

Finding Transients with SPT-3G (and CMB-S4?)

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SPT-3G Transient Search

- Second transient search with the South Pole Telescope*
- 2-3x more sensitive than SPTPol over a 15x larger area.
- Two parallel pipelines
 - **Offline:** search for transients in 2019 dataset.
 - **Online:** live search for fast transients, with automated alerts.

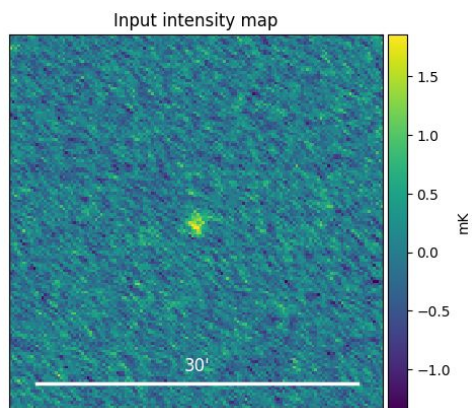
*Whitehorn et al (2016) arxiv:1604.03507

SPT-3G Transient Search: Offline

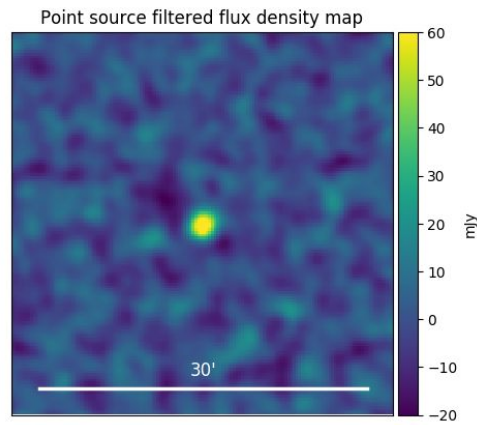
- Search for transients in 2019 data, on all timescales (half a day to many months).
- Current status: unblinding soon.
- Next few slides: method summary.

SPT-3G Transient Search: Offline

- Input data: 3G maps for high-ell science.
 - 1500 deg² every 12 hours.
 - Shared with other high- and low level analyses: point sources, clusters, data quality.
- Further processing: subtract background and filter.



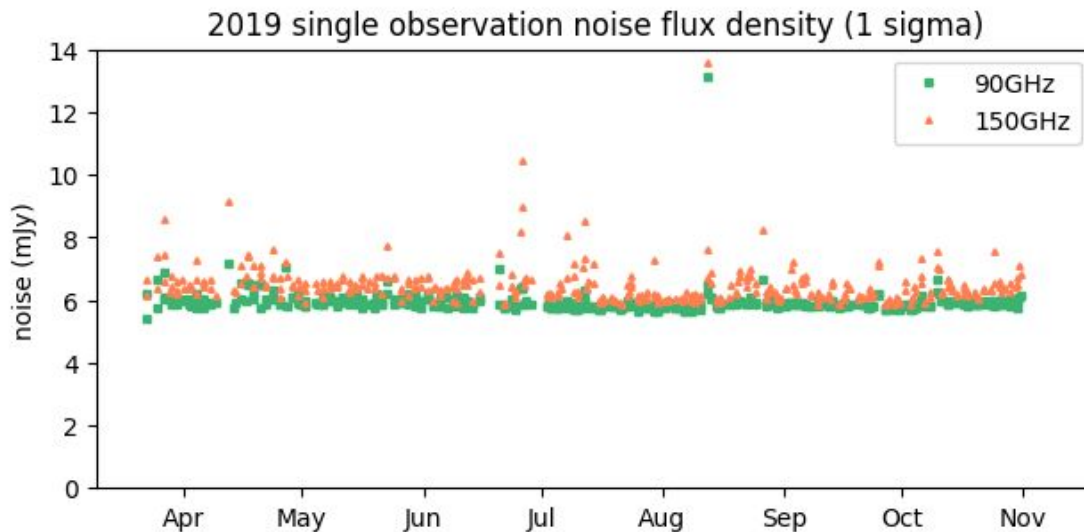
(Simulated source)



(Simulated source)

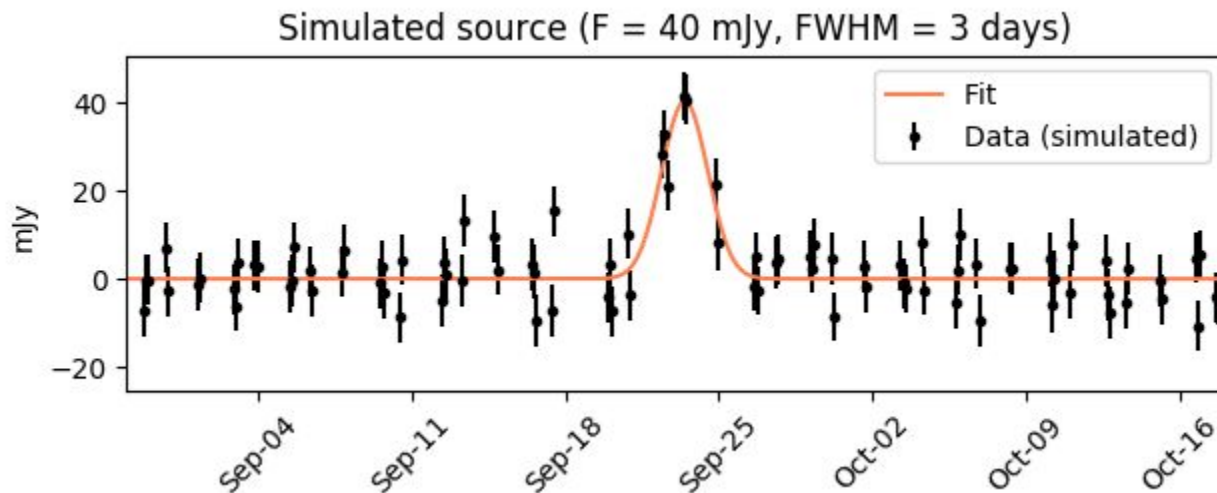
SPT-3G Transient Search: Offline

- Final 2019 data set:
 - ~ 400 maps (223 days) with 0.25' resolution.
 - Mean 1 sigma point source sensitivity of 5.9 mJy at 90 GHz, 6.4 mJy at 150 GHz.



SPT-3G Transient Search: Offline

- Final 2019 data set:
 - ~ 35 million pixel timeseries.
 - Fit 4 parameter gaussian flare model ($F_{90}, F_{150}, t_0, \sigma$) with ML



SPT-3G Transient Search: Online

- Real-time search for < week-scale transients.
- Automated system to make maps, point source filter, search for flares, send (internal) alerts.
- Current status: **On-sky!** Internal alerts only, working out the kinks. Expect external (ATel) soon.

SPT-3G Transient Search: Online

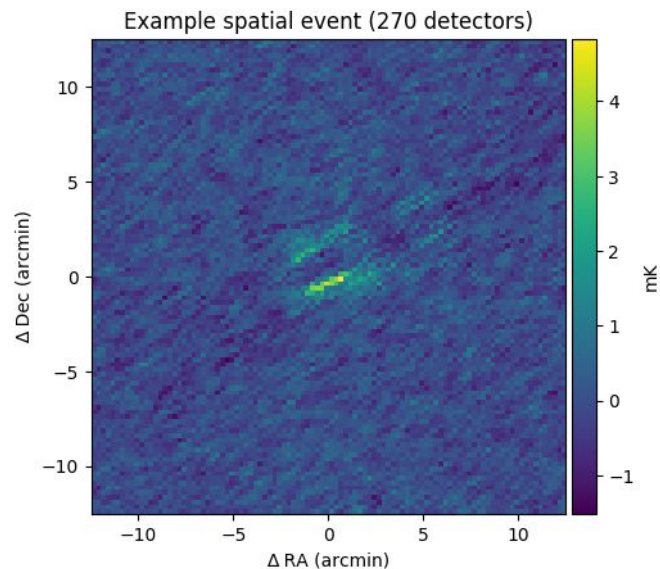
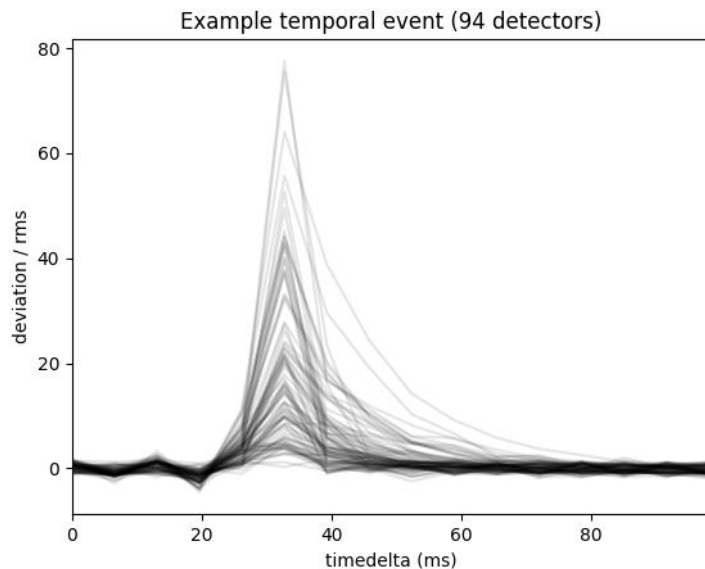
- Take the offline analysis software, automate it, run it daily on a small window of data, send alerts for significant events.
- Aim to minimize lag between transient observation and resulting alert.
- Huge amount of work went into computational optimization of all the steps: calibration processing, mapmaking, filtering, lightcurve fitting. Example: mapmaking was 20 hours, now 4.
- Current lag is ~ 12 hours!

SPT-3G Transient Search: Glitches

- First trial runs uncovered some obvious data glitches.
- In the broadest sense, any non-astronomical non-gaussianity in the data.
- Many different sources: SQUID flux jump, Cosmic Rays, satellites, etc. Still relatively rare.
- CMB and “steady source” science: sufficient to catch bright events, say > 5 sigma in a single detector.
- Transient analysis is uniquely sensitive to glitches. Need more sophisticated tools.

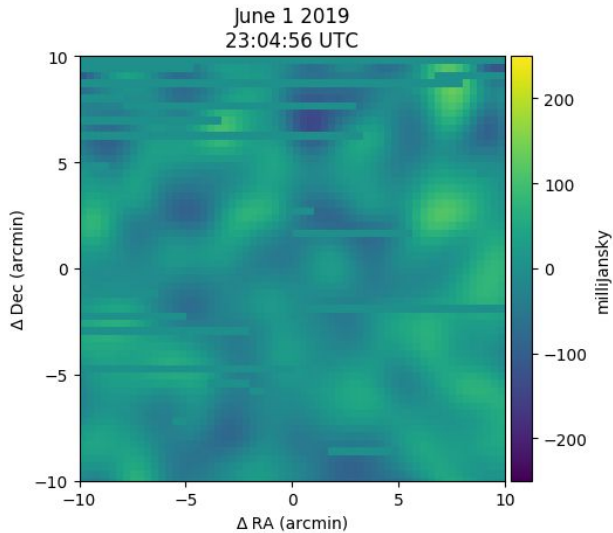
SPT-3G Transient Search: Glitches

- Bright glitches can leak through into maps when there is a substantial population of sub-threshold (< 5 sigma in a single timestream) detectors.
- Two broad classes: **temporally** and **spatially** correlated.



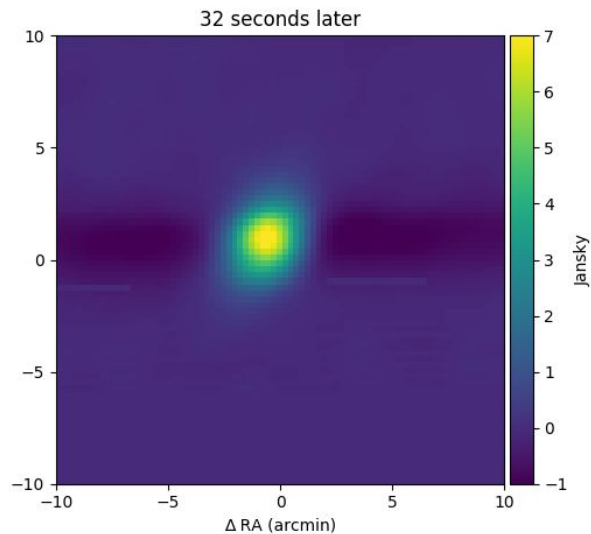
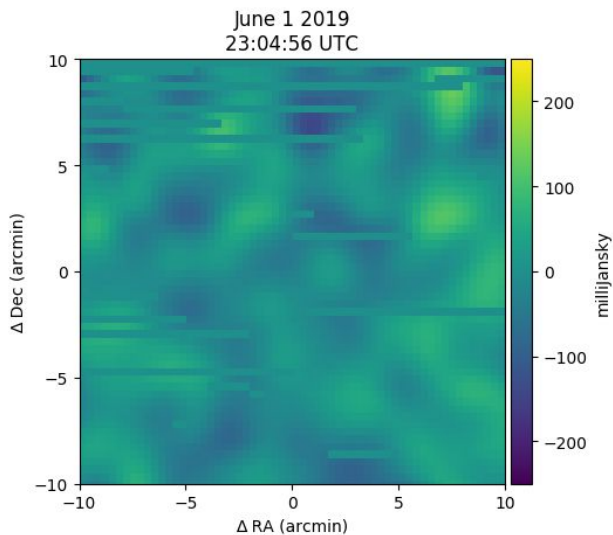
SPT-3G Transient Search: Glitches

- Why call the second one a glitch and not a transient?



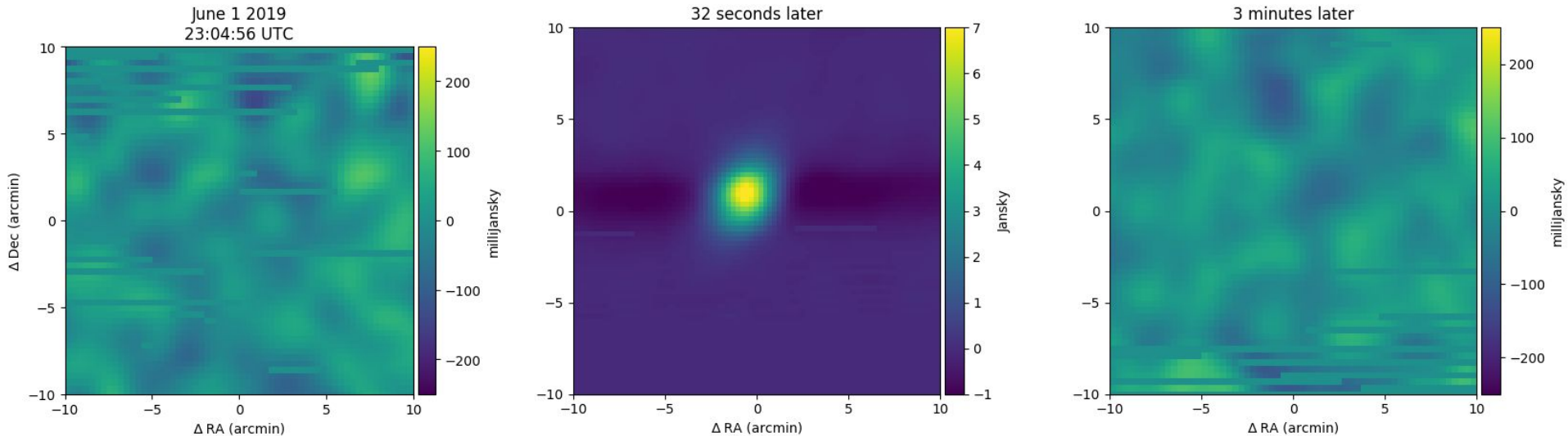
SPT-3G Transient Search: Glitches

- Why call the second one a glitch and not a transient?



SPT-3G Transient Search: Glitches

- Why call the second one a glitch and not a transient? Any GRB should be constant over the course of a 2 hour observation.



SPT-3G Transient Search: Glitches

- Brighter than brightest AGN in our field at all frequencies.
- No evidence for this source in any other scan or observation. Movement during 2 seconds of observing indicates an LEO satellite.
- Bright enough to be highly significant in the 2 hour map, even with 5 sigma glitch removal.
- Currently only anecdotal data about how common these are. The types and number of satellites detectable with SPT-3G is not (yet) known. Number of LEO satellites will skyrocket in the coming years. **Potential to create challenges for observations with CMB-S4.**

SPT-3G Transient Search: Glitches

Currently pursuing two separate tracks (both WIP):

1. **More advanced glitch finding algorithm.** Find glitches that co-occur in time or space, cut all detector data in a small window. Essentially removes all short duration (< 100 s) bright (> 1 Jy) events from data.
2. **Satellite tracking.** Using the event database from track 1, try to match to known satellite orbits. See if there's any recurring culprits, and what if any their emission mechanism is. Some preliminary evidence that it could be a satellite constellation like SWARM or GRACE-FO.

Transients with CMB-S4

- Huge potential to explore both sides of dN/dS with small and large area surveys.
- Small Area: same sky area as 3G, much deeper.
- Large Area: same depth as 3G (90/150), 10-20x as much sky.

Develop all the tools now with 3rd-gen experiments, hit the ground running!