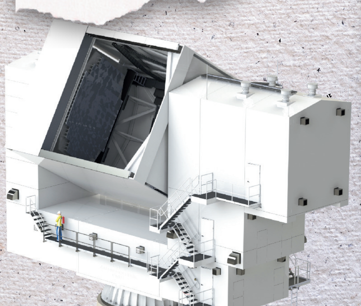
FINDING TRANSIENTS

IN TIME ORDERED DATA

WITH THE LARGE APERTURE TELESCOPE



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2024

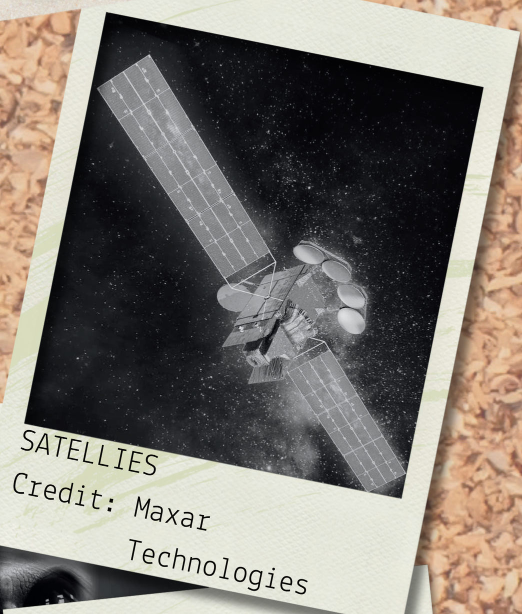
Why search in TODs??

Transient events occur over a large range of timescales. Whilst detection in map space [1] is reliable and can cover a large range of events, it is blind to timescales less than a few minutes (which is significant in the zoo of astrophysical transients [2]!) By looking directly in the LAT time ordered data we increase our time resolution up to the scanning speed of the instrument itself, allowing us to discover much faster events such as rapid flares occuring in the span of seconds. This also allows for higher time resolution lightcurves to be constructed.

Blind TOD searches coincidentally act as an alternate point source detector that may be passed into the map-making pipeline to be masked or catalogued.

With enough detection confidence, event detections in TODs can also trigger alerts for follow-up!

SUSPECTS INCLUDE



SATELLIES
Credit: Maxar Technologies

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Credit: Getty Images

Gamma Ray Bursts
Credit: NASA, ESA, & M. Kornmesser

STELLAR FLARES
Credit: S. Dagnello, NRAO/AUI/NSF

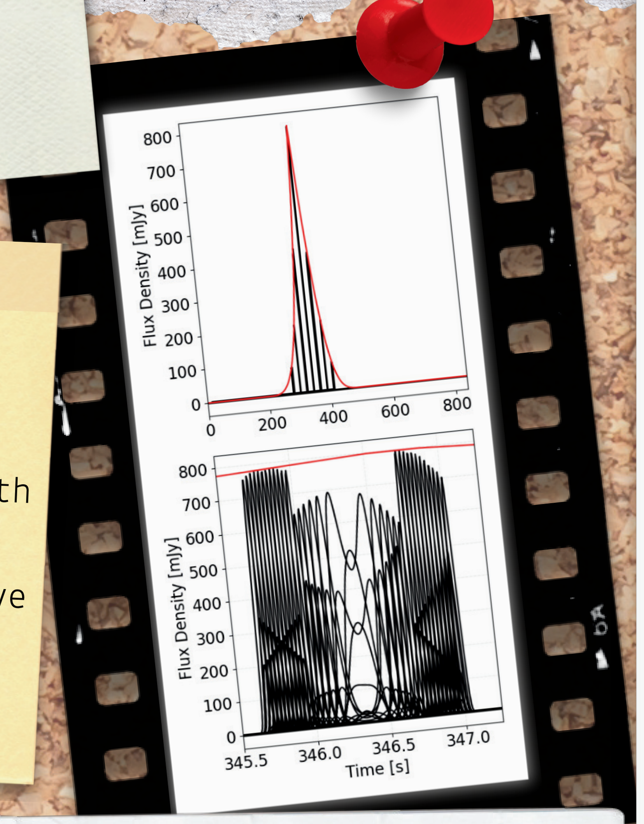


Figure 1
Top: Simulated stellar flare lightcurve (Red) with wafer response
Bottom: Zoom of above showing individual detector response (Black)

Simulations

To construct and test the pipeline we utilise the LAT *V5* and *Deep56* simulations.
Simulated flare-like events are generated with variable peak flux, rise & fall time and position on sky, and injected into the TODs before any processing is completed.
We can see a simulated flare with the detector response across a full wafer in figure 1, note in the zoomed image, the individual detector peaks follow a Gaussian beam response as would be expected when scanning over point sources.
Forecasts are underway to explore the LAT capabilities.

Pipeline

::: TOD Processing :::

1. Load Obs
2. Fix boresight glitches
3. Flag and remove signal glitches
4. Correct for gain and boresight offsets

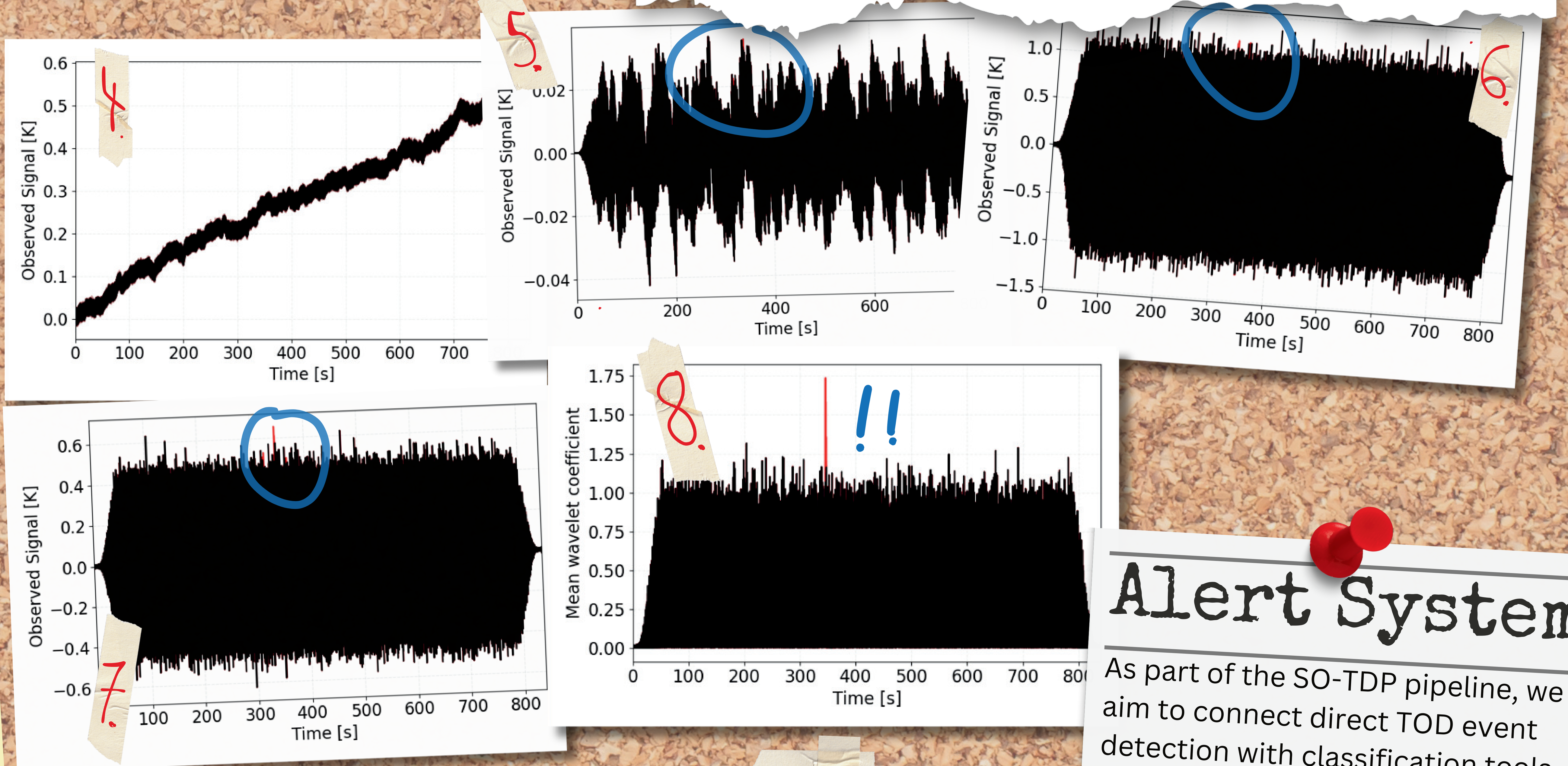
::: TOD Filtering :::

5. Detrend TOD
6. Equalize TOD with noise PSD
7. Apply bandpass filter
8. Apply continuous wavelet transform [3]

::: Peak Detection :::

9. Apply cut at chosen S/N
10. Bin peaks per detector and merge across wafer
11. Apply cuts to ensure astrophysical signals
    - No. detectors/pixels hit
    - Separation on sky
    - Separation in time
12. Fit key parameters per remaining bin
    - Flux density
    - Source position (RA,Dec)
    - ctime

Figure 2 | Base (black) & simulated flare added (red) TODs as visualized at marked pipeline steps.
Left: Pre-processed TOD, *Middle*: Detrend applied, *Right*: Equalized TOD, *Bottom left*: Bandpass Filtered TOD, *Bottom middle*: Mean CWT coefficients



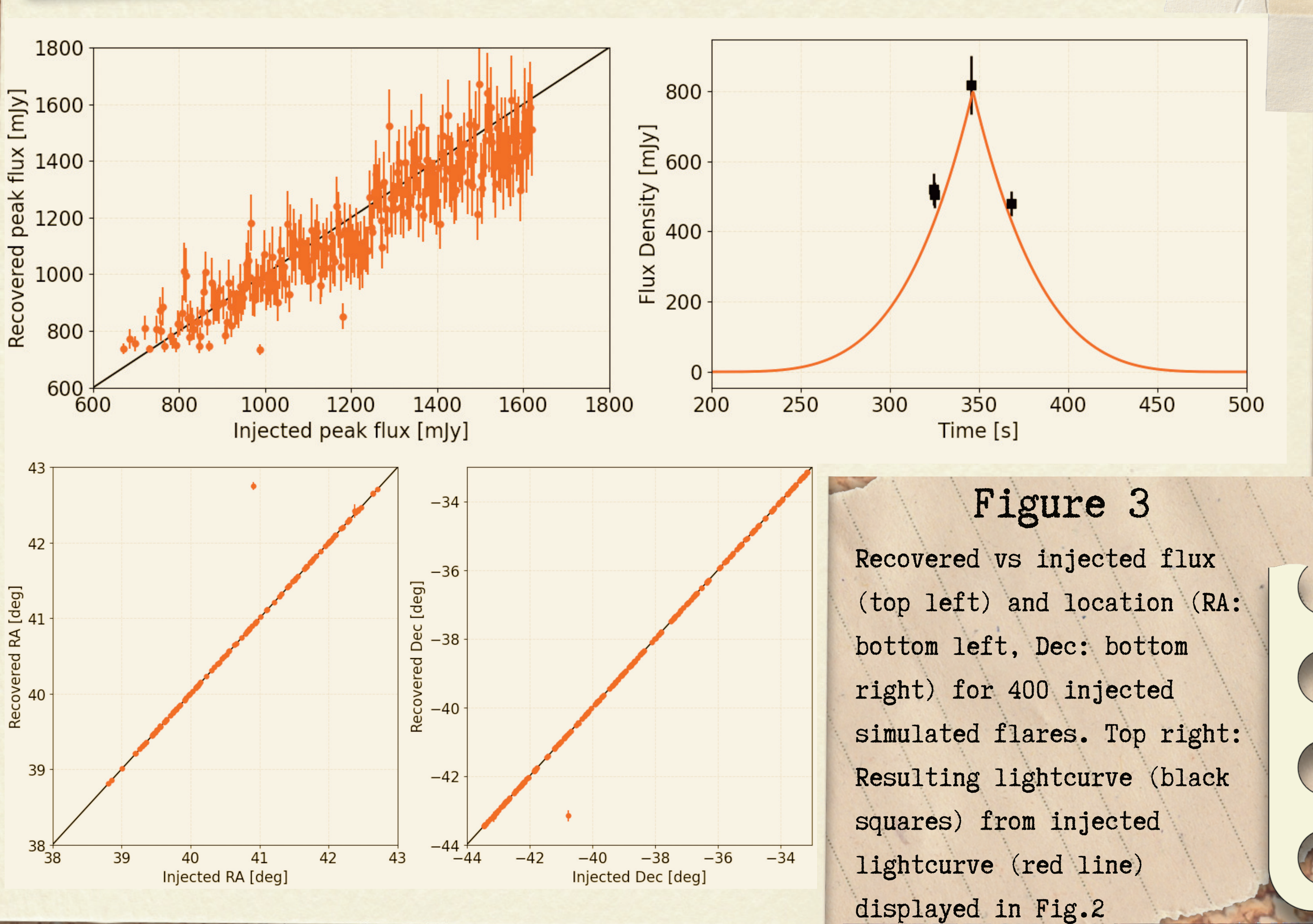


Figure 3
Recovered vs injected flux (top left) and location (RA: bottom left, Dec: bottom right) for 400 injected simulated flares. Top right: Resulting lightcurve (black squares) from injected lightcurve (red line) displayed in Fig.2

Alert System

As part of the SO-TDP pipeline, we aim to connect direct TOD event detection with classification tools such that we can integrate this into an alert pipeline.
This will allow us to rapidly send out public alerts for multi-wavelength follow up and wider community analysis.
Planned alert outputs include: Event ID, source coordinates (RA,Dec), ctime, possible associations, etc.

References

[1] Li Y. et al., 2023, ApJ, 956, 36
[2] Andreoni I. et al., 2020, MNRAS, 491, 6852
[3] Sadowsky, J., 1994, Johns Hopkins APL Tech. Dig. 15(4), 306-318