Magnetar Twists: Fermi / GBM Detection of SGR 1550-5418

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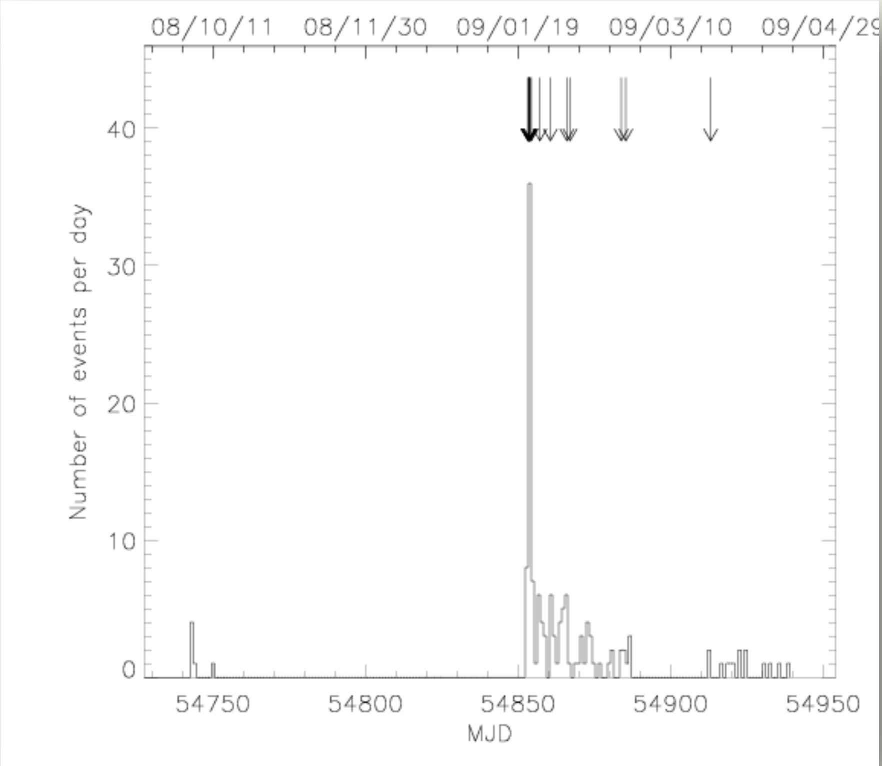
SGR 1550-5418 = 1E 1547.0-5408

- ASCA, XMM: "Magnetar Candidate" *(Gelfand & Gaensler 2007)*
- Radio observation: P = 2.0698 s, $\ddot{P}$ = 2.3 x 10^{-11} s / s

  B = 2.2 x 10^{14} G → Magnetar *(Camilo et al. 2008)*



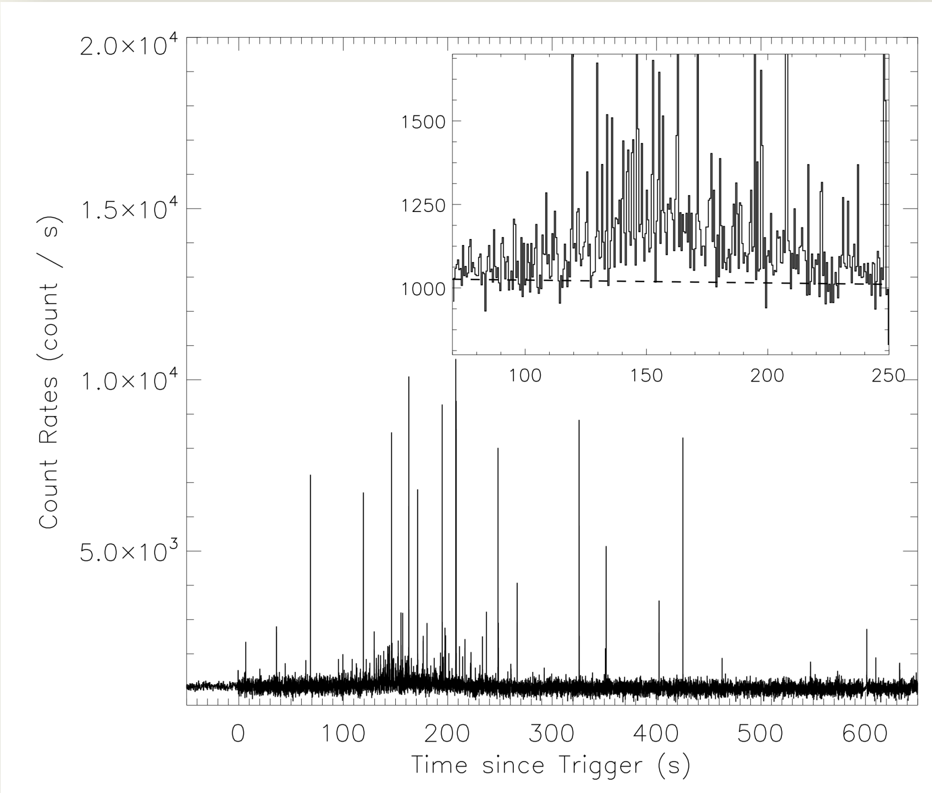
- SGR-like bursts:
  - Oct 2008 (~1 week)
  - Jan-Feb 2009 (~1 month)
  - Mar -Apr 2009 (~1 month)

- Most intense bursting on **January 22, 2009**

  ~450 bursts

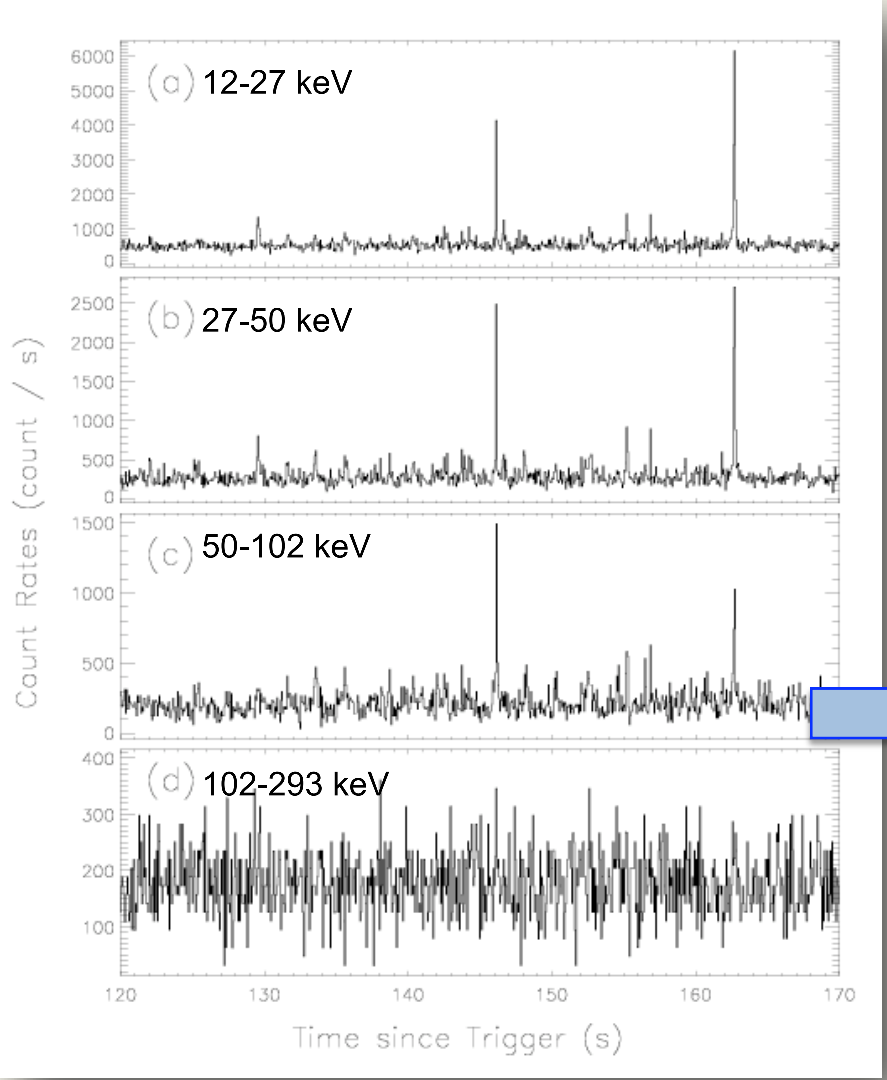
GBM Trigger 090122037

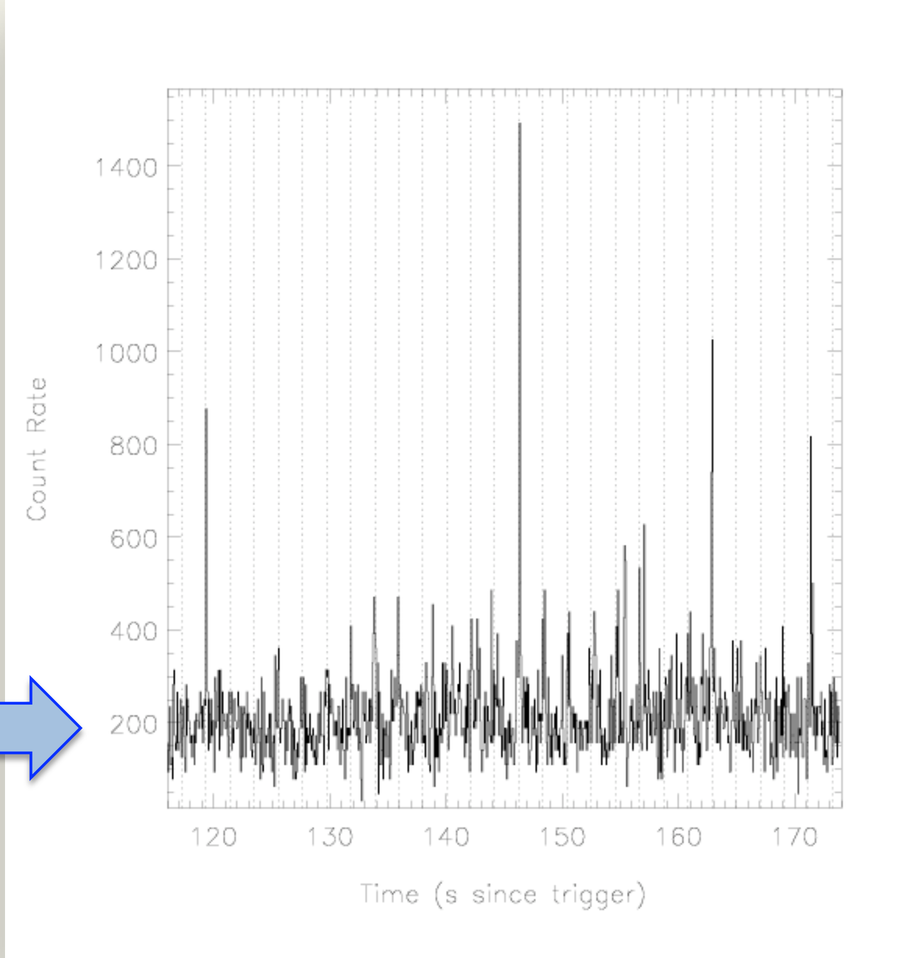
Enhanced Persistent Emission



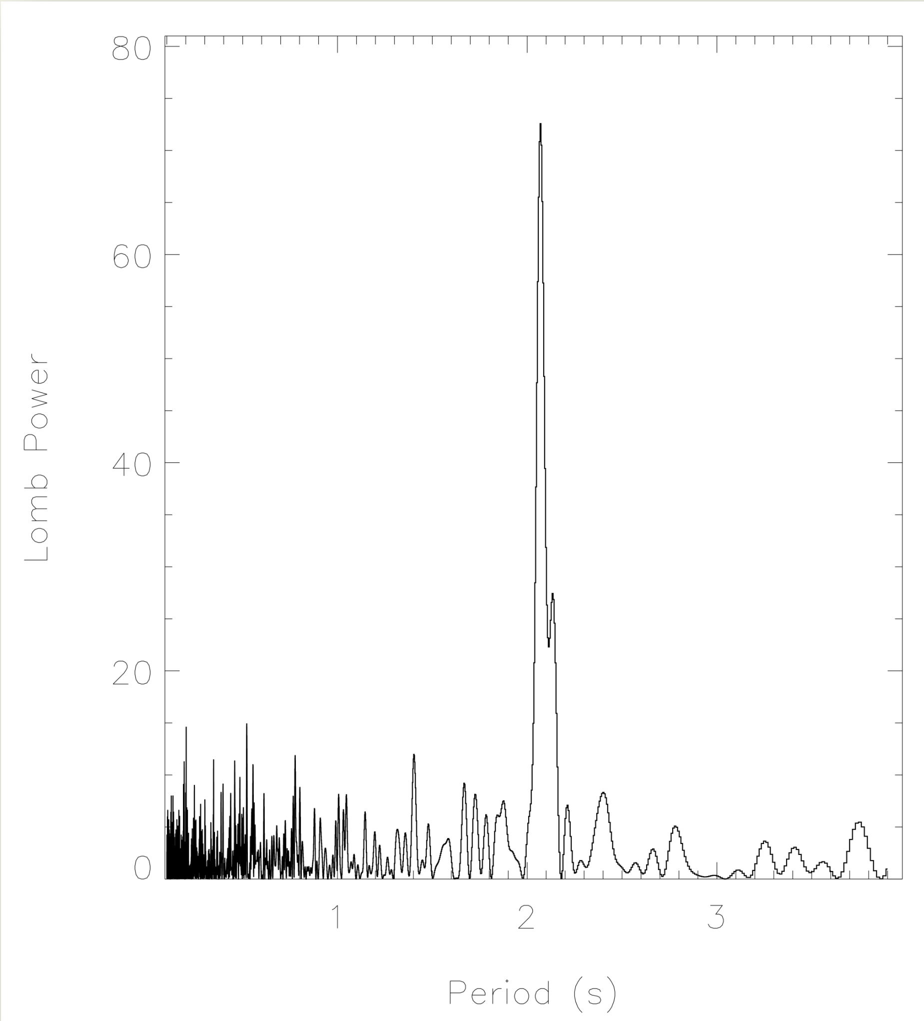
- Trigger at 00:53:52 UT on January 22, 2009
- 1st of 41 GBM Triggers
- Trigger data for 600 s
- 58 untriggered bursts identified within 600 s

Pulsation Detection





Timing Analysis



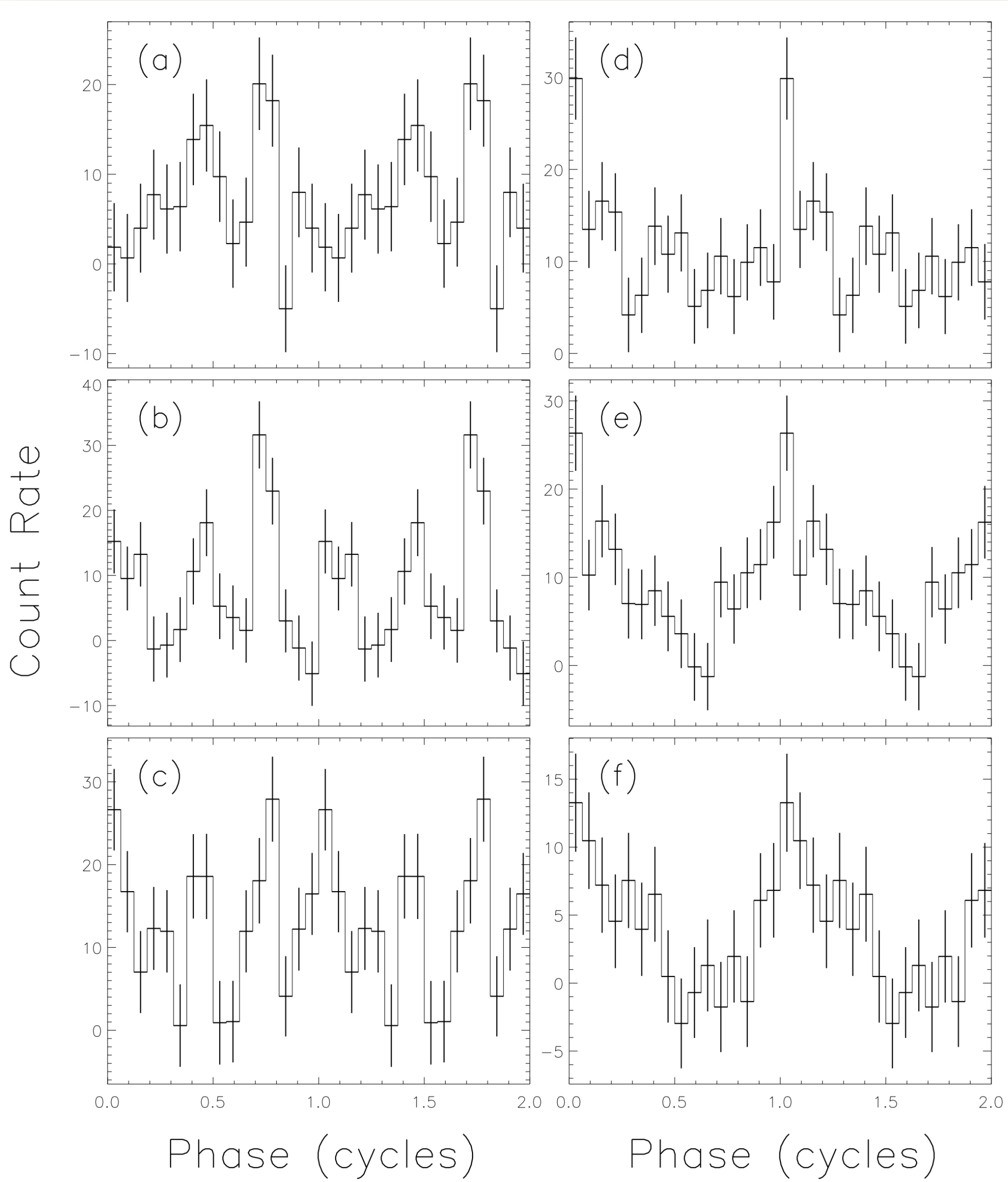
- Lomb – Scargle test:
  P: 0.1 → 10 s in 50 – 100 keV

P = 2.0699 ± 0.0024 s

- Coherent signal: strongest in T_0 **+ 120 – 210 s**

- No other episode of pulsations on this day or the following four days.

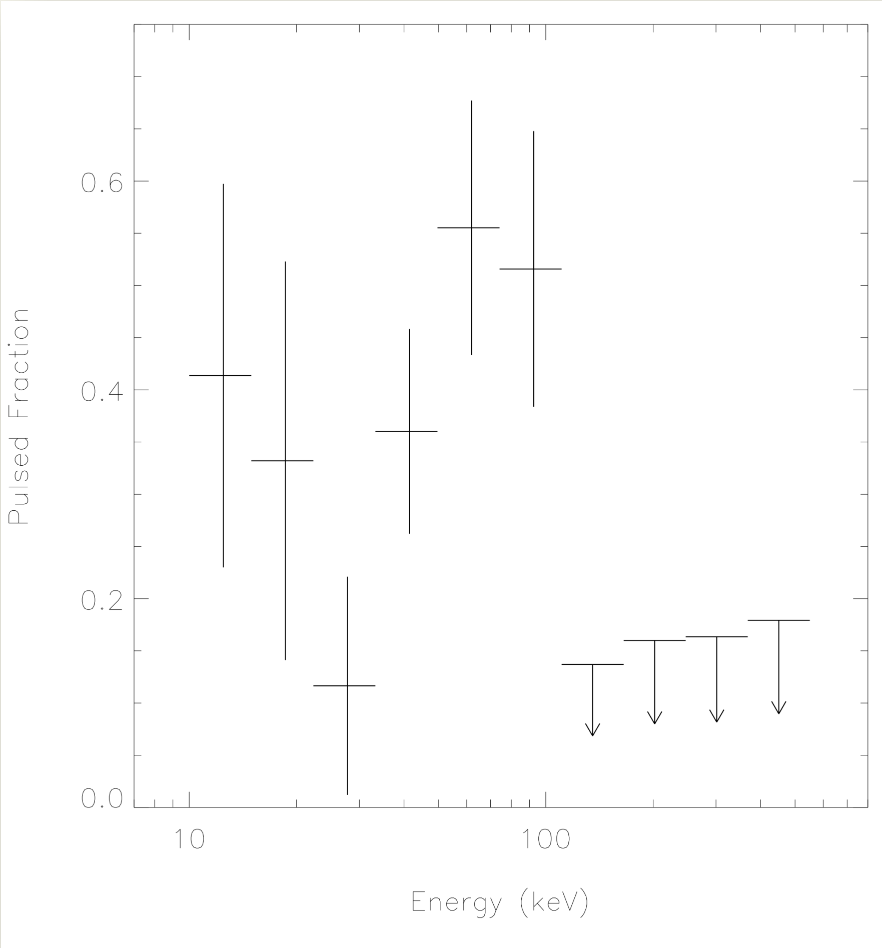
Pulse Profiles



- Double peak at low E
- Single peak at high E
- No pulsation > 110 keV

(a) 10 – 14 keV
(b) 14 – 22 keV
(c) 22 – 33 keV
(d) 33 – 50 keV
(e) 50 – 74 keV
(f) 74 – 110 keV

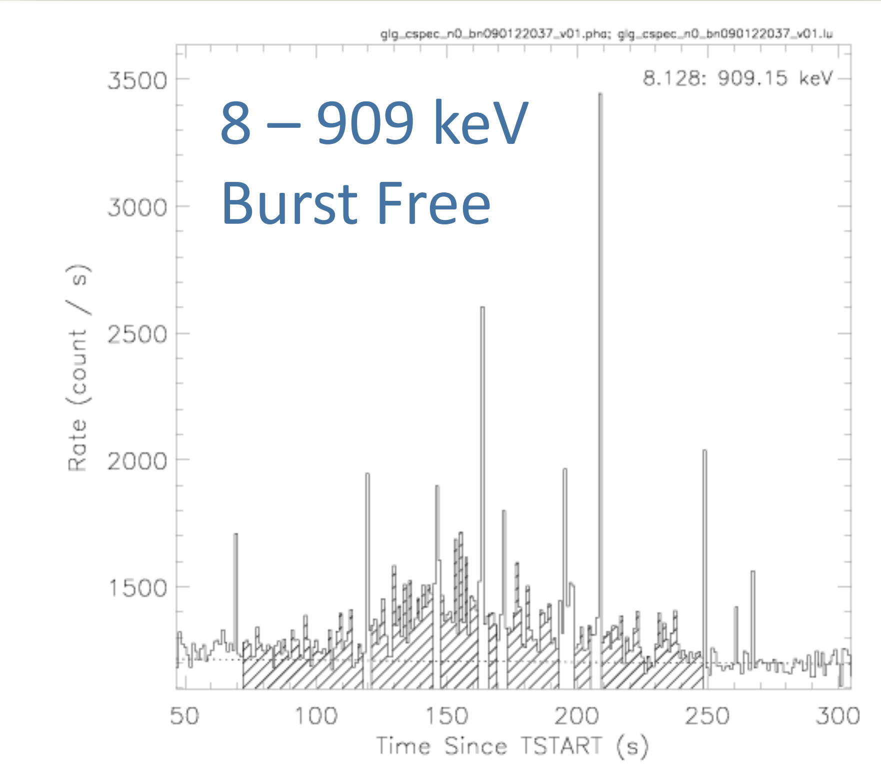
RMS Pulsed Fraction Spectrum

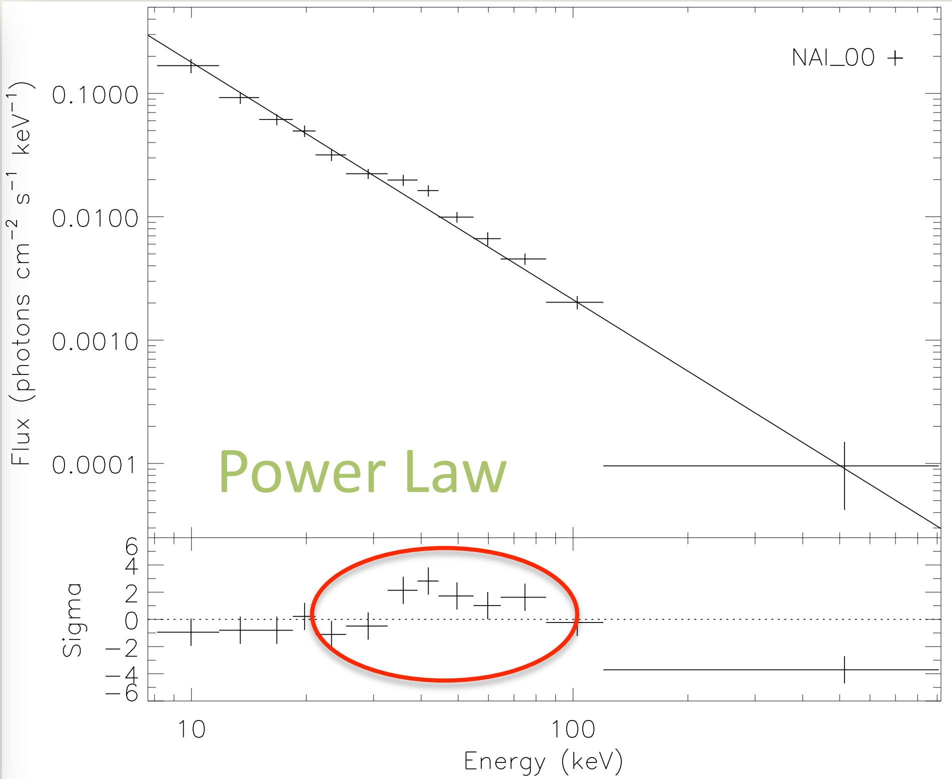


- Correlates with energy
- Peaks in 50 – 74 keV
- Not significant > 110 keV
- Indication of a “dip”

Spectral Analysis

Time Integrated Spectrum [T_0 + 72 – 248 s]





Total Energy

4.3 × 10^{40} ergs

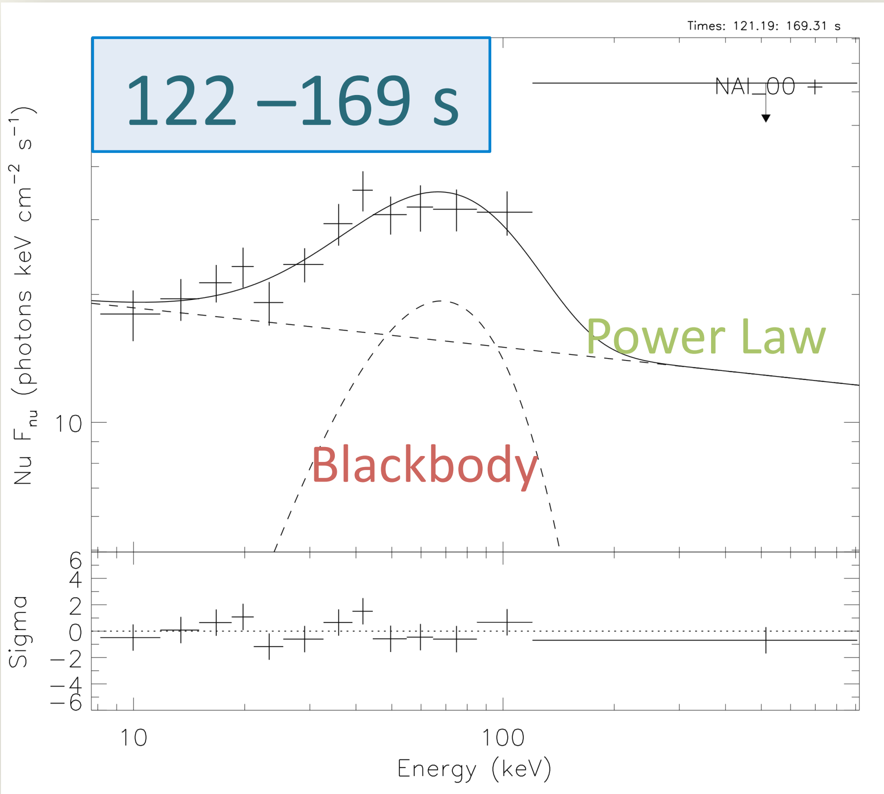
Additional Blackbody (kT = 18 keV) :

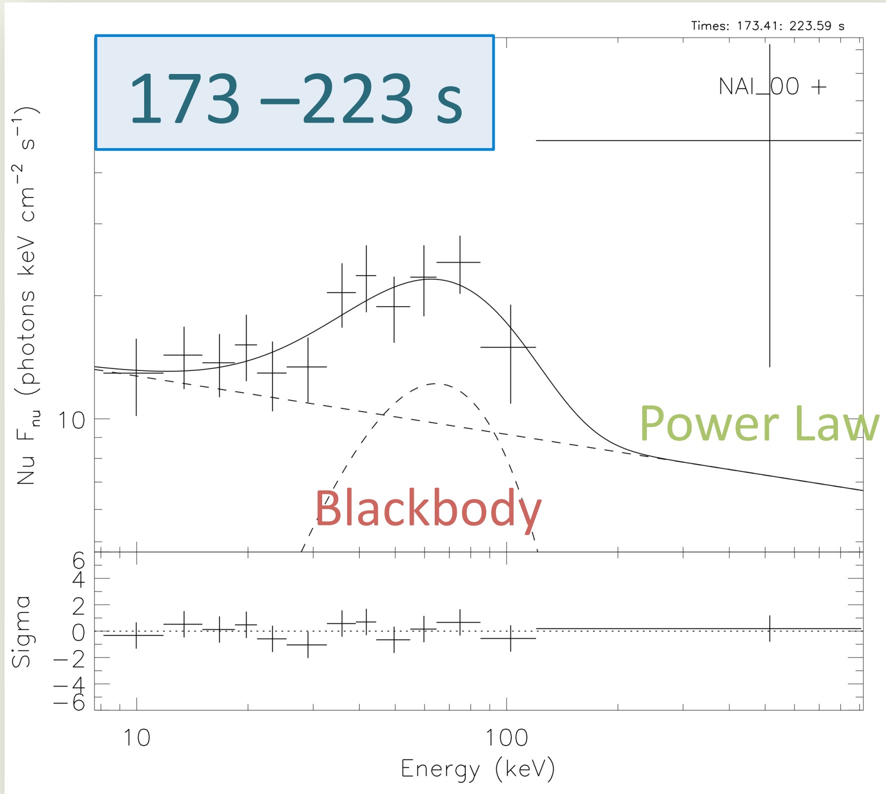
ΔCstat = 13.5 (for 2 DOF)

Time Resolved Spectra (νF_ν)

[T_0 + 72 – 117, 122 – 169, 173 – 223 s]

74 – 117 s   Power Law only (Blackbody is not needed)





F_{BB}/F_{TOTAL} = 26%   25%

Discussion

Evidence of the Blackbody Component

Temporal Properties

- Pulsations most significant in **120 – 210 s**
- Pulse fraction peaks in **50 – 74 keV**
- Pulsations not seen above 110 keV

Spectral Properties

- Blackbody required in **122 – 223 s**
- Blackbody *kT* ~ 17 keV (**Wien peak ~50 keV**)
- F_{BB} → 25%
  F_{PWRL} → 75%

Discussion

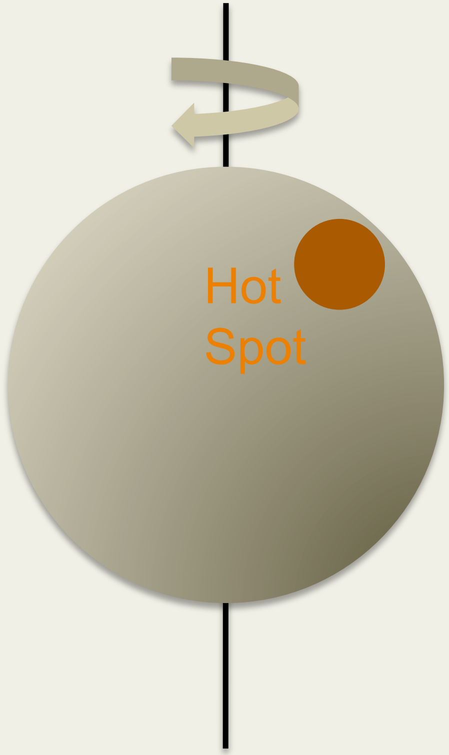
Blackbody: Radius of the Emitting Region

Assuming a hot spot of radius R_{HS} on the neutron star surface

For D = 5 kpc, kT = 17 keV :

$A_{HS} \approx 0.044\ (D/5\ \mathrm{kpc})^2\ \mathrm{km}^2$

→ **$R_{HS} \approx$ 120 m**



Discussion

Twisted B-Field

Corona on Magnetars by Beloborodov & Thompson (2006)

Dissipation rate: $L_d \sim I\ \Phi_E$ Net current: $I \propto B, \Delta\psi, a^2$

$L_{obs} = 2.8 \times 10^{38}$ erg $s^{-1} >> L_d$

→ inconsistent with observation

Trapped Fireball

$e^{\pm}$ plasmas & photons confined by closed B field region

Trapped energy: $E_B(a) = 1/6\ a^3 B^2 > E_{iso,BB}$

For a = 120 m & $E_{iso,BB} = 5.6 \times 10^{40}$ erg: **$B > 1.4 \times 10^{14}$ G**

→ consistent with $B = 2.2 \times 10^{14}$ G from $P\dot{P}$

Discussion

Blackbody from Twisted B-Field

Energy dissipated in the corona is radiated in two forms:

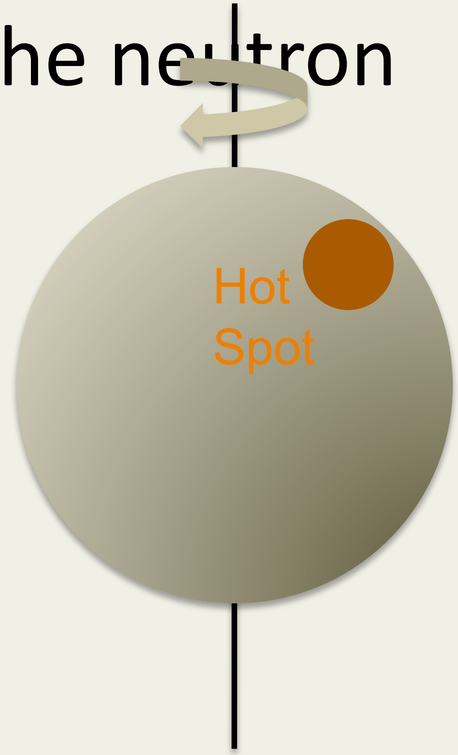
- non-thermal, high energy radiation produced by collisionless dissipation of the coronal beam

- blackbody radiation by thermalization: as the remaining energy dissipated in the corona enters the dense atmosphere, the crust is thermalized by two-body collisions and e^-/e^+ pair formation

Both components are expected to have comparable luminosities.

Conclusion

Assuming a hot spot of radius R_{HS} on the neutron star surface



For D = 5 kpc, kT = 17 keV :

$A_{HS} \approx 0.044(D/5\ \mathrm{kpc})^2\ \mathrm{km}^2$

→ $\boldsymbol{R_{HS} \approx 120\ \mathrm{m}}$

which is the size of the <u>magnetically-confined hot plasma</u> and is << 1% of the NS surface area