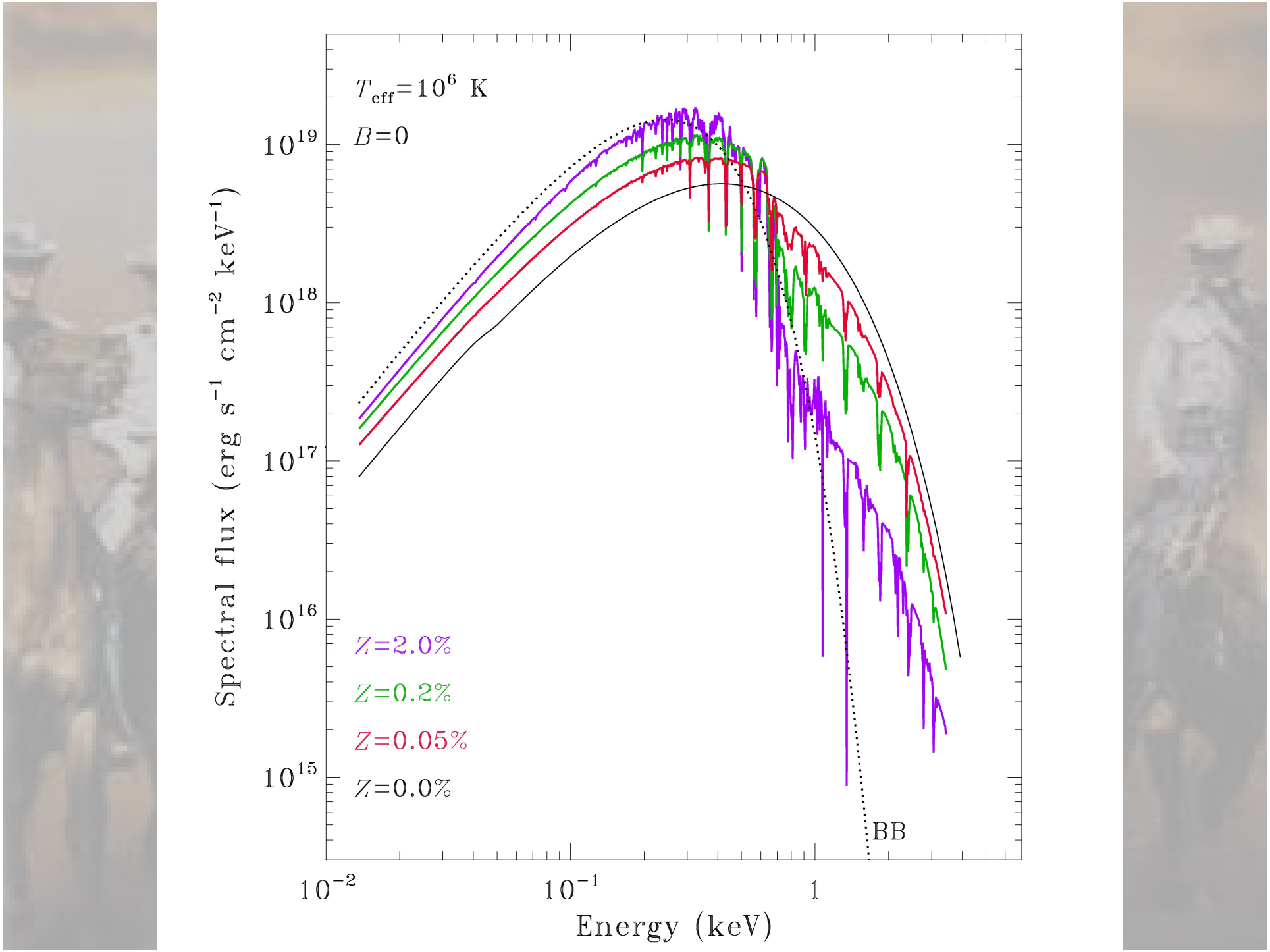

L'ULTIMO DEI MAGNIFICI SETTE
STARRING:
RX J1856.5-3754,
RX J0720.4-3125, RX J0420.0-5022,
RX J0806.4-4123, RX J1605.3+3249,
RBS 1223, RBS 1774
DIRECTED BY:
ANDREA TIENGO & SANDRO MEREGHETTI
BASED ON A TRUE STORY
(TIENGO & MEREGHETTI 2007, APJ 657, L101)

The Magnificent Seven

- Discovered by *ROSAT* as soft X-ray sources with no optical counterpart. Thermal spectrum, low absorption, some are X-ray pulsars (P=3-12 s) $\Rightarrow$ nearby (~100 pc) **neutron stars**
- Among ~2,000 neutron stars, **only** the M7 have pure thermal spectra $\Rightarrow$ we directly observe the hot (~10^6 degrees) neutron star surface

Why Magnificent?

- **Direct test of neutron star atmospheric models**


$T_{\rm eff}=10^6$ K
$B=0$
10^{19}
10^{18}
10^{17}
10^{16}
10^{15}
Spectral flux (erg s^{-1} cm^{-2} keV^{-1})
$Z=2.0\%$
$Z=0.2\%$
$Z=0.05\%$
$Z=0.0\%$
BB
10^{-2}
10^{-1}
1
Energy (keV)

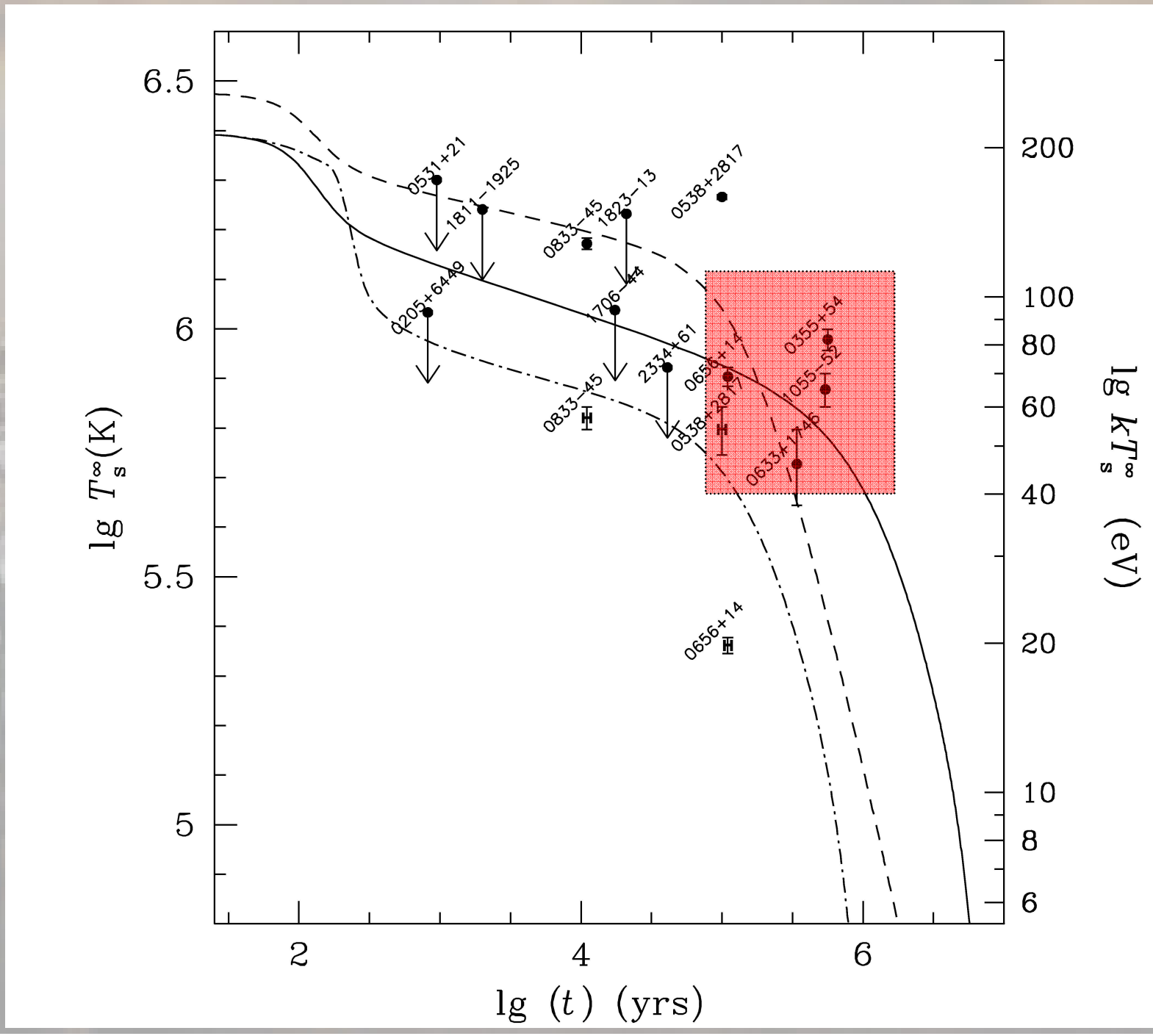
Why Magnificent?

- **Direct test of neutron star atmospheric models**

  Which model give best fit? ***Blackbody*…**

- From BB normalization and distance: neutron star **radius** $\Rightarrow$ test neutron star equation of state (**EOS**)

- From BB **temperature** and age: cooling curves $\Rightarrow$ test **EOS**


6.5
6
5.5
5
2
4
6
lg T_s^∞(K)
lg (t) (yrs)
lg kT_s^∞ (eV)
200
100
80
60
40
20
10
8
6
0531+21
1811−1925
0833−45
1823−13
0538+2817
0205+6449
1706−44
2334+61
0355+54
0656+14
1055−52
0538+2817
0633+1746
0833−45
0538+2817
0656+14

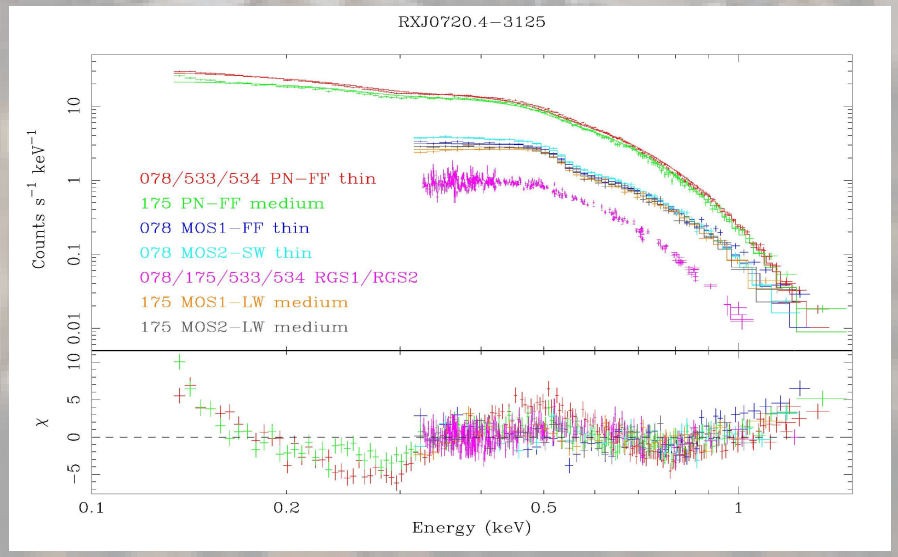
RX J1856.5-3754: the M7 leader

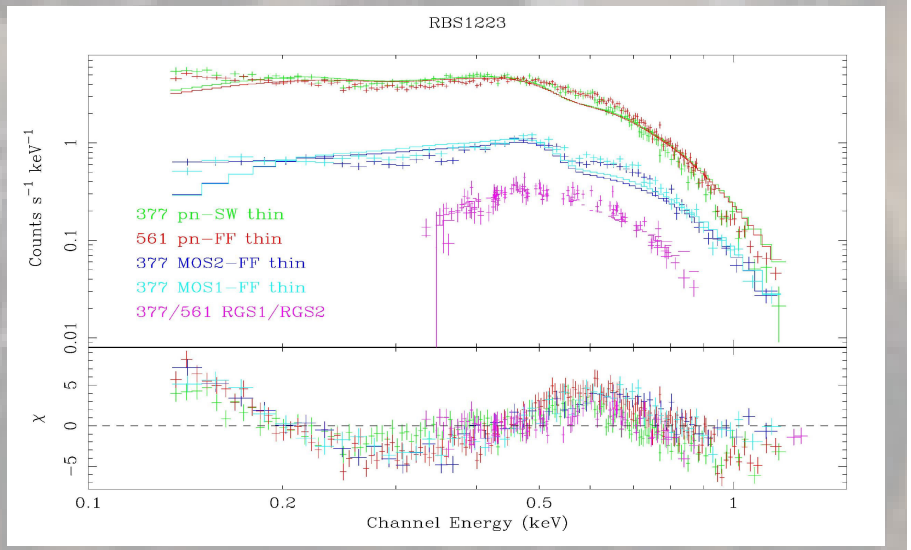
- **First** discovered: *Walter et al. 1996*
- **Brightest**: >7 cts/s in PN (0.15-1 keV)
- **Highest quality** observations:
  >500 ks Chandra, >300 ks XMM-Newton, >40 HST orbits, …
- Parallactic **distance**: first 62 pc, then revised to 117±12 pc

RXJ1856 anomalies: the spectrum

X-ray spectra of 6 of the M7 have broad absorption features

If proton **cyclotron** lines, B=(5-15)x10^{13} G





RXJ1856 has pure BB X-ray spectrum: most perfect BB in the Universe after CMB

RXJ1856 anomalies: pulsation

5 (+1) of the M7 pulsate with 3-12 s periods

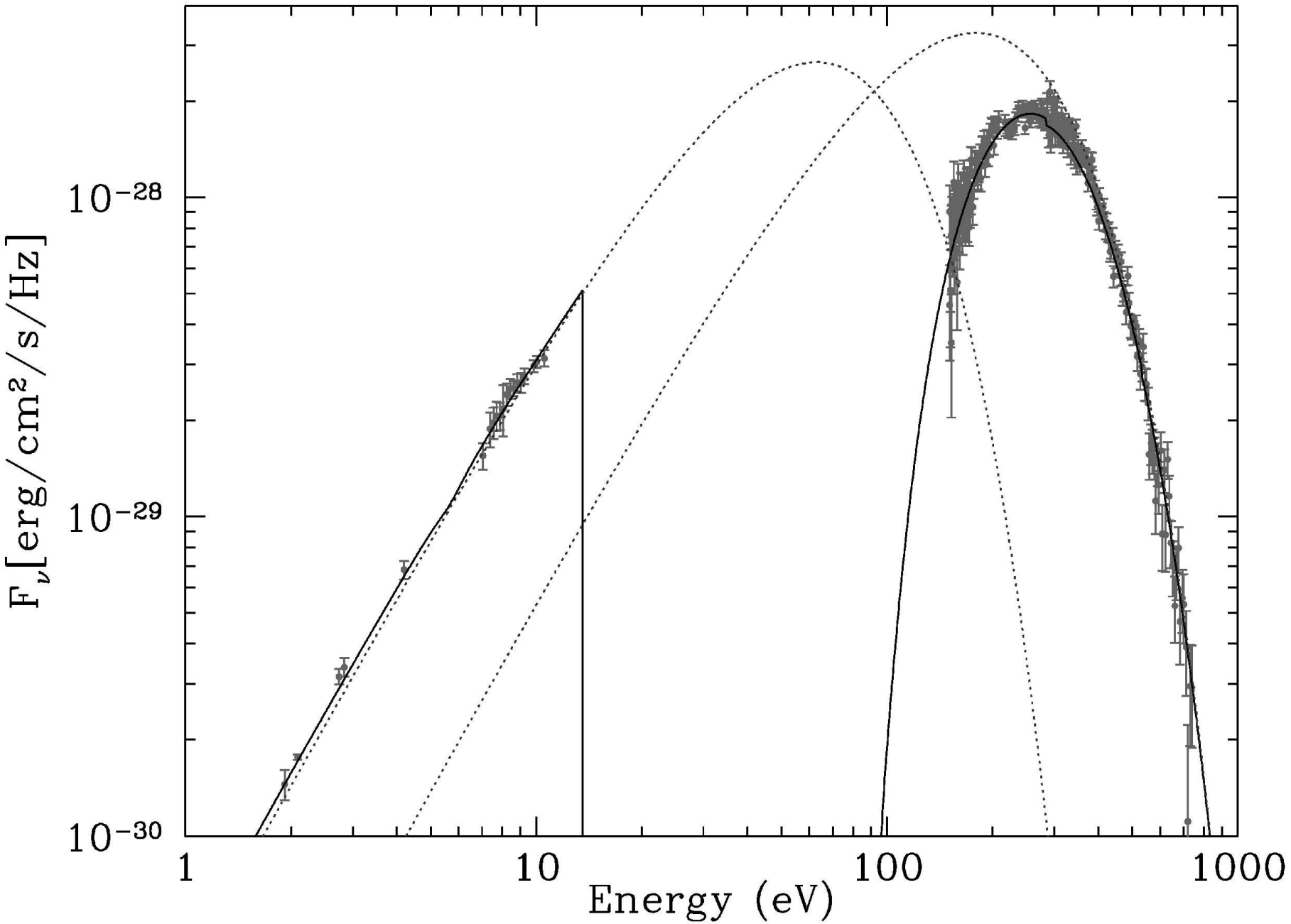
Despite 10 years of searches, **no pulsation** found in RXJ1856 (pulsed fraction<1.2%)

Why?

- ✓ Fast (or slow) rotator?
- ✓ Aligned rotator?
- ✓ Perfectly uniform temperature?

  Small BB radius ⇒ quark star *(Drake et al. 2002)*

  But optical excess suggests 2nd BB


10^{-28}
10^{-29}
10^{-30}
F_ν[erg/cm^2/s/Hz]
1
10
100
1000
Energy (eV)

RXJ1856: the last one of the M7

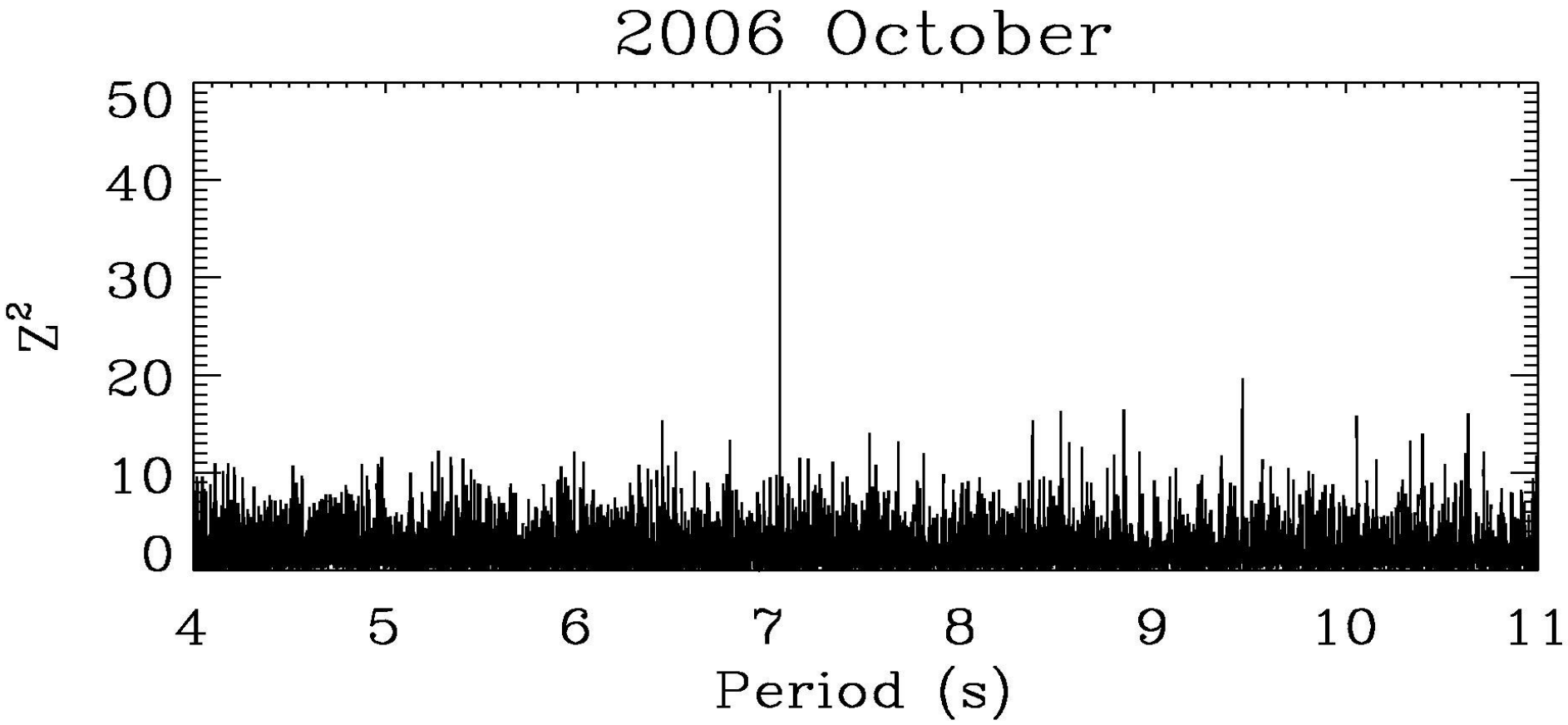
(Tiengo & Mereghetti 2007, ApJ 657, L101)

RXJ1856 is a **calibration** target for XMM $\Rightarrow$ ~1 observation/6 months

I decided *(why?!)* to analyze the last XMM-Newton observation (70 ks long, like the previous one) and…

RXJ1856: the last one of the M7

(Tiengo & Mereghetti 2007, ApJ 657, L101)



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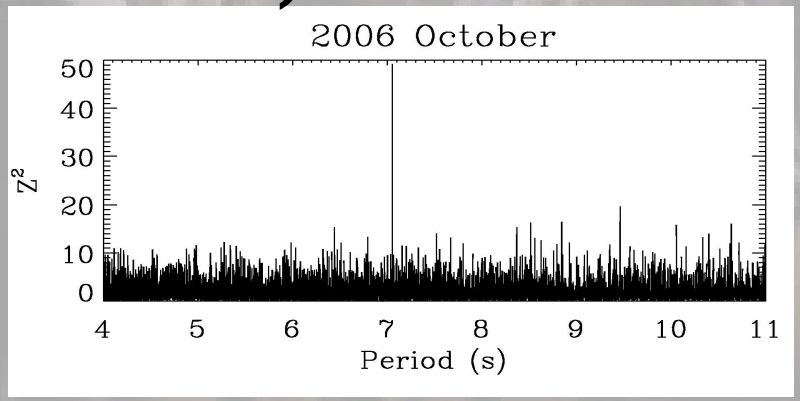

Although the peak is significant (p=6x10^{-4}), it is better to search for confirmations…

RXJ1856: the last one of the M7

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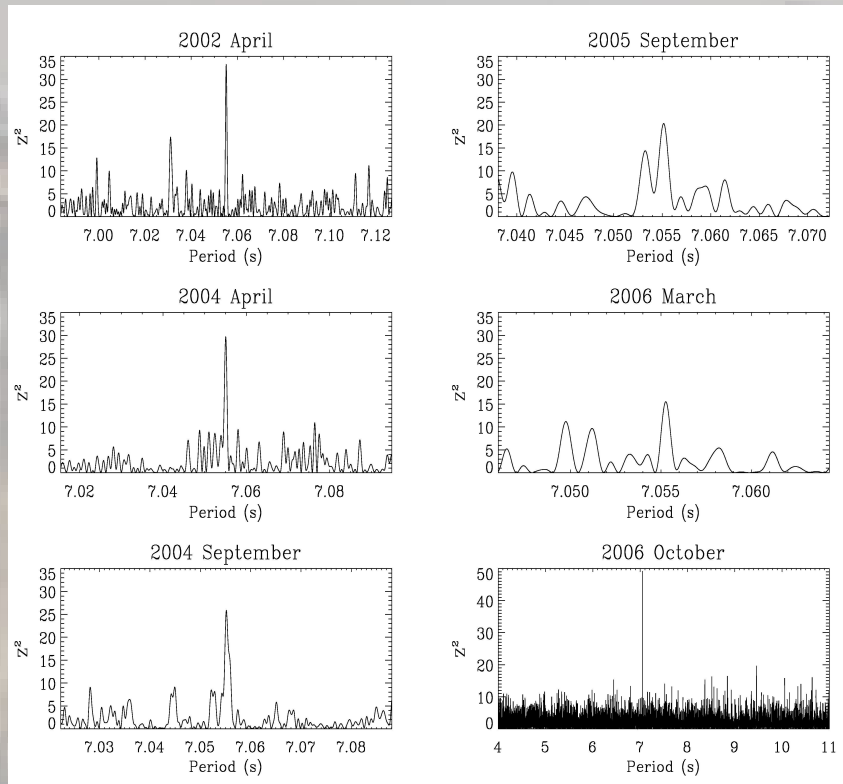
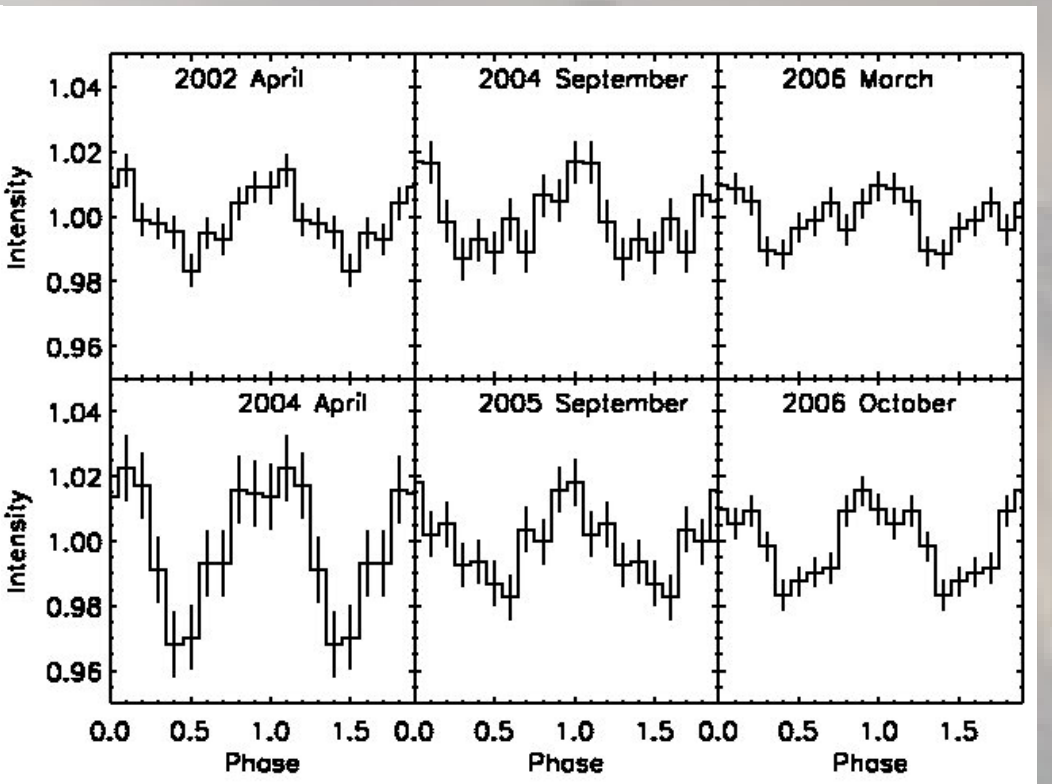


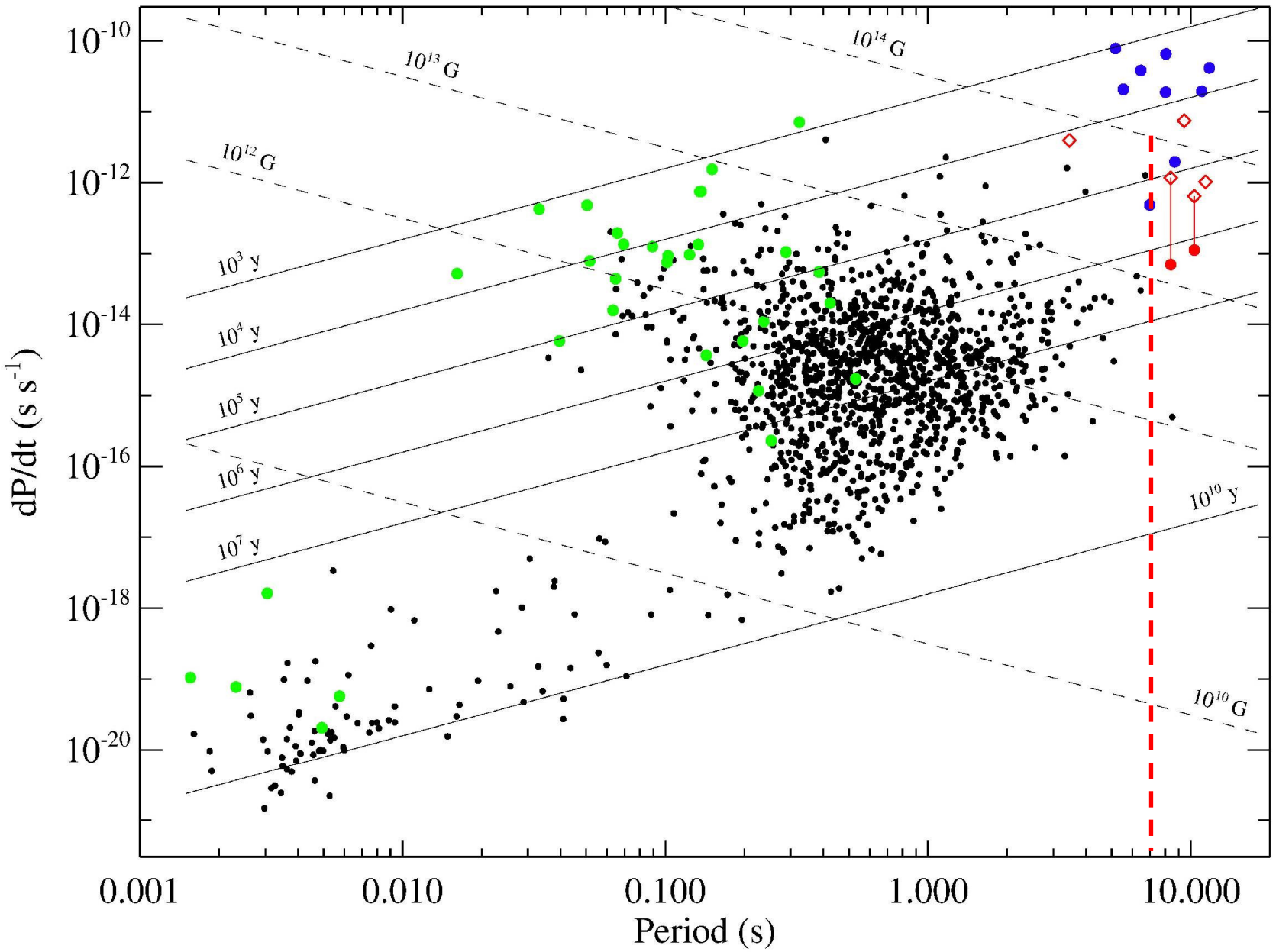


$P=7.05515$ s, PF≈1.2%, $\dot{P}<1.9\times10^{-12}$ s s^{-1} ⇒

$B<1.2\times10^{14}$ G, $\tau>6\times10^{4}$ yrs, $\dot{E}<2\times10^{32}$ erg s^{-1}

The future

- *Can the RXJ1856 period be measured with better precision?*
  Yes, but ONLY with *XMM-Newton*.
- *Why are more precise periods needed?*
  To measure $\dot{P}$.
- *Why is $\dot{P}$ important?*
  Low B might justify absence of cyclotron line


10^{-10}
10^{-12}
10^{-14}
10^{-16}
10^{-18}
10^{-20}
dP/dt (s s^{-1})
10^{13} G
10^{14} G
10^{12} G
10^{3} y
10^{4} y
10^{5} y
10^{6} y
10^{7} y
10^{10} y
10^{10} G
0.001
0.010
0.100
1.000
10.000
Period (s)