

Extreme event - Quick summary of results

- Fastest variation observed in gamma-rays for an extragalactic object. The rise time of the first pulse is $T_{\text{rise}} = 77 \pm 23 \mu\text{s}$ (Figure 2, panel e).
- Highest photon energy, ~ 3 MeV, and peak energy ($E_{\text{peak}} \sim 2$ MeV) associated with the initial pulse emission of a magnetar giant flare (Figure 3 and Table 1).
- First conclusive proof of relativistic motion (Lorentz factor lower limit: $\Gamma \gtrsim 6$).
- High total and peak luminosity and total energy $L = (1.07 \pm 0.17) \times 10^{47} \text{ erg s}^{-1}$, $L_{\text{max}} = (1.53 \pm 0.13) \times 10^{48} \text{ erg s}^{-1}$ and $E = (1.51 \pm 0.021) \times 10^{46} \text{ erg}$ (see Table 1).

Lightcurve

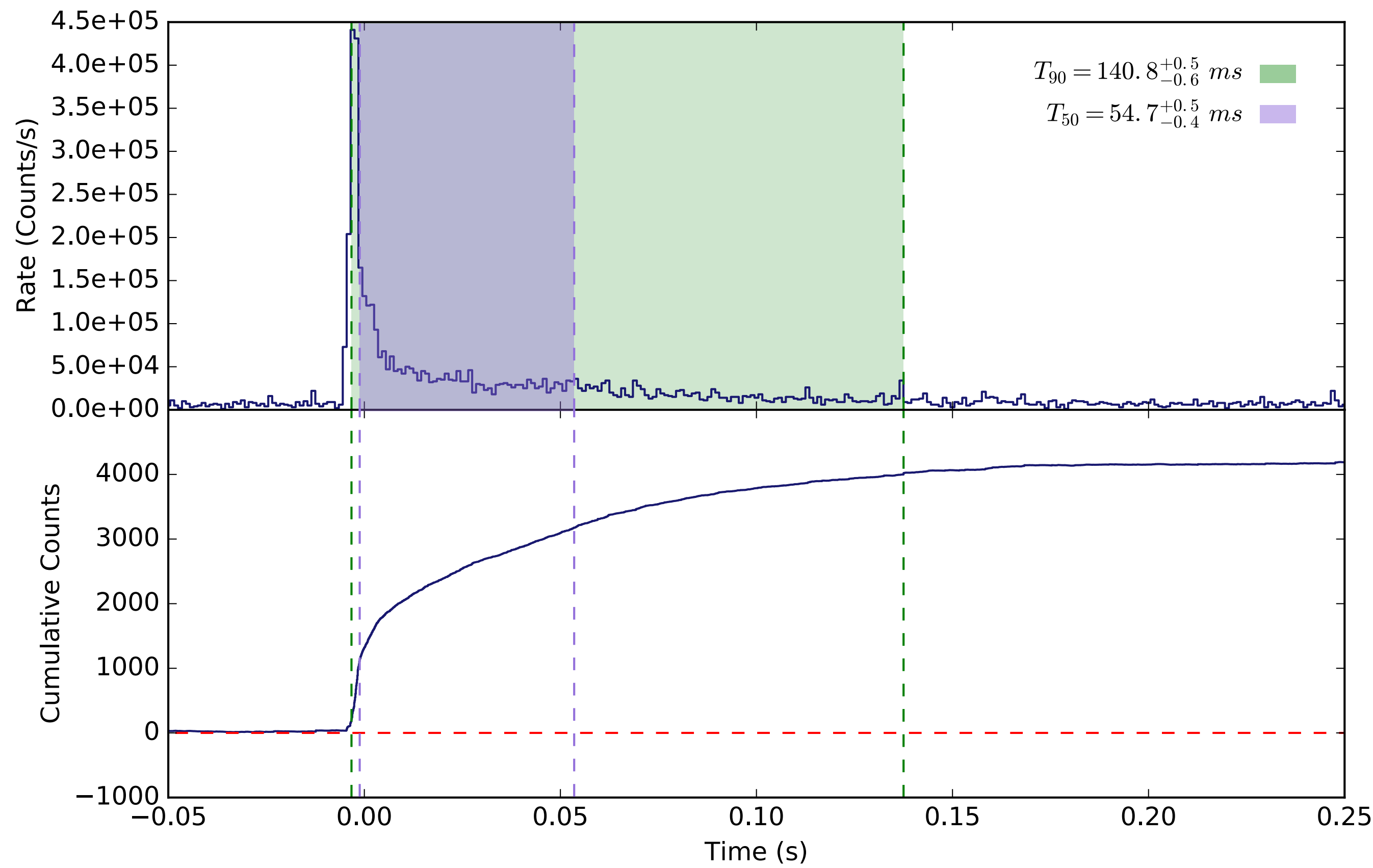


Figure 1. The duration of GRB 200415A. The T_{90} (green) and T_{50} (purple) durations, calculated using the Swift-BAT data in counts-space. Bottom panel shows the cumulative plot.

Abstract

We present the observations of the first unambiguous magnetar giant flare from outside of our galactic neighborhood. At the beginning, GRB 200415A was identified as a short GRB, but upon further investigation and observations from additional instruments, we concluded this event was a giant flare from a magnetar located in the Sculptor galaxy, 3.5 Mpc away. The GBM lightcurve shows very fast (shorter than 0.1 ms) variability, which is unprecedented among both magnetar giant flare and GRB observations. Based on the MeV range photons that Fermi-GBM detected, we find proof of relativistic expansion.

Lightcurve and spectra for the brightest part

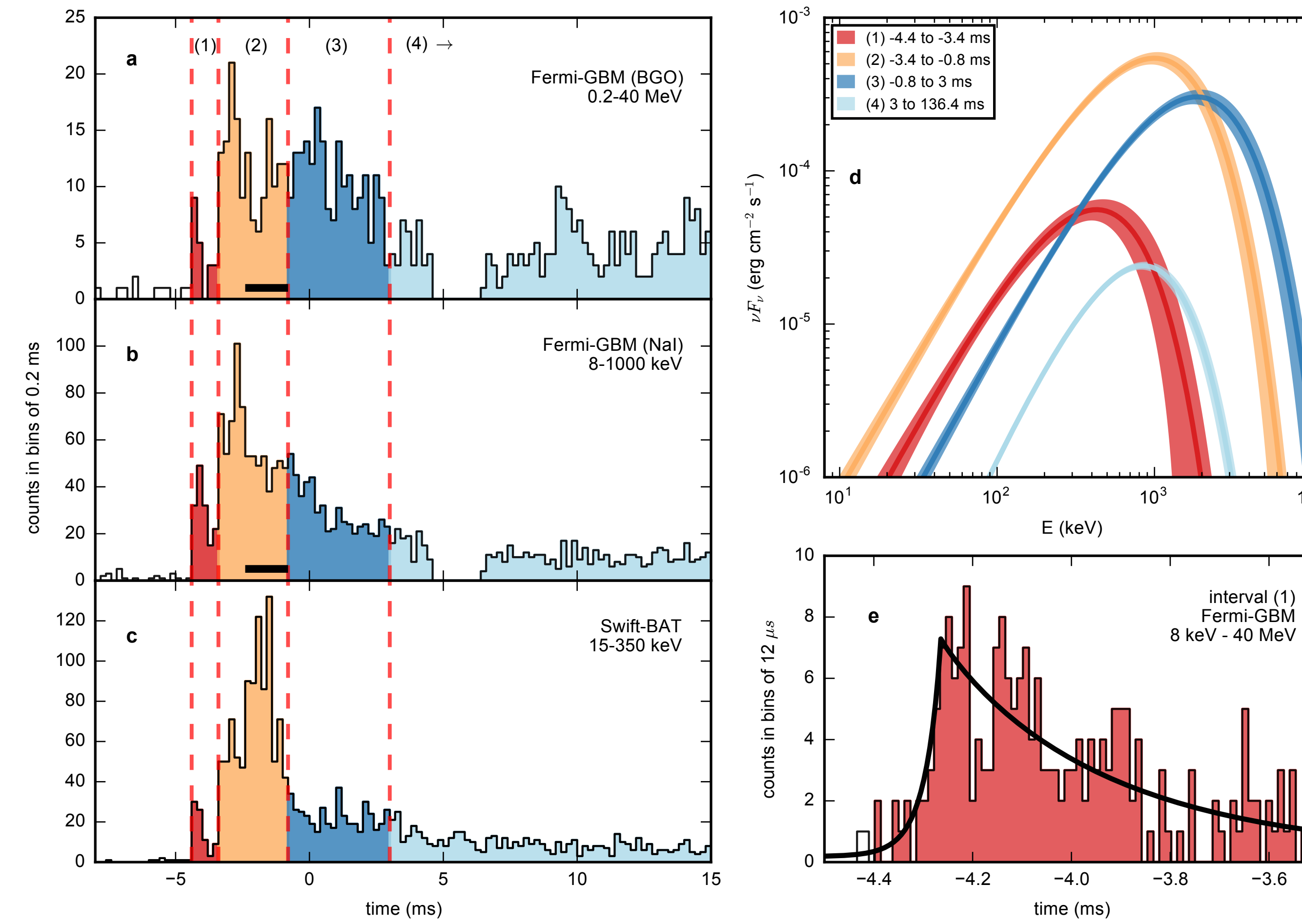


Figure 2. Temporal and Spectral Variability of GRB 200415A. (Left:) Lightcurves with 0.2 ms resolution for a Fermi GBM BGO detector (a), NaI detector (b) and Swift-BAT (c). The BAT lightcurve was shifted by $5.7 \mu\text{s}$ to account for the light-travel time between the spacecrafts. Panel (d) shows the spectra for the four intervals. The shaded area indicates 1σ confidence regions. Using the BAT TTE data, we identify that the GBM TTE bandwidth was exceeded from -2.4 ms to -0.8 ms (horizontal black lines in panels a,b), resulting in a 47.3% loss of flux in interval (2). There is also a ~ 1.8 ms data gap from 4.6 to 6.4 ms caused by a CSPEC packet blocking the GBM TTE data, resulting in a 3.47% loss in interval (4). Panel (e) shows the first pulse with high temporal resolution ($12 \mu\text{s}$) and the fitted pulse profile.

Energetics

Table 1. Spectral parameters, luminosity and emitted energy for the four time intervals identified in Figure 2a, relative to the GBM trigger time. The 1.896 factor corrects for the saturation in interval (2) by comparing the GBM flux in the 15-350 keV range with the Swift-BAT flux in the same interval.

Time (ms)	E_{peak} (keV)	photon index	Flux ($10^{-5} \text{ erg cm}^{-2} \text{ s}^{-1}$)	Corr.	$L_{\gamma,iso}$ ($10^{47} \text{ erg s}^{-1}$)	$E_{\gamma,iso}$ (10^{45} erg)
(1) -4.4 to -3.4	428 ± 71	-0.08 ± 0.23	9.9 ± 1.2	1.0	1.51 ± 0.18	0.15 ± 0.02
(2) -3.4 to -0.8	997 ± 77	-0.21 ± 0.08	33.7 ± 1.5	1.896	15.3 ± 1.3	3.97 ± 0.33
(3) -0.8 to 3.0	1856 ± 155	-0.11 ± 0.08	17.5 ± 0.81	1.0	8.29 ± 0.38	3.15 ± 0.15
(4) 3.0 to 136.4	846 ± 39	0.34 ± 0.08	2.69 ± 0.06	1.036	0.58 ± 0.032	7.79 ± 0.43
T_{90} Duration (140.8)					1.07 ± 0.17	15.1 ± 2.46

Highest energy photon

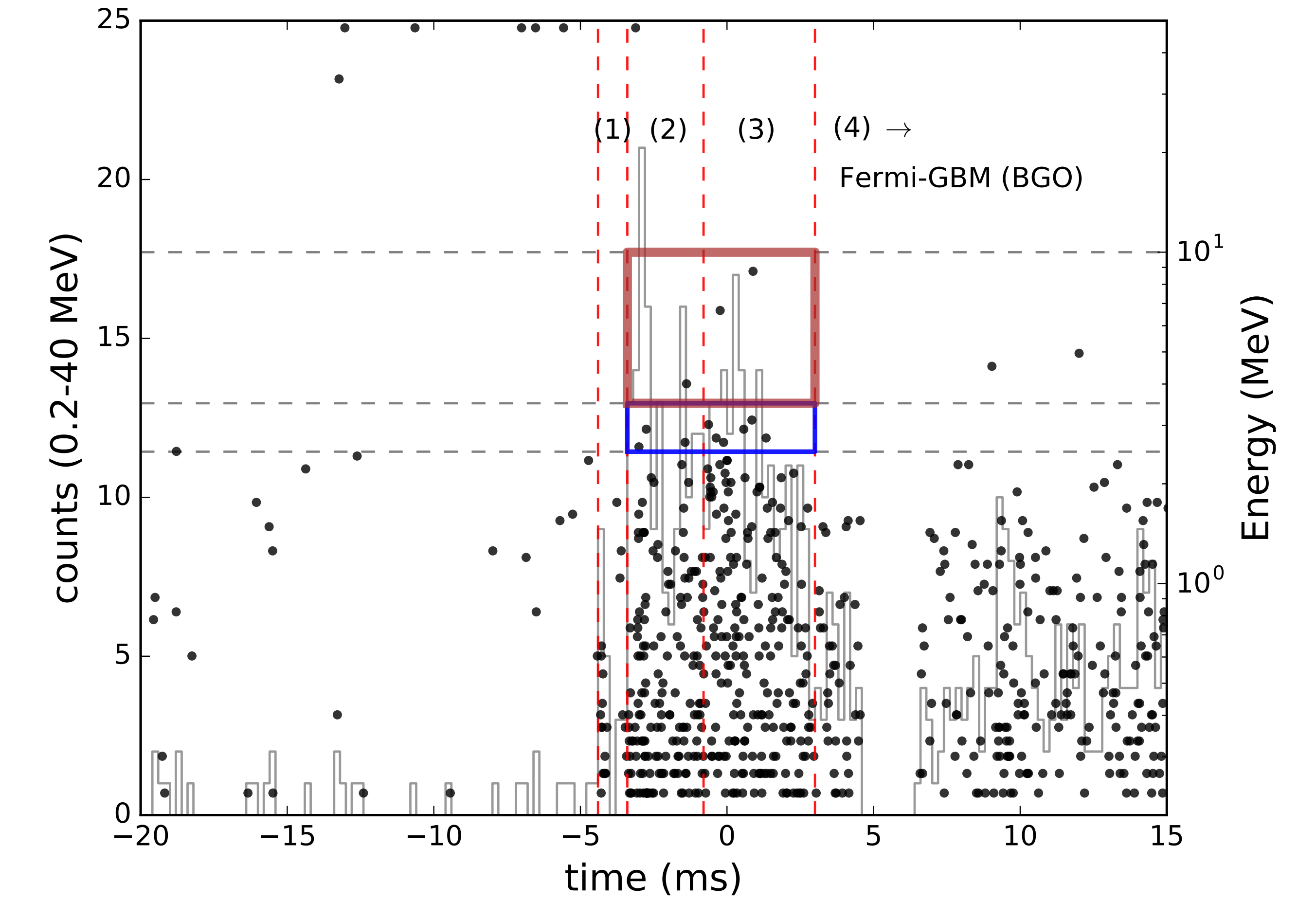


Figure 3. Energetic photons from GRB 200415A. Individual Time-Tagged Events of GBM BGO detector 0 (black dots). The blue rectangle indicates energies from 2.5 to 3.5 MeV in intervals (2) and (3), while the red rectangle shows energies from 3.5 to 10 MeV. We conclude that the highest photon energy unambiguously associated to GRB 200415A is 3 MeV.

References

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