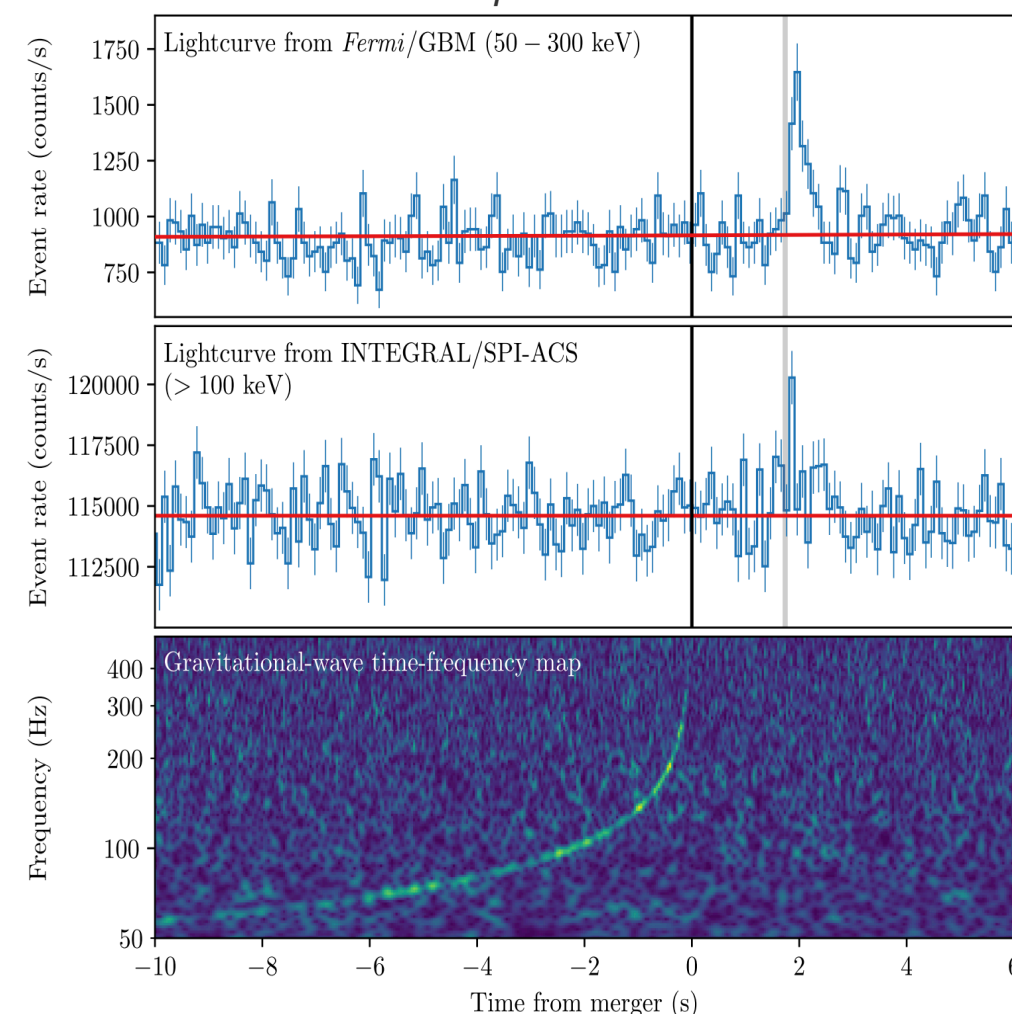


Fermi GBM Observations during O4

Suman Bala (USRA) on behalf of the Fermi GBM Team

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B. P. Abbott et al 2017 ApJL 848 L13



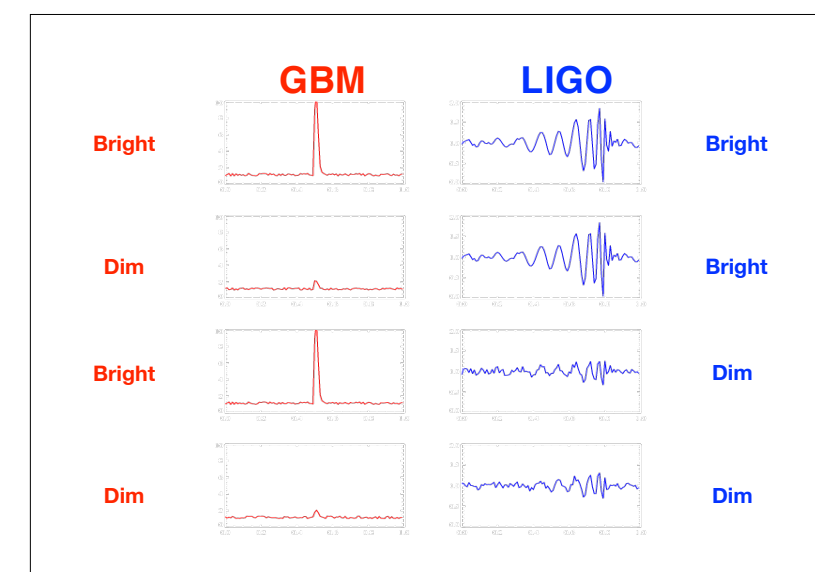
Motivation

The joint detection of GRB 170817A / GW170817

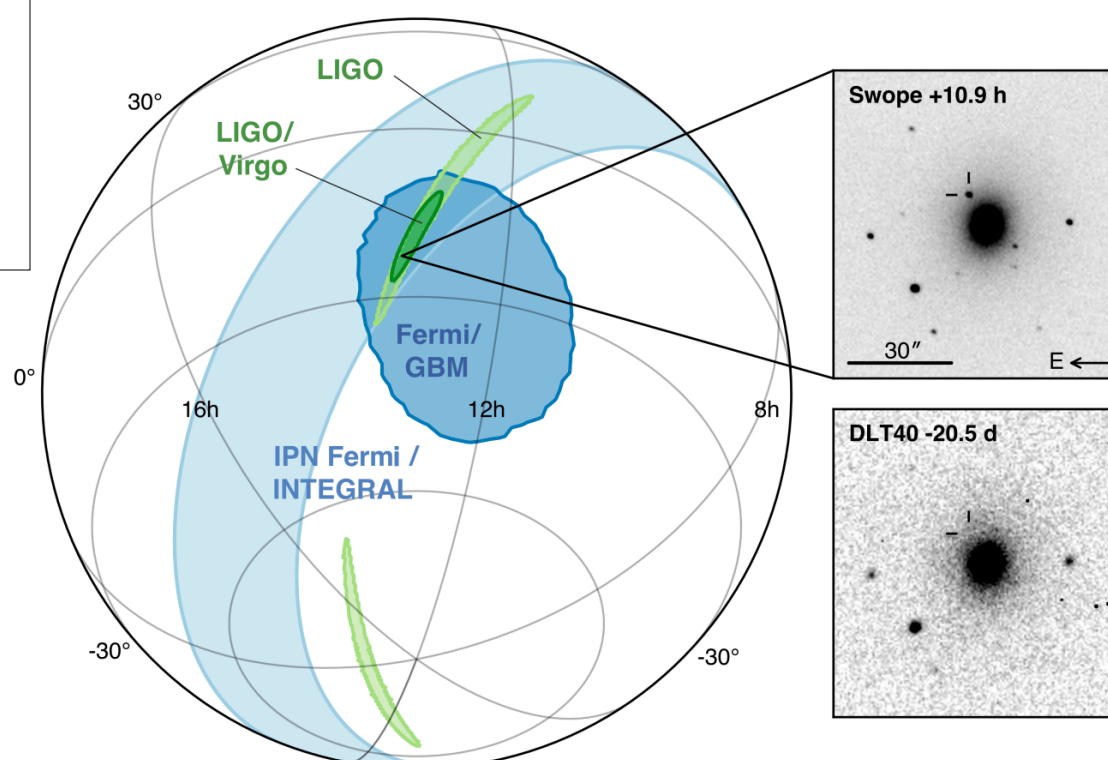
- Indicates that **Binary Neutron Star (BNS)** mergers are progenitors to short GRBs
- Constraints on gamma-ray emitting region in the GRB
- It helps to place constraints on speed of gravity, Lorentz invariance, Shapiro delay
- Explains the origins of heavy elements via detection of subsequent kilonova
- Gamma-ray emission from GRB 170817A is notable because it is nearby (~40 Mpc), but intrinsically dim.
- There may be nearby dim bursts, and we must use subthreshold searches to find more joint detections.

Questions yet to explore

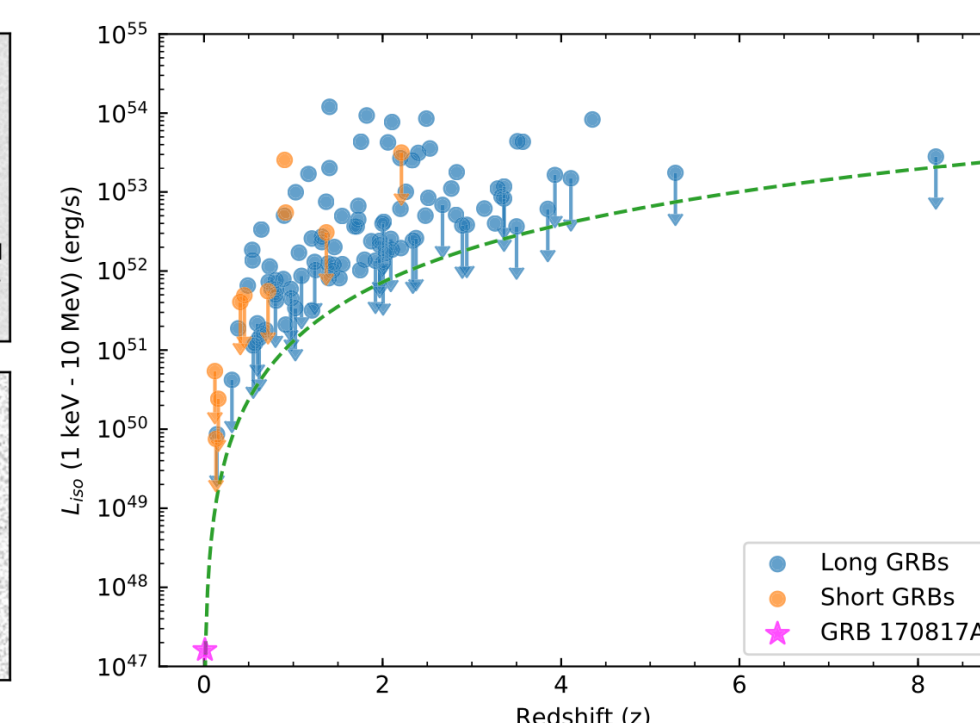
- The rate of kilonova production via BNS mergers.
- The structure of off-axis emission in GRBs
- The distribution of time delay between GW and GRB signals.



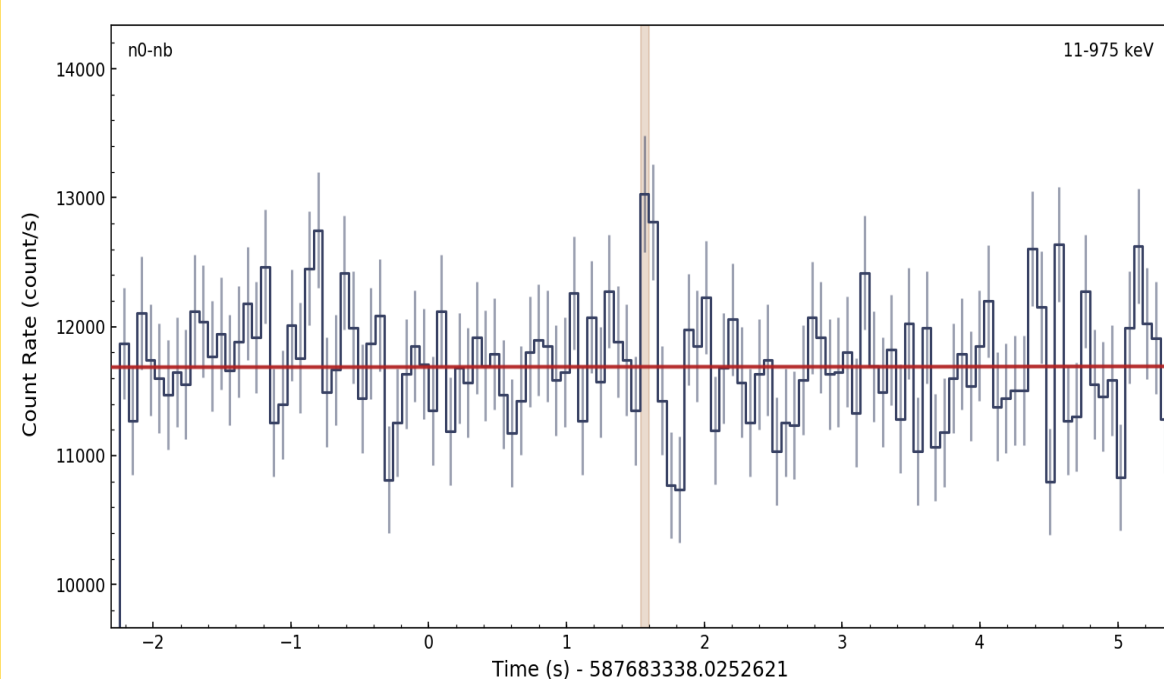
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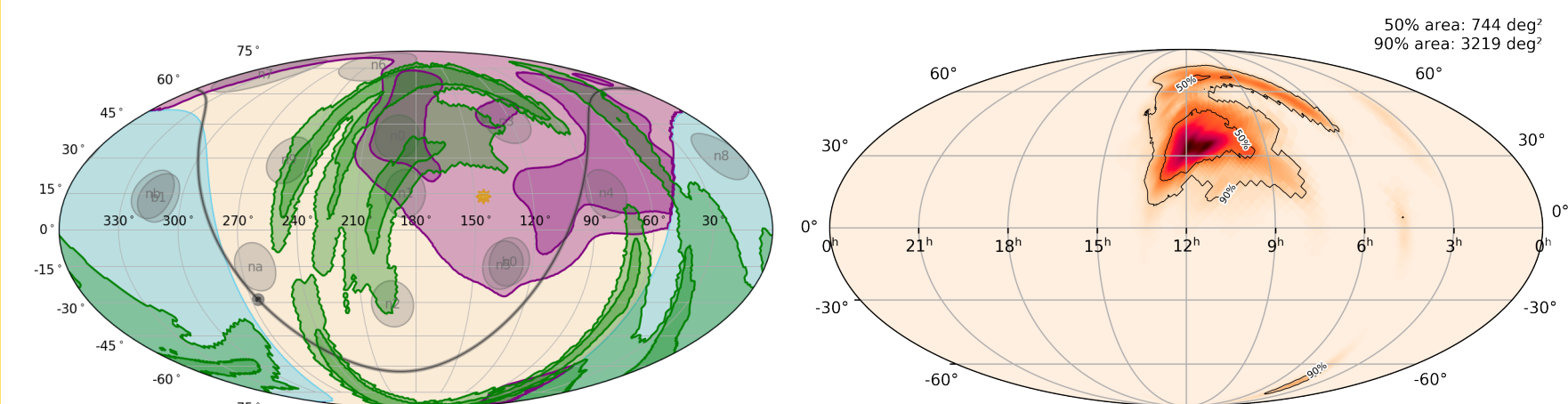


GBM-190816 (subthreshold GRB-GW candidate)



Targeted search

- Targeted Search**, scanned continuous time tagged event (CTTE) data [-1 s, +11 s] around each GW event.
- Returns a likelihood ratio of signal & background of GRB-like transients with 3 characteristic spectral templates (soft, normal, hard).
- Average latency of the search is 4-5 hours due to data downlink (could be much faster if the trigger happens near a ground station).
- Reports short GRB candidates with detector light curves and HEALPix localization maps



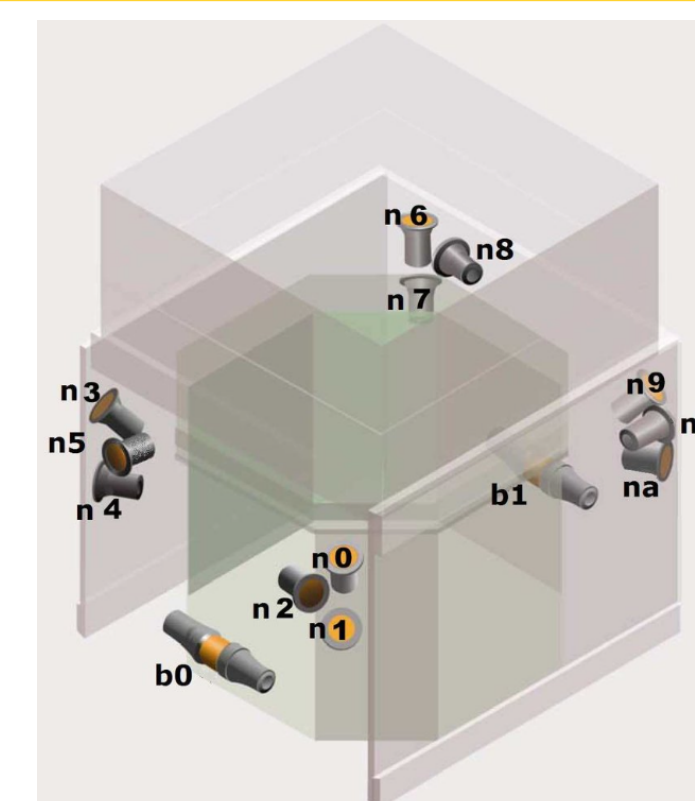
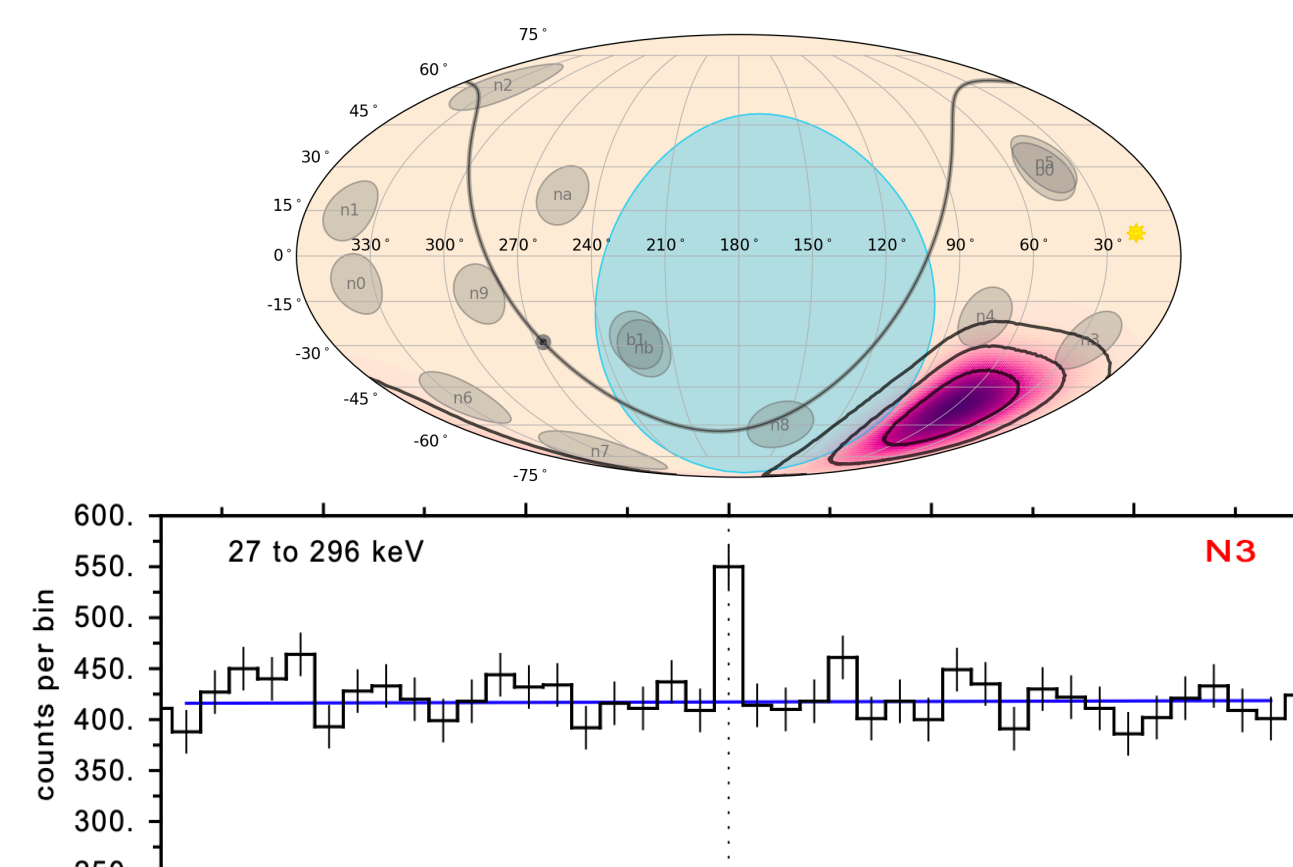
Green: Localization by GW,
Purple: localization by Fermi-GBM,
sky-blue: Earth occulted region for GBM

Combined Localization by GW & Fermi-GBM

Untargeted search

- Searches CTTE data continuously for GRB-like transients below the onboard trigger threshold with average 4-5 hr latency.
- Offline, agnostic search over all CTTE data using lower trigger threshold and with a better background estimation.
- Reports short GRB (& GRBs up to 10 s duration) candidates with detector light curves and HEALPix map
- Search results distributed via GCN
- Trigger rate ~80 candidates / year (twice more than onboard trigger rate) with ~1/3 of high reliability candidates confirmed by other instruments

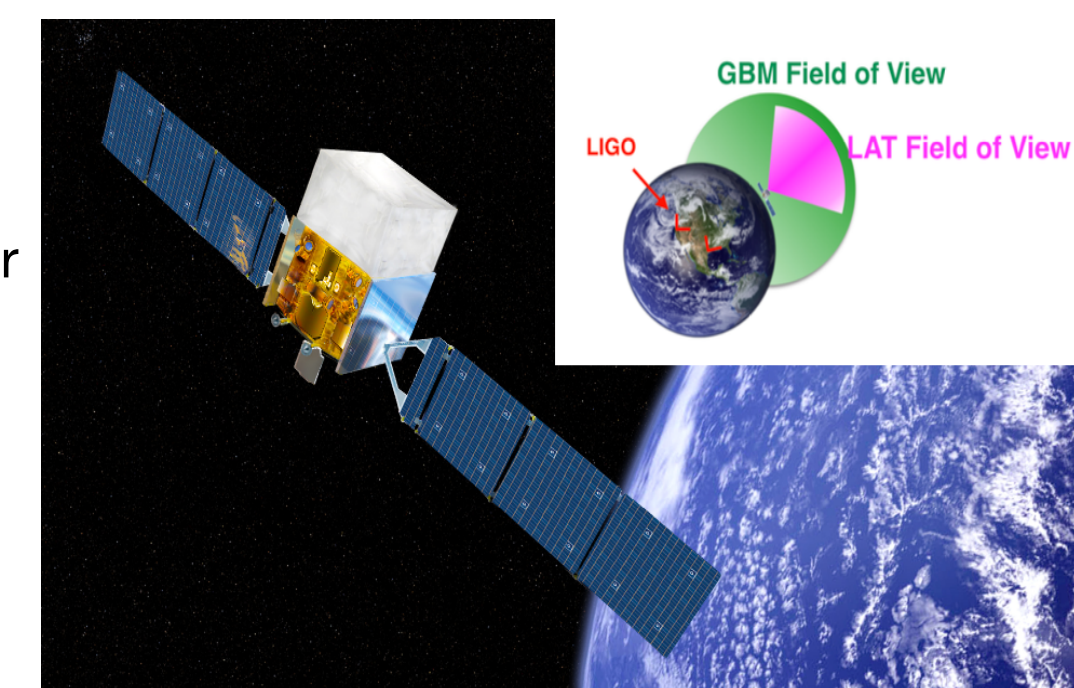
GRB 200409A detected by **untargeted** search and also seen by *Swift*



Charles Meegan et al 2009 ApJ 702 791

Fermi Gamma-ray Burst Monitor (GBM)

- Energy range: 8 keV - 40 MeV
- Detects ~40 short GRBs per year, more through subthreshold searches
- Continuous time-tagged event (CTTE) data for offline analysis, with 2.6 microsecond timing resolution and 128 energy channel resolution
- GBM monitors for gamma-ray transients with >8 sr FOV.
- Covers entire sky every ~90 min
- Localizations ~few deg



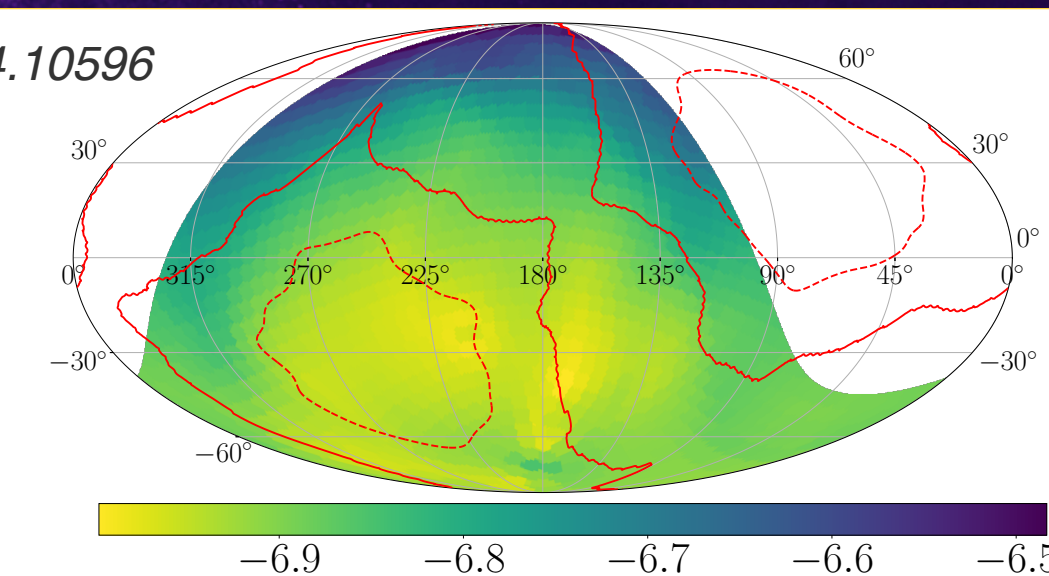
Improvements in O4

- Removal of 4-12 keV energy channel in the NaI detector data to remove detector noise and Galactic transients.
- Better background fitting near the SAA, this reduces local particle background triggers.
- The systematic uncertainty associated with the localization is improved. Previously, in a few cases we could not apply the atmospheric scattering, because of being outside the normal assumed spacecraft rocking profile. Now, the localization systematic is properly accounted for those cases.
- Decreasing the resolution from 1 to 5 degree for the grid of sky positions analyzed during the search to reduce the runtime and without affecting the sensitivity.

O4 Results/ Statistics

- GW candidates: 117** (133 Total & 16 Retracted).
- Only 7 (~6%) cases are found with probability of NSBH more than 5%.
- Publish GCN for a significant joint detection, or the upper limit when the probability of BNS or NSBH more than 5%.
- No significant detection of EM counterpart of BNS, NSBH or BBH.
- Low Significance Detection Candidates: 2149 (Total)

arXiv:2404.10596



Example of O4 search result:

Top: Fermi-GBM 5 σ upper limits (15-350 keV, 1s time scale) for the event GW230529. Solid and dashed lines are the GW contours at 90% and 50% credibility, respectively.

Left: Fermi GBM-230619, subthreshold gamma-ray transient coincident with S230619bd. Likely to be a Galactic transient but can not rule out as an off-axis GRB despite that being unlikely.