



SOXS Instrument Overview

P. Schipani

***SOXS Consortium Science Meeting
Napoli, 25-27 June 2024***



SOXS



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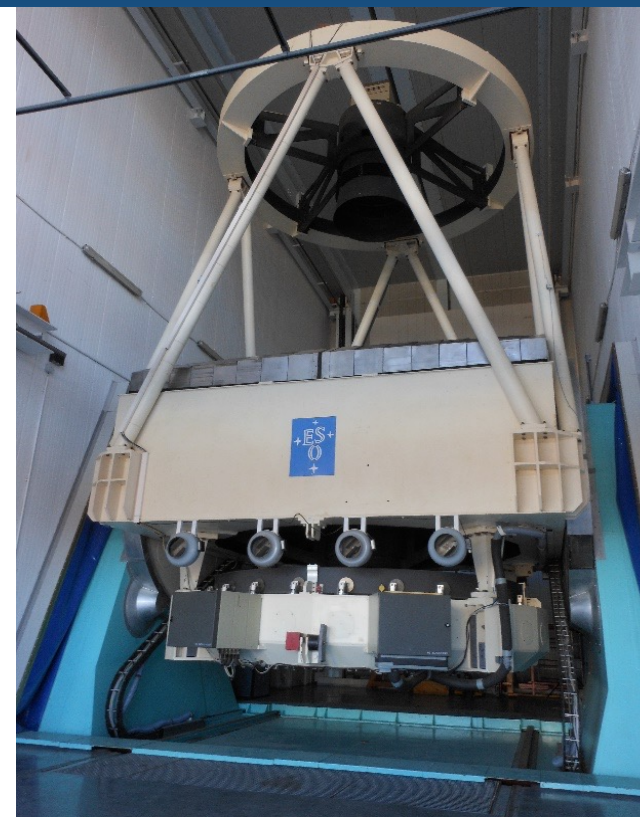


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Son Of X-Shooter

- ❑ Single-object wide band spectrograph from U to H band @ESO-NTT 350-2000 nm
- ❑ *'Similar'* to X-Shooter @VLT
- ❑ Two arms (VIS + NIR) with partial overlap around 800 nm to cross-calibrate spectra
- ❑ $R \sim 4,500$ (3,500-6,000)
- ❑ Acquisition camera to perform photometry ugrizY-V (3.5' FoV)



ESO La Silla (LPO)



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Consortium

Institutes from 6 Countries

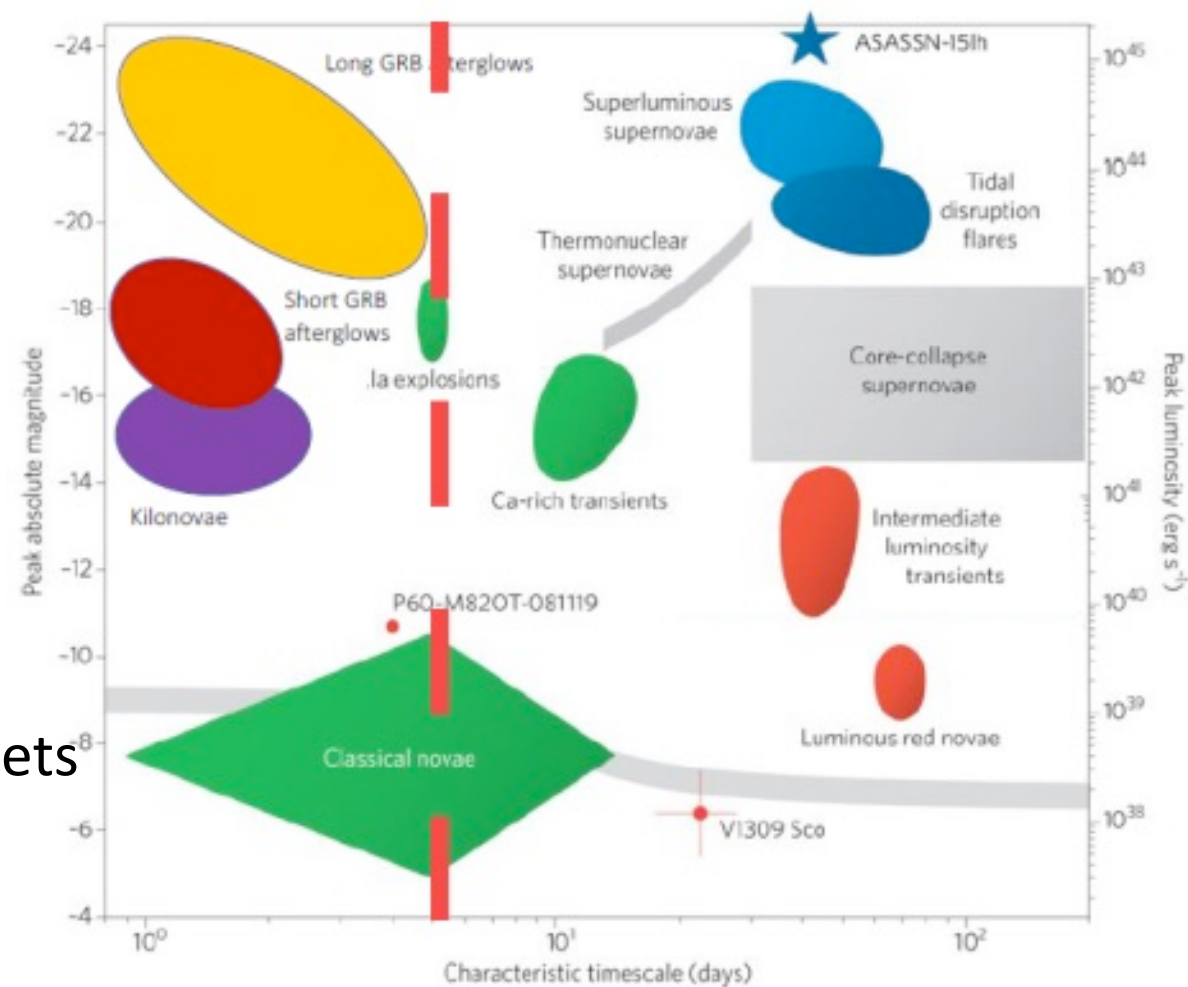
- ❑ Istituto Nazionale di AstroFisica (INAF), Italy
- ❑ Department of Particle Physics and Astrophysics, Weizmann Institute of Science, Rehovot, Israel
- ❑ Instituto de Alta Investigación, Universidad de Tarapacá, Chile
- ❑ FINCA - Finnish Centre for Astronomy with ESO & Turku University, Turku, Finland
- ❑ Queen's University Belfast, Oxford University, UK
- ❑ Tel Aviv University, Israel
- ❑ Niels Bohr and Aarhus University, Copenhagen, Denmark





Spectroscopic follow up of transients

- Classification of transients
- Supernovae (all flavours)
- Gravitational Wave events
- Neutrino events
- Blazars and AGN
- Nuclear transients and Tidal Disruption Events
- GRB and FRB
- Transient X-ray binaries, magnetars, ultra - luminous X-ray sources (NS & BH)
- Young Stellar Objects, stellar variability, exoplanets
- Asteroids and Comets
- The Unknown





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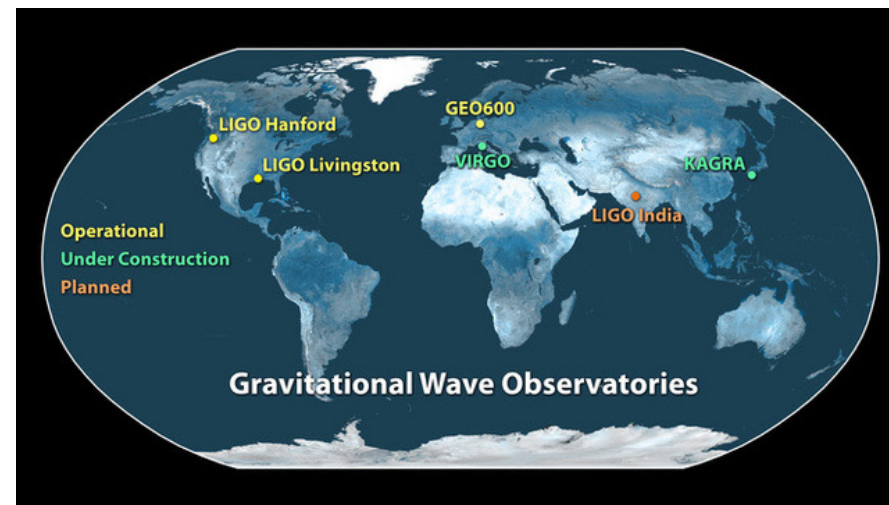


Synergies

SOXS will have 180 n/yr (for ≥ 5 yr)
 $\sim 3,000-4,000$ spectra/yr

A spectroscopic machine for the transient sky

- New deeper survey: Vera Rubin, PanSTARSS, DES, ZTF, ...
- Space optical missions: Gaia, EUCLID, ...
- Space high-energy missions: Swift, Fermi, SVOM, ...
- Radio new facilities: MeerKAT, SKA, ...
- VHE: CTA
- Messengers: aLIGO-Virgo, KM3Net, ANTARES, ...





	UV-VIS	NIR
Spectral range	350-850 nm	800-2000 nm
Resolution (1" slit)	>3600 (\approx 4500 avg)	5000
Slit widths	0.5 - 1 - 1.5 - 5 arcsec	0.5 - 1 - 1.5 - 5 arcsec
Slit height	12 arcsec	12 arcsec
Detector	e2V CCD44-82 2Kx4K	Teledyne H2RG 2Kx2K
Pixel Size	15 μ m	18 μ m
Detector Scale	0.28"/pixel	0.25"/pixel

	Camera
Spectral range	360-970 nm
Detector	Andor iKon M-934 1Kx1K
Field of View	3.5'
Pixel Size	13 μ m
Detector Scale	0.205"/pixel



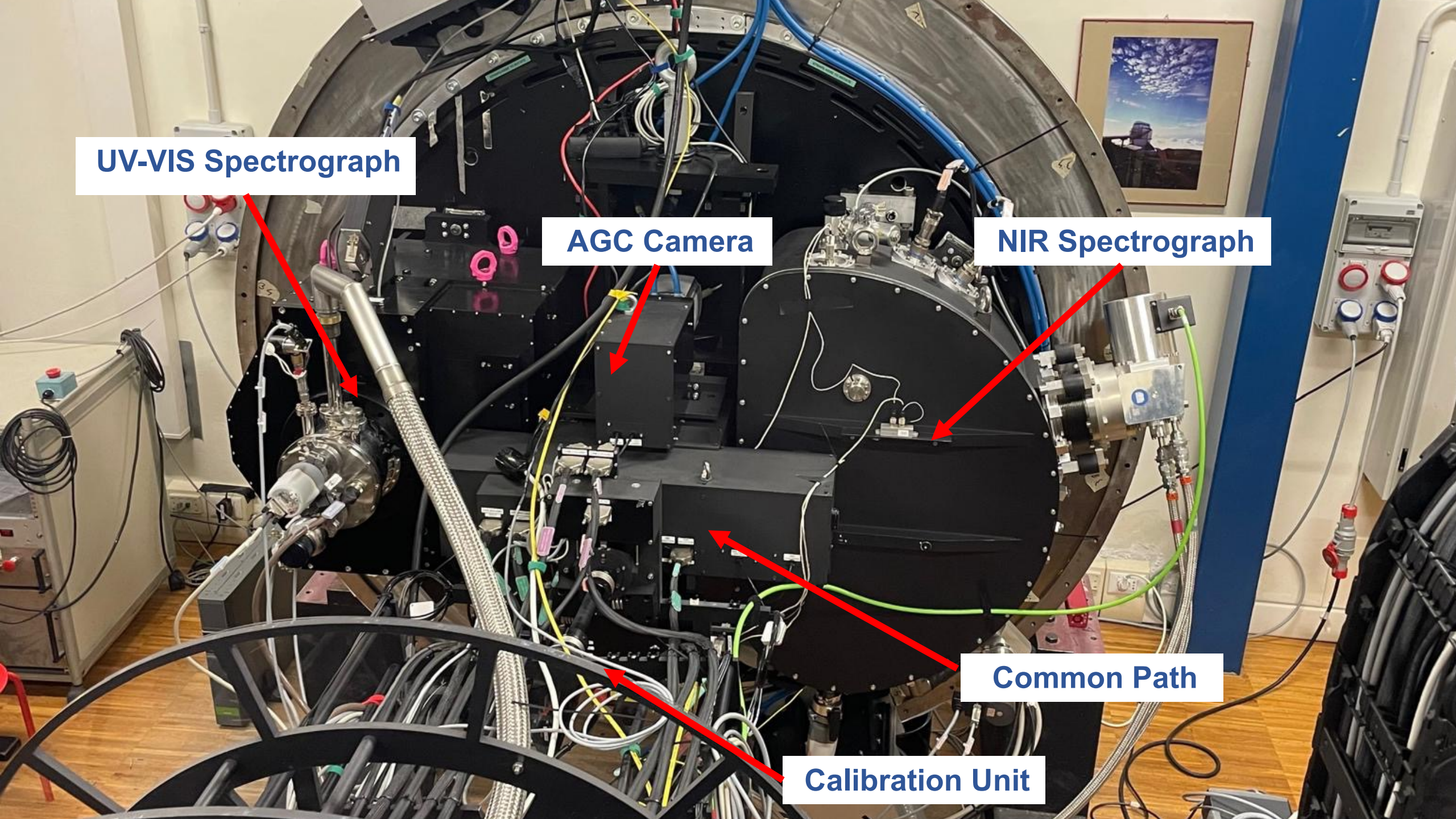
UV-VIS Spectrograph

AGC Camera

NIR Spectrograph

Common Path

Calibration Unit

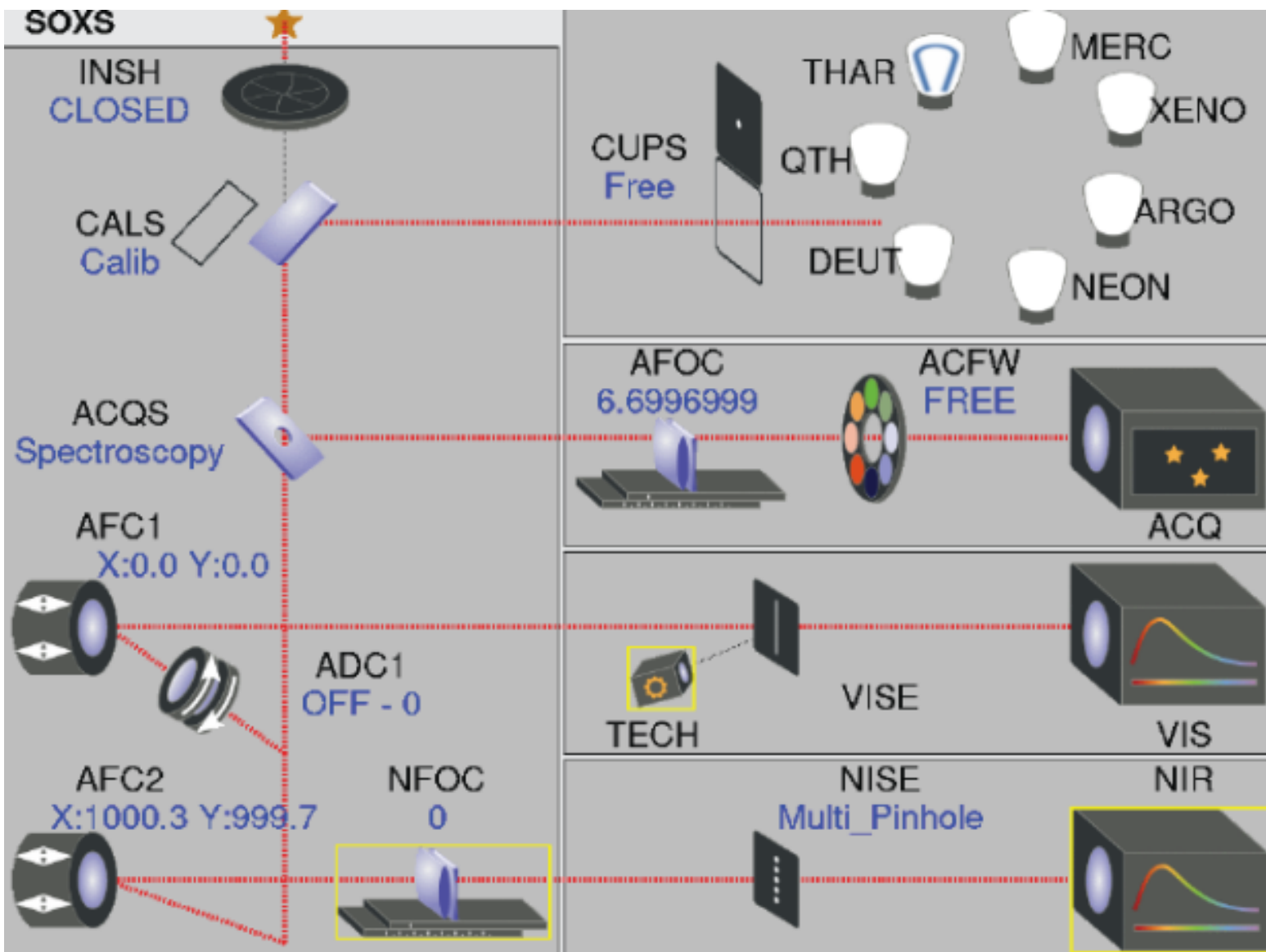




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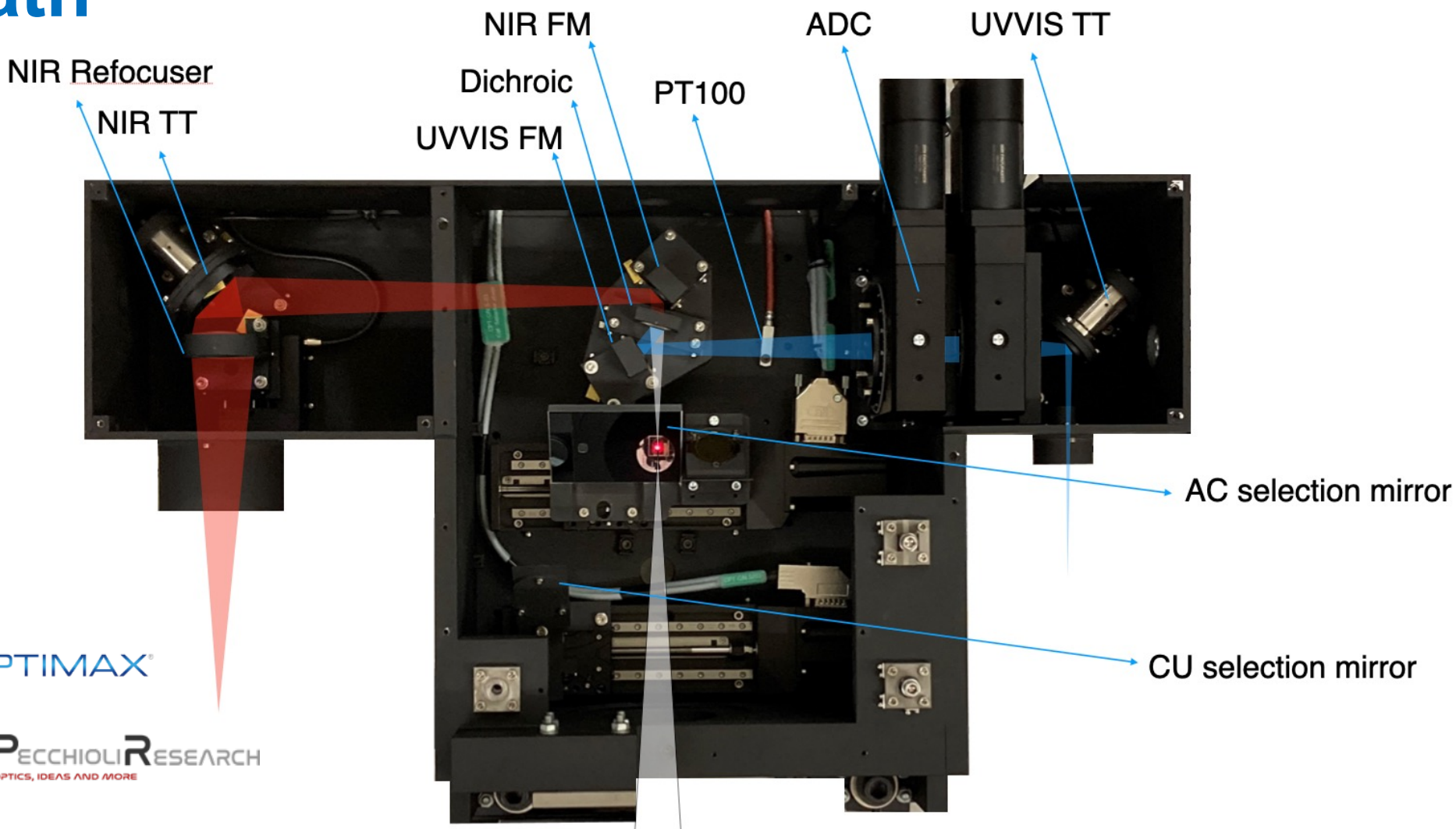


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Common Path

Receives F/11 beam from the telescope and feeds the spectrographs with F/6.5 beam



Archer OptX
Optical Precision. Optimal Outcome.

OPTIMAX

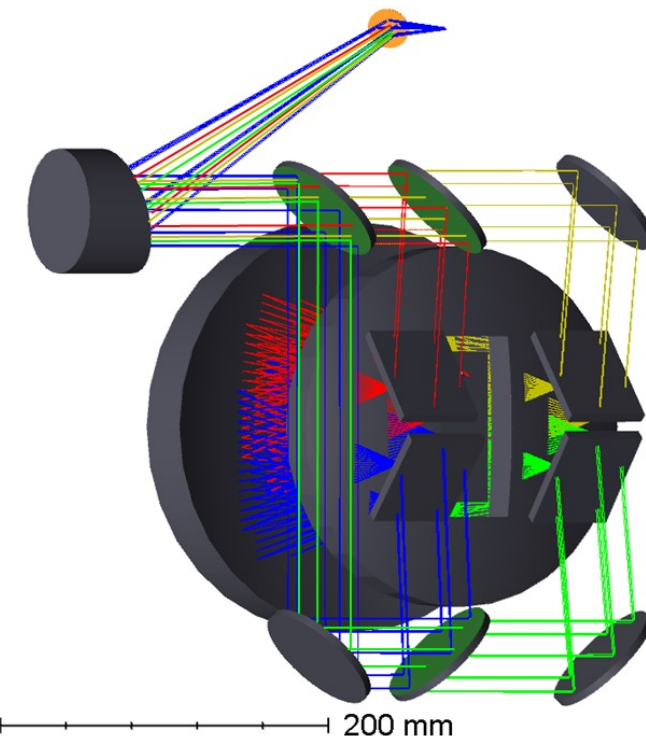
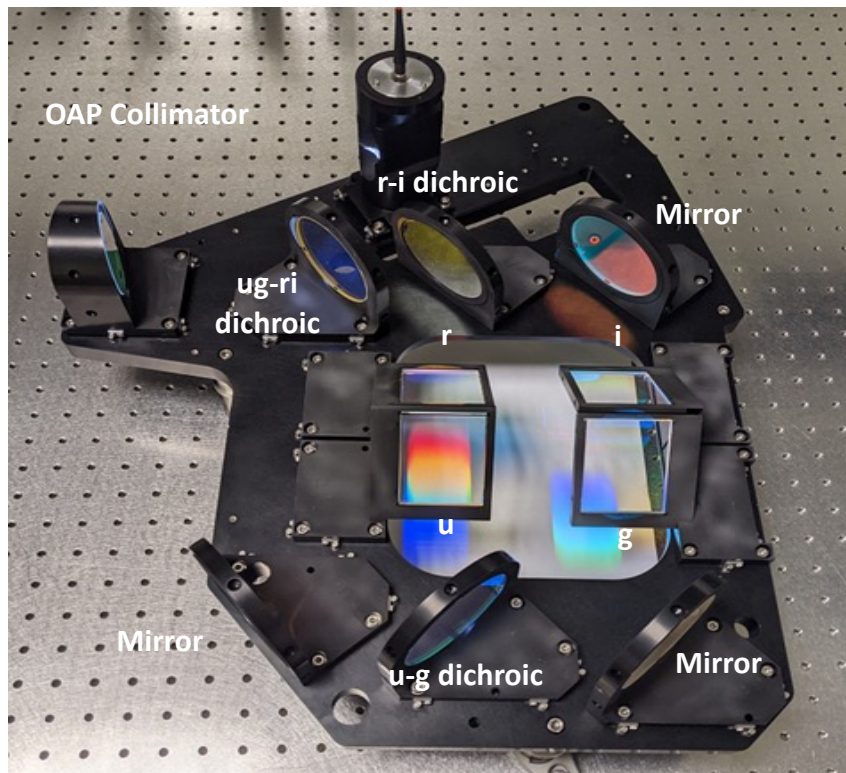
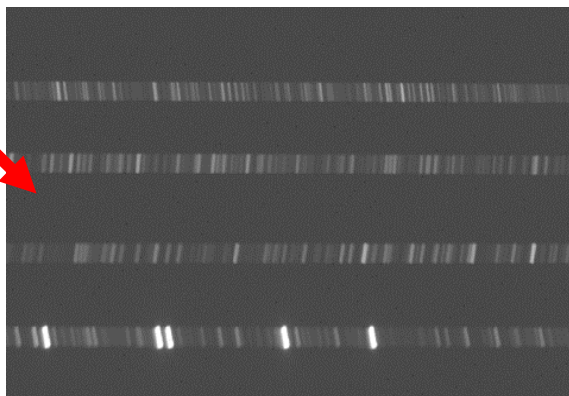
ASAHI SPECTRA USA

PECCHIOLI RESEARCH
OPTICS, IDEAS AND MORE



UV-VIS Spectrograph

- ❑ Collimated beam is divided to 4 bands using 3 dichroics.
- ❑ Each band has its own optimized disperser
- ❑ Single camera
- ❑ 1st order dispersion, $\mathcal{R} \sim 4500$ at α_{Lit} .
- ❑ 4 bands quasi-orders are imaged onto a single 4kx2k CCD.



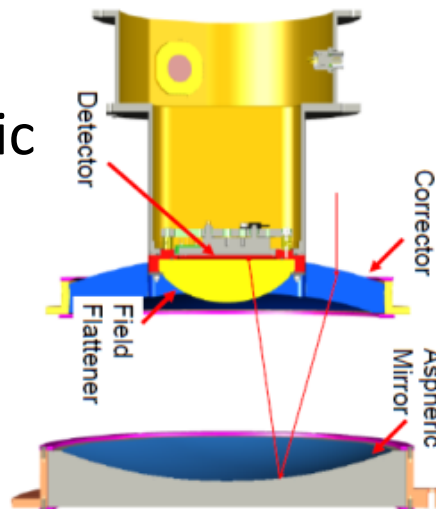
Quasi-Order	Wavelength Range [nm]
<i>u</i>	350 – 439.5
<i>g</i>	427 - 547
<i>r</i>	527 - 680
<i>i</i>	664 – 850



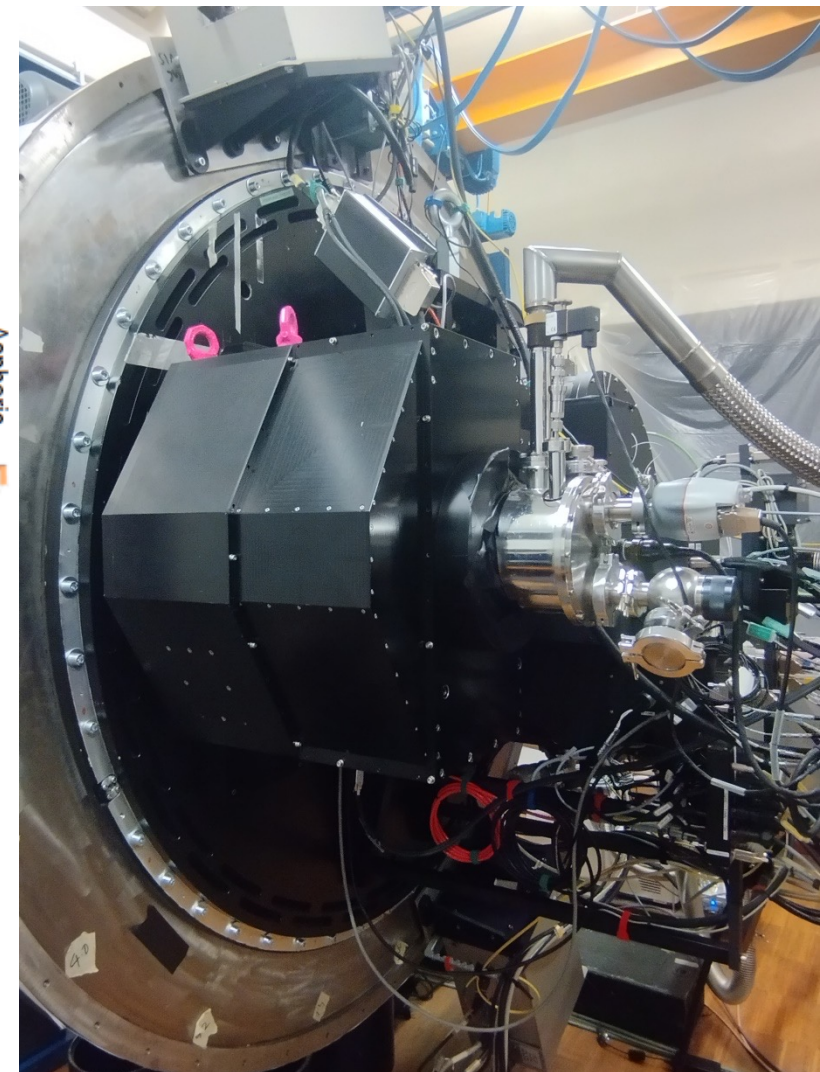
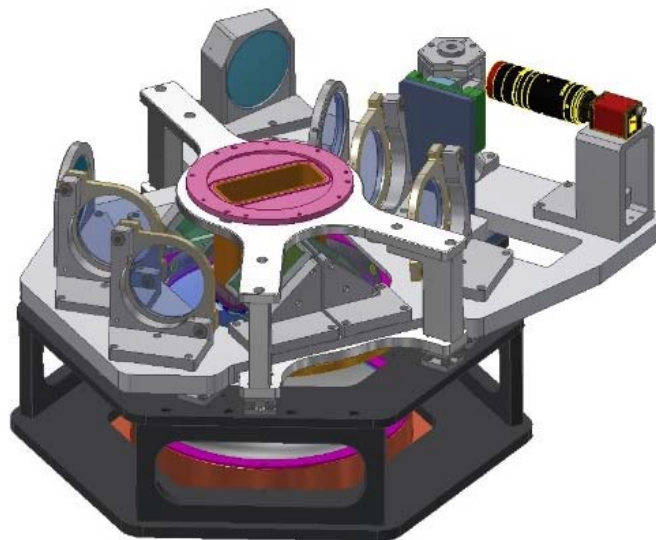
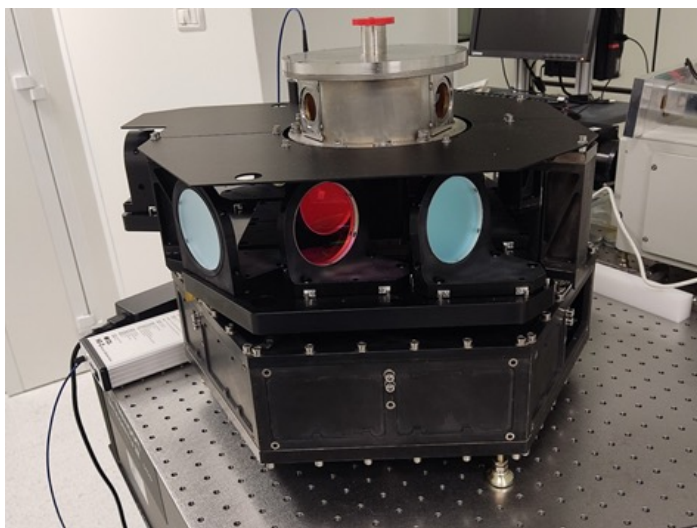


UV-VIS Camera

- ❑ Three element catadioptric camera - all aspheric
- ❑ Used as 4 off axis F/3.1 cameras.
- ❑ CaF2 corrector + Fused Silica Field Flatteners
- ❑ Low CTE=>Athermal camera

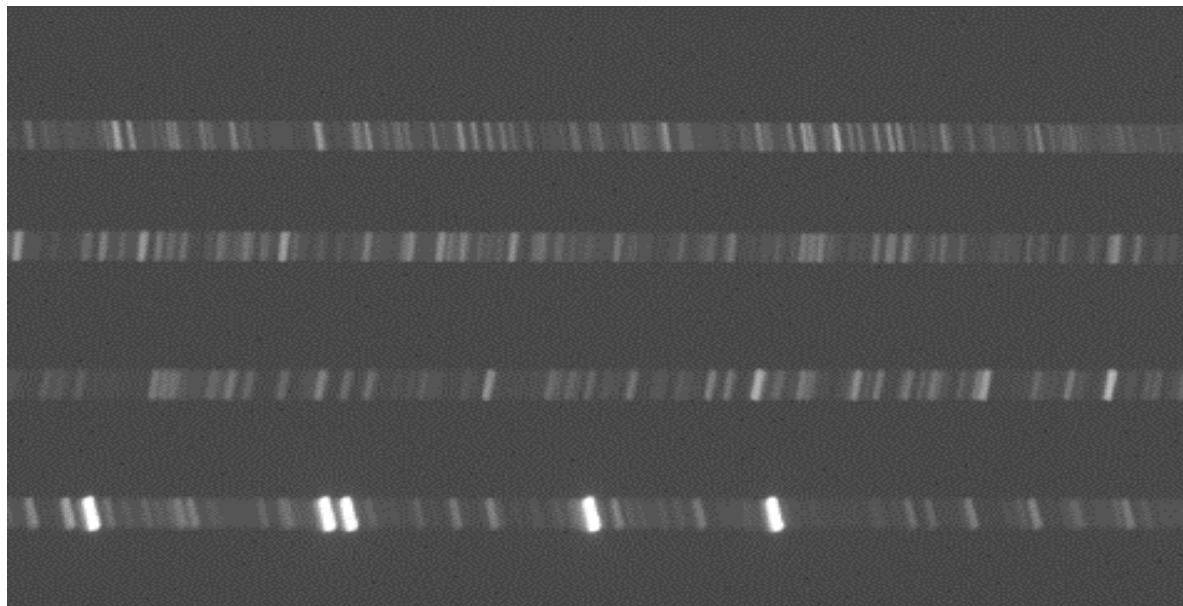


Feed + Camera

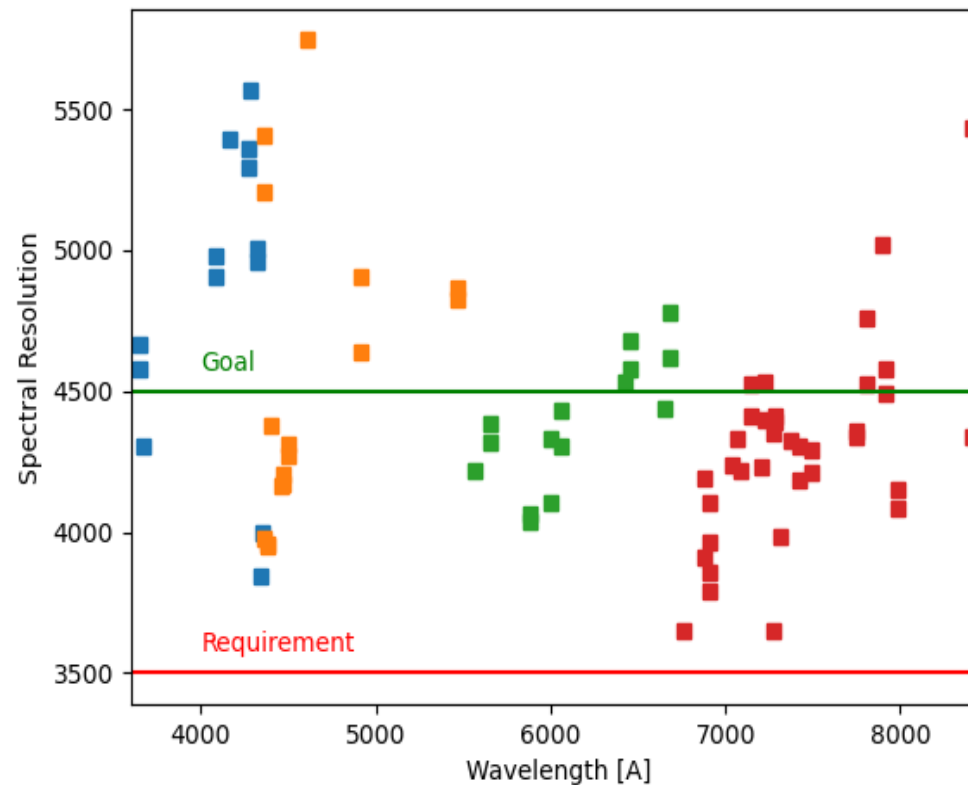




UV-VIS Spectrograph



UVVIS four traces when fed through the CP using SOXS CBX arclamps.



Measured spectral resolution, shown average resolution of $\mathcal{R} \sim 4500$



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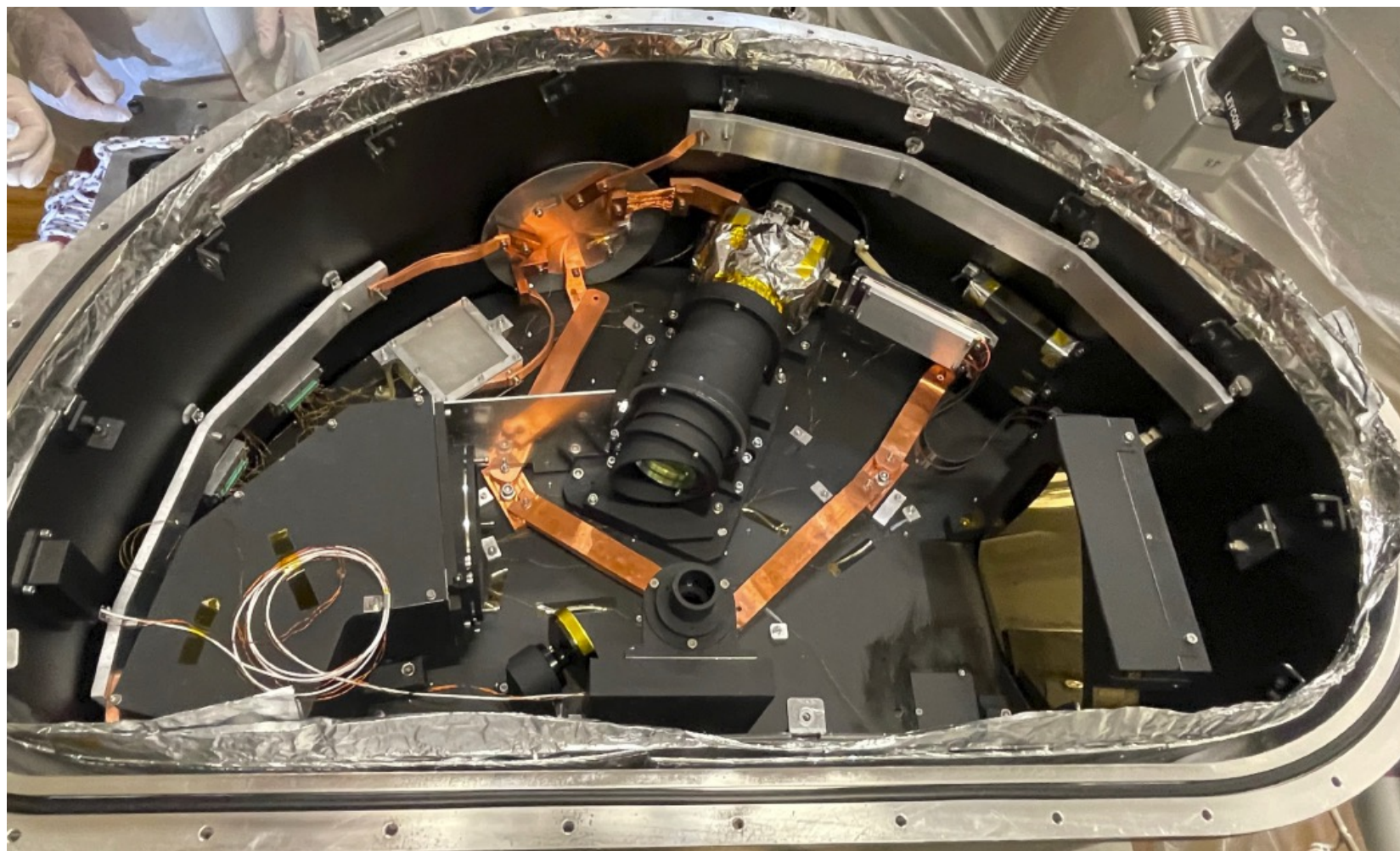
NIR Spectrograph

4C Design

Spectrograph with
Collimator Compensation
of Camera Chromatism
Echelle Cross-Dispersed

$R \sim 5000$, $0.25''/\text{px}$

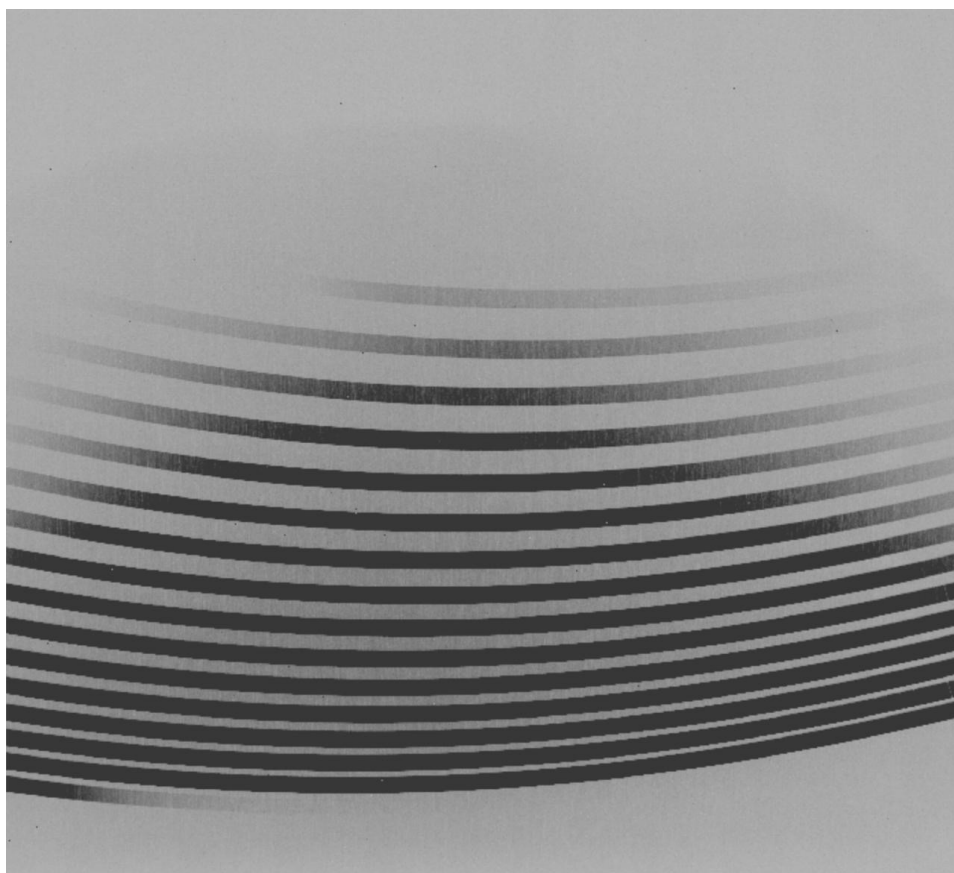
F/3.7 camera, H2RG + NGC



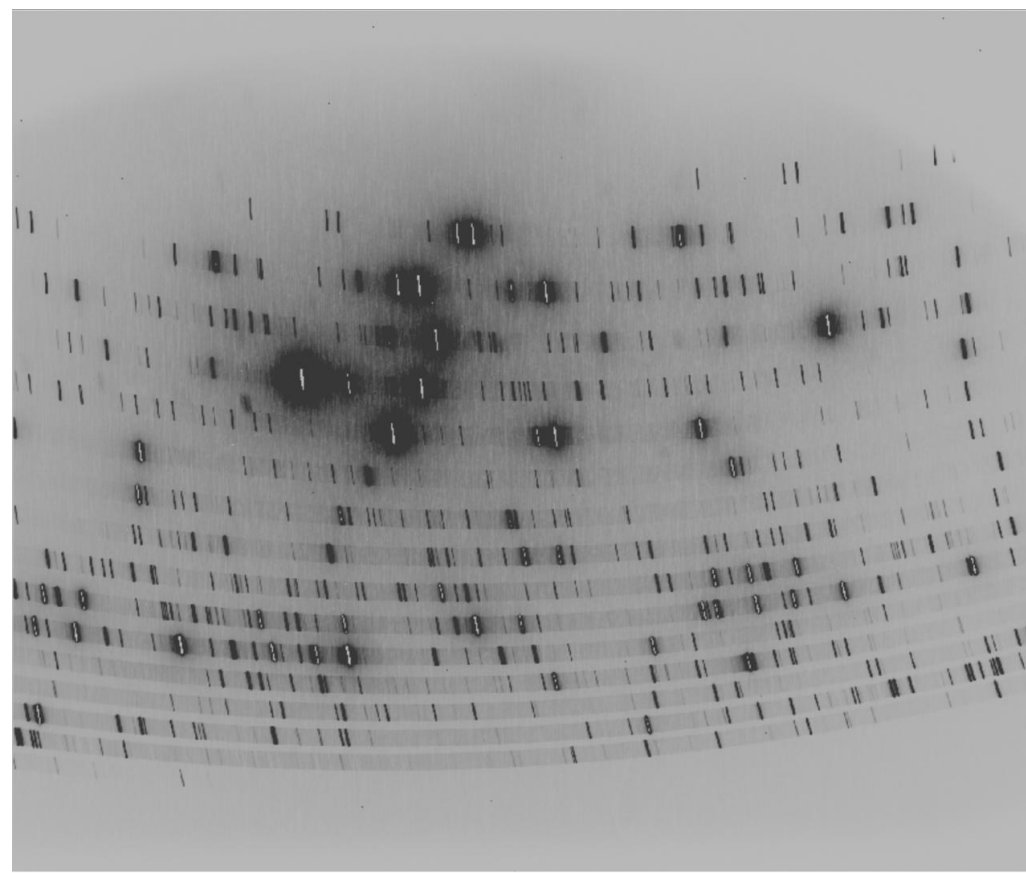


NIR Spectrograph

QTH 5s exp. raw frame

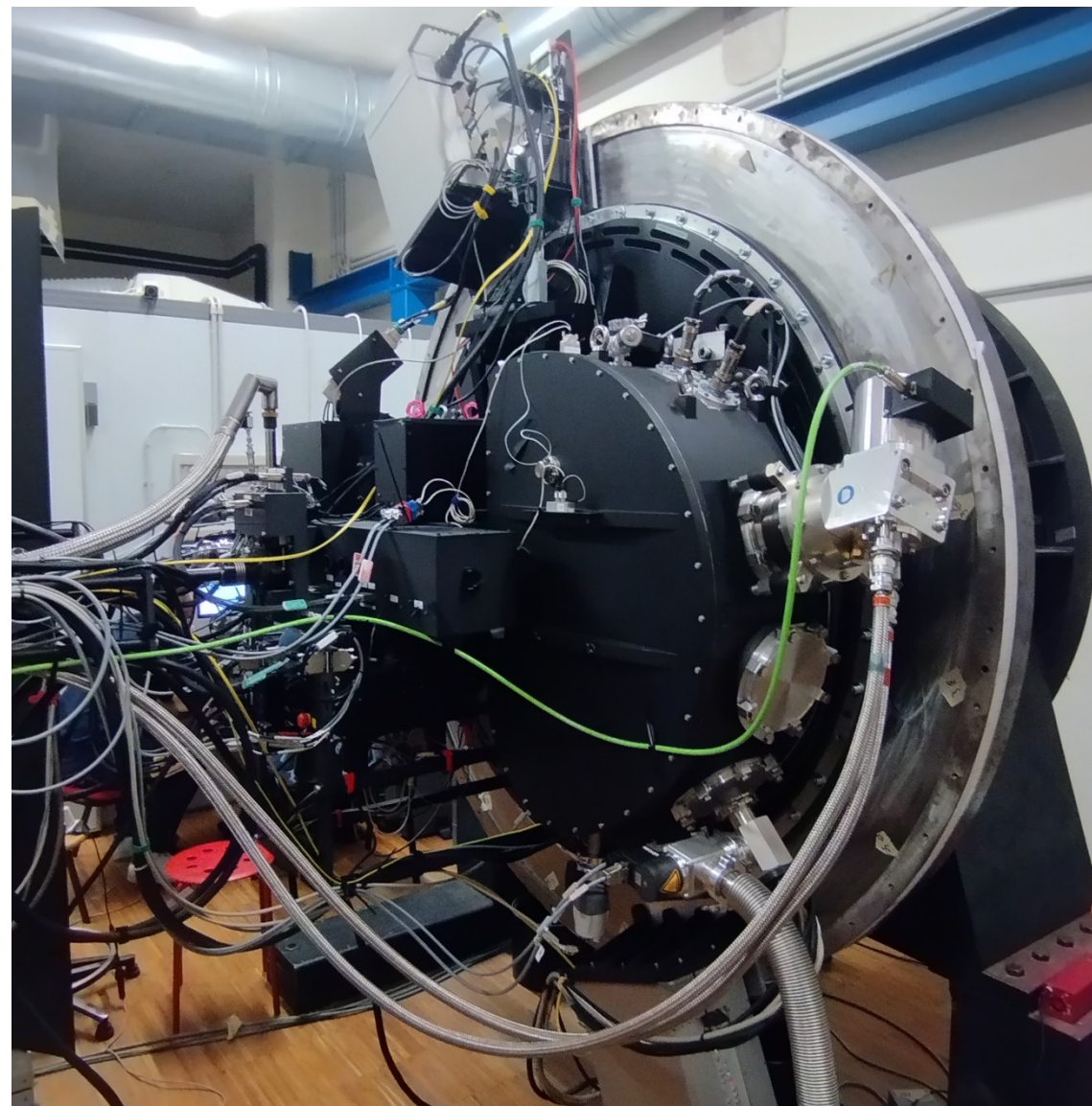
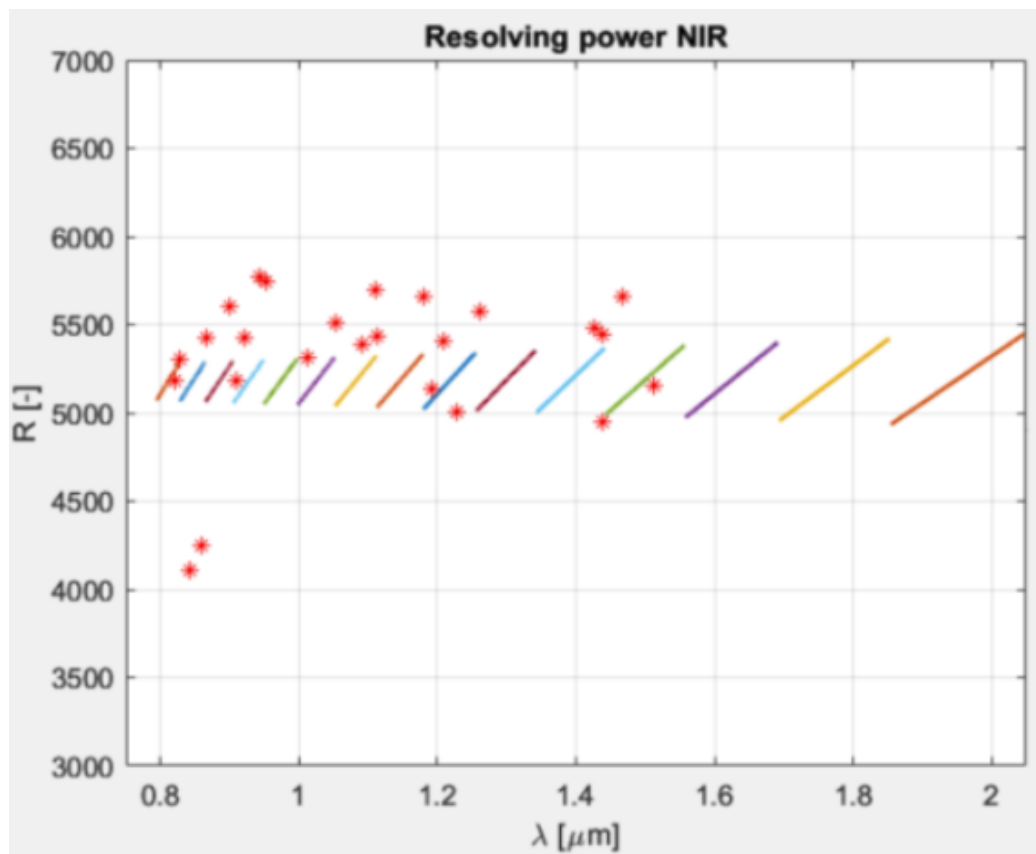


Arc lamps 15s exp. raw frame 0.5" slit





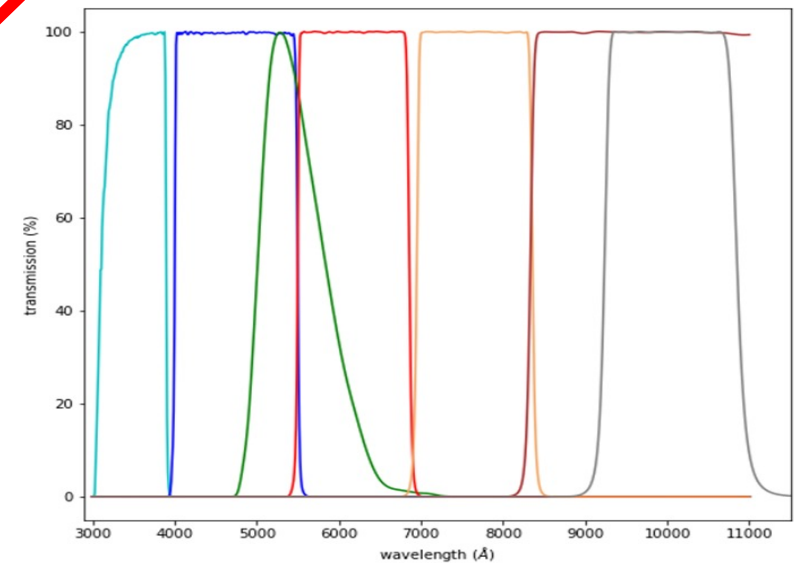
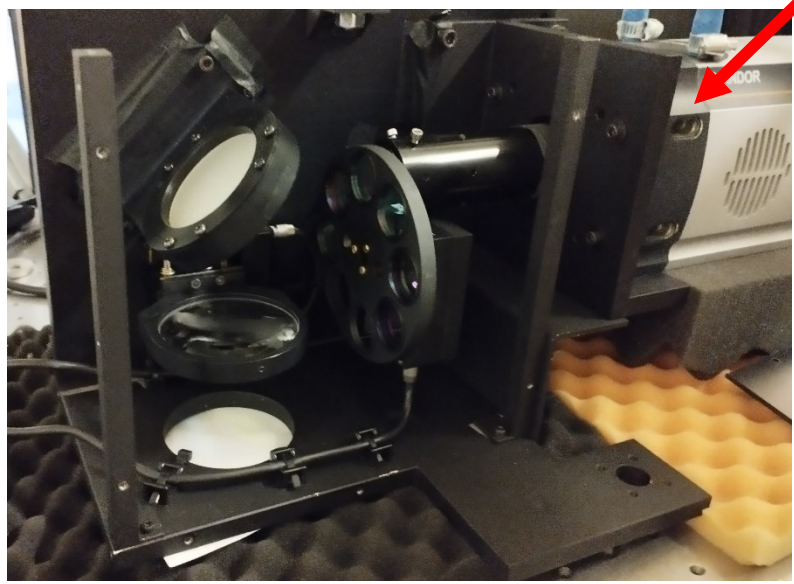
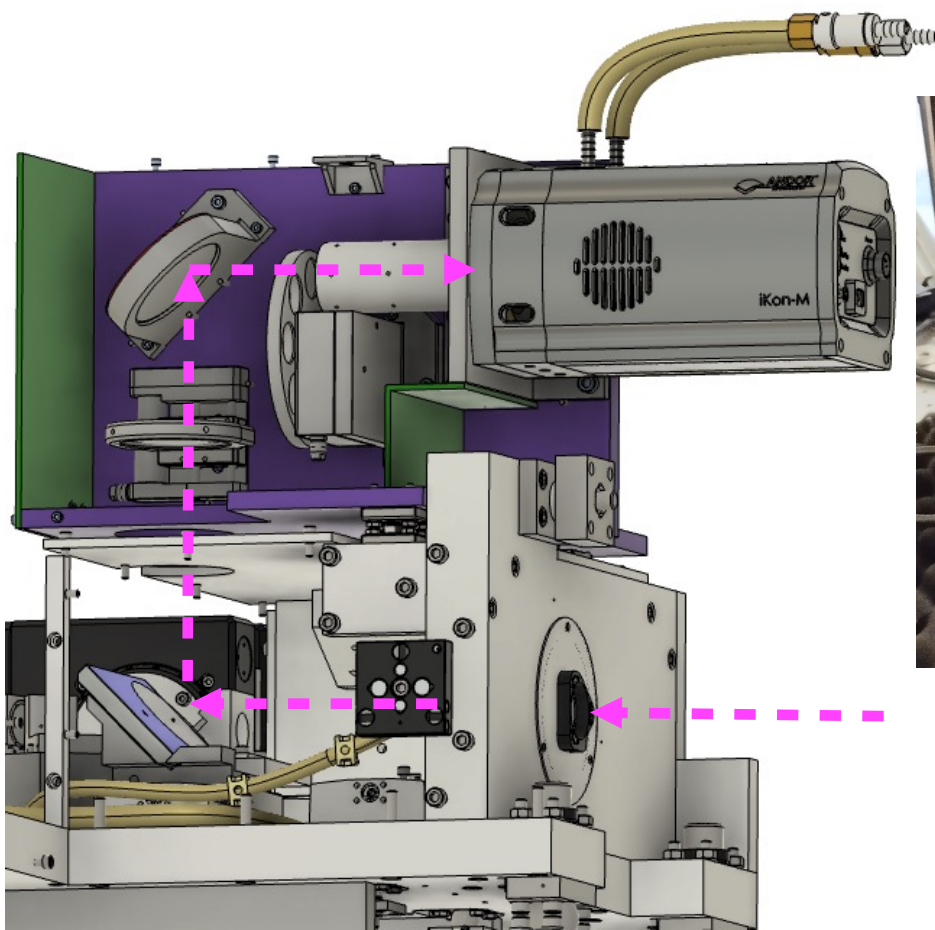
NIR Spectrograph





A&G Camera

Andor iKon M934 1024x1024
13μm/px 0.205 "/px

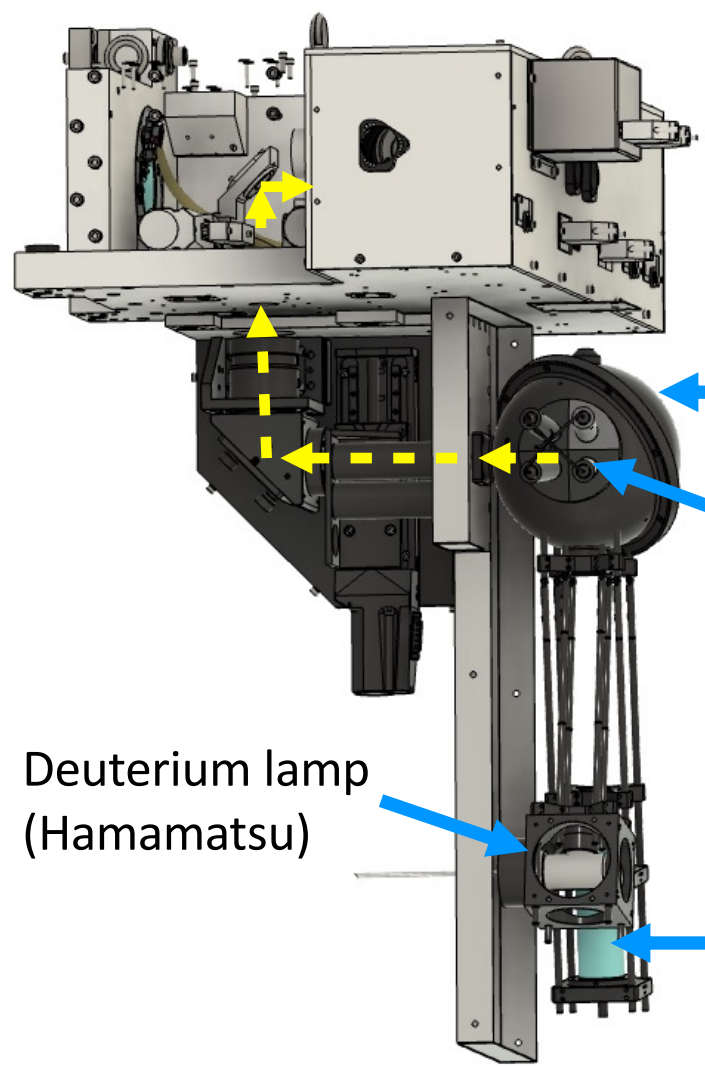


- Target Acquisition
- Secondary guiding
- Photometry

Filters: ugrizY + V
FoV: 3.5'



Calibration Unit

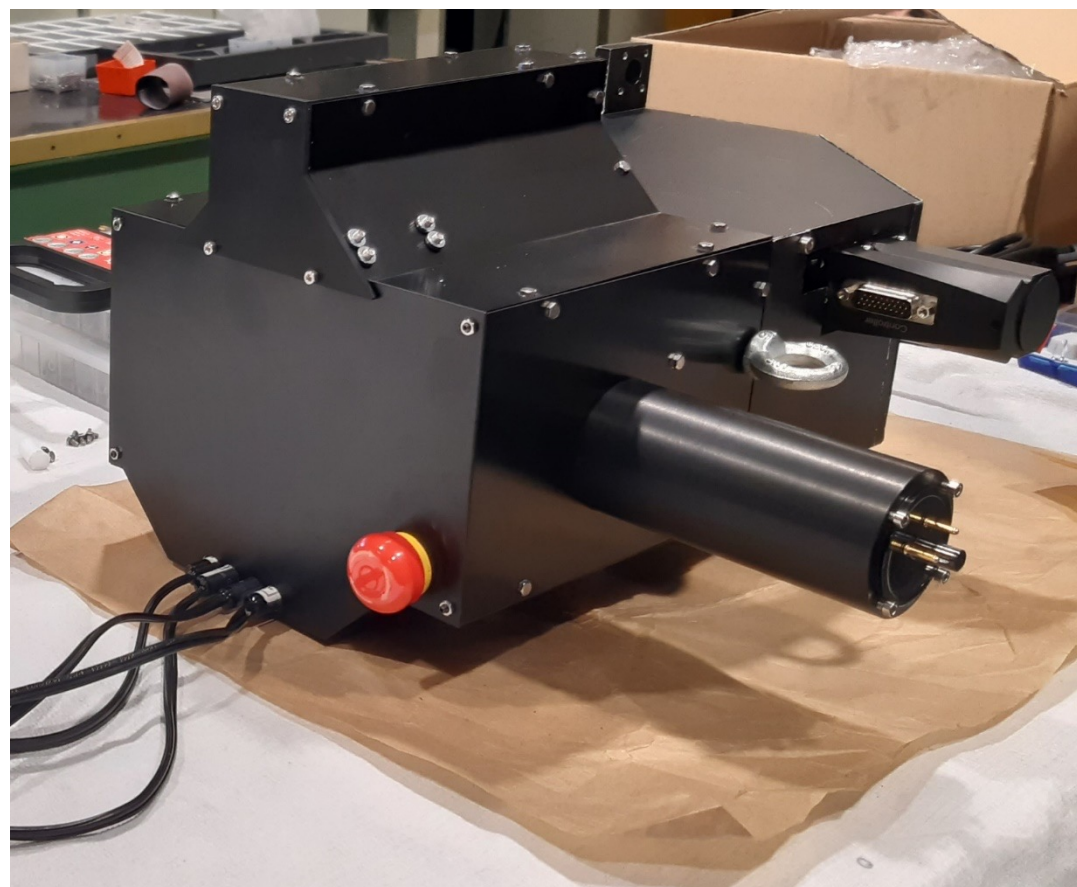


QTH lamp
(Osram)

NeArHgXe
Penray lamps
(Newport)

Deuterium lamp
(Hamamatsu)

Th-Ar lamp
(Photron)



Ctrl Electronics

- Motors
- Lamps

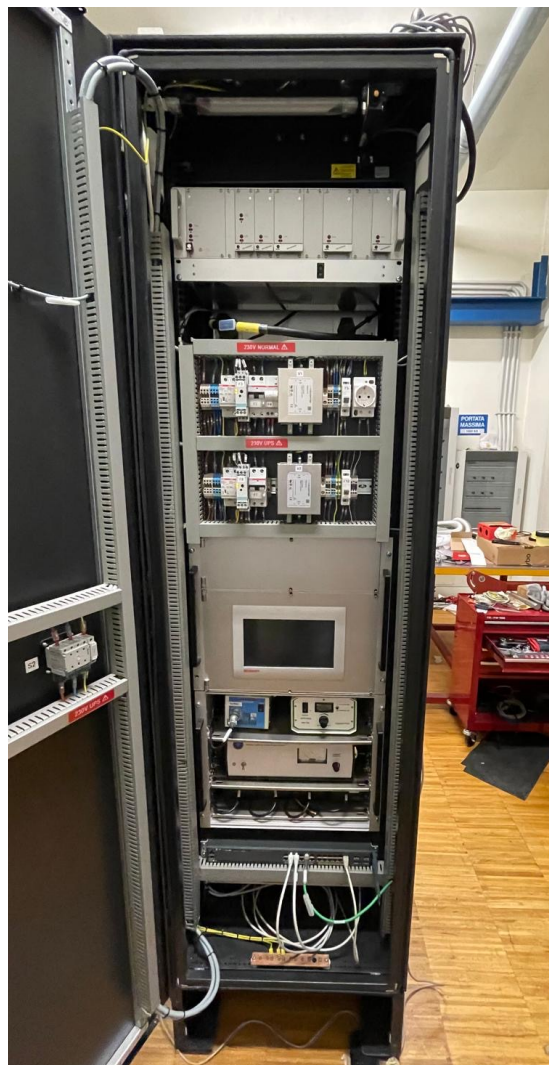
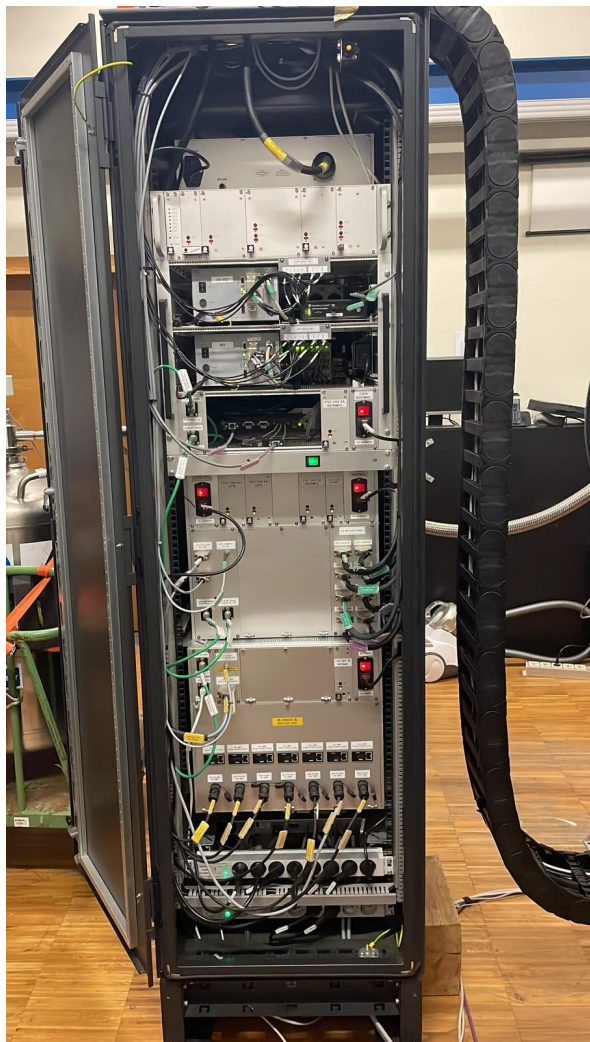
Ctrl Electronics

- Cryovacuum
- Detectors
- Co-rotator





Electronic cabinets





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Instrument Software

Based on VLT Common SW

SOXS State: **ONLINE** idle Op. mode: **NORMAL** ICDFBs **OK**

Imaging and Spectroscopy | NIR Sensors | Other Sensors | Piezo and Calibration

Device	State	Mode	Value 1	Value 2	Unit
acfw	ONLINE	SIM	0	0.00	SDSS-u
cups	ONLINE	SIM	0	0.00	Free
cal	ONLINE	SIM	0	0.00	Calib
acqs	ONLINE	SIM	0	0.00	Spectroscopy
vis	ONLINE	SIM	Blank	0	Slit_0.5
nise	ONLINE	SIM	Slit_0.5	0	Slit_0.5
afoc	ONLINE	SIM	0	mm	
nfoc	ONLINE	SIM	0	mm	
adc1	ONLINE	SIM	OFF	0.0	0.0
adc2	ONLINE	SIM	OFF	0.0	0.0
crot	ONLINE	SIM	ON		Active

Device	State	Mode	Value 1	Value 2
insh	ONLINE	SIM	CLOSED	
qth	ONLINE	SIM	OFF	OFF
deut	ONLINE	SIM	OFF	OFF
neon	ONLINE	SIM	OFF	OFF
argo	ONLINE	SIM	OFF	OFF
xeno	ONLINE	SIM	OFF	OFF
merc	ONLINE	SIM	OFF	OFF
thar	ONLINE	SIM	OFF	OFF
afc1	ONLINE	SIM		
afc2	ONLINE	SIM		

Mode: REF Set: 0.0 0.0 Cur: 12.3 56.8

Mode: REF Set: 0.0 0.0 Cur: 12.3 56.8

Command Feedback Window Options

```

14:39:45 SIMULAT > REPLY/ L Successfully put device: CROT in requested mode
14:39:51 ONLINE > INVOKED "-function crot"
14:39:52 ONLINE > REPLY/ L OK
  
```

SOXS Status - @wsxs

File Std. Options Help

SOXS Status

Ins Mode: **Undefined**
State: **LOADED**
Substate: **idle**

TCS
State: **ONLINE** Tracking: **ENABLED**
Substate: **IDLE** RA: 104.89044
Access: **IGNORE** DEC: -795221.276

Shutter and calibration slides

INSH	LOADED	HW	CLOSED
CALS	LOADED	HW	FAIL 122
CUPS	LOADED	HW	FAIL 16

Calibration Lamps

QTH	LOADED	HW	OFF
DEUT	LOADED	HW	OFF
NEON	LOADED	HW	OFF
ARGO	LOADED	HW	OFF
XENO	LOADED	HW	OFF
MERC	LOADED	HW	OFF
THAR	LOADED	HW	OFF

Sensors

CVTS P	2.49
CVTS T	2.49
CPTS T	350.00
CRAC	█
CRNF	█
CRMS	█
CRSW	█

NIR - Near Infrared Spectrograph

NIR	ONLINE	LCU-SIM	idle
Exposure	inactive	DIT	5.00
Remaining	0	NDIT	1
AFC2	LOADED	HW	X 0 Y 0
NFOC	LOADED	HW	FAIL 99899
NISE	STANDBY	SIM	0

VIS - Visible Spectrograph

VIS	ONLINE	HW-SIM	idle
Exposure	1	DIT	0.00
Remaining	0	NDIT	F
AFC1	LOADED	HW	X 0 Y 0
ADC1	LOADED	HW	ERROR
ADC2	STANDBY	SIM	STANDING
WISE	STANDBY	SIM	2
TECH	ONLINE	SIM	IDLE

ACQ - Acquisition Camera

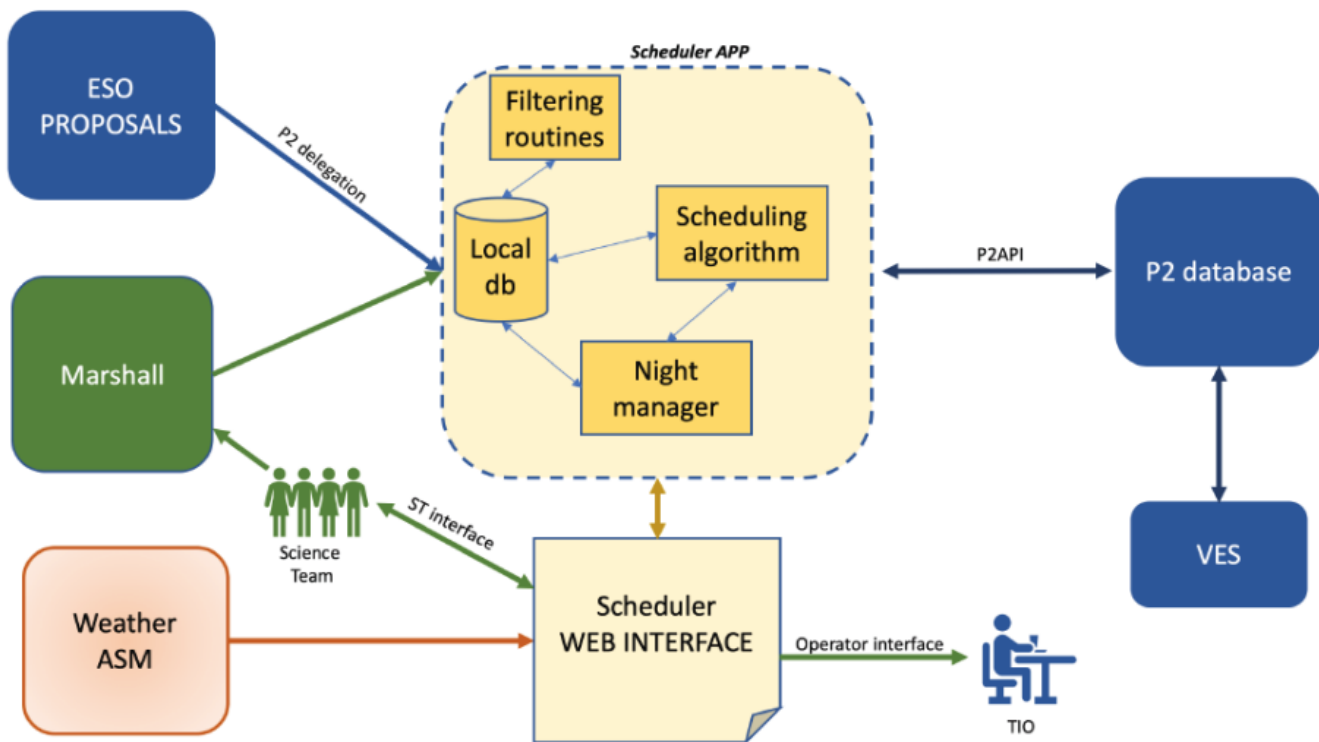
ACQ	ONLINE	SIM	IDLE
ACQS	LOADED	HW	FAIL 106
ACFW	LOADED	HW	571151
AFOC	LOADED	HW	FAIL 54671



Scheduler

- ❑ Schedule is updated daily
- ❑ Telescope operator on site

- ❑ P2 system, vOT interface with ESO
- ❑ Web based app



ID	Scheduled	Target	Type	Obs. Start	Obs. End	Actions
8973	•	ATLAS2jqc	ESO OB	2023-07-27 23:31:09.894	2023-07-28 00:31:09.894	[Q] [IL] [T]
7294	•	AT2022nph	CLASSIFICATION	2023-07-28 00:31:09.704	2023-07-28 00:41:09.704	[Q] [IL] [T]
7241	•	AT2022nml	CLASSIFICATION	2023-07-28 00:41:09.704	2023-07-28 02:06:09.704	[Q] [IL] [T]
7280	•	AT2022now	CLASSIFICATION	2023-07-28 02:06:09.704	2023-07-28 03:36:09.704	[Q] [IL] [T]
7924	•	AT2022okx	CLASSIFICATION	2023-07-28 03:36:09.704	2023-07-28 04:06:09.704	[Q] [IL] [T]
9131	•	No Name	ESO OB	2023-07-28 04:06:09.894	2023-07-28 04:56:09.894	[Q] [IL] [T]
9129	•	No Name	ESO OB	2023-07-28 04:51:09.894	2023-07-28 05:46:09.894	[Q] [IL] [T]

Marshall

Feeders:

- ❑ ZTF, ATLAS, PanStarrs, LSST-Lasair, etc.
- ❑ TNS, Atel, GCN, etc.



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Pipeline

Several rounds with ESO counterpart (A. Modigliani) done
Pre-pre-PAE Interactions started well before

SOXS ETC

Available: <http://192.167.38.34/>









First steps into the PAE

June 2024: pre-delivery of documentation on ESO PDM

June 2024: visit of ESO SW counterpart (G. Zins)

July 2024: visit of ESO EMC counterpart (A. van Kesteren)

End of July 2024: internal deadline for ALL documents delivery

September 2024: visit of ESO Safety counterpart (S. Alvarez Diaz)

End of September 2024: deadline for ALL documents delivery



Timeline

Other ESO visits – RIXs – discussions (September – October)

All SOXS people shall interact with ESO through JIRA

First week of November 2024: PAE closure

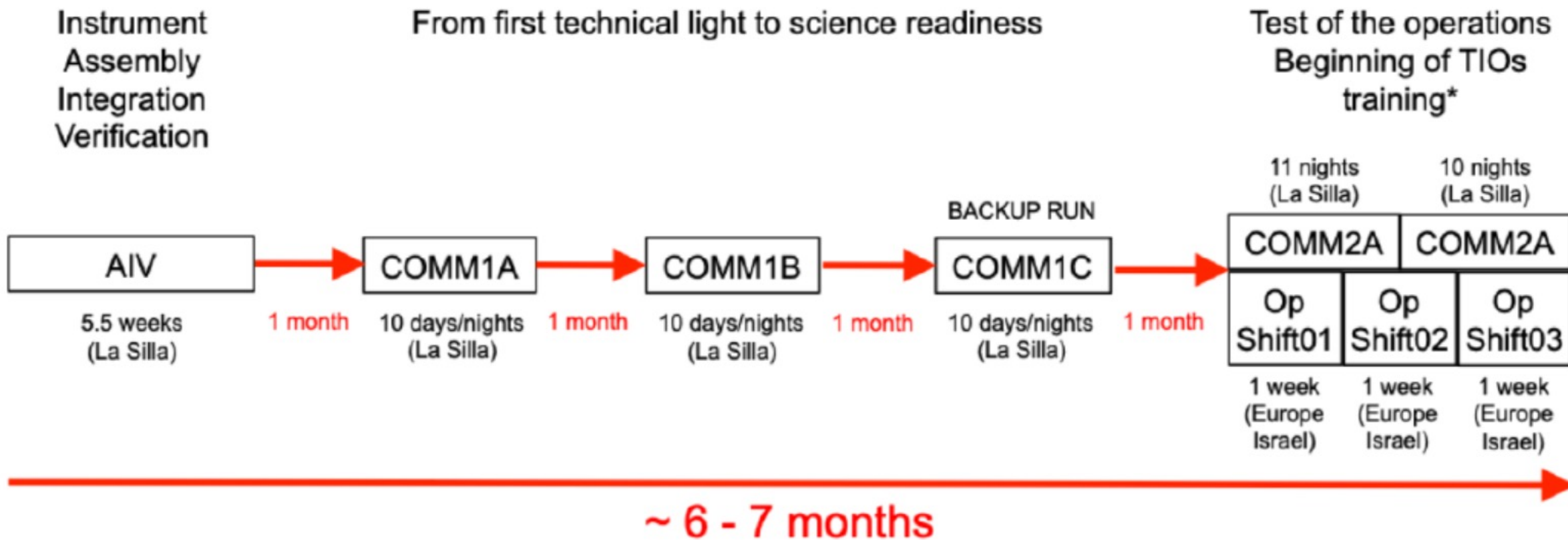
November 2024: Packing

December 2024: Shipping

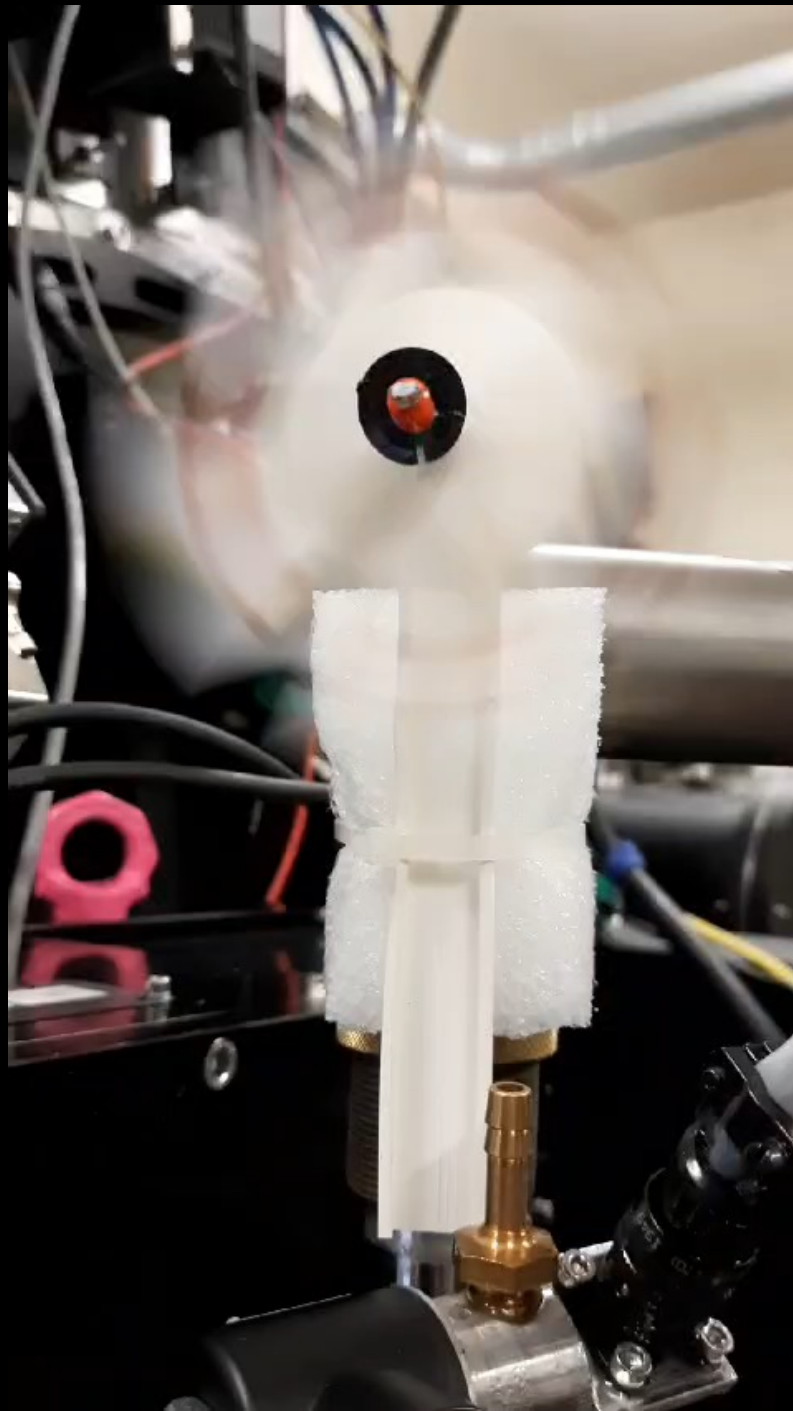
January 2025: Start of AIV in Chile...



Timeline (Chile)



*also SOXS GTO time can be used to test operations and to train TIOs



See you soon





SPIE. ASTRONOMICAL TELESCOPES + INSTRUMENTATION

Ground-based and Airborne Instrumentation for Astronomy X

- P. Schipani, et al., "Walking with SOXS towards the transient sky"
- F. Vitali, et al., "The Status of the NIR arm of the SOXS Instrument toward the PAE", AS24-AS105-42
- K. Radhakrishnan, et al., "Integration and Verification of the SOXS Instrument", AS24-AS105-187
- J.A. Araiza-Durán, "Final Alignment and Image Quality Test for the Acquisition and Guiding System of SOXS", AS24-AS105-209
- R. Cosentino, et al., "Characterisation and Assessment of the SOXS Spectrograph UV-VIS Detector System", AS24-AS105-302
- M. Genoni, et al., "SOXS NIR: Optomechanical integration and alignment, optical performance verification before full instrument assembly.", Paper n. AS 13096-104

Modeling, Systems Engineering, and Project Management for Astronomy XI

- A. Scaudo, et al., "End-to-End simulation framework for astronomical spectrographs: SOXS, CUBES and ANDES", AS24-AS108-71
- R. Claudi, et al., "SOXS System engineering from design to installation. Challenges and results.", AS24-AS108-76

Software and Cyberinfrastructure for Astronomy VIII

- L. Asquini, et al., "Automated scheduler for the SOXS instrument: design and performance", AS24-AS110-31
- D. Ricci. et al., "The SOXS Instrument Control Software challenges approaching the PAE", AS24-AS110-32
- M. Colapietro, et al., "The integration of the SOXS control electronics towards the PAE", AS24-AS110-55