IRT CU Status

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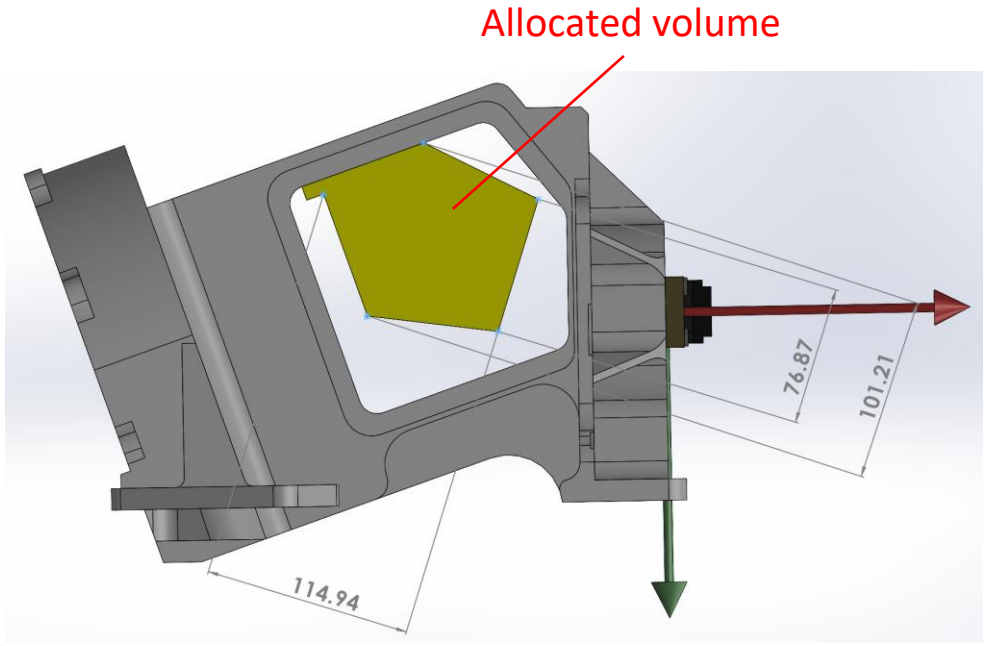
Goal of the Calibration Unit

- Goal: characterise the detector across the five photometric bands of the Infrared Telescope (IRT)
- Using LEDs as light sources
  - Redundancy: 2 sources for each of the 5 bands, 10 LEDs
- Off-axis alignment inside Camera cavity
  - No moving parts needed
  - Smaller volume
- High spatial uniformity
  - < 1% small-scale, 10% on whole detector surface
- Low straylight level
  - No emission when switched off
- EUCLID NISP calibration unit as a “model”

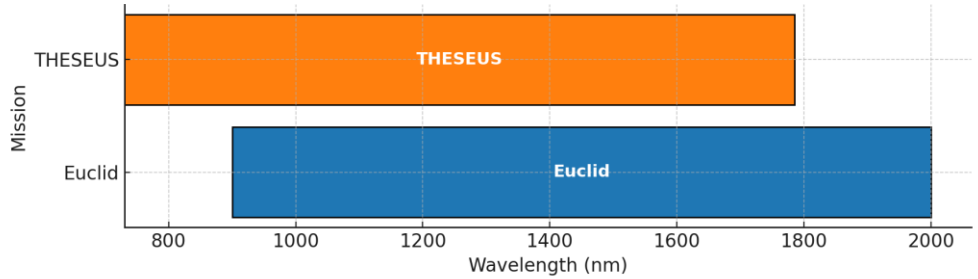


I	731 – 881 nm
Z	825 – 975 nm
Y	960 – 1080 nm
J	1115 – 1325 nm
H	1475 – 1785 nm

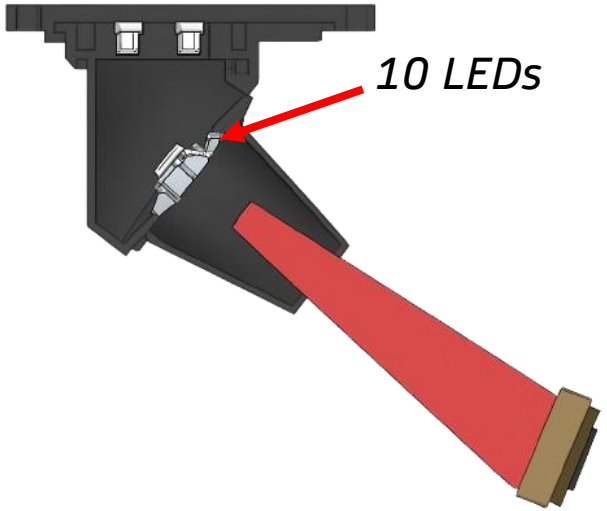
Major challenges

- **1st challenge**: we can’t use the Euclid NISP calibration LEDs (wavelength range, provider)
- **2nd challenge**: IRT_CUA volume < EUCLID NISP, but we need to fit in the same functions
- **3rd challenge**: required high homogeneity at the detector
- **4th challenge**: minimizing straylight
- **5th challenge**: finding H space industry partners

Note: It will be the 2nd time to build an LED based calibration unit in Europe, but we can not simply “copy and paste”.



Wavelength Coverage



IRT CUA M5 baseline design

The LED substitution challenge and the solution – LED manufacturers

Market research -> Potential manufacturers:

- Euclid heritage: Epigap
- HUN Team market research: *Thorlabs, TechLED*
- ESA - Alter study: InPhenix, Hamamatsu, Superlum

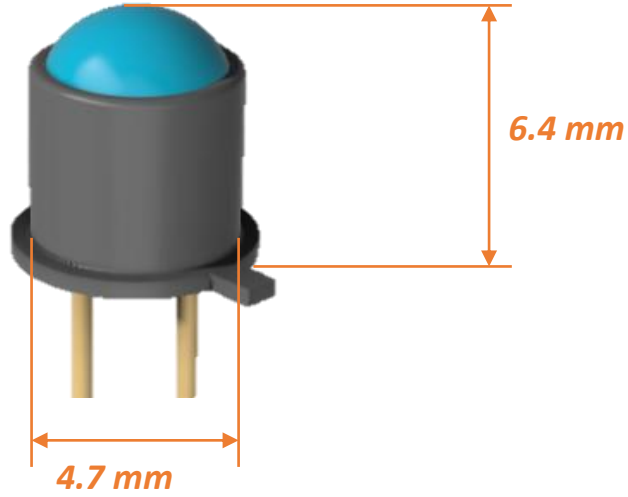
✅ **Baseline requirements met:**

- Spectral coverage (I - H bands)
- Packaging available (TO-CAN or after packaging)

⚠️ **Space requirements still unverified:**

- Cryogenic operation
- Lifetime & ON/OFF cycling
- Flux stability over mission lifetime
- Radiation tolerance (TID, TNID)
- Mechanical robustness (vibration, shock)

TO-18 LED packaging



All manufacturers require testing + development of test electronics

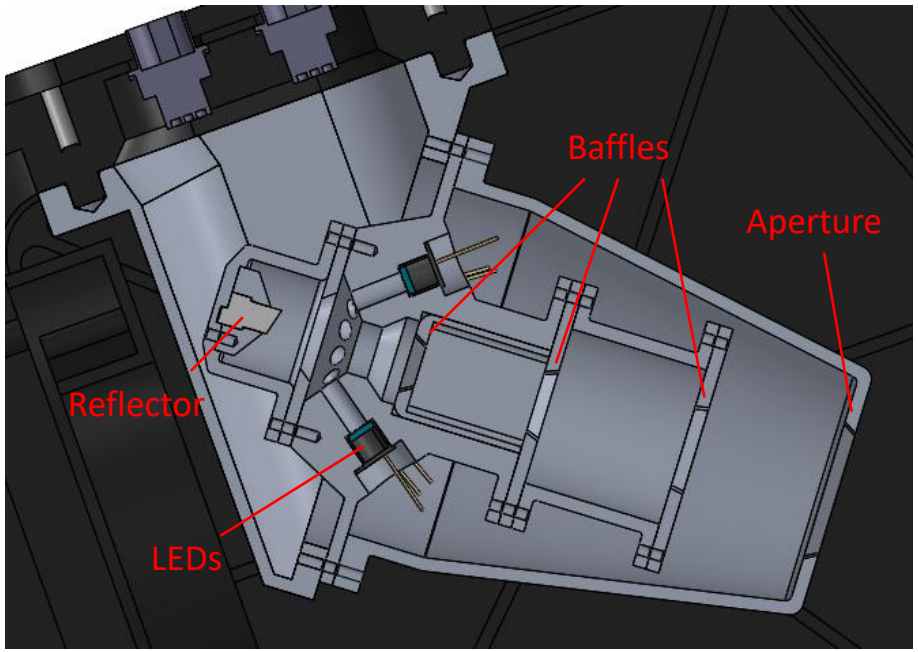
LED Selection Matrix

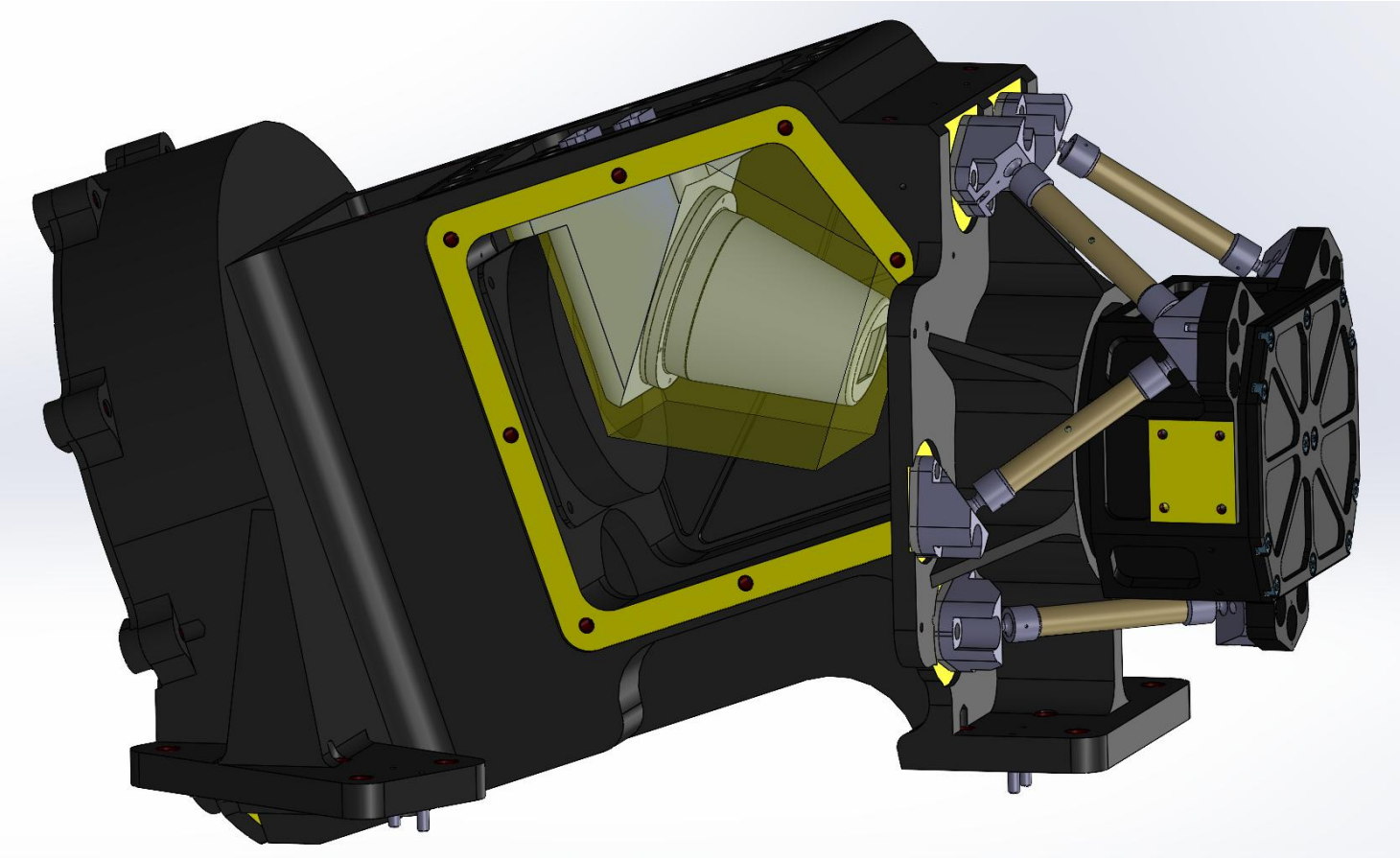
Good / Completed
In progress
Minor issues
Needs further attention
New info

Manufacturer	Spectral band	Peak wavelength (nm)	Spectral width (nm)	Tested operating temperature	Cryogenic & mechanical compatibility	Packaging	Availability		Price/ 1 pc (EUR)	Lead time
Epigap	I band	770	27	Depends on packaging	Needs packaging & qualification	Bare die, 365 um x 365 um	In-stock		1.00	1-3 business days
	Z band	910	60			Bare die, 365 um x 365 um			1.00	
	Y band	970	35			Bare die, 365 um x 365 um			1.05	
	J band	1200	59			Bare die, 350 um x 350 um			4.70	
	H band	1550	98			Bare die, 350 um x 350 um			4.60	
Thorlabs	I band	770	28	-40 - 100 °C	Needs qualification	TO-18, glass lens	In-stock		10.32	1-3 business days
	Z band	910	44	-40 - 100 °C					9.14	
	Y band	1050	50	-20 - 90 °C					27.73	
	J band	1200	70	-20 - 90 °C					28.54	
	H band	1550	120	-20 - 90 °C					26.92	
TechLED	I band	810	35	-40 - 80 °C	Needs qualification	TO-18, glass lens	Partially not in stock:	1	26.50	8-10 weeks after receipt of an order
	Z band	870	40	-30 - 80 °C				11	Obsolete	
	Y band	1050	50	-40 - 100 °C				180	31.40	
	J band	1200	90	-40 - 100 °C				25	31.40	
	H band	1550	110	-40 - 100 °C				2	31.40	
InPhenix	I band	750	10	Manufacturer contacted	Needs qualification	TO-8, TO-9, TO-56	MOQ: 5 Recommended packaging: TO-8 or Butterfly with TEC Packaging without TEC: TO-9, TO-56 Next step: Submit spec form for quote			
	Z band	900	30							
	Y band	1020	60							
	J band	1310	55							
	H band	1550	50							
Hamamatsu	I band	860	35	-30 - 85 °C	Needs qualification	TO-CAN	Request clarified – awaiting reply			
	Z band	945	60	-30 - 85 °C		TO-CAN				
	Y band	-	-	-		-				
	J band	1200	80	-30 - 85 °C		TO-CAN				
	H band	1550	120	-30 - 85 °C		TO-CAN				
Superlum	I band	770 - 890	40	-55 - 85 °C	Needs qualification	DIL or TOSA	Reply: Complimentary sample of TOSA packaging, no price or stock info			
	Z band	930	60 - 80	-55 - 80 °C						
	Y band	1000 - 1020	80 - 100	-55 - 65 °C						
	J band	1300	70	-55 - 75 °C						
	H band	1560	120	-55 - 70 °C						

Preliminary mechanical design

- 3rd iteration (v03b)
- Fixed mount to trap door interface
  - Also considering bipods
- Structure: heritage from NICU

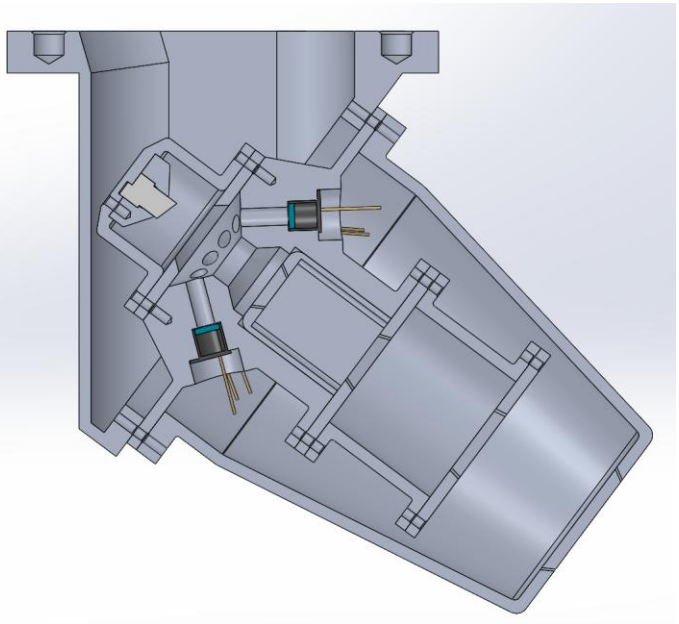


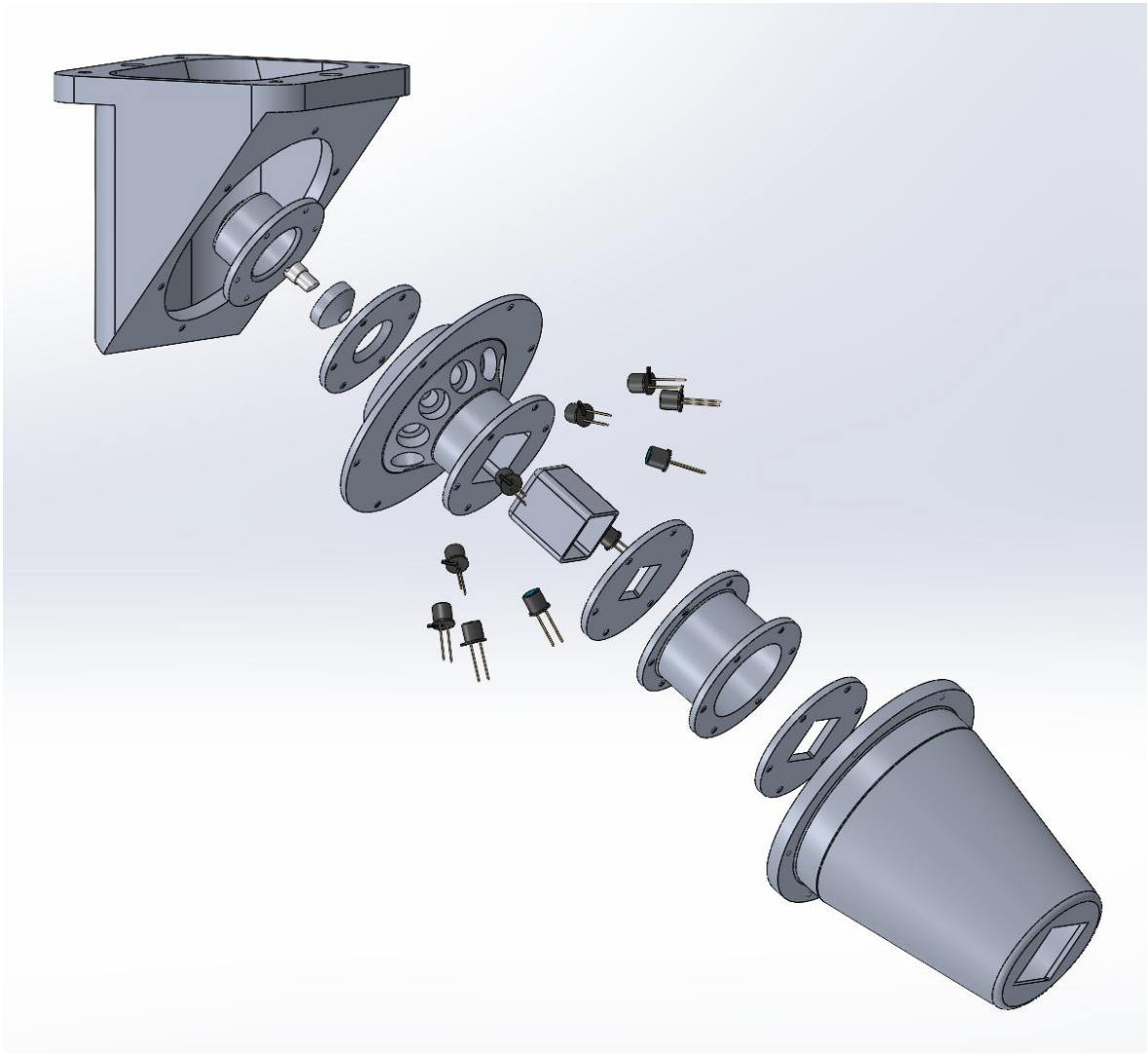


- Alignment plan: larger illuminated surface
  - Measurement still to decide

Preliminary mechanical design

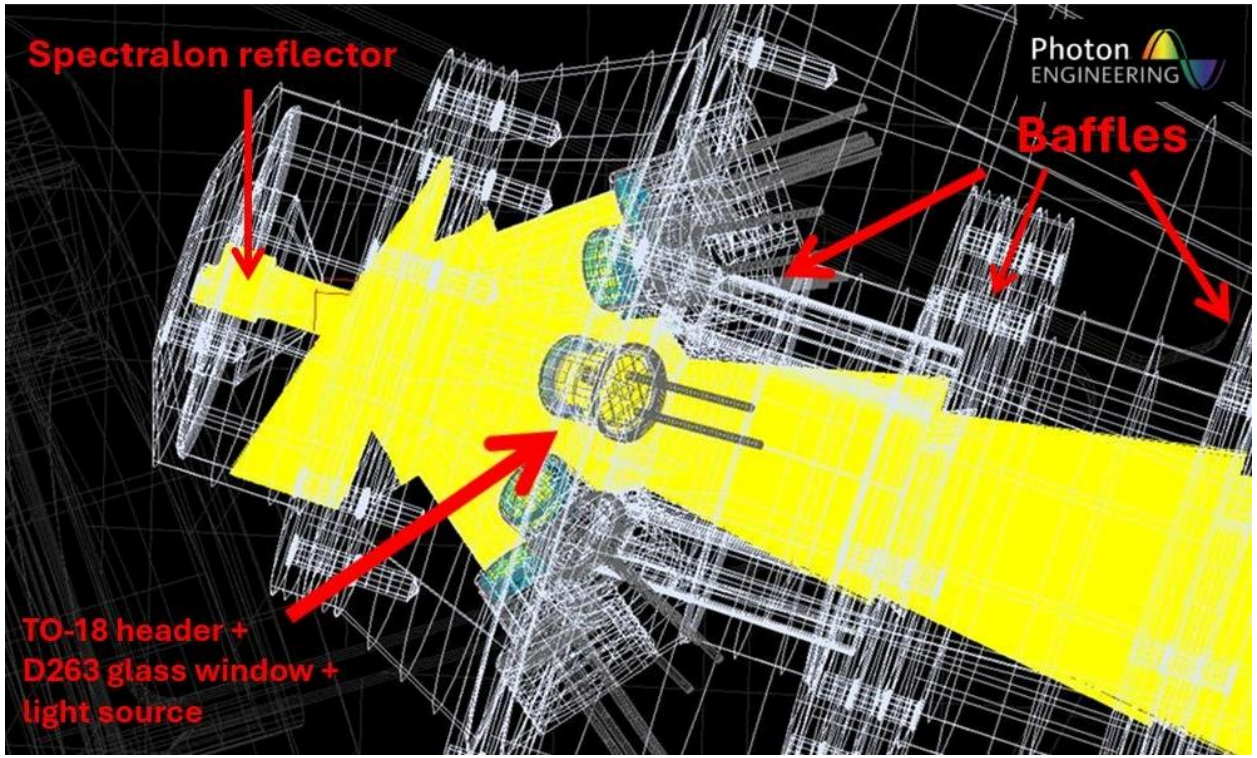
- Details to be added:
  - Fastenings, Positioning and Conducting elements (pins, washers…)
  - PCB and harness (from Electrical Design)
- Mass so far: 331 g (Alu 6061 T6)
  - We estimate to fit the 0.7 kg budget + margin

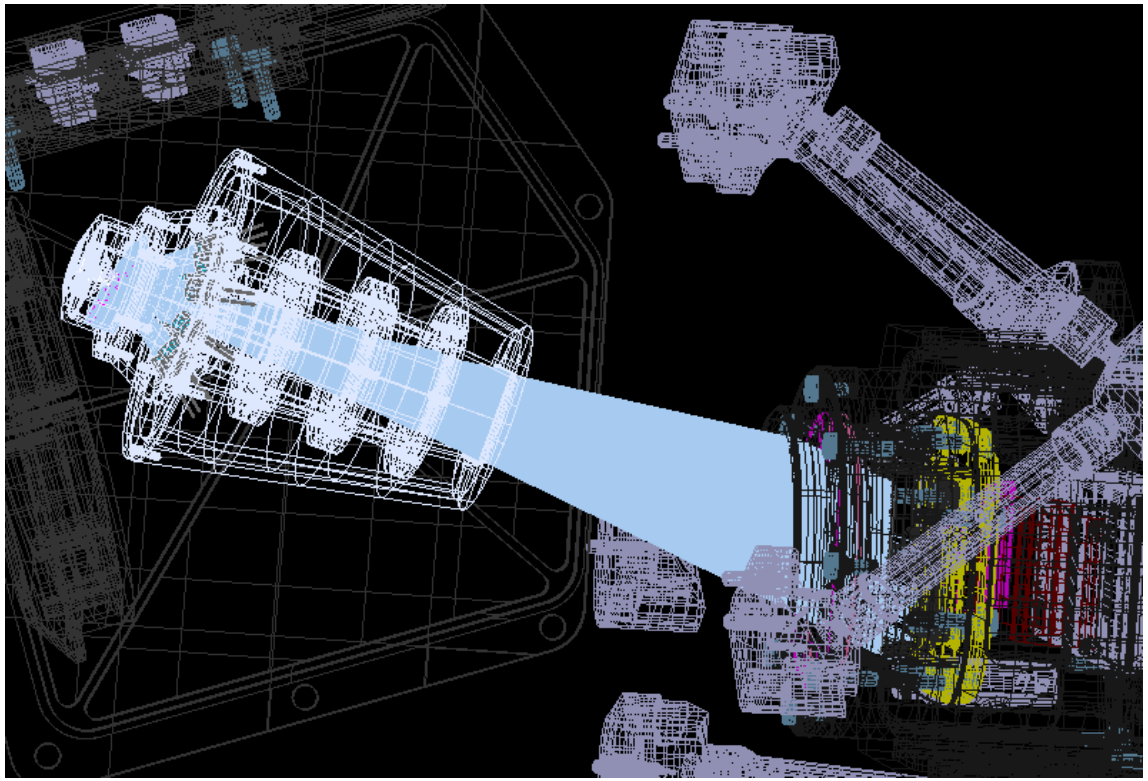




Optical modelling

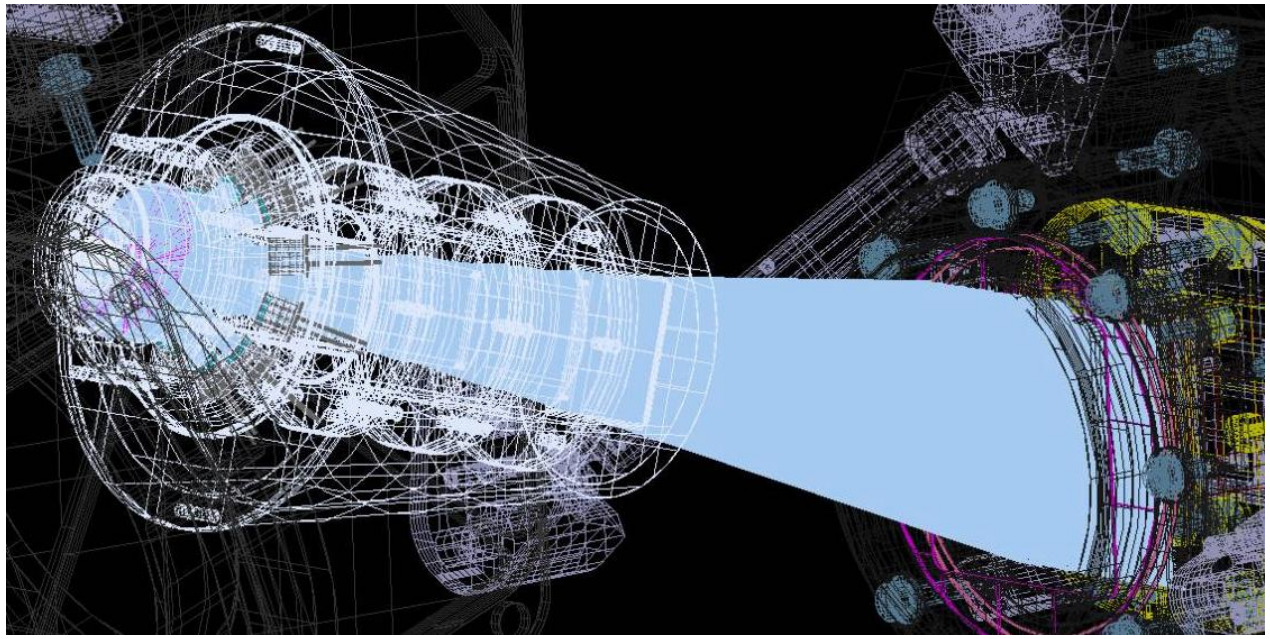
- CUA, CAM and FPA in model
- Point light source @ 0.808 µm
- LED TO-18 header window (Borosilicate glass)
- Spectralon reflector (Lambertian profile)
- Series of baffles, aperture

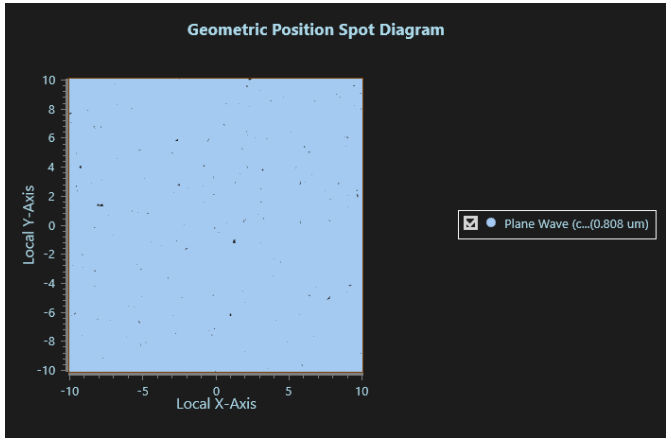


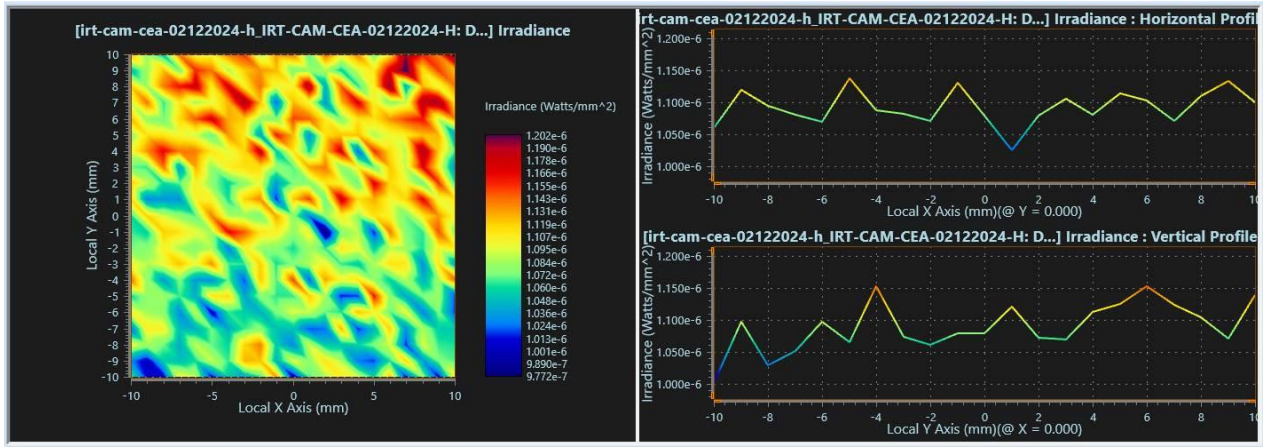


Optical modelling

- Detector surface analysis
- Low-resolution simulations for baffle design and coverage
  - Next step: high-resolution simulations for homogenity
- Feedback to Mechanical Design







Documentation

Interface Requirement Document

Elements	*Camera body*	Interface plate	Bipods	Mounting bracket	Reflector housing	Reflector	LED housing	LED	Baffle assembly	Tube	PCB	Cold harness	Connector	Thermal strap	*Detector*
Camera body		M, Tc	M, Tc	Tr	Tr					Tr					
Interface plate			M, Tc										M, Tc	M, Tc	
Bipods				M, Tc											
Mounting bracket					M		M			M				M, Tc	
Reflector housing						M, Tc									
Reflector							O	O	O	O					O
LED housing								M, Tr	M		M	M			
LED											E				
Baffle assembly															
Tube															
PCB												E			
Cold harness													E, Tc		
Connector															
Thermal strap															
Detector															

Legend:	
M:	Mechanical
Tc:	Thermal (conductive)
Tr:	Thermal (radiative)
E:	Electrical
O:	Optical

Product tree

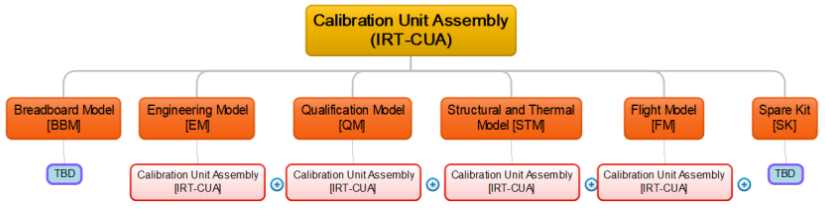


Figure 3: Top-level product tree

CUA product tree is shown in Figure 4 through the FM. Items are categorized according to their main functions. At the time of writing no configuration identification requirements are available, thus the identification numbers below are defined according to ADM's best practices which can be modified once identification requirements are available.

Figure 4: CUA product tree

Documentation

RSD suggestions, verification methods, risk identification

- To be discissed with CEA

F29 | ADM proposed addition:

	A	B	C	D	E	F	G	H	I	J
1	Section	Initial release	Last updated	Identifier	Title	Specification	"in reply to" (Parent)	Level (CAM or CUA)	Verification method	Justification, Note
13		31/01/2025	14/05/2025	IRT-CCU-FUN-070	Collimator geometry	the collimator shall be designed such a way that the full surface of the detector is illuminated but no light exceed the detector corners to avoid parasitic light reflection. SEE IRT-CCU-PER-.		CUA	R, A, T	Remark: Square collimation to only illumina goal. See IRT-CCU-PER-050
14		31/01/2025	14/05/2025	IRT-CCU-FUN-080	Off-state	The number of emitted photons when the LED command is off shall be minimised (with an appropriate control electronic circuit). See IRT-CCU-PER-030		CUA	R, A	
15		14/05/2025		TBD	TBD	UoD suggested addition: Required switch on / off sequence (Slow switch on for reducing thermal transients? On sequence max time?)		CUA	R	
16		14/05/2025		TBD	TBD	UoD suggested addition: The sub-assembly shall be designed to be single fault tolerant in critical opto-mechanical, electro-optical and electronic subsytems. (a very general requirement)		CUA	R	
17		14/05/2025		TBD	TBD	UoD suggested addition: Item interfaces shall be asymmetric or be otherwise keyed to prevent integration in an incorrect orientation.		CUA	R	Remark: the sum of all functional requirem technology
18	4				Performance (Optical) Requirements					Remark: to achieve these requirements, ge (source-detector distance and relative pos account to translate into requirements at t sources. By default, performance requirem
19		31/01/2025	14/05/2025	IRT-CCU-PER-010	Flux dynamic range	the minimum flux on the detector with stable operation of the calibration source is 5.105 photons/s/cm2 on the detector. The maximum flux to provide by the calibration source on the detector is 5.109 photons/s/cm2 on the detector. Intermediate tunable values will be defined in a logarithmic scale to properly cover the dynamic range (5.105, 106, 2.106, 5.106, 107, 2.107, 5.107, 108, 2.108, 5.108, 109, 2.109, 5.109- indicative values only, real fluxes to be calibrated) UoD comment: HDR seems too large, EUCLID CU could reach ~100 - Control problem TBC		CUA	R, A, T	Minimum flux is defined by the sensitivity o magnitude of 20.8 in H band), Maximum flu flux source (43 mJy in H band = AB magnitu median value of the population + 5*the sta population.
20		31/01/2025	14/05/2025	IRT-CCU-PER-020	Photon flux knowledge	Knowledge on the absolute flux on the detector shall be better than 5% TBC over the flux dynamic rage, the operating temperature range, even after ageing and radiation damage.		CUA	R, A, T	Remark: variations with temperature are ac characterised and can be corrected.
		31/01/2025	14/05/2025	IRT-CCU-PER-030	Off state light emission	the photon flux emitted on the detector when the LED are off shall at least 10 times lower than the background level, i.e. 104 photons/s/cm2 TBC. This		CUA	R, A, T	

Spectral band	Flux in photons/s/pixel Min (M_{AB} = 20.8)	Max (M_{AB} = 12.3)	Mi
I	1,7	5072	2.2
Z	1,5	4540	2.0
Y	1,0	3201	1.4
J	1,5	4689	2.0
H	1,7	5184	2.3

Cover Page | RS status | Requirements assessment | Verification methods

Ongoing work

- Mechanical design all parts (PCB, harness, fasteners)
- Optical design refinement (baffle and aperture optimization, alignment sensitivity, preliminary straylight analysis)
- Preliminary thermal and structural analysis
- Requirement Specification Document additions/suggestions
- Phase B test definitions – facilities & equipment, setups

Publications, conferences

- Star Formation, Stellar Feedback, and the Ecology of Galaxies, Visegrád, Hungary, May 2025
  - THESEUS (András JOÓ +)
- IBWS Zatec Czechia, May 2025
  - THESEUS IRT_CUA (András JOÓ +) → paper submitted to Astronomische Nachrichten
- Cold Cores 2025 Helsinki Finland, June 2025
  - THESEUS and the Study of YSOs (Áron JUHÁSZ +)
- Meeting of Hungarian Astronomers, Budapest, Sept 2025
  - THESEUS IRT_CUA (Rebeka KISS +)
- Planned: Granada March 2026

Phase B1 workplan – Involving Hungarian partners

- Main space industrial partner: ADMATIS – already in phase A
- Optical tests: eCon
- Irradiation tests: ATOMKI
- Vibration tests: REMRED
- LED spectral & cryogenic tests: Institute of Technical Physics and Materials Science
- Scientific program
  - Early Universe: Eötvös Loránd University, HUN-REN Konkoly Observatory
  - Transients (GRB, SN, etc.): Eötvös Loránd University, HUN-REN Konkoly Observatory, Ludovica University of Public Service
  - YSOs: Eötvös Loránd University, HUN-REN Konkoly Observatory
- + Foreign consultative partners in engineering in France and Germany