Seyferts : AstroSat Results

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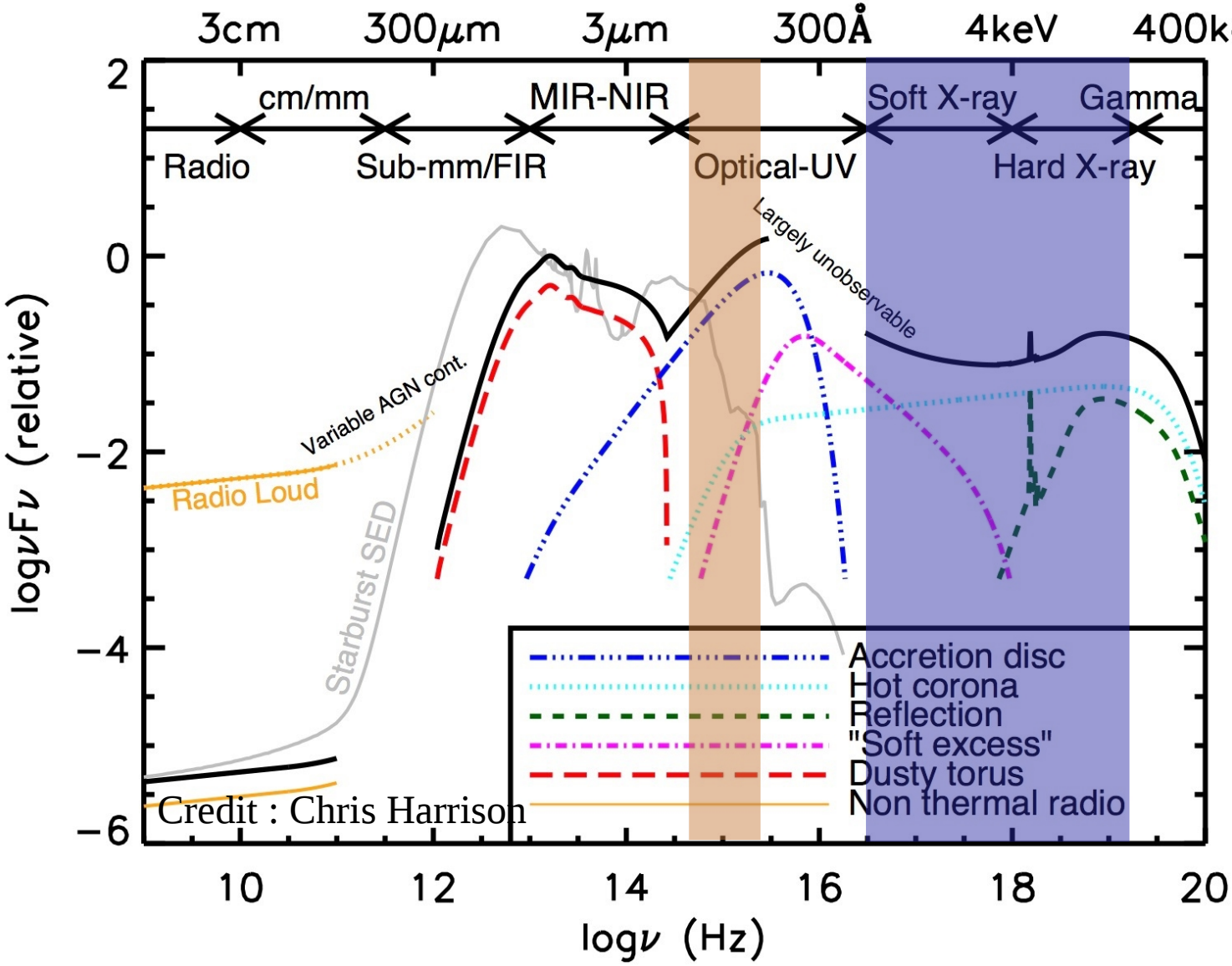
Thanks to
AstroSat team members, Main Pal & Labani (IUCAA), Pramod Pawar (SRTM Univ, Nanded)
Ian McHardy (Southampton, UK), Iossif Papadakis (Crete, Greece)

X-ray study of Seyferts in India

- Pioneered by KP
  - Discovered Soft X-ray Excess emission from a Seyfert 1 galaxy in 1985. (Soft excess was also discovered independently by Arnaud et al. 1985).
  - Wrote 11 papers (many on Seyferts) during 1991-92 with Rao & Vahia
  - Identification of new NLS1s from KP's catalog of ultrasoft X-ray sources (1995)
- Also worked on radio galaxies, blazars, clusters of galaxies, SNR, CVs, active stars, normal galaxies
- From Indian perspective, enormous effort of building SXT, PV and science observations.

AGN SED & Astrosat coverage



UVIT : FUV/NUV/VIS
15 optical/UV filters
(1300 - 5500A)

SXT (0.2-8 keV)

LAXPC (3-80 keV)

CZTI (10-100 keV)

AGN truly MW objects

Astrosat well suited for MW study of nearby bright AGN

Seyferts observed during PV & GT

~20 Seyferts observed with AstroSat

Mrk110	G05	SXT
NGC4051 (3 obs)	G05	SXT/UoL/UVIT
RE1034+396	G05	SXT
Fairall 9	G06	SXT
NGC3998	G05	SXT
MCG-6-30-15	G05	SXT-UoL
PG1415+451	G05	SXT-UoL
PDS456	G05	SXT-UoL
NGC4593	G05	CZTI
NGC7314	G06	UVIT
NGC4736	G05	UVIT
NGC1672	G05	UVIT
NGC7582	G05	UVIT
NGC4258	G05	UVIT
NGC4151	PV	MW

G06 and A02 cycle observation is ongoing

G06 : yet to be observed
SXT : Mrk766, NGC4151

A02

NGC3227, Mrk766, NGC4388, MCG-6-30-15, PDS456, IC4329A, NGC1365 Ark564, Mrk926

Seyferts : SXT Results

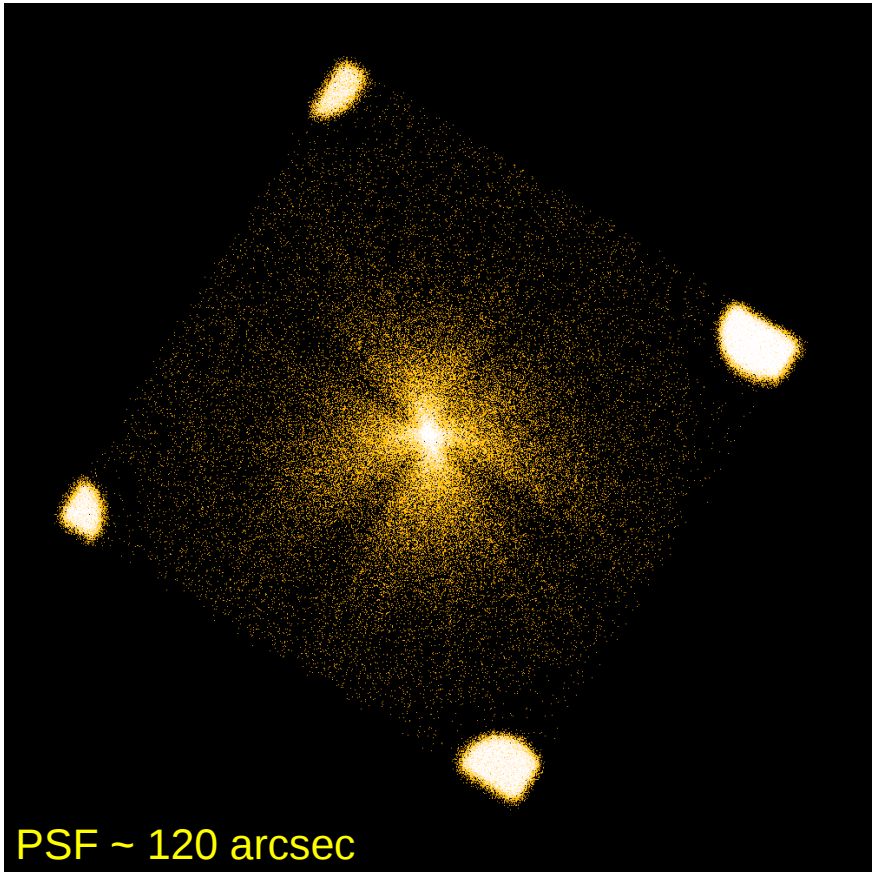
(Preliminary)

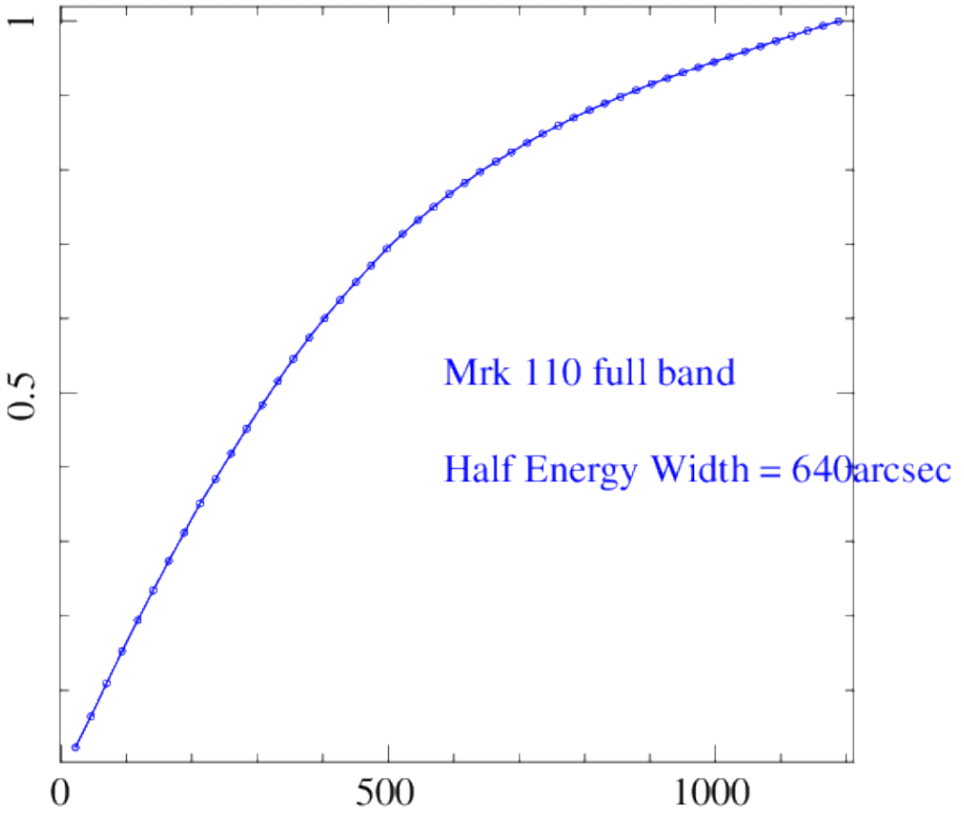
- **Mrk110** (2016-04-16 04:30 – 2016-04-17 19:13)

  Net SXT exposure : 38.7ks

Flux(2-10keV) ~ 2.8e-11 cgs

BH mass : 2x10^7 solar mass

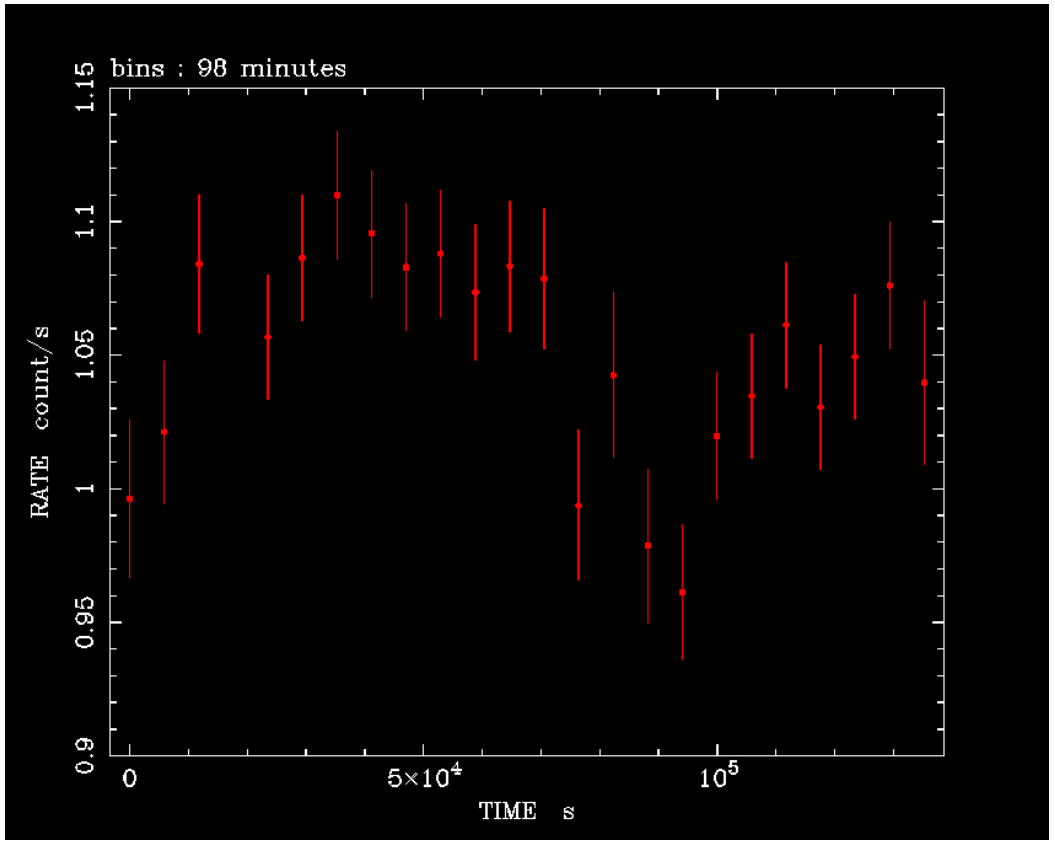


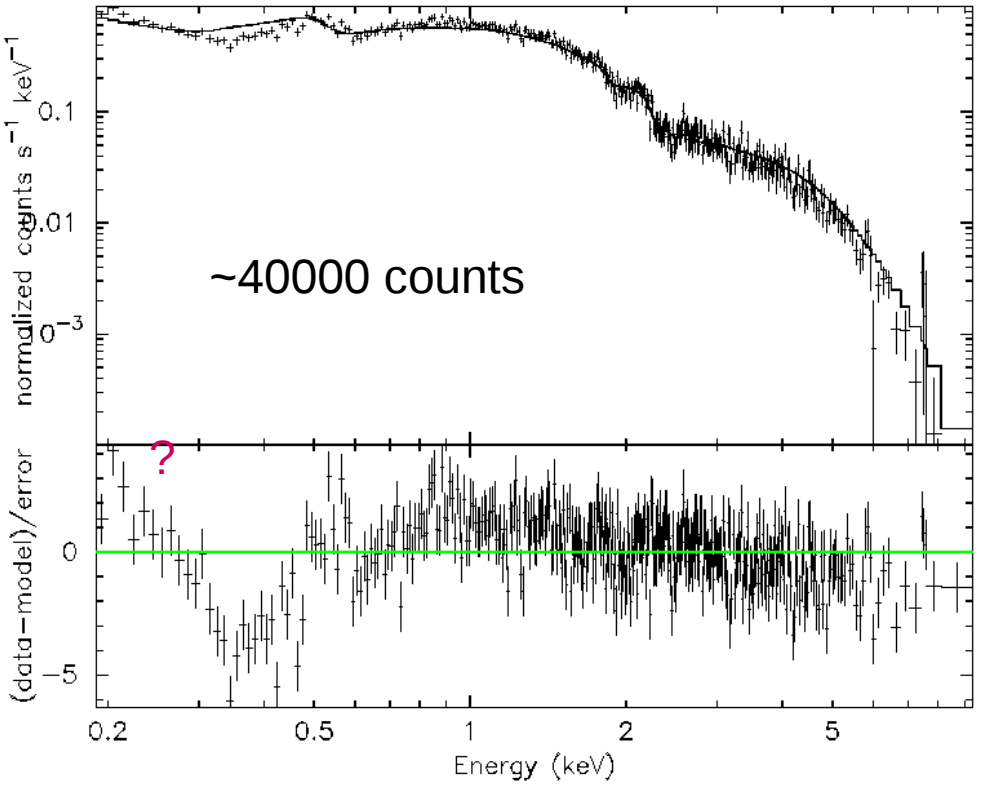


Mrk110 : Lightcurve and spectrum

Flux(2-10keV) ~ 2.8e-11 cgs

BH mass : 2x10^7 solar mass



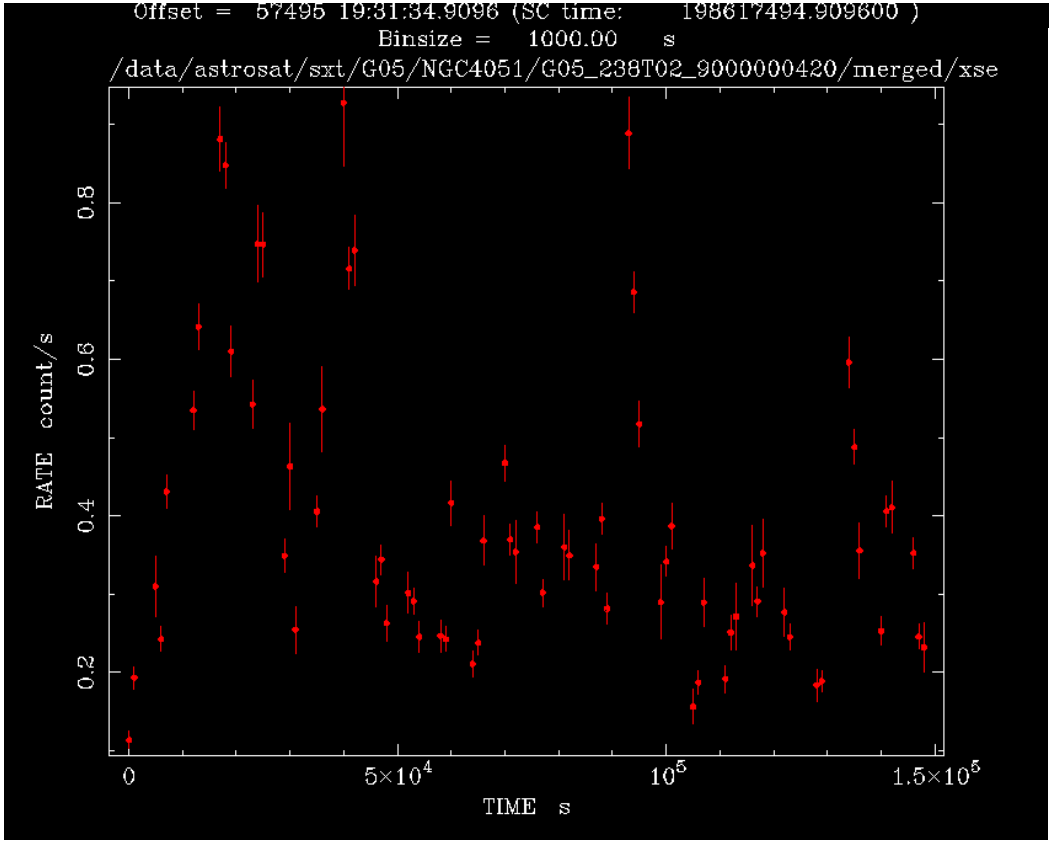


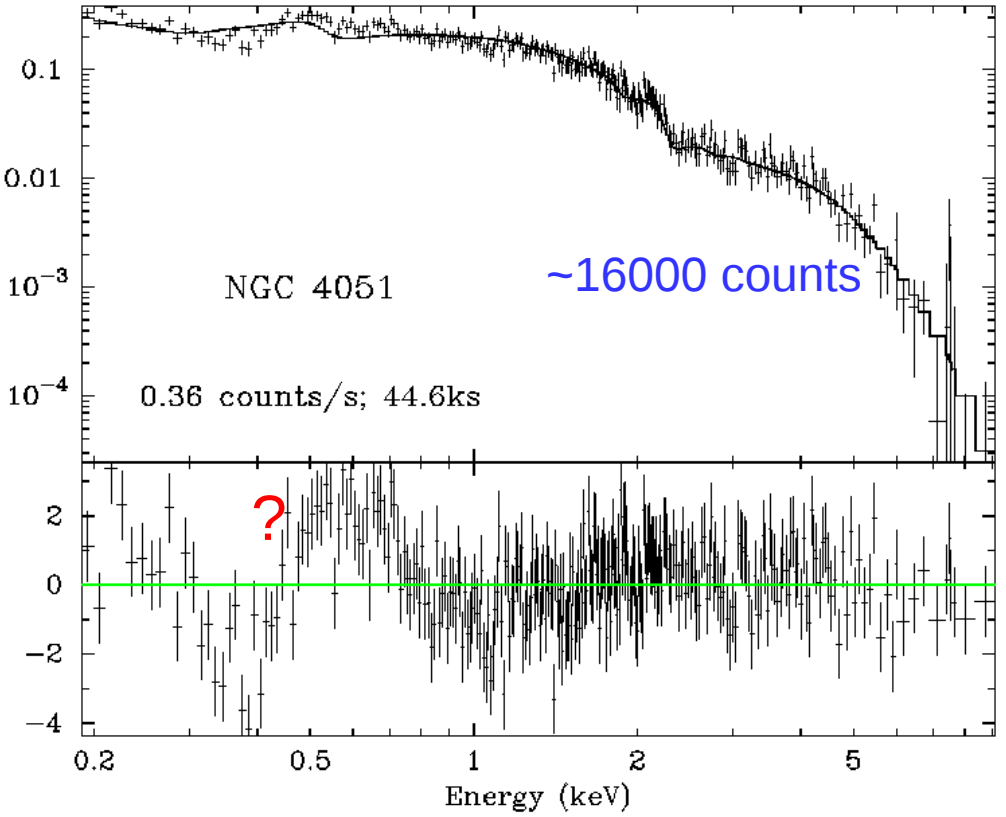
Seyferts : SXT Results

- **NGC4051** (2016-04-17 19:23 - 2016-04-19 13:32)

Net SXT exposure : 44.6 ks

BH mass : 1.3x10^6 solar mass,
flux (2-10) ~ 3e-11 cgs





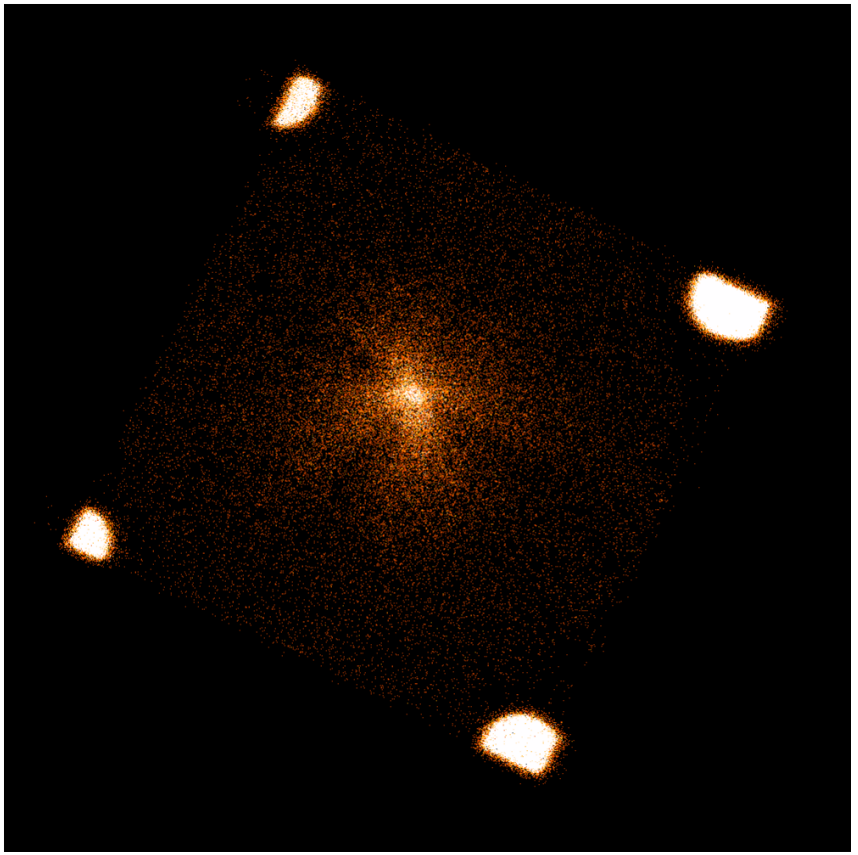
Seyferts : SXT Results

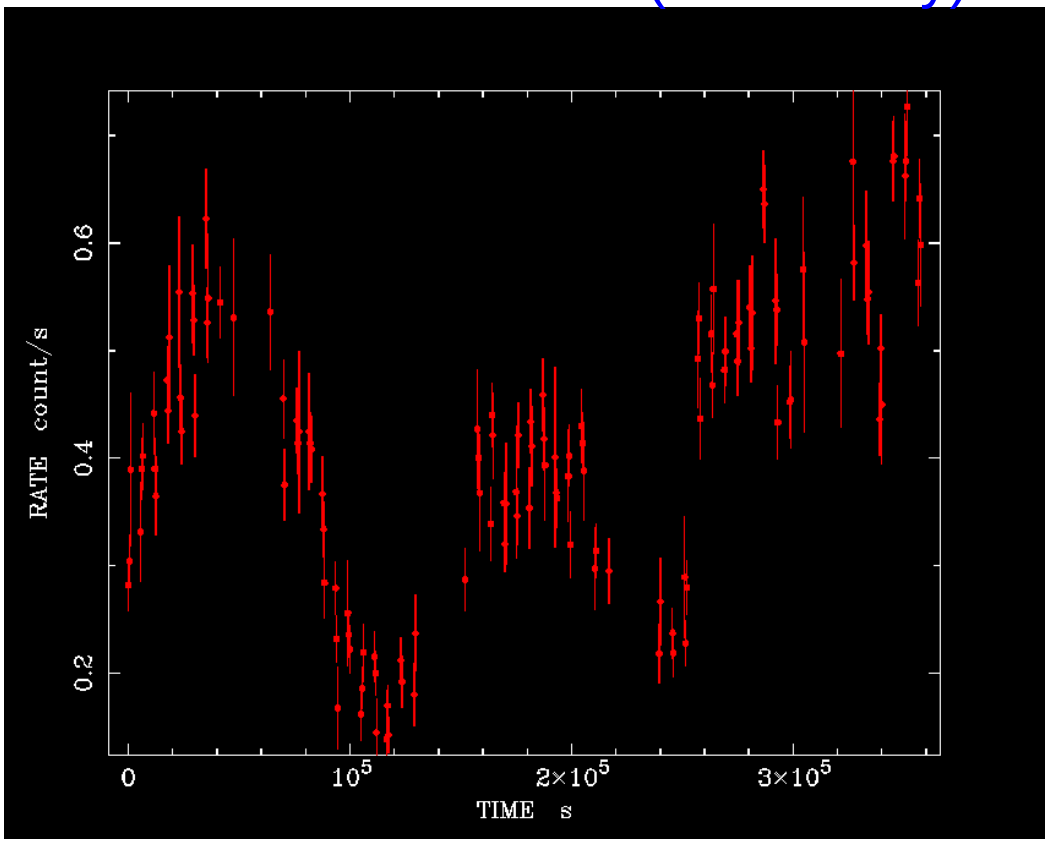
- **NGC 4593** (2016-07-14 10:06 – 2016-07-18 15:11)
- Net SXT exposure : 46.4ks

BH mass : 6x10^6 solar mass

F(2-10keV) ~1e-11 cgs

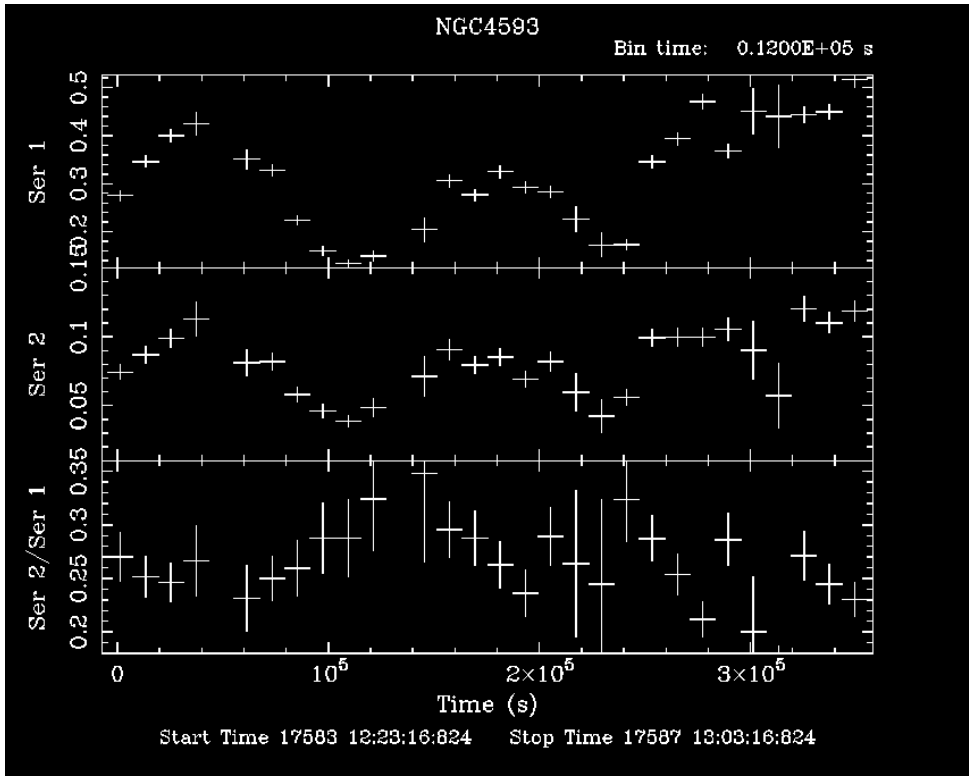
Simultaneous observations with XMM-Newton and Swift (I. McHardy)



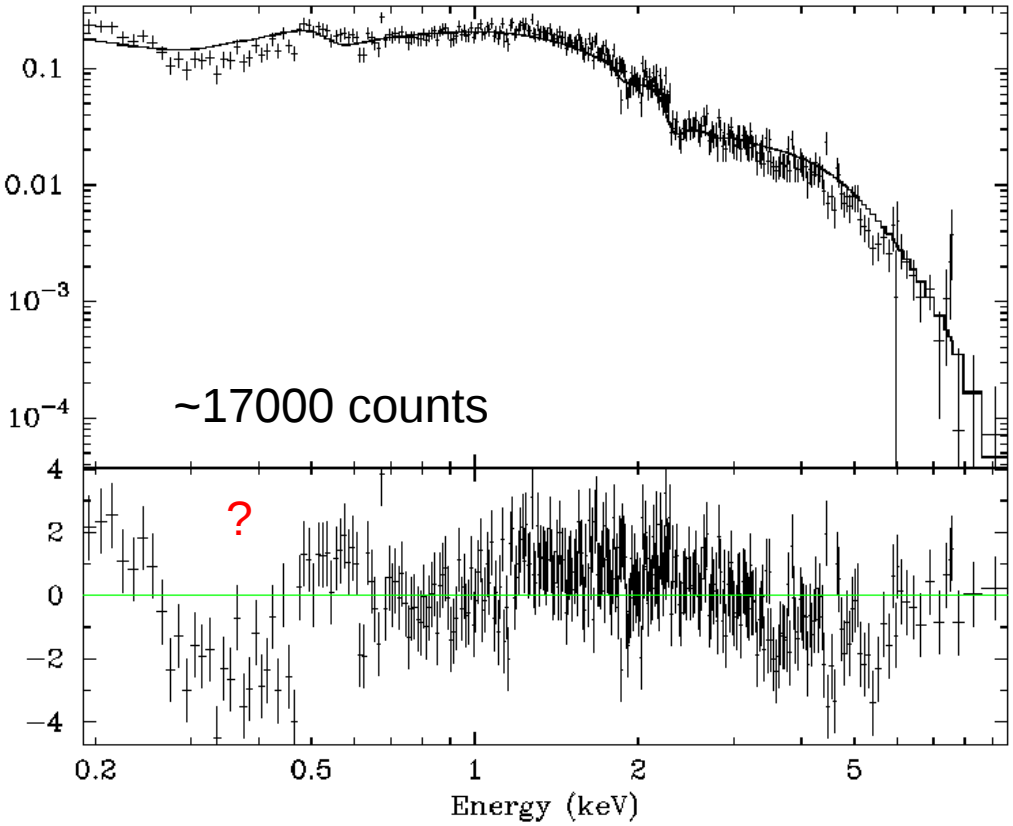


NGC4593 : Hardness ratio and spectrum

Spectral softening with flux



Mean spectrum : calibration issues

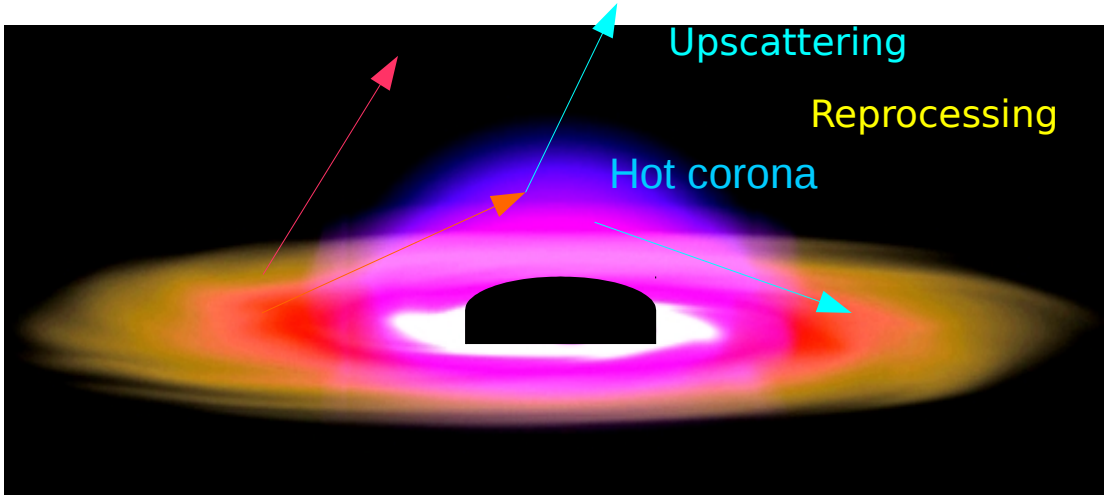


Long lightcurves

SXT data show excellent promise for X-ray/UV correlation studies.

UVIT data are being made available.

Optical/UV and X-ray Connection



Ian's Talk

- Reprocessing of X-rays into optical/UV
- Compton upscattering of optical/UV photons into X-rays
- Propagation of accretion rate fluctuations

} Optical/UV should lag behind X-rays with light crossing time

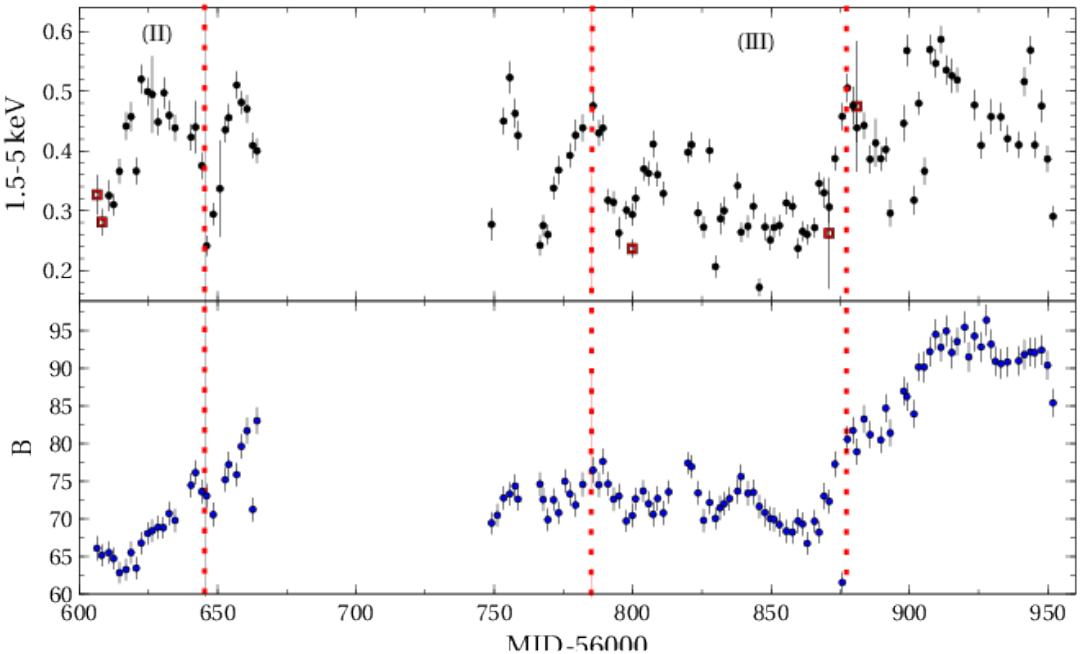
Time lag Vs wavelengh => Probe accretion disks

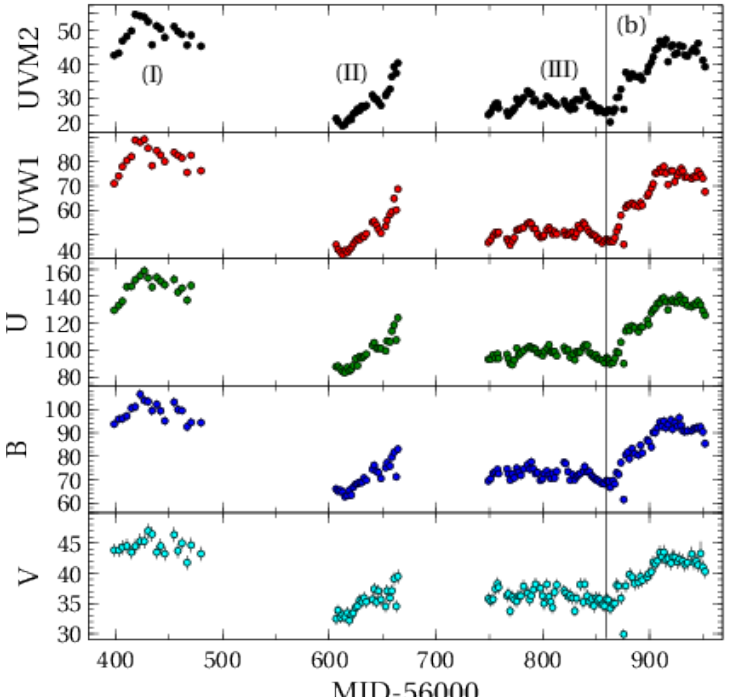
} Optical/UV should lead X-rays

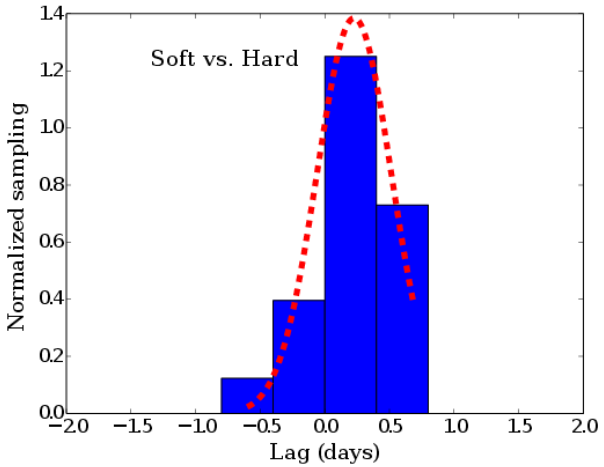
} Optical/UV should lead X-rays

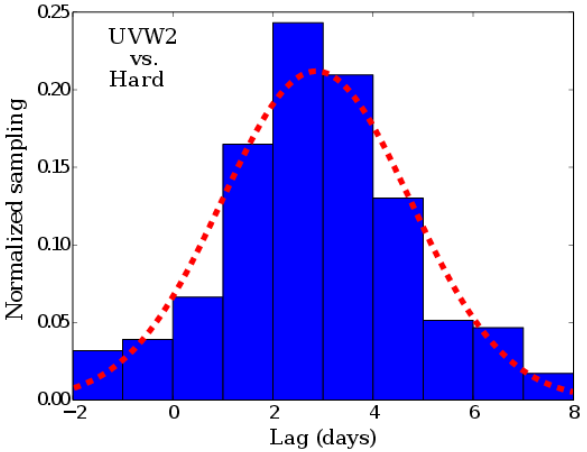
Fairall 9: UV/X-ray connection

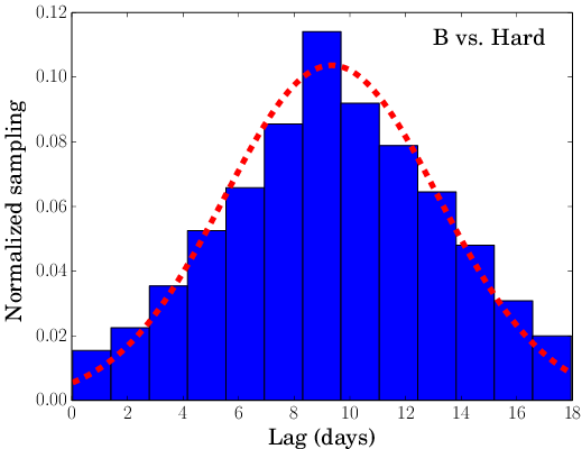
~2 year Swift monitoring (Pal, GCD+ 2016)



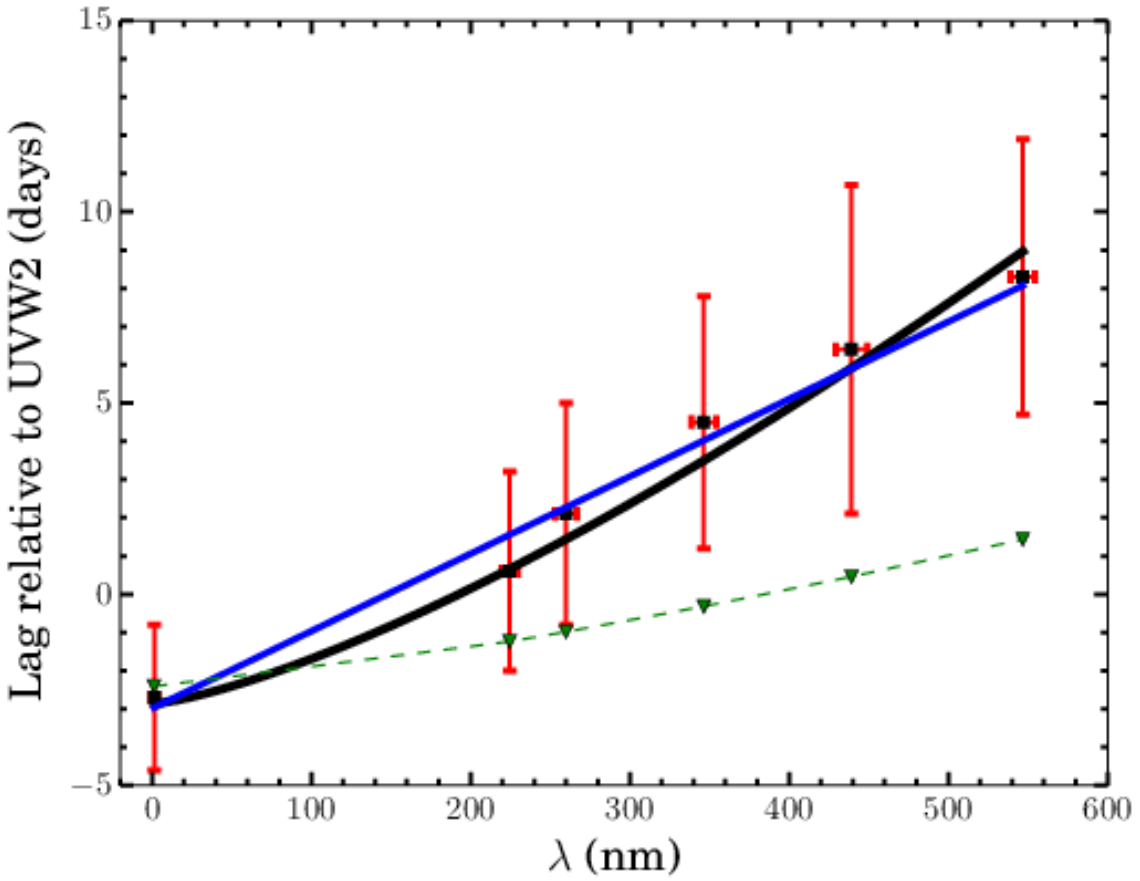








X-ray to UV lag Vs wavelength



Real accretion disks larger than the standard disks?

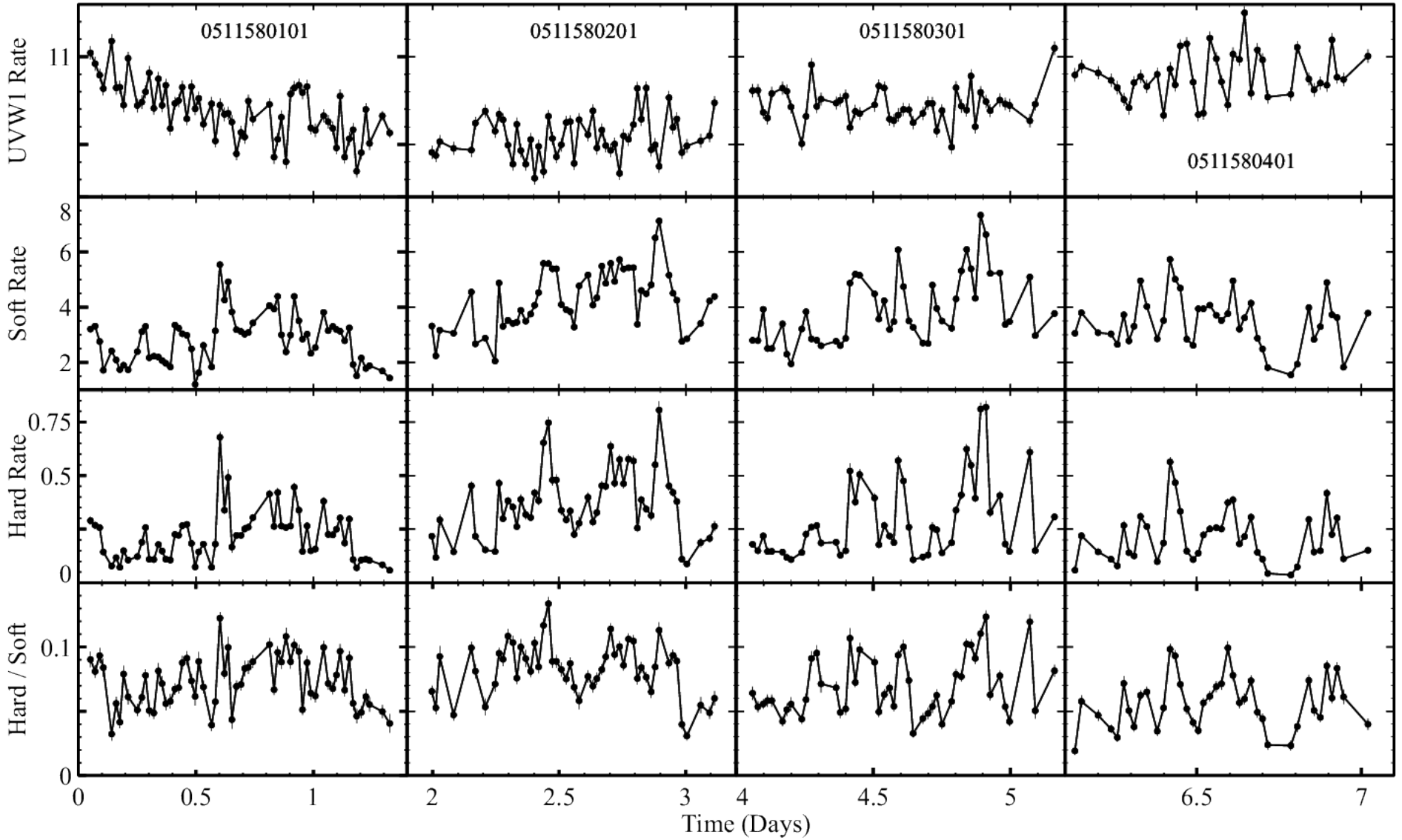
Found earlier in a few other Seyfert 1s (Ian's Talk).

Need to probe this relation in other Seyferts with different accretion rates. Use AstroSat.

Pal, GCD+2016

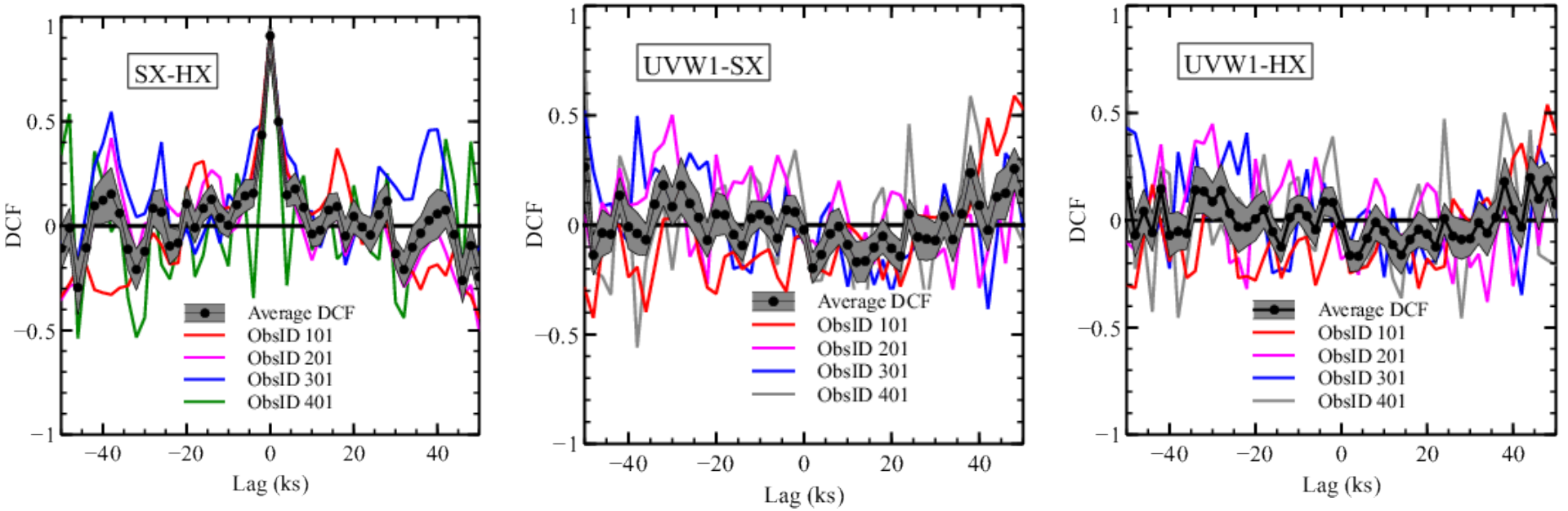
1H0707-495 : NLS1s (High acc. rate)
X-ray/UV connection

XMM-Newton observations (Pawar, GCD+2017, to be submitted)



Absence of UV/X-ray correlation in 1H0707-495

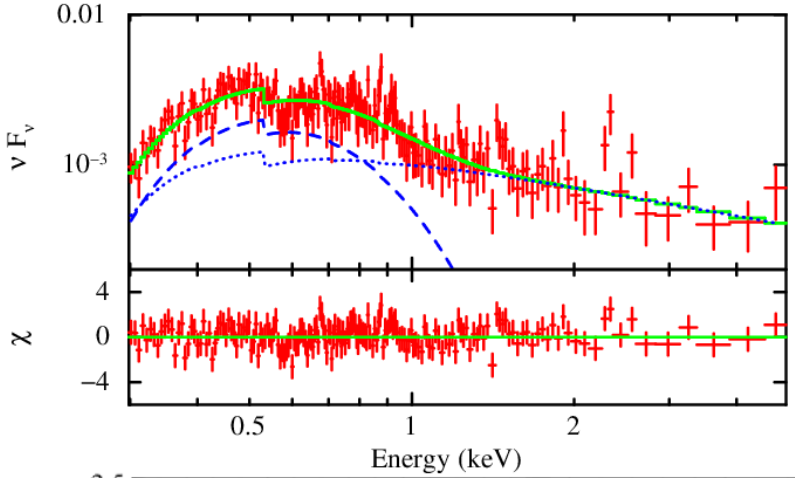
Pawar, GCD+2017, To be submitted

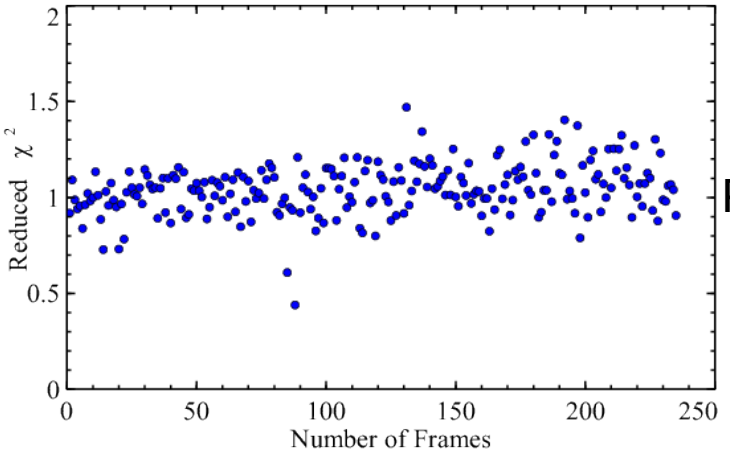


1H0707-495 well known for strong and broad iron K and L lines => strong light bending.

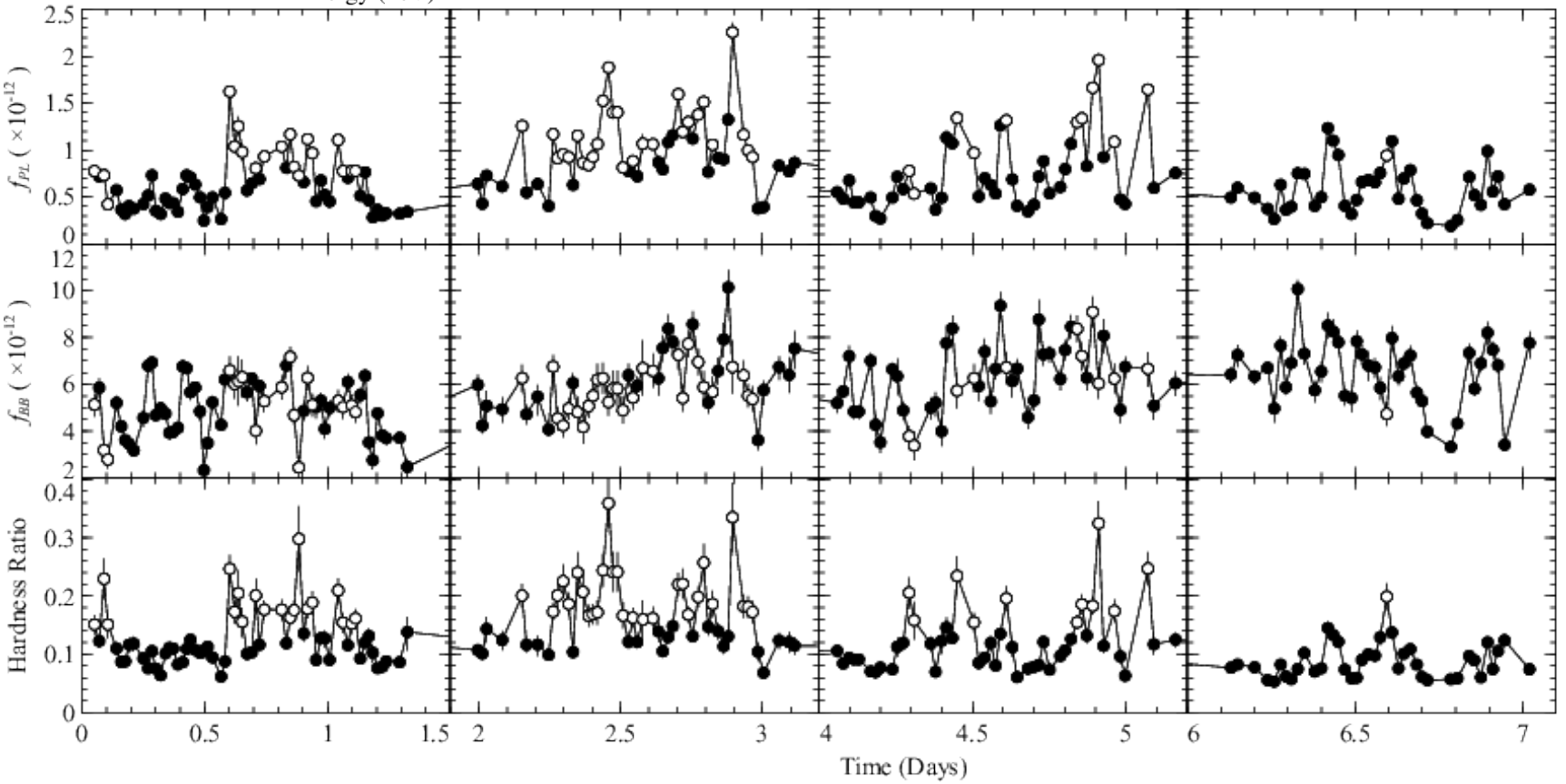
X-ray illumination mostly in the innermost regions. Optical/UV emitting regions not illuminated strongly.

Time-resolved spectroscopy

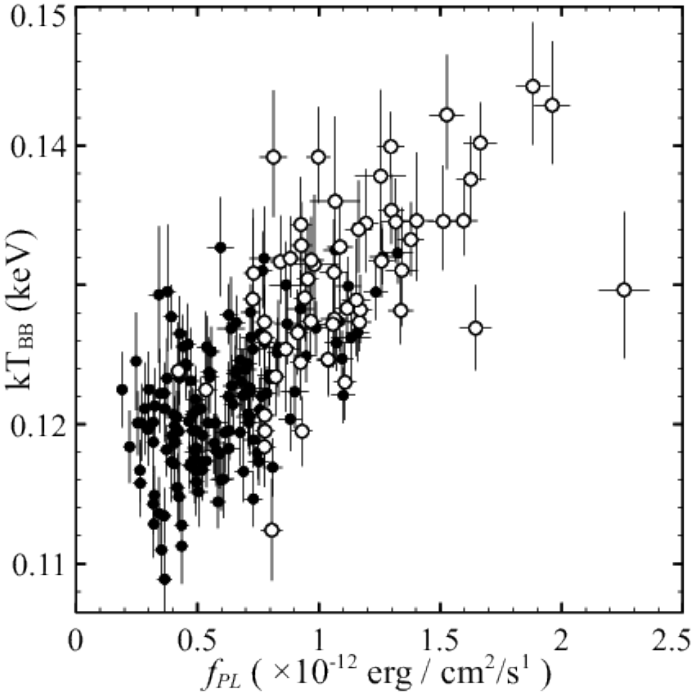


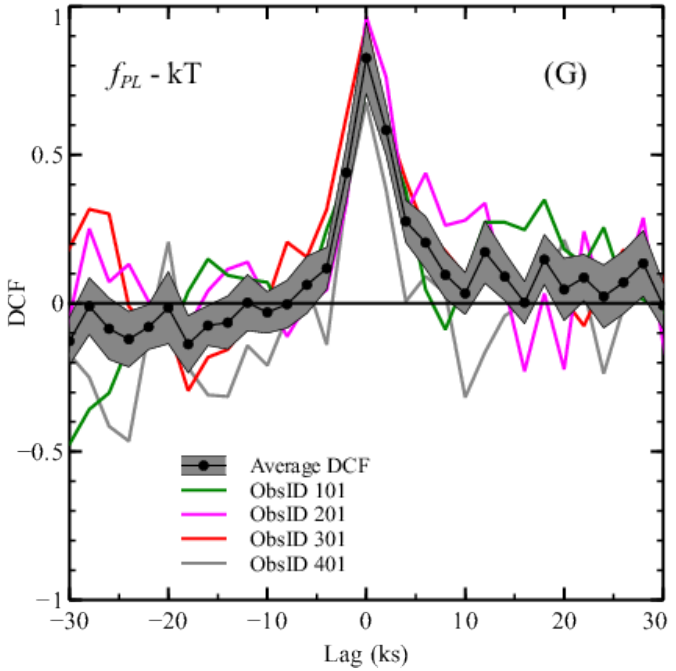


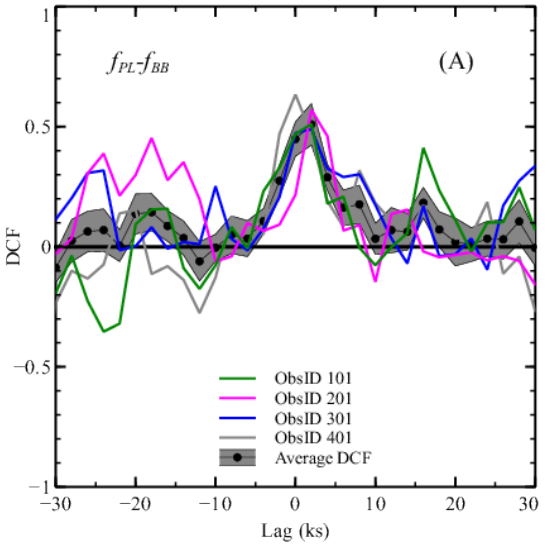
Pawar, GCD+2017,
To be submitted



Observed correlations







GR Light bending

Strong X-ray illumination
In the innermost regions

Reprocessed soft X-ray Excess emission in addition to the reflection.

Hotter inner disk => longer optical/UV lags in some AGNs

Pawar, GCD+2017, To be submitted

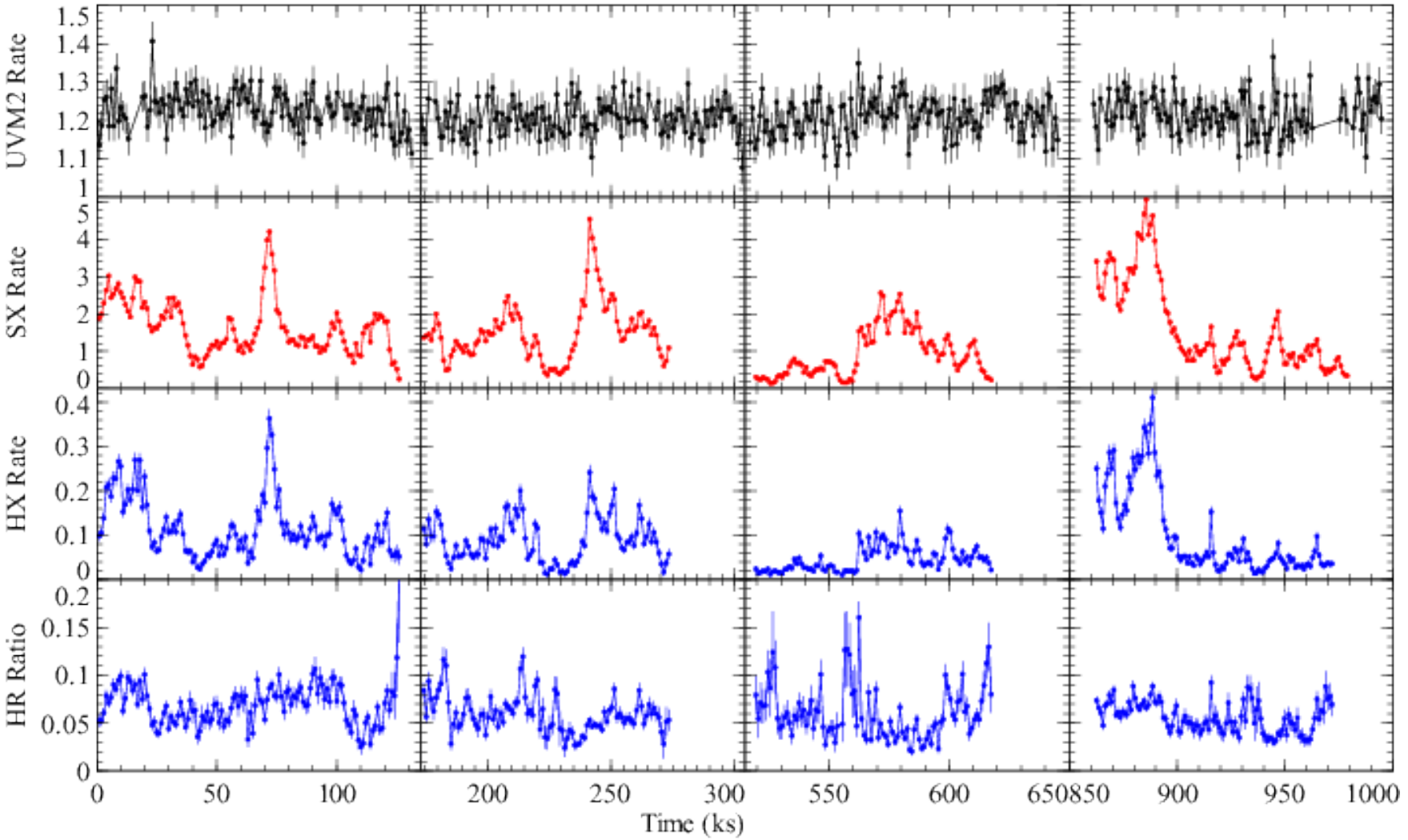
Summary

- Preliminary analysis of AstroSat observations shows excellant promise for X-ray/UV corrlation studies in bright Seyfert 1s.
- Measured lags larger than that predicted by SS disk in Fairall 9
- No strong optical/UV reprocessed emission in 1H0707-495
- A signficant fraction of soft excess likely reprocessed thermal emission in 1H0707-495
- Complex UV/X-ray connection in Seyferts, need more observations. AstroSat can play very important role.

Thanks

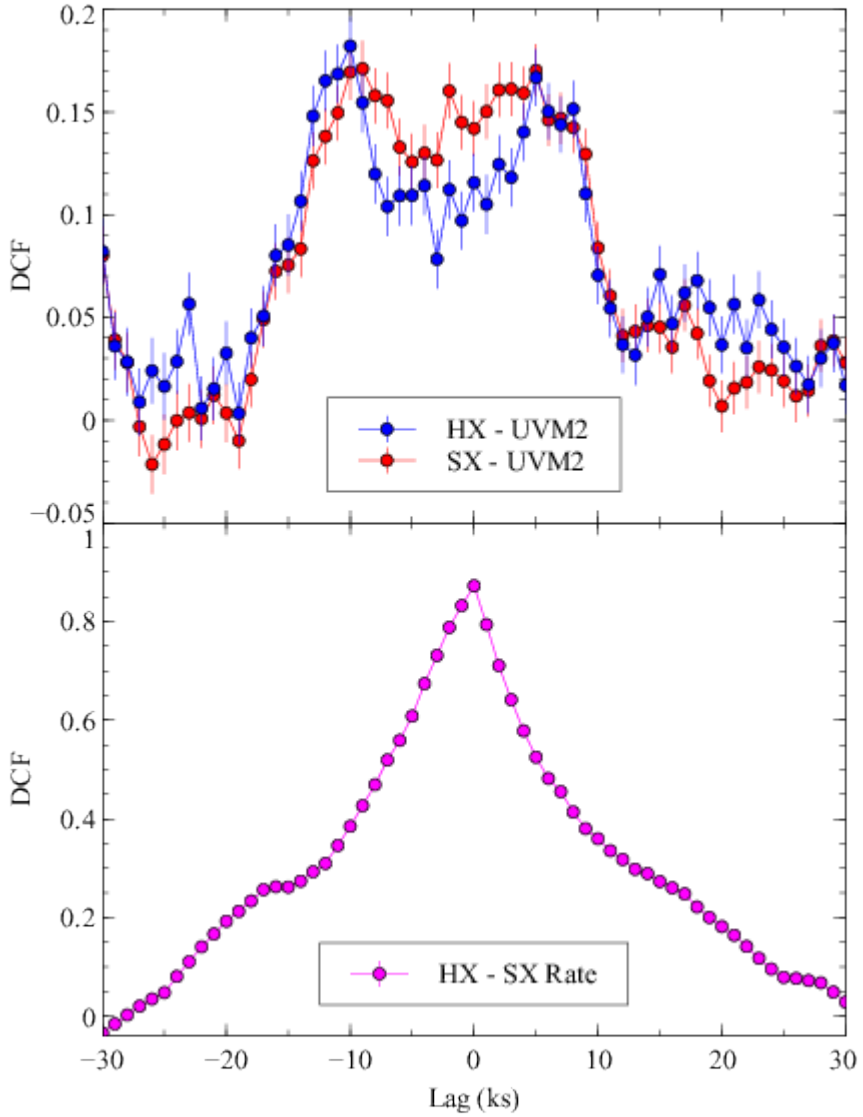
IRAS 13224-3809 – NLS1

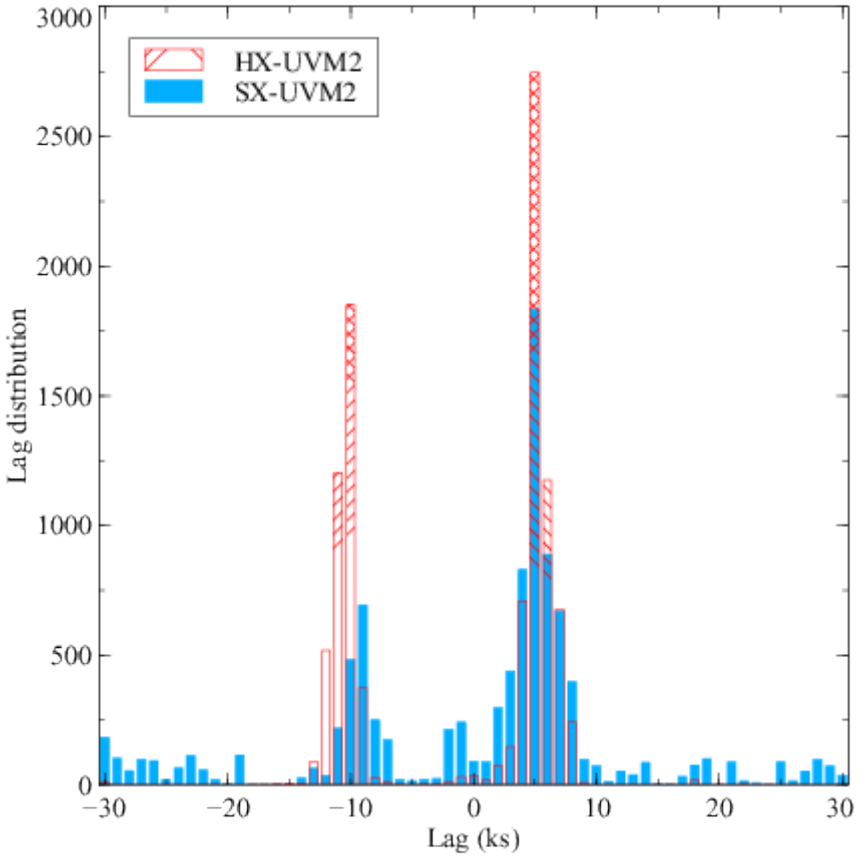
XMM observations



Pawar, GCD+2017, in prep.

IRAS 13224-3809: UV lead and lag





Pawar, GCD+2017, in prep.