Observations of Soft Gamma-ray Sources >100 keV Using Earth Occultation with GBM

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Summary

The sources Crab, Cyg X-1, Swift J1753.5-0127, 1E 1740-29, Cen A and GRS 1915+105 are detected by GBM at energies above 100 keV using the Earth occultation technique after ~400 days of observations.

Introduction to Earth Occultation with GBM

The GLAST Burst Monitor is the secondary instrument onboard the *Fermi* satellite. It consists of 12 NaI detectors 5" in diameter by 0.5" thick mounted on the corners of the spacecraft and oriented such that they view the entire sky not occulted by the Earth. GBM also contains 2 BGO detectors 5" in diameter by 5" thick located on opposite sides of the spacecraft. None of the GBM detectors have direct imaging capability.

Known sources of gamma-ray emission can be monitored with non-imaging detectors using the Earth occultation technique, as was successfully demonstrated with BATSE (Ling et al 2000, Harmon et al. 2002). When a source of gamma rays is occulted by the Earth, the count rate measured by the detector will drop, producing a step-like feature. When the source reappears from behind the Earth's limb, the count rate will increase, producing another step. These steps are fit along with a quadratic background to determine the detector count rate due to the source. The instrument response is used to convert the count rate to a flux. Up to 31 steps are possible for a given source in a day, and these steps are summed to get a single daily average flux.

This work uses the GBM CTIME data, with its 8 broad energy channels and 0.256-second resolution, rebinned to 2-second resolution. The occultation technique relies on an input catalog of known sources, and currently we are monitoring 33 sources. Of these 33 sources, 6 are detected above 100 keV with a significance of at least 5s after ~400 days of observations.

We show GBM light curves generated from the Earth occultation analysis in several energy bands with one day resolution for these 6 sources. The 10-50 keV band is similar to the nominal Swift band (15-50 keV) and is shown to illustrate the low energy behavior of these sources. Table 1 gives the fluxes and significances averaged over all the days from Aug 12, 2008 (the beginning of science operations) to Sep 30, 2009, approximately 400 days.

These results are preliminary. We have not completed the fine tuning of our algorithms, though the average fluxes are not expected to change much. Future work will include using the GBM CSPEC data, with its finer energy binning, to examine the detailed spectra for these sources.

Discussion of Individual Sources

The **Crab** spectrum in the hard x-ray/low energy gamma-ray region can be described by a broken power law, with the spectrum steepening at ~100 keV and then hardening at ~650 keV (Ling & Wheaton 2003, Jourdain & Roques 2009). While the GBM CTIME data does not have the spectral resolution to observe these breaks, GBM is able to see significant emission above 300 keV, consistent with the canonical hard spectrum.

Cyg X-1 is a HMXB and one of the first systems determined to contain a black hole. It has been observed to emit significant emission above 100 keV including a power law tail extending out to greater than 1 MeV (McConnell et al. 2000, Ling & Wheaton 2005). The GBM results show significant emission above 300 keV, consistent with the power law tail observed when Cyg X-1 is in its hard state.

SWIFT J1753.5-0127 is a LMXB with the compact object likely being a black hole. Swift discovered this source when it observed a large flare in July of 2005. The source did not return to quiescence but settled into a low intensity hard state (Cadolle Bel et al. 2007). BATSE occultation measurements from 1991-2000 showed no significant emission from this source above 25 keV (Case et al. 2010). The GBM results show that this source is still in a hard state, with significant emission above 100 keV. We will continue to monitor this source while it is in the hard state, with longer observations potentially verifying significant emission above 300 keV.

1E 1740-29 is a LMXB very near the Galactic Center. It is a microquasar, and spends most of its time in the low/hard state. Integral observations indicate the presence of a power law tail above 200 keV (Bouchet et al. 2009). The GBM results are consistent with this high energy emission. In the future, we will use the GBM CSPEC data with its finer energy bins to obtain a fit to the spectrum and compare the power law index to that measured by Integral.

Cen A is a Sy 2 galaxy that is the brightest AGN in hard x-rays/low energy gamma rays. It has a hard spectrum (Γ= 1.8) and has been observed at energies >1 MeV (Steinle et al. 1998). The GBM results are consistent with this hard spectrum, though GBM does not have the sensitivity to determine if the hard spectrum continues beyond 300 keV or if the spectrum cuts off.

GRS 1915+105 is a LMXB with the compact object being a massive black hole. Evidence for emission above 100 keV has been seen previously (Case et al. 2005) with BATSE. The GBM light curve integrated over ~400 days shows significant emission above 100 keV.

References

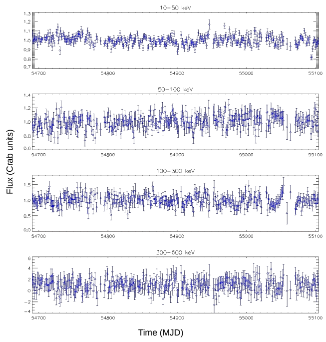
Bouchet et al. 2009, ApJ, 693, 1871
Cadolle Bel et al. 2007, ApJ, 659, 649
Case et al. 2010, in preparation
Case et al. 2005, ChJAA Suppl., 5, 341
Harmon et al, 2002, ApJS, 138, 149
Jourdain & Roques, 2009, 704, 17
Ling & Wheaton, 2005, ChJAA Suppl., 5, 80
Ling & Wheaton, 2003, ApJ, 598, 334
Ling et al. 2000, ApJS, 127, 79
McConnell et al, 2000, ApJ, 543, 928
Steinle et al. 1998, A&A, 330, 97

Table 1: Fluxes and significances in high energy bands

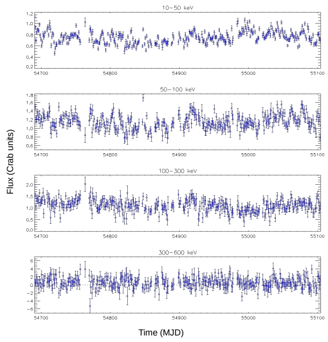
Name	50-100 keV			100-300 keV			300-600 keV		
	Flux (mCrab)	Error (mCrab)	Signif.	Flux (mCrab)	Error (mCrab)	Signif.	Flux (mCrab)	Error (mCrab)	Signif.
Crab	1000	4	238	1000	8	124	1000	57	17.8
Cyg X-1	1155	5	246	1116	9	127	602	60	10.1
SWIFT J1753.5-0127	144	6	25	166	11	15	213	78	2.7
Cen A	68	4	16	106	8	13	36	56	0.6
1E 1740-29	112	6	19	103	11	9	0	78	0.0
GRS 1915+105	118	5	26	49	8	6	19	59	0.3

Light curves

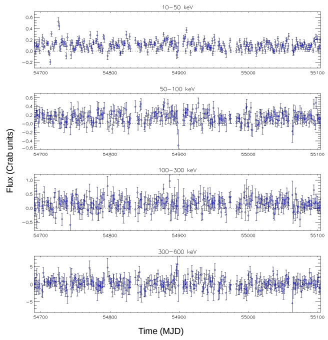
Crab



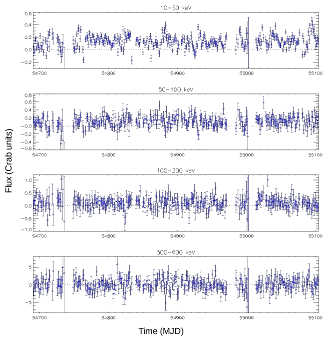
Cyg X-1



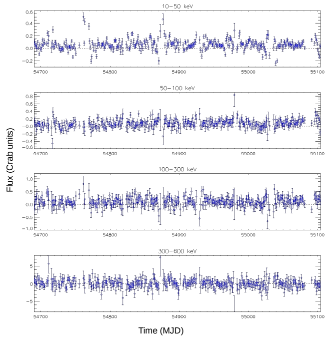
SWIFT J1753.5-0127



1E 1740-29



Cen A



GRS 1915+105