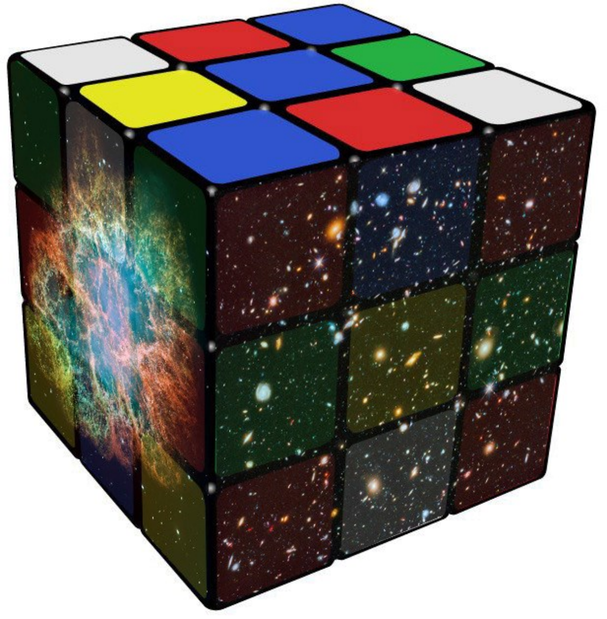


CUBES

Cassegrain U-Band Efficient Spectrograph

Phase-B KOM (Consortium)

Matteo Genoni (SE)

« … Instructions … »

- These slides are a summary (maybe not 100% exhaustive) of the work done in Phase A.
- They are intended as a usefull basis for the Ph-B starting discussion in (this) Consortium-KOM + Recurrent dedicated teleconfs
- <45 minutes for summary talk + specific subsystems/topics discussions
- The follwing color legend apply:

  Potential issue with ESO standard requirments
  To be studied (designed/analysed) in Phase-B

FUNCTIONAL SCHEME

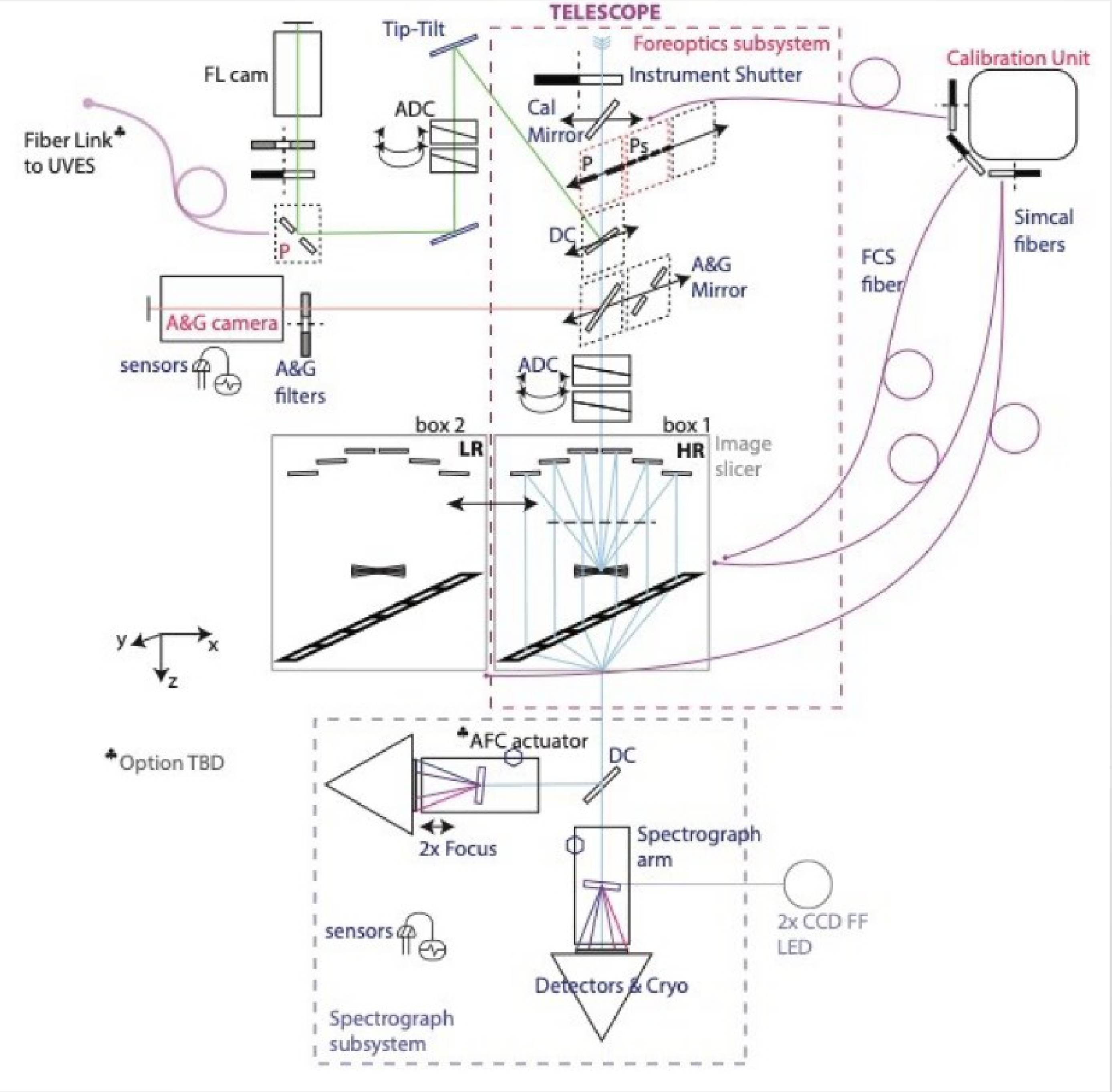
Main path:
- Fore-optics
- 2 slicer → 2 Res.Modes
- Spectrograph (2 arms)

Calibration functions:
- daytime calibration,
- simultaneous calibration,
- FCS light source

Fiber-Link to UVES

Moving Units:

- *Cal*
- *A&G*
- *Slicer mode*
- *AFC*



FUNCTIONAL SCHEME: Functions list

#	Device	Type	Status / Position	Remarks
1	Calibration mirror slide	LIN	IN / OUT	
2	Flat Field lamp (LDLS)	LAMP	ON / OFF / WARMUP	LDLS needs some warmup time
3	Wavelength calibration lamp	LAMP	ON / OFF / WARMUP	e.g. ThAr
4	Simultaneous calibration lamp	LAMP	ON / OFF / WARMUP	e.g. ThAr
5	Active Flexure Compensation system lamp (TBD)	LAMP	ON / OFF / WARMUP	Penray e.g. Hg(Ar), always on when instrument in OPERATIONAL state
6	Alignment lamp (Hg)	LAMP	ON / OFF / WARMUP	
7,10	Flat field lamps for UVES calibration	LAMP	ON / OFF	QTH lamp for flat fielding UVES CDx, optimized colour balancing filter.
11,16	Lamp bench shutters	SHUT	OPEN / CLOSED	One shutter for each lamp bench
	Diagnostic sensors	SEN	TBD	

22	Instrument shutter	SHUT	OPEN / CLOSED	Slow shutter for daytime calibrations and protection
23	Pinhole mask	LIN	Single hole / Multi hole	To check focus and alignment.
24	Fiber-link dichroic mirror	LIN	IN / OUT	To send light to UVES
25	ADC 1	ROT	Continuous angular positioning.	Two counter rotating prisms.
26	ADC 2	ROT	Continuous angular positioning.	
27	A&G mirror slide	LIN	IN / OUT / FIELD	Field position has 6 x 10" slot to allow viewing field while observing
28	Filter Wheel	ROT	TBD positions	Colour filters for acquisition and photometry.
29	Image Slicer slide	LIN	HR / LR	
	Diagnostic sensors	SEN	TBD	

17	Fiber-link ADC 1	ROT	Continuous angular positioning.	Two counter rotating prisms, always in the beam.
18	Fiber-link ADC 2	ROT	Continuous angular positioning.	
19	Fiber-link tip-tilt mirror	PZT		Two axis stage with continuous positions. To center 500 nm on fiber while tracking for 350 nm.
20	Fiber-link filter wheel 1	ROT	TBD positions	TBC - ND filters for standard stars.
21	Fiber-link filter wheel 2	ROT	TBD positions	Colour filters for acquisition.

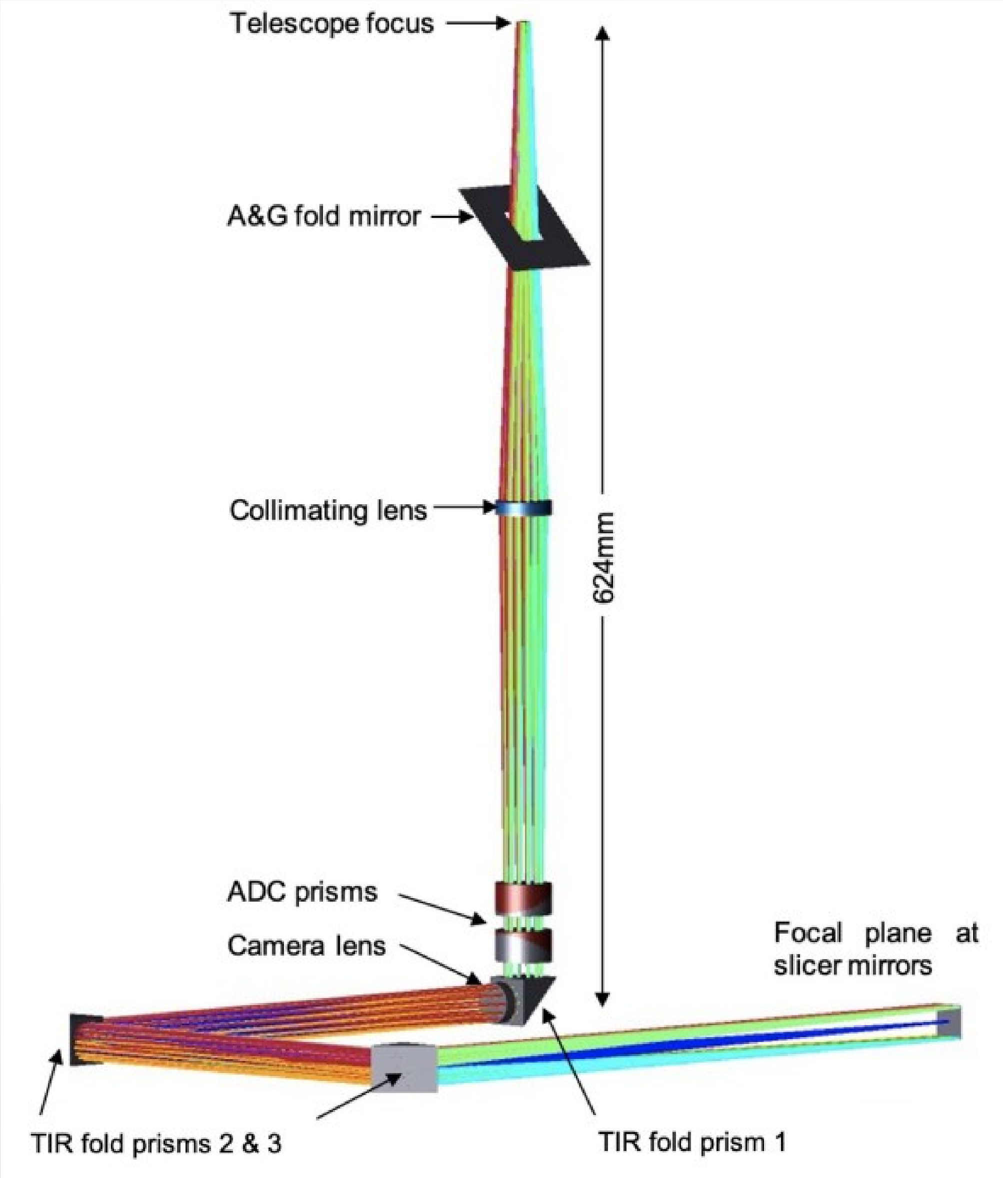
30	AFC actuator 1 (collimator lens)	TBD	XY	Flexure compensation in spectrographs (TBC)
31	AFC actuator 2 (collimator lens)	TBD	XY	Flexure compensation in spectrographs (TBC)
32	Camera focus actuator 1	LIN	Z	Motorized or using expansion element (TBD)
33	Camera focus actuator 2	LIN	Z	Motorized or using expansion element (TBD)
	Diagnostic sensors	SEN	TBD	

SubSystem WP5000 Optics: FORE-OPTICS

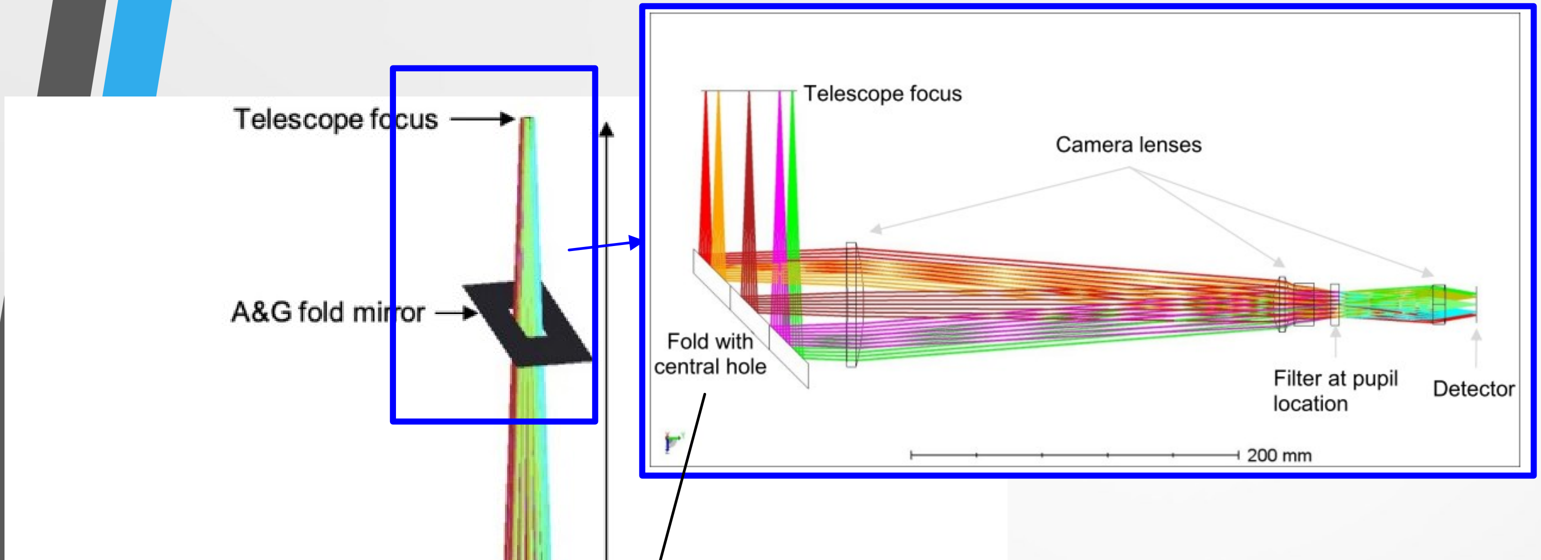
- Transfer and magnify a total (max) FOV of 6 x 10 arcsec from telescope focus to Image Slicer (scale of 0.5 arcsec/mm)
- Provide atmospheric dispersion correction over a wavelength range of 300-405 nm for zenith angles of 0-60 deg (ADC 2 fused
- silica/CaF2 cemented prism pairs)

- Nominal environment values of T=10C and P=750mbar
- All foldings of the science beam are obtained by total internal reflection prisms to maximize the throughput.

- IQ → rms diameter 0.02 arcsec



SubSystem WP5000 Optics: A&G



Central hole FOV of 6 x 10 arcsec
For initial acquisition the mirror is translated in-plane so also the central part of the field can be viewed.
A&G reimages a 100arcsec diameter FoV onto a detector focal plane at a scale of 130microns/arcsec.

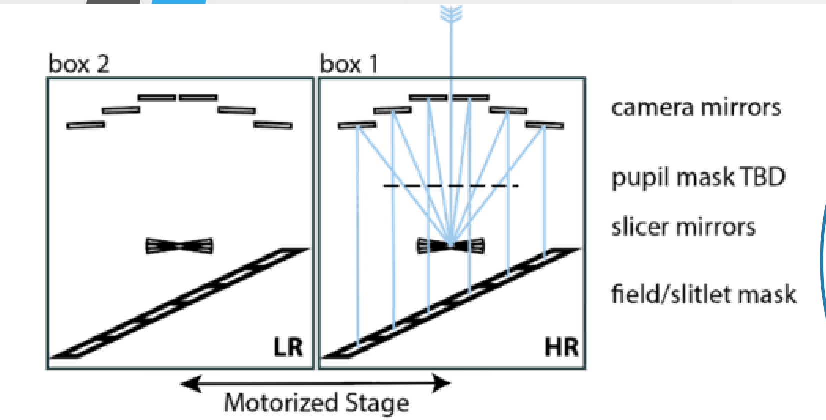
A filter wheel will have a number of filter positions: Free, U, LSST filter names TBD. (6 or more positions)

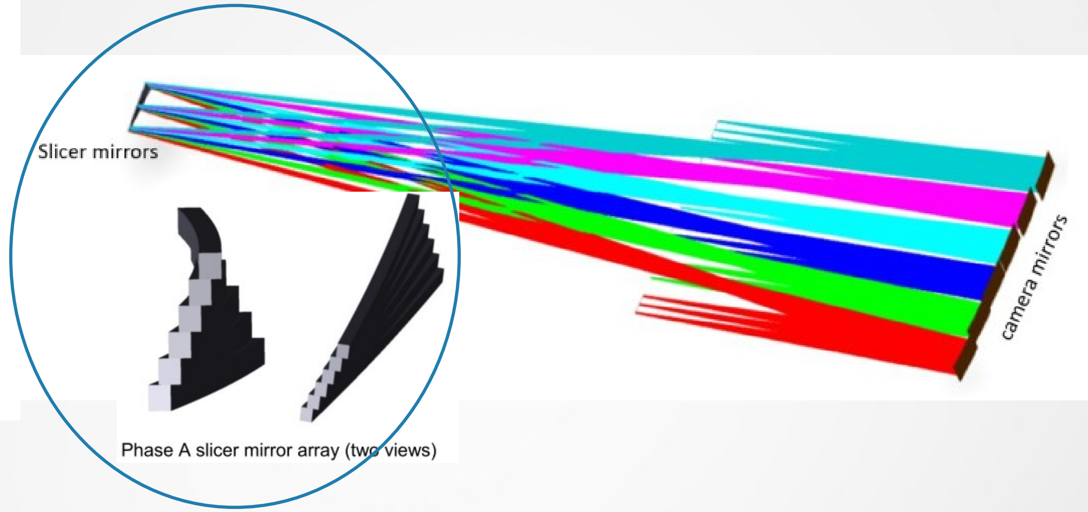
TCCD reqs: i) Ethernet IF – ii) capabilities of GigE protocol for control – iii) Cooling liquid @ 10bar
Axiom Optics ELSE-I camera (1k-x-1k, 13 um pixels, sampling of 0.1 arcsec/pixel, binning option YES)

- i) YES – ii) No (→ special device in the ICS) – iii) 8bar →Customization of the cooling system (?)
- Shutter inside the chassis → MTBF estimation, maintenance procedures

Camera focus compensation for thermal effects (passive or motorization)

SubSystem WP5000 Optics: SLICER(S)





2 housings on a motorized linear stage, which will allow the user to select the resolution mode

The components of each image slicer, within each housing include:

- Slicer mirror array and camera mirror array (all spherical) integrated on a Zerodur baseplate → avoid changes due to thermal effects.
- Slitlet mask at the image slicer output defining the spectrograph entrance slit

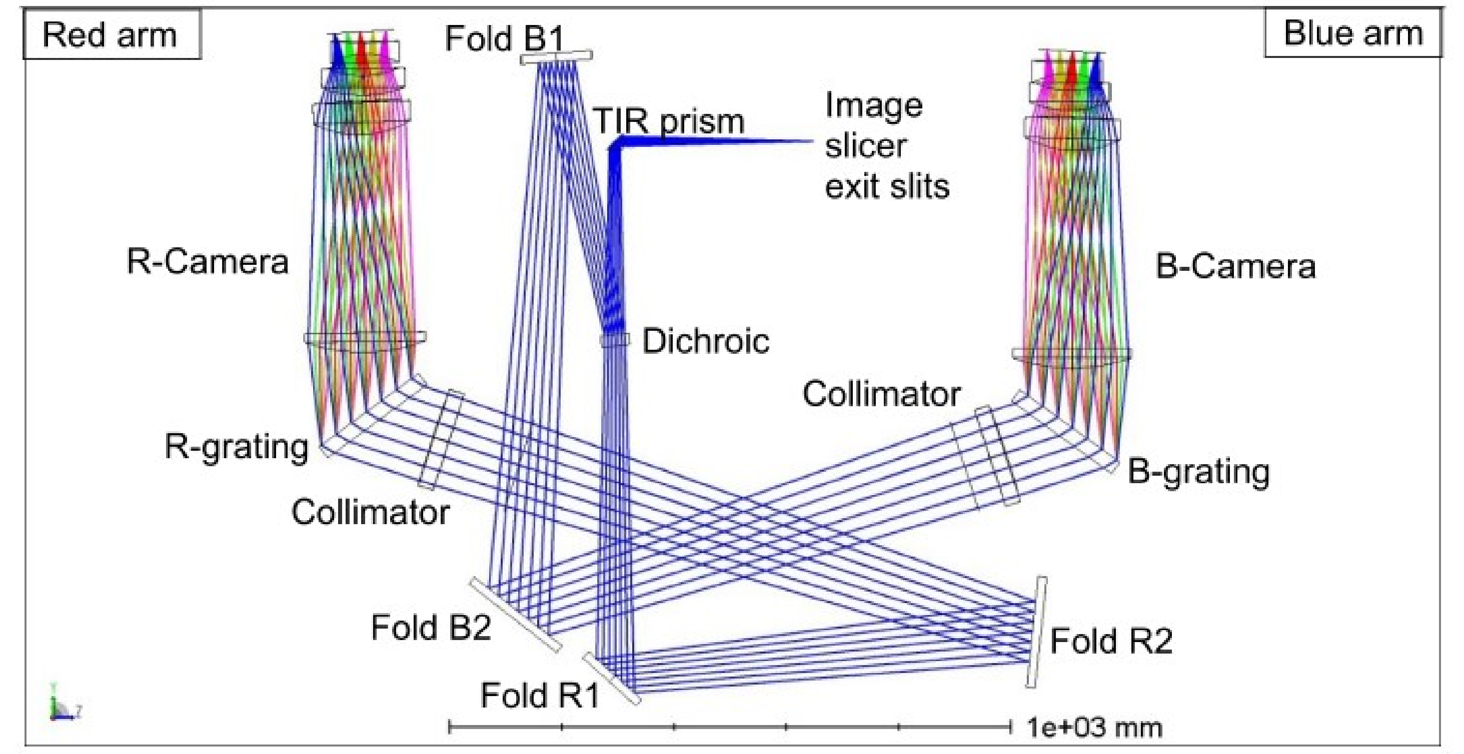
IQ close to diffraction limited (both resolution modes)

Radii of curv of all slicer and camera mirrors are different → straight output slit (XYZ)

Having 3 sets of same radii of curvature to reduce costs (keeping straightness and IQ ok) → PhB

Vignetting max/worst case <4% in the external slices for HR mode → PhB optimization (with Fore-otpics)

SubSystem WP5000 Optics: SPECTROGRAPH



Blue arm: 300-352 nm – Red arm: 346-405 nm

Entrance slit considered for the design: form slicer + 3 fibre (2xSim-Cal + AFC) total 110 mm slit length

Dichroich splitting arms AOI = 12 deg

Cameras composed by 4 lenses (4 surfaces are spherical – 4 surfaces modest conic constant)

Last camera lens is used as cryostat window for each detector

To correct for thermal changes in focus → the first 3 lenses (in each camera) are moved as a single unit.

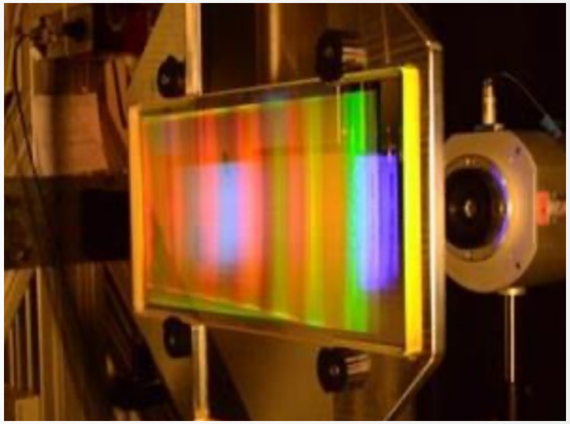
To implement a flexure compensation system → the collimator lenses will be moved on XY mechanisms.

First-order transmission gratings to maximize efficiency.
(in our budget reflection and manufacturing error accounted for 5% level)

The entrance surface is A/R coated. The exit is the grating surface.
Size 180x220 mm both.

Blue graitng prototyping in Ph-B→ sample size 30x30 mm - 2 options:
an all-Silica grating
one with wider grooves and an Al2O3 ALD coating to "fill in" the profile.

The tech-spec and iteration with IOF already «on the-way»,
prototyping desing and test report for end PhB



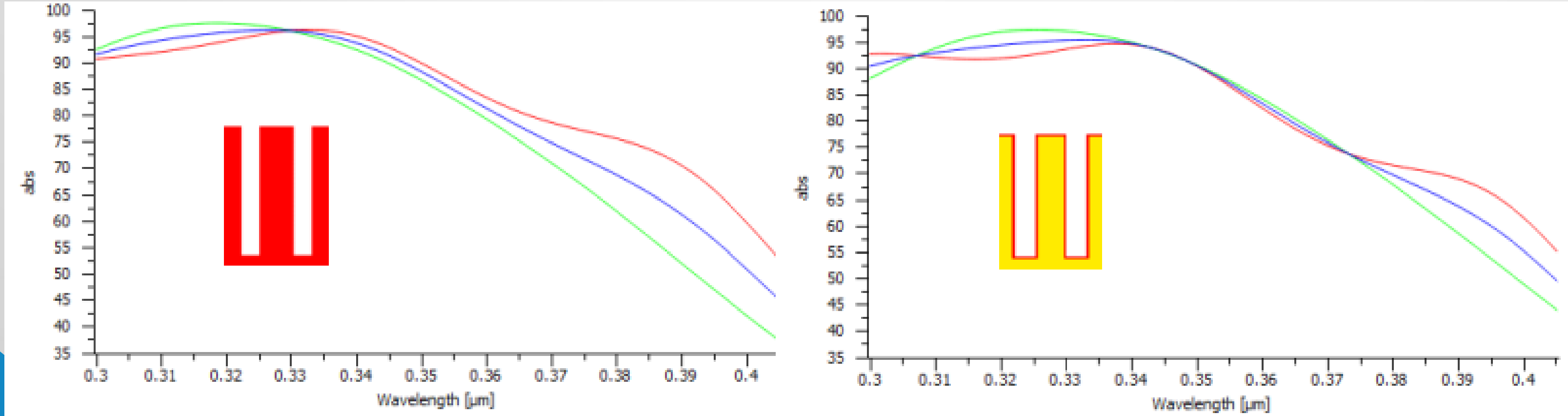


Figure 26. Theoretical diffraction efficiency of grating #1 with the two manufacturing options: solid FuSi and 15 nm ALD Al2O3 coating

SubSystem WP6ooo MECHANICS – Telescope Adapter

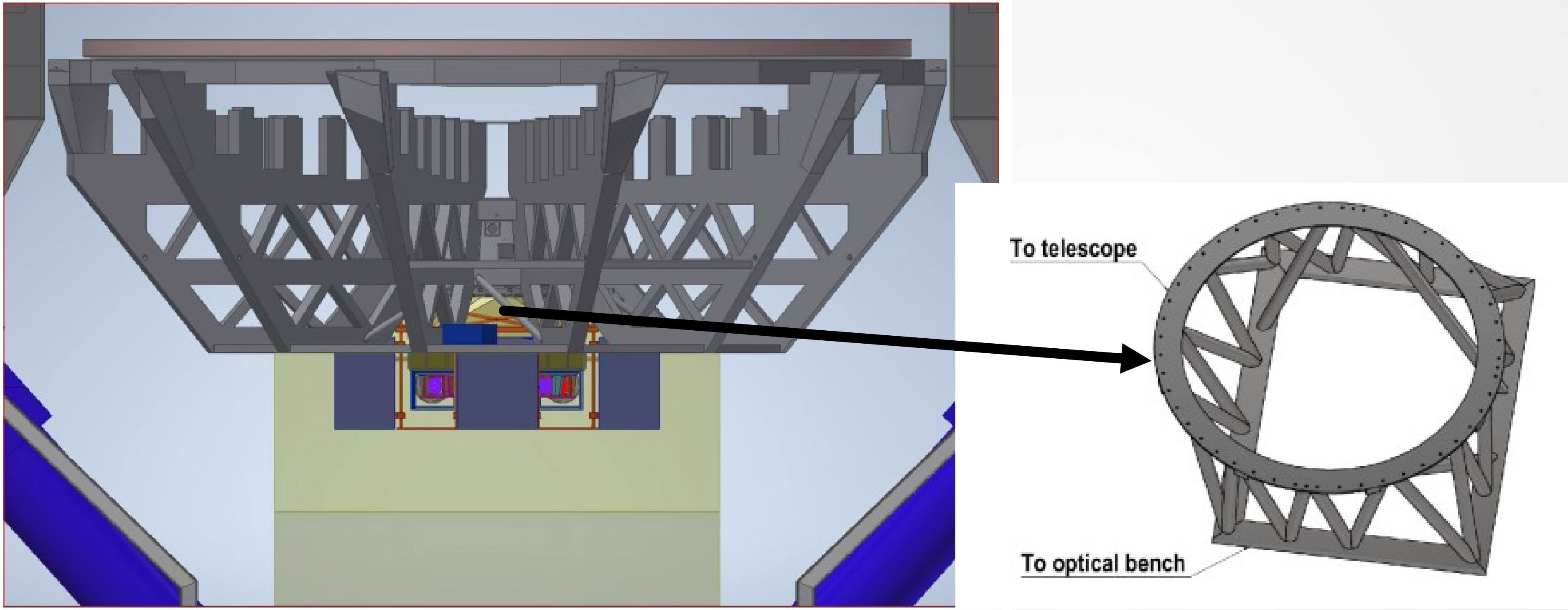


Figure 29. CUBES as mounted on the Cassegrain port of a UT telescope. The yellow envelope indicates the available space envelope for instruments.

The telescope adapter is a truss-like flange connecting the UT Cassegrain flange to the main optical bench.
→ it transforms the shape of the circular Cassegrain adapter to a rectangle to match the shape

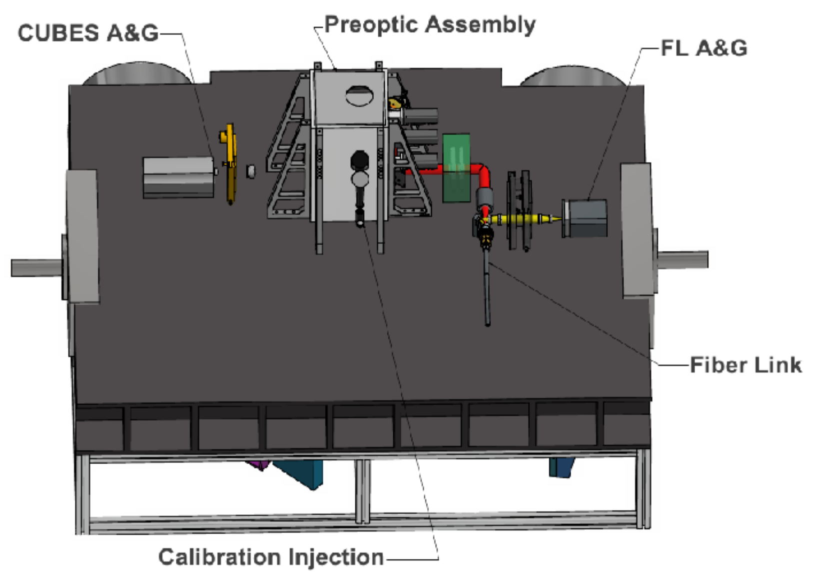
The telescope adapter overall weight ~180 kg.

The top part of the truss also provides an interface for the support frame assembly.

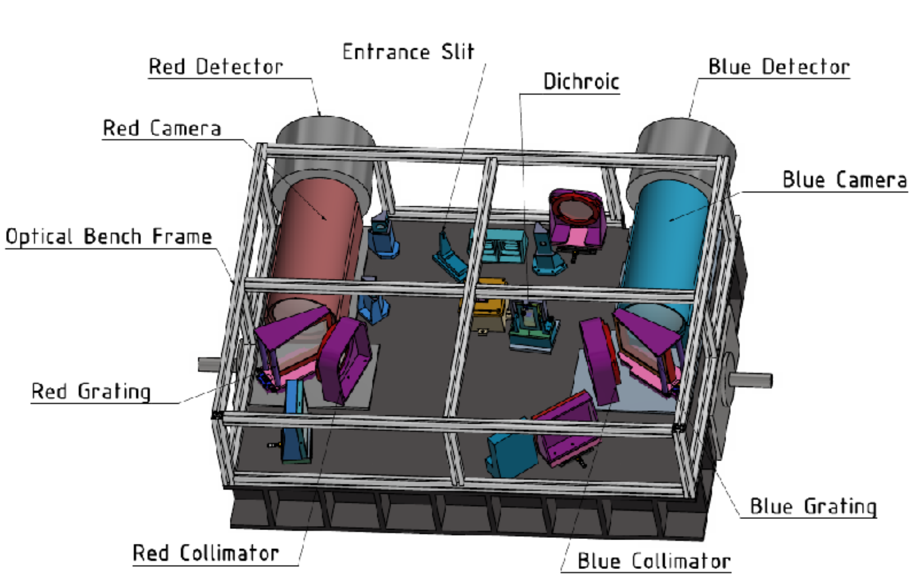
Preliminary FEM analysis → the maximum displacement of the bench to ~20 μm (~0.04 arcsec on VLT FP)

The exact/detailed design of the truss (the number of truss elements, the diameter of the steel tubes) will be optimized in the Phase B.

SubSystem WP6ooo MECHANICS – Optical bench



Top side: Fore-Optics + A&G + Calibration + FL



Bottom side: spectrograph opto-mechanical elements

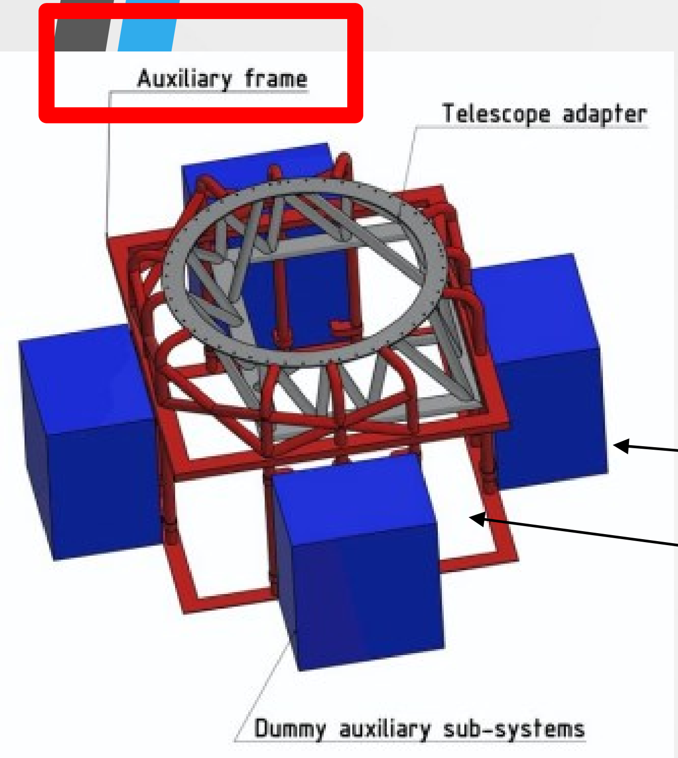
Spectrograph side is in «hanging» configuration:
→ the center of gravity closer to the Cass-flange → it minimizes the torque perpendicular to the VLT optical axis

The optical bench is:
- a rectangular shaped CFRP structure
- 250 mm thick
- sandwich-structured →two 20 mm thick plates connected internally by a regular grid of 20 mm thick ribs
- Coordination with vendors to optimize the bench layout form PhB

Light-tight cover consisting of aluminum system profiles and sheet metal (TBC).
The cover shall also provide some amount of thermal insulation to dampen environmental temperature (PhB)

FEM analysis:
- Average OB displacement <15 um → displacement of object on IS < 0.08 arcsec → corrected by A&G
- Diff displacement btw slit & detectors ~10 um → optimization of detector structure support + AFC(PhB)

SubSystem WP6ooo MECHANICS – Support Frame Assembly



The current support frame design:

- attaches to the instrument flange at the top only
- allows for lateral relocation of auxiliary subsystems to adjust the mass distribution with no need to include dummy (dead) weights

Rear access to cabinets

Corner access to the optical bench

4 dummy boxes:
Estimated size of 900×800×600 mm^3
Estimated mass of 150 kg
(values are the expected upper limits)
Refinement in PhB

First FEM analysis:
→ Max 1.7mm flexures at the bottom of racks.
This flexure response that does not interrupt the functionality of the support frame.
Refinement in PhB. (Fatigue analysis)

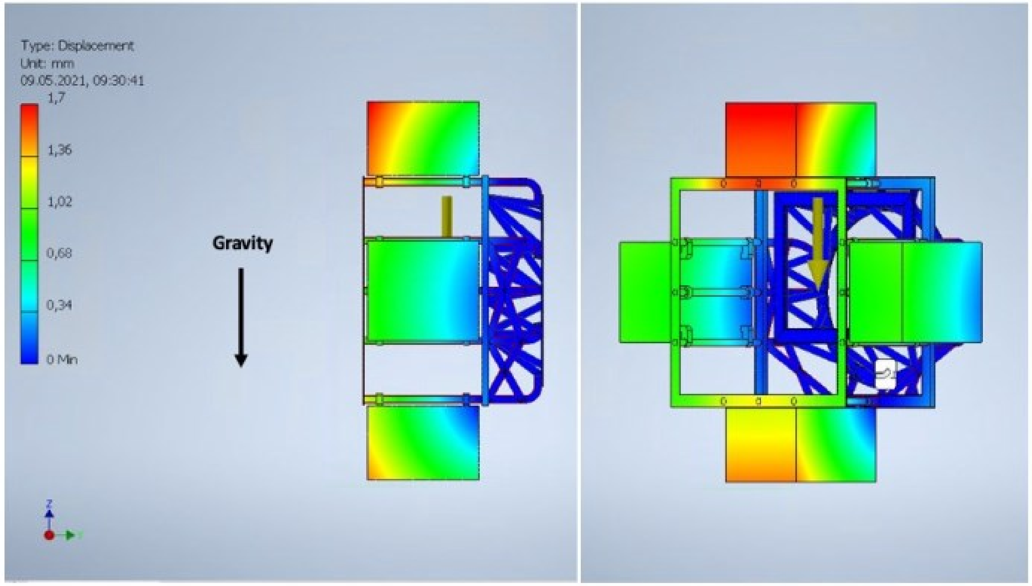
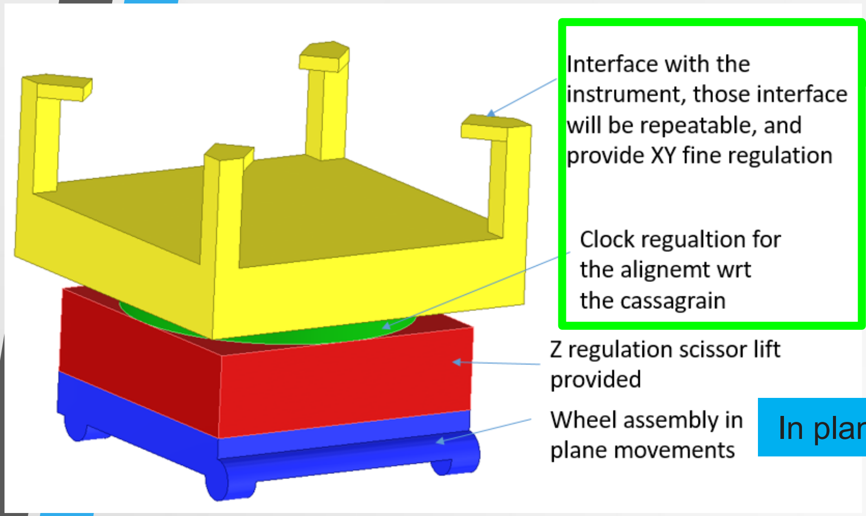


Figure 10. FEM analysis of the support frame of CUBES while at 90° off-zenith. The maximum displacement at the bottom of the racks and is about 1.7 mm.

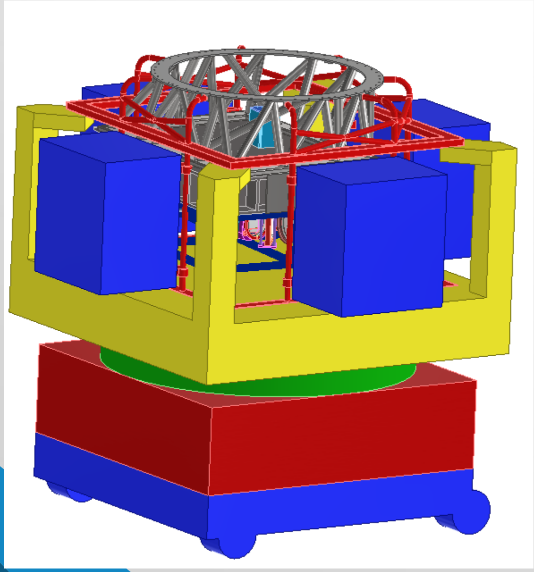
SubSystem WP6000 MECHANICS – Carriage tool



Fine alignment

Carriage conceptual design:

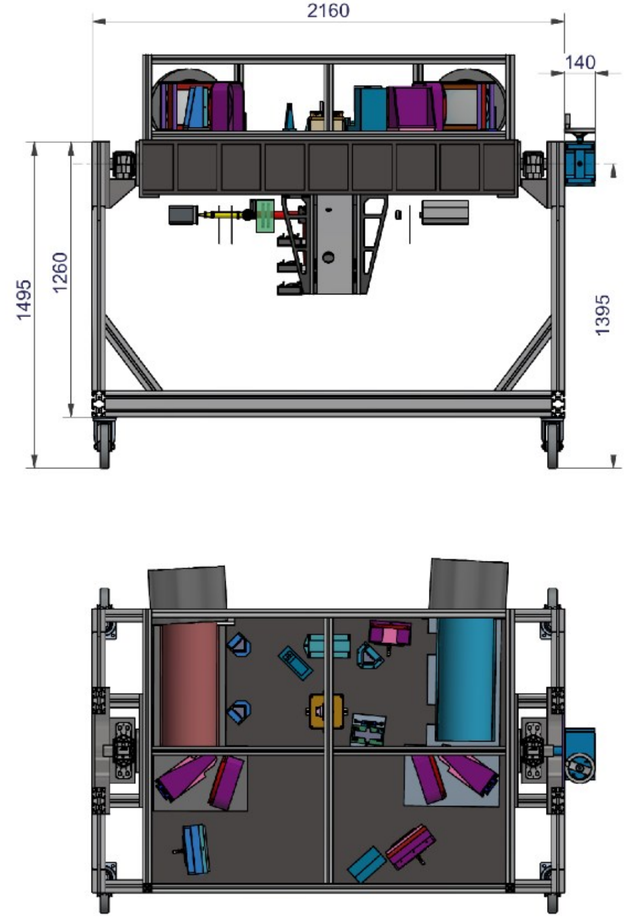
In plane, coarse and large motion (inside Tel-Dome and under M1 cell)



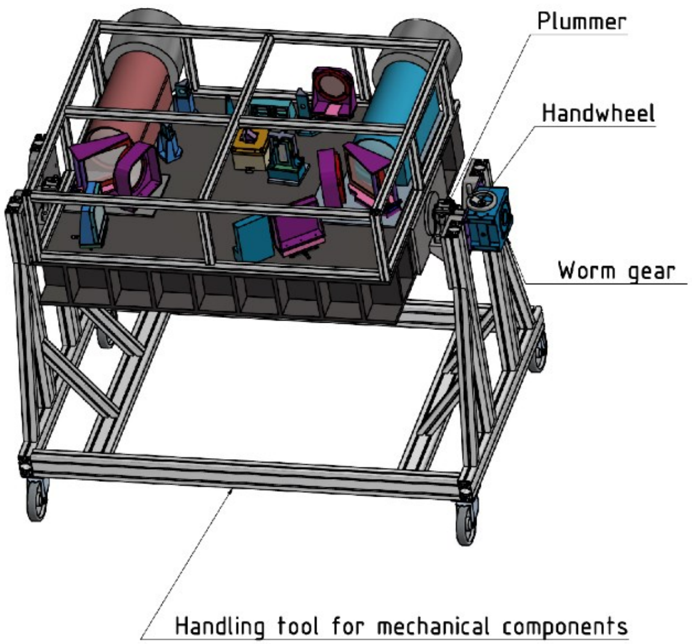
Conceptal design… Refinement(s) of PhB:

- Definition of load capacity and the mass of the system
- Validation through an FEM analysis.
- Safety → subject to the approval of the German National Technical agency (TÜV).

SubSystem WP6ooo MECHANICS – Handling tool



Auxiliary Handling tool (AHT) conceptual design:



When unrestricted access to the opto-mechanics is needed (for instance during initial assembly, integration or maintenance operations) the optical bench assembly is placed on the AHT.

AHT is a mount, which enable to support and to flip the bench assembly.

PhB evaluation → the AHT functionality can be integrated in the carriage & storage tool ???

SubSystem WP8000 CALIBRATION – Sources

1. Wavelength source for daytime calibrations
2. Flatfield source for daytime calibrations
3. Source for optical alignment of pre-slit and arms
4. Source for flexure compensation (AFC) verification
5. Wavelength source for Sim-Cal
6. Wavelength source for UVES link
7. Flatfield source for UVES link

Photodiode sensors and/or current sensors to track the lamps intensity and stability over time.

SubSystem WP8ooo CALIBRATION – Sources

1. Wavelength source for daytime calibrations
2. Flatfield source for daytime calibrations
3. Source for optical alignment of pre-slit and arms
4. Source for flexure compensation (AFC) verification
5. Wavelength source for Sim-Cal
6. Wavelength source for UVES link
7. Flatfield source for UVES link

Photodiode sensors and/or current sensors to track the lamps intensity and stability over time.

1 Hg lamp for alignment
1 ThAr for daytime wavelenght cal (+ AFC)
1 ThAr (dimmed) for sim-cal wavelenght cal

LDLS for daytime flatfiled
QTH filterd for UVES FL flatfield
Possible WL-filter to flatten the LDLS curve (science feedback)

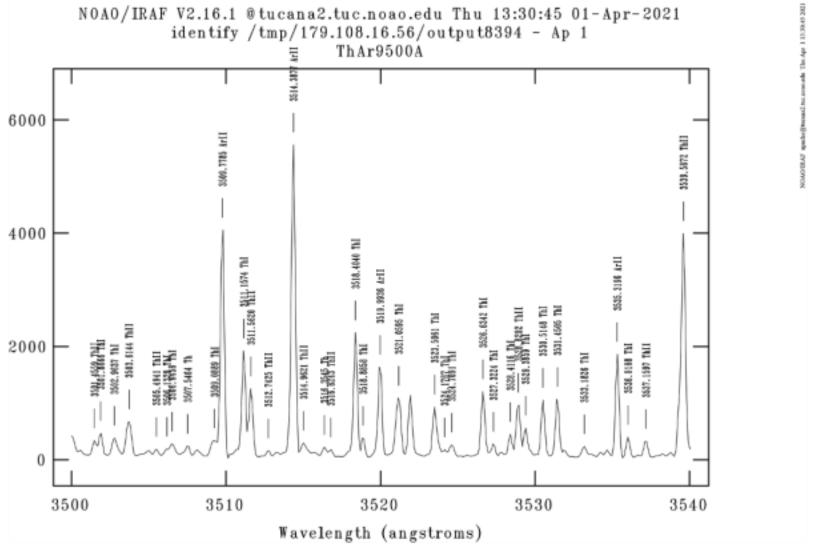


Figure 40. *Example of the Photron ThAr lamp spectrum on the CUBES region, with R=18k, yielding an RMS = 0.06.*

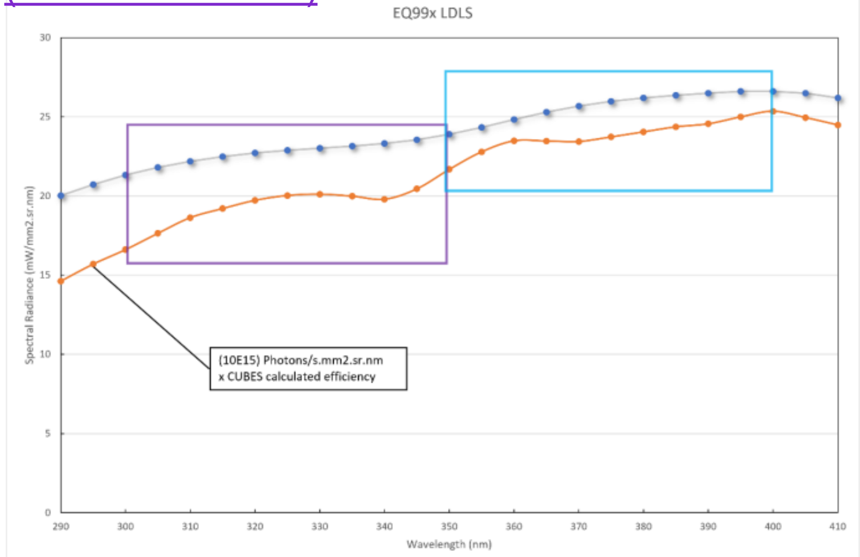
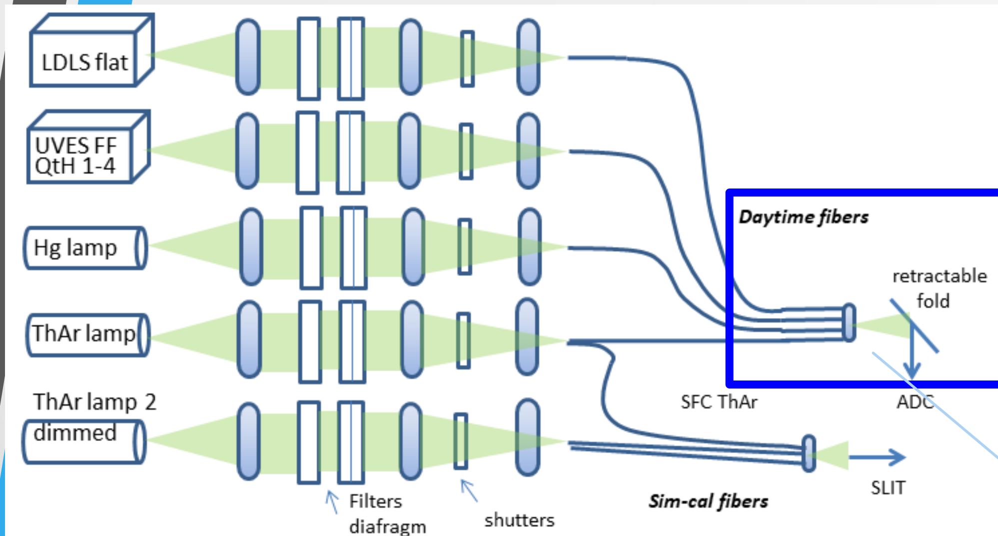
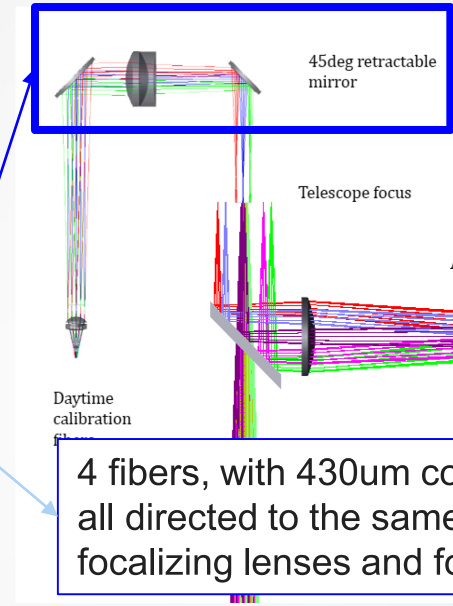


Figure 43. Spectral radiance for EQ99x LDLS on the CUBES region and showing the range for both arms (linear scale)

SubSystem WP8000 CALIBRATION – Architecture and I/F (optical)

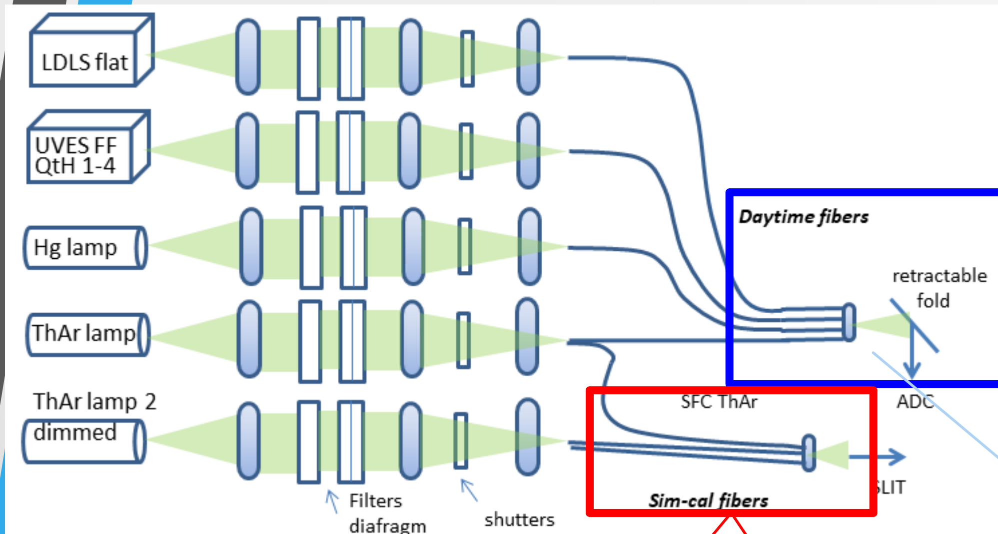


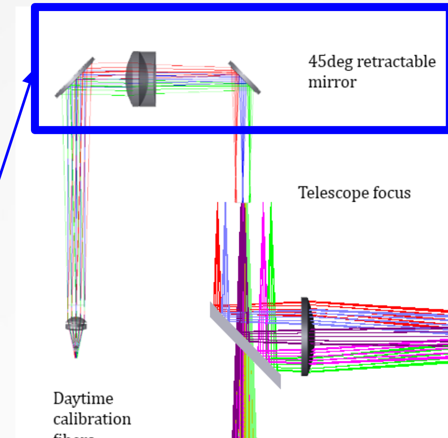


45deg retractable Calib mirror is before the FL dichroic

4 fibers, with 430um core, all directed to the same focalizing lenses and fold mirror

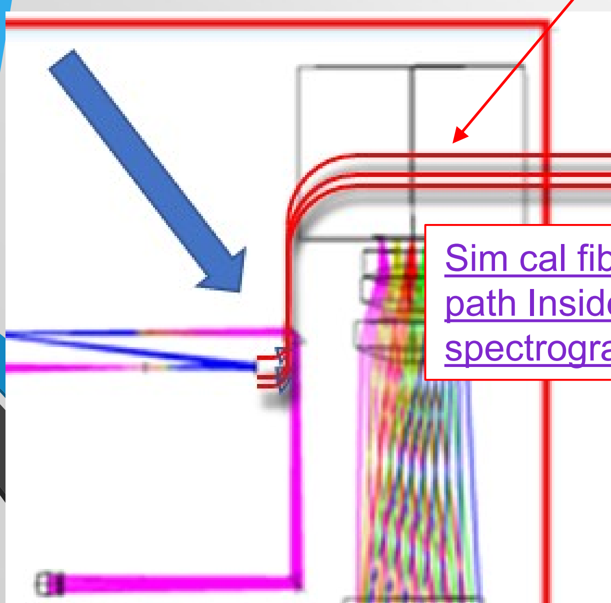
SubSystem WP8000 CALIBRATION – Architecture and I/F (optical)



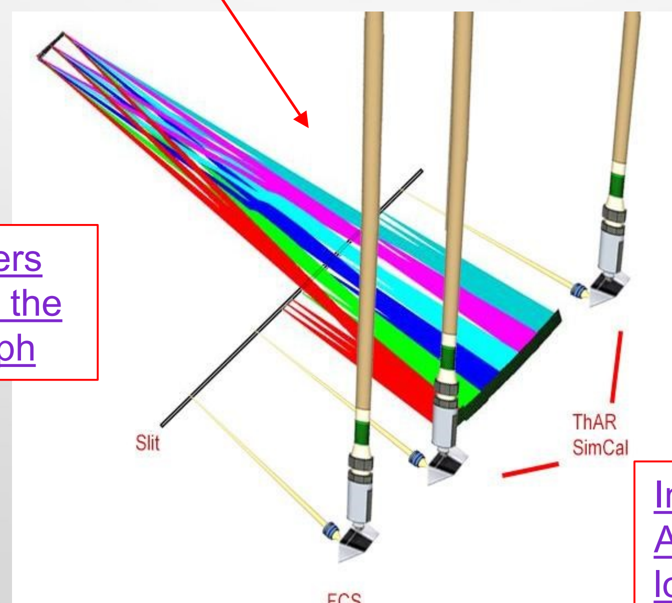


45deg retractable Calib mirror is before the FL dichroic

4 fibers, with 430um core, all directed to the same focalizing lenses and fold mirror

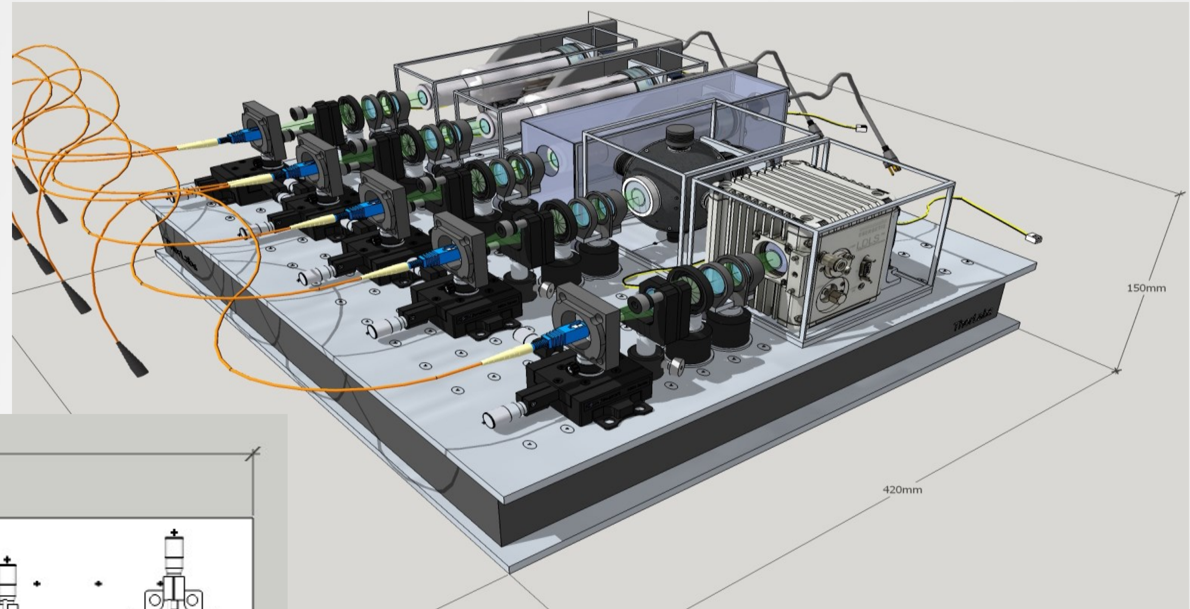


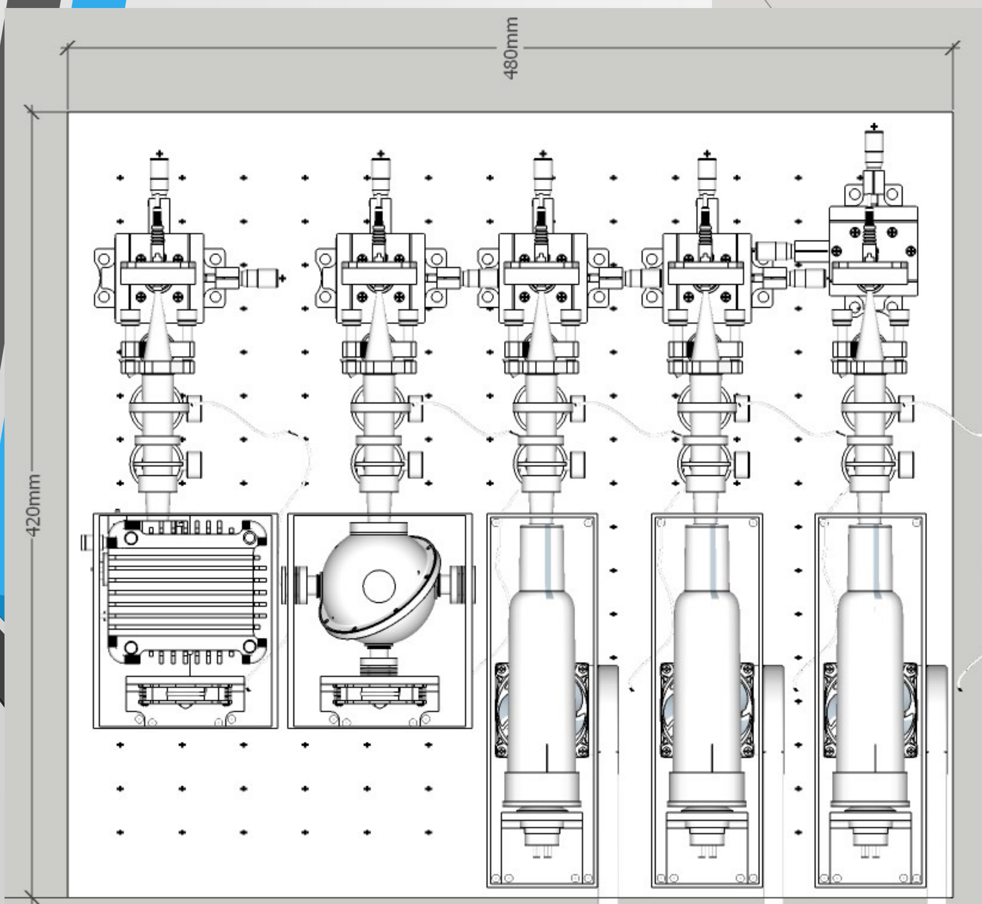
Sim cal fibers path Inside the spectrograph



Injection of Sim-cal fibers At the Slicer camera mirror location

CAL lamp-bench + Cover conceptual design:





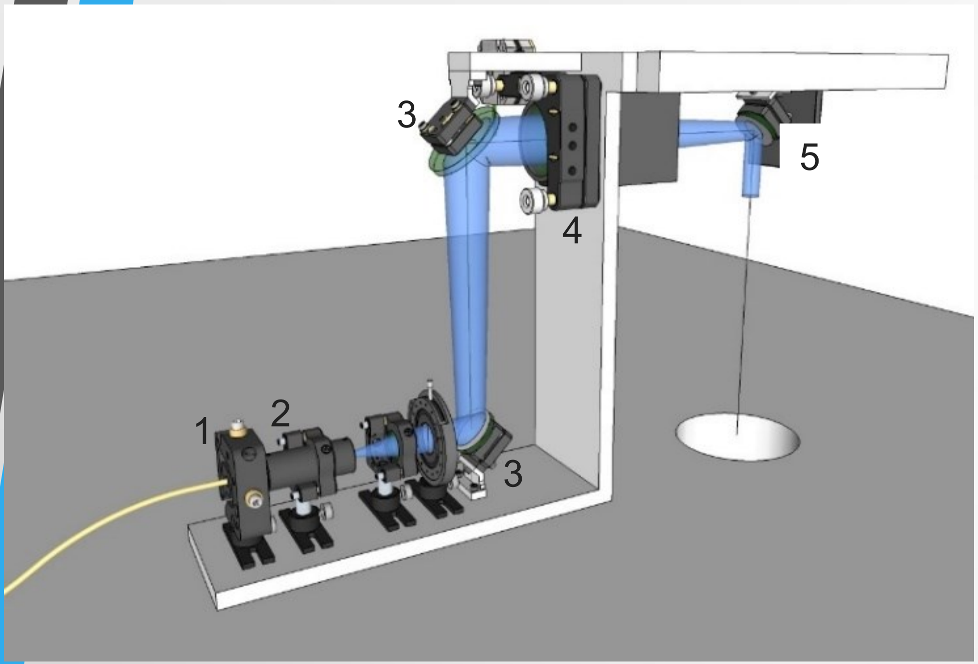
COTS + Customs components
The calibration unit bench is planned to have:

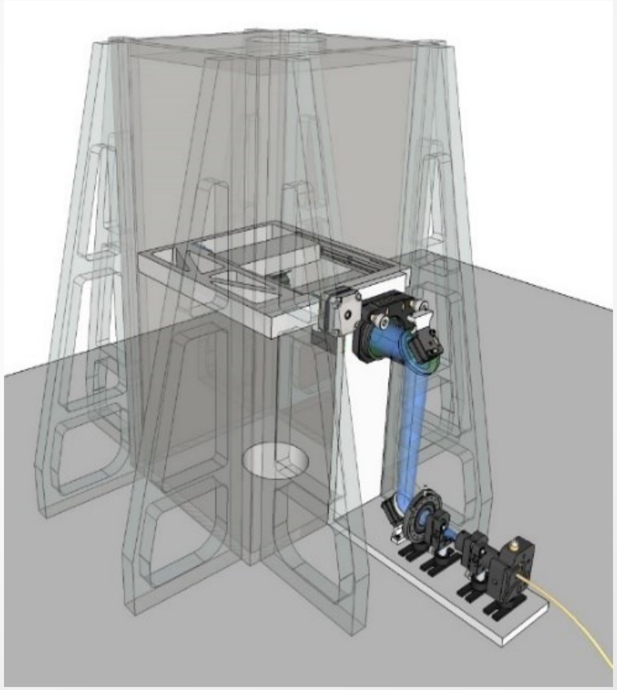
- Size: 480 x 420 x 200 mm
- Mass: 45kg
- custom Divinicel light/dust tight cover
- independent covers and fans for refrigeration of different lamps

SubSystem WP8000 CALIBRATION – Mechanics

CAL injection fiber bundle:

support structure holds the fiber bundle and optics 50mm above the telescope focus position

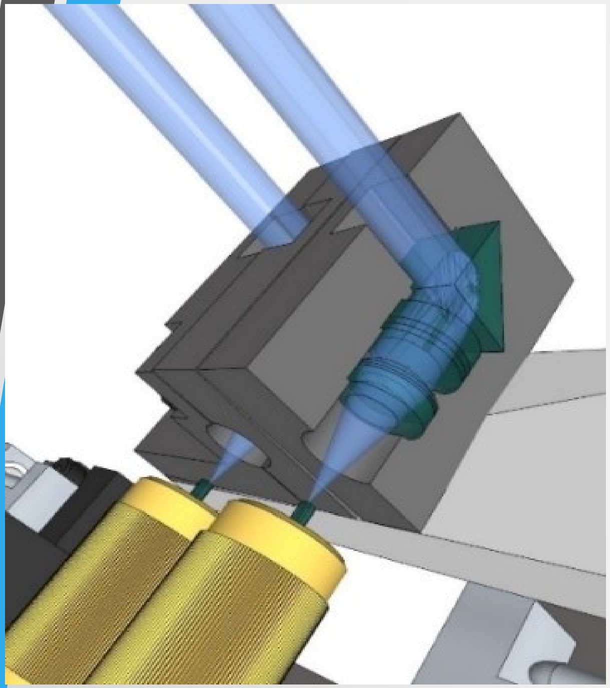


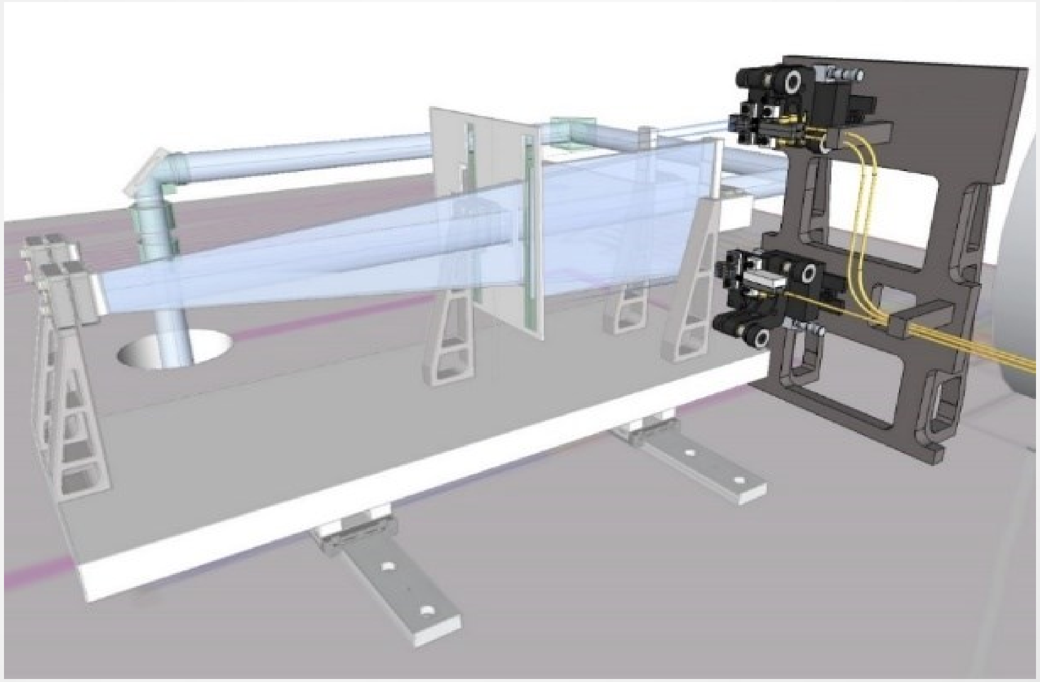


1 - box containing the fibers support with a 4 axes adjustment
2 - a hexagonal fused silica homogenizer rod
3 - two fold mirrors
4 - doublet kinetic support
5 - the 45deg retractable motorized fold mirror

The present concept was based mostly on off the shelf components but depending on the final sizes and distances of the optics a custom designed and fabrication will be performed. → PhB iteration

Sim-CAL injection fiber bundle: Conceptual design



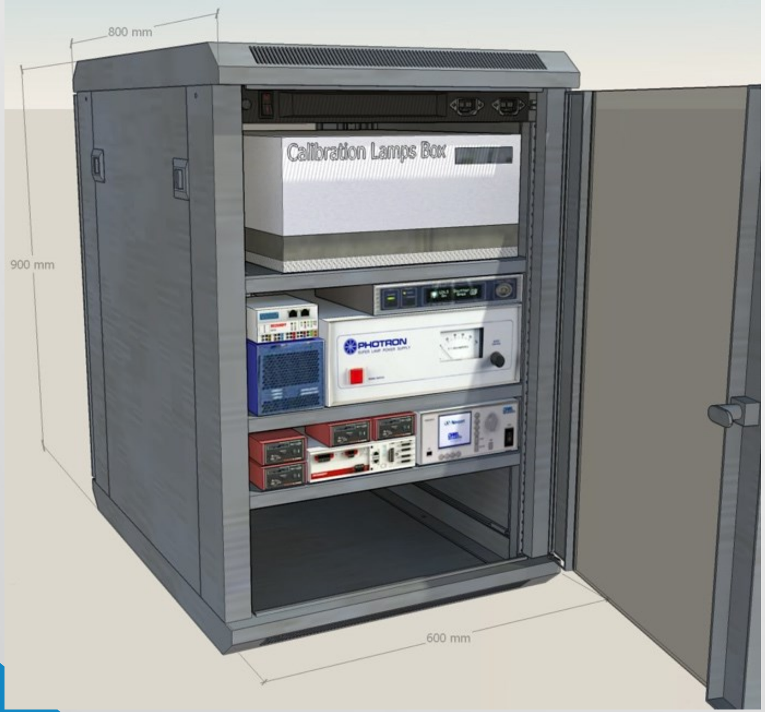


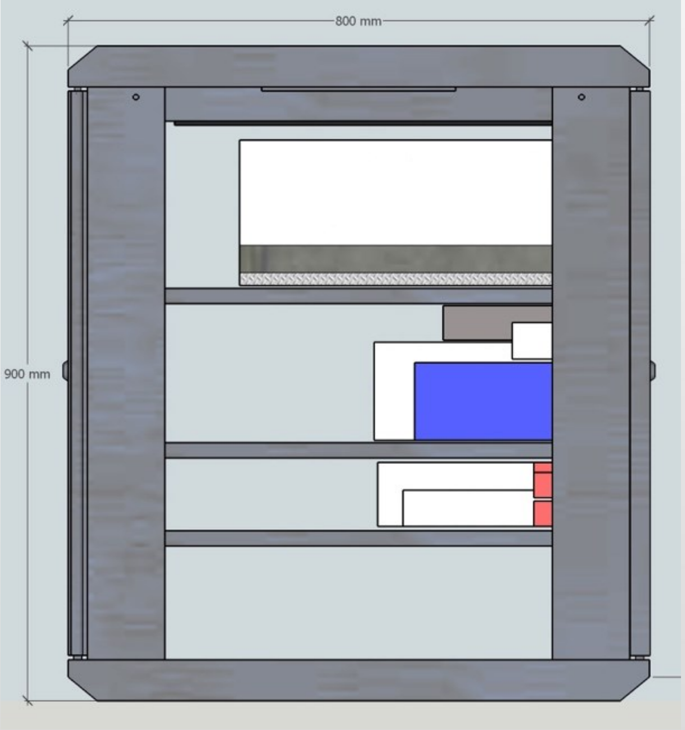
The support structure must be designed together with the slit mechanical design. → PhB progress

SubSystem WP8000 CALIBRATION – Electronics

The control of the Calibration Unit and its respective functions → CUBES ICS

- On/off for all lamps (8x) independently.
- Open/closed (exposure controlled) shutter for all lamps (5x) independently.
- Open/closed (exposure controlled) shutter for SFC ThAr (1x).
- In/Out daytime calibration retractable mirror.
- On/off photodiode or current sensors (TBD).
- On/off (coordinated with lamp on-off) on-time counter for the lamps lifetime estimate (TBD).

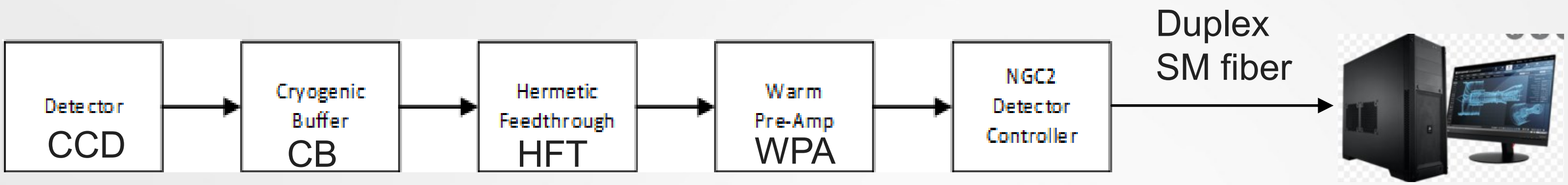




Total estimated volume: 660 x 360 x 270mm – Total estimated mass: 25kg – Total estimated power: <400W

SubSystem WP7000 DETECTOR – CCD & Electronics

Detector Signal Architecture Path (per arm)



Metric	CCD290-99 
# of pixels	9216 (H) × 9232 (V)
Pixel size	10 µm square
Image area	92.2 mm x 92.4 mm
Outputs	16
Clocking Regns	2
Readout noise (rms)	4 e- at 500 kHz 2.5 e- at 50 kHz → <3 e- at 100 kHz (TBC)
Dark signal	3 e-/pix/hr @ 273K → 0.5 e-/pix/hr @ 165K
Max data rate	3 MHz
pixel full well	90,000 e-
Flatness	~20 µm (peak to valley)
Package size	98.5 x 93.7 mm

The CCD290-99 will be operated at 100 kHz using 8 channel outputs. (From RIX RCO-7)
Use of 2 NGC "FEB" board per device → ~33 seconds to read the science region.
All 4 FEB boards contained in 1-NGC-6slot housing.

QE → AR «UV1-New» from E2V (ROM quote of 2020)
As of May-2021 Confirmed by E2V
Additional test scheduled for 2022-2023

SubSystem WP7000 DETECTOR – Cryo-Vacuum

The proposed baseline cryostat design is a LN2 bath in line with ESO heritage.

Individual baths fitted to each detector cryostat.
→ perpendicular layout similar to X-Shooter

CCD (@100kHz) + ColdMask + Rad-Shield + G10 + cabling → Total heat load 2.9W
→ LN2 bath minimum 3 litres

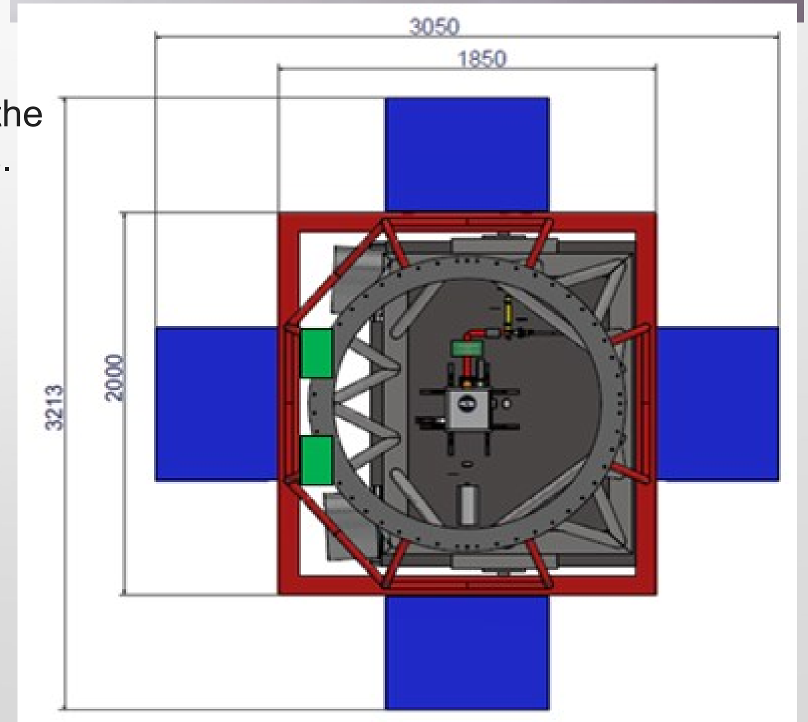
Vibration of the pump specs according to: VLT-SPE-ESO-20200-5926

Each cryostat has its own dedicated pump mounted on the instrument support frame adjacent to the detector heads. Proposed pumps → Agilent TPS-Mini units.

Vacuum System based on the 1-10 litre standard ESO

Identified components:

- PVP + TMP
- EGV + PVV
- PSW + VAG
- GEX
- SOV
- SOP
- N2V
- LN2 level



SubSystem WP7000 DETECTOR – Control Electronics

Where possible it will use components from the CUBES system level architecture → WP9000

System Components

Siemens S7 1500 PLC Control System, Including Touch Panel

Power Supply for Warmup Heaters (shared), ~50Watts

2x Lakeshore 336 Controllers, Both Rack Mounted → connected to PLC with Ethernet;

American Magnetics LN Level Controller

Mains Conditioning (Where not included by higher level Cubes System).

Temperature Control

- 2 x Cold Finger Heater, <25Watts (TBD), used for warmup and coarse temperature control. → PT100 + implementation of PID control in the (IHE) PLC (form ESO maintained code)
- 2 x Lakeshore 336 for fine control of Detector operating temperature. → Cool-down & Warm-up rates programmable

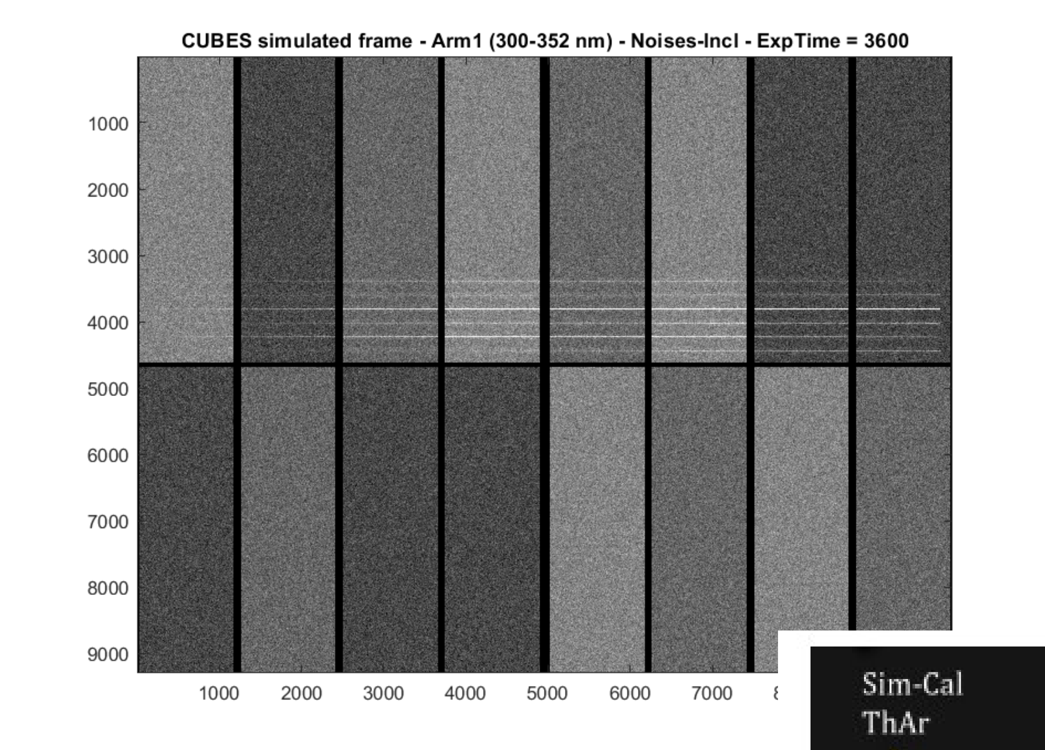
Historically ESO have asked that one Lakeshore 336, controls one detector, this is why two Lakeshore 336 controllers are included.

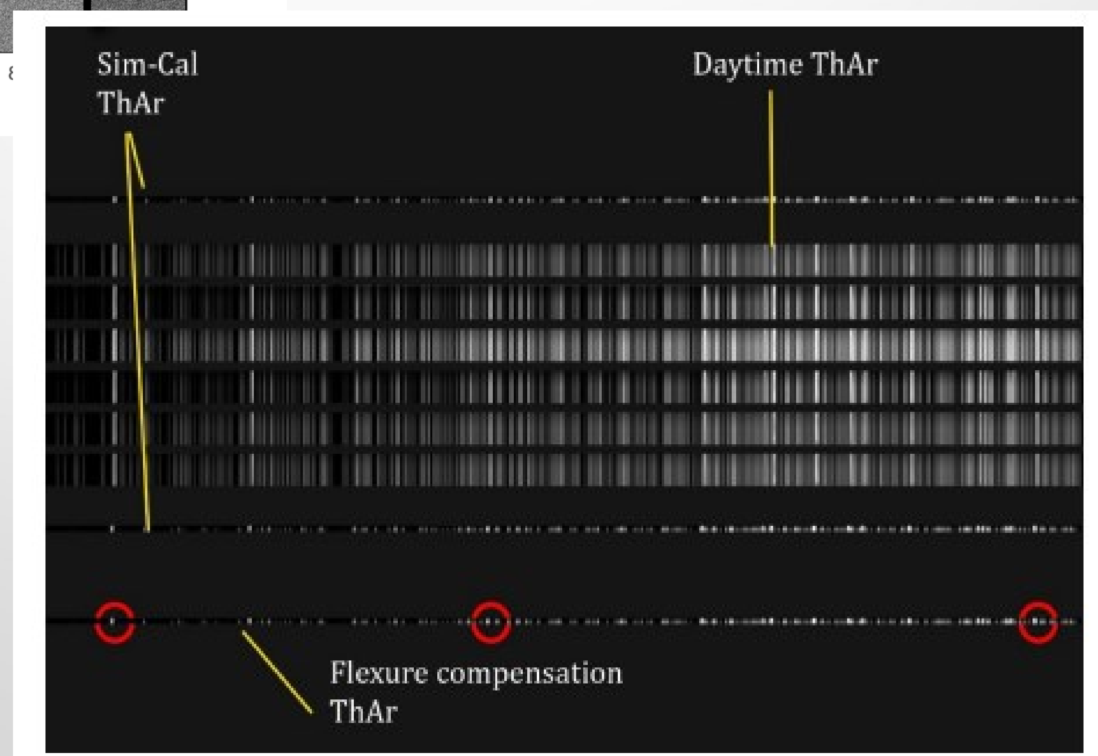
Vacuum Control

Assuming two Cryostats, each connected with a dedicated pump, the Vacuum System might consist of:

- 6 x Edwards WRG Gauges Pressure Gauges (2 on each Cryostat and one on Foreline)
- 2 x Pfeiffer CMR361 Pressure Gauges (One on each foreline)
- 4 x Solenoid Vacuum Valves, Two acting as fore-line valves and two as a N2 re-pressurisation valve.
- Sorption pump (with PT100 for feedback) → specs watt is TBD → PhB
- 2 x Agilent TPS Mini or equivalent

Water cooling for WP7300 control electronics, compirsed of manifold leak detection, flow meters, water temperature (monitored by WP7300???)


CUBES simulated frame - Arm1 (300-352 nm) - Noises-Incl - ExpTime = 3600
1000
2000
3000
4000
5000
6000
7000
8000
9000
1000
2000
3000
4000
5000
6000
7000


Sim-Cal
ThAr
Daytime ThAr
Flexure compensation
ThAr

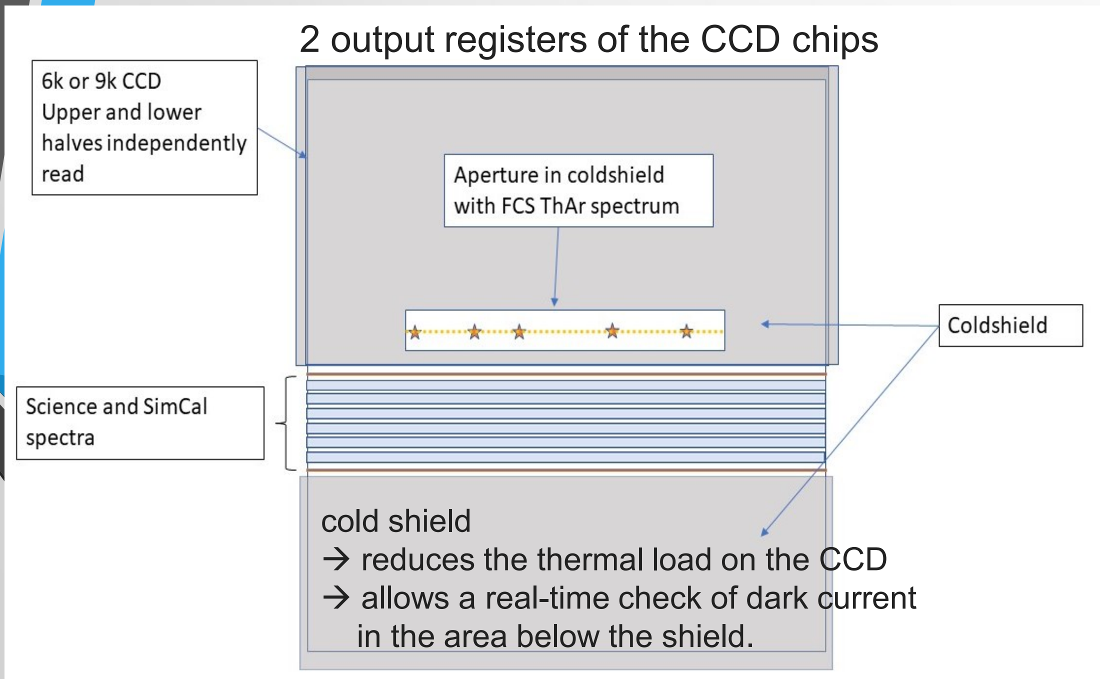
SubSystem AFC – The concept

The AFC in CUBES compensate for flexure occurring between
the slicer exit slit mask and the detector plane. → ~10 um (slide 12 WP6000 Optical-Bench)

The AFC light follows the same path as the science spectrum
→ identical shifts due to flexure (elastic and non-elastic) and thermal drift

a shutter on the AFC lamp is only opened for duration of the AFC exposure,
→ is read out in fast mode, independently from the science half

The light level in the AFC spectra should be adjusted
→ to be as low as possible to reduce the chance of stray light in the science spectra (PhB).



XY motion of the collimating lens:
compensate for the measured flexure offset and maintain the AFC spectrum stable on CCD (lens motion ~ 50/100 um)

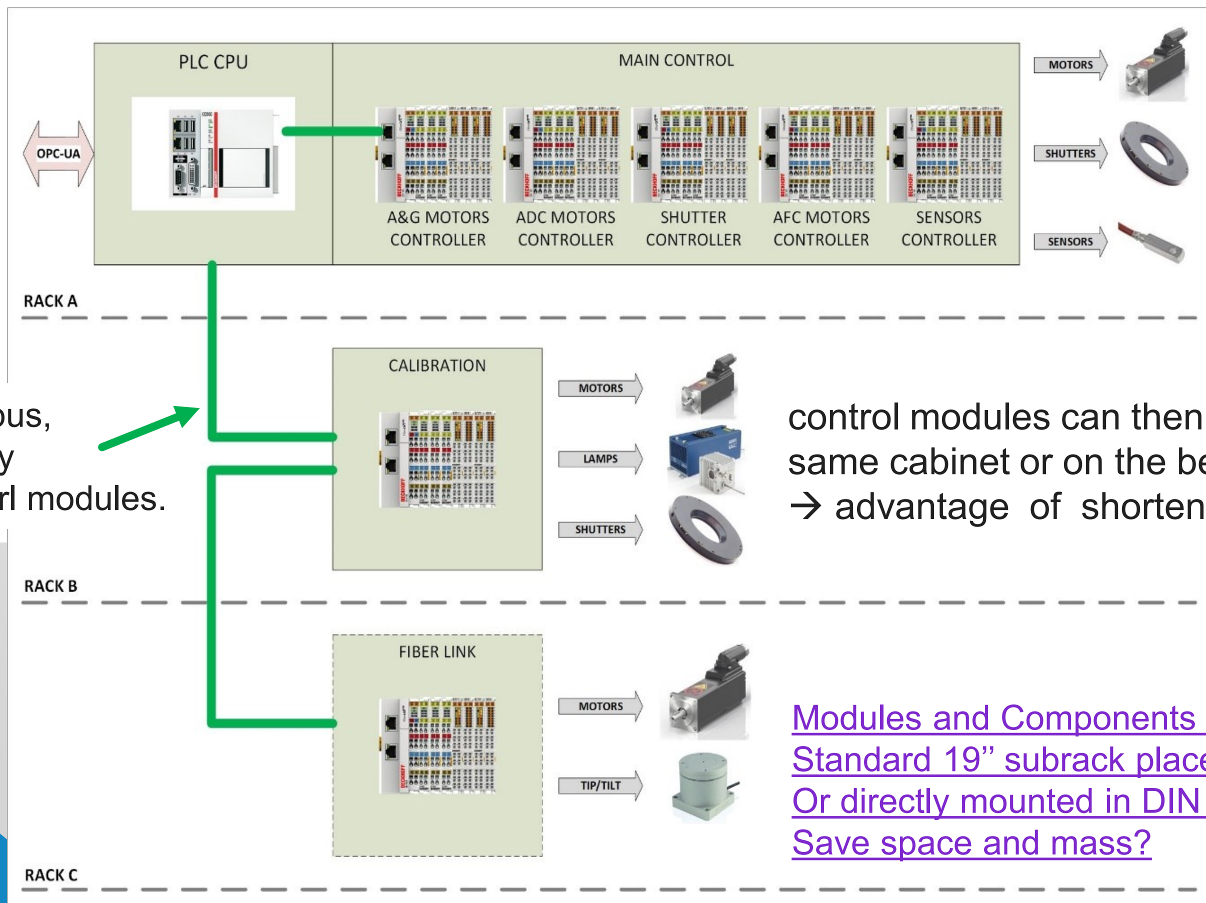
→ moving the lens moves all features in the spectrum by the same amount

It will in principle be possible to achieve a stability of better than 0.1 pixels under all conditions (TBC):

- during a long exposure during the night,
- over the full range of telescope movement
- **over periods of 24h or even longer**

SubSystem WP9000 Instrument Control Electronics

- ICE Based on **PLC** : compliant to latest ELT design electrical standard → Beckoff CX2030 CPU
- ICE provides the control functions for all the functions in the instrument (see slide 4), excluding the Scientific Detector system and its associated Cryostat and Vacuum controller
- Concept of LCU → Manages all the local devices (motors, sensors, lamps, shutters, cooling) with specialized control modules
- Control modules can be either connected on the CPU itself, or decentralized (PCU)



EtherCAT industrial bus, which allows the easy decentralization of ctrl modules.

control modules can then be put in the same cabinet or on the bench of the unit, → advantage of shortening the connections

Modules and Components mounted in:
Standard 19'' subrack placed in standard cabinets
Or directly mounted in DIN rails in bare plates
Save space and mass?

CABINETS:

The current proposal foresees to use four standard cabinets (approximate dimension 900 x 600 x 800 mm) attached to the support frame

The allocation proposed at this stage is as follows:

Rack A – Main control electronics

Rack B – Calibration unit optics and control electronics

Rack C – Fiber link control electronics, ICP and spare for Detector system

Rack D – Detector and Cryo-Vacuum control system (Space allocation to be updated for NGCII- see RIX DJI-22, but space will remain the same)

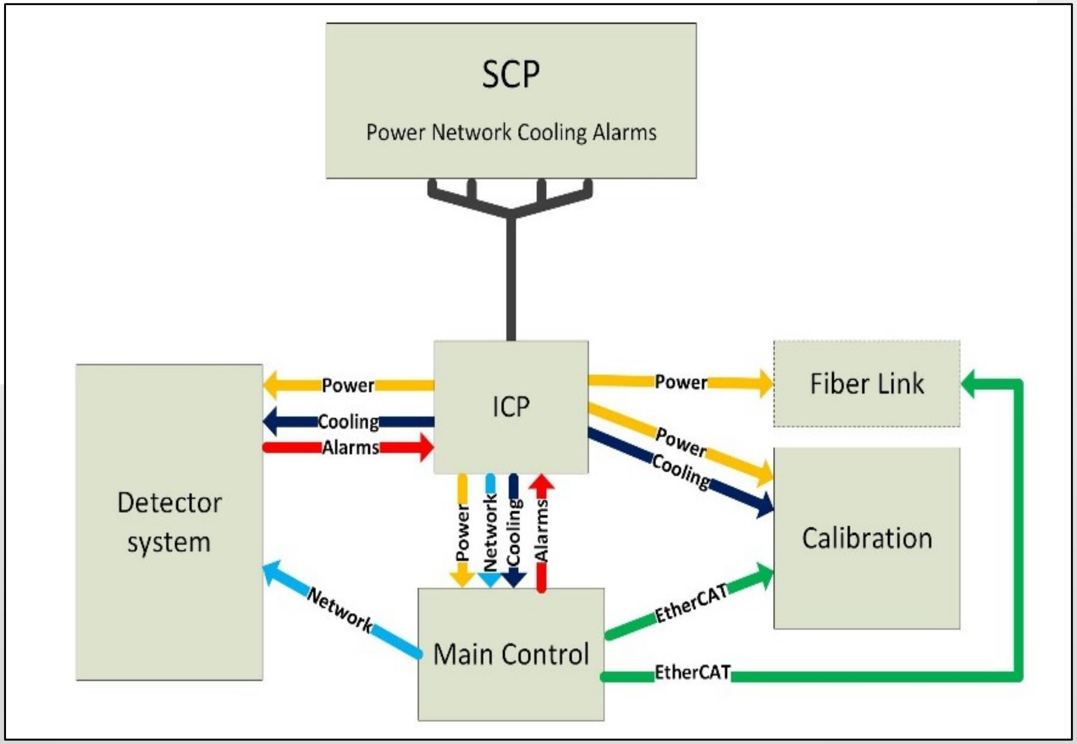
A proper thermal stabilization will be provided either by employing dedicated temperature controller or managed by the PLC, if available in the cabinet. → Offered By ESO

SubSystem WP9000 Instrument Control Electronics

Instrument Connection Point (ICP): an intermediate component that is the main interface to the Service Connection Point (SCP) on the telescope for the whole instrument.

ICP distributes the services to the single subsystems, depending on the needs. These include:

- power supply: fist stage of power conditioning and protection (+ add protection for each cabinet)
- network connection: for PLC-CPU, Detector system, TCCD
  (other control devices are connected to the PLC)
- alarms, interlocks
- cooling liquid: distributed to the cabinets for thermal control



SubSystem WP10000 FIBER-LINK – Architecture + General

The fiber link subsystem enable simultaneous observations with UVES

UVES echelle spectrograph:

- VLT-UT2 Nasmyth B focus.
- Resolving power ~40,000
- UVES has two arms that cover a total wavelength range of 300-1100 nm. → *420-1100 nm*

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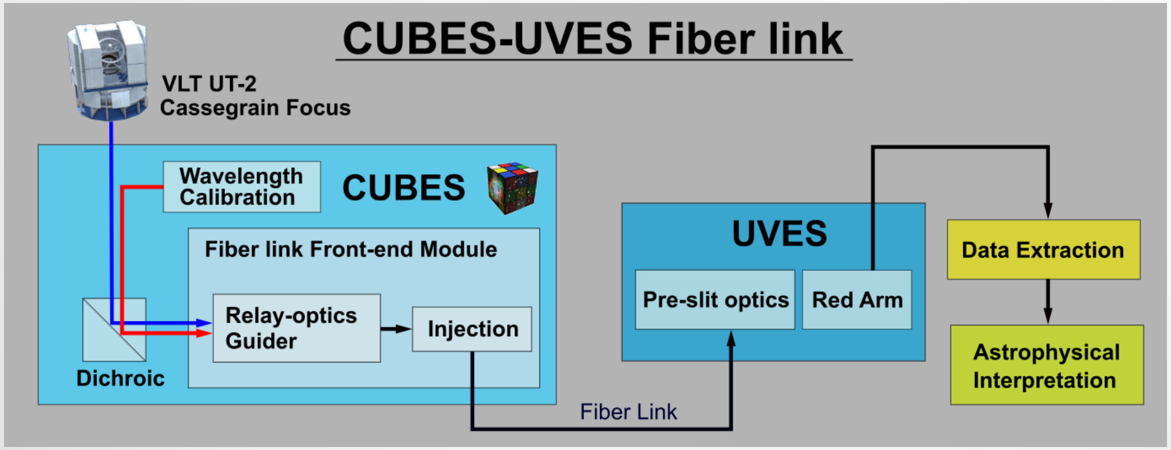
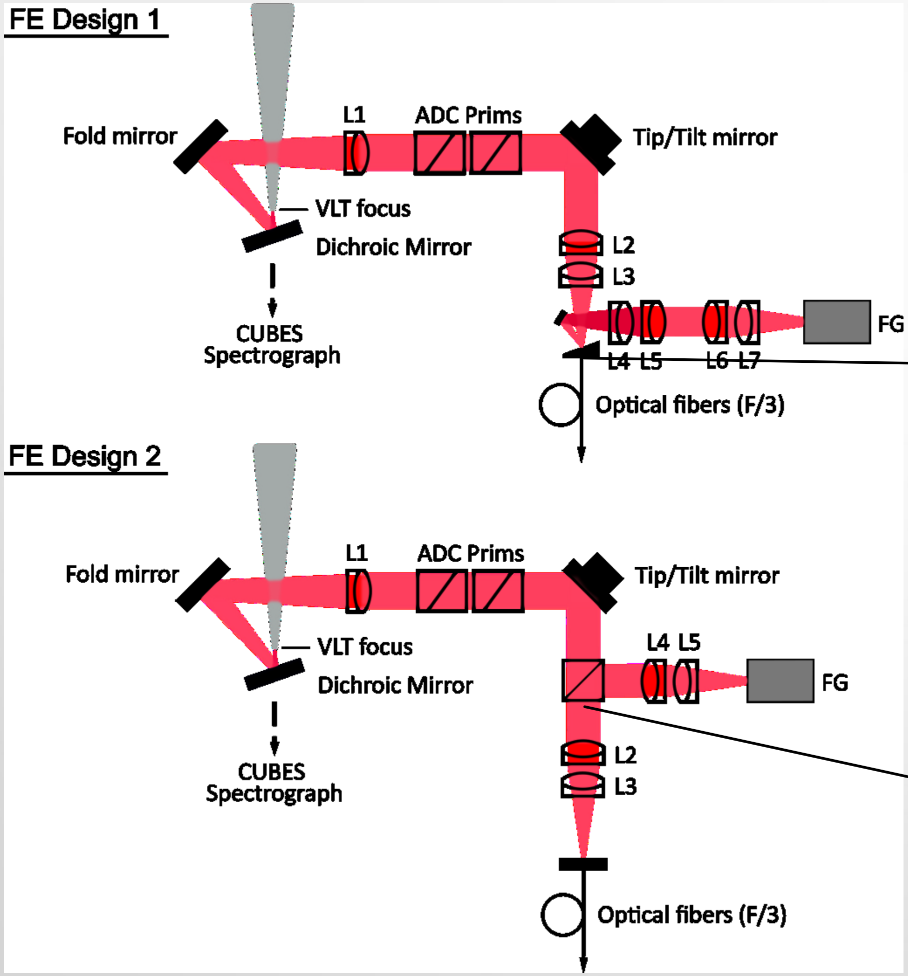


- Calibration light from CUBES CAL
- Front-End Module:
  - FL dedicated ADC: Reqs (T>85%, disp corr better than ±100mas) TBC
  - TT system: Reqs (resolution, max stroke, responsiveness, OL-CL operation) TBC
  - Guiding system: reflective aluminum wedge –vs- beam splitter ; detector same as A&G → PhB definition

- Optical fibers: 1-Obj + 6-Sky in a hexagonal grid of 10arcesc diam - Same as FLAMES (120 um core) – lenght 40 meters – protection tube + conduit cable – FC/PC-vs-SMA connetion

- UVES INTERFACE: feeding the UVES pre-slit unit, light goes in the red arm

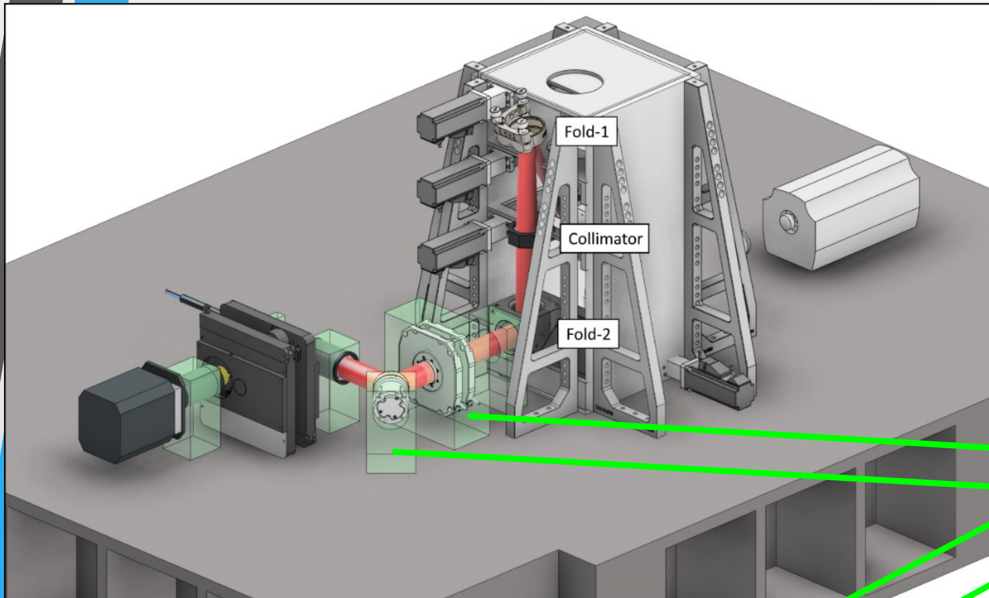
SubSystem WP10000 FIBER-LINK – Optics –Front-End module

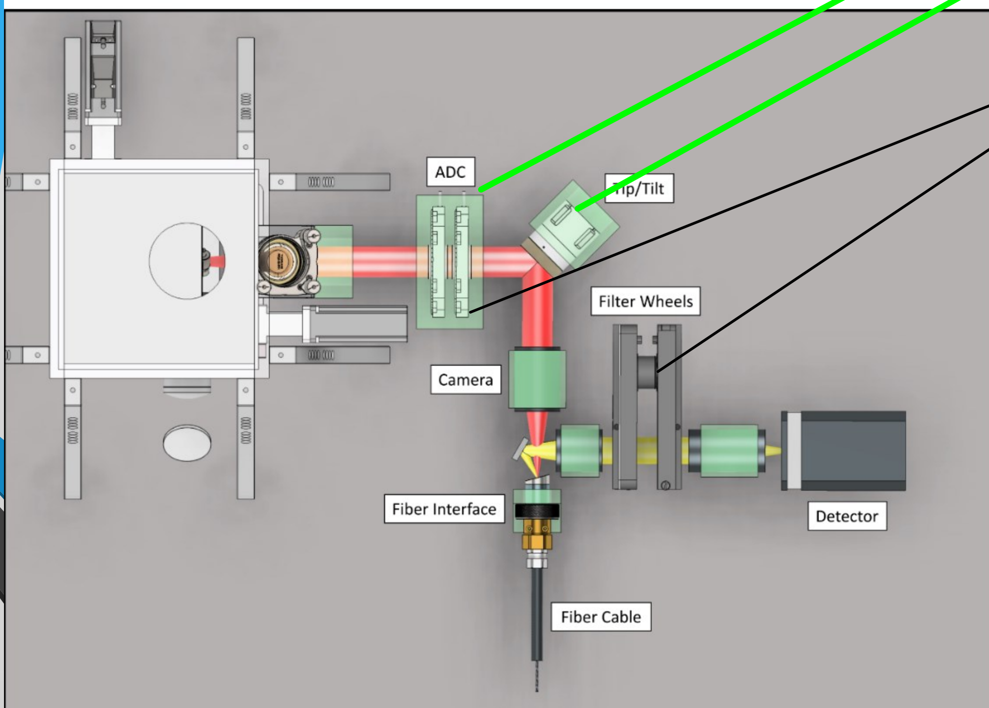


reflective aluminum wedge placed in the fp of the camera lens (L2-L3)

beam splitter placed between tip/tilt mirror and camera lens.

SubSystem WP10000 FIBER-LINK – Mechanics Front-End module



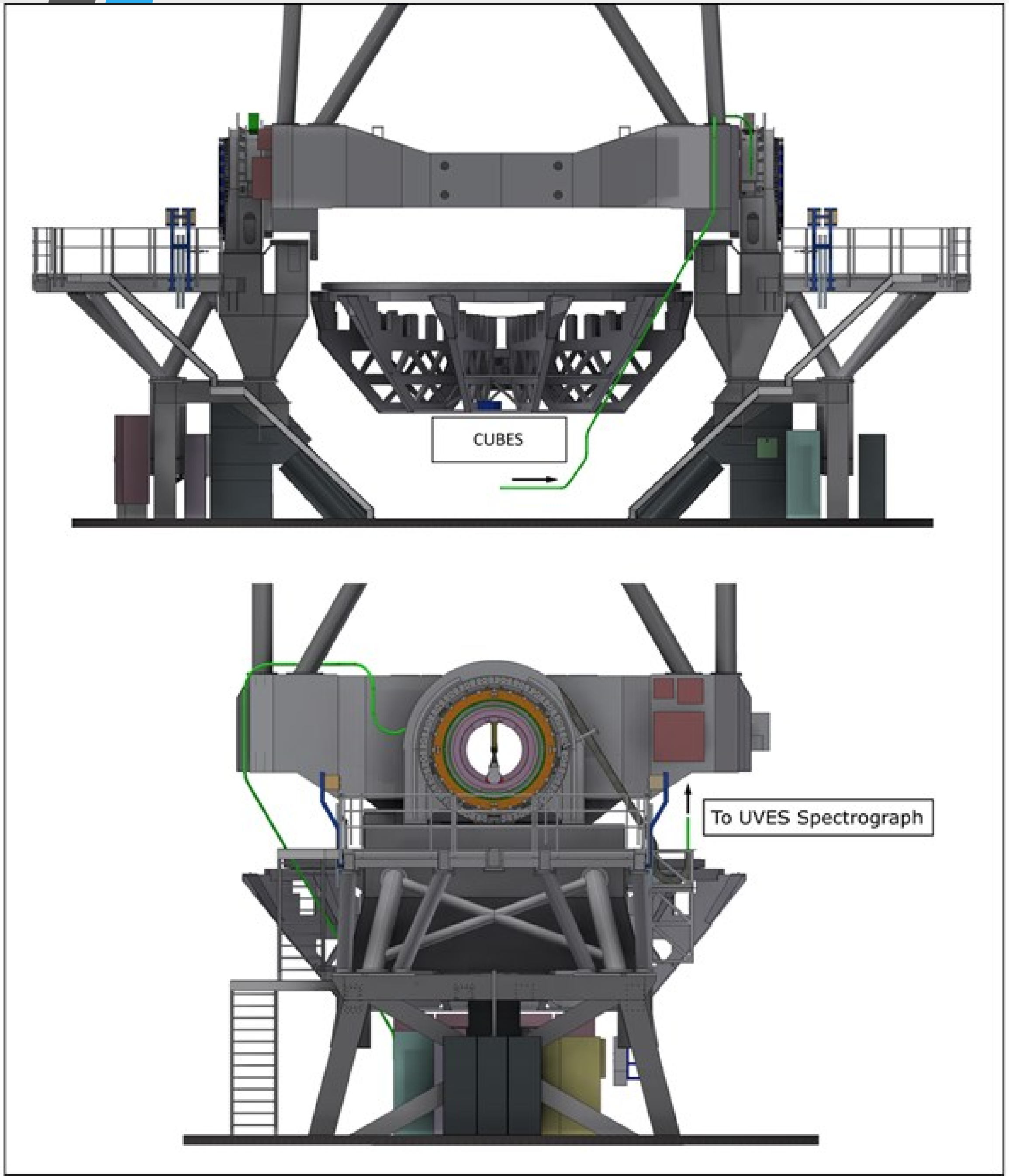


approximate build volumes for holders and brackets of the FE components. (indicated as translucent green boxes)

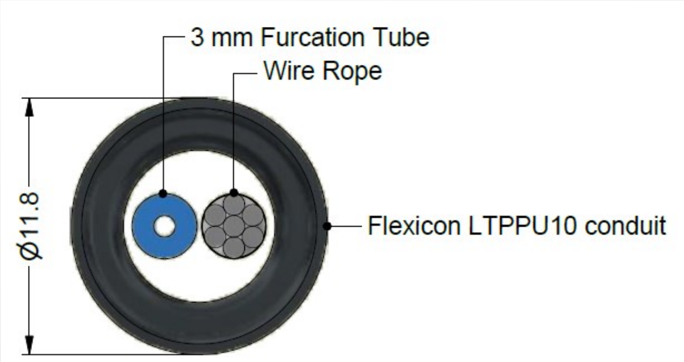
The FE module will use similar rotation stages and filter wheels used for the CUBES ADC and A&G module.

Max space envelop from WP6000

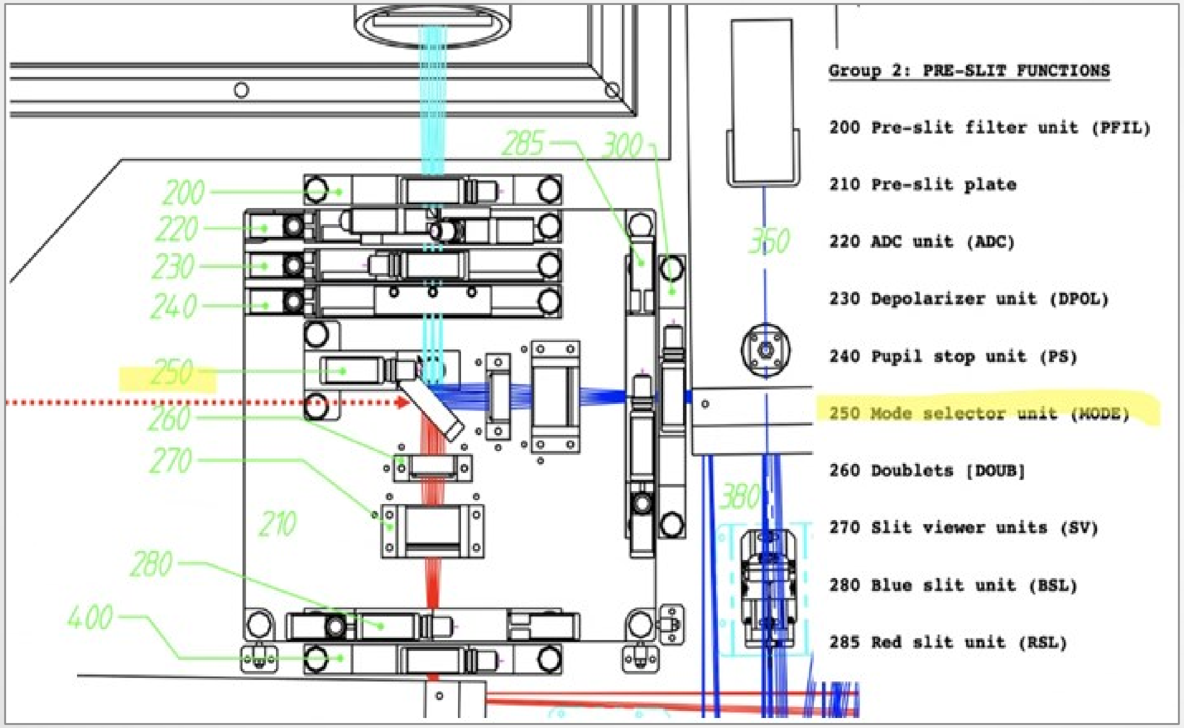
SubSystem WP10000 FIBER-LINK – fibers route

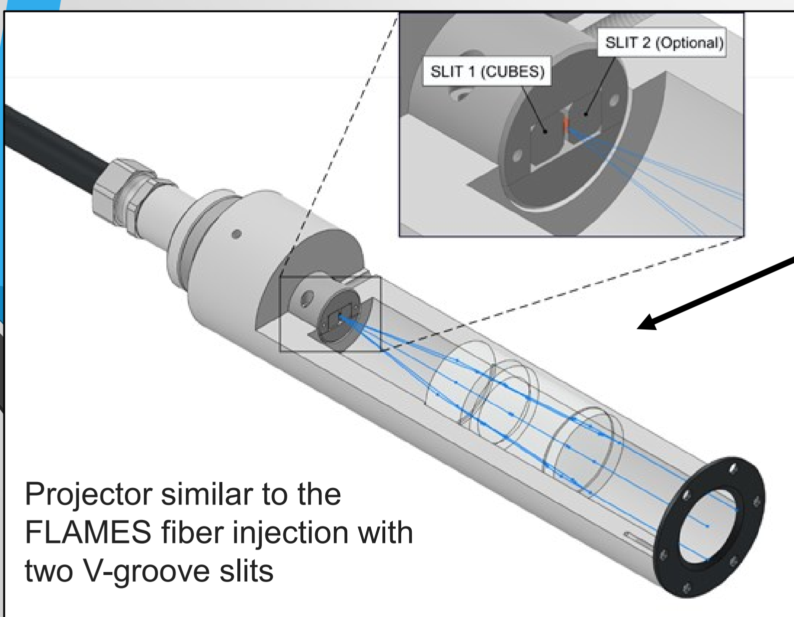


TOTAL fiber cable lenght 40 m

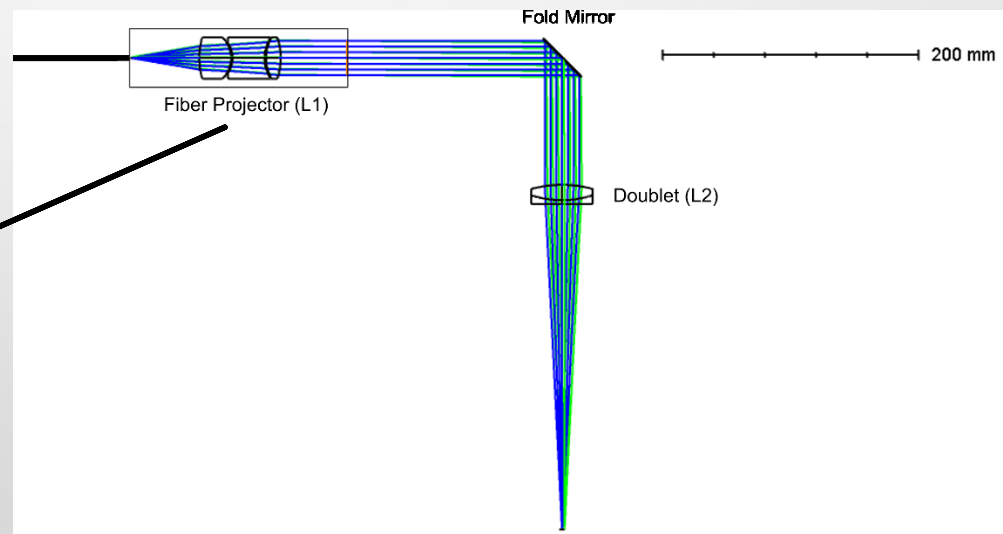


SubSystem WP10000 FIBER-LINK – UVES INTERFACE





Projector similar to the FLAMES fiber injection with two V-groove slits



Performance

PARAMETER	
Science Spectrum U-mag	18.77 (AB) – 18 (Vega)
Instrumental	
CCD RON (e- rms)	9K – 10um 2.5
DC (e-/pix/hr) "goal case"	0.5
DC (e-/pix/hr) "conservative case"	3
Sampling GEO at min λ (pix) Sampling GEO central λ (pix)	2.3 2.5
Optics PSF, gauss FWHM (pix)	0.65
Flexure blur, FWHM (pix)	0.5
CCD diffusion (pix) (According to E2V communications)	0.9
Sampling LSF FWHM fit, at min λ (pix)	2.35
Performance	
Res-Power minimum (related to gauss fit of the resulting LSF)	21000
S/N 1x1 at 313nm "goal"	16.6
S/N 1x1 at 313nm (0.007nm/bin) "goal"	19
S/N 1x2 at 313nm (2 in spatial dir) "goal"	18.6
S/N 1x2 at 313nm (2 in spatial dir) (0.007nm/bin) "goal"	21
S/N 1x1 at 313nm "conservative"	12.5
S/N 1x1 at 313nm (0.007nm/bin) "conservative"	14.5
S/N 1x2 at 313nm "conservative"	14
S/N 1x2 at 313nm (0.007nm/bin) "conservative"	16

TLR-27 Reformulation:

U-band mag = 17.5
(in Vega system)

Conservative Case DC

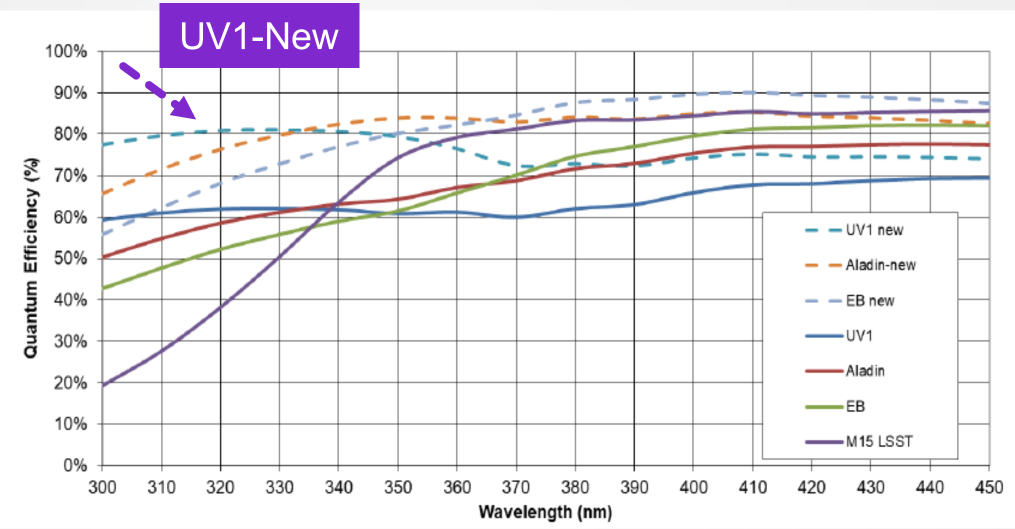
Binning 1x2 (0.007nm/bin)

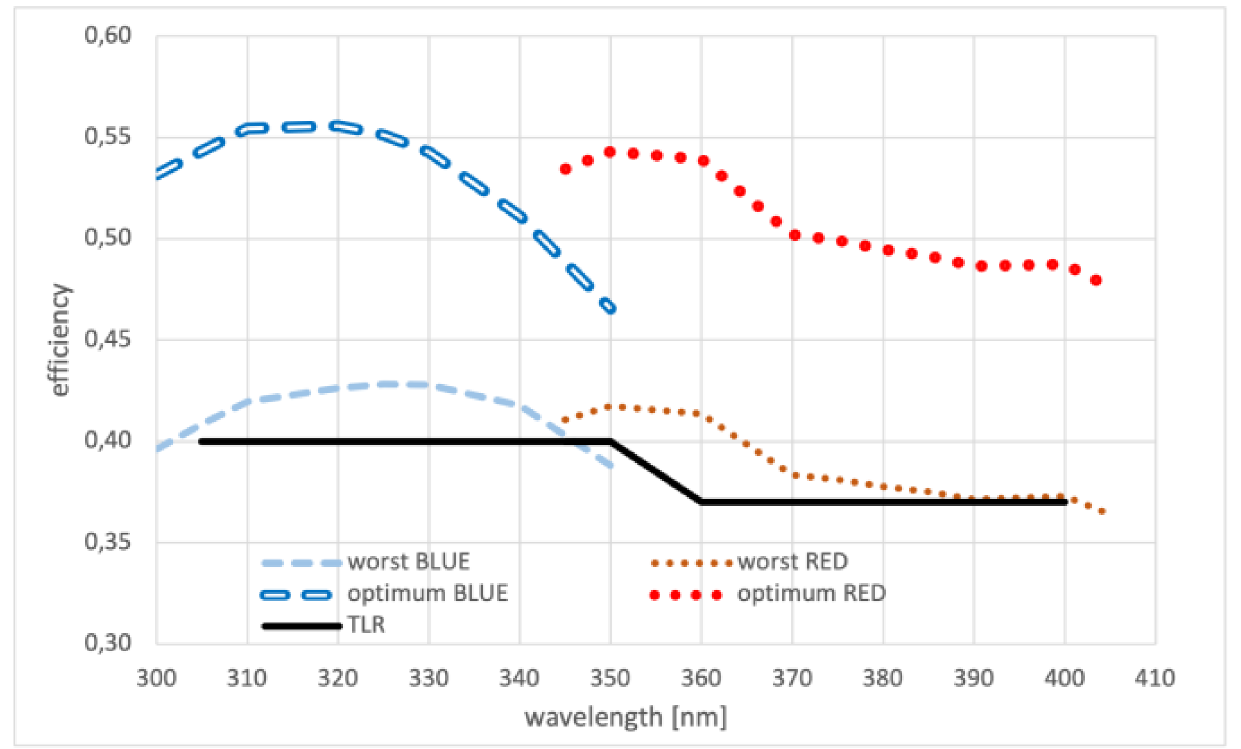
S/N >20

Performance

Performance

	Optimum case	*Worst case*
AR coating	0.997	0.995
Cement	0.995	0.99
High refl. mirror coating	0.98	0.97
Dichroic coating	0.97	0.97
High refl. slicer mirror coating	0.97	0.95
Detector coating	datasheet QE [13]	datasheet QE [13] × 0.95
Slicer vignetting	0.98	0.97
Grating (w/AR coating backside)	manufacturer's simulation [10] × 0.95	manufacturer's simulation [10] × 0.90





OpenTrade off – AFC-vs-Sim-Cal

	Sim-Cal	AFC	Justification
Maintain resolution during long exposures	o	+	Sim-Cal only monitors R so if flexure occurs, the observer is informed. AFC periodically re-positions the spectrum on the CCD
Proper wavelength scale after daytime calibration	+	+	Sim-Cal requires extra DRS step to adjust wavelength scale
Proper calibration of pixel response	o	+	AFC keeps FF spectra stable which makes flatfielding insensitive to slicer edge defects, CCD cosmetics and dust; no risk of not being able to flatfield ends of the slitlets
No showstoppers @ end of Phase A	–	+	Sim-Cal implies that one must fully rely on estimates that are not yet confirmed (FEM and thermal analysis, intrinsic stability of components). All these potential showstoppers are largely removed by AFC.
Risk of delays during Phase B and MAIT	–	o	In case of Sim-Cal, some showstoppers may be only discovered in phase B or C and may require redesign or modifications. The risk also exists, but is lower with AFC.
Need for elaborate telescope simulator	–	o	In case of AFC, the telescope simulator can be a rather simple device since one only needs to test AFC functionality and correction range in a few positions e.g., 0, 30, 60, 90 deg.
Operation and reliability	+	o	Mechanical or SW failure of AFC will have a big impact on spectral format and may lead to the instrument being down.
Data quality, ease of data reduction	o	+	Will be straightforward with AFC. Sim-Cal needs measuring night/day shift and applying it to the regular Wav-Cal spectra before feeding them into the DRS pipeline
FTE SW dev FTE MAIT	Low TBD	TBD TBD	Sim-Cal needs some effort in DRS. AFC needs significant development and test of special ICS, DCS and SW modules. (RIX ASM-9 → AFC data saved in different files w.r.t. OB ?) MAIT effort for both depends on what is found during testing
Cost	~10 kE	~20 kE	Hardware only

FEA and thermal analyses, stray light studies, assessment of the achievable accuracy of AFC and Sim-Cal, cost and FTE considerations

OpenTrade off: Detecotors

Further discussion of detector subsystem rixes resulted in the recommending, before PDR, further investigations regarding:

- options for relaxing specs on cosmetic quality for a large fraction of the detetor area (however, even the store shield needs a minimum spec on hot pixels/columns)
- Suitability of the STA 10Kx10K 9um device as an alternative
- possibility to relocate the AFC onto a cheaper smaller device that could be located adjacent to the science device in the focal plane (of course this is not necessary if the design stays with the large monolithic device that has plenty of avalable pixels for AFC)
- Getting quotes (already in progress) so that we have an idea how much could be saved by using two or more smaller devices instead of the 9Kx9K monolithic solution. (Its clear that there would be many added complexities to using several devices, the point is to check if the price difference is so dramatic that its worth investigating the option further)

OpenTrade off: Detecotor system Cooling options

Score	Requirement	Cooling power margin at 170K	Vibration characteristics	Mass	Overall volume	Operational requirements	Heritage
	Weighting	30	20	20	10	5	15
380	LN2 bath (ESO standard design)	5	5	2	1	1	5
300	RAL Small Scale Cooler	2	3	5	4	5	1
350	Sunpower DS mini	5	2	4	4	5	1
355	Sunpower MT	5	3	3	3	5	2
305	Leybold COOLPOWER [50]	5	1	2	2	3	4
275	Leybold COOLPOWER [7/25]	5	1	1	1	3	4
0	5 stage thermoelectric	0	5	5	5	5	2

commercial stirling coolers

Review the weighting given to the figures of merit (PBr 32 RIX from Ph-A)

Phase A review ESO suggested to have a discussion with Paranal concerning Praticality of using the commercial stirling coolers instead of LN2 bath

WORKPACKAGES INTERFACE FOR (MECH) DESIGN PROGRESS

OPTICS:
- Consolidation of optical design elements
- Sensitivity / Tolerance / Thermal
- Camera elements AIV with manufacturer (1st iteration)

Fiber-Link:
- Consolidation of optical design elements (incl. Fibers)
- Sensitivity / Tolerance / Thermal
- Fiber-Guiding option selection (reflective-wedge –VS- Beam-splitter)
- Optomechanics (CUBES side & UVES side)
- Consolidation of Fiber routing inside CUBES + UVES I/F …

MECHANICS:
- Opto-mechs mounts refinement definition/design
- Tel-Adapter design refinement
- Bench (incl. Fore optics support) design refinement
- Bench <-> first ROM quote and interaction with manufacturers
- Support-Frame-Assembly design refinement
- General mechanical analysis → FEM-EQ-Thermal
  - Flexure Compensation system
- Handling and storage tool design refinement (Edoardo Redaelli)

ELECTRONICS:
- Confirmation of mass and volume and cables

DETECTOR:
- *CCD & Electronics*
  - NGC2 specification from ESO (1 NGC2 for both CCDs)
  - ARCoating confirmation from E2V
  - Space, mass and power for the NGC2 (& rack server 4 det ctrl)
- *CryoVac*
  - Thermal Power budged refinement → Consumption of LN2
  - Geometrical layout similar to XSHOOTER confirmation
  - **Need for heating exhaust gas from LN2 bath?**
  - Positions of the pumps (1 for each cryostat)
  - Structural and vibration analyses
- *Cryostat control electronics*
  - Control components/logic shared with CUBES system?
  - Siemens S7-1500 PLC + (2) Lakeshore + PowerSupp: → mass & volume refinement for Electrical Cabinets + Mechs
  - Heater number and requirred power (Watts)
  - Sorption pump type and specs

CALIBRATION UNIT:
- Control electronics confirmation: items, mass, volume, functions
- Consolidation of optical design elements
- Sensitivity / Tolerance / Thermal
- Confirmation ThAr lamps ok for WL-calib
  - ThAr lamps not from PHOTRON?
- Flat fielding the LDLS
- Lamps-Bench mechanical design confirmation
- Confirmation of I/F with Fore-Optics for Daytime cal
  - Datytime injection bundle confirmation
- Confirmation of I/F with slit-space for Sim-cal + AFC
  - Sim-Cal injection bundle confirmation

WORKPACKAGES INTERFACE FOR (MECH) DESIGN PROGRESS

From WP interfaces… to proposed preliminary/first-guess schedule

AD technical (some of the "most relevant") Document list

IN THE OWNCLOUD FOLDER: PROJECT_PHASES/PHASE_B/ESO_AD_DOC:

Common Req:

ESO-379353_3 Common Requirements for VLT Instruments.pdf
ESO-379345_1_Common ICD between VLT Scientific Instruments and LPO_toward_final version.pdf

Exampele of Technical Standards + (non-exhaustive list):

ESO-044295_4 Electrical and Electronic Design Standards.pdf
ESO-046147_5 Vacuum and Cryogenics Standard Components.pdf
ESO-232765_1 ESO Technology Readiness Levels.pdf
ESO-253475_1 PLC Standards.pdf
ESO-395771_1 Optical analysis for Instrumentation until PDR and FDR3.pdf
GEN-SPE-ESO-50000-5600_2 ESO Engineering Analysis Standard.pdf
GEN-SPE-ESO-59100-5516_4 CAD Data Format Requirements.pdf
New Integration Hall (NIH) User Manual.pdf
NGCII Requirements_v1.2[2].pdf
VLT-SPE-ESO-20200-5926_iss1 - VL T Vibration Specification.pdf

The complete list agreed with ESO is the folder above!

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NATIONAL INSTITUTE FOR ASTROPHYSICS

LNA LABORATÓRIO NACIONAL DE ASTROFÍSICA

Science & Technology Facilities Council
UK Astronomy Technology Centre