IMPERIAL

Detecting submm transients (and dodging satellites)

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7 September 2026 - UK Transients 2026

This work is presented on behalf of the Simons Observatory collaboration. Simons Observatory is supported by the Simons Foundation, the Heising-Simons Foundation, UKRI, and other research institutions within the collaboration.

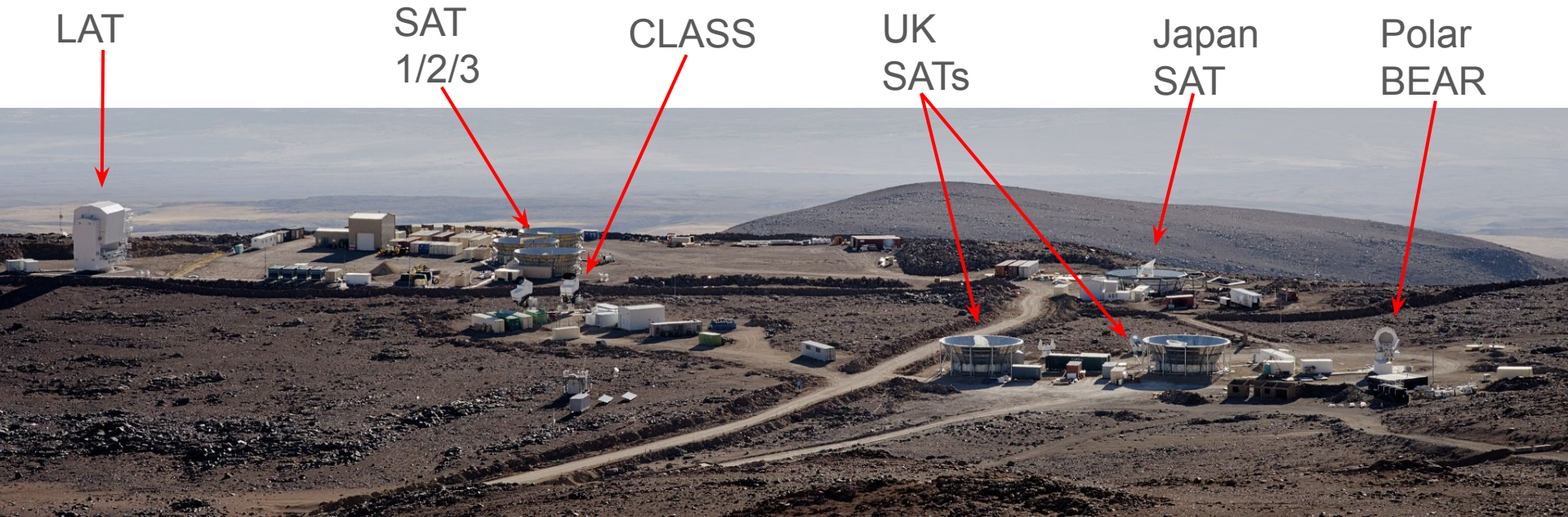
HEISING-SIMONS FOUNDATION

NSF

SIMONS FOUNDATION

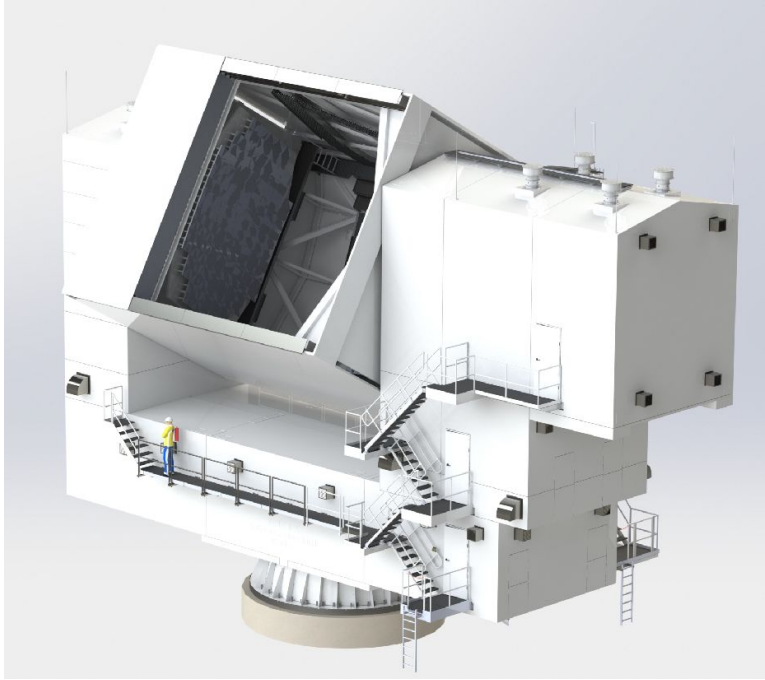
UKRI

JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE
日本学術振興会



Large Aperture Telescope - LAT

New 6-meter-primary telescope
>60,000 Transition Edge Sensor detectors
Intensity + polarisation



	LAT ($f_{\rm sky} = 0.4$)		
Freq. [GHz]	FWHM ($'$)	Noise (baseline) [μK-arcmin]	Noise (goal) [μK-arcmin]
27	7.4	71	52
39	5.1	36	27
93	2.2	8.0 } 6 µk-arcmin	5.8
145	1.4	10 }	6.3
225	1.0	22	15
280	0.9	54	37

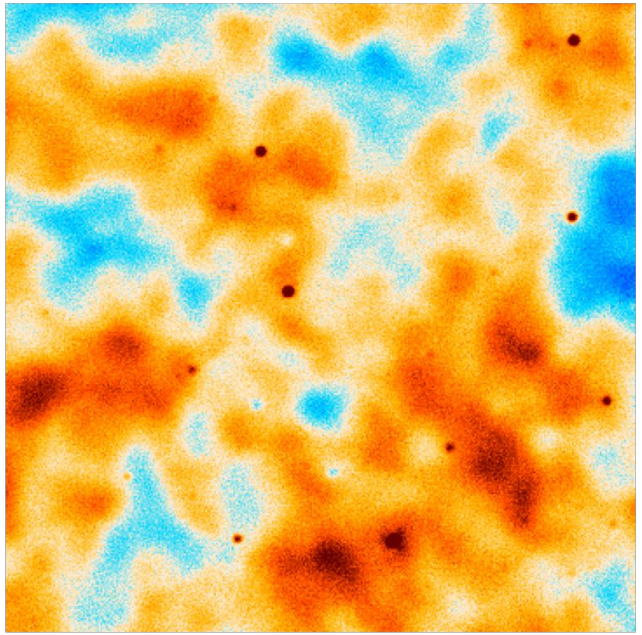
SO: New Opportunities in mm-Transient Science

Variable Active Galactic Nuclei:
track thousands daily/weekly/monthly at 1-10 mm.

Potential of mm transients:
e.g. orphan afterglows of Gamma Ray Bursts

Potential follow-up of Rubin Observatory optical transients

In addition to wealth of CMB science (early and late-time signals), 30k high-z dusty galaxies, 20k clusters and Galactic science



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ACT-T J061647-402140: a Strongly Variable, Flaring Source at 90, 150 and 220 GHz Positionally Coincident with the Transient Gamma-Ray Blazar, Fermi 0617-4026

ATel #12738; *Sigurd Naess (Center for Computational Astrophysics, Flatiron Institute) on behalf of the ACT Collaboration*
on 8 May 2019; 23:32 UT
Credential Certification: John P. Hughes (jph@physics.rutgers.edu)

Subjects: Millimeter, Gamma Ray, AGN, Blazar, Transient, Variables

SO: Time Domain

Daily monitoring of ~half the sky

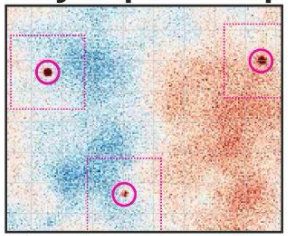
Publish light curves of all sources detected >3σ at day/week/month depth
~7.5k (12k) AGN at **day** (week) cadence

Transient alerts issued to the public **within 30 hours of data collection**, along with associated light curves!

Much more:

https://doi.org/10.48550/arXiv.2503.00636

Daily Depth-1 Maps



SO Time Domain Pipeline

Source extraction, forced photometry, etc.

open-source python pipeline

photutils
An Astropy Package for Photometry

PREFECT

Goal Daily Sensitivity

27 mJy	at	27 GHz
19 mJy	at	39 GHz
7 mJy	at	**93 GHz**
9 mJy	at	**145 GHz**
17 mJy	at	225 GHz
34 mJy	at	280 GHz

Storage and API access

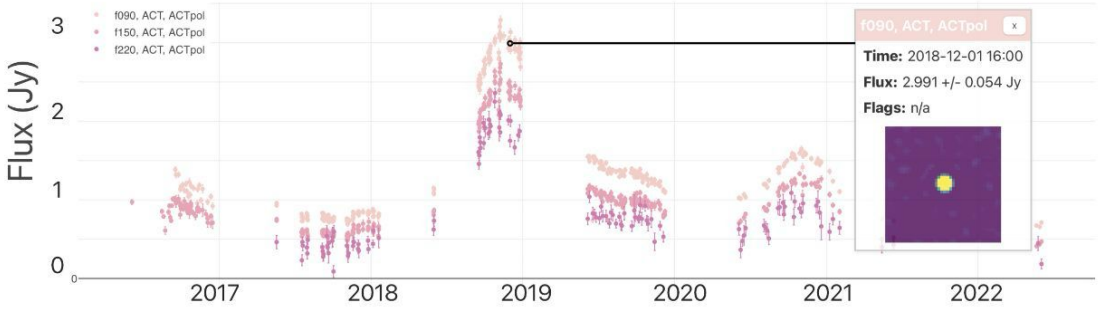
Database, API service, downloads, etc.

postgresql as backing database

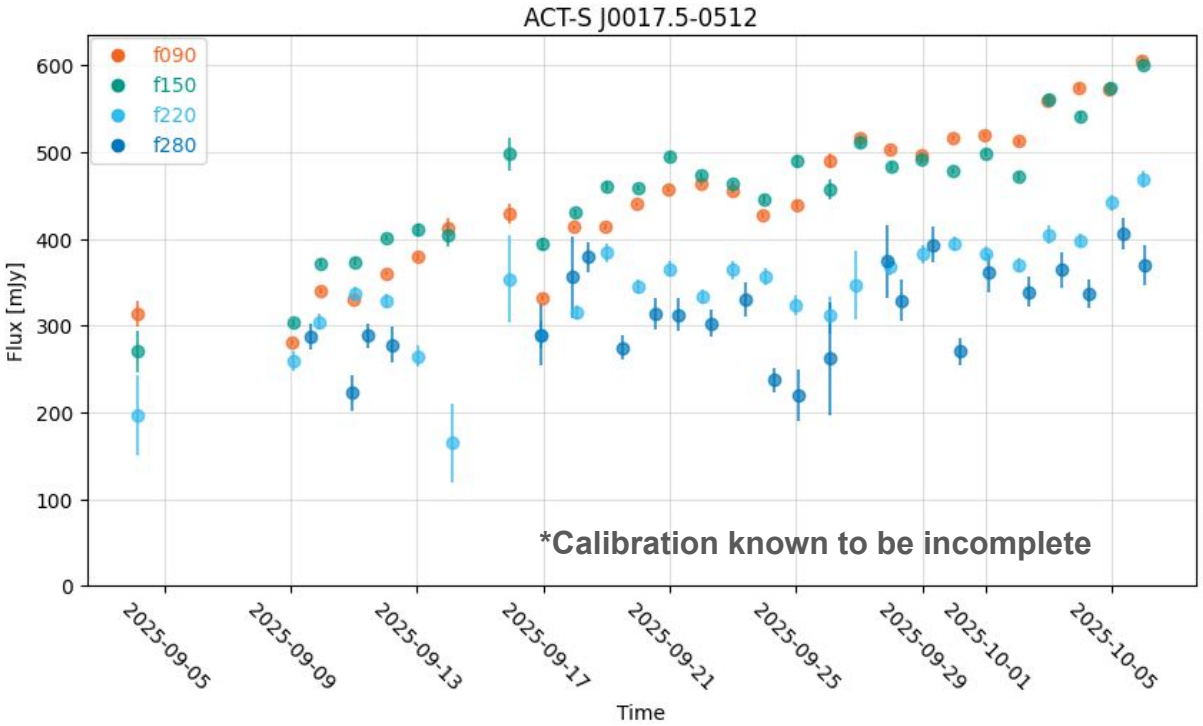
FastAPI

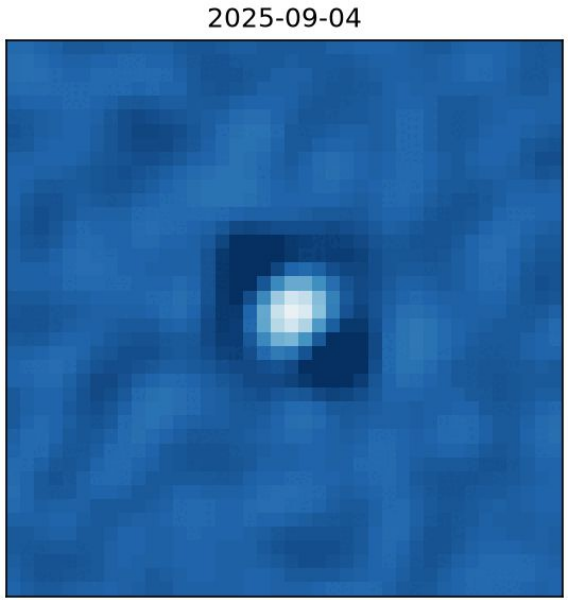
SQLModel

Interactive Visualization



SO LAT source lightcurves





f090 daily thumbnail

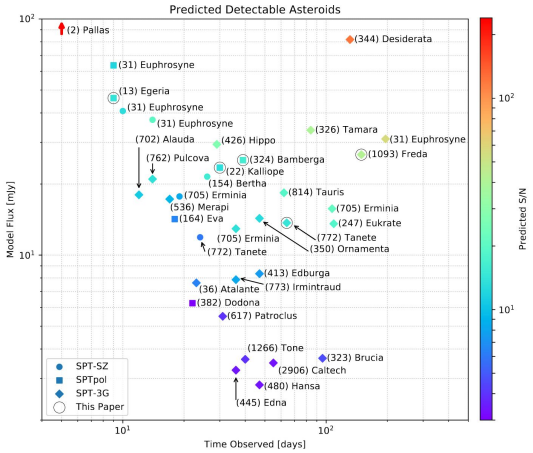
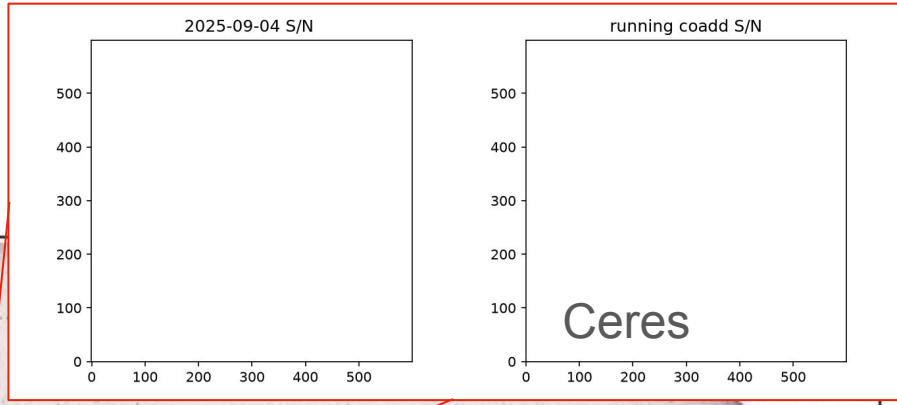
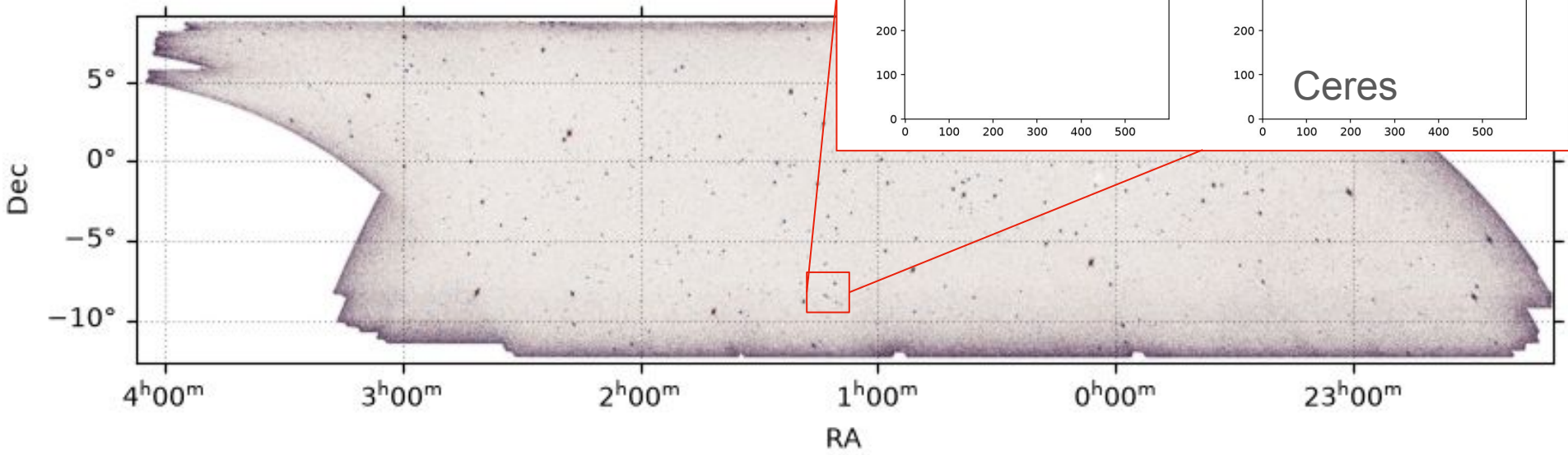


Figure 7. Objects with predicted S/N > 3 at 2.0 mm in all historic and planned future SPT data. We expect to observe (2) Pallas, plotted off scale, with a mean flux density near 725 mJy.

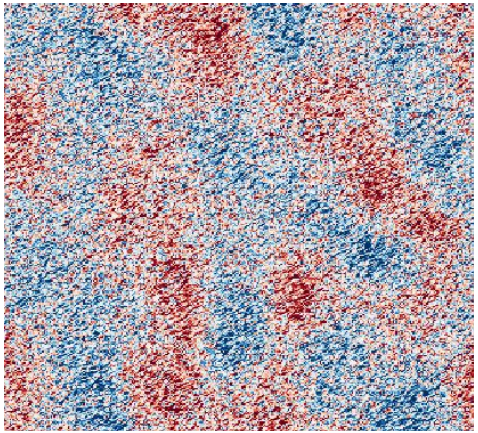
SO expected to detect O(10k) asteroids after stacking. Already monitoring asteroids in early observations!

Predictions from Chichura et al. (2022), "Asteroid Measurements at Millimeter Wavelengths with the South Pole Telescope", arXiv:2202.01406



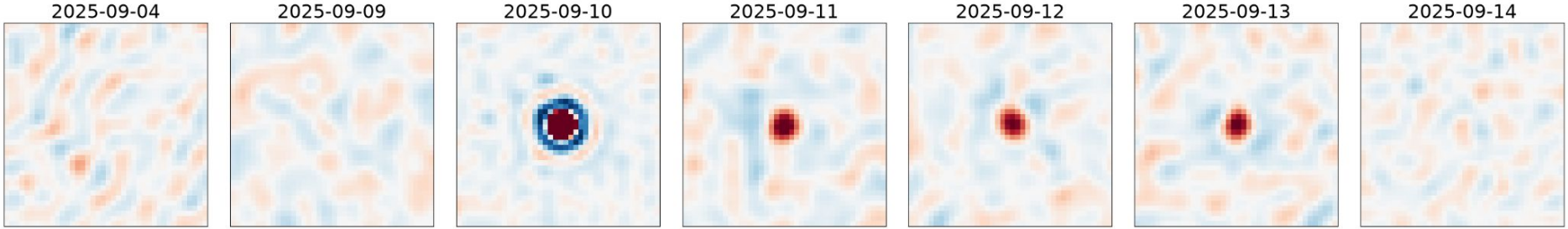


Flare stars



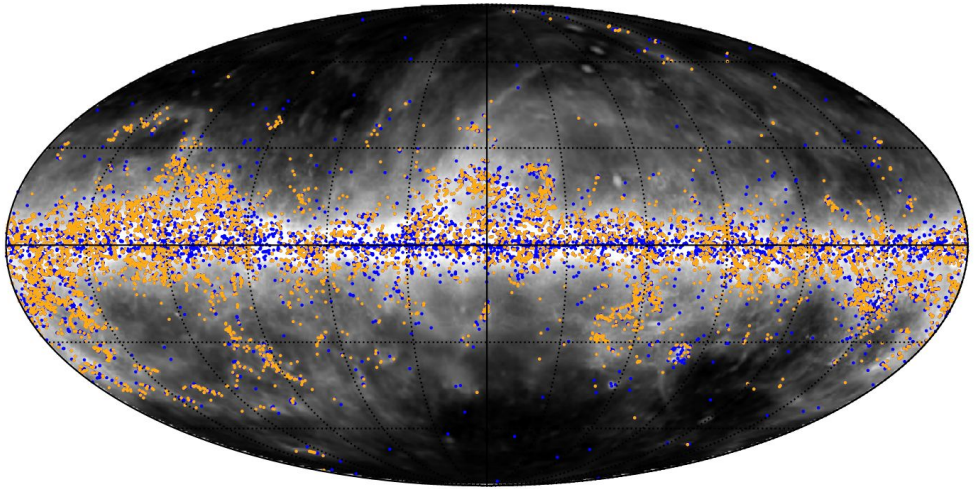
← SPT-3G first detection of flare star Z Ind. (2020)

SO first detection of a flare star SZ Psc (2025)



Also lots of Galactic & extragalactic sources to analyse

- E.g., Clancy et al. (2023), "Polarization fraction of Planck Galactic cold clumps and forecasts for the Simons Observatory", MNRAS (accepted), arXiv:2303.02788
- Based on Planck data, stacking analysis shows ~2% polarisation on average
- Expect to see ~12,000 cold clumps in intensity + ~430 in polarisation in SO
- Also many extragalactic sources (radio sources like quasars, thermal sources like nearby galaxies, etc.)
- (some varying, others not, but all interesting, e.g., spectral energy distributions/component separation/etc.)



Cold cores in Planck data: blue, complete set, orange, high S/N & well-separated subset used in Clancy et al. (2023)

The Atacama Large Aperture Submm Telescope (AtLAST)

- ✔ First high-res (<2.5" at ν>600 GHz) and wide-field (> 1 deg) single-dish submm observatory
- ✔ Pioneering sustainable astronomy: tailored off-grid renewable energy system
- ✔ Global effort building upon European and Japanese submm expertise
- ✔ A facility for >30 yr, committed to open science

MILKY WAY, GALAXIES, AND COSMOLOGY

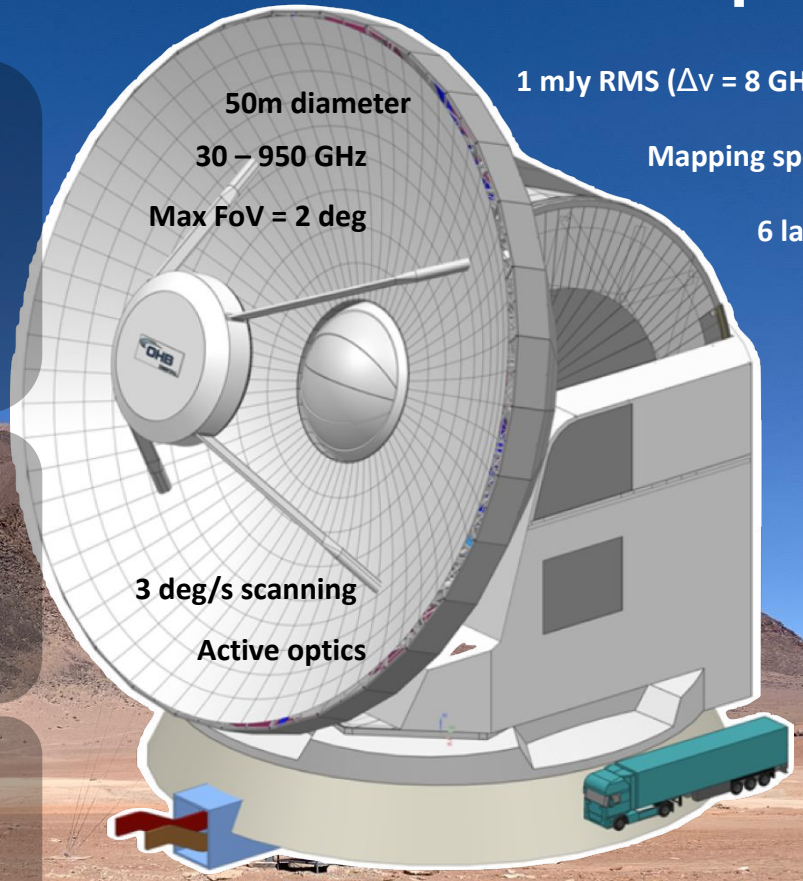
- Link sub-pc protostellar cores & disks with their large-scale environment in our Galaxy
- Resolve the cosmic infrared background
- SDSS-like submm surveys of the local Universe
- Map elusive gas flows and cosmic web filaments

CROSS-FIELDS

- Discover transient & time-varying submm sky
- Solve missing flux issue of interferometers

SOLAR SYSTEM

- Track solar activity driving space weather
- Survey HDO & D_2O in comets



1 mJy RMS (Δν = 8 GHz) @ 350 GHz in < 8 s

Mapping speed 10^3 - 10^5 x ALMA

6 large instrument cabins

Multi (>10^5)- beam & multi-band receivers

Time domain science

Solar observations

Continuum & line polarization

Find out more:
atlast-telescope.org

Funded by the European Union

Satellite constellations

Satellites have always been an issue for astronomy...

Starlink started launches in 2019 when there were ~5k satellites. Now **~18,000** in Low Earth Orbit (LEO).

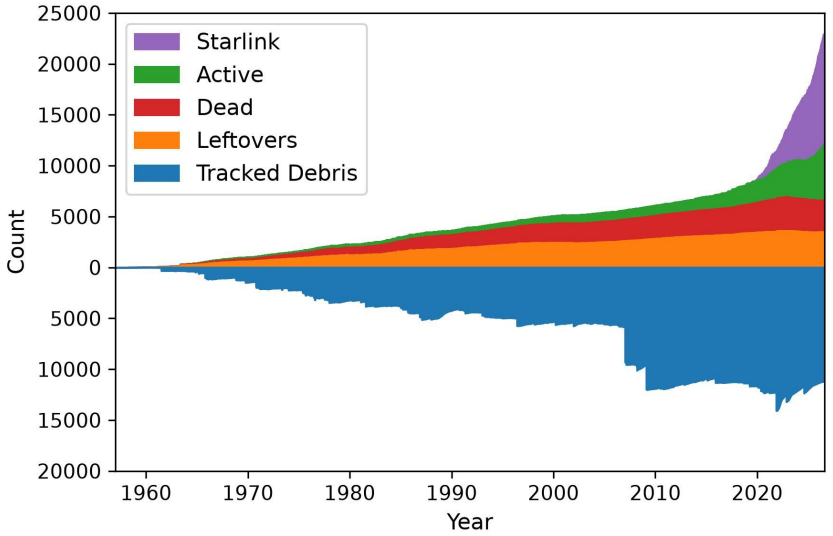
O**ver 2,500,000 new satellites proposed in the next decade**, via Starlink/OneWeb/Kuiper/many other companies.

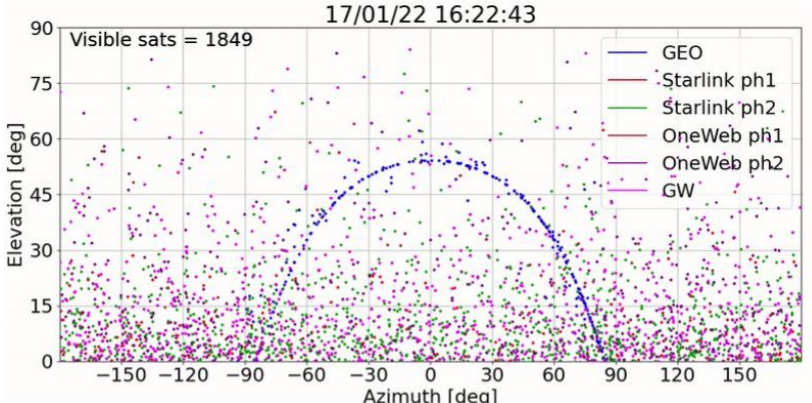
Orbital AI Data Centres and 'Daylight as a Service' coming

Can (and already have!) mimic astronomical transients
(GN-z11-flash was a rocket body...)
(Don't ask asteroid observers about Musk's car...)

Join us at SatHub to collect and analyze satellite observations, and build software tools. Part of the IAU Centre for the Protection of the Dark and Quiet Sky.

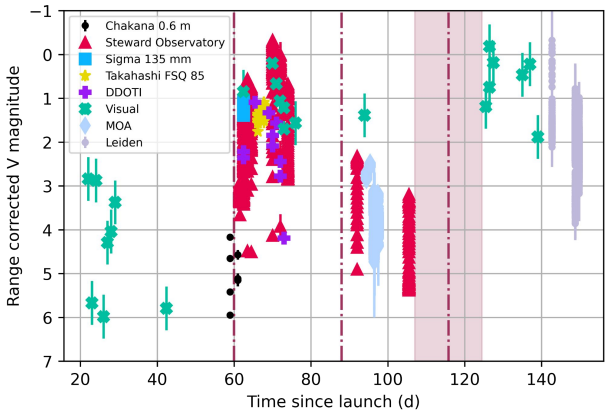
Apply here: https://cps.iau.org/





Bright across the EM spectrum

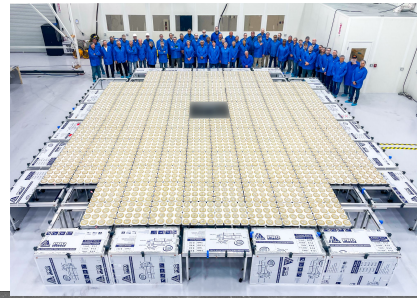
Reflections from the sun in late evenings / early mornings in optical/nir.
Large direct-to-cell satellites can be the brightest objects in the sky, e.g., BlueWalker3 (negative mag!).
Will affect surveys like LSST with Vera C. Rubin Observatory, amongst others. Not even Hubble escapes due to LEO (but JWST in L2 is fine).



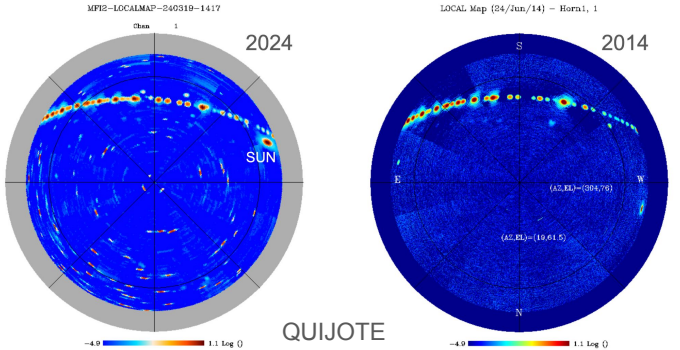
https://www.nature.com/articles/s41586-023-06672-7

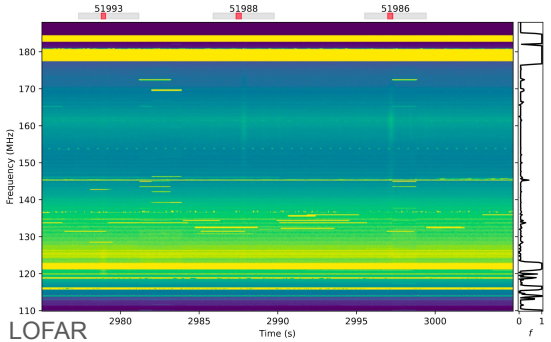
Active and highly variable transmissions at radio frequencies.
QUIJOTE observing at 10-20GHz used to just see geostationary satellites, now Starlink is everywhere.
Even seen with LOFAR/SKA-low at ~100MHz through unintended emission (digital hardware etc. also transmits at clock freqs!)

BlueWalker3



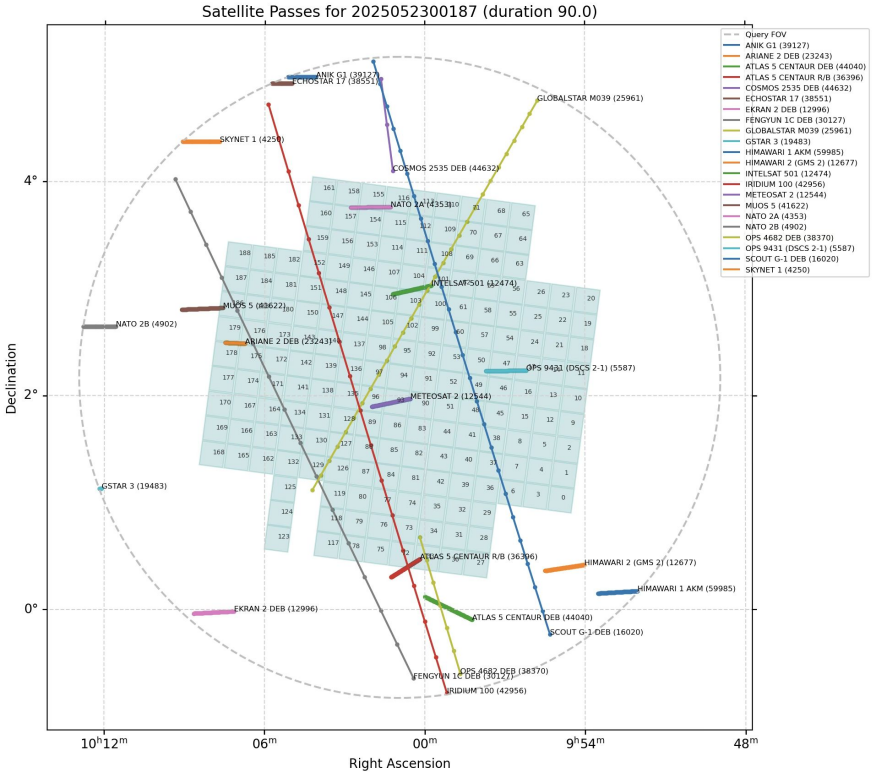
Bright in submm/mm through thermal emission.





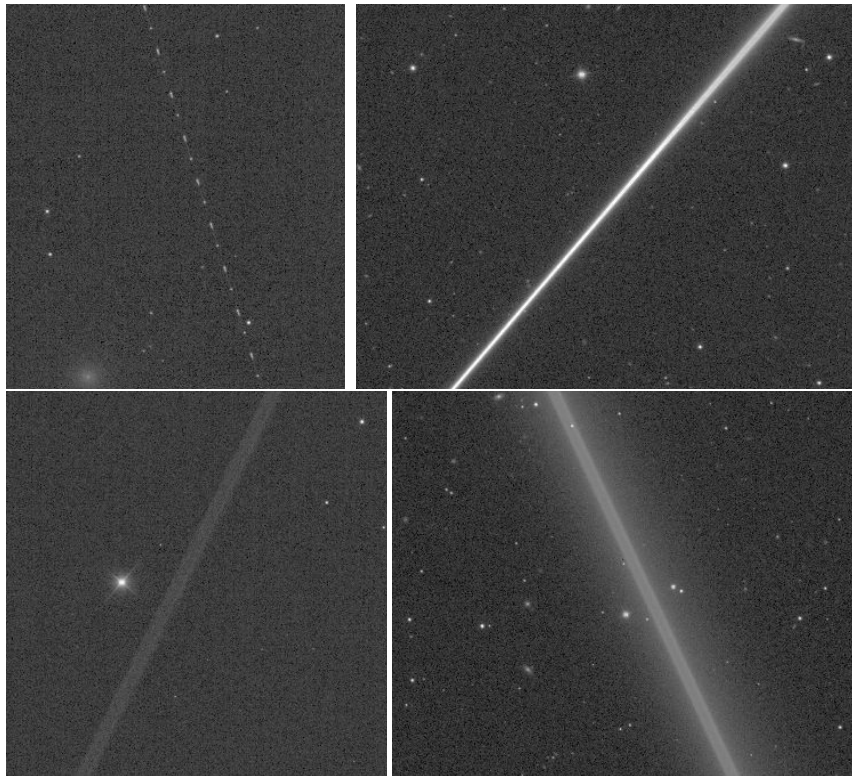
Hubble

Satellites in Rubin observations



Position predictions by https://satchecker.readthedocs.io/

From Jangid et al. poster at
2025 Rubin Community Workshop

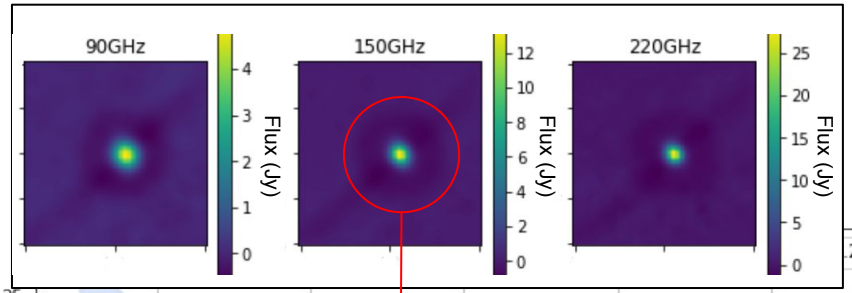


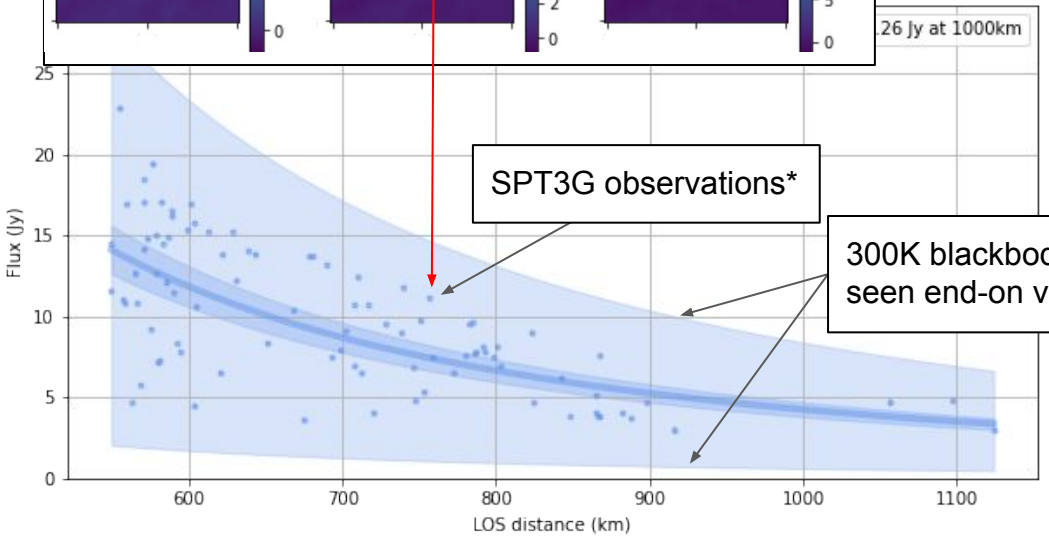
https://community.lsst.org/t/rrb-satellite-constellations-and-lsst-new-tools-and-impact-assessments/10729

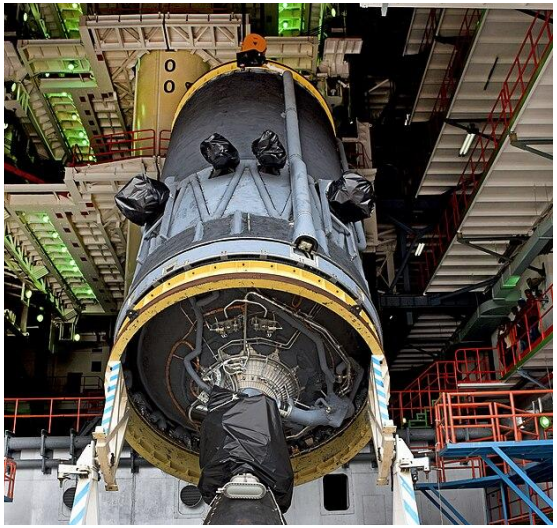
Example from SPT3G - Thermal Emission

(Foster et al., arXiv:2411.03374)

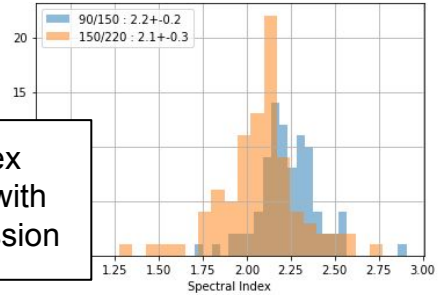
Even if not actively emitting RF signal, satellites can be millimeter bright!





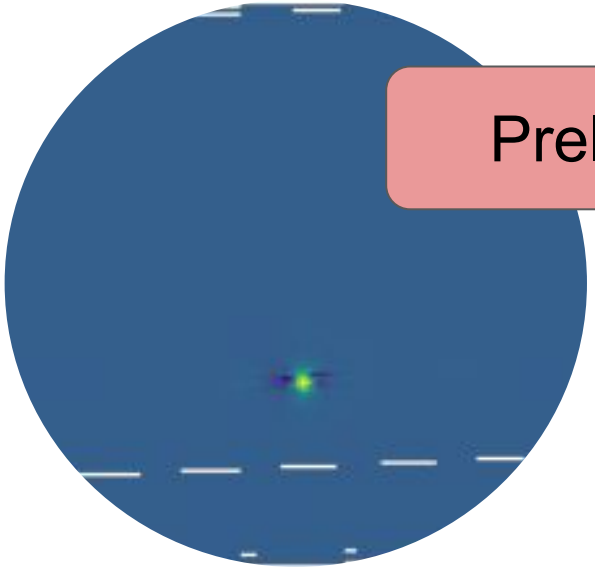


LVM3 Upper stage : 4m diam. x 13.5m long

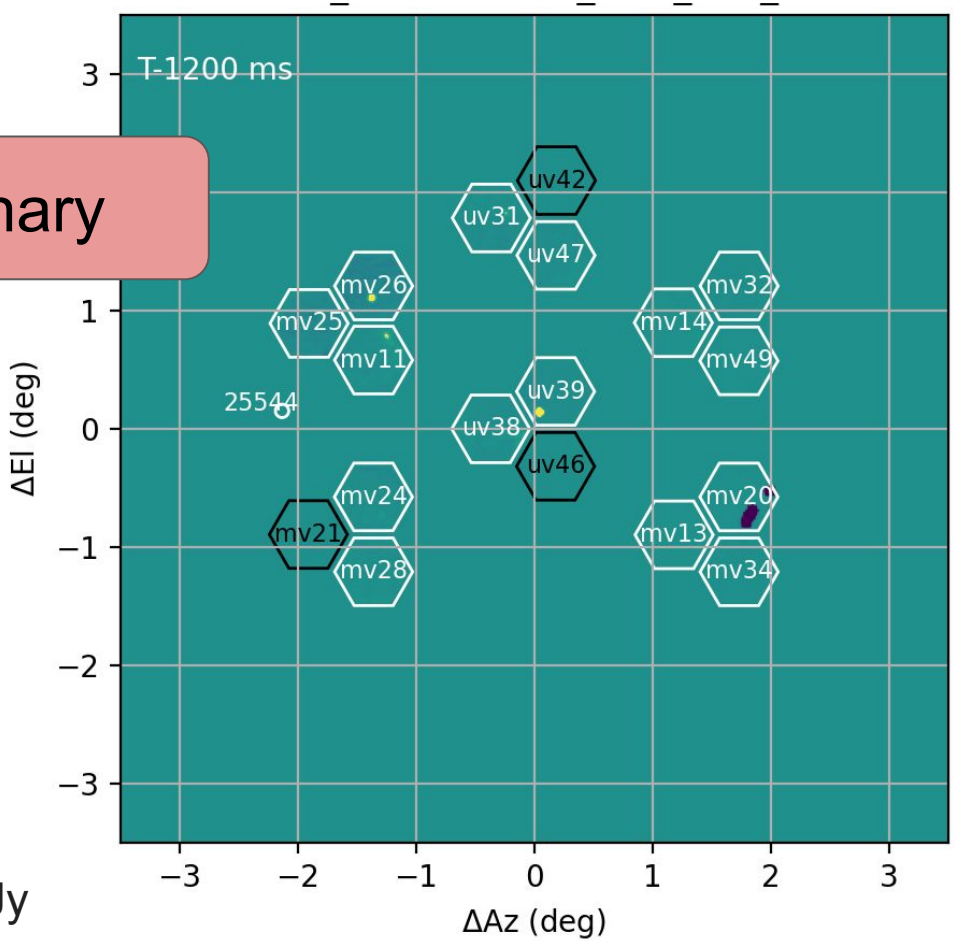


Spectral index ~consistent with thermal emission

* observed both in direct sunlight and in Earth's shadow. Very high S/N.



Preliminary



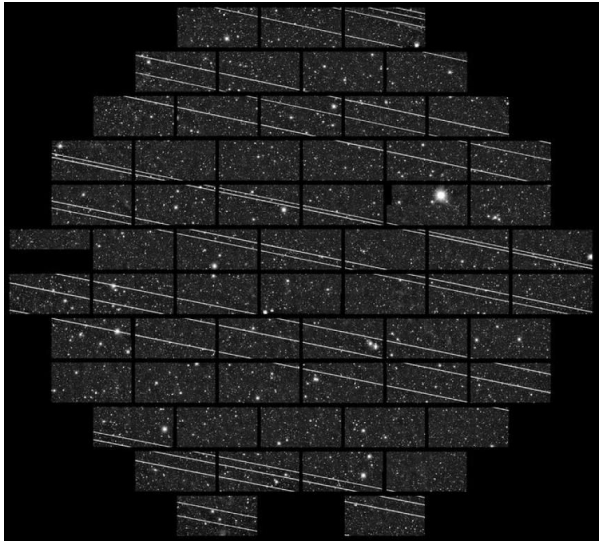
SO detects thermal emission from the International Space Station!

Estimated to be on the order of 100 Jy at 100 GHz!

IMPERIAL

RAS Specialist Discussion Meeting

- Dark and Quiet Skies and Satellite Constellations
- Friday 16 October 2026, 10-17h
- Burlington House + online (fully hybrid)
- £15 (in-person) / £5 (online) / £0 (RAS Fellows)
- Abstract deadline: Wednesday 16 September
- https://www.ras.ac.uk/events-and-meetings/ras-meetings/dark-and-quiet-skies-and-satellite-constellations



Credit: CTIO/NOIRLab/NSF/AURA/DECam DELVE Survey

IMPERIAL

Conclusions

- Simons Observatory has started regular observations
  - ACT observations completed, SPT ongoing, AtLAST (50m) & PRIMA (mid-IR) in the future?
- LAT expect to see transients from a variety of different sources (stars, AGN, other Galactic and solar system objects) - planning to share alerts publicly.
- Also see satellites through their thermal emission
  - ...and higher frequency active transmissions coming
- Join the RAS meeting on 16 October to learn more about satellites...!
- Lots to learn in the years to come!
- Questions?