IACHEC 2020

Observer Symposium
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NICER

Neutron star Interior Composition ExploreR

NICER Cross Calibration

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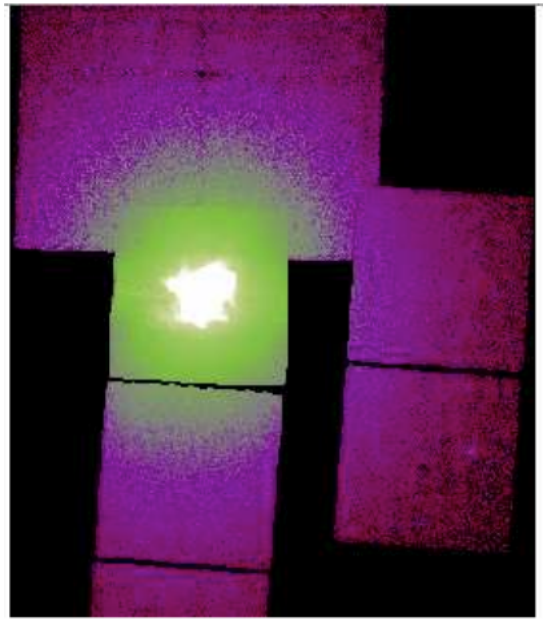
Overview

- Cross-calibration comparisons
  - Crab
  - “Faint” source: 3C 273 (M. Loewenstein)
  - “Bright” sources: 4U 1735-44 and 4U 1543-624 (Renee Ludlam)
  - Isolated neutron star RX J1856
- NICER, NuSTAR and Swift agree to within 4-6%

Cross Calibration and Dust Halos

- Dust scattering halos have significant effects
  - Energy dependent
  - Aperture size dependent
    - complicates comparing observatories with different apertures (NICER 360”, RXTE 1°, CCD imagers ~few arcsec)
  - **Halo is time dependent if source varies**
  - ‘xscat’ model in XSPEC recently updated by Randall Smith for larger radius apertures such as NICER. Use radius=180”
- Summary: cross-comparison, even of strictly simultaneous observations, can be tricky

Crab Dust Halo
(Chandra ACIS)



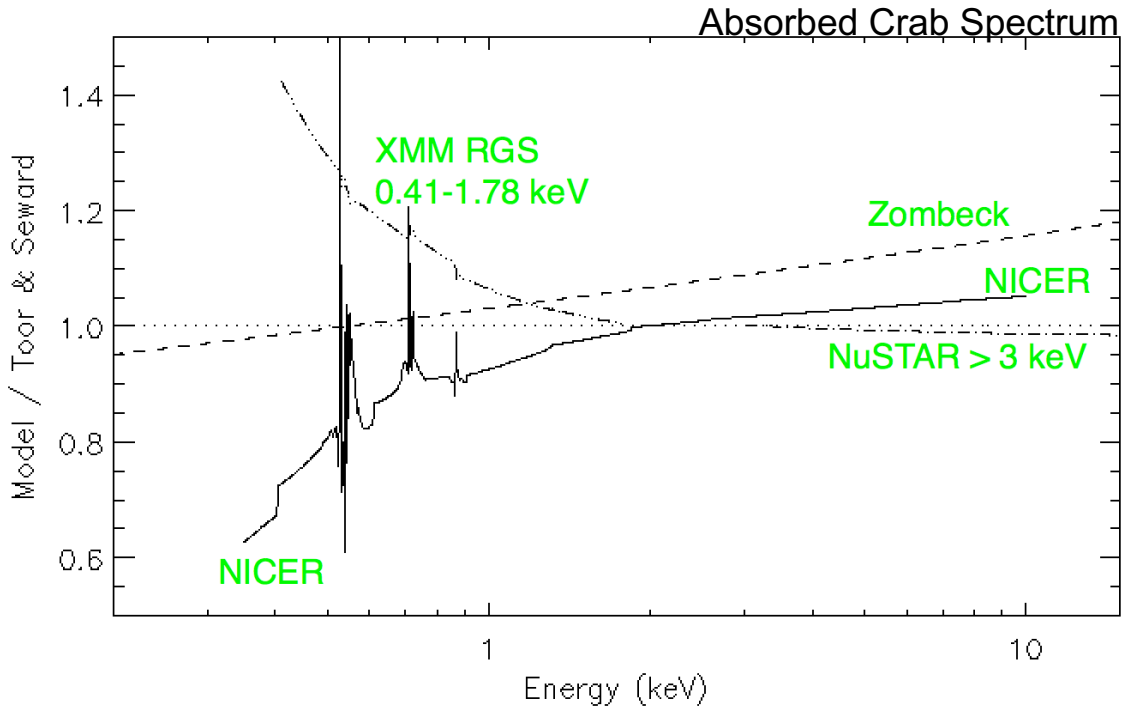
Seward et al. 2005

Crab

Power Law	NuSTAR (3-50 keV)	NICER (0.25-10 keV)	Difference
Norm	9.71	9.19	-5.3%
Index	2.106	2.105	0.001

- Not strictly simultaneous
  - NICER Observations: 2017-2019, 60 ksec
  - NuSTAR Observations: 2015-2016, ~100 ksec
- On its face, NuSTAR and NICER compare well in overall shape/slope, within ~5% in norm
- Comparing single numbers can be somewhat misleading however

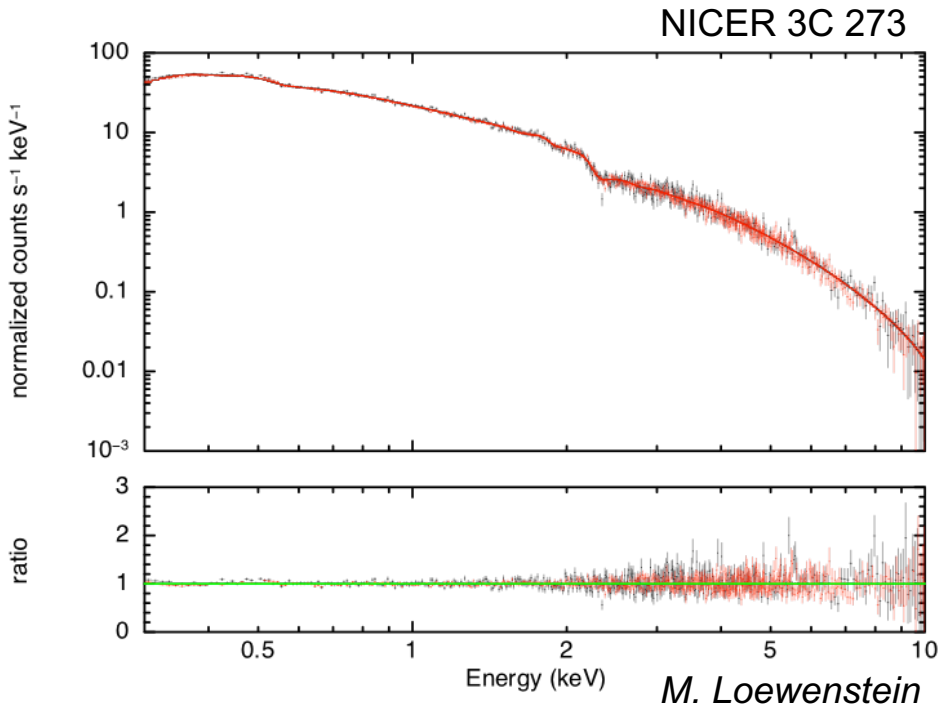
Crab Spectral Comparison



- Basis of comparison is Toor & Seward (1978) result, extended to lower energies
- NICER agrees with NuSTAR to with ~5%
- Very significant differences between XMM RGS (Kaastra et al. 2009) and NICER
  - These are primarily driven by minor differences in absorption and dust scattering which lead to large apparent differences in flux

Faint Source: 3C 273

- Analysis work performed by Mike Loewenstein (GSFC)
- Cross calibration campaign in 2019-07, Swift, XMM, NICER included
- Two-component power law



3C 273: Two-Component Flux Comparisons

- NICER & Swift fluxes agree to within a few percent in three energy bands
  - XMM ~10%
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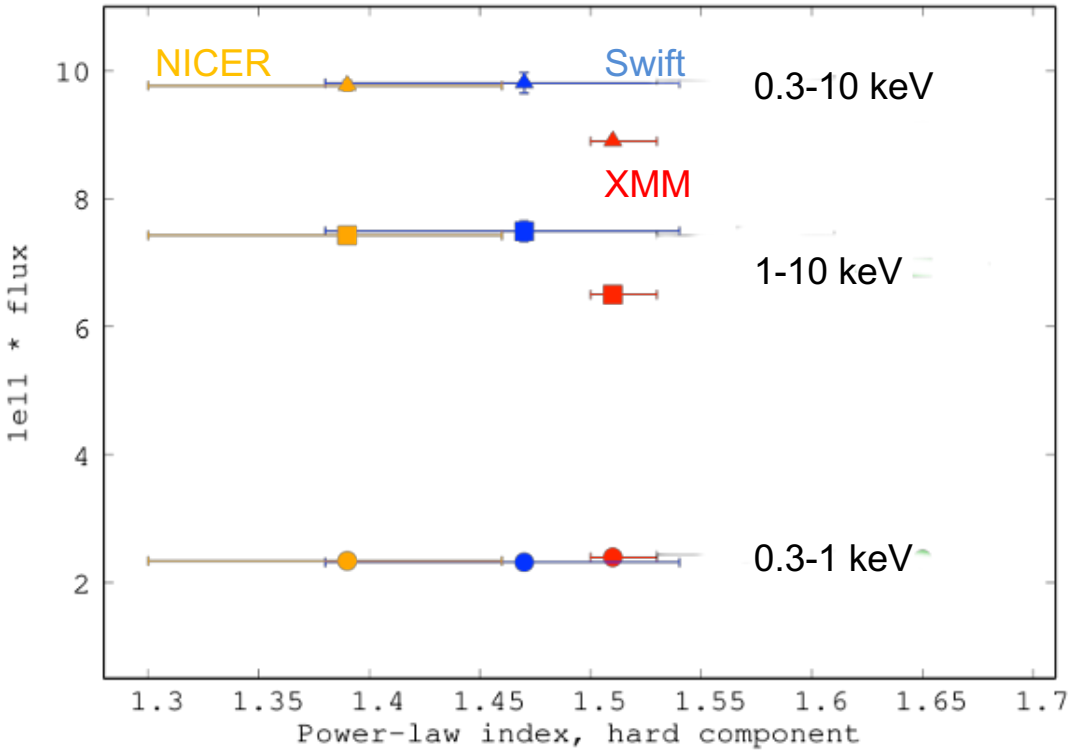
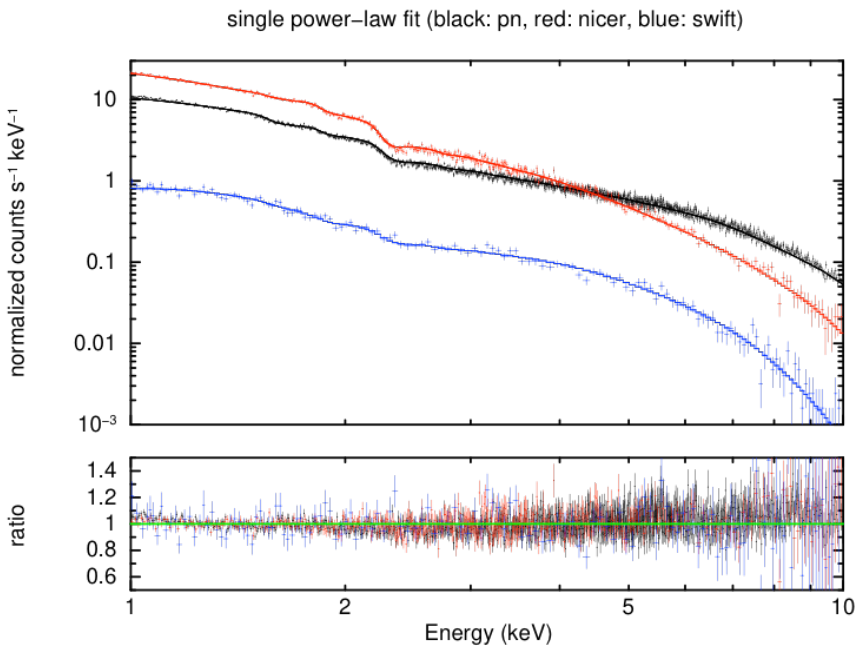
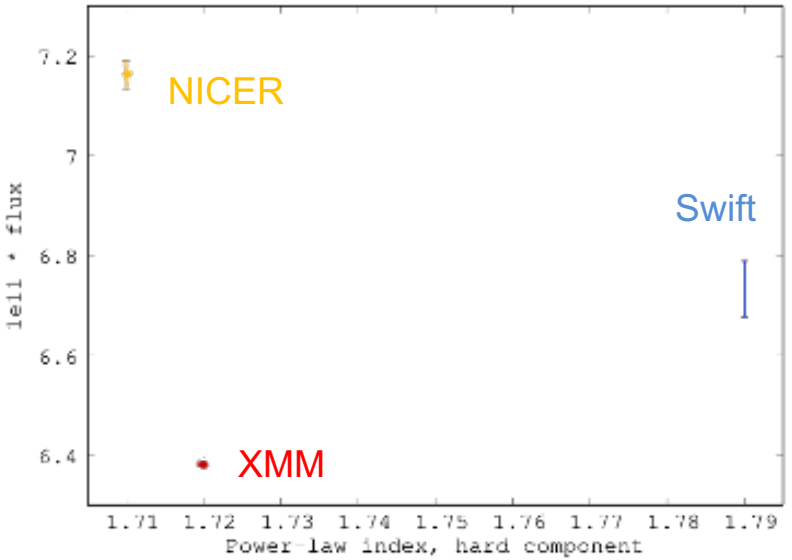


M. Loewenstein

3C 273: Single Component (1-10 keV)

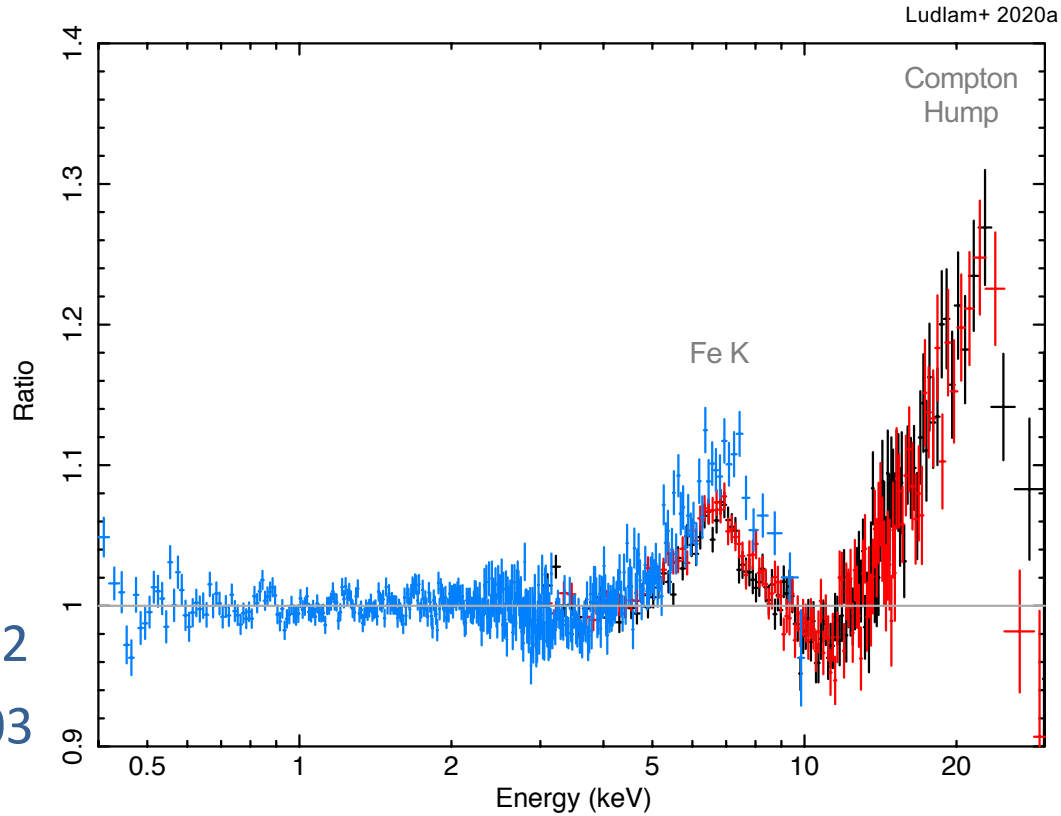




- Single power law indices compare within ~0.08
- NICER and Swift compare ~6%
  - XMM ~12%

4U 1735-44: NICER+NuSTAR

- Ratio of the data to simple continuum model of a thermal disk, single-temp blackbody, and power-law
- Two edge components at 0.81 keV and 0.52 keV
- Multiplicative constant:
  - C_FPMA = 1.00 (fixed)
  - C_FPMB = 0.996 +/- 0.002
  - C_NICER = 1.040 +/- 0.003



NICER + NuSTAR Work shown in next slides courtesy of Renee Ludlam (Caltech)

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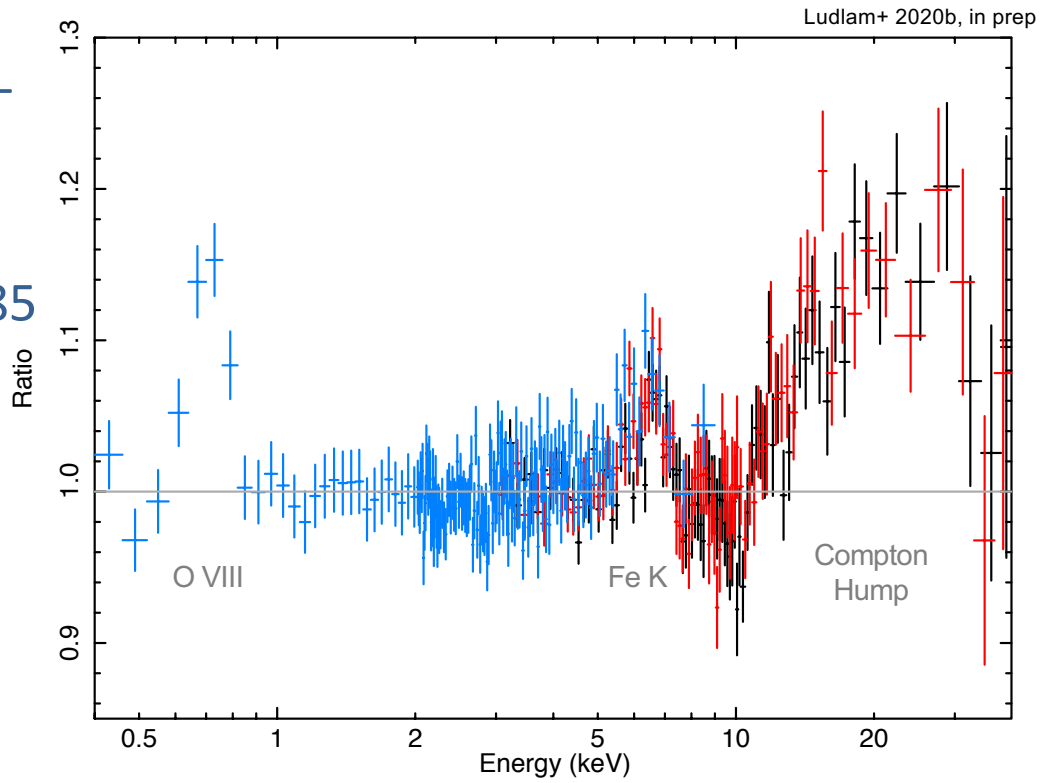
4U 1543-624: NICER+NuSTAR

- Ratio of the data to simple continuum model of a single-temp blackbody and cut-off power-law
- Two edge components at 0.85 keV and 0.52 keV
- Multiplicative constant:
  - C_FPMA = 1.00 (fixed)
  - C_FPMB = 1.01 +/- 0.01
  - C_NICER = 1.03 +/- 0.01



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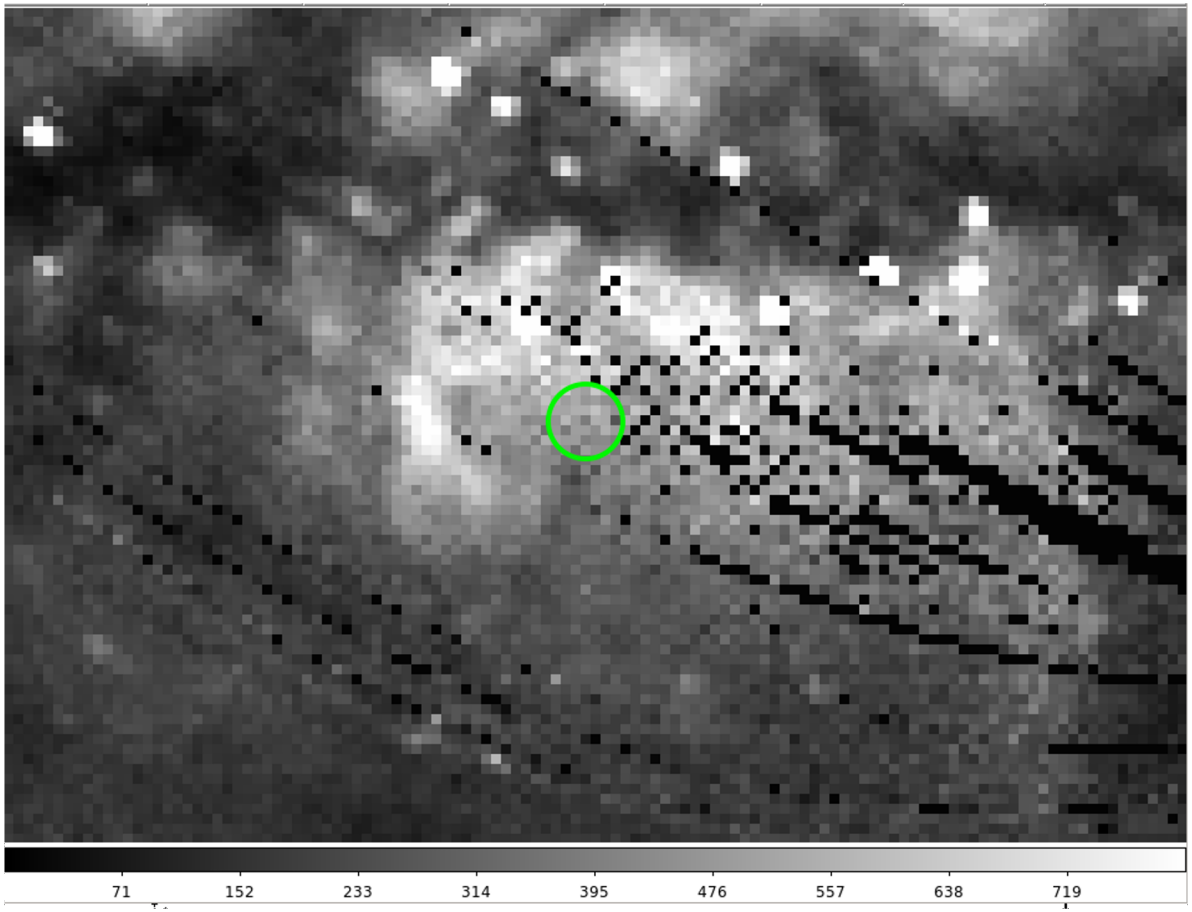
RX J1856.6-3754

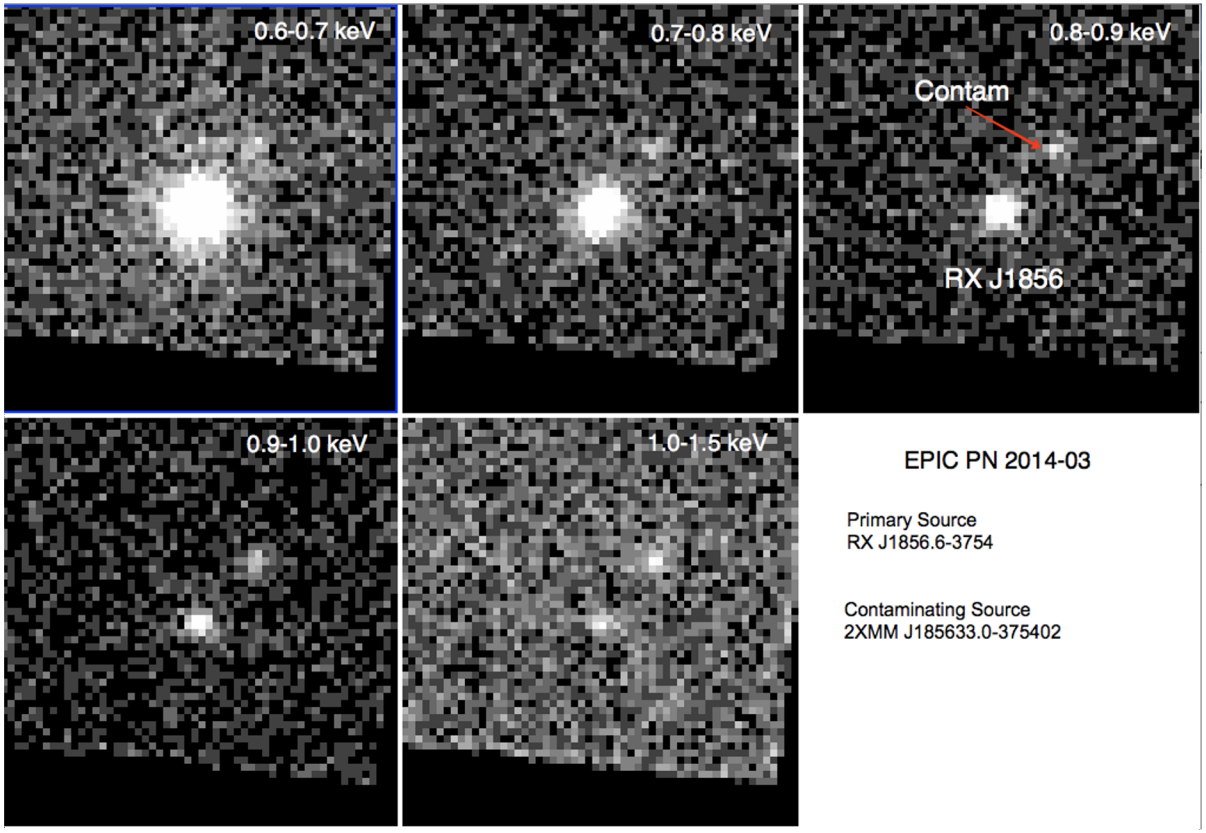
- RX J1856.6-3754 is isolated neutron star
  - soft spectrum (kT < 65 eV)
  - low absorption
  - constant intensity (assumed)
- Claims of hard X-ray tail by Yoneyama et al. 2017 (Suzaku XIS)
- Source is also embedded in Galactic bulge diffuse emission which is significant at ~10% level compared to point source

RX J1856 Diffuse Emission



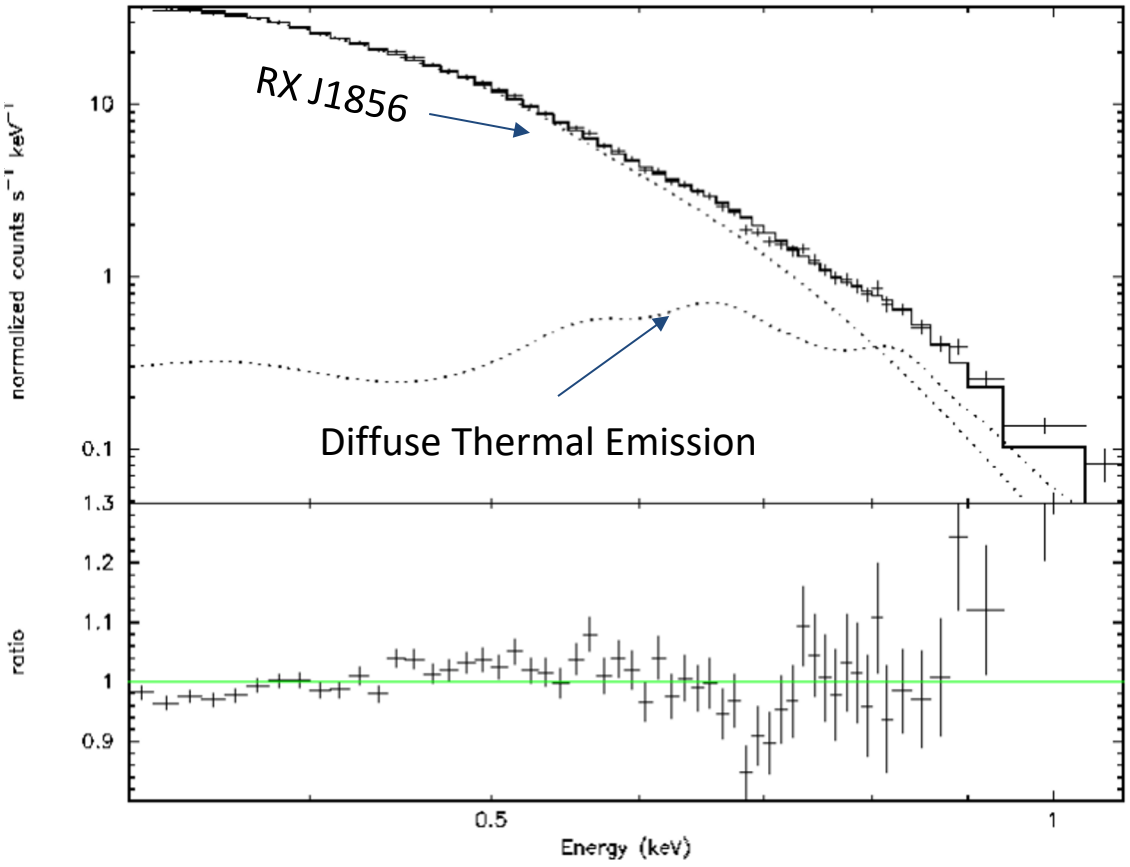
ROSAT All-Sky Survey ¾ keV ~ 500 ct/s/arcmin^2

RX J1856 Nearby Contaminator



Hard source 38” from RX J1856, spectrum consistent with kT=140 eV, highly variable on timescale of weeks-years; far enough away to not contaminate XMM or Chandra spectra

RX J1856 NICER Spectrum



Spectral shape fixed at IACHEC values (NICER norm 93%), diffuse emission is consistent with ROSAT levels

Summary

- Based upon Crab, 3C 273, 4U 1735-44 and 4U 1543-624
  - NICER typically measures lower fluxes by 4-6% compared to Swift and/or NuSTAR
  - Reasonable spectral shapes (photon indices within 0.1)