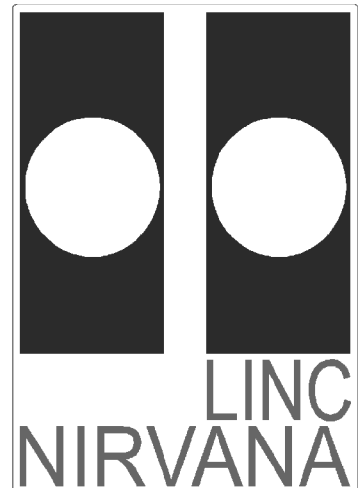


LINC-NIRVANA

The **L**BT **I**Nterferometric **C**amera and
Near-**I**nfra**R**ed / **V**isible **A**daptive
iNterferometer for **A**stronomy

A collaborative project of the MPIA Heidelberg, INAF-Arcetri,
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<http://www.mpia.de/LINC>



LINC-NIRVANA

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Operations

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1 Scope

The document will describe the operational scenario of LINC-NIRVANA (LN), the particularities to be considered when observing with LN as well as a typical observation cycle. Further operational aspects are discussed, such as i.e. data logging, data archiving, etc. From the scenario we derive requirements on the functionality of software and hardware.

2 Applicable documents

No.	Title	Number & Issue
AD1	LINC-NIRVANA - Error Budget	LN-MPIA-FDR-GEN-001
AD2	LINC-NIRVANA – Implementation, Commissioning and Acceptance plans and procedures	LN-MPIA-FDR-AIT-006
AD3	The Software Package AIRY. A tool for the reconstruction of LN images	LN-GENOVA-FDR-ASW-001
AD4	Data Reduction Software	LN-MPIFR-FDR-ASW-001

3 External Interfaces

Item	Short description

4 Acronyms and abbreviations

AO	Adaptive Optics
FFT	Fringe and Flexure Tracker
LN	LINC-NIRVANA
MCAO	Multi-Conjugated Adaptive Optics
MTF	Modulation Transfer Function
OB	Observation Block
OP	Observation Program
OPC	Observation ProCedure
OTU	Observation Target Unit

PDR	Preliminary Design Review
PSF	Point Spread Function
SW	Software
WFS	Wave Front Sensor

5 Introduction

LINC-NIRVANA (LN) is a Fizeau (Imaging) Interferometer using the two 8.4m mirrors of the LBT in the combined back bent focus of the LBT. It can obtain images in K, H and J Band over a 10"x10" Field of View with Multi-Conjugated Adaptive Optics (MCAO) and a Fringe and Flexure Tracker (FFT). Along the baseline of the two mirrors the spatial resolution of the image will be that of a 22.8m telescope while in the perpendicular direction the spatial resolution will be that of a 8.4m telescope (see Figure 1). With observations of the same source at different parallactic angles on the sky, it is possible to reconstruct an image with the full spatial resolution of a 22.8m telescope in all directions. To achieve this, the data needs a minimum quality, which implies well prepared and performed observations. Thus the efficiency of LN is strongly dependent on software to support the operations of the instrument in flexible scheduling of observations and tracking of observation programs.

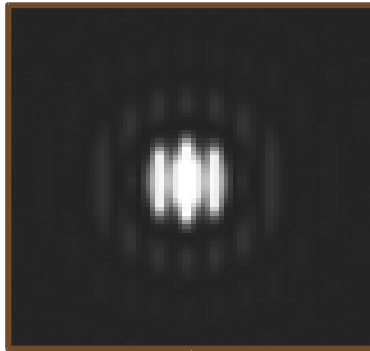


Figure 1. Typical PSF with LINC-NIRVANA for a point like source

6 Functions

In this document we will discuss following issues:

- Observation
- Data logging
- Data hand-over / archiving

- Manpower to operate the instrument

7 Observation

7.1 Purpose

The unique capability of LN is high angular resolution imaging over a wider range of sky. An image with the full spatial resolution in all directions can be obtained with a minimum of three images at parallactic angles each rotated of 60 degrees (see Figure 2). The direction and power of the spatial frequencies are understood best through the MTF in the uv-plane [AD1] (see Figure 3). An observation program (see the definition of OP in chapter 7.4) will be completed satisfactorily when the intended uv-plane is covered and the target signal to noise is reached. Especially for deep extragalactic observations, it might not be possible to get all images necessary within one night, and due to different seeing conditions during one night, it might be necessary to repeat the observations. Thus, it will not be unusual that OP are spread over several nights, or even months, and therefore need sequences which can be repeated temporarily detached (Observation Blocks).

A further issue are the different instrumental modes. There will be various schemes to use the AO system, which will not only be offered during the different implementation phases (see document [2]) but also later.

In this chapter, we lay out a scheme to perform the observations in an efficient and optimized way.

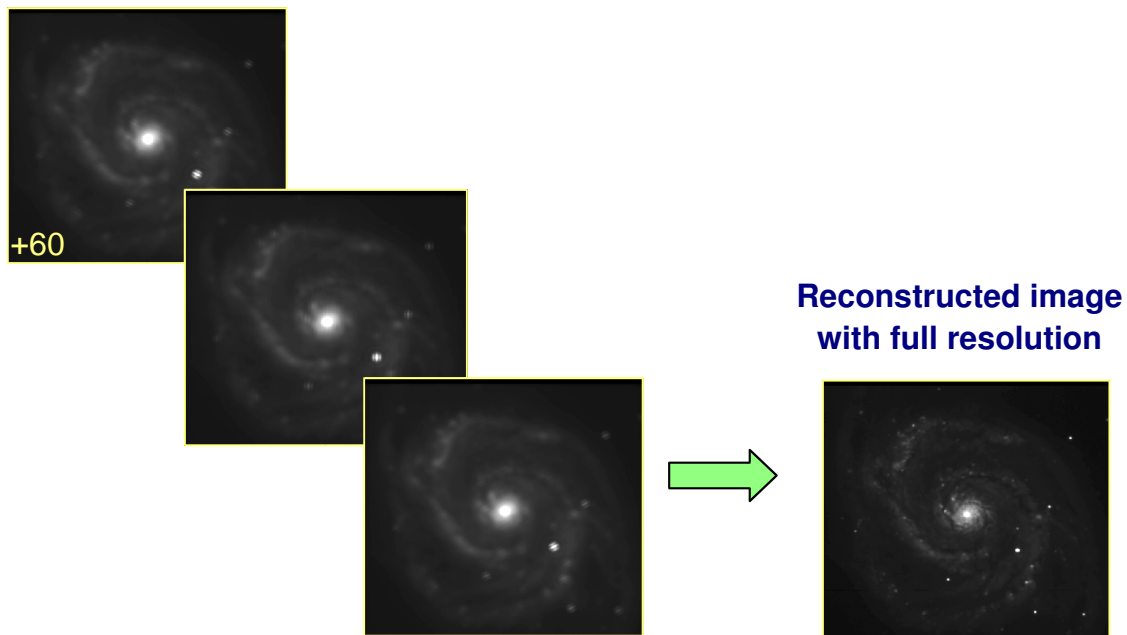


Figure 2. From three images, each with an parallactic angle rotated of 60 degree, one image with the full spatial resolution in all directions can be reconstructed [AD3, AD4].

7.2 Requirements

The requirements are defined by the conditions and constraints on the observation given through the scientific target and atmospheric constraints:

1. The performance strongly depends on atmospheric conditions.
2. The observations at different parallactic angles put strong constraints on scheduling.
3. Observations are done in different observation modes. This requires calibration, adding complexity in scheduling and maintenance procedures.
4. Ability to observe the object at all parallactic angles
5. The complexity of the instrument implies well trained specialist for observation
6. To reduce travel costs, pooling of observation programs with one observer group is of advantage

7.3 Layout

The requirements on the observation argues for queue observation with a large pool of observation programs balanced to the atmospheric conditions and availability of the targets. Thus, a typical observation cycle will look like the following:

1. Proposal preparation (some targets might already be ruled out because they can't be

observed to the extent that is desired – to low declination)

2. Proposal submission
3. Scientific evaluation and ranking of the proposal, taking in to account the shares for each partner
4. Observation preparation
 1. Final target selection
 2. performance evaluation -> constraints
 3. observation schedule evaluation (single proposal) -> constraints
 4. final definition on range of the observational constraints
5. Submission of OP to repository
6. Pre-scheduling for next observation run with all accepted proposals depending on priority and completion
7. Pre-scheduling of night depending on atmospheric conditions, priority and completion of available programs
8. Execution of Observation Blocks defined for the next time slot.
9. Exposures
10. Data evaluation on-line
11. Continuing at 7. until night is over
12. Data evaluation off-line
13. Continuing from 6. until program is finished and data accepted

Tasks 1-5 are done by the observing astronomer at his home institute.

Tasks 6-11 are done by the LN team astronomer at the LBT, might be assisted by the observing astronomer if he is at the site.

Task 12 is done by the observing astronomer either at LBT if he is at the site or at home.

7.4 Specifications

Observation Program

An observation program (OP) consists of all observations to be done to accomplish the target of the initial proposal. The OP can have several targets which will be observed at different angles and with different filters. The observation program will consist of several temporally detached

observation blocks, sequences which are repeated at different time.

The OP consists of:

- multiple targets
- multiple instrument setups
- multiple exposures
- temporally detached observation blocks

Observation Target Unit

An Observation Target Unit (OTU) contains all information associated with one target. Thus, for each new science target, a separate OTU is defined. There may be several OTU within one OP.

The OTU has:

- a single target
- multiple instrument setups
- multiple exposures
- temporally detached observation blocks

Observation Block

An observation block is a logical sequence of observation procedures belonging to one object which can be executed as one sequence. The block consists of observation procedures and has:

- a single target
- multiple instrument setups
- multiple exposures
- one temporal sequence

Observation Procedure

An observation procedure consists of a script with a sequence of commands and parameters which can be filled (parameter file) and others which are fixed (configuration file). The Observation procedure script is executed by a software called the Observation Executor.

There exist four kinds of observation procedures:

- ACQ - **acquisition procedures** for telescope, AO and FFT.
- OBS – for each observation mode, there is one procedure, minimum.
- CAL – for each observation mode, there is minimum one **calibration procedure** to perform the necessary calibrations to reduce the data in an optimal way later on.
- TEC – **technical procedures** are scripts which will be used in the alignment and the nightly setup phases.

Each OP exists of:

- a script
- a configuration file with fixed basic and default parameters
- a parameter file which is filled by the observer through the OPS.

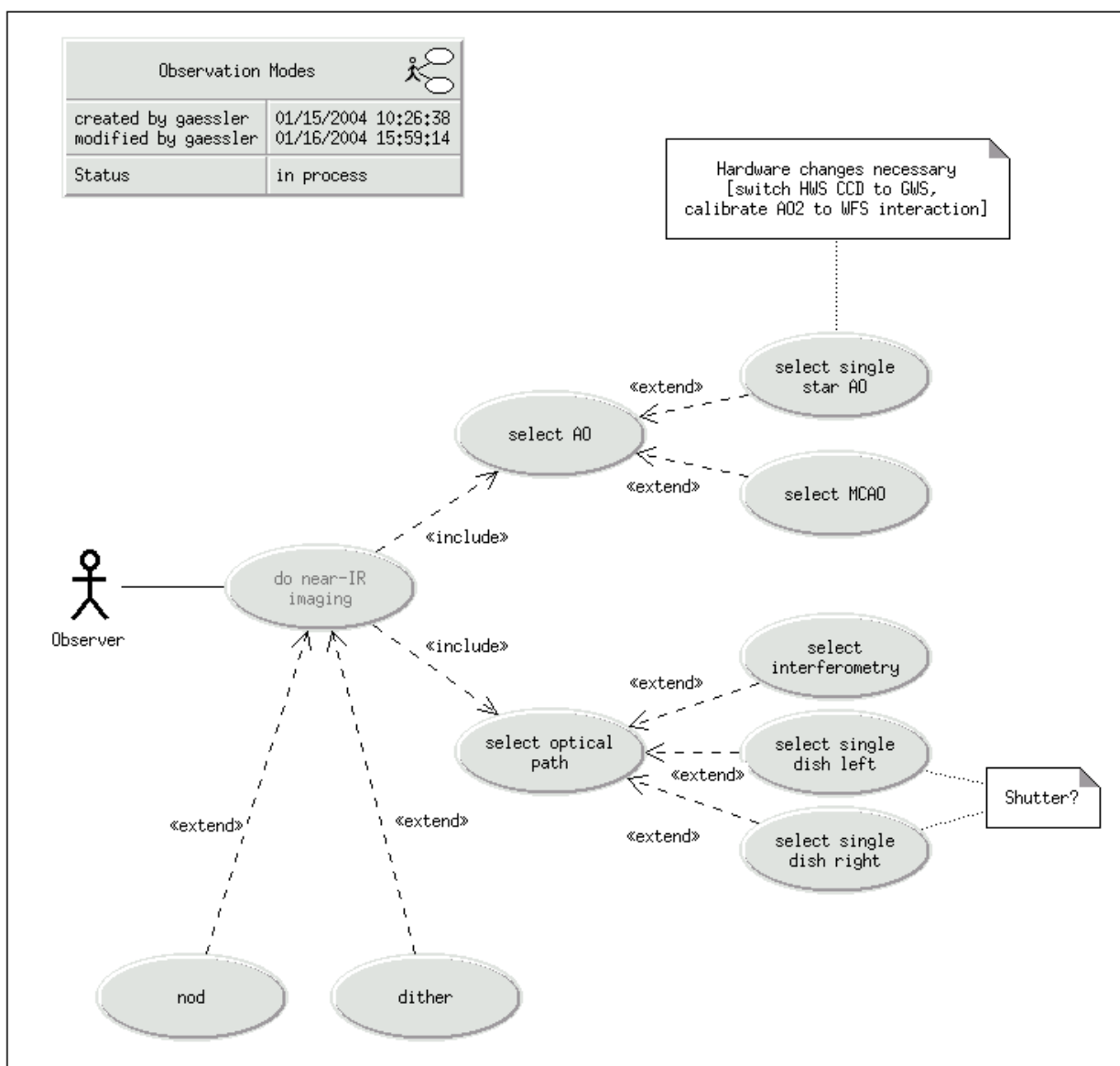


Figure 4. Use case diagram of LN observation modes

Observation Modes

The observation modes describe how the instrument is used. LN is doing only NIR-imaging, but due the instrument layout the interferometric capabilities and the MCAO system can still be used in several different ways.

There are two selection possible for the AO system, single star AO with one DM per arm, or MCAO with two or more DM per arm.

On the other, hand it is also possible to use LN as a single-eye telescope in a non interferometric way. Both sides can be used.

Whatever instrument configuration is chosen, because the images will be sky background dominated, a nodding or dither pattern has to be performed. Nodding and dithering differ only in the fact that with nodding, the AO loops will be kept closed and the pattern is restricted to offsets smaller than 5", while with dithering, the loops will be opened and the offset can be larger than 5".

8 Activity log

8.1 Purpose

The task of operations is not only to execute observations, but also to provide the observation activity logs with parameters characterizing the target and setup of the observation. LBT does not provide a general tool for such matters. Therefore, it is the responsibility of each instrument team to come up with a concept.

8.2 Requirements

A data log should provide the following information:

- image name
- target
- instrument setup (reduced set of parameters)
- observation conditions
- comments

8.3 Layout

Maintaining a record of the observational activity is primarily the responsibility of the observer. However, we will provide scripts which are able to extract out of the FITS header the most important parameters and write it to a activity log file. Some browsing GUI would be useful.

9 Data hand-over/archiving

9.1 Purpose

In this section we discuss the issue of data hand-over and archiving.

9.2 Requirements

The following estimates consider only image data without WFS information and overhead. The worst case with 12 hour of observation, 5 seconds average exposure time and 100 percent instrument efficiency is considered.

- storage space: 72GB per night
- data rate: 14Mbit/s

9.3 Layout

As there is no central archive at LBT, archiving has to be handled individually for each instrument. The external bandwidth from LBT is in a changing situation and it is not sure if a direct data dump is possible in an appropriate time. Therefore, it is planned to have hot swappable hard disks and other media to get the data off the mountain.

At first, the backup is the responsibility of the observer. Mirroring of the hard disks will be provided. The ability to burn DVD or write tapes is provided but is not automatic.

Hard disk space for an observation run will be supported (72GB per night). The disks will be changed by the LN team astronomer when full and taken after the observation run to a his home institute from where the data will be distributed.

9.4 Specifications

- 72GB hot swappable hard disk per night

- Data mirror for backup
- Software to manage data and extract data from disk to distribute
- Data center (optional, but useful)

10 Manpower

10.1 Purpose

LN is a quite complex instrument and will need more people to support the instrument than others, especially in the beginning. However, we will here consider only the final manpower needed to operate the instrument.

10.2 Requirements

- one instrument operator
- one telescope operator
- astronomer
- software engineer on call
- technical engineer (electronics/mechanics/optics) on call

10.3 Layout

The instrument will be run by the instrument operator, which should be a person familiar with the instrument and AO observations. The telescope operator will be responsible for the telescope and its operation. As a lot of the telescope functions are taken over by LN, the telescope operator should be familiar with the instrument.

The support astronomer will be responsible for scheduling and proper execution of the OB and will do the on-line data evaluation to control the data reliability.

A software engineer and a technical engineer familiar with the telescope and instrument should be available on call if problems appear, which cannot be corrected by the operators.