
# Fermi GBM Status, Results, Plans

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Fermi Users Group
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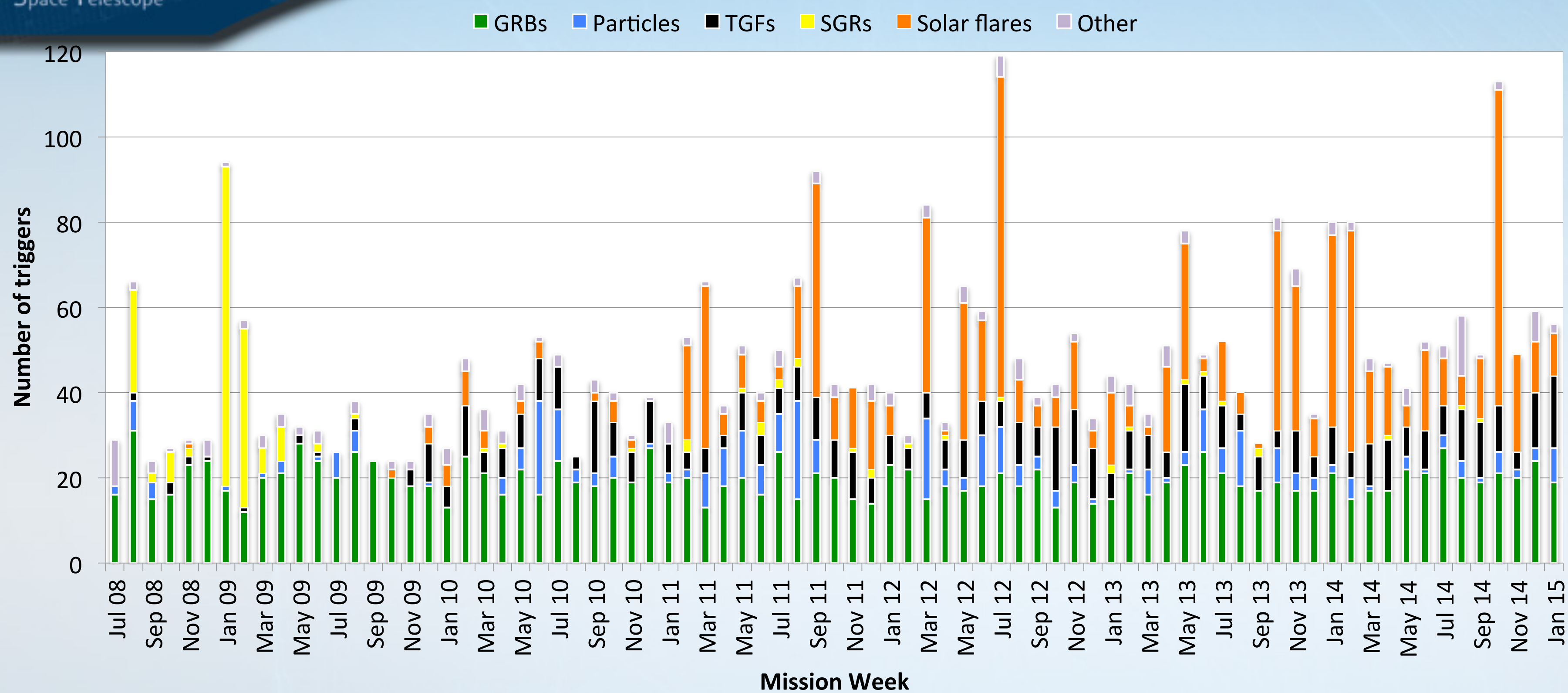
# GBM Trigger Rate

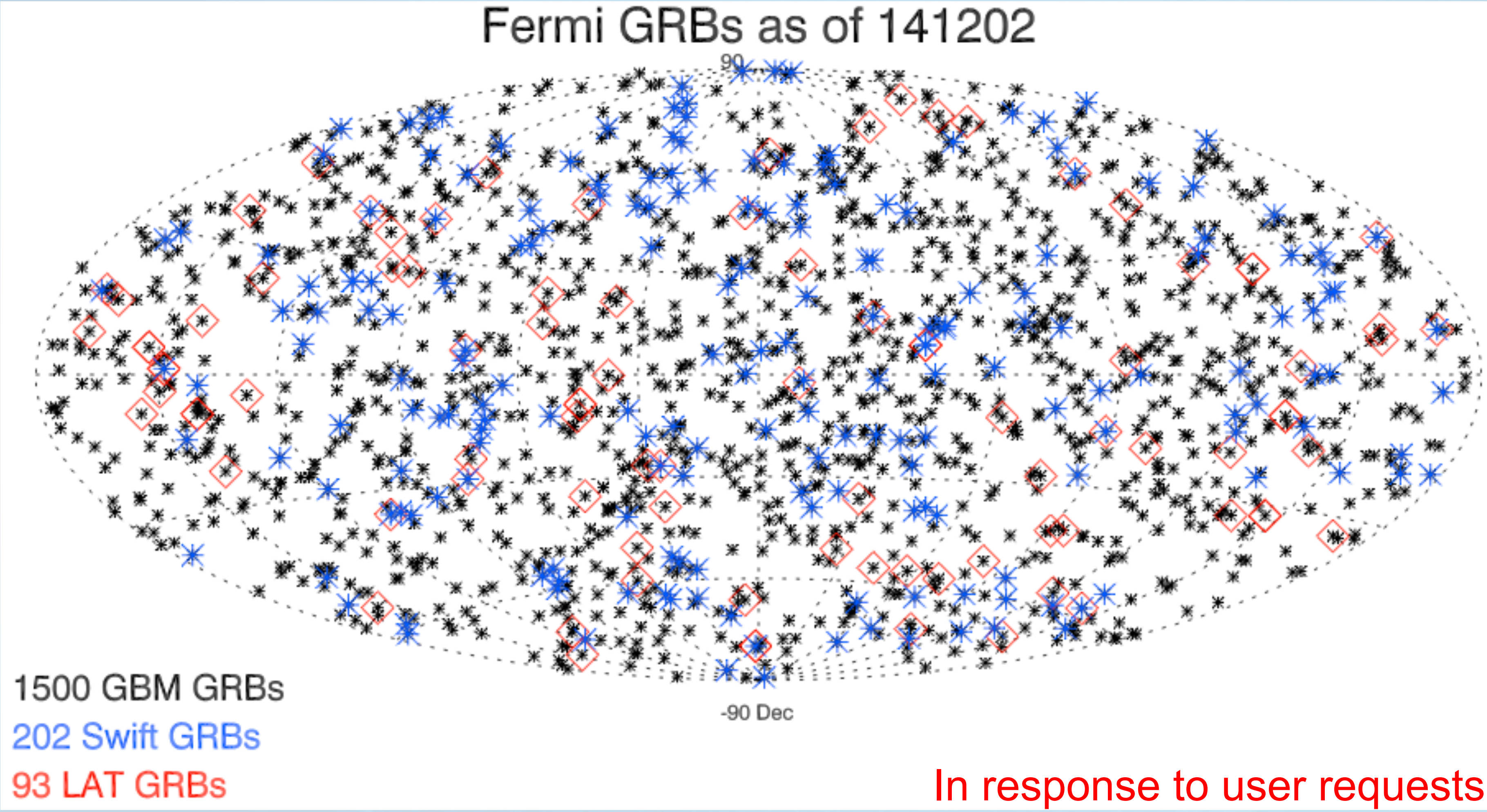



3767 triggers as of January 31, 2015 (excluding commanded)

- Gamma-ray bursts (GRBs): 1542 (triggered twice on each of two long GRBs)
- Soft gamma repeaters (SGRs) aka magnetars: 200 (from 5 sources)
- Terrestrial gamma flashes (TGFs): 545 (more than 2200 additional untriggered)
- Solar Flares: 939
- Others (particles, galactic XRBs, accidental, uncertain): 539

137 positive Autonomous Repoint Recommendations

# GBM has now seen 1500 GRBs

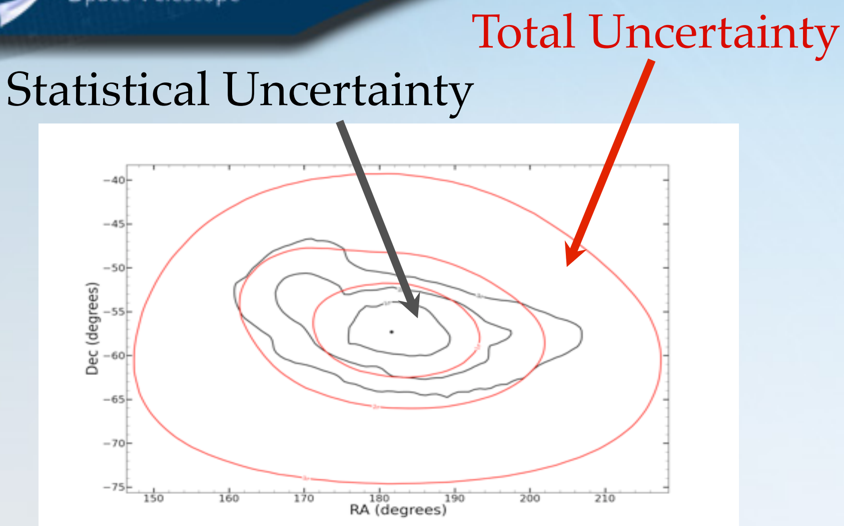


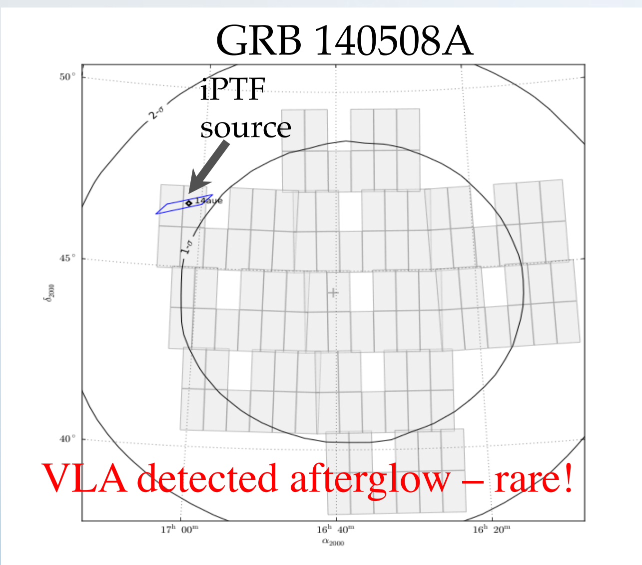

In response to user requests, GBM GRB catalog is now updated within 1 hour, spectral information ~weekly

# Operational Changes & Improvements

- We continue to disable soft energy (22–50 keV) trigger algorithms at weekends & periods of high solar activity
- Continuous Time Tagged Event (TTE) data are available since 2012.11.26. In August 2014, the TTE pipeline code was updated to fix occasional missing TTE data files and a timing glitch; a clock rollover ("Y2K" problem) was handled pre-emptively without causing problems. Documentation is ready for the next rollover in 12.5 years…
- Capabilities to search continuous TTE data off-line for short GRBs that did not trigger GBM:
  – Work in progress (next talk by M. Briggs)

# GRB Localization & Follow-up




- GBM proposal: GBM locates bursts to 15°
- Main error sources are systematic: analysis in V Connaughton et al. 2015 ApJS 216, 32 (arXiv:1411.2685)
- GBM ground automated processing (<1min) yielded location to 7-8° for 68% of bursts
- Since Jan 2014, improved location to ~6°
- In ~ a month: BAP will be modified to include FITS maps of ground-automated probability contours (red curves, top plot)
- Human being (~1 hour) locates 68% of bursts to ~5°, 90% of bright bursts to ~6° Error ellipse files are uploaded when final position GCN is sent
- 8 successful follow-ups (~41 attempts) with iPTF using GBM contour files for location; GRBs 140801A (auto loc), 150210A (human loc) found by MASTER based on GBM data
- Collaborations with iPTF, IPN, FIGARO, RAPTOR, MASTER, aLIGO, IceCube, Swift

# Gamma Ray Burst spectroscopy

**4-year catalog of time-integrated Gamma Ray Burst spectra is now published**: D Gruber et al 2014 ApJS 211,12

**4-year catalog of time-resolved spectroscopy is in progress** for 81 bursts with high fluence, peak flux, signal-to-noise: H-F Yu et al. 2015

**Examples of science enabled by GRB spectroscopy:**

"Synchrotron cooling in energetic gamma-ray bursts observed by the Fermi Gamma-Ray Burst Monitor": time-resolved spectroscopy of 8 bright bursts, H-F Yu et al 2015 A&Ap 573, 81

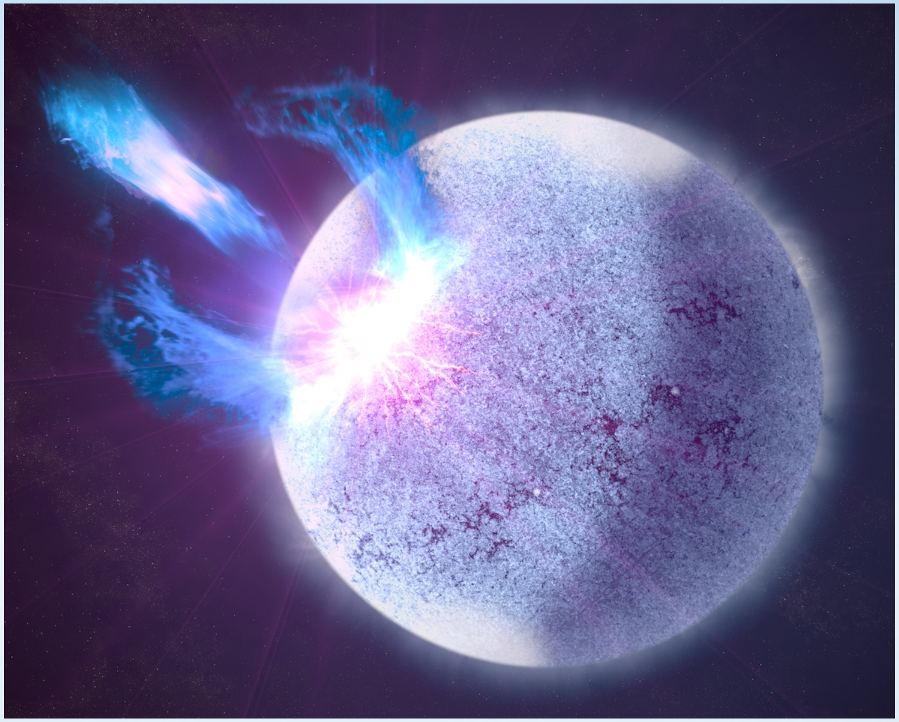
"The width of gamma-ray burst spectra": width in $EF_E$ distinguishes long and short bursts, M Axelsson & L Borgonovo, MNRAS, 447, 3150, 2015

"Are GRB blackbodies an artefact of spectral evolution?" JM Burgess, & F Ryde, MNRAS, 447, 3087, 2015

# Starquakes in Magnetar Storm

**Press release 21 Oct 2014**

SGR J1550−5418 is a magnetar, a highly magnetized neutron star with B>$10^{14}$G.  In 2008-9 it had a series of soft gamma-ray outbursts.



Huppenkothen et al (ApJ 1 Jun 2014) analyzed GBM observations of 286 bursts in a ‘storm’, Jan 22-29 2009.  They found quasi-periodic oscillations at 260Hz.

Just as earthquakes travel deep inside the Earth, and solar oscillations probe the Sun’s interior, these oscillations sample the equation of state of matter (plus a strong magnetic field) at neutron star densities.

# Gamma rays from thunderstorms

**Press release 15 Dec 2014**

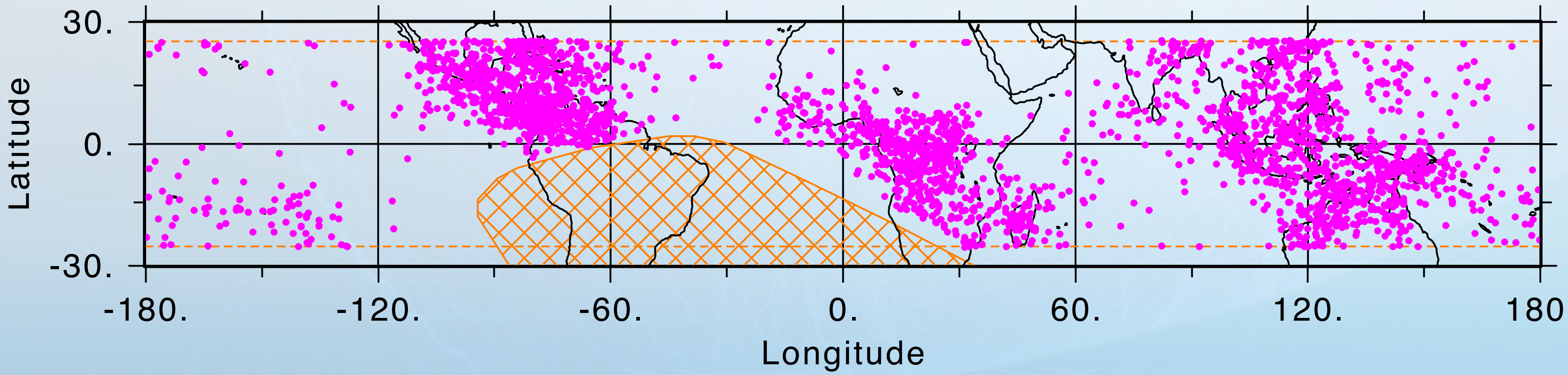
With continuous time-tagged event data, GBM now detects 5 times as many gamma-ray flashes from thunderstorms.

M. Briggs and collaborators tracked simultaneous strong bursts of radio waves to locate the gamma-ray flashes to a specific storm.

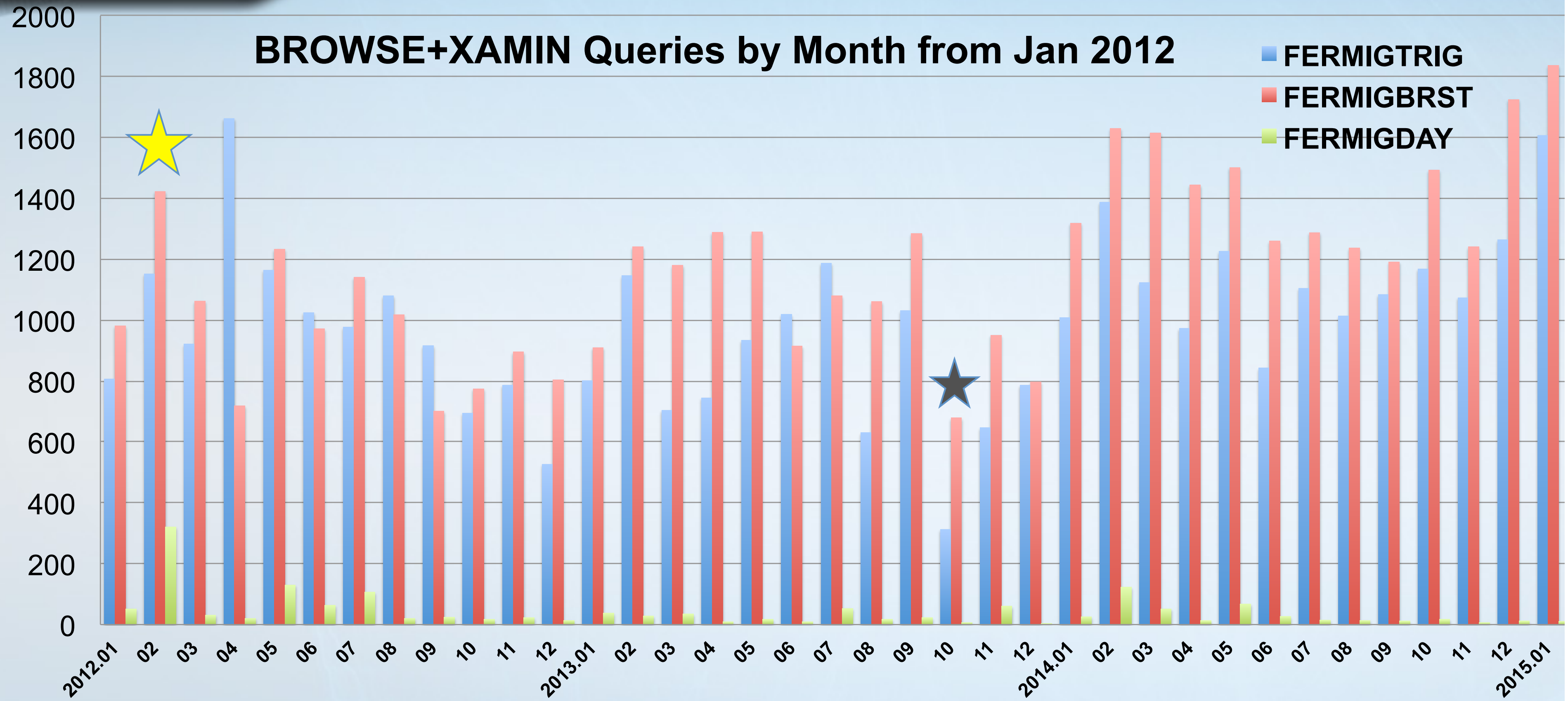
All thunderstorm types, strong and weak, appear to produce gamma rays.

GBM sees flashes from the upper regions of thunderstorms – gamma rays from lower down may be absorbed in air before reaching Fermi.

The first GBM TGF catalog was released Jan2015, at http://gammaray.nsstc.nasa.gov/gbm/science/terr_grf.html



# Usage of GBM archived data



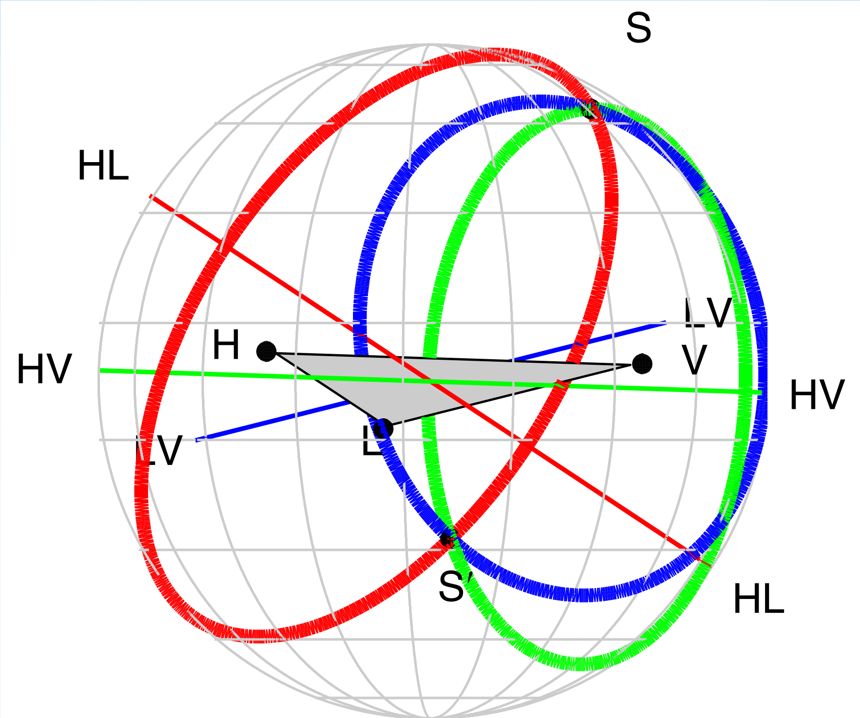

Bright star marks the 2-year GRB catalog release in early 2012; query numbers have remained high, apart from October 2013 (government shut down, dim star). XAMIN queries have increased the totals since Dec 2013.

# The Future

**Advanced LIGO** begins observing late in 2015.

Short GRB (<1s) are likely mergers of compact stellar-mass objects – these are the main expected LIGO sources! GBM triggers on ~40/year.

For an electromagnetic signal, to identify the source for follow-up, **GBM is the best bet!**




Timing measurement on each baseline localizes a source on an annulus in the sky. A-LIGO alone will locate sources to 100-1000 $deg^2$, but we'd have to get lucky: expect only ~0.01/year close-enough short GRB (more from untriggered TTE search). With Advanced Virgo, after 1-2 years, sensitivity improves and sources will be located to tens of $deg^2$.

Second joint LIGO-Fermi workshop in Pasadena, CA: 2015 March 14-15 includes Swift: http://www.ligo.caltech.edu/~jkanner/ligo-fermi/

# Summary & Near-term Plans

- GBM operations and performance are nominal
  - Full-orbit untriggered Time Tagged Event data collection is proceeding smoothly
- No significant operational changes planned for next few months
- Work on searching TTE data for short GRBs continues: M Briggs talk
- Will add FITS files distribution for GRB localization contours
  - Planned work to improve localization algorithms: summer student may work on atmospheric scattering
- Science catalogs
  - GBM Burst Catalog is now continuously updated on-line at FSSC; next catalog paper likely when data doubles (8 years) rather than at 6 years
  - GRB 4-year spectroscopic catalog published; 4-year catalog of time-resolved spectroscopy in preparation
  - Terrestrial Gamma-Ray Flash catalog released January 2015
  - Earth Occultation Light Curves and Spin Histories for accreting pulsars being updated: access via http://fermi.gsfc.nasa.gov/ssc/data/access/gbm/
  - 3-year catalog of Type 1 X-ray bursts in preparation (see image)