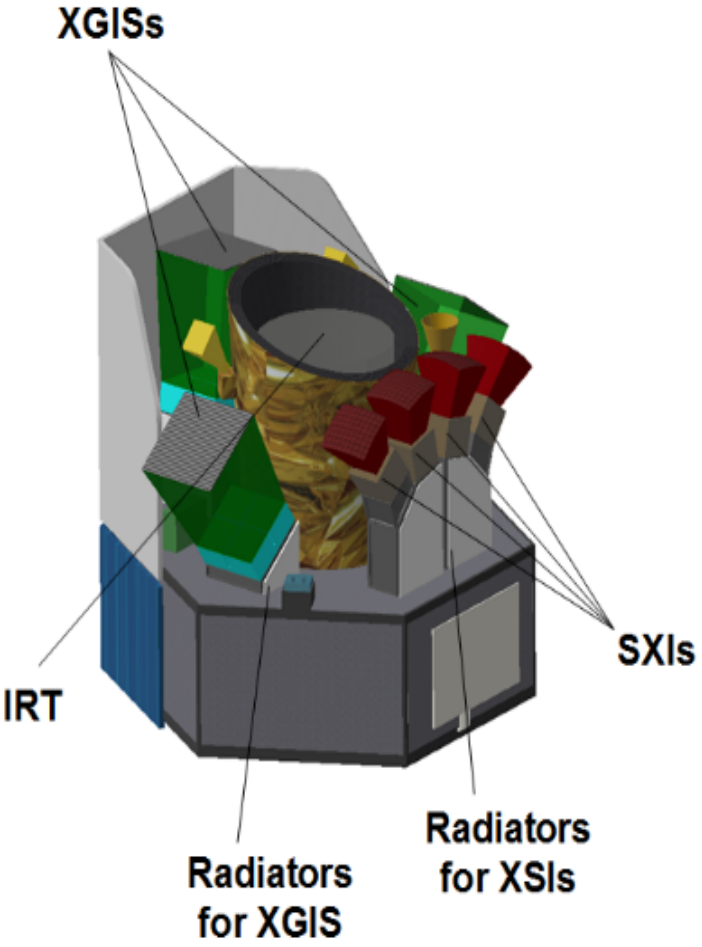

theseus
TRANSIENT HIGH ENERGY SKY AND EARLY UNIVERSE SURVEYOR

THESEUS Payload

- **Soft X-ray Imager (SXI):** a set of four sensitive lobster-eye telescopes observing in 0.3 - 5 keV band, total FOV of ~1sr with source location accuracy < 1-2'.

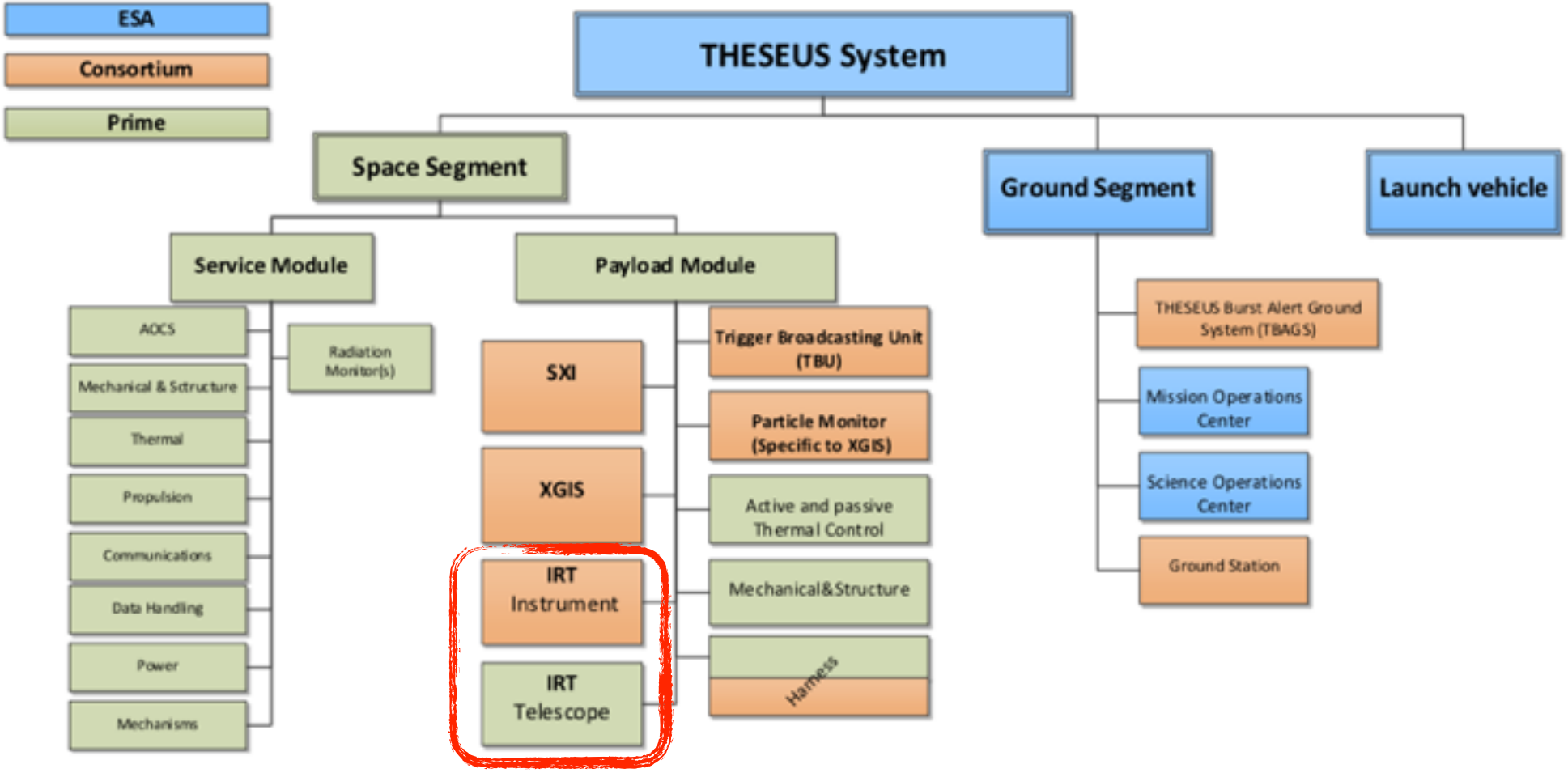
- **X-Gamma rays Imaging Spectrometer (XGIS,)**: 3 coded-mask X-gamma ray cameras using bars of Silicon diodes coupled with CsI crystal scintillators observing in 2 keV – 10 MeV band, a FOV of ~1sr, overlapping the SXI, with ~5' source location accuracy.

- **InfraRed Telescope (IRT): a 0.7m class IR telescope observing in the 0.7 – 1.8 μm band, providing a 10'x10' FOV, with both imaging and moderate resolution spectroscopy capabilities.**

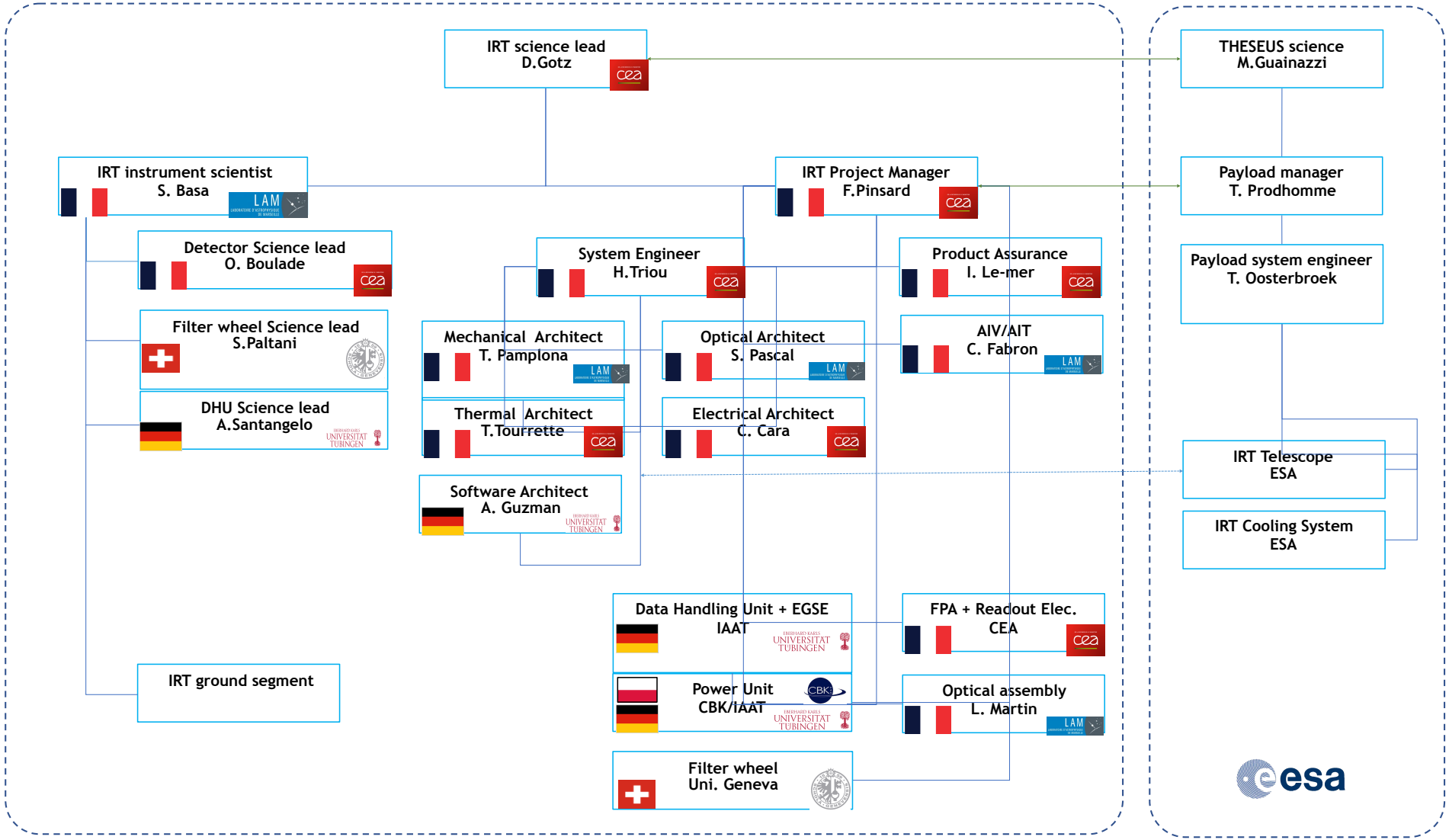


- LEO (< 5°, ~600 km)
- Rapid slewing bus
- Prompt downlink

THESEUS
- Sharing of the Responsibilities -

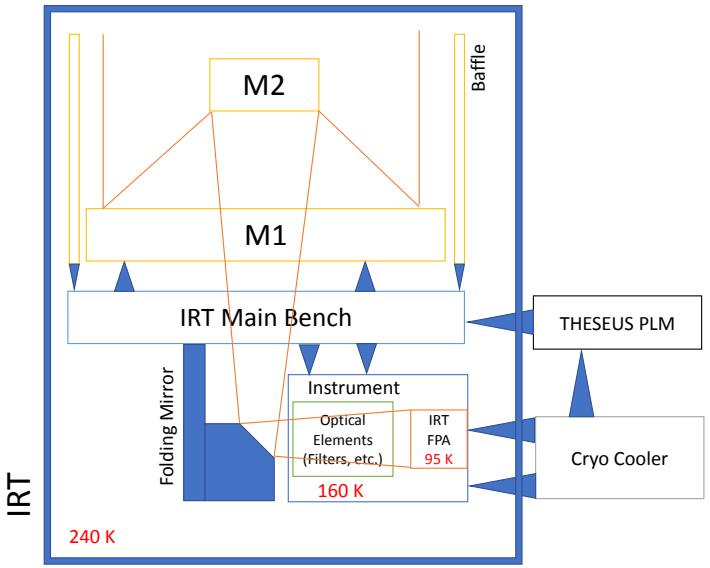


The InfraRed Telescope (IRT)
- General Organization -



The InfraRed Telescope (IRT)
- Overall Specifications -

Telescope type:	Off-axis Korsch		
Primary & Secondary size:	700 mm & 230 mm		
Material:	SiC (for both optics and optical tube assembly) or Zerodur+CFRP, or other combination of materials satisfying requirements.		
Detector type:	European ALFA 2048x2048 pixels detector (15 μm pixels) or Teledyne Hawaii-2RG 2048 x 2048 pixels (18 μm each)		
Imaging plate scale	0".45-0.7"/pixel (depending on the S/C jitter/drift)		
Field of view:	15' x 15'	15' x 15'	5' x 5' (2' x 2' goal)
Resolution (λ/Δλ):	2-3 (imaging)	20 (low-res)	500 (high-res)
Sensitivity (AB mag):	H = 20.6 (300s)	H = 18.5 (300s)	H = 17.5 (1800 s)
Filters:	ZYJH	Prism	VPH grating
Wavelength range (μm):	0.7-1.8 (imaging)	0.8-1.6 (low-res)	0.8-1.6 (high-res)

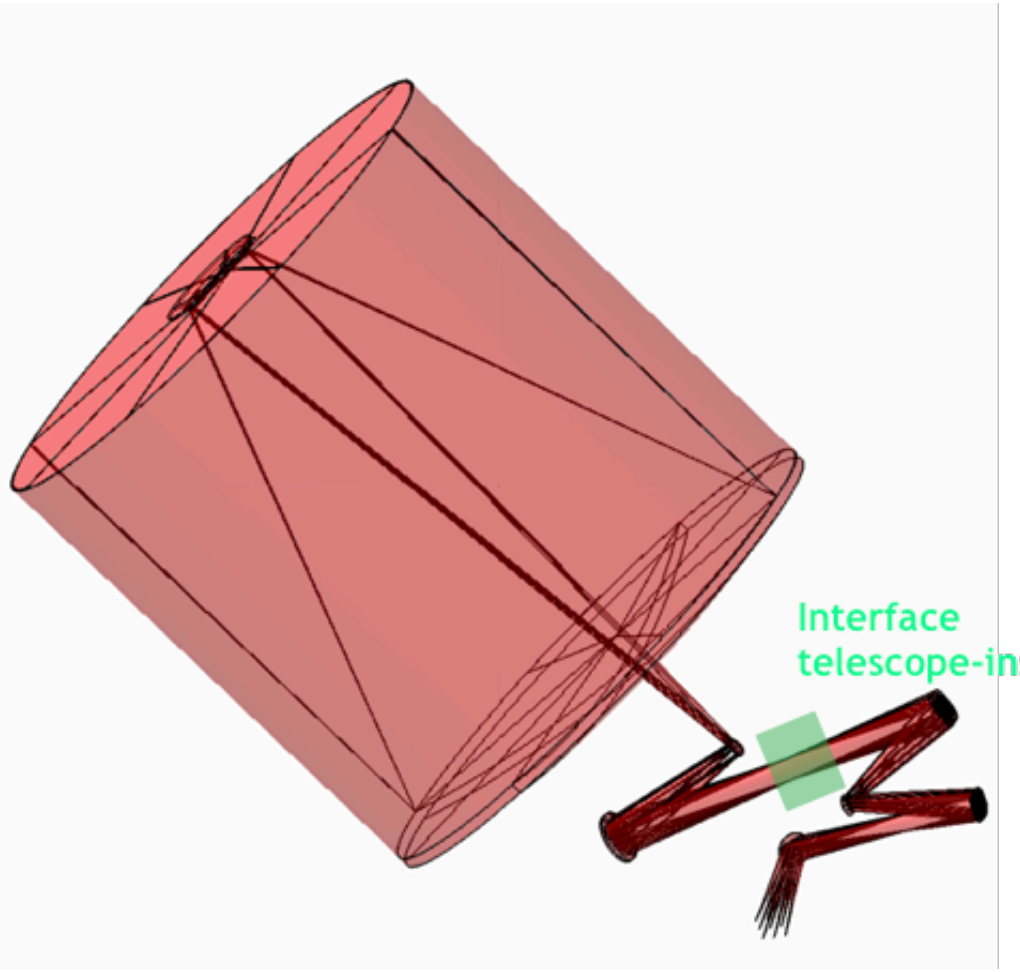


The InfraRed Telescope (IRT)
- Telescope Optical Design -

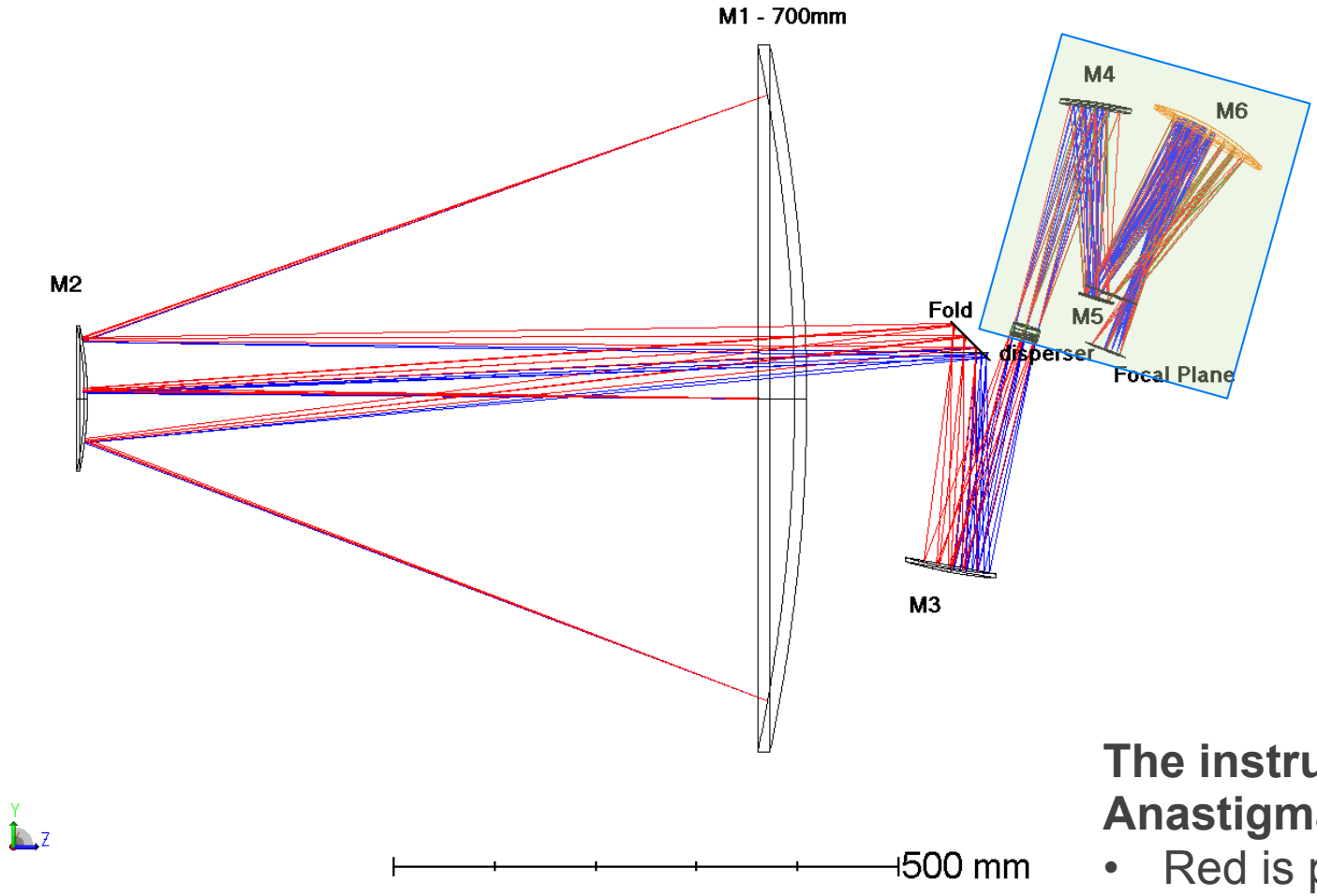
Baseline since the ESA CDF: Korsch off-axis telescope (as Euclid).

Advantages:

- **The telescope and the instrumen have a clear mechanical interface.**
- **Good image quality at this interface: telescope and instrument can be tested separately by the Prime and the Consortium.**



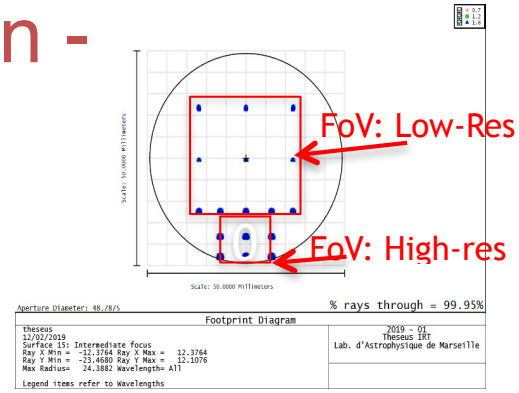
The InfraRed Telescope (IRT)
- Instrument Optical Design -

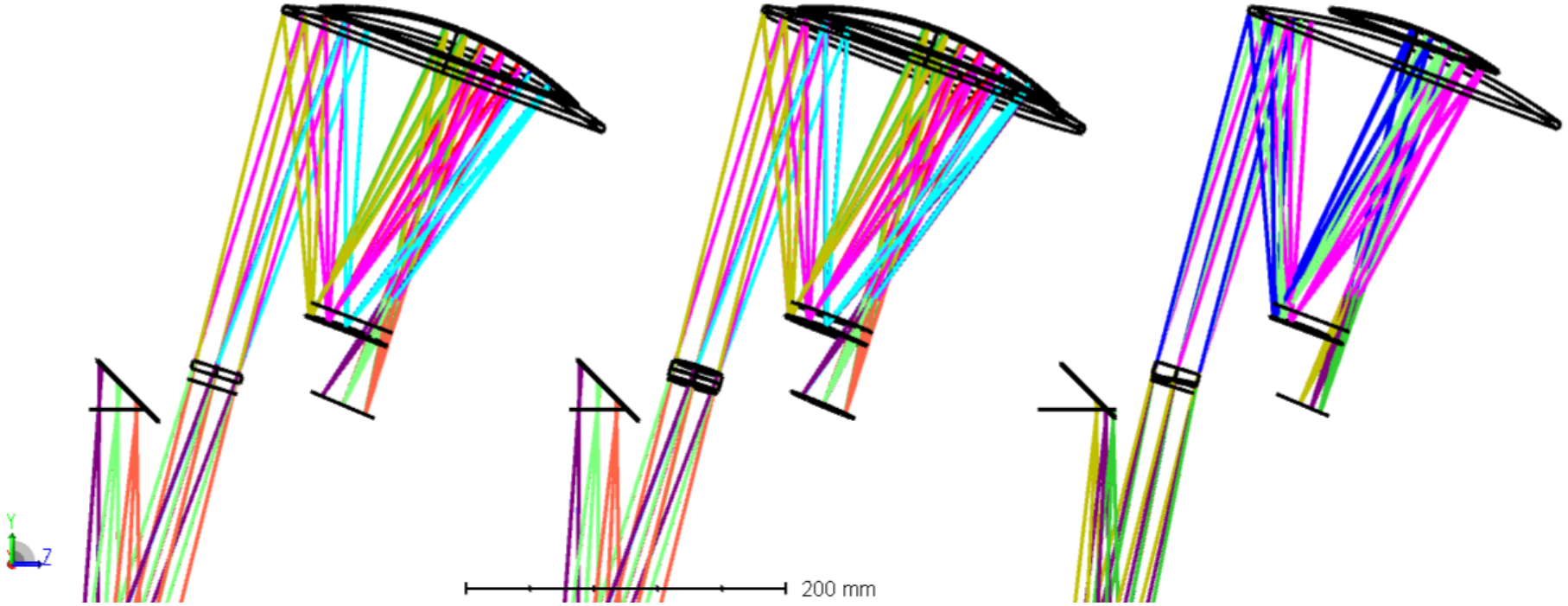


The instrument is a Three Mirrors Anastigmat (TMA):

- Red is photometric and low resolution modes.
- Blue is high resolution mode.

The InfraRed Telescope (IRT)
- Instrument Optical Design -



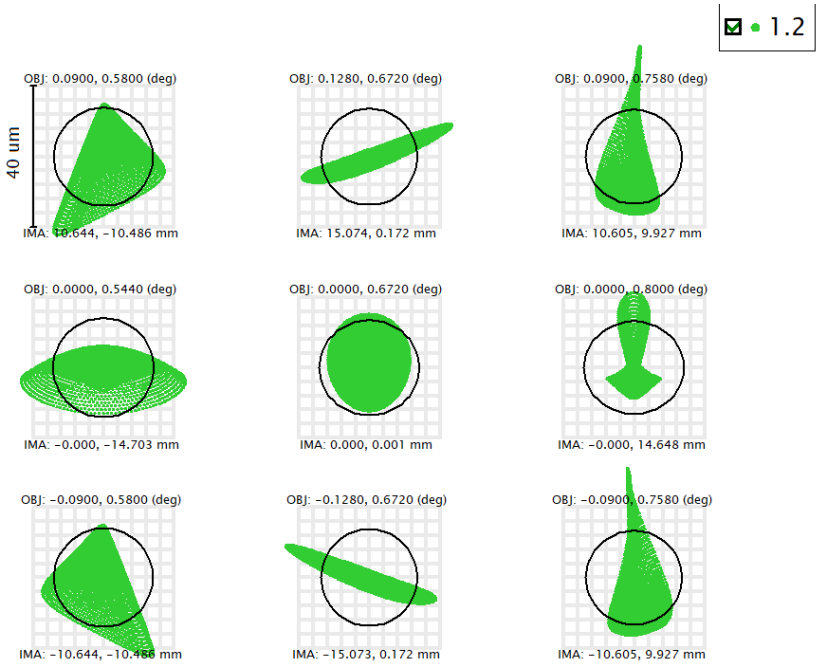


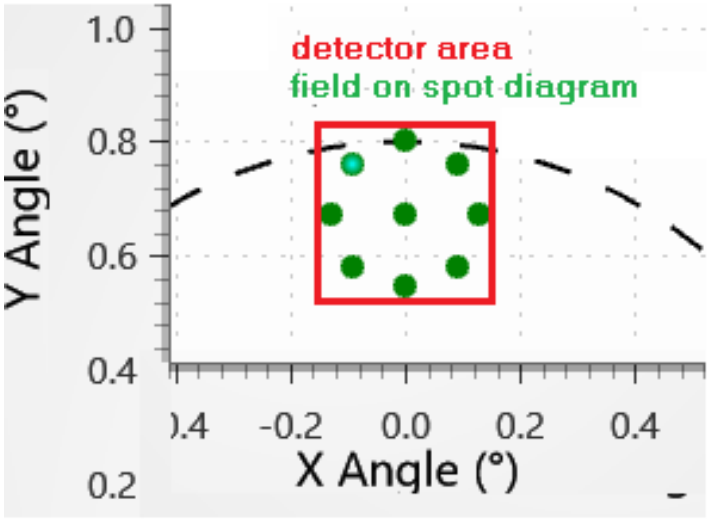
Photometric mode
- Filter (parallel plate)

Low Resolution mode
- Double prism

High Resolution mode
- Grating + prism (rotaded axis)
- Grating: 30 lines/mm
- Prism: 8° (get back on-axis) / 4° (grating deviation compensation)

The InfraRed Telescope (IRT)
- Instrument Image Quality -



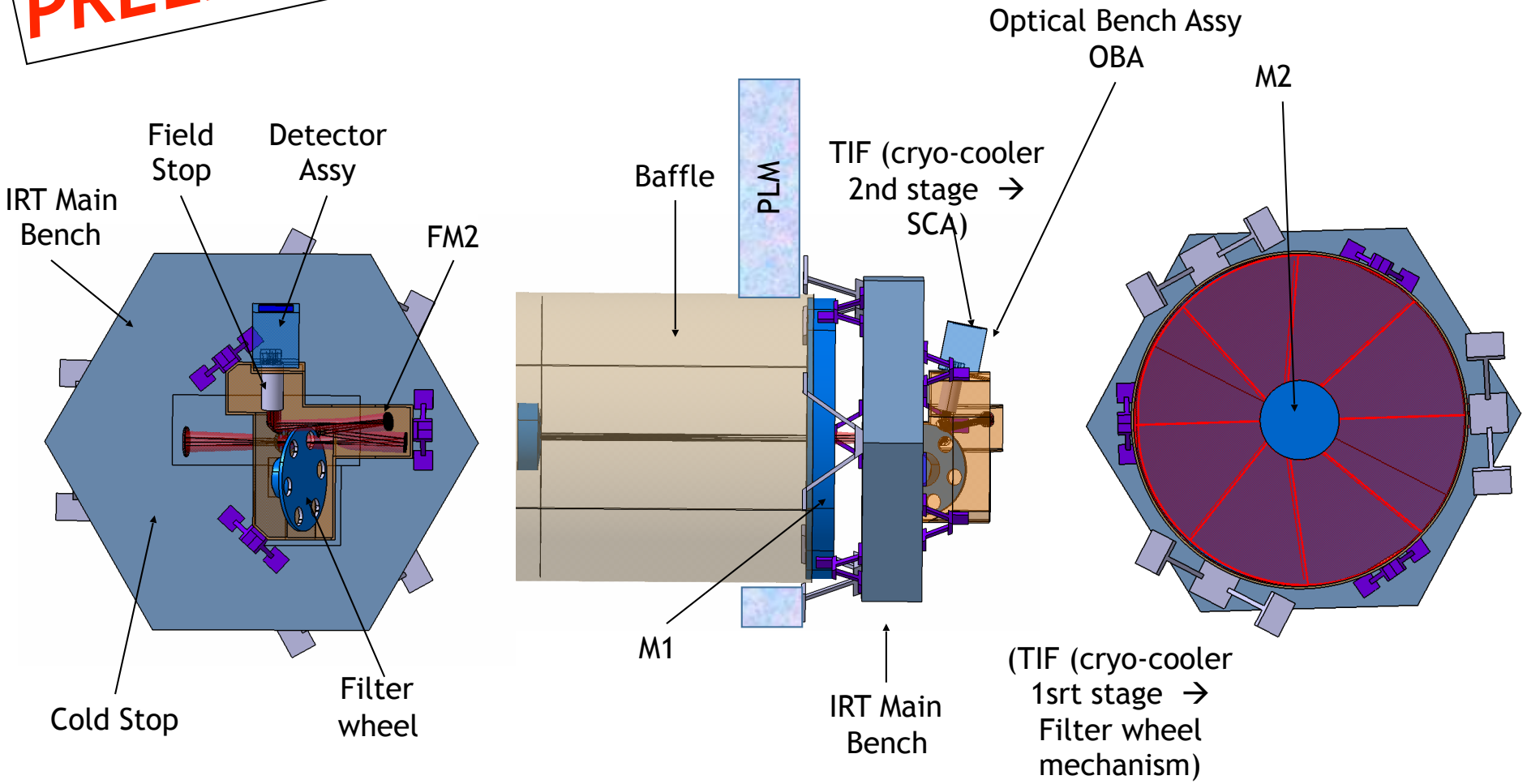


Surface: IMA

Spot Diagram	
Units are µm. Airy Radius: 21.19 µm. Legend items refer to Wavelengths Field : 1 2 3 4 5 6 7 8 9 RMS radius : 11.622 11.715 13.184 11.584 9.289 7.893 11.622 11.713 13.183 GEO radius : 25.904 25.209 31.383 23.600 15.195 21.239 25.907 25.205 31.380 Scale bar : 40 Reference : Centroid	2019 – 01 Theseus IRT Lab. d'Astrophysique de

The InfraRed Telescope (IRT)
- Possible Implementation -

PRELIMINARY

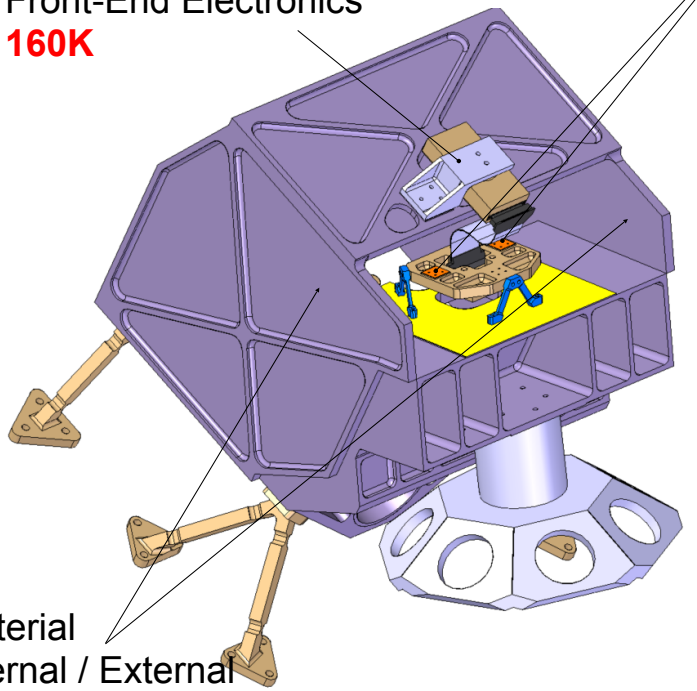


➡ **To be discussed with the Prime!**

The InfraRed Telescope (IRT)
- Mechanical Concept -

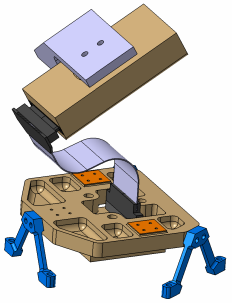
PRELIMINARY

Material and characteristics of the I/F support
Front-End Electronics
160K

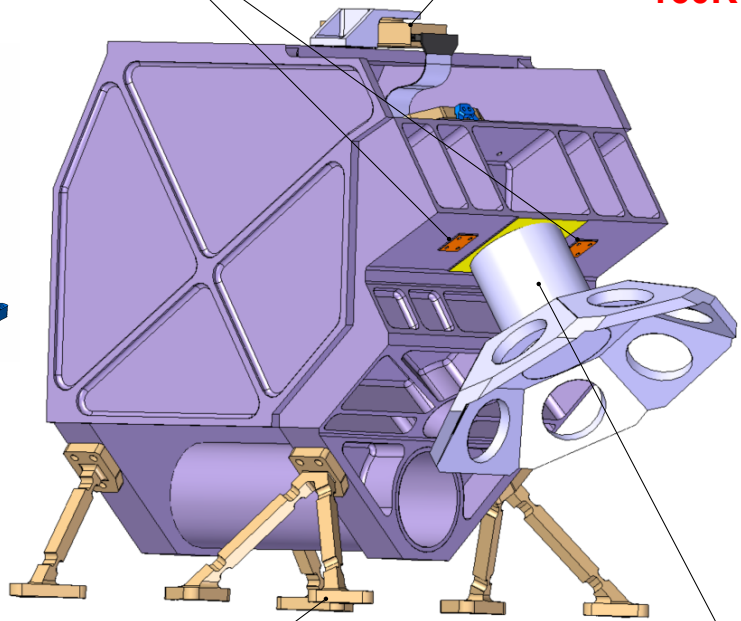


Material
Internal / External
Surface coating
External MLI **160K**

Thermal I/F
towards cryocooler



Front-End Electronics
Internal dissipation
160K

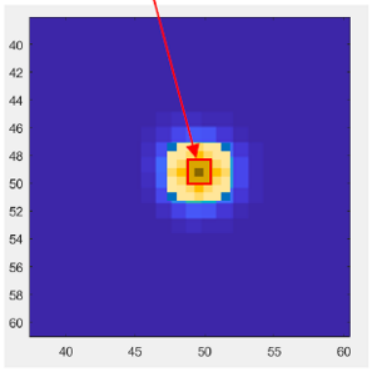


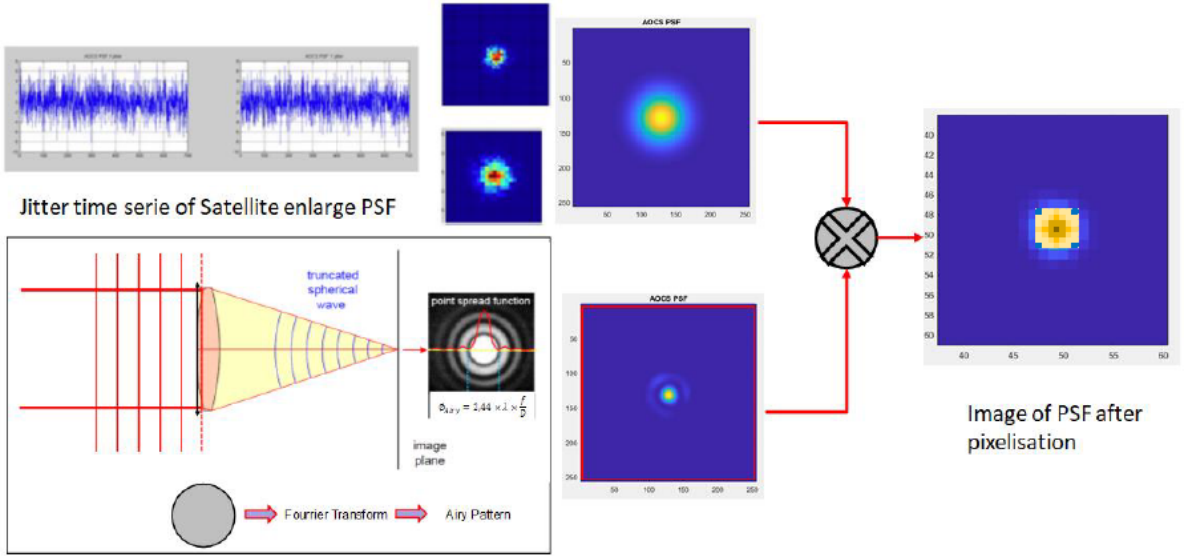
Thermal I/F towards IRT main structure
4 feet
Material, Geometry, I/F. **240K**

Filter wheel engine
Internal dissipation

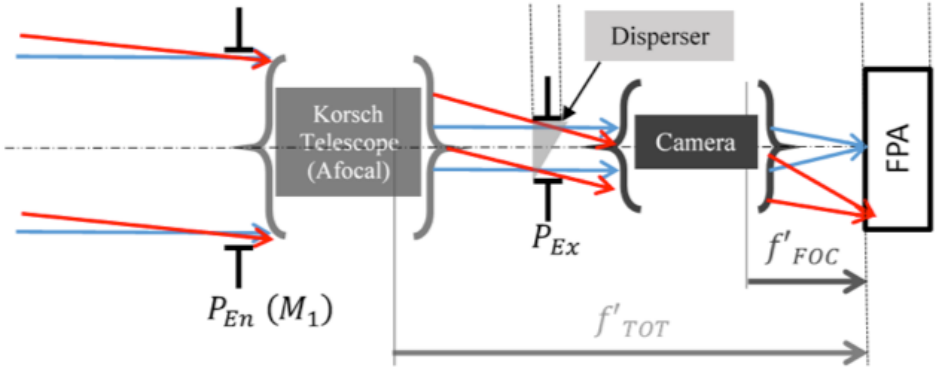
The InfraRed Telescope (IRT)
- Performances Simulation Tools -

~64% of energy in N_{pix} = 9 pixels aperture.





$$Signal = F_{Source} . \%EE . T_{int}$$



The InfraRed Telescope (IRT)
- Some Preliminary Results -

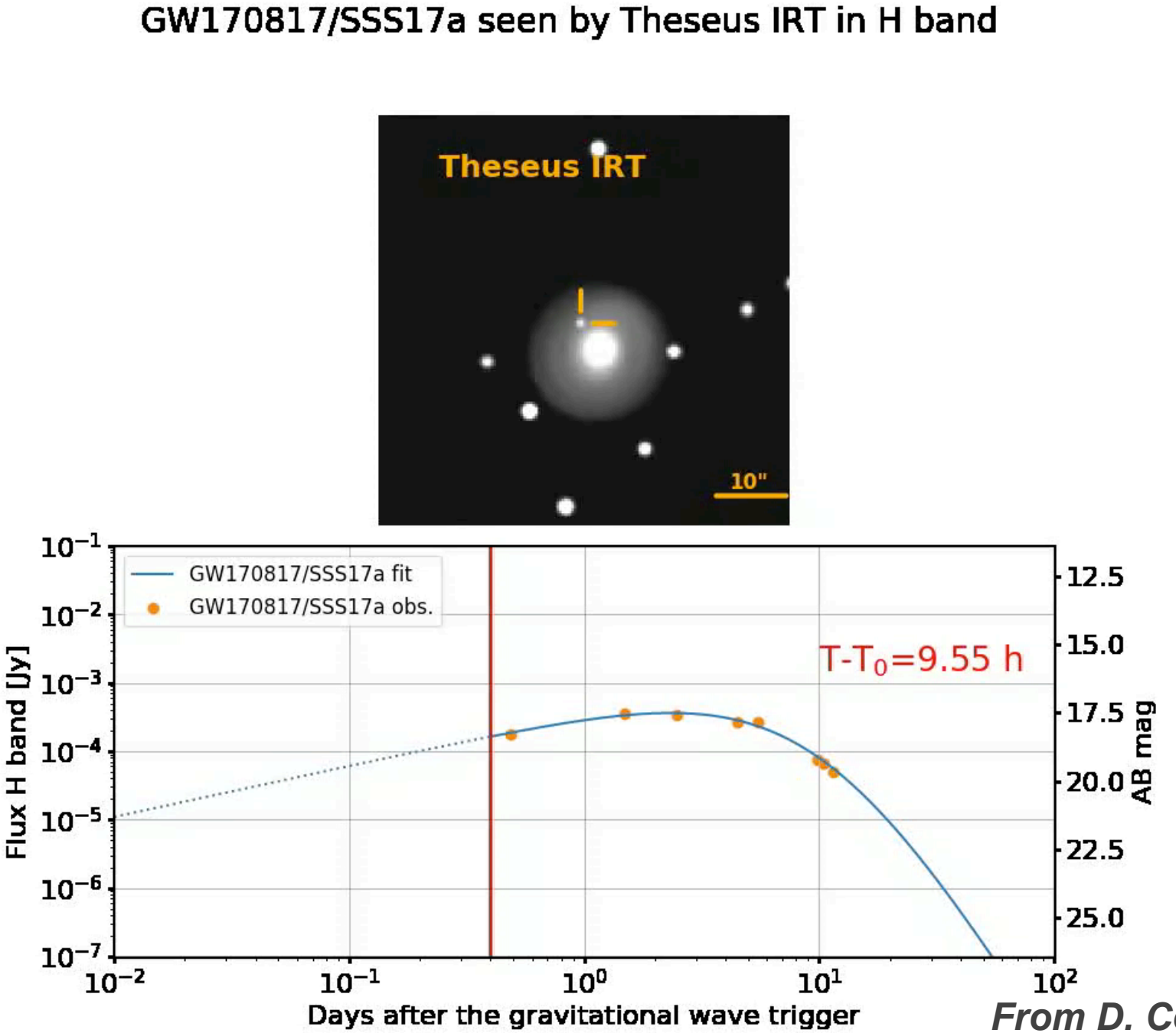
With a 0.7 m aperture space borne NIR telescope (telescope baseline).

For 0,45" pixel size, 16 pixels in photometric aperture (~76 % of the source flux)

Scenario	1 : Beginning Of Life	2 : End of Life	3 : Current best estimate
SNR (Jitter + drift considered) ; σ_{RON} = 7 e- SNR (Jitter + drift considered) ; σ_{RON} = 18 e-	15 6.8	13,1 6,0	20,1 20.1
SNR (Jitter + drift considered); σ_{RON} = 11,5 e-	10.2	8.9	13.5

➡ **Studies are continuing within the framework of the Theseus System Working Group.**

A Well-Known Example



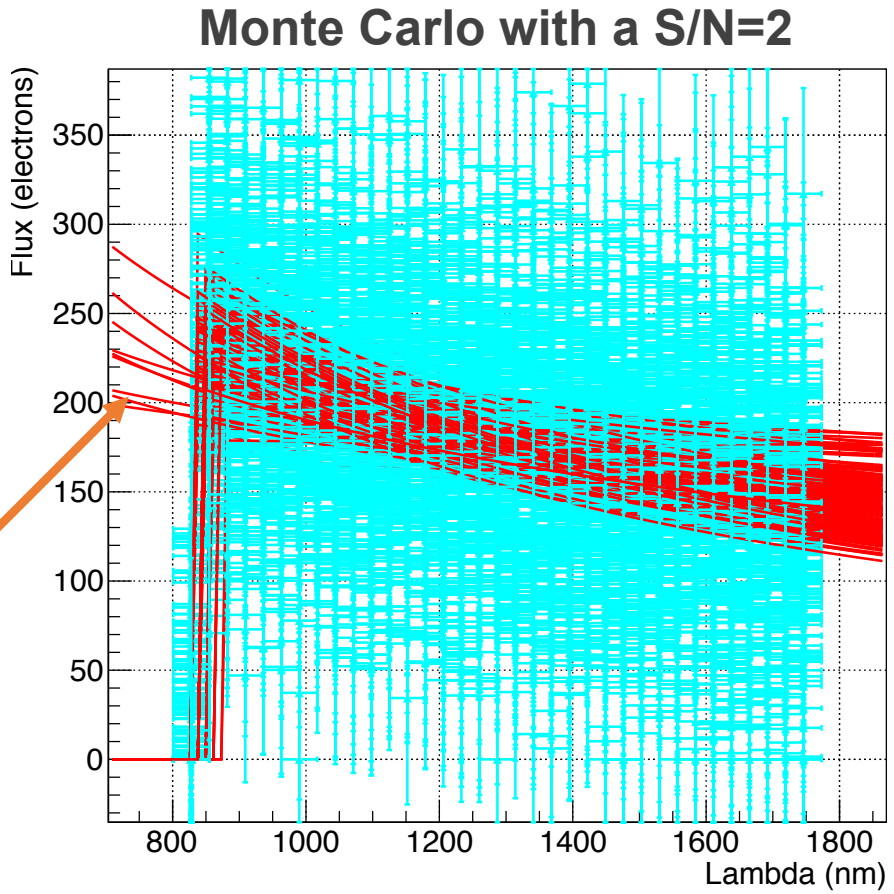
From D. Corre

The InfraRed Telescope (IRT)
- Redshift Performances -

Initial values:

- $Z = 6.0$
- $\beta = 0.66$

➡ ***With a S/N=2, possible to measure the redshift with an accuracy <10% and an efficiency of 90%…***

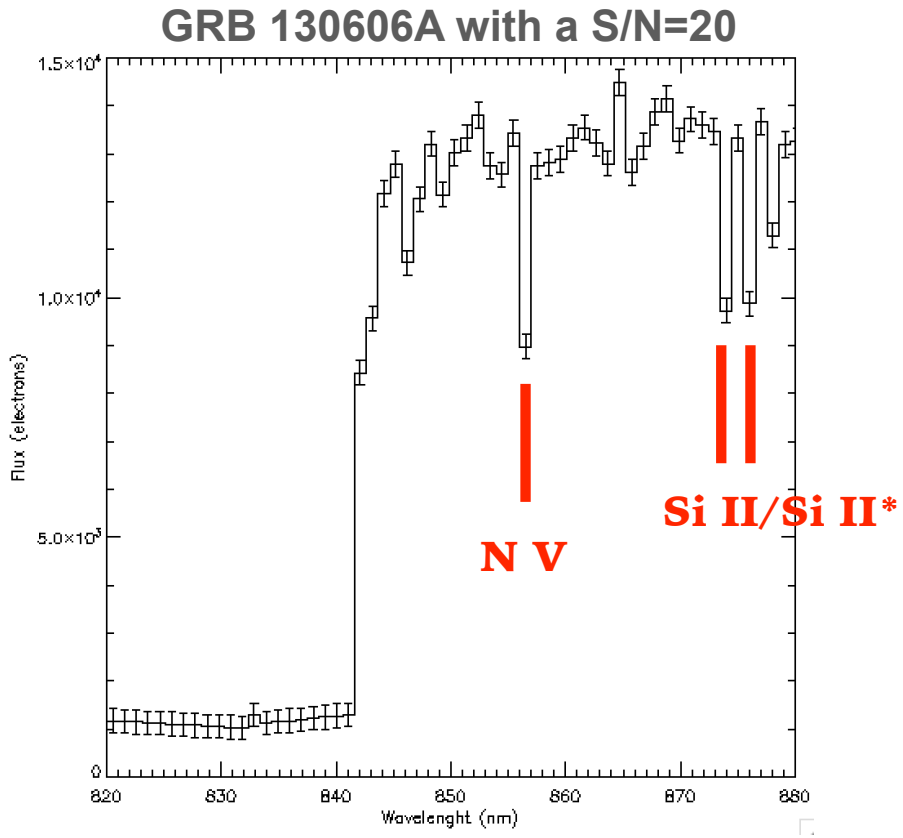


Fit having failed

The InfraRed Telescope (IRT)
- Redshift Performances -

Questions arise in this mode:
- The resolution is not so high and the sensitivity remains limited.
- Not easy to measure abundances…

➡ **The Theseus Science Study Team (TSST) is working on its optimization…**



The InfraRed Telescope (IRT)
- Risks Analysis -

- ✓ The opto-mechanical concept remains very classical and is largely based on the developments carried out on Euclid:
  - ➡ **No risk identified at this level.**

- ✓ The baseline for the sensor is the ALFA from Lynred (aka SOFRADIR):
  - ✓ Clearly not a mature sensor, but very important efforts from ESA to reach TRL5 in time for the M5 mission selection.
  - ✓ But the Teledyne sensor may be suitable and is already qualified.
    - ➡ **Manageable risk at this level of project definition.**