X-ray Emission from Seyfert Galaxies and the Unification

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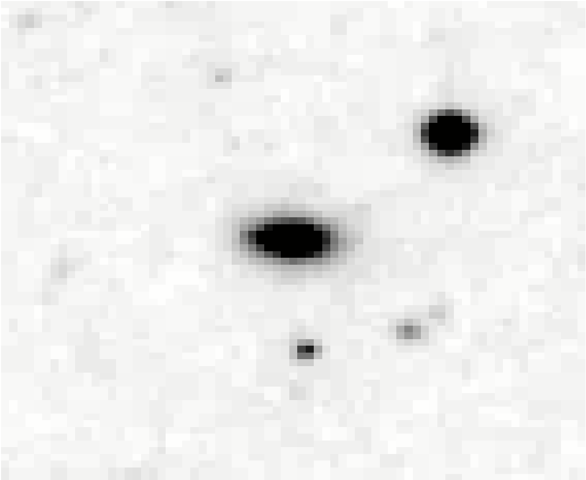
Seyfert Galaxies

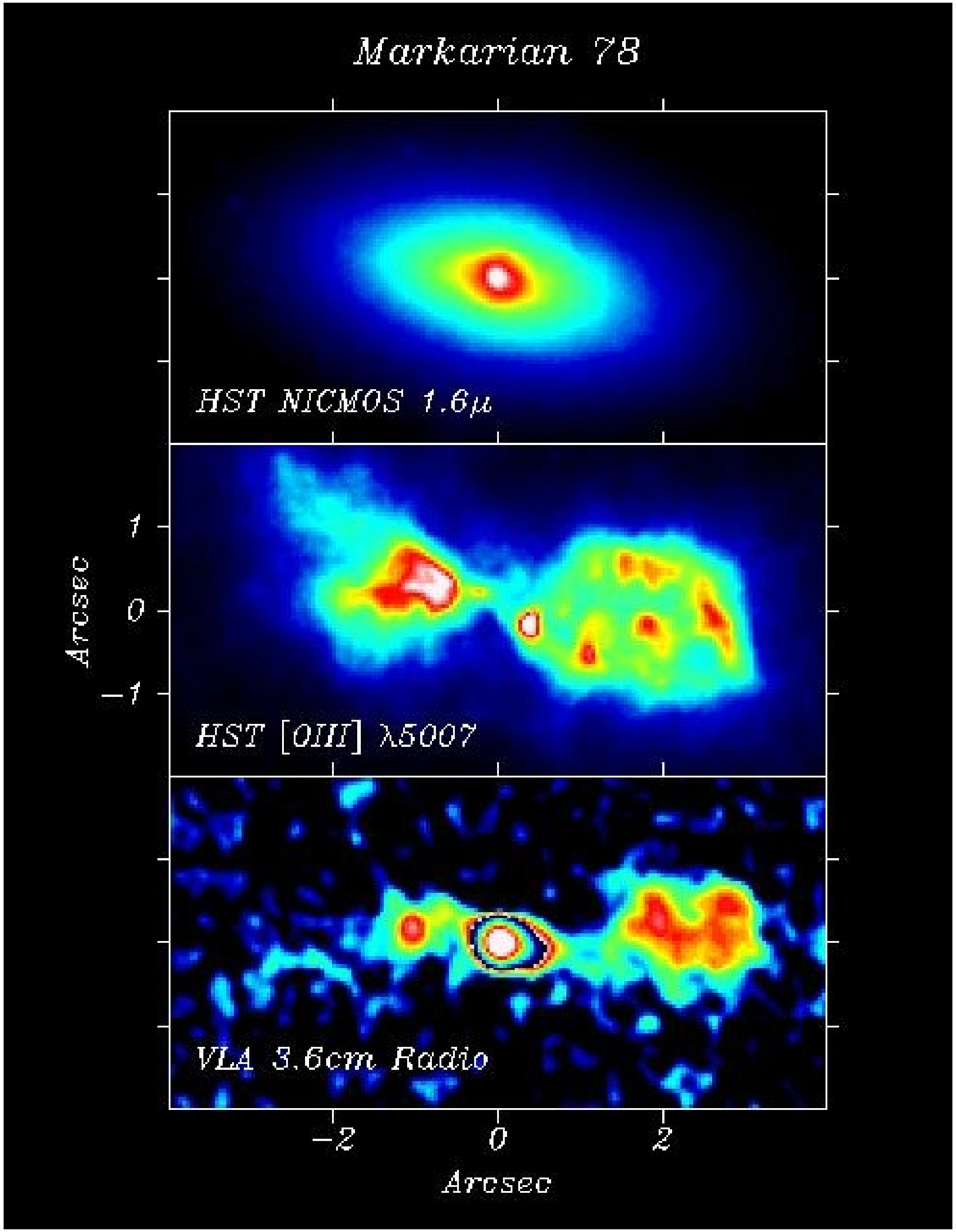
- low optical luminosity
  (M_B > -23) *(Schmidt & Green 1983)*

- radio-quiet AGNs
  ($F_{5GHz}/F_{B\ Band}$ < 10)
  (Kellermann et al.1994)

- Hosted in spiral or lenticular galaxies *(Weedman 1977)*



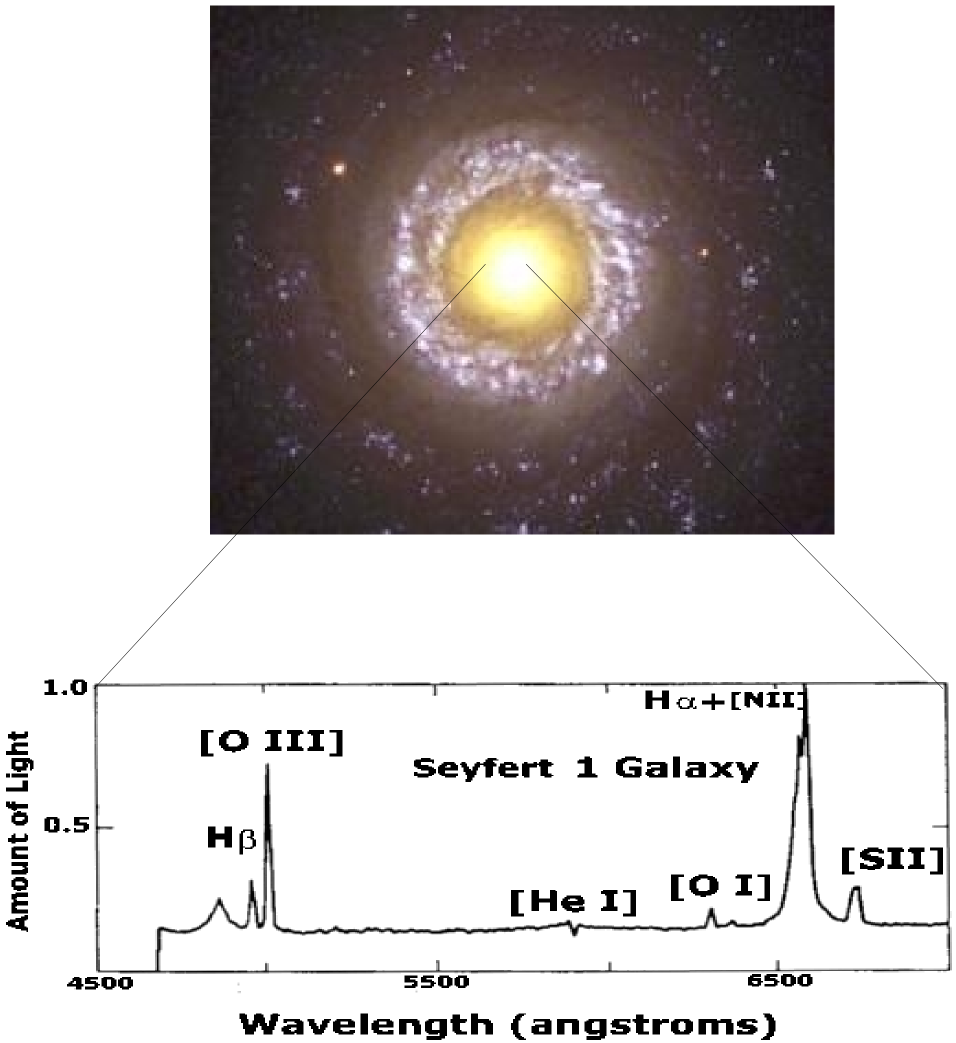
Optical image of Mrk 78 from DSS at 6450 Å



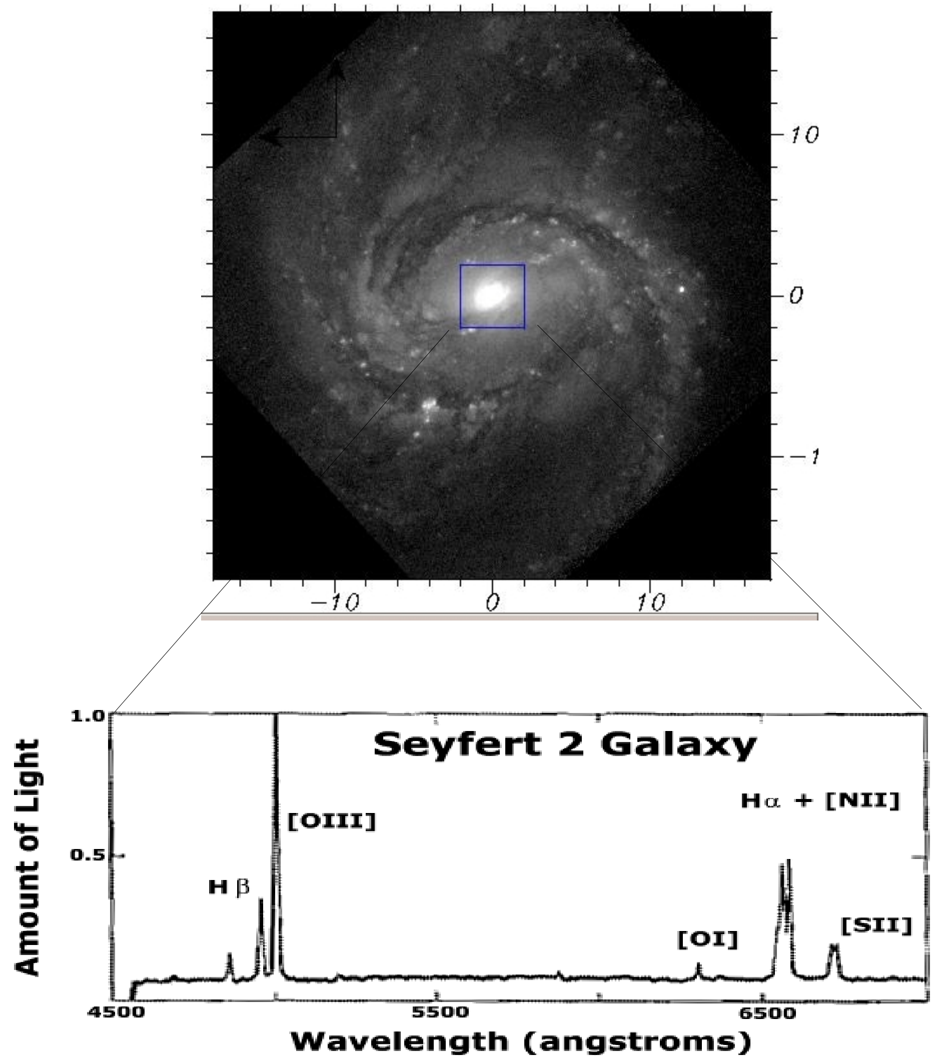
Courtesy: Mark Whittle

Seyfert Classification

Type 1



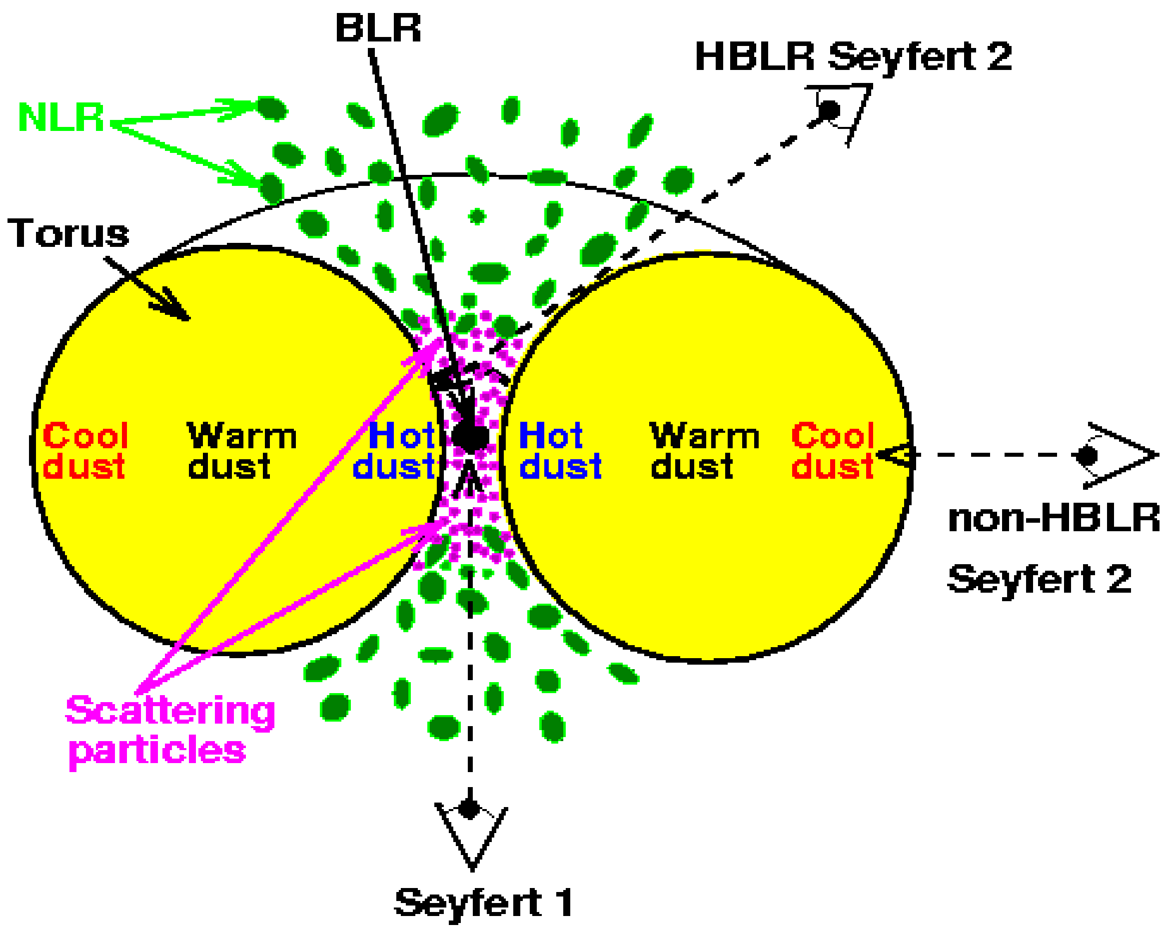
Type 2



Unification Scheme

(Lawrence & Elvis 1982; Antonucci & Miller 1985; Antonucci 1993)

The two subclasses constitute the same parent population and differ only due to the inclination w.r.t. line-of-sight of anisotropically distributed dusty, molecular material (“torus”) around the nucleus.



Supportive Evidence for Unification Scheme

- Broad spectral lines in type 2 sources in polarised light
  (Moran et al. 2000)
- Biconical structure of narrow line region *(Wilson 1996)*
- Systematically higher X-ray column density in type 2 sources
  (Cappi et al. 2006)
- Similar pc-scale radio structure in both subclasses
  (Shastri 2001; Lal et al. 2004)

Results Inconsistent with Unification Scheme

- Type 1s are preferentially hosted by galaxies of earlier Hubble type *(Malkan et al. 1998)*
- Environments of two Seyfert subclasses differ *(Dultzin-Hacyan 1999)*
- Seyfert 2s are more likely to have starbursts *(Buchanan et al. 2006)*
- Absence of hidden Seyfert 1 nuclei in many Seyfert 2s *(Tran 2001, 2003)*
- Lack of X-ray absorption in several Seyfert 2s *(Panessa et al. 2002)*

Objective: Testing Unification Scheme

Are the properties of the observed X-ray continuum from Seyfert nuclei for a rigorously selected Seyfert sample consistent with the predictions of the unification scheme?

Methodology

The two subclasses of purportedly pole-on & edge-on Seyferts being compared are chosen to be intrinsically similar in the framework of unification scheme.

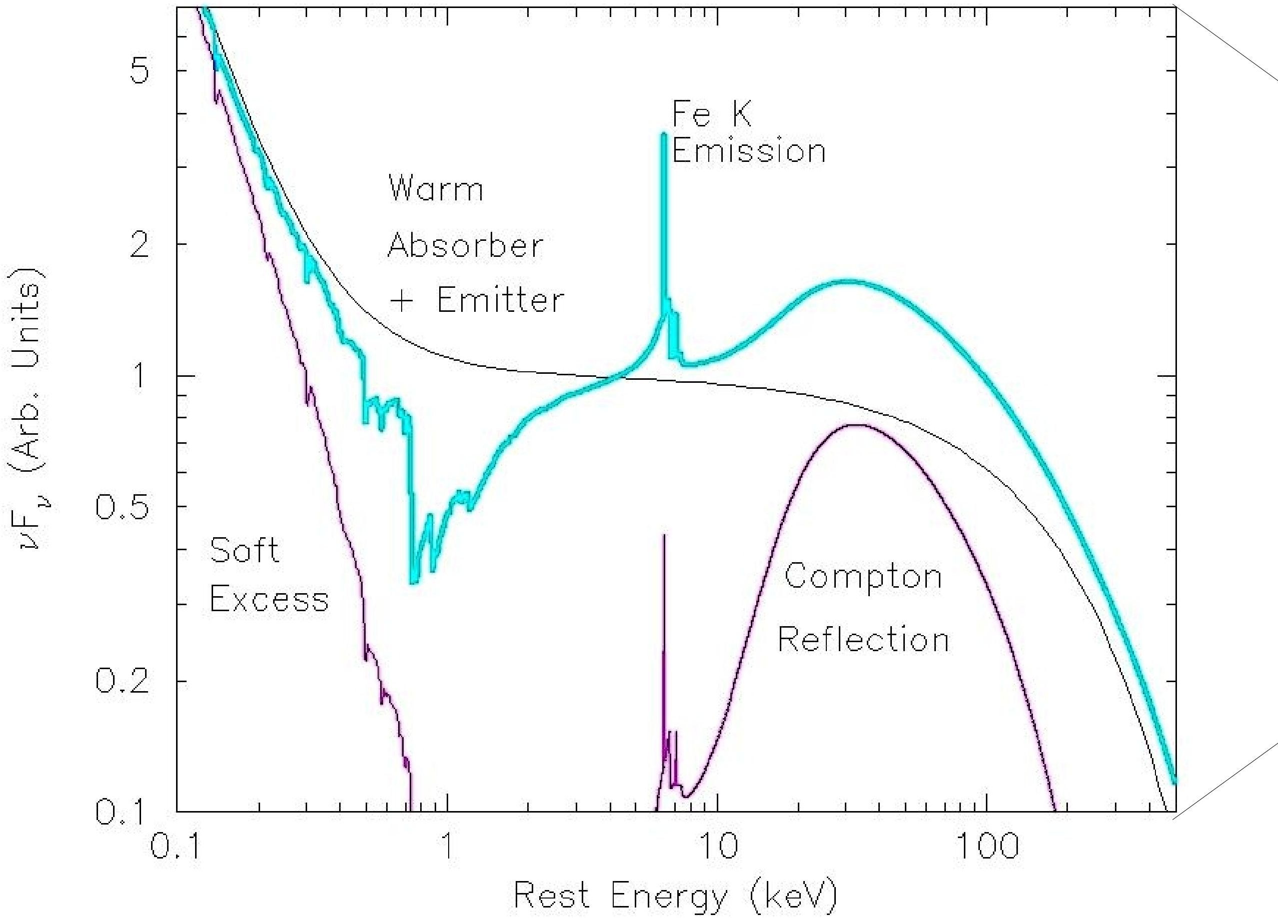
The Sample: Total 20 (10 type 1 and 10 type 2) sources.

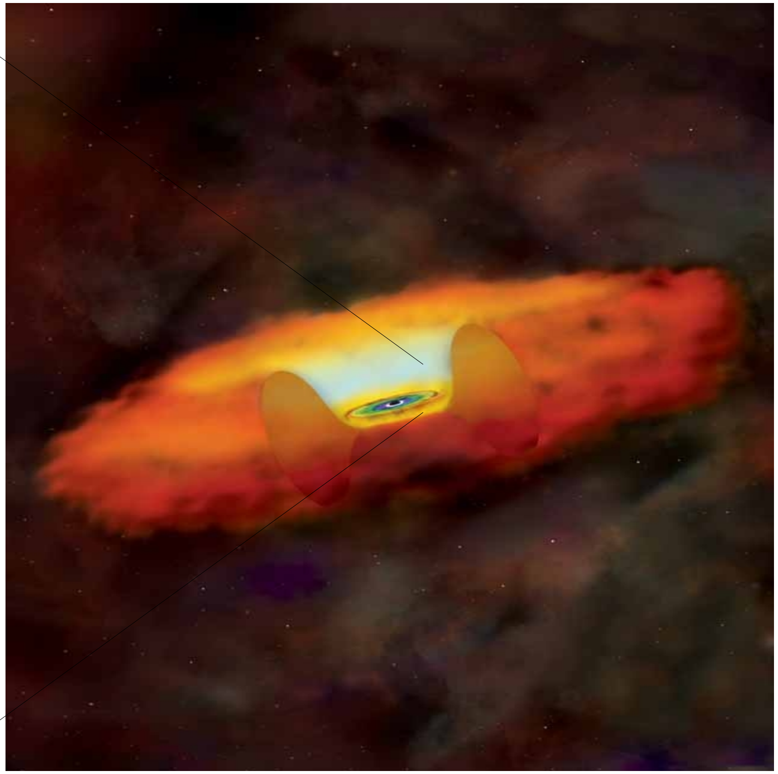
Sample Selection Criteria

The two subclasses are matched in orientation independent parameters of host galaxies and AGN,

- Host galaxy Hubble type
- Host galaxy stellar luminosity
- Bulge absolute magnitude
  (related to SMBH e.g., Kormendy & Richstone 1995))
- Cosmological Redshift (Control over cosmological evolution)
- [O III] λ5007 luminosity
  (proxy of AGN power *(Pogge 1989, Whillte 1992, Heckman 2005))*.

X-ray Emission from Seyferts is believed to arise from the inner part of the accretion disk.





Unification Scheme predicts that the soft X-ray photons will be absorbed by the 'torus' while the hard X-ray (> 3 keV) photons are expected to the penetrate the torus. *(Turner et al. 1997)*

X-ray Observations

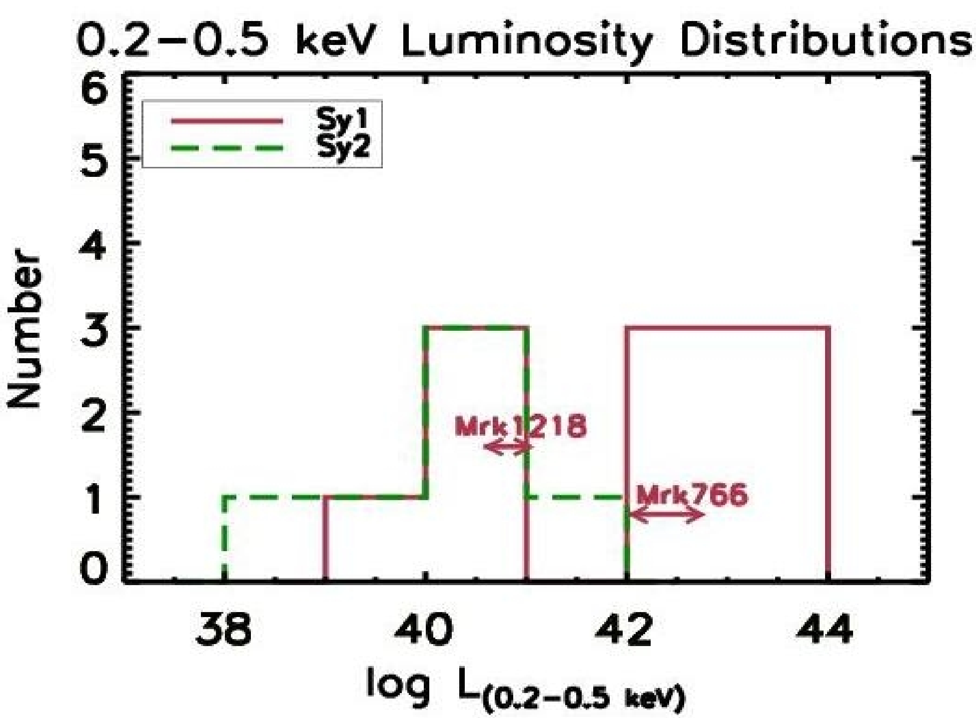
- For 10 type 1 & 6 type 2 Seyferts we use *XMM-Newton EPIC* fluxes from the *2XMM-Newton* Serendipitous Survey

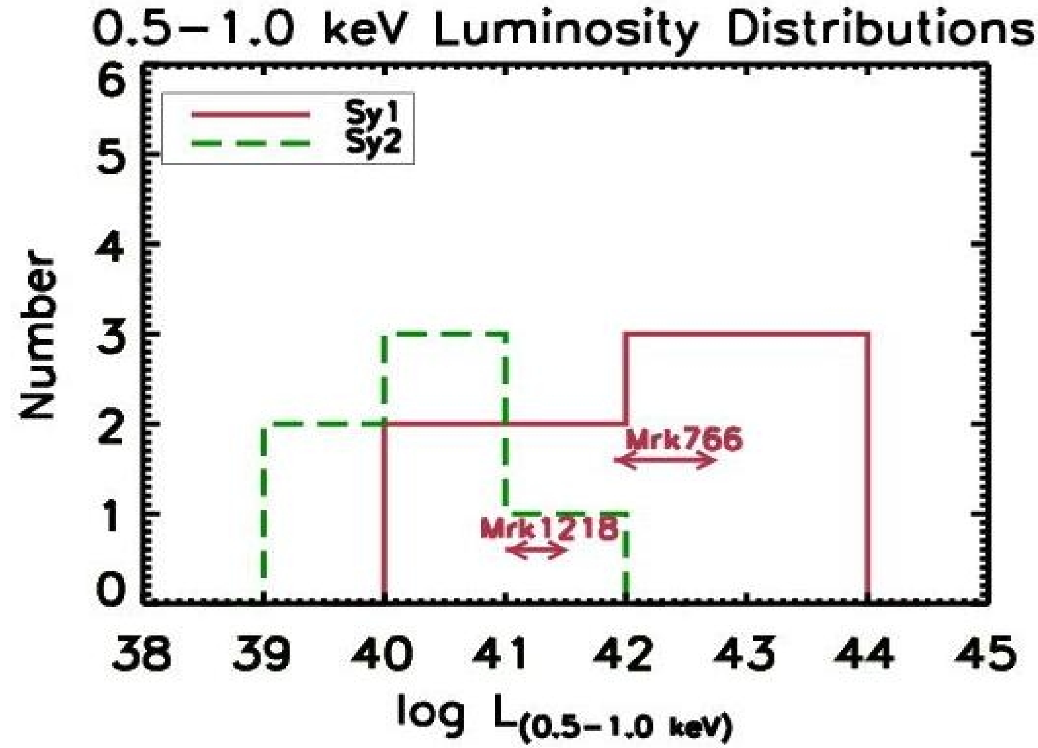
- In a few broad-bands cases ASCA measurements are used.

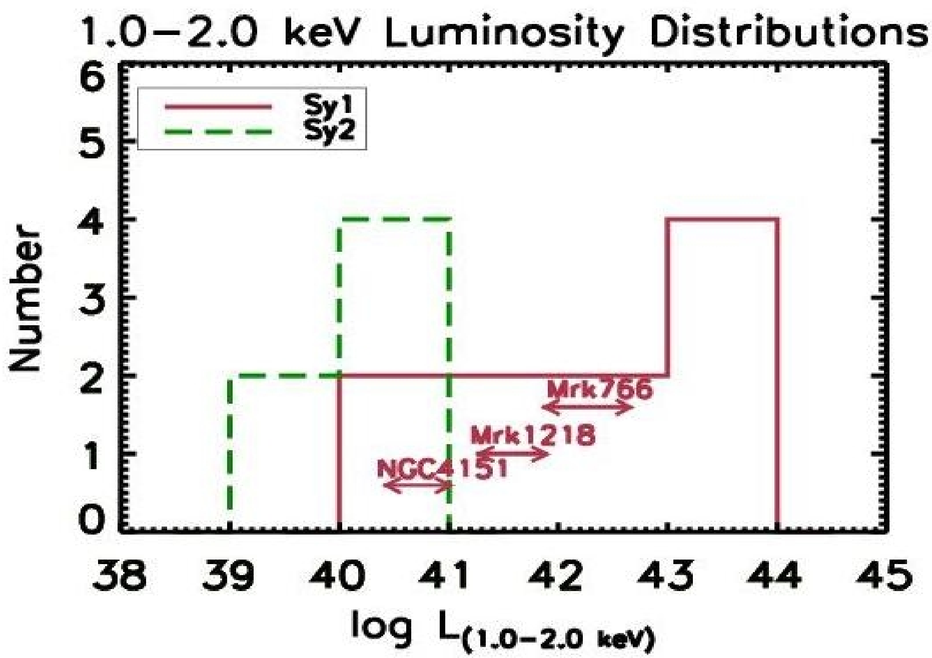
Narrow-bands considered:
0.2- 0.5 keV (Ultra-soft), 0.5-1.0 keV (Soft), 1.0- 2.0 keV (Soft),
2.0 - 4.5 keV (Medium), 4.5 -12.0 keV (Hard)

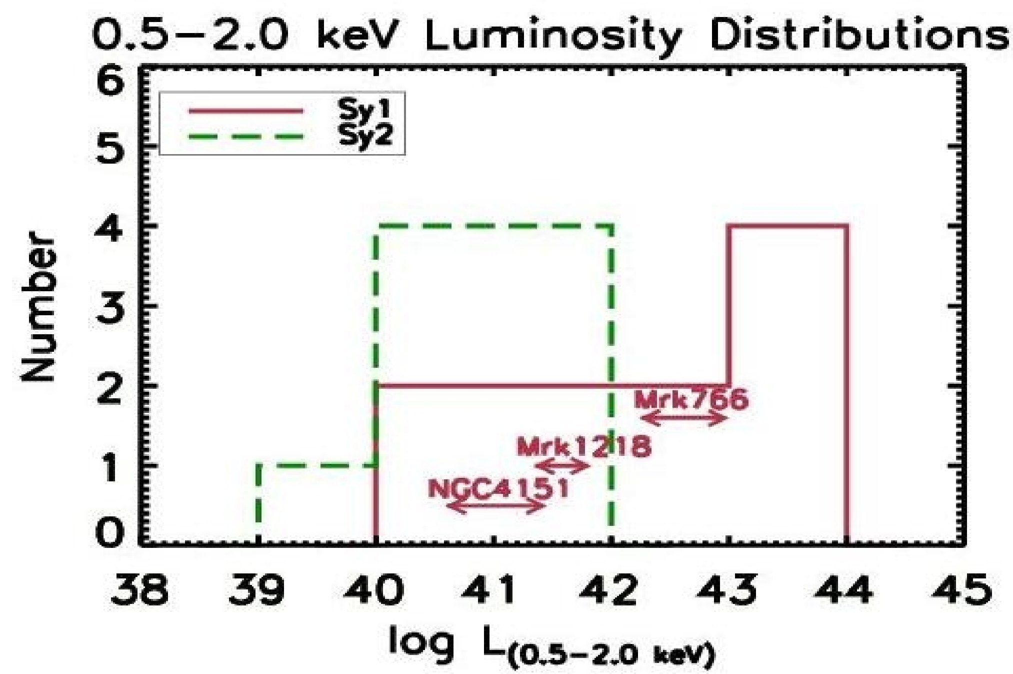
Broad-bands considered: 0.5-2.0(Soft), 2.0 -12.0 (Hard)

Luminosity Distributions

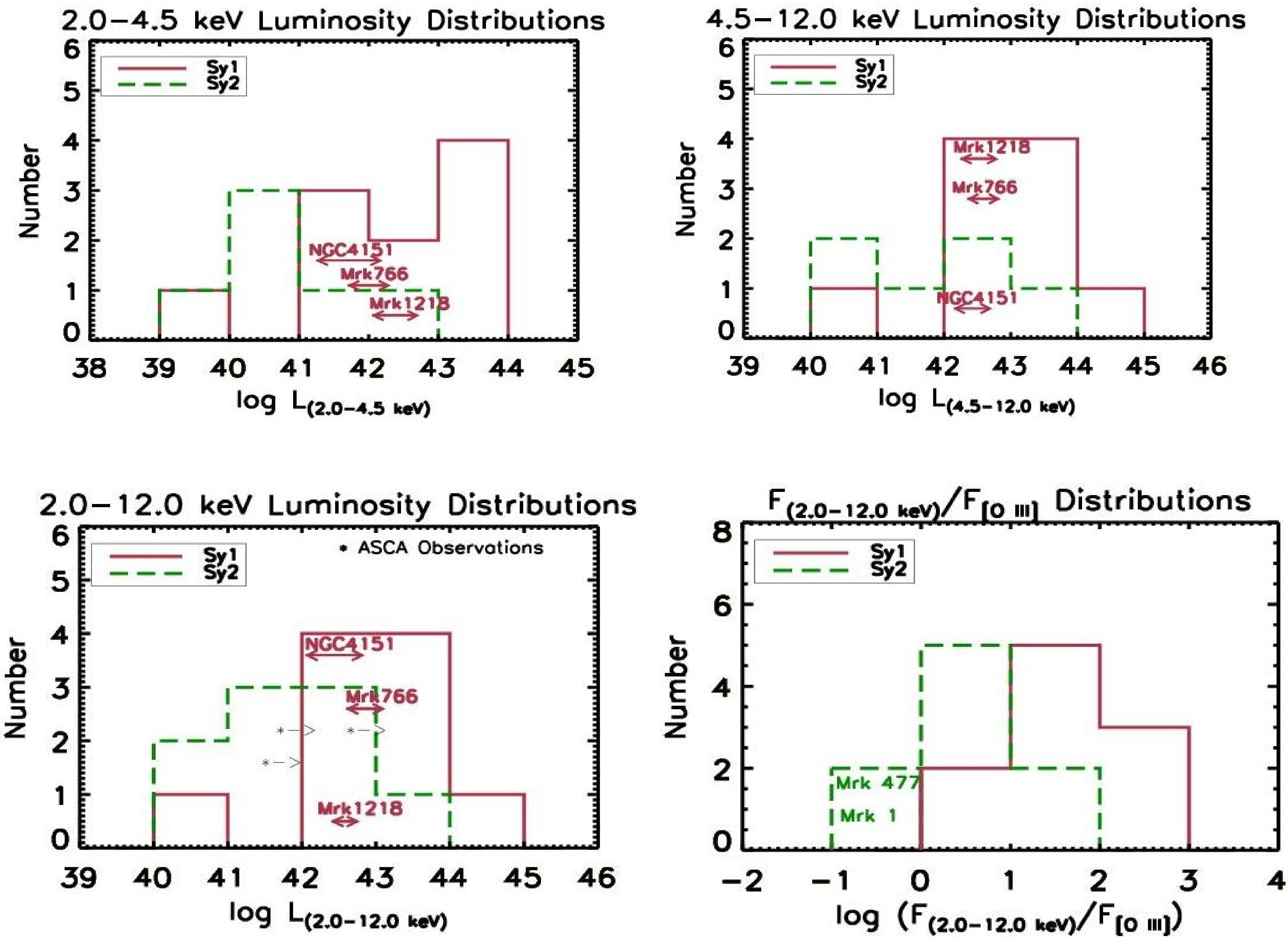






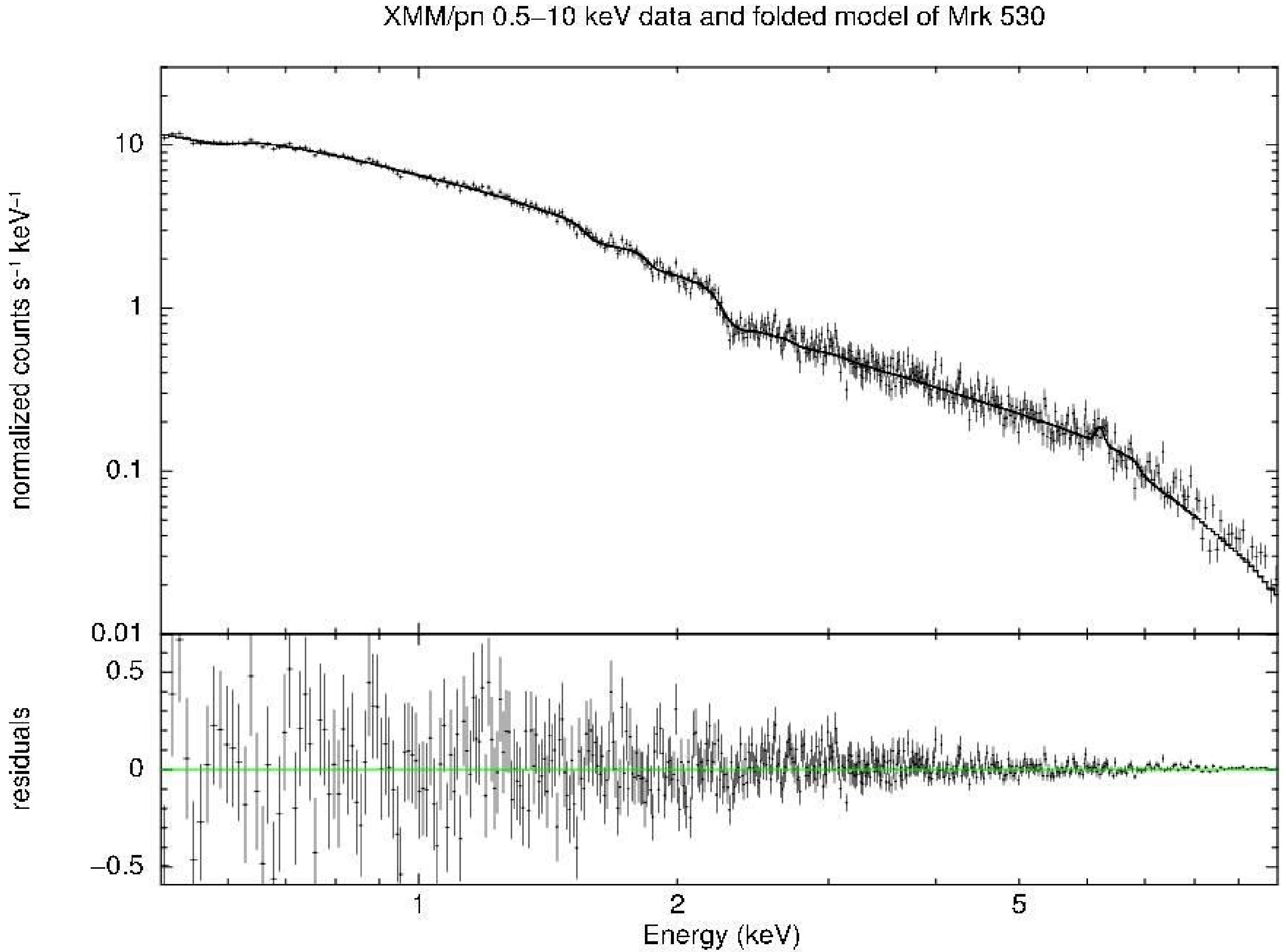


Luminosity and Flux ratio Distributions



Medians of the X-ray Luminosity Distributions (in units of erg s^{-1} on a log scale)			
X-ray Bands	Seyfert 1	Seyfert 2	Difference
Narrow Bands			
0.2-0.5 keV	42.4	40.2	2.2
0.5-1.0 keV	42.5	40.4	2.1
1.0-2.0 keV	42.5	40.5	2.0
2.0-4.5 keV	42.6	40.6	2.0
4.5-12.0 keV	42.8	41.7	1.1
Broad Bands			
0.5-2.0 keV	42.8	40.8	2.0
2.0-12.0 keV	43.0	41.6	1.4

XMM-N/pn Spectral Studies

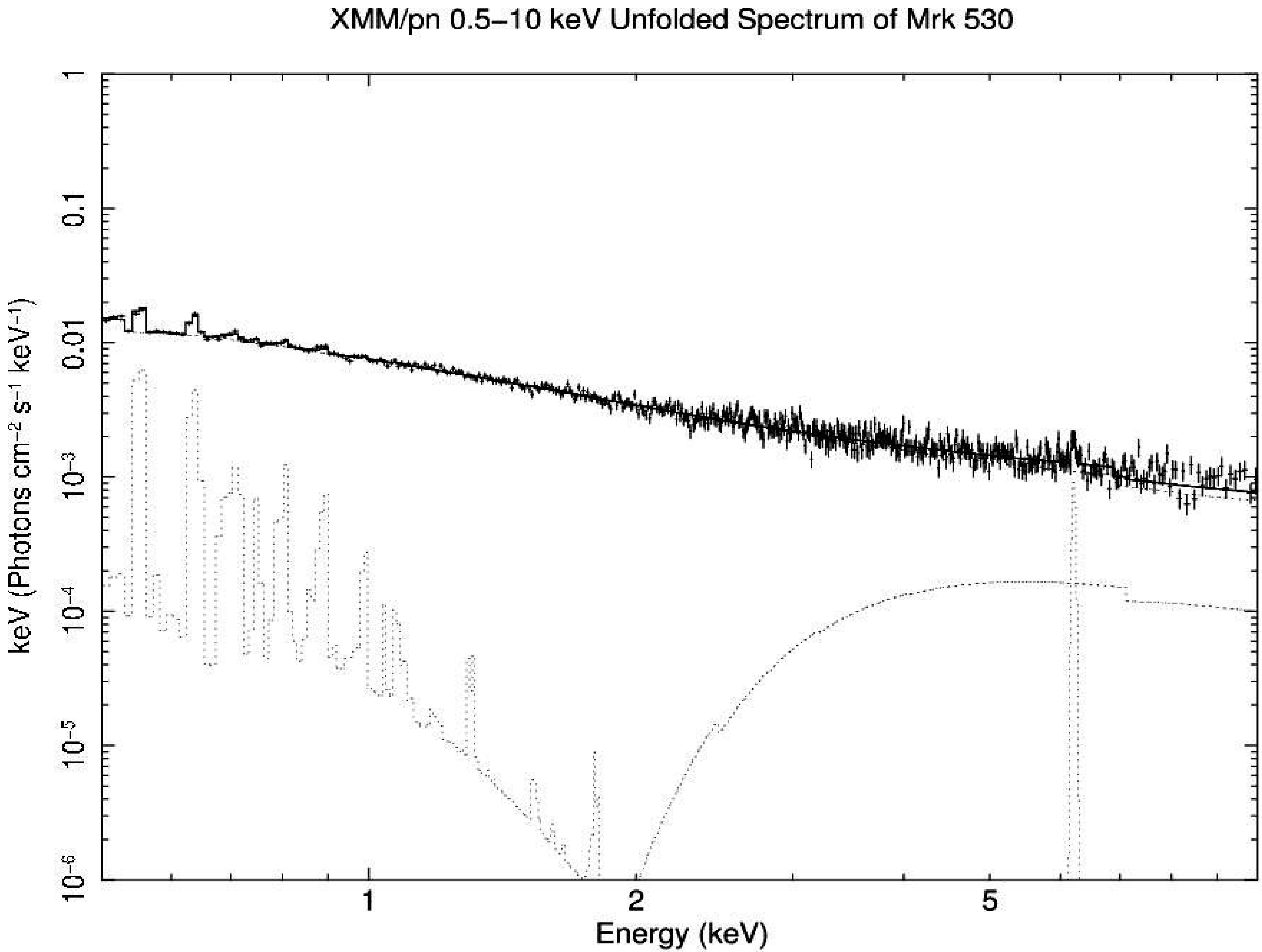


Absorbed powerlaw (N_H = 15.2 x 10^{22} cm^{-2}, Γ = 2.28) + reflection component +

Fe Kα li ne (narrow Gaussian, EW = 43.6 eV) + Soft excess modeled with thermal component (kT = 0.02 keV)

(Singh V., Shastri P. & Risaliti G., 2008 (*in preparation)*)

XMM-N/pn Spectral Studies



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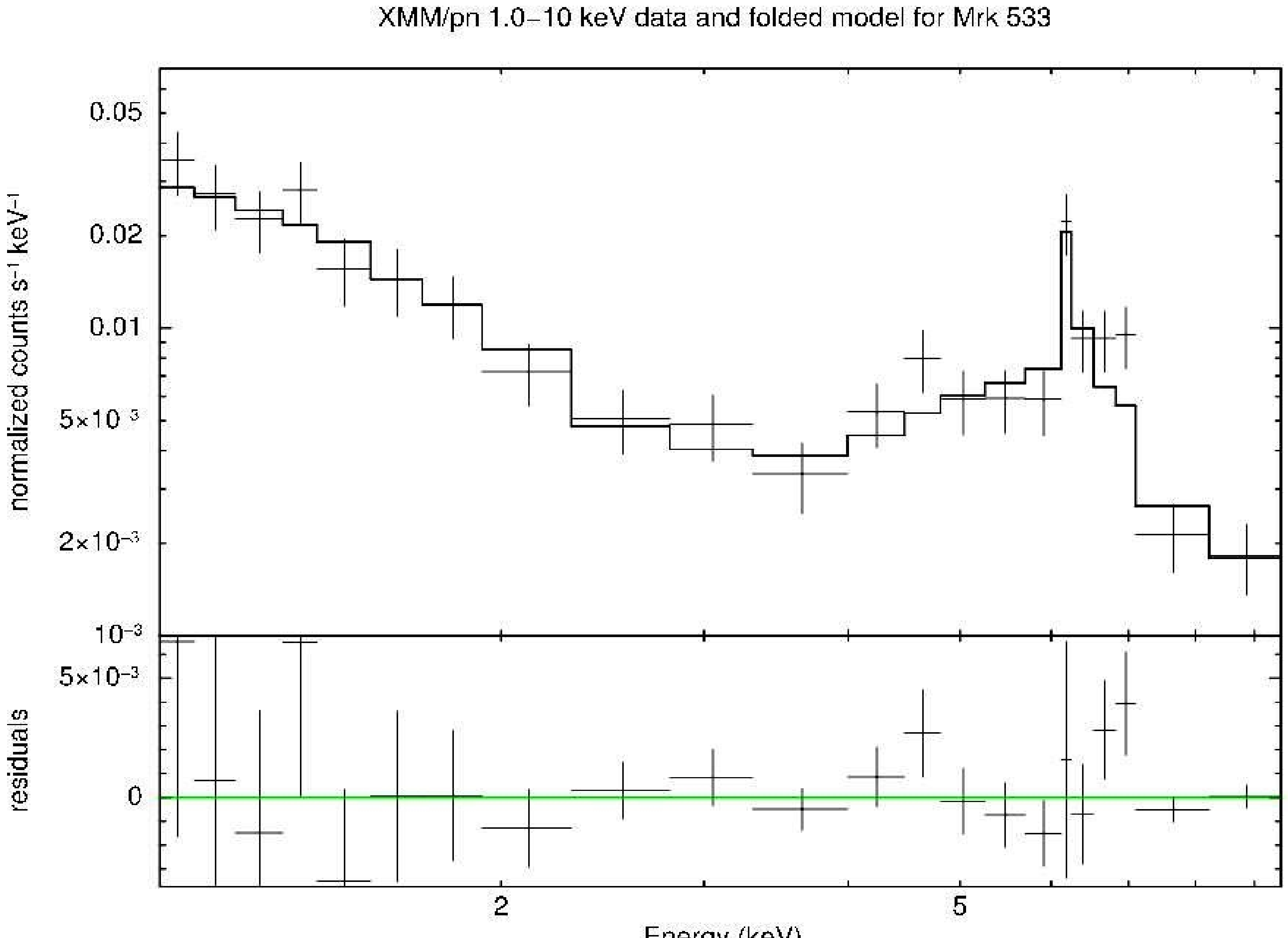
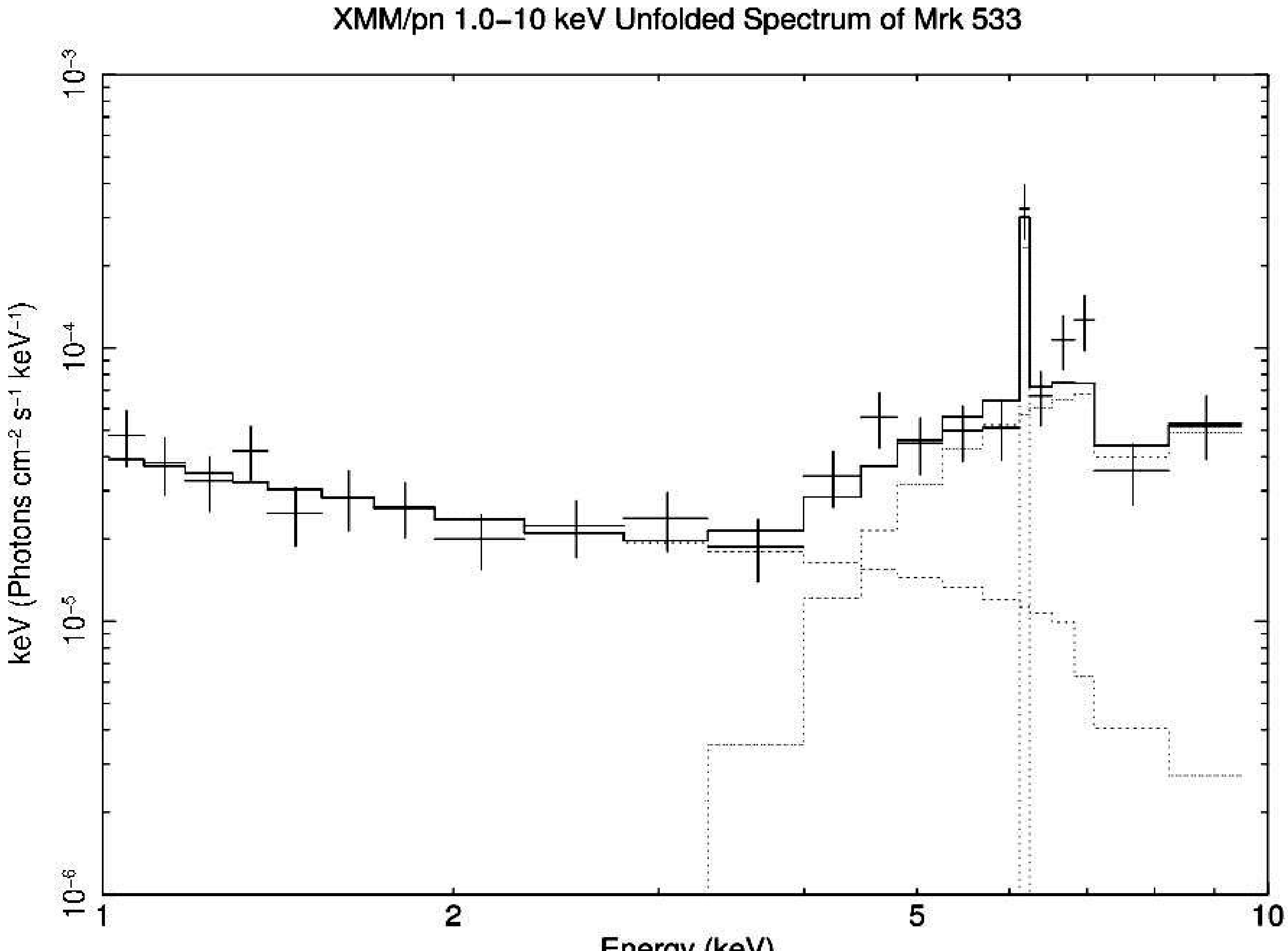
XMM-N/pn Spectral Studies



Highly absorbed powerlaw (N_H = 47.27 x 10^{22} cm^{-2}, Γ = 1.89) + reflection component + Fe Kα li ne (EW = 409.5 eV) + two thermal component

(Singh V., Shastri P. & Risaliti G., 2008 (*in preparation*))

XMM-N/pn Spectral Studies



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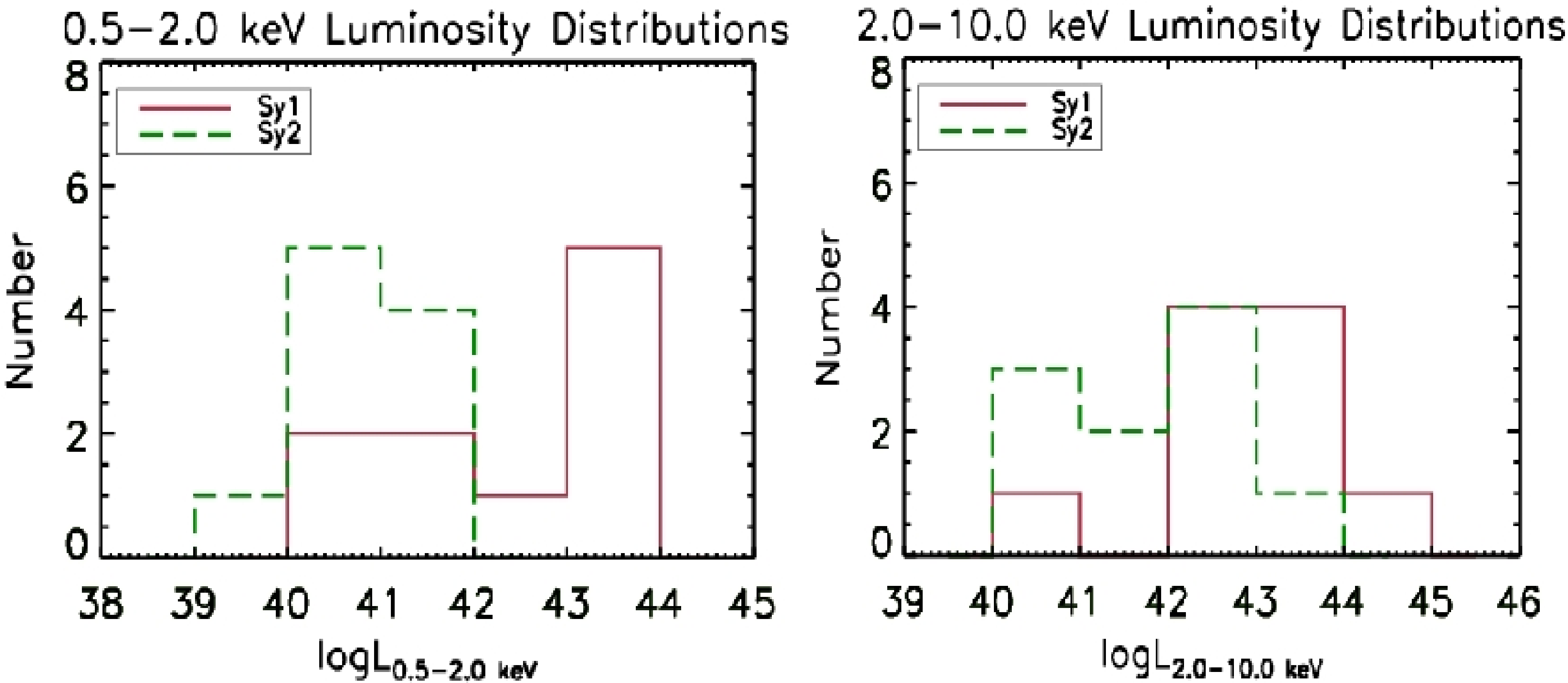
Preliminary Results From Spectral Analysis

Luminosity Distributions



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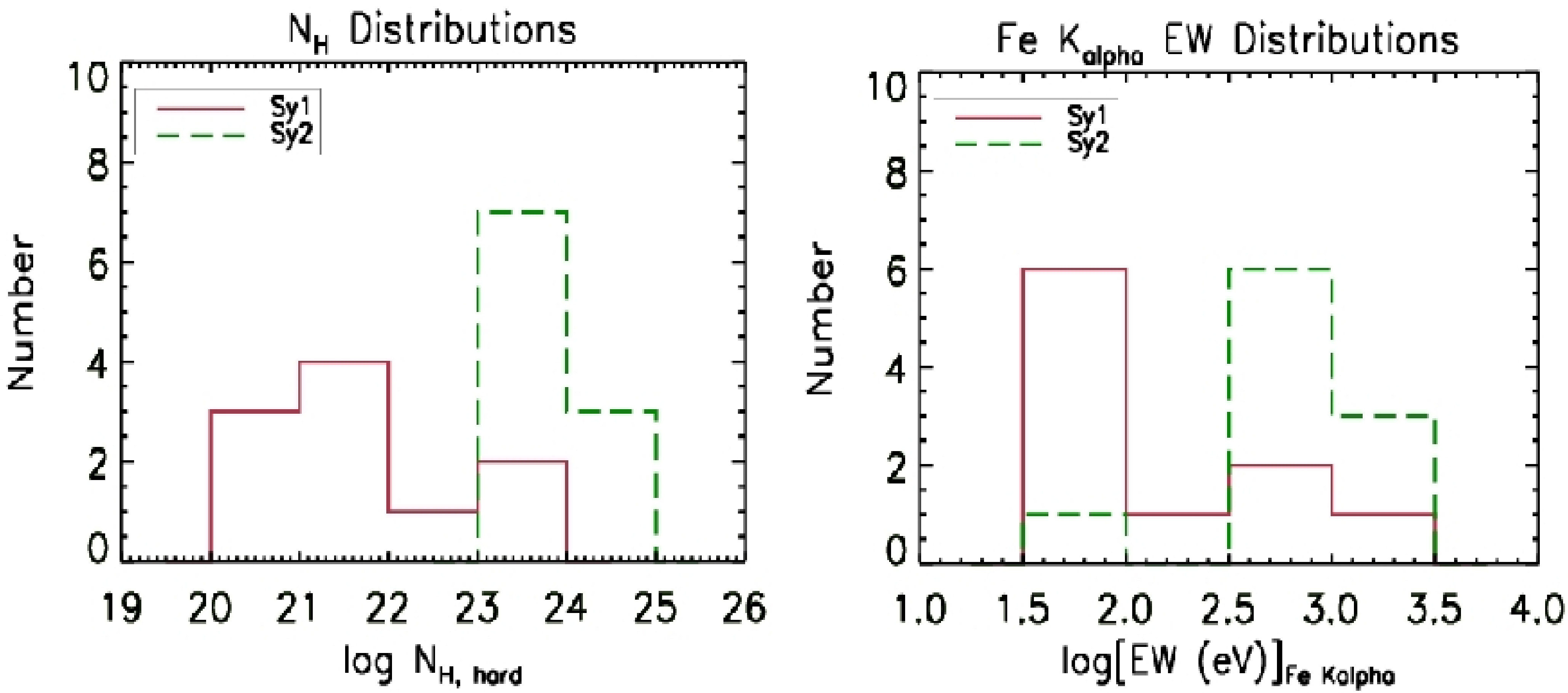
Preliminary Results From Spectral Analysis

Spectral Parameters



(Singh V., Shastri P. & Risaliti G., 2008 (*in preparation*))

Results & Conclusions

- For our sample, the type 2 Seyferts, i.e. purportedly obscured ones, have systematically lower X-ray luminosity in compared to type 1 Seyferts in soft (< 2.0 keV) as well as in hard (2.0 – 10.0 keV) X-ray bands.

- The flux ratio of hard X-ray (2-10 keV) to [O III] λ5007 line emission for Seyfert 2s is systematically lower than 1s.

- We find that distributions of X-ray continuum luminosity in different bands, spectral and diagnostic parameters (N_H, Γ, EW of Fe Kα, flux ratio of hard X-ray to [O III] line) are broadly consistent with the predictions of the Unification Scheme.

Thank You