

Status of detection chains for ongoing infrared optical instruments developments at Airbus Defence and Space

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Infrared Detection for Space Applications 2023

7th-9th June 2023, Toulouse, France

Outline of the talk

- ❑ Optical Instruments Division of Airbus Defence and Space
- ❑ Instruments on-board METOP
- ❑ Stand-alone instruments

Airbus Defence and Space Optical Instruments Division

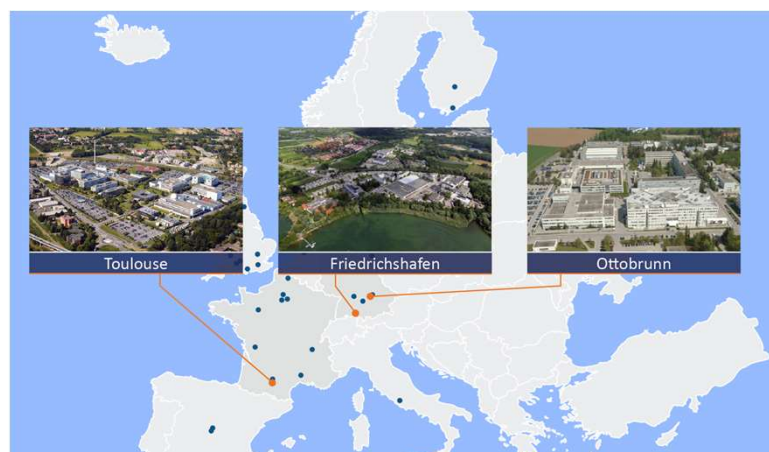
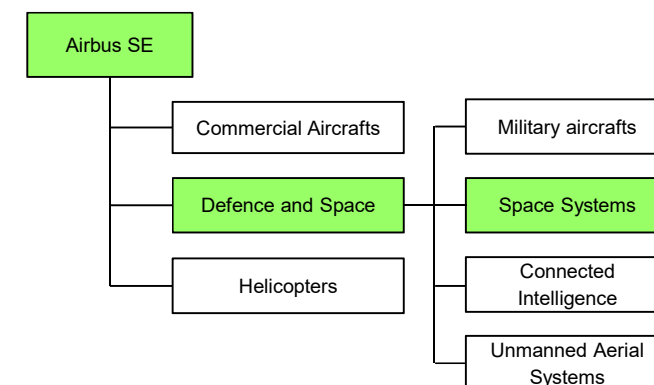
❑ Airbus Defence and Space is a division of Airbus Group

❑ Optical Instruments Division

- ✓ Host of #400 enthusiasts
- ✓ Developing world-class space instruments
Gaia, Aeolus/Aladin, JWST NIRSPEC, Pleiades NEO

❑ 3 sites : Toulouse (TLS) / Ottobrunn (OTN) / Friedrichshafen (FHN)

- ✓ 2 detection laboratory to support R&T, early developments and on-going programs (TLS-OTN)
→ See Markus Haiml's talk on Friday !



Status of infrared detection chains in development @AIRBUS

Outline of the talk

Airbus DS Optical Instruments Division

Instruments on-board METOP-SG

Microcarb

TRISHNA

LSTM

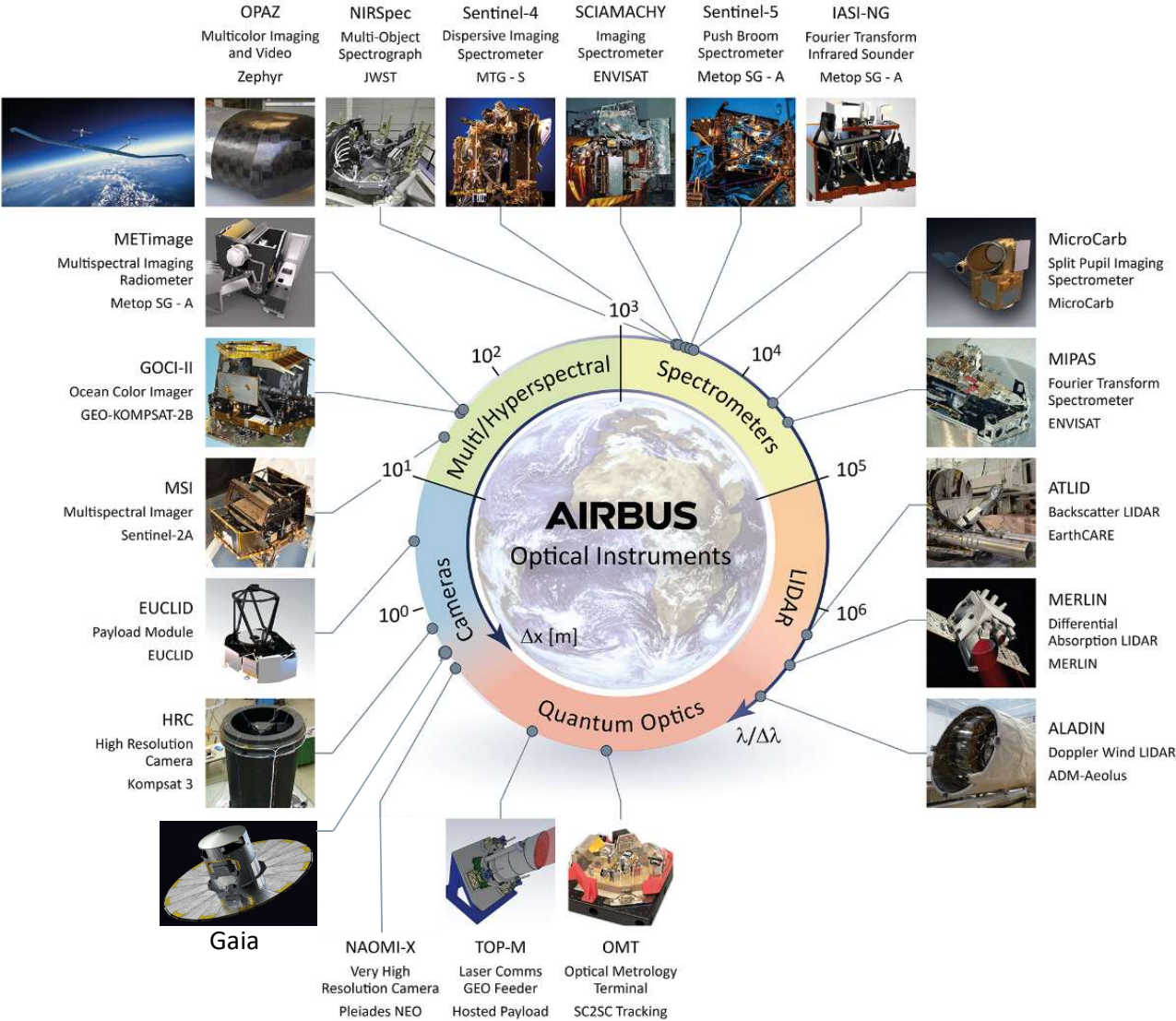
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Conclusion

Infrared Detection for Space Applications 2023

Airbus Defence and Space Optical Instruments Division



METOP-SG

- ❑ Upcoming Eumetsat operational mission for continuous monitoring of Earth atmosphere to feed numerical weather prediction models, hydrology, oceanology, climatology, land mapping, disasters nowcasting
- ❑ Two platforms A/B LEO polar orbit, mid-morning local-time
- ❑ 3 flight models >7.5yrs in-orbit operation each
- ❑ Three of the instruments are contributed by European agencies as Customer Furnished Items
 - ✓ IASI-NG (CNES)
 - ✓ Instrument Prime Airbus DS TLS
 - ✓ MetImage (DLR)
 - ✓ Instrument Prime Airbus DS FHN
 - ✓ Sentinel-5 (ESA)
 - ✓ Instrument Prime Airbus DS OTN

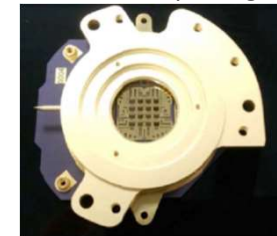


(1) IASING

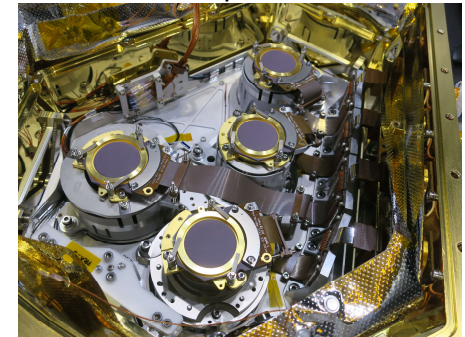
- ❑ Sounder for atmospheric gas concentration monitoring, based on a Mertz interferometer concept observing in 4 bands - MWIR to VLWIR

Spectral band	B1	B2	B3	B4
Spectral range	8.7-15.5μm	5.1-8.7μm	4.3-5.1μm	3.6-4.3μm
Detector type	MCT PC	MCT PV	MCT PV	MCT PV
Operating temp	>75K	>80K	>80K	>80K

- 16 macro pixels per detector packages (Leonardo UK)
 - ✓ 4 Front-End Electronics / 16 channels each
 - ✓ 16 macro pixels shuffled over the 4 FEE for improved reliability
 - ✓ Extensive characterization in detection lab to support development



- ☐ Detection chain hardware all delivered
 - ✓ PFM integrated, tested and delivered to the customer
 - ✓ FM2 integrated and tested
 - ✓ FM3 in course of integration



(2) Metimage

- ❑ 2670-km-swath / 500m resolution whisk-broom scanner for DLR for AVHRR continuity (Metop) and NOAA complementary imaging radiometry
- ❑ 20 bands from 460nm up to 13.3 μ m
 - ✓ VISNIR multilinear detector from Teledyne-e2v (UK)
 - ✓ SMWIR multilinear detector from LYNRED (FR)
 - ✓ LVLWIR multilinear detector from LYNRED (FR)
 - ✓ 1 FEE with 3 proximity electronics from JOP (G)
 - ✓ Detectors all delivered
- ❑ Detection chain hardware testing at Airbus
 - ✓ PFM + FM2 integrated into Cold Imaging Assembly, tested and delivered to instrument for further integration
 - ✓ FM3 to be integrated and tested Q4 2023

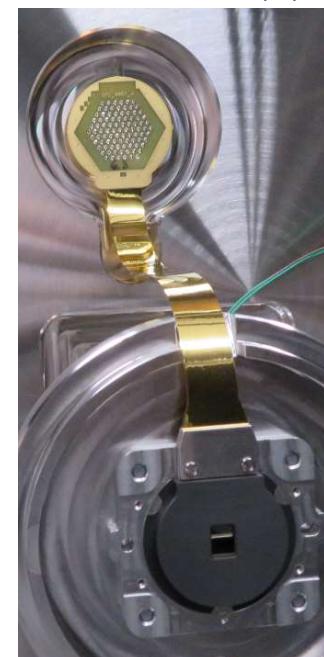
Instrument CAD Model



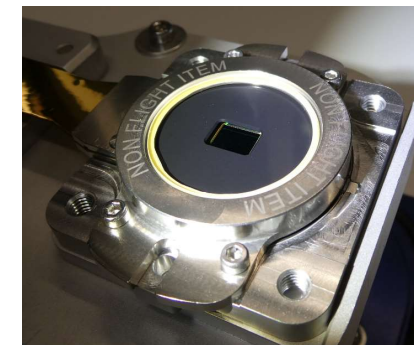
PFM Instrument during AIT



LVWIR Detector in test equipment



SMWIR Detector with cold shield



(3) Sentinel-5

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Instruments Division

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Microcarb

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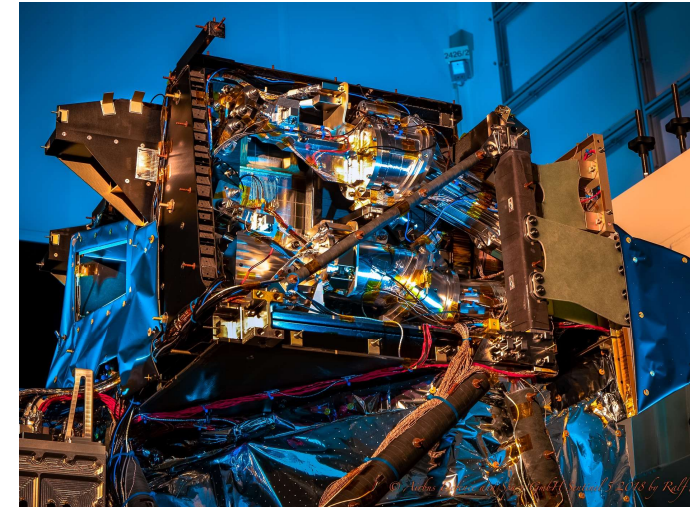
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Conclusion

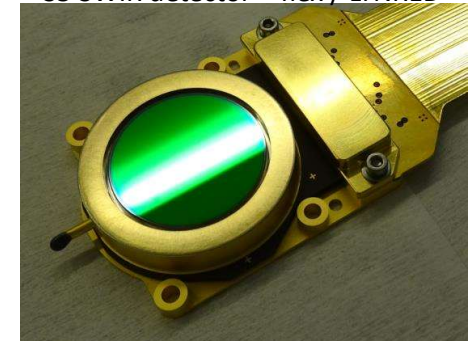
Infrared Detection for
Space Applications 2023

- ❑ Push-broom spectro-imager for trace gases and aerosols measurement / air quality and climate monitoring
 - ✓ 2670-km swath / 7.5km resolution
 - ✓ 5 Spectrometers from UV to SWIR
 - ✓ UV/VIS/NIR channels : CCD 314 from Teledyne-e2v (UK)
 - ✓ SWIR channels (1590-1675 / 2305-2385 nm) – LYNRED (F)
 - ✓ For the SWIR channels:
 - Procurement Airbus Tlse, CFI for Leonardo (IT) for integration into the SWIR subsystem of Sentinel-5



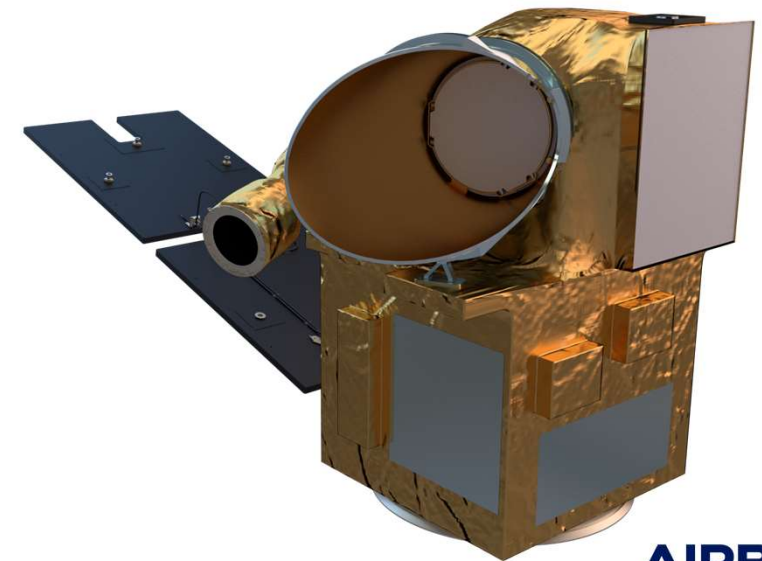
- ❑ Detector supplied from LYNRED (F)
 - ✓ 1024 x 1024 pixels / 4 outputs @ 3MHz
 - ✓ 2.5µm cut-off MCT operated at 145K (passive cooling)
 - ✓ PFM SWIR1 & SWIR3 delivered, integrated, instrument TVAC to start
 - ✓ FM2 detectors delivered (formal DRB on-going)

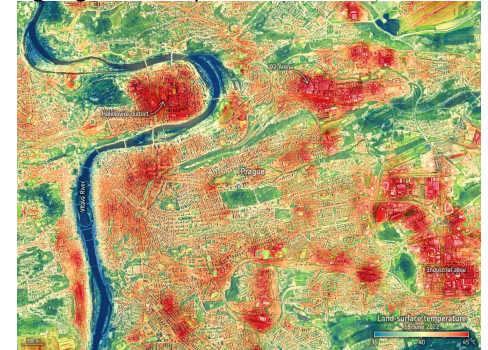
S5 SWIR detector + flex / LYNRED



Microcarb

- ❑ Push-broom spectro-imager for global scale CO₂ life cycle assessment
- ❑ 4 spectral bands 760 nm, 1.27 μm, 1.6 μm, 2.03 μm with a spectral resolution of 10pm multiplexed on a single SWIR detector
- ❑ Detection chain implements
 - ✓ One NGP 2.5-μm-cut-off by Lynred (F)
 - ✓ One Front-End Electronic from Airbus CRISA (SP)
16 bits digitization at 3Msps, up-the-ramp
 - ✓ Extensive testing in detection lab
- ❑ Flight model integration and testing of instrument completed and delivered to platform (TAS-UK)





LSTM – TIR Channels

Land Surface Temperature Monitoring for ESA/Copernicus

- ✓ Map surface temperatures : agriculture management (evapotranspiration, water drought) / urban heat islands / coastal management
- ✓ Whisk-broom scanner instrument with 417-km-swath
- ✓ 2 satellites due for launch in 2028 to ensure continuity of Trishna

Detector supplied from AIM (G)

- ✓ 16 outputs @ 8.33MHz
- ✓ 1088 x 32 lines x 5 bands / 25 μm^2 / BDI
- ✓ Cosmetic down-selection of 23 lines only

	TIR1	TIR2	TIR3	TIR4	TIR5
Central wavelength	8.6 μm	8.9 μm	9.2 μm	10.9 μm	12 μm
Bandwidth	0.18 μm	0.18 μm	0.18 μm	0.4 μm	0.47 μm
Detector material	p-on-n MCT @ 10.95 μm			p-on-n MCT @ 13.6 μm	

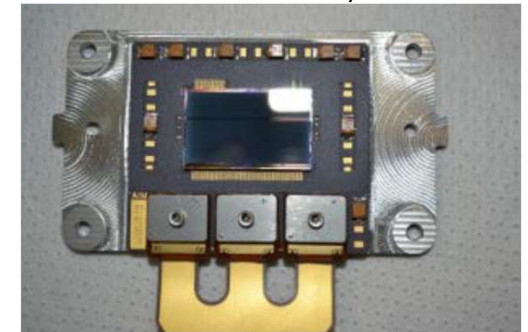
Front-end electronics by Airbus CRISA (SP)

- ✓ 16 video chains / 16 bits / 8.33Msps
- ✓ **Digital TDI on the fly on a further down-selection of operable pixels**

On-going development

- ✓ Instrument PDR successful Q4'22
- ✓ EM detector tested at Airbus detection lab / MTF in TIR
- ✓ FEE BB expected end of 2023

LSTM TIR detector / AIM



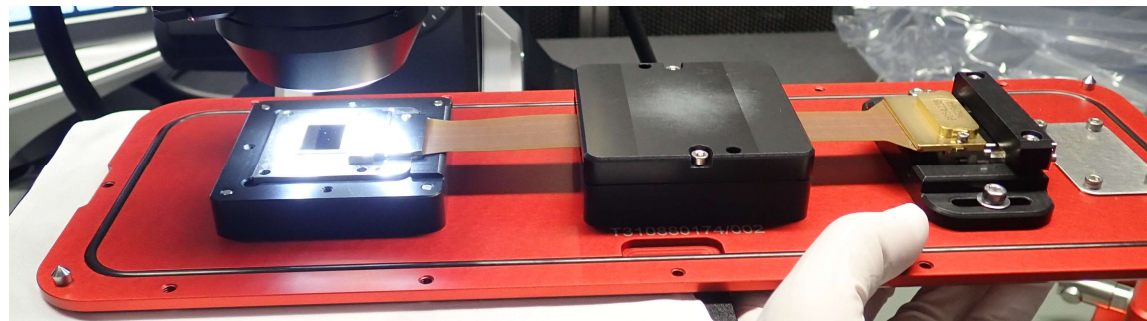
LSTM – NIRSWIR Channels

	VNIR3	SWIR1	SWIR2
Central wavelength	945nm	1375nm	1610nm
Bandwidth	20nm	30nm	90nm
Detector material	n-on-p MCT @ 2.5μm		

- ❑ Detector supplied from LYNRED (France)
 - ✓ 1200 x 12 lines x 4 bands (VNIR3 is duplicated) / 15μm² / CTIA
 - ✓ **12-stage on-chip analogue TDI w/ deselection**
 - ✓ 4 outputs @ 5.56MHz

- ❑ Front-end electronics by EREMS (France)
 - ✓ 4 video chains / 14 bits / 5.56Msps

- ❑ On-going development
 - ✓ TRL6 expected to be demonstrated Q3'23
 - ✓ EM detector tested at Airbus detection lab
 - ✓ FEE DM expected beginning Q3'23



Merlin

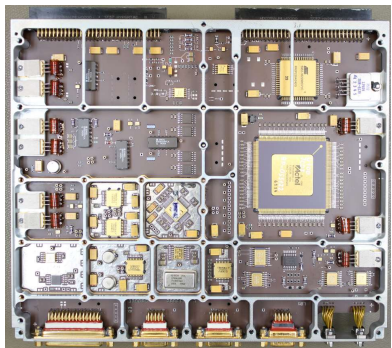
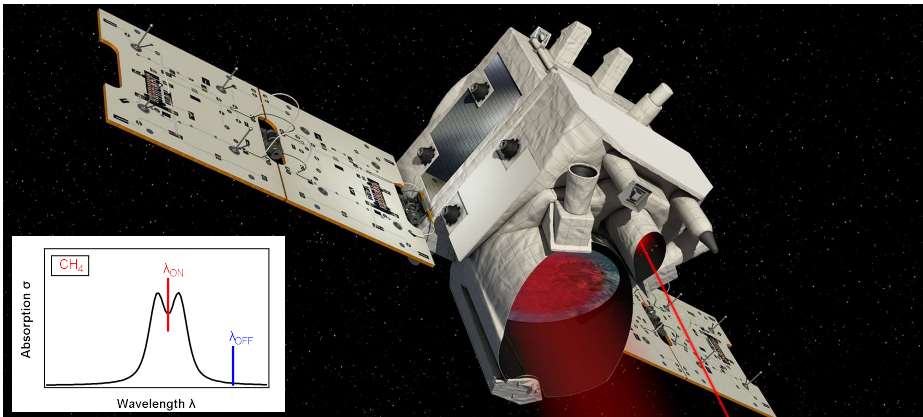
- CNES-DLR cooperation
- Methane remote sensing LIDAR
 - ✓ Global mapping of CH4 for better understanding of its lifecycle
 - ✓ Integrated-Path Differential Absorption (IPDA)
 - ✓ Launch expected early 2027

- NIR laser for TX sensing @ 20Hz

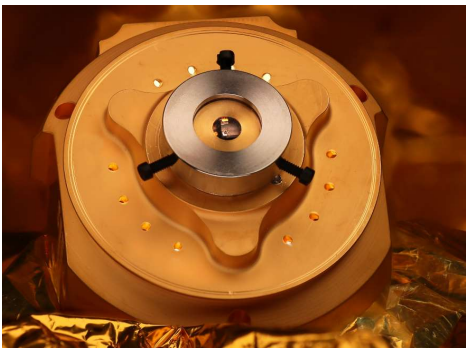
	Value	Unit
Laser-on Line Centre wavelength	1,645.552	nm
Laser-off Line Centre wavelength	1,645.846	nm

- Single pixel InGaAs APD for RX
- Sampling rate: 75 MHz / 14 bit

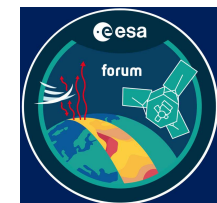
Parameter	On-line	Off-line
Ground Albedo (nom) / Signal Photons per Shot	1964	5670
Ground Albedo (nom) / Background Photons per Shot	153	153
Ground Albedo (max) / Signal Photons per Shot	13450	25379
Ground Albedo (max) / Background Photons per Shot	7120	7120



DCM Board (part of ICU)



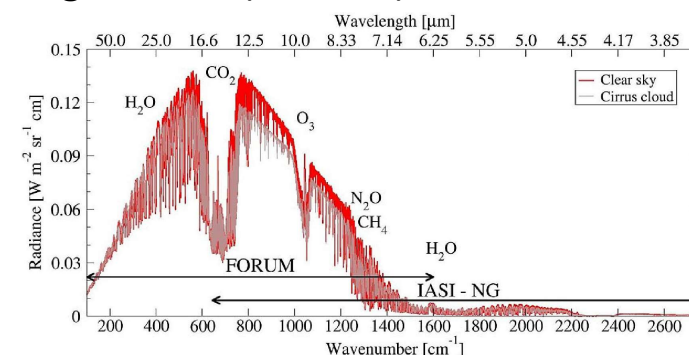
SICA Housing with InGaAs Detector



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Far-Infrared Outgoing Radiation Understanding and Monitoring mission (FORUM)

- ✓ Earth Explorer 9 mission (ESA)
- ✓ Monitor Earth's global "heat radiation" in the mid/far IR
- ✓ Analyse Earth's energy balance in the context of global warming and trace gas contribution to green house effect.
- ✓ Orbits in constellation with MetOp-SG (IASI-NG, METImage)

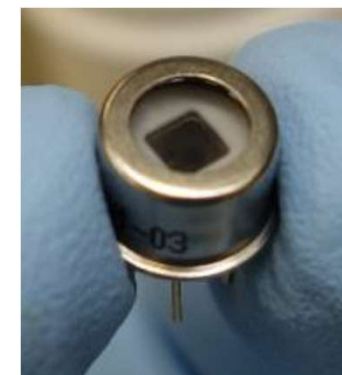
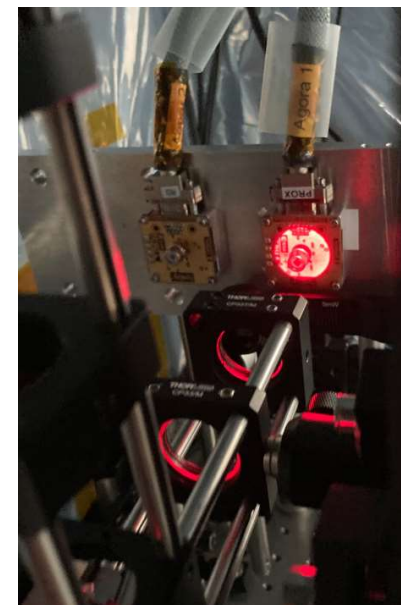


FORUM Sounding Instrument (FSI) FTIR detection chain

- ✓ Based on a LEONARDO (UK) COTS pyro-electric DLaTGS (*) detector with specific diamond lens as entrance window
- ✓ 2.3 x 1.7 mm² photo-sensitive area
- ✓ Spectral range 6.25 – 100 μm
- ✓ corresponding to 19 – 319 Hz electrical spectral range

Front-end electronics by vH&S (Germany)

- ✓ 6.5 kHz temporal over-sampling
- ✓ 16-bit science data / 14-bit metrology data
- ✓ Amplitude and phase shaping for group-delay-dispersion compensation



Leonardo UK S106
DLaTGS single pixel
pyro-electric detector

(*) Deuterated L-alanine doped triglycene sulphate

Airbus DS is committed to deliver high-end infrared optical instruments in deep cooperation with

- ❖ National and European agencies **ESA / CNES / DLR / Eumetsat**
- ❖ Detectors industrials **AIM / LYNRED / LEONARDO**
- ❖ Electronics suppliers **JOP / Airbus CRISA / vH&S**
- ❖ Internal support from Airbus detection laboratories
- ❖ Airbus **thanks** you all for your **discontinued** trust and support !

AIRBUS DS is thrilled to support upcoming infrared challenges

- ❖ IR programs : Truths, EE11 (CAIRT/Nitrosat), Sentinel-2 NG, ...
- ❖ New detector programs and technologies

!! Thank you for your attention !!

IASI PFM integration on METOP-SG A1 platform

