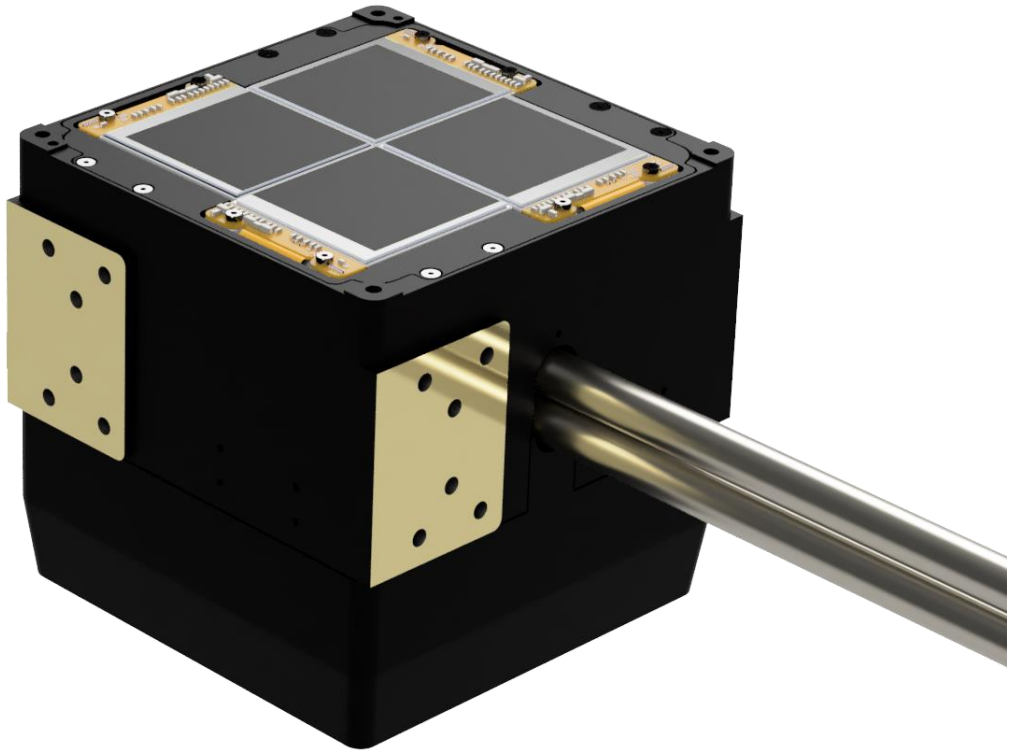
ULTRASAT UV camera

Design and first characterization results



Francesco Zappon
on behalf the DESY camera team
21st of October, 2022

HELMHOLTZ

The ULTRASAT mission

Spacecraft

- ~1000 Kg spacecraft
- Expected launch: 2025
- Mission lifetime: 3 years (with fuel capabilities for an extension up to 6 years)
- Geo-stationary orbit: continuous communication to ground station

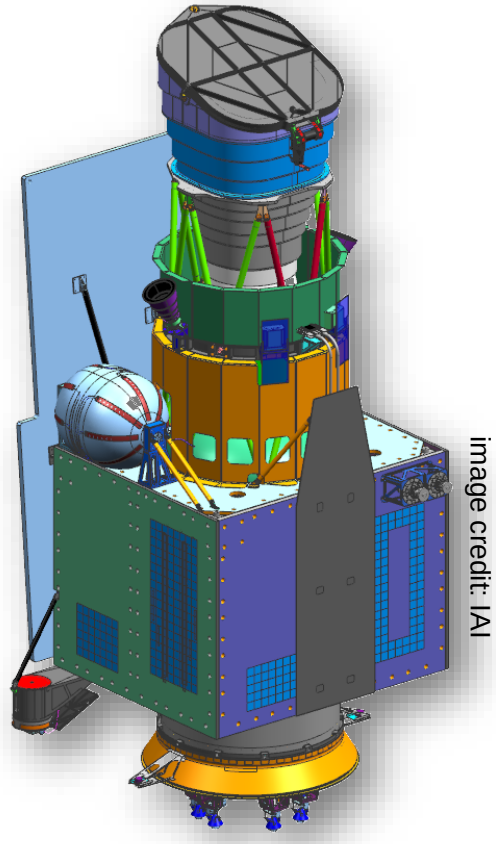


image credit: IAI

Payload

- UV telescope:
  - operational band 220 – 280 nm
  - large field of view (200 deg²)
- Schmidt design: detector is in the optical path

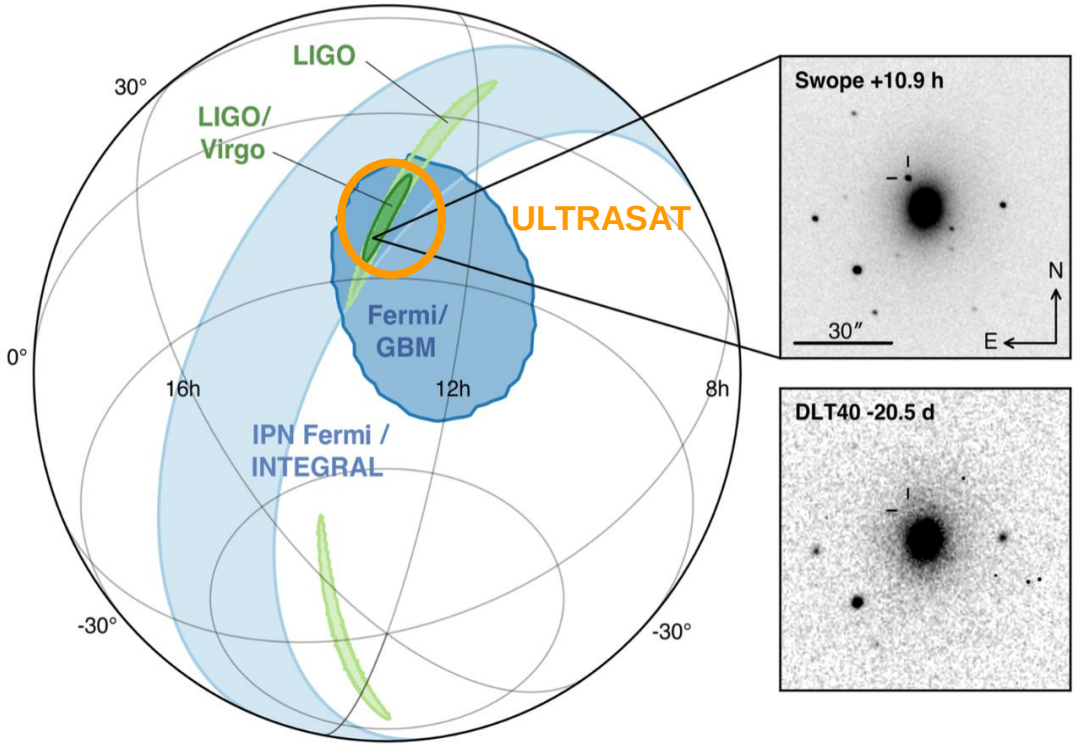
Organizations

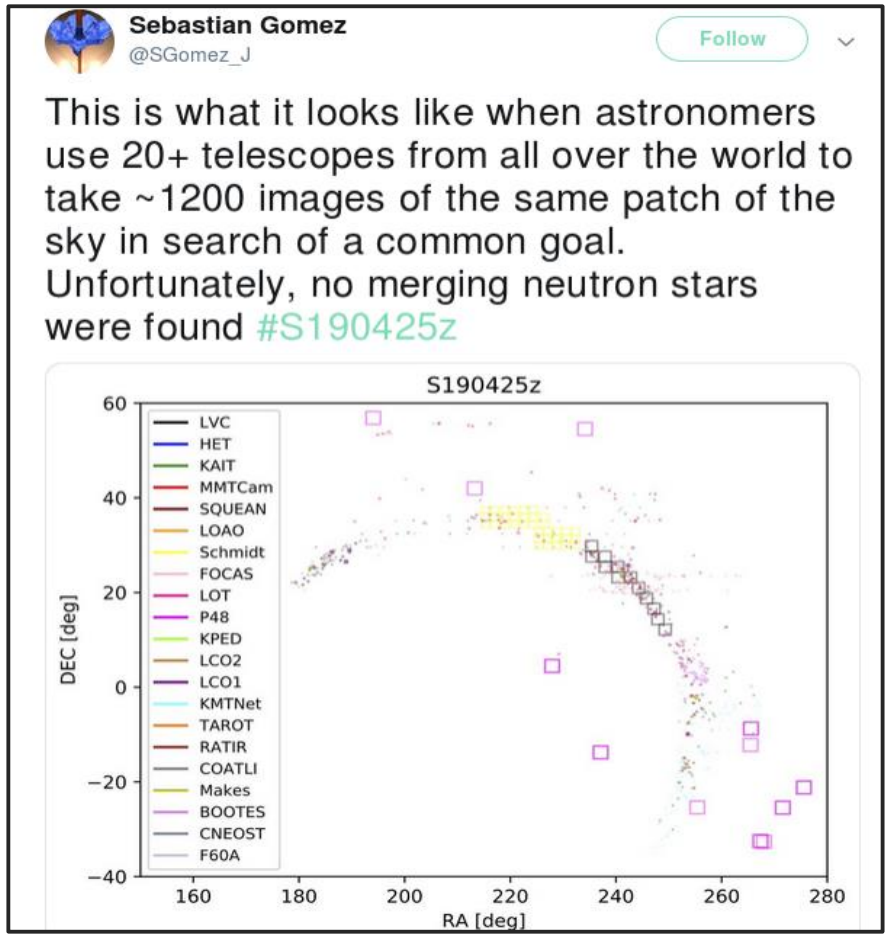
- Developed by Israeli industries (IAI, ELOP) with scientific lead of Weizmann Institute, and ISA with collaboration of DESY and NASA
- DESY joined in 2019 and will provide the UV camera

ULTRASAT science

Gravitational Wave counterparts

Large field of view (200 deg²) allows rapid transient follow-up (<3 min) and alerts (<30 min) of the astrophysics community.



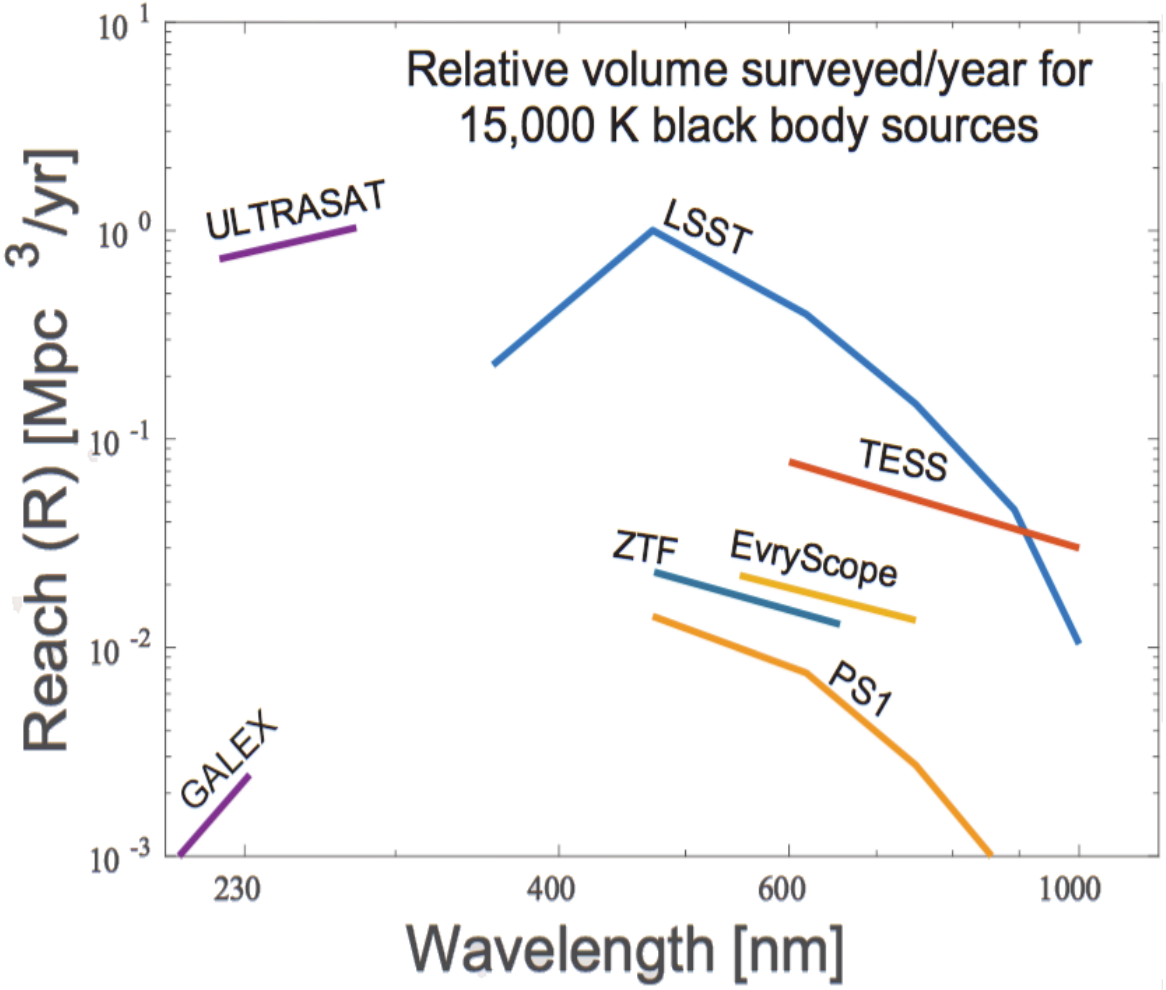


ULTRASAT science

Deep surveys and serendipitous discoveries

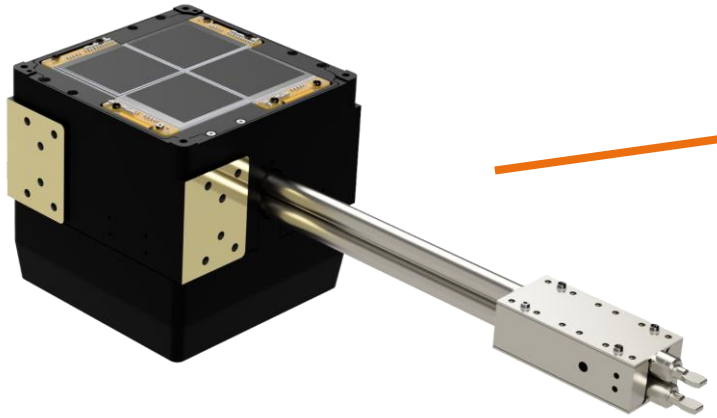
1. Stellar collisions
   - How are heavy elements formed?
   - How do black holes form?
   - What is the expansion rate of the Universe?
2. Supernovae
   - How do stars explode?
   - How do they affect their environment?
3. Active Galactic Nuclei
   - How is mass accreted on black holes?
   - How is the accretion disk connected to jet emission?

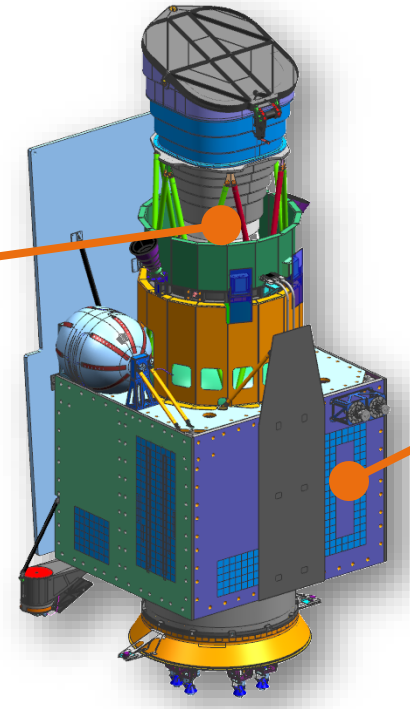
... and many more …



The UV camera

System description





Detector Assembly

- Contains:
  - UV sensor
  - Sensor power and telemetry circuitry
  - Thermal elements (heat pipes, straps)
- Dimensions: 135 mm × 135 mm × 131 mm
- Mass: 5.3 Kg

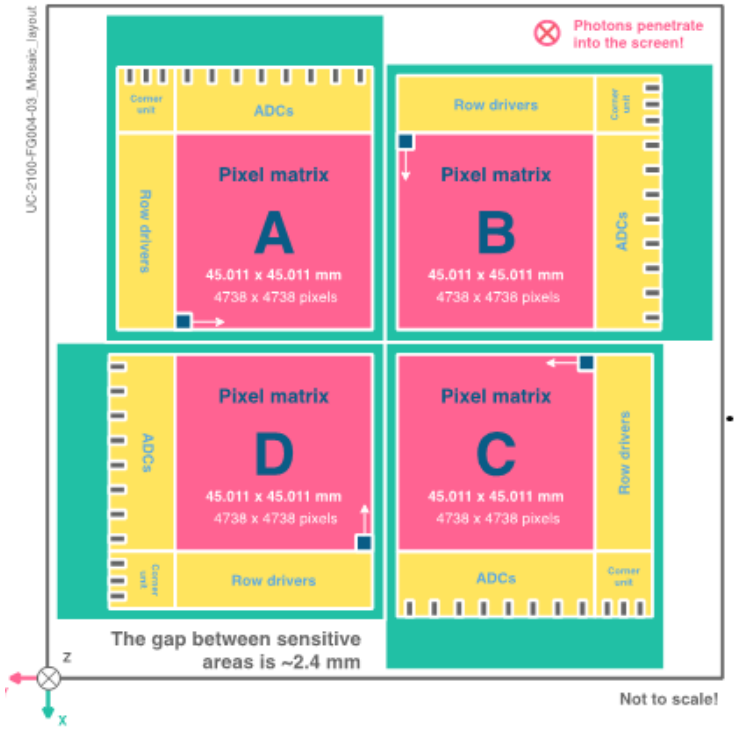
Remote Electronics

- Contains:
  - Interfaces to S/C (commands, telemetry, science data, power)
  - FPGAs to control the entire camera
  - Main power conditioning
- Dimensions: 296 mm × 196 mm × 97 mm
- Mass: 5.0 Kg

The UV sensor

System description

- Custom designed and fabricated by TowerJazz
  - Back-Side-Illuminated (BSI) process
  - Uses stitching to achieve large active area
- Full mosaic (90 Mpixel): 4 sensors in windmill configuration
- Rad-hard by design
- Operated at 200 K to reduce Dark Current
- Field flatteners and filter directly on top of the mosaic (~550 um)



Property	Value
Pixel size	9.5 µm
Sensitive area (W x H)	4738 x 4738 Pixels
	45.011 x 45.011 mm
Die dimensions (W x H)	47.135 x 50.080 mm
Pad size	100 x 200 µm
Pad pitch	150 µm
Wafer flatness	< 100 µm
Dark Current (25°C)	30 – 50 e/sec/pixel
Dark Current (200K)	< 0.026 e/sec/pixel
Operation temperature	195 – 205 K

Thermal and mechanical challenges

Mechanical challenge

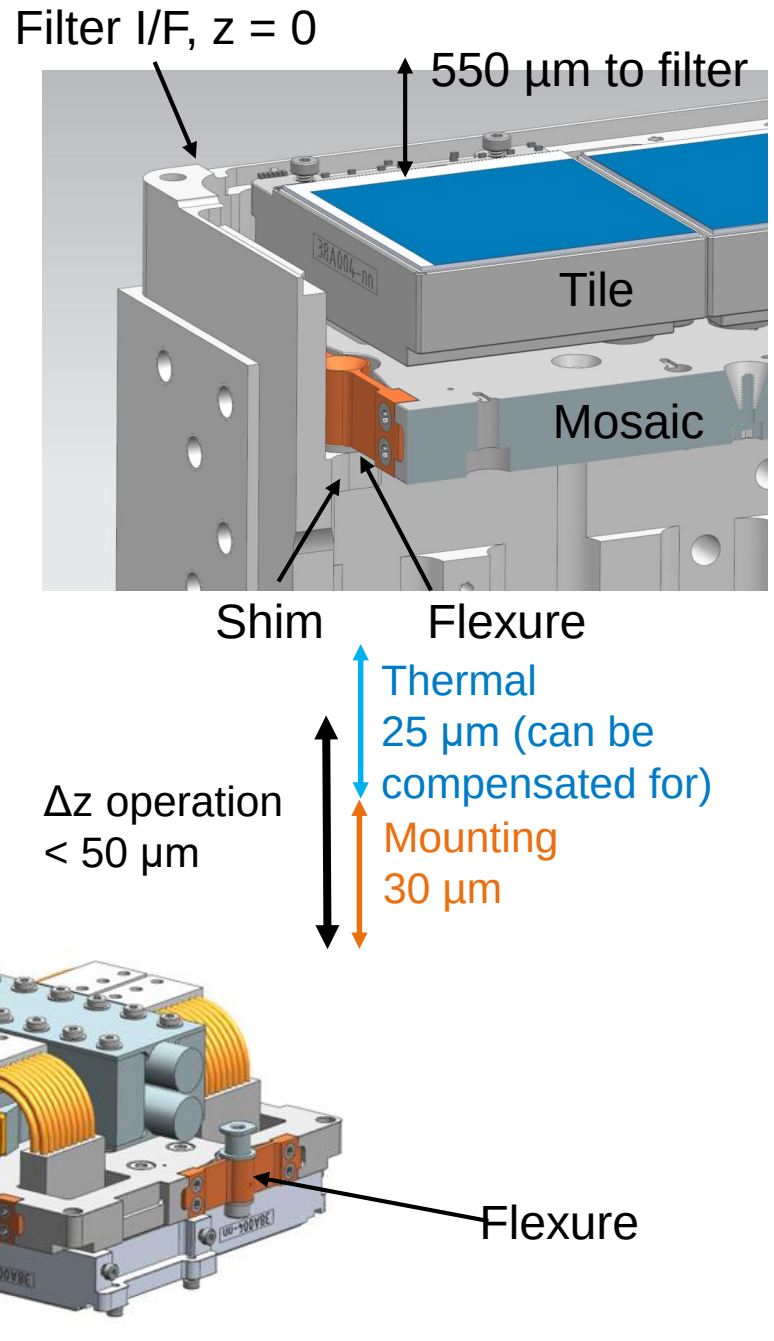
Requirements:

1) Focal Plane to Filter Mounting reference < 50um
2) Mosaic Array Plane curvature < ±10um

Two steps approach:

- Mount and correct at ambient temperature
  - Sensor P2V < 5 um
  - Mosaic < 20 um
  - Shimming < 5 um target
- Take into account shrink at operationl temperature
  - Constant offset compensated by shimming at ambient temperature

→ Clearance to filter is extremely important (e.g. at launch)!



Thermal challenge

Two parts of the same assembly to be kept isolated at different temperatures

- mosaic: 200 K
- DA frame: ambient temperature (292-298 K)

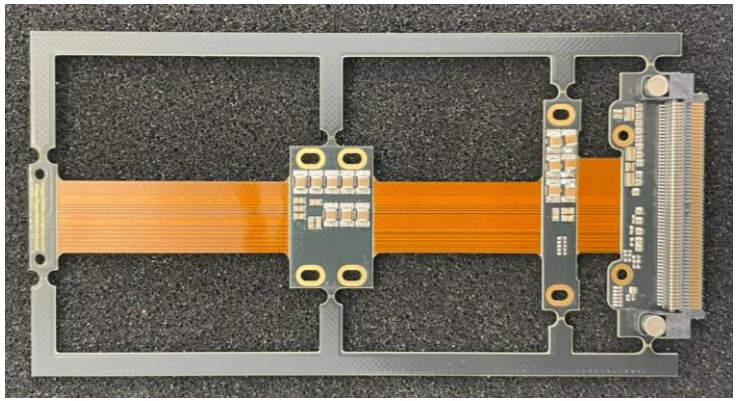
Ultem flexures:

- Thermally isolating
- Locations: Mosaic to DA frame and heat pipe to DA frame

Electronics challenges

Sensor low noise requirements

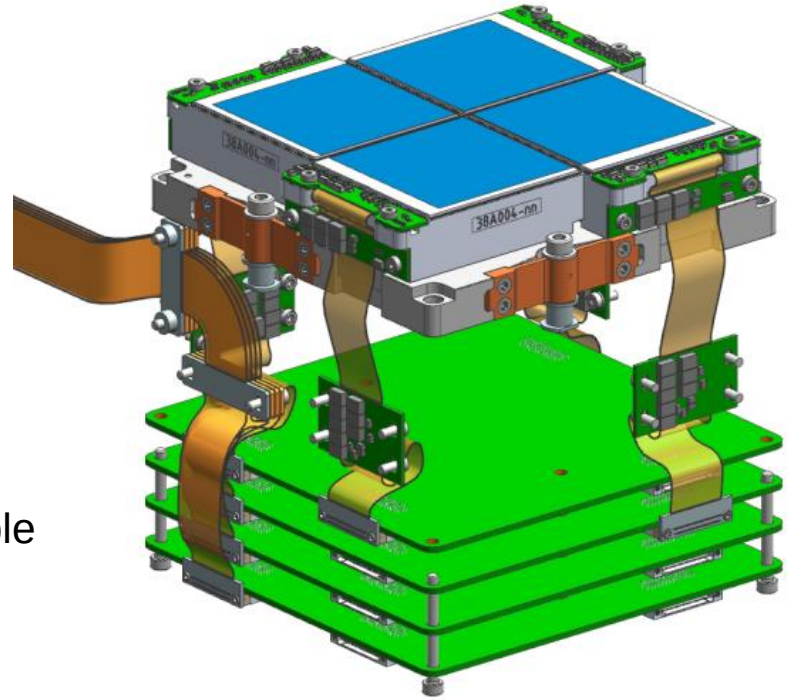
- Extremely low noise sensor’s requirements
- Source-of-load to point-of-load ~ 15 cm
- Requires a lot of capacitance to compensate the impedance



Supply	Description	Voltage, V	Current, mA	Noise, mVrms
VDDD	Digital supply	3.0 - 3.6	162	20
VDDA	Analog supply	3.0 - 3.6	280	1
VDD_RST_H	Reset supply high	2.7 - 3.6	0	1
VDD_RST_L	Reset supply low	0 - 1.3	0	1
VDD_SEL_RST	Select and reset gate signal supply	3.0 - 4.0	0	1
VDD_SEN	SEN (low/hi gain) gate signal	3.0 - 4.0	0	1
VDD_TX	Transfer gate signal	3.0 - 4.0	0	1
VDD_SF	Pixel source follower supply	3.0 - 3.6	47.42	0.2

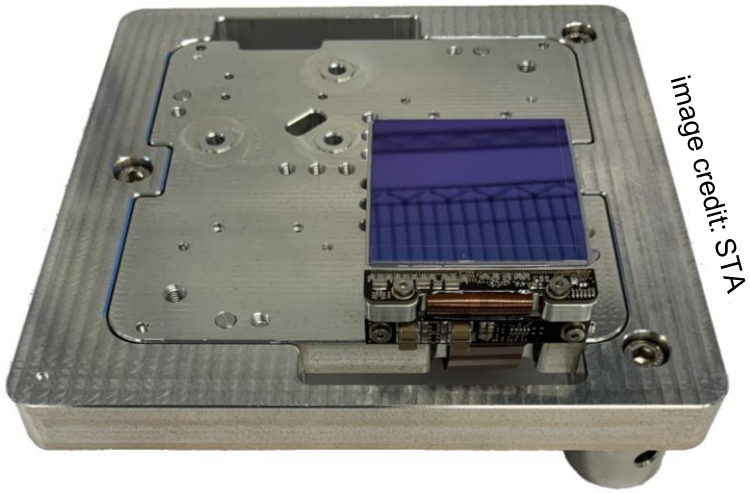
DA-RE distance and EMC requirements

- Distance between RE and DA ~ 3 m: cable + flex PCB
- Noisy environment due to all other spaceraft sub-systems
- Design precautions taken at every step: connector backshells, twisted pairs, cable shielding, low switching frequencies where possible, don’t operate sub-systems together



Status and milestones

- First packaged sensor at DESY next week
- Flight version of several parts have already been produced (heat pipes, thermal straps)
- Electronic development models have been produced
- Functional and optical tests performed on the first sensors by the end of the year
- Radiation tests at the beginning of 2023
- Delivery of the first Engineering Model of the camera to the telescope designer in 1st half of 2023
- Integration of the Flight Model of the camera ~ end of 2023
- Integration of telescope and S/C ~ 2024
- Launch ~ 2025



One sensor mounted onto an Aluminum mosaic plate

Thank you.

HELMHOLTZ

DESY.