The X-ray timing behavior of γ-ray pulsars: J1741-2054 and J1813-1246

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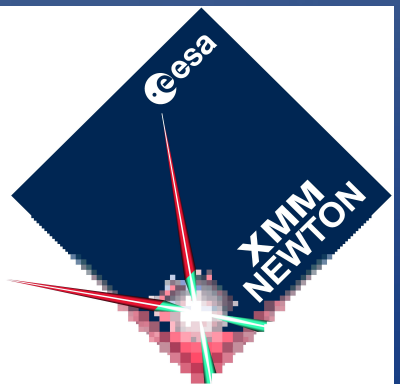
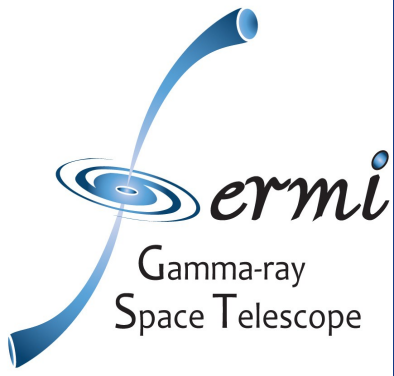
(marelli@lambrate.inaf.it)

on behalf of the Fermi-LAT collaboration



(Marelli et al. ArXiv 1404.1532)
(Marelli et al. in publication)

The X-ray Universe 2014 - Dublin



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- This would also allow us to localize the emitting region(s) responsible for the non-thermal X-ray emission

X-ray pulsations from NSs

Takata&Chang2007,Harding+2008 modelled the aligned X-ray and γ-ray peaks of the Crab pulsar:

High-altitude curvature, synchrotron, and inverse Compton radiation of both primary electrons and pairs is expected to produce a broad spectrum of emission from infrared to GeV energies => non-thermal X rays

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BUT in the last years we discovered many new X-ray pulsars!

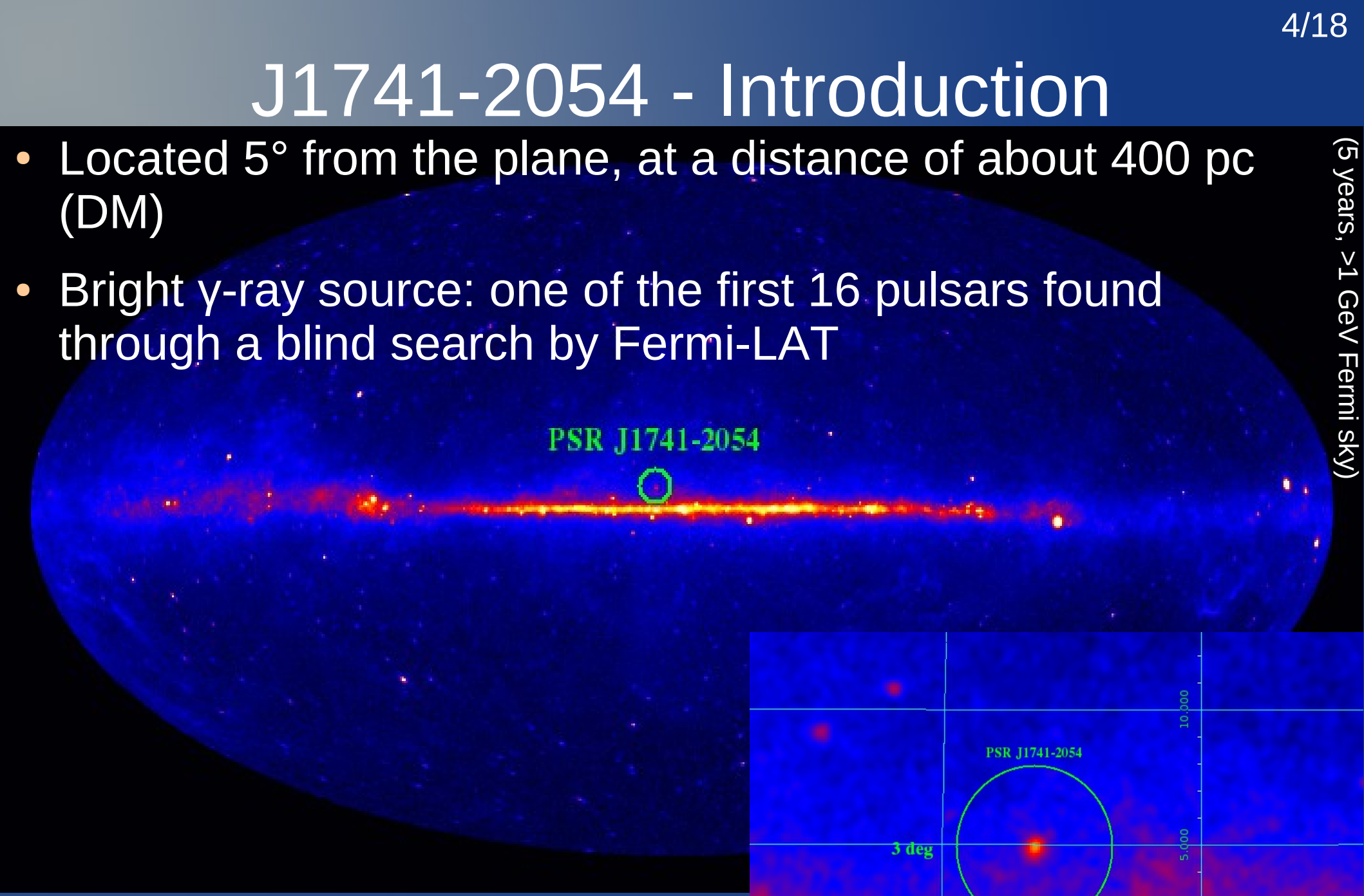
Before Fermi (2008):	Now (2014):
YP: 47 detected, 25 pulsating	92 detected, 40 pulsating
MSP: 41 detected, 10 pulsating	55 detected, 10 pulsating

Now we are facing more and more high-resolution

X-ray light curves!

J1741-2054 - Introduction

- Located 5° from the plane, at a distance of about 400 pc (DM)
- Bright γ-ray source: one of the first 16 pulsars found through a blind search by Fermi-LAT



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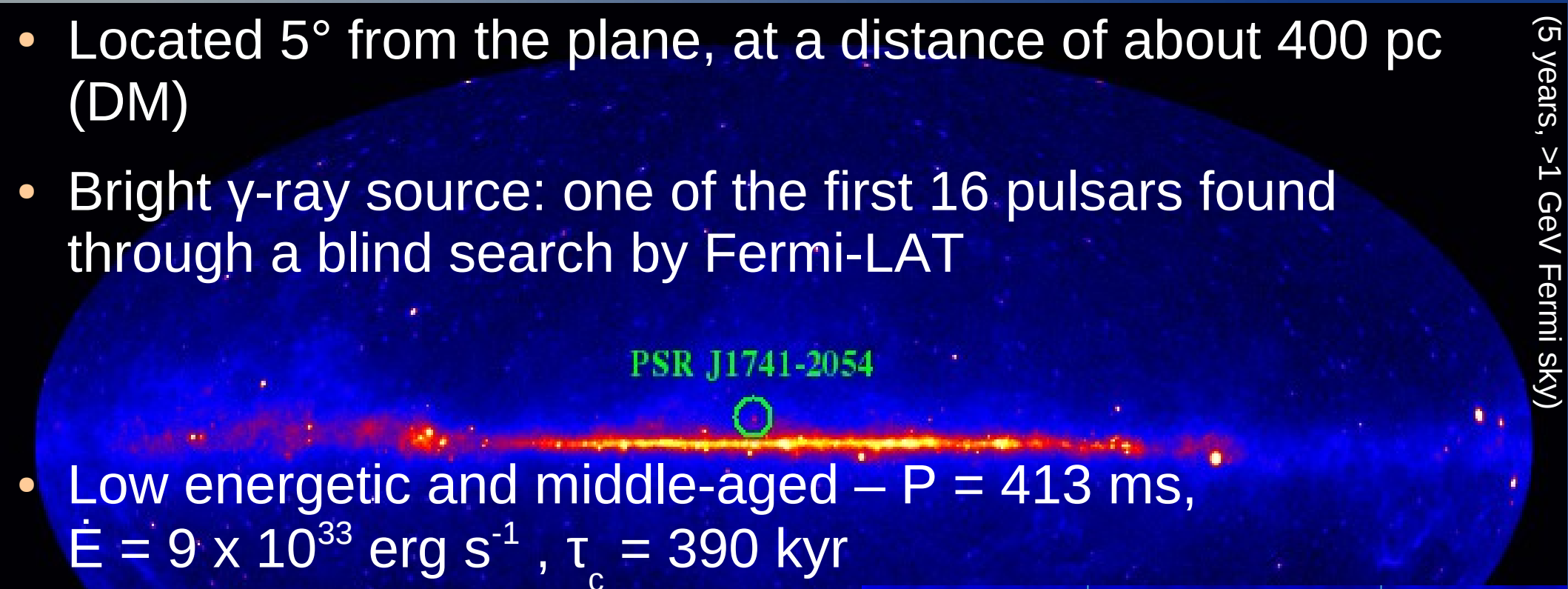
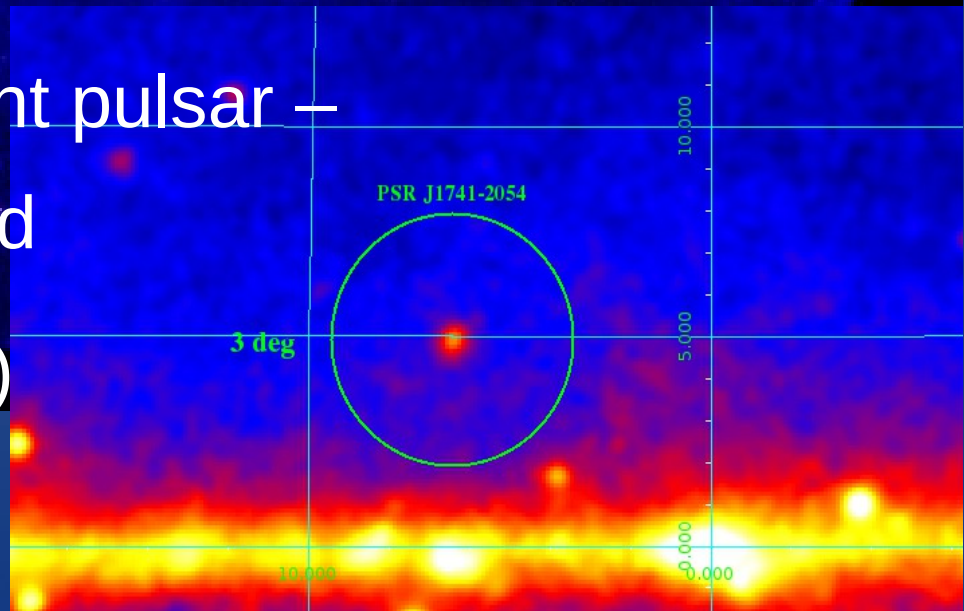


- Low energetic and middle-aged – P = 413 ms, $\dot{E} = 9 \times 10^{33}$ erg s^{-1} , τ_c = 390 kyr
- Parkes detected it as a radio-faint pulsar –

  flux density$_{(1400MHz)}$ = 0.16 mJy and

  DM = 4.7 pc cm^{-3} (Camilo+2009)



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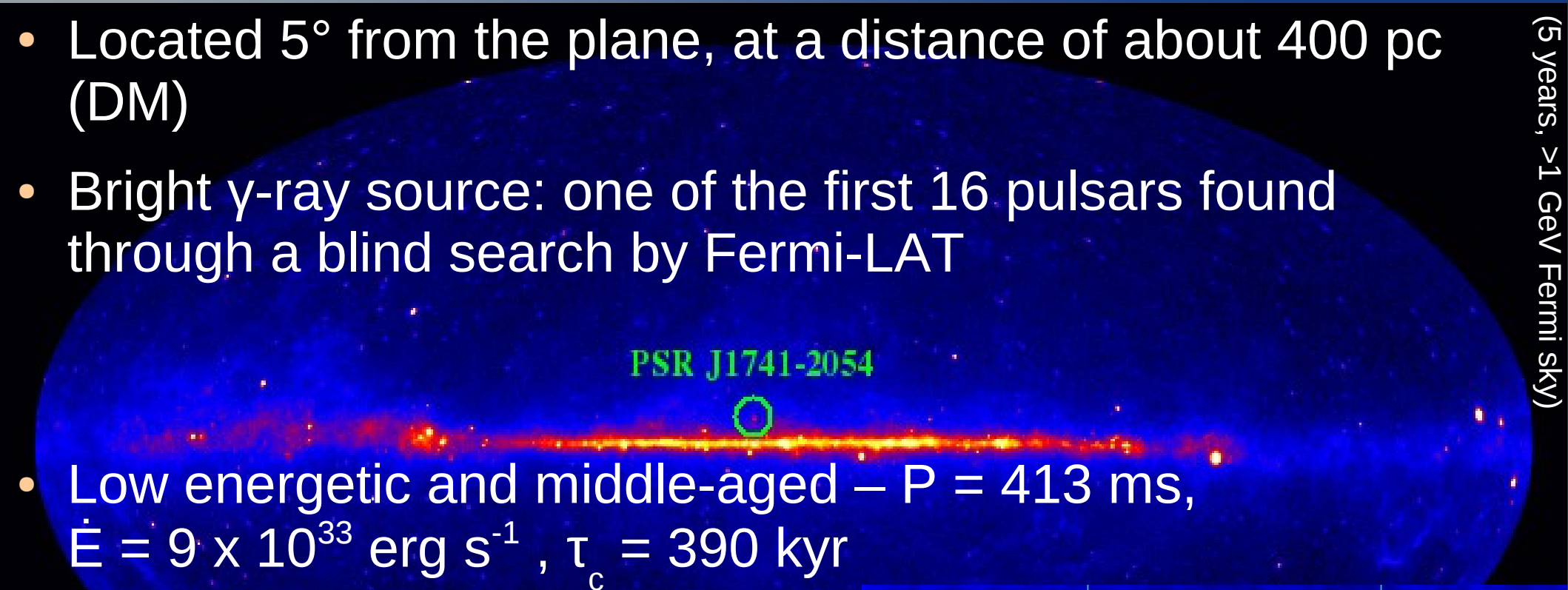

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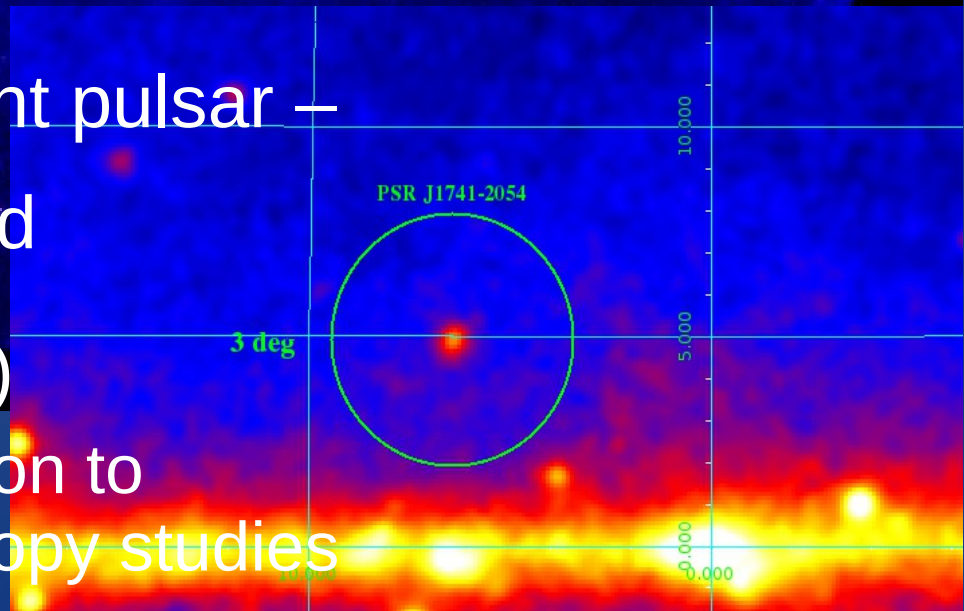
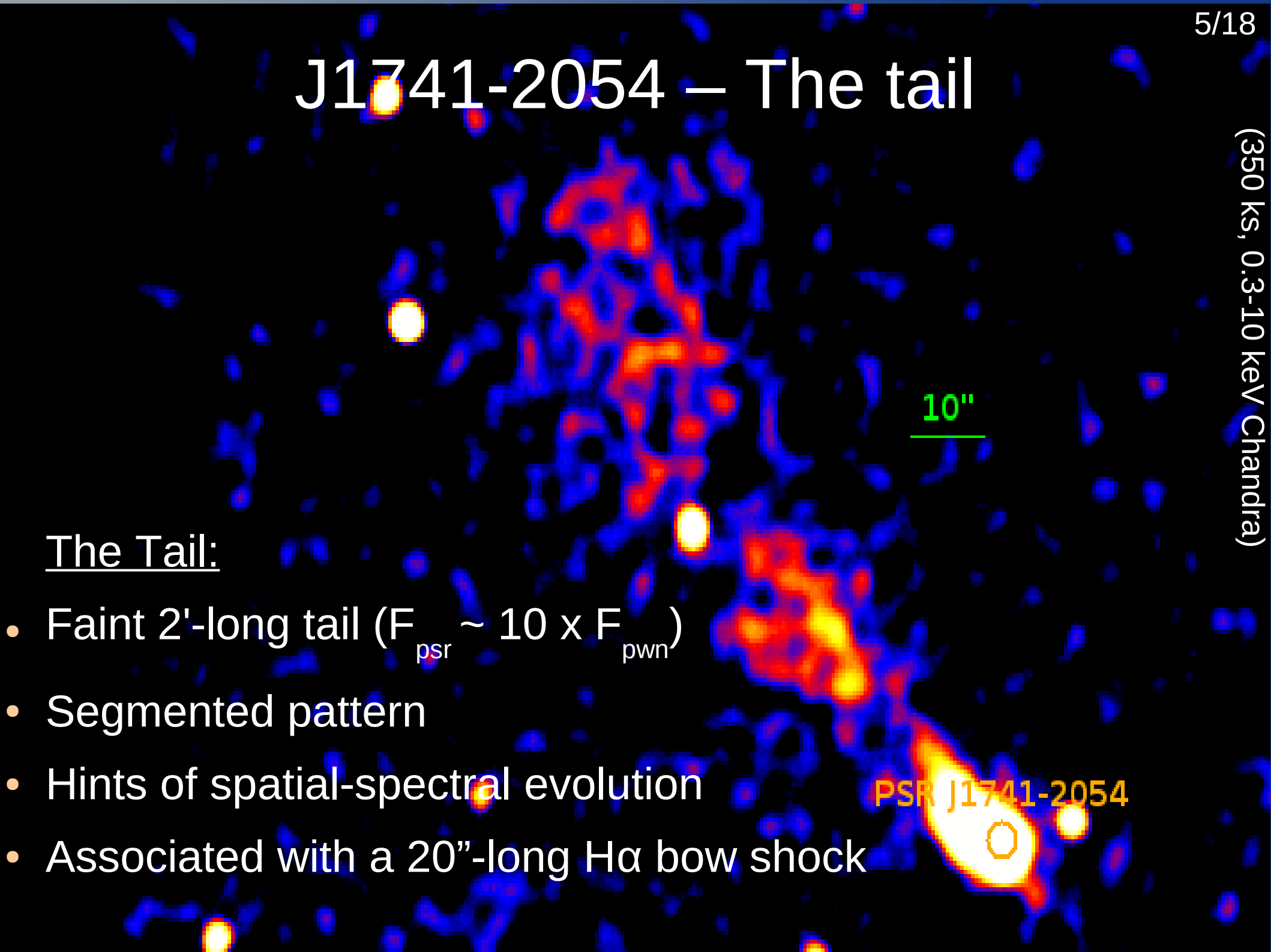


- New deep XMM-Newton observation to perform phase-resolved spectroscopy studies

J1741-2054 – The tail

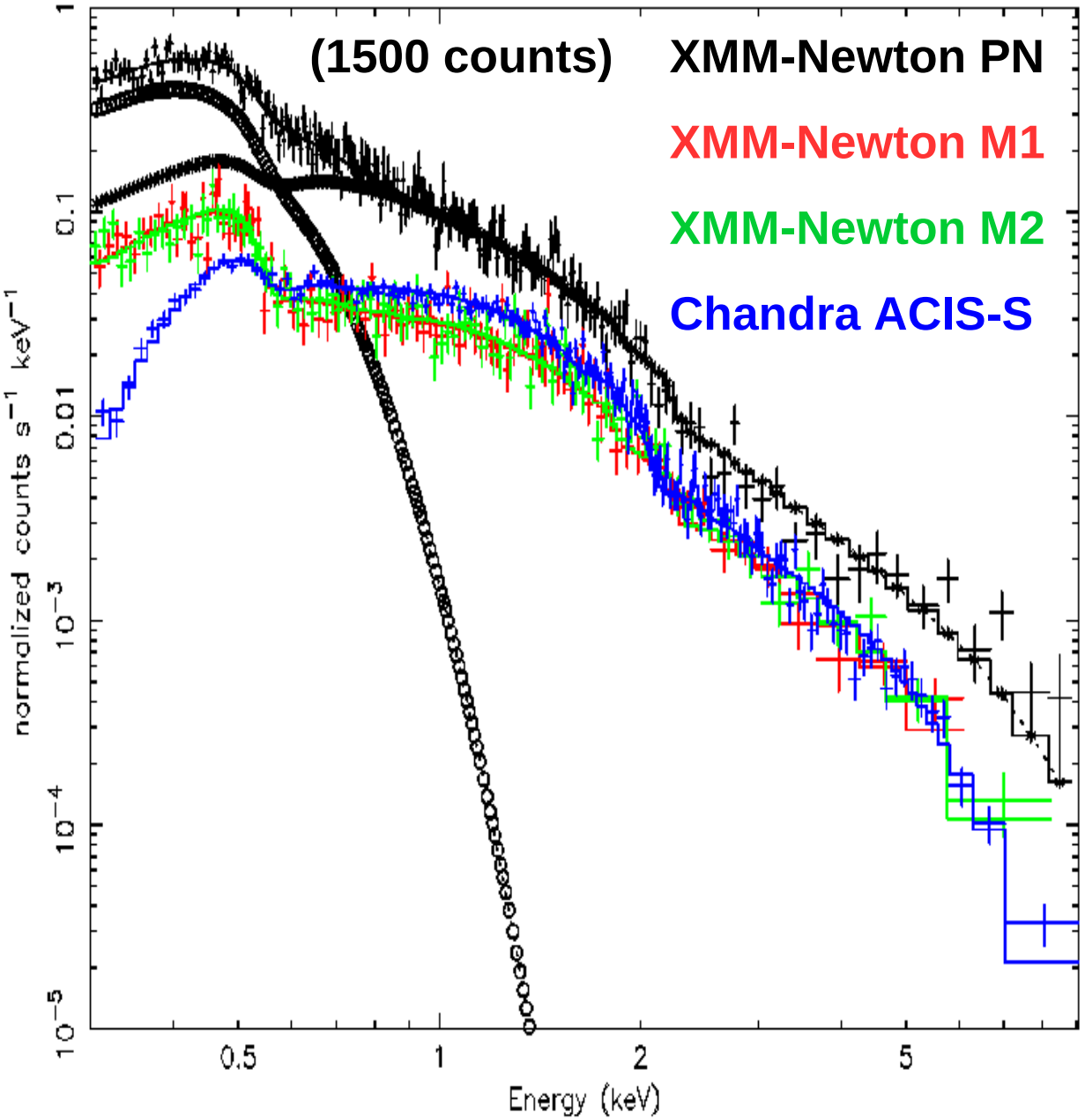


(350 ks, 0.3-10 keV Chandra)

<u>The Tail:</u>

- Faint 2'-long tail ($F_{psr} \sim 10 \times F_{pwn}$)
- Segmented pattern
- Hints of spatial-spectral evolution
- Associated with a 20”-long Hα bow shock

J1741-2054 – The pulsar (1)



Composite spectrum:

Thermal – BB with $T=(7.1\pm0.2) \times 10^5$ K, $R_{380pc}=5.4\pm0.5$ km $F_{th}=(5.5\pm0.1) \times 10^{-13}$ erg cm^{-2} s^{-1}

+

Non-thermal – PL with $\Gamma=2.75\pm0.03$, $F_{nth}=(7.7\pm0.2) \times 10^{-13}$ erg cm^{-2} s^{-1}

$n_H=(1.21\pm0.01) \times 10^{21}$ cm^{-2}

J1741-2054 – The pulsar (2)

- Weighted/Unweighted MCMC:

  $H\text{-value}_y = 4800$

  $H\text{-value}_x = 585$

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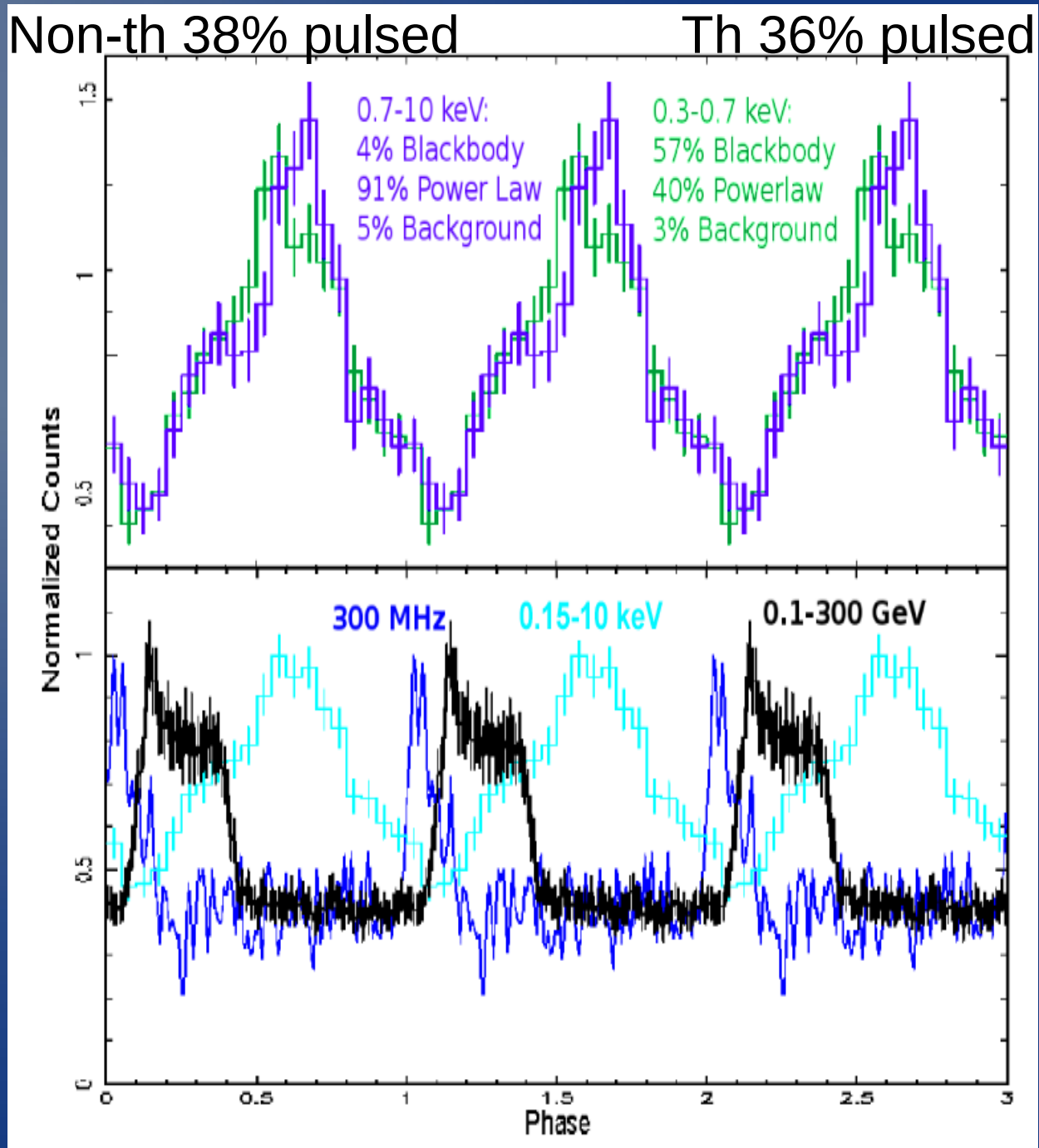
- BB and PL ~40% pulsed
- Thermal and non-thermal peaks in phase



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  $H\text{-value}_y = 4800$

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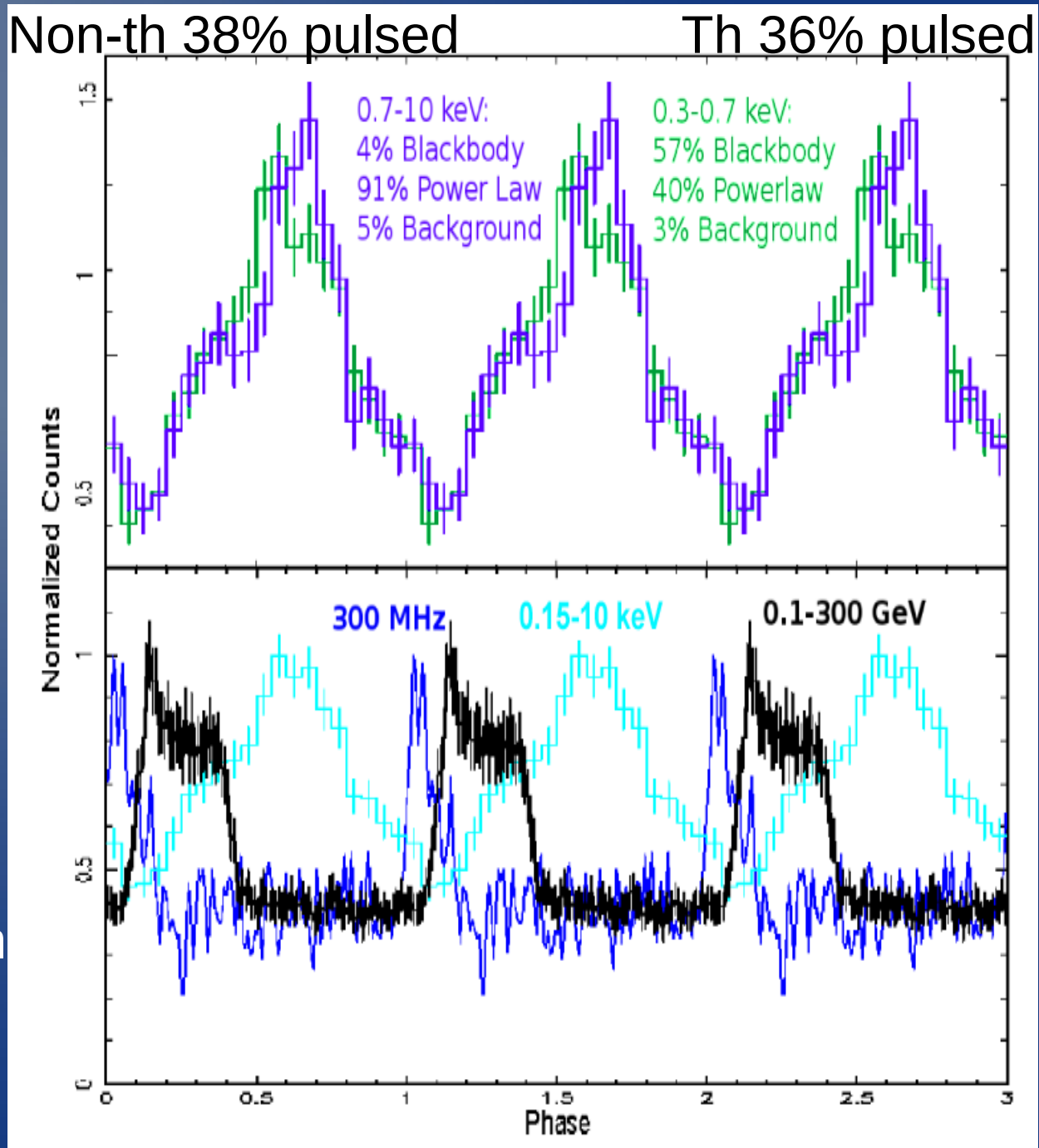
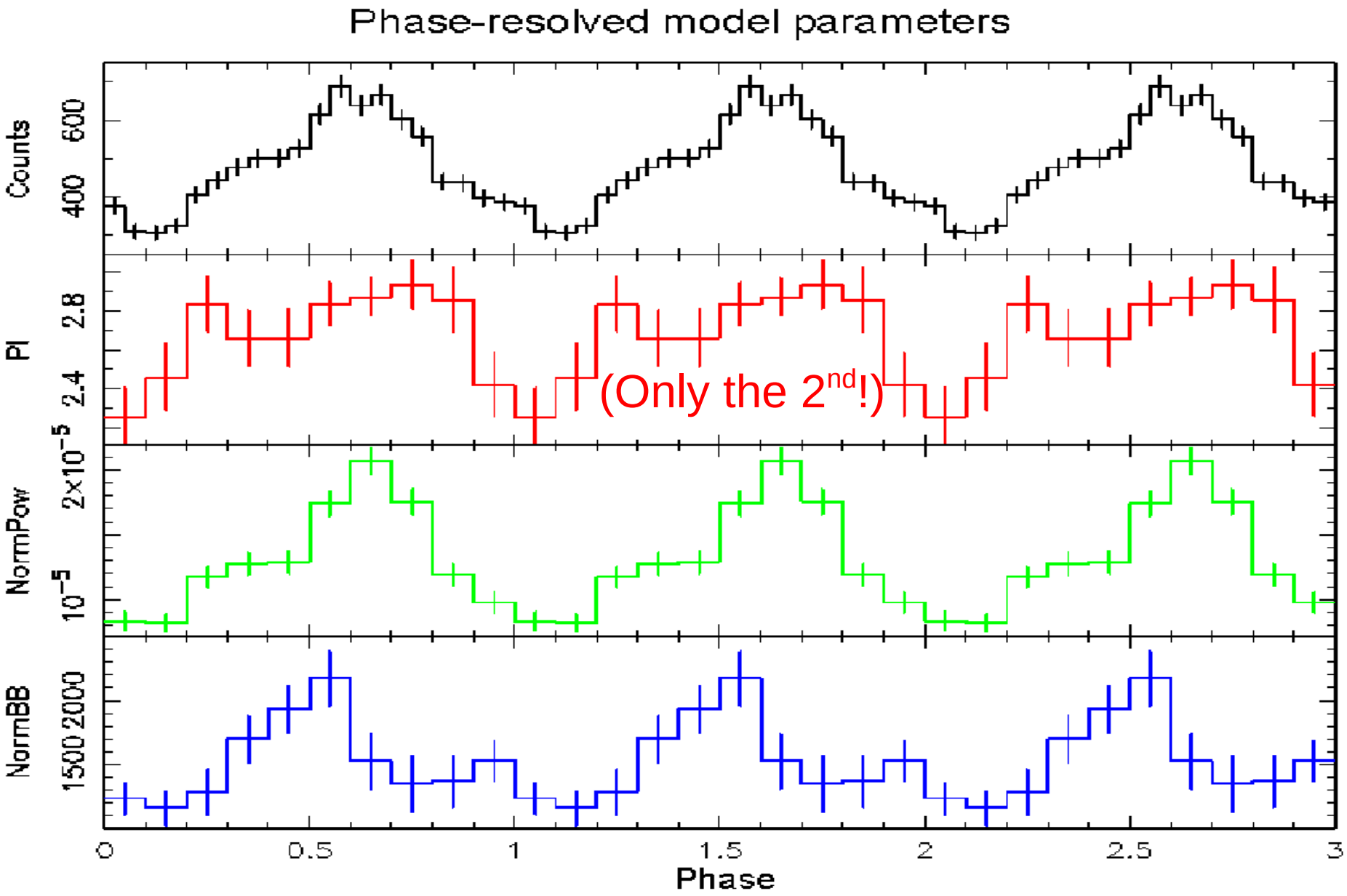
- BB and PL ~40% pulsed
- Thermal and non-thermal peaks in phase
- X, radio, γ-ray peaks out of phase
- No γ-ray spectral variation with phase
- X-ray spectral variation with phase

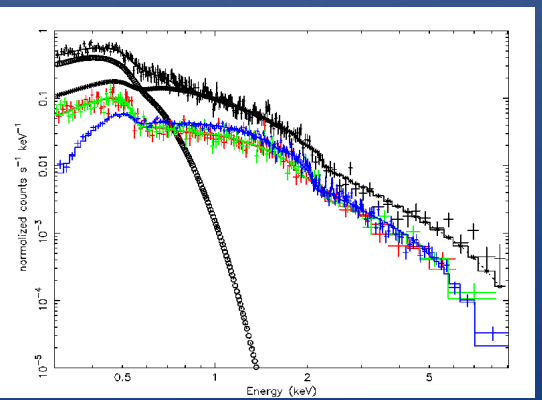


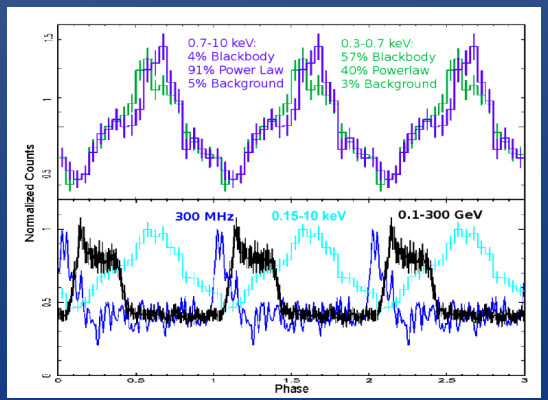
J1741-2054 – phase-resolved analysis

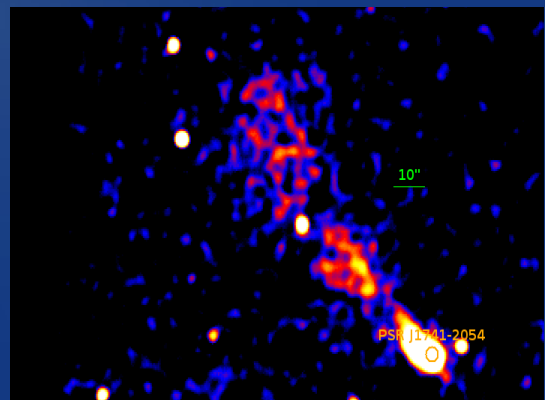


J1741-2054 – Conclusions
(Middle-aged, nearby pulsar)

- Composite thermal+non-thermal spectrum
- Both the components are 35-40% pulsed
- The two components peaks are aligned (within 0.1 ph)
- 2nd pulsar (after the Crab) to show X-ray photon index variation with phase: not clear why
- Radio, X-ray and γ-ray peaks not aligned (unlike the Crab): the model cannot account for the X-γ phase lag



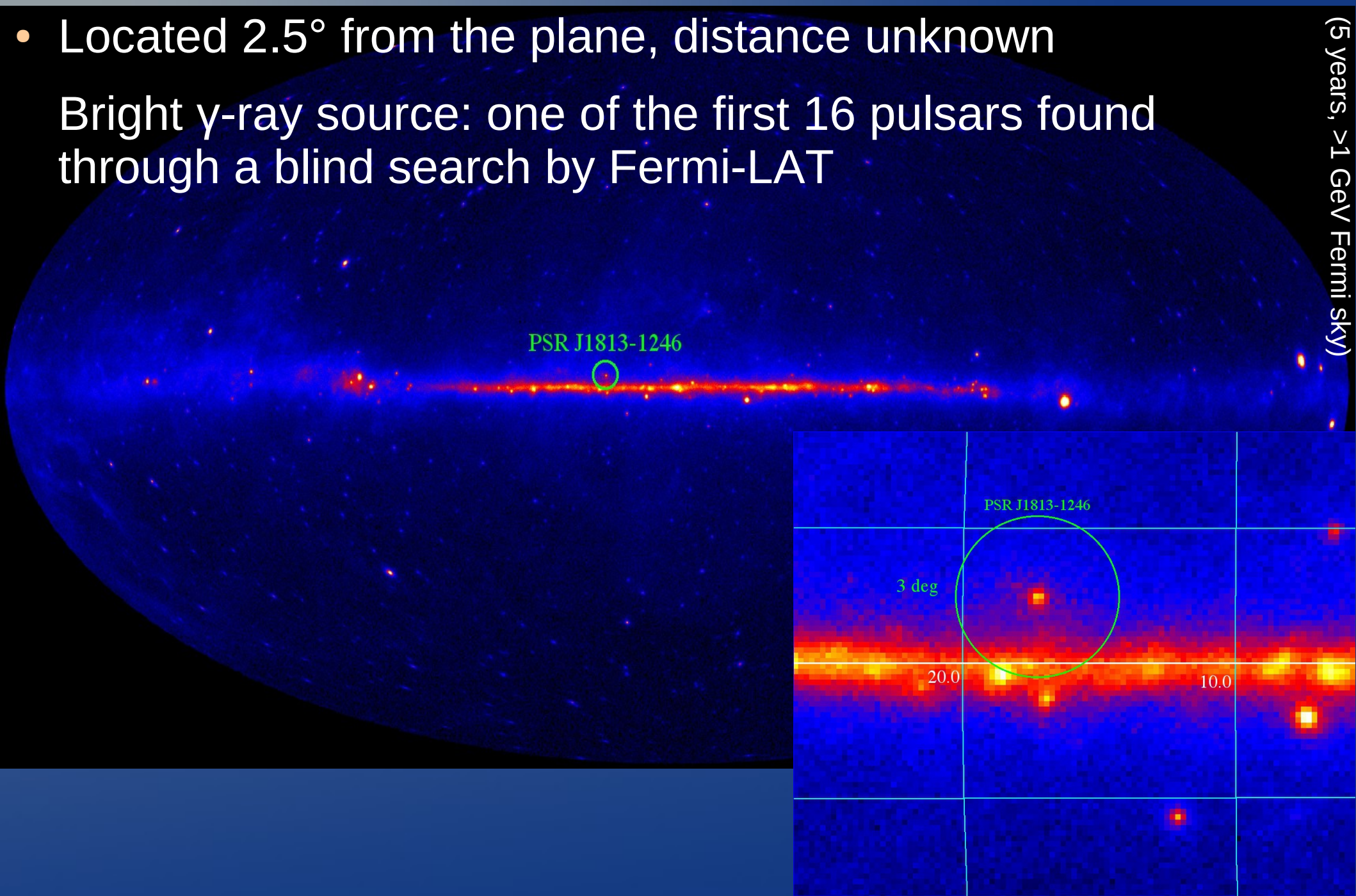




J1813-1246 – Introduction

- Located 2.5° from the plane, distance unknown

Bright γ-ray source: one of the first 16 pulsars found through a blind search by Fermi-LAT



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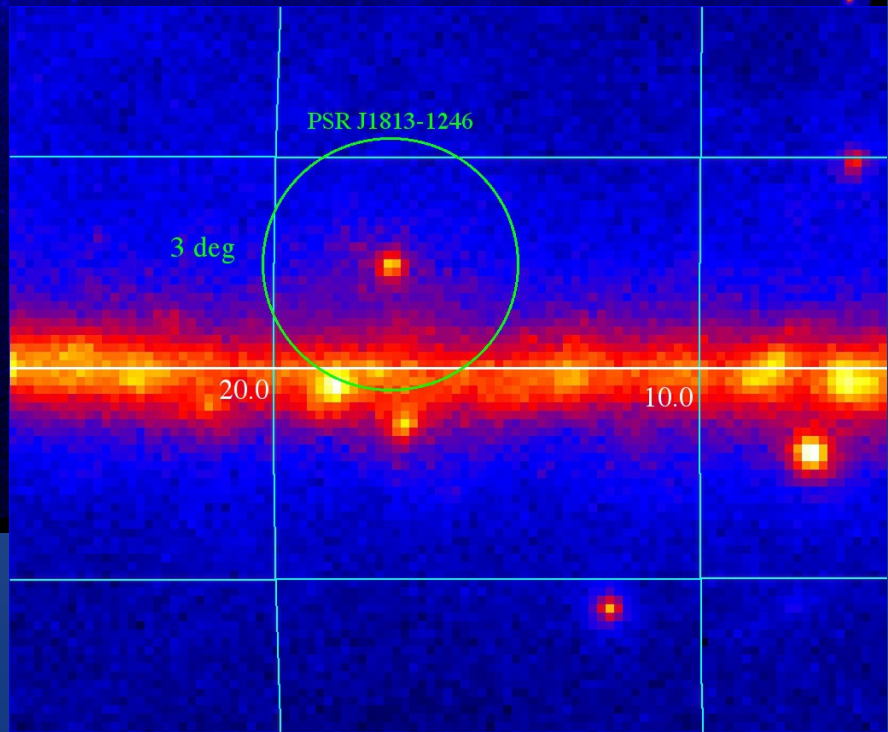

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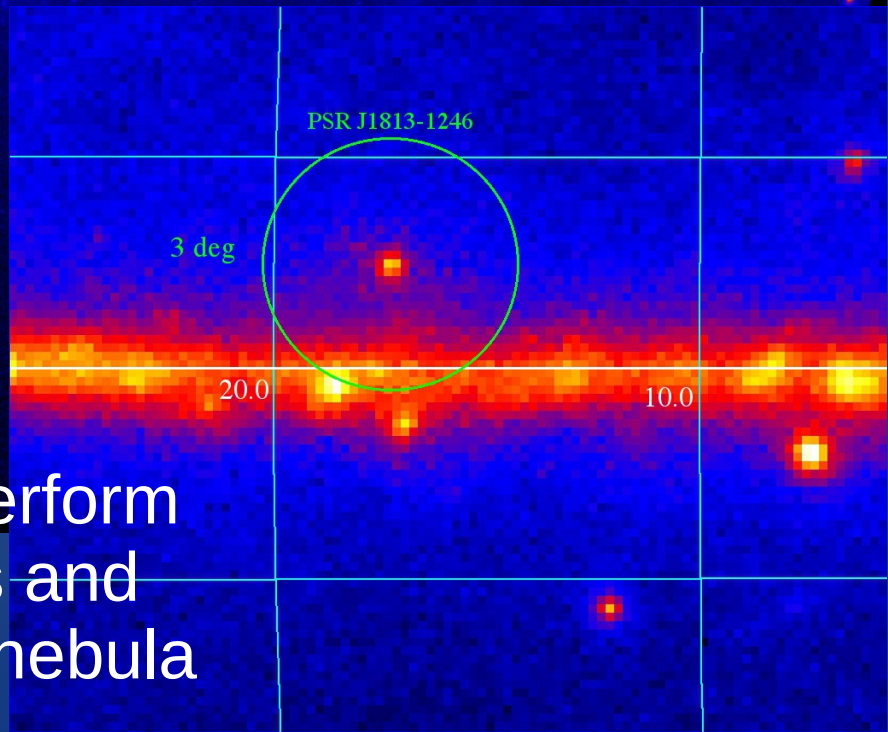
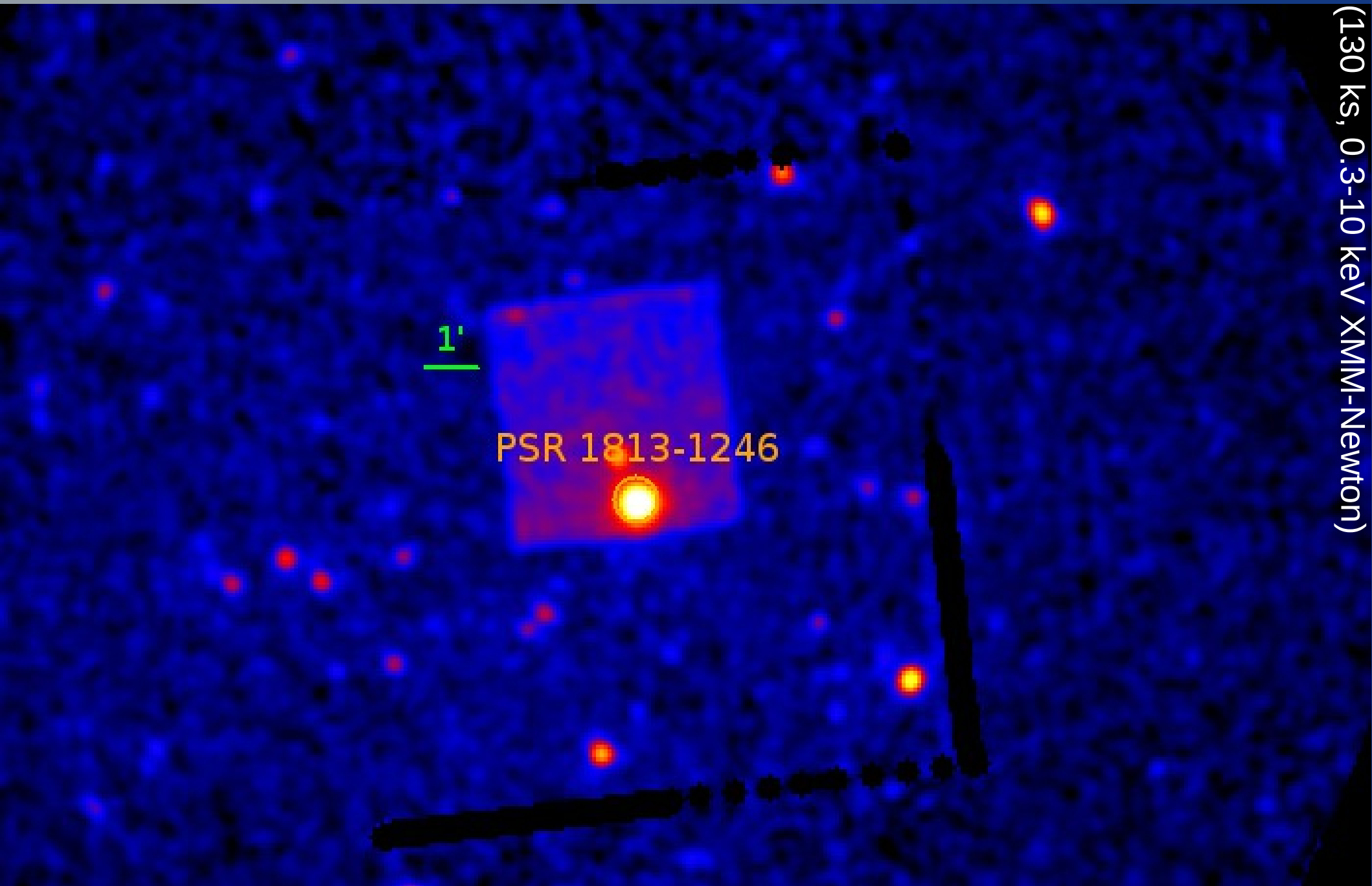


- Deep XMM-Newton observation to perform phase-resolved spectroscopy studies and Chandra observation to search for a nebula

J1813-1246 – Imaging



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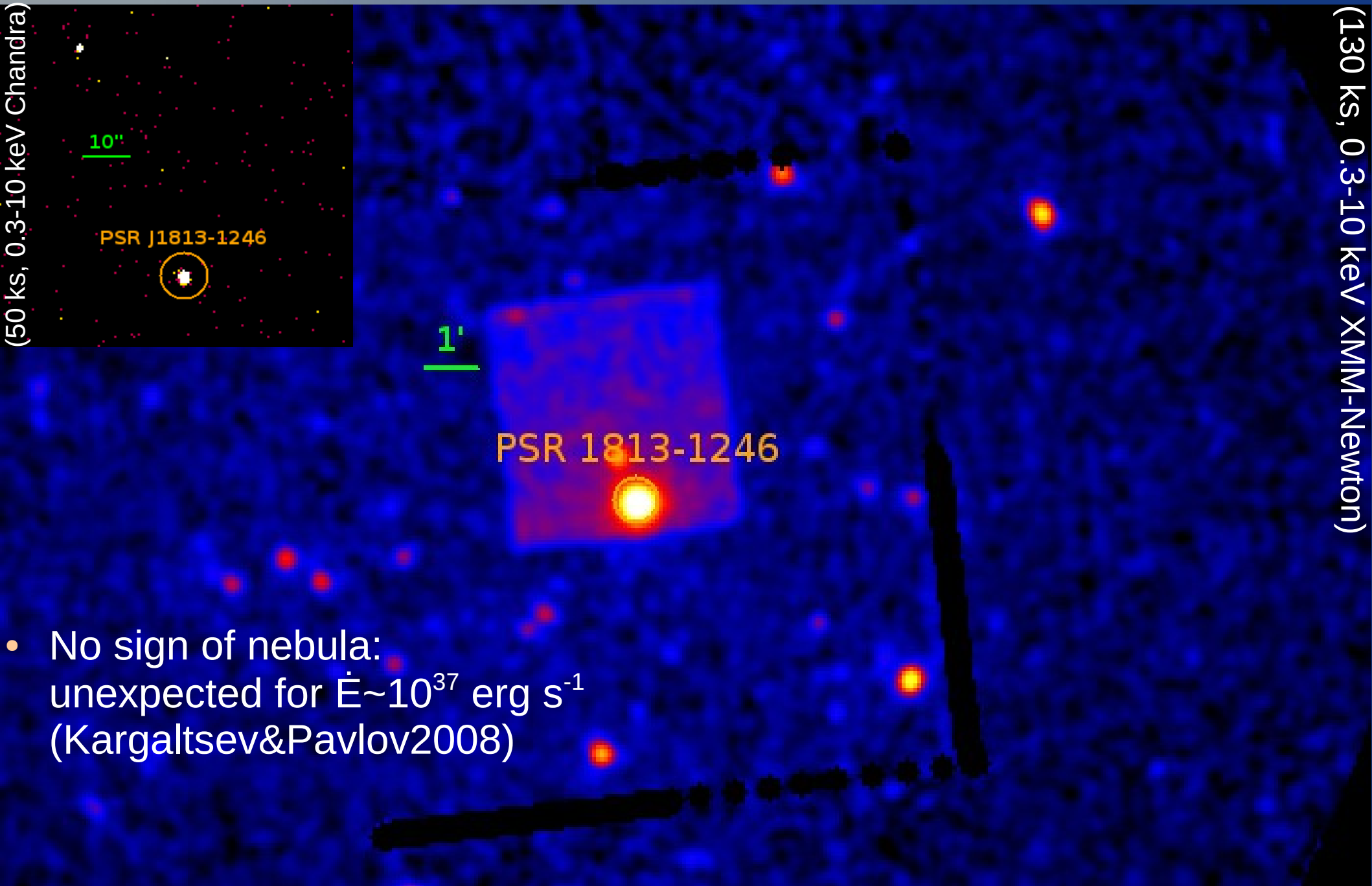

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  unexpected for $\dot{E} \sim 10^{37}$ erg s^{-1}
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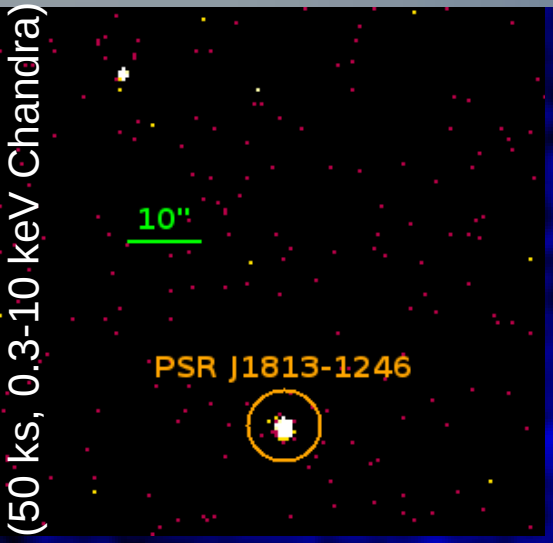


(50 ks, 0.3-10 keV Chandra)

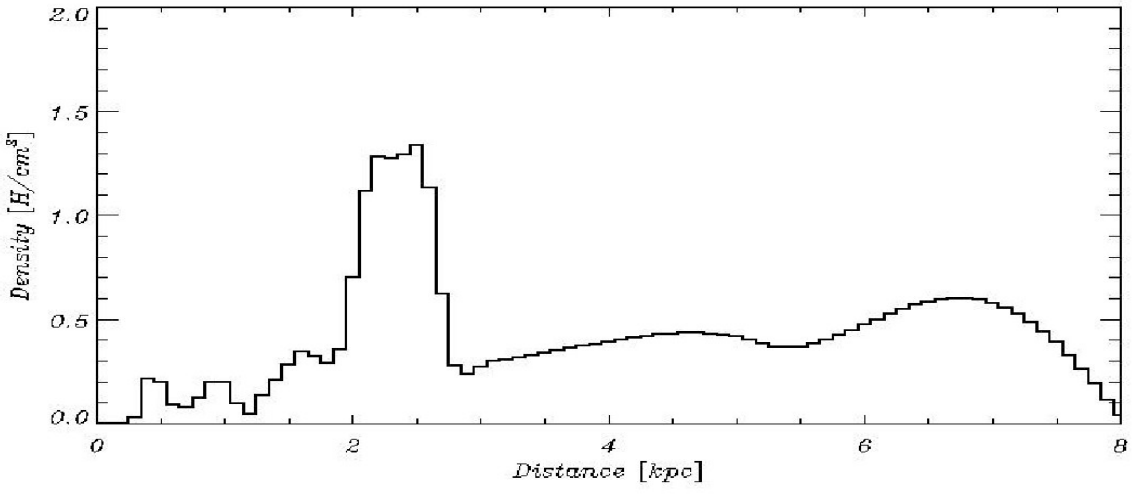
1'

PSR 1813-1246

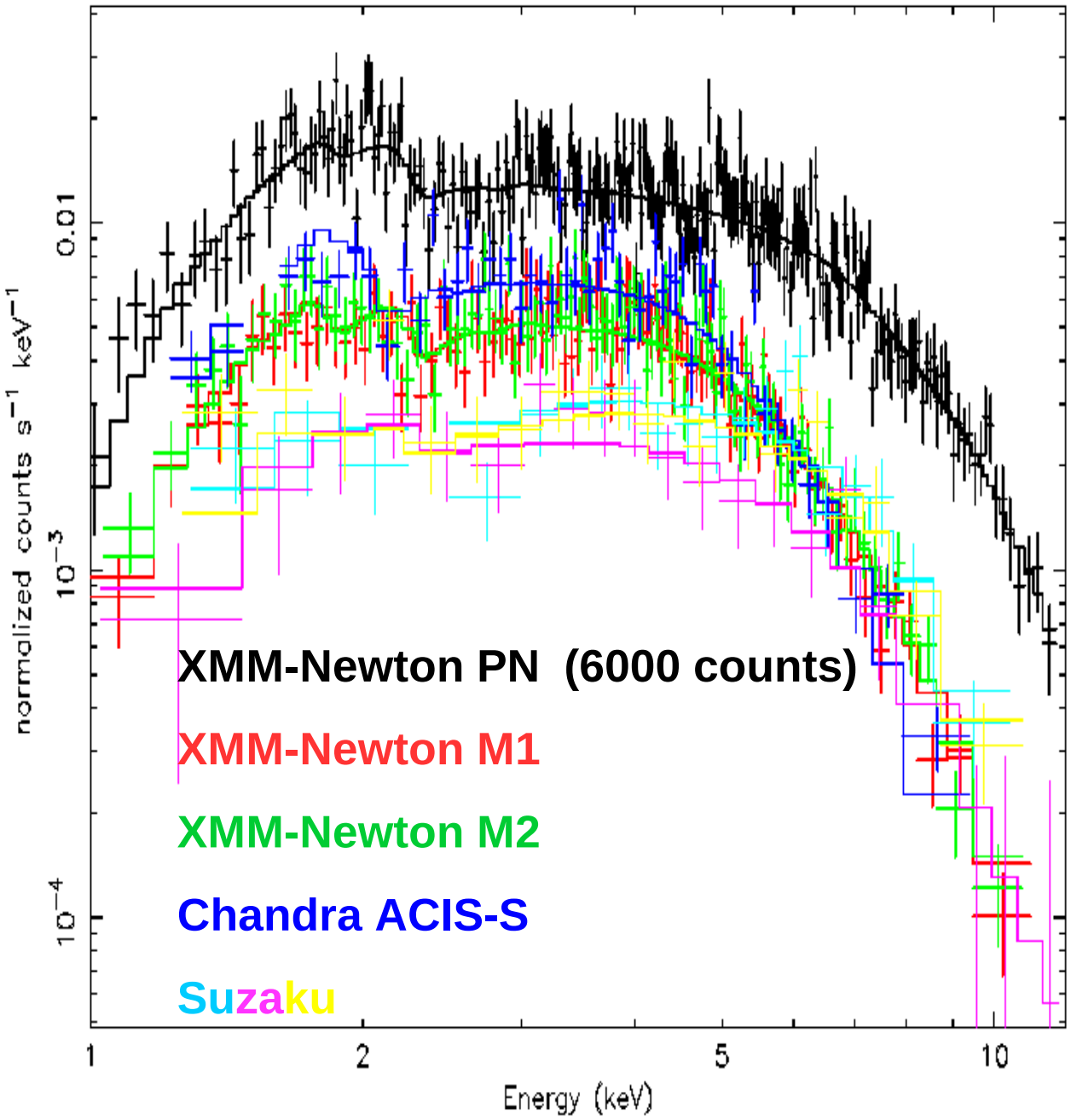
(130 ks, 0.3-10 keV XMM-Newton)

- Optical, IR and Radio observations revealed the presence of thick dark clouds located at about 2.5 kpc => the X-ray absorption is a powerful method for distance extimate

- No sign of nebula: unexpected for $\dot{E} \sim 10^{37}$ erg s^{-1} (Kargaltsev&Pavlov2008)



J1813-1246 – X-ray spectrum



- VERY absorbed

  $n_H=(1.56\pm0.07)\times10^{22}$ cm^{-2}

  => beyond the clouds

  (D>2.5kpc)

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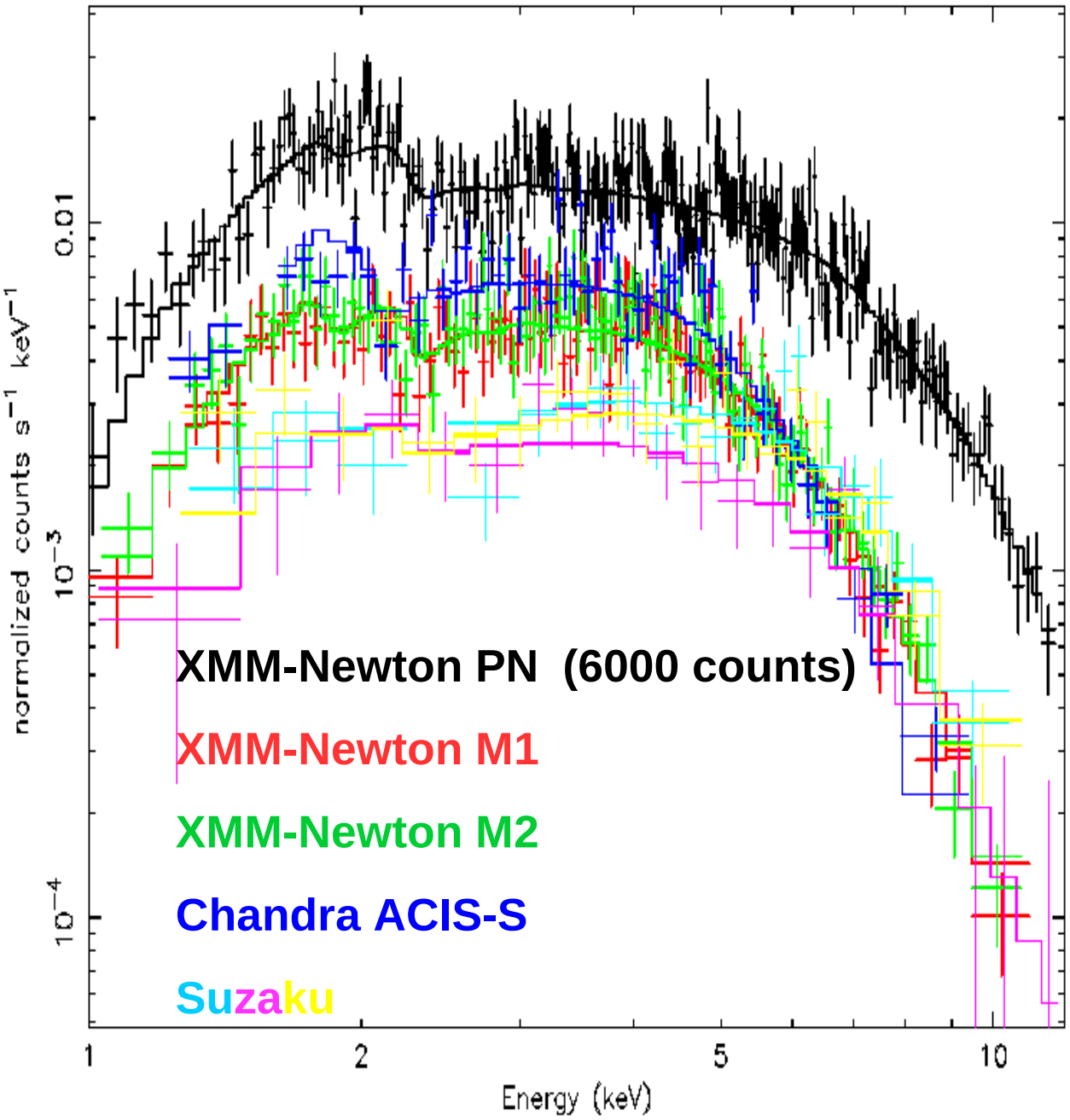

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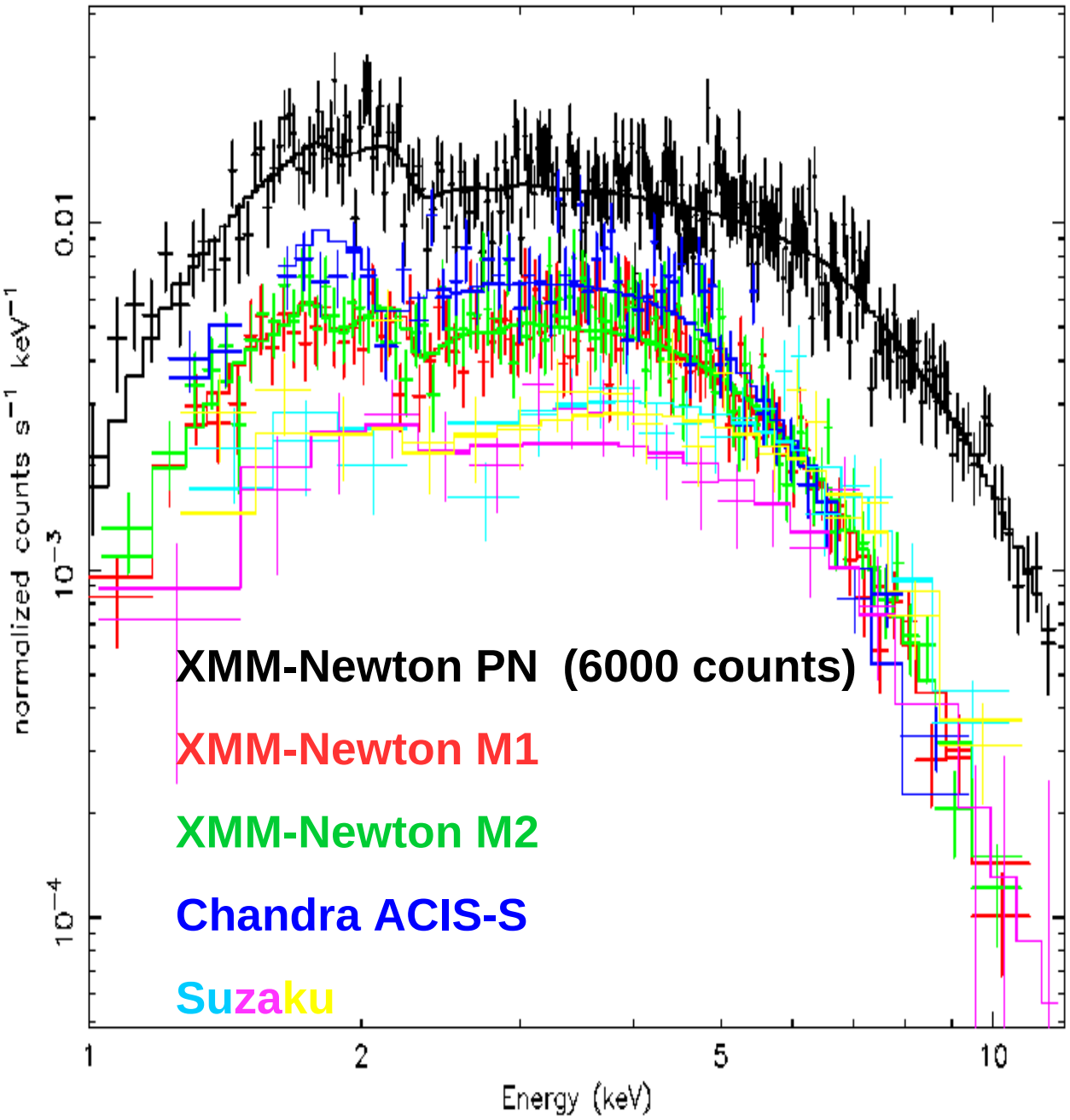

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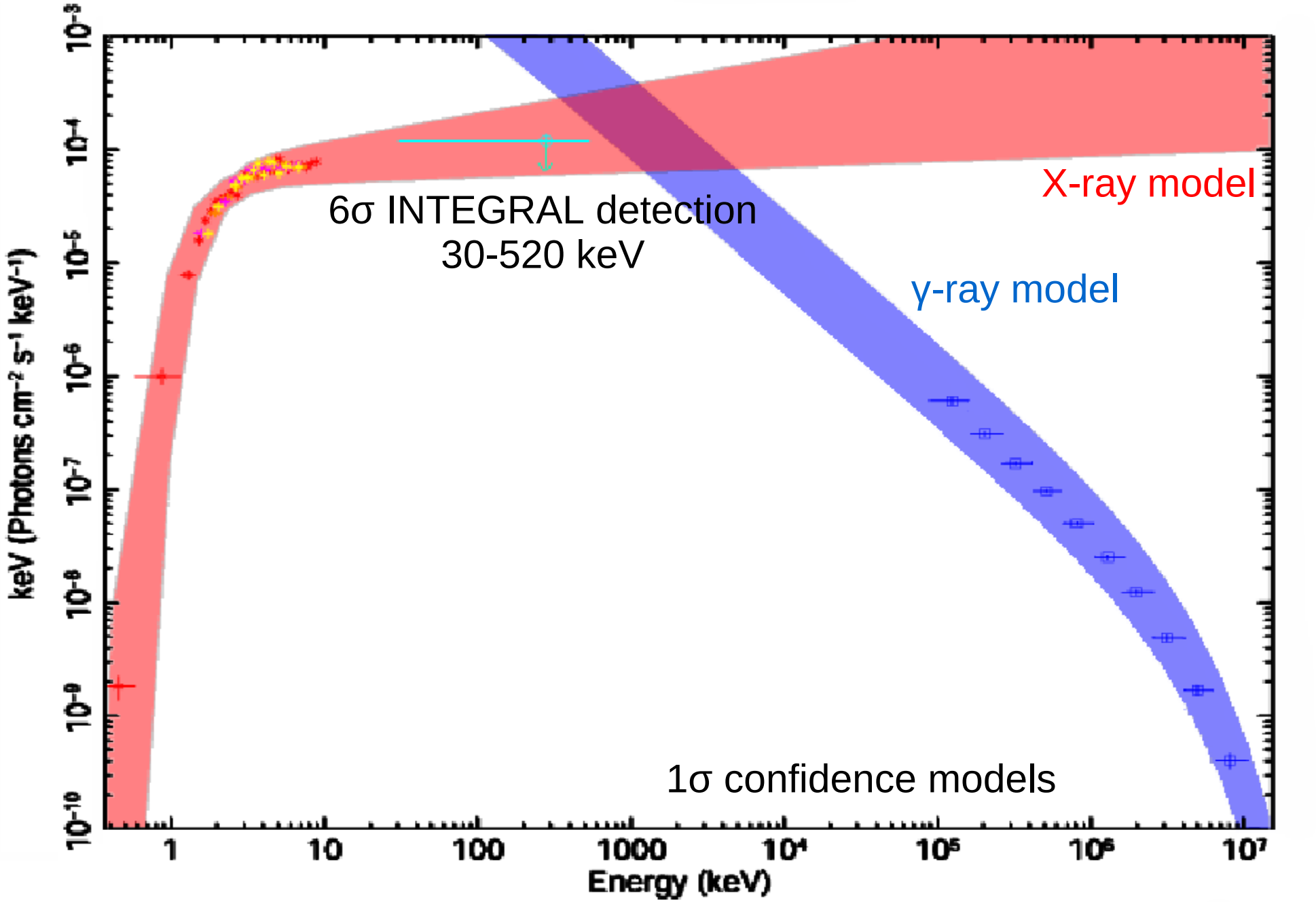
- The brightest non-thermal emission from a radio-quiet pulsar:

  $F=(1.08\pm0.01) \times 10^{-12}$ erg cm^{-2} s^{-1}

J1813-1246 – Energy Spectrum



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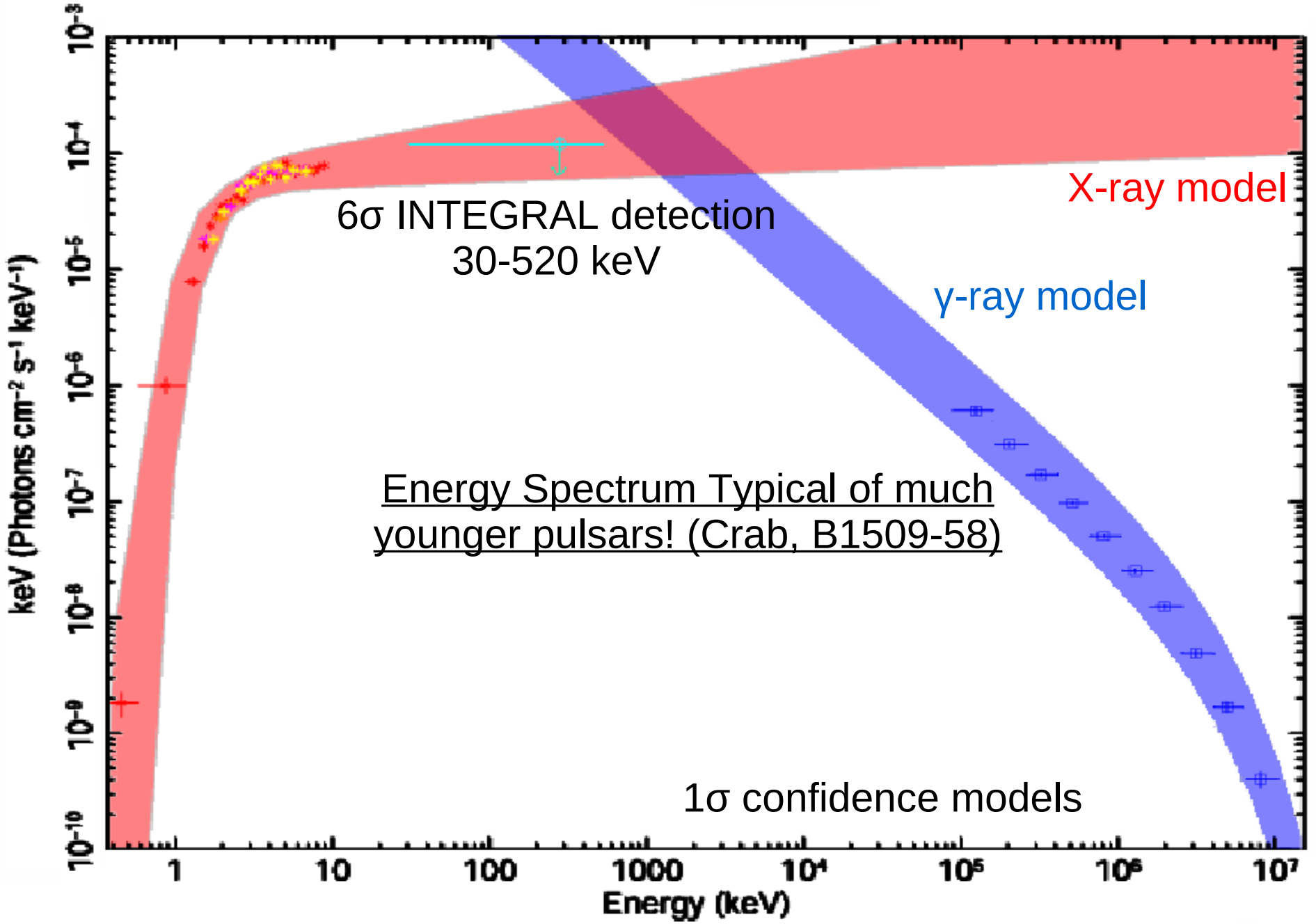

PRELIMINARY!

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- Weighted MCMC: we built 5-years ephemeris
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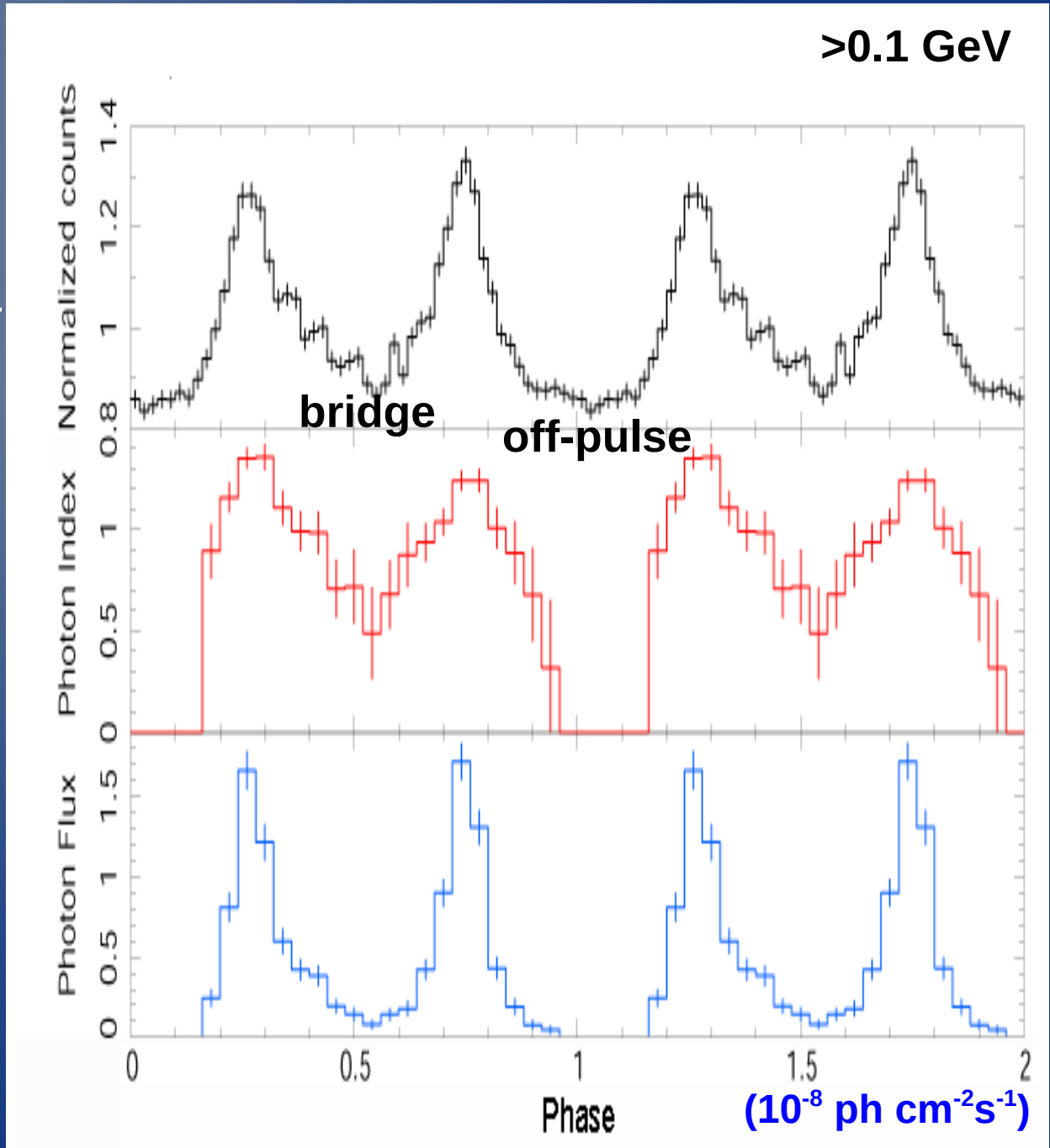

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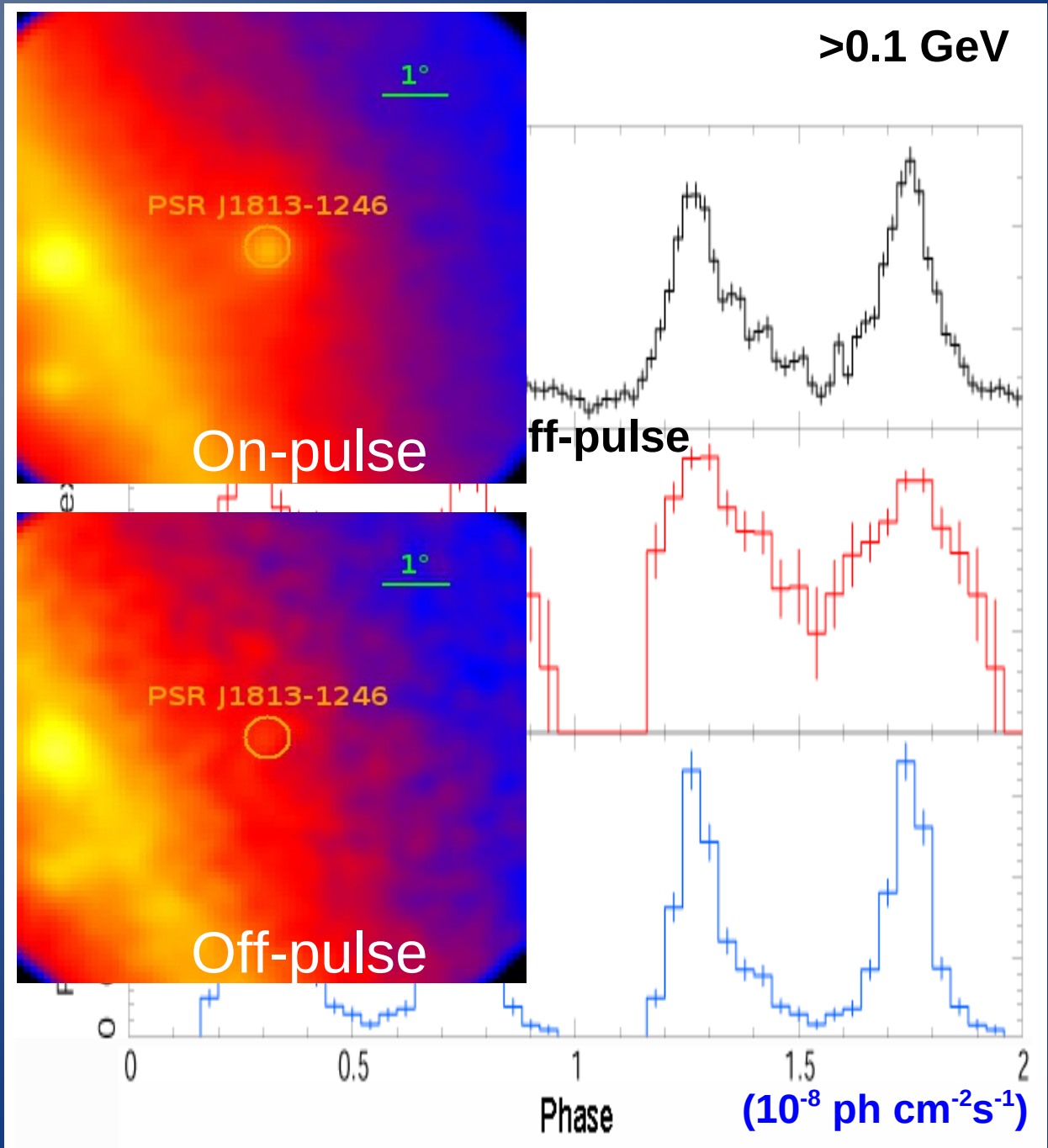

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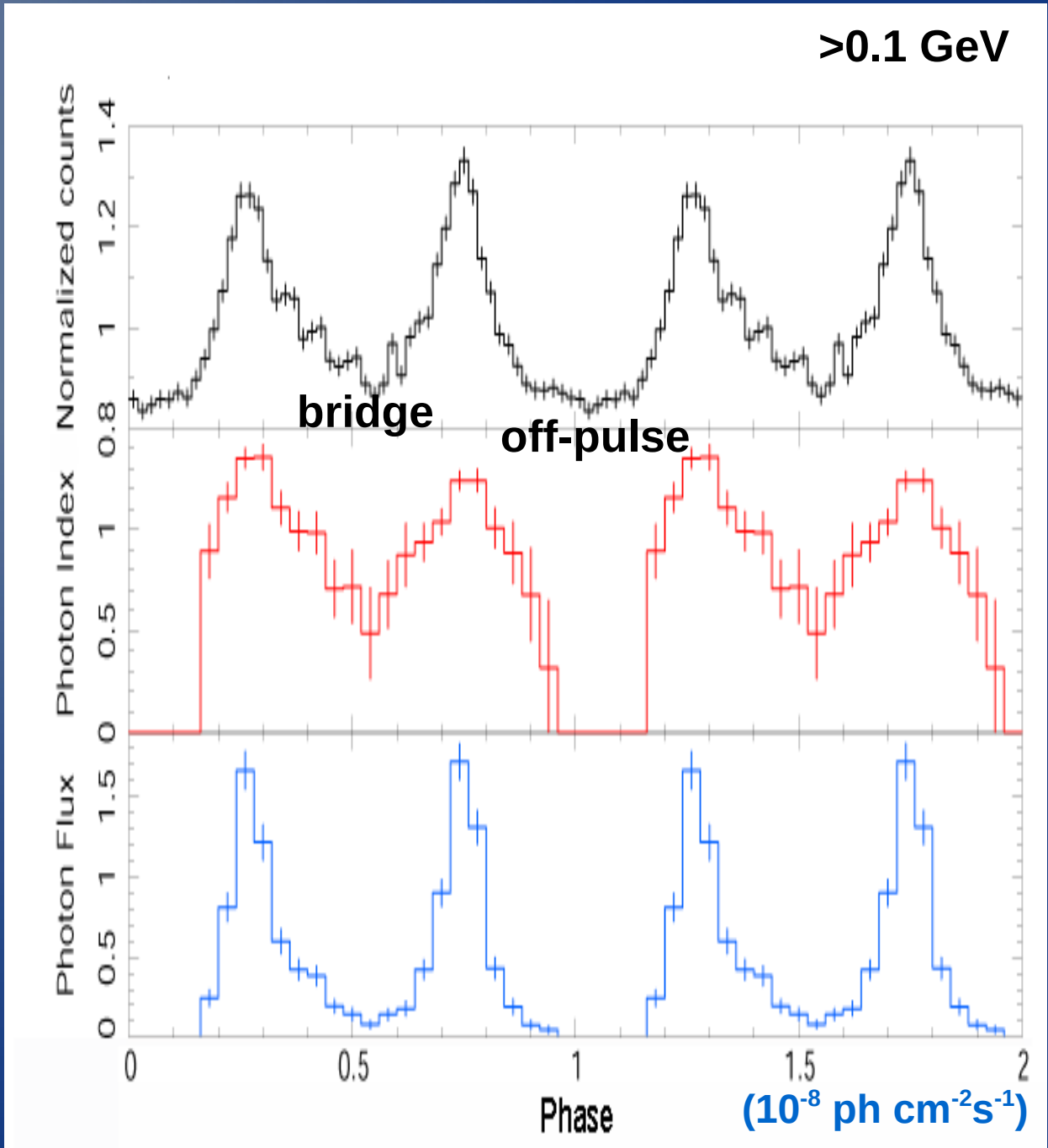
- Very significant (>>10σ) spectral variation with phase, mainly due to Γ, with softening during peaks



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  PF = (96 ± 3) %
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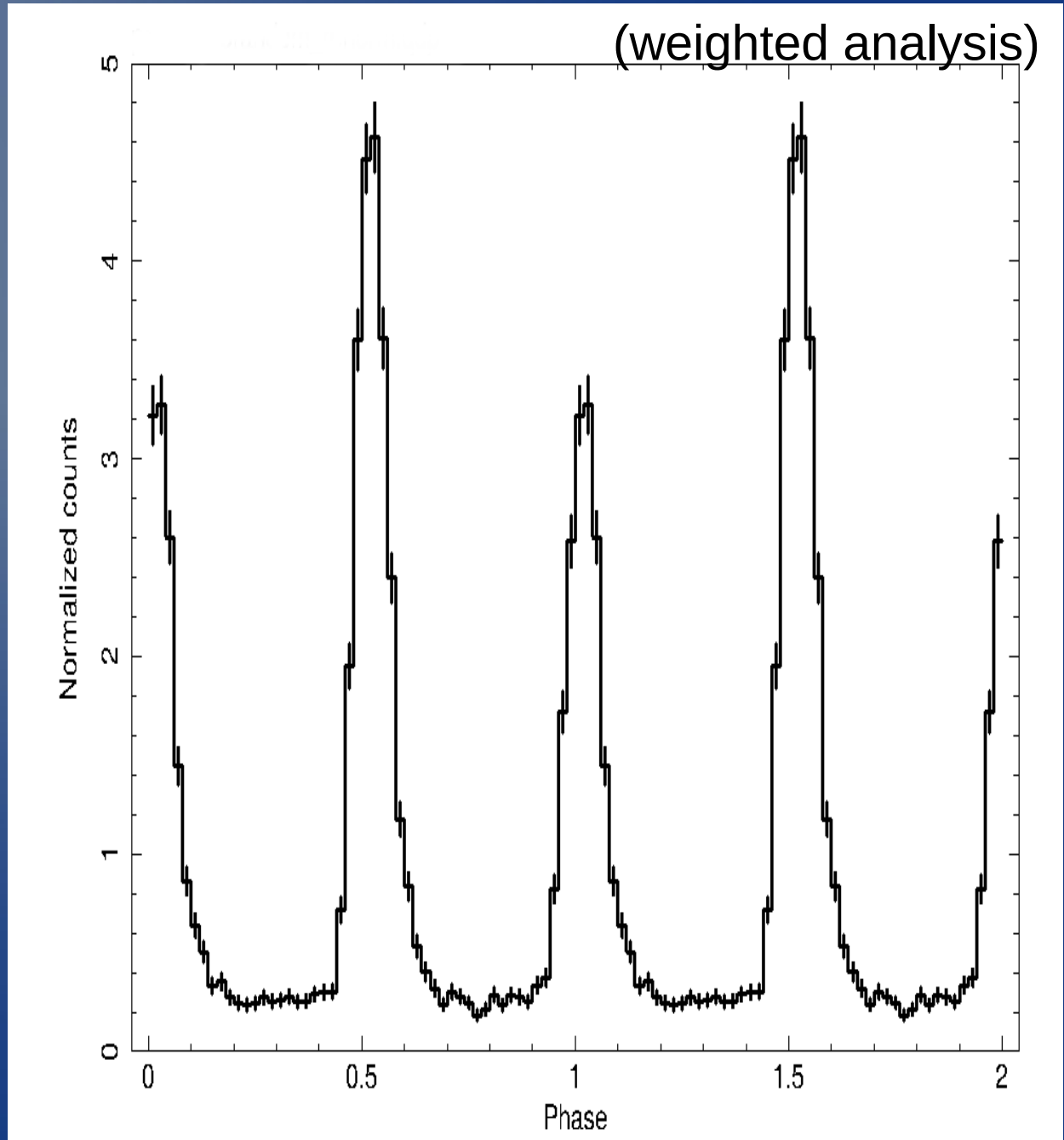

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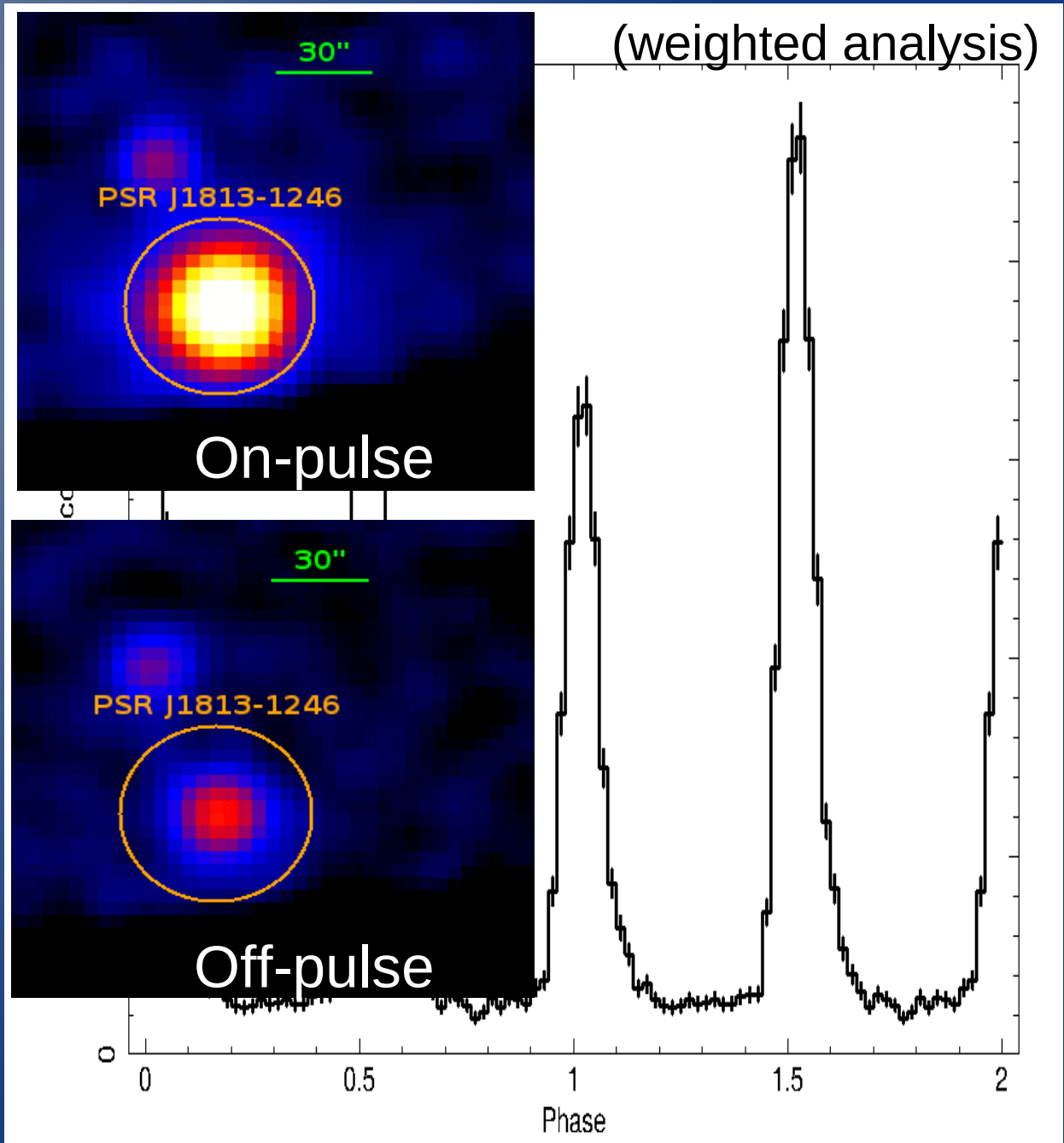

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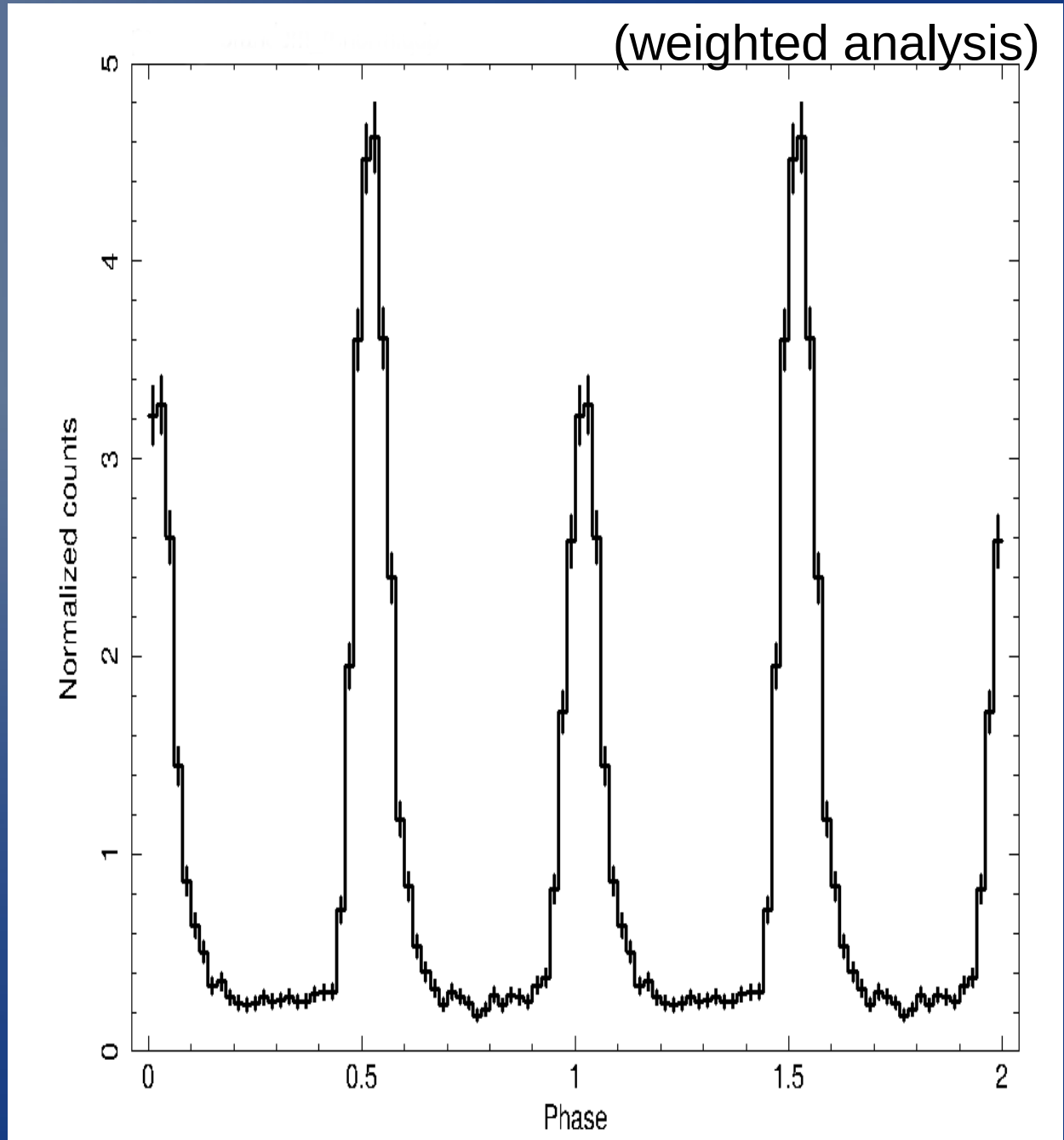
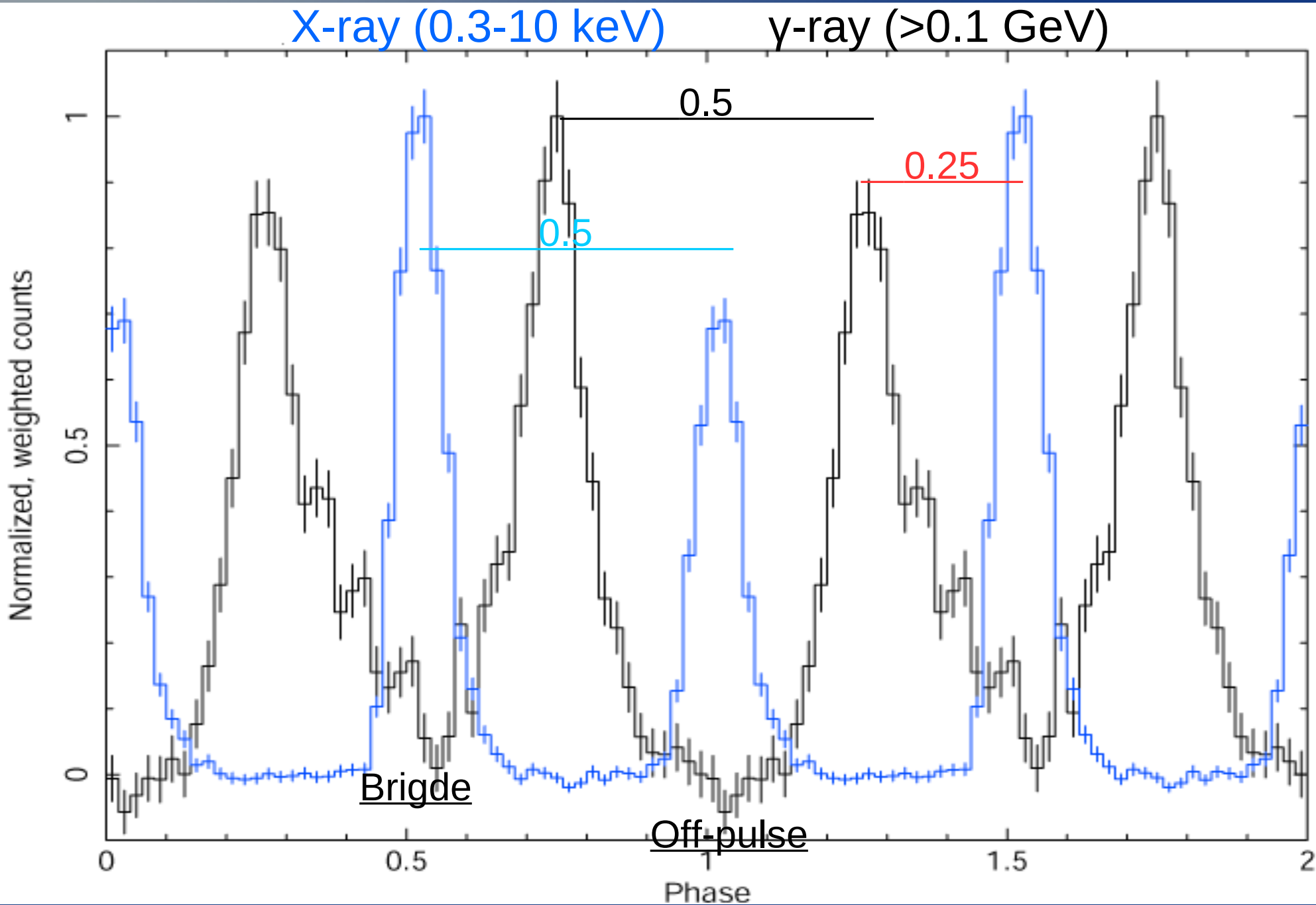
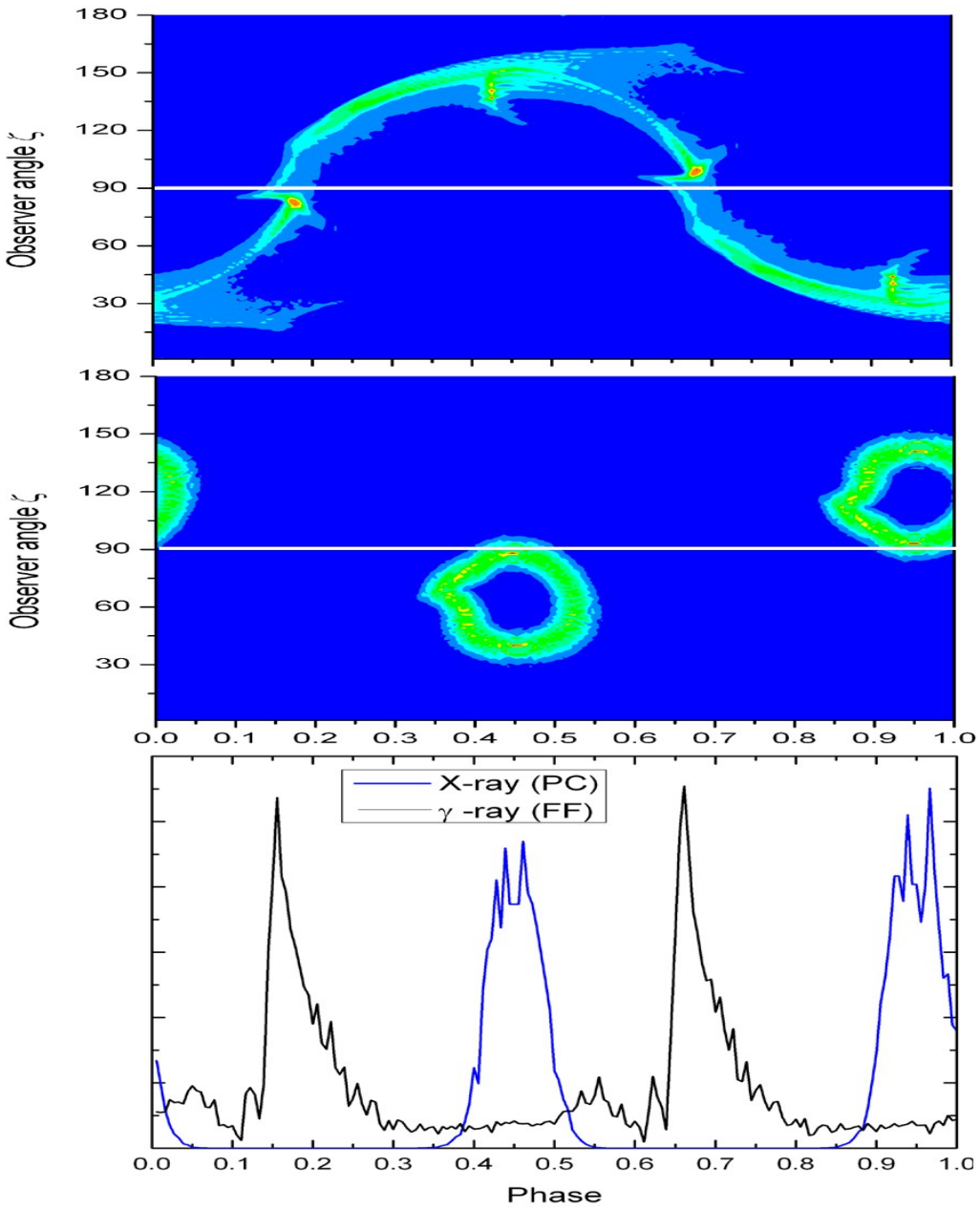
- No spectral variation with phase down to 0.08 in Γ (3σ)



J1813-1246 – MWL light curve



J1813-1246 – New model for X-rays



- magnetic inclination angle of 60°
- a) simulated γ-ray caustic emission from the outer magnetosphere for a separatrix layer model in a force-free magnetic field
- b) simulated cone beam X-ray emission from the polar caps for an emission altitude 0.2 R_{LC}
- c) Model γ-ray and X-ray light curves for a viewing angle of 90°

PRELIMINARY!

J1813-1246 – Conclusions

(Young, far pulsar)

- Spectral/MWL analysis: distance grater than 2.5 kpc
- X-ray spectrum: very hard.. not sure why
- X-ray spectrum: no thermal emission due to absorption
- No (or very faint) X-ray nebular emission: flux barely in agreement with expectations only if pulsar is 100% pulsed
- Energy Spectrum more similar to younger pulsars (Crab)
- Unusual X-ray light curve and phase lag between X and γ-ray light curve (X-ray emission from polar cap)