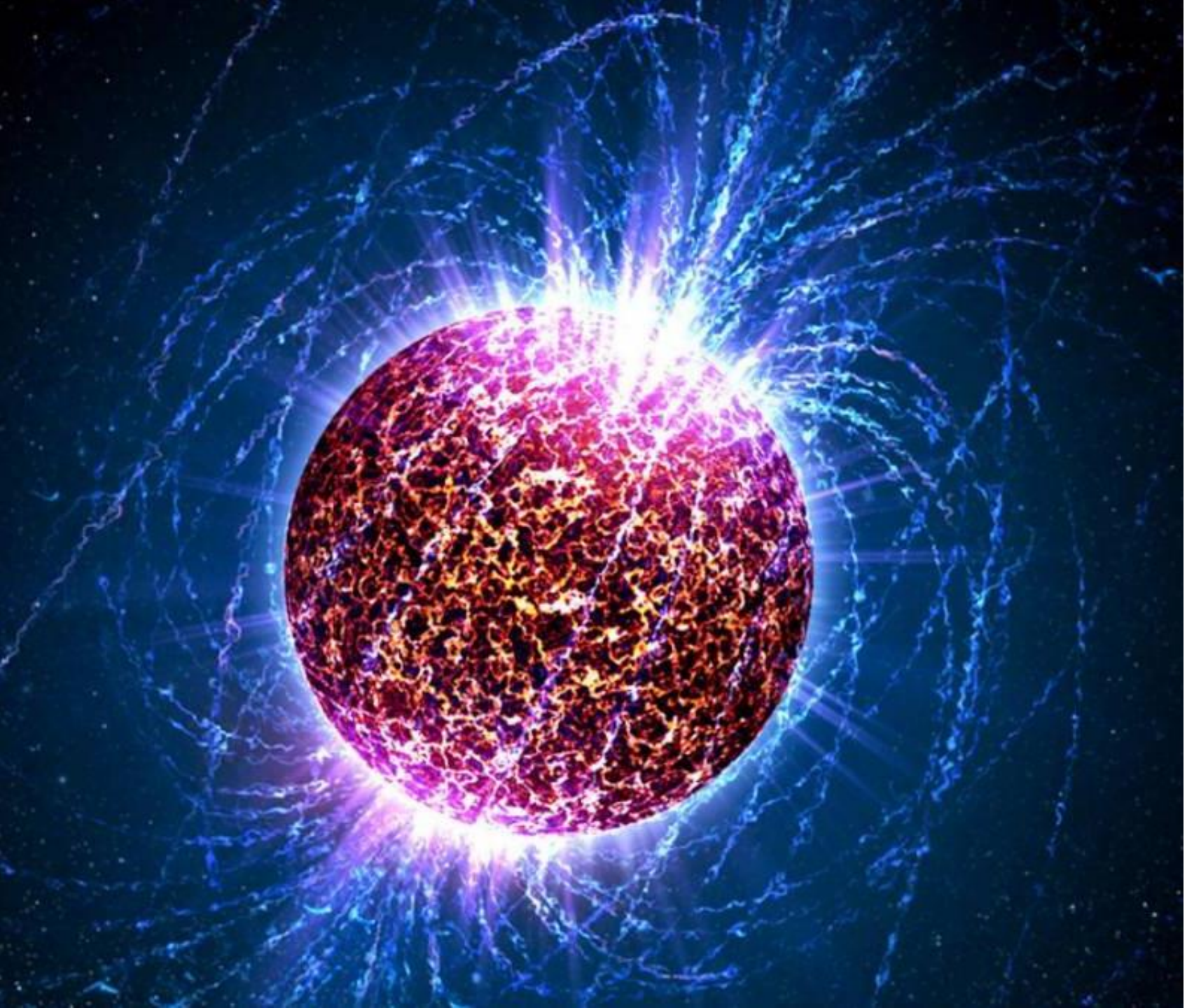


X-ray signatures of axions

Christopher Dessert
LCTP, University of Michigan

Phenomenology 2020 Symposium

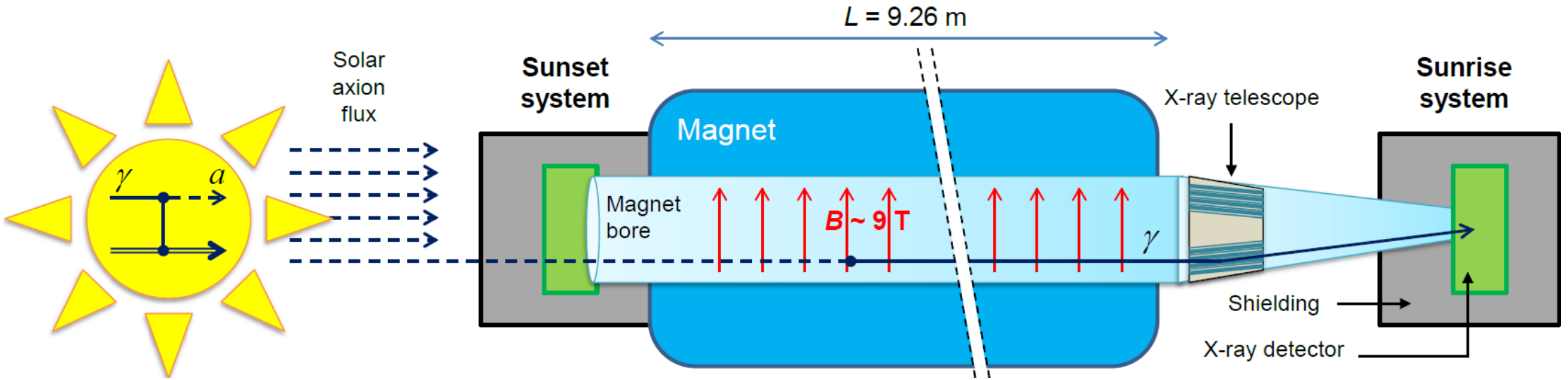
1910.02956: **CD**, J. Foster, B. Safdi
1910.04164: M. Buschmann, R. Co, **CD**, B. Safdi

Why Axions?

- The QCD axion is a highly-motivated extension of the Standard Model
- Here we focus on axion-like particles
- Both couple to electromagnetism and matter

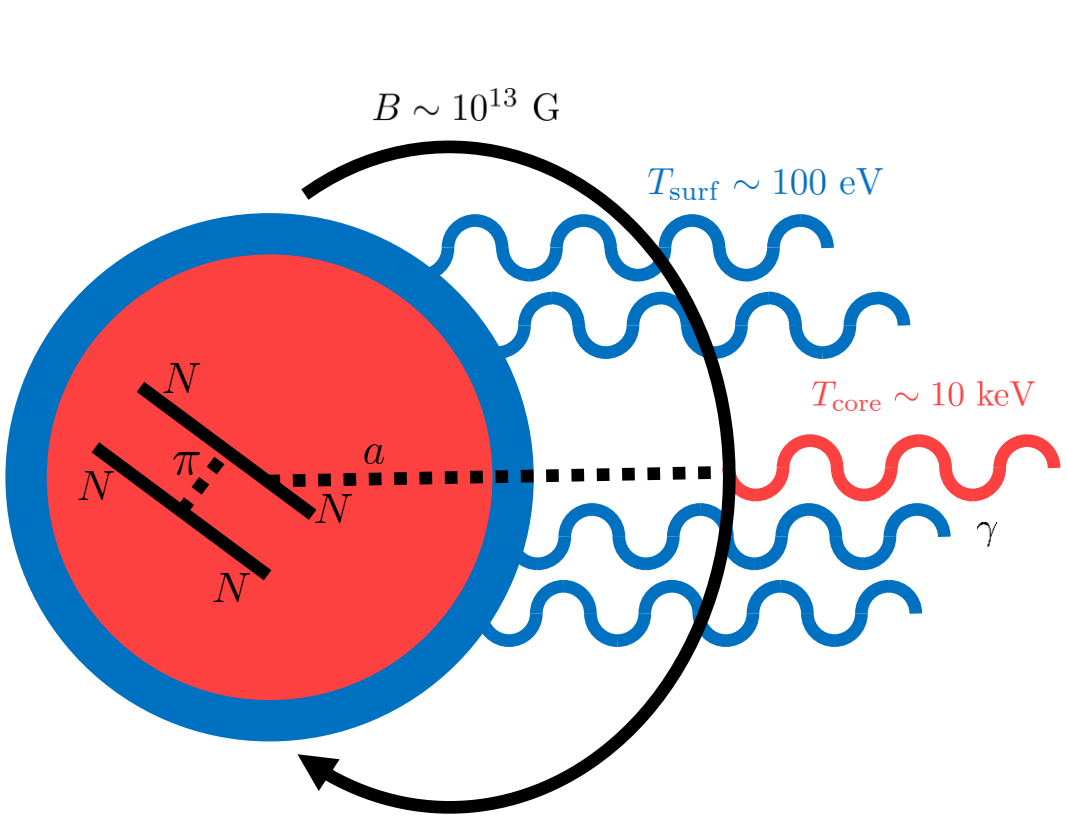
The CAST Experiment

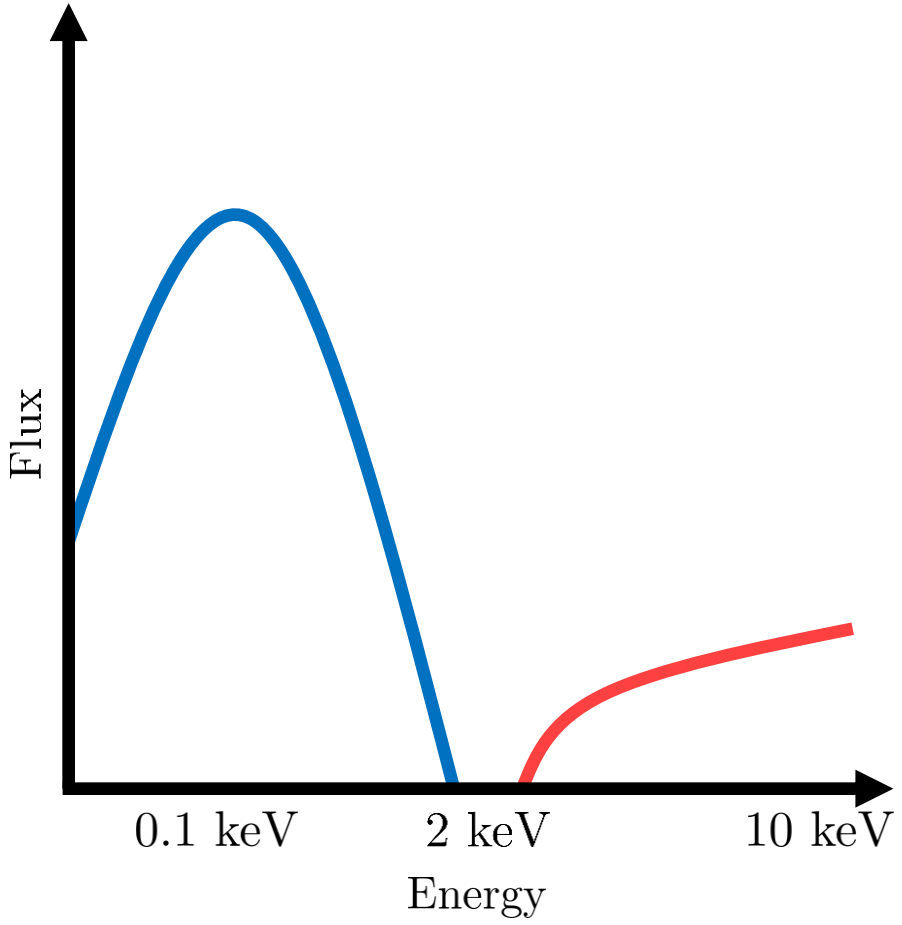
$$\mathcal{L} = g_{a\gamma\gamma} a E \cdot B$$
$$P_{a\to\gamma} \approx \left(g_{a\gamma\gamma} B L\right)^2$$



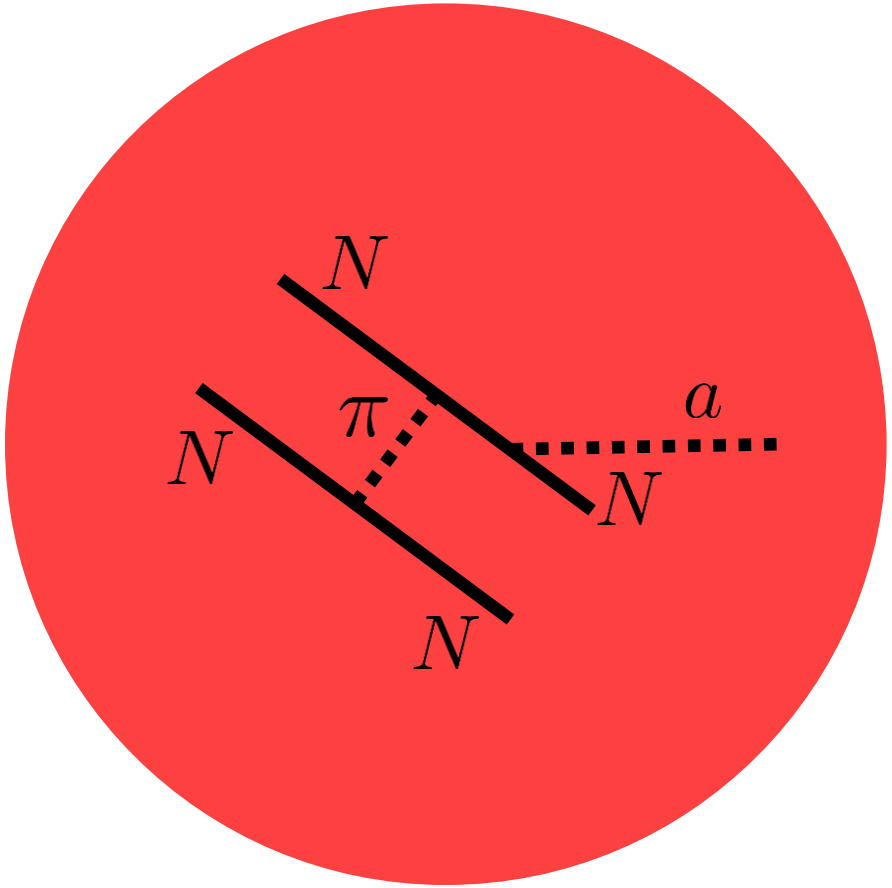
1705.02290: CAST Collaboration

Neutron Stars and Axions





Axion Production in Neutron Stars



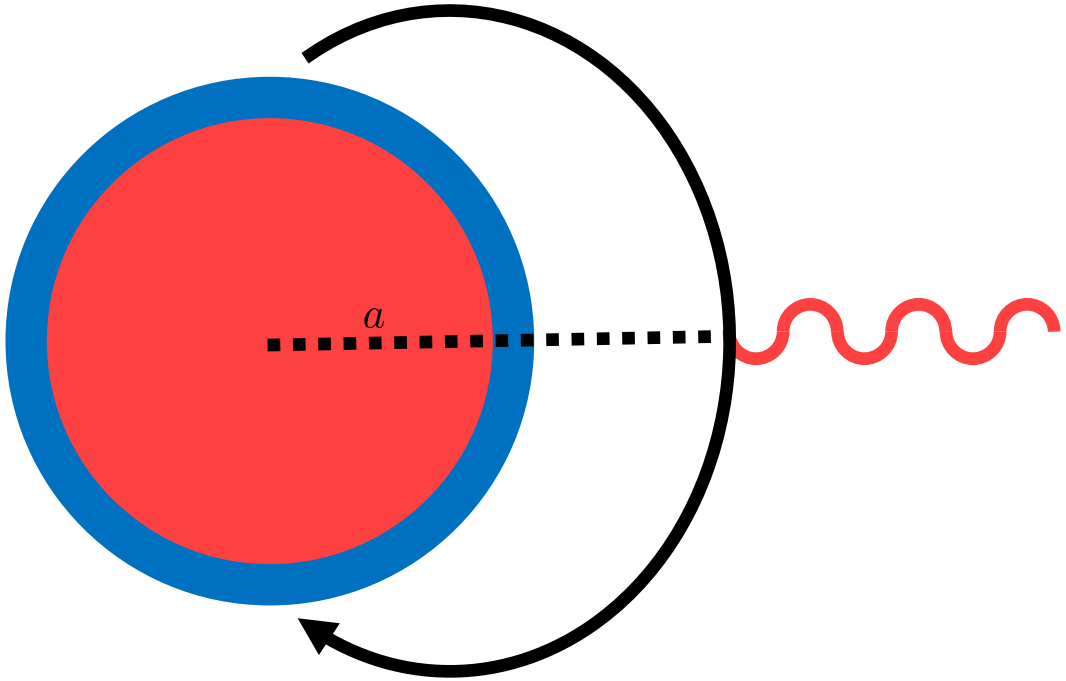
$$\mathcal{L}_{aNN} = \frac{C_N}{f_a}(\partial_\mu a)\bar{N}\gamma^\mu\gamma_5 N$$

$$\frac{dF}{dE} \propto \frac{z^3(z^2+4\pi)}{e^z-1}, z = E/T$$

$$L_{\mathrm{NS,a}} \approx 0.05 L_\odot \left(\frac{g_{ann}}{10^{-10}}\right)^2 \left(\frac{T_c}{10^8\ \mathrm{K}}\right)^6$$

N. Iwamoto, Phys. Rev. Lett. 53, 1198 (1984).

Axion-photon conversion – Strong Dipole



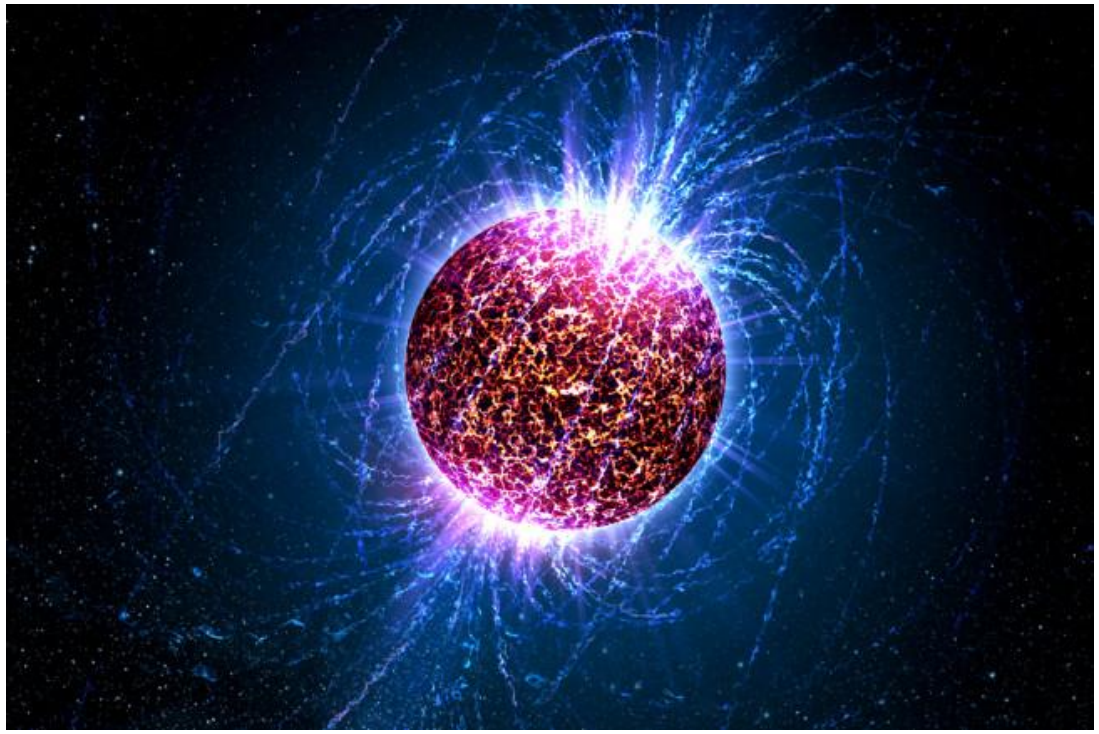
$$P_{a\to\gamma} \approx 10^{-4} \left(\frac{g_{a\gamma\gamma}}{10^{-11}\ \mathrm{GeV}^{-1}}\right)^2 \left(\frac{1\ \mathrm{keV}}{\omega}\right)^{4/5} \left(\frac{B_0}{10^{13}\ \mathrm{G}}\right)^{2/5} \left(\frac{R_{\mathrm{NS}}}{10\ \mathrm{km}}\right)^{6/5}$$

1903.05088: **CD**, A. Long, B. Safdi, PRL

Neutron Star Targets

The Magnificent Seven:

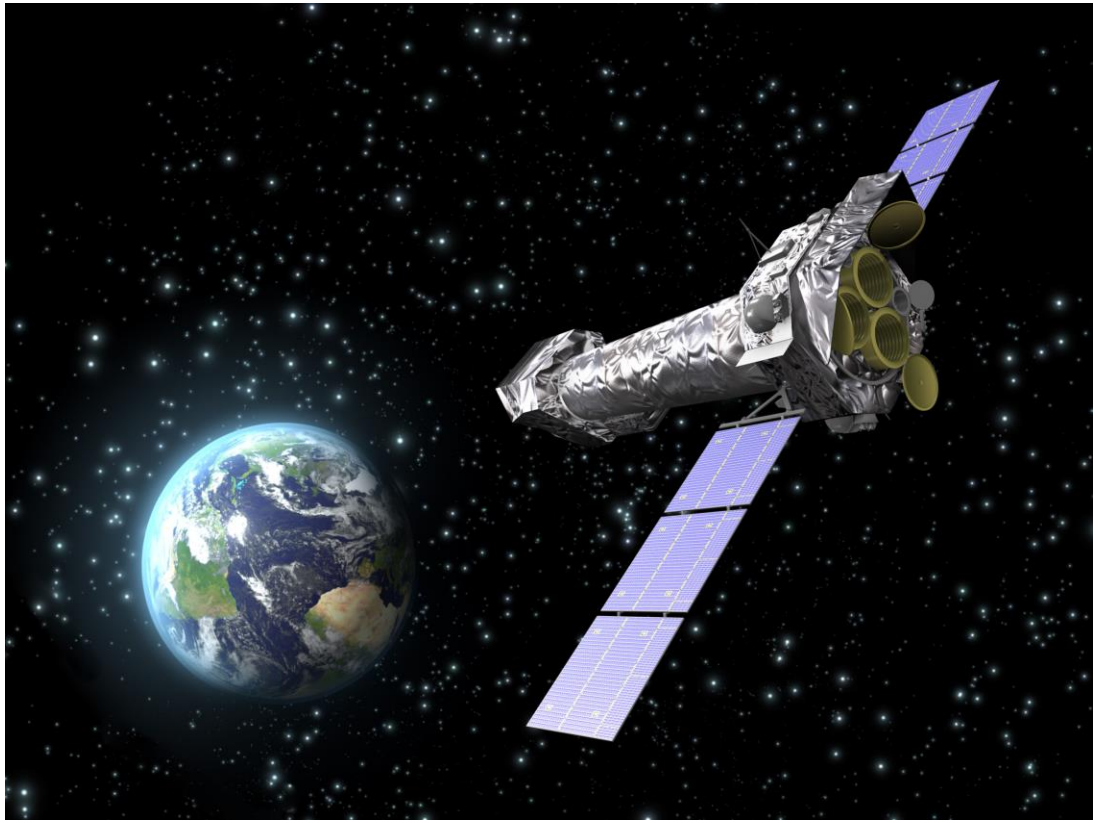
- 7 neutron stars 100 pc away
- $B \sim 10^{13}$ G
- $T_{\rm surf} \sim 100$ eV
- Near-perfect blackbodies
  $\rightarrow$ zero background > 1 keV

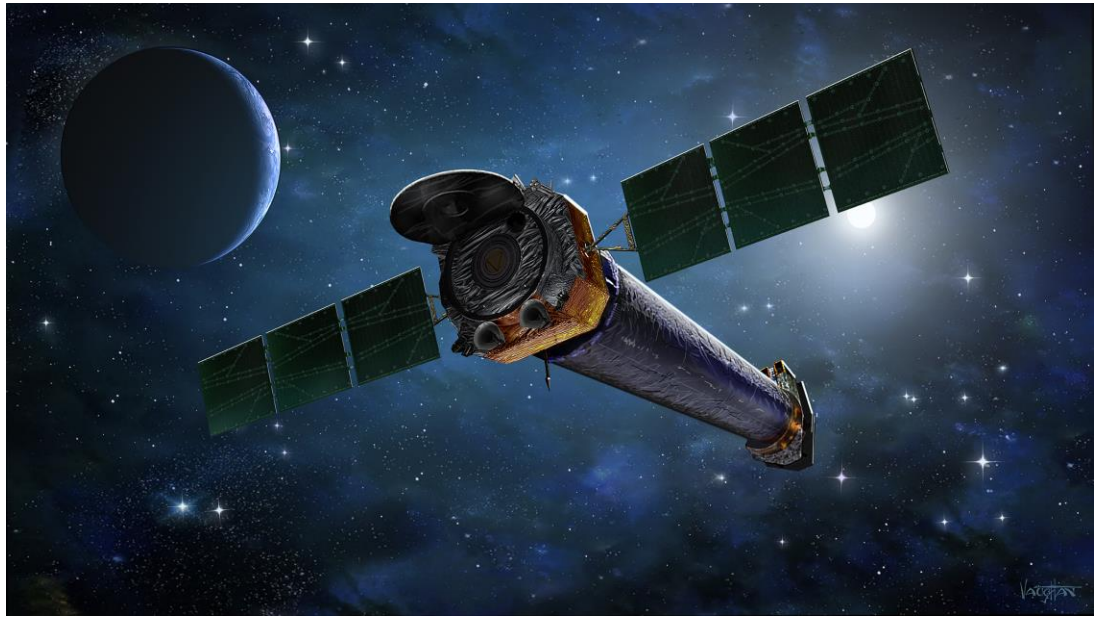


Casey Reed – Penn State University/Wikimedia Commons

XMM-Newton and Chandra

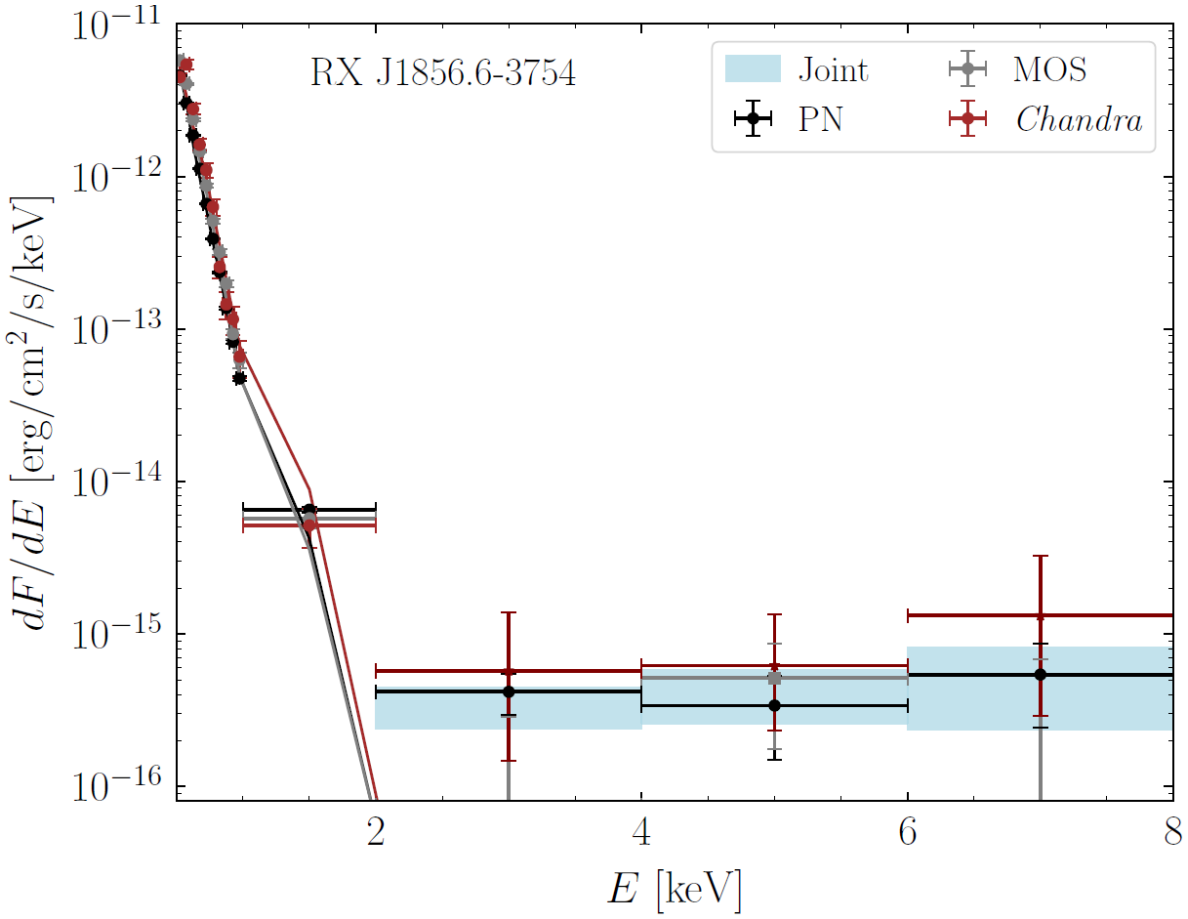
(PN, MOS)





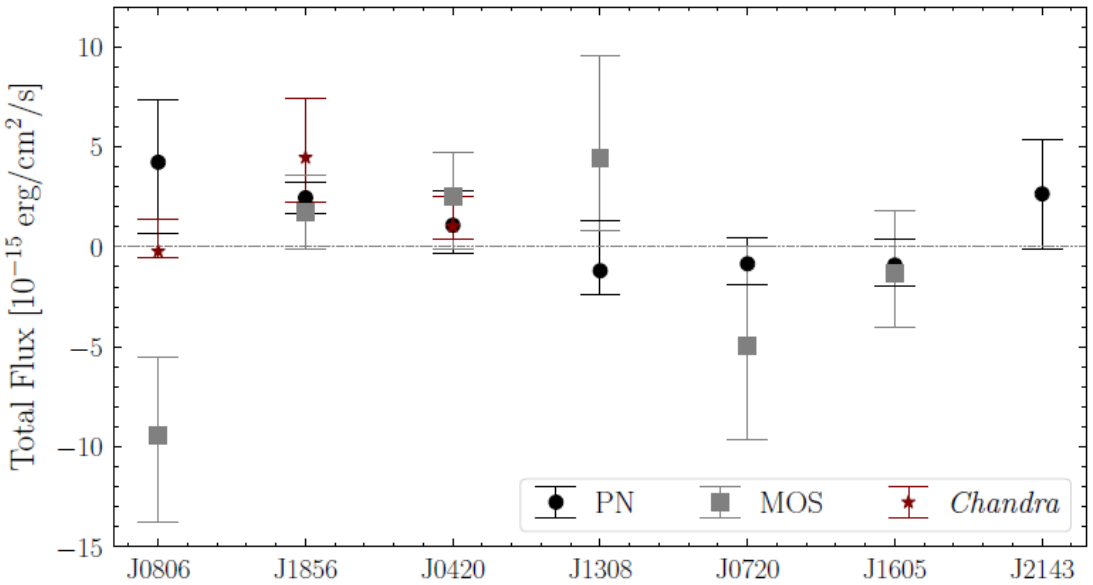
ESA/NASA

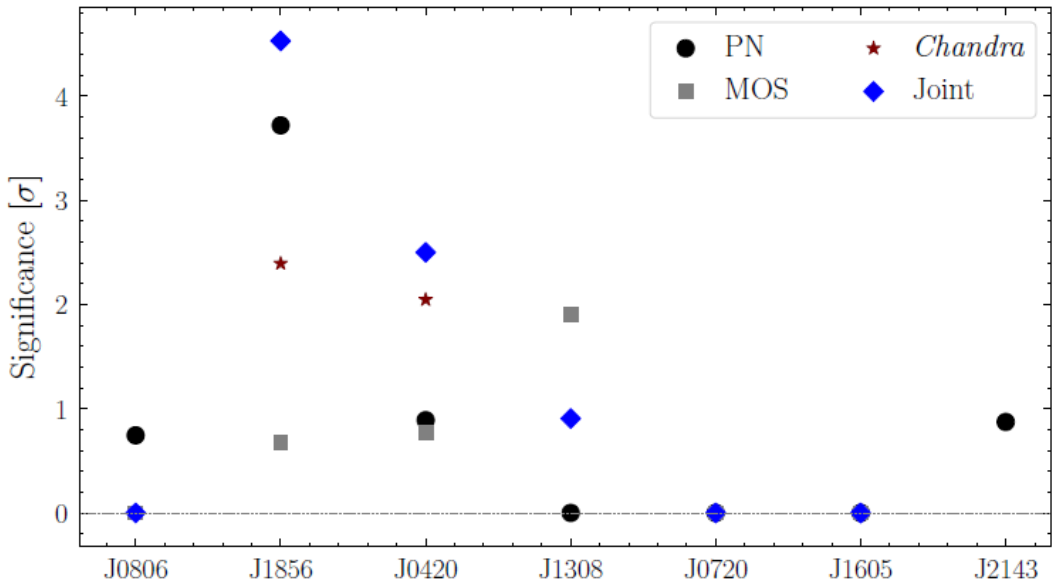
RX J1856.6-3754 spectrum



1910.02956: **CD**, J. Foster, B. Safdi

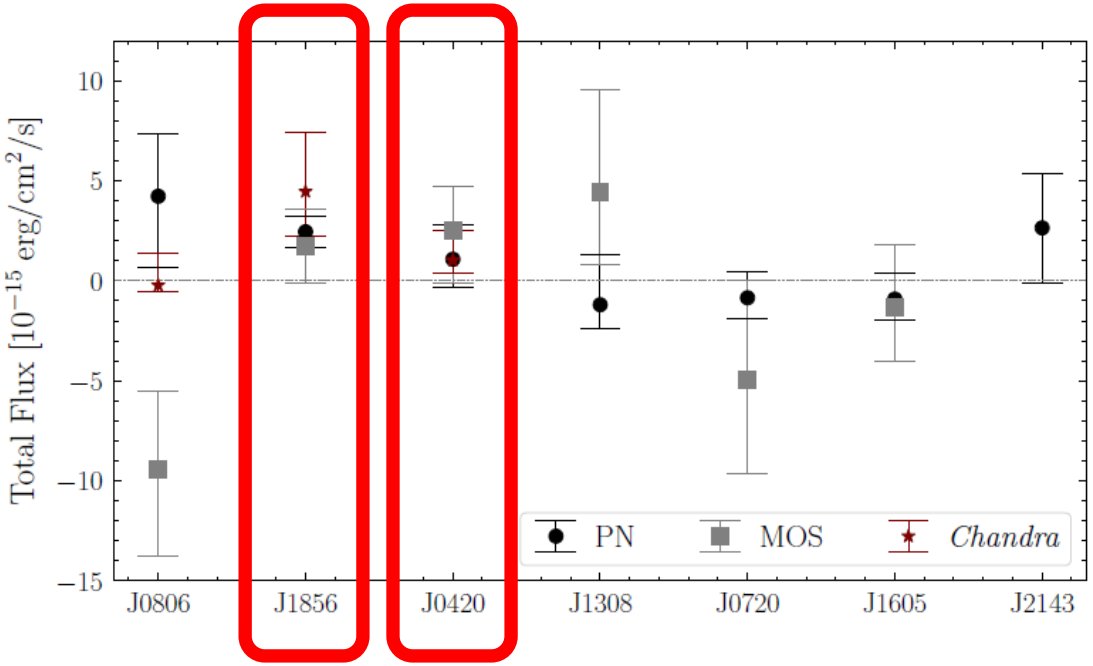
Data Summary

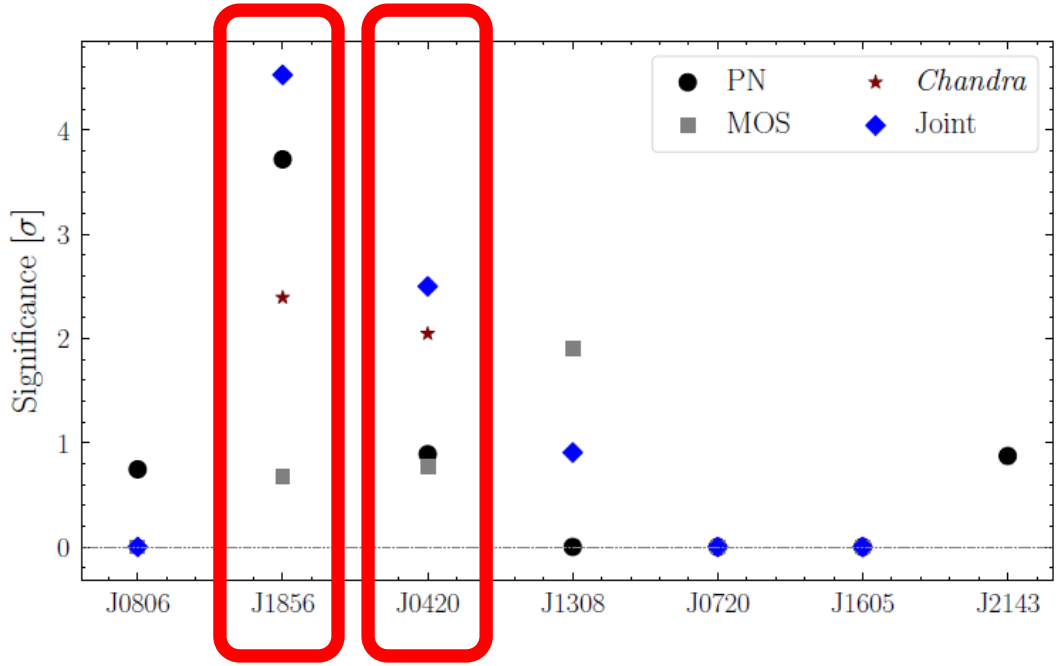




1910.02956: **CD**, J. Foster, B. Safdi

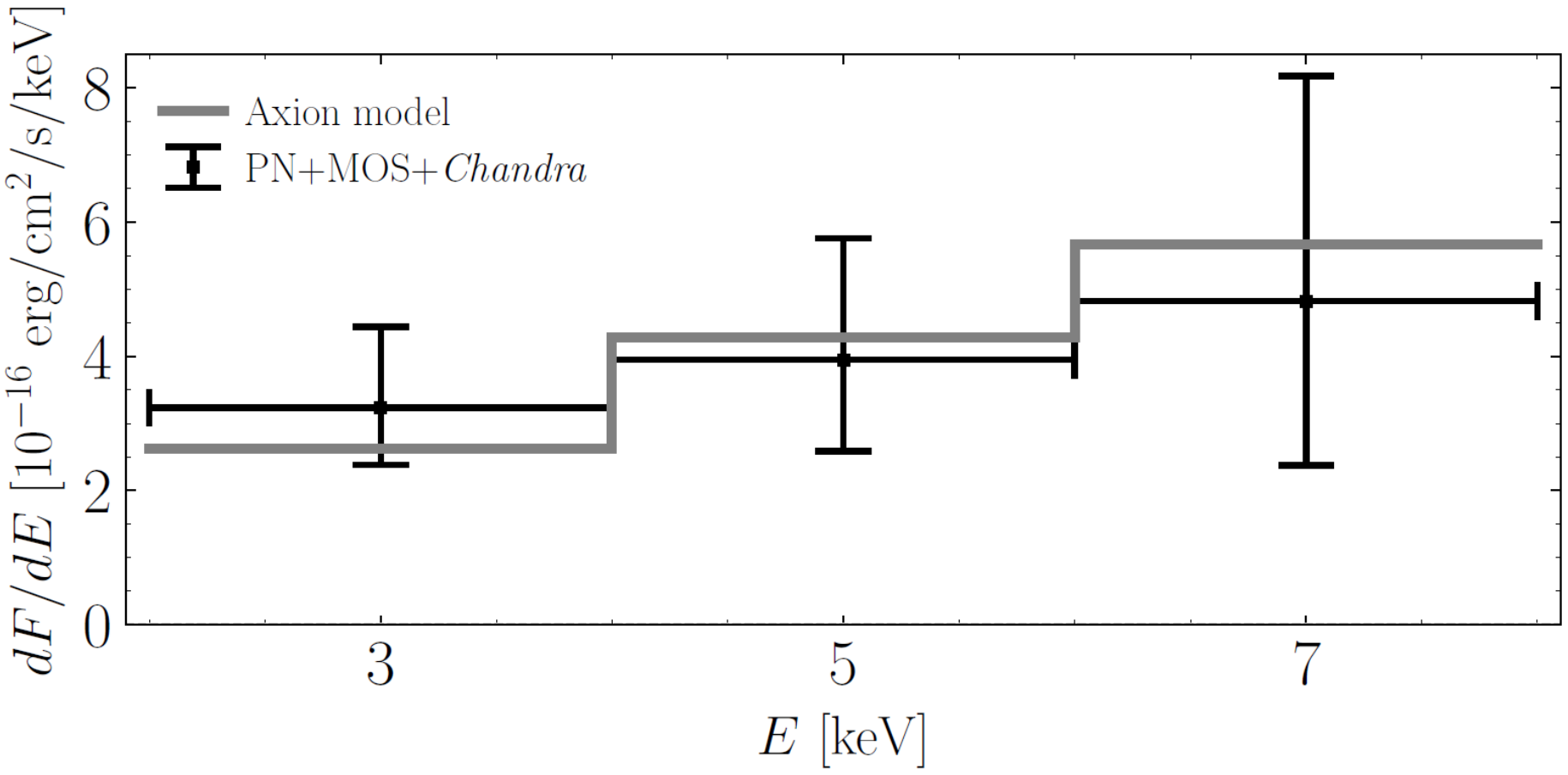
Data Summary





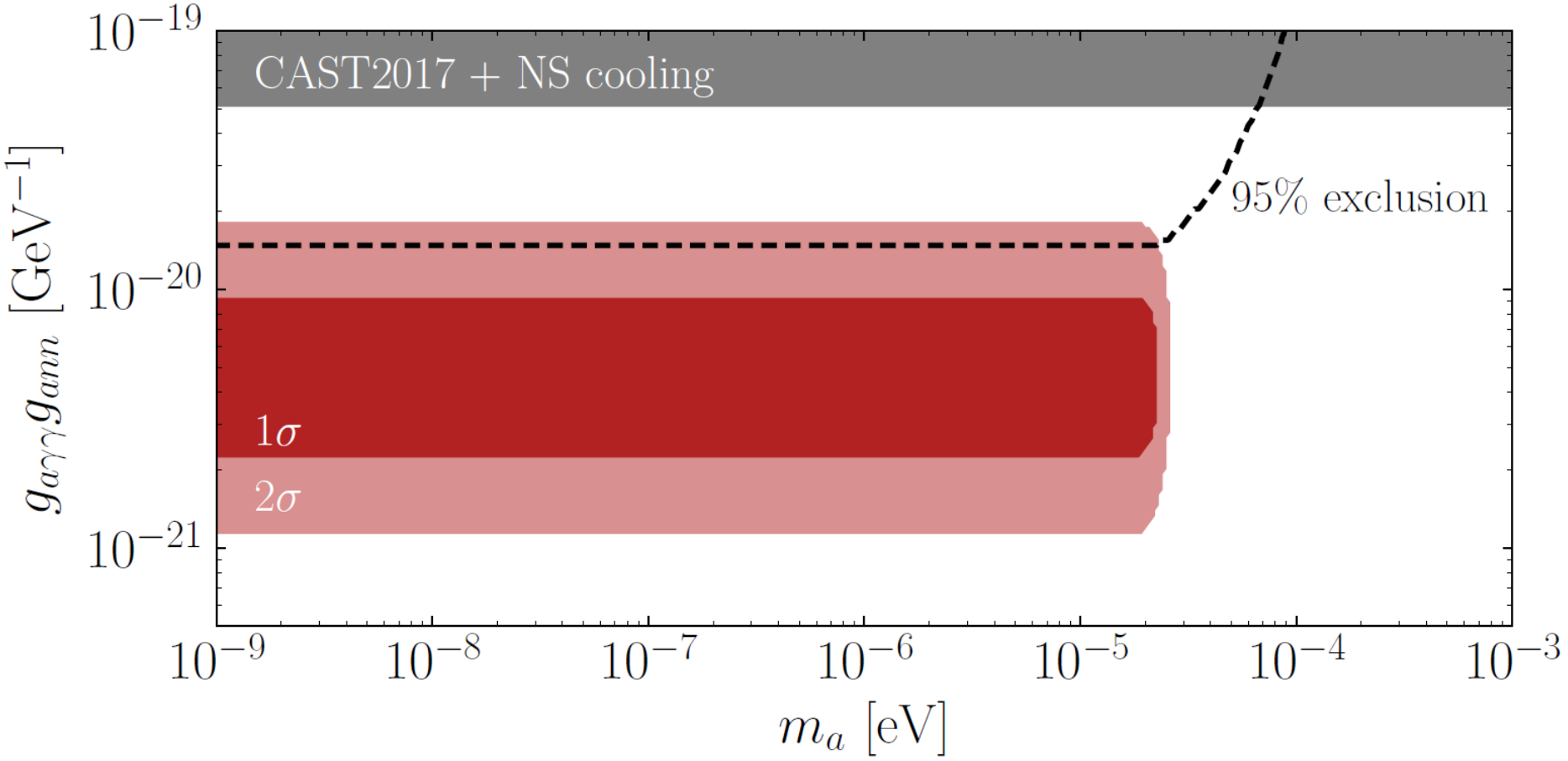
[1910.02956](): **CD**, J. Foster, B. Safdi

RX J1856.6-3754 Axion Predictions



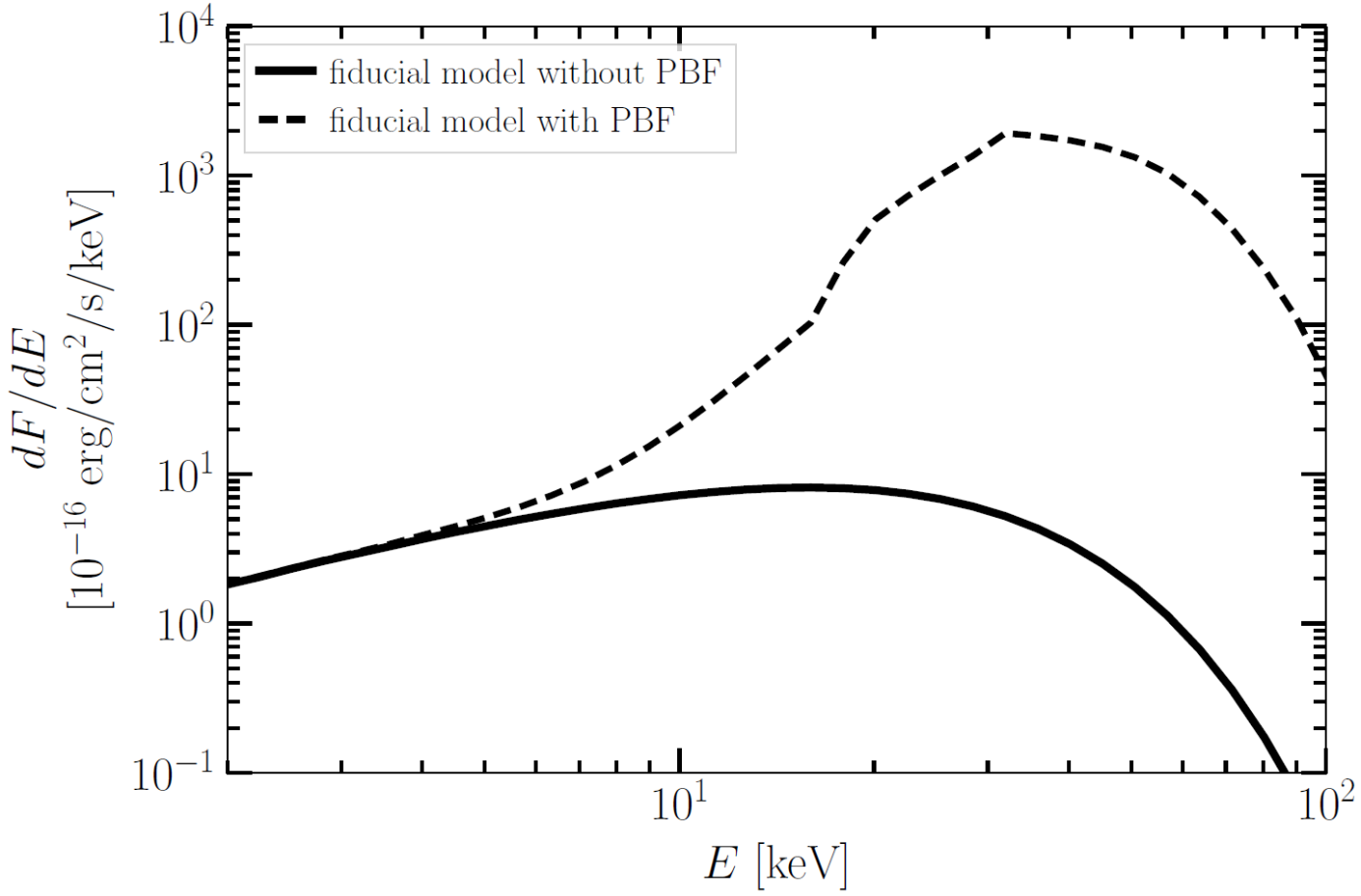
1910.04164: M. Buschmann, R. Co, **CD**, B. Safdi

Results: Limits and Preferred Region



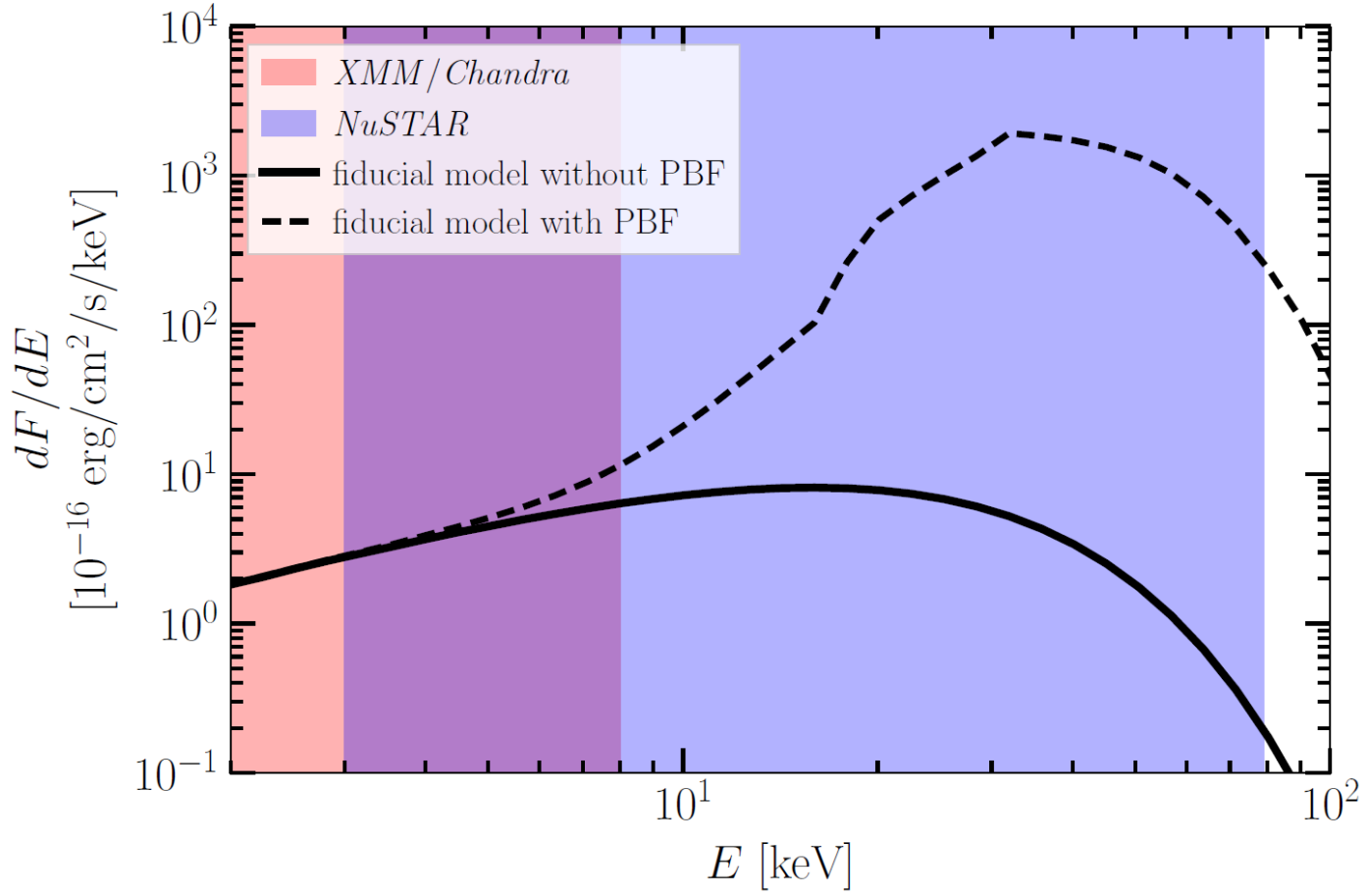
1910.04164: M. Buschmann, R. Co, **CD**, B. Safdi

Follow-up Measurements: High Energy



1910.04164: M. Buschmann, R. Co, **CD**, B. Safdi

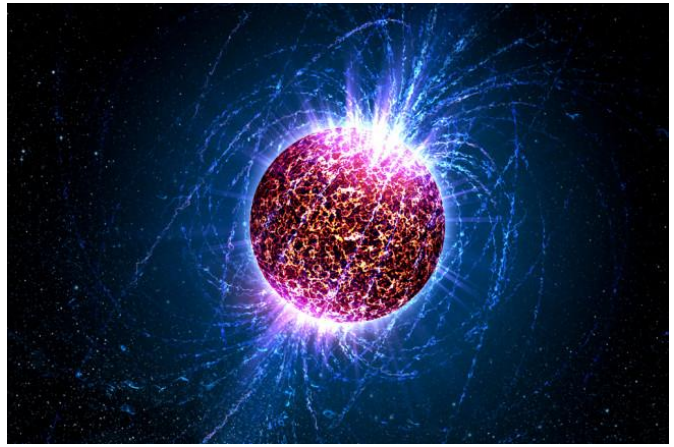
Follow-up Measurements: High Energy



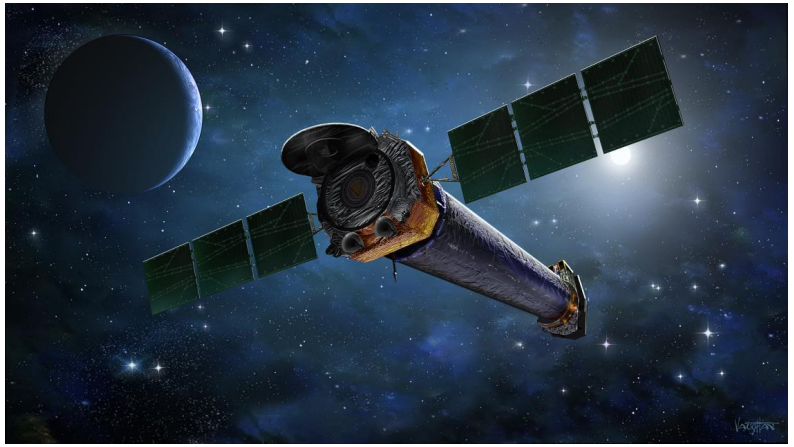
1910.04164: M. Buschmann, R. Co, **CD**, B. Safdi

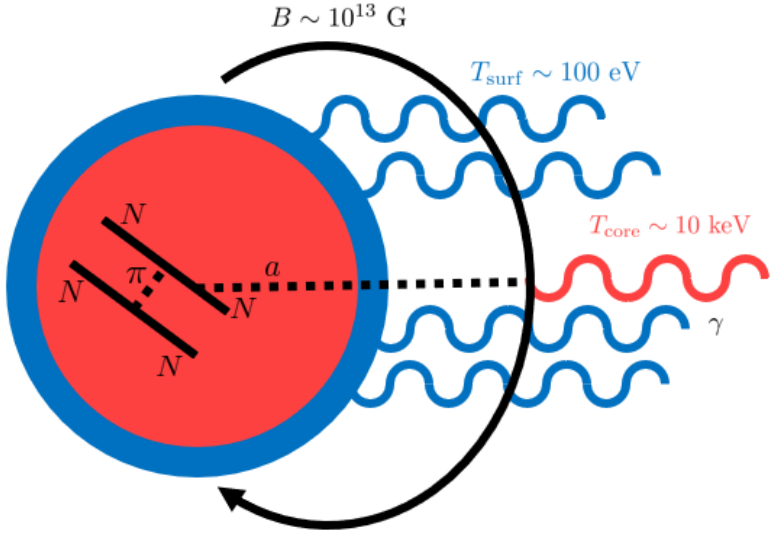
Conclusion

- Astrophysics is a powerful probe of axions.
- We found an excess of X-rays in the Magnificent Seven neutron stars that is consistent with an axion-like particle interpretation.
- Instrumental origin seems unlikely!
- Several ideas to further characterize the nature of this excess.

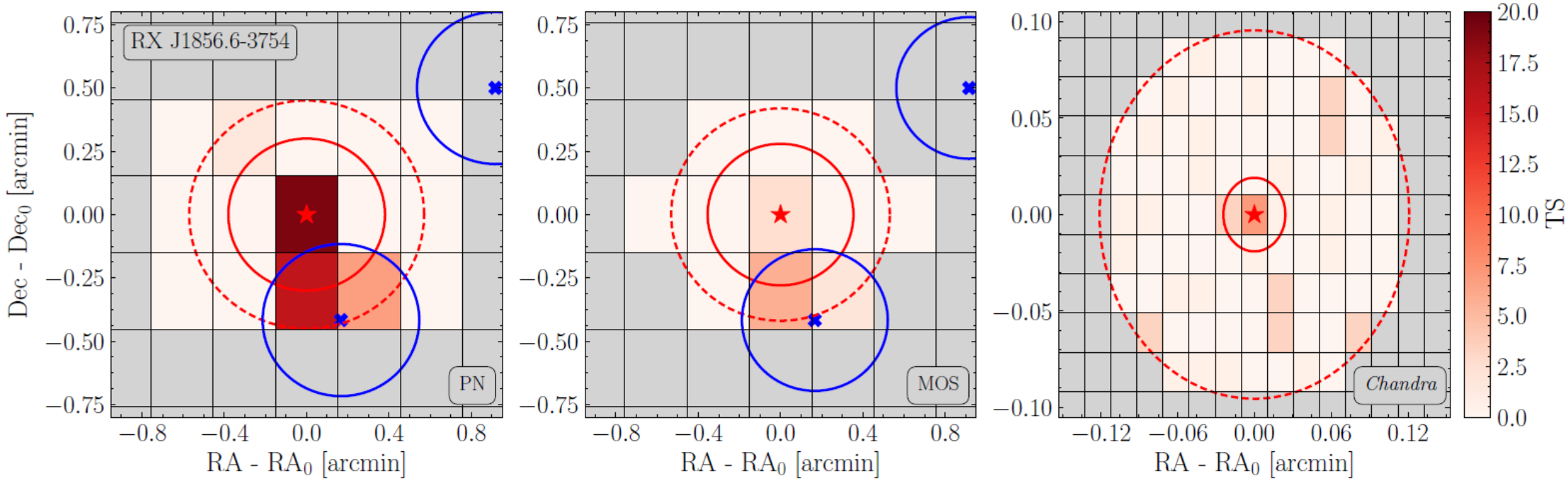


Questions?




$B \sim 10^{13}$ G
$T_{\rm surf} \sim 100$ eV
$T_{\rm core} \sim 10$ keV
N
π
a
N
N
N
γ

Systematics: Background Point Sources



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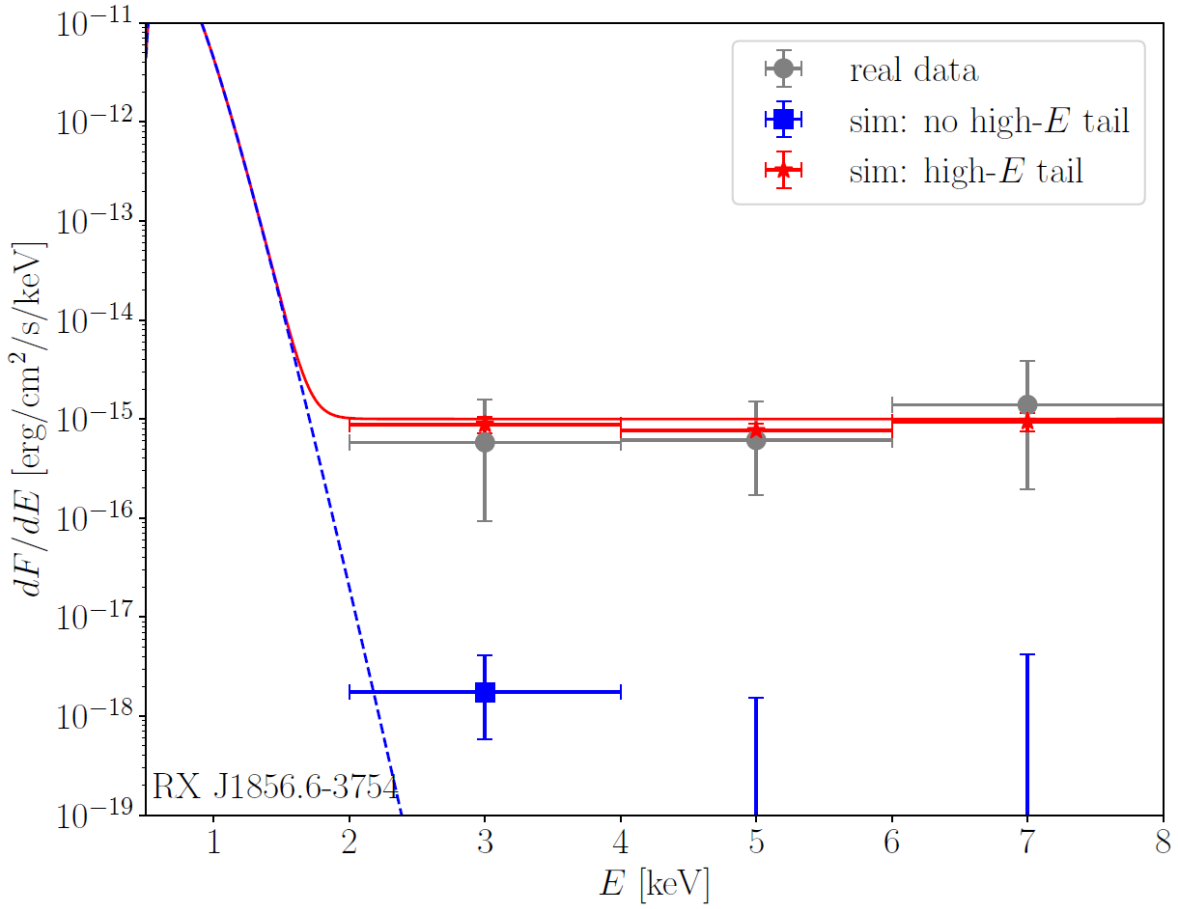
Systematics: Pileup



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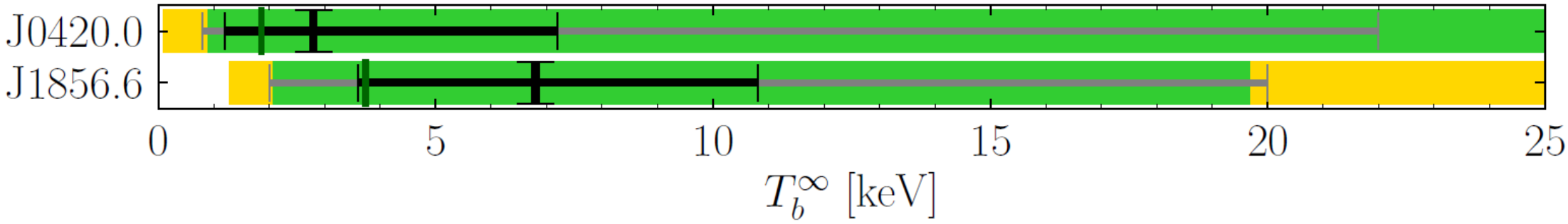
Inferred Core Temperatures

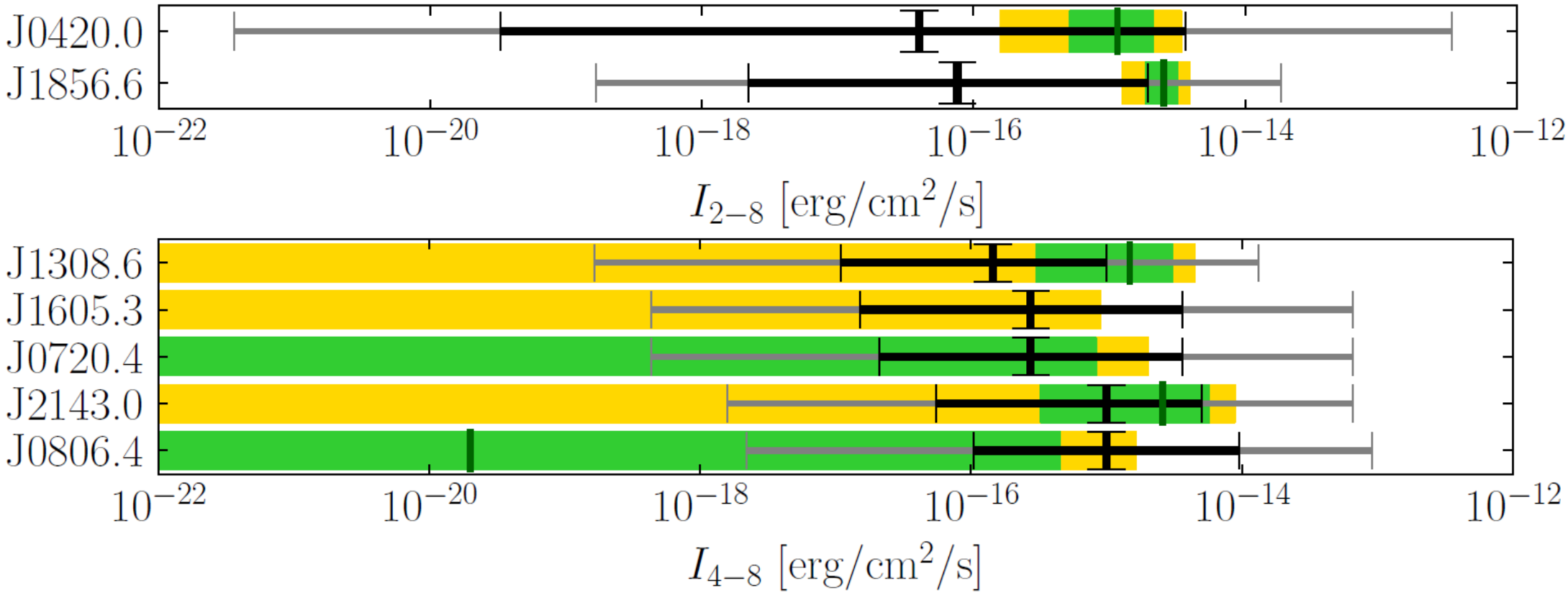


1 and **2** σ predictions from NS modeling

1 and **2** σ measurement from X-ray data

[1910.04164](1910.04164): M. Buschmann, R. Co, **CD**, B. Safdi

Intensity Predictions



1 and **2** σ predictions from NS modeling

1 and **2** σ measurement from X-ray data

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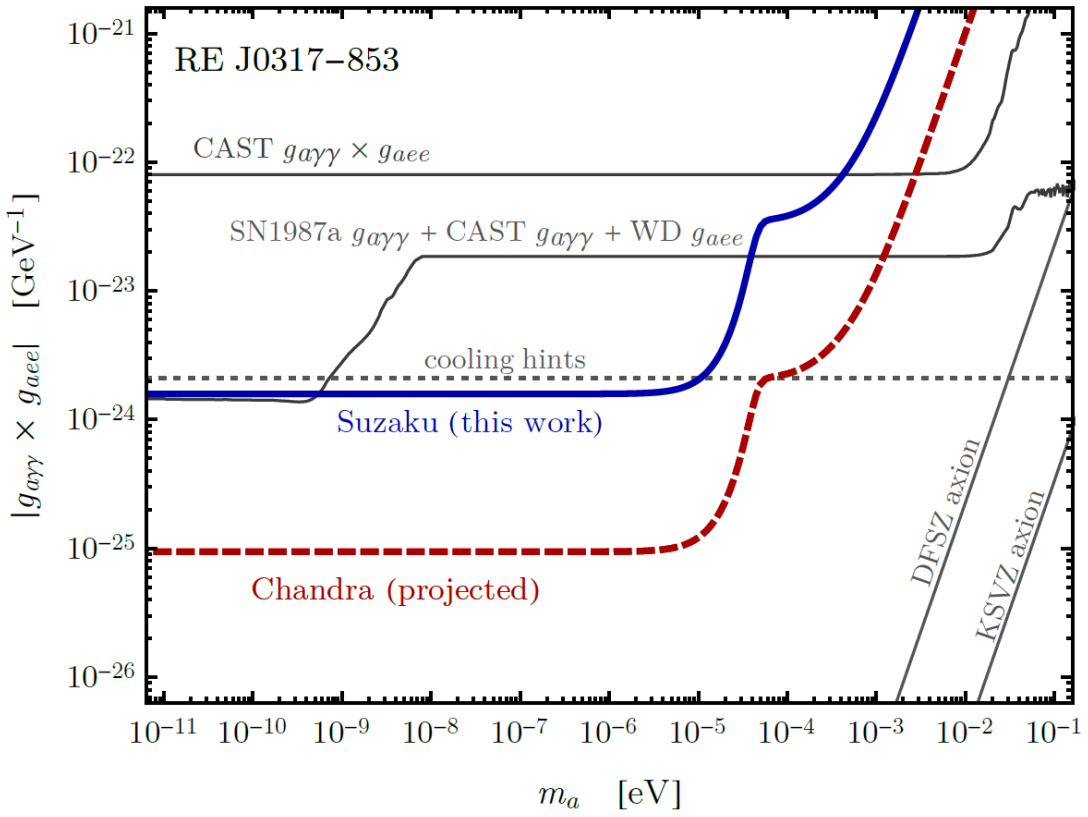
Follow-up Measurements: White Dwarf

- RE J0317-853: the hottest known magnetic white dwarf
- 40 ks Chandra data this year!



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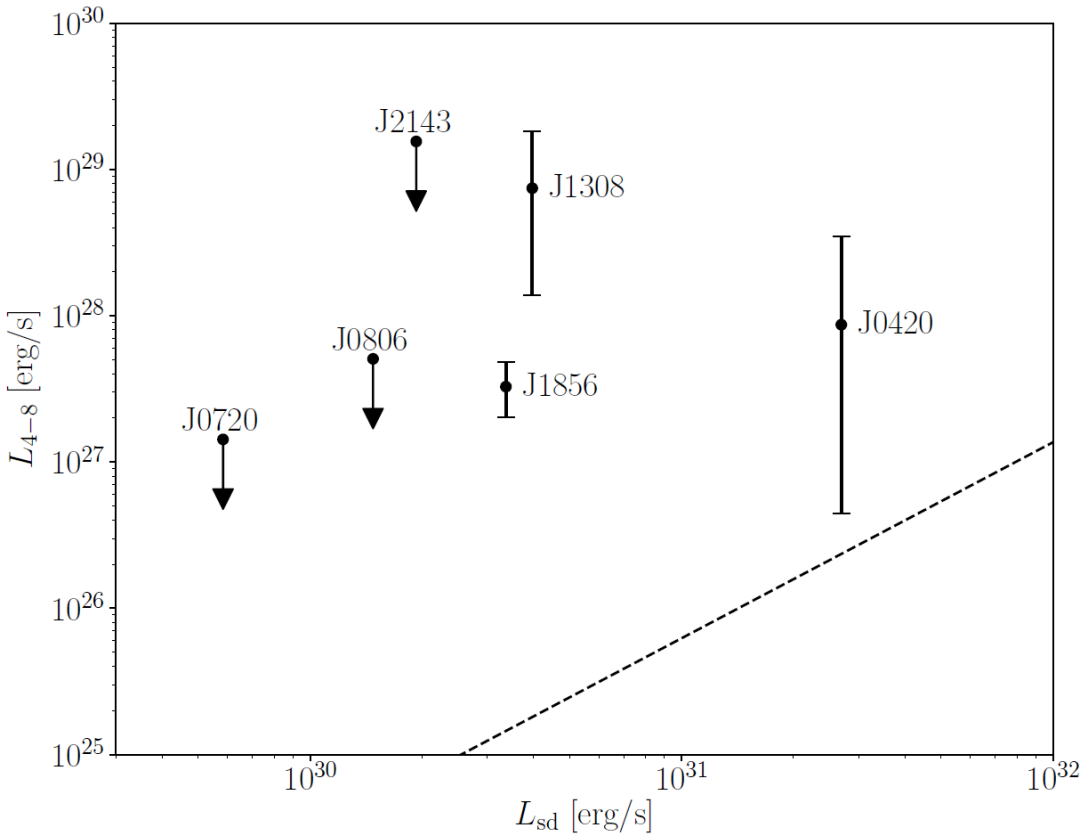
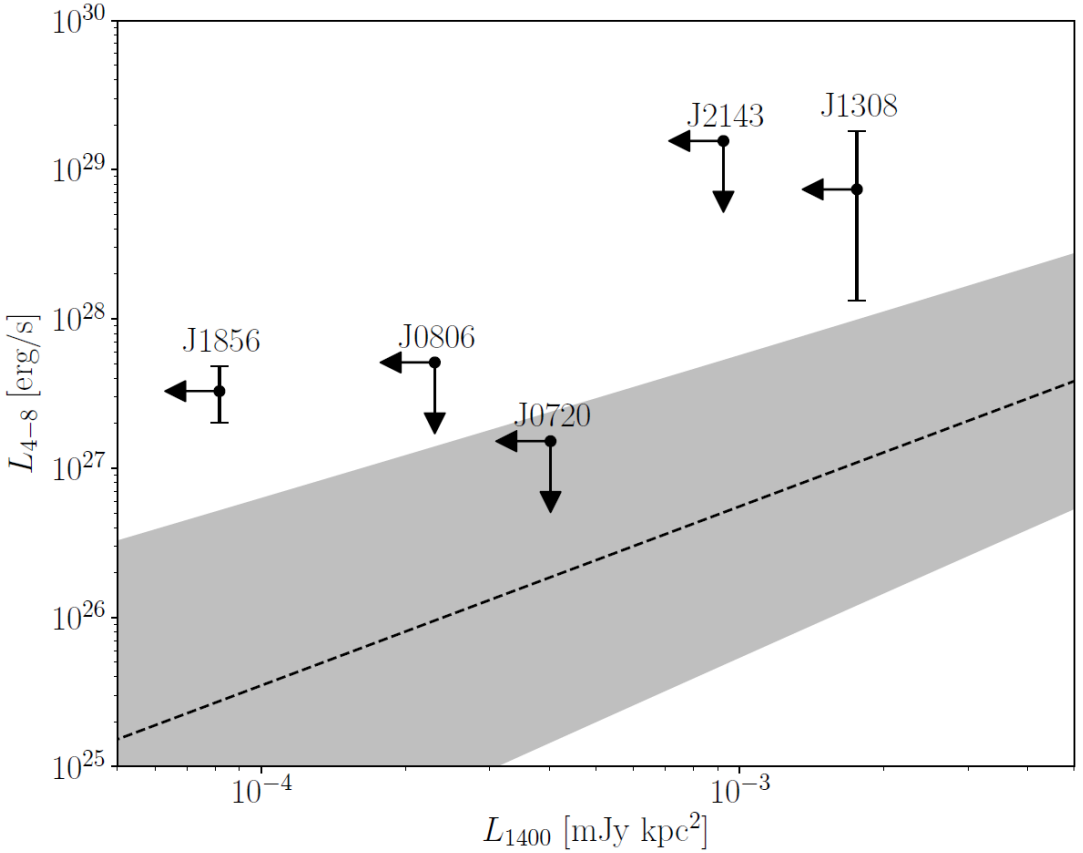
Other Emission Mechanisms?





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