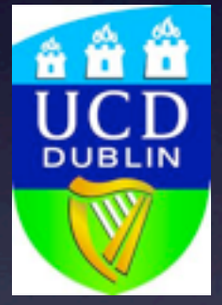
# Fermi Gamma-ray Burst Monitor Science Highlights








Sheila McBreen for the GBM Team

# Gamma-Ray Burst Monitor (GBM) on Fermi

The Large Area Telescope (LAT)

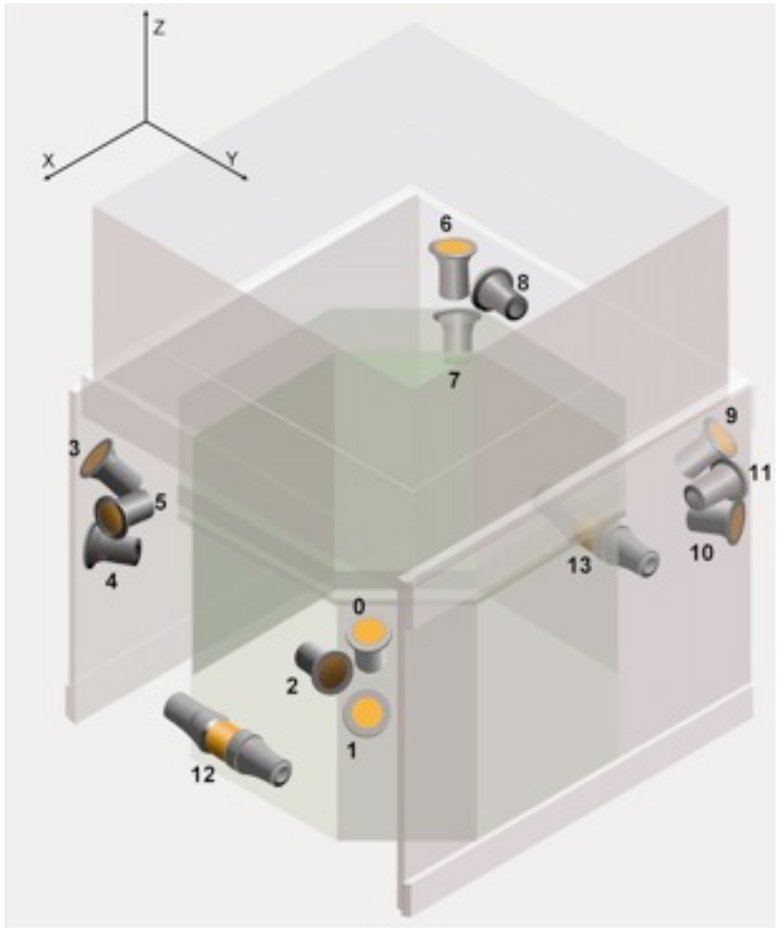
**BGO detector.**
200 keV -- 40 MeV
126 $cm^2$, 12.7 cm
Spectroscopy
Bridges gap between NaI and LAT.

**NaI detector.**
8 keV -- 1000 keV
126 $cm^2$, 1.27 cm
Triggering, localisation, spectroscopy.

http://fermi.gsfc.nasa.gov/ssc/

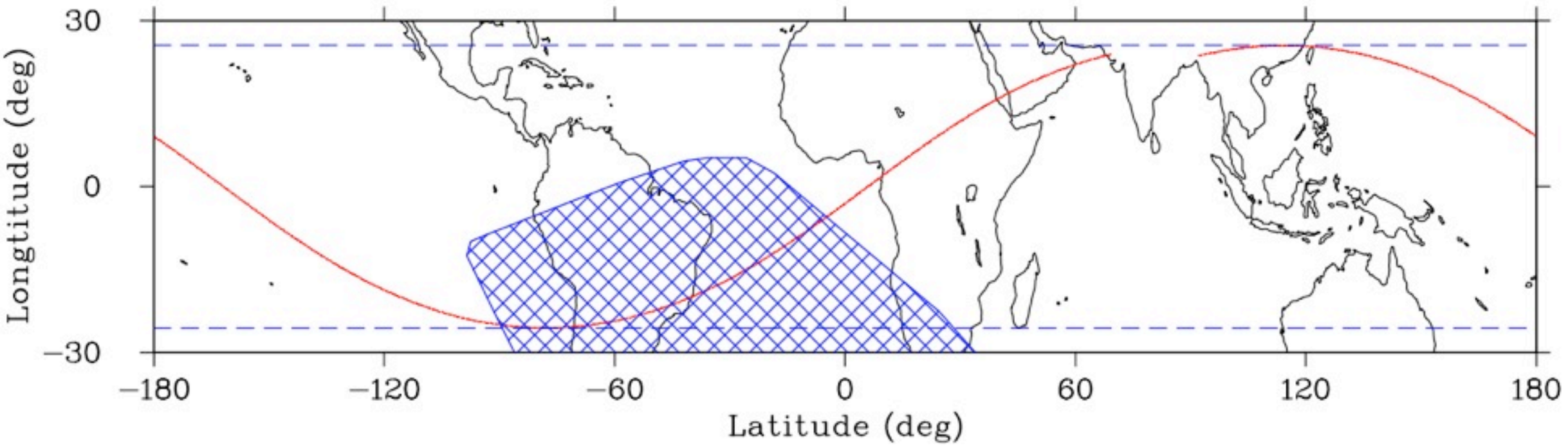
GBM Instrument: Meegan et al. 2009, ApJ, 702, 791.

# Triggering



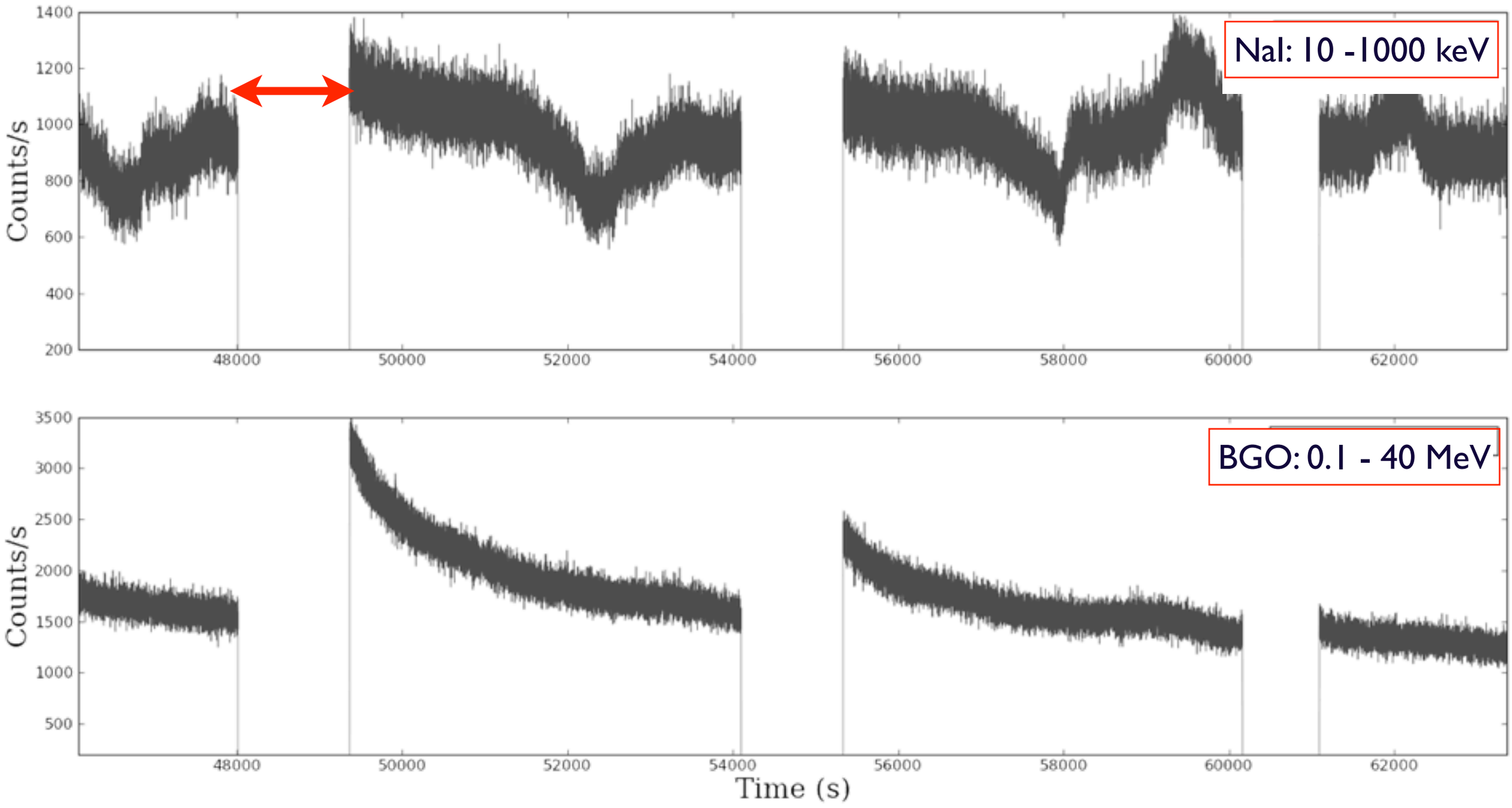

- Two or more NaI detectors require a significant rate increase to trigger.
- 119 possible and 71 enabled triggers (5 TGF specific)
- Energy: **50 - 300** , 25 - 50, > 100 keV & > 300 keV
- Timescales: 16 ms, 32 ms .... 4.096 sec
- Bayesian classification algorithm
- Automatic Repoint Requests (ARRs) sent to LAT - 61 so far for GRBs.

# Orbit

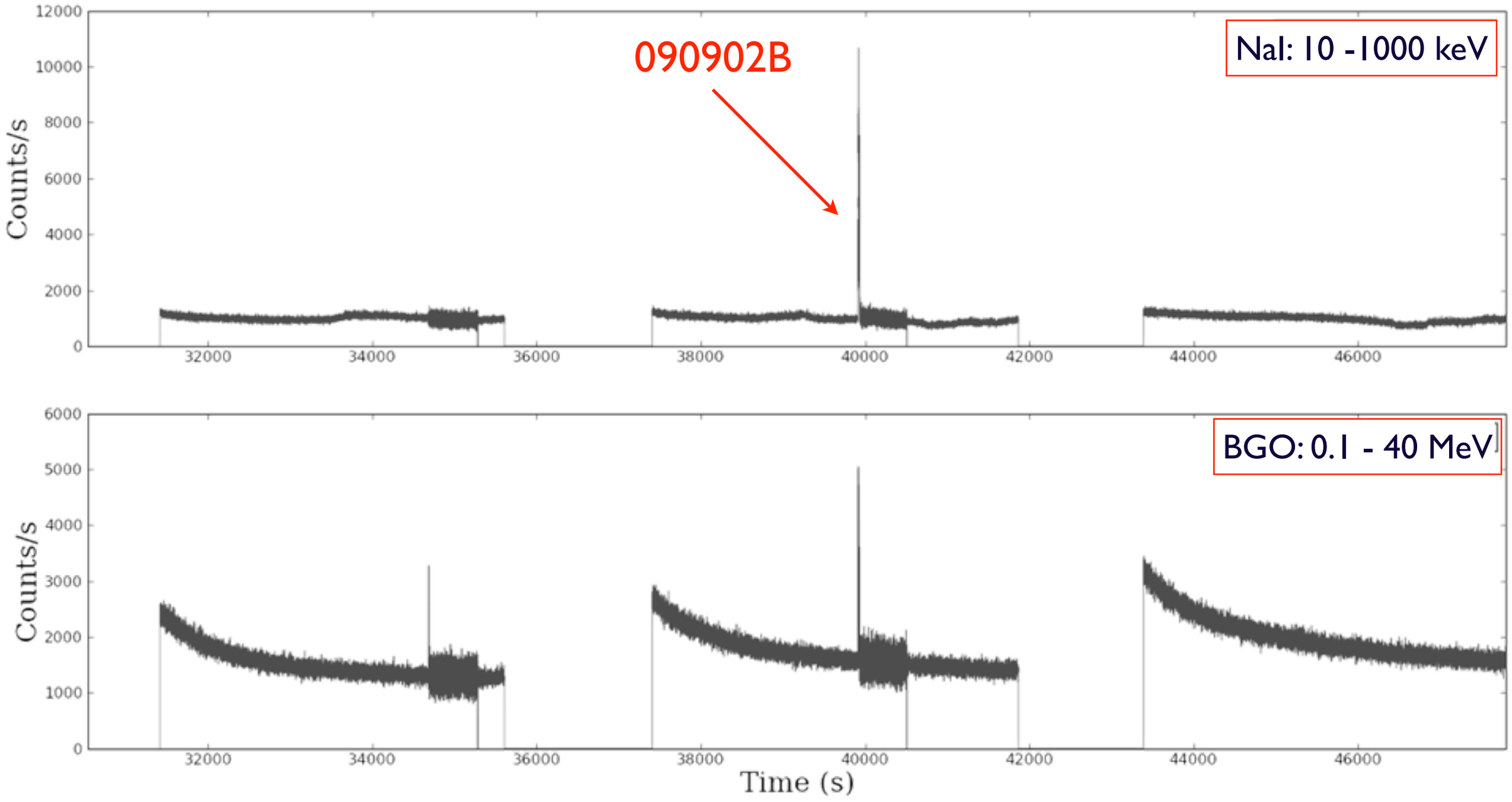


# Background rates in orbit

SAA

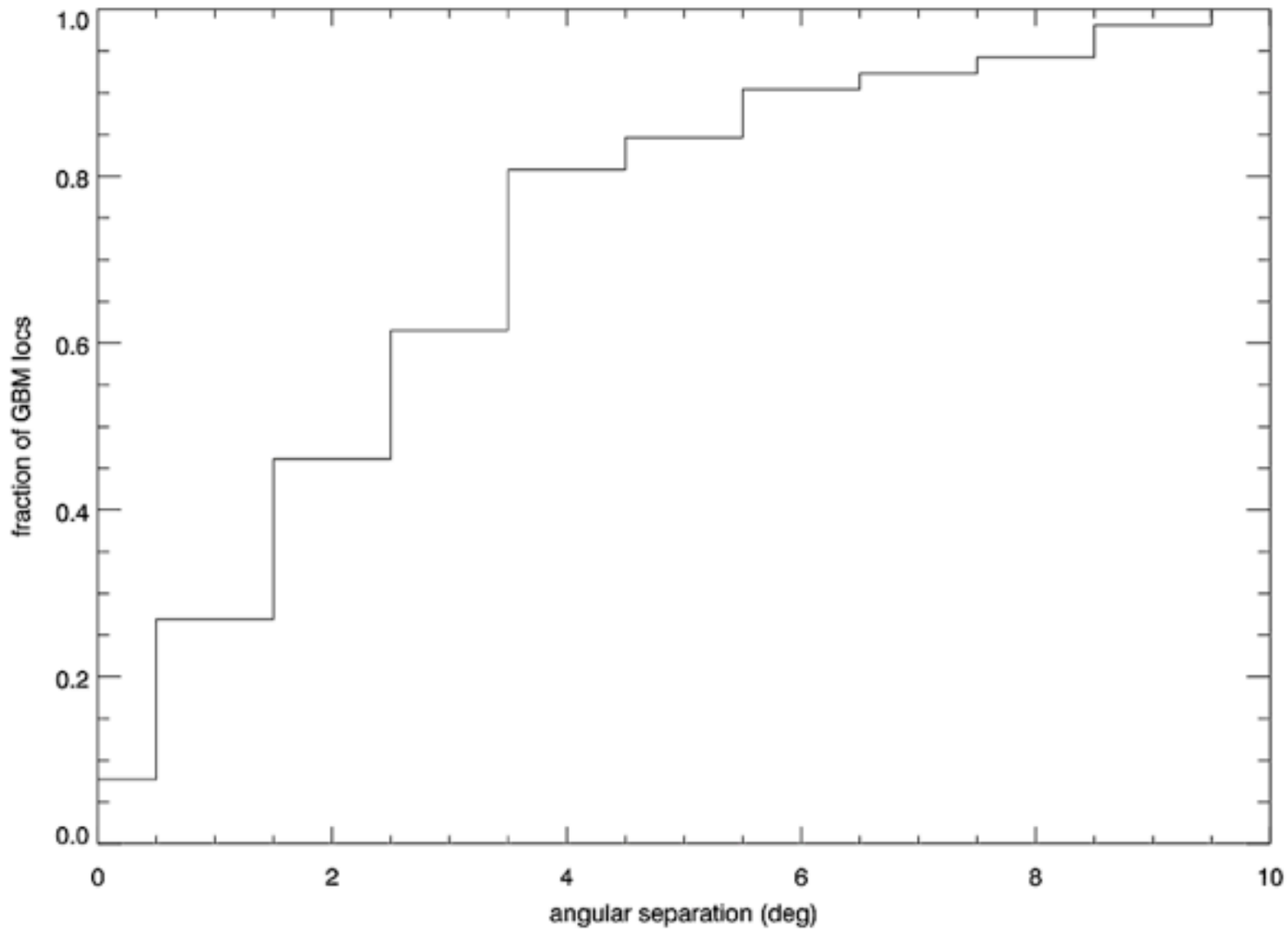


# Triggering on a GRB



# Locations from GBM

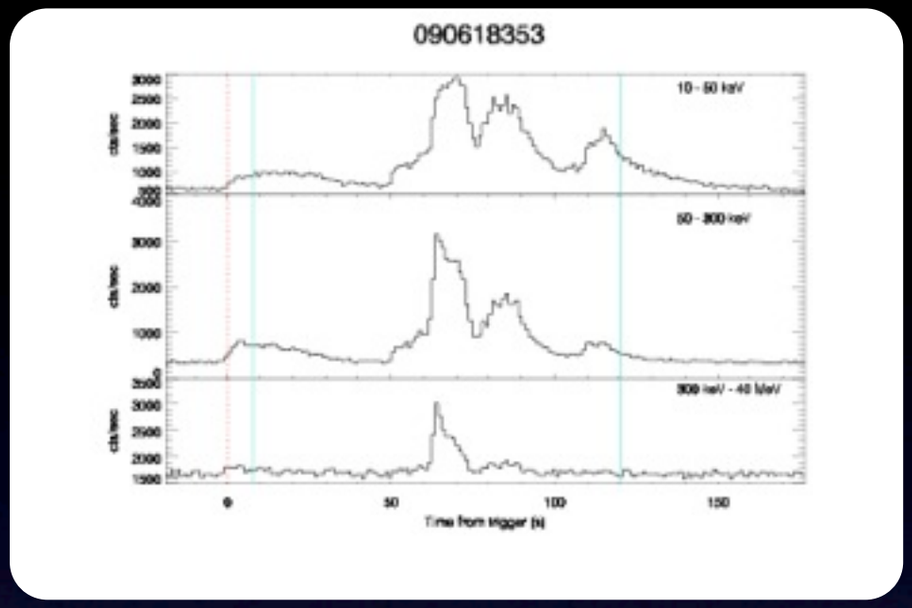
- Flight
- Ground Automated
- Final Position
- Systematic errors: 2.6° with 72% weight and 10.4° with 28% weight.




**Poster**: Hurley et al The IPN Supplement to the Fermi GBM 2-year Catalog

# Science with background-limited detectors

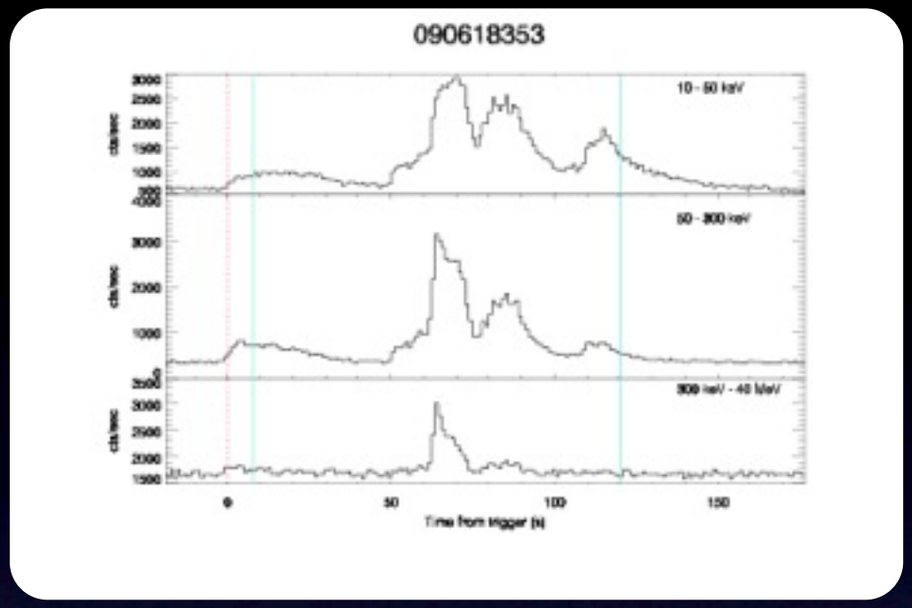
# Science with background-limited detectors




1. GRB

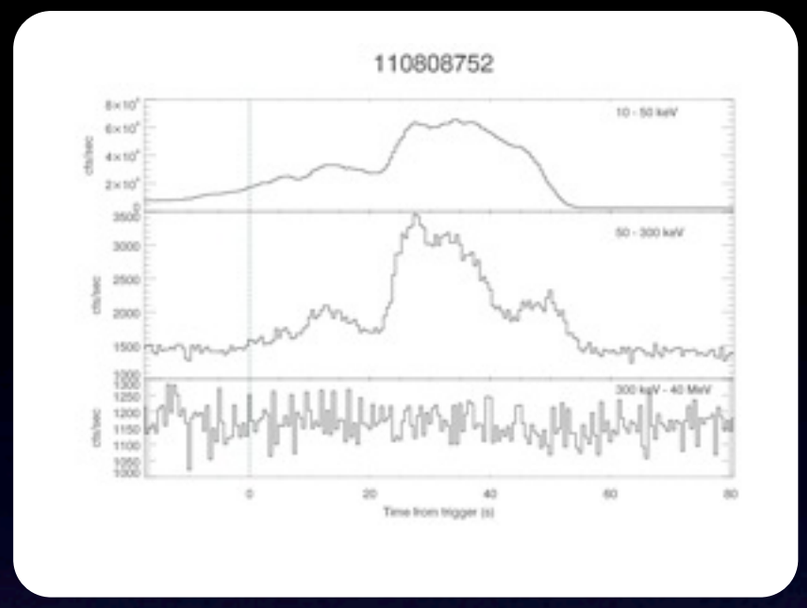
~ 100 s

# Science with background-limited detectors




1. GRB
~ 100 s

2. Solar
Flare ~ 100 s



# Science with background-limited detectors

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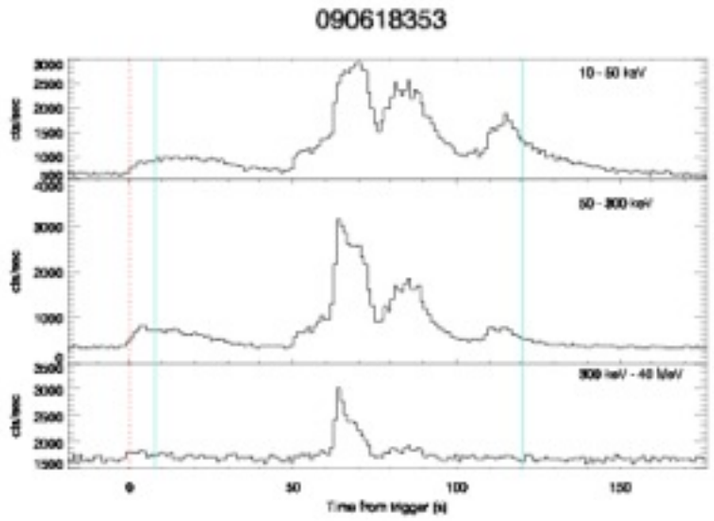
~ 100 s

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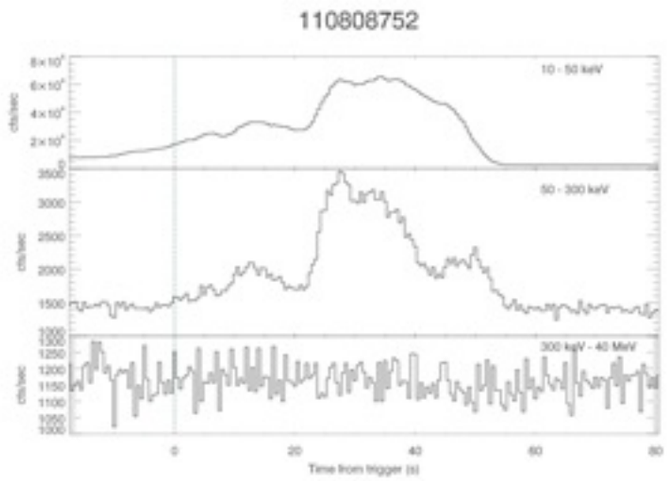
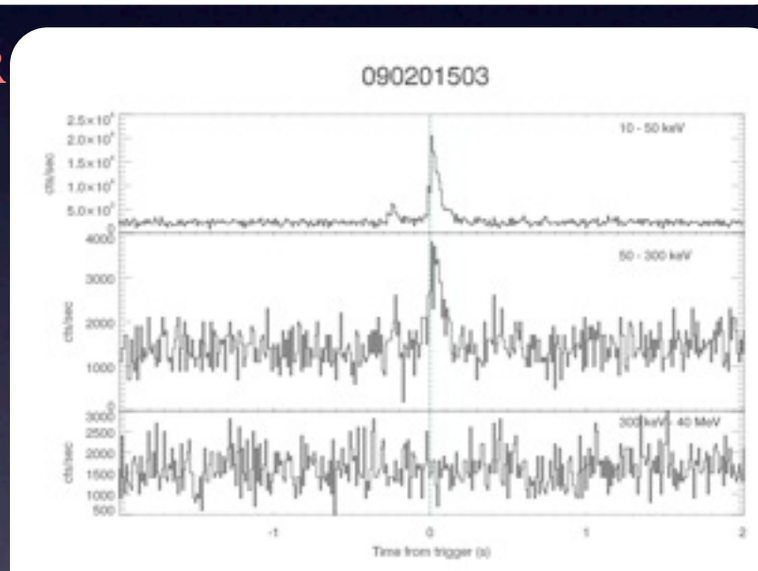



3. SGR
~ 0.1 s



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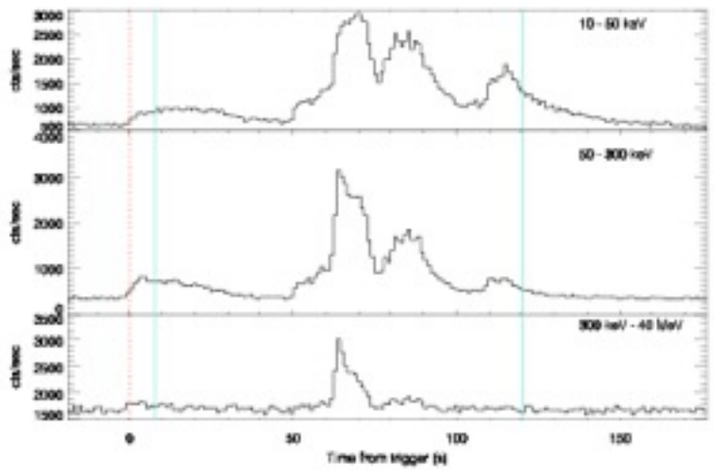


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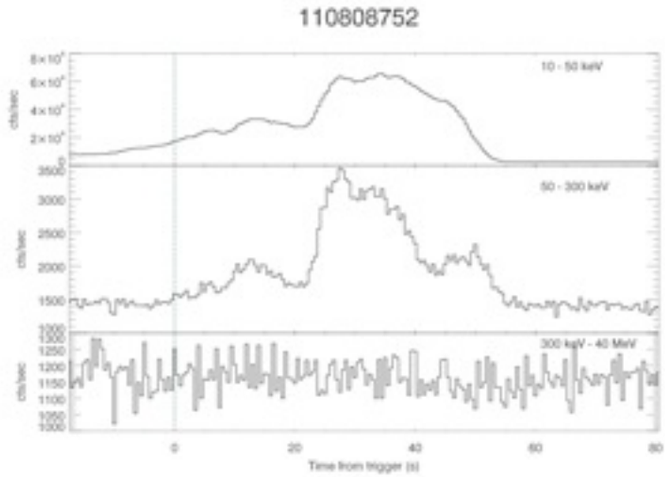


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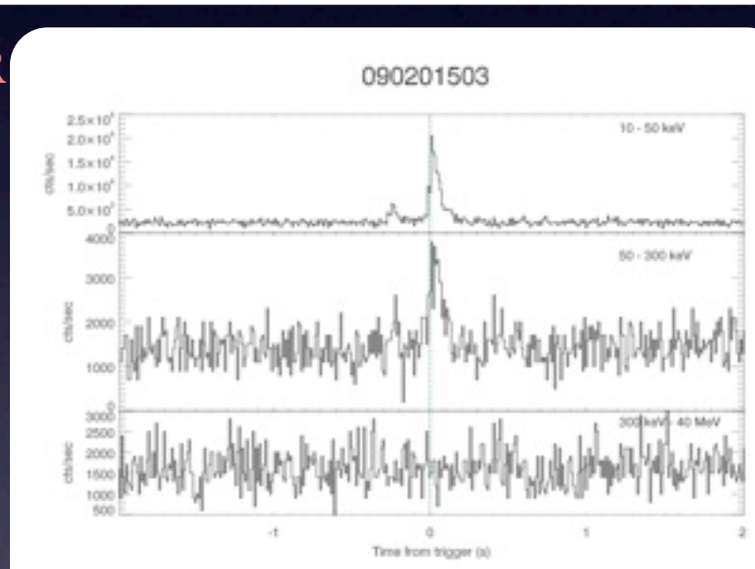
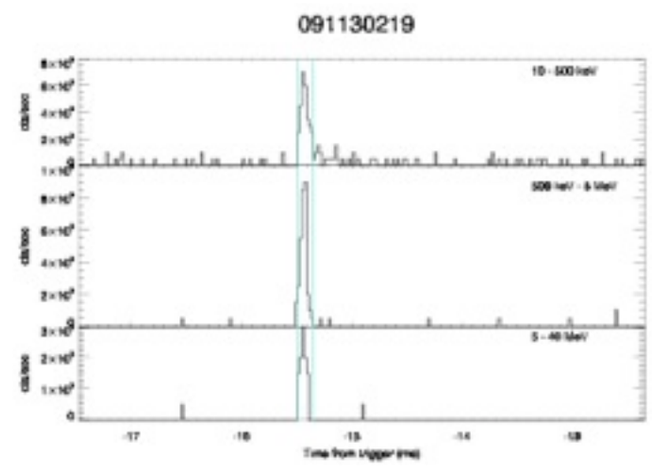



4. TGF
~ 1 ms



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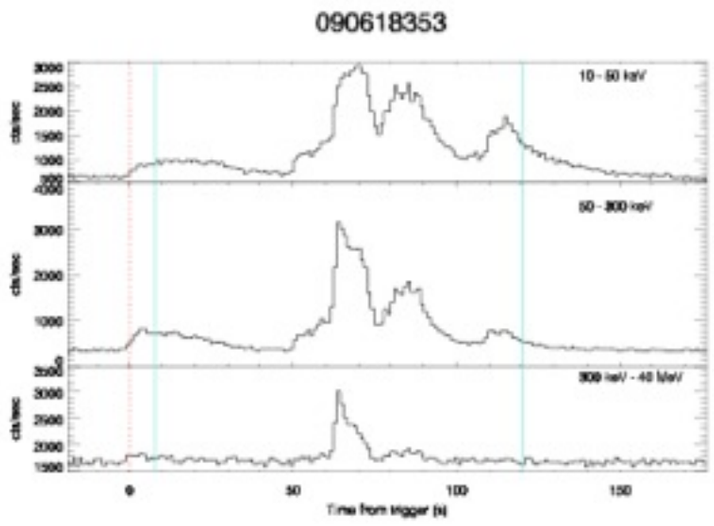


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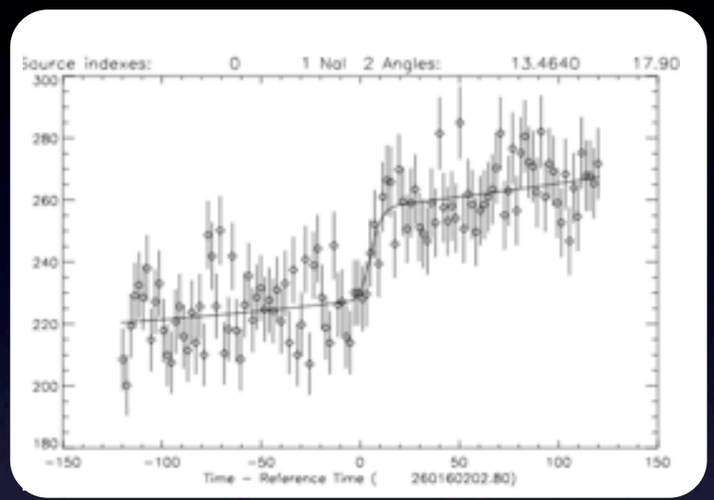
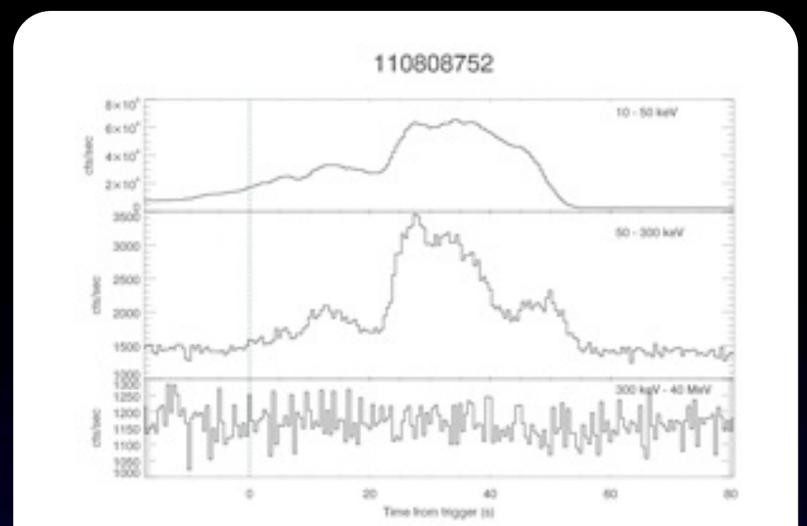
Flare ~ 100 s

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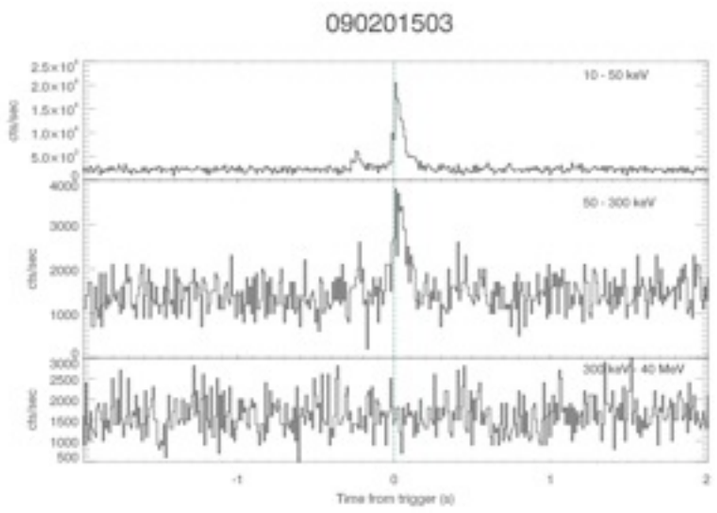


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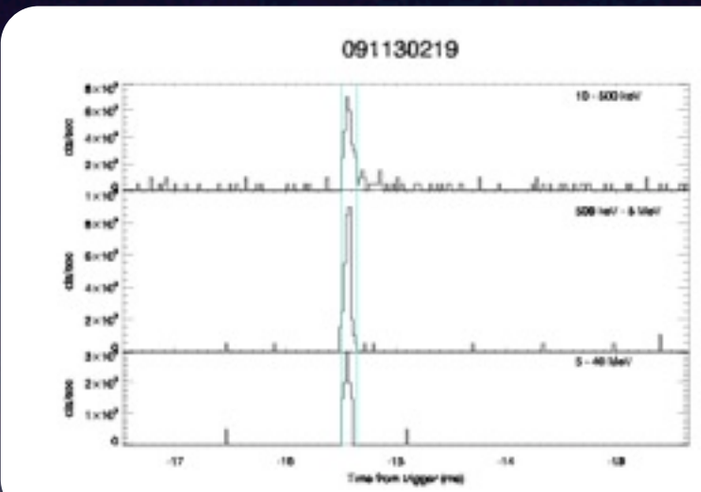
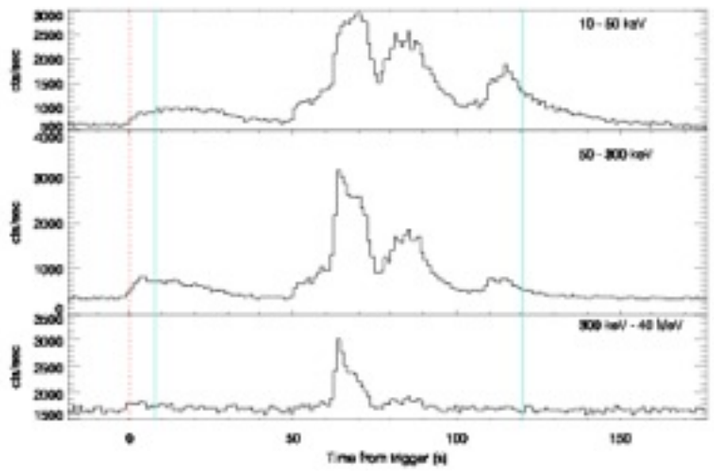
~ 1 ms



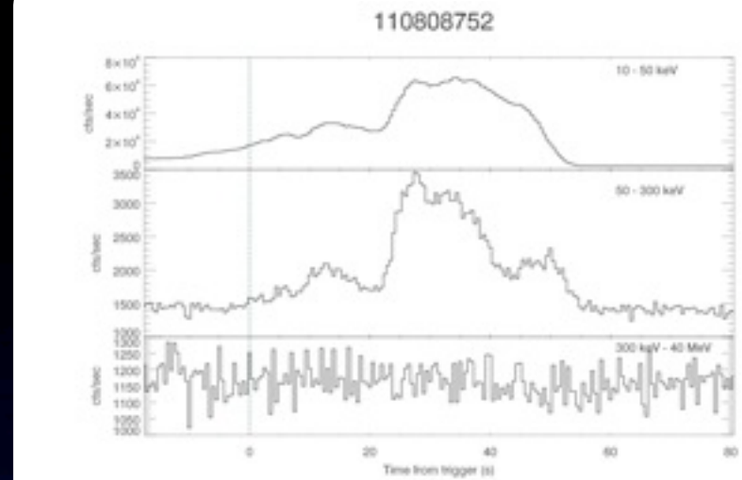

5. Occultation: 200+ monitored, 102 detected sources

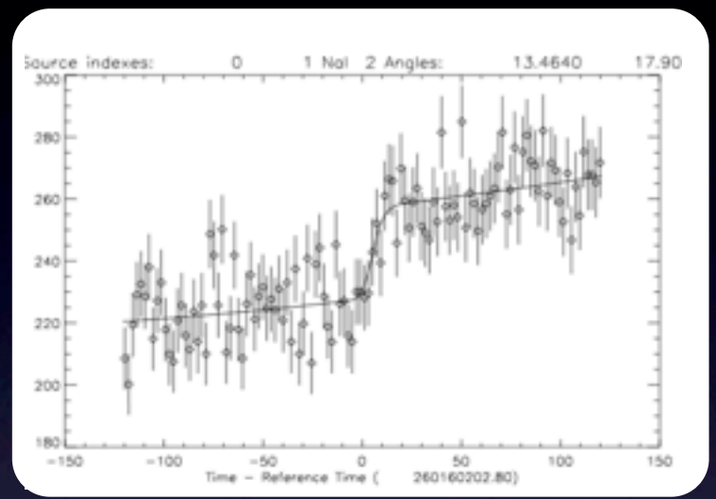
# Science with background-limited detectors

1. GRB
~ 100 s

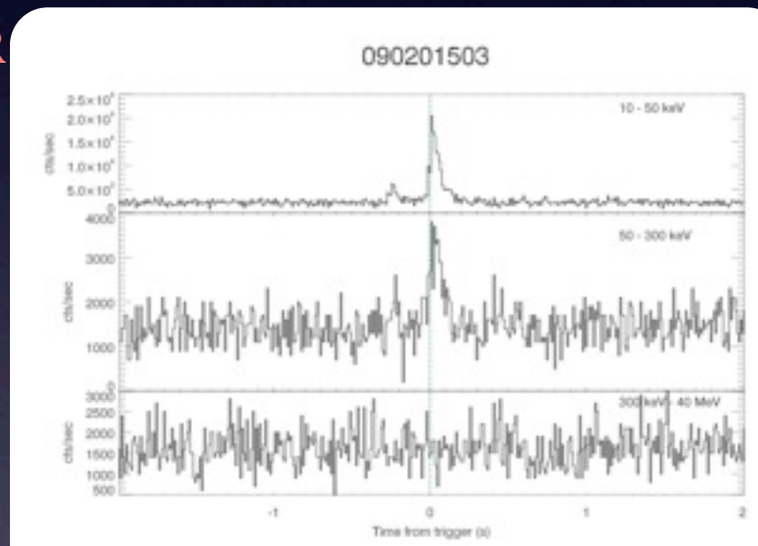



2. Solar
Flare ~ 100 s

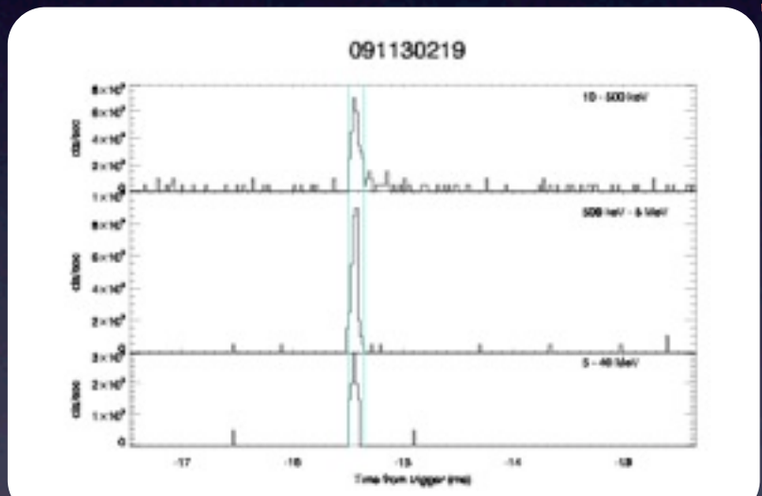



3. SGR
~ 0.1 s




4.
TGF
~ 1
ms




5. Occultation: 200+ monitored,
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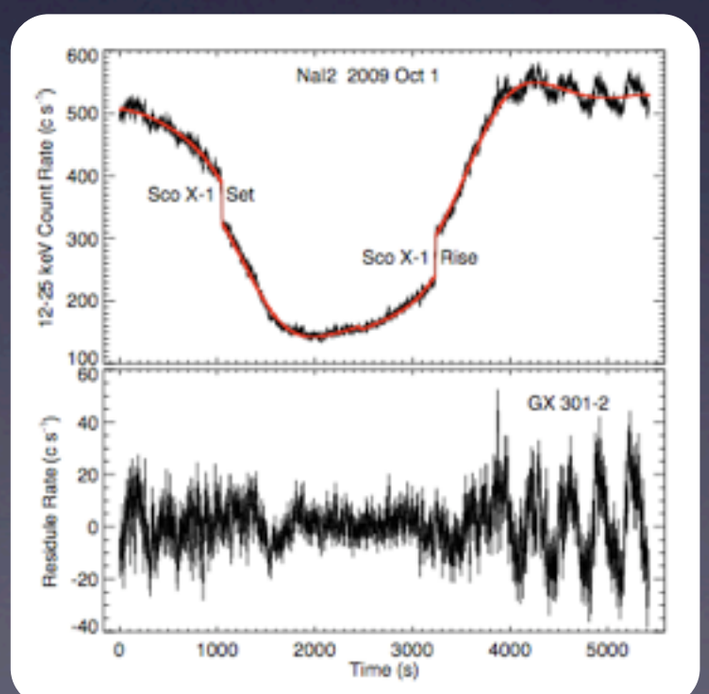
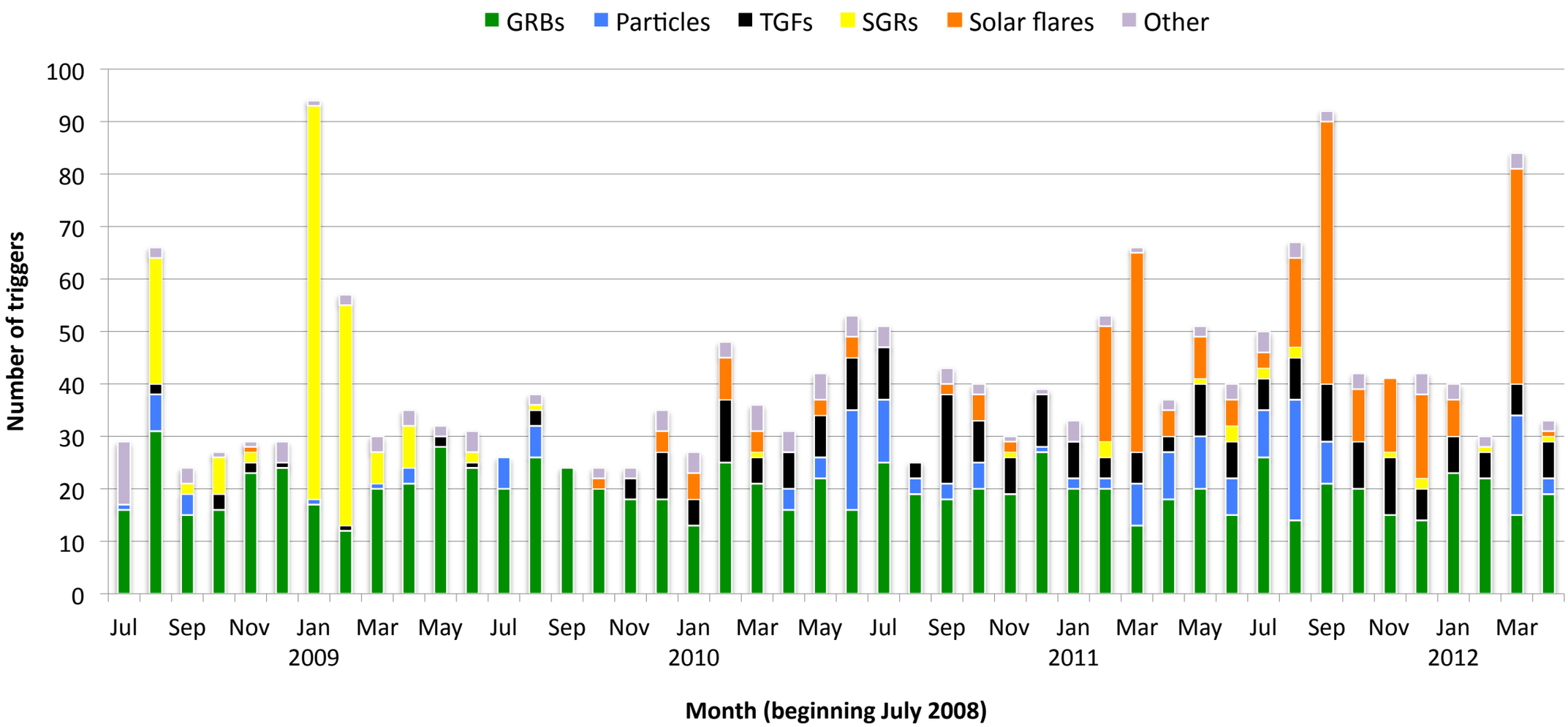



6. Pulsars: persistent
and transient.

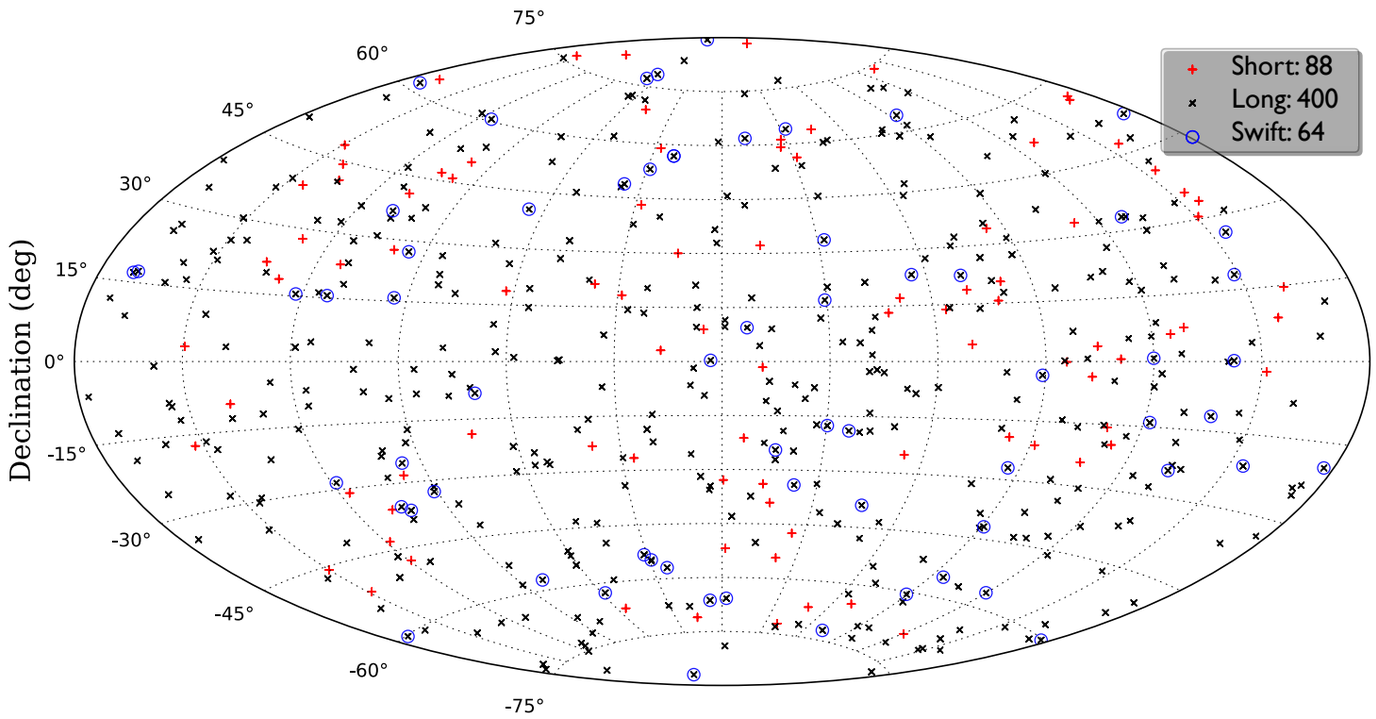
# GBM Monthly Triggers



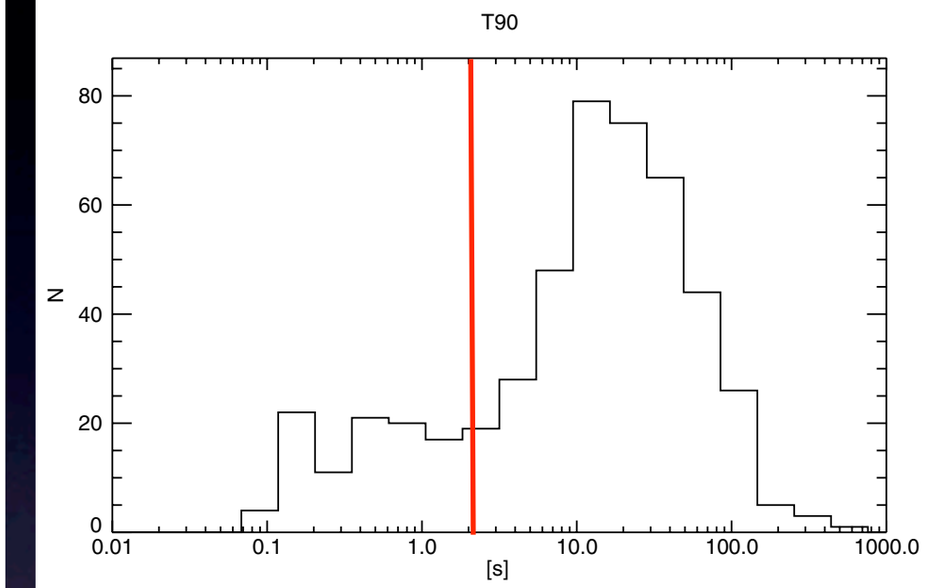

1st GBM Trigger and Spectral Catalogs

917 GRBs to date.

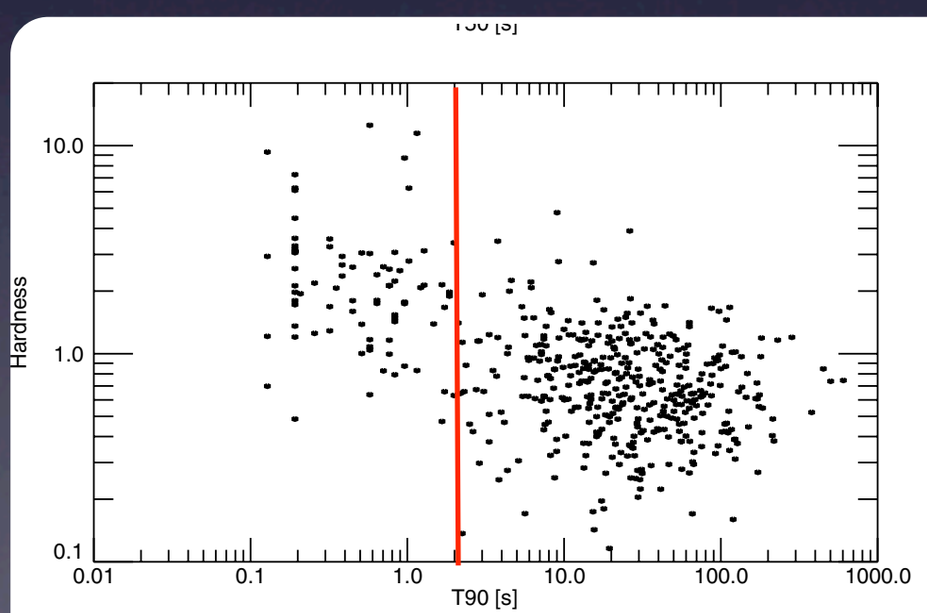
# GBM Catalog: 2 years of GRBs




## Duration distribution




## Hardness-duration relation

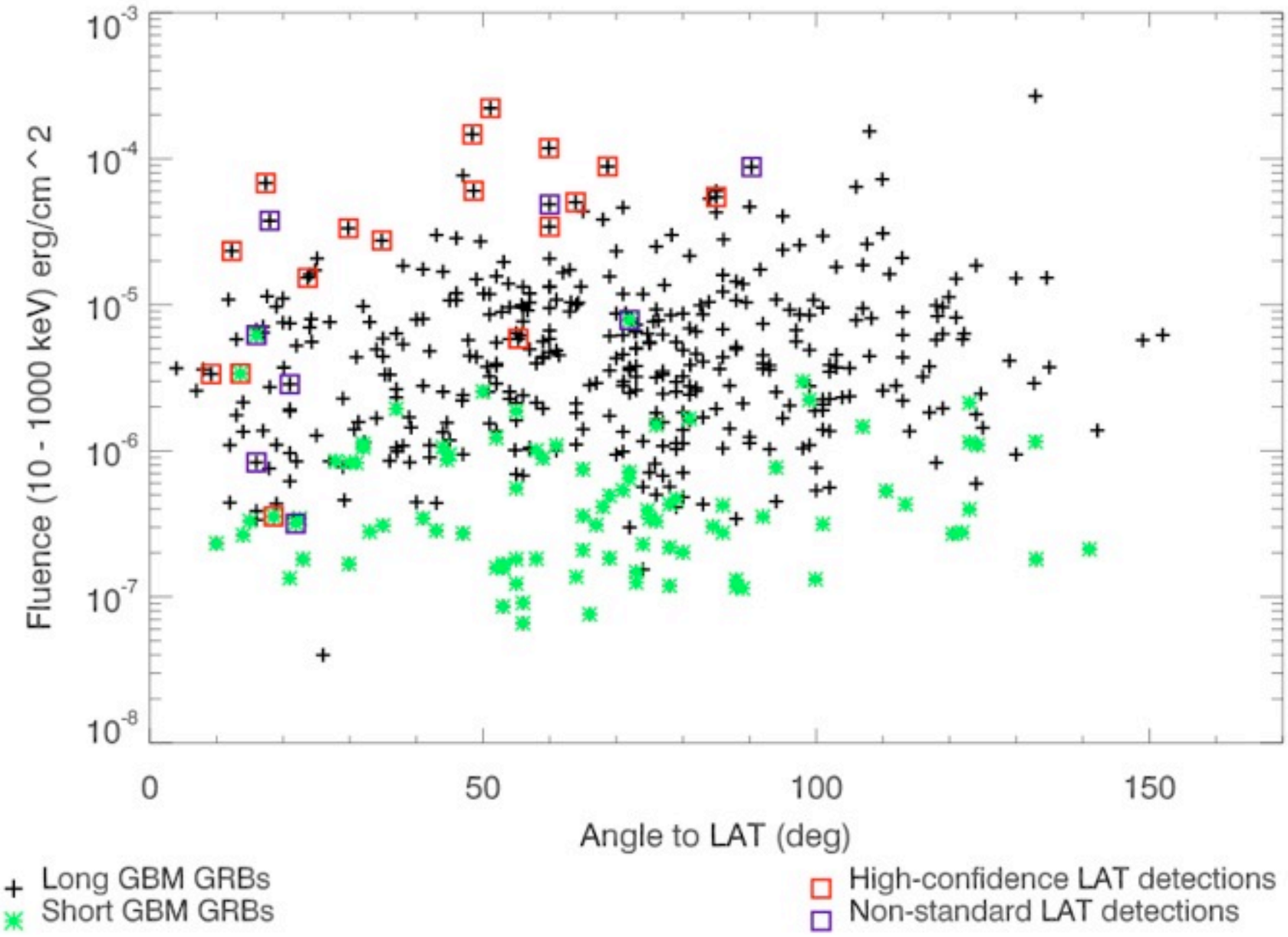



Paciesas et al, ApJSS, 199, 18, 2012

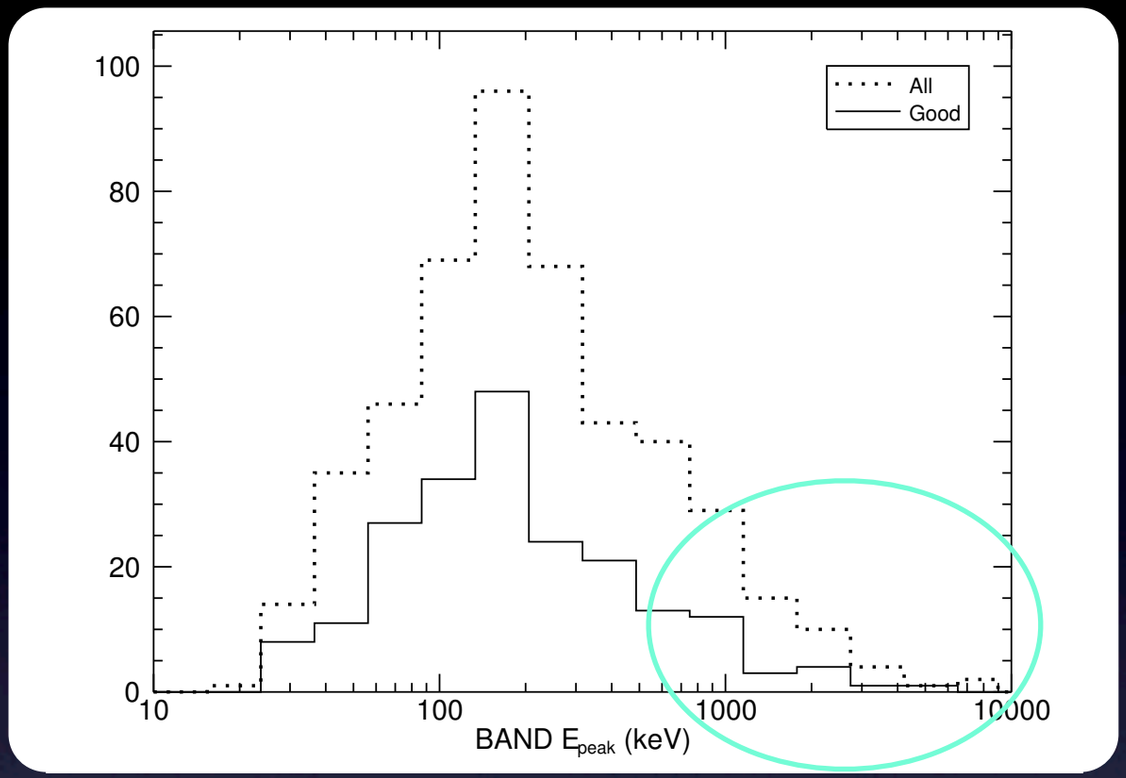
Catalog available online via FSSC.

For an update see poster from A. von Kienlin.

# GBM 1st GRB Catalog fluences



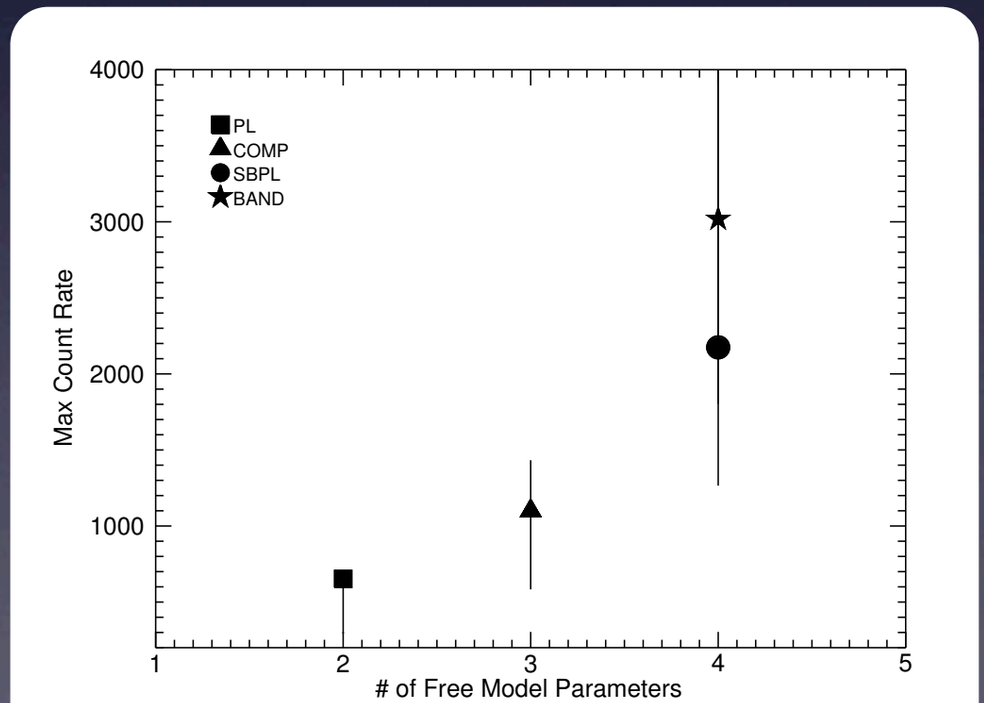
# 1st GBM GRB spectral catalog




Measuring the $E_{Peak}$ distribution to high energies

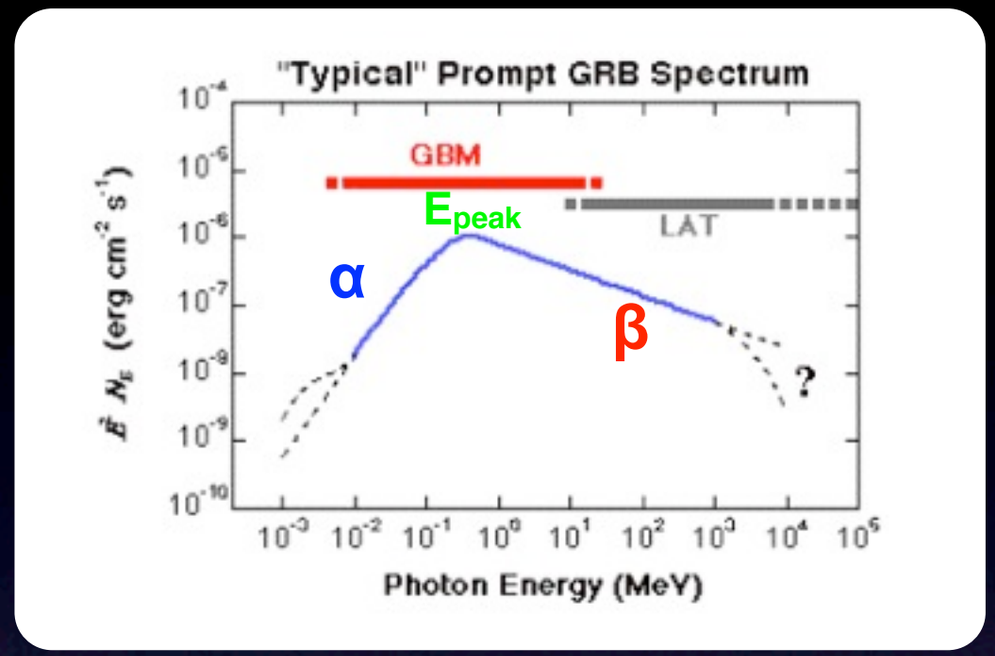
| PL | SBPL | BAND | COMP |
|---|---|---|---|
| **Fluence Spectra** | | | |
| 113 (23%) | 67 (14%) | 75 (15%) | 231 (48%) |
| **Peak Flux Spectra** | | | |
| 152 (31%) | 48 (10%) | 69 (14%) | 214 (44%) |

Goldstein et al. ApJSS, 199, 10, 2012.
Catalog available online via FSSC.




For details see poster from A. Goldstein.

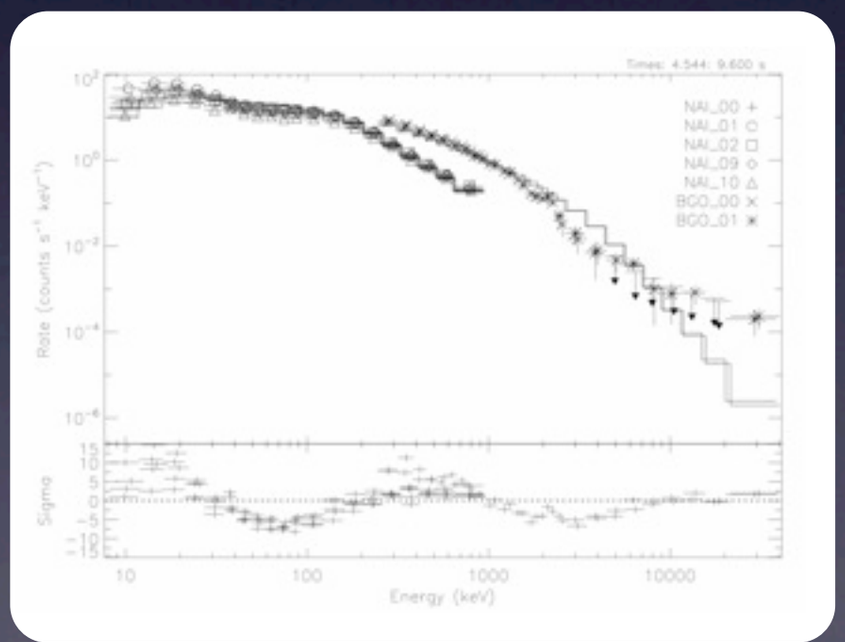
# GBM GRB spectra: Low-energy excess

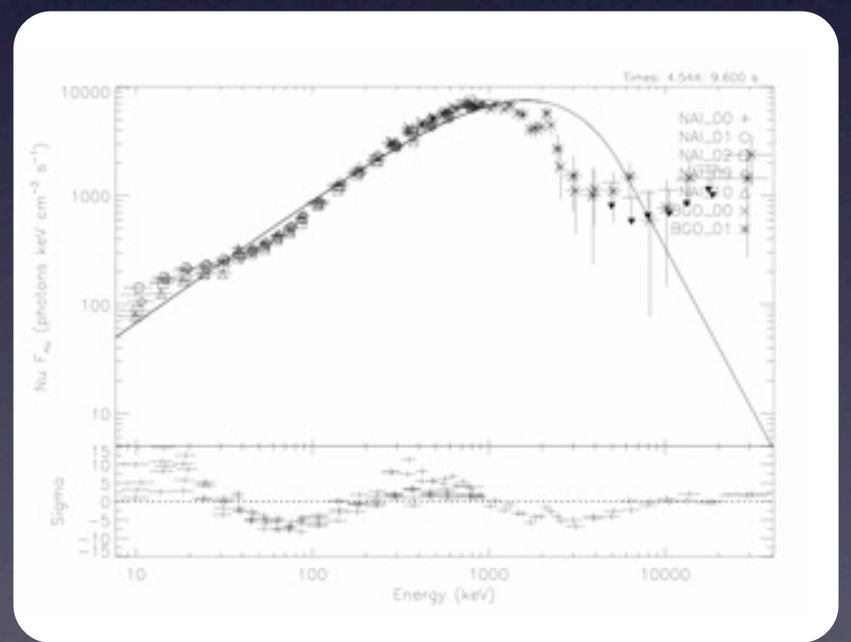


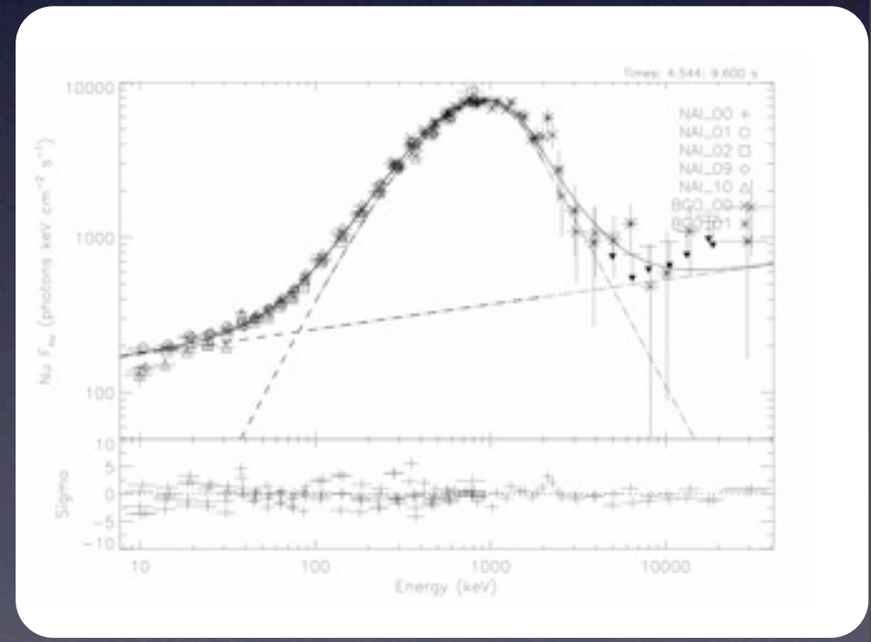

GRB090902b Count spectrum: deviations from Band function at LE

nuFnu spectrum: deviations from Band function at LE

nuFnu spectrum: addition of power-law improves fit



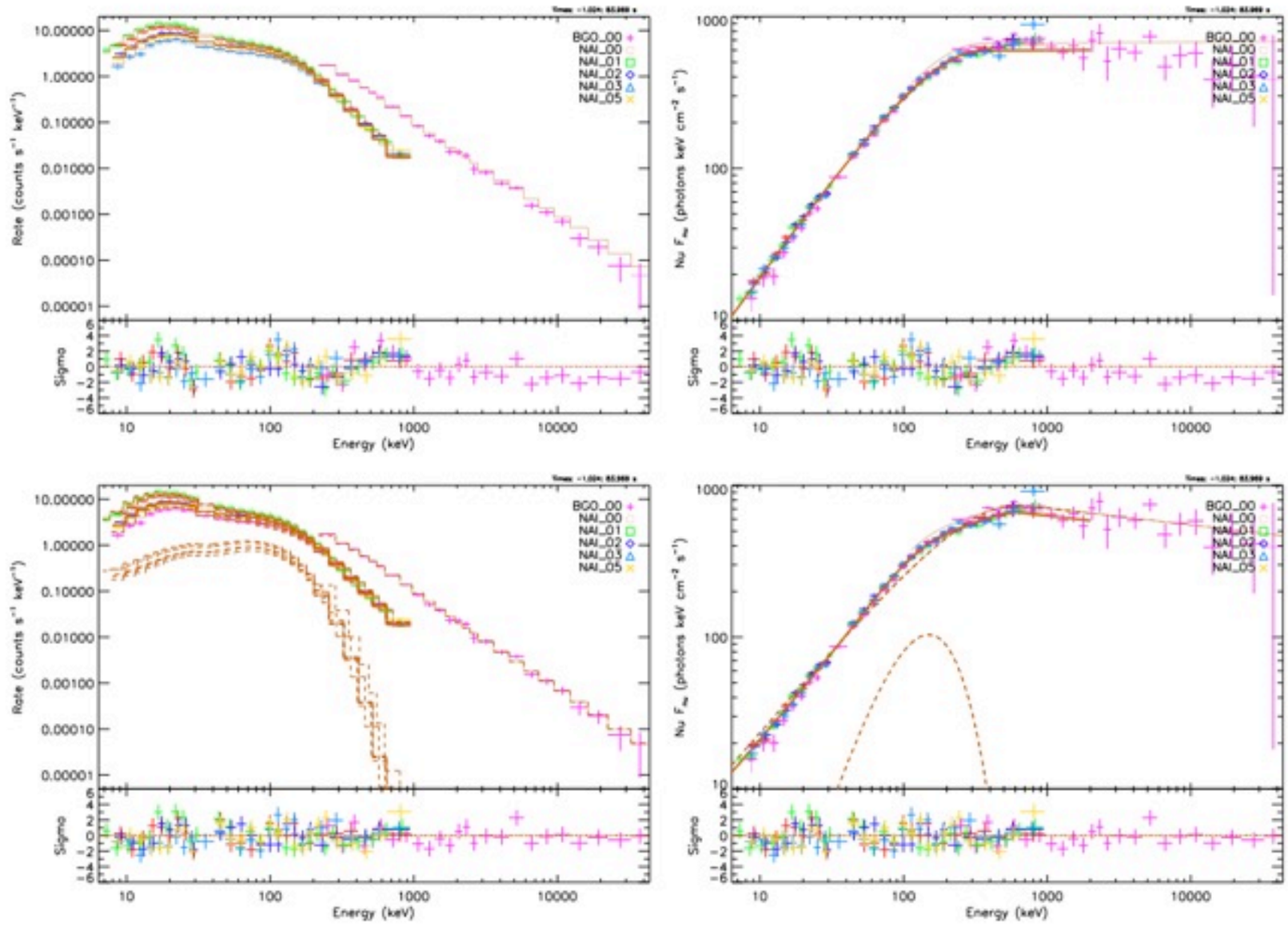




Systematic search for deviations at low energies: see poster by Dave Tierney.

# GBM GRB spectra: thermal signature

**GRB100724B: Count spectra show systematic deviations in "heart" of GBM energy range.**

**Count spectra residuals improve with addition of blackbody.**

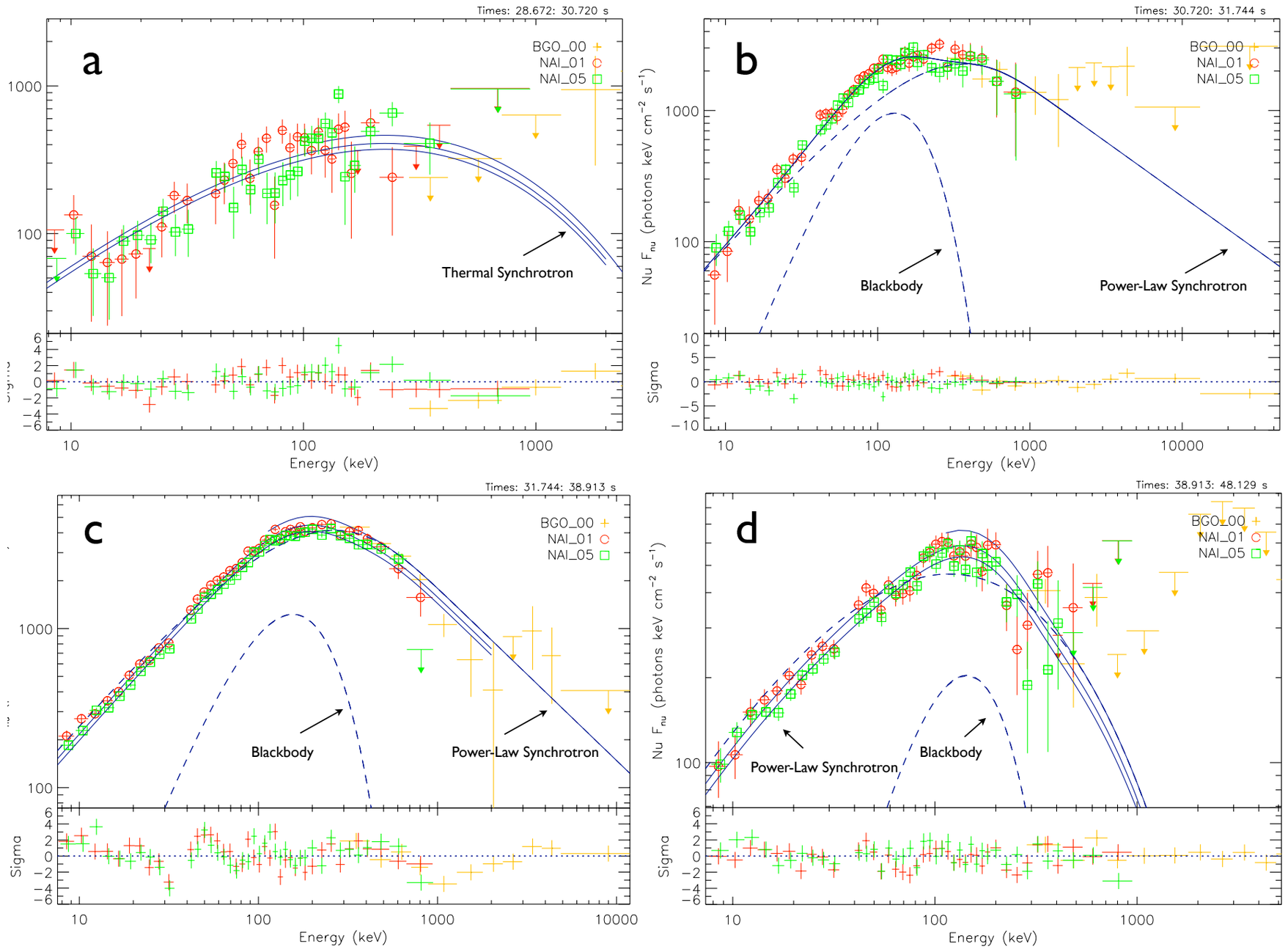



| Models | Standard Model | | | |
|---|---|---|---|---|
| | Band | | | BB |
| Parameters | $E_{peak}$ | $\alpha$ | $\beta$ | kT |
| Band | 352 | −0.67 | −1.99 | |
| | ±6 | ±0.01 | ±0.01 | |
| Band+BB | 615 | −0.90 | −2.11 | 38.14 |
| | ±29 | ±0.02 | ±0.02 | ±0.87 |

Guiriec et al., ApJL, 2011

# GBM GRB Spectra: Fitting Physical Models

**GRB090820A: Thermal and non-thermal synchrotron models with blackbody component to model a simple GRB.**

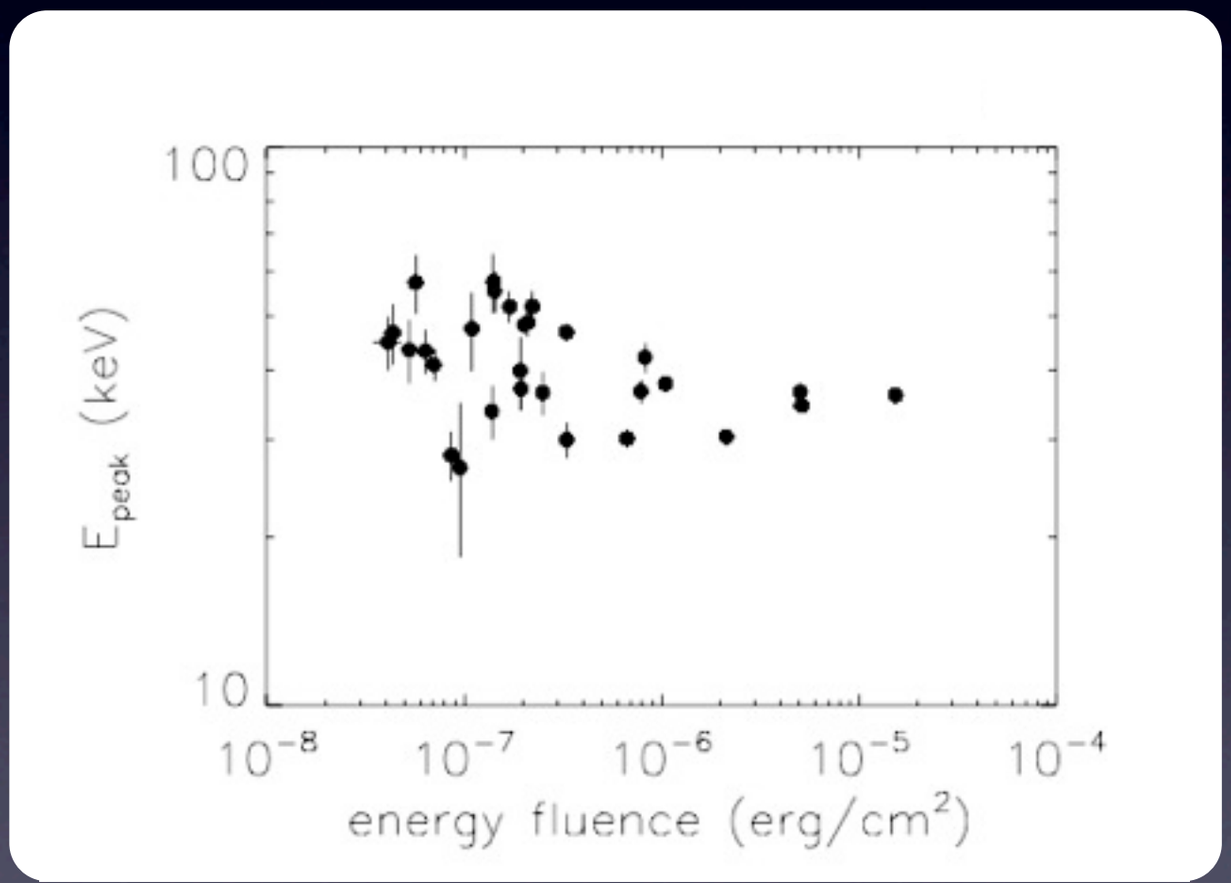



Burgess et al., ApJL, 2011

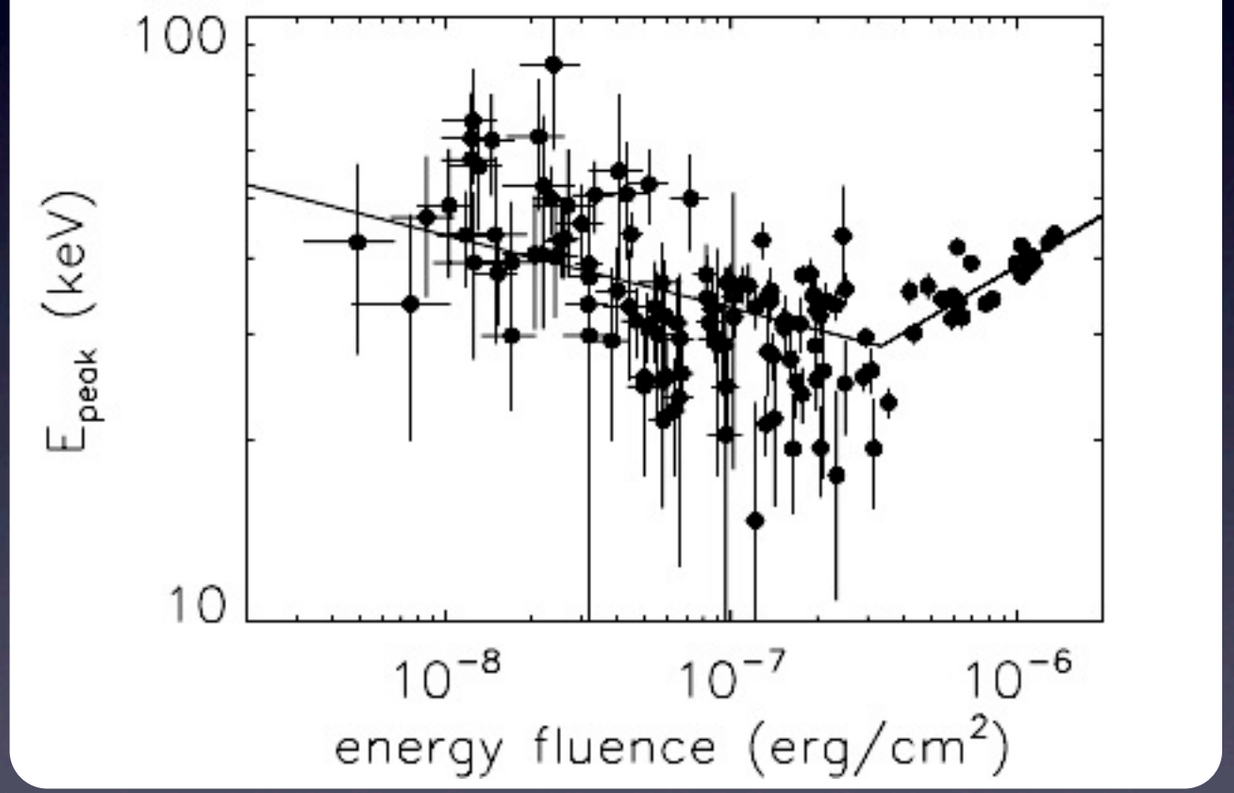
# Soft Gamma-ray Repeaters

**5 different sources:** one of them seen in 2 outbursts, 1 of them newly discovered using the GBM triggers to identify source as an SGR.

http://gammaray.nsstc.nasa.gov/gbm/science/magnetars




SGR 0501+4516 : 29 bursts in Aug 2008

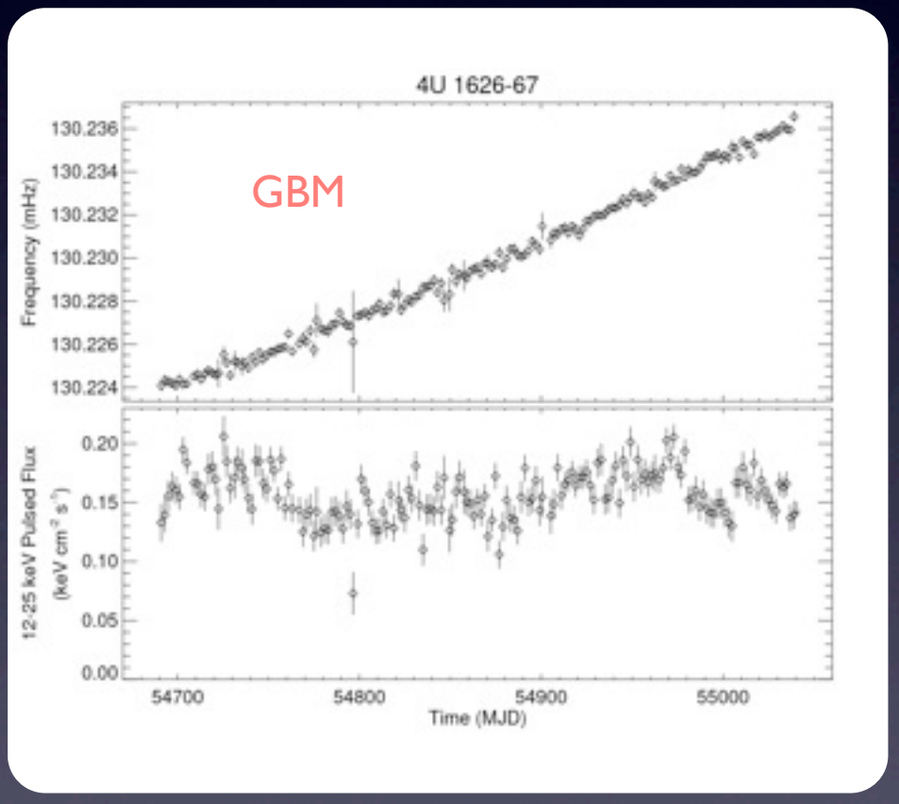



SGR 0501+4516 : Time resolved for brightest 5 triggers.

Lin et al., ApJ 2011

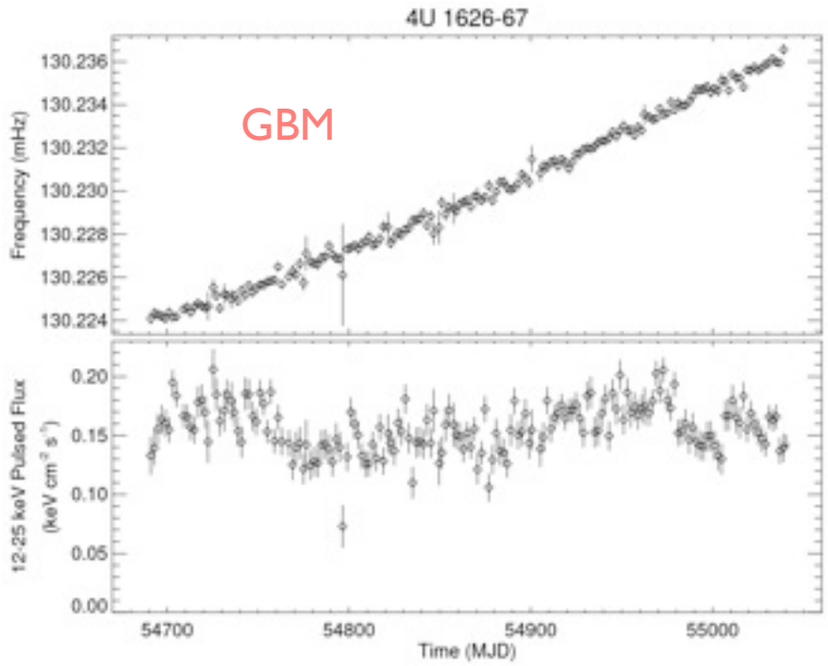
# Accreting pulsar project: monitoring

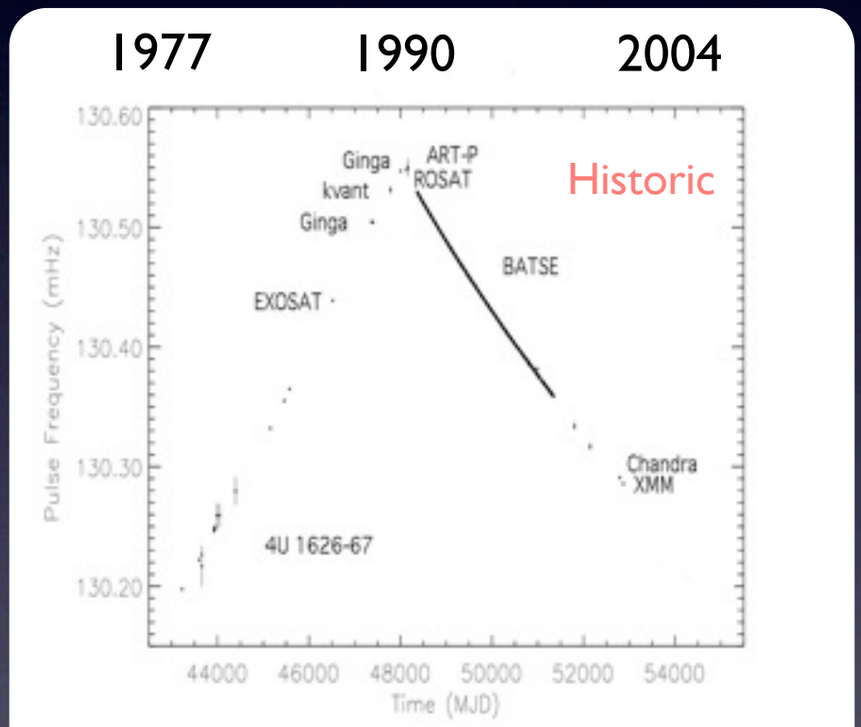
- http://gammaray.nsstc.nasa.gov/gbm/science/pulsars



# Accreting pulsar project: long term behavior

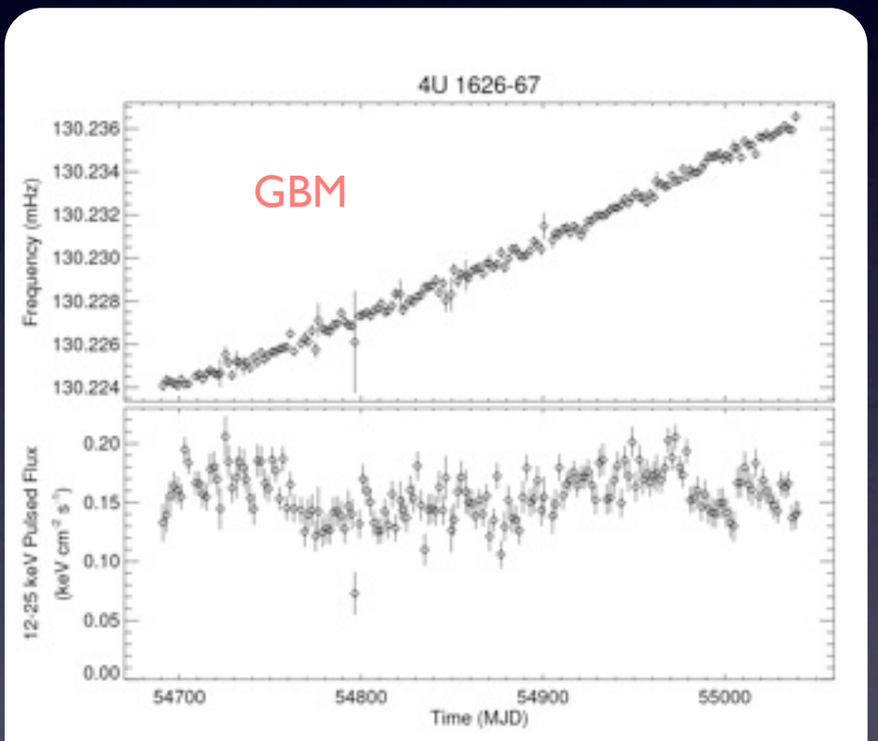
- Monitoring of LMXB shows torque reversal

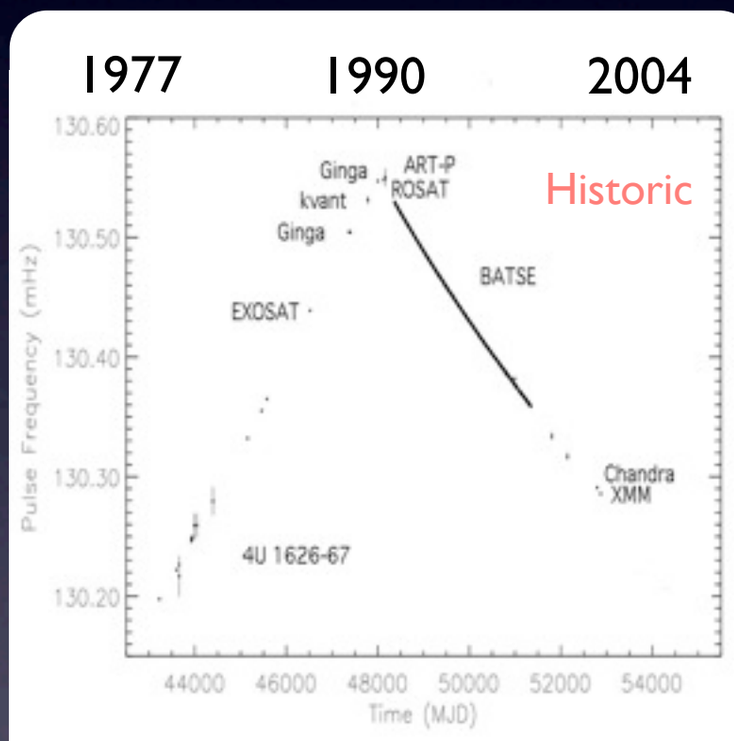


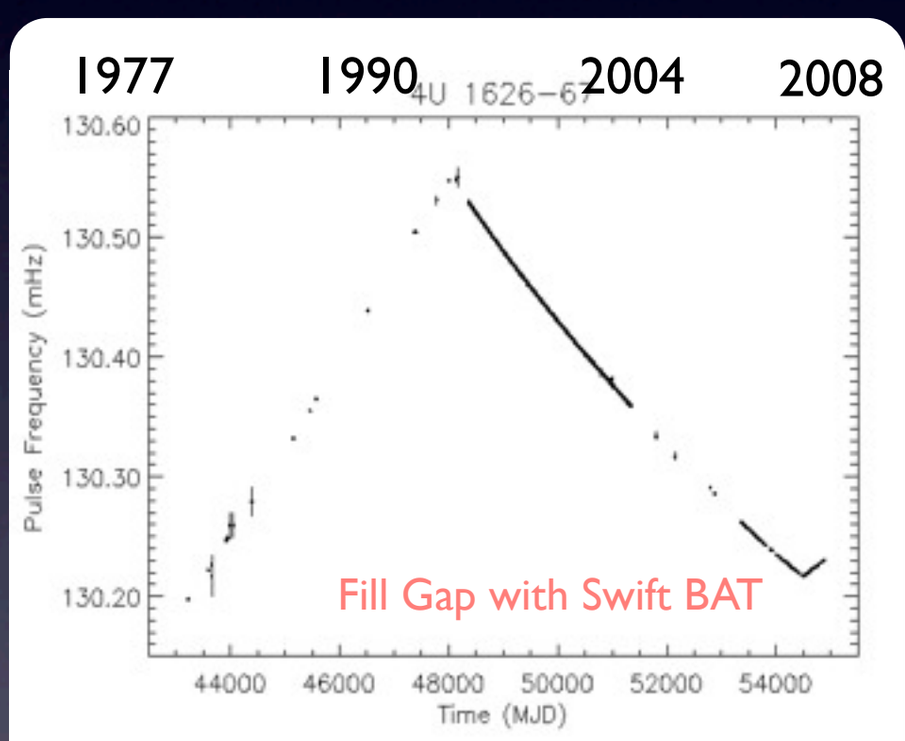



# Accreting pulsar project: long term behavior

- Studying flux and spectrum during torque reversal challenges models.



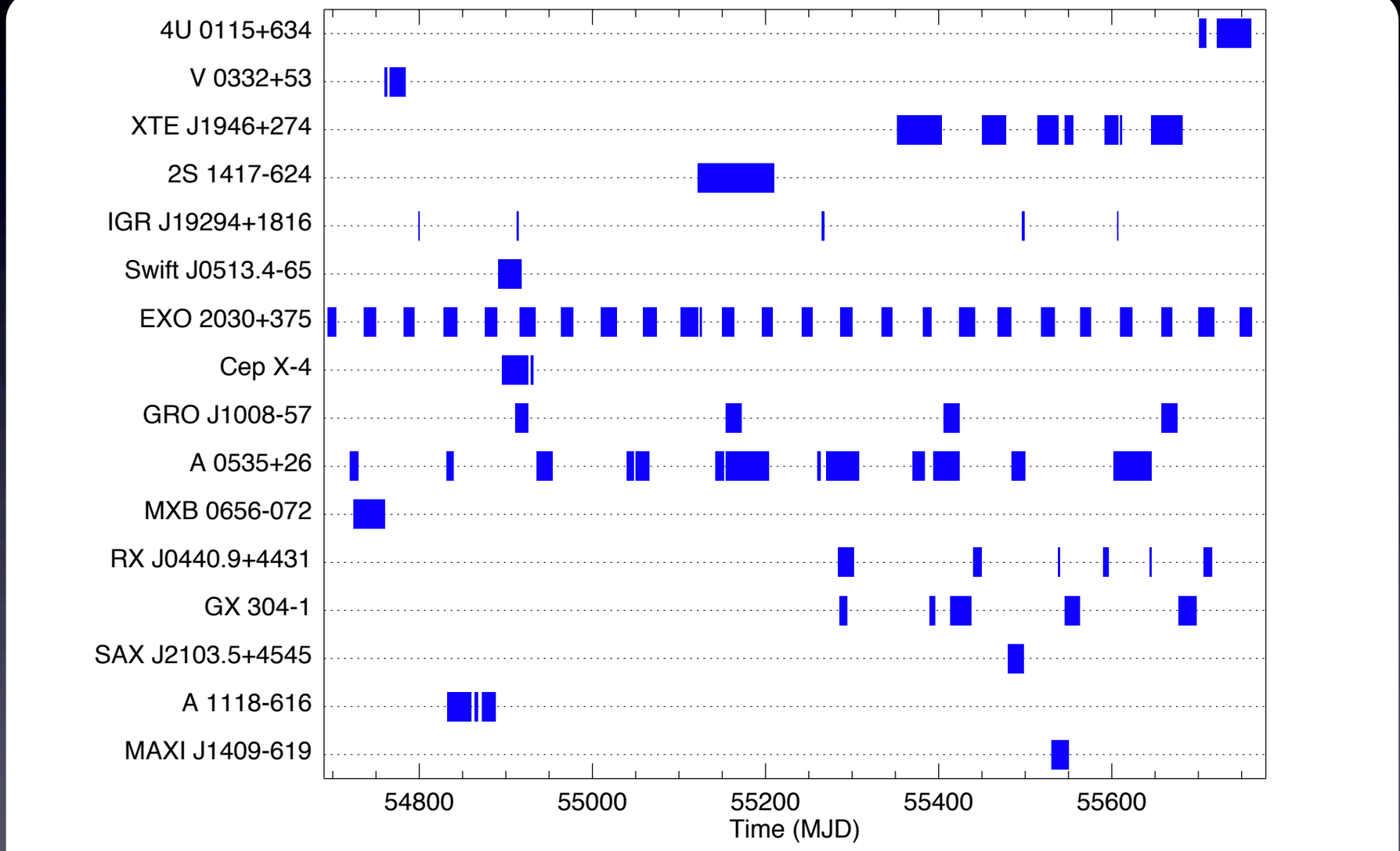



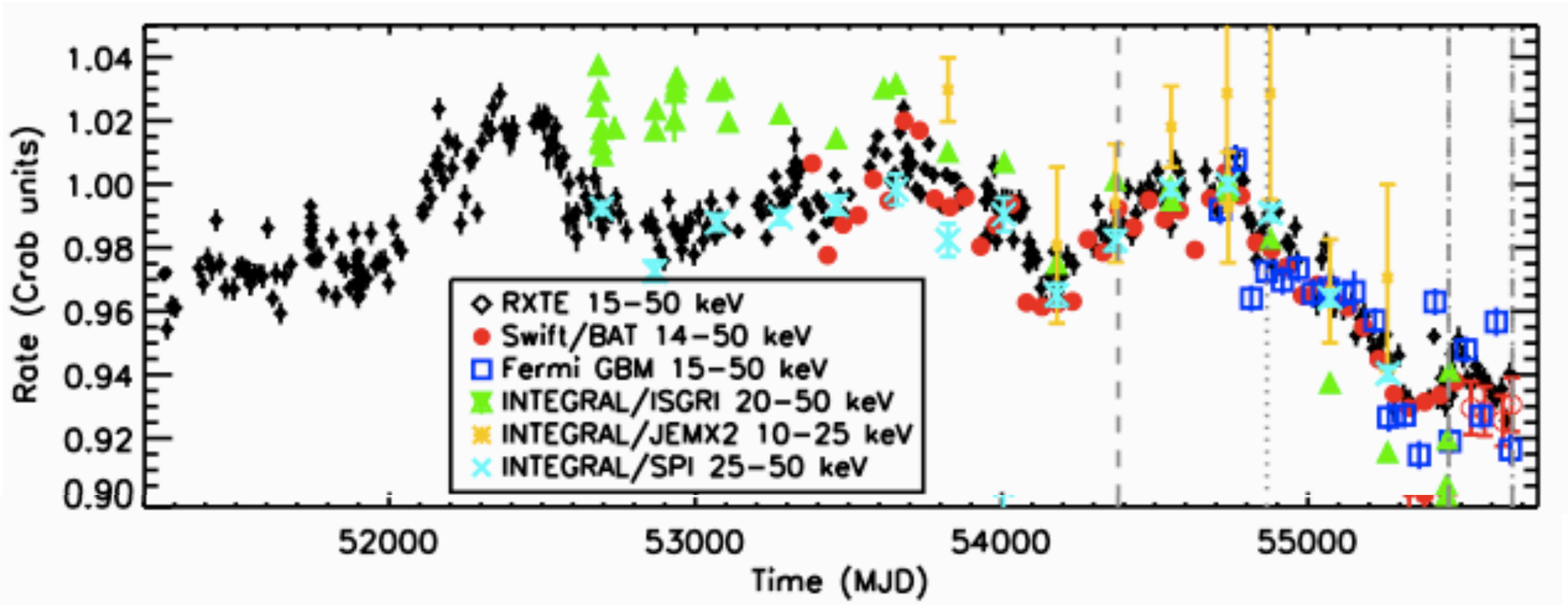

Camero-Arranz et al., ApJ 2010

# Pulsars: Outburst monitoring

http://gammaray.nsstc.nasa.gov/gbm/science/pulsars

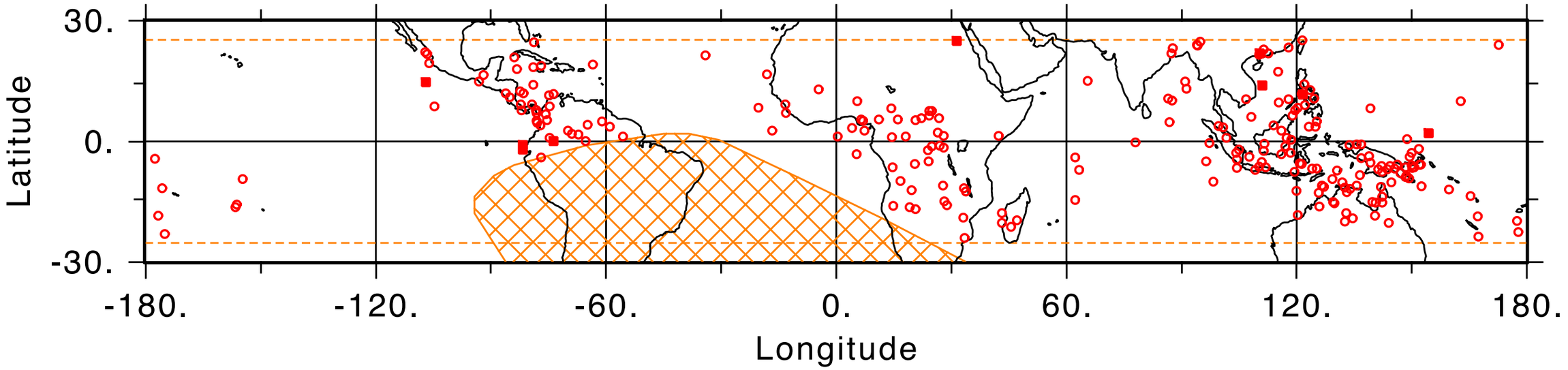


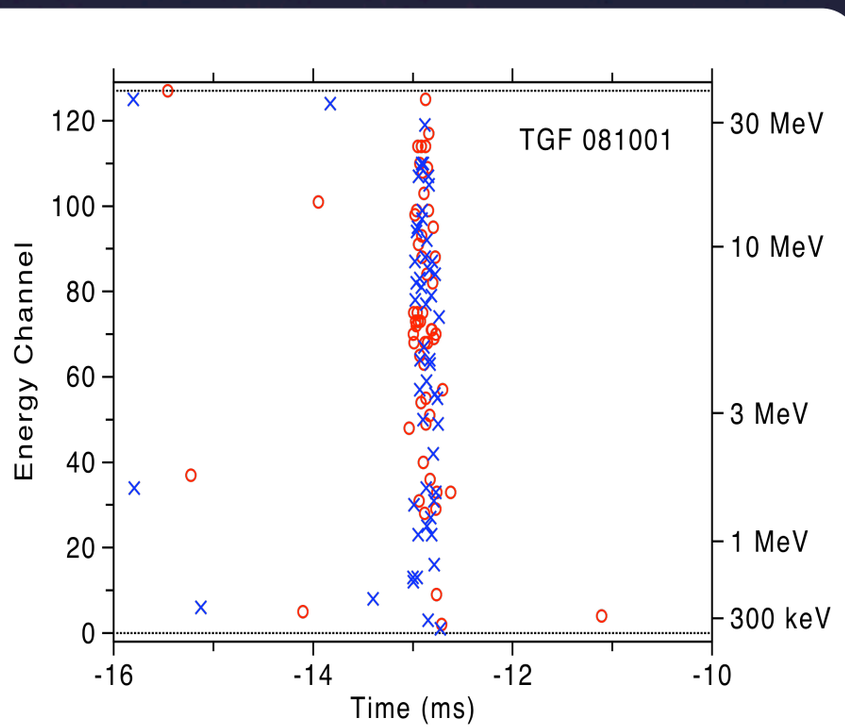
# Earth Occultation Project : Crab




Wilson-Hodge et al., ApJ 2011

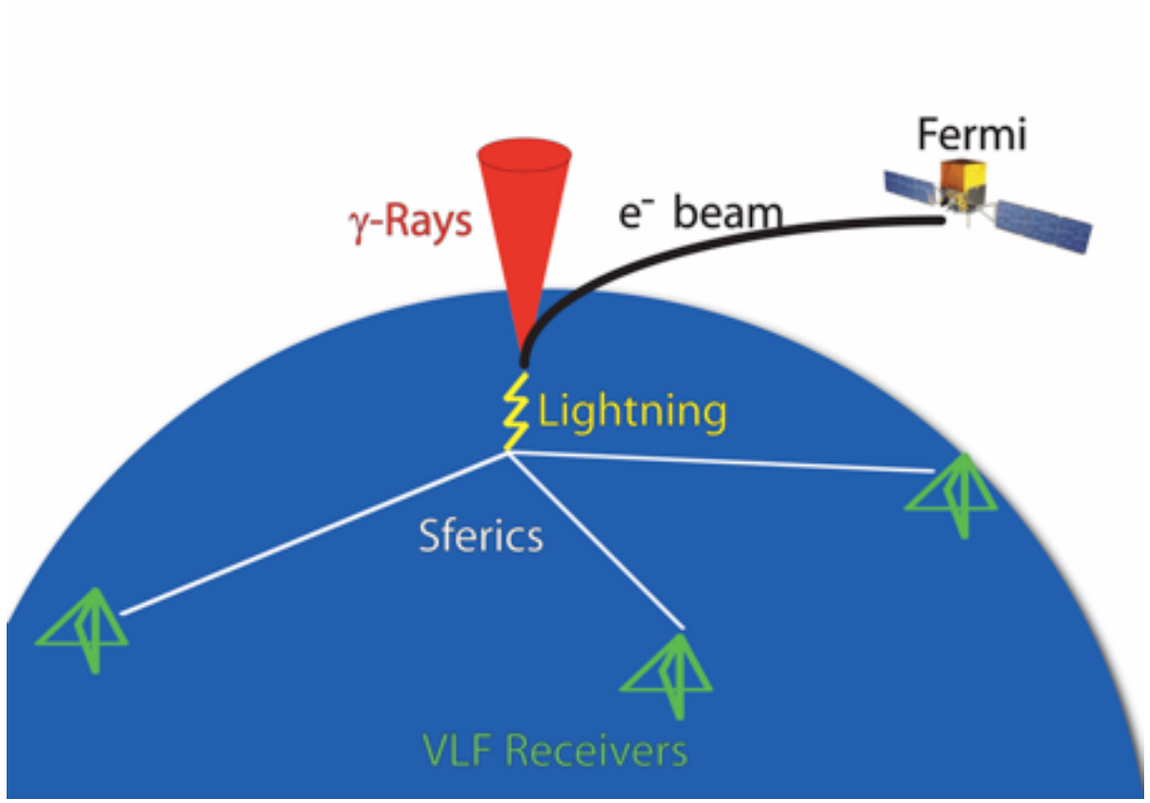
# Terrestrial Gamma-ray Flashes

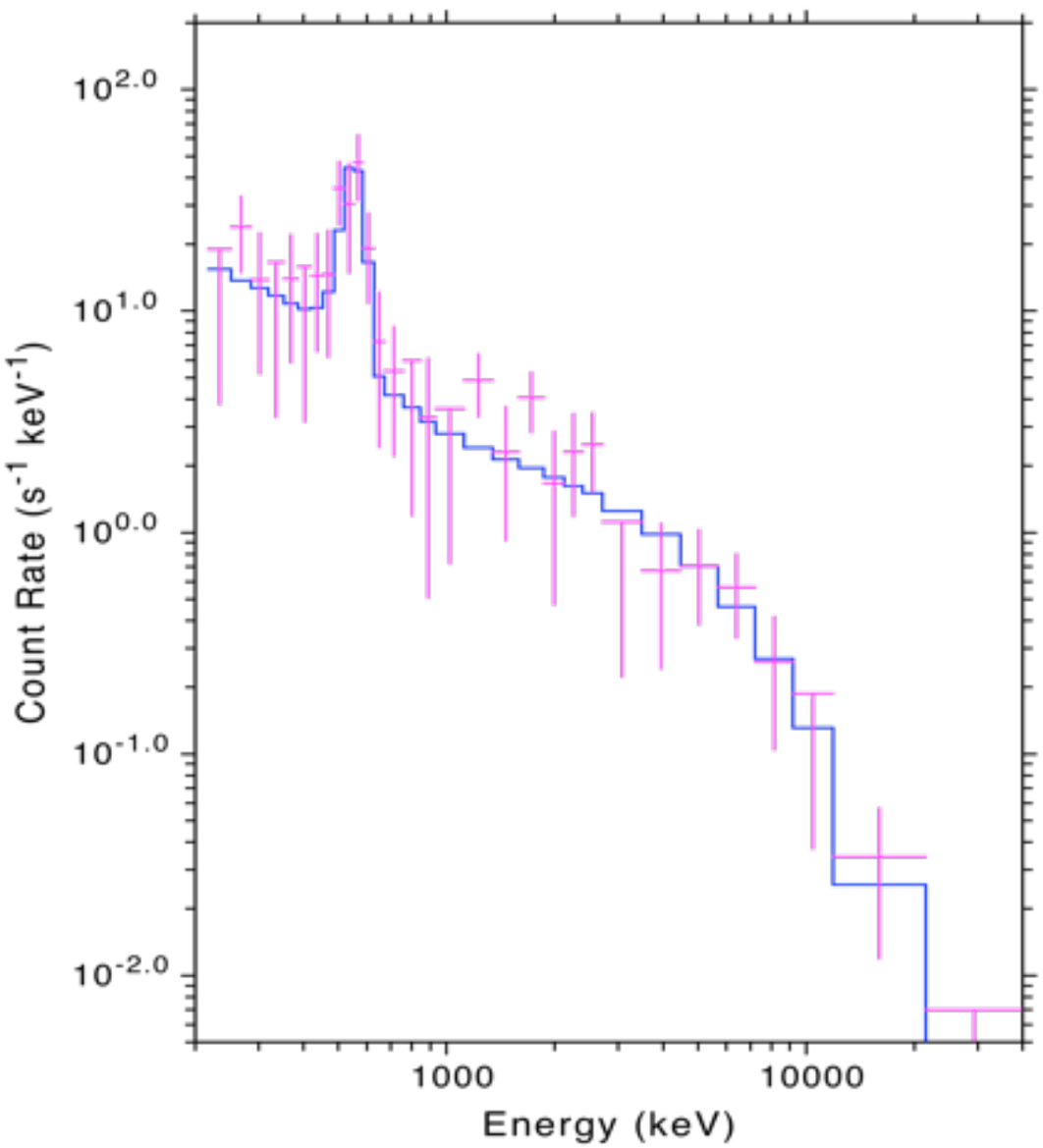



< 1 - 25 ms duration (most < 1 ms).
Hard spectra
Associated with thunderstorms.
"Runaway electron" processes.

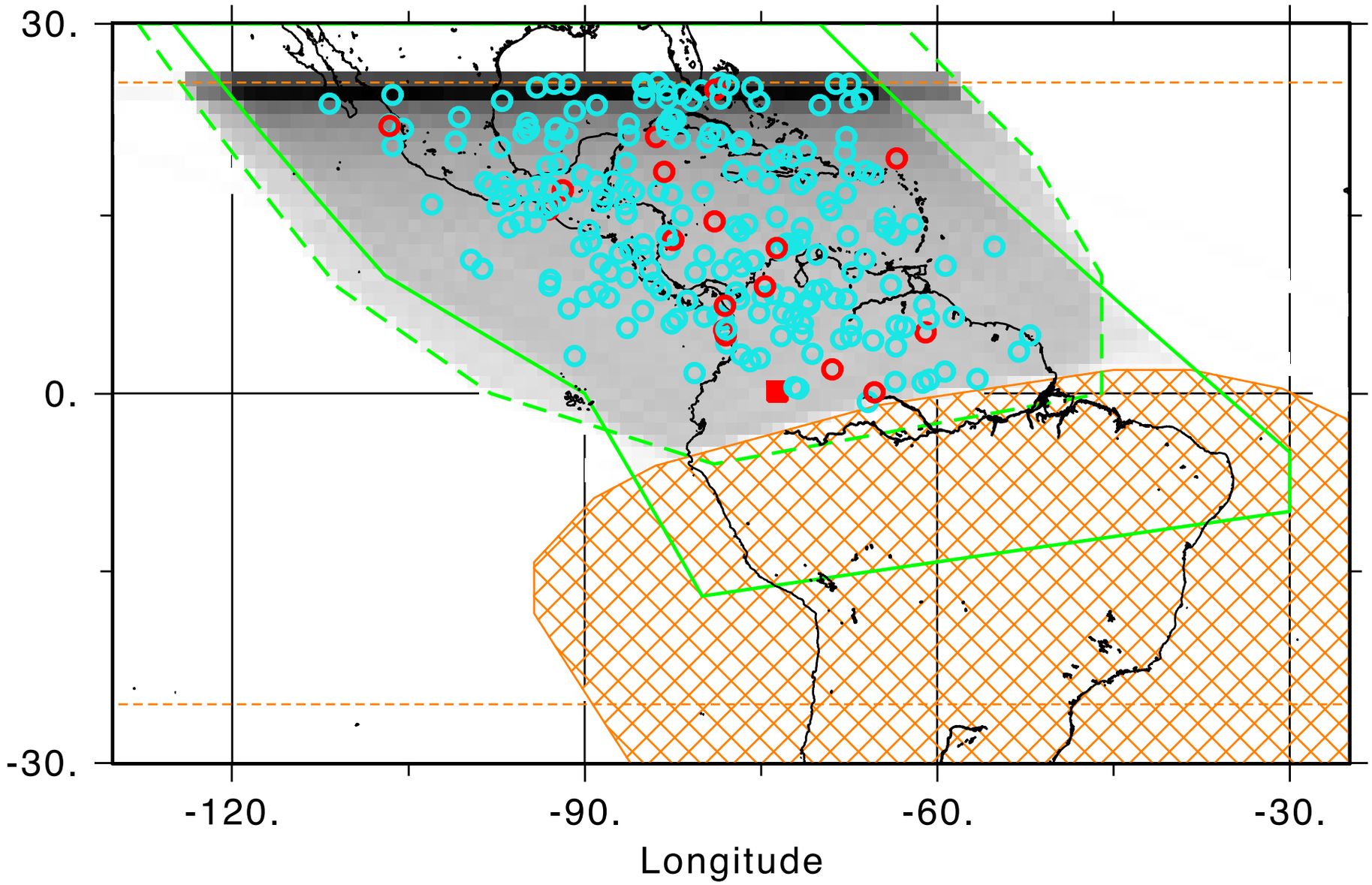
# Positron Fraction: 10 - 20 %




Briggs et al.2009.

# TGFs Ground Search




18 triggered TGFs, 210 ground search.

Briggs et al., In Prep, 2012.

# GBM Science in First 3.5 Years of Fermi

- GBM GRB observations allow broad-band and detailed spectral analyses, giving clues to physical mechanisms.
- GBM locations and repoints facilitate GBM/LAT discoveries.
- GBM  is contributing to SGR science through spectral and temporal analyses.
- Occultation and pulsar projects help monitor the galaxy.
- The sun is active.  First *Fermi* HE gamma-ray flare has been detected and studied.
- TGF science is proving unexpectedly rich for GBM.

# Posters at this conference

- **Tierney**: Searching For Low Energy Deviations In GRB Spectra With GBM
- **Fitzpatrick:** Search for extended emission in Fermi/GBM GRBs
- **Sonbas:** GRB Spectral Lags in The Source Frame: An Investigation of Fermi-GBM Bursts
- **Hurley:** The IPN Supplement to the Fermi GBM 2-year Catalog
- **von Kienlin**: The Fermi GBM Gamma-Ray Burst Catalog: Years Three & Four
- **MacLachlan:** Minimum Variability Time Scales of Long and Short GRBs
- **Ghirlanda**: GRBs in the comoving frame: the link between the jet opening angle and the bulk Lorentz factor and the interpretation of the spectral-energy correlations.
- **Gruber:** Search for untriggered GRBs in GBM data
- **Goldstein:** The Fermi GBM Gamma-Ray Burst Spectral Catalog: The First Two Years