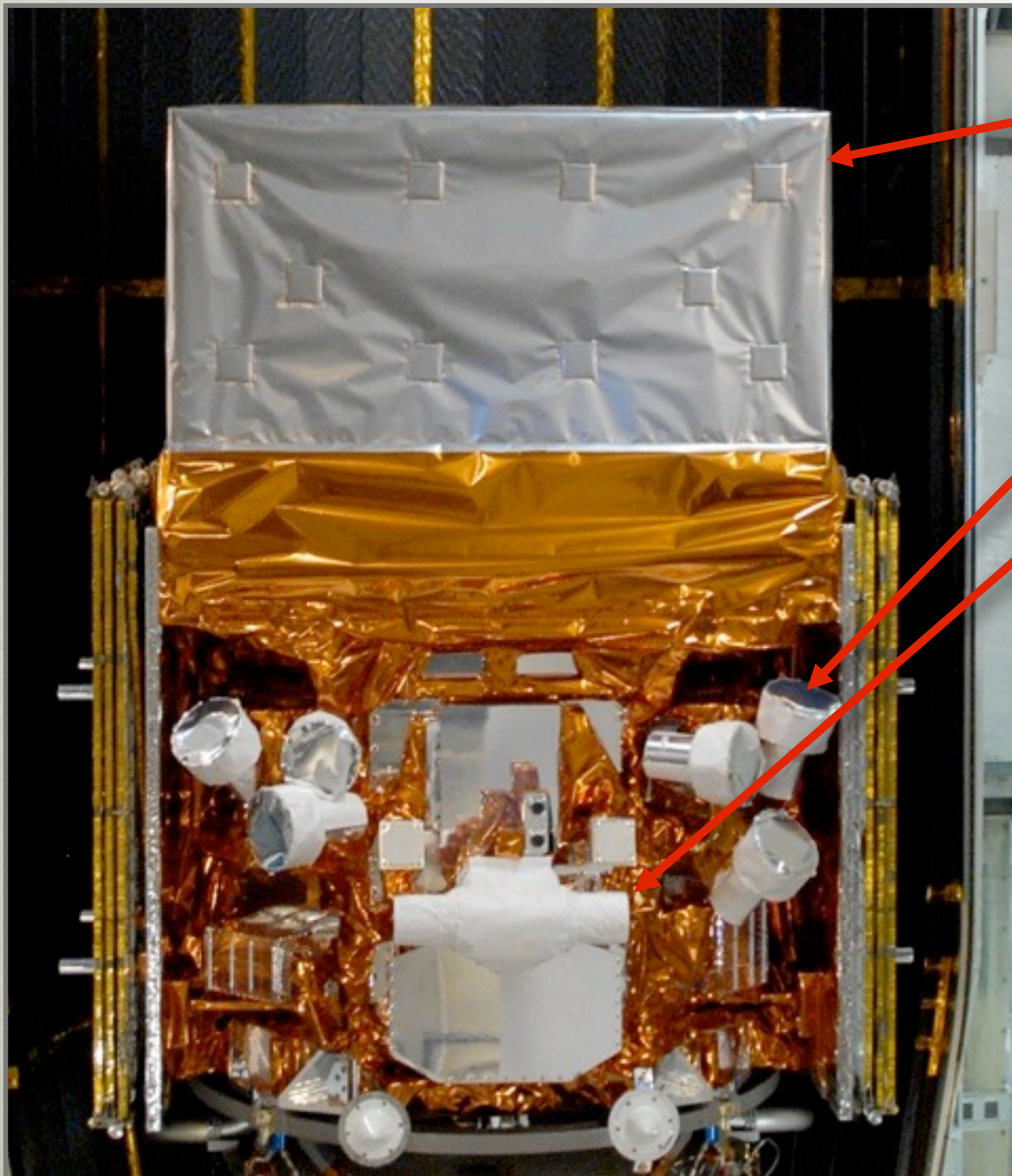
Fermi GBM GRB Science in the Advanced LIGO Era

The Fermi Spacecraft



Large Area Telescope (LAT

30 MeV -> 300 GeV

Gamma-ray Burst Monitor (GBM)

NaI and BGO Detectors

8 keV -> 40 MeV

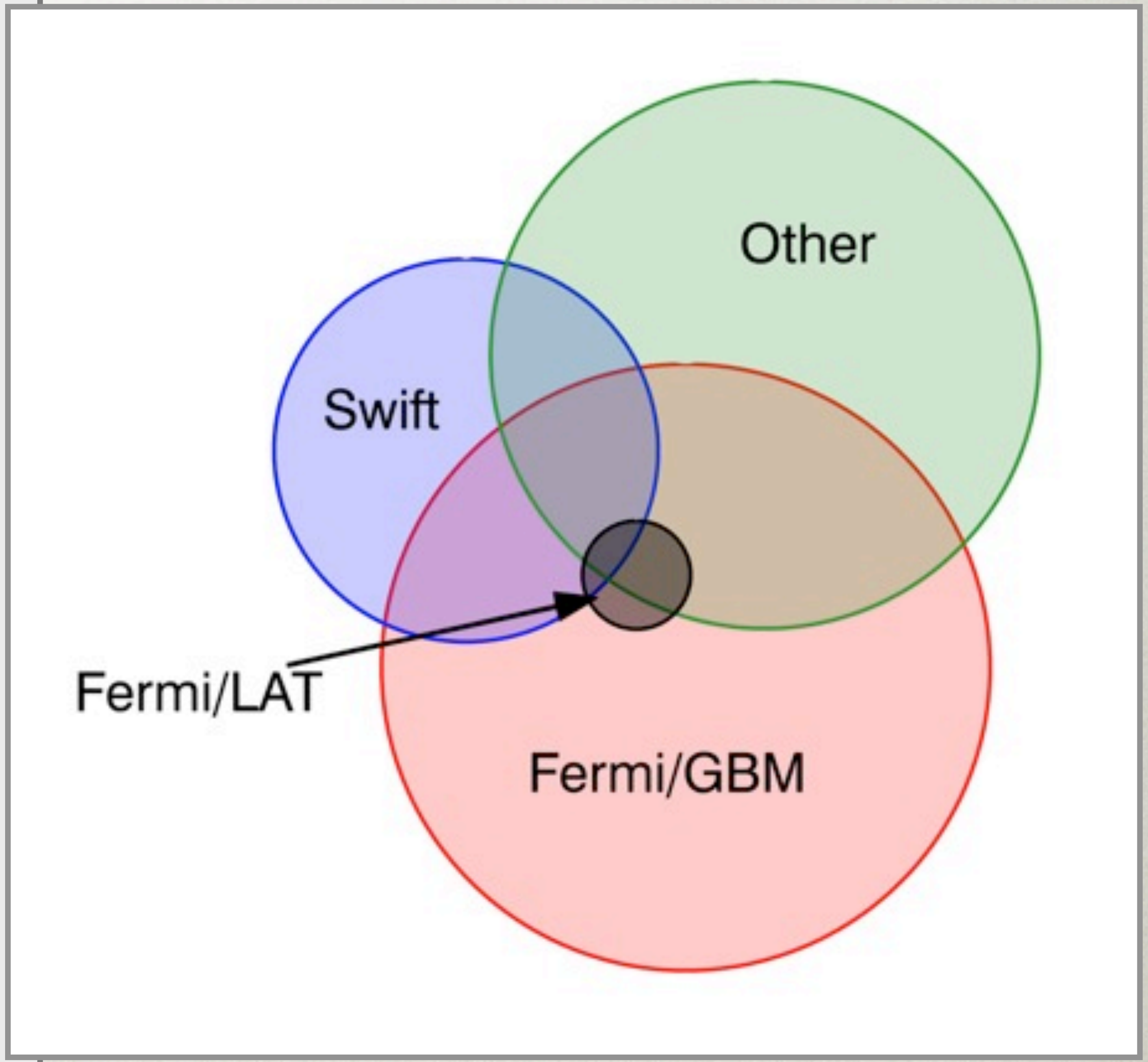
KEY FEATURES

- Huge field of view
  - –LAT: 20% of the sky at any instant; in sky survey mode, expose all parts of sky for ~30 minutes every 3 hours. GBM: whole unocculted sky at any time.
  - –Decreased detection dead time 2.6 μs
- Huge energy range, including largely unexplored band 10 GeV - 100 GeV. Total of >7 energy decades!

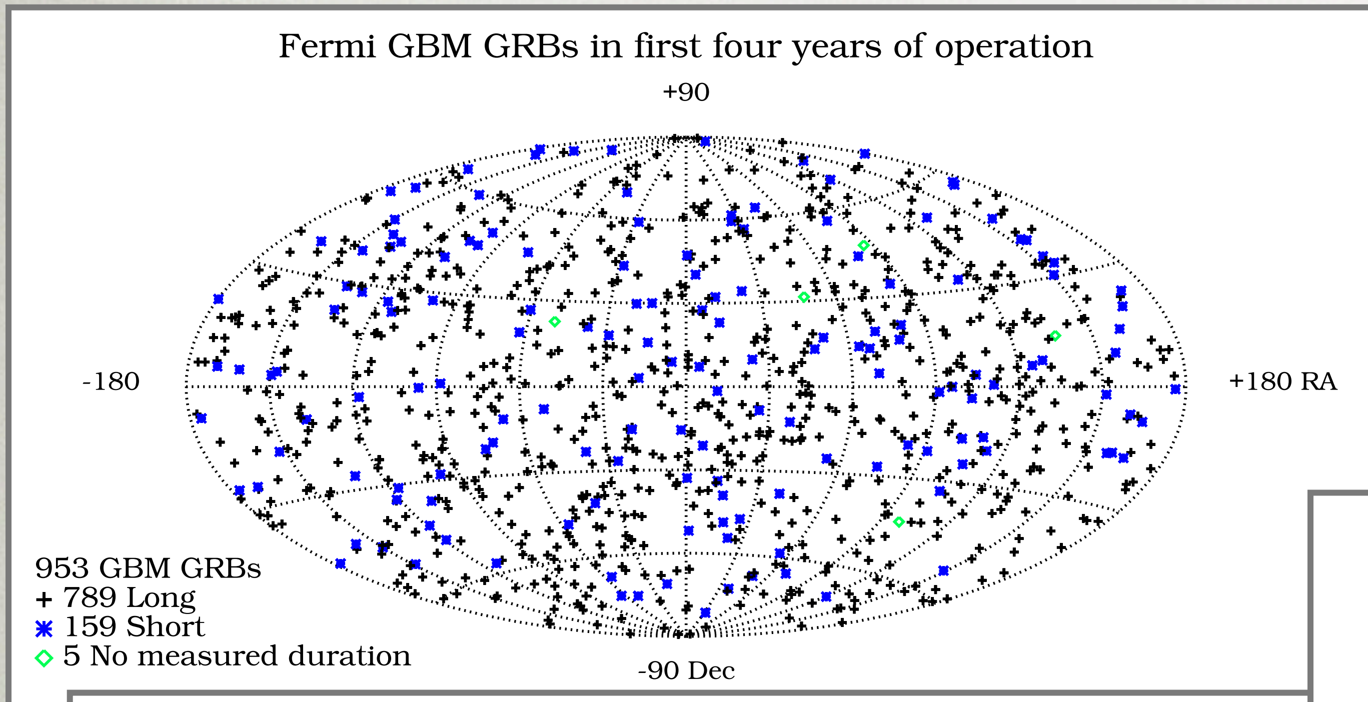
Fermi GBM Observational Synergy

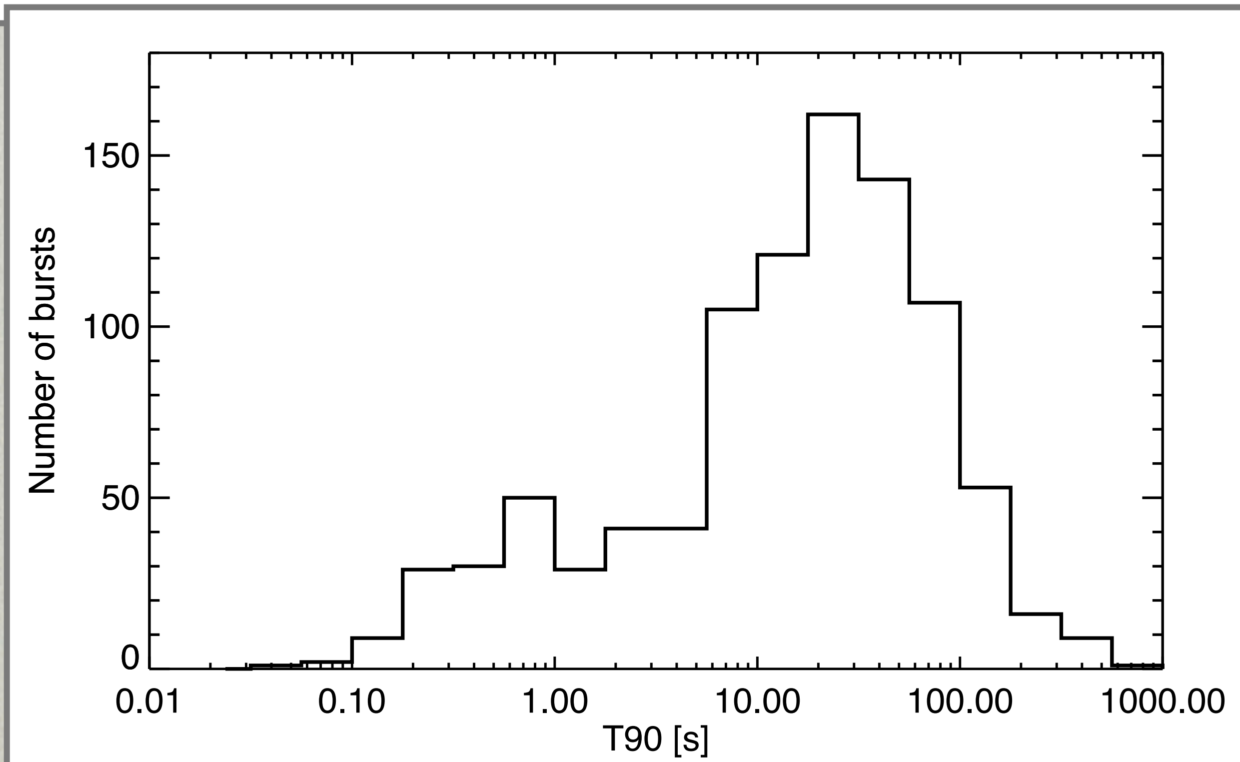
Through May 2014:

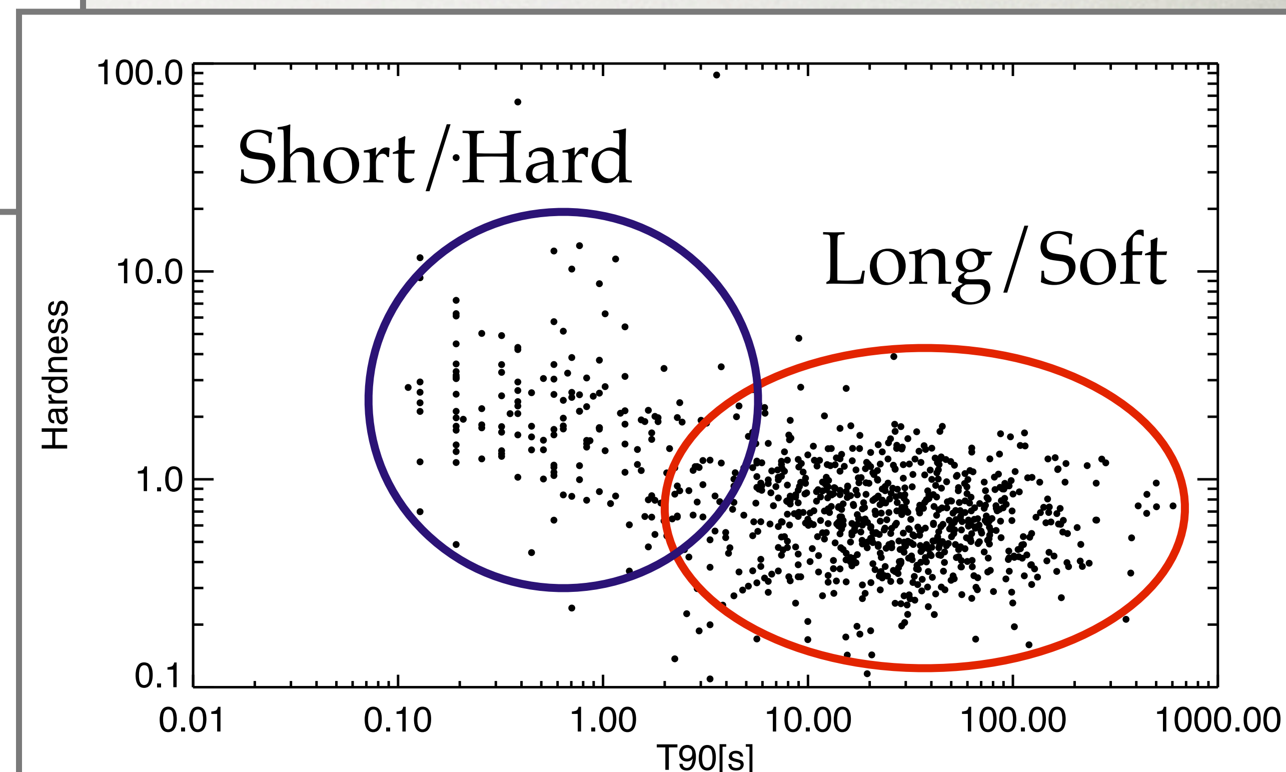
- 1380 GBM GRBs
- ~230 Swift+GBM
- ~80 LAT+GBM
- >400 GBM+other
- 329 GRBs resulting in 3272 GCN Circulars (since Sep 2009)



GBM GRBs

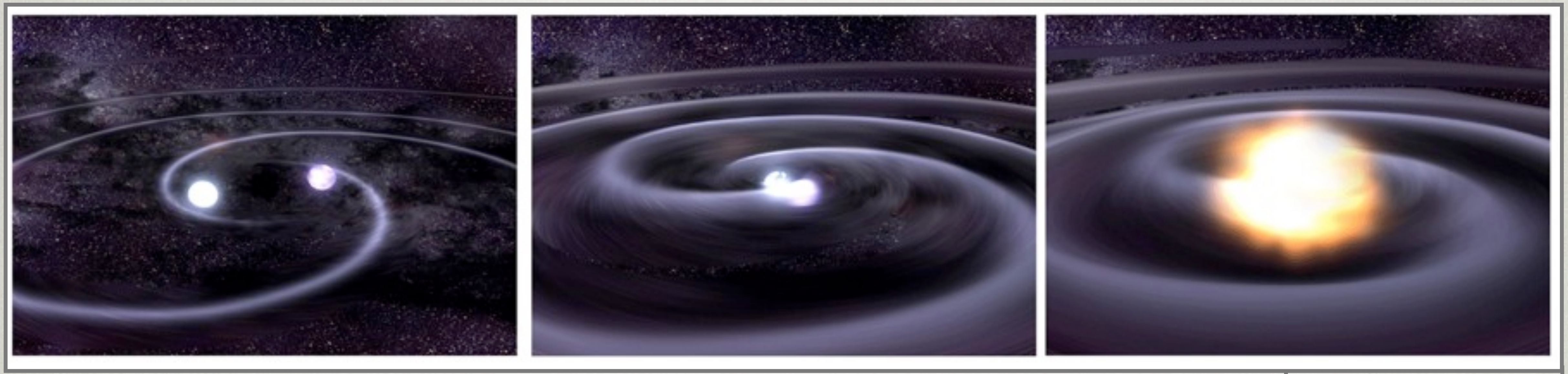






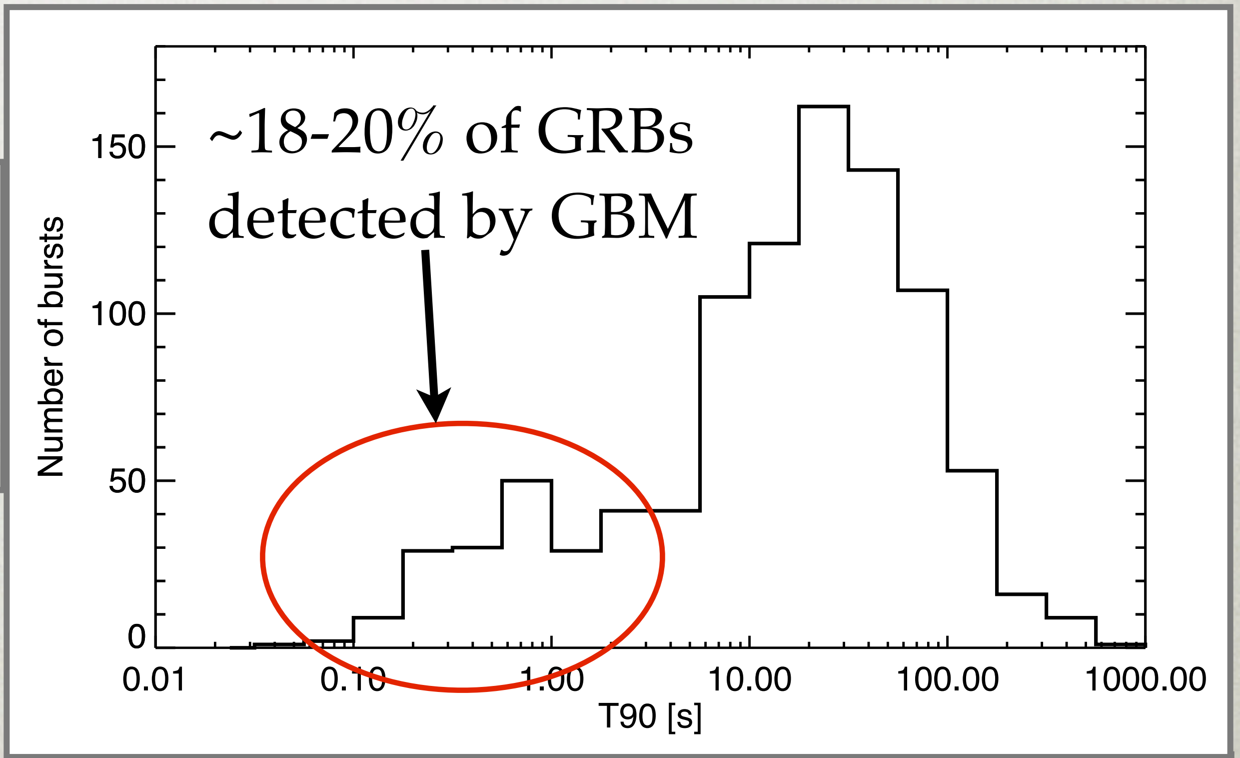
von Kienlin+ 2014, ApJS, 211, 13

Short GRBs as GW Sources



LIGO Collaboration

Short GRBs -> NS-NS, NS-BH
GBM: ~44 short GRBs/year
(Swift: ~9 short GRBs/year)

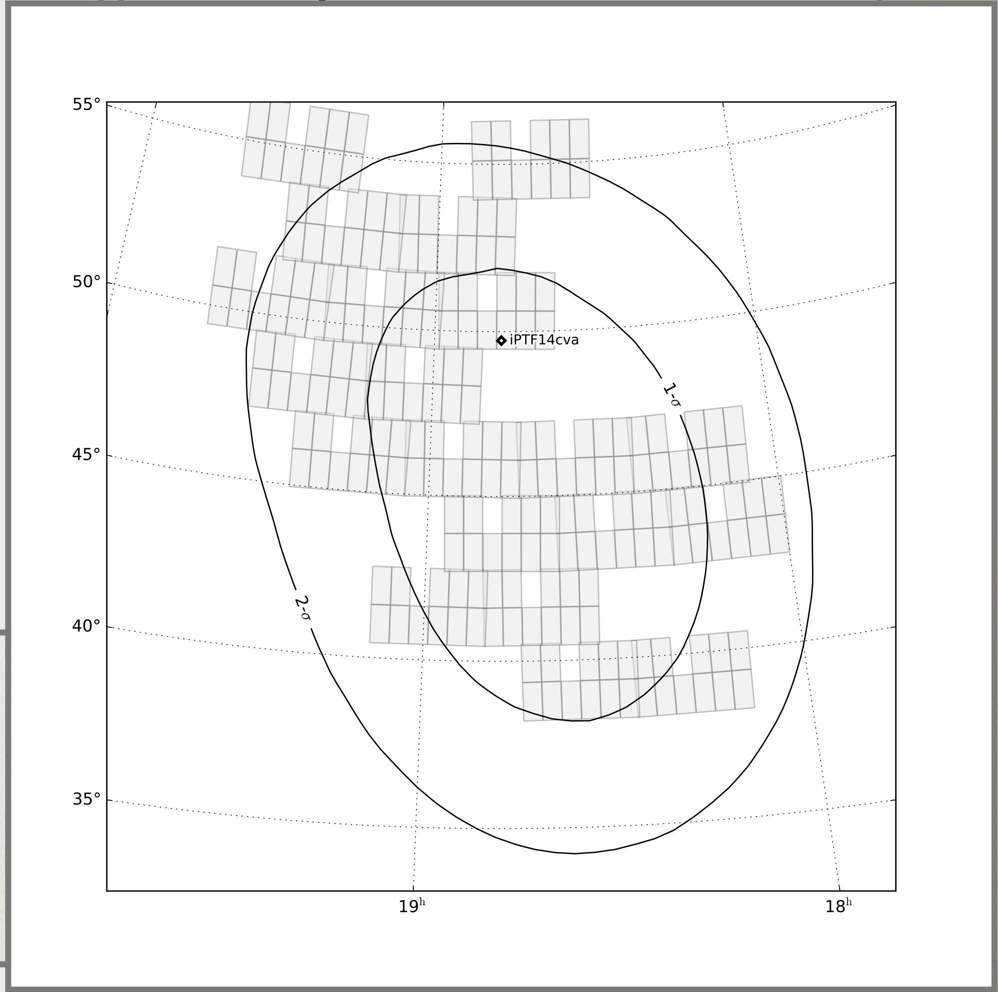


von Kienlin+ 2014, ApJS, 211, 13

GBM Follow-ups

130702A -> Magellan **z = 0.125**
131011A -> VLT **z = 1.87**
131231A -> VLT/X-shooter **z = 0.642**
140508A -> VLA **radio**, NOT & WHT **z=1.03**
140606B -> Keck **z=0.384**
140620A -> Gemini **z=2.04**
140623A -> Gemini **z=1.92**
140808A -> VLA & AMI **radio**, GTC **z=3.29**
140801A -> MASTER OT, NOT & BTA **z=1.32**

Example: GRB 140620A



- **8** detections by iPTF from **35** follow-ups
- **130702A** & **131231A** were detected by iPTF **independent** of LAT position
- **140801A**: **1st Master OT** found from the ground automated location
- **All iPTF detections used the new GBM localization contours that are now available**

Swift BAT and Fermi GBM Short GRB Comparison - Eric Burns

Collaborators: Valerie Connaughton, Binbin Zhang, Adam Goldstein, Veronique Pelassa, Swift: Amy Lien, Eleonora Troja

We compare the short GRBs observed by both instruments to determine if energy range and instrumental effects are causing BAT and GBM to have different short GRB populations. We also use more sensitive ground analyses to search for untriggered GRBs as well.

	Detected sGRB's	Triggered sGRB's	Ground Analysis (offline)	sGRBs in Common	Unobservable (occulted)	Missed
BAT	54	48	6	27	25	2
GBM	255	250	5	28	225*	2*

Conclusions

- Both instruments can detect nearly all GRBs that are observable
  - Swift's sGRB redshift distribution should be close to that of Fermi GBM's
  - Both instruments are seeing the same sGRB population
- Both instruments can detect weaker sGRBs with more sensitive searches in the high time resolution data (offline)
  - Need to calibrate

*The missed (seen in one mission while the other one did not trigger) rate in BAT may increase slightly as the effect of the large GBM error box is still being considered

Search for untriggered GRBs with known Supernova

Collaborators: Eric Burns (UAH), Valerie Connaughton (UAH), Bin-Bin Zhang (UAH), Raffaella Margutti (Harvard)

First analysis (in progress):

- 15 H-stripped supernova (Type Ib/Ic will be considered in a later search)
- Search for a GRB-like event consistent with a specific location and a time range (a few days)

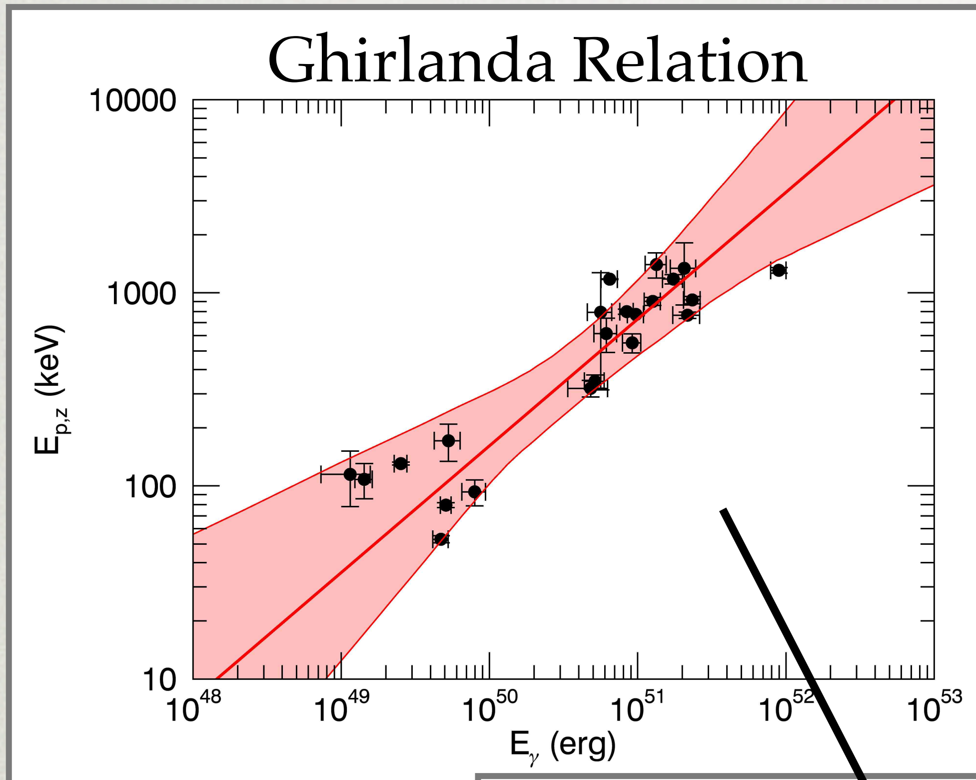
Statistical Argument:

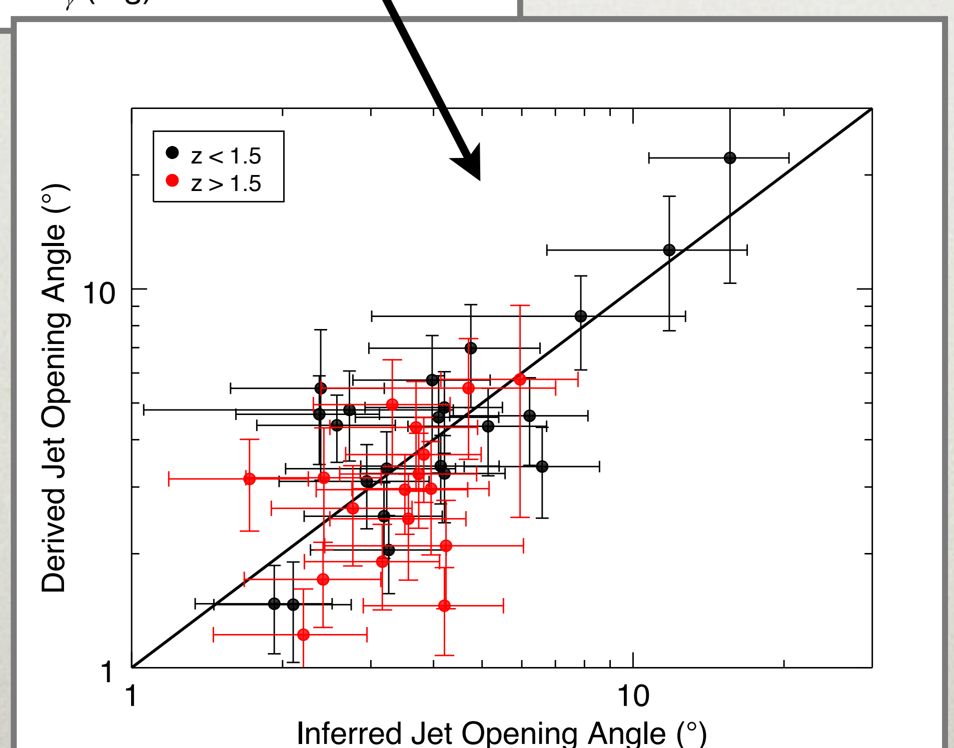
- With GBM error boxes and large time windows expect some chance coincidence
- Building a tool to calculate the chance coincidence of a GRB with uncertain location and time

Possible Outcomes:

- Provide evidence for or against the “dark phase” of SN
- Constrain fraction of SN that produce observable GRB (jet opening angle?)

Derived Jet Opening Angles





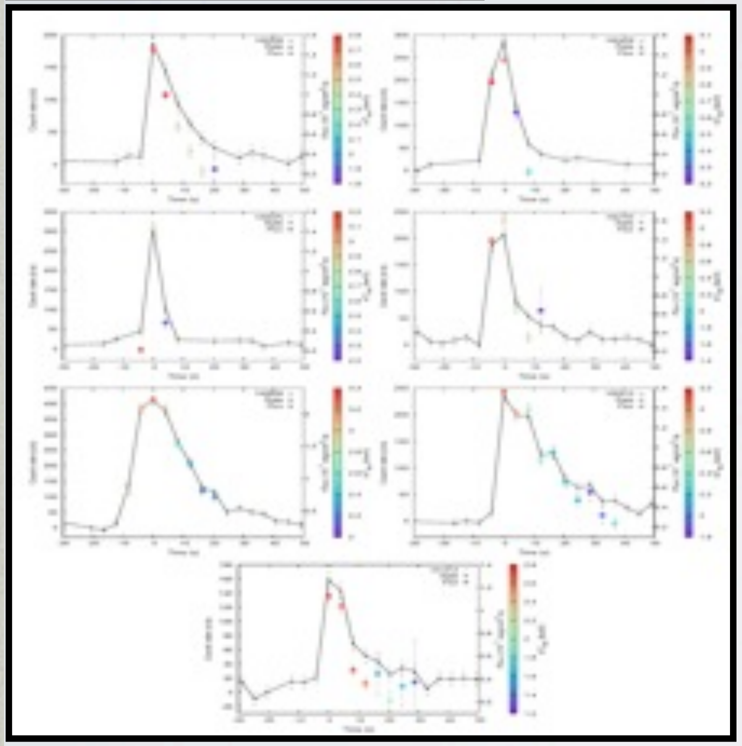
- Calibrate Ghirlanda relation using low-z long GRBs and SNe Ia
- Invert the Ghirlanda relation to derive jet opening angle
- Good agreement between inferred and derived opening angles
- Similar investigation for short GRBs?

Type I X-ray Bursts Detected by GBM

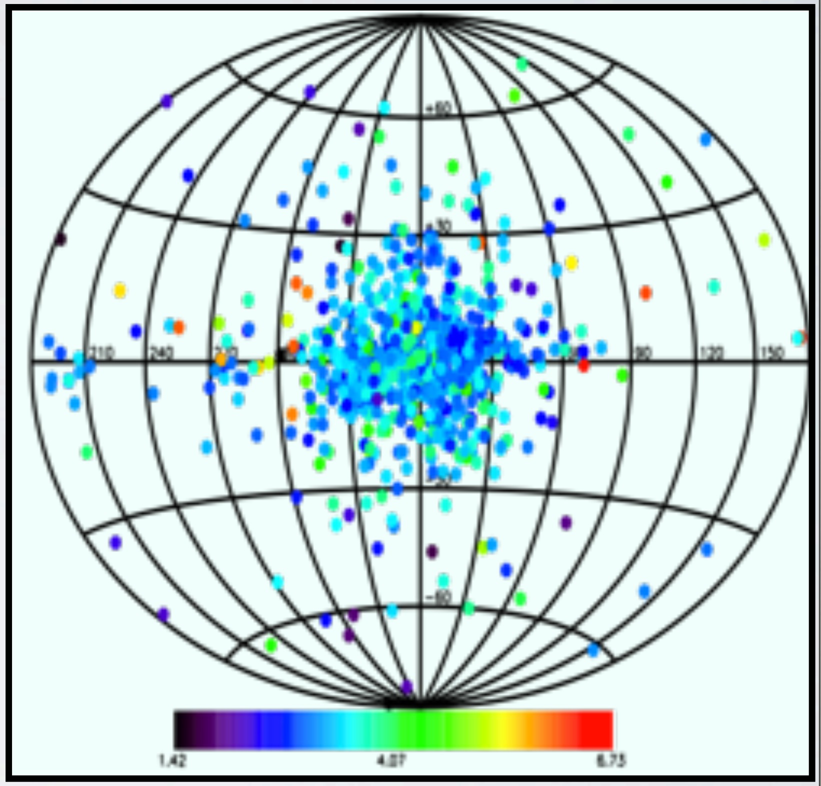
776 Photospheric Radius Expansion Bursts detected in 3 years

Pete Jenke

...and we have many more!



4U 0614+09



- **The highest detection rate of PRE bursts for any current or past instrument.**
- PRE bursts directly probe neutron star EOS.
- Type I X-ray bursts probe extreme conditions that lead to thermonuclear runaway.
- Great laboratories for accretion physics. Processes occur on observational time scales.
- GBM has the potential to discover new bursters by associating high latitude source with GC.
- Type I X-ray bursts might contribute to Galactic metallicity.