

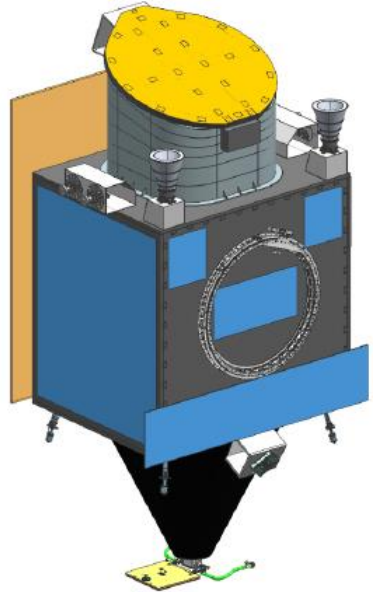
ULTRASAT: Project overview

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Implementation

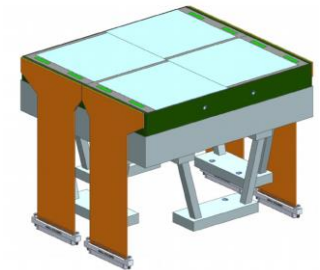
Spacecraft: IAI



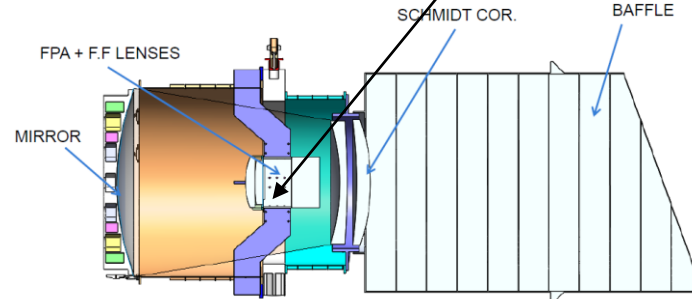
Telescope: Elop/Elbit



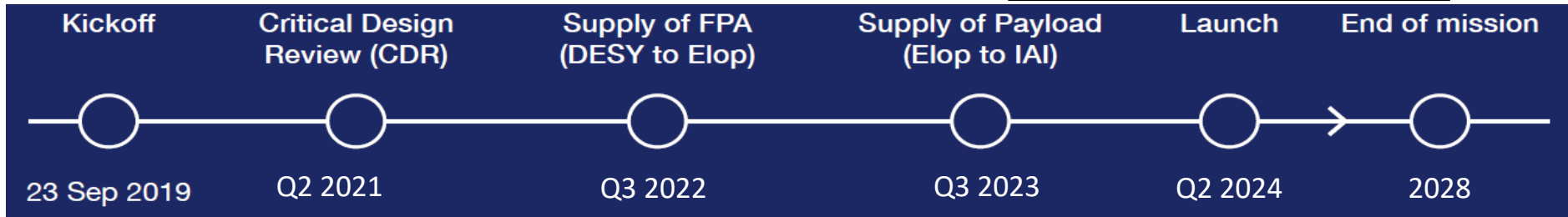
Focal Plane Array (Camera):
DESY/Helmholtz



Dimensions: 2.6 x 1.5 x 1.2 (m³)
Power: 300 W
Mass: 300 kg

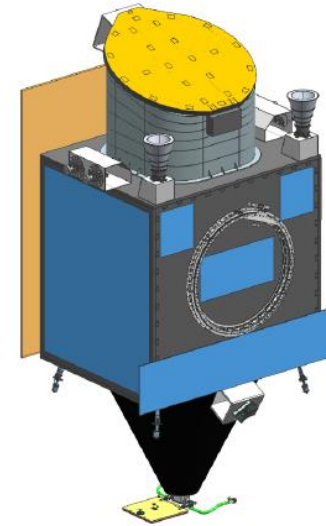


Hosted launch to GEO



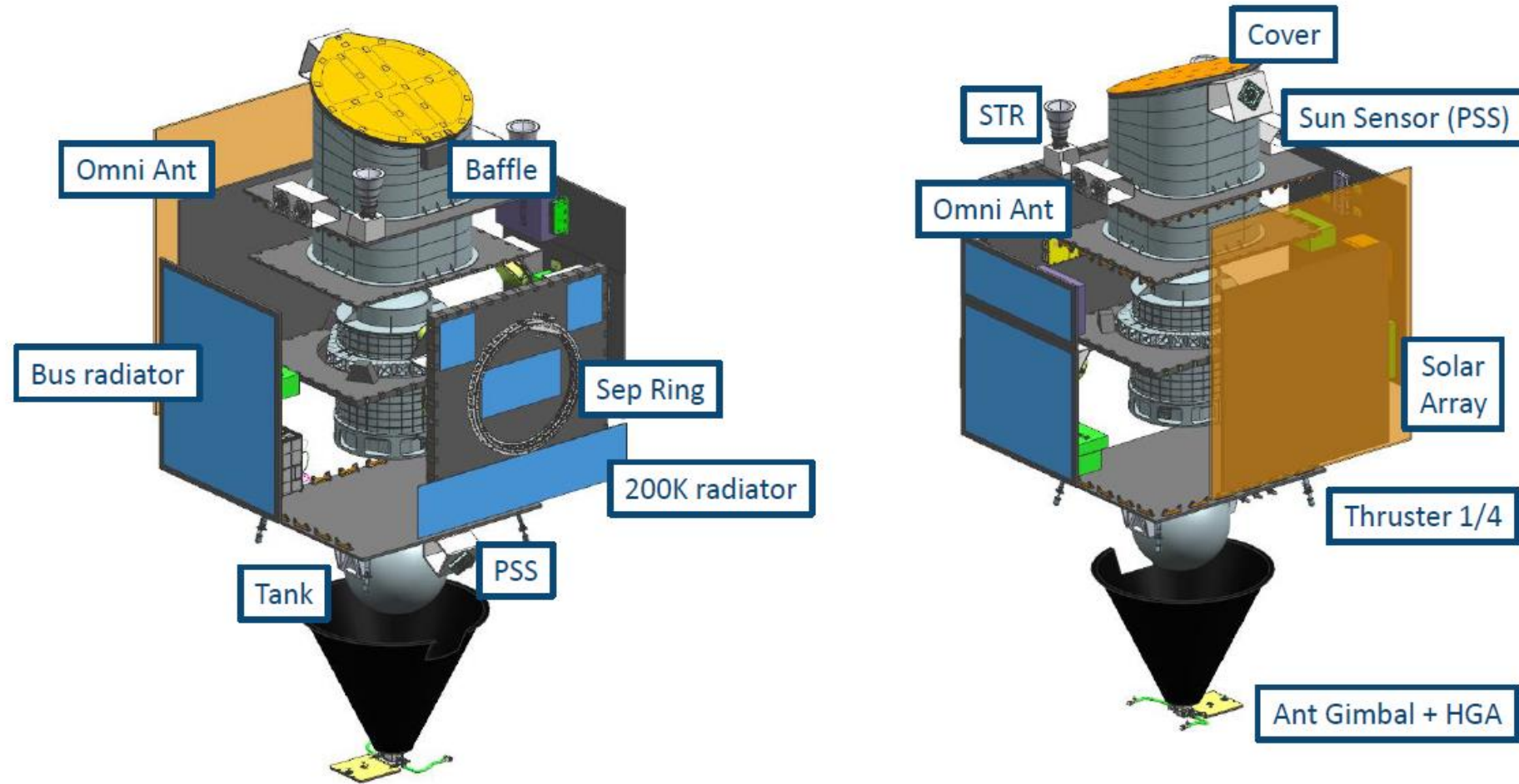
Spacecraft

- Launch into GEO orbit
 - Final orbit – Slot 4-West (under discussion)
 - Full Station Keeping
- Continuous transmission, except for 13% of ToOs (Antenna limits)
- Instantaneous >50% of the sky in <10 min for >3 h
- No limit on ToO number, except for ~13% with Sun angle > 144° (Power limit)



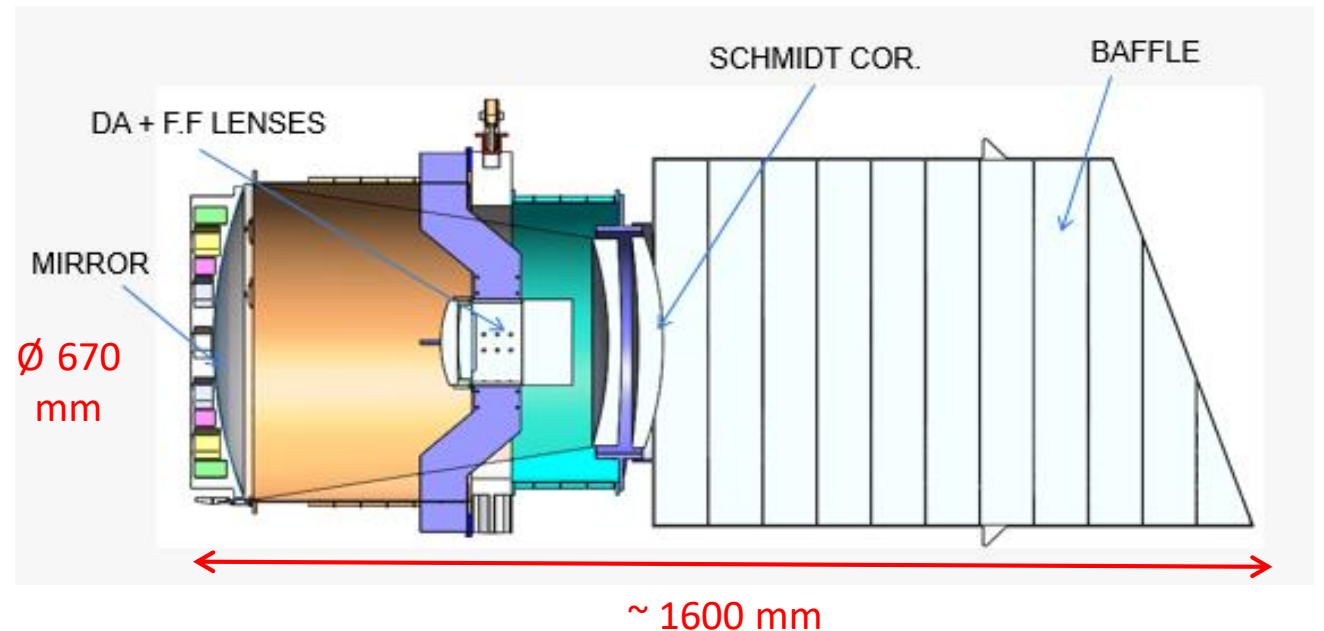
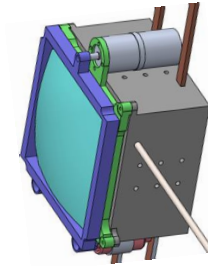
Mission lifetime	3 years
Kinematic lifetime	6 years
Science observations availability	>90%
Pointing stability	<3.0" over 300s (3 σ)
Data Downlink rate	>5 Mbps
Pointing slew agility	30°/min

S/C Configuration



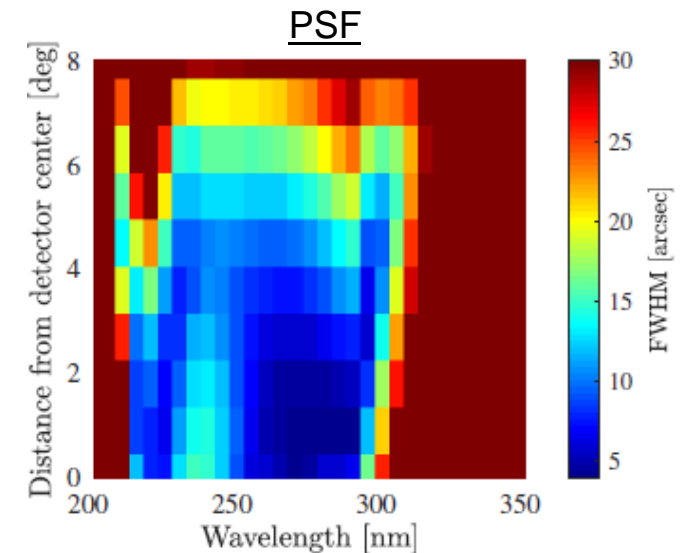
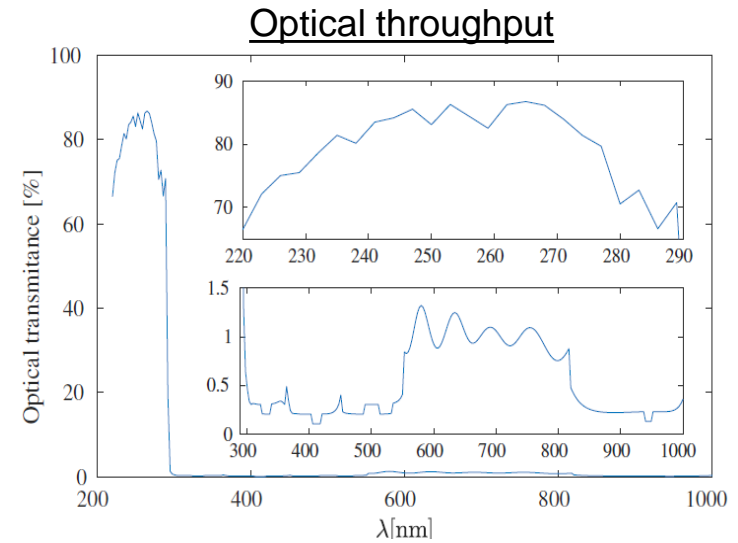
Telescope

- Schmidt design:
 - 2 Schmidt correctors (33cm) + 1 mirror (50cm) + 2 flat-field correctors
 - Each pair of lenses: Fused Silica + CaF2
 - Focus mechanism: FF vs Mirror
- Baffle
 - Reduce stray light
 - Cerenkov Radiation Suppression
- Highly sensitive to contamination:
 - No complex material
 - Several outgassing cycles
- Optimized PSF in the UV + large FoV:
 - PSF radial variation
 - PSF wavelength variation



Telescope main Spec.

Aperture	33cm
Field of View	200 deg ²
Mean in-band PSF FWHM	<13"
Pixel scale	5.44"/pix
In-band optical throughput	>0.8
Out-of-band attenuation	<4x10 ⁻³
Obscuration	<0.31

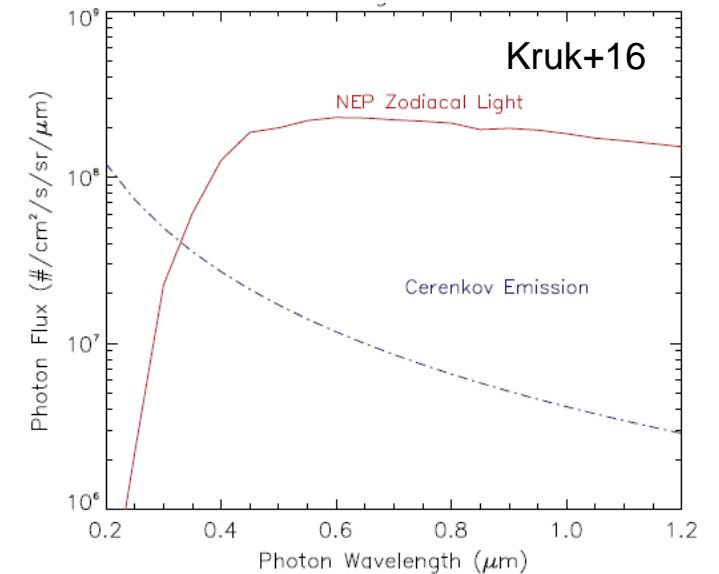
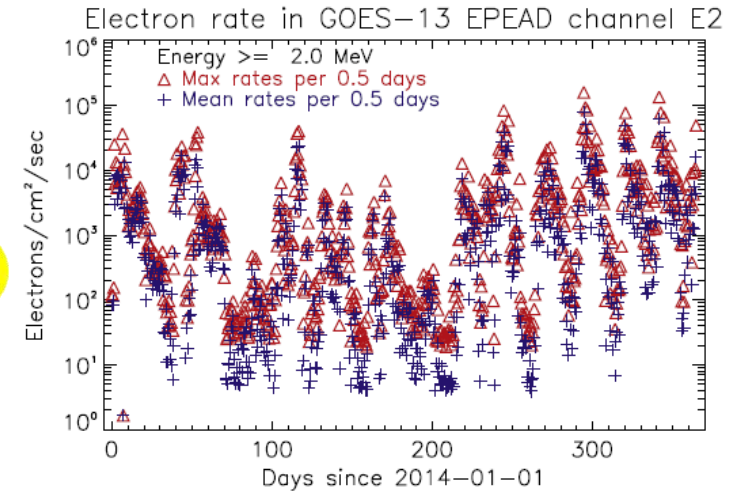
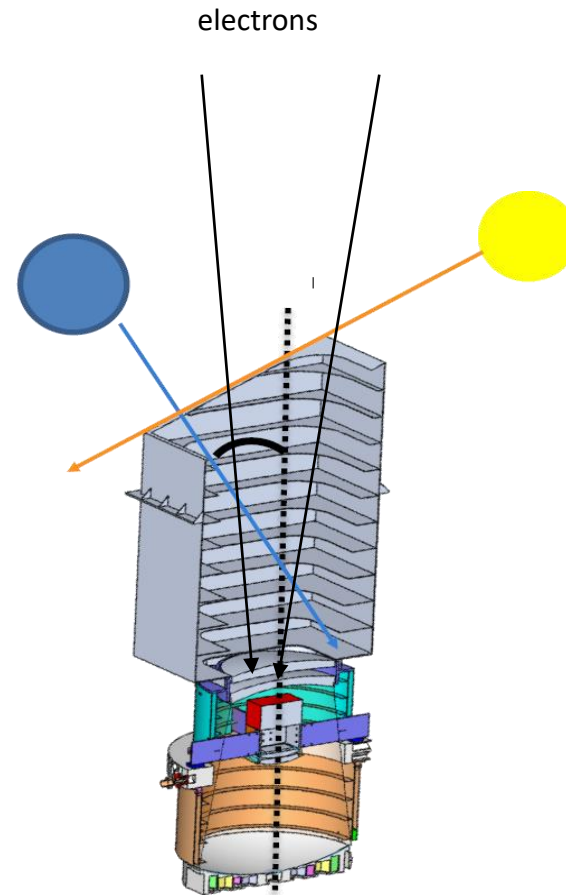


Baffle – Cerenkov radiation

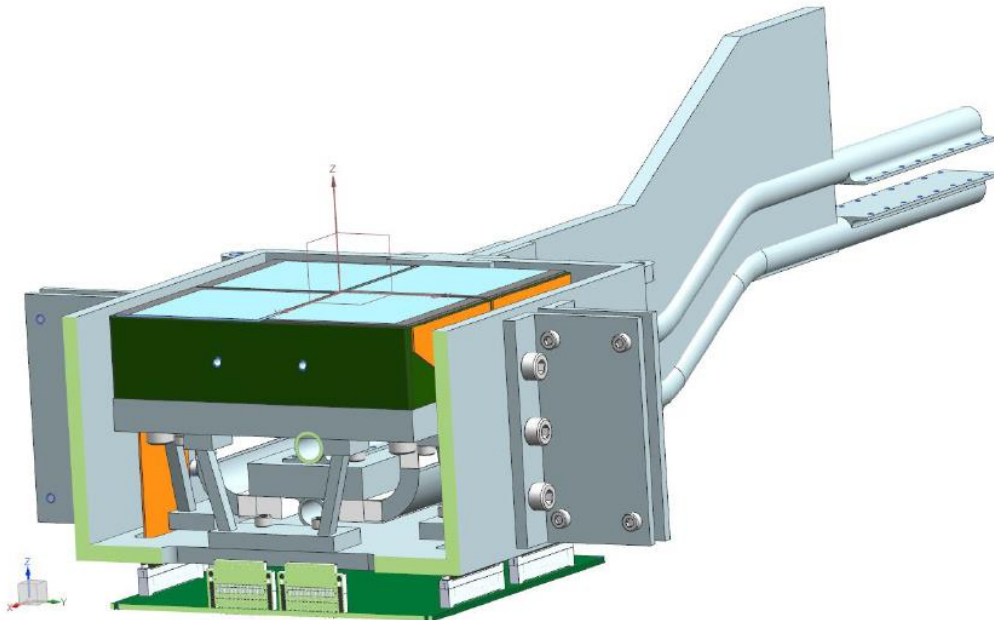
- Trapped relativistic electrons propagating through the corrector glass emit Cerenkov UV radiation
- Isotropic radiation
- Large temporal variations

Baffle main Spec.

Stray light suppression factor	$>4.5 \times 10^{10}$
Solid-angle suppression (Cerenkov)	1/6
Baffle Column Density (Cerenkov)	1 g/cm ²
Sun pointing angle	$>70^\circ$
Earth (/moon) pointing angle	$>48^\circ$



- Developed and supplied by DESY
- 4 quadrants BSI CMOS from TowerJazz
- Ramon Space support for space qualified design (e.g., radiation hardness)
- Optimized UV QE using high-K dielectric coating

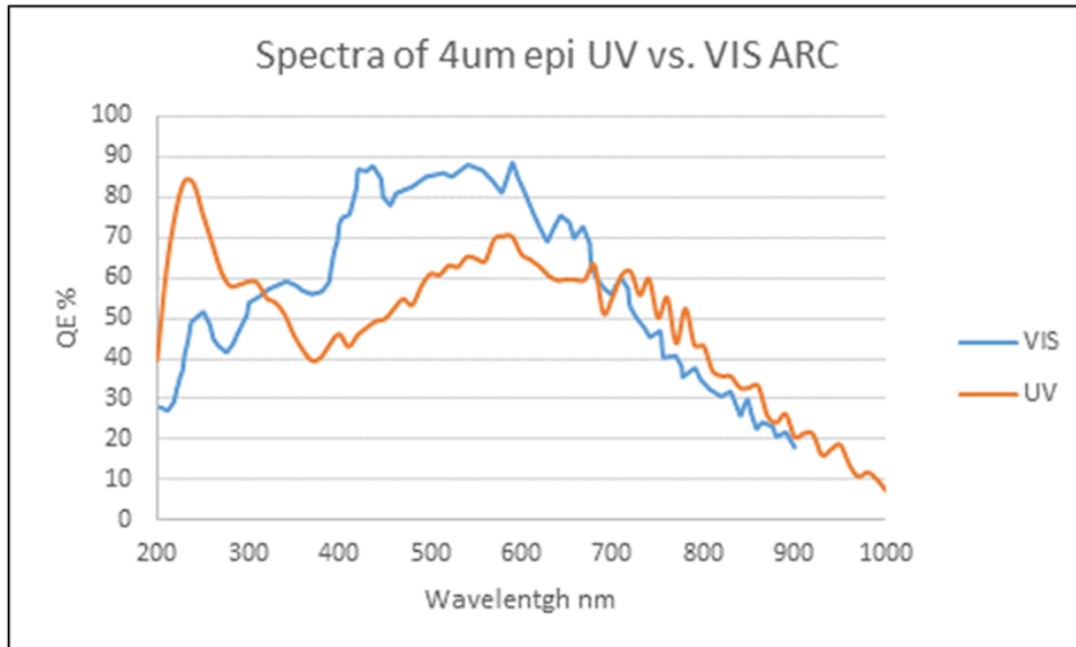


Sensor main Spec.

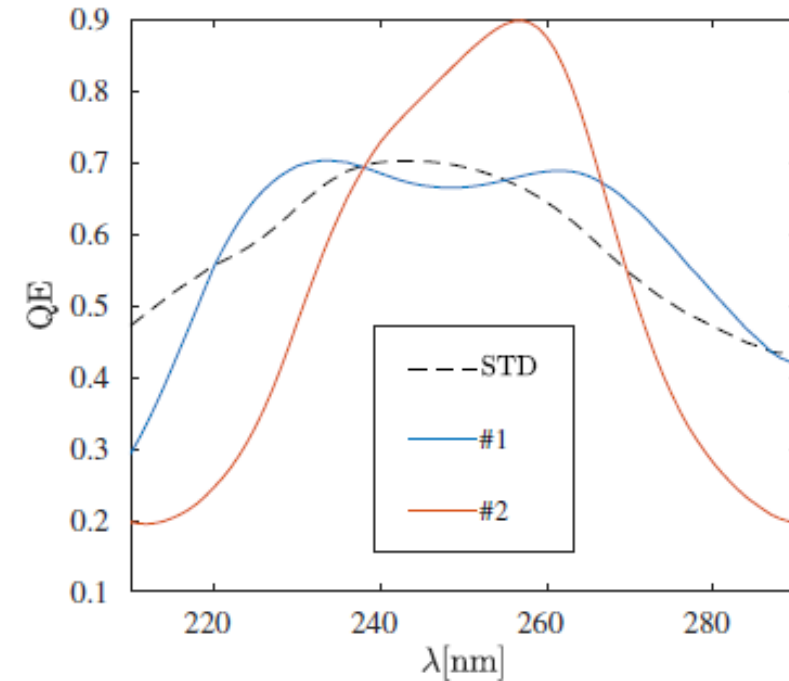
Photosensitive surface (4 quadrants)	90x90 mm
Pixel size	9.5 μm
Operation waveband	220-280nm
Mean QE in Operation band	>60%
Operation temperature	200 \pm 5 $^{\circ}\text{K}$
Dark current @ 200 $^{\circ}\text{K}$	<0.03 e ⁻ /sec
Readout mode	Rolling shutter
Readout time	<25 sec
Readout noise @ High-gain	<3.5 e ⁻ /pixel
Electronic cross-Talk	<0.01%
Pixel sampling scheme	HDR capability
Low-gain Well capacity	140-155 Ke ⁻
High-gain Well capacity	16-21 Ke ⁻
Bits per Pixel – total (data only)	14 (13)

QE optimization

- Scouts with 3 ULTRASAT-optimized coatings
- One of which already measured and proven

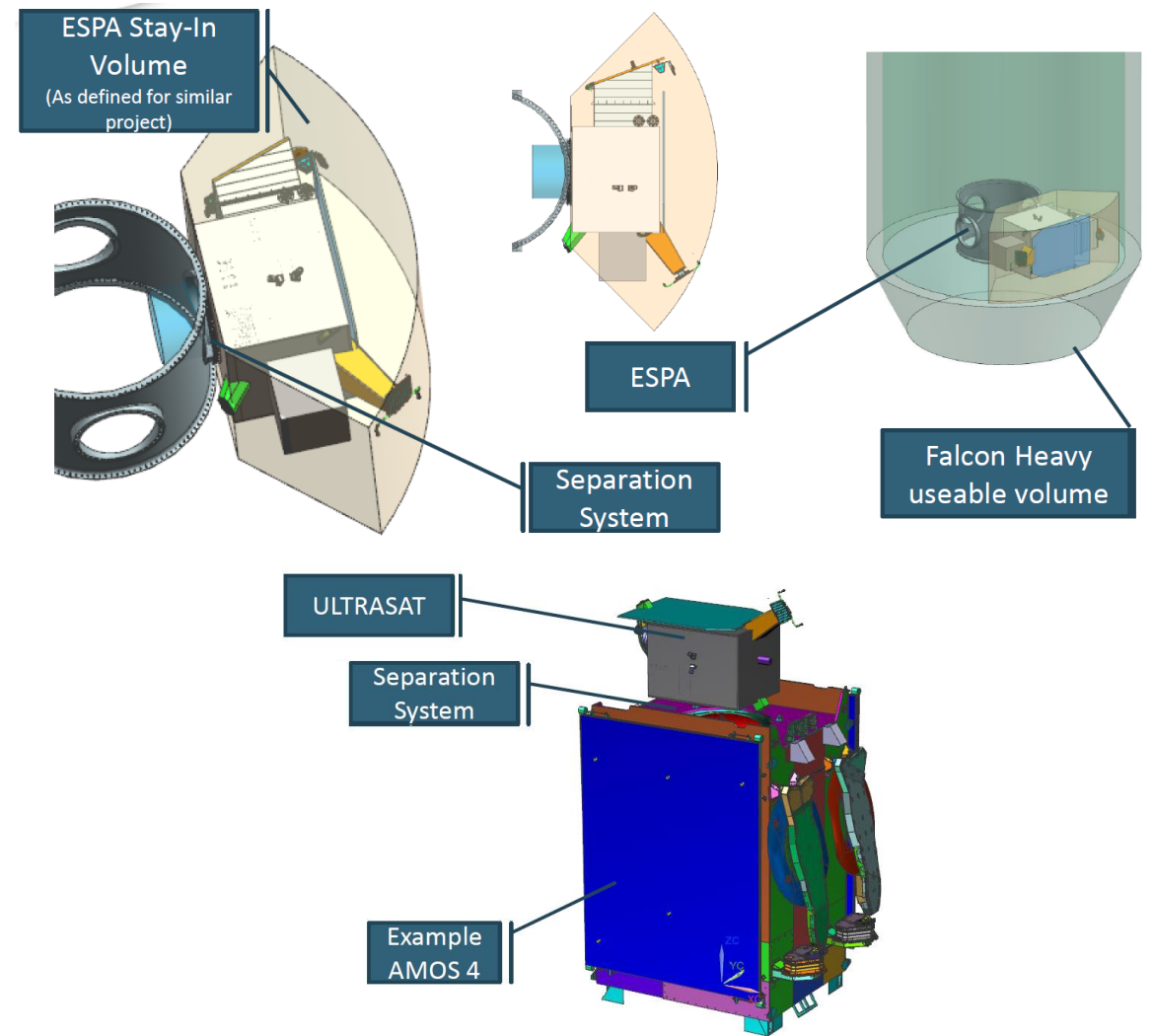
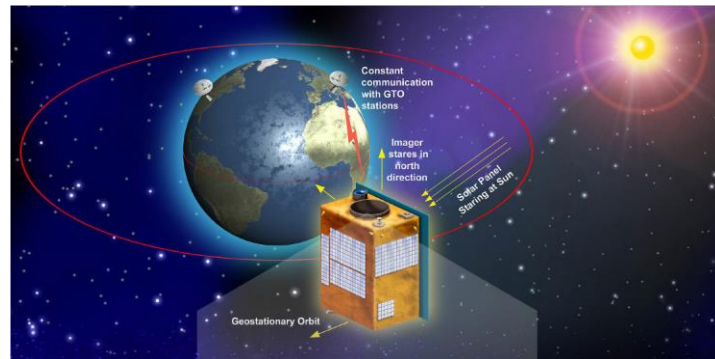


Option	Mean QE (220-280)	+/-5% thickness	Minimum QE @>290
STD	62.2%	1%	30%
#1	65.5%	2.6%	30%
#2	61.8%	2.6%	18%



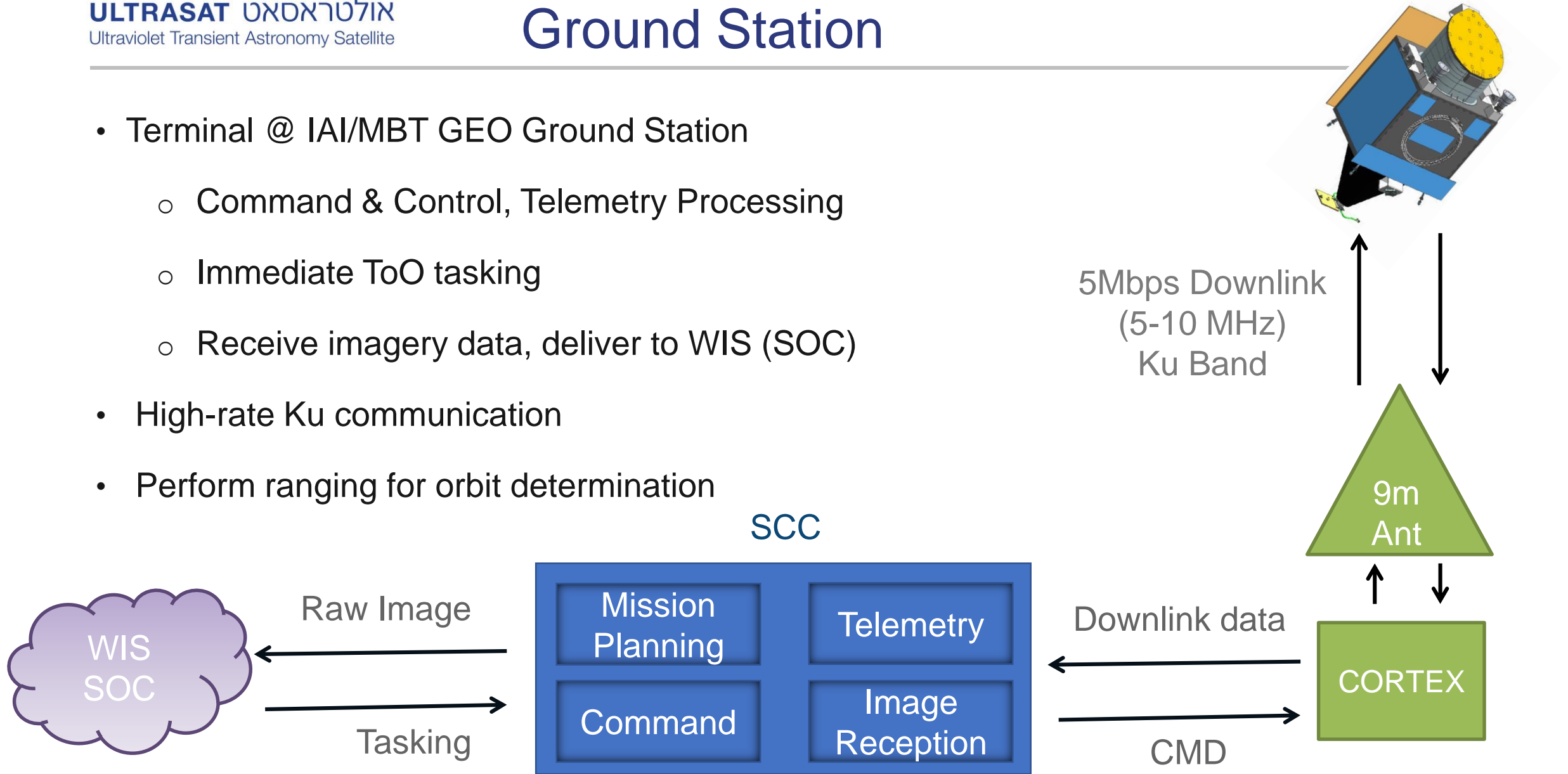
Launcher

- Hosted launch to GEO
 - Direct to GEO on the launcher
 - Or
 - Piggy back on a larger satellite, then GTO to GEO
 - Up to 6 month slot acquisition to final orbit
- ULTRASAT compatible to ESPA port



Ground Station

- Terminal @ IAI/MBT GEO Ground Station
 - Command & Control, Telemetry Processing
 - Immediate ToO tasking
 - Receive imagery data, deliver to WIS (SOC)
- High-rate Ku communication
- Perform ranging for orbit determination



Program Time Table

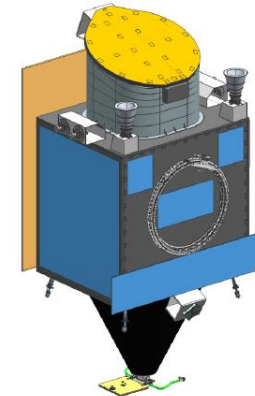
Mile Stone	ARO + Month	Time
Kick off	0 (23 September 2019)	“Q4” 2019
SRR	3	Q1 2020
SDR	6	Q2 2020
PDR	12	Q4 2020
CDR	18	Q2 2021
Supply of Camera	35	Q3 2022
Supply of Payload	45	Q3 2023
DRB	52	Q1 2024
EIOT	56	Q2 2024

Survey modes

- Main survey mode (→ Key goal: Death of massive stars)
 - 2 directions near the Ecliptic poles
 - minimize Galactic extinction and zodiac background
 - Continuous visibility
 - Switching between fields every 6 months
 - Cadence – 300s
 - Real-time data download and analysis
 - Alerts within 20min of exposure end
- Alternative survey mode
 - Each season - Cycle through several (<10) adjacent (<40 deg) fields near the nominal fields
 - 6x300s images at each field

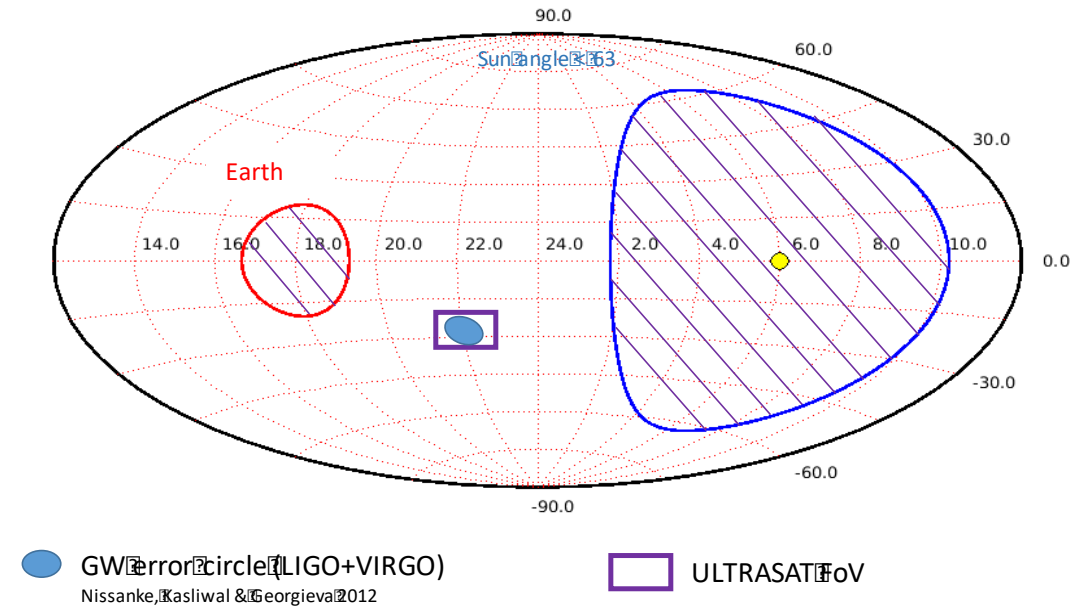
Nominal fields

Field	RA, DEC
N1	220°, +66°
S1	42°, -66°

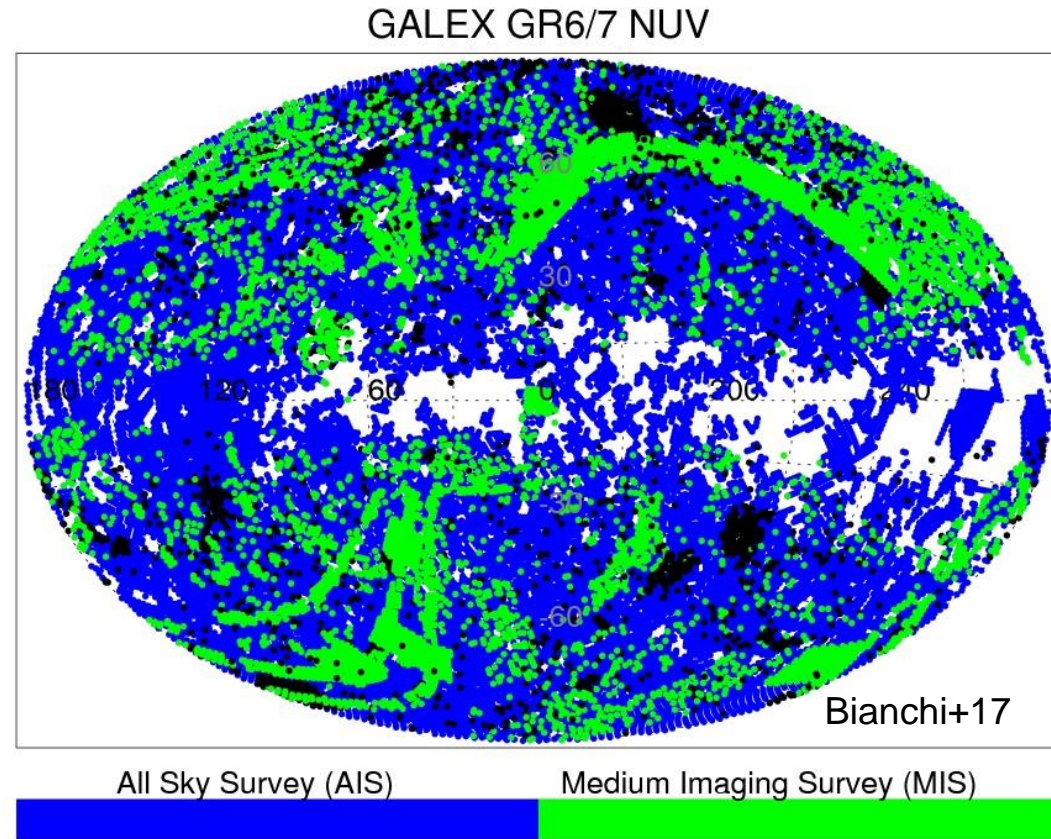


- ToO's: (→ Key goal: Neutron star mergers)
 - Instantaneous >50% of the sky in <15 min for >3 h
 - Continuous transmission to the ground, except for 13% of ToO's
 - No limit on ToO number, except for 13% with Sun angle >144° (Power limit)

ULTRASAT's ToO access



- 3hr/day during the first 6 months
- Using the ToO mode
- 23 AB limiting mag ($|b| > 30^\circ$), 7x deeper than the GALEX all-sky survey
- Building reference images for transient detections



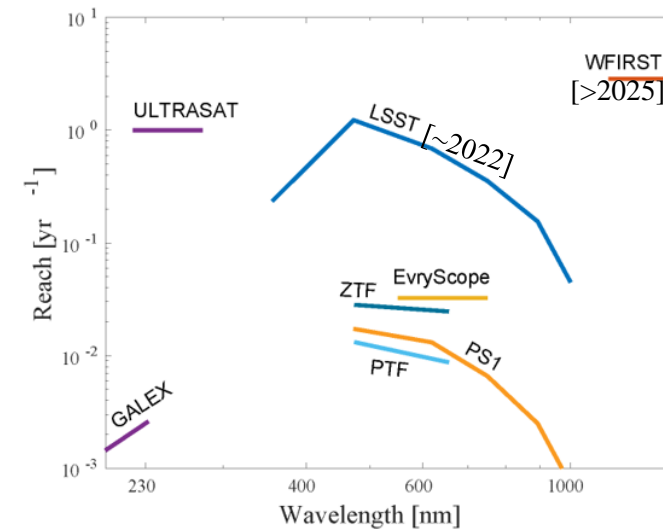
Noise sources

Field of View	200 deg ²
Band	220-280 nm
Cadence	300 s
Limiting AB mag	22.3 (5s, 900s)
PSF, pixel #	<13", 90Mpxl
Alert distribution	<20 min
ToO	50% of sky in <15min for >3hr

Source	Variance (e ⁻ /pix)
Zodiac (Survey)	140
Cerenkov (75%)	125
Stray light (max)	12
Readout noise [²]	12
Dark current	8
Electronic Crosstalk	2
Gain	1
Quantum Yield	<1
Total	300

Field of View	200 deg ²
Band	220-280 nm
Cadence	300 s
Limiting AB mag	22.3 (5s, 900s)
PSF, pixel #	<13", 91Mpxl
Alert distribution	<20 min
ToO	50% of sky in <15min for >3hr

Transient detection rates of leading surveys



- New window in wavelength (NUV) and in cadence (min).
- Drive vigorous ground-based follow-up programs.
- Potential serendipitous discoveries.