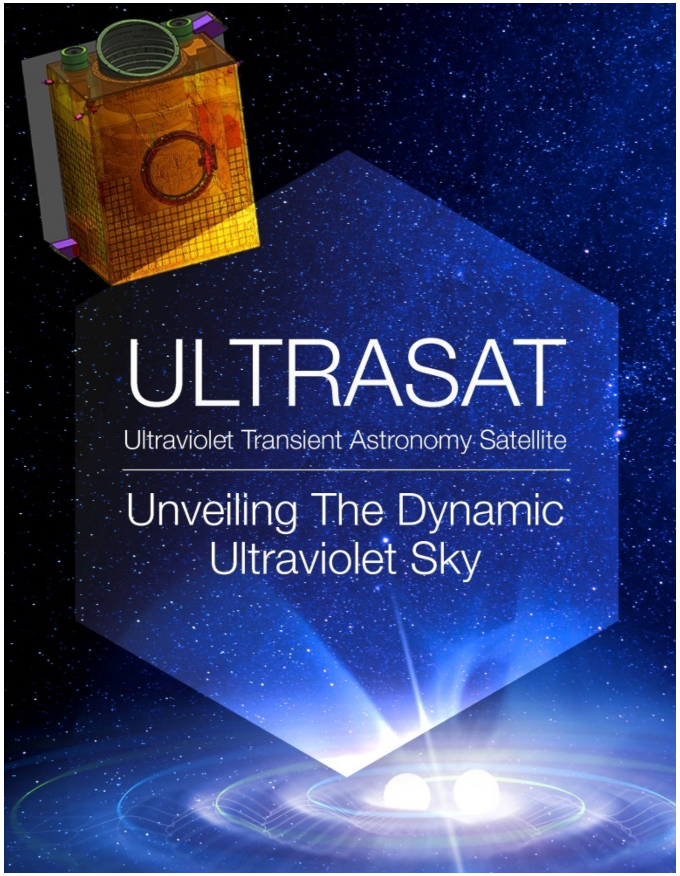
ULTRASAT
Ultraviolet Transient Astronomy Satellite

Eli Waxman, Weizmann Inst. of Science
Feb. 2017



S. Kulkarni
E. S. Phinney
M. Kasliwal
G. Hallinan
S. Nikzad
S. Gezari
J. Kollmeier

E. Waxman
A. Gal-Yam
E. Ofek
J. Topaz
I. Sagiv
O. Lapid
M. Soumagnac
S. Ben-Ami
O. Aharonson
D. Maoz

ULTRASAT: Science vision

- It is time for Time-Domain Astronomy.
- Exciting frontiers, e.g. cosmic explosions, require wide field transient surveys.
- Enabled by current technology.

- TDA drives observatories in
  Optical (LSST), Radio (LOFAR, SKA),
  X/γ-ray (Swift/Fermi/AstroSAT/e-Rosita).

- Missing: UV.
  Will address major open questions:
- Deaths of massive stars,
- Counterparts of Gravitational wave sources,
- Ia SN progenitors,
- Tidal disruption events (100/yr),
- Variability from min to month time scale for
  - Active galactic nuclei (>10^3),
  - Variable/flaring stars (>10^5),
- Star-planet connection
- …

ULTRASAT will revolutionize our understanding of the transient UV universe.

Field of View	210 deg^2
Band	220-280 nm
Cadence	900 s
Limiting mag	21.9 (5σ, 900s)
PSF, pixel #	20", 40Mpxl
Alert distribution	<20 min
ToO	50% of sky in <5min for >2.5hr
2π Galactic survey	30mag/arcsec^2
Extra-Galactic deep drills	33mag/arcsec^2

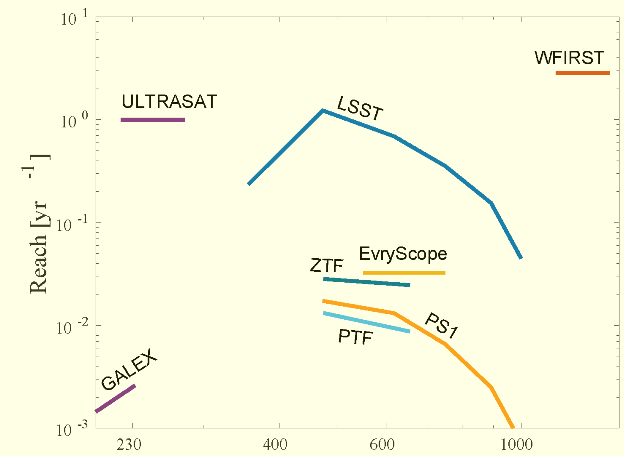
- 300 times the survey capacity of GALEX.
- Drive vigorous ground-based follow-up programs.

ULTRASAT: Science vision

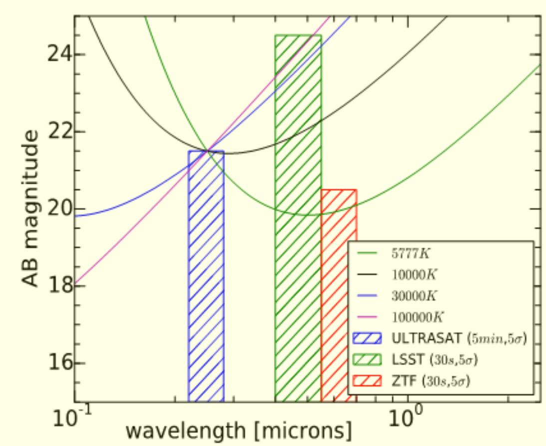
- ULTRASAT's survey reach is comparable to LSST,
  but it opens a new band (NUV) and
  a new temporal cadence (minutes)
  not be accessible to any other survey.

- For hot sources (e.g. young supernovae) ULTRASAT's sensitivity is competitive even with LSST, the deepest wide-field survey planned.

Volume accessible to
current and planned synoptic surveys
(per unit time, normalized to ULTRASAT)



Sensitivities of synoptic surveys



ULTRASAT: Science highlights

Source Type		# Events	Science Impact
Supernovae			
	Shock break-out and Early (shock cooling) of core collapse SNe	>30 >400	Understand the explosive death of massive stars
	Superluminous SNe	>200	Early evolution, shock cooling emission
	Type Ia SNe	>30	Discriminate between SD and DD progenitors
Compact Object Transients			
	Emission from Gravitational Wave events: NS-NS and NS-BH	~20	Constrain the physics of the sources of gravitational waves
	Cataclysmic variables	>20	Accretion and outburst physics
	Tidal disruption of stars by black holes	>200	Accretion physics, black hole demographics
Quasars and Active Galactic Nuclei			
	Continuous UV lightcurves	>6000	Accretion physics, BLR Reverberation mapping
Stars			
	M star flares	$>3\times10^5$	Planet habitability, magnetospheres
	RR Lyrae	>800	Pulsation physics
	Nonradial hot pulsators, e.g., α Cyg, δ Scuti, SX Phe, β Cep etc. types	>200	Asteroseismology
	Eclipsing binaries	>300	Chromosphere and eclipse mapping
Galaxies and Clusters			
	All Sky Survey – galaxies	$>10^8$	Galaxy Evolution, star formation rate

Science goal I: Deaths of Massive stars

- Supernova mechanism not understood.
- Key to progress:
- Identify the "initial conditions", which stars explode as which SNe?
- So far- a handful of associations (pre- vs post- explosion high-res. host galaxy images).

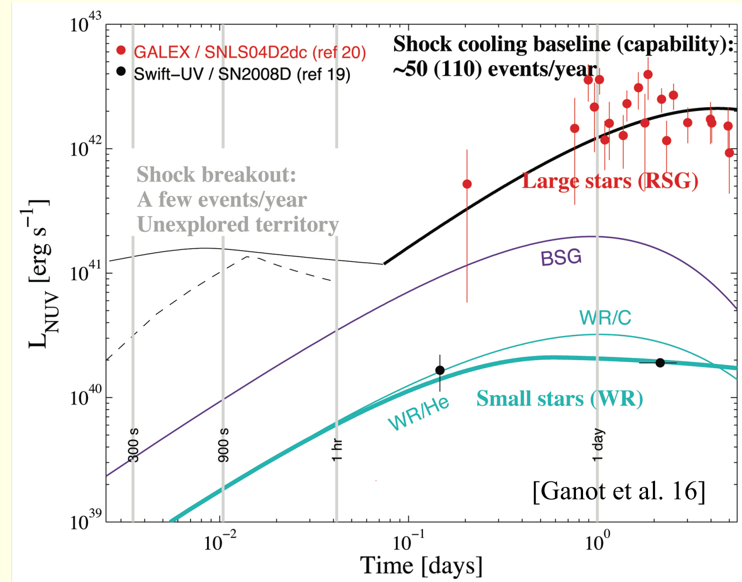
- An alternative- Early, <1d, UV emission carries unique signatures of the progenitor ("erased" at later time):
  Progenitor type (size, envelope composition),
  Explosion properties,
  Pre-explosion evolution.

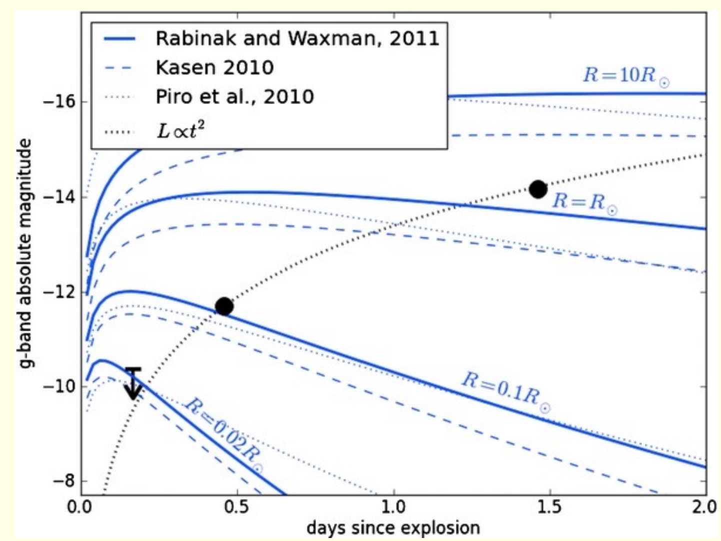
Science goal I: Deaths of Massive stars

- Early UV/opt.: status.
- A handful of (late, low-quality)
  Red-Super Giant explosion detections.
- Space UV (lucky) detection of 1 SN Ib:
  $R=10^{11}$cm; He + C/O envelope; E/M
  → Mixed He Wolf-Rayet;
  Explosion energy.
- Handful of type Ia non detections:
  $R_* < 4\times10^9$cm → White Dwarfs.

- Current data
- Validate models,
- Direct constraints on compact progenitors,
- Demonstrate potential.

- ULTRASAT:
- >100/yr, <1d, high quality UV,
  Map all (including rare) SN types.
- Rapid alerts for follow-ups.

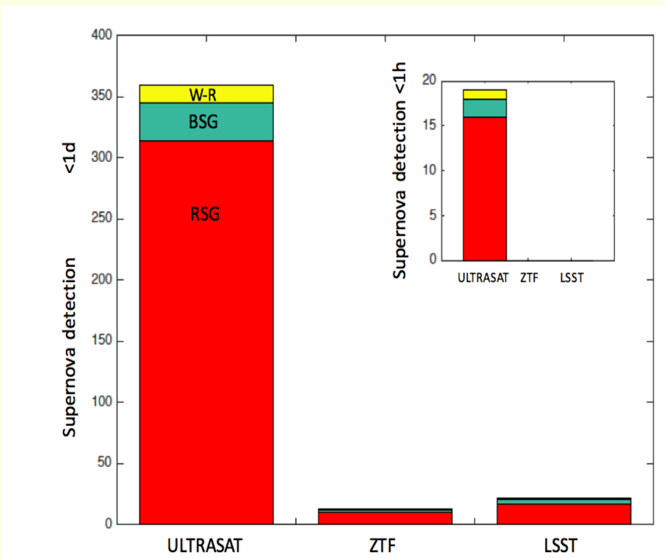




[Bloom et al. 11, Maoz et al. 14]

Science goal I: ULTRASAT's uniqueness

ULTRASAT is an order of magnitude more powerful discovery machine than any other survey

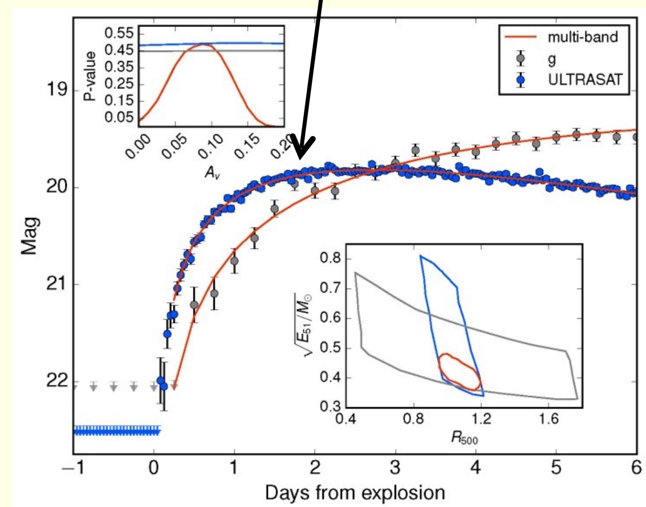


Ganot et al. 2016; ApJ, 820, 57

ULTRASAT will map all (including rare) SN types

Why UV?

t (T=1 eV) → R_*



[Rubin et al. 16]

Recombination at T < 1 eV
→ no optical peak, structure degeneracy

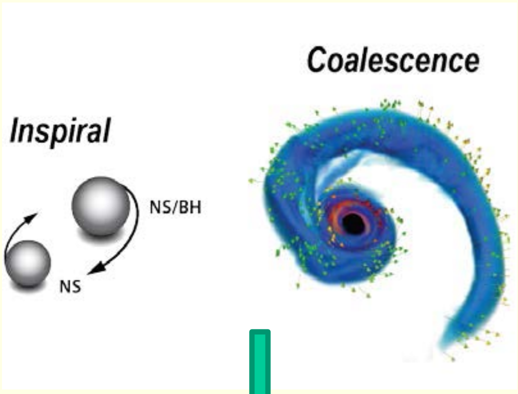
Science goal II: Gravitational wave sources

- LIGO detected BH-BH merger GWs.

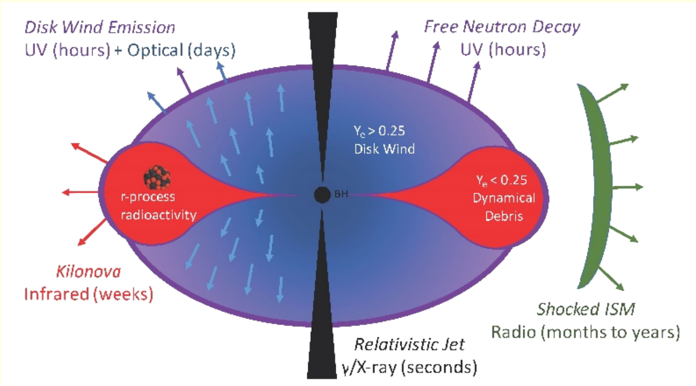
- GWs from NS-NS mergers expected.
  100 deg^2 error box, d<200Mpc.

- EM detection: localization, distance, phys.
  - X-rays: likely 1:100 (beamed).
  - Radio: ~1yr delay, requires CSM.
  - IR: challenging (wide field inst.).
  - Optical: more difficult than UV.

Neutron star mergers



Radio to gamma-ray "Afterglow"



Science goal II: Gravitational wave sources

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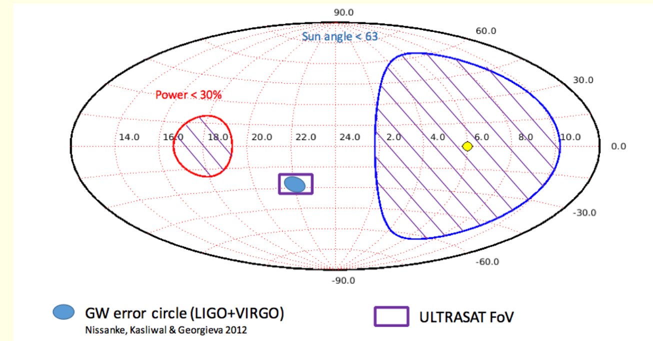
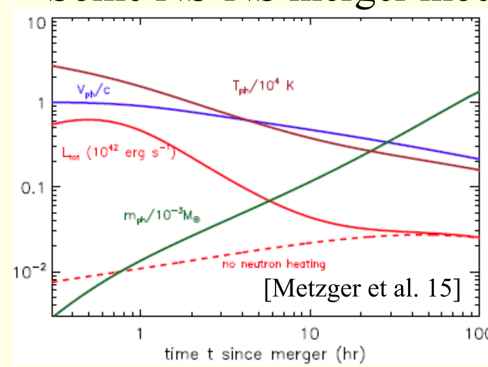
- ULTRASAT
  - Instantaneous >50% of sky (8 times better than ground based), in <5 min for >2.5hr.
  - GW error box in a single image.
  - Sensitive out to 200 Mpc to early UV signals predicted in common models.

ULTRSAT's ToO access



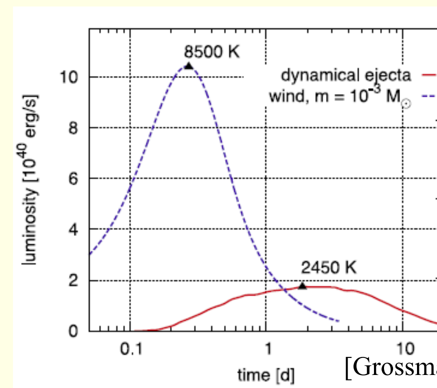
Some NS-NS merger model predictions



Free neutrons

L~10^{42}erg/s
T ~ 1 eV
t ~ 1 hr

ν irradiated wind

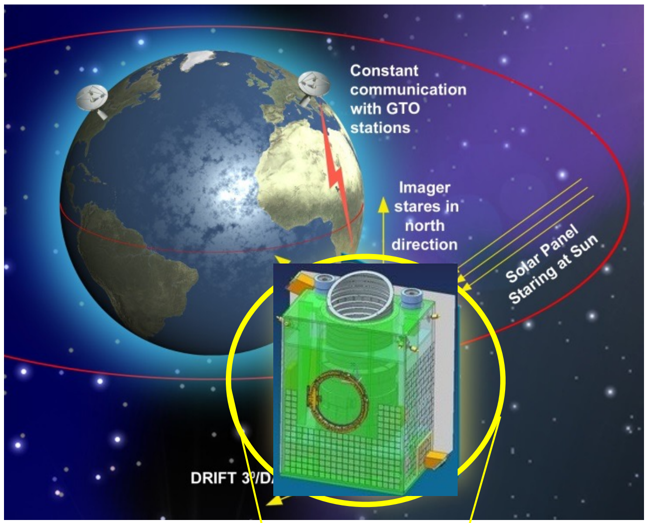


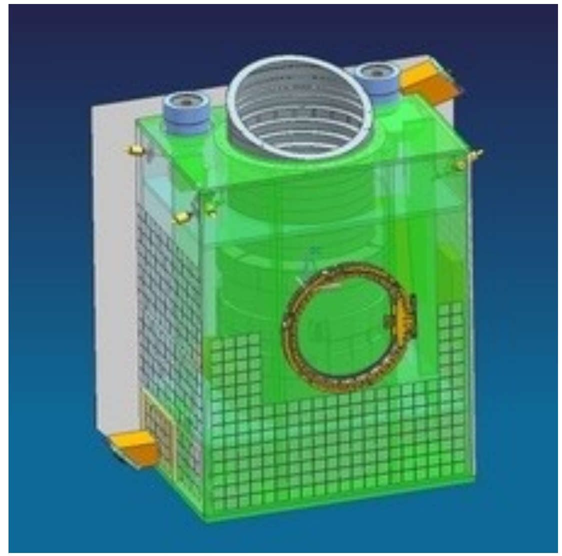
[Grossman et al. 14]

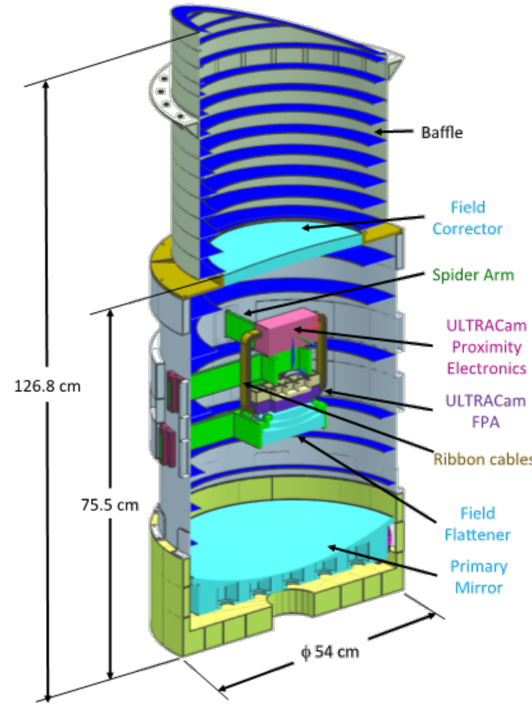
L~10^{42}erg/s
T~ 1 eV
t ~ 6 hr

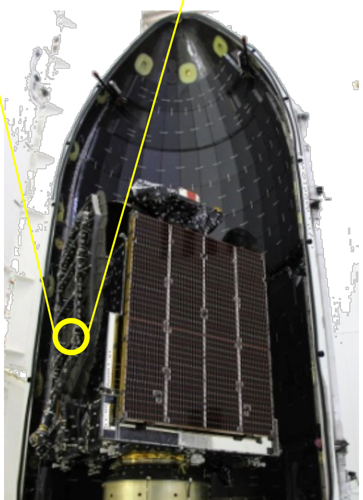
ULTRASAT: Implementation

ISA committed (>50%),
NASA MOO proposal- Dec 2016.





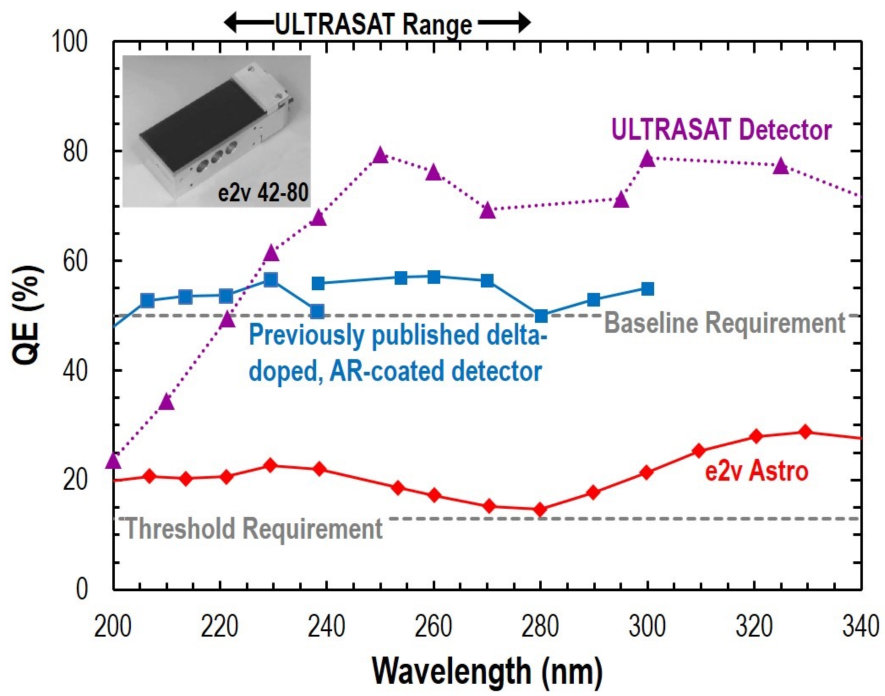




Hosted Launch to GEO+300km (Graveyard) orbit.

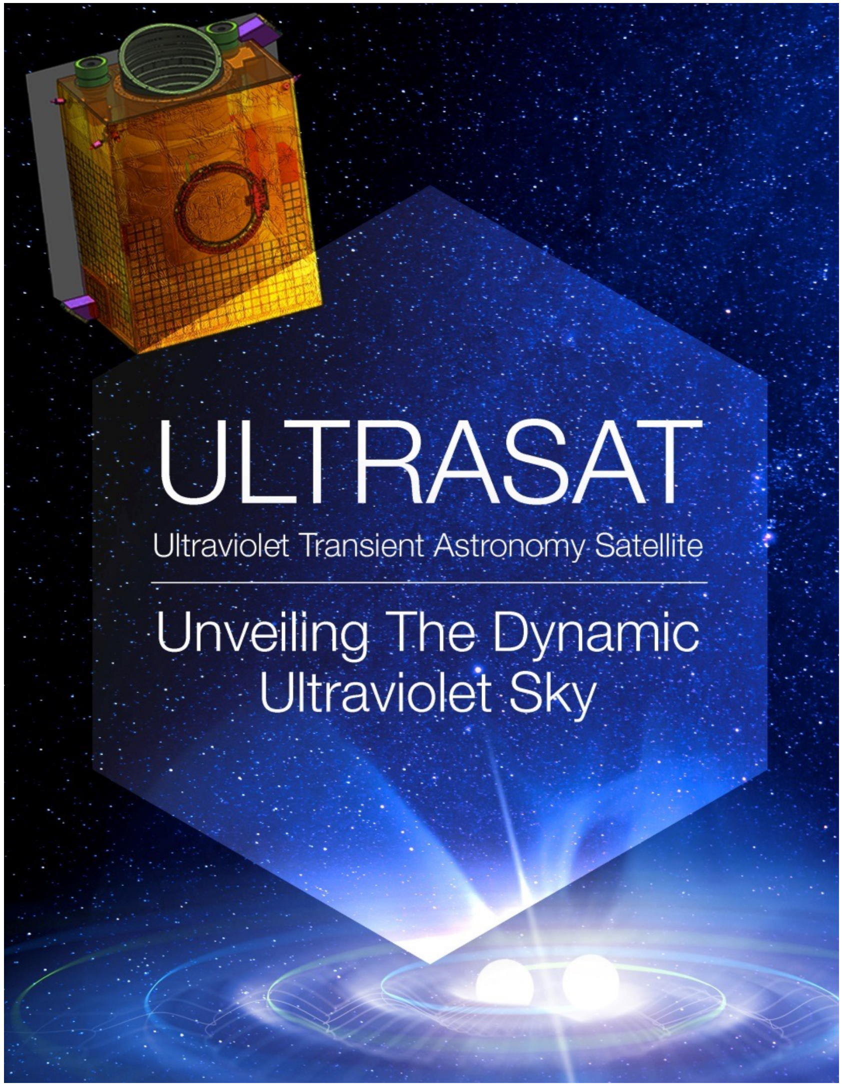
Dimentions: 1.2 X 1.2 X 0.6 (m^3)
Power: 150 W
Mass: 160 kg
Cost (incld. Launch & Operation): $100M

ULTRASAT: UV detectors



[JPL- Nilkzad et al. 16]

Outlook: The importance of an ISRAELI lead breakthrough science mission



- ULTRASAT: breakthrough science with agile, low cost satellite mission.

- Attract talent to science & technology.
- First large scale collaboration of Israeli space industry with NASA.
- Lead the way to future missions, with Israeli industry at an advantage point.