Comprehensive Overview of SGR J1550-5418 Bursts Detected with Fermi/GBM

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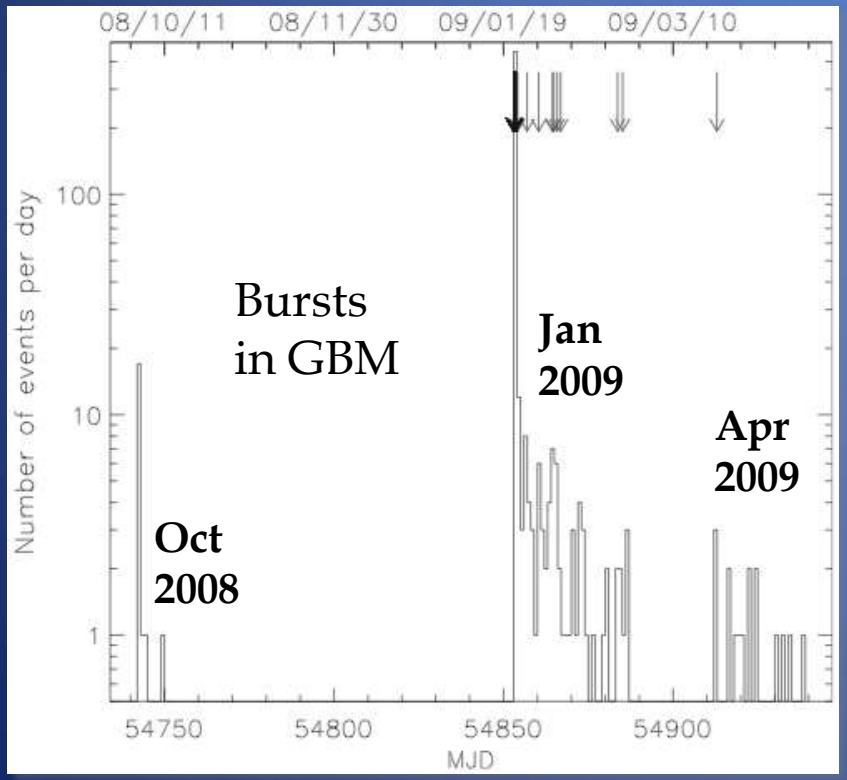
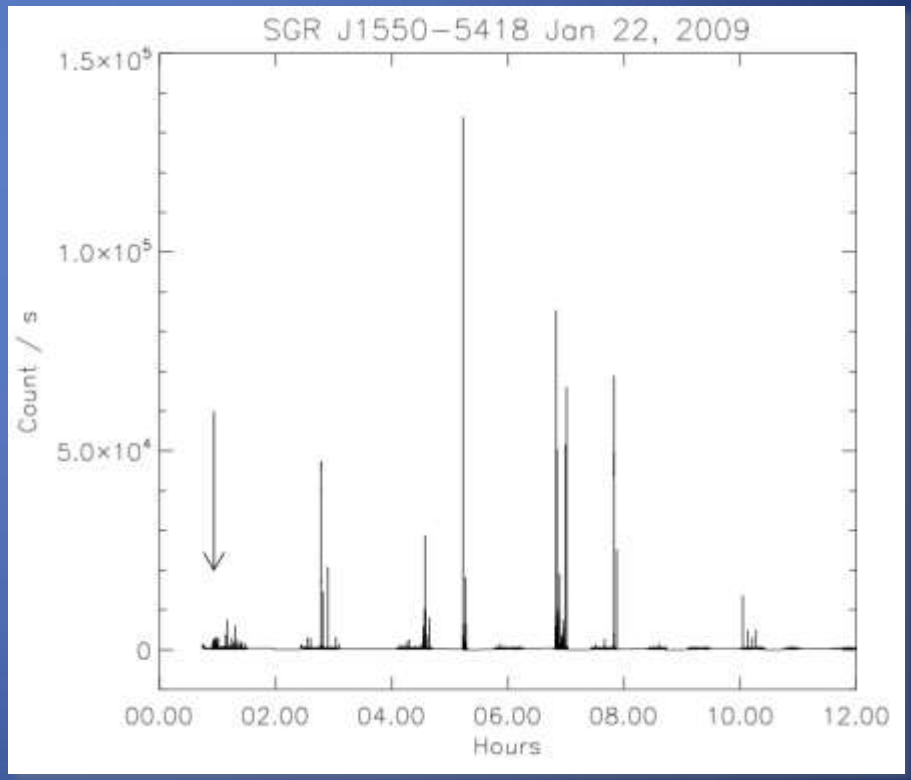
Thanks to the GBM Magnetar Team

SGR J1550-5418

- SGR J1550-5418 = AXP 1E1547.0-5408
- ASCA, XMM-Newton: magnetar candidate
- Radio: P = 2.07 s, $Pdot$ = 2.3×10^{-11} s/s, B = 2.2×10^{14} G
- Fastest rotating magnetar; only 4 radio magnetars



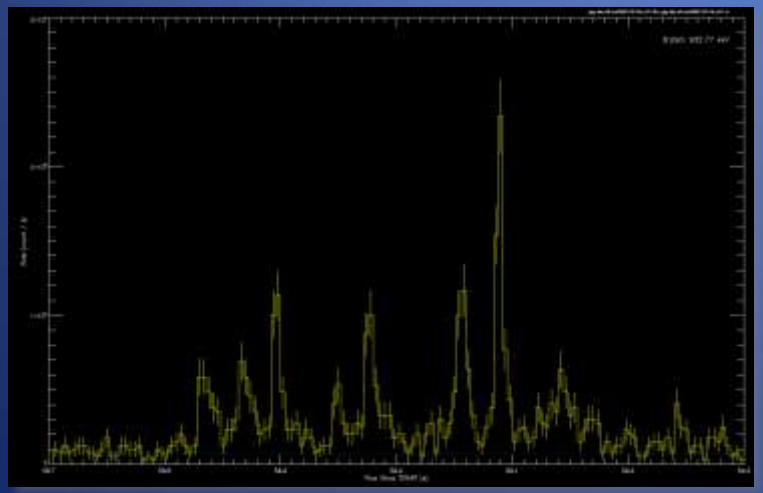
von Kienlin et al. 2012

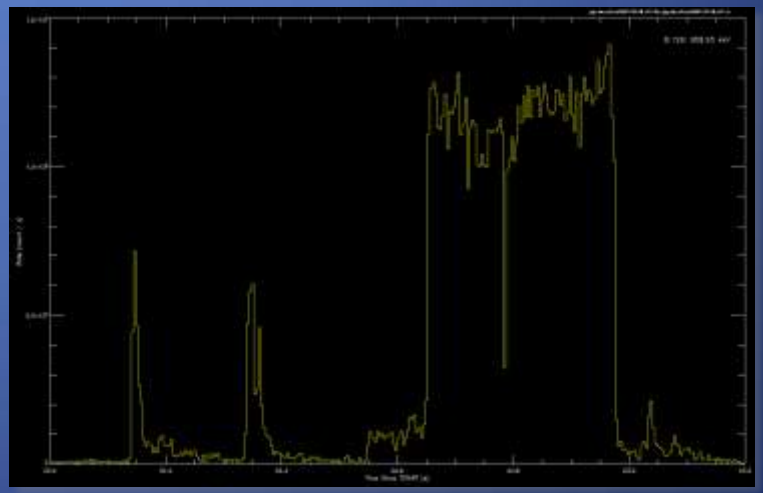


Kaneko et al. 2010

Spectral Analysis of Bursts

- Time-integrated & time-resolved spectroscopy
- Photon models:
  - Power law (PL)
  - Black body (BB)
  - Optically Thin Thermal Bremsstrahlung (OTTB)
  - Comptonized: PL with exponential cut-off
  - Power law + Black body (PL+BB)
  - Black body + Black body (BB+BB)

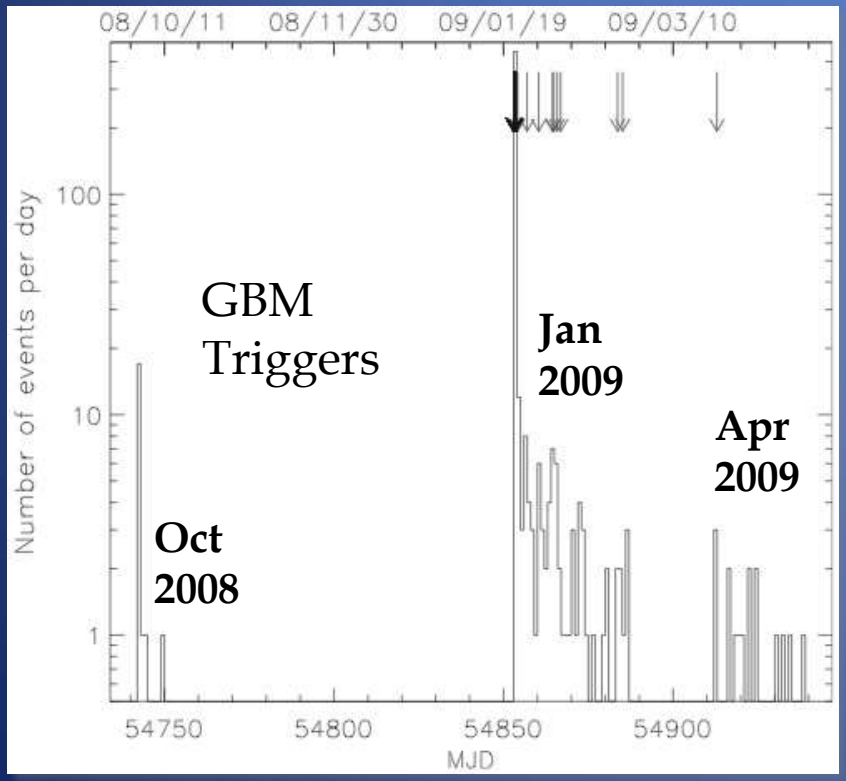


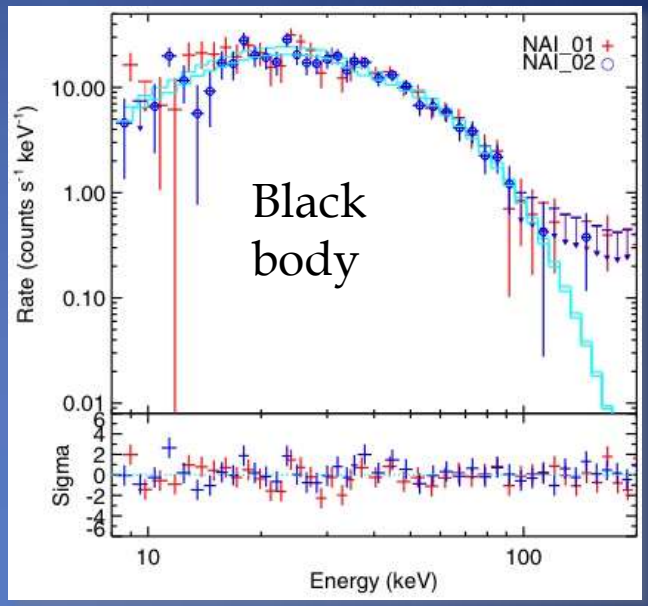


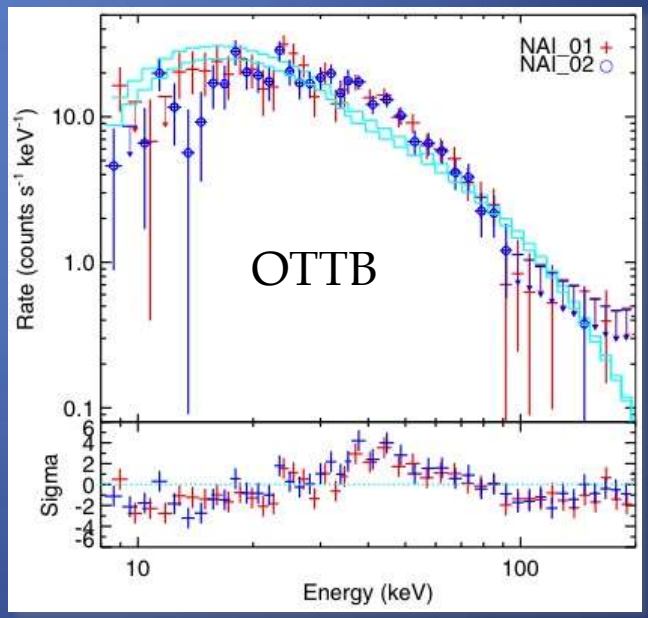
1st Active Episode

Best spectral fits for Oct 2008:

- Black body (~12 keV)
- Comptonized: index ~ 1







von Kienlin et al. 2012

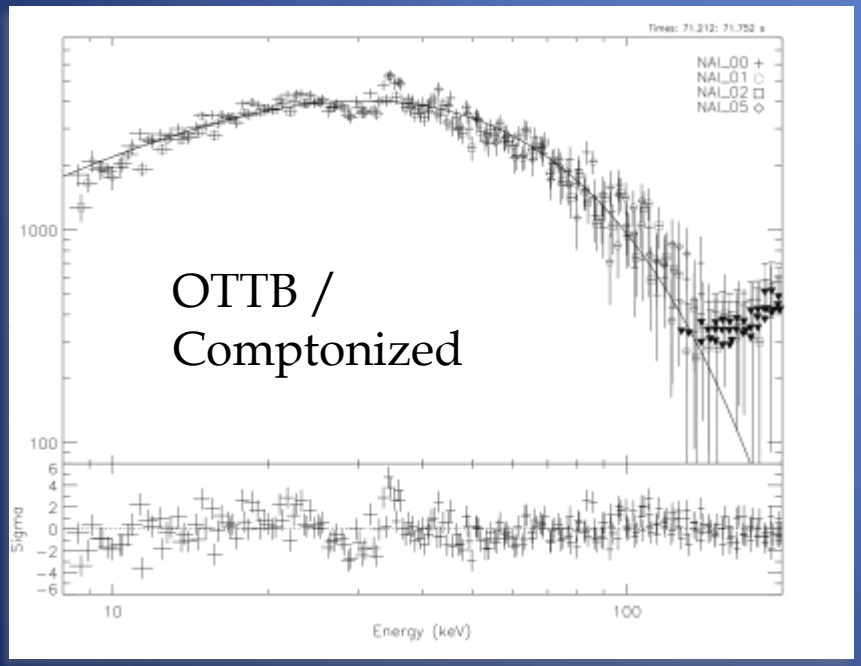
2nd & 3rd Active Episode

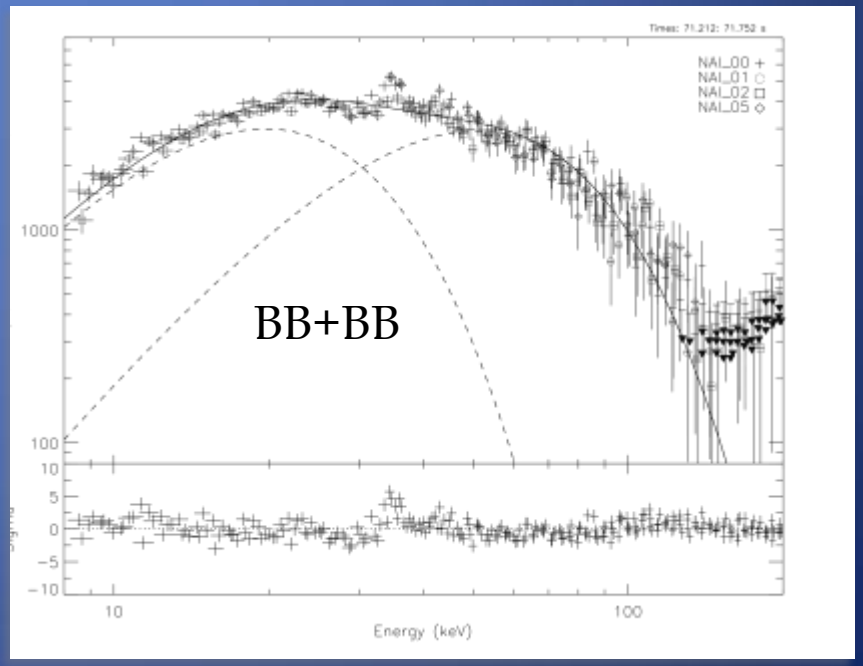
Best spectral fits for Jan-Apr 2009:

- OTTB
- Comptonized: index ~ -1

Brightest bursts:

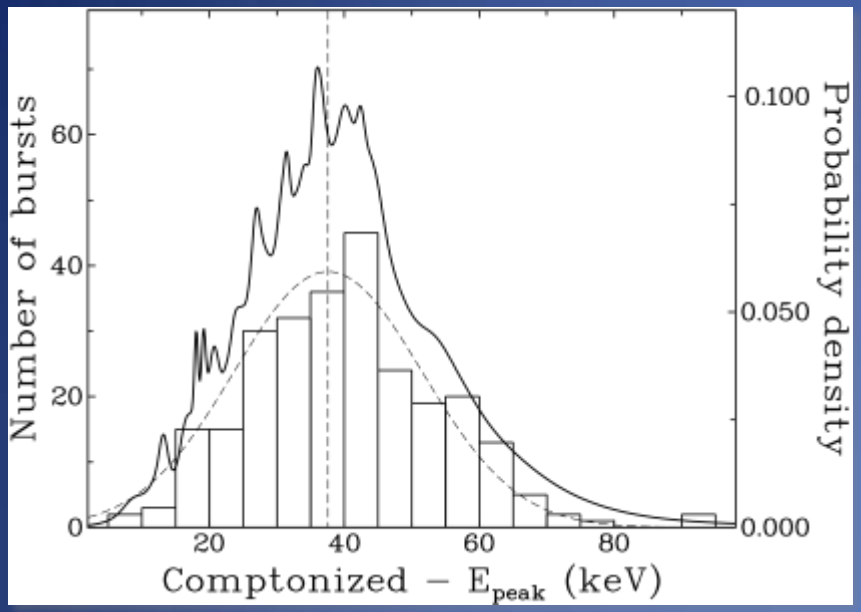
- BB+BB frequently preferred (~5 and ~14 keV)

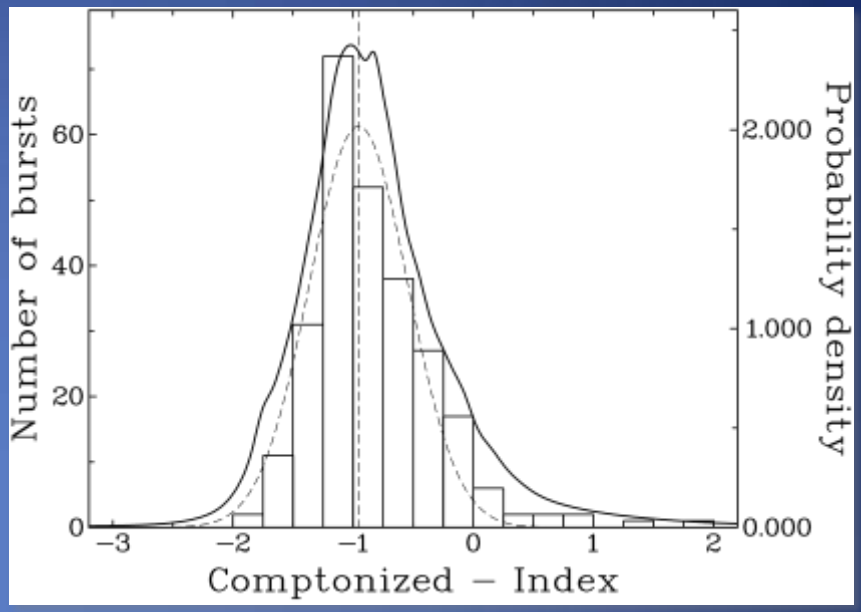




van der Horst et al. 2012

January 2009 Bursts



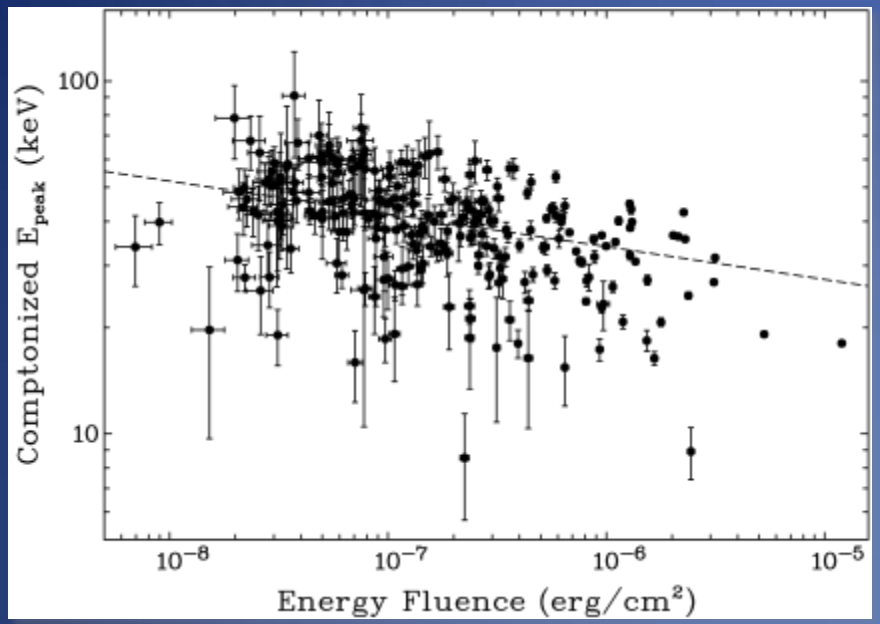


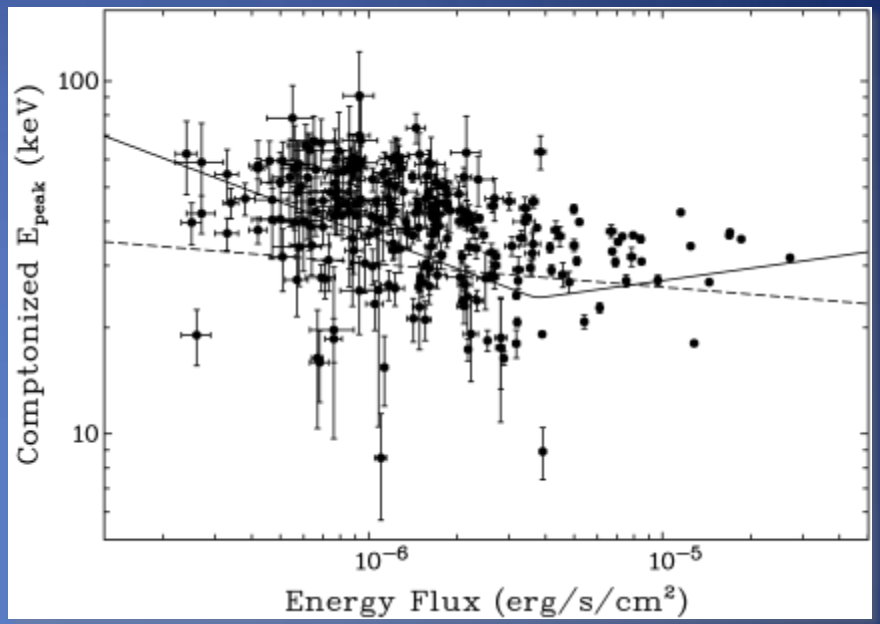
van der Horst et al. 2012

Comptonized index ~ -1 → OTTB recovered

- Clear difference: Oct 2008 vs Jan-Apr 2009
- SGR J0501+4516 with GBM: index ~ -0.3
- Varying indices caused by differences in magnetic field strength, geometry, plasma temperature, opacity

Hardness vs Brightness





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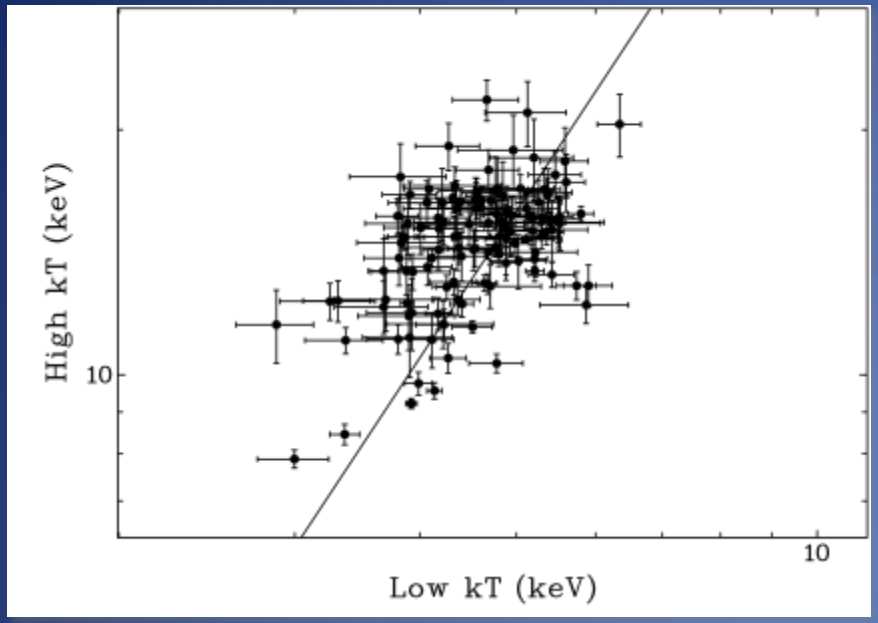
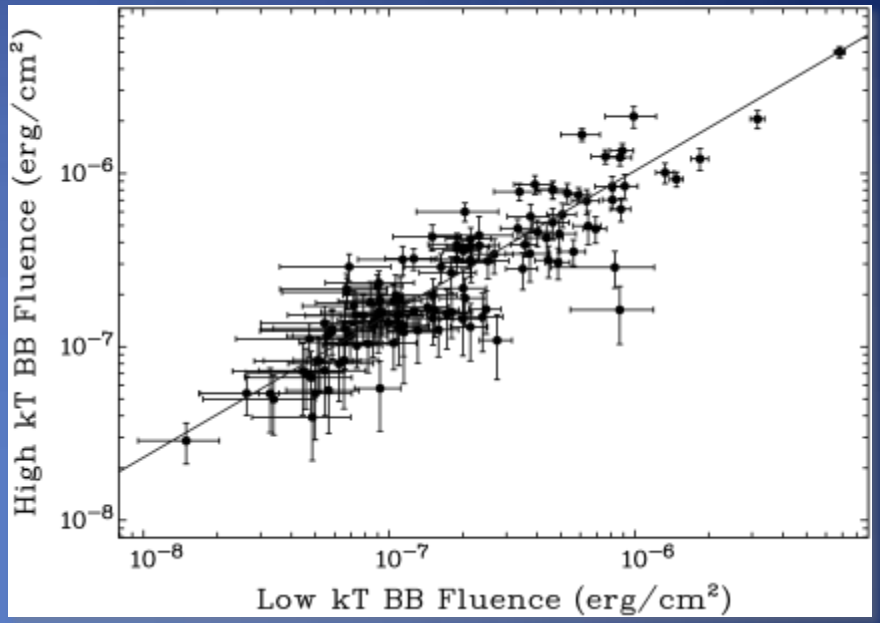
- GBM data → E_{peak} as hardness indicator
  - More accurate than hardness ratios
- Large flux/fluence range: not a simple (anti-)correlation
- Similar to SGRs J0501+4516, 1806-20, 1900+14

BB+BB Correlations





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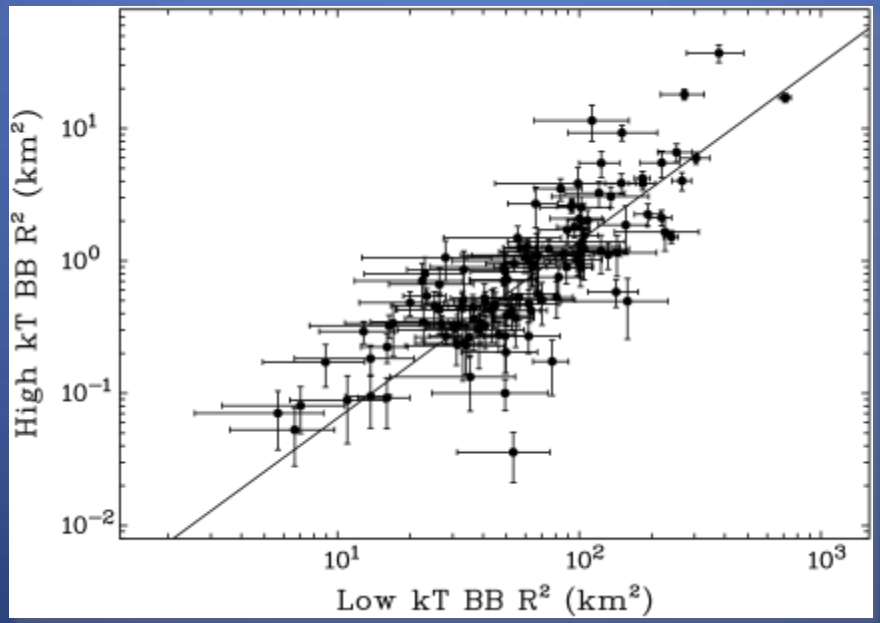
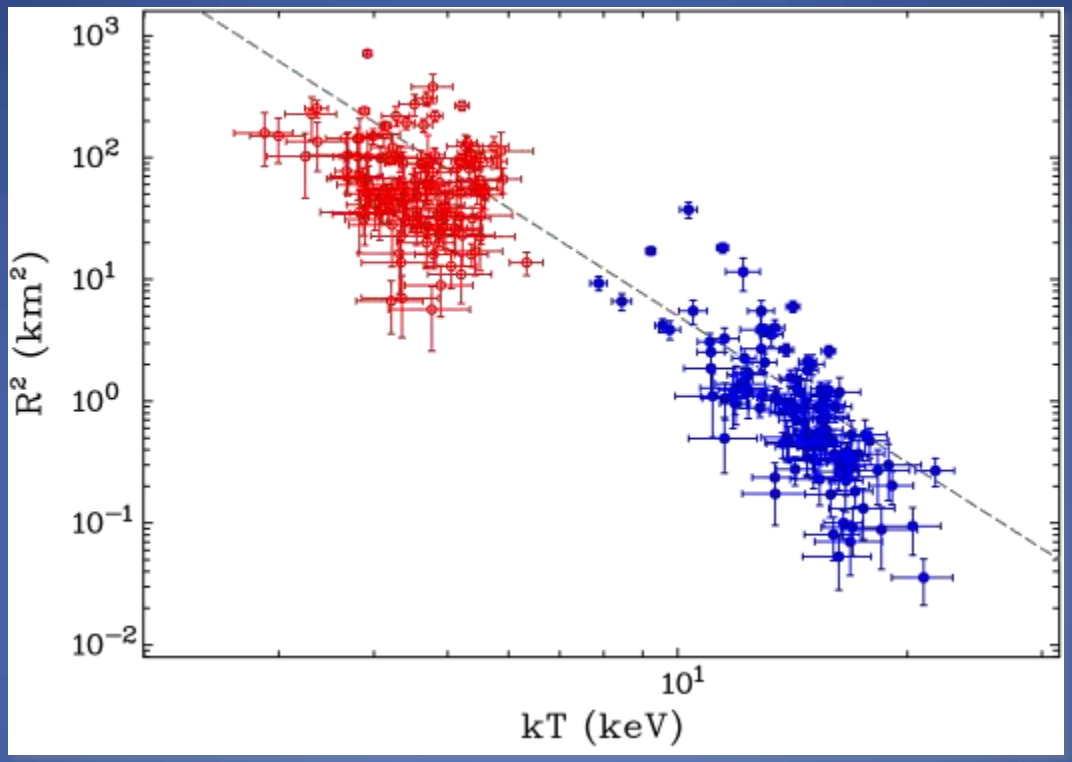


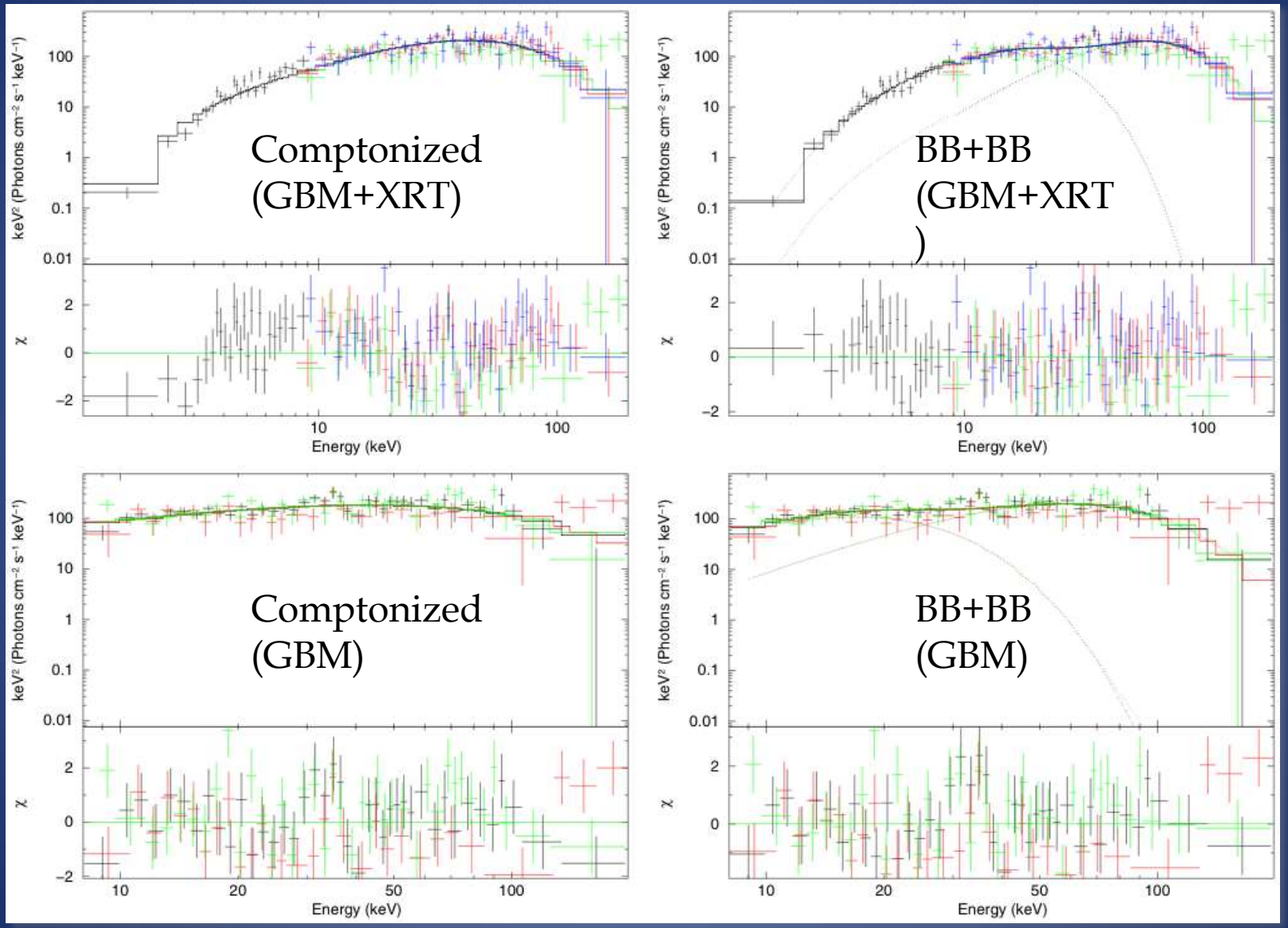
Emission Area vs Temperature



van der Horst et al. 2012

- Low-temperature BB
  - Area comparable to NS area
- High-temperature BB:
  - Area down to few hundredths of km^2
  - Strong area-temperature anti-correlation

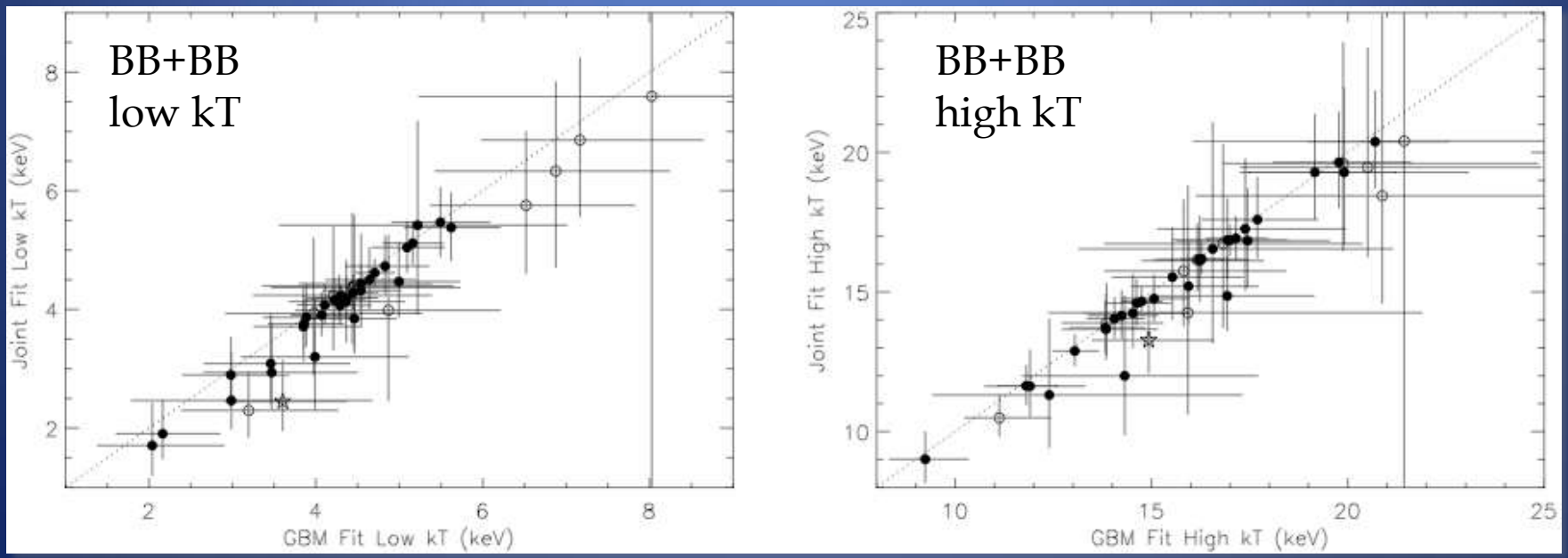
Broadband Spectra



Lin et al. 2012

GBM + XRT

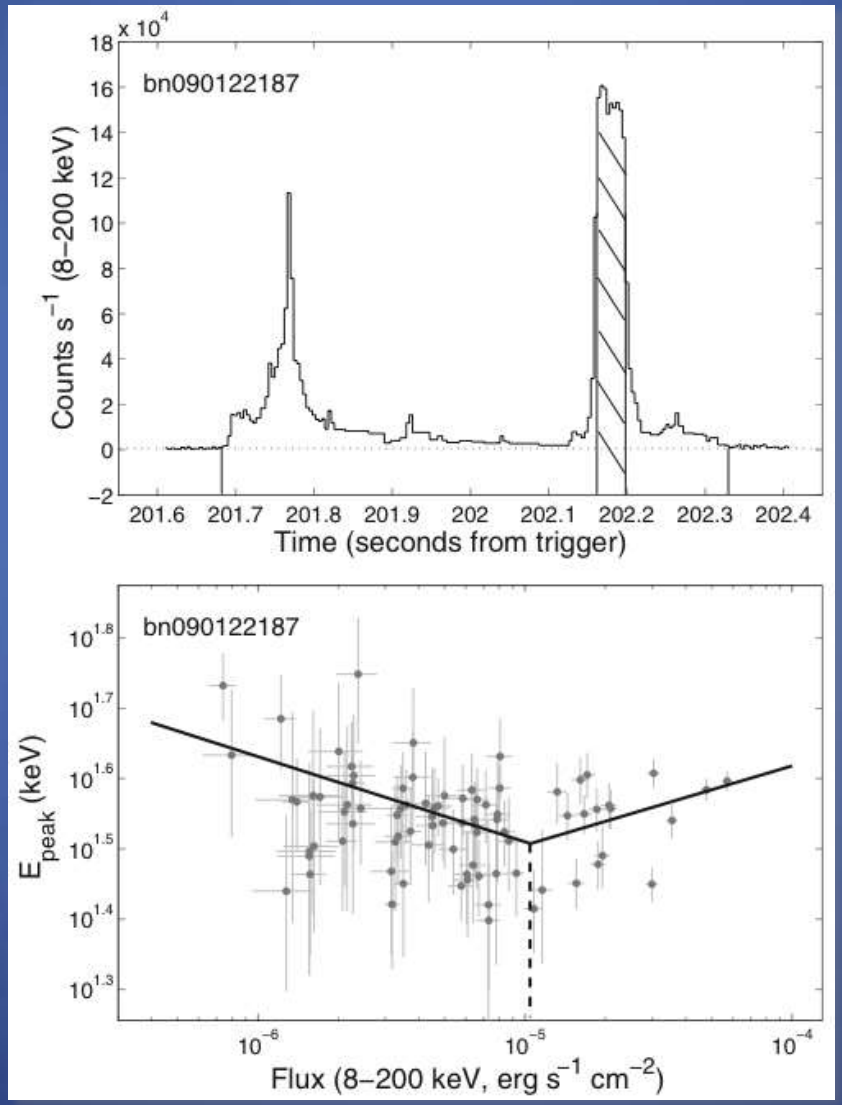
- 42 bursts in Jan 2009
- Best spectral fits:
  - 31 bursts: BB+BB
  - 1 burst: Comptonized
- Comptonized index ~ -0.5 instead of ~ -1
- Multiplicative factor between GBM and XRT: ~ 1



Lin et al. 2012

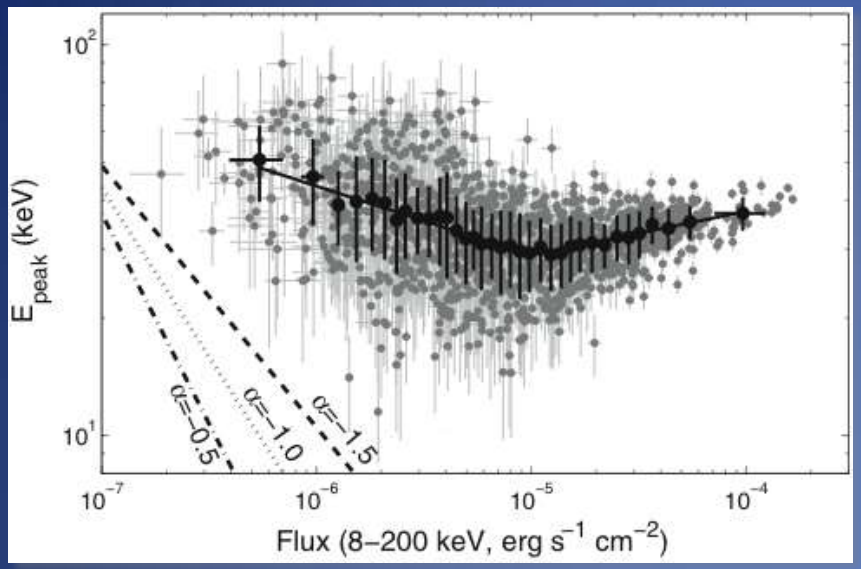
Time-resolved Spectroscopy

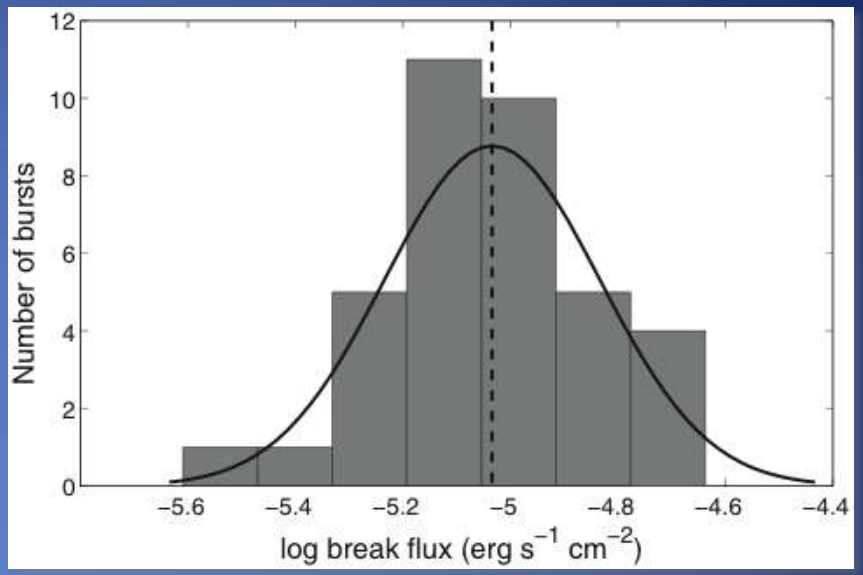
49 brightest bursts: Comptonized & BB+BB

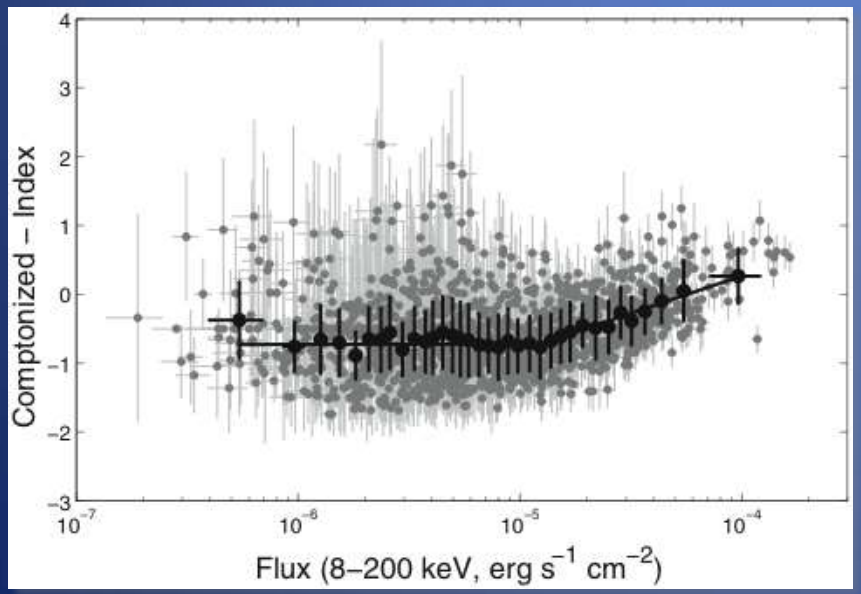


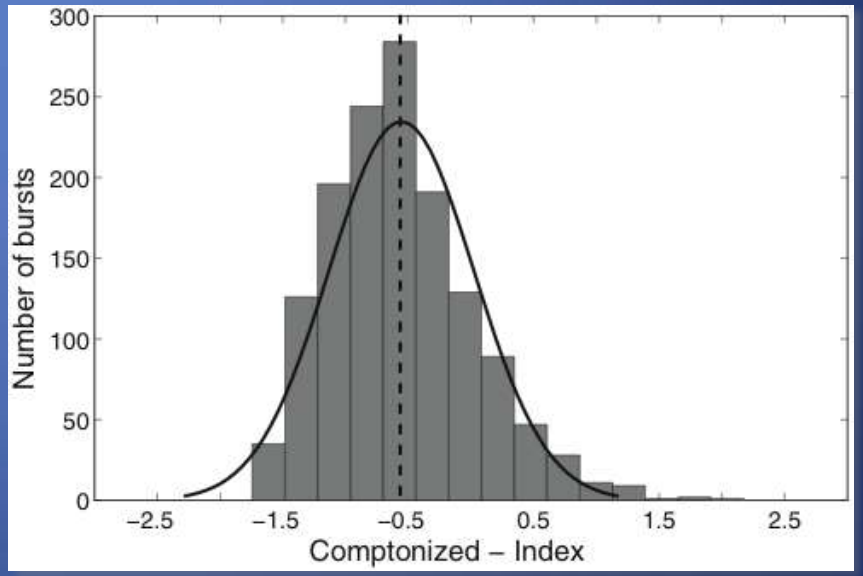
Younes et al. 2014

Comptonized Results









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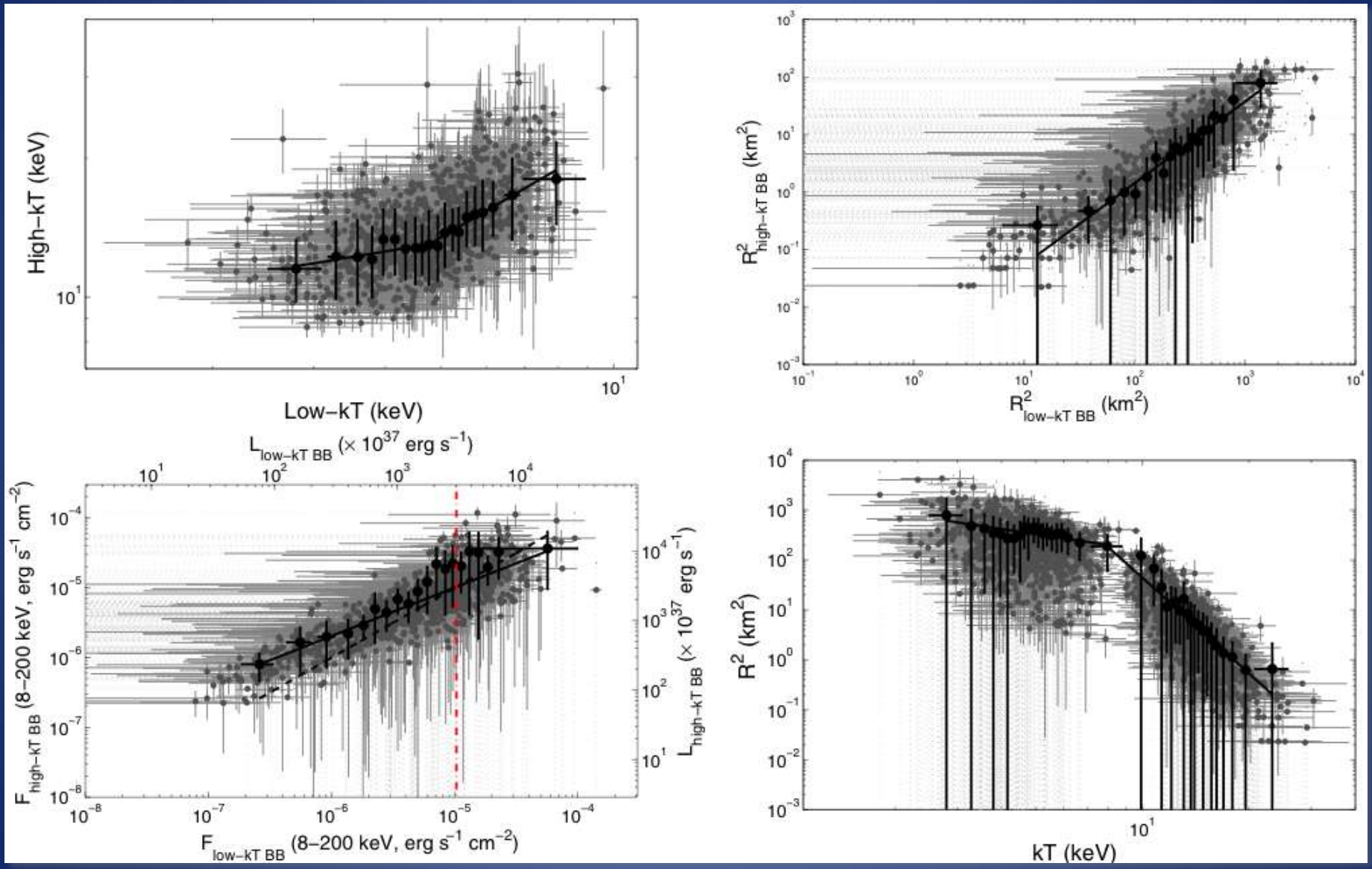
BB+BB: Correlations



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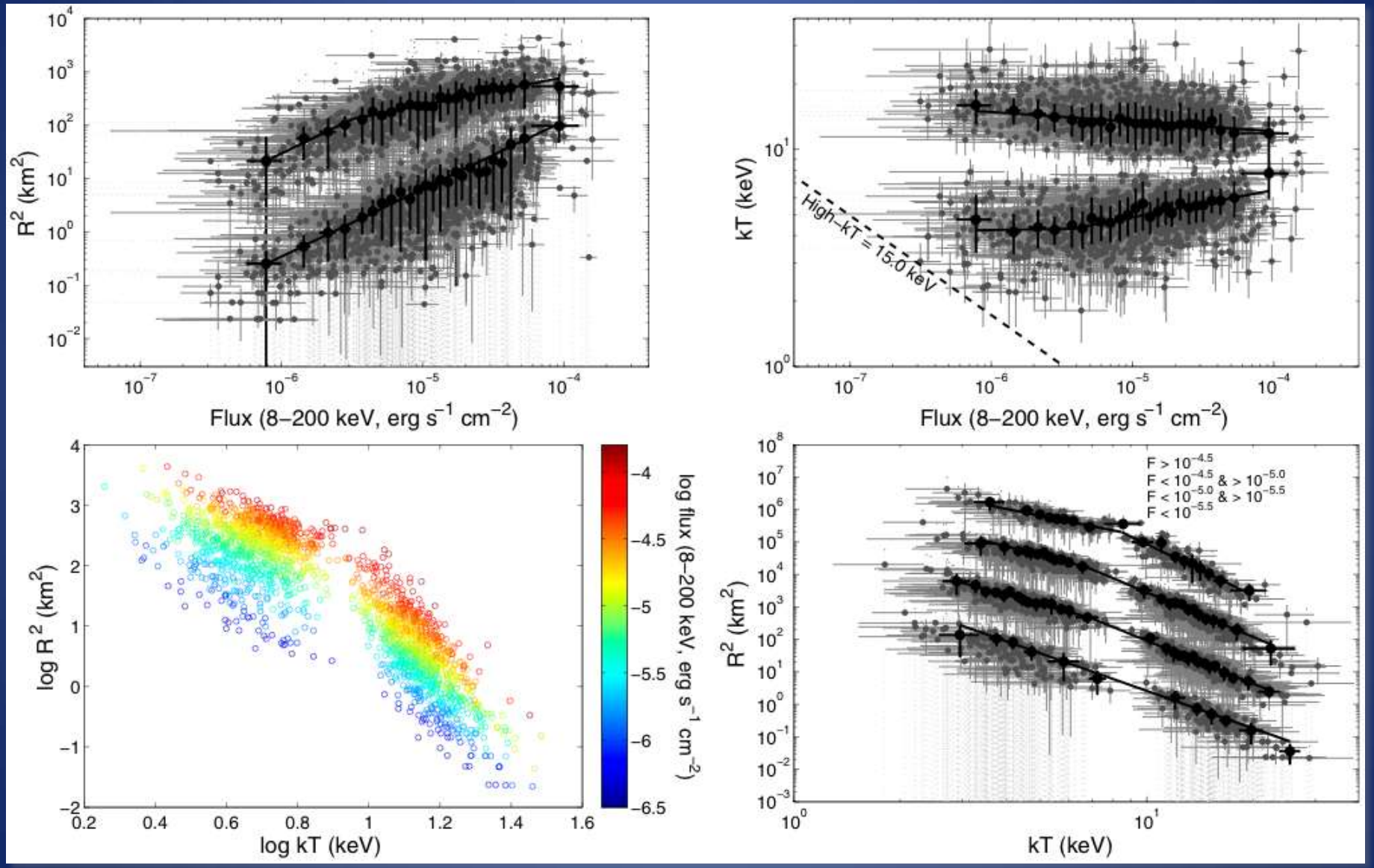
BB+BB: Flux Dependence



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Trends in Time-Resolved Spectra

- Comptonized:
  - E_{peak} – flux correlation: break at 10^{-5} erg cm^{-2} s^{-1}
  - New: index – flux correlation break at same flux
- BB+BB:
  - high-kT: R^2 increases & kT decreases with flux → adiabatic cooling of fireball
  - low-kT:
    - < $10^{-5.5}$ erg cm^{-2} s^{-1}: R^2 increases & kT constant with flux
    - > $10^{-5.5}$ erg cm^{-2} s^{-1}: R^2 saturates & kT increases with flux
    - saturation R = 30 km → maximum fireball R → internal magnetic field > 4.5×10^{15} G
  - flux dependence of R^2 – kT correlation

Conclusions

- Extreme bursting activity of SGR J1550-5418: wealth of data and lots of "food for thought"
- Time-integrated spectral analysis:
  - Spectral evolution over burst activity episodes: BB in Oct 2008 vs OTTB/BB+BB in Jan–Apr 2009
  - Complex E_{peak} – fluence (anti-)correlation
  - BB+BB: ~10 km cool BB and small hot BB
  - GBM+XRT: BB+BB preferred
- Time-resolved spectral analysis:
  - E_{peak} – flux & index – flux correlations with break
  - high-kT BB: adiabatically cooling fireball
  - low-kT BB: coupled with high-kT BB, but nature uncertain