

Partial Covering X-ray absorption & Variability in AGN

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Collaborators:

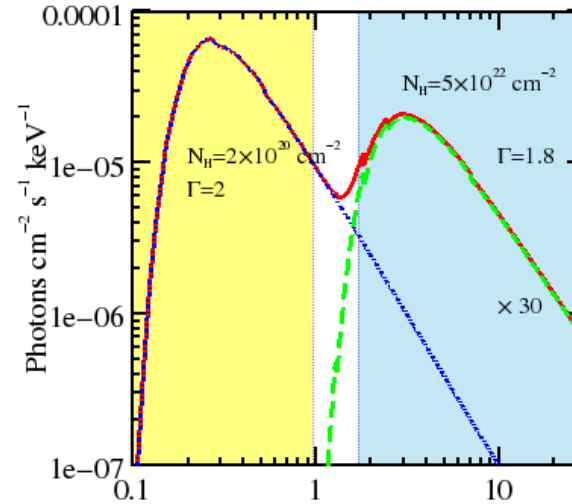
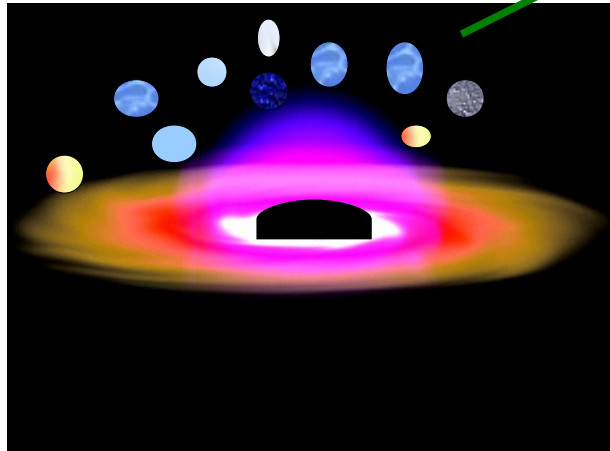
Ranjeev Misra (IUCAA), Dipankar Bhattacharya (IUCAA)



Partial Covering X-ray Absorption (PCA)

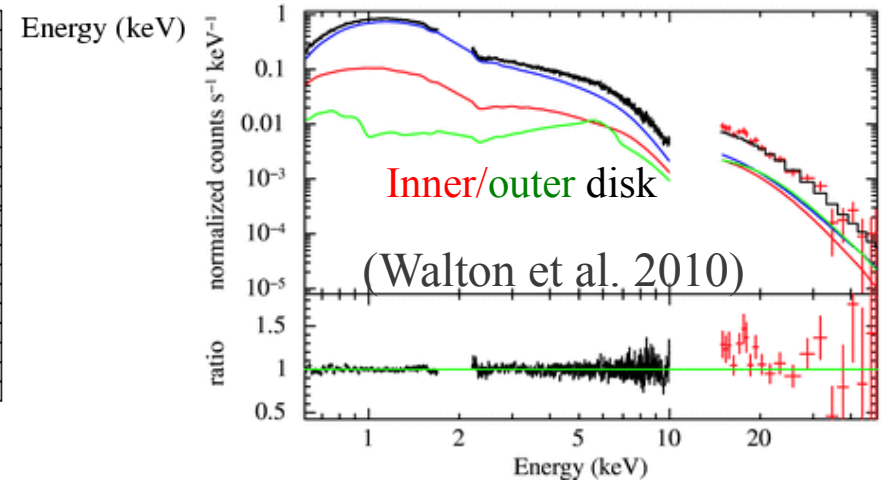
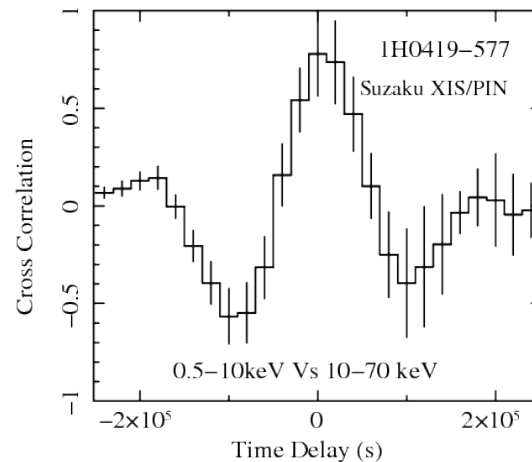
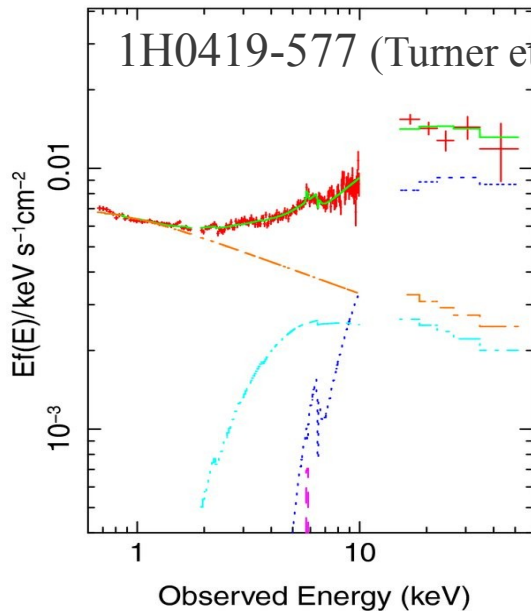
Patchy Absorber

Holt et al. 1980



Correlated X-ray variability between soft & hard bands.

Difficult to find such AGN?

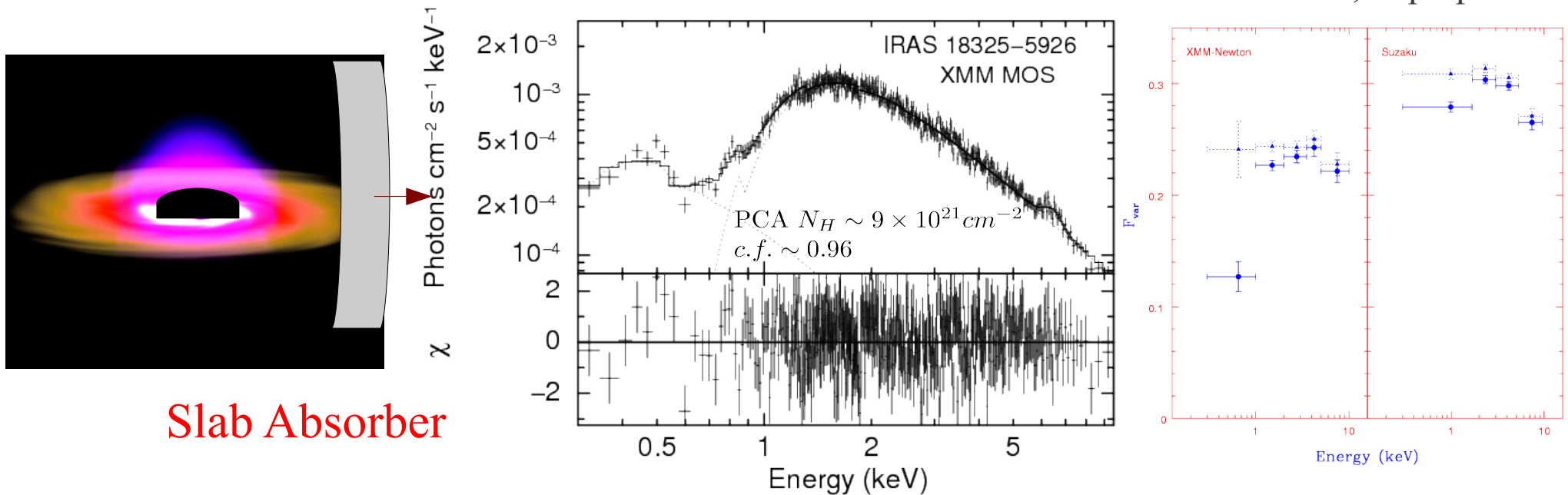


1H0419-577: Not a unique PCA source.



PCA model in Seyfert 2s (Scattered + direct emission)

Cheeran et al. 2011, in prep.

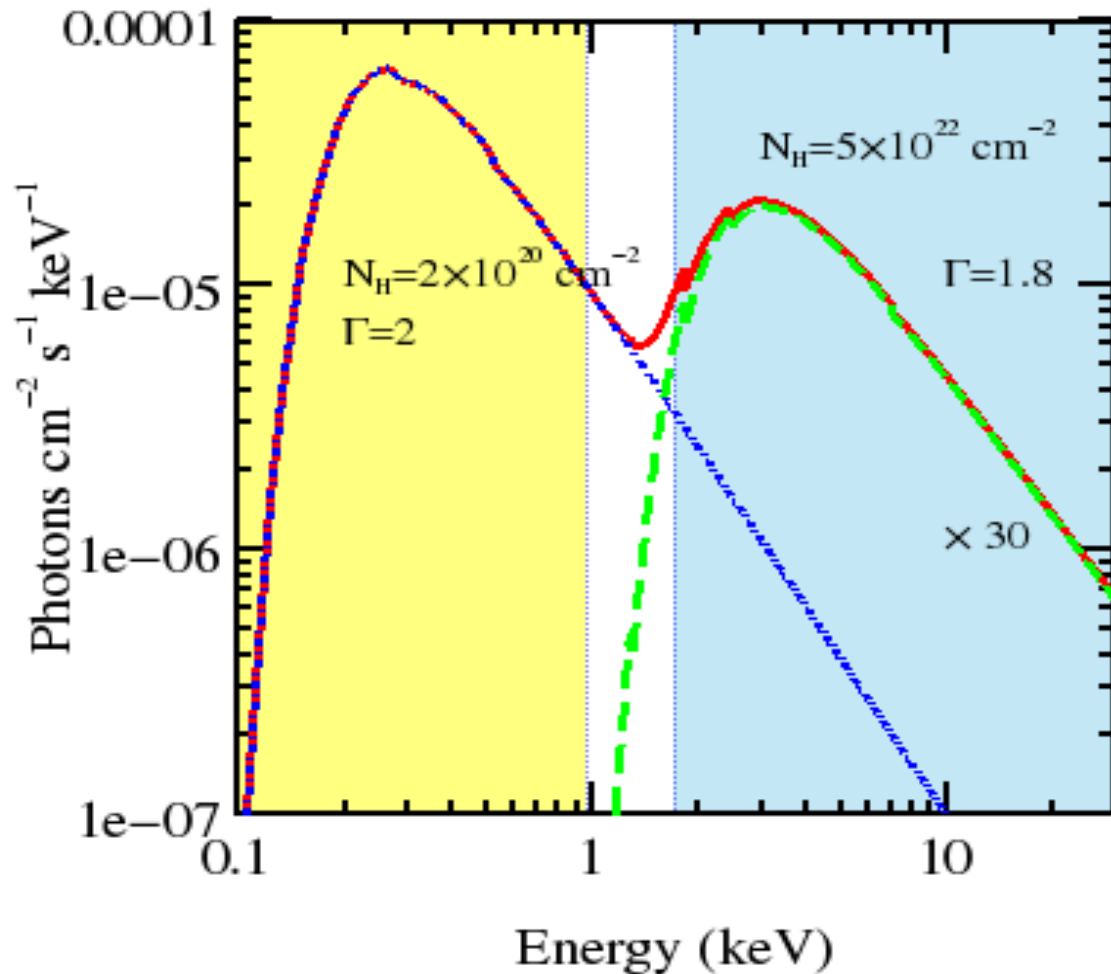


Slab Absorber

- Scattered component \sim a few % of the primary emission
- Variable primary emission but constant scattered component on short time scales



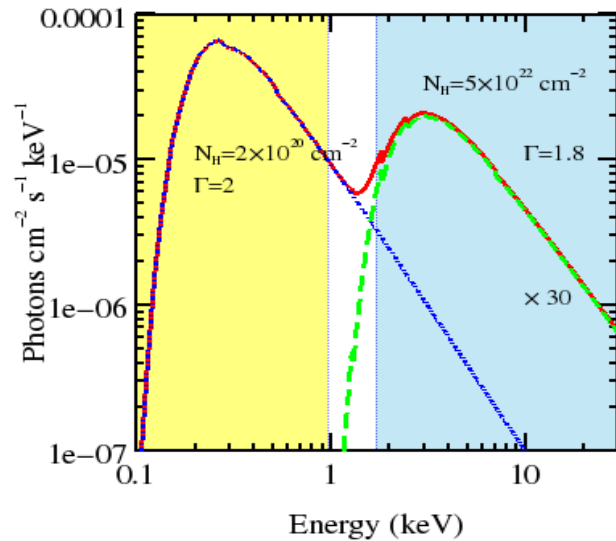
PCA model



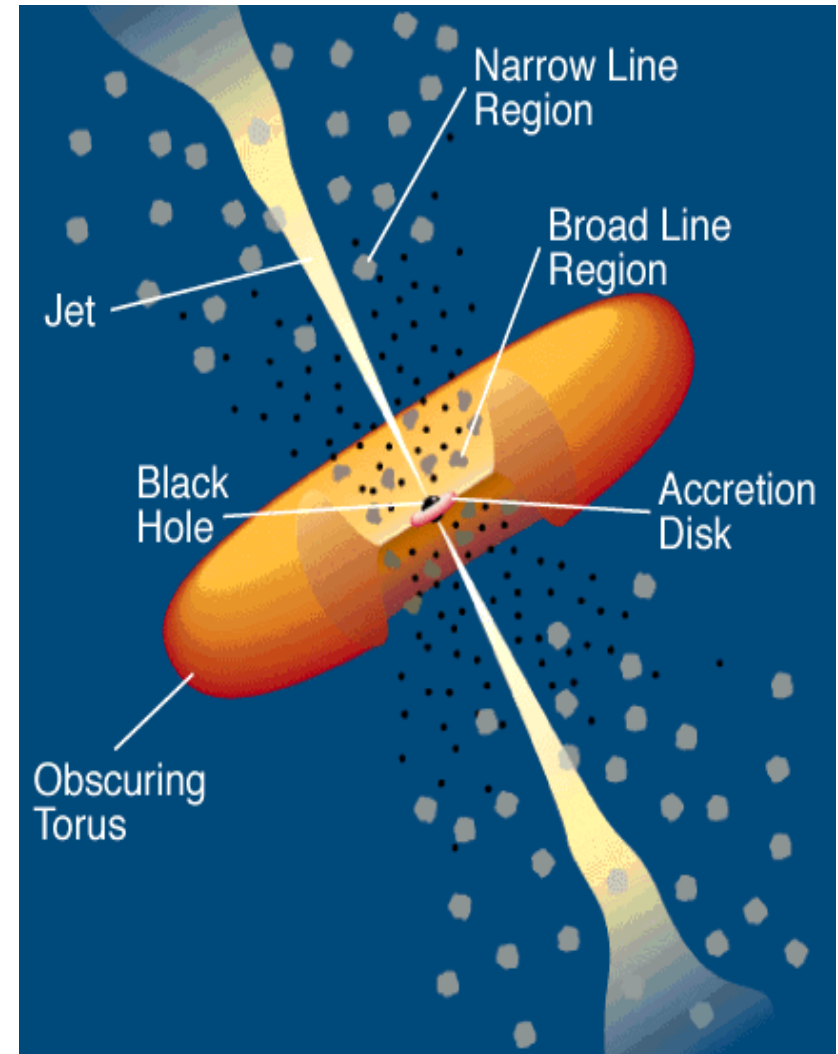
If the absorbed & Unabsorbed parts are both variable **but not correlated?**



PCA model – **Disk-Jet** connection



- The low energy unabsorbed component can arise from a jet.
- High energy absorbed component can be the primary emission absorbed by the cold torus.
- Disk-Jet connection



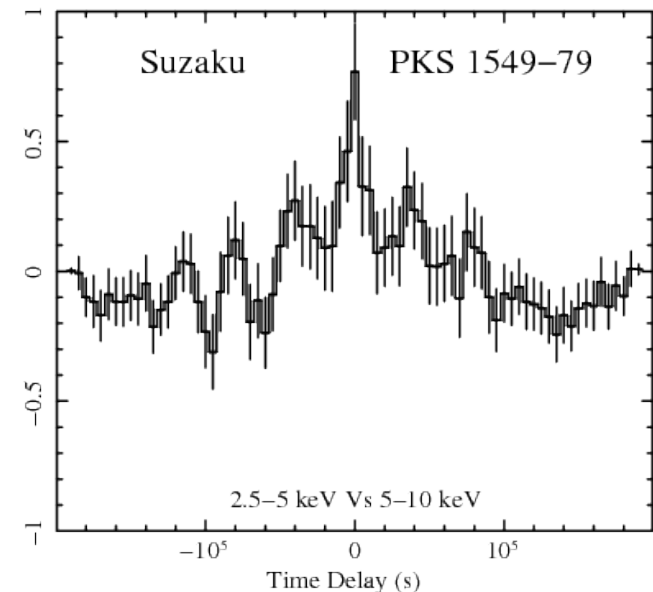
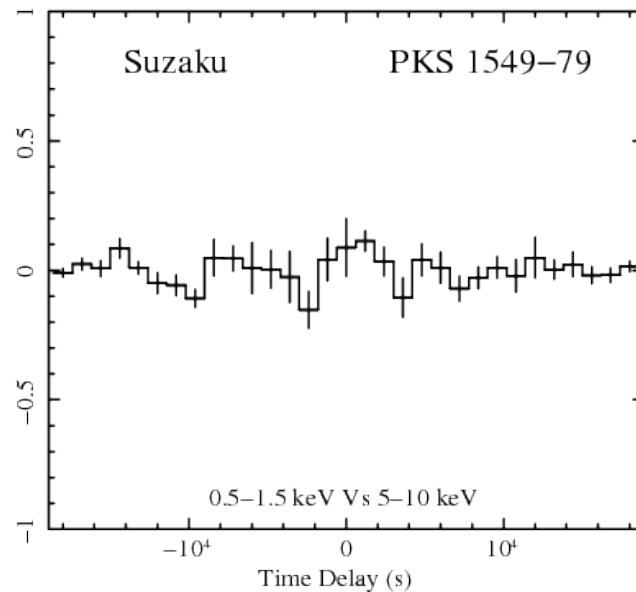
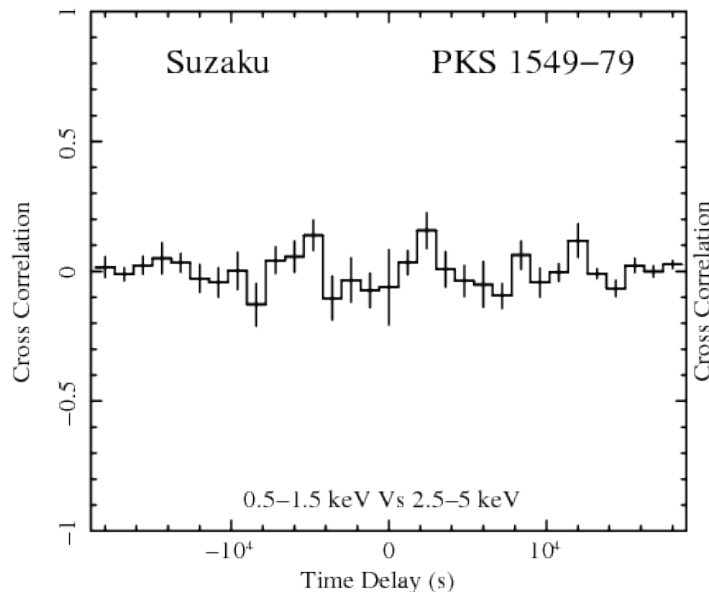
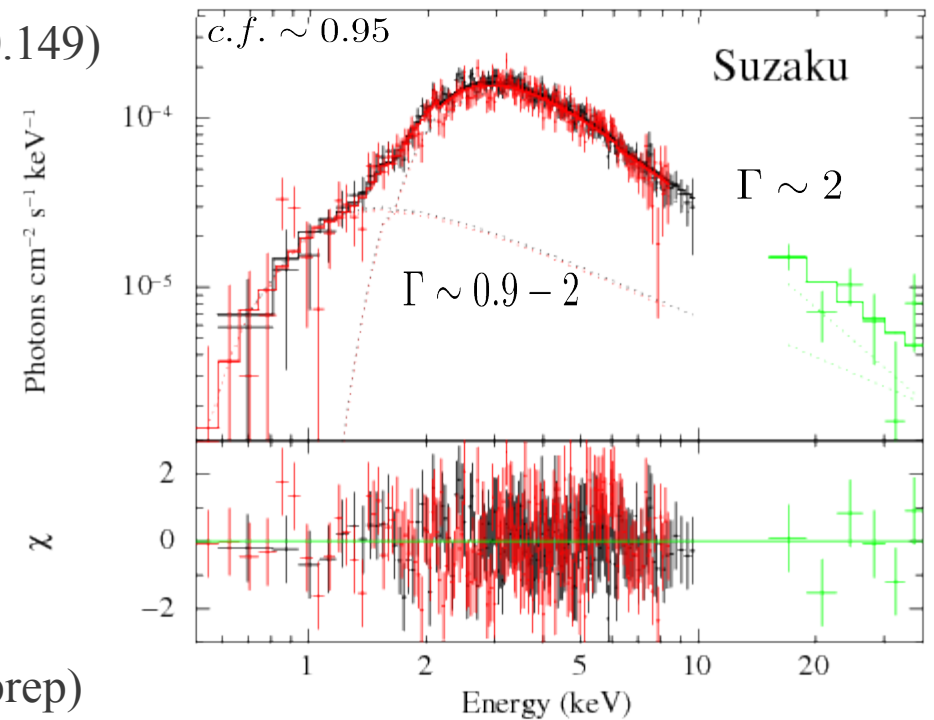
PKS1549-79

($z=0.149$)

Radio-loud NLS1

- Variability on scales of 10ks
- No correlation between unabsorbed and absorbed PL
- Two bands of absorbed PL correlated.

(Dewangan et al. 2011, in prep)

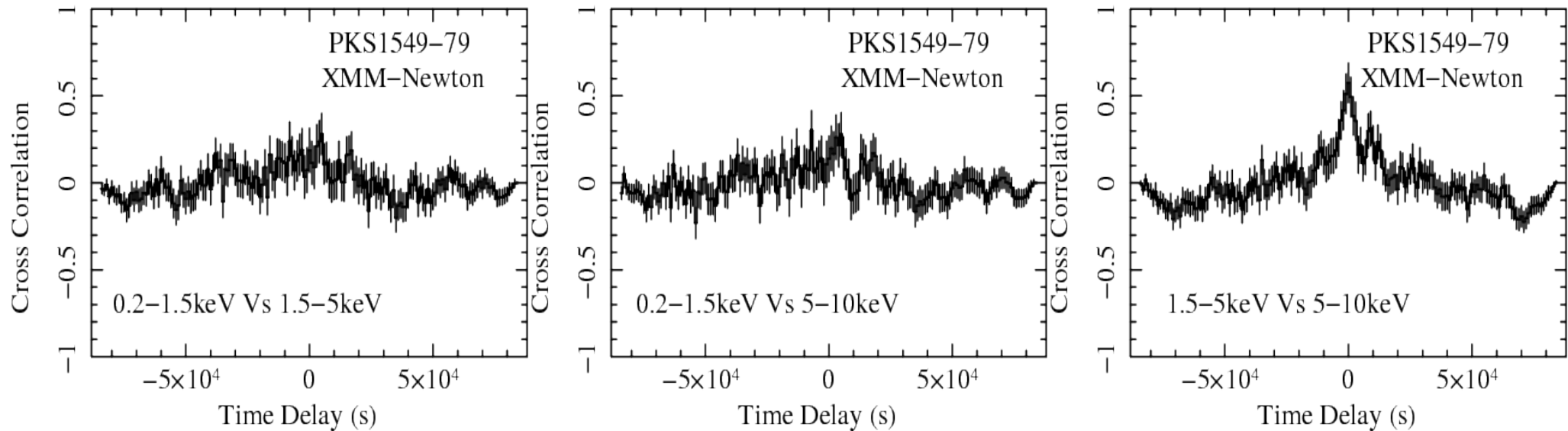
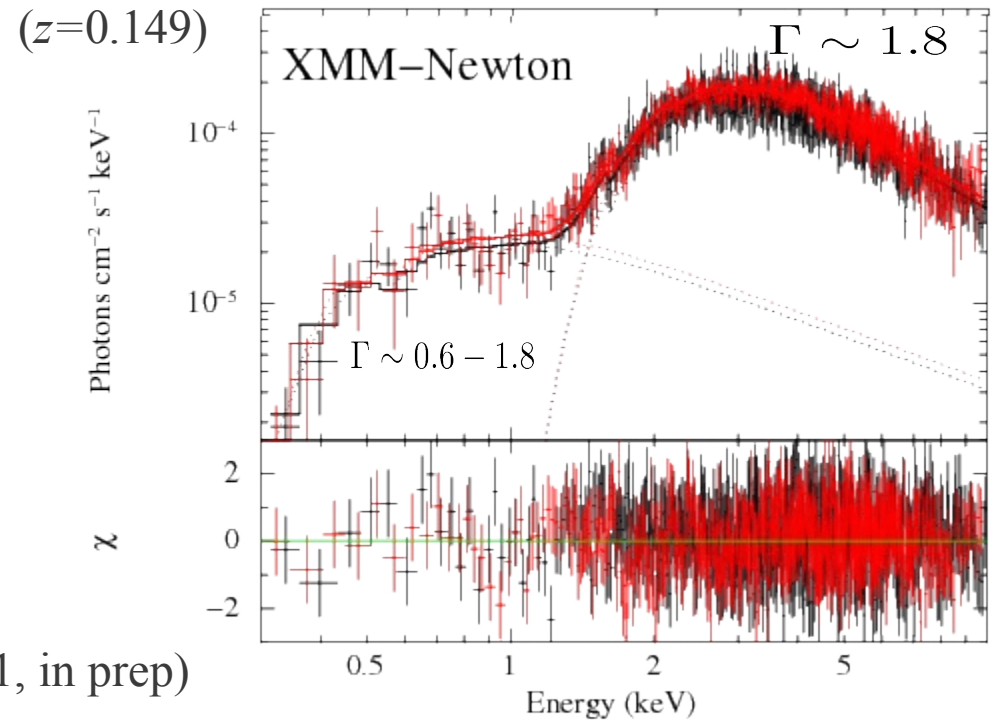


PKS1549-79

A radio-loud NLS1

- No correlation between unabsorbed and absorbed PL
- Two bands of absorbed PL correlated.

(Dewangan et al. 2011, in prep)



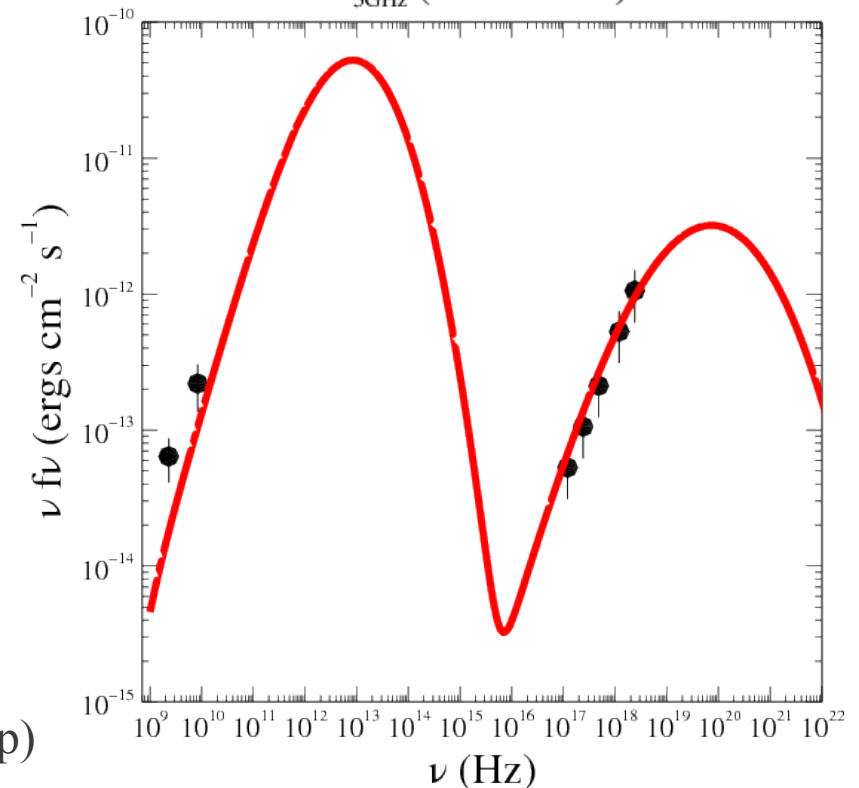
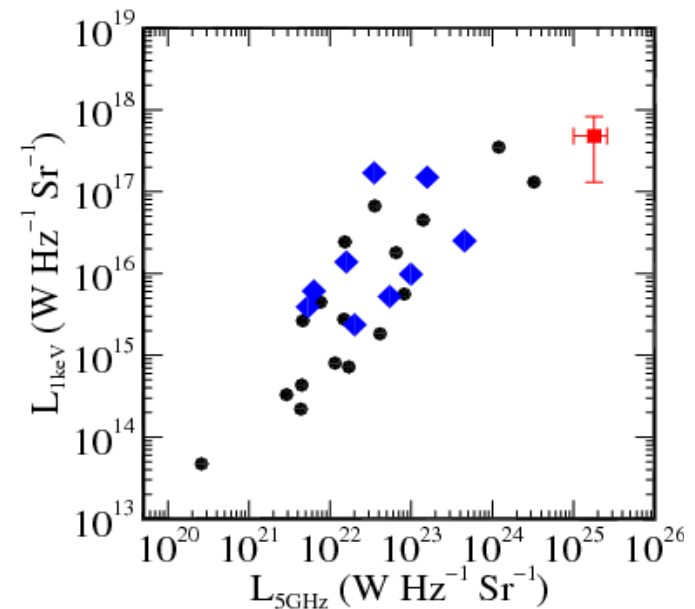
PKS1549-79 – Soft PL

- Radio-X-ray correlation
- consistent with RLAGNs
(Evans et al. 2006)

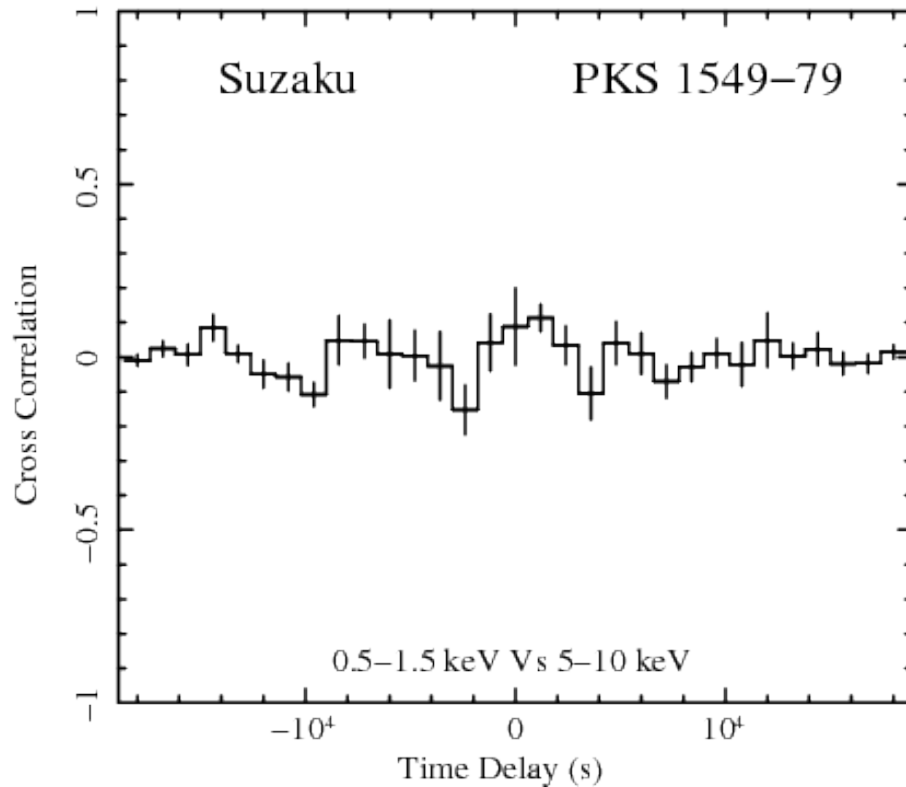
- SED well described by an SSC model by Tramacere et al. (2009) with LP electron energy distribution

$$n(\gamma) = K(\gamma/\gamma_0)^{-s} \quad (\gamma \leq \gamma_0)$$
$$n(\gamma) = K(\gamma/\gamma_0)^{-(s+r \log(\gamma/\gamma_0))} \quad \gamma > \gamma_0$$

- Soft PL is the X-ray jet emission
(Dewangan et al. 2011, in prep)



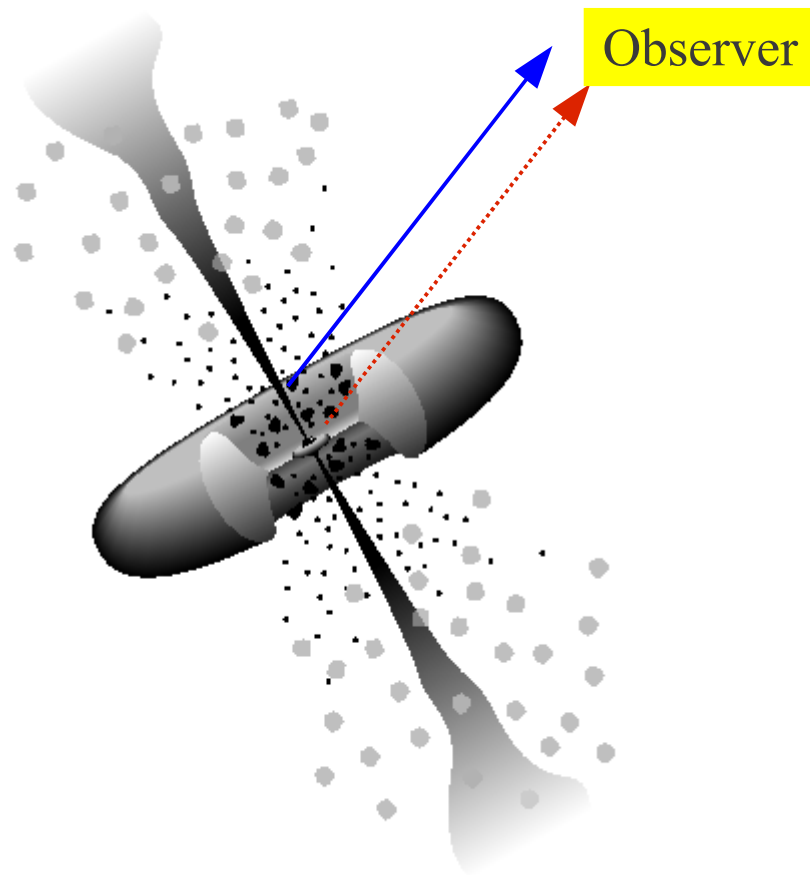
PKS1549-79 – Disk-Jet connection



- Soft PL – X-ray Jet
 - Radio-X-ray correlation
- Absorbed hard PL – disk/corona emission
 - Strongly absorbed
- No correlation on short time scales
 - No disk-jet coupling?



PKS1549-79 – Disk-Jet connection

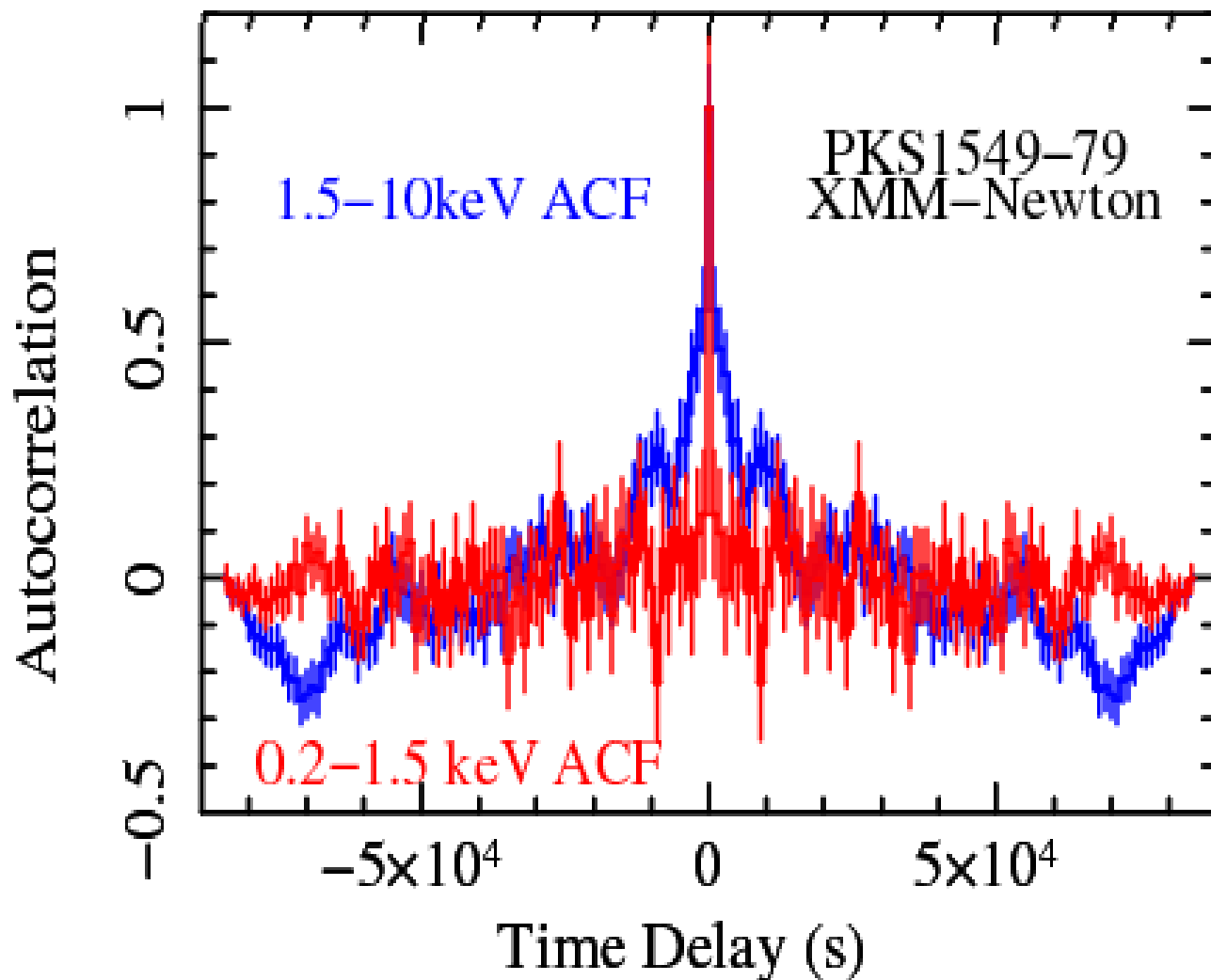


- X-ray jet & disk/corona components are probing different length scales.
- **At the base, jet and disk/corona emission are coupled?**
- **Variability properties are similar with a lag? Long monitoring observations will probe this.**



PKS1549-79 – Disk-Jet connection

Does the disk/corona drive the jet?



- Disk/corona emission with broader ACF cannot drive X-ray jet with narrower ACF.
- No disk-jet coupling at the shortest time scales?

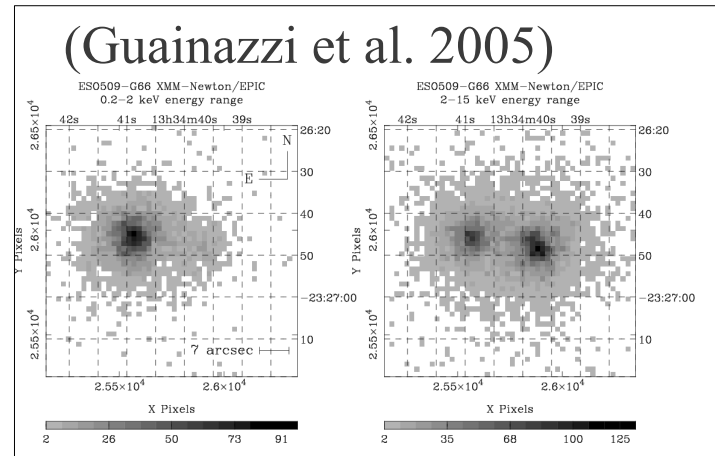
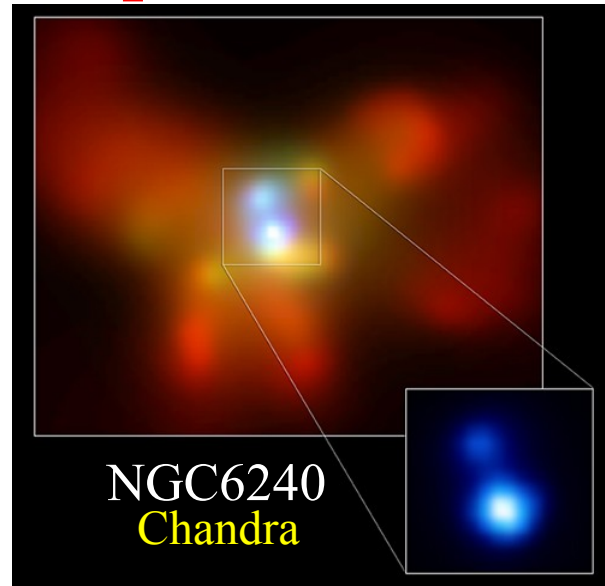


PCA model for RQ AGNs- ??

If the low energy component does not arise from a jet.

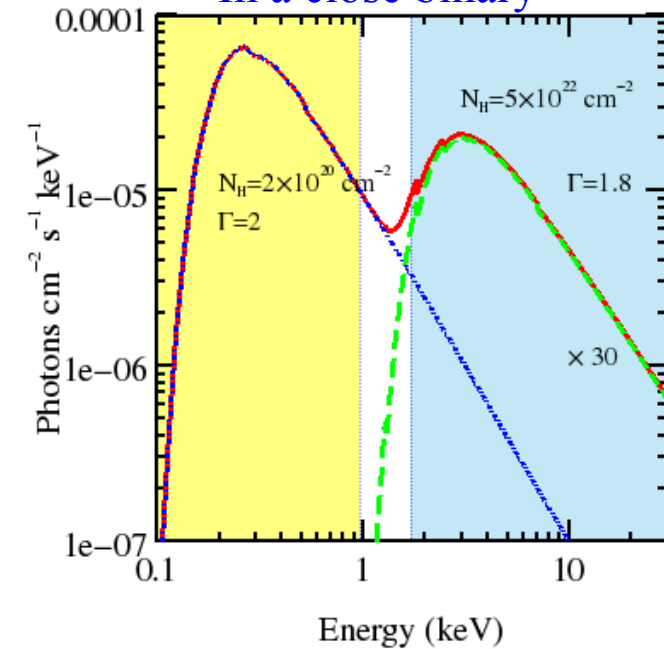
(Komossa et al 2003)

- Two hard X-ray nuclei with $L_X \sim (1.9, 0.7) \times 10^{42}$ ergs/s.
- Different amount of absorption columns.
- Both show flat PL and iron $K\alpha$ lines
- Separation ~ 1.4 kpc



(Dewangan & Misra 2011, in prep.)

Two close active nuclei
 Absorbed + Unabsorbed nuclei
 In a close binary



*Uncorrelated X-ray
 Variability between
 Soft & hard bands.*

PCA+X-ray Variability \Rightarrow Unresolved binary SMBHs

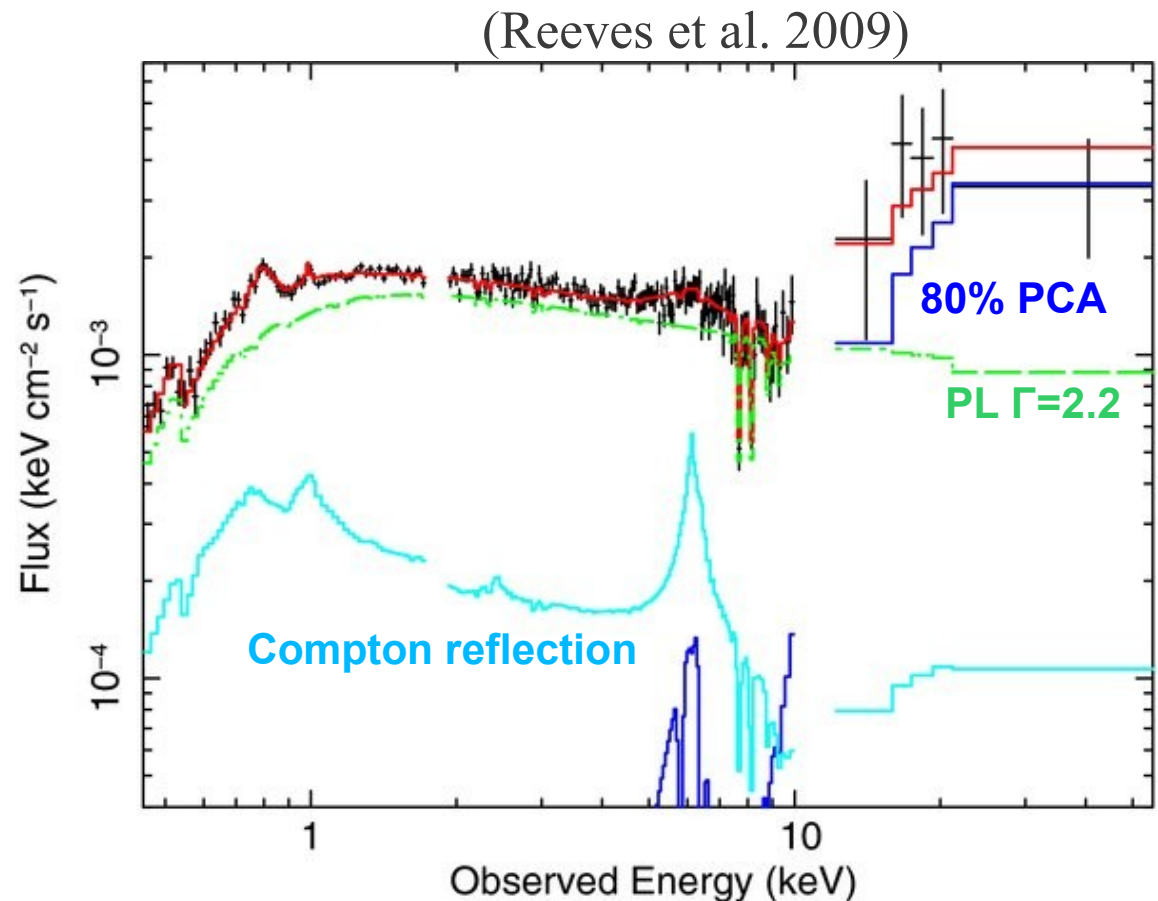


PDS456 – Previous Suzaku study

- Most powerful quasar in the local universe.

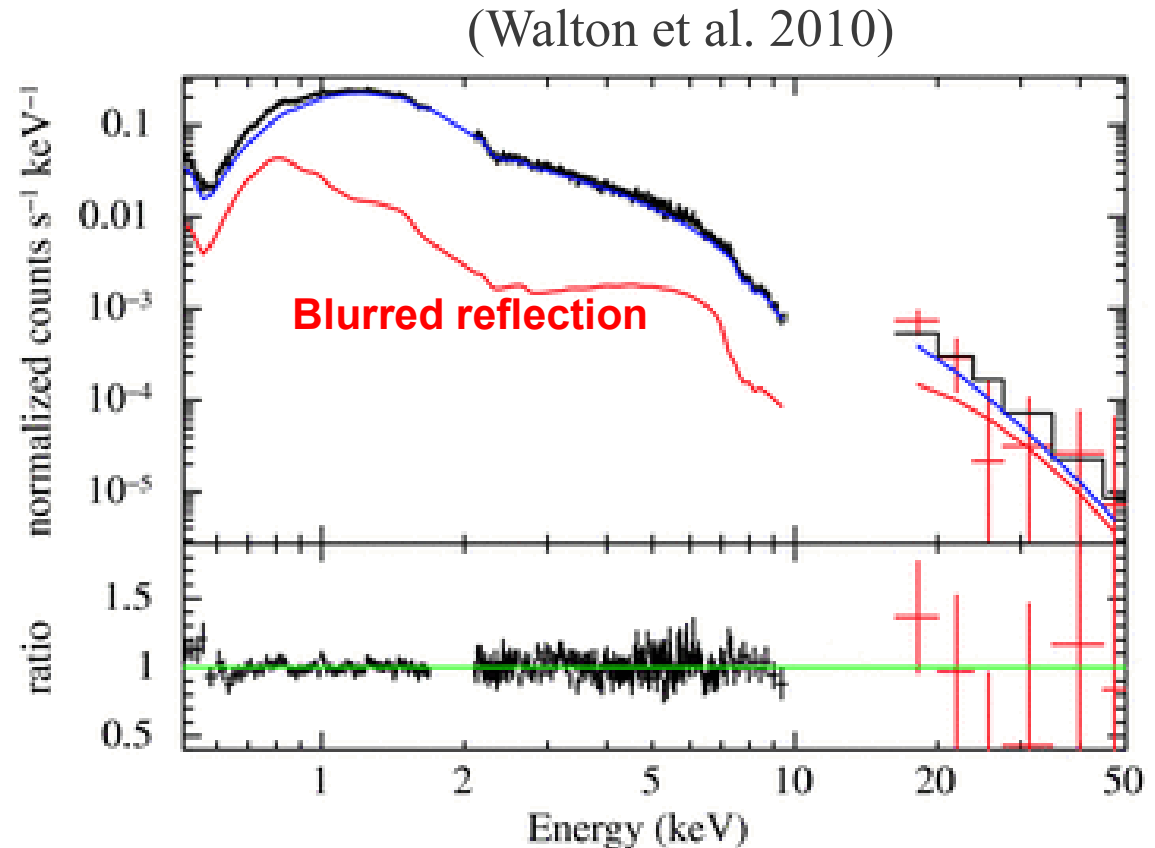
$$L_{bol} \sim 10^{47} \text{ ergs s}^{-1}$$

- $M_{BH} \sim 10^9 M_{\odot}$
- High velocity outflows ($v \sim 0.25c$)
- **Hard X-ray excess – Compton thick PCA**

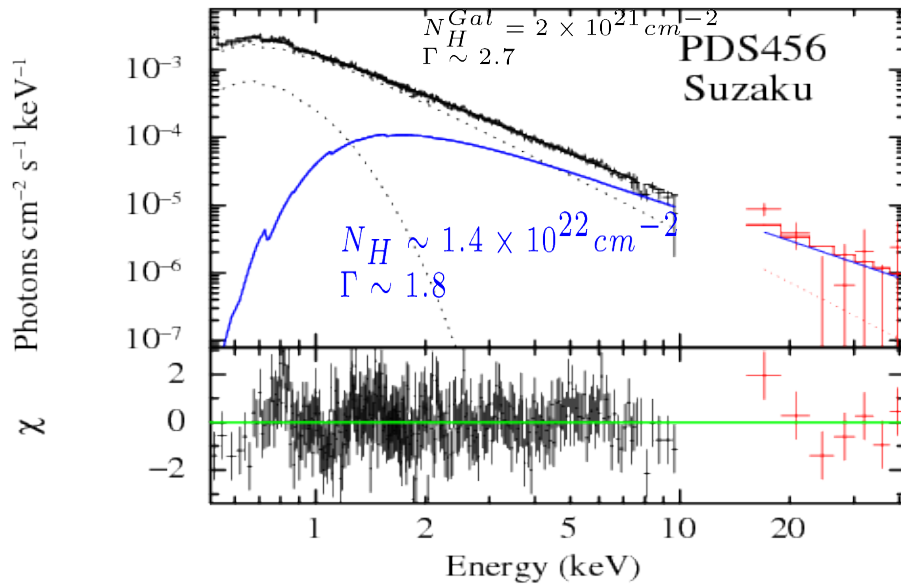


PDS456 – Previous Suzaku study

- Reanalysis with updated background for HXD/PIN
- **Reduced hard excess**
- **Blurred reflection from partially ionized accretion disk**
 - **Highly inclined disk ($i = 70$ degrees)**
 - **High iron abundance**
 $A_{Fe} > 8.6$ Solar

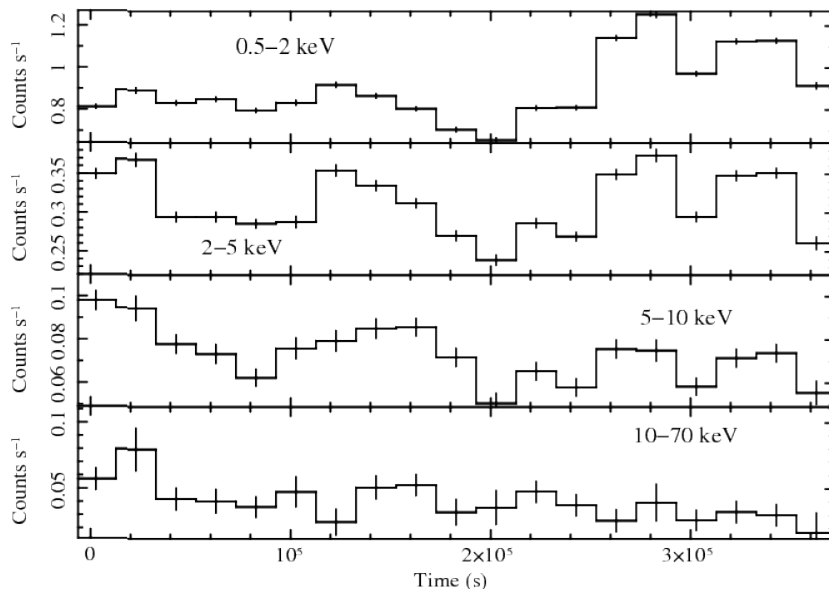


PDS456 - X-ray Emission

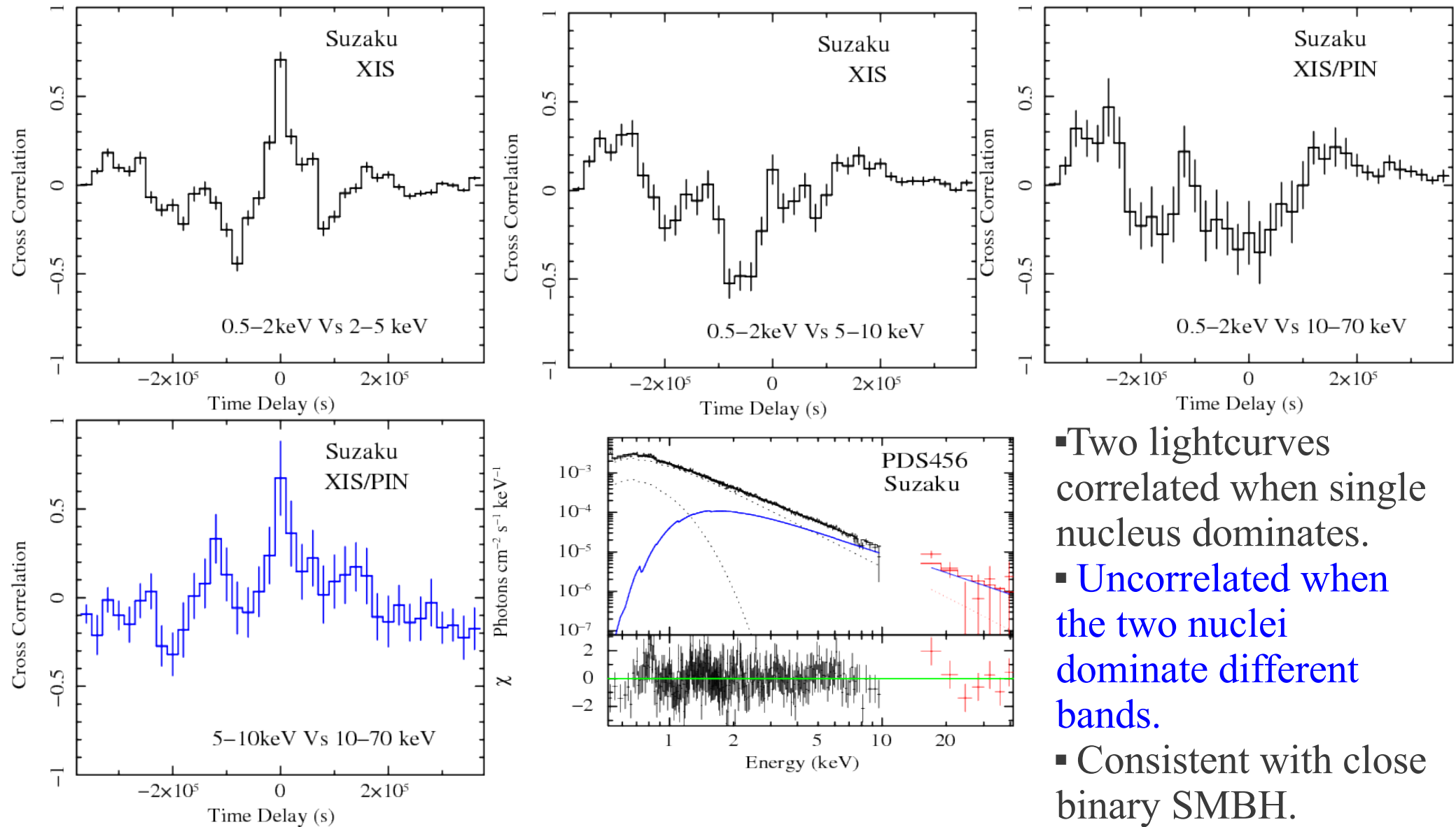


(Dewangan & Misra 2011, in prep.)

- A combination of absorbed PL
 $N_H \sim 1.4 \times 10^{22} \text{ cm}^{-2}$
 $\Gamma \sim 1.8$
- & relatively unabsorbed **blackbody** ($kT \sim 140 \text{ eV}$)
 + PL ($\Gamma \sim 2.7$)
- **Binary active nuclei?**
- **Complex X-ray Variability – Correlations consistent with binary SMBH model.**



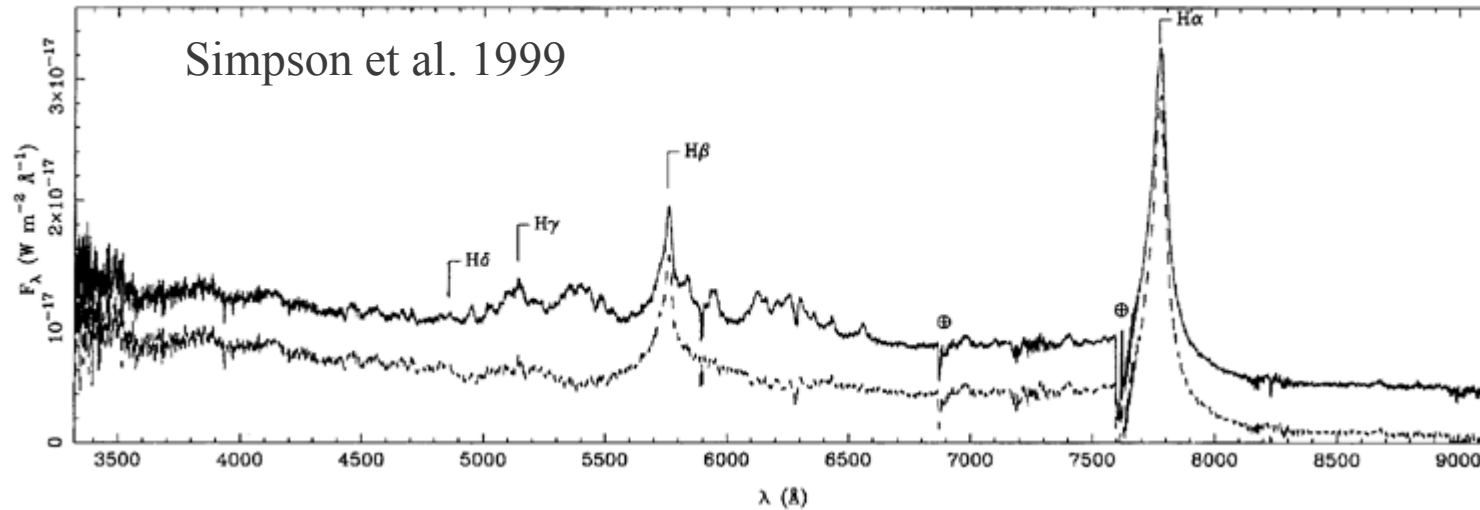
PDS456 - Cross-correlation



- Two lightcurves correlated when single nucleus dominates.
- Uncorrelated when the two nuclei dominate different bands.
- Consistent with close binary SMBH.



PDS 456 as Binary SMBH



- Common BLR
- Separation $<$ BLR size

$$M_{BH1} + M_{BH2} \sim 10^9 M_\odot$$
$$L_{bol} \sim 10^{47} \text{ ergs s}^{-1}$$

$$\text{Size } R_{BLR} \sim 0.7 \text{ pc}$$

$$\text{Separation } d < 0.7 \text{ pc}$$

$$M_{BH1} \sim M_{BH2} \sim 5 \times 10^8 M_\odot, P < 2000 \text{ yrs}$$



Summary

- PCA shaped X-ray spectrum can arise from different physical scenarios.
- PCA and X-ray variability together can constrain physical models.
- PCA, X-ray variability & radio emission can be used to separate X-ray jet contribution and study disk-jet connection. **In the NLS1 PKS1549-79, the disk/corona and jet may not be coupled on short time scales.**
- In Radio-Quiet AGN, PCA & X-ray variability can be used to identify close, unresolved binary SMBHs. PDS 456 may be one such candidate.



THANK YOU

