The SOXS instrument: an overview

P. D'Avanzo

on behalf of the SOXS Team

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~4,500 (3,500-6,000)
- Acquisition camera to perform photometry ugrizY-V (3.5'⌀ FoV)

Consortium

Institutes from 6 Countries

- Istituto Nazionale di Astrofisica (INAF), Italy
  leading Institute (PI: Sergio Campana)
- 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

SOXS@INAF

OA Brera
(Principal Investigator, Instrument Scientist, WP: Mechanics, Scheduler, ETC)

OA Capodimonte
(Project Manager, WP: Electronics)

OA Padova
(System Engineer, WP: AIT, Software)

OA Arcetri
(WP: Acquisition Camera)

OA Catania
(WP: Optics, Cryogenics)

OA Roma
(WP: NIR Spectrograph)

TNG
(WP: UV-VIS Detector)

7 Structures

~ 100 people
(including contributions to the Science Board, Science WGs, Operations)

SOXS

INAF ISTITUTO NAZIONALE DI ASTROFISICA

מכון ויצמן למדע WEIZMANN INSTITUTE OF SCIENCE

QUEEN'S UNIVERSITY BELFAST

MILLENNIUM INSTITUTE OF ASTROPHYSICS

Turun yliopisto University of Turku

TEL AVIV UNIVERSITY

ESO

2014: ESO CALL

2015: SOXS IS SELECTED

2016-2018: DESIGN (SOXS ON PAPER)

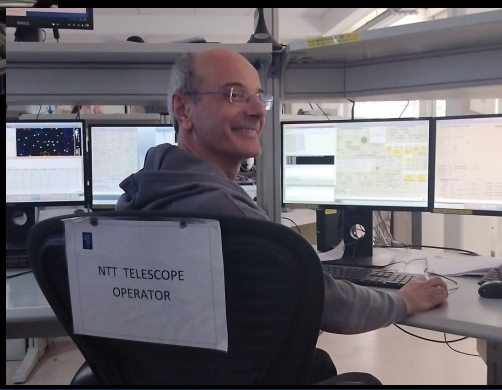
2018-2024: MAIT

Dec 2024: PAE

Jan 2025: SOXS @ LA Silla: AIV & COMMISSIONING (still ongoing)

Dec 2025: OFFICIAL 1st LIGHT

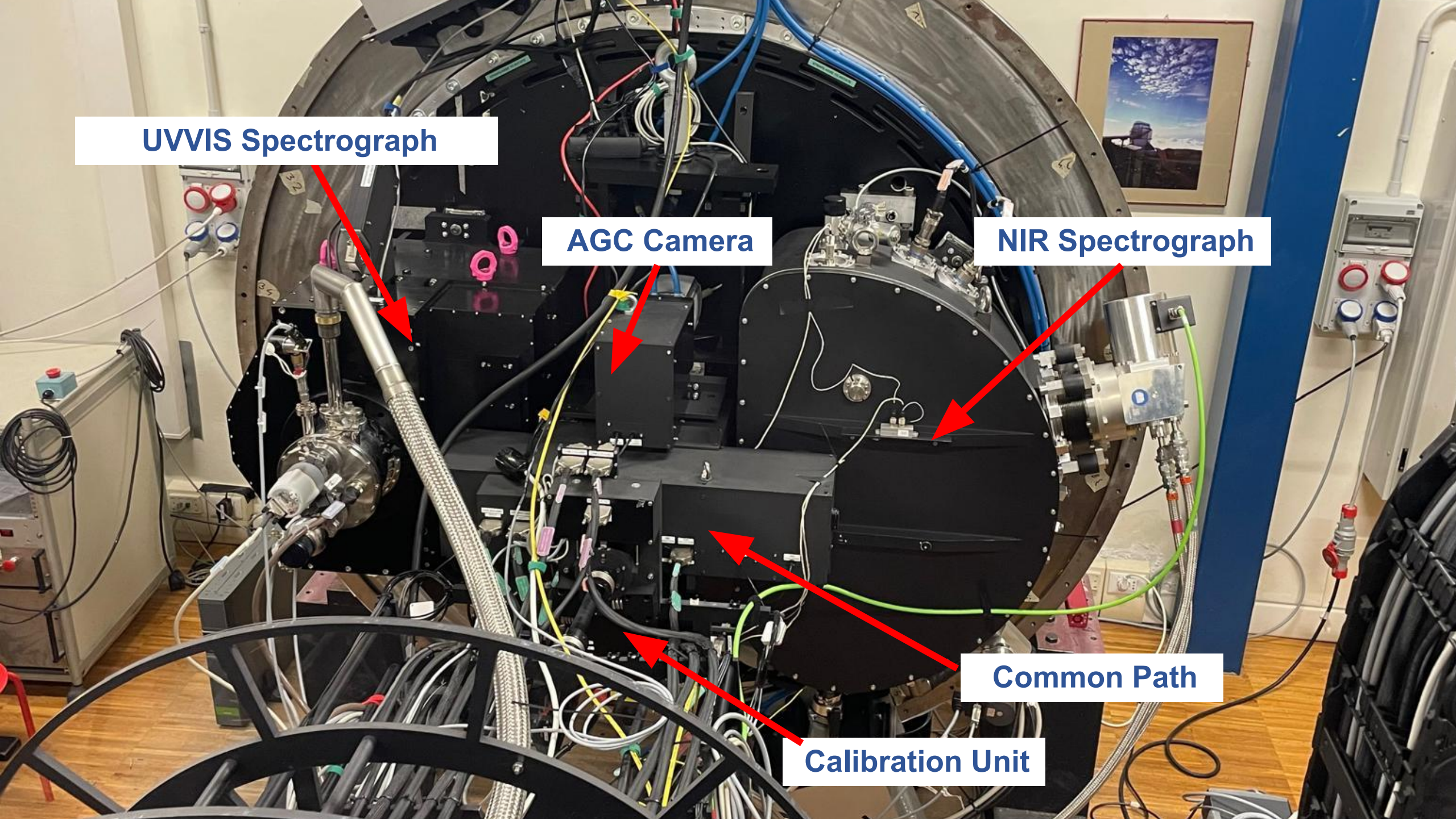
2026: EXPECTED START OF OPERATIONS

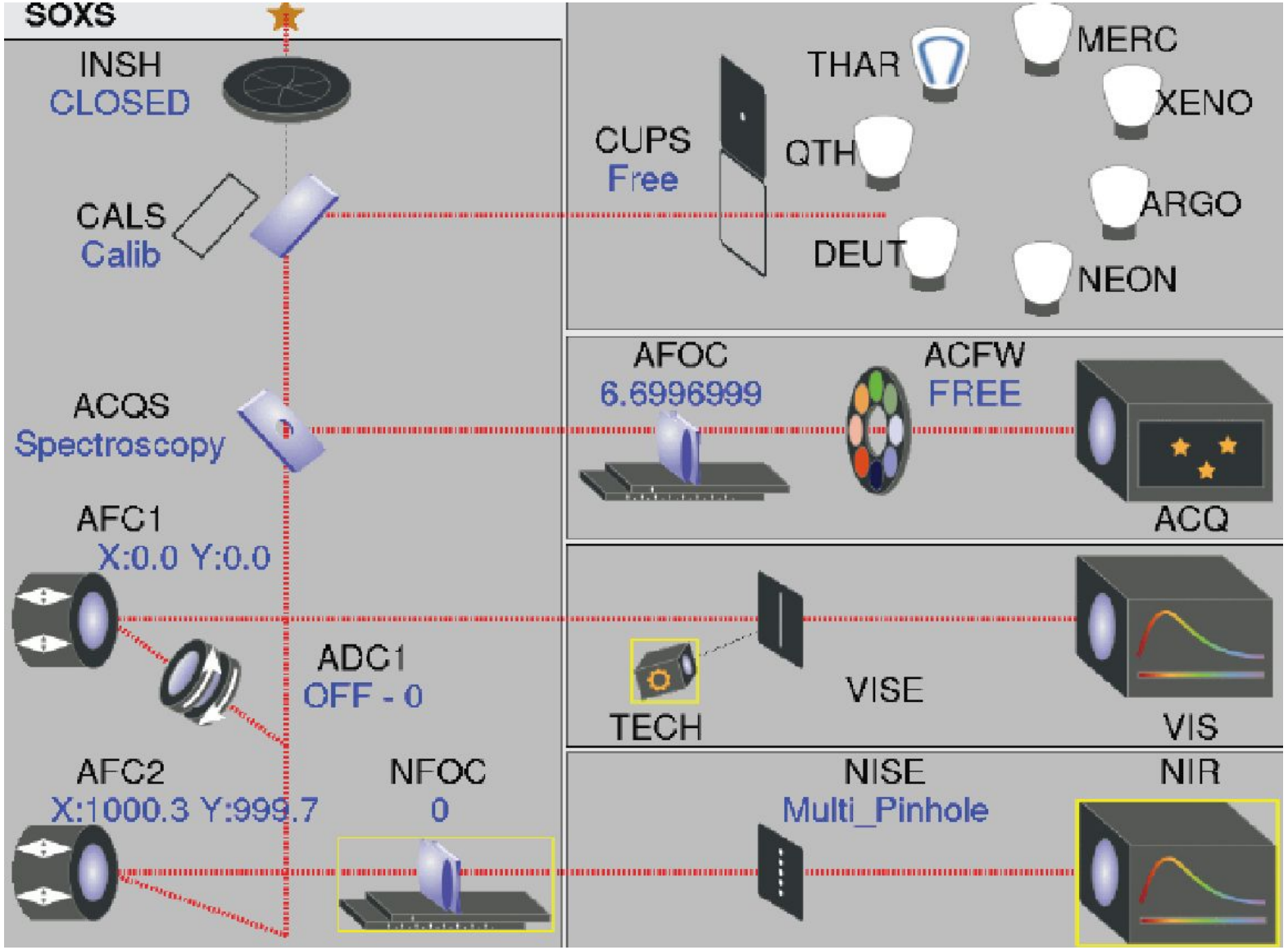


Credits: M. C. Baglio

	UV-VIS	NIR
Spectral range	350-850 nm	800-2000 nm
Resolution (1" slit)	>3600 (≈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 µm	18 µm
Detector Scale	0.28"/pixel	0.25"/pixel

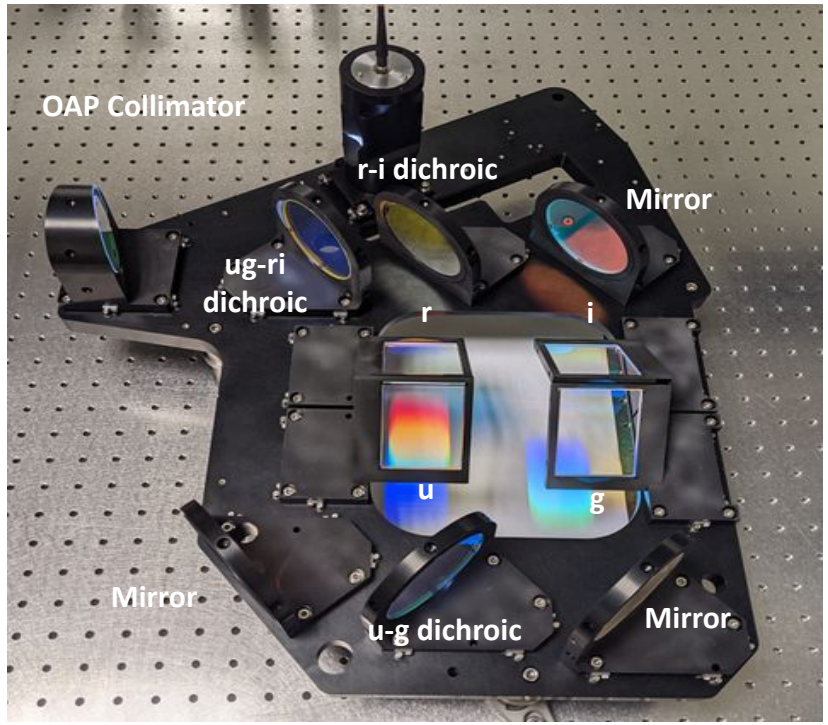
	Camera
Spectral range	360-970 nm
Detector	Andor iKon M-934 1Kx1K
Field of View	3.5' squared
Pixel Size	13 µm
Detector Scale	0.205"/pixel

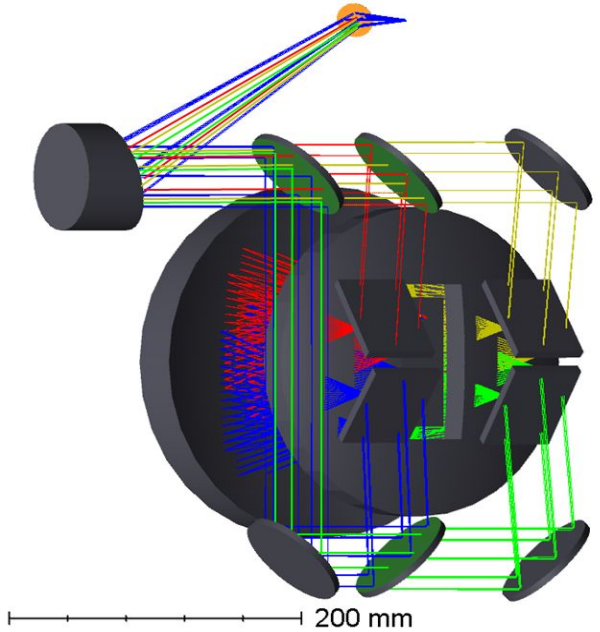

UVVIS Spectrograph
AGC Camera
NIR Spectrograph
Common Path
Calibration Unit


SOXS
INSH
CLOSED
CALS
Calib
ACQS
Spectroscopy
AFC1
X:0.0 Y:0.0
ADC1
OFF - 0
AFC2
X:1000.3 Y:999.7
NFOC
0
CUPS
Free
THAR
MERC
XENO
QTH
ARGO
DEUT
NEON
AFOC
6.6996999
ACFW
FREE
ACQ
TECH
VISE
VIS
NISE
Multi_Pinhole
NIR

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, $\mathcal{R}\sim4500$ at α_{Lit}.
- 4 bands quasi-orders are imaged onto a single 4k×2k CCD.





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

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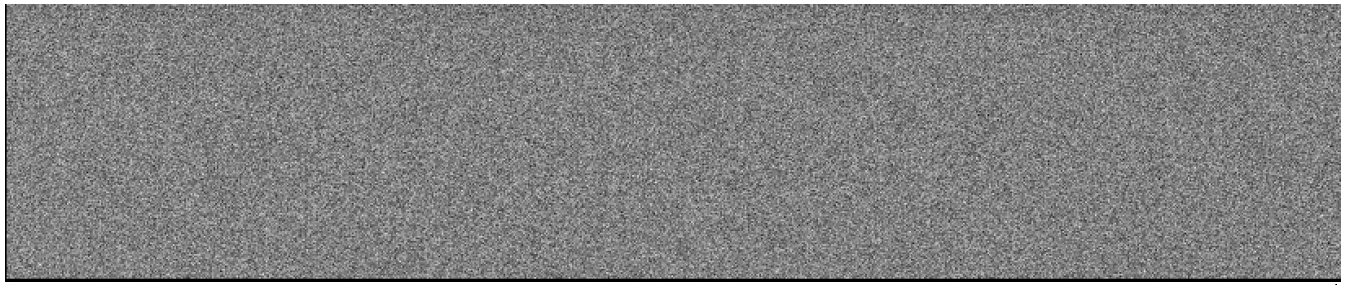
Winlight System ASAHI SPECTRA USA Fraunhofer IOF

UV-VIS Spectrograph

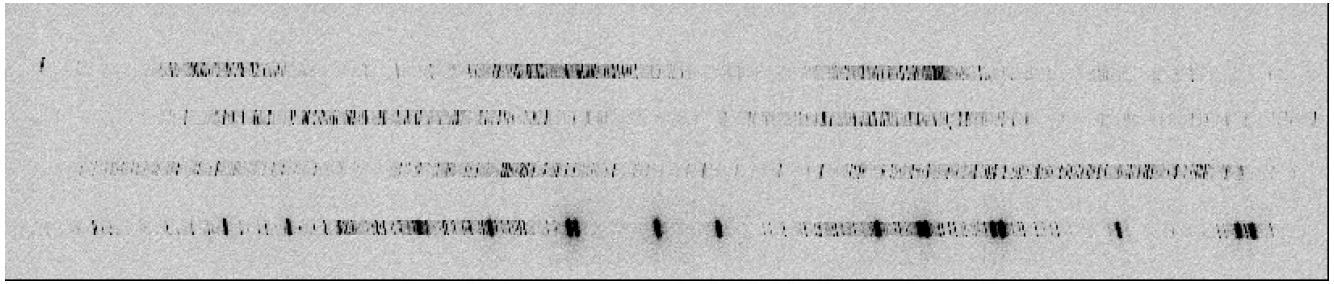
Bias

Flat
(halogen lamp)

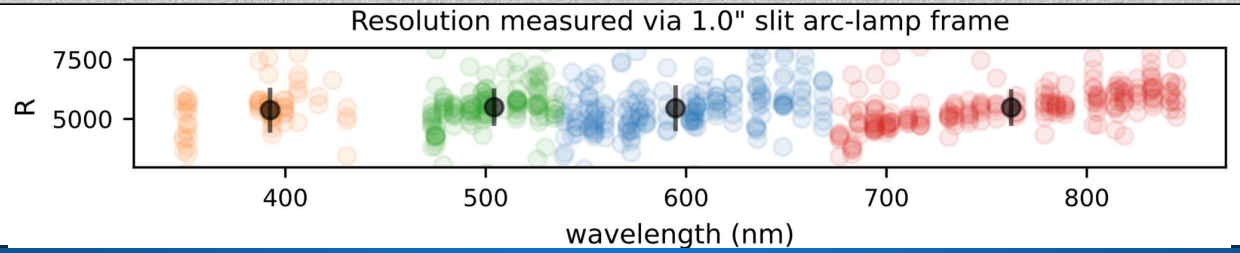
Arcs
(ThAr lamp)



r u g i



r u g i



NIR Spectrograph

4C Design

Spectrograph with **C**ollimator **C**ompensation of **C**amera **C**hromatism Echelle Cross-Dispersed

R ~ 5000, 0.25”/px

F/3.7 camera, H2RG + NGC

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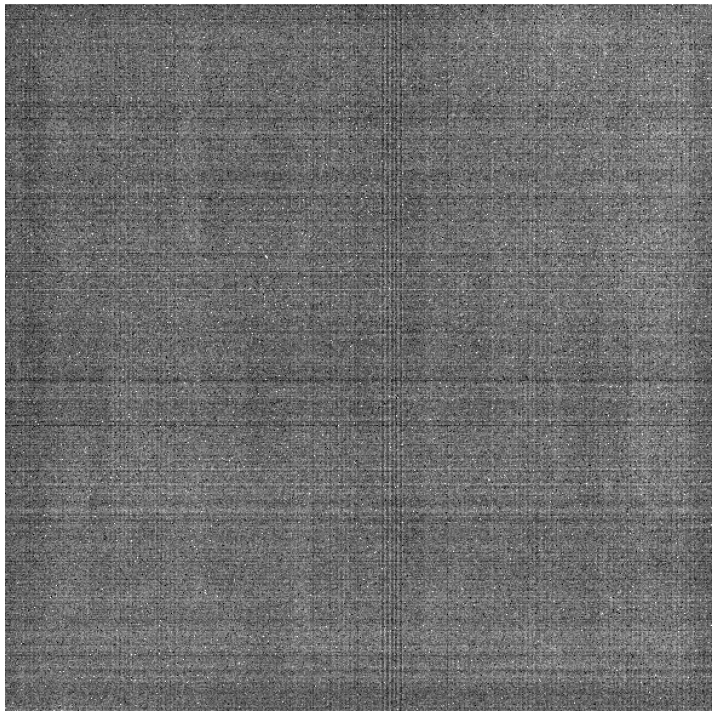
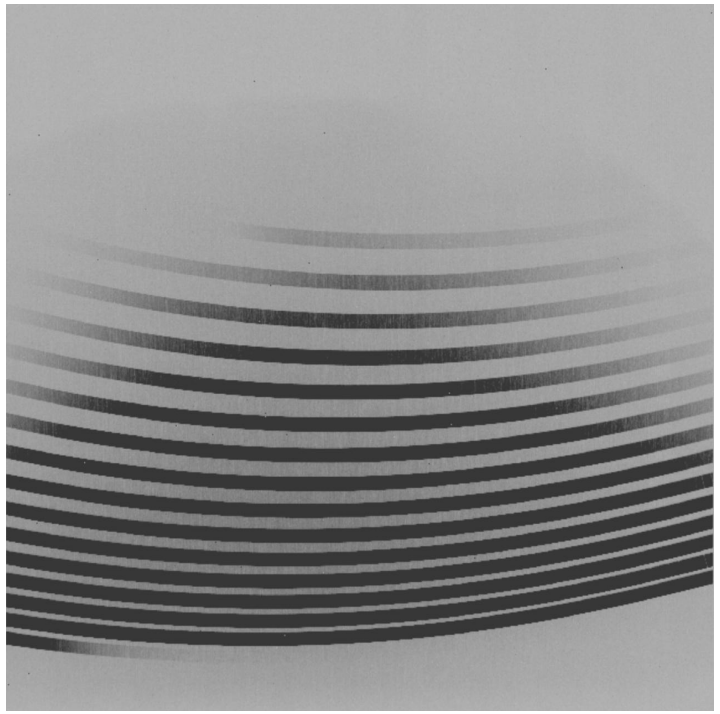
Richardson Gratings™ A Newport Corporation Brand
CRYSTRAN UV · VISIBLE · IR SPECIALIST OPTICS
OPTIMAX
ASAHI SPECTRA USA
OFFICINASTELLARE OUR WORLD, YOUR SPACE
NOVA

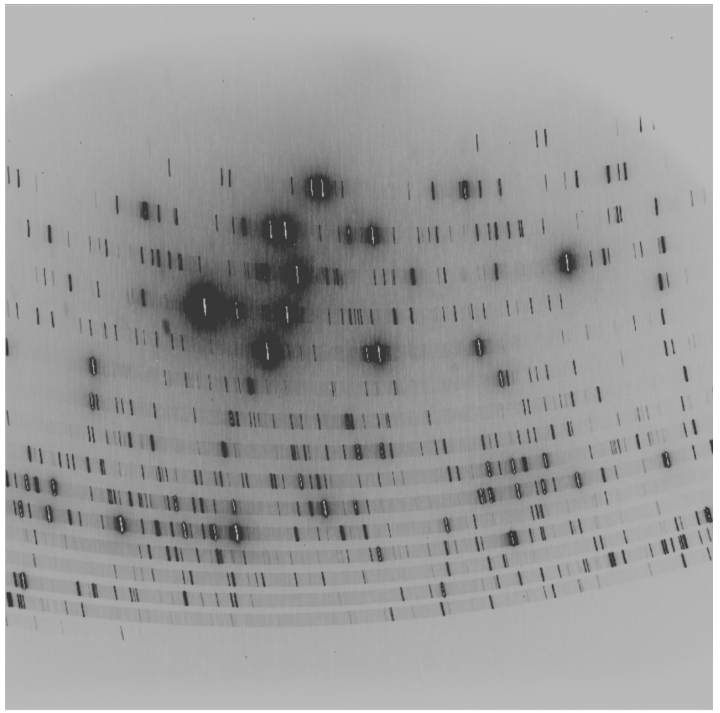
NIR Spectrograph



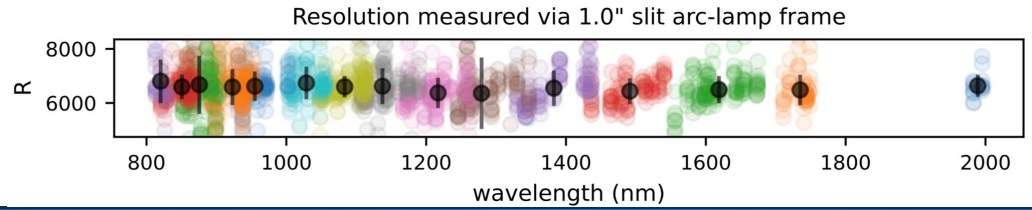
Dark



Flat (halogen lamp)

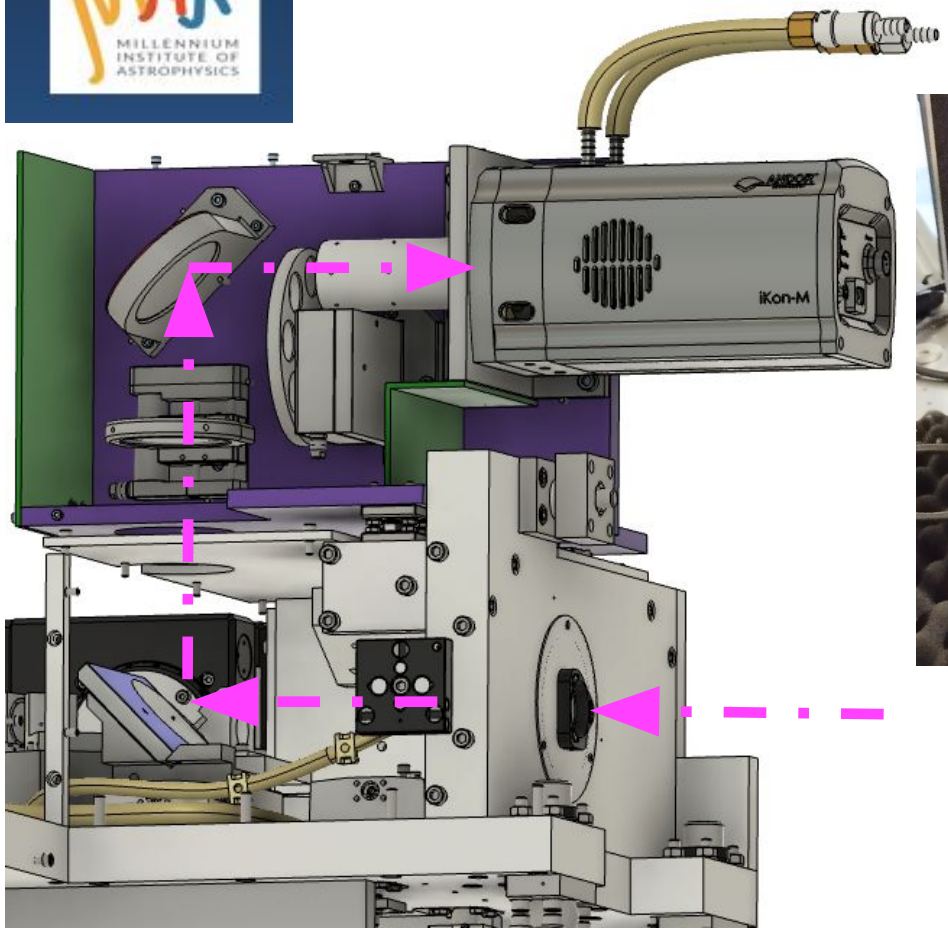


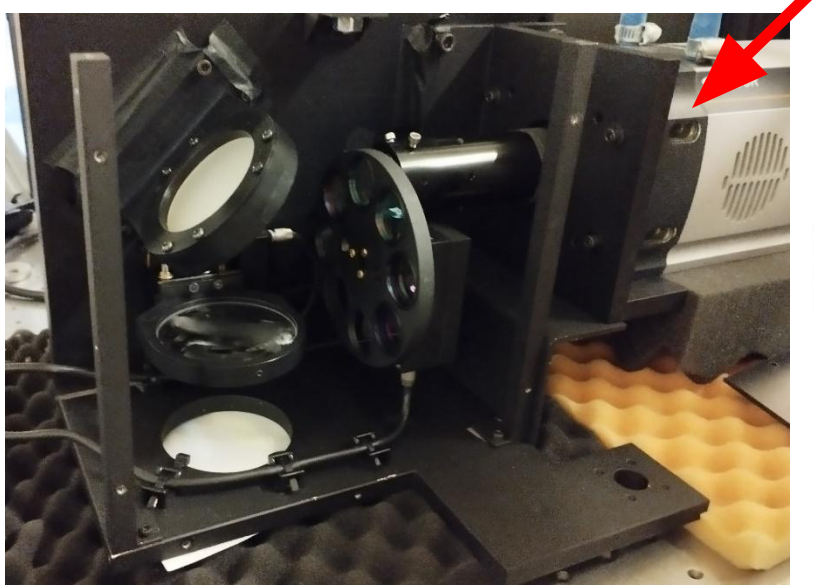
Arcs (ArHgNeXe lamps)

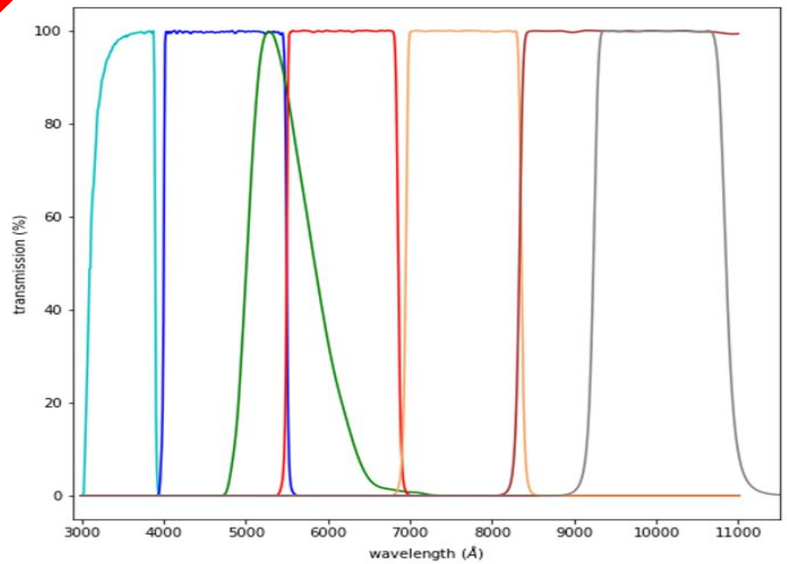


Acquisition Camera

Andor iKon M934 1024x1024
13µm/px 0.207 “/px







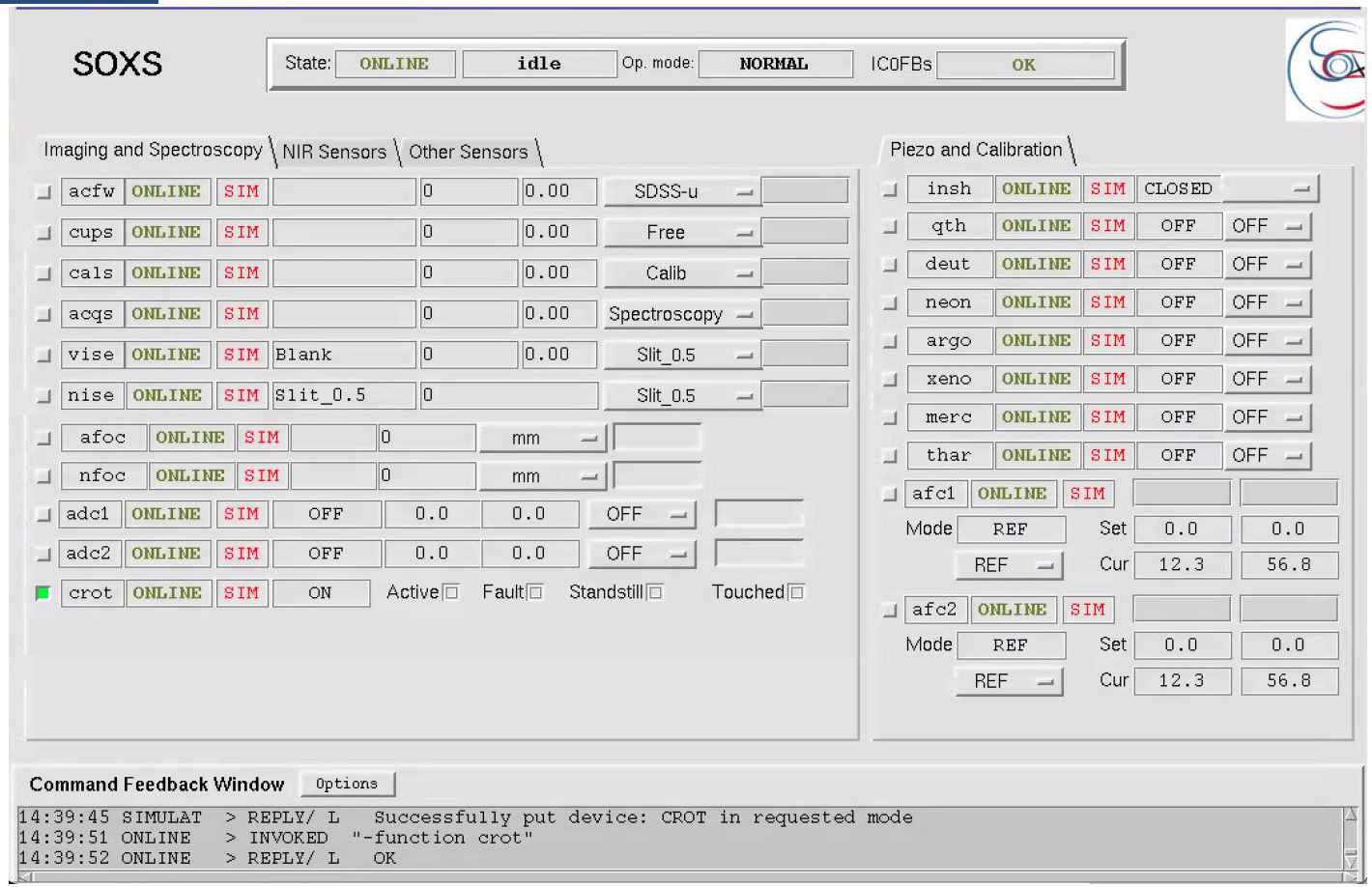
- ❑ Target Acquisition
- ❑ Photometry

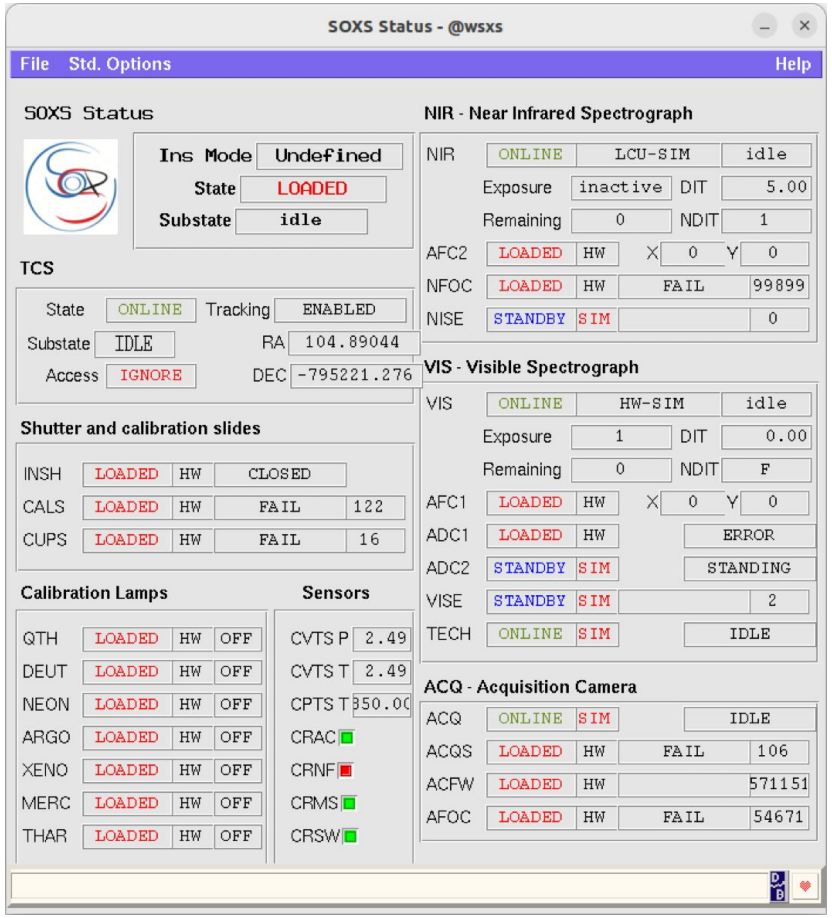
Filters: ugrizY + V

FoV: 3.5’

Instrument Software

Based on VLT Common SW (v.2024)





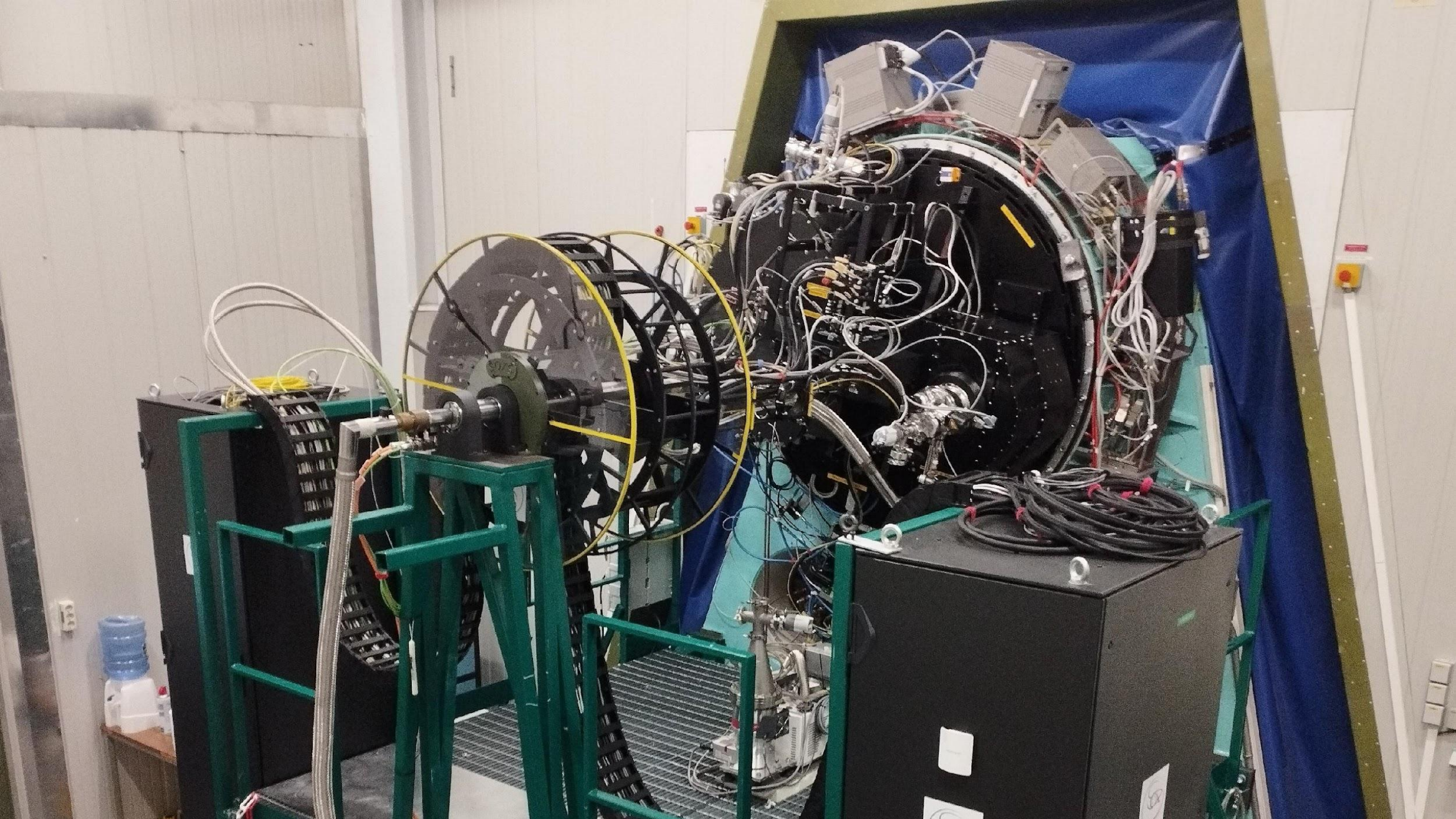
SOXS ETC

Avalaible:https://soxs-etc.brera.inaf.it/

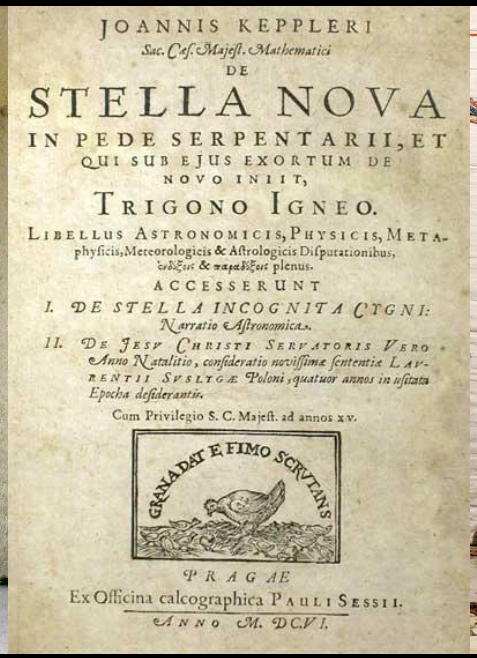
Operational (continuously refined using on sky commissioning data)

Pipeline

- Pipeline extensively tested first with XSH and now with SOXS data
- It works with full automation (data are reduced as soon arrive on the workstation)
- Installed in La Silla
- Code available here https://github.com/thespacedoctor/soxspipe



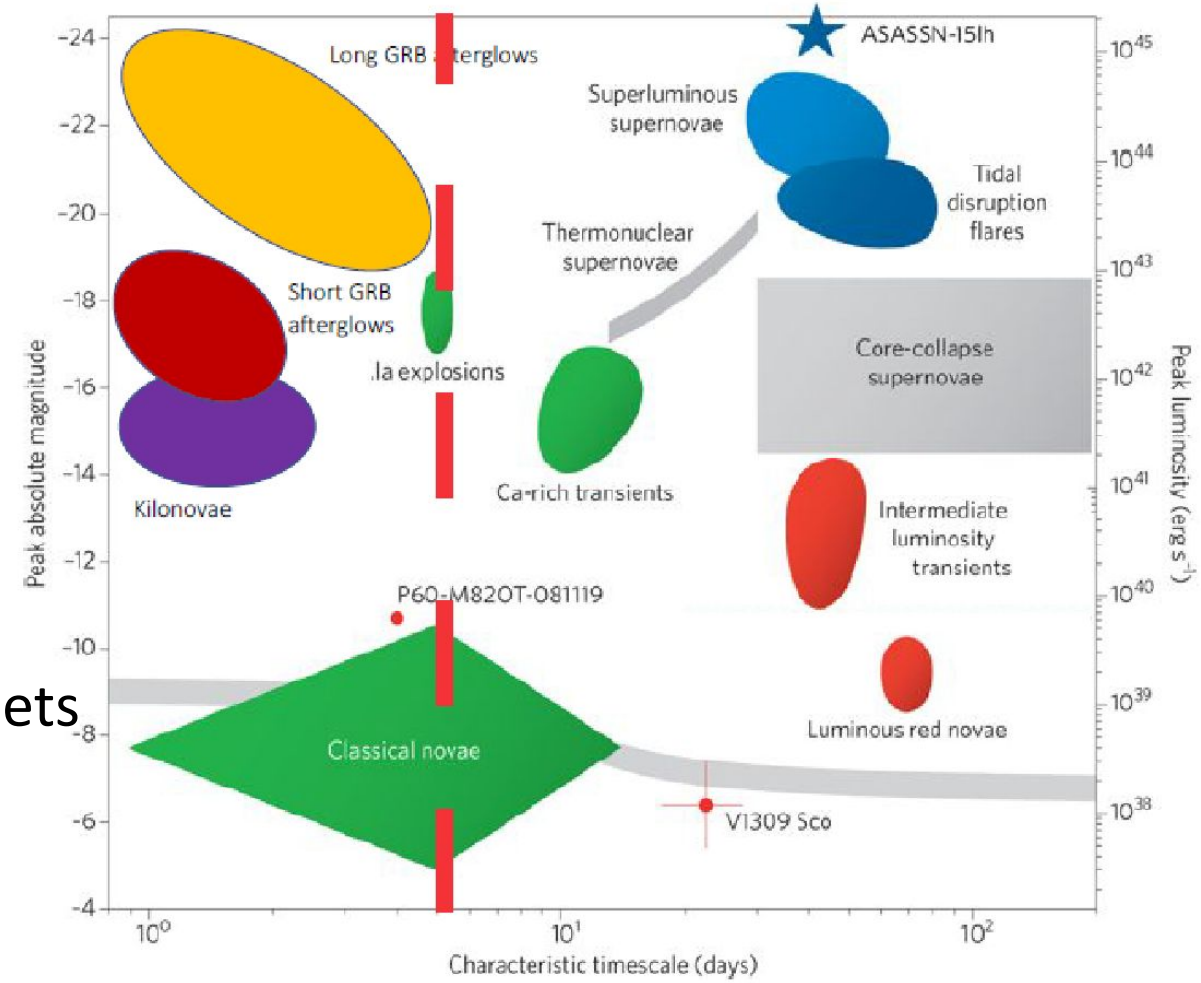
Science @ SOXS



JOANNIS KEPPLERI
Sac. Cæs. Majest. Mathematici
DE
STELLA NOVA
IN PEDE SERPENTARII, ET
QUI SUB EJUS EXORTUM DE
NOVO INIIT,
TRIGONO IGNEO.
LIBELLUS ASTRONOMICIS, PHYSICIS, METAphysicis, Meteorologicis & Astrologicis Disputationibus,
ἐνδείξεις & παραδείγεις plenus.
ACCESSERUNT
I. DE STELLA INCOGNITA CYGNI:
Narratio Astronomica.
II. DE JESU CHRISTI SERVATORIS VERO
Anno Natalitio, consideratio novissima sententiæ LAVRENTII SVSLYGÆ Poloni; quatuor annos in usitata
Epocha desiderantis.
Cum Privilegio S. C. Majest. ad annos XV.
GRANA DANT E FIMO SCRVTANS
PRAGAE
Ex Officina calcographica PAULI SESSII.
ANNO M. DC. VI.

Spectroscopic follow up of transients

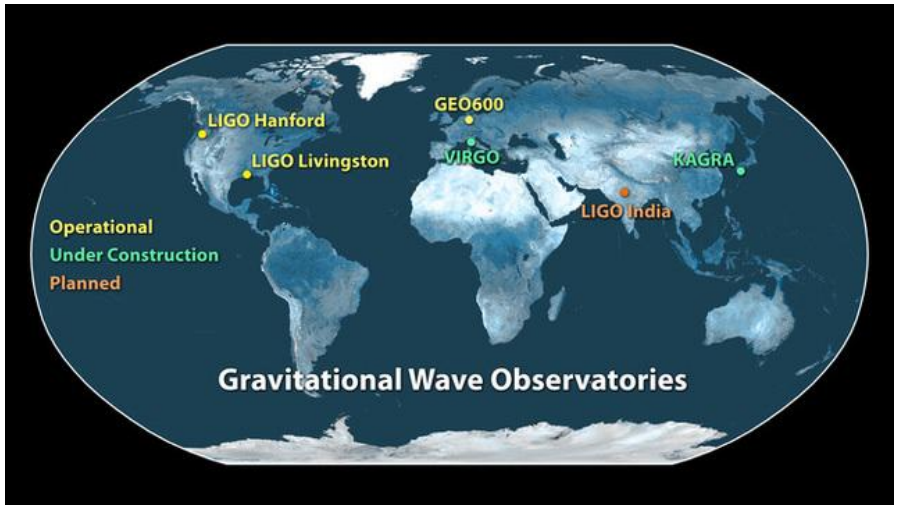
- ❑ Classification of transients
- ❑ Supernovae (all flavours)
- ❑ Gravitational Wave and neutrino events
- ❑ GRB and FRB
- ❑ Blazars and AGN
- ❑ Nuclear transients and Tidal Disruption Events
- ❑ Transient X-ray binaries, magnetars, ultra -luminous X-ray sources (NS & BH)
- ❑ Novae and cataclysmic variables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



Synergies

A spectroscopic machine for the MW and MM transient sky

- ❑ New deeper survey: Vera Rubin, LAST, PanSTARSS, DES, ATLAS, ZTF
- ❑ Space optical missions: Gaia, EUCLID
- ❑ Space high-energy missions: Swift, Fermi, SVOM, Einstein Probe
- ❑ Radio new facilities: MeerKAT, SKA
- ❑ VHE: CTA, Astri, MAGIC, LHAASO
- ❑ Messengers: aLIGO-Virgo, KM3NeT



KM3NeT

SKAO

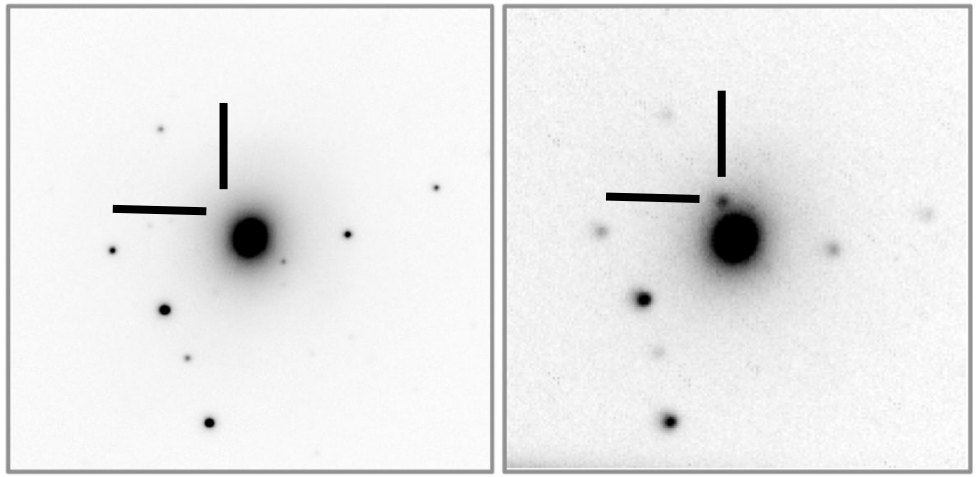
VERA C. RUBIN OBSERVATORY

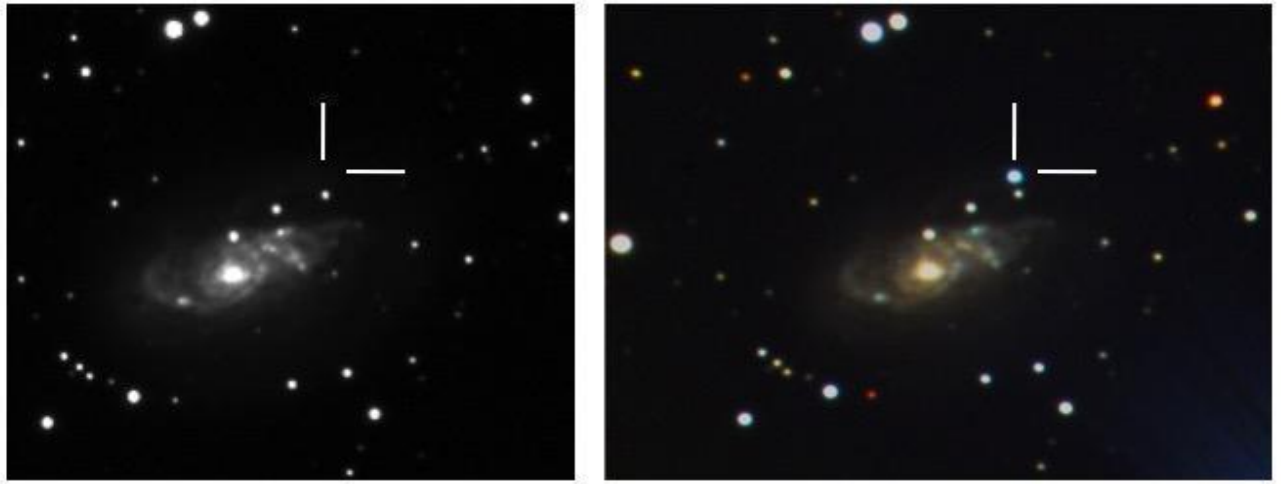
cta cherenkov telescope array

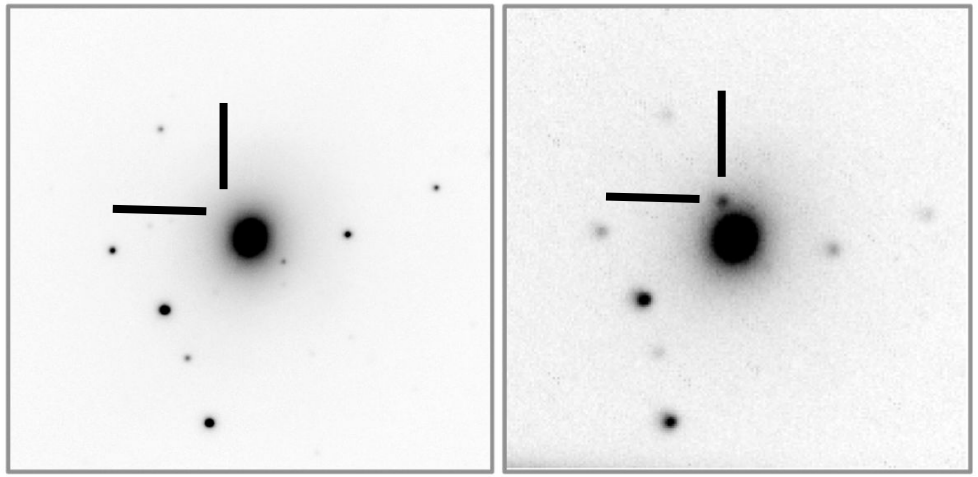
Swift

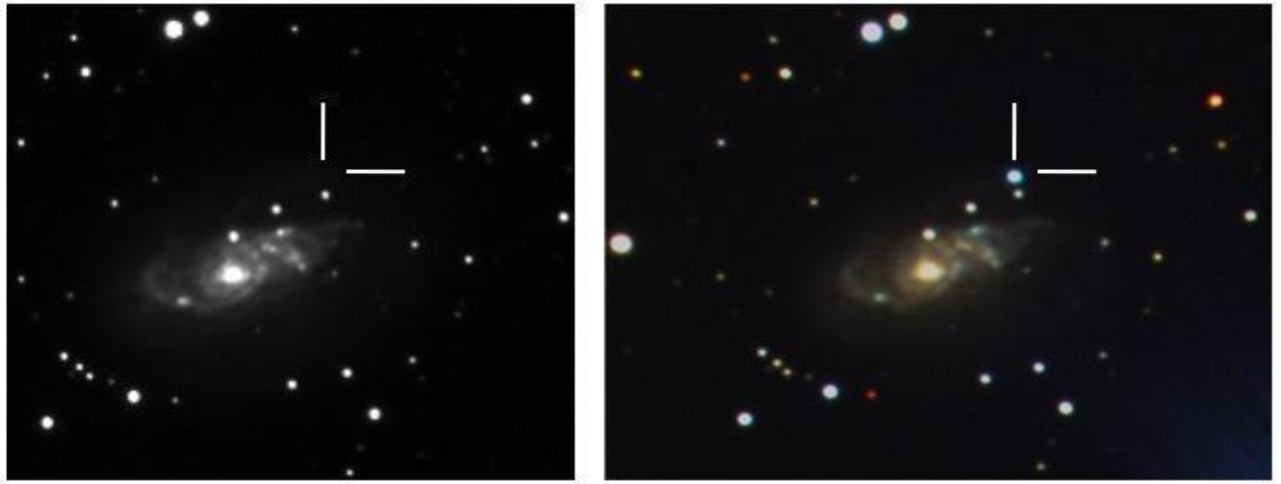
SVOM

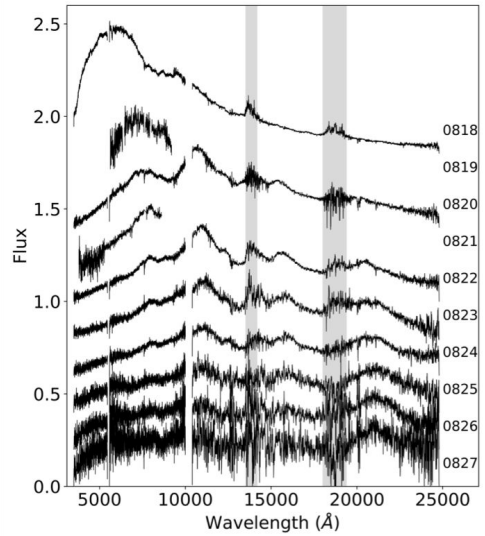
einstein probe 爱因斯坦探针 exploring the dynamic x-ray universe



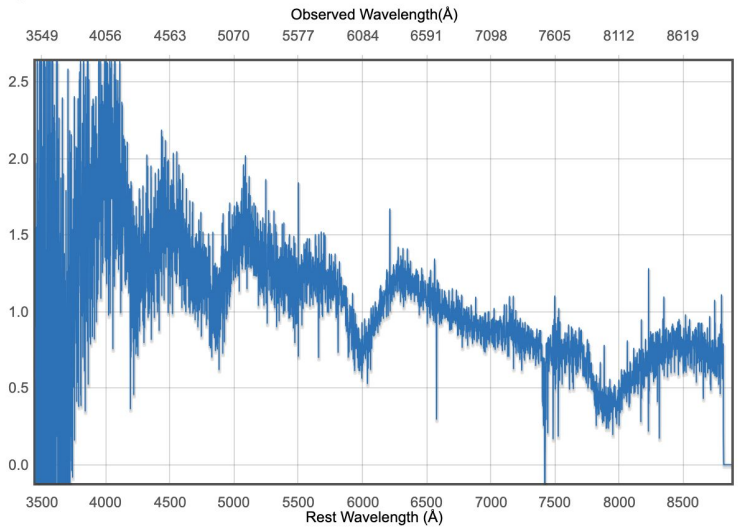








Kilonova



Supernova Ia

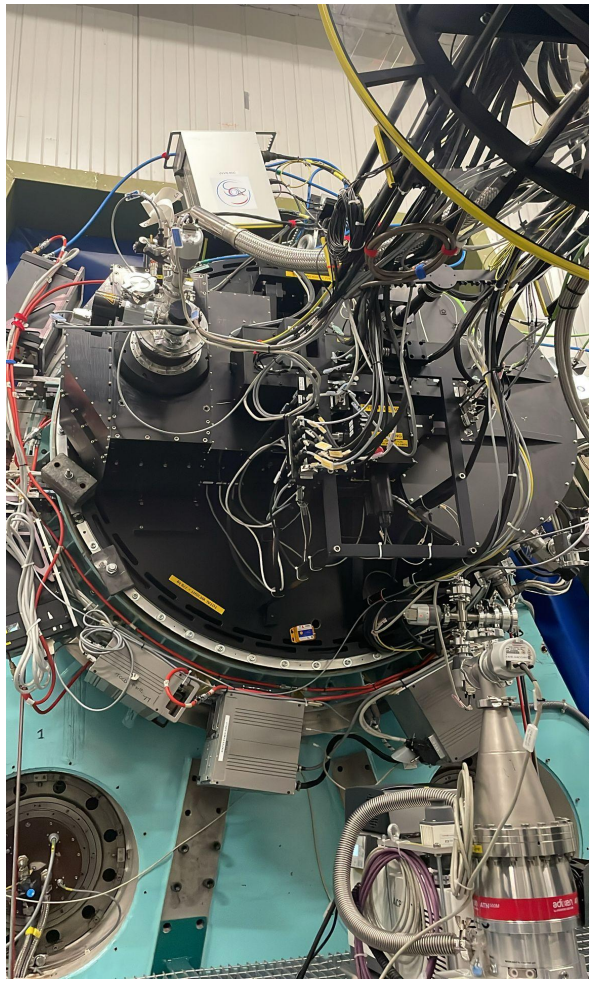
SOXS GTO

The SOXS consortium will have 180 nights/year for 5 years 49% of this time will be INAF (consortium) time.

There will be “open” time too (the remaining 180/nights year), to which it will be possible to apply for through the usual ESO call for proposals.

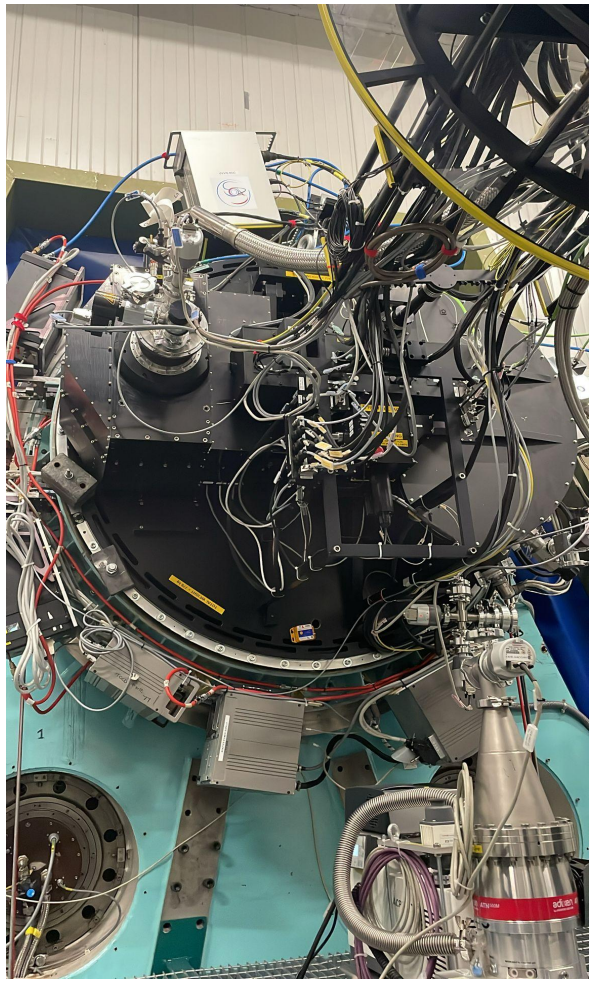
GTO time will be on transients (ToO observations). GTO targets will be protected.

“ESO” time can be on non-transients sources too.



SOXS Science WGs

	WG Topic	WG Leader	WG Deputy
1	Small bodies and comets	**Dotto**	
2	Stellar variability, exoplanets and Young Stellar Objects	**Pagano**	Alcalà
3	Transient X-ray binaries, magnetars, ultra-luminous X-ray sources (NS & BH)	**Casella**	Veledina
4	Cataclysmic variables, novae and white dwarfs	**Della Valle**	Ben-Ami
5	Supernovae Ia and thermonuclear transients	Stritzinger	Kotak
6	Fast and extreme transients (including SLSNe)	Nicholl	Arcavi
7	Intermediate luminosity transients	Kotak	**Pastorello**
8	Core Collapse Supernovae	Gal-Yam	Pignata
9	AGN and blazars	**Landoni**	**Sbarrato**
10	Tidal Disruption and Nuclear Events	Mattila	Arcavi
11	Gamma Ray bursts & Fast radio bursts	**D'Avanzo**	Fynbo
12	Gravitational wave and neutrino counterparts	**Campana**	Smartt
13	Classification	**Benetti**	**Botticella**

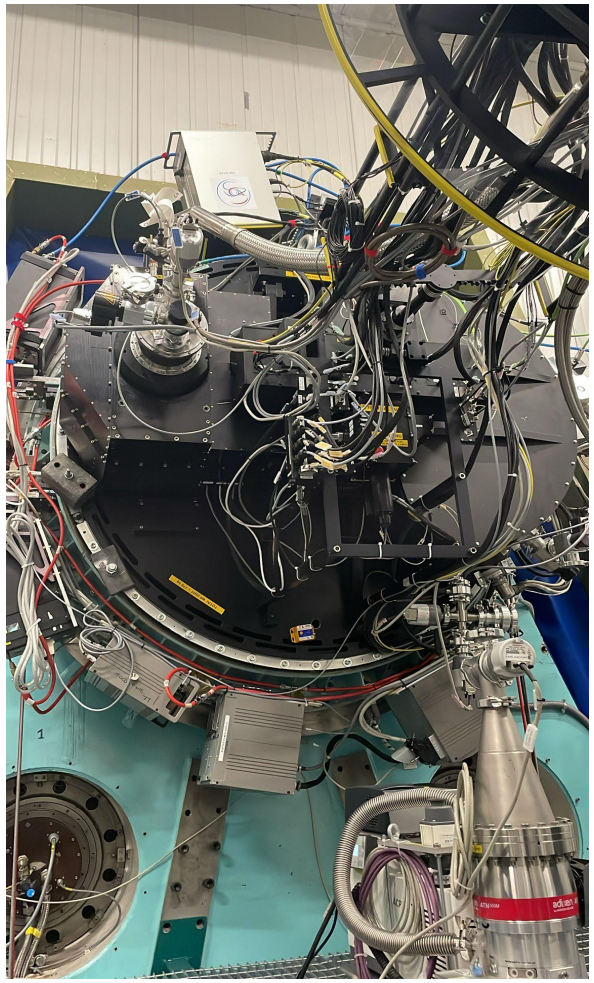


SOXS Operations

SOXS will be operated on site by the ESO TIOs (Telescope and Instrument Operators), with the remote (when needed) support of SOXS astronomers. It will be always available

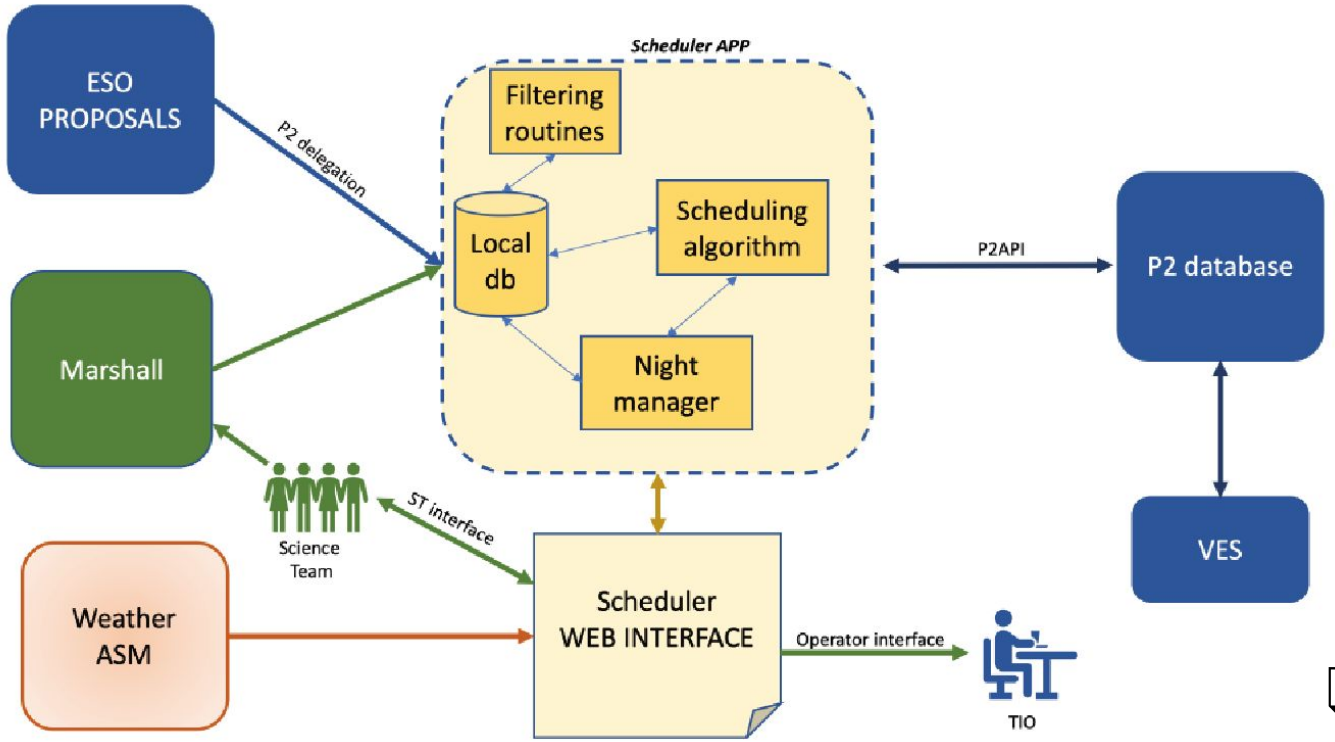
At variance with other ESO instrument/telescopes, the schedule will be done day-by-day and can dynamically change (even during the night) according to the occurrence of new transients.

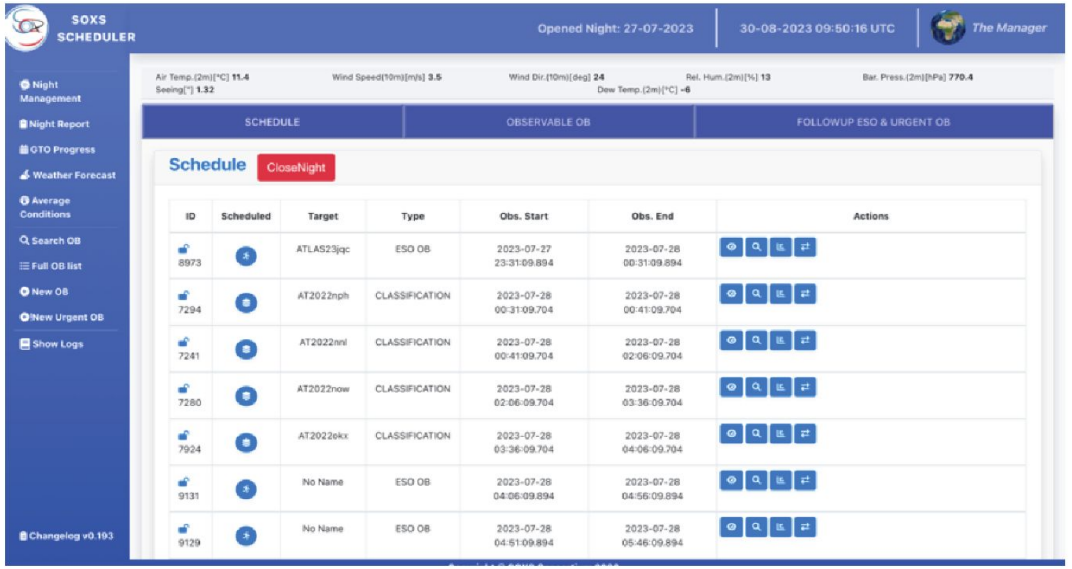
Scheduler developed (and tested)



Scheduler

- ❑Schedule is updated daily
- ❑Telescope operator on site
- ❑P2 system, vOT interface with ESO
- ❑Web based app





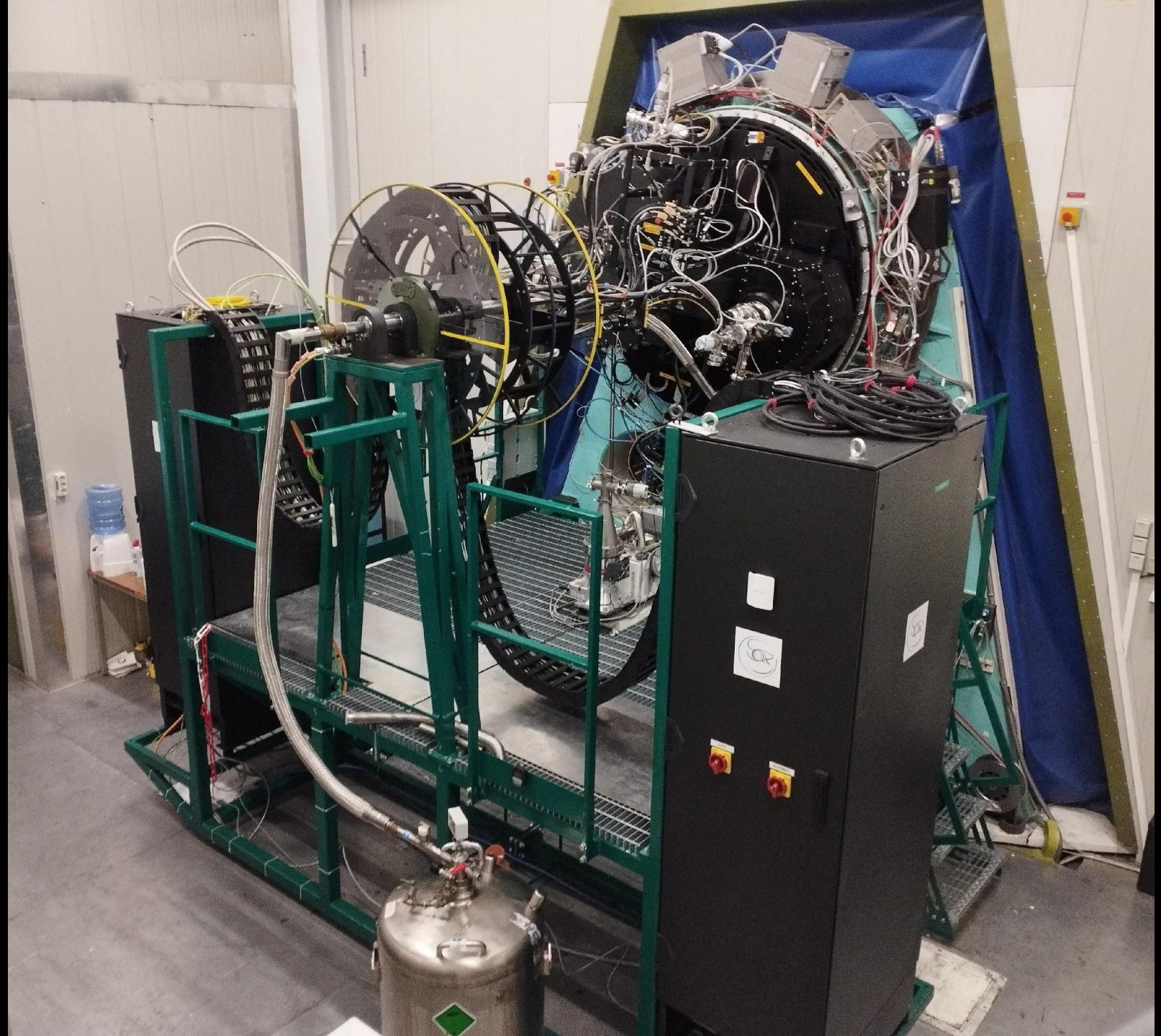
Marshall

Feeders:

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

November, 2023

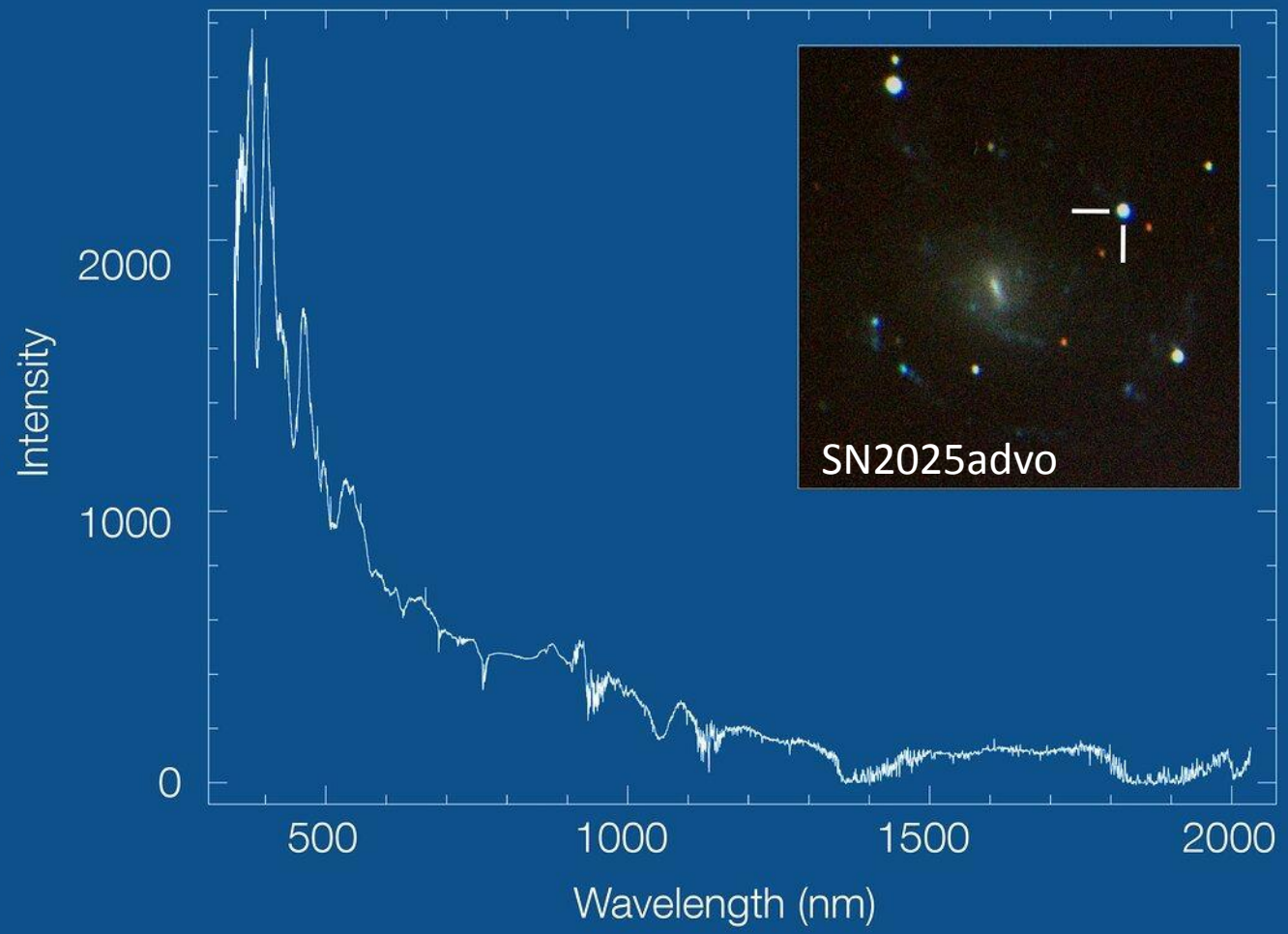
March, 2025



Commissioning is ongoing

- May 2025 run (done)
- June 2025 run (done)
- September 2025 run (done)
- October 2025 run (done)
- November - December 2025 run (done)
- January 2026 run (done)
- End of Spring / Summer 2026 run -> towards the start of science operations (PAC, May 2026)

SOXS



European Southern Observatory

Announcement

New SOXS instrument ready to observe fleeting cosmic events

16 December 2025