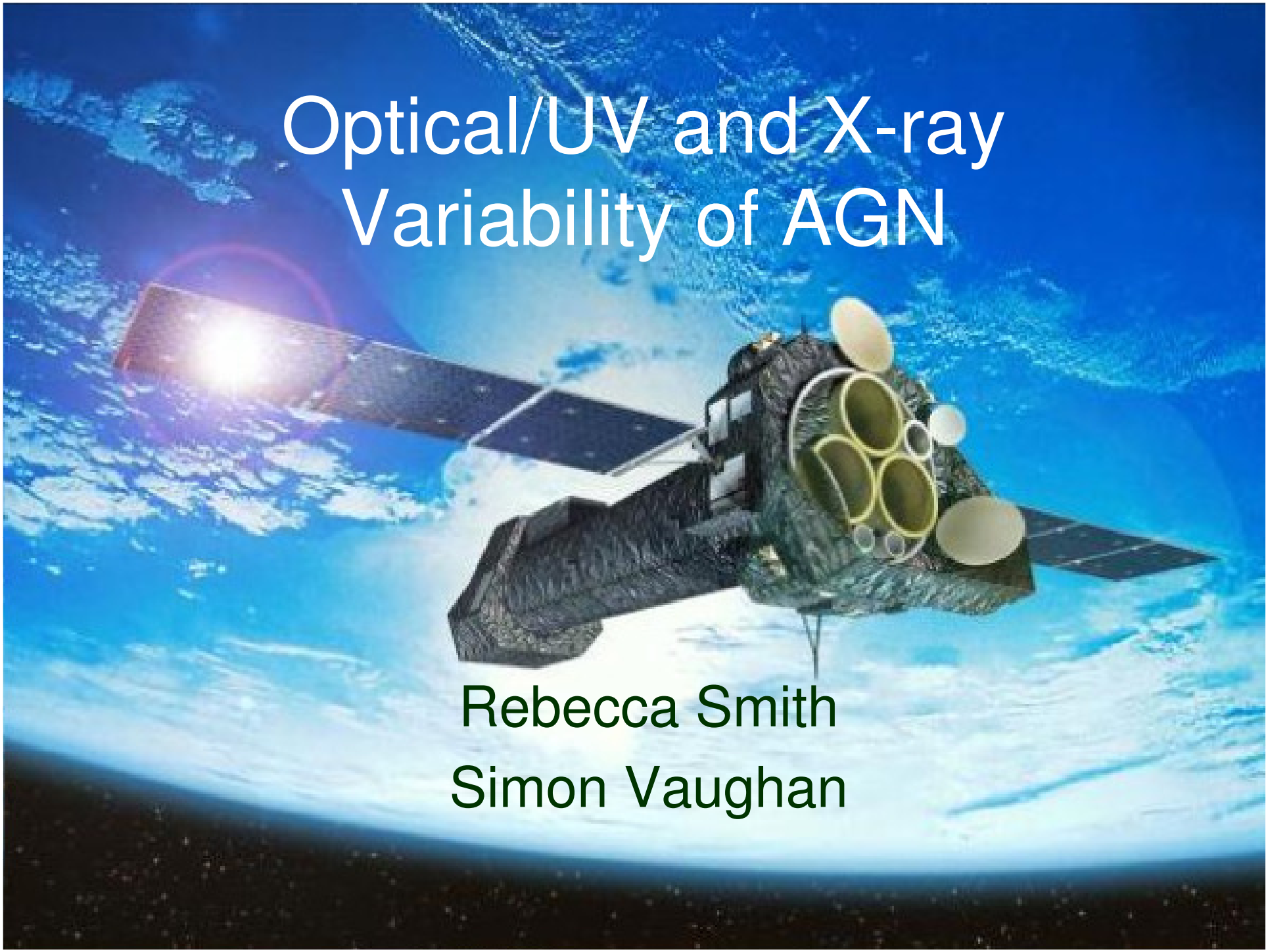
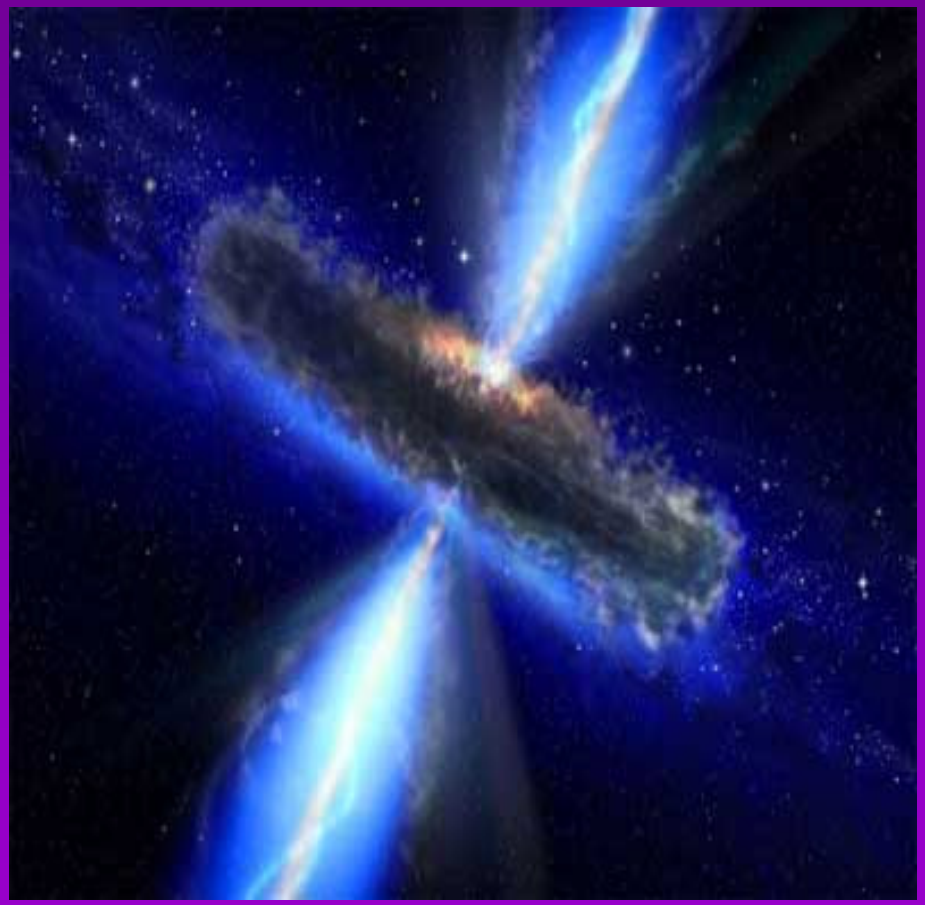
Optical/UV and X-ray Variability of AGN



Rebecca Smith

Simon Vaughan

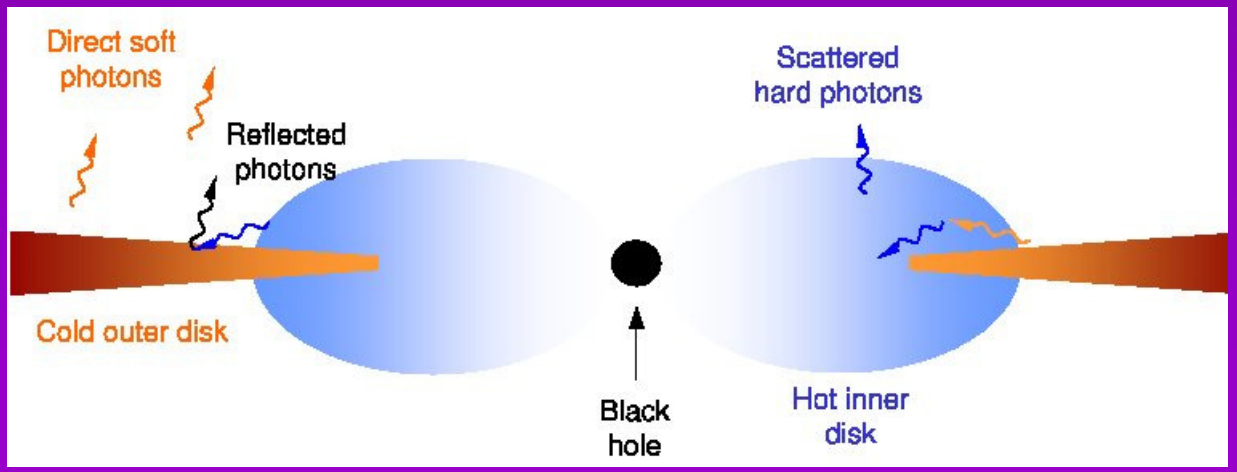
Active Galactic Nuclei



- Energetic across broad wavelength range
- Key characteristic is variability
- X-ray emission from hot corona
- Optical/UV emission from disk

Variability in AGN

- Emission from different regions connected?
- Reprocessing of X-ray to optical/UV photons?
- Comptonization of UV to X-ray photons?
- Use variability to investigate
  - Is reprocessing important?
  - If so, which way round?



From Zdziarski et al, 2002, ApJ, 578, 357

Investigating variability

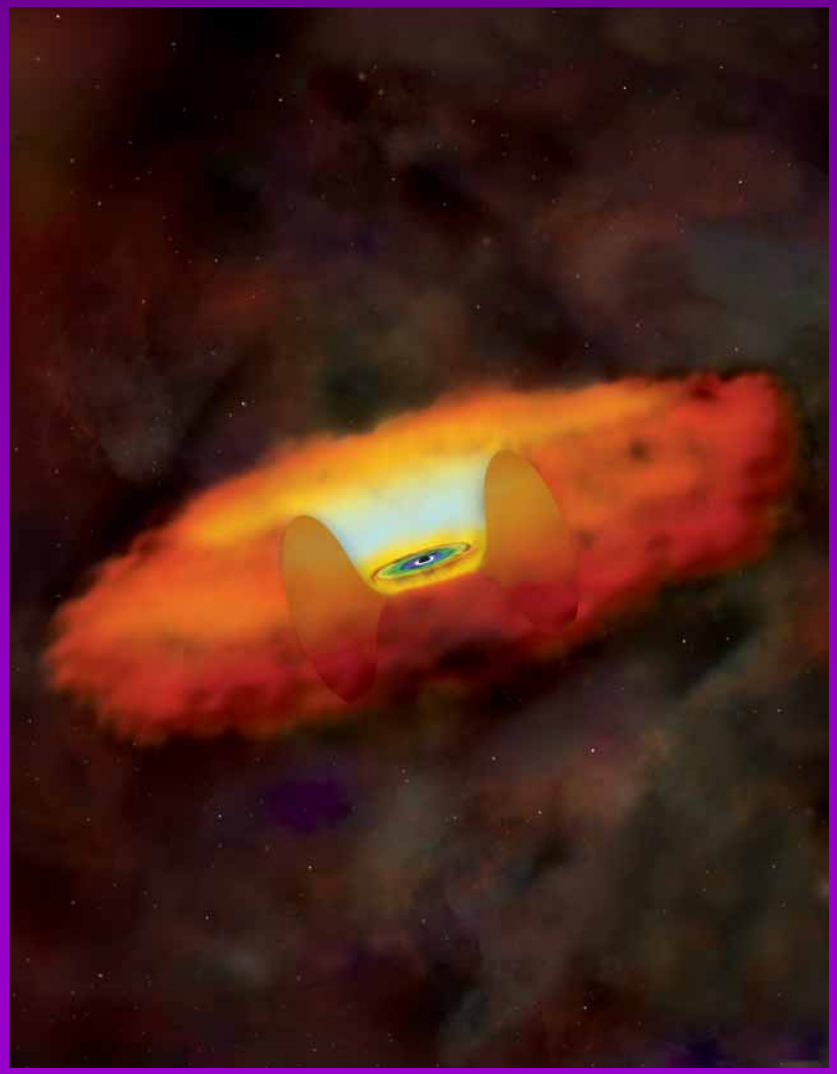
- Need simultaneous optical/UV and X-ray observations of source
  - Difficult to schedule
- XMM-Newton provides solution – OM
- Construct lightcurves
- Look for correlations

  ➔Learn about the relationship between emission regions

Previous studies

- No definitive conclusion so far:
  - Edelson et al, 2000: NGC 3516 with HST, RXTE & ASCA → **no significant correlation**
  - Shemmer et al, 2001: Ark 564 with HST & RXTE → found evidence of **UV trailing X-ray**
  - Uttley et al, 2003: NGC 5548 → strong correlation with **no lag**
- Only 2 results published using XMM & OM:
  - Mason et al, 2002: NGC 4051 → found some evidence of **UV trailing X-ray**
  - Arévalo et al, 2005: MCG-6-30-15 → found evidence of **X-ray variation trailing UV**

Targets

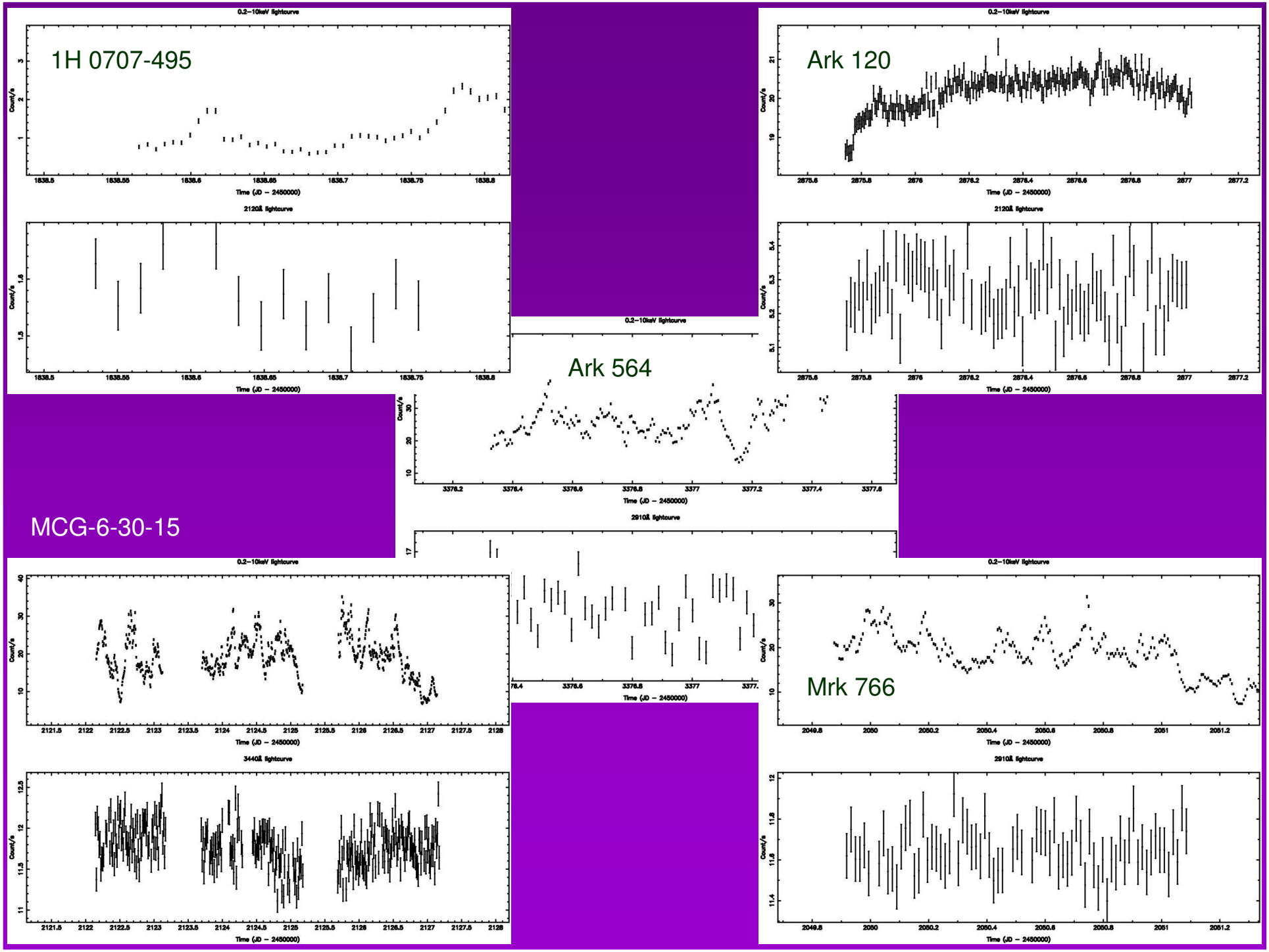


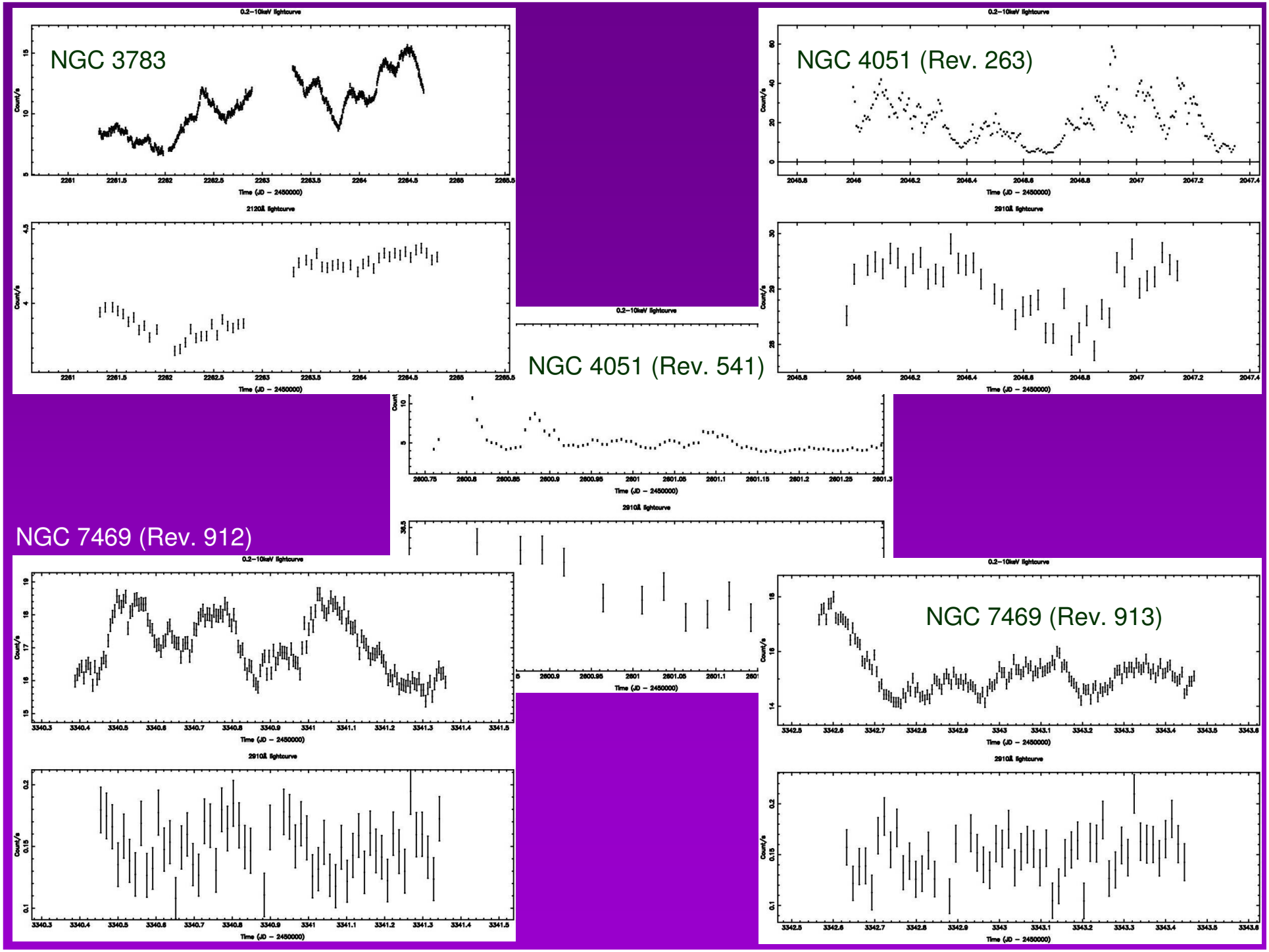
- Nearby, low luminosity Seyfert 1 galaxies
  - Low L = smaller BH
  - Smaller delay time ∴ good chance of measuring
- XMM archive
- Plenty of exposures in single OM filter

Object	Filter	Maximum observation length (days)	Internal heating delay (days)	External heating delay (days)
1H 0707-495	UVW2 (2120Å)	0.23	0.02 – 0.03	0.16
Ark 120	UVW2	1.27	0.25 – 0.54	1.10
Ark 564	UVW1 (2910 Å)	1.15	0.15 – 0.32	0.98
MCG-6-30-15	U (3440 Å)	5.05	0.03 – 0.07	0.69
Mrk 766	UVW1	1.18	0.03 – 0.07	0.62
NGC 3783	UVW2	3.51	0.09 – 0.18	0.39
NGC 4051	UVW1	1.21	0.02 – 0.04	0.08
NGC 7469	UVW2	0.91	0.05 – 0.10	0.48

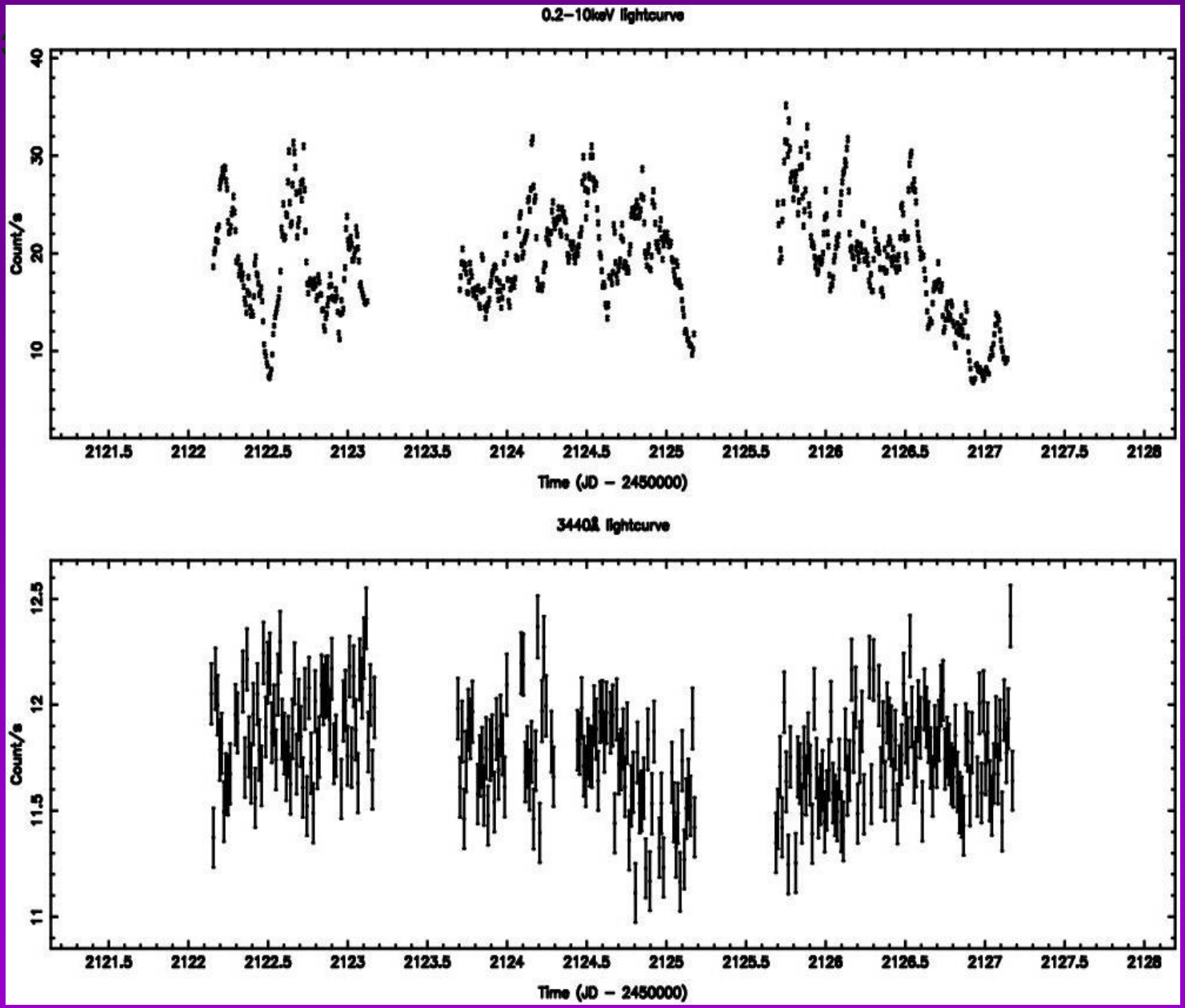
Internal delay: Standard thin disk. Distance from black hole to radius at which temp. peaks in OM filter. Assumed accretion rate of 0.01 – 0.1 Eddington.

External delay: Distance from BH to radius at which disk is heated by X-ray luminosity to a temp. that peaks in OM filter. $L_x = A\sigma T^4$

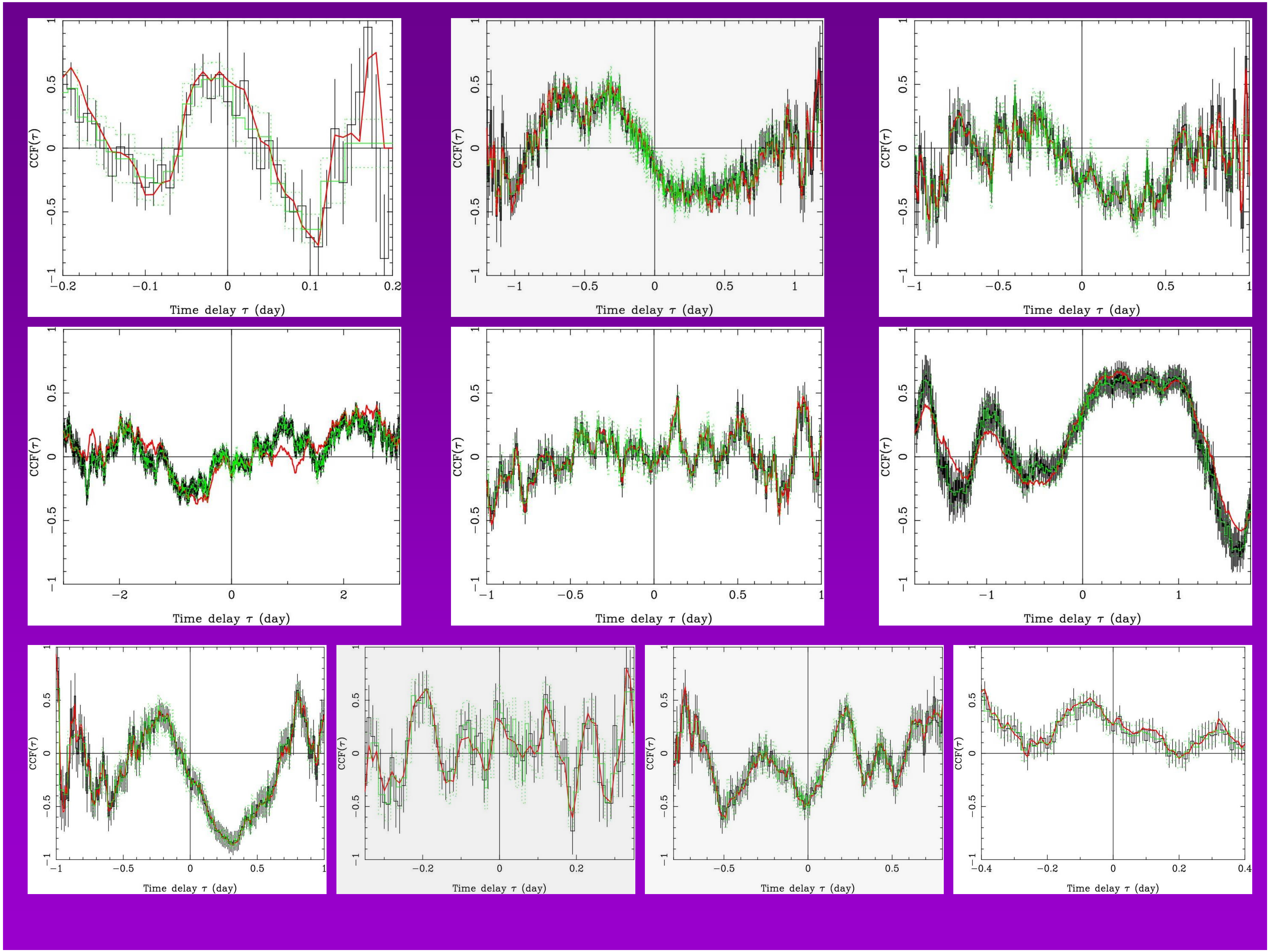

1H 0707-495
Ark 120
Ark 564
MCG-6-30-15
Mrk 766
0.2–10keV lightcurve
2120Å lightcurve
2910Å lightcurve
3440Å lightcurve
Count/s
Time (JD − 2450000)


NGC 3783
NGC 4051 (Rev. 263)
NGC 4051 (Rev. 541)
NGC 7469 (Rev. 912)
NGC 7469 (Rev. 913)
0.2–10keV lightcurve
2120Å lightcurve
2910Å lightcurve
Count/s
Time (JD − 2450000)

NGC 378



MCG-6-30-15



CCF(τ)
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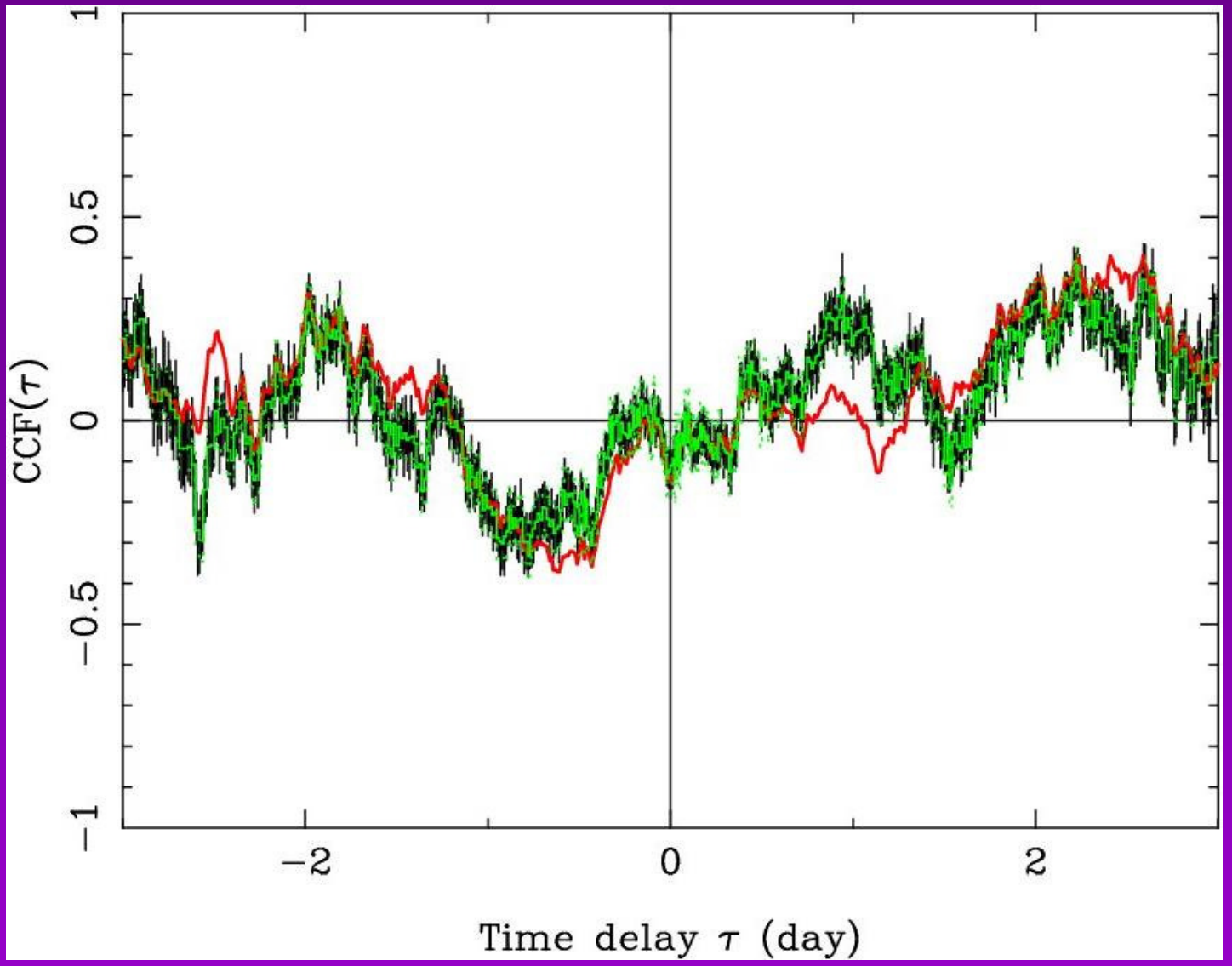
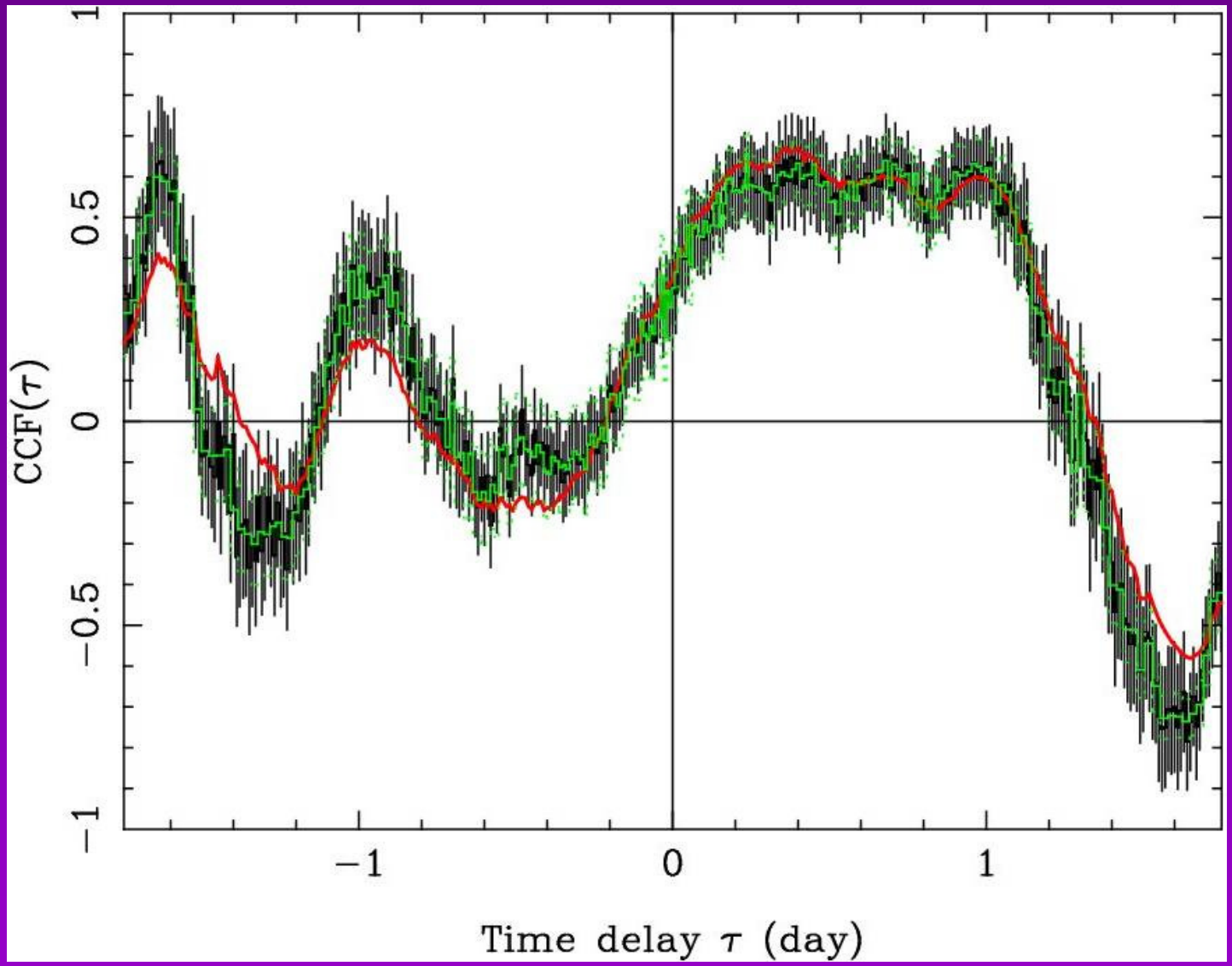


MCG-6-30-15

Predicted lag ~ 0.7 days

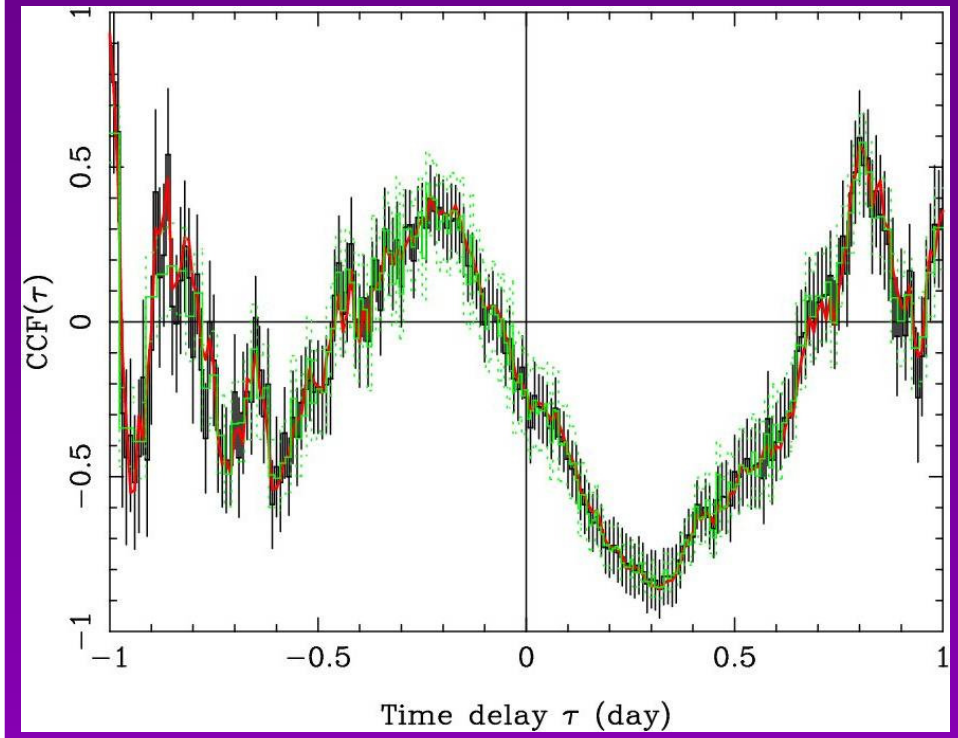
No evidence for correlation

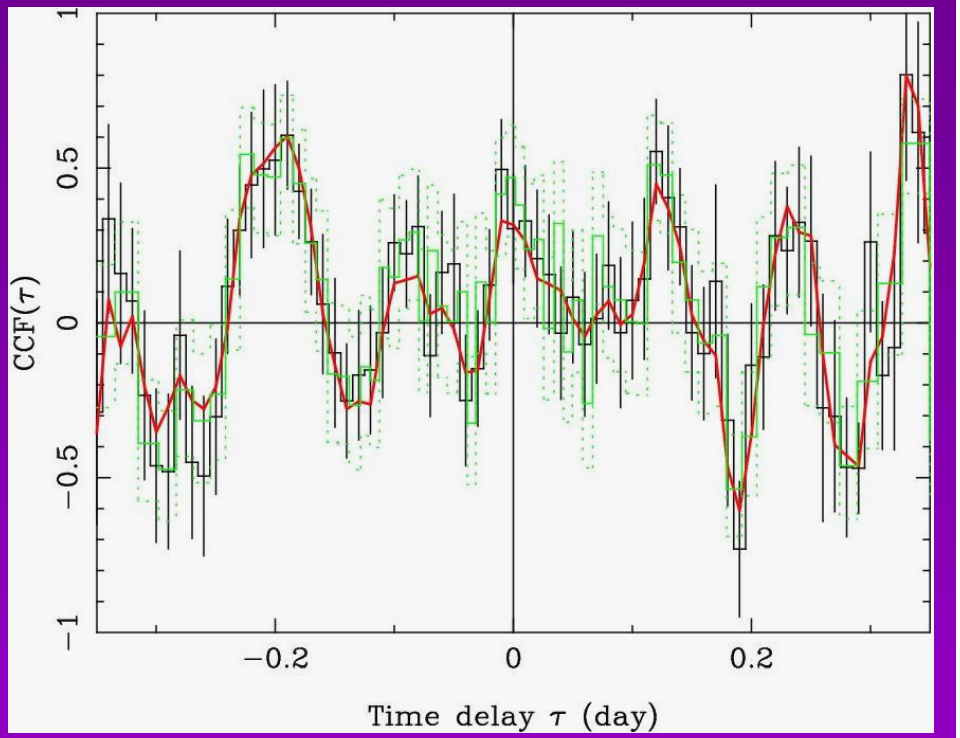


NGC 3783

Predicted lag ~ 0.4 days

Evidence for correlation around 0.2-1?





NGC 4051

Predicted lag ~ 0.1 days

Evidence for anti-correlation around 0.3 in Revolution 263

Little evidence for correlation in Revolution 541

Results

Object	OM rms (10^{44}erg s^{-1})	X-ray rms (10^{44}erg s^{-1})	Expected lag	Observed lag
1H 0707-495	0.17	0.19	0.16	~0.1?
Ark 120	0.09	0.41	1.10	X
Ark 564	0.05	1.09	0.98	X
MCG-6-30-15	1.7×10^{-2}	0.36	0.69	X
Mrk 766	0	0.48	0.62	X
NGC 3783	0.07	0.50	0.39	0.2-1?
NGC 4051	0.5×10^{-2}	0.03	0.08	Anti ~0.3?
NGC 7469	0.9×10^{-2}	0.30	0.48	X

Conclusions

- Variability ➔ information about emission
- OM + XMM archive provide economical way to study many sources
- Sample of 8 different objects studied
- Majority show no evidence for reprocessing on these timescales
- Results imply disk emission is almost entirely internal