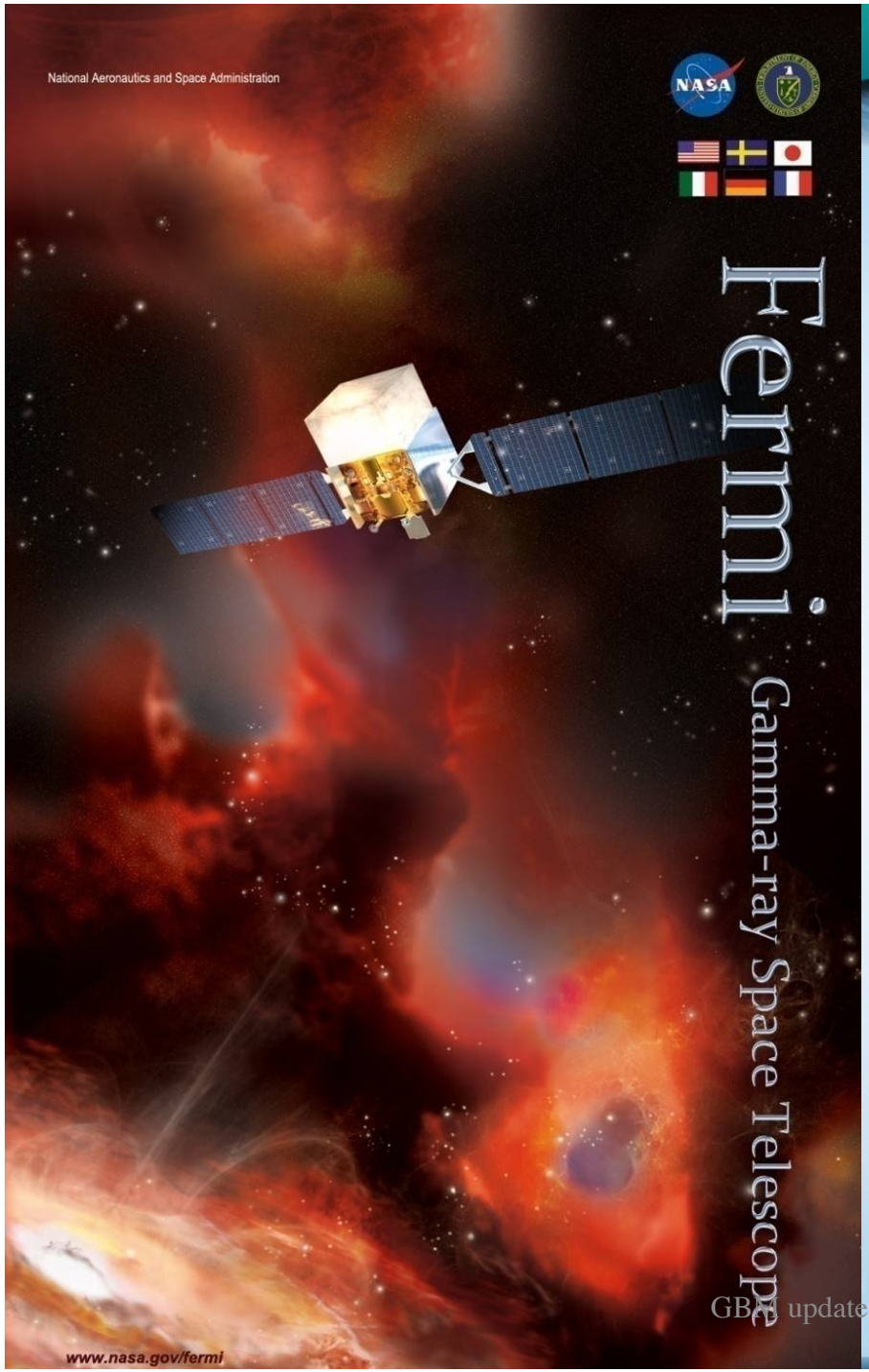
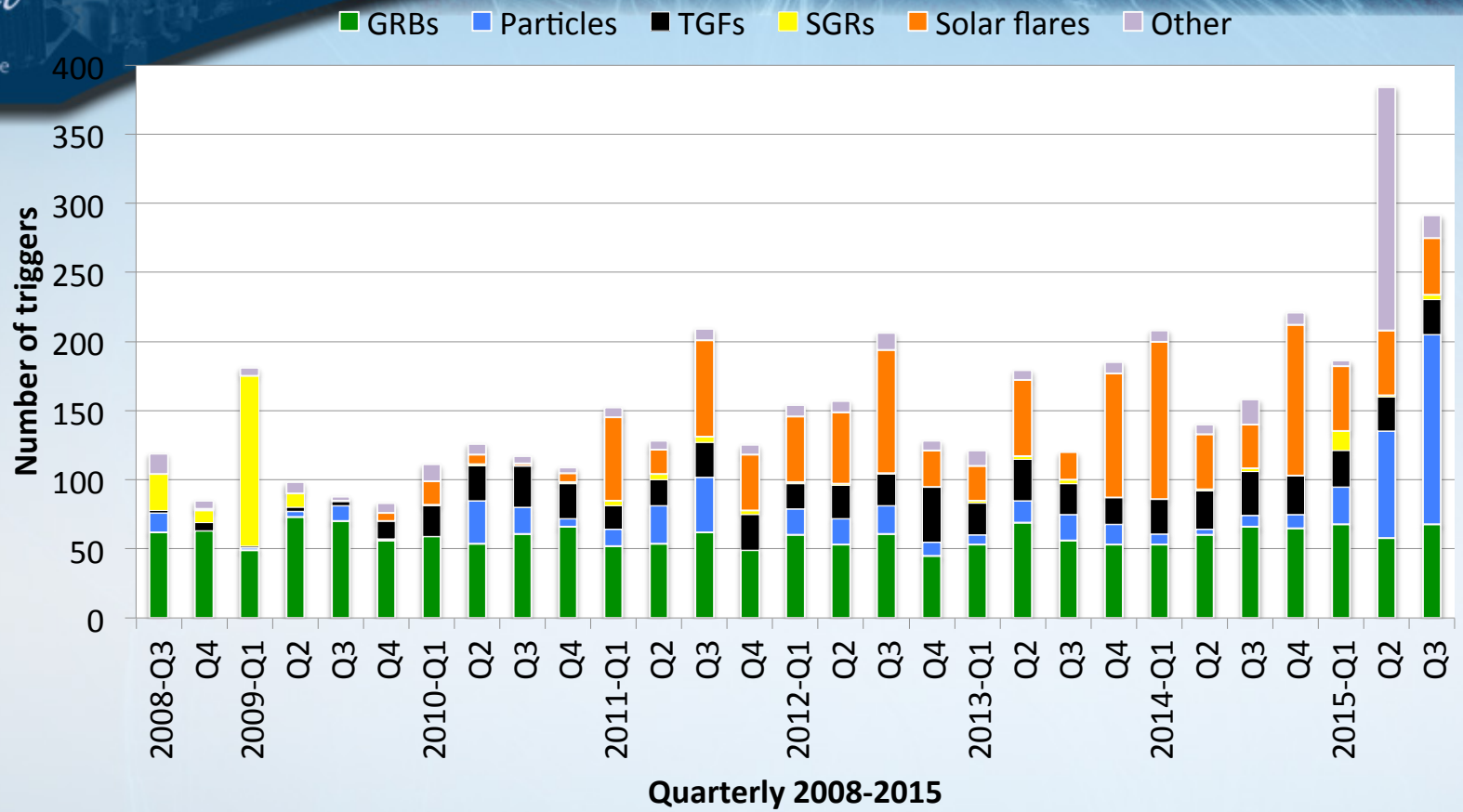


Fermi GBM Status, Results, Plans

Linda Sparke
NASA HQ, on detail to MSFC

Fermi Users Group
6 November 2015

GBM Trigger Rate

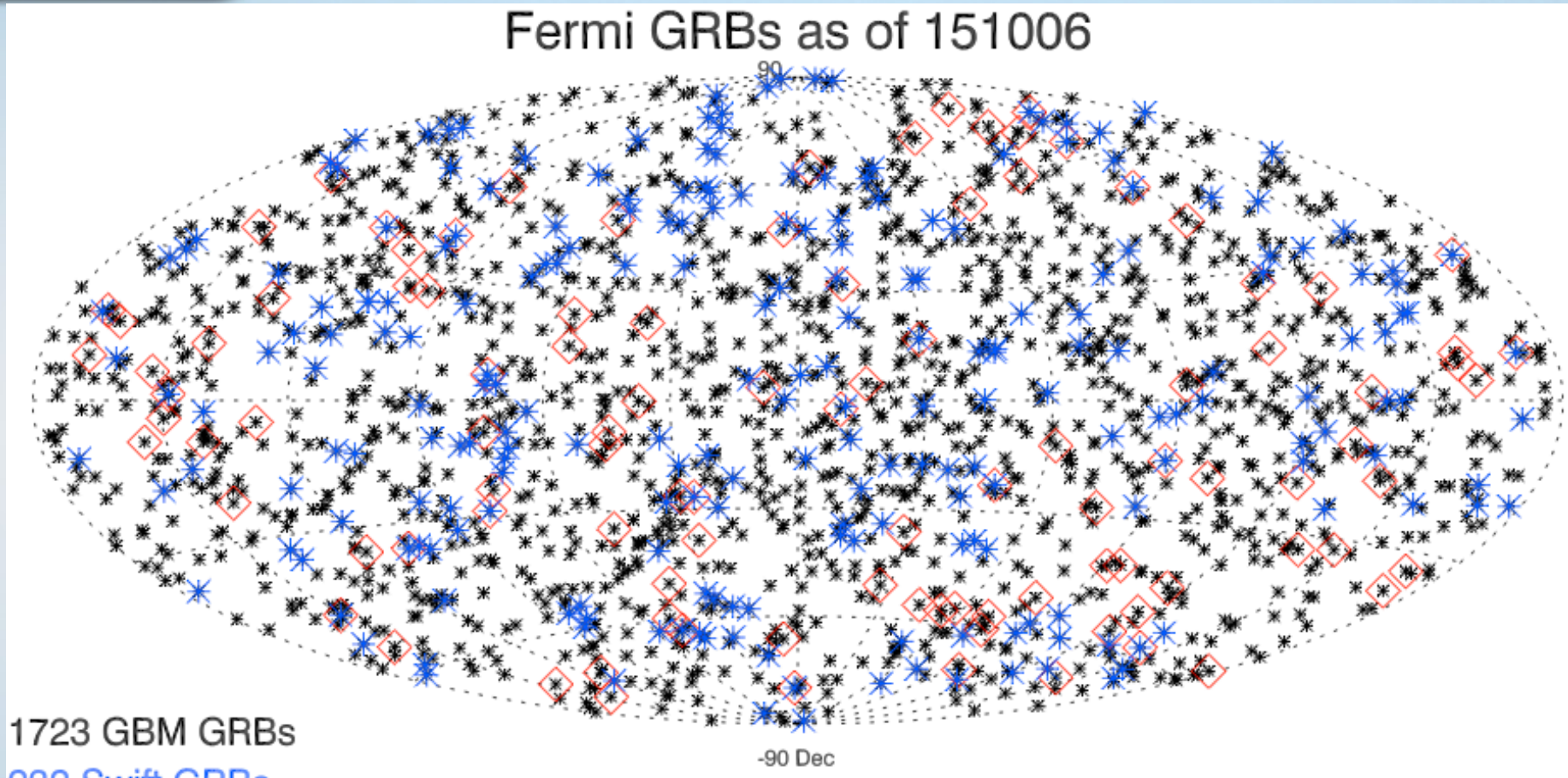


4572 triggers as of September 30, 2015

- Gamma-ray bursts (GRBs): 1718 (triggered twice on each of three long GRBs)
- Soft gamma repeaters (SGRs) aka magnetars: 219 (from 5 sources)
- Terrestrial gamma flashes (TGFs): 605 triggered, ~5x more untriggered
- Solar Flares: 1063
- Others (particles, galactic XRBs, accidental, uncertain): 964 (169 from V404 Cygni)

151 positive Autonomous Repoint Recommendations

GBM has now seen >1700 GRBs



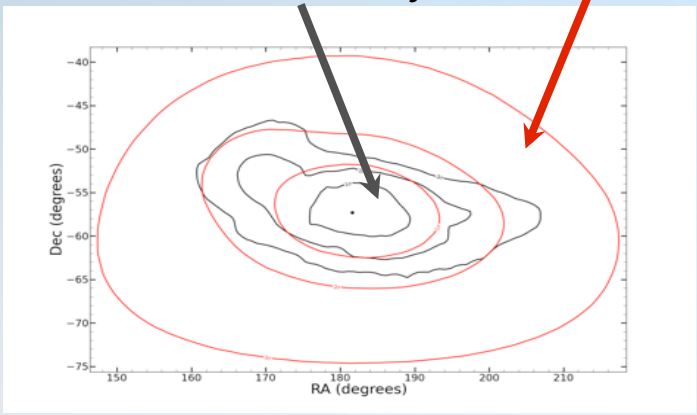
In response to user requests,

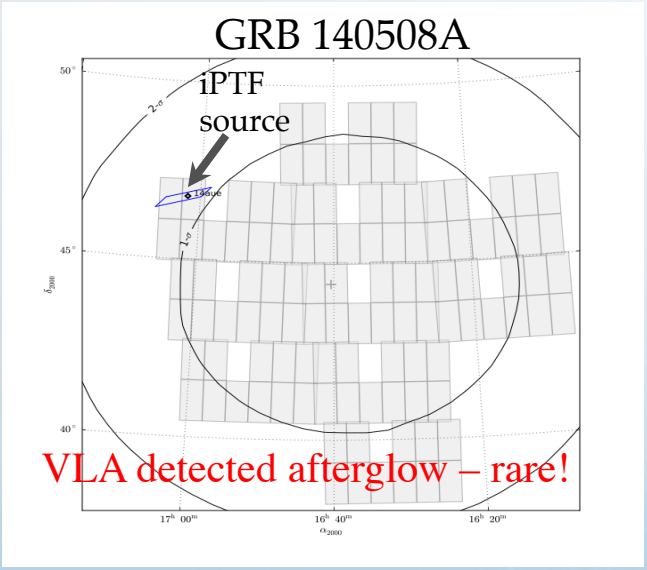
GBM GRB catalog is now updated within 1 hour, spectral information ~weekly

Operational Changes & Improvements

- We continue to disable some soft energy (22–50 keV) trigger algorithms at weekends & periods of high solar activity.
- Continuous Time Tagged Event (CTTE) data available since 2012.11.26. When the Sun is active, CTTE data are suppressed (throttled) from Sun-facing detectors. An M7-class flare on 28 September 2015 still produced a flood of CTTE data: we will investigate more conservative throttling.
- When soft gamma repeater SGR 1935 +2154 was active in late February 2015, we disabled continuous TTE data. A really bright flare could exceed available CTTE bandwidth, so we would lose data on brightest activity.
- From early 2016, CTTE data will be easier to use: delivered as hourly files (name marks start time). Old files will be re-made to remove timing glitches.
- Search of continuous TTE data off-line for short GRBs that did not trigger GBM: delivers increased numbers of sGRB. Now working to characterize false trigger rates.
- Gains in the two PMTs for each of two BGO detectors: gains were equalized soon after launch, by running one PMT at a time and tweaking voltages. Drift in PMT gains would modestly degrade resolution. GBM may repeat after the current LIGO run ends in mid-Jan 2016: normal BGO science data interrupted for several hours.

GRB Localization & Follow-up





- Proposal required GBM to locate bursts to 15°
- Main error sources are systematic: analysis in Connaughton et al. 2015 ApJS 216, 32
- New in 2015: ground automated processing (<1min) now yields location to ~5° (1-sigma), and supplies FITS maps of ground-automated probability contours (red curves, top plot)
- Coming by the end of 2015: RoboBA. Ground-automated positions to ~4.5° with contours, based on 10 minutes of trigger data, supplied about 1 minute after trigger ends.
- RoboBA fails to localize in ~2% of bursts (bad background, missing data, etc.), and will alert a human BA. Corrected files will be uploaded with final position GCN.
- We have had successful follow-ups with iPTF using GBM contour files for location.
- Collaborations with iPTF, IPN, FIGARO, RAPTOR, MASTER, Advanced LIGO, IceCube

Catalogs from GBM

4-year catalog of time-resolved spectroscopy for 81 bursts with high fluence, peak flux, signal-to-noise: H-F Yu et al. 2015 **Under revision after referee report.**

6-year catalog of Gamma Ray Bursts is submitted for publication: 1403 bursts, N Bhat et al 2016

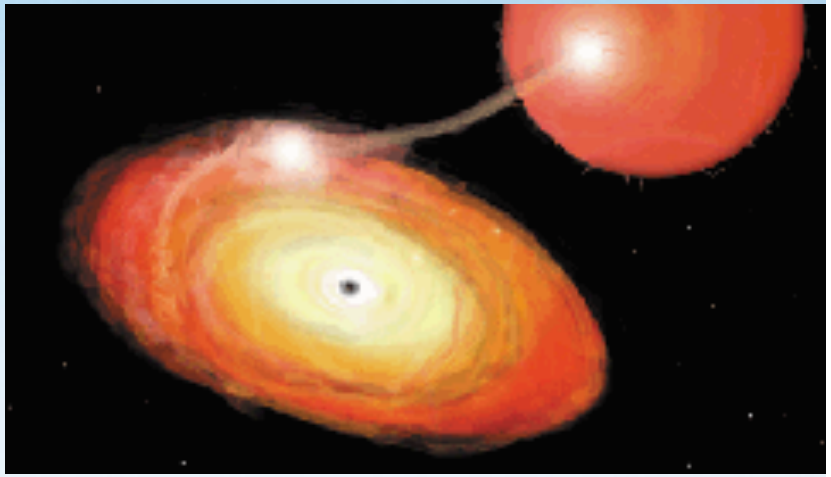
The **GBM catalog of Terrestrial Gamma Ray Flashes** (TGF) will be updated in January 2016: M. Briggs et al. This is the first catalog to include radio data, which will provide localization to ~10 km, for ~35% of TGFs.

The **GBM catalog of Type 1 X-ray Bursts** (P. Jenke at al) is now live, at http://gammaray.nsstc.nasa.gov/gbm/science/xrb.html

GBM and Swift see the same population of short GRBs: E Burns et al, submitted for publication; posters at Fermi Symposium on flux calibration of GBM vs INTEGRAL/SPI (von Kienlin), INTEGRAL/IBIS (Fitzgerald) and KONUS (Burns).

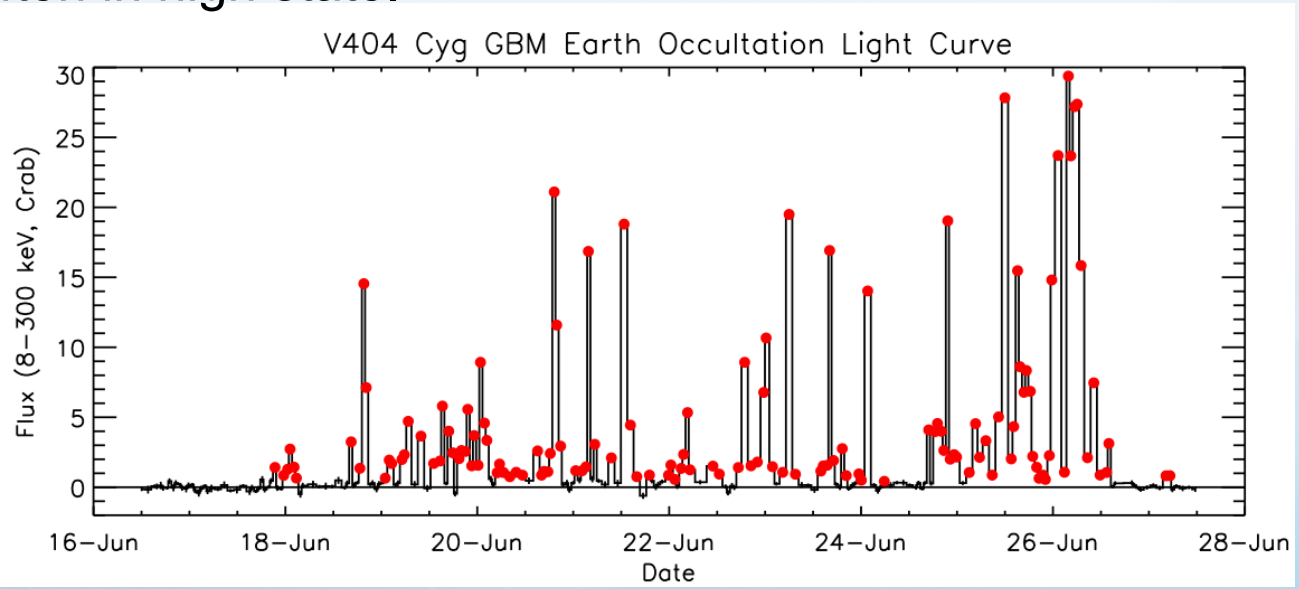
A Black Hole Wakes: V404 Cygni

Press release 30 June 2015:
"mailbox spammed by a black hole"

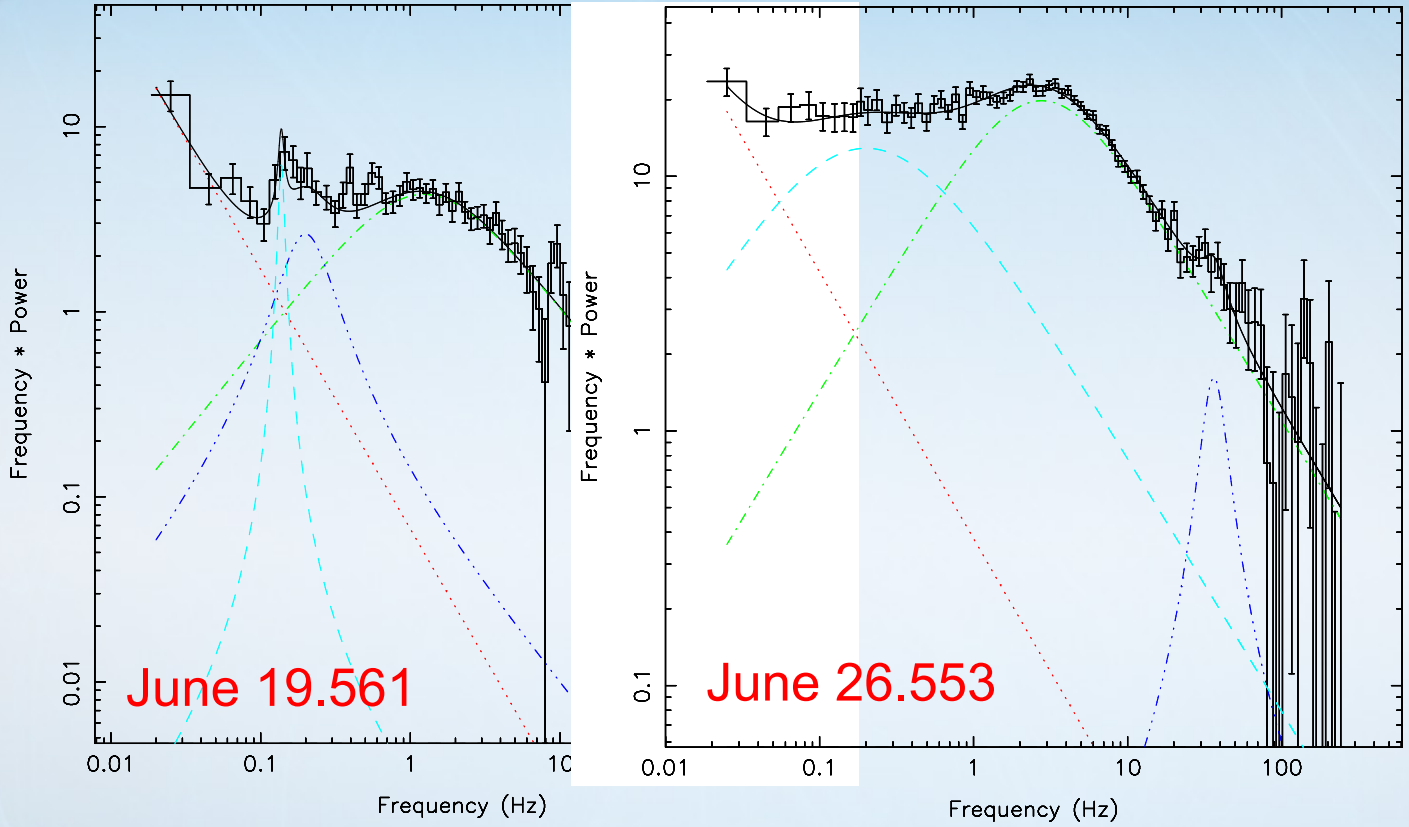


Black hole binary V404 Cygni triggered GBM 169 times over 13 days, starting on 15 June 2015.
In 73 flaring episodes, it reached 30 x Crab at energies to 300keV.
Unusually, the source spectrum was hard throughout: did not soften in high state.

Spectral fits show a hot corona, with variable absorption from ejected material.
As flares fade, T_e drops.



Oscillations in the disk: V404 Cygni



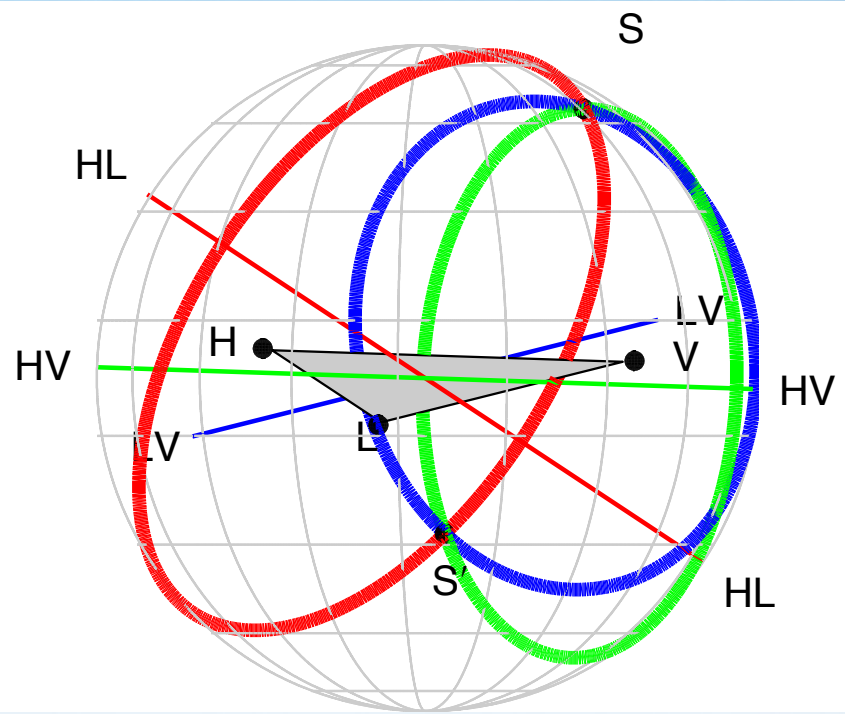
8-100keV CTTE data binned to 2msec:
Low-frequency QPOs, strongly peaked noise, high-frequency structure
Peter Jenke, 6th Fermi Symposium

Short GRB and Advanced LIGO

Advanced LIGO began its first observing run in September 2015.

Short GRB (<2s) 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. Advanced LIGO alone will locate sources to 100-1000 deg^2, but we'd have to get lucky: design sensitivity predicts ~1 close-enough short GRB per year. When Advanced Virgo is added after 1-2 years, sensitivity improves and sources will be located to tens of deg^2.

Searching GBM untriggered data

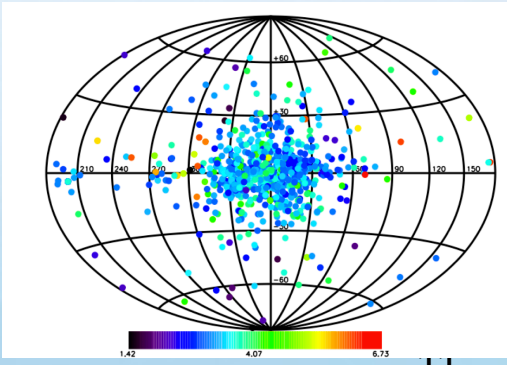
Under an MOU with the LIGO consortium, GBM has implemented searches of untriggered CTTE data for short GRB as counterparts of candidate gravitational wave (GW) events:

- We do a seeded search (Blackburn et al 2015 ApJS 217, 8) of GBM CTTE for prompt emission at time of a LIGO candidate event.
- We use two methods of unseeded search for sub-threshold short GRB in CTTE data. These deliver candidate short GRBs at a false-trigger rate selected by the user.
- Current effort is to calibrate the false-trigger rate for use when only GBM sees prompt effects. Swift and GBM see 'the same bursts' – the 7 Swift bursts that did not trigger GBM were on edge of GBM's view, 4 seen in CTIME or CTTE data (Burns et al 2015). Next step is comparing with INTEGRAL ACS sub-threshold data, which has timing but no localization info.

GBM Summary

- GBM operations and performance are nominal
  - Full-orbit untriggered Time Tagged Event data collection is proceeding smoothly
- Prompt distribution of ground localization and FITS contours will facilitate rapid follow-up of bursts not seen by other satellites.
- Advanced LIGO now in its first run: GBM is searching untriggered data for short GRBs
- Science and catalogs
  - GBM Burst Catalog is now continuously updated on-line at FSSC; 6-year GRB catalog paper is submitted for publication
  - GRB 4-year catalog of time-resolved spectroscopy is in revision after referee report
  - Terrestrial Gamma-Ray Flash catalog released January 2015; release with radio localizations to 10km expected in January 2016.
  - Earth Occultation Light Curves and Spin Histories for accreting pulsars regularly updated: access via http://fermi.gsfc.nasa.gov/ssc/data/access/gbm/
  - GBM catalog of Type 1 X-ray bursts is live

  at http://gammaray.nsstc.nasa.gov/gbm/science/xrb.html



Backups