Mullard Space Science Laboratory
University College London

Multiwavelength campaign on Mrk 509: the nature of the soft X-ray excess

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G. Branduardi-Raymont, J. S. Kaastra, P. O. Petrucci, G. A. Kriss, G. Ponti, A. J. Blustin, S. Paltani, M. Cappi, R. G. Detmers, K. C. Steenbrugge

Mehdipour et al. (2011), arXiv:1107.0659v1
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Multiwavelength campaign on Mrk 509

- Nearby Seyfert-1 AGN $(z = 0.0344)$
- High luminosity and BH mass $M_{\rm BH} = 3 \times 10^8\ {\rm M}_\odot$

  $L_{\rm bol} = 2-3\ \times 10^{45}\ {\rm erg\ s^{-1}}$ $L_{\rm X} = 3-5\ \times 10^{44}\ {\rm erg\ s^{-1}}$
- Variable on timescale of a few days, good for a spectral timing campaign to study its warm absorber
- 10 × 60 ks XMM-Newton observations taken in Oct-Nov 2009, plus monitoring with Swift for 100 days and observations with HST/COS
- In this talk, I discuss the intrinsic optical-UV-X-ray variability and its association with the soft X-ray excess in Mrk 509

Extraction of optical-UV-X-ray continuum

Galactic reddening and absorption

$E(B-V) = 0.057$ mag (Schlegel et al. 1998)

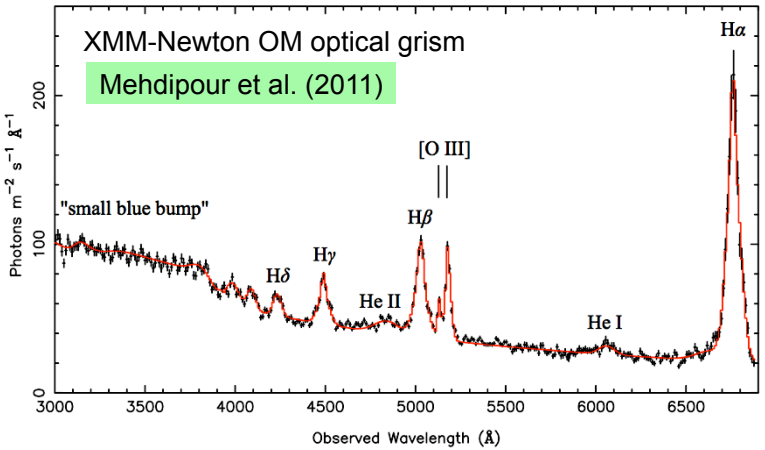
$N_{\rm H} = 4.44 \times 10^{20}$ cm^{-2} (Murphy et al. 1996)

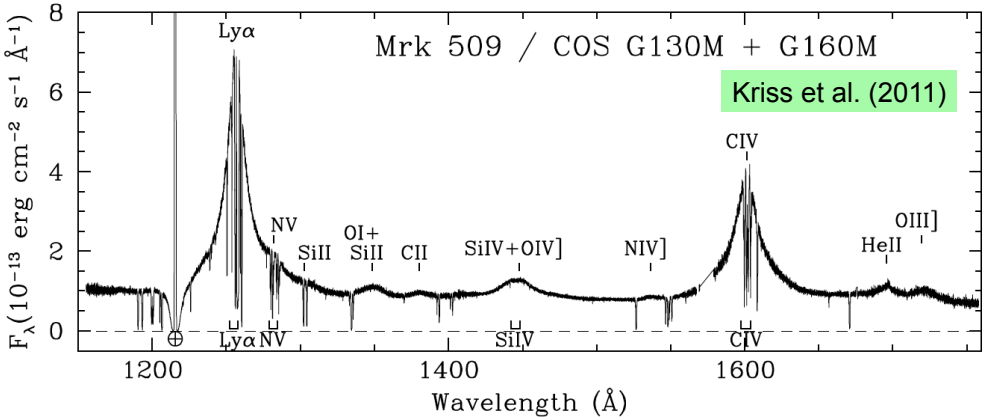
AGN host galaxy emission

$F_{\rm gal,\ 5100\ Å} = 2.52 \pm 0.23\ (10^{-15}$ erg s^{-1} cm^{-2} Å$^{-1})$

(Bentz et al. 2009 using HST)

BLR and NLR optical-UV emission

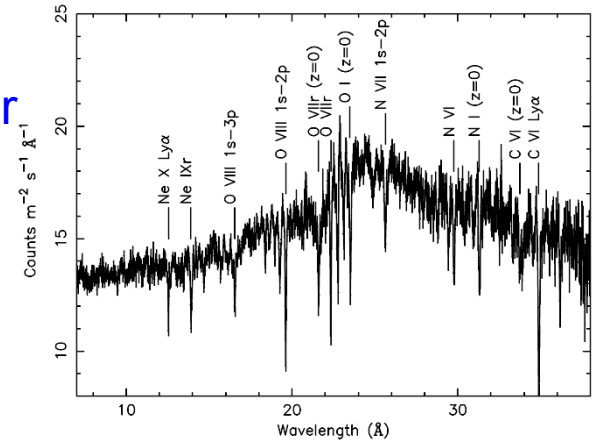


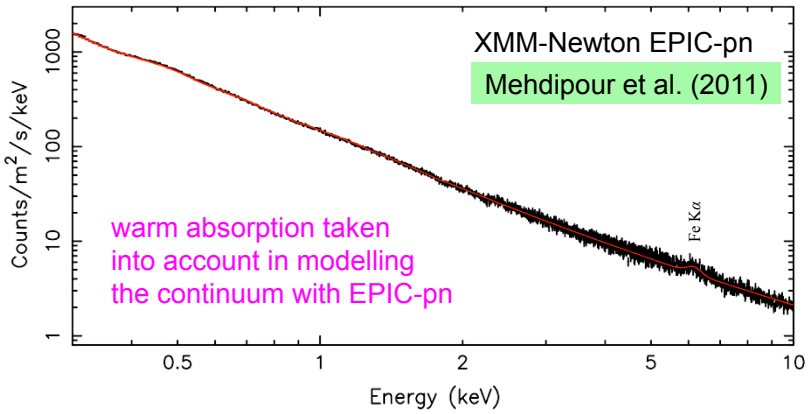


Absorption by the AGN warm absorber

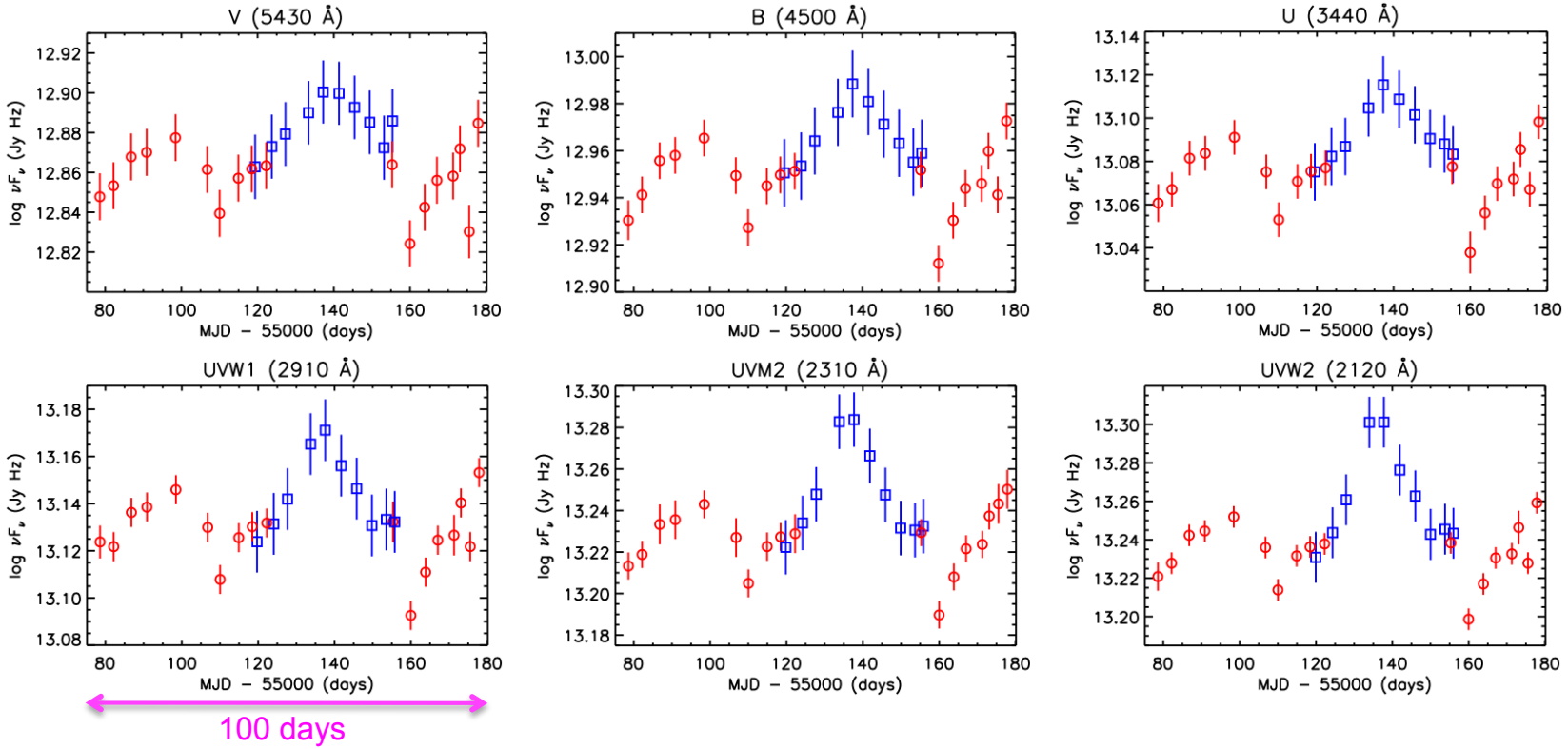
XMM-Newton RGS

Detmers et al. (2011)

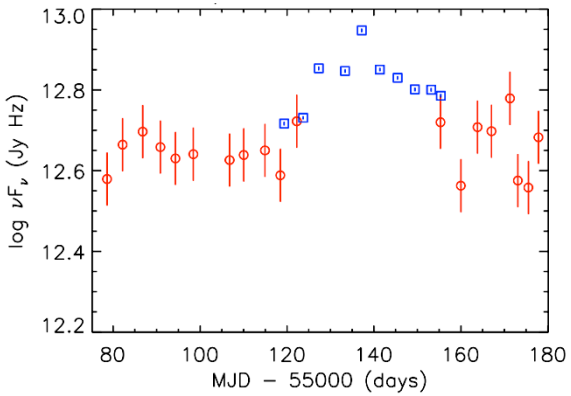




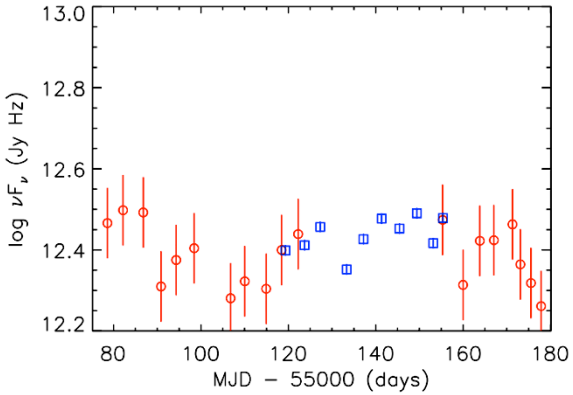
Optical-UV continuum lightcurves



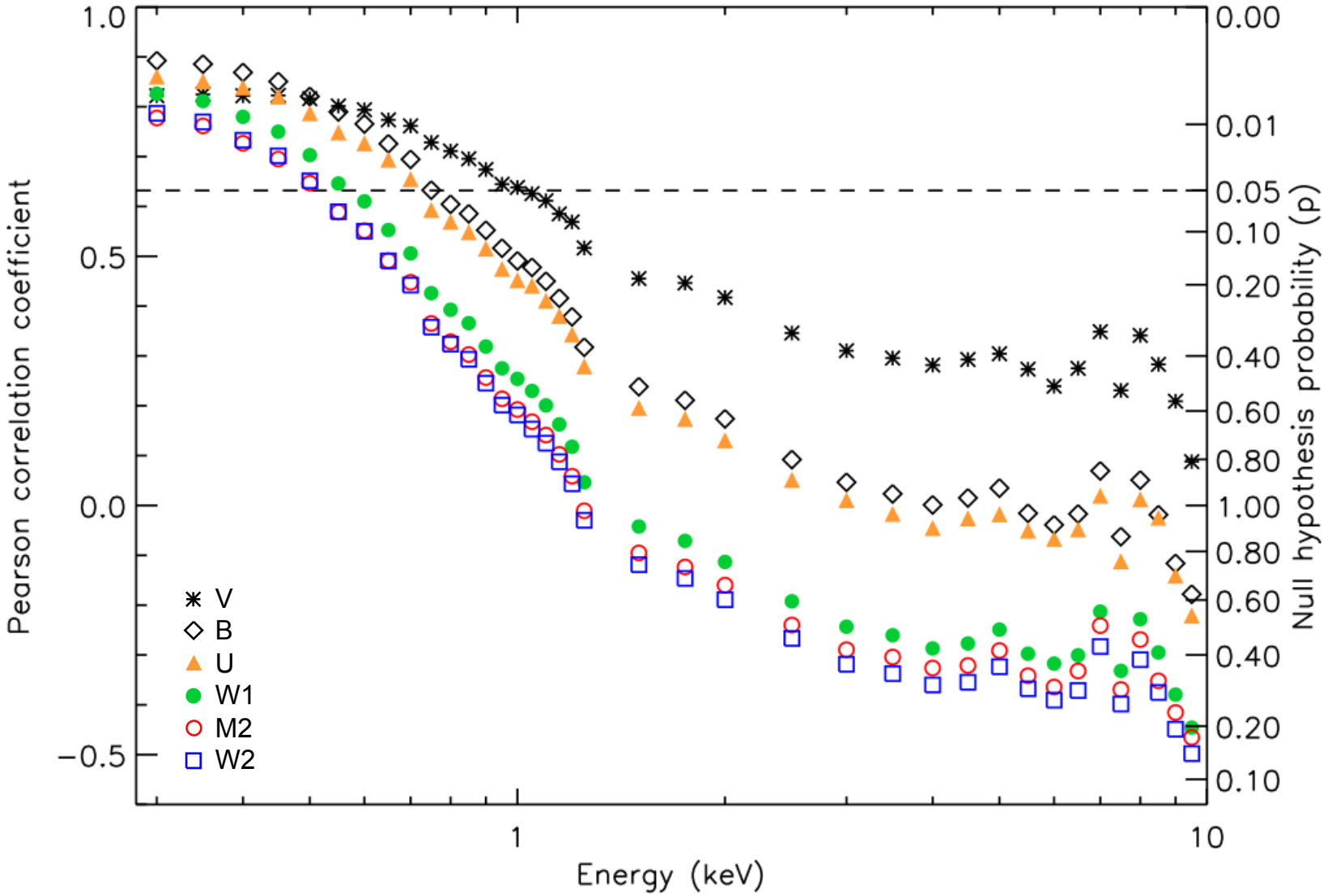
Soft X-ray continuum lightcurve



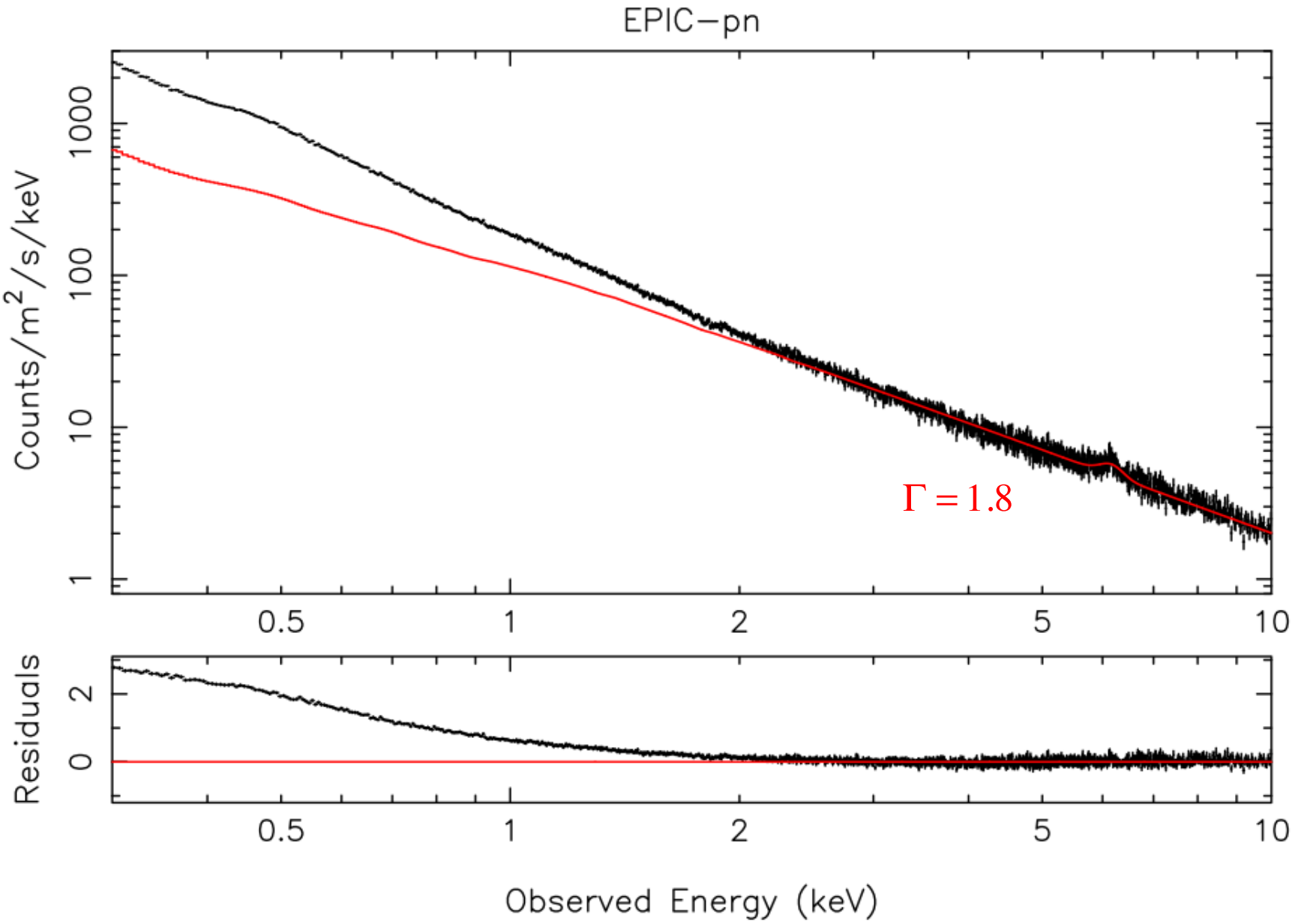
Hard X-ray continuum lightcurve



Model-independent correlation between optical-UV and X-ray count rates



The soft X-ray excess in Mrk 509



The origin of the soft X-ray excess

An area of active research. Different interpretations can be found in the literature, such as:

- the high energy tail of the thermal emission from the accretion disc
  (e.g. Pounds et al. 1986)
- an artifact of relativistically smeared absorption by an ionised disc wind
  (e.g. Gierliński & Done 2004)
- part of a relativistically blurred photoionised disc reflection spectrum modelled by Ross & Fabian (2005)
  (e.g. Crummy et al. 2006)
- 'warm' Comptonisation:
  up-scattering of seed disc photons in a Comptonising medium which has lower T and higher τ than the one responsible for the X-ray power-law
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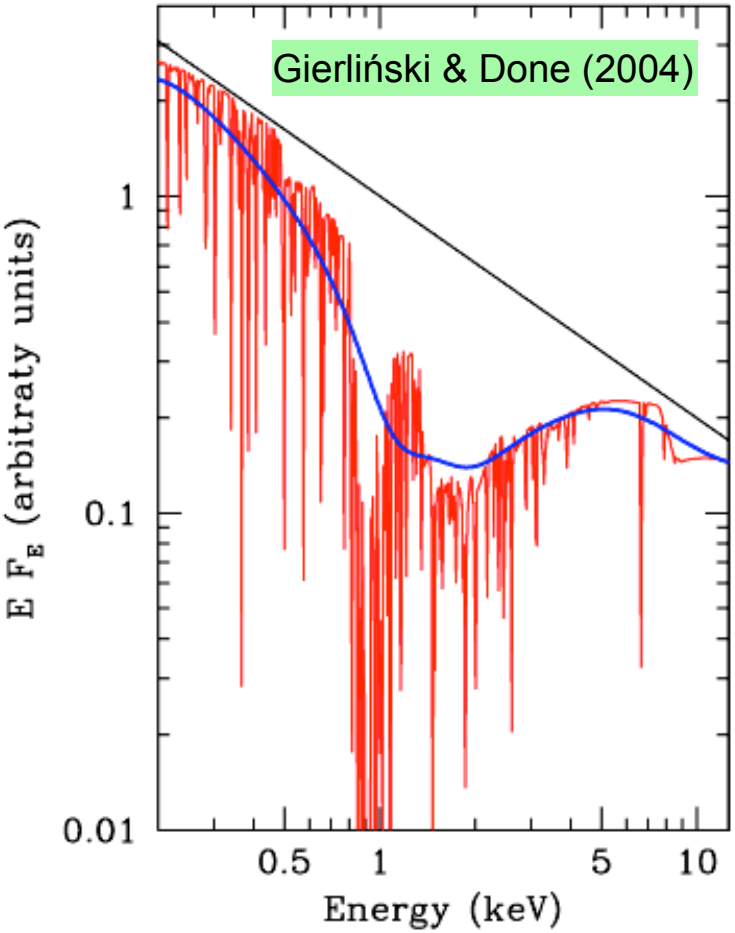

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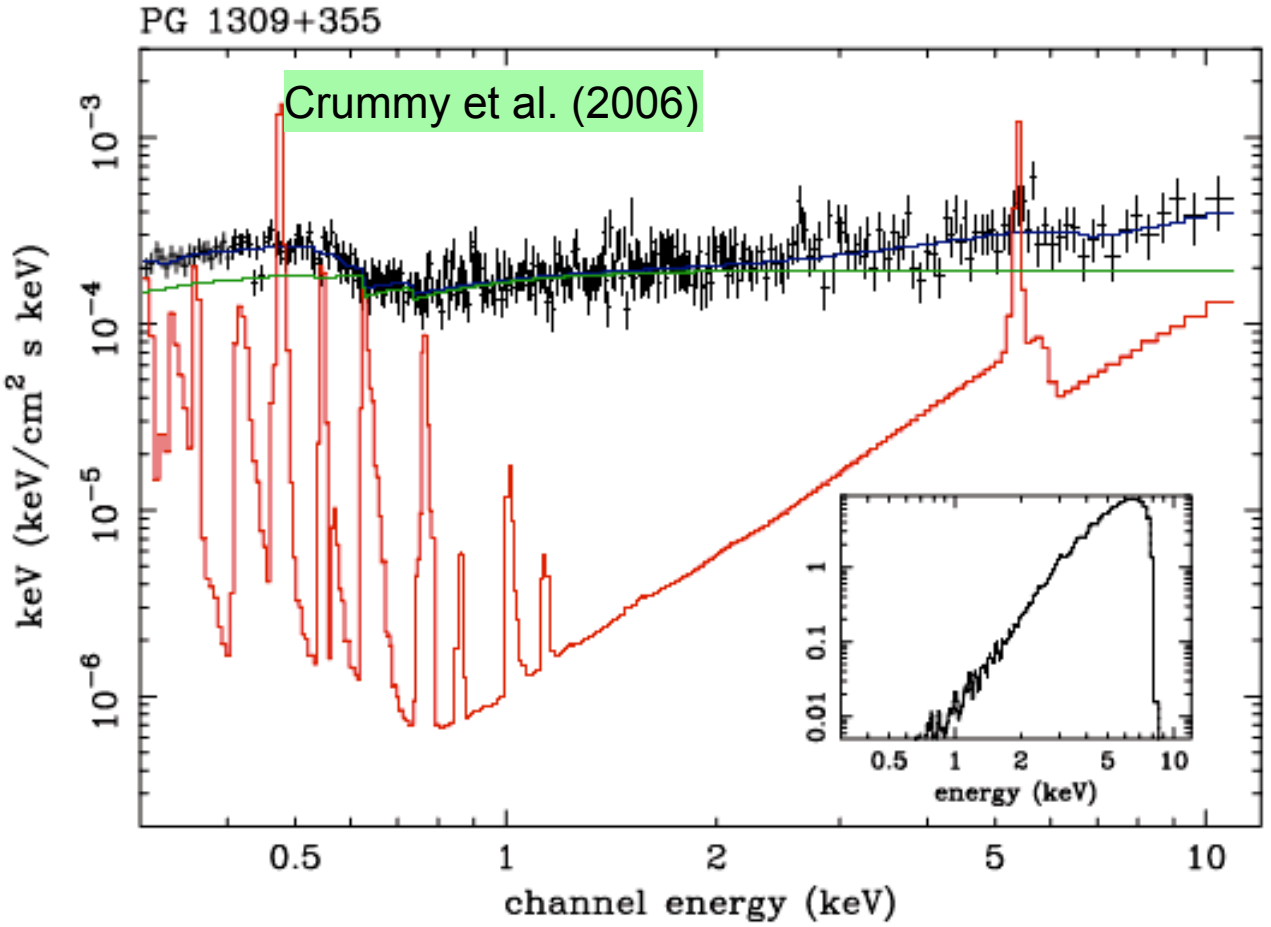

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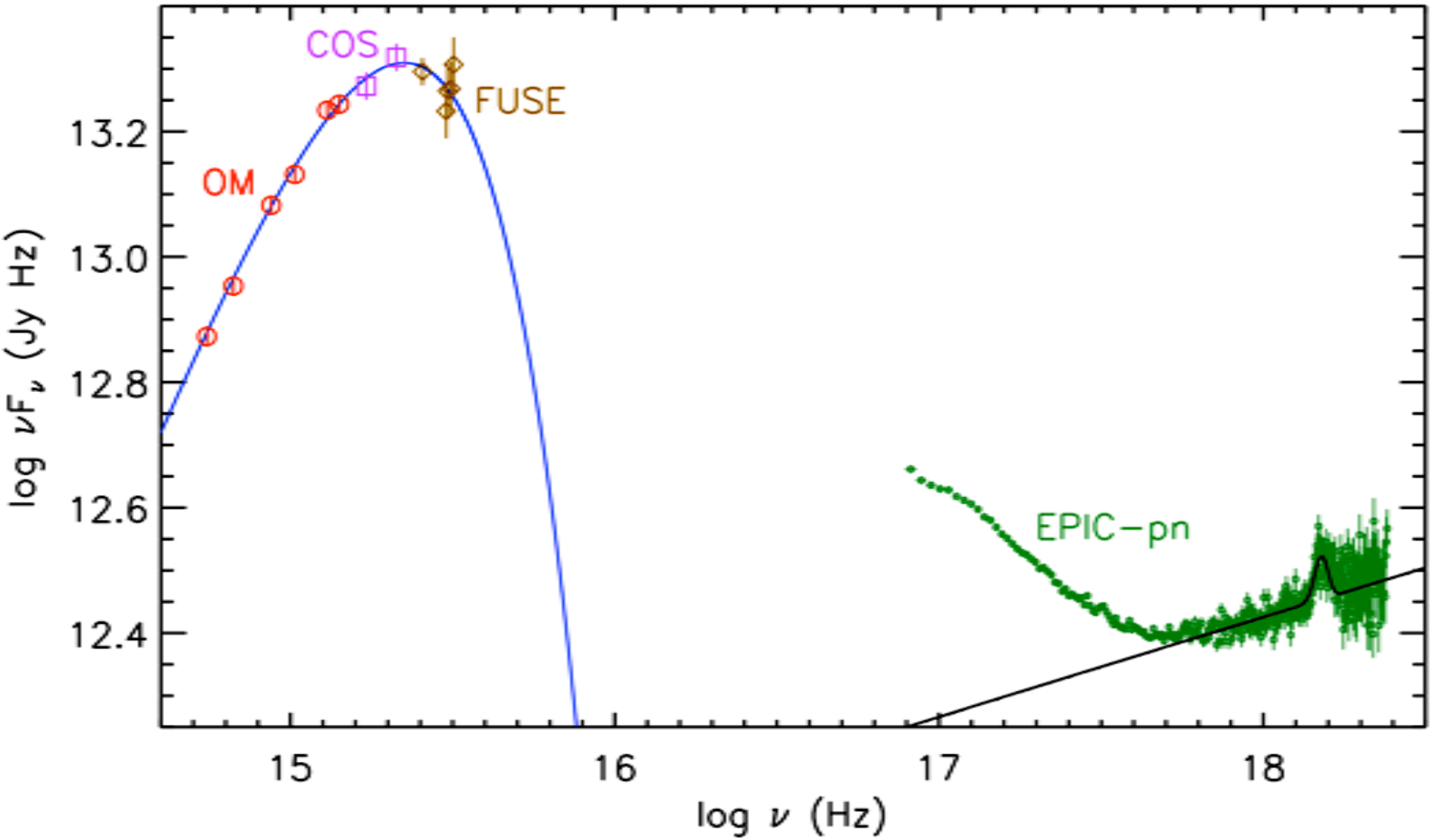
Spectral Energy Distribution of Mrk 509



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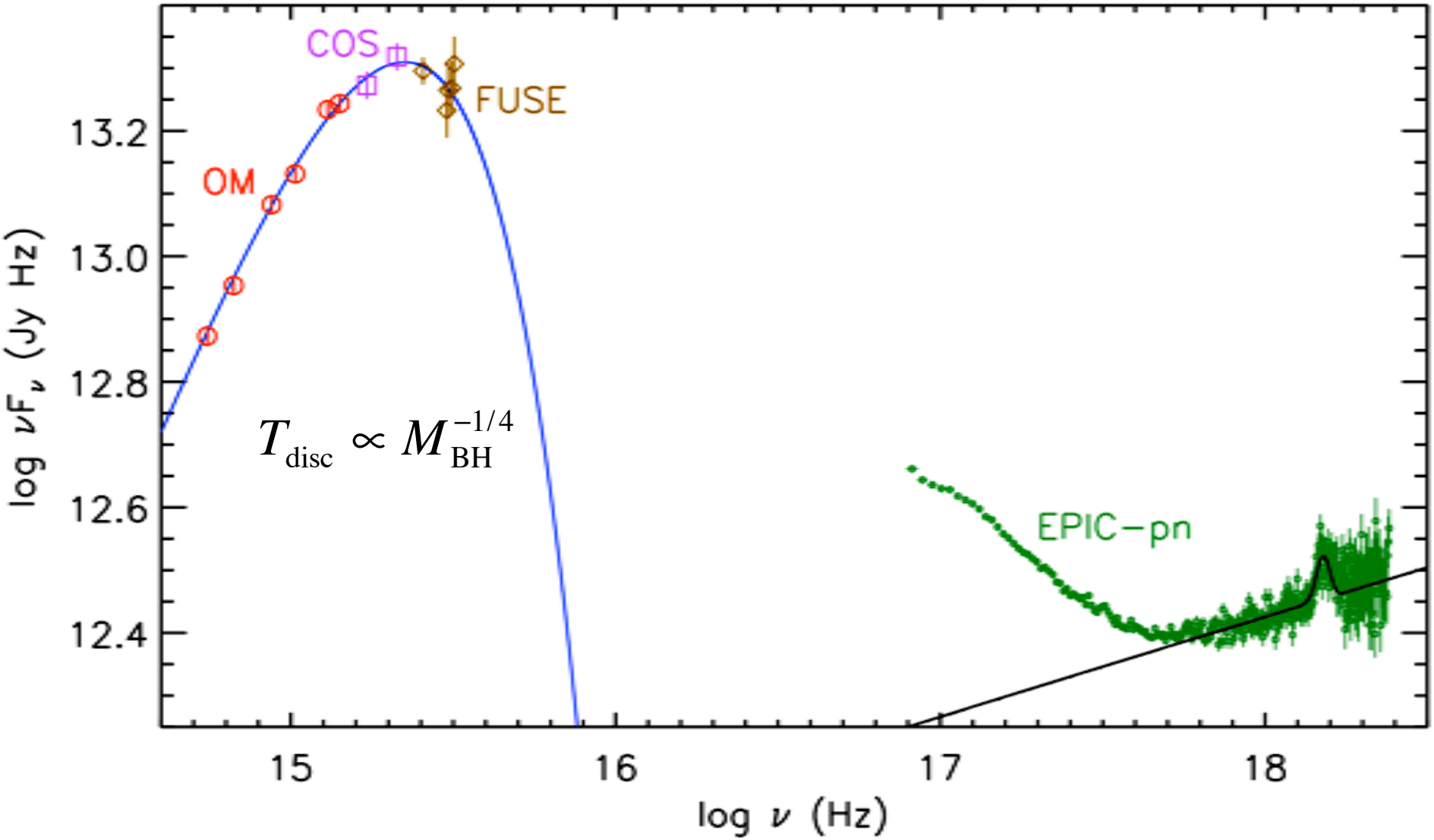
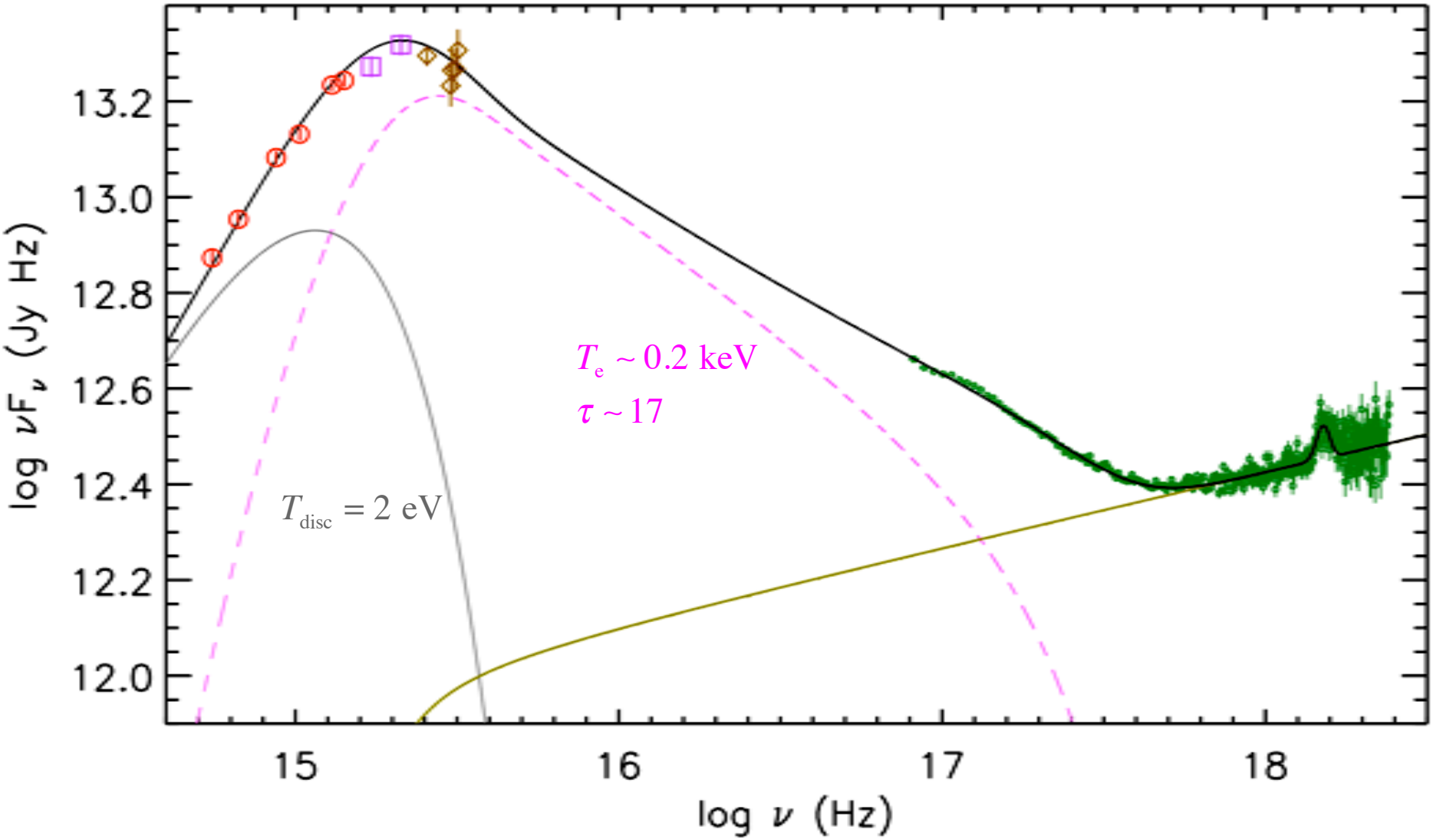


Broad-band modelling of Mrk 509 continuum using ‘warm’ Comptonisation



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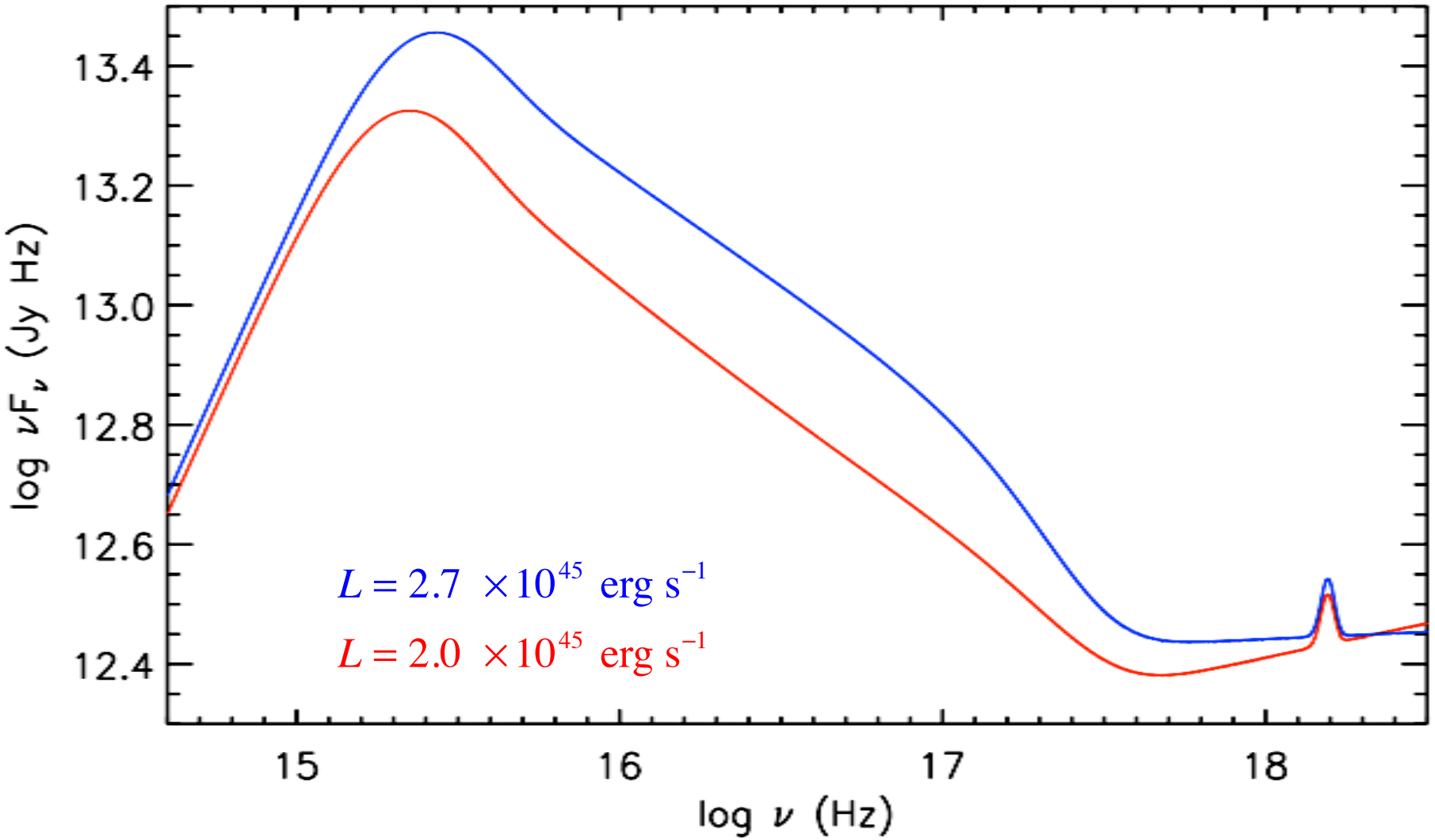

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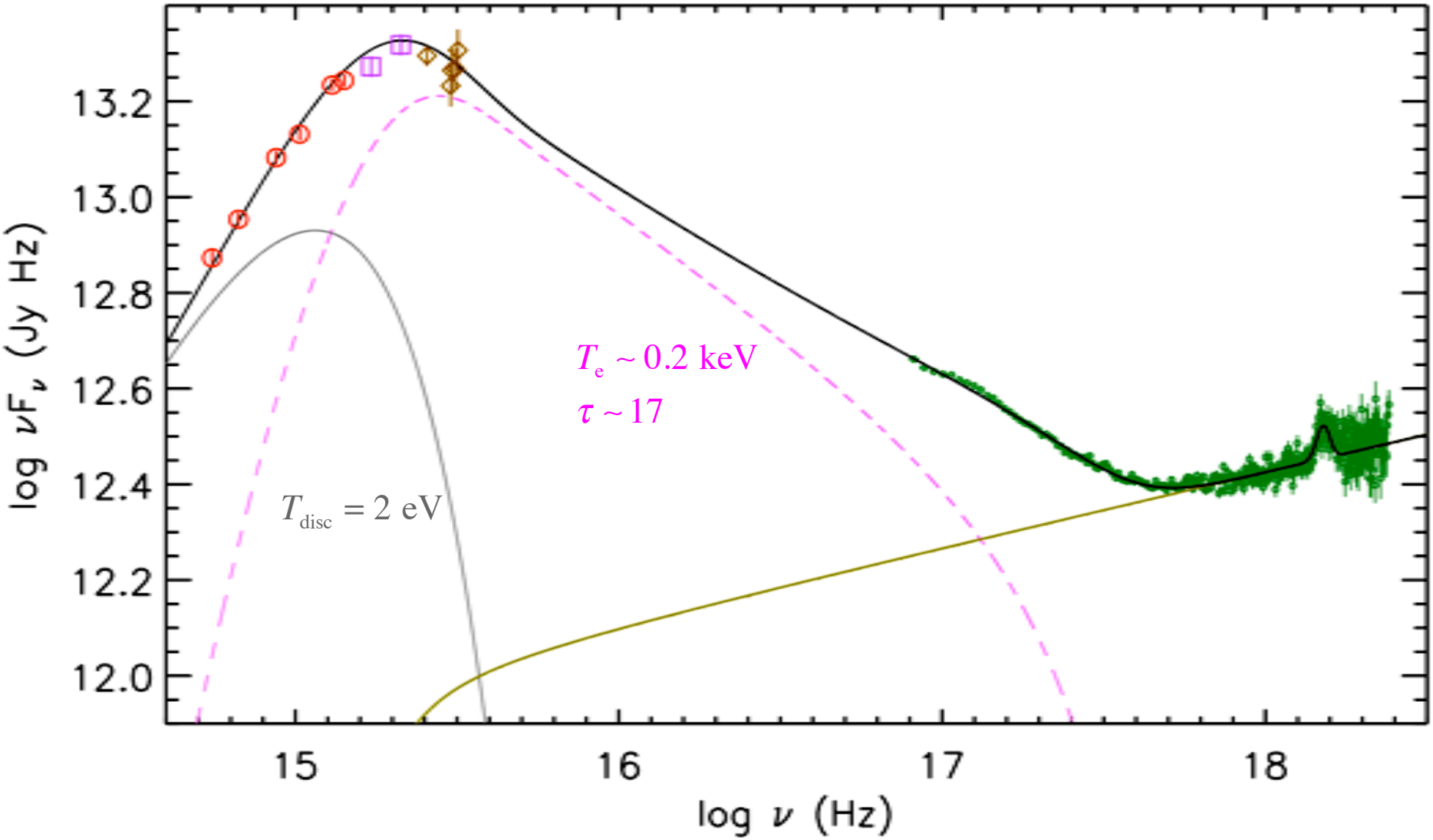
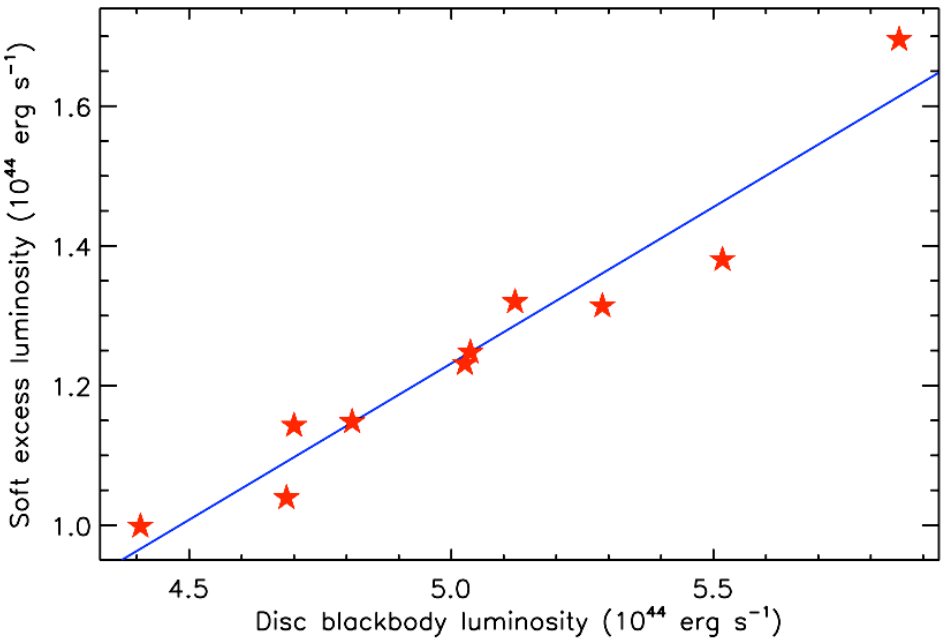


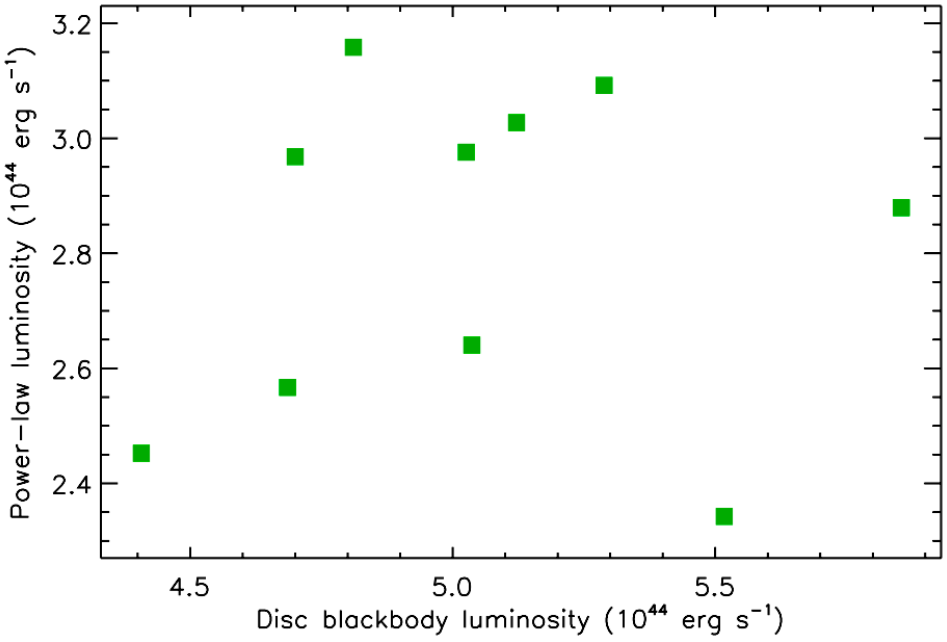
Soft X-ray excess vs. disc blackbody luminosity



$$L_{\text{soft excess}} = 0.45 L_{\text{disc}} - 1.0$$

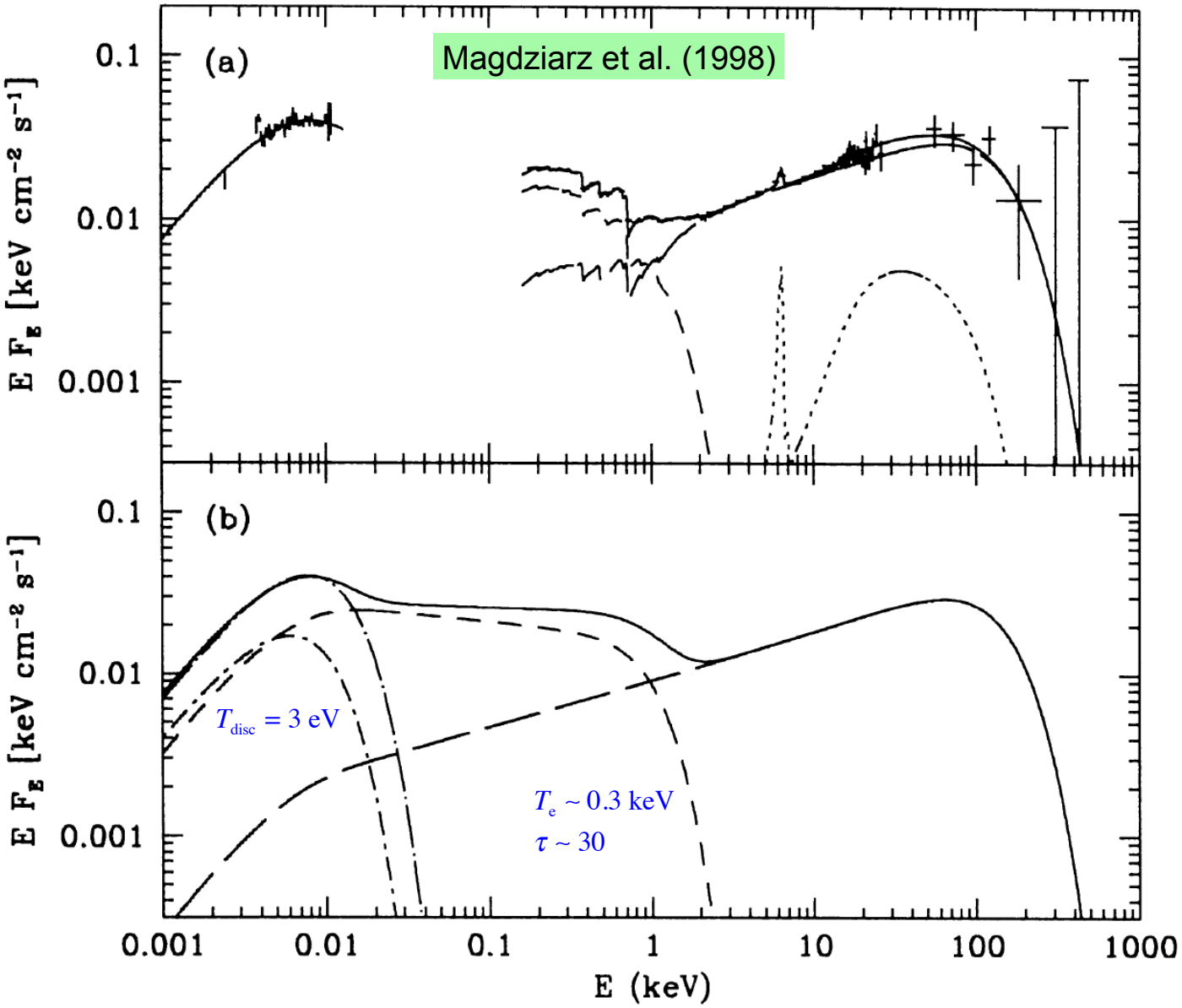
in units of 10^{44} erg s^{-1}

X-ray power-law vs. disc blackbody luminosity



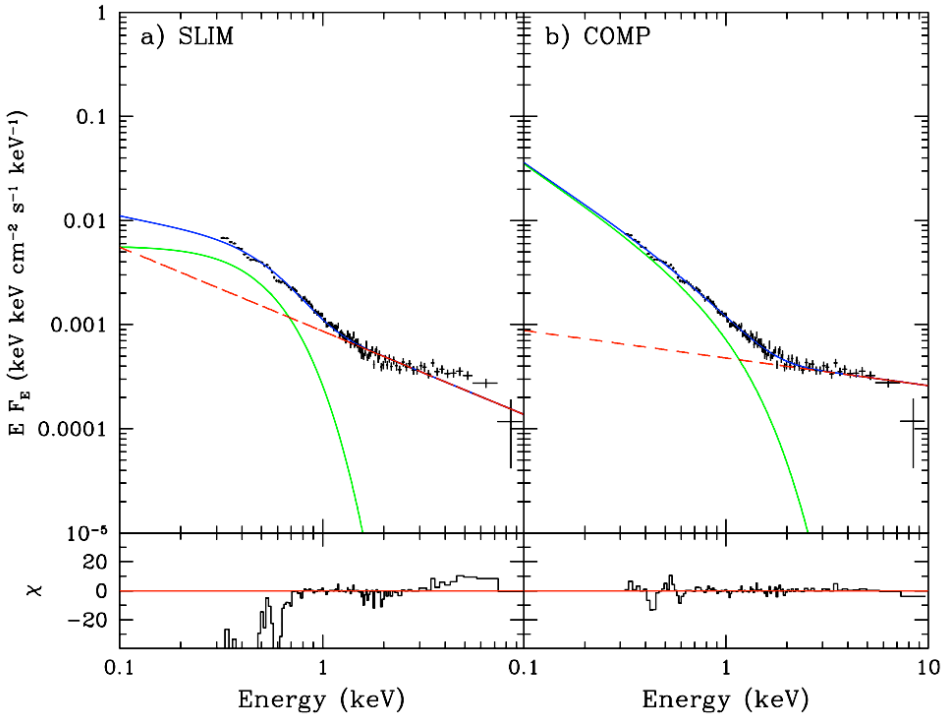
No obvious correlation

The soft X-ray excess in Seyfert-1 NGC 5548



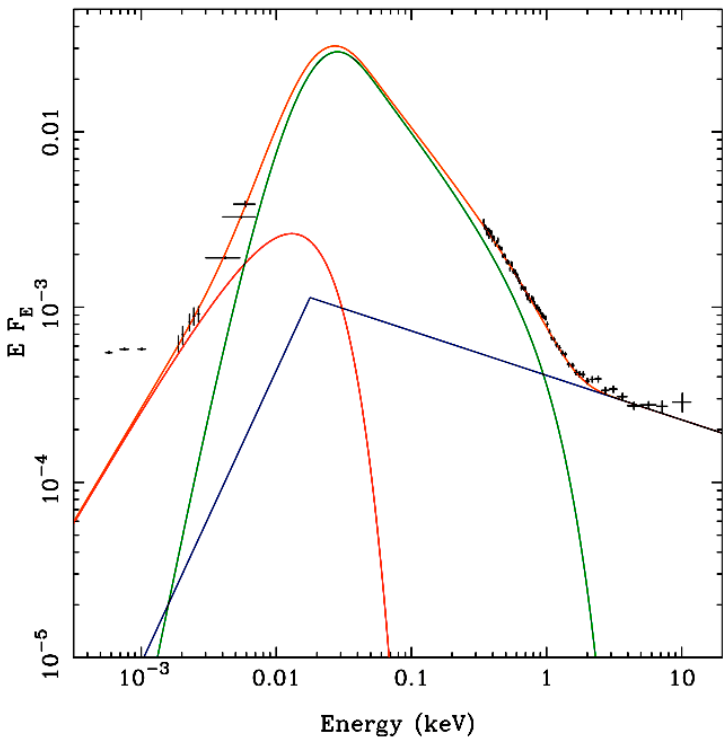
The strong soft X-ray excess in NLS1s

RE J1034+396



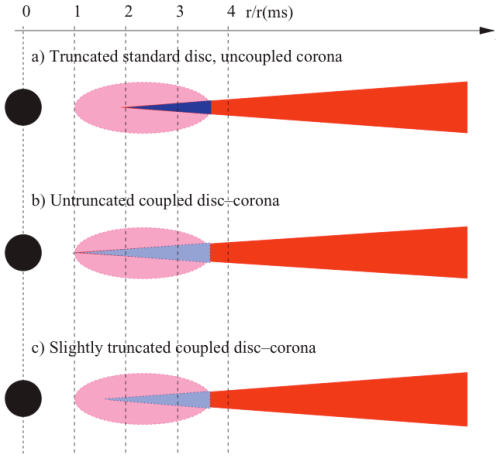
Middleton et al (2009)

RX J0136.9−3510

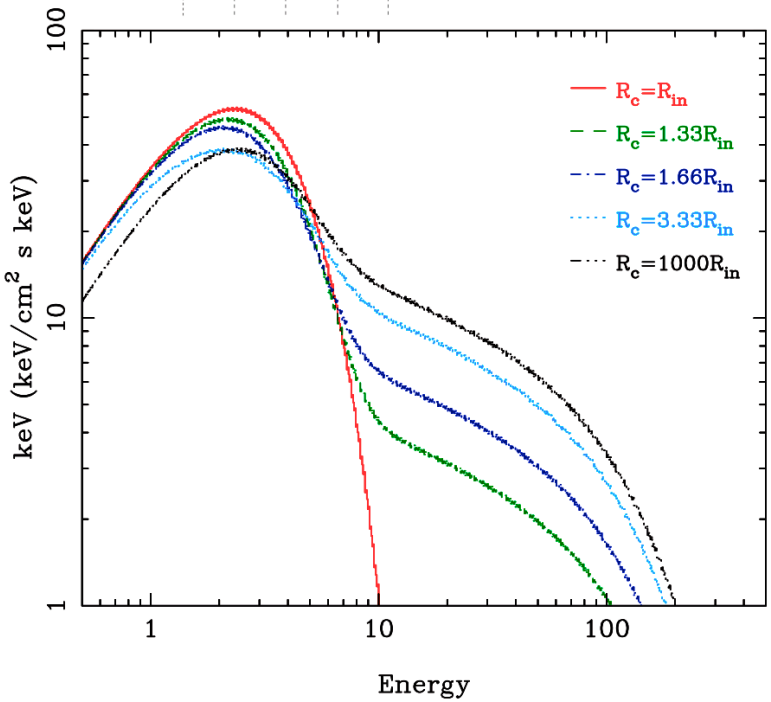


Jin et al (2009)

Inner-disc corona model for BHBs

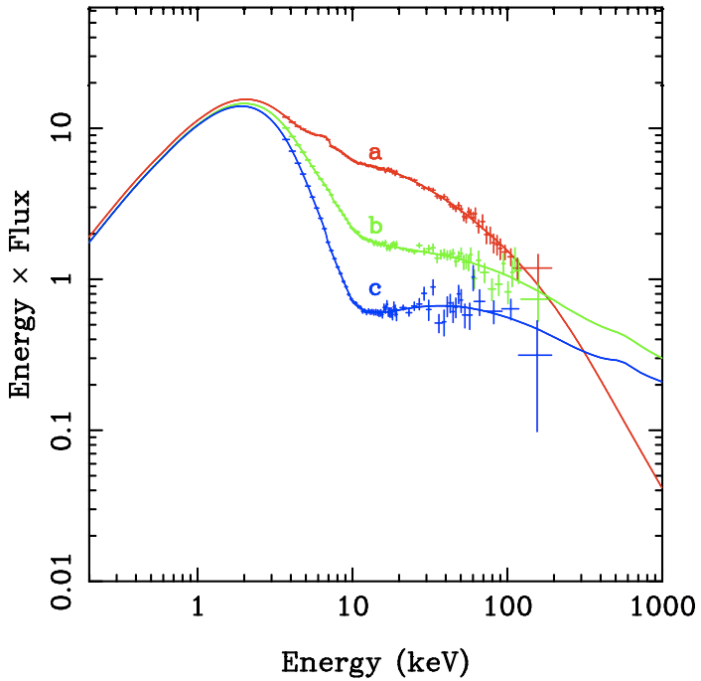


An optically-thick Comptonising corona over the inner regions of the disc in some BHBs, can distort a standard disc spectrum to produce a strong, steep tail extending to higher energies, seen in the Very High State.



Done & Kubota (2006)

XTE J1550-564



(Done et al 2007)

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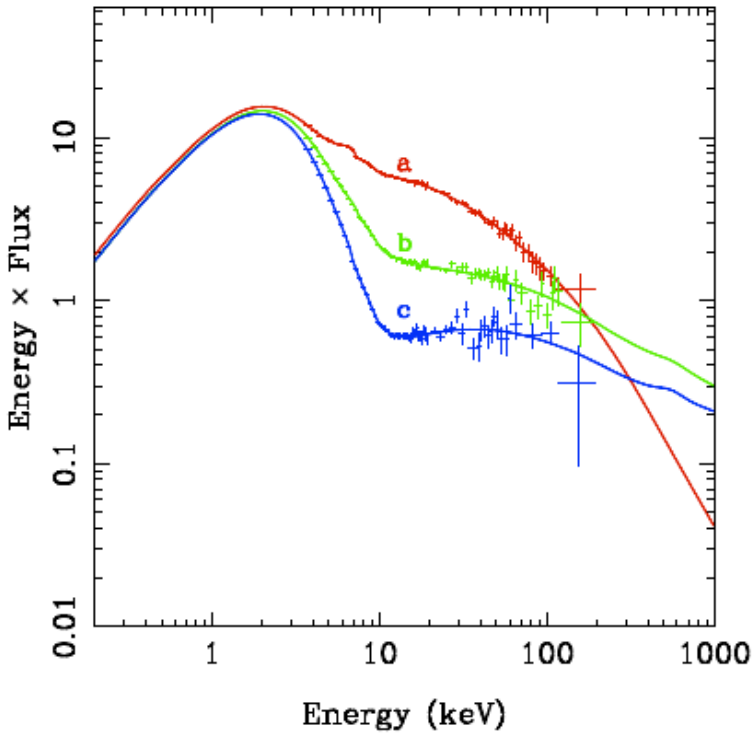

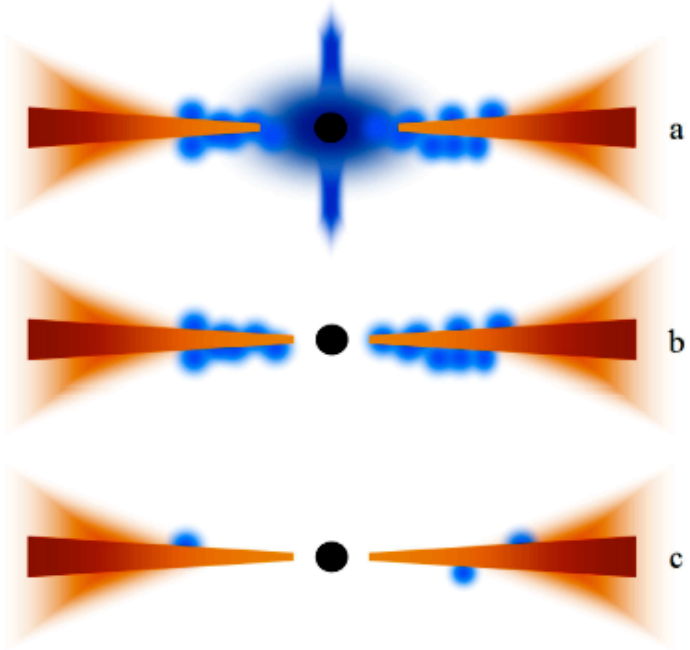

(Done et al 2007)

Conclusions

- The optical-UV continuum of Mrk 509 is consistent with thermal emission from a thin optically thick disc with $T_{\rm disc} \sim 2$ eV
- The X-ray continuum is composed of two distinct components: a power-law with $\Gamma \sim 1.8$ and a soft excess below about 2 keV
- From our multi-wavelength campaign, we find the variability of the soft excess is strongly correlated to the optical-UV emission from the disc
- The variability of the power-law (albeit smaller) is uncorrelated to that of the soft excess or the disk emission
- Our results suggest that, the soft excess is produced by the Comptonisation of the thermal optical-UV photons from the disc by a warm $(T_{\rm e} \sim 0.2$ keV$)$ optically thick $(\tau \sim 17)$ corona surrounding the inner regions of the disc
- Mrk 509 is the highest mass known system to display such behaviour and origin for the soft X-ray excess