



SHARK-NIR: Hunting for Exoplanets and Beyond

Tania Gomes Machado

on behalf of the SHARK-NIR team

28th June 2024



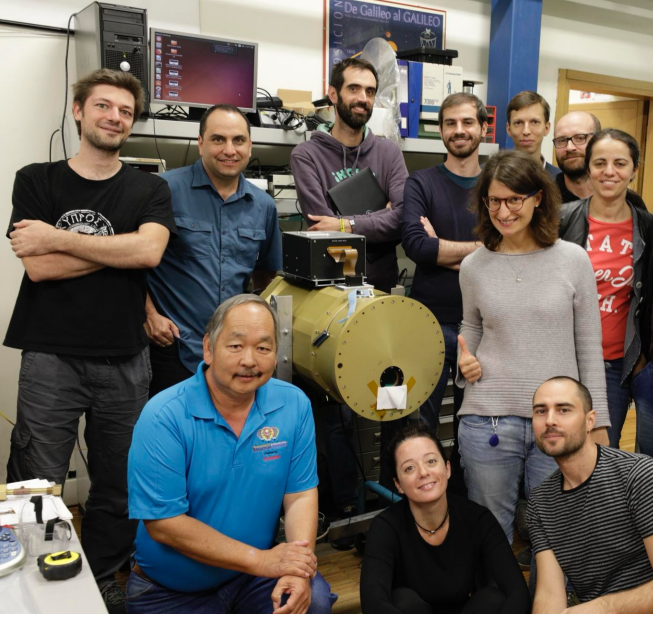
THE UNIVERSITY OF ARIZONA
COLLEGE OF SCIENCE

Astronomy
& Steward Observatory

THE Padova SHARK-NIR TEAM



- ✓ **PI:** J. Farinato
- ✓ **System Engineer:** V. Viotto
- ✓ **Project Manager:** M. Bergomi
- ✓ **Optical design:** D. Greggio, D. Magrin
- ✓ **Mechanical design:** Tomelleri Srl with a local interface: L. Marafatto
- ✓ **Procurement:** M. Bergomi, D. Greggio, D. Vassallo, V. D'Orazi, L. Marafatto, S. Chinellato
- ✓ **AIV Team:** L. Marafatto, F. Biondi, E. Carolo, L. Lessio, G. Umbriaco, M. Bergomi, J. Farinato, M. Dima, D. Greggio, D. Vassallo, K. Radhakrishnan
- ✓ **SW Team:** M. De Pascale, A. Baruffolo, D. Ricci, F. Laudisio, A. Lorenzetto, B. Salasnich, D. Fantinel
- ✓ **Data reduction:** D. Mesa, E. Carolo, D. Vassallo
- ✓ **Coronagraphic performance & simulation:** D. Vassallo, E. Carolo, B. Bottazzi Baldi
- ✓ **Science Team:** D. Mesa, V. D'Orazi, D. Barbato, C., C. Lazzoni, R. Gratton, S. Desidera
- ✓ **Comissioning Team:** J. Farinato, L. Marafatto, M. Bergomi, A. Carlotti, E. Carolo, P. Cerpelloni, S. Di Filippo, M. Dima, V. D'Orazi, D. Greggio, F. Laudisio, L. Lessio, A. Lorenzetto, T. Machado, D. Mesa, D. Ricci, G. Rodeghiero, G. Umbriaco, D. Vassallo



THE SHARK-NIR CONSORTIUM



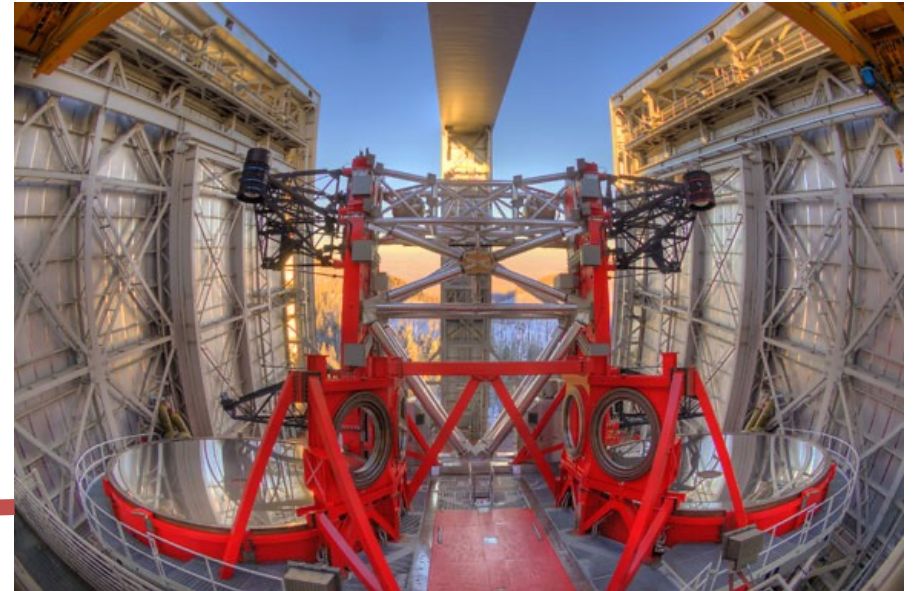
- ✓ **Steward Observatory** (LBTI interfaces, NIR camera sub-system)
- ✓ **MPIA** (Motors electronics and SW design support)
- ✓ **IPAG** (Coro mask design)
- ✓ **INAF-Brera** (Dispersive elements design)
- ✓ **INAF-Trieste** (Data archiving)
- ✓ **INAF-Arcetri** (AO Interface)
- ✓ **INAF-Roma** (Synergy with VIS Channel)
- ✓ **INAF- Padova** (see next slide)
- ✓ **Science team** (astronomers from 12 institutes, coordinated by Valentina D'Orazi)

WHAT IS SHARK-NIR?



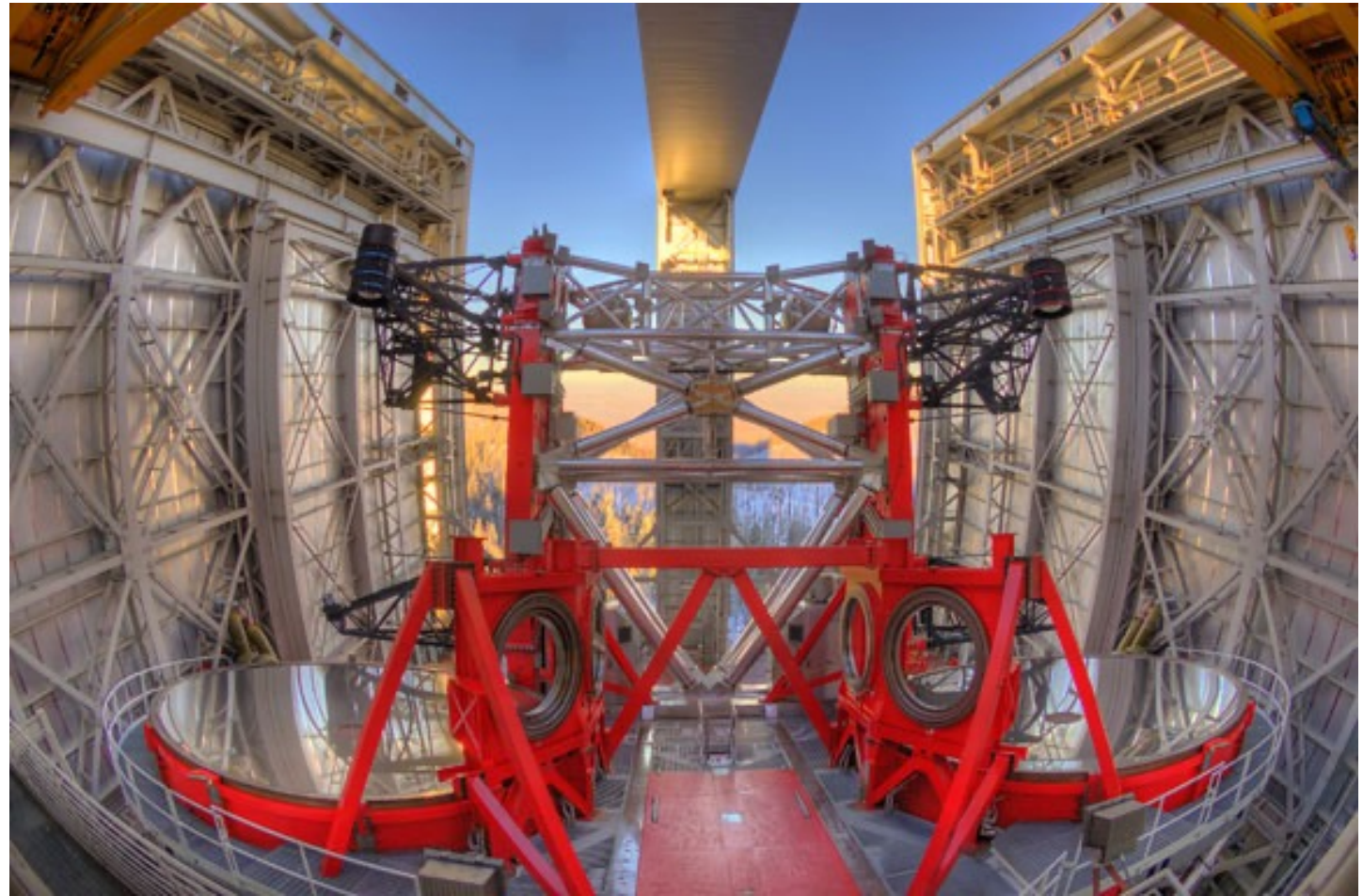
System for coronagraphy with **H**igh order **A**daptive **O**ptics from **R** to **K** bands - **N**ear **I**nfra**R**ed

- Coronagraphic camera with also a spectroscopic channel (LSS), mainly dedicated to detection and characterization of exoplanets
- Takes advantage of the extreme adaptive optics correction of **SOUL**, allowing high resolution and contrast for direct imaging

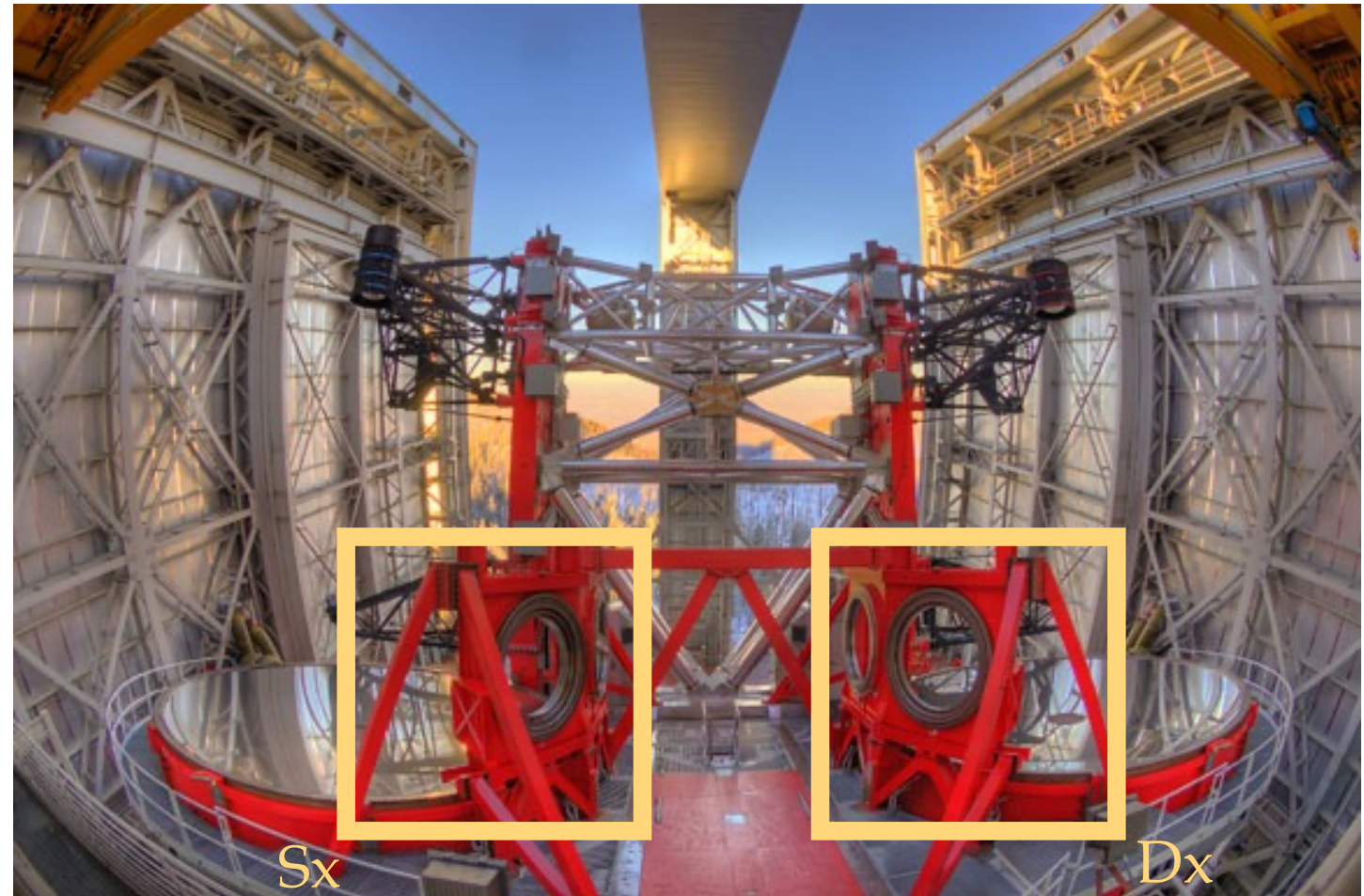


Large Binocular Telescope
Mount Graham, Arizona

WHERE IS SHARK-NIR?



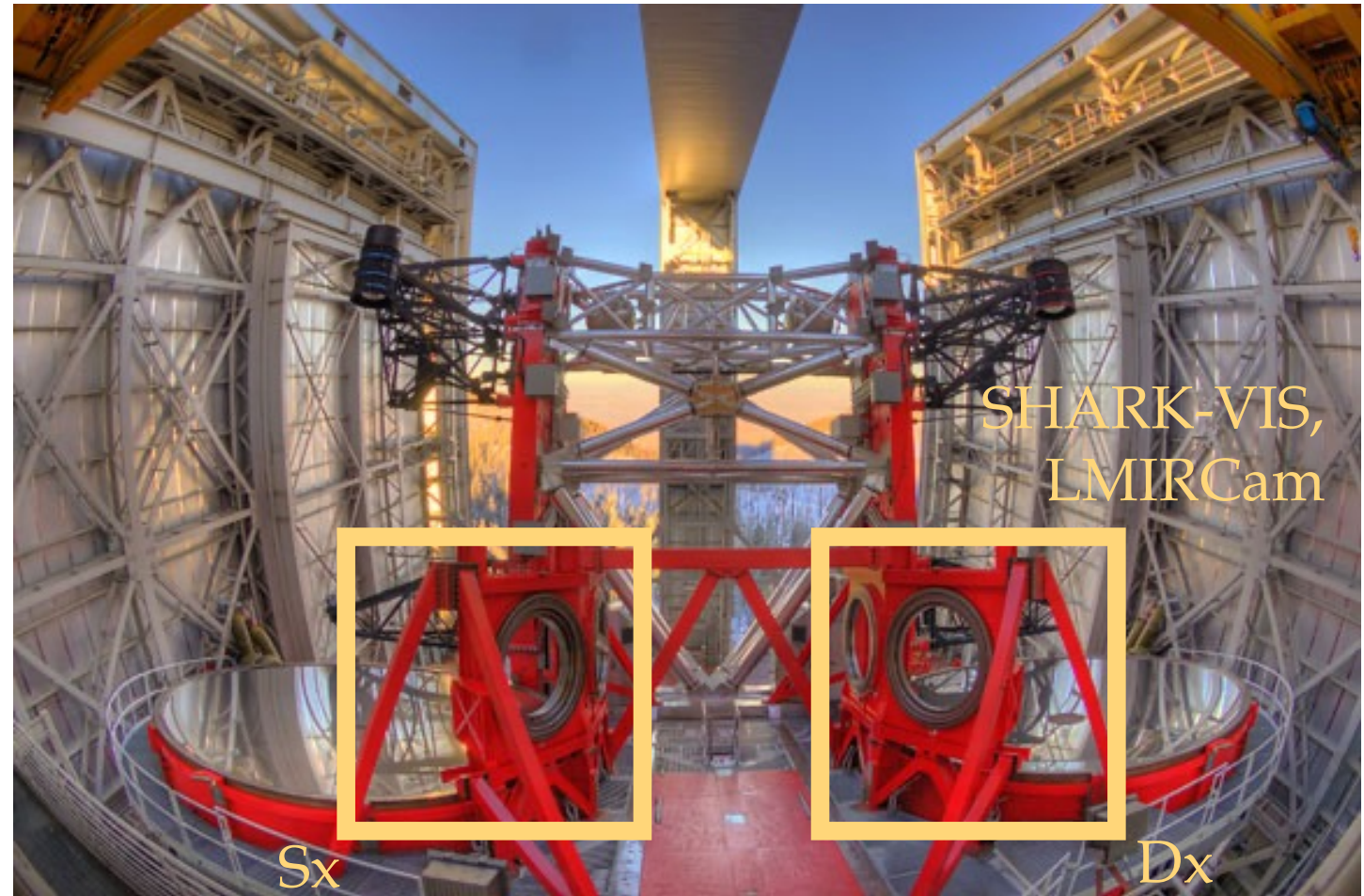
WHERE IS SHARK-NIR?



Sx

Dx

WHERE IS SHARK-NIR?

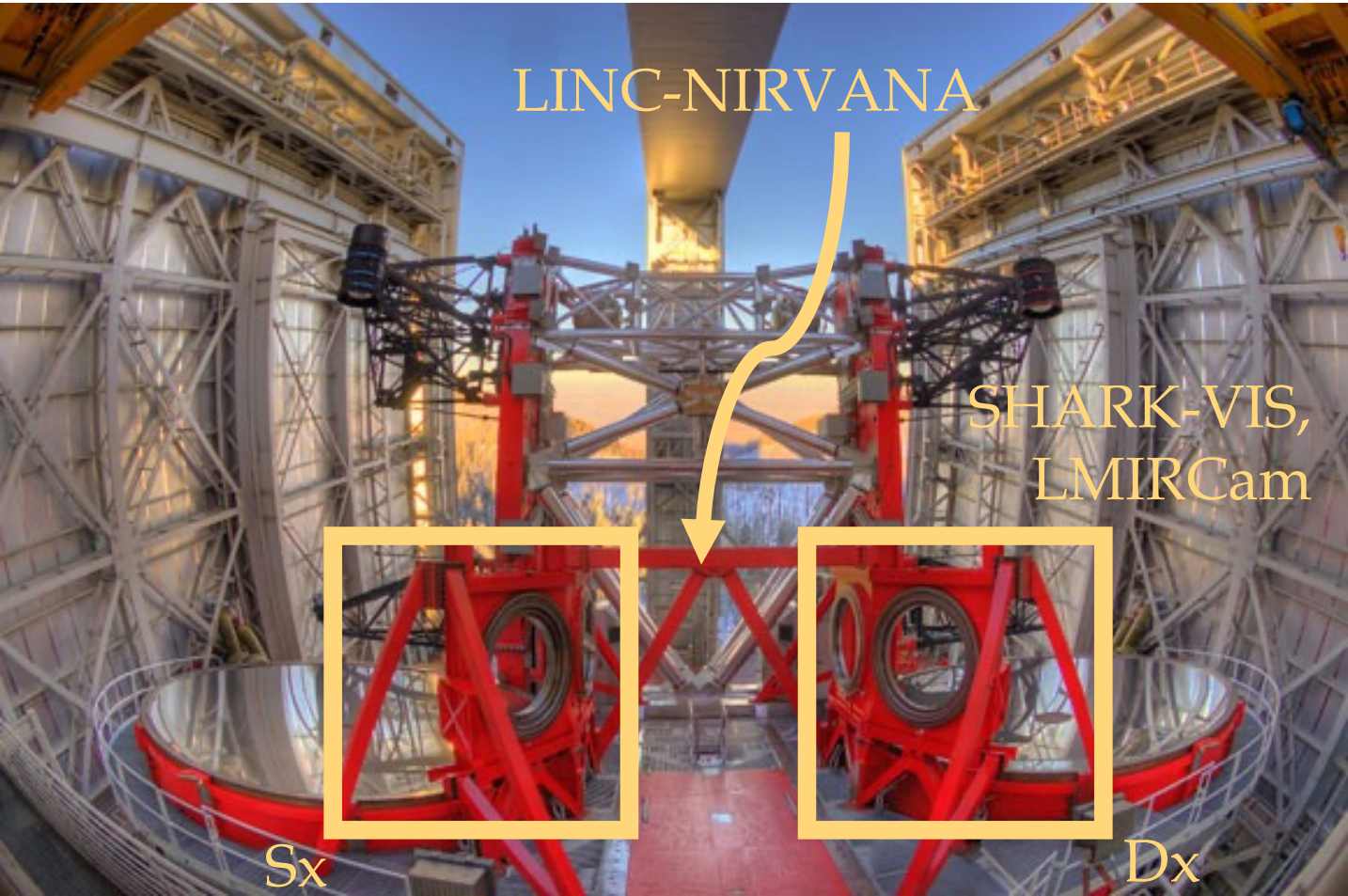


SHARK-VIS,
LMIRCam

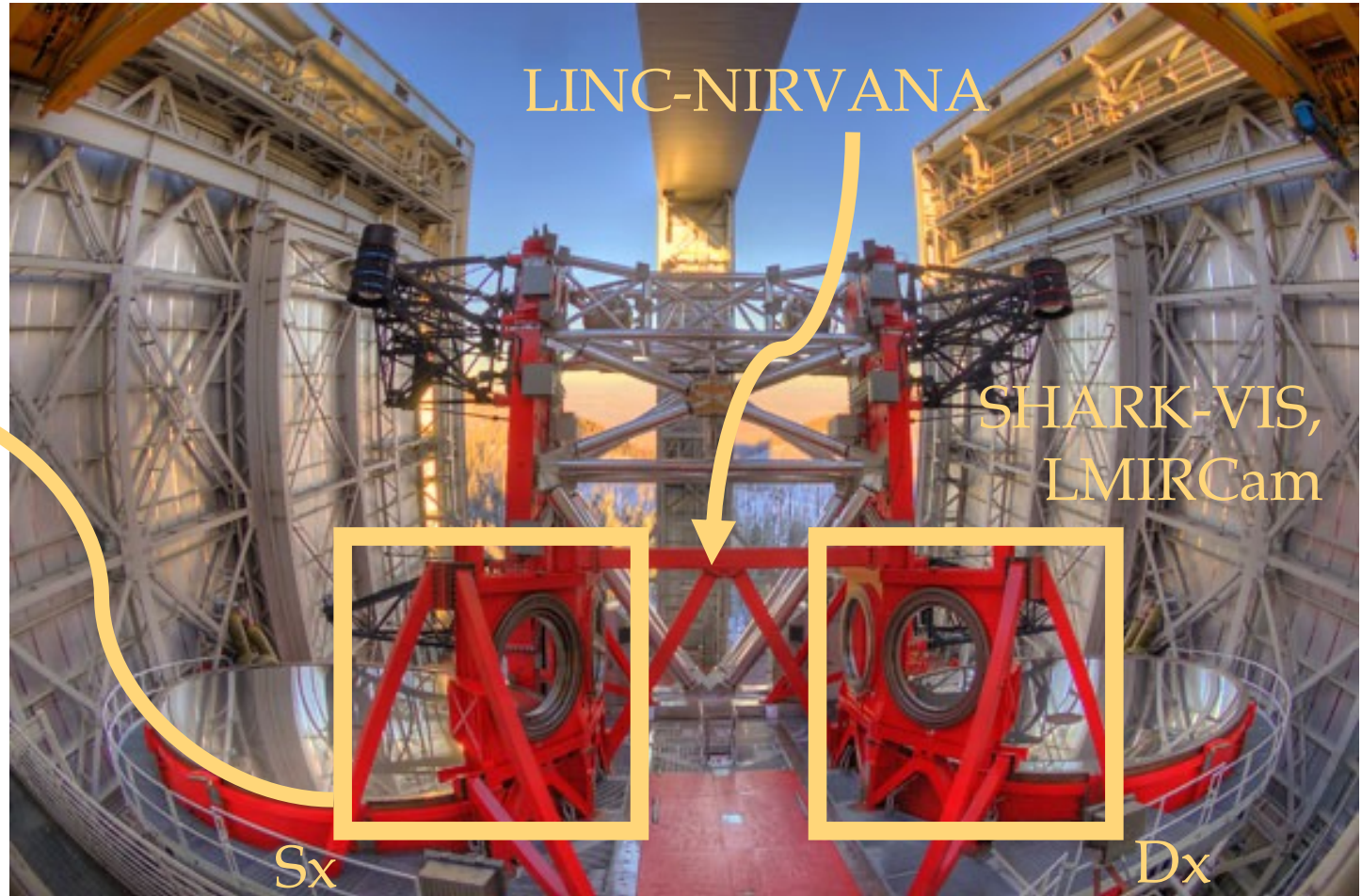
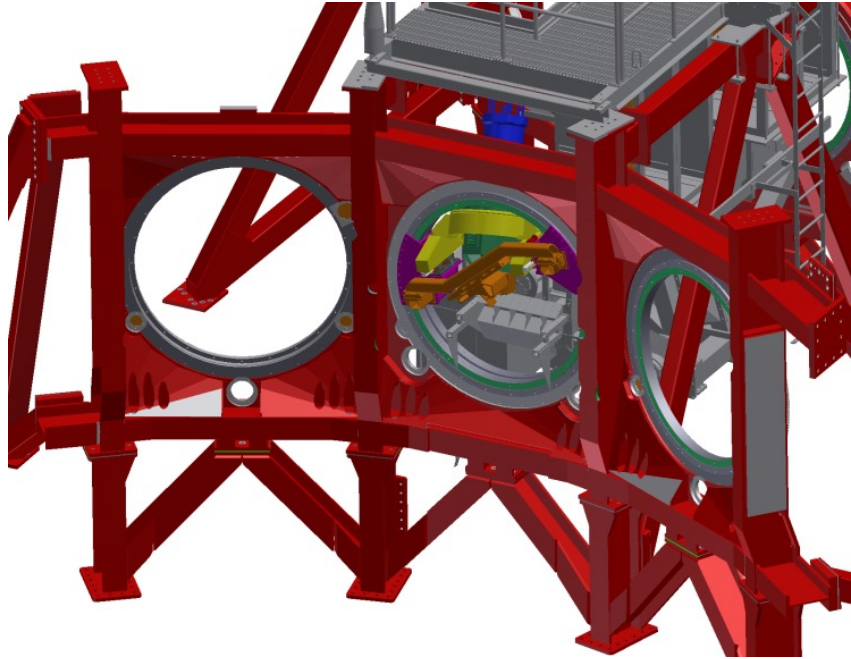
Sx

Dx

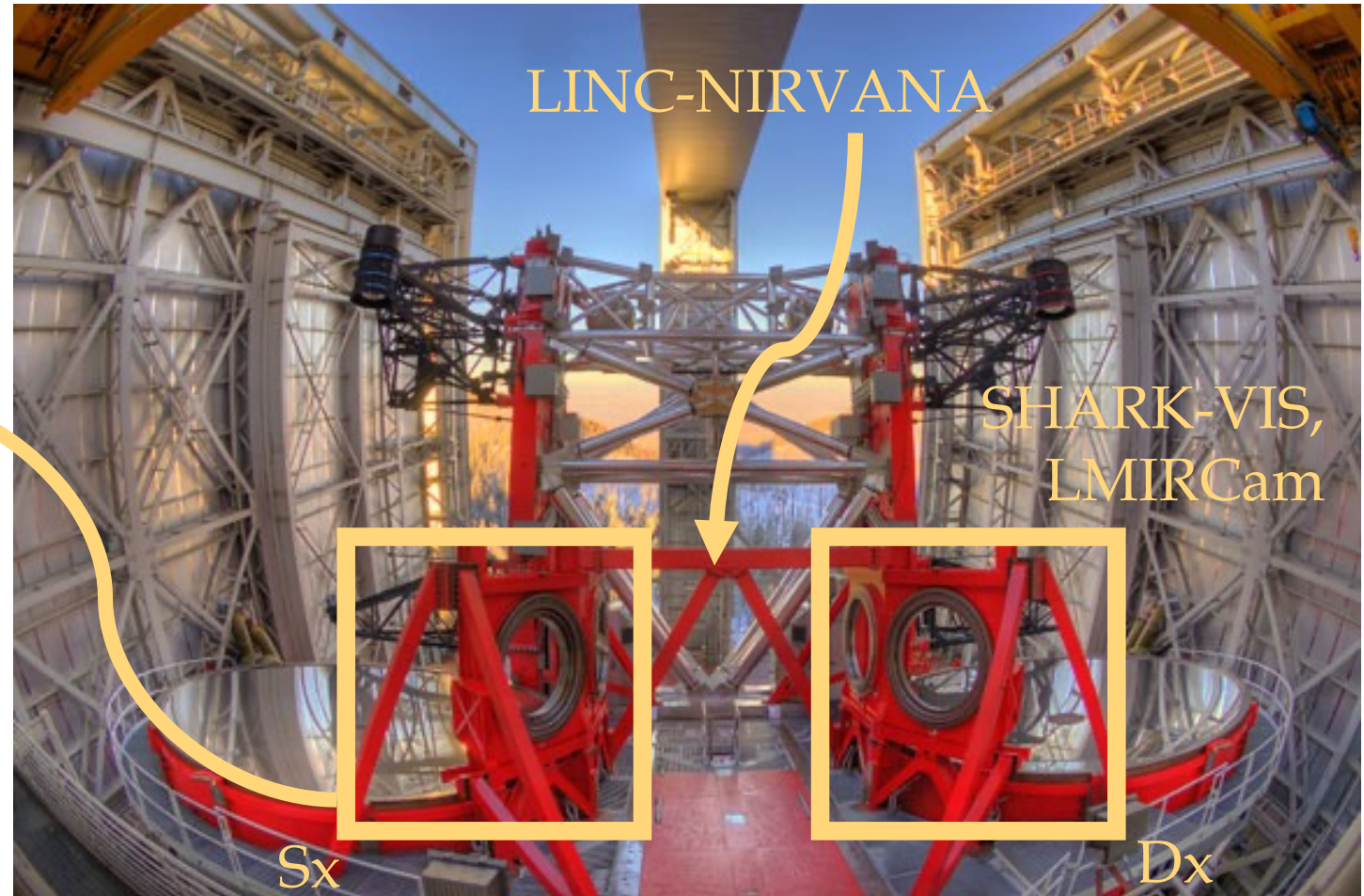
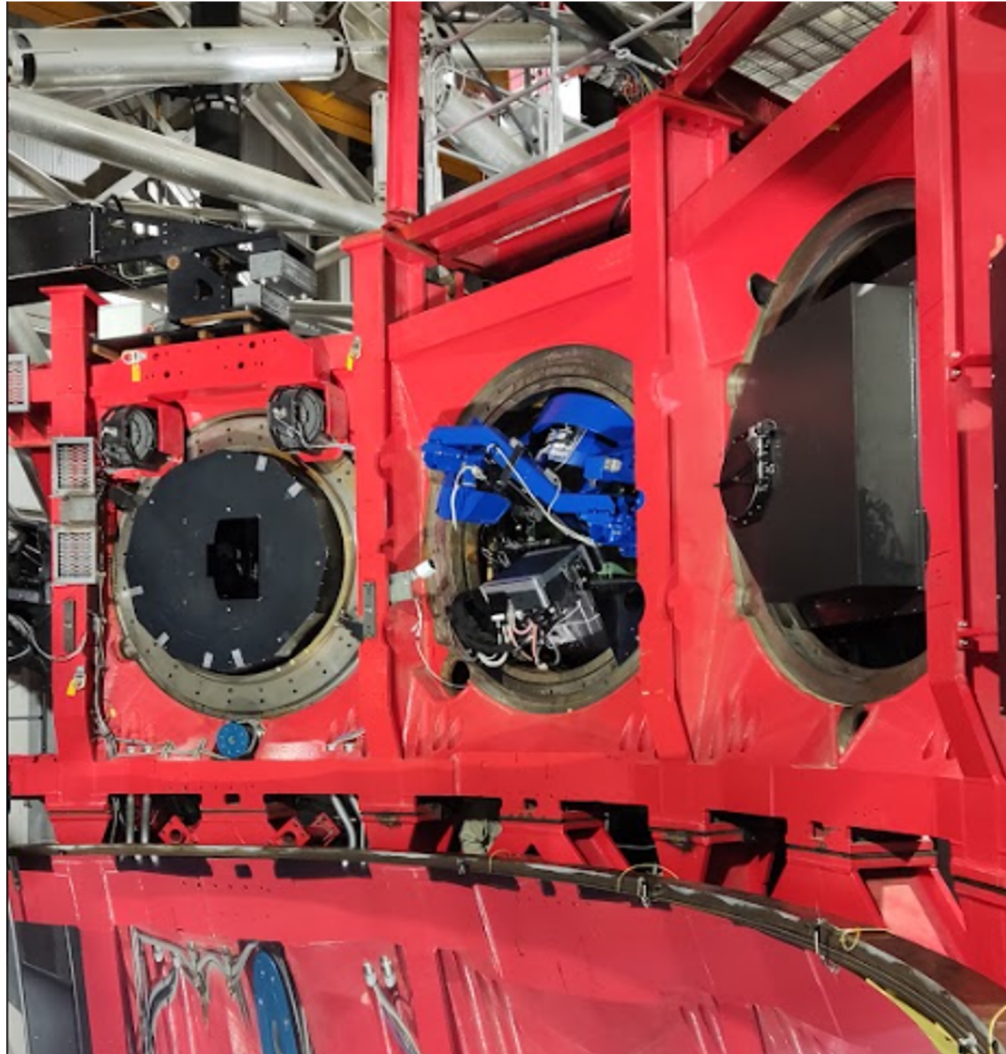
WHERE IS SHARK-NIR?



WHERE IS SHARK-NIR?



WHERE IS SHARK-NIR?



HOW DID SHARK-NIR END UP AT LBT?



2014 Feb LBTO Call for proposal for second generation instruments



Farinato et al. 2014

HOW DID SHARK-NIR END UP AT LBT?



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2016 Feb. Conceptual Design Review end

2017 Jan. Final Design Review

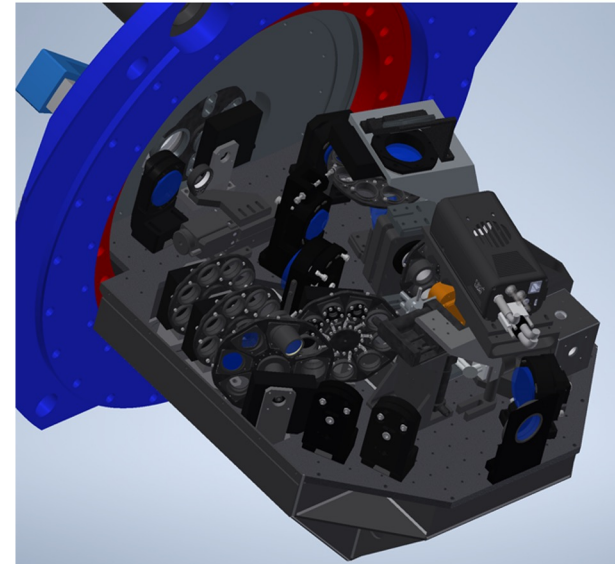
2017 Jul. Board approval

2017 Aug. Start of procurement phase

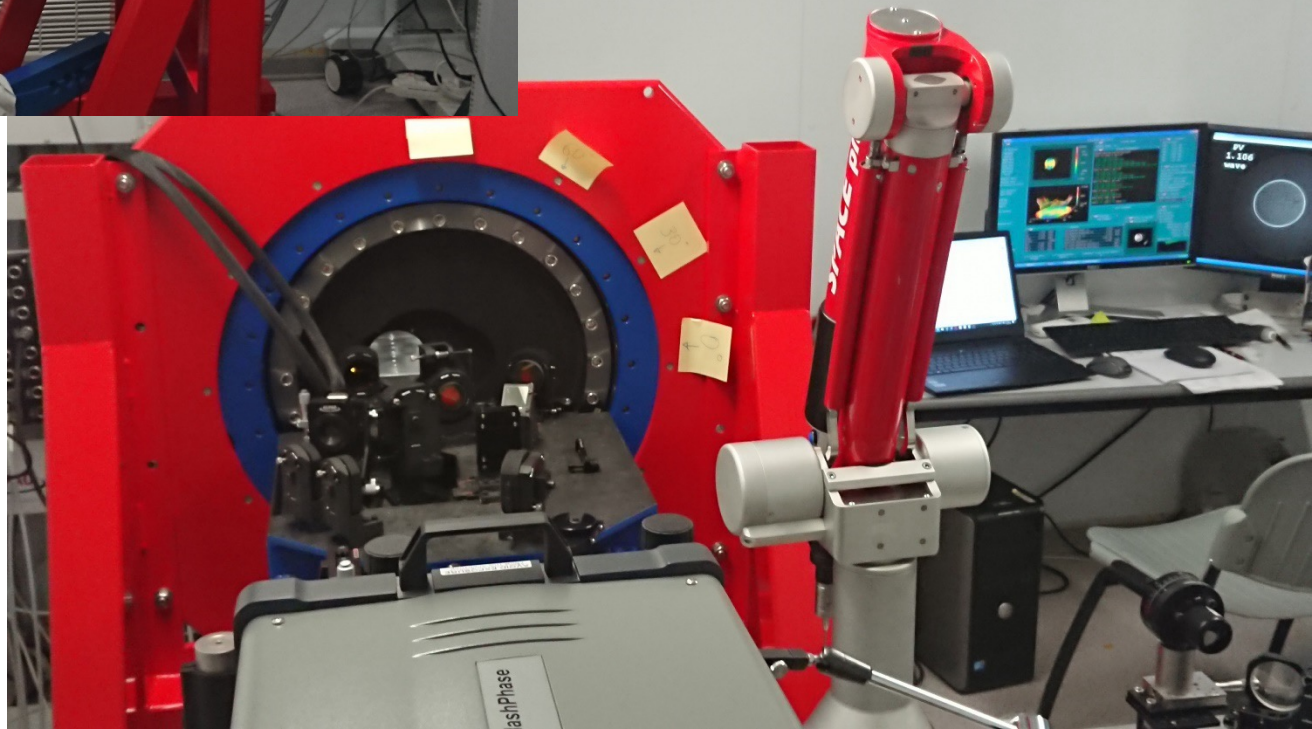
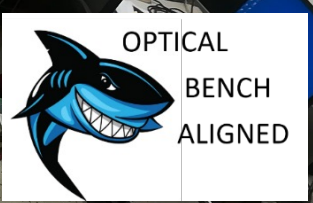
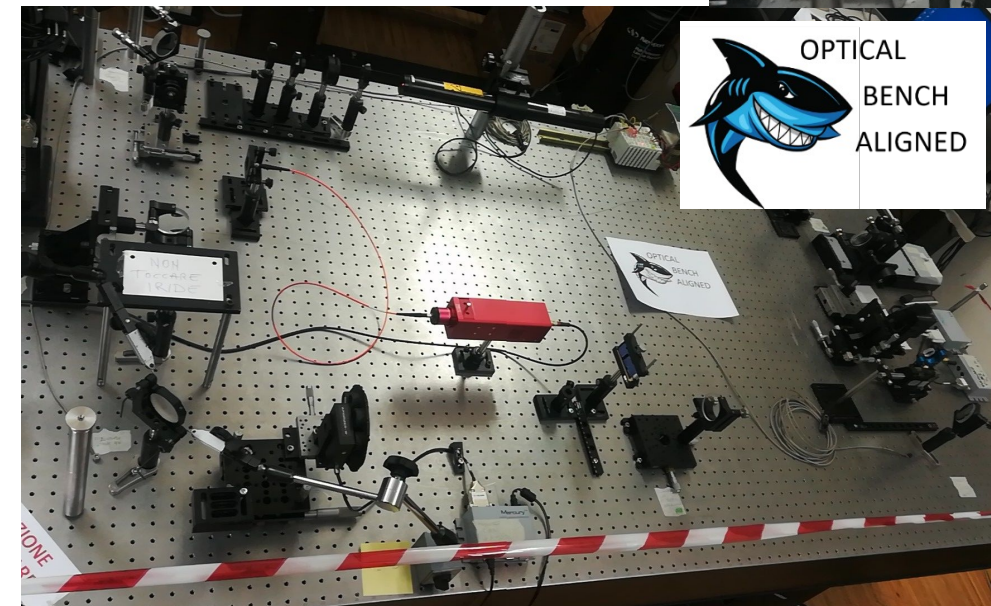
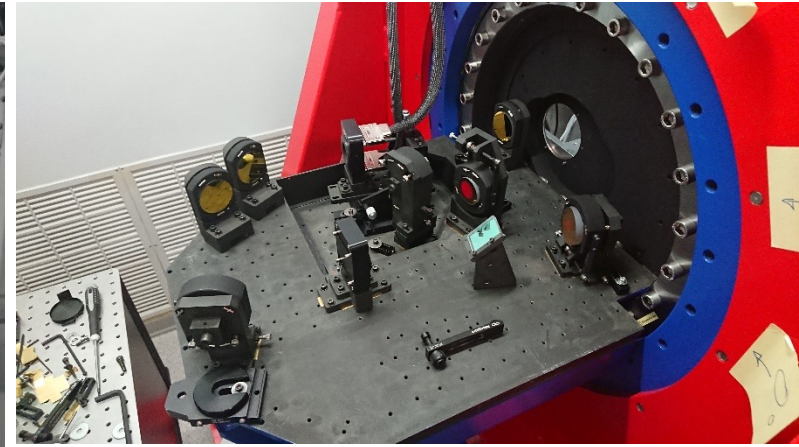
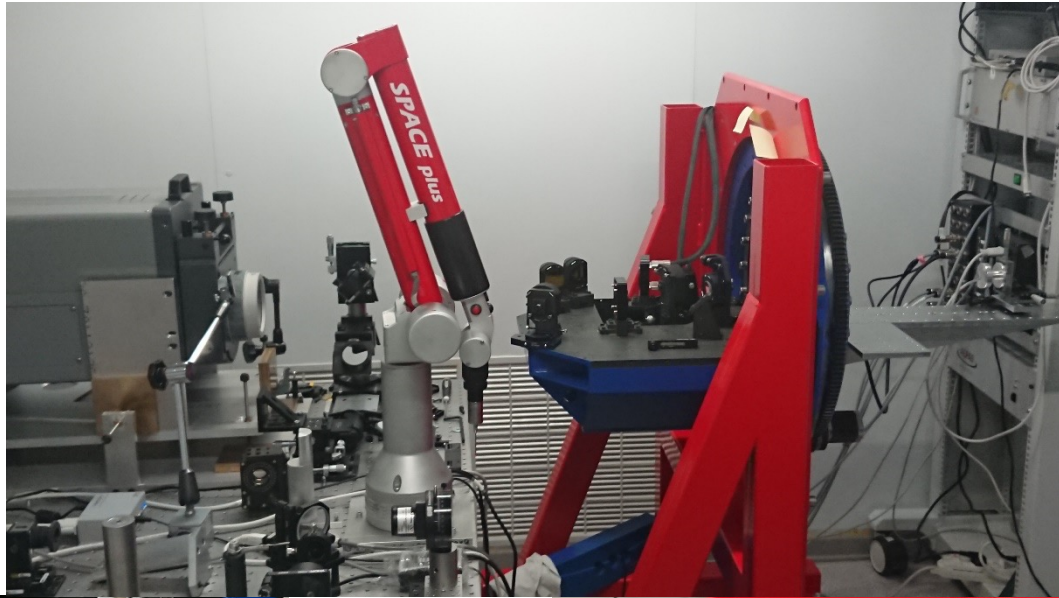
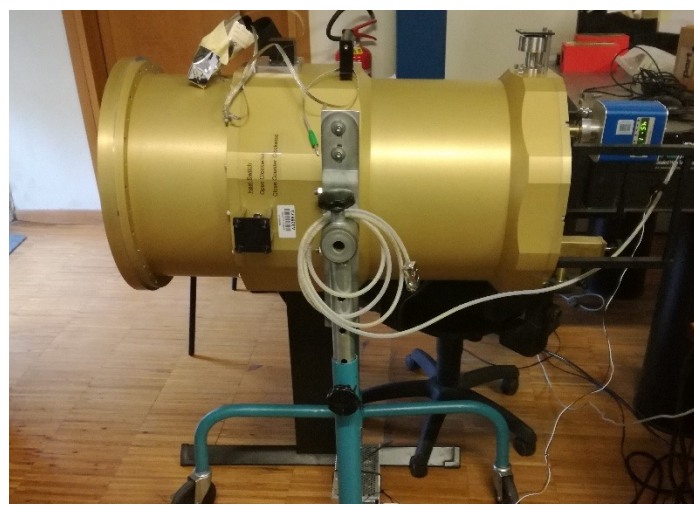
2017 Nov. Start of AIV phase with component tests

COVID

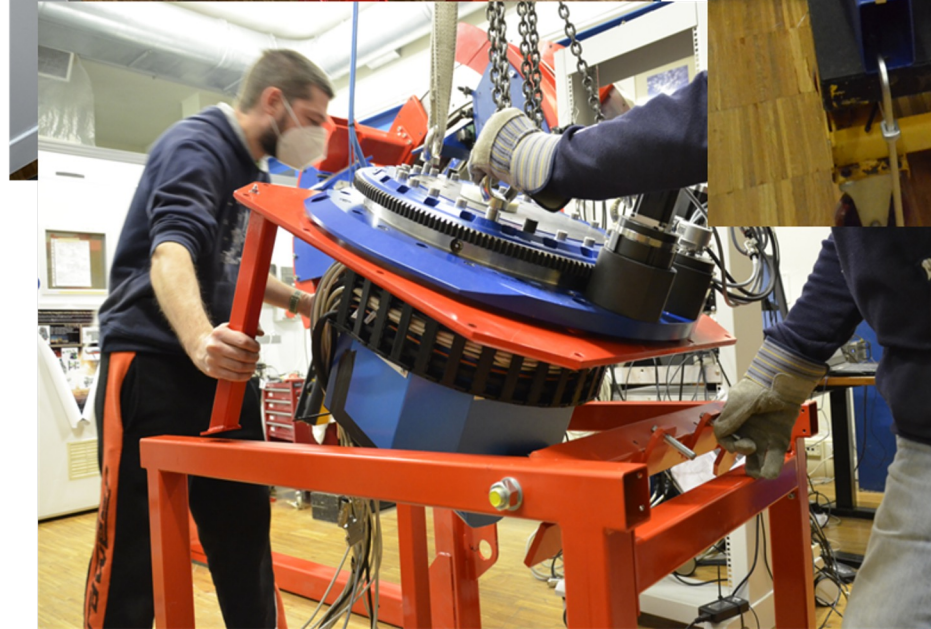
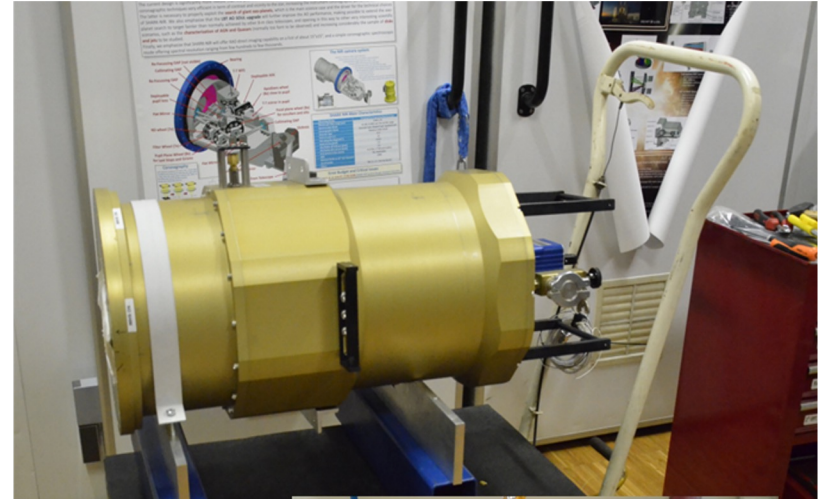
2022 Feb. End of AIV phase



AT THE CLEAN ROOM AND LABS AT PADOVA



AT THE LABORATORY AT PADOVA



HOW DID SHARK-NIR END UP AT LBT?



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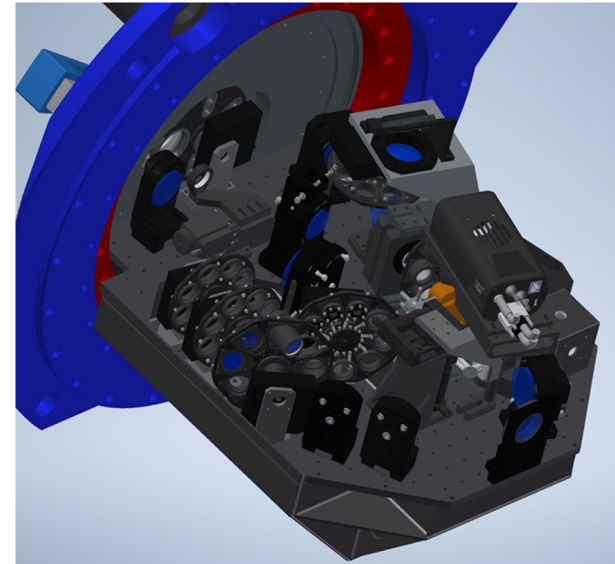
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2022 Feb. End of AIV phase

2022 Jun. Shipping of the instrument



READY FOR SHIPPING



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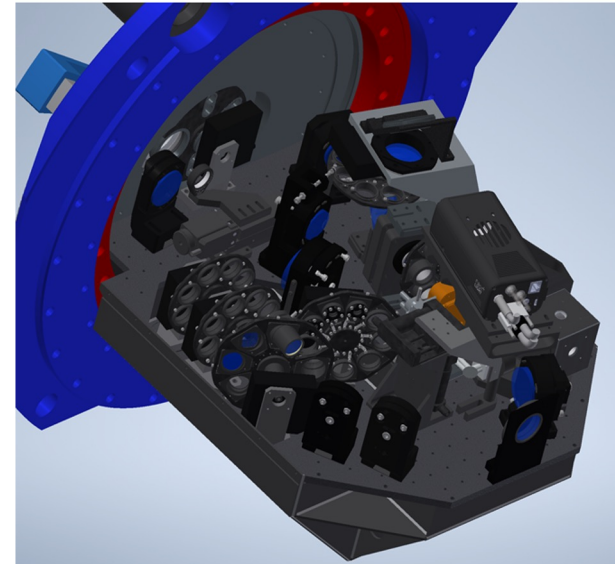
COVID

2022 Feb. End of AIV phase

2022 Jun. Shipping of the instrument

2022 Jun. Arrival at the telescope

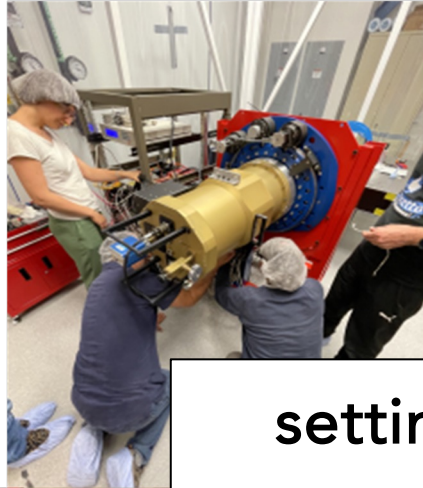
2022 Jul. Pre-com-1: Ready for installation at the telescope



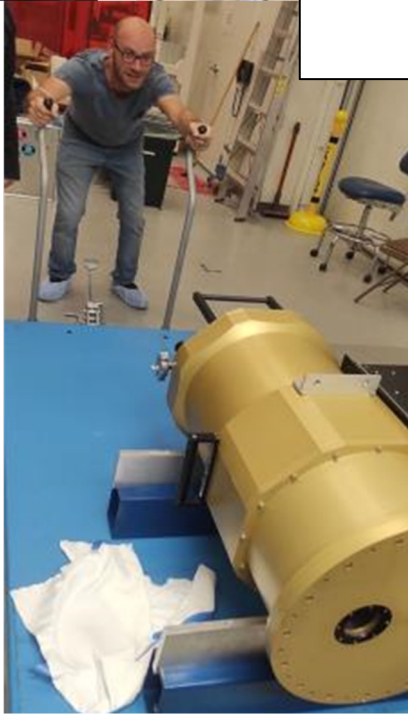
PRE-COM-1



unpacking



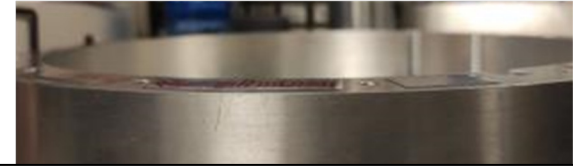
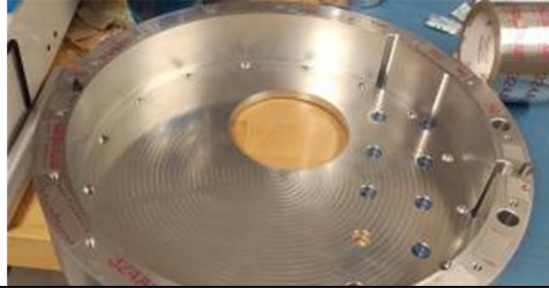
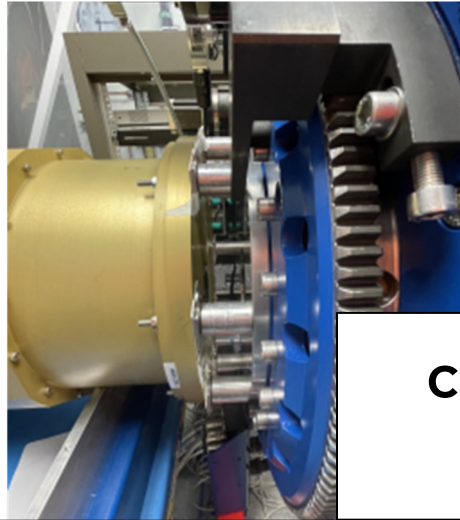
setting up the SCICAM in the clean tent lab



PRE-COM-1

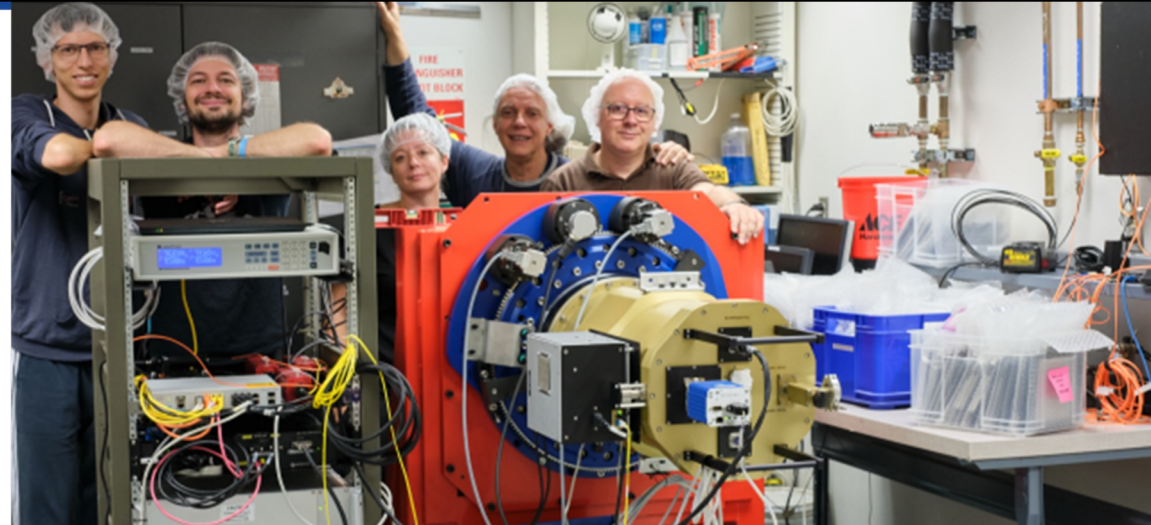


cleaning



checking the best focus for the SCICAM and preparing the shims

storing the boxes and resting on them!



SHARK-NIR re-integrated and working in the lab!

HOW DID SHARK-NIR END UP AT LBT?



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2022 Feb. End of AIV phase

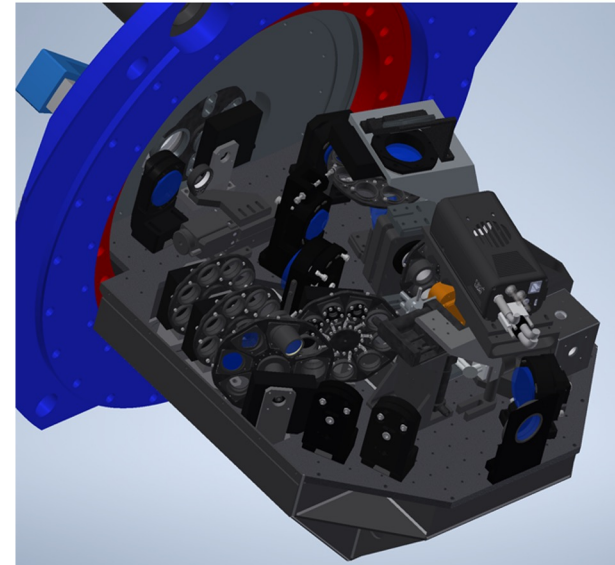
2022 Jun. Shipping of the instrument

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2022 Jul. Pre-com-1: Ready for installation at the telescope

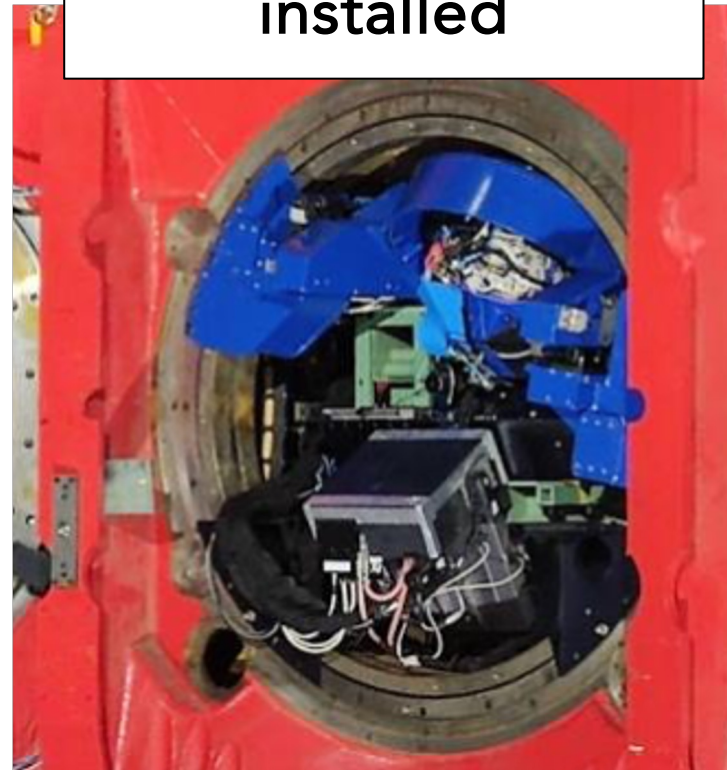
2022 Oct Pre-com-2: Installation at the telescope and alignment

2022 Nov Pre-com-3: Operations pre on-sky





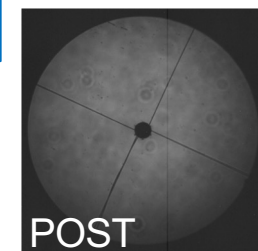
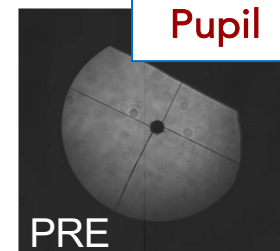
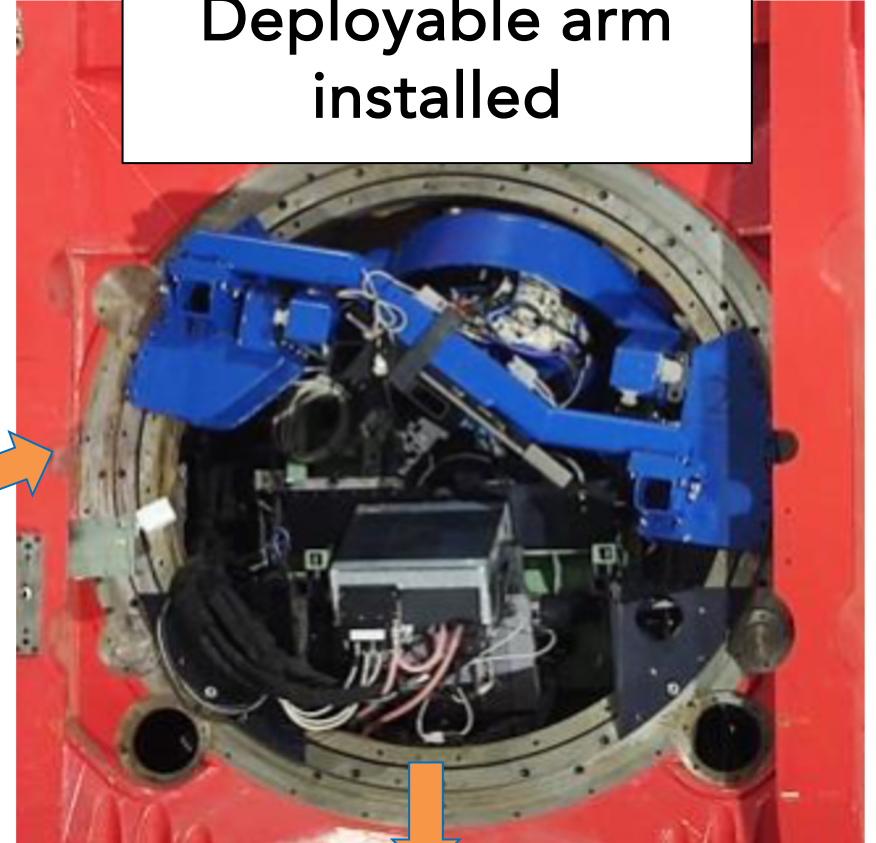
SHARK-NIR bench
installed



SCICAM
installed..!



Deployable arm
installed



SN Aligned



HOW DID SHARK-NIR END UP AT LBT?



A lot of hard blood sweat and tears after...

SHARK-NIR is on-sky: Commissioning phase



HOW DID SHARK-NIR END UP AT LBT?

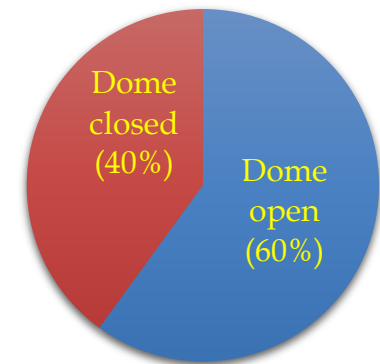


A lot of hard blood sweat and tears after...

SHARK-NIR is on-sky: Commissioning phase

- SHARK-NIR **first light on January 6, 2023**
- 4 commissioning runs in 2023 (16.5 nights in total)
- Overall, ~10 nights of open dome over 16.5 (only ~3 with a seeing of about ~1"-1.2")

ALMOST ALL FORESEEN ACTIVITIES (NO DB)
HAVE BEEN SUCCESSFULLY PERFORMED



HOW DID SHARK-NIR END UP AT LBT?



A lot of hard blood sweat and tears after...

SHARK-NIR is on-sky: Early Science Verification



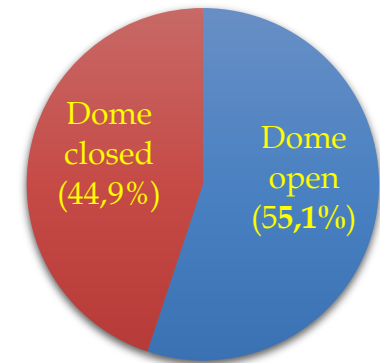
HOW DID SHARK-NIR END UP AT LBT?



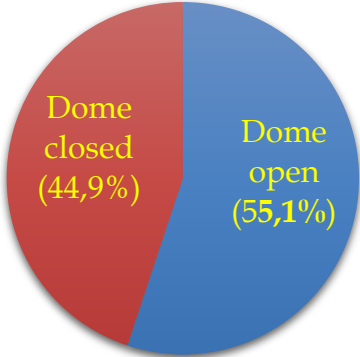
A lot of hard blood sweat and tears after...

SHARK-NIR is on-sky: Early Science Verification

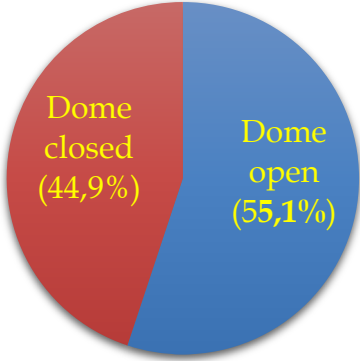
- 4 early science runs in 2023-2024 (20.5 nights in total)
- Overall, ~11.3 nights of open dome (only ~4.3 with a seeing of about $<1''$)



HOW DID SHARK-NIR END UP AT LBT?



HOW DID SHARK-NIR END UP AT LBT?



HOW TO OPERATE WITH SHARK?

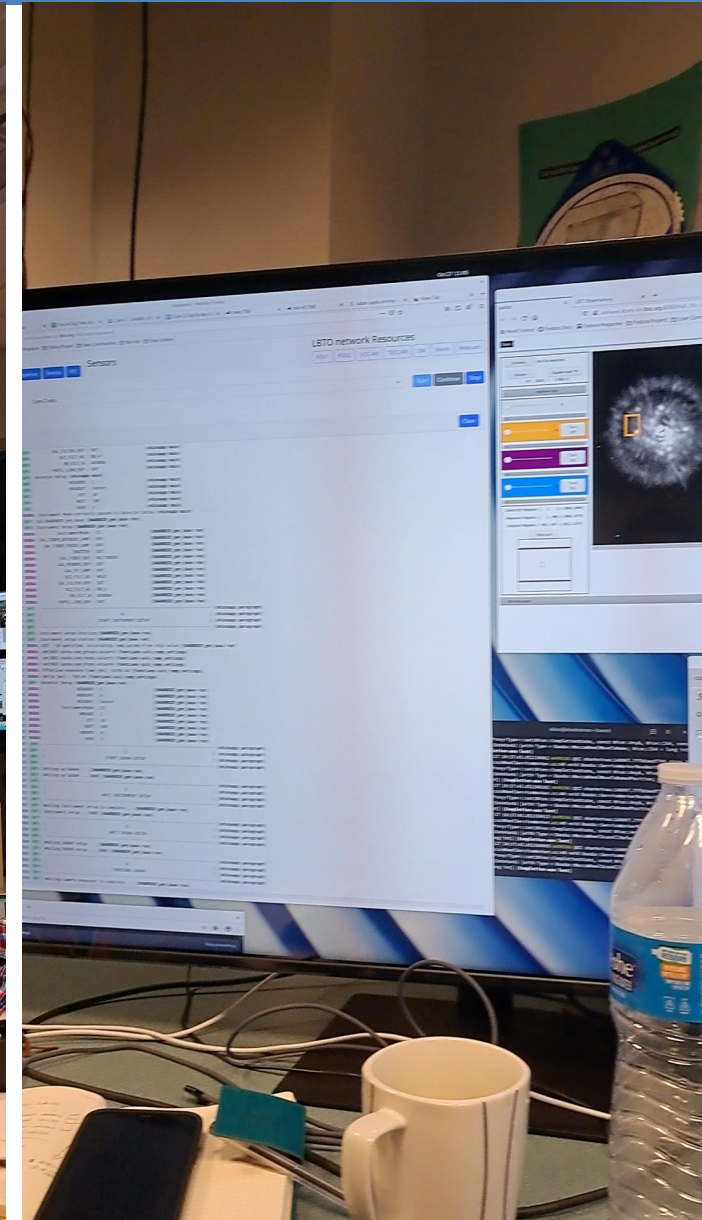


1. Get time on LBT
2. Choose your science targets
3. Gather the team: astronomer, softwarista, operator, extra help
4. Take the plane (or stay at Sala della Madonna)

HOW TO OPERATE WITH SHARK?



1. Get time on LBT
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4. Take the plane (or stay at Sala della Madonna)
5. Open all necessary instrument screens



HOW TO OPERATE WITH SHARK?

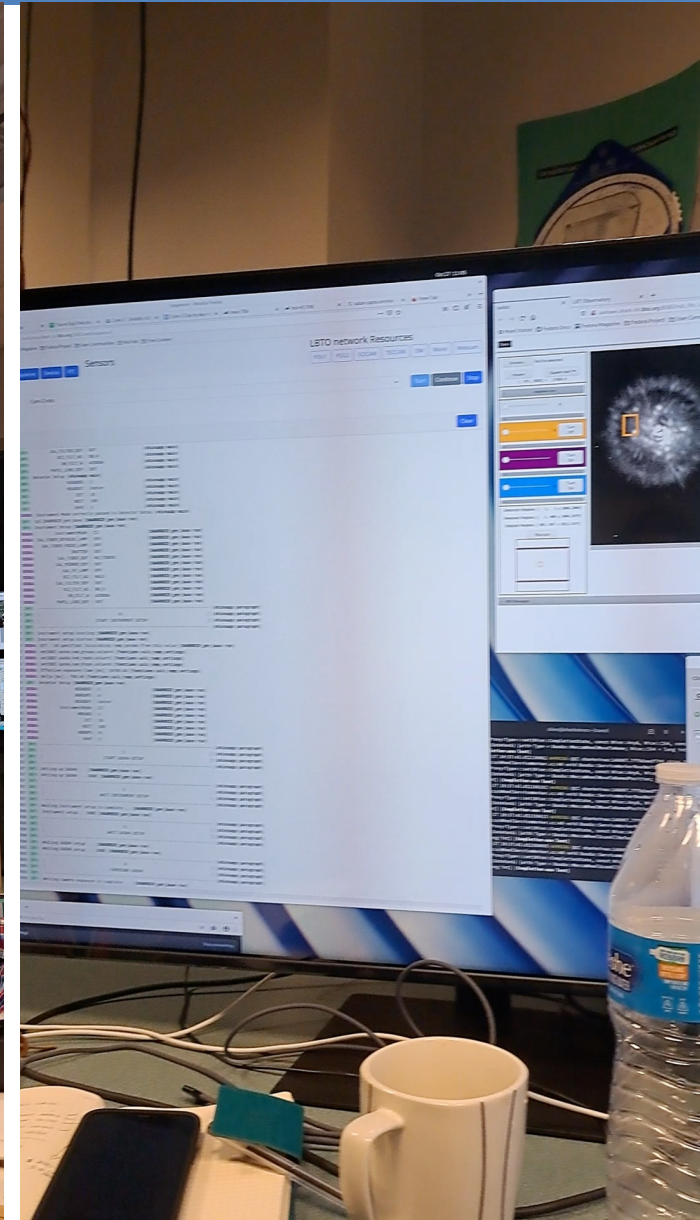


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5. Open all necessary instrument screens
6. Follow the instructions



Operate with SHARK: scheme

File Modifica Visualizza Inserisci



HOW TO OPERATE WITH SHARK?



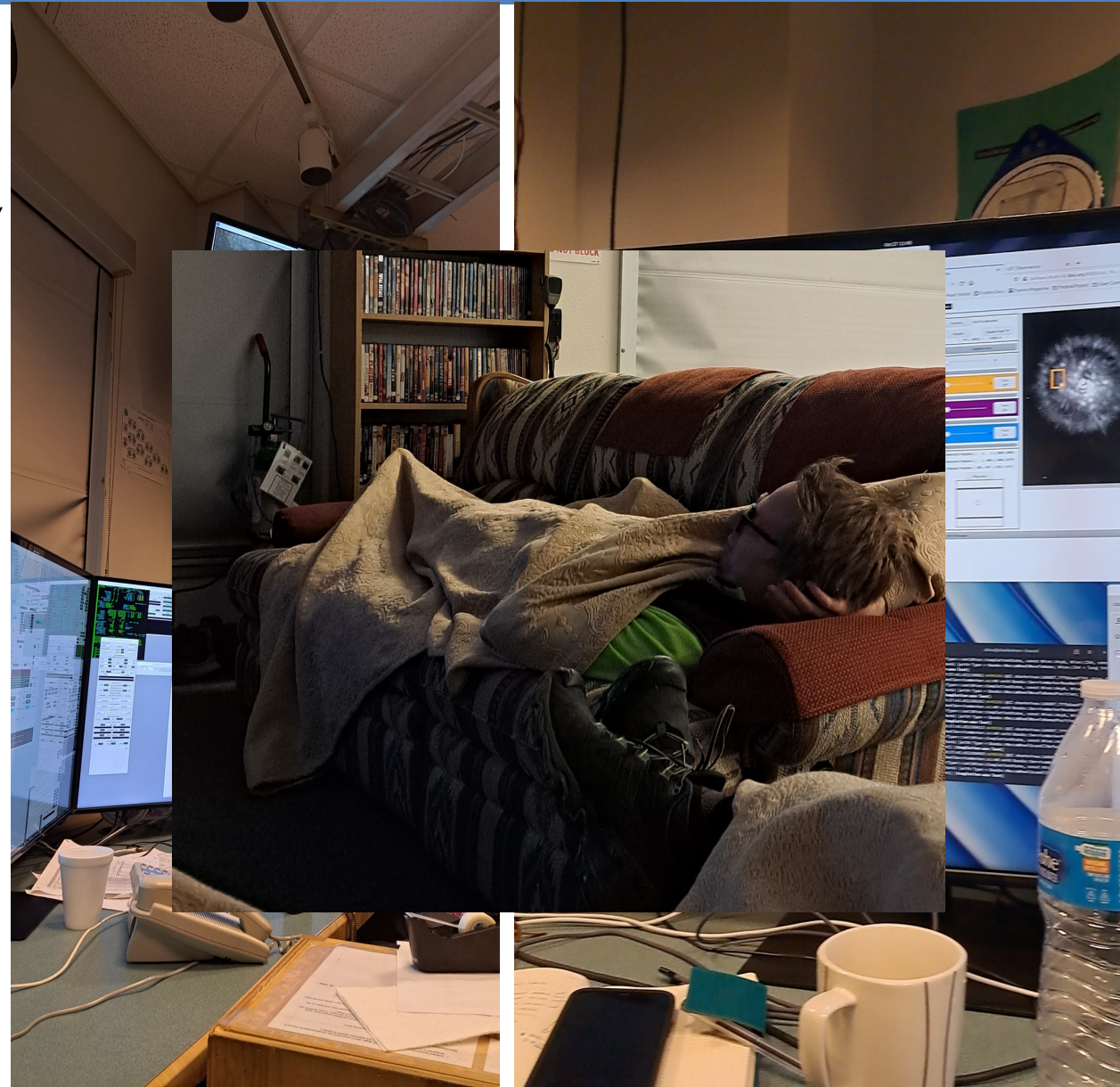
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Operate with SHARK: scheme

File Modifica Visualizza Inserisci

7. Pray for good seeing, low wind, no snow



HOW TO OPERATE WITH SHARK?



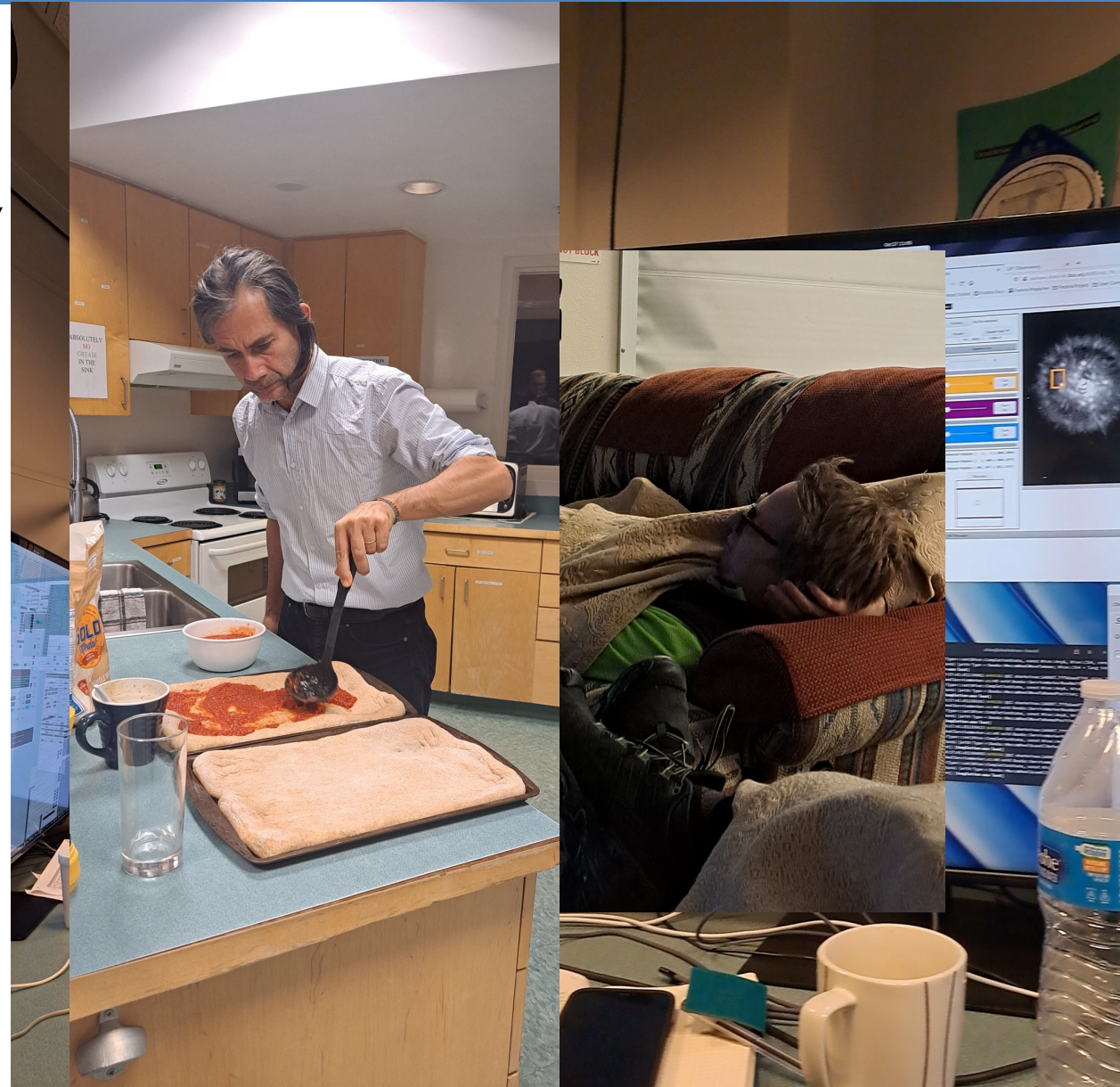
1. Get time on LBT
2. Choose your science targets
3. Gather the team: astronomer, softwarista, operator, extra help
4. Take the plane (or stay at Sala della Madonna)
5. Open all necessary instrument screens
6. Follow the instructions



Operate with SHARK: scheme

File Modifica Visualizza Inserisci

7. Pray for good seeing, low wind, no snow
8. Cook !



SCIENCE TARGETS

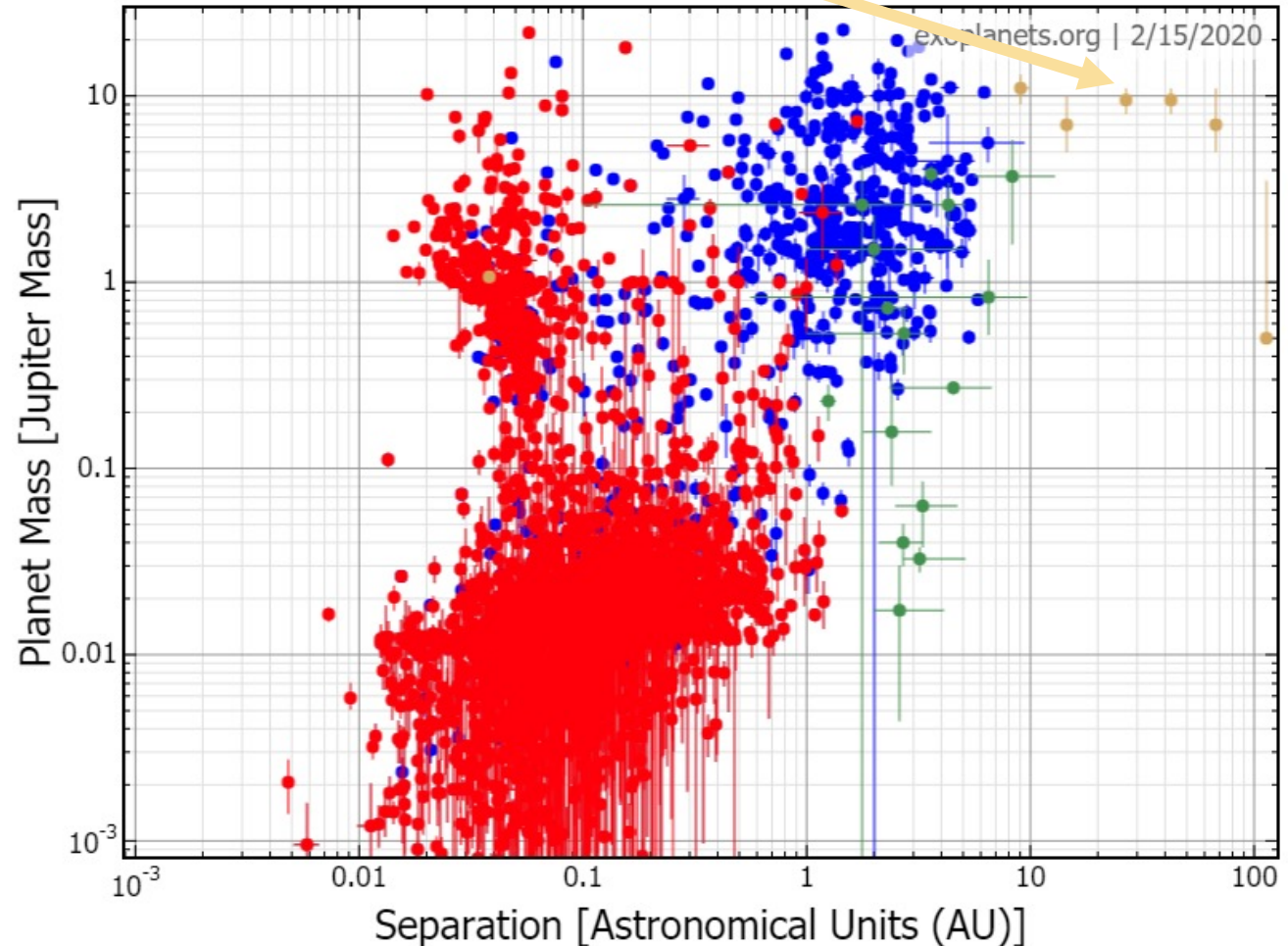
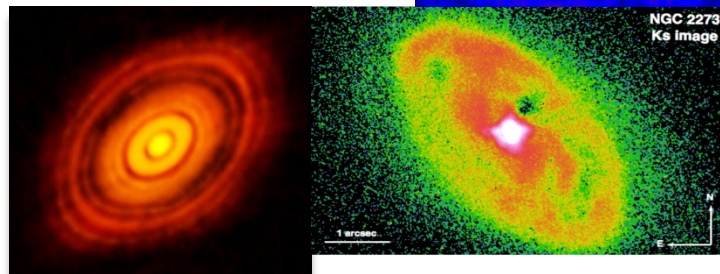
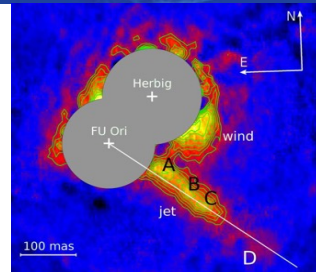
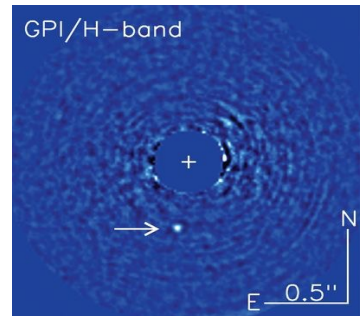


Main science target: direct imaging of **exo-planets/BDs** (detection and characterization):

- require high angular resolution and contrast

Other science:

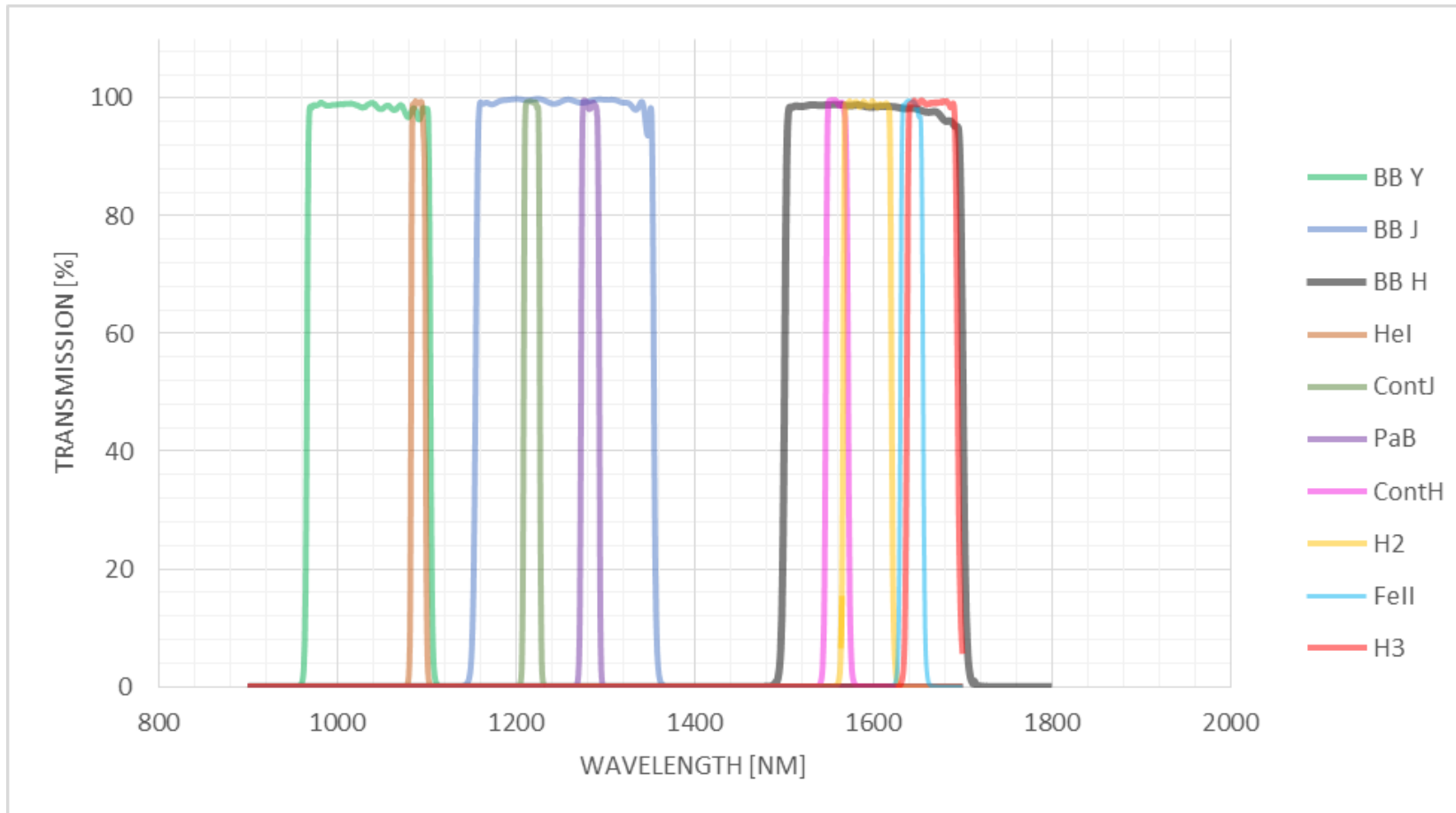
- Protoplanetary disks
- Stellar jets
- AGN/QSOs
- Solar system bodies



INSTRUMENT SPECIFICATIONS



- **Wavelengths:** 960-1700 nm Y, J, H bands
- **FoV:** 18'' x 18'', along the diagonal 25.5 ''



INSTRUMENT SPECIFICATIONS



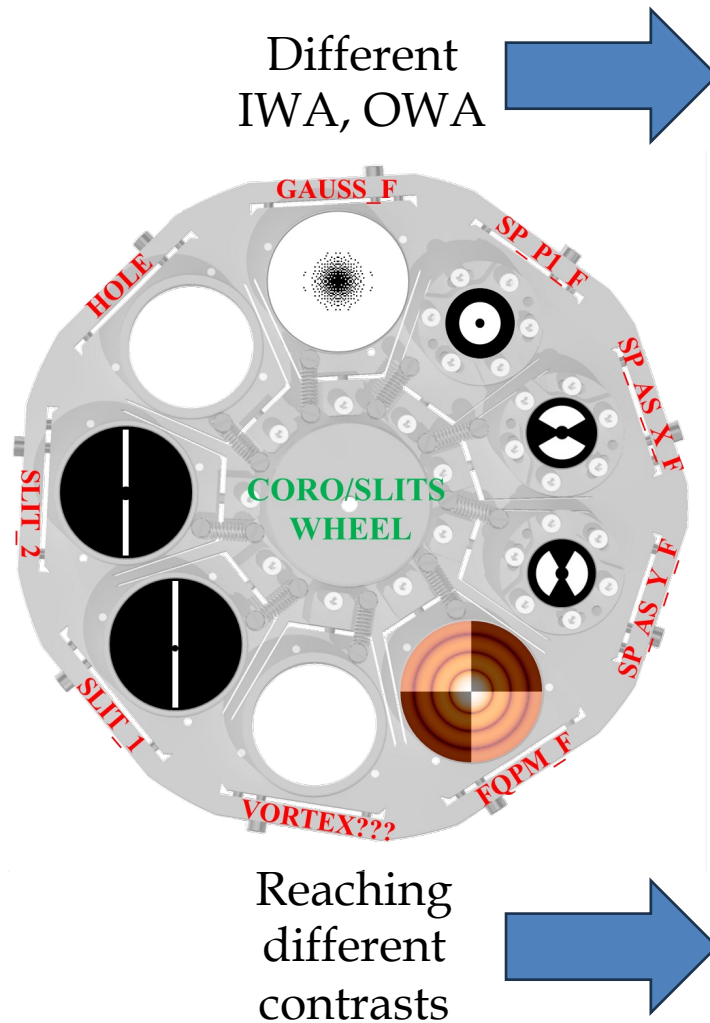
- **Wavelengths:** 960-1700 nm Y, J, H bands
- **FoV:** 18'' x 18'', along the diagonal 25.5 ''

- **Observation modes:**
 - Imaging
 - Coronagraphic imaging
 - Long-slit coronagraphic spectroscopy
 - Dual-band simultaneous imaging

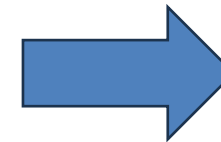
INSTRUMENT SPECIFICATIONS



Coronagraph
Gaussian Lyot
Shaped Pupil 1
Shaped Pupil 2
FQPM



Discovery Space
360°
360°
220°
360°

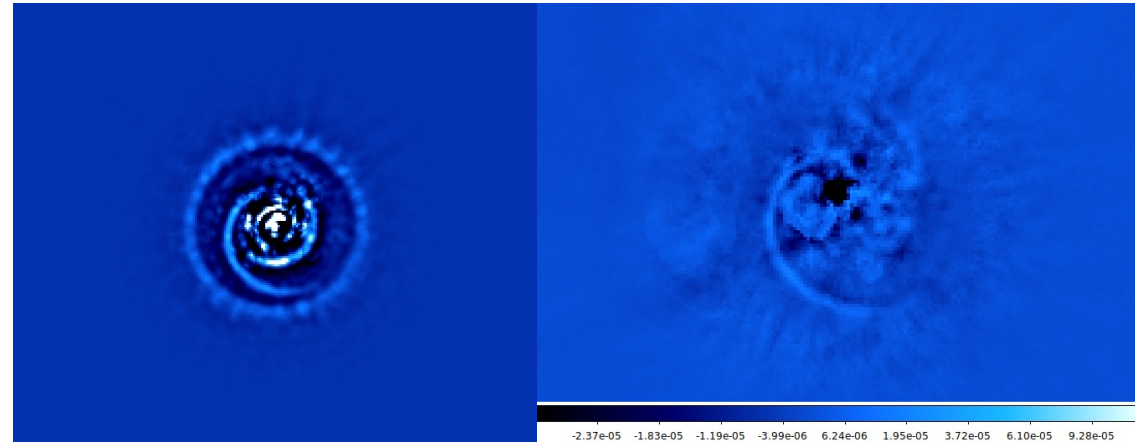
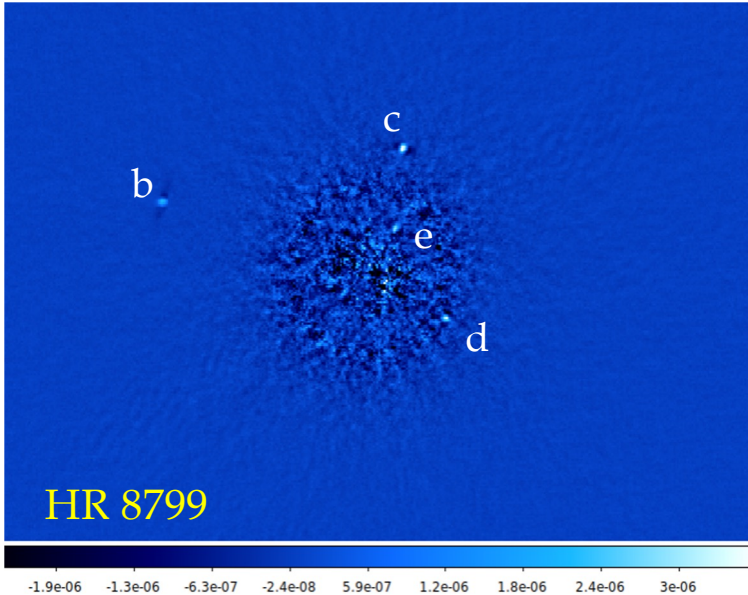


Science
Disks/Jets/AGN/Exoplanets
Exoplanets
Exoplanets
Exoplanets

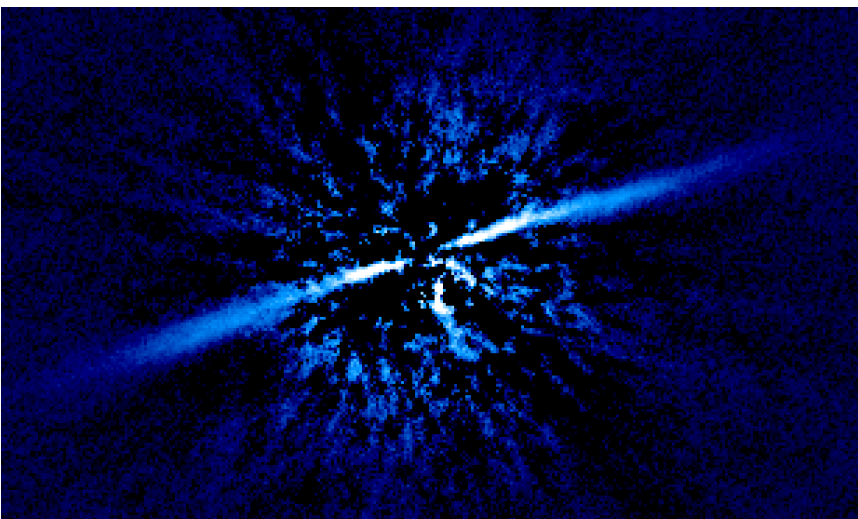
MAIN RESULTS



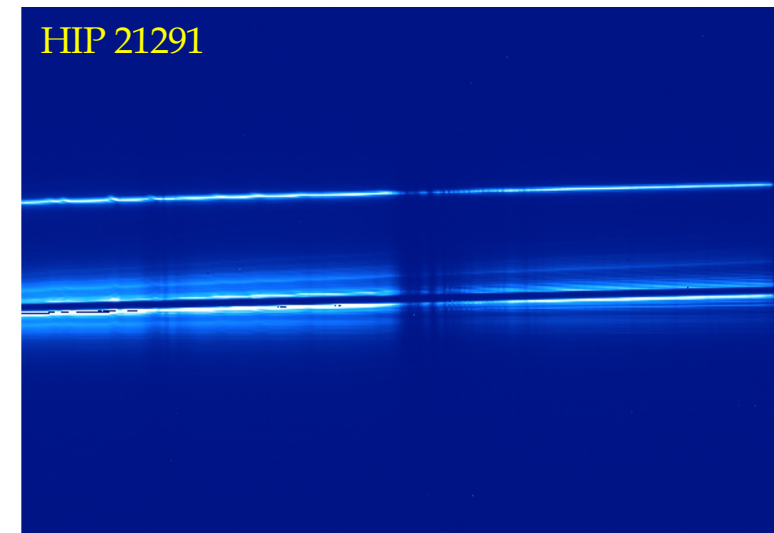
HR 8799: Showing 4 giant planets



MWC758: right image with angular differential imaging (ADI); left image: with reference differential imaging (RDI). Both spiral arms clearly visible.



BD+45 598: edge-on debris disk, young star in the beta Pic moving group (BPMG) with an age of ~ 24 Myr

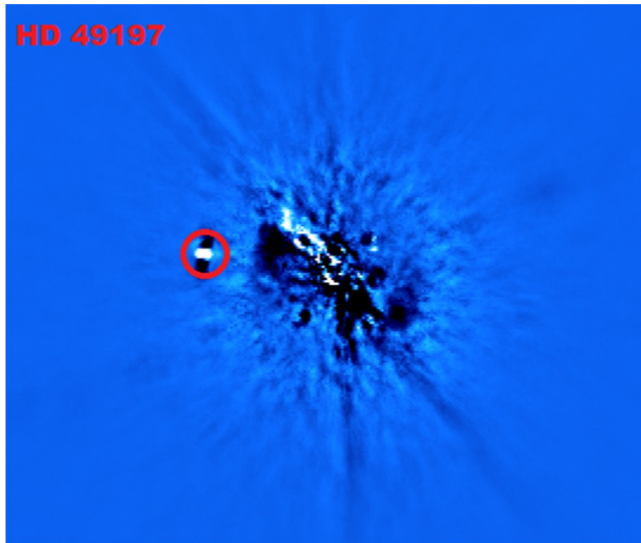


HD21291: double star with a companion at a separation of $2.3''$ with a contrast (in H) of around 3 magnitudes.

MAIN RESULTS

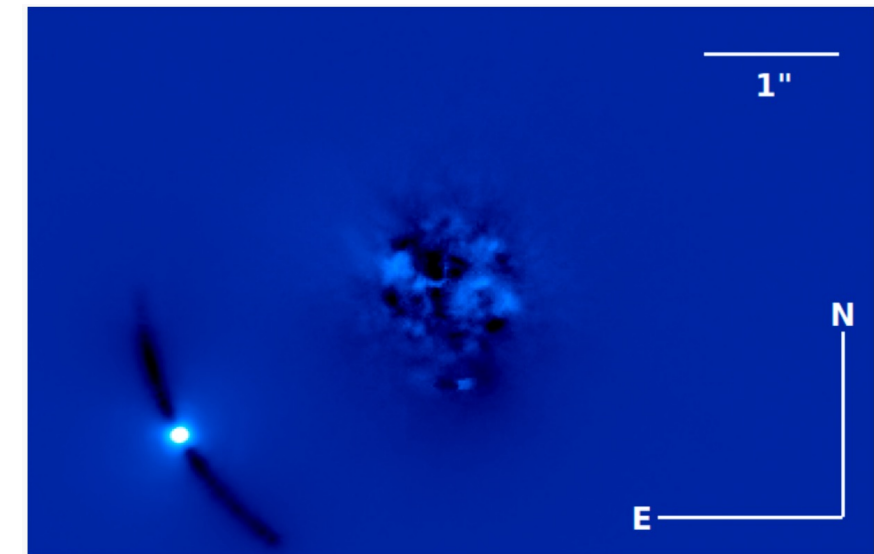
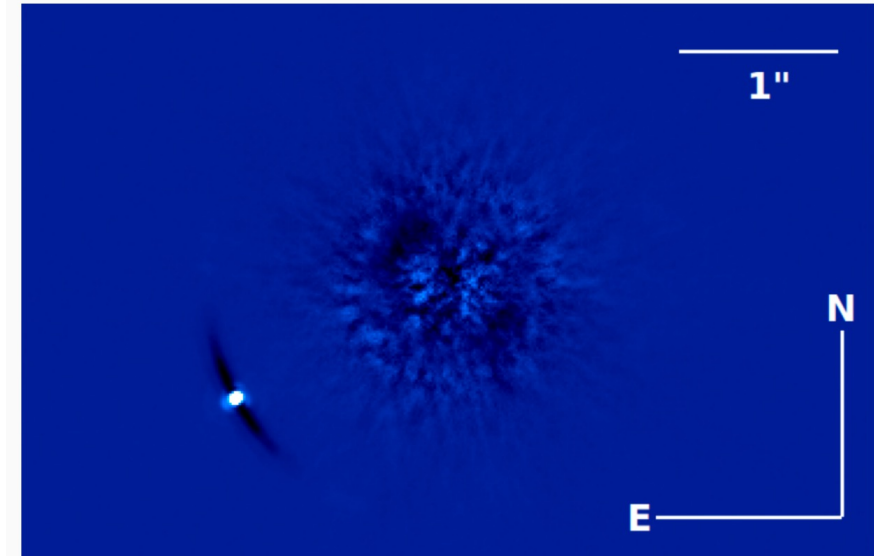


HD 49198: hosts a known BD companion



PMA Targets:
Top picture, no companion detected but constrains on mass and distance of possible companion.

Bottom picture, detections at 2'' and possible detection at 0.62''. To be presented by Mesa et al., in prep.





CONCLUSIONS

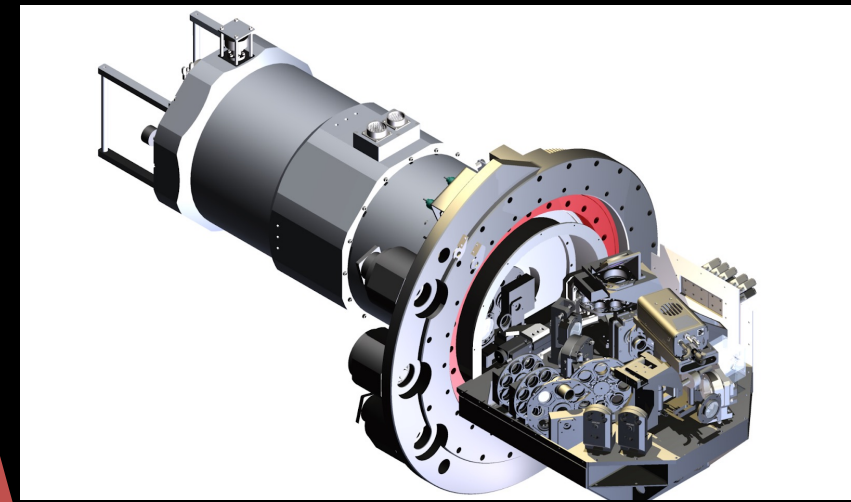
SHARK-NIR is an instrument currently operating at the Large Binocular Telescope in Arizona.

SHARK-NIR is a complex instrument that was planned, designed, assembled and prepared **almost entirely at Padova**, right behind this wall!

SHARK-NIR can be used for many scientific scopes, in particular characterisation and detection of exoplanets or brown dwarfs.

SHARK-NIR will be offered to the INAF community in the 2024B-2025A semesters and possibly offered to the LBT community from 2025A.

Contact the science team for more information on proposals!



There are others like SOXS, MAVIS, MORFEO

See poster by Elena Carolo about on going laboratory activities

See poster by Gabriele Umbriaco about the 4D interferometer



Thank you for your
attention!

