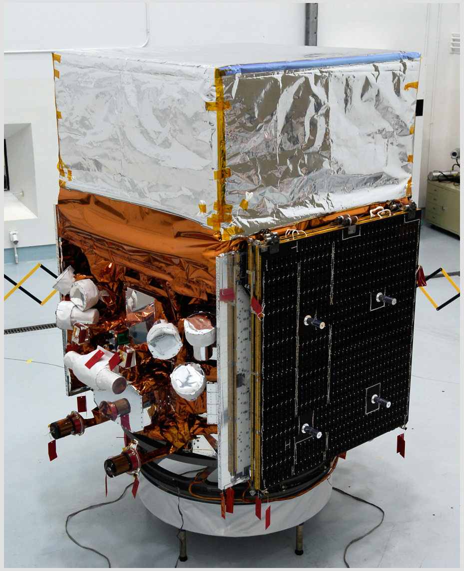
Fermi GBM Observations of Gamma-Ray Bursts

Michael S. Briggs
on behalf of the Fermi GBM Team

Max-Planck-Institut für extraterrestrische Physik

University College Dublin



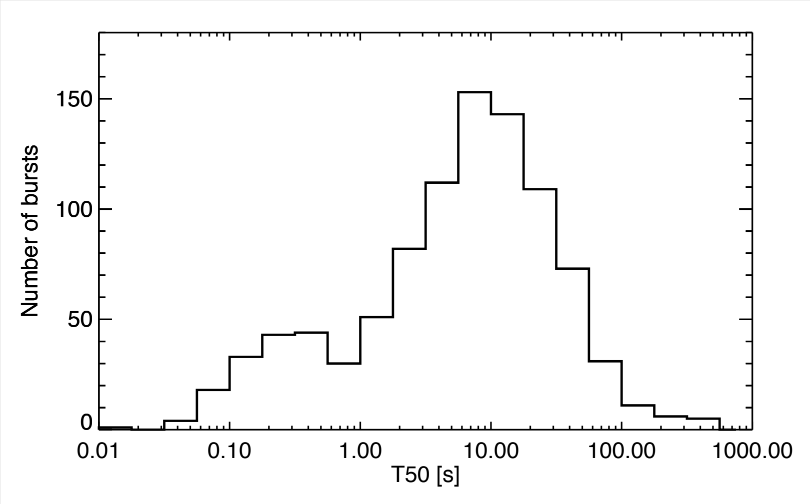
1472 GRB triggers as of yesterday.

GBM has 12 NaI detectors for 8 KeV to 1 MeV and 2 BGO detectors for 200 keV to 40 MeV.

GRB localizations are performed using rate triangulation.

GBM generates Autonomous Repoint Requests (ARRs) to maintain the GRB in the LAT FoV, supporting afterglow observations.

Fermi Gamma-ray Space Telescope



GRB Catalog: Von Kielin et al, 2014:

- 28 trigger algorithms currently in use, 16 ms to 4 s,
- 240 GRB per year: cf BATSE, which had 300 year – the closeness in rates, despite the smaller size of GBM, is due to the 2 & 4 s triggers timescales of GBM.
- ~19% / 45 per year are short. The reduced fraction compared to BATSE is due to improved detection of long GRBs.

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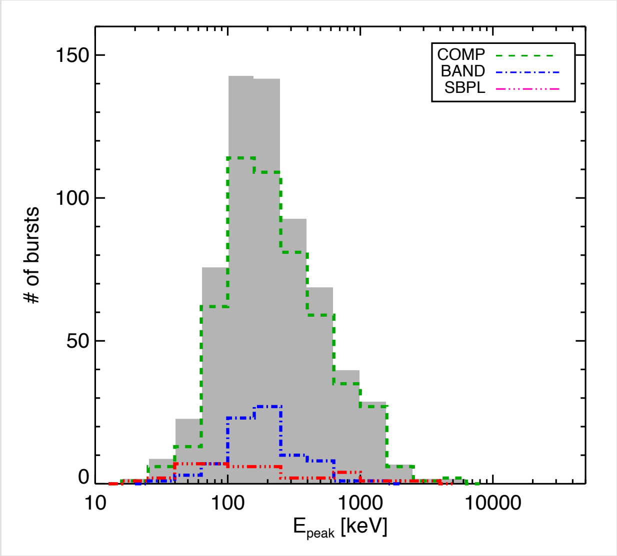

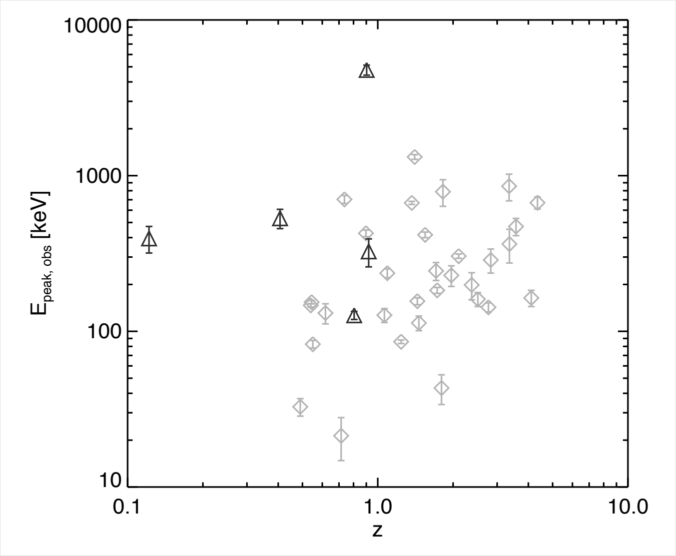

Spectroscopy Catalog: Gruber et al 2014:

- Fluence and peak flux spectra for 943 GRBs,
- Rest-frame properties for 48 GRBs with redshifts.

GBM GRB Localizations

Localizations are produced by three methods, with increasing accuracy but greater delays.

Method	Typical Latency	Typical Statistical Uncertainty
Flight Software	15 to 30 s	8° to 15°
Ground Automatic	30 to 40 s	5°
Human in the Loop	30 to 60 min	3°

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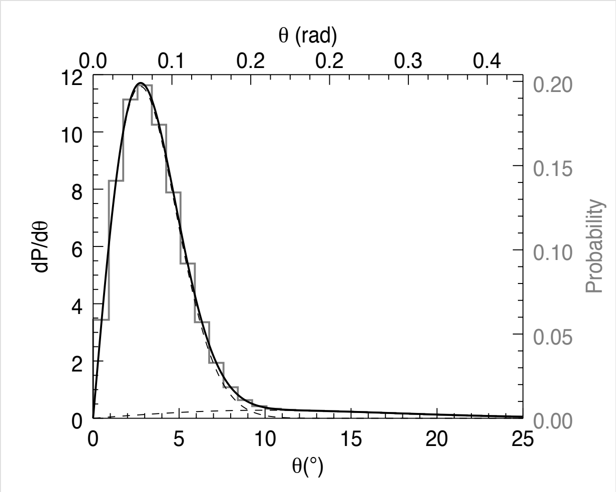
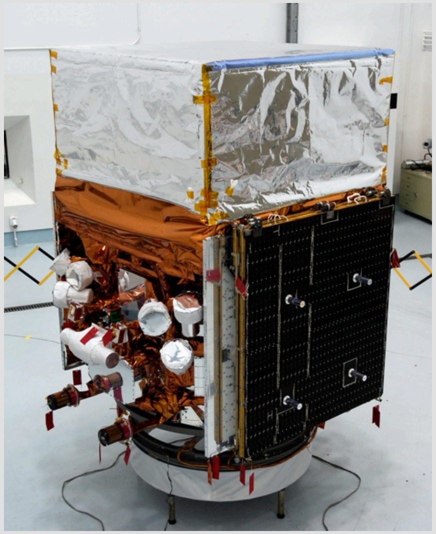
Localization Systematics

Improved understanding of the localization uncertainties, including modeling of the systematic errors by a Bayesian comparison to reference locations from other instruments. (Connaughton et al. 2014)





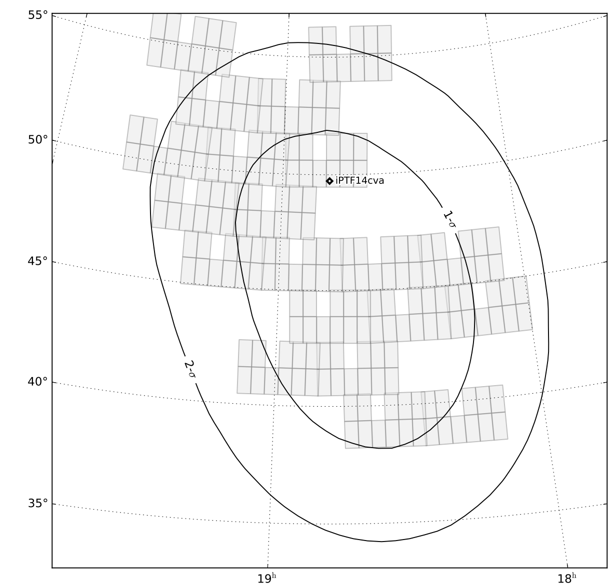
Fermi Azimuth	Sigma-core	Core fraction	Sigma-tail
A detector side	4.2°	91%	15.3°
A “blank” side	2.3°	88%	13.2°

➔New product: Location Contours

GBM+iPTF (& MASTER) GBM Follow-Ups

130702A
131011A -> VLT **z = 1.87**
131231A
140508A -> VLA **radio**, NOT & WHT **z=1.03**
140606B -> Keck **z=0.384**
140620A -> Gemini **z=2.04**
140623A -> Gemini **z=1.92**
140808A -> VLA & AMI **radio**, GTC **z=3.29**
140801A -> MASTER OT, NOT & BTA **z=1.32**

Example: GRB 140620A



- **8** detections by iPTF from **35** follow-ups (L. Singer, in preparation)
- **130702A** & **131231A** were detected by iPTF **independent** of LAT position
- **140801A**: **1st Master OT** found from the ground automated location
- **All iPTF detections used the new GBM localization contours that are now available**

GBM Data

TRIGDAT: limited data received in near real-time for triggers. 8 channels, 64 ms to 8 s. Used for producing localizations.

Science Data:

Data Type	Spectral Resolution (channels)	Continuous Temporal Resolution (s)	Trigger Temporal Resolution (s)
CTIME	8	0.256	0.064
CSPEC	128	4.096	1.024
TTE	128	N/A	2 µs

TRIGDAT, CTIME and CSPEC: binned in time.
TTE: Time-Tagged Events: individual counts.

GBM Data

NEW:

CTTE: Continuous Time-Tagged Events: individual counts with continuous coverage. Intermittent coverage since July 2010. Fully continuous since November 2012.

What can be done with this new data type?

Short GRBs and Gravitational Waves

Short GRBs are less understood than long GRBs. In gamma-rays, their light curves appear compressed in time and the spectra boosted in energy. They are believe to originate from mergers of compact objects (NS-NS or NS-BH). These mergers are the most likely events to be detected by the gravitational wave detectors LIGO and Virgo.

The predicted joint detection rate between GBM and LIGO/Virgo at the full sensitivity is 0.1 to 2 per year (Metzger and Berger, 2014; Clark et al. 2014). The characteristic of the GRB detector to maximize the joint detection rate is field of view.

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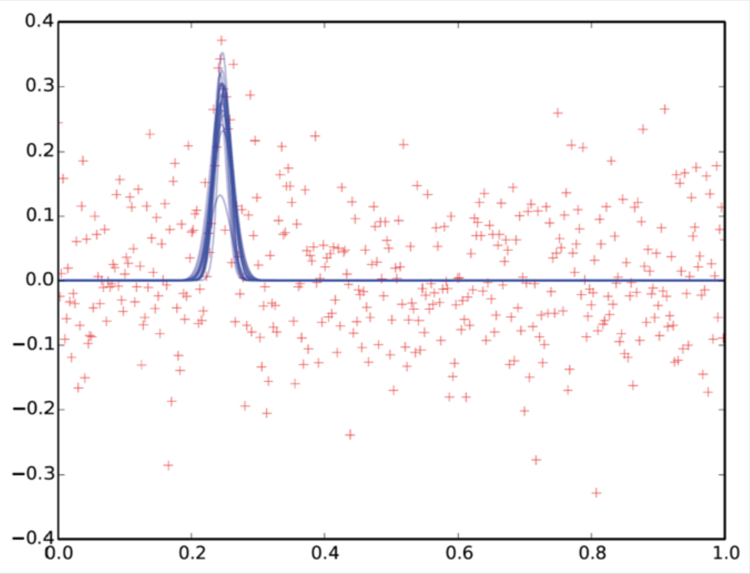
Short GRB search

- A SGRB detection would increase the sensitivity of a GW search,
- A joint SGRB – GW detection would:
  - Increase the confidence in a GW detection,
  - Yield more scientific information.

So, search CTTE!   Under development by Binbin Zhang

Search by fitting pulse shapes.

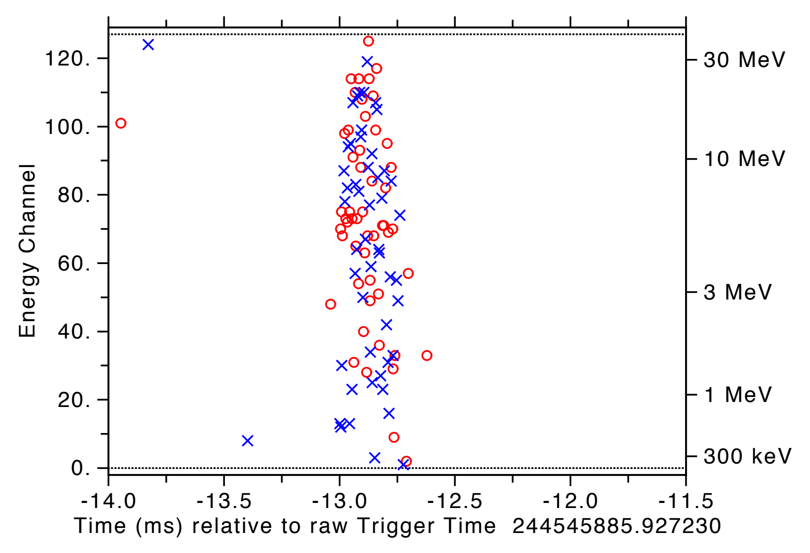


Consistency tests applied to candidates:

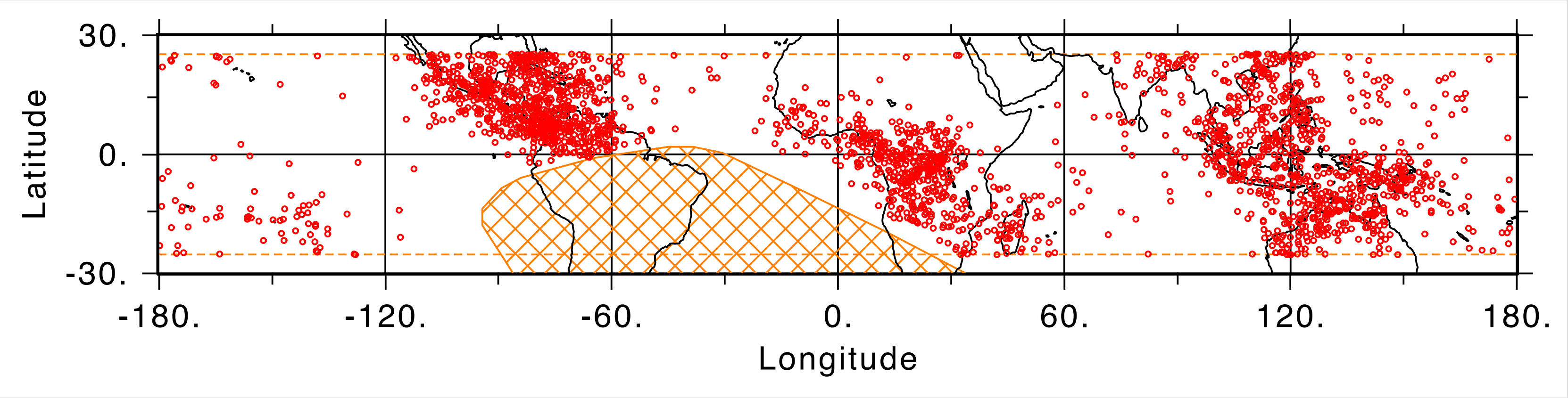
- Two or more detectors,
- Good localizations,
- GRB-like spectrum

Of the 7 short Swift GRBs that are possible for GBM to detect (Fermi not in SAA, GRB not behind the Earth) and which did not trigger GBM, the method finds 4. Of the remaining 3, 2 are in the bottom 20% of the Swift fluence distribution and one is 134° from the LAT boresight. (Burns, et al., submitted)

Currently the search increases the GBM SGRB rate > x2. Improvements are underway…. See poster 9.10.



TGFs are short, typically 100 to 500 µs, so CTTE is extremely useful for detecting and studying TGFs. With full CTTE, GBM is detecting ~850 TGFs per year. Cosmic rays are rejected using LAT calorimeter data.



2279 TGFs through 2013 December 31

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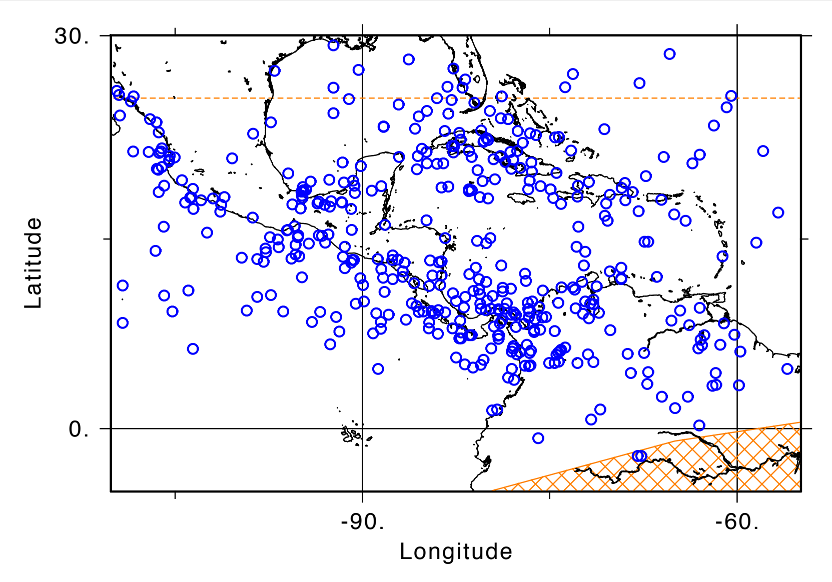
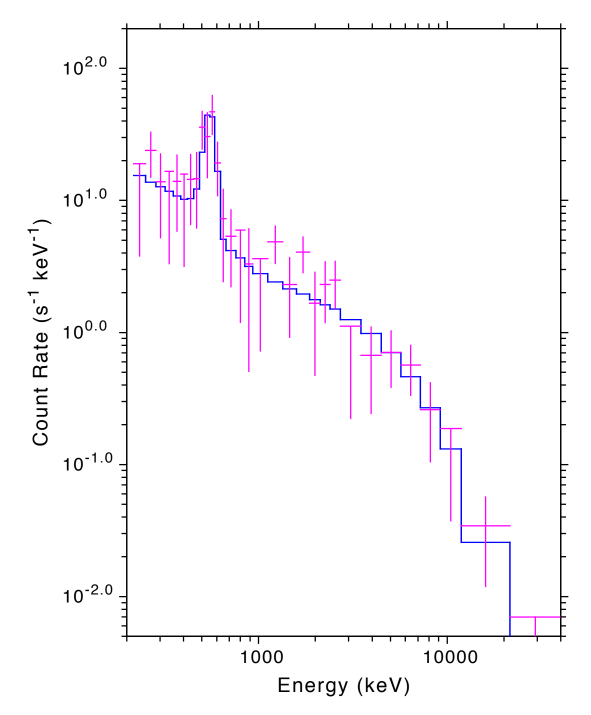


The associated radio signals originate, in most cases, from the TGF electrons (Connaughton et al., 2013).
These radio signals provide localizations of ~km accuracy.

TGFs also inject electrons into space – this subtype is less commonly observed because the charged particles form a narrow beam along the magnetic field line. Fermi GBM discovered this beam to also include positrons (Briggs et al., 2011).



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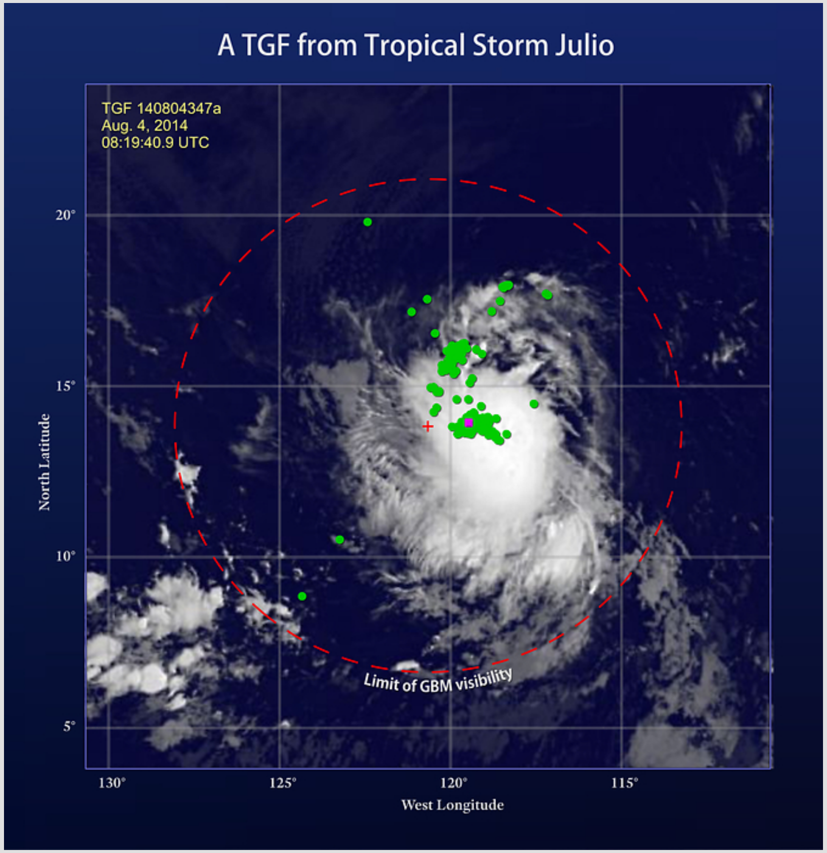
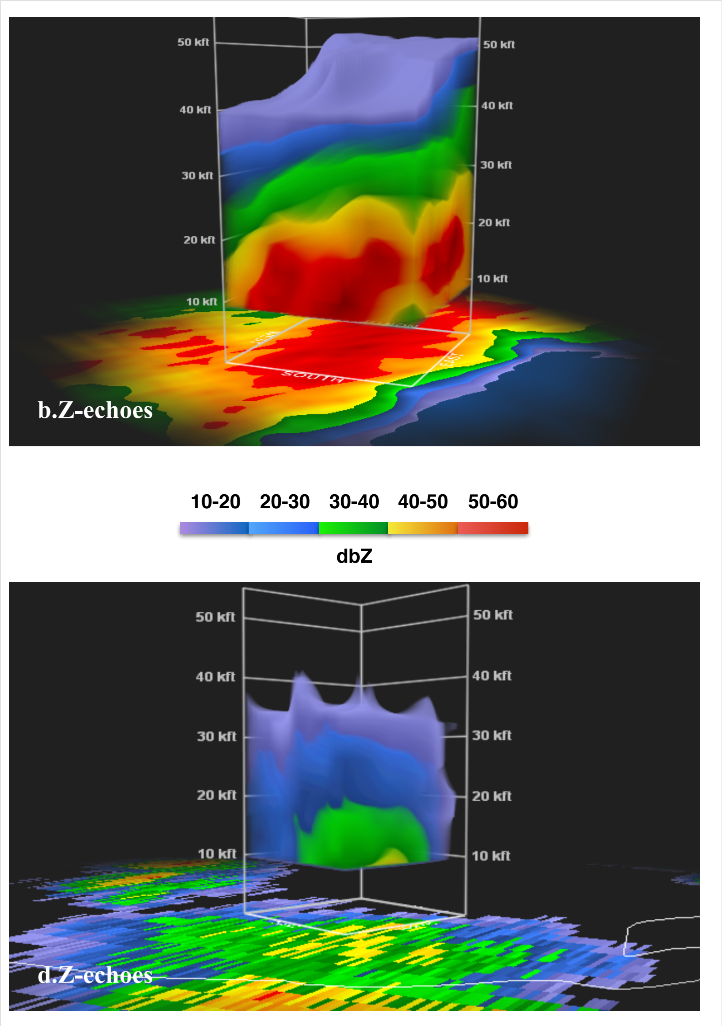


Briggs & Reddy



Chronis et al, submitted

GBM is provides critical support to Multi-Messenger observations (neutrino, gravitational wave) because of its very large FoV.

Optical detections from GBM GRB localizations are possible. Performing these searches will increase in importance when LIGO and Virgo resume observations.

What can you do with the new GBM data products?
Location contours and Continuous Time-Tagged Events

If you wish to use GBM localizations, we can provide advice on which product (FSW, ground-automatic, human-in-the-loop) is the best to use.

The GBM Team / University of Alabama in Huntsville has a postdoc opening for TGF & GRB research.