

# ***Suzaku* Observations of Hard X-rays of SGRs and AXPs**

T.Enoto (University of Tokyo)

Y.E. Nakagawa, N. Rea, K. Makishima, P. Esposito, K. Hurley,  
S. Yamada, K. Nakazawa, K. Yamaoka, T. Sakamoto, A. Yoshida,  
and Suzaku team

Nakagawa+08 PASJ, 59, 653 (SGR 1806-20, SGR1900+14)  
Esposito+07 A&A, 476, 321 (SGR 1806-20, SGR1900+14)  
Enoto, Nakagawa, Rea+08 ApJL, accepted (SGR 0501+4516)  
Enoto+09 ApJL, submitted (4U 0142+61)  
Morii+09 PASJ, submitted (1E 1841-045)

# Hard X-rays of Magnetars

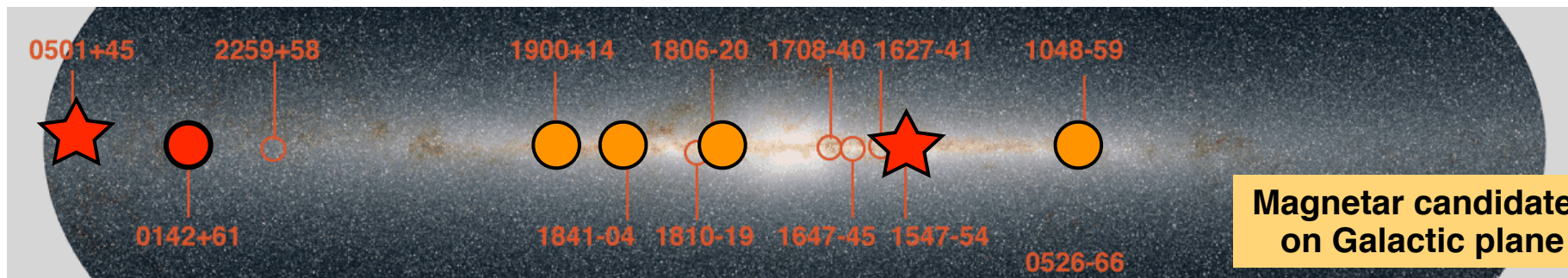
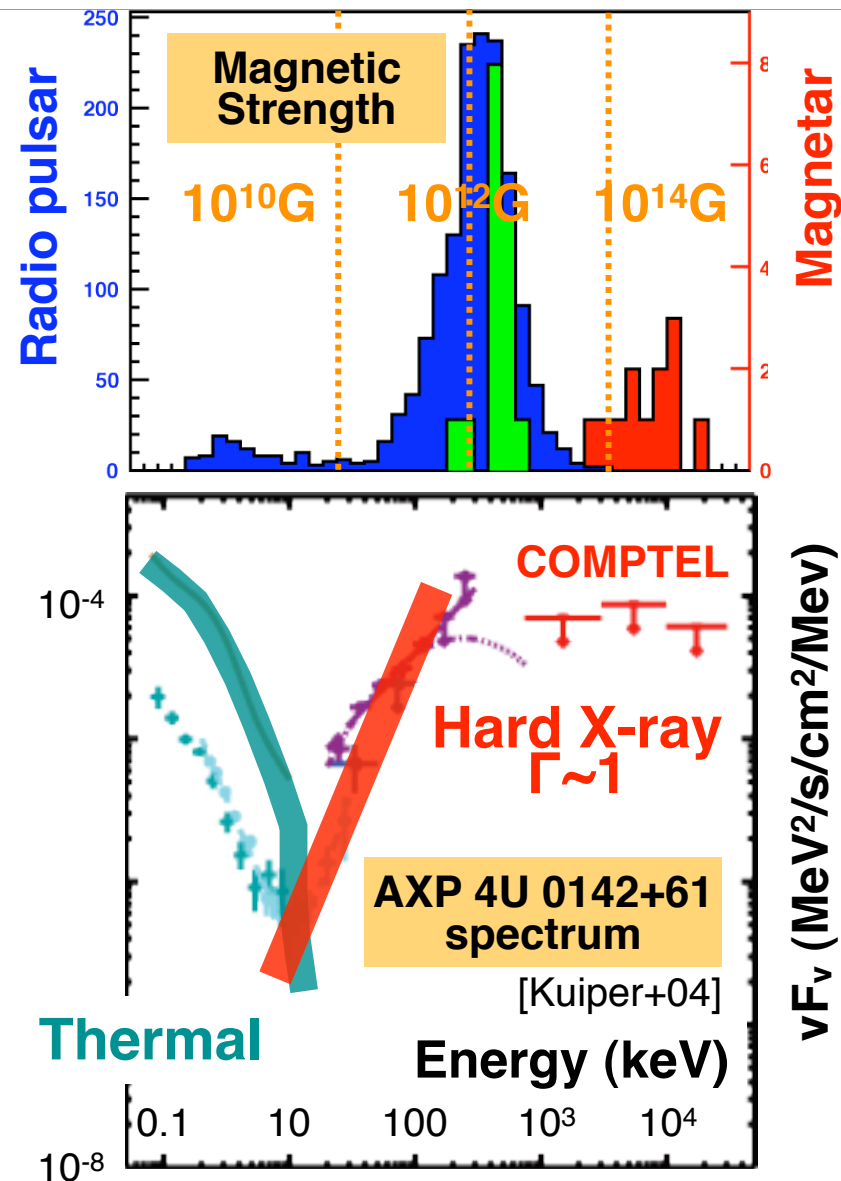
## - Magnetar candidates

- Soft Gamma Repeater (~5 #)
- Anomalous X-ray Pulsar (~10 #)
- $P \sim 5-12$  s,  $\dot{P} \sim (1-100)E-12$  s/s
- $B > 1E+14$  Gauss
- $L_{X\text{-ray}} \gg L_{\text{SpinDown}}$  ( $<10$  keV)
- X-ray Emission using magnetic energy

## - X-ray emission states

- Quiescent (persistent emission)
- Outburst (persistent + burst activity)

**Suzaku observations of Hard X-rays from Magnetars.**

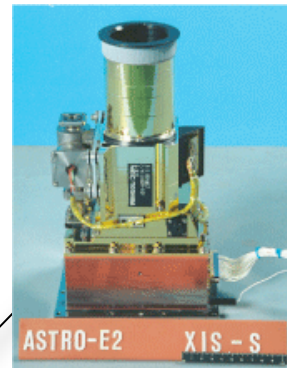


# Japanese X-ray Satellite Suzaku

- Launched on 2005 July 10 from Japan [Mitsuda+07]
- **Low background & Wide energy band (0.2-600 keV)**
- Suitable for low flux objects in the hard X-rays
- observed ~1000 objects **including 3 SGRs & 5 AXPs**



X-ray Telescope (XRT) [Serlemitsos+07]

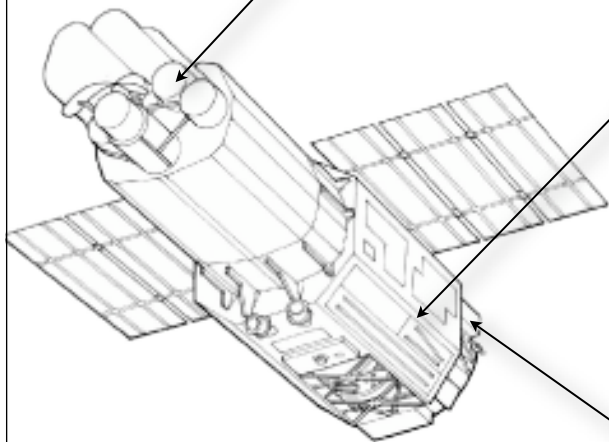


X-ray Imaging Spectrometer (XIS) [Koyama+07]

- Three X-ray imaging CCD cameras
- 0.2-12 keV
- FOV : 17'.8 x 17'.8

Hard X-ray Detector (HXD) [Takahashi+07]

- Non-imaging spectrometer
- 10-600 keV
- 34' x 34' (<100 keV)
- **Extremely low background**



# Newly Discovered SGR 0501+4516

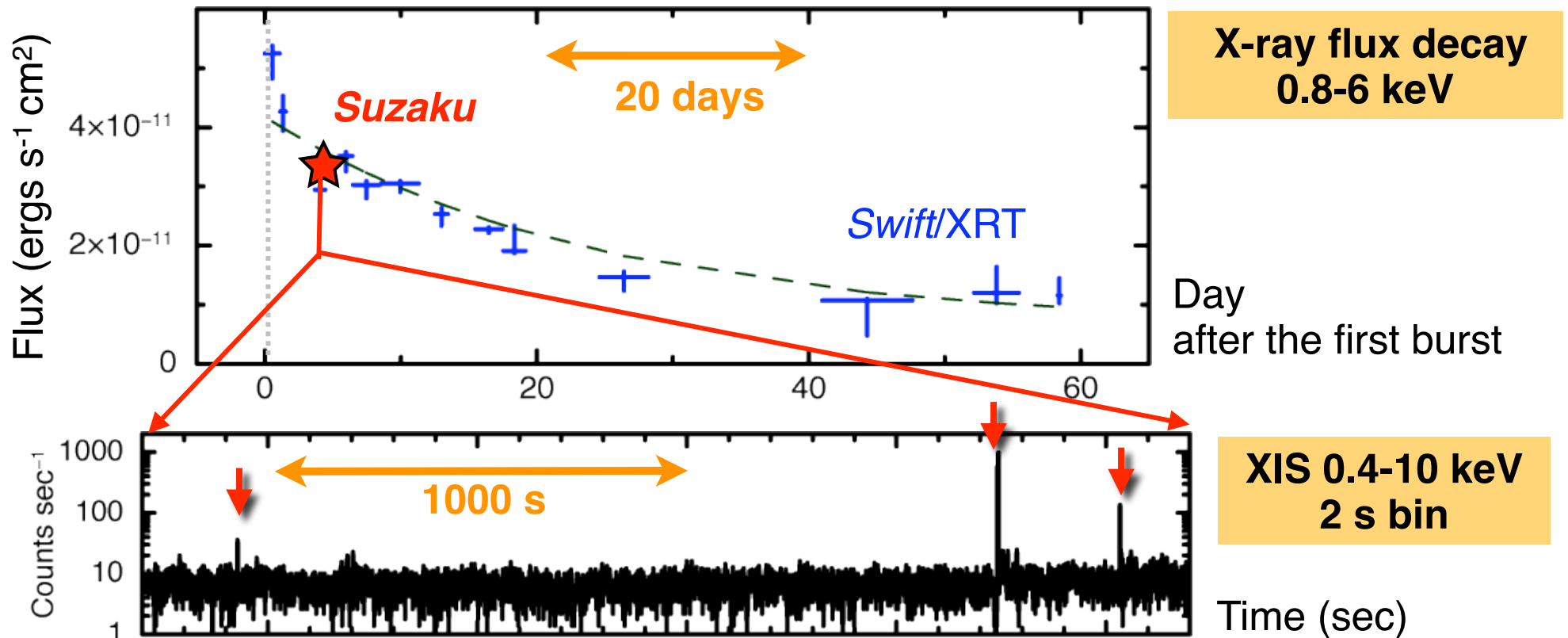
- Discovered on 2008 August 22 (UT) by *Swift* [Holland & Sato, 08][Barthelmy+08]

**Newly Discovered SGR for the first time in a decade!**

- $P \sim 5.7$  s [GCN 8118],  $\dot{P} \sim 5E-12$  s/s [GCN 8118]

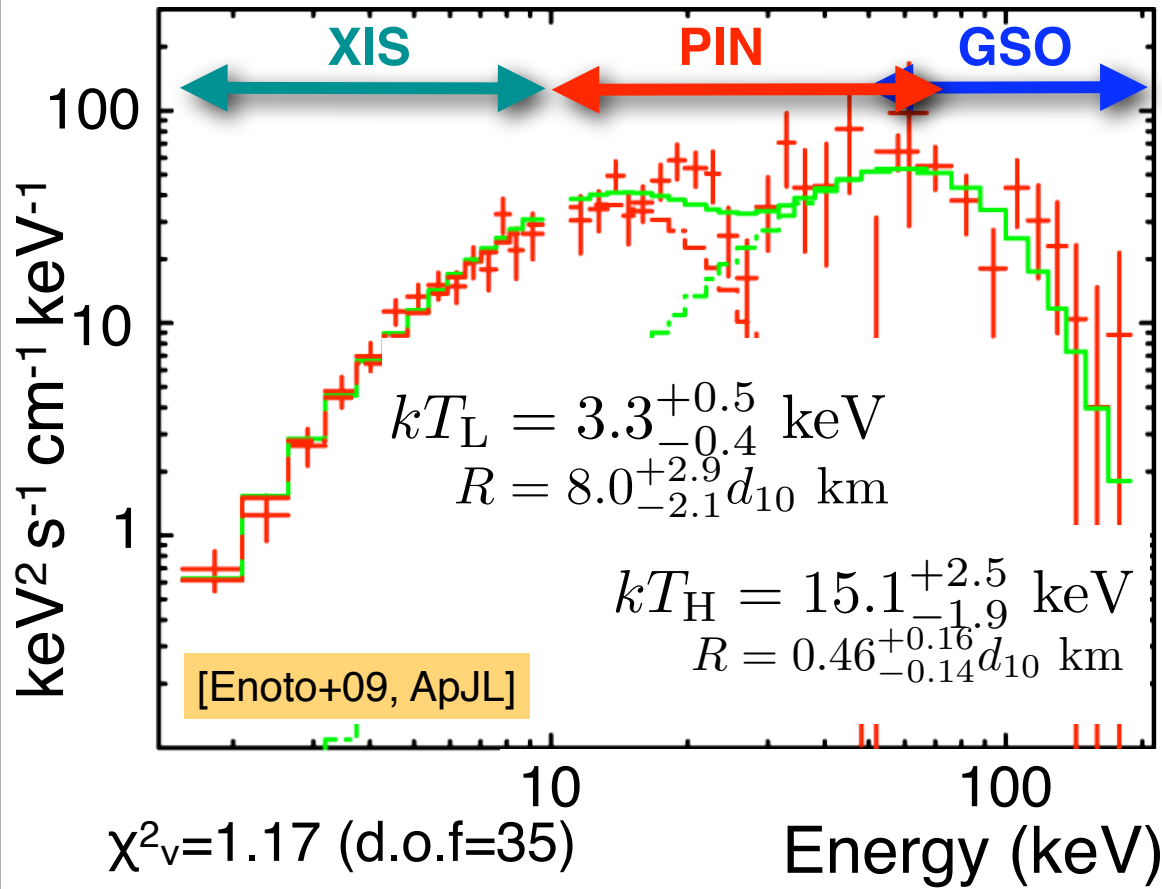
$\Rightarrow B \sim 1.7E+14$  G, age  $\sim 18$  kyr

- *Suzaku* Observation on August 26 for  $\sim 40$  ks [Enoto, Nakagawa, Rea+08]

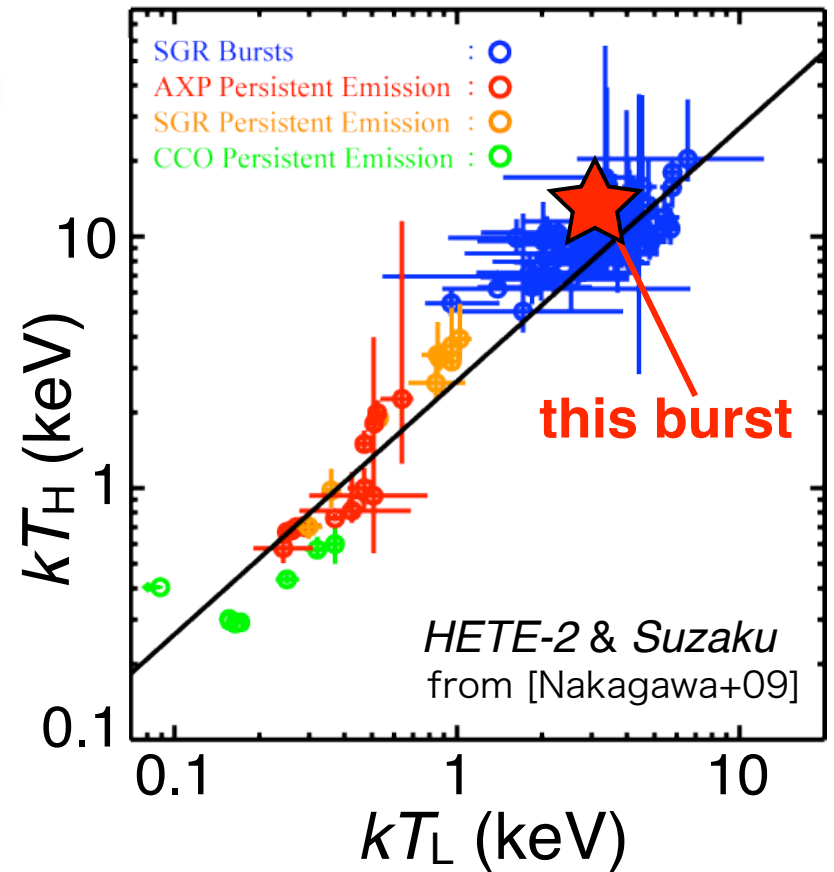


# Short burst spectrum

An absorbed 2BB model



Scaling between two 2BB Temp.



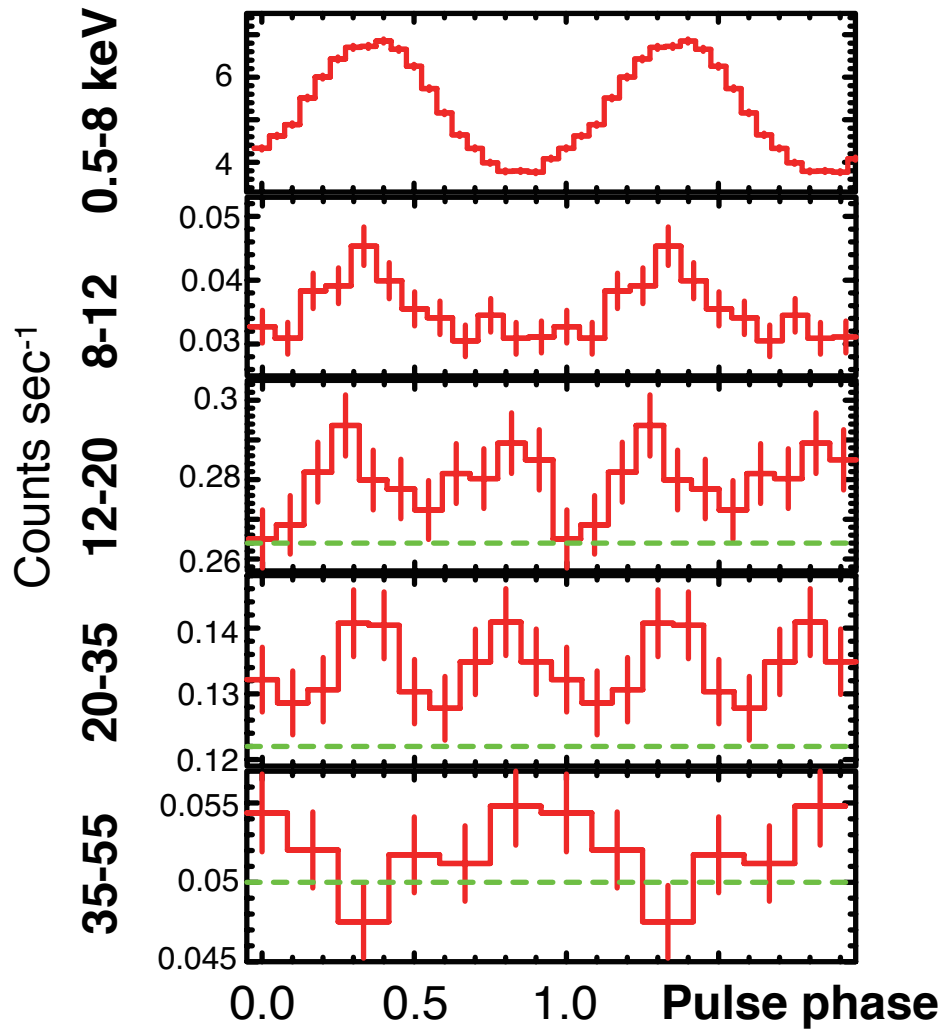
- XIS detected 32 bursts. Biggest one was  $\sim 23$  Crab (Ave.) @ 40 keV.
- Short burst ( $\sim 200$  ms) spectrum was detected up to **200 keV**.
- Two blackbody spectrum with  $kT \sim 3$  keV, 15 keV.

# Persistent emission

40 ks exposure  
up to 70 keV!

## Pulse Profile

[Enoto, in prep]

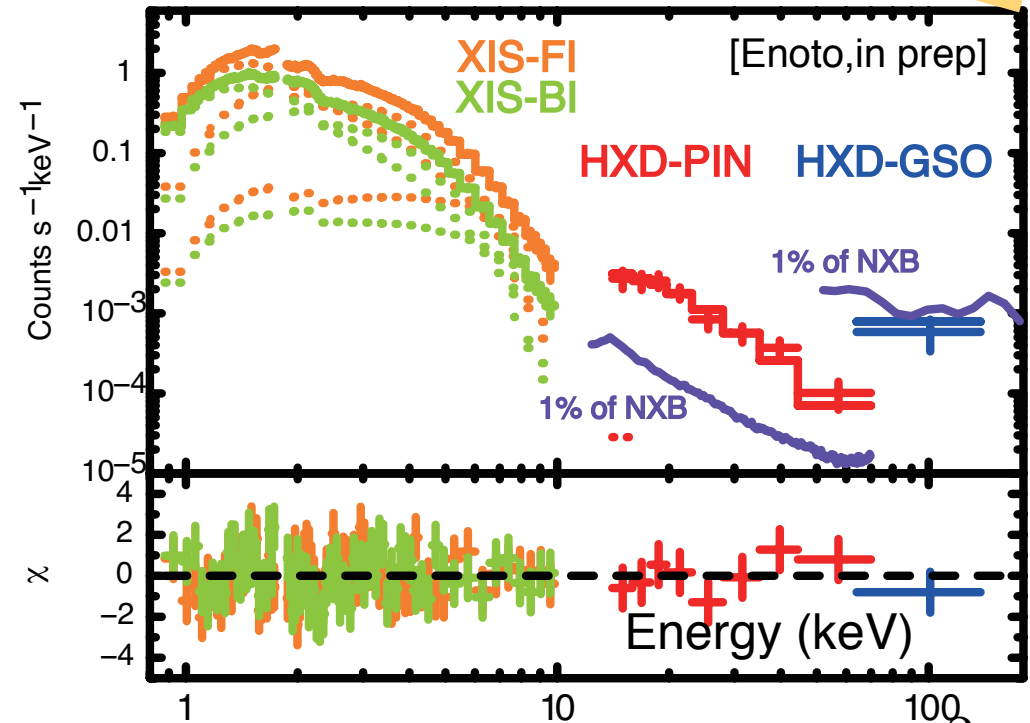


$P = 5.762072$  s,  $\dot{P} = 6.66 \times 10^{-12}$

one/two sinusoidal shapes  
below/above 12 keV

## Wideband spectrum

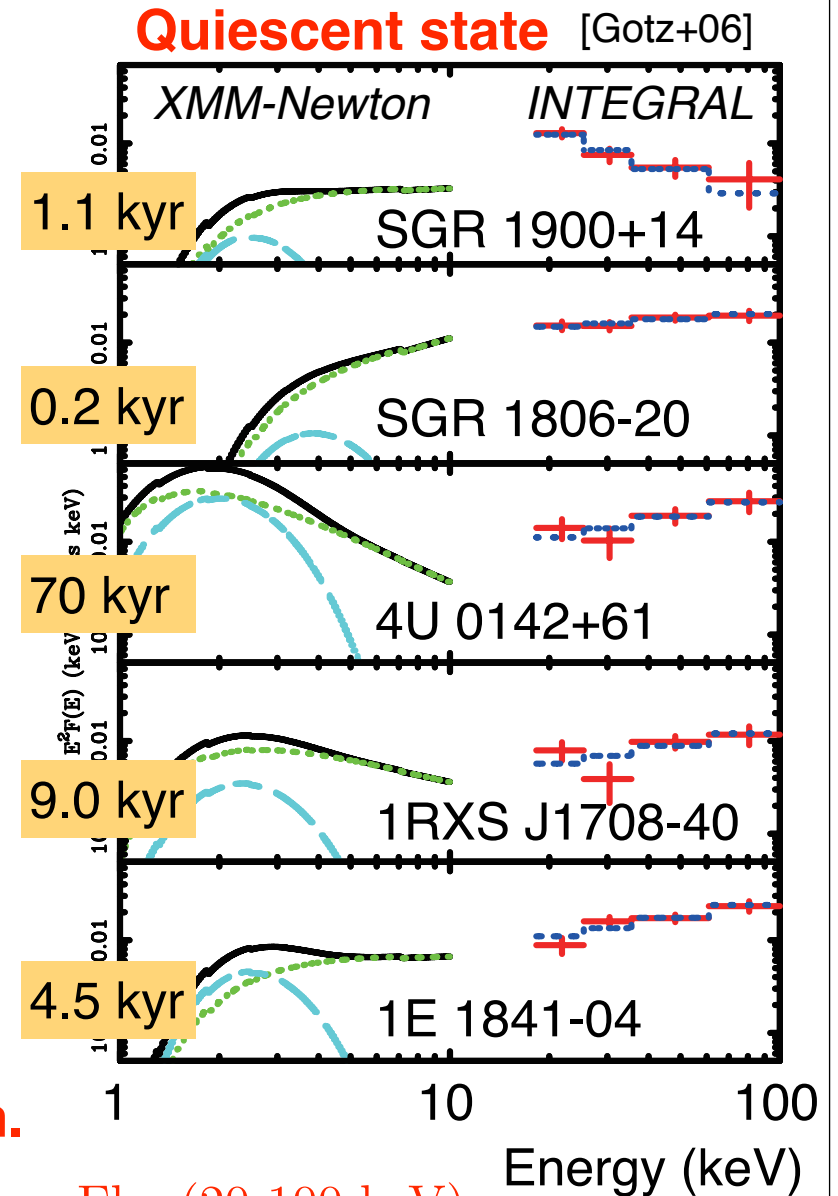
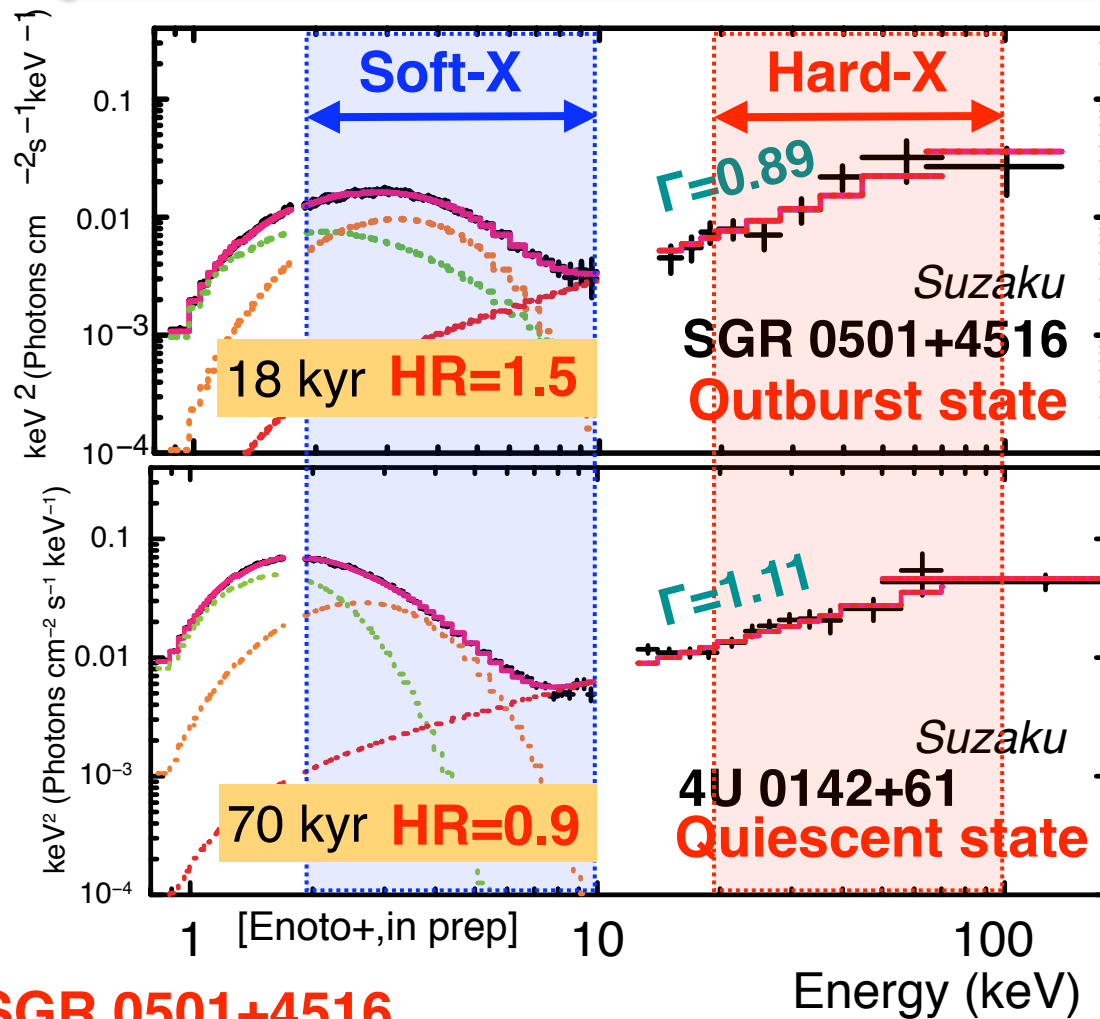
[Enoto, in prep]



- Thermal** (<10 keV) + **Hard X-ray**  $\chi^2_\nu$
- a. 2BB (0.3 keV & 0.7 keV) + PL 1.06
  - b. BB+PL (0.7 keV &  $\Gamma \sim 3.1$ ) + PL 1.11
  - c. BB+CutoffPL (0.7 keV &  $\Gamma \sim 2.1$  &  $E_c \sim 2.3$  keV) + PL 1.09

$$\Gamma = 0.89^{+0.22}_{-0.47} \text{ at } >10 \text{ keV}$$

# $\nu F_\nu$ spectrum of SGR 0501+4516



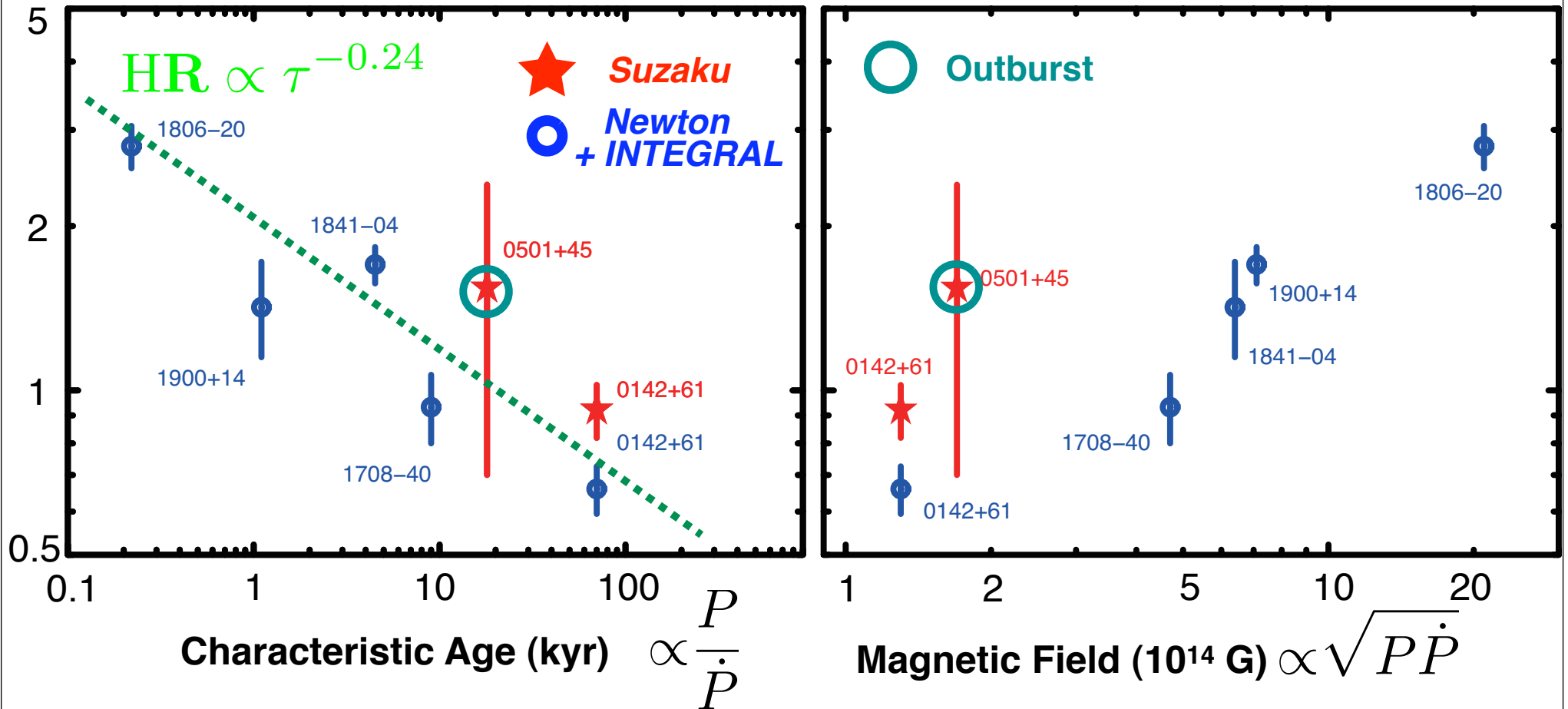
**SGR 0501+4516**  
 showed the SGR-like burst activity  
 and AXP-like persistent wideband spectrum.

Index for the hard-X intensity    Hardness Ratio =  $\frac{\text{Flux}(20-100 \text{ keV})}{\text{Flux}(2-10 \text{ keV})}$

# Correlation between HR and Age (Magnetic Field)

$$\text{Hardness Ratio} = \frac{\text{Flux}(20-100 \text{ keV})}{\text{Flux}(2-10 \text{ keV})}$$

[Enoto+, in prep]

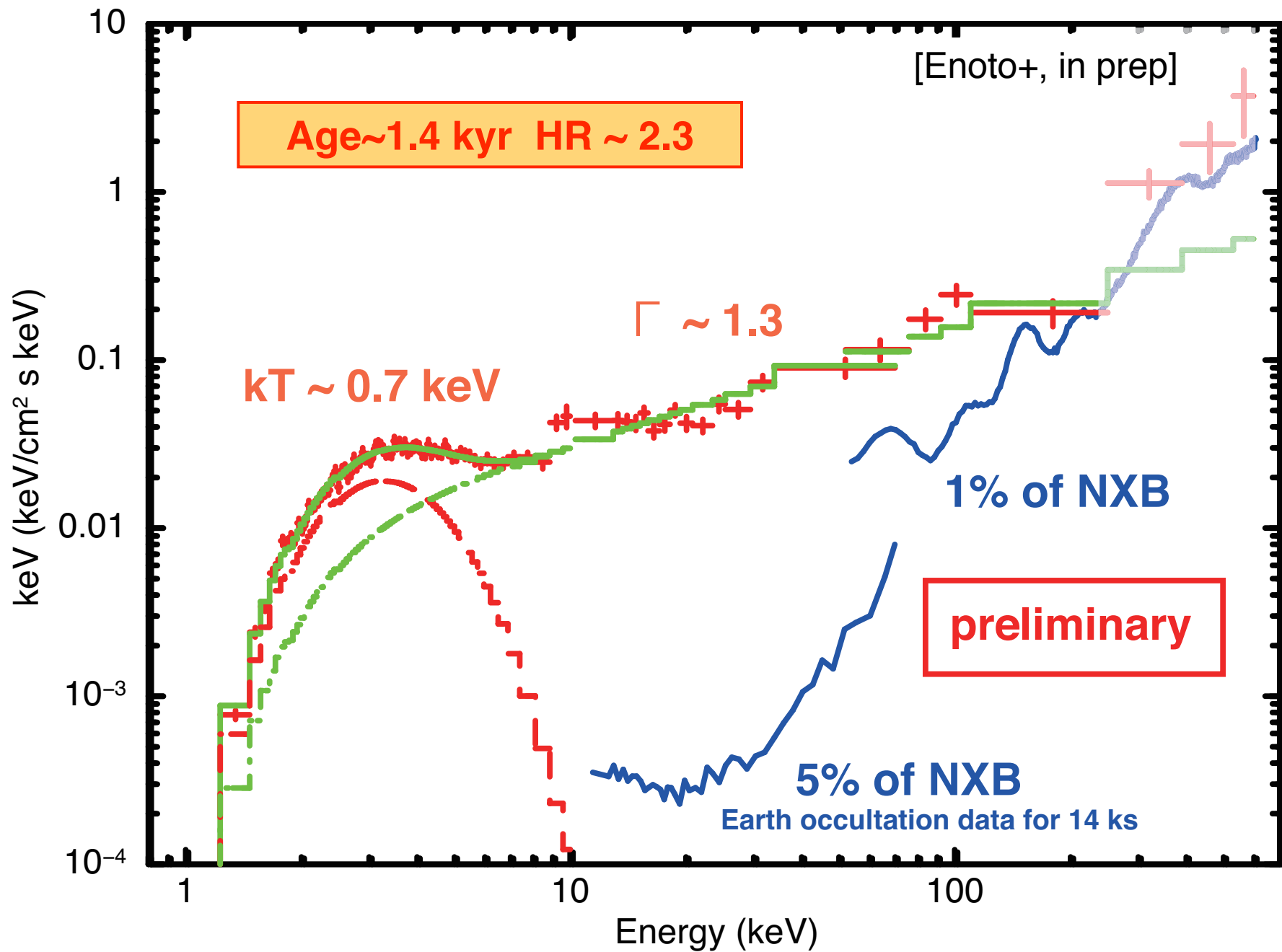


- Hard tail intensity (relative to the soft component) appears to correlate negatively/positively with characteristic ages/magnetic field.

Any other magnetars in outburst ?



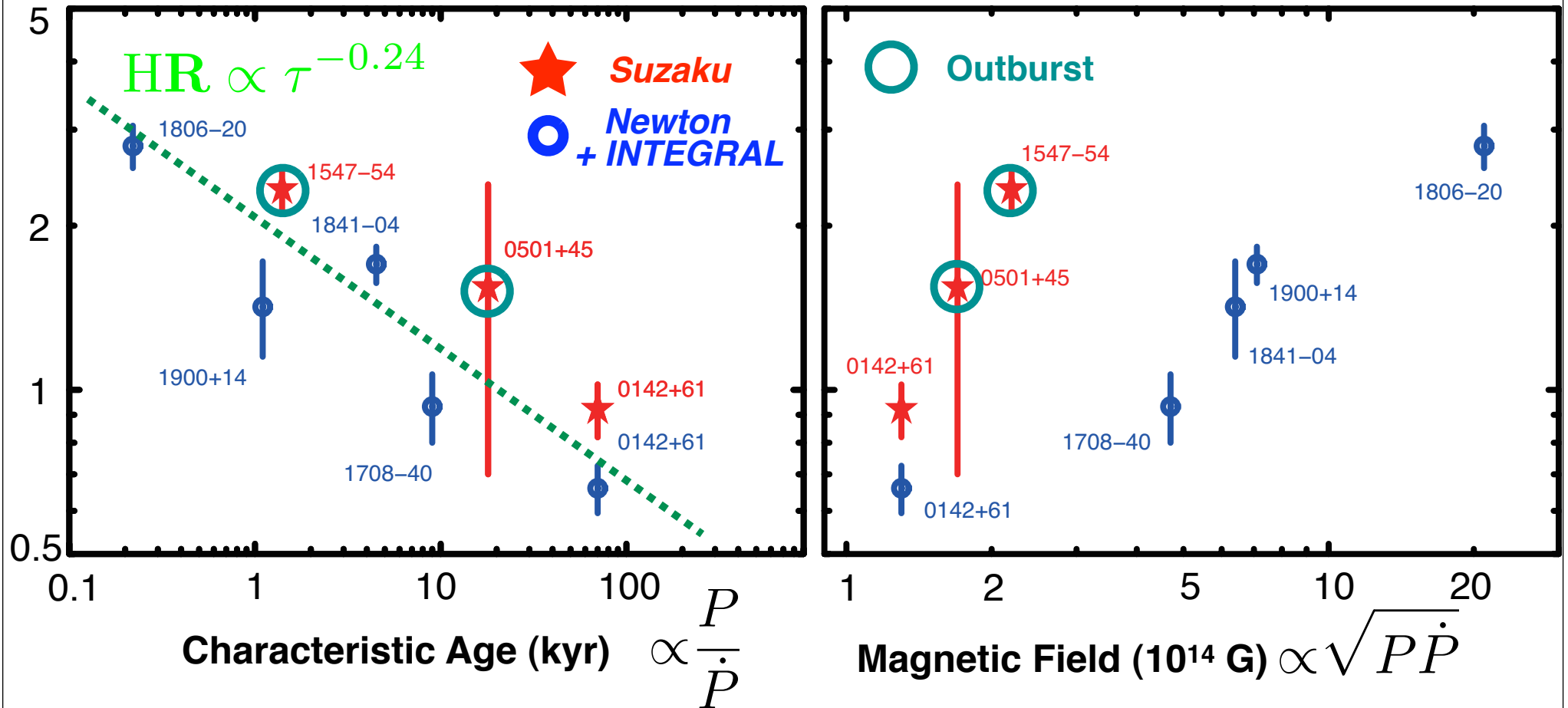
# $\nu F_\nu$ spectrum of 1E 1547.0-5408



# Correlation between HR and Age (Magnetic Field)

$$\text{Hardness Ratio} = \frac{\text{Flux}(20-100 \text{ keV})}{\text{Flux}(2-10 \text{ keV})}$$

[Enoto+, in prep]



- Hard tail intensity (relative to the soft component) appears to correlate negatively/positively with characteristic ages/magnetic field.

Any other magnetars in outburst ?

# Summary

---

- *Suzaku* allows us to measure the soft and hard components of magnetars, simultaneously and in short exposures
- We detected persistent X-ray emissions, from SGR 0501+4516 up to 70 keV, 4U 0142+61 up to 200 keV, and 1E 1547.0-5408 above 100 keV.
- SGR 0501+4516 shows
  - the SGR-like burst spectrum (two blackbodies; 3 keV and 15 keV)
  - the AXP-like persistent and wideband spectrum.
- Intensity of the hard X-ray tail relative to the soft component appears to be negatively (positively) correlated with the characteristic age (magnetic field).