Commissioning LINC-NIRVANA on the Large Binocular Telescope: Real World Challenges of Natural Guide Star Adaptive Optics

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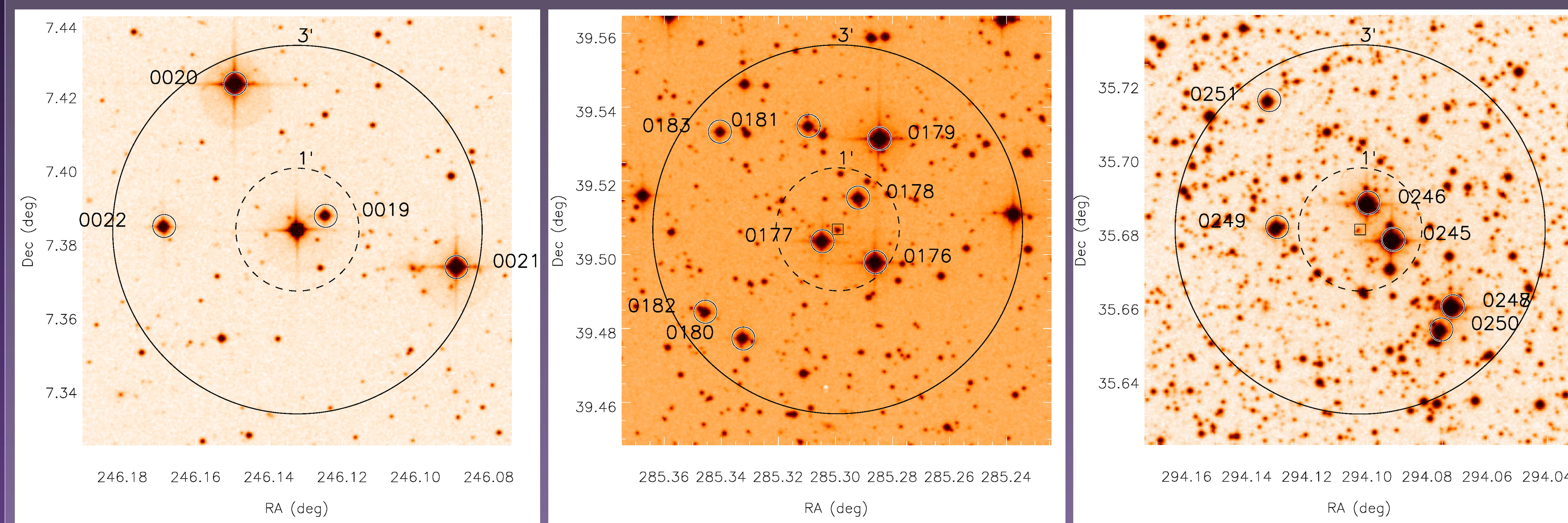
Summary

LINC-NIRVANA (LN) is an innovative, high-resolution near-infrared imager for the Large Binocular Telescope. Its Multi-Conjugate Adaptive Optics (MCAO) system uses natural guide-stars (NGS) and provides high sky coverage for single-eye and binocular observations. LINC- NIRVANA uses the layer-oriented approach to Multi-Conjugate AO, in which two or more wavefront sensors focus on the turbulence within particular layers, sampling the signal from multiple stars simultaneously. After being shipped internationally and reassembled, LN was installed in late September 2016 and acquired its first "technical photons" a month later. Since then, we continue to bring the various control loops online, finalize interactions between telescope alignment and instrument calibration, incorporate the rotations and coordinate flips into the control software, and commission the instrument with early science targets.

Hunting for Commissioning Fields…



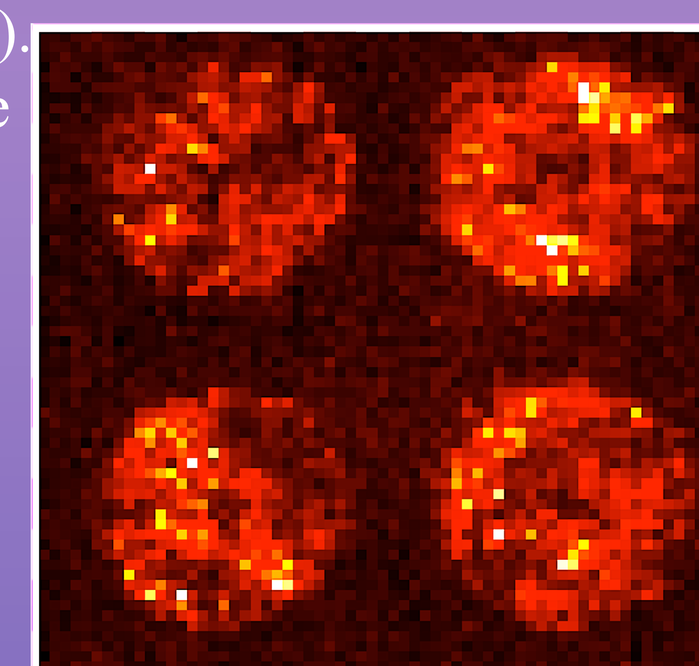
- To begin commissioning, we need fields that contain multiple, bright, well-spaced USNO-B1 guide stars at various separations, with a bright target in the center for auto-guiding.
- For these initial runs, we searched for evenly-spaced constellations of stars brighter than 12th Rmag. The GWS requires stars with radii between 60" – 180", and the HWS requires stars with radii up to 60".

Fields Visualizer to Handle Flips and Rotations

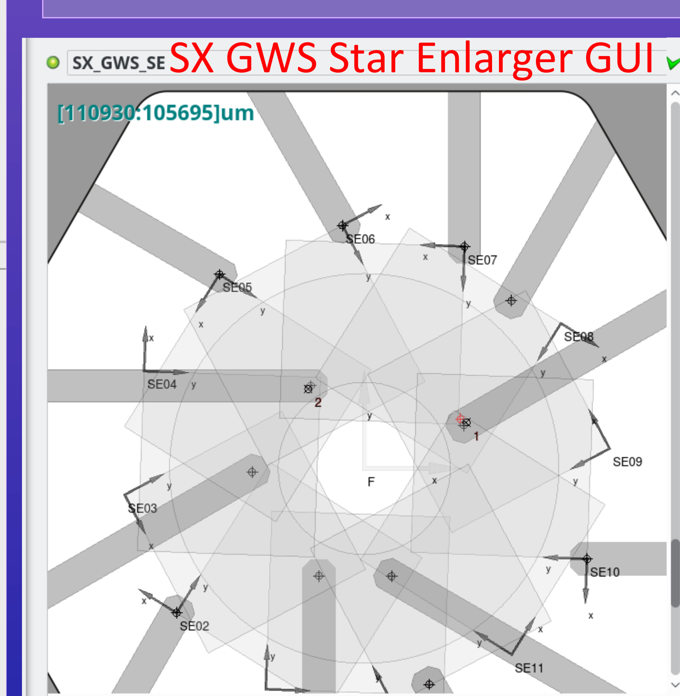
The many fields of view (sky, telescope, GWS, HWS, science) with their own coordinate systems and various optics leading to net rotations and flips. Creating a visualization tool to track the view of each field has greatly aided in commissioning the wavefront sensors and science detector.

Everything Must Work to Close the Loop

- Collimate the telescope on a bright star near the field
- Preset the telescope to the field
- Begin de-rotating
- Center the target on the Patrol Camera hot pixel
- Begin auto-guiding
- Rotate the target coordinates into GWS and HWS frames
- Acquire and center the stars for the GWS & HWS WFSs: 1st GWS, 2nd HWS.
  - Send the SEs to the appropriate positions (while previous steps ongoing)
  - Move all SEs but one with the brightest star to their shadow position (slightly off position so the SE blocks the light).
    - If no light is in the pupils, manually move the SE to search for the star, or use the Spiral Search script to look in widening loops.
    - If light is in the pupils, center the light between the 4 pupils either manually or using the CenteringSE script.
  - Repeat until all stars are centered
  - Close the loop
- Start CCD tracking service (DNE)
- Observe!

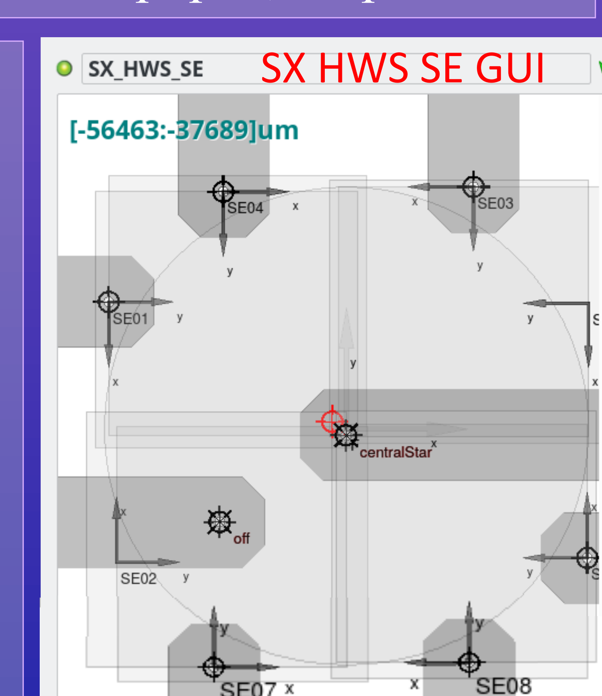


SX GWS Camera with centered pupils, loop closed



Gotta Catch 'em All!

- SX GWS (*left*) and HWS (*right*) star enlarger (SE) GUIs. SE positions can be input manually, clicked in the GUI, or moved with a step paddle.
- Acquiring 3 GWS and 2 HWS initially took 20-30 minutes; after practice it took 5-10 min.



- The beams from the two telescopes have different input rotations, leading to each field being derotated separately. Thus, the orientation of our WFSs change with respect to their corresponding deformable mirrors, making it complex to use interaction matrices to close the loop. We have calculated and saved interaction matrices for every 1° of the possible rotator ranges for the GWS and HWS.