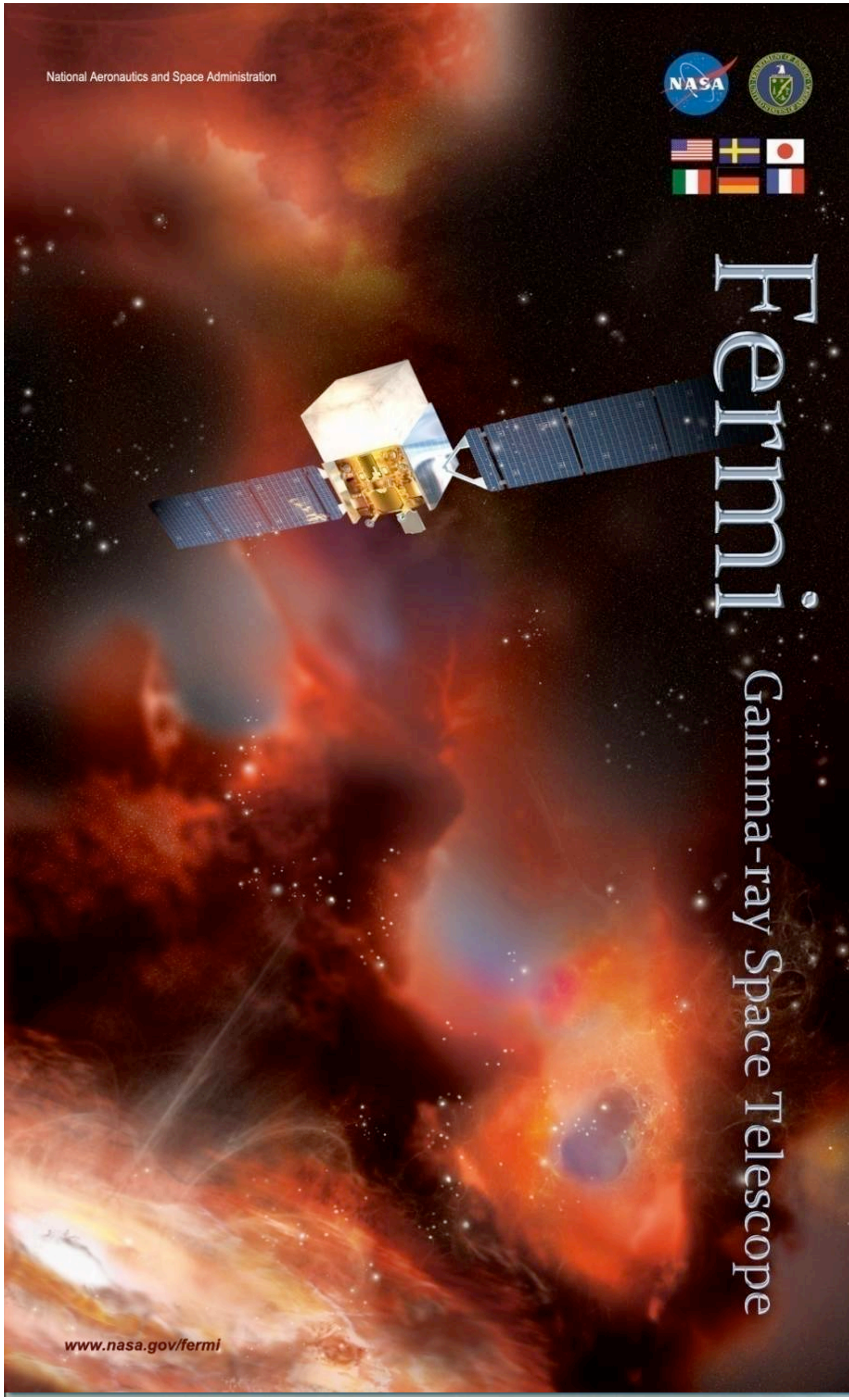
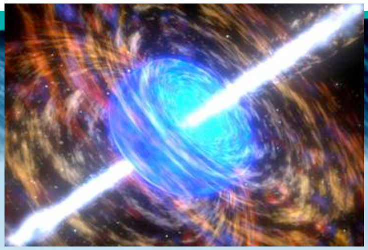


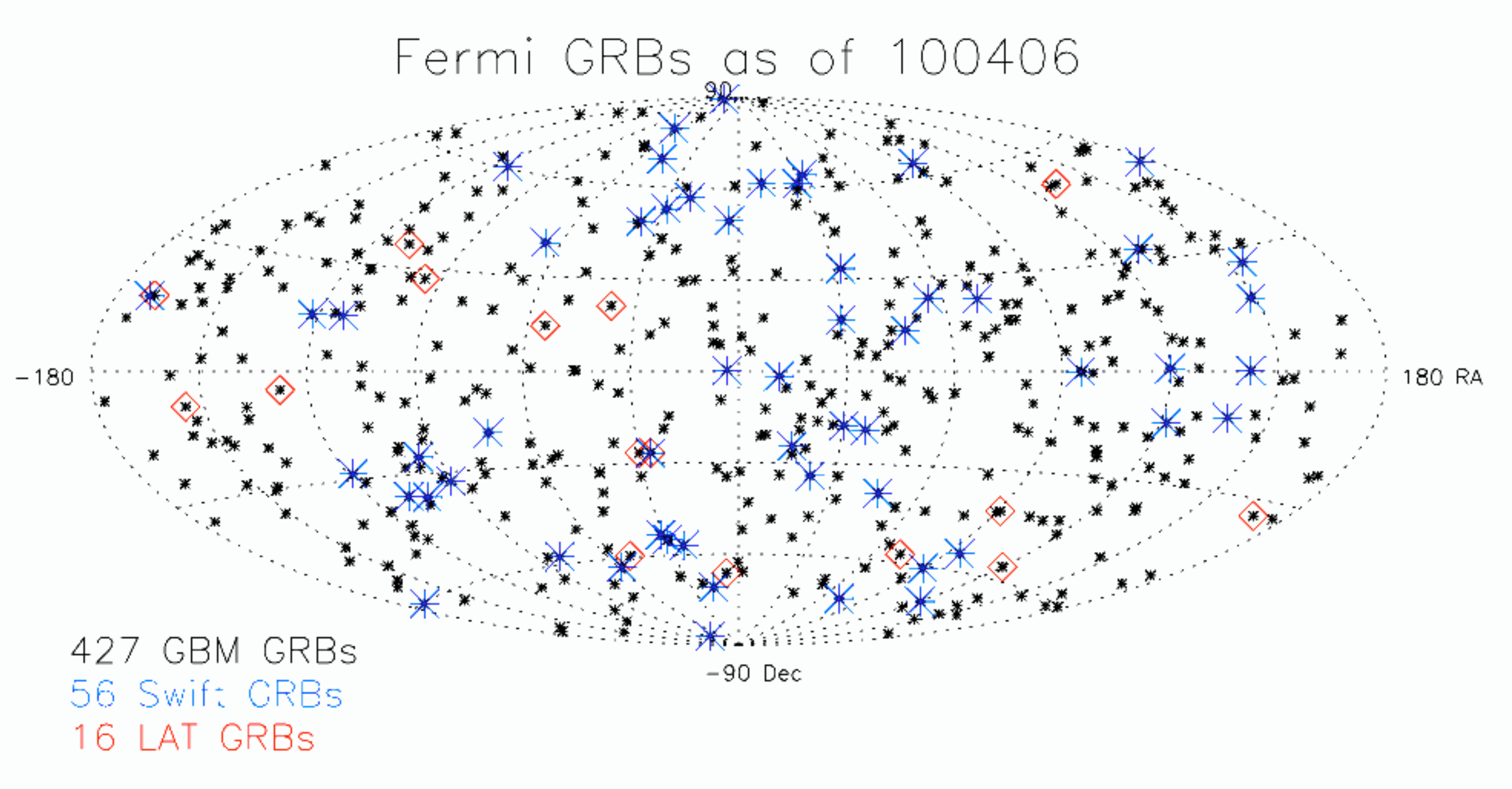
Fermi GBM Status, Results, Plans

Bill Paciesas

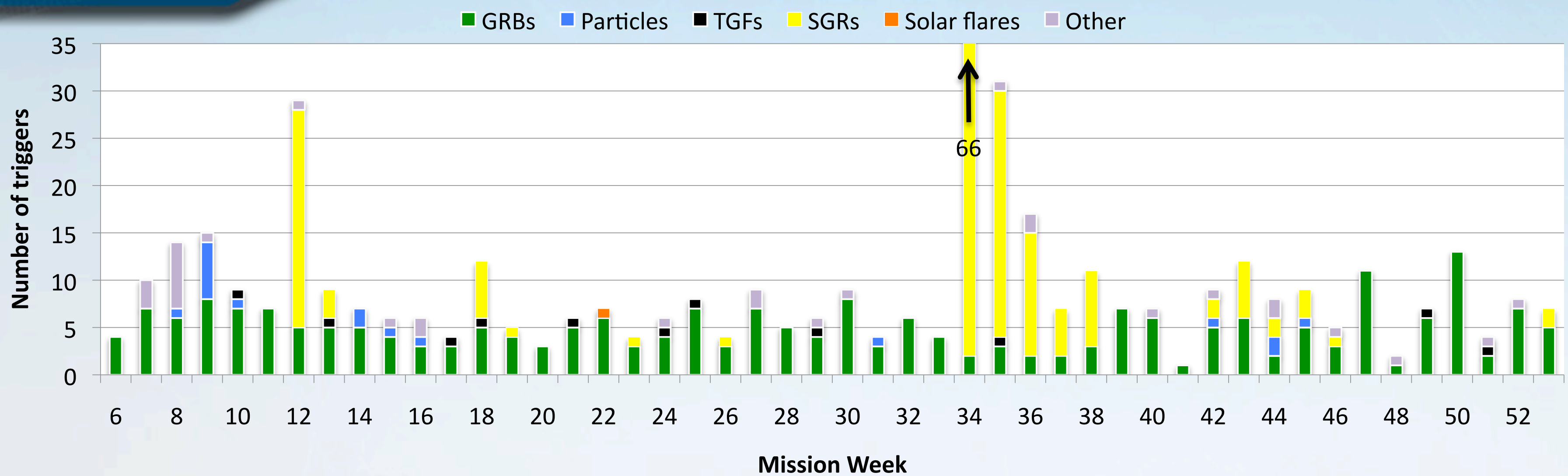
Fermi Users Group
12 May 2010

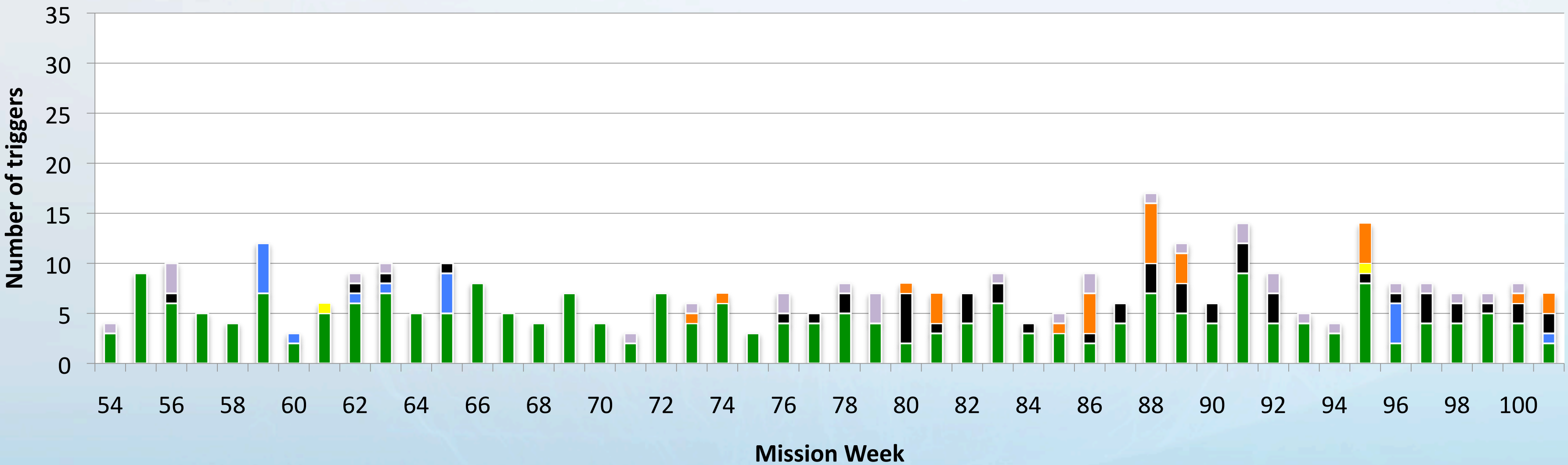
Gamma Ray Bursts





GBM Trigger History





GBM Triggered Sources

(as of May 10)

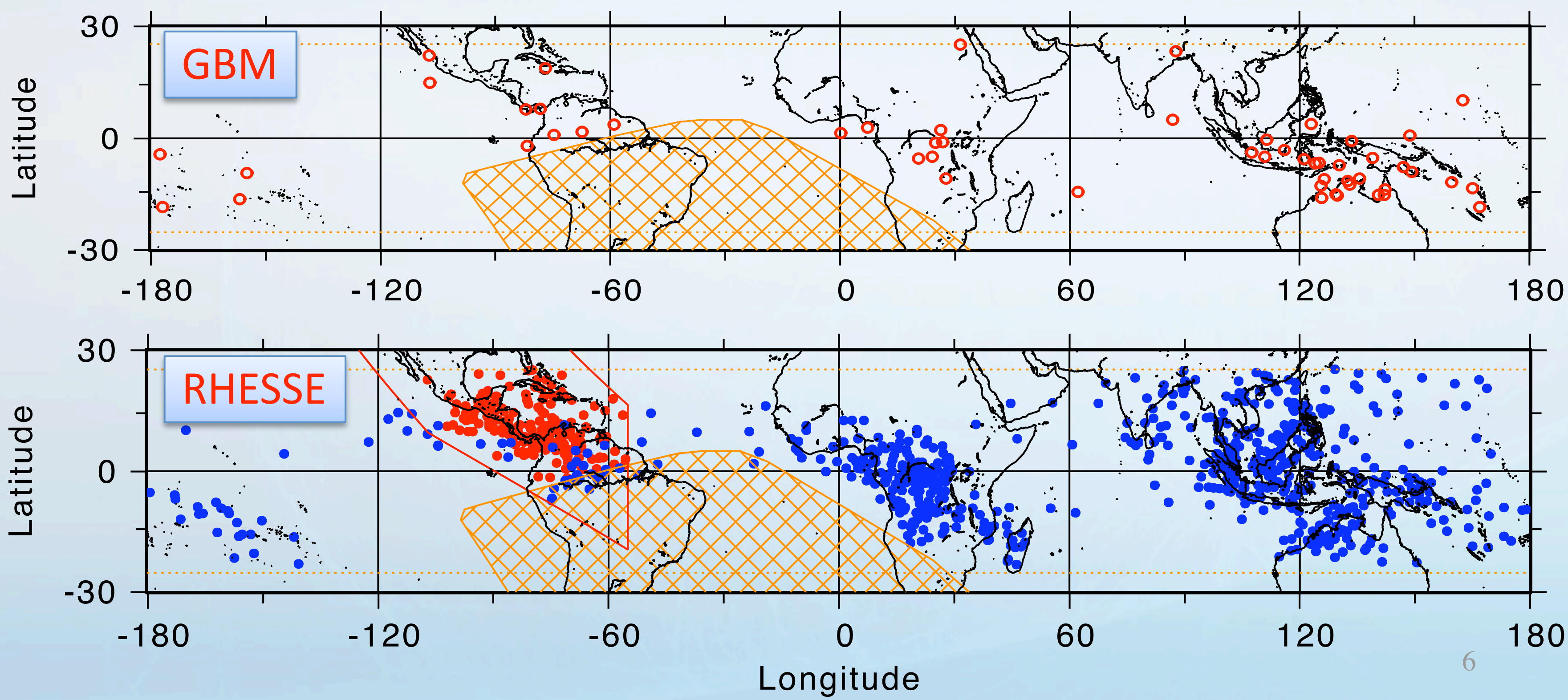
- 810 triggers (excluding commanded)
  - Gamma-ray bursts (GRBs): 462
  - Soft gamma repeaters (SGRs) aka magnetars: 170 (from 4 sources)
  - Terrestrial gamma flashes (TGFs): 61
  - Solar Flares: 28
  - Short transients detected by on-board trigger algorithm: 1-2
- ~40 ARRs

FSW Version 2.5

– Installed 10 Nov 2009
– Added special trigger algorithms for TGFs
  - Algorithm 116 triggers based on a significant rate increase being present in at least two NaIs and at least one BGO. The detectors can be any NaI detectors and either of the BGO detectors.
  - Algorithms 117 and 118 also require a significant rate increase in at least two NaIs and at least one BGO, but impose the additional requirement that the detectors with the rate increase be on the same side of the spacecraft (117 ➔ +X, 118 ➔ -X).
  - Algorithm 119 requires a significant rate increase in both BGO detectors (independent of NaIs).
  - All algorithms use the same (configurable) BGO energy range.
  - All algorithms currently use the same trigger timescale (16 ms).
– Add more ARR decision info to TRIGDAT
– Misc operational improvements

TGFs

- 61 GBM TGFs, from 2008 July 11 to 2010 May 10
- Rate from 2008 July 11 to 2009 Nov 9: one TGF per 32 days
- Rate from 2009 Nov 10 to 2010 May 10: one TGF per 3.9 days

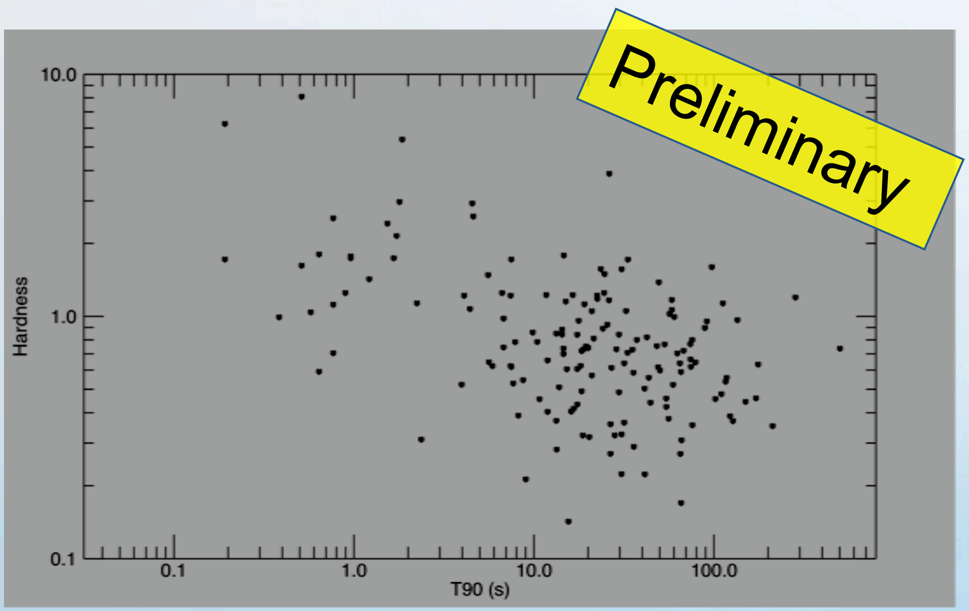


GBM GRB Catalog (in progress)

Paciesas et al. 2010

- Locations
  - RA, Dec
- Durations
  - (t_{50}, t_{90}) in 50–300 keV
- Peak flux (ph/cm^2-s)
  - 64 ms, 256 ms, 1024 ms
  - 50–300 keV, 10–1000 keV
- Fluence (erg/cm^2)
  - 50– 300 keV, 10–1000 keV
- Light curves

Will be accessible on-line through FSSC



Trigger Summary (July 12, 2008 - July 11, 2009)	
Gamma-Ray Bursts	258
Soft Gamma Repeaters	168
Terrestrial Gamma Flashes	12
Solar Flares	1
Particles (local or distant)	17
Commanded tests	62
Others (sources, accidentals, unclassifiable)	35
Total	553

Current total number of GRBs detected: 448

Two GBM GRB Spectral catalogs

Goldstein et al. 2010, Preece et al. 2010

1. The **"Peak Flux and Fluence"** Spectral Catalog:
   - Two Spectra from all but the weakest GRBs:
   - 2.048 s Peak Flux Spectrum
   - > 3.5 sigma integrated Fluence Spectrum
   - Approximately 200 bursts per year

   (BATSE Heritage: Mallozzi et al. 1995; Goldstein et al. 2010)
2. The **"Time-Resolved"** Spectral Catalog for Bright Bursts:
   - At least two spectra for each burst, fit as a time sequence:
   - > 15 sigma integration for each spectrum
   - Approximately 50 bursts per year

   (BATSE Heritage: Preece et al. 2000; Kaneko et al. 2006)

Four Spectral Models Fit to each spectrum:

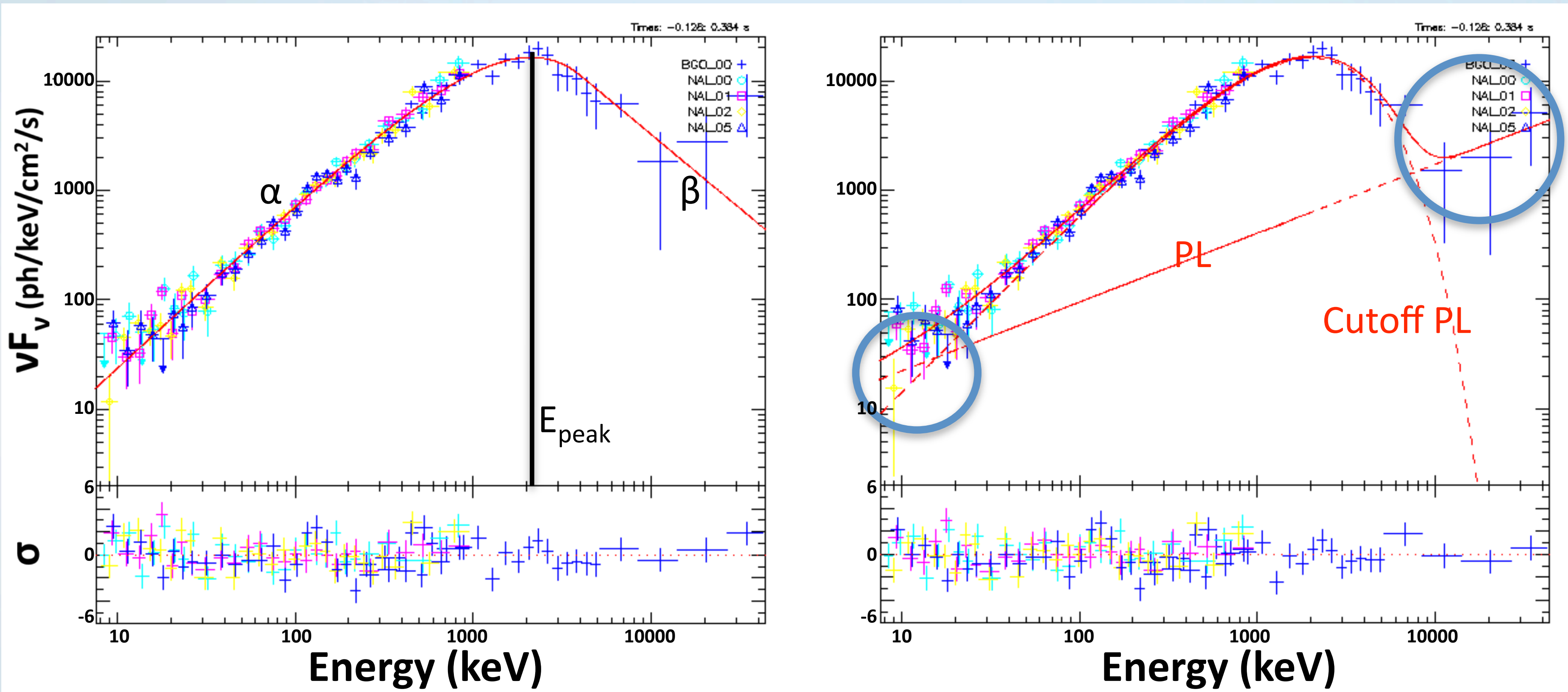
- Power Law: A & α
- Exponentially-attenuated Power Law ("Comptonized"): A, α & E_{peak}
- Band function: A, α, β & E_{peak}
- Smoothly-Broken Power Law: A, α, β, Δ & E_{break}

Will be accessible on-line through FSSC

Time-integrated spectral analysis of the short GRB 090227B

Band (Cstat: 699/607 dof)

Cutoff PL + PL (Cstat: 689/606 dof)

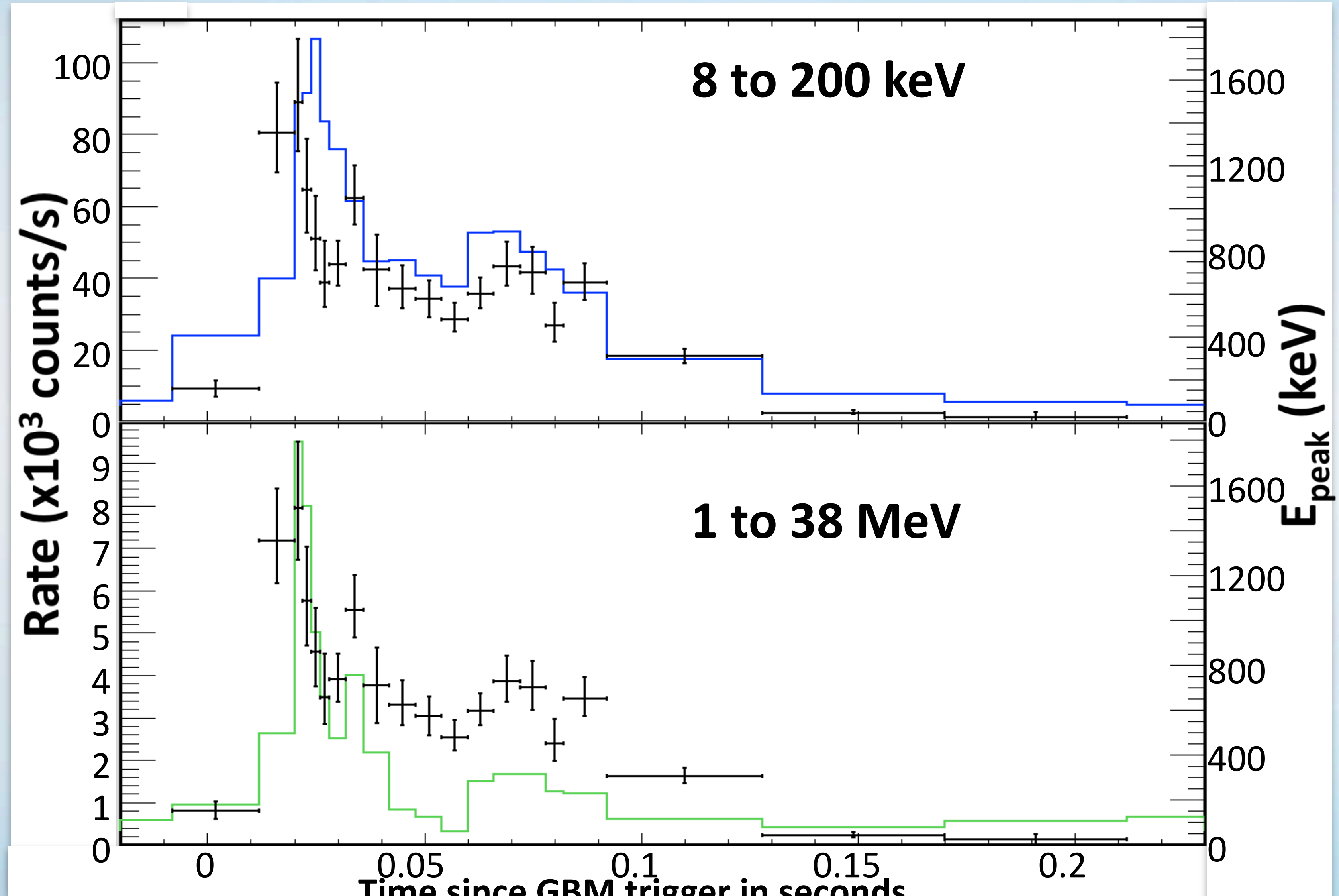


Cutoff PL+PL prefered over the Band function => Additional component ?

Guiriec et al. 2010

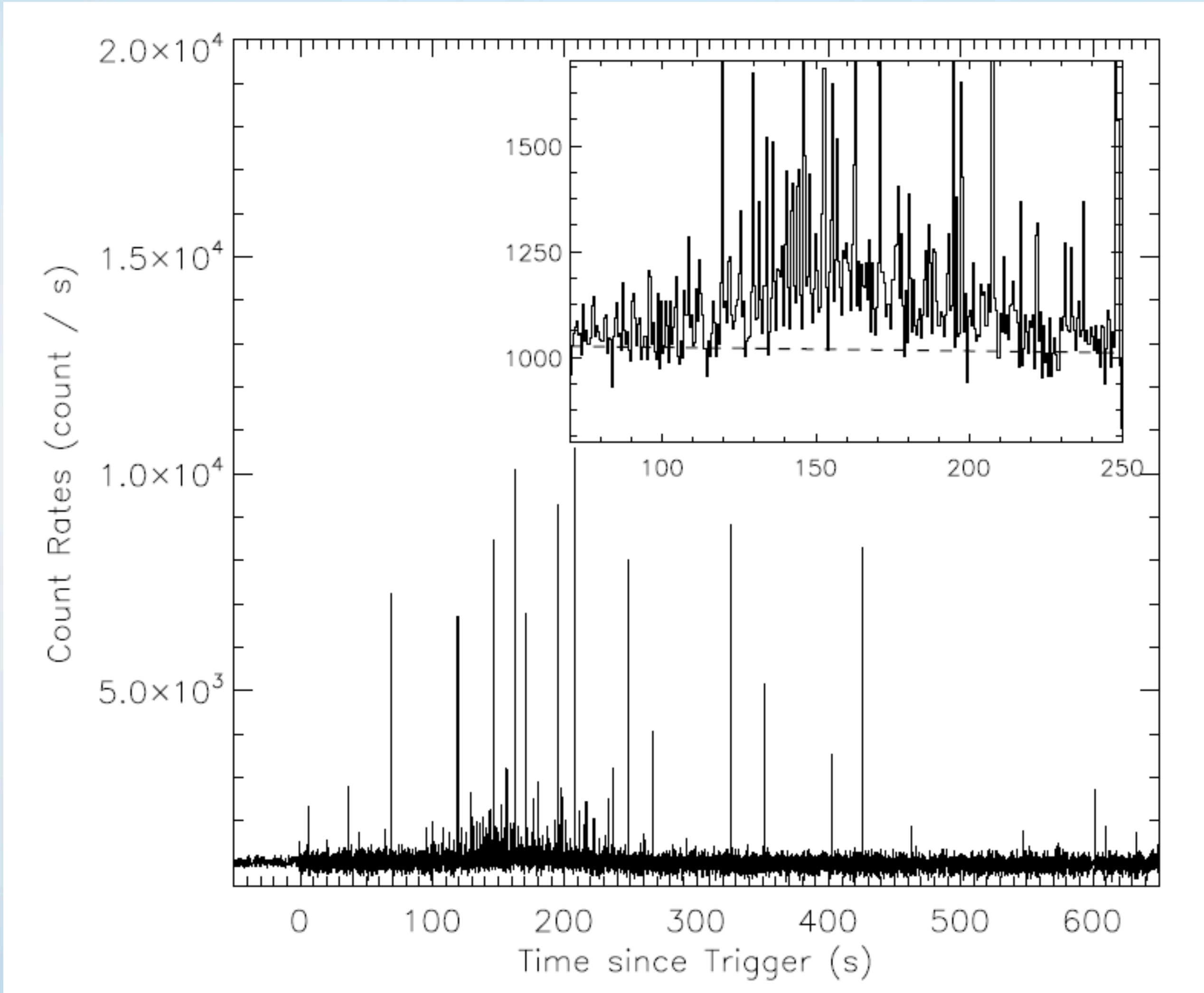
E_{peak} Evolution in GRB090228

Guiriec et al. 2010



Magnetar twist and shake…

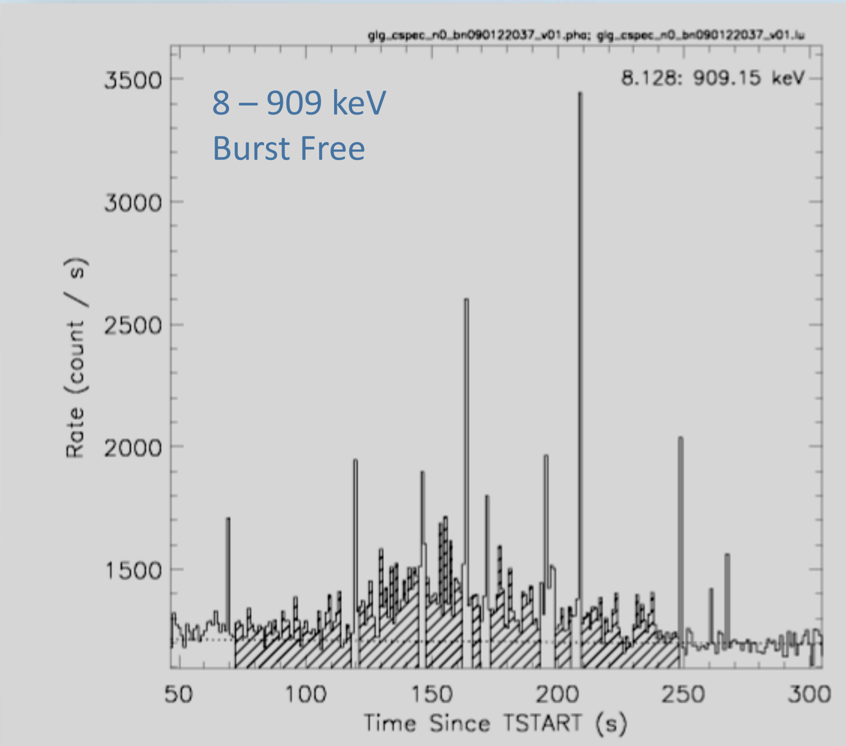
SGR J1550-5418 (AXP 1E1547.0-5408)

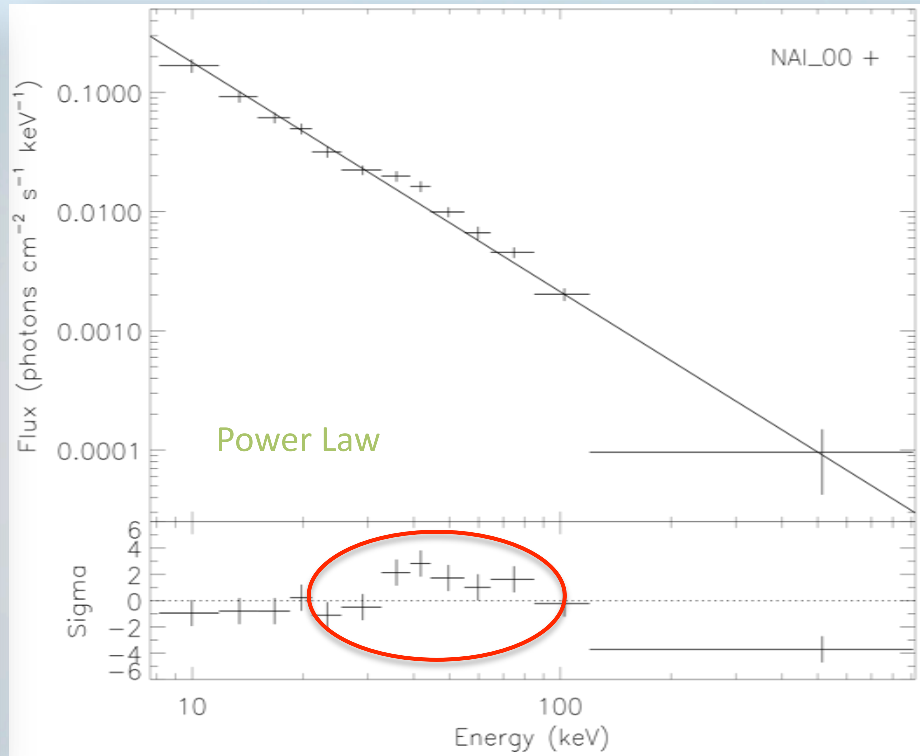


Kaneko et al. 2010

Spectral Analysis

Time Integrated Spectrum [T_0 + 72 – 248 s]





<u>Total Energy</u>

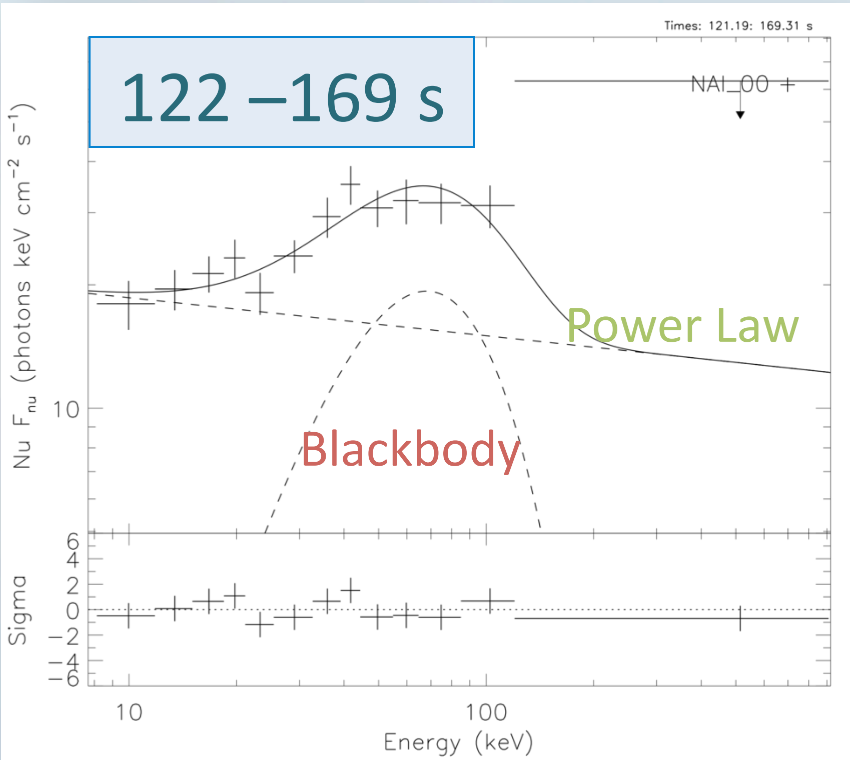
4.3×10^{40} ergs

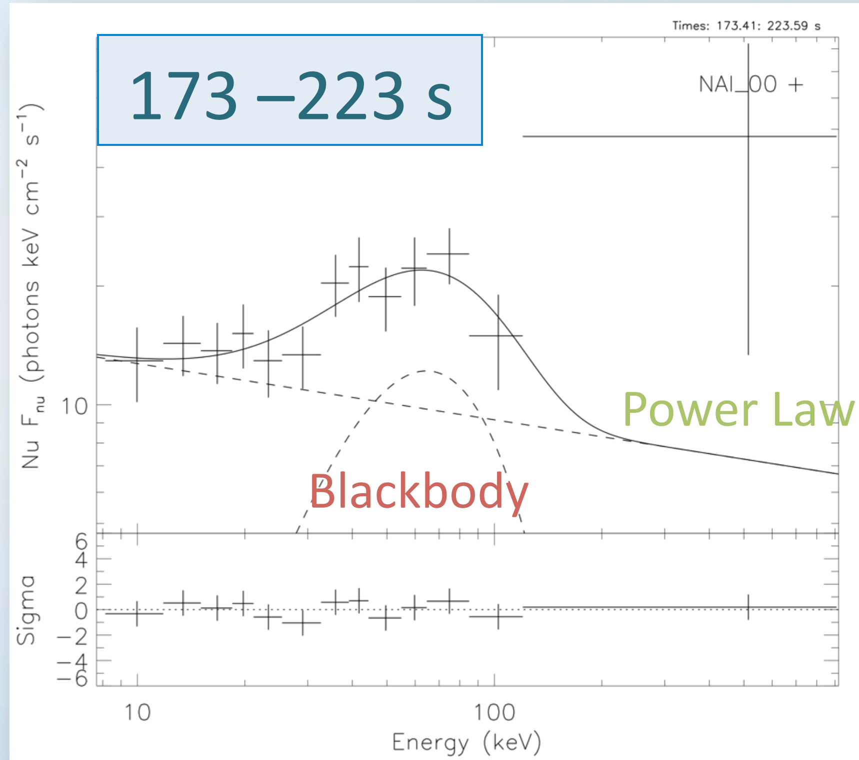
Additional Blackbody (kT = 18 keV) :
DCstat = 13.5 (for 2 DOF)

Kaneko et al. 2010

Time Resolved Spectra (νF_ν)
[T_0 + 72 - 117, 122 - 169, 173 - 223 s]

74 – 117 s Power Law only (Blackbody is not needed)





F_{BB}/F_{TOTAL} = 26% 25%

Kaneko et al. 2010

Evidence for the Blackbody Component

Temporal Properties	Spectral Properties
• Pulsations most significant in **120 – 210 s**	• Blackbody required in **122 – 223 s**
• Pulse fraction peaks in **50 – 74 keV**	• Blackbody *kT* ~ 17 keV (**Wien peak ~50 keV**)
• Pulsations not seen above 110 keV	• $F_{BB} \rightarrow 25\%$ $F_{PWRL} \rightarrow 75\%$

Kaneko et al. 2010

Blackbody: Radius of the Emitting Region

Assuming a hot spot of radius R_{HS} on the neutron star surface

For D = 5 kpc, kT = 17 keV :

$A_{HS} \approx 0.044\ (D/5\ \mathrm{kpc})^2\ \mathrm{km}^2$

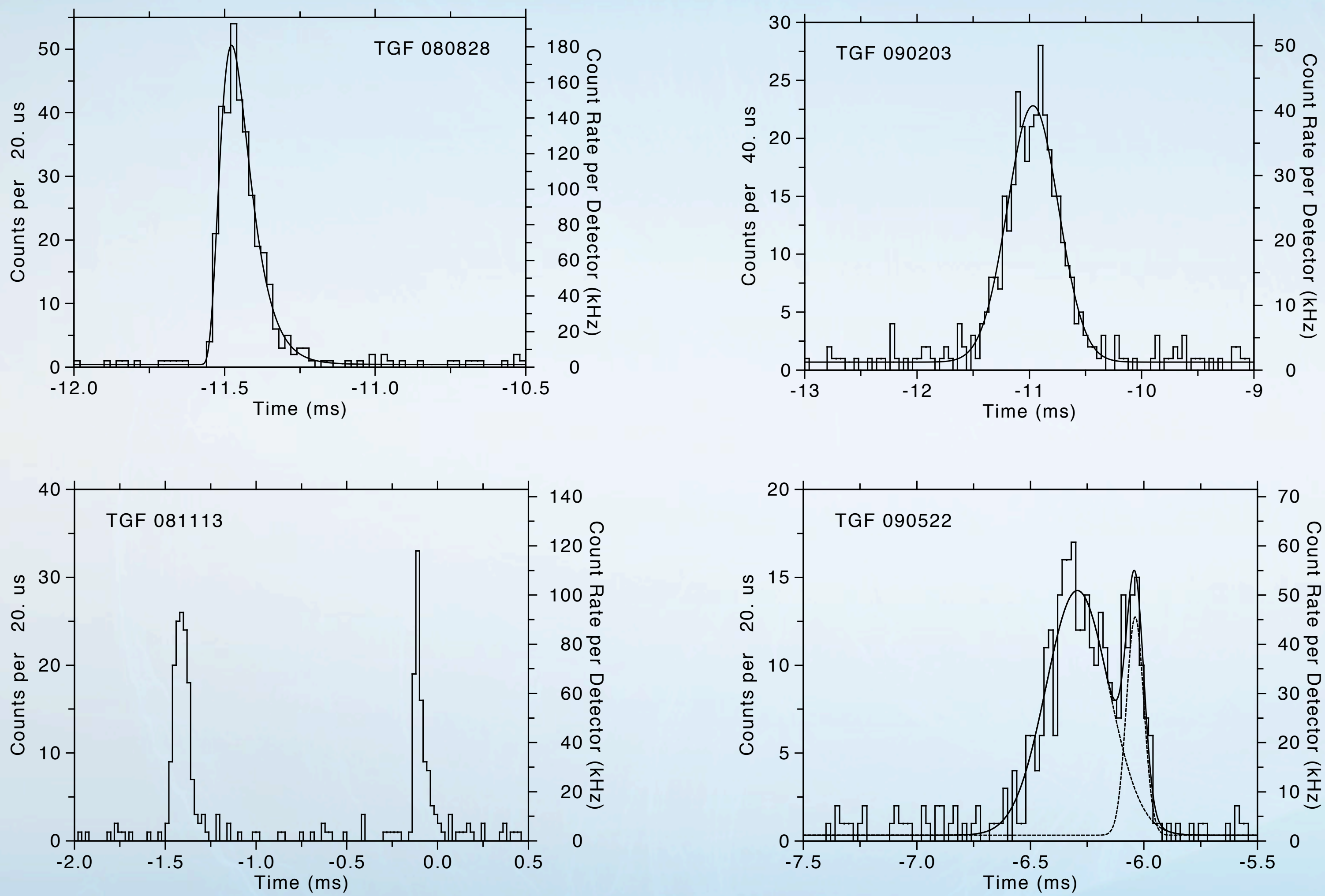
$\rightarrow$ $\boldsymbol{R_{HS} \approx 120\ \mathrm{m}}$

which is the size of the <u>magnetically-confined hot plasma</u> and is << 1% of the NS surface area

Kaneko et al. 2010

Terrestrial Gamma-ray Flashes

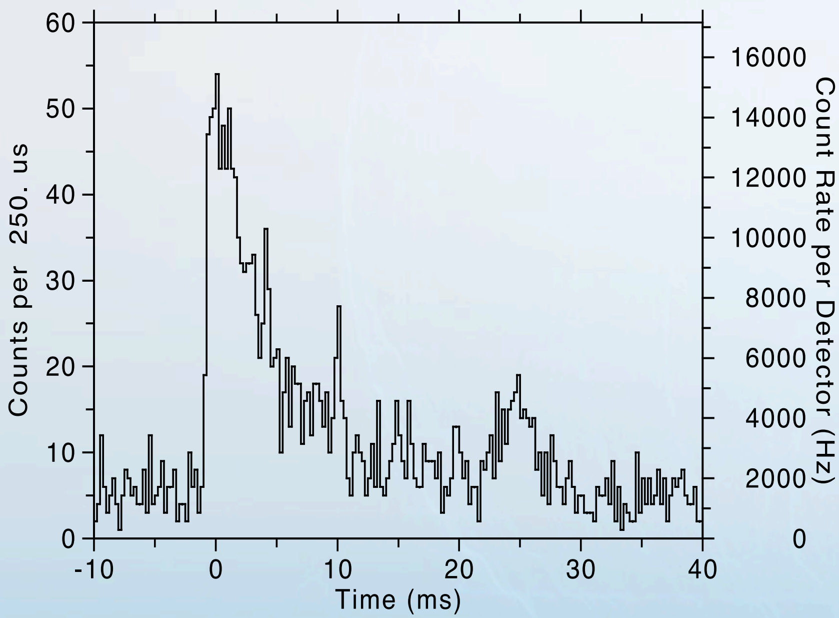
Briggs et al. 2010

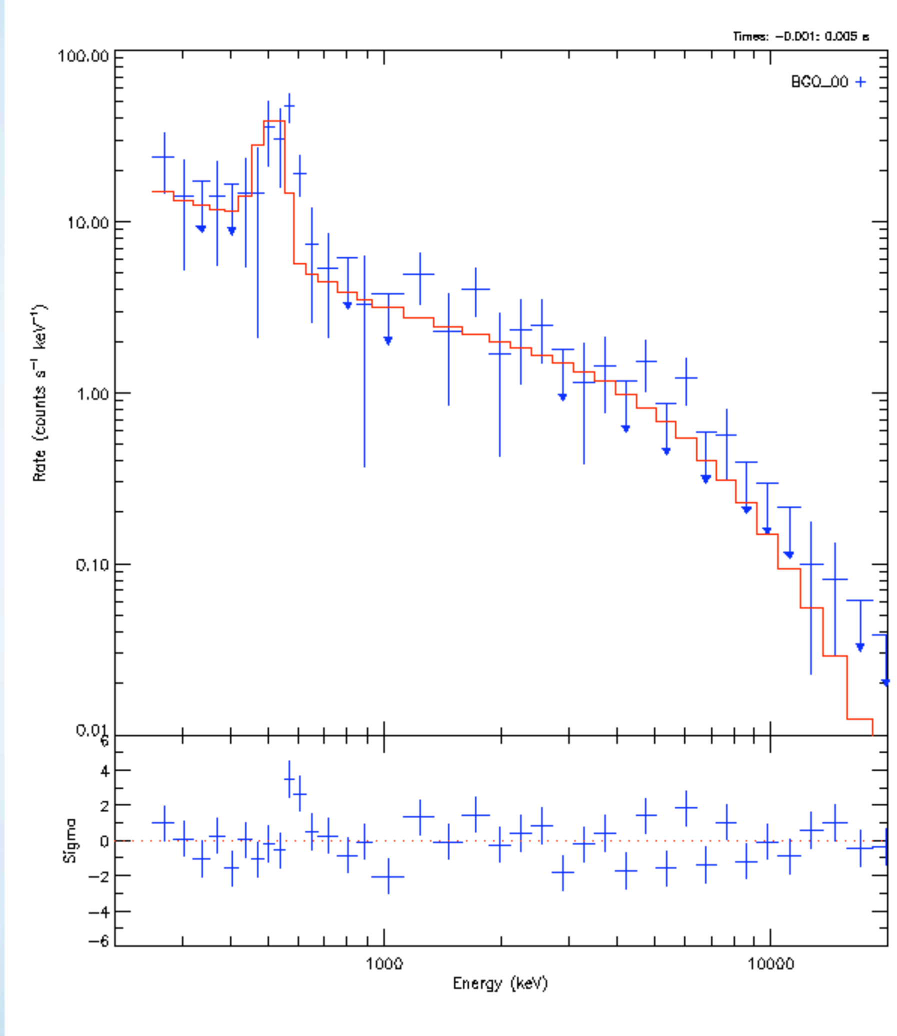


TGF: Direct Particles?

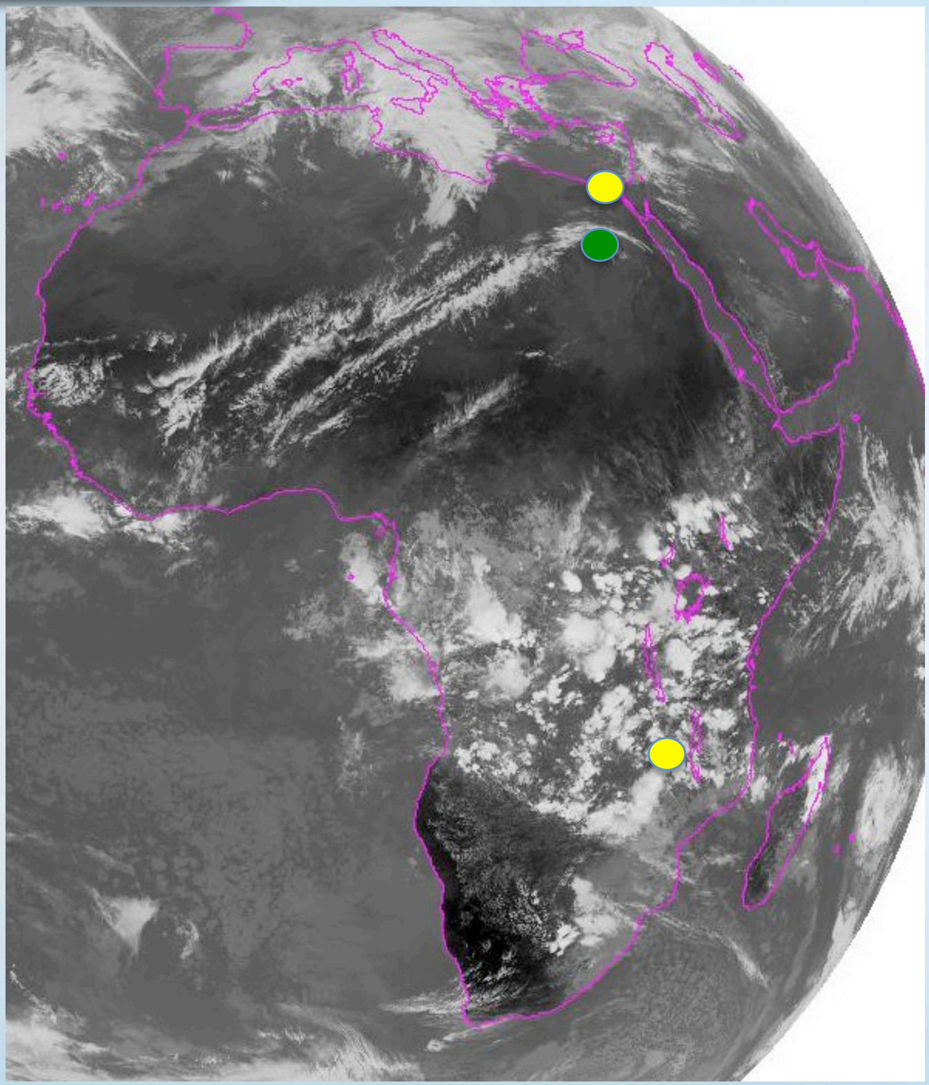
Briggs et al. 2010

- TGF duration distribution is bimodal
- ~10% are much longer
- Direct particles
- GBM sees 511 keV line ➔ positron component

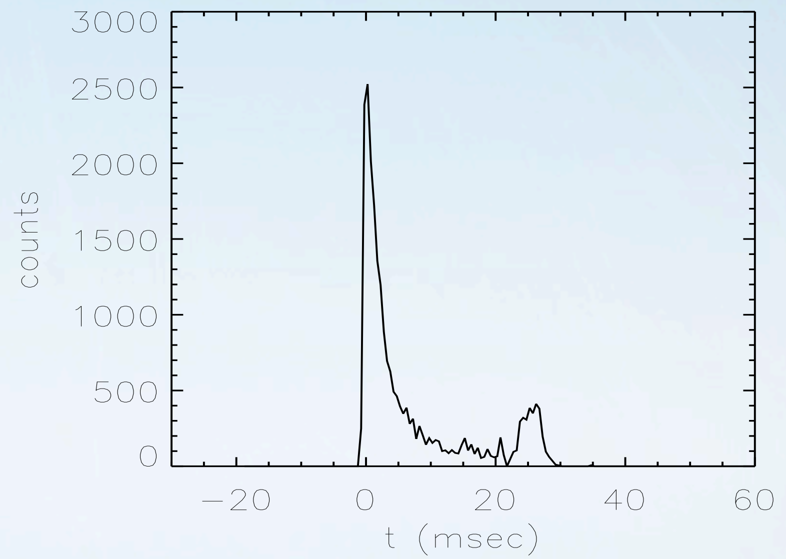


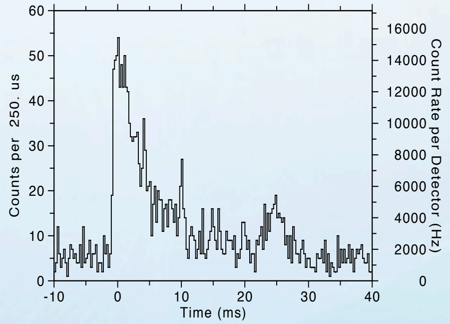


Particle TGF



Simulation by J. Dwyer (FIT)



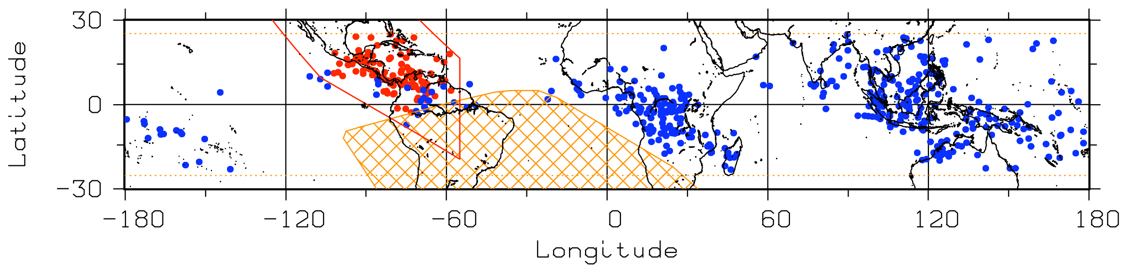


Evidence for two types of TGFs

- Bimodal duration distribution
- In some cases, lack of thunderstorms & lightning under Fermi, while thunderstorms & lightning exist at a magnetic footprint
- Time histories explained according to the geomagnetic configuration, including in some cases a second pulse due to mirroring
- NEW with Fermi: a strong 511 keV line, that is difficult to explain except via positrons directly reaching Fermi

Near-term operational plan

TTE for portions of the orbit



- Idea: downlink TTE for selected portions of the orbit: by geography and season,
- The figure shows a polygon for The Americas, with TGFs marked in red for the season May to November.
- This selects 108 of 500 TGFs,
- The telemetry is 4.0 Gbits per day (from measured count rate in this polygon of 120×10^6 counts per day),
- TGFs in The Americas are the most valuable because this region has the best VLF radio (sferic) coverage.

Scientific Gains

- More TGFs to correlate with lightning via VLF radio detection (sferics)
  - Temporal relation between TGFs and lightning, including multiple-pulse TGFs & multiple stroke sferics
  - Characteristics of the lightning: current, altitude, etc
  - Larger sample for offsets from sub-spacecraft point ➔ beaming
  - Characteristics of the associated storms
- Study flux & fluence distributions
- Spectroscopy of the brightest additional TGFs (fainter ones may have too few counts)
- Verify deadtime & pulse pileup corrections with less intense events

Implementation

- FSW revision
  - Additional commands to start/stop continuous TTE
  - Logistics to handle case where trigger is in progress when TTE start command is received
  - Handle case where trigger occurs during continuous TTE
- Add ATS commands to turn TTE on/off when inside selected geographical region
  - Command times based on orbit predictions
- Data are public & delivered to FSSC