Results from Electromagnetic Counterpart Search Programs with Fermi GBM

Péter Veres

University of Alabama in Huntsville

on behalf of the GBM-LIGO working gorup

IAU 2017 Symposium Gravitational Wave Astrophysics: Early Results from GW Searches and Electromagnetic Counterparts
October 16-19, 2017

Fermi GBM detects a gamma-ray burst 2 seconds after a binary neutron star merger

Péter Veres

University of Alabama in Huntsville

on behalf of the GBM-LIGO working gorup

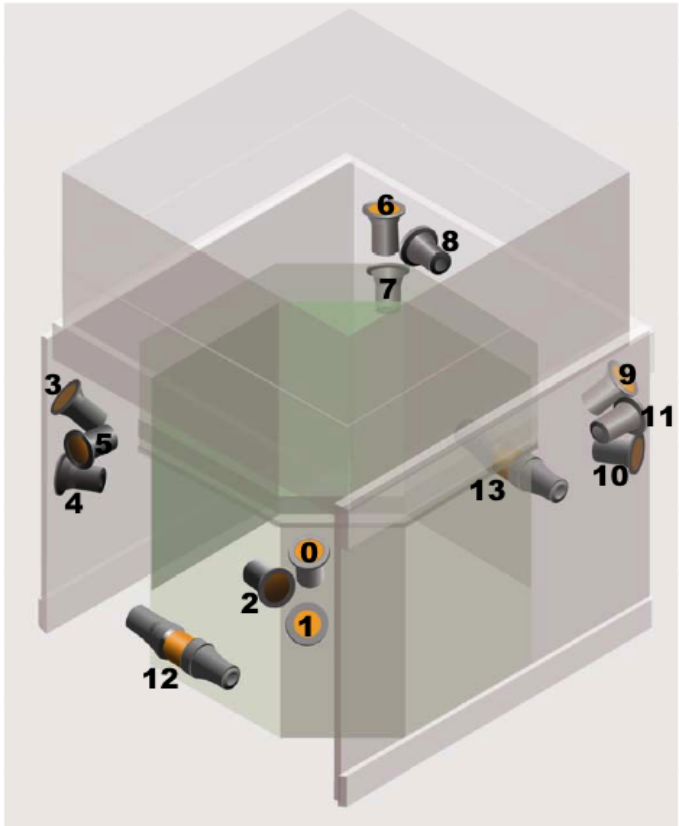
A. Goldstein, E. Burns, M. S. Briggs, R. Hamburg, D. Kocevski, C. A. Wilson-Hodge, R. D. Preece, S. Poolakkil, O. J. Roberts, C. M. Hui, V. Connaughton, J. Racusin, A. von Kienlin, T. Dal Canton, N. Christensen, T. Littenberg, K. Siellez, L. Blackburn, J. Broida, E. Bissaldi, W. H. Cleveland, M. H. Gibby, M. M. Giles, R. M. Kippen, S. McBreen, J. McEnery, C. A. Meegan, W. S. Paciesas, and M. Stanbro

papers: Goldstein et al. 2017, LVC-GBM-ACS 2017 (ApJL)

IAU 2017 Symposium Gravitational Wave Astrophysics: Early Results from GW Searches and Electromagnetic Counterparts
October 16-19, 2017

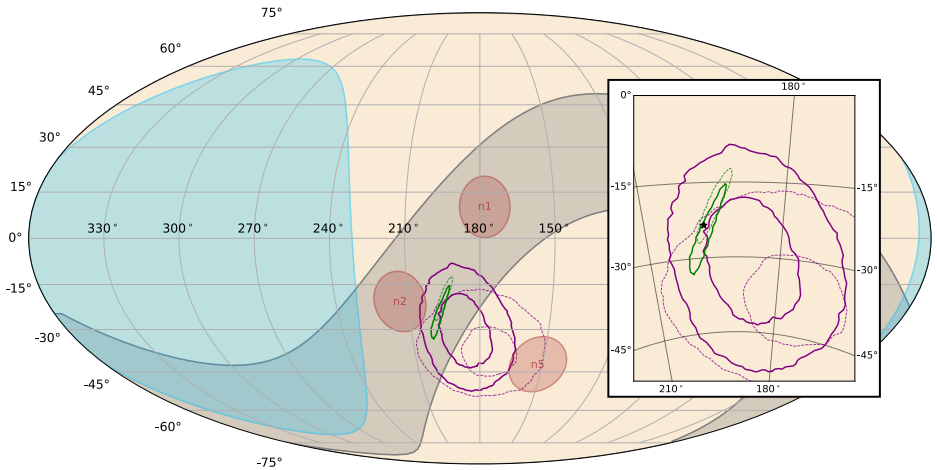
Fermi Gamma-ray burst Monitor (GBM)

- 12 NaI (8-1000 keV),
  2 BGO (0.2-40 MeV)
- 87% uptime (SAA), 67% of the sky,
  any location: $\sim$ 60% of time
- **Triggers**:
  in orbit detection of rate increase
- Short GRB: $\sim$ 40 per year
- Offline searches increase sensitivity:
  Targeted: GW 150914-GBM,
  talk by T. Littenberg
  Untargeted: Briggs+17 in prep.,
  poster by R. Hamburg
- **Localization**:
  compare relative counts in detectors



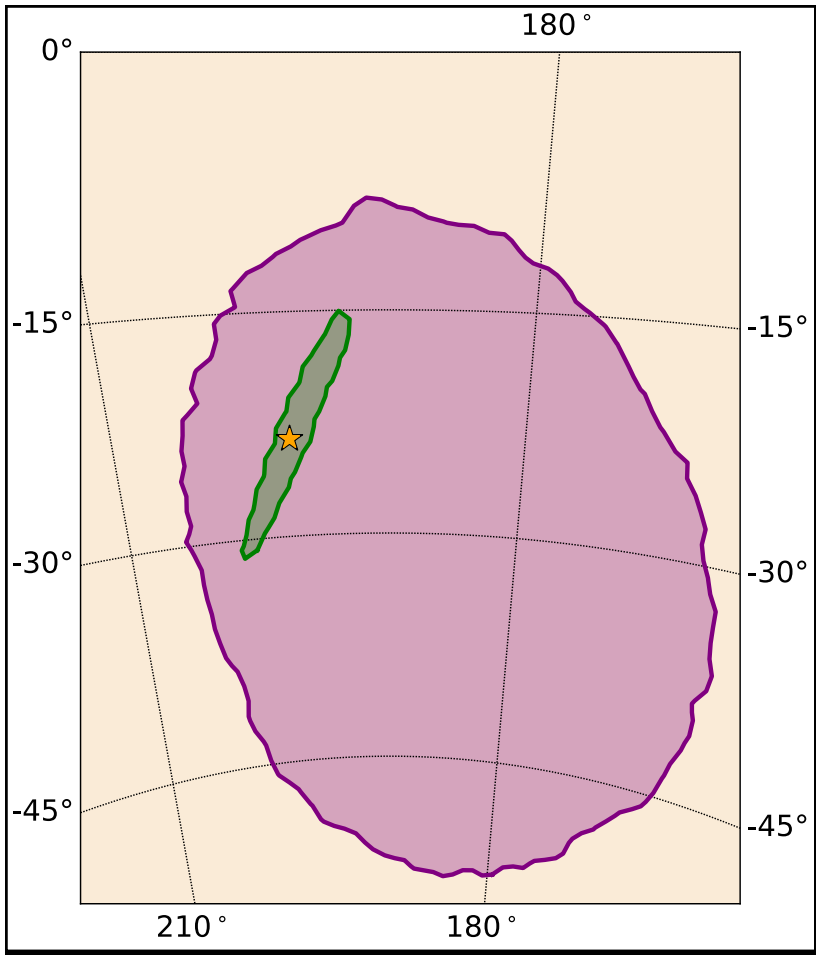
GRB 170817A - location - timeline

- $T_{GW} = T_{GRB}$ - 2.02 s
- T_{GRB}+14 s: first notice by flight software
- T_{GRB}+45 min: improved human-guided location
- Initial single interferometer location consistent with GBM inital (dashed)
- T_{GRB}+67 min: report GRB properties
- First HLV map: still consistent (that was when we knew they are surely associated)
  $P = 5 \times 10^{-8}$ (5.3 σ)



GRB 170817A - location - timeline

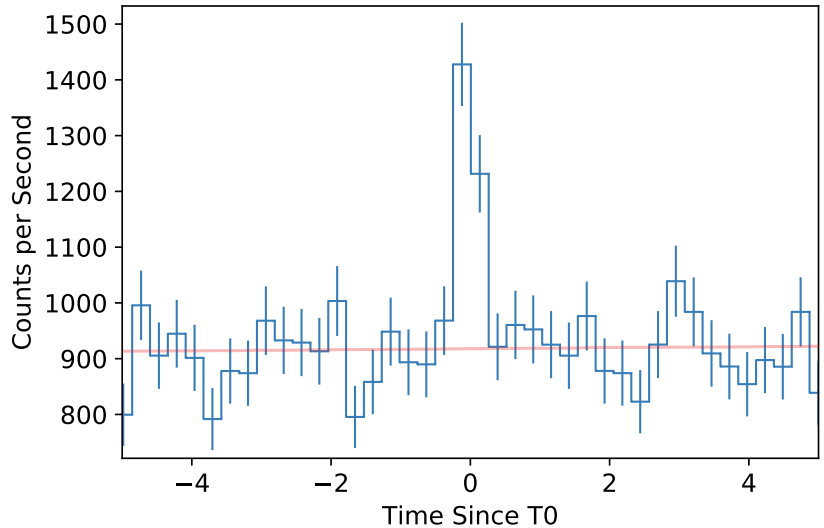
- $T_{GW} = T_{GRB}$ - 2.02 s
- T_{GRB}+14 s: first notice by flight software
- T_{GRB}+45 min: improved human-guided location
- Initial single interferometer location consistent with GBM inital (dashed)
- T_{GRB}+67 min: report GRB properties
- First HLV map: still consistent (that was when we knew they are surely associated)
  $P = 5 \times 10^{-8}$ (5.3 σ)



final HLV map

GRB 170817A - Basic information

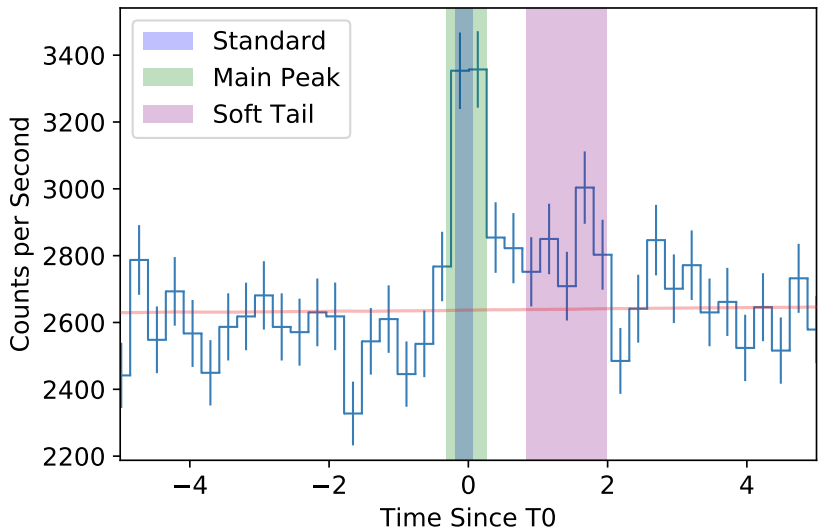
- GRBs brightest in 50-300 keV
- Triggered GBM: excess counts on 256 ms timescale
- Duration, $T_{90} = 2.0 \pm 0.5$ s
- "By eye" it's only 0.5 s long
- Main peak + soft component $\sim$ 1 to 2 s after trigger



50-300 keV lightcurve

GRB 170817A - Basic information

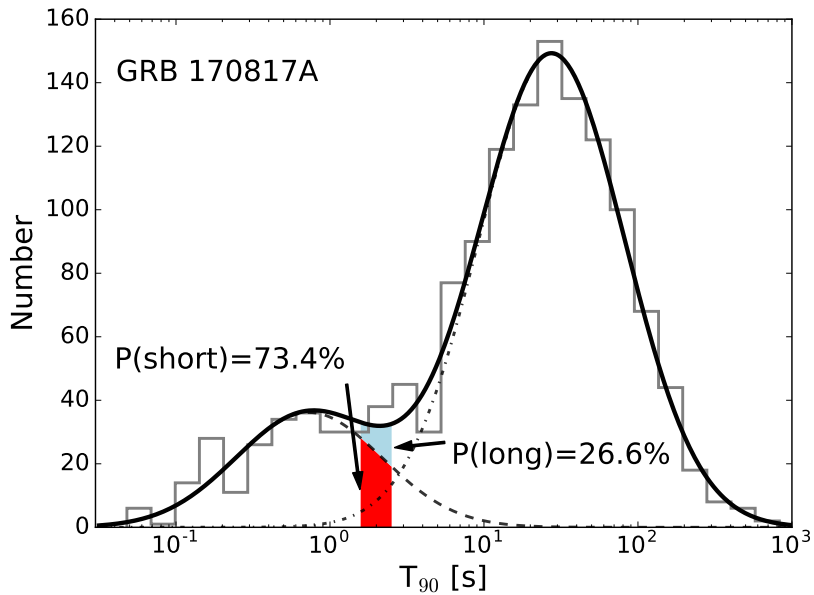
- GRBs brightest in 50-300 keV
- Triggered GBM: excess counts on 256 ms timescale
- Duration, $T_{90} = 2.0 \pm 0.5$ s
- "By eye" it's only 0.5 s long
- Main peak + soft component $\sim$ 1 to 2 s after trigger



10-300 keV lightcurve

GRB 170817A - Is this a short GRB?

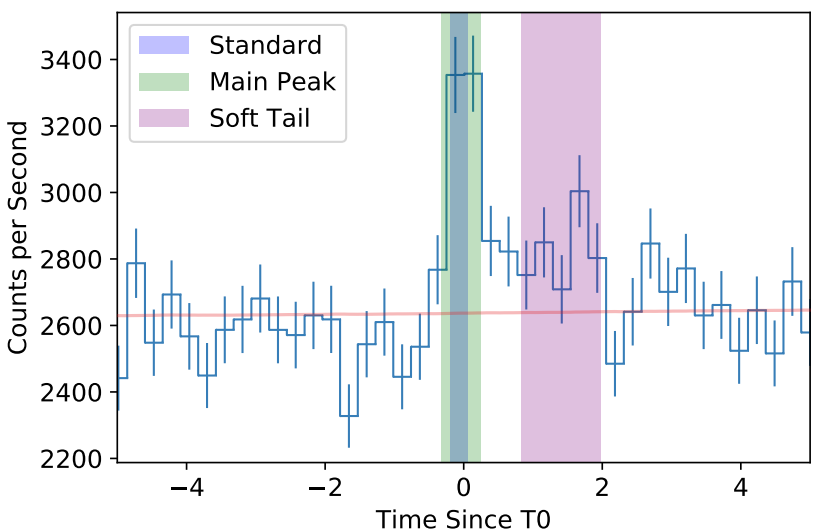
- Short - long divide (2 s ?)
- 3^{rd} GBM GRB catalog
- $T_{90} = 2.0 \pm 0.5$ s $\rightarrow$conservative ($\sim$ 0.5 s + soft episode)
- 2 log-normals describe the duration distribution
- Answer: YES, short more likely ($\sim$ 3:1)

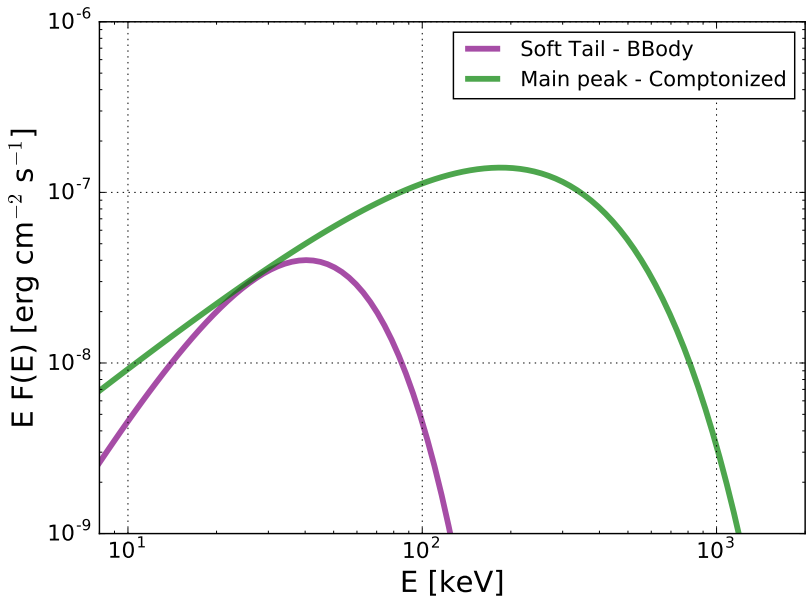


GRB 170817A - spectrum

Time Range (s)	Model	E_{peak} (keV)	Index	kT (keV)	Energy Flux (10^{-7} erg s^{-1} cm^{-2})
		Standard Analysis			
−0.192:0.064	Comp	215 ± 54	0.14 ± 0.59	-	5.5 ± 1.2
−0.128:-0.064	Comp	229 ± 78	0.85 ± 1.38	-	7.3 ± 2.5
		Detailed Analysis			
−0.320:0.256	Comp	**185 ± 62**	−0.62 ± 0.40	-	3.1 ± 0.7
0.832:1.984	BBody	-	-	**10.3±1.5**	0.53 ± 0.10

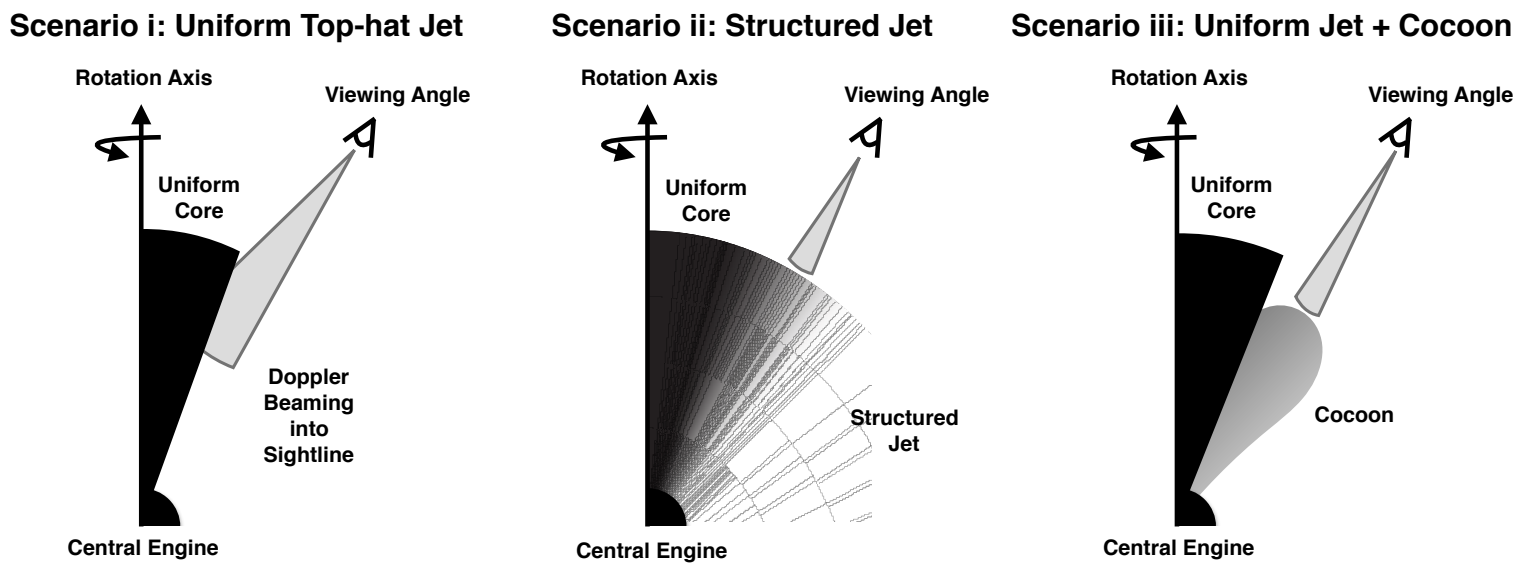
- Except soft episode, weak but **ordinary** short GRB





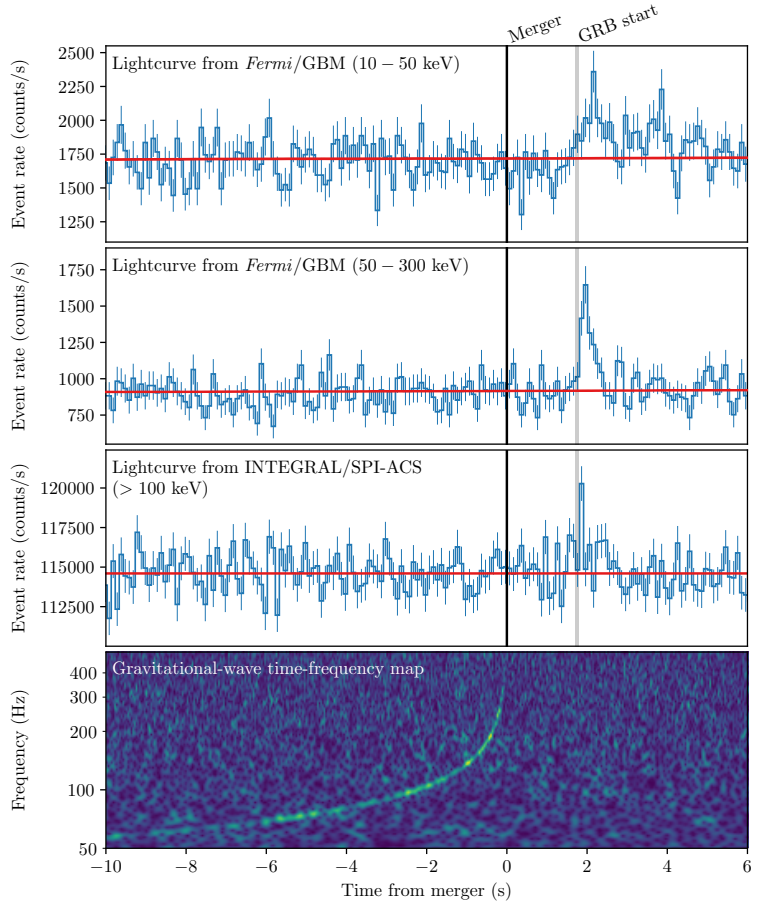
GRB 170817A some interpretation

- Observations: ordinary GRB
- Distance information: very dim GRB
- GRB viewed off-axis
- Intrinsically dim GRB on-axis
- Soft pulse: cocoon emission - most unusual



Conclusions

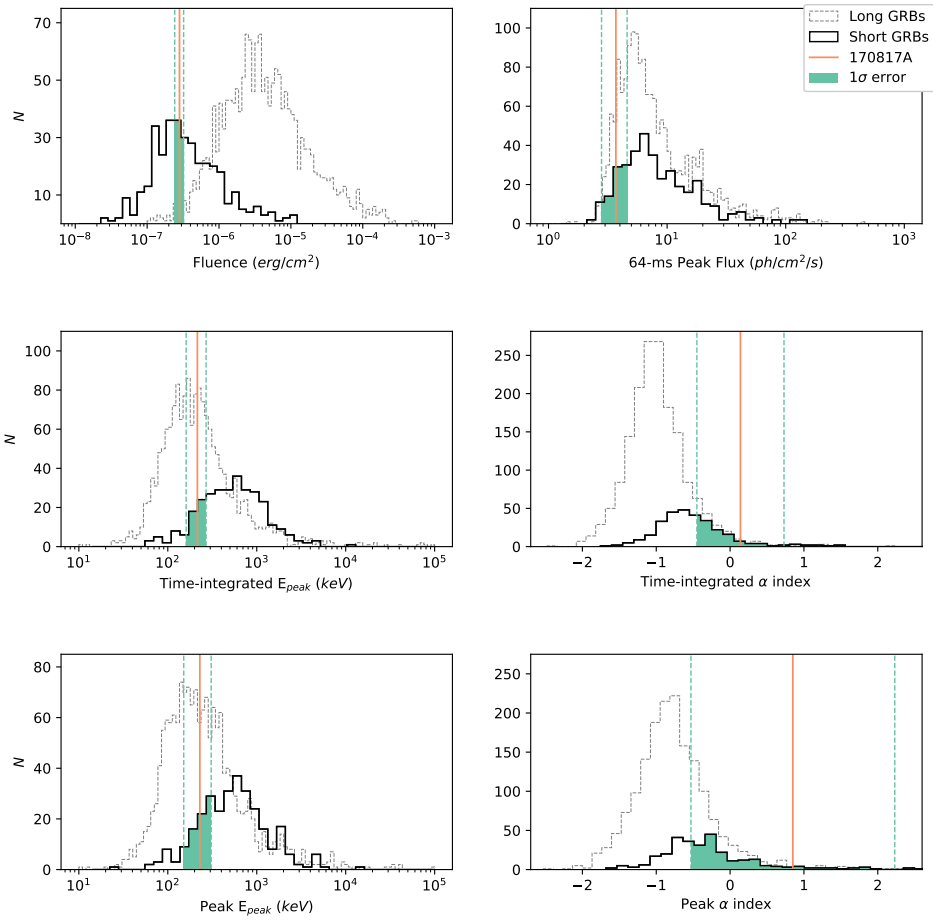
- Fermi-GBM can detect GW counterparts!
- At least some short GRBs originate from binary neutron star mergers!
- Better sGRB/NSNS rates K. Siellez' talk tomorrow
- GRB models informed by central engine properties
- Speed of gravity, LIV, WEP



GW, GRB comparison (LVC-GBM-ACS ApJL, 2017)

Where does it fit?

- All GBM GRBs analyzed consistently
- Generally: dimmer/softer than sGRBs but not unusually so
- As GBM observed it, this is a run-of-the-mill short GRB



GRB 170817A - Fermi location at the time of discovery

- SAA high levels of charged particles
- Slightly different shape for LAT