ARIEL Infra Red Spectrometer (AIRS)

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On Behalf of the AIRS team members

AIRS Architecture

AIRS Architecture

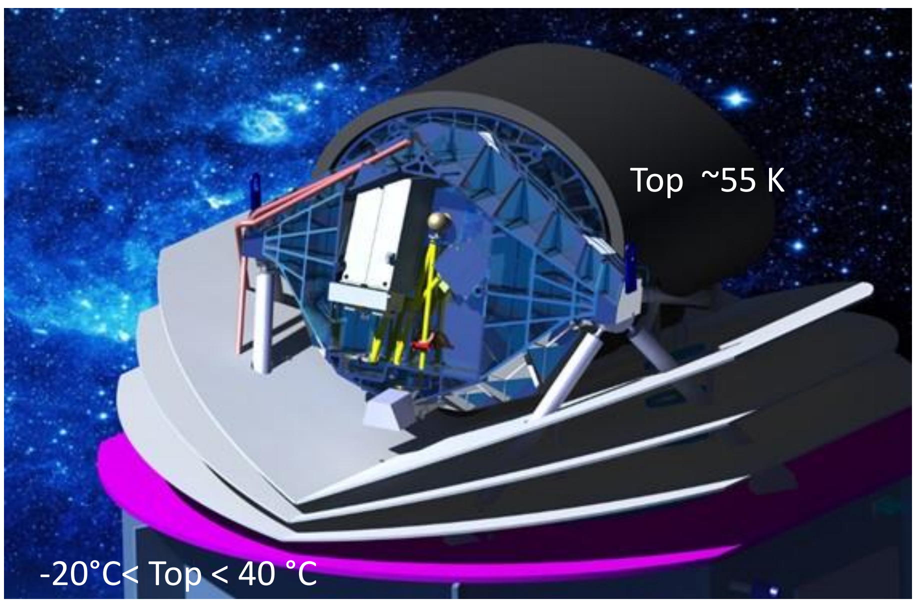
Ariel Infra-Red Spectrometer (AIRS) is the science instrument of the Ariel Payload providing Low Resolution Spectrum of the observed targets over broad IR wavebands covering the [1,95-7,8] µm range.

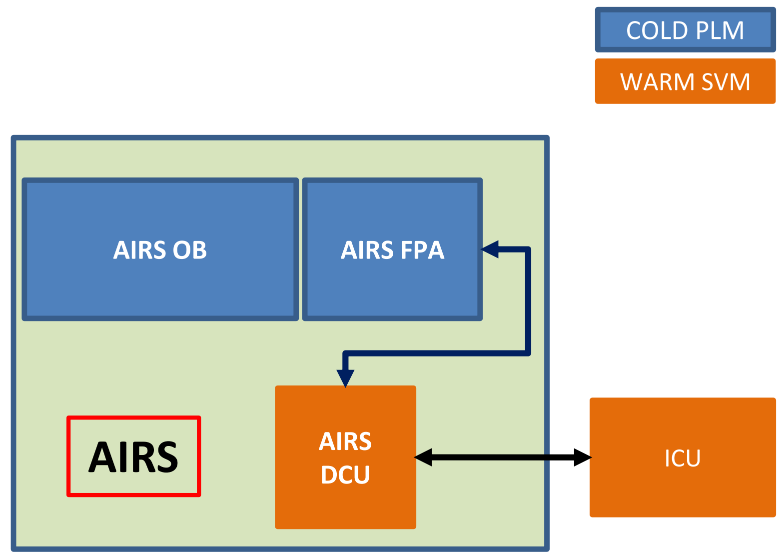
AIRS Baseline Architecture is composed of three main architectural blocks:

1. AIRS Optical Bench (**AIRS-OB CH0 and CH1**)
2. AIRS Focal Plane Assembly (**AIRS-FPA-0** and **AIRS-FPA-1** include **CFEE**)
3. AIRS Detector Control Unit (**AIRS-DCU-0 and DCU-1**)

Items 1–2: Located on the cold PLM: 55 K

Item 3: Located on the warm SVM



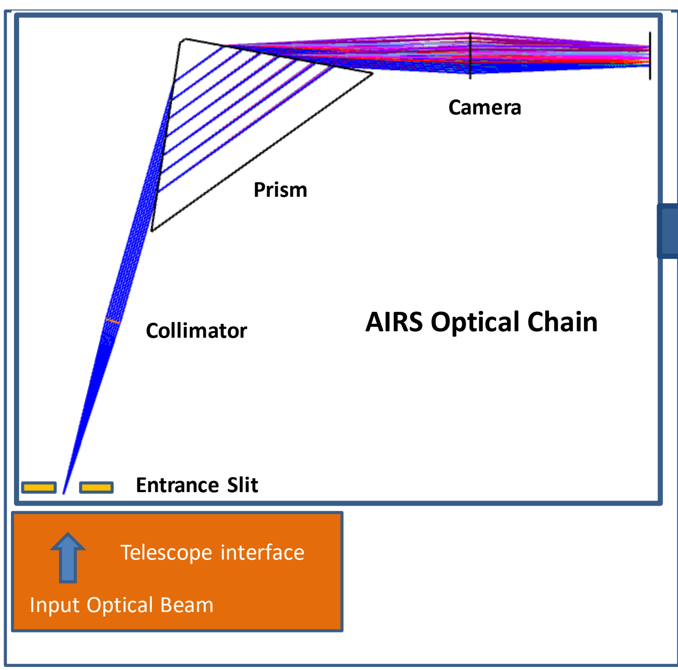


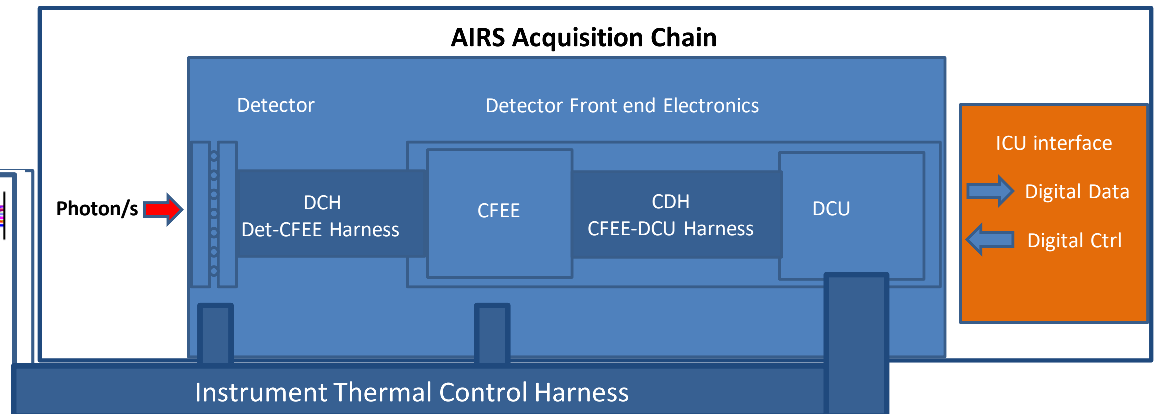
AIRS functional analysis

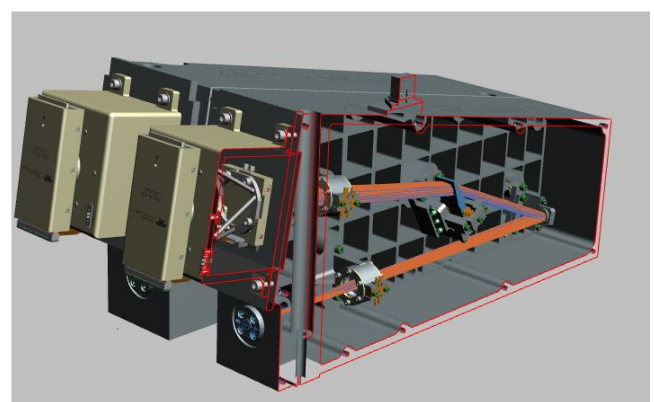
Ariel Infra-Red Spectrometer (AIRS) is the composed of 2 main functionnal chain:

- The Optical Chain Function which is converting the entrance optical object into a spectrum in the image focal plane of the system.
- The Acquisition Chain Function which convert the incoming optical spectrum into digital science data packets that will be sent to the ground.

AIRS OPTICAL CHAIN





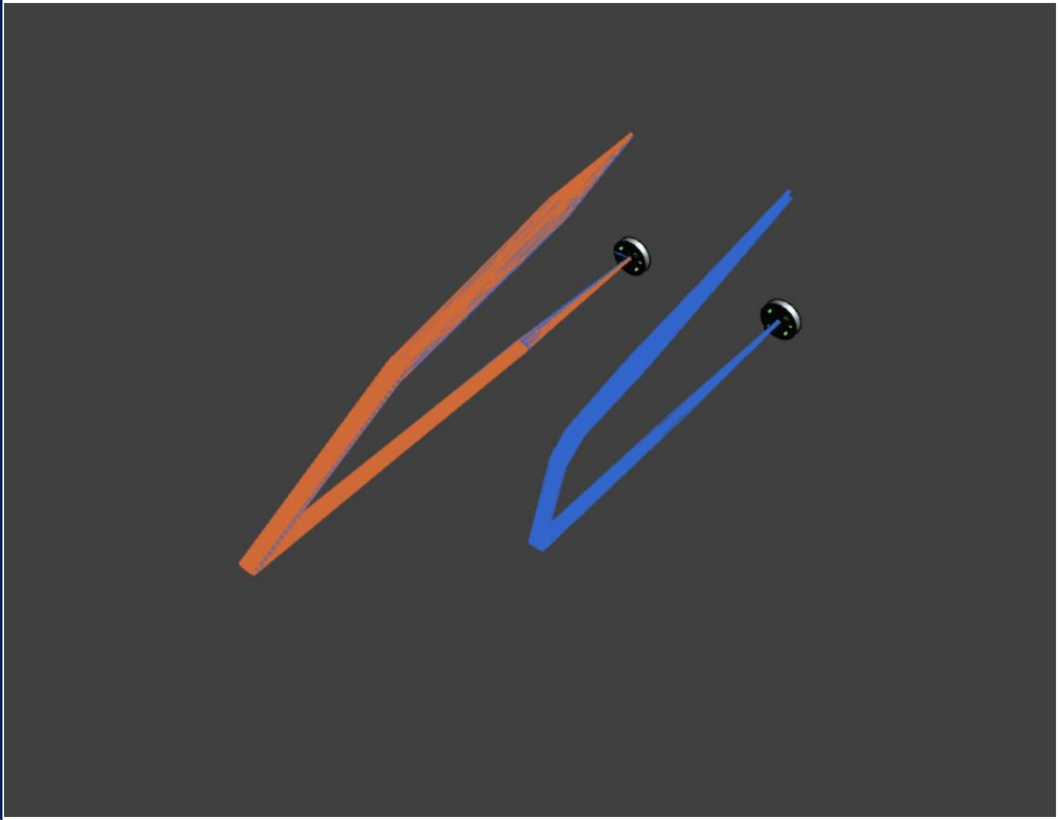


AIRS Opto-Mechanical Design

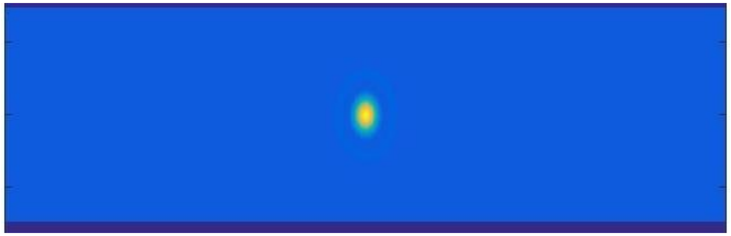
Opto-mechanical Design

Opto-mechanical baseline:

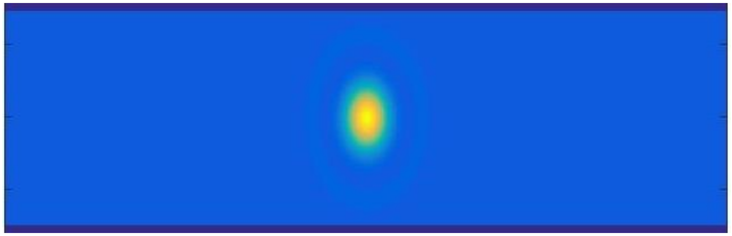
- Optical baseline based on 2 independant Channel for Channel 0 [1,95-3,90] µm and Channel 1 [3,90-7,80] µm
- Interface with Telescope in intermediate image focal plane: 2 mechanical slits



CH0 Slit λmin



CH0 Slit λmax



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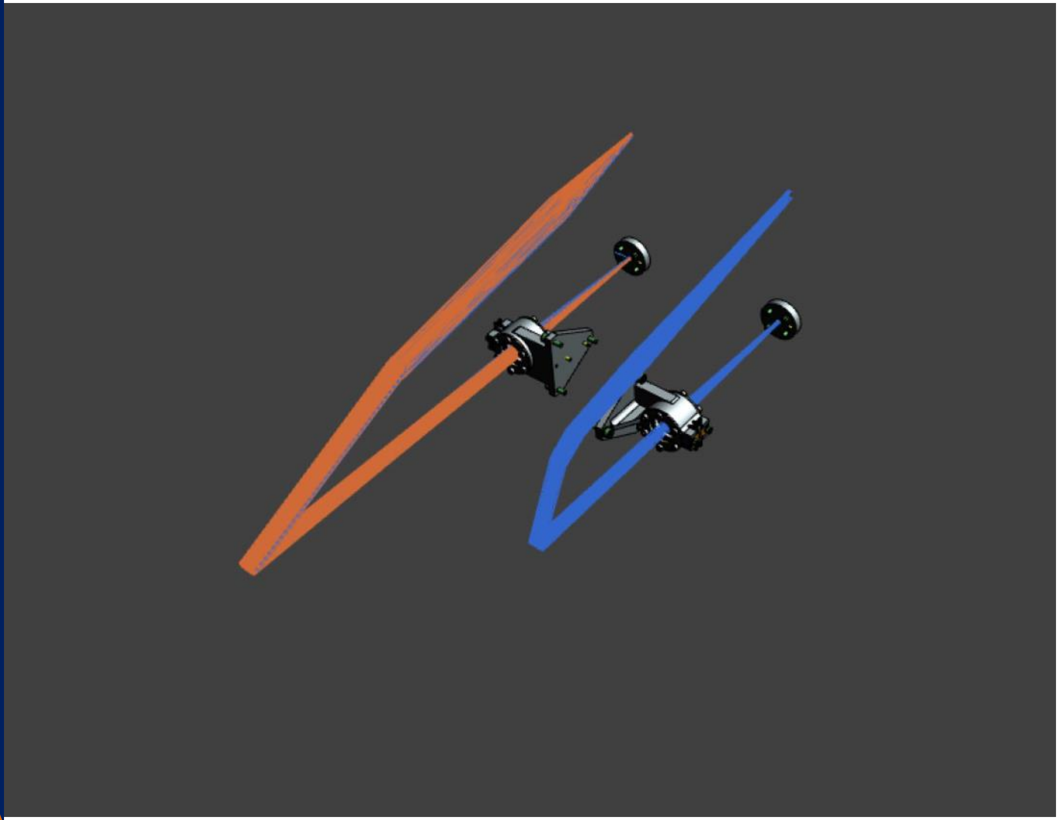

For each channel:

- **Collimator**: collimates the beam on the Prism (CaF2 / ZnSe).
- **Fold mirror**: allow having both channel entrance planes and exit plane (detector plane) collocated.
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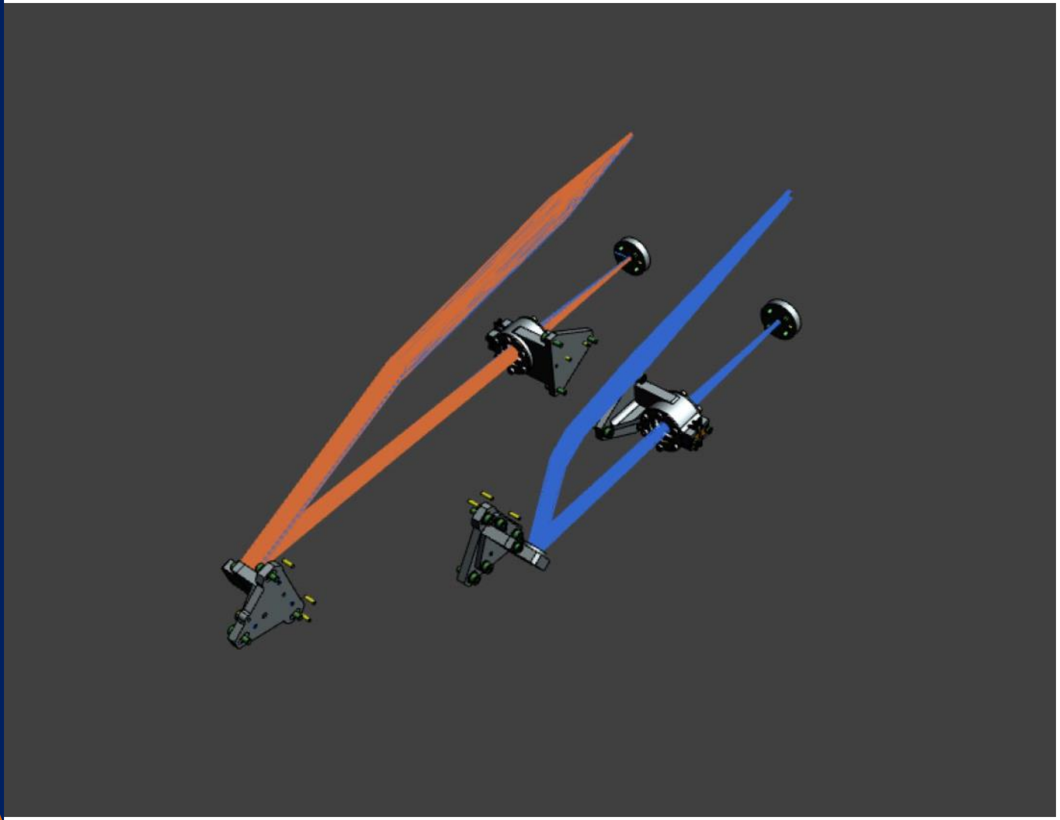

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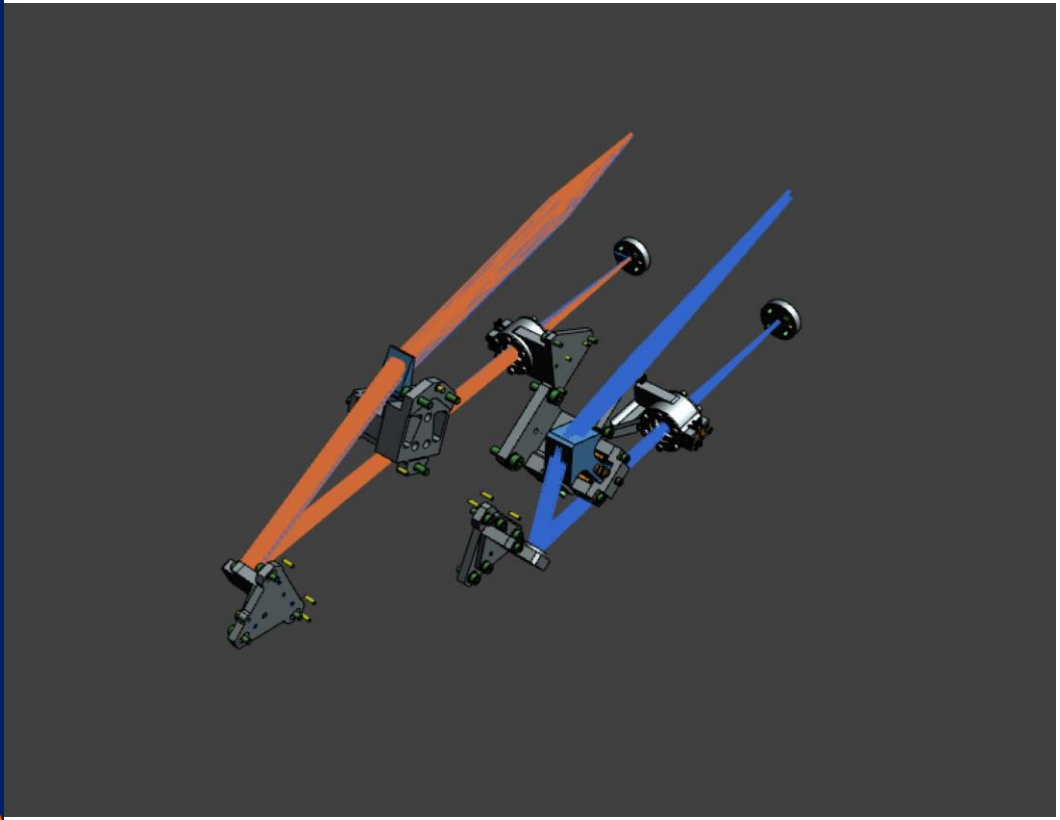

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Critical Item: Prism holder design

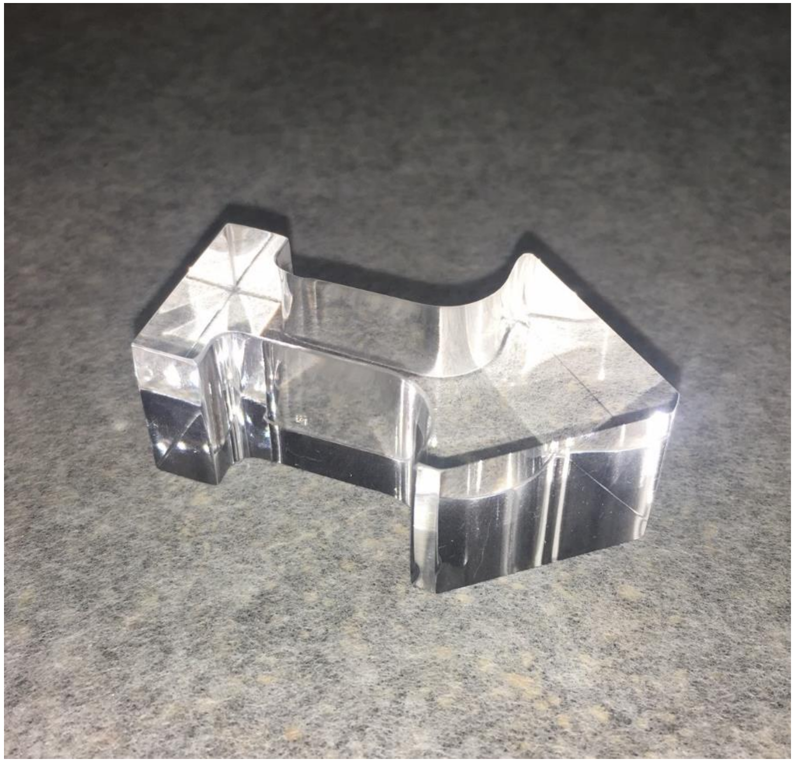
1) Critical question of CaF2 prism

Glueing and molecular adhesion have been discarded: design rely on standard holder design but the prism mechanical machining is more complex

Improvement of holder design to limits stress in the CaF2 material: The prism is kept in position using springs and rods. Pads in Teflon are used at the interface between springs and prism.

Flight like model have been:

- Manufactured
- Polished
- Vibrated succesfully



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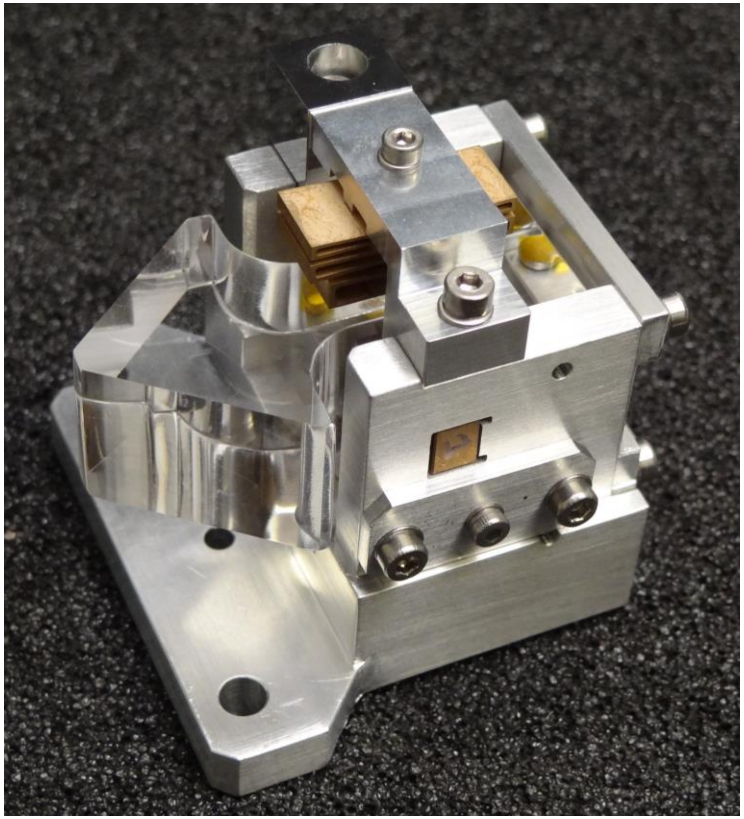

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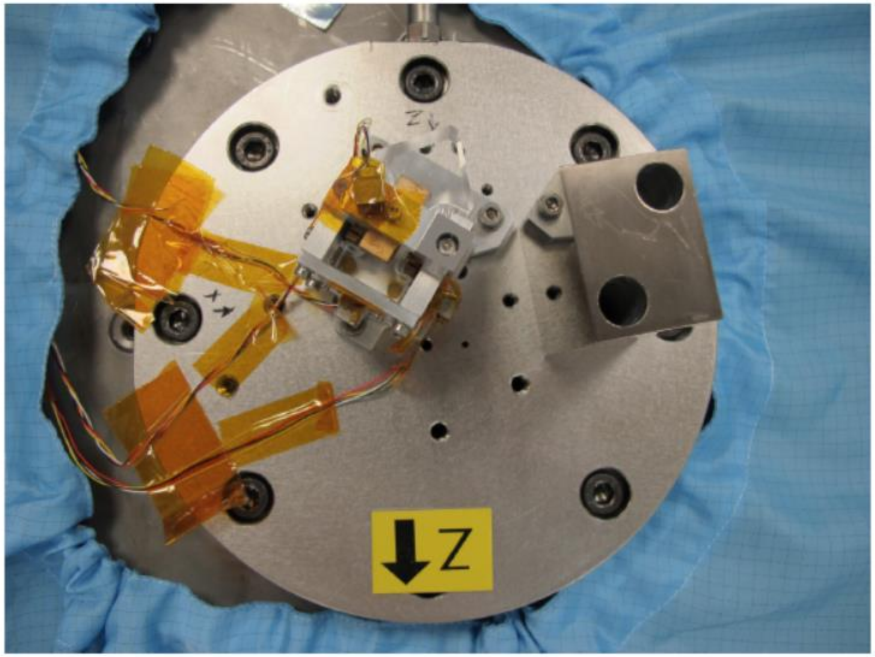

No damage at Qualification levels

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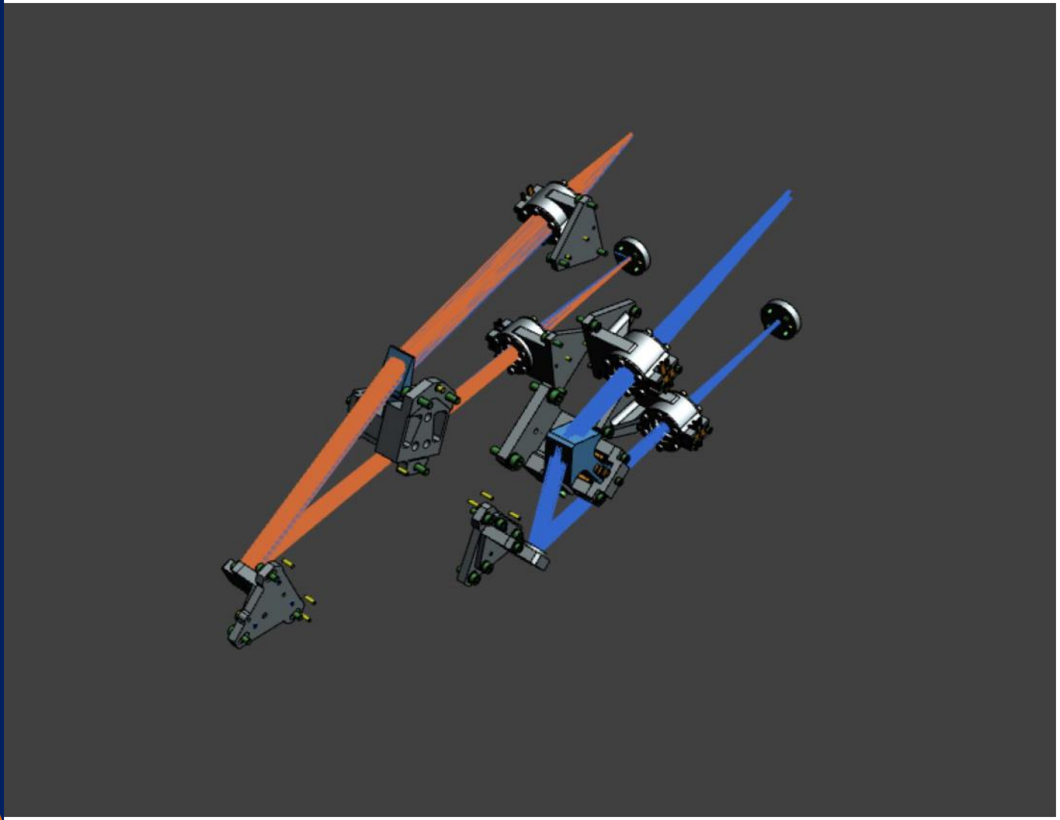

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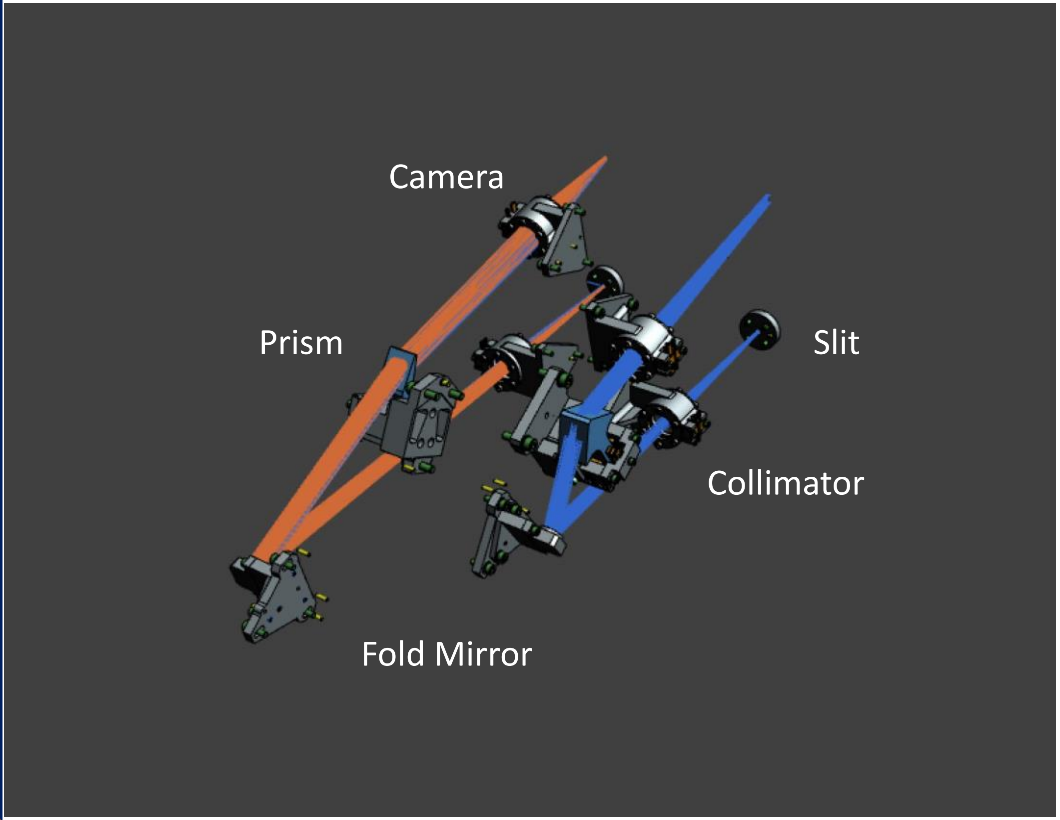

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Spectrum Performance

Instrument Performance are estimated in both channels in terms of resolution, size of spectrum and flux

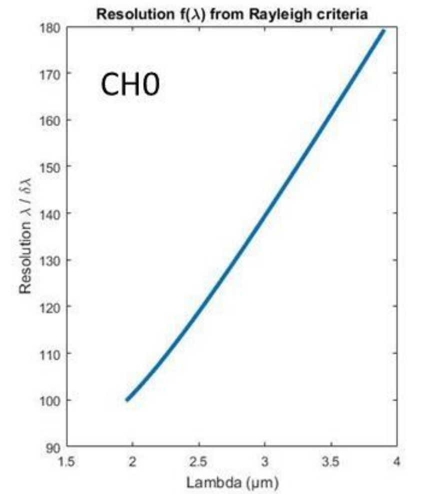
CH0 spectrum window: 270 x 64 pixels

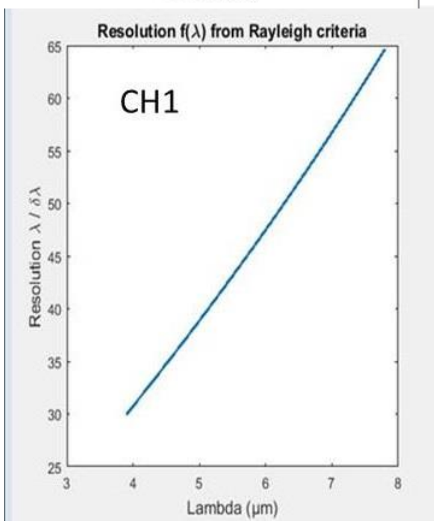
Resolution > 100 in CH0

Dynamics of Signal from 100 000's e-/s/ pix to 100's e-/s/pix

CH1 spectrum window: 100 x 64 pixels

Resolution > 30 in CH1





Opto-mechanical Design

<u>Opto-mechanical baseline</u>:

- **Aluminium 6061** structure to provide homothetic shrinking design at cold and good thermal coupling with the ARIEL optical bench
- AIRS-OB cool-down **passively to 55-K** through thermal conductance at interface with the ARIEL Optical Bench

Baseline 2 channels with 2 detectors and associated ASICS (H1RG + CFEE).

Design fits into <**15 kg** allocation with the 2 AIRS detector boxes.

Detector System Boxes: thermal mechanical boxes containing for each channel the Detector System and the Front End Electronics located close to the detector.

Detector System are cooled down actively to <**42 K** by cold finger (thermally regulated by the instrument).

Front End Electronics is linked to Detector ROIC with a dedicated harness.

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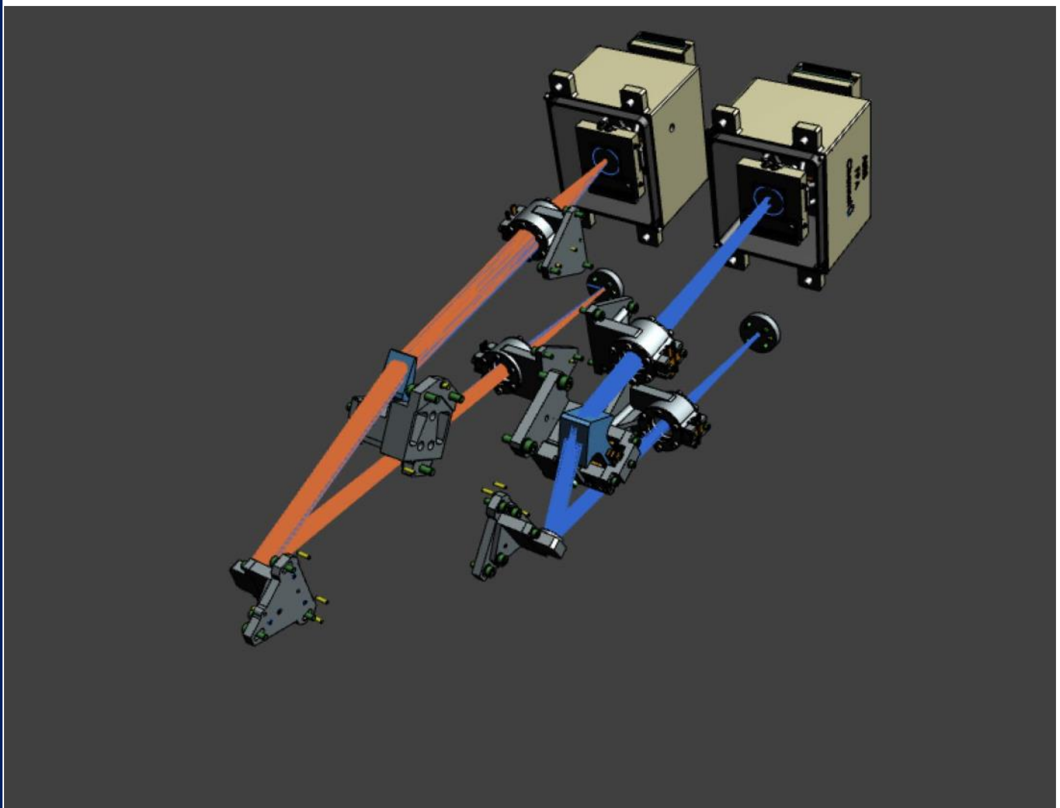

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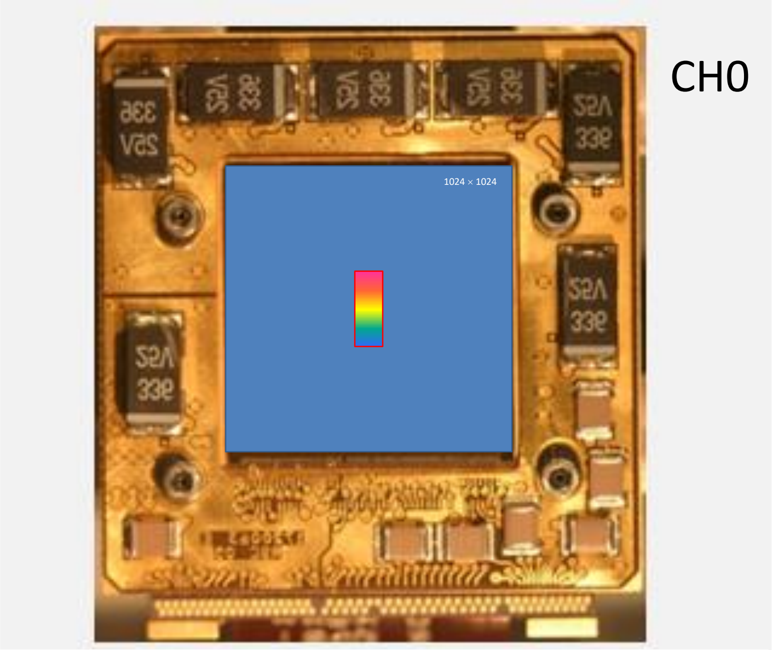
Detectors Baseline

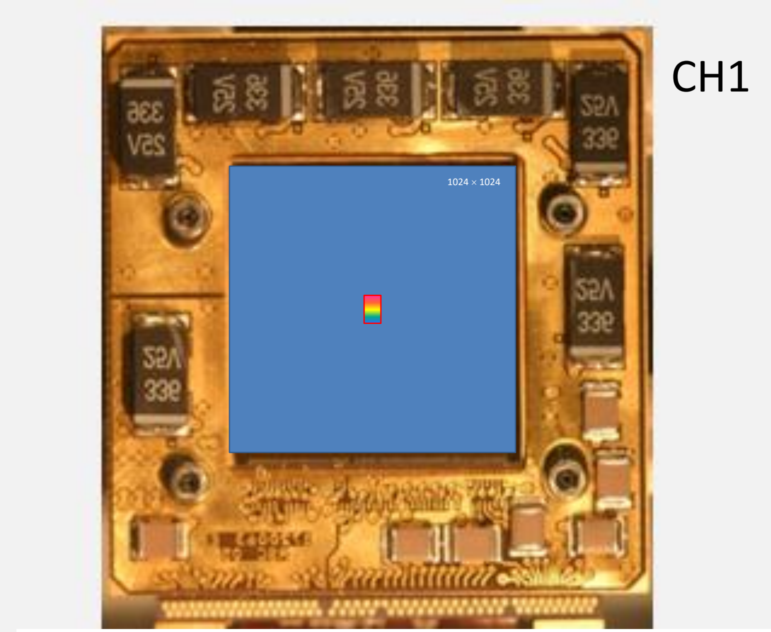
Detector Baseline is 2 x H1RG from Teledyne with specific requirements per channels in order to have best performance:

- 2 detectors (1024x1024 pixels) and a pixel size of 18 µm
- CH0 H1RG with cut-off at 4,0 µm or 5,3 µm
- CH1 H1RG with cut-off at 8,0 µm

} High performance (QE / Dark) and maturity



Read out = 20 e-rms (median value)
Dark Current = 0.1 e-/s/pixel (median value)
QE CH0 > 70% [1,95-3,90] µm



Read out = 25 e-rms (median value)
Dark Current = 1 e-/s/pixel (median value)
QE CH1 > 65% [3,90-7,80] µm

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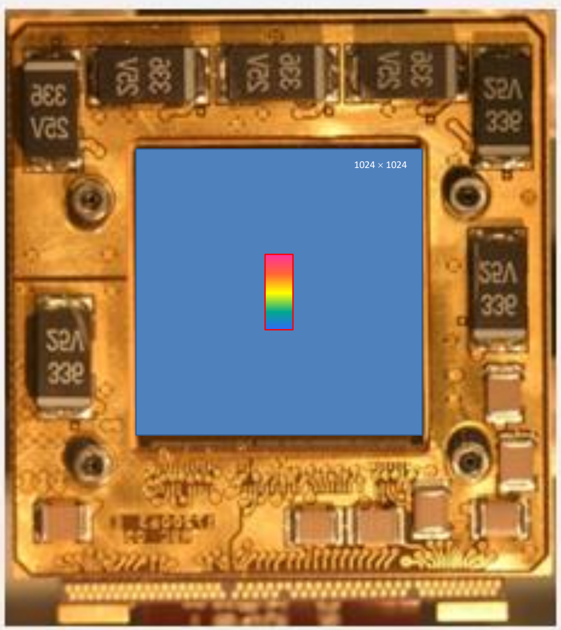

CH0

Engineering models delivered end of 2019 for performance assessement of CH1 performance;

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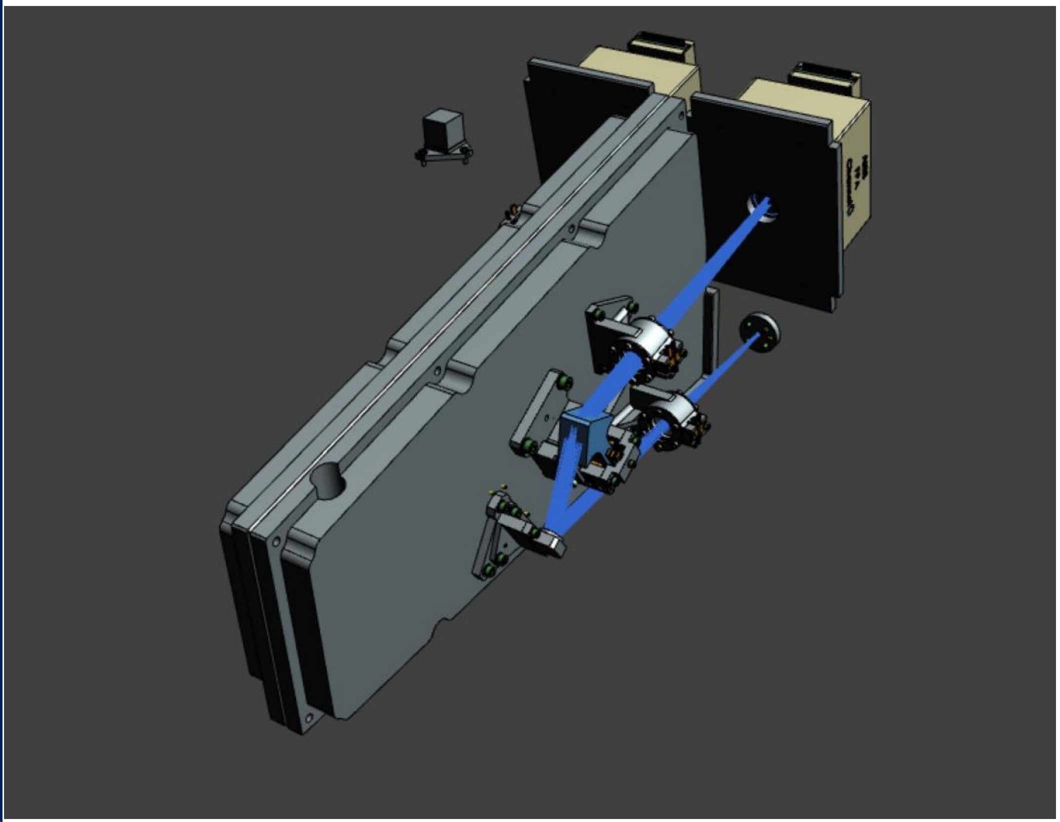

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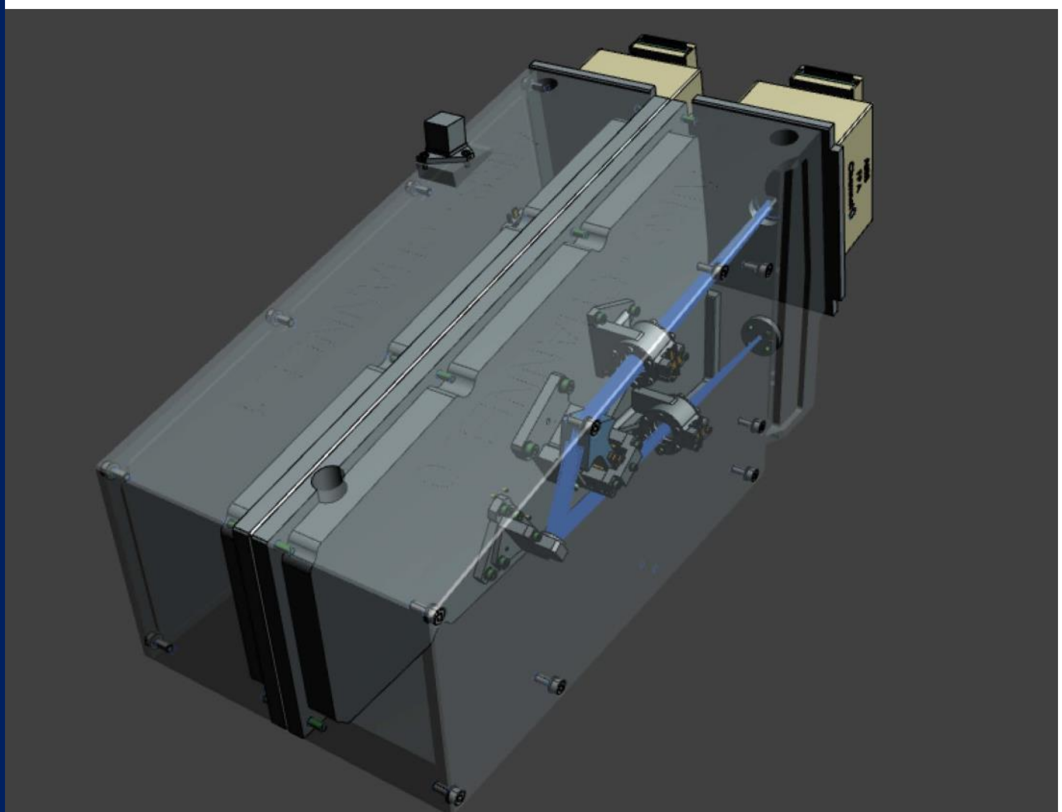

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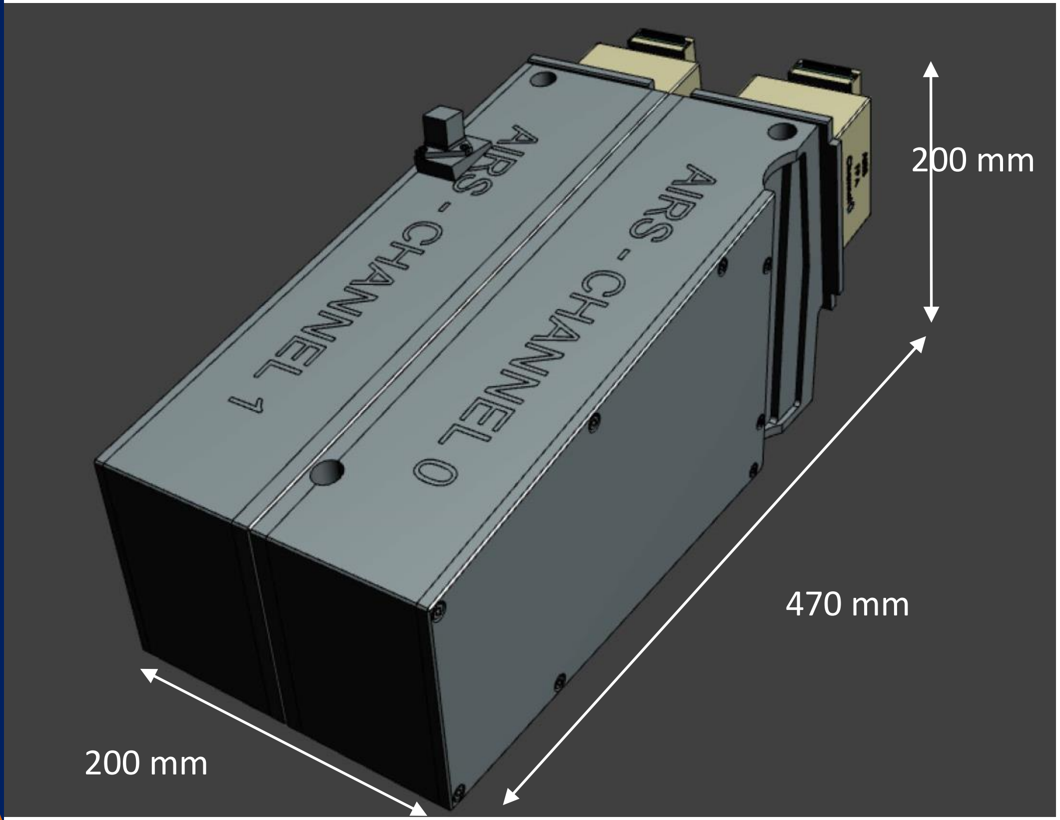

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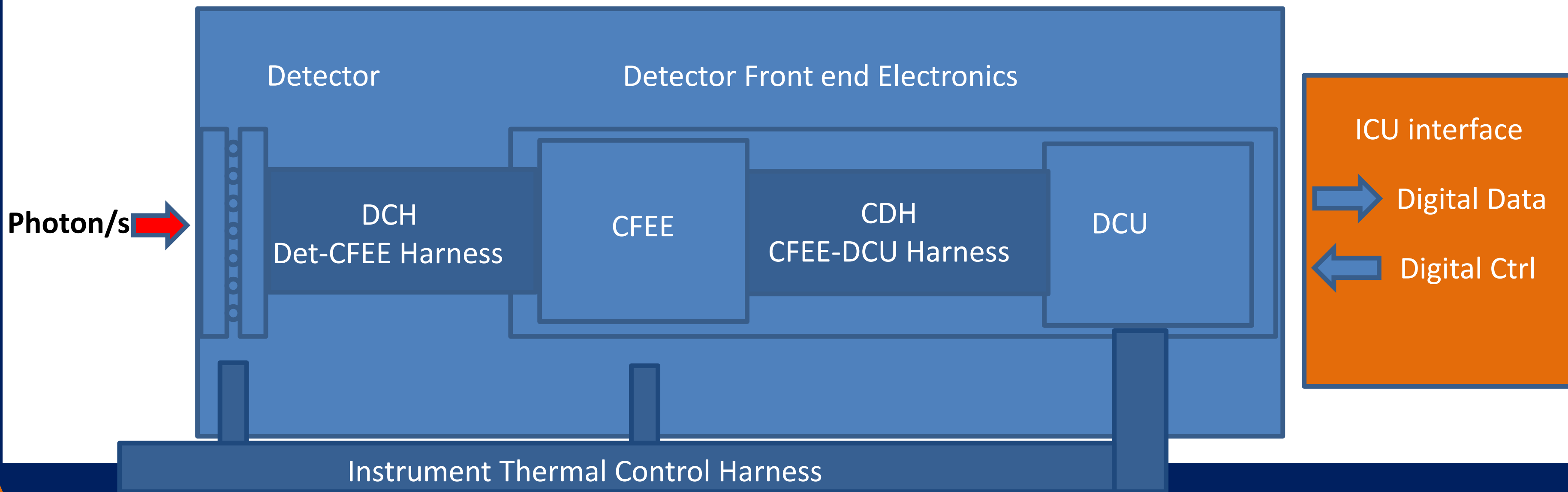
AIRS Acquisition Chain Design

AIRS Acquisition Chain architecture

AIRS Acquisition chain is in charge of acquisition and processing of the science data.
The architecture of the acquisition chain is composed of:

- **Detector + ROIC**
- **Detector to CFEE Harness: DCH**
- **Detector Front End Electronics: DFEE composed of:**
  - **Cold Front End Electronics: CFEE**
  - **functions in Detector Control Unit: DCU (including Detector and CFEE Thermal Control)**
- **Cold FEE to Warm DCU Harness: CDH**
- **Detector Control Unit**

AIRS Acquisition Chain



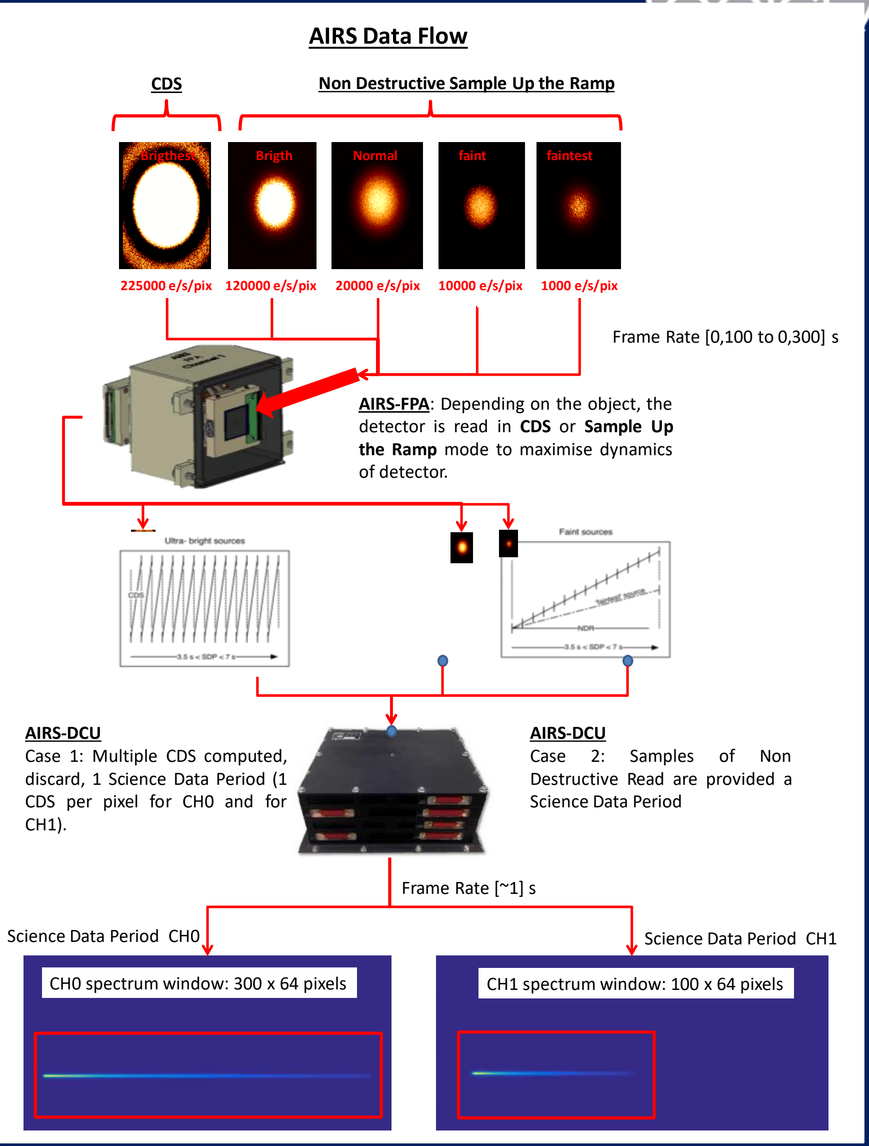
Operation mode

- Detector will be read at constant pixel rate (100 kpixels/second): this will make a steady baseline of observation with adapted electronics and calibration
- Frame generated are either CDS frames (for the few brightest stars) or MACC (with groups of 1 frames and drops between groups).
- Groups will be generated by DCU at maximum Science Data Frame rate of ~0,8 s
- This will maximise the data flow into the 45 Gbits/day allocated to AIRS.

	N# bit	N#row main	N#col main	Npix main	Npix ref
CH0	16	300	56	16800	4
CH1	16	100	56	5600	4

T DCU (s)	N#frame/DCU	N#DCU /day	Data rate (kbytes/s)	N# bit/frame
0,796	4	108548	48,21	314368
0,781	11	110643	17,13	109568
		total AIRS	65,34	kbytes/s
		ALLOCATION	**65**	**kbytes/s**

ICU comp	N Gbit/day	
1	31,8	
1	11,3	
Total data	43,1	Gbit/day
ALLOCATION	**45,3**	**Gbit/day**
Allocation	**317**	**Gbit/wk**



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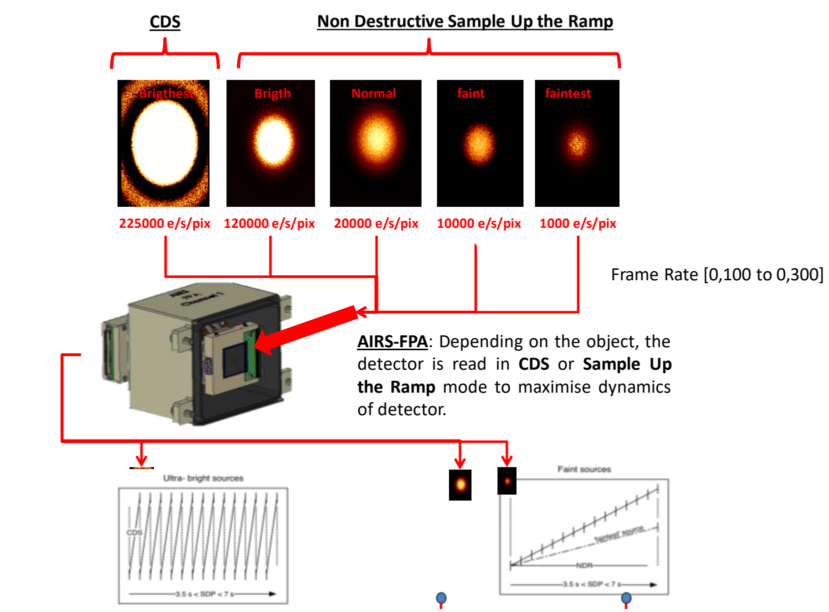
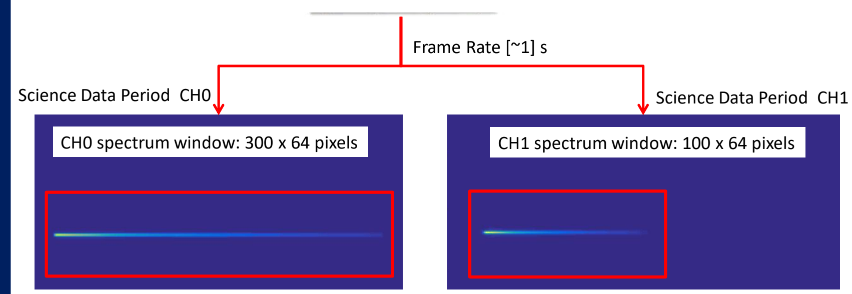
AIRS Data Flow

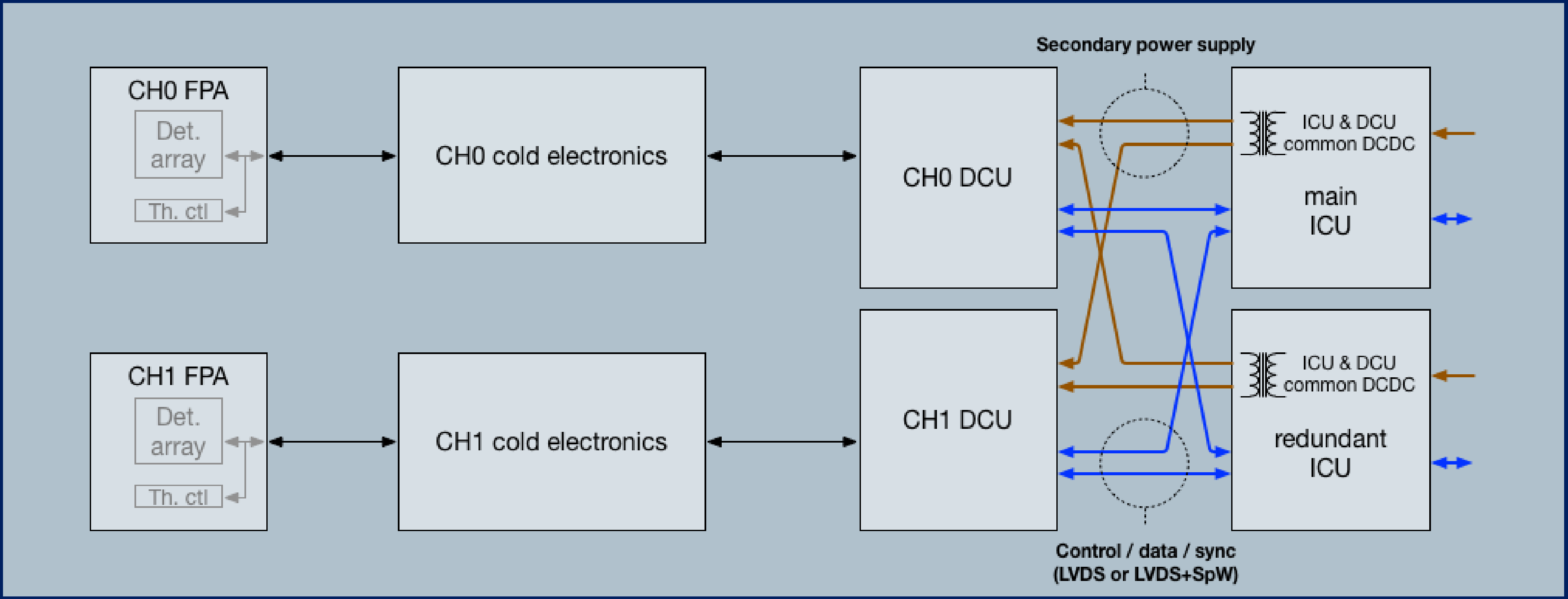


1) No on board processing (slope computation) performed by DCU.
2) Only compression by ICU



Overall electrical architecture

- Electrical architecture is assembly of two independent and complete channels, starting from the detector and ending with the AIRS-DCU (including critical thermal control).
- No redundancy is implemented in the channels to the exception of focal planes thermal control that are duplicated.
- AIRS-DCU is interfacing to the ICU for scientific & housekeeping data transmission and for the transmission of configuration command.



CFEE open options

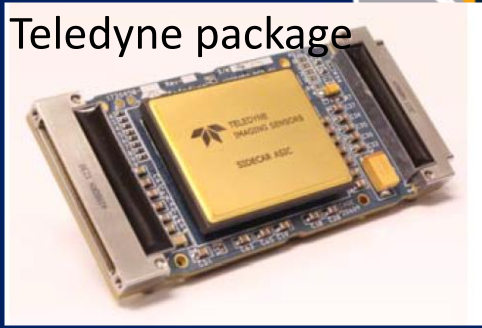
Because of the issue of qualififcation of Teledyne SIDECAR packages for Euclid below 120 K we need to review 3 options:

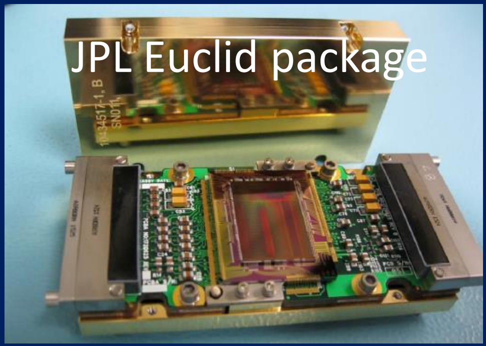
1. SIDECAR package design used at > 120 K
   - (+) Availability to be confirmed (JPL or Teledyne)
   - (-) thermal problem for instrument and payload

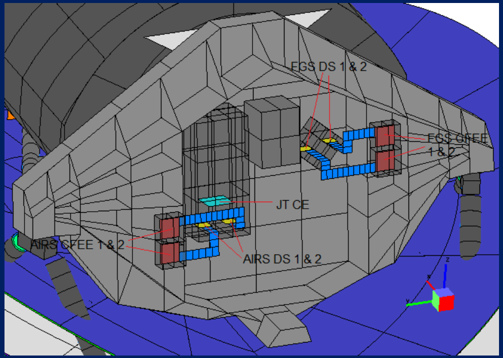
1. SIDECAR JPL package design qualified to 55 K (JWST heritage)
   - (+) best system solution (detector / thermal)
   - (-) qualification is not done

1. Dedicated discrete eletronics chain with pre-amplification stage at 55K and ADC in the DCU (on the warm electronics SVM stage).
   - (+) tailored to the strict ARIEL needs
   - (-) need to qualify componants

The final selection of design will be closed before system PDR



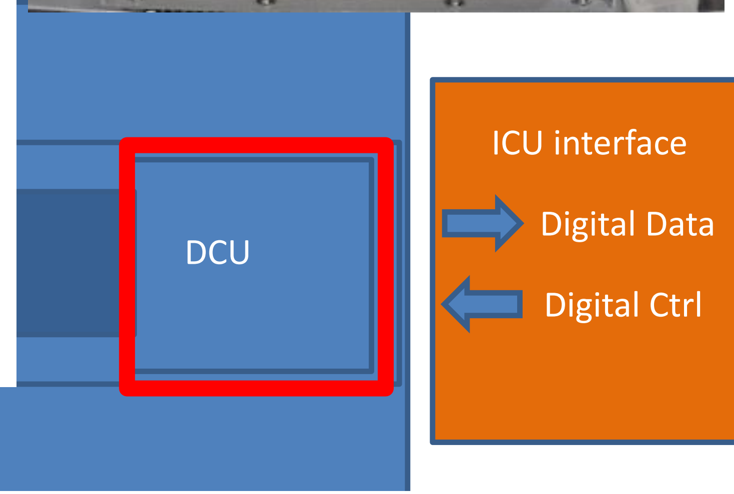




DCU design options

Euclid VIS PMCU (CEA)

Euclid NISP DCU (INAF / OHB)



DCU design will largely rely on heritage from Euclid gained in France and Italy

System Status

Going toward SRR with no critical design issues identified

TRL increase:

- Optics breadboard / Coating
- Derisking on componants: SEU radiations / dose / thermal performance.
- Bread board of DCU +CFEE + ROIC perf
- Detector characterization

But specific items will require specific attention:

- Selection of the CFEE baseline (SIDECAR or Discrete) have at AIRS and Payload level (thermal)
- Performance of stability need to be validated

Next STOP: L2