Finding sub-luminous accreting black holes and neutron stars using eROSITA

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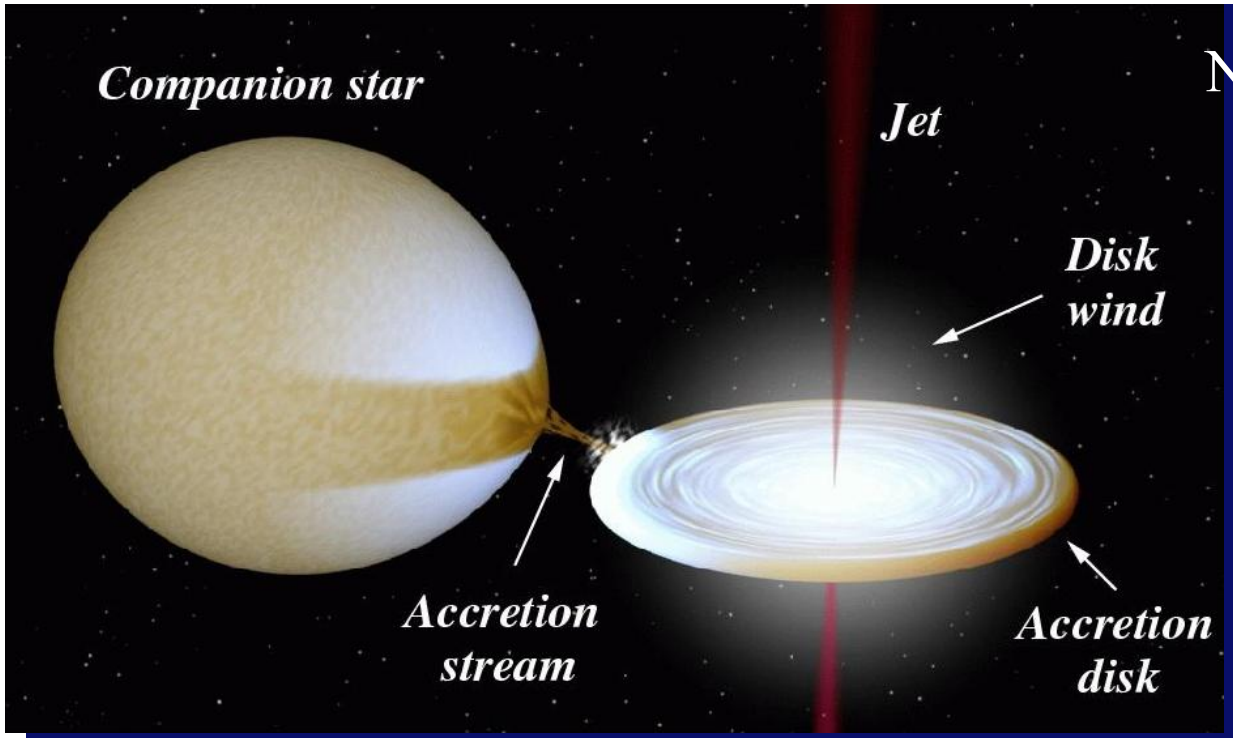
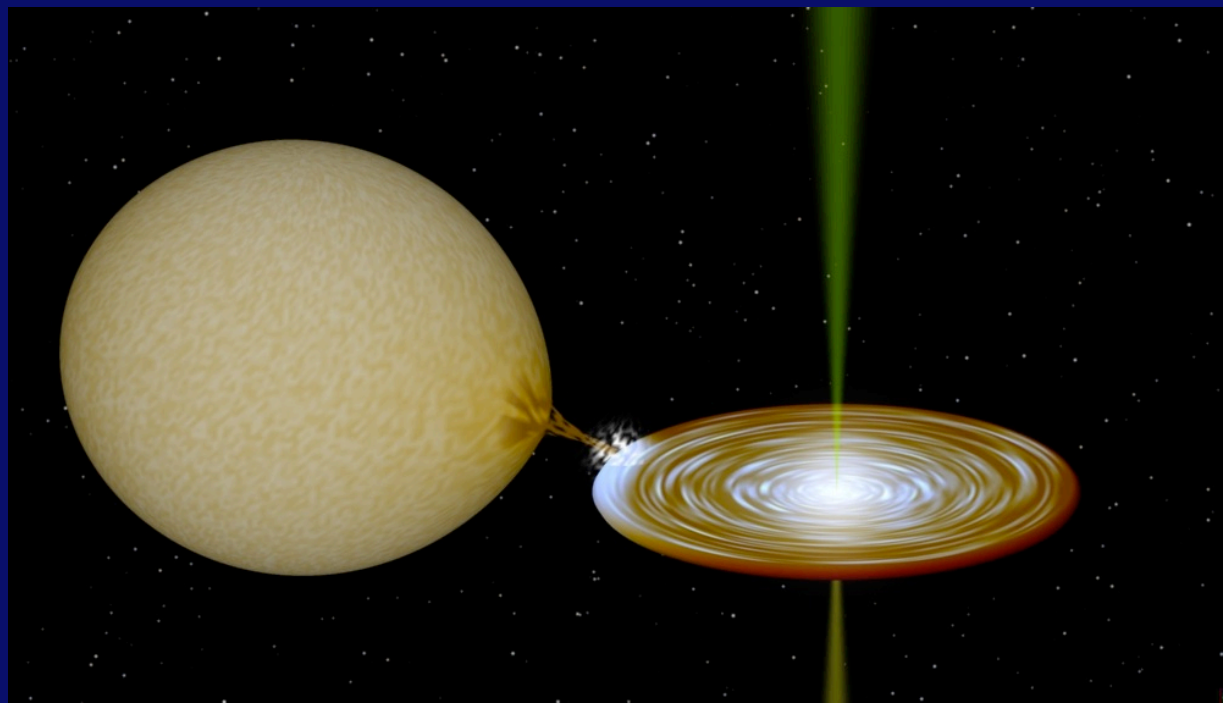


Normal low-mass X-ray binaries

- $L_x \gtrsim 10^{36}$ erg s^{-1}
- 2-10 keV
- 1%-100% L_{Edd}
- Faint to (very) bright

Sub-luminous LMXBs

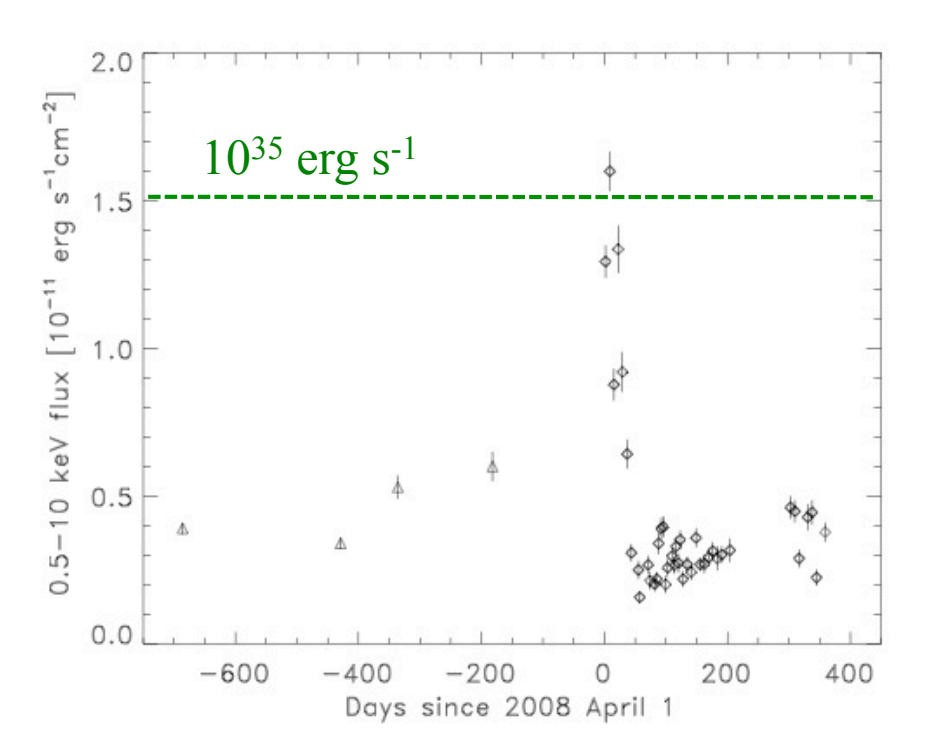
- $L_x = 10^{34\text{-}35}$ erg s^{-1}
- 2-10 keV
- 0.01%-0.1% L_{Edd}
- Very-faint

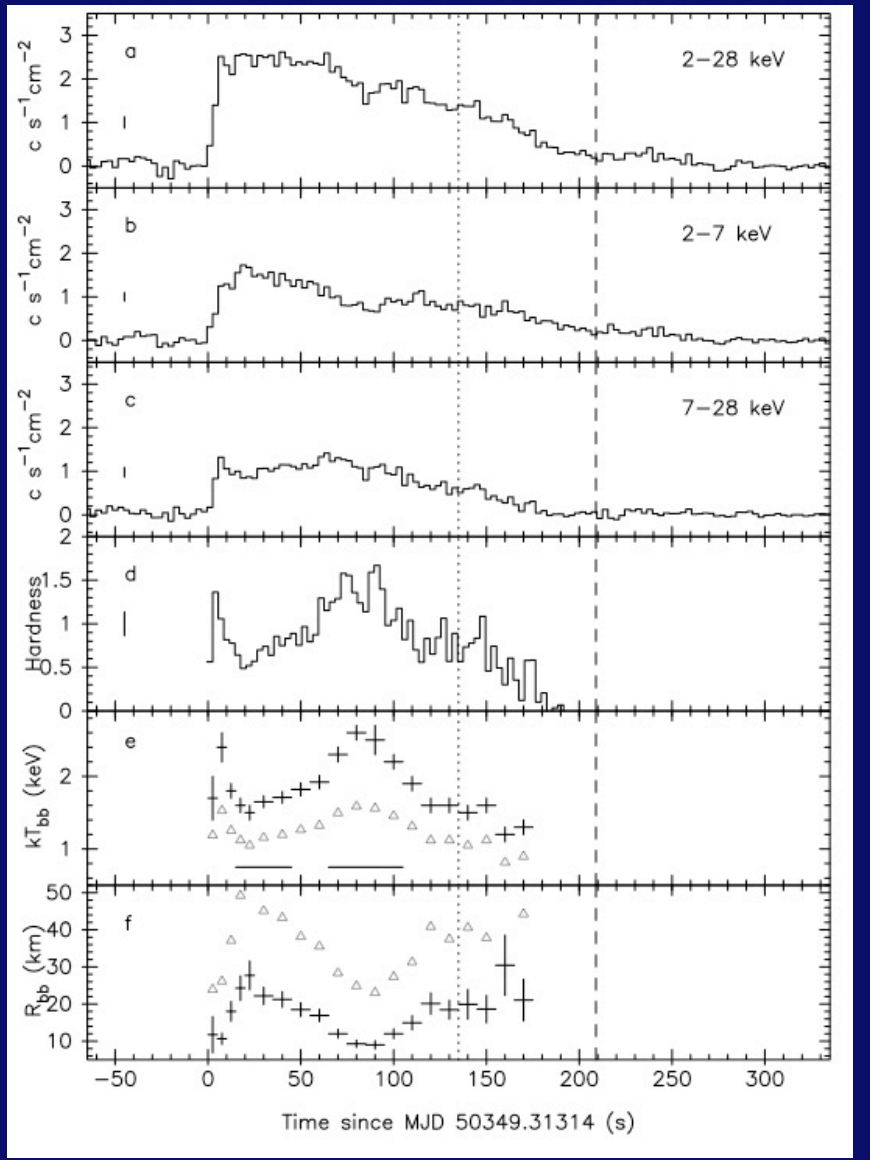


Very-faint persistent systems

Only confirmed NS systems and a bunch of candidate LMXBs

1RXS J170854.3-321857, 1RXS J171824.2-402934, 1RXH J173523.7-354013, AX J1754.2-2754, XMMU J174716.1-281048



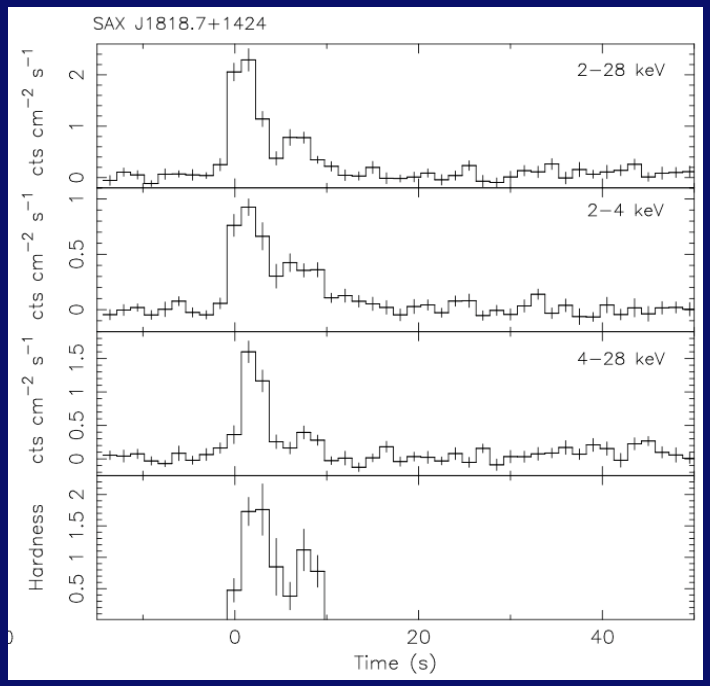


1RXS J171824.2-402934; Kaptein et al. 2000; in 't Zand et al. 2009

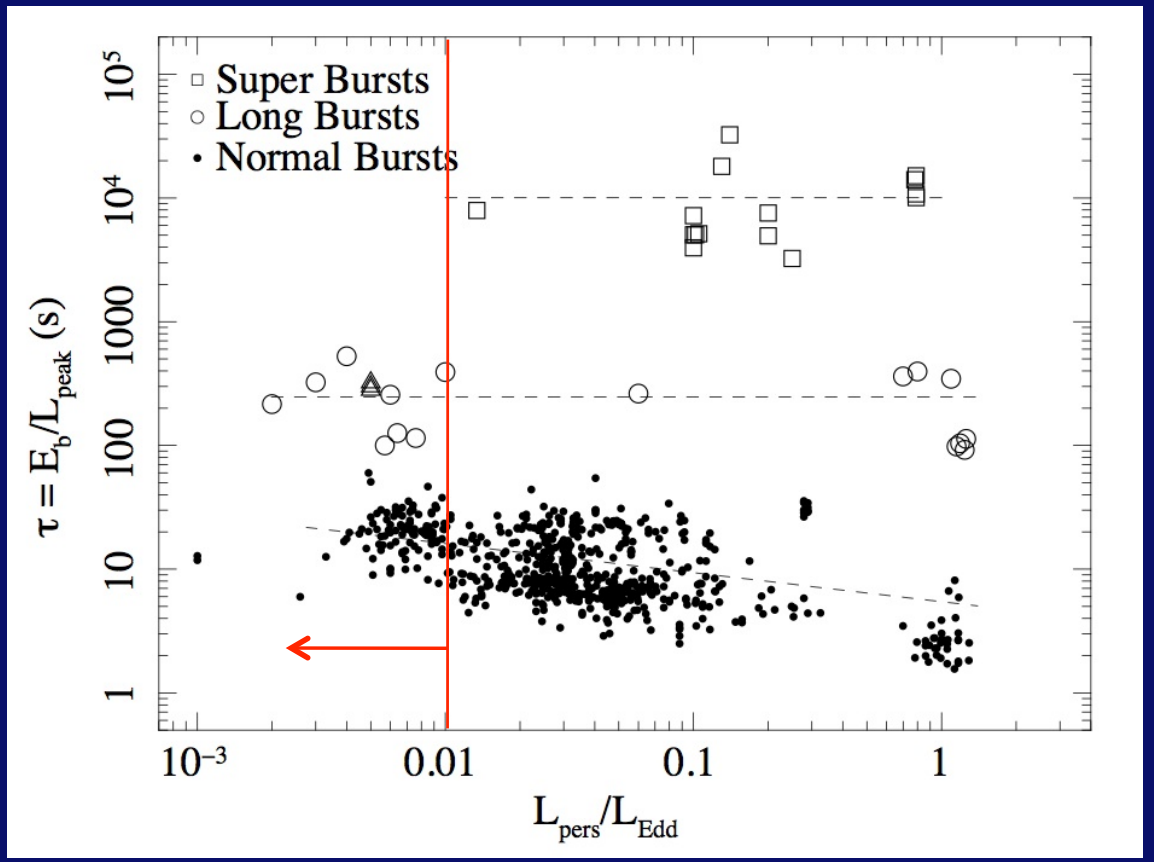
Why study them?

- What kind of binary and how are they formed?
  - Orbital period, companion star?
- How many in our Galaxy and where located?
  - Are we ignoring a large population or not?
  - How to identify the black hole systems?
- What is the accretion geometry?
  - Why are they so faint? Why are the persistent?
  - Connection with other types of LMXBs
  - New mode of accretion? ADAF like accretion flows?
  - Any outflows?
  - Comparison with low/intermediate luminosity AGN?
  - Compact object physics at very low accretion rates.

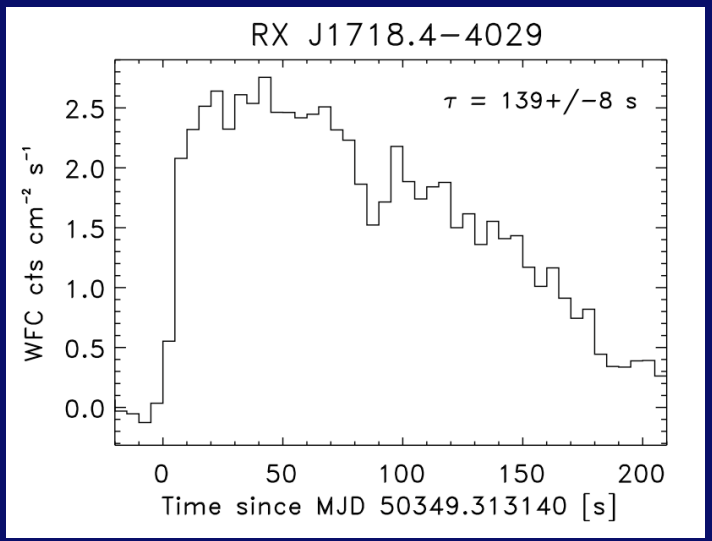
Thermonuclear flashes



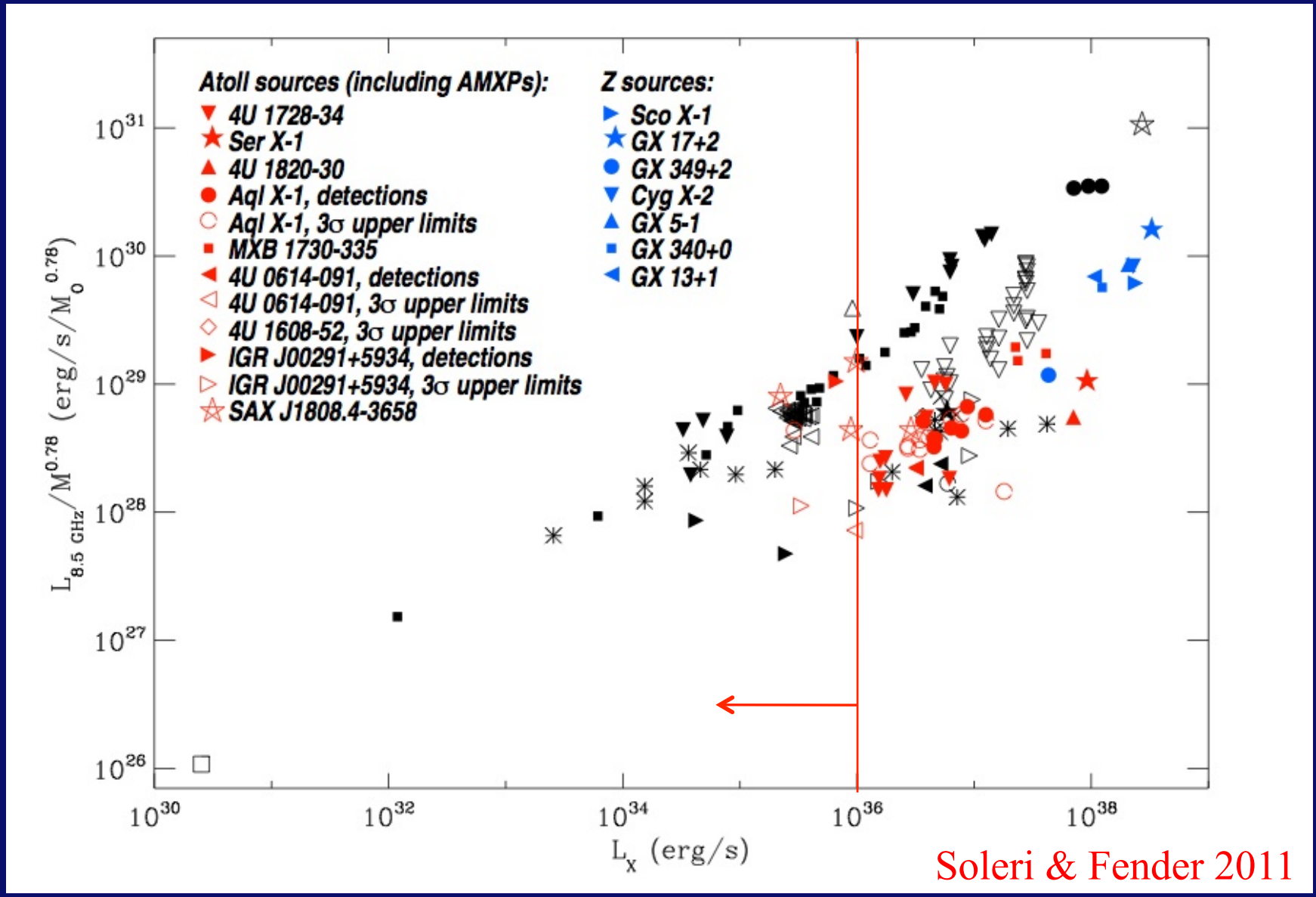
Cornelisse et al. 2003
In ‘t Zand et al. 2007



Falanga et al. 2008



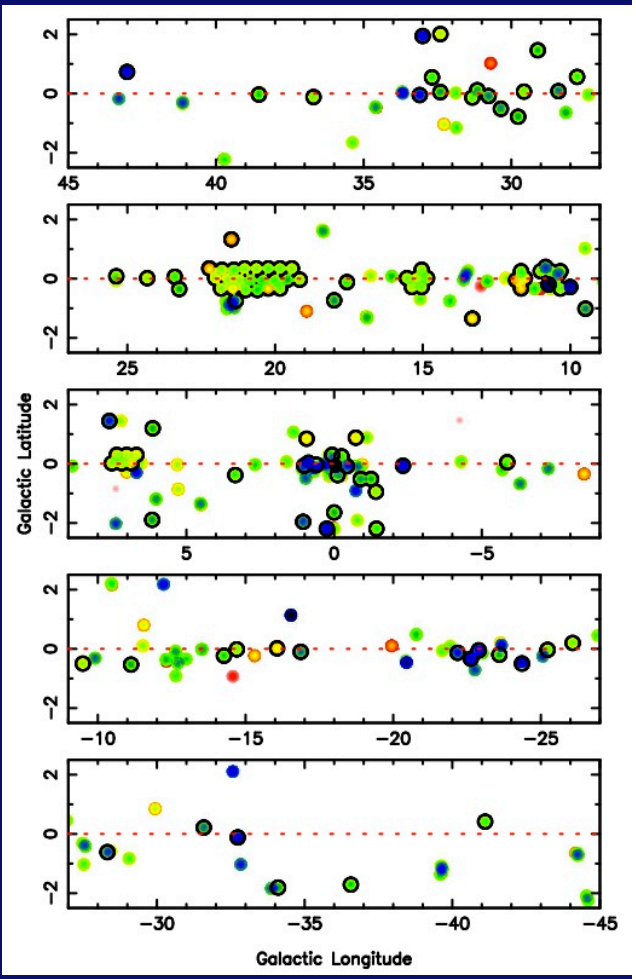
Outflow studies



Soleri & Fender 2011

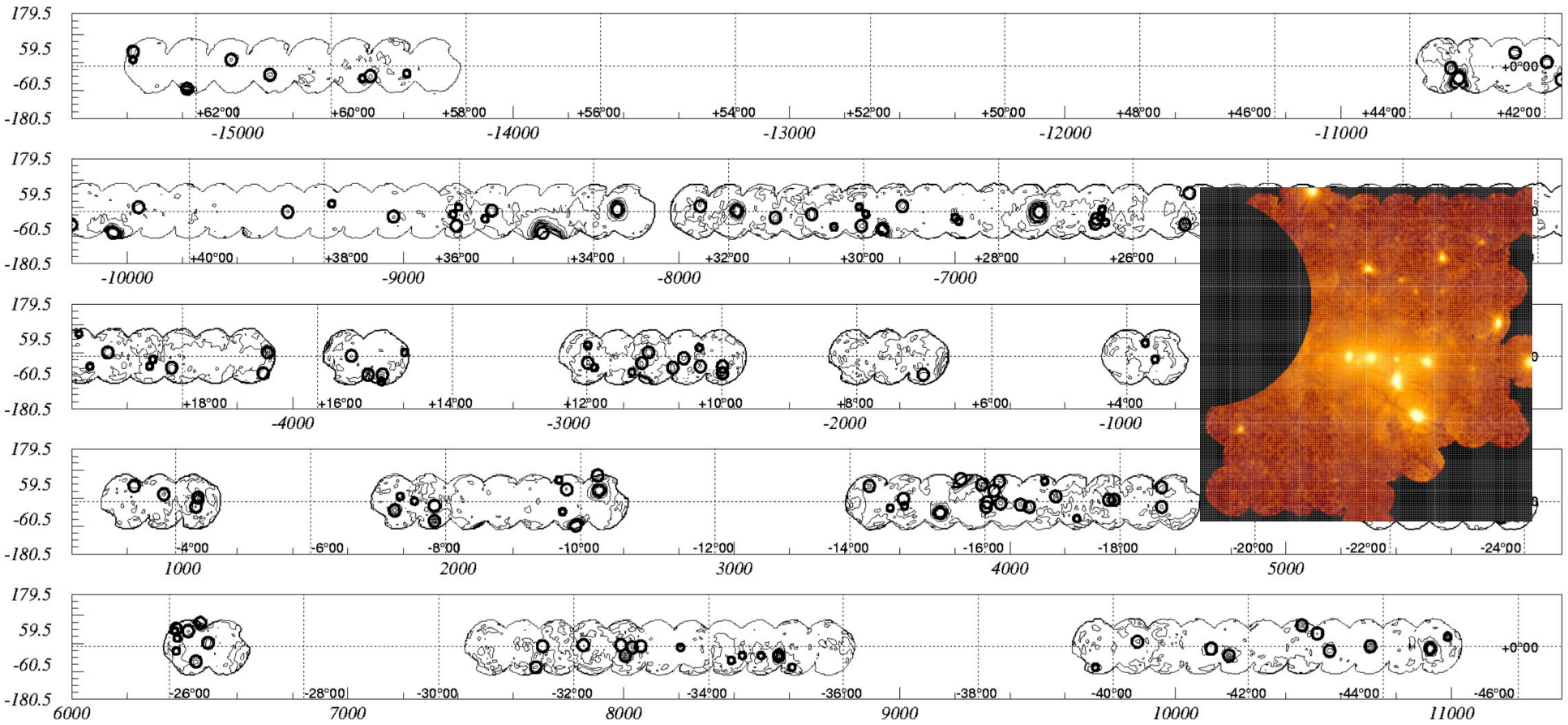
How to find them?

- Need sensitive Galactic surveys
- Past surveys
  - ROSAT
    - All sky and dedicated areas
    - Not so good for absorbed sources
  - ASCA Galactic center/plane survey
    - Limited FOV, not complete Galaxy
  - Smaller surveys
    - Chandra/XMM-Newton/Swift/Integral
    - Limited FOV and/or sensitivity



XMM-Newton; Warwick et al. 2011

ASCA Galactic center and plane survey
Sakano et al. 2002; Sugizaki et al. 2001



Down to a few times 10^{-13} erg s^{-1} cm^{-2}

Which corresponds to a few times 10^{33} erg s^{-1} at 8 kpc

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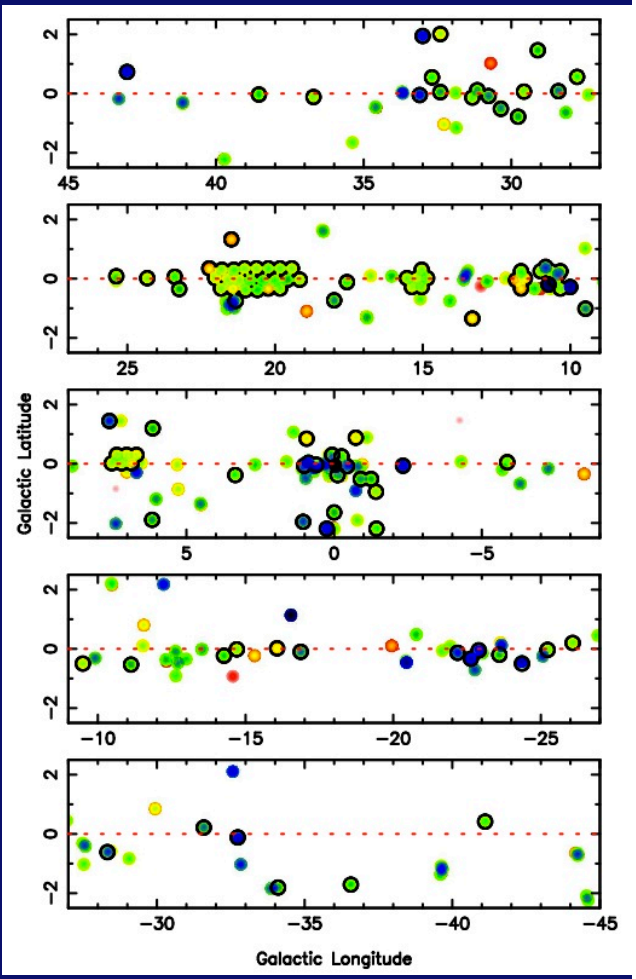
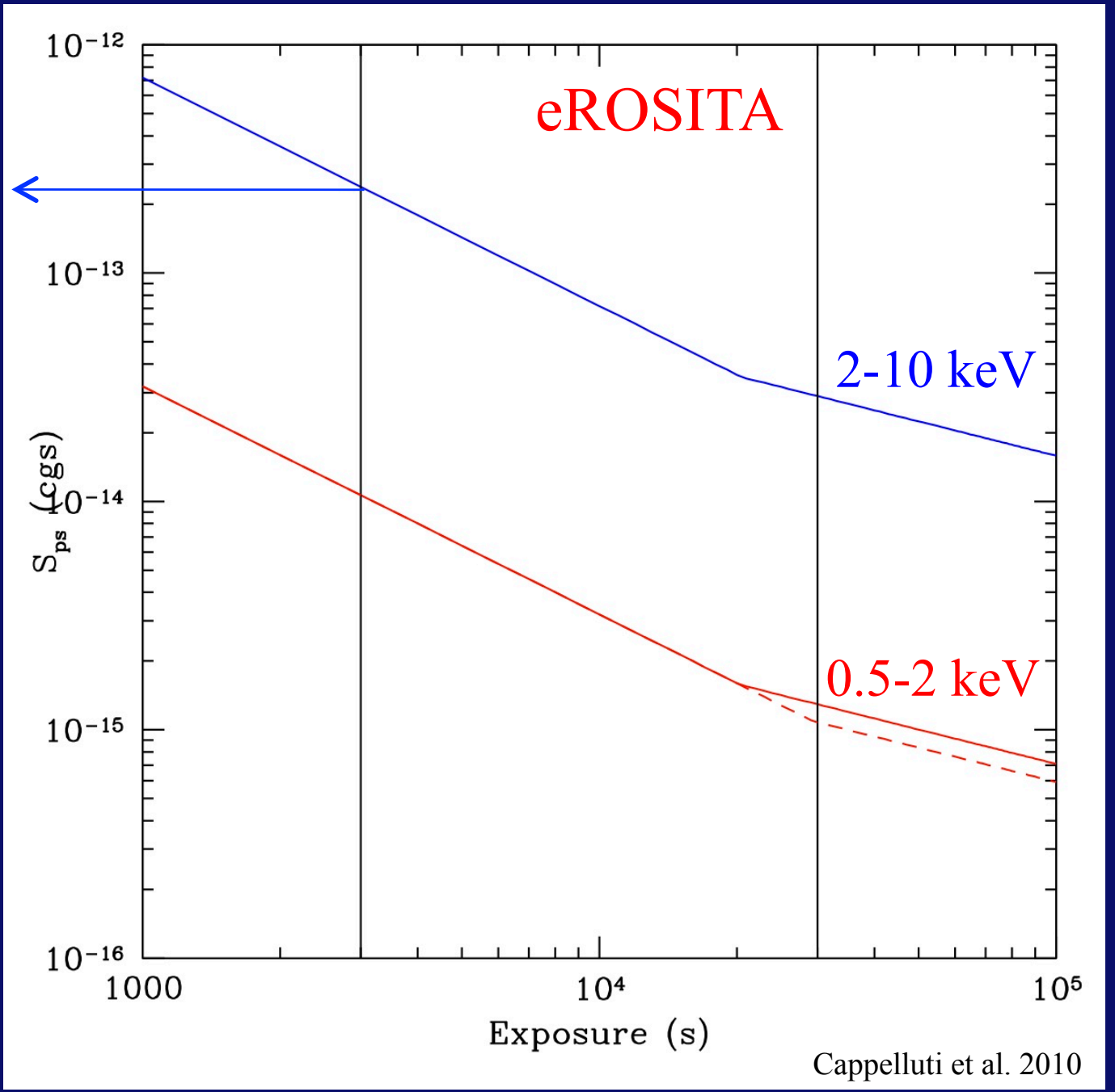


XMM-Newton; Warwick et al. 2011

~2 x 10^{33} erg s^{-1} at 8 kpc

~10^{34} erg s^{-1} at 20 kpc

eROSITA will detect a large fraction of the systems in our Galaxy!



Cappelluti et al. 2010

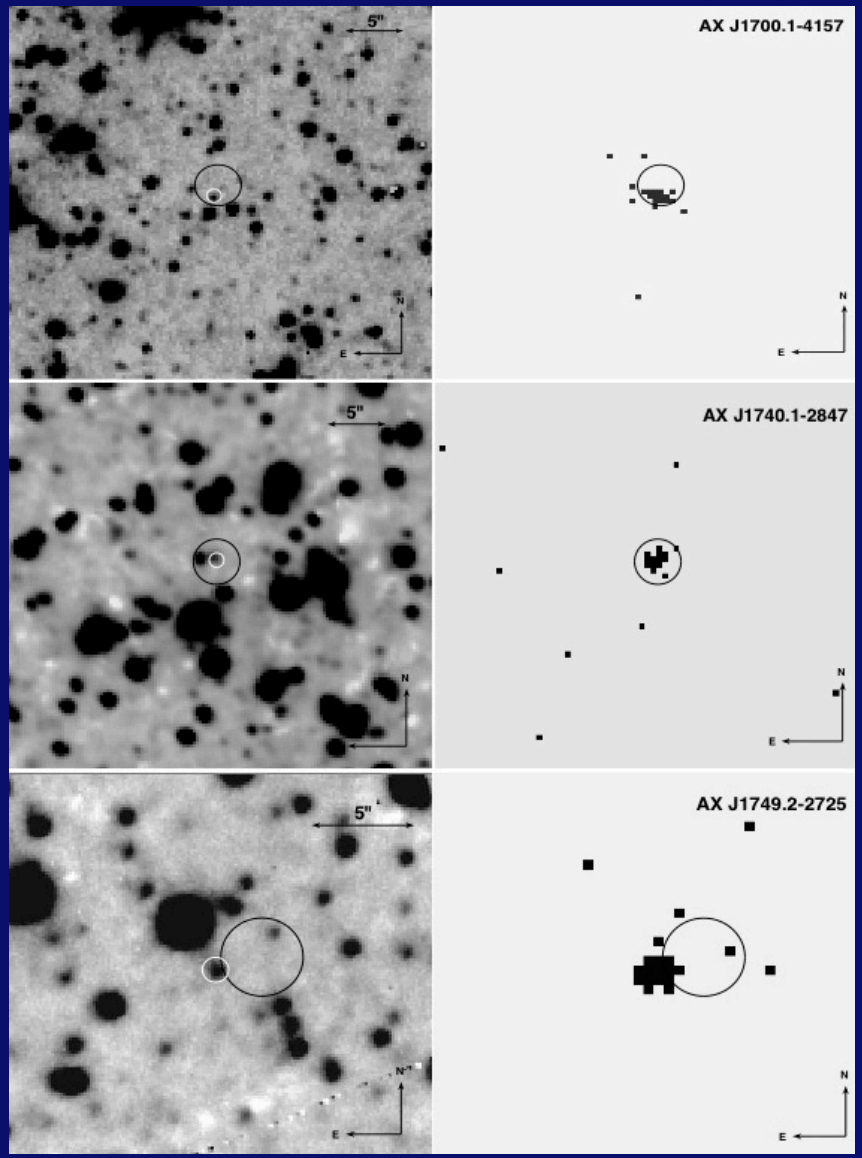
How to identify them?

- Finding them is not the end, just the beginning
- Identification is needed
  - Will be a major challenge!
  - High absorption does not help
  - Contribution of AGN and other Galactic sources
  - Hunt for unusual/unexpected sources
- First selection using eROSITA flux + spectrum
  - Power-law model with photon index 1.5-3.0
- Correlate with other catalogs and surveys
- Follow-up observations → long-term program

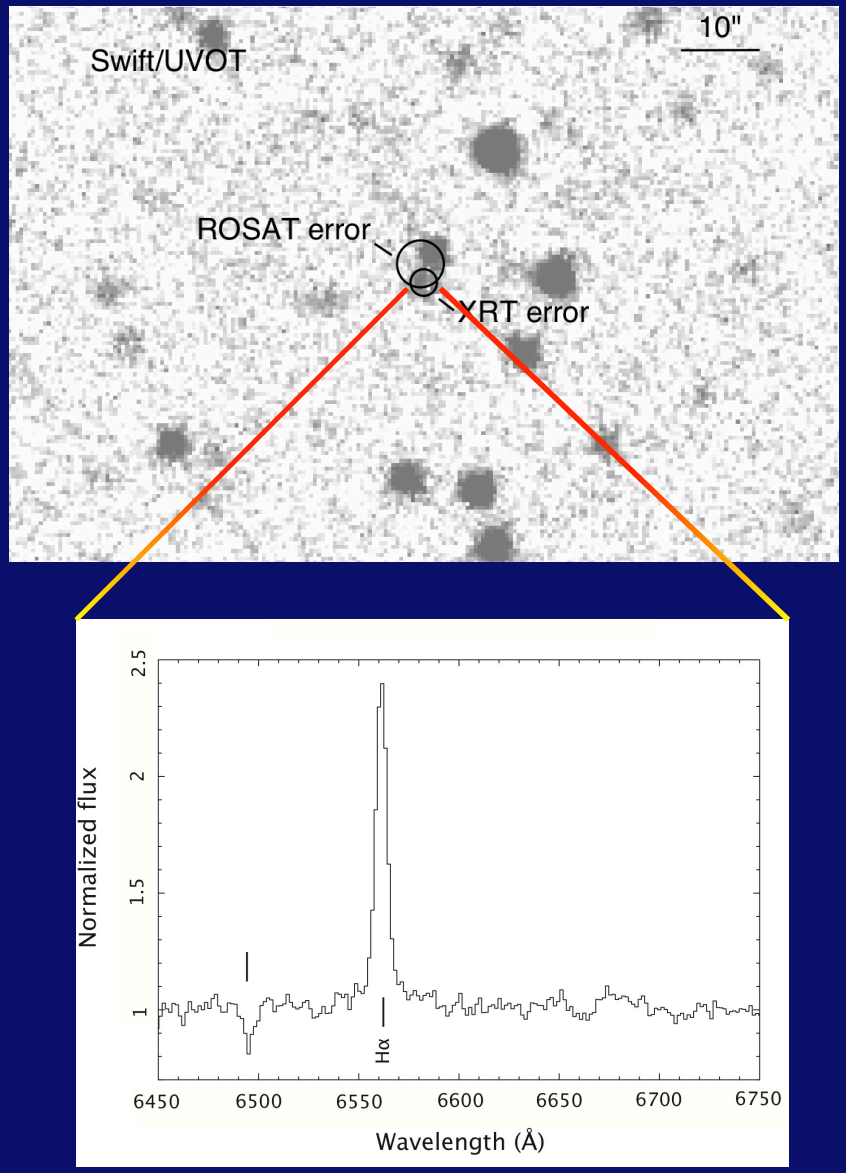
Follow-up observations

- Chandra → best X-ray position
- XMM-Newton
  - Best X-ray spectrum
  - Variability studies (also LOFT)
    - Pulsations, aperiodic variability
- Optical/NIR/radio → counter part studies/outflows
- If (very) lucky we catch a thermonuclear flash
  - Integral and Swift only catch the most energetic ones
  - LOFT Wide Field Monitor: 2-50 keV
- Need eROSITA source catalog

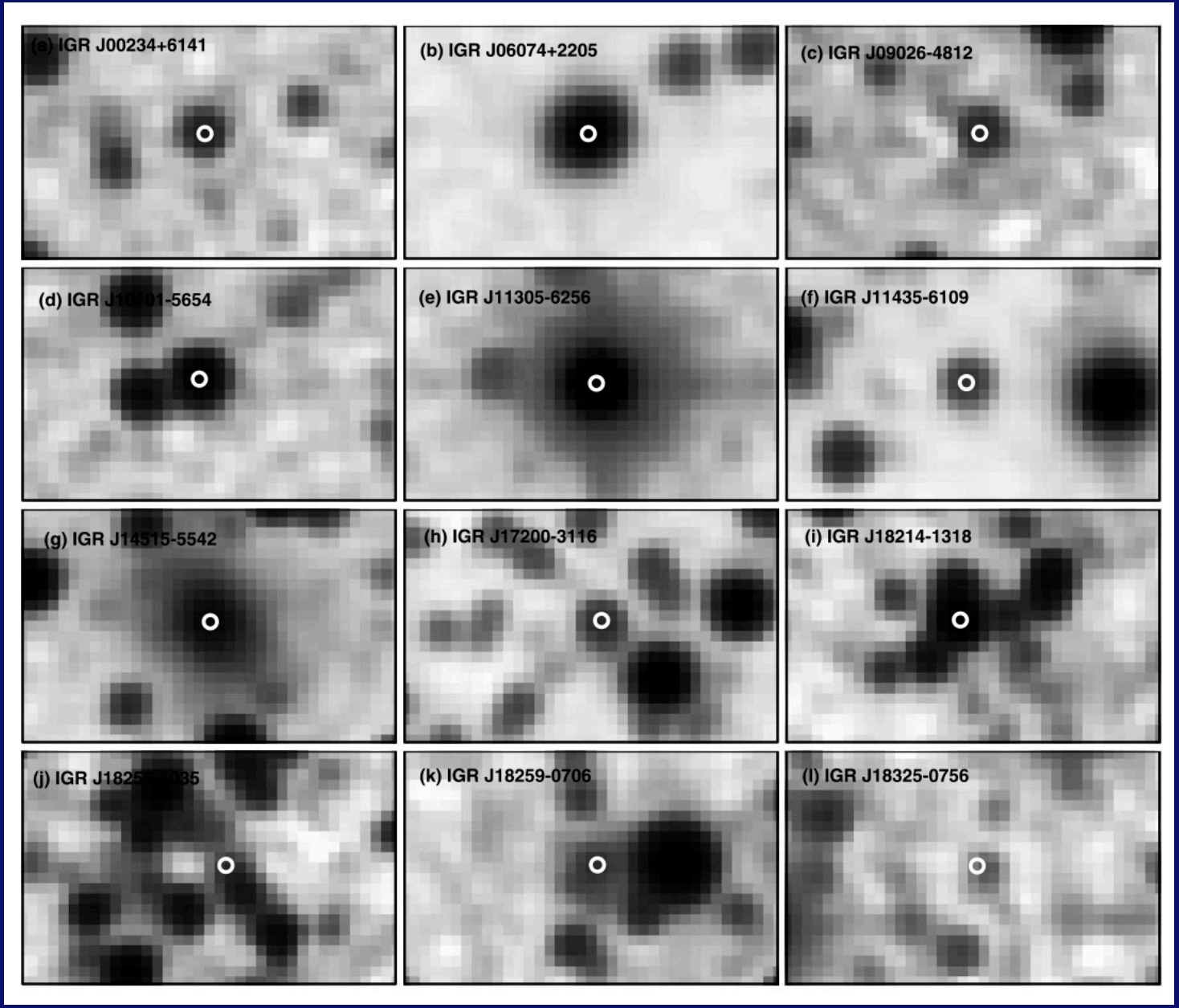
Some results of known sources



Kaur et al. 2010

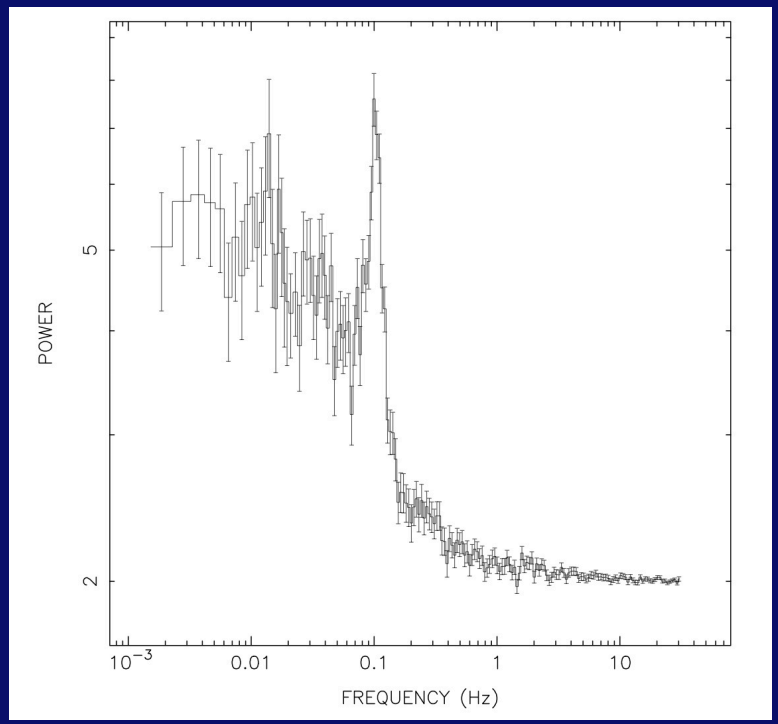


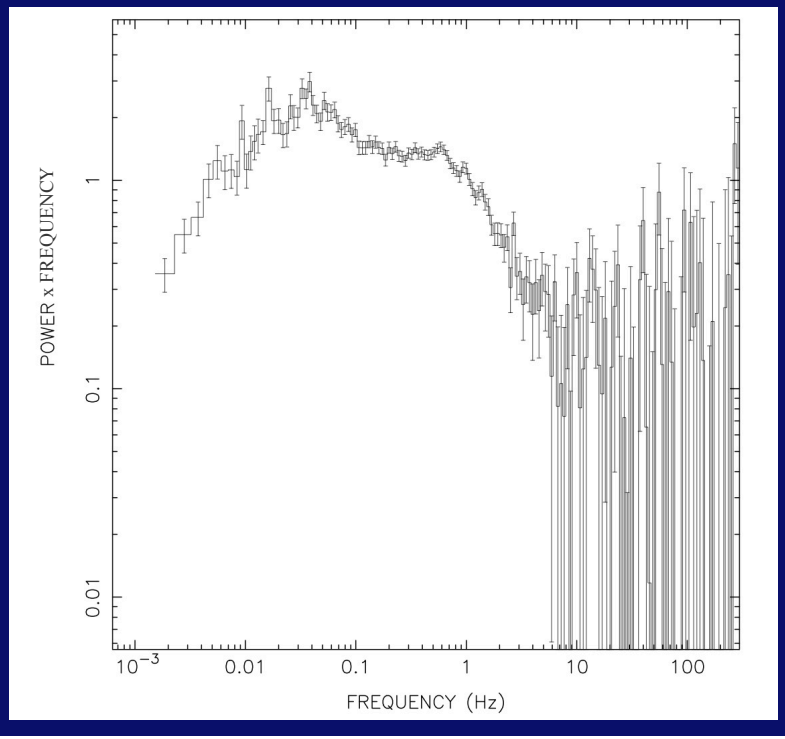
1RXH J173523.7-354013; Degenaar et al. 2010

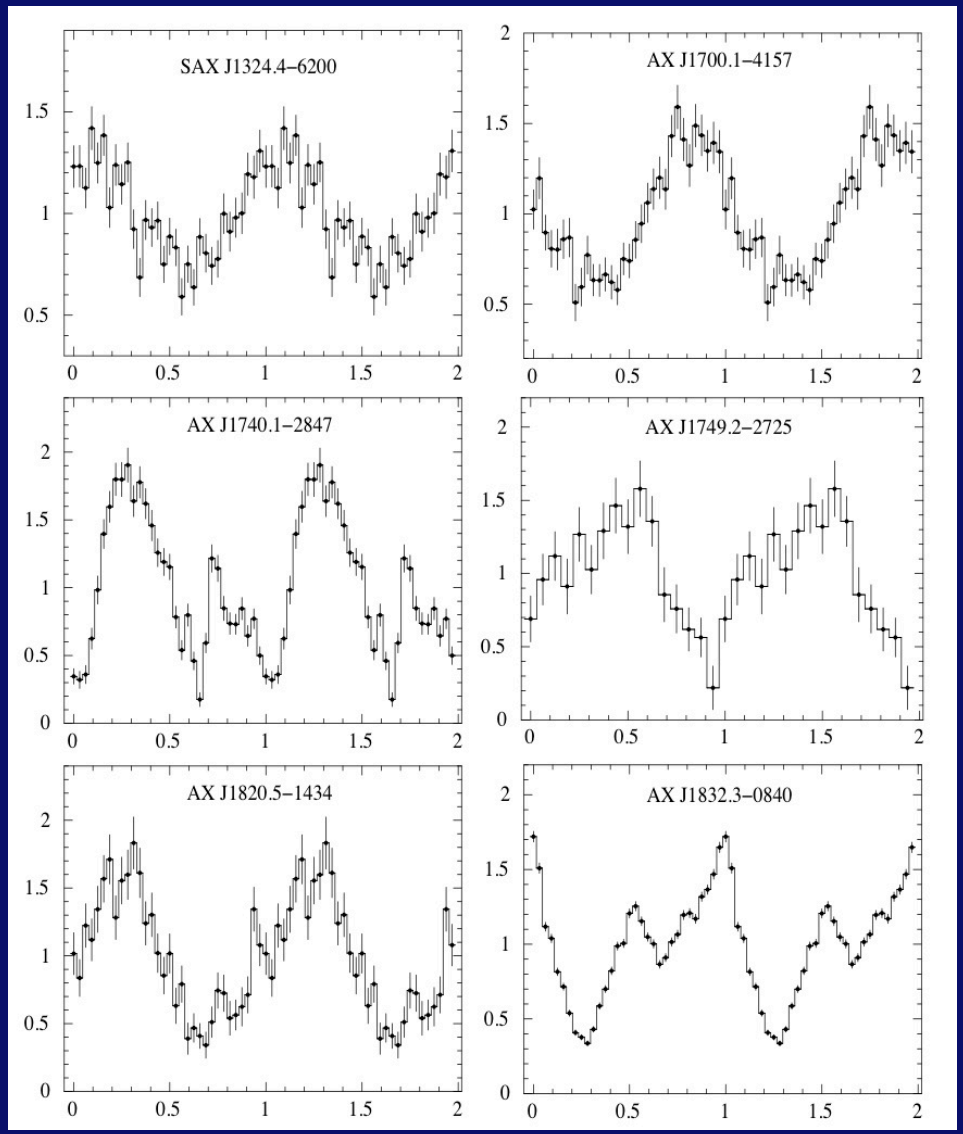


Tomsick et al. 2008, 2009

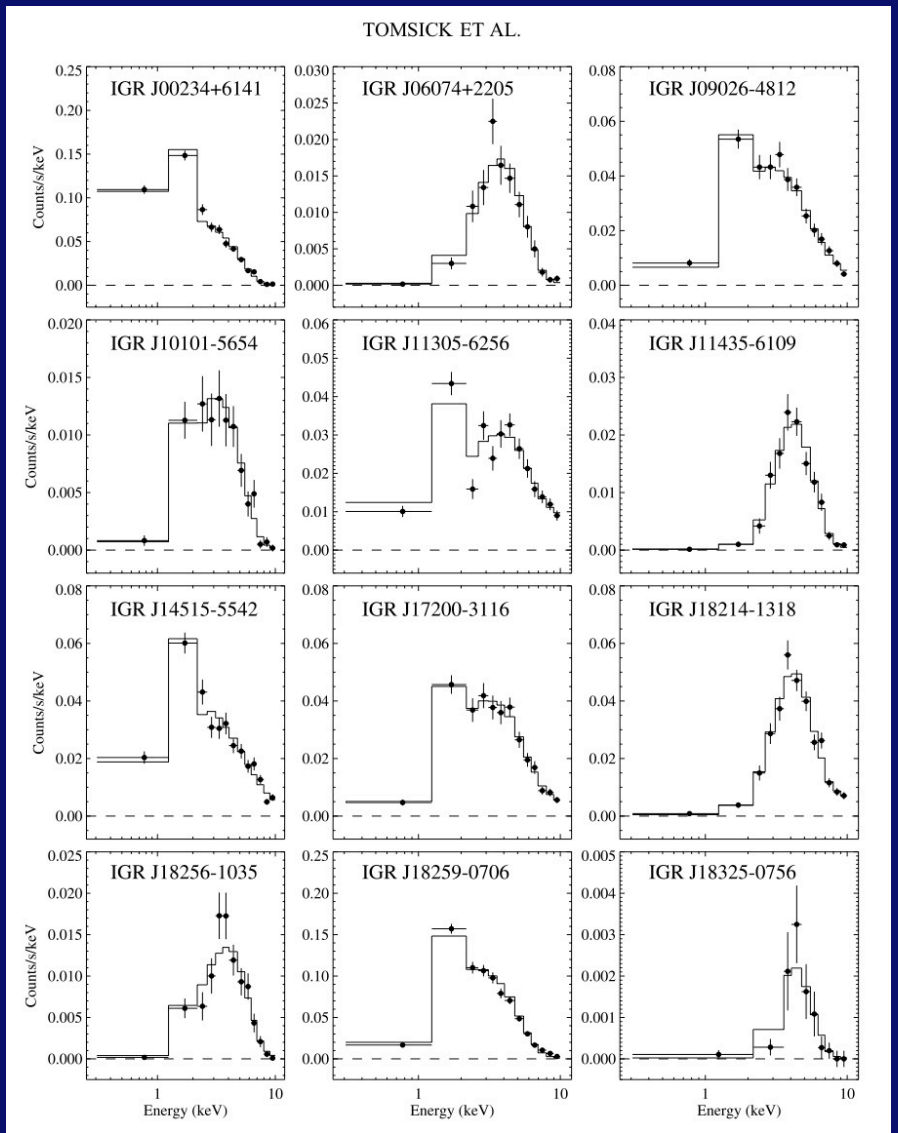
XMM timing results



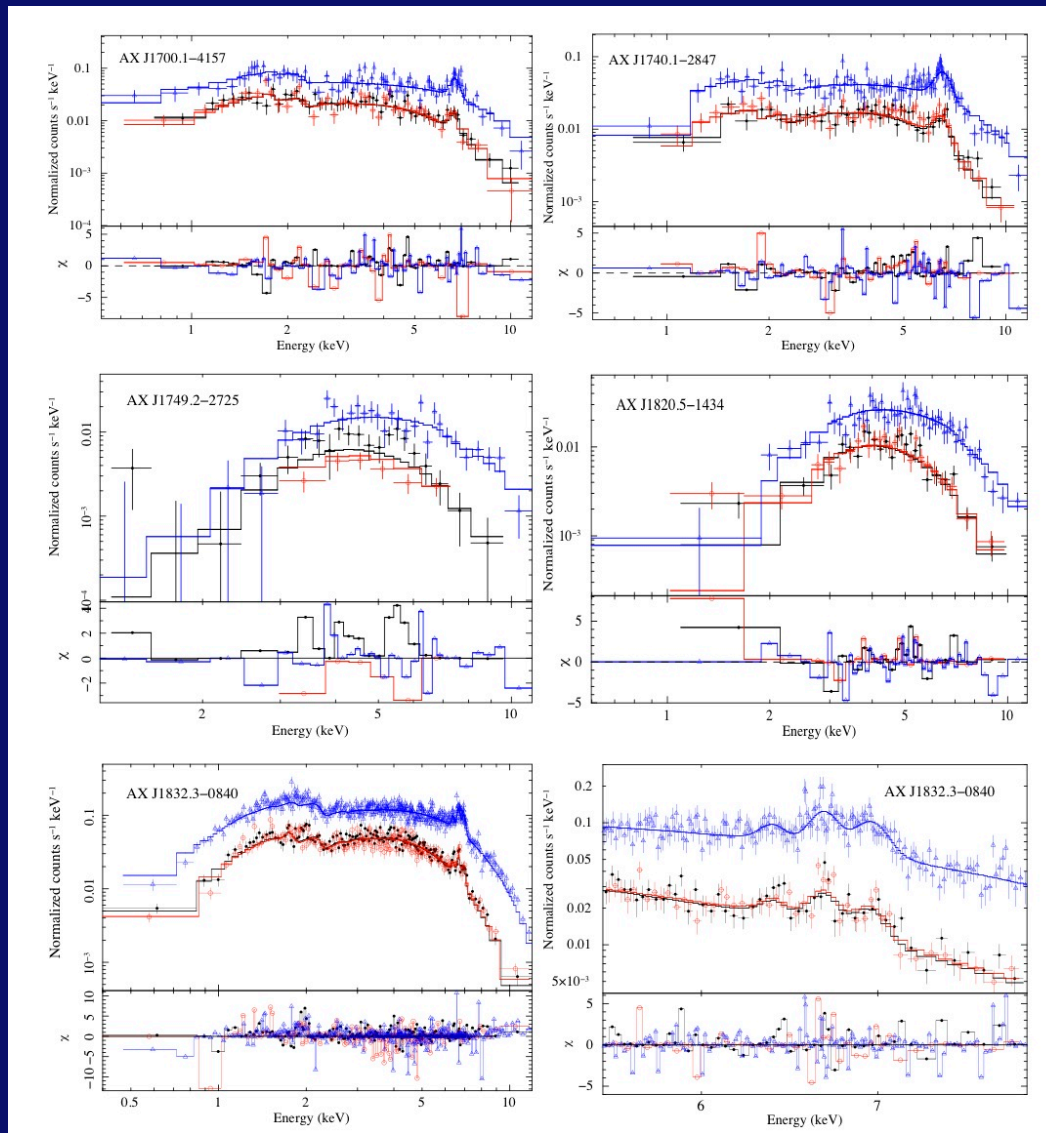




Kaur et al. 2010



Tomsick et al. 2009



Kaur et al. 2009