W. M. KECK OBSERVATORY

Keck Adaptive Optics Note #378

Laser Guide Star AO Acquisition Procedure

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1. Introduction

This document describes the procedure that the summit Observing Assistant, the LGSAO operator, and the Observer should follow for acquiring a target in LGSAO mode.

2. On-axis vs off-axis observations:

LGSAO observations require the use of a Laser Guide Star (LGS) for high order wave front sensing as well as the use of a Natural Guide Star for tip-tilt referencing (NGS TT reference) on STRAP. This NGS TT reference star is also used for focusing and image sharpening using the Low Bandwidth Wave Front Sensor (LBWFS). The NGS TT reference star can be as faint as ~18th magnitude in R.

From the observer perspective, a science target can be used for Tip-tilt sensing if it is bright enough; the observations are referred to as "on-axis" observations. Alternatively, a science target could be too faint or too extended and require a separate, "off-axis" NGS TT reference star. In the later case, the OA should acquire the off-axis TT reference star. The name of the TT star is what will appear in FACSUM.

Below is shown two examples for a starlist; the first target `GOODS_S_104` corresponds to on-axis observation while the next one `LC-2` requires an off-axis NGS TT reference:

```
GOODS_S_104 03 32 37.679 -27 40 29.35 2000.00 lgs=1 rmag=16.8  b-r=0.7

LC-2            18 43 22.100 +40 40 21.00 2000.0 lgs=1
   1306-0305887 18 43 23.368 +40 40 53.04 2000.0 rmag=14.8 sep=35.1 b-v=0.75 b-r=1.08 S=0.27
```

The summit OA will center the TT reference star (which is either the science target `GOODS_S_104` or the off-axis star `1306-0305887`) on the requested pointing-origin. The LGSAO operator will setup the LGSAO system for the TT star. Note that for both examples here, a `b-v` or `b-r` value was provided which allow the AO system to compensate for Differential Atmospheric Refraction (DAR) and maintain the science target at the same location on the science array.

Once the LGSAO acquisition is complete, the LGSAO operator, or the Observer, will offset to the science target.

3. Time Sequence

1. To identify the next object to acquire, the Observer shall always provide to the summit OA and the LGSAO operator both the target science name and specify which NGS TT reference will be used. Some of the summit OAs like to be provided only the name of the NGS TT reference star .
2. The Observer shall prepare the finding chart for the next target and/or load the new target on the TSS Acquisition widget.[1]
3. The Observer shall, as much as possible, keep the LGSAO operator and the Observing Assistant aware of his/her observing plans and provide the name of the next target a few minutes before the end of the observing sequence, e.g. "we will be done observing this target in about 2 minutes, then we would like to go to science target `xxx` for which we will use the first TT reference below the target line".
4. Once the observing sequence is complete, the LGSAO operator will need to "open LGSAO loops". It ensures that the Na layer altitude and other LGSAO parameters are being updated for the next acquisition.
5. Once the loops are open, the summit OA will be commanding the telescope to SLEW.
6. While the telescope is slewing the LGSAO operator will setup the bench for the next TT reference star and handover the system to the summit OA. By default, the DAR compensation is ON.
7. During the slew, the observer should set the position angle via either the TelGui (OSIRIS) or the rotate

1 When using TSS as the finding chart, be sure the compass rose aligns with the guider compass rose. This requires a 180 degree flip.

command (on NIRC2).

8. Once the telescope is tracking on the field, the summit OA will request the observer to identify the TT reference star in the field and provide the ACAM pixel coordinates for the TT reference star.
9. When observing faint extragalactic science targets, the observer may request the summit OA to center the TT reference star on REF-L and, via the "Adjust Pointing" button on xguide, correct ca and ce for each new target. This ensures that the coordinates in the FITS header can be used for data reduction in a reliable way[2]
10. The summit OA will center the TT reference star on the requested pointing origin (NIRC2, OSPEC, OSIMG) and let the LGSAO operator know when this is complete. The LGSAO operator shall acknowledge this information.
11. The LGSAO operator will start the LGSAO acquisition script immediately and request permission to propagate on that target very shortly thereafter. Note that there is no formal need to wait for the audio message "please request laser propagation".
12. Once the summit OA has granted his/her permission to propagate, there is a period of two minutes to propagate the laser, If the laser is not being propagated within these two minutes, the OA should set his/her permission back to deny[3].
13. As soon as the LGSAO acquisition is complete, the LGSAO operator will update the Observer on the progress on image sharpening and let him/her know whether a test exposures can be recorded on-axis and/or whether the offset to science target has been performed and/or "the target is ready for observation".
14. The observers should notify the LGSAO operator when they plan to record images on NIRC2 without using an lgbxy*n* script (or any script that calls the "setlbwfstime" routine). It is very important to ensure that the LBWFS keeps recording images and updating the focus even during NIRC2 or OSIRIS test exposures.

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2 Note for OAs: in general there are three operations that affect the coordinate zero-point: adjust pointing, mark base, and goto base. As above, adjust pointing changes Ca/Ce (Collimation correction to azimuth and elevation) but not either ra/dec pair (it does move the telescope). Both mark base and goto base have the effect of zeroing the offsets (displayed in arcseconds below the two RA/Dec pairs), but equating the two RA/Dec pairs. Mark base does not move the telescope, but copies the current RA/Dec to the base Ra/Dec. Goto base does the opposite; that is, it moves the telescope back to the base Ra/Dec. Also, note that telescope coordinates on the sky will be *incorrect*, if the catalog coordinates of a star used for "Adj Pointing" are inaccurate. That is why our standard procedure is to only use GSC or similar catalogs, with accurate proper motions, for this step. Observers should be warned that recorded sky coordinates will only be as accurate as their supplied TT star coordinates.

Note for Observers: that the FITS header information for OSIRIS is determined from either the pointing origin from the Imager or the Spectrograph. Meaning that if a user defines the pointing origin for the Imager then switches to the Spectrograph (in the OSIRIS otgui) the FITS coordinates will be associated to the original pointing origin.

3 This step should be automated in a near future.