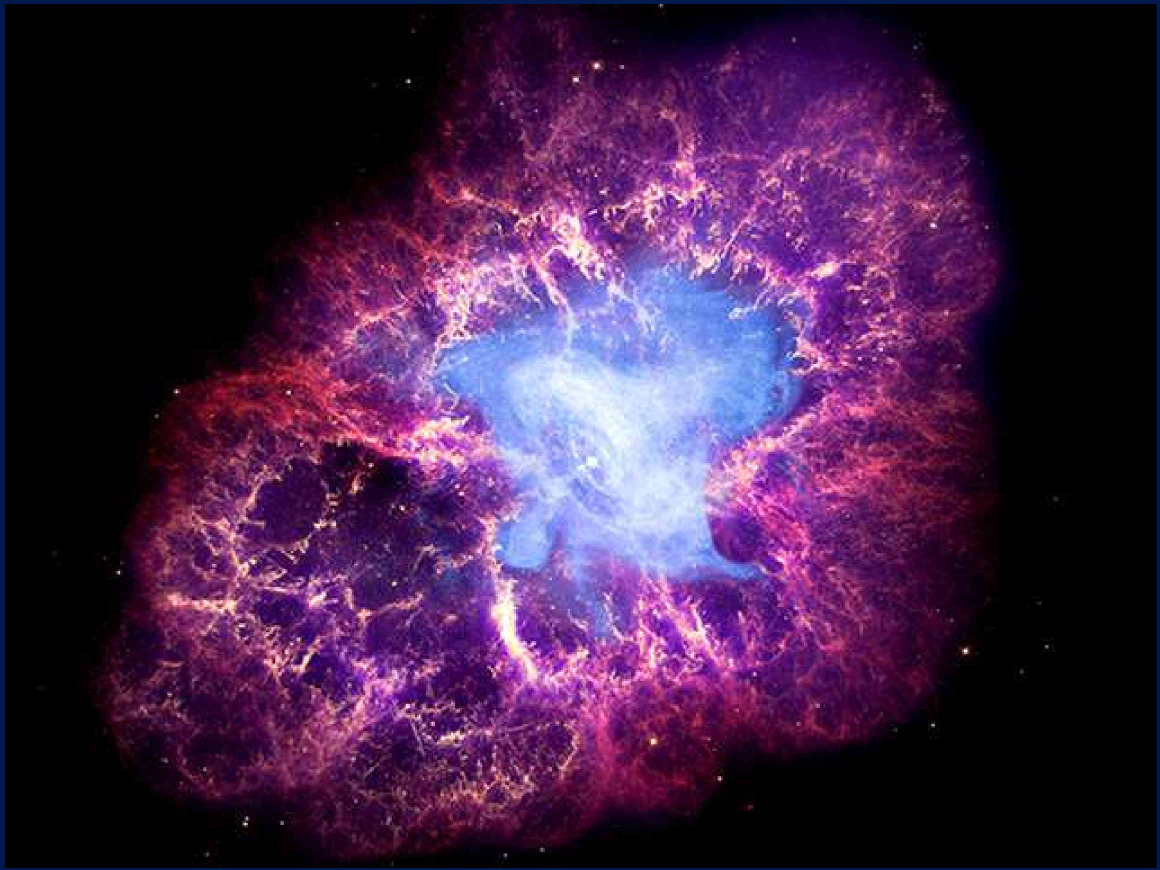
The Crab Light Curve and Spectra from GBM: An Update



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IACHEC, Warrenton, VA ,12 May 2014

Collaborators

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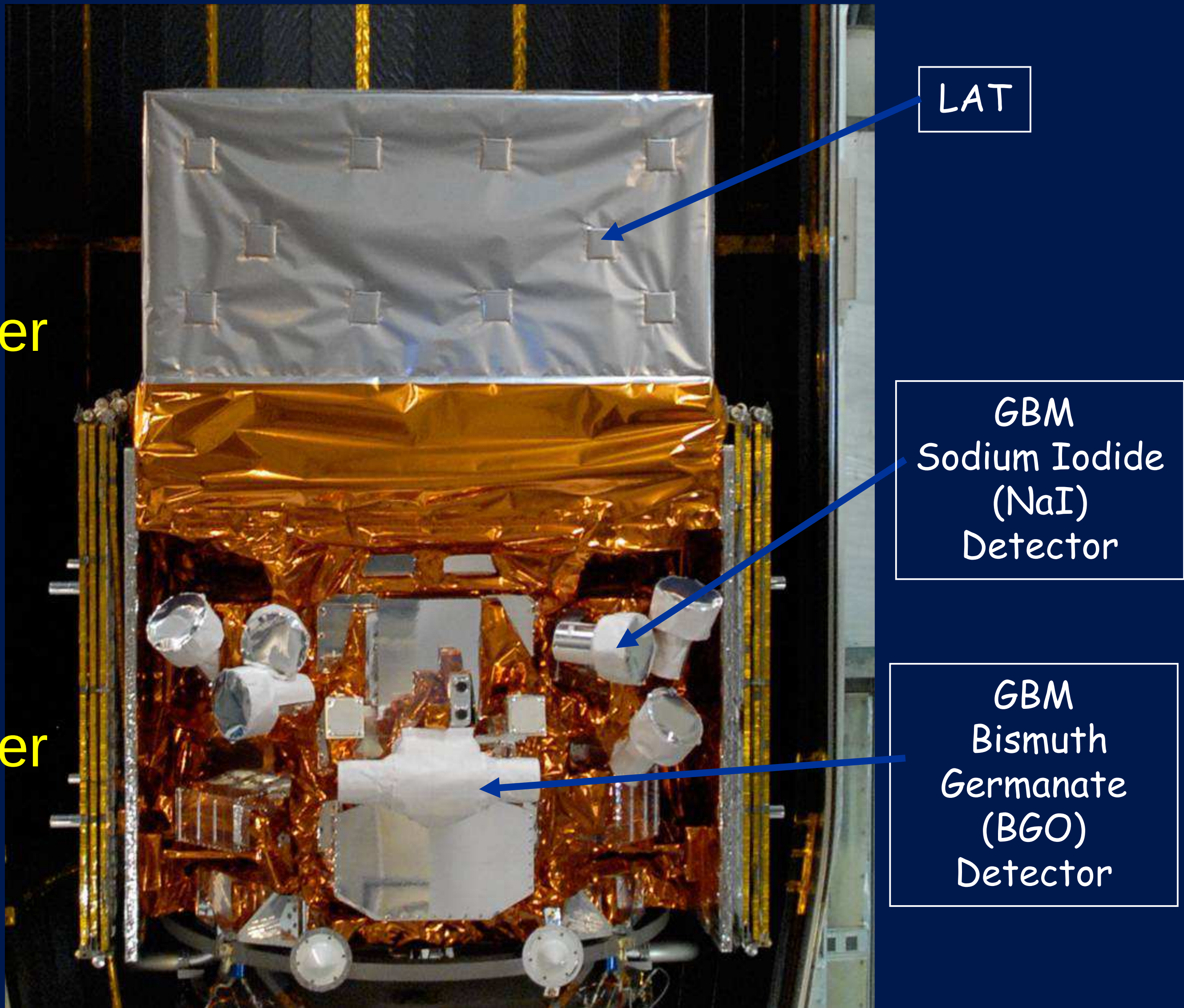
The *Fermi* Satellite

Gamma-ray Burst Monitor (GBM)

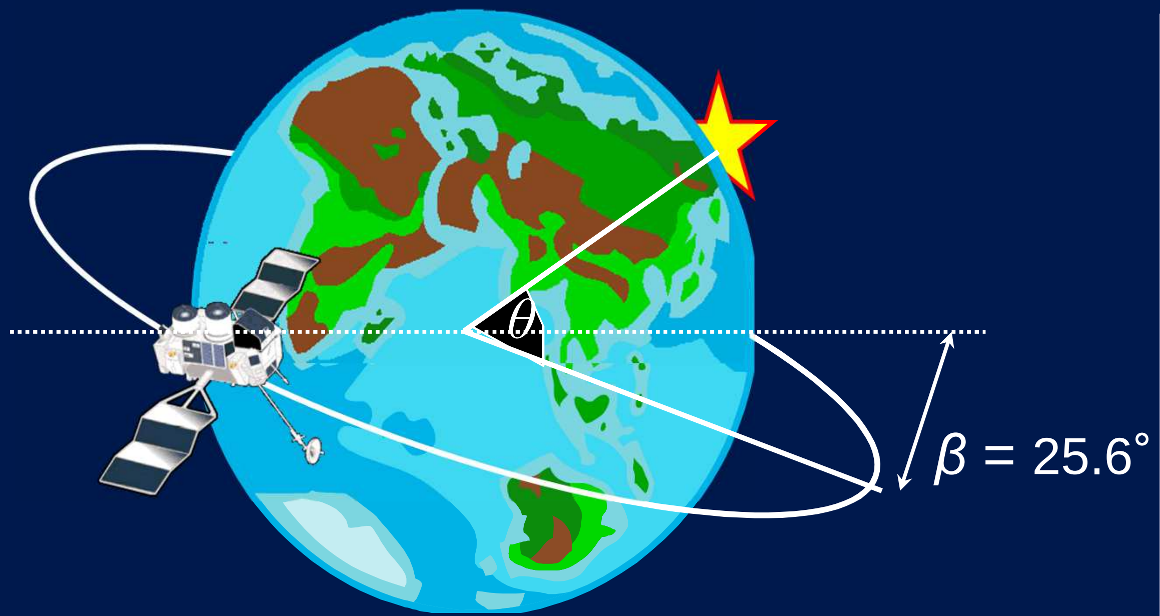
- 12 NaI detectors
  - 12.5 cm diameter x 1.25 cm thick
  - 8 keV - 1 MeV
- 2 BGO detectors
  - 150 keV - 40 MeV
  - 12.5 cm diameter x 12.5 cm thick
- All GBM detectors are non-imaging

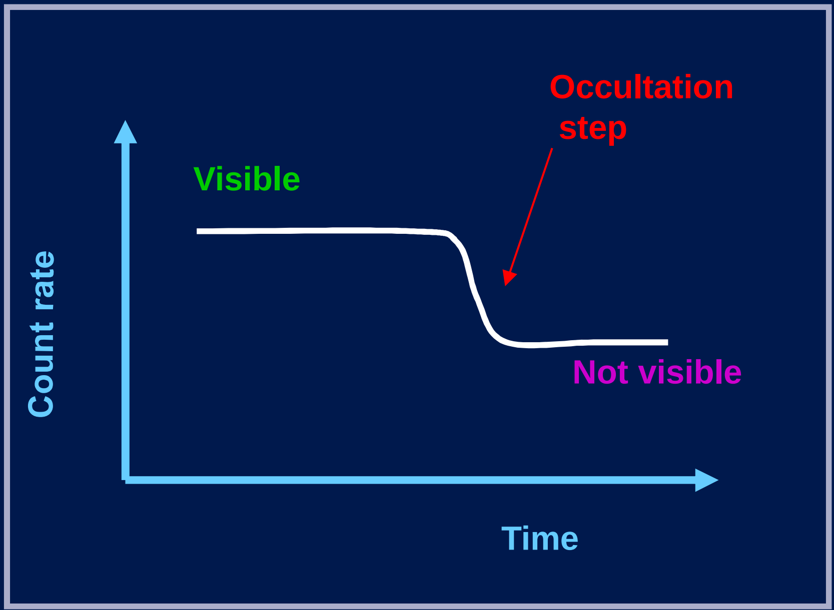


Earth Occultation

Question: How do you measure the intensity of a source if your detector doesn't know where the photon came from?

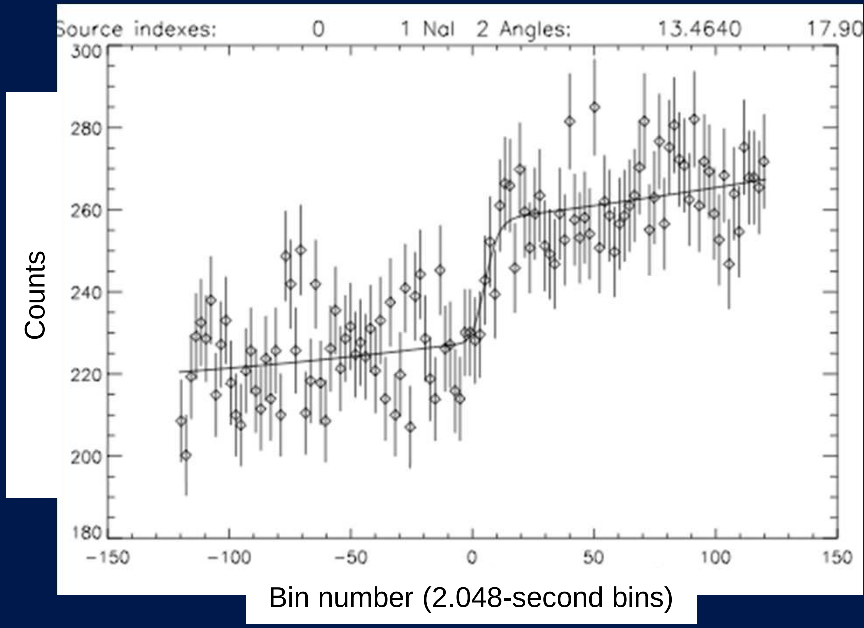
Answer: Earth occultation technique





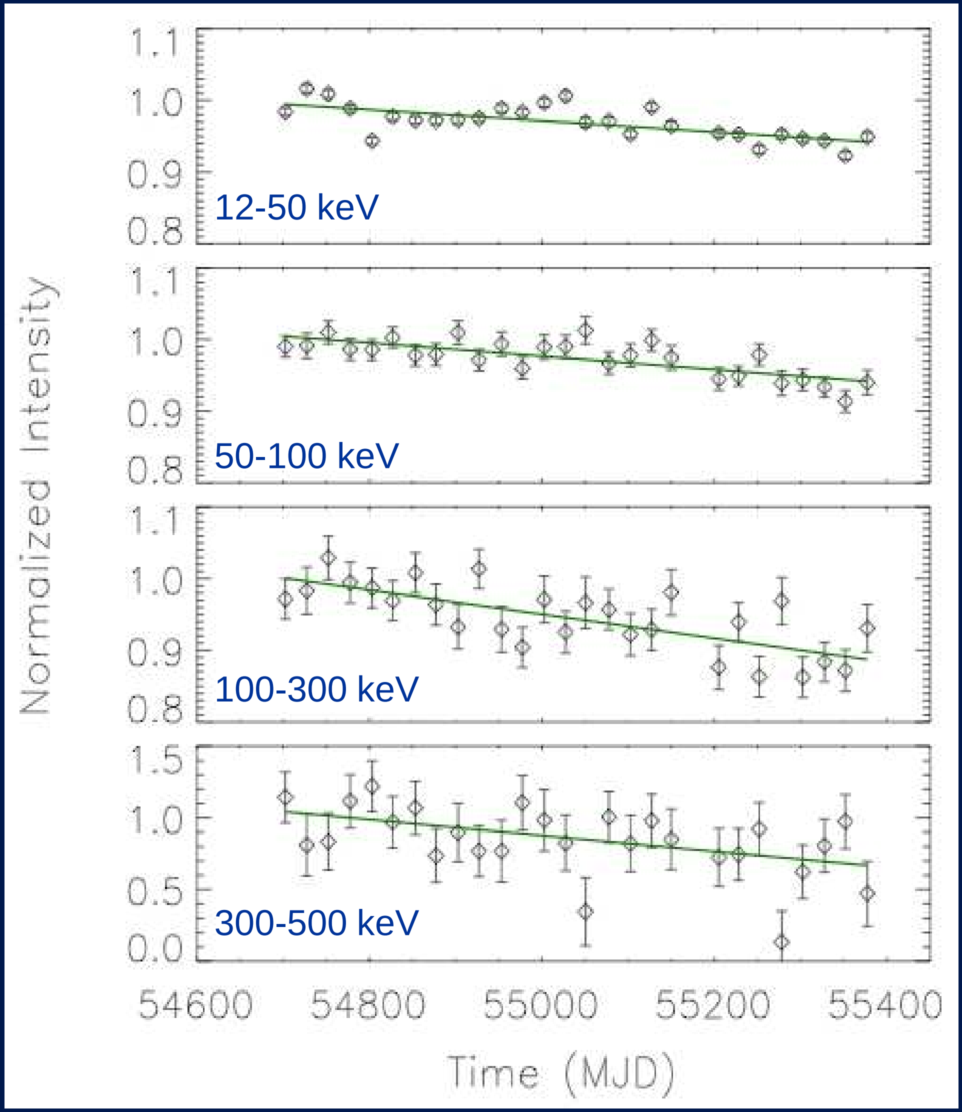
GBM Earth Occultation Technique

- Current input catalog includes 232 sources, primarily recently active X-ray binaries, the Crab, AGN, SGRs, CVs, and the Sun
- Calculate occultation times and center each step in four minute window for each detector and each energy band (8 energy bands in CTIME data)
- Generate source model: assumed spectrum convolved with changing detector response and atmospheric transmission
- Fit data to source model, plus source models for interfering sources, and quadratic background
- 120+ sources detected <100 keV, 9 sources detected >100 keV
- Advantages of GBM monitoring:
  - Continuous monitoring
  - No solar pointing constraints
  - Useful response up to ~300 keV



Fermi/GBM: Crab Light Curves

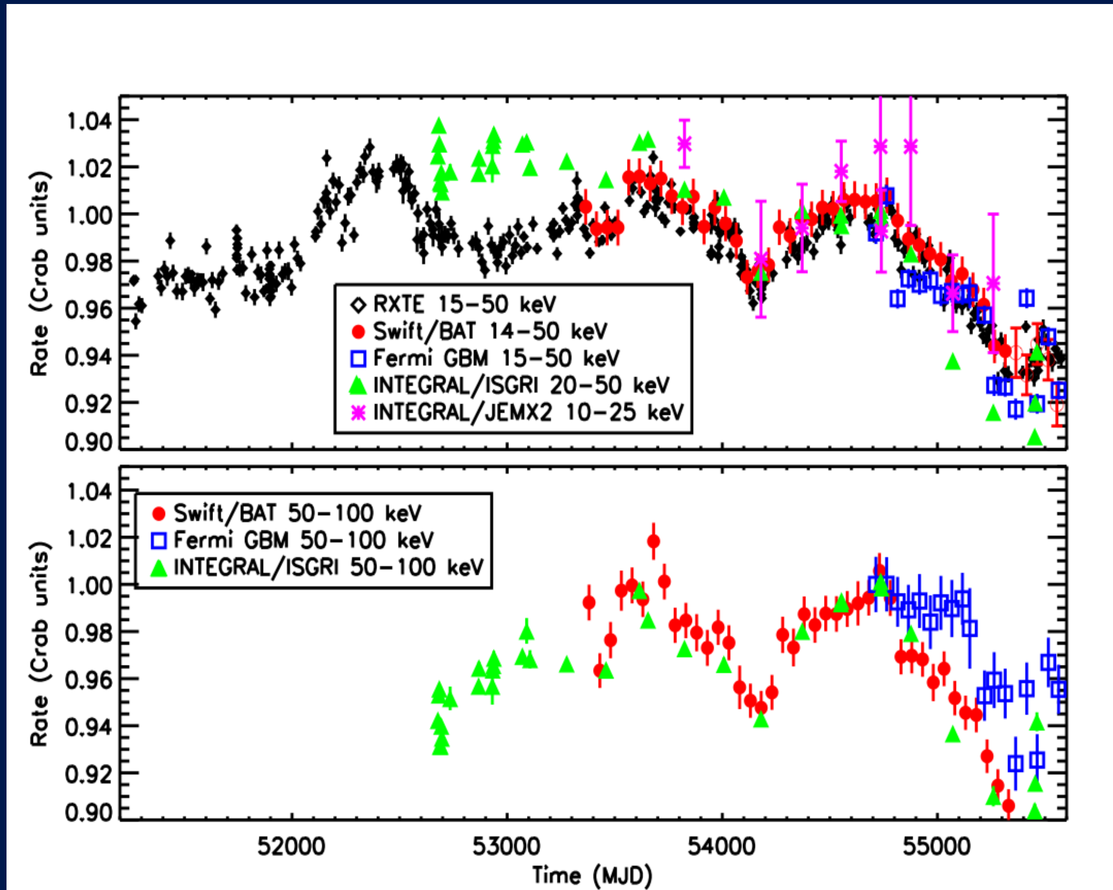
- 25-day averages
- Normalized to the first 100 days in each band
- Decline in Crab flux:
  - 5.4 ± 0.4% 12-50 keV
  - 6.6 ± 1.0% 50-100 keV
  - 12 ± 2% 100-300 keV
  - 39 ± 12% 300-500 keV
- No changes in GBM response or calibration
- Decline appears to become larger as energy increases – spectral softening?



The Declining Crab

- Light curves for each instrument are normalized to its average rate from MJD 54690-54790.
- RXTE/PCU2 - Black Diamonds
- BAT - Red Circles
- ISGRI - Green triangles
- JEM-X - Pink asterisks
- GBM - Blue squares

Instruments on four separate spacecraft show ~7% decline in Crab flux since August 2008!

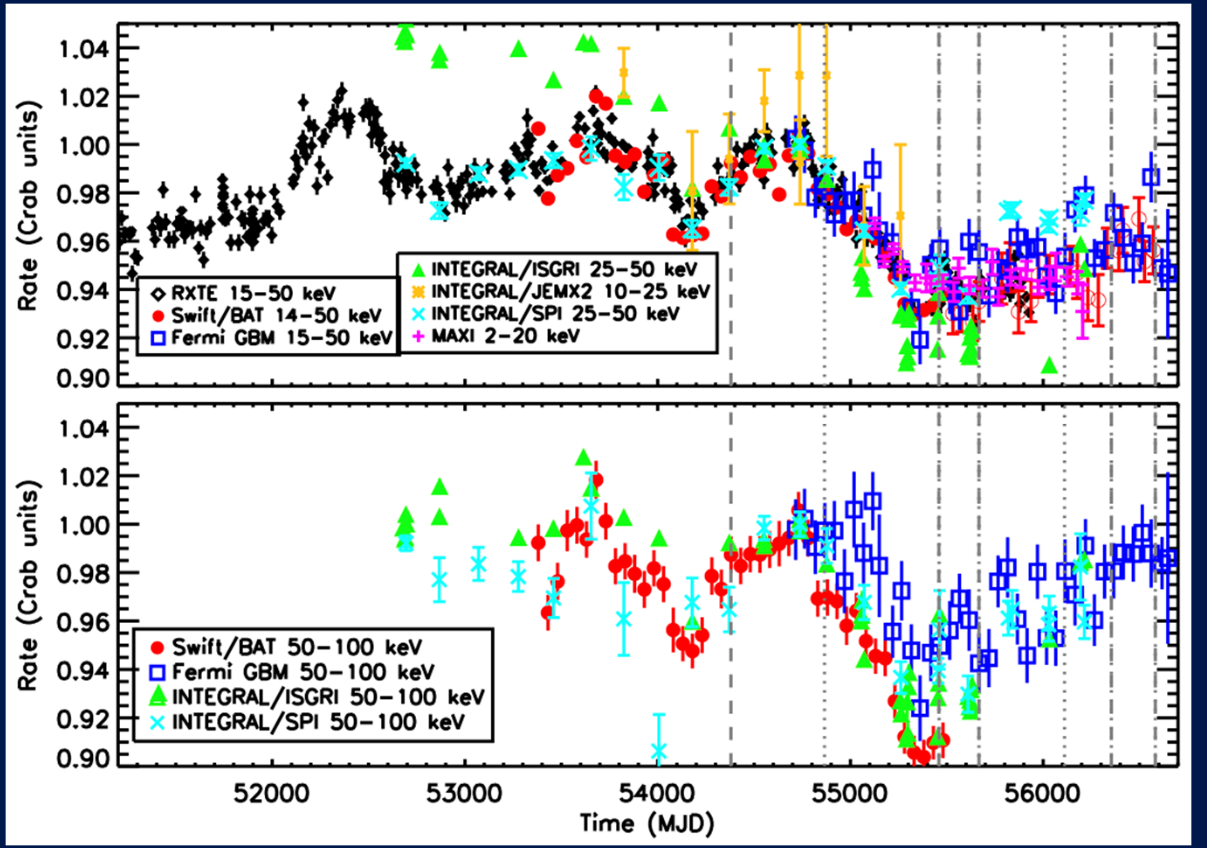


Wilson-Hodge et al. 2011, ApJ, 727, L40

What the Crab has Been Up to Lately…

- Light curves for each instrument are normalized to its average rate from MJD 54690-54790.

- GBM – Blue squares
- RXTE/PCU2 – Black Diamonds
- BAT – Red Circles
- ISGRI – Green triangles
- JEM-X – Orange asterisks
- SPI – Cyan X's
- MAXI – Pink plus signs



(Thanks to Colleen Wilson-Hodge)

50-100 keV band has nearly recovered to pre-decline level

15-50 keV band has only increased ~30% of the way back to pre-decline level

Fermi/GBM: Crab Spectra

- Complicated by the fact the response is constantly changing
- Use CSPEC data binned into 16 channels from 10-400 keV
- Preliminary results:

MJD 54690-54790

α_1=1.49±0.03
E_{b1}=18.0±0.4
α_2=2.102±0.007
E_{b2}=166±15
α_3=3.04±0.26

MJD 55400-55500

α_1=1.65±0.04
E_{b1}=17.4±0.5
α_2=2.068±0.007
E_{b2}=97±12
α_3=2.29±0.05

MJD 56500-56600

α_1=1.69±0.03
E_{b1}=18.9±0.6
α_2=2.054±0.008
E_{b2}=96±9
α_3=2.35±0.05

- Statistical errors only used in fit

Conclusions

- Four instruments (Fermi/GBM, RXTE/PCA, Swift/BAT, INTEGRAL/ISGRI) showed a ~7% (70 mCrab) decline in the Crab from Aug 2008 – Aug 2010.
- Since then, 15-50 keV band has partially recovered to pre-decline levels.
- 50-100 keV band has nearly recovered to pre-decline levels.
- Preliminary GBM spectra do not always appear to agree with what we know from the light curves?
- But more work needs to be done to understand GBM spectra, particularly at low energies.
- GBM will continue to monitor the Crab.