ULTRASAT WG2

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WG2 members

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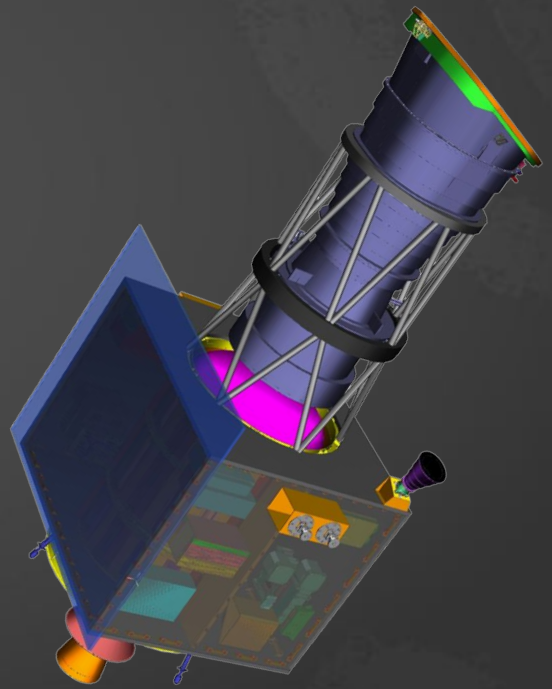
- Dan Maoz (Tel Aviv University)
- Iair Arcavi (Tel Aviv University)
- Assaf Horesh (Hebrew University of Jerusalem)
- Barak Zackay (Weizmann Institute of Science)
- Ofek Birnholtz (The Hebrew University of Jerusalem)
- Doron Kushnir (Weizmann Institute of Science)
- Marek Kowalski (DESY)
- Rolf Buhler (DESY)
- Hagai Perets (Technion)
- Michael Coughlin (University of Minnesota)
- Mukremin Kilic (University of Oklahoma)
- Brad Cenko (NASA-GSFC)
- Daniel Stern (NASA- JPL)
- Jacob Nordin (DESY)
- Jonathan Morag (Weizmann Institute of Science)
- Gilad Sade (Weizmann Institute of Science)
- Ben Shenhar (Weizmann Institute of Science)
- Tal Wasserman (Weizmann Institue of Science)
- Or Guttman (Weizmann Institute of Science)
- Gokul Srinivasaragavan (University of Maryland)

Science goals

- Early UV detection of GW triggered events
- Early UV detection of GW un-triggered events
- Bolometric LCs of events
- Study ejecta components/profile/velocity/opacity
- Large sample for H0 measurements

ULTRASAT advantage (for GW)

- 50% sky accessibility at any given moment
- Geo orbit / Direct comm.
- FOV comparable to LIGO-VIRGO error regions
- Sensitivity good to >200 Mpc
  - 240 (t_exp/15min)^(1/4) Mpc
- Importance of UV
  - probe early time T
  - Opacity + velocity distribution
- <Arcsec localization



GW detectors time line

- ToO observations of GW (~1 kHz) detections
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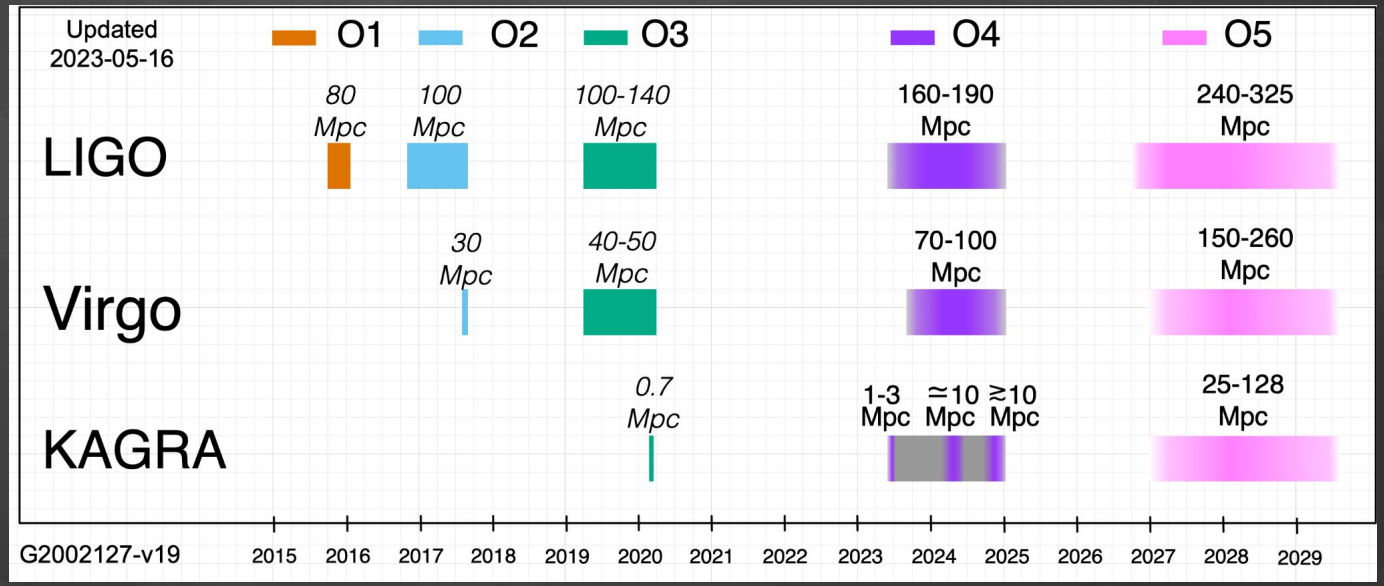
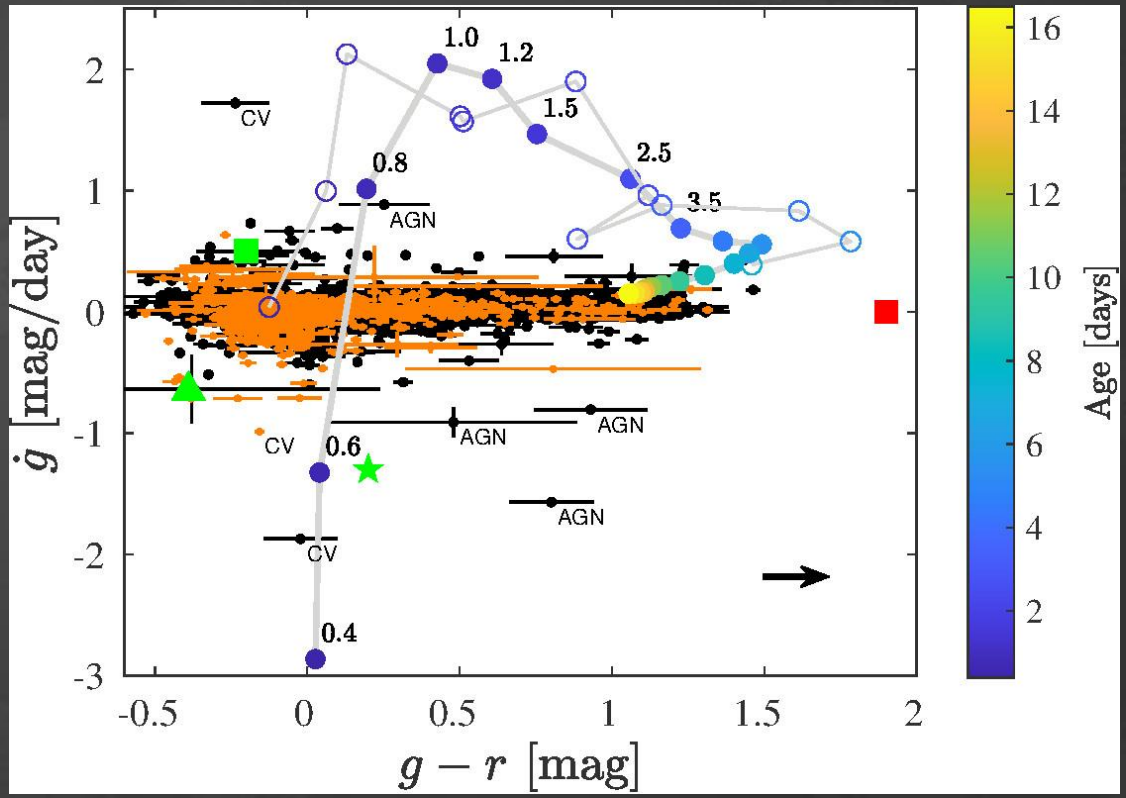


Problem I

- Screening GW events (mainly relevant for blind search)?
- Need to map background/foreground event rates
  - Unknown transients
  - E.g., M-dwarfs flares (Param's talk)
    - Solution? LSST deep coadd images
  - Fast transients
    - Solution?: Single detection is not enough
  - Known transients

Problem I

- Partial solution?
- Extend to UV…



Ofek et al., submitted

Problem II

- Cadence for blind search? (Doron’s talk)

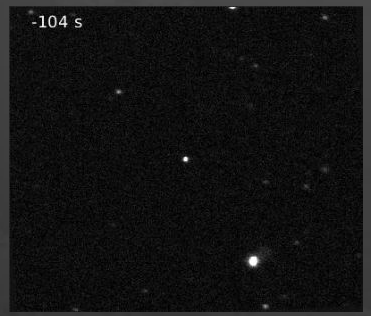
Pre launch (and early mission) goals

- Design the all sky survey to maximize variability information
- Design screening strategy (M, DN, Trans., AGN)
  - Study variability on short time scales
    - Lack of X/UV/Optical variability studies
    - Chandra (Soumagnac)
    - UV (GALEX-PTF + GALEX photons [Param's talk])
    - Optical (LAST)
- Create a catalog of potential back/foreground sources
- Design a blind search strategy (cadence?)
- Follow-up resources
- Theory!

end

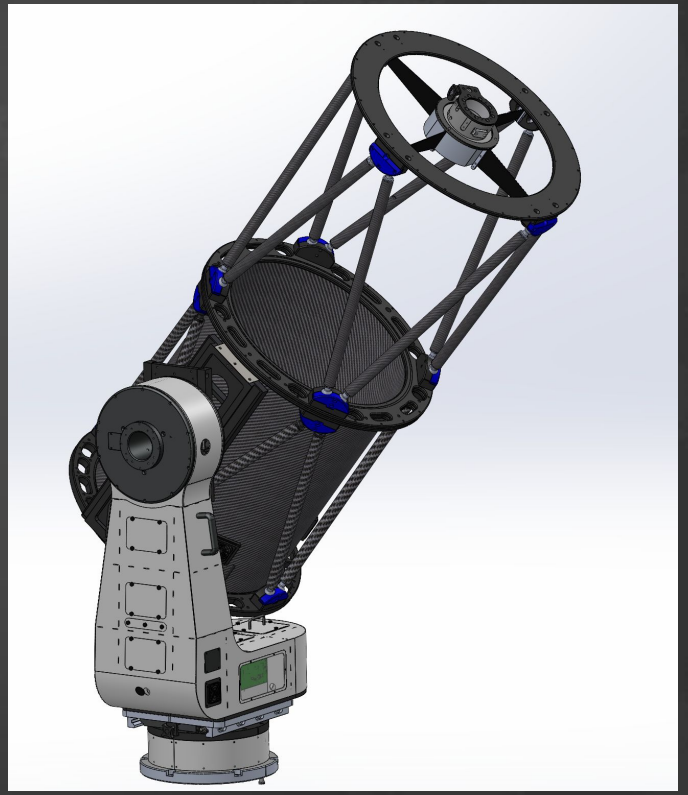
The Large Array Survey Telescope (LAST)

- 48 28-cm f/2.2 tel. ($1.4M)
- 7.4 deg^2
- PIs: Ofek + Ben-Ami
- 2.2 GBit/s data rate
- Equivalent to:
  - 1.9-m w/7.4 deg^2
  - 28-cm w/355 deg^2



The Multi Aperture Spectroscopic Telescope (MAST)

- 20 60-cm f/3 tel. ($3M)
- Low res (R~600), high Th. spec.
- PIs: Ben-Ami + Ofek
- Equivalent to:
  - 2.7m telescope

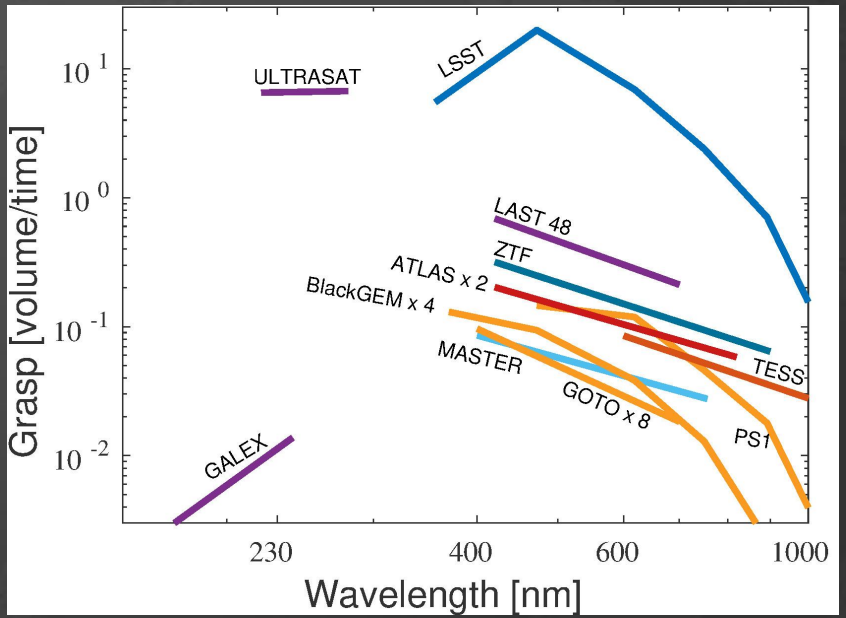


Additional projects

- FAST: 55cm f/2 Schmidt + Fast readout camera (Nir et al. 2020;21ab,23ab)
- PAST: 4x35cm f/11 + 8 overlapping wide bands cameras

Cost effectiveness

- LAST is x10-x50 more cost effective than existing systems



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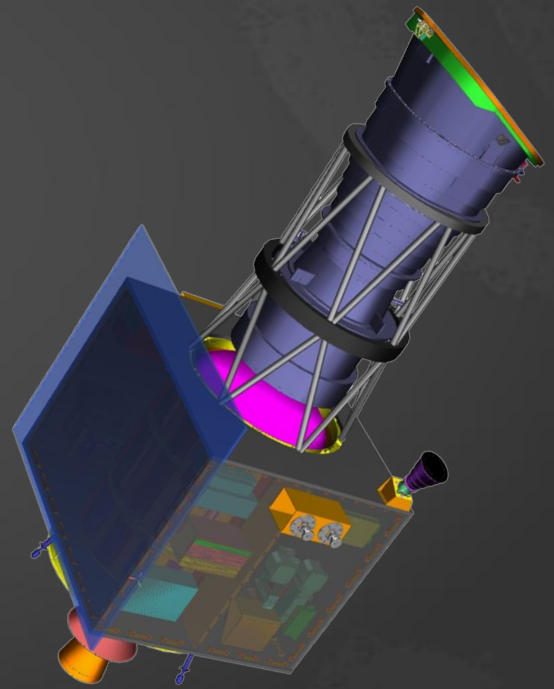
ULTRASAT

- A space based UV survey telescope
  - WIS, IAI, DESY, NASA; PI: Waxman
- 33-cm, f/1.1 / 200 deg2 / 5”/pix
- 5-s lim mga 22.5 (AB) in 300x3s
- Vol/time eq. To LSST
- Main focus: high cadence (GW/SN)
- Launch: 2026



The Grasp

- For a survey telescope
- Observed volume per unit time

$$\left(\frac{\mathrm{S}}{\mathrm{N}}\right) = \sqrt{\int_0^\infty 2\pi r dr \frac{F^2 A_{\mathrm{eff}}^2 t_{\mathrm{E}}^2}{B A_{\mathrm{eff}} t_{\mathrm{E}}} \frac{e^{-r^2/(\sigma^2)}}{4\pi^2\sigma^4}} = \frac{F A_{\mathrm{eff}} t_{\mathrm{E}}}{\sqrt{4\pi\sigma^2 B A_{\mathrm{eff}} t_{\mathrm{E}}}}.$$

$$\mathcal{G} \propto \Omega \left(\frac{S}{N}\right)^{-3/2} A_{\mathrm{eff}}^{3/4} B^{-3/4} \sigma^{-3/2} \frac{t_{\mathrm{E}}^{3/4}}{t_{\mathrm{E}} + t_{\mathrm{D}}}$$

FoV

Area

Seeing

Exp. Time

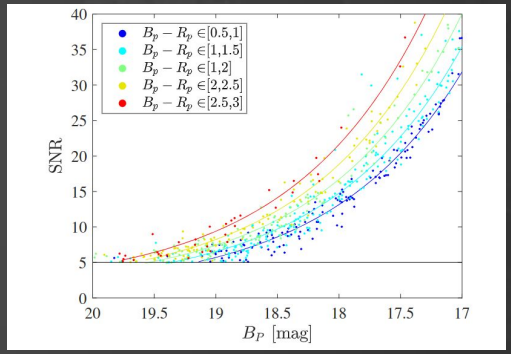
Dead Time

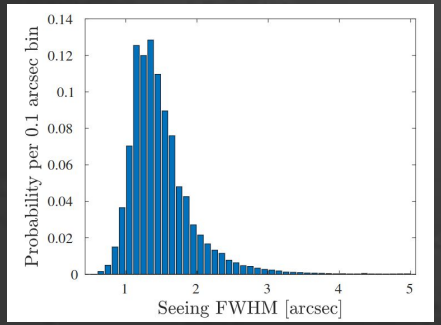
Background

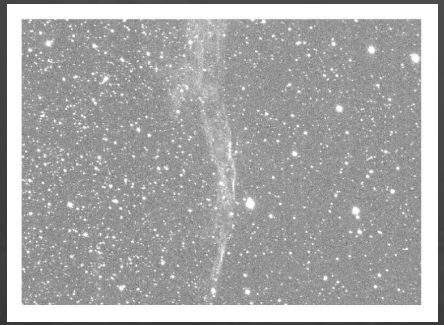
Ofek & Ben-Ami 2020

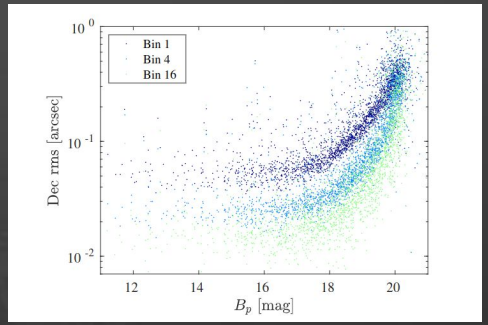
Performances

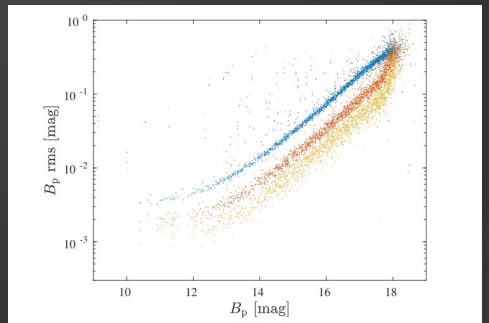
- 5s limi. mag : 19.6 (21.0) @ 20s (20x20s) [losing 0.2mag to RN]
- ~15 mmag absolute calibration
- ~4 (1.5) mmag rel. Phot. in 20 (320)s
- ~60 mas (15 mas)
- Image quality: 2-2.8”
- Site: 1.4” median seeing











Science goals

- Transients
  - Gravitational waves events
  - Fast transients
  - Supernovae
- Planets around WD
- AGN variability
- Asteroids
- ...

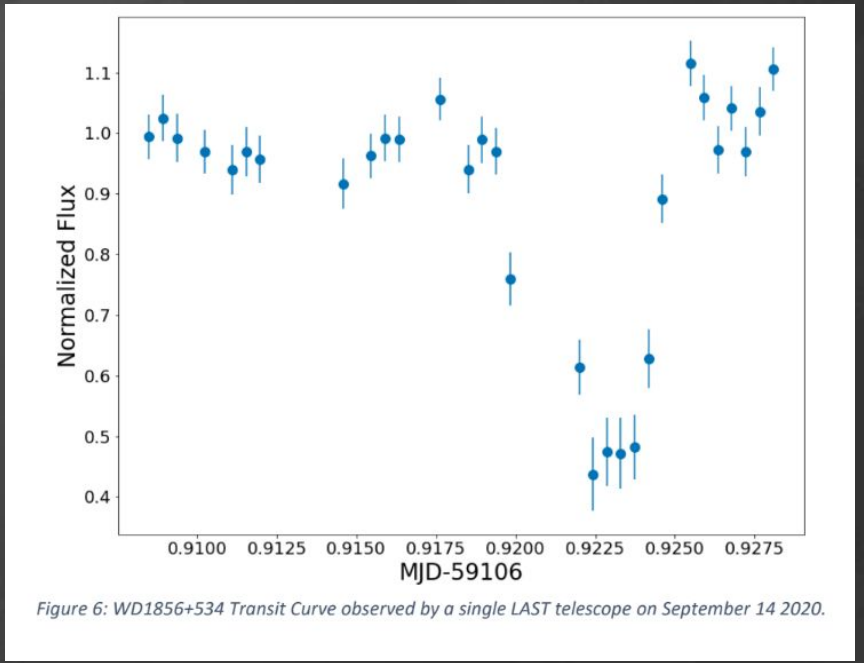


Figure 6: WD1856+534 Transit Curve observed by a single LAST telescope on September 14 2020.

End

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Performances

- Image quality and observability