Searching for Transients using CZTI

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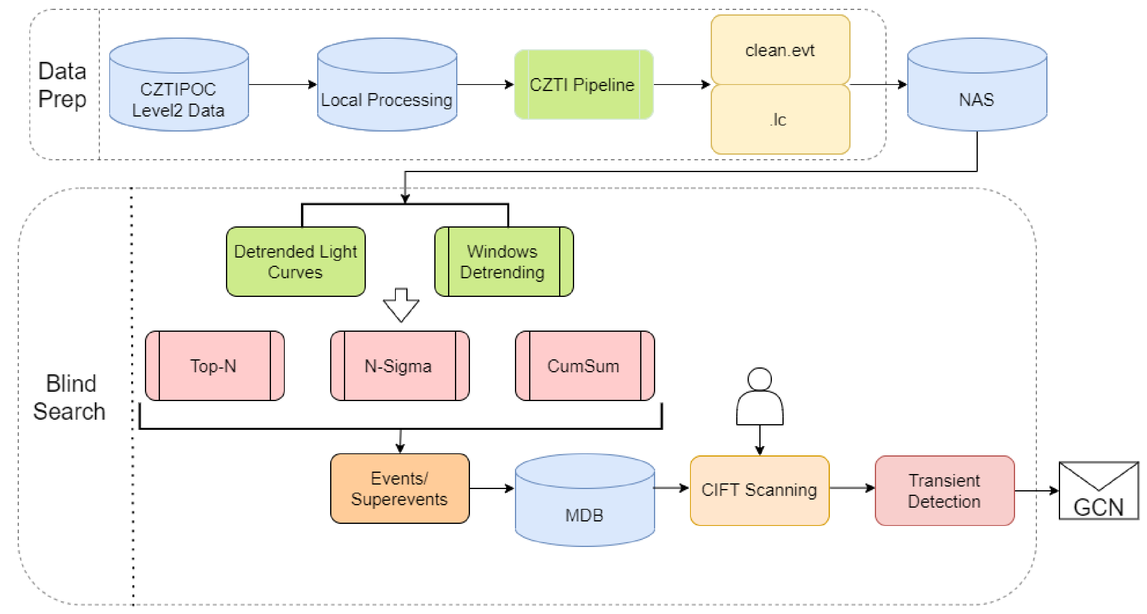
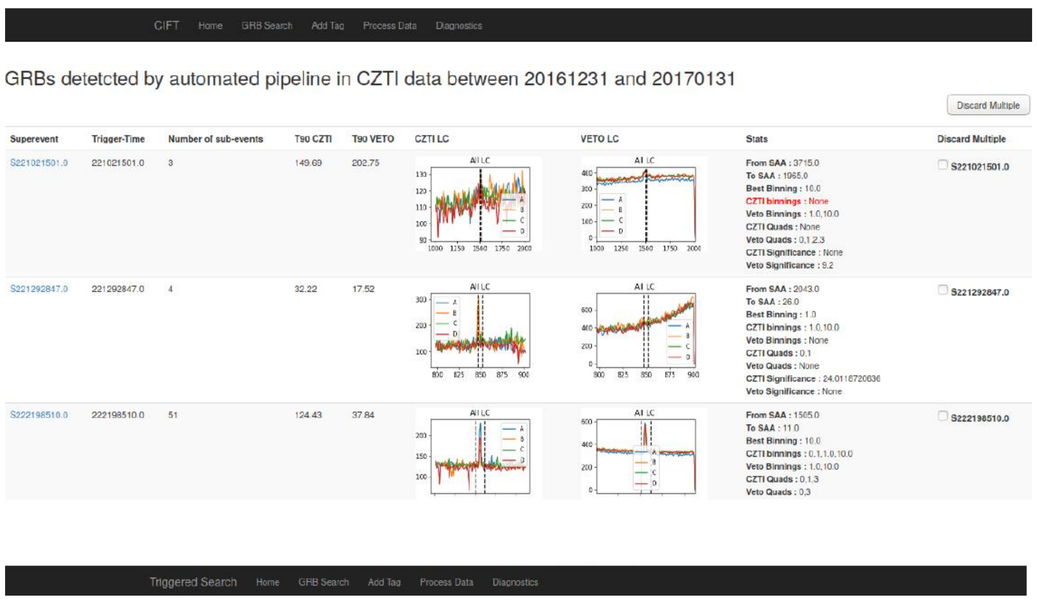
Abstract

We present the search algorithms & a customized web-interface used for searching for fast-transients like Gamma-Ray Bursts (GRBs), Fast Radio Bursts (FRBs), counterparts to gravitational waves, in CZTI onboard AstroSat.

We compare our searches to the ones already in place on the 5 years of CZTI data since the launch of AstroSat in 2015 and propose some improvements to the algorithms & interface to enable a faster turn-around in detecting these fast-transients.



CIFT: CZTI Interface for Fast Transients



Algorithms in Blind Search

- N-sigma: Iterative sigma-clipping
- CR algorithm: Cut-off rate from False Alarm Probability
- TopN: Brightest N Bins

- Done for both CZT & Veto (CsI)

- Candidates that satisfy a minimum detection requirement flagged & grouped together as superevents, which are then displayed using CIFT.

Triggered Search

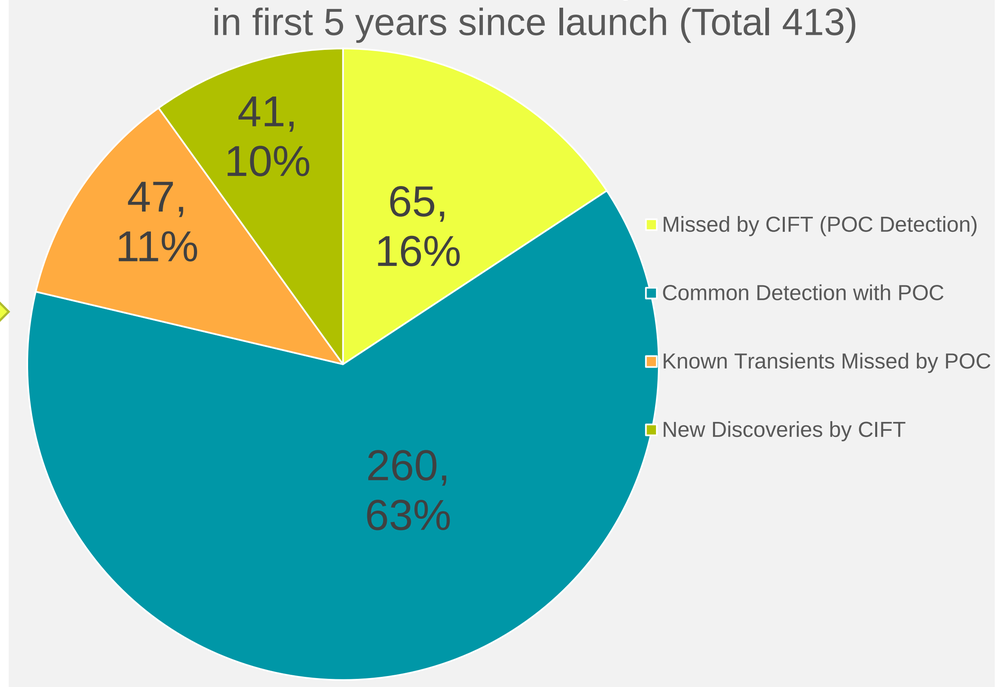
If the trigger time or position of a transient are already known, we generate spectrograms to inspect the candidate manually.

Detection: Estimate duration (T_{90}), peak rate (R_p) above background (R_b), and the total counts (C_{tot}).
Non-detection: Estimate upper limits on counts consistent with noise.

Overall Performance (Pipeline and Algorithms)

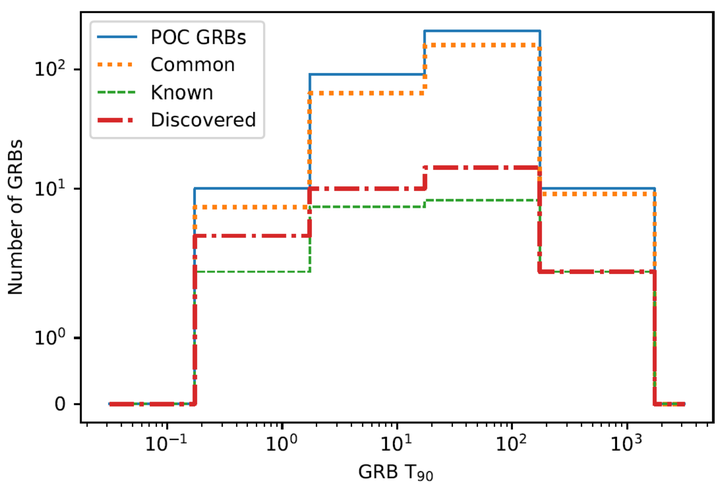
- 1 Hour to search 1 month of data (~ 130 GB). Creating plots is the slower part.
- 340 Superevents flagged every month (average for CZTI & Veto combined)
- False positives mainly due to False peaks near SAA & Particle events in Veto.
- Pie Chart: CIFT detected GRBs share out of a total 413 GRBs over 5 years.

Common detections (260 GRBs detected by both CIFT, POC), Missed by CIFT (65 GRBs that only POC detected), Known Transients (47 reported GRBs that POC missed but CIFT detected), and New Discoveries (41 GRBs that CIFT detected which were not reported by any other instrument).

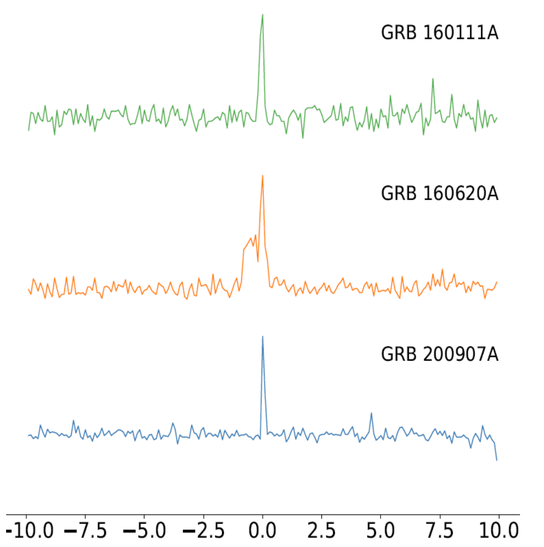


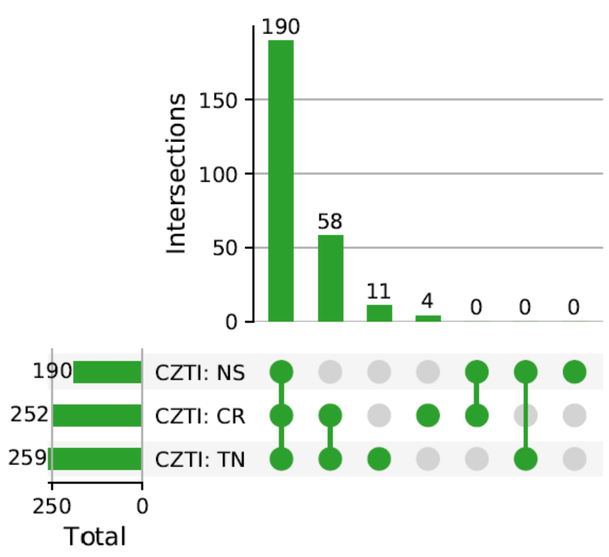
- Swift-BAT ~ 92 GRBs per year from on-board triggers
- CZTI ~ 83 GRBs per year
- Fermi-GBM ~ 235 GRBs per year.

New transients detected by CIFT ranged from 0.13 s to 290 s as their T_{90}, with a short GRB detection share (10%) that is similar to the share of Swift-BAT (Lien et. Al. 2016)



Normalised lightcurves of some short GRBs detected by CIFT.





Performance of the 3 algorithms (for CZTI). The three bottom rows show transients seen in each algorithm whereas bar charts at the top show their overlaps.

Based on: Sharma et al. 2020.

Future

Developing + deploying new algorithms (Bayesian)

New noise-rejection methods (Ratheesh et al. 2020)

To quantify the statistical significance of a GRB

Improving interface functionality to undertake searches for FRBs, SGR, GW counterparts, etc.

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