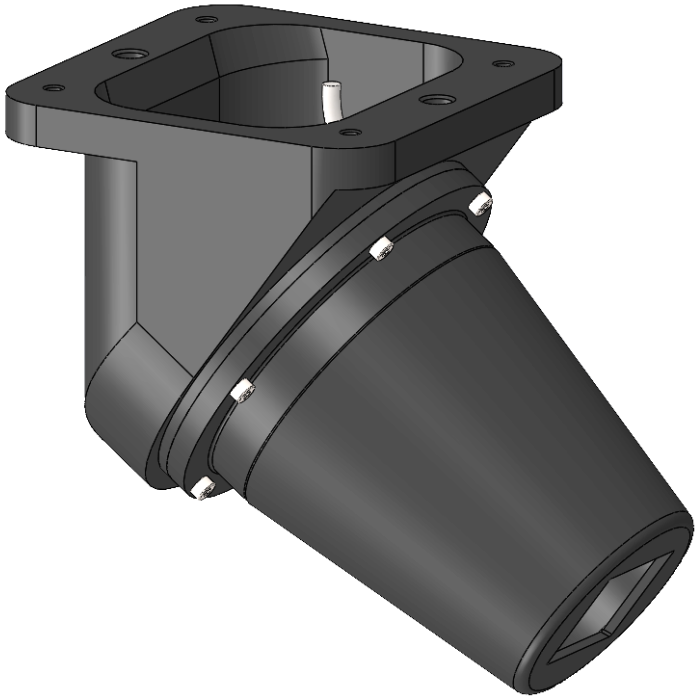
Mechanical Design Concept Challenges for the THESEUS InfraRed Telescope's Calibration Unit

FIKUT 2026
04-06 November 2026 Budapest, Hungary



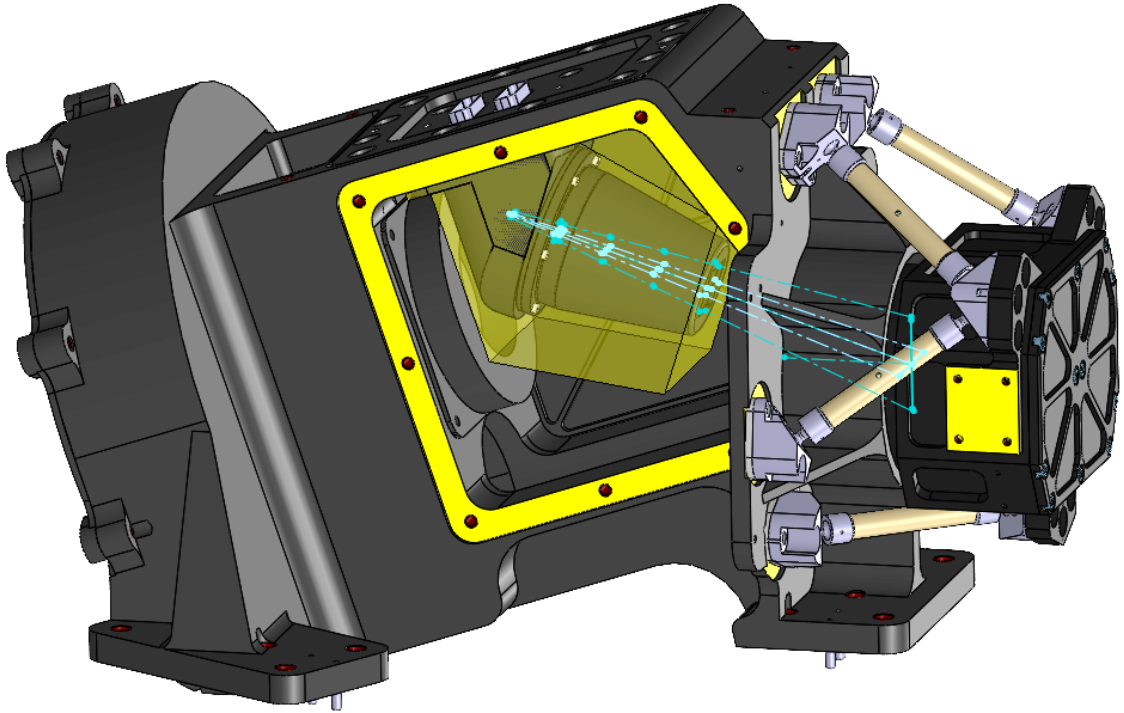
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Goal of the Calibration Unit

- Goal: characterise the detector across the five photometric bands of the Infrared Telescope (IRT)
- Using LEDs as light sources
- Off-axis alignment inside Camera cavity
  - No moving parts needed
  - Smaller volume
- High spatial uniformity
  - Inhomogeneity <1% small-scale, 10% on whole detector surface
- Low straylight level
  - No emission when switched off
- EUCLID NISP calibration unit as heritage

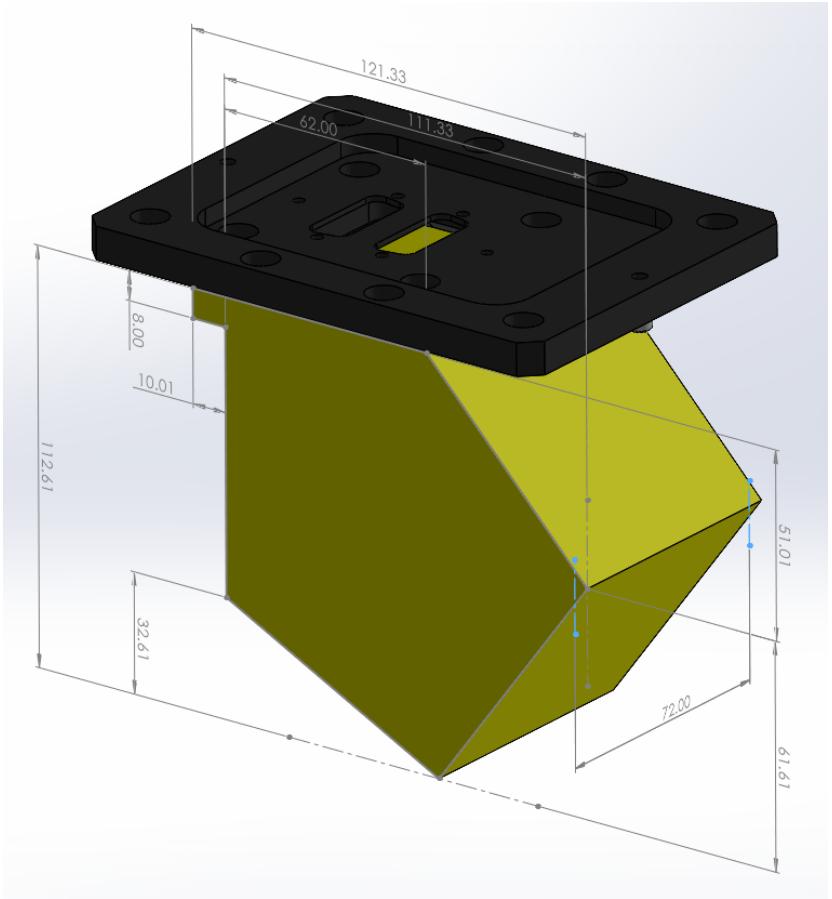


Design challenges for the Calibration Unit

- Tight volume
  - Fit 10 LEDs, 2 for each wavelength

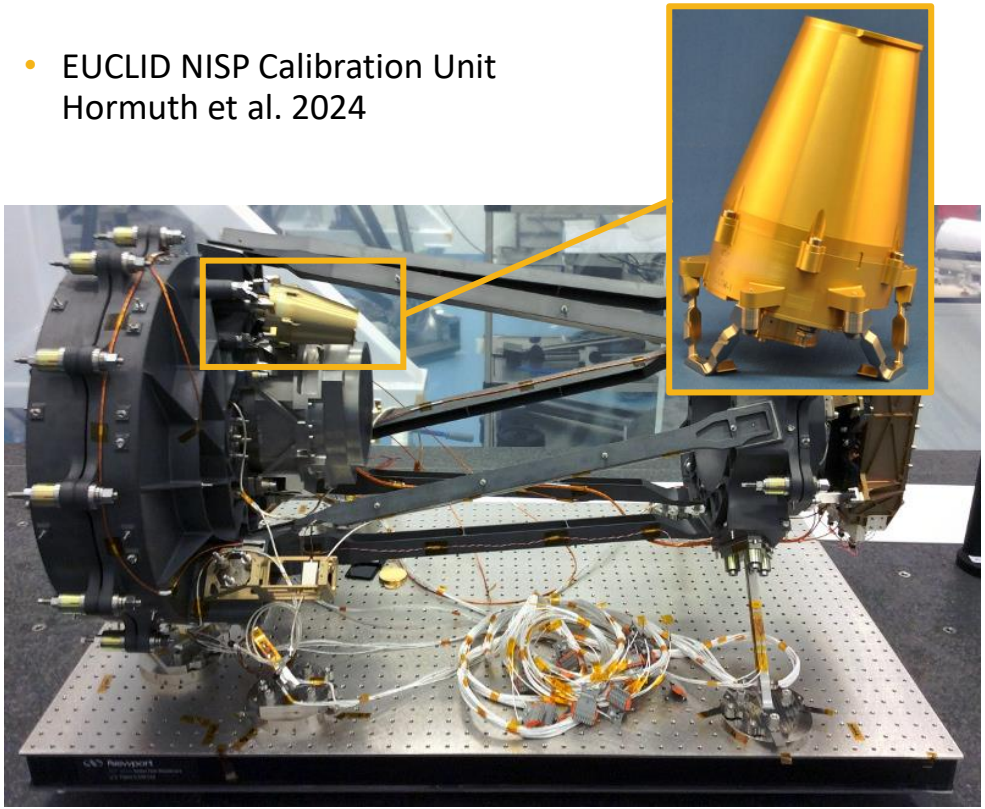
I	731 – 881 nm
Z	825 – 975 nm
Y	960 – 1080 nm
J	1115 – 1325 nm
H	1475 – 1785 nm

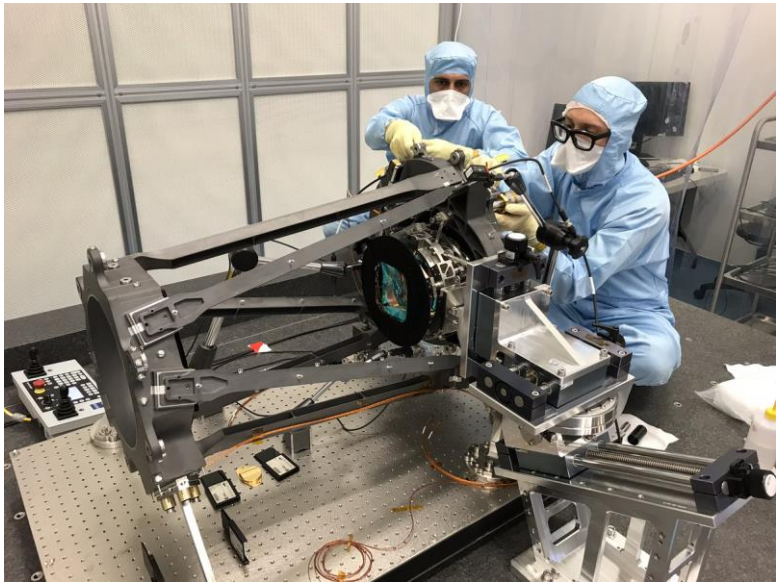
  - Fit optical system
- Short optical path – homogeneity, cutoff
- Closed environment – straylight, thermal management
- 0.7kg total mass budget (+margin)



NI-CU

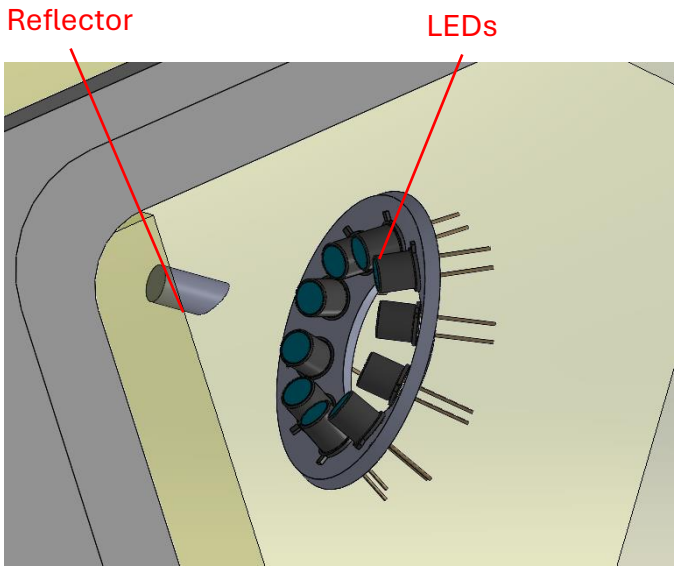
- EUCLID NISP Calibration Unit
  Hormuth et al. 2024

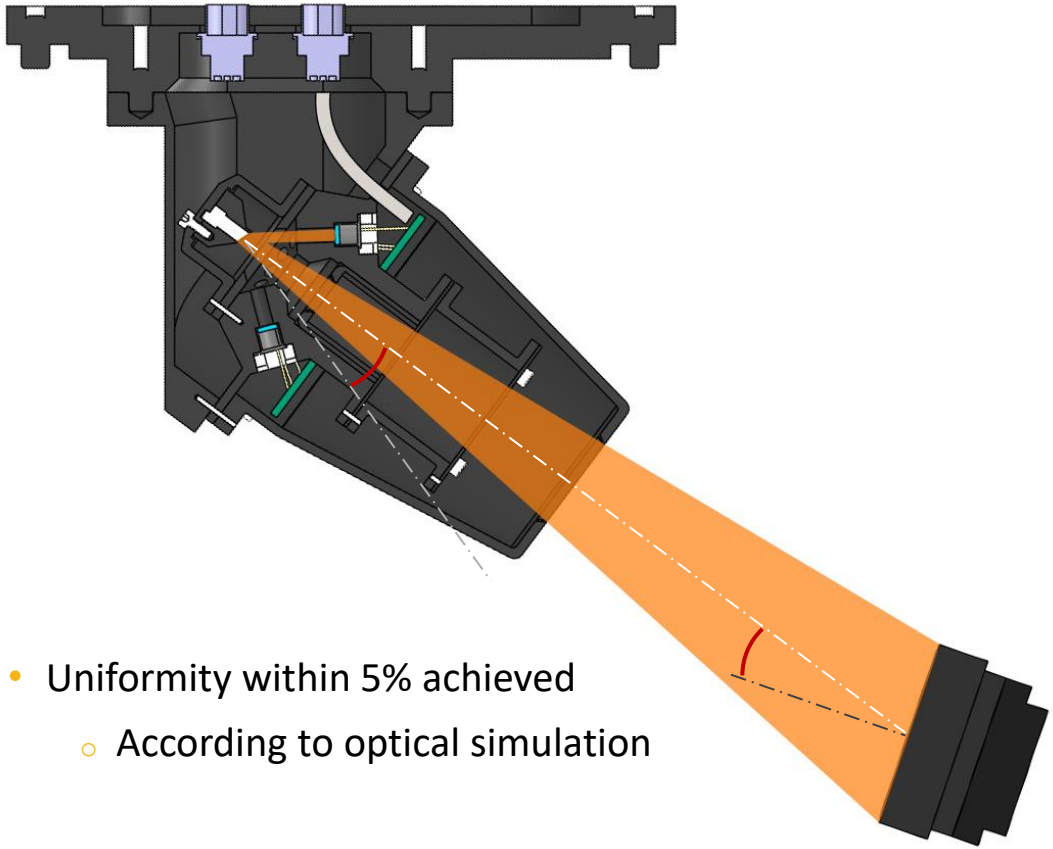




Solving optical challenge: Homogeneity

- LEDs pointed at Reflector with tilted surface
  - EUCLID heritage
  - Lower gradient on detector

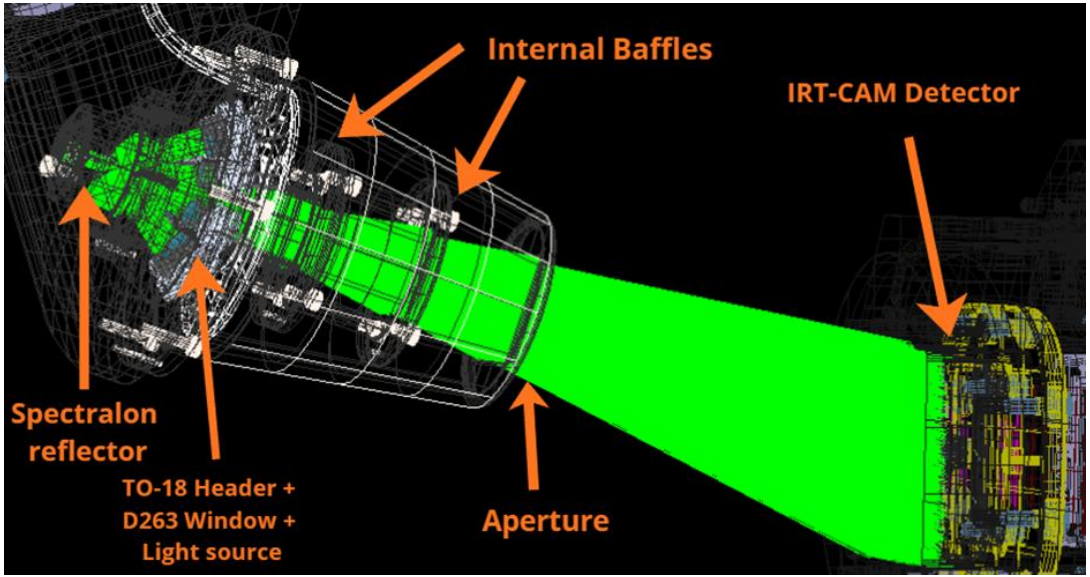




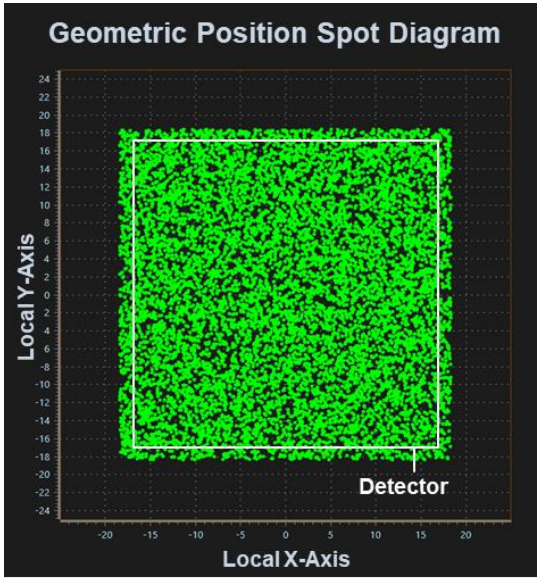
- Uniformity within 5% achieved
  - According to optical simulation

Solving optical challenge: Alignment

- Larger illuminated surface
  - Compensates misalignments caused by thermal movements and tolerances
- FRED iterative optical modelling for optimisation



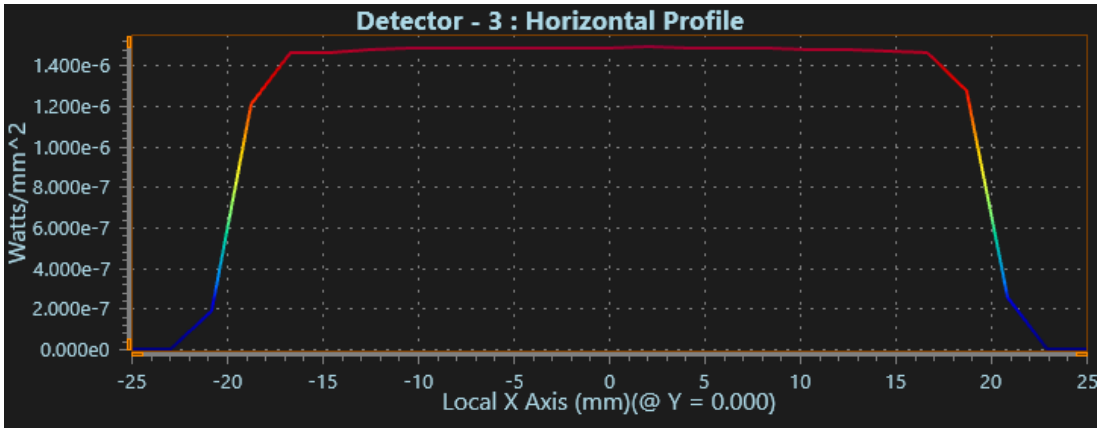
Optical modelling



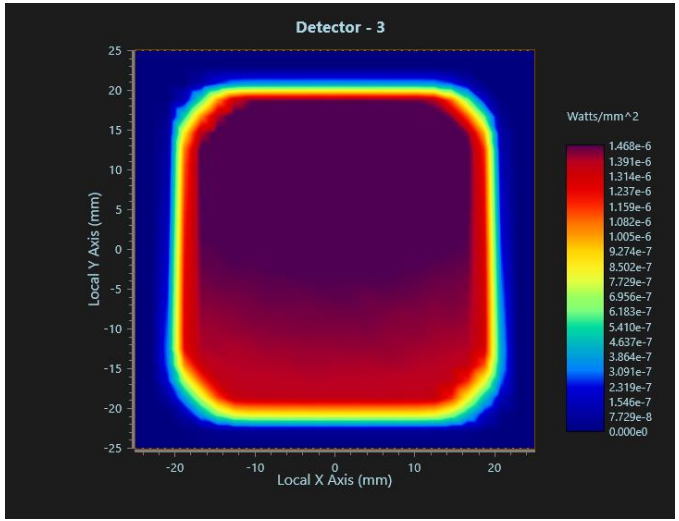
Good alignment

Solving optical challenge: Straylight

- Baffle system & aperture
  - sharp cutoff at illumination edge minimises straylight
- Anti-reflective coating (PNC)
- Result: preliminary design fulfils the alignment and homogeneity requirement (<10% full detector)
- more in Bendegúz's talk



Illumination profile



Illumination

Solving mechanical challenge: Volume and mass

- Compact design
  - 10 LEDS with PCB connection and harnessing
  - Reflector and reflector housing
  - Baffle system
  - Housing and aperture
  - Mounting bracket
- Structural parts material: Al 6061-T6
- Mass so far well within budget (~0.34kg)

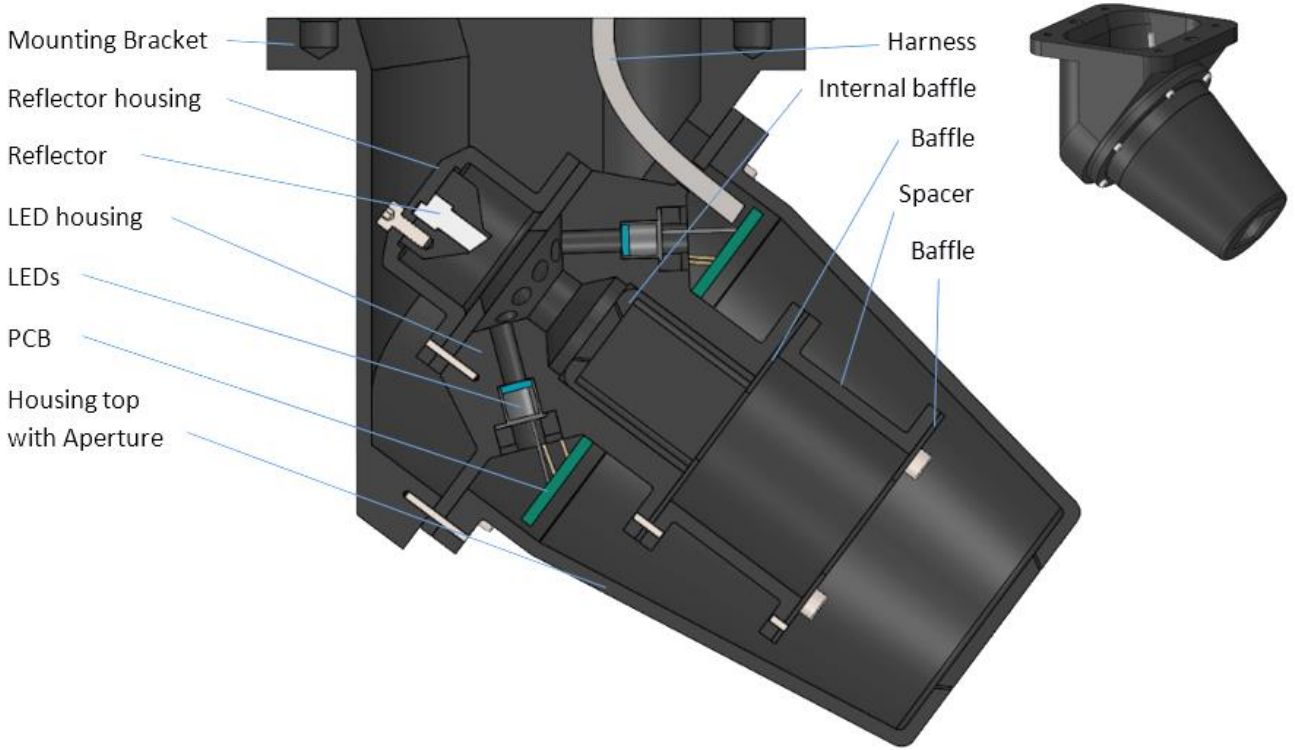
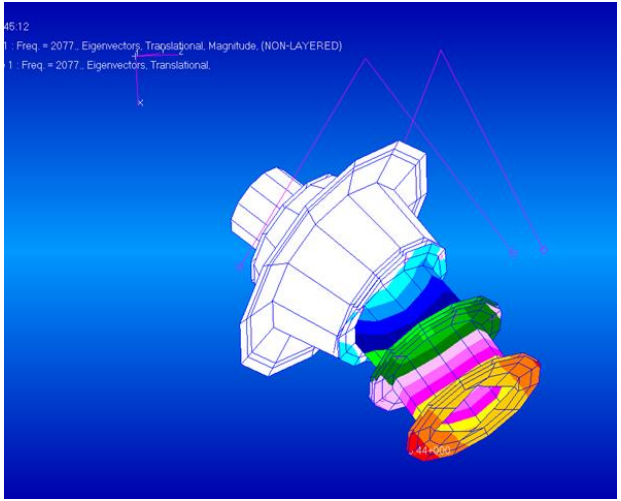


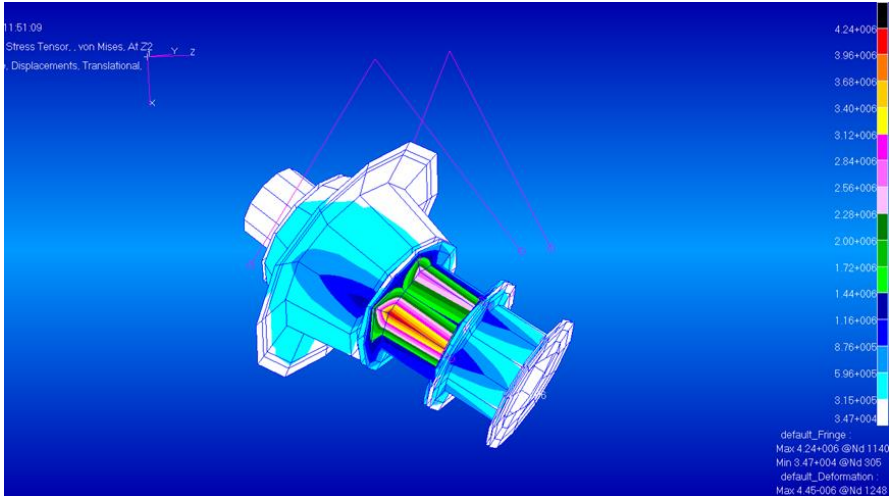
Figure 3: Calibration Unit Section with full view in top right

Solving mechanical challenge: Mechanical analysis (ADMATIS)

- Preliminary structural analysis (PATRAN/NASTRAN): Results good – high eigenfrequency, small loads
  - Fixation with aluminium bracket is more rigid, so the „worst case” has been analysed
  - First eigenfrequency is above 2000Hz with ideally rigid fixation
  - Maximum stress under 60g quasistatic load along all axes is less than 5MPa
  - Identified risk: Thermo-elastic loads between LED and housing could cause performance loss -> Mitigated with Alignment strategy



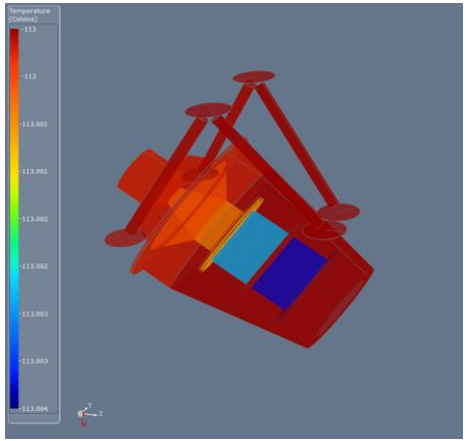
Deformation analysis



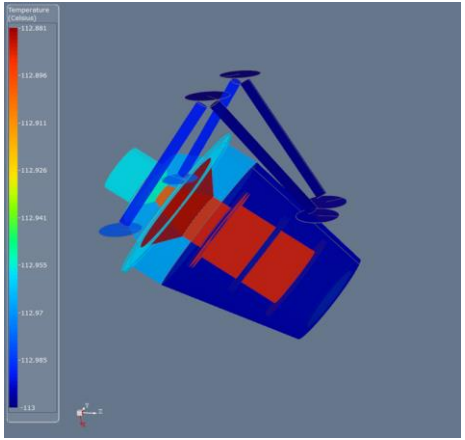
Stress analysis

Solving mechanical challenge: Thermal analysis (ADMATIS)

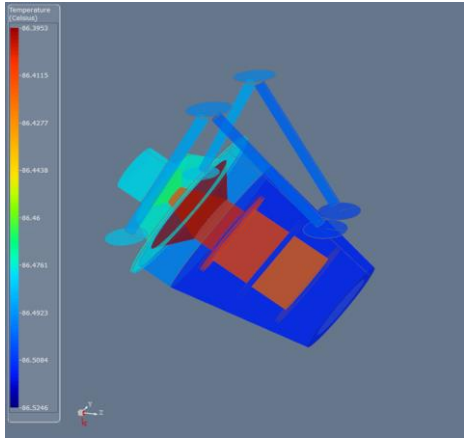
- Preliminary thermal analysis: Results good – good conductance within assembly
  - Nominal cold case temperature (CU is OFF) is defined by the baseplate temperature
  - Nominal hot case temperature (CU is ON) is also defined by the baseplate temperature
  - Extreme hot case temperature (CU is ON & no conduction at mounting the Interface) is defined by Camera cavity temperature resulting about 27K temperature increase compared to nominal hot case)
    - Identified risk: CU temperature highly depends on conductive path (trapdoor, IRT structure) and sligthly depends on parasitic heat through harness -> mitigated in Interface requirements definition



Nominal cold case temp.



Nominal hot case temp.

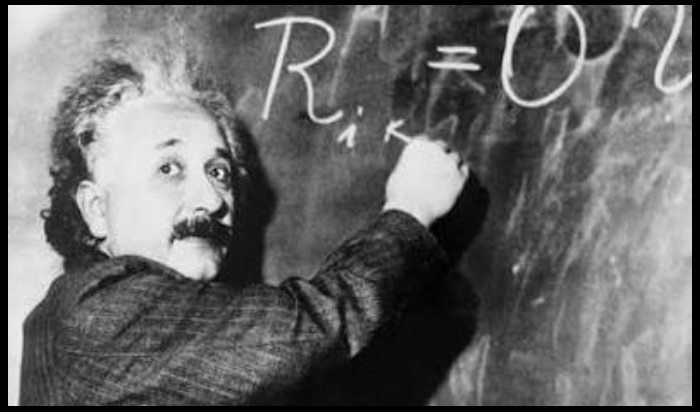


Extreme hot case temp.

ESA Project



What my parents think I do



What my friends think I do



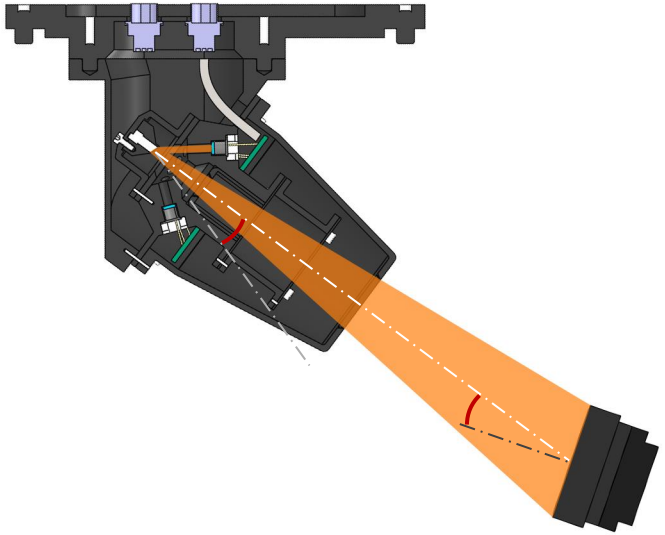
What I think I do

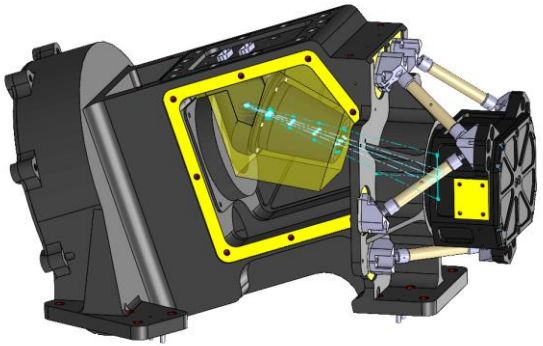


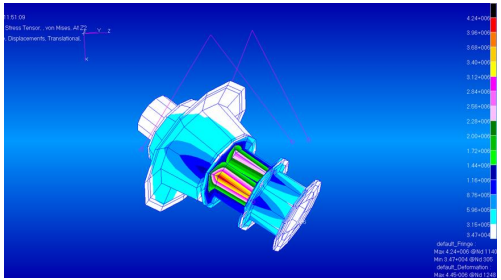
What I really do

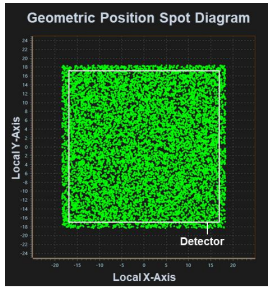
Summary

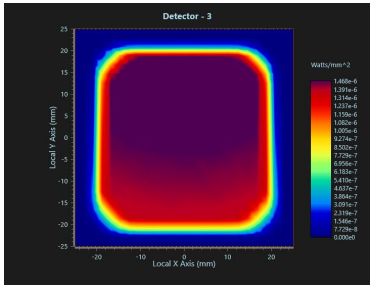
- Optical challenges solved
  - Homogeneity
  - Alignment
  - Straylight/cutoff
- Mechanical challenges solved
  - Tight volume
  - Mass budget
  - Mechanical loads
  - Thermal stability
- Well within requirements

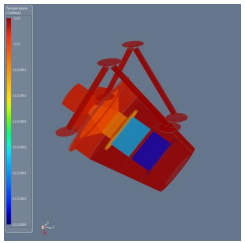


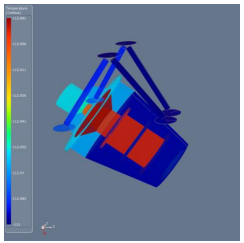












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