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Stereo SCIDAR User Manual

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2	All After Comm1 in April 2016
3	All After Comm 2 in July 2016
4	After last Comm, and added section “Instructions for scidar operator” (by D. Laidlaw)
5	After autoguider integration December 2017

Contents

Abbreviations

A.D.	Applicable Document
ADC	Analog-to-Digital Conversion
AO	Adaptive Optics
ASM	Astronomical Site Monitor
AT	VLT Auxiliary Telescope
CCD	Charge-Coupled Device
CfAI	Centre for Advanced Instrumentation (of Durham University)
C-SCIDAR	Cute-SCIDAR
DIMM	Differential Image Motion Monitor
E-ELT	European Extremely Large Telescope
EMCCD	Electron Multiplying CCD
ESO	European Southern Observatory
GIS	Gravity-Invariant Station
GLAO	Ground Layer Adaptive Optics
GUI	Graphical User Interface
IAC	Instituto de Astrofísica de Canarias
LPO	La Silla Paranal Observatory
MASS	Multi-Aperture Scintillation Sensor
MLE	Maximum Likely Earthquake
ORM	Observatorio del Roque de los Muchachos
P/N	Part Number
PoE	Power over Ethernet
P-V	Peak-to-Valley

QE	Quantum Efficiency
RMS	Root-Mean-Square
SCIDAR	Scintillation Detection and Ranging
SLODAR	Slope Detection and Ranging
SNR	Signal-to-Noise Ratio
S-SCIDAR	Stereo SCIDAR
TCS	Telescope Control System
TIO	Telescope / Instrument Operator
UROS	Upper Relay Optics Structure
UT	VLT Utility Telescope
VLT	Very Large Telescope
VLTI	VLT Interferometer
WFE	Wave-Front Error
WP	Work Package

1. Scope

This document is the user manual of the Stereo-SCIDAR optical turbulence profiler developed by CfAI for ESO under the auspices of WP 5425 “Site Monitoring Facilities” within the “Control System” Project of the E-ELT Programme. This document is part of the project deliverables, as defined in the Statement of Work (A.D. 1).

The Stereo-SCIDAR instrument will be installed at the Coudé focus of one of the VLTI-AT. Operation of the SCIDAR on the 1.8 m AT telescope will provide profiles of the optical turbulence strength and wind speed with a vertical resolution of approximately 500 m or better, to a maximum altitude of around 20 km. The goal is to obtain data with the system during approximately 6 nights per month for a period of at least 1 full year.

The instrument was developed as a “Fast Track Visitor Instrument” in order to take advantage of the closure of the VLTI for major upgrade during the summer of 2015. During this period, at least one or two of the ATs will not be used for VLTI operations, thus providing an opportunity to operate SCIDAR on an AT. As a “Visitor Instrument”, the SCIDAR will not be operated by ESO. This avoids some of the requirements normally placed on ESO Instrumentation (A.D. 2). Observing time with the SCIDAR on the AT is regarded as technical time and therefore has to be requested through the technical time request for the respective period.

2. Applicable Documents

A.D. 1	ESO-254277	Stereo-SCIDAR Project & Management Plan for Phases C/D, E and F
A.D. 2	VLT-SPE-ESO-10000-2723	Requirements for Scientific Instruments on the VLT Unit Telescopes
A.D. 3	CAD-124500	Stereo SCIDAR Interface Drawing

3. Introduction

This document is an update of the Chapters 9 and 10 of the Design Report ESO-281135.

The User Manual and in particular the operation procedure of the Stereo SCIDAR was updated after the commissioning runs in April, July and November 2016. The user guide was updated after an autoguider was commissioned in December 2017.

4. Instrument interface

The GUI displays the following data to the user via the terminal of the supervisor PC:

- images from the acquisition camera
- images from the two SCIDAR pupil (science) cameras
- the turbulence profile through the night
- some data on the current target and atmospheric conditions
    - target id
    - the time until it sets
    - the time at which it sets
    - the current r0, theta0, tau0 and scintillation index
    - the fraction of turbulence up to 300m, 600m, 900m and 2000m

The instrument is on the VLTI control network it can also be controlled via the command terminal from AT1/2/3/4.

- $ssh -Y scidar@134.171.207.3 (host: scidar; user: jura; pswd: scidar)

4.1 IP addresses

Stereo Scidar WS: IP 134.171.207.3

Stereo Scidar PC: IP 134.171.207.4

4.2 Stereo Scidar GUI

Below are images of the GUI and data displays.

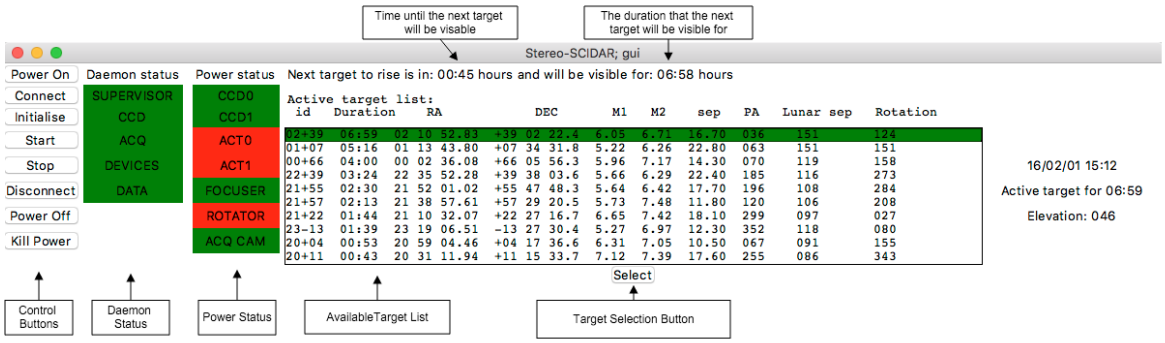


Figure 1. The stereo-SCIDAR GUI.

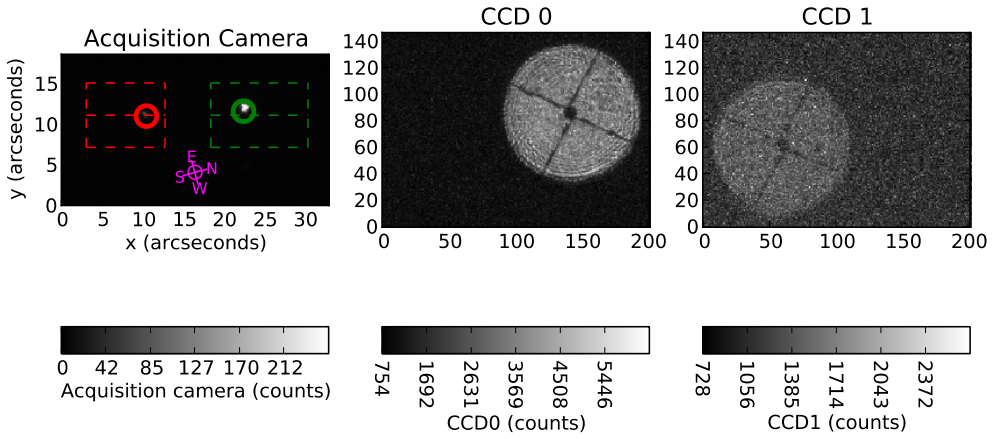


Figure 2. The stereo-SCIDAR camera images. The acquisition camera is on the left. The rotation should be such that the green circle (indicating the brightest star) is on the green (right hand side) of the frame. This is to ensure that the system knows the orientation of the sky. Each of the two pupil images are shown on the centre and right.

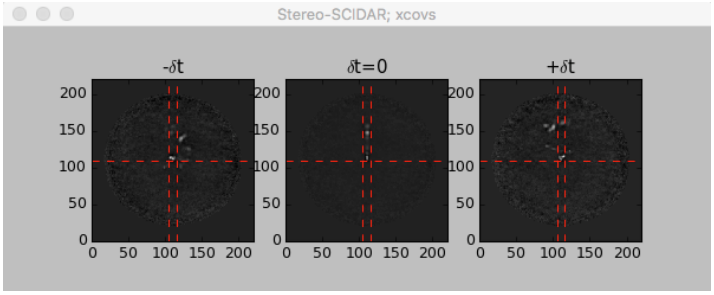


Figure 3. Spatio-temporal cross-covariance function

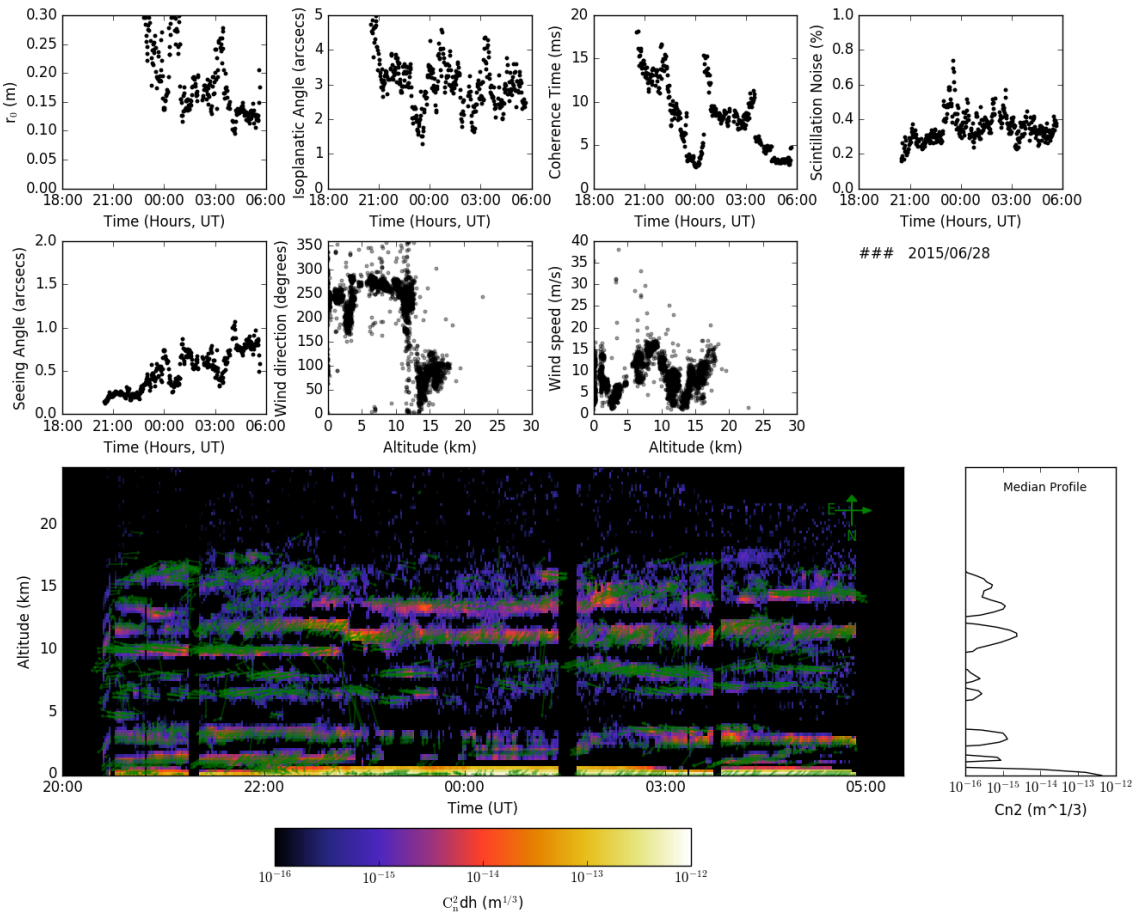


Figure 4. Stereo-SCIDAR real-time display

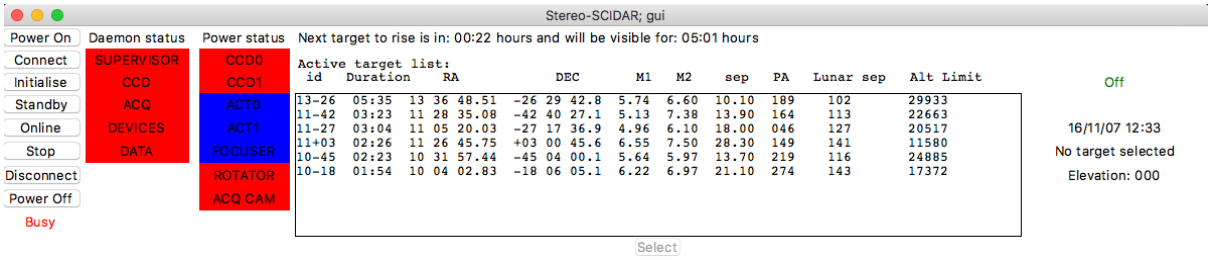
5. User Manual

Operation of the SCIDAR instrument is designed to be as automated as possible. However, as there is no communication between the SCIDAR and the telescope, the telescope operator will be required to point the telescope and enter some basic commands at the supervisor PC to start data acquisition. These commands can be issued from a GUI or via a terminal prompt.

Please read **all** of the following before operating the SCIDAR instrument:

5.1 GUI:

The operation of the SCIDAR is via a GUI. There are several control buttons on the left hand side. The software state indicators and the power state indicators are in the next two columns. The central table displays all the targets which are currently observable, see section 5.6 on notes for target selection. The panel on the right shows the current state of the system. The 'Busy' indicator below the control buttons shows when the system is busy. New commands should only be entered when the system is not 'Busy'.



5.2 Commands:

Notes: After a command 'Busy' will appear under the buttons. Wait for 'Busy' to disappear before proceeding to the next step

1. $ssh -Y scidar@134.171.207.3 (hostname:jura; username:scidar; pswd:scidar)

2. $scidar gui

3. > Power On

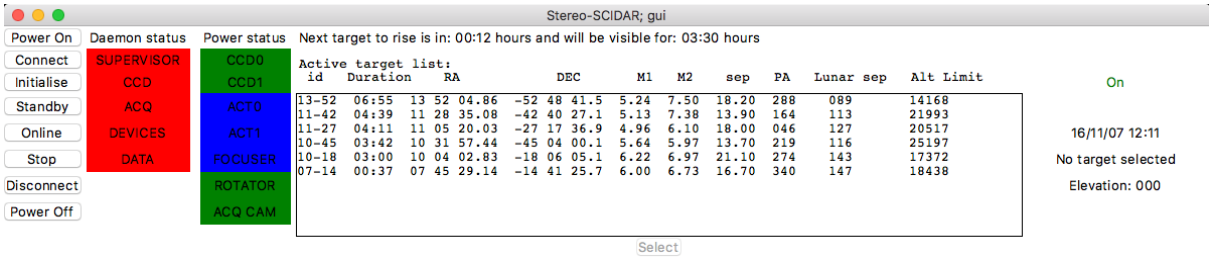
(wait for rotator to datum, ~3.5 minutes)

(ignore ACT0, ACT1, FOCUSER)

CCD0, CCD1, ROTATOR and ACQ CAM will go green

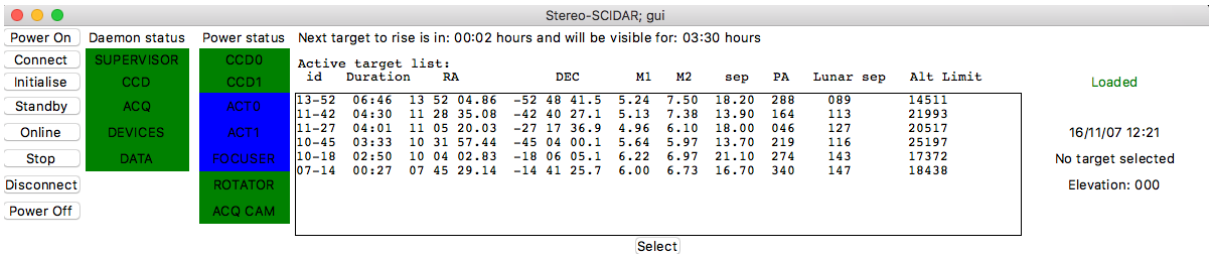
Status changes from 'Off' to 'On'

Wait for 'Busy'



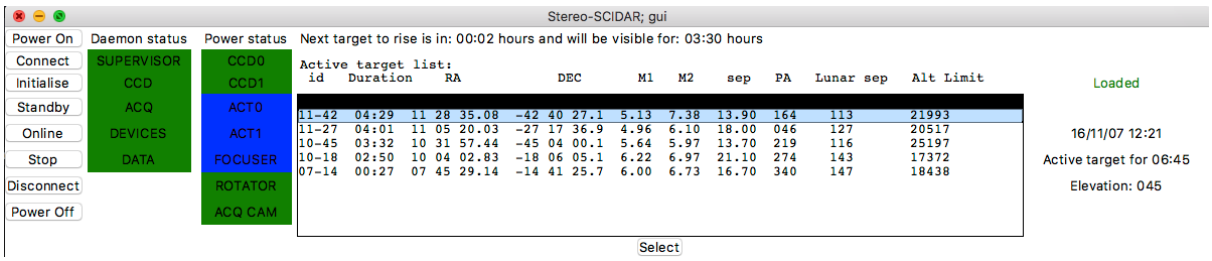
4. > Connect
(wait for software daemons – indicators turn green)

Status changes to 'Loaded'



5. > click on on target
(See notes on target selection)

The 'Duration' column states the time remaining for each target and are ordered with the longest duration at the top.



6. > Select
(SCIDAR will rotate to correct orientation)

Message 'Active target for xx:xx'

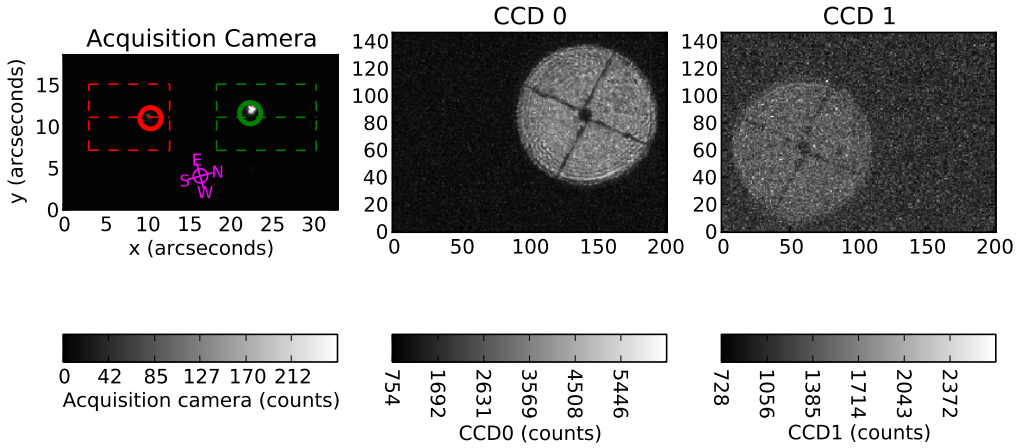
AT Acquisition Procedure:

Once target has been selected, point telescope to target coordinated. When the SCIDAR target has been selected and the status is no longer 'Busy' the rotation will have been set automatically. Now the stars should be approximately aligned with the long axis of the acquisition camera. Some searching may be required to find both stars, offsets of up to 20 arcseconds are often required to find the target and offsets up to 1' have been known. A spiral search procedure with step size of 5" is recommended. Step sizes that are too large and fast risk missing the star altogether. It is recommended to record the offsets for each target on the first night of each run as it is likely that the same targets will be used every night.

The telescope should be positioned such that the stars are in the box denoted by the dashed lines. The red circle in the red box and the green circle in the green box).

At this stage, check the focus on the acquisition camera image. This should be done for each target, and some time more often, especially if the temperature is variable.

Pointing compass is only valid when system is not busy.

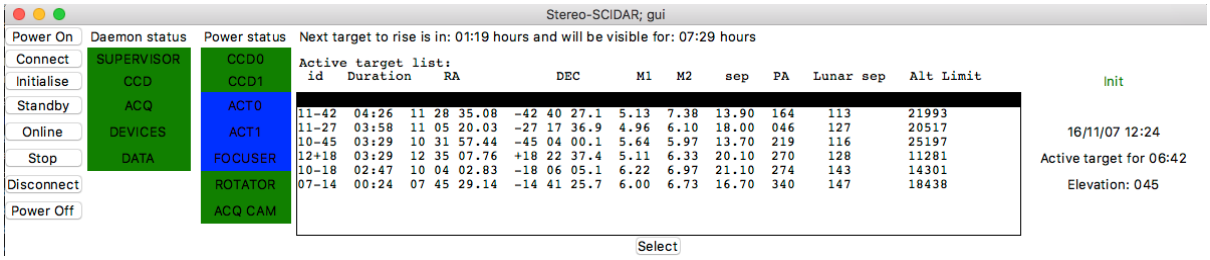


7. > Initialise

(SCIDAR will fix rotation and prime EMCCDs)

Only select ‘initialise’ when in ‘Loaded’ mode

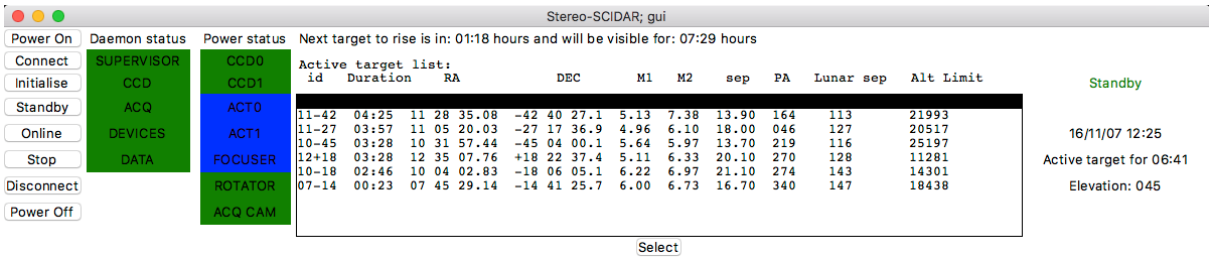
Status to ‘Init'



8. > Standby

(Can be used to pause acquisition)

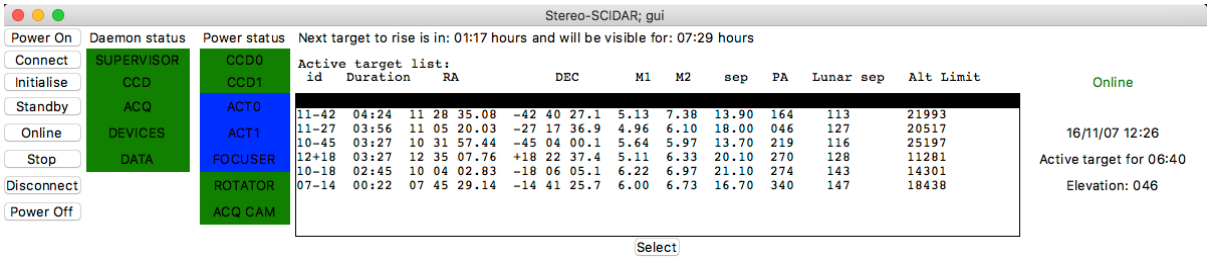
Status to ‘Standby'



9. > Online

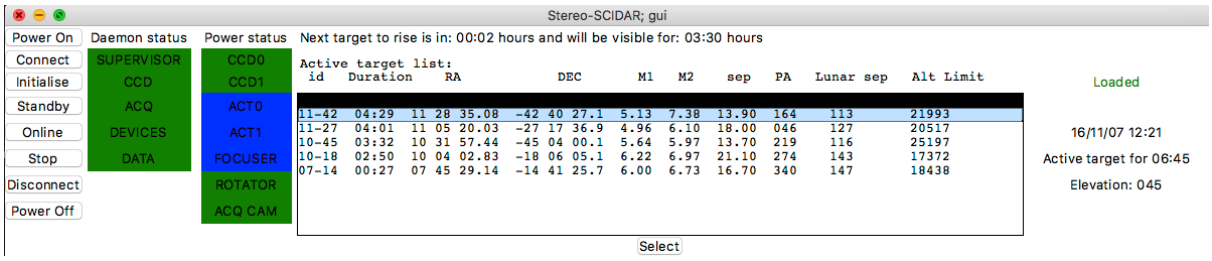
(Data analysis starts, autoguider starts automatically)

Status to ‘Online’ and ‘processing data...'



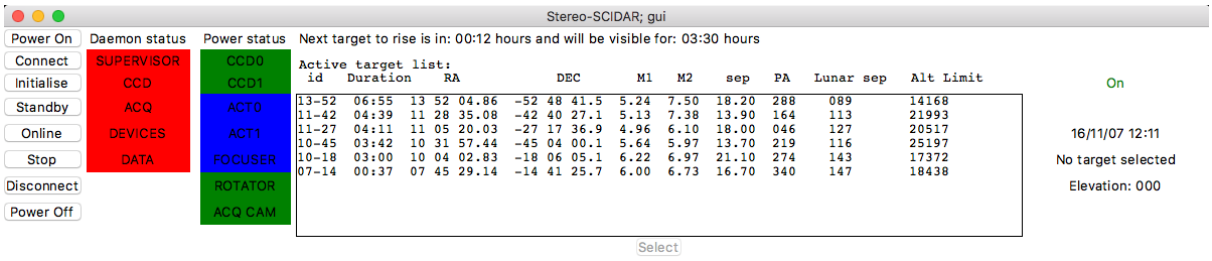
10. > Stop
(Data analysis stops, emccds to standby)

Status to ‘Loaded'



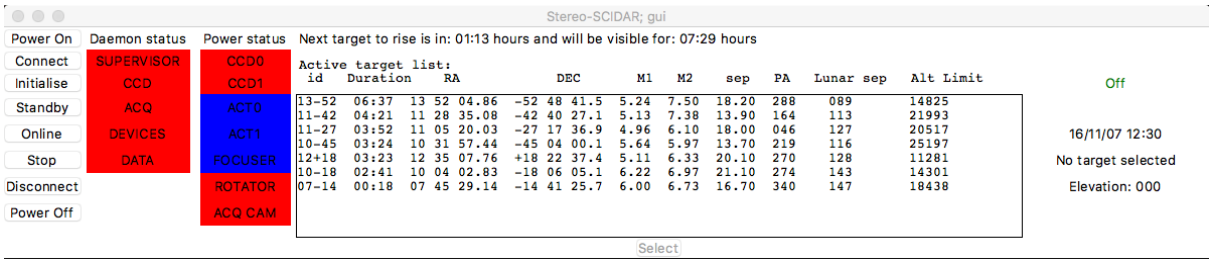
11. > Disconnect
(Daemons disconnected - software shutdown)

Status to ‘On'

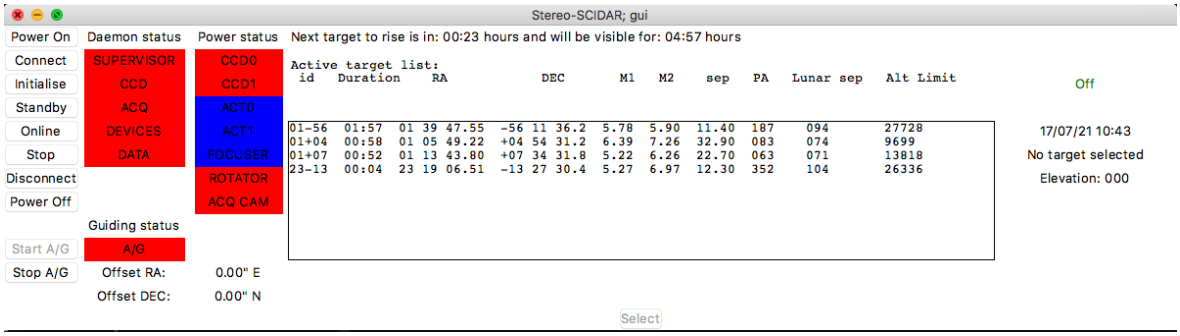


12. > Power Off
(Powered down)

Status to ‘Off'



Other functions:



13. > Start A/G

Start the autoguider (only in ‘Standby’ mode)

14. > Stop A/G

Stop the autoguider (only in ‘Standby’ mode)

15. > Take dark

The AG relies on the acquisition camera to identify the stars. The camera can develop hot pixels. These can be identified as very bright points in the image. Often in the case of hot pixels, the identification circles will highlight the hotpixel and not move. If this happens, make sure the system state is not ‘Online’ and offset the telescope away from any stars and select ‘Take dark’. A prompt will appear in the command terminal and ask you to confirm that no stars are in the acquisition field. If this is the case, press ‘y’, to cancel the dark calibration select ‘n’.

5.3 Autoguider

The autoguider can be used in ‘standby’ or ‘online’ modes. Updates are applied approximately every 15s. A script must be started on the AT TCS for the AG to function.

On at3 workstation:

atoptScidarGuider

When the A/G indicator is green the AG is active and offloading to the telescope, if the AT scripts is running. The offsets are also displayed on the GUI.

5.3.1 AG operational procedure

Standby mode:

The AG can be started or stopped using the ‘Start A/G’ and ‘Stop A/G’ buttons.

Online mode:

The AG will start automatically. To stop the AG select ‘Stop’ button. Note, the ‘Start A/G’ and ‘Stop A/G’ buttons do not work in ‘online’ mode. The AG will always be operational when online and will stop automatically when an error is detected.

Errors:

If an error is detected, the system returns to ‘Standby’ and the AG is stopped. If the error is resolved the system will return to ‘online’ mode and the AG will restart automatically. The only exception to this is if the EMCCDs are over exposed, in which case the gain is set to zero and the system returns to ‘Loaded’ state.

5.4 Operation:

5.4.1 To start:

Follow steps from 1 to 6.

Point telescope such that the red circle is in red box and green circle is in green box, close to centre line and in the middle of boxes, (small rotations will be fixed on initialize).

Follow steps 7 to 9.

Once ‘online’ the system will run unsupervised until the target sets (or the stars are lost due to cloud, bad seeing or wind shake). When the target reaches the SCIDAR altitude limit, it will return to ‘Loaded’ state and stop autoguiding.

5.4.2 To apply manual offsets:

The autoguider will maintain the position of the stars. However, if something goes wrong it is possible to apply offsets manually.

From ‘Online’ select ‘Standby’. The data analysis will pause and the acquisition camera will frame more quickly for easier guiding. Apply offsets manually to telescope.

Select ‘Online’ to restart data processing

5.4.3 To change target:

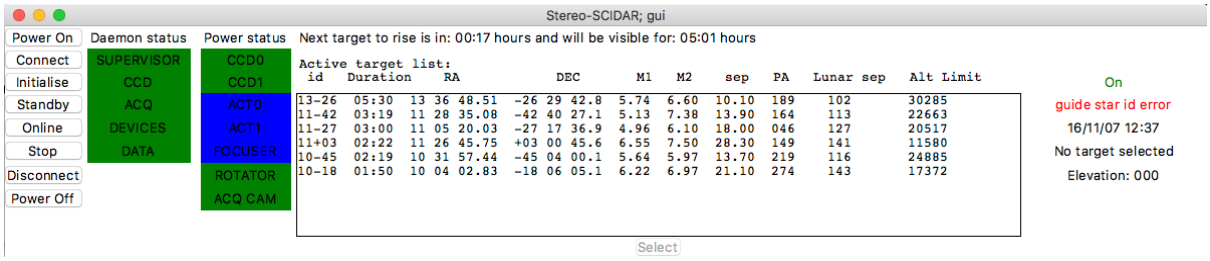
Select ‘Stop’ to change status to ‘Loaded’. Return to step 5.

5.4.4 To Shutdown:

Follow steps 10 to 12.

5.4.5 Errors:

The system checks the data and raises the following errors on the GUI:



The system will recover from errors on its own if possible. For example, if the stars on the acquisition camera are lost due to cloud or bad seeing, then the system will automatically go to ‘standby’ mode. If the stars are re-acquired the system will automatically go ‘online’ and re-start the AG.

5.4.6 Error list:

1. ‘guide star not found’

   The system can not identify the stars on the acquisition camera,

   Move telescope to put stars in field (spiral search may be required)

   if they are faint try a brighter target

2. ‘EMCCD flux error’

   The counts on the ccd is too high (saturating) or too low.

   Try re-initialising or a different target

3. ‘rotation error’

   The rotation of the stars is out of range

   Try re-initialising or a different target

4. ‘guide star error’

   The stars have left the field of view of the science cameras (shown by the red and green boxes on the acquisition camera.

   Offset telescope to put stars in box and then select ‘Online’

5. ‘guide star below altitude limit: Change target now!’

The target has reached the SCIDAR minimum elevation. The system will go to ‘Loaded’ state. Change target and re-initialise.

6. Data analysis states ‘no data…’ in terminal but GUI says processing data

The data pipeline has discovered an error, probably that the stars are too faint to process or they have moved too far and a new region of interest is required – re-initialise should fix this.

5.5 Notes / known features:

1. Operate only in clear conditions

2. For display issues, live profile not updating

```
$ ssh -Y scidar@134.171.207.3          ## new terminal prompt
$ scidar stopdisplays
$ scidar startdisplays
```

3. Occasionally some targets are incorrect in the catalogue (don't exist, wrong separation, no companion) - double check and make a note, we can edit the target catalogue. Remember that offsets of up to 1' can be expected.

4. Data analysis states 'no data…' in terminal but GUI says processing data
   The data pipeline has discovered an error, probably that the stars are too faint to process or they have moved too far since initialisation and a new region of interest is required – re-initialise should fix this.

5.6 Target selection:

The targets are listed in order of duration visible.

The optimal target is visible for the longest duration [Duration column], the Alt Limit should be above 20000 m and the targets should be as bright as possible. The target should be changed when the altitude limit reaches 20000m, or the target sets (horizon set to 45degrees). Targets with a profiling altitude above 20km are shown in the target selection panel.

The system has been tested with targets down to M=8.0, however, faint targets (M>6.75) should be avoided at low elevation (<60degrees), in non-photometric nights and in bad seeing. In this case select brighter targets from the list, if possible.

5.7 Command Line; Advanced commands

These commands are reserved for advanced users and should not be used by a general operator.

5.7.1 Software daemons

scidar startd [kwrds: ccd, pit, acq, data]

Start the specified daemon

scidar stopd kwrds: [ccd, pit, acq, data]

Stop the specified daemon

scidar pingd [kwrds: ccd, pit, acq, data]

Ping the specified daemon

scidar killd [kwrds: ccd, pit, acq, data]

Kill the specified daemon, if not responding

scidar ping_all

Ping all of the daemons

5.7.2 EMCCD commands

scidar autogain

Run automatic gain function for SCIDAR EMCCD cameras

scidar autoroi

Run automatic region of interest function for SCIDAR EMCCD cameras

scidar setexp [kwrds: x]

Manually set exposure of SCIDAR EMCCD cameras to x

scidar setroi [kwrds: xbin, ybin, xLo, xHi, yLo, yHi]

Manually set region of interest of SCIDAR EMCCD cameras

scidar setgain [kwrds: gain0 gain1]

Manually set the EMgain of the SCIDAR EMCCD cameras to gain0 and gain1. If only one value is entered both cameras are set to the same gain

scidar setpacketsize [kwrds: x]

Set packet size for data reduction to x frames per dataset

scidar savefits [kwrds: yes/no]

Save fits / stop saving fits files of the SCIDAR EMCCD cameras to disk

scidar setobjname [kwrds: x]

Manually set object name to ‘x’

scidar setconjalt [kwrds: x]

manually set conjugate altitude of analysis to x. Note that this does not move the cameras.

scidar setfilesuffix [kwrds: x]

Set file suffix of fits files to x

5.7.3 Acquisition camera commands

scidar acq_setexp [kwrds: x]

Set acquisition camera exposure time to x

scidar acq_getexp

Get acquisition camera exposure time

scidar acq_autoexp

Automatically optimise acquisition camera exposure time

scidar acq_setgain [kwrds: x]

Set acquisition camera gain to x

scidar acq_getgain

Get acquisition camera gain

scidar acq_getfrate

Get acquisition camera frame rate

scidar calibrateAcq

Calibrate the acquisition camera by taking a dark frame

5.7.3.1 Power commands

scidar powerquery

Query status of power for all devices

scidar power [kwrds: act0, act1, acq, ccd0, ccd1, foc, pitpc, rot] [on, off, status]

Manually change status of power of individual device

5.7.4 Display commands

scidar startdisplays

Start SCIDAR data displays

scidar stopdisplays

Stop SCIDAR data displays

5.7.5 Actuator commands

scidar startact

Start actuator control, must be done before they can be contolled

scidar stopact

Stop actuator control

scidar setactpos [kwrds: act0x act1x]

Set actuator position, if only one argument given sets both actuators to the same value.

scidar getactpos

Get current position of actuators

scidar datumact

Datum actuators

scidar autoconj

Automatically find conjugate position of pupil image and move the SCIDAR cameras to this position

5.7.6 Rotator commands

scidar startrot

Start rotator control, must be done before they can be contolled

scidar stoprot

Stop rotator control

scidar setrotpos [kwrds: x]

Set rotator position

scidar getrotpos

Get rotator position

scidar datumrot

Datum rotator

scidar autorot

Automatically rotate instrument from acquisition camera images

scidar trackrot [kwrds: yes/no]

If yes the rotation will be tracked with the sky – this will update at a rate defined in the parameter file.

5.7.7 Focuser commands

scidar startfoc

Start focus control, must be done before they can be contolled

scidar stopfoc

Stop focus control

scidar setfocpos [kwrds: x]

Set position of focuser

scidar getfocpos

Get position of focuser

scidar datumfoc

Datum focuser

scidar autofoc

Automatically focus the instrument

5.7.8 Common devices

scidar startdevices

Start all SCIDAR devices (actuators, rotator, focusser)

scidar stopdevices

Stop all SCIDAR devices (actuators, rotator, focusser)

5.7.9 GUI

scidar gui

Start SCIDAR gui

5.8 Instructions for scidar operator ("visitor mode")

Before the scidar run

- The main scidar responsible in Paranal is X. Haubois (Sciops / VLTI). He is also in charge of scheduling the relocation of the AT to the scidar pit for the period. The VLTI astronomer on the mountain (vlti@eso.org) makes sure that the relocation happens on the day of the observation (or earlier). The Day Shift Coordinator on the mountain (sciops-dsc@eso.org) makes sure that a TiO is affected. Since the scidar operations involve several groups in Paranal, the people to keep informed are:

  X. Haubois (xhaubois@eso.org), S. Brillant (sbrillan@eso.org), M. Boccas (mboccas@eso.org).

  In addition, one should keep scidar experts in Europe aware of what happens to the scidar, so that help can be obtained (on short notice) if needed: M. Sarazin (msarazin@eso.org), F. Derie (fderie@eso.org), M. Le Louarn (lelouarn@eso.org), J. Osborn (james.osborn@durham.ac.uk).

  And because of the turno system, additional people to keep informed are sciops-dsc@eso.org and par-vltimanagers@eso.org

A few days before leaving for Paranal, make yourself known by email, and make sure the people above are aware of your imminent arrival. Some tests (like the ping – see below), could be made a few days earlier, just to have a bit more time to debug potential problems.

Also, it is very usefull, when preparing your trip to Chile, to ask parlogs to get a car, when you arrive to Paranal.

Upon Arrival

- Get a radio from reception.
- Make yourself known to the COE (par-coe@eso.org), Shift Coordinator (sciops-dsc@eso.org) and the VLTi manager (par-vltimanagers@eso.org).
- Make sure that there is a plan to move an AT to the pit where SCIDAR is located (should be, in principle, E0 in P99, could also be G2 the maintenance pit). The responsibility of the AT movement is with PME (Mechanics, par-mech@eso.org). If possible, be on the platform for the AT movement, to check that the scidar is operational (see below).
- Make sure there is a TiO assigned for the Scidar nights.

Testing Instrument (done by VLTI-manager or operator)

- From a VLTI console, login to the SCIDAR workstation (
  $ssh –Y scidar@134.171.207.3
  Password: scidar
- Ping the instrument
  $ping 134.171.207.4
  IF there is no ping:

1. Check that there is power to the pit/instrument. In principle, the power should be left on at all times, but still a check is good to be sure. For some pits it is possible to access the SCIDAR through a VLTi tunnel (e.g. G2 the maintenance pit). If the pit and the instrument have power you should see a red light from the power box, a green light from the PC and an orange light from the network switch. Make sure that SCIDAR's female power inlet is plugged into the pit when moving the instrument - it is possible to forget this step. [Picture to be added]
2. Check with the networking team that everything is OK.
3. If above conditions are met and you still cannot talk with SCIDAR, the most likely explanation is that cabling has come loose or that the PC is in safe mode due to improper start-ups/shutdowns. Both scenarios require lifting the ROS (see section *Moving the AT*).
4. After SCIDAR has been lifted, check cabling and then try to ping the instrument again. **DO NOT** switch power off/on - this is an improper shutdown/start-up of the PC.
5. If the above step fails, monitor the lights from the Ethernet ports of the PC. If activity only shows a flash every couple of seconds it can be assumed that the PC is in safe mode. To exit, plug a keyboard into the PC and hit enter. The lights from the PC's Ethernet ports should temporally turn off before coming back on with increased activity. Try to ping the instrument again.
6. Plug a monitor to the PC, to see if more can be learned on the state of it (safe mode, error messages…). An DVI/HDMI adapter is available to use a standard monitor on the PC.
7. If it is still not possible to talk to the instrument, there is a spare PC in the maintenance station (see pictures below). Try replacing the PC – this may require someone from IT to help set-up. Note that this is a last resort and all other possibilities should be thoroughly explored first.
8. Stay in contact with the scidar team in Europe, they may be able to help.

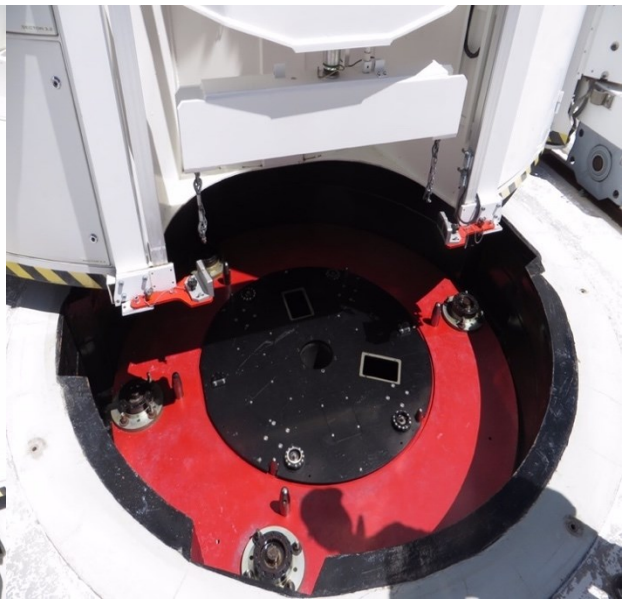
9. An almost fail safe solution for scidar would be to use the G2 pit – a VLTI maintenance station, since at that location, one has continuous access to the scidar via a tunnel. This is however not the standard procedure, because G2 is also used by other projects, and using it involves precious time to

relocate the scidar back and forth (because it is stored in E0, and cannot be continuously stored in G2).

- Start the SCIDAR gui :
  $ **scidar gui**
- If you can bring up the gui then SCIDAR should be ready to go!
- The scidar then initializes, and all columns should become green – note that this takes a while.

Moving the AT (done by PME)

- When the AT is ready to be put on top of SCIDAR, remove the lid as well as the plastic cover from the ROS. Store the plastic cover within the AT.
- If required, the AT may now lift the ROS. When SCIDAR is above-ground make sure that all cables are taped away from the rotator. As SCIDAR is lowered back into the pit, ping the instrument at all stages to make sure that everything is OK.
- The AT will not be able to complete its last stage of attachment (clamping to the top of the ROS) if SCIDAR is not in the correct orientation. When in the pit, make sure that SCIDAR appears as below:



- If the instrument is working (see section *Testing Instrument*) the AT may be placed on top of the pit.
- You are now ready to observe!
- After the run – when the AT is removed – don't forget to return SCIDAR's plastic cover. This is done by PME (person moving the AT), the plastic cover is stored inside the AT. The power plug of the instrument is left on, no need to touch the instrument.

6. Instrument Control Software Architecture

The software package is built around four software daemons that run in the background. These daemons initiate, monitor and control all of the instrument devices and processes:

- ccd_daemon > (CCD) to control the two Andor Luca EMCCD cameras
- acq_daemon > (ACQ) to control the PointGrey Blackfly acquisition camera
- pit_daemon > (PIT) to control the rotator, focuser and actuator mechanisms
- data_daemon > (DATA) processes the SCIDAR raw data into turbulence profiles
- supervisor_daemon > (SUPERVISOR) supervises the whole system

The **supervisor daemon** runs on the supervisor PC in the telescope control room. This script monitors the status of the system as a whole, gathering data returned from the daemons. All information to the control daemons is passed through the supervisor script with the exception of the raw data images which pass directly from the ccd_daemon to the data_daemon.

In addition, there are three other major scripts:

- scidar_api > (SCIDAR API) used to control the instrument
- scidar_reduce > (DATA REDUCTION) functions for the data analysis
- targets > (TARGET LIST) calculates visible targets

Figure 5 is a diagram of the software architecture.

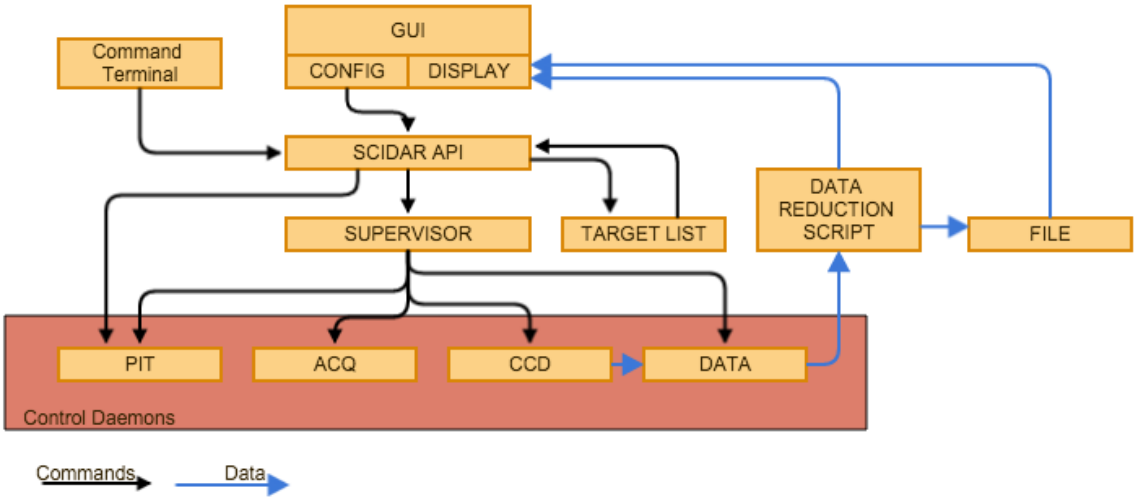


Figure 5. Software architecture diagram.

A SCIDAR API script allows the user to control the SCIDAR system via a small number of commands, entered at the command line of the supervisor PC. These commands, e.g. to start or stop data acquisition, are checked and then passed on to the relevant daemon.

The software is designed for the instrument to be as automated as possible and therefore includes the following utilities:

- Automatic rotation

    - The field rotation will be optimised automatically using images from the acquisition camera. The rotation will be monitored during the observations by the supervisor and data acquisition will be halted while rotation corrections are applied.
- Automatic focus
    - The focus will be estimated by fitting a Gaussian to the intensity distribution of the brightest star in the acquisition camera image. The focuser will be set at a range of positions and the FWHM of the fitted Gaussian recorded for each. The minimum of a quadratic fit to the set of FWHM values versus focus position will be calculated to estimate the optimum focus. As the focus is not expected to change significantly during data acquisition, this process will only be utilised when a new target is selected.
- Automatic pupil conjugation
    - The pupil conjugation position is found by moving the actuators, and hence the SCIDAR cameras in the conjugate volume. Away from the telescope pupil the images will have diffraction rings at the outer edge of the image. Therefore, we use the spatial variance of the outer region of the pupil image to determine the distance from pupil. A Gaussian function will be fitted to the set of values of variance versus actuator position, in order to find the actuator position of minimum diffraction - this will define the actuator position of the pupil. This process will be required at startup at the beginning of night, at most, and may be required only as a calibration when initiating the instrument after it has been moved.
- Automatic region of interest
    - To maximise the frame rate of the science cameras, and minimise the data transferred over the network between the local control PC (with the cameras) and the supervisor pc (where the data will be processed) the SCIDAR cameras will be windowed tightly around the pupil image rather than processing the full frames. This is done by correlating the image with a theoretical pupil and clipping around the maximum correlation position. This is done independently for each camera.
- Automatic gain of SCIDAR ccd
    - The SCIDAR EMCCD cameras will be fixed to an exposure time of 1 or 2 ms. This exposure time is set by the scientific requirements. Therefore, in order to optimise the signal to noise ratio of the pupil images we can only optimise the EM gain of the cameras. The EM is set to zero and increased until the images saturate. A linear fit is then used to calculate the gain curve and the optimal gain for each camera (not necessarily the same) is chosen and applied. The gain will be monitored by the supervisor and adjusted if necessary.
- Automatic exposure of acquisition camera
    - The exposure time of the acquisition camera is increased in logarithmic steps and a linear fit is used to approximate the response of the camera. The exposure time is then set to the optimum value to allow for maximum signal to noise without saturation. The flux of the acquisition camera is monitored by the supervisor and re-calibration is performed as required during observation.

The **directory structure** of the supervisor PC is as follows:

- Software scripts

- ‘/home/scidar/scripts/’
- Source files
  - ‘/home/scidar/src/’
- Data files
  - ‘/home/scidar/data/YYMMDD/
- Log files
  - ‘home/scidar/logs/’

System Parameters: A parameter file (params.py) is used to store the parameters for the system. The parameter file is commented. These parameters are fixed for this system and should not be altered, except by an advanced user under direction from a contact from Durham University. The parameter file is located in the scripts directory on the supervisor PC.

7. Data Archive

Real-time data reduction: The data reduction pipeline runs on the supervisor PC. It processes the images from science cameras in real time to yield the optical turbulence strength and wind velocity profiles, as well as derived atmospheric parameters such as the isoplanatic angle and the coherence time-scale. The data reduction pipeline is identical to that used by existing stereo-SCIDAR instruments and details can be found in the paper: Shepherd et al. MNRAS 437(4) 3568-3577, 2013.

Each profile is saved in an individual ASCII file with the filename format specifying the date and time of the observation: YYYY-MM-DD_HHhMMmSSs_profile.txt. At the top of each profile file is a header displaying key information:

### FILENAME	YYYY-MM-DD_HHhMMmSSs	- the name of the file
### DATADURATION	xxx.x	- duration of the data acquisition
### INSTRUMENT	scidar	- name of the instrument
### TELESCOPE	XXX	- name of the telescope
### RADEC	XX XX XX.xx +/-XX XX XX.xx	- RA DEC of target
### CONJALT	XXXX	- Conjugate altitude of detectors
### NWSLAYERS	X	- Number of turbulent layers detected
### AIRMASS	X.xxx	- Airmass
### DOME	XXXX	- Turbulence strength in the dome
### FIELDS	altitude, Cn2dh, layer_wind_speed, direction	- Data fields
### UNITS	m, m^(1/3), m/s, deg	- Data units
### END		

After the header the profile is presented in four columns of altitude, turbulence strength, wind speed and direction. Each row displays the parameters for a specific altitude.

At the end of each night a summary file is generated which lists the Freid's parameter (r_0), seeing angle, coherence timescale (τ_0), isoplanatic angle (θ_0) and a photometric scintillation noise parameter for each profile.

It is also possible to save fits files of the raw images from the EMCCD cameras and the cross-covariance functions, by selecting options at the SCIDAR supervisor PC terminal. The system does not save images or cross correlations by default.

7.1 Hardware Control Test Script

A script has been generated to test the software and the mechanical control. To run this script, in a terminal type:

python scidar_test.py

The script will attempt to:

- Power on all devices
- Start each of the software daemons
- Test the communications between the two instrument computers, the devices and the software daemons.
- Datum each device and move the full range of motion
- Park the devices in nominal positions
- Shutdown the software daemons
- Power off the devices

The script will log all of the tests and report to the console of any failures. In case of failure, in the first instance try re-running the script as it is possible that some of the devices were in an error state on initiation. This is possible if they were not shut down correctly, if *scidar killpower* is used for example. The next option is to inform the contact at Durham University of the error messages and seek advice.

8. Earthquake Inspection

In case of earthquake event a basic inspection of the Stereo Scidar shall be requested.

The Stereo Scidar being not accessible in the E0 AT pit, a visual inspection of the hardware is not possible.

For inspection run the script described in 7.1.

To run this script, in a terminal type:

python scidar_test.py

Report possible failure and agree with SCIDAR responsible on recovery action if necessary.

9. Stereo-SCIDAR OPERATION SCRIPT

9.1 Operation Procedure

9.1.1 Observation Request

- ⇨ Issue TTR for a number of night in a TBD Period
- ⇨ Wait for Paranal Director's Approval
- ⇨ Plan the observation runs (responsible, trips, …)

9.1.2 Relocation AT and Status test before Observation runs

- ⇨ Day zero-15, Issue ticket for AT movement to E0 (responsible to PARMEC)
- ⇨ Day zero-1, PARMEC move AT to E0, connect the SCIDAR and make After Relocation of the AT. Report Problem
- ⇨ Day zero-1, SCIDAR Responsible make a check of the SCIDAR status (python scidar_test.py)
- ⇨ Report and apply recovery action if needed

9.1.3 Observations Day n (n=0 to x nights),

- ⇨ Beginning of the night, after authorisation to open AT, prepare for the observations
  - AT start-up (Day to Obs script, see picture of the configuration)
  - SCIDAR GUI (steps 1-4)
  - Report and correct problems
- ⇨ Observations
  - SCIDAR GUI (steps 5-10)
  - Select target on SCIDAR panel
  - Preset AT on target on AT panel
  - Acquire profile
  - Apply preset offset on AT panel
  - Change target and acquire profiles as above steps above
  - Repeat observation as above
- ⇨ End of the night, after authorisation to close AT and SCIDAR
  - AT Shutdown (Obs to Day script, see picture of the configuration)
  - SCIDAR GUI (steps 11-12)

- Report and correct problems
- Archive profiles recorded and stored on Scidar machine

9.1.4 Relocation AT and Status test after Observation runs

- ⇨ Day zero-15, Issue ticket for AT movement from E0 (responsible to PARMEC)
- ⇨ Day n+1, PARMEC move AT from E0, and make After Relocation of the AT on new station. Cover the SCIDAR with plastic bag in E0. Report Problem
- ⇨ Day n+1, SCIDAR Responsible check of the SCIDAR status (python scidar_test.py)
- ⇨ Report and apply recovery action if needed

9.2 Operation Script Summary

Please read **all** of the following before operating the SCIDAR instrument:

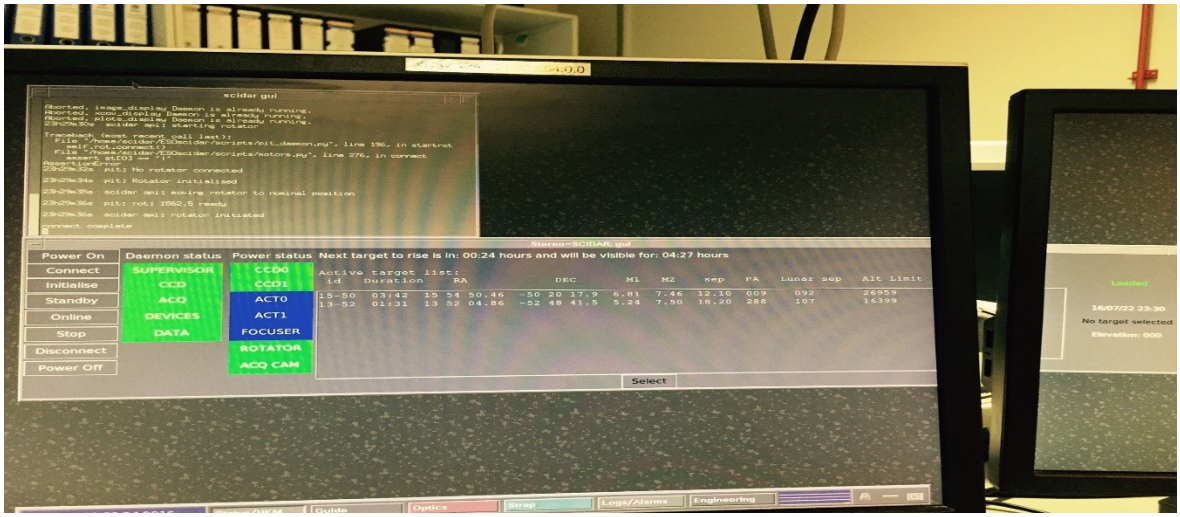
1. Open telescope as per Day to OBS script

2. Connect to Scidar Workstation

   $ssh -Y scidar@134.171.207.3 (scidar; jura; scidar)
   Password: scidar

3. Open GUI

   $scidar gui



4. > Power On
(wait for rotator to datum)

(ignore ACT0, ACT1, FOCUSER)

log: 'power on complete'

Status changes from 'Off' to 'On'

5. > Connect
(wait for software daemons)

log: 'connect complete'

Status changes to 'Loaded'

6. > click on on target
(See notes on target selection)

7. > Select
(SCIDAR will rotate to correct orientation)

Message 'Active target for xx:xx'

- Preset AT on Target coordinates, make snoopy search, acquire target on ACQ CAM.

8. > Initialise
(SCIDAR will fix rotation and prime EMCCDs)

log: 'init complete'

Status to 'Init'

9. > Standby
(Can be used to pause acquisition for offsets)

(Pauses data pipeline)

- OFFSET AT to centre target on ACQ CAM.

(Move stars back into centre of boxes)

log('paused')

Status to 'Standby'

10. > Online
(Data analysis starts)

Status to 'Online' and 'processing data...'

11. > Stop
(Data analysis stops, emccds to standby)

Status to 'Loaded'

12. > Disconnect
(Daemons disconnected - software shutdown)

Status to 'On'

16. > Power Off
(Powered down)

Status to 'Off'

- Close AT as per OBS to DAY script

10. AT setup instruction (courtesy C. Cid)

The following modules must be in SIMULATION, ONLINE and UNIGNORED:

AT STATUS:

- M6 / XY Table / Probe / CFD / FSS / NDF
- The CCD can be just IGNORED and in LOADED.
- The rest ONLINE as usual

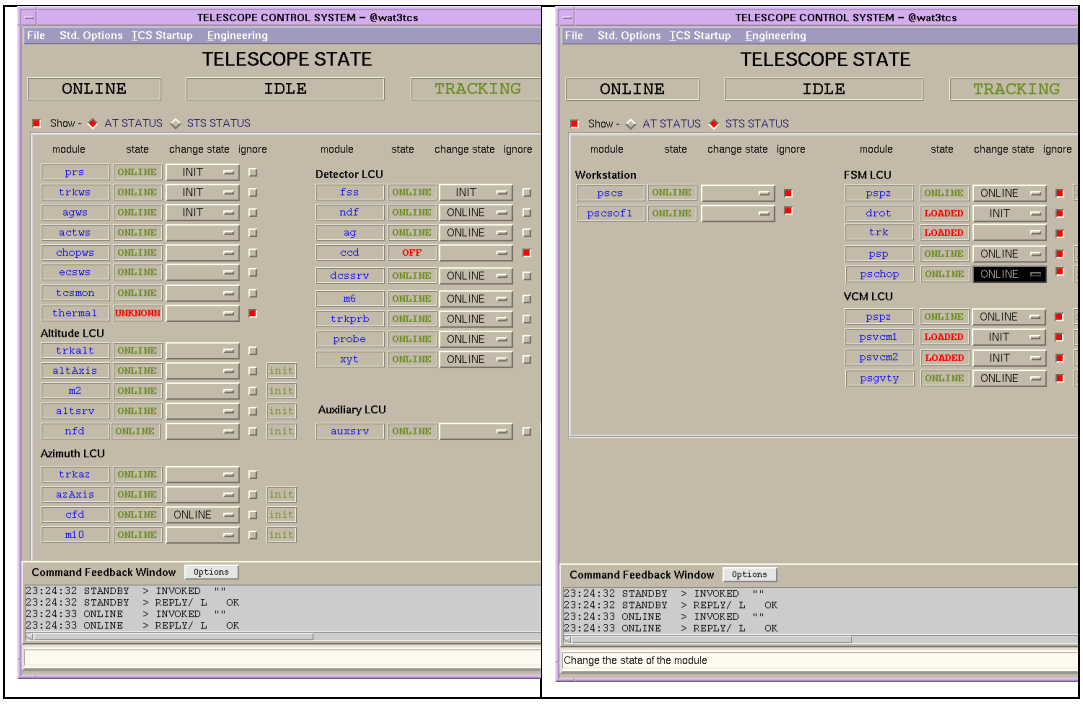
STS STATUS:

- FSM and VCM should be in SIMULATION.

- All modules of STS can be ignored.

Issues:

- Initializing the FSS in Simulation takes many tries. Patience.
- The PRESET will complain if some module is not ignored (especially from the dcs) and the logMonitor will guide you into figuring out how the preset is trying to communicate.
- I have had problems when some of the ignored modules of the FSM and VCM are ignored and LOADED. For this I am leaving the following configuration in the STS STATUS:



The PRESET is done from the Main TCS Panel, I have tried with “Transparent” and with “Preset”. Transparent doesn’t work it remains presetting forever and ends up failing with a prsAction error. With PRESET I have not had any issues, nor does SCIDAR have to spiral search too much for its stars. The E0 pointing model must be installed from the atpomgui, interface.

11. AT setup Electronics (courtesy L. Caniguante)

ROS SHUTTER SIMULATION.

I implemented a small box with a switch at the bottom of the Signal Cabinet to simulate the status. See picture:

- (MEC) Normal AT3 operations and relocations: Position of the switch must be **NOT SIM**.
- (MEC) Before to start an AT3 relocation from any station to SCIDAR station (E0): Position of the switch must be **CLOSED**.
- (MEC) Before to start an AT3 relocation from SCIDAR station (E0) to any other station: Position of the switch must be **CLOSED**.
- (VLTIM) AT3 in SCIDAR station (E0) during the day: Position of the switch must be **CLOSED**.
- (VLTIM) AT3 in SCIDAR station (E0) before the start up and during the night operation: Position of the switch must be **OPEN**.

AFTER RELOCATION SCRIPT IN SCIDAR STATION (E0).

- (MEC) There will be no ROS so any ROS component will produce errors during the run of the script. Skip and continue the script at the moment of those errors.
- I will add more details of those errors when I am present during some run.

DAILY OPERATIONS.

- (VLTIM) AT3 in SCIDAR station (E0) during the day: Position of the switch must be **CLOSED**.
- (VLTIM) AT3 in SCIDAR station (E0) before the start up and during the night operation: Position of the switch must be **OPEN**.
- (VLTIM) There will be no ROS so any ROS component will produce errors during operations. Those components must be ignored or simulated (preferable simulated when is is allowed).
- I will add more details of those subsystems when I am present during some run.