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# INAF facilities in the Optical-NIR

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Optical-IR division

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# INAF facilities at a glance

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**ESO** instruments: accessed by winning proposal BUT significant investments in instrument building gives access to Granted Time Observations.

**LBT**: 25% is reserved to Italian PIs

**TNG**: Italian PIs + Opticon International call

**WHT**: INAF contributes to the construction of WEAVE

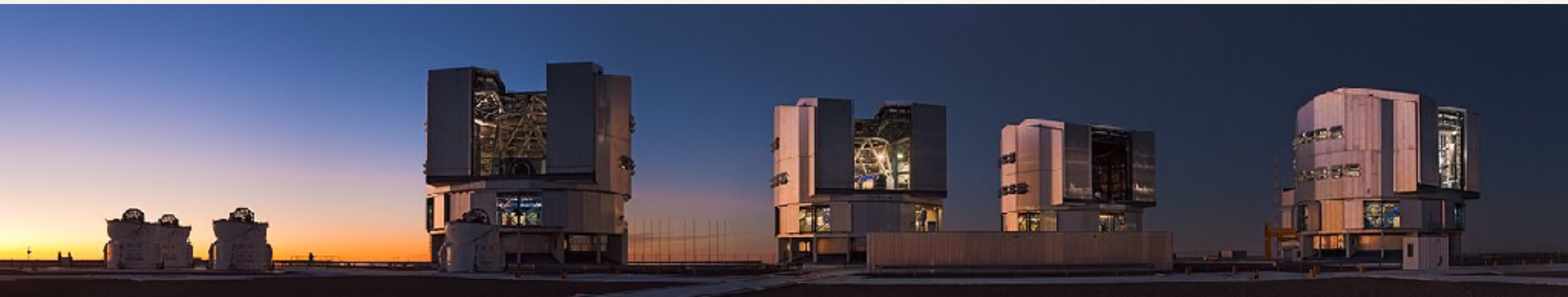
**VST** From 2021 the ongoing surveys will be finished, ample space to cooperate

**REM**: robotic telescope for fast transient, ample options to cooperate

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# ESO Paranal

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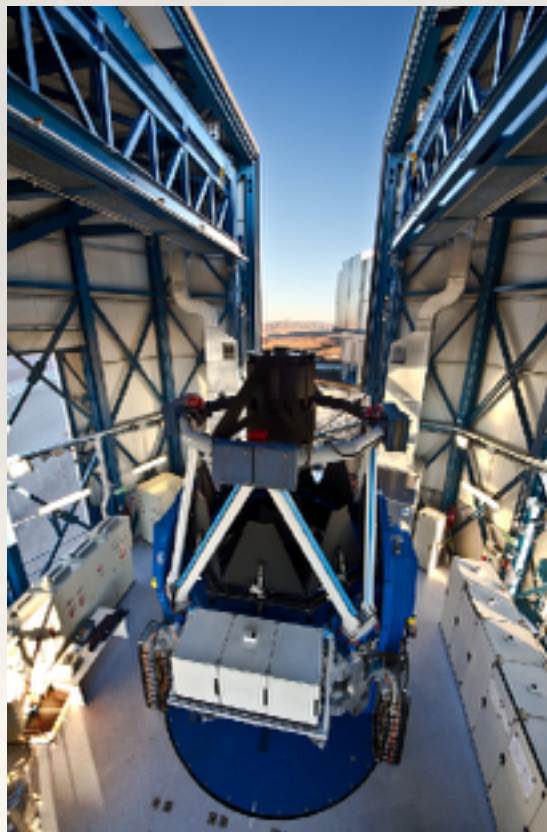
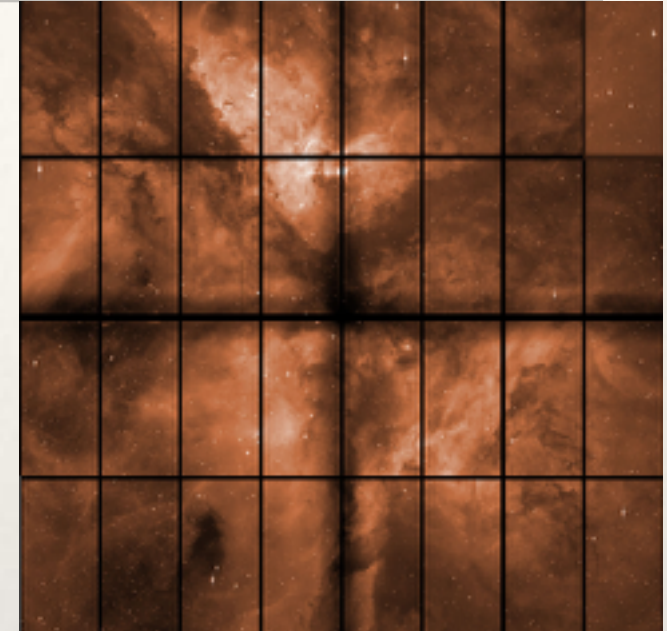




# Paranal - VST



2.65m Survey Telescope  
FOV: 1 sqdeg  
Developed and built by INAF



By 2021, ongoing surveys will be over.  
INAF will take full ownership.

Ample space for collaborative projects

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# ESO - La Silla

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## SOXS

### Son Of X-Shooter

Medium Resolution single-object spectrograph

Optical-NIR (U-to-H)

$R \sim 4500$

#### Science cases:

- Minor planets and solar system objects

- Exo-planets and stars

- Young Stellar Objects

- X-ray and binary transients

- Novae and Cataclysmic variable

- SNI and Core collapse SN

- GRB and SN

- Fast radio bursts

- AGN and blazers

- Gravitational Waves

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# NTT - SOXS

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**Son Of X-Shooter**

**Under development - delivery foreseen 2020**

SOXS is led by an Italian team

PI: Sergio Campana (Milano Merate Observatory)

Total cost is ~2 ME

Reward is high: 180 night/year for 5 years of GTO

Operational costs are also significant  
(observations and data reduction over the 5 years).

Minor parties contribute with 5-10% contributions, plus 1-2 persons/year  
for operational support.



# ESO ELT

INAF is leading the construction of two (out of 5) ELT instruments:

**MAORY:** 1st light MCAO module to feed MICADO;

**HIRES:** 2nd generation high resolution optical/NIR spectrograph



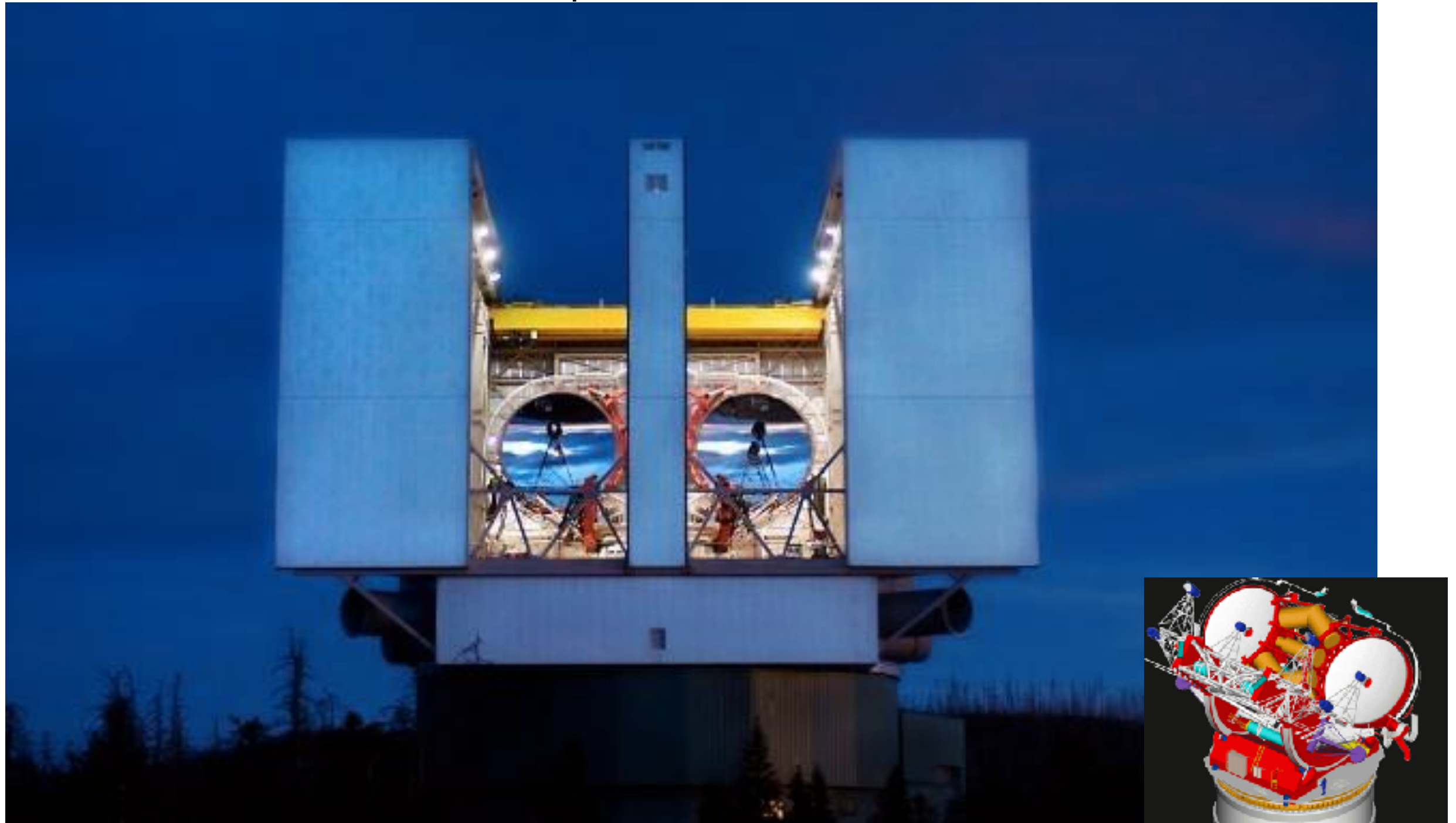
The cost of these instruments is in the 20-40ME ballpark.

In principle they cover most of the technical areas:

Adaptive Optics, Mechanics, Optics, Electronics, Software

# The Large Binocular Telescope is the most revolutionary optical telescope in the world.

The unique feature of LBT is its binocular configuration, that enables LBT to operate as a single telescope of 22.8 m of diameter.



LBT is a joint enterprise of INAF (25%), Univ. of Arizona, Ohio University, Research Corporation, and other U.S. organizations (50%) and the Max Planck Society (25%) and is located in Arizona

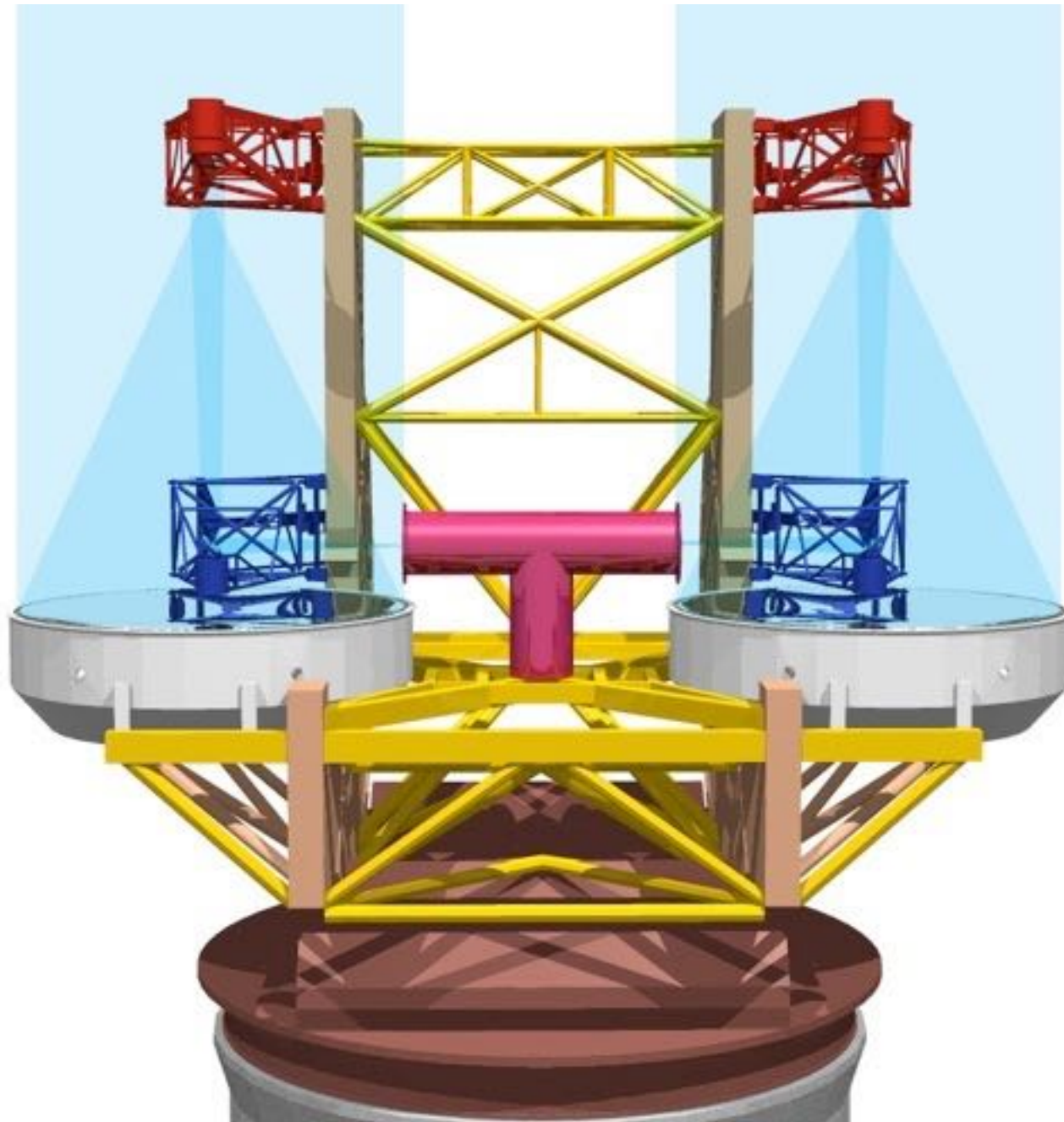


# LBT Main features

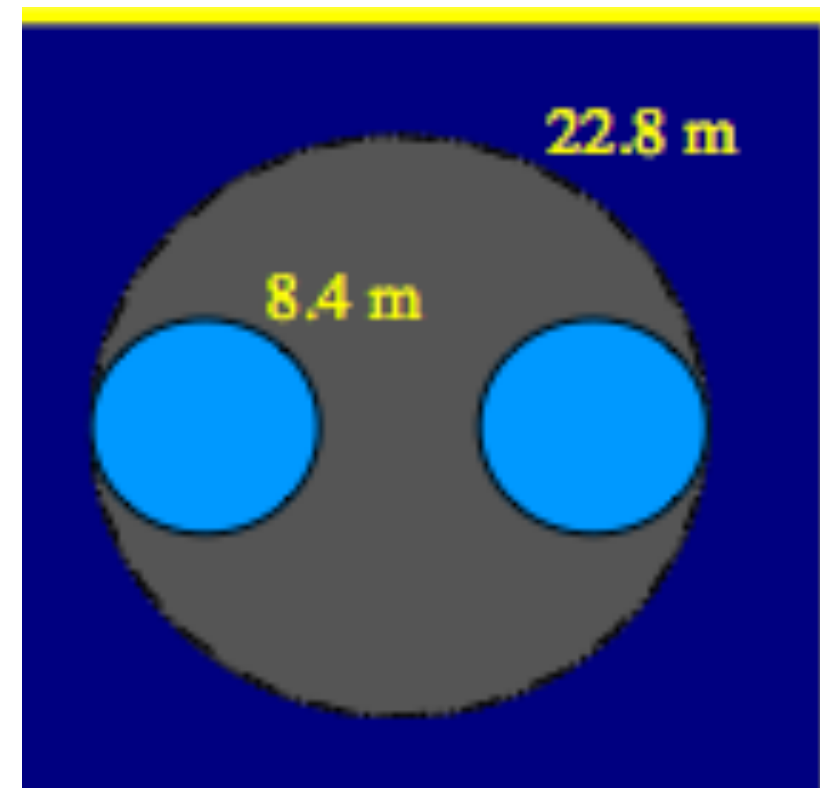
Stiff binocular configuration: binoc. vision

Adaptive optics correction on secondary mirrors

Interferometric images



Collecting area: 2x  
Resolution 3x





# The heart of LBT is an innovative system for “adaptive optics”.

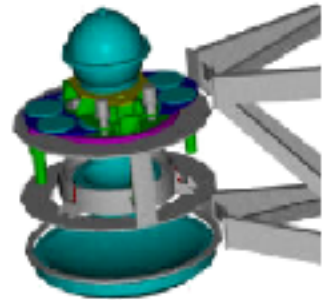
Thanks to a mirror that oscillates 1000 times each second, the system compensates for the aberrations due to the atmosphere, and makes the images as sharp as if LBT were placed in space



The system has been conceived, designed and built in Italy (INAF Arcetri)

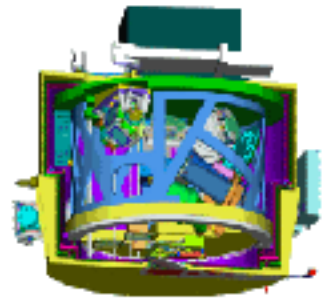
# LBT as a working telescope#1: a “normal” 2x8m telescope

## Prime Focus Optical camera - Large Binocular Cameras (LBC)



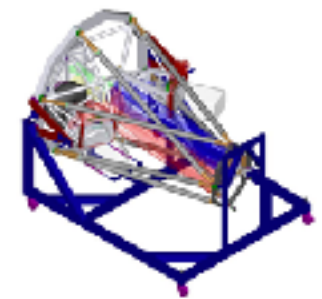
- The Large Binocular Camera (LBC) is a wide field imager made of two channels, one optimized for the UBV bands and one optimized for the RIZ bands. The field of view is approximately 23' x 23', with the two channels observing simultaneously the same region of the sky.
- More Informations are available at the [LBC website](#).

## Near-IR imager and spectrograph (LUCI)



- **LUCI**, (LBT NIR spectroscopic Utility with Camera and Integral-field unit, formerly known as LUCIFER) is a near-IR spectrograph and imager mounted at the Nasmyth focus. LUCI has two arms highly optimized for the Blue and Red portions of the spectrum (i.e. 1-2). It offers imaging, long-slit and multi-object (MOS) spectroscopy in the wavelength range 1-2.5  $\mu\text{m}$  over a field-of-view  $\sim 4' \times 4'$ . All modes currently work in seeing-limited mode.
- More Informations are available at the LUCI websites [here](#), [here](#) and [here](#).

## The Multi-Object Double Spectrographs for the Large Binocular Telescope (MODS)



- MODS MODS1-2 (The Multi-Object Double Spectrographs for the Large Binocular Telescope) is an optical spectrograph and imager mounted at the SX Nasmyth. MODS has two arms highly optimized for the Blue and Red portions of the spectrum (i.e. 1-2). With a 6 arc-minute square field of view it is capable of long-slit and multi-slit spectroscopy as well as imaging in the ugriz bands from 0.33 to 1.1  $\mu\text{m}$ . All modes currently work in seeing-limited mode.
- We remark that MODS, at the current time, has passed major milestones in the commissioning but has not been fully tested nor calibrated. In addition, only very preliminary planning tools are available.**
- More informations are available at the MODS websites [here](#) and [here](#).

3+1 Instruments in operations:

- LBC (2 instruments)
- MODS1 (1 instr., 2 channels)
- LUCI1

LBC and MODS have been working quite reliably over the last two years.

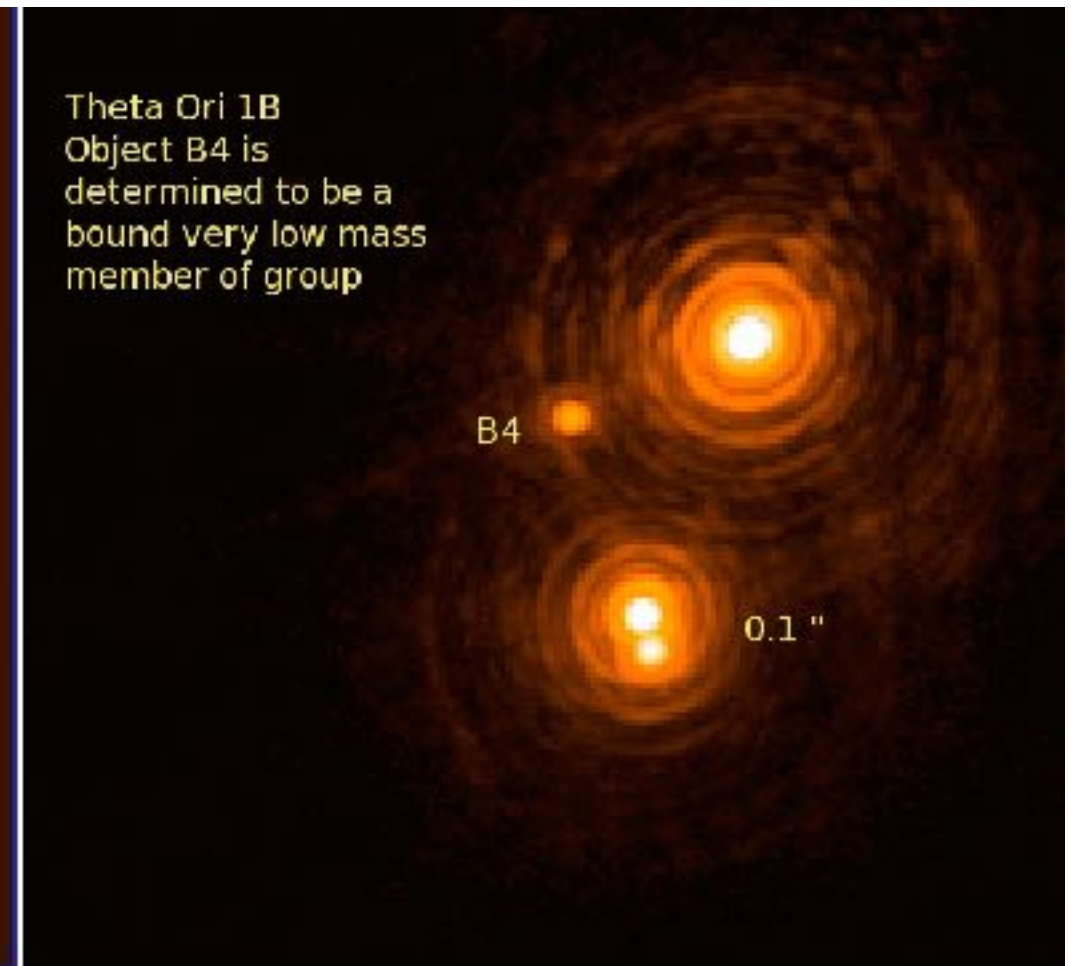
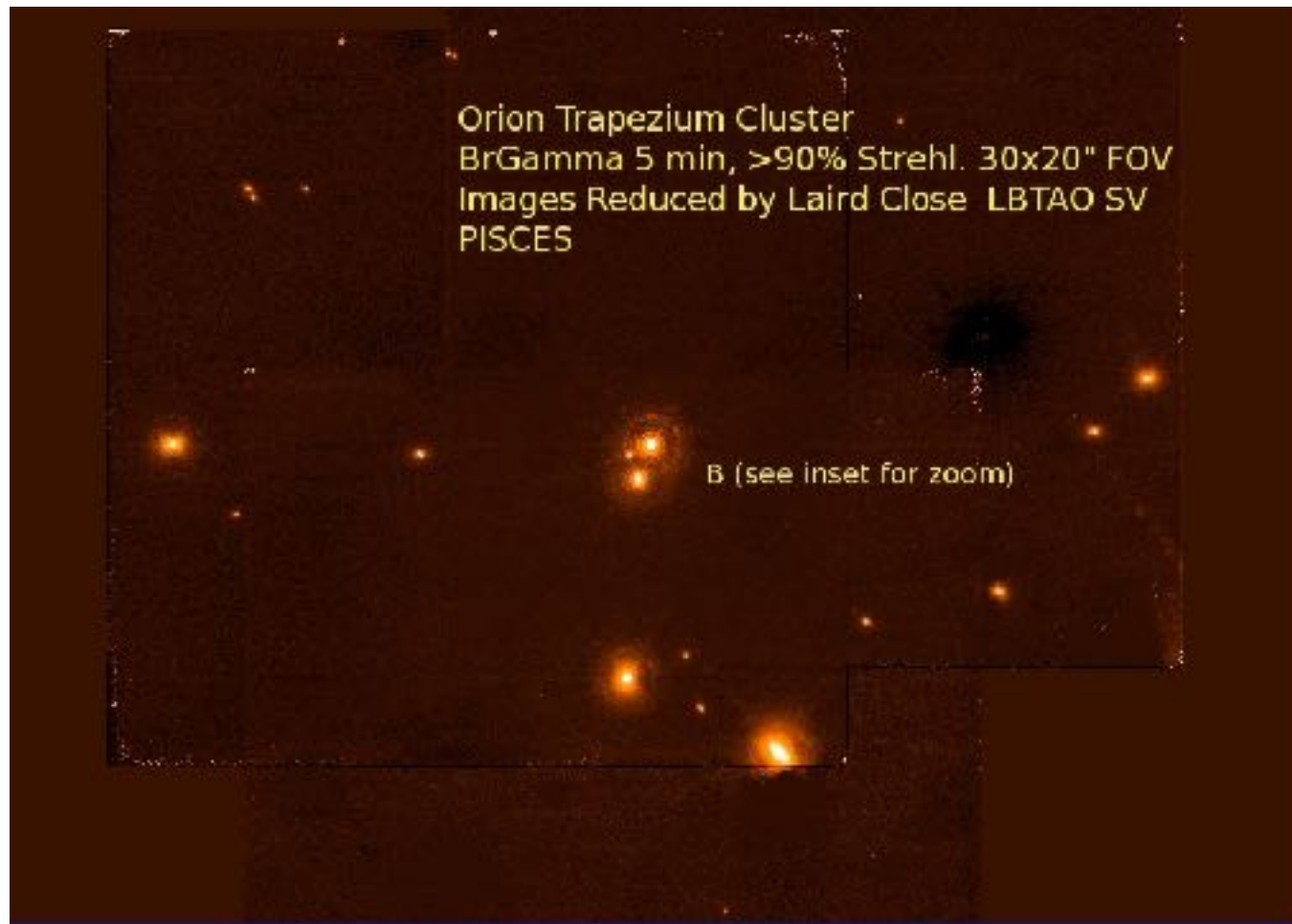
LUCI unfortunately suffered from repeated failures.

MOS is currently not operational.



# LBT AO: the first Extreme Adaptive Optics in the world

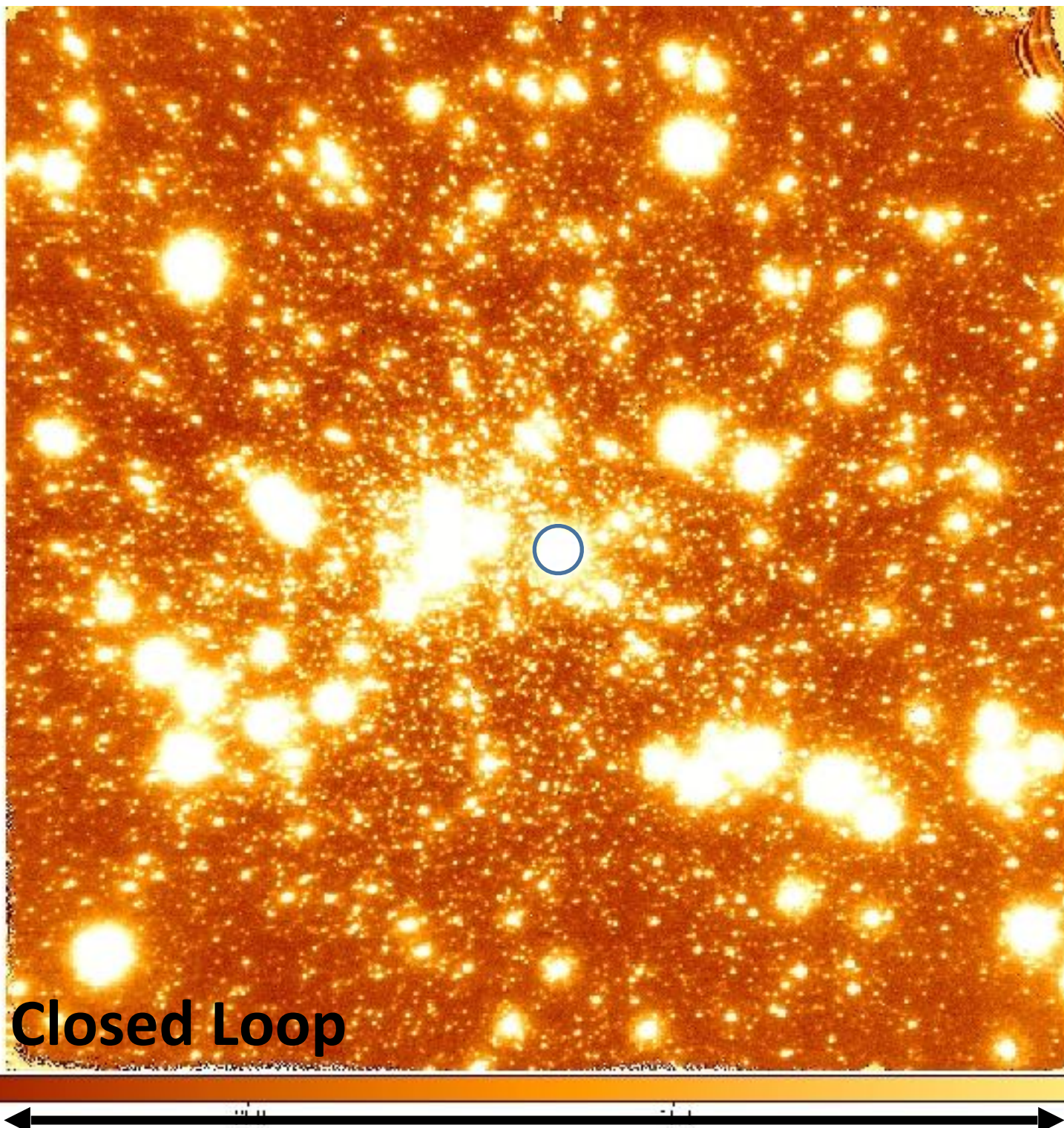
Oct 2011





# M15 globular cluster

AO loop closed on the central region of the globular cluster. Test for AO correction in very crowded FoV. The circle gives the location of the reference star.

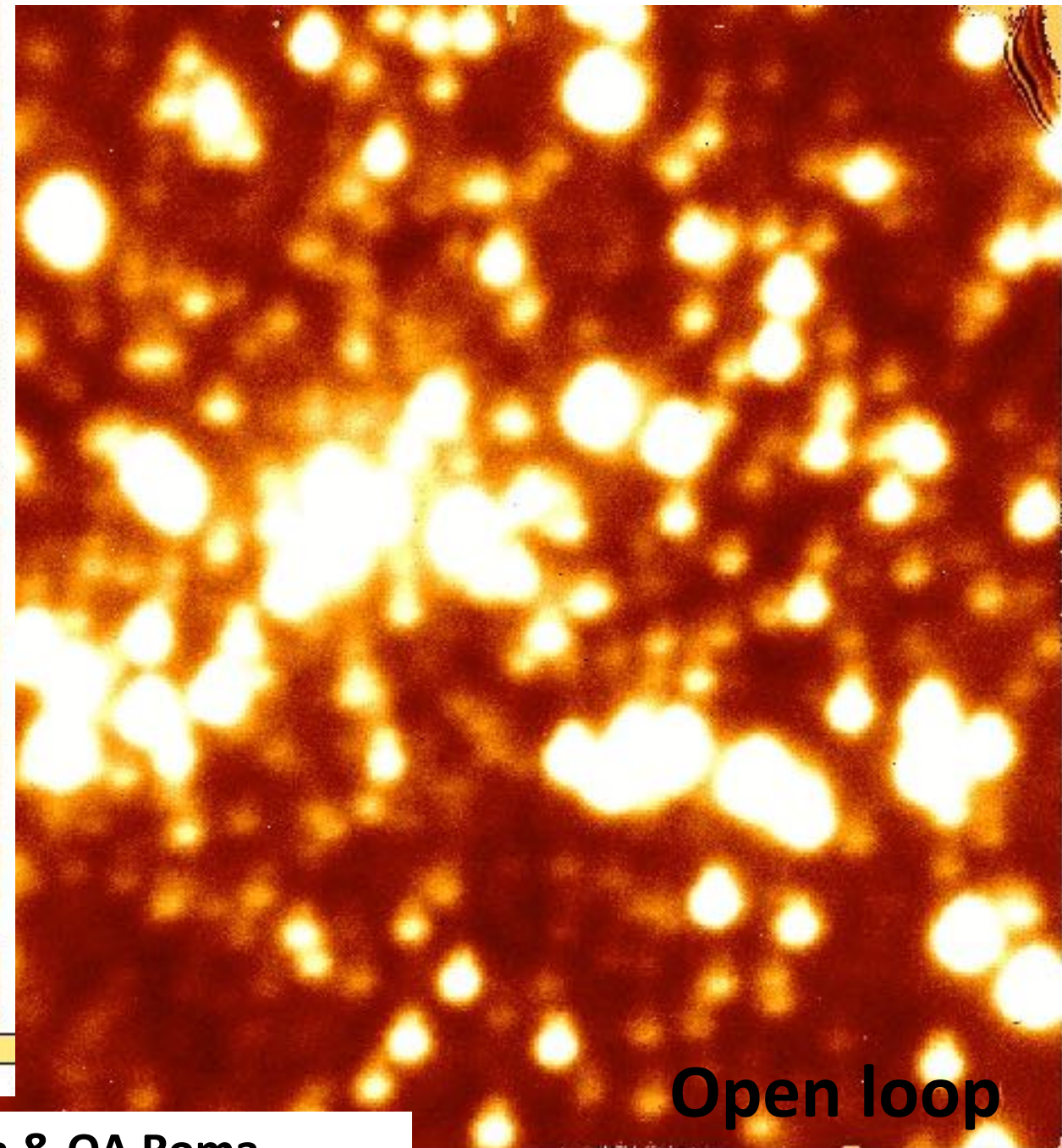


**Closed Loop**

**20 arcsec**

Image reduction V. Testa & OA Roma

H band images, 9x30 sec frames  
Same observations in J and Ks.



**Open loop**

-150

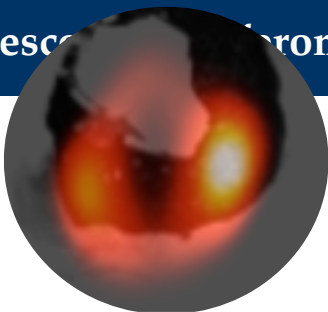
-100

-50

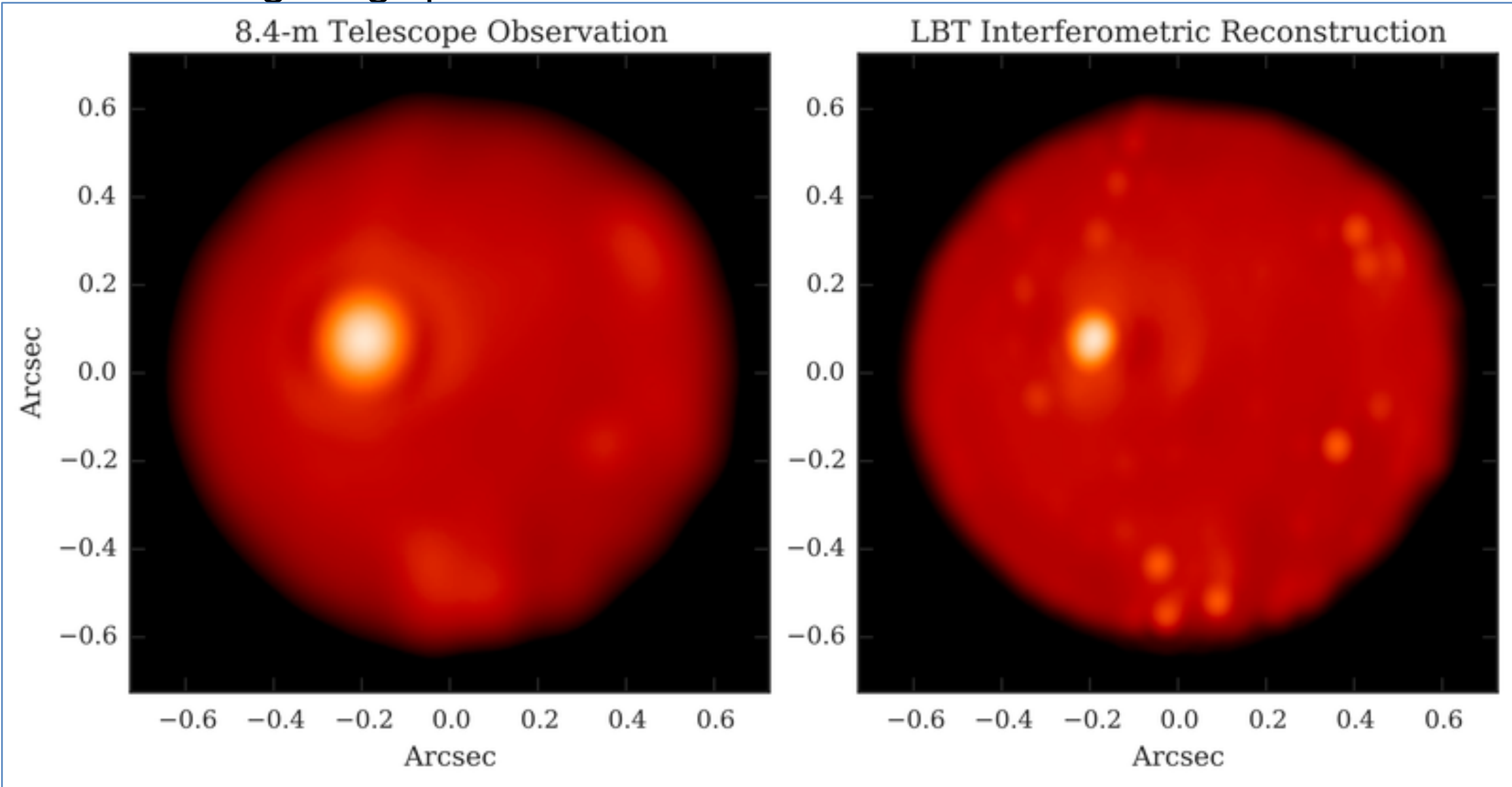
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# Interferometry in the NIR - Loki Resolved –



The resulting image provides better than twice the resolution



The resolution in this infrared image is the same as the 20-meter

telescopes (at K-band most volcanoes are invisible)

Conrad, et al. AJ 149 173 (2015)



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# SHARK @ LBT

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Two-channels instrument to achieve the highest resolution.

Two channels (VIS and NIR)

Include coronagraphy for removal of central star

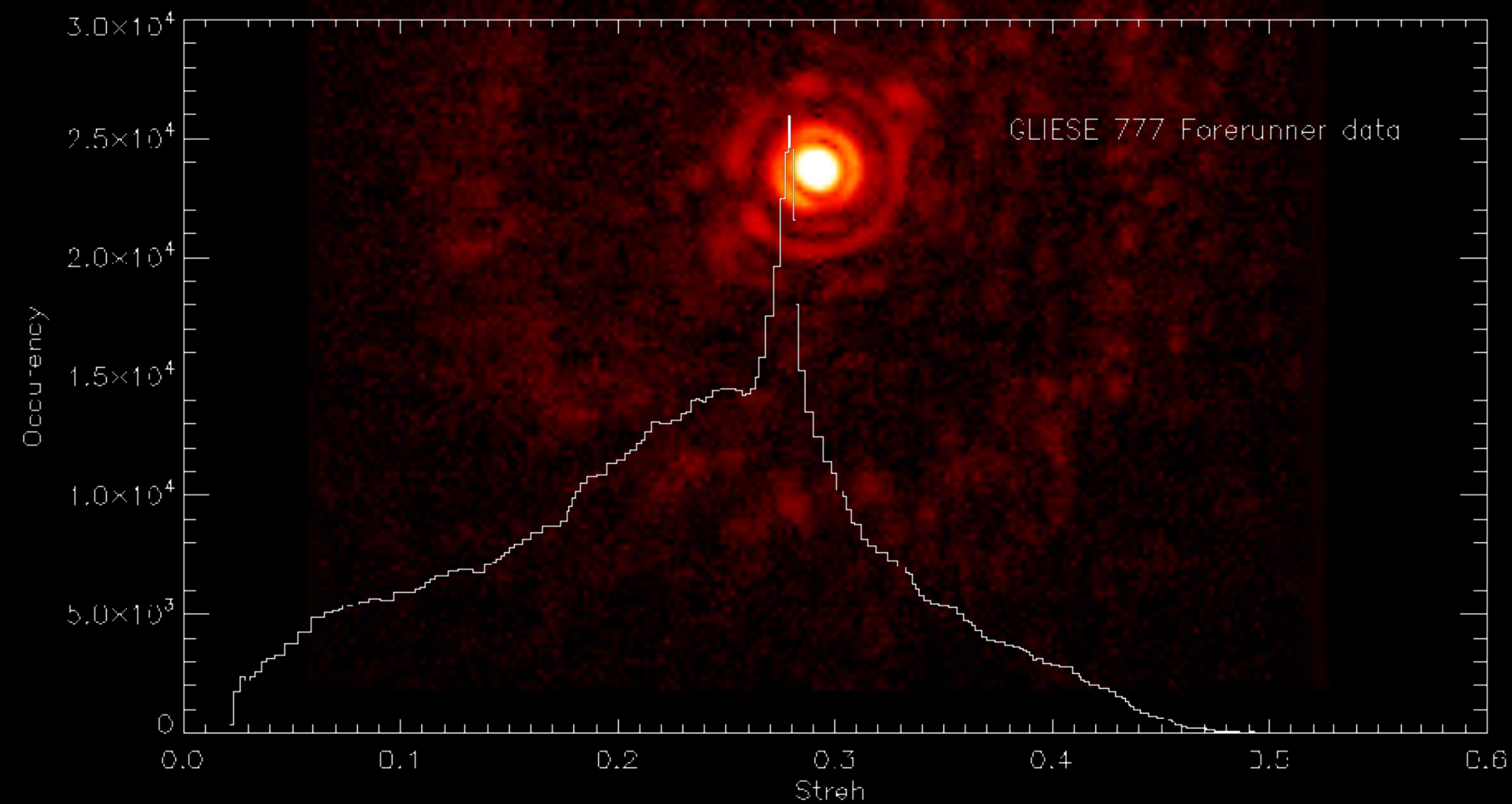
Optimized for search of exo-planets and other ultra-compact objects

Strehl ratio at 90% (NIR) and 50% (VIS)

FWHM 17.3 mas

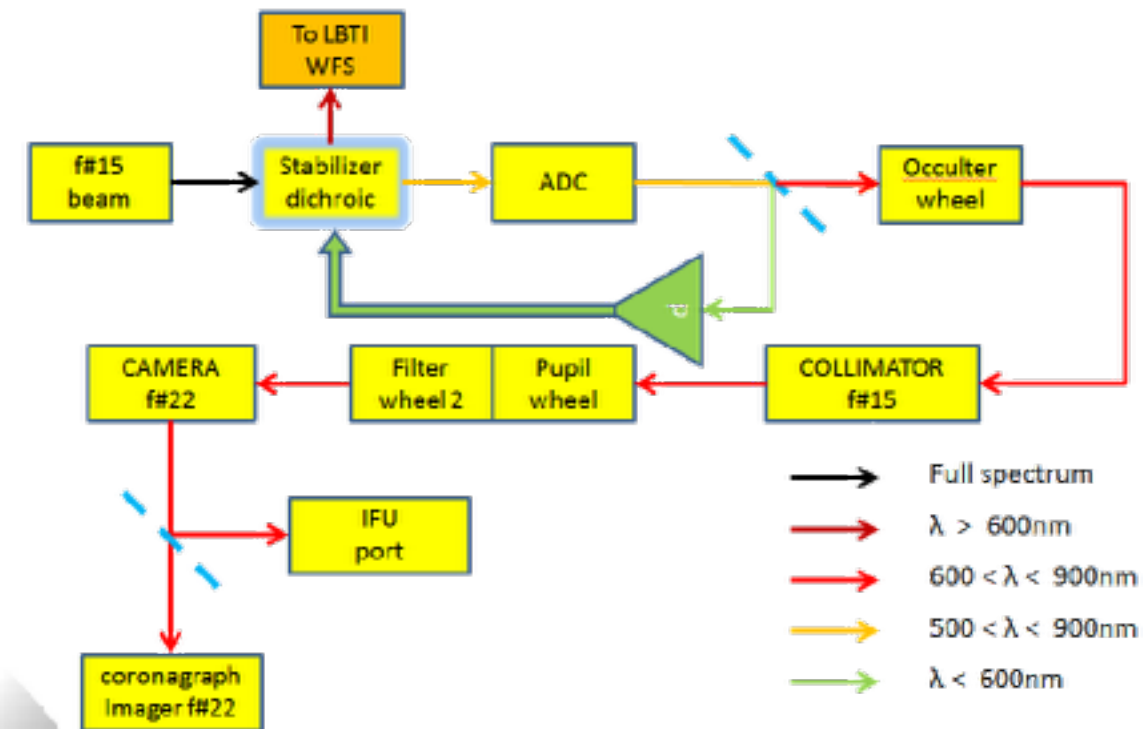
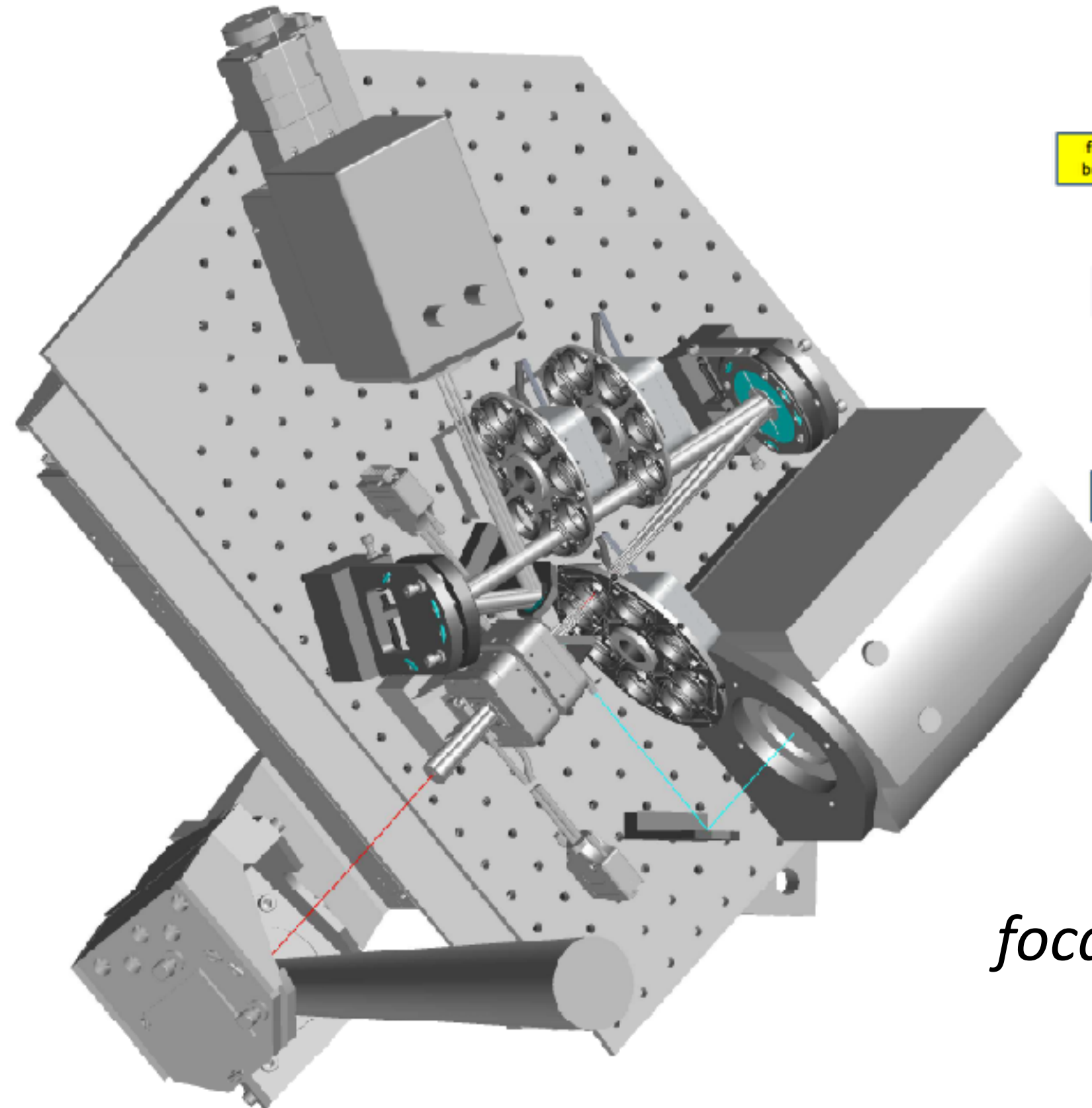
S=0.5

630nm



# CDP V-SHARK BASELINE

*Looks solid, minimal, modular and versatile*

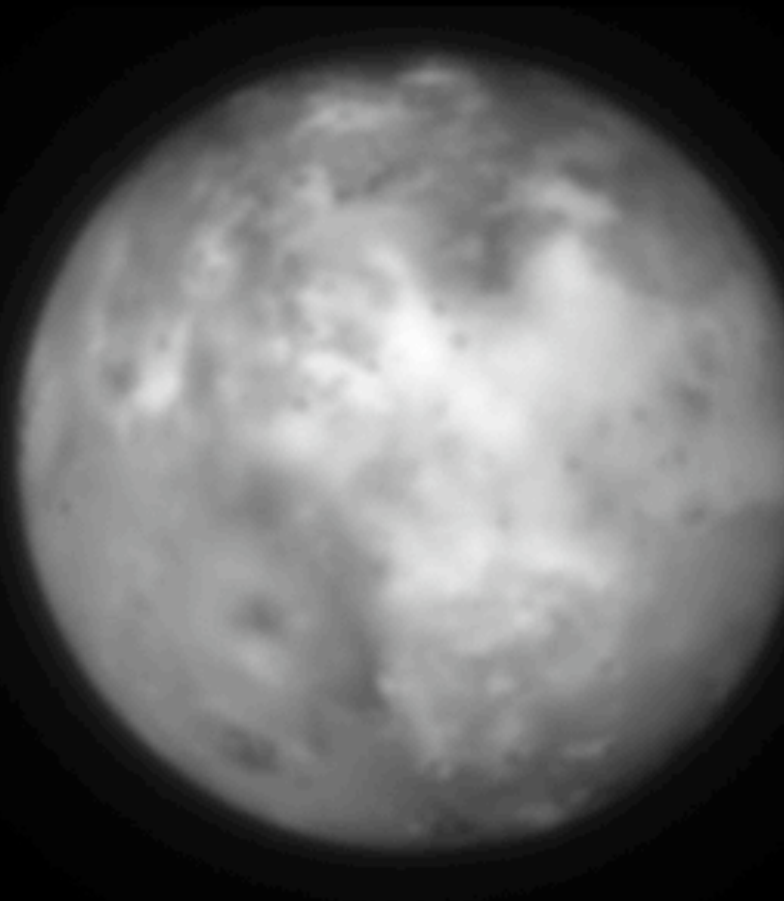


*Optical relay allows use of focal plane and pupil plane to deploy optical devices*

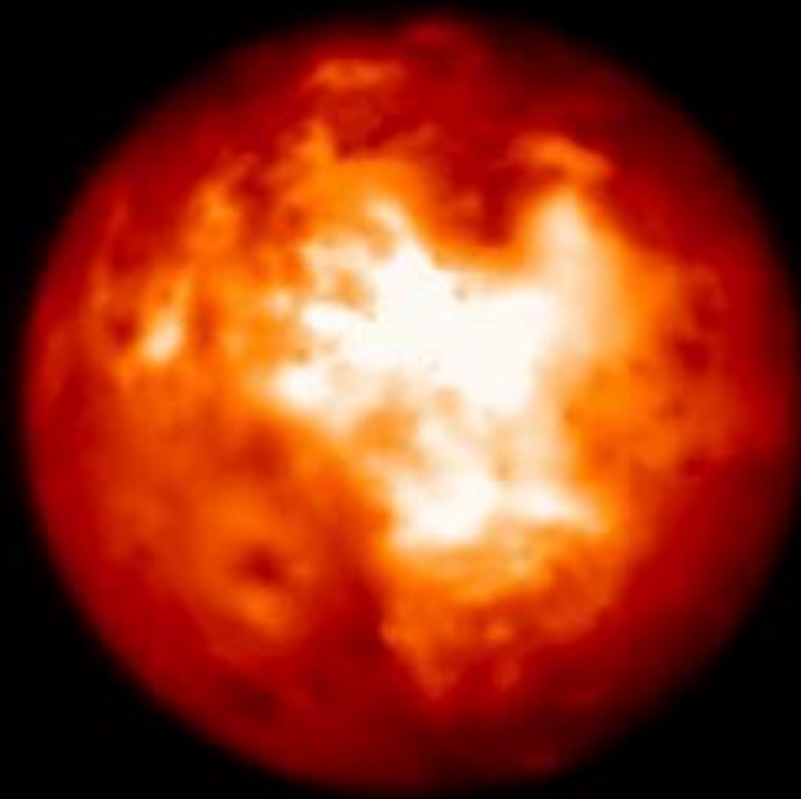
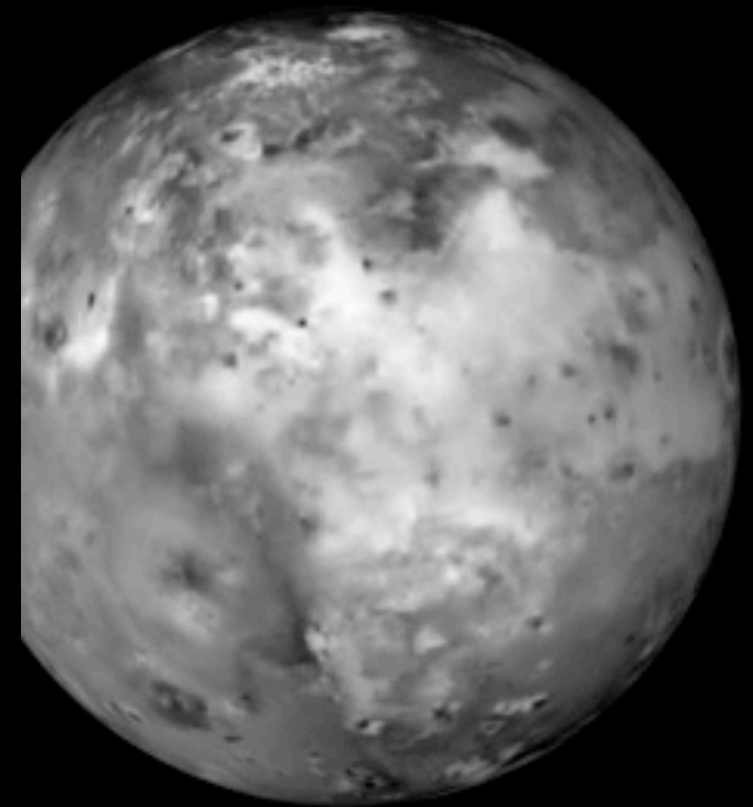


# Forthcoming science cases for Solar system bodies and asteroids

starting image



Reference sat



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# SHARK @ LBT

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Two-channels instrument to achieve the highest resolution.

Two channels (VIS and NIR)

Include coronagraphy for removal of central star

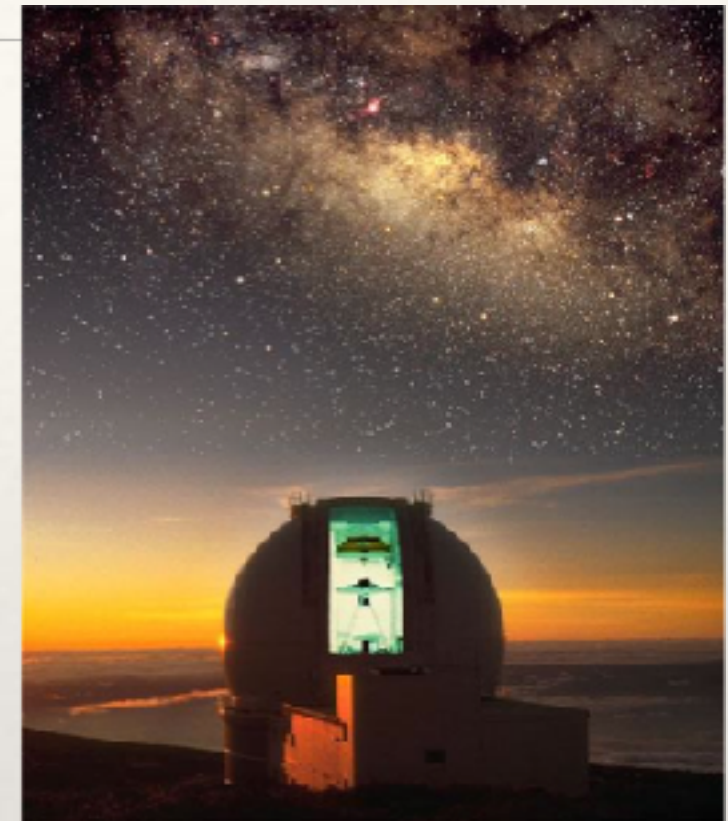
Optimized for search of exo-planets and other ultra-compact objects

Strehl ratio at 90% (NIR) and 50% (VIS)

SHARK-VIS and SHARK-NIR are in the budget range 1-2 ME.

Entering the consortia (even with a small investment) could allow  
access to GTO

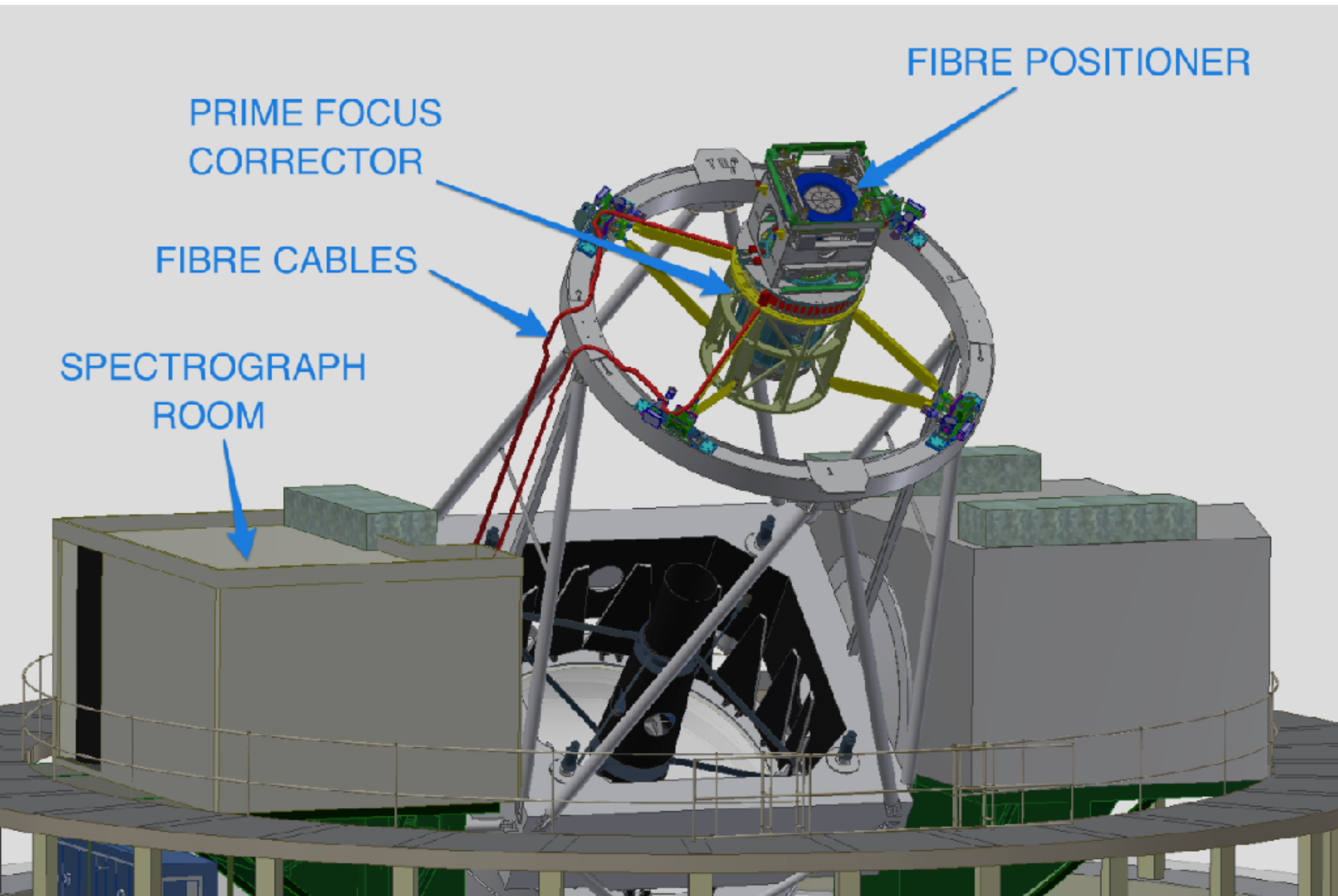
# WEAVE - William Herschel Telescope





# WEAVE characteristics

Telescope, diameter	WHT, 4.2m
Field of view	2° ø
Number of fibers	960 (plate A)/940 (plate B)
Fiber size	1.3"
Number of small IFUs, size	20 x 11"x12" (1.3" spaxels)
LIFU size	1.3'x1.5' (2.6" spaxels)
Low-resolution mode resolution	5750 (3000–7500)
Low-resolution mode wavelength coverage (Å)	3660–9590
High-resolution mode resolution	21000 (13000–25000)
High-resolution mode wavelength coverage (Å)	4040–4650, 4730–5450 5950–6850

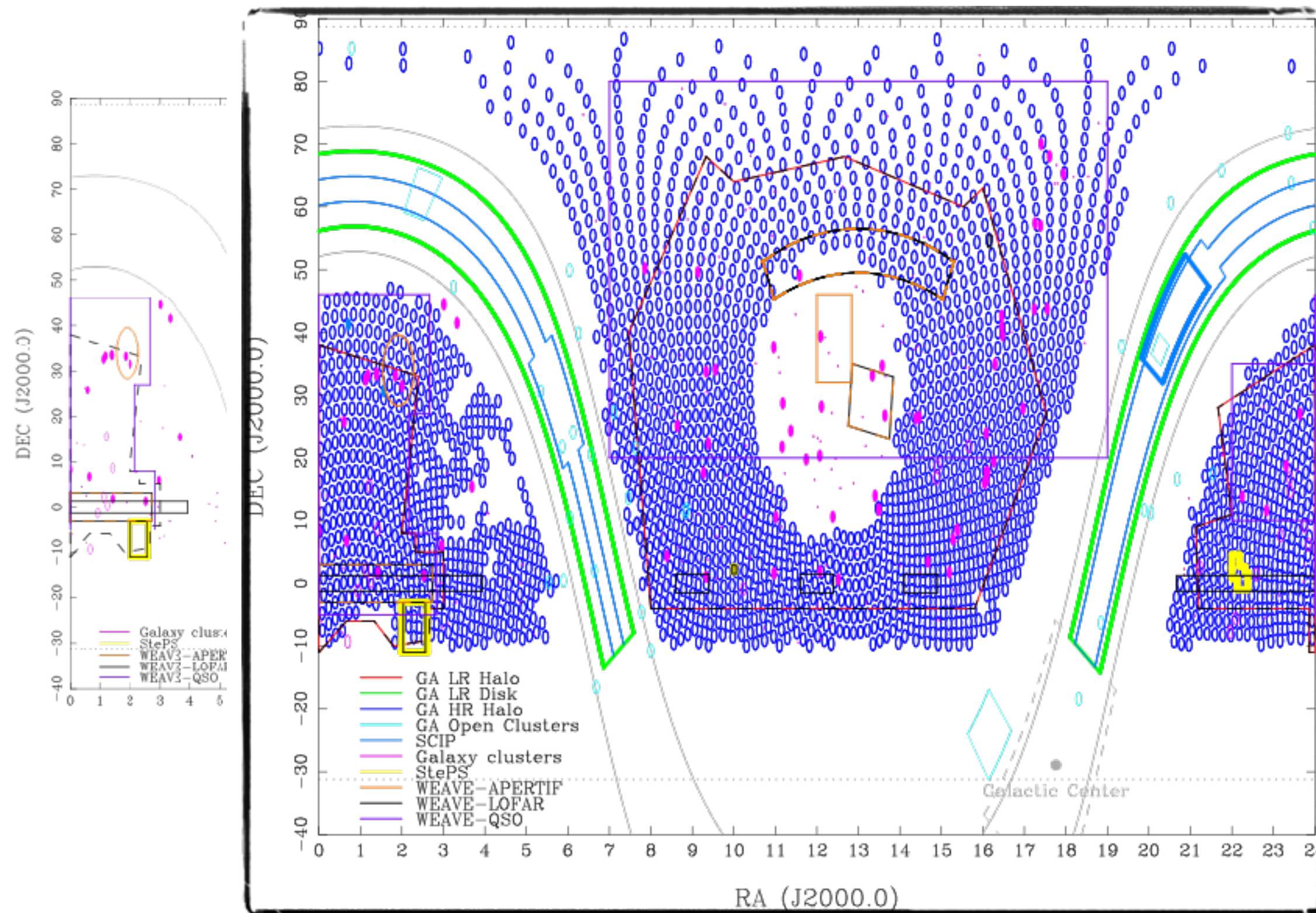


# The WEAVE Primary Science Surveys

- There are six primary science cases for WEAVE:
  - Galactic Archaeology
  - Stellar, Circumstellar, and Interstellar Physics
  - Galaxy Clusters
  - Galaxy Evolution (WEAVE-APERTIF + StePS)
  - WEAVE-LOFAR
  - WEAVE-QSOs



# Survey areas





# TNG TELESCOPIO NAZIONALE GALILEO

- LA PALMA, CANARY ISLANDS, LAT  $+29^{\circ}$
- 3.6M DIAM M1
- ACTIVE OPTICS ON M1+M2
- TURNABLE M3 TO FEED NASMYTH A AND B
- 4 INSTRUMENTS AVAILABLE ONLINE
- BENCH FOR EXPERIMENTS AND FUN





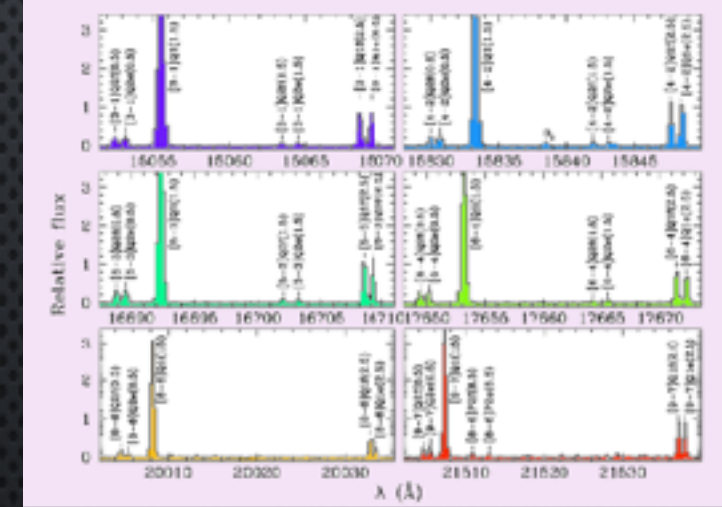
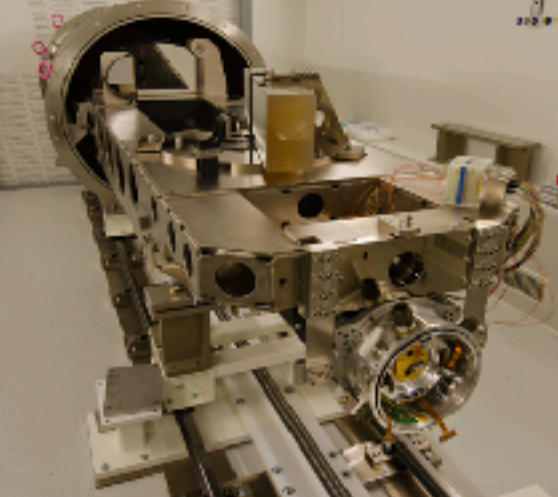
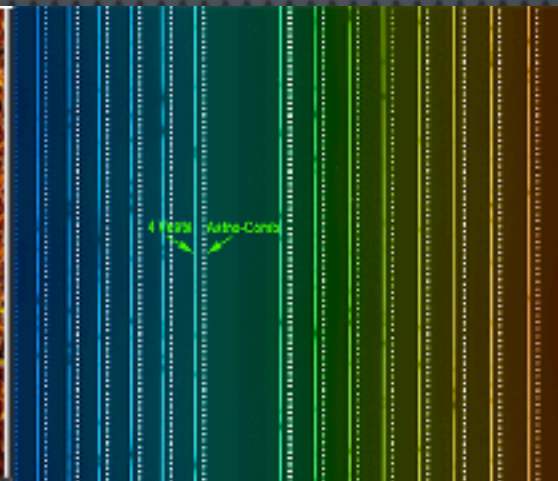
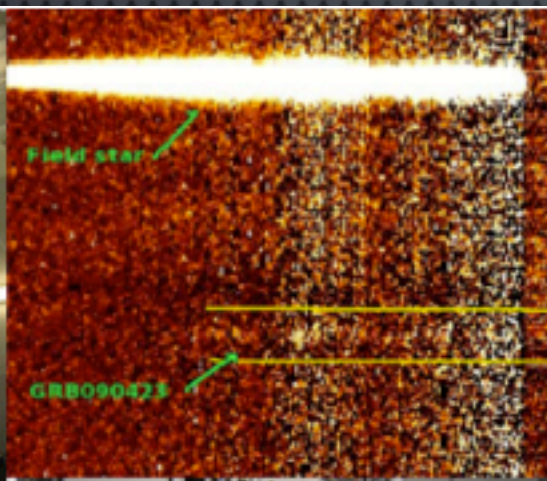


# DLR

# NCS

# HAN

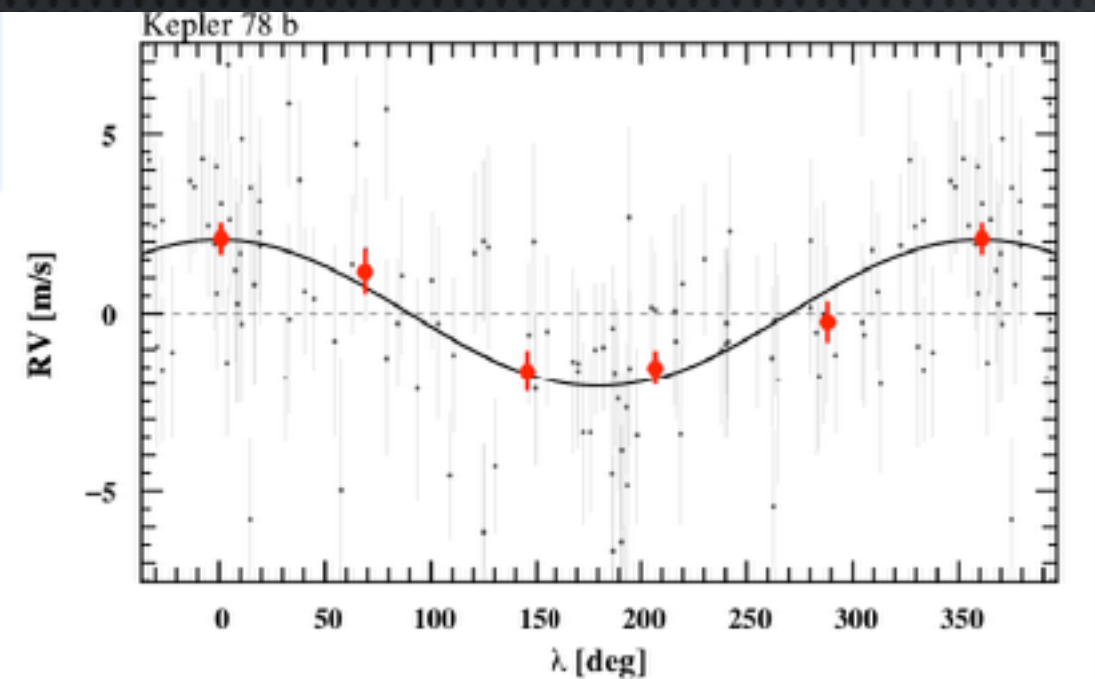
# GNO



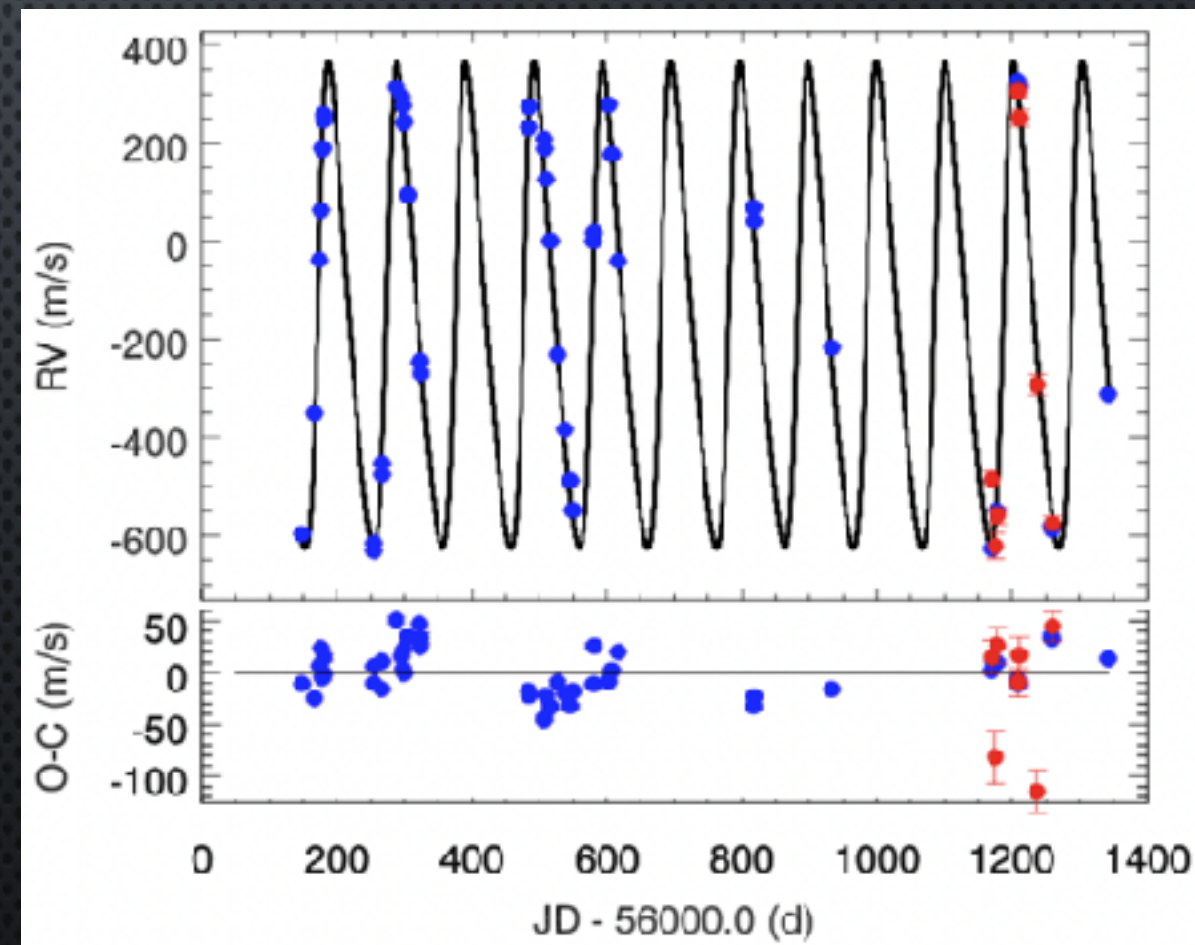


# TDA @ TNG (3): HARPS-N & GIANO-B, THE EXOPLANET MACHINES

- NEED TO COVER ALL THE ORBIT PHASES IN ORDER TO UNDERSTAND THE ARCHITECTURE OF THE PLANETARY SYSTEM



Pepe et al 2013  
Gonzalez et al 2016





# International time at Canary telescopes



Instituto de Astrofísica de Canarias - IAC

 Español |  English

ABOUT

OBSERVATORIOS DE CANARIAS

PROJECTS

INSTRUMENTATION

GRADUATE STUDIES

IAC TEC

EDUCATIONAL OUTREACH

GENERAL INFORMATION

SERVICES

## OBSERVATORIOS DE CANARIAS

### CCI and Agreements

#### 5% International Time

→ Night time

Day time

ITP Awards

Report on the use of 5%  
International Time

CCI meetings

FSC meetings

ORM-CSC Meetings

OT-CSC Meetings

### 5% International Time

#### Night time

The [2018-2019 call](#) is open and will close on February 28, 2018.

The application form is available here ([WORD docx Annex 1](#)) and should be submitted as a pdf to: [cci@iac.es](mailto:cci@iac.es)

#### Contact details for the telescopes in the ITP:

- Gran Telescopio Canarias (GTC), 1040 cm. ([Web](#))
- William Herschel Telescope (WHT), 420 cm. ([Web](#))
- Isaac Newton Telescope (INT), 250 cm. ([Web](#))
- Telescopio Nacional "Galileo" (TNG), 350 cm. ([Web](#))
- Mercator Telescope 120 cm. ([Web](#))
- Liverpool Telescope, 200 cm. ([Web](#))
- STELLA Robotic telescopes ([Web](#))

<http://www.iac.es/en.php?op1=5&lang=en>



# REM IN THE SOUTHERN EMISPHERE

- LA SILLA, CHILEAN ANDES, LAT  $-29^{\circ}$
- 0.6M DIAM M1
- 2 INSTRUMENTS AVAILABLE ONLINE AND AT THE SAME TIME
- G,R,I,Z',+ 1 IR FILTER (Z,J,H,K') AT THE SAME TIME
- OPEN TO PIGGY-BACKS

