The Fermi Gamma-Ray Burst Monitor

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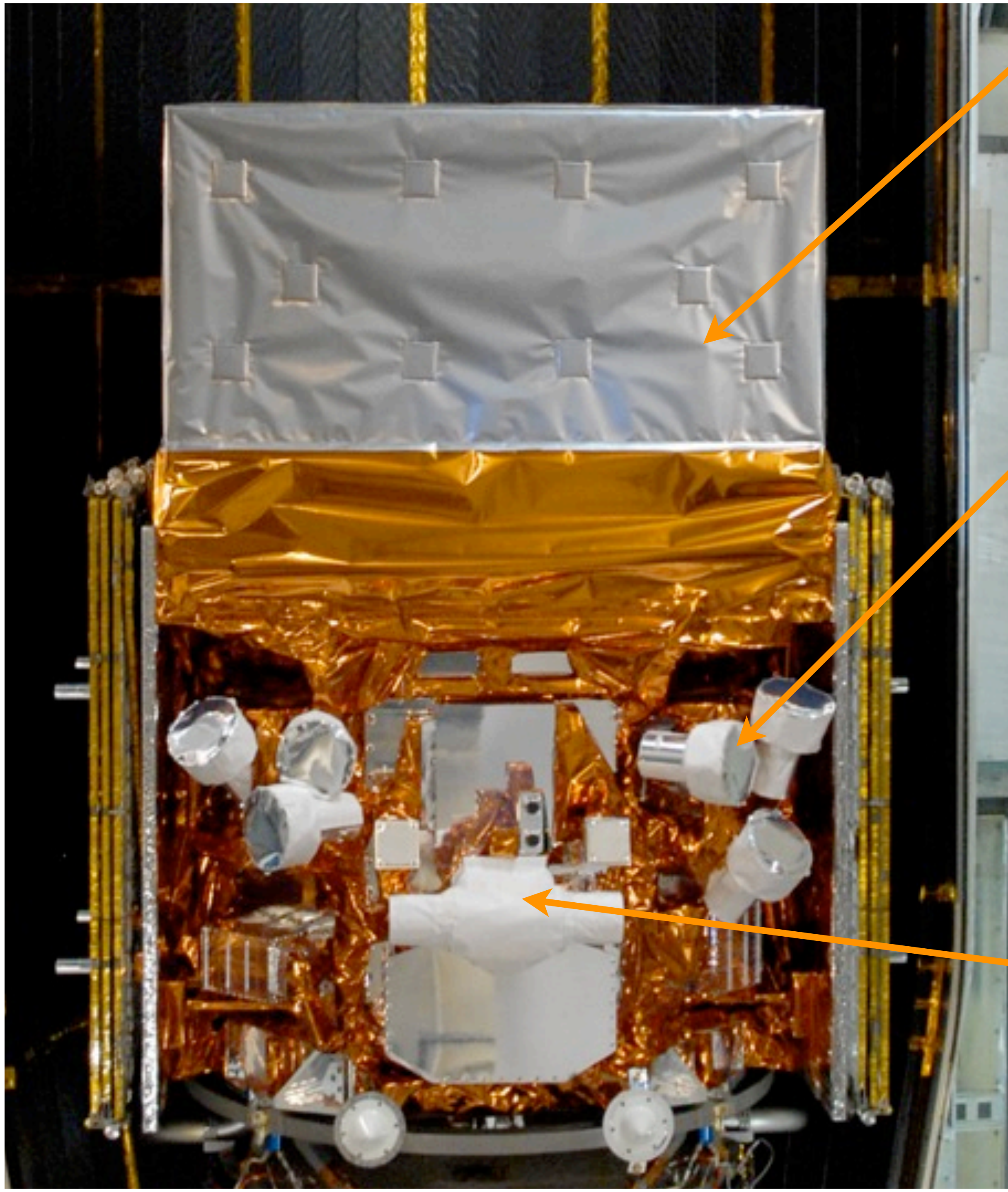
The Gamma-Ray Burst Monitor (GBM) is the secondary instrument on-board the Fermi spacecraft.

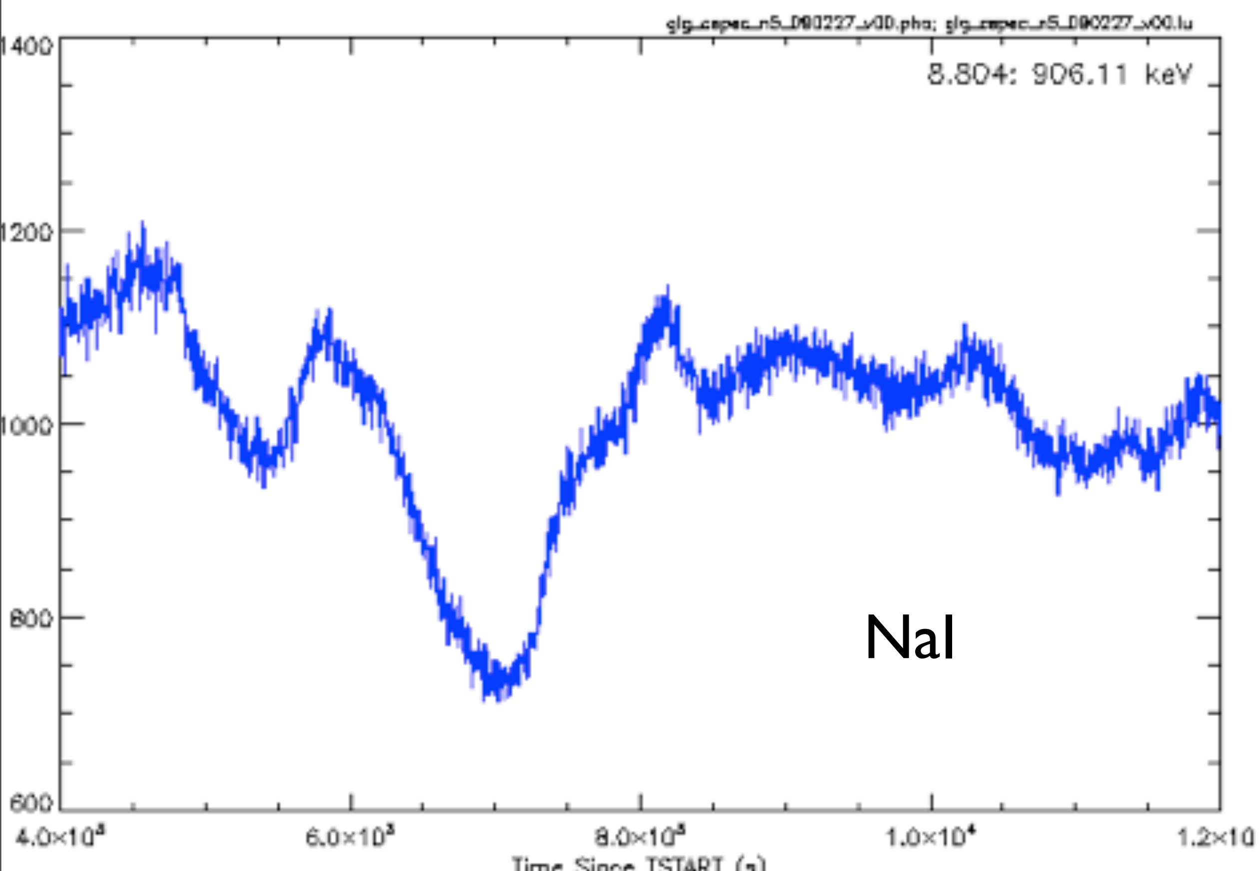


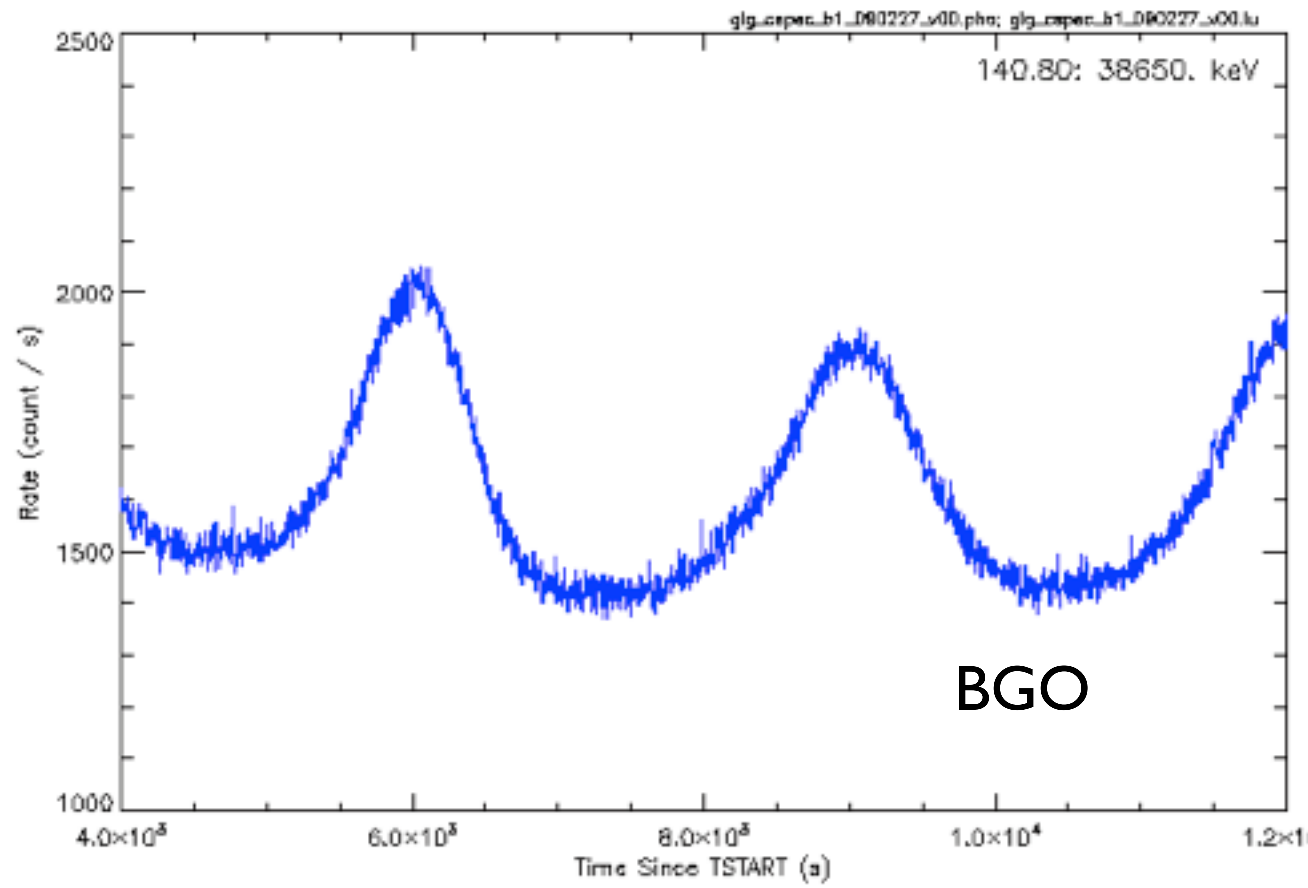
The Large Area Telescope (LAT)

GBM NaI detector x 12.
8 keV -- 1000 keV
126 cm^2, 1.27 cm
Triggering, localization, spectroscopy.

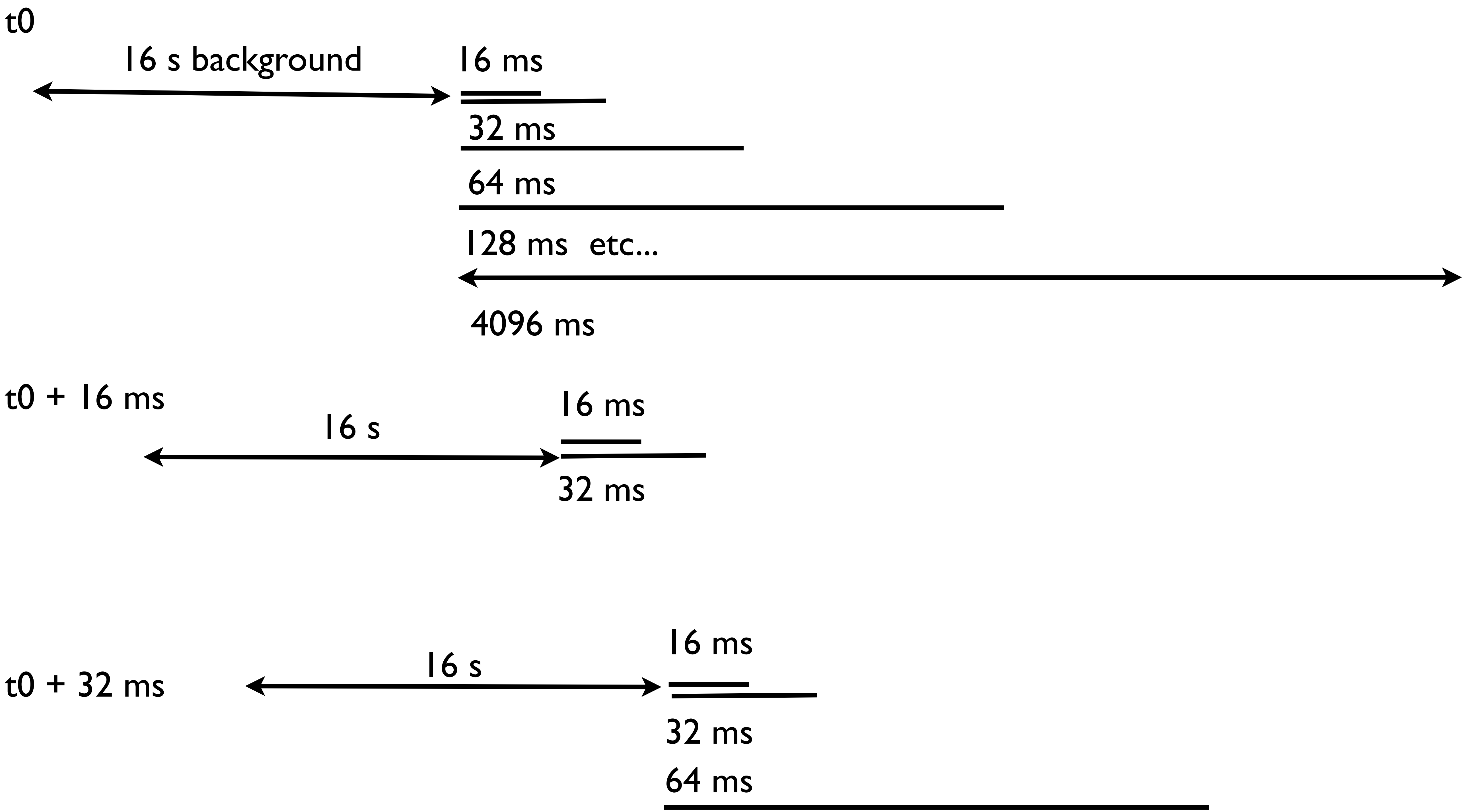
GBM BGO detector x 2.
200 keV -- 40 MeV
126 cm^2, 12.7 cm
Spectroscopy
Bridges gap between NaI and LAT.

GBM is a background-limited instrument

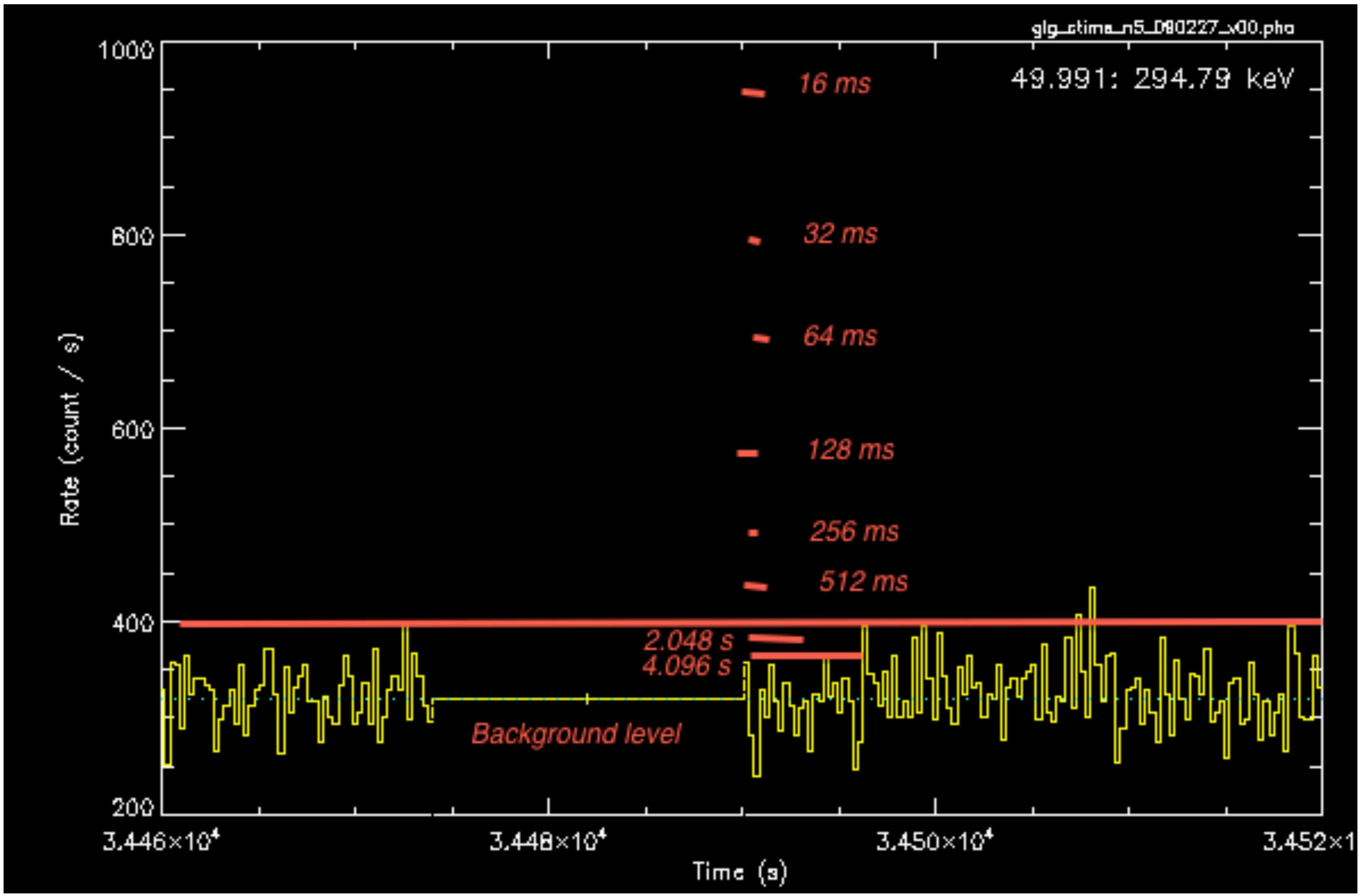




GBM triggers on time-scales from 16 ms to 4.096 s in several energy bands (20 - 100 keV, 50 - 300 keV, 100+ keV...)

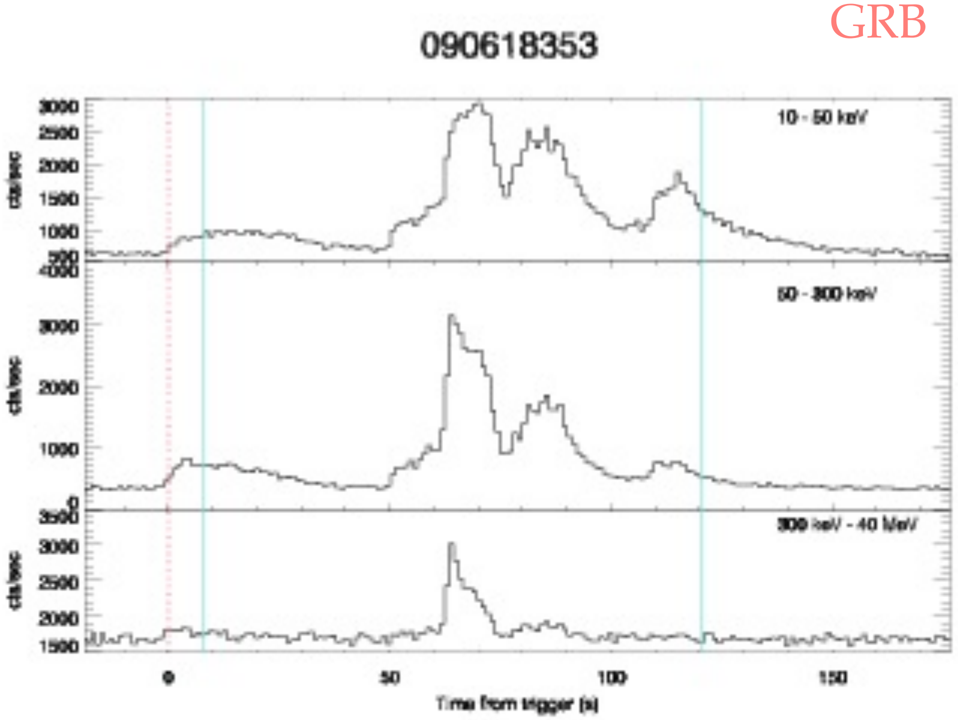


The triggering time-scale is a measure of how impulsive the triggering event is

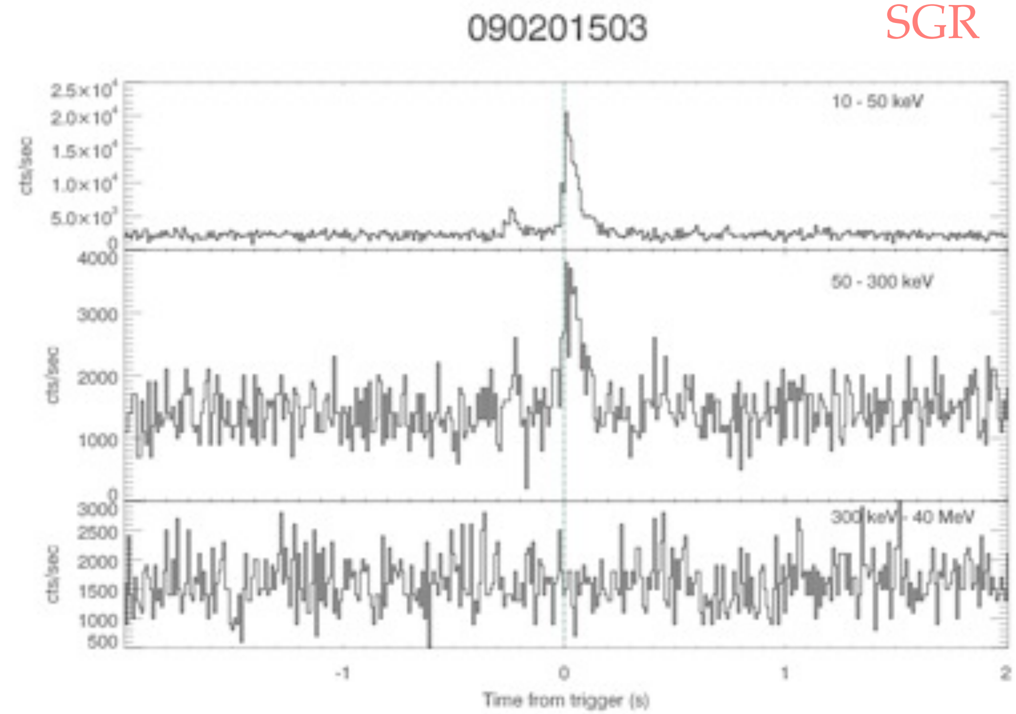


What does GBM trigger on?

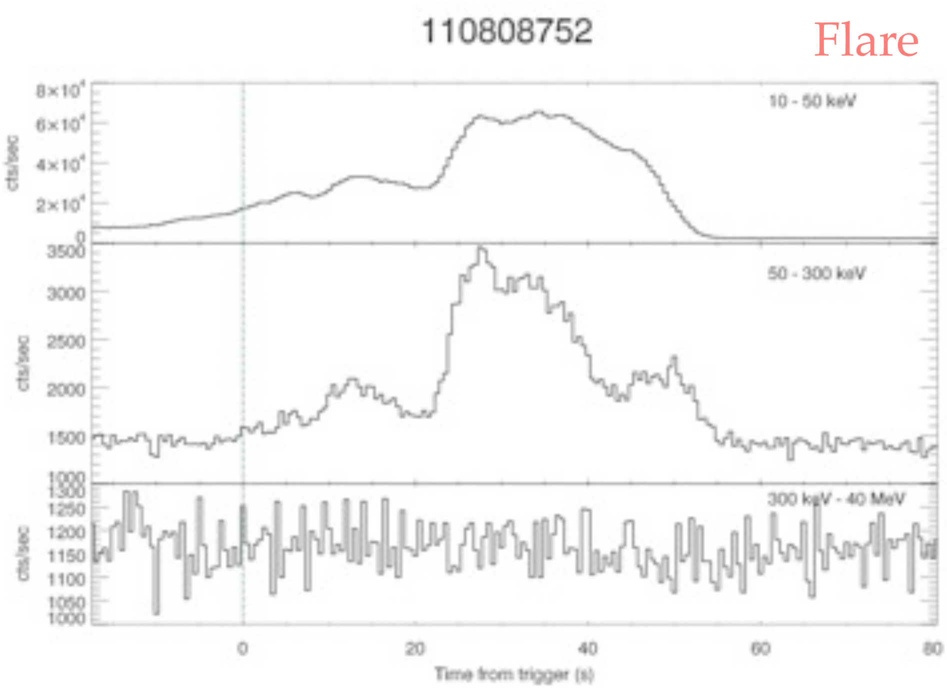
GRB



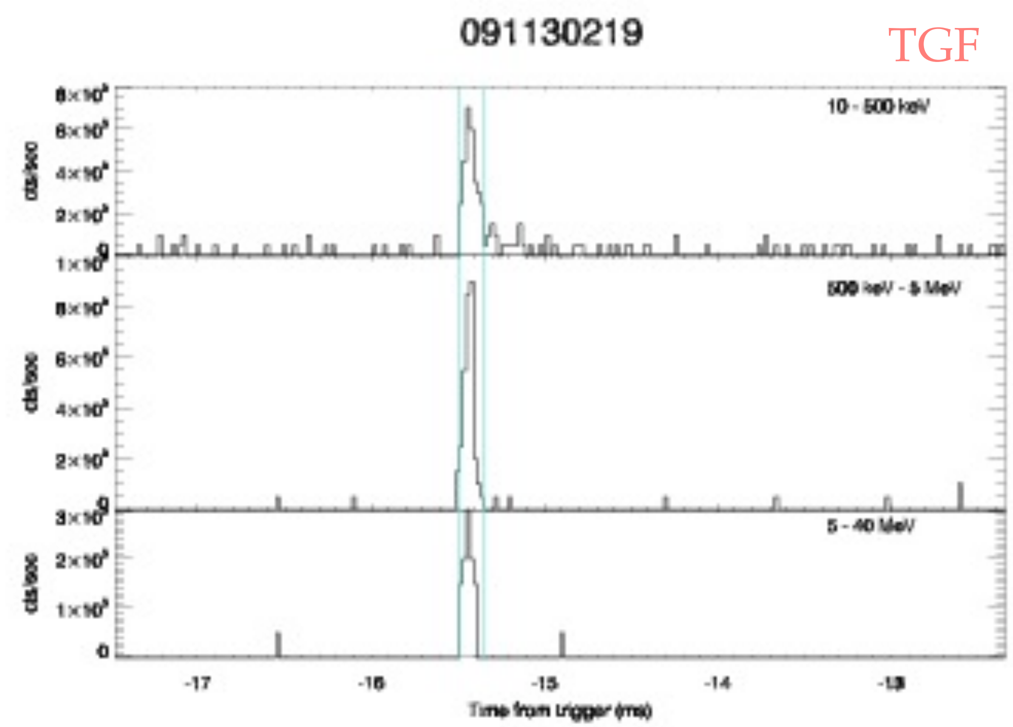
SGR



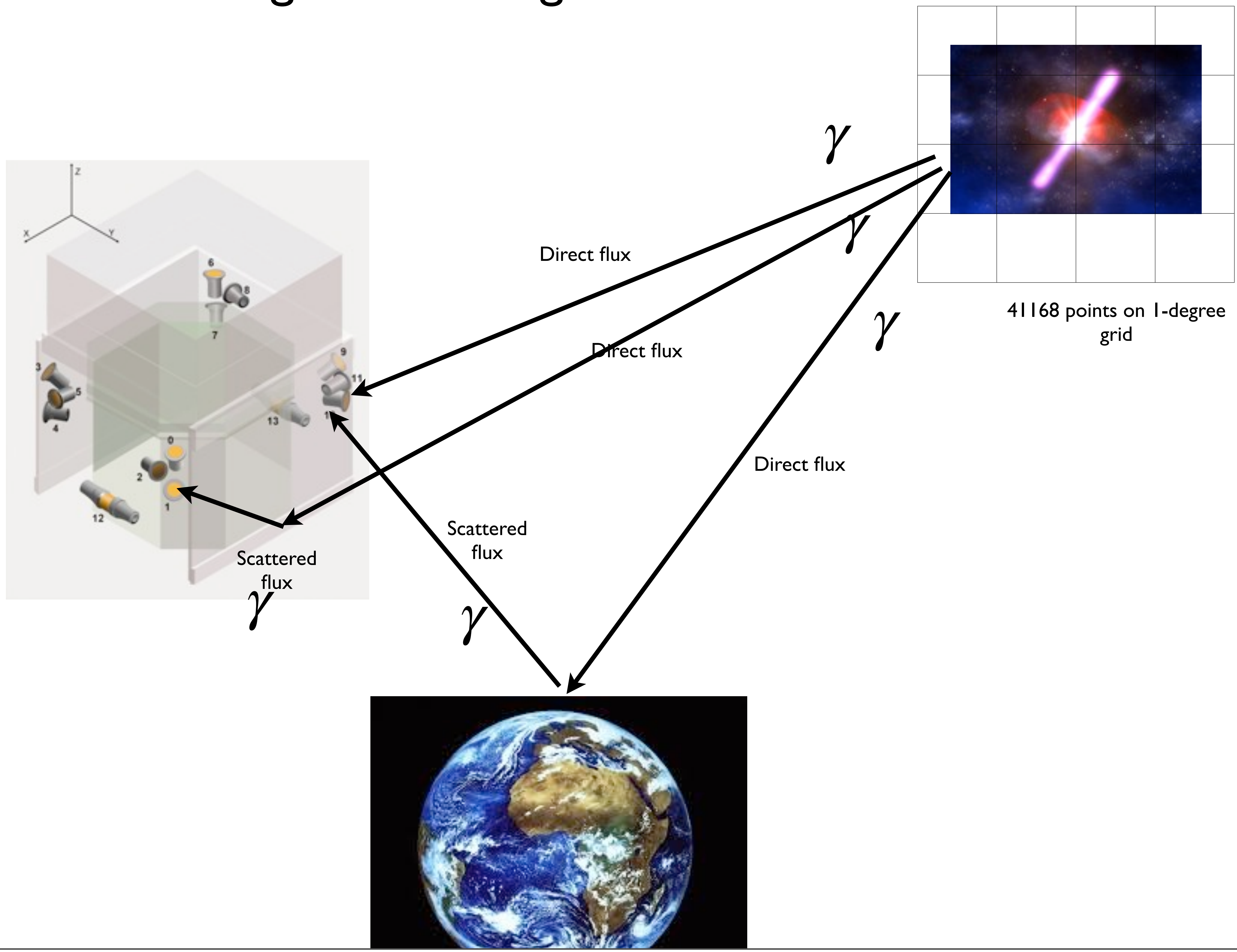
Solar Flare



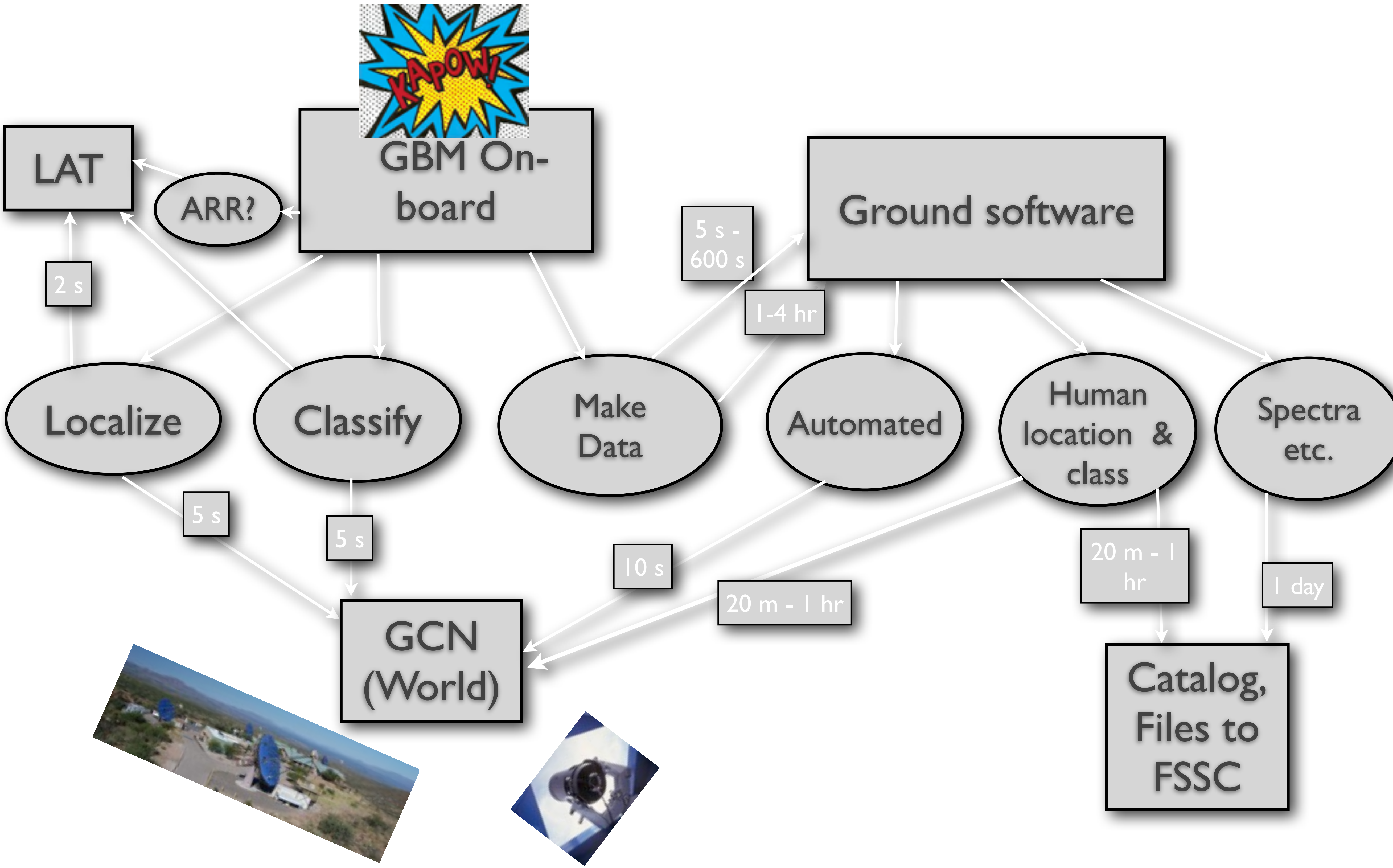
TGF



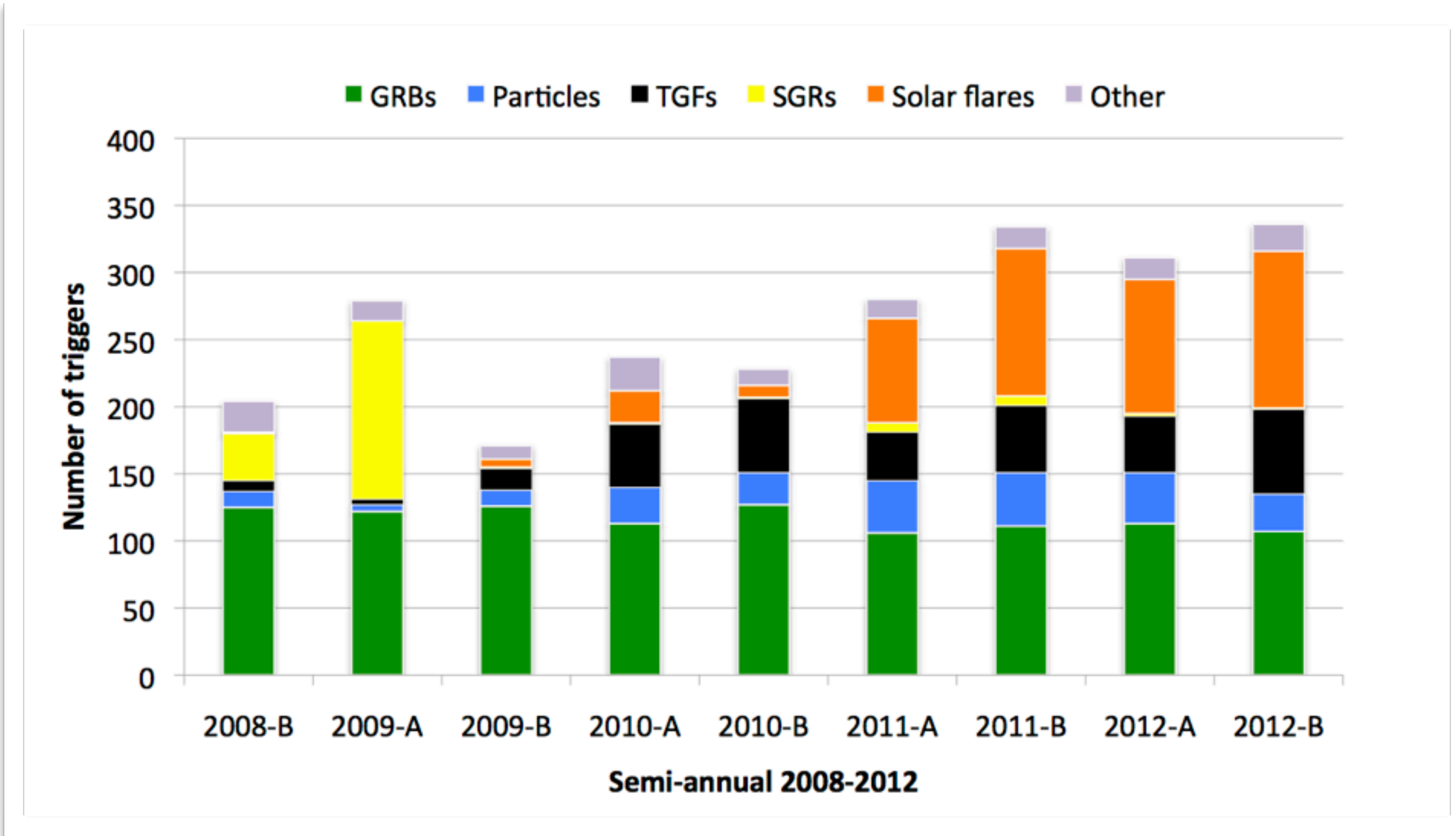
Source localization with GBM uses triangulation and is accurate to about 3-4 degrees for bright GRBs



Actions on GBM triggering



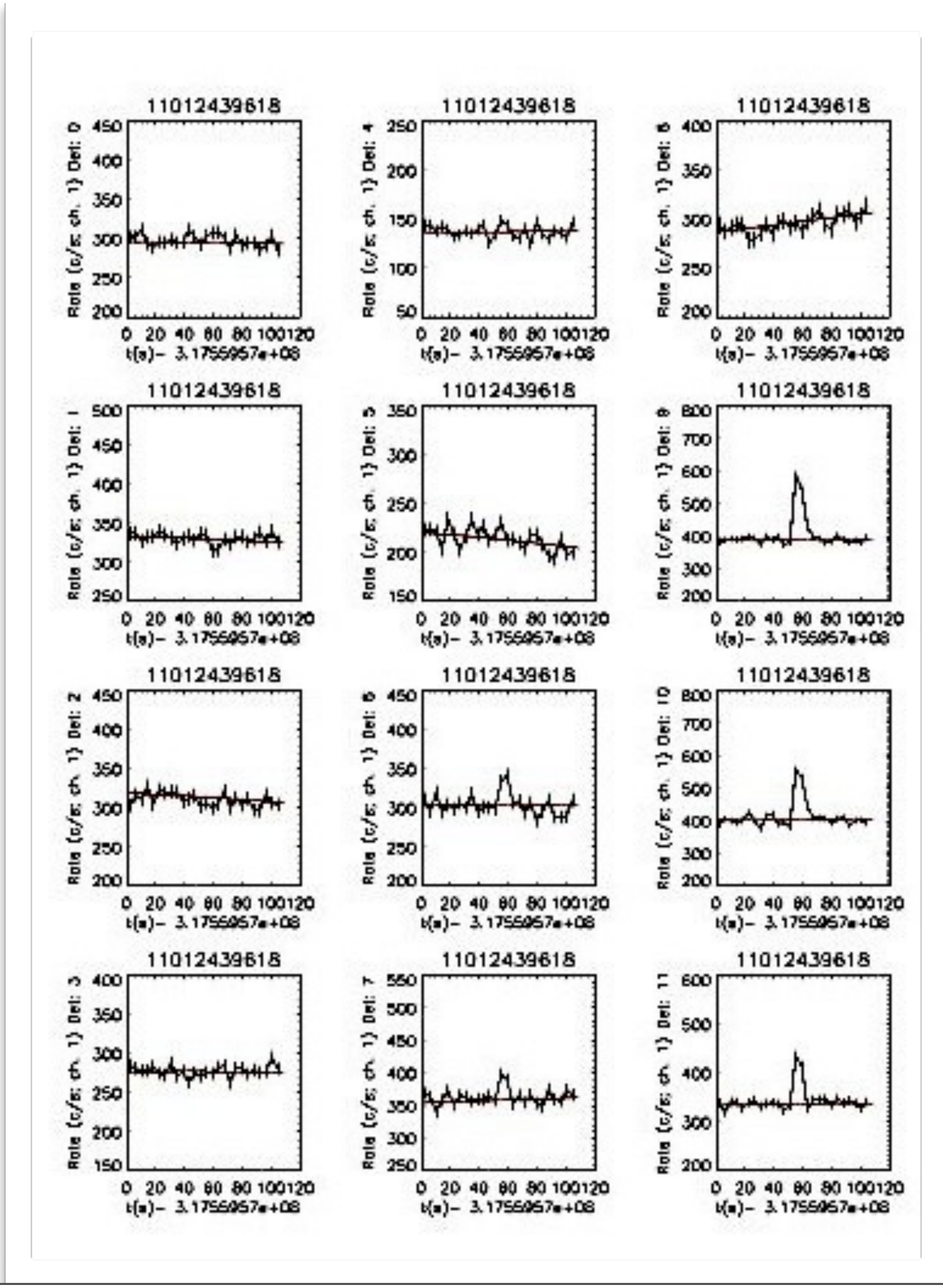
GBM triggers on a wide variety of phenomena from very local (Earth!) to very distant (GRB)

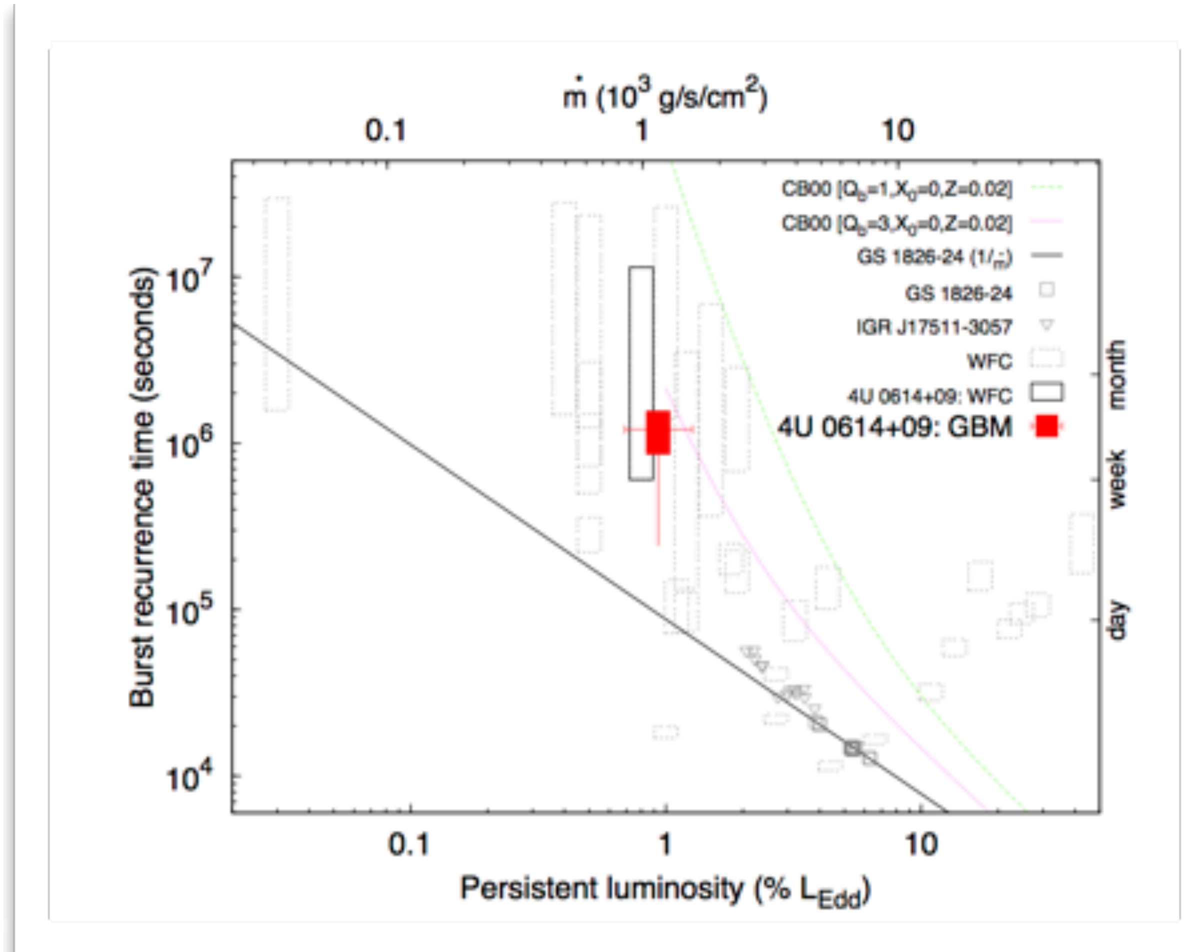


GBM does not trigger efficiently on...

- very soft events (20 - 100 keV is lowest trigger band)
  - Untriggered (offline) search from 8 keV
- non-impulsive events (4 s is longest window)
  - Earth Occultation
  - Pulsar searches
- very short events (compared to 16 ms window)
  - New data mode

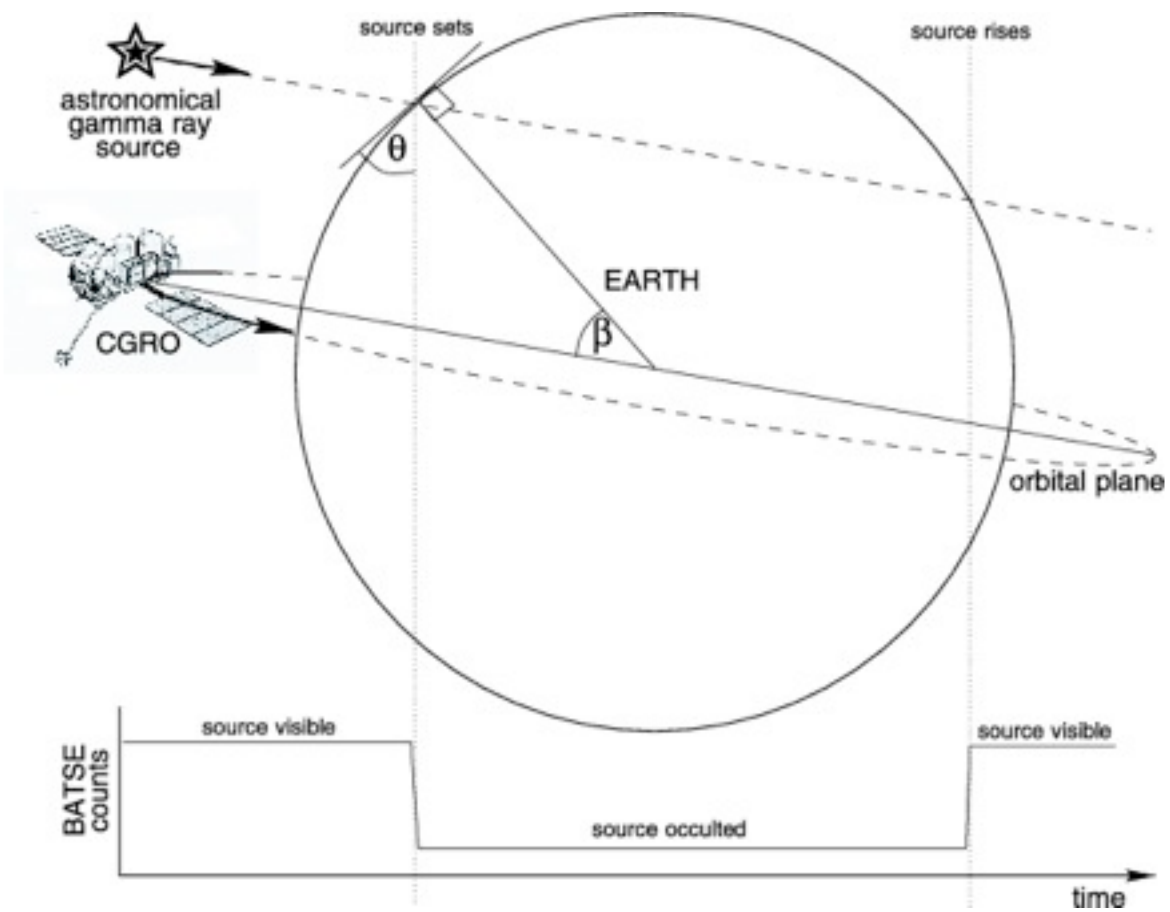
We can find untriggered events from Type-1 X-Ray Bursts

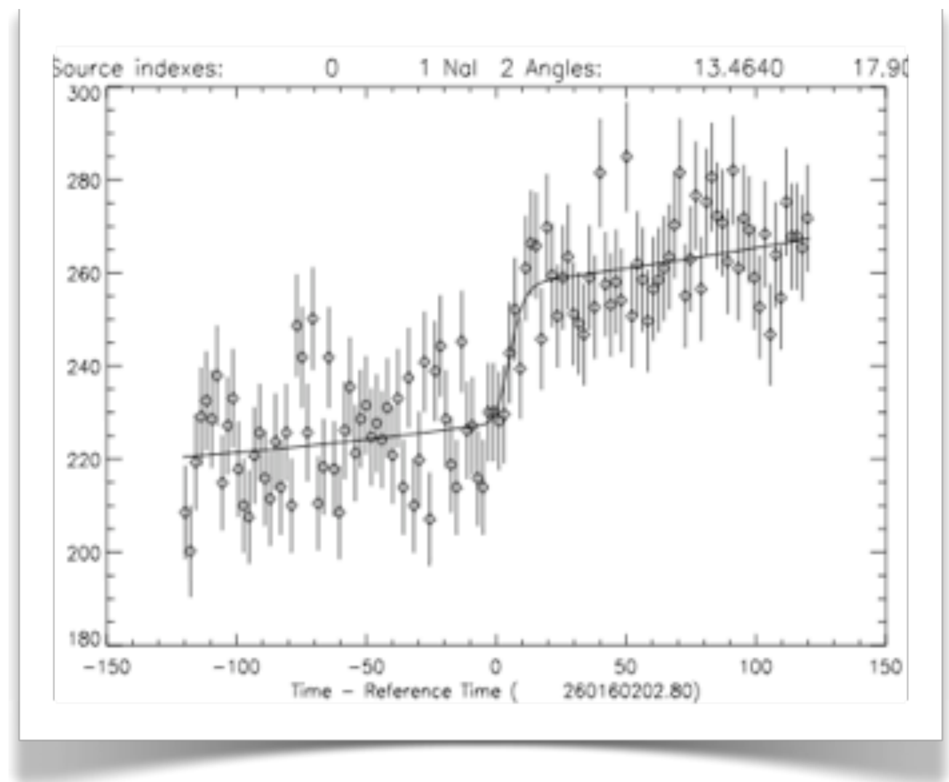




Linares+ ApJ 2012

Grabbing sources from background: Earth Occultation Technique

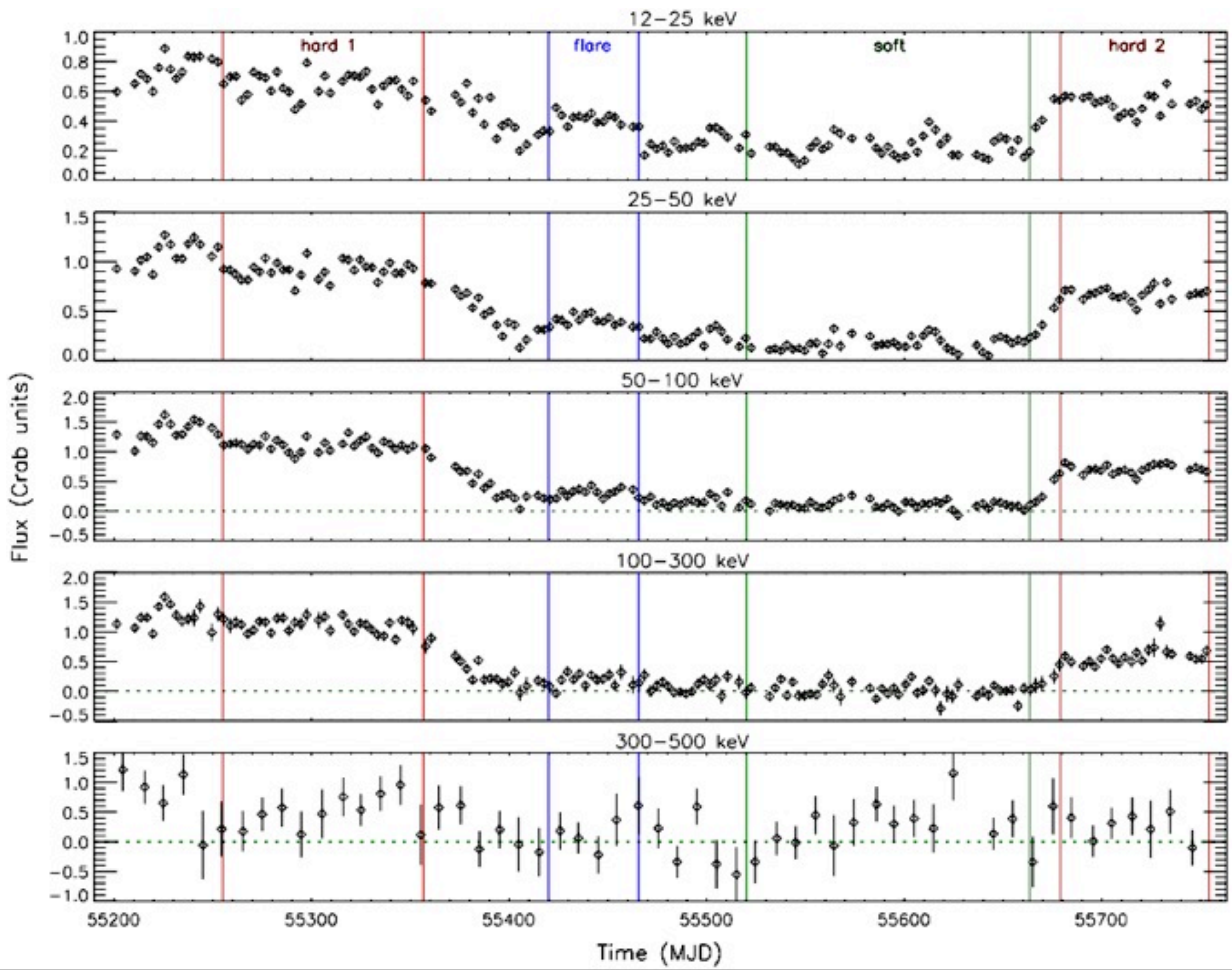




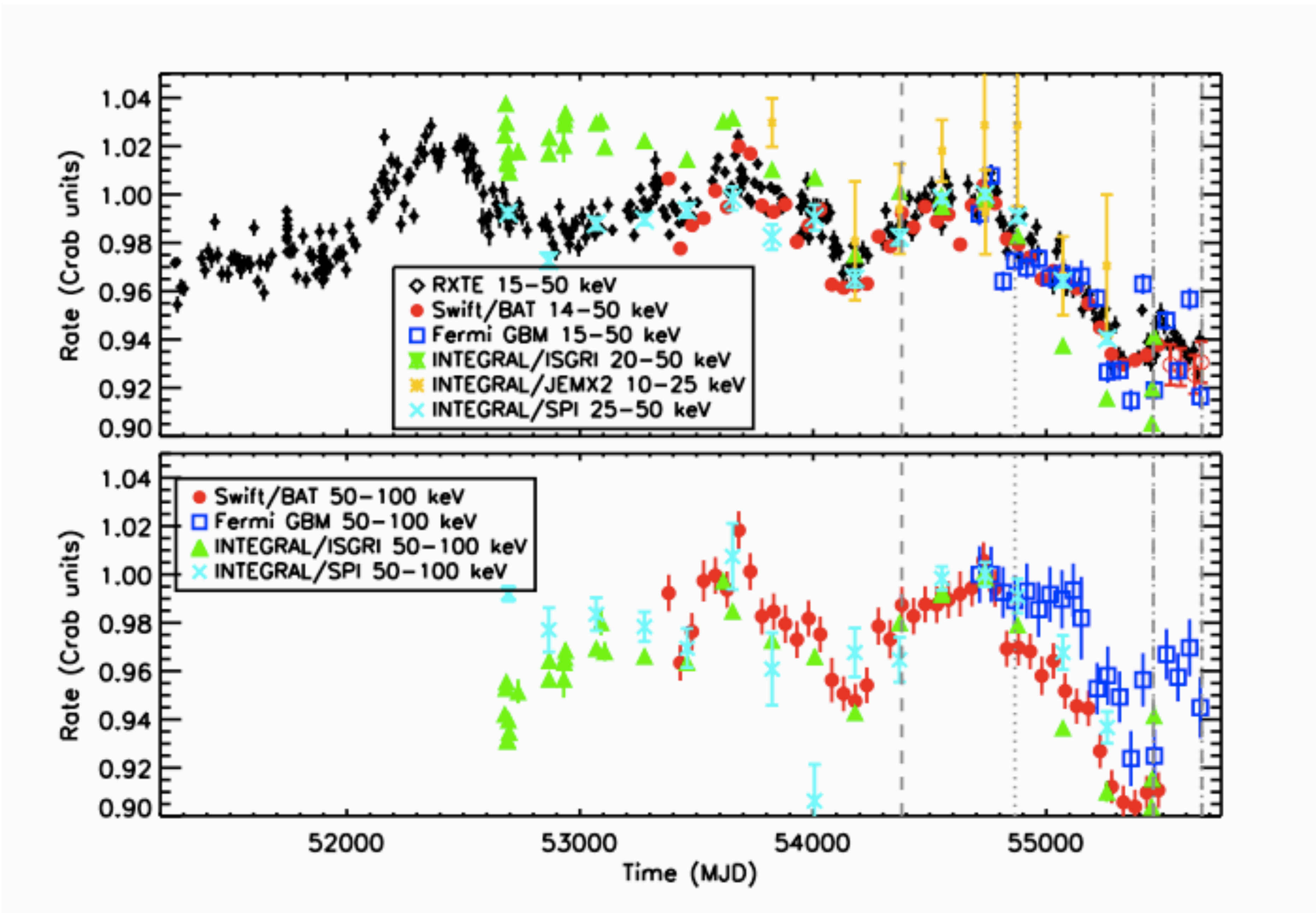
Crab rise in GBM

Shaw+ A&A 2004

Earth Occultation Technique:
Monitoring long-term behavior of sources (i) Cyg X-1



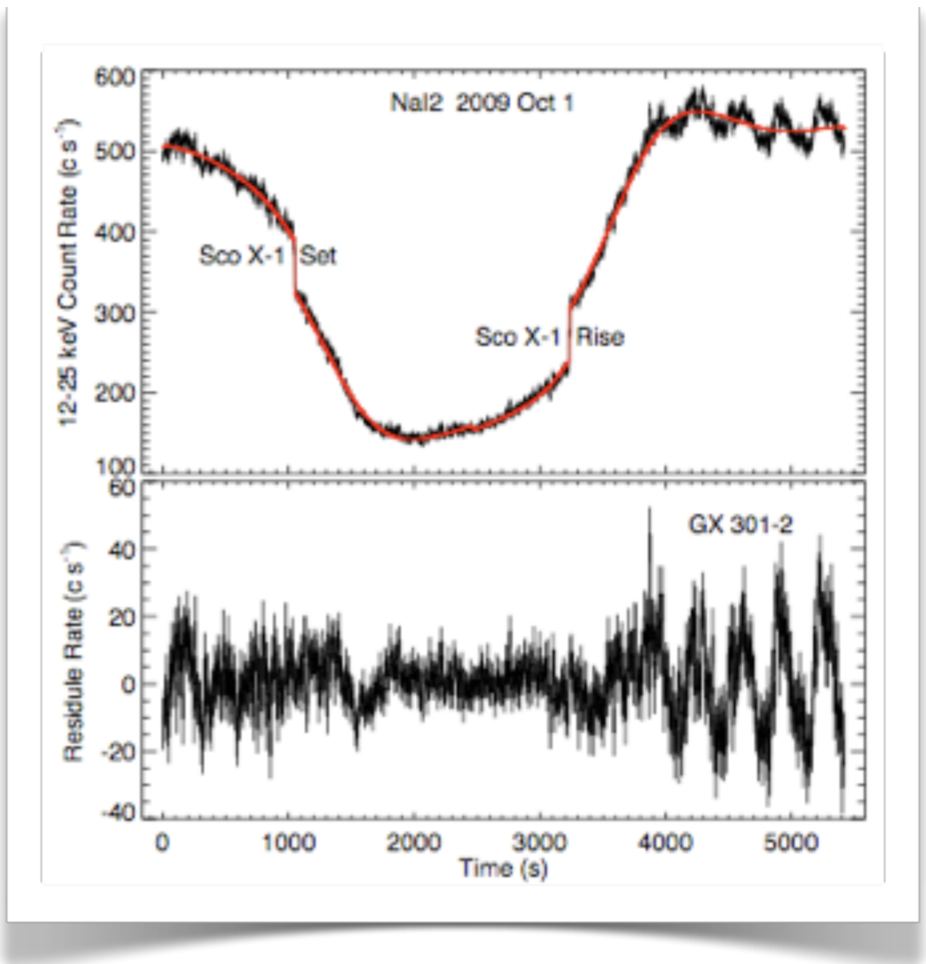
Earth Occultation Technique:
(ii) Finding the Crab flux varies!



Wilson-Hodge+, ApJ 2011

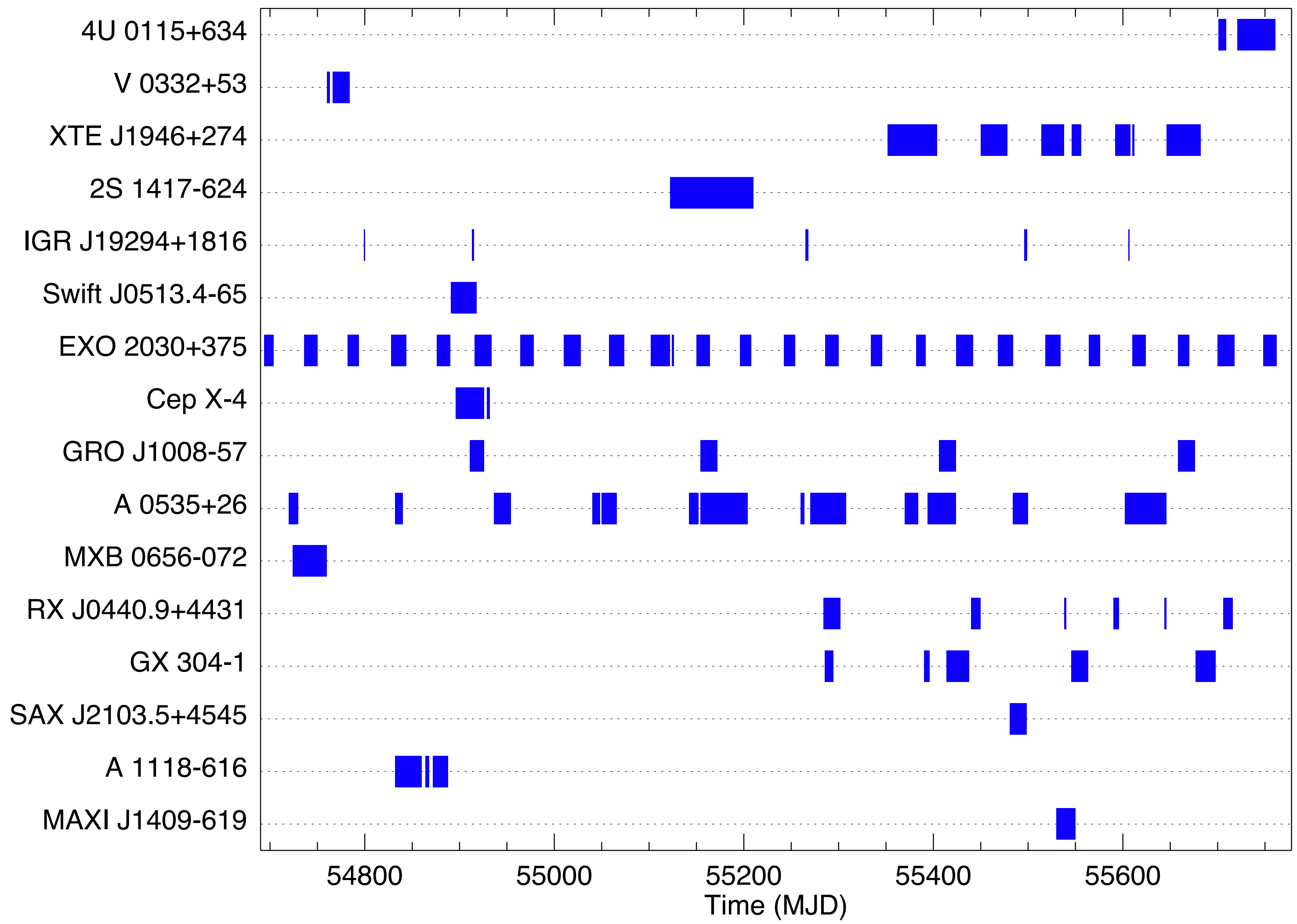
Grabbing sources from background: Pulsar Technique

- Until recently limited to 0.5 s to 1000 s accretion-powered pulsars

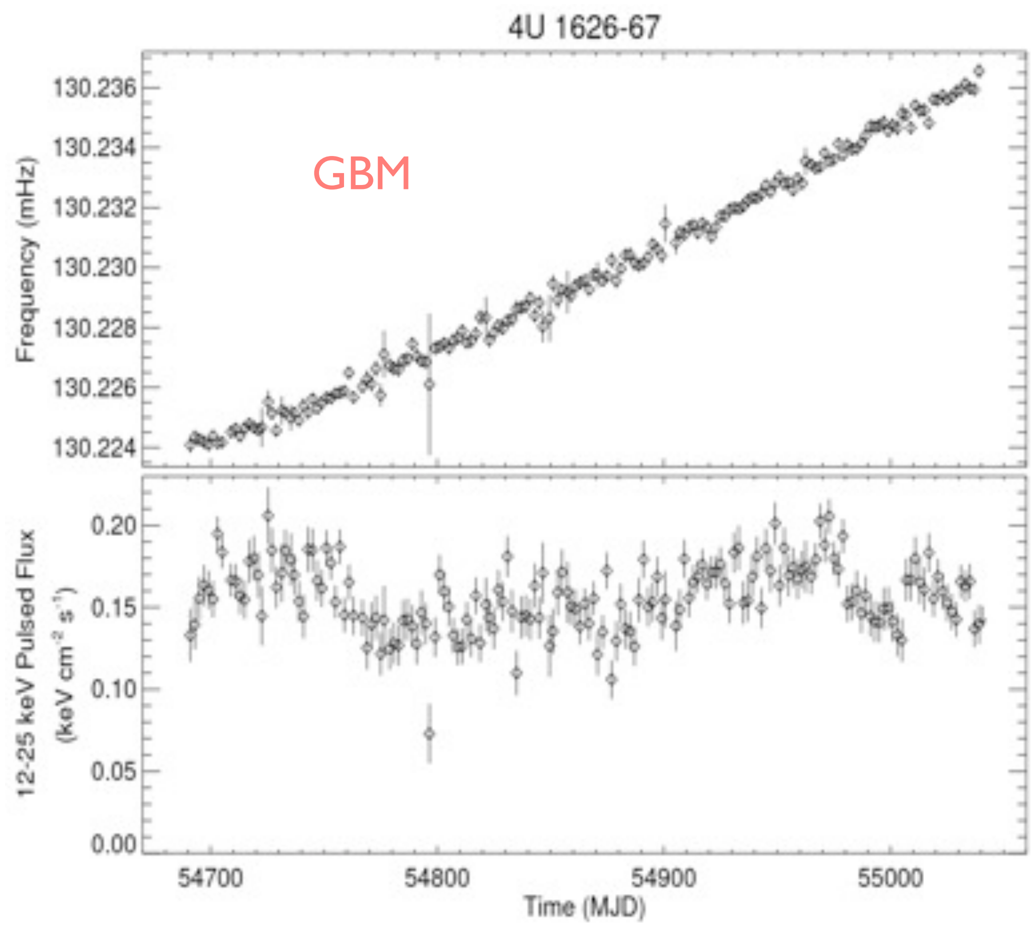


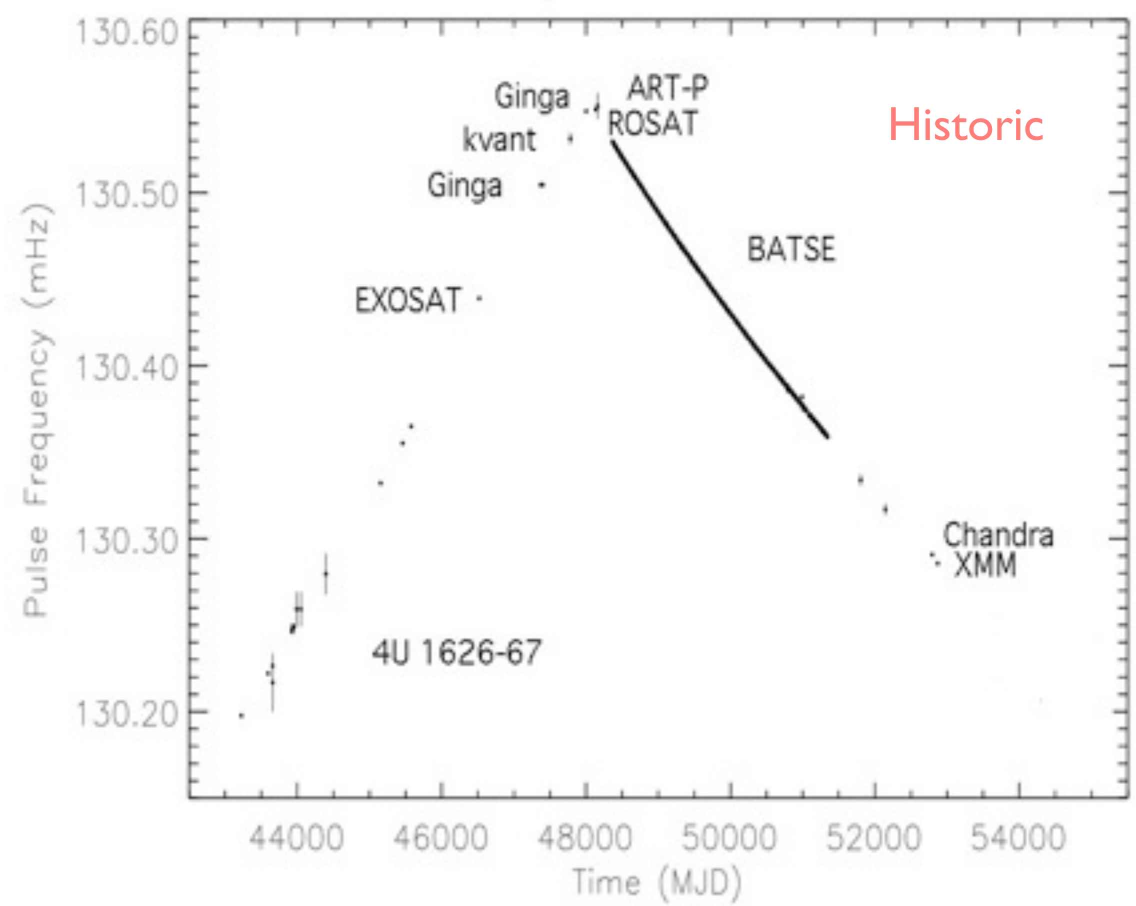
http://gammaray.nsstc.nasa.gov/gbm/science/pulsars

Pulsar monitoring with GBM: Detecting outbursts



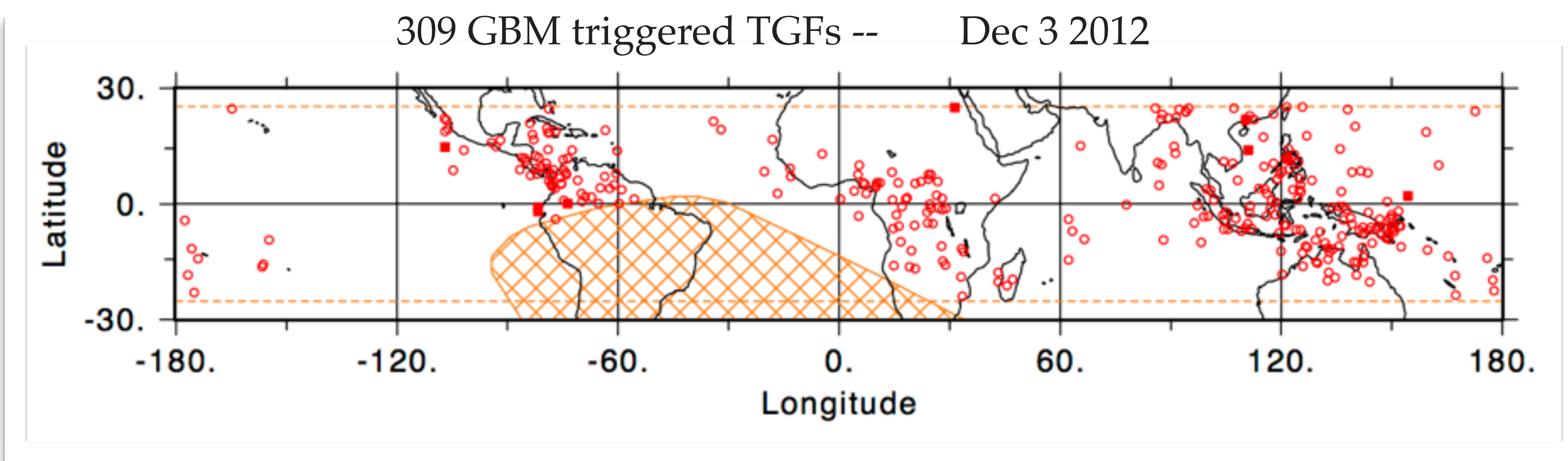
Pulsars with GBM:
Detecting torque reversals

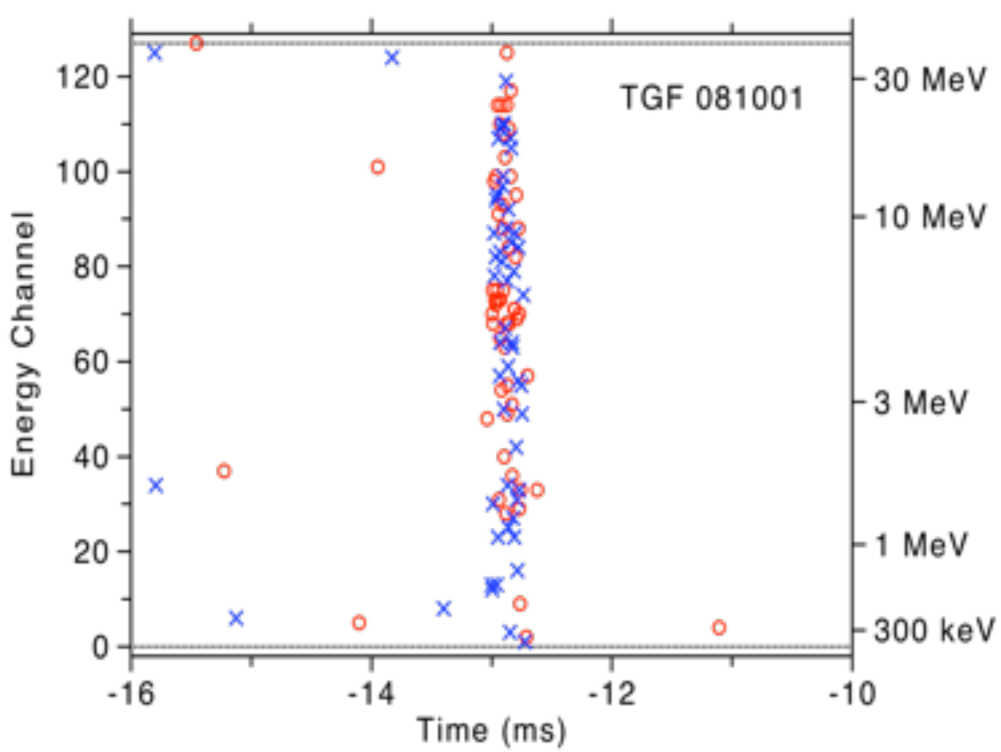




Camero-Arranz+ ApJ 2010

Terrestrial Gamma-Ray Flashes (TGFs):
Particle acceleration in the Earth's atmosphere





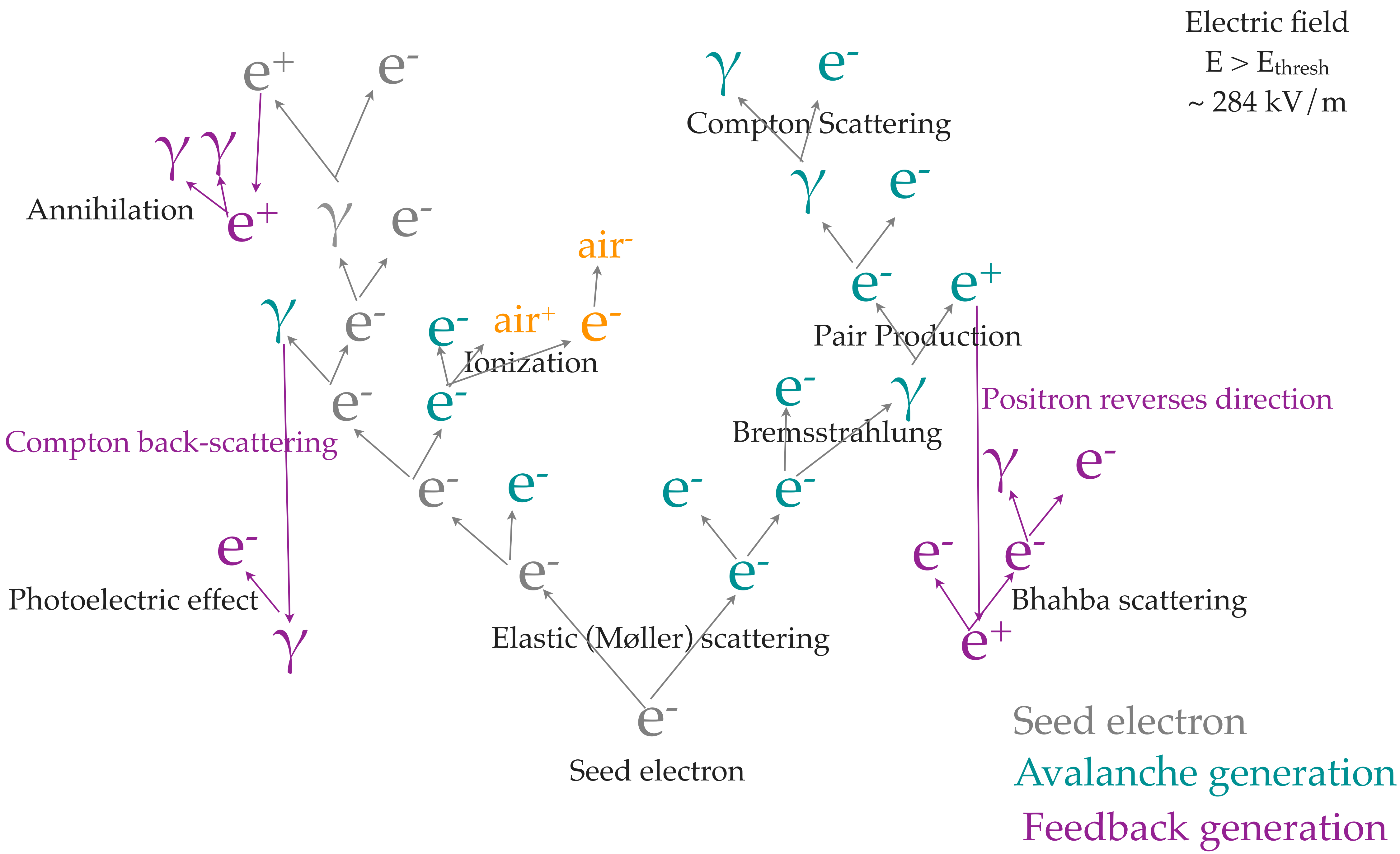
< 1 - 25 ms duration (most < 1 ms).

V. Hard spectra > 30 MeV

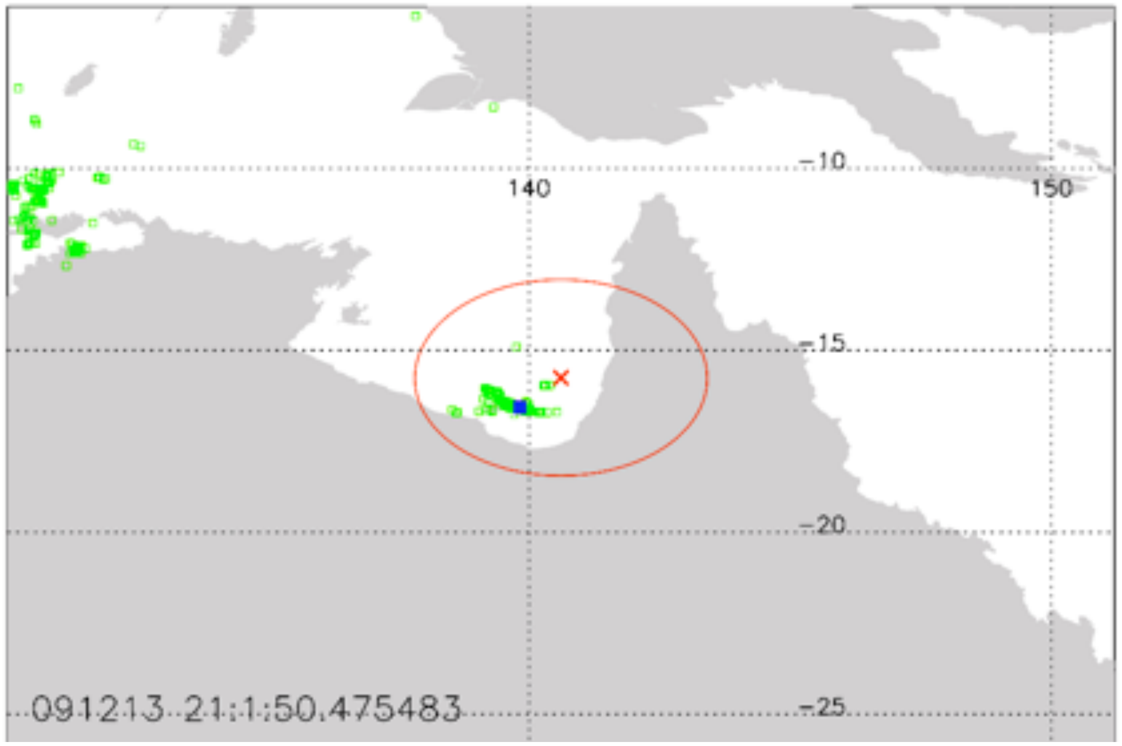
Associated with thunderstorms.

"Runaway electron" processes.

TGFs: particle acceleration in the atmosphere



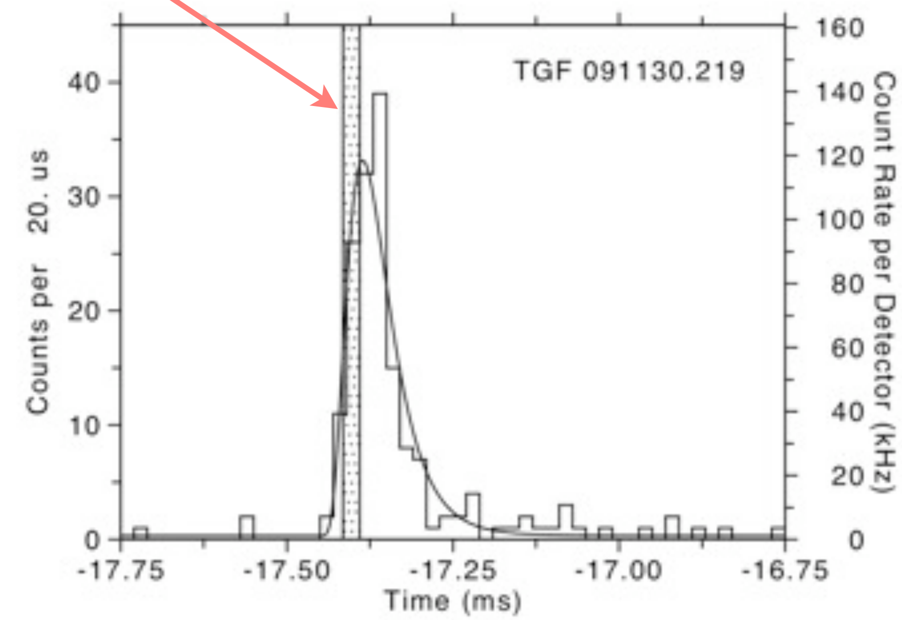
TGFs are seen in gamma rays or in leptons depending on the geometry of Fermi to the initiation point

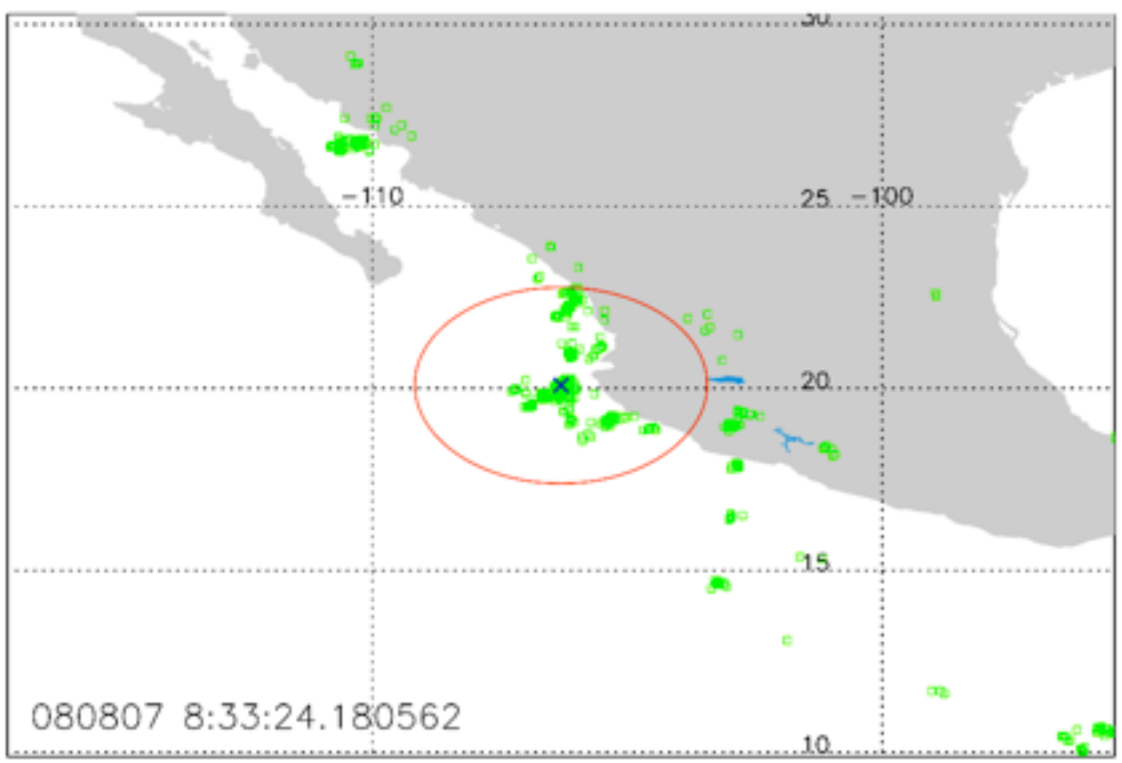


Storm under Fermi

Short TGF =
γ-ray TGF

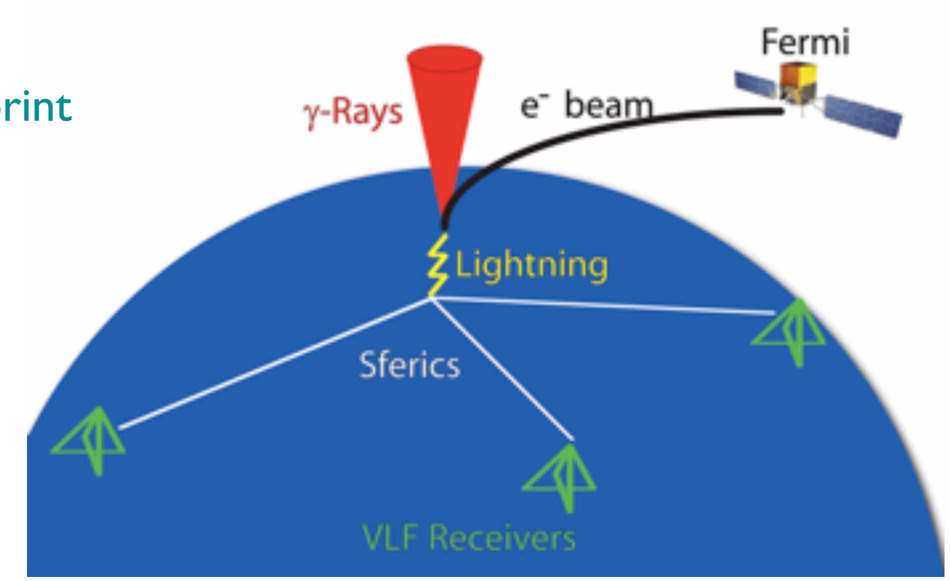
VLF discharge time: 30% of GBM TGFs have associated discharge, most within 20 μs of peak



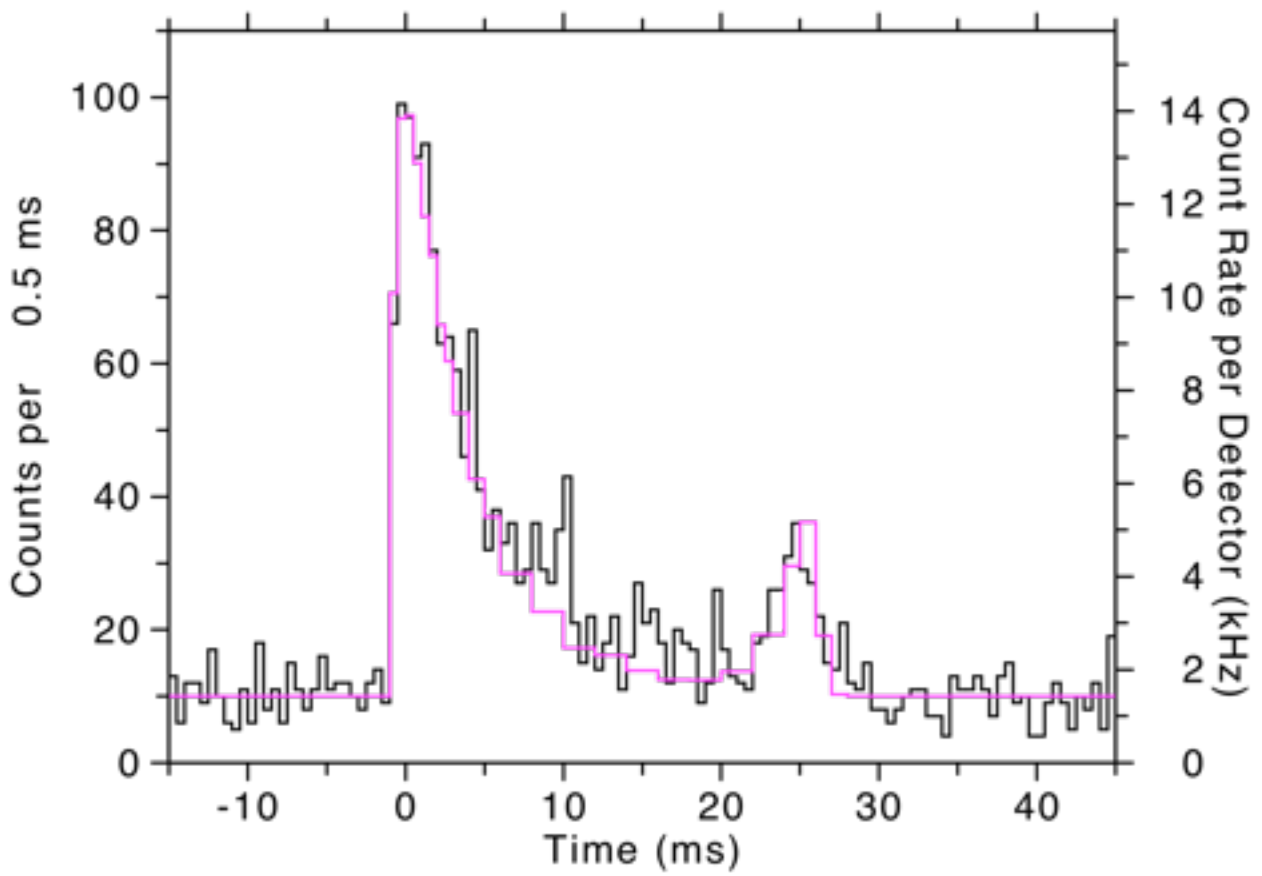


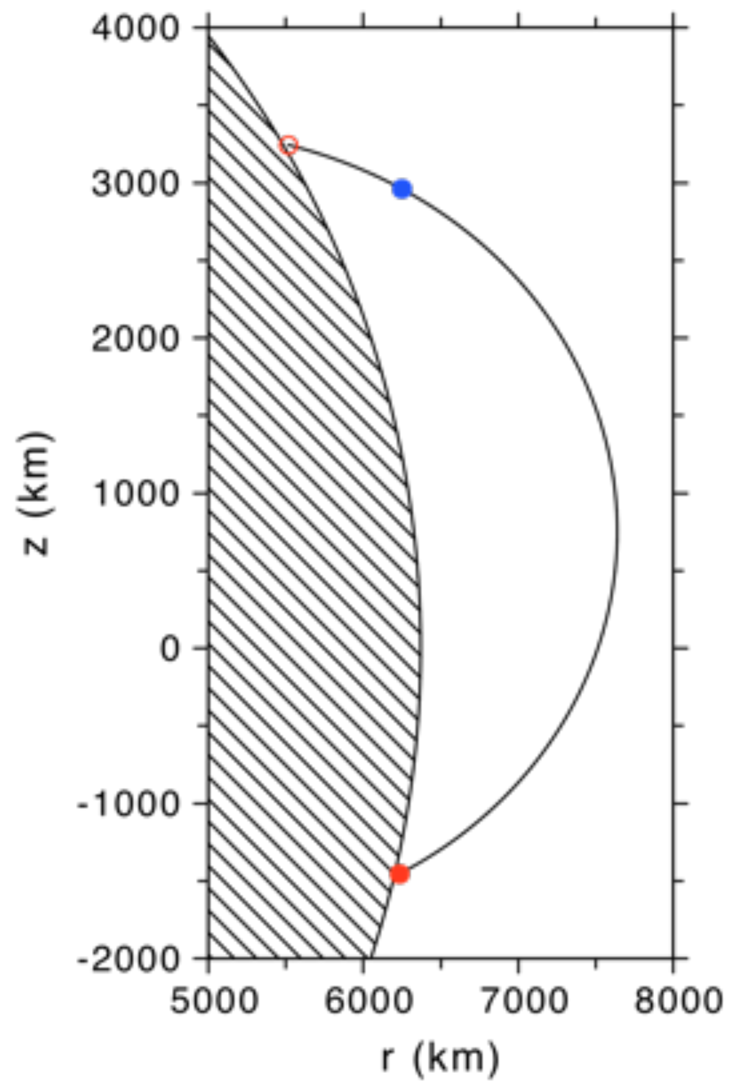
Storm at magnetic footprint

Long TGF =
e^- beam TGF

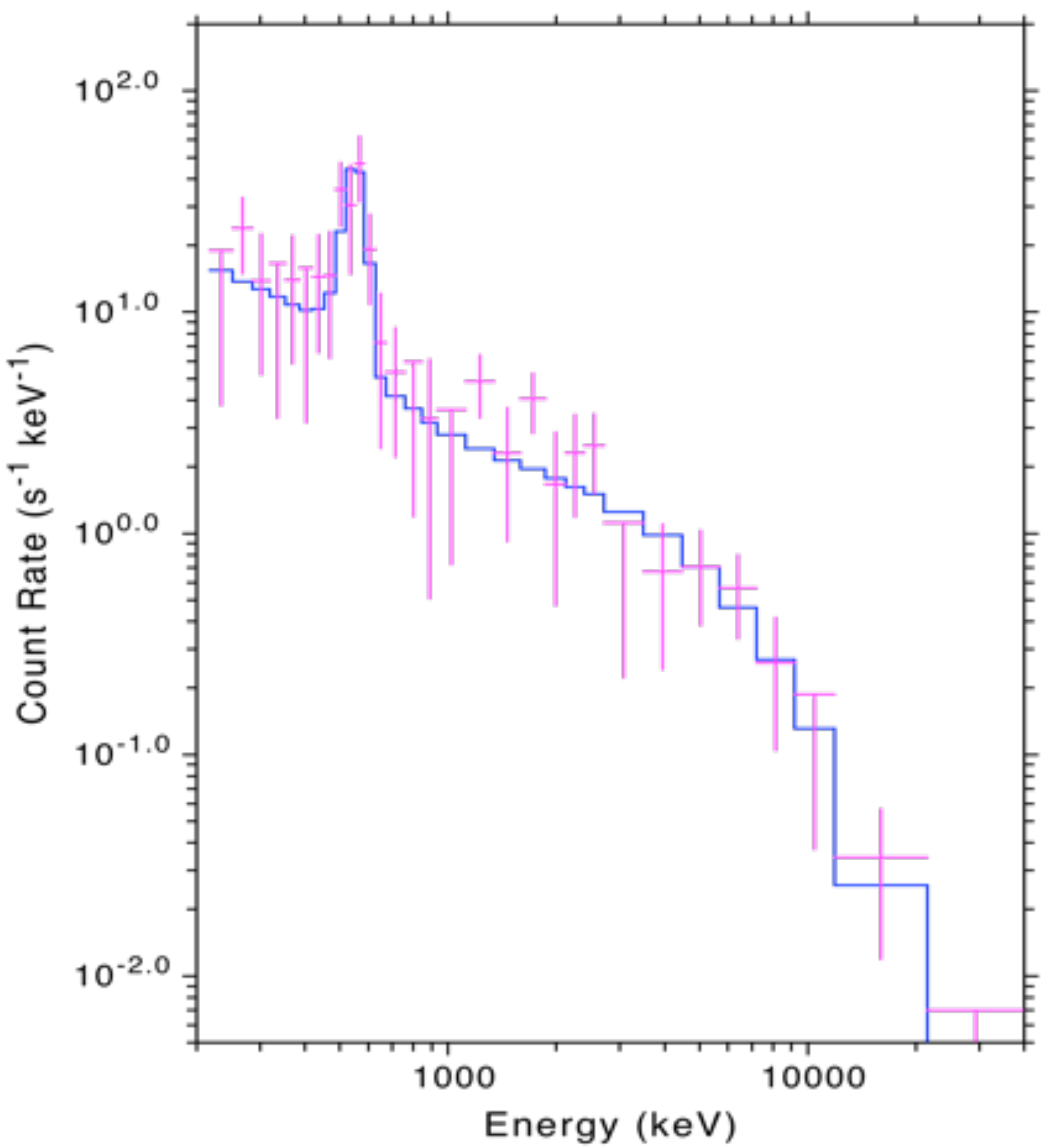


Magnetic mirroring can produce two peaks in lepton TGFs





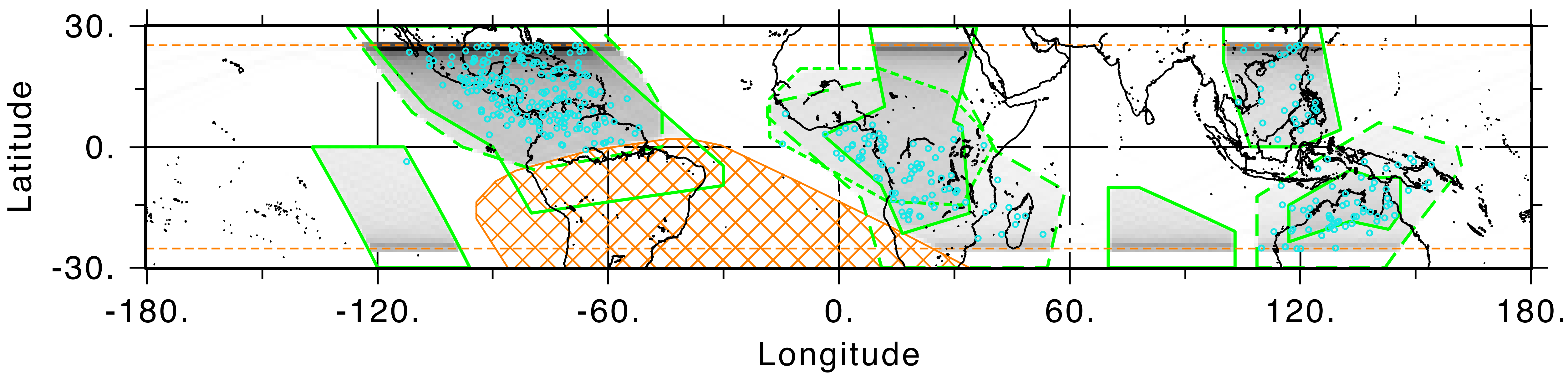
Lepton TGFs have positrons as well as electrons!

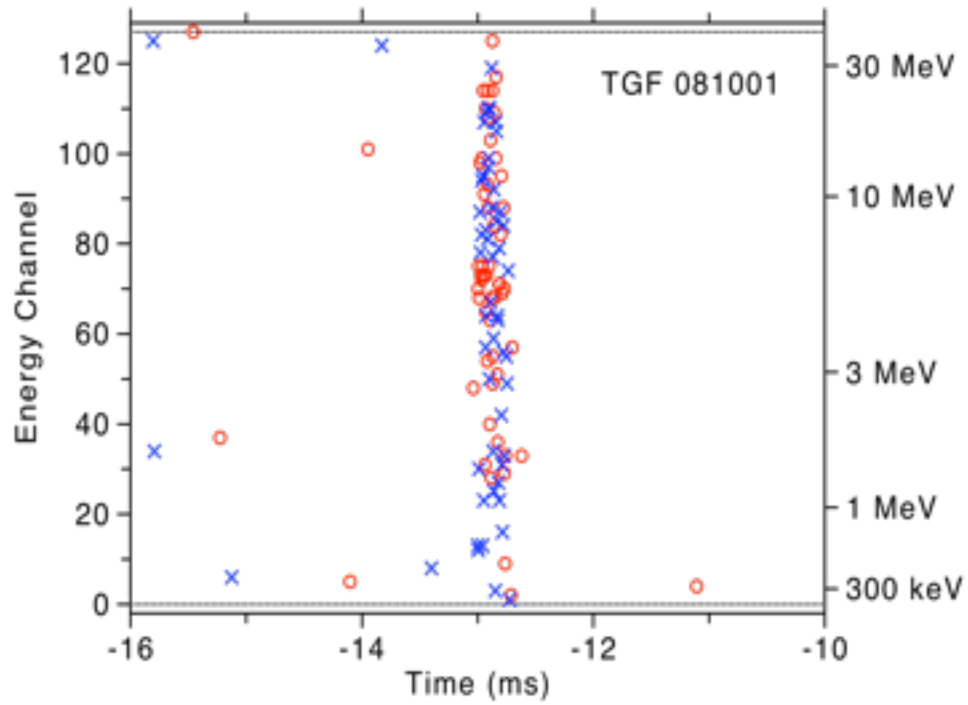


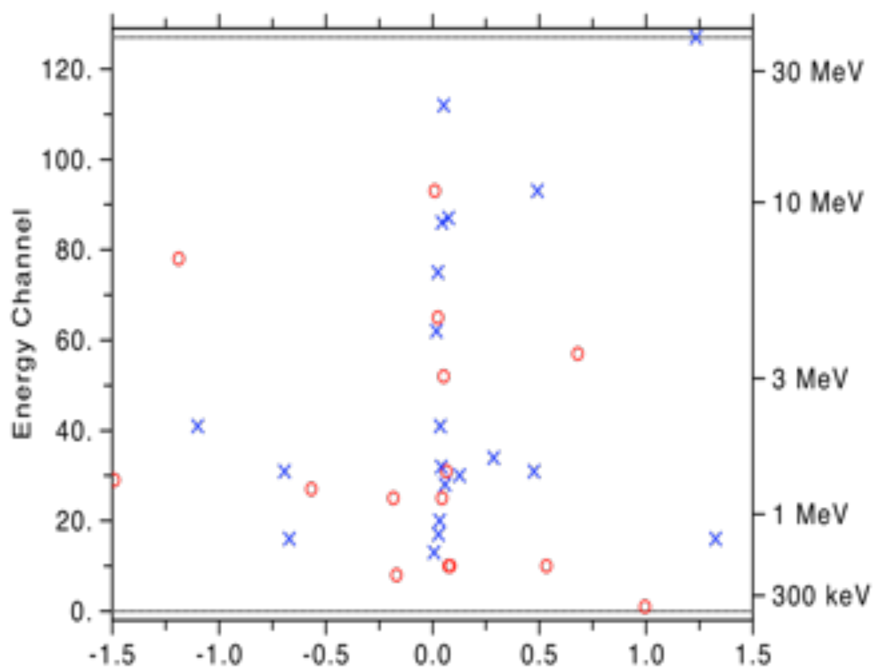
Briggs+ GRL 2010

GBM: What can we do better?
All-TTE All The Time (ATTATT)

384 TGFs found offline versus 39 triggered on-board







What have we learned from 10x more TGFs?

- Increased detection footprint to 800 km from 300 km
- Calculated annual all-sky rate of 300 000 TGFs!
- Found ratio of lightning to TGFs seen by GBM 2400:1
- Begun to see weather patterns: coastal and intertropical convergence zones conducive to TGFs
- Concluded TGFs generate their own current, detected in radio waves!

ATTATT: uncovering rotation-powered pulsars