Scaling between black hole binaries and AGN

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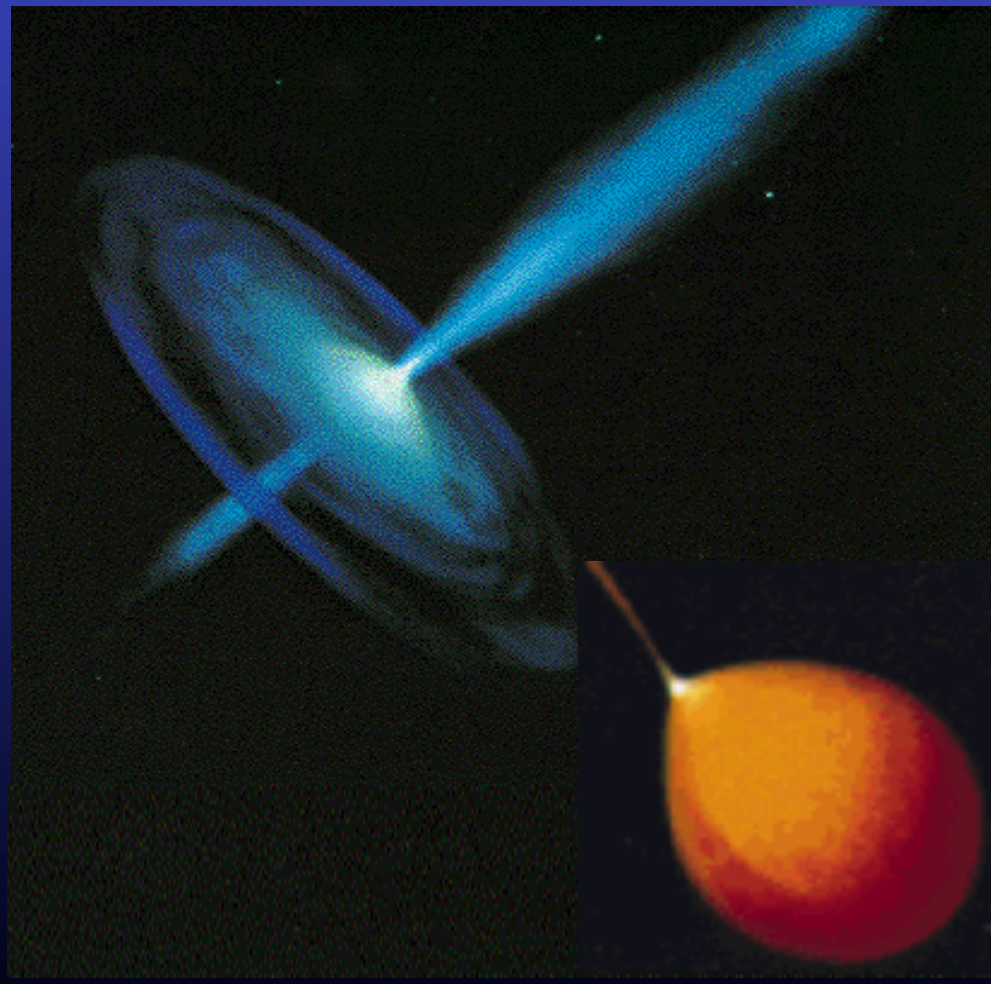
Accreting black holes

- LMXRB – many are transient so get sequence of spectra as function of L/LEdd
- Most have similar black hole mass (10M) can combine them all together to get sequence of spectra as function of L/LEdd
- But transients – accretion can be non steady state - hysteresis
- Spectral states
- Do AGN show similar states – does accretion simply scale with mass for the same L/LEdd



Spectral states in LMXRB

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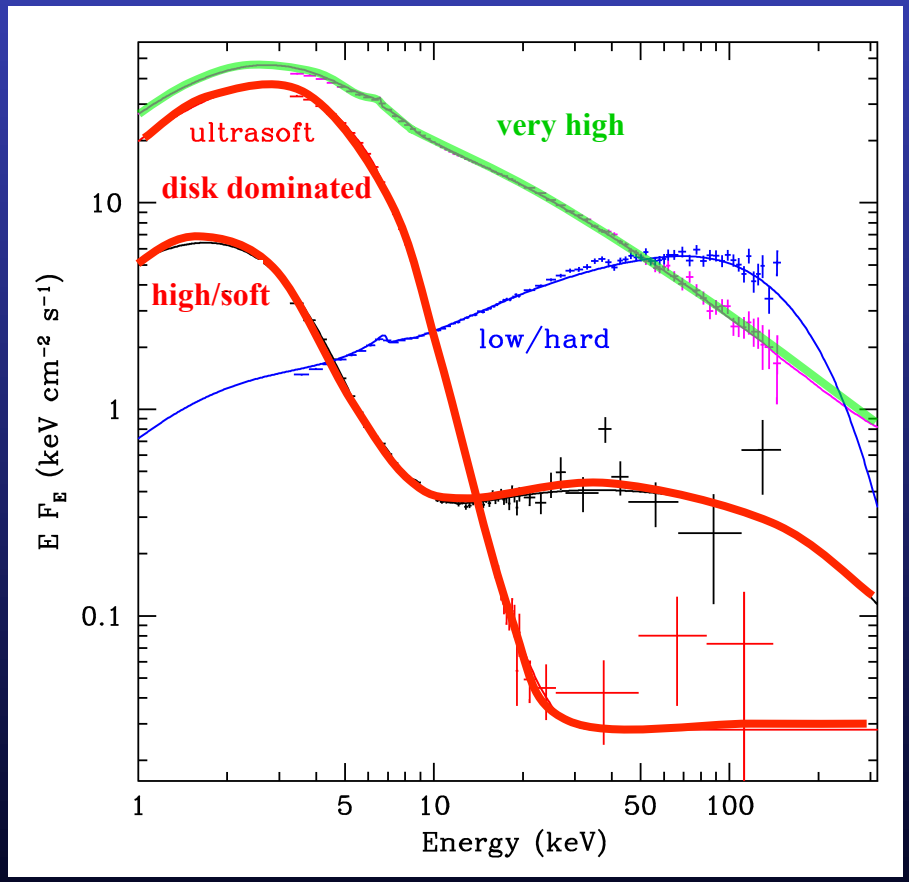

Gierlinski & Done 2003

Spectral states in AGN ?

- LMXRB – many are transient so get sequence of spectra as function of L/LEdd
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- Spectral states
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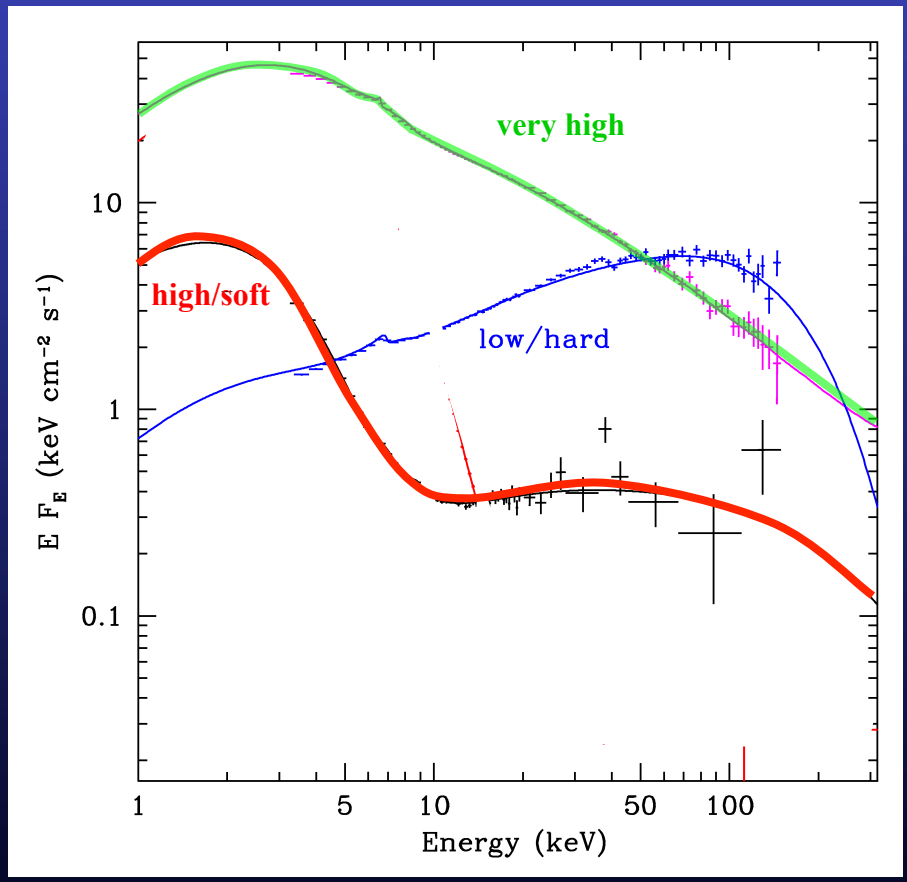
Spectral states

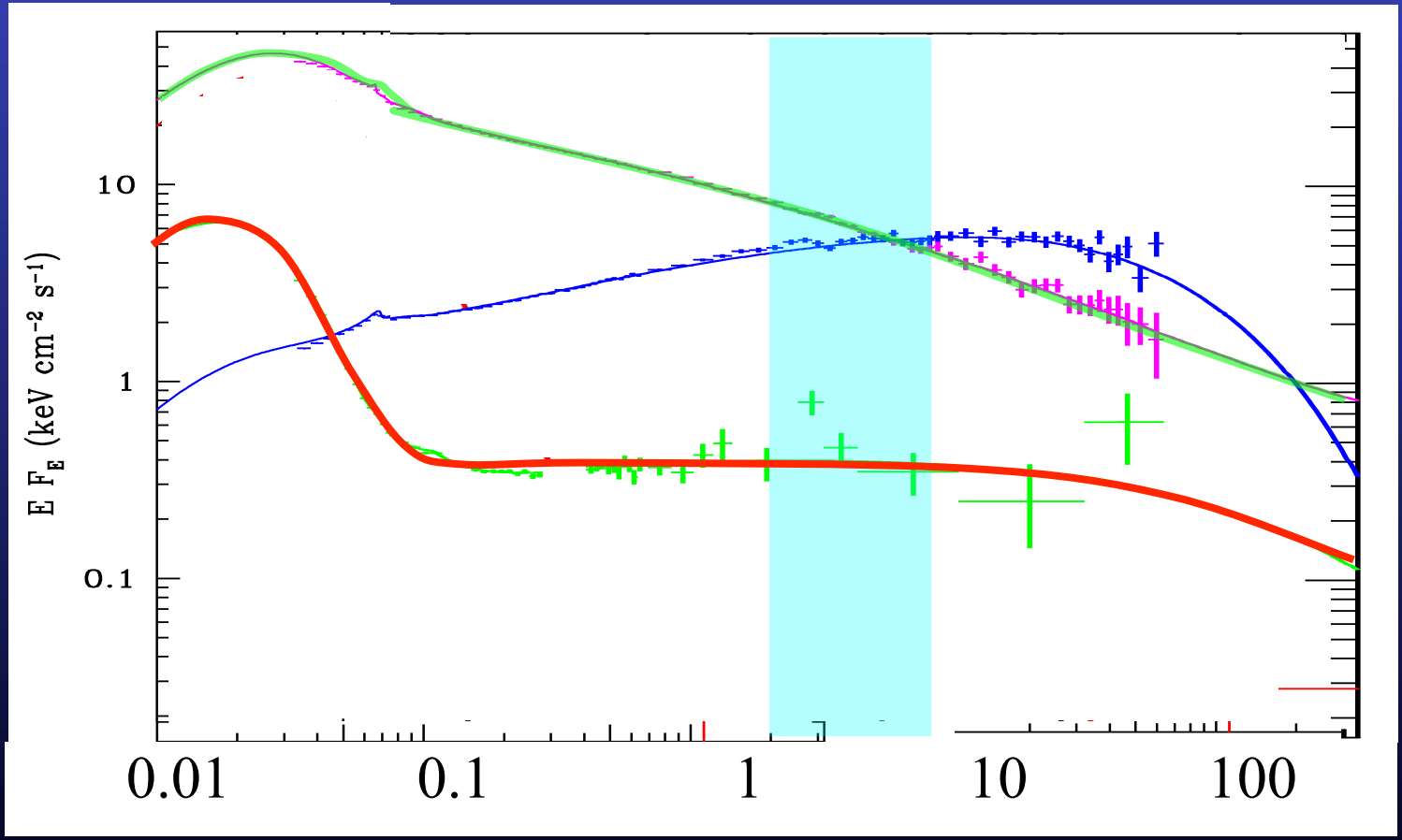
- Dramatic changes in continuum – single object, different days
- Underlying pattern in all systems
- High $L/L_{\rm Edd}$: soft spectrum, peaks at $kT_{\rm max}$ often disc-like, plus tail
- Lower $L/L_{\rm Edd}$: hard spectrum, peaks at high energies, not like a disc (McClintock & Remillard 2006)



Gierlinski & Done 2003

‘Spectral states in AGN’

Disc BELOW X-ray bandpass. Only see tail



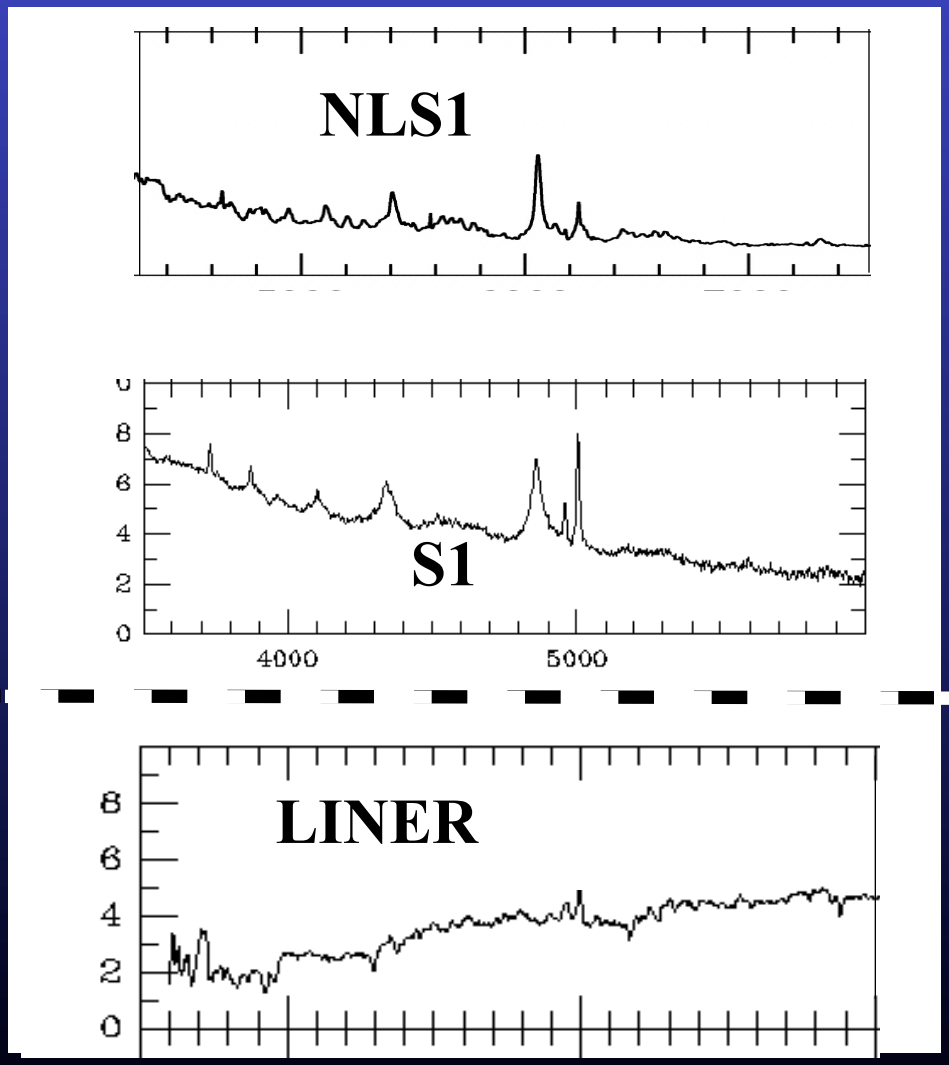
Any evidence for this? Different ionising continuua

LINERS-S1-NLS1

Similar mass.
Different L/L_{Edd}
Different ionisation

Increasing L/L_{Edd}

disc

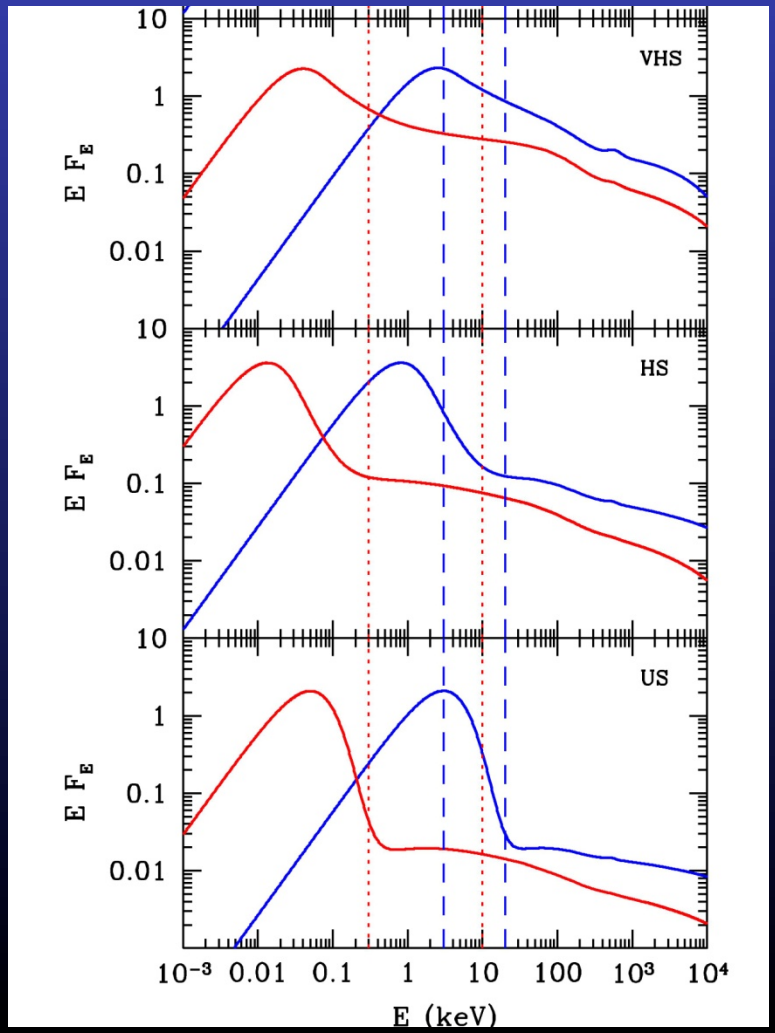


Hot inner flow, no UV bright disc

Jester 2005; Leighy 2005; kording et al 2007

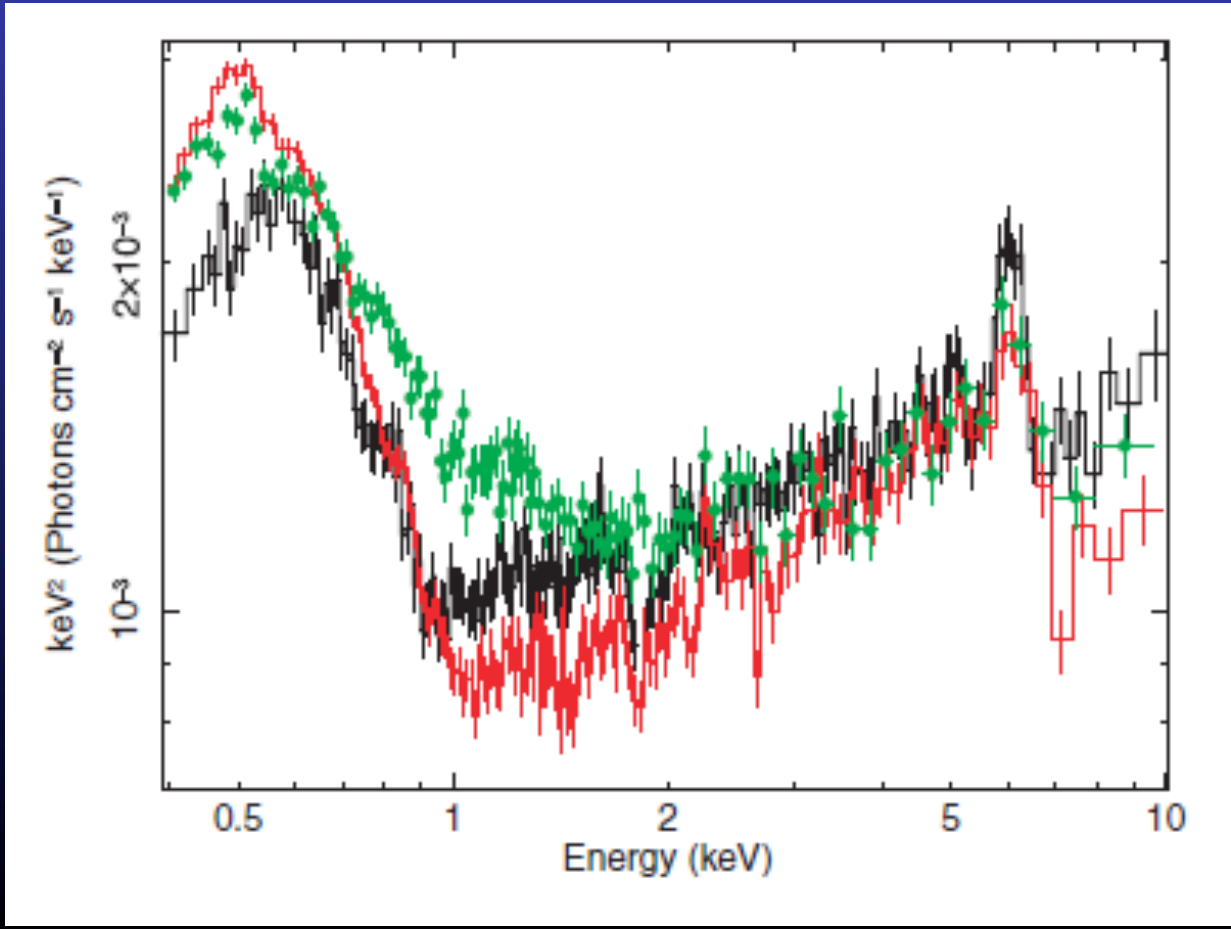
Implications for high L/L_{Edd}

- High L/L_{Edd} objects easy to find. Typically most PG QSO's have $L>0.05\ L_{Edd}$
- For these, soft excesses should be very rare in XMM bandpass. When seen they should be very steep, and low temperature
- Power law at high energies should be steep, Γ=2-2.5



What not to see…

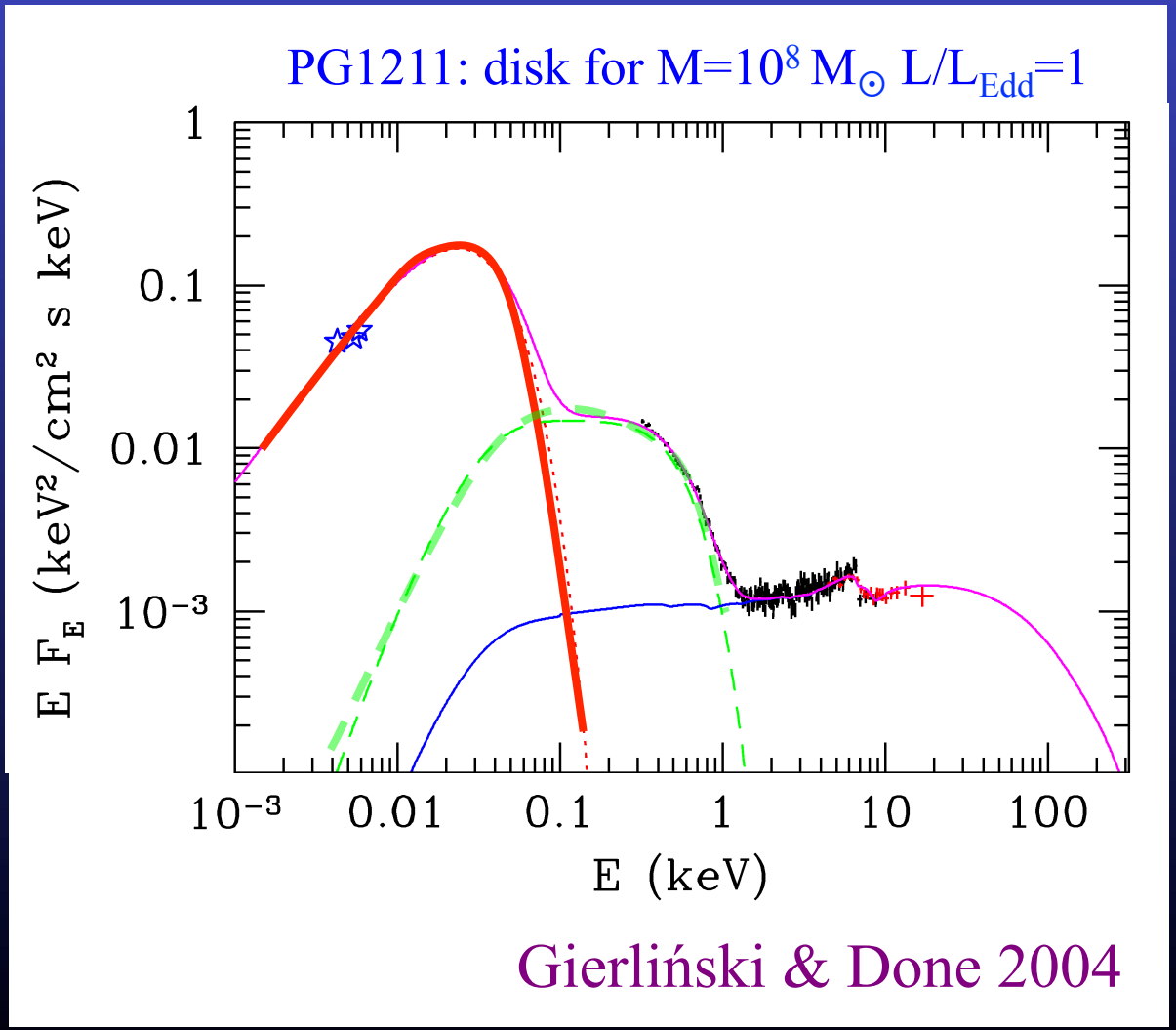
- Strong soft excess to ~1keV, flat power law at high energies



Reeves et al 2008

Soft excess? NOT from the disc!

- NOT THE DISC - doesn't get close to rise in data at 1keV
- Compton scattering of disc by low T_e, high τ material? Magdziarz et al 1998, Czerny et al 2003

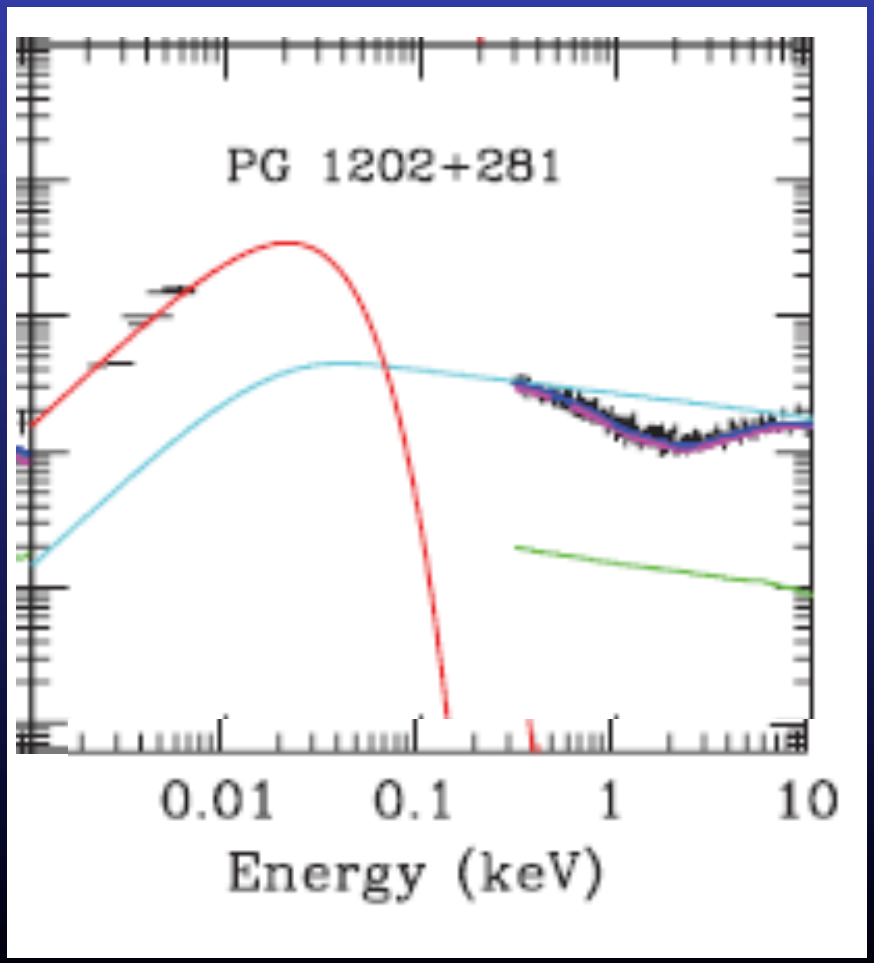


Gierliński & Done 2004

But some discs do get close…

Middleton et al 2007

- Problems not limited to PG1211
- ALL PG QSO need soft excess! This is very gradual and smooth, not steep, though strength varies
- Often seen with $\Gamma<2$
- Generally too hot to be the disc – we know mass and L/LEdd from optical and Hβ



The PG QSO sample in XMM

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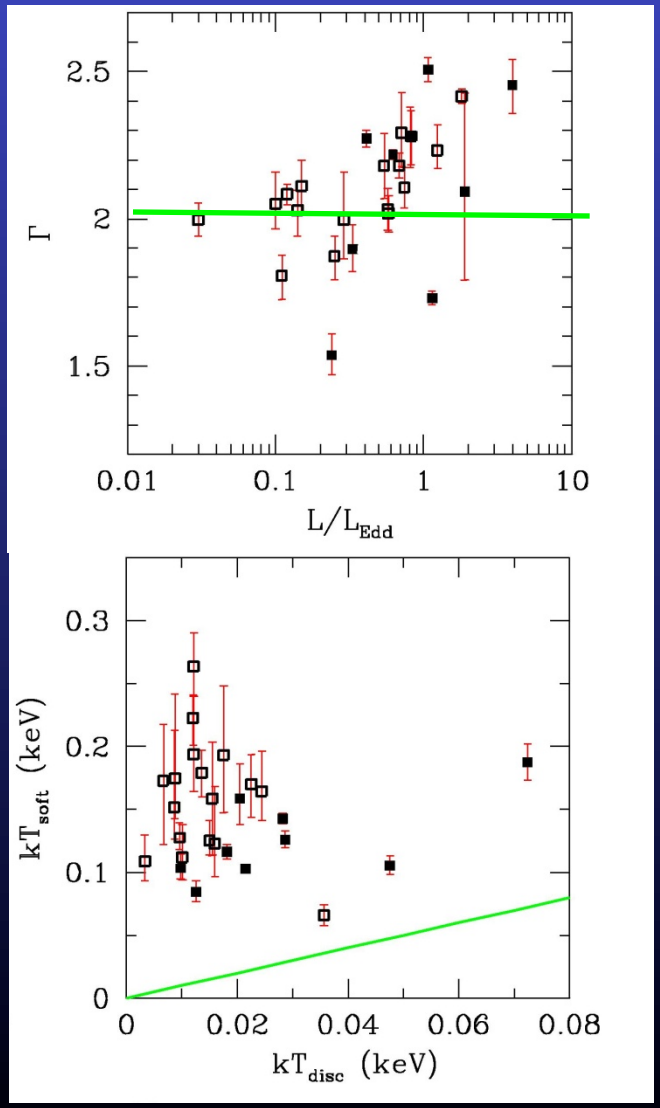
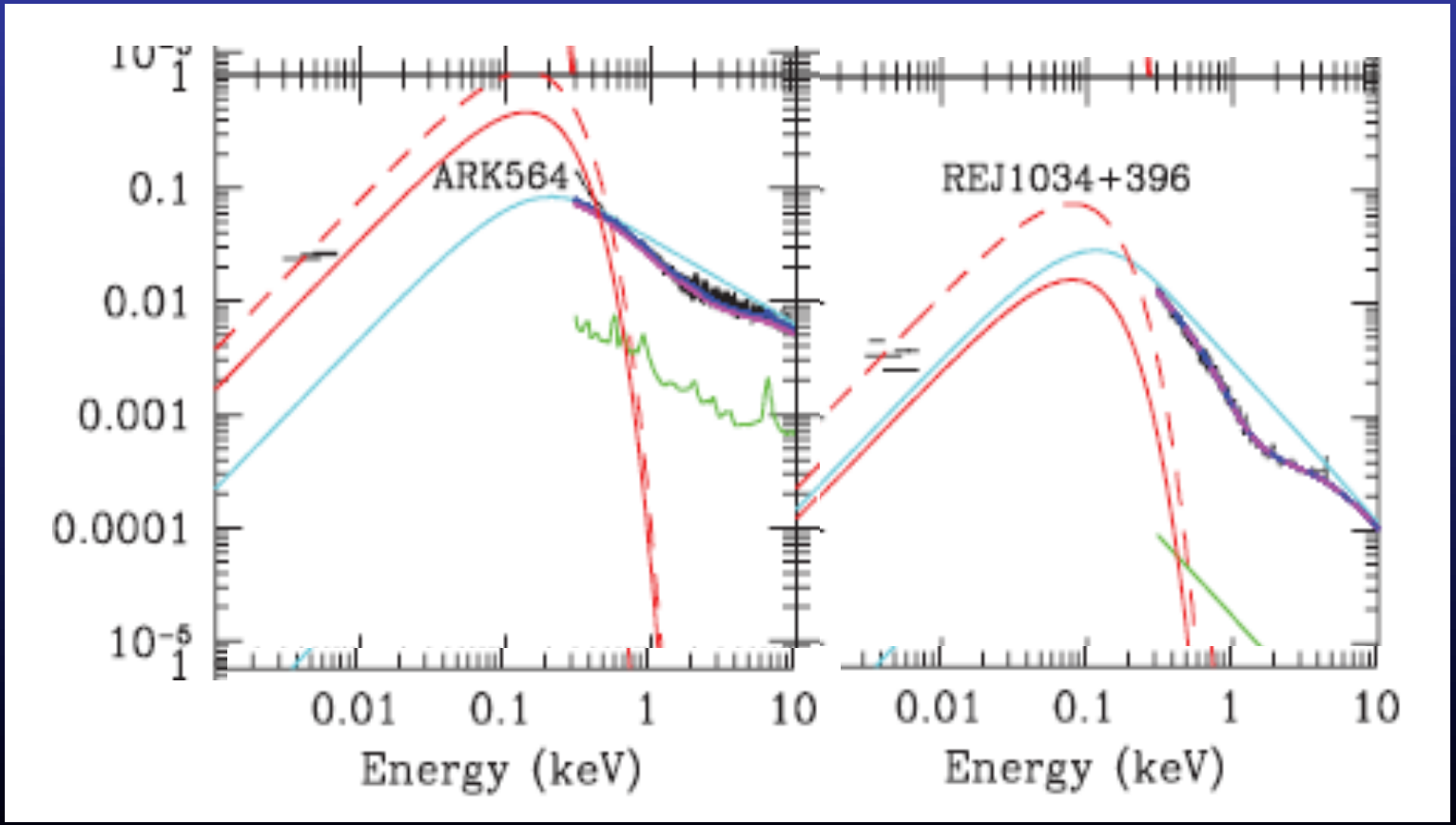


But some discs do get close…

- Low mass, high L/L_{Edd} – NLS1 !!
- Typically the objects with the biggest SX….

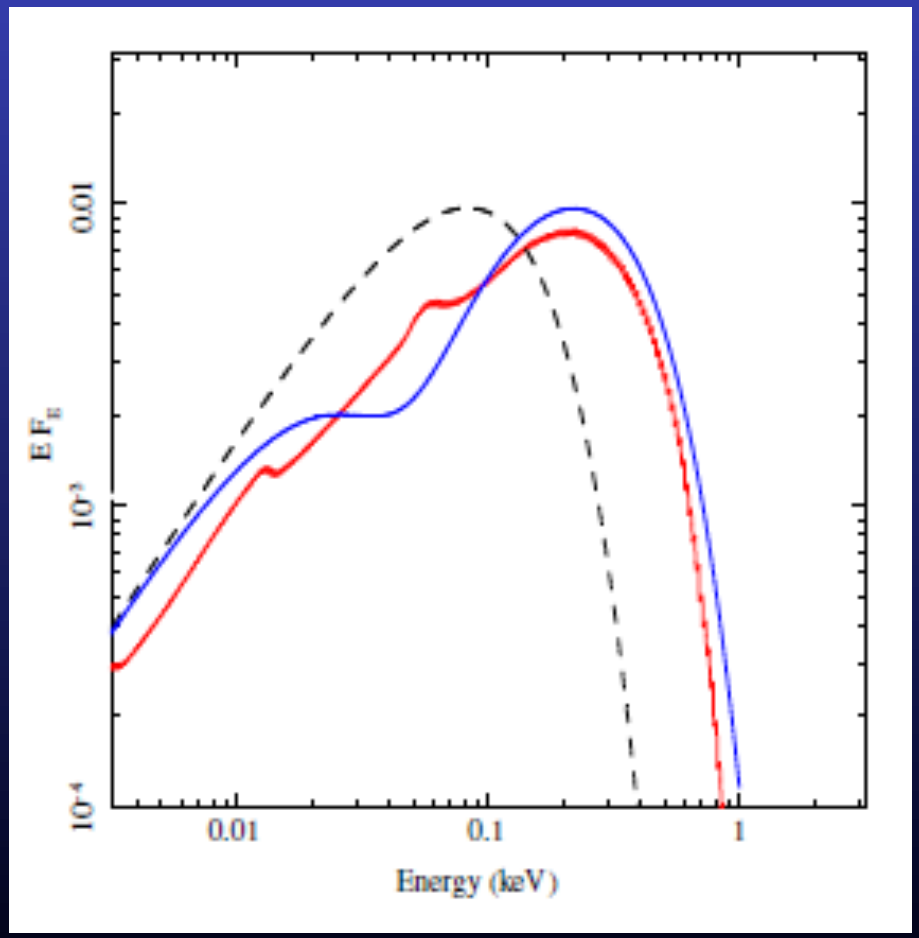


Middleton et al 2007

Disc spectra from 10^6 M L/L_{Edd} ~1

- Standard SS disc temperature – assumes energy thermalises
- BHB discs - Colour temperature correction as scattering > absorption opacity. Tobs =fcol Teff where fcol=1.8
- AGN discs even more scattering dominated as less dense !! Factor 2.4 !! cf Ross Fabian & Mineshige 1992
- fcol=2.4 for $T>10^5$ K

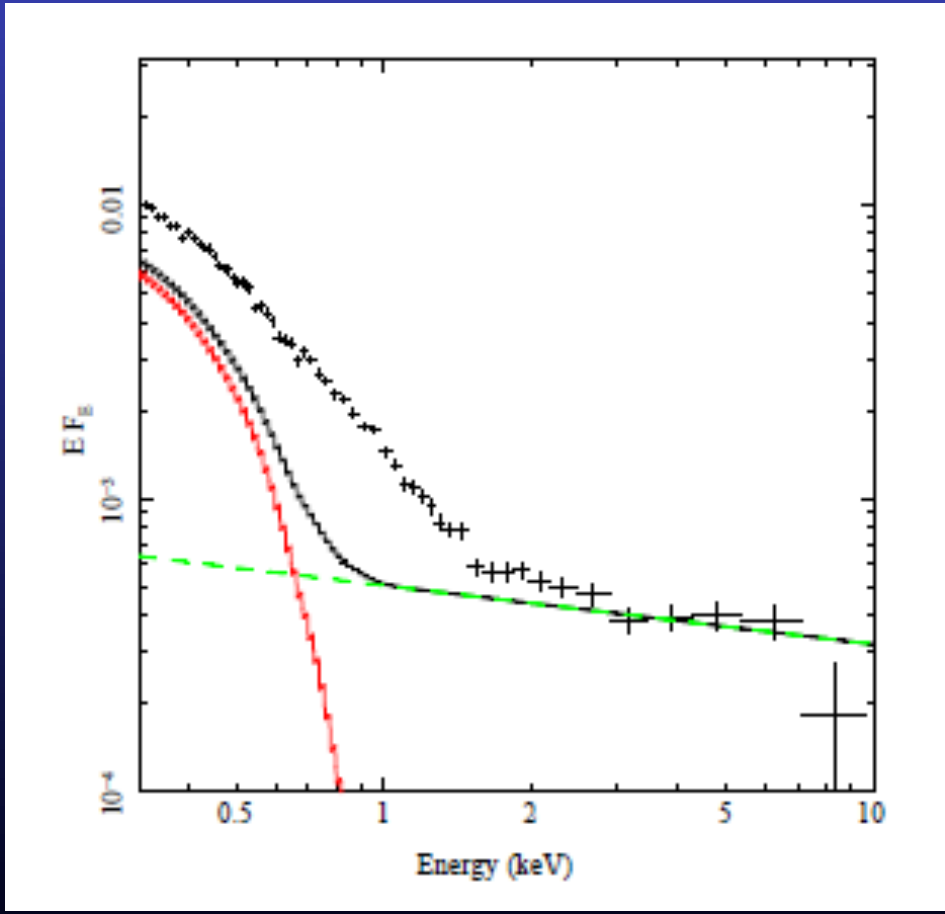
Done, Davis, Jin, Blaes Ward 2011



Disc spectra from 10^6 M L/L_{Edd} ~1

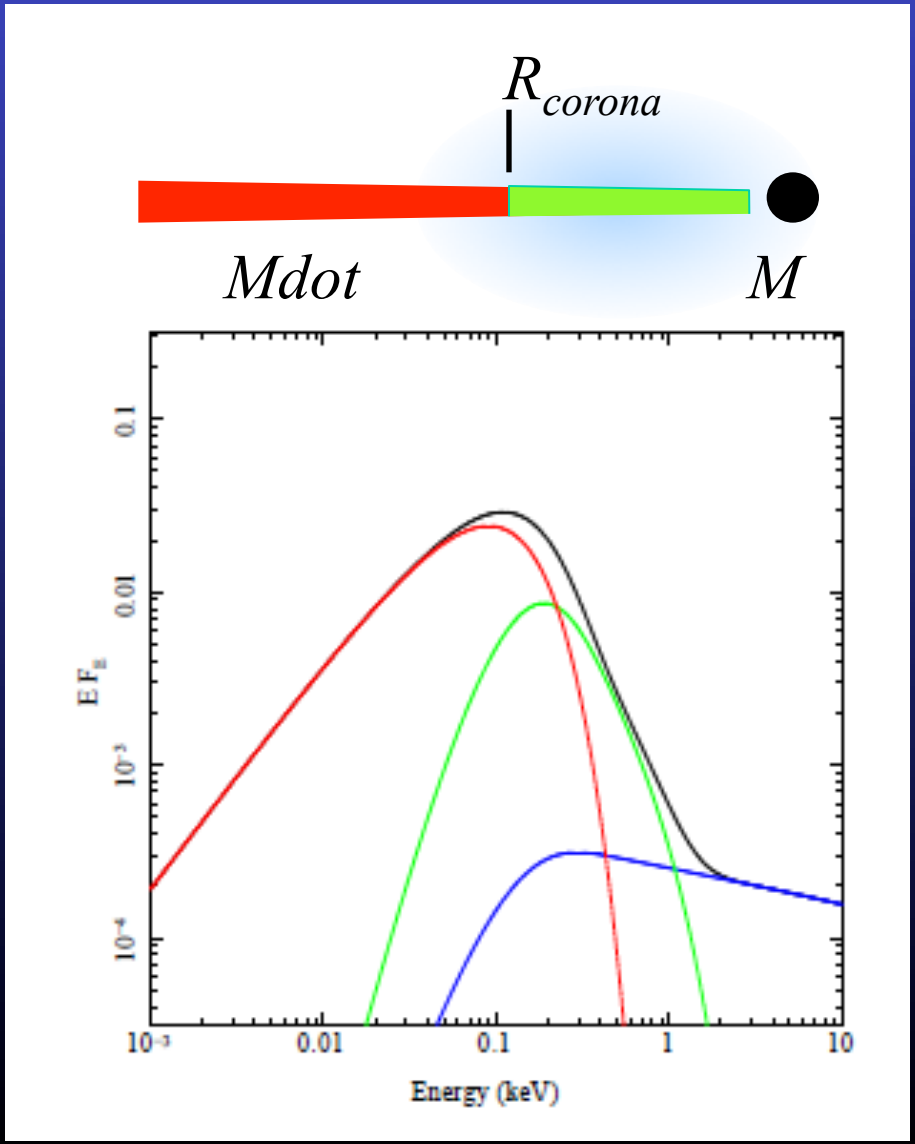
Done, Davis, Jin, Blaes Ward 2011

- Enourmous soft excess in REJ1034
- But actually a lot of it should be the bare disc!
- Plus a little bit of soft comptonisation !
- More like disc dominated black holes



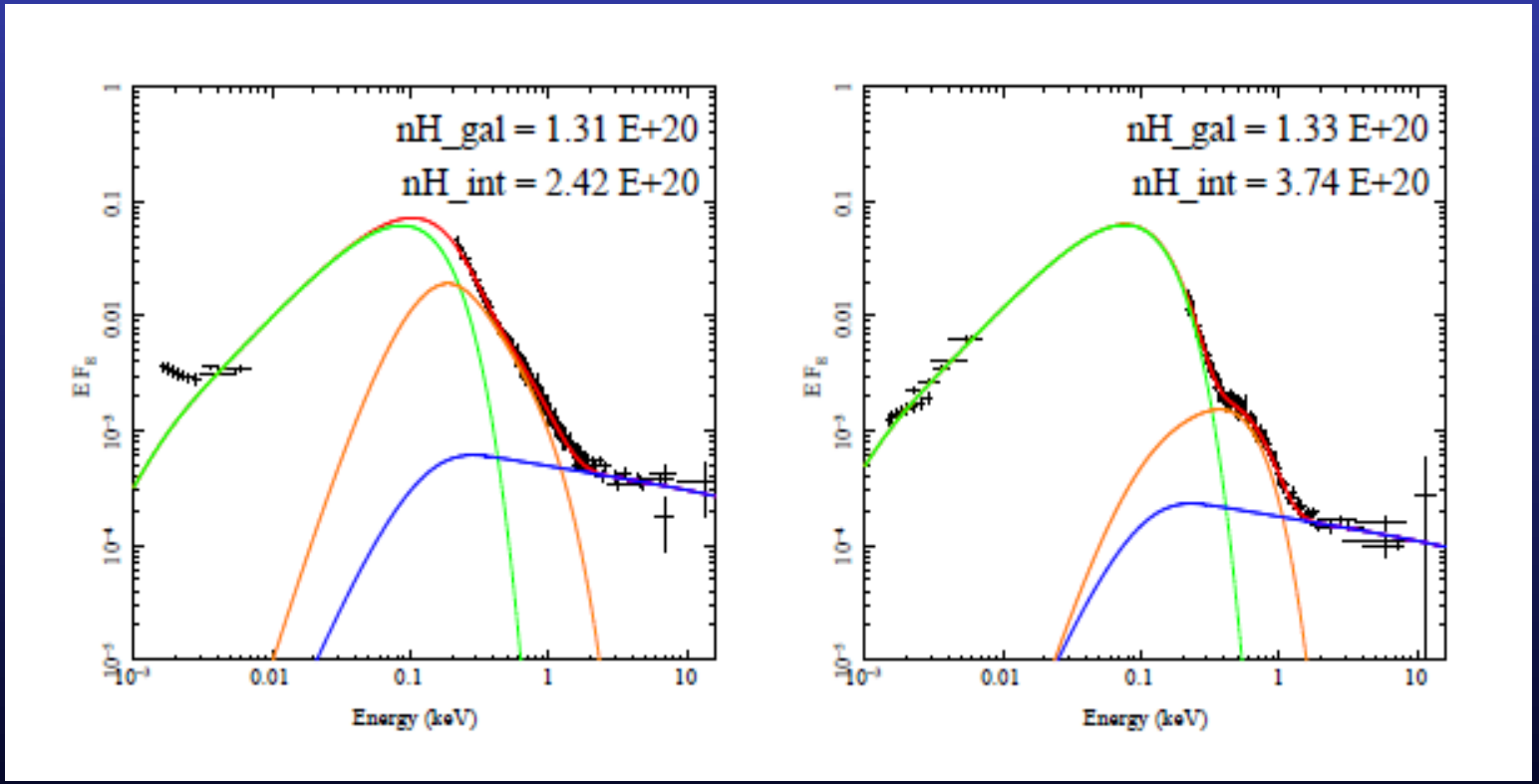
Models conserving energy!!

- Lopt ∝M Mdot
- Know M from optical and Hβ
- Measure Mdot from L opt. Lbol = η Mdot c^2
- Schwarzchild a=0 η=0.0572
- If powered by accretion of material through the outer disc then this also makes soft excess and power law tail
- Thermal down to R_{corona}, comptonised/power law after this – XSPEC optxagn Done et al 2011 cf dkbbfth Done & Kubota 2006



So what do AGN look like?

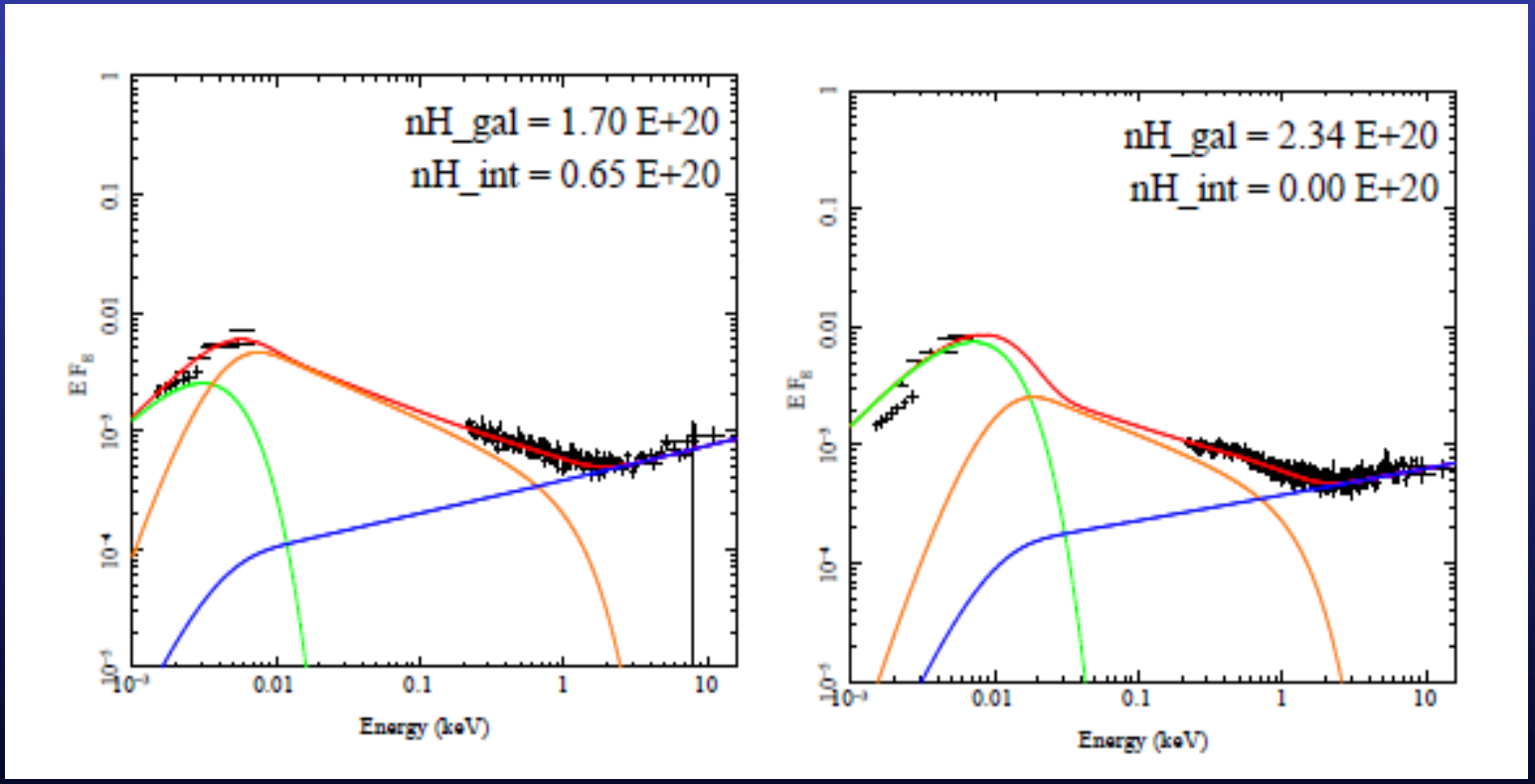
- 51 objects with SDSS-2XMM with high s/n and low absorption
- Low M, high L/LEdd, part of SX connected to disc



Jin et al 2011

So what do AGN look like?

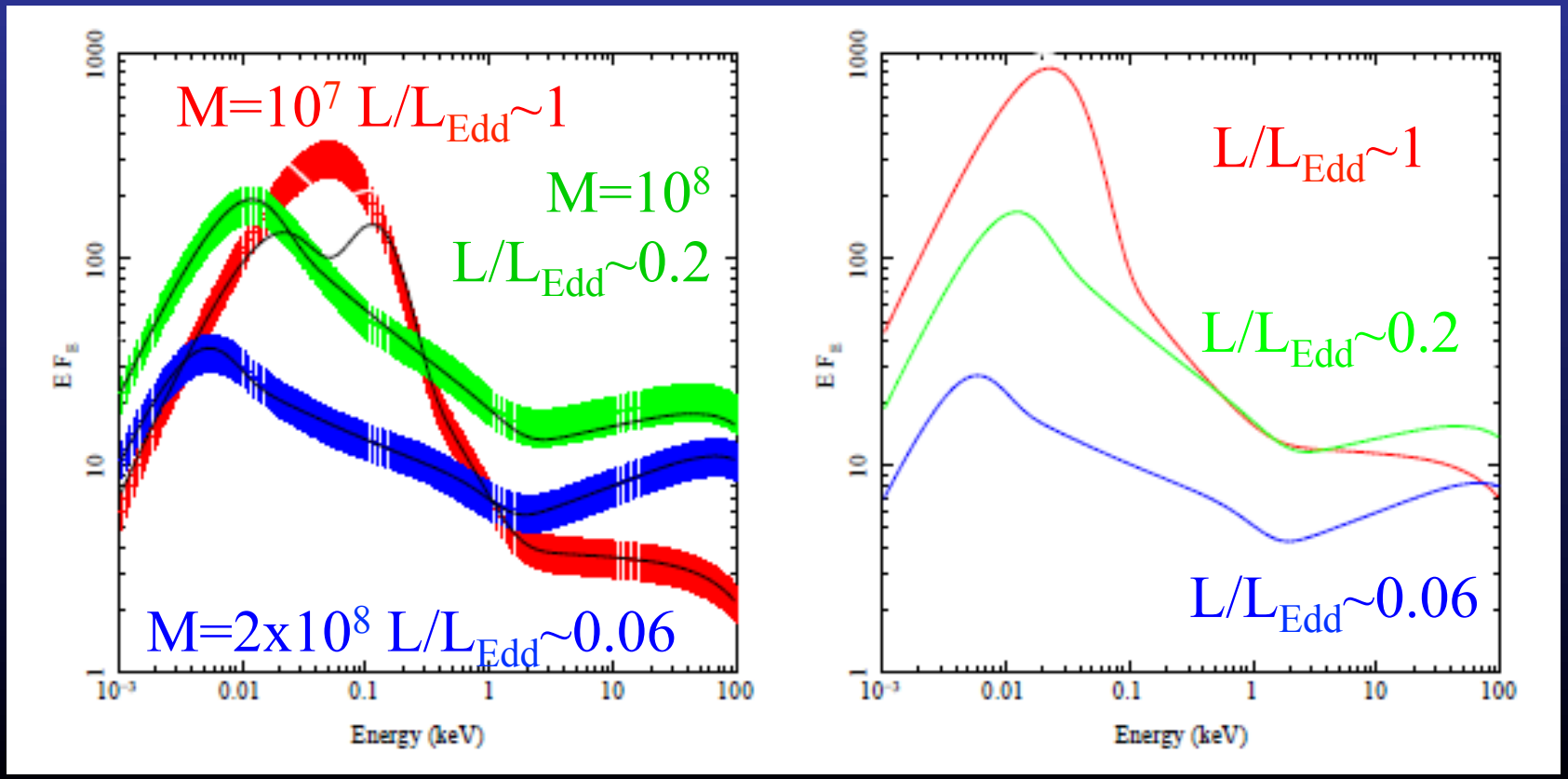
- 51 objects with SDSS-2XMM with high s/n and low absorption
- High M, low L/LEdd, disc far from SX



Jin et al 2011

So what do AGN look like?

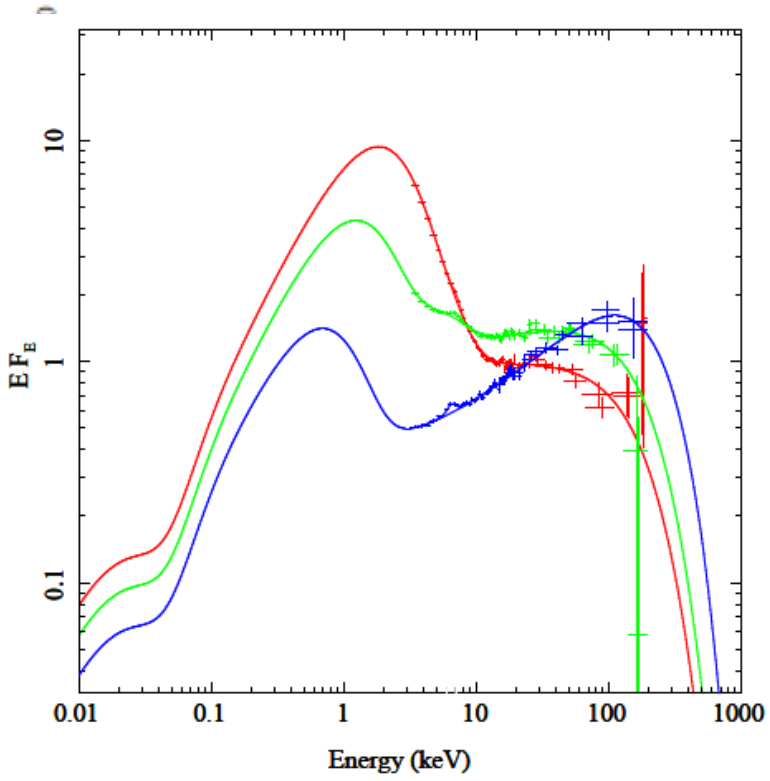
- Co-add models in 3 bins of L/L_{Edd}
- Correlates with M due to galaxy formation. high mass objects have low L/L_{Edd} in local Universe – downsizing
- Physical model so shift to same mass $M=10^8$ to compare with BHB

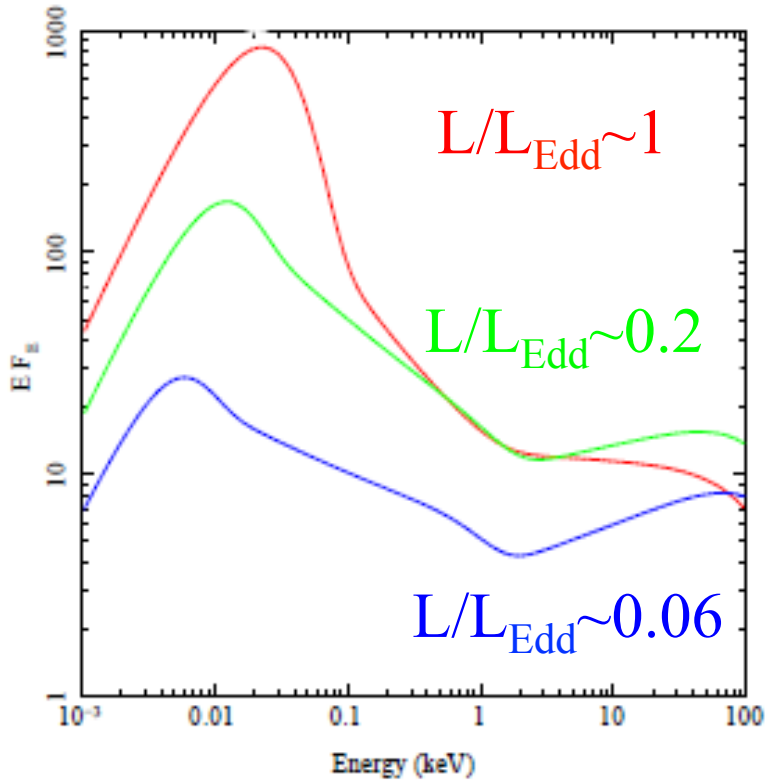


Done et al 2011

Low/hard to high/soft ?

- Looks good to zeroth order… but….
- Transition at L/LEdd=0.02 in steady state accretion - 0.2 in AGN
- Transition fast so see very few spectra like middle one yet this is classic QSO spectrum we see everywhere. And index wrong!

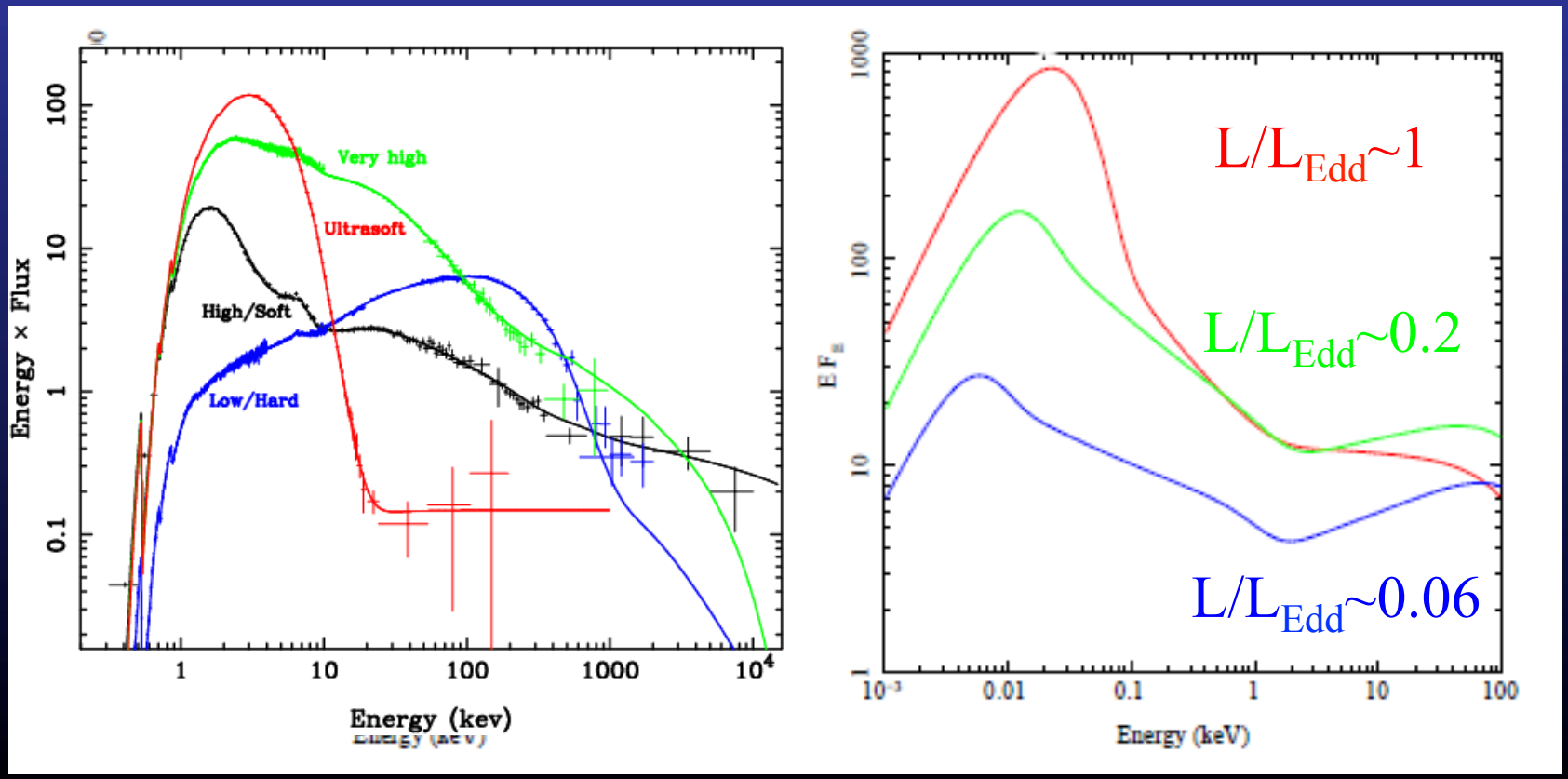




Done et al 2011

Very high to ultrasoft ?

- Looks good !
- Transition at ~0.2 is fine. Frequently see this state at this luminosity
- index wrong!

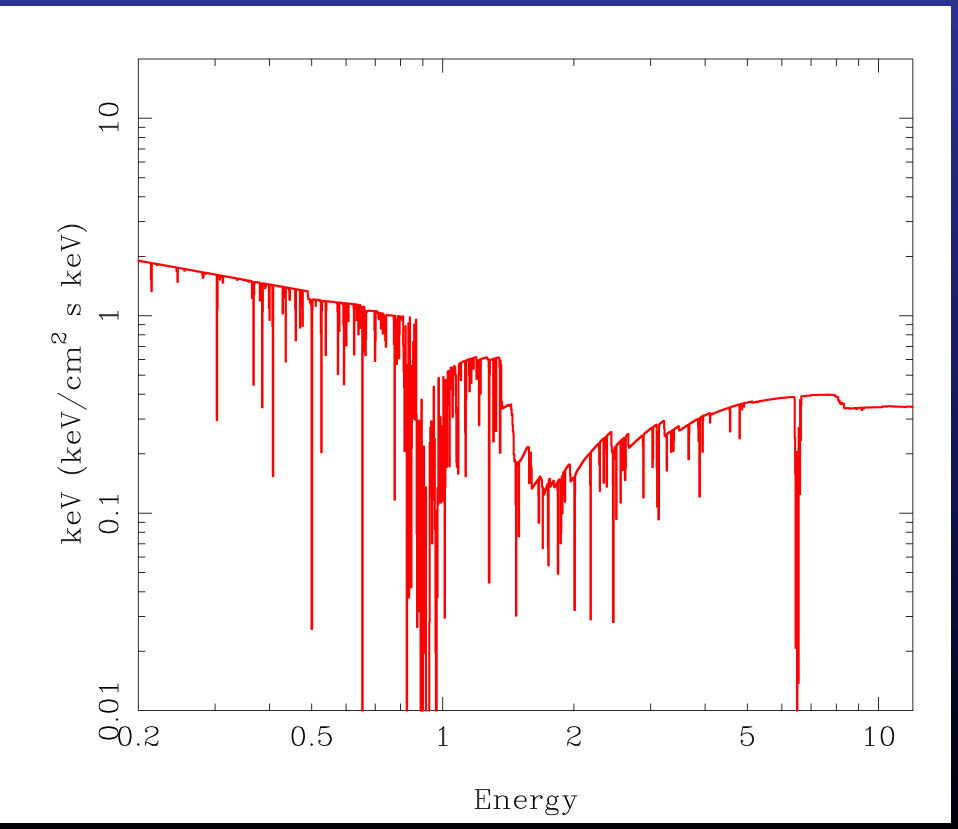


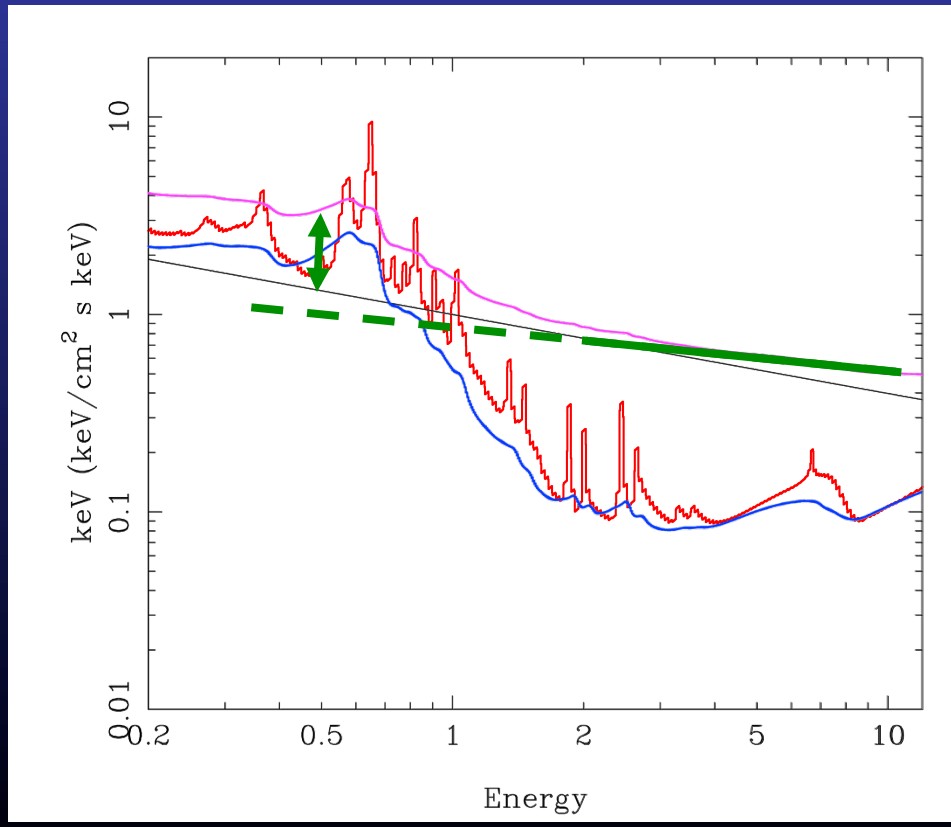
Done et al 2011

Partially ionised, relativistic material

- Atomic features not seen so extreme relativistic smearing

Fabian et al 2002; 2004 Miniutti & Fabian 2004

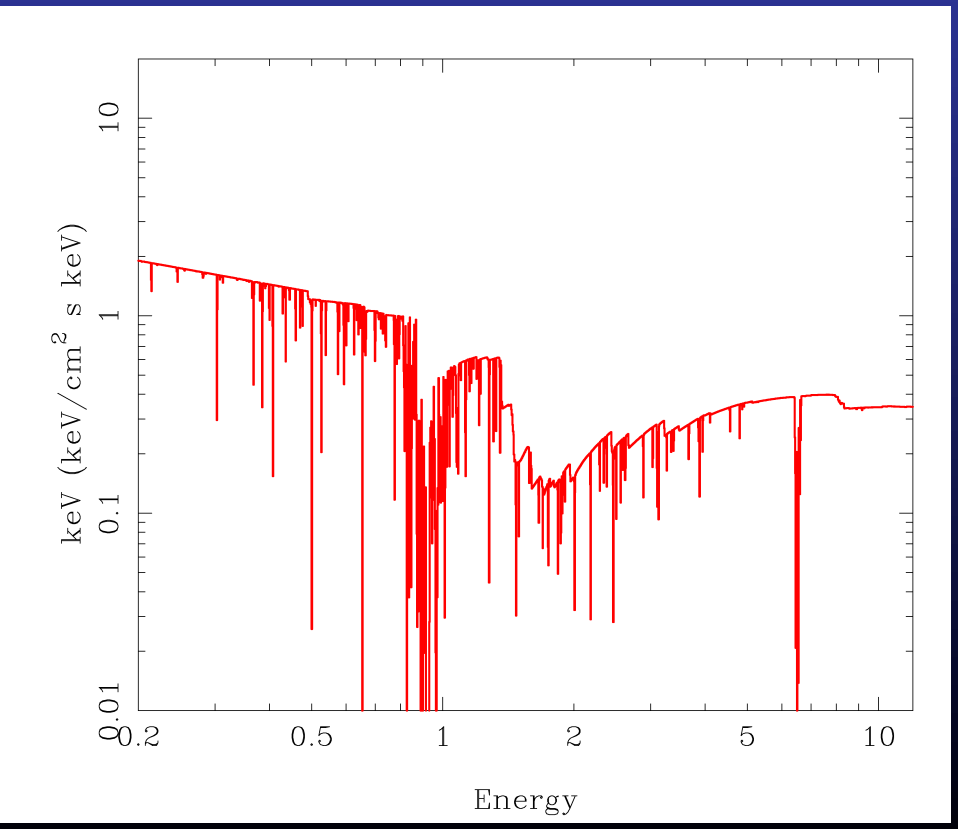


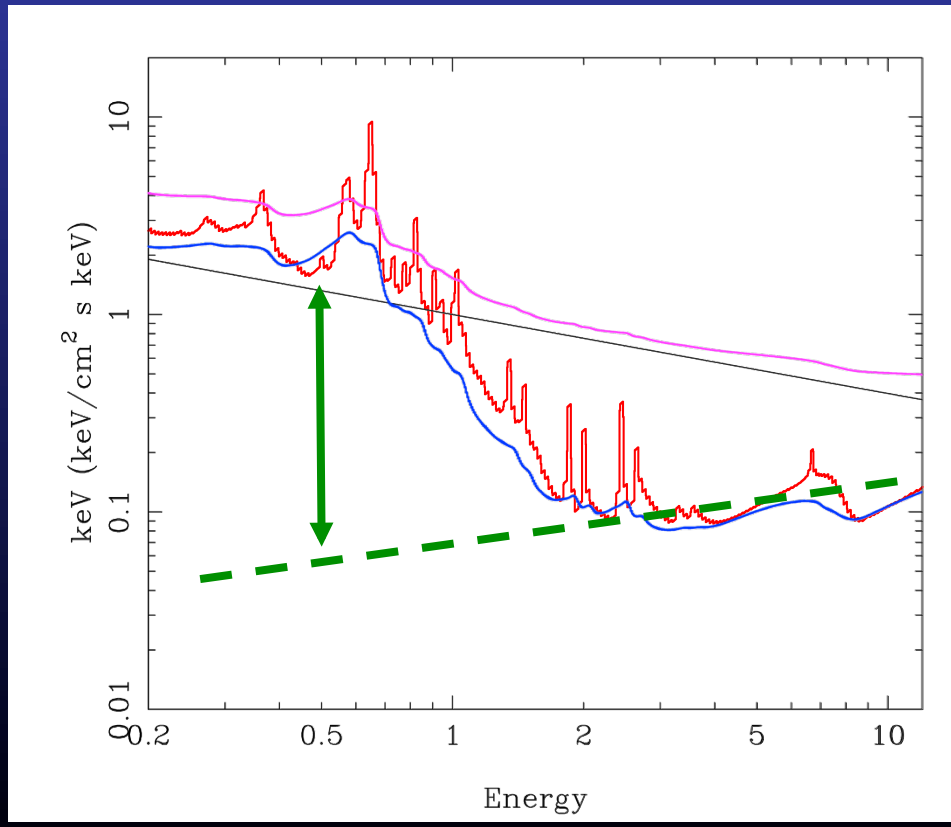


Partially ionised, relativistic material

- Atomic features not seen so extreme relativistic smearineed to supress
- intrinsic continuum to get very large SX and hard 2-10 keV spectrum

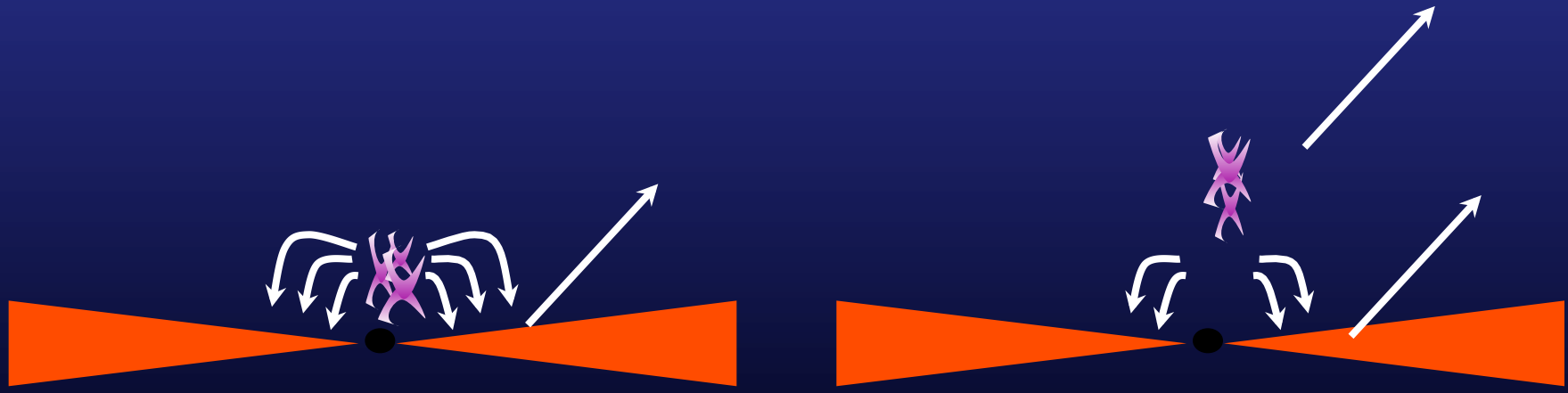
Fabian et al 2002; 2004 Miniutti & Fabian 2004





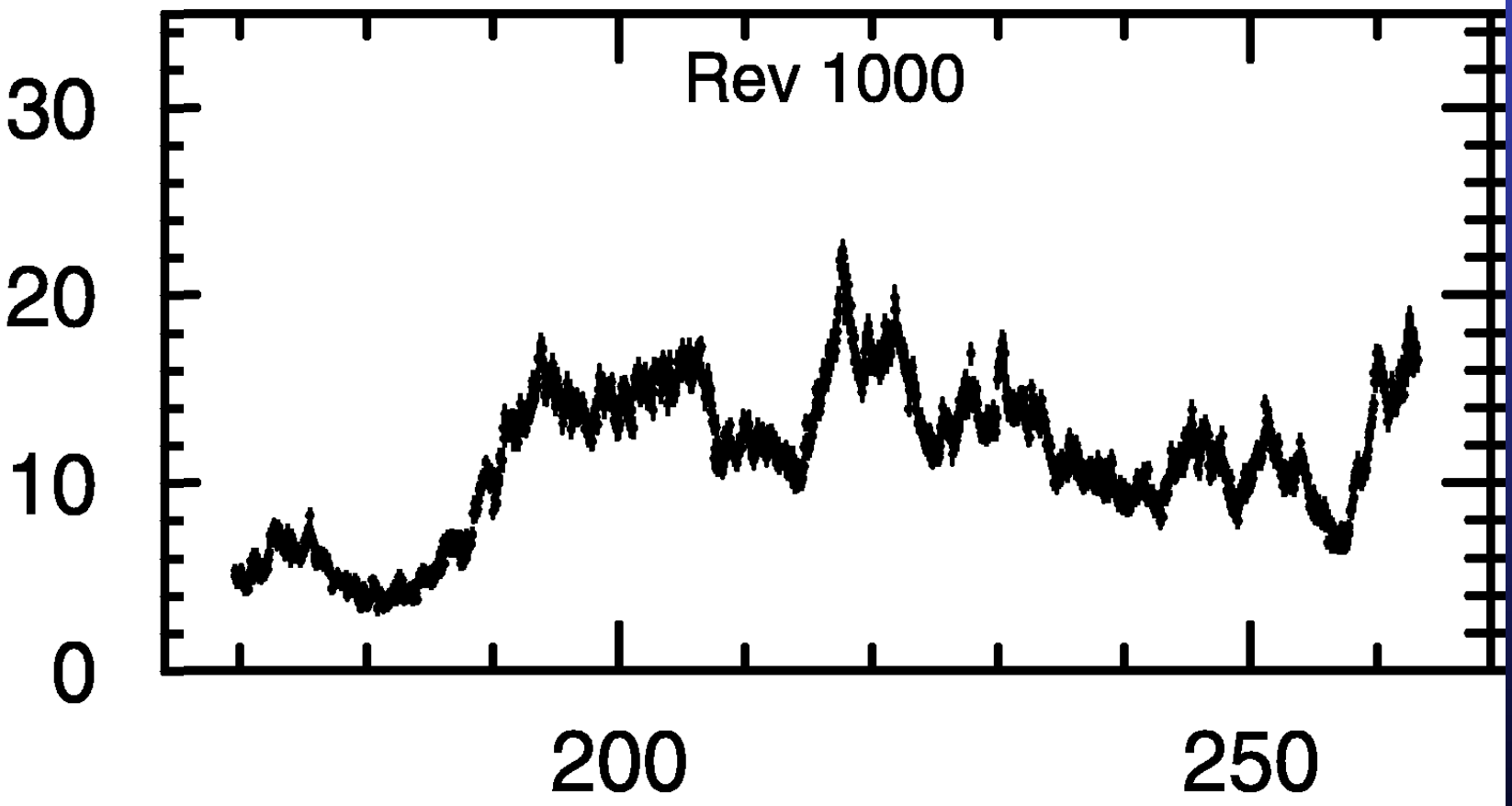
Soft excess from reflection from partially ionised material

Fabian et al 2002, 2004, 2009 Miniutti & Fabian 2004,

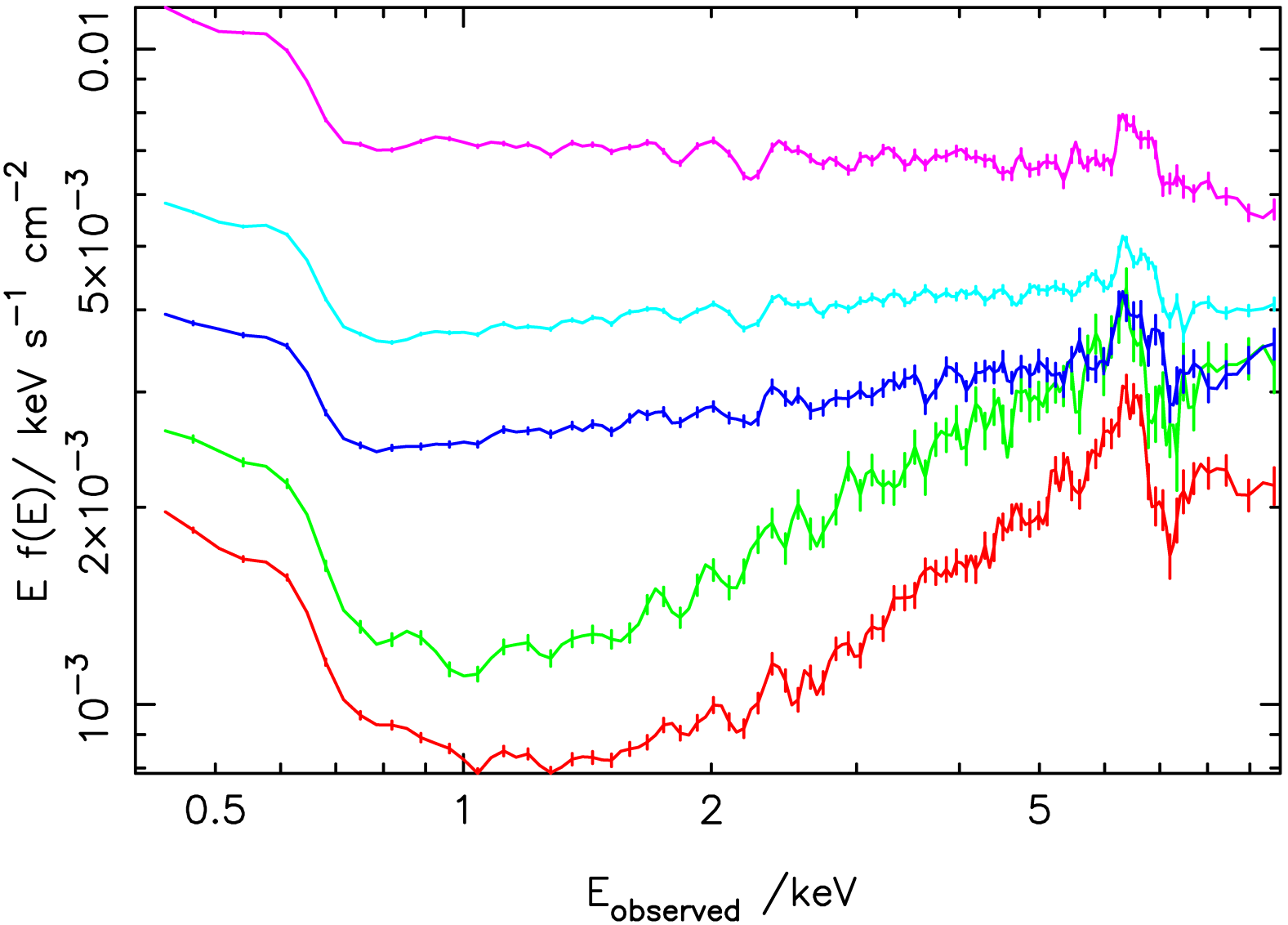


Reflection

AGN variability

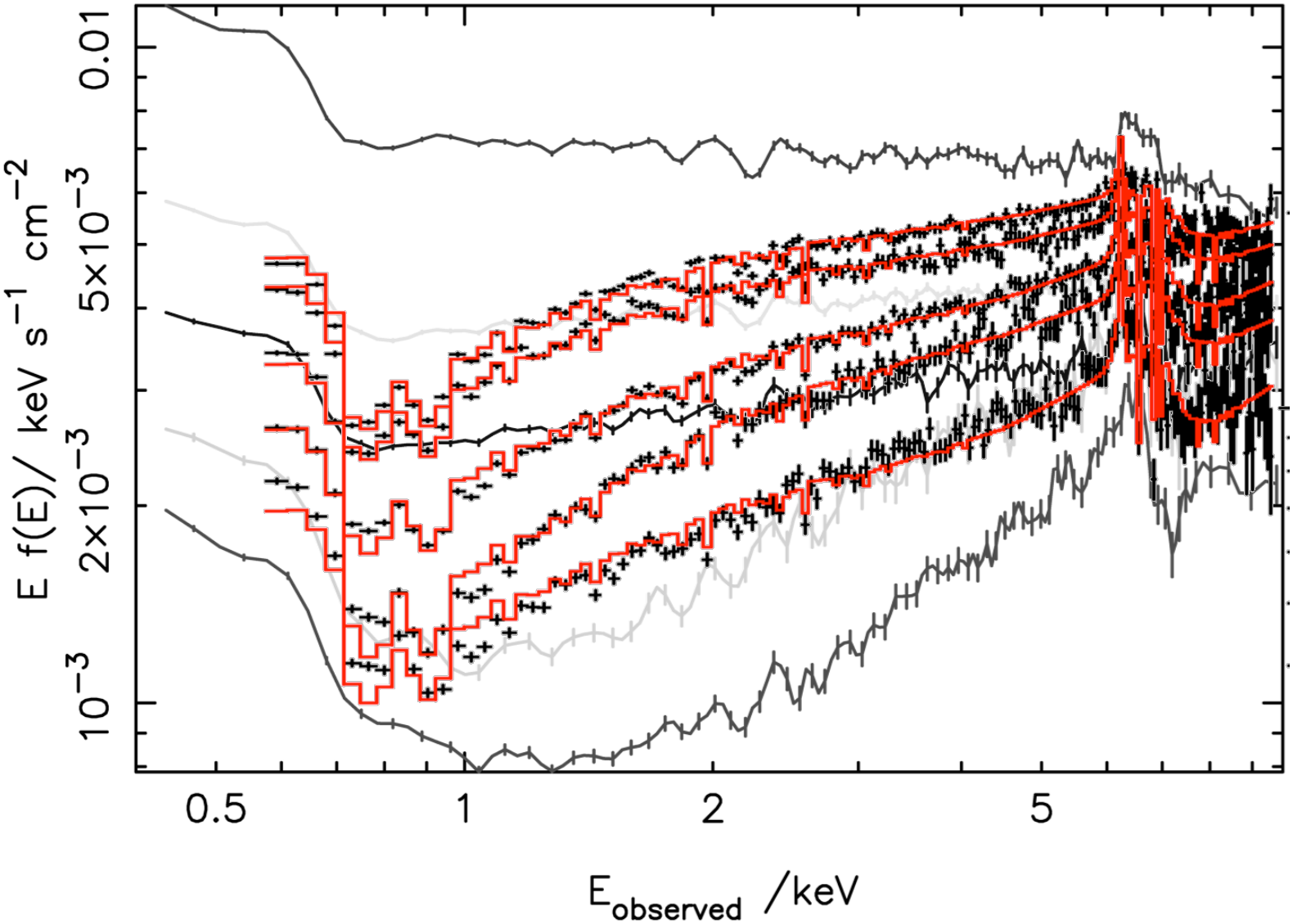


More soft excesses in AGN



Miller et al 2007, Miller et al

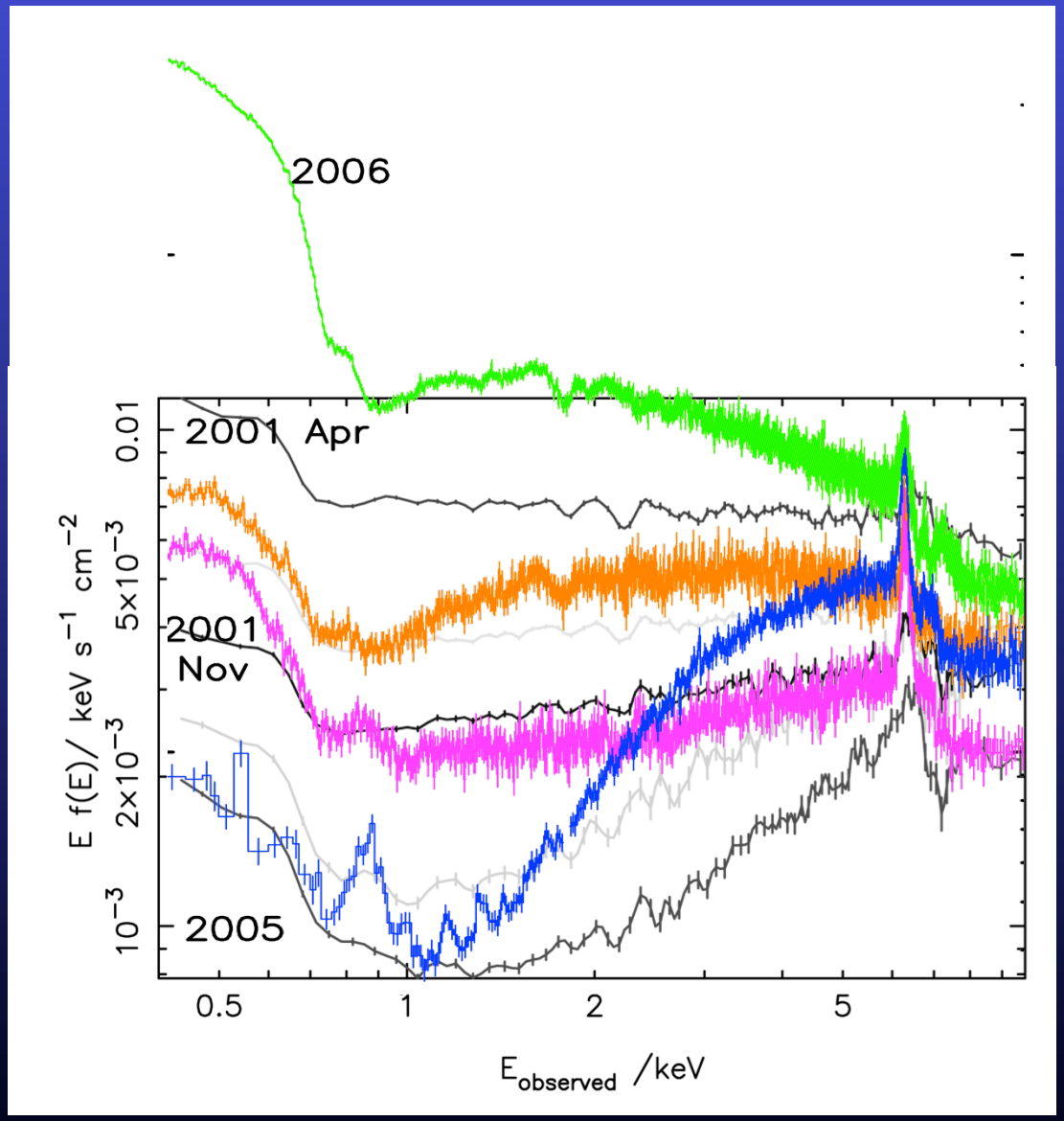
Can fit all spectral data



Miller et al 2007, Miller et al

NGC3516

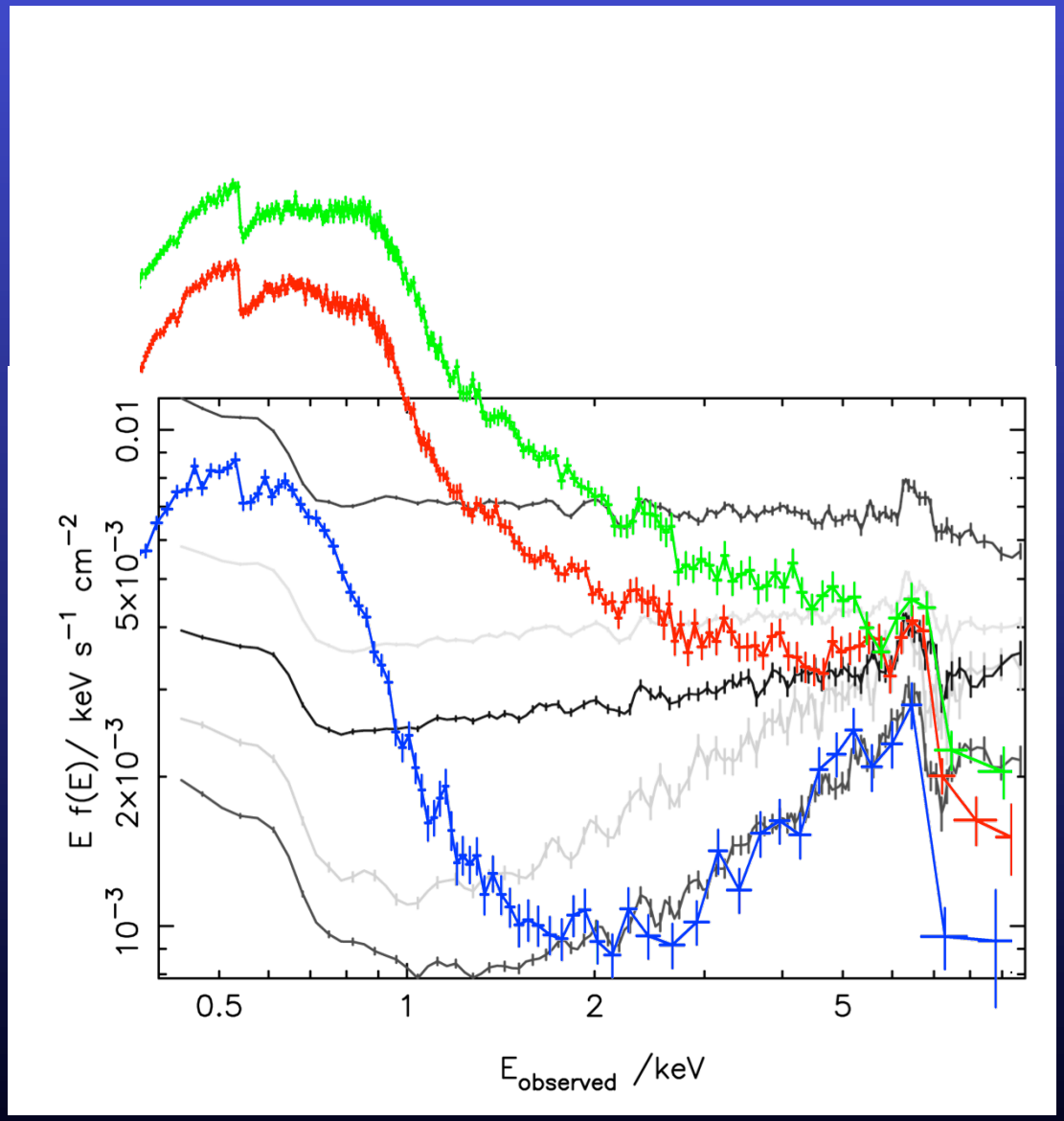
- Much more variability – clearly at least part of this is absorption Risaliti et al 2007; Turner et al 2008



Turner et al 2008 Miller et al 20072008

1H0707

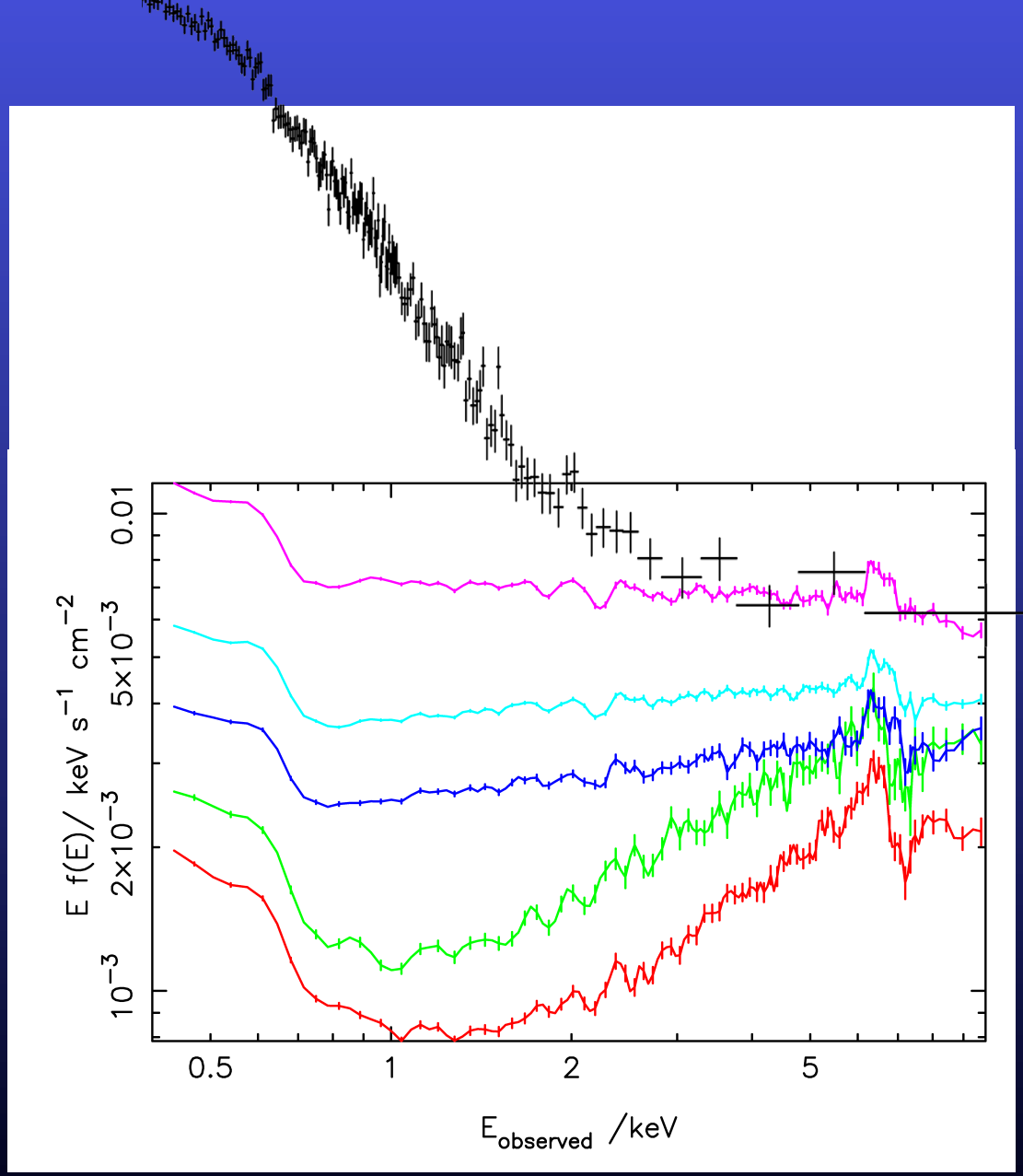
- Huge drop at iron K (plus huge SX)
- Bet some of this is the disc



Miller et al 2007, Fabian et al 2009; Zoghbi et al 2010

RE1034

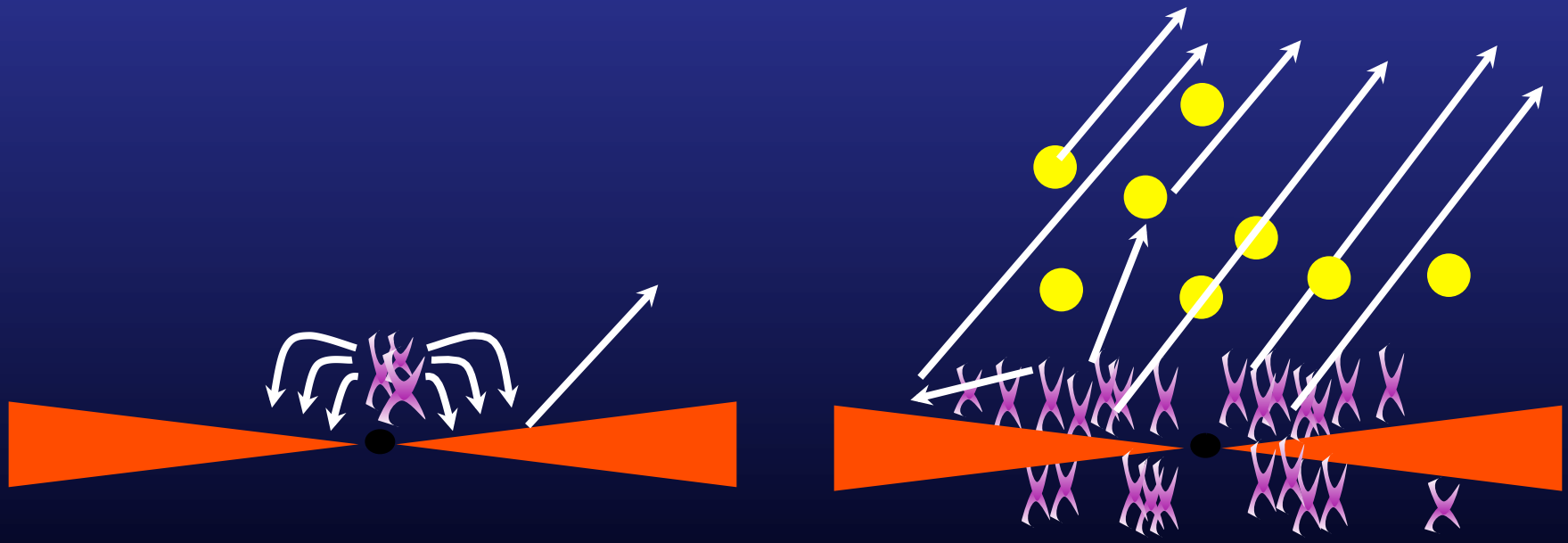
- Huge SX (similar size to softest 1H0707 spectra)
- And some of this IS the disc



Miller et al 2007 Middleton et al 2008

Alternative geometries for soft excess from partially ionised material

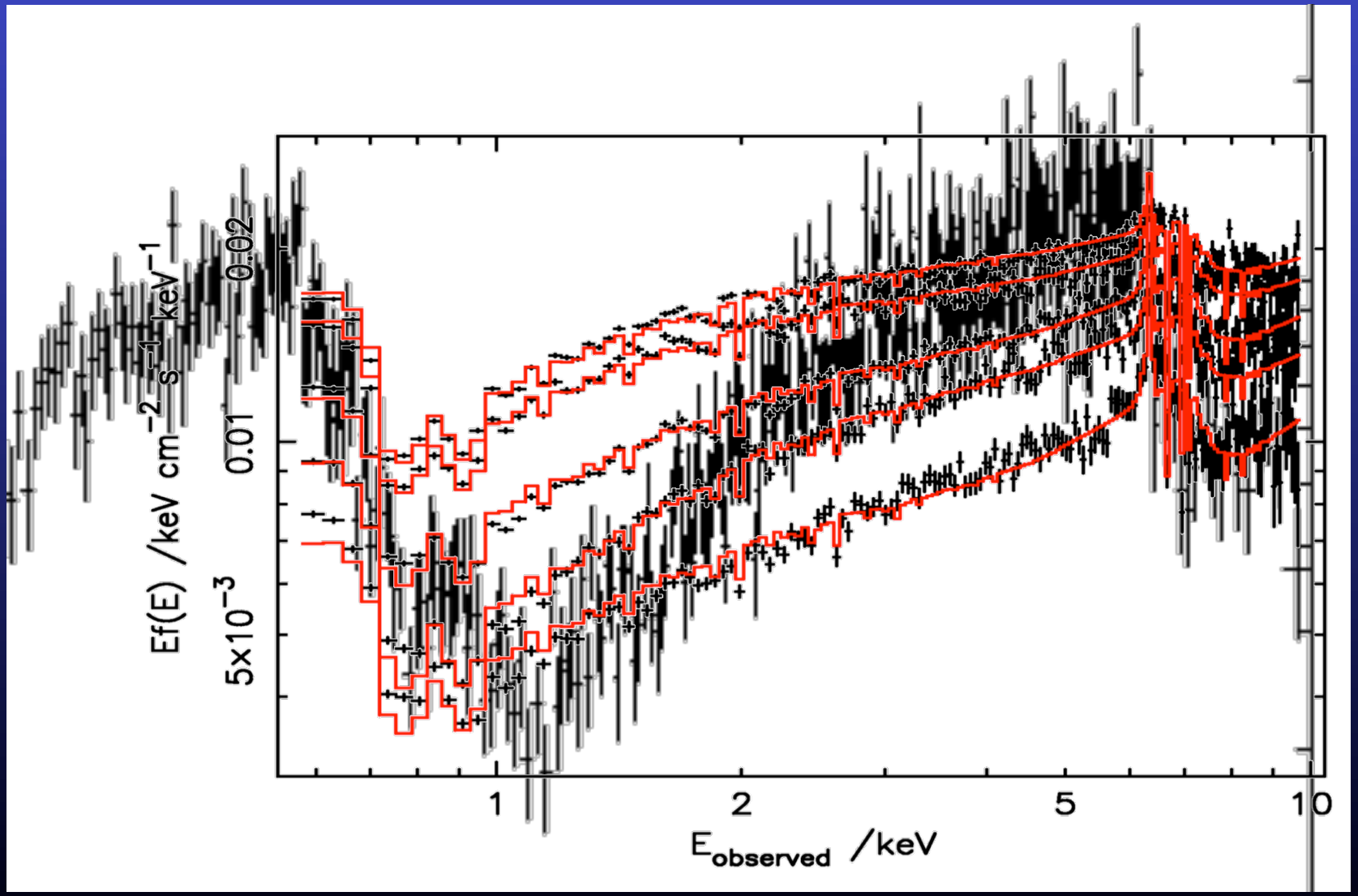
Fabian et al 2002, 2004, 2009 Miniutti & Fabian 2004, Done & Gierlinski 2004, Schurch & Done 2007, Miller, Turner et al 2007, 2008



Reflection

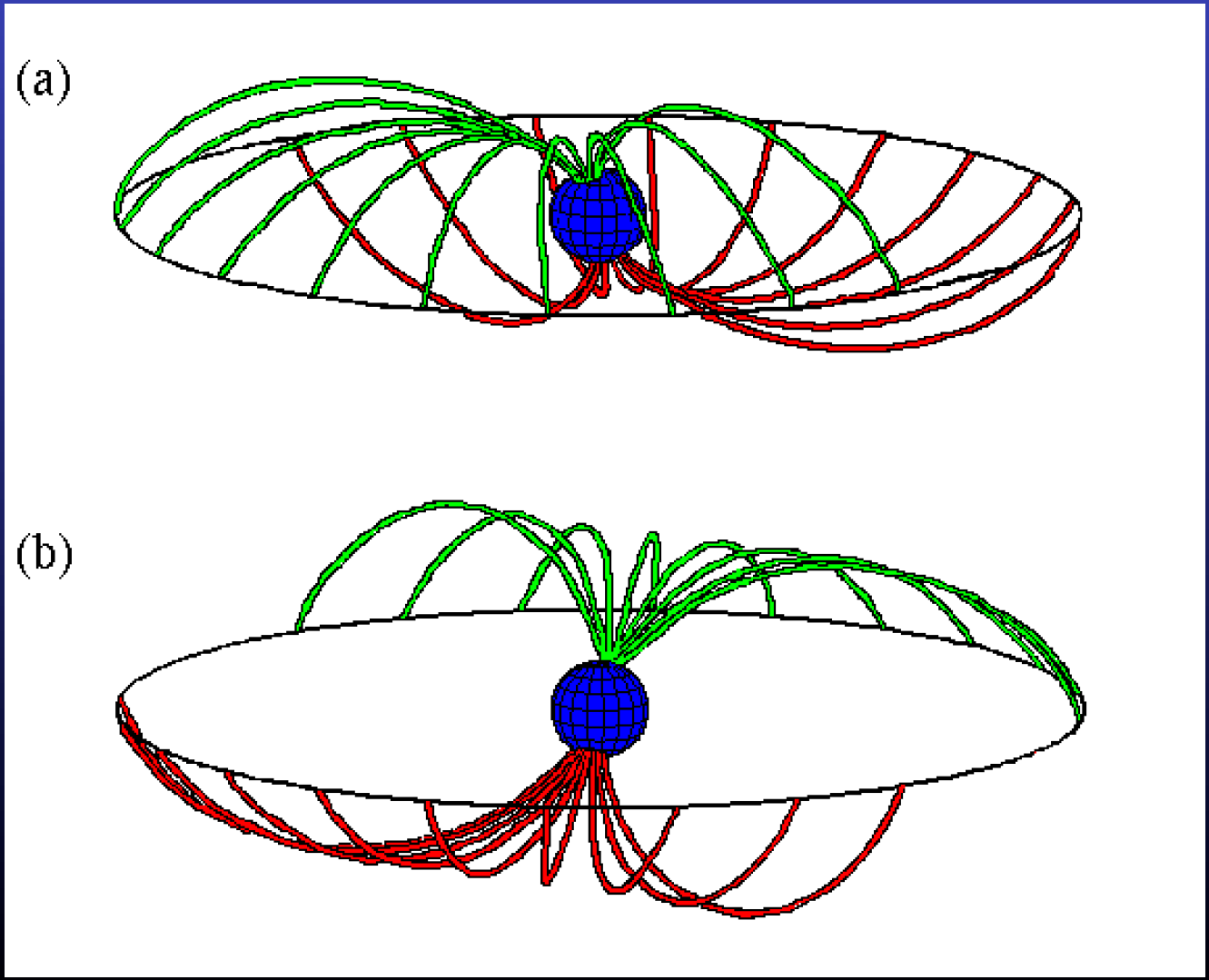
Absorption

And BAL QSOs…

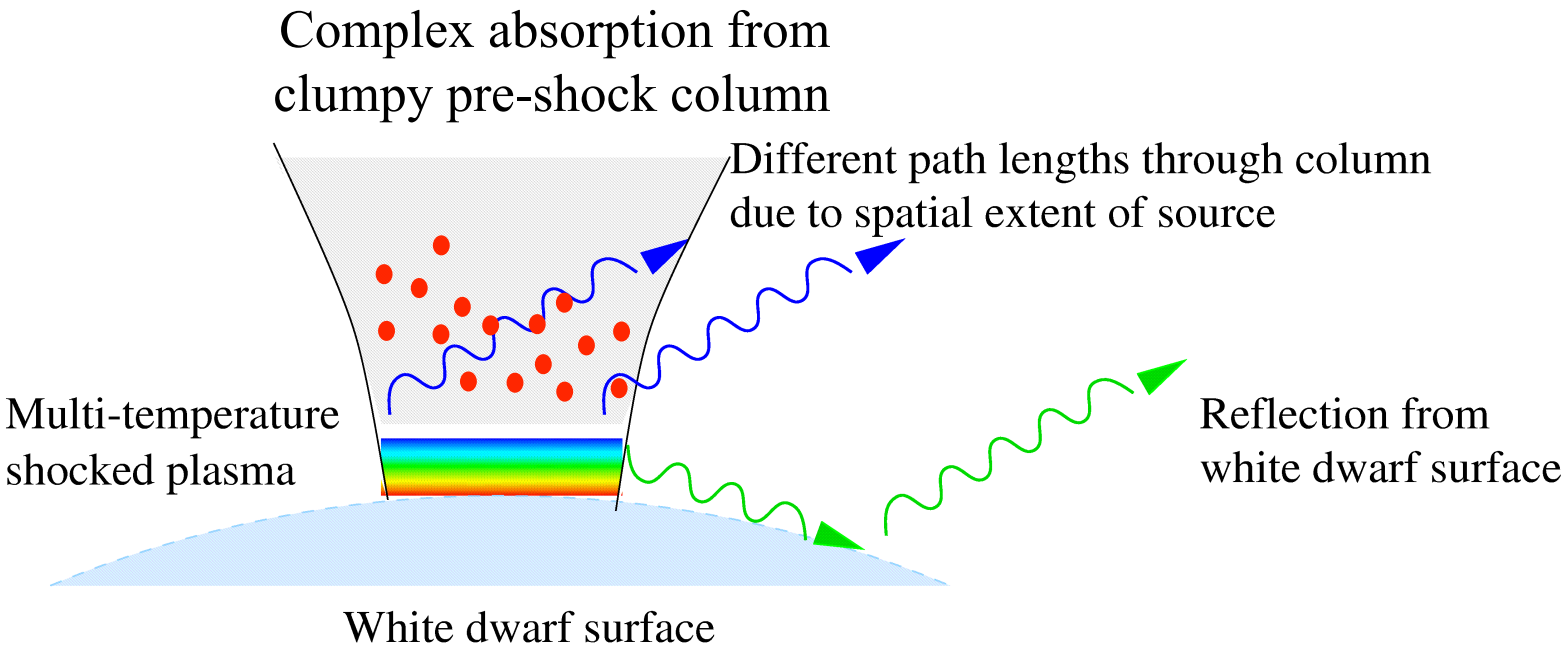


Miller et al 208 Guistini et al 2011

Disk and accretion curtain



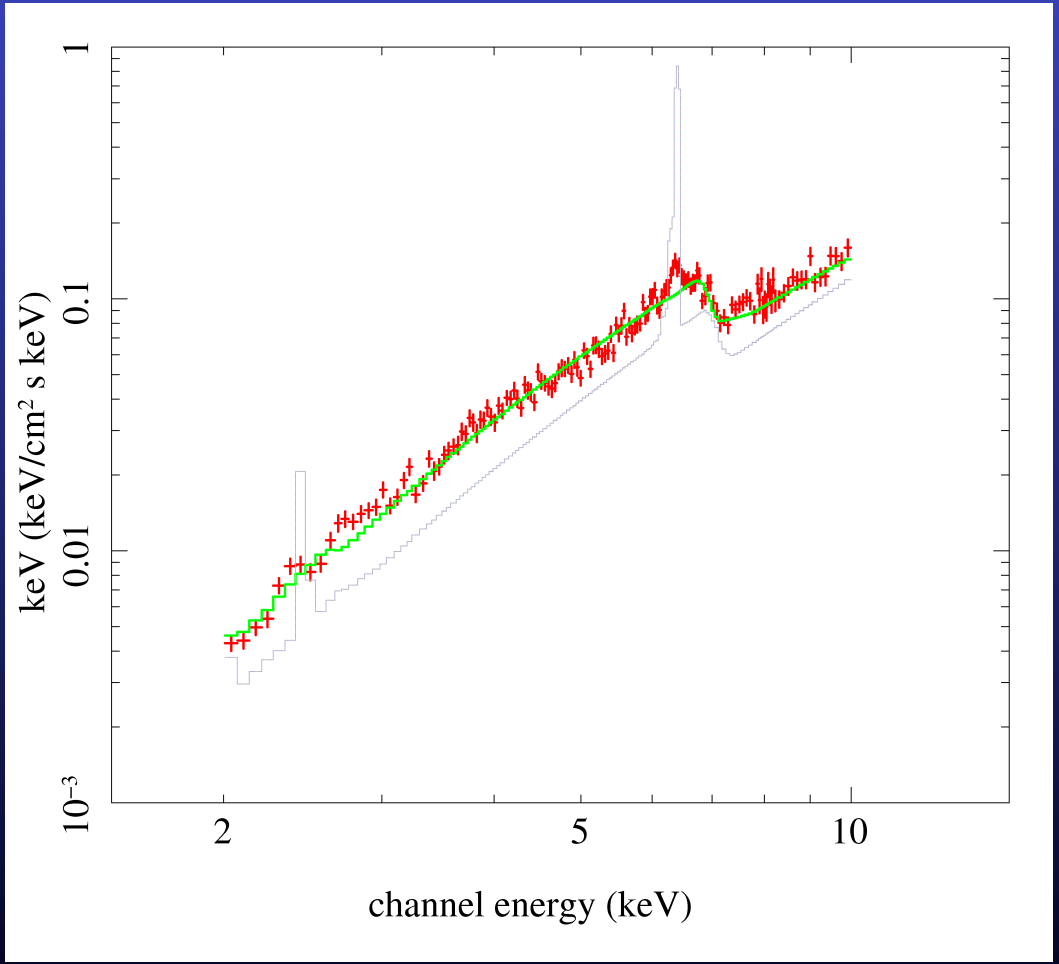
Accretion column



Magdziarz & Done 1999

Complex absorption

- GK Per Titarchuck et al 2009 – but some others look the same (V1223…
- Take best reflection models (reflion: Ross & Fabian), and convolve with laor profile for 1.9 power law as in AGN
- Rin=1.235 (<1.6) Rg
- i=37- 40 degrees
- Emissivity b=3.1±0.1

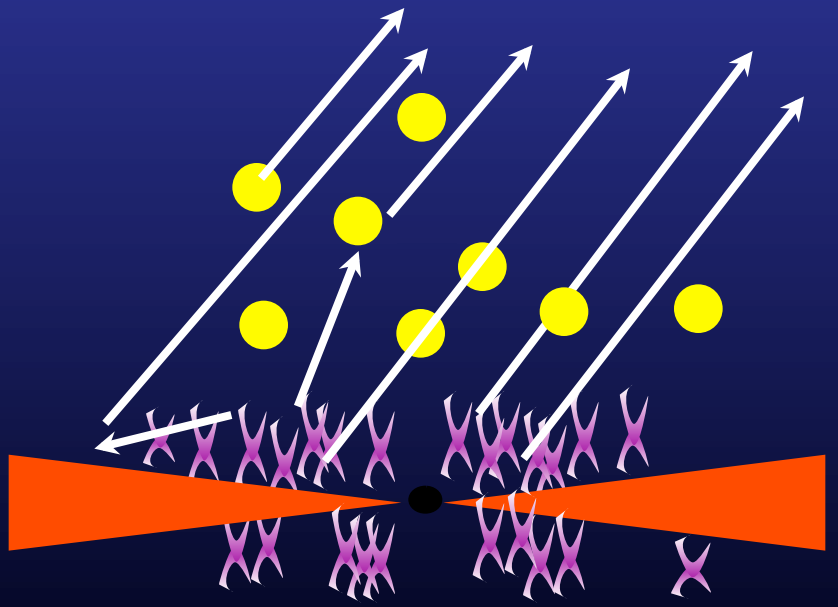


Alternative geometries for soft excess from partially ionised material

- Accretion geometry
- Scales with mass….
- But ionised reflection in BHB so more variability in AGN

- Wind in AGN not BHB
- Additional extrinsic variabilty in AGN

Reflection



Absorption

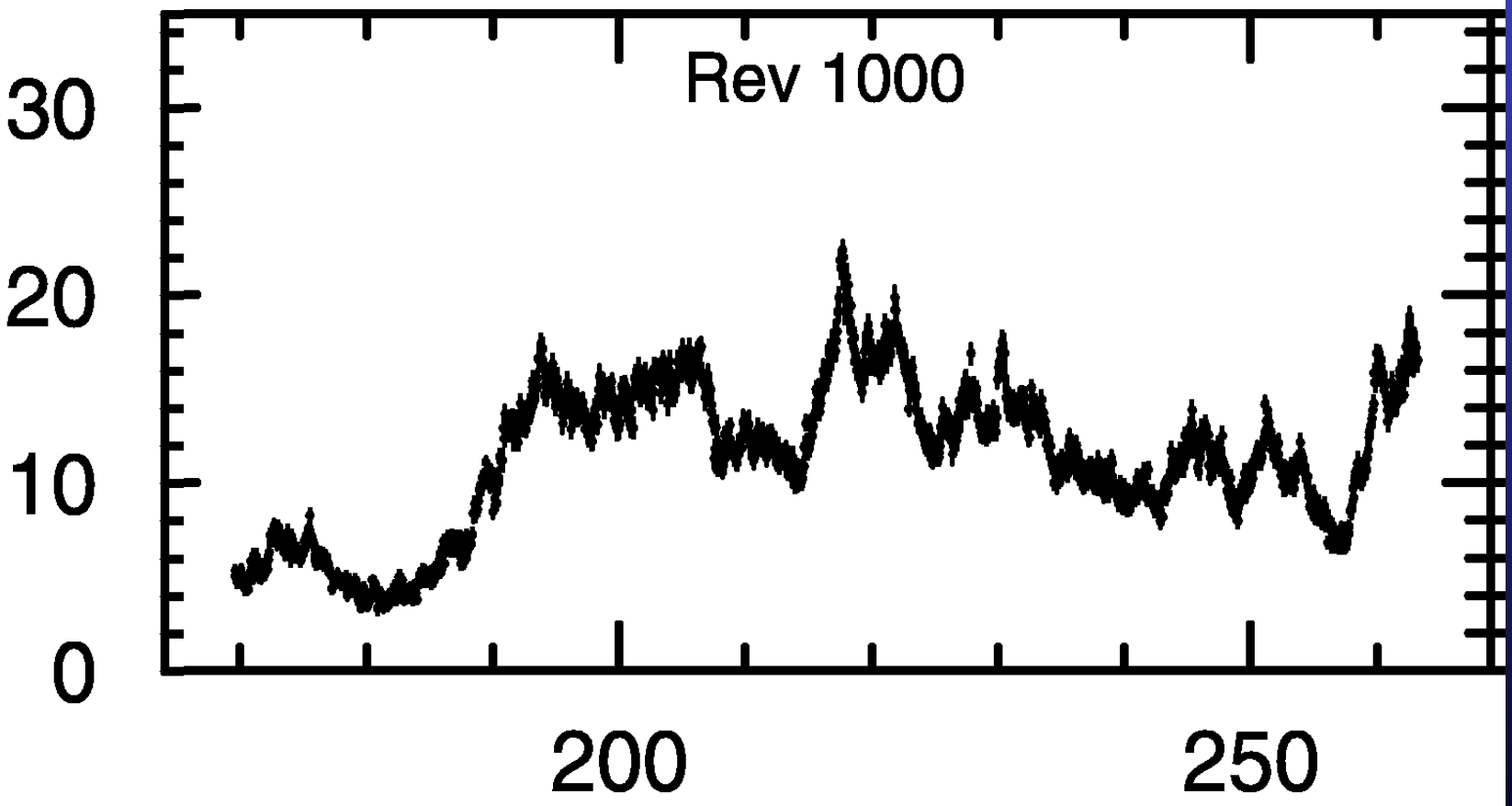
Alternative geometries for soft excess from partially ionised material

- Accretion geometry
- Scales with mass….
- But ionised reflection in BHB so more variability in AGN

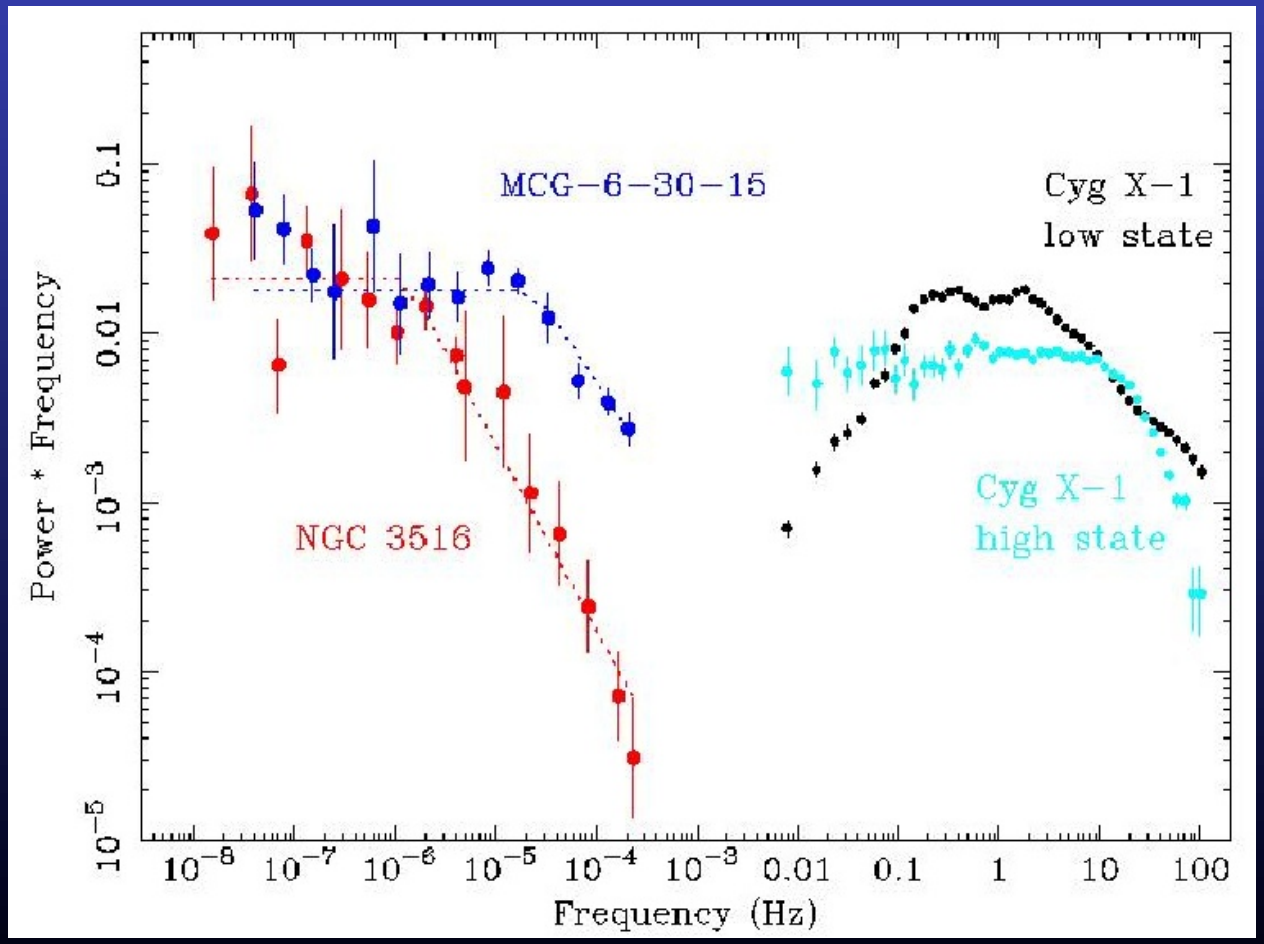
- Wind in AGN not BHB
- Additional extrinsic variabilty in AGN (Turner, Miller)

Reflection

AGN variability



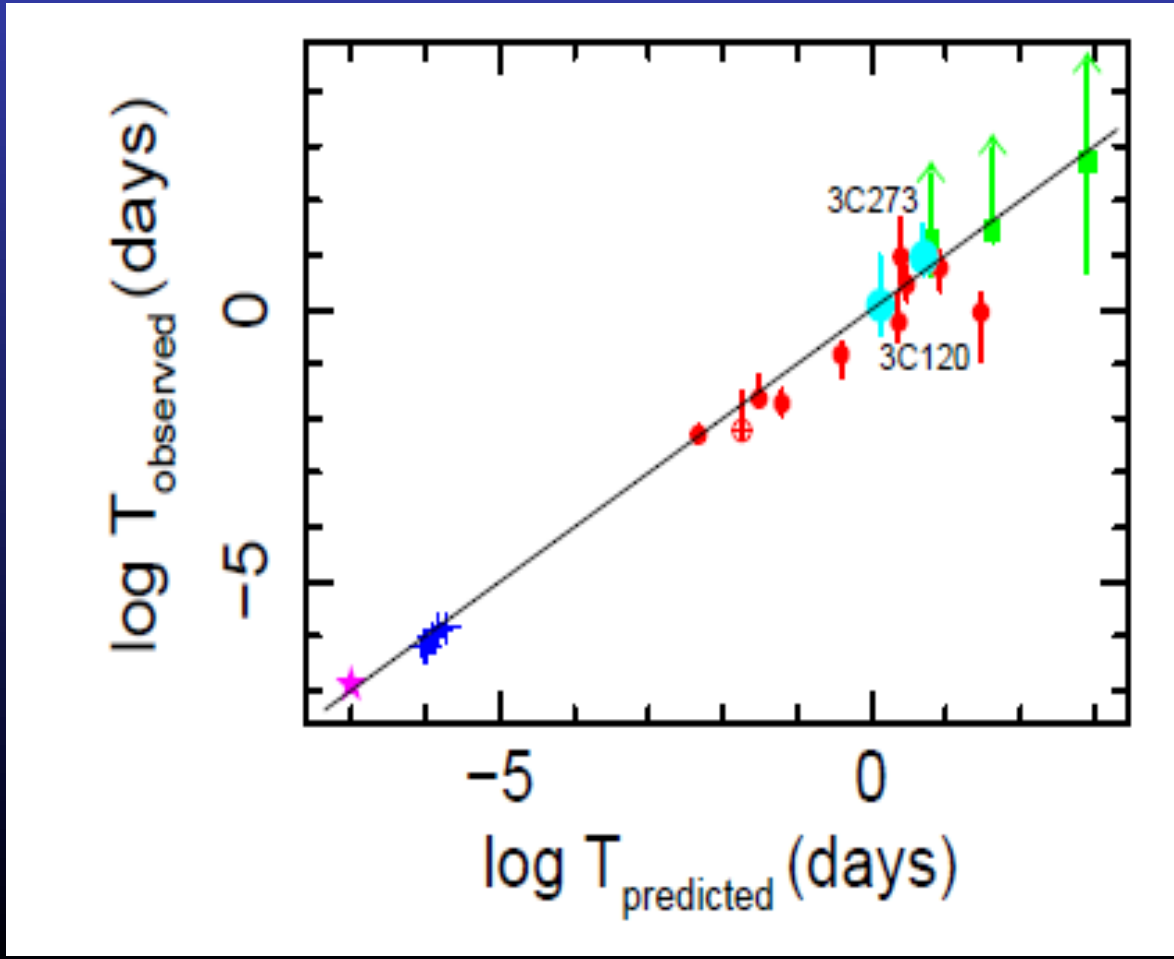
High frequency break in BHB and AGN – McHardy, Uttley…



High frequency break in AGN M and L/LEdd

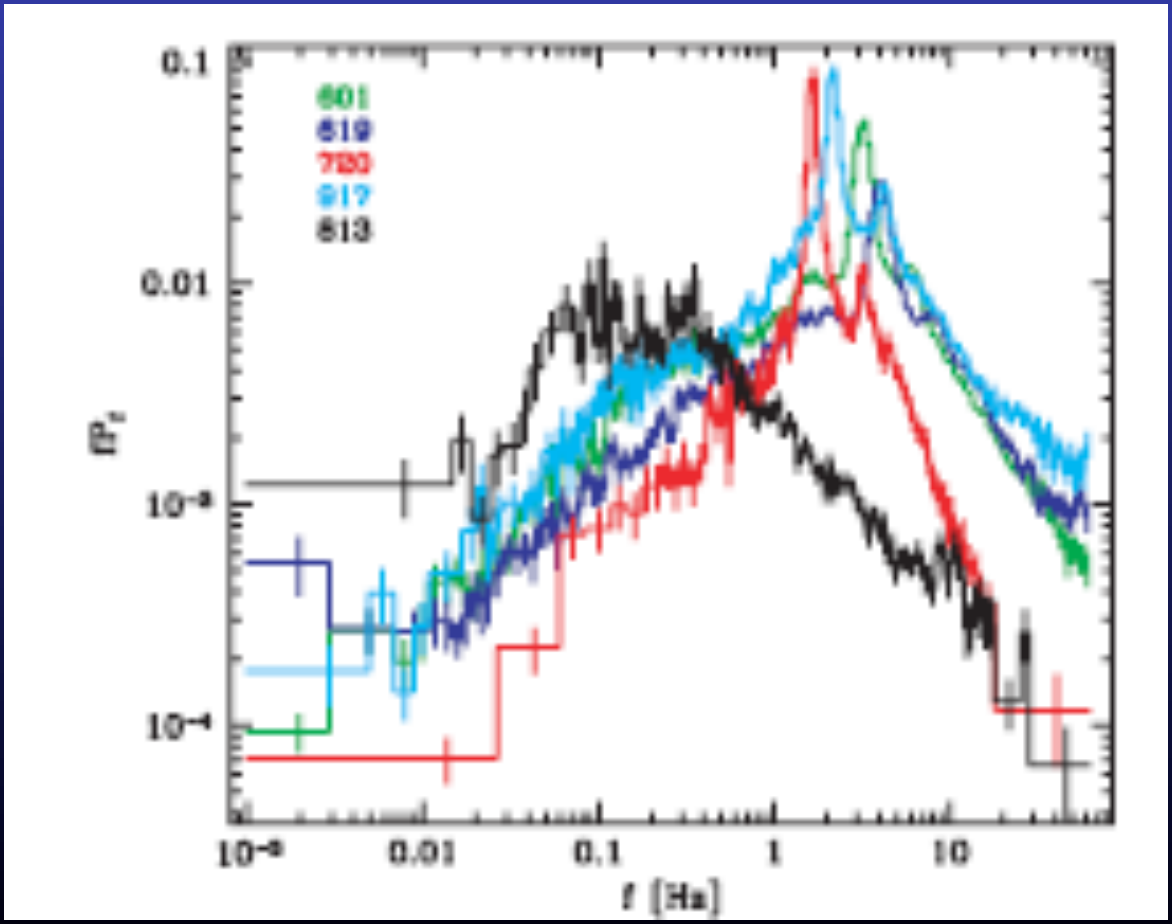
- 10 Hz in Cyg X-1 at ~0.02 LEdd
- So 100 Hz for standard QSO at 0.2 LEdd
- And 500 Hz for LEdd

McHardy et al 2006

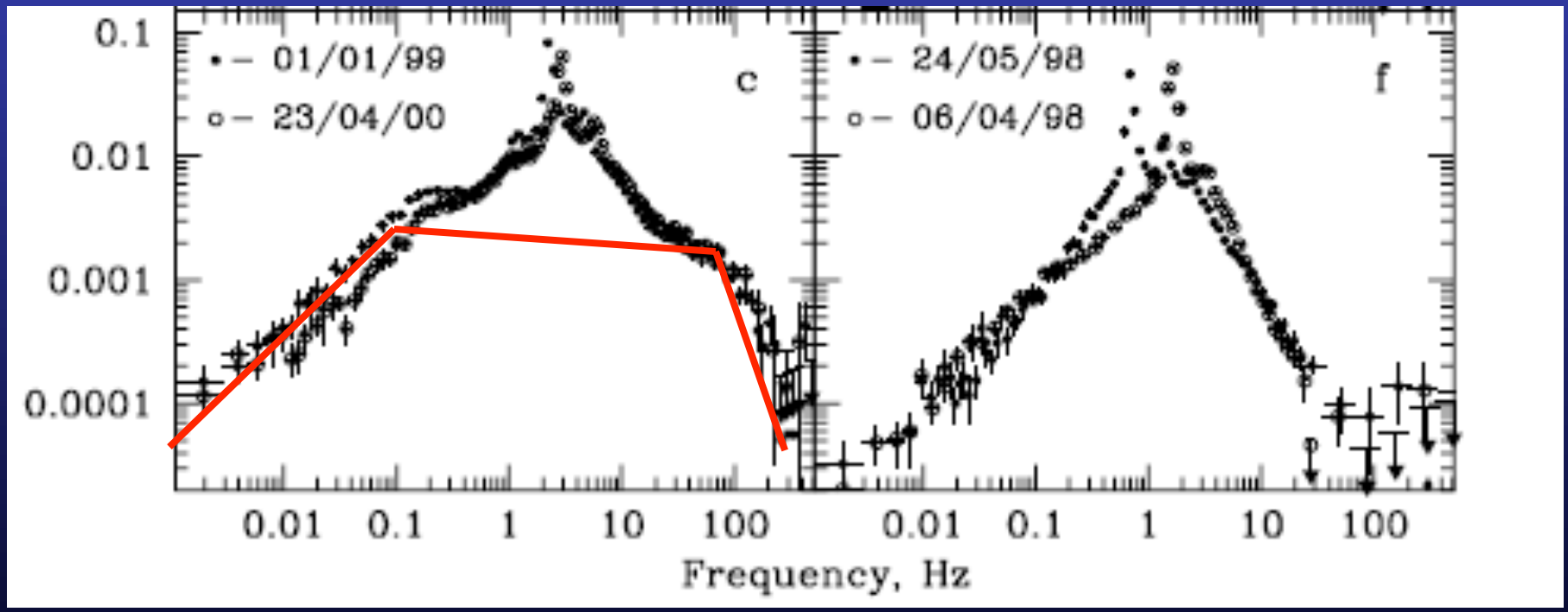


High frequency break in BHB at high L/L_{Edd} – GRS1915+105

- Similar to other very high states from XTE J1550-564, GX339-4
- But some of these are close to LEdd!



High frequency break in BHB at high L/L_{Edd} – GRS1915



Conclusions

- Low mass, high L/LEdd AGN like REJ1034 (QPO AGN) have discs which MUST extend into soft X-rays.
- Much of soft X-ray excess in NLS1 is the bare disc. Then need SMALL soft Comptonisation to get soft excess. Lsx/Lbol<<1
- Typical QSO has L/LEdd ~ 0.2, Lsx/Lbol~0.5 Γ(2-10)<2
- Not likely low/hard state
- Could be very high (steep power law state) if Γ(2-10) distorted by reflection/absorption which also makes SX
- BOTH of these have additional variability compared to BHB
  - Reflection – disc is partially ionised in AGN, completely ionised in BHB
  - Absorption from winds – present in AGN and not in BHB
- PDS of AGN should not quite scale with BHB....
- Winds WILL be present in UV bright AGN. So is the disc !