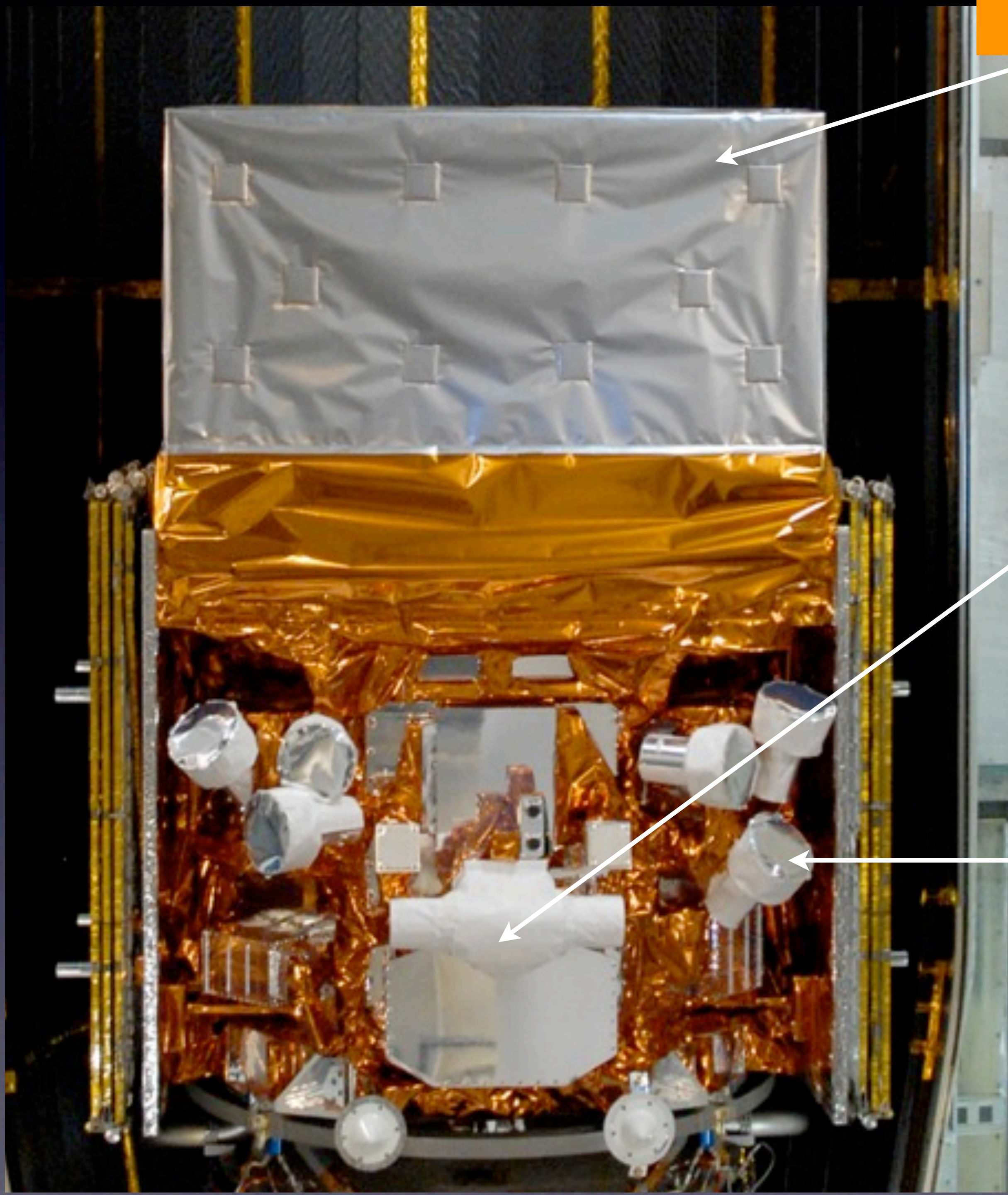
The Fermi Gamma-Ray Burst Monitor.

Valerie Connaughton of the GBM Team.

Gamma-Ray Burst Monitor (GBM) on Fermi Spacecraft.

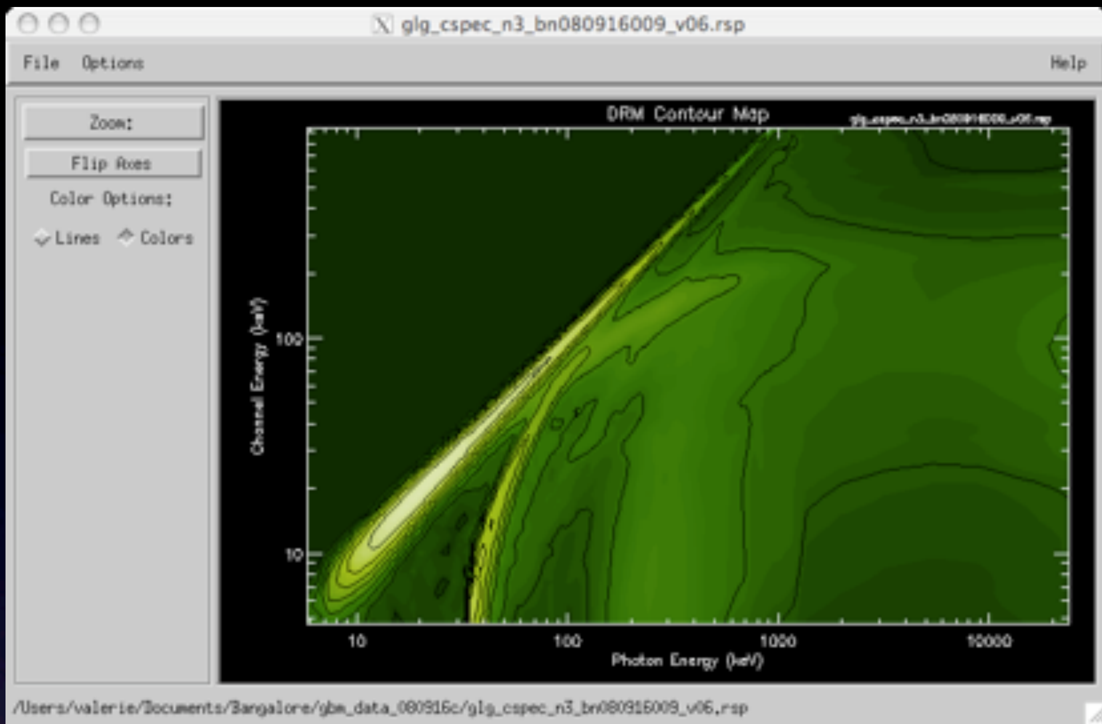


The Large Area Telescope (LAT)

GBM BGO detector.
200 keV -- 40 MeV
126 cm^2, 12.7 cm
Spectroscopy
Bridges gap between NaI and LAT.

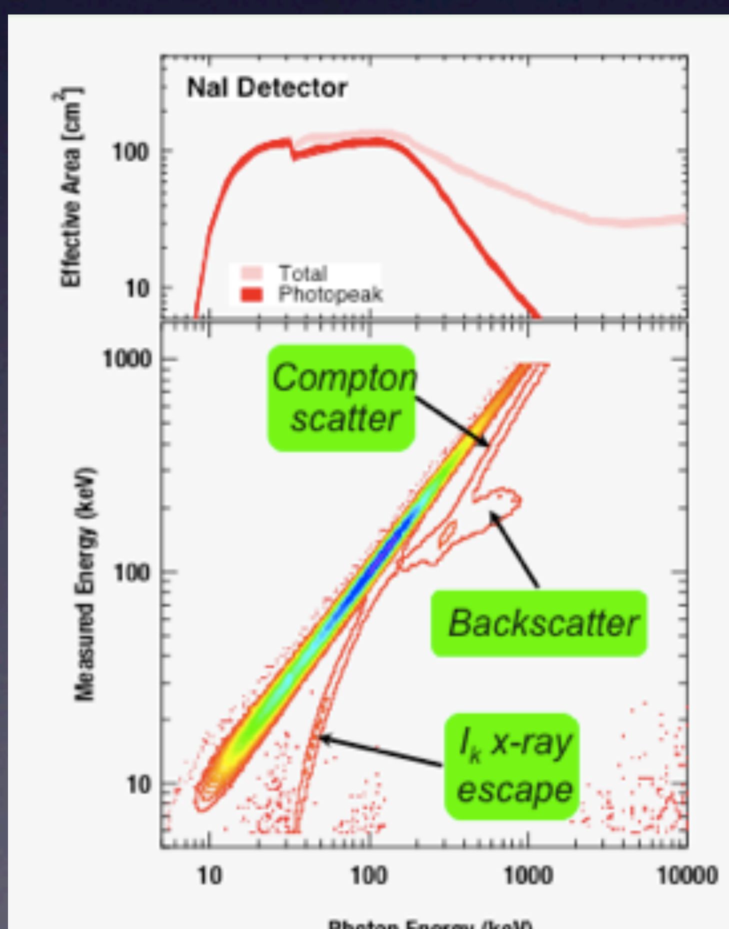
GBM NaI detector.
8 keV -- 1000 keV
126 cm^2, 1.27 cm
Triggering, localization, spectroscopy.

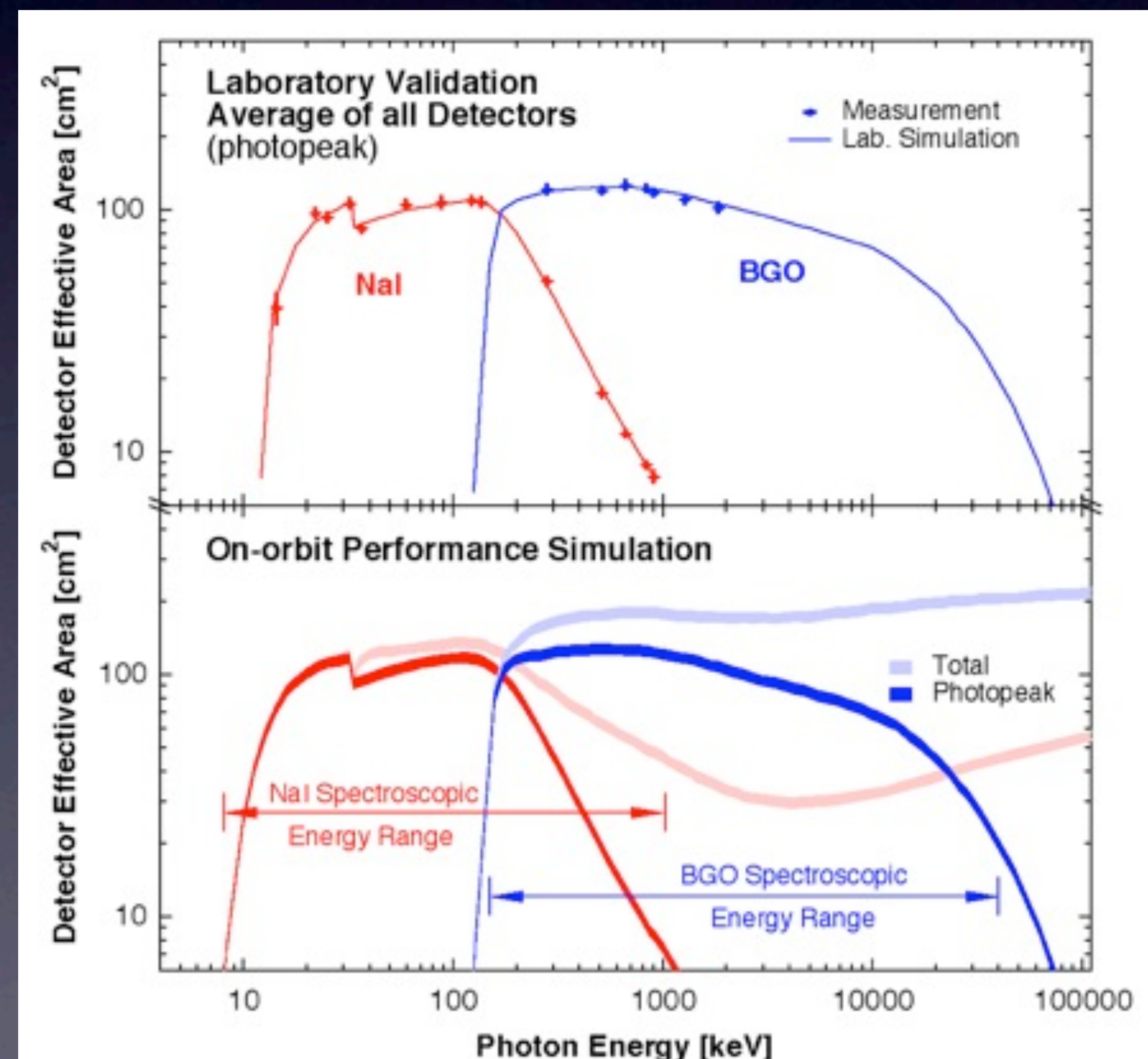
Scintillator detector responses



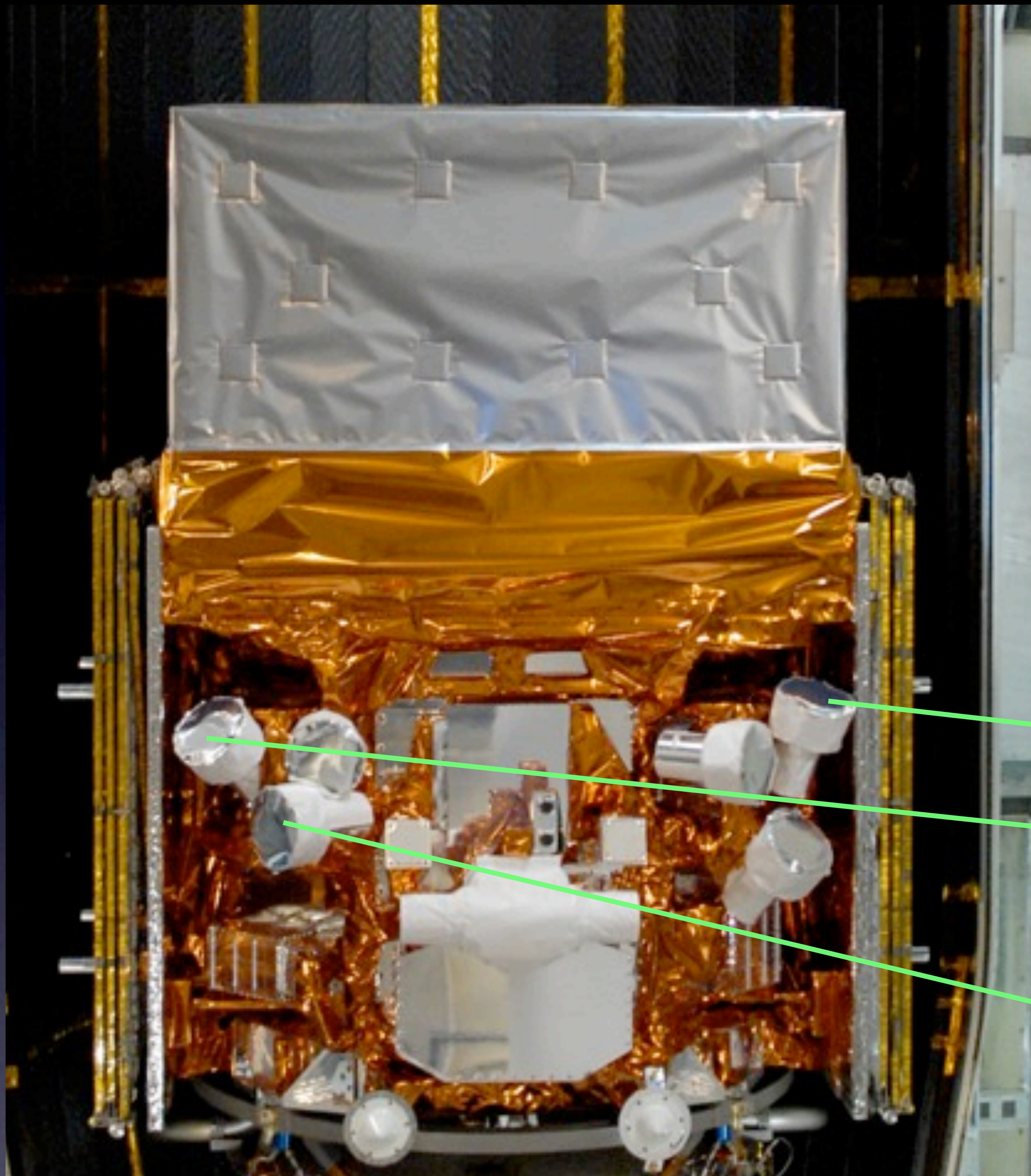
- Response of detector is a combination of direct photopeak response i.e. the photon loses all its energy in the detector; a scattered response where only partial deposition occurs; and an indirect response from photons scattered off the Earth's atmosphere.

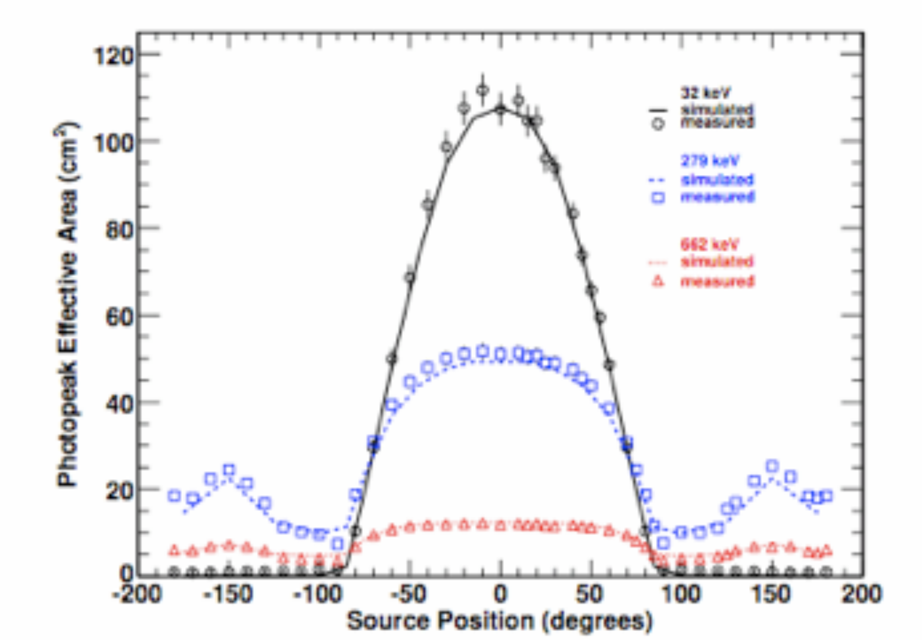
NaI

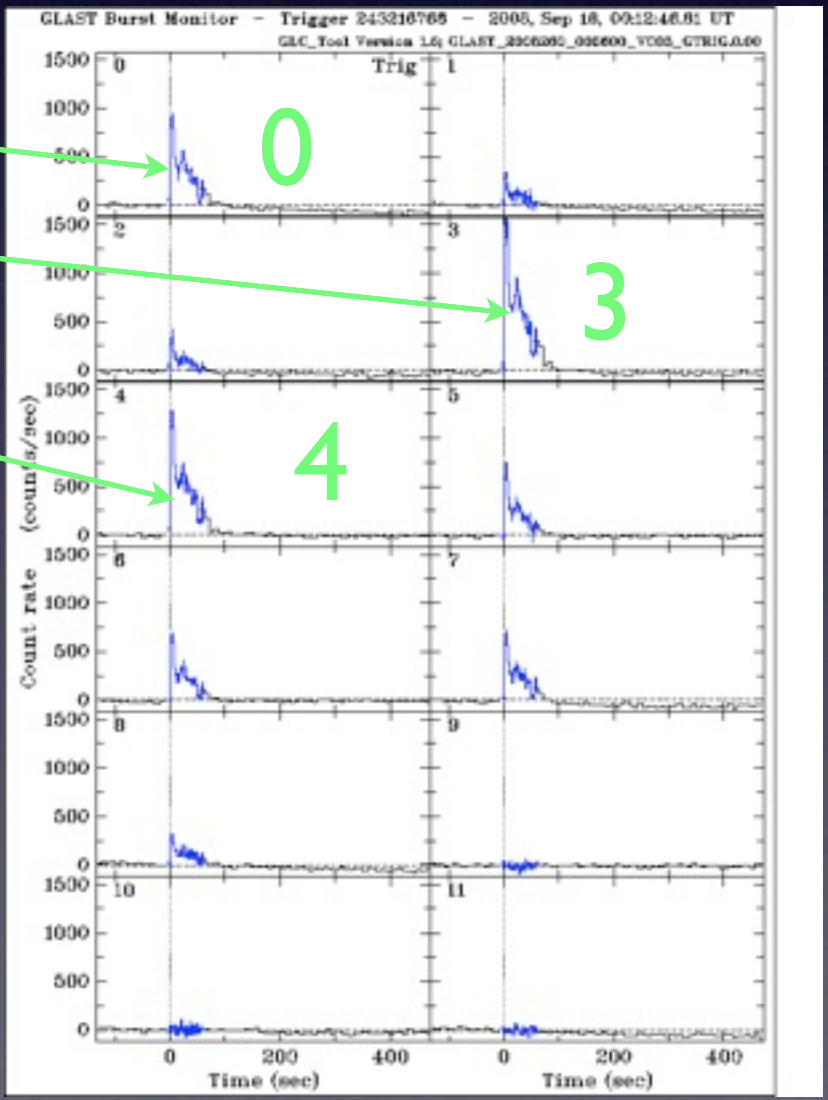




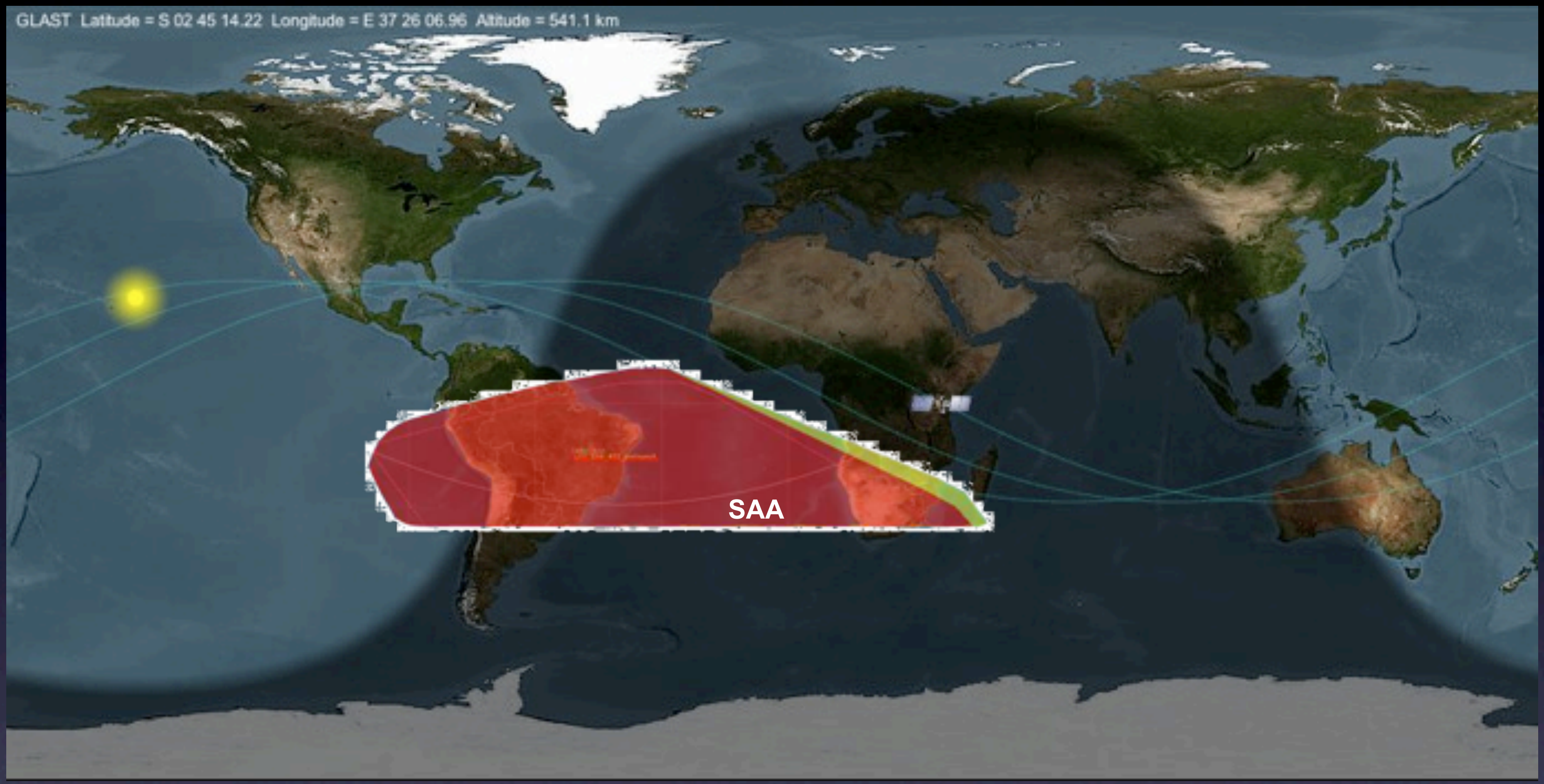
Source localization







The Fermi Orbit

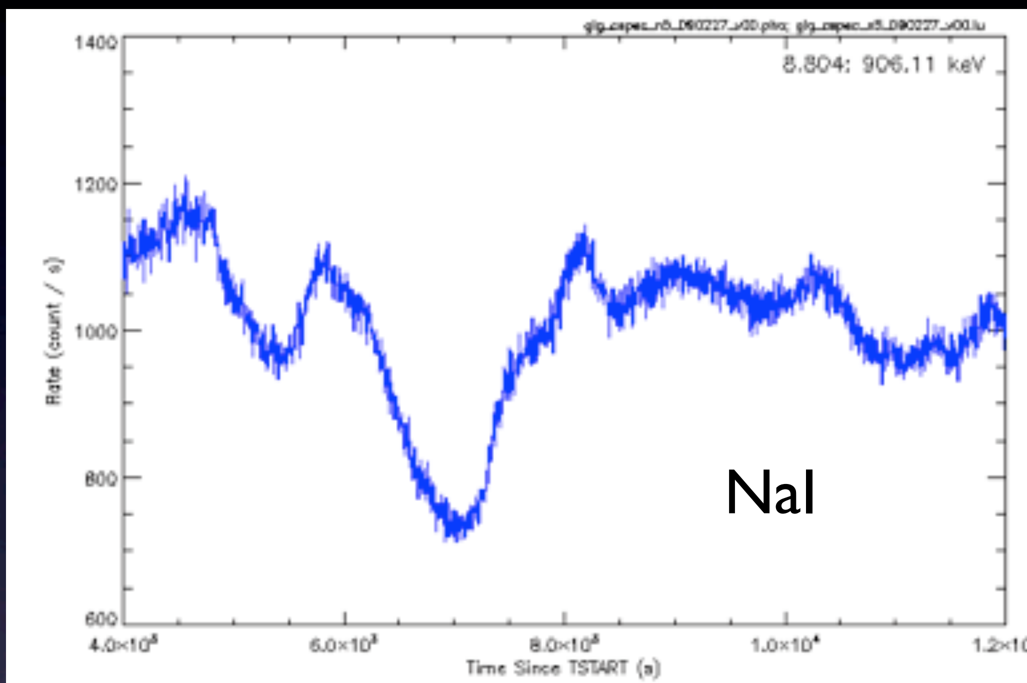


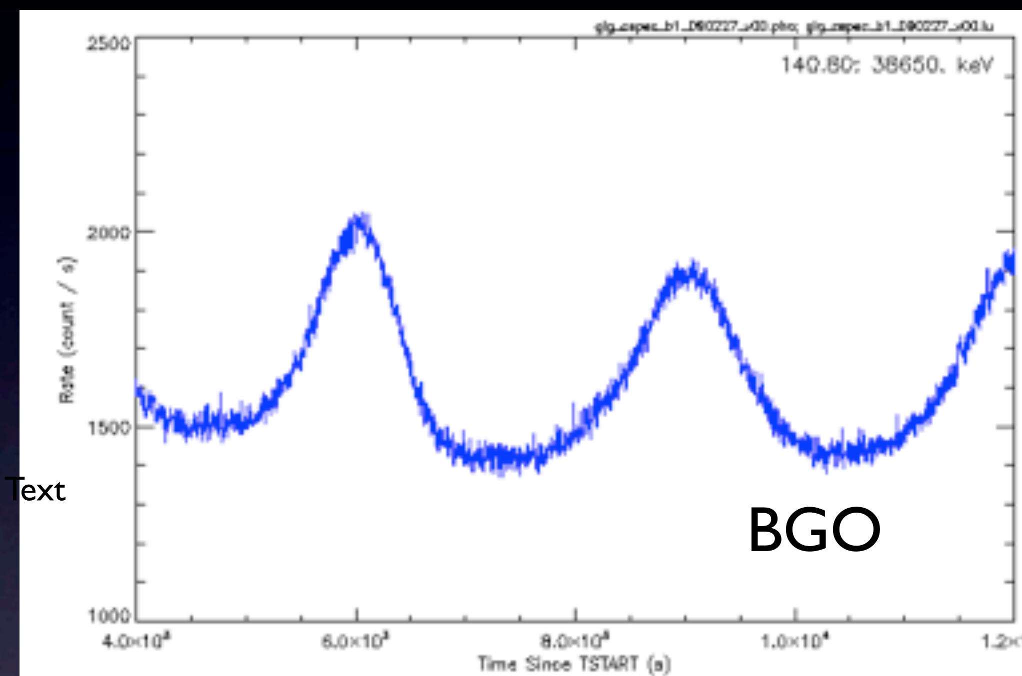
Fermi is now in 25.6^{o} orbit 565 km above Earth with 96 min orbit. Both LAT and GBM record data continuously except when HV are turned off in SAA.

GBM continuous data

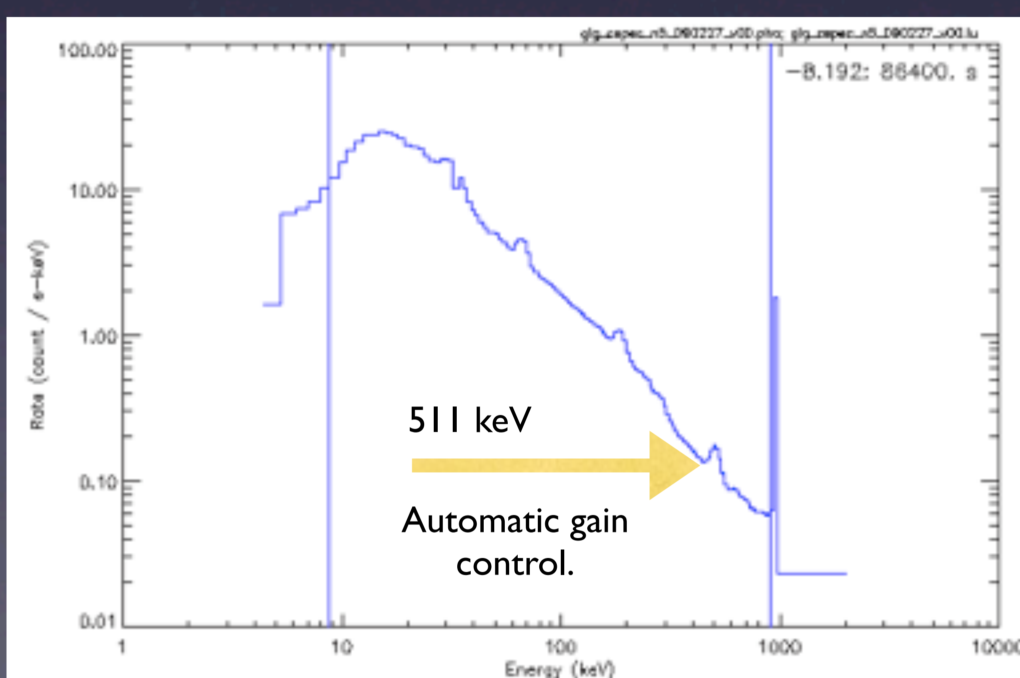
2 Varieties: CSPEC (4.096 s, 128 energy channels),

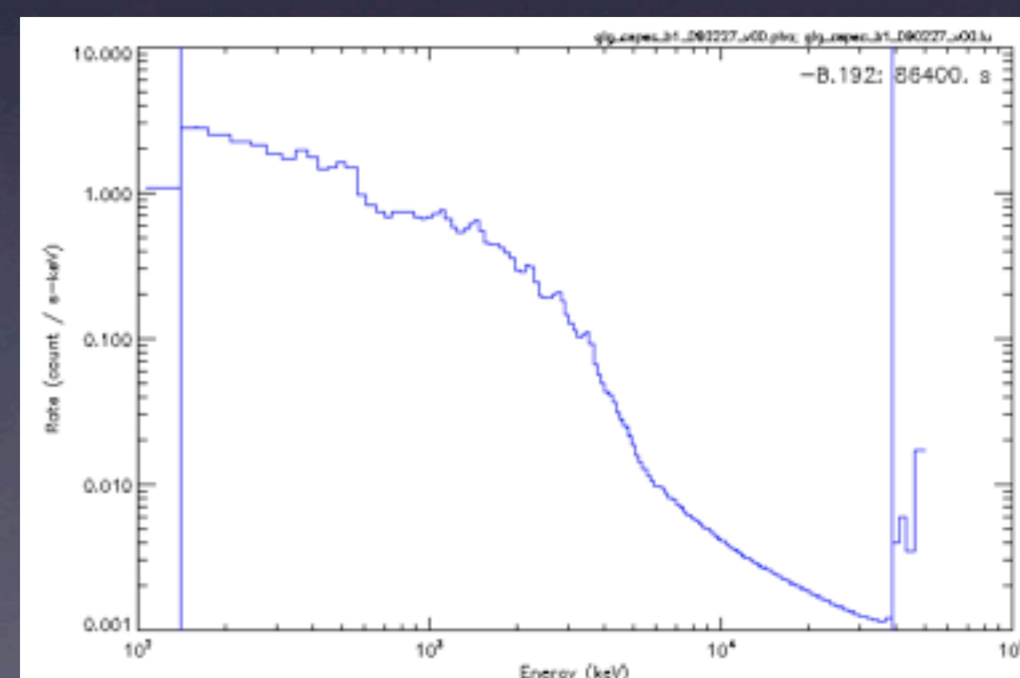
CTIME (0.256 s, 8 energy channels).





Text

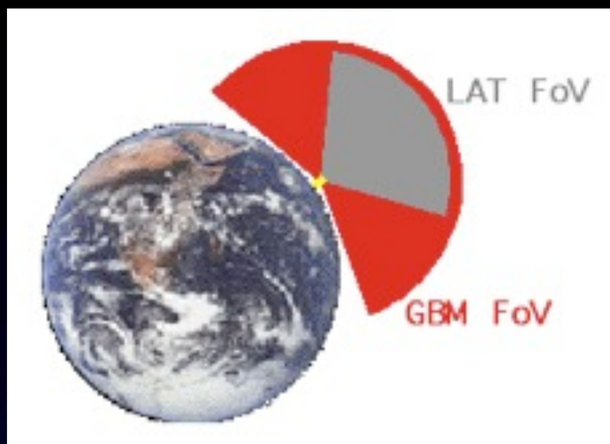


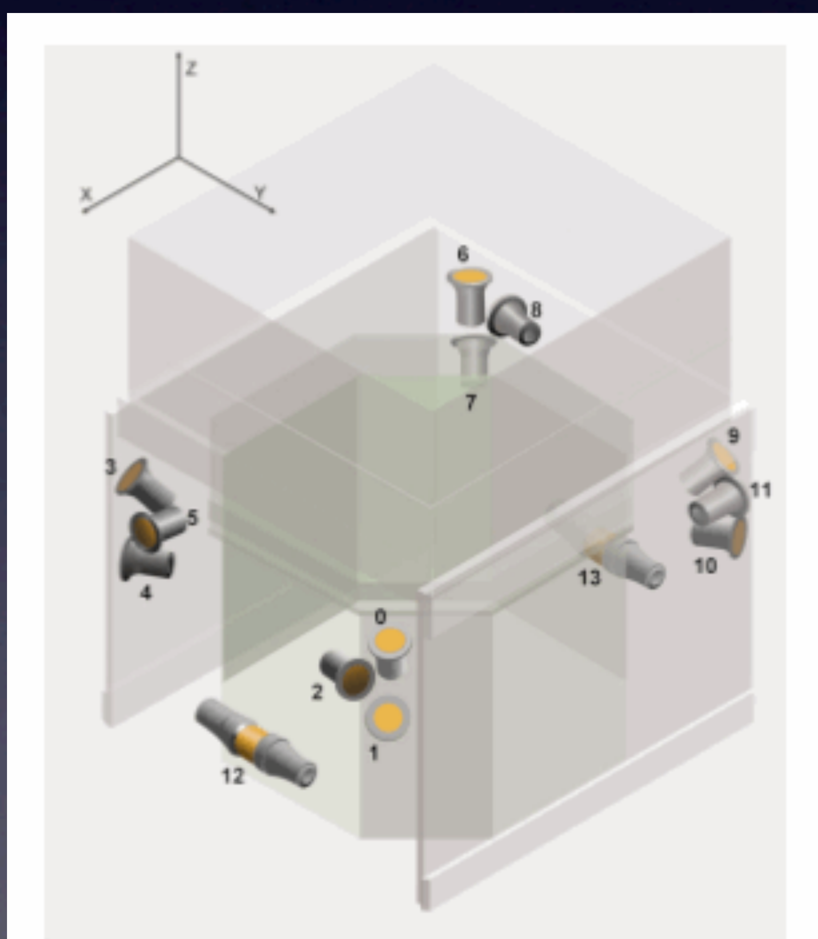


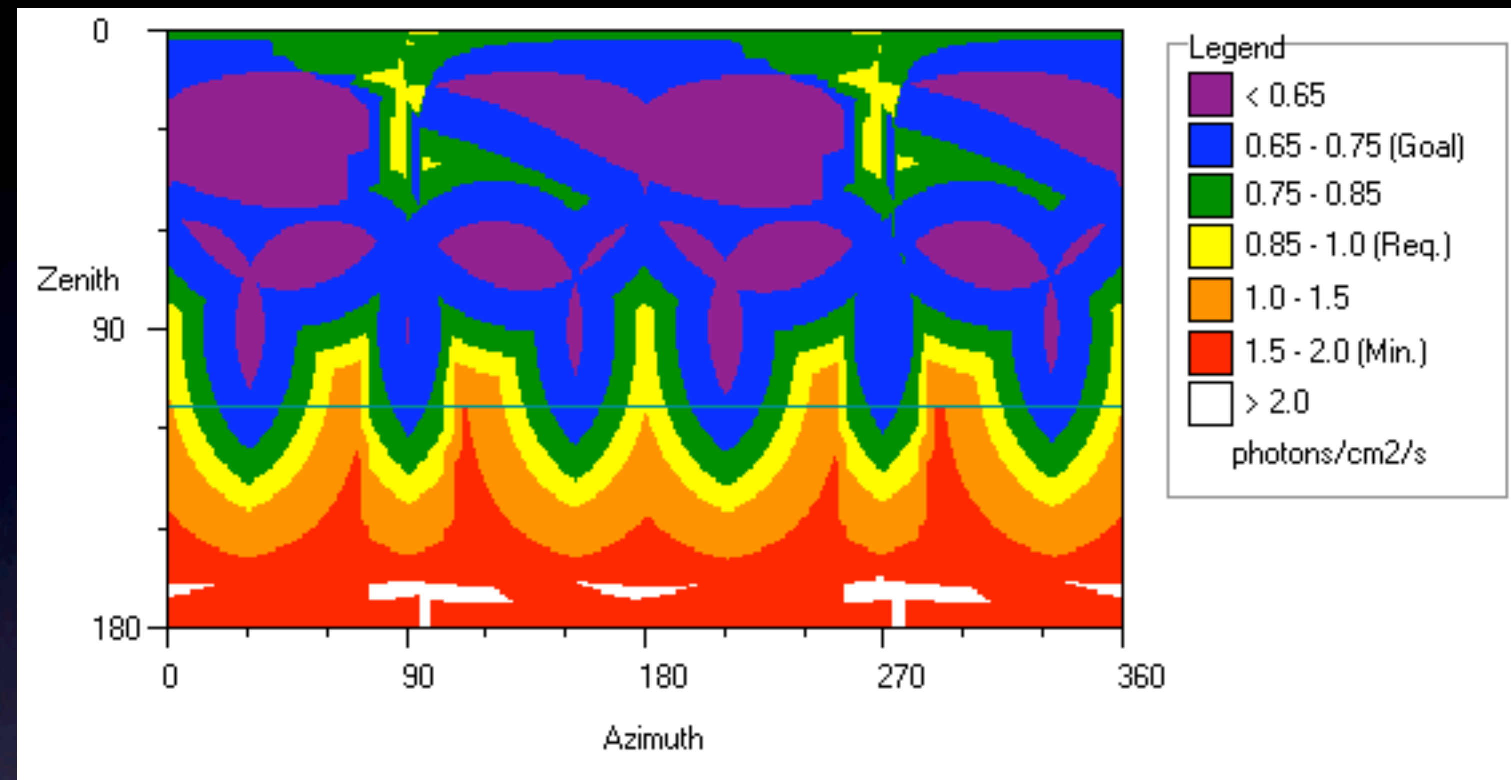
GBM Triggering

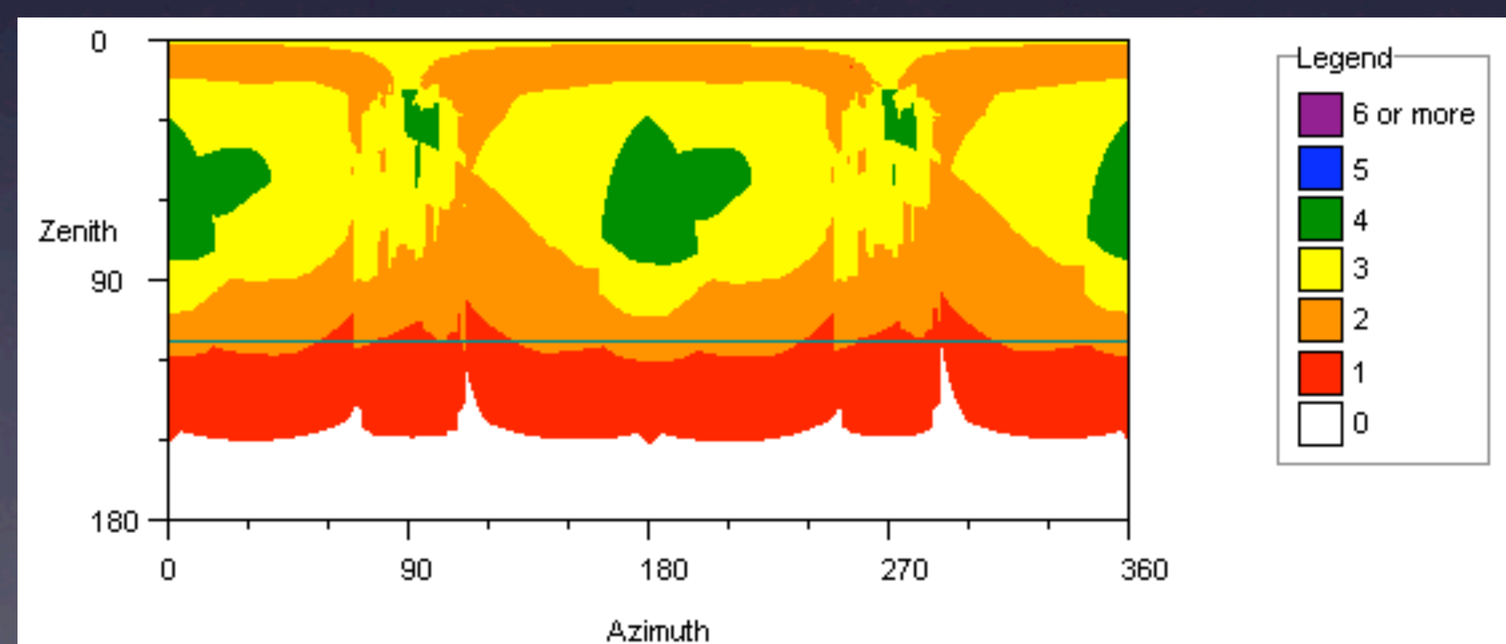
- GBM triggers when 2 or more detectors exceed background by n sigma over t timescale in e energy band.
- 62 algorithms operating simultaneously.
  - $4.5 \leq n \leq 7.5$
  - $16 \text{ ms} \leq t \leq 8.096 \text{ s}$
  - e = one of 25 - 50 keV, 50 - 300 keV, 100 - 300 keV, > 300 keV
- On triggering, CSPEC and CTIME are accelerated (1.024 s and 64 ms resolution). TTE (Time-Tagged Events) are produced for ~ -25 s -- 300 s from trigger time. These record time to 2 microsecond precision.

All-sky Trigger sensitivity and effective area



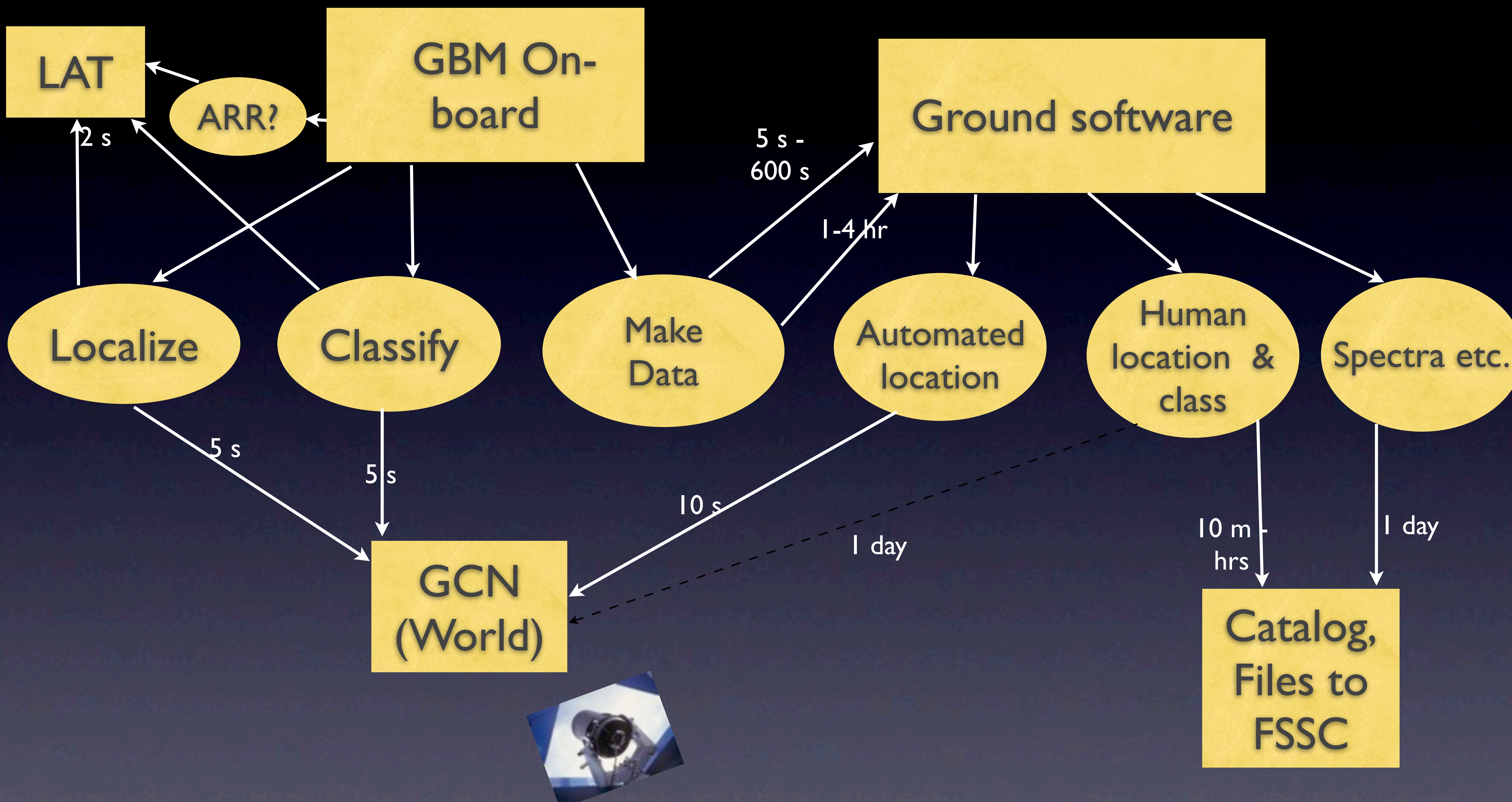






Instrument details:
Meegan et al. 2009 ApJ 702 p.791

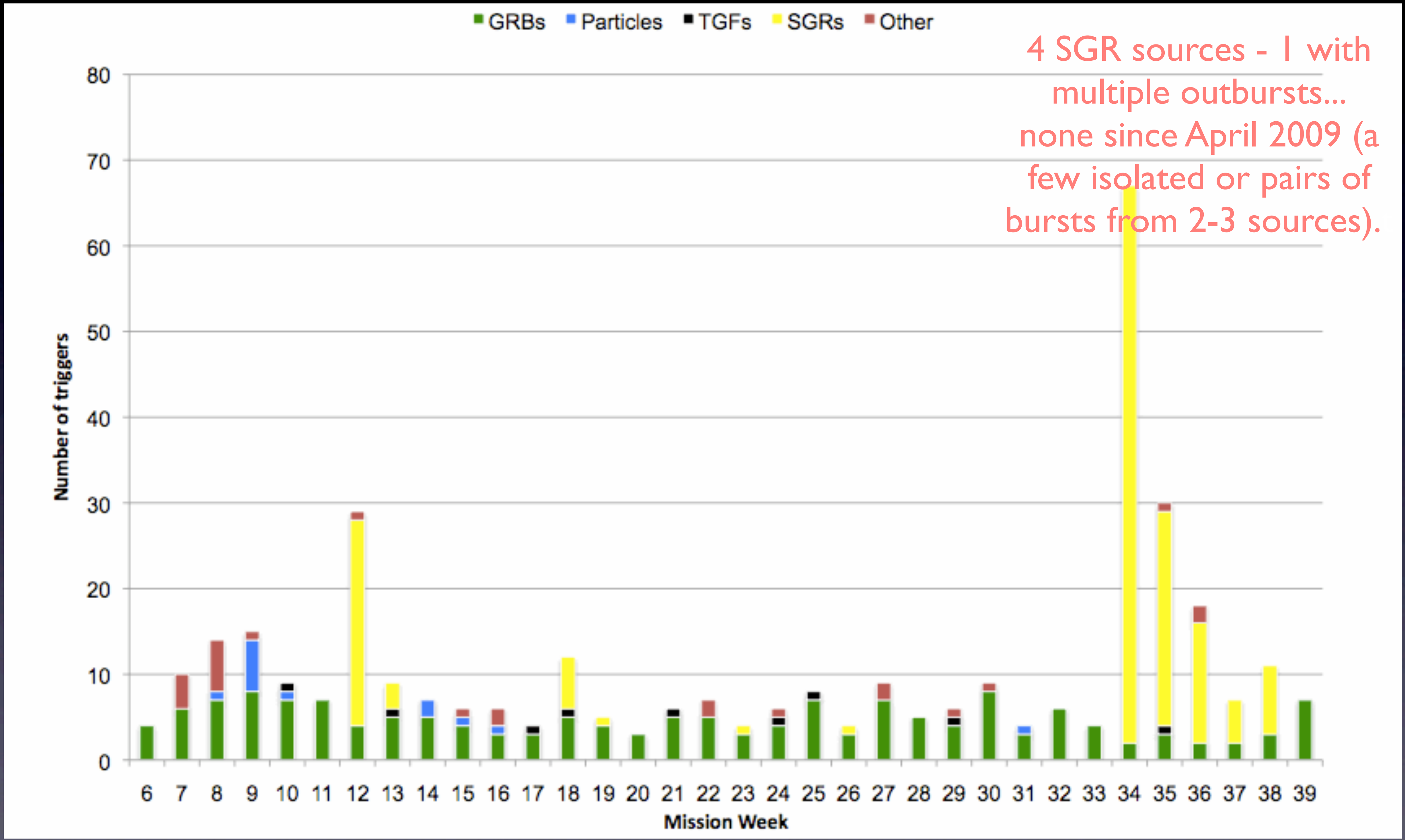
GBM Actions on Triggering



All GBM Data are public at the FSSC:

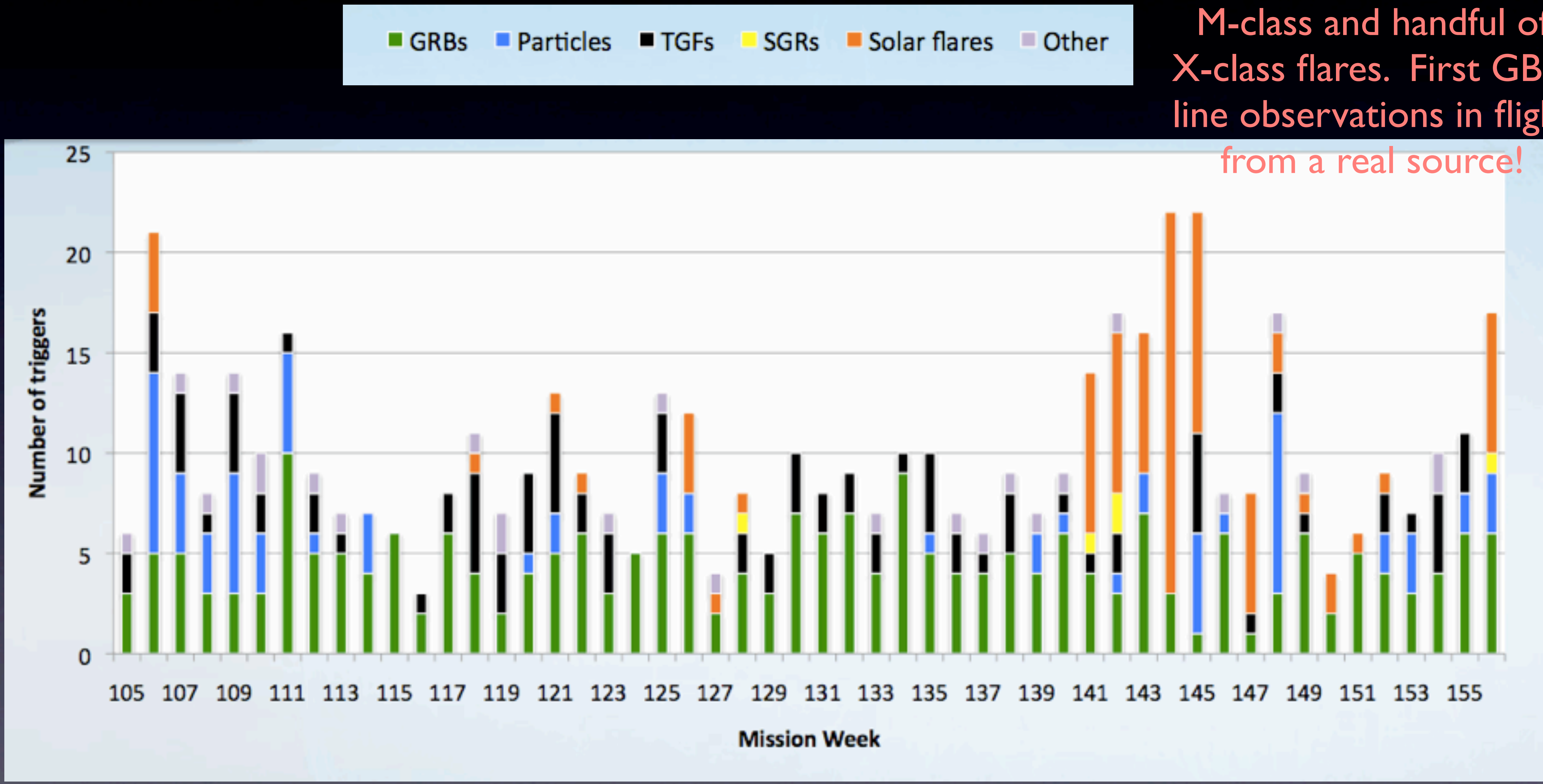
- *http://fermi.gsfc.nasa.gov/ssc/data/access/*

GBM Weekly Triggers

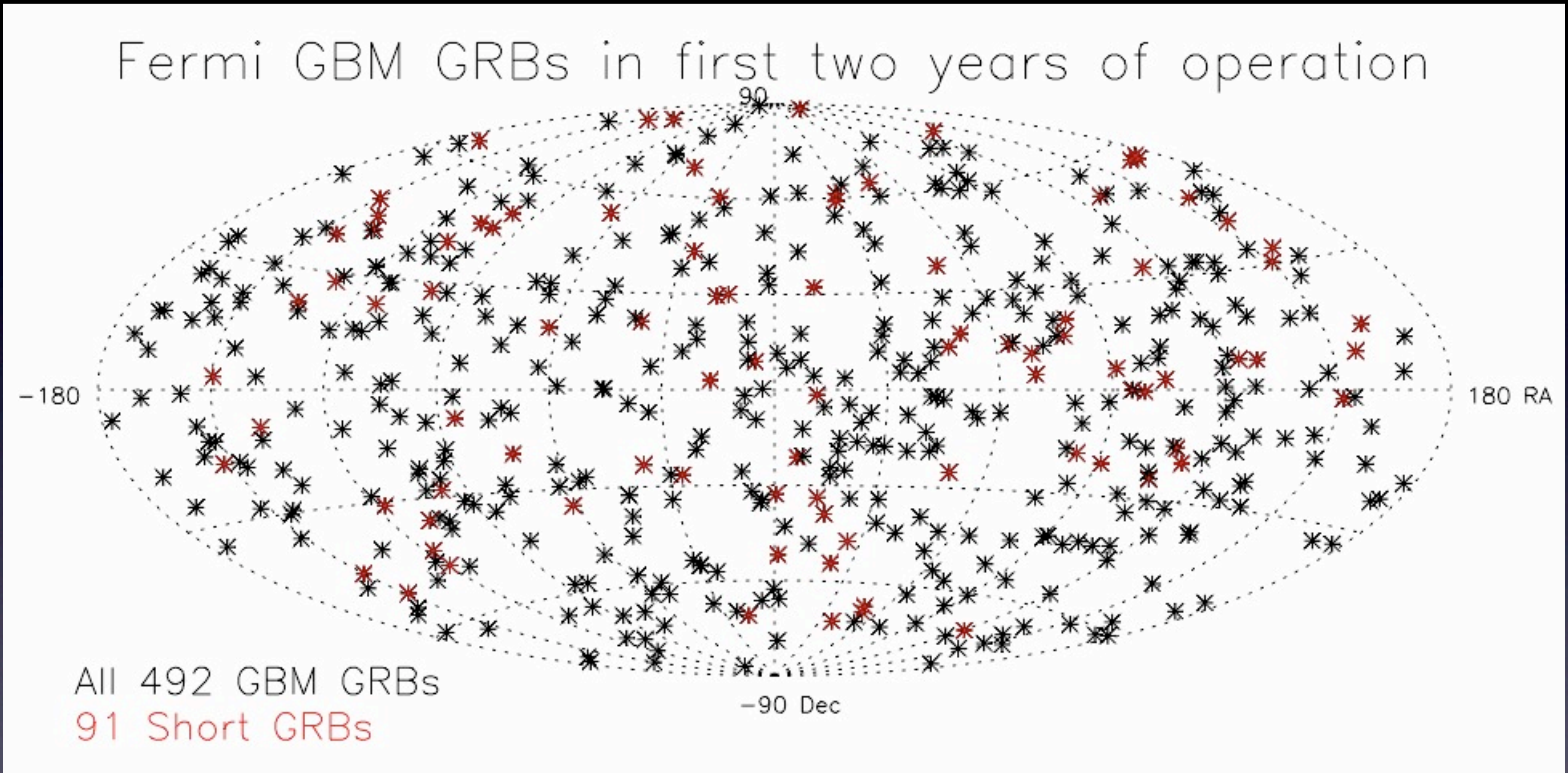


Recent GBM Weekly Triggers

Sun is now active with numerous C-class, a few M-class and handful of X-class flares. First GBM line observations in flight from a real source!

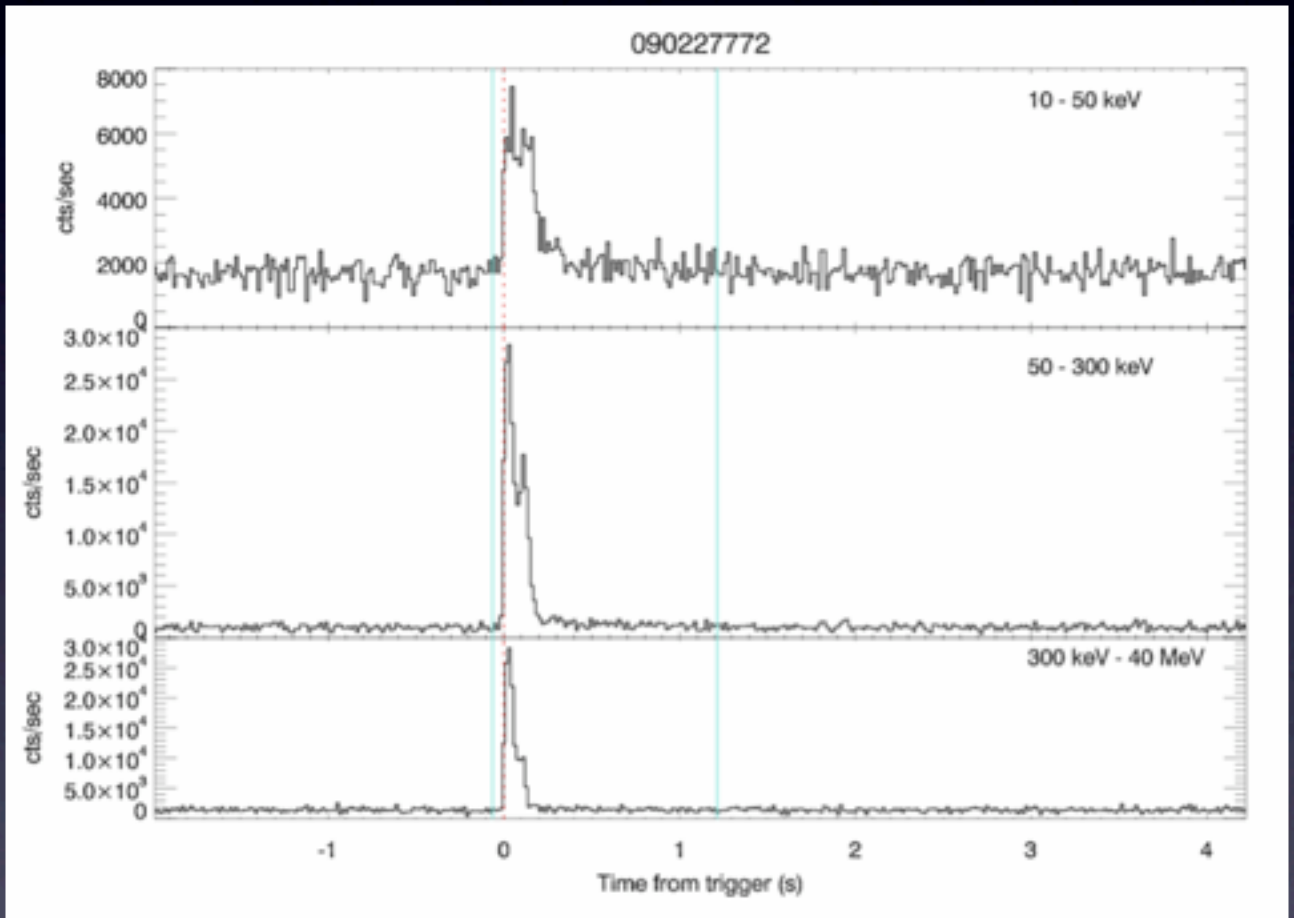


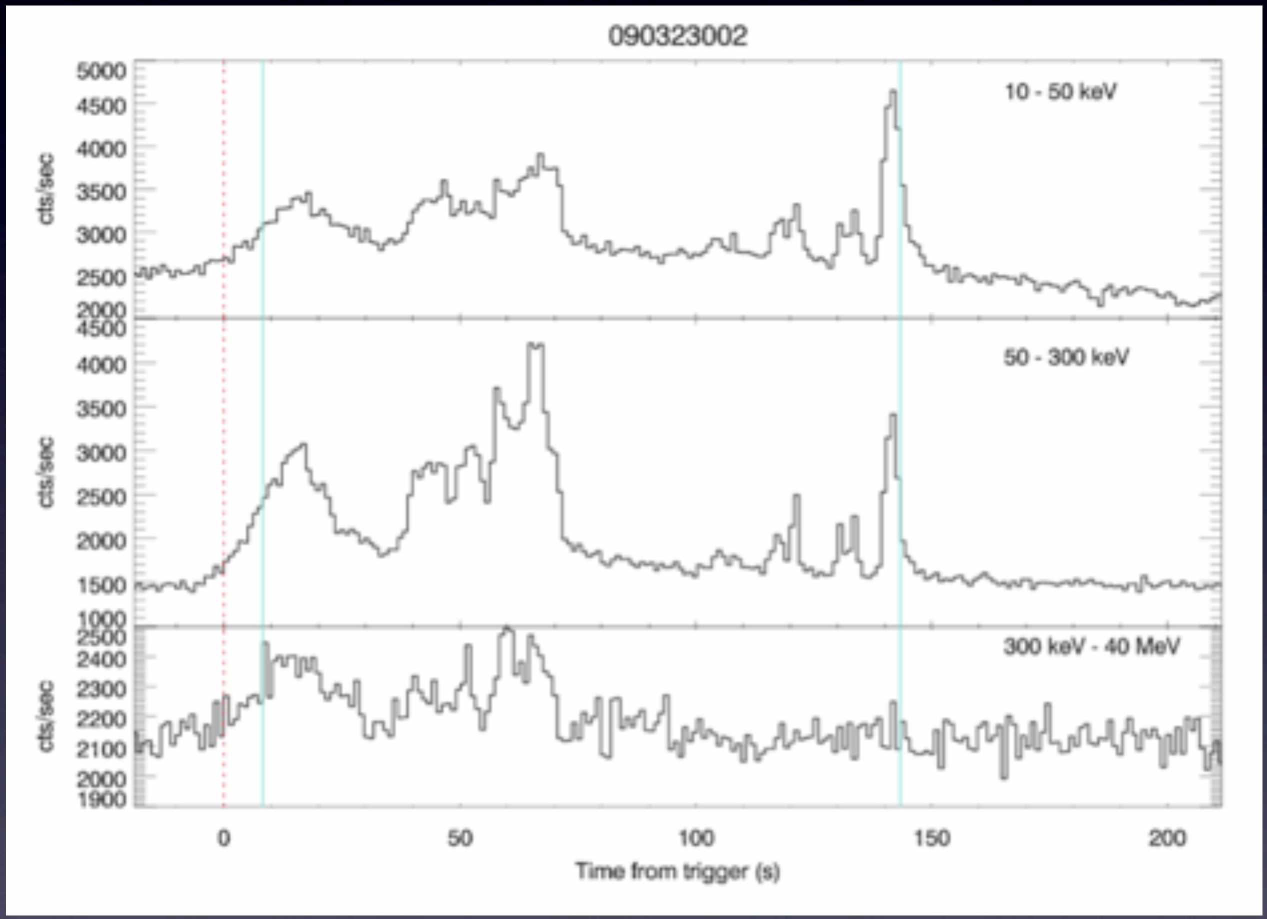
The first GBM GRB catalog



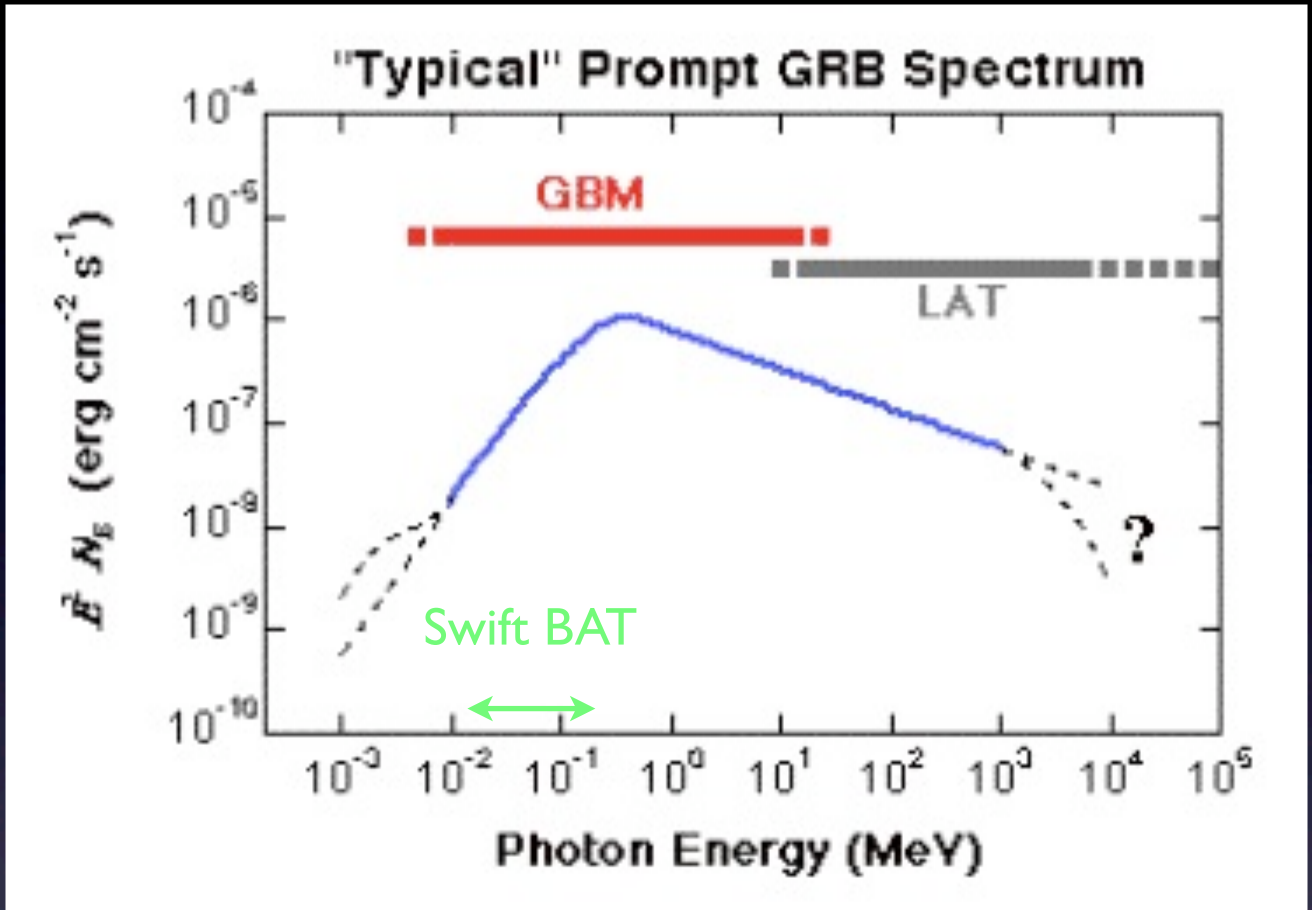
- Paciesas et al. in prep.

Some nice GBM GRBs





GRB Spectra

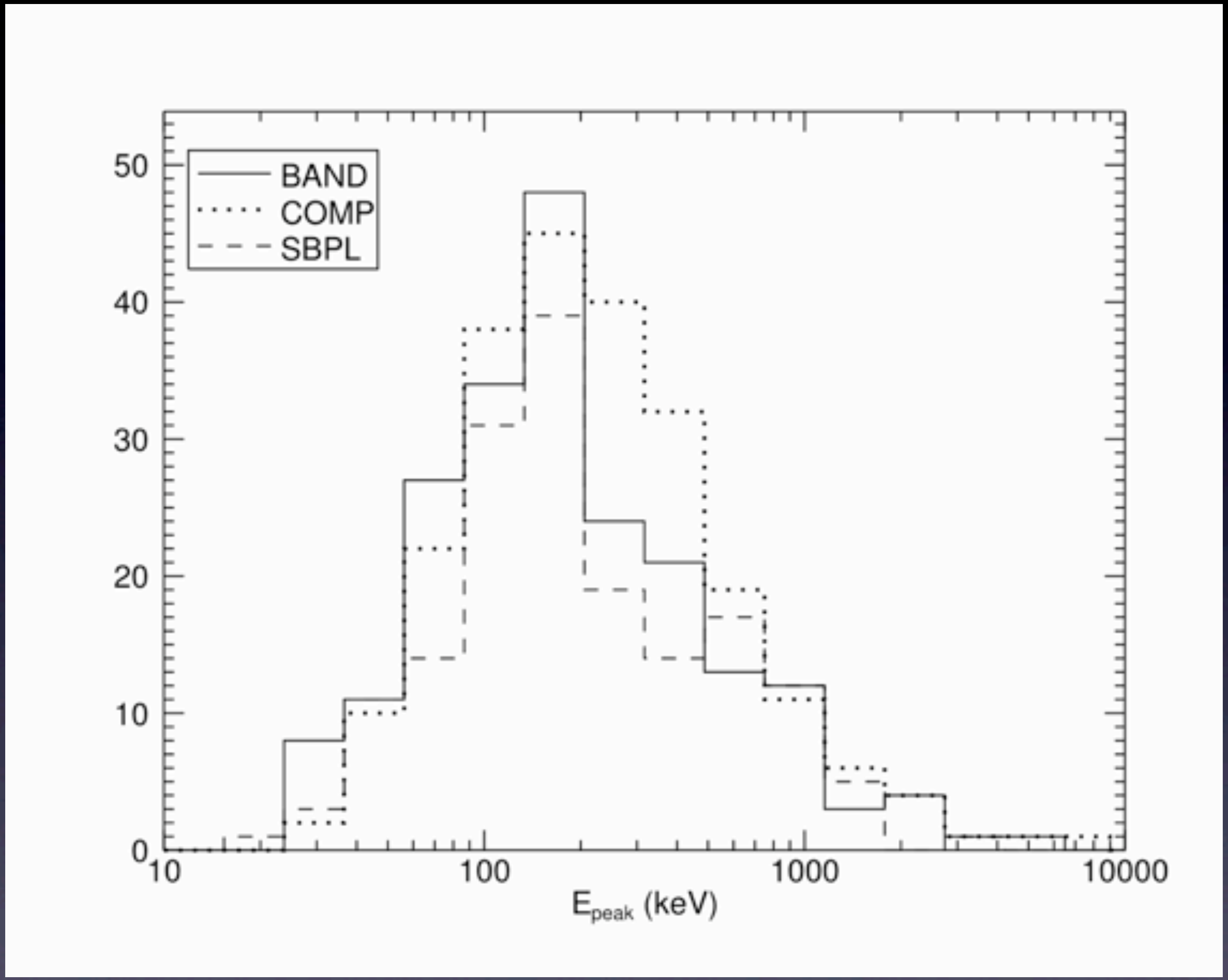


The Band Function: α,β, E_{peak}

Comptonized E_{peak} Model: when HE PL β is ill-constrained i.e. E_{peak} is high, or GRB is weak with too few HE photons. Use exponential cut-off instead of HE PL.

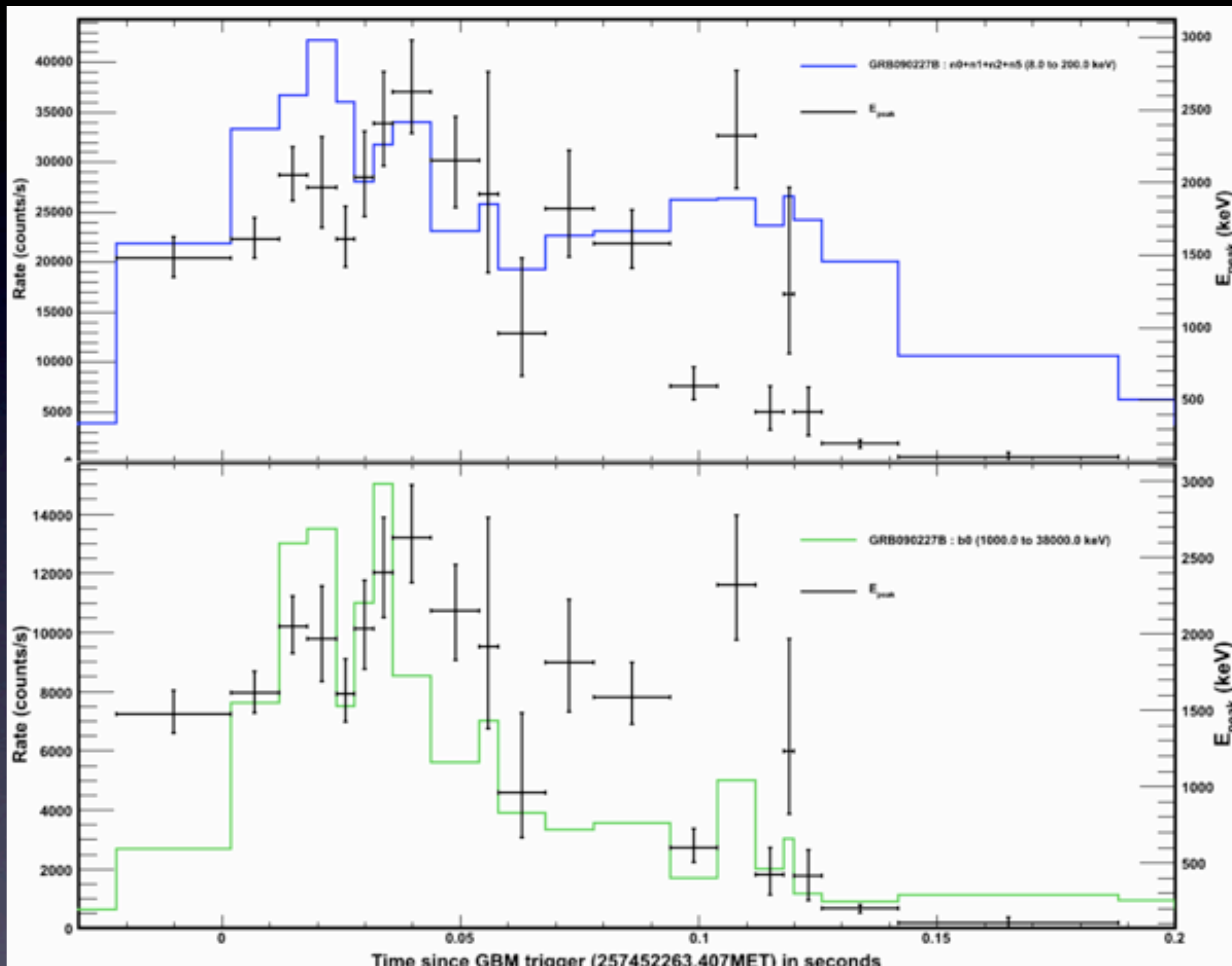
Single Power-Law: E_{peak} undetermined. Either the instrument bandpass is too narrow to measure the curvature (e.g. Swift) or burst is too weak to see curvature in spectrum.

GBM Spectroscopy - EPeak



Goldstein et al. in prep.

GBM Observations of Short Bursts

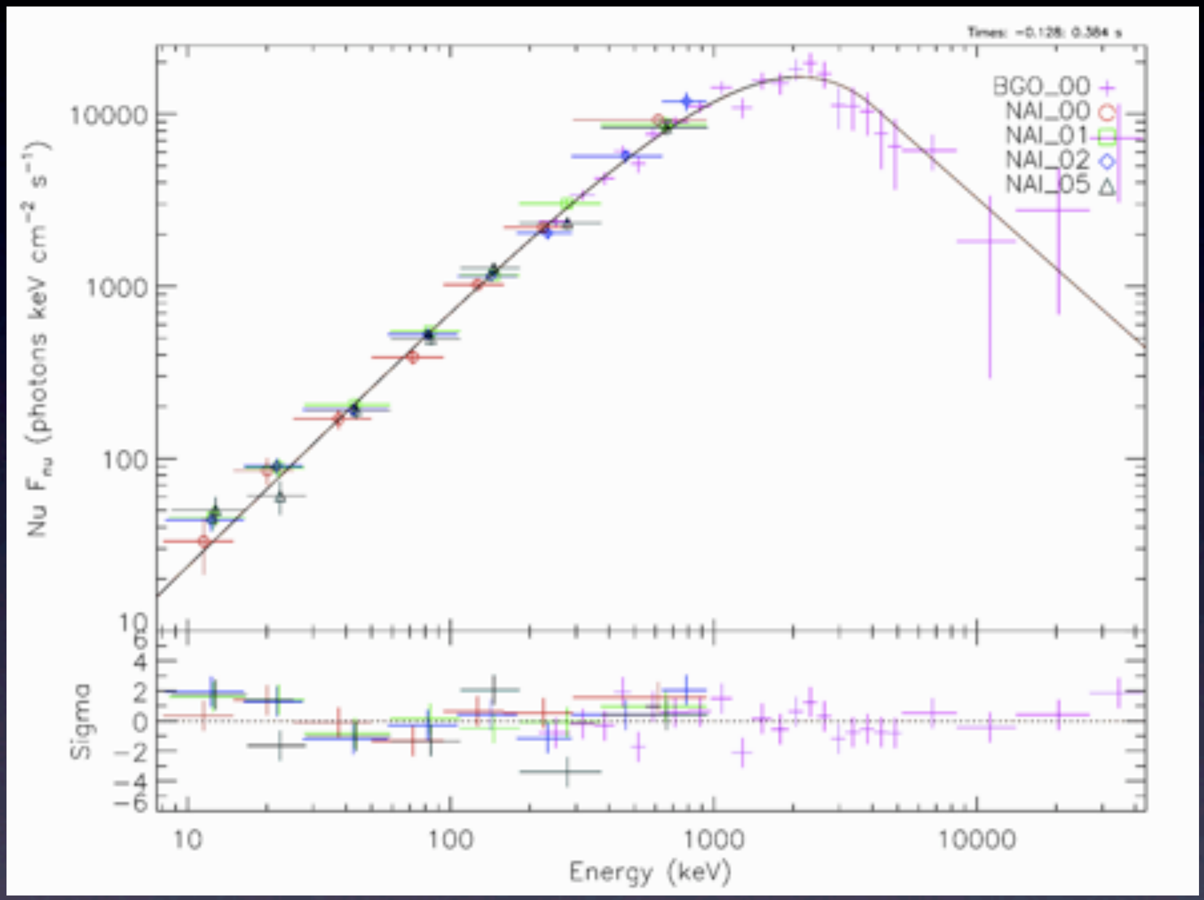


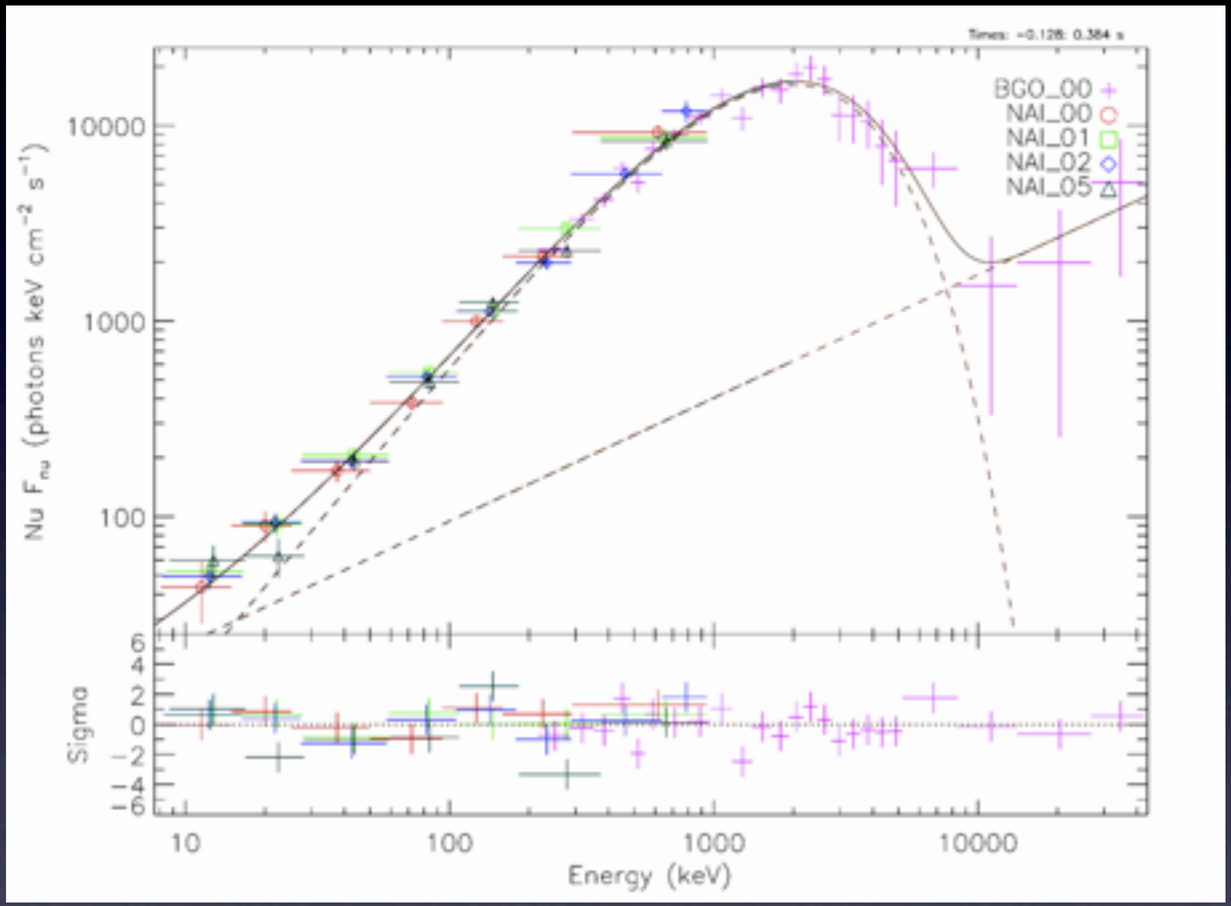
NaI 8 - 200 keV

BGO > 1 MeV

Guiriec et al. 2010, ApJ, 725, 225.
GRB 090227B

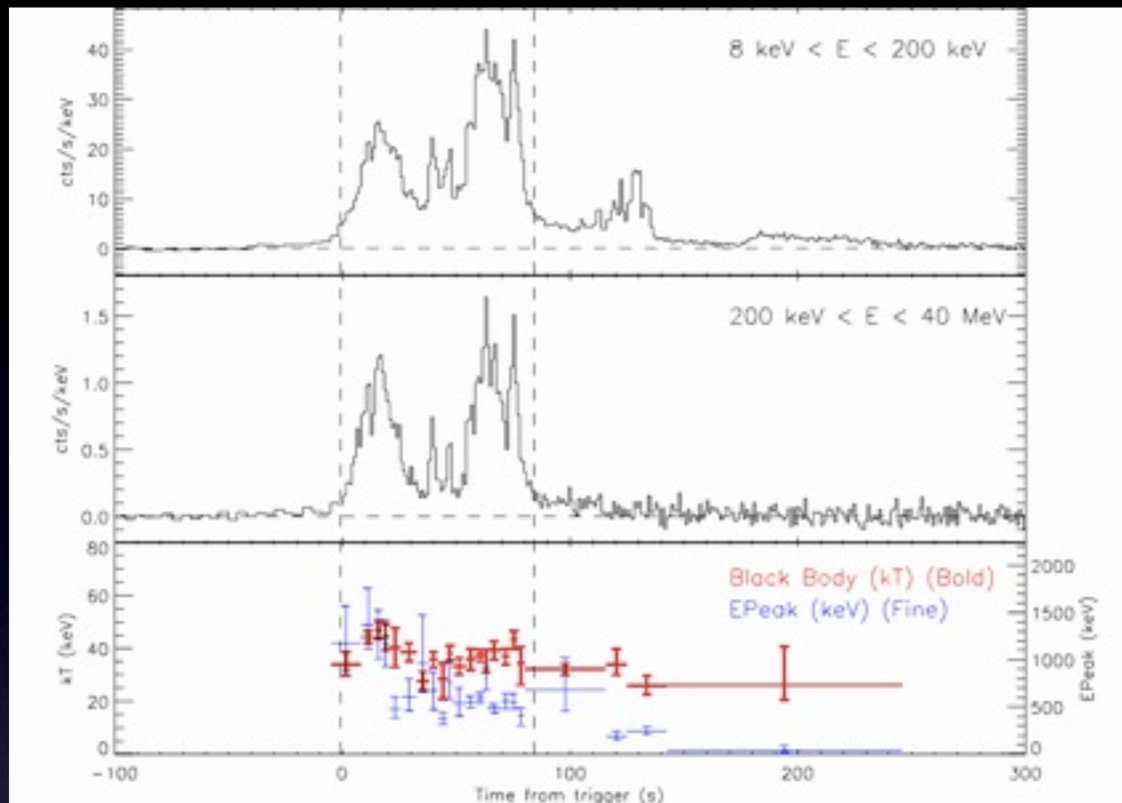
Is Band the full story?
(i) HE deviations



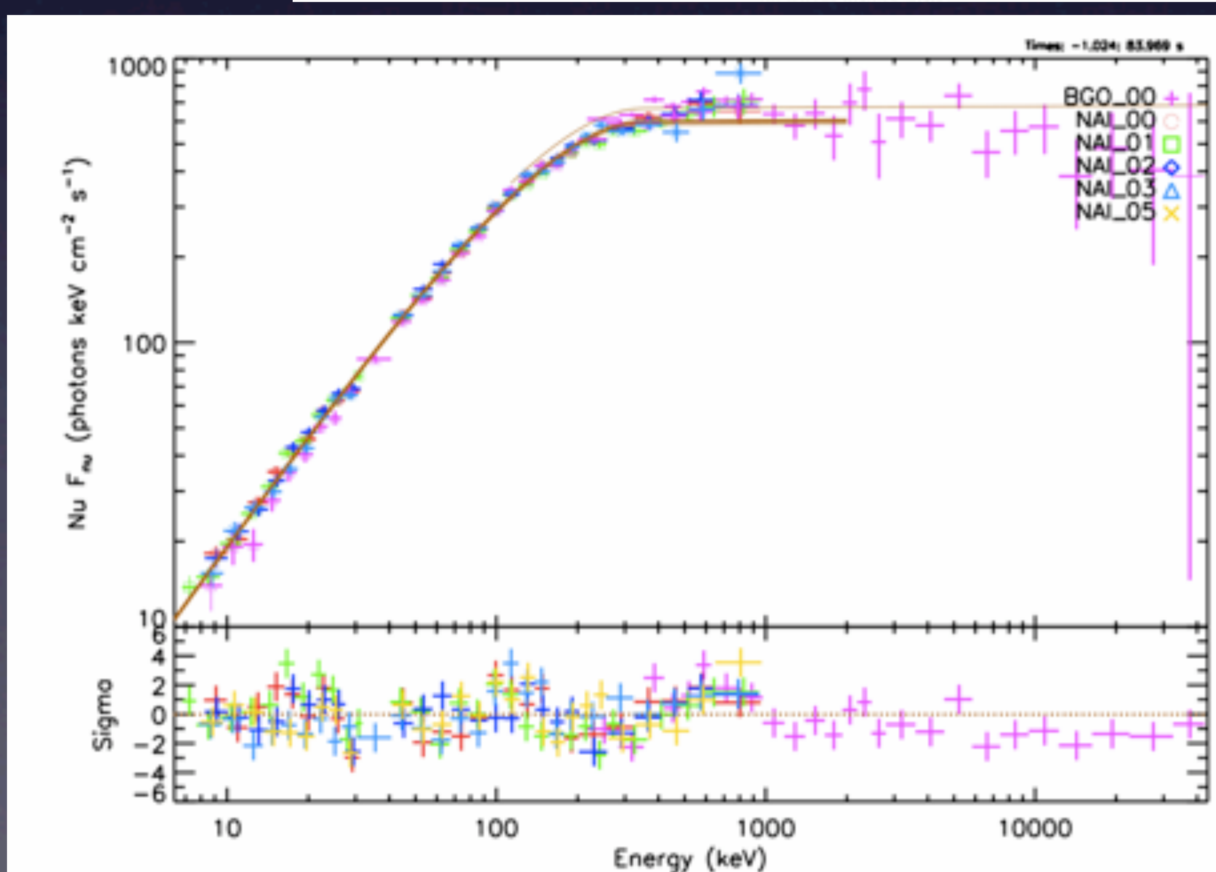


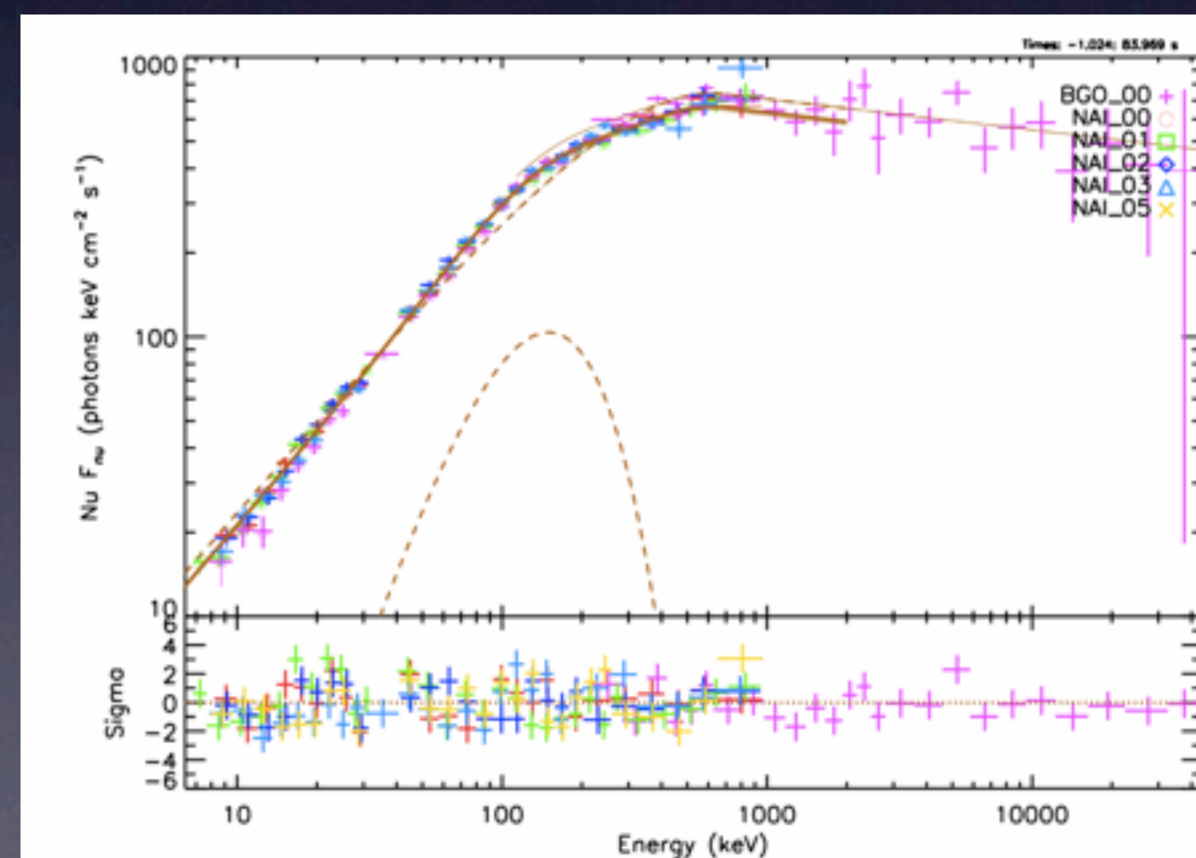
Guiriec et al. 2010, ApJ, 725, 225.
GRB 090227B

Is Band the Full Story?
(ii) Thermal components

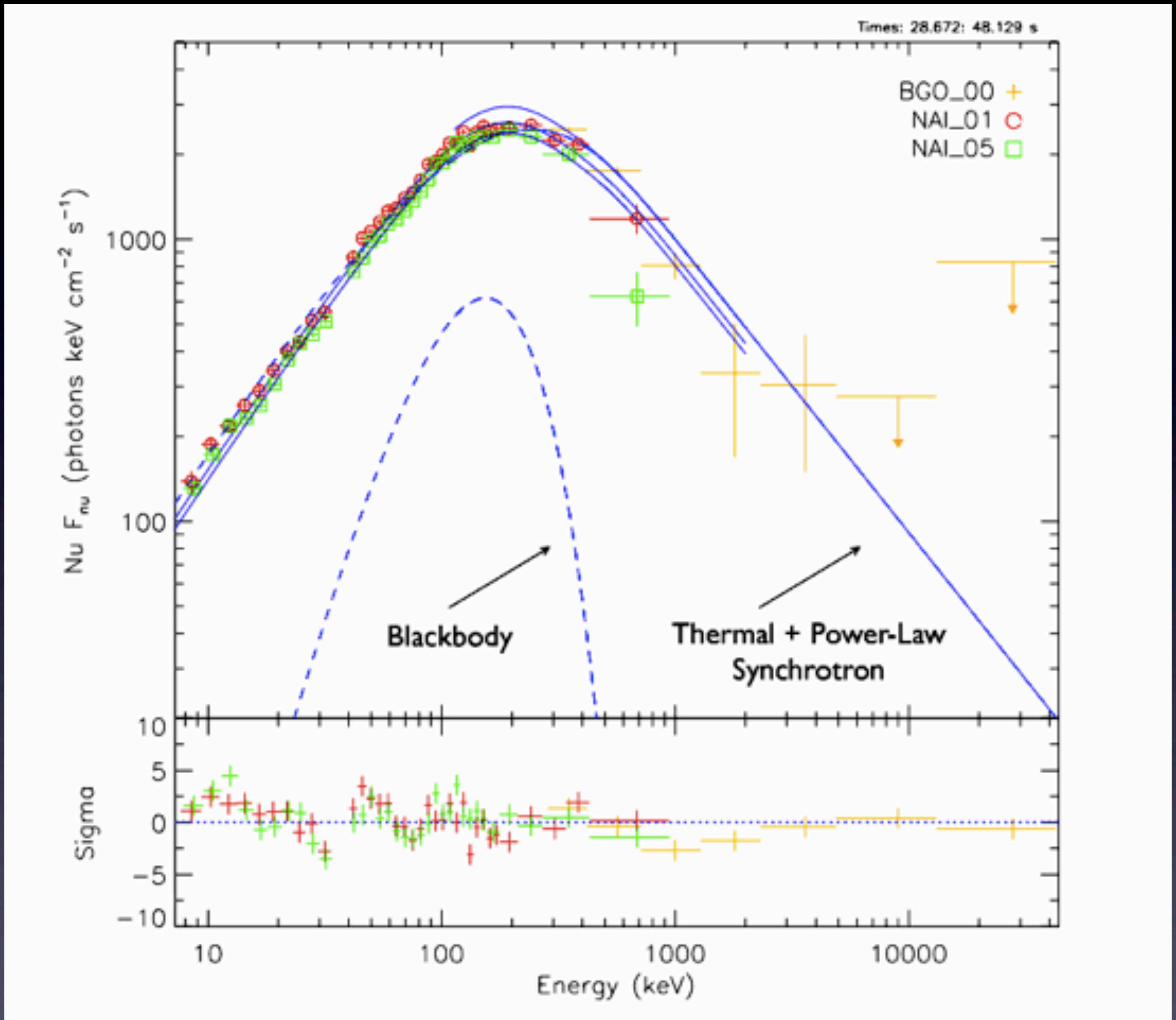


Guiriec et al. 2011, ApJL, 727, L33.
GRB 100724B

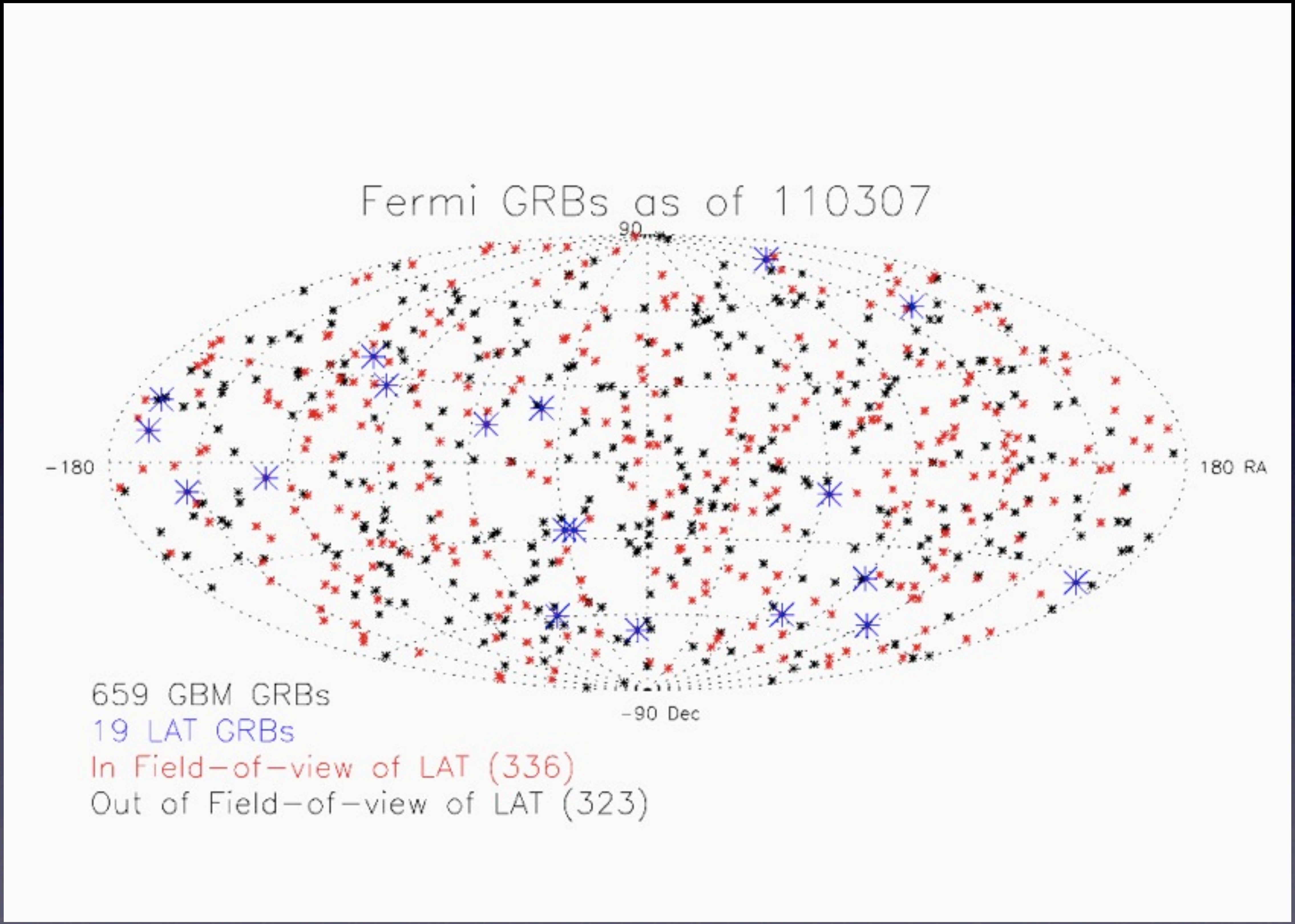




Moving towards physical models?

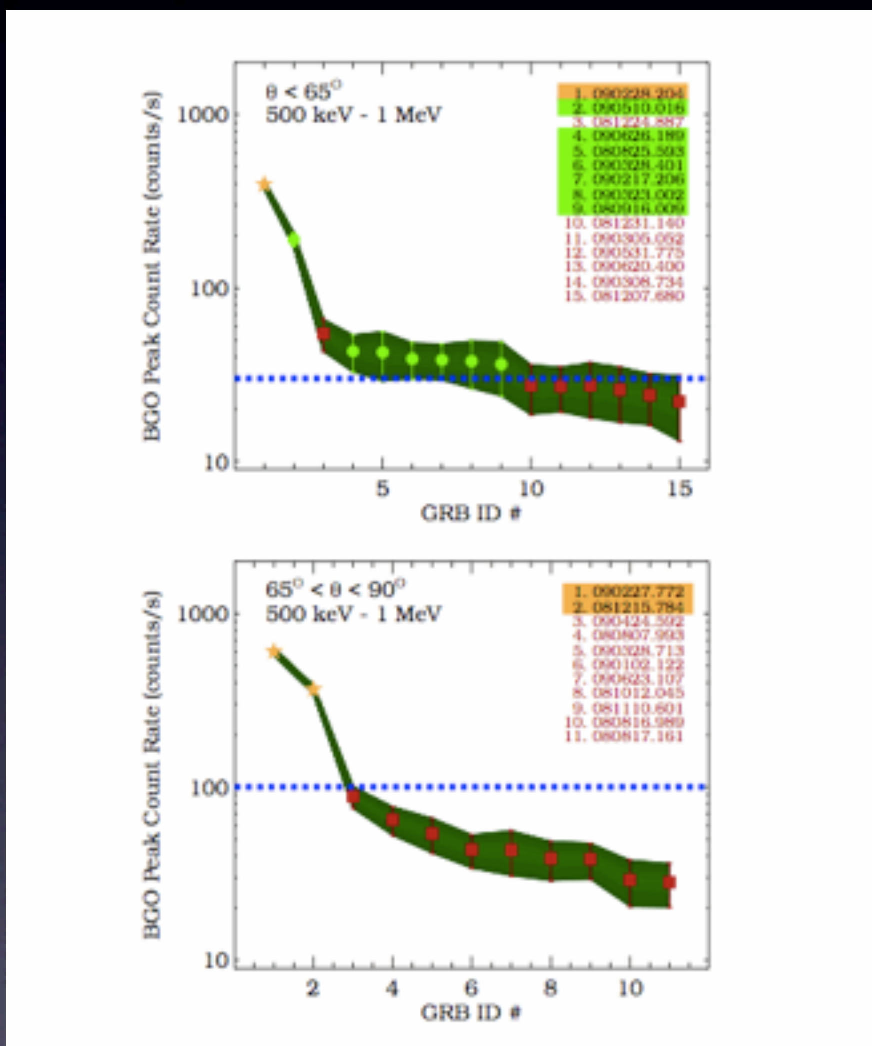


Burgess et al., submitted to ApJL.
GRB 090820


Fermi GRBs as of 110307
90
-180
180 RA
-90 Dec
659 GBM GRBs
19 LAT GRBs
In Field-of-view of LAT (336)
Out of Field-of-view of LAT (323)

How do we predict a LAT burst?

- It must be BRIGHT!   More specifically.... BGO-bright.

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TITLE:            GCN/FERMI NOTICE
NOTICE_DATE:      Thu 20 Jan 11 16:00:22 UT
NOTICE_TYPE:      Fermi-GBM Ground Position
RECORD_NUM:       70
TRIGGER_NUM:      317231981
GRB_RA:            65.650d {+04h 22m 36s} (J2000),
                   65.773d {+04h 23m 06s} (current),
                   65.094d {+04h 20m 22s} (1950)
GRB_DEC:          -18.350d {-18d 21' 00"} (J2000),
                  -18.325d {-18d 19' 28"} (current),
                  -18.466d {-18d 27' 57"} (1950)
GRB_ERROR:        1.00 [deg radius, statistical only]
DATA_SIGNIF:      51.30 [sigma]
DATA_INTERVAL:    4.096 [sec]
GRB_DATE:         15581 TJD;    20 DOY;   11/01/20
GRB_TIME:         57579.23 SOD {15:59:39.23} UT
GRB_PHI:          133.00 [deg]
GRB_THETA:         18.00 [deg]
E_RANGE:          44.032 - 279.965 [keV]
LOC_ALGORITHM:    413 (Gnd S/W Version number)
SUN_POSTN:        302.43d {+20h 09m 43s}  -20.10d {-20d 05' 51"}
SUN_DIST:         112.46 [deg]   Sun_angle= -8.2 [hr] (East of Sun)
MOON_POSTN:       132.30d {+08h 49m 13s}  +14.51d {+14d 30' 23"}
MOON_DIST:         73.31 [deg]
MOON_ILLUM:       99 [%]
GAL_COORDS:       214.33,-40.87 [deg] galactic lon,lat of the burst (or
transient)
ECL_COORDS:        59.64,-39.26 [deg] ecliptic lon,lat of the burst (or
transient)
COMMENTS:         Fermi-GBM Ground-calculated Coordinates.
COMMENTS:         Bright hard burst in LAT Field-of-view.
COMMENTS:         This Notice was ground-generated -- not flight-generated.
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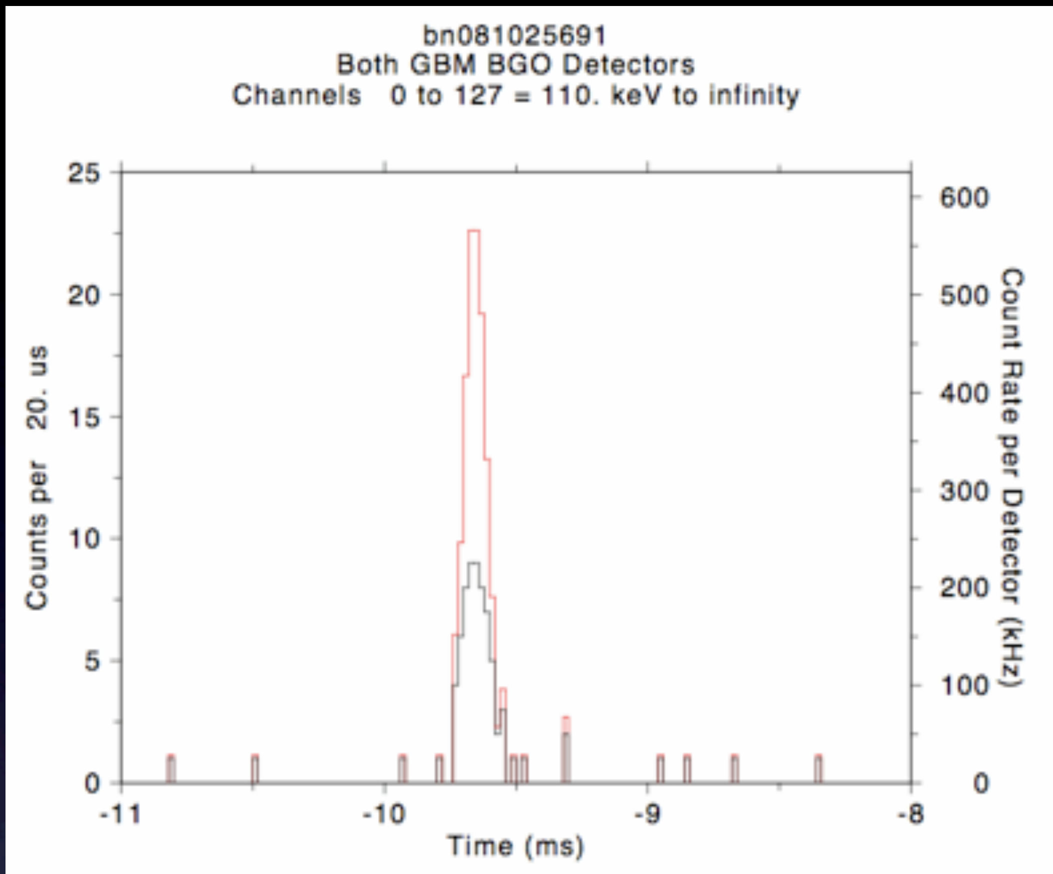
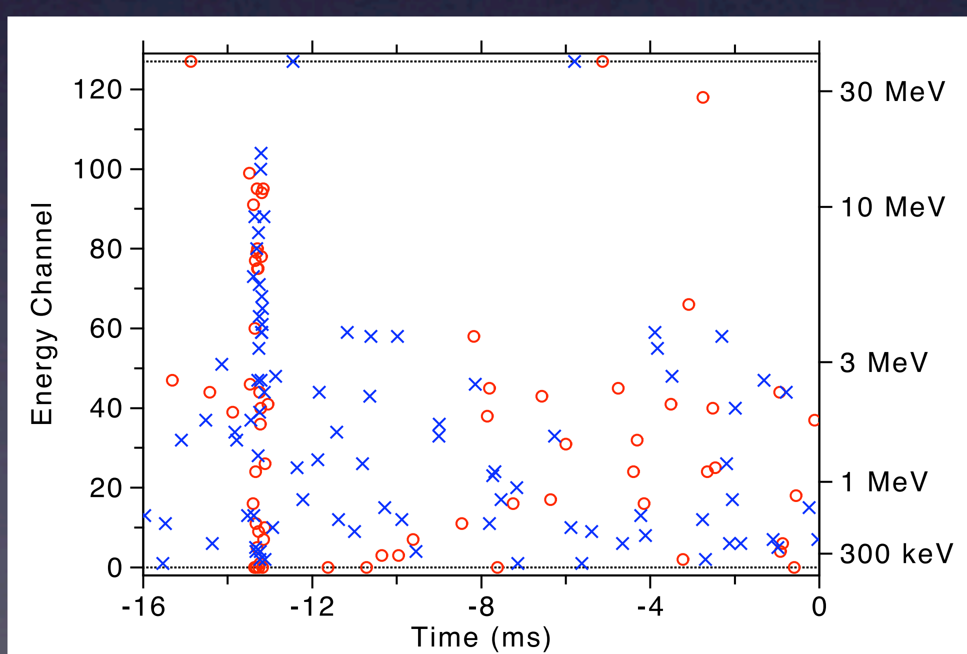
Bissaldi et al. 2011,   ApJ, 733, 97.

We can predict in real-time!   (GCN Circular 11574)

Terrestrial Gamma-ray Flashes

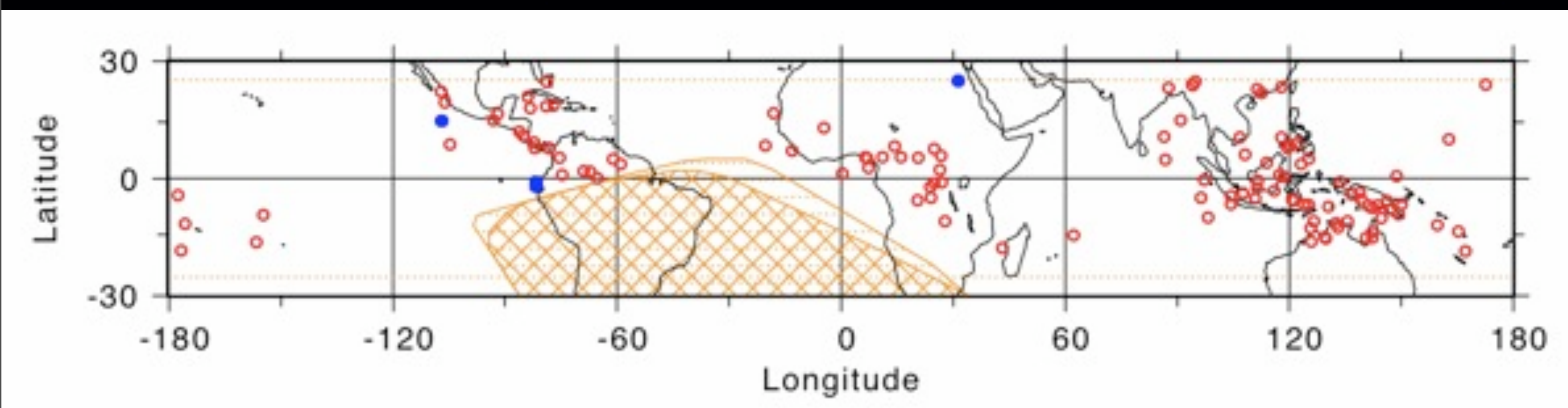




< 1 - 25 ms duration (most < 1 ms).
V. Hard spectra > 30 MeV
Associated with thunderstorms.
"Runaway electron" processes.
170 triggered TGFs so far.

Papers on GBM TGFs:
http://gammaray.nsstc.nasa.gov/publications/tgf_journal.html

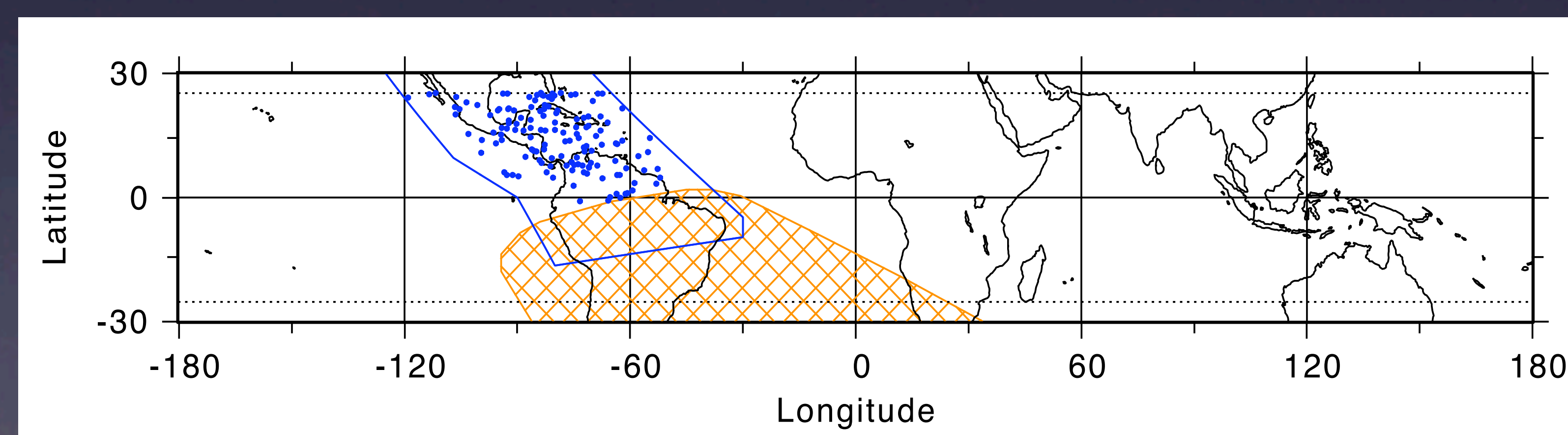
GBM TGF detection history



Flight Software Change! Triggering scheme more sensitive to TGFs.

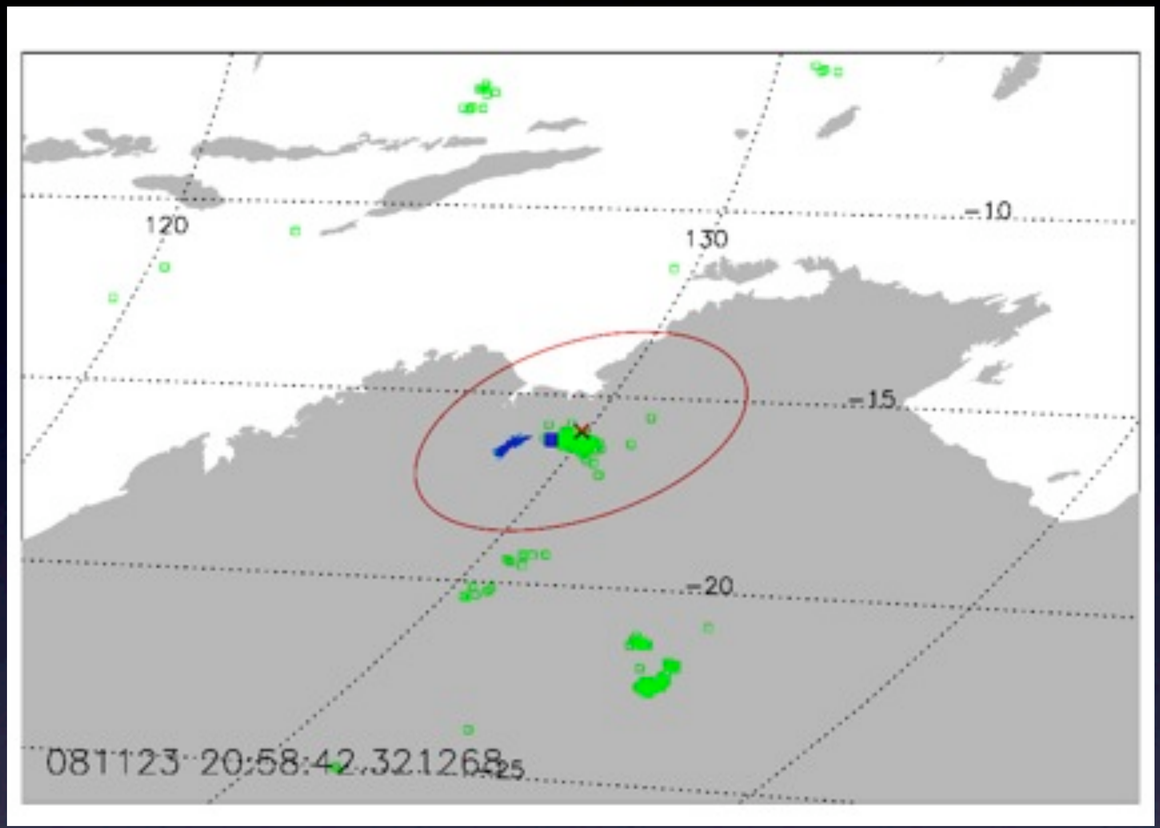
From 11 July 2008 to 9 Nov 2009: 1 TGF every 32 days
From 10 Nov 2009 to 30 Nov 2010: 2 TGFs per week.
Total: 120 Triggered TGFs.

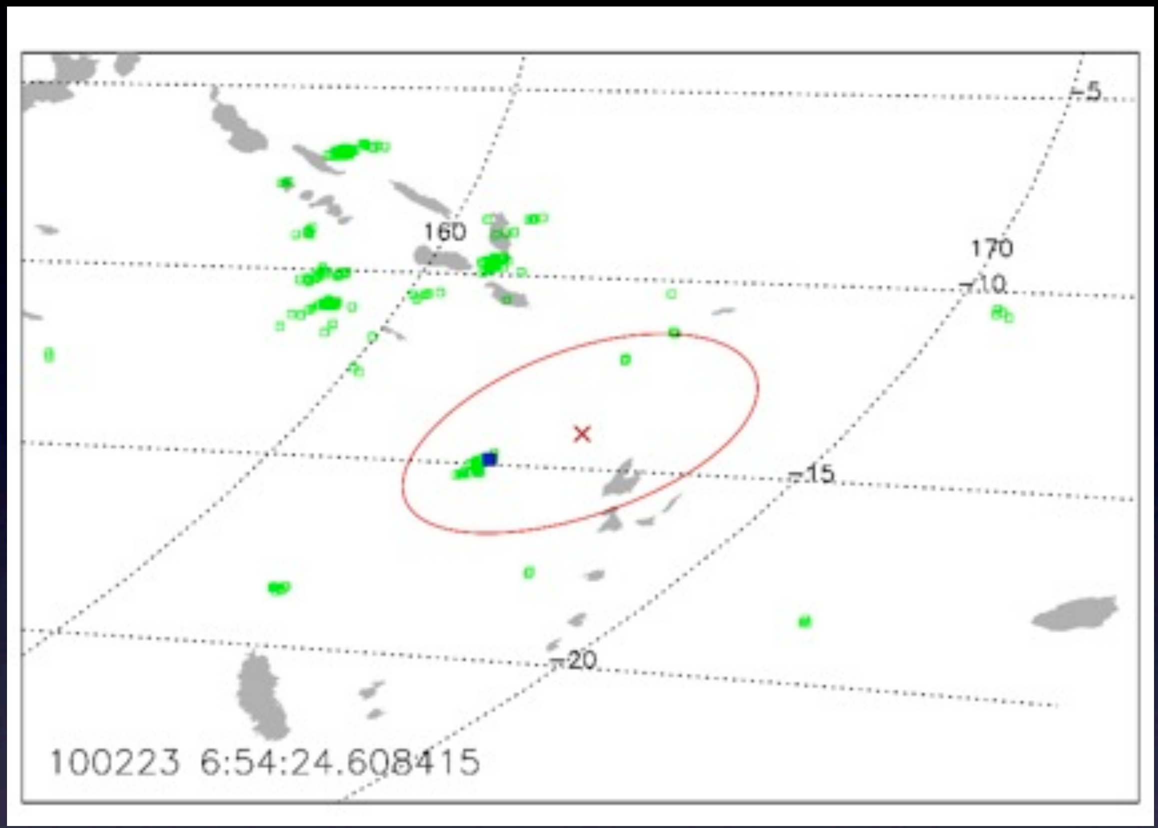
NEW! Untriggered search in 'Americas Box'.



In 113 days over summer: 1.25 untriggered per day = 141 total
In same region of orbit: 4 triggered TGFs

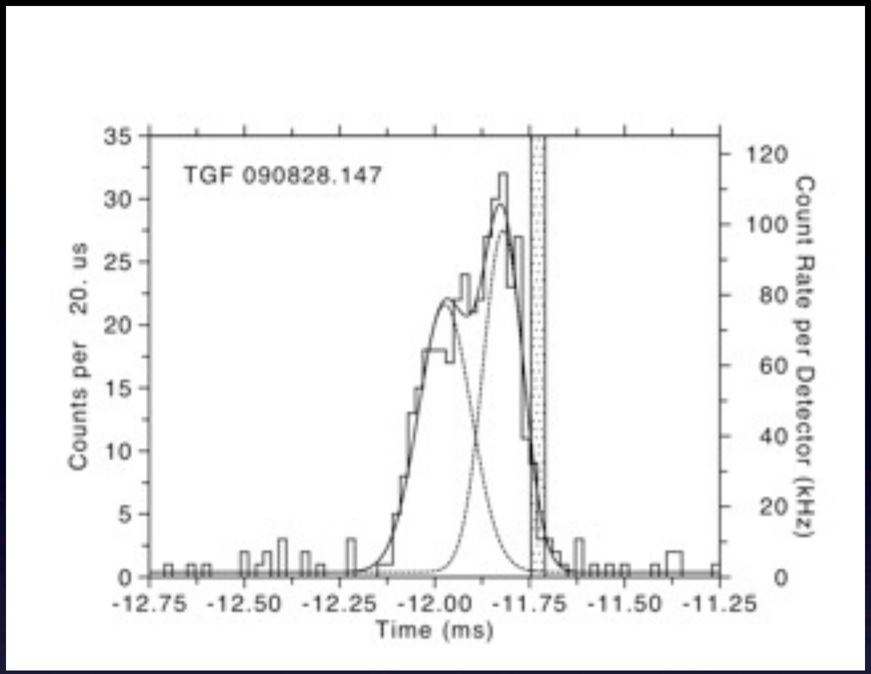
Associations between discharges and short GBM TGFs

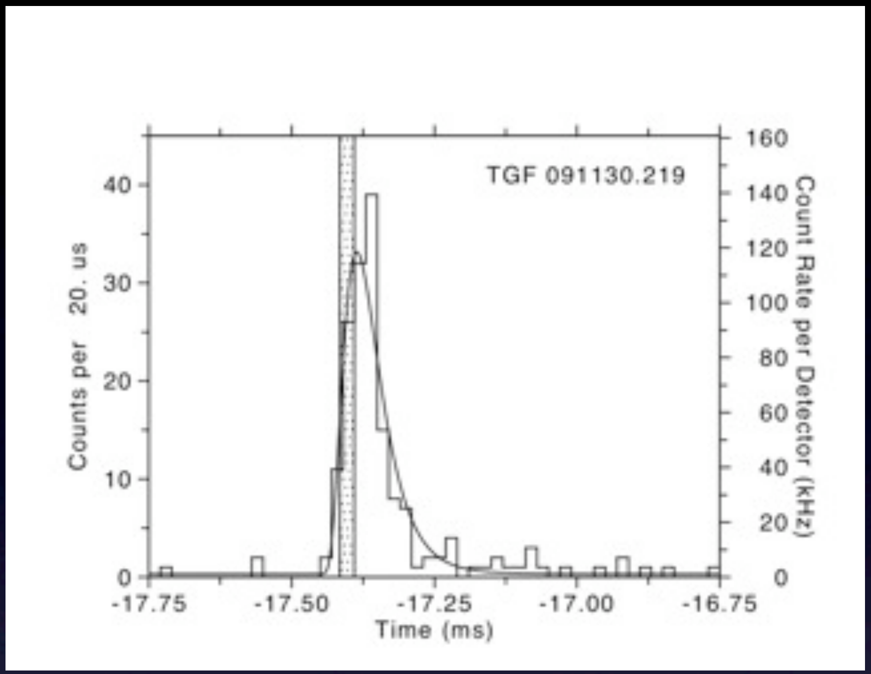


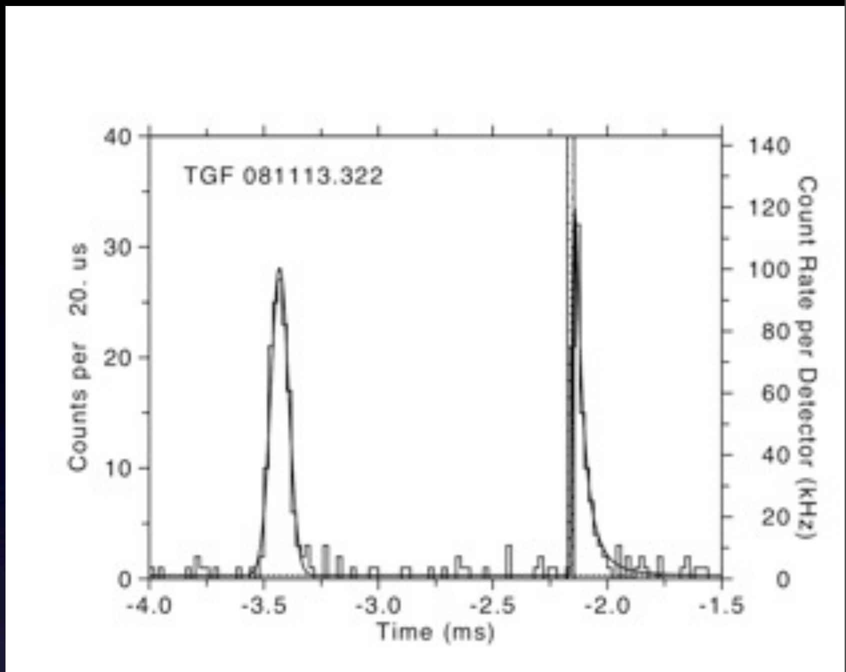


- 30% of GBM gamma-ray TGFs have match with individual discharge within 5 ms of TGF peak and 1000 km of sub-spacecraft position.
- Blind searches reveal false positive rate very small (1-7 per 1000).
- Triggered TGFs usually within 300 km of sub-spacecraft position.
- Untriggered seen out to ~800 km.

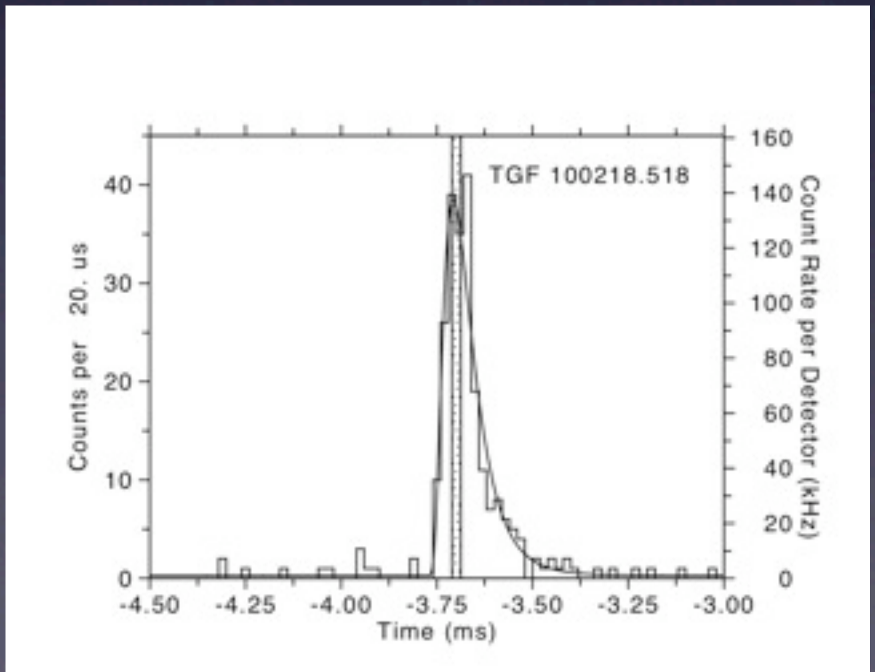
TGF-lightning are Simultaneous!

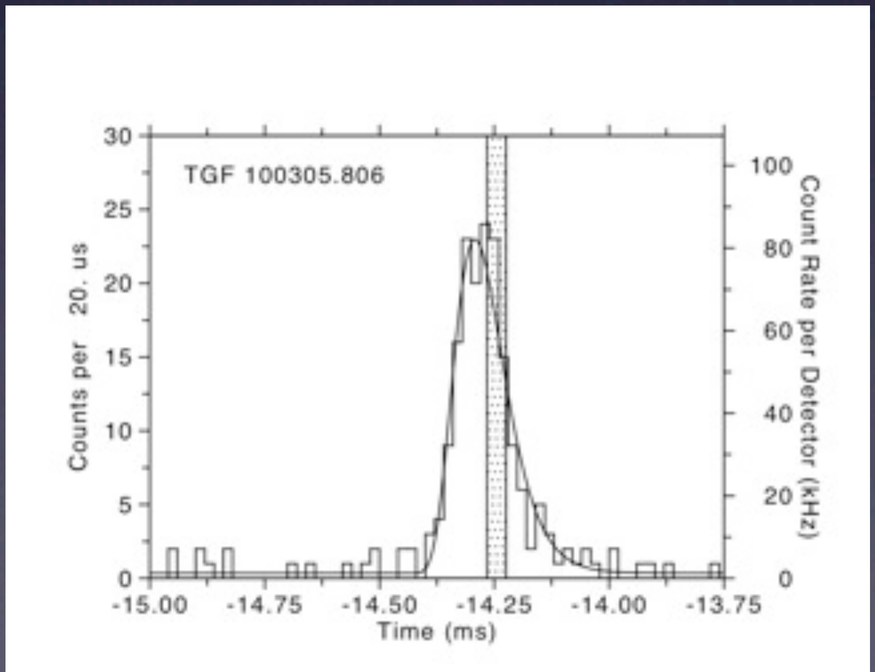


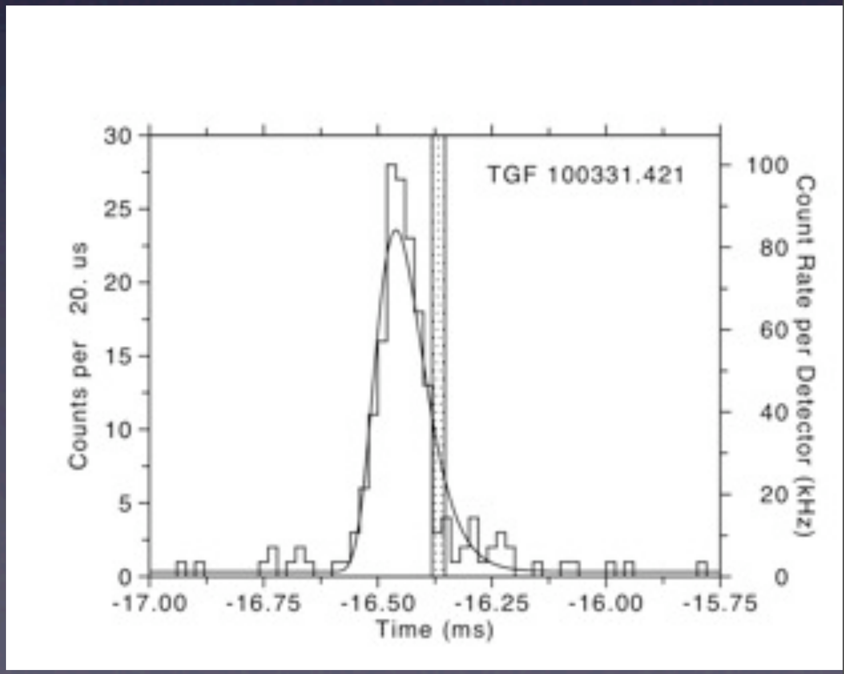




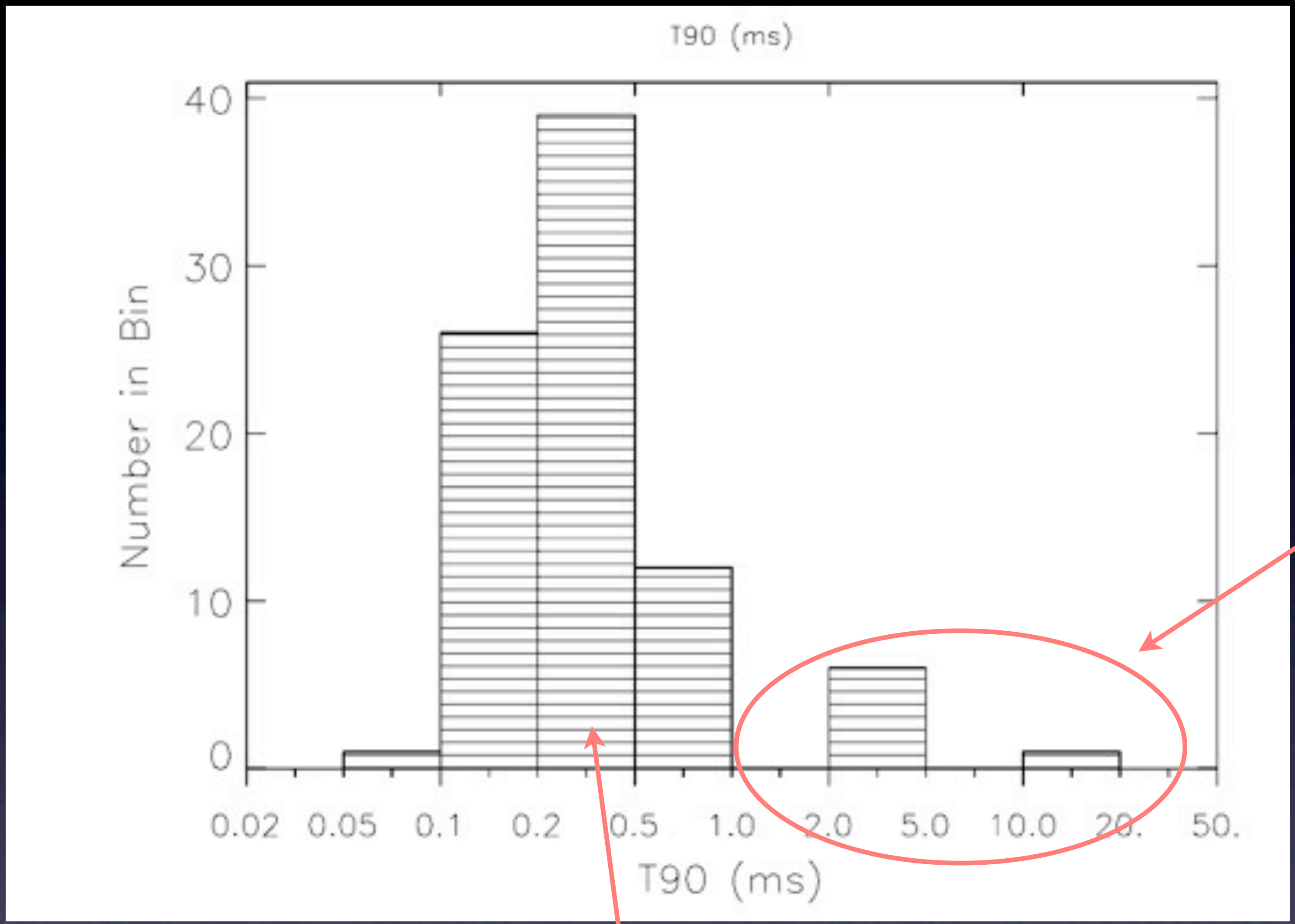
Connaughton et al. 2010, JGR ,11512307C.







TGF Pulse Durations

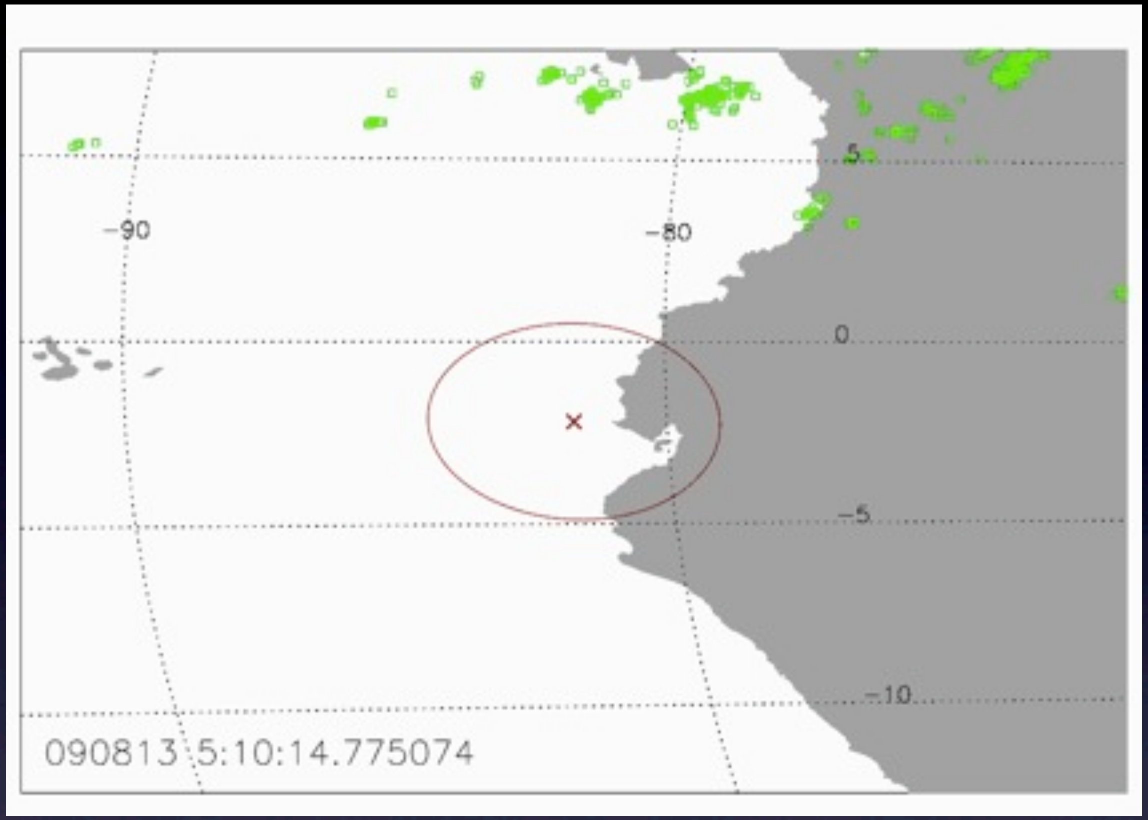


Long TGF pulses = electron events.

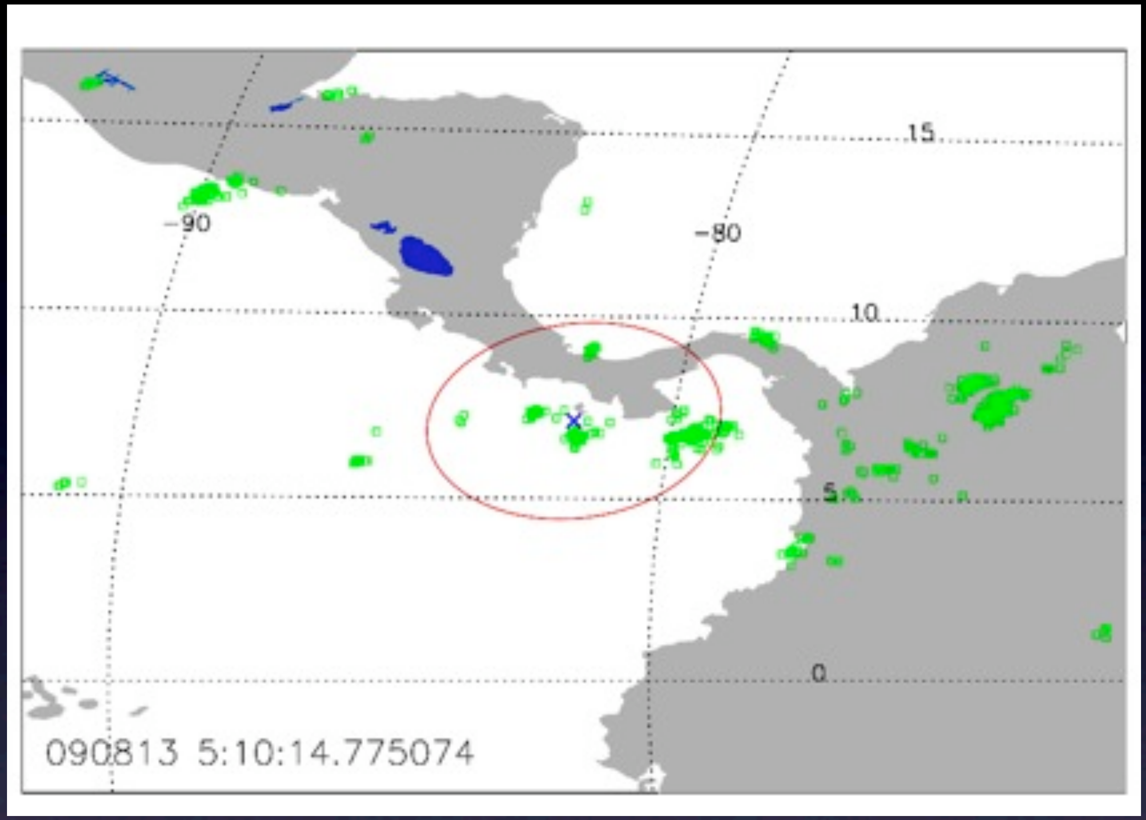
Short TGF pulses = gamma-ray events.

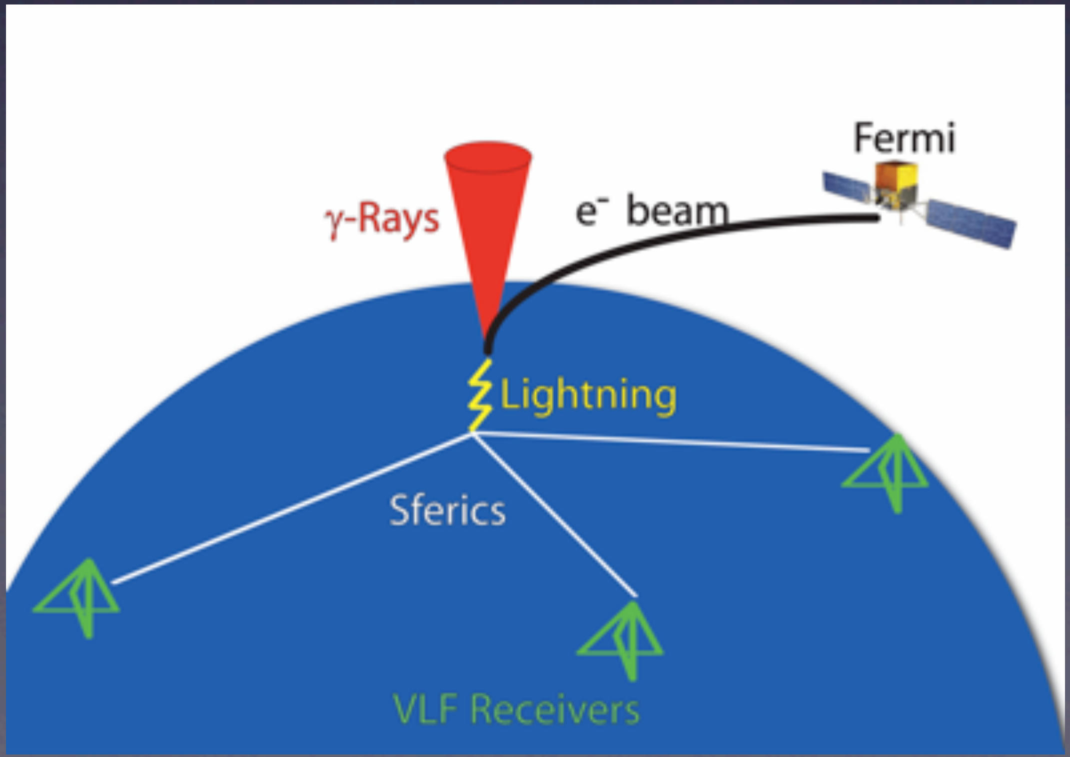
Storm systems for long TGFs?

Sub-spacecraft

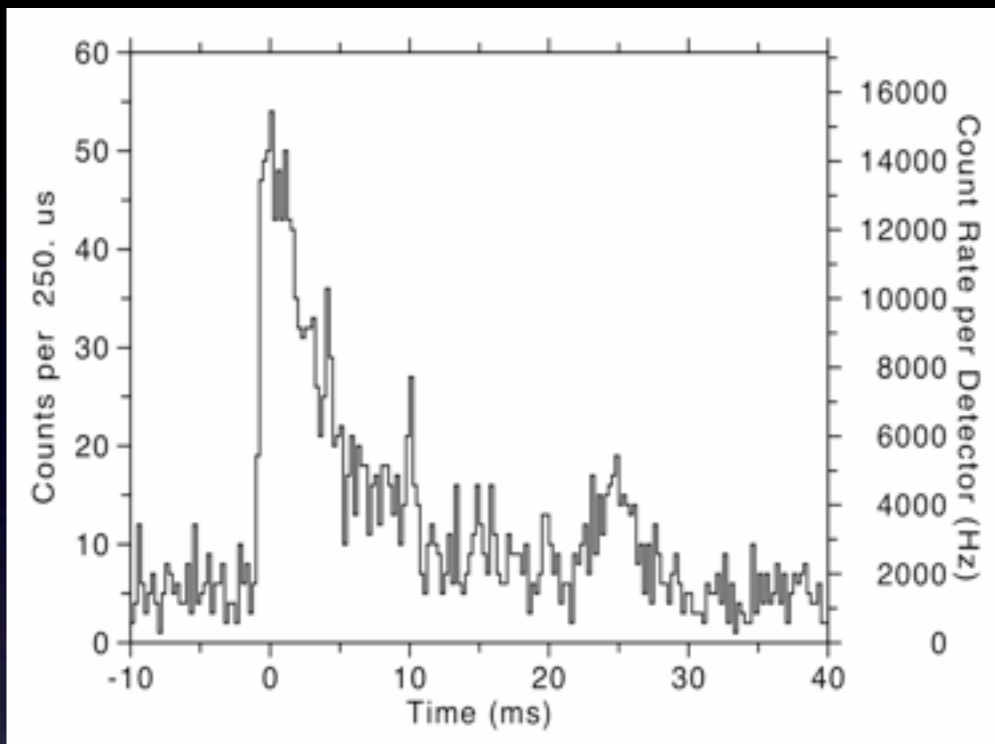


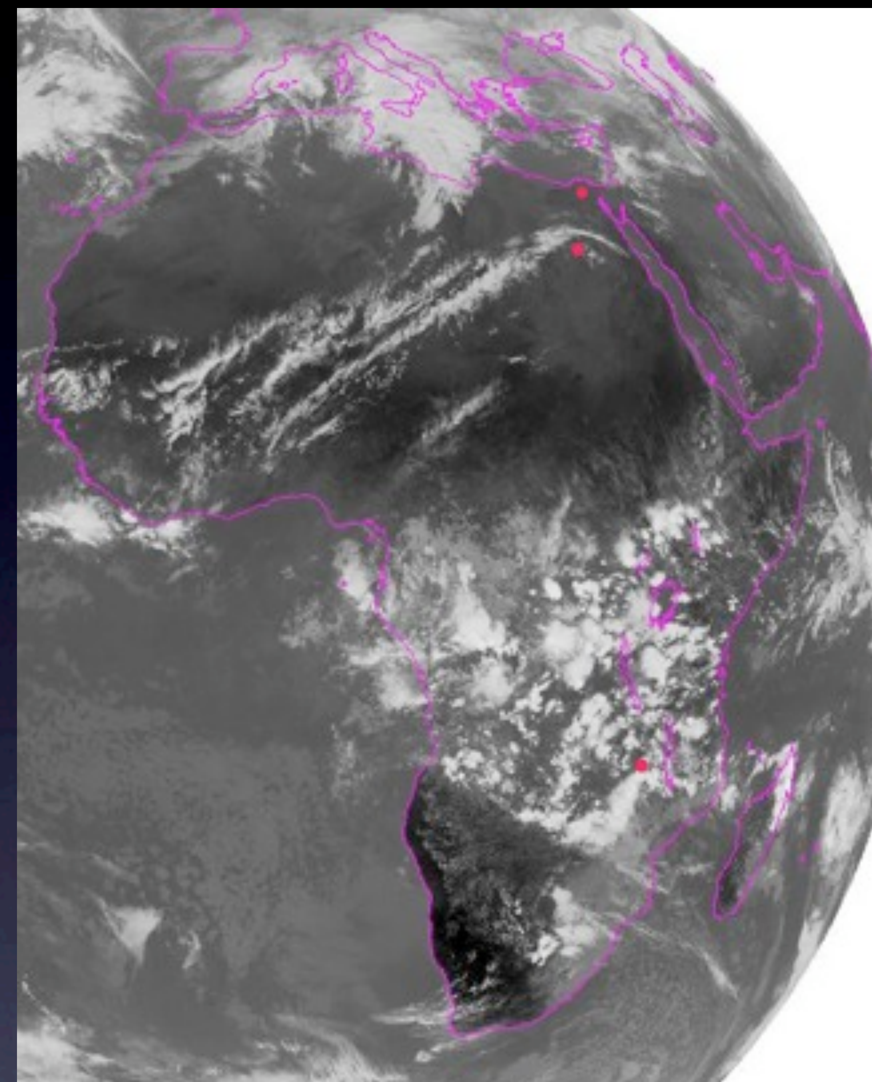
Magnetic footprint

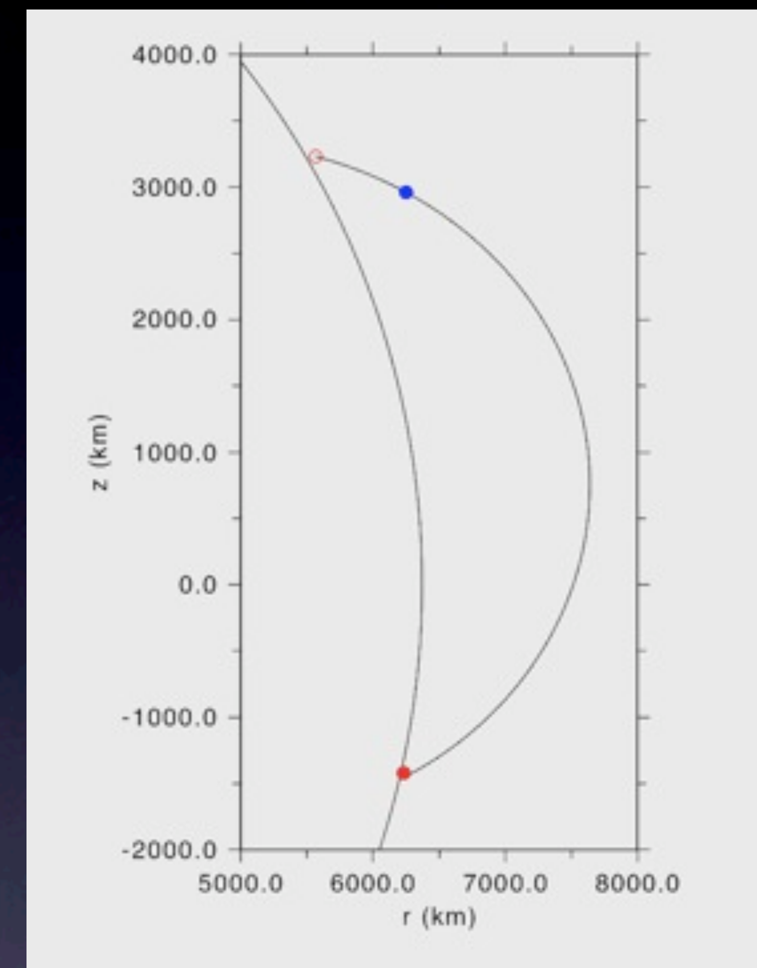


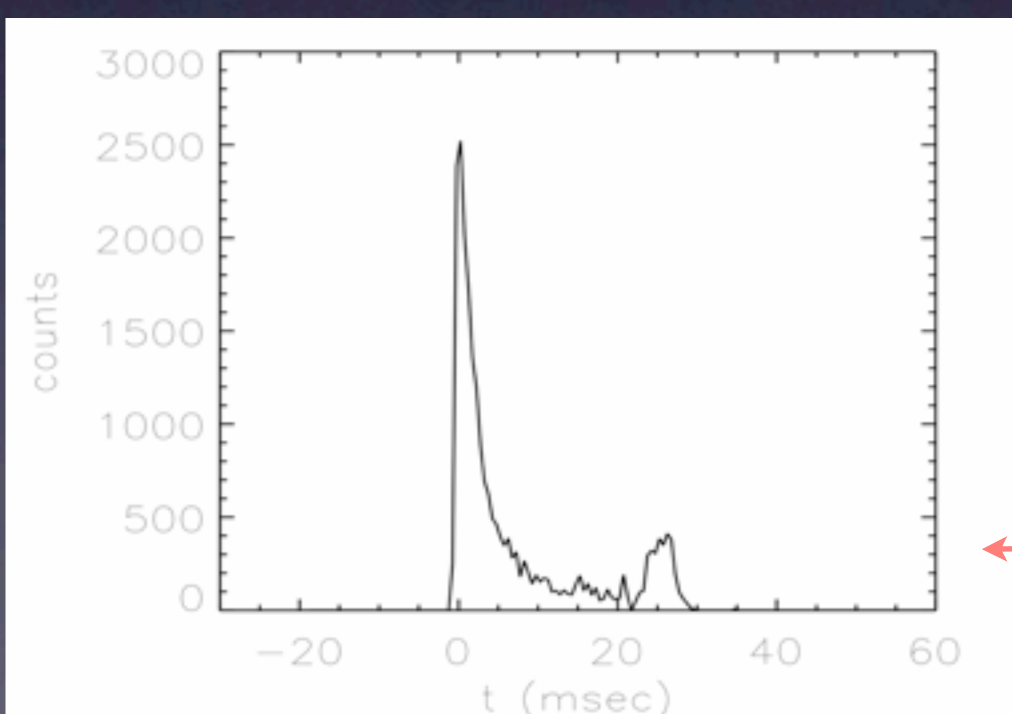


Magnetic mirroring in TGF 091214



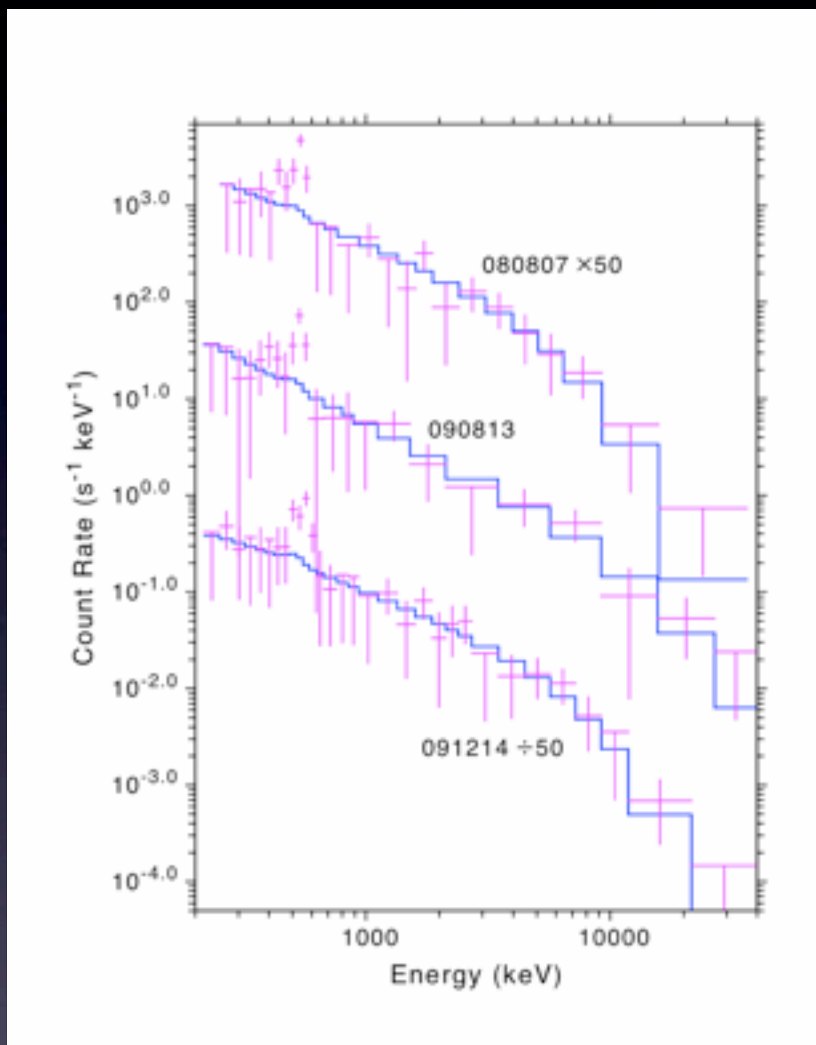




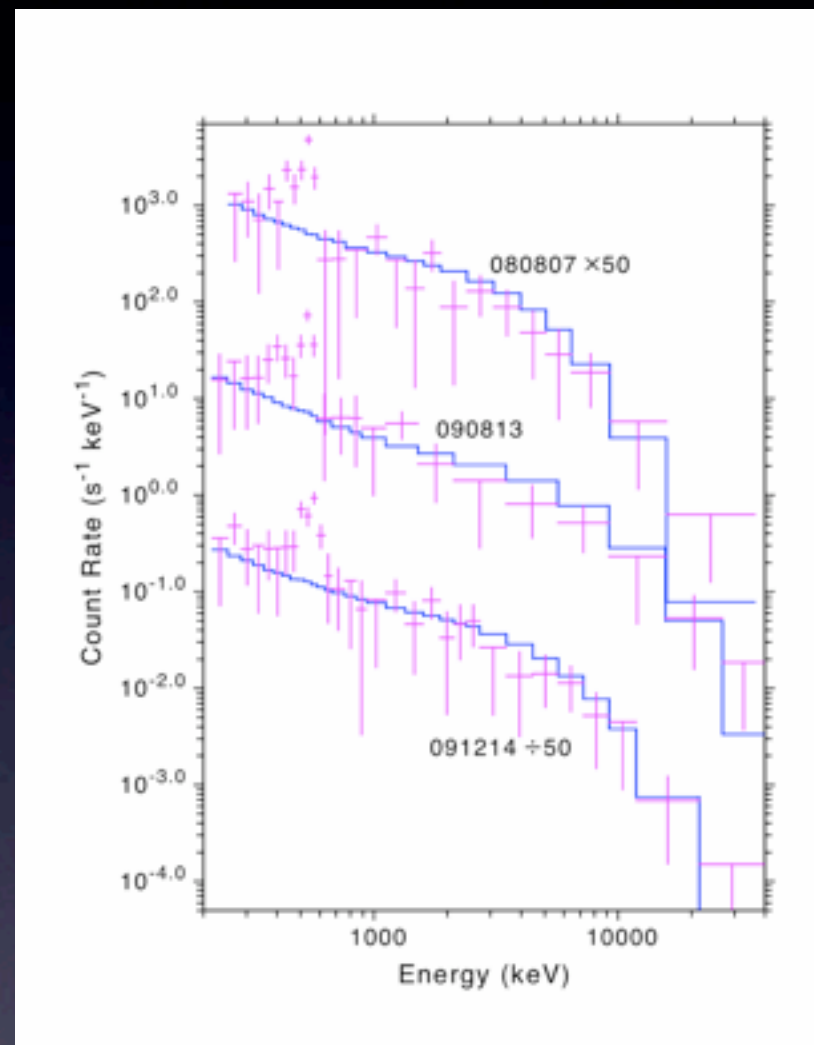


Simulation from Joe Dwyer.

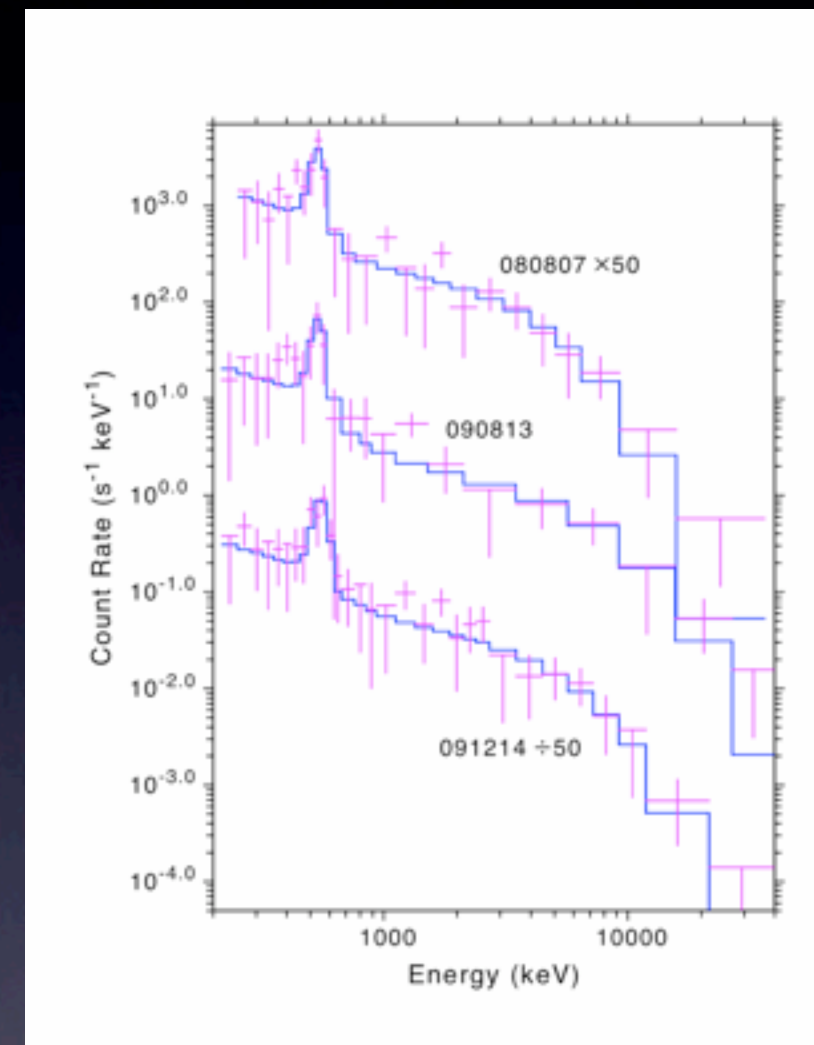
Electron event spectra



Photon response



Electron response

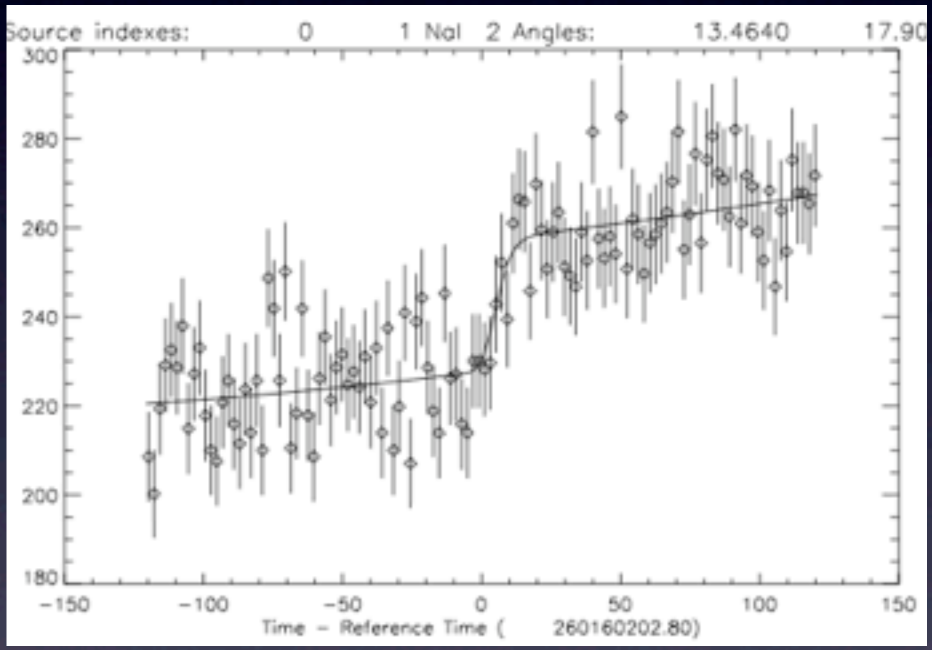


Electrons and positrons

Briggs et al. 2011, GRL, 3802808B

"Background" Investigations

- Earth Occultation Technique: Every orbit, sources hide behind and rise from the Earth's limb when viewed from Fermi. Can we measure the contribution these sources make to the rates measured in the GBM detectors?
All-Sky Earth Occultation Observations with the Fermi GBM, Wilson-Hodge et al., arXiv0912.3831. http://gammaray.nsstc.nasa.gov/gbm/science/occultation



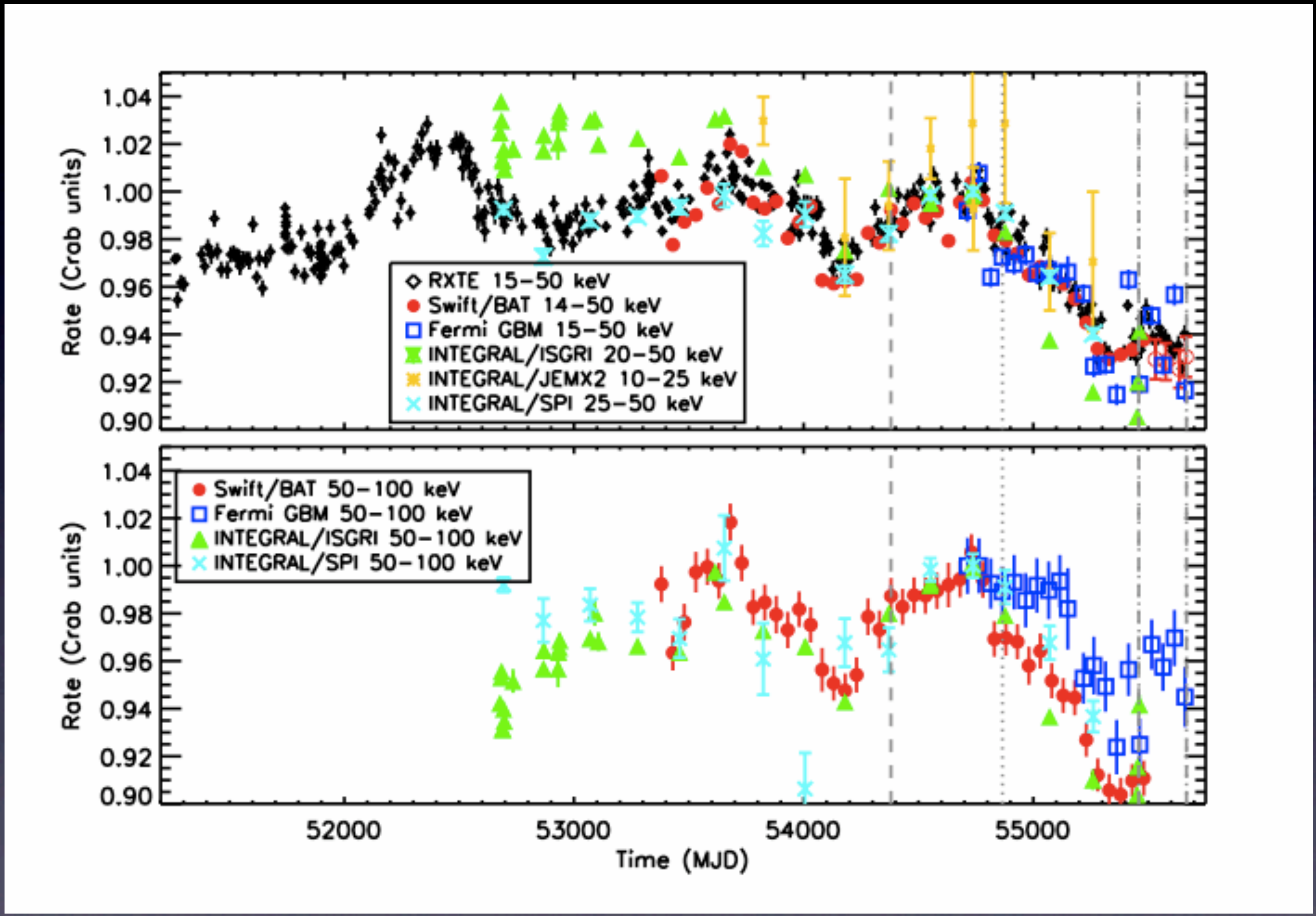
- Pulsars: By fitting and subtracting the obvious trends in the GBM data, including bright source occultations, and excluding periods of obvious "noise" (triggers!), can we measure in the residuals the temporal signature of expected and new pulsars? http://gammaray.nsstc.nasa.gov/gbm/science/pulsars
Long-term Monitoring of Accreting Pulsars with Fermi GBM, Finger et al., arXiv0912.3847.

For those interested in GBM analysis...

- Our data are PUBLIC
  - http://fermi.gsfc.nasa.gov/ssc/data/access/
- Our software is PUBLIC:
  - http://fermi.gsfc.nasa.gov/ssc/data/analysis/user/ rmfit + tutorial.
  - Look for an update next week!

BACKUPS

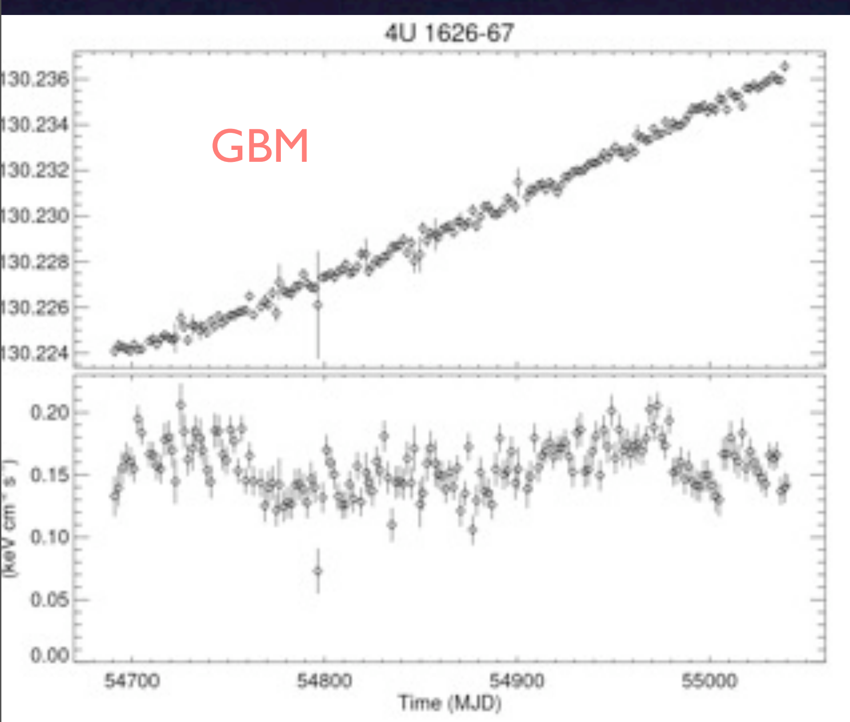
Crab flux over time



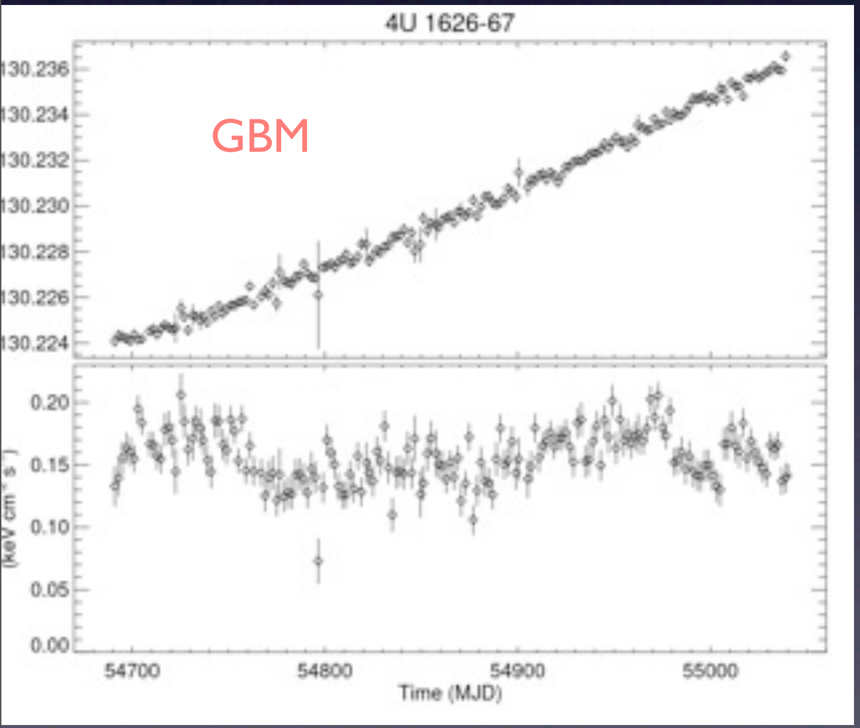
Wilson-Hodge et al. 2011, ApJ, 727, 40.

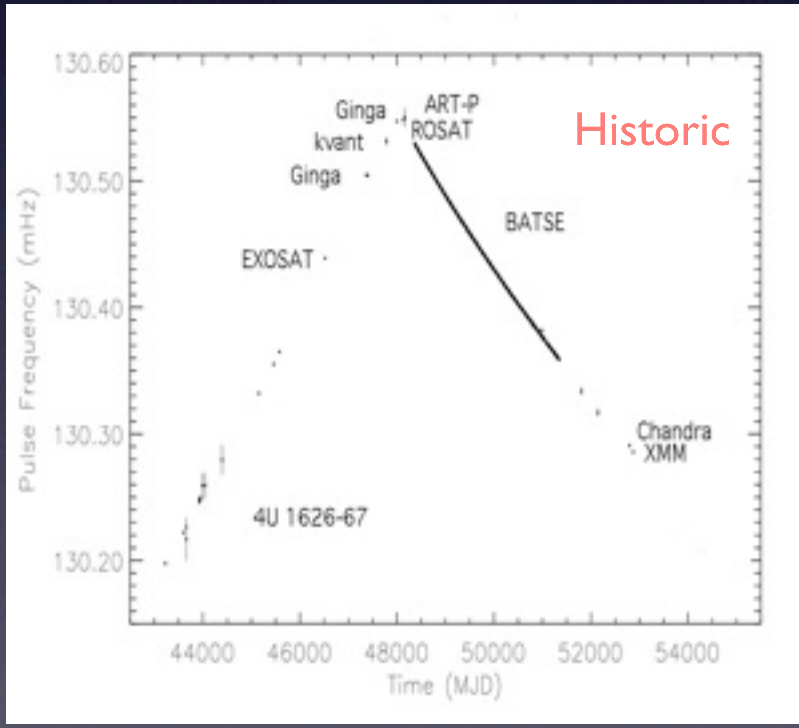
GBM Pulsar Results

- Search for pulsars from 1 mHz -- 2 Hz in CTIME data.
- Several seen routinely: 4U 1626-67, Cen X-3, OAO 1657-415, GX 1+4, Vela X-2, GX 301-2.
- Several seen in outburst: EXO 2030+375, A 0535+6, A 1118-615.

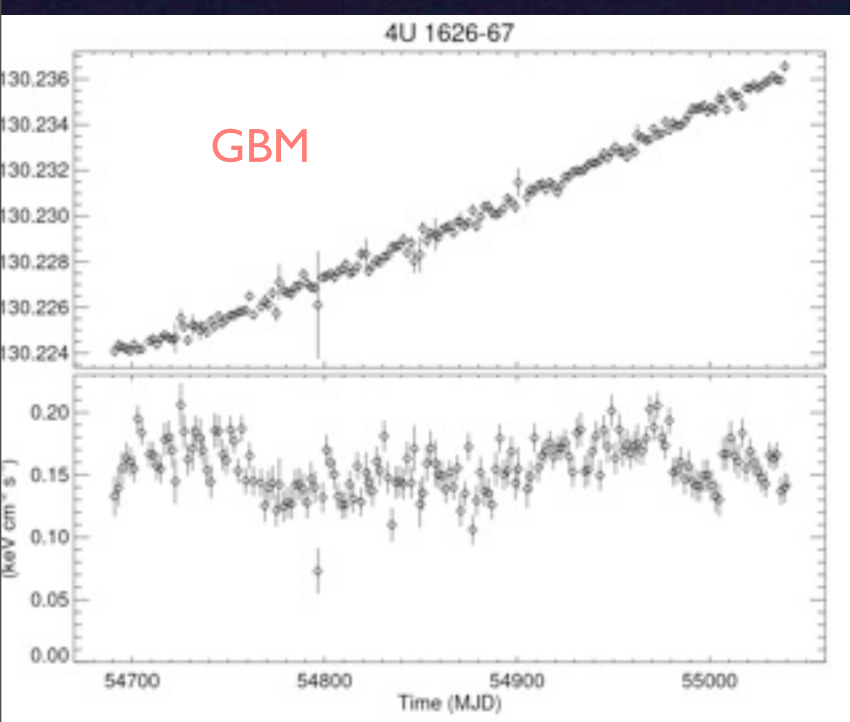


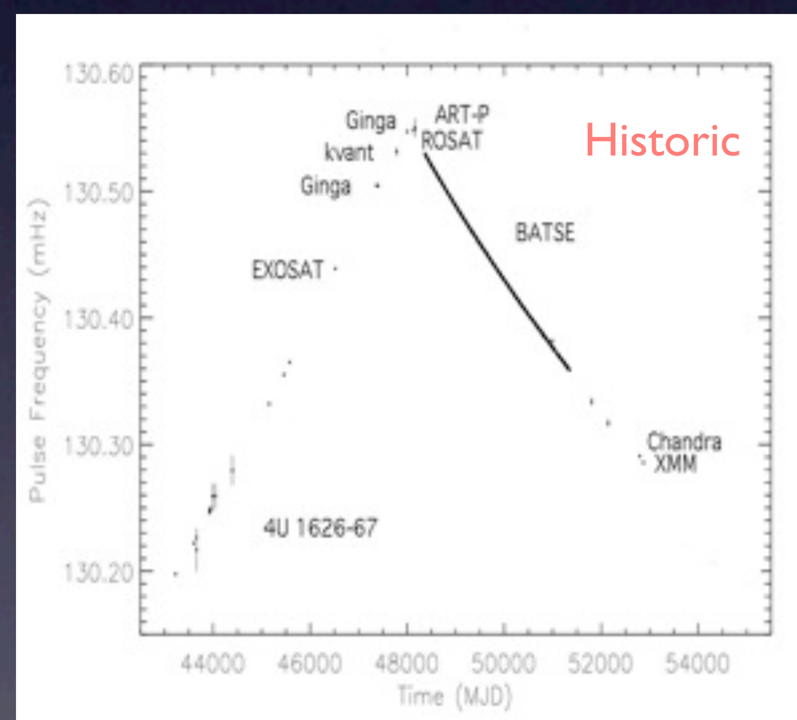
GBM Pulsar Results

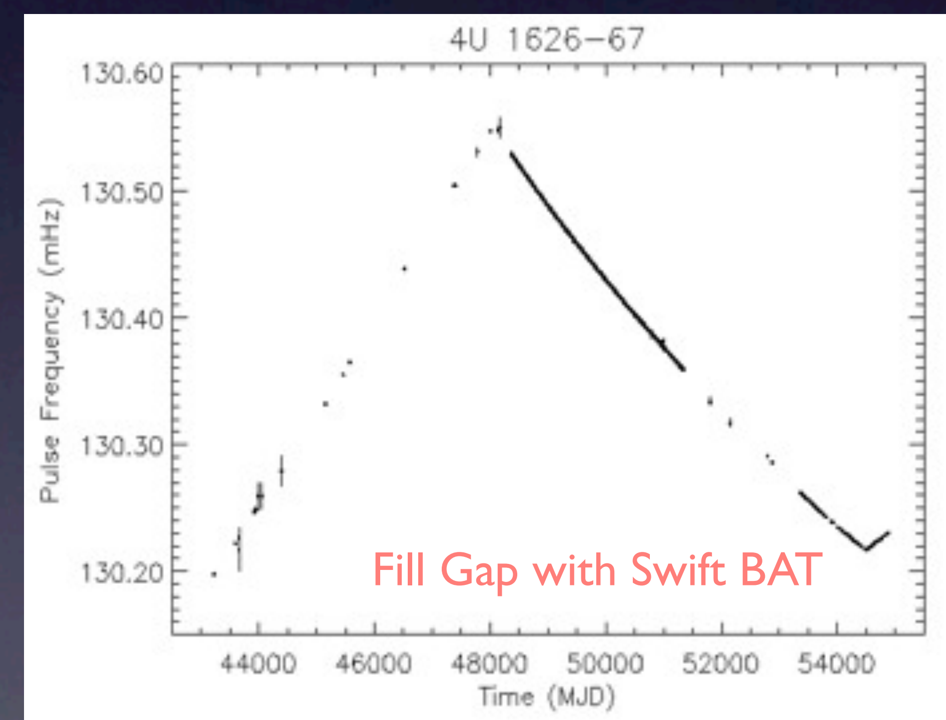




GBM Pulsar Results







Camero-Arranz et al. 2010, ApJ, 708, 1500.