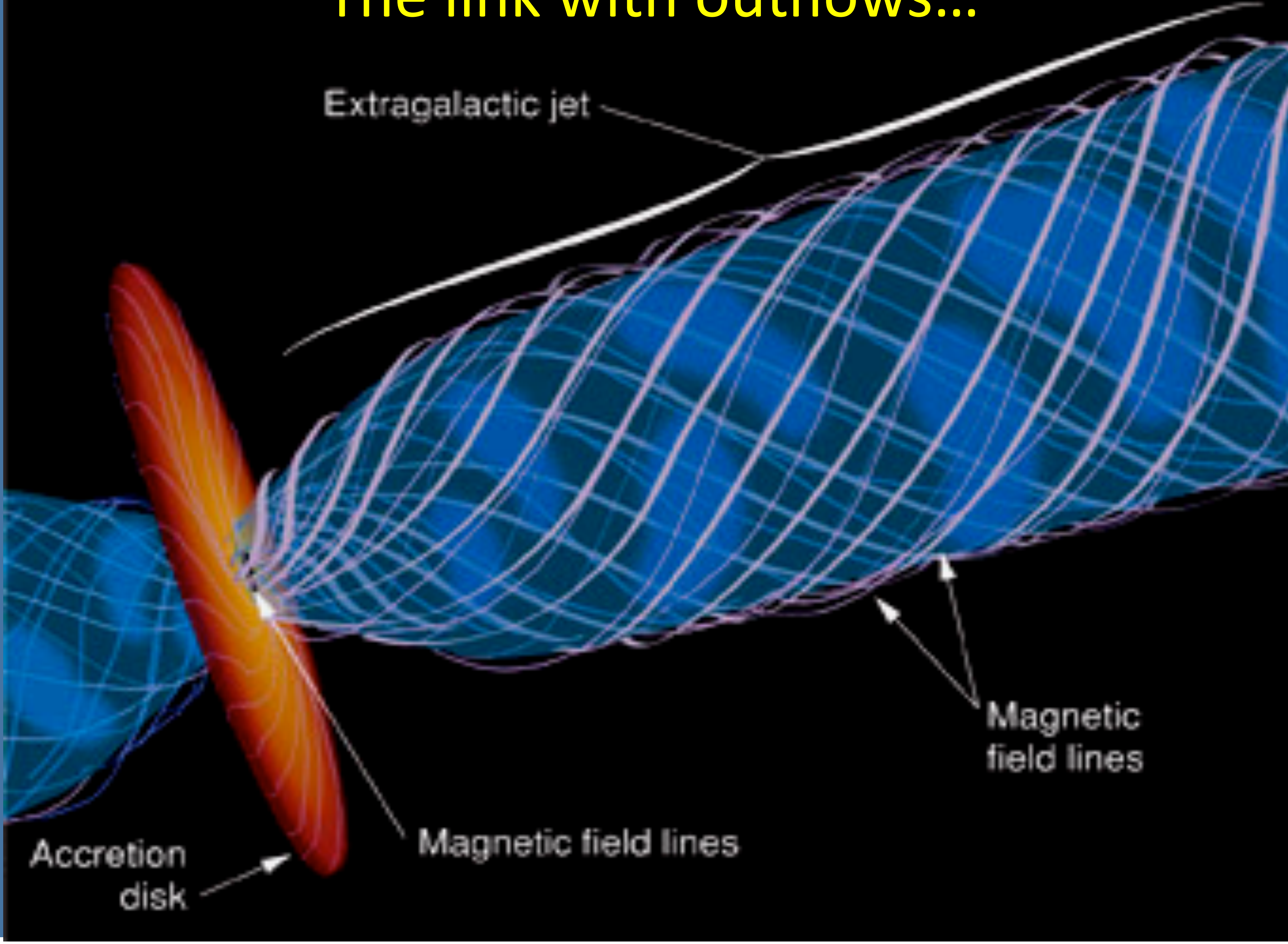
Martin Ward (Durham University, UK)

A new model of AGN X-ray to Opt. SEDs

together with Chris Done and Chichuan Jin

The link with outflows…



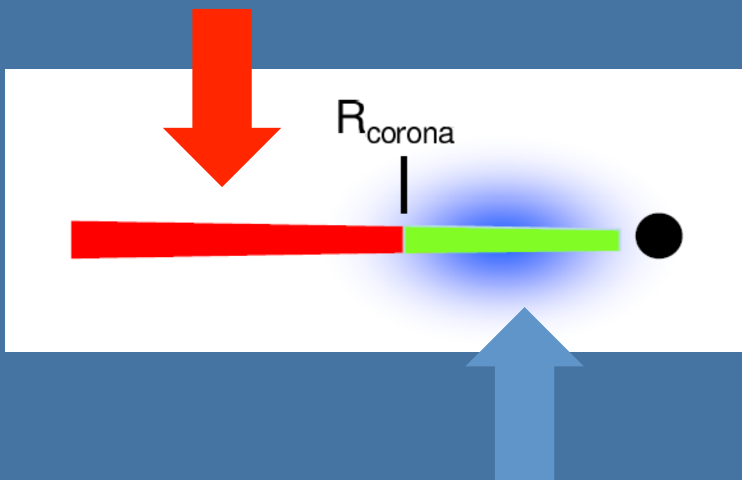
The AGN Sample
2XMMi - SDSS DR7 Cross-correlation

- A total of 51 Type 1 AGNs satisfying the following criteria:
- 1. high quality XMM & SDSS optical spectra
- 2. redshift < 0.4 (so that Hα covered for classification, and Balmer line component fits)
- 3. >2000 counts in at least one XMM-Newton EPIC camera (pn, MOS1, MOS2)
- 4. Fit error 2-10keV spectral index ($\Gamma_{2\text{-}10keV}$) ≤ 0.25
- 5. low dust reddening, no strong X-ray absorption features i.e. we see the *intrinsic spectrum*

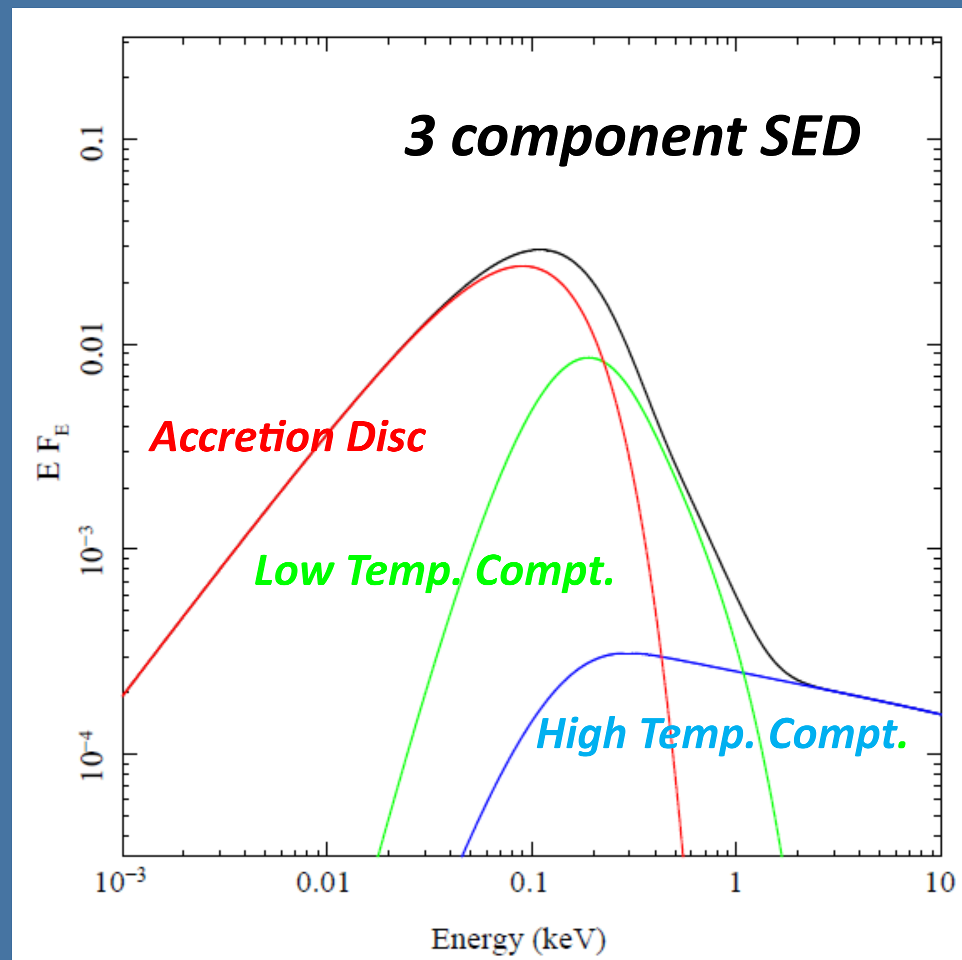
Broadband SED Model

Xspec: optxagn (Done et al. 2011, MNRAS in press)

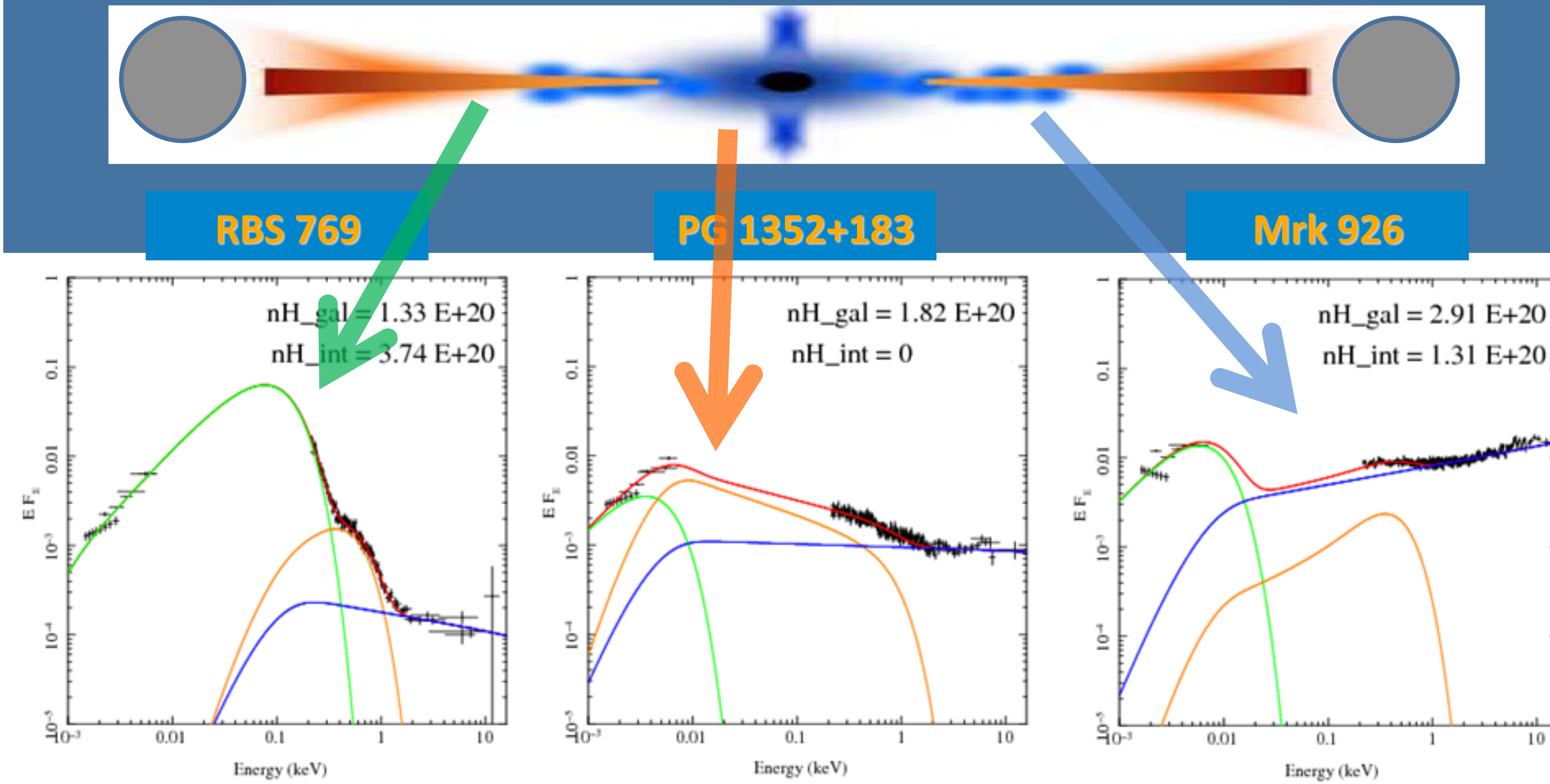
Above *R_corona* exists a standard multi temp. SS accretion disc



Below *R_corona*: disc photons are Compton up-scattered to higher energies by two hot electron populations (energy is conserved)

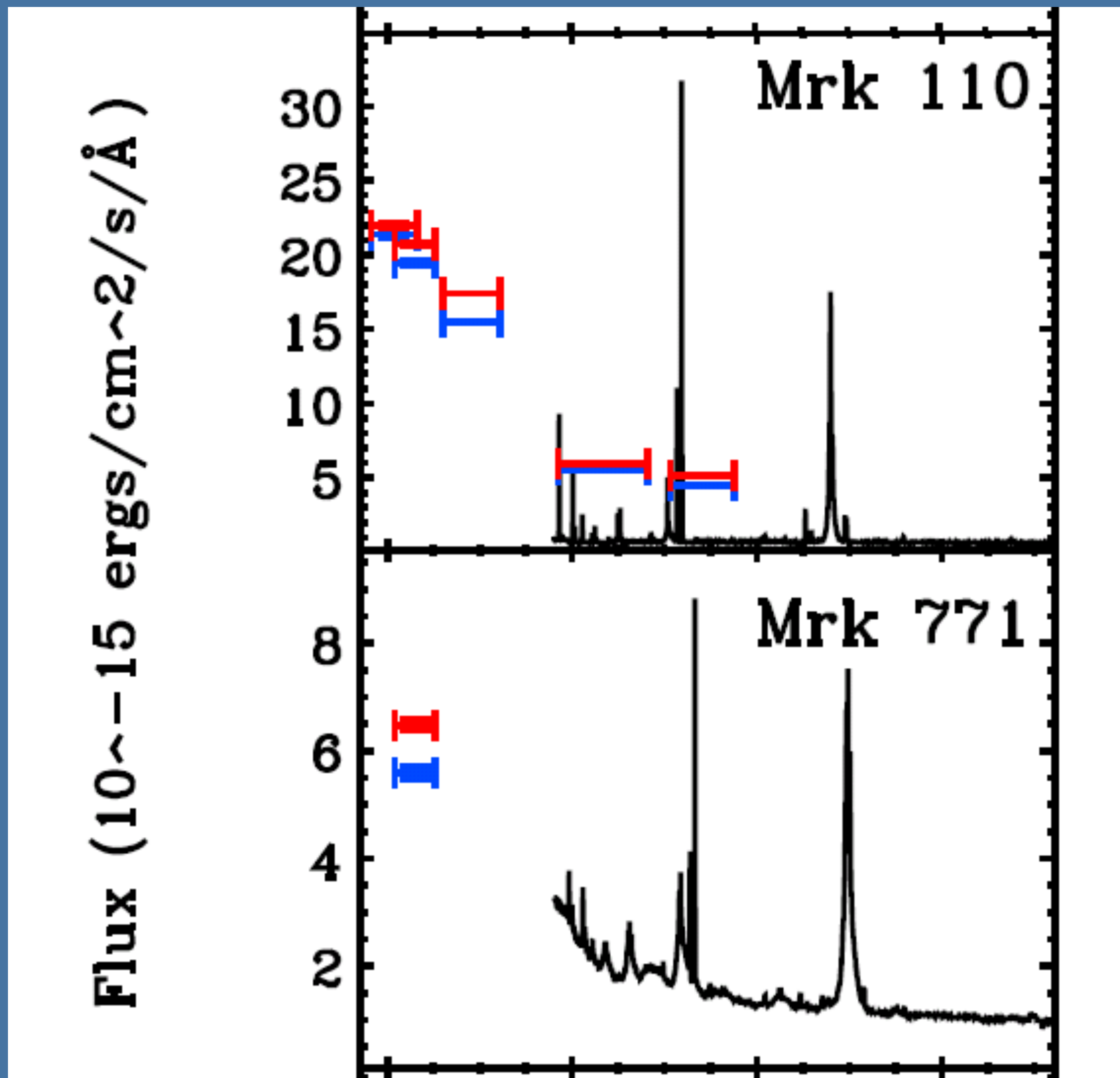


Broadband SED Model

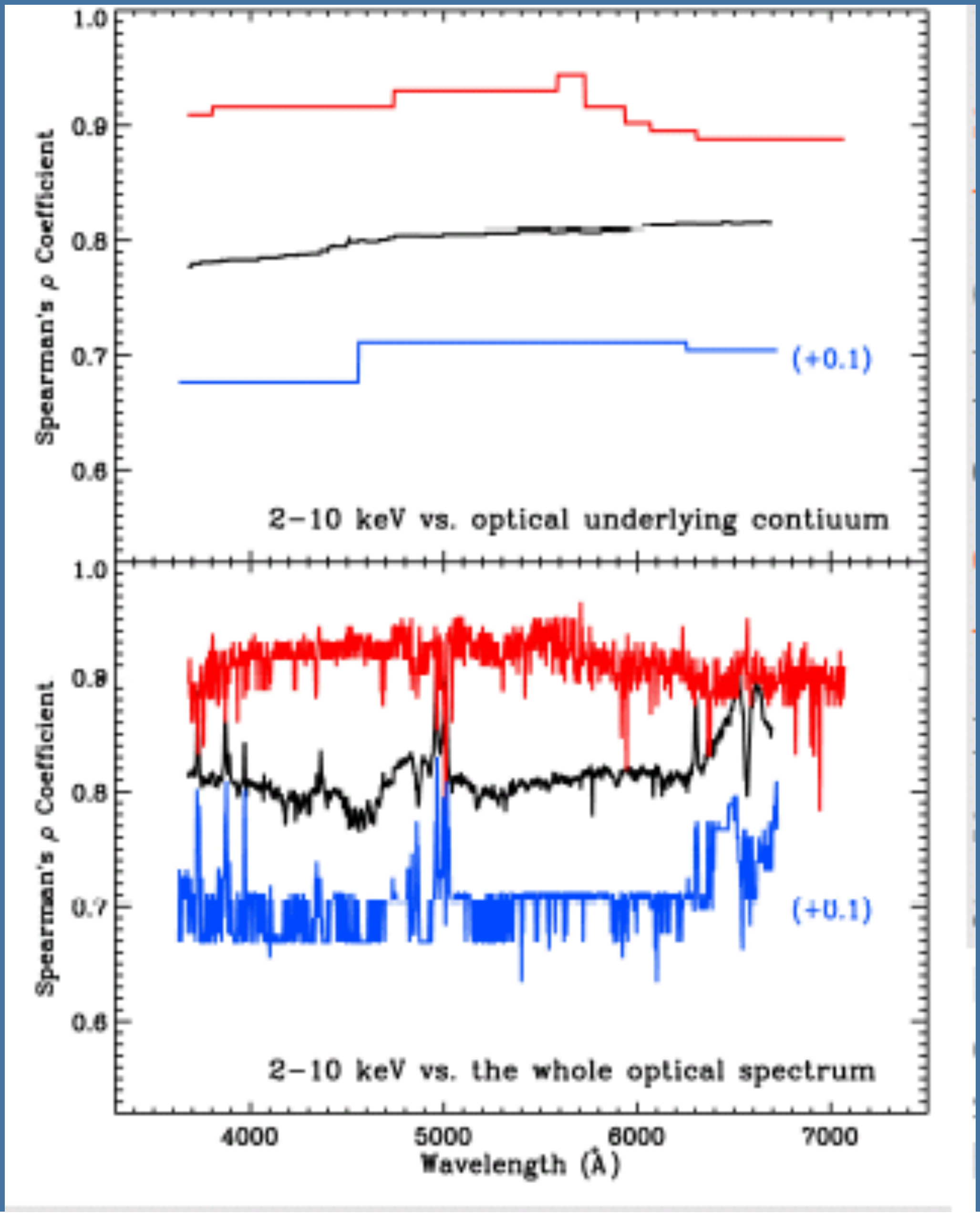


Xspec Model: optxagn (Done et al. 2011)

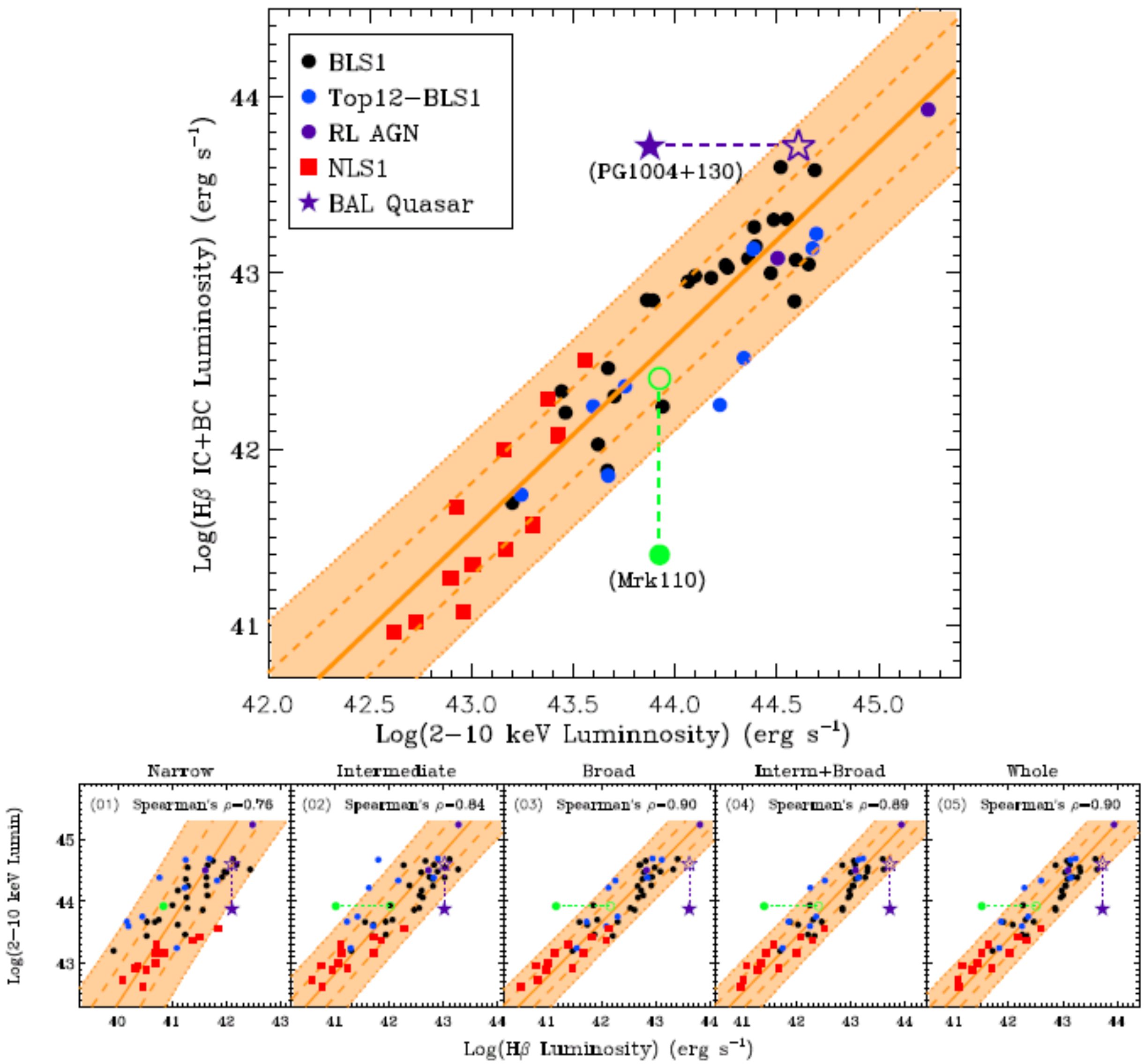
Variability: the case of the high Edd. AGN MKN110



Auto- correlation Spectrum for X-ray vs. SDSS



H Beta vs Hard X-ray Component



[OIII] line two components 1) classic NLR and 2) broad blue shifted (outflow)

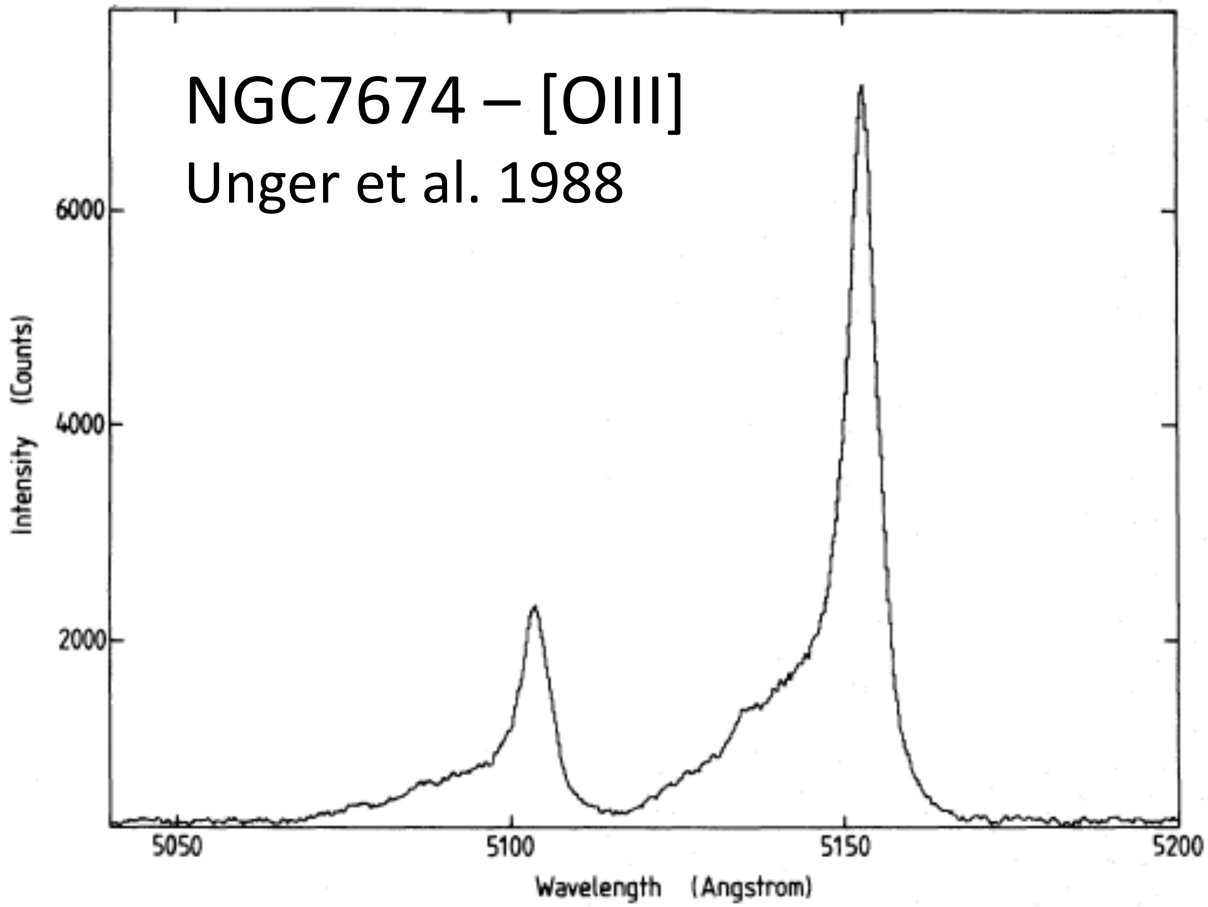
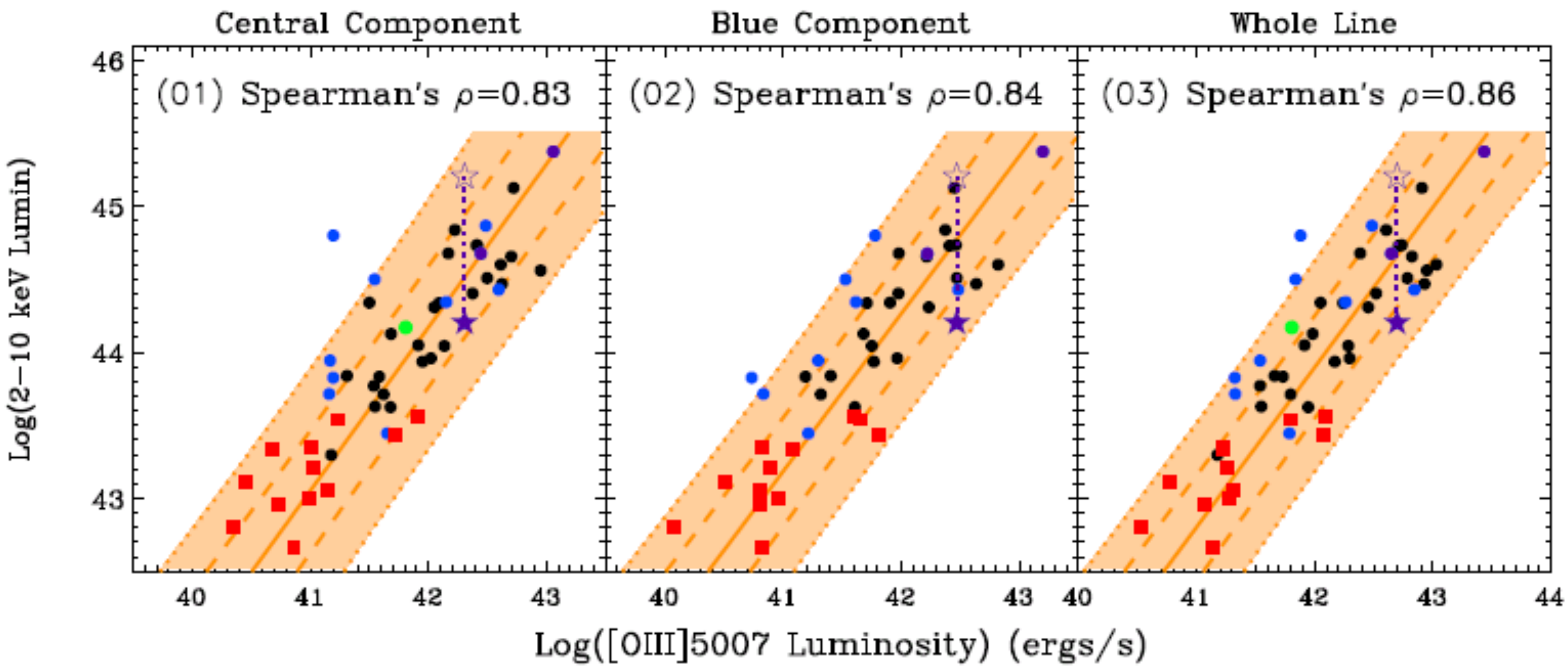


Figure 4. Line profile of the high-excitation nuclear gas, obtained by adding together all the IPCS spectra at [O III] λ4959, 5007 listed in Table 1, after applying a heliocentric correction. Both lines of the [O III] doublet are shown since they merge into one another.

[OIII] versus hard X-ray Component

A Spectral Study of Unobscured Type 1 AGN - II. Optical and X-ray Correlations 15



BCS for [OIII] luminosity versus X-ray Energy

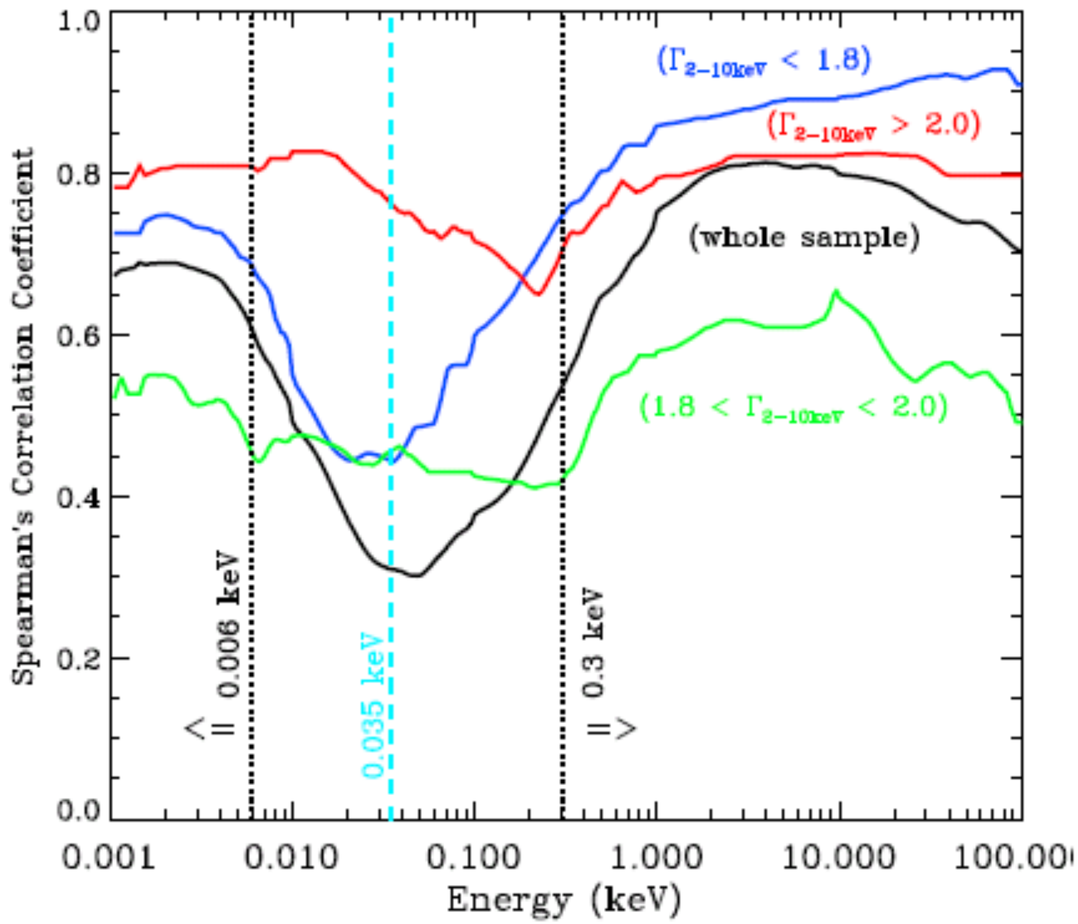
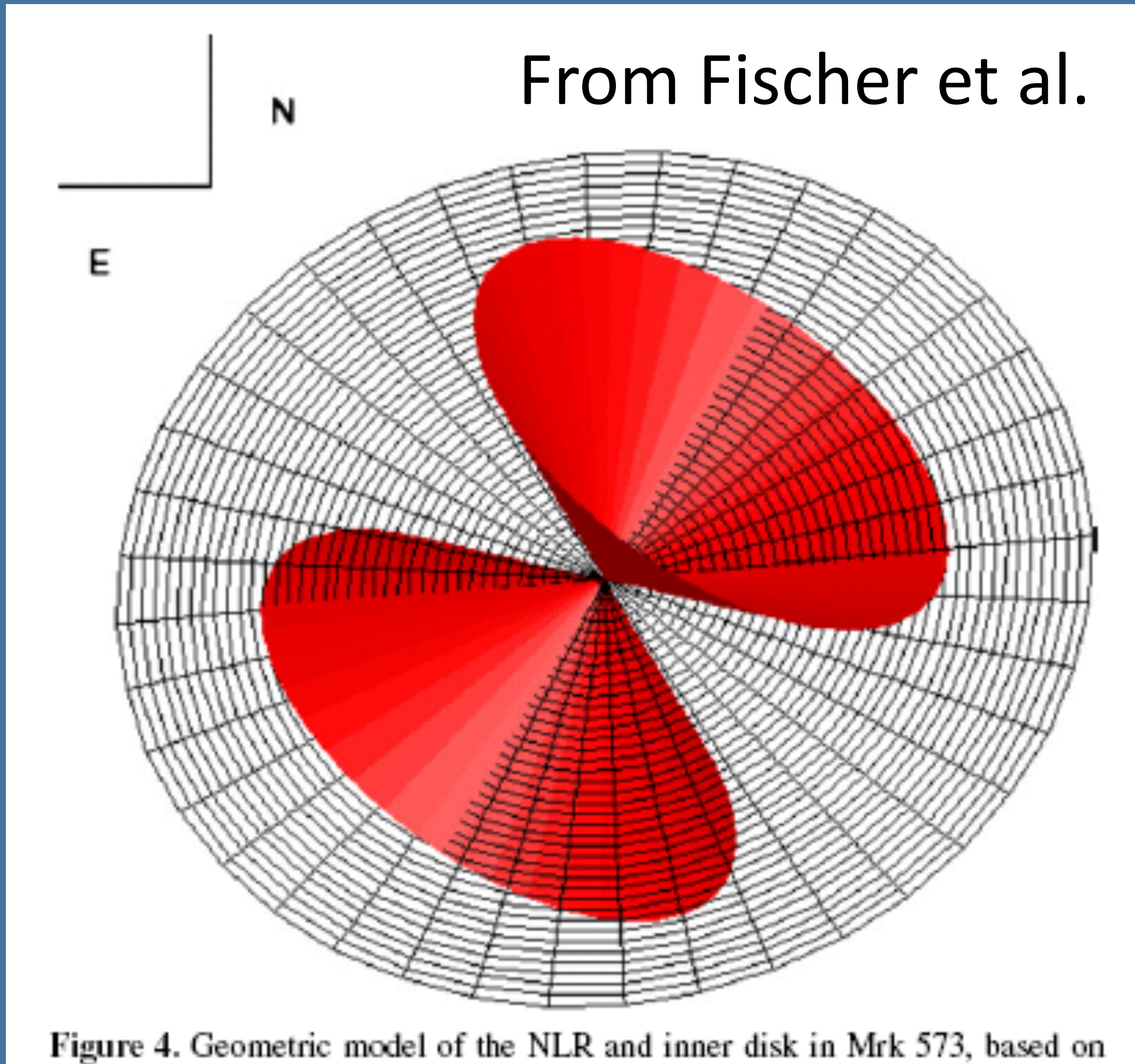


Figure 12. The 'Broadband Correlation Spectrum (BCS)' for [OIII] λ5007 luminosity. This is produced by calculating the Spearman's rank coefficient between the [OIII] λ5007 luminosity and the luminosity contained in each energy bin of broadband SED, thus the highest point shows the best correlation in that energy bin. Lines of different color show the BCS of different subsets as been labelled in the plot. The $\Gamma_{2-10keV} \geqslant 2.0$ subset (S1) contains 16 AGNs; the $\Gamma_{2-10keV} \leqslant 1.8$ subset contains (S2) 18 AGNs; the $1.8 < \Gamma_{2-10keV} < 2.0$ subset (S3) contains 16 AGNs. Only spectral ranges bellow 0.006 keV and above 0.3 keV have observational data. The ionizing flux responsible for [OIII] λ5007 emission is above 0.035 keV.

Correlation between [OIII] line and X-ray Components

		SED Component Luminosity										2-10 keV Energy Band					
		Disc		Compton		Power law		Com+Pow		Bolometric		$\Gamma_{2-10keV}$		Lumin		$frac_{2-10keV}$	
		ρ_s	d_s	ρ_s	d_s	ρ_s	d_s	ρ_s	d_s	ρ_s	d_s	ρ_s	d_s	ρ_s	d_s	ρ_s	d_s
[OIII]5007	Centre	0.48	-3	0.48	-3	0.74	-9	0.67	-7	0.64	-6	-0.31	-2	0.83	-13	0.37	-2
Lumin	Blue	0.49	-4	0.44	-3	0.63	-6	0.59	-5	0.64	-6	0.05	0	0.61	-6	0.11	0
	Whole	0.53	-4	0.53	-4	0.79	-11	0.72	-9	0.71	-8	-0.24	-1	0.86	-15	0.33	-2
[OIII]5007	Centre	-0.13	0	-0.09	0	0.04	0	-0.03	0	-0.12	0	-0.35	-2	0.18	0	0.38	-2
EW	Blue	0.07	0	0.09	0	0.17	0	0.15	0	0.13	0	0.09	0	0.15	0	0.11	0
	Whole	-0.06	0	-0.03	0	0.11	0	0.03	0	-0.04	0	-0.27	-1	0.22	0	0.34	-2

Why is [OIII]5007 so well correlated with the X-ray 2-10 keV component?



SED Parameter Correlations

- We conducted a systematic correlation study of the following 9 key SED parameters:

  $\Gamma_{2-10keV}$, $\kappa_{2-10keV}$, $\kappa_{5100Å}$, λ_{Edd}, Hβ FWHM, M_{BH}, α_{ox}, L_{bol} and $L_{2-10keV}$
- First we study correlations in various parameter spaces
- Then we produce correlation matrices and perform principal component analysis (PCA)

Correlations are widely found among these 9 SED parameters:

$\Gamma_{2-10keV}$, $\kappa_{2-10keV}$, $\kappa_{5100Å}$, λ_{Edd}, Hβ FWHM, M_{BH}, α_{ox}, L_{bol}, $L_{2-10keV}$

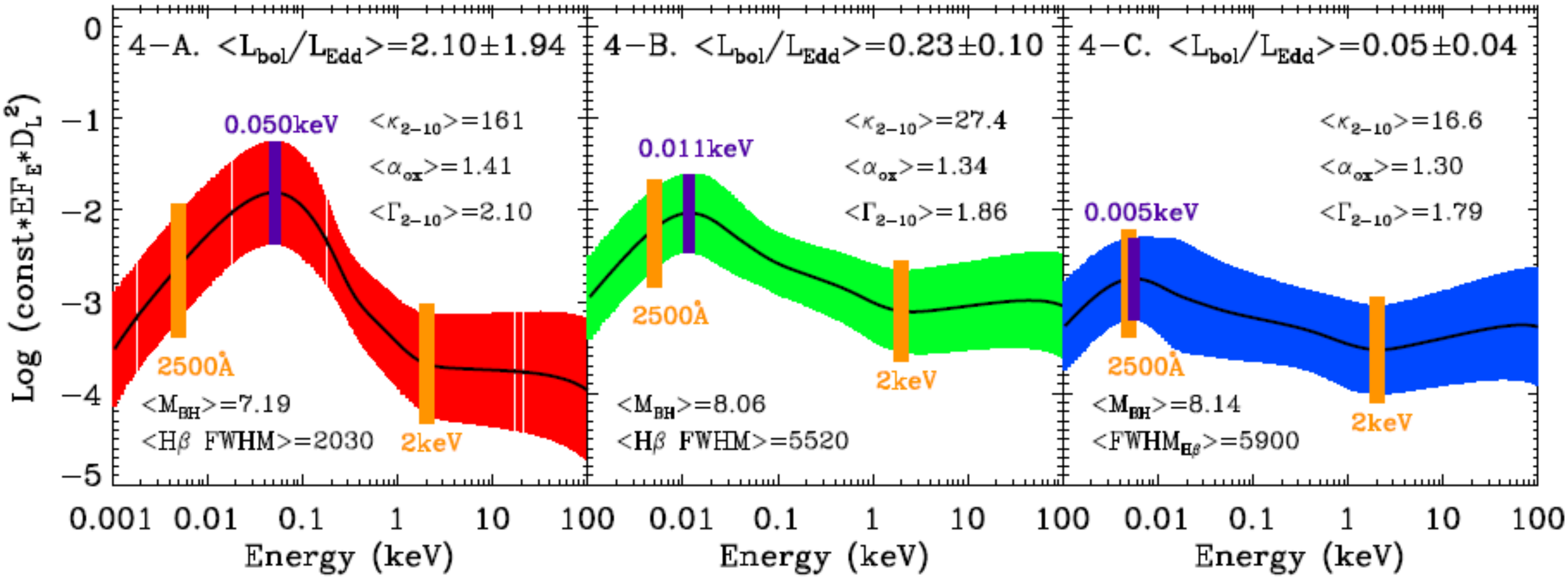
Question: which of these parameters are the most important in driving these correlations?

Mean SEDs for sub-sets of sample

- According to each of the 9 parameters, we divide the whole sample (51 AGNs) into three subsets, so each subset contains 16~17 AGNs
- The mean SED is calculated for each of the three subsets

Various Mean SEDs

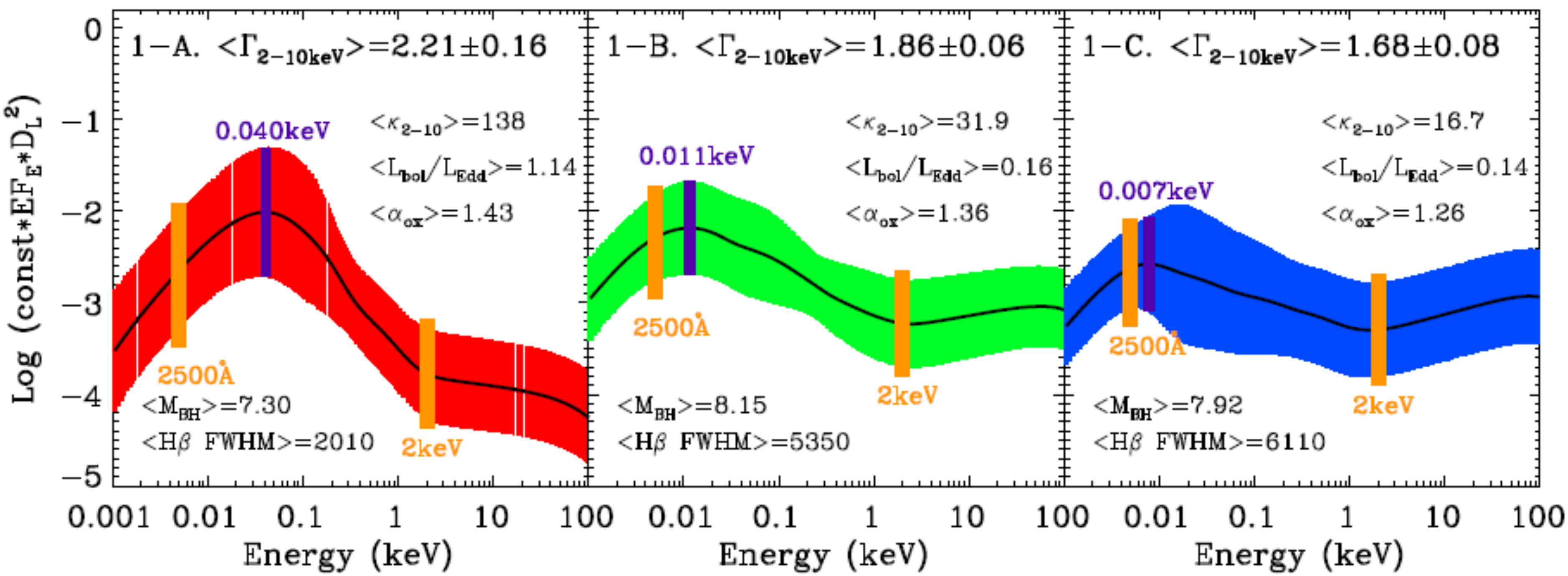
Mean SEDs Based on λ_{Edd}



Jin et al. (2011) in prep.

Various AGN Mean SEDs

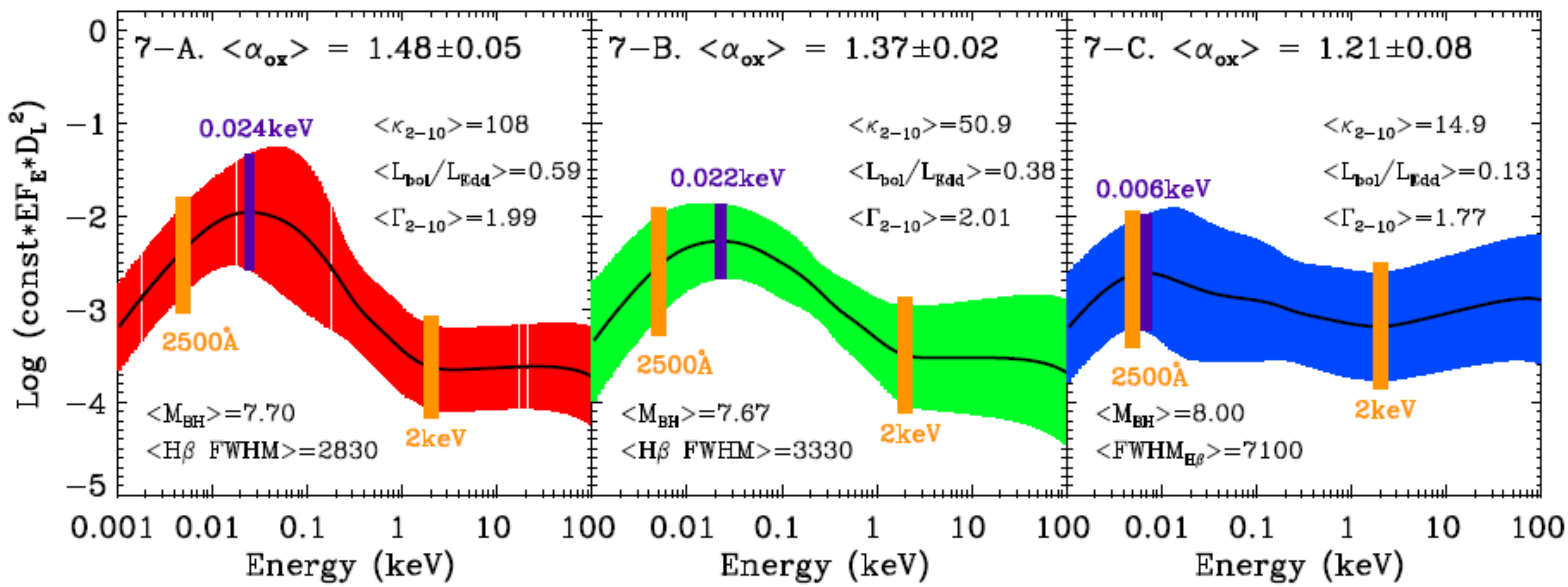
Mean SEDs Based on $\Gamma_{2\text{-}10keV}$



Jin et al. (2011c) in prep.

Various AGN Mean SEDs

Mean SEDs Based on α_{ox}



Jin et al. (2011c) in prep.

SED shape differences are found for each of the 9 parameters

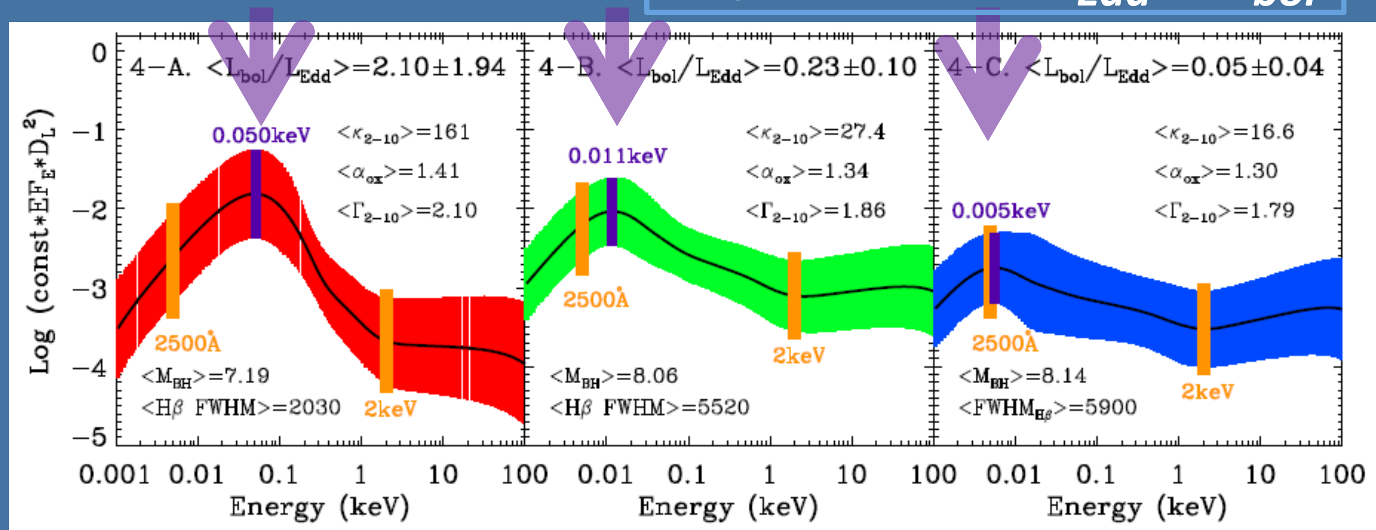
Question: which parameter is the best indicator of the SED?

The Best SED Shape Indicator

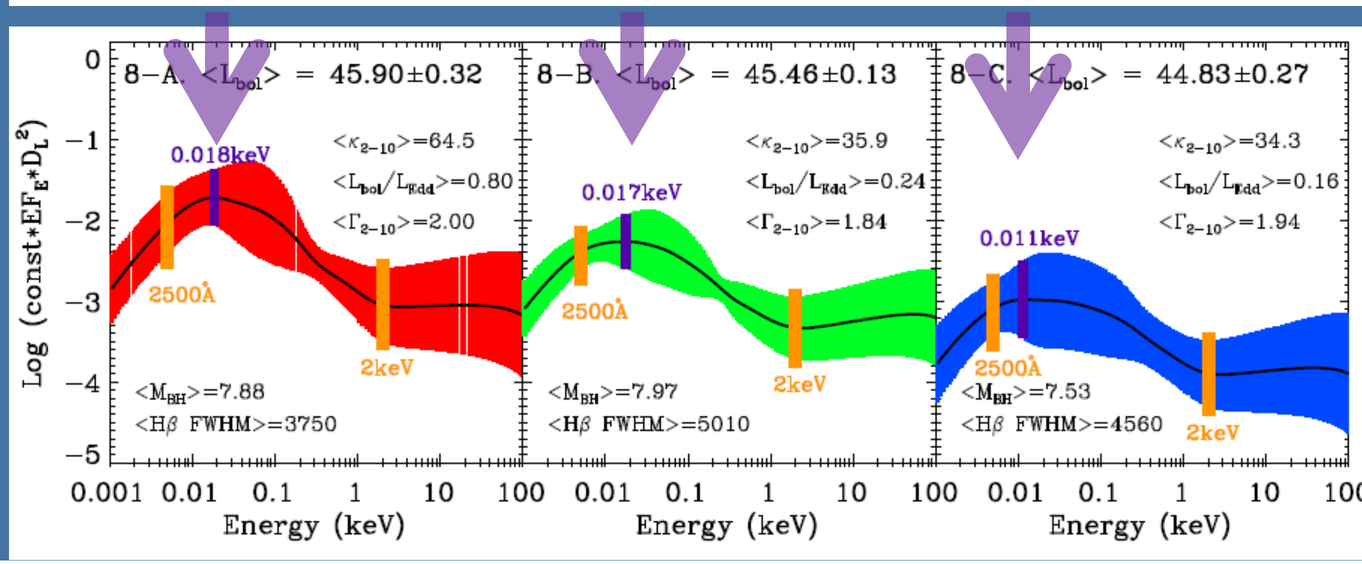
- **Difference in Peak Energy**

Difference: λ_{Edd} > L_{bol}

λ_{Edd}



L_{bol}

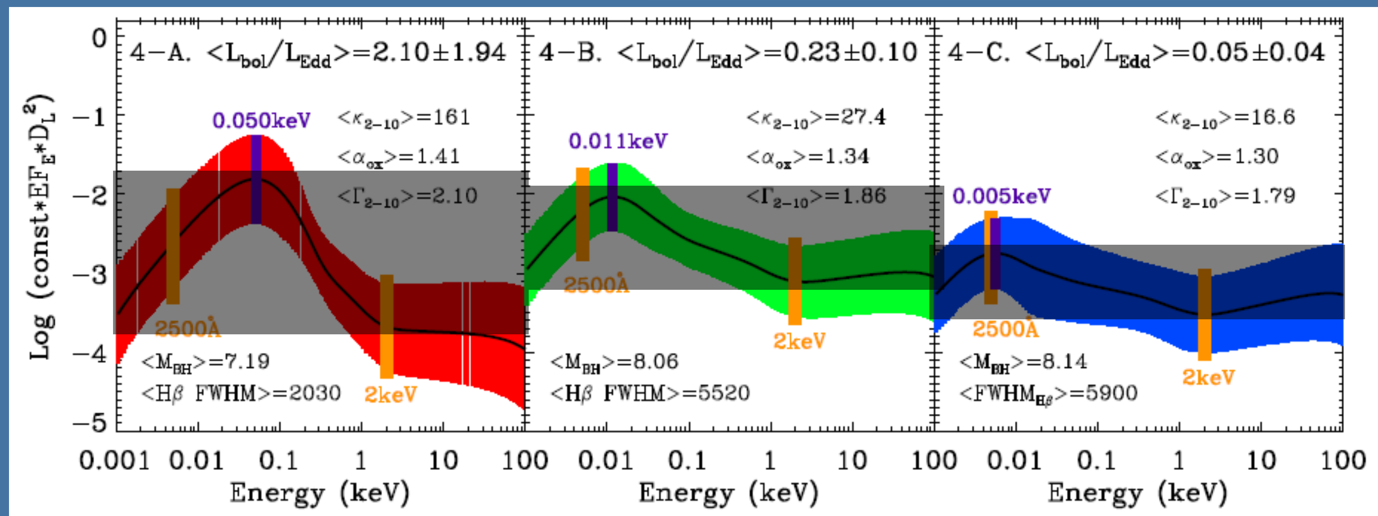


The Best SED Shape Indicator

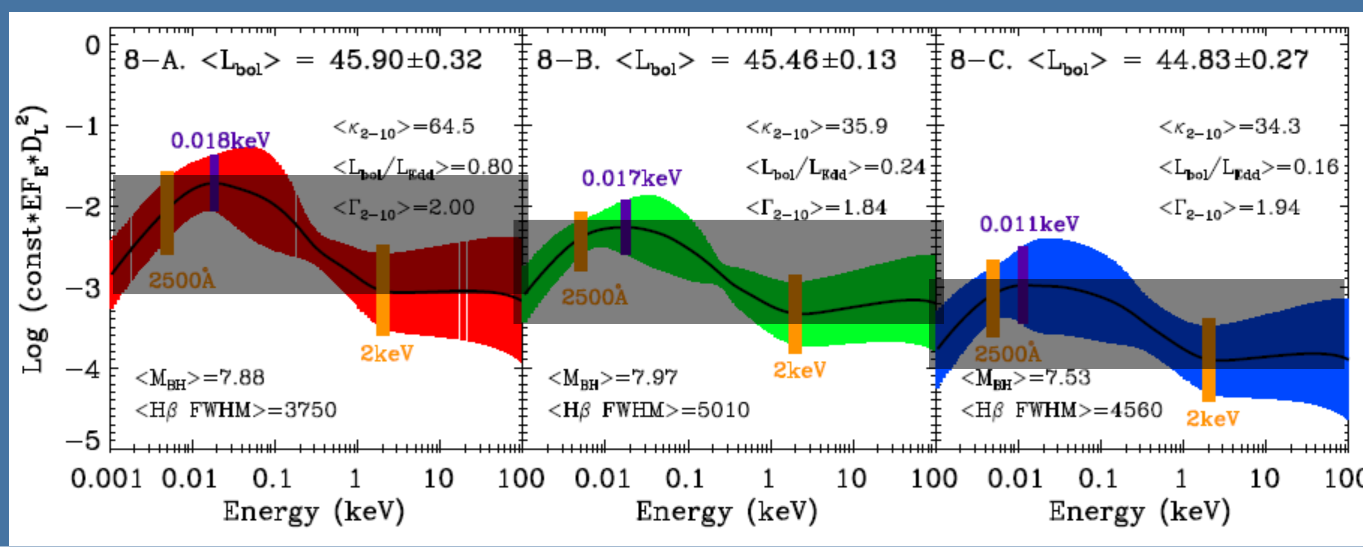
- Difference in BBB Strength

Difference: λ_{Edd} > L_{bol}

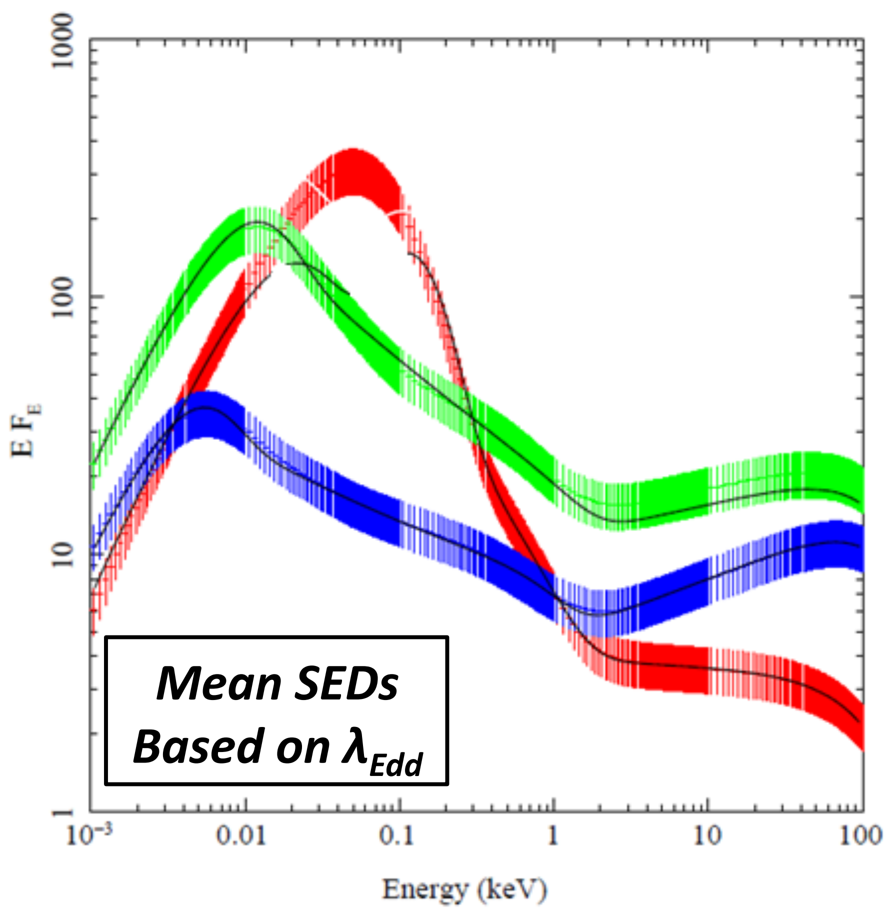
λ_{Edd}

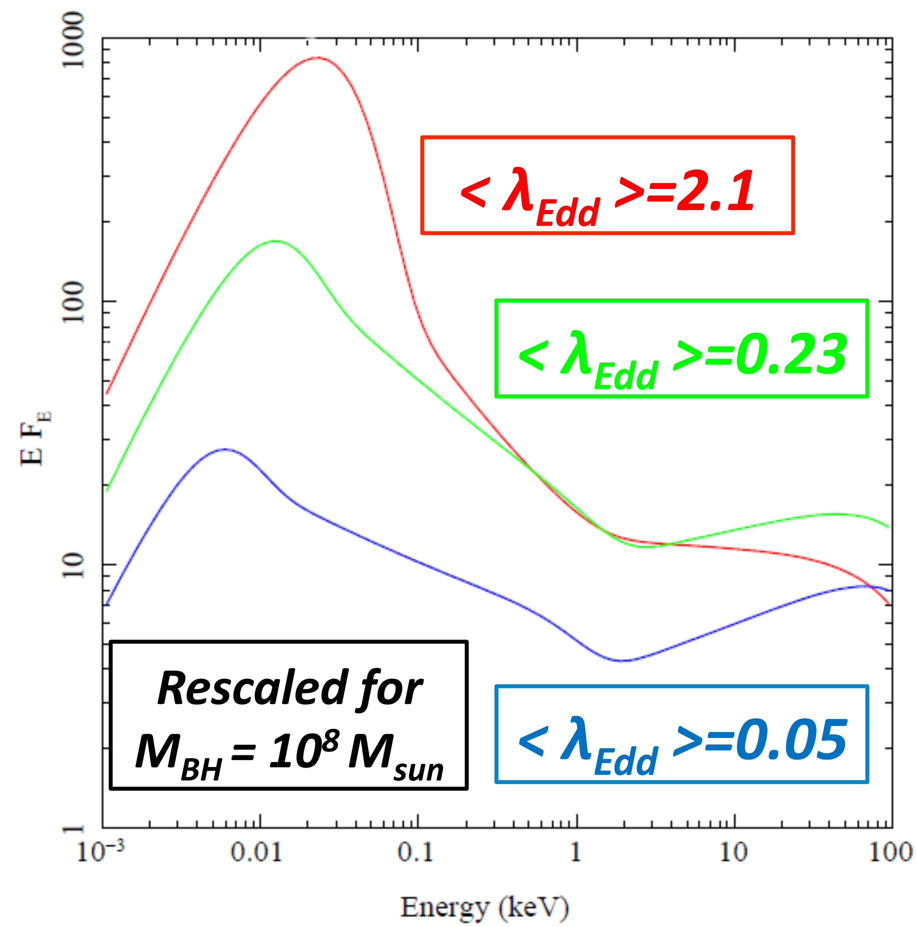


L_{bol}



The Best Indicator of SED Shape





Done et al. 2011; Jin et al. (2011)

Future refinements to model

- 1. Modifications to SS disc, full radiation transfer
- 2. Mass loss via disc wind in high Eddington ratio sources such as the extreme NLS1s (work in progress)

Model used by Jin et al, 51 AGN

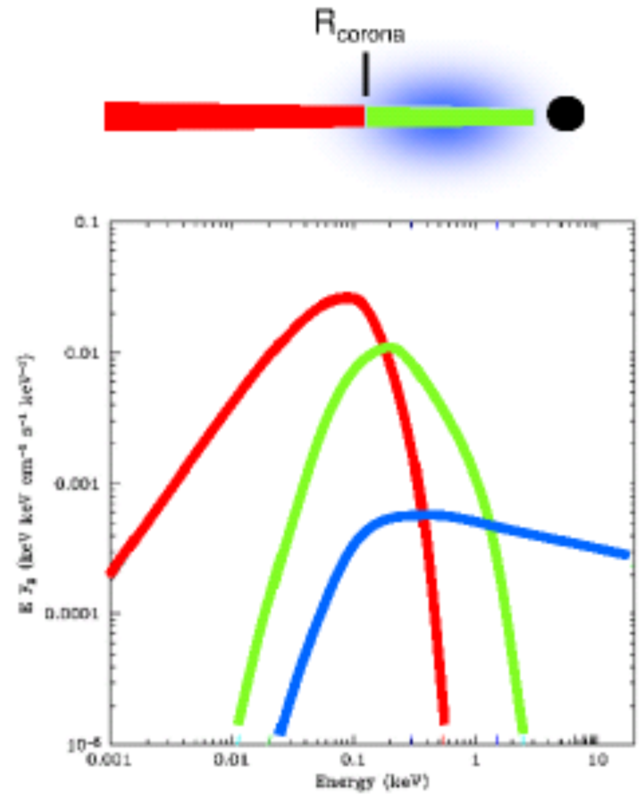


Figure 5. A schematic of the model geometry and resultant spectra, with outer disc (red) which emitts as a (colour tempearture corrected) black-body, and an inner disc (green) where the emission is instead Compton up-scattered (perhaps by bulk turbulent motion in the disc, or by there being more dissipation in the effective photosphere than assumed in the standard Shakura-Sunyaev vertical dissipation profile). Some fraction of the energy is also Compton upscattered in a corona (blue) to produce the power law tail to high energies.

Refinements to the model

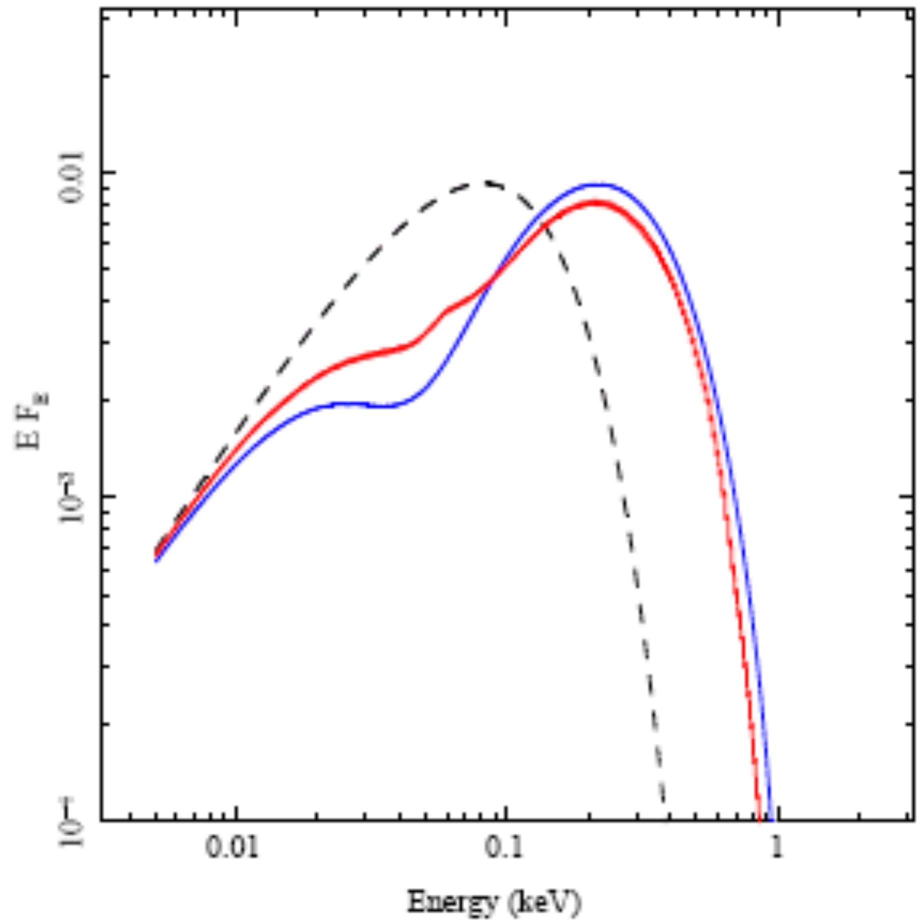
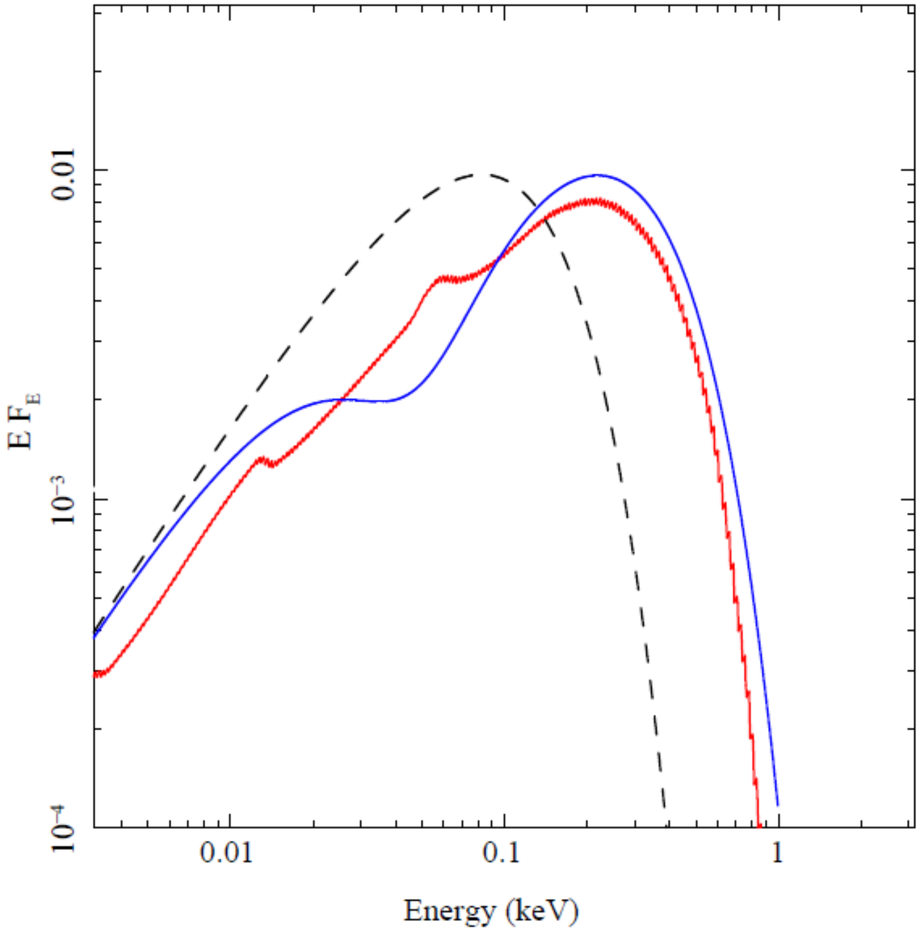
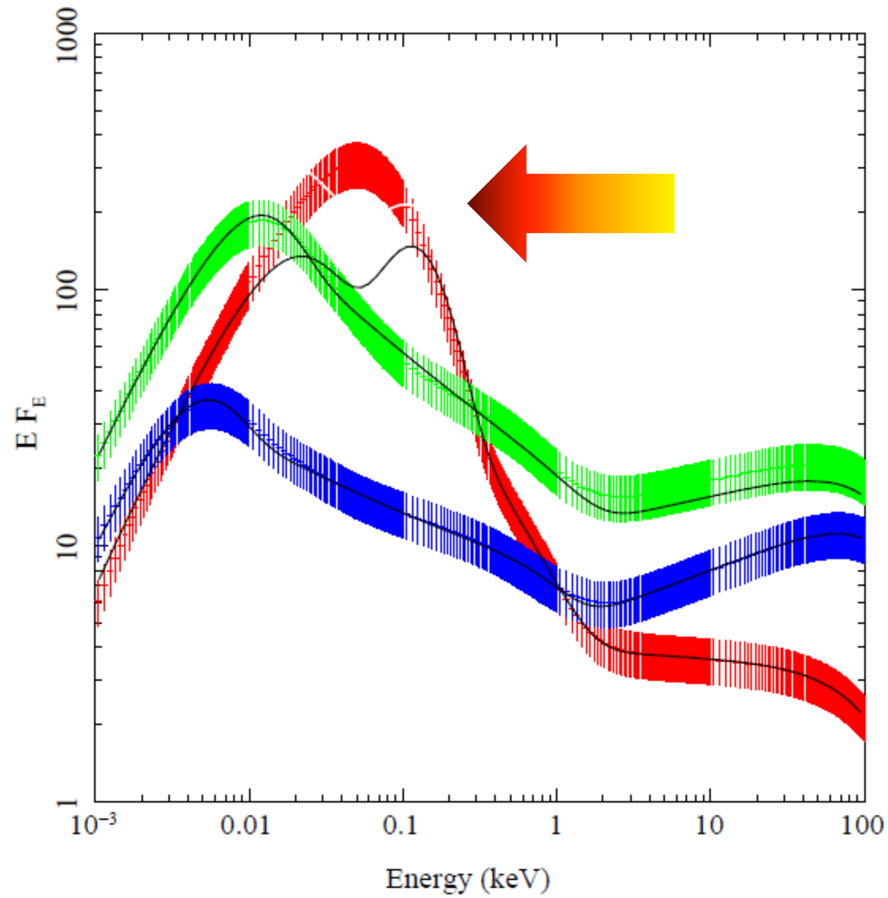


Figure 1. The black dashed line shows the spectrum expected from a standard Shakura-Sunyaev disc assuming that the energy thermalises completely ($f_{col} = 1$). The red line shows instead the spectrum calculated from full radiative transfer through the disc photosphere for temperatures $> 10^5$ K, which is very similar to that produced by assuming a Shakura-Sunyaev disc with $f_{col} = 2.6$ for these temperatures (blue line).

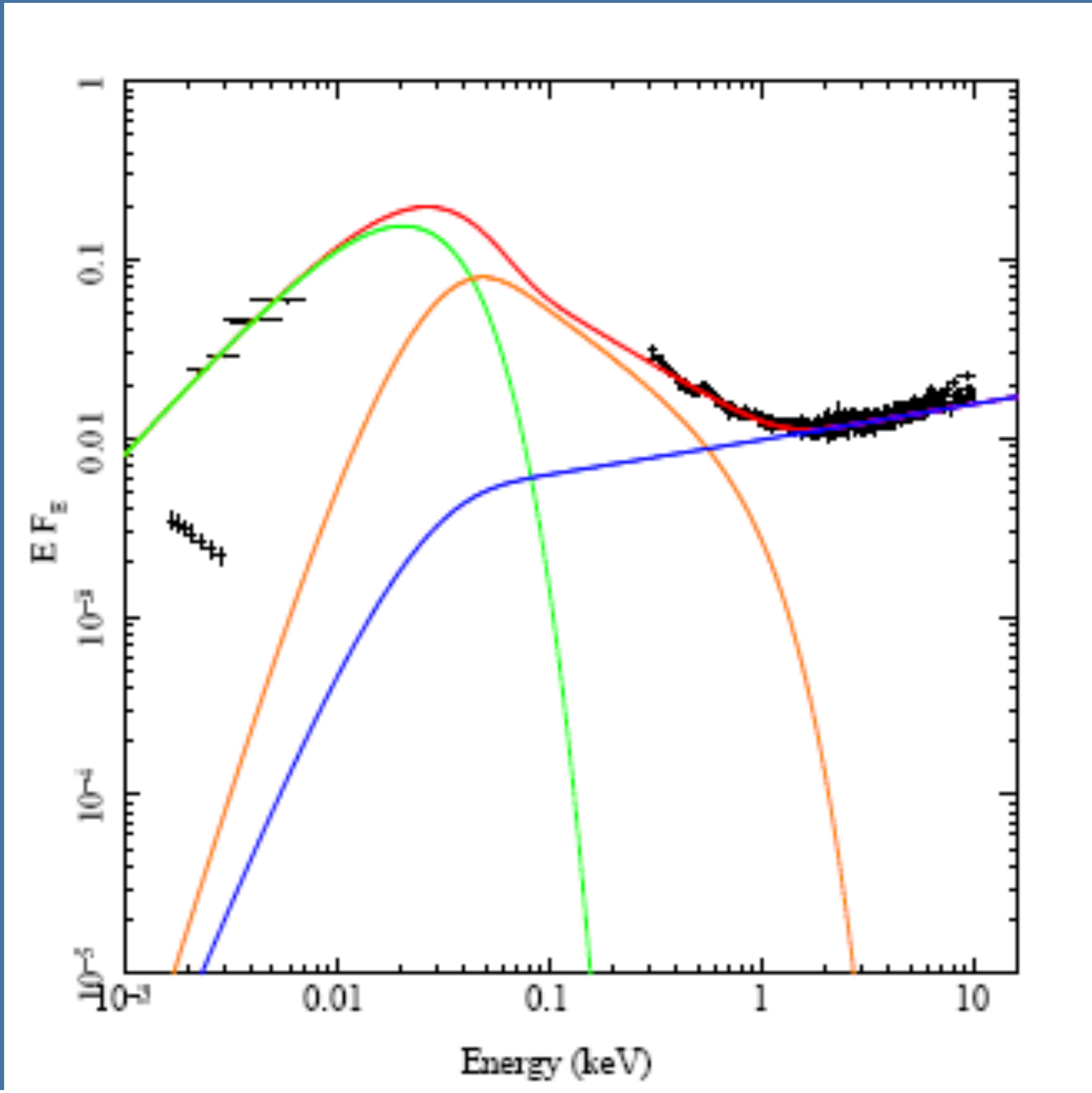
Effect on SED of Colour Correction



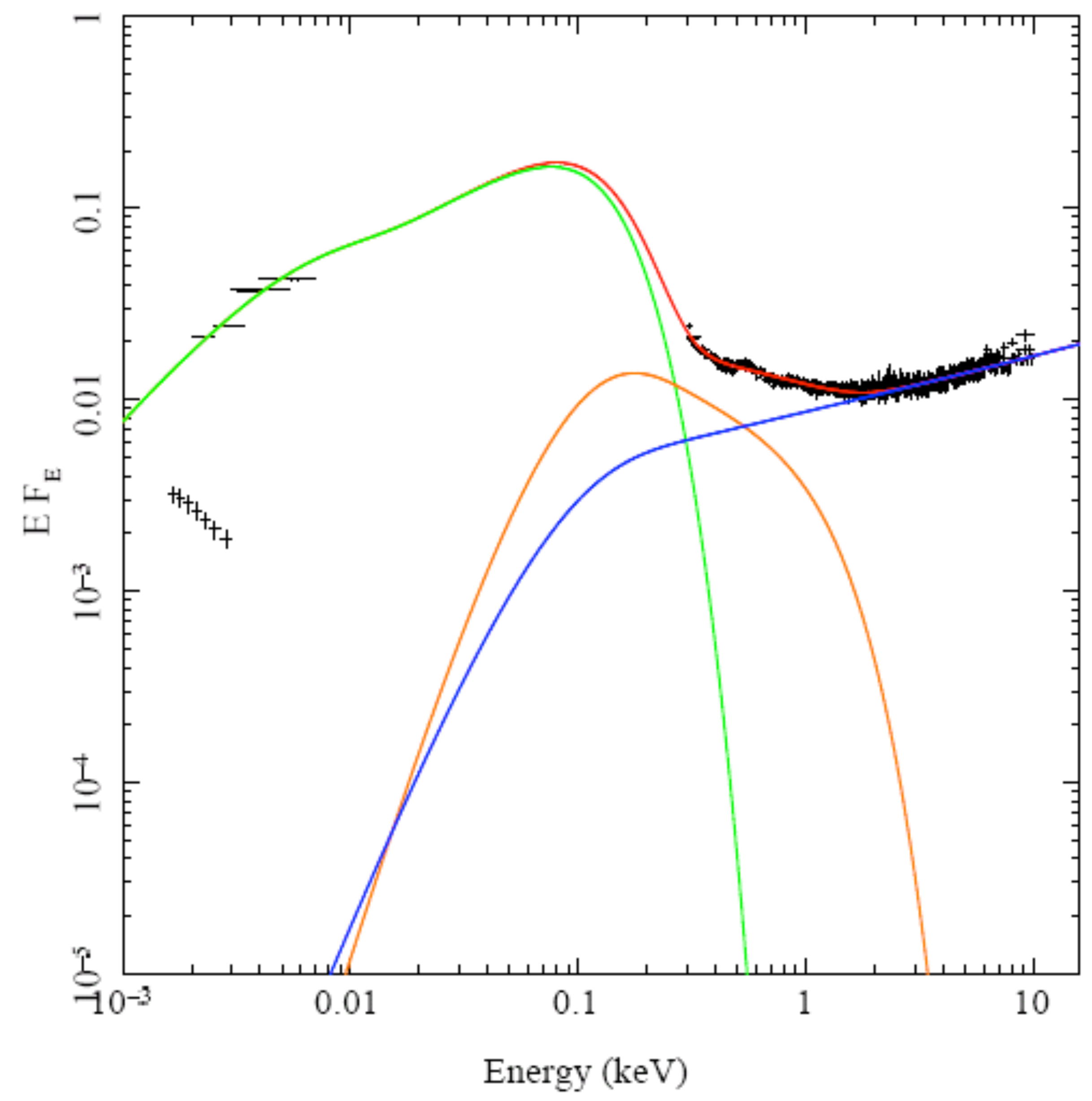


Done et al. 2011; Jin et al. (2011a)

Mkn110 – Standard Disc Model

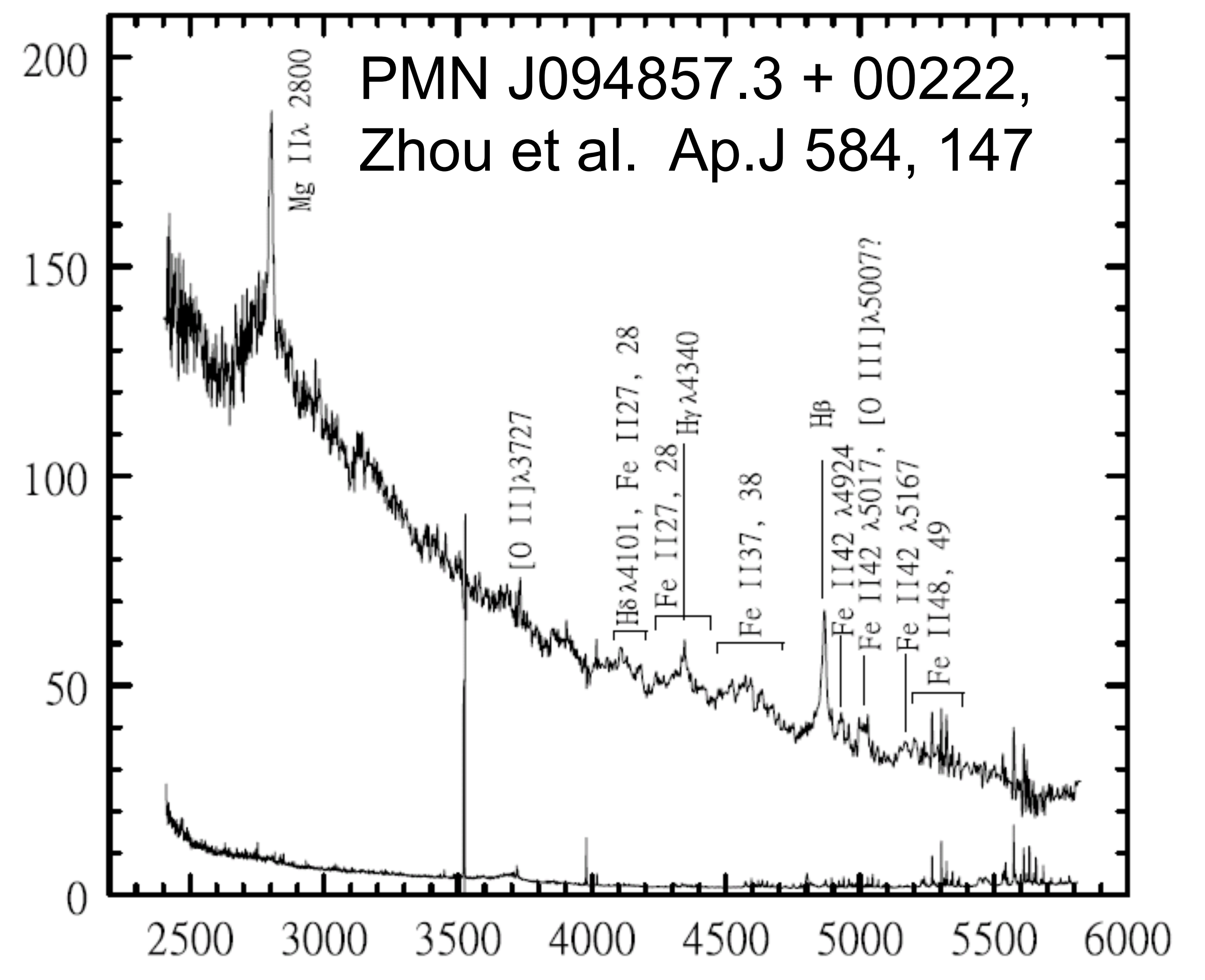


Mkn110 - Modified Disc Model



Next step

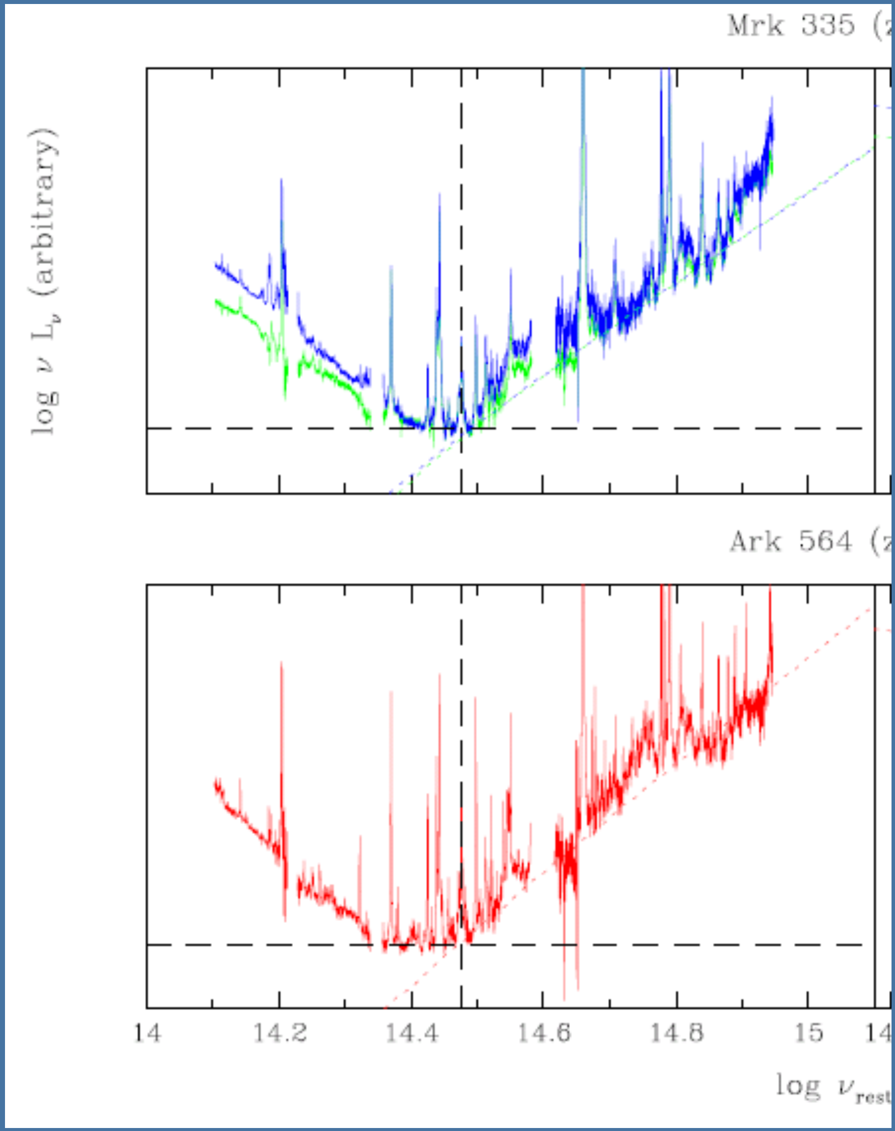
Construct a new sample at z ~ 2,
disc peak shifted into optical, H Beta still visible in SDSS



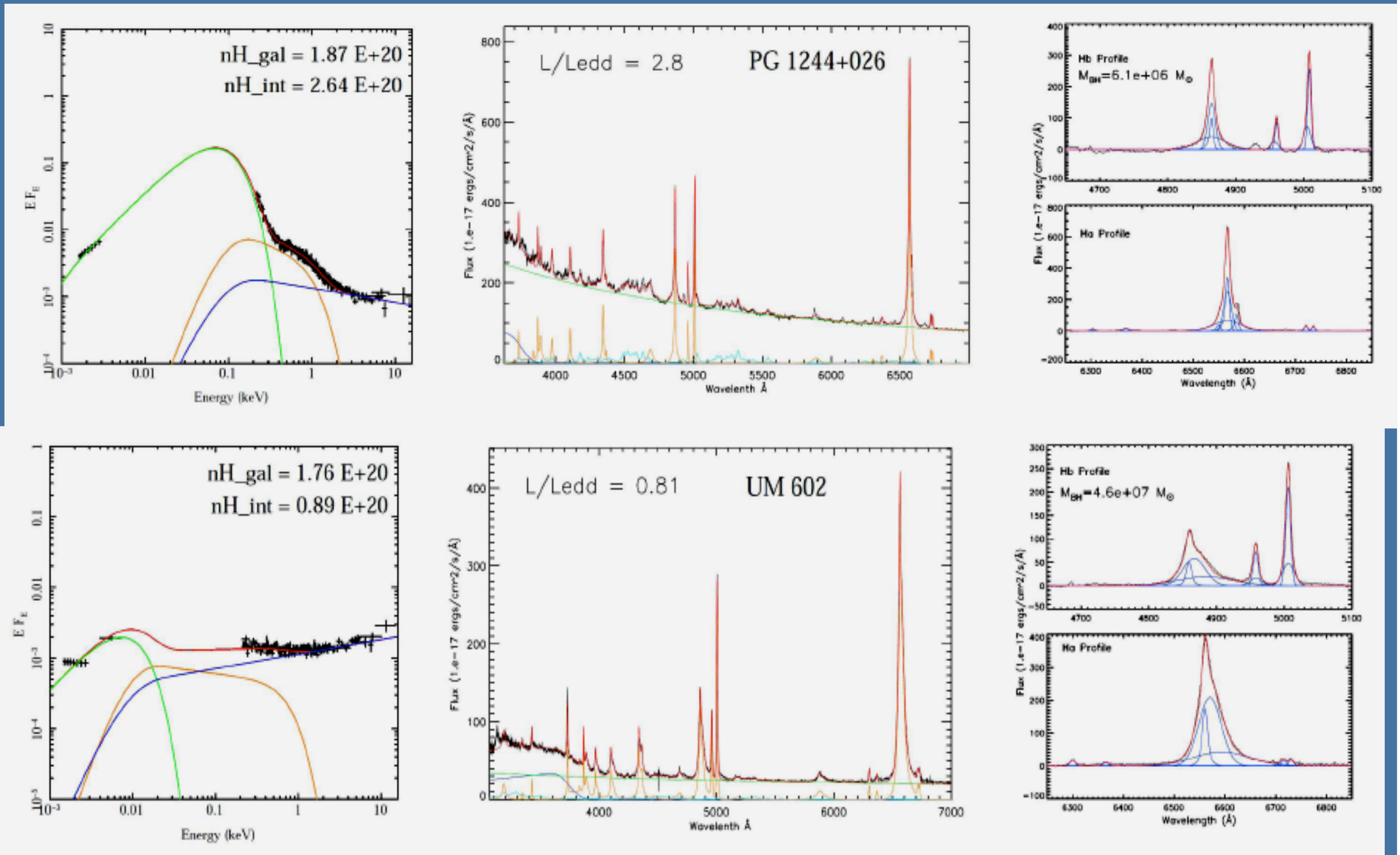
Summary

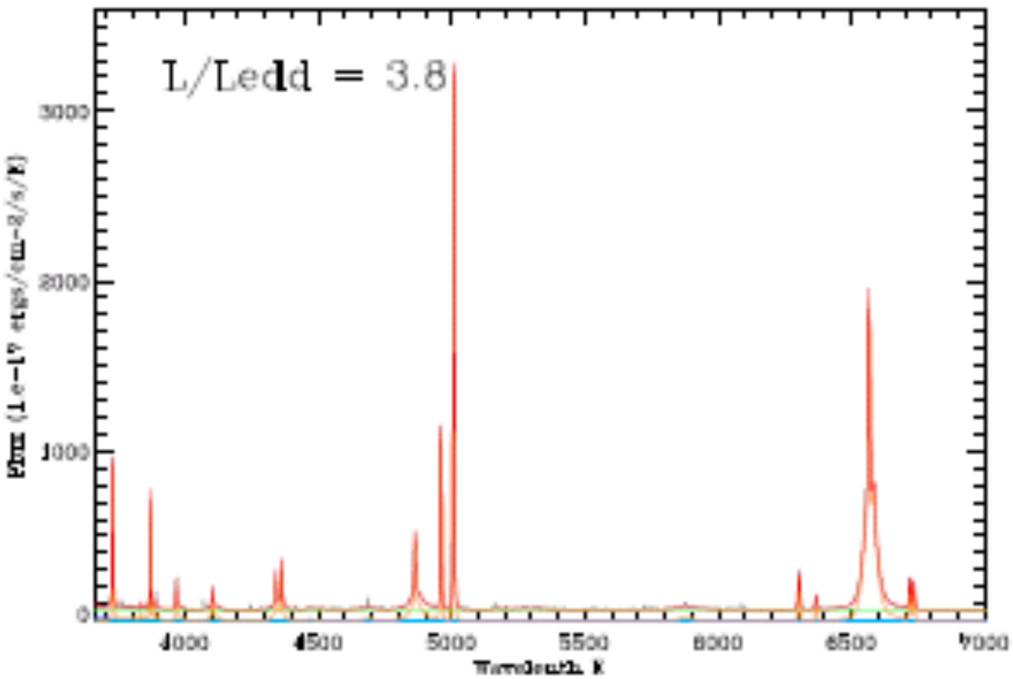
- By modelling the separate components of the optical – X-ray continuum, we can look for physical links between these and other properties eg. emission lines
- Understanding the properties of the inner disc is crucial to links with outflows
- The simplistic application of bolometric corrections may be seriously flawed, given the diversity of the SEDs

Extending the SED into the Near-IR: recent study by Landt et al. 2011



A new study of radio-quiet NLS1s,
Jin et al. (2011) *MNRAS*, accepted, on *Astro-Ph*





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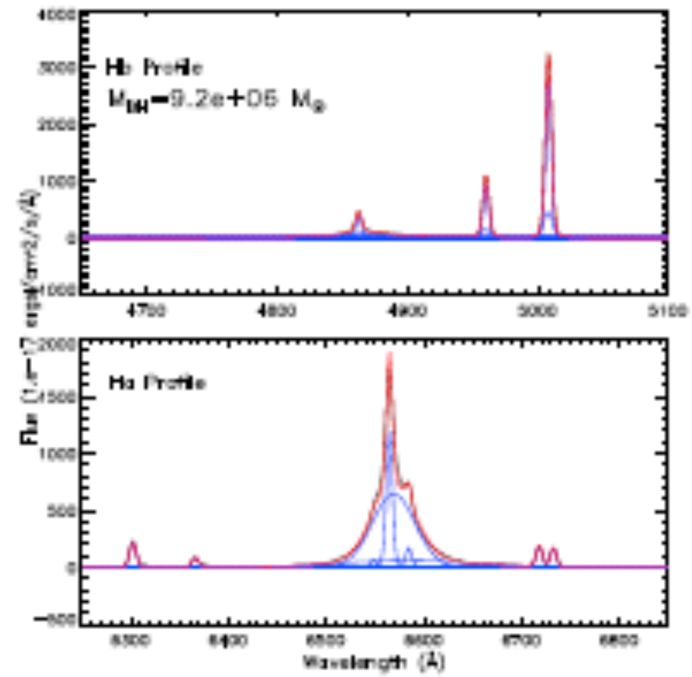

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