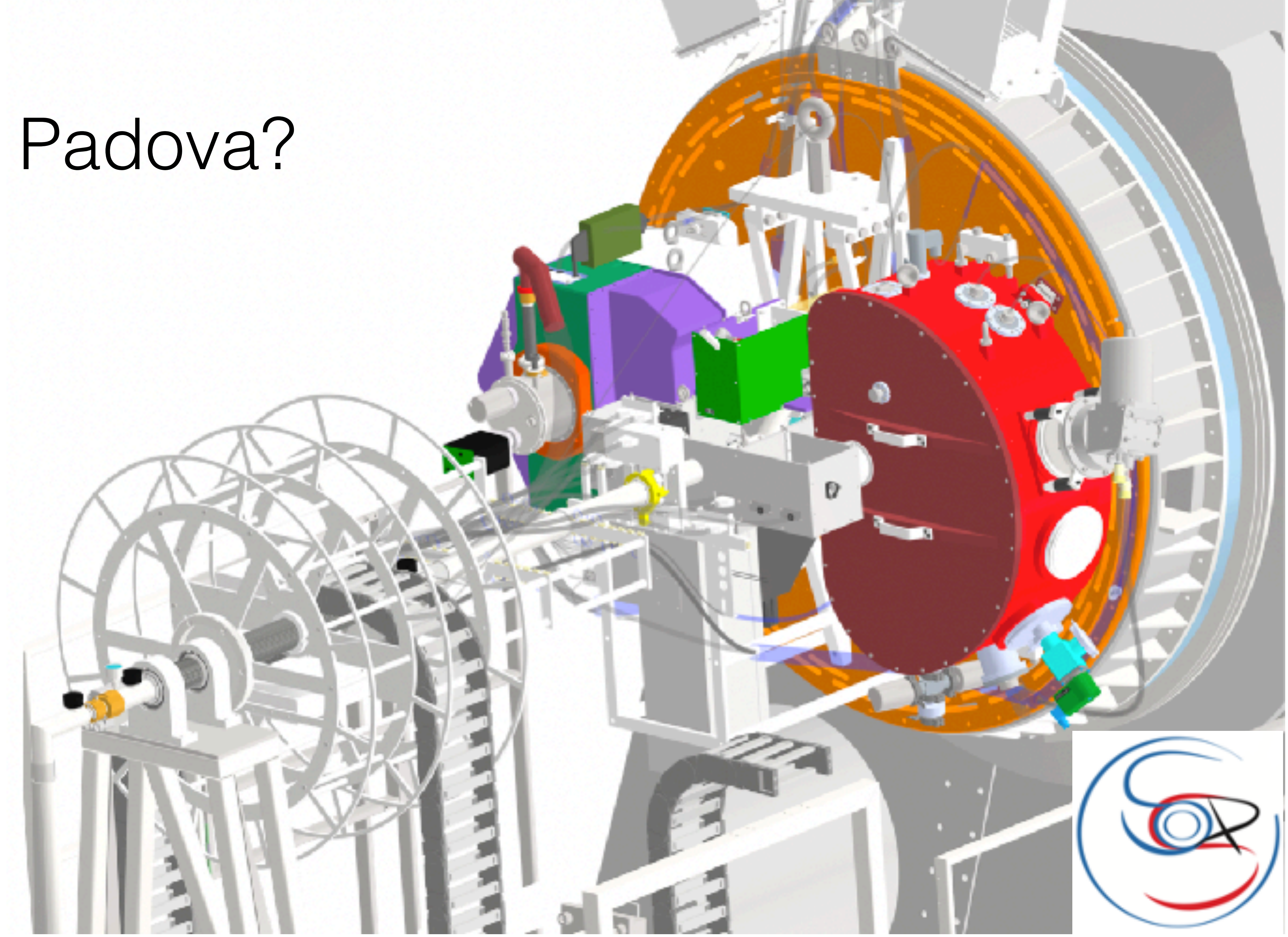
What is going on in Padova?



Kalyan Radhakrishnan & AIV Team

SOXS Instrument AIV Lead & Deputy System Engineer,

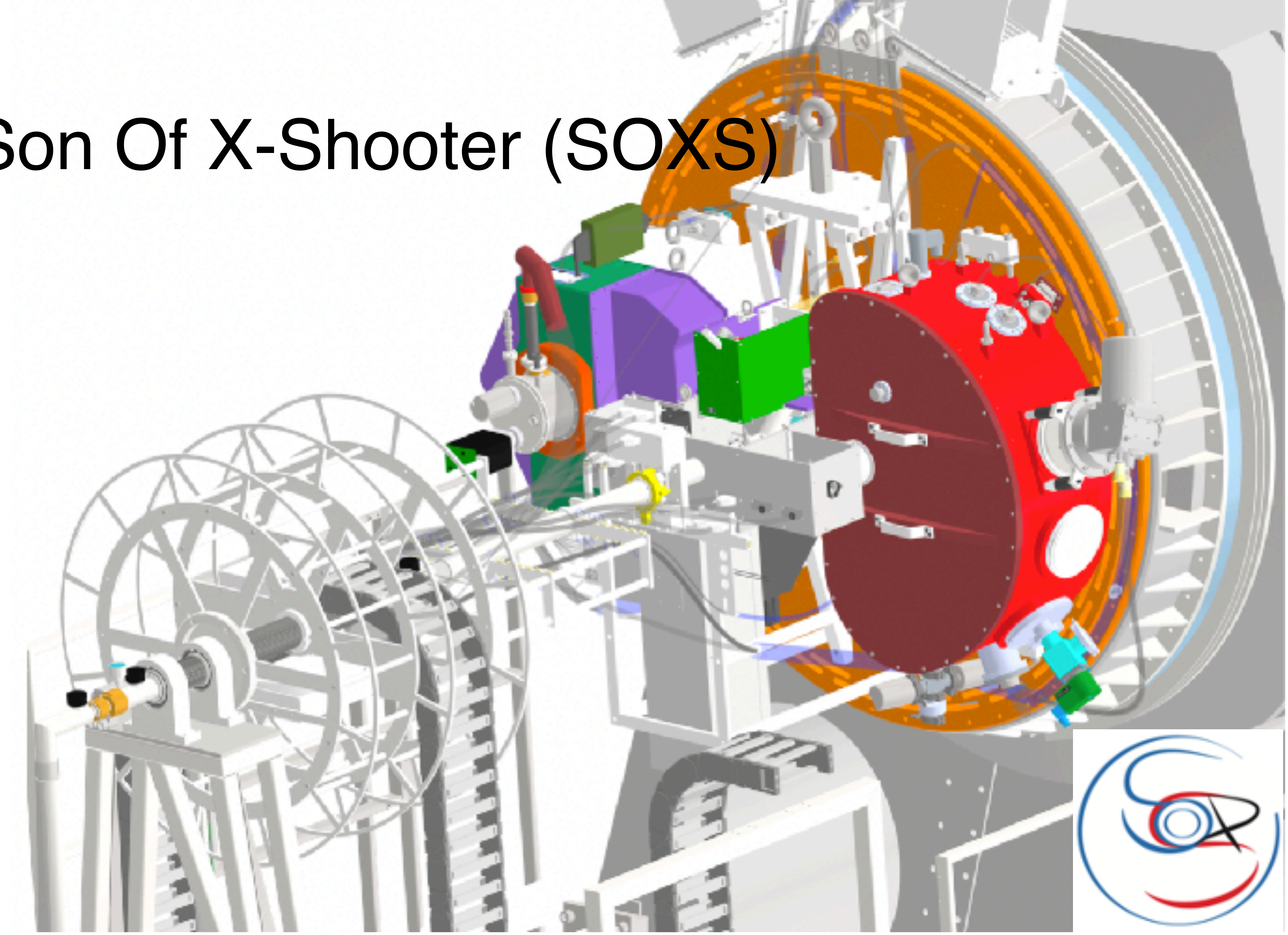
Astronomical Instrumentation and Adaptive Optics Group,

INAF-Osservatorio Astronomico di Padova (INAF-OAPD),

Padova, Italy

"SOXS Science Meeting"
INAF-Osservatorio Astronomico di Capodimonte
25 June 2024

The Making of the Son Of X-Shooter (SOXS)



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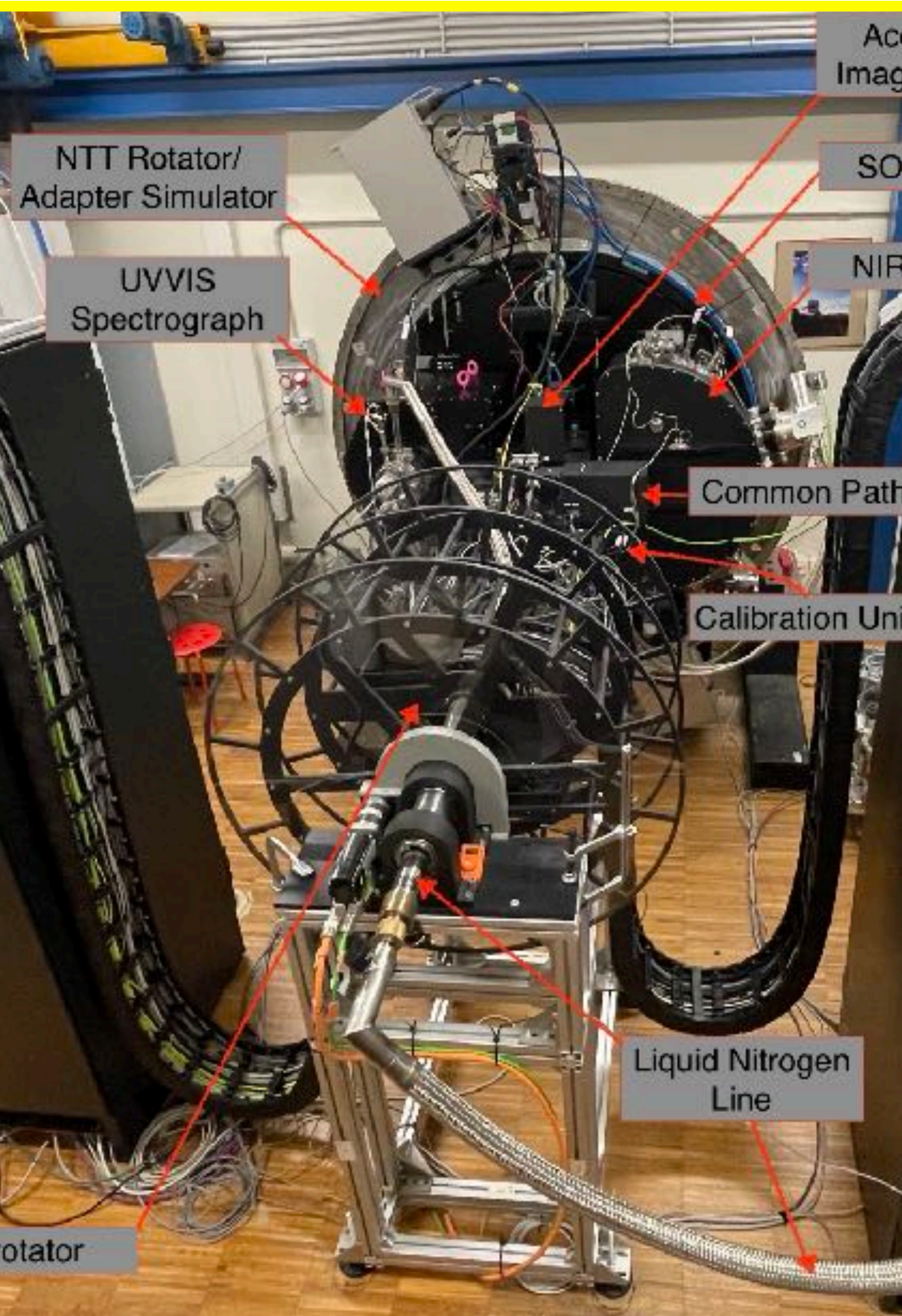
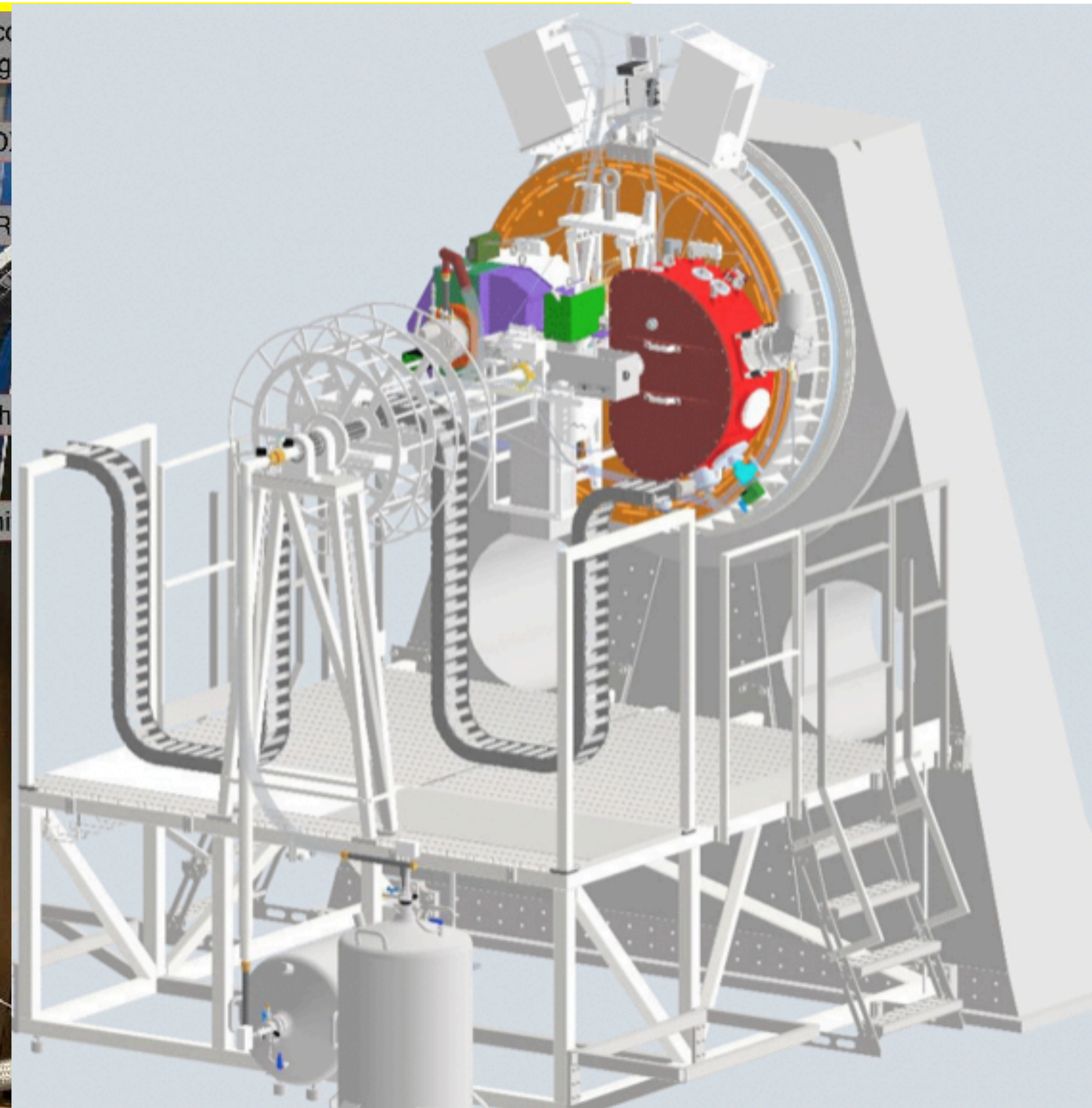
25 June 2024

Outline

Helium Gas Lines Going to Compressor - Cooling Down NIR Vessel and Detector using a CryoCooler
NTT Rotator/ Adapter Simulator
UVVIS Spectrograph
Acquisition & Imaging Camera
SOXS Flange
NIR Spectrograph
Cabinet 2
Common Path
Cabinet 1
Calibration Unit
Liquid Nitrogen Line
Liquid Nitrogen Tank - Cooling Down UVVIS CCD using a CFC
Corotator
The SOXS Instrument @ INAF-OAPD...

La Silla vs Padova





SOXS in numbers

	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”	0.5”, 1”, 1.5”, 5”
Slit height	12”	12”
Detector	e2V CCD44-82 2k x4k	Teledyne H2RG 2k x 2k
Pixel Scale	15um	18 um
Detector Scale	0.28”/pixel	0.25”/pixel

	Acquisition Camera
Spectral Range	360 - 970 nm
Filters	SDSS u, g, r, i, z, LSST y, and VIMOS V
FoV	3.5” x 3.5”
Detector	Andor iKon M-934 1k x 1k
Pixel Scale	13um
Detector Scale	0.205”/pixel

SOXS subsystems

INAF

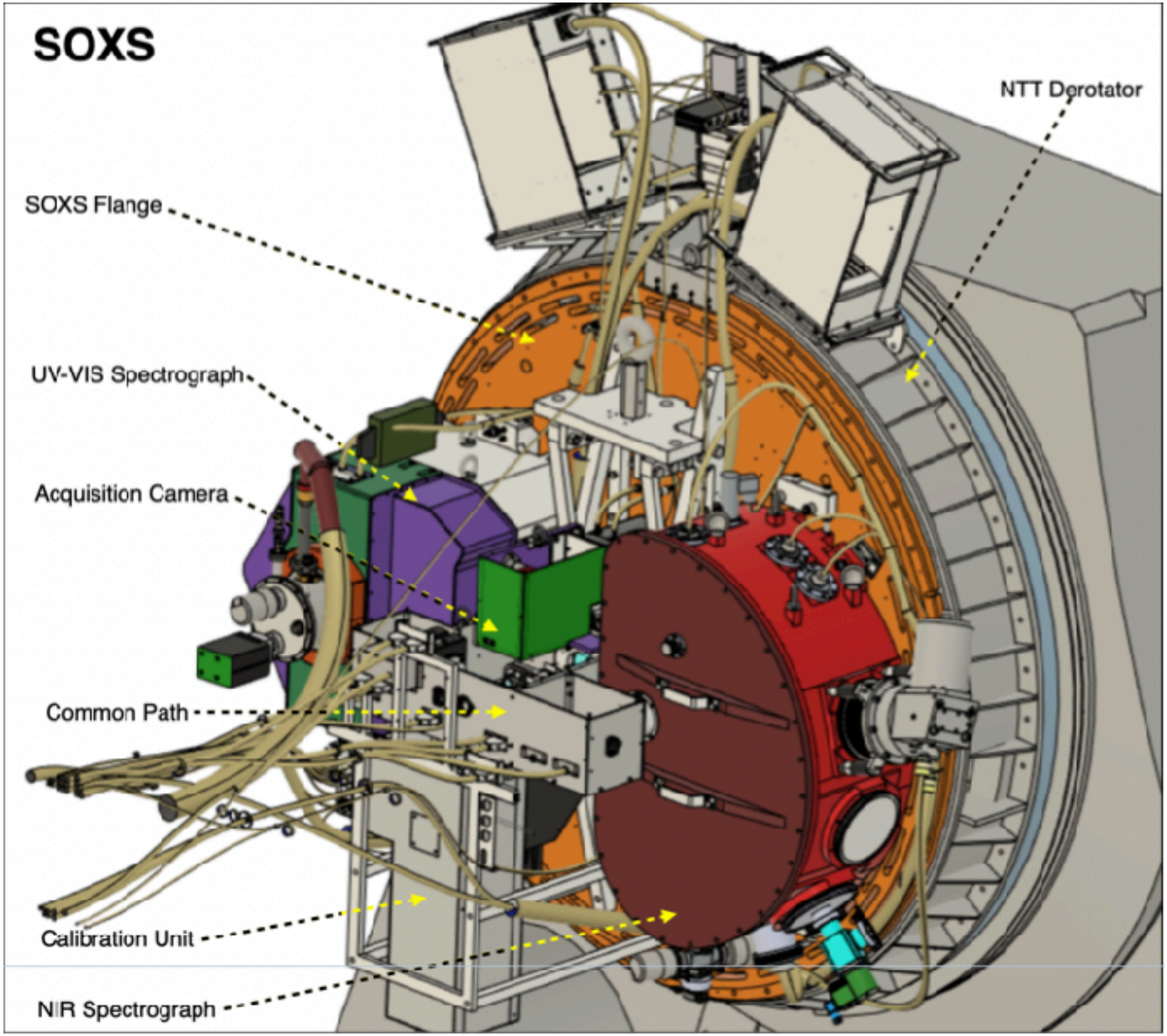
Israel

Chile

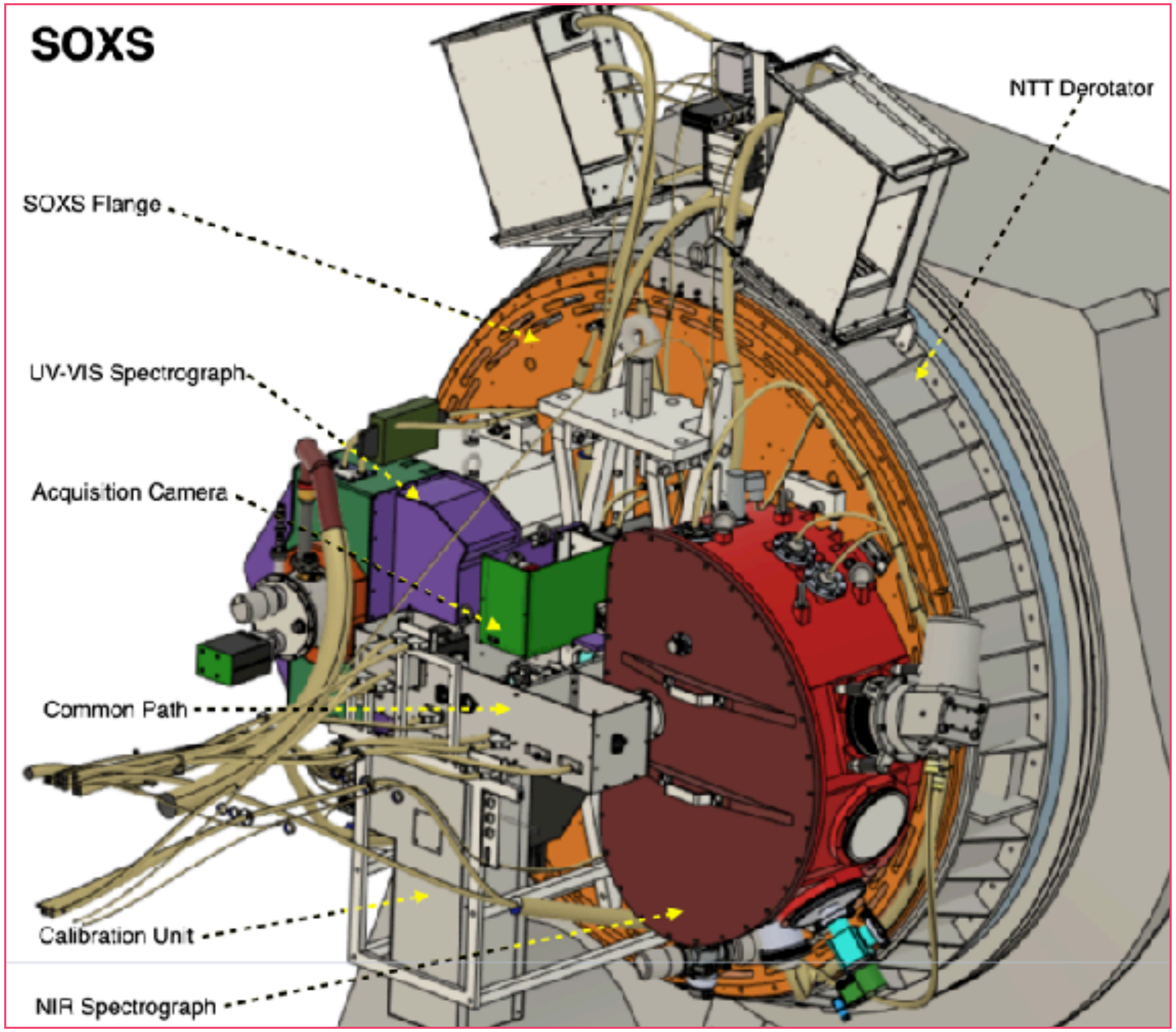
INAF

Finland

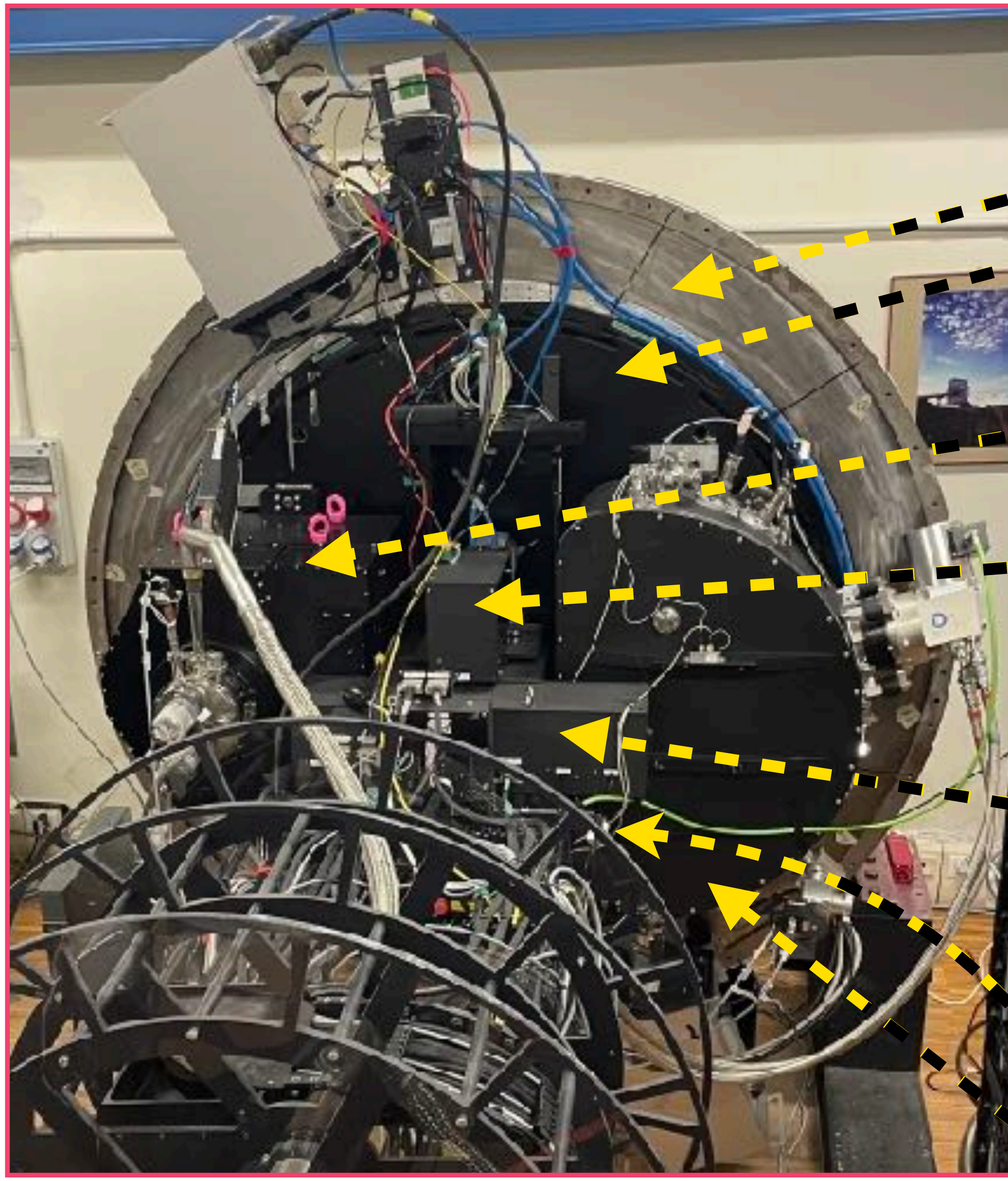
INAF

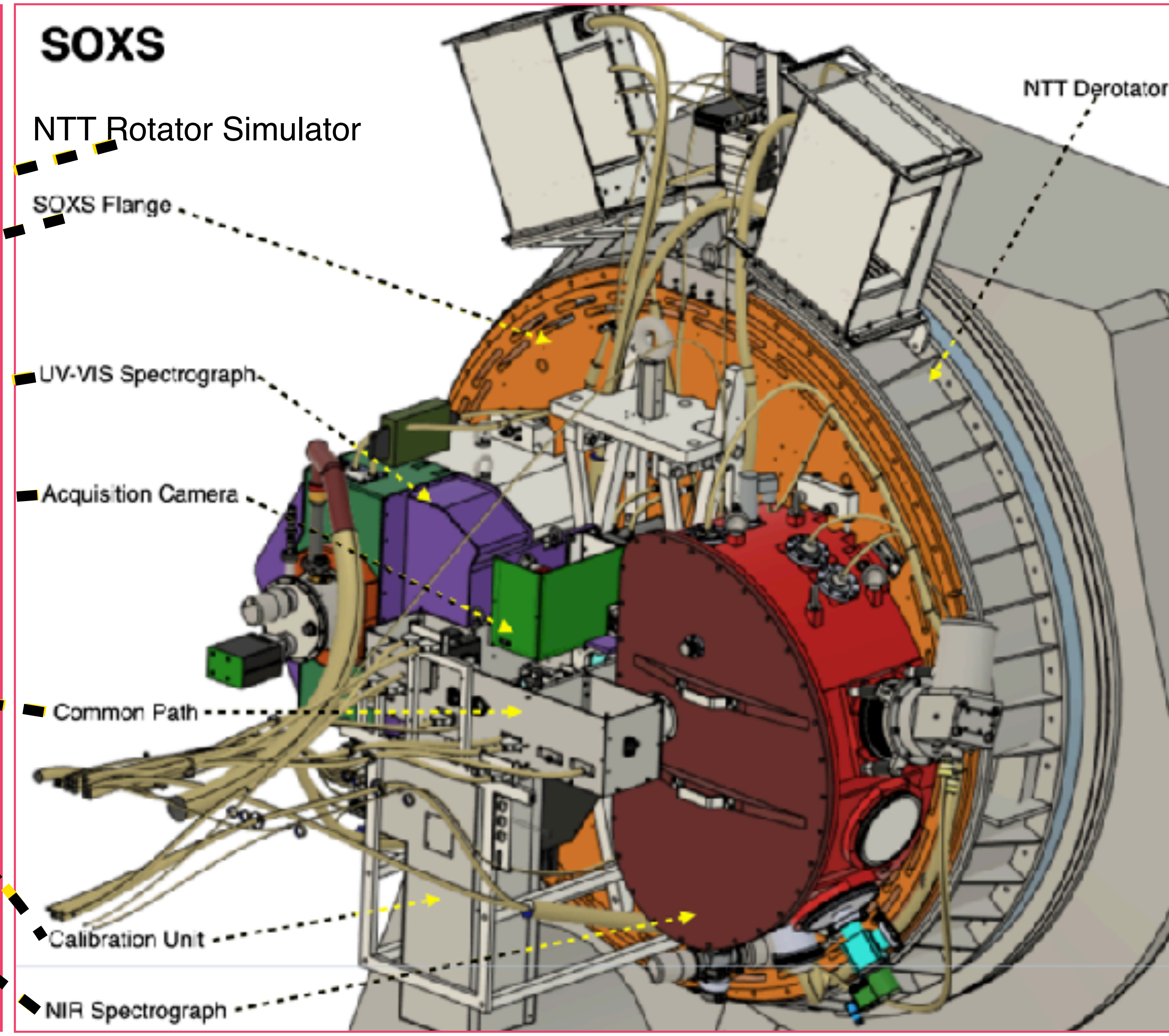


SOXS subsystems

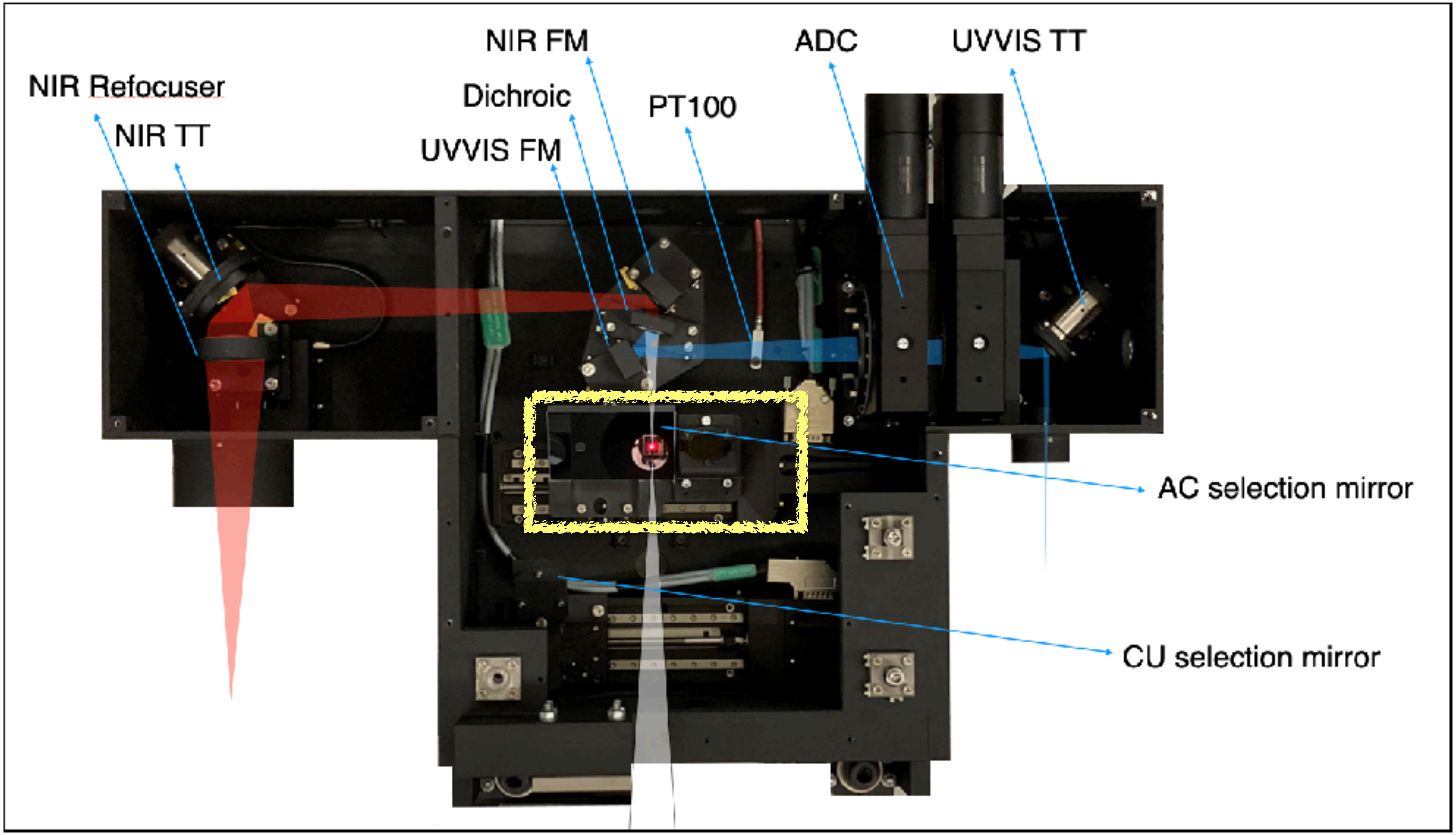


SOXS subsystems

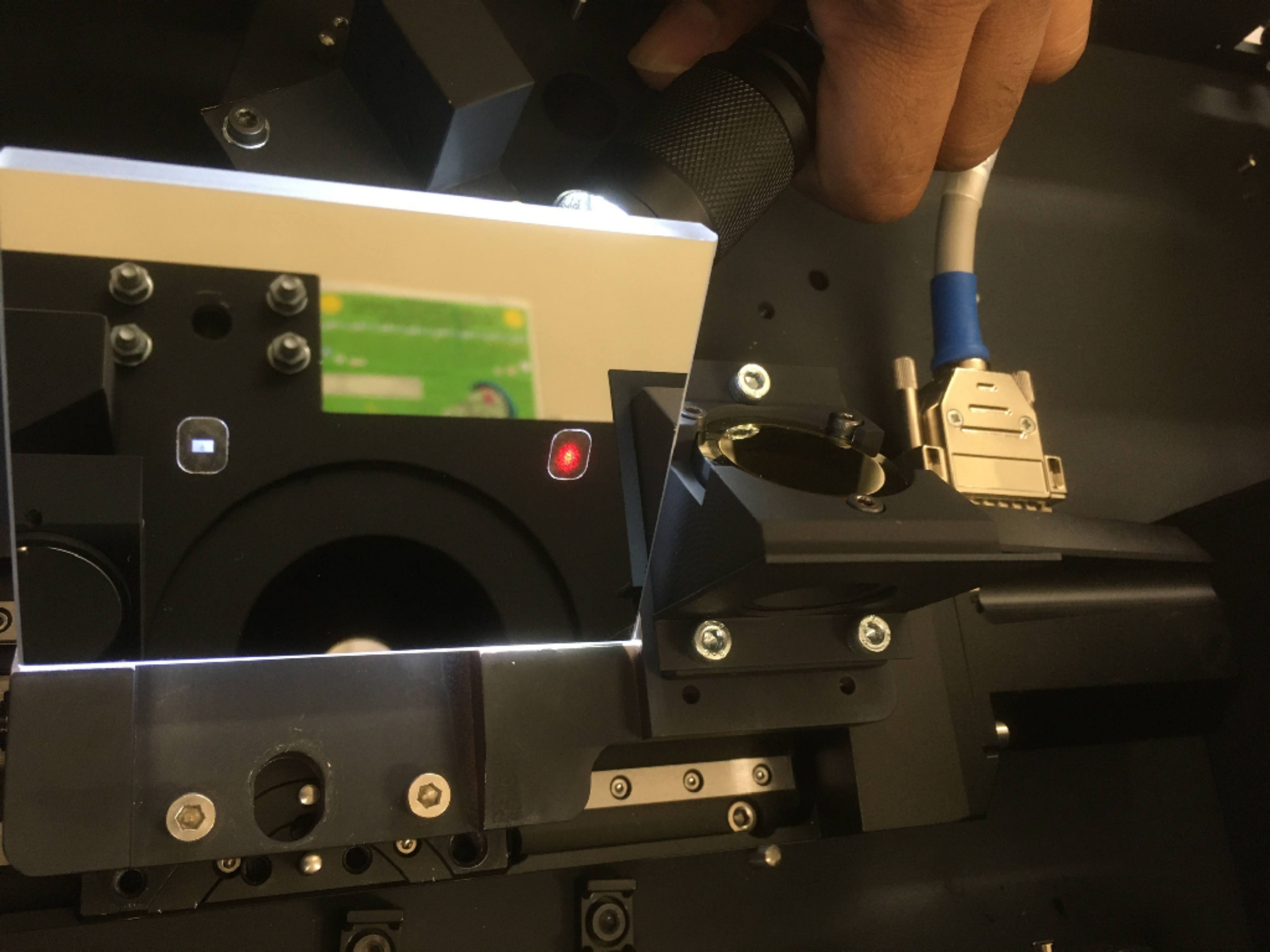




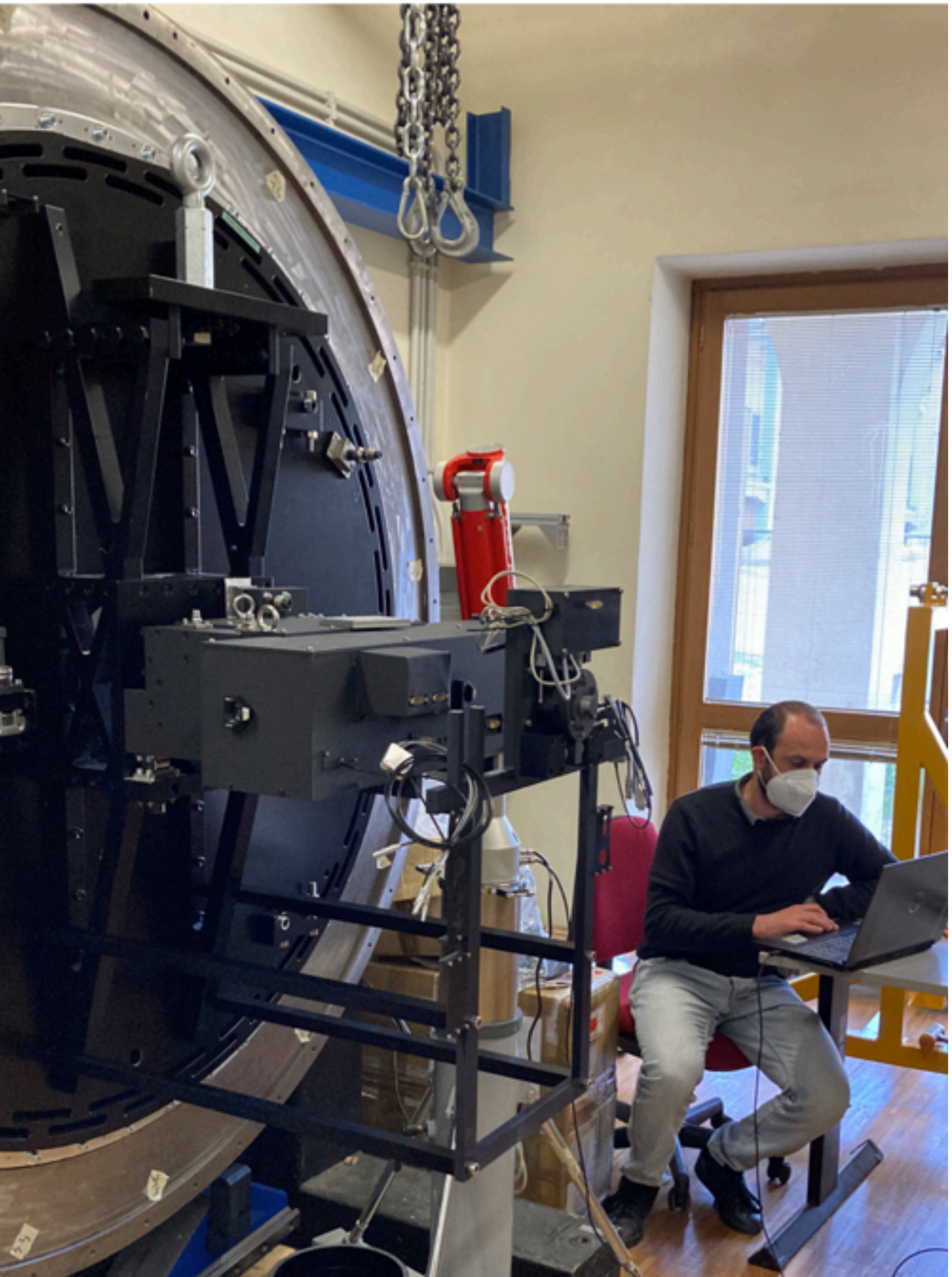
Common Path

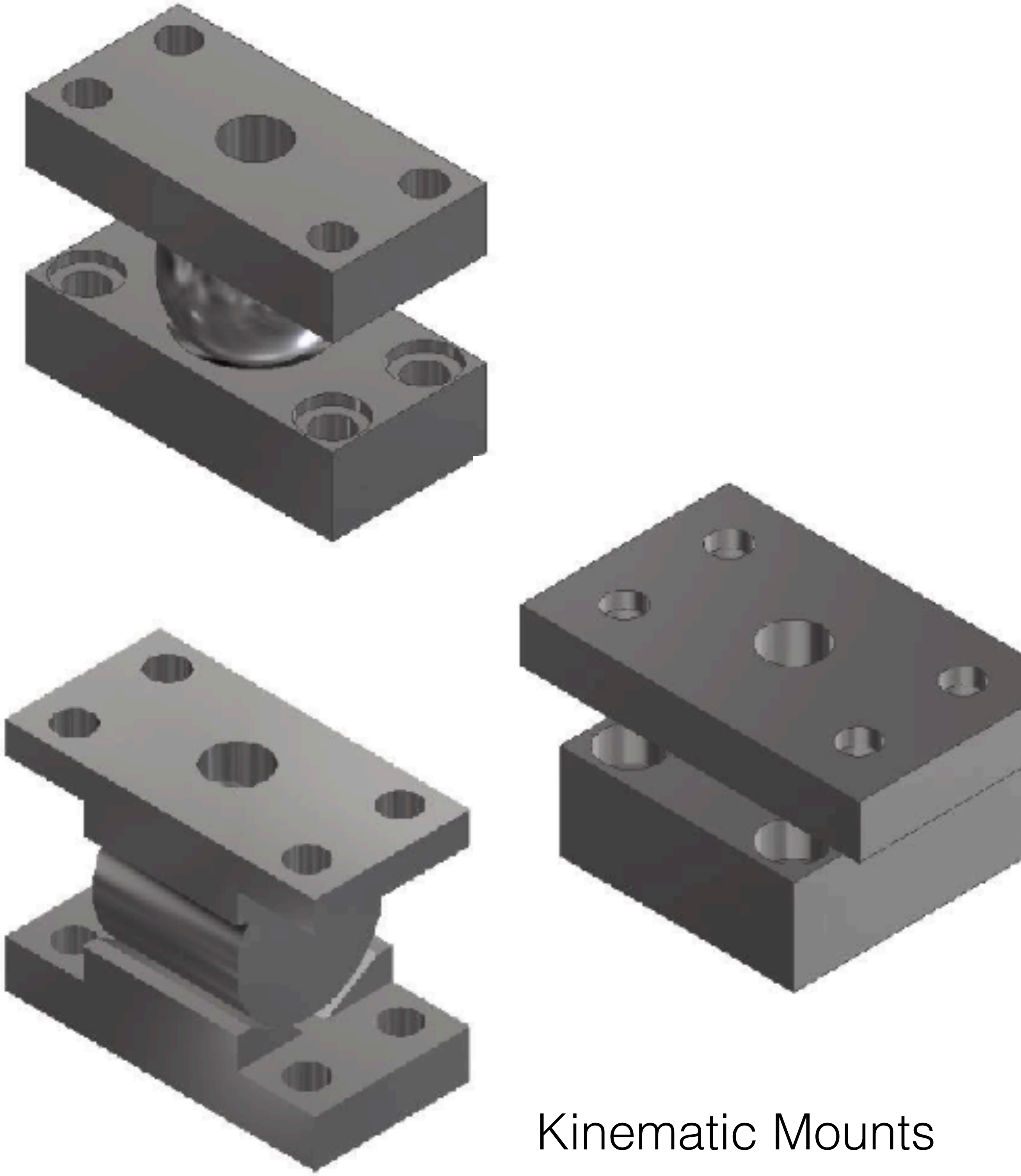


- Receives the F/11 beam from the telescope and feeds the spectrographs with an F/6.5 beam

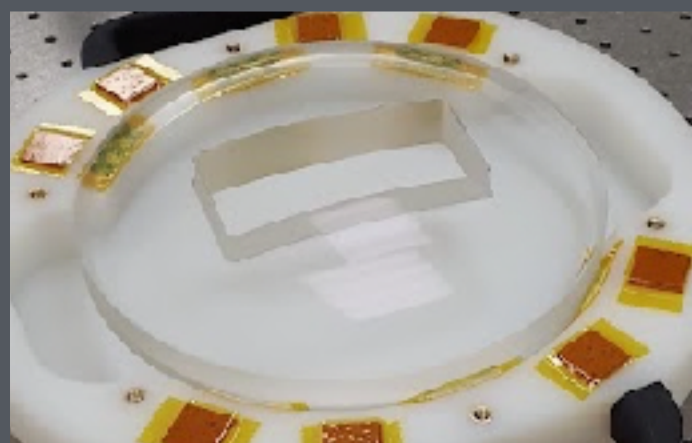
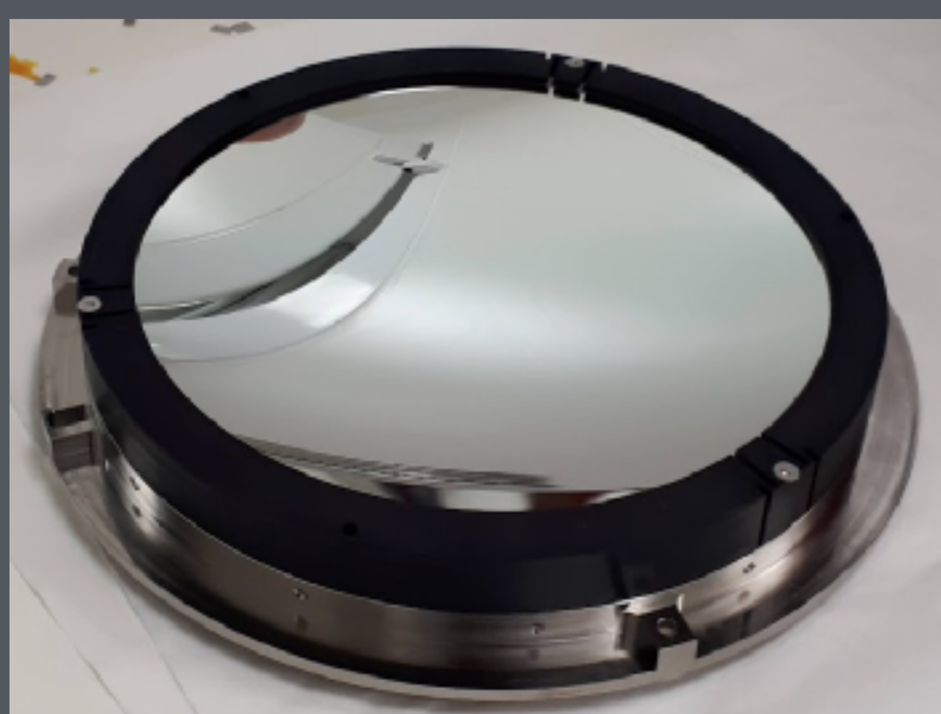
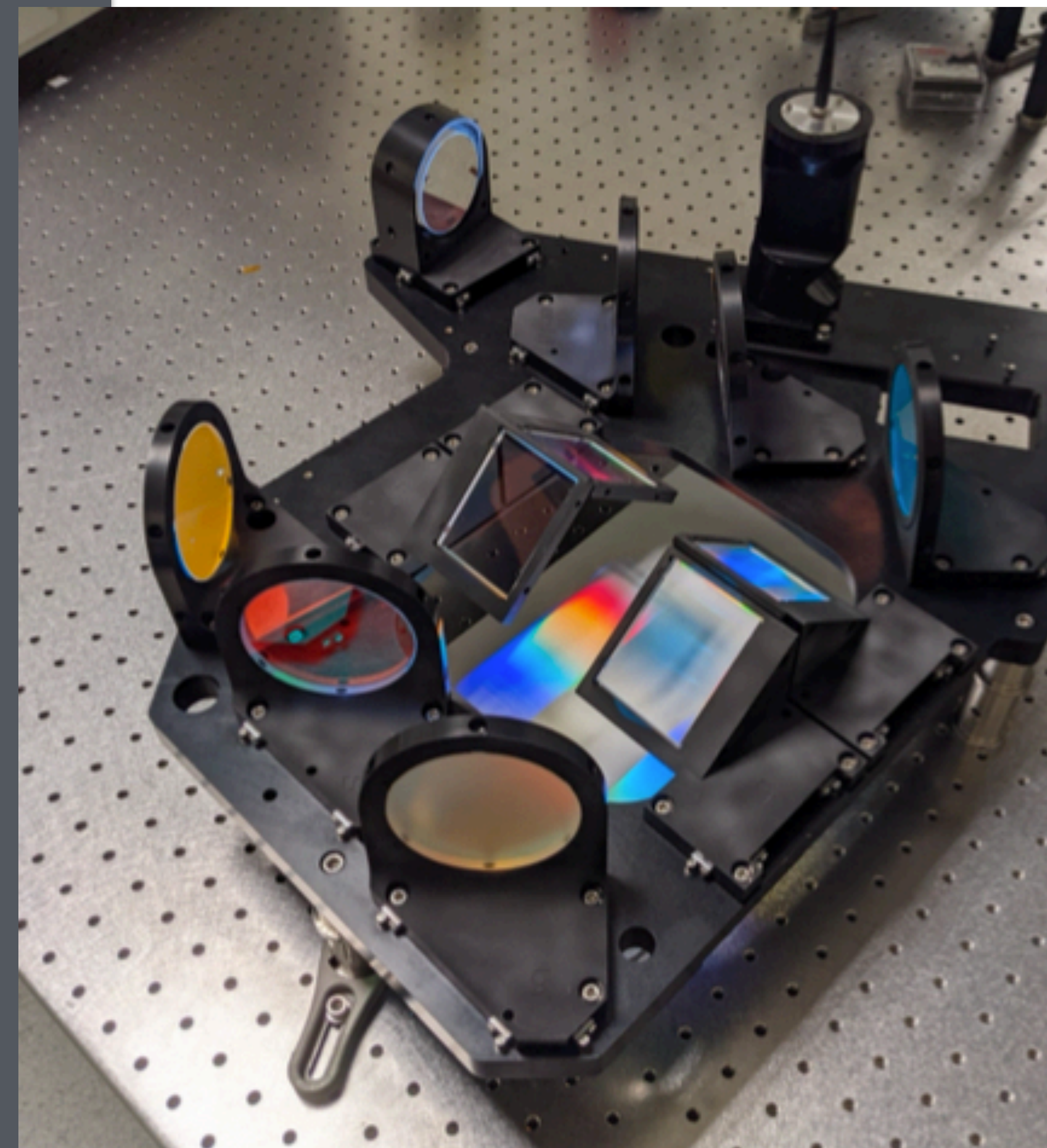


Mounting to the Flange using Kinematic Mounts





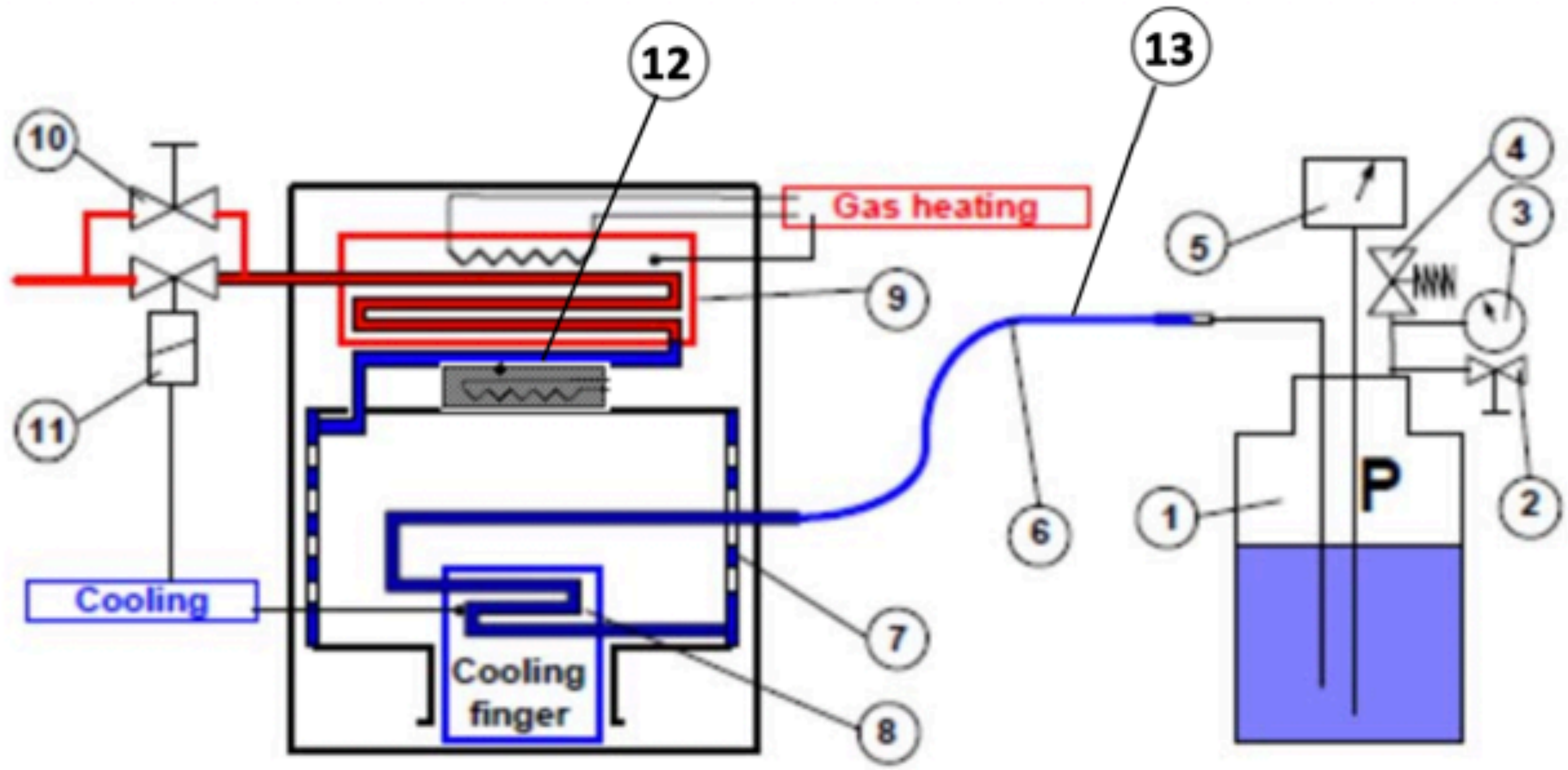
Kinematic Mounts

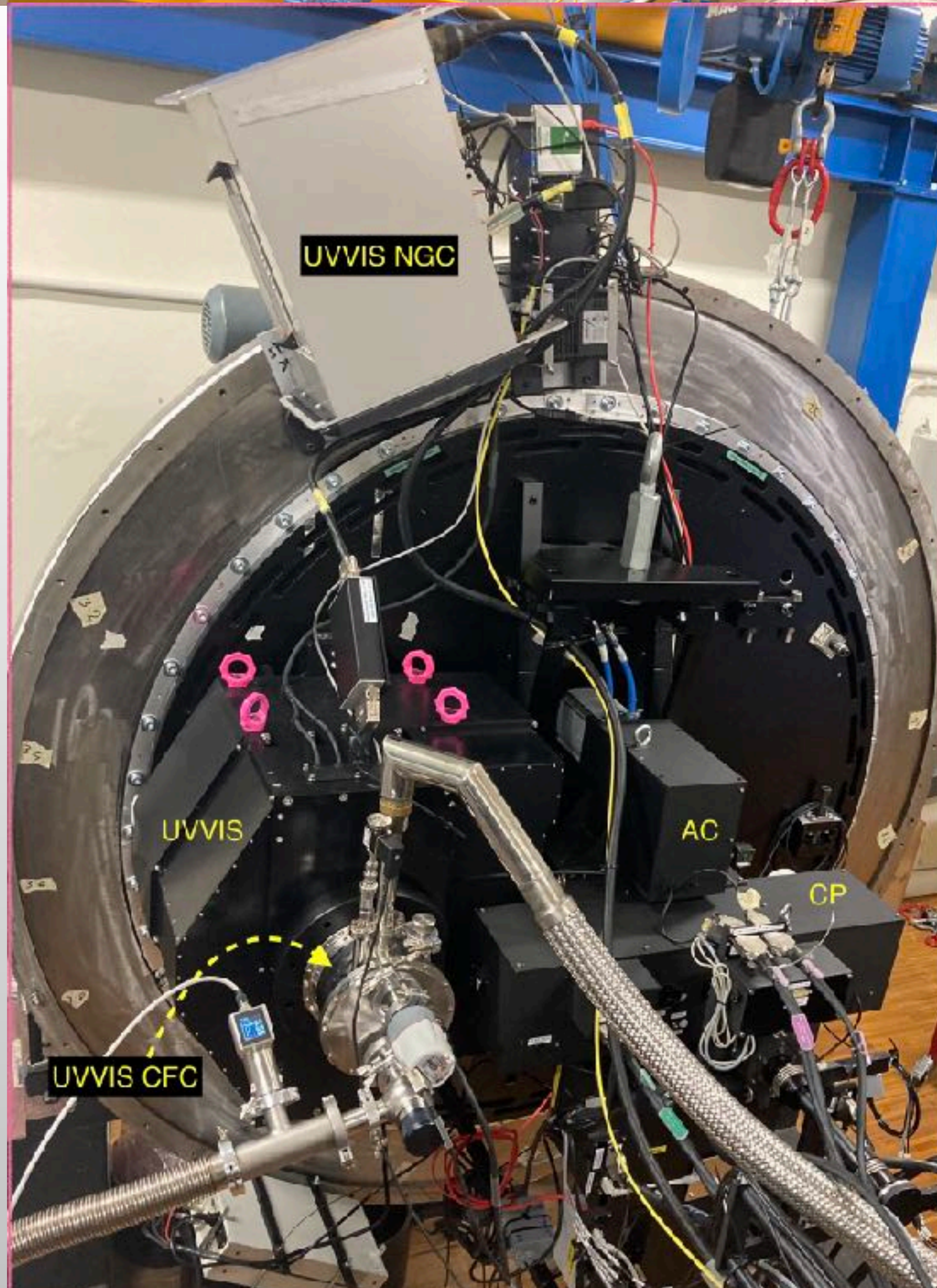
UV-VIS Cryogenic System

- A Continuous Flow Cryostat (CFC) is used to cool down the CCD.

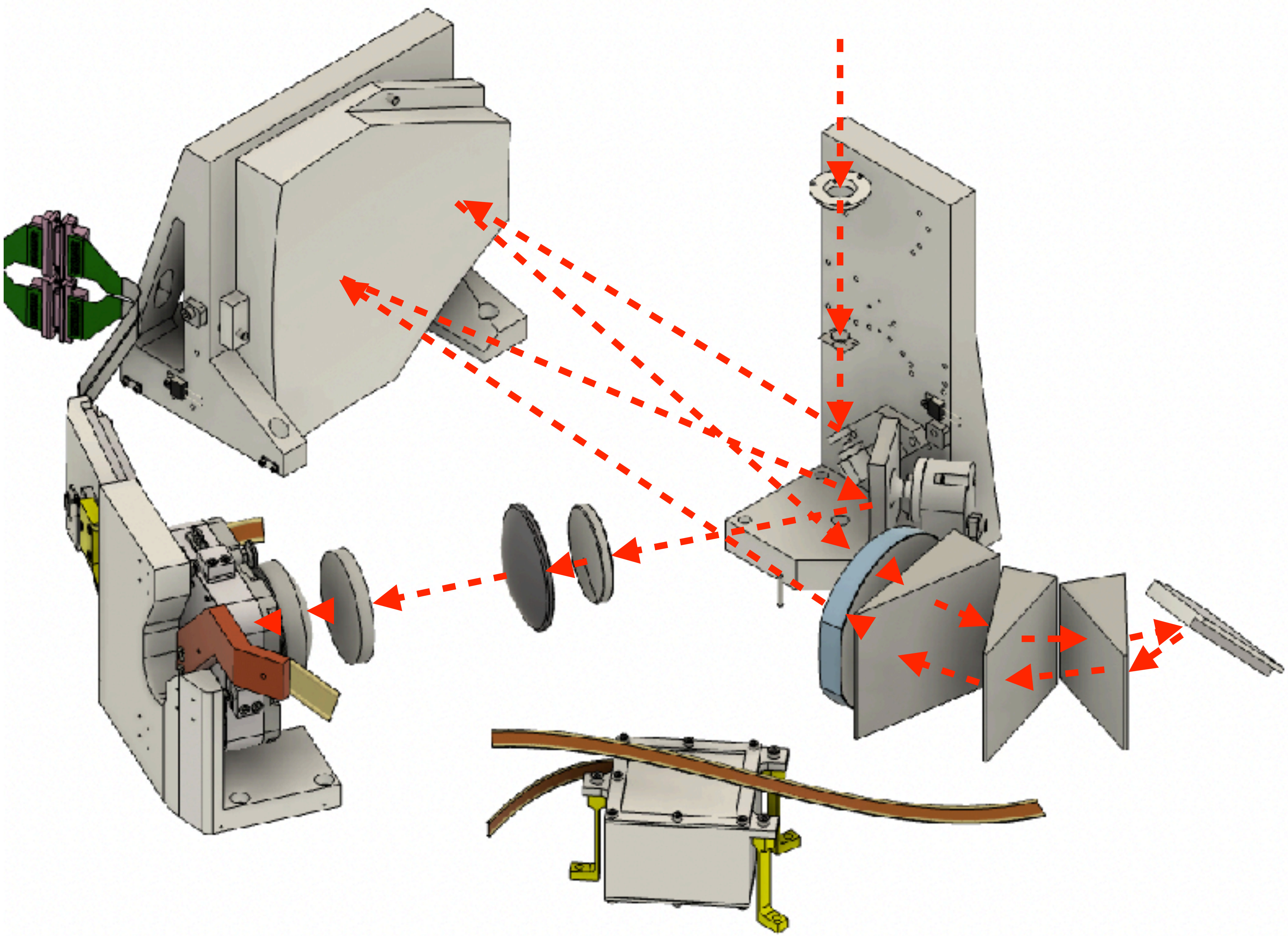
- The CFC together with the detector head makes the UV-VIS cryostat.



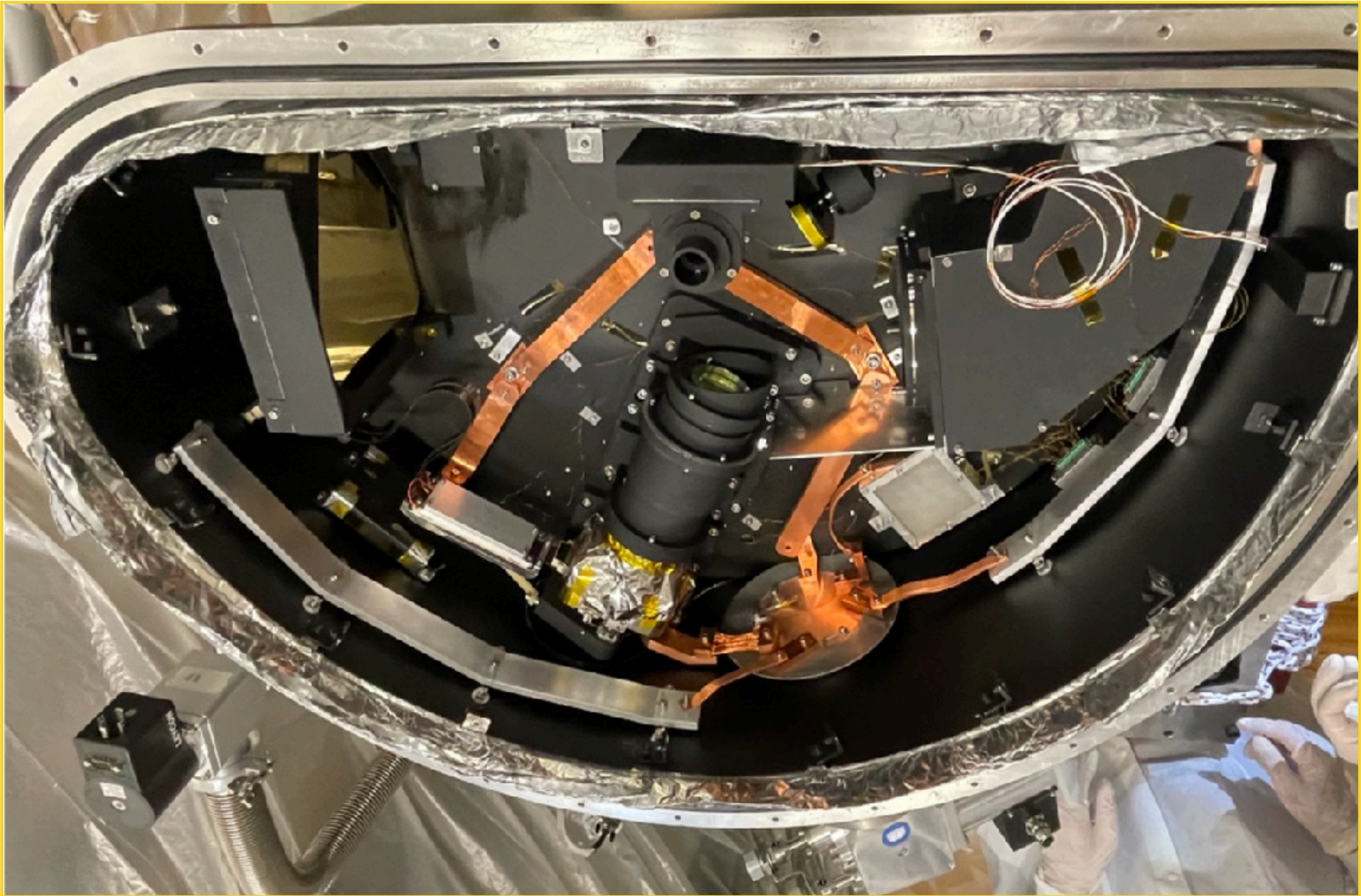
CFC principle: 1. LN2 storage tank, 2. De-pressurization valve, 3. Manometer, 4. Over-pressure valve, 5. Liquid nitrogen level gauge, 6. Vacuum insulated transfer line, 7. Radiation shield heat exchanger, 8. Cooling heat exchanger, 9. Gas heater, 10. Bypass valve, 11. Regulation valve.

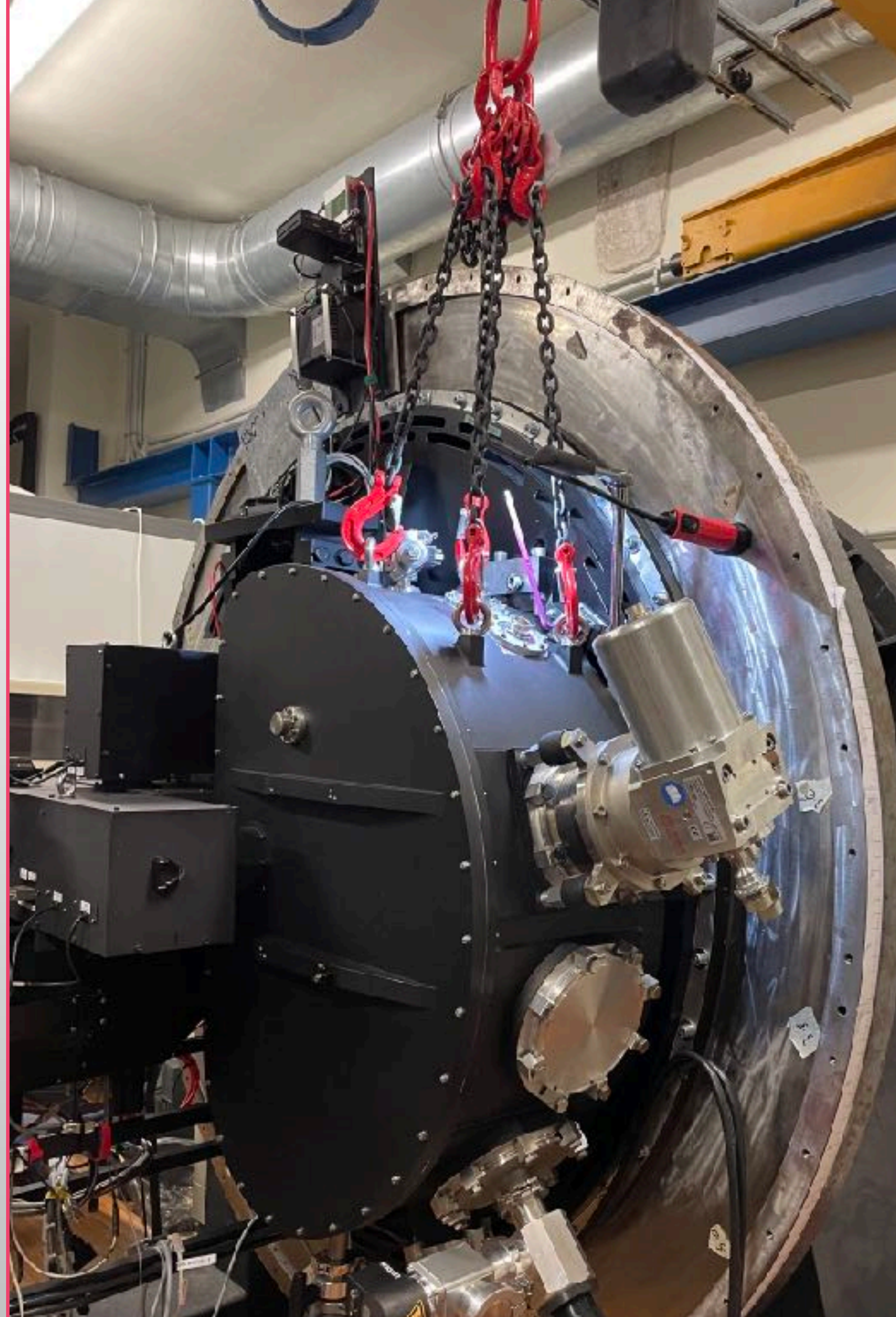

UVVIS NGC
UVVIS
AC
CP
UVVIS CFC

NIR Spectrograph

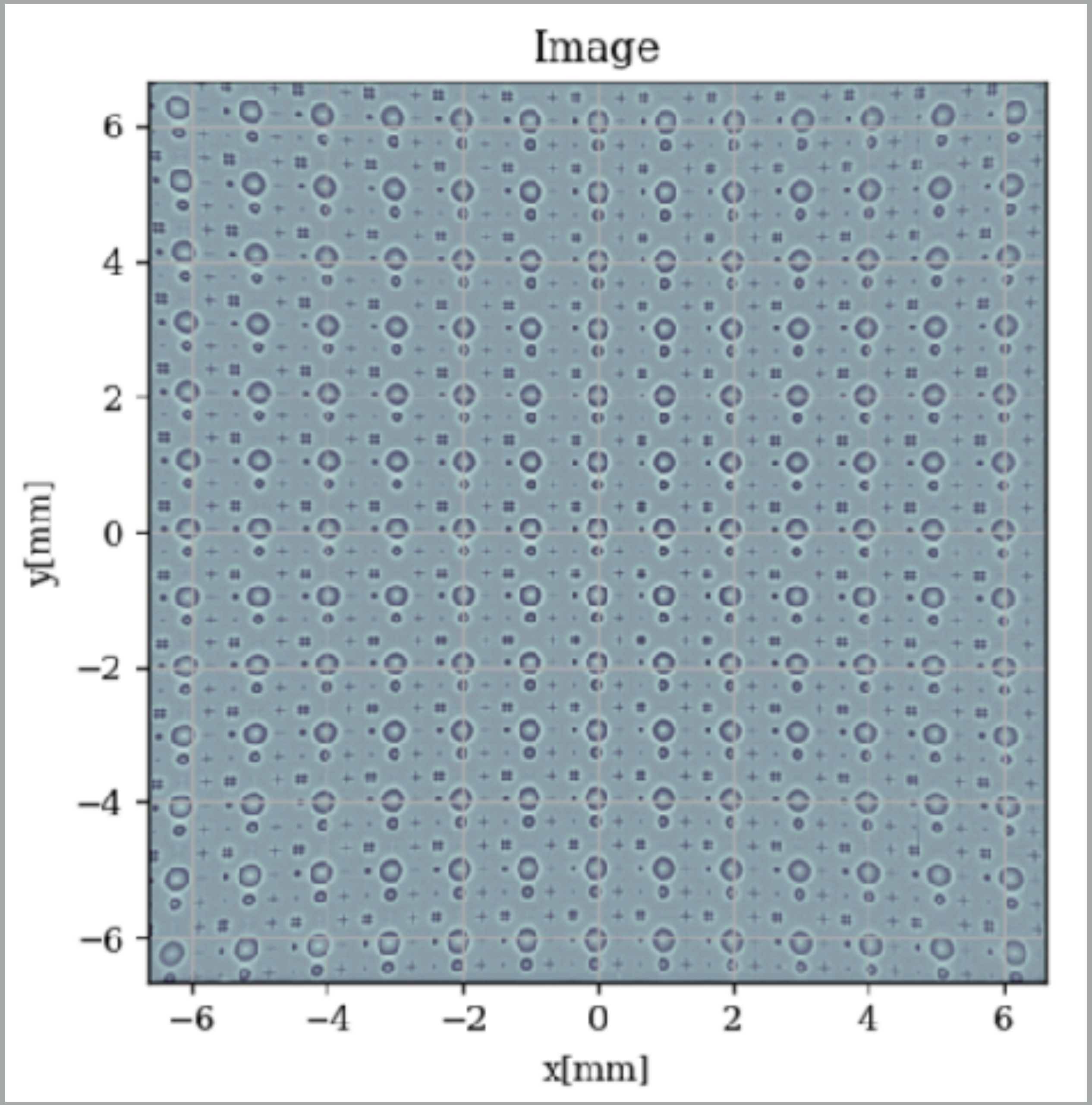


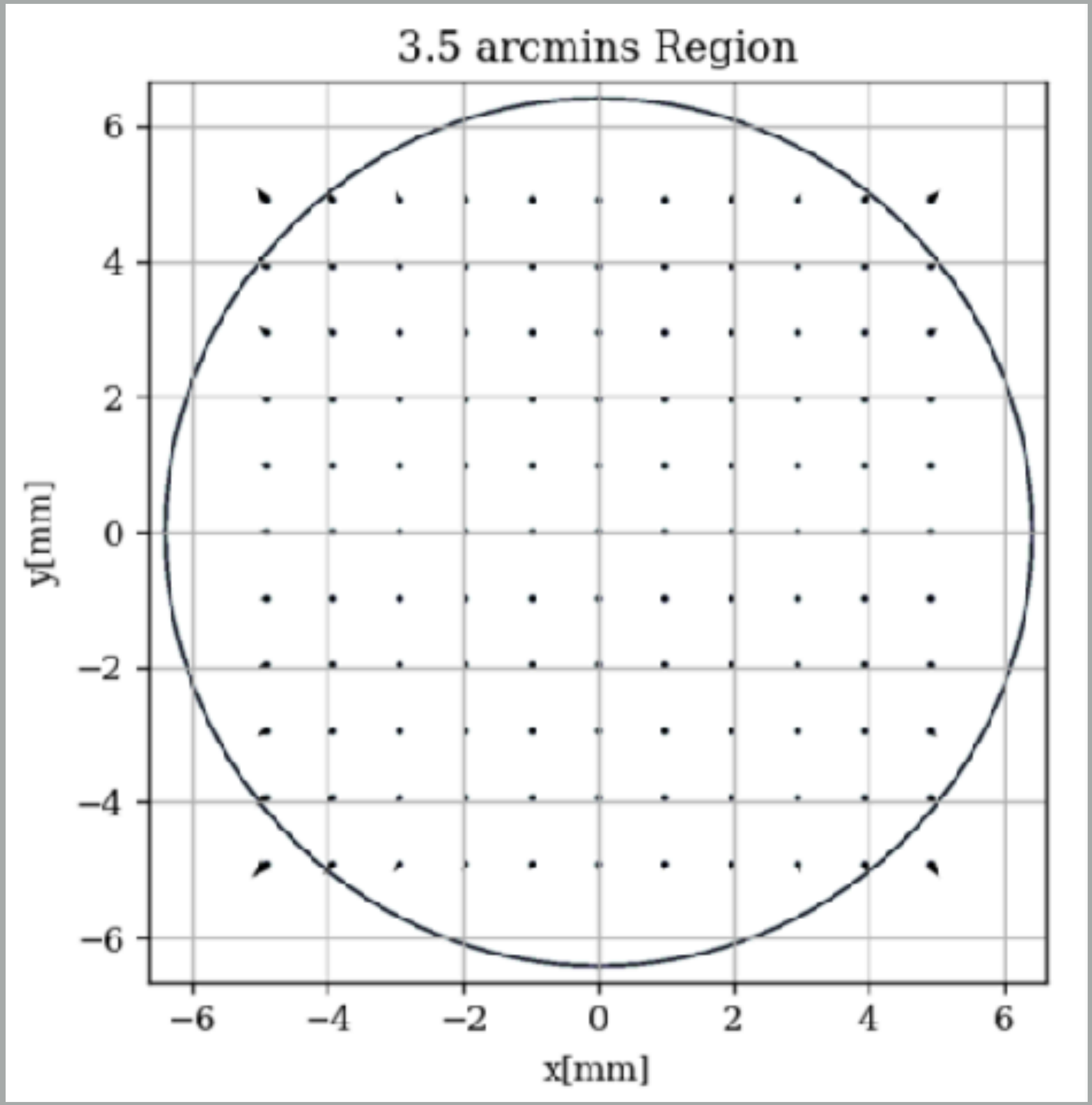
NIR Spectrograph



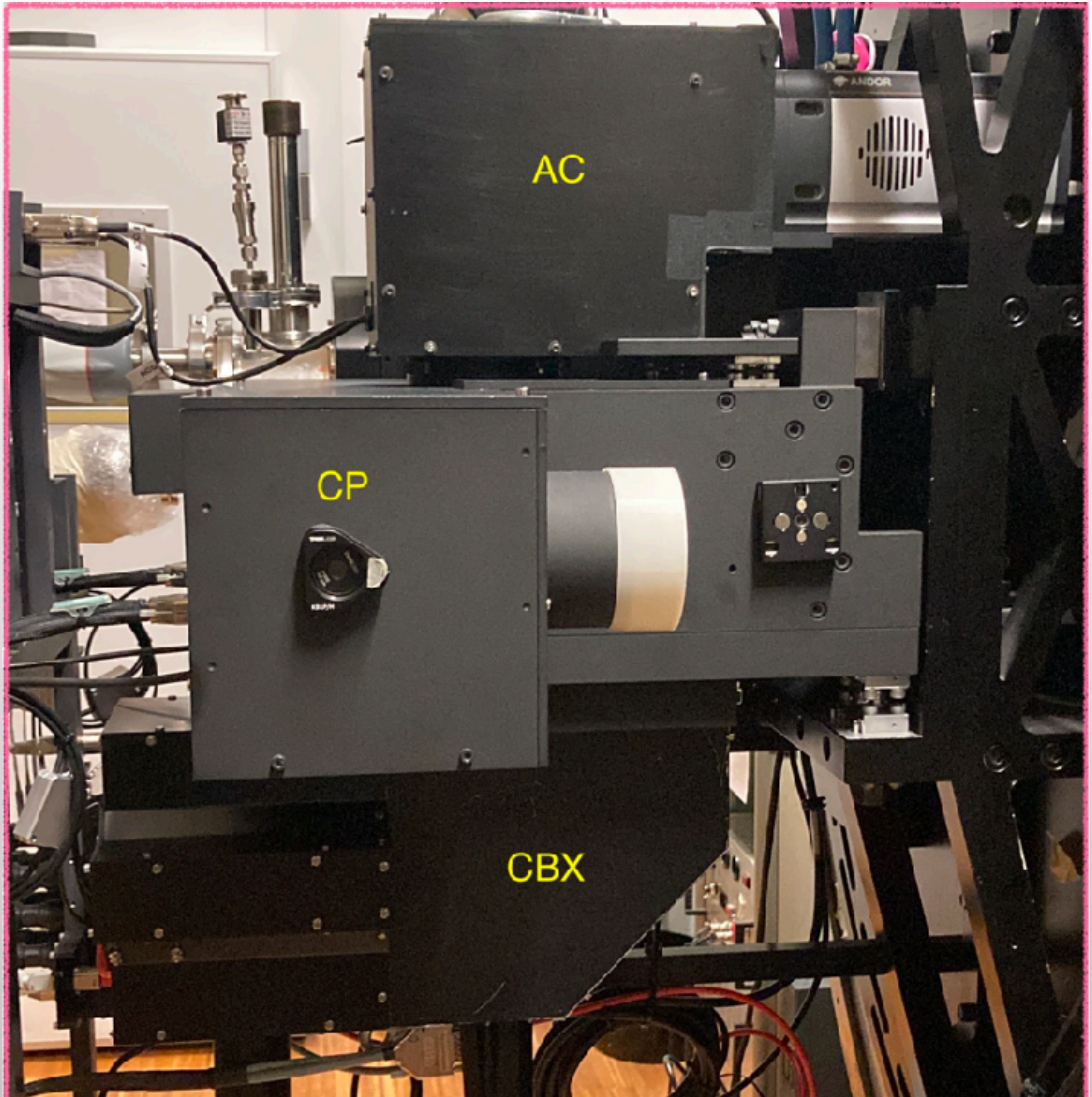


Acquisition Camera





Calibration Unit



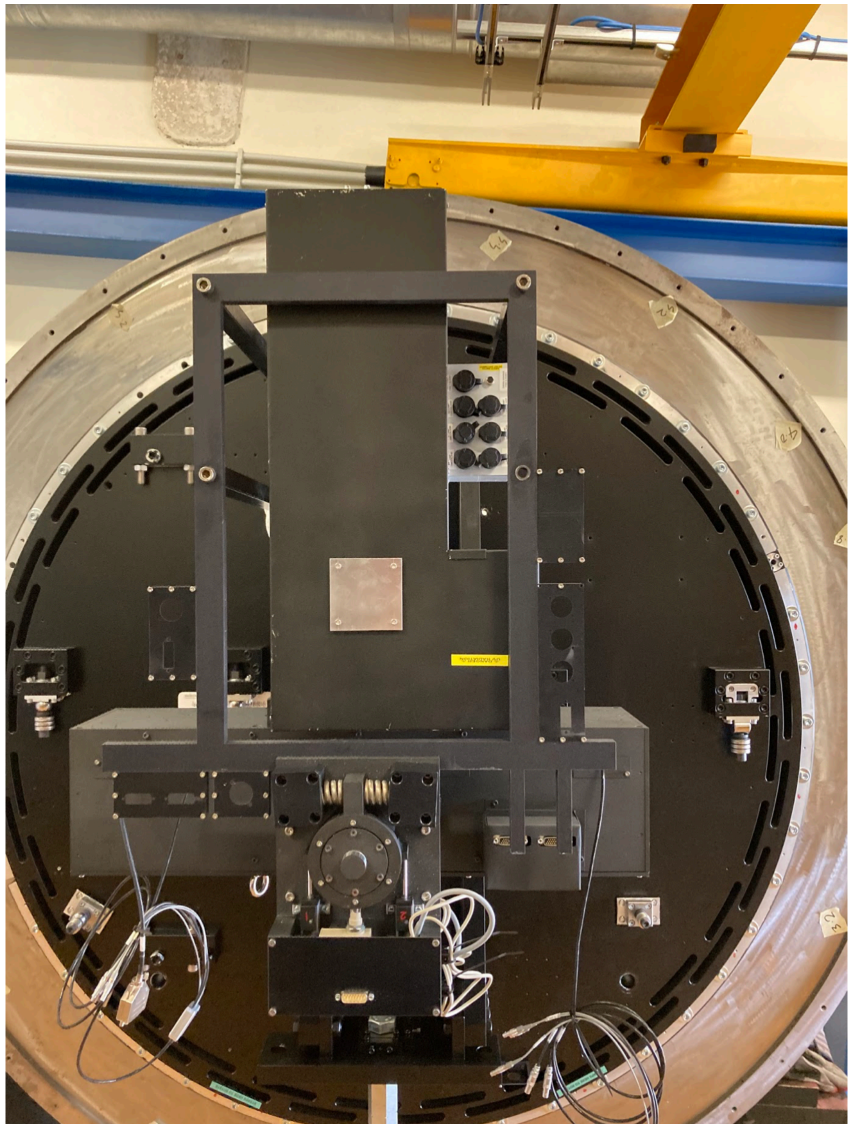
Where We Started …

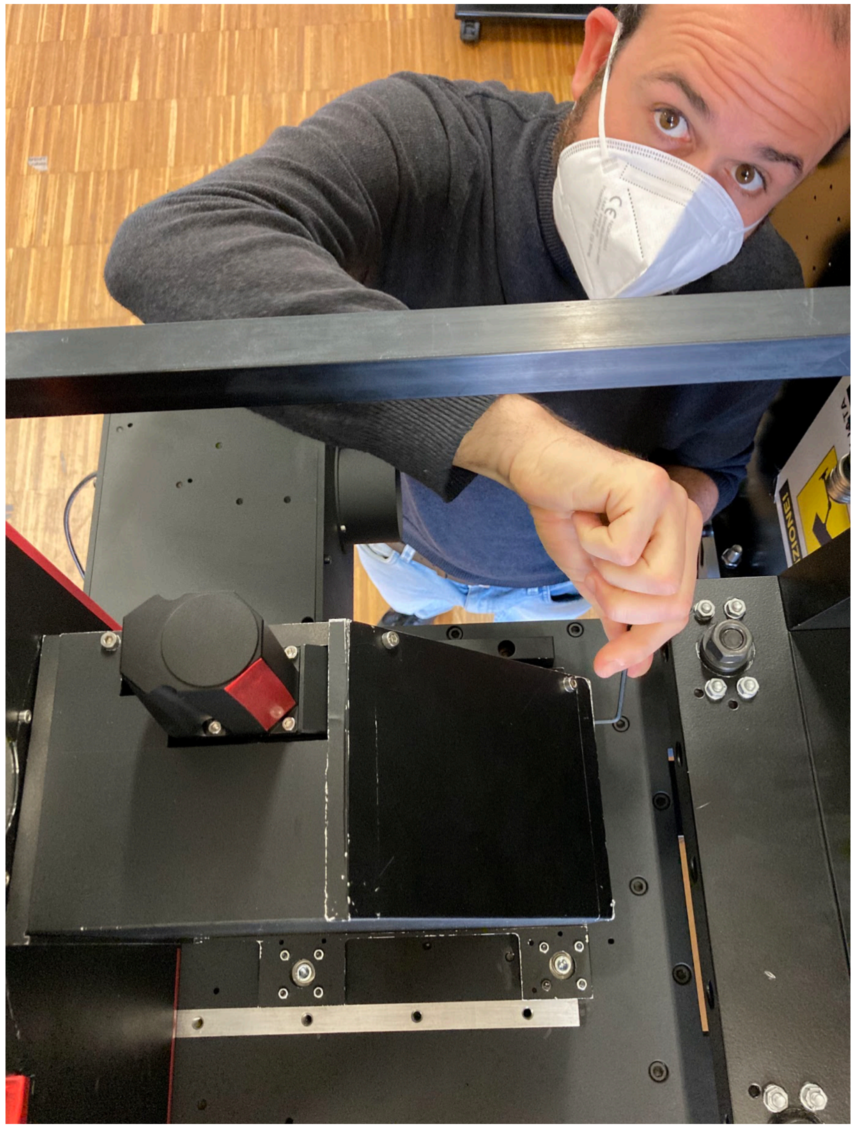
Mounting the SOXS Flange

Corotator Holding Structure

Common Path Mounting

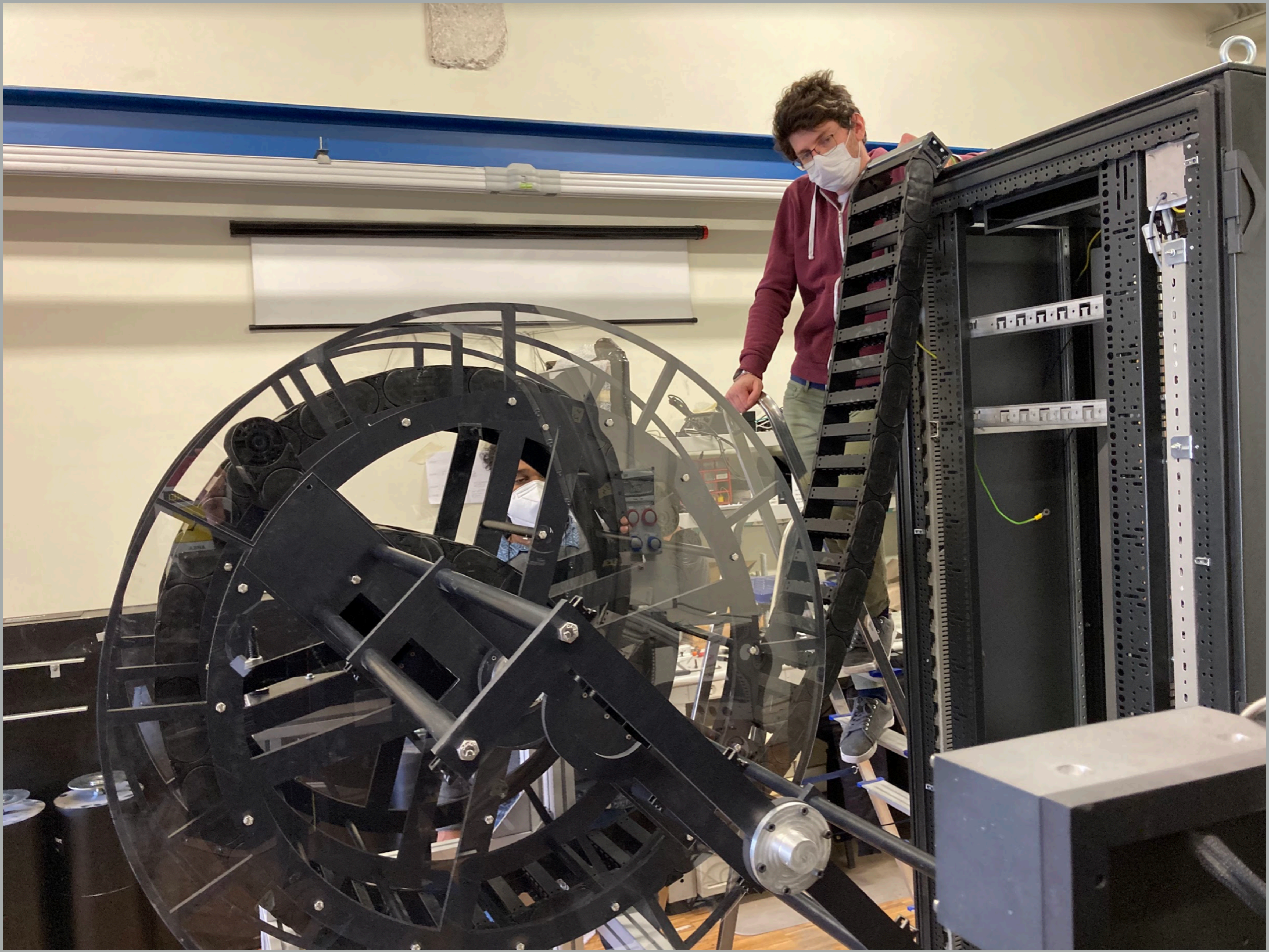
Mounting the Calibration Unit (old)



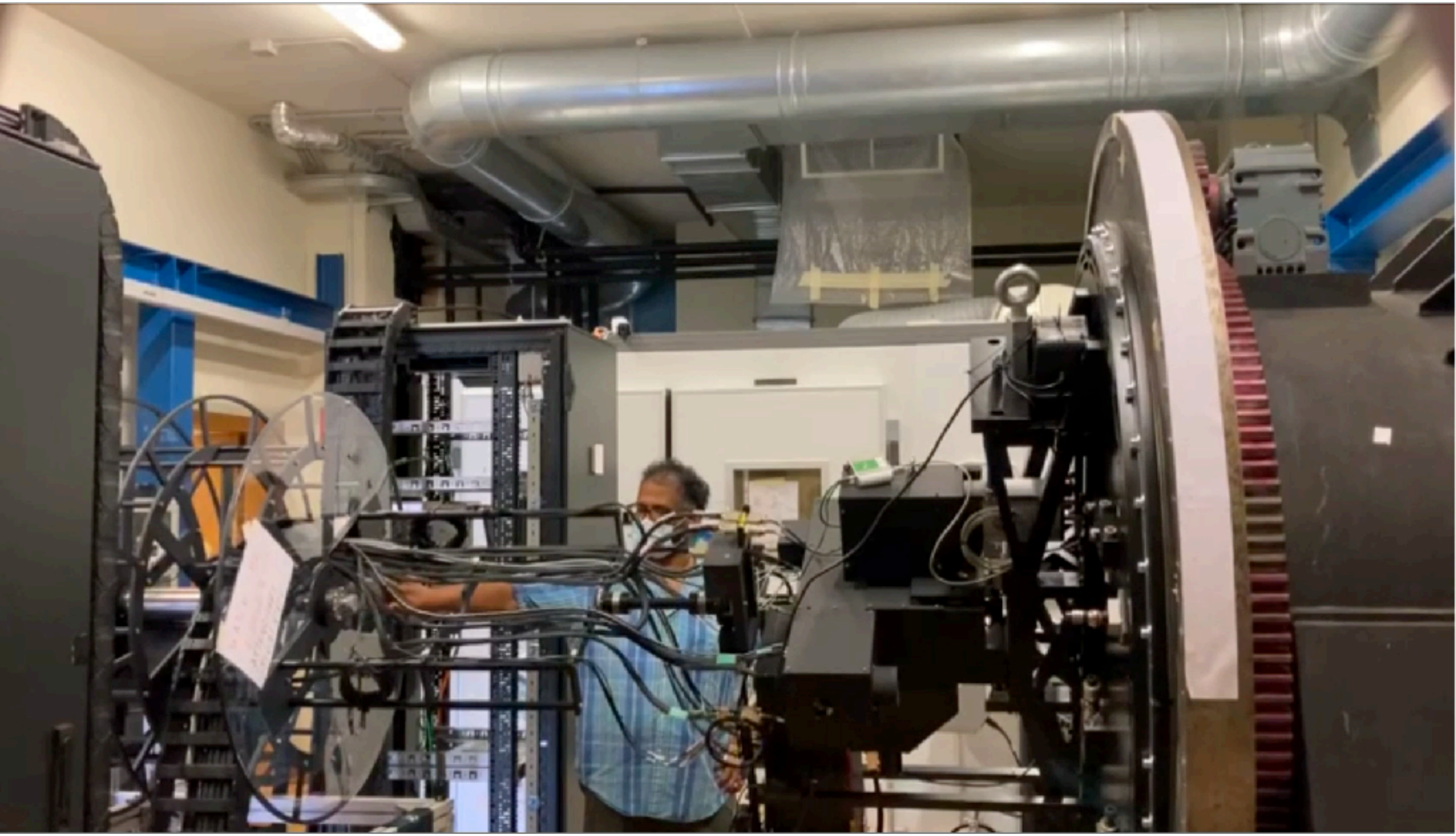


Mounting the Acquisition Camera

Cabinets and Cable Chains



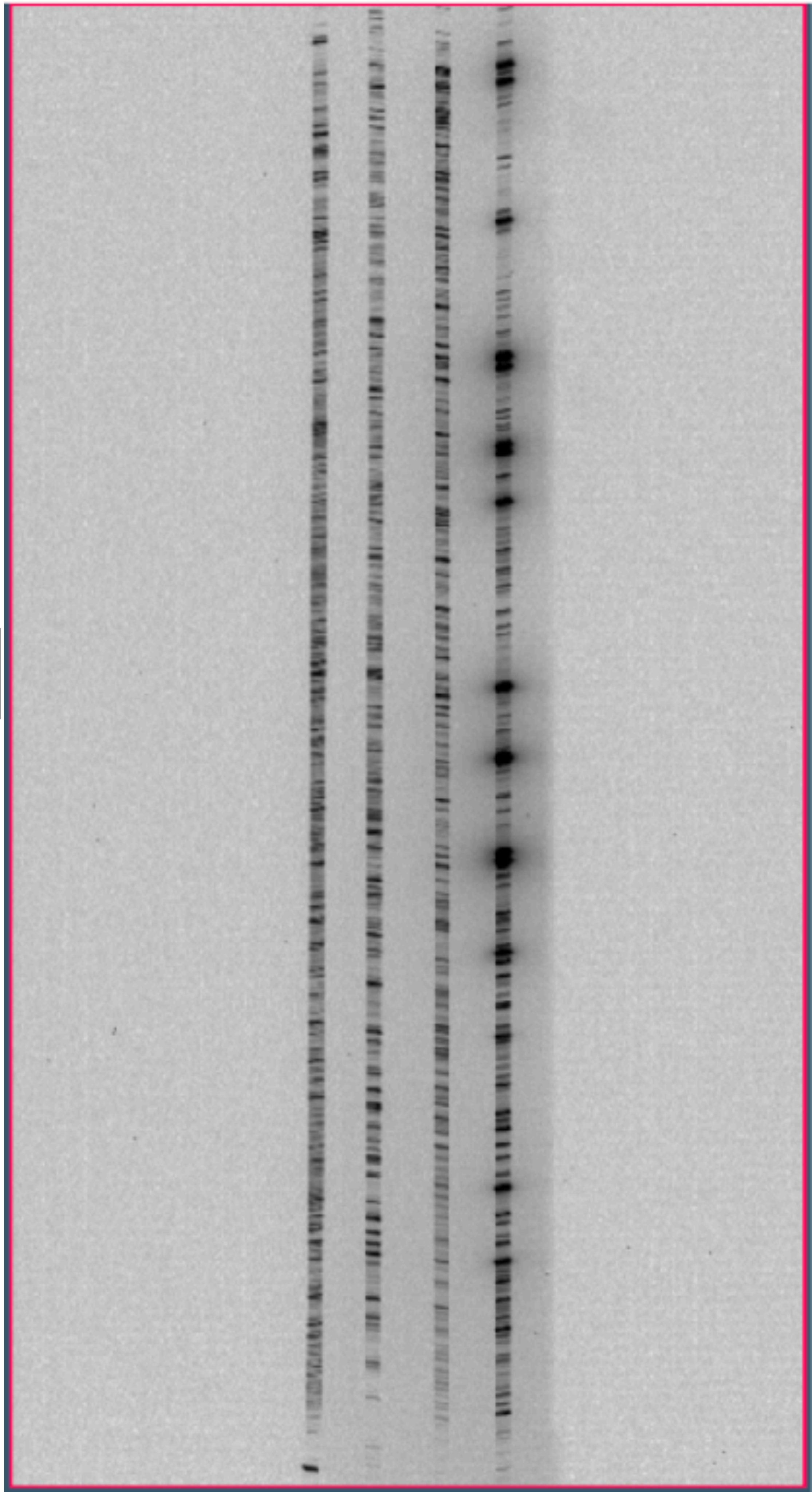
Corotator co-rotating…



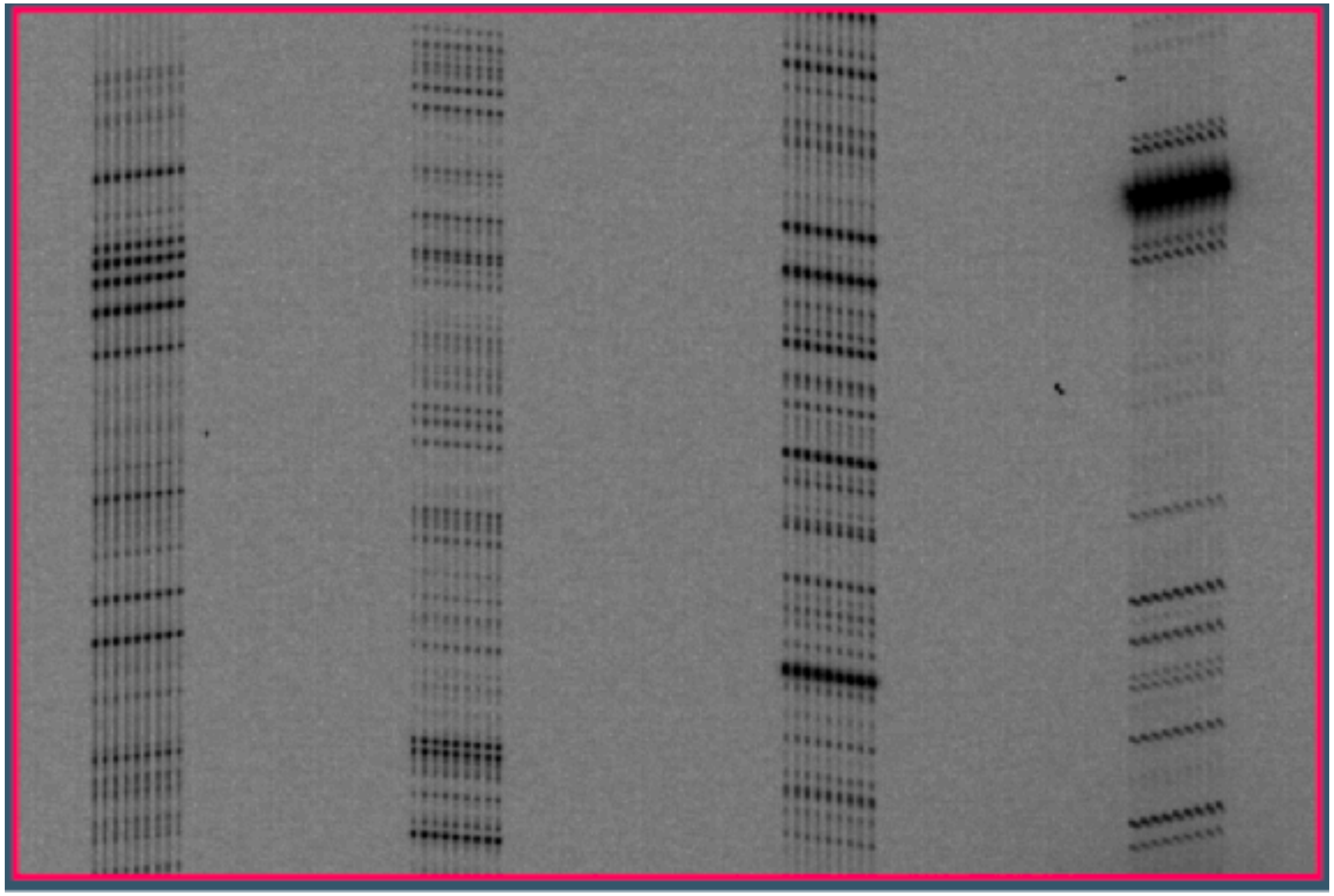
Finally everything together…

Now, some UVVIS spectra …

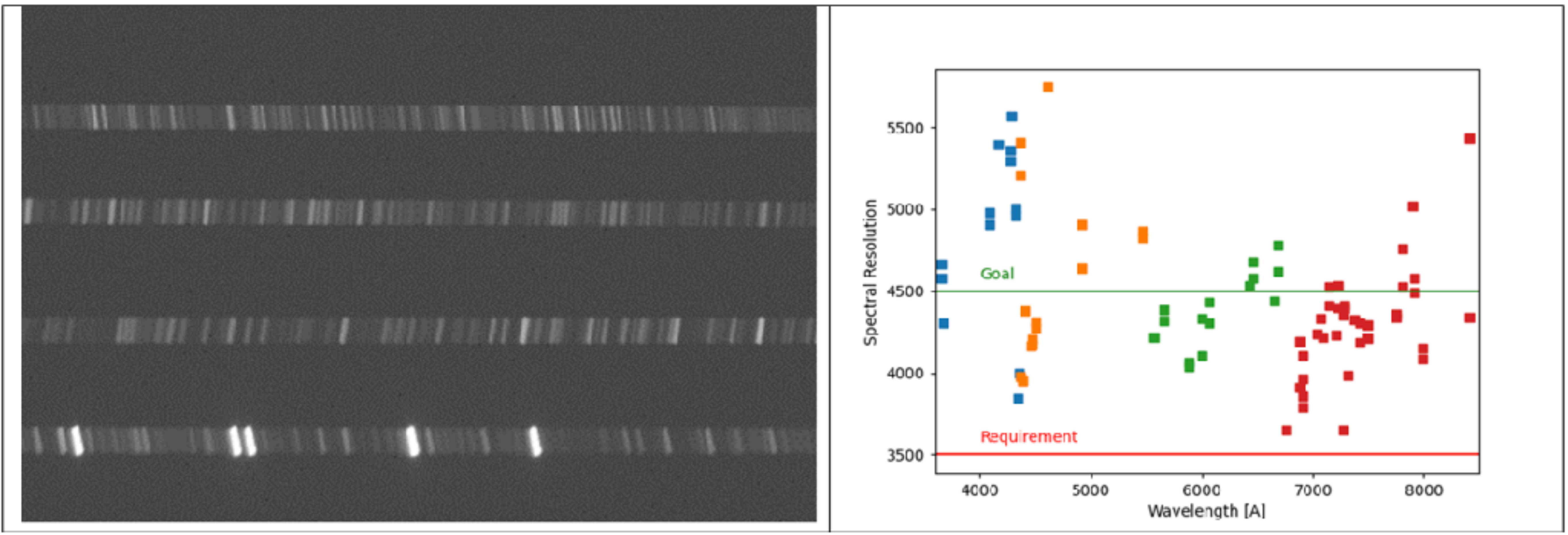
1” slit, ThAr arc lamps with DIT of 300s



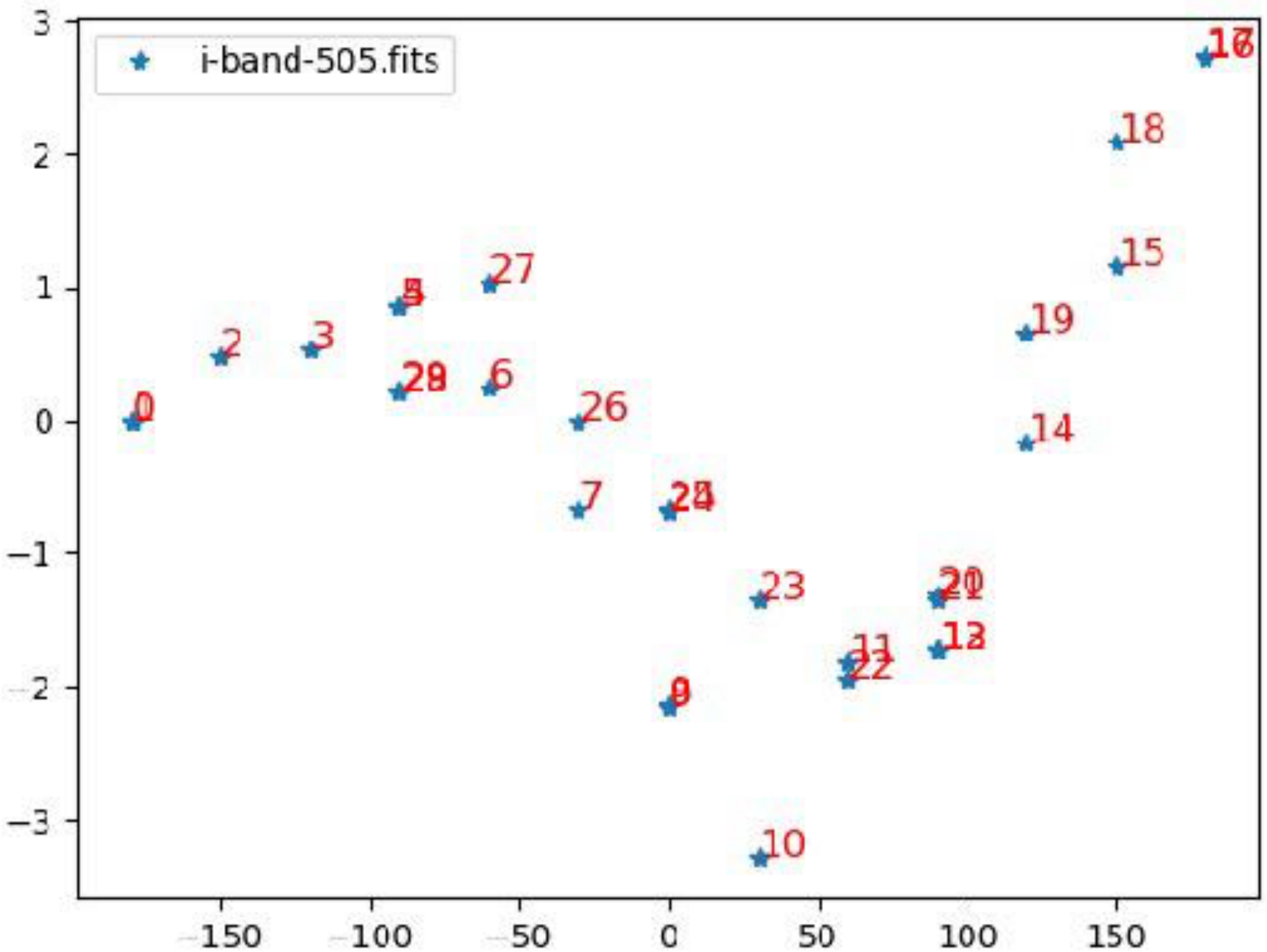
Multi-Pinhole, ThAr arc lamp with DIT of 300s

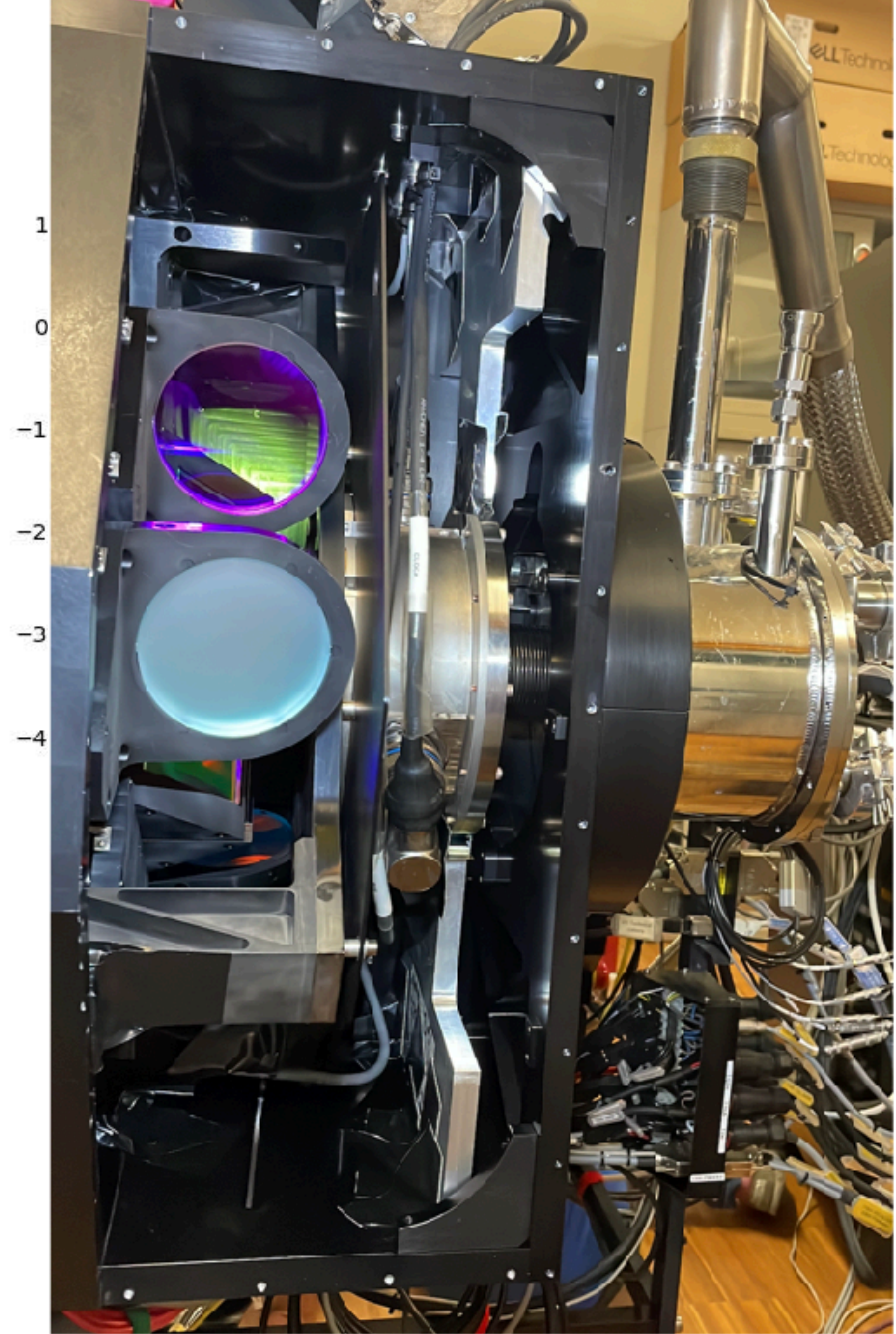


UVVIS Resolution

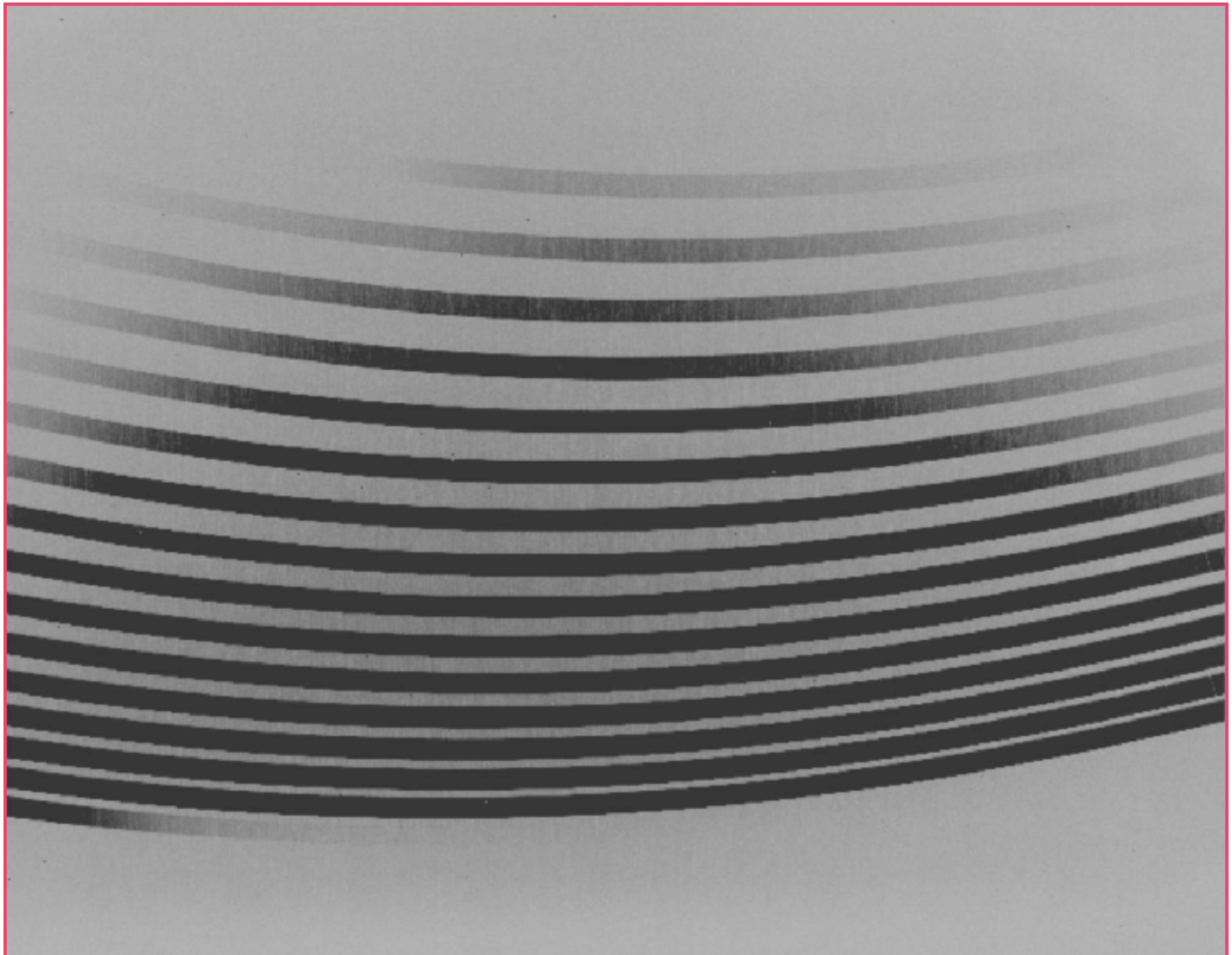


UVVIS Flexure



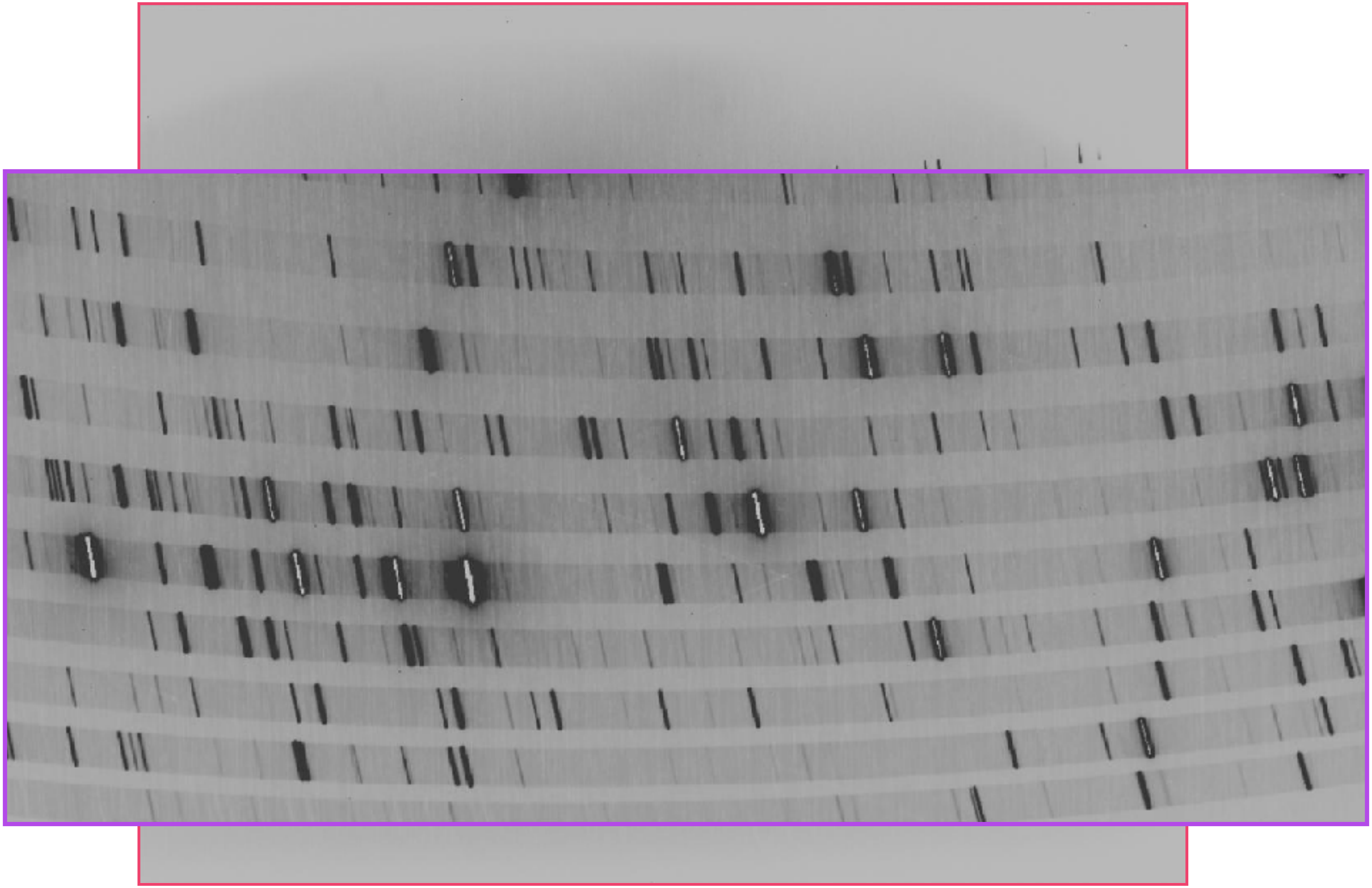


And NIR spectra …



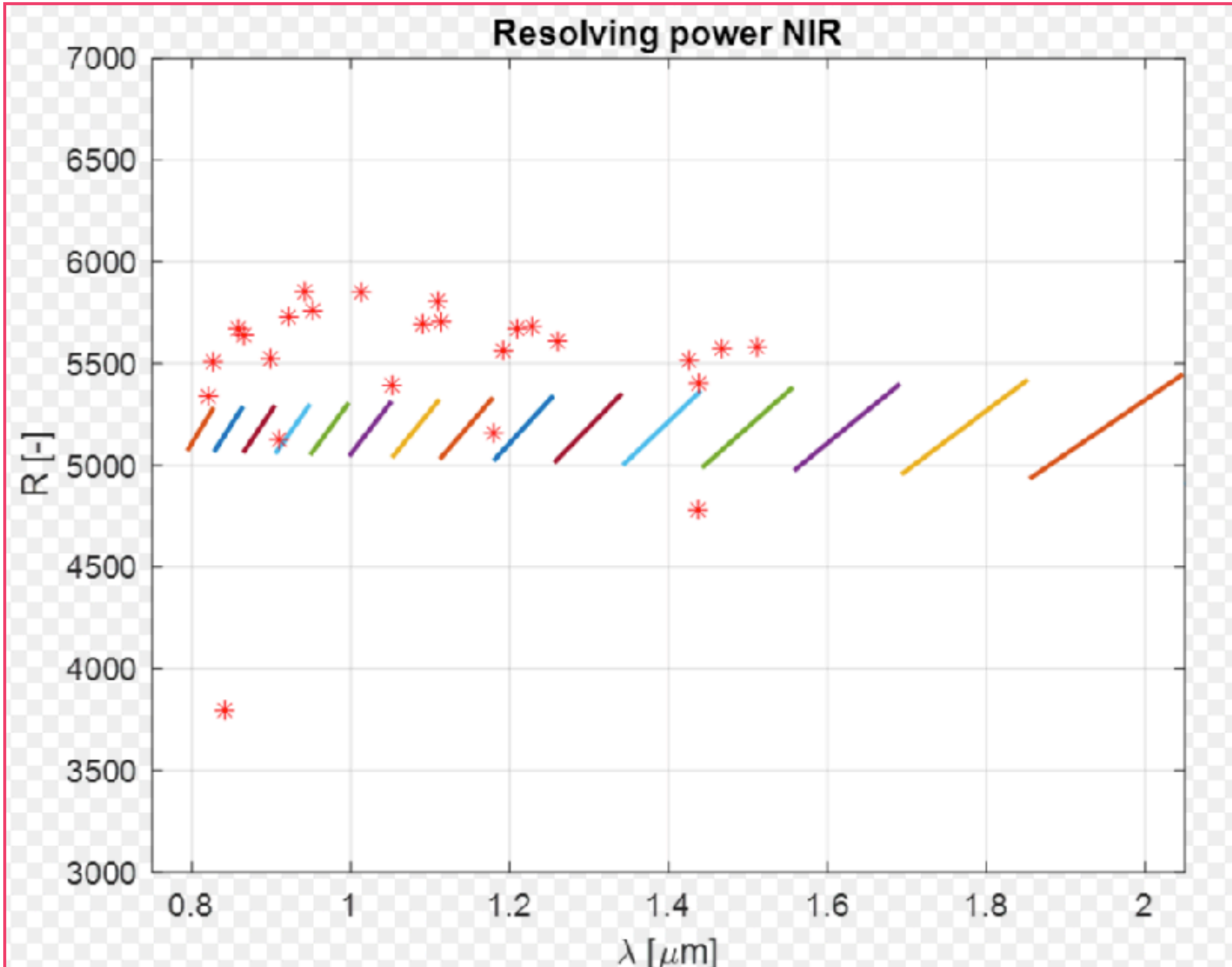
QTH continuum lamp with 0.5” slit and 5s exposure time

And NIR spectra …

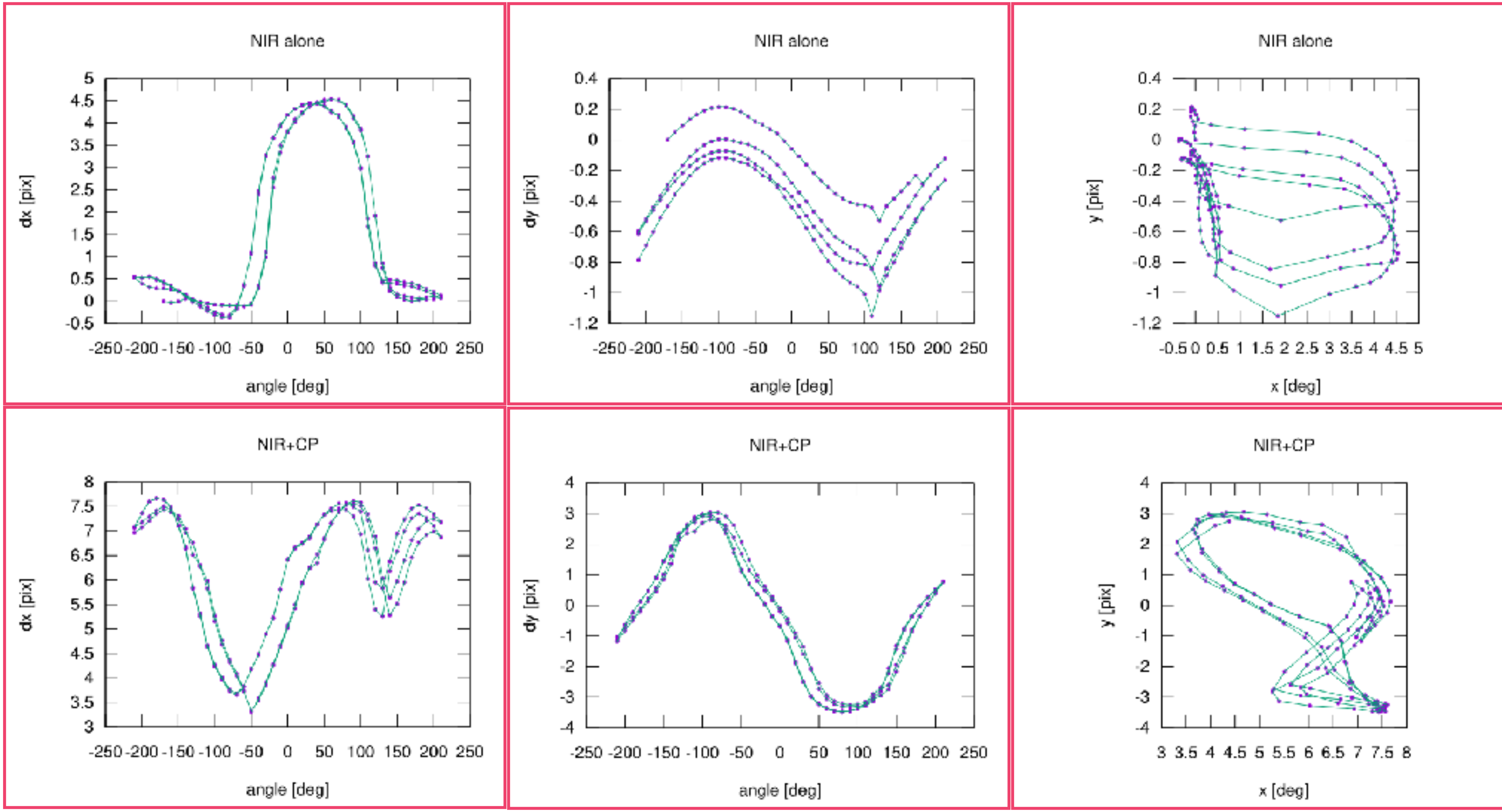


Arc lamps (Ar, Ne, Hg, & Xe) with 0.5” slit and 15s exposure time

NIR Resolution

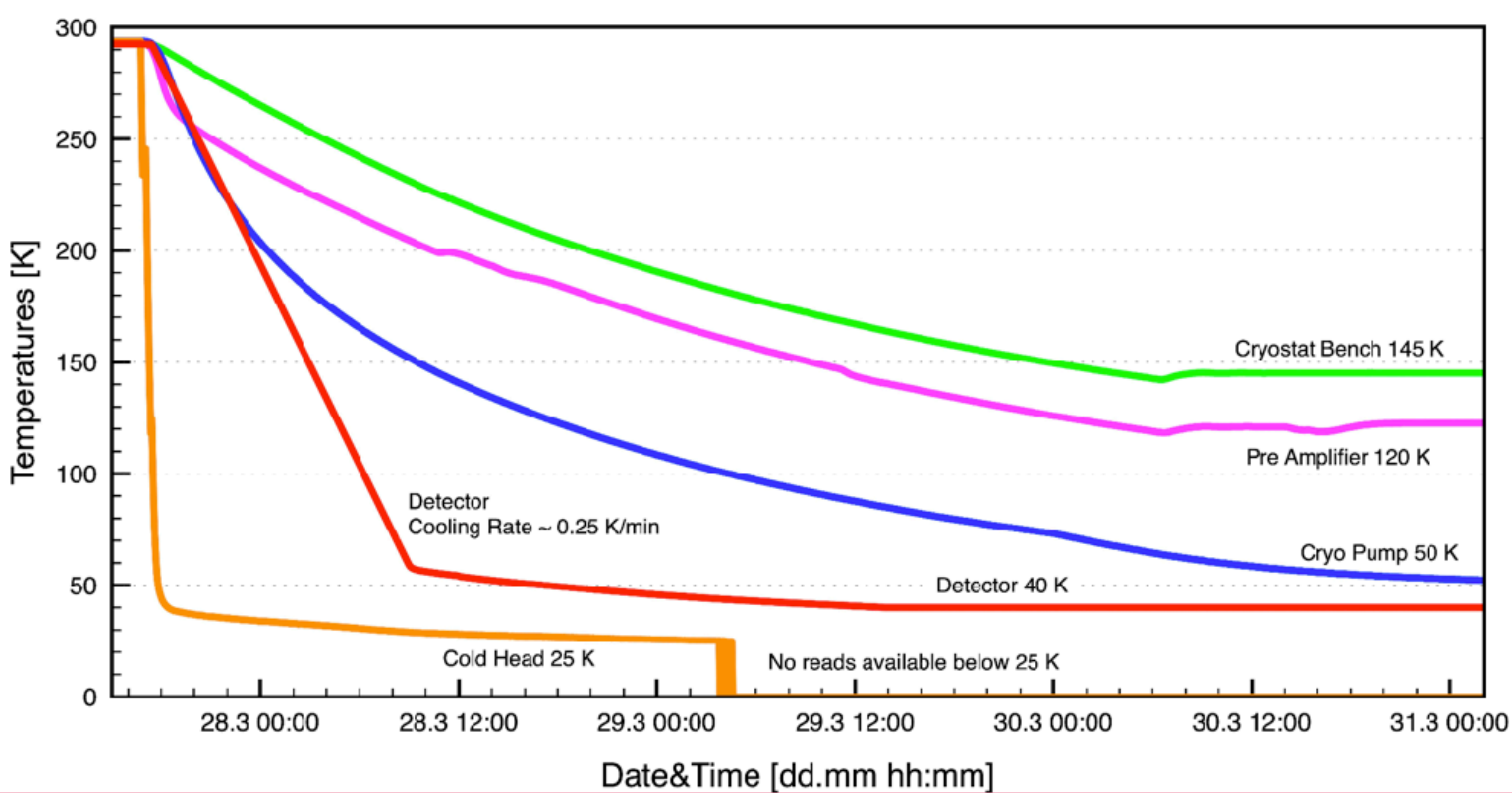


NIR Flexure

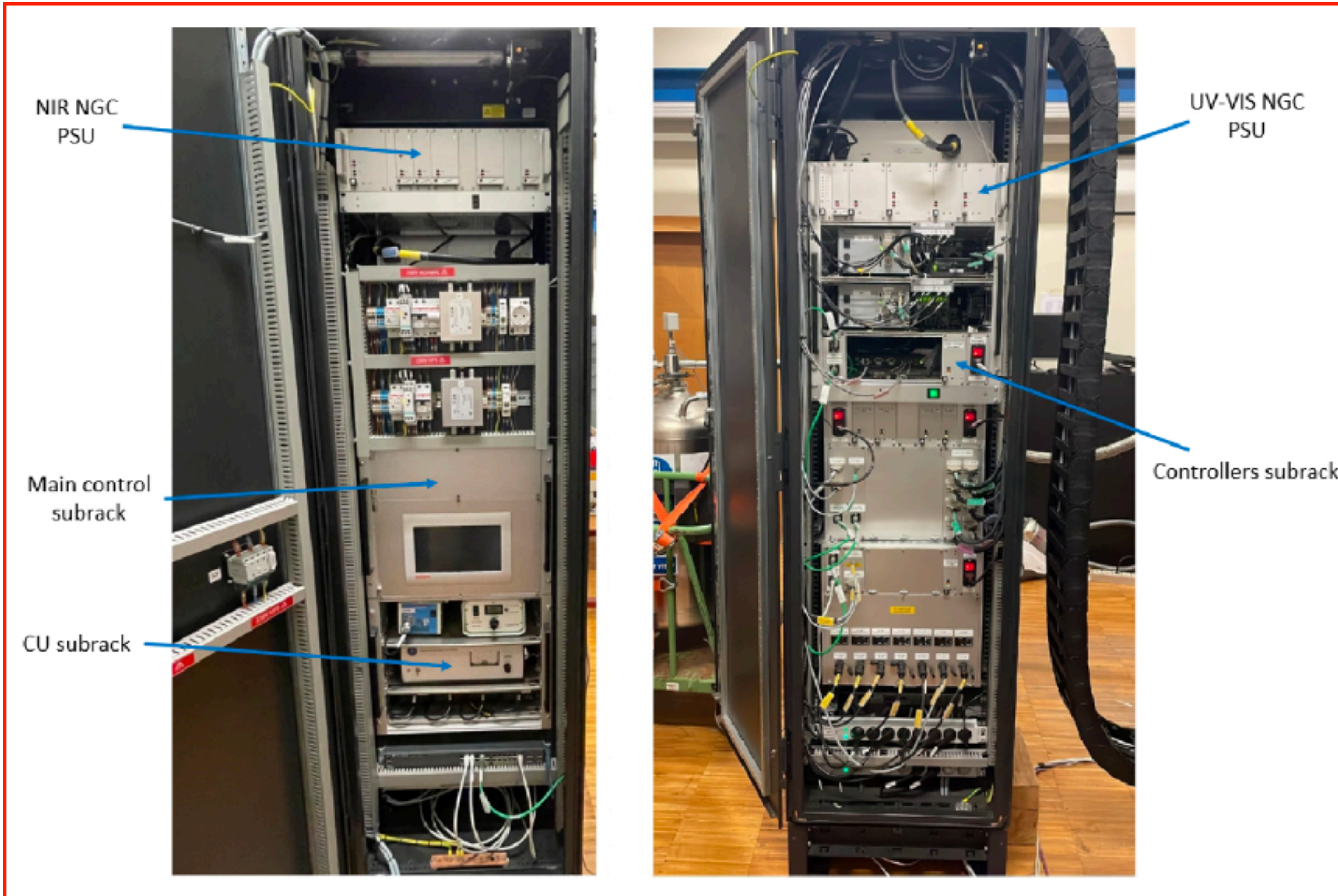


Measured flexure of the NIR alone (top) and NIR+CP (bottom)

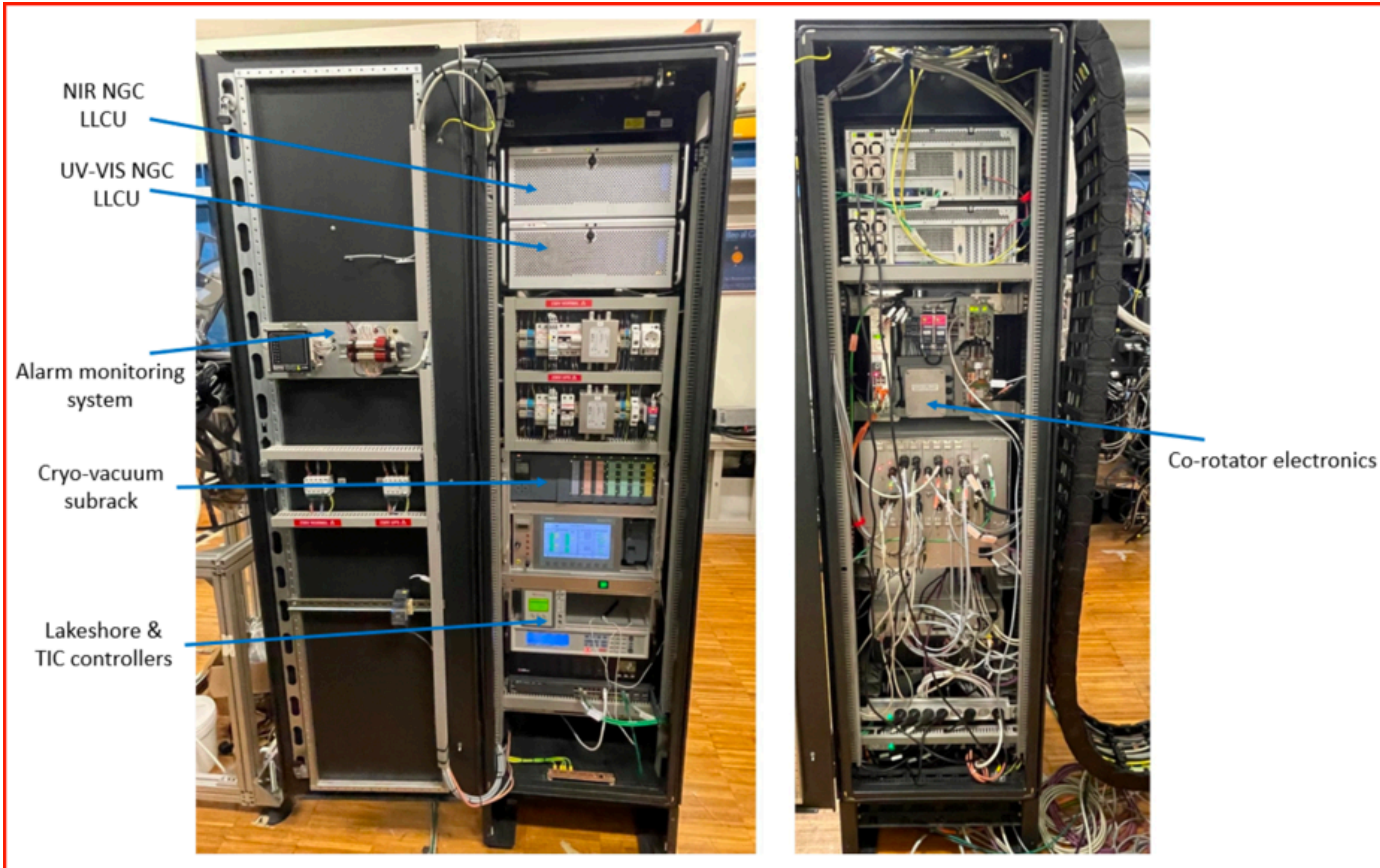
Cryo-Vacuum System



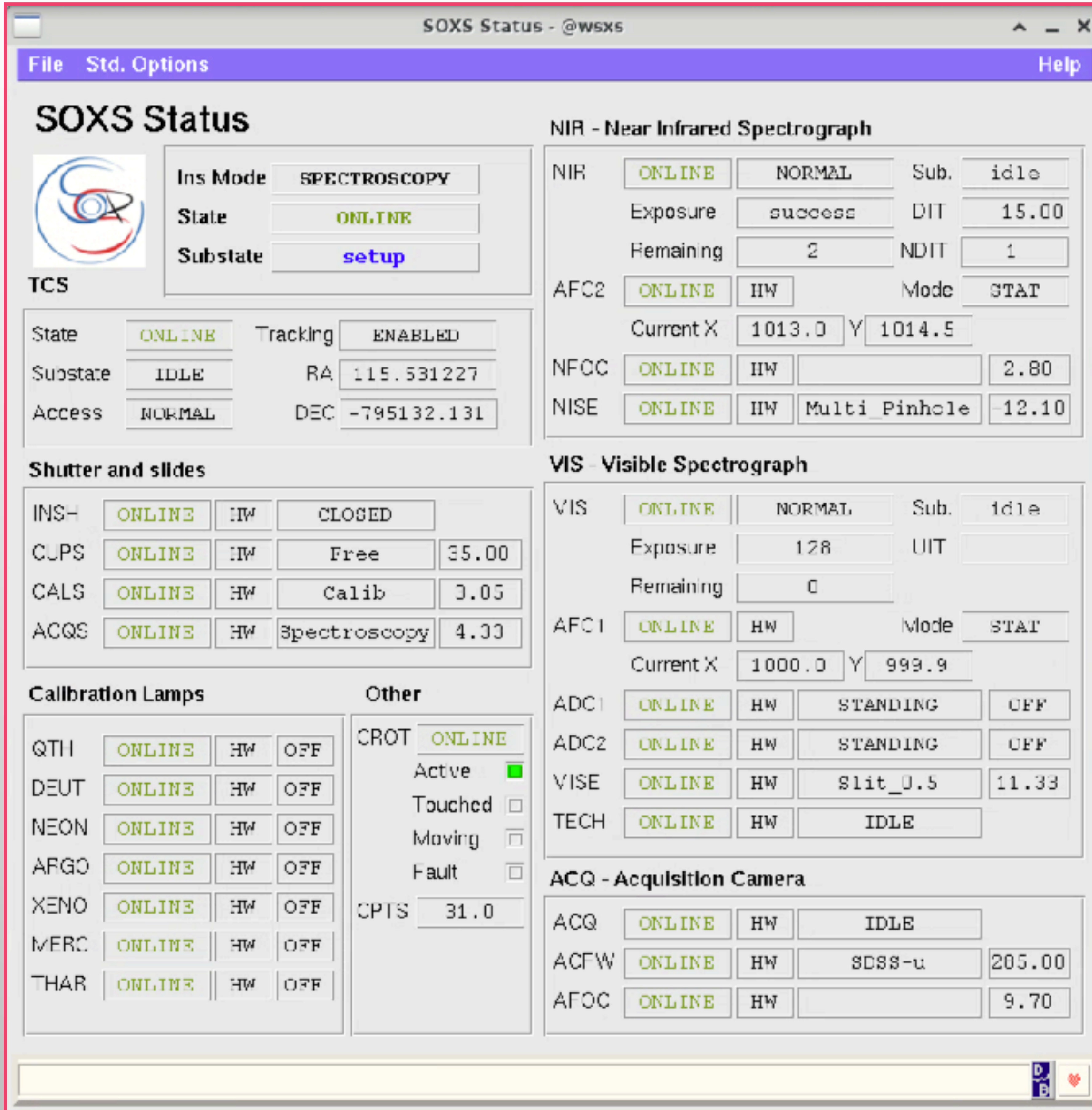
Instrument Control Electronics



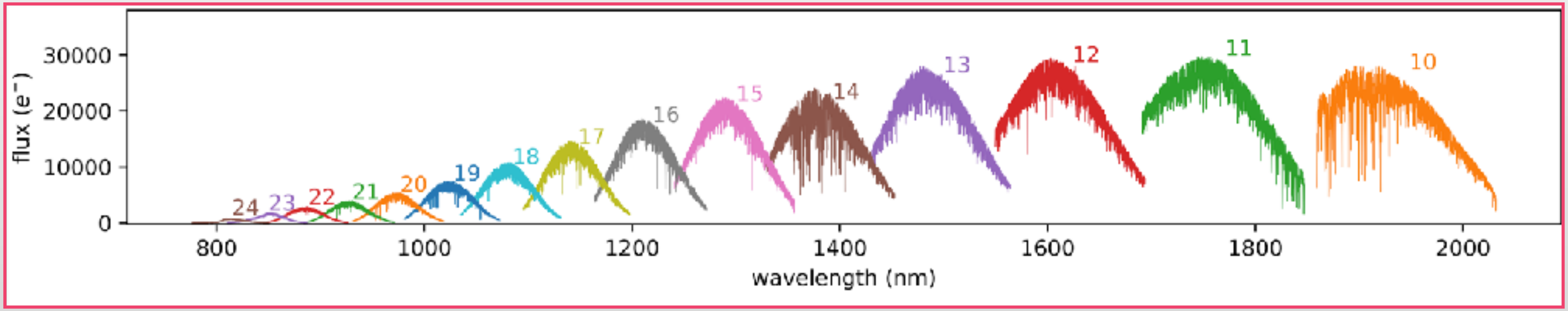
Instrument Control Electronics



Instrument Control Software



Data Reduction Software



All the spectral orders extracted from the NIR flat QTH calibration spectrum

SOXS Platform

AIV @ La Silla

Activity Name	Duration [hours]	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16	D 17	D 18	D 19	D 20	D 21	D 22	D 23	D 24	D 25	D 26	D 27	D 28	D 29	D 30	D 31
Flange Mounting	4	X							C	C																						
Flange Position Repeatability Verification	3	X							C	C																						
Flange Position Nighttime Verification	4		X						C	C																						
Electronics Cabinets Installation	8		X	X					C	C																						
Corotator structure installation and testing	3	X		X					C	C																						
Instrument Workstation Installation	4	X							C	C																						
INS network setup	4	X	X						C	C																						
Electronics and SW functional verification	4			X					C	C																						
Setting up interlock b/w corotator and NTT rotator	4				X				C	C																						
Corotator Position Verification and Functioning	4				X				C	C																						
Setting up the alarm handling system	4						X		C	C																						
CP Alignment Verification	14		X	X	X				C	C																						
CP Mounting to the Flange	2				X	X			C	C																						
CP Functional Verification	3				X	X			C	C																						
CP Nighttime Verification	4					X			C	C																						
AC Alignment Verification	10			X	X	X			C	C																						
AC Mounting to Flange	1					X	X		C	C																						
AC Functional Verification	3					X	X	X	C	C																						
CBX Mounting Lamps	4			X	X				C	C																						
CBX Testing Lamps	3					X			C	C																						
CBX Mounting to Flange	1						X	X	C	C																						
CBX Functional Verification	6						X	X	C	C																						
CP + AC + CBX Nighttime Testing	3								X																							
UVVIS: Integrating CCD chamber to the main unit	6									X	X							C														
UVVIS: Stand-alone Alignment and Functional Tests	3										X	X						C														
UVVIS: Warm Functional Tests with SOXS electronics	2											X						C														
UVVIS: Cryo-vacuum Functional Tests (without connecting to UVVIS)	6										X	X						C														
UVVIS: Cryo-pump Regeneration	2											X	X					C														
UVVIS: Cryo-vacuum Functional Tests (Warm)	6											X	X					C														
UVVIS: Vacuum and cool down the spectrograph	4												X	X				C														
UVVIS: Verification of the Image Quality & Spectral Resolution	8													X				C														
UVVIS: Mounting to Flange	6														X			C														
UVVIS: Alignment to CP	3														X			C														
UVVIS: Functional Verification	2															X		C														
UVVIS: Vacuum & Cool down on the flange, cryo-vacuum tests	4															X	X	C														
UVVIS: Verification of Image Quality and Spectral Resolution on the flange	4															X	X	C														
UVVIS: Nighttime Verification	4																	X														
NIR: Mounting on Flange	6																	X	X							C						
NIR: Alignment to CP (using mechanical references)	4																		X	X						C						
NIR: Cryo-Vacuum Testing (without connecting to HW)	4																	X	X							C						
NIR: Cryo-pump Regeneration	2																		X	X						C						
NIR: Warm Functional Tests (including cryo-vacuum)	8																			X						C						
NIR: Cooldown the vessel	54																			X	X	X	X			C						
NIR: Optical Alignment Verification	8																					X	X			C						
NIR: Verification of the Image Quality and Spectral Resolution	16																						X	X	X	C						
NIR: Nighttime testing	4																									X						
Verification of the position of the TT mirrors for various NTT derotator angles compensating the flexure	16								X	X																X	X					
Verification of the UVVIS and NIR image quality and Spectral resolution for various derotator angles using CBX light sources	16																										X	X	X			
Full system Electronics and SW tests (including testing some OBs for repeatability and reliability)	40											X	X			X	X				X								X			
Training the ESO staff for preventive and corrective maintenance - Part 1	16								X	X								X												X	X	
Training the ESO staff for preventive and corrective maintenance - Part 2	16								X	X								X												X	X	
Full System Nighttime testing before the Commissioning	32																													X	X	X

Legend

X	Daytime Activity
X	Technical Night Requested
C	Contingency day

SOXS timeline

Date	Activity	
June 2014	ESO Call for New Instruments at NTT	✓
February 2015	Proposal Submission	✓
May 2015	SOXS selected by ESO (out of 19 proposals)	✓
October 2016 - July 2017	INAF approval + PDR phase	✓
August 2017 - Sept 2018	FDR Phase	✓
October 2018 - February 2022	Procurement, Sub-system AIVT (delay due to Covid-19)	✓
March 2022	Integration Started	✓
March 2022 - July 2024	Integration & System level tests	✓
July 2024	Preliminary Acceptance Europe start	✓
November 2024	PAE complete and start packing	✓
December 2024	Shipping SOXS to La Silla, Chile	✓
January 2025	AIV @ La Silla	✓
March 2025	Commissioning Start	✓

The SOXS Instrument @ INAF-OAPD

Extra Slides

Name	Initials	Institution	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16	D 17	D 18	D 19	D 20	D 21	D 22	D 23	D 24	D 25	D 26	D 27	D 28	D 29	D 30	D 31	D 32	D 33	D 34	D 35	Total
Kalyan Radhakrishnan	KRA	INAF-Padova	X	X	X	X	X	X	X	X	X	X	X	X	X																			X	X	X	X	17
Federico Battaini	FBA	INAF-Padova	X	X	X	X	X	X	X	X															X	X	X	X	X	X	X	X	X	X	X	X	X	21
Simone Di Filippo	SDF	INAF-Padova	X	X	X	X	X	X	X	X																												8
Riccardo Claudi	RCL	INAF-Padova									X	X	X	X	X	X	X	X	X																			9
Lorenzo Cabona	LCA	INAF-Padova														X	X	X	X	X	X	X	X	X	X													10
Davide Ricci	DRI	INAF-Padova	X	X	X	X	X	X	X	X	X	X	X										X	X	X	X	X	X	X	X	X	X	X					22
SoftWare Person	SWP	INAF-Padova												X	X	X	X	X	X	X	X	X												X	X	X	X	13
Matteo Aliverti	MAL	INAF-Brera	X	X	X	X	X	X	X							X	X	X	X	X	X	X	X	X														16
Matteo Genoni	MGE	INAF-Brera																		X	X	X	X	X	X	X	X	X	X	X	X	X	X					14
Sergio Campana	SCA	INAF-Brera																																X	X	X	X	4
Paolo D'Avanzo	PDA	INAF-Brera																																X	X	X	X	4
Pietro Schipani	PSC	INAF-Napoli	X	X	X	X	X	X	X	X	X	X													X	X	X	X	X	X	X	X	X	X	X	X	X	23
Mirko Colapietro	MCO	INAF-Napoli	X	X	X	X	X	X	X																													7
Sergio D'Orsi	SDO	INAF-Napoli	X	X	X	X	X	X	X																													7
Salvatore Savarese	SSA	INAF-Napoli																							X	X	X	X	X	X	X	X	X	X	X	X	X	13
Guilio Capasso	GCA	INAF-Napoli																							X	X	X	X	X	X	X	X	X	X	X	X	X	13
Fabrizio Vitali	FVI	INAF-Rome														X	X	X	X	X	X	X	X	X														9
Francesco D'Alessio	FDA	INAF-Rome														X	X	X	X	X	X	X	X	X														9
Salvatore Scuderi	SSC	INAF-Milan											X	X	X	X	X	X	X	X	X	X	X	X														12
Antonio Micciché	AMI	INAF-Catania														X	X	X	X	X	X	X	X	X														9
Sagi Ben-Ami	SBA	Weizmann								X	X	X	X	X	X																							6
Adam Rubin	ARU	Weizmann								X	X	X	X	X	X																							6
Ofir Hershko	OHE	Weizmann								X	X	X	X	X	X																							6
Rosario Cosentino	RCO	TNG									X	X	X	X	X																							5
Rachael Bruch	RBR	Weizmann																								X	X	X	X	X	X	X	X	X	X	X	X	12
Guiliano Pignata	GPI	Universidad An																										X	X	X	X	X	X					6
		Total/day	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**8**	**8**	**8**	**8**	**9**	**9**	**9**	**9**	
																																			Total number days for all people on-site			**281**

Summary

- SOXS is a Single object spectrograph offering simultaneous spectral coverage in UV-VIS and NIR, with imaging capabilities in the visible.
- It will be a precious facility for the spectroscopic follow-up of transient sources.
- SOXS installation, commissioning, and science verification will be in the year of 2024.

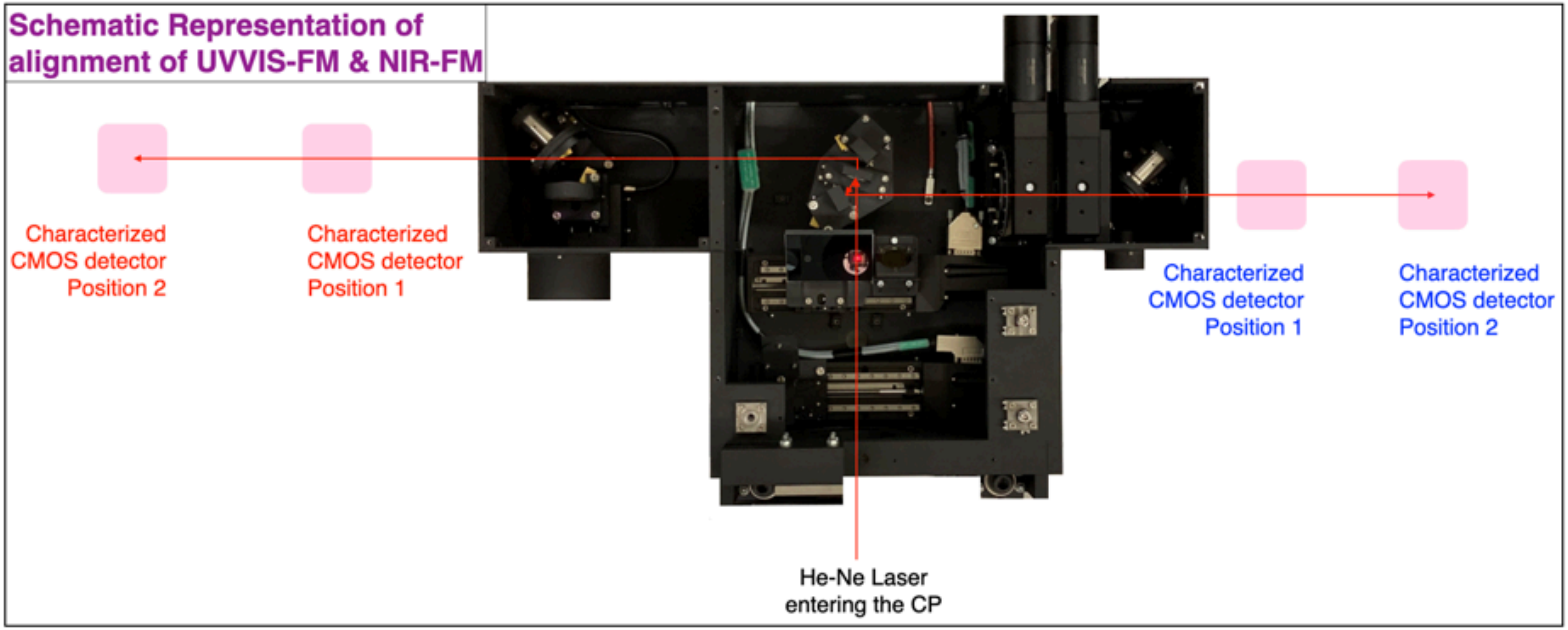
Mounting the UVVIS Spectrograph on the SOXS Flange

Thanks

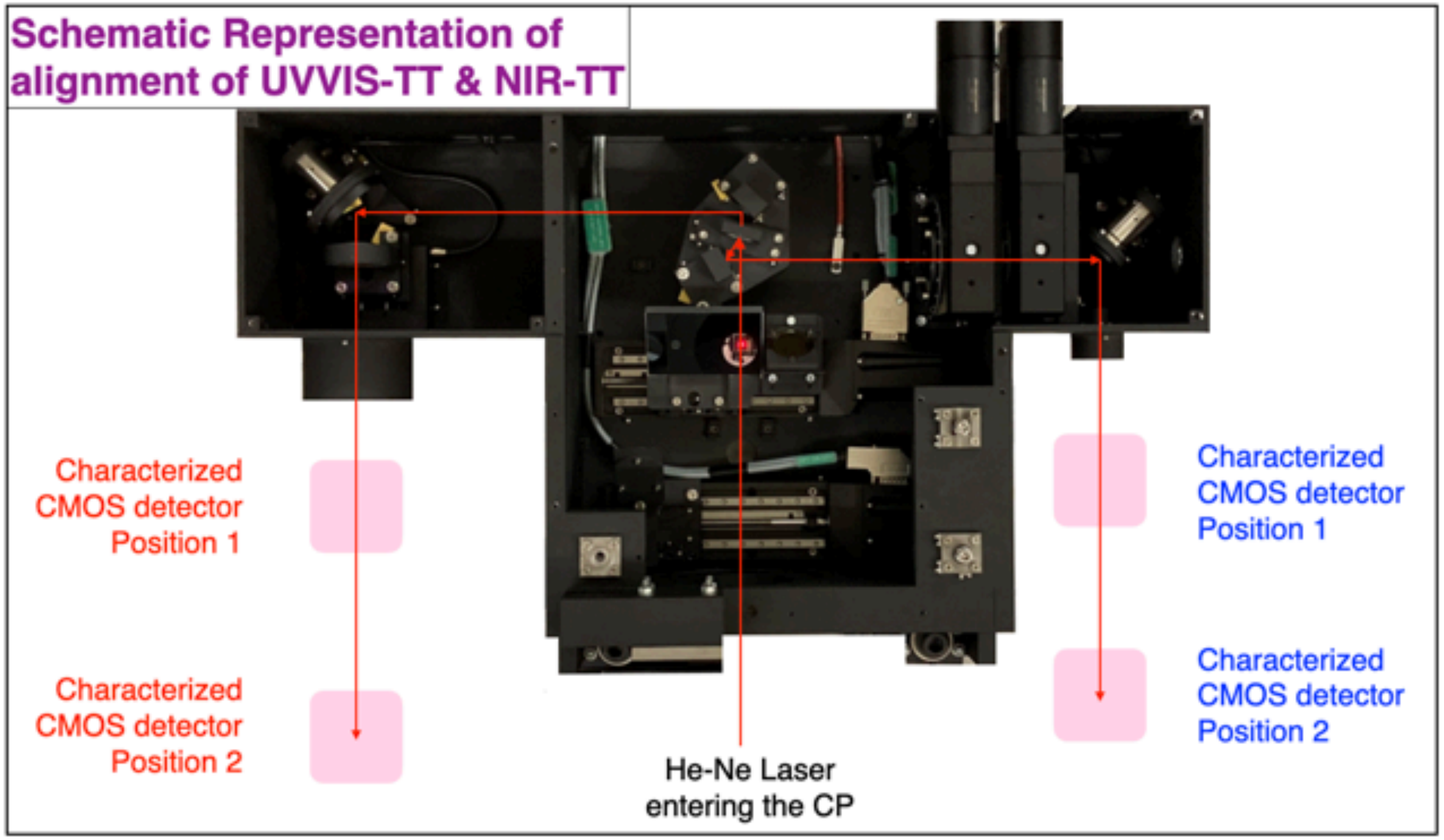
SOXS Consortium

- INAF - Common Path sub-system, NIR-spectrograph, control software and electronics, vacuum and cryogenics, detector control.
- Weizmann Institute of Science - UV-VIS spectrograph
- Universidad Andres Bello & Instituto Milenio de Astrofisica - Acquisition Camera sub-system
- Turku University - Calibration Unit sub-system
- Queen's University -Data reduction

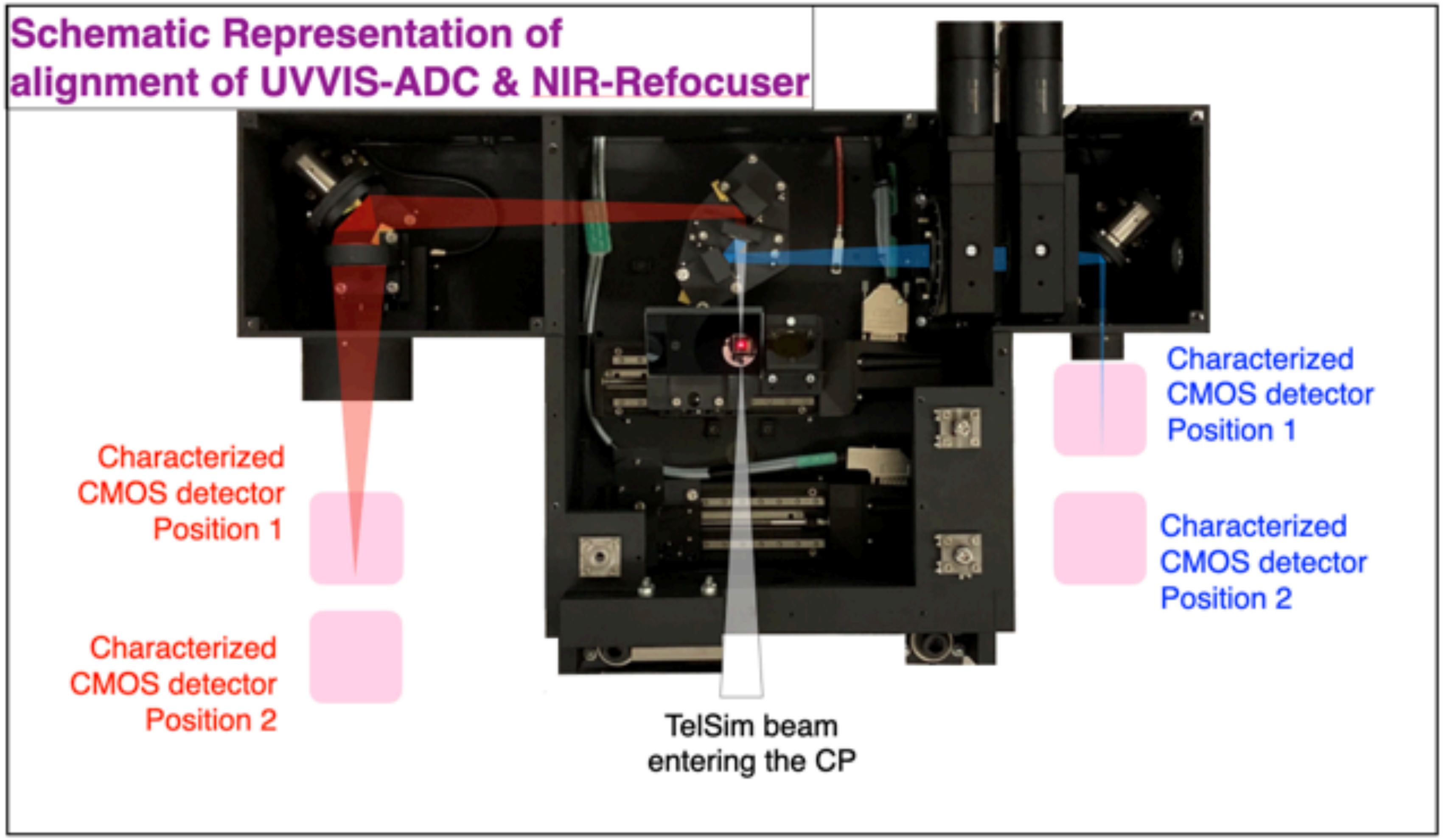
Common Path Alignment



Common Path Alignment

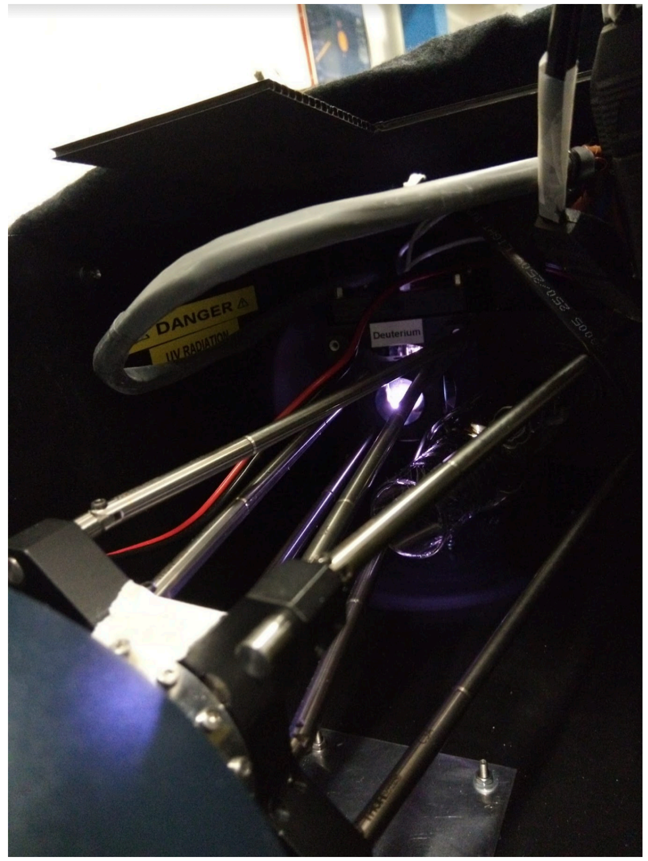


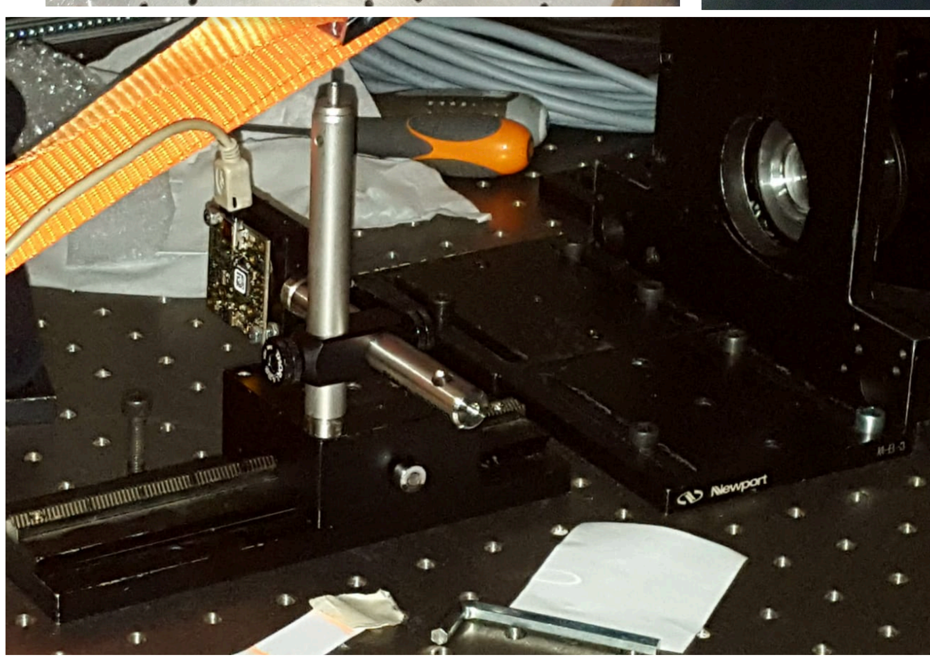
Common Path Alignment

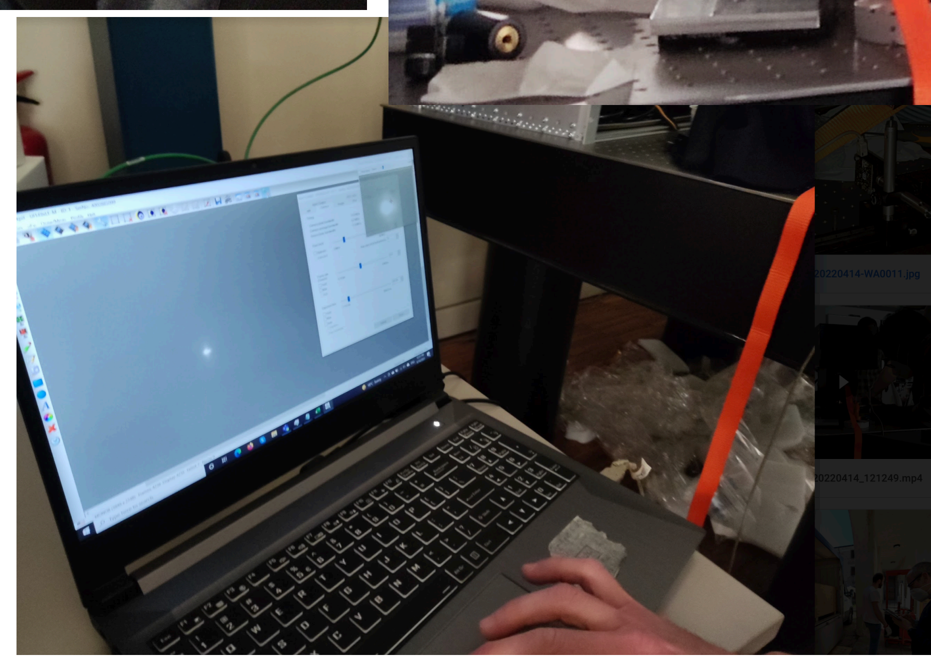


Integration and Testing

Integration and Testing

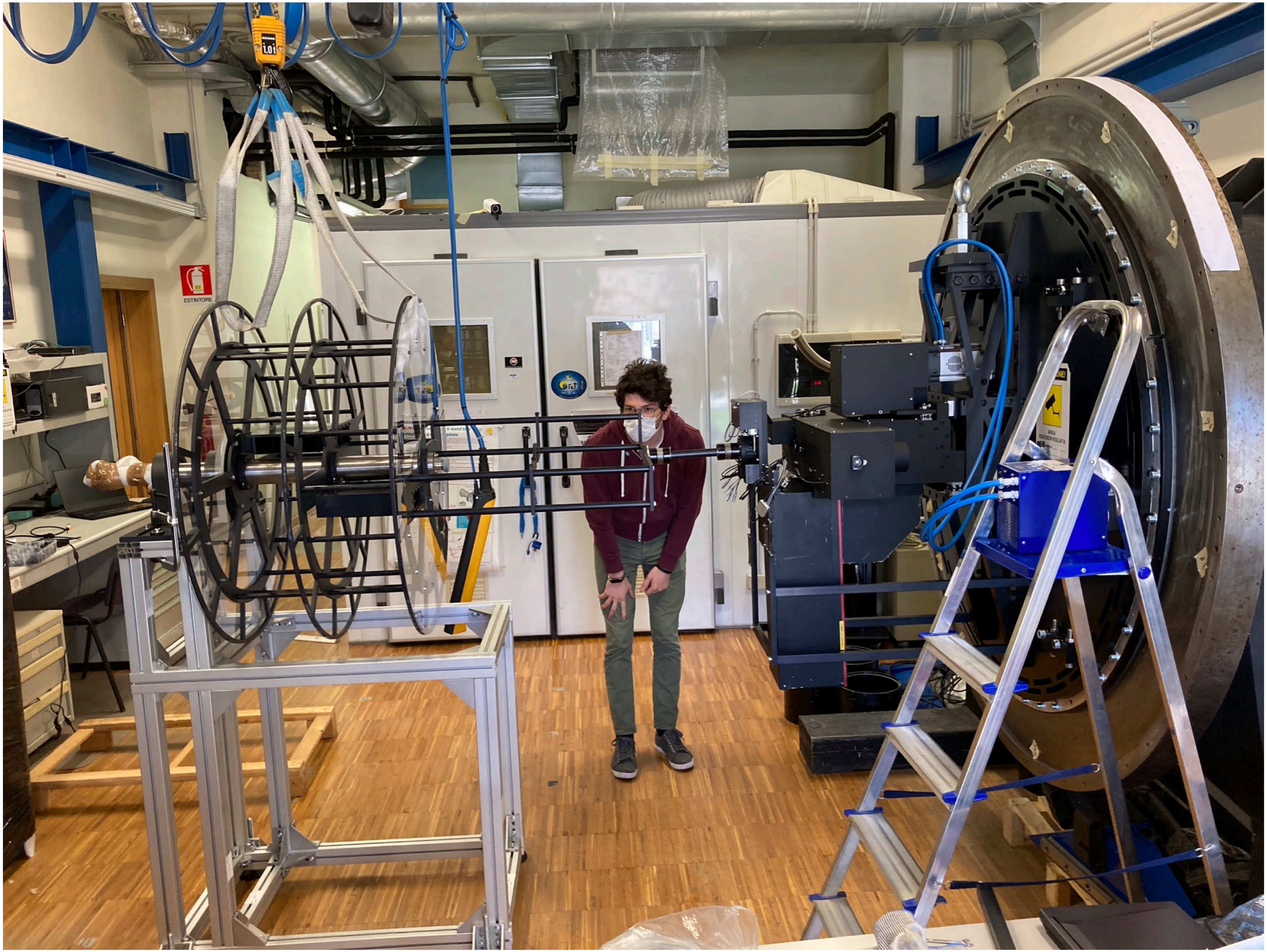






Integration and Testing

Integration and Testing



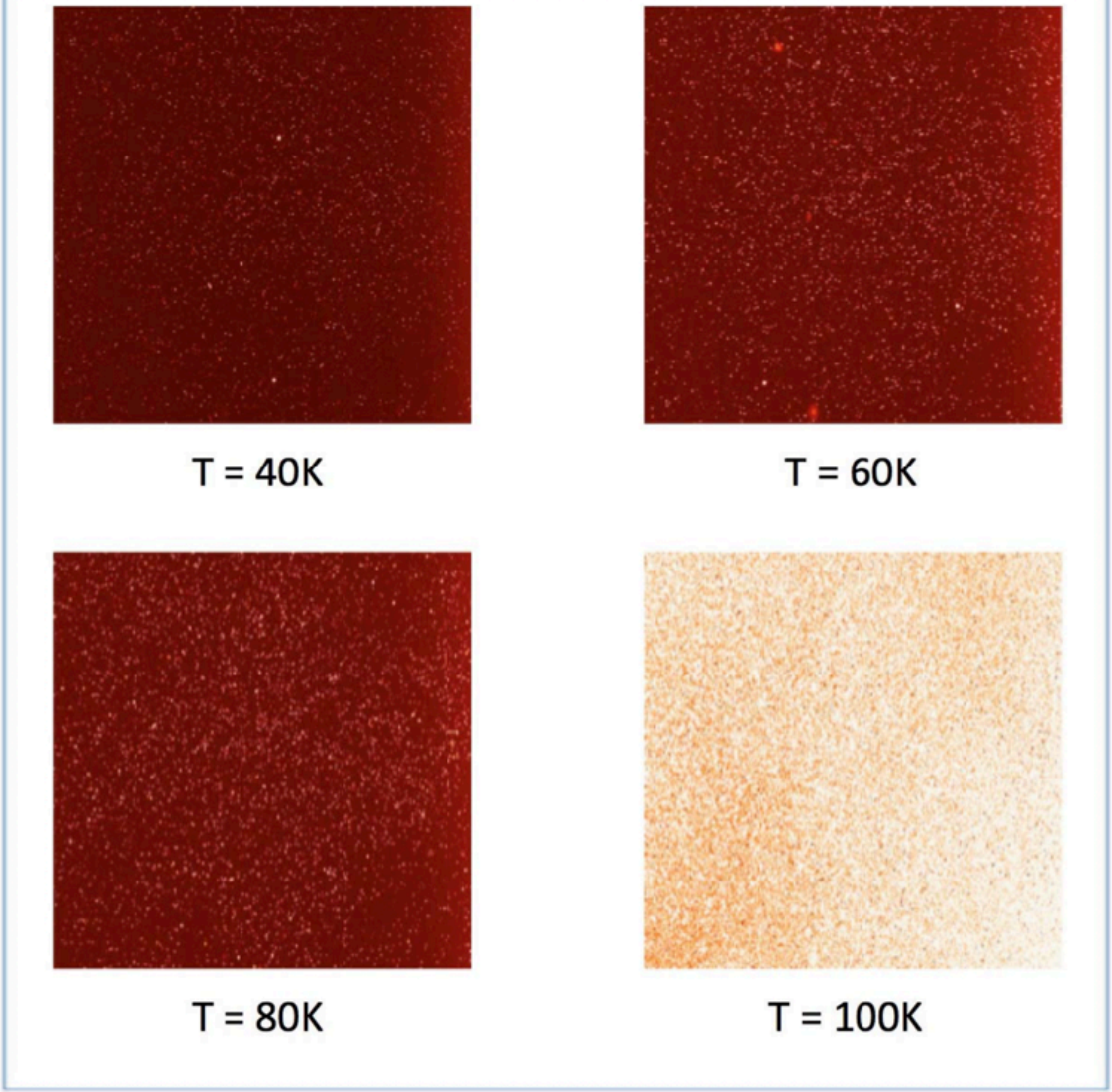


Figure 2 – HAWAII 2RG Cosmetics at 40, 60, 60 and 100 K

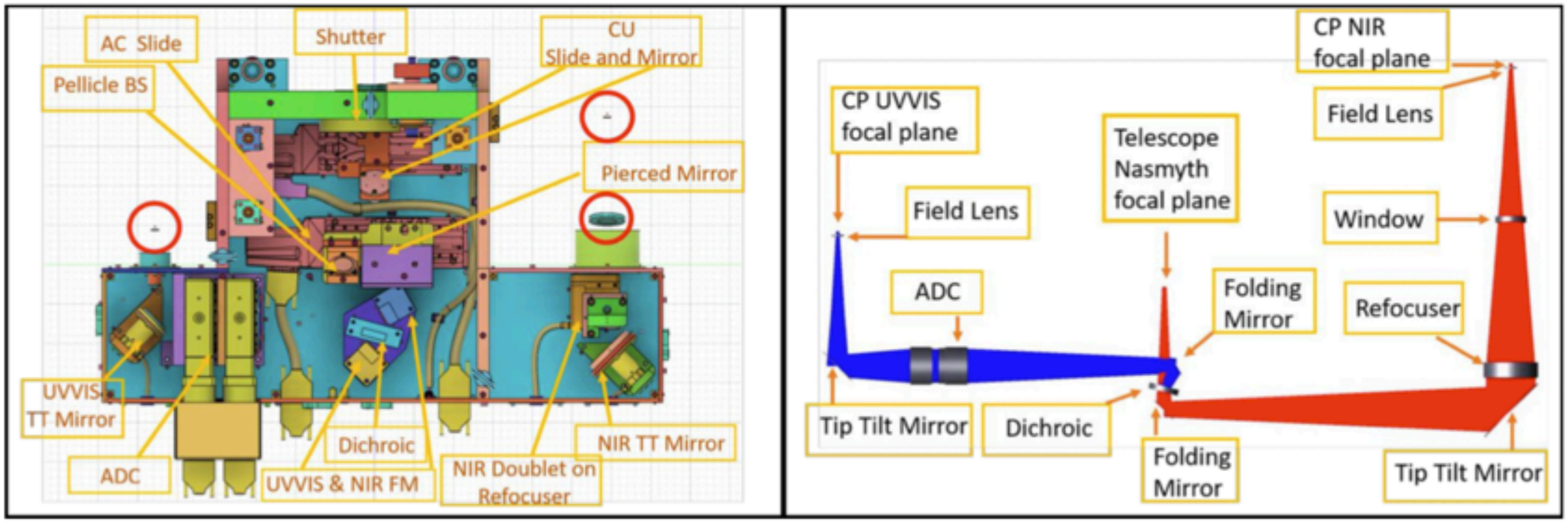


Figure 1. *Left panel*: Common Path CAD image displaying its components. *Right panel*: The CP light path.

The optical components UVVIS field lens, NIR window, and NIR field lens (marked within red circles in Figure 1 are formally a part of the CP, but physically present within the spectrographs. Without these components, the CP produces an $F/6.91$ beam at the UVVIS CP exit and an $F/6.8$ beam at the NIR CP exit.

History (more recent)

ESO call for new instruments at NTT (06/2014)

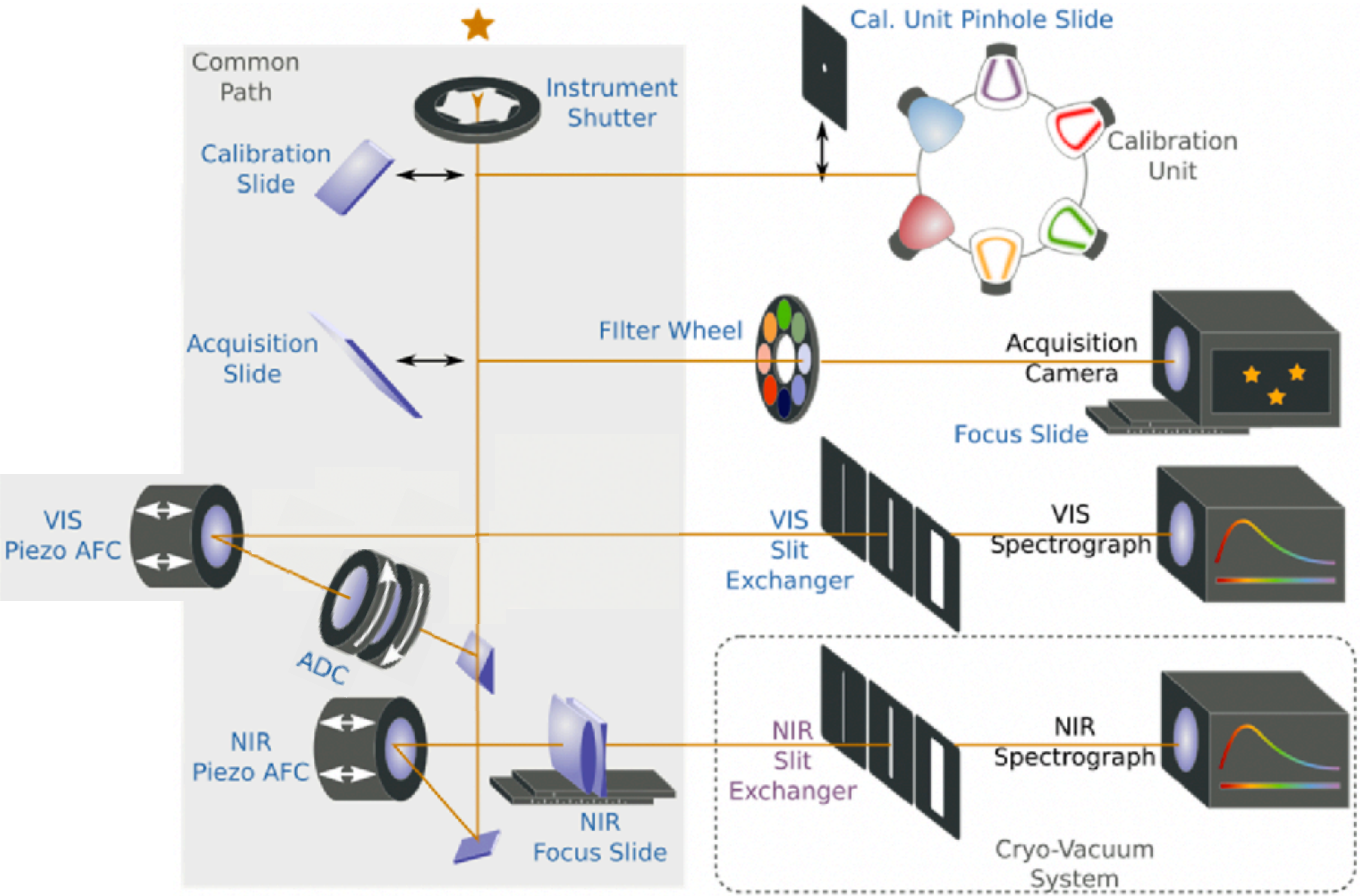
Proposal submission (02/2015)

SOXS selected by ESO (05/2015) out of 19

Signed MoU INAF-ESO
Signed MoU INAF-Partners

Project Phase	Start	End	Duration
Preliminary Design	08/2016	07/2017	12 months
Final Design	08/2017	10/2018	14 months
MAIT	11/2018	11/2022	48 months+COVID
PAE	12/2022	02/2023	3 months
Commissioning & SV & PAC	03/2023	09/2023	6 months
Operations & GTO	2023	2028	

SOXS block diagram



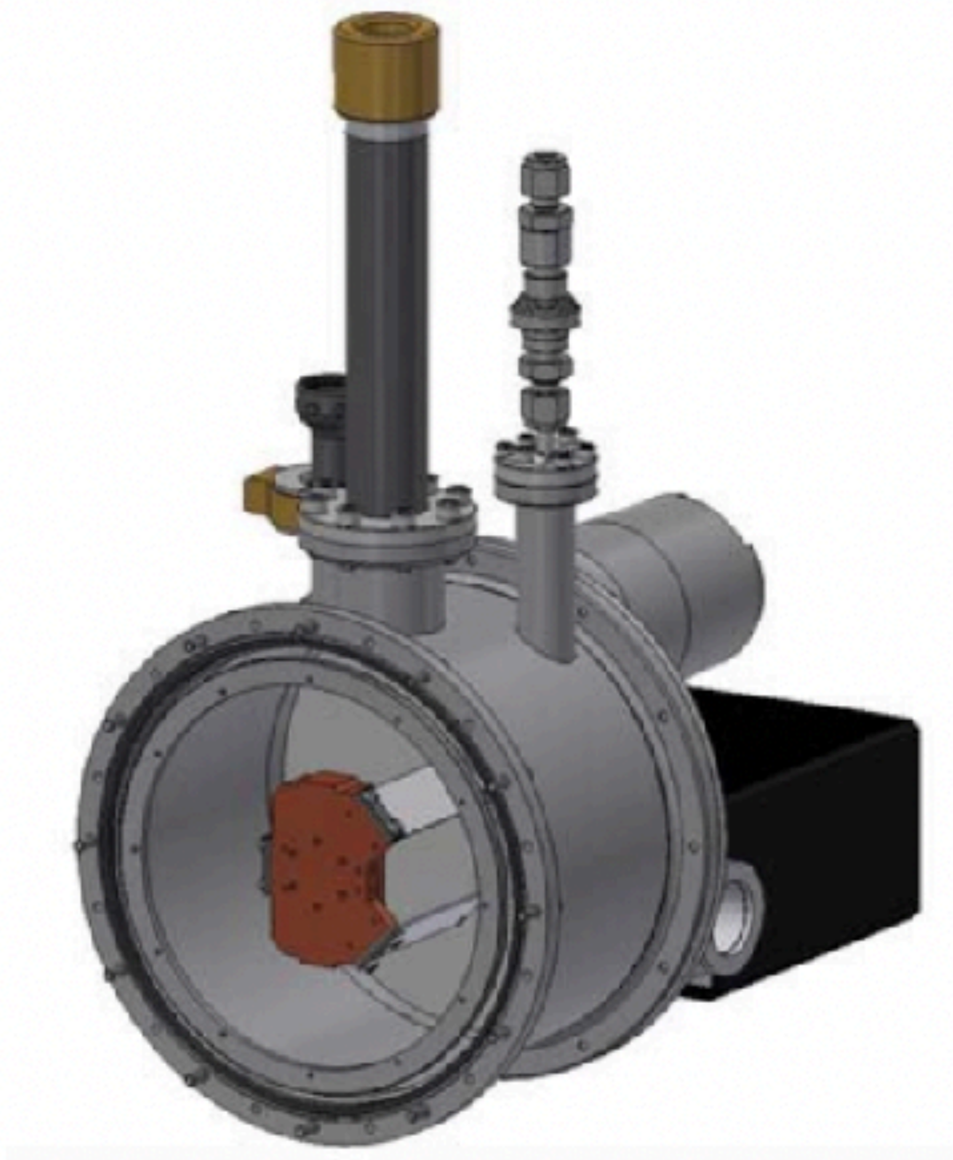
4.1 Mounting to the NTT Derotator

The following table describes what all components go on the NTT derotator, their weights, and where they are attached.

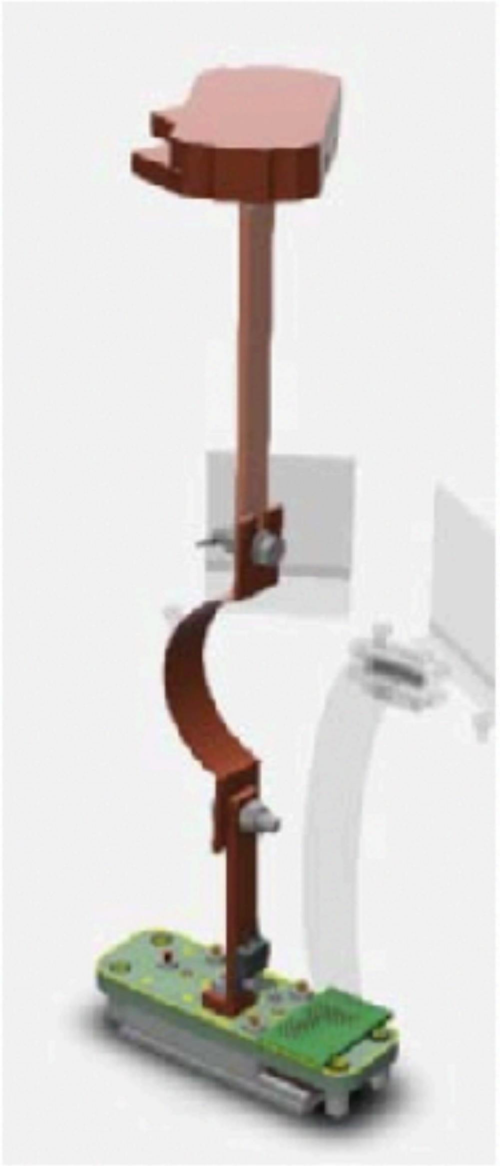
#	What	Weight measured at INAF-PD [kg]	Where is it attached
1	SOXS Flange + Support Structure	~ 355	NTT Derotator
2	Common Path	46	SOXS Flange
3	Calibration Unit	9	SOXS CP
4	Acquisition Camera	11	SOXS CP
5	UVVIS Spectrograph	140	SOXS Flange
6	NIR Spectrograph	~ 217	SOXS Flange
7	NGC - UVVIS + Support Structure	17	NTT Derotator
8	NGC - NIR + Support Structure	~ 17	NTT Derotator
9	Power Supply Support Structure	~ 6	NTT Derotator

Table 2. The table shows the weight of the components that will be mounted to the flange (highlighted in green) and onto the NTT rotator adaptor (highlighted in blue).

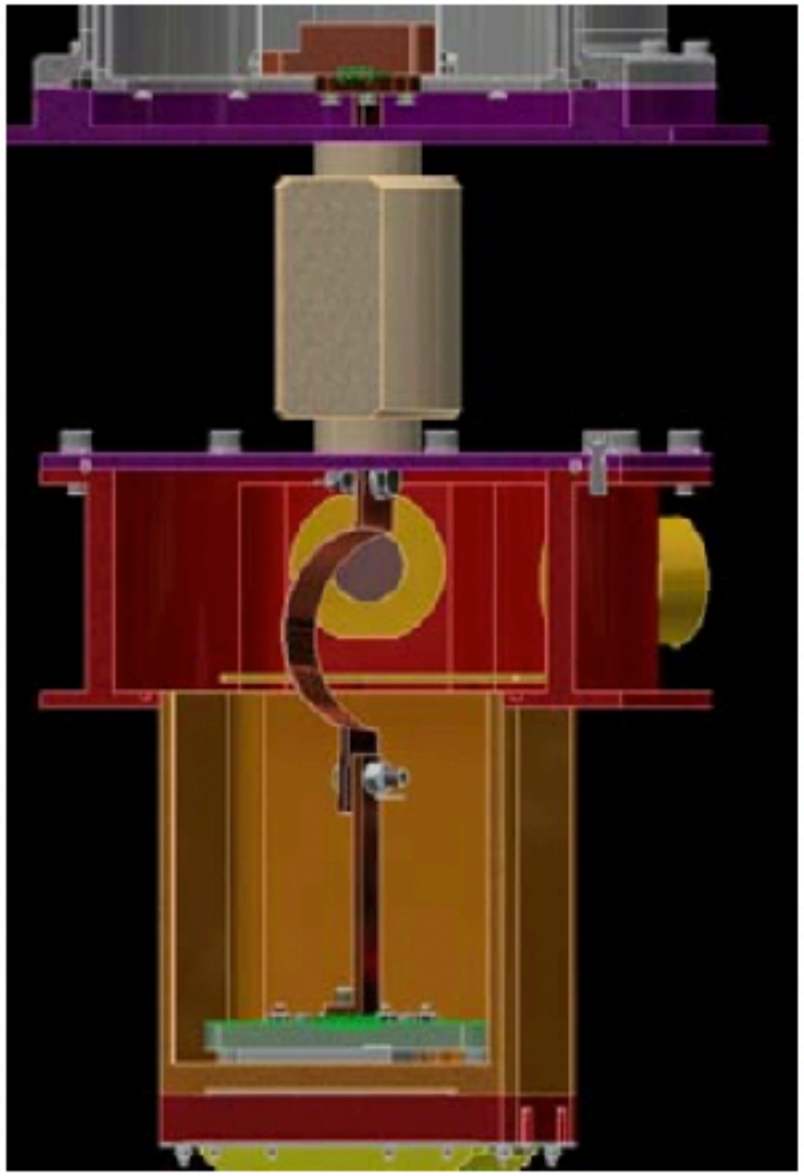
UV-VIS Cryogenic System



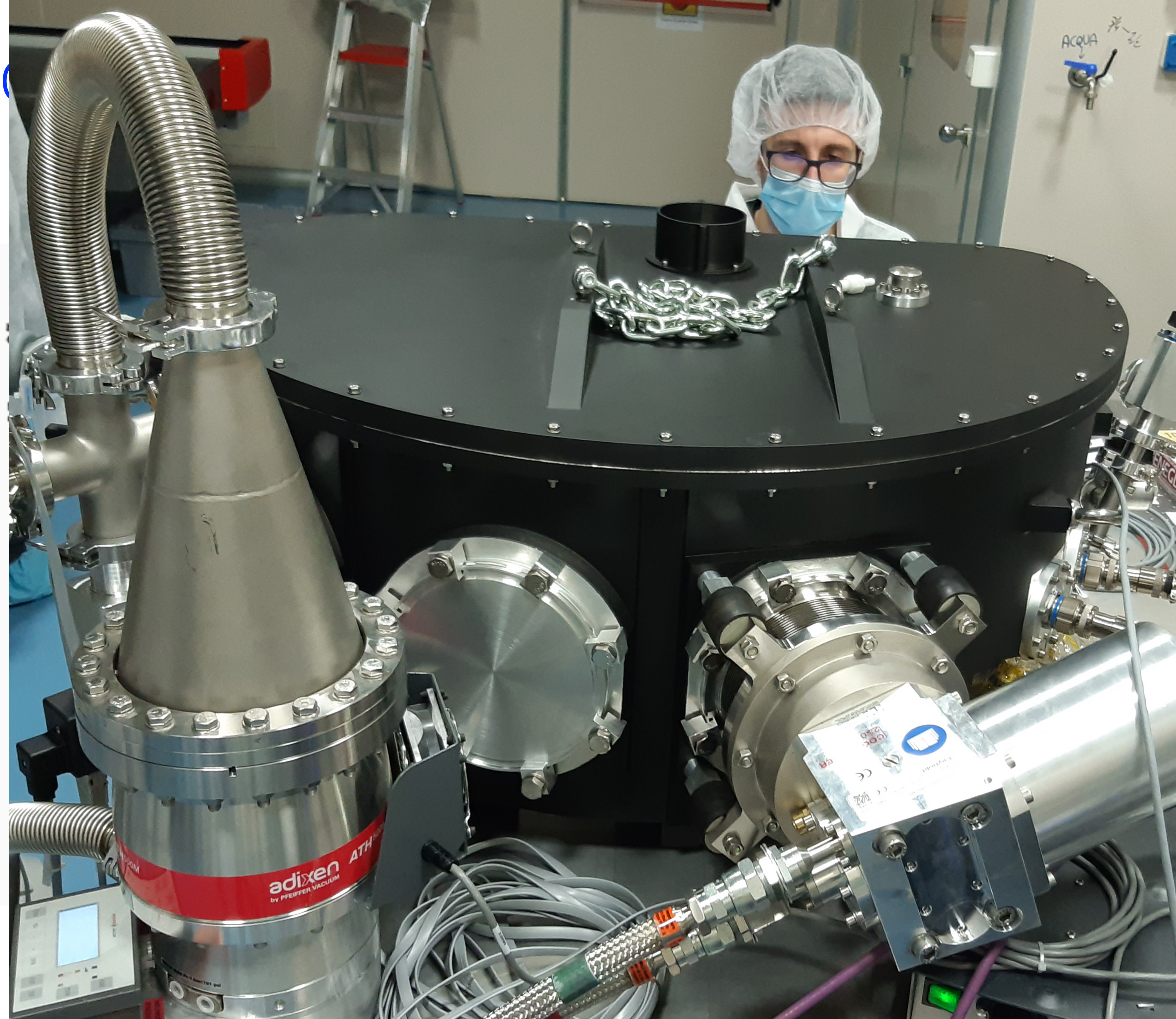
The cold finger of CFC.



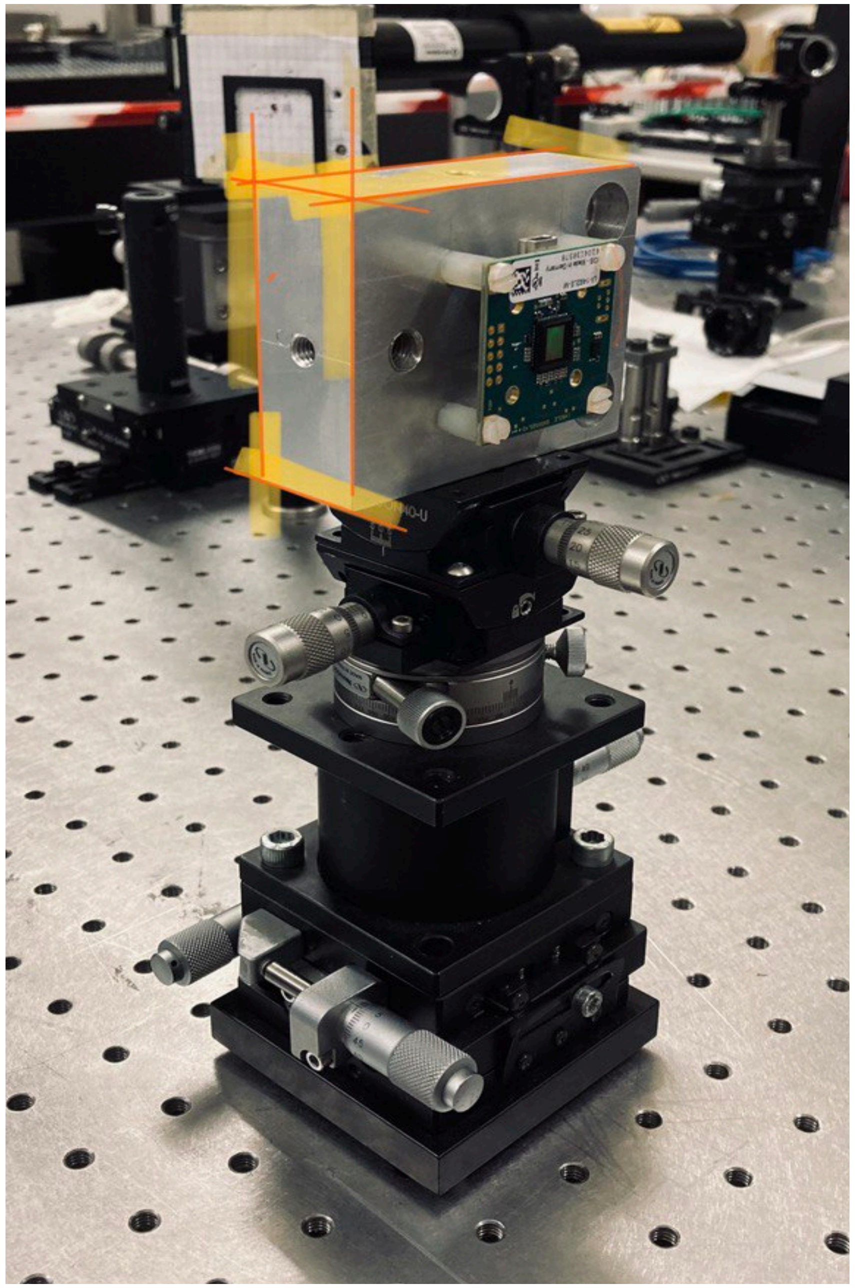
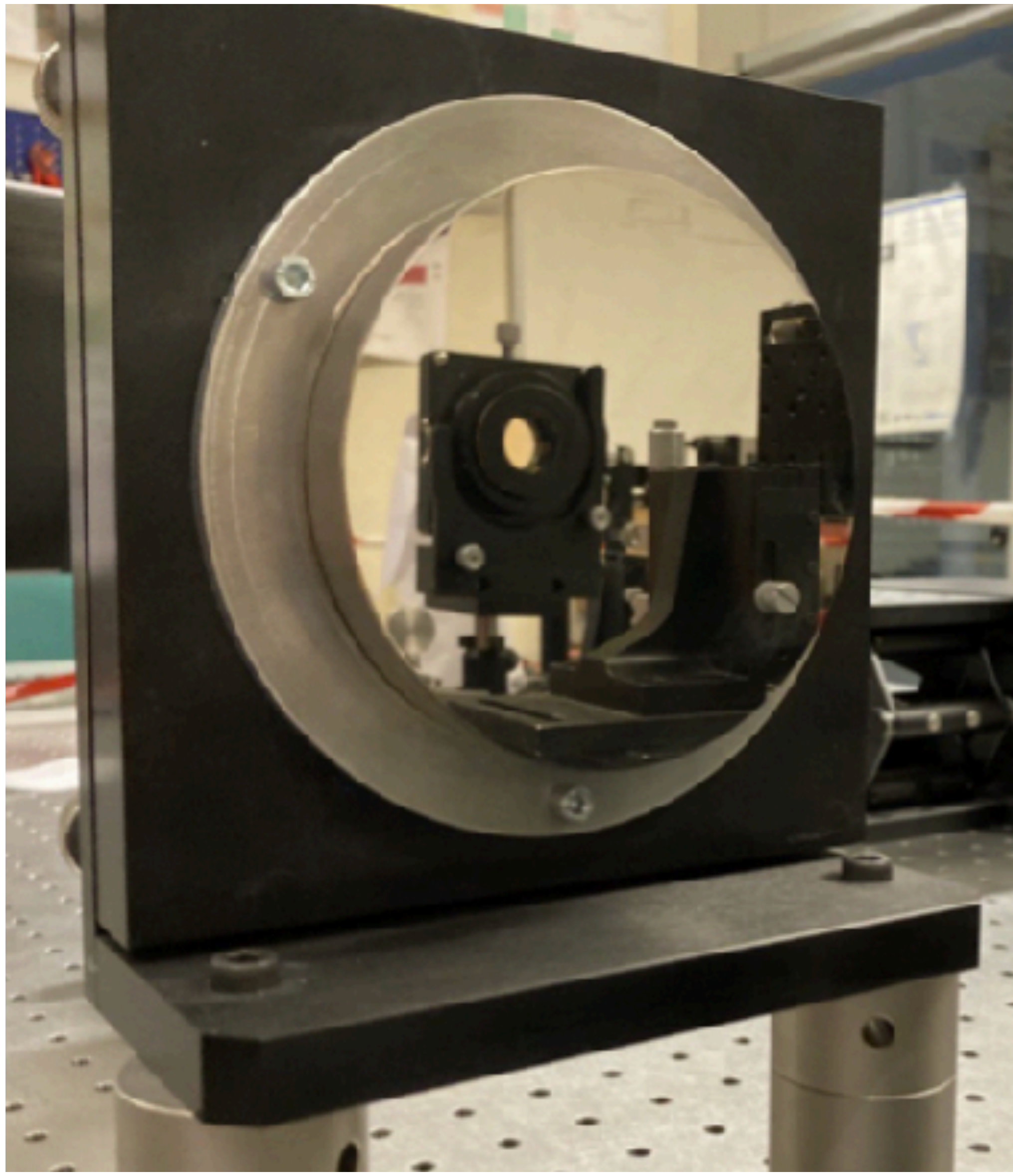
The thermal connection from CFC to CCD.



Section of the UV-VIS cryostat showing the thermal connection.


ACQUA
adixen
by PFEIFFER VACUUM
ATH

Common Path Alignment Tools

Portable Coordinate Measuring Machine

Characterized CMOS detector

10cm diameter (aluminum) mirror

What is SOXS?

- Single object spectrograph offering simultaneous spectral coverage in UV-VIS (350-850nm) and NIR (800-2000nm) with an average R ~ 4500 for an 1” slit.

- Can perform photometry in 360-970nm (ugVrizY) (3.5’ x 3.5’, 0.2”/pixel).

- Final destination: Nasmyth platform of the 3.58m ESO New Technology Telescope (NTT) at the La Silla Observatory in the Southern part of the Chilean Atacama Desert.

- Designed to observe all kinds of transients and variable sources.

- SOXS consists of 5 sub-systems - CommonPath (CP), Calibration unit (CU), Acquisition Camera (AC), UV-VIS spectrograph, and the NIR spectrograph.

Science with SOXS

- Classification
- Super Novae
- Gravitational Waves EM counter parts
- Tidal Disruptive Events & Nuclear transients
- Gamma Ray Bursts and Fast Radio Bursts
- Blazars & AGN

ExtraGalactic

- X-ray binaries & magnetars
- YSOs & Stars
- Novae, Cataclysmic Variables, & White Dwarfs

Galactic

- Astroids & Comets

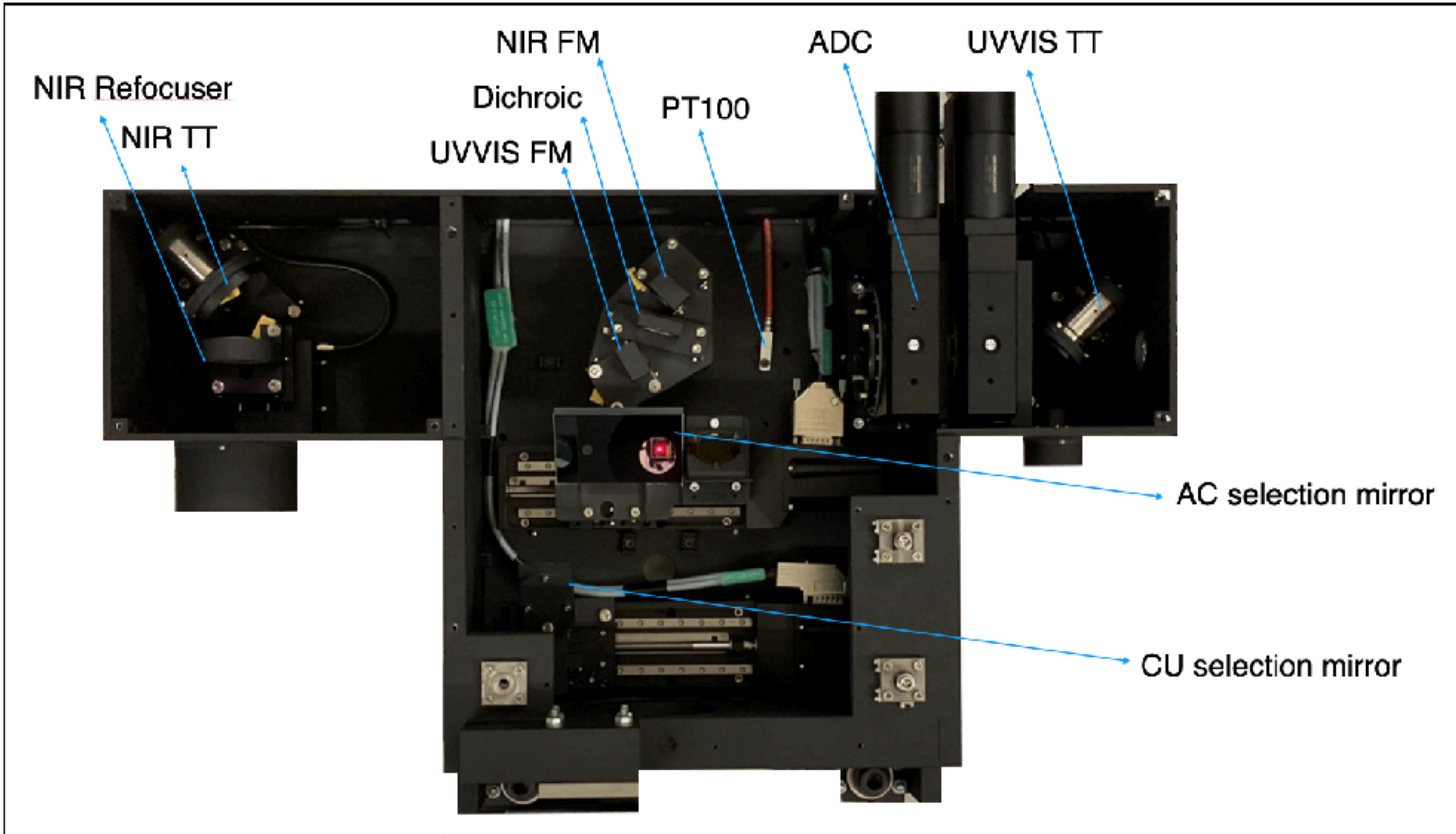
Solar System

- Unknown

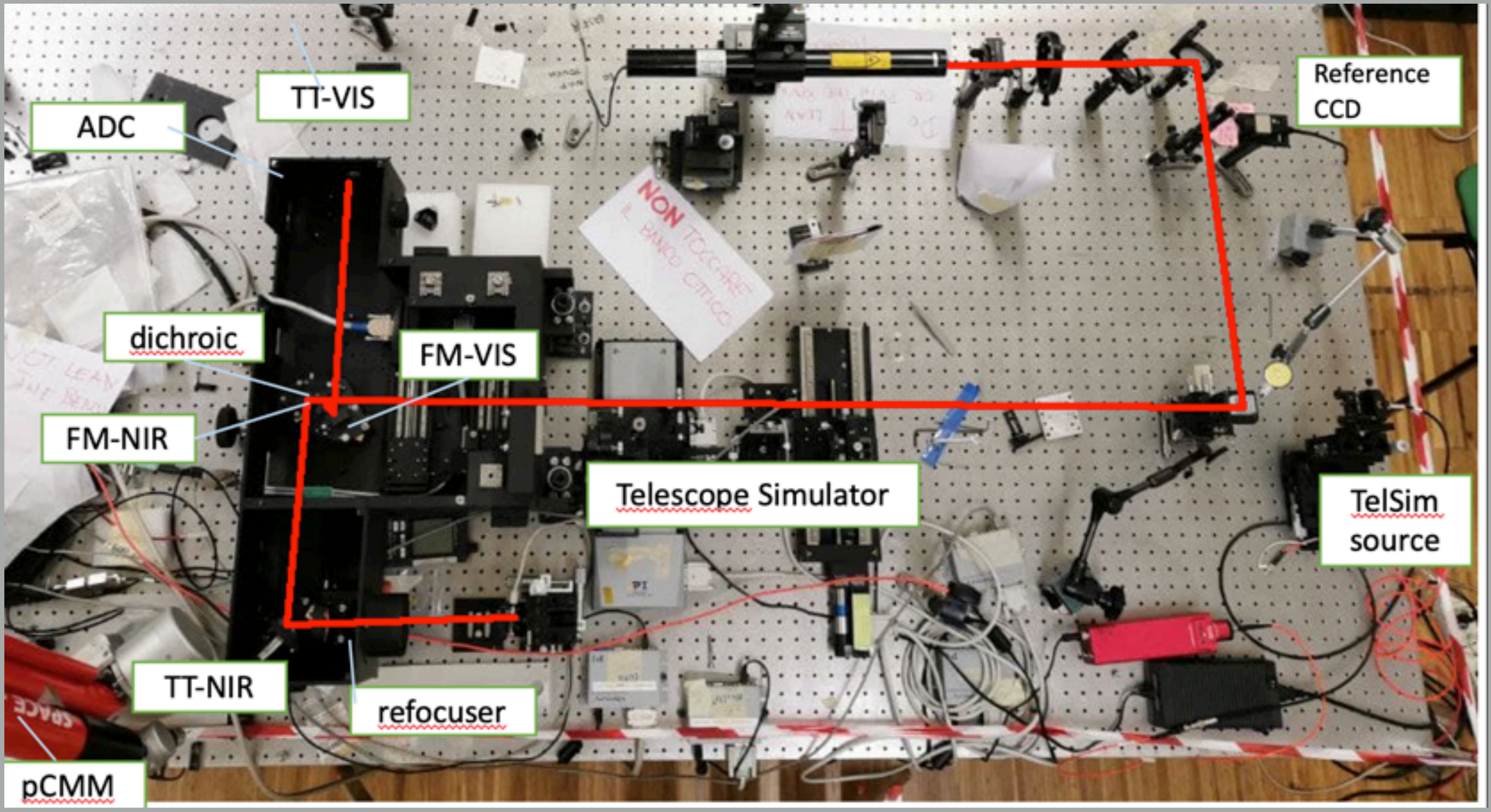
SOXS Consortium

- Istituto Nationale di AstroFisica (INAF) - Italy
- Weizmann Institute of Science - Israel
- Universidad Andres Bello & Instituto Milenio de Astrofisica, Chile
- Turku University, Finland
- Queen's University, UK
- Tel Aviv University, Israel
- Niels Bohr & Aarhus University, Denmark

Common Path

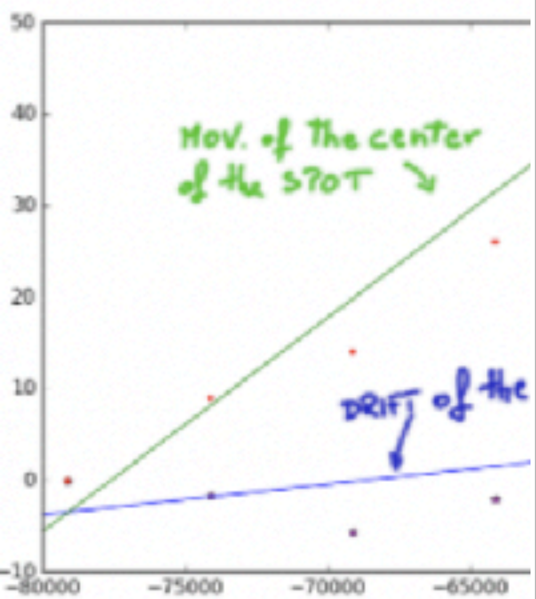


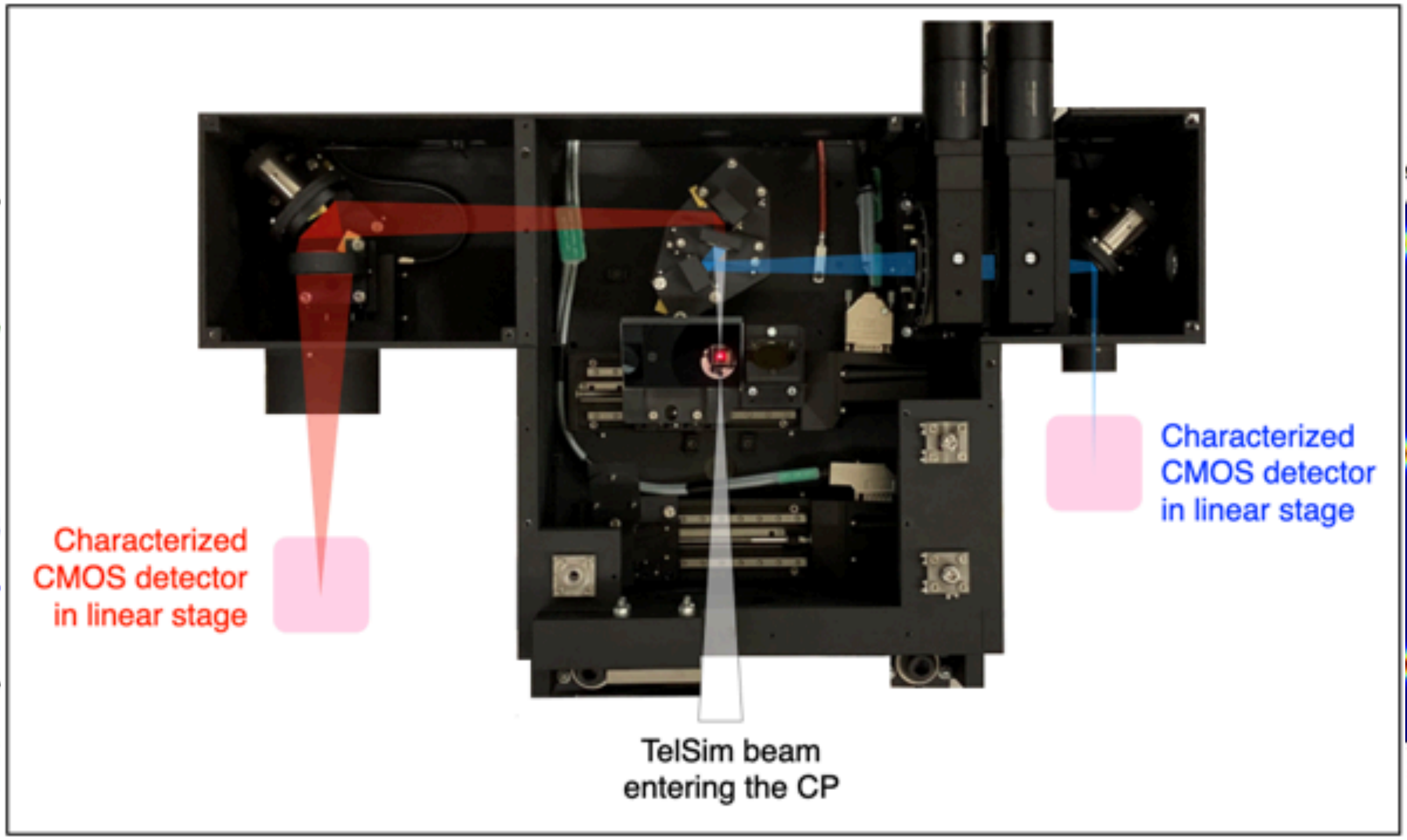
- Receives the F/11 beam from the telescope and feeds the spectrographs with an F/6.5 beam

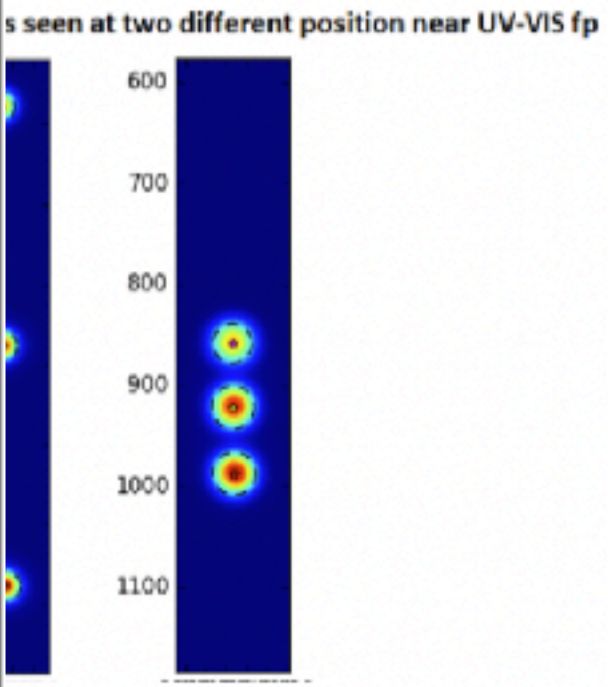

TT-VIS
ADC
Reference CCD
dichroic
FM-VIS
FM-NIR
Telescope Simulator
TelSim source
TT-NIR
refocuser
pCMM
NON TOCCARE IL BANCO OTTICO

Common Path Alignment Verification

- CP exit beam position, tip-tilt, and focal number

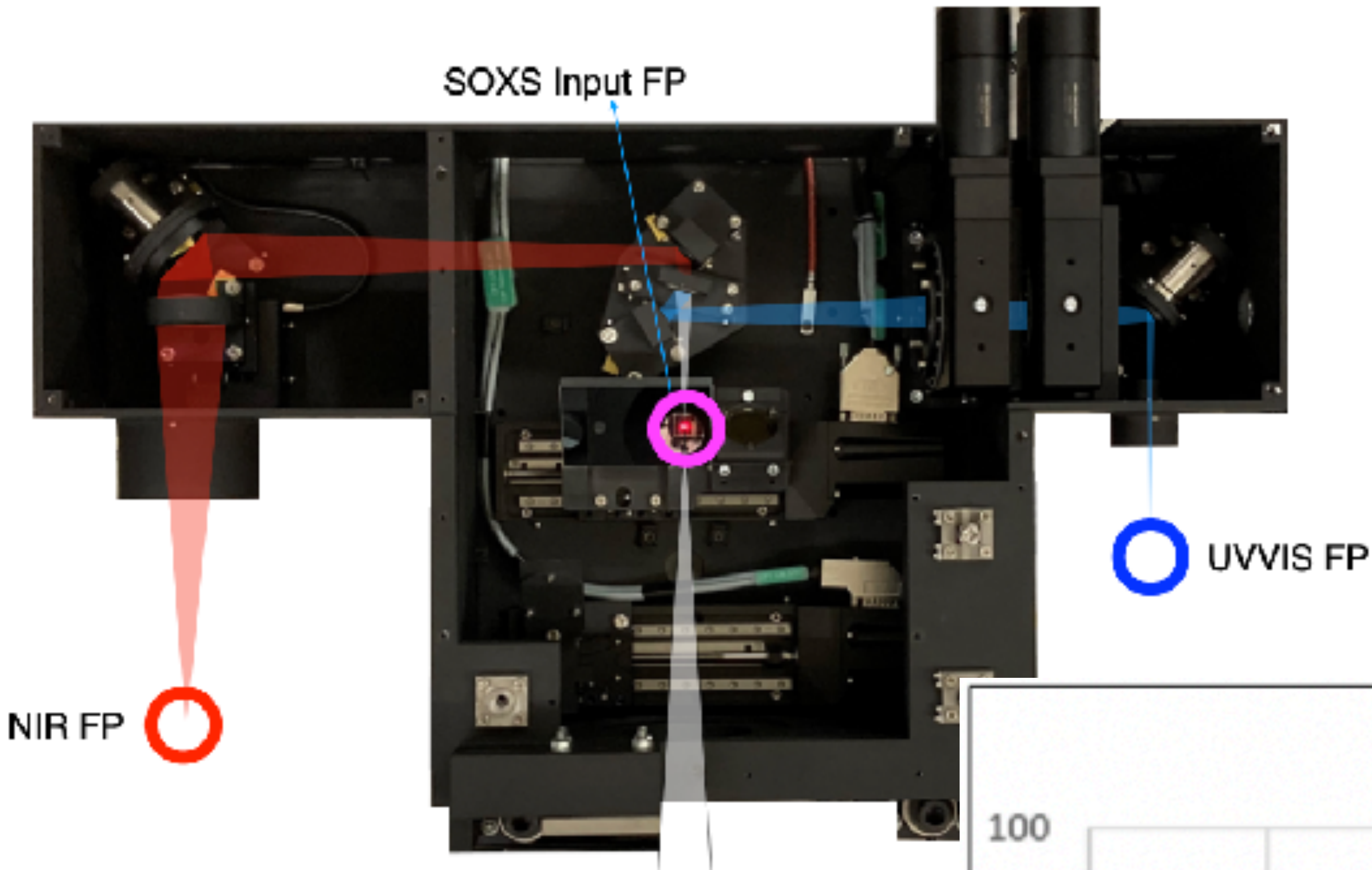


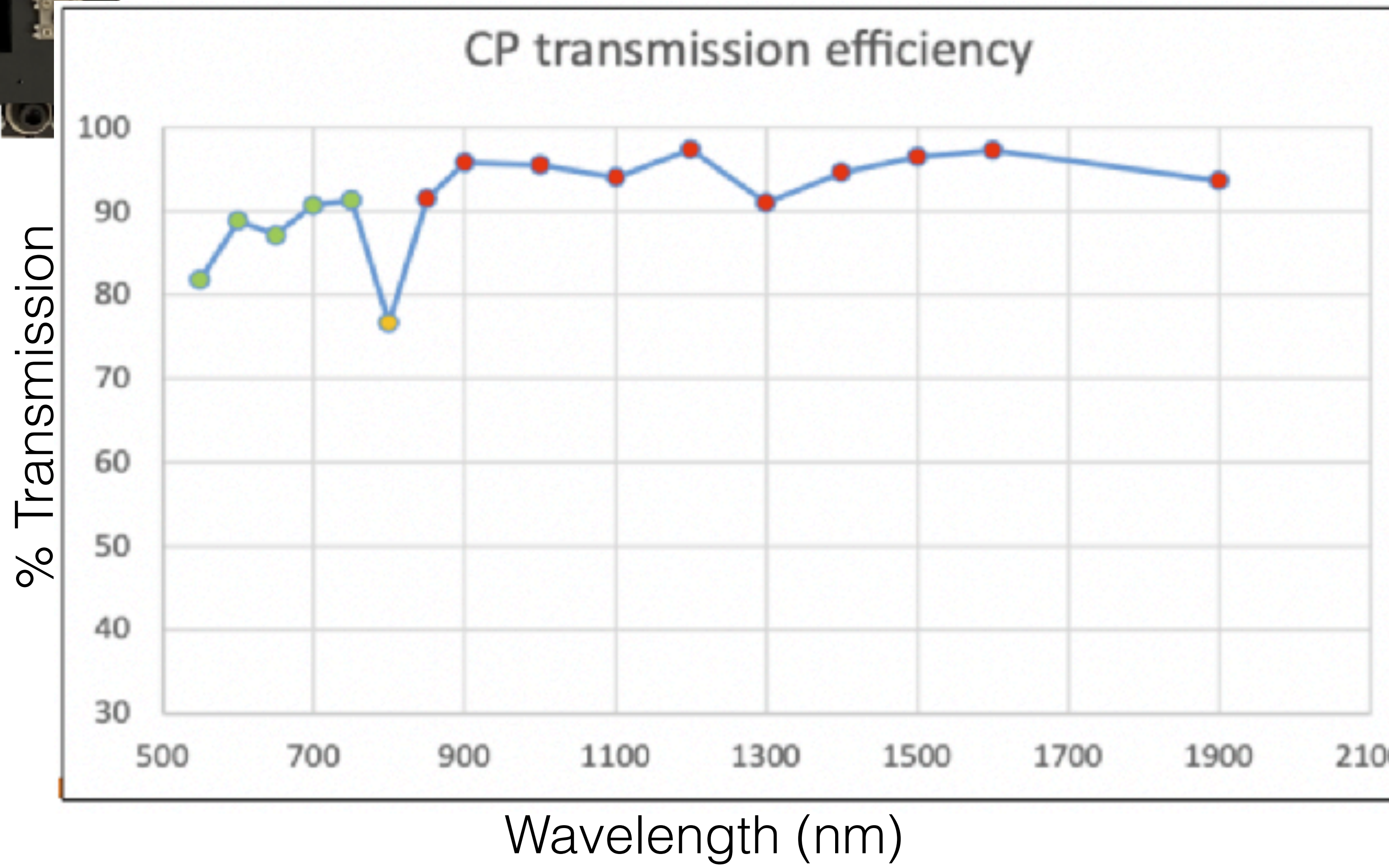




	Decenter–X (μm)	Decenter–Y (μm)	Decenter–Z (μm)	Tilt-X (”)	Tilt-Y (”)	$F/\#$
UVVIS exit beam	230 ± 60	-145 ± 60	<30 ± 60	-413 ± 100	37 ± 100	6.93
NIR exit beam	45 ± 60	3 ± 60	<30 ± 60	-250 ± 32	-255 ± 32	6.94

Common Path Alignment Verification





Integration and Testing

Integration and Testing

Integration and Testing

Continuum source spectra

ThAr Arc lamp spectra