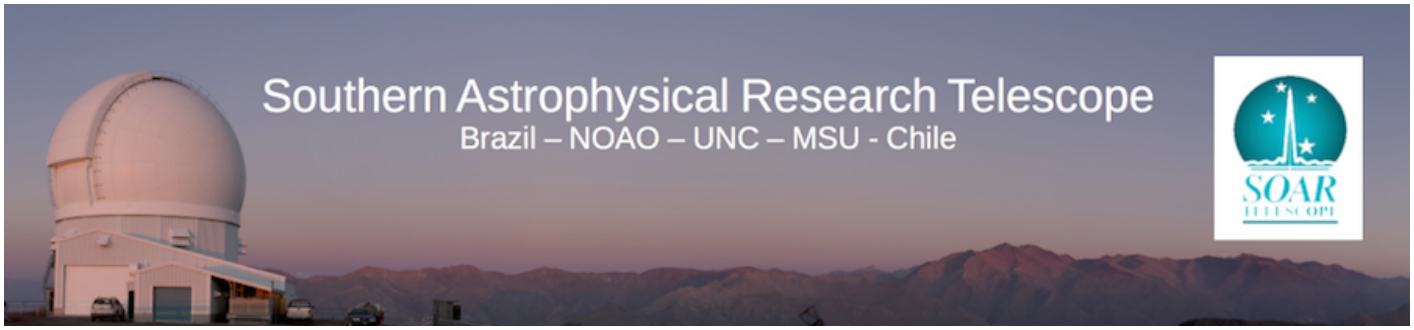
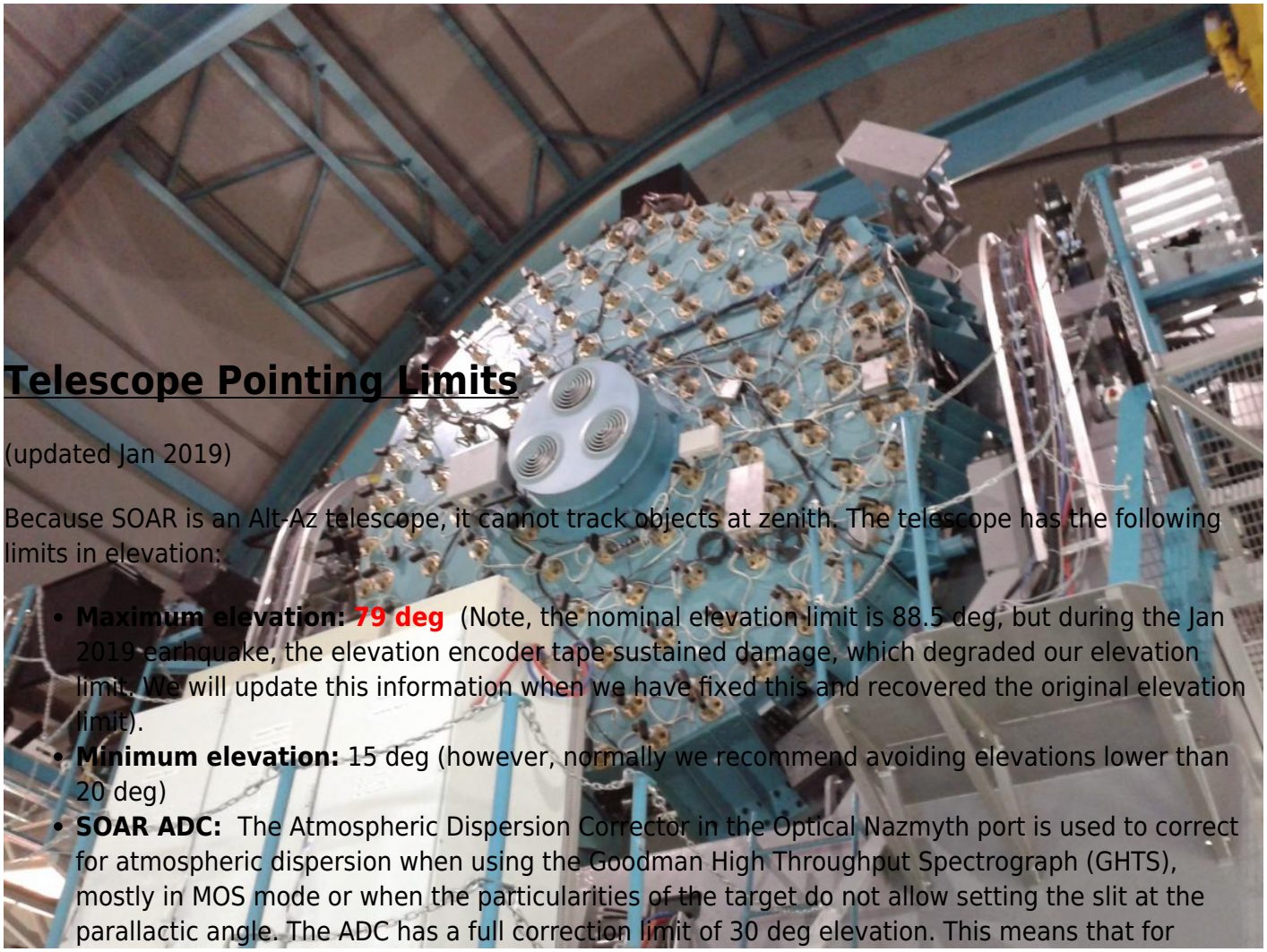


Observing with SOAR: limits, overheads and efficiency



Telescope Pointing Limits

(updated Jan 2019)

Because SOAR is an Alt-Az telescope, it cannot track objects at zenith. The telescope has the following limits in elevation:

- **Maximum elevation: 79 deg** (Note, the nominal elevation limit is 88.5 deg, but during the Jan 2019 earhquake, the elevation encoder tape sustained damage, which degraded our elevation limit. We will update this information when we have fixed this and recovered the original elevation limit).
- **Minimum elevation:** 15 deg (however, normally we recommend avoiding elevations lower than 20 deg)
- **SOAR ADC:** The Atmospheric Dispersion Corrector in the Optical Nazmyth port is used to correct for atmospheric dispersion when using the Goodman High Throughput Spectrograph (GHTS), mostly in MOS mode or when the particularities of the target do not allow setting the slit at the parallactic angle. The ADC has a full correction limit of 30 deg elevation. This means that for elevations below 30 deg the correction will be only partial.

Overheads with the SOAR Telescope

(updated 30 Mar 2016)

Overheads depend on many issues, like how widely distributed your targets are on the sky and what instrument/configuration you are using. However, for the guidance of the user when preparing the observations, we post here some general figures:
1) Overheads due to Telescope+Dome+Nasmyth Rotator: *For all-sky slews the average overhead is 2.4min***.** This is from the moment the Telescope Operator selects a new target, to the moment the telescope is guiding on its next field. *If you are moving from object to object on the same part of the sky (a few degrees) this overhead goes down to ~1min*. However, even in all-sky mode you may have as little as 1m25s of overhead or as much as nearly 5min. This depends on whether you moved 20 deg in azimuth but at roughly the same elevation or if you are now pointing to the other direction of the sky, and going from a low elevation to a high elevation, such that not only the telescope has to slew over ~180 deg, but the main mirror optics have to readjust for the large change in elevation, and the Nasmyth rotator may have to move by a large amount.

2) Instrument Overheads.
2.1) Goodman Spectrograph (GHTS) [1] + Goodman Acquisition Camera (GACAM) [2] **= ~ 1min.** This is the recommended mode for acquiring targets in spectroscopic mode down to V~18 in fields which are not crowded. Average acquisition time is ~1min (from the moment the Telescope Operator has locked on a guide star, to the moment you click on the Start Exposure button). The GACAM also provides savings in time by doing away with the need to move anything other than the slit positioner, including avoiding changing the readout mode when going between imaging and spectroscopic mode.

2.2) Goodman Spectrograph (GHTS) [1]+ Pre-imaging **= ~ 6 min.** This is the original acquisition mode of the GHTS. It the default mode for observations in Multi-Object Slit (MOS) mode, and recommended for very faint, specially extended objects, or very crowded fields. In this mode an image of the target is first obtained in Imaging Mode, then an Image of the slit (or slit mask in MOS mode), in order to calculate the offset between object and slit. Usually a third image is done to make sure the target is well centered on the slit.
The whole process, assuming 20s exposures and a 20s readout (in 400 kHz ATTN0 fast readout mode, and selecting a smaller region of the CCD to read) if done efficiently, requires on average ~6min.

2.3) SOAR Adaptive Optics Module (SAM) [3]. This instrument uses its own guiders, and requires a pre-image to determine a precise offset so the small field-of-view guiders (~10x10 arcsec) can zero in on any selected guide star. The overhead from one target to the next, assuming they are in the same part of the sky, is ~6min.

Therefore, if observing with Goodman + GACAM, estimate ~1min overhead per target. For Goodman + pre-maging, stimate average overheads of ~6min per target (~8-10 min if you want to be conservative or have little experience with the instrument)**. With SAM, ~6-7min.**

Minimizing overheads

There are several good practices when observing with SOAR that will help you minimize the overheads:

- **Avoid large slews:** SOAR is equipped with an Active Optics system for its primary 4.3m mirror

(M1) that relies on 120 actuators that adjust the shape of the thin (10 cm) and light piece of glass, to mantain optimal image quality at differing pointings, and as a function of temperature. However, this complex mechanism requires time to re-adjust when the telescope pointing goes through large changes in elevation. Therefore, one way to minimize overheads due to re-adjustments of the M1 optics, in case you have targets widely distrubuted over the sky, is to plan your observing so that you groups targets with roughly the same elevation, or even better, in the same part of the sky. The worse case is when going from elevations of ~20 deg to ~70-80deg; under such circumstances the telescope cannot make elevation changes of >~20 deg, taking ~2-3min in each to adjust the optics, so you may end up losing anywhere between 5 min and 10 min waiting for the mirror to re-adjust.

Another penalty you incur as the result of making many large slews is time lost waiting for the dome to reach its position for the selected target. Because the dome rotates slower than the telescope slews, pointing to a location far from your previous position means you will probably have to wait for the dome to complete its movement (the dome moves at a rate ~1deg/sec, so turning 180 deg takes 3min.

- **Send your target list in advance.** In this way, the Telescope Operator will have your coordinates loaded into the telescope TCS, and going from target to target will go smoother.

- **Have finding charts at hand.** Identifying objects in a crowded field, especially if the target is faint, will be much easier if you have prepared your finding charts before hand. It also helps if you know your field before hand, so suitable guiding stars can be selected quickly.

- **With the Goodman HTS:**
  - When acquiring a new target, use the Acquisition ROI (Region Of Interest) in the ROI menu (or set up your own to read an even smaller region of the detector, depending on your project) and set your readout to 400 KHz.
  - Change your setup from spectroscopic to imaging mode while the telescope is slewing to the new target, in this way you will be ready to start your first acquisition exposure as soon as the Telescope Operator has locked on the guide star.

Links
[1] https://www.ctio.noirlab.edu/soar/content/goodman-high-throughput-spectrograph
[2] https://www.ctio.noirlab.edu/soar/content/goodman-acquisition-camera-gacam
[3] https://www.ctio.noirlab.edu/soar/content/soar-adaptive-optics-module-sam