Detection Capabilities of SHARK-NIR's High-Contrast Imager at the LBT

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Summary

SHARK-NIR is a near-infrared instrument developed for the Large Binocular Telescope (LBT) under the *"2014 Call for Proposals for Instrument Upgrades and New Instrument"*. It offers both imaging and spectroscopy, enhanced by its Extreme-AO system. Since its commissioning, it has performed five observation runs focusing on the newly formed stars in the Taurus constellation, Here, we describe the instrument, and provide the latest detection limits based on recent observations of HIP 11696 and MWC 758 in coronagraphic mode. Our results demonstrate impressive sensitivity down to 10E-7, proving its potential in detecting faint companions in the near future.

The Instrument

- SHARK-NIR installation at the LBT
- Operations pre on-sky

Jun - Nov 2022 — **Pre Commissioning phase**

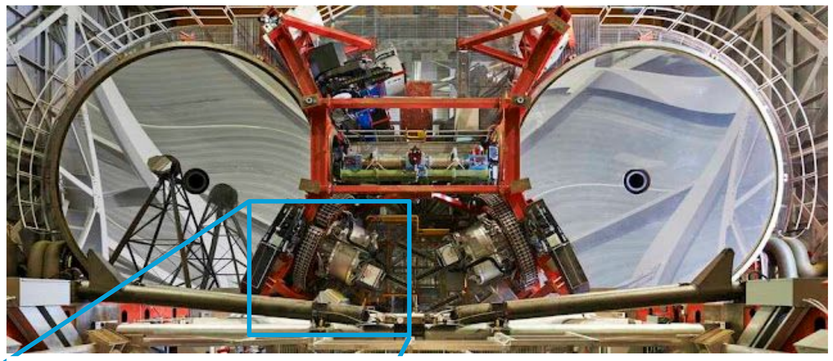
Jan 2023 — **Commissioning Phase**

- Tests and characterization on-sky
- **First imaging sequence**
- Spectroscopic mode observations

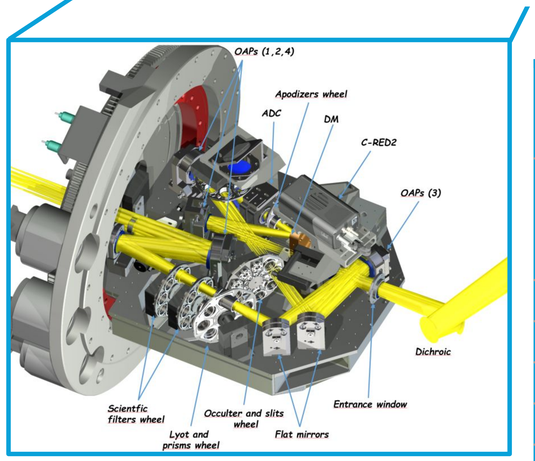
- Science runs

Oct 2023 — **Early Science Phase**

Jul 2024



The LBT comprises two identical 8.41-meter telescopes. Combined, they provide an effective aperture of a single 11.8-meter telescope.



Instrument Specifications

Science Cases	Exoplanets Brown Dwarfs Protoplanetary disks
Observation Modes	Direct Imaging Coronagraphy Dual-band Imaging Long Slit Spectroscopy
Spectral coverage	0.96 µm to 1.7 µm (Y, J, H)
Detector format [px]	2048 x 2048
Waveband [µm]	0.96 - 1.7
FoV ['']	18 x 18
Pixel scale [mas/px]	14.5
Nominal Strehl	> 98%

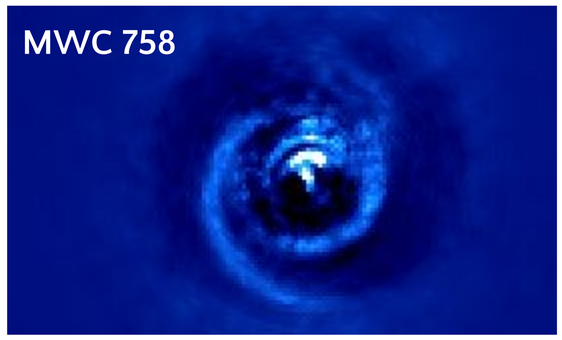
Coronagraphic Techniques

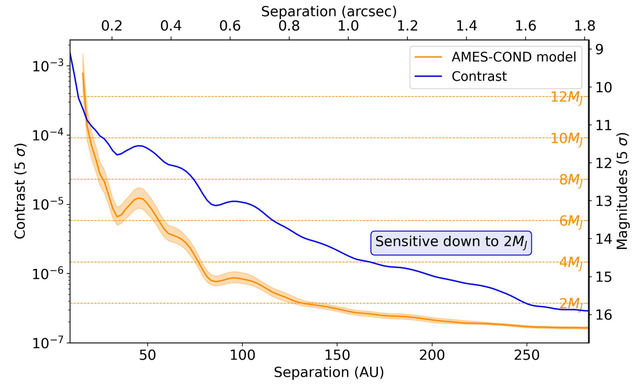
Coronagraph	IWA [mas]	OWA [mas]	Contrast	Throughput	Band
Gaussian Lyot	150	-	5E-4 ÷ 10E-6	56%	J, H
Shaped Pupil 1	100	320	2E-5	22%	H
Shaped Pupil 2	140	320	10E-7	26%	H
4QPM	40	-	10E-4 ÷ 5E-6	95%	H

Extreme AO

SOUL, the Single Conjugate Adaptive Optics Upgrade for the LBT, enhances real-time atmospheric turbulence correction using pyramid wavefront sensors and deformable secondary mirrors with 672 actuators. The upgrade offers a faster loop framerate (up to 2kHz), low readout noise (0.4e-), reduced time delay (1.8ms), and 40 sub-apertures on the pupil diameter providing high spatial sampling.

Results





Architecture:

- MWC 758: Protoplanetary Disk

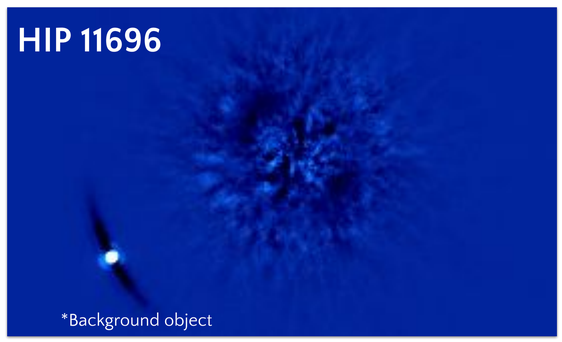
Diameter (AU)	490

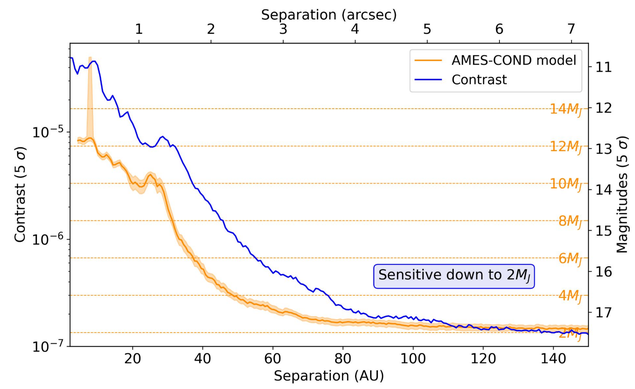
★ MWC 758

Spectral type	A8Ve Herbig Star
Teff (K)	7314.0 ± 147.047
Distance (pc)	155
Age (Myr)	3.5 ± 2.0
Mass (M⊙)	1.5 ± 0.2

Observations:

- ➔ 80 min observation in Coronagraphy mode with the Gaussian Lyot and 4QPM coronagraphs.
- ➔ Atmospheric Conditions:
  - ◆ Seeing varying from 1'' to 2''
- ➔ Data reduction using SHARP (SHARK Pipeline, Mesa et al. 2024, in prep)
- ➔ Post-processing: ADI, noADI, RDI using 5 modes PCA technique.





Architecture:

◎HIP 11696: High Proper Motion Star

Spectral type	F5V
Teff (K)	5667
Distance (pc)	49.3
Age (Myr)	137 ±12
Mass (M⊙)	1.326

Observations:

- ➔ 80 min observation in Coronagraphy mode with the Gaussian Lyot coronagraph.
- ➔ Data reduction using SHARP.
- ➔ Post-processing: ADI using 5 modes PCA technique.

Acknowledgments

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