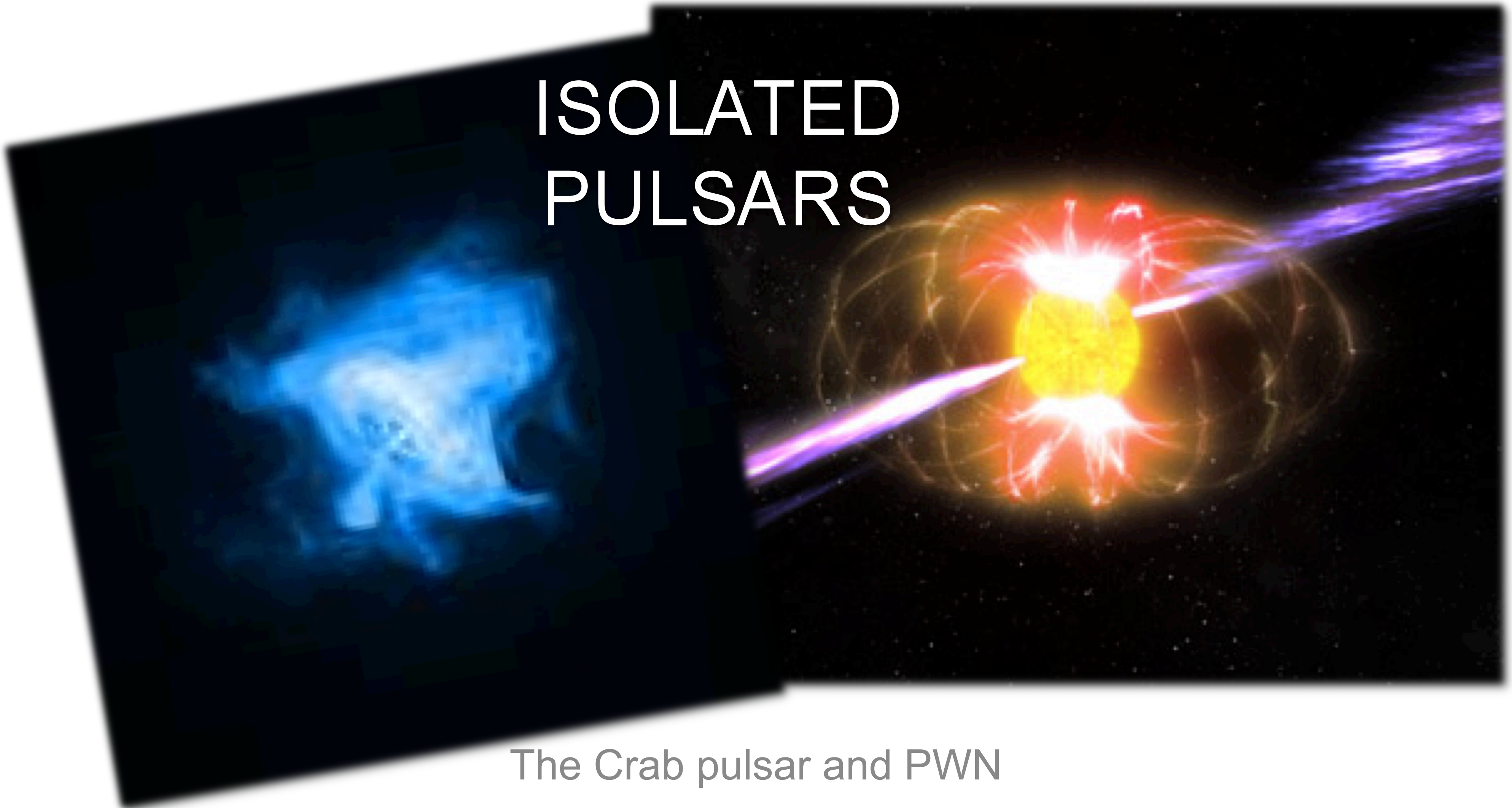


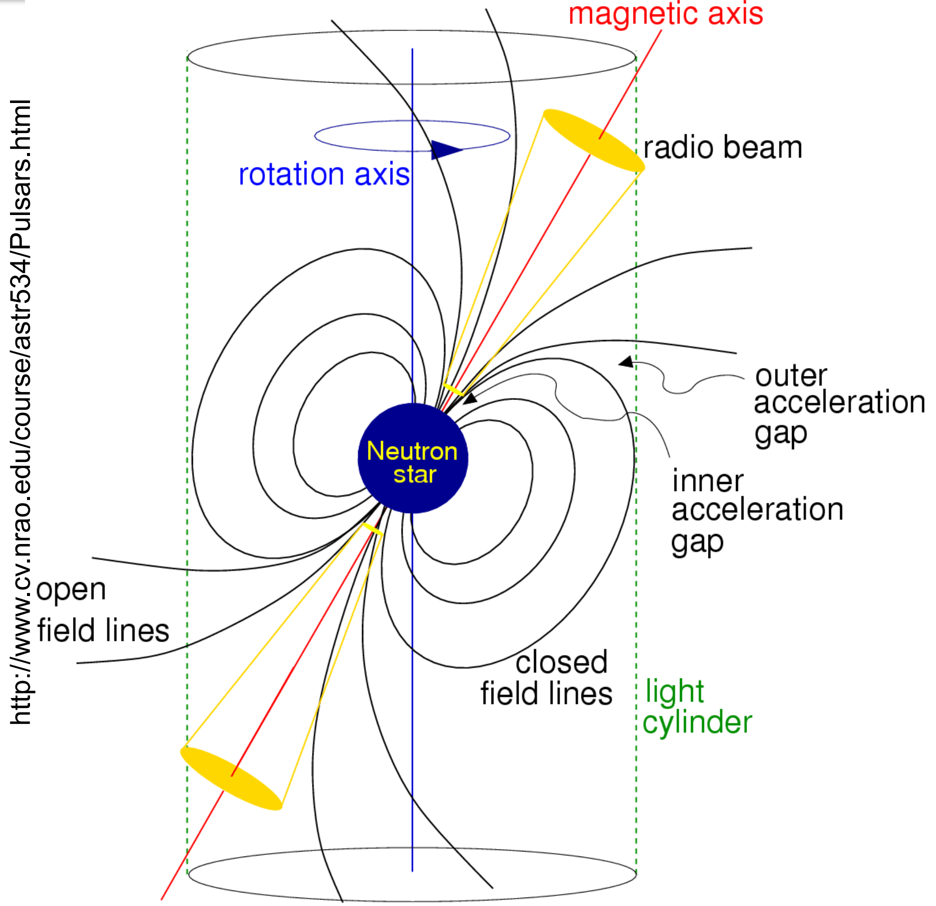
ISOLATED PULSARS

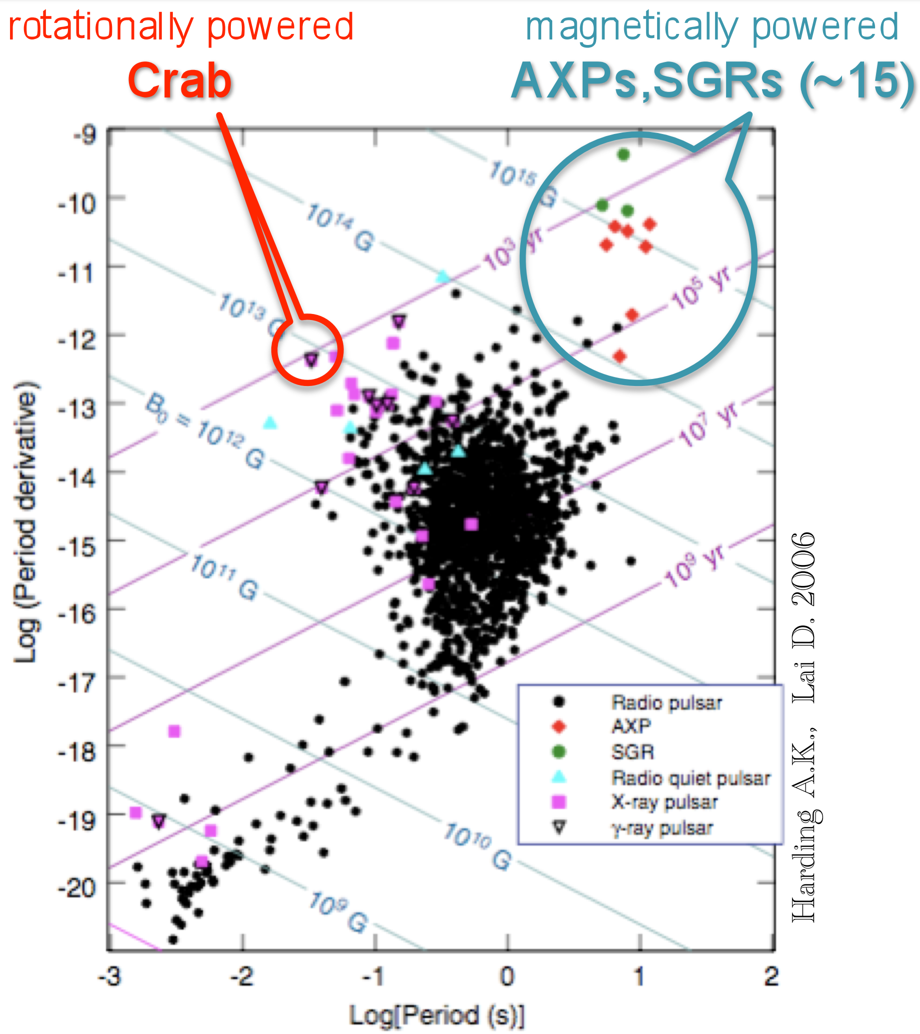
The Crab pulsar and PWN

Magnetars: Strange hard tails of AXPs

SGRs: the giant outburst of 1E 1547.0-5408

isolated pulsars





Radiated power : losses due to a rotating dipole (Larmor eq.)

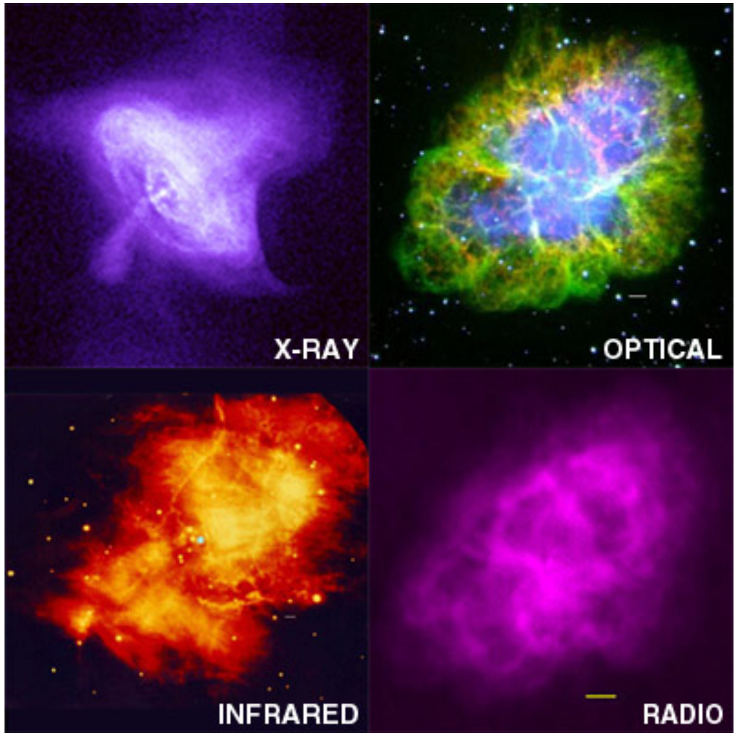
$$B \simeq 6.4\ 10^{19} \sqrt{P\dot{P}}\ [\mathrm{G}]$$

Radiative losses spin down the NS ($\dot{E}_{rot} < 0$)

$$\tau = \frac{P}{2\dot{P}}$$

Emission process of the Crab

- data on the Crab PWN collected on >5.5 yr
- study the variability in intensity and spectral shape with Energy with SPI.
- single power-law cannot explain the data
- calibration of SPI based on ground calibrations and MonteCarlo simulations → absoulte measure of the Crab emission

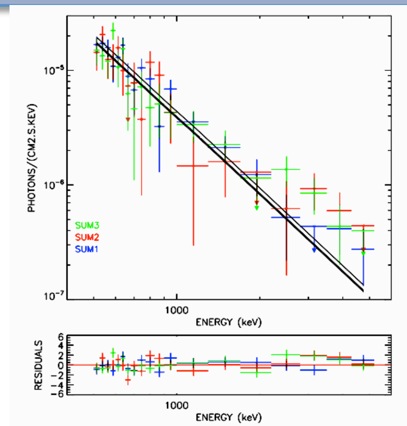


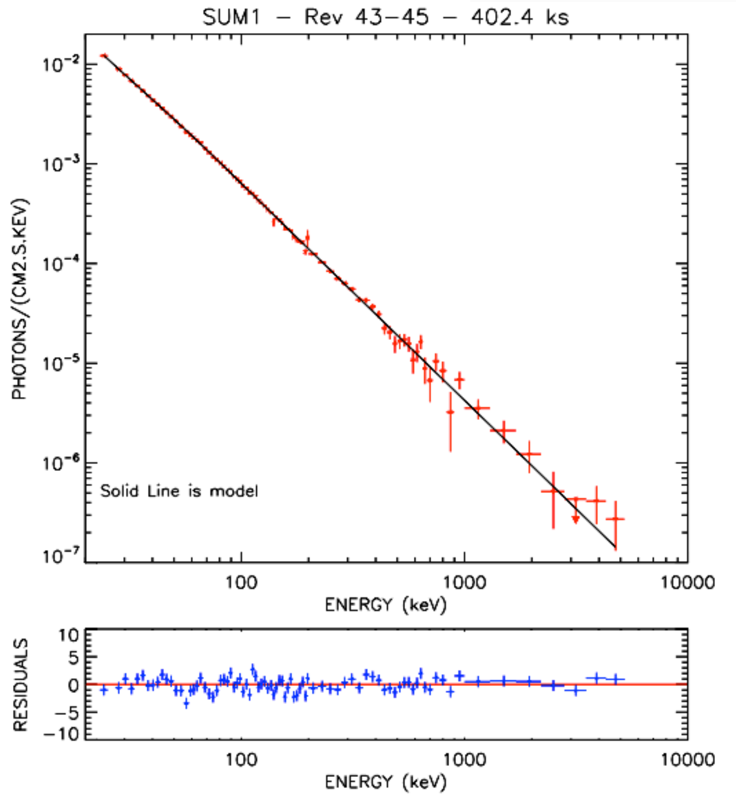
http://www.aip.org/png/html/crabneb.html

- average spectrum of the PWN+pulsar over all phases

the PWN seen with SPI

- Analysis on 3 different epochs:
  rev.43-45
  rev.239-605
  rev.665-727
- broken powerlaw needed, energy break ~ 100keV
- data collected up to 6MeV, fitted with pl Γ_{soft}=2.0 Γ_{hard}=2.2
- at low energies high S/N
- curved slope emission due simultaneously to the charged particles **distribution** and **geometry** of the magnetic field.
- Great stability in the emission, useful to test stability in the detector



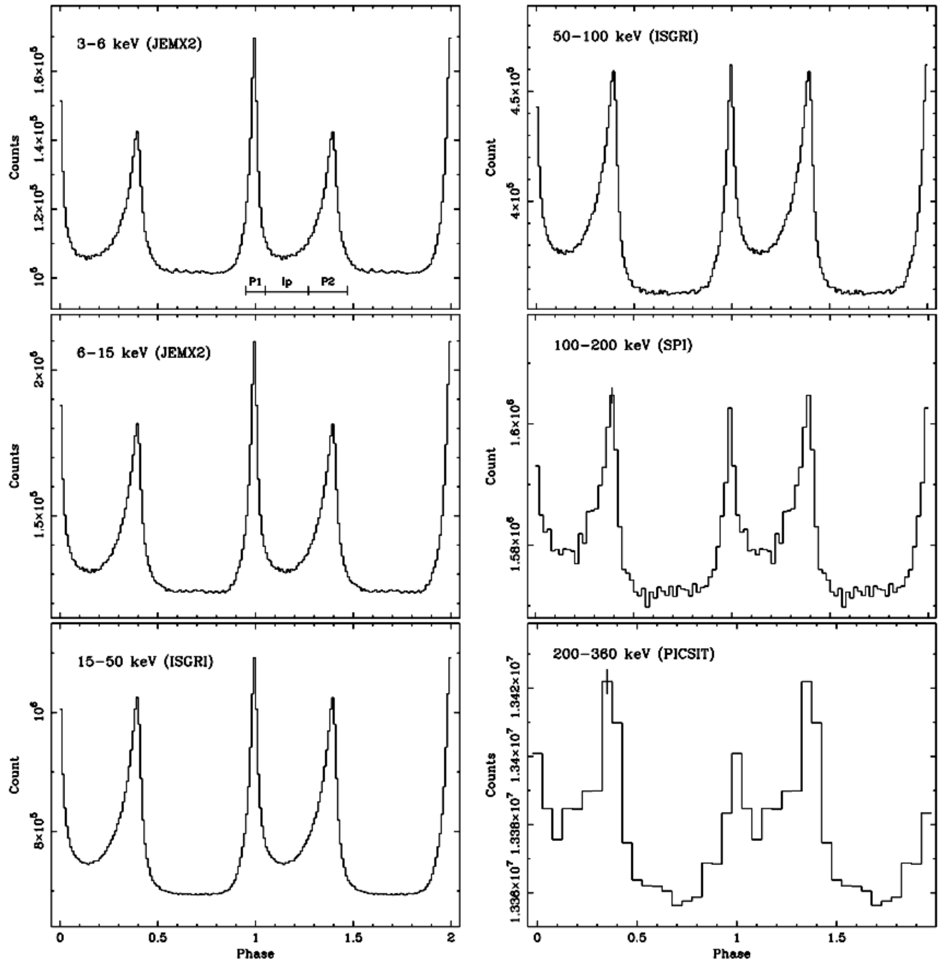


Jourdain & Roques, 2009

the Crab pulsar

- possibility to go in deeper detail analyzing the phase-emission of the pulsar
- Crab pulsar, analyzed in almost all energy bands
- P=33.5ms
- double peak structure (P1, P2), phase separation 0.4
  - what vary is: intensity, height, width
  - P1 dominant at low X energies
- INTEGRAL data analyzed from 3keV (JEM-X) up to 2 MeV (SPI)

Mineo et al. A&A 2006

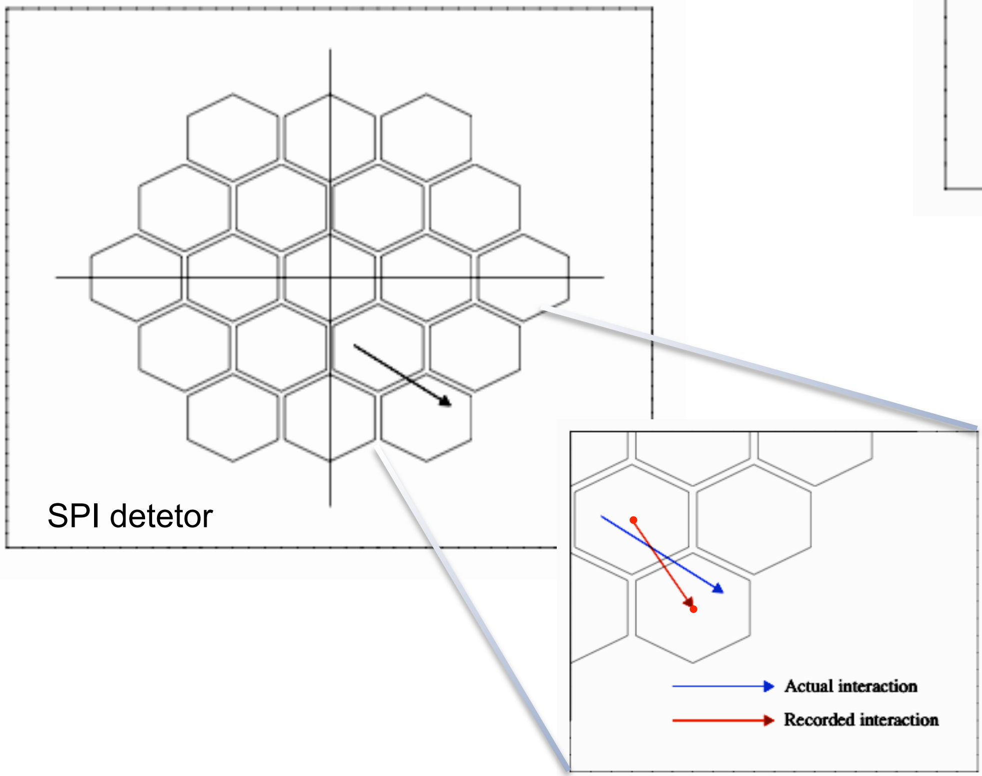


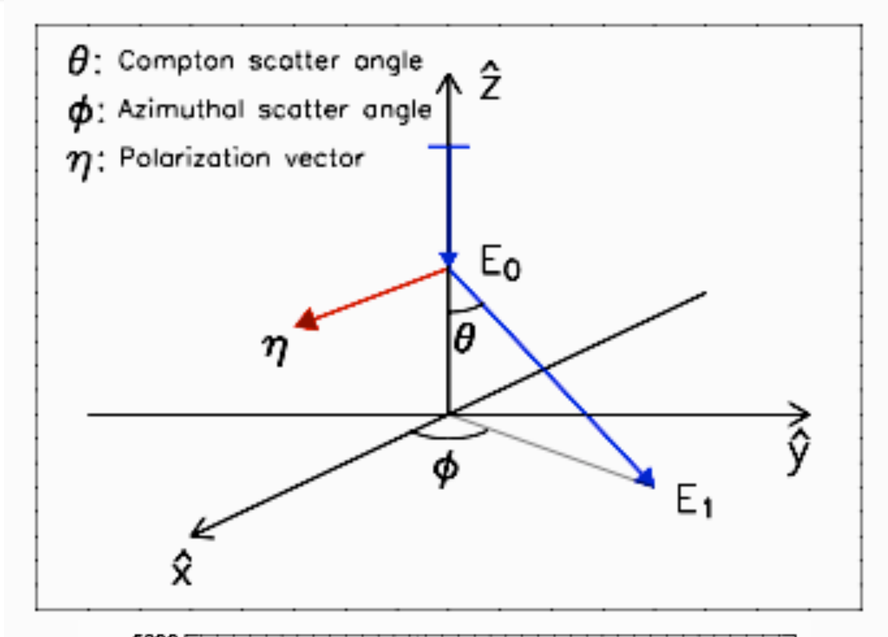
$$F(E) = K\ E^{-(a+b\log(E))}$$

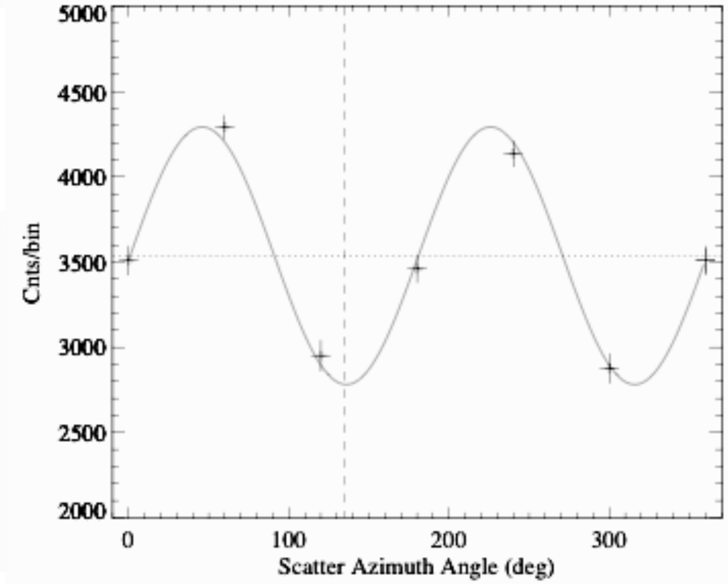
Analysis of curves *a (phase)*, *b (phase)*

Polarization measures with SPI

- linearly polarized γ-photons scatters ⊥ incident polarization vector (η) → $\phi \approx 90°$
- multiple events on SPI allow measure of ϕ distribution
- assumed from center to center of each detector on SPI



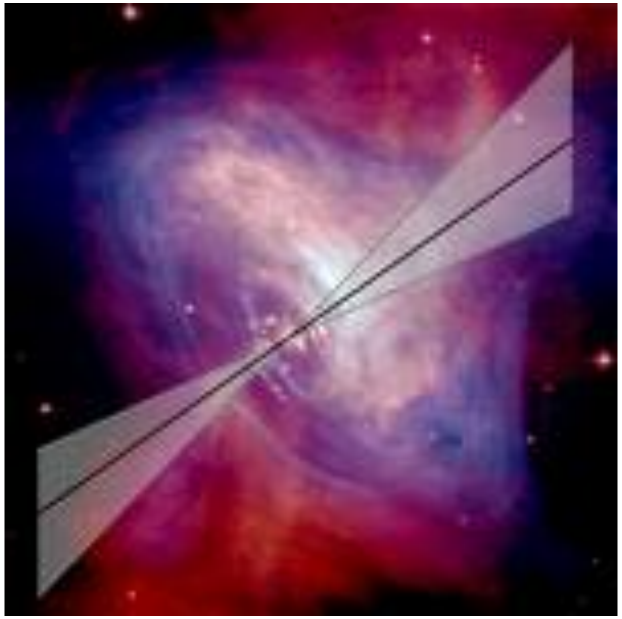




Kalemci E. et al. 2004

an example: the Crab

Dean et al. 2008

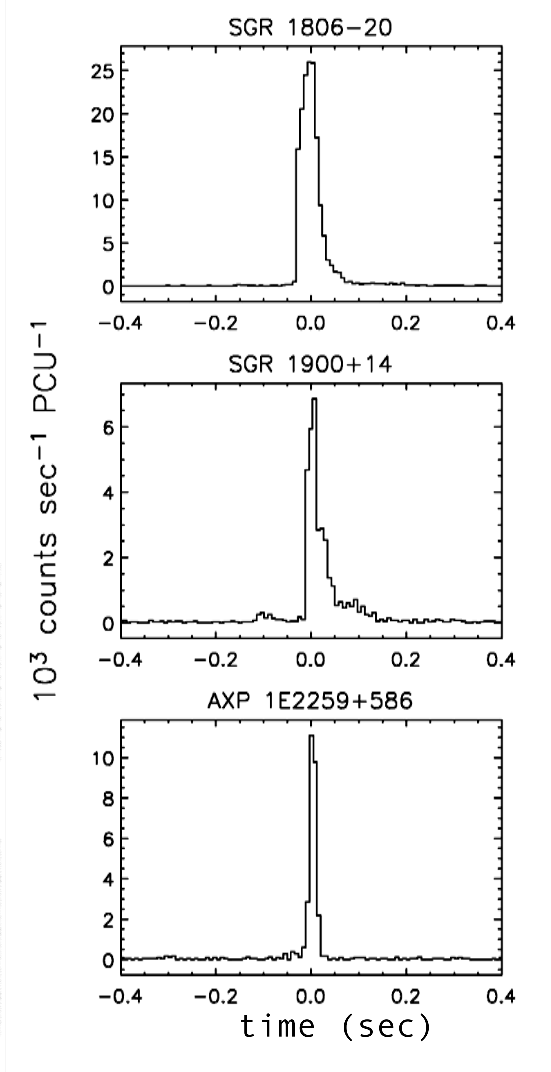


- polarization measures of H.E. radiation to locate where particles are accelerated: energetic e^- produce γ-rays within the magnetic field structure in the PWN, but they radiate only on very short-time scale, i.e. close to the accelerating zone
- measured in off-pulse phase with SPI
- in 0.1-1 MeV (→ Compton scattering range)
- looking for asymmetries in the ϕ distribution, comparing data with simulated events
- data consistent with a linearly polarized beam, 123°±11° ≈ pulsar spin orientation
- polarization detected from the vicinity of Crab pulsar, 46±10% → high uniformity in the B field configuration associated with the unpulsed emission

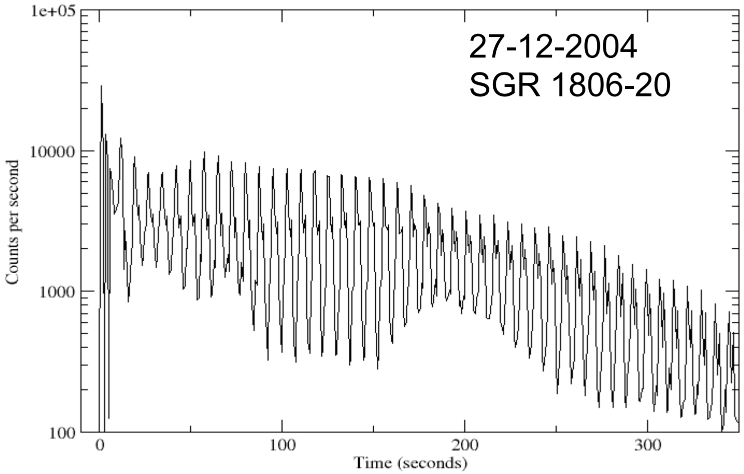
what's a magnetar? (AXP, SGR)

- Isolated neutron star
  - pulsated emission: P (2-12 s), Pdot (10^{-13} - 10^{-10} s s^{-1}).
- flares, erratic burst activity: not predictable starting time.
  - generally 0.1-1 sec, L_{peak}~10^{41} erg/s
  - giant flares (3) L_{peak}~10^{45-47} erg/s
- B_{surf} ~ 10^{14-15} G > B_{crit} ~ 4 ·10^{13} G

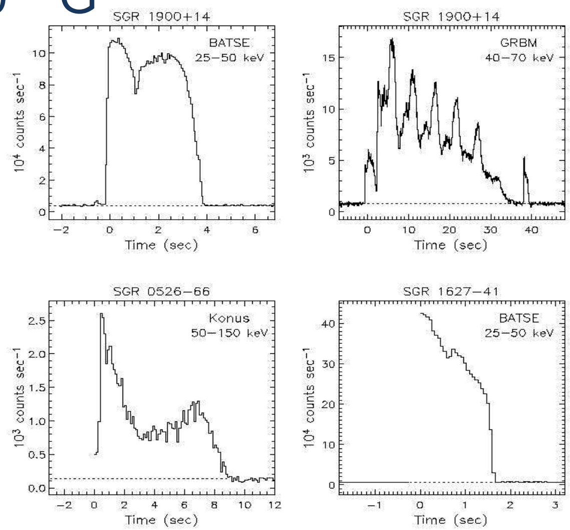
common flares in AXPs and SGRs



Woods & Thompson 2006



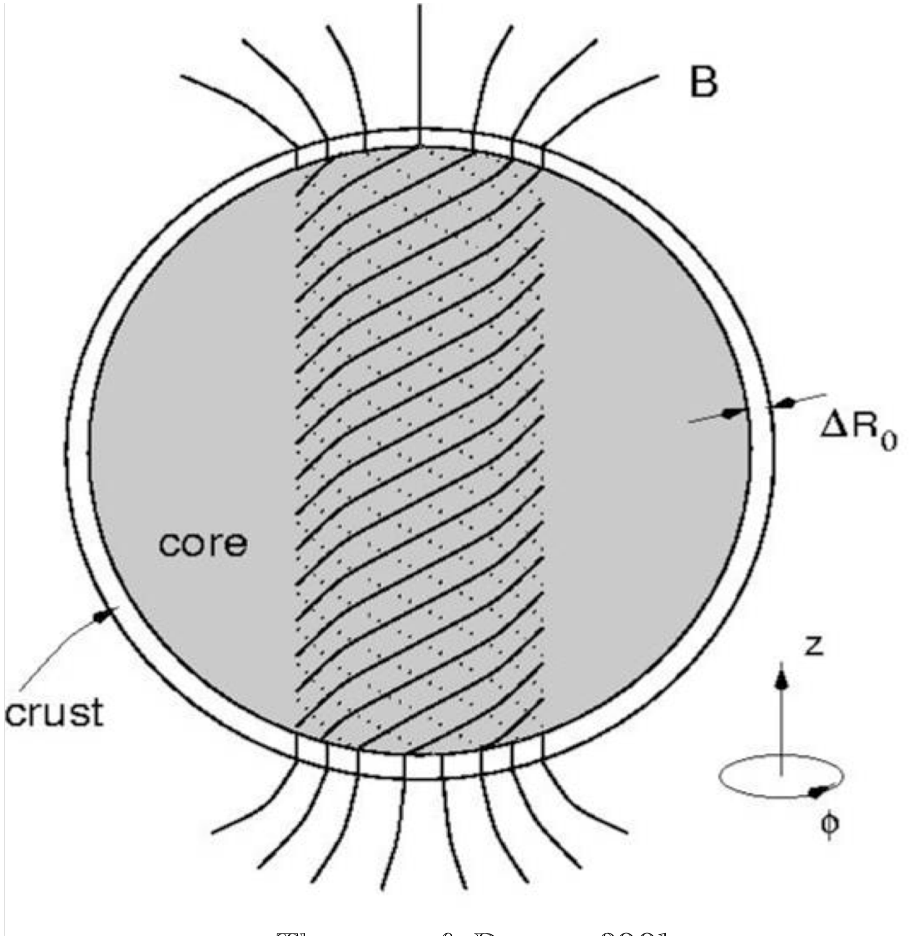
giant flare (Palmer et al. 2005)



medium flares in SGRs
(from Woods, Thompson 2004)

The “standard” model

- Isolated NS with huge B field
- Internal field:
  toroidal ≈ poloidal component
- Induced rotation of surface layers
- Gradual (quasi-plastic) deformation of the crust
- The external field twists up (Thompson, Lyutikov & Kulkarni 2002 or TLK’02)

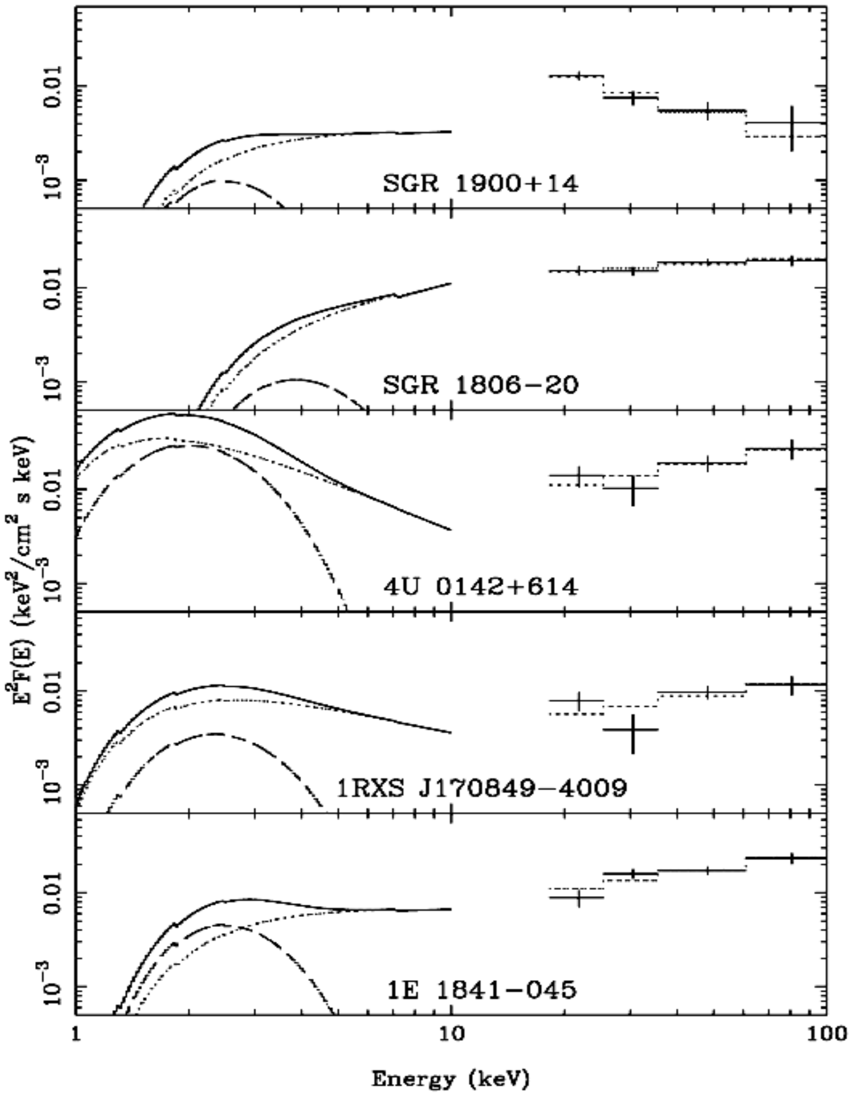


Thompson & Duncan, 2001

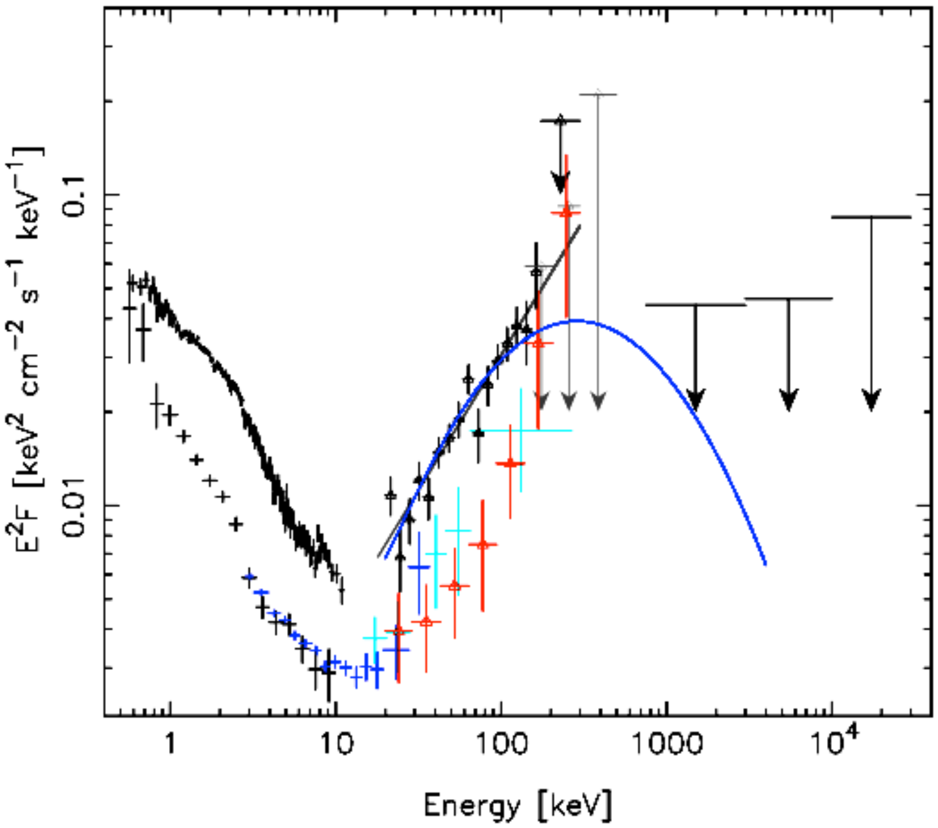
Catching AXPs from the tails

- first high-energy detection (>20 keV): SGR 1806-20, during outbursts
- integrating 2.5Ms (2003-2004), INTEGRAL detect unexpected emission from SGR 1900+14 in *quiescence* (Götz et al. 2006)
- for the sample of magnetars now detected: hard power law tails Γ≈ 1-3 (20-100keV)
- Hard Emission pulsed: confirmation it's coming from the pulsar
- distorted BB: up-scattering of photons by charged particles in the magnetosphere

Götz et al. 2006

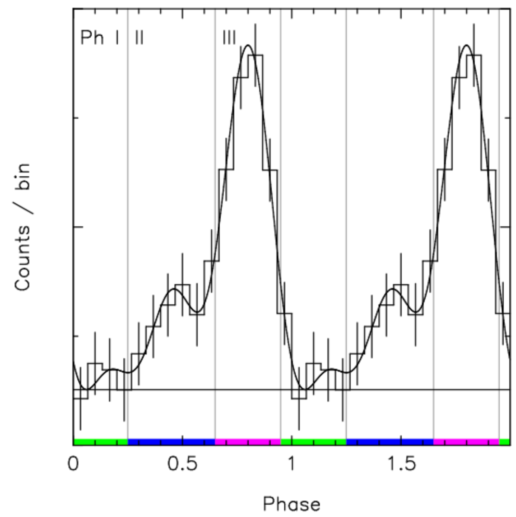


deeper view of AXP 1RXS J1708-4009



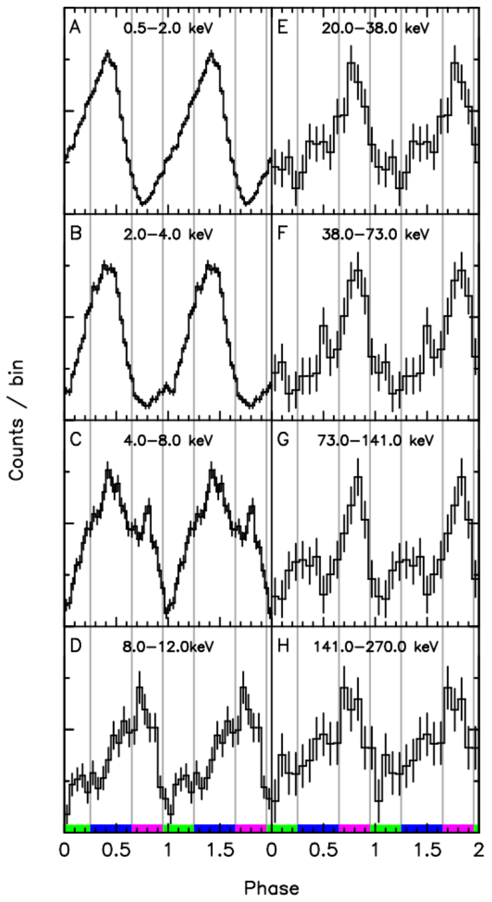
den Hartog et al. 2008

- Analysis of the whole X-ray emission: integration of INTEGRAL-XMM Newton-RXTE data → up to ~175 keV
- 20-175 keV emission (7.7 10^{-11} erg/cm^2/s) > 2.3 times the emission in 2-10 keV
- no evidence for a spectral breaking below 300 keV
- no significant time variability above 20keV
- pulsed emi



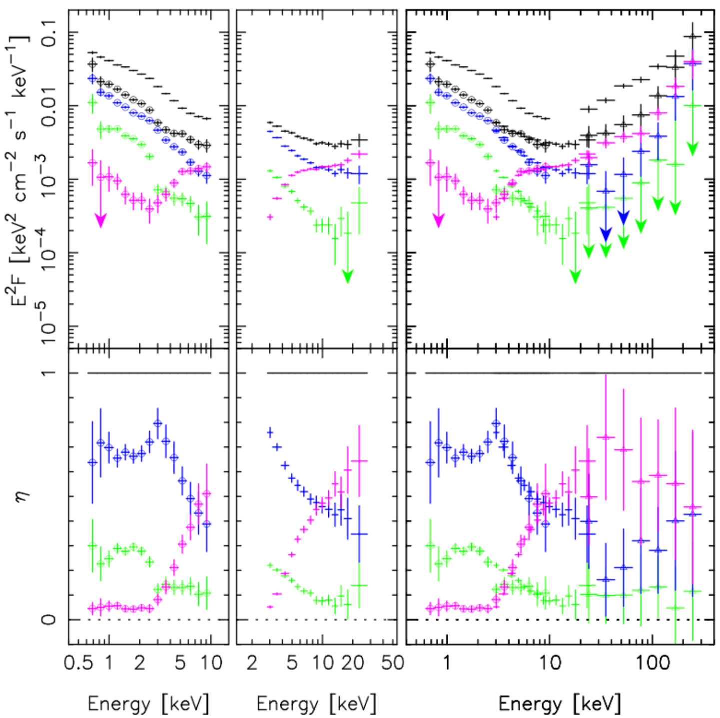
pulse profile 1RXS J1708-40 with INTERAL in 20-270keV (den Hartog et al. 2008)

phase-resolved spectrum



den Hartog et al. 2008

- spectral components:
  hard pulse >4keV, ph. 0.8
  soft pulse 2-4 keV, ph.0.4
  very soft pulse <2keV, p.0.8
- the hard one dominates for ~ 1/3 of the period

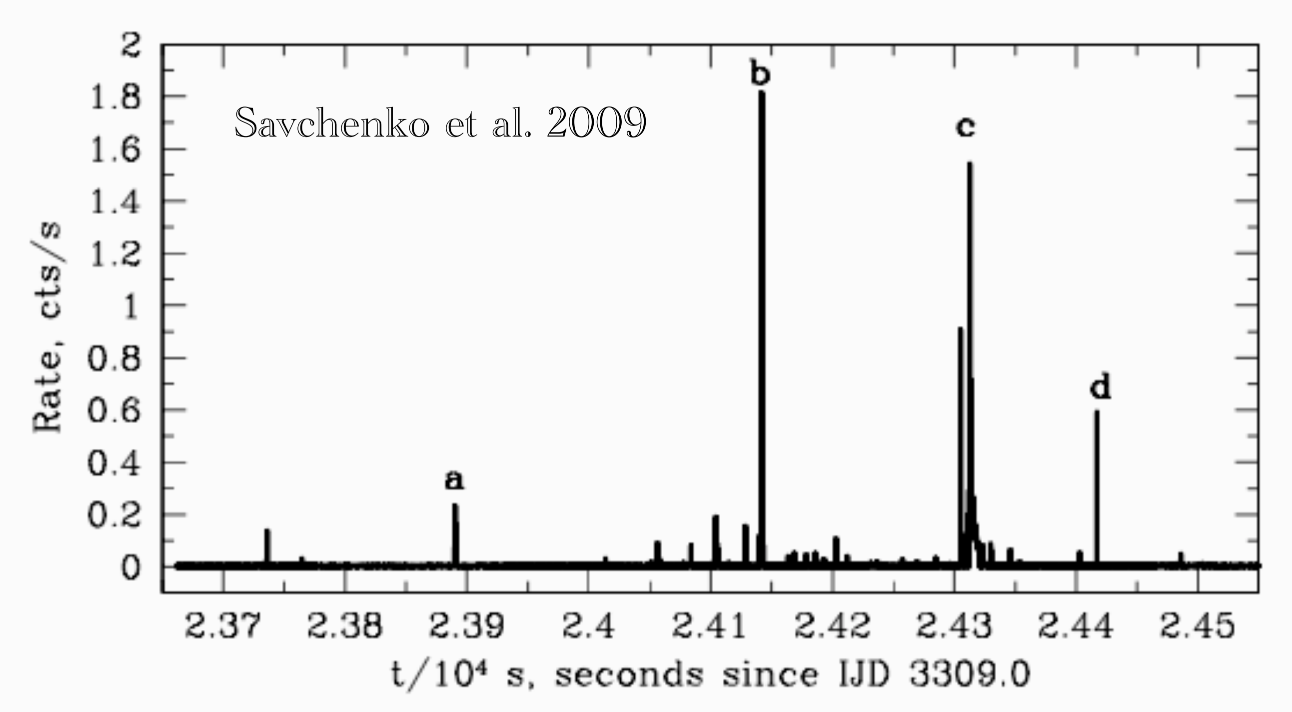


- INTEGRAL permits analysis of phase-resolved spectra
- Extreme spectral variations with *phase* discovered in the 1-200 keV emission:
  gradual change soft single powerlaw Γ=3.6→ complex multi-component shape → hard single powerlaw Γ=0.99

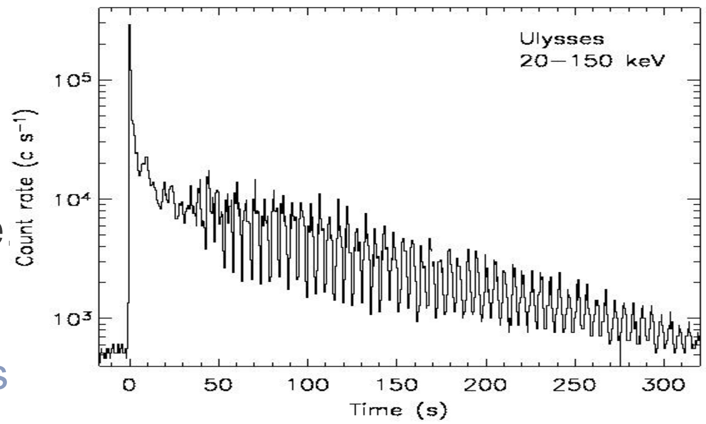
constraint on the topology of the magnetic field

results similar to 4U 0142+61 not explained under the standard magnetar model → more details neede in the model (e.g. more complexity in the geometry of the B field)

The strange case of 1E1547.0-5408

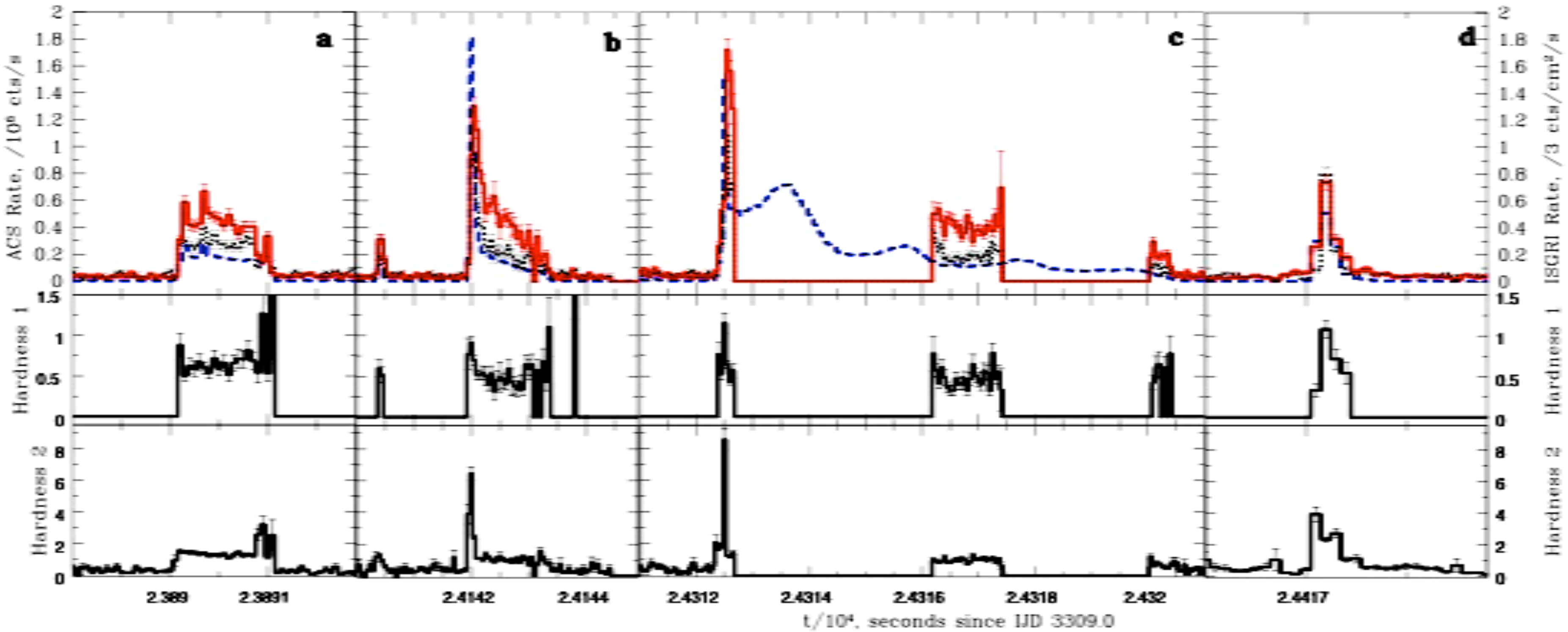


- X-ray source known since 1981, classified as AXP only in 2007 (Gelfand & Gaensler, ApJ)
- P = 2.07 s (smallest period among magnetars)
- The January 22, 2009 enhanced activity
  - major active episode detected by Swift
  - INTEGRAL was directed 60° away from the source
    - ACS of SPI detected ~200 bursts (0.1-10s)
- L > 10^{42} erg/s → >> L_{AXP}, comparable to SGR giant flares
- cluster of bursts typical of SGRs.



Hurley et al. 1999

A zoom on the 4 major bursts…



Savchenko et al. 2009

from the 2 dataset it is possible to extract information on HR, statistical analysis on burst duration, time interval between the bursts

The burst timing characteristics can be followed very well.

References:

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