

living planet symposium

BONN
23–27 May
2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE



FORUM Payload: status and technical challenges

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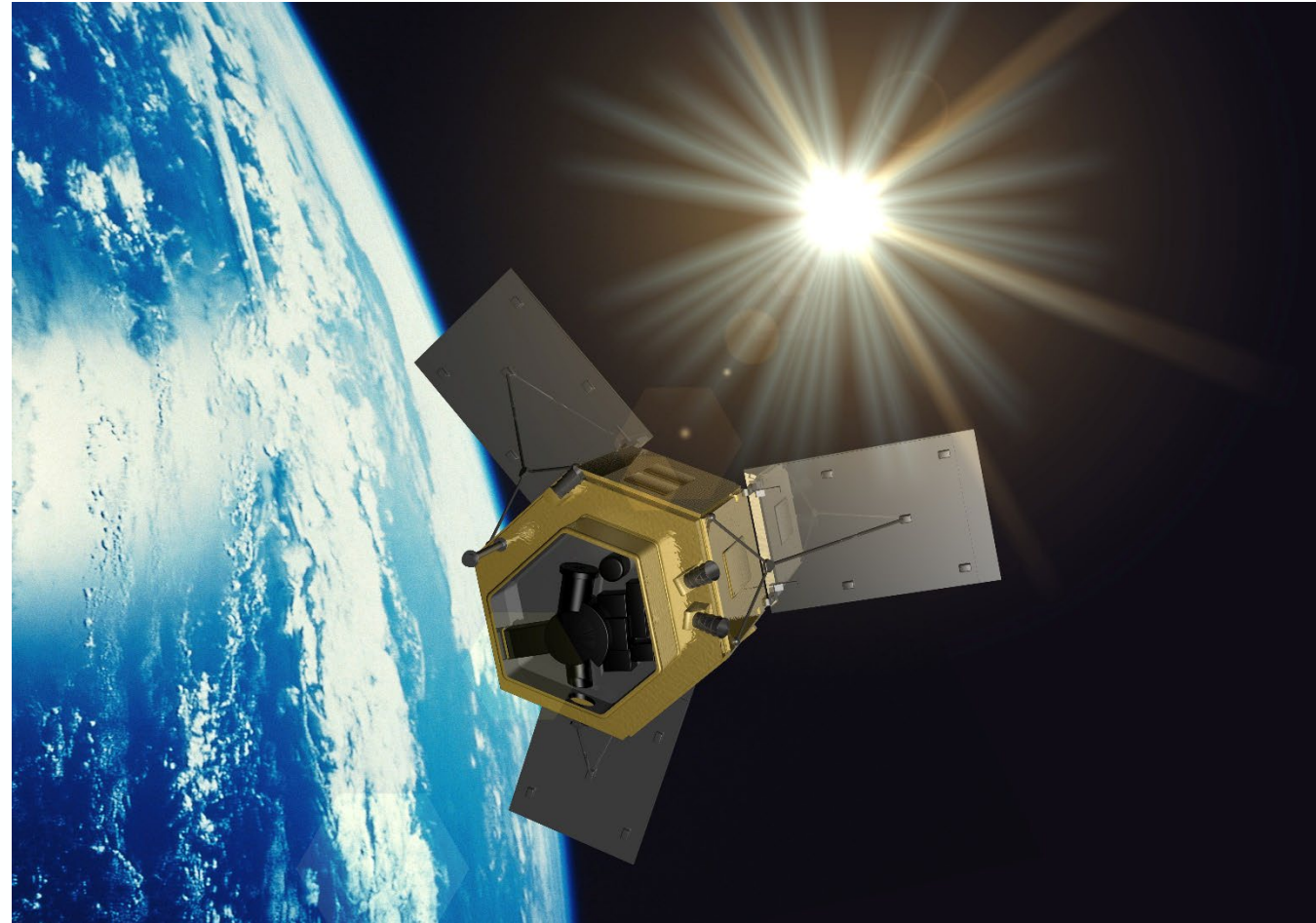
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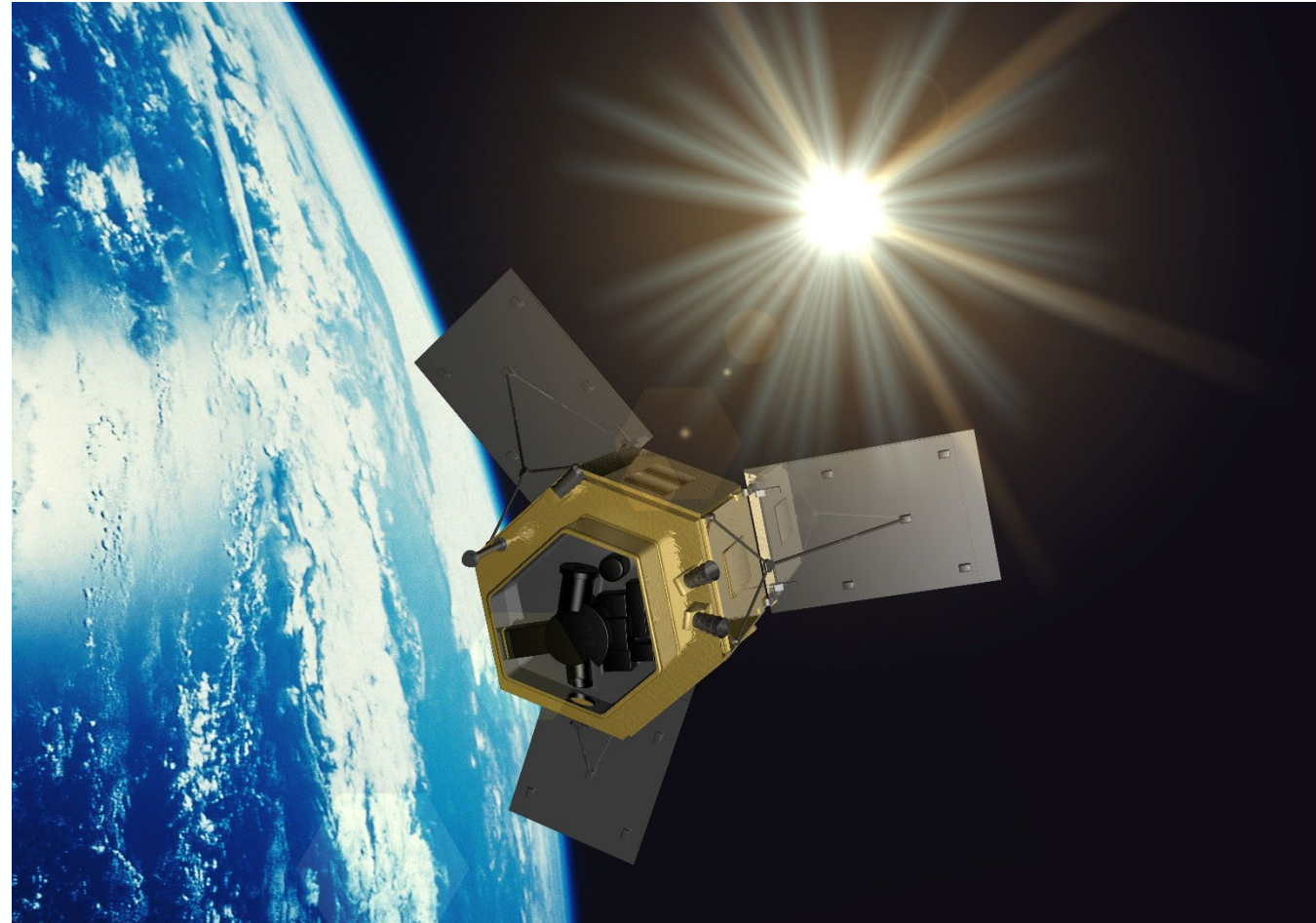
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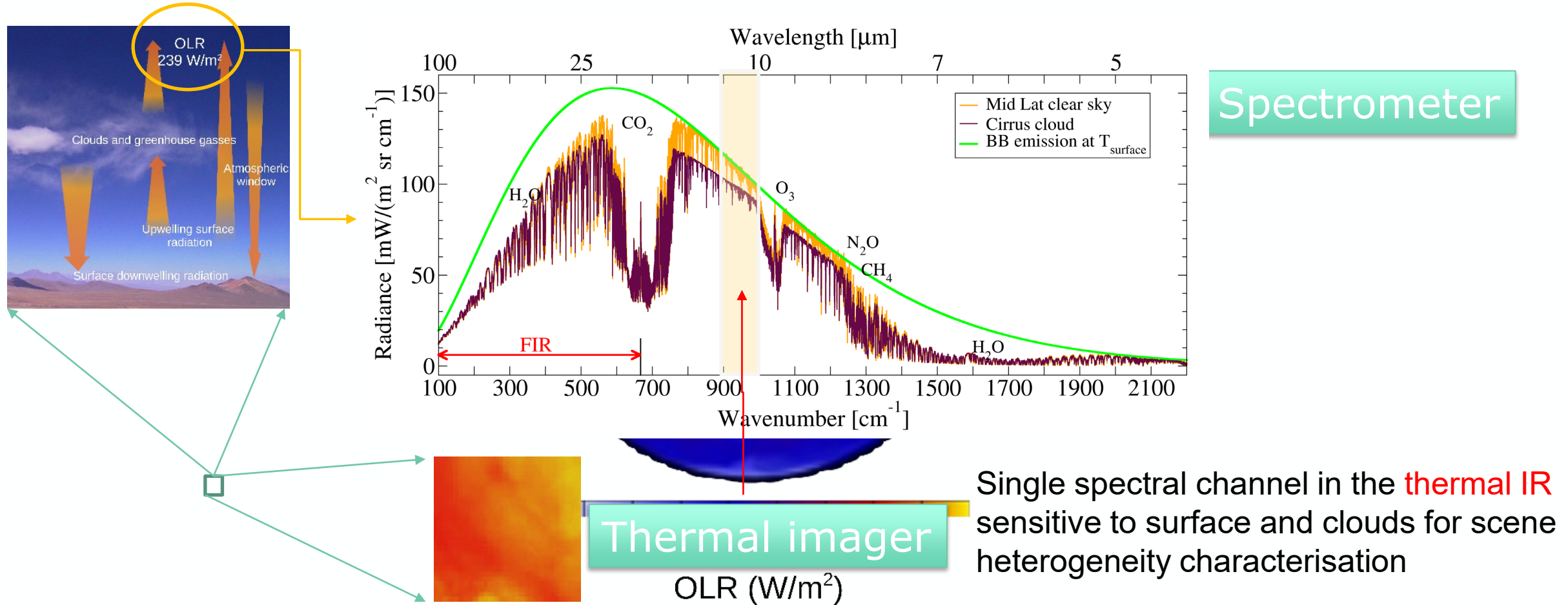
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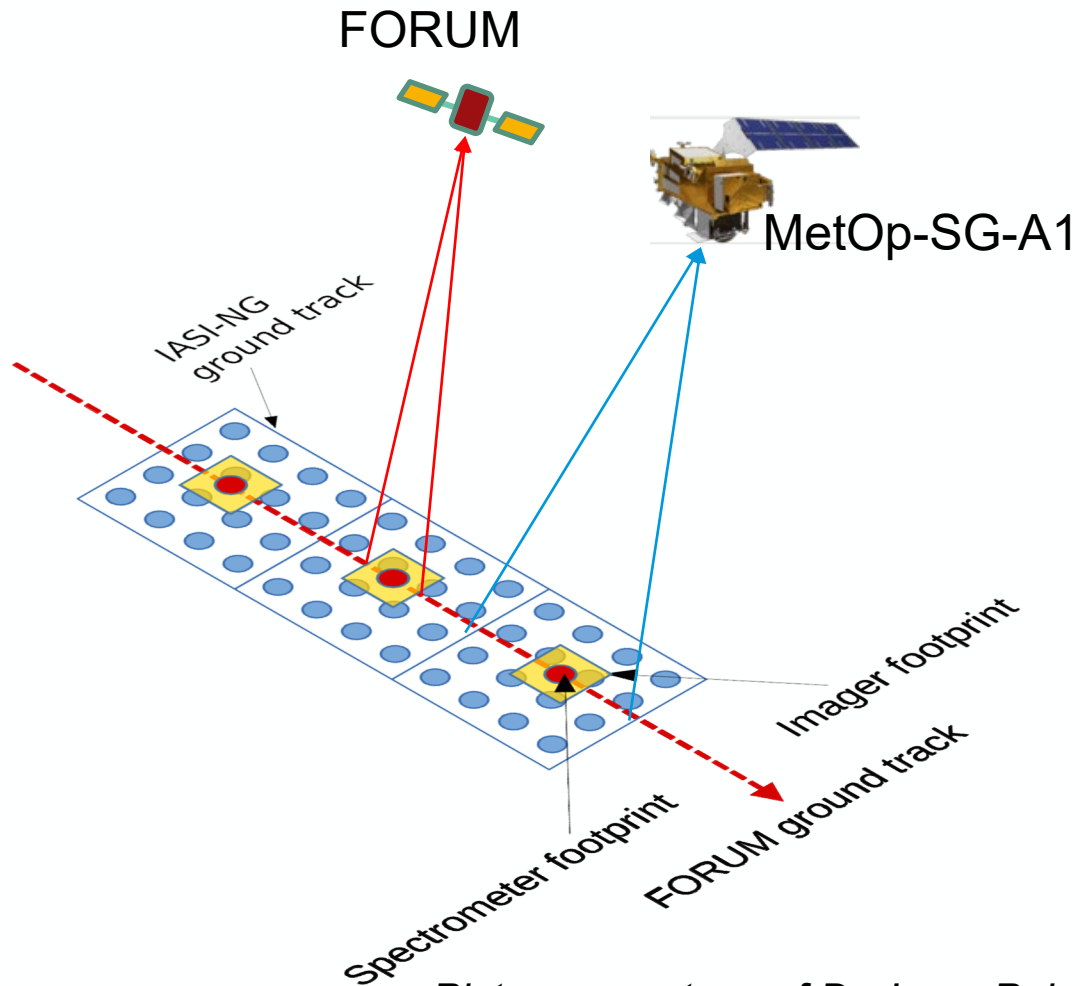
- **FORUM** – Far-infrared Outgoing Radiation Understanding and Monitoring
- Measure outgoing longwave radiation (between **6.25 μm and 100 μm**) at the top of atmosphere
- *Providing the necessary spectral coverage, resolution and radiometric accuracy to understand and quantify radiative processes*
- **Measure climate-relevant quantities**
 - Water vapour,
 - Ice clouds properties
 - Surface emissivity
- Measuring from space the missing range of the FIR (>15 μm)
- Flying in loose formation with the MetOp-SG satellite carrying the IASI-NG



Measurement of the spectrally-resolved radiance emitted by the Earth at Top-of-Atmosphere



Pictures courtesy of Dr. Luca Palchetti.



Pictures courtesy of Dr. Luca Palchetti.

Nadir-looking observations

Spectrometer footprint

- single circular **pixel $\varnothing = 15$ km**

Along-track sampling step

Requirement = 100 km

Thermal imager footprint

- 60x60 pixels, 36x36 km²
- **resolution = 0.6 km**

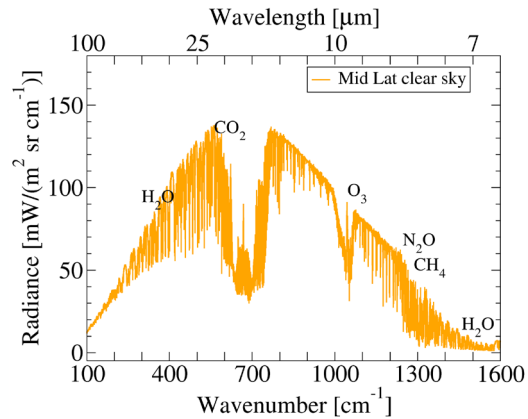
Lifetime = at least 5 years to resolve seasonal & inter-annual variability

Flight in **loose formation with MetOp-SG-A1**

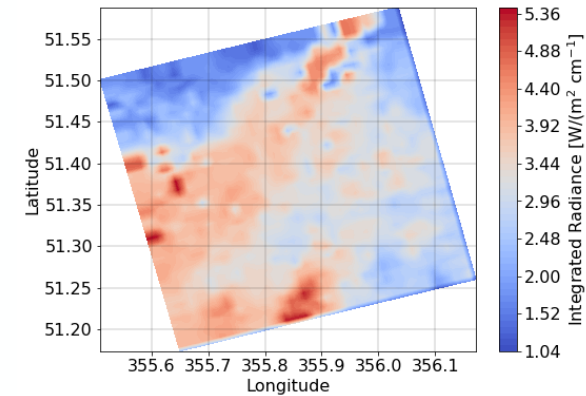
LEO, SSO at 9:30 LT DN – average altitude = 830 km to exploit synergy with IASI-NG

Main Mission Payload Requirements

Spectrometer = FORUM Sounding Instrument (FSI)

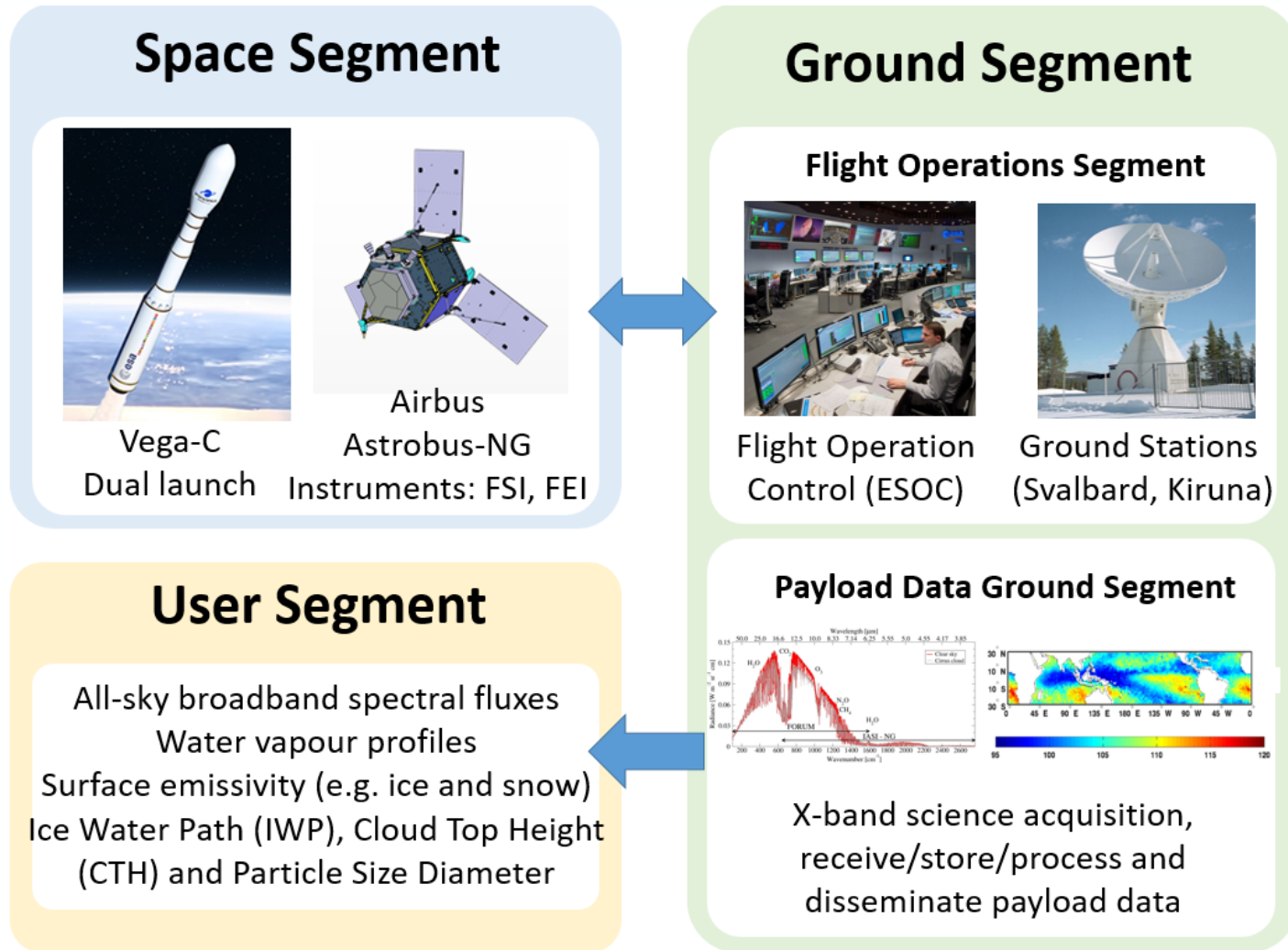


Thermal Imager = FORUM Embedded Imager (FEI)

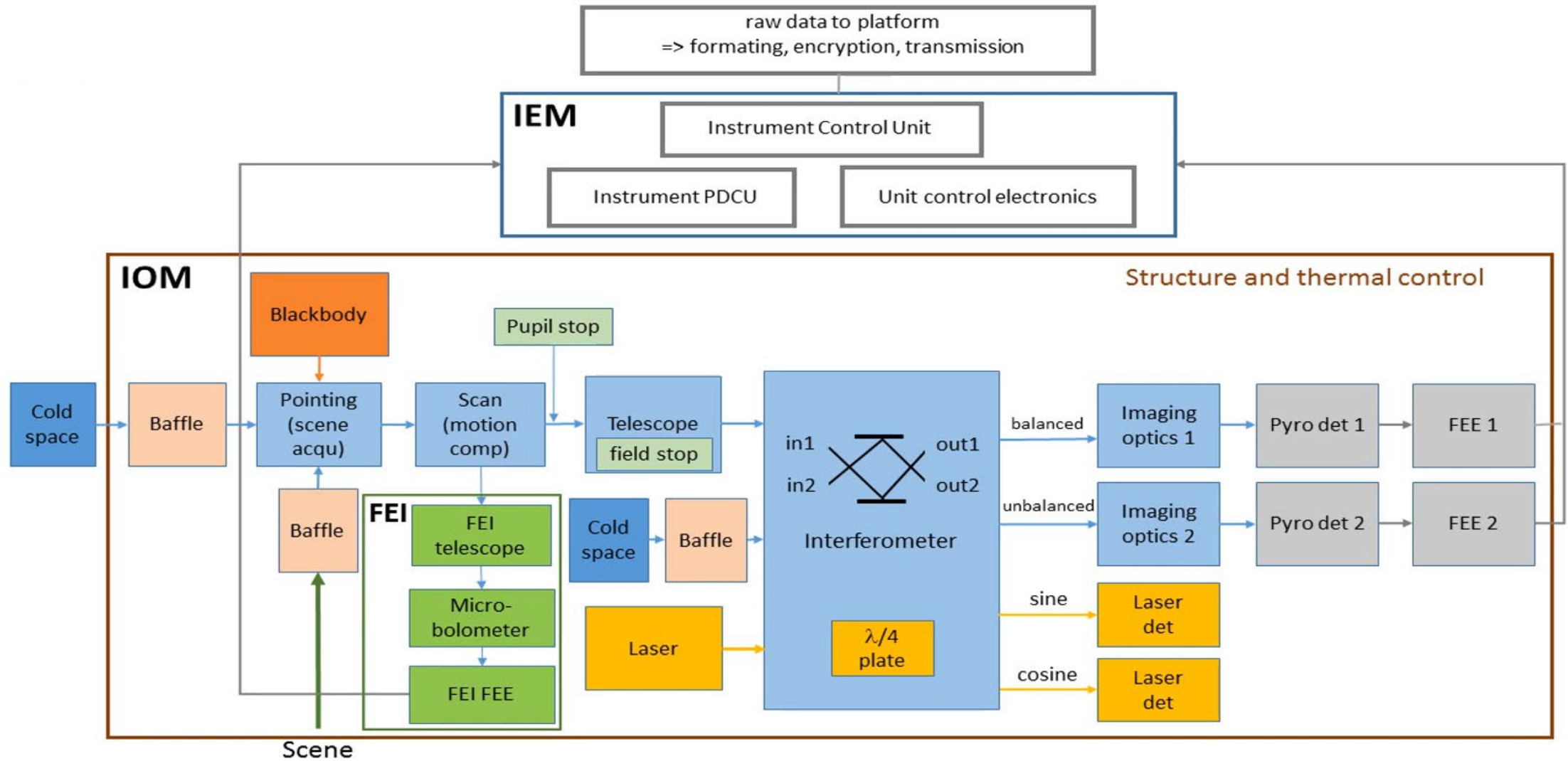


Parameter	FSI requirements
Spectral range [cm ⁻¹]	100-1600 cm ⁻¹
Spectral resolution [cm ⁻¹]	0.5 cm ⁻¹
Absolute Radiometric Accuracy (ARA), in terms of brightness temperature accuracy [K] in applicable range 190-300K	<0.1 K in [300-1100 cm ⁻¹], <0.2 K in [200-300 cm ⁻¹] and [1100-1300 cm ⁻¹], <1 K elsewhere
Noise-Equivalent Spectral Radiance (NESR) in [mW/(m ² sr cm ⁻¹)]	< 0.4 in [200-800 cm ⁻¹], < 1.0 elsewhere

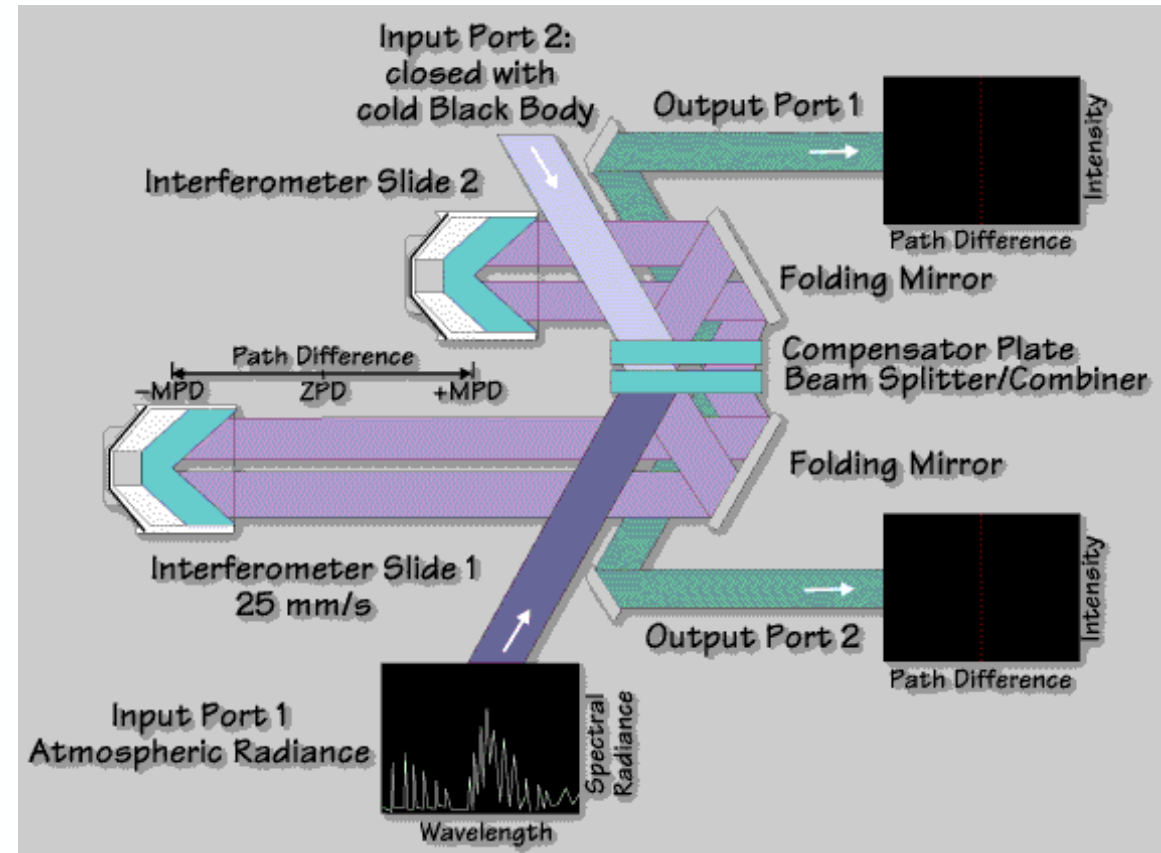
Parameter	FEI requirements
Spectral range [μm] goal	Centre: 11.5 μm, Width: 2.0 μm
Absolute Radiometric Accuracy (ARA), in terms of brightness temperature accuracy [K]	<2 K (goal 1 K) at 210 K reference temperature
Noise-Equivalent delta Temperature (NEdT) goal in [K]	<0.7 K (goal 0.3 K), At 210 K reference temperature

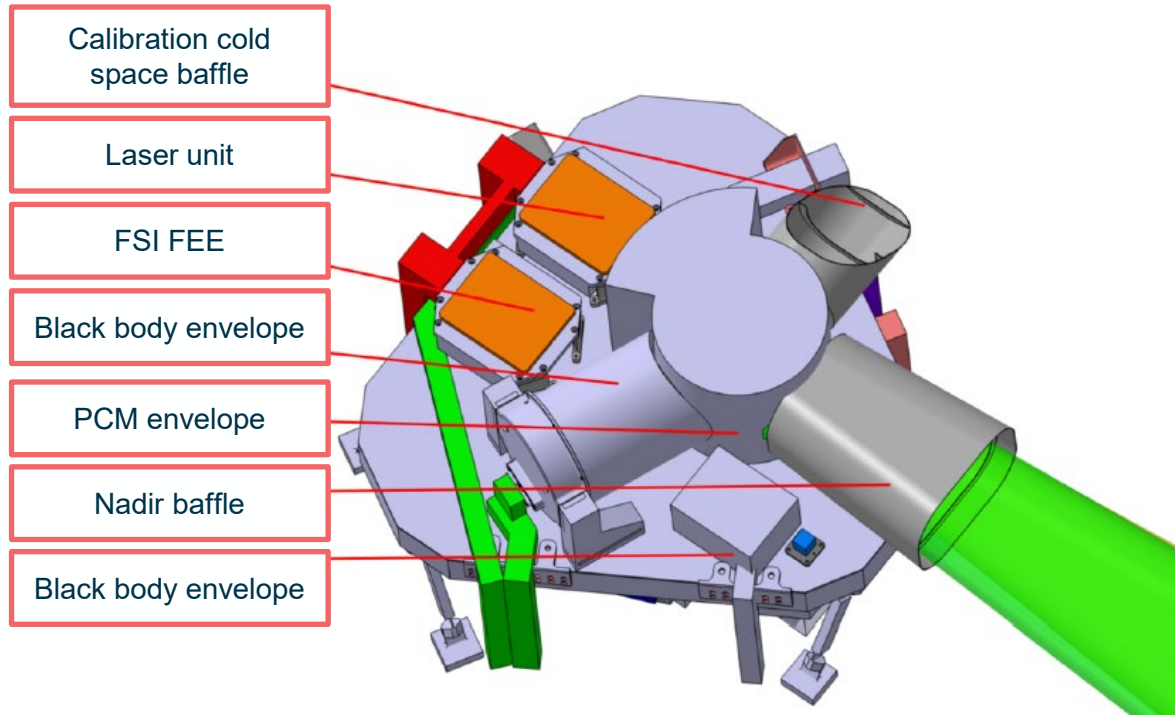


FORUM Payload block diagram

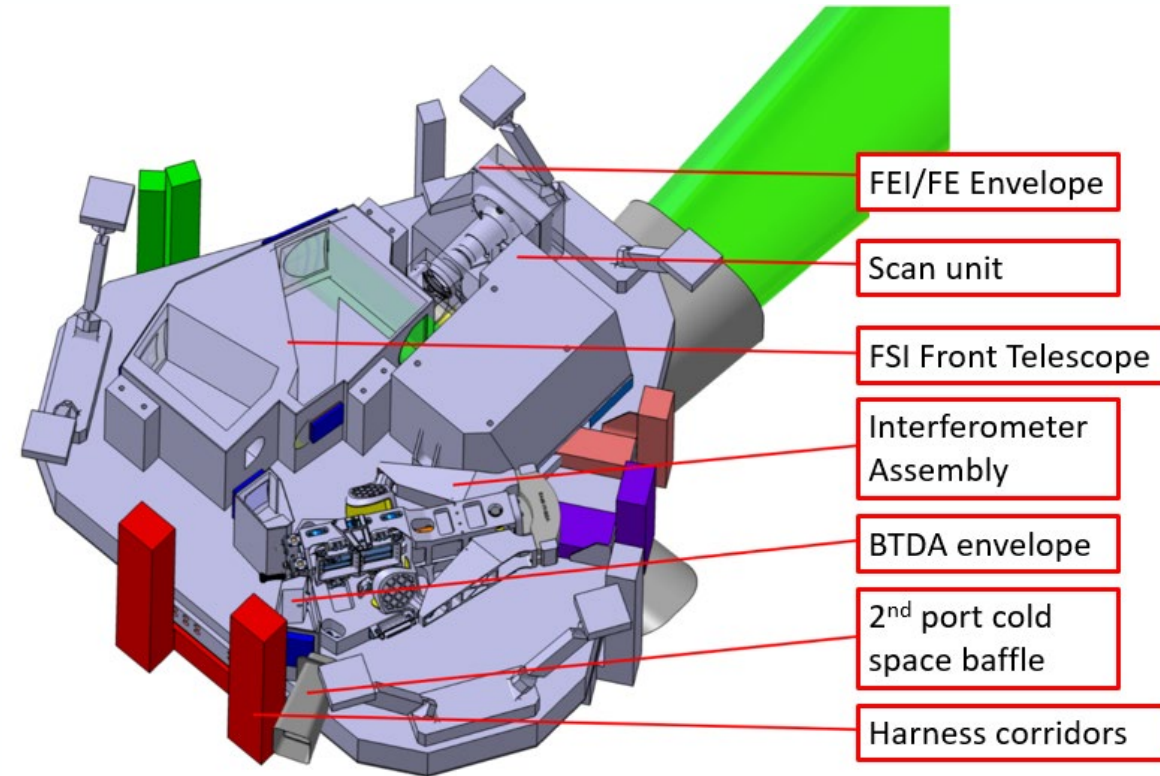


- The FSI is a Fourier Transform Spectrometer (FTS)
- It is a modified Michelson interferometer using double input-output concept
- The Optical Path Difference (OPD) is introduced by a double pendulum
- The FTS measures the interferogram, which is the radiance as a function of OPD
- By Fourier Transform of the interferogram, the spectrum is obtained in the 100-1600 cm^{-1} range (PDGS)

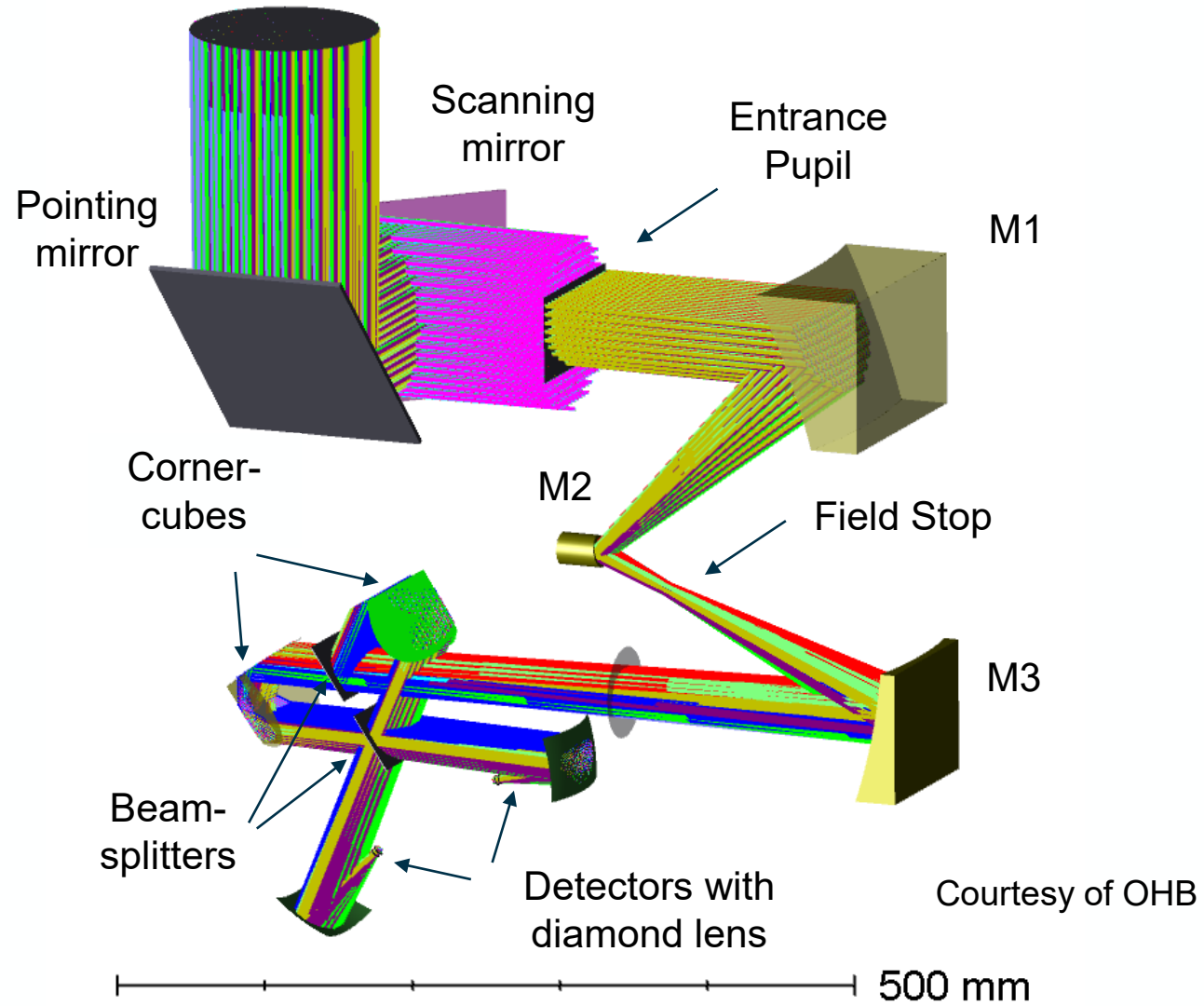


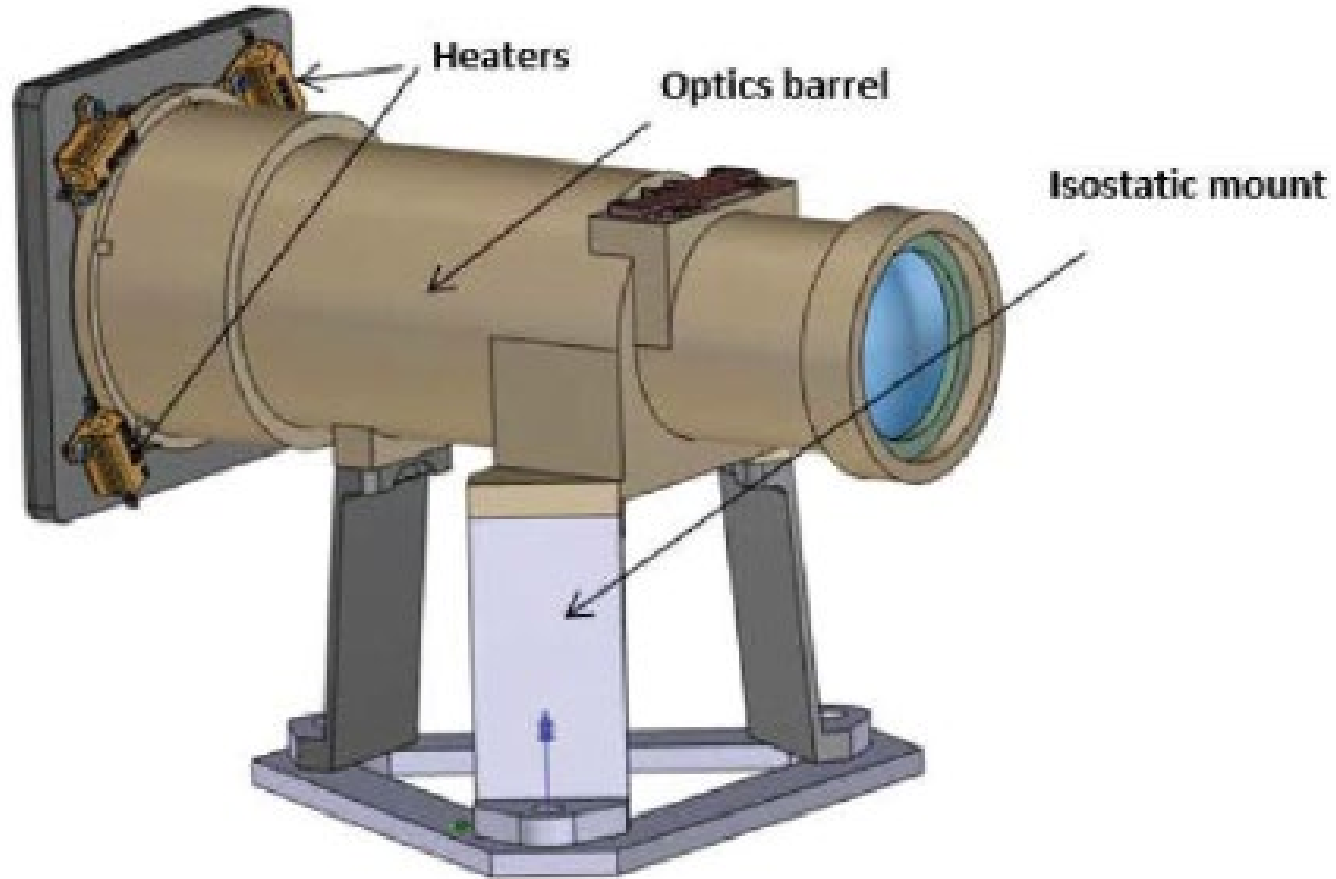


Top view of the FORUM Instrument Optical Module (IOM). Courtesy of OHB.



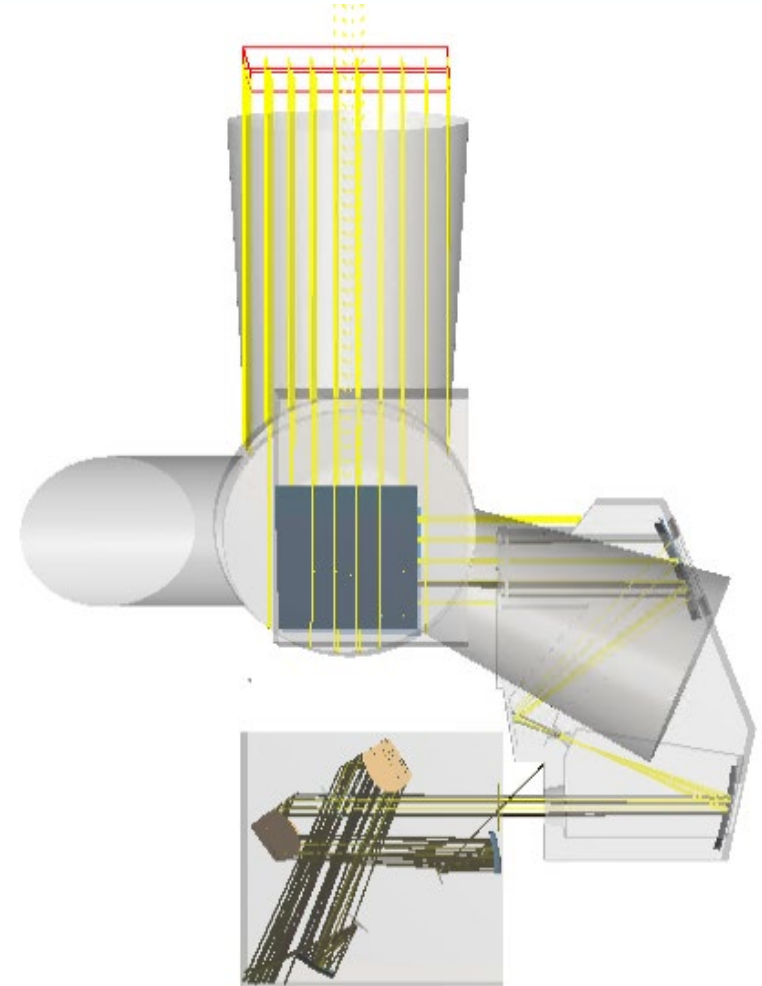
Bottom view of the FORUM Instrument Optical Module (IOM). Courtesy of OHB.



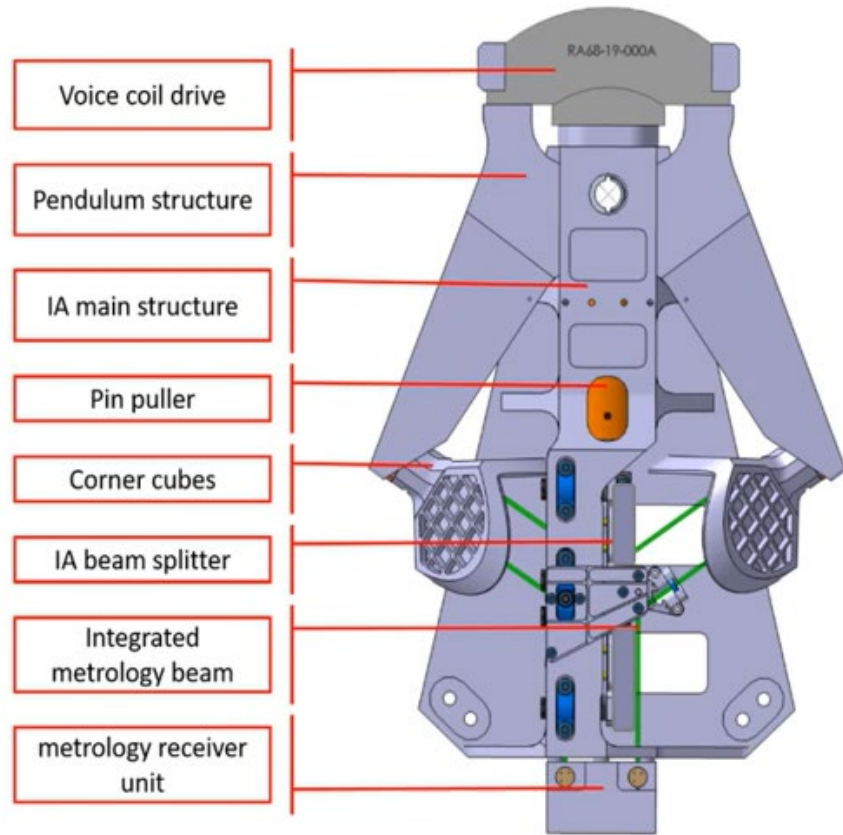


Courtesy of Leonardo

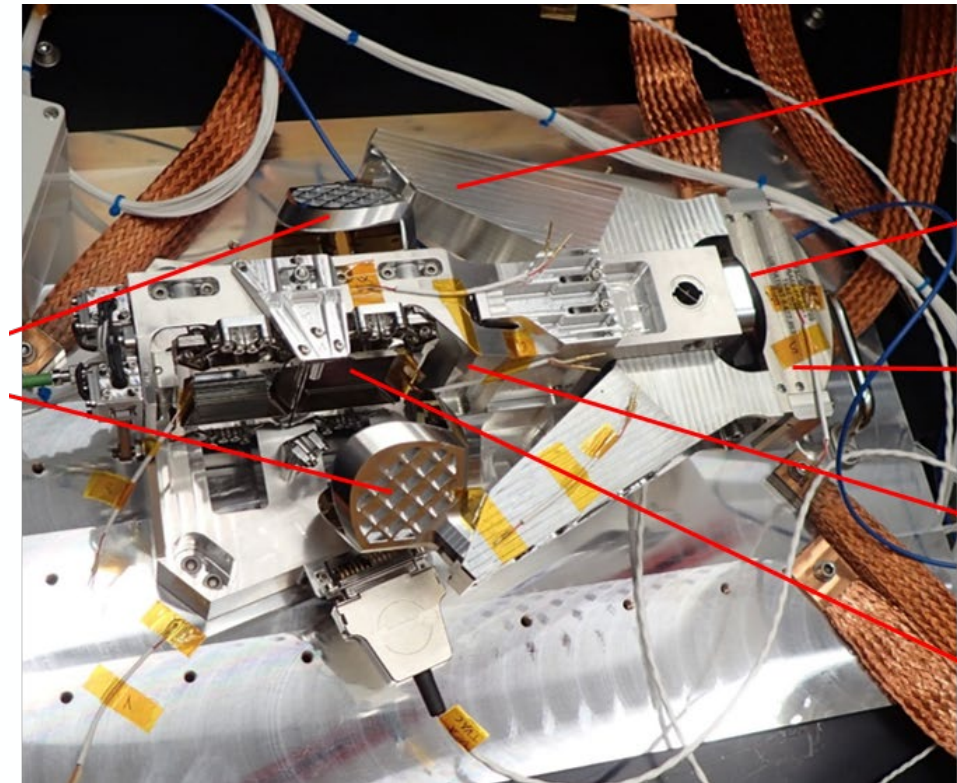
- Most critical requirements are **Absolute Radiometric Accuracy (ARA)** and **Noise-Equivalent Spectral Radiance (NESR)**
- Allocations are made (top-down) and by analyses / tests budgets are consolidated (bottom-up)
- Some of the critical components and their contribution are the following:
 - **Black-body calibration (ARA)**
 - **Stray light** from scene/black-body/cold space ports (ARA)
 - **Polarization (ARA)**
 - **Thermal stability**
 - **Micro-vibrations**
 - **Pendulum motion**



Pre-developments – Interferometer Assembly (IA)



The IA opto-mechanical design.
Courtesy of OHB



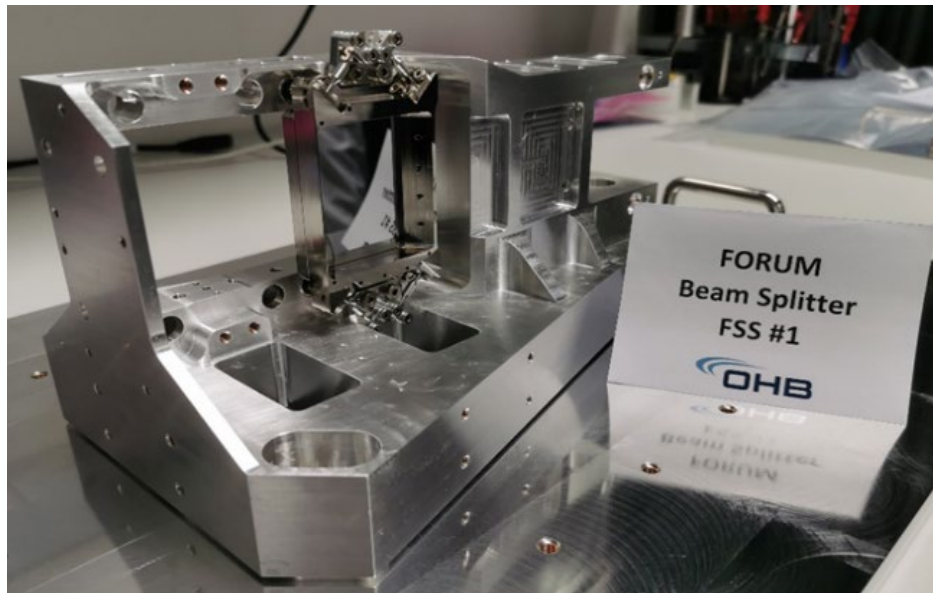
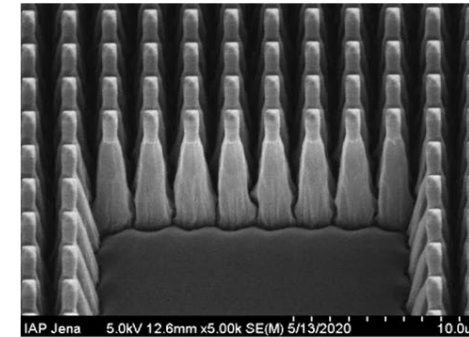
Corner cubes

The IA was extensively tested and TRL5 was achieved during phase B1. Courtesy of OHB.

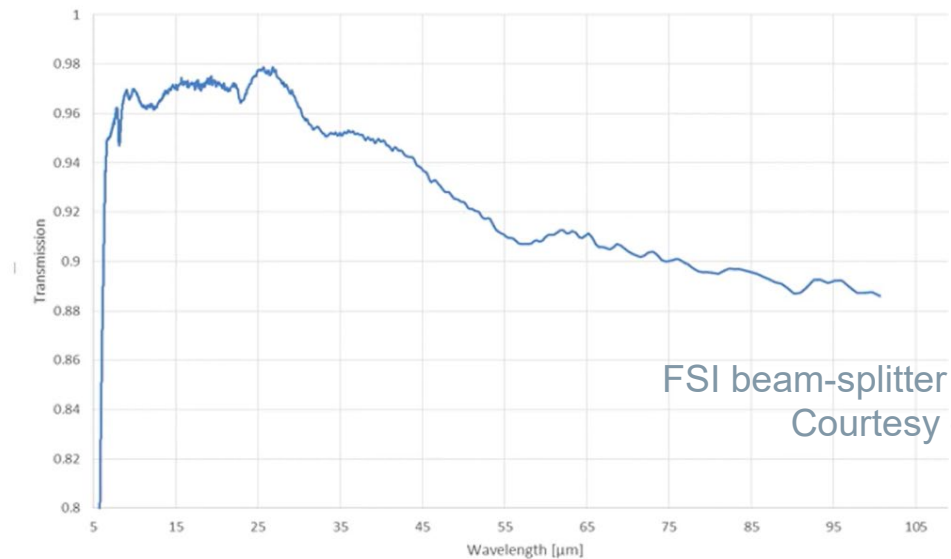
Pre-developments – FSI beam-splitter

- Beam-splitter substrate diamond, made by CDV
- Wedged to decrease ghosts
- Splitting side – Ge coating
- AR surface – microstructured surface, periodic structure, several micron high
- AR transmission ~93%
- EM test: thermal-vacuum, vibrations, shock, etc.

Beam Splitter with Germanium Coating on Front Surface
Microstructures on Rear Surface as Broad Band Anti-Reflective Coating

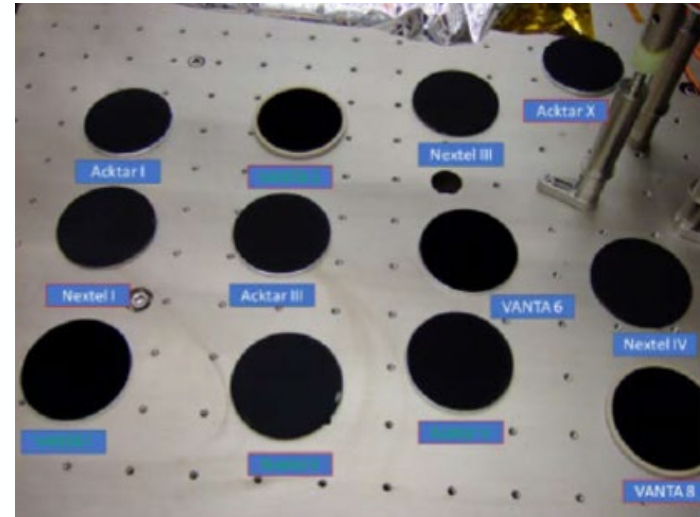


IR Transmission of Microstructured Diamond Surface (6.25 μ m - 100 μ m)

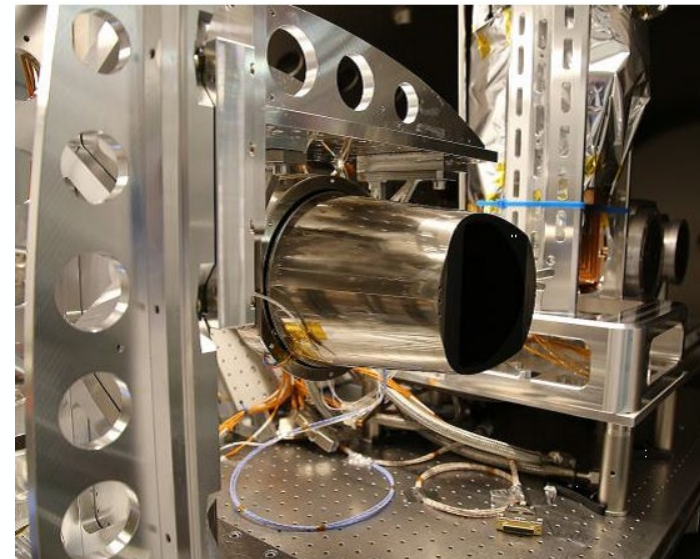


FSI beam-splitter (TRL6).
Courtesy of OHB.

Black-coated samples prepared for environmental tests. Courtesy of Micos.



The assembled FORUM blackbody (TRL5).
Courtesy of PTB.



- **Main Industrial consortia established** led by Airbus UK (system prime) with OHB D (payload prime)
- **Launch of the satellite planned for 2027**
- FORUM requires several additional **novel developments and campaigns** requiring new Airborne and Ballon-based instruments, and test facilities
- Preparation of adequate **End to End simulation** environments for L1 and L2 products with **synergies with IASI-NG**.

Our Earth Explorer 9 is a challenging mission that will uncover exciting information allowing the understanding of the evolution of our *Climate*

We all are very excited to begin this adventure...

Question?