Long-term AGN variability

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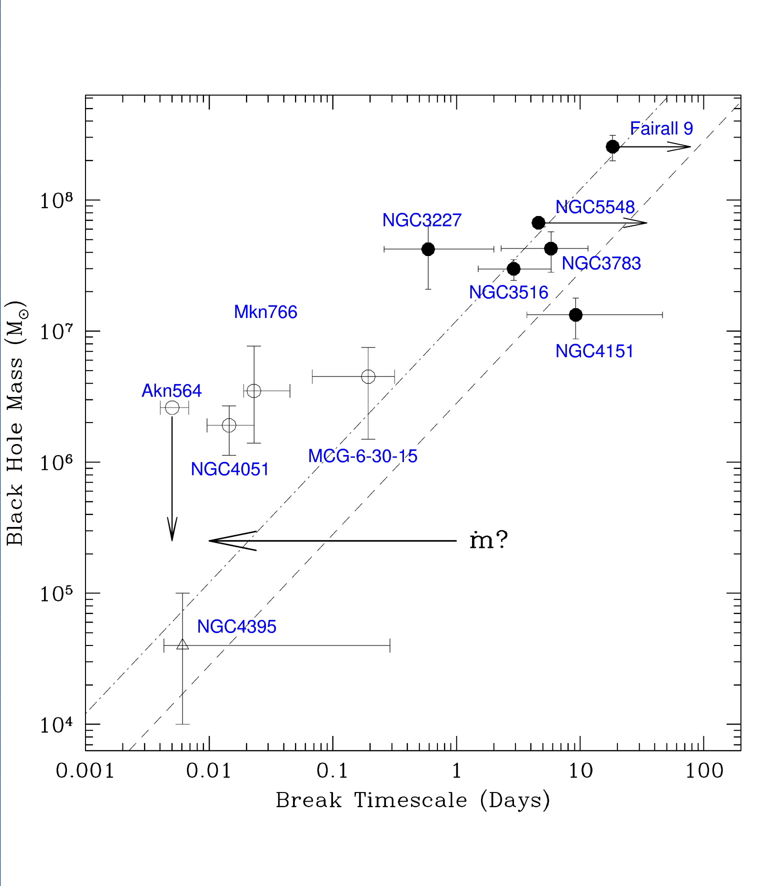
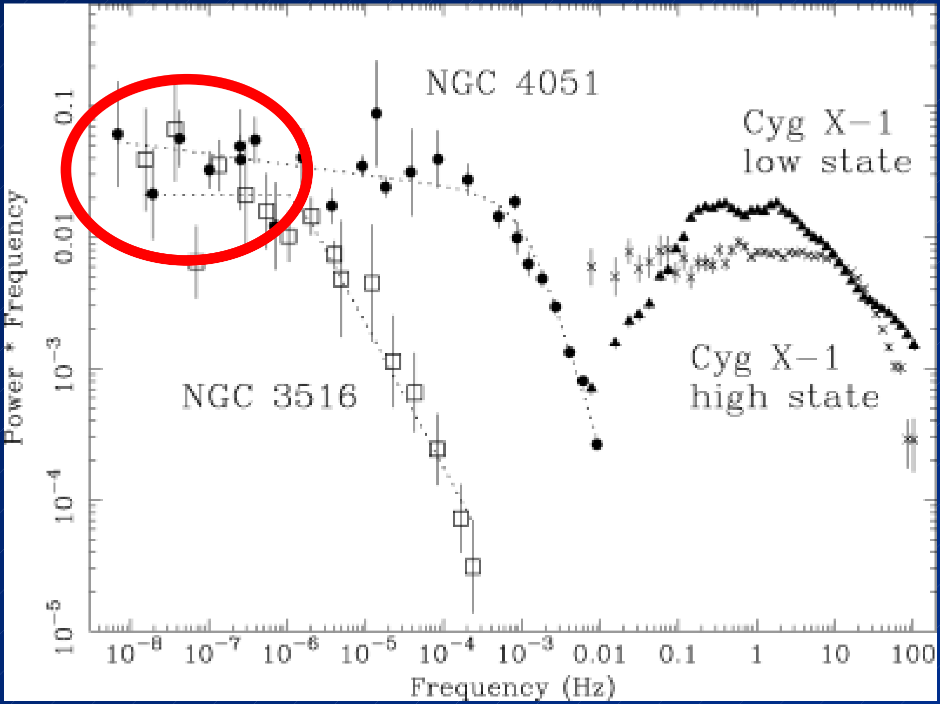
Short-term X-ray variability



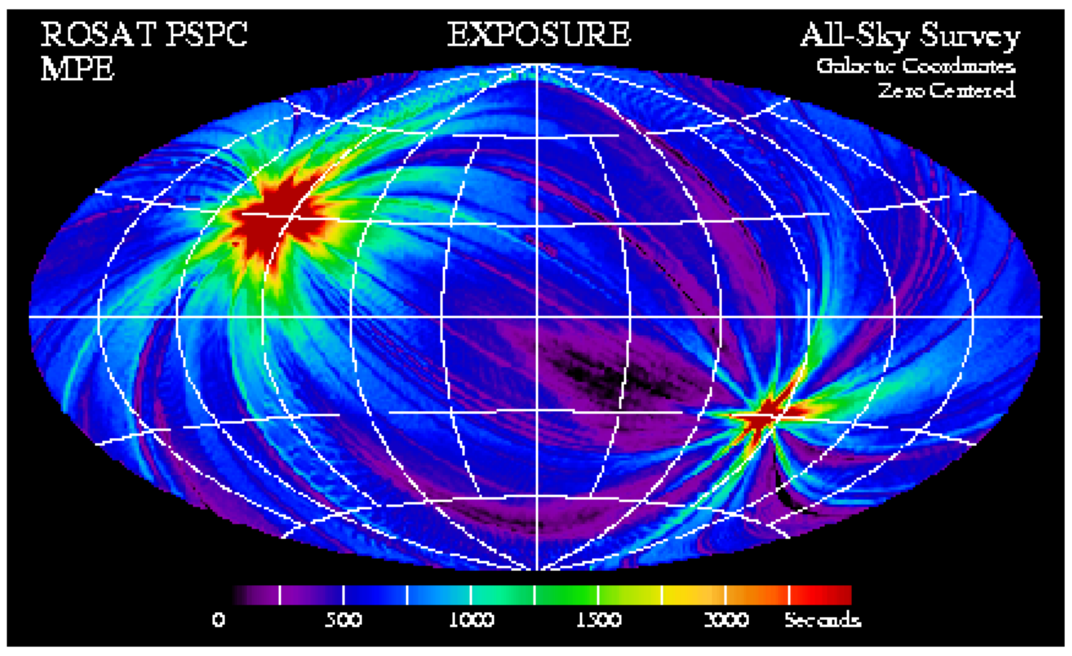
McHardy et al. 2006



McHardy et al. 2004

What about long-term variability, beyond the characteristic timescale?

ROSAT

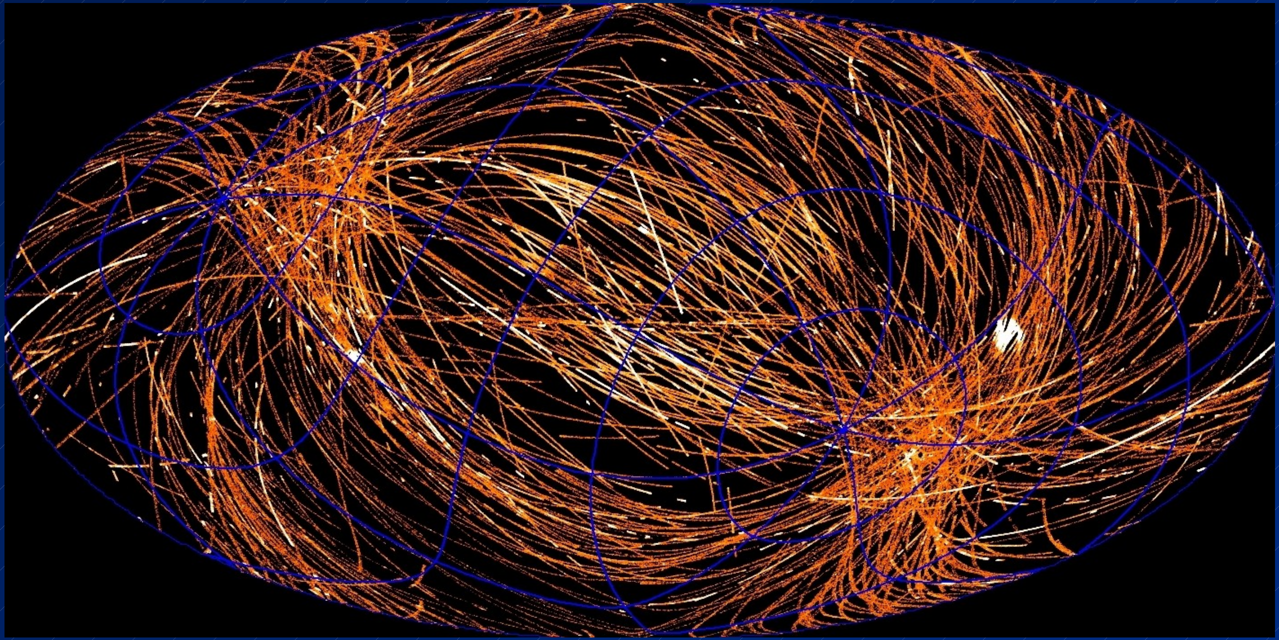


RASS and ROSAT pointed observations

RASS - median flux limit = 3E-13 ergs/s/cm2 - observations in 1990

ROSAT pointed: 25% of sky, flux limit typically few x E-14 cgs - obs from 1991 – 1998.

XMM-Newton slew

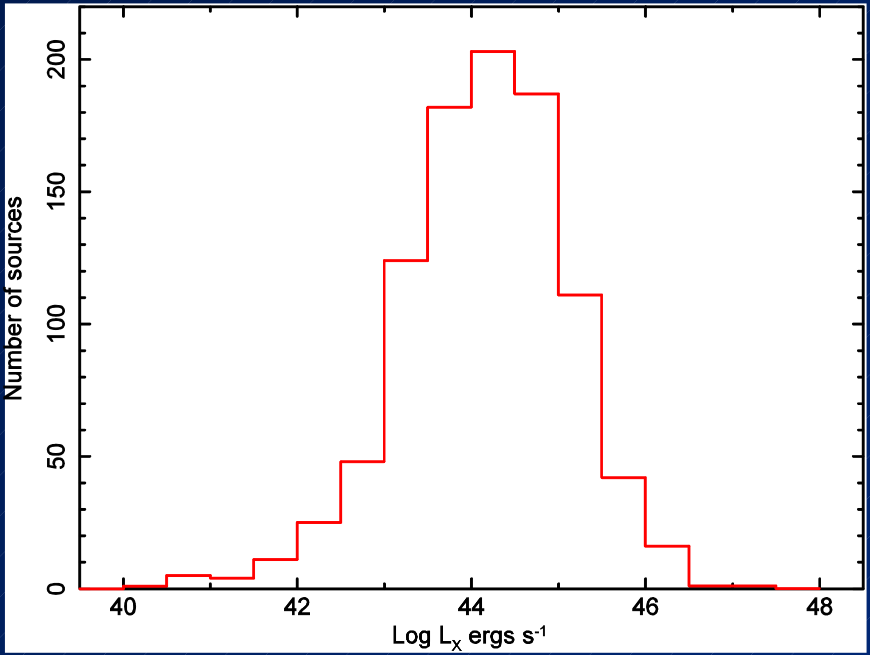


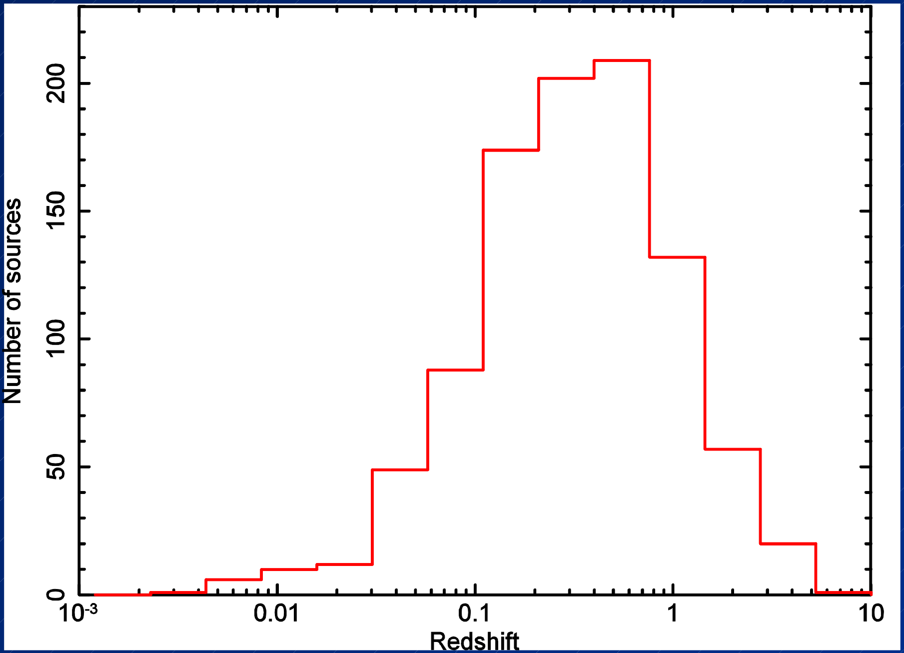
Flux limit of 6x10^-13 ergs/s/cm2

Comparison made with 35% of sky covered – now 51%

Observations from 2001 - 2009

Demography

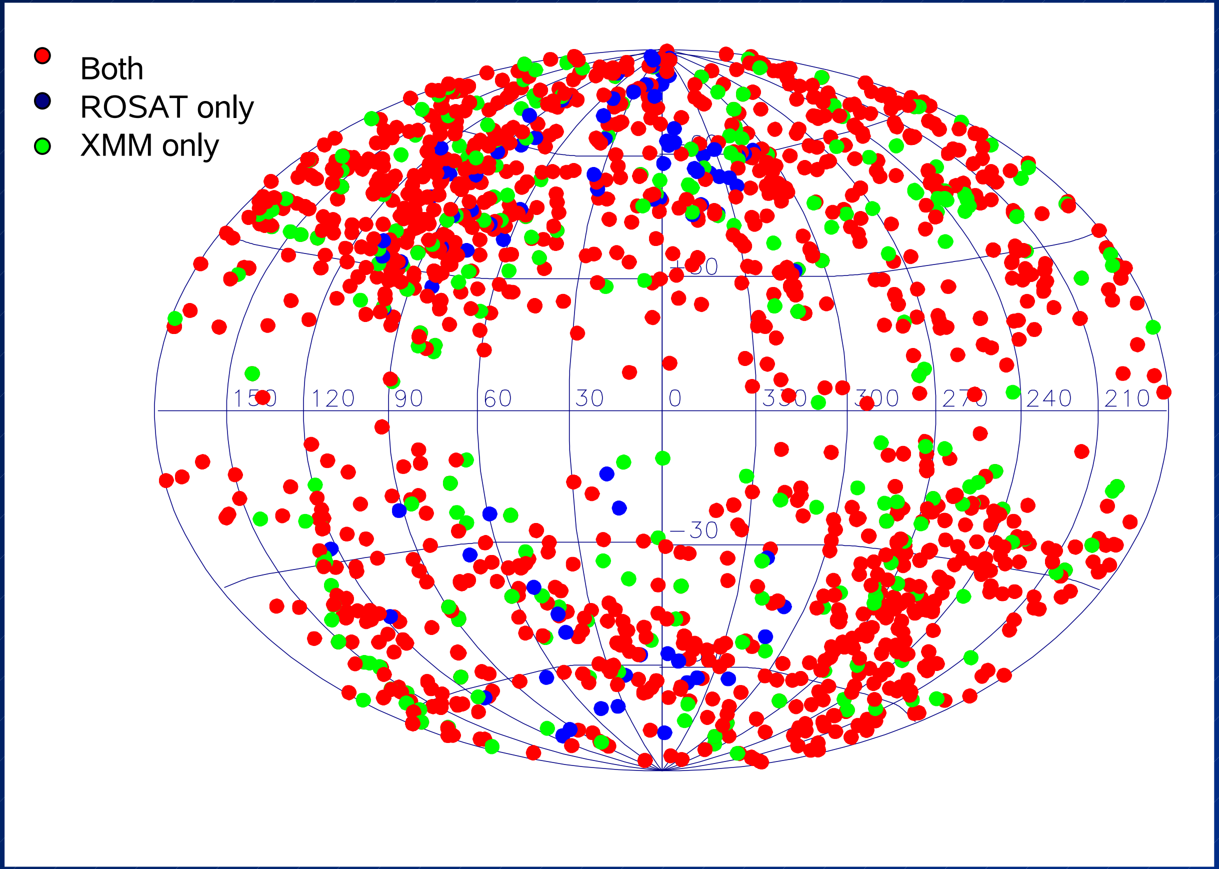




Probing principally 10^{42}<Lx<10^{46}

0.03<z<2.0

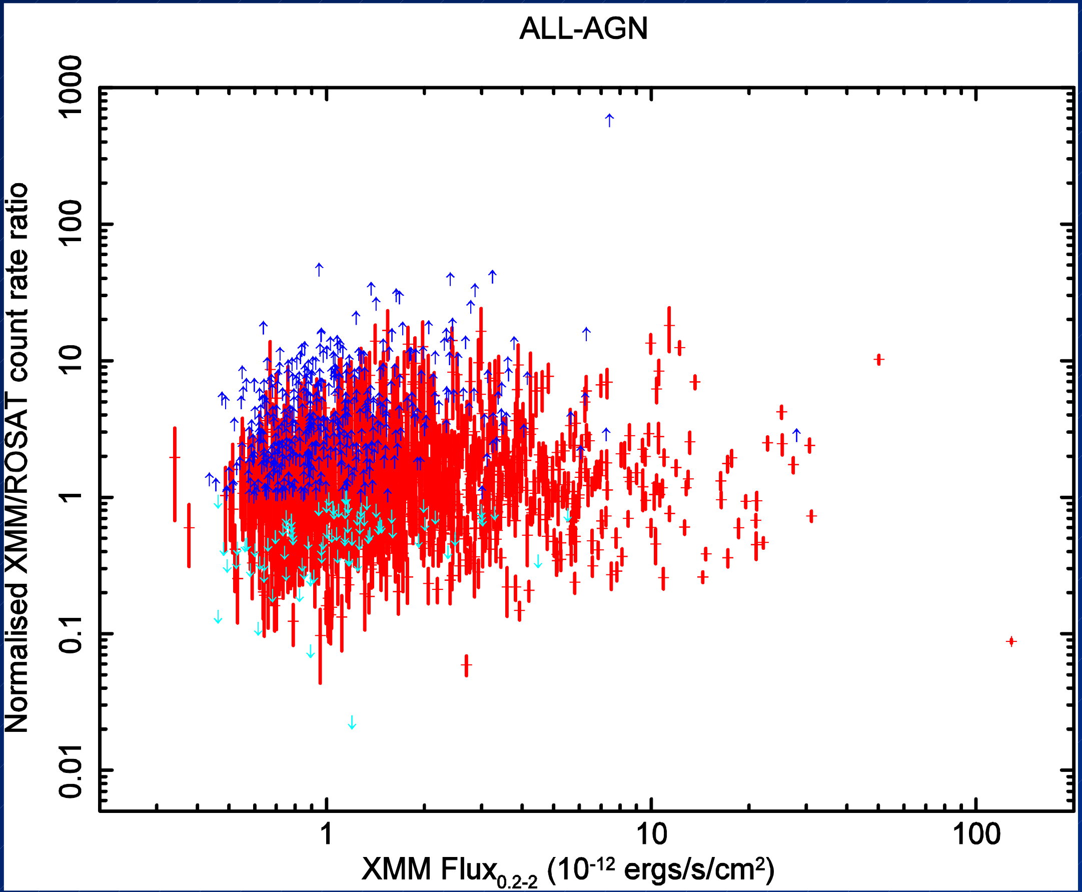
AGN combination



Overlap with 1038 AGN with detection in both instruments or detection in one and a useful upper limit in the other.

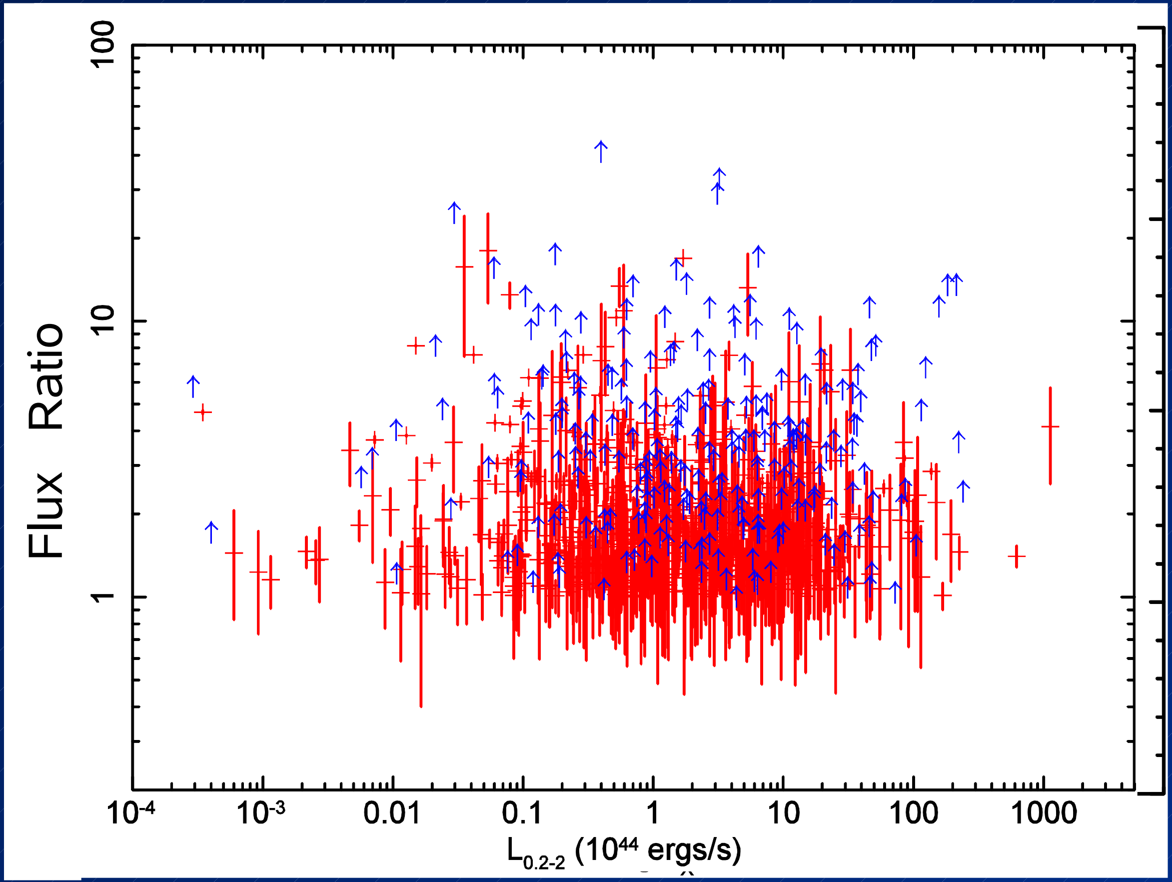
Compare flux over a baseline of 3 – 19 years (mostly 11-19 years)

Variability



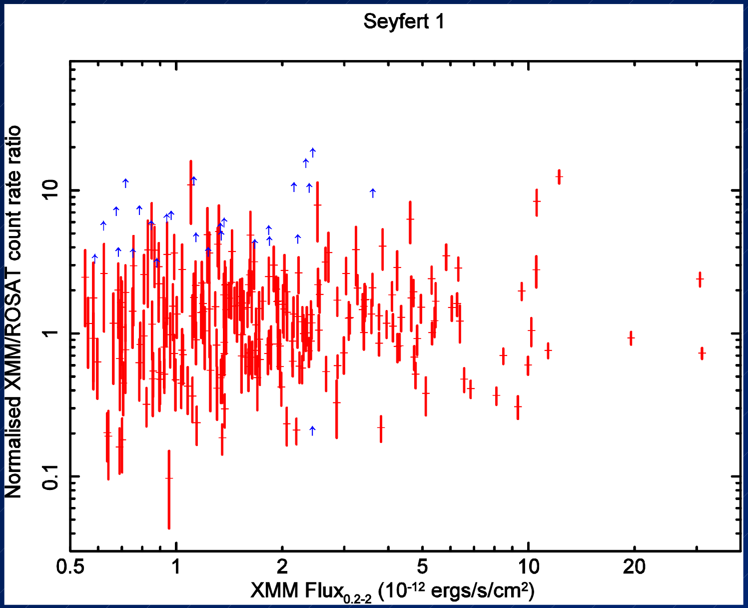
Median flux variability of ~80%

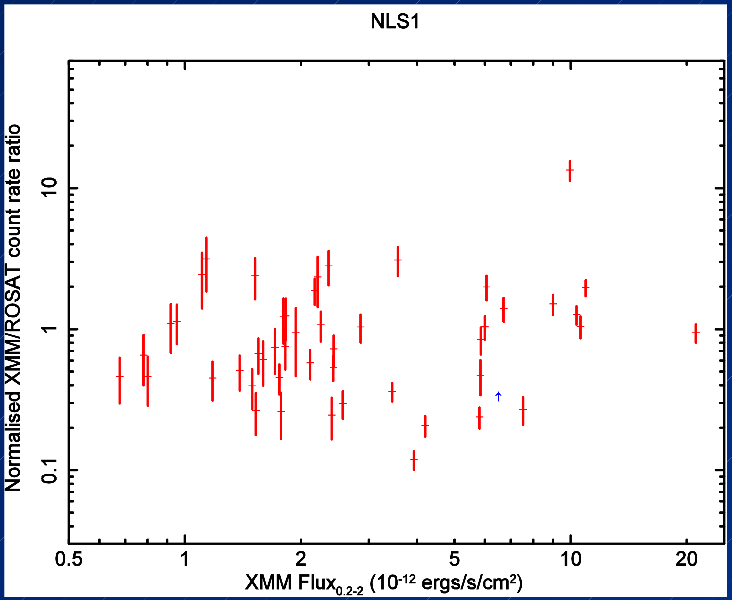
Variability v Luminosity (0.2-2 keV)

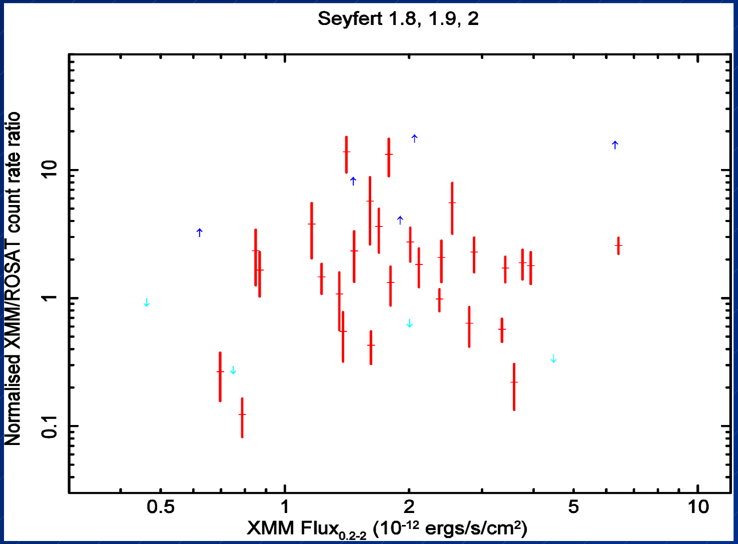


No correlation of variability with X-ray luminosity on these timescales

Variability with source type







High variability sources

CLASS	NSRC	V>10
ALL	717	4.9±0.8%
S1	220	4.1±1.4%
S1.2	36	0.0%
S1.5	60	3.3±2.4%
S1.8/9/2	30	13.3±6%
NLS1	49	4.1±2.9%
QSO	124	4.8±2.0%
BLAZAR	116	3.4±1.7%

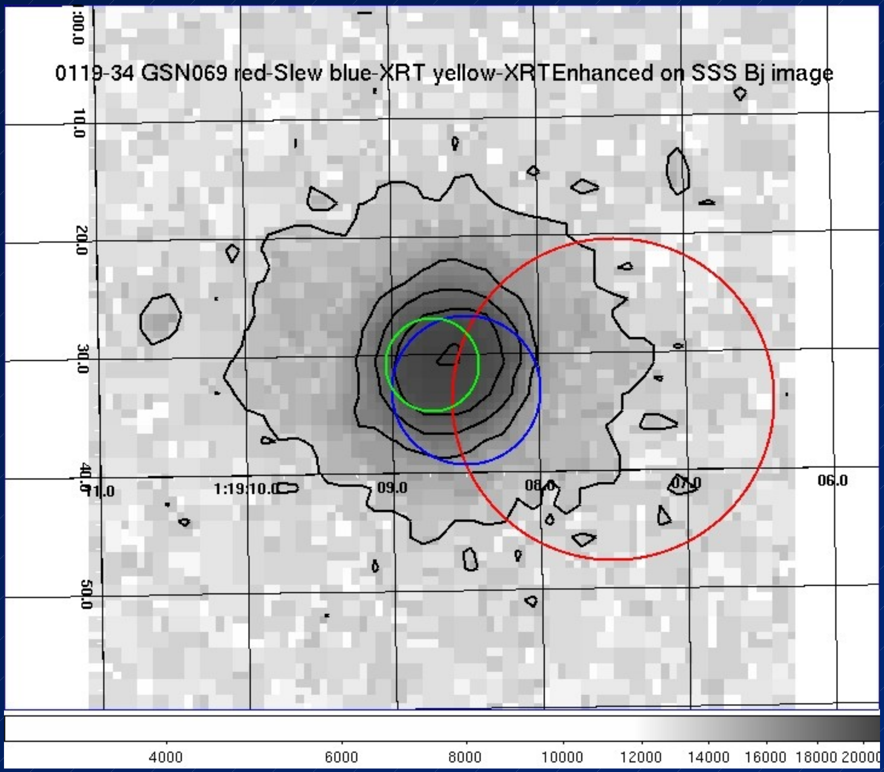
V>10, beyond the limit of ordinary disk / comptonisation variations. What fraction have this ?

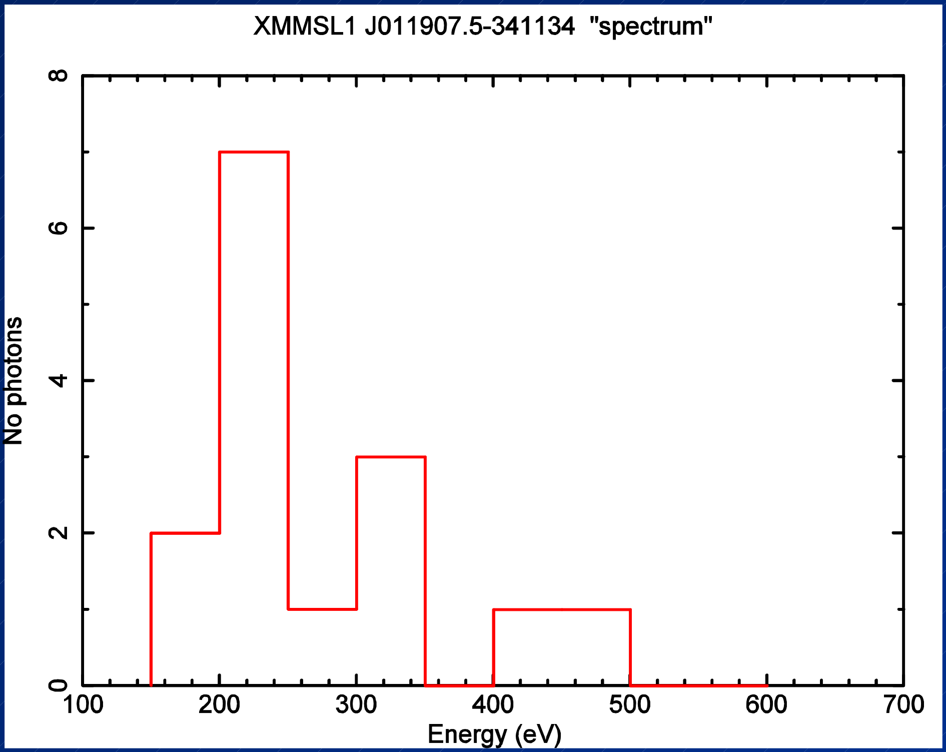
Four high variablity S 1.9 / 2 have:

L_X=2, 3, 6, 18 x 10^{42} ergs/s

- **Change in obscuration ?**
- **Mass addition ?**
- **Disk state change ?**

Soft flare from GSN 069





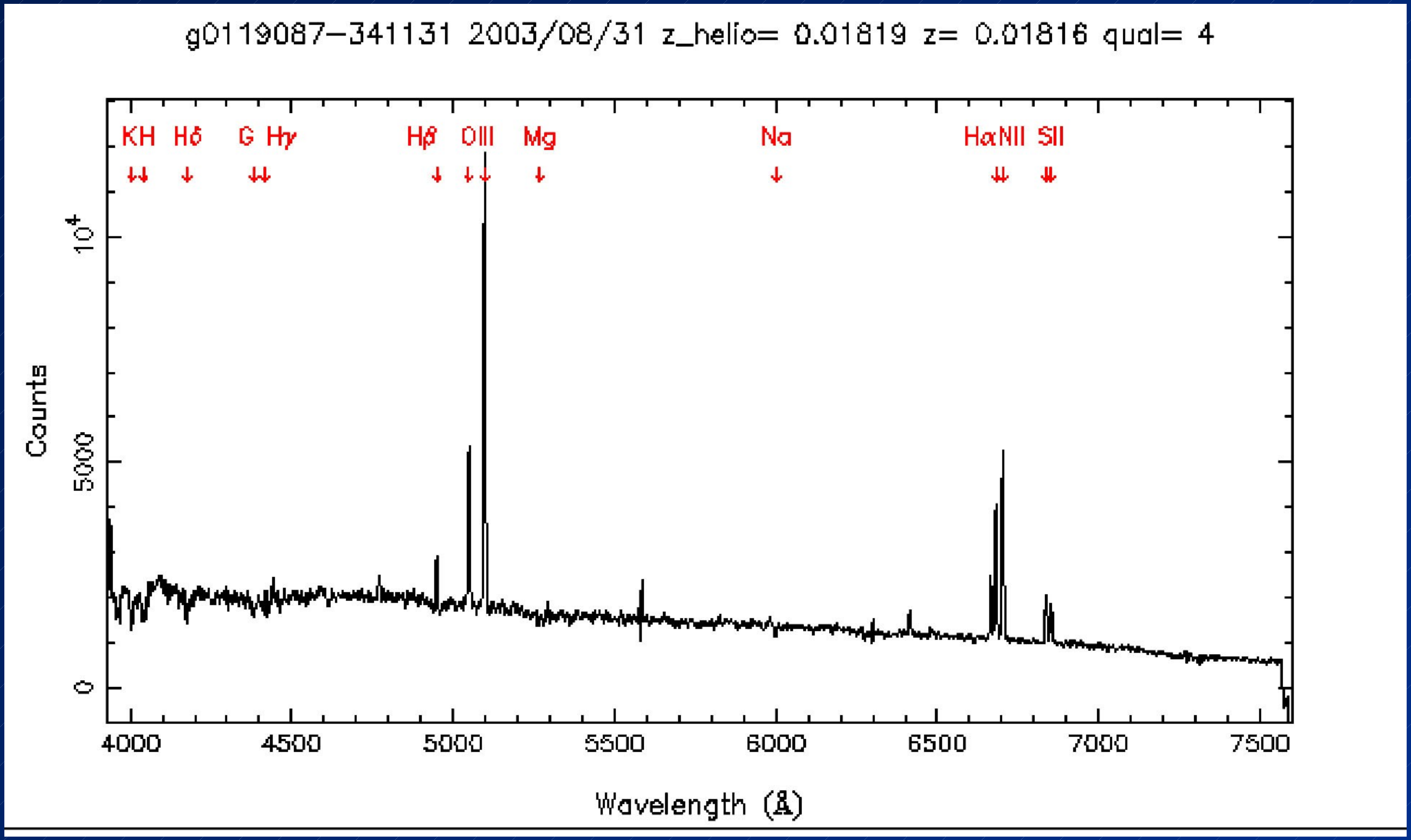
July 2010 - XMM slew source found with

$F_{0.2\text{-}2keV}$ =3E-12 ergs/s/cm^{-2}

Very soft spectrum (15 photons)

Factor 200 higher than ROSAT upper limit; coincident with GSN 069

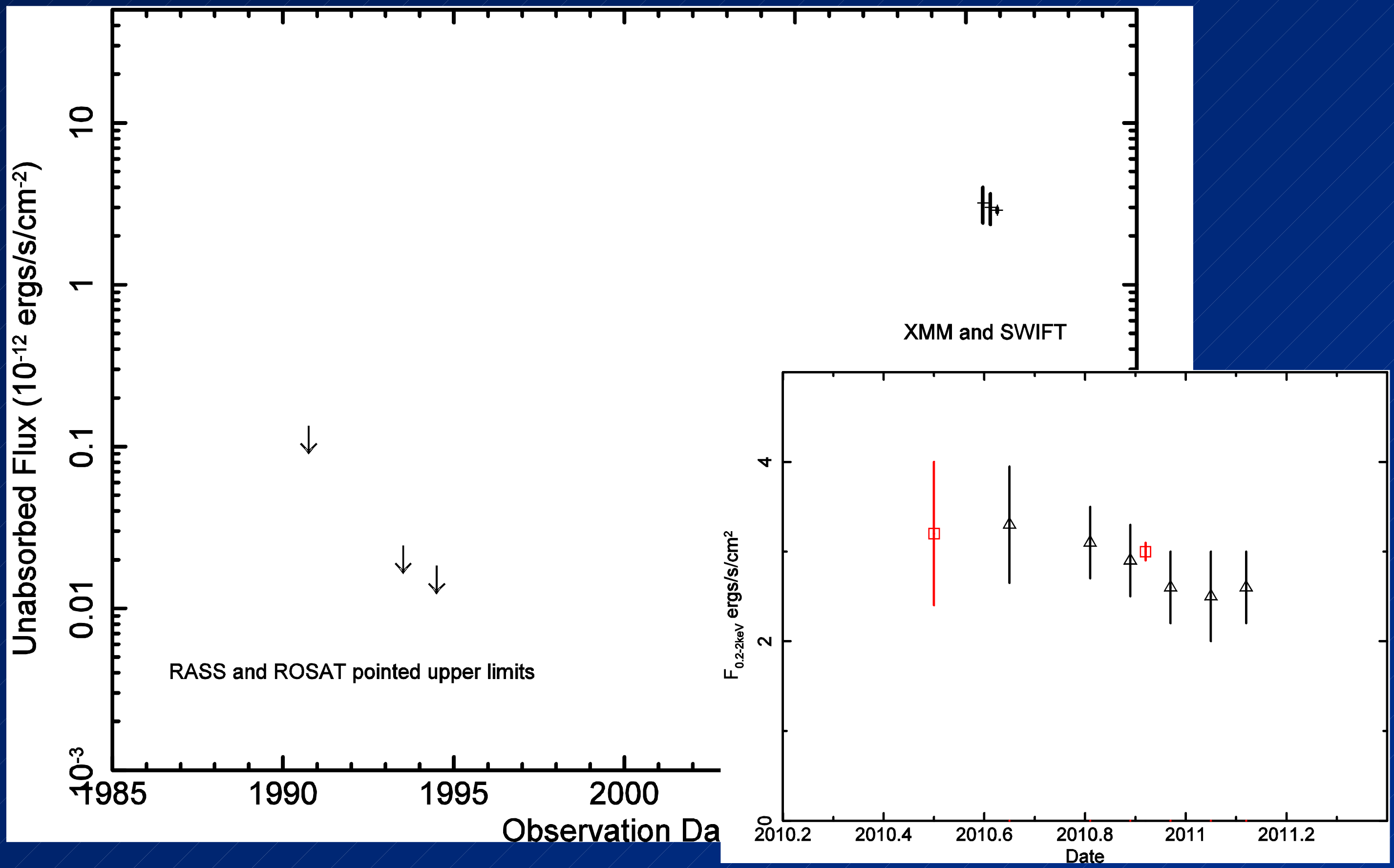
GSN 069 – optical spectrum (6DF)



Clearly a Seyfert 2 - line widths are <200 km/s – z=0.01816

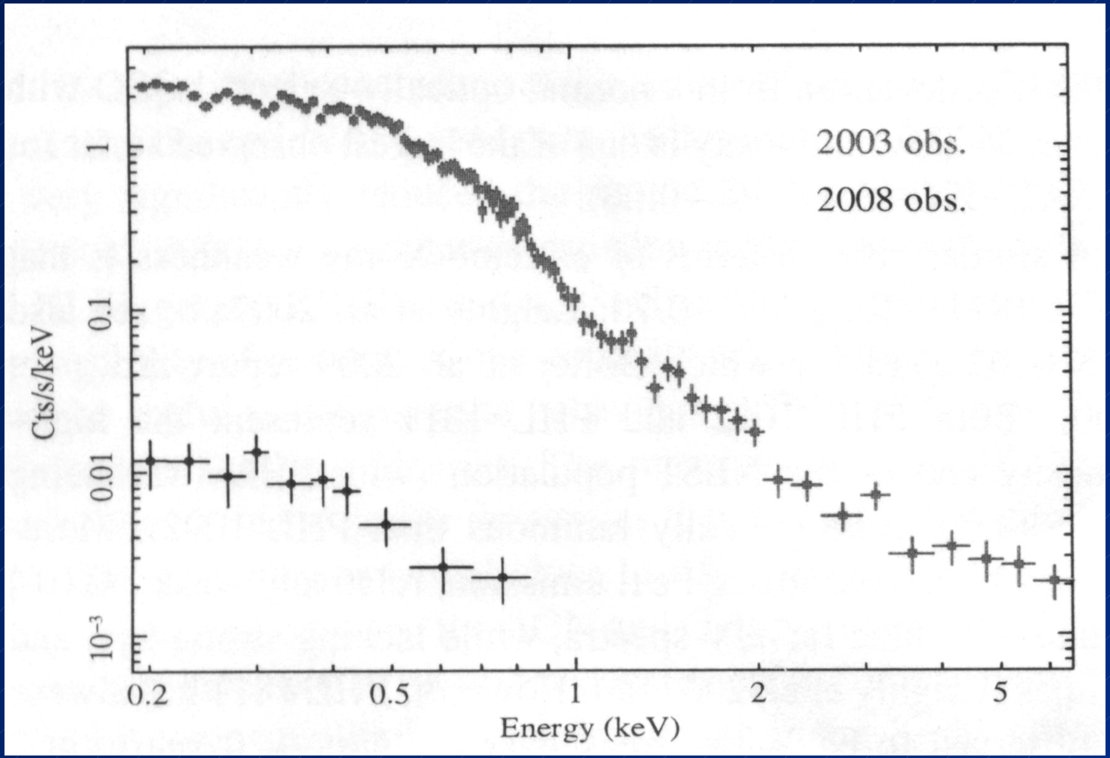
$L_{BOL\_[OIII]}$= 10^{42} ergs/s

GSN 069 – X-ray light curve



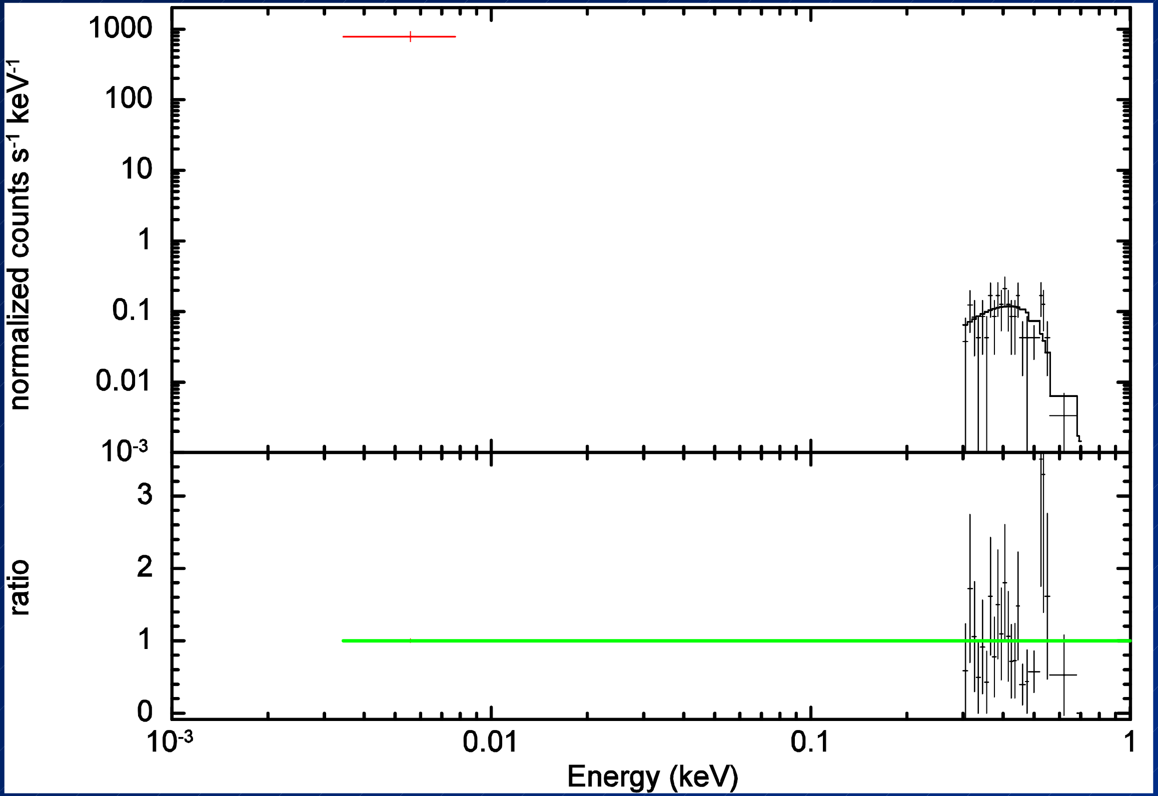
Monitoring with SWIFT and XMM-Newton

GSN 069 – precedents



Variability matched by PHL 1092 (Minuitti et al. 2009)

GSN 069 – X-ray spectrum (SWIFT)



Simple spectral fit TBABS*ZTBABS*BBOD -> kT=33+/-2 eV; NH=3+/-1 x10^21

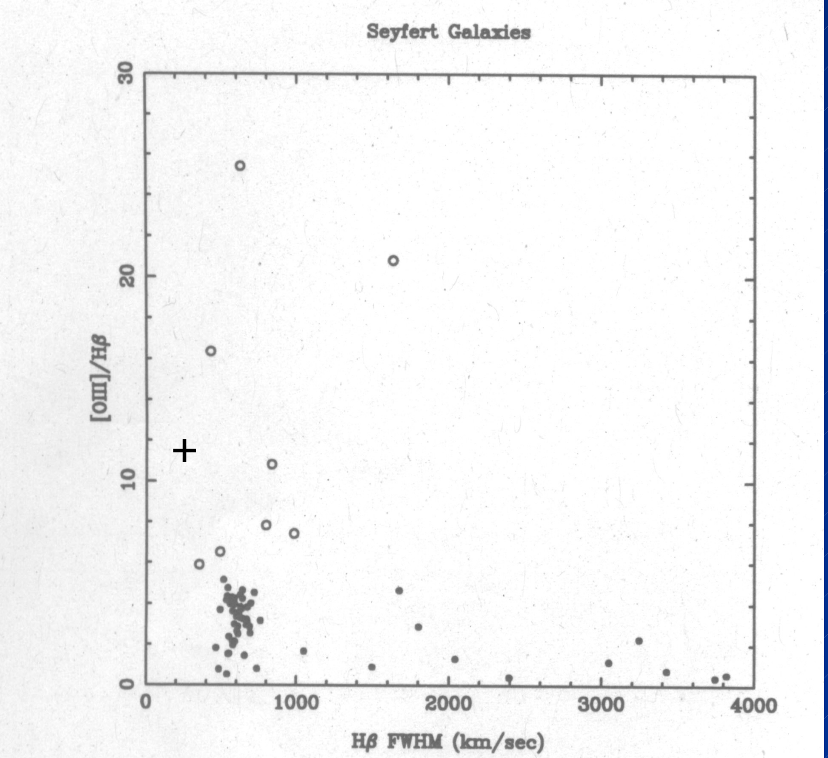
Unlikely to be Sy II due to absorption unless very dusty absorber which the Balmer decrement argues against.

GSN 069 – SY II due to absorption ?

Reasons why unlikely to be absorption:

-Soft X-ray spectrum
- NH, very low -> low column
- Balmer decrement (5) -> not too much dust
- Coincidence to have hole in absorbing screen and a super-soft spectrum

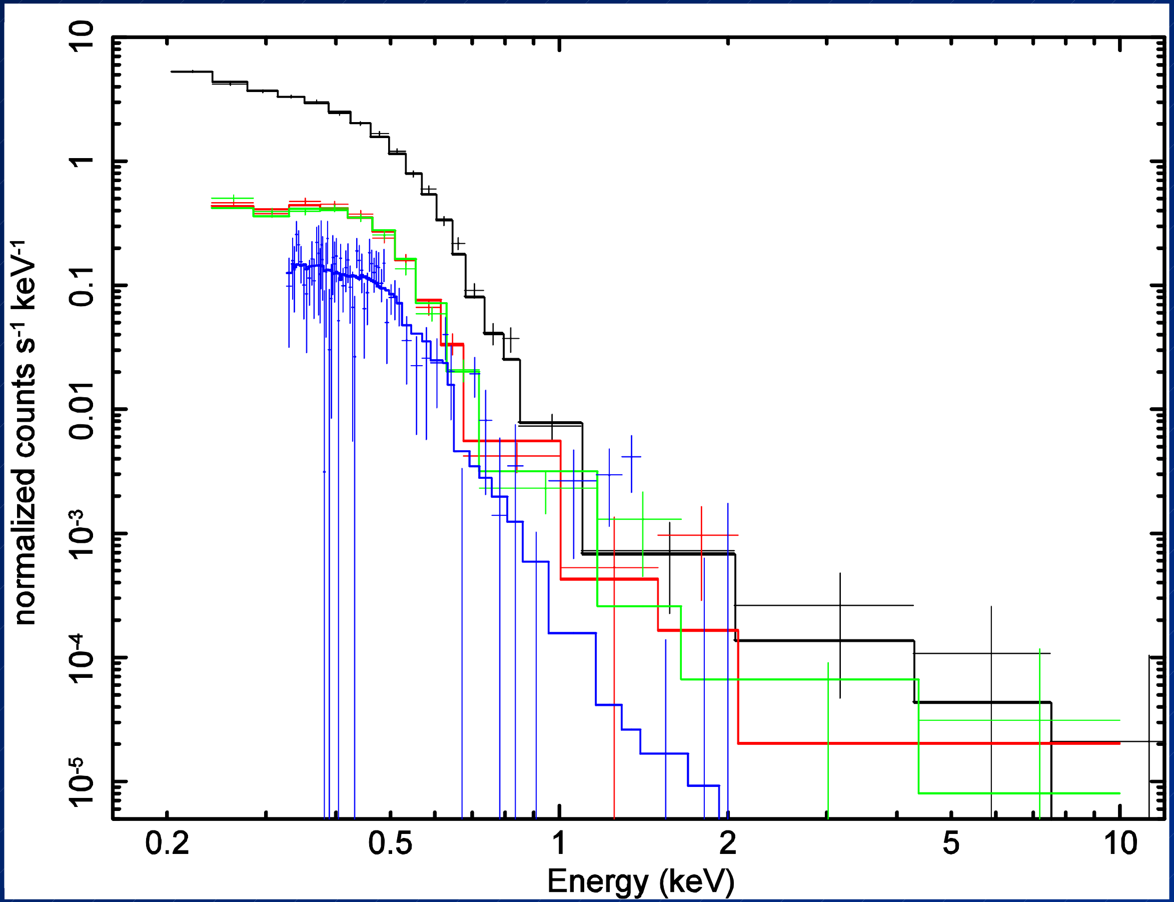
Hawkins 2004



GSN 069 – X-ray spectrum (XMM)

PN=72.5±1.5 eV
MOS1=69+5-3 eV
MOS2=64±3 eV
RGS=67±6 eV

X^2=1.05 / 106 dof



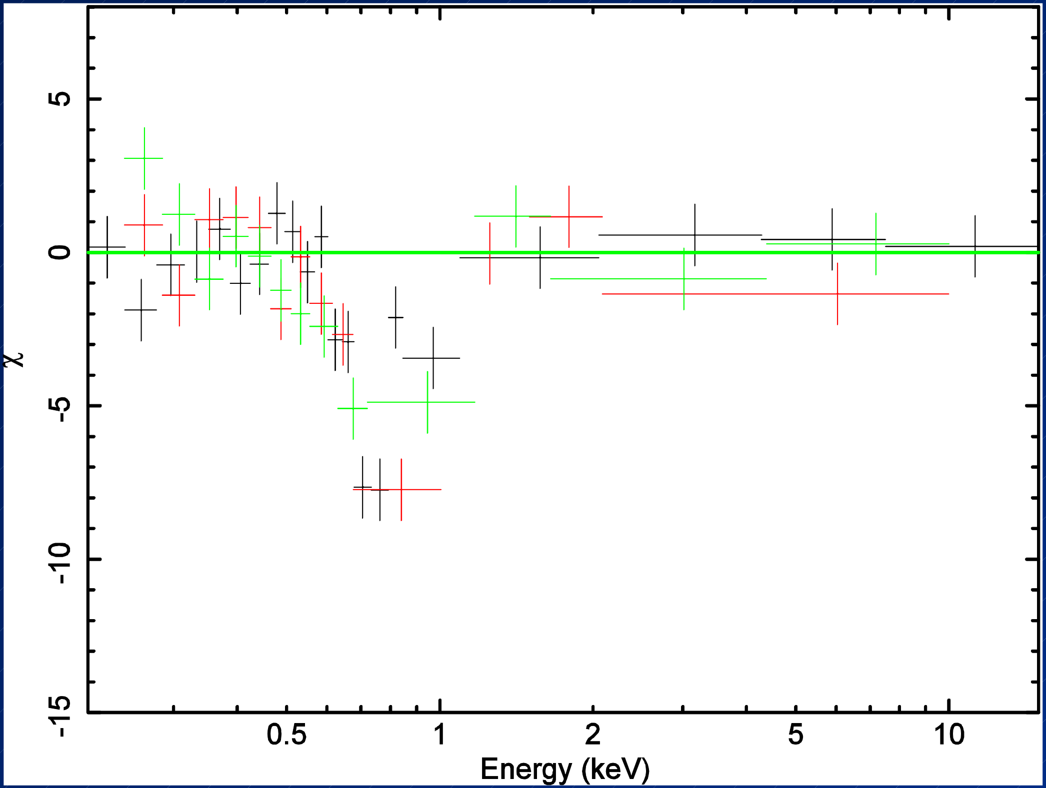
10ks XMM TOO - Power-law fit – slope=9.5 – bad fit

(DISKBB(71.5±1.eV) + PLAW) * EDGE(644+16/-8 eV, Tau=1.4) * $N_{H,Gal}$

$L_{2-10}=10^{40}$ ergs/s; $L_{0.2-2}=4.6\times10^{-12} = 5\times10^{42}$; $L_{bol}\sim10^{43}$

L_{bol} / Lx ~1000

GSN 069 – X-ray edge



If OVII, inflow of 0.1c

(DISKBB(71.5±1.eV) + PLAW) * EDGE(644+16/-8 eV, Tau=1.4) * $N_{H,Gal}$

GSN 069 – parameters

Infer M_{BH} = 1.2-5.2 x 10^5 from spectral modelling (assuming X-ray flux is thermal emission from the accretion disk)

M_{BH}=1.1-2.5x10^6 from K band flux (Marconi & Hunt 2004)

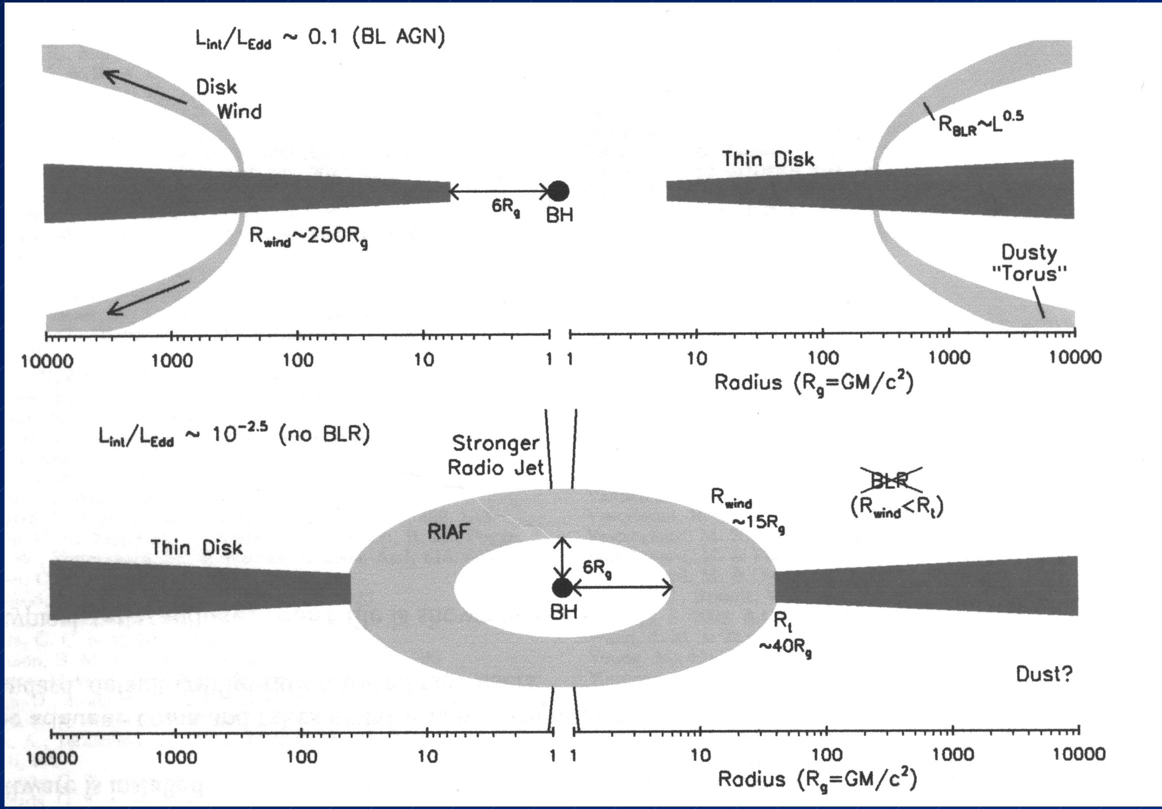
Bolometric luminosity changed from ~10^42 (from [OIII] emission) to ~10^43 from the XMM spectrum.

Assuming M_{BH}=2x10^6, Mdot has changed from 0.004 to 0.04

This is not a flare (e.g. tidal disruption, as the X-ray flux is too constant over 5 months).

Changed from RIAF to thin disk ?

GSN 069 – disk scenario



Trump et al. 2011

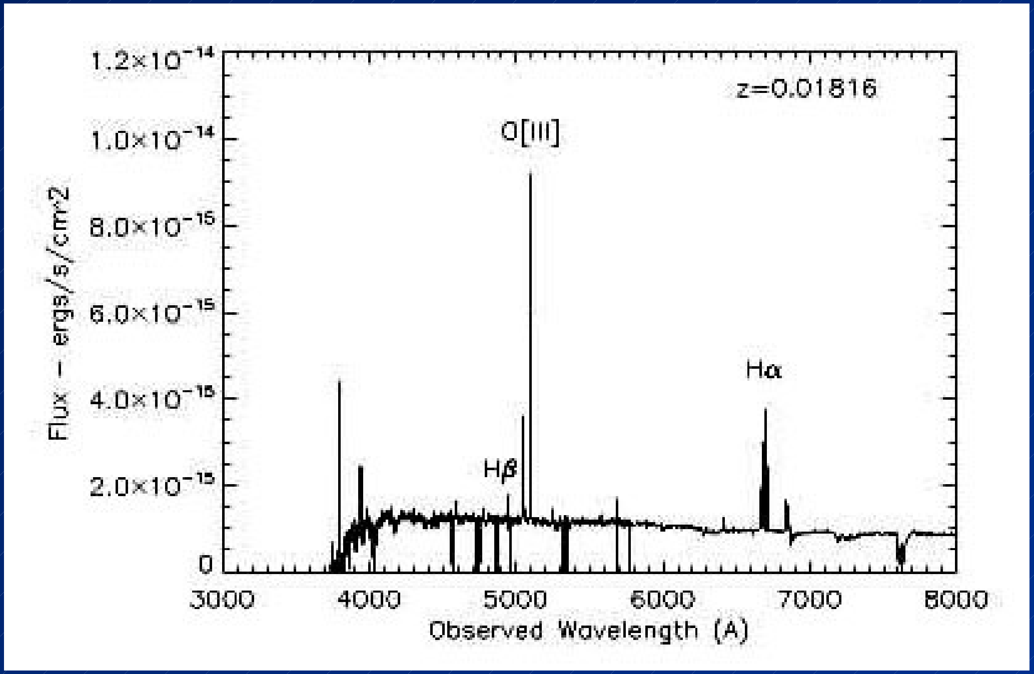
Changed from inefficient to efficient accertion; disk has moved in and is emitting thermally in soft X-rays. Comptonisation region squashed ?

Optical line widths

Following Nicastro 2000, outflow = BLR scenario, source should now have L/L_{edd} large enough to produce an outflow and form a BLR. We would expect the line widths to now be ~1500 km/s from McHardy et al. 2006.

The BLR distance should be ~10 light days for Lbol~10^43 (Denny et al. 2010). So if expansion velocity is

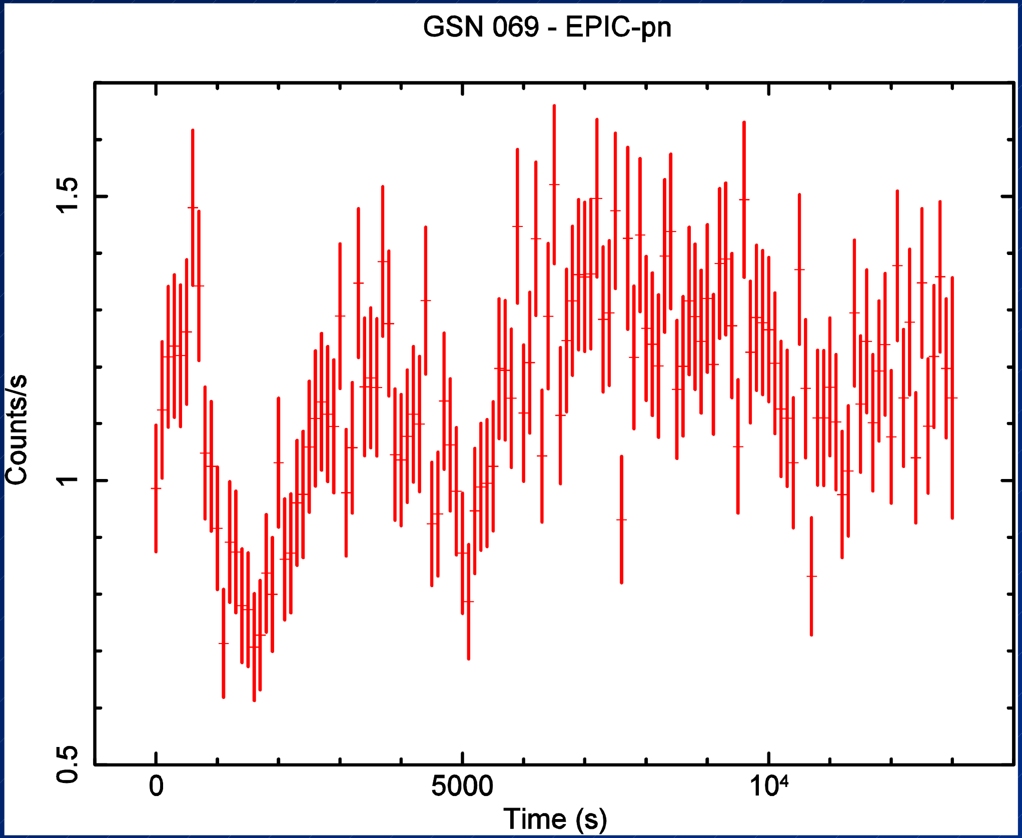
1000 km/s; we might expect to see a BLR building up after ~1 year.



AAT spectrum Oct 2010

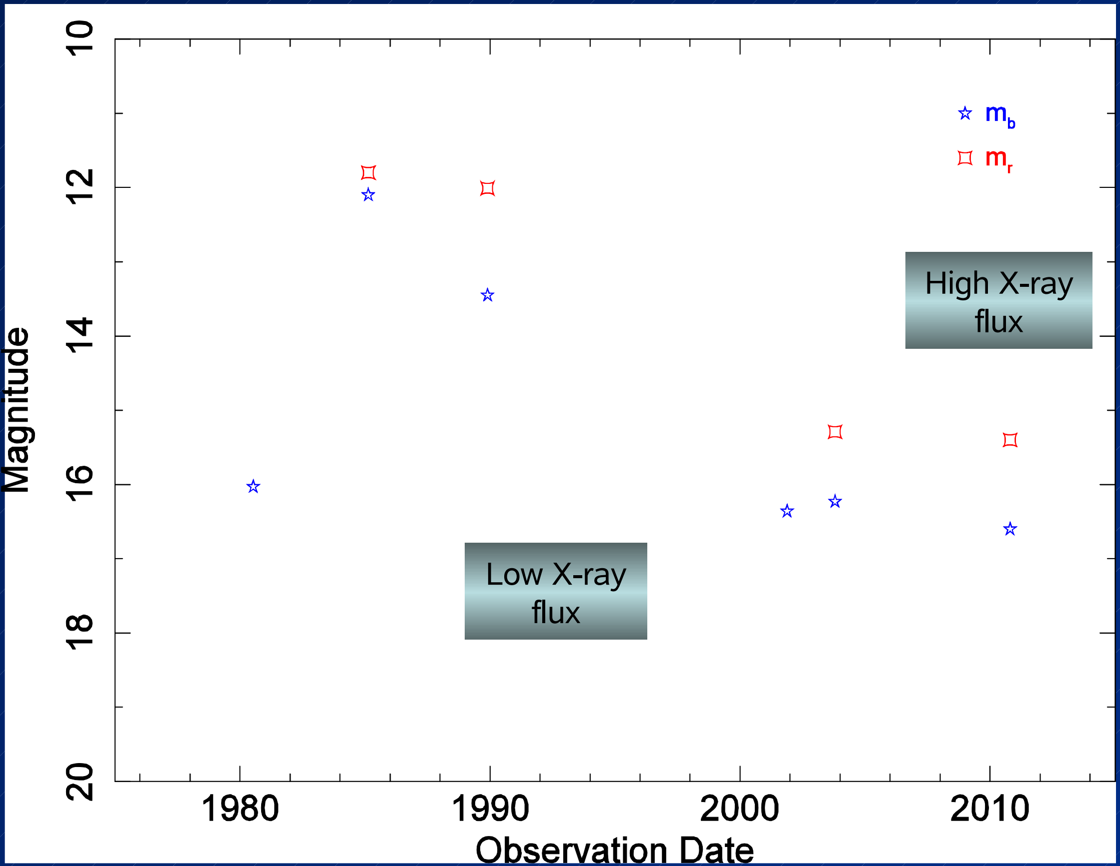
Nothing yet but continue monitoring

XMM light curve



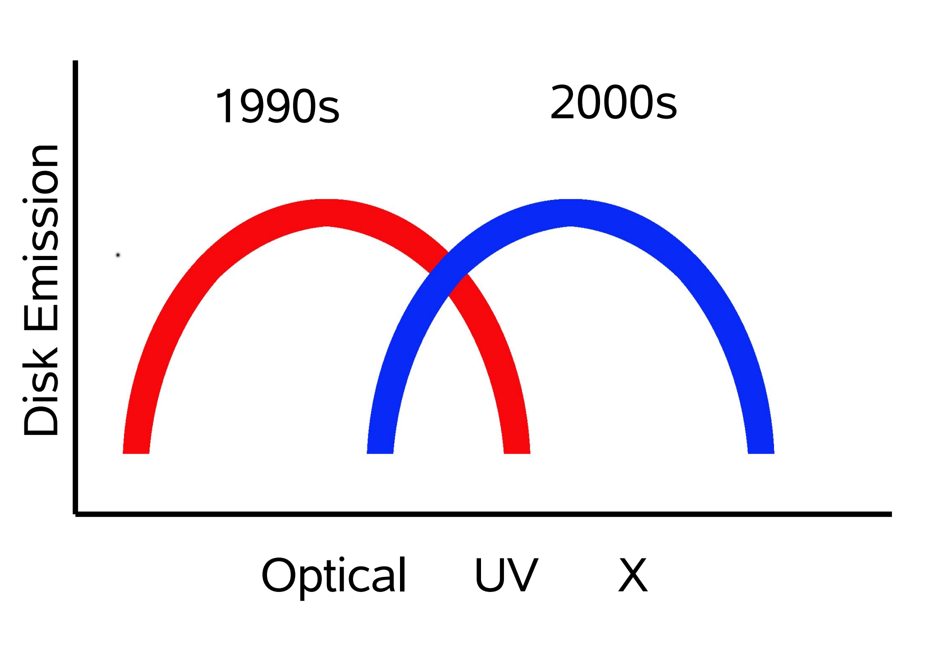
Very variable, factor 2 in 1000s, hence seeing direct emission, not hole in absorption screen. Compatible with small BH mass

GSN 069 – long-term optical LC



Something has happened to the disk – less optical flux now but more X-rays. Shift of big-blue bump to higher temperatures ?

Scenario



Conclusions

- High variability occurs in all source classes. Sy2 may be disproportionally represented.
- GSN069 (a Sy2) shows large variability and is v. soft in X-rays
- Looks like a 'true-Sy2' without a BLR
- Looks to have changed its effective disk temperature

- Where are the hard X-rays ?
- What is causing the edge at 650 eV ?
- Will it form a BLR in time ?