New optical/UV counterparts and SEDs of Isolated NS

ATISH KAMBLE, D. KAPLAN (UW-MILWAUKEE), M. VAN KERKWIJK (TORONTO) AND W. HO (SOUTHAMPTON)

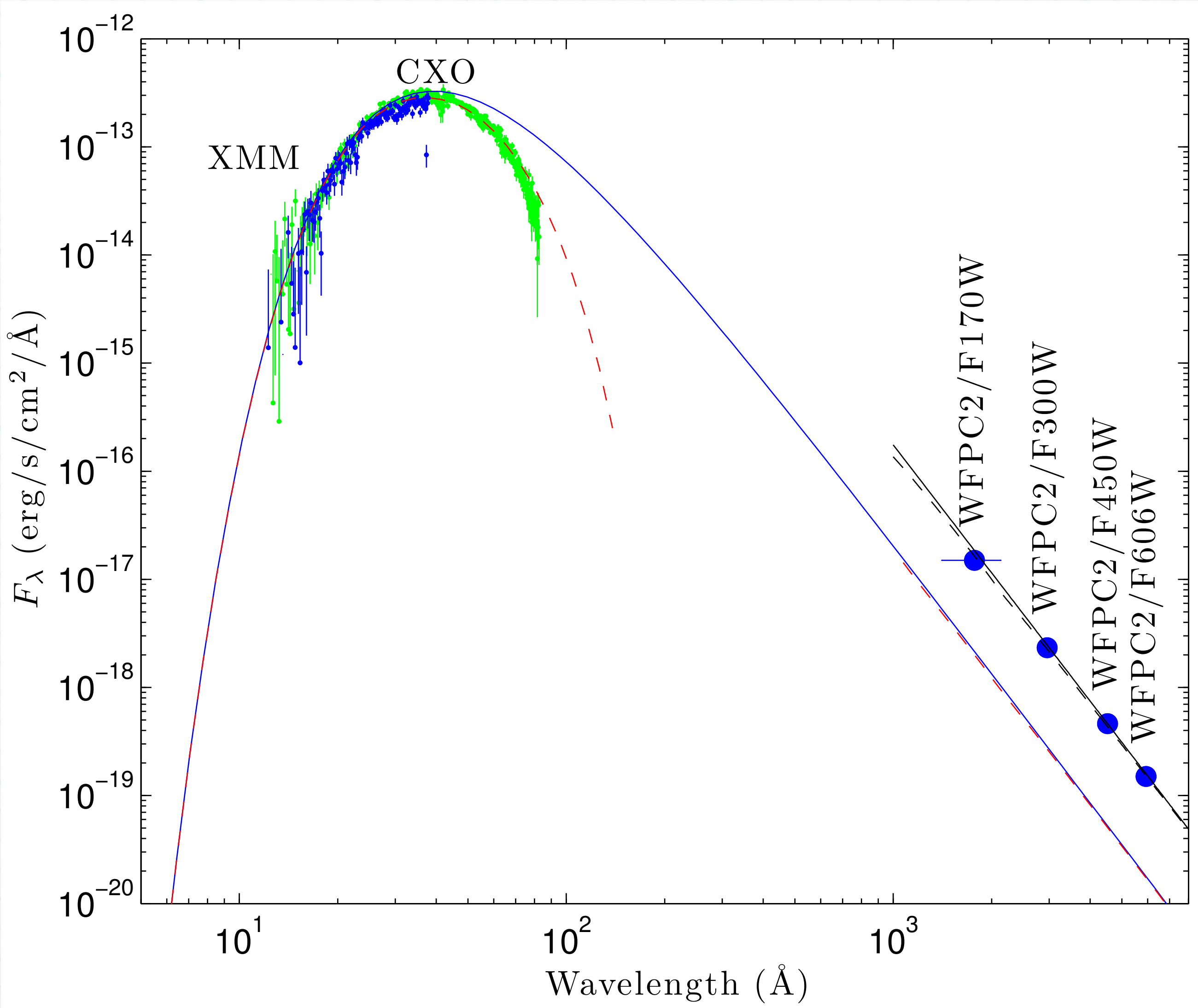
RX J1856...a puzzle !

* Featureless BB spectrum instead of harder than Wien tail or any spectral features (Burwitz et al 2001, 2003)

* Optical excess = 8 (Walter & Matthews 1997; van Kerkwijk & Kulkarni 2001) but Rayleigh-Jeans

* X-ray => Too small Radii

* Optical => too large Radii (Braje & Romani 2002)

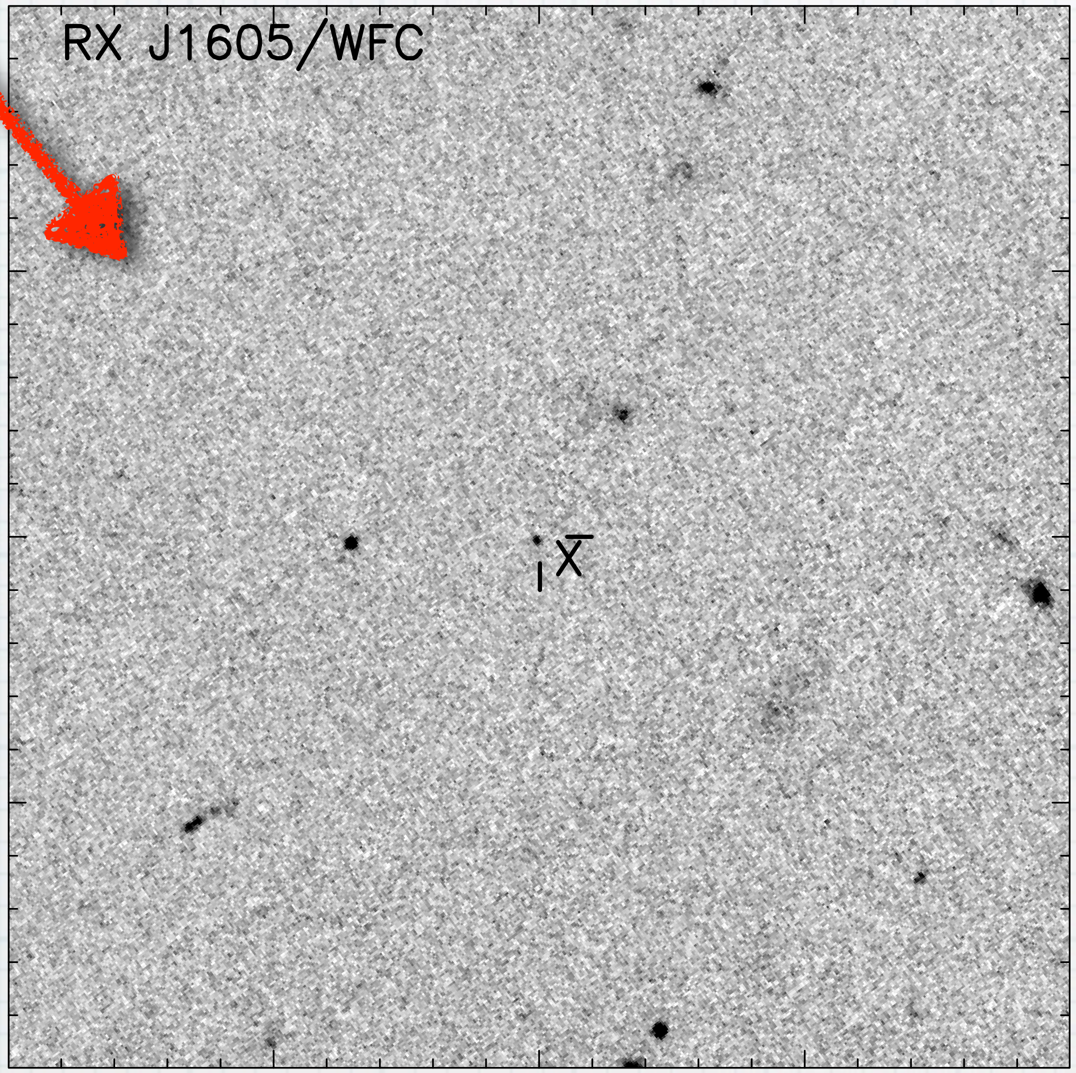


* Is RX J1856 special or do all INSs show similar behavior (Optical Excess, Rayleigh-Jeans spectrum) ?

* Could this behavior be explained ?

Identifying counterparts

easy

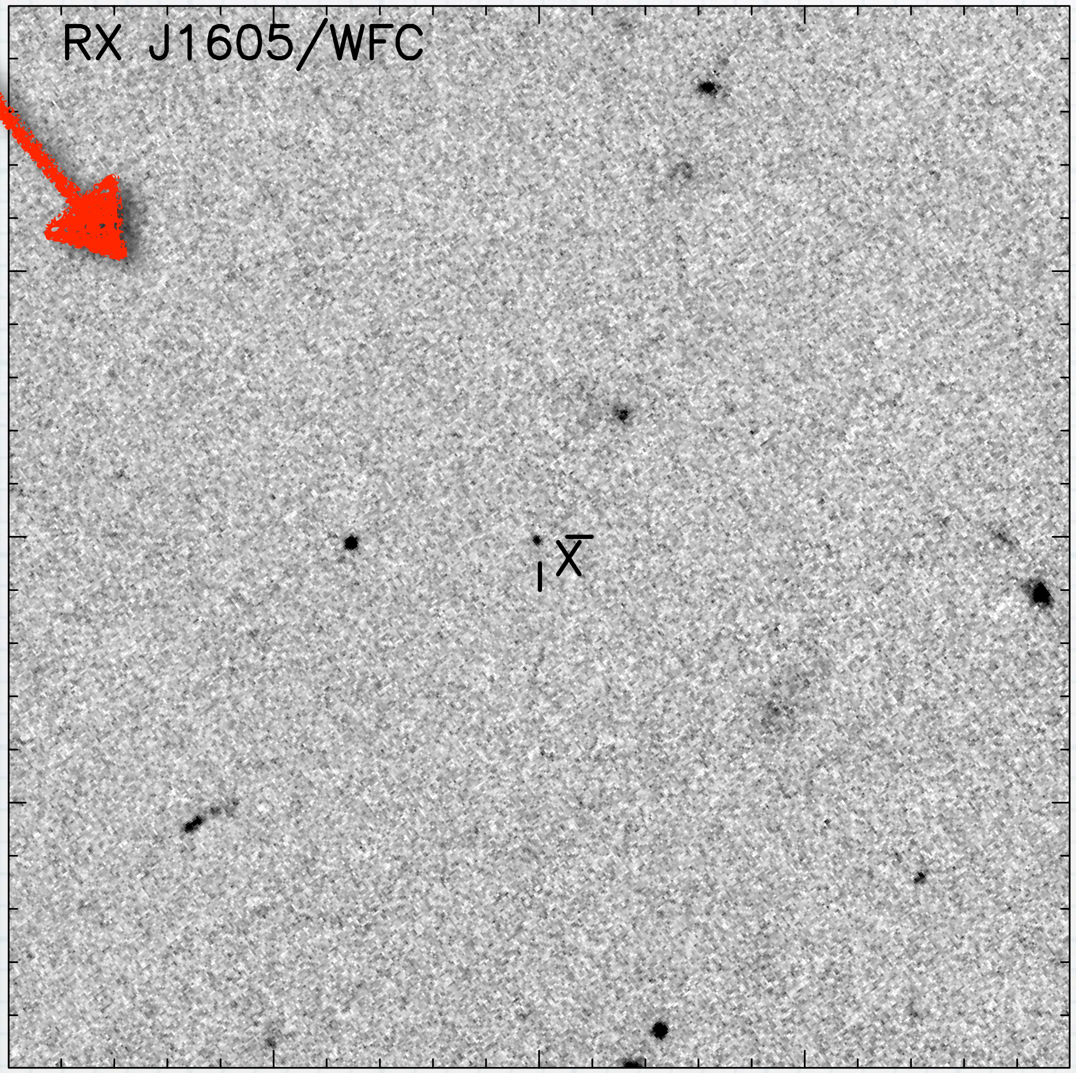


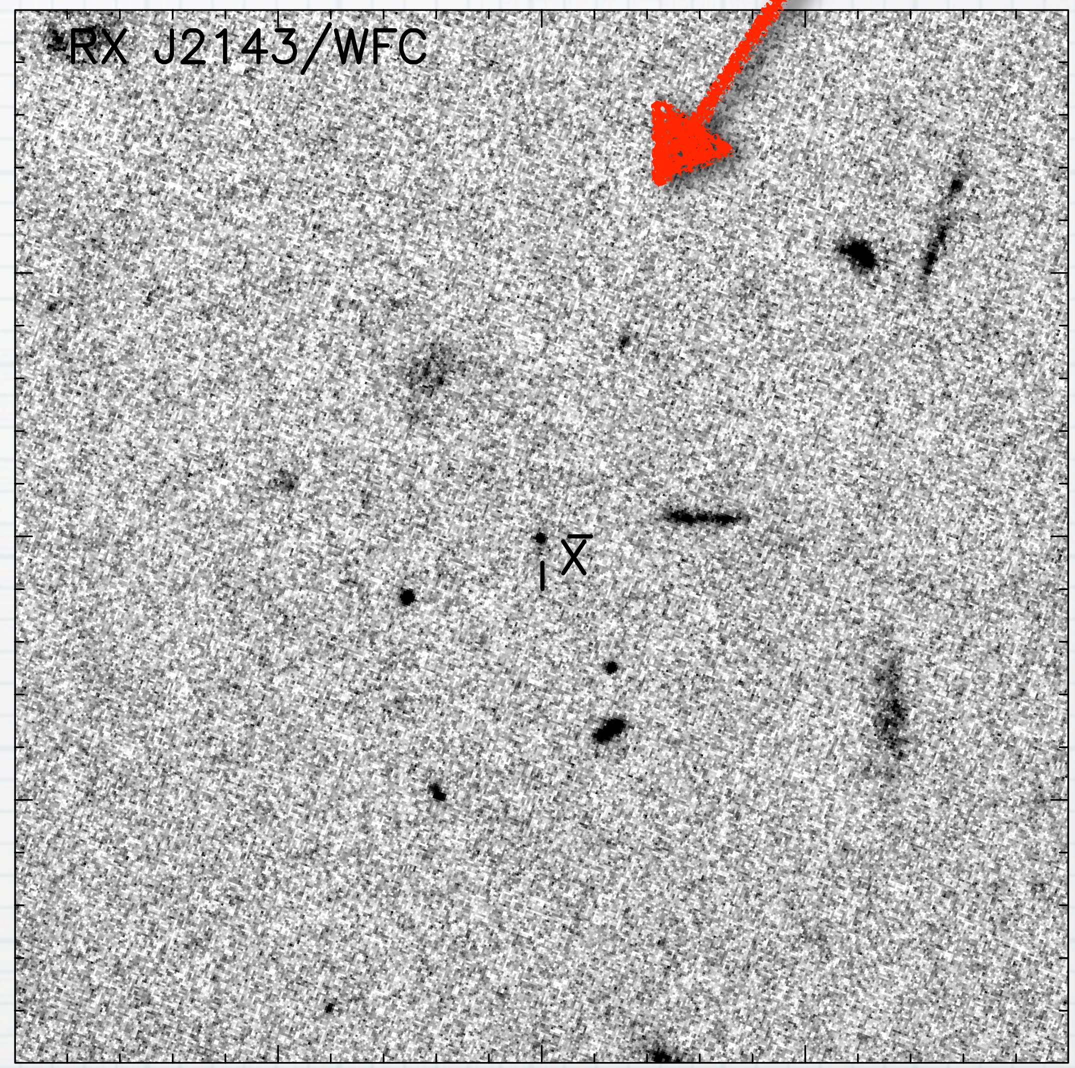
HST photometry => very reliable

Identifying counterparts

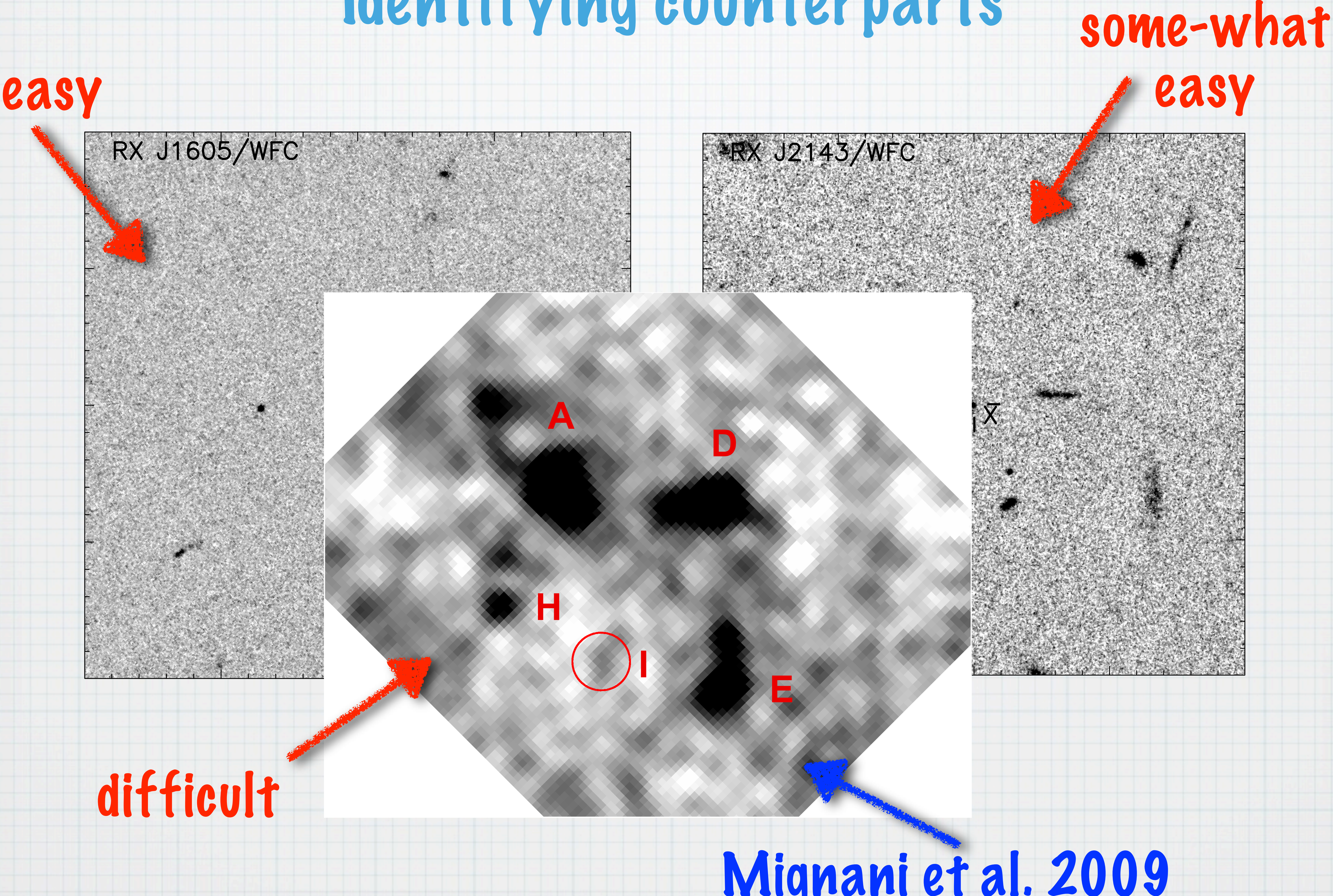
easy

some-what easy

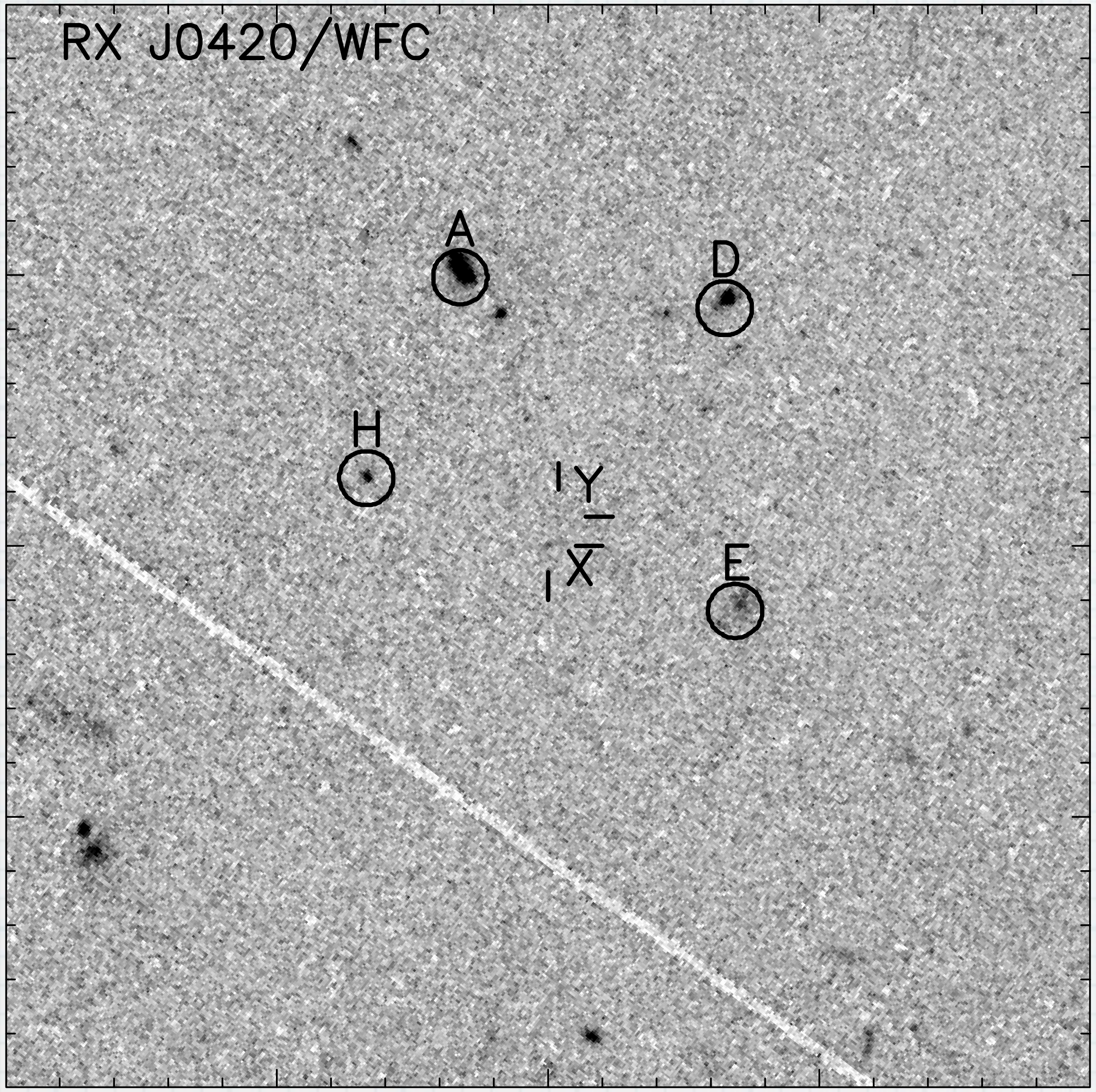




Identifying counterparts

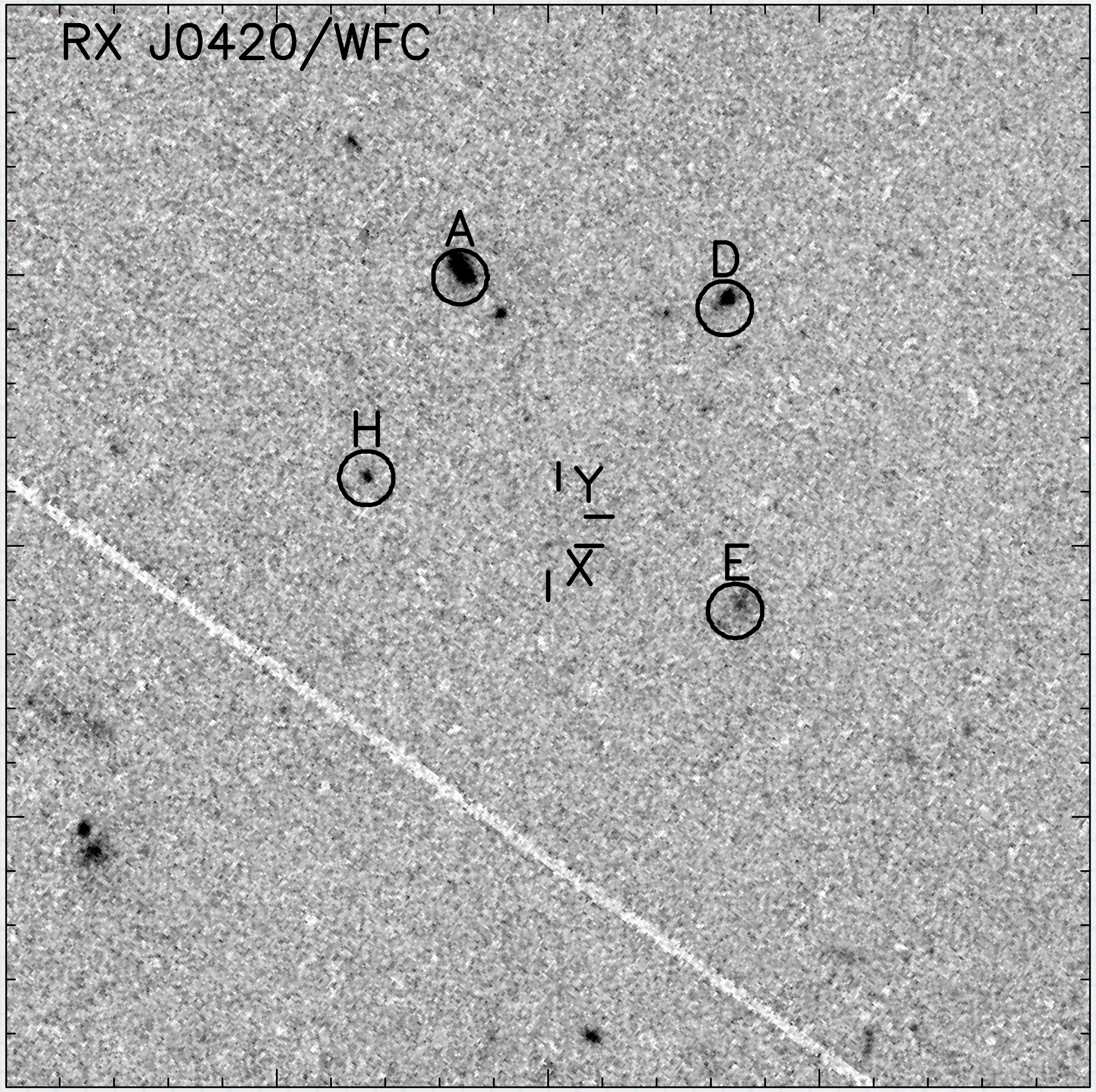


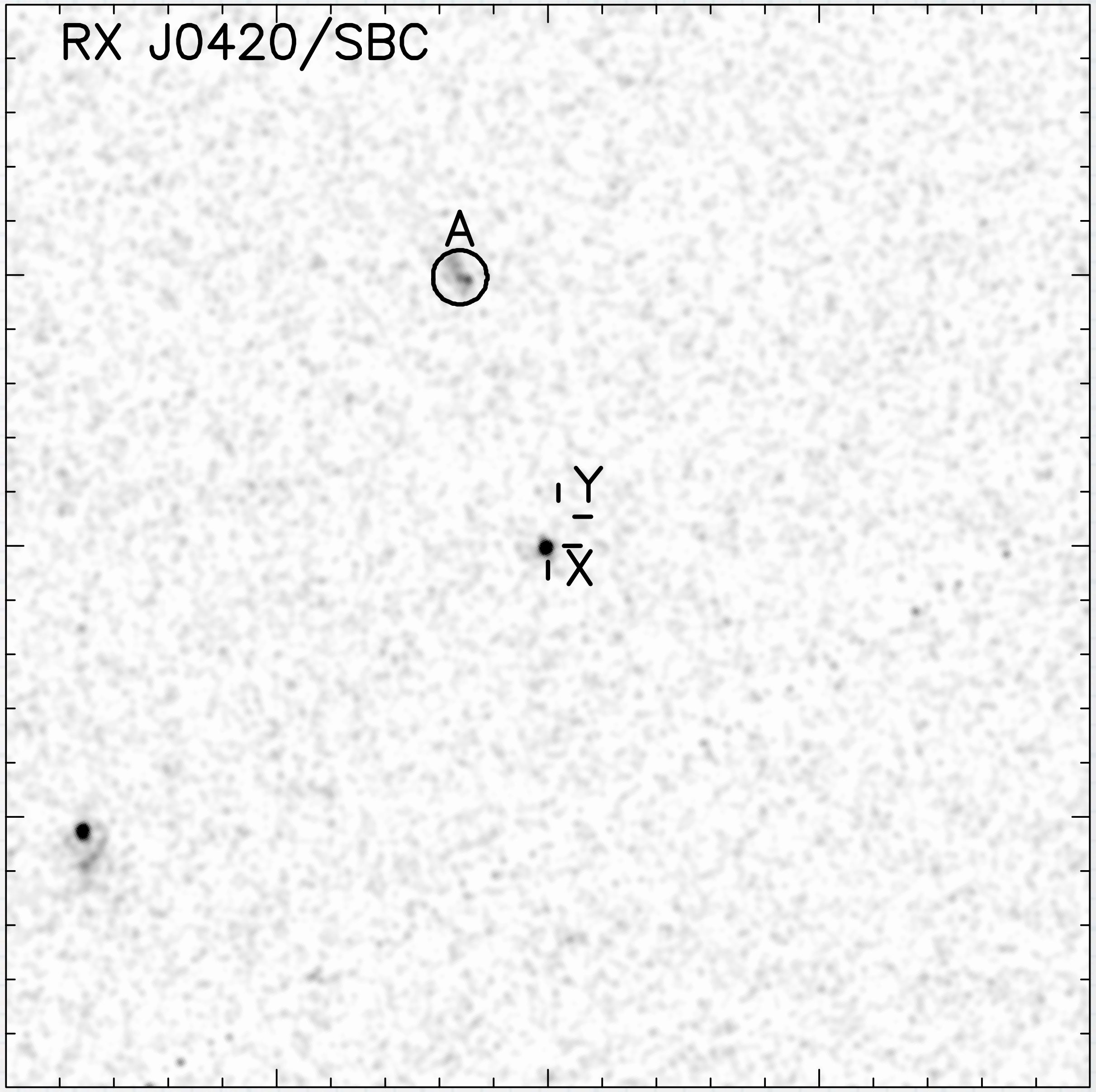
Identifying counterparts



optical

Identifying counterparts

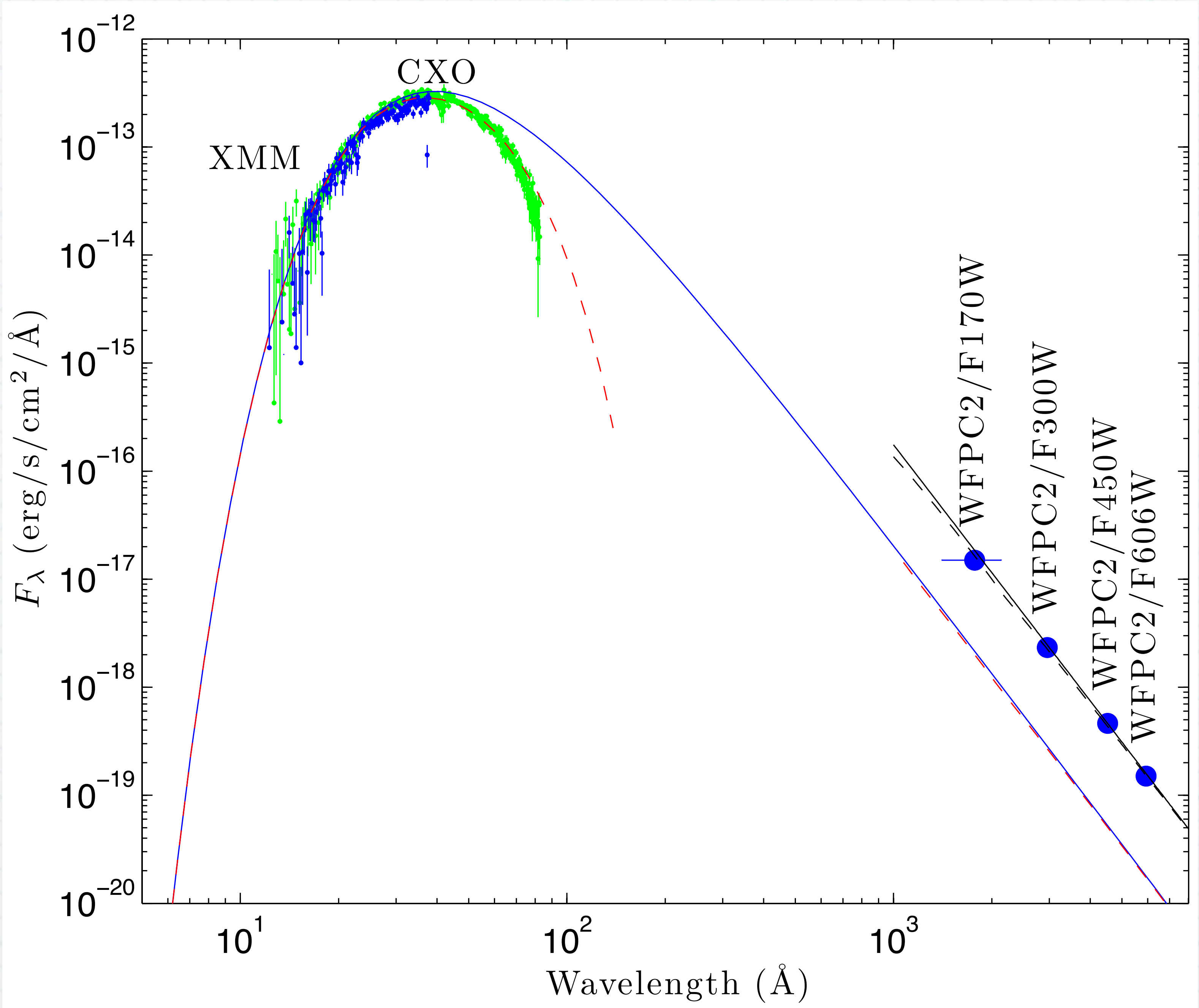




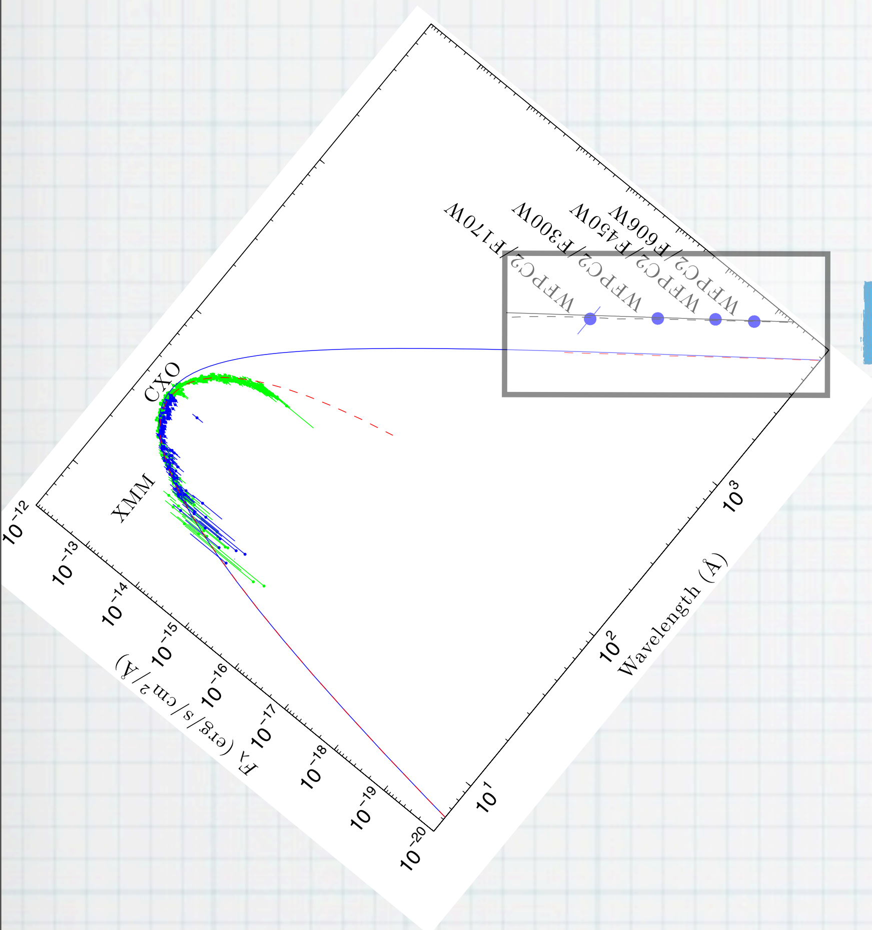
optical

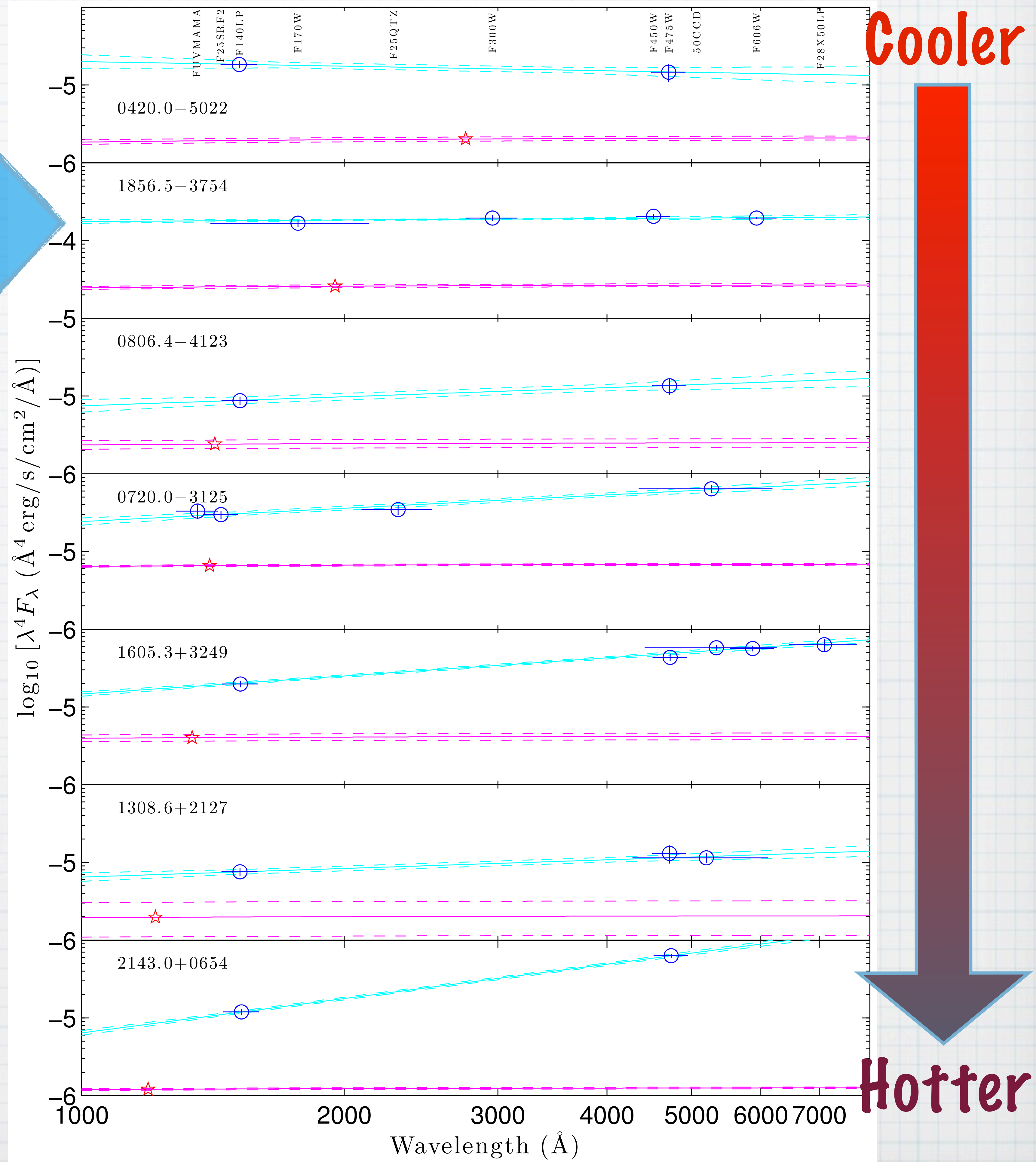
UV

Estimated proper motions => consistent with Motch et al. (2005, 2009)



CXO
XMM
WFPC2/F170W
WFPC2/F300W
WFPC2/F450W
WFPC2/F606W
F_λ (erg/s/cm^2/Å)
Wavelength (Å)

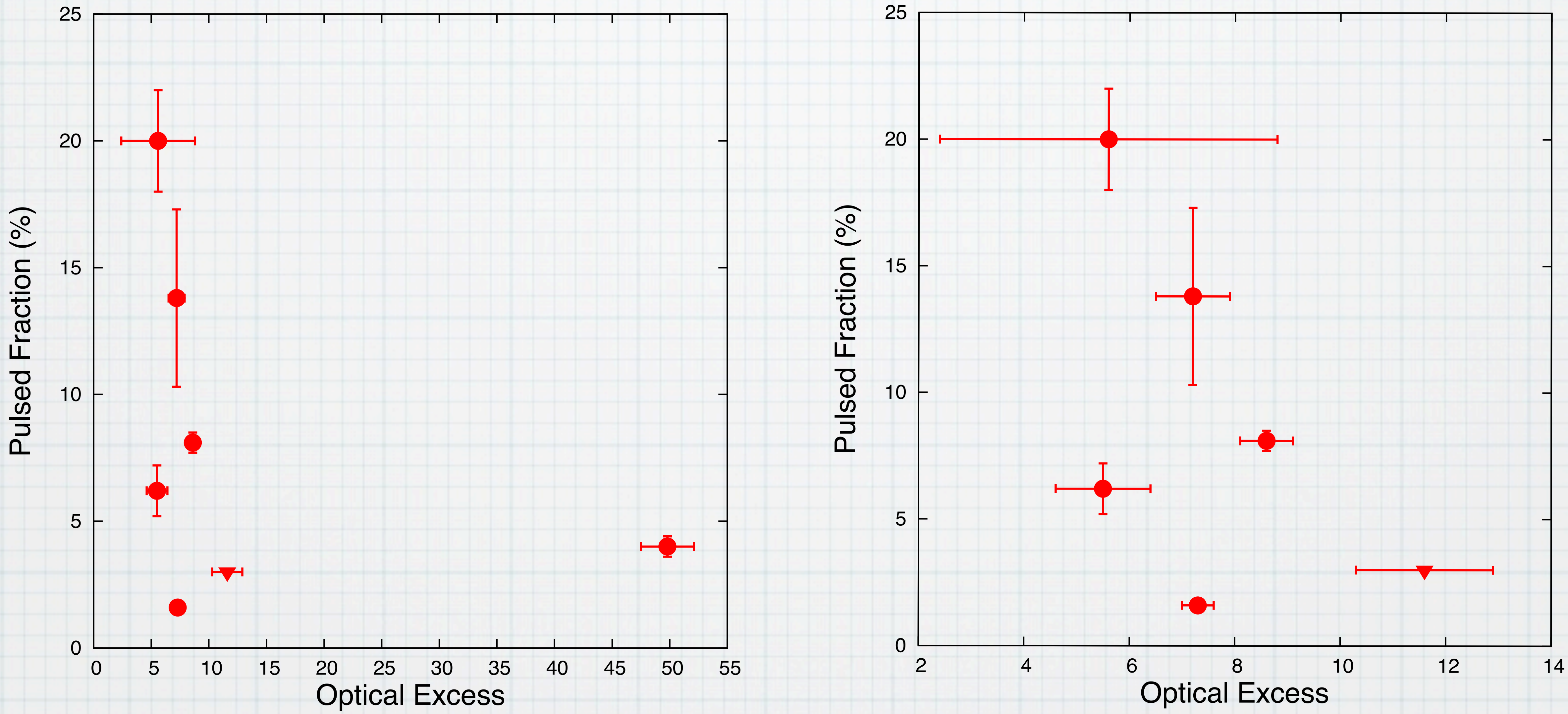




- power law with index : 4.2 - 2.5
- opt excess : 5 - 50
- power law might be too simplistic => lines/wings (Pavlov's talk PSR0656)

Different emission regions :
Pulsed fraction v/s Optical Excess

Braje & Romani 2002, Kaplan et al. 2011

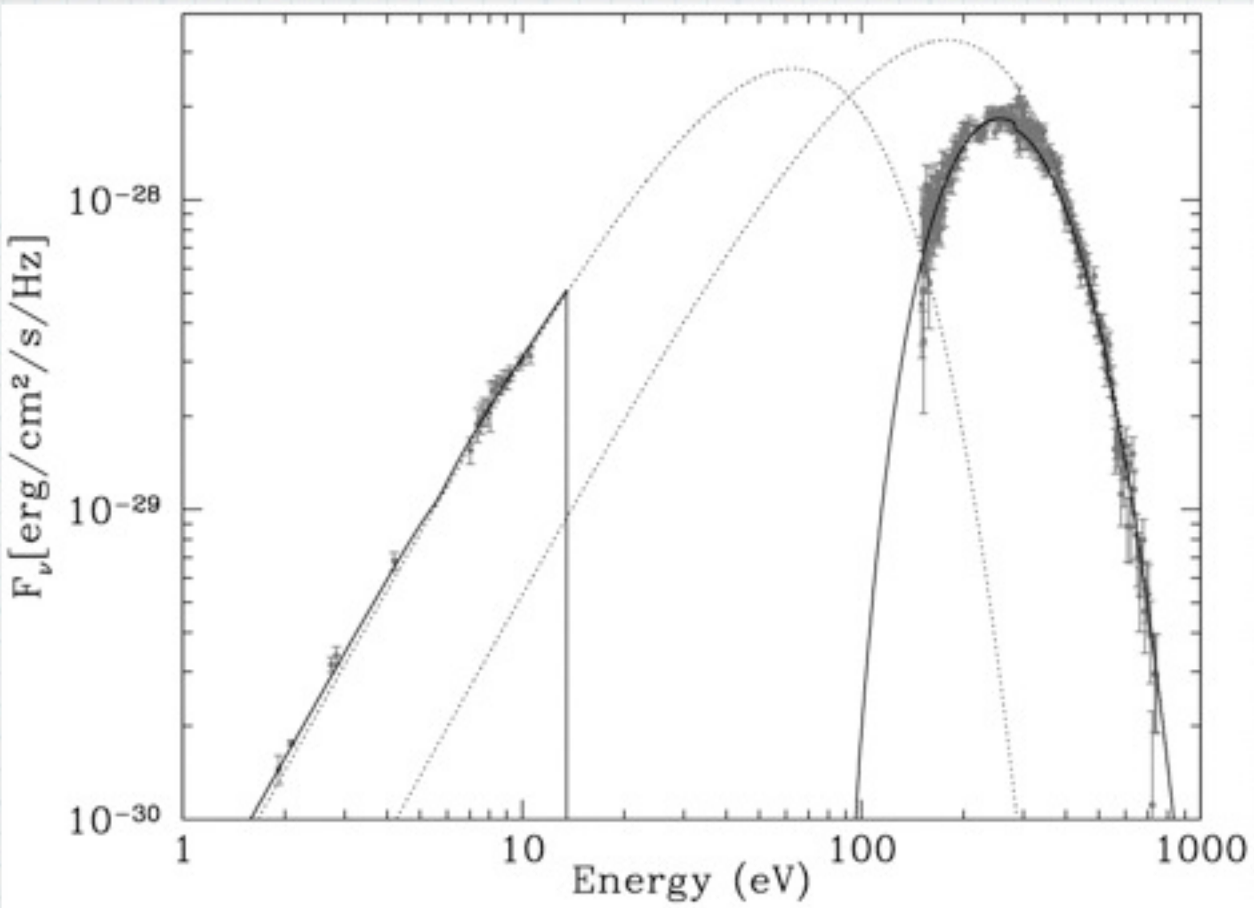


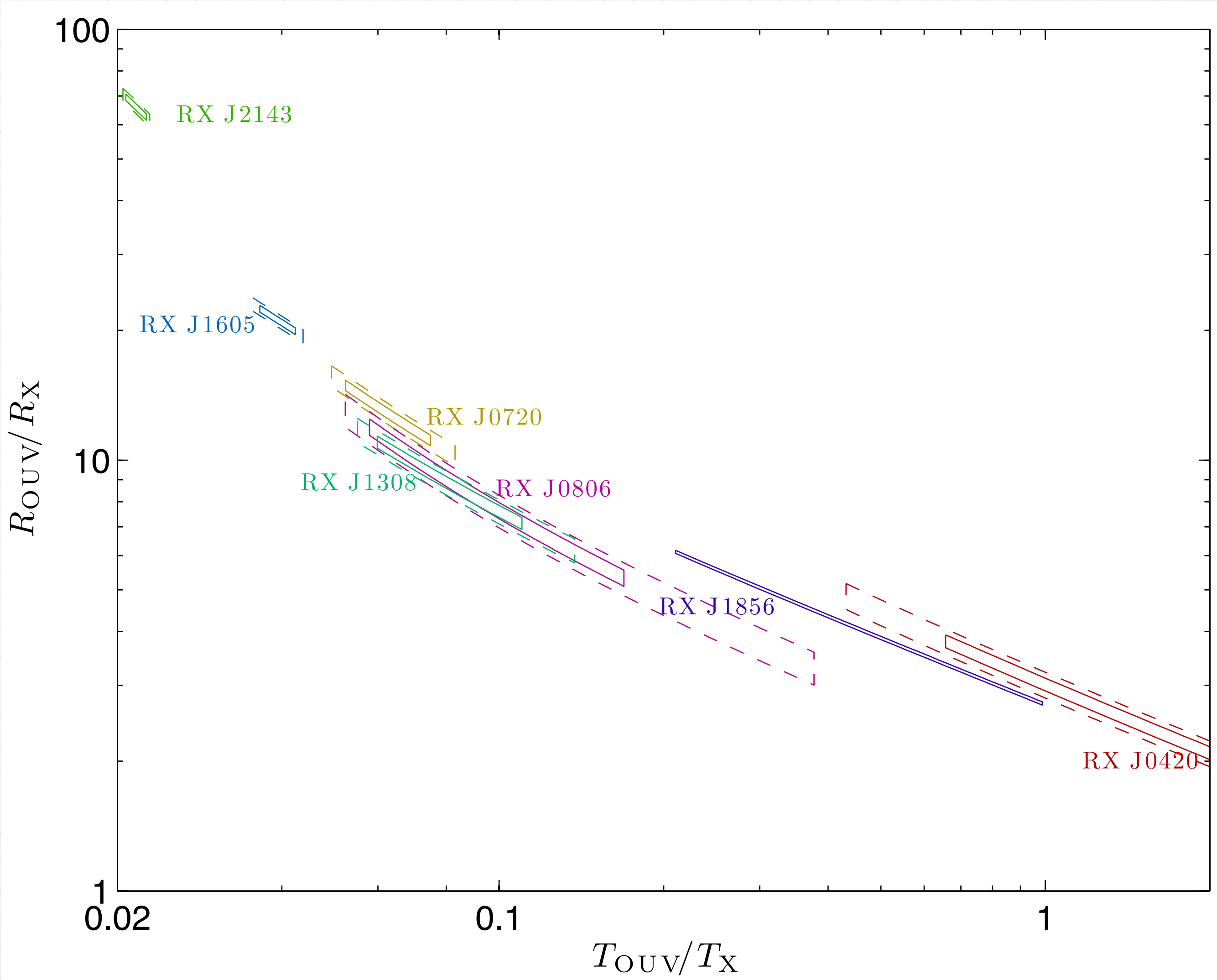
* small hotspot => large pulsed fraction and optical excess : No strong correlation

Different emission regions :

Opt/UV as separate BBs

Braje & Romani 2002, Kaplan et al. 2011



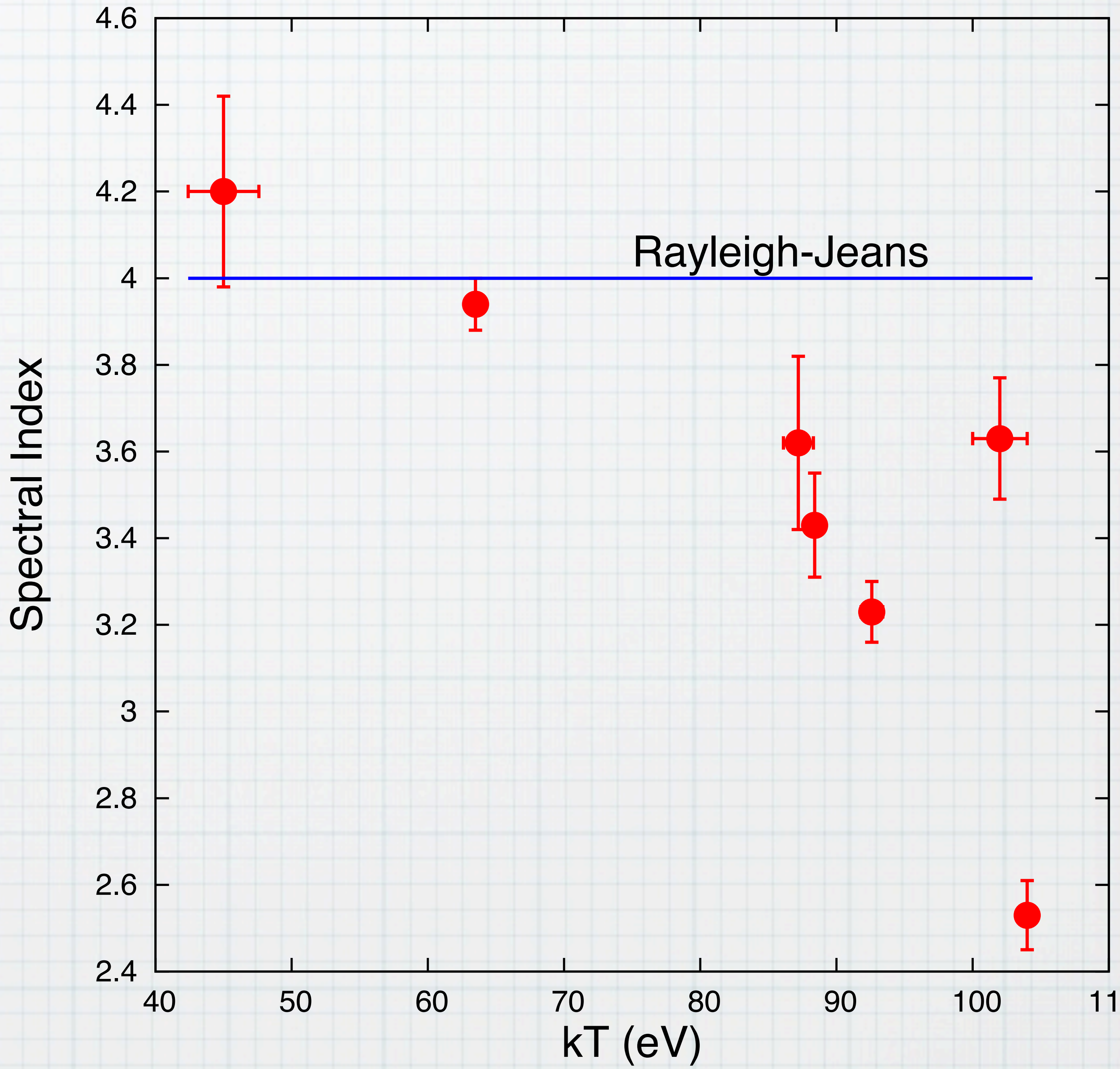


Dotted lines : unabsorbed BB

Different emission regions :
Pulsed fraction v/s Optical Excess

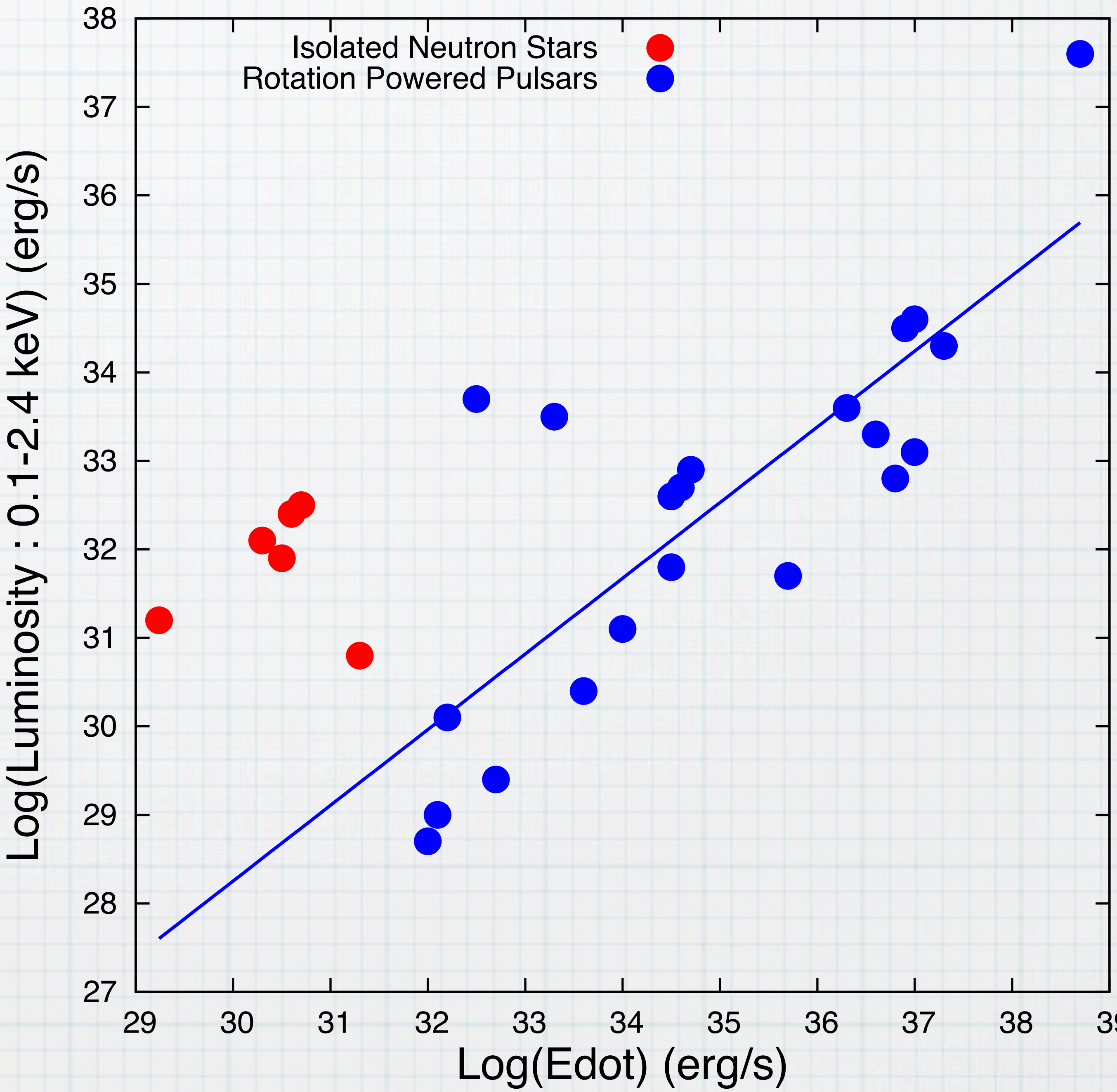
Braje & Romani 2002, Kaplan et al. 2011

* small Hotspot => large pulsed fraction and optical excess : No strong correlation
* Separate BB : Unreasonably high radii for NS
* spectral-index v/s kT : Hotter objects have smaller spectral index



Magnetospheric emission :
non-thermal Lum-X v/s Edot

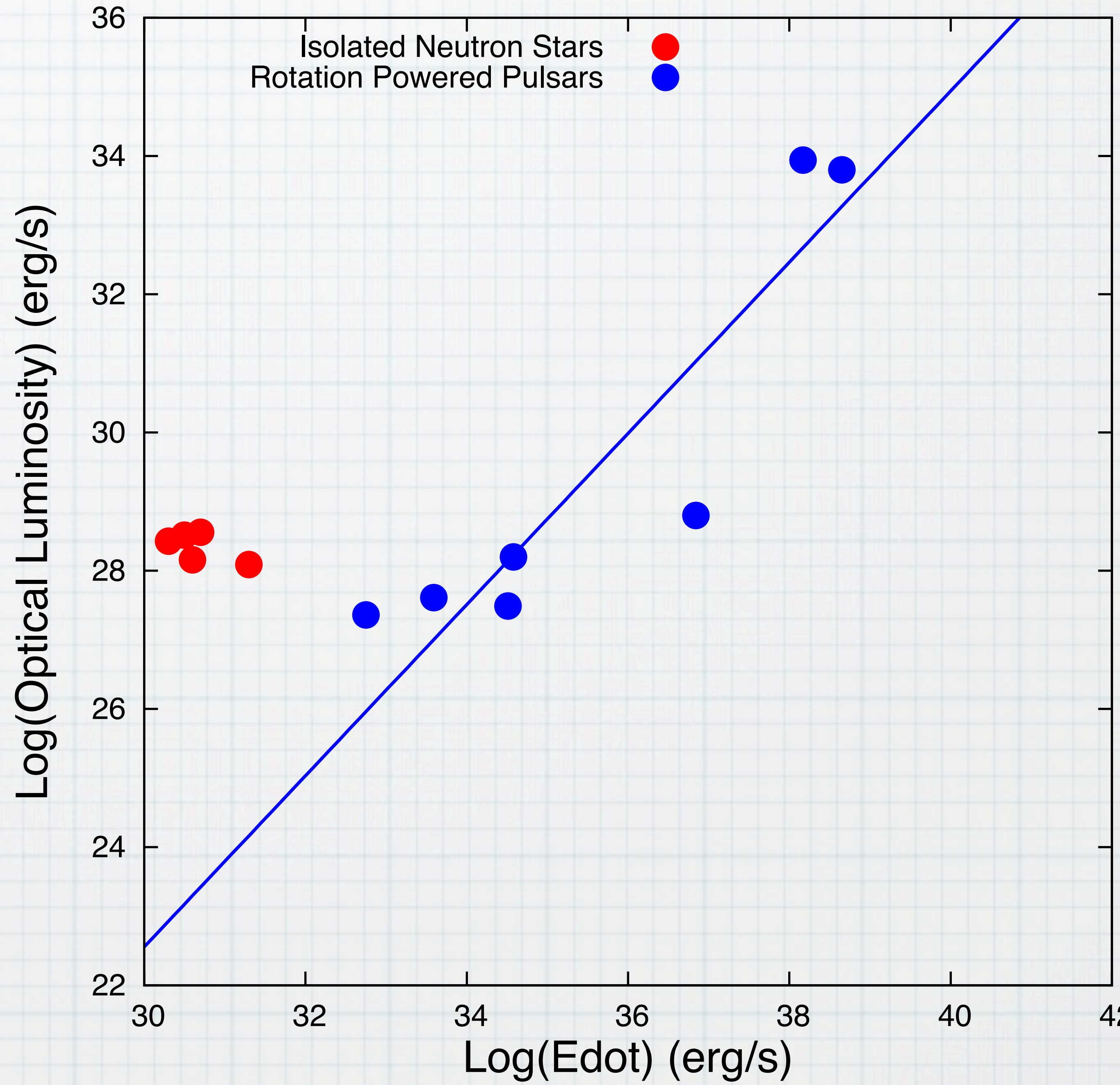
* NT Lum-X of INSs are close to 100% of Edot. Comparatively, radio pulsars have NT Lum-X = 10^-3 x Edot (Becker & Trumper 1997)



Magnetospheric emission :
Lum-opt v/s Edot

* NT Lum-X of INSs are close to 100% of Edot. Comparatively, radio pulsars have NT Lum-X = 10^-3 x Edot (Becker & Trumper 1997)

* Lum-Opt of INSs are >10^-3 x Edot. Radio pulsars have Lum-Opt <10^-6 x Edot (Zalin & Pavlov 2004)



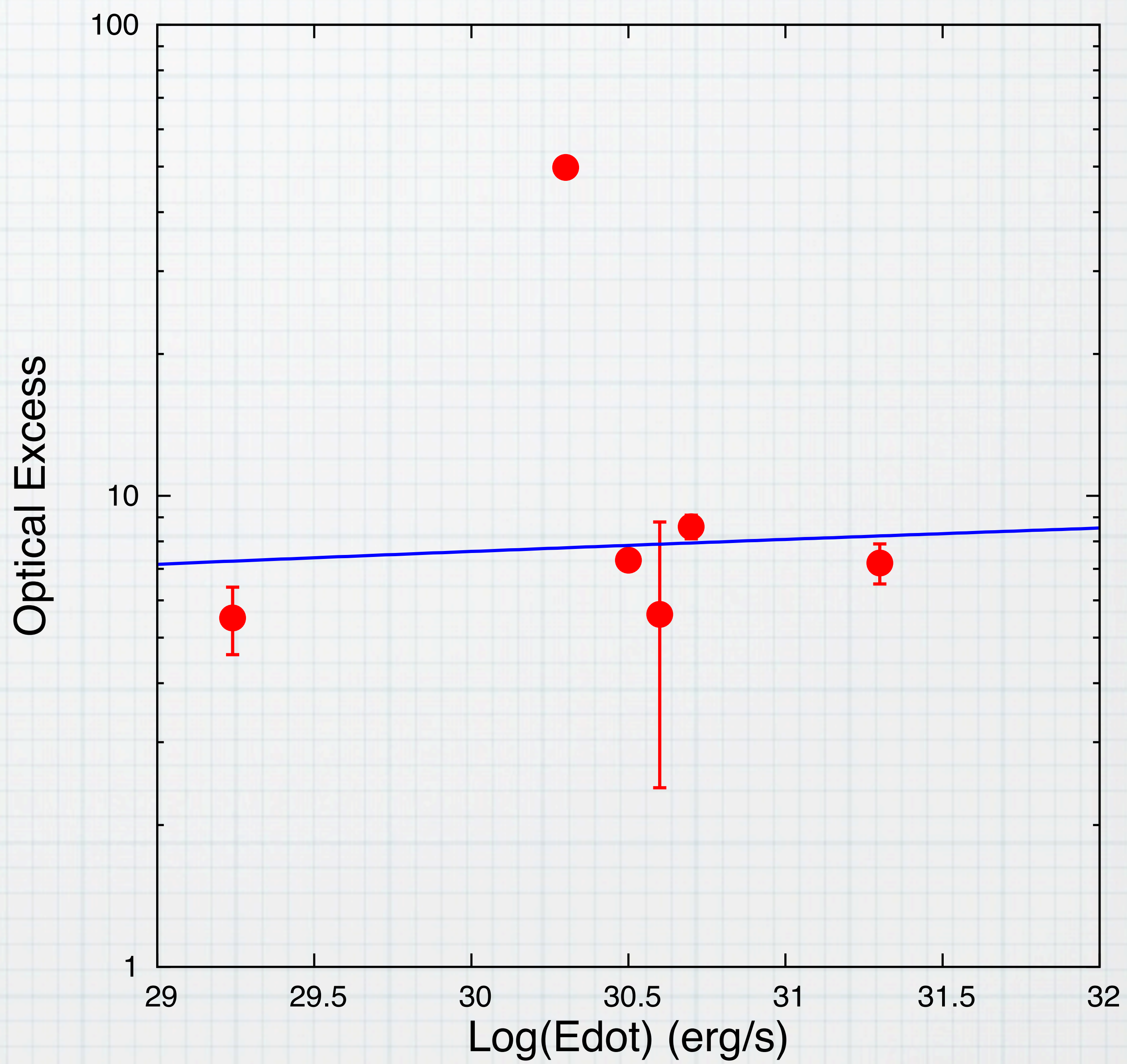
Magnetospheric emission :

Optical Excess v/s Edot

* NT Lum-X of INSs are close to 100% of Edot. Comparatively, radio pulsars have NT Lum-X = 10^-3 x Edot (Becker & Trumper 1997)

* Lum-Opt of INSs are >10^-3 x Edot. Radio pulsars have Lum-Opt <10^-6 x Edot (Zalin & Pavlov 2004)

* If part of the optical emission is due to spin down => Optical Excess - Edot correlation : No such definitive correlation is seen



Magnetized Atmosphere models

* Magnetized atmosphere models (Ho et al. 2008) => Optical/UV excess may depend on B
* models : B = 1-30 x 10^12 G, kT = 20-400 eV, partially ionised hydrogen
* Brightness differs from BB but Rayleigh-Jeans behavior stays
* Wings of Proton-Cyclotron line can reproduce the spectral behavior of INSs partly => B_model << B_timing

Conclusions

* Counterparts of all seven INSs have been identified unambiguously
* All INSs show optical excess
* The "Excess" in some cases deviate significantly from the Rayleigh-Jeans regime
* Explanations ranging from different emission regions to mechanisms considered. None seems sufficient.
* More observations required to clearly characterize the optical/uv excess

Details & Back up slides

RCS models

* Resonant Cyclotron Scattering (Lyutikov & Gavriil 2006) => thermal photons matching cyclotron freq. of the NS magnetosphere undergo efficient repeated scatterings

* Photons are up-scattered => Thermal spectrum gets modified => produces BB+PL hard tail (see Rea et al. 2008)

* The model would retain Rayleigh-Jeans spectrum

* Would it produce optical/UV excess ? (Also see Tong et al 2010, 2011)