Time-domain astronomy with the Fermi Gamma-ray Burst Monitor in the multi-messenger era

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on behalf of the Fermi-GBM team

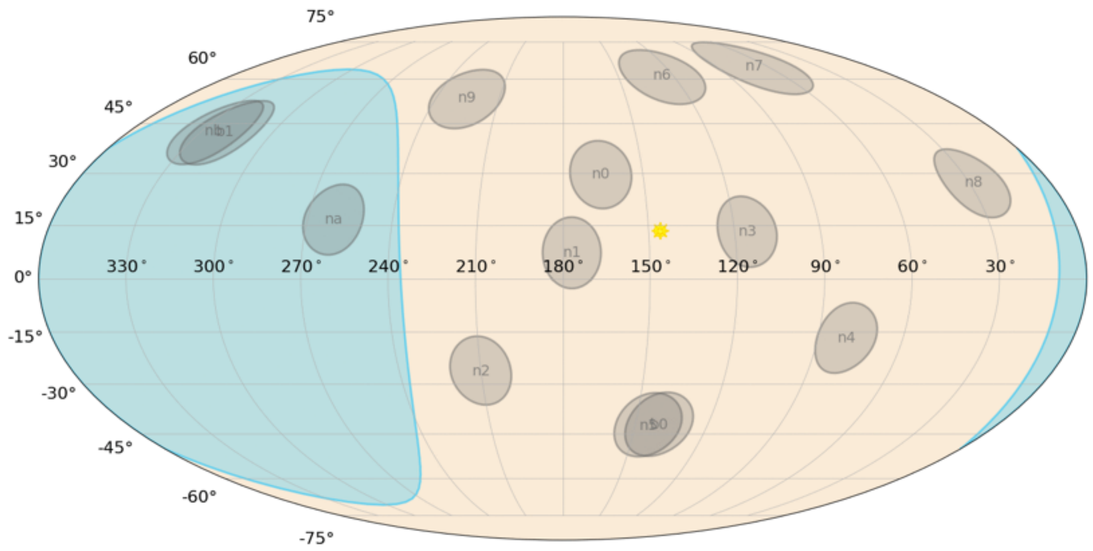
Fermi Gamma-ray Space Telescope

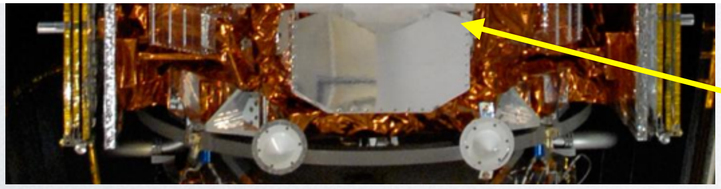
http://gammaray.nsstc.nasa.gov/

GBM:

- FOV >8sr
- Whole sky every ~90min

GBM detector pointings in 2-hr time frame





2 BGO detectors
(200keV—40MeV)

Data products:

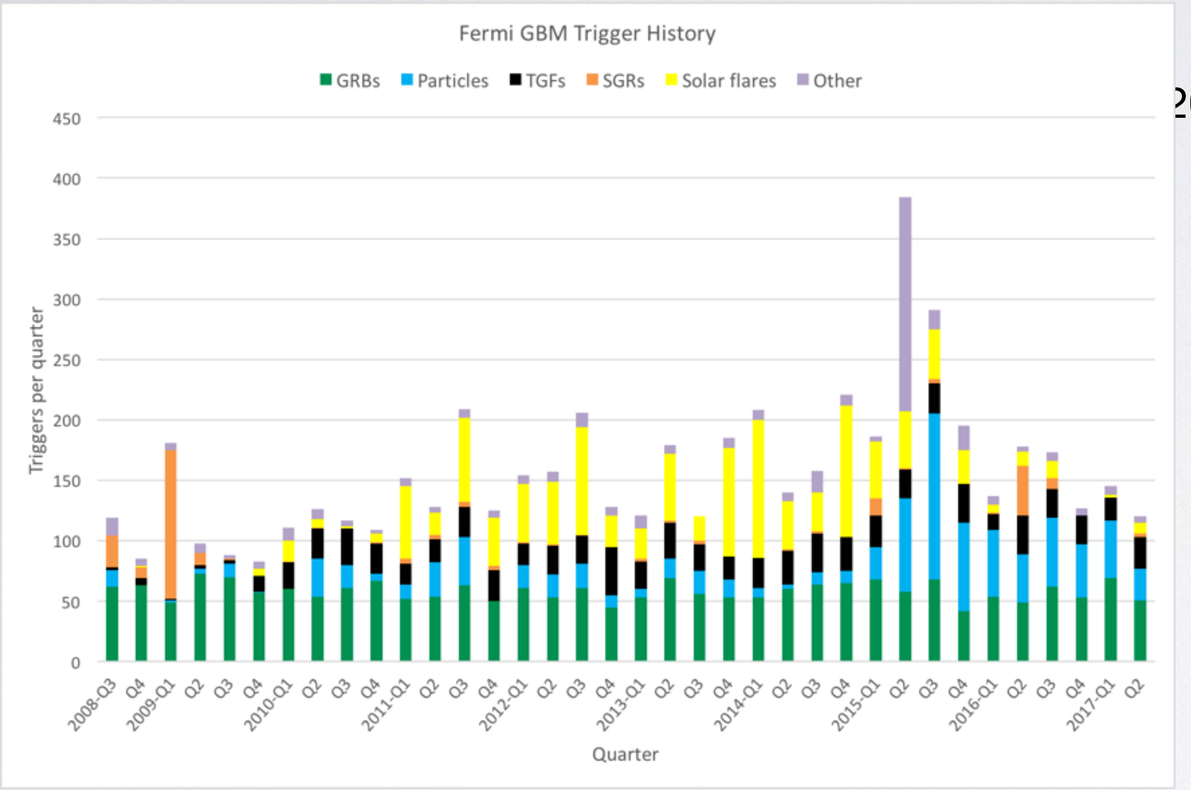
https://fermi.gsfc.nasa.gov/ssc/data/access/gbm/

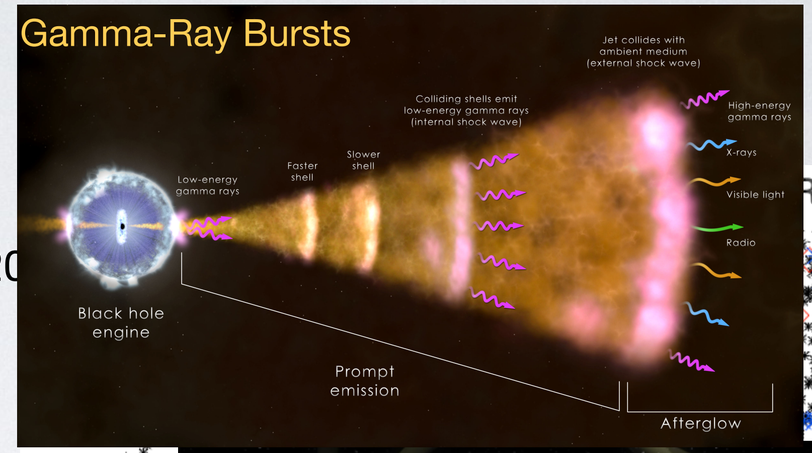
- triggered burst products
- hourly: continuous time tagged events (TTE)
  - 2μs, 128 energy channels
- daily:
  - continuous high time resolution (CTIME)
    - 256 / 64 ms, 8 energy channels
  - continuous high spectral resolution (CSPEC)
    - 4096 / 1024 ms, 128 energy channels

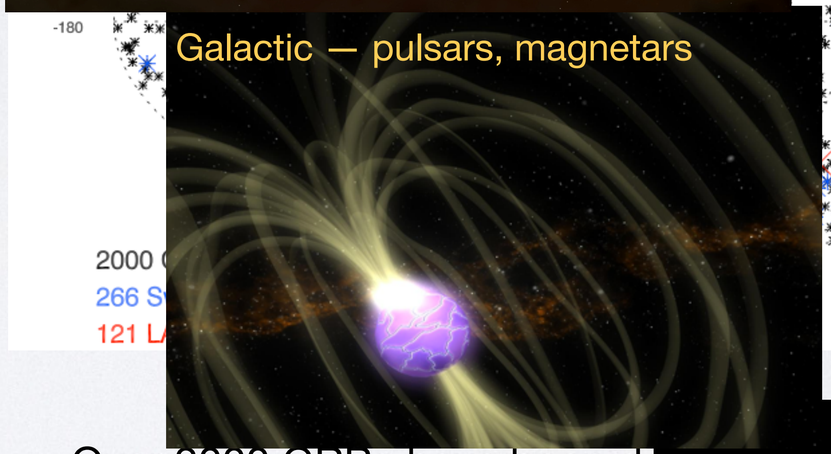
Triggering algorithms:

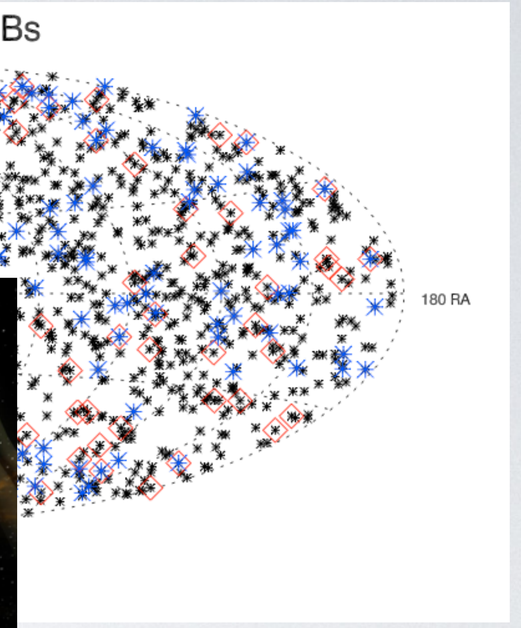
- In-orbit count rate increase in 2+ NaI detectors above adjustable threshold above background
  - 10 timescales — 16ms up to 4.096s
  - 4 energy ranges — [50-300], [25-50], >100, >300 keV
- Ground-based offline search for rate increase
- Earth occultation
- Pulsar phase folding

Fermi GBM Science

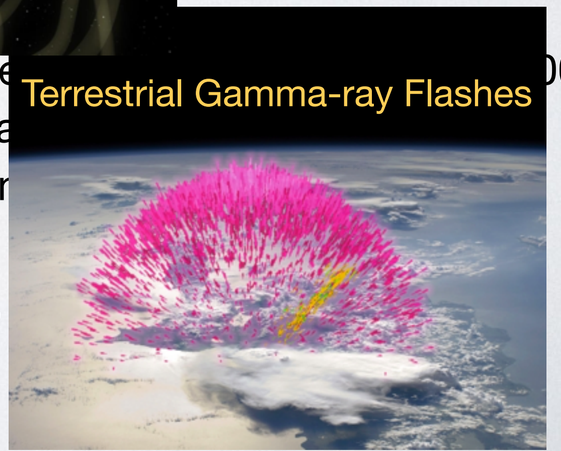








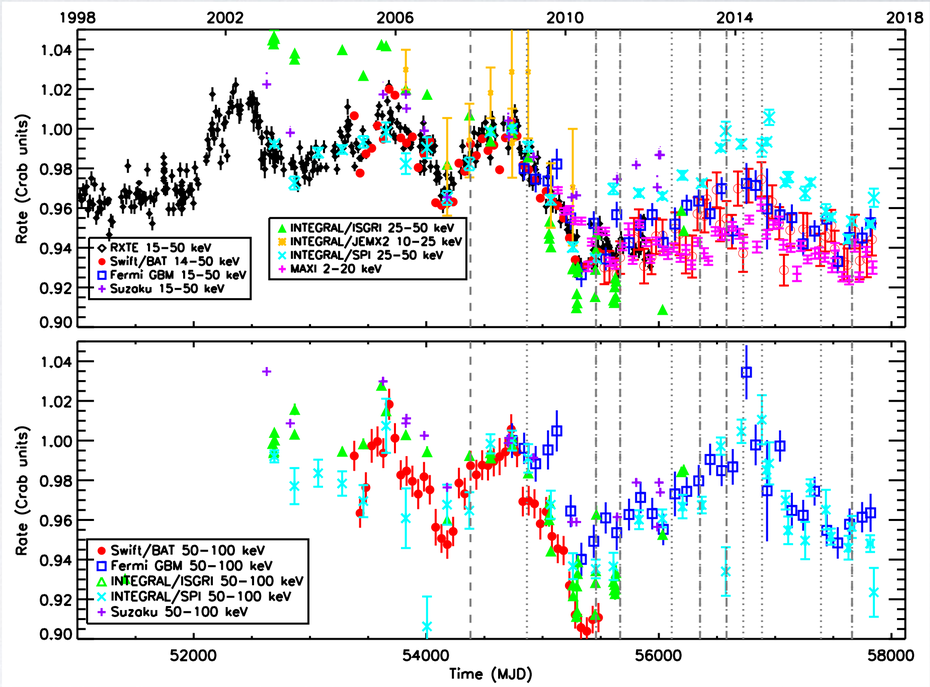
- Over 2000 GRBs have been de 008.
  - 200 long GRBs / year -> ma
  - 40 short GRBs / year -> cor
  - 13% seen by Swift.
  - 52% within *Fermi* LAT FOV,



Monitoring by Earth Occultation

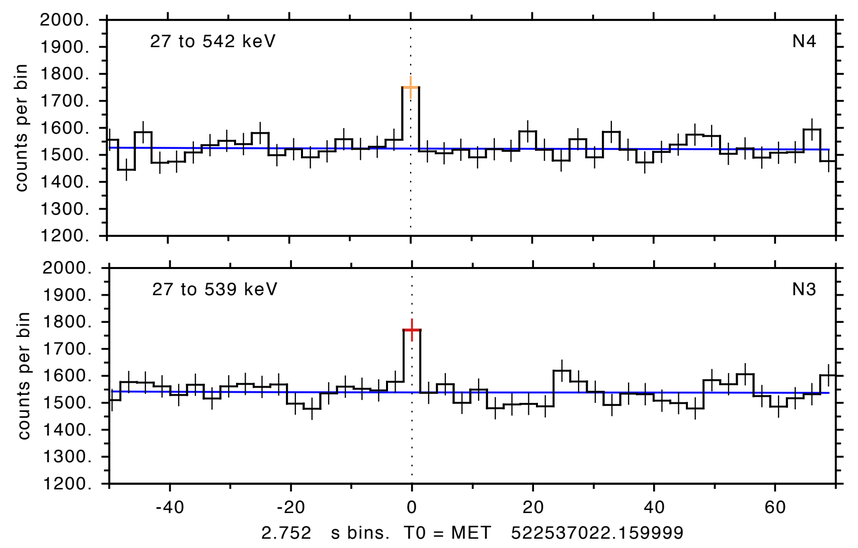
https://gammaray.nsstc.nasa.gov/gbm/science/earth_occ.html

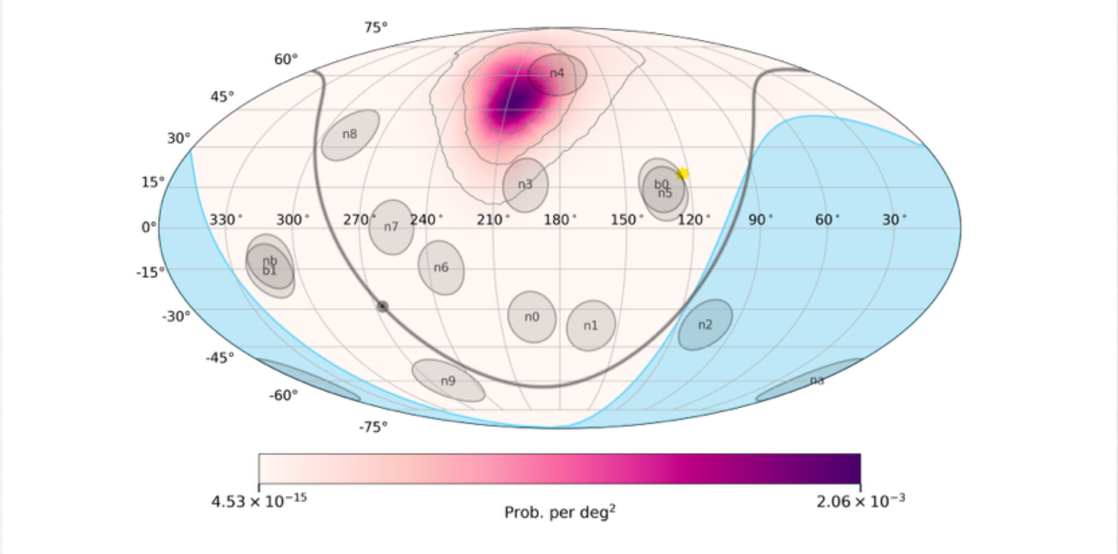
- 200+ sources are monitored from X-ray binaries to Active Galactic Nuclei.
  - 102 detections, 9 at >100 keV.
  - Daily lightcurve and occultation steps fits file are available.
- Crab Nebula flux variations over the past decade, averaging 10% and up to 40% at 300—500 keV (Wilson-Hodge et al. 2011).
  - Changes in shock acceleration or nebular magnetic field



Untargeted transient search

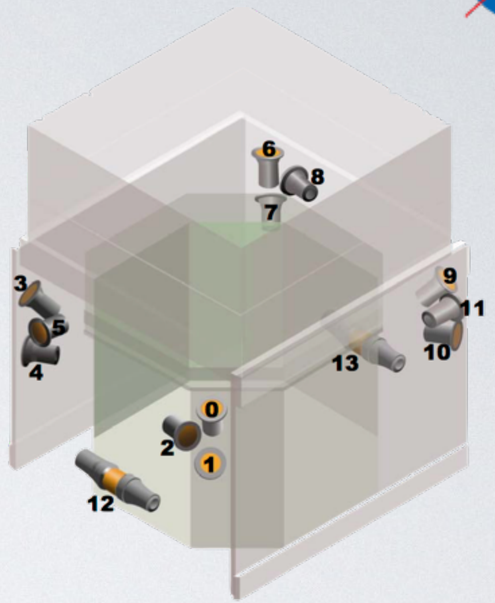
- GCN notice type Fermi-GBM SubThreshold now available.
  https://gcn.gsfc.nasa.gov/fermi_gbm_subthreshold.html
- Time delay for notice range from 0.5 to 6 hours, due to telemetry schedule.
- List of candidates from older data (2013 and on) are available.
  http://gammaray.nsstc.nasa.gov/gbm/science/sgrb_search.html
- Available with the GCN notice:
  - Localization FITS file
  - Contour sky map
  - Lightcurve

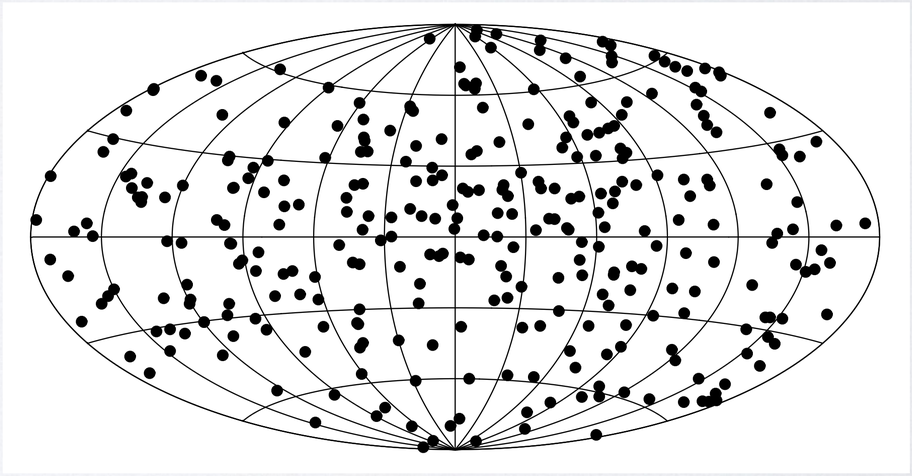




Untargeted transient search

- Looks for signals in 2 NaI detectors with 2.5σ and 1.25σ excess above background in the continuous time-tagged events (2μs resolution, 128 energy channels).
- The 2 signal detectors must have valid geometry for a point source.
- 18 timescales: 64ms to 31s.
  - Only candidates <2.8s are reported at the moment.
- 4 energy ranges optimized for short GRBs.
  - 27—539 keV; 50—539 keV; 102—539 keV; 102—985 keV
- 1-day Poisson probability calculated for each event, threshold for short candidate notice is 1e-5.
- Expected rate of notice ~70/month, higher during active periods of galactic transients.





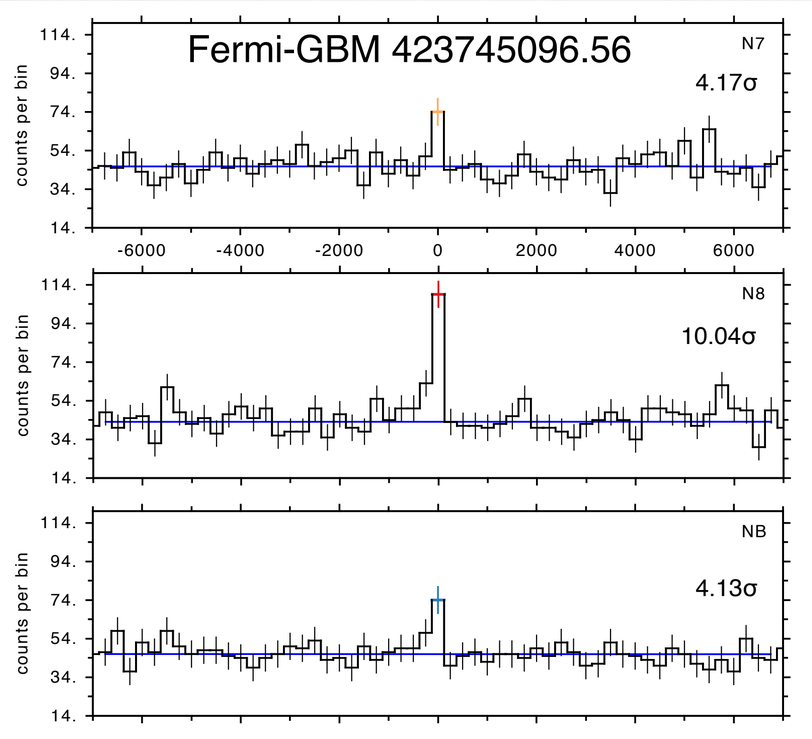
- 318 short, hard candidates found in 46 months in previous study.

  ➡~80 per year, twice the rate of GBM triggered short GRBs.

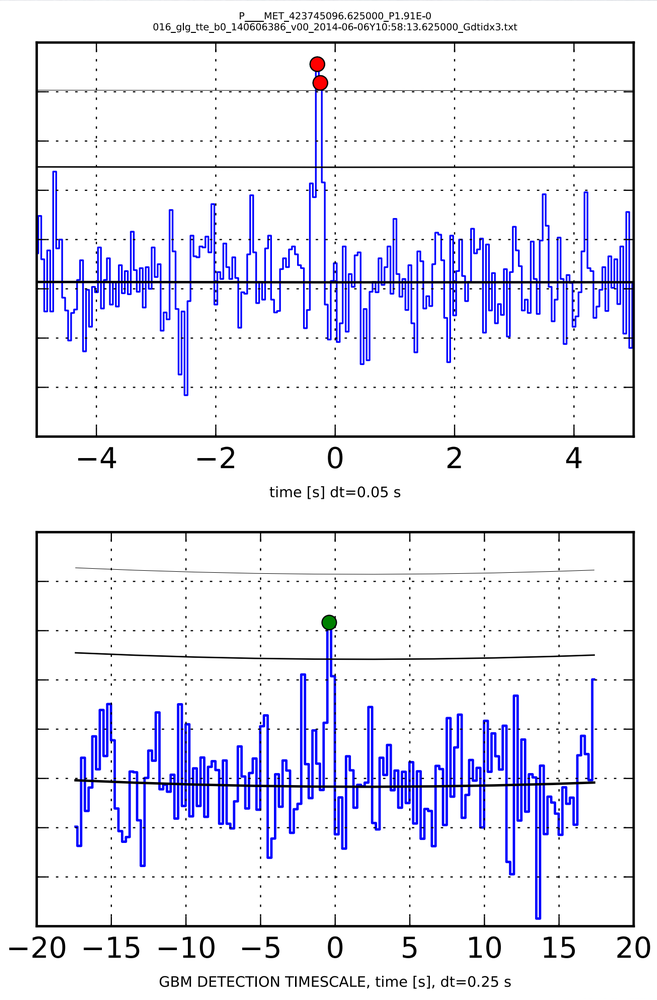
Known GRB Comparison

Swift GRB 140606A

- Fermi-GBM did not trigger due to low peak flux
- Found in 0.25s time binning
- 93 - 494 keV energy range



INTEGRAL Anti-Coincidence Shield (ACS) lightcurve



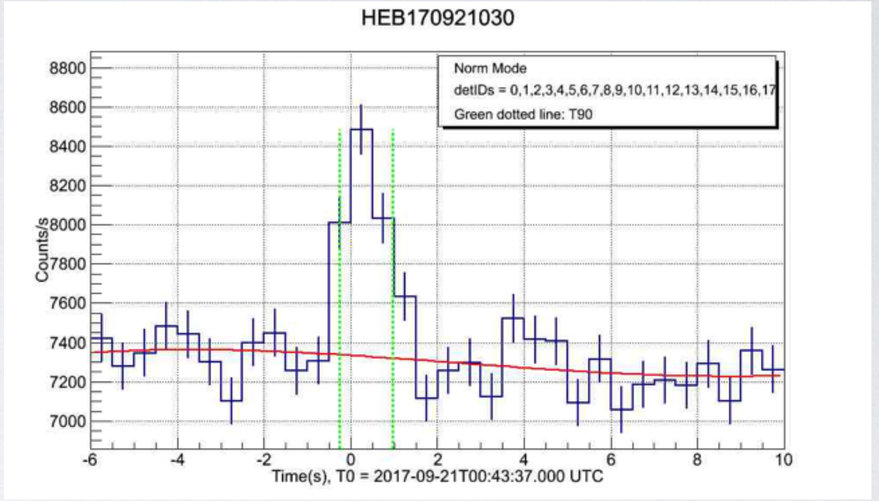
Known GRB Comparison

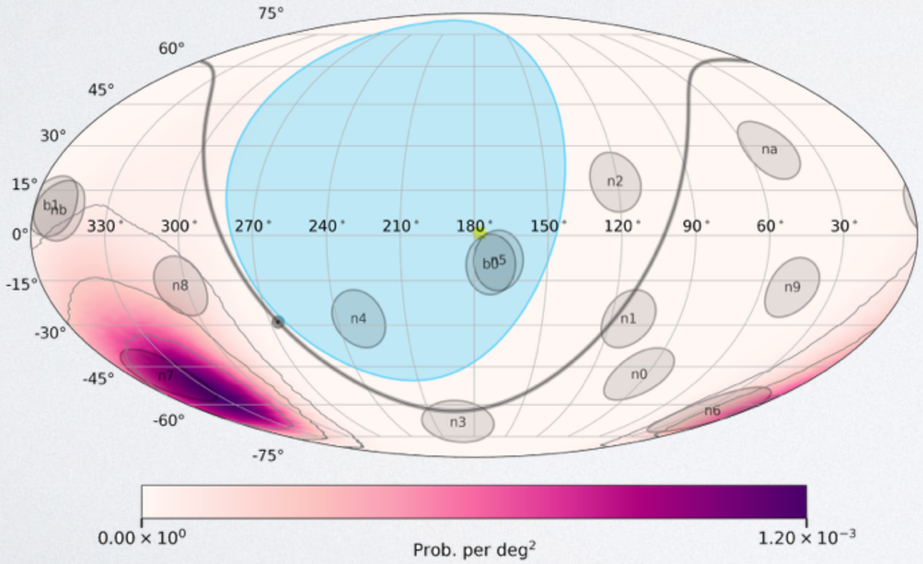
GRB 170921C [Zhang et al. GCN 21919]

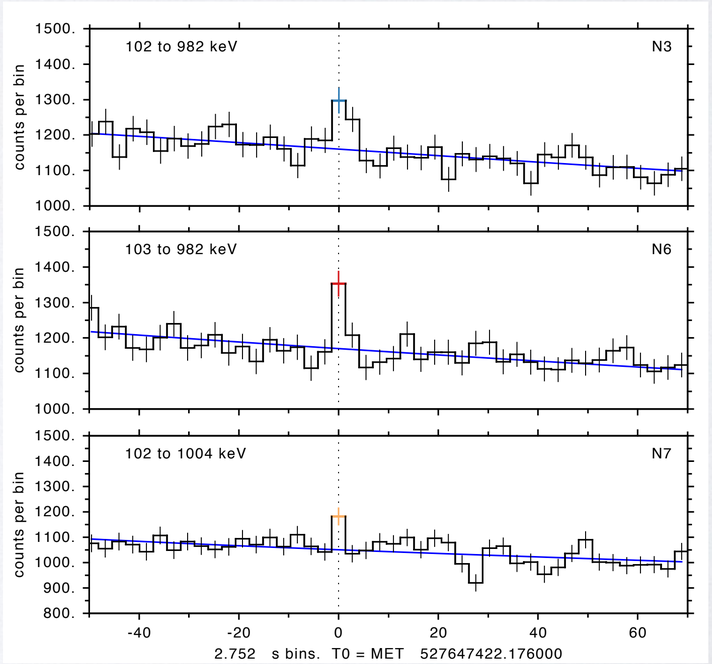
- Insight-HXMT 12σ detection coincident with Fermi-GBM subthreshold transient 527647422.
- T90 is 1.2s, energy range ~200-800 keV.

Fermi-GBM transient 527647422 info:

- High reliability candidate
- 3 detectors >4σ
- 2.8s long







Summary

- GBM continues to be prolific in detecting GRBs and monitoring pulsars and Galactic transients.
- GCN notice of subthreshold GRB candidate events are available for subscription.
  - https://gcn.gsfc.nasa.gov/fermi_gbm_subthreshold.html
- Continued development of searches for joint detection of astrophysical transients with neutrinos and gravitational waves:
  - On-board triggers.
  - Targeted search using event time.
  - Untargeted search within the hour.
  - Earth occultation technique.