Transiting Exoplanet Survey Satellite

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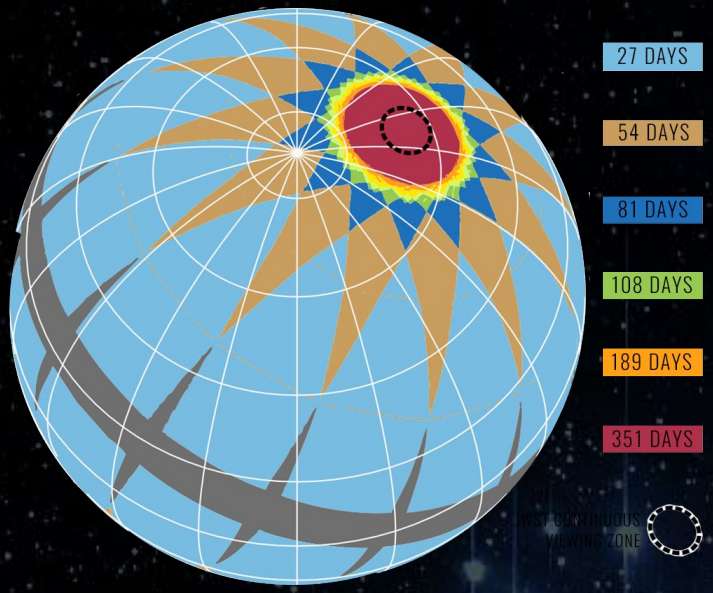
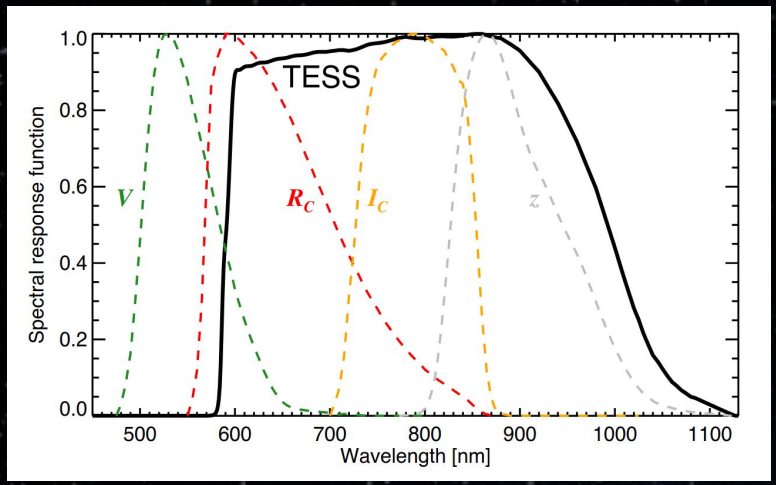
Introduction

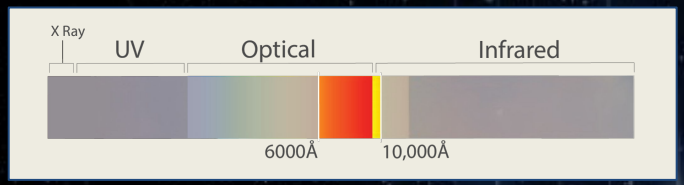
- Created as a follow-up for Kepler. Concentrates on exoplanet detection on near/bright stars.
- Targets should be candidates for **follow up spectroscopy** to measure planetary masses and atmospheric composition.
- High cadence “postage stamps” generated for special targets
- Searching for:
  - Earth-Neptune objects (super earths).
  - Broad range of orbital periods
    P_{min} = several hours P_{max} = 10-40 days.
  - Longer period ranges coincide with visibility of JWST (ecliptic poles)



Design

- CCD gives high linearity and dynamic range for bright stars
- Wide bandpass (600-1000 nm)
  Centered on I_C = 806 nm Red limit of silicon CCD.
- Aperture size determined target exoplanets.
  Simulations suggest 50cm² of collecting area, leads to diameter of 10cm.
- TIme sampling dictated by transits (most in hours).
  Partial transit phases for super-earths are in minutes.
    - Choosing 2 minute samples also allow asteroseismology.





Specifications

- 4x mosaiced lens (with 2mm gap)
  - Focal ratio: f / 1.4
  - Diameter: 10.5.cm
  - FoV= 24 degree × 24 degree
- MIT/Lincoln Lab CCID-80
  - Area: 2048×2048 pixels
  - Pixel scale: 0.35 arcmin
  - Ensquared energy*: 50% one pixel
    90% 4×4 pixel
- Streaming 2 second exposure time, summed in buffer in groups of 60.

* Fraction of the total energy of the PSF that is within a square centered on the peak.

Survey	Mag limit	Cadence (hours)
TESS	19.1 - 18.5 - 17.9	**0.5 - 0.16 - 0.06**
ASAS-SN	18.5	20
ATLAS	19.5	48
ZTF	20.5	72
PanSTARRS	22.0	120
Rubin	24.0	**72**

Mission

Continuous sector observations for 27.4 days.

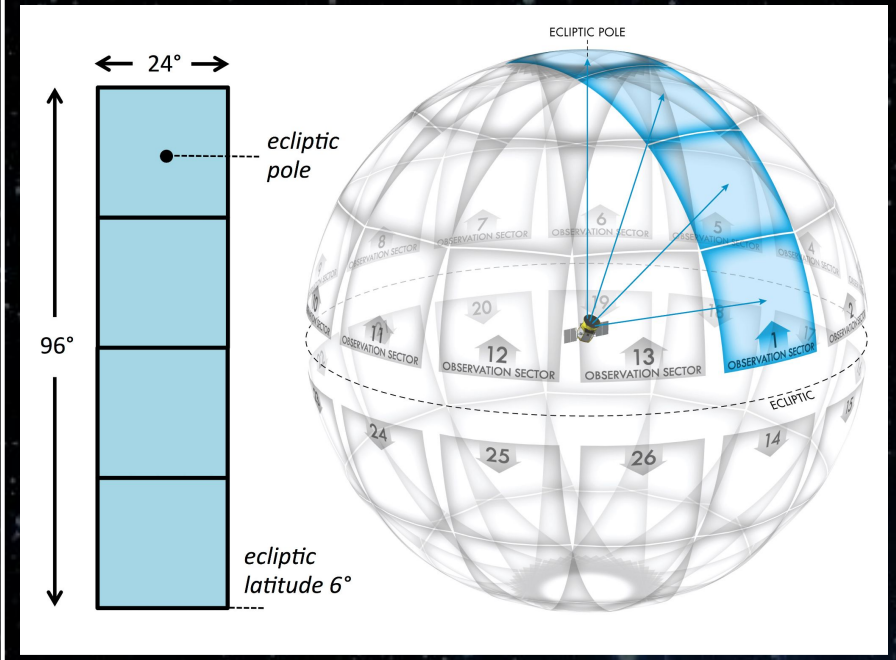
Highly elliptical orbit, inclined on the ecliptic plane.
13.7 day period. 2:1 resonance with Moon

Prime Mission: 2018-2020
Sectors 1-26. Cadence 1800 sec. (Cycles 1, 2)

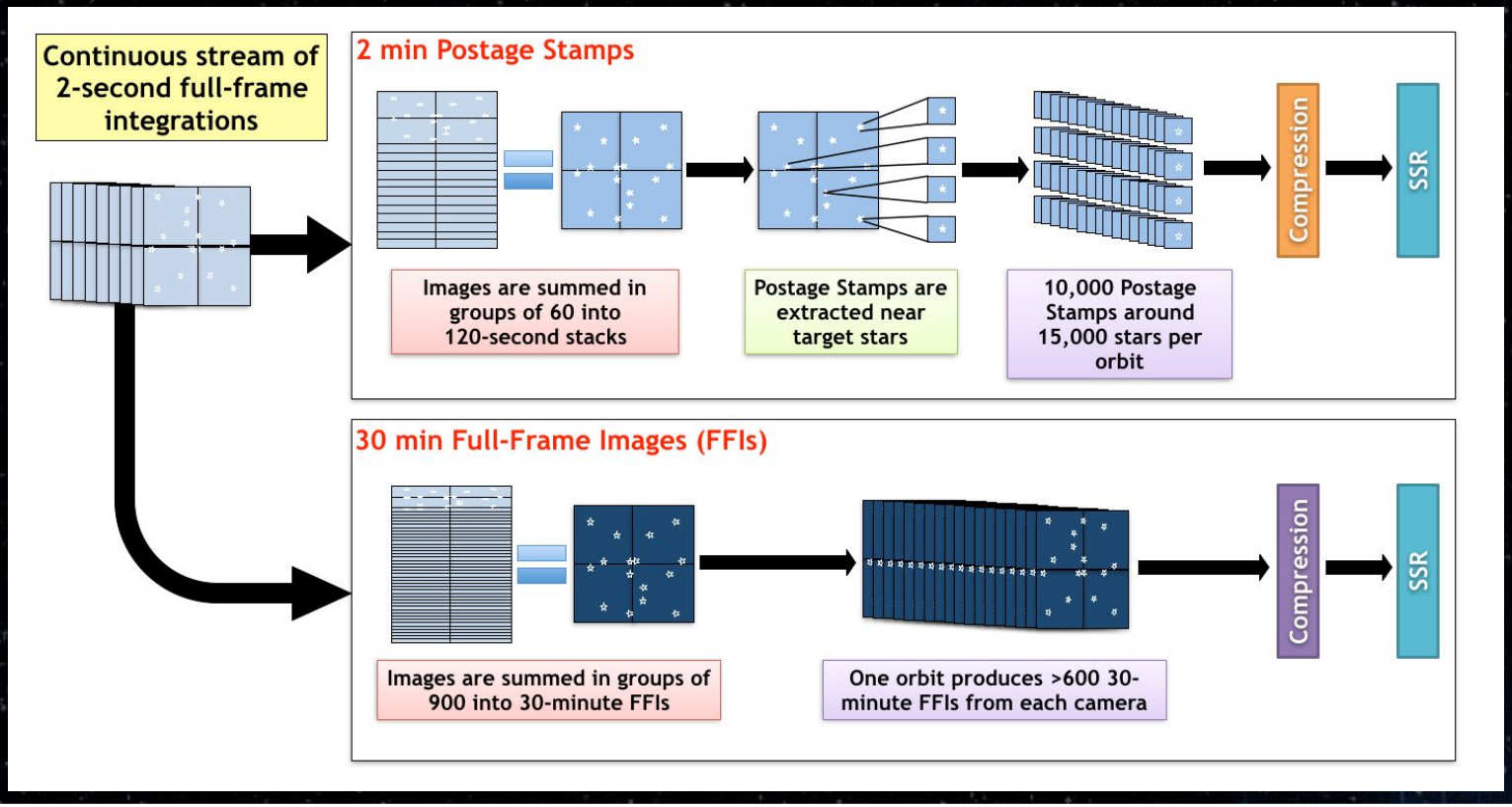
Extended Mission 2020-2022
Sectors 27-35 Cadence 600 sec (Cycles 3, 4)

Second Extended Mission 2022-2025
Sectors: 56-83 Cadence 200 sec (Cycles 5, 6, 7)

Currently finishing Cycle 6 (Sector 83)
01 Oct 2024



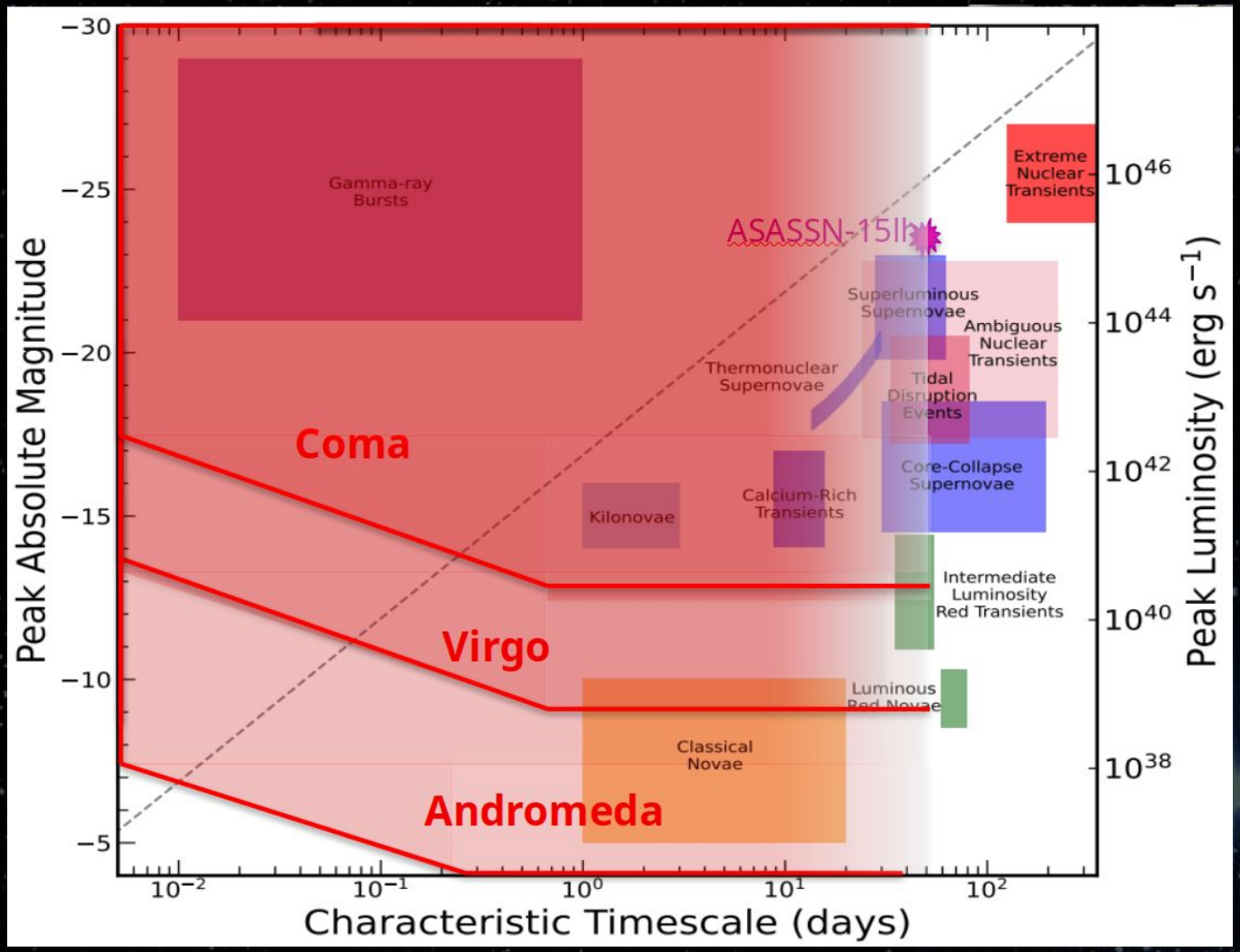
Data Products



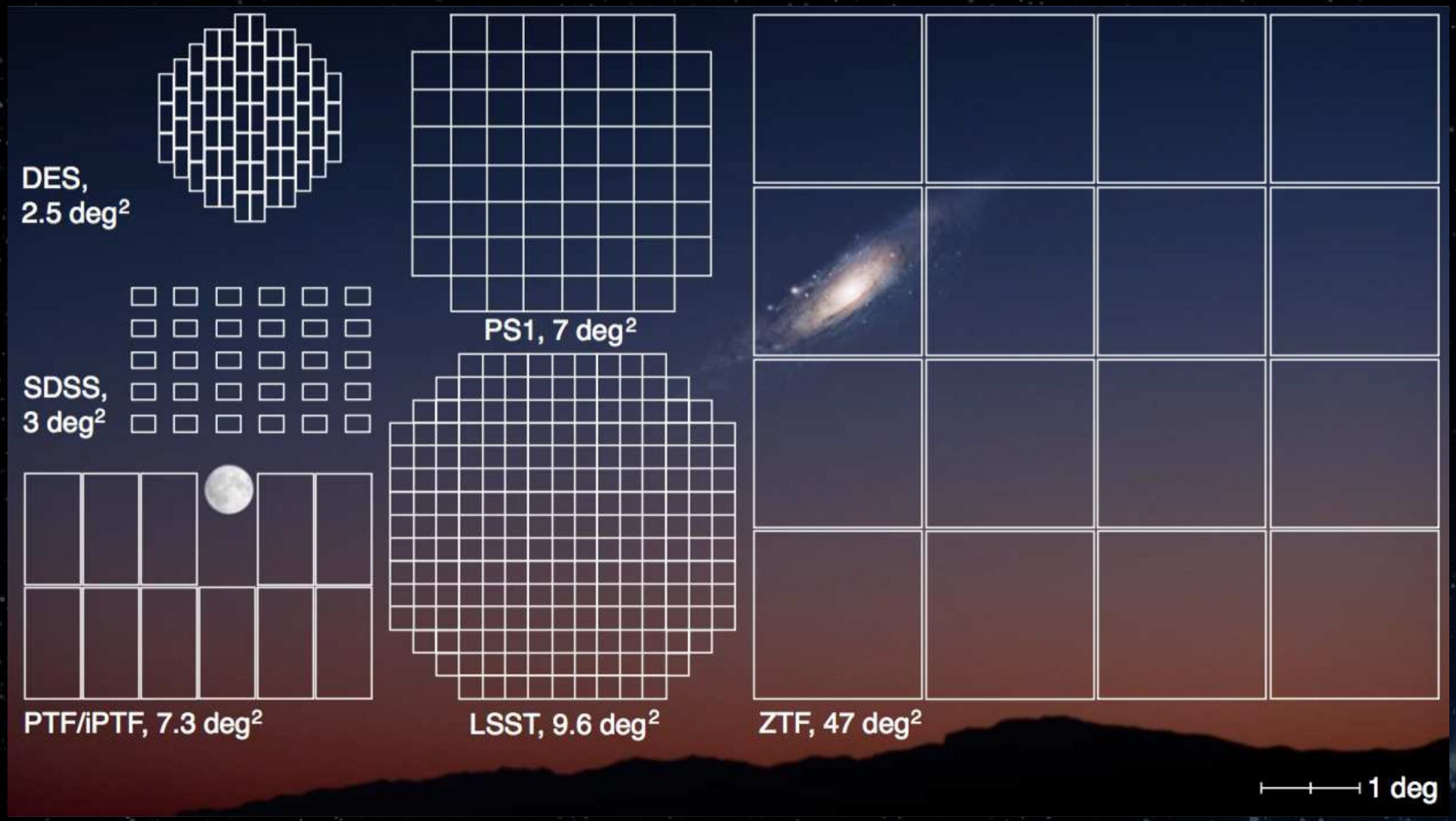
Target Pixel Files (TPFs) and Full-Frame Images* (FFIs) available through MAST

* Calibrated via Science Processing Operations Center (SPOC) - Prime Mission
MIT's TESS Image CAlibrator (TICA) - Extended Missions

Coverage Depth



Coverage Area



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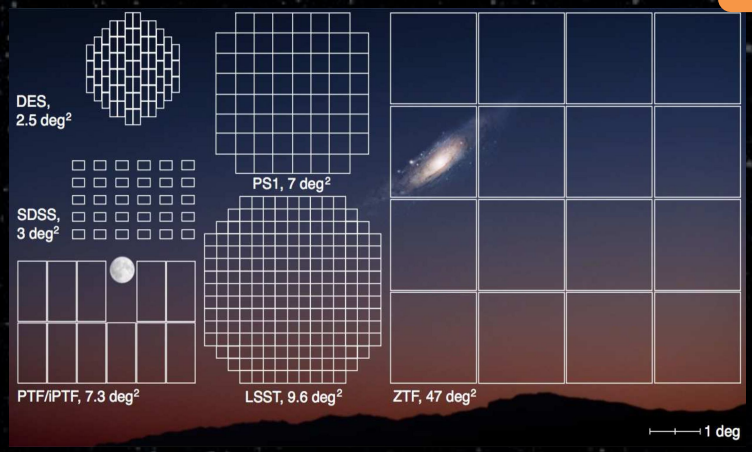

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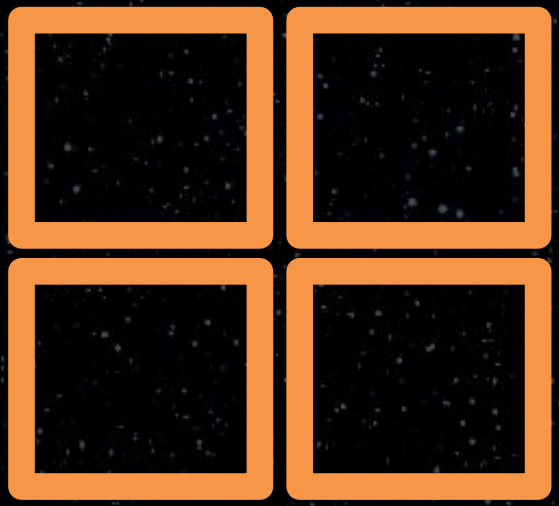
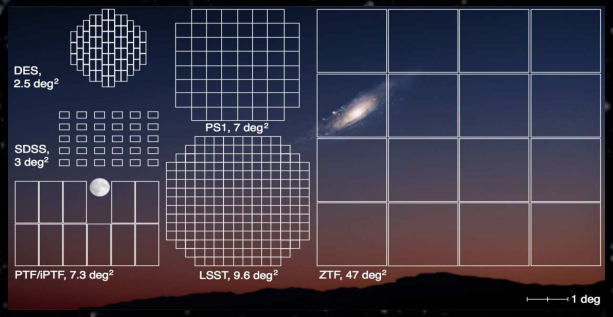


ASAS SN



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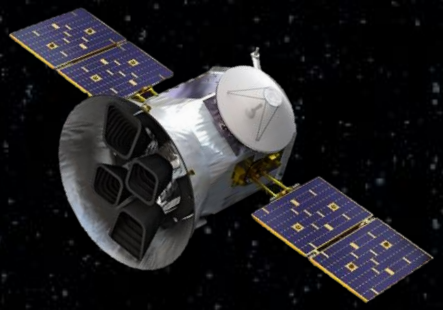
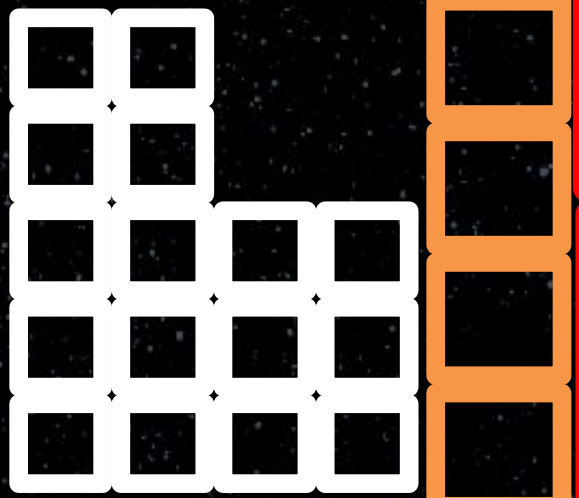
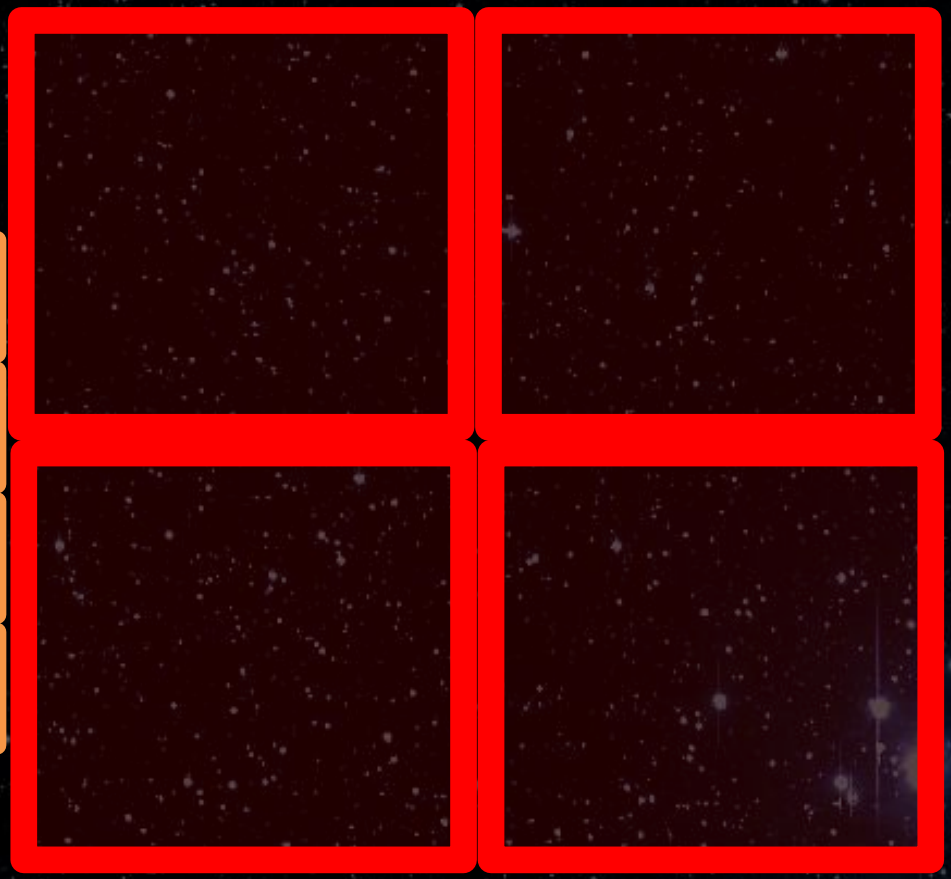
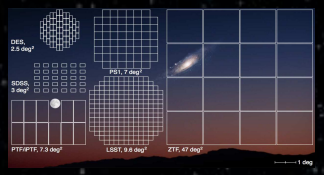
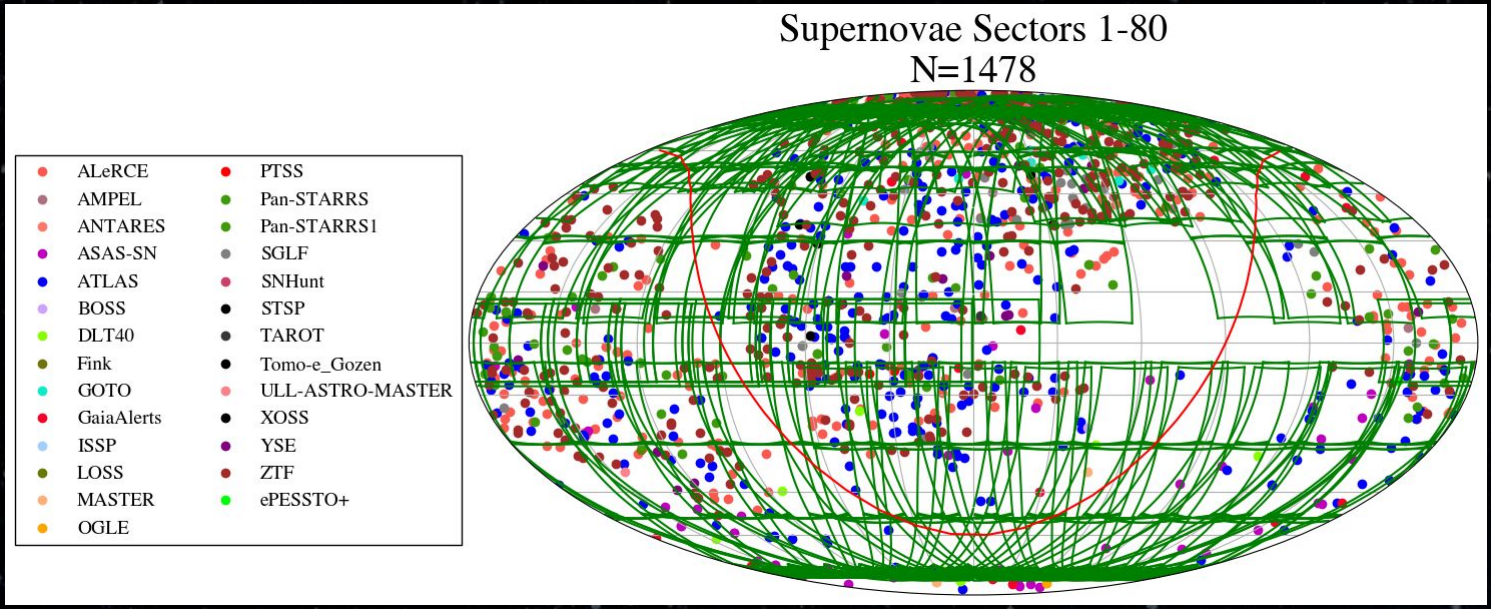








Science



Cataclysmic variables & Novae
Young Stellar Objects (YSOs)
Stellar flares
Gravitational Wave counterparts
Supernovae
Gamma-Ray Bursts
AGN/Blazar/Quasars
Tidal Disruption Events
Fast Radio Bursts

GRB Optical Counterpart

07 Mar 2023, the Fermi Gamma-ray Burst Monitor (GBM) triggered

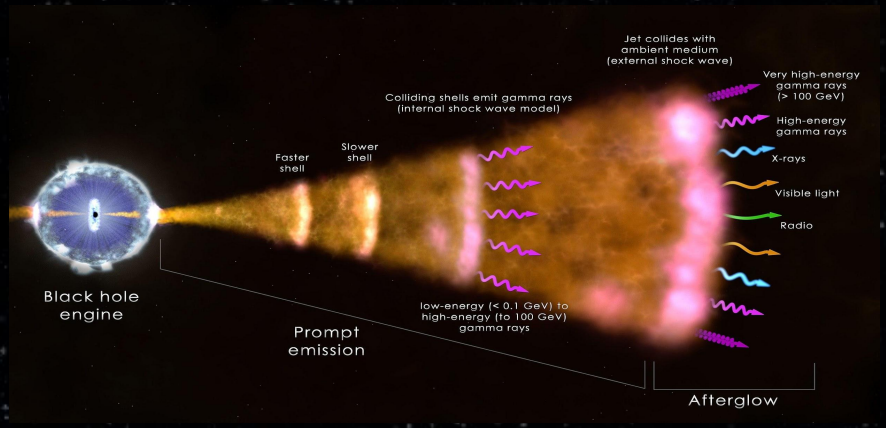
09 Mar 2023, optical afterglow detected by ULTRACAM on Gemini South

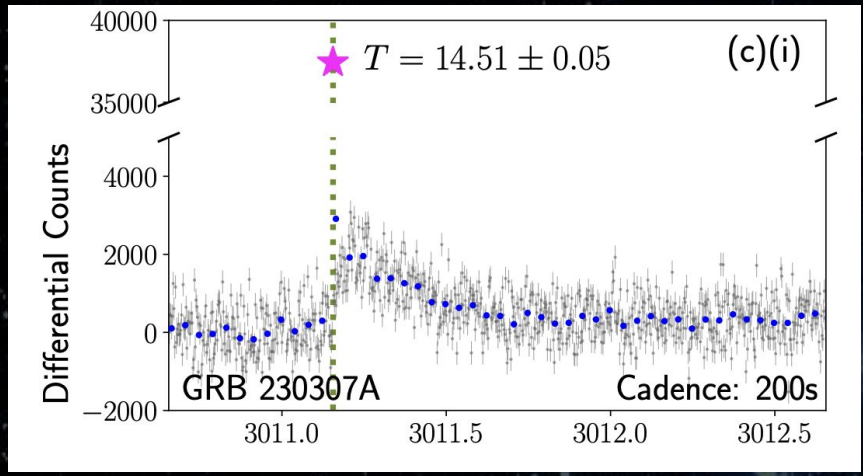
10 Mar 2023, Deep Space Network (DSN) begins downlink with TESS

11 Mar 2023, Payload Operations Center (POC) calibrates and delivers to MAST

12 Mar 2023, MAST makes data public

MIT Quick Look Pipeline confirms location, with prompt emission and afterglow



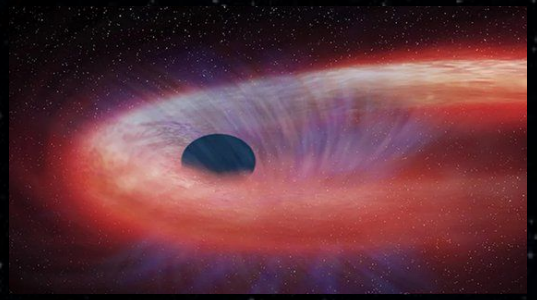


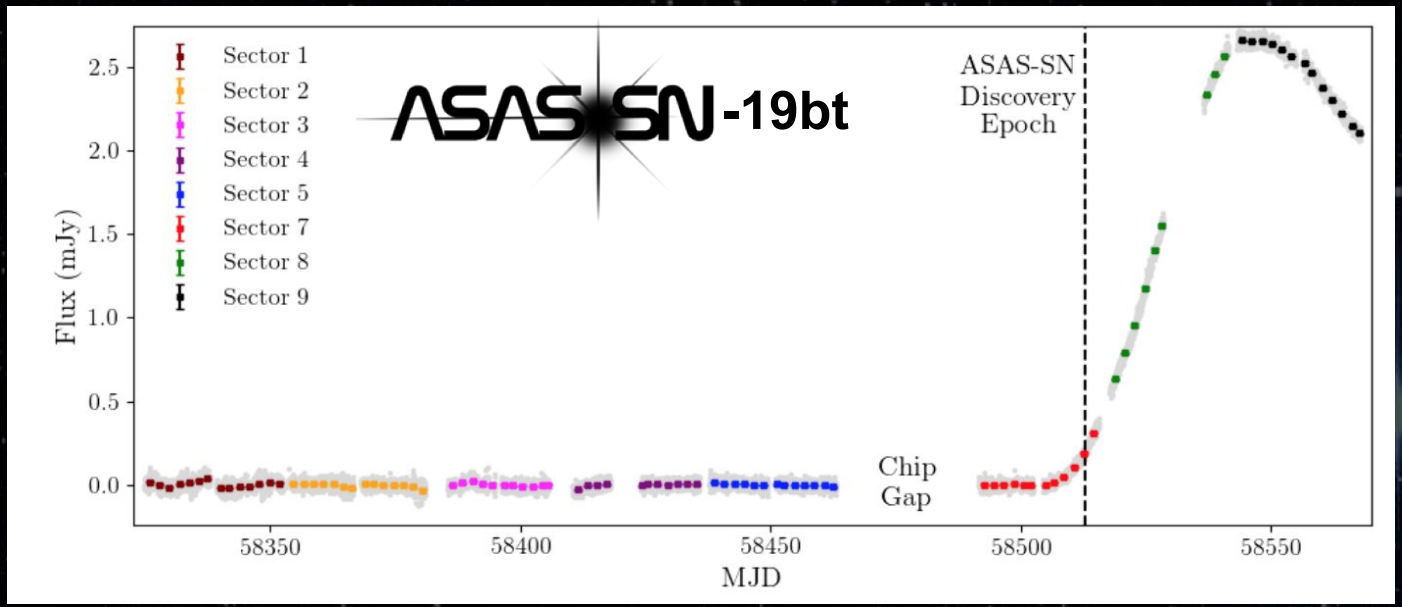
Tidal Disruption Events

29 Jan 2019: transient detected by ASAS-SN
31 Jan 2019: spectroscopic follow-ups by Magellan Clay 6.5m

Target-of-Opportunity (TOO) follow-up observations by
Swift UVOT and XRT

Luckily, event was located in TESS continuous viewing zone (CVZ)



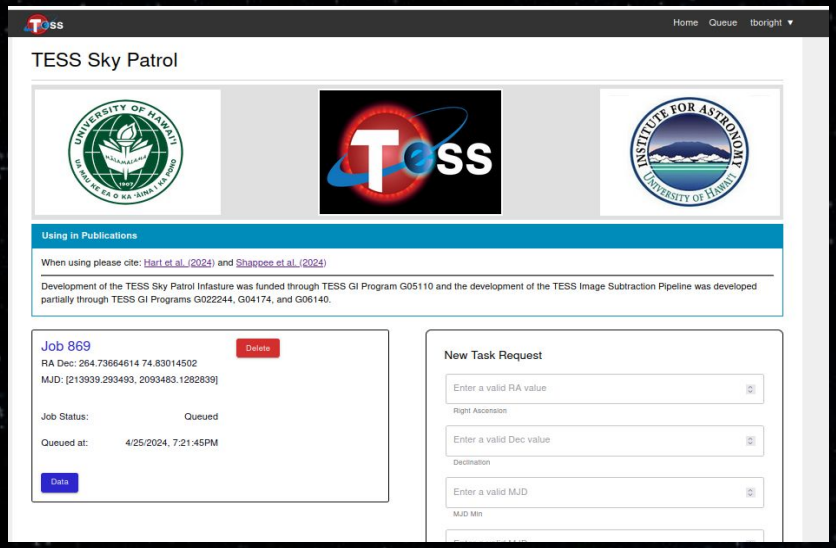


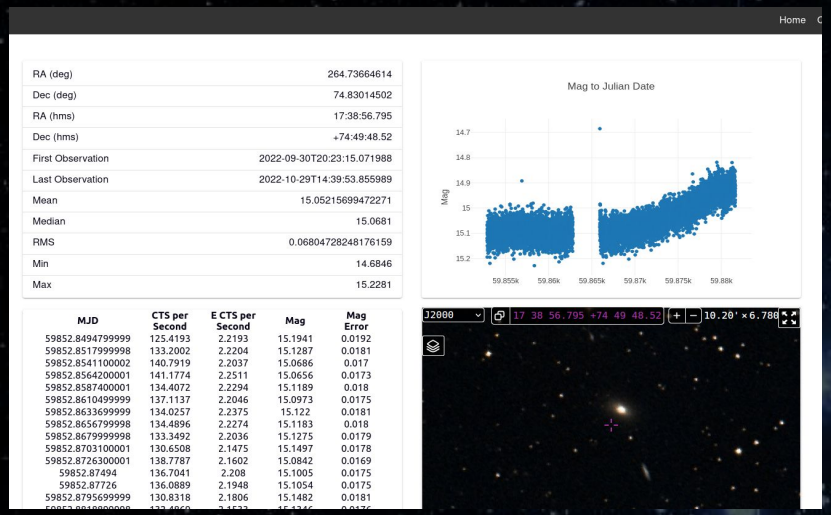
TESS Patrol

Forced Photometry Service
- Based on ASAS-SN SkyPatrol.
- Hosted and operated by U. of Hawaii.
- Account based system (similar to ATLAS).

Spec:
- Field-wise reference subtraction pipeline via ISIS.
- Photometry performed via coordinates or SIMBAD lookup.
- Query via website, API, or Python client.

Open beta available in 1-2 months.





References

‘Discovery and Early Evolution of ASASSN-19bt, the First TDE Detected by TESS’. https://doi.org/10.3847/1538-4357/ab3c66. arXiv.

Fausnaugh, Michael M., Christopher J. Burke, et al. ‘Calibrated Full-Frame Images for the TESS Quick Look Pipeline’. https://doi.org/10.3847/2515-5172/abd63a.

Fausnaugh, Michael M., Rahul Jayaraman, et al. ‘Observations of GRB 230307A by TESS’. https://doi.org/10.3847/2515-5172/acc4c5. arXiv.

Cacella, P., et al. ‘ASASSN-19acc: Discovery of A Bright Type IIn Supernova in the TESS Field’. The Astronomer’s Telegram, vol. 13326, Dec. 2019, p. 1.

Fausnaugh, Michael, George Ricker, et al. ‘Four Years of Type Ia Supernovae Observed by TESS’. American Astronomical Society Meeting Abstracts, vol. 243, 2024, p. 331.02. American Astronomical Society Meeting Abstracts.

References

Vallely, P. J., et al. ‘ASASSN-18tb: A Most Unusual Type Ia Supernova Observed by TESS and SALT’. https://doi.org/10.1093/mnras/stz1445.

Burke, Colin J., et al. ‘Optical Variability of the Dwarf AGN NGC 4395 from the Transiting Exoplanet Survey Satellite’. https://doi.org/10.3847/1538-4357/aba3ce. arXiv.

Ricker, George R., et al. ‘Transiting Exoplanet Survey Satellite’. https://doi.org/10.1117/1.jatis.1.1.014003.

Fermi GBM Team. ‘GRB 230307A: Fermi GBM Final Real-Time Localization’.

‘Calibrated Full-Frame Images for the TESS Quick Look Pipeline’. https://doi.org/10.3847/2515-5172/abd63a.

Caldwell, Douglas A., et al. ‘TESS Science Processing Operations Center FFI Target List Products’. https://doi.org/10.3847/2515-5172/abc9b3. arXiv.