the next save command.

– 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 6 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 10.

The appearance of the Command Shell and logging windows (sizes, colors,...) is defaulted as for X-terminals as set at the standard places in the file system, $HOME.Xdefaults, $HOME/app-defaults etc.

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 6 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 11–12. 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

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

to obtain the logs from the critical up to the warning level.

The monitor of the ROE logs, Figure 11, 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 12, tracks log/cmd*.log. The inter flags that the line 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.

4.3.3 Real-time Display

4.3.3.1 Introduction The display tool, Figure 13 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.

\texttt{xpa} is compiled for example by installing the \texttt{heatools} (Section A.6.4). If \texttt{xpa} available, users can send a duplicate of each new FITS file that is generated by the \texttt{save} command to an online \texttt{ds9} application by adding two lines like

\begin{verbatim}
Xpaset='type xpaset | awk '{print $3}''
cat $1 | $Xpaset ds9 fits
\end{verbatim}

to the \texttt{QueueFiles} shell script (Sec. 3.3). As an alternative to using the \texttt{type} command one may use the full path of \texttt{xpaset} or make sure by symbolic links that the path contains the executable. Note that \texttt{ds9} sometimes needs to read \texttt{ds9-64} depending on how this was compiled. With that setup, opening the GUI in Figure 13 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. It is also easier to navigate through pictures if windowing was used, because GEIRS does not glue a set of subwindows while composing FITS files. (geirs2Panic has been written to merge these frames after they have been stored as FITS files.)

The real-time display polls the shared-memory database (with a combination of \texttt{get INT\_STOP\_SEC}, \texttt{get READBUF} and \texttt{get NIMAGE}) each $1\frac{1}{2}$ seconds to check whether a new image is available.\footnote{That interval can be changed by modifying the 1500 milliseconds of the \texttt{pollTmr} in \texttt{de/m*/m*/g*/DisplayGUI.java}.} It then requests the recent image from the data server and adds it to its circular buffer.
Figure 13: Current Exposure Display. Right after GEIRS startup this shows the white-on-blue logo of the MPIA.
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 13 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.\(^{24}\) 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.

---

\(^{24}\)It does not just add the pixel values in the tiles because that would require adjustment 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 $\gamma$-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 labels 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 6.4.

- 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 6 with -i checked and all other options uncheck.

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 (see Sections A.6.1A.6.4), 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 is a cut levels selector which offers either fixed or a range of numbers are not adapted to the current image but stay fixed as new images arrive, and the cut levels may be edited by changing the lower and upper limit in the two fields underneath. If fixed, one may enter a pair of numbers where the left number (lower limit) is larger than the right number (upper limit) to revert the levels; then stars appear dark on a brighter (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 accuracies 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 14). 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 function 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.

![Figure 14: Examples of cut plots activated with the `horiz.` or `vert.` buttons of Fig. 13.](image)

They are not cutting through the location where the additional FWHM centroid may appear.
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 $293 \times 293$ 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 $2\sigma$.

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 4 and/or not getting 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 further 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 $2\sigma$ 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 15, which shows a horizontal time axis and FWHM values on the vertical axis. FWHM values above 2 arcsec/px are not included.

Figure 15: Intermediate FWHM history while the FWHM button of Figure 13 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.

### 4.3.4 Telescope control window

*Section 4.3.4 has no relevance to instruments besides PANIC.*

Virtual control of the telescope, such as moving to an absolute position or offsetting from the current position, is done on the telescope control panel. The basic information from the telescope, such as airmass, UT, and current telescope position is also displayed here. This GUI panel should
start automatically when the GUI is first initialized. If not, you can call it up from the camera control window (Fig. 6) in the menu Modules→Telescope.

GEIRS keeps some basic set of telescope parameters for the displays and for inclusion in FITS header keywords. This set of values is not necessarily up-to-date, because GEIRS reads the parameters from the EPICS interface only if it itself has forwarded one of the telescope commands and if that action terminated successfully. GEIRS does not poll telescope parameters, which means any change of pointing coordinates or focus offset and so on by any commands that bypass GEIRS will not be reflected correctly in GEIRS GUI's or FITS files up to the next telescope command.

The three buttons in the display implement the three subcommands of the telescope command, see Section 5.3.

The air mass as a function of time for the current sky coordinate is plotted by a call to a web page on swarthmore.edu with a submenu of the File menu. This requires a reasonable setting of the CAMBROWSER environment variable of Section 3.2.26.

4.3.4.1 Moving to an absolute position An absolute position can be entered directly in the RA and Dec windows. The position can be sent to the telescope by clicking on the preset tel. button. The RA and Dec windows also display the current telescope position after each offset.

4.3.4.2 Relative offsets An offset in arcseconds and a direction on the sky in degrees can be entered and send to the telescope with the move tel. button. The angle is measured in sky coordinates relative to the δ-coordinate such that 0 refers to a change along +δ and 90 to a change along +α. Both parameters, the throw and the angle, are signed values. Flipping the sign of the distance is equivalent to adding or subtracting 180 to/from the direction.

GEIRS keeps track of the total vectorial sum of these offsets. A throw of 0 arcseconds (that otherwise would not make sense) can be used to reset both components of that cumulative sum to zero.

4.3.4.3 Focus A request to change the focus position by moving M2 is triggered by the move tel. focus button. The value in the input field is a relative amount in units of µm. The total

26which is for example displayed when GEIRS is started...
value in units of mm is shown two lines higher up.

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 6 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. 6. 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 erroneously 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:

```plaintext
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 squeezed into short forms and cannot be swapped with non-optional arguments nor be clumped without spaces, as some Unices allow in their shells or some higher programming languages support with some getopt(3) libraries. Example:

```plaintext
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, four 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 6, if the **full** path name of a browser has been set in environment variable **CAMBROWSER** in the startup file **scripts/Generic**. 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 17. 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 4.)
## GEIRS Command Interface

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In consequence the read abort cancels a wait status for further frames (if the abort occurs before the readout is completed), from which no useful information (i.e., image) can be extracted. 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 completed) prematurely.

Alternatively, you would like to wait for the regular passing of the full integration time or perhaps use a different method to freeze the detector, so the srr does no longer digitize data, and starts to execute the idle loop. This is for example useful if the readout was started in the endless mode.

Aborts the execution of the read and/or macros:

- "+r": abort read only. See Chapter 51 [read], page 26. Causes sends a command to 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 readout was started in the endless mode.
- "+m": abort macro only. See Chapter 39 [macro], page 20.
- "+s": shorten the initial wait time of the sync command and abort the read 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 sent to the interpreter. See Chapter 66 [sync], page 38.
- "+t": abort test only. See Chapter 72 [test], page 43.
- "+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 tew or srr mode with only two reads, where any abort results in only a single remaining frame (the root 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 shortened 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 shorter abort, do not send a sync until you really mean it.

Note that a PLX Aperture 512 will generally be emited by the PLX driver because the abort cancels a wait status for further frames (if the abort occurs before the readout...
2 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 subdirectory of $SCAMHOME/Options/sounds. '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.

3 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 file $SCAMHOME/shell#4.ext. The available wheel indices '0' 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.

4 autosave
type: USER
syntax: autosave [yes|on|no|off]

Moves the current directory to the home directory of the user. The directory of the 'save-path' and the free disk space in that directory are returned.

If autosave 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 minimum integration time, figures out during the observation when the integration time meets some criteria 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.

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

If the IP address of the telescope, the Cassegrain angle is provided by the telescope (TECS) and that directory already contains files with north of.

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.

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.

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.

6 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 cassegrain 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 CAS_NORTH environment variable, measured in degrees, to an angle, which differs from the default, below starting GEIRS. (The implicit default of CAS_NORTH is +90; measured counter-clock-wise from the horizontal x-axis coordinate in the FITS images. This means to instruct GEIRS that north of PANIC images is not up but slightly more to the left, use a value of CAS_NORTH that is slightly larger than 90.)

7 casspos
type: USER
syntax: casspos [angle]

Sets 'angle' to be the actual cassesgrain angle. The default value of the angle when GEIRS starts is the one obtained from the EPOCS interface of the telescope. The Cassesgrain 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 cassesgrain angle minus cassesgrain. If called without parameter, the actual cassesgrain-angle relative to NSEW will be returned. The command is only relevant for PANIC.

8 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 Chapter 41 [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 starts 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.

9 clobber
type: USER
syntax: clobber [yes|no|off]

Enables/disables overwriting existing FITS files generated with the common save. The default is yes.
The clobber mechanism always overwrites files, independent of the clobber flag value.

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

10 continue
type: USER
syntax: continue

Continues a macro and other processing of commands if paused.

11 control
type: USER
syntax: control [xserver] [y font]

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

- x: X-display in which the window is opened (e.g. x:28.0)
- y: font-family for buttons and fields (e.g. helvetica)

12 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 'cl': sets the counter 'name' to 0
- incr: increments the counter (default 1)
- decr: decrements the counter (default 1)
- set: sets counter to 'set-value'

That means, to determine and check capacity of the current directory, execute cd or even better pot. 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.
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 `v` of geirs_xarseConfig. An argument equivalent to the `p` of geirs_xarseConfig does not exist because `ctype xarse` always writes the patterns into the currently active pattern director(!). There is a modest shell-type expansion mechanism applied to the name of the configuration file, which means wild cards like the title (or the home directory) or SCAMERNS etc. will be recognized/expanded.

Note that switching to this xarse mode may trigger a full download of an entirely new pattern to the BOE which typically takes 18 seconds to complete and takes the same time before the command returns. GEIRS compares the age of configuration files in the file system with the last time it has updated the pattern in the BOE 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 menu after clicking on the Read Mode button of the controls GUI. Examples:

<table>
<thead>
<tr>
<th>ctype</th>
<th>xarse</th>
<th>xarse 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>xarse 7</td>
<td>/home/astrophysics/Gusev/crunk/roof/7519/roof/xarse/MaxA0/cameras</td>
<td></td>
</tr>
<tr>
<td>xarse 5</td>
<td>/home/astrophysics/Gusev/crunk/roof/7519/roof/xarse/MaxA0/cameras</td>
<td></td>
</tr>
<tr>
<td>xarse</td>
<td>xarse</td>
<td>xarse 12</td>
</tr>
<tr>
<td>xarse 7</td>
<td>/GEIRSs/pat renaming status</td>
<td></td>
</tr>
</tbody>
</table>
22 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 stores wheels.

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

- `*` names: 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. Each other line is converted to uppercase letters for further use. 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/wheel0-[9].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 effect on the telescope may cause GEIRS to emit a slave tele pos focus offset on the telescope may cause GEIRS to emit.

23 fits

**type:** USER

### 23.1 specified header card

**syntax:** fits fits

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 COMMT 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 single key, the HIERARCH prefix will be dropped.

- `fits HIERARCH HUGO = 1 / this will become simple HUGO=1`
- `fits HIERARCH HUGO SAI/ANDS = v / this will become simple HIERARCH HUGO SAI/ANDS = v`

Attempts to add cards with organizational FITS information like BINTOF 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.

25 gui

**type:** USER

**syntax:** gui [x server] [if font]

Starts the graphical user interface (GUI) for the camera. For the description of the options, see Chapter 11 [control], page 5.

26 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 (curious) 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 `()'`.

27 history

**type:** USER

### 27.1 history

**syntax:** history

Print the GEIRS shell command history.
Chapter 34: lamp

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}

39 init

Type: USER

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.

29.1 camera


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, Camenes, Aip, NTEimg and NTEspec).

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

Example:

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 over-written 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 MPAIA 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,low}
- -s: status = {offline,online} (access to ROE hardware)
- -t: temperature-controller = {offline,camera,direct}
- -r: init camera name 's' does re-init but also re-setting all important last camera settings.

Last without parameters returns the states of the instrument parts.TBD

Chapter 32: itime


Sets the integration time. If only the option -o is given, it sets a constant offset to the integration time.

30 wheels

Syntax: wheels

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

31 interactive

Syntax: interactive [on,off,_macro]

If you use the interactive-mode, the outputs in the shell are blocked after 10 lines, until you enter 'SET'. Default is 'on'. (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.)

32 itime

Type: USER

Syntax: itime [time] [-stdout / -stderr] [-m[ultiple] #sec]

Sets 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 Chapter 66 [sync], page 78.

If 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: offset = 0.0313 sets adding of constant offset of 0.0313 seconds
- -m: motors = 0.020 sets adjusting time to a multiple of 0.020 seconds

Rule: adjusted time always >= given time.

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

Note: These values can be configured by the user 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.

33 kill

Type: USER

Syntax: kill name [or #] 

If name is one of the set {display, satchet, asleep, gui, control, telgu, telpum, telap, inideon, inimind} 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, telo, wheel, filter, hyst, aperture, optics} then first a 'soft-kil' signal is sent to the process. If after timeout (default 10 seconds) the process is still alive, a 'kill-s' signal is sent to the process.

The option ‘v’ 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 closed, 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 clears the macro status.

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

34 lamp

Type: USER

Syntax: lamp ALLOFF
Syntax: lamp L1(1213415) OFF
Syntax: lamp L1(12134) ON
Syntax: lamp L5 ON {112131...9}

The command is only available if GEIRS is started for PANIC. Controls the calibration lamps by executing .lamp.sh with the syntax of the common rflat CAHA command. The .lamp is executed on ultral if GEIRS is started with TELESCOPE set to C2.2m, and on ultral if set to 3.5m.

It can see the interactive-mode, the outputs in the shell are blocked after 10 lines, until you enter 'SET'. Default is 'on'. (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.)

35 last

Type: USER

Syntax: last [logfile]

Retruns the filename of the most recent image that was saved and stores the filename into ‘logfile’ (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 ‘geirsLastFile’ in the directory $CAMHOME (which usually is ‘/tmp’).

36 load

Type: USER

Syntax: load filename [if] [stdin]

Loads a single FITS file 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 (nominal) 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 CAMITIME environment variable.

If option -ncr 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
37 log

<table>
<thead>
<tr>
<th>type: USER, ENG</th>
</tr>
</thead>
<tbody>
<tr>
<td>syntax: log [module] [</td>
</tr>
</tbody>
</table>

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 log-level 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.

- logging levels: 0 1 2 3 4 5
- log-switches: main / object

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.

<table>
<thead>
<tr>
<th>options:</th>
</tr>
</thead>
<tbody>
<tr>
<td>m:main // selects a sub-process</td>
</tr>
<tr>
<td>o:object // selects a source object (file)</td>
</tr>
<tr>
<td>c:cond // controls the logging levels</td>
</tr>
<tr>
<td>h:help // prints the supported modules or objects (or use tab in shell)</td>
</tr>
</tbody>
</table>

To switch to a different log-switch, you need to toggle the online display from the current image to the current frame view, or to switch to a different module with the new parameter set

- nutil - only the nutil module is changed
- cstxlib - only the cstxlib module is changed
- all - all processes are changed with the new parameter set

38 ls

<table>
<thead>
<tr>
<th>type: USER</th>
</tr>
</thead>
<tbody>
<tr>
<td>syntax: ls [</td>
</tr>
</tbody>
</table>

Executes the ls (UNIX style with options)

<table>
<thead>
<tr>
<th>syntax:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ls</td>
</tr>
<tr>
<td>ls [-l] aa0010.fits</td>
</tr>
<tr>
<td>ls *.fits</td>
</tr>
</tbody>
</table>

Print contents of current save-directory. see Chapter 18 [dir], page 9.

Chapter 41: next 21

39 macro

<table>
<thead>
<tr>
<th>type: USER</th>
</tr>
</thead>
<tbody>
<tr>
<td>syntax: macro [+</td>
</tr>
</tbody>
</table>

Executes the macro defined in the file filename.

If the 'clear' option is given alone, the last macroname is just cleared in the parameter table (and therefore in GUI).

The file filename contains command lists like any of the command shell. Be careful when invoking commands like read, telescopes 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 user macropath.

If the filename starts with a slash '/', the directory of the filename is used if the subsequent save commands are issued without their optional file name argument. The file macroname has to be added to the list of the macros in the GUI.

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.

The options described above are valid also for the macro commands. See Chapter 41 [dir] page 21.
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, .fits, .fits, and increases the largest 4-digit number found by 1 to create the default file name of the FITS file.

- **next**
  - usage: next
  - description: If next is given without any parameter, the command returns the next default and next test file name. After the next command is given, there is also an option for overwriting (`-o`) or not (`-n`).

- **save**
  - usage: save [no filename] creates save_filename.fits if no filename present.
  - description: The naming scheme is preserved during quit (shutdown) and restart operations because GEIRS stores the active filenames in a last dump and reads it from there at startup. Option `-t` (with or without a filename) 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.

- **put**
  - usage: put varname [value]
  - description: Put 'text' as OBJECTS in the save operation (UNIX style) and the free space in Mbytes.

- **pipe**
  - usage: pipe [-nowait] [-list] [-timeout #secs] command [par1] [par2] [...]
  - description: Sends 'command' to the camera-electronics. In the instrument shell, a command list is attached here without their instrument suffixes. The search path is the CAMBUILD/ptsrsub directory. In this format with the `-list` option, expansion of the multipliers, substitution of variables and so on. See the pattern constructor manual for details.
  - options:
    - `-i` interprets the command and optionally any of the further parameters as the name of files with a command list. These files are attached here without their instrument suffixes. The search path is the CAMBUILD/ptsrsub directory. In this format with the `-list` option, expansion of the multipliers, substitution 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.

- **observer**
  - usage: observer
  - description: Prints the current observer.

- **optics**
  - usage: optics [wheel-position]
  - description: Moves a wheel of the camera optics. Without parameter all possible positions and the actual positions are printed.

- **pause**
  - usage: pause [macro]
  - description: 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. Command/macro will be continued by entering the continue command or may be aborted by abort.

- **ptime**
  - usage: ptime
  - description: Sets the base time for the pixel time (which is #time in the roe interface).
    - for observers: ptime = default slow: sets the configured base-times for #time
    - for engineers: ptime = val | value >=0 as base-time

- **put**
  - usage: put [varname] [value]
  - description: Prints the current directory for the save operation (UNIX style) and the free space in Mbytes.
Chapter 1

Chapter 66

Win

Example:

repeat 2 macro xyz
repeat 2 test
repeat 5 ; read ; sync * ; EMUX
repeat 5 read ; sync # gives 5 reads with only one final sync, hazardous.

53 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 emu (electronic multi-sampling) value to 1 to make sure that the samples fit into the half-samples of the read time.
  - Cution 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.
  - Cution ii) possibly rebuild the rtms command to force a recalculatation of the fastest frame rate after changing the pread parameter.
  - pkip 200 - sets pixel skip time to 200 ns
  - lkip 300 - sets line skip time to 300 ns

- options
  - crop roert - crop loop ROE-macro is doing the cycle-restart.
  - crop count - ROE-macro only counts down the cycles seen but the cycle-loop is done by the pattern-endless.
  - flows - ROE-macro only patterns as an endless loop and the software will stop the ROE.
  - cop N - 0 or 1, 0=continues [i=] - countdown
  - gap - status of gap. (used to exclude itimegap-pattern)
  - pulsa - status of pulse-pat-table-clue
  - fpft N - 1: J-escape protection (0: faster subwindowing)
  - ubrupt N - N=1: overlimit-escollection on time end

commands:

- verify - checks the SW-state against the HW-state of the ROE. Output to SCAMTMP/verify核实状态.log
- real - evaluates the timings of the pattern and puts it into SCAMTMP/timingvals.log

parameters:

- short 1 - parameter 1 activates, parameter 0 de-activates the short subfield integration type

56 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.

57 save

type: USER

syntax: save [a] [f d] [a] [e n d] [a] [s 1 -l] [f d] [a] [k] [m] [e] [c] [f] [d]

Save frames in the shared memory formatting them according to the current readout mode / cycle type (type). A comma delimited saving sets, dumping actually copies of the same data frames.

- a: save immediately after image completion. Do not wait until the cycle is all completed but start saving as soon as the correlated frames have arrived.
- l: save from frame `i' (= first frame) [l =] save up to frame `i' (= last frame) "r: save only frames from `n1' through `n2'. Default is all.
- s: 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.
- d: 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 disk. The variable PGOUT-PORT provides the file name and needs to have .df as a substring.
- c: overwrite existing files (for this save-operation only).
- z: do not save the actual sequence but the previous one.

Option -p is only meant for interactive use. 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.

If this option is combined with the -1 option, the extensions are FITT cubes and each of these contains layers with the succession of exposures in that subwindow.
Chapter 59: savepath

58.1 savepath

syntax: set savepath [pathname] [dirname]

Echo or set the directory/path (for saving files).

If the directory does not exist, it is created.

- `=` append the string of the data-format _YYYYMMDD_hhmmss to pathname
- `-v` create pathname as subdirectory of the current savepath

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 create this directory or any of its parent directories.

The command may fail 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 CAMTOMP/campaths such that the next GEIRS session reads it from this file to provide the new default. Note that this mechanism of renaming 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 2013_11_10 for example during a session in Nov. 10th, GEIRS is shut down and restarted a month later, the path name is still initially 2012_11_10 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 as also the first-stage pipeline will not find them.

58.2 macropath

syntax: set macropath [pathname]

Echo or set the directory path for macros.

59 sdfump

Syntax: sdfump [pathname] -i

Specifies a configuration file with instructions to dump a set of windows of each single-frame to a directory while in multi-correlated or multi-correlated read mode. The command merely configures the action; GEIRS actually dumps the files if it 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 lowercase suffix `off`, dumping is deactivated and the previous configuration file name is forgotten. This state is also the initial state at GEIRS startup for most instruments; for CARMENES however, the default is full frame dumps on behalf of the first-stage pipelines executed by GEIRS.

Any other argument is interpreted as a file name of 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 the current directory and the SAVEMODE keyword will then be set to single.frame.read and will differ from the value of the READMODE keyword.

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/Queues/Files, are checksum aware, which means, they either update the value or delete the keyword once they change keywords or data of the FITS.

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 create this directory or any of its parent directories.

The command may fail 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 CAMTOMP/campaths such that the next GEIRS session reads it from this file to provide the new default. Note that this mechanism of renaming 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 2013_11_10 for example during a session in Nov. 10th, GEIRS is shut down and restarted a month later, the path name is still initially 2012_11_10 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 as also the first-stage pipeline will not find them.
65 subwin

type: USER

syntax subwin [HW] [SW | auto] [HW] xsize ysize swwin [type] # define/add SW subwindow

Example:

```
subwin SW 2 2049 1 2048 2048
```

65 status

type: USER

status returns parameter set defined in $status_xml_file.

Example:

```
status returns parameter set defined in $status_xml_file.
```

Chapter 65: subwin

This means the windows shown in the FITS files may be slightly larger than the parameters xsize and ysize submitted by the observer.

If the region of a user window stretches beyond the current detector area (2048 x 2048 for the instrument), subwindows are only possible to deactivate all of them. Still the deactivation needs to be followed by a subwin auto on. ANI: If subwindowing is switched on, each set of subwindows is implemented with the following scheme:

```
subwin auto on
```

The union of the barren windows are the data read from the ROI to the GEIRS workstation via the fibers. Hardware means that the patterns run on the firmware of the ROI, determine which parts 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-windows of the hardware windows repeated in each of the 32 readout channels on each detector.

The subwindows deal directly with HW windows are only meant for use with detector engineering.

The software windows with different #wid indices may overlap. This means the windows shown in the FITS files may be slightly larger than the parameters xsize and ysize submitted by the observer.

The order of the non-numerical parameters (clear, on, off, SW, auto, HW) can be swapped.

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```
subwin auto on
```
66 sync

type: USER
syntax: sync [read tele [slew] [slew] [text] [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, and-slew 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 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 wait 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.

time = [0] time!

waits on the argument list until until sync itself finishes. In practice these 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 wait immediately the error of a background process.

To clear all last errors of any background process use sync -e.

time = [0] time!

waits on the argument list until until sync itself finishes. In practice these means do not send a sync if you may wish to abort the read at some time in the future:

If the argument name 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 # indicate that this duration may be specified in a floating point format.

Examples:

sync - synchronize with all background processes after sending a default time

sync 1.5 - synchronize with all background processes after waiting 1.5 seconds

68 tdebug

type: USER
syntax: tdebug [text] [anytext] [anytext] [anytext] [anytext] [anytext]
Writes an entry in the format '2004-05-28 ... wants, but is compatible with the software run on CAHA for earlier Omega cameras. It has been argued that the telescope...

69 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 coordinate in GEIRS’s internal data base such that they appear in FITS headers (unless removed by the geirsPflushd 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 Invalid number of arguments.

5 TELESCOPE environment variable not set.

26 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 controlled by GEIRS.

69.1 absolute

syntax: [tele] [scope] [absolute] [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_point 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 infers a value equivalent to now (when the command is executed). This may not be what the astronomer wants, but is compatible with the software run on CAHA for earlier Omega cameras. It has been argued that the telescope...
Chapter 71: tempplot


71 tempplot

type: USER

syntax: tempplot file [-x time1 time2] [-f time1] [-y temp1 temp2] [-d xserver]

Creates a X11 window plotting temperatures from the log file (that was created by
...
ctime 1.186678, FULL-frame 1, npixel 1048576)
output#1: 2004.20 3.839 2621440
...
output#4: 2004.32 3.921 2621440

73 ustatus

type: ENG

syntax: ustatus

Returns the user status, one of [astronomer, engineer, experimenter]

75 verbose

type: USER

syntax: verbose [on, off, system]

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 macro line is being executed. Default is yes.
If no parameter is provided, verbose prints the value of the verbose flag.

76 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.

77 wheel

type: USER

77.1 Basic use

syntax: wheel [ #wheel [ #position-name] ]

Only relevant to some Calar Alto instruments that control motorized wheels by GEIRS.
Move wheel number ‘w’ 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 2 Returns overview of all wheels;
wheel 2 returns current wheel positions.
wheel 2 wollaston45 Moves wheel2 to the wollaston45 position.

wheel becomes a background process and should be followed by a sync as called from within
a macro.

77.2 focus

syntax: wheel focus [on, off, new]

wheel focus on “re-activates the focus correction for
the subsequent filter wheel commands, which are tagged

72 test

type: ENG

syntax: test { std, med, var } [-q] [-n n] [-r len] [-v var]

Computes pixel statistics and displays the results to the file

"chiptest: log", either in $KMCSTP
(usually /tmp) or in the current directory:

- std: prints average and deviations over all pixels in all images of each channel
  and the same for the full image (with additional stdv of channels-stdv).
- 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 of the user’s flips or rotations. That means the
channel enumeration is usually not trivially related to the display orientation.

Options:

- -q, for ‘test var’: de-activates median of variances independent of median-pixel
  values (takes it from the average-pixel).
- -n n: median value.
- -r len: use images n through n2 (e.g. ‘test var -r 2 11’)
- -v var: use images n through the last (e.g. ‘test var -v 2’)
- -x: use the software subroutines for the tests if activated. Instead of the default statistics
  calculations, the quadrants, the statistics is done by subwindow.
- -s: use only quadrant or output-channel or SW-subwindow number ‘q’, where the
  numbering starts at 1 (e.g. ‘test var -s 1’). This option is only available with the var parameter.

Warning: the combination ‘-q’ is not allowed.

If the ‘a’ option is not used, all HW-read data are accumulated to get the statistics. With the
‘a’ option, statistics is calculated in SW-subwindows, ignoring in which HW channels
these are located.

The default output of the command ‘test’ for PYRAMID (4 channels) for example is:

test std
mean \& stdv & n \{ 4 output, 10 images, \}
couple study, camera Pyramis, site=1,00000, \nctime 1.186678, FULL-frame 1, npixel=1048576
output#1: 2004.20 3.839 2621440
... output#4: 2004.32 3.921 2621440

... which shows for each ADC-channel the mean, standard deviation 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’.
Chapter 77: wheel

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.)

### 77.3 relative

**syntax:** `wheel [ #wheel relative #offsetsteps]`

wheel 2 rel -25 Moves wheel2 25 steps backwards.

### 77.4 init

**syntax:** `wheel init`

### 77.5 warninit

**syntax:** `wheel initwarn`

### 77.6 dialog

**syntax** `wheel dialog [on,off]`

The syntax with dialog on or dialog off enables or disables warning and error GUIs. Dialogs are usually shut off if GEIRS is driven by an external handler and there is no operator that could click on the buttons.

### 77.7 rdb

**syntax:** `wheel rdb`

wheel rdb re-reads the wheel and wheel-macro database files.

### 77.8 aperture

**syntax:** `wheel aperture`

Yields a list of wheels in the aperture class. For PANIC this is the cold stop wheel.

### 77.9 optics

**syntax:** `wheel optics`

Yields a list of wheels in the optics class. For PANIC this list is empty.

### 77.10 filter

**syntax:** `wheel filter`

Provides a list of filter macro positions.

Index

(Index is nonexistent)
Figure 17: 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 contains a command of the set of Section 5.3 for every action normally assembled by using the camera GUI or typing commandos into the GEIRS shell.

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, so 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.

Every macro command may be issued with the prefix from MIDAS.

Macro files are started from the camera control window (lower part, see Figure 6) 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 6 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 menu of Figure 6 or the associated set macropath GEIRS shell command, and saved across GEIRS shutdown/startup cycles in the file $CAMTMP/CAMMACROS. 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`:

```bash
#!/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`:

```awk
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

```m4
#define a m4 macro expo with a roe-subwin-read-sync-save-sync atomic operation
define(expo,
    # interpret the first argument as an ems parameter
    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 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:

```python
import os
for e in [1,2,4]:
    os.system('cmd_nirvana_new roe ems '+str(e))
    for w in [1,2,4,5]:
        os.system('cmd_nirvana_new subwin SW 1 ' + str(w*128) + ' ' + str(w*128) + ' 128 128')
        os.system('cmd_nirvana_new subwin on auto')
        os.system('cmd_nirvana_new read')
        os.system('cmd_nirvana_new sync')
        os.system('cmd_nirvana_new save -i')
        os.system('cmd_nirvana_new sync')
        os.system('cmd_nirvana_new subwin clear')
        os.system('cmd_nirvana_new subwin off')

In the more familiar bash shell an example might look like

```bash
#!/bin/bash
for (( j = 1 ; $j <= 10 ; j++ )) ; do
    echo starting exposure $j ;
    snd_panic_new read ;
    snd_panic_new sync ;
    snd_panic_new save ;
    sleep 10 ;
    snd_panic_new sync ;
    echo done exposure $j ;
do
```

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(1)                                                          General Commands Manual                                                       dfits(1)

SYNOPSIS

start_ice2_new [-iwin] [-gui] [-cmd] [-data] [-ice]
start_ice2_old [-iwin] [-gui] [-cmd] [-data] [-ice]
start_ice1_new [-iwin] [-gui] [-cmd] [-data] [-ice]
start_ice1_old [-iwin] [-gui] [-cmd] [-data] [-ice]
start_ice_new [-iwin] [-gui] [-cmd] [-data] [-ice]
start_ice_old [-iwin] [-gui] [-cmd] [-data] [-ice]
start_app_new [-iwin] [-gui] [-cmd] [-data]
start_app_old [-iwin] [-gui] [-cmd] [-data]
start_app [-iwin] [-gui] [-cmd] [-data]
start_app old [-iwin] [-gui] [-cmd] [-data]
start_asteep_new [-iwin] [-gui] [-cmd] [-data]
start_asteep_old [-iwin] [-gui] [-cmd] [-data]
start_asteep [-iwin] [-gui] [-cmd] [-data]
start_asteep old [-iwin] [-gui] [-cmd] [-data]
start_carmenes_new [-iwin] [-gui] [-cmd] [-data]
start_carmenes_old [-iwin] [-gui] [-cmd] [-data]
start_carmenes [-iwin] [-gui] [-cmd] [-data]
start_carmenes old [-iwin] [-gui] [-cmd] [-data]
start_luci1_new [-iwin] [-gui] [-cmd] [-data]
start_luci1_old [-iwin] [-gui] [-cmd] [-data]
start_luci1 [-iwin] [-gui] [-cmd] [-data]
start_luci1 old [-iwin] [-gui] [-cmd] [-data]
start_luci2_new [-iwin] [-gui] [-cmd] [-data]
start_luci2_old [-iwin] [-gui] [-cmd] [-data]
start_luci2 [-iwin] [-gui] [-cmd] [-data]
start_luci2 old [-iwin] [-gui] [-cmd] [-data]

OPTIONS

-o  Opens the auxiliary initialization window
-w Opens the controls GUI. This only makes sense for interactive use of GEIRS.
-d Opens the GUI with the real-time image display of the pixels. Makes only sense for interactive use of GEIRS.
-c Starts the command server. Usually important to run GEIRS, because this is the core command dispatcher.
-i Starts the data server. This is required if the real-time display is used or if data are requested via the ICE server.
-g Starts the ICE server. Linc-Nirvana is the only instrument where ICE is installed on the mountain and on ESO@WASP. In other environments ICE is probably not installed and the server not even running.

DESCRIPTION

TwoMassCnvrte xtracts positions and magnitudes from the 2MASS catalogue (on the user’s file system) and generates an ASCII format of the stars distributed over the pixels in the field of view in the catalog style of SkyMaker.

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The command interprets all arguments that start with a dash as ds9(1) options, and all others as directories.

EXAMPLES


NAME
dfits(1)                                                          General Commands Manual                                                       dfits(1)

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EXAMPLES


NAME
fits2csv(1) General Commands Manual fits2csv(1)

SYNOPSIS

OPTIONS
-c: The first command line argument is the file name of an existing FITS file which is to be modified, i.e.,
contains a primary header. The program opens an interactive GUI if called without command line options.
If called with command line options, the two options -c and -o must both be present and be followed by their arguments. This calls the program as a batch program which is working in the background, so the
fits2csv will start after the Linux command line prompt has reappeared.

NAME
fits2csv(1) General Commands Manual fits2csv(1)

SYNOPSIS

DESCRIPTION
The program reads an existing FITS file and generates a text file which is then piped into gnuplot.

NAME
fits2csv(1) General Commands Manual fits2csv(1)

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DESCRIPTION
The program reads an existing FITS file and generates a text file which is then piped into gnuplot.
NAME
fitsort(1) - General Commands Manual
fitsort(1)

SYNOPSIS
dfits [-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 sub-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
guits_carmen_pipe(1) - General Commands Manual
guits_carmen_pipe(1)

SYNOPSIS
guits_carmen_pipe.input.fits

OPTIONS
none

DESCRIPTION
This is the start of the first stage pipeline which calls in succession:
  • pipFits_input (to collect the names of the raw FITS frames that are the main input with some Fowler-type of
    selection criterion),
  • pipFits_sel (to apply a nonlinearity correction to the raw frames that are selected),
  • and pipFits_end 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 SBE(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 SCAMMOS*QueueFiles.log, which usually is the same as
SCAMHOME/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 (!), for example if the GEIRS save command
does not succeed.

Note that this pipeline script is a bash script, so editing the parameters that are used for the sub-steps is a
straightforward matter of editing that ASCII file.

ENVIRONMENT
SCAMHOME/Scripts contains scripts used by the pipeline. Therefore this should be in the PATH variable.
SCAMTMP must contain the file pipFits_input.fits which is the specification of the nonlinearity correction
coefficients for the full frame. The subdirectory SCAMTMP/pipe will be used for scratch files and cleaned
immediately by the pipeline script according to its own needs.

EXAMPLES
guits_carmen_pipe ./DATA/2015-06-11/car-20150612T10h30m7s-get-our.fits

NAME
guits_cleanpect(1) - General Commands Manual
guits_cleanpect(1)

SYNOPSIS
guits_cleanpect [-v] [-d] [-t] [-p /path/]

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.
-p allows to specify the path name of the temporary files. The default is the caller’s SCAMTMP,
STMPDIR, STMP and then ‘tmp’ directory. This option is usually needed if the CAMTMP environment
variable defined in the $SHMPTMP script is not defined in the caller’s shell, but TMPDIR and/or TMP are
defined and differ from CAMTMP.

DESCRIPTION
The script shuts down a GEIRS run by sending signals to the four components (the two GUIs, the
command manager and the shared memory manager) and removing the shared memory blocks and shared
memory sockets.

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 in some unreachable state.

ENVIRONMENT VARIABLES
The variable CAMTMP (with a default backup of $HOME/tmp) is used to locate the shared memory socket
to be removed.

EXAMPLES
guits_cleanpect -v -d
NAME

geirs_control(1) General Commands Manual
geirs_control(1)

SYNOPSIS

gear_control [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, LuciC, LuciI, NTEram and so on) must be the command line parameter.

DESCRIPTION

The control GUI is usually 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_control' 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, etc) is available in the Sounds submenu.

EXAMPLE

NAME

geirs_display(1) General Commands Manual
geirs_display(1)

SYNOPSIS

gear_display [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 display 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 affect the copies of the real-time display on other screens as well.

EXAMPLE

exh -X images\lircs geirs_display2 Nirvana
exh -X images\lircs "/hpx\geometry=geirs_display2 Nirvana"
exh -X images\lircs "GEIRS/scriptx/geirs_display2 Nirvana"

ENVIRONMENT

The environment variable CAMBIN must be set and point to a valid GEIRS directory of compiled binaries.

NAME

geirs_dataServer(1) General Commands Manual
geirs_dataServer(1)

SYNOPSIS

gear_dataServer [ -c [instrument] ]

OPTIONS

• -c triggers a (explicit) compactification (de-fragmentation) of the memory tables.

DESCRIPTION

Requests to receive the pixels of the image number given by the additional argument. The frame number is counted from 1 upwards, and may be as large as the cycle repetition number of the active or terminated ra done. If the instrument returns 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 of x 4096 x 4096 for PANIC or PANIC, 4 bytes of x 4096 x 2048 for CARMENES, and 4 bytes of 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 y is absent, the serial order starts at the bottom row and works upwards (which is the FITS order).

• -f framerate

• -y framerate 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 uniplet short (2 byte) format of the pixels. The variant which includes the y in the command is again introducing a fly along the y-coordinate such that the order is the natural for windowing applications, and otherwise the FITS order. Not yet implemented

The image and frame orientation pays attention to the CAM_DETBUF[0] and CAM_DETBUF[1] modifiers of the configuration, so it is compatible with the orientation of the real-time display and FITS files.

NAME

geirs_dropcaches(1) General Commands Manual
geirs_dropcaches(1)

SYNOPSIS

gear_dropcaches [-m MiB] [-c]

OPTIONS

• -c 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).

DESCRIPTION

The program executes effectively a

```
				
```

when the free amount of memory drops below the threshold (which lies the Linux OS clear the current cache 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

```

to the GEIRS interpreter. It can be changed using the put command of the GEIRS interpreter while GEIRS is running, for example

```

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_dataServer place the system and memory caches kept in memory

SYNOPSIS

gear_dataServer [-m MiB] [-c]

OPTIONS

• -c 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).

DESCRIPTION

The program executes effectively a

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when the free amount of memory drops below the threshold (which lies the Linux OS clear the current cache 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

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to the GEIRS interpreter. It can be changed using the put command of the GEIRS interpreter while GEIRS is running, for example

```

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

SYNOPSIS

gears_lamp.sh ALLOFF

gears_lamp.sh L1 (ON | OFF)

gears_lamp.sh L2 (ON | OFF)

gears_lamp.sh L3 (ON | OFF)

gears_lamp.sh L4 (ON | OFF)

gears_lamp.sh ST A TUS

gears_lamp.sh L5 OFF

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
+ echoes a string suitable for storage in the GEIRS online database.

Warning: no timeout is currently implemented. If the script 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 P ANIC at the Calar Alto.

EXAMPLES

geirs_lamp.sh L5 ON 4

geirs_patterns(1)                                            General Commands Manual                                           geirs_patterns(1)

SYNOPSIS

geirs_patterns [option]

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 built into the
readout.

The command helps to find the version (the directory) that will be automatically selected by GEIRS at
stamp 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 SCAMHOME environment variable is set
correctly and that the directory layout is a standard one as described in the
GEIRS manual.

EXAMPLES

geirs_patterns luci1

geirs_patterns luci2

geirs_patterns carmenes

geirs_patterns Nirvana

geirs_patterns Panic

FILES

The output of the command is registered in SCAMTMP/geirsPhduAdd.panic_1. If CAMTMP is not
mentioned, it is replaced by SCAMHOME/.

EXIT VALUE

Always 0 (success)

geirs_roeDump(1)                                            General Commands Manual                                           geirs_roeDump(1)

SYNOPSIS

geirs_roeDump [-t] instrument

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 ROE FPGA 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.

ENVIRONMENT VARIABLES

The variable SCAMHOME must point to the top directory of the installation. The log file to be scanned is in
SCAMHOME/log/.

EXIT VALUE

Always 0 (success)

EXAMPLES

geirs_roeDumpLuci1

geirs_roeDumpLuci2

geirs_roeDump Panic

geirs_roeDump Nirvana

geirs_roeDump Carmanes

rflats status

geirs_roeDump [-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.

The argument instrument is a string like Luci1, Luci2, Panic, Carmanes or Nirvana referring to the
instrument. It is case-sensitive. If the argument is missing, the program reads from standard input.

NAME  
geirs_quitXterm.sh

SYNOPSIS

gears_quitXterm.sh

DESCRIPTION

This script is called for example when a quit command is received by the GEIRS command (shell)
interpreters.

EXIT VALUE

Always 0 (success)

EXAMPLES

gears_quitXterm.sh

NAME  
geirs_patterns

SYNOPSIS

gears_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 built into the
readout.

The command helps to find the version (the directory) that will be automatically selected by GEIRS at
stamp 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 SCAMHOME environment variable is set
correctly and that the directory layout is a standard one as described in the
GEIRS manual.

EXAMPLES

geirs_patterns luci1

geirs_patterns luci2

geirs_patterns carmenes

geirs_patterns Nirvana

geirs_patterns Panic

FILES

This file has no use beyond GEIRS implementing P ANIC at the Calar Alto.

EXIT VALUE

Always 0 (success)

EXAMPLES

geirs_patterns

NAME  
geirs_roeDump.pl

SYNOPSIS

gears_roeDump.pl [-t] instrument

DESCRIPTION

This file has no use beyond GEIRS implementing P ANIC at the Calar Alto.

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
+ echoes a string suitable for storage in the GEIRS online database.

Warning: no timeout is currently implemented. If the script 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 P ANIC at the Calar Alto.

EXAMPLES

geirs_roeDump.pl dump the current contents of the ROE FPGA to standard output

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.

The argument instrument is a string like Luci1, Luci2, Panic, Carmanes or Nirvana referring to the
instrument. It is case-sensitive. If the argument is missing, the program reads from standard input.

NAME  
geirs_roeDump.pl

SYNOPSIS

gears_roeDump.pl instrument

DESCRIPTION

This file has no use beyond GEIRS implementing P ANIC at the Calar Alto.

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
+ echoes a string suitable for storage in the GEIRS online database.

Warning: no timeout is currently implemented. If the script 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 P ANIC at the Calar Alto.

EXAMPLES

geirs_roeDump.pl dump the current contents of the ROE FPGA to standard output

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.

The argument instrument is a string like Luci1, Luci2, Panic, Carmanes or Nirvana referring to the
instrument. It is case-sensitive. If the argument is missing, the program reads from standard input.

NAME  
geirs_quitXterm.sh

SYNOPSIS

gears_quitXterm.sh

DESCRIPTION

This script is called for example when a quit command is received by the GEIRS command (shell)
interpreters.

EXIT VALUE

Always 0 (success)

EXAMPLES

gears_quitXterm.sh
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.

EXAMPLES

run tmp.fits ; geirs_srreConfig -f psf.fits -N 18 -w 20 -h 20 -v -o tmp.fits

NAME

geirs_start

SYNOPSIS

gears_start[-N wincnt][-h]

OPTIONS

- N specifies the number of reset windows to be created.
- h defines the height of each reset window in units of pixels.
- w defines the width of each reset window in units of pixels.
- o specifies that the FITS output file should show the reset window pixels as zeros, but (in reverse) all the other pixels as ones.
- f specifies that the dark regions are defined by setting with respect to median, not with respect to integral sum of the pixel values. Note that this will slow down the operation considerably, but is more tolerant with respect to hot or cold bad pixels.

DESCRIPTION

See the GEIRS user manual.

The general application of the third syntax is to compute the three parameters (two of offsets for translation and one angle) of an image relative to some other image of the same pixel scale in the field of view by localization of a small set of bright stars. The main problem here is that a simple moving/scanning window and one angle) of an image relative to some other image of the same pixel scale in the field of view by localization of a small set of bright stars. The main problem here is that a simple moving/scanning window

EXAMPLES

NAME

geirs_tempplot

SYNOPSIS

gears_tempplot

OPTIONS

- 

DESCRIPTION

This command is only relevant to PANIC.

ENVIRONMENT

The environment variable CAMLOG should be the full path name of the directory with the panic temp log file. If the variable is not set, the log file must be in CAMHOME/log.
**NAME**

geirs_wheelJ

**SYNOPSIS**

ggeirs_wheelJ

**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 environment variable CAMBIN must have a name of an existing subdirectory of one of the GEIRS installations. It usually has the format /home/user/GEIRS/home/admin.

**EXAMPLE**

```bash
rm badpix.fits ; pipFits_bad -R ~/GEIRS/INFO/badpix els.carmenes badpix.fits
```

The following program is usually called from a crontab(1) entry with a syntax like

```bash
10 11 * * * export CAMHOME=${HOME}/GEIRS ; cd $CAMHOME/log ; ./glogRotate.sh 2>&1 >dev/null
```

**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.

**EXAMPLE**

```bash
rm badpix.fits ; pipFits_bad -R ~/GEIRS/INFO/badpix els.carmenes badpix.fits
```

**DESCRIPTION**

The files in the working directory which start with the ISO day indicator (YYYY-MM-DD....log) and are older than 14 days are compressed with xz(1). In detail this concerns files with the format ???.??-??-??[p]ix.el.log and ???.??-??-??[p]ix.el.log which are the names used by GEIRS.

In addition, files with template names save_CA.log and [p]tmp.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 YYYY-??-??*.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

```bash
10 11 * * * export CAMHOME=${HOME}/GEIRS ; cd $CAMHOME/log ; /glogRotate.sh 2>&1 >dev/null
```

**EXAMPLE**

```bash
cd $CAMHOME/log ; glogRotate.sh
```

**NAME**

pipFits_bad

**SYNOPSIS**

pipFits_bad [-4] [-v] [-R]

**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 outfile is specified 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 fits does not start with a slash, the file is assumed to be in $CAMINFO directory.

**EXAMPLE**

```bash
infile.txt
```

**NAME**

pipFits_badconvert a bad pixel mask from ASCII to FITS format

**SYNOPSIS**

pipFits_bad [-4] [-v] [-R] infile out 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 outfile fits specifies bad pixels of the detector 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 fits does not start with a slash, the file is assumed to be in $CAMINFO directory.

**EXAMPLE**

```bash
rm infile.txt ; pipFits_bad [-R] ~/GEIRS/INFO/badpixels.carmenes infile fits
```

**NAME**

pipFits_cube

**SYNOPSIS**

pipFits_cube infile 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 outfile fits specifies bad pixels of the detector 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 fits does not start with a slash, the file is assumed to be in $CAMINFO directory.

**EXAMPLE**

```bash
rm infile.fits ; pipFits_cube outfile fits infile fits
```
DESCRIPTION

The program reads the pixel values in fits files, computes for each of the two chips (i.e., images extensions) separately a histogram of these values, and discards the pixels that are not in the percent or the two percentiles. The lower percentile should be large enough to discard most 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 pseudo-adapted is applied to the pixel in the percentile bracket separately for each chip spanning the two FITS files. 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 -l option (larger than 50) will affectively destroy 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 -p is not recommended, because the result will show all the known ringing artifacts of polynomial fits.

**EXAMPLES**

rm 00{$f}.fits; pipFits_flat -l 10 -h 90 -p 1 Linrty_No_six0087.fits tf.fits

fitsImg2Asc -r '[400:400,400:400]' 00${f}1.fits'[1]' | sed '/$'/d ; rm 00${f}1.fits ; pipFits_nonl Linrty_No_six00${f}1.fits pipNonl.fits 00${f}1.fits

rm tf.fits ; pipFits_flat -v -l 10 -h 90 -p 1 Linrty_No_six0087.fits tf.fits

The two different synopses refer to the tasks of (i) converting a sequence of calibration exposures with the same time stamp, i.e., the files that are listed in a single line.

**SYNOPSIS**

```
NAME

pipFits_noise(1)  General Commands Manual  pipFits_noise(1)

SYNOPSIS

pipFits_noise [-i] infile1.fits infile2.fits [infileN.fits ...] outfile.fits

OPTIONS

-a indicates that the name of the output file should be deri
vived 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 of the input files are dark exposures with variable sets of integration times.

-n indicates that some progress of the calculation is to be verifi
ed periodically (to prevent it to slow).

DESCRIPTION

For each pixel in the input files root mean squared noise parameter is computed (in ADU units). This means by 'looking' at a pixel through the 'cube' of data of the fits images, a mean(root sum, 2) is derived, then a variance, k(pix[mean]^2) kpix is derived, then a variance sum, j(pix[mean]^2)]kpix kpix is derived, 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 -m option 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 PERCENT000 keyword (50 percentile, median) from the primary header or extension header of the output file:

dfits = a 1 outfile.fits | fgrep PERCENT000
```

**SYNOPSIS**

```
NAME

pipFits_nonl(1)  General Commands Manual  pipFits_nonl(1)

SYNOPSIS

pipFits_nonl -c $flist pipNonl.fits

OPTIONS

-c specifies that the list of time-ordered files only the first Aperature and the last Aperature are to be printed.

-v specifies that the first Aerture files are not taken into account (skipped)

-x specifies that the set of files that is printed is the complement of the full set with the common start time stamp, i.e., the files that are not taken into account.

DESCRIPTION

The complete number is converted from the header of the file fitsin.fits and all files in the same directory created with the same read time 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 Bệpfits-046 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 Aperature and the last Aperature of the fits 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 nondisturbance infrared detector readout.

The value of the option hard-coded into geta_calmen, pip to 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 -M 4 /DATA/00000.fits

pipFits_ls - M = /DATA/00000.fits
```

GEIRS

Tue Dec 17 2019

1
NAME
pipFits_olsOrdinary 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 1r 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 get 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 7.6), 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 6.7).

   GEIRS started for CARMENES uses this to create snapshots of each read during the multi-correlated non-destructive 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.\footnote{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.}

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\footnote{Note the simple arithmetics: $N = 7$ reads corresponds to $N - 1 = 6$ intervals.}—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.

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.
5.6.2.2 Reads Parameter  

The number of samples along the “ramp” is an integer

\[ N \geq 2 \]  

(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 \( \mu \)s (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

\[ N - 1 \leq I/(1.4s). \]  

(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.
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 \texttt{read}. [In fact this is set with the \texttt{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

\[
N \leq \frac{R}{2 \times 2 \times N_d \times 2048^2}.
\]

Note that this number needs in addition to be divided by the cycle repetition parameter (\texttt{crep} in Section 5.3), if exposures are scheduled to follow immediately on each other.\footnote{This is not relevant for the standard CARMENES operation because the \texttt{abort} command would terminate the entire sequence of exposures. So \texttt{crep} is almost always 1 here.} For the CARMENES workstation we have \( R \approx 32 \text{ GB} \), and each raw frame needs \( 2 \times 2 \times 2048^2 \) \( \text{B} = 16 \text{ MB} \). So a maximum of \( 32,000/2/16 \approx 1,000 \) frames can be stored

\[
N \leq 1000.
\]

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 \texttt{ctype} in Section 5.3), it is trivial to figure out that upper limit as follows: Either

\[ N \leq 1000. \]
1. Send a `ctype` request with much larger number to the shell and read the result

   ```
   linux> snd_carmenes_new 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 6) 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

   $$N - 1 \geq I/I_s. \quad (7)$$

   • 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

   $$N - 1 \geq I/T_c. \quad (8)$$

   • 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
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 $180,000/11 \text{ s} \approx 16,000 \text{ s} \approx 4.5 \text{ hours}$.

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 usually not needed and has some disadvantages detailed above, there is an online GEIRS mechanism (command `sfdump` in Section 5.3 and Section 6.7) which stores the frames on disk while the exposure continues. The configuration options explained in Section 6.7 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 22 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 22: 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.$^{30}$

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

$^{30}$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 administration 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 \texttt{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.\textsuperscript{31}

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 7.7) opportunity to extract line shape information even at these places within the reset windows.

\textbf{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 \texttt{srr} mode in the \texttt{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 \texttt{Carmenes-r6}, \texttt{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 \texttt{srr} configuration (windows and auxiliary parameters) prior to the next call of a \texttt{read} in \texttt{srr} 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 practice only the headers of old FITS files reveal old window sets via the \texttt{RESWN} keywords (Section 6). 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 \texttt{pttrns} directory with a call to \texttt{geirs.srrConfig} prior to calling the \texttt{read}. Note that the next \texttt{read} in the \texttt{srr} 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 \texttt{ctype} \texttt{srr} (after the number of reads) each time it has been changed. This generates the pattern files and loads them to the ROE.\textsuperscript{32}

The configuration file looks like a FITS template file and contains lines of the following format:

\textsuperscript{31}We plan to drop the first pair for the Fowler-Type of interpretations somewhen in the future for the same reason.

\textsuperscript{32}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.
• \text{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 \text{CAM\_DETROT90} and \text{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 \text{xend} and \text{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 \text{CAM\_DETROT90} and \text{CAM\_DETXYFLIP}. Ill-formatted specifications, like those where the quotation marks are missing or the \text{xend} is smaller than \text{xstart} or \text{yend} is smaller than \text{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 \text{x} and \text{y} FITS coordinates—which in fact means that for CARMENES a window definition with \text{xstrt} \leq 2048 and \text{xend} \geq 2049 will define only a window on SCA2.

GEIRS will also reduce the windows to fit into the active 2040 \times 2040 inner region of the chips; reset pixels covering the reference pixels are filtered by the software.

The letters after the \text{WIN} (shown as \text{idx} above) should be non-negative integer numbers, and each \text{idx} should occur only once (outside comments) in the configuration file. There may be holes in the index list. (So you might insert a \text{COMMENT} in front of the \text{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 \text{WIN00}, \text{WIN0100} or \text{WIN8} are alright. Leading zeros in the \text{idx} are ignored, so \text{WIN09} and \text{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 \text{WIN01}, \text{WIN08}, \text{WIN12} and \text{WIN13} on either SCA1 or SCA2, and for example 6 windows \text{WIN02}, \text{WIN03}, \text{WIN07}, \text{WIN11}, \text{WIN10} and \text{WIN20} on the other.

The FITS-style comments in the lines are \textit{not} copied to the corresponding FITS header keywords in the images—at least not by GEIRS.

• \text{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 \text{CAM\_DETROT90} of the user who calls \text{geirs\_srreConfig}. If this is also not set, the default is 1 for CARMENES and 1 for both LUCI's.

• \text{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 \text{CAM\_DETXYFLIP} of the user who calls \text{geirs\_srreConfig}. If this is also not set, the default is 2 for CARMENES and 1 for both LUCI's.

• \text{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 \text{NDET} environment variable may be set in the startup script and selected in the GUI of Figure 4.

• \text{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.

• \text{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_serreConfig.

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_serreConfig 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 wishes 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_serreConfig 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

geris_serreConfig -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:\(^{33}\)

\[
\text{pdir}=$(\text{geirsCmd version } -p) \\
\text{geirs_srreConfig -i configfile -p } \{\text{pdir}\}
\]

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

\[
\text{pdir}=$(\text{geirs_patterns luci1}) \\
\text{geirs_srreConfig -i configfile -p } \{\text{pdir}\}
\]

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 `$/CAMTMP/configfile` if the environment variable `CAMTMP` is set, otherwise `$/TMPDIR/configfile` and then `$/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 `CAMTMP` 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.

\(^{33}\)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]'" > $CAMTMP/srre.cfg
echo "WIN2 = '[700:710,200:200]'" >> $CAMTMP/srre.cfg
echo "DETROT90 = 2" >> $CAMTMP/srre.cfg
echo "DETXYFLI = 1" >> $CAMTMP/srre.cfg
...
```

and then use either

```
# update the pattern files in the pattern subdirectory
%geirs_srreConfig -i $CAMTMP/srre.cfg -p $CAMINFO/Carmenes_r9
cambuild=$(geirs_build)
geirs_srreConfig -i $CAMTMP/srre.cfg -p $cambuild/pttrns/Carmenes
# start exposure in srre mode
snd_carmenes_new ctype srre 10
snd_carmenes_new read
snd_carmenes_new sync
snd_carmenes_new save
```

or

```
# configure and start exposure in srre mode
snd_carmenes_new ctype srre 10 $CAMTMP/srre.cfg
snd_carmenes_new read
snd_carmenes_new sync
snd_carmenes_new 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.

downloads 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.

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


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.6.1 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 environment 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

\[34\] 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,\textsuperscript{35} if the \textit{width} and \textit{height} are chosen to match the typical FWHM of the PSF.

The option \texttt{-v} increases verbosity and lets the program report also the average ADU’s in the computed subwindows. If the options \textit{width} and \textit{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 \texttt{-N} is missing, a default of 10 is substituted.

The option \texttt{-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 \texttt{fitsofile} with a copy of the image in \texttt{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 \texttt{-r} flag which reverses/complements the set of pixels in \texttt{fitsofile}, which means, \texttt{fitsofile} shows only the pixels of \texttt{fitsfile} that are inside the bright regions.

The option \texttt{-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 \texttt{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 \texttt{fitsfile}, it will be used to shift the coordinates; DETROT90 and/or DETXYFLI keywords in \texttt{fitsfile} will also be evaluated.

Also note that \texttt{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 \texttt{geirs\_srreConfig}, the first with \texttt{-f} analysing a previous image, the second with \texttt{-i} and \texttt{-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$^\circ$, . . .)

In almost all cases the \texttt{fitsfile} will contain a full image, which means, not an image with darkened areas of the data by production with a previous \texttt{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 \texttt{sfdump} command.

This invocation can only scan images in the primary HDU of the \texttt{fitsfile};\textsuperscript{36} if the image is in FITS extensions, it may be copied to a temporary file with that format through the \texttt{ftcopy} command of the \texttt{heatools} in the style of

\begin{verbatim}
ftcopy 'origfile.fits[SCA1_1]' tmp.fits copyall=no
\end{verbatim}

or using the \texttt{pipFits} \texttt{zech(1)} program with its \texttt{-P} option to merge the images in the extensions into a single image in the primary HDU, for example

\begin{verbatim}
35The 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.
36this may change in the future
\end{verbatim}
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 submenu in Figure 6.

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 $CAMTMP/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 $CAMTMP/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 place of the FITS files.

#### 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):

```bash
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

```bash
ctype sfr
itime 5
read
sync
ctype lir
read
sync
save
sync
itime 10
cetype 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):

```plaintext
cctype 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

```plaintext
cctype 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 another 14 images with the same integration time but reading the full detector and store it in the primary header of another file:

```plaintext
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 FITS OUTPUT

6.1 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
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-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)
START_INT= 33398.779494 / [s] '09:16:38.7795' start integration (UT)
STOP_INT= 34400.185113 / [s] '09:33:20.1851' stop integration (UT)
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 cycle-type
SAVEMODE= 'o2.single.corr.read' / save cycle-type
CPAR1 = 50 / cycle type parameter
ITIME = 1000. / [s] (on chip) integration time
CRATE = 1001.370302 / [s] read-mode cycle time
EMSAMP = 1 / [ct] electronic multi-sampling
FRAMENUM= 47 / of 50 saved
NCOADDS = 1 / [ct] # of software coadds
DETSIZX= '[1:2048,2049:4096]' / [px] x-range 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, y-range 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_VNBIAB= 0. / [V] det. bias voltage VNBIA 0
B_VNBIAS= 0. / [V] det. bias voltage VNBIA 0
B_VNBIAS= 0. / [V] det. bias voltage VNBIA 0
B_VPBIAB= 0. / [V] det. bias voltage VPBIAS 0
B_VPBIAS= 0. / [V] det. bias voltage VPBIAS 0
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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.

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 than 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 slightly larger than 33 MB.

To check compliance of FITS files on the computer with the standards call `ftverify` of the
heatools (Section A.6.4). This is equivalent to the fitsverify online tool of HEASARC.

6.2 Online Keyword Modification

Section 6.2 is irrelevant for CARMENES because there are no auxiliary FITS data on the NIR computer.

6.2.1 PANIC Temperatures and Pressures

This section is only relevant for PANIC. The values of the keywords TEMPMON_i (where i is a small number with offset 1), and of PRESS_i are acquired by GEIRS by parsing the last line of the current contents of the text file GEIRS/log/instrtemp.log. This must contain twelve blank-separated values as follows: (i) A date in the YYYY-MM-DD format, (ii) a time in the HH:MM format, (iii) two pressures in scientific/ floating point format units of mbar—which is the same as hPa—, (iv) eight temperatures in floating point format in units of K. The file caha/INSTALL.CAHA in the source code addresses how this may be automated. By convention (and implementation), the time stamps are in the local time zone of the computer on which GEIRS is run. The pressure unit is changed to Pascal (applying a factor of 100) within GEIRS while transferring the pressures to the FITS header. For the test cryostats at the MPIA, this can be achieved as described in caha/INSTALL.MPIA in the source code.

6.2.2 File-based Subscriptions

Supervisor software can funnel primary header keyword lines into the new FITS files by writing them into the $CAMTMP/geirsPhduAdd.instrument or $CAMTMP/geirsPhduAdd.instrument_i file before the FITS file is generated with the save command.

(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 erase these files with different frequencies.

6.2.2.1 PANIC convention The current convention is that

1. $CAMTMP/geirsPhduAdd.instrument is manipulated by online tools, [15]
2. $CAMTMP/geirsPhduAdd.instrument_1 is reserved for the lamp.sh output (Section ??),
3. $CAMTMP/geirsPhduAdd.panic_2 for any further generic cleanup within GEIRS;
4. $CAMTMP/geirsPhduAdd.panic_3 is reserved for infrequent long-term logging and event data [16].
5. $CAMTMP/geirsPhduAdd.panic_5 is reserved for logging of meteo data with geirs_ambiPhdu.sh.
6.2.2.2 Linc-Nirvana convention

1. `$CAMTMP/geirsPhduAdd.nirvana.1` is used to adapt the GEIRS conventions to some quasi-conventions of the LBTO;

2. `$CAMTMP/geirsPhduAdd.nirvana.2` are keywords collected by the Python BASDA script on lircs;

3. `$CAMTMP/geirsPhduAdd.nirvana.3` is constructed by the initialization window filled in at startup time, Figure 4.

4. `$CAMTMP/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. `$CAMTMP/geirsPhduAdd.nirvana.5` duplicates RA and DEC as equivalent WCS keywords.

6.2.2.3 LUCI convention

1. `$CAMTMP/geirsPhduAdd.luci2.1` and `$CAMTMP/geirsPhduAdd.luci1.1` clean up superfluous GEIRS keywords and boost them to hierarchical keywords, and

2. `$CAMTMP/geirsPhduAdd.luci2.2` and `$CAMTMP/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.

6.2.2.4 CARMENES convention  `$CAMTMP/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.

6.2.2.5 NTE convention  `$CAMTMP/geirsPhduAdd.instrument.1` is used by GEIRS to push its keywords to the hierarchical format and to clean up keywords related to instrument control software.

6.2.2.6 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 `$CAMTMP/geirsPhduAdd.panic.3`, `$CAMTMP/geirsPhduAdd.panic.4`, and `$CAMTMP/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. 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.
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 6.4). Because GEIRS never knows the position of the camera wheel, it cannot fill in that value reliably; consequently the geirsPhduAdd.lucil1 and geirsPhduAdd.lucil2 contain a line that deletes the PIXSCALE keyword—and leave it to any of the other geirsPhduAdd files to refill the keyword and value.

To add flexibility, GEIRS calls the script scripts/QueueAFiles before assembling the FITS files (if it exists). This script is “triggered” at the start of each save command. This is currently used for LN to create $CAMTMP/geirsPhduAdd.nirvana.2. (The mechanism 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 $CAMTMP.)

6.2.3 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 $CAMTMP/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.)

6.3 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, AIRMASK, and OBJECT. This behavior is actually triggered by starting the software setting the telescope control system to the offline mode (Figure 4). 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 6.2 is also applicable (and more efficient) to modify the primary header keywords.

### 6.4 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 [12], 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 remains a UTC time because another keyword is used which flags that times are in UTC [17]. 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 \texttt{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 [18, 19].

  For LN, the keywords \texttt{UTC}, \texttt{LST}, \texttt{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-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 [20]. Three additional keywords \texttt{OBSGEO-X}, \texttt{OBSGEO-Y}, and \texttt{OBSGEO-Z} will be created if the preprocessor variable \texttt{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 4.

• **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 literal 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 [21]. 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 version is 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 7.7. 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 $1 \times 10^{-6}$ years in the numerical value of a year is only equivalent to $\approx 30$ 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 6 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, 21].

  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 6 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... [22, 23]. 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-ramp 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.\footnote{which means: do not use software which is partially FITS unaware.}

- **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 6 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 6.7.

- **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] x-range and y-range 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] x-range and y-range 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.

- **DETSIZE = ’[1:2048,1:2048]’ / [px] x-range, y-range of full frame**
  
  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 × 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 positive 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 7.8). 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.\(^{38}\)

• 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 happen 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.

\(^{38}\)There is an unfortunate and irritating practise inside the CARMENES ICS client to use the srre mode with
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.
The keywords \texttt{CHECKSUM} and \texttt{DATASUM} appear if the associated \texttt{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 \textit{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 \( \alpha/\delta \) pointing refers to the center of the image. Obviously, that grid is typically wrong by roughly half of the gap, \( \approx 80 \) 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).

\section*{6.5 Image Location}

For Hawaii-2 RG detectors (PANIC, 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 \textit{not} contain regular data, and that the usable region is only a maximum of 2040 \( \times \) 2040 pixels per chip.

Using (or not using) the \texttt{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 \texttt{filename[.extname..]}, where the piece in brackets is the name of the extension as shown in the \texttt{EXTNAME} keyword of the HDU, this is:

\begin{verbatim}
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
\end{verbatim}

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, \texttt{wini} 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.

\begin{verbatim}
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
\end{verbatim}

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, \texttt{wini} 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.
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.

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 `Qd_w` for PANIC, `SCA1|SCA2_w` for CARMENES, and `wind_w` for the other instruments, where `d` is the chip number from 1 to 4 and `w ≥ 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.

---

39There is a bug of incorrect BSCALE/BZERO values in some `chimgtyp` output files which will probably be fixed in HEAsoft 6.23. See [FTOOLS #2427].
6.6 Image Construction With srre(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 srre 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 than 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.

   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.\textsuperscript{40}

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 13, and to the FITS image stored on disk with save\textsuperscript{41}.

For CARMENES a dedicated postprocessing procedure has been added that mainly i) applies a nonlinearity-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 [24]. 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.

6.7 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)\textsuperscript{40}Changing the default that applies after starting GEIRS needs a change in the source code that initializes these data.
\textsuperscript{41}Of course the reduction does not apply to the the single-frame formats described elsewhere in the manual.
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 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

```bash
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 abortion) in the RAM is

\[
N_F = 1 + \left\lfloor \frac{N - 1}{s} \right\rfloor.
\]  

(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.\(^{42}\)

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.\(^{43}\)

The implementation is by default dumping data into a directory without any overwrite protection (!)\(^{44}\) 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:

\(^{42}\)This file format can for example be read with od -d ....

\(^{43}\)The current implementation also copies reference pixels of Hawaii2-RG detectors into the regions, which may change in the future.

\(^{44}\)i.e., the definition of the clobber command are ignored
• COMMENT [anything...] lines to be ignored, only for documentation purposes

• WINidx = '[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 WINidx 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 WINidx parameters. Think of this as stacking two sets of masks (hardware 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.

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 \texttt{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 associated 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 \$CAMTMP/fits. If the string is empty, the directory is the same directory (dynamically) as where the other FITS files go.\(^{45}\) 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 \(<\text{FDIR}/<\text{FNAM}>/<4\text{digitFrameNo}.fits\) if they are FITS files, otherwise \(<\text{FDIR}/<\text{FNAM}>/<4\text{digitFrameNo}>\). 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 (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 \textit{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 \texttt{sfdump} is used. GEIRS attempts to open and read the configuration file are done later with the next \texttt{read}.

\(^{45}\) Again: this is \textit{definitely not} recommended because the files there are considered permanent data and the \texttt{sfdump} subroutine may erase files there...
Example of a well-formed configuration file:

```
COMMENT example 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 example 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 ${CAMTMP} ${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 [24].
7  EXPOSURE TIME

7.1  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.

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 6 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.

7.2  Lir with idle break

If the readout mode is line.interlaced.read with idle mode break the time is

\[ t[\text{sec}] \approx 0.3 \times N_f + t_{\text{cyc}}[\text{sec}] \times N_f \]  \hspace{1cm} (10)

where the number of frames \( N_f \) has been set by the application with the crep command and where \( t_{\text{cyc}} \) is the cycle time.
7.3 frr with idle break

If the readout mode is fast-reset-read.read with idle mode break the time is

\[ t[\text{sec}] \approx N_f \times t_{\text{cyc}}[\text{sec}] + 0.03 \times N_f. \]  

(11)

7.4 mer with idle break

If the readout mode is multiple.endpoints with idle mode break the time is

\[ t[\text{sec}] \approx N_f \times t_{\text{cyc}}[\text{sec}] + 0.003 \times t_{\text{cyc}}[\text{sec}] + 0.005 \times N_f. \]  

(12)

There is no explicit dependence on the CPAR1 parameter (number of Fowler pairs) which is already incorporated in the cycle time.

7.5 sfr with idle break

If the readout mode is single.frame.read with idle mode break the time is

\[ t[\text{sec}] \approx N_f \times t_{\text{cyc}}[\text{sec}] + 0.06 \times N_f. \]  

(13)

7.6 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.\footnote{The \texttt{subwin auto on} command dissects windows that cross chip or quadrant boundaries so the observer does not need to be fully aware of details.}

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 23: 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 6 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.)

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 6), the increase in time is $128 \times 10$ 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 6 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 $\$CAMTMP/timing_cmds.log$, 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.

### 7.7 Higher resolutions

#### 7.7.1 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 24 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 $\approx 1.4$ seconds—half of (1)—for the standard PSKIP, LSKIP etc. parameters.

![Figure 24: Pattern/distribution of effective pixel time as a function of Hawaii-2 pixel position.](image)

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.

### 7.7.2 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

$$T_s(x) = T_0 + \frac{1}{2048} T_c \times \begin{cases} 
(x - 1), & \text{SCA2} \\
(4096 - x), & \text{SCA1}
\end{cases}$$

the start time as a function of FITS $x$ coordinate. For the srre 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 \( T_0 \)—see Section 8.1—, 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

\[
c \equiv \lfloor \frac{E}{D_0 + D_1} \rfloor.
\] (15)

The effective integration time is

\[
es(x) = (c + \epsilon(x))D_1
\] (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 \( D_1 = 0.12s \), \( D_0 = 4D_1 \), \( E = 4 s \) 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.

### 7.8 Bright Sources, High Speed

If the illumination on the detector is faint, the fundamental means to adjust to the basically 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\(^47\). 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 \texttt{prd} button in Figure 6 and the \texttt{ptime} command 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 \texttt{roe} command).

2. Skipping pixel lines in the slow direction by hardware windowing (Section 7.6) 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 \texttt{lir} mode with two reads per scan but only a mode with one read per scan is used, for example the \texttt{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 \texttt{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 9.1).

5. Taking an idle mode with the most frequent resets is also advantageous to avoid persistence effects (button in Figure 6 and the \texttt{idlemode} command). Note that for a \texttt{srr} mode with two reads the \texttt{ReadWoConv} may be faster than the default \texttt{Lir} idle mode, because the associated cycle time may be slower if the integration times are short anyway. The \texttt{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 \texttt{srre} mode (Section 5.6.2).

In summary, \textit{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\(^48\) or even reducing logging. That sort of package options of commands looks like:

\begin{verbatim}
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
\end{verbatim}

\(^{47}\)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 \([4]\).

\(^{48}\)with the disadvantage that one needs a pipeline that subtracts consecutive pairs of 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.

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.

### 7.9 Time between Reset and First Read

The internal analysis of the timing is dumped by GEIRS into the file $\text{CATMP/timing cmds.log}$. 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
<table>
<thead>
<tr>
<th>ctype</th>
<th>ems</th>
<th>subwin corner</th>
<th>subwin size</th>
<th>pread (ns)</th>
<th>ΔT (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lir</td>
<td>4</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>10000</td>
<td>0.157</td>
</tr>
<tr>
<td>lir</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>10000</td>
<td>0.171</td>
</tr>
<tr>
<td>lir</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>9000</td>
<td>0.155</td>
</tr>
<tr>
<td>lir</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>8000</td>
<td>0.139</td>
</tr>
<tr>
<td>lir</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>6000</td>
<td>0.103</td>
</tr>
<tr>
<td>lir</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>4000</td>
<td>0.0710</td>
</tr>
<tr>
<td>lir</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>2000</td>
<td>0.03535</td>
</tr>
<tr>
<td>lir</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>1500 ∼</td>
<td></td>
</tr>
<tr>
<td>lir</td>
<td>1</td>
<td>700 × 700</td>
<td>16 × 16</td>
<td>6000</td>
<td>0.00434</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>10000</td>
<td>0.0858</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>8000</td>
<td>0.0696</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>4000</td>
<td>0.03555</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>2000</td>
<td>0.0177</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>128 × 128</td>
<td>1500 ∼</td>
<td></td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>64 × 64</td>
<td>10000</td>
<td>0.0430</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>64 × 64</td>
<td>8000</td>
<td>0.0348</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>64 × 64</td>
<td>7000</td>
<td>0.0300</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>64 × 64</td>
<td>6000</td>
<td>0.0259</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>64 × 64</td>
<td>4000</td>
<td>0.0178</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>64 × 64</td>
<td>2000 ∼</td>
<td>0.0089</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>32 × 32</td>
<td>4000</td>
<td>0.00515</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>32 × 32</td>
<td>2000</td>
<td>0.00271</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>16 × 16</td>
<td>6000</td>
<td>0.00222</td>
</tr>
<tr>
<td>srr 10</td>
<td>1</td>
<td>700 × 700</td>
<td>16 × 16</td>
<td>3000</td>
<td>0.00123</td>
</tr>
</tbody>
</table>

Table 1: Image and frame rates as a function of window size and pixel read parameter measured with a Hawaii2 RG LUCI setup.
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 × 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 6.4), which is 200 kHz effectively for each value submitted; that is packed into the second 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 6. 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 ×[(2048−y)mod64], 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].
8 COORDINATE SYSTEMS

8.1 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\footnote{a slightly higher mark is chosen for CARMENES}. 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\footnote{which actually does not exist under Linuxes} with the aid of the PLX library, 8 MB for each $2k \times 2k$ detector chip, in chunks which are some fraction of the maximum of 4 MB. If this does not succeed right away (usually caused by fragmentation of the slab tables, which unfortunately is correlated with the file caching mechanism), GEIRS attempts 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 \texttt{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.


9 TROUBLE-SHOOTING

9.1 ROE Interface

1. Problem: No data appear and the main screen of Figure 13 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/Generic 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
```

If messages of the sort

```
INFO MPIA-ROE3 reset - '33 8 0 1'
INFO Seen ROE3 rocon 'DETPGA' 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.\(^{51}\)

If you powered the ROE on after starting GEIRS, GEIRS will be unaware of the presence of the ROE\(^{52}\), and the ROE will not host any patterns. The options are

(a) load a standard pattern to the ROE with the File→Init/Reboot ROE menu of the controls menu (Figure 6).

(b) quit GEIRS and restart it while the ROE is on.

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 25. 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 13 remains gray. Solution: If messages of the

```
(E_ptimeout=21) timeout on OPTPCI interface
```

\(^{51}\)Unfortunately starting GEIRS with the Java GUI Figure 5 never generates output on the Linux standard output, so that test is not available if that method of starting is used.

\(^{52}\)GEIRS does not poll the ROE status
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 13 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 26) [26]. Effectively a single fiber pair connects an ROE and an OPTPCI at the workstation. 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 OPTPCI 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 2.1.9).

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/GENERIC`, otherwise make sure this is the `/dev/plx-00` pair.\(^53\)

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 GENERIC 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 4. For a quick temporary check whether the IP address is the culprit, one can either use the engineering GUI in Figure 5, 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) the value of the environment variable CAMROE_REV (Sec. 3.2) defined in the `scripts/GENERIC` file points to a wrong or non-existing directory.

(b) 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 4. However, if the two main processes (`shmmanager` and `cmdServer`) and/or the other processes (control, disp) 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 6.

(c) 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 6 or the `init camera` command of Section 5.3—will remove the problem.

(d) GEIRS was not started in simulation mode but the ROE does not respond—for any of the reasons described in Section 9.1.

(e) 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
```

(f) 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:

---

\(^{53}\)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 13 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 (≈ 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 PANIC:

`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\(^{54}\). 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 6) 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 5). 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 (PANIC 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.

\(^{54}\)which warms up the pre-amplifiers that have some minimum operating temperature
7. Error messages of the form

```
libplxmpia.c:233: [plx_find_device] ERROR) Error in Plx device found (u=2/chan=0): ffff 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 2.1.9. 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.

8. 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. 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).

9. 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.

10. Problem: The ROE lamps 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 lamps as possible. The reason is that the standard operation of the ROE is in telescope domes where permanent light pollution 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 lamps, 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.
9.2 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-... # 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-... # 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 4.

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 4, 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. 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 absolutely 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.

4. 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).

5. 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.

6. 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.

7. Problem: Anything seems to work well but there are no stars. Solution: Check the third button in the display window Figure 13 for the image selection back to `current` so the images are updated.

8. Problem: The GUI in Figure 6 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/GENERIC` (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. The general solution is to split the exposures into smaller packets so each of them fits into the margins.

9. Problem: When `saving`, 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 6 for future use, which will by default be created with

---

55 The exception is the two LUCI’s where the assumption is made that binocular mode requires two GEIRS sessions; so there is room by a factor of two then.
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.

10. Problem: the `ctype srre` responds with an error of the format `ERROR Too large tblindex 256 of max. 256 in dettable=2`. Solution: reduce the number of reset windows defined in the configuration file. The current limit is near 80 windows on each individual detector chip.

11. Problem: `geirs_clean-up` responds with a message of the form `If 'cleanup' is not a typo...` Solution: expand the `PATH` variable as described in Section 2.5.2.

12. Problem: After the read process finished the `save` button in the controls GUI in Figure 6 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.)

13. 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 6.2 is left alone and further FITS files are generated using GEIRS as 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.

14. 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.

15. Problem: The `read` of Linc-Nirvana never produces any frames or images, not even with the data generator of the OPTPCI nor if GEIRS is started in simulation. Solution: Linc-Nirvana may be configured to start a rewind of the derotator stage of the detector prior to each readout. If the associated motor server does not finish this rewinding, GEIRS may wait forever in that phase without actually forwarding the read command to the ROE in the next phase. The simplest workaround is to insert a `exit 0` very early in the file `~/GEIRS/scripts/QueueEFiles` such that the bash script that tries to initiate the motor is effectively not doing anything. An alternative is to uncheck the `~Q` flag in the controls GUI before starting the `read`, which also skips calling the rewinder script. A third option is to stop the server that is running the motor such that requests for the rewinding are quickly rejected:

```
lneng@lircs:> rcbasdard.sh stop lircs.moe.derot-svr
```

The obvious disadvantage is that the casual observer forgets to undo that change later on.
Perhaps (not tested) switching the power of CRY-MOT-1 off in the lsys.cab.ps-svr_GUI.sh has the equivalent effect.

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.\(^{57}\)
- 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 reads 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 6) 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 snd_luci{12} new 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 in Figure 6) 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: 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

\[ \text{journalctl} \]

\(^{57}\)This is a deliberate design choice to support smooth processing with the first stage pipeline.
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.

20. 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 13.

### 9.3 Operating System

1. Problem: After `start* -gui` time GEIRS complains that `DISPLAY` is not set.\footnote{Of course this has nothing to do with GEIRS.} 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`,
   - 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 [7].

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: GEIRS fails to open its GUIs claiming that it cannot allocate its color maps. Solution: close some of the other graphics intense programs that are currently running on the same display and/or invest into contemporary hardware.

5. 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.
9.4 Motor Interface

This has no relevance to instruments besides PANIC.

1. Problem: A lot of ERROR with MOT2-answer... timeout.. before getting complete answer appear. Solution: check that cables are connected to the auxiliary rack and that the rack is powered on and connected to the Ethernet. If this does not seem the cause of the problem, restart GEIRS to start a freshly synchronized command exchange with the MoCon.

9.5 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 26: 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 installation (host: Dell R515), at the right the Figure 30 of the ROE manual [26] or PANIC (host: PowerEdge R720).
9.6 Recent Changes

A summary of the GEIRS changes between version 780M-21
(as described in my e-mail of Feb 15, 2019) and the current
version 789M-7 (available on ftp://ftp.mpia-hd.mpg.de/pub/mathar/ )
from the application/operator point of view looks as follows:

- Hawaii-4 RG support (for the PANIC upgrade) has been debugged
to the extend that at least the Multiplexer is read out
as expected with the standard 64-channels readout.
The selection of PANIC at startup now requires a single Hawaii-4 RG
chip (or multiplexer or simulation); the old 2x2 Hawaii-2RG variant is no
longer supported and moved to a camera Aip. The distinction between
DETSIZE and DATASIZE in the FITS headers has been dropped for Hawaii-4RG
(assuming that the 4 ref pixels will be used like standard pixels).

- At startup, the default FITS output file name is set to
a device name and time stamp (not aa0001). The default data
(sub)directory is derived by subtracting 7 hrs from the local time
at the observatory and using the associated date as the name.

- The PANIC telescope menu (probably never used ?) has also
been ported from X11 to Java. Replacement of X11 GUIs
by Java GUIs is complete.
Availability of a Java compiler is now mandatory.
Font sizes can be selected in the startup menu.
The left-mouse click and drag is used to compute a histogram
of the data in a rectangle of the real-time display (no longer
a method to adapt cut levels and saturation levels).

- All logging (with the exception of PANIC temperature logs
and its file saved logs) now go into syslog, no longer
into log files. The log rotator script and the log filters
in the menu are adapted. Jitter log files are no longer created.

- Due to restricting changes of the Oracle JDK licensing
as introduced for their JDK 12, , heading towards commercializing Java,
development is now based on the default Linux open Java library which allows
use in our telescopes.
- Support for Ubuntu 16.xx has been added, mostly related to the autotools variables; further updates of the NTEimg and NTEspec cameras (which are currently just Luci1/2 equivalents). At MPIA we will not have a OPTCI board plugged into an Ubuntu-computer, so tests of that operating system and its 5.xx kernels with the PLX driver are postponed...

- Support for PLX device drivers <= 7.10 has been dropped. The platform is now PLX SDK 8.00 (which supports 4.xx and 5.xx Linux kernels).

- All locally compiled external packages (cfitsio, xercesc, iausofa etc) have been continuously upgraded.

- On request a default voltage for Linc-Nirvana has been changed after the detector replace campaign. Voltages for PANIC are now the same as for the CARMENES/LUCI detectors (and remain to be defined).

- Some bug in observing the TMOUT parameter (automatic GEIRS termination after idle period) has been removed.

- A program fits2tiff that converts FITS images to TIFF 6.0 files has been added.

- The parameter NQCHAN (the number of detector channels) is now pushed into the FITS header data (anticipating that readouts with less than the maximum number of channels might be useful in "long" spectroscopic modes...).

- The meaning of the 'fits' command has been changed: it does no longer report a virtual set of keywords that would appear in potential FITS files of the future, but adds FITS lines into the files that will be saved afterwards. [This is another keyword merger channel beyond the previous file-based FITS-keyword gatherer.]

- The nominal beam center in the Linc-Nirvana images has been updated to a value calibrated in Com-9.

- the xserver command has been removed.

- the status scanner and status collect servers have been removed.

- The development platform is openSUSE 15.1.

Developer's aspects:

- There is some support for engineering type setups where the number of ROE ADC36-boards is not the full number...
required for the chip-type and number. (That was triggered by the need to simulate the Hawaii-4 RG readout on a test ROE with only one ADC36 board.)

- Untested variants of 4-channel readout-mode for Hawaii-2 and 32/16-channel readout-modes for Hawaii-4 RG have been added.

- Once more cleanup of old patterns that are no longer supported (other than Hawaii-2, Hawaii-2RG and Hawaii-4RG). (Software coadds, some readout mode residuals for Omega2000, the CAHA 1.2m, ...)

- Further (incomplete) upgrade of the ICE server for Linc-Nirvana. This is actually not yet used.

- The interface from the shared memory data to the real-time display has been re-factorized and is now based on an intermediate data server.

- Almost all patterns which are compatible between instruments and detector types have been massively reduced in number by using a large amount of symbolic links between the pattern subdirectories. (Benefit of an earlier decision not to put the patterns in distributed SVN repositories anymore.)

- Compilation of the test subdirectory is also supported on CentOs 7.

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\textsuperscript{59}

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 ReadOutElectronics. You should see a message like this:

\textsuperscript{59}Contribution by U. Mall, 29 Feb 2015
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 board 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):

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
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 separating 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 computer's 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. 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.

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 \((1,0)\) of order 4—,
- the two pure flips \((0,1)\) and \((0,2)\)—each of order 2—,
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.

- and the two flips along the two diagonals, (1, 1) and (1, 2)—each of order 2.

For inspection of sky rotation or pointing parameters one may compare the images with 2MASS images by submitting the pointing coordinates to the “quicklook” in http://irsa.ipac.caltech.edu/applications/2MASS/IM/interactive.html.

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

\[
\text{cat /proc/asound/cards} \\
\text{amidi -l} \\
\text{/usr/sbin/alsa-info.sh}
\]

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 27. This is configured basically as follows:

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 \texttt{sudo /sbin/yast2}, selecting the Software management submenu, searching for \texttt{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 menu via **System → Configuration → PulseAudio Preferences**.

The disadvantage of this setup is that the remote computer broadcasts continuously 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 `zero-conf` 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 submenus.

**paprefs** can alternatively be called from the Desktop menu 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`.

---

**Figure 27: Potential of sound forwarding**
3. On the remote computer the pulseaudio server needs to run. This can be checked with

```bash
ps -C pulseaudio
```

and is generally implemented by a non-comment line of the format

```plaintext
autospawn = yes
```

in `/etc/pulse/client.conf`. If this does not work, start the pulseaudio server on the remote computer manually:

```bash
pulseaudio --start
```

and if this is refused with

```bash
pulseaudio -D
```

(This might be included in the scripts/Generic 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:

```bash
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

```bash
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

```bash
xprop -root | fgrep PULSE
```

on the remote computer. If this information does not show up on the remote machine, either

```bash
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

```plaintext
cpcm.!default {
  type pulse
  hint {
    show on
    description "Default ALSA Output (currently PulseAudio Sound Server)"
  }
  fallback "sysdefault"
}

cctl.!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:

```plaintext
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 (after translation to csh syntax) in the $CAMHOME/scripts/GENERIC 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 availability of a DNS server from the remote computer.

8. Set the environment variable CAMAUDIOPLAY (in the scripts/GENERIC) 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

```plaintext
cd $CAMHOME/SOUNDS
aplay -Dpulse rooster.au
paplay rooster.au
```

on the remote (GEIRS) workstation plays sound on the local workstation. If the call

```plaintext
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 weakened (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 Network Time

Under openSUSE, configuration of the NTP is to be done in /etc/ntp.conf, or easier with the network configuration within yast. The daemon appears as /usr/sbin/ntpd with ps -ef | fgrep ntp. A running daemon does not guarantee that the clock on the system is updated, for example if hosted behind a firewall\(^\text{60}\), so it is advised to monitor /var/log/ntp or the equivalent log-file set in /etc/ntp/conf for the (irregular) corrections and to check that for example ntpdate pool.ntp.org or whatever server is mentioned in /etc/ntp.conf is responding.

Under CentOS 7, we edit /etc/chrony.conf (for example adding

server time.mpio-hd.mpg.de iburst

at the MPIA), or

server gps0.mountain.lbto.org
server gps1.mountain.lbto.org
server ntp1.arizona.edu
server ntp2.arizona.edu

at the LBT, then

systemctl enable chronyd.service
systemctl start chronyd.service

A.5 X11

A.5.1 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/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 submenu Security and Hardening, then the submenu Enable extra services in runlevel 5 and switch the entry for the sshd to Yes. On Ubuntu use apt install openssh-server.

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.

\(^\text{60}\)this is the MPIA case. nslookup time will reveal the IP address of the local time server
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.5.2 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 yoursshname@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 transfer the files with

```
verdi9> scp -p -r -P 2022 geirsname@localhost:/dir/full/path/on/luci /full/path/on/verdi9
```
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 if one has an account on rigel.mpia-hd.mpg.de. The principle is again to open a tunnel through rigel with some unused port (here: 2022) mapped on port 22 of the MPIA computer:

```
extr> ssh -X -N -L 2022:yourmpiacomp:22 rigelusername@rigel.mpia-hd.mpg.de
extr> rigeluserpassw
```

and then open another terminal on the external computer to reach your MPIA computer:

```
extr> ssh -X -p 2022 mpiacompusername@localhost
extr> mpiacompuserpassw
```

### A.5.3 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 under openSUSE:

```
zypper install libXvnc1 libvncclient0 libvncserver0 tigervnc vncmanager xorg-x11-Xvnc # openSUSE
yum install tigervnc-server # CentOS
apt-get install tigervnc-common tigervnc-standalone-server # Ubuntu
```

Log into the remote computer via ssh and start the vnc server there:

```
verdi9> ssh -X yoursshname@external
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@ln-lircs
ln-lircs> vncserver -autokill # example response: ln-lircs:2
verdi9> ssh -N -L 5922:localhost:5902 ln-lircs # take 5922 because small probability already in use
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).

Alternative tools for X11 speed-up are NX (Section A.5.4) and x2go (Section A.5.5).
A.5.4 NX client

To connect via tunneling through the LBTO port machine to a remote computer on the LBT network with newer versions of NX, first set up a tunnel through ssh.lbto.org

verdi9> ssh -X -N -L 2022:xxx.yyy.www.zzz:22 yoursshname@ssh.lbto.org

in one terminal. (This will not show anything after you typed in your password and seems to hang.) Here xxx.yyy.www.zzz is the IP address of the remote computer; using a symbolic name like luci.luci may no longer work. Then start the NX client with

nxplayer (under Linux)

nxplayer.exe (under Windows)

in another window. If the command nxplayer is not found under Linux, use the full path name of the installation to start (/usr/NX/bin/nxplayer) or add /usr/NX/bin to the PATH. If /usr/NX is absent, install the software by downloading the RPM package from the company and install it first (as root) with

yum install nomachine_4.6.4_13*.rpm #under CentOS

zypper install nomachine_4.6.4_13*.rpm #under openSUSE

In the NX configuration use

- ssh as the protocol,
- use the same port as with the tunnel (2022 in the example),
- use the localhost as the machine to connect to,
- use the login account (for example readout1 and password on the remote machine)

Just after installation, the NX support is running under an openSUSE system (ps -elf | fgrep nx), because /etc/systemd/system/multi-user.target.wants contains a nxserver.service entry. To disable this automated start each time the computer boots, use /sbin/yast2, the System submenue with the Service Manager, and disable the nxserver. In this case one needs to activate the service explicitly (as root) either from the same menu or by calling /etc/NX/nxserver --startup.

A.5.5 x2go

If the operating system is openSUSE, x2go is installed on the remote workstation with

zypper ar obs://X11:RemoteDesktop:x2go/openSUSE_13.2 x2go

zypper ar obs://X11:RemoteDesktop:x2go/openSUSE_Leap_42.1 x2go # for openSUSE Leap 42.1

zypper refresh

zypper in x2goclient

If the operating system is CentOS 7, x2go is installed on the remote workstation with

yum install epel-release

yum --enablerepo=epel install xgoserver-xsession

yum --enablerepo=epel install x2goclient
The session is started with

```
x2goclient
```

Note that GNOME sessions seem not to work, only KDE sessions.

### A.5.6 Fonts

If the font system of the current X11 system does not offer the `courier-medium` and `courier-bold` fonts for the GUI's (revealed with `xfontsel` and `xlsfonts`) a modest adaptation is available by switching to another font in the style of

```
setenv CAMFONT courier
```

before starting GEIRS, for example `fixed`. There is an equivalent editable entry in Figure 5 for experimentation.

### A.6 FITS

#### A.6.1 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. 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
```

to render the image with an approximately correct gap between the two chips.

#### A.6.2 ds9loop

A command `ds9loop` with the syntax

```
ds9loop [ds9options...] dir1 [dir2 ...]
```

---

61 This is a user's note that has nothing to do with GEIRS.
is in the GEIRS scripts which calls \texttt{ds9} in a loop over all fits files in the named directories. The only required interaction by the user is to close \texttt{ds9} for moving on to the next. Examples:

\begin{verbatim}
ds9loop .
ds9loop -mosaicimage /data1/Panic
\end{verbatim}

\section*{A.6.3 fits2csv}

The program \texttt{fits2csv} opens the GUI of Figure 28 and scans recursively a list of directories for all files with suffix \texttt{.fits}. The FITS header keywords that match a finite list of strings defined by the user are searched in a HDU of each of the files and written as a comma-separated list of values (CSV), into a text file specified by the user.

The keywords should be provided as regular expressions of the form \texttt{HIER.*keyword} if there are some general hierarchical prefixes in front of them.

The GUI is not opened if \texttt{fits2csv} is called with any command-line options (in batch mode), see the man-page in Section 5.5.

The standard way of using this new text file is to open it with a spread-sheet editor like open office, specifying the comma as the delimiter.
Figure 28: The GUI called in by fits2csv
A.6.4 FTOOLS

The heatools mentioned at many places in this manual are compiled as follows:

1. Ensure that you have a recent version of compilers of your operating system, including gfortran. On openSUSE for example, use /sbin/yast2, the software management, and look into the RPM group under Development - Languages - Fortran. You may also need to install the libXt-devel package such that X11/Intrinsics.h is known.

2. Download the source code from the download page. Select the Source code (CentOS or openSUSE or both), not any precompiled binaries, and select the General-Use FTOOLS, de-select the Attitude, Caltools, HEASim, HEASPtools, HEAGen, Time and Xspec packages which are not of much interest to optical Astronomy, and click Submit. Download everything (roughly 100 MB) to $HOME/heasoft-6.23.src.tar.gz.

3. Unbundle with

   cd $HOME
   rm -rf heasoft-6.25
   tar xzf heasoft-6.25src.tar.gz

4. umask a+r
   cd heasoft-6.25/BUILD_DIR # depending on tar version also ..-6.22.1...
   ./configure --x-libraries=/usr/lib --x-includes=/usr/include # openSUSE 13.2
   ./configure # CentOS 7 or openSUSE Leap 42.2
   nice make & tee build.log
   nice make install & tee install.log
   chmod +x headas-init.*

5. add to $HOME/.bash_login or $HOME/.bashrc (details of the libc will probably differ, current CentOS 7 systems end in libc2.17):

   export HEADAS=${HOME}/heasoft-6.25/x86_64-pc-linux-gnu-libc2.26
   export LD_LIBRARY_PATH=${LD_LIBRARY_PATH}:${HEADAS}/lib
   . $HEADAS/headas-init.sh >& /dev/null

   and make sure that your terminals are login terminals.

As an example of how shell scripting with these tools work, consider the task of subtracting the first slice from the second, the second from the third, and the third from the fourth slice of an image cube. The script extracts slices with ftcopy, converts them to a floating point (BITPIX -32) version to avoid underruns while subtracting them if they are unsigned short integers, and subtracts them pairwise with ftpixcalc:

#!/usr/bin/env bash

# Generate arithmetic differences of consecutive slices of a FITS cube.
# Note: this makes heavy use of the HEATOOLS.

# Usage:

# pipFits_cdiff.sh fitsinputfile.fits outfilestub

# The first command line argument must be an existing and readable FITS file, # the second command line argument is a file name stub for the differential # images to be created. The second command line argument should not collide # with names of existing files.

# $Header$
# since 2018-03-14

if [ $# -ne 2 ] ; then
    echo Usage: $0 inputfitsfile.fits outfilenamestub
    exit 1
fi

# save command line argument for input file name
ifi=$1
ofi=$2

if [ ! -r ${ifi} ] ; then
    echo Cannot read $ifi
    exit 1
fi

naxes3=$(dfits ${ifi} | fgrep NAXIS3 | awk '{print $3}')
if [ $naxes3 -lt 2 ] ; then
    echo Less than 2 slices in ${ifi} PHDU image
    exit 1
fi

# loop over slices 2 up to the number of slices
for (( j=2 ; $j <= $naxes3 ; j = $j + 1 )) ; do
    # get the previous slice number (one less)
i=$(( $j -1 ))
    echo $i $j
    # extract slices i and j into files named with suffix tmp1 and tmp2
    ftcopy "${ifi}[*,*,${i}:${i}]" ${ofi}.tmp1 clobber=yes
    ftcopy "${ifi}[*,*,${j}:${j}]" ${ofi}.tmp2 clobber=yes
    # convert slices to floating point representation (avoid underflow if integer)
    chimgtyp ${ofi}.tmp1 ${ofi}.tmp1F FLOAT Fnull=0.0 clobber=yes
    chimgtyp ${ofi}.tmp2 ${ofi}.tmp2F FLOAT Fnull=0.0 clobber=yes
    # subtract the two slices and call the result sub_.....fits
    ftpixcalc ${ofi}_${j}.fits 'A-B' a=${ofi}.tmp2F b=${ofi}.tmp1F clobber=yes
done

exit 0

Note that this program is imperfect. It does not erase the invalid CHECKSUM and DATASUM keywords
of the old header, for example.

### A.6.5 ds9

ds9 is obtained from [http://ds9.si.edu/site/Download.html](http://ds9.si.edu/site/Download.html). If `xslt-config` is not in the path (apparently the case for CentOS 7) install the package with

```bash
yum install libxslt libxslt-devel # CentOS
zypper install libxslt-tools libxslt1 libxslt-devel # openSUSE
```

Ensure for openSUSE that the xml2 and openssl libraries are available:

```bash
zypper install libxml2-devel libopenssl-devel
```

Assuming the sources are from the Beta Version of the web site, compile ds9 with

```bash
tar xzf ds9.7.6.tar.gz
cd SAOImageDS9
# patch for hard-coded library placement under openSUSE
mkdir -p lib
ln -s lib lib64
unix/configure
make
# cp bin/ds9 ${HOME}/bin # optional
cp bin/ds9 ${INSROOT}/bin

cd ..
rm -rf SAOImageDS9
```

If the openssl version of the operating system is 1.0 or higher, indicated for example in `/usr/include/openssl/opensslv.h`, DS9 versions up to and including 8.0rc2 cannot compiled that way, because the API of the library changed. A patch for that scenario exists. For recent CentOS and openSUSE systems RPM packages have been put on openSUSE build server.

Ubuntu users can obtain ds9 via

```bash
apt install saods9
```

### A.6.6 siril

The fastest way to fit a star blob in a FITS image to a Gaussian is apparently by opening it in siril and dragging a box around the feature. This is in particular useful for LN where the diameters under standard seeing conditions are 100 to 200 pixels. The source code is obtained from [https://free-astro.org/index.php?title=Siril:0.9.8](https://free-astro.org/index.php?title=Siril:0.9.8). Compilation (under openSUSE):

```bash
bunzip2 siril*tar.bz2
tar xf siril-0.9.8.tar
zypper install libconfig-devel opencv-devel
cd siril-0.9.8
./autogen.sh
make
make install
```
Under Centos one needs to install a higher version than 1.5 of libpng first from https://sourceforge.net/projects/libpng/files/:

```
unxz -c libpng-1.6.32.tar.xz | tar x
cd libpng-1.6.32
./configure --prefix=/usr
make install
```

bunzip2 siril.tar.bz2
tar xf siril-0.9.8.tar
yum install gtk3-devel libconfig-devel opencv-devel # CentOS
cd siril-0.9.8
./autogen.sh
# edit Makefile and src/Makefile to replace png15 -> png16 throughout
make
make install

A.6.7 SkyMaker

To simulate images with the `TwoMassConvert(1)` program one needs `sky(1)`. The source code is obtained from http://www.astromatic.net/software/skymaker. The FFTW library is needed, for example under CentOS implemented with `yum install fftw-devel`. SkyMaker is then compiled with

```
tar xzvf skymaker-3.10.5.tar.gz
cd skymaker-3.10.5
./configure --prefix=$HOME --disable-threads
make
make install
```

We assume that `$HOME/bin` is in the `$PATH`.

A.7 SVN installation

An SVN installation happens by downloading the gzipped tar ball from https://www.apache.org/dist/subversion/, then

```
tar xzvf subversion-1.9.3.tar.gz
cd subversion-1.9.3
./configure --prefix=$HOME
make
make install
```