Exploiting X-ray flares from galactic nuclei: lessons learned from XMM-*Newton*

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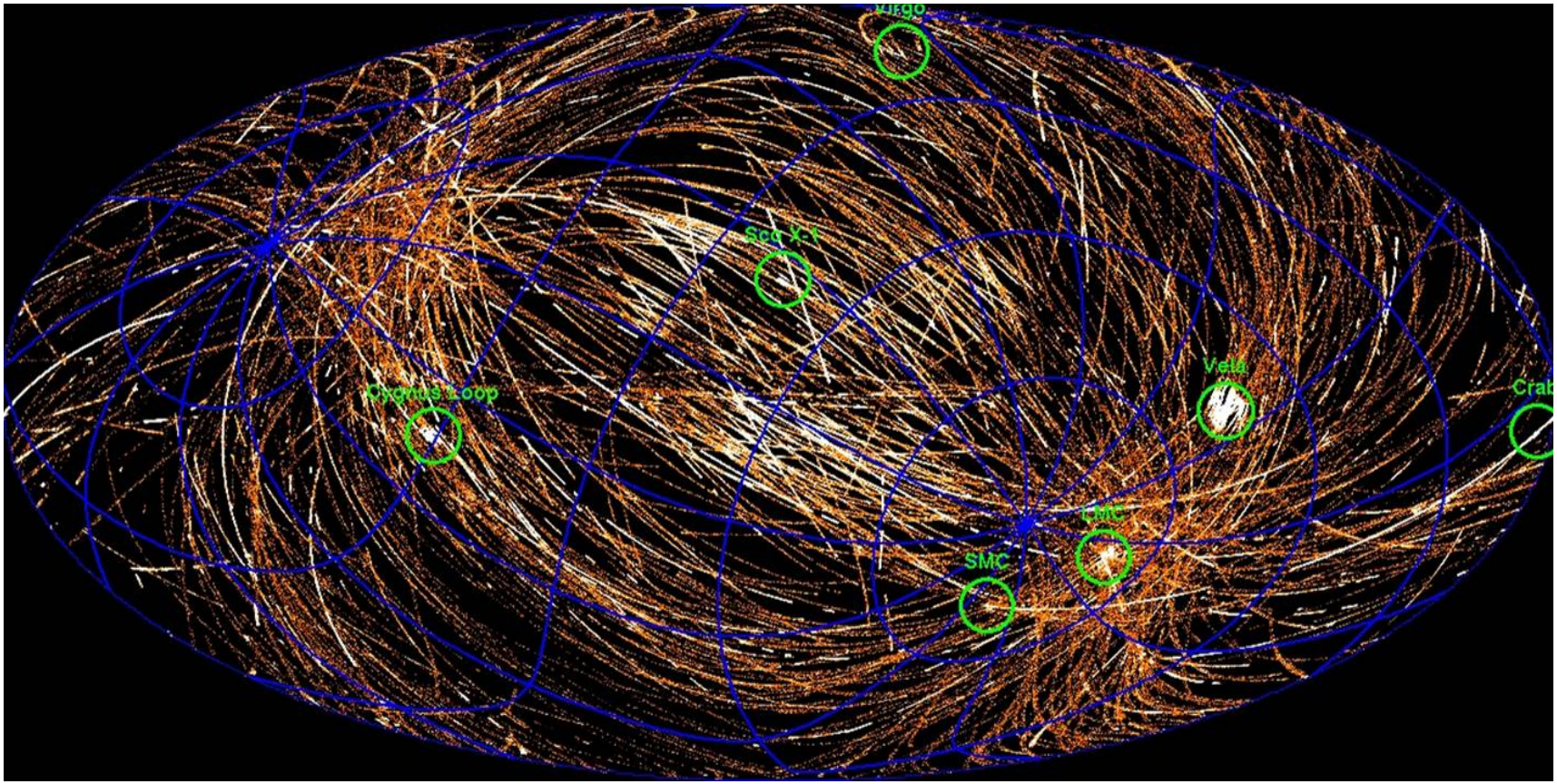
XMM-Newton slew survey



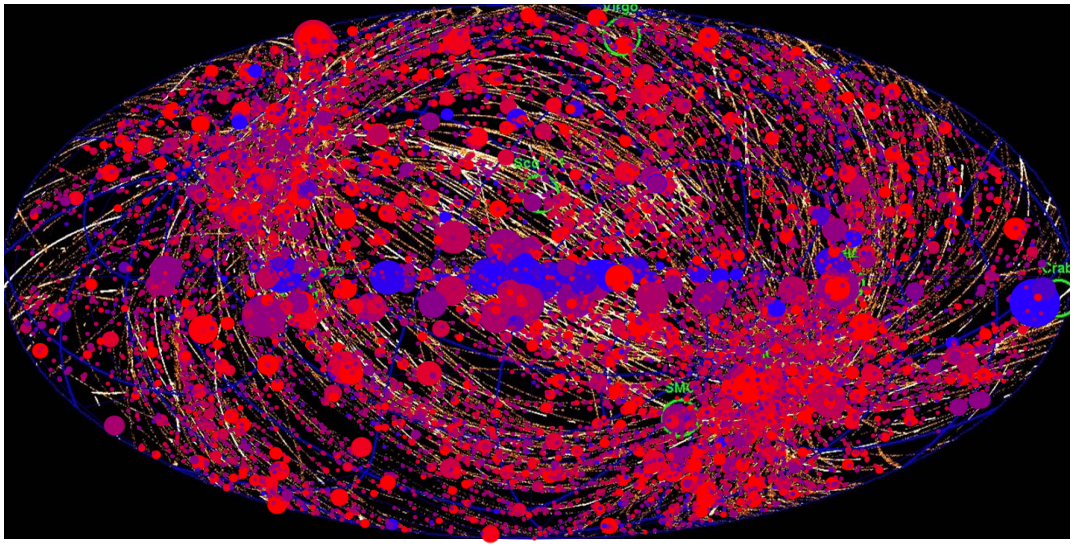
- 4000 deg^2 / year
- Currently 55% of sky covered
- $F_{0.2\text{-}2}$>6x10^{-13} cgs
- $F_{2\text{-}10}$>4x10^{-12} cgs

- 8” pointing accuracy

Searching for flares

XMM
Slew survey

find sources within a few days of a slew being made



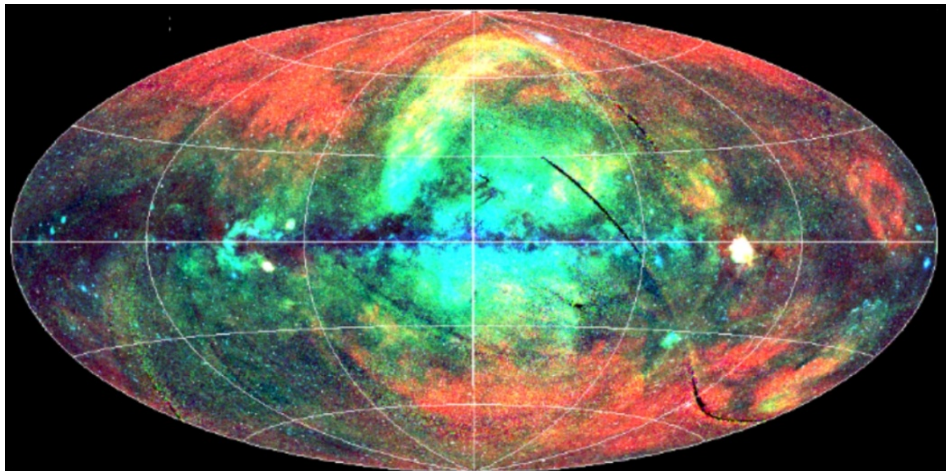
4000 deg^2 / year

Currently 55% of sky.

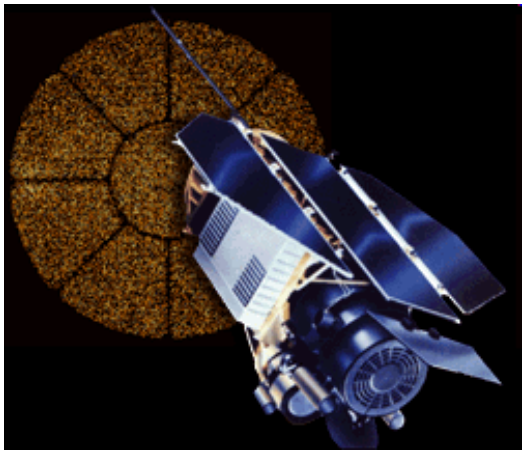
$F_{0.2\text{-}2}$>6x10^{-13} cgs

$F_{2\text{-}10}$>4x10^{-12} cgs

and compare with…..



Full sky in 1990 / $F_{0.2\text{-}2}$>3x10^{-13} cgs



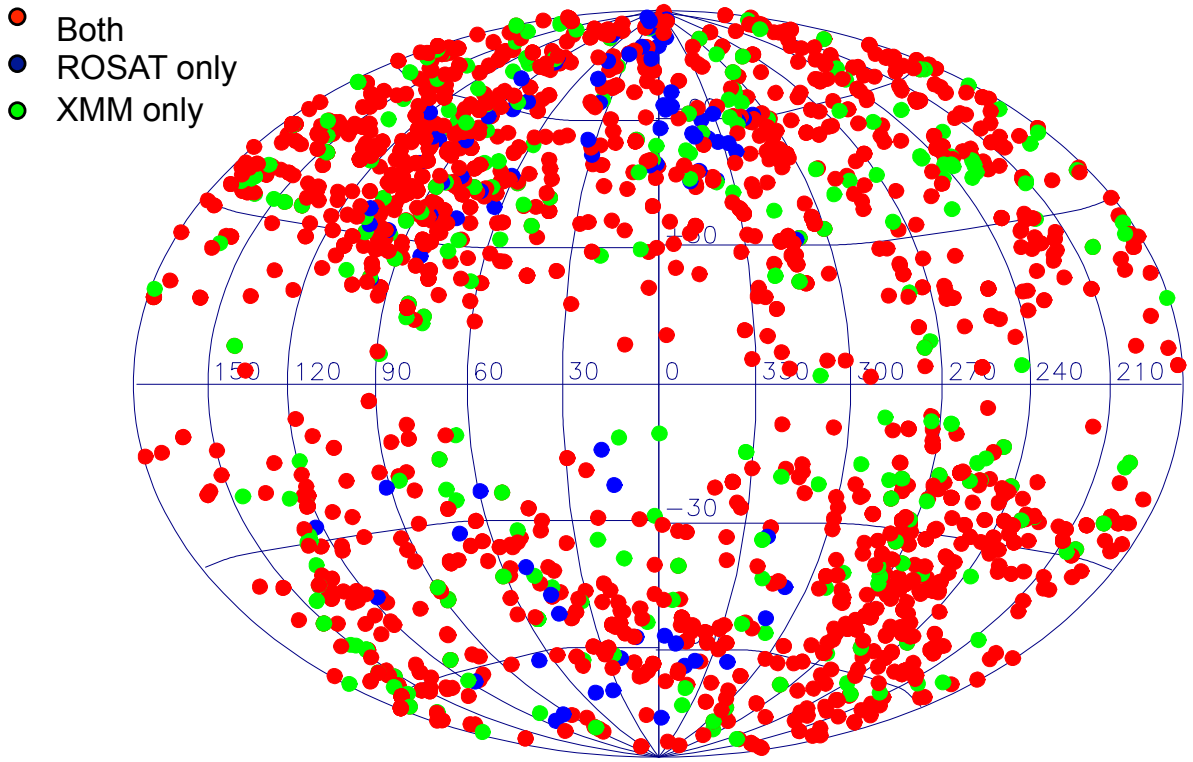
25% of sky from1990-1998

Soft X-ray variability from:

- Novae
- Flare stars
- High-variability AGN
- Tidal disruption events

Pioneering discoveries made by ROSAT
Particularly by S. Komossa, D. Grupe and Th. Boller.

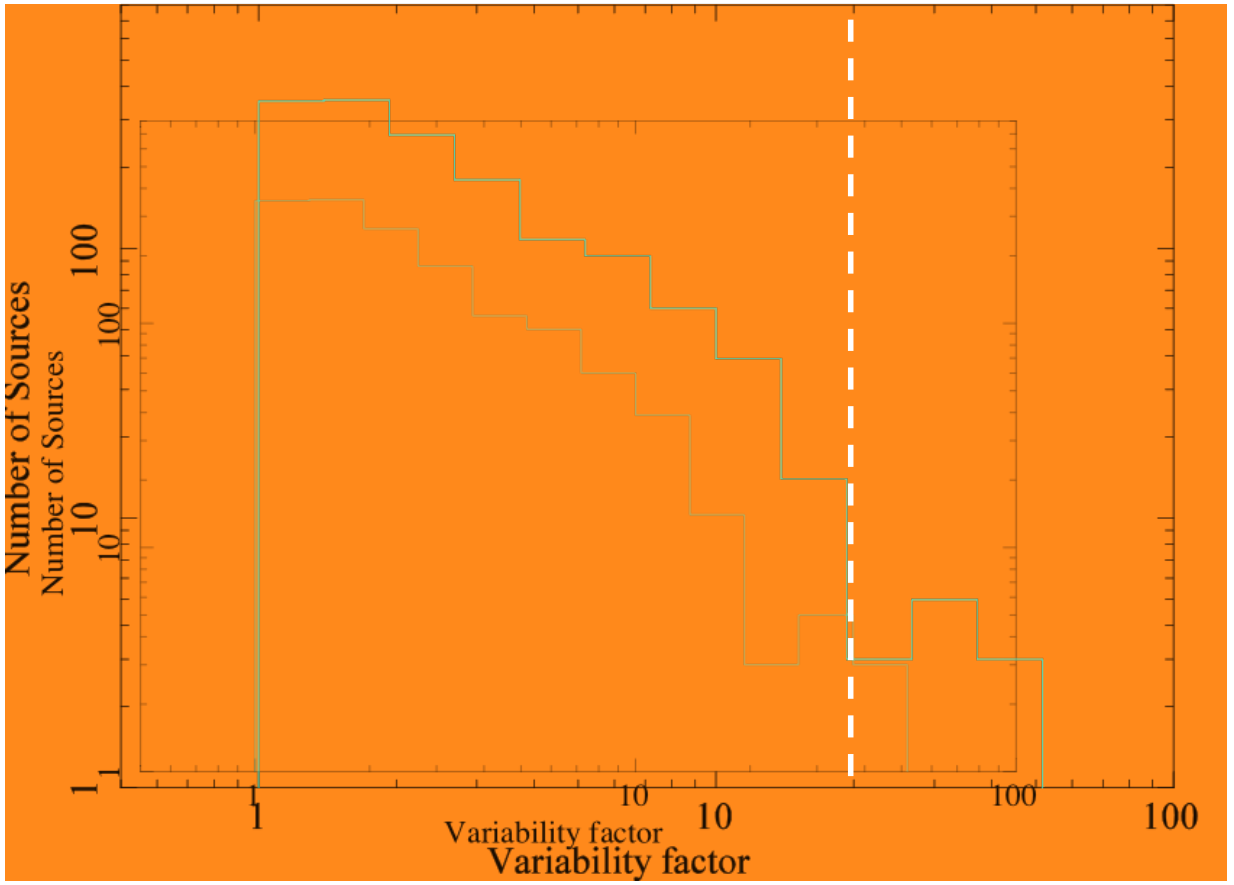
AGN combination



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 – 21 years (mostly 11-21 years)

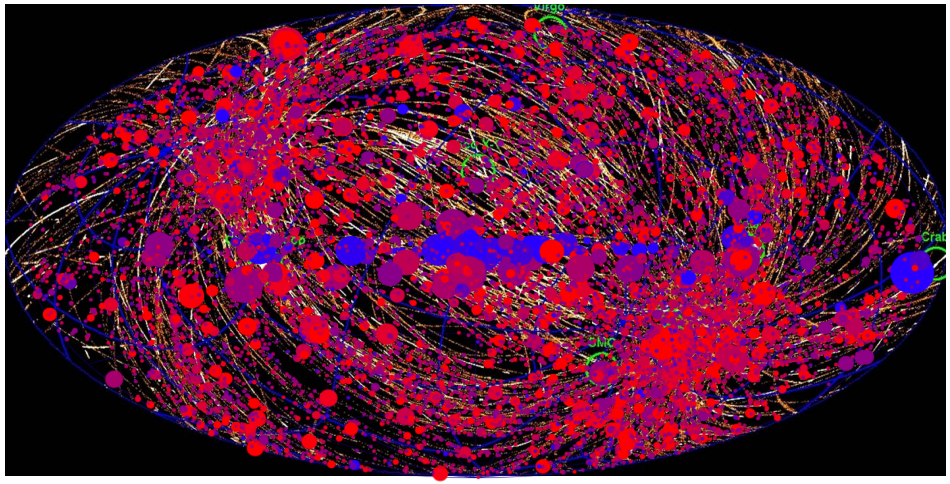
AGN long-term variability



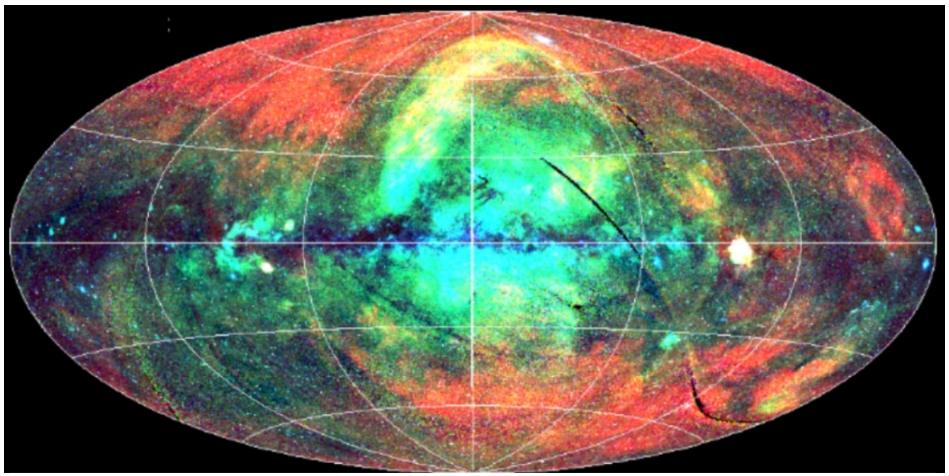
Most AGN consistent within factor 3

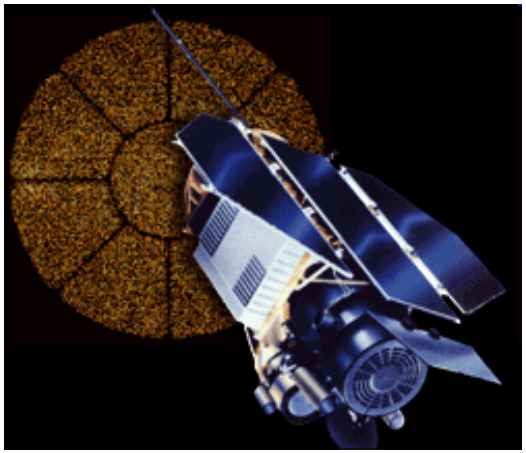
5% of AGN vary by >10 and 1% by factor >20

Effective flux limit



Use factor 20 as a cut-off for interesting sources which implies…

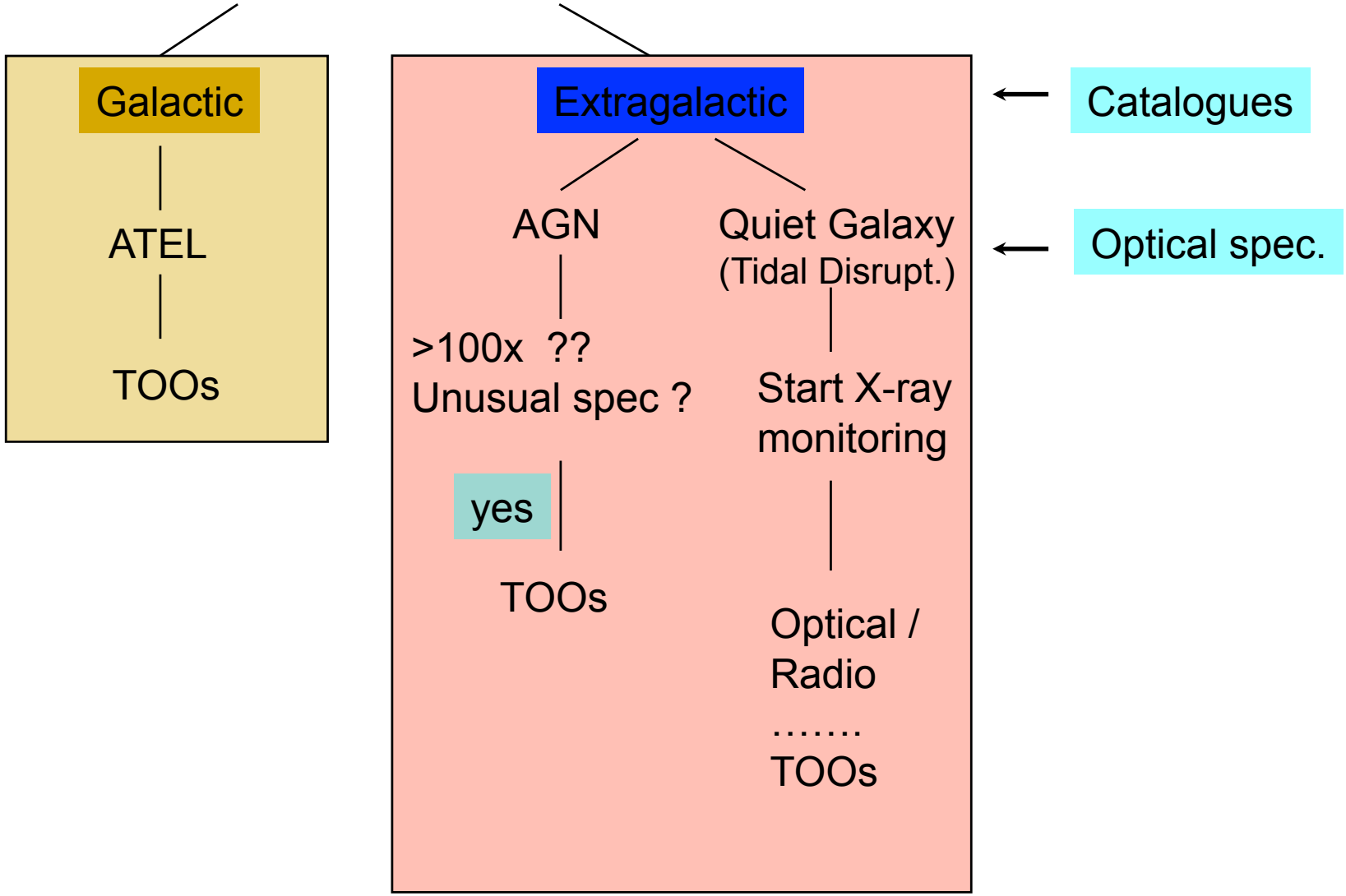




$F_{0.2\text{-}2\ keV}$ = 3x10^-13 * 20 >= $6x10^{-12}$ cgs

$F_{0.2\text{-}2\ keV}$ = $1x10^{-14}$ * 20
Actually slew limited to 8 photons
= $1.2x10^{-12}$ cgs

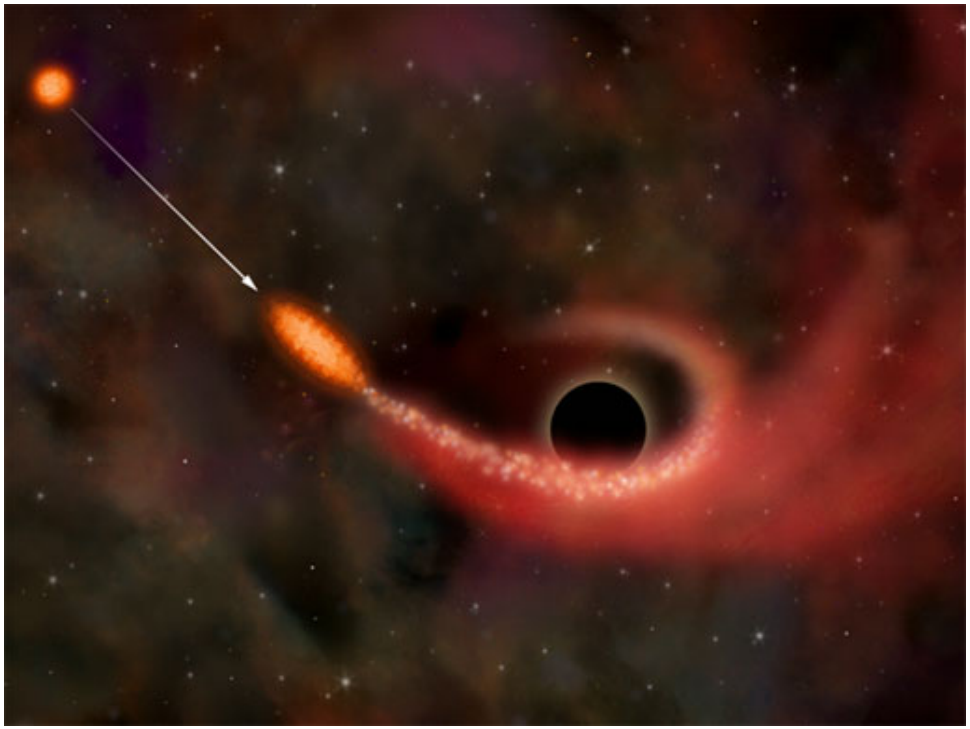
Identify source type



Tidal Disruption of a Star by a Central Massive Black Hole

If a star gets very close to the BH, it is spun-up, disrupted and forms a disk around the BH. This can fuel the BH as a bright X-ray source for months to years. 10-50% of the star can eventually be swallowed by BH.

XMM slew has seen 3/4 in 8 years. Two in the early phase before we were geared-up.

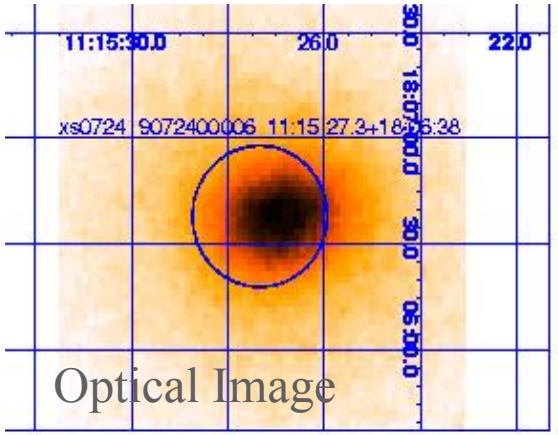


Very rare – We expect such an event every 100,000 years (in a MilkyWay-like galaxy)

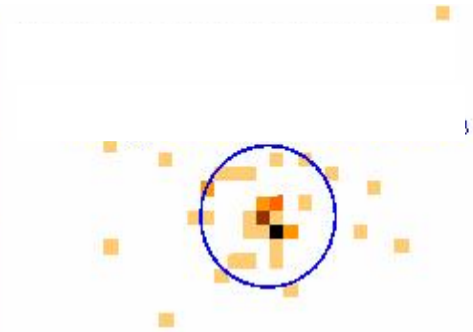
We expect to see:

- One Single, soft (40-60eV), giant X-ray burst
- Coincident with the centre of an otherwise inactive galaxy
- Extremely luminous at peak
- Lasts a few weeks at peak brightness and then fades (theory predicts decline as $t^{-5/3}$)

NGC 3599



Optical Image



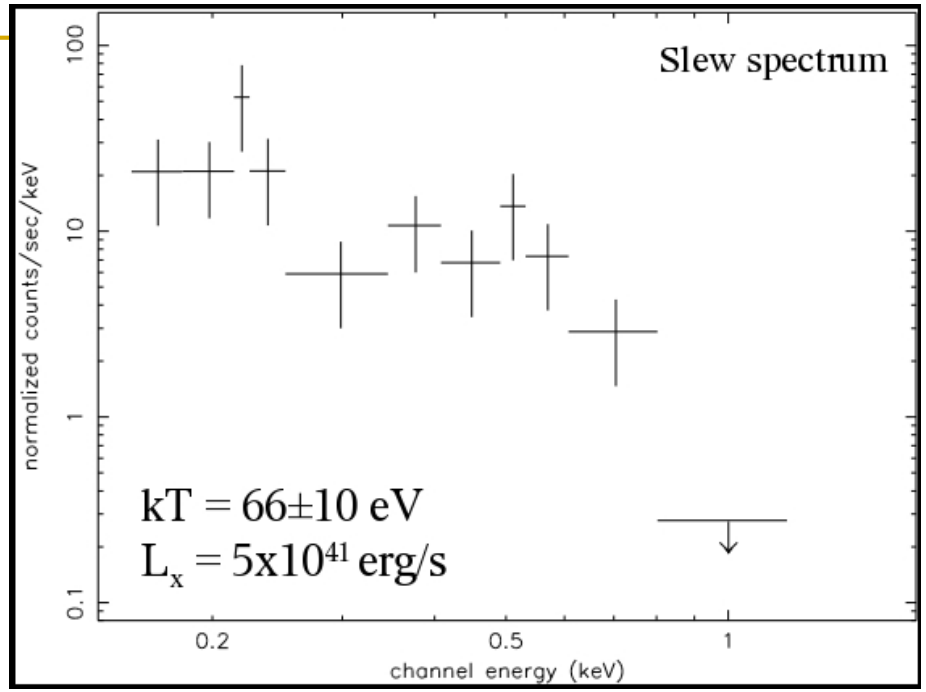
Slew – total band

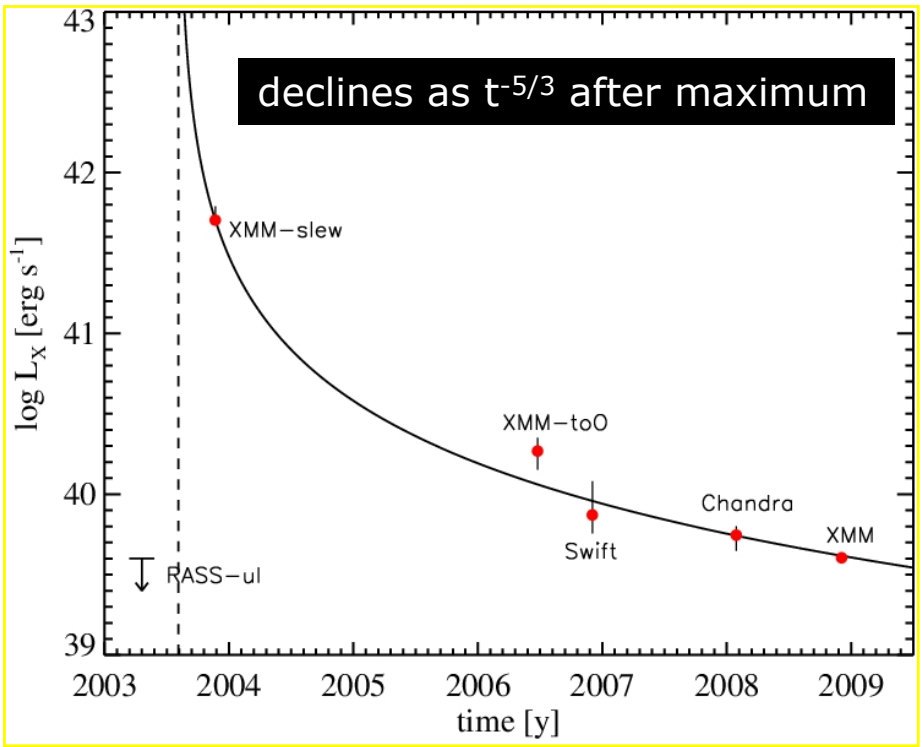
Slew – soft band

Slew – hard band

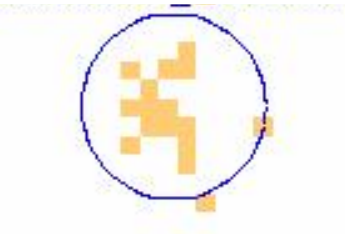
- Distance = 65 million light years
- Closest tidal disruption candidate to date

(Esquej et al, 2007, 2008)

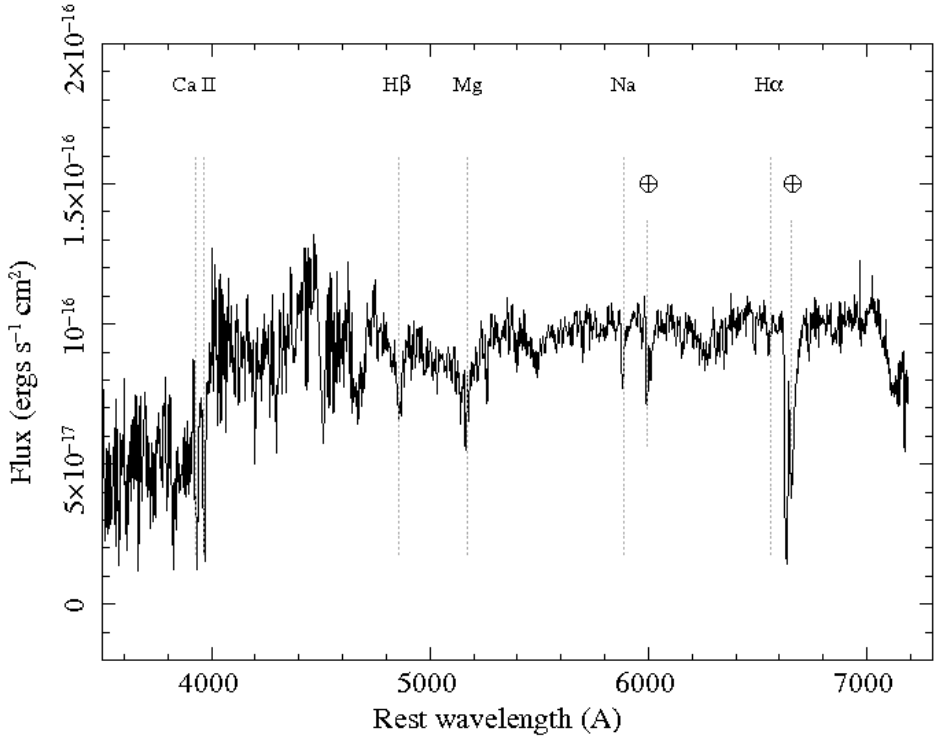


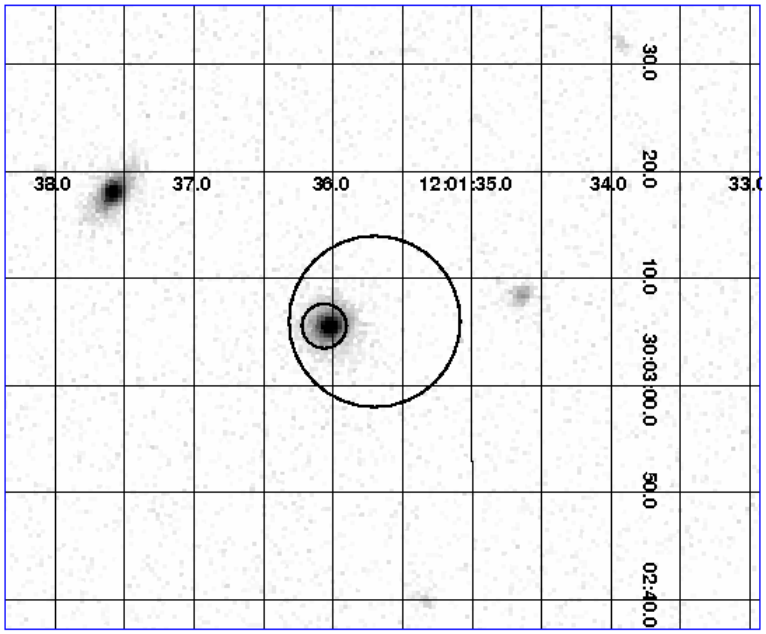


SDSS1201+30: well-monitored Tidal Disruption candidate – discovered June 2010

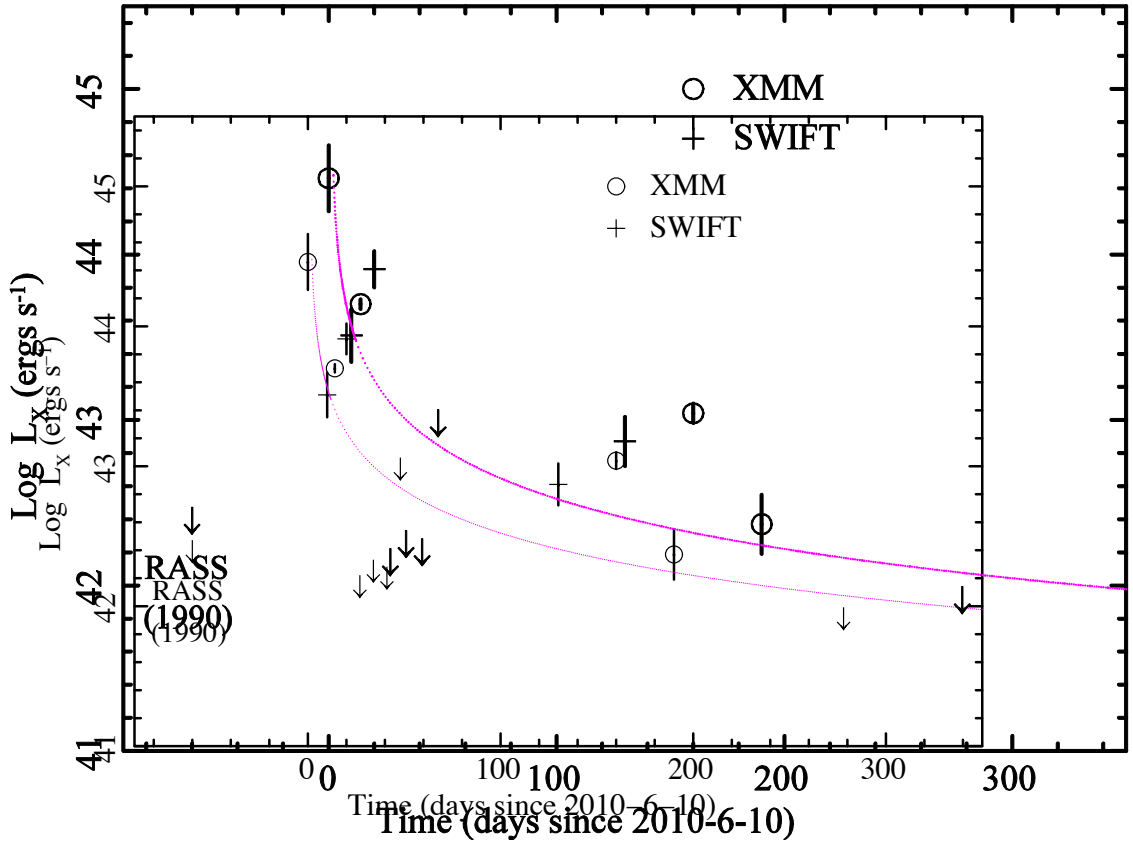


- Bright slew source in a SDSS galaxy
- 56x brighter than RASS upper limit.
- Very soft X-ray spectrum
- Optical spectrum shows no emission lines (L_{bol}<3E41 ergs/s)
- Lx=3E44 ergs/s (z=0.146)





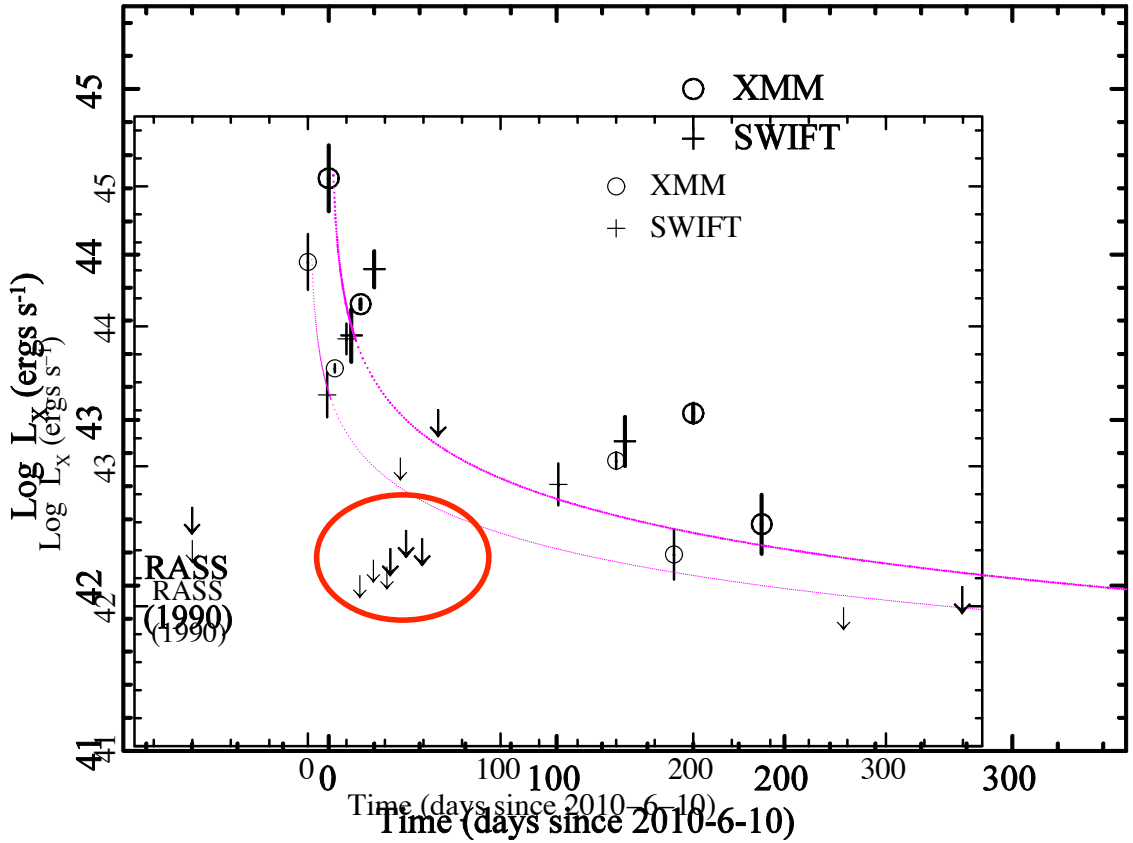
SDSS1201+30: light curve



$= t^{-5/3}$

Monitoring started 10 days after the XMM slew, every week by SWIFT and a long-look initially and then again after six months by XMM.

SDSS1201+30: light curve

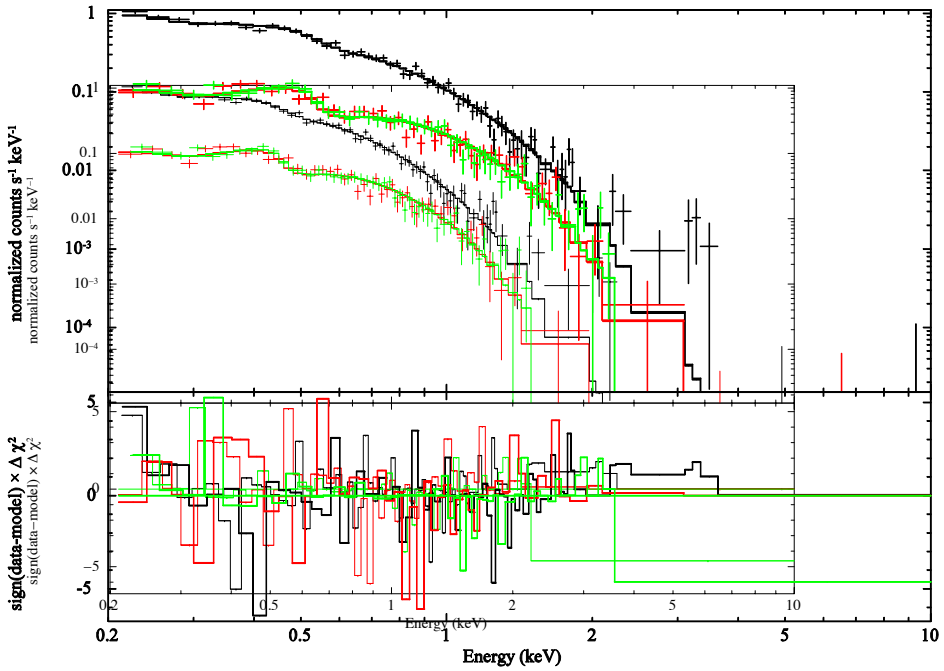


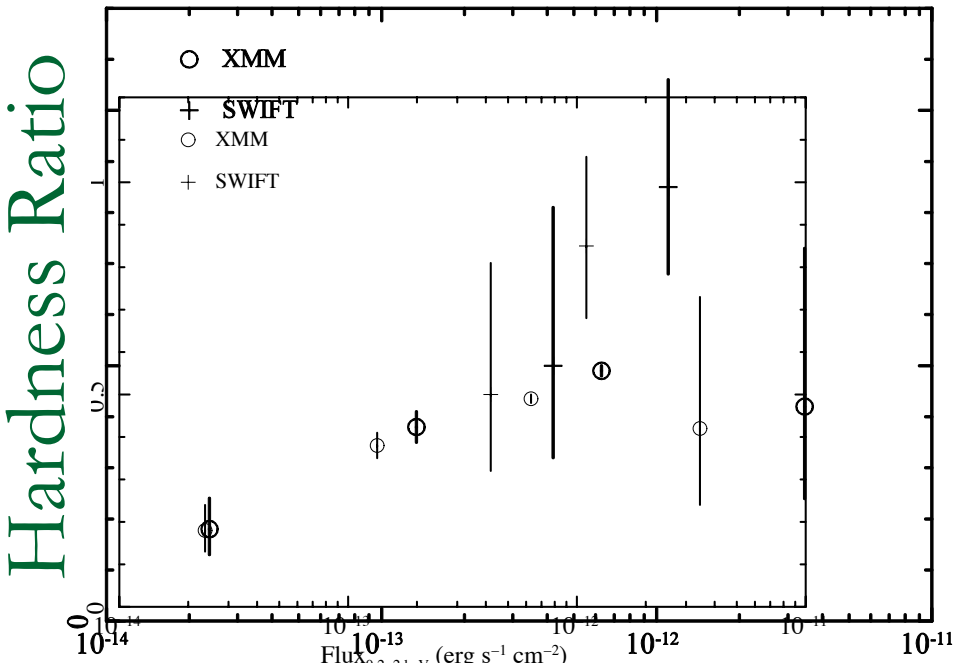
>50x drop in flux in 1 week

? Clumpy accretion
? Jet instabilities
? Absorption

Strubbe & Quataert, 2009, 2011 :
Dense accretion, $L>L_{edd}$ -> outflows -> variable absorption.

SDSS1201+30: spectrum





Flux 0.2-2 keV

Soft, Brem=390 eV or bkn power-law.

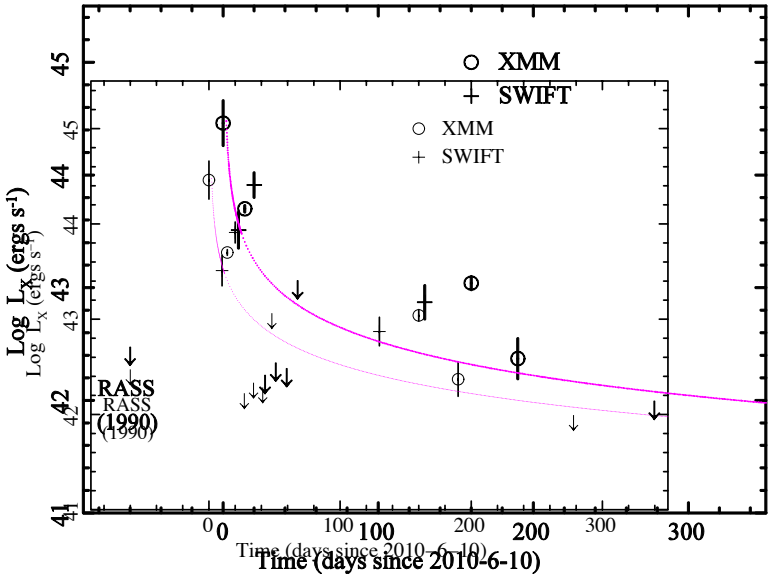
NOT black-body !

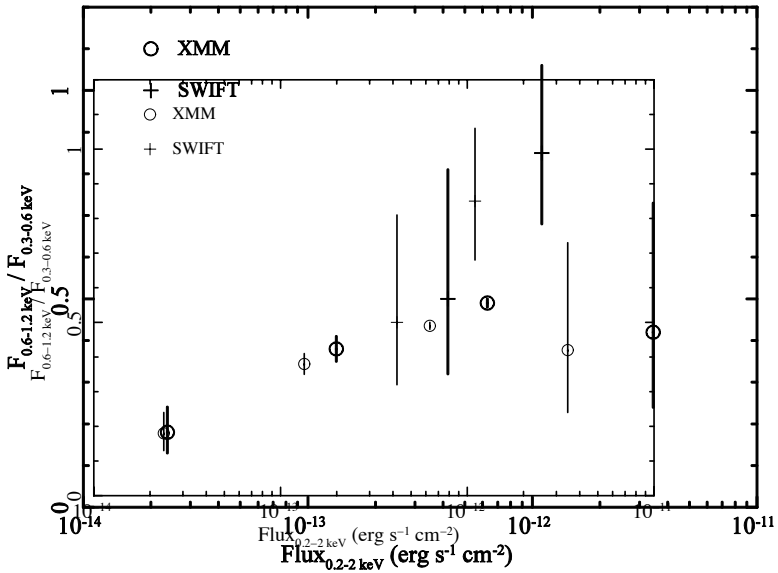
? Partial thermalisation
? Jet emission

Softens with time / decreasing flux

This, expected for both mechanisms
But not for comptonisation from a forming accretion disk – will this come later ?

SDSS1201+30: well-monitored Tidal Disruption Candidate



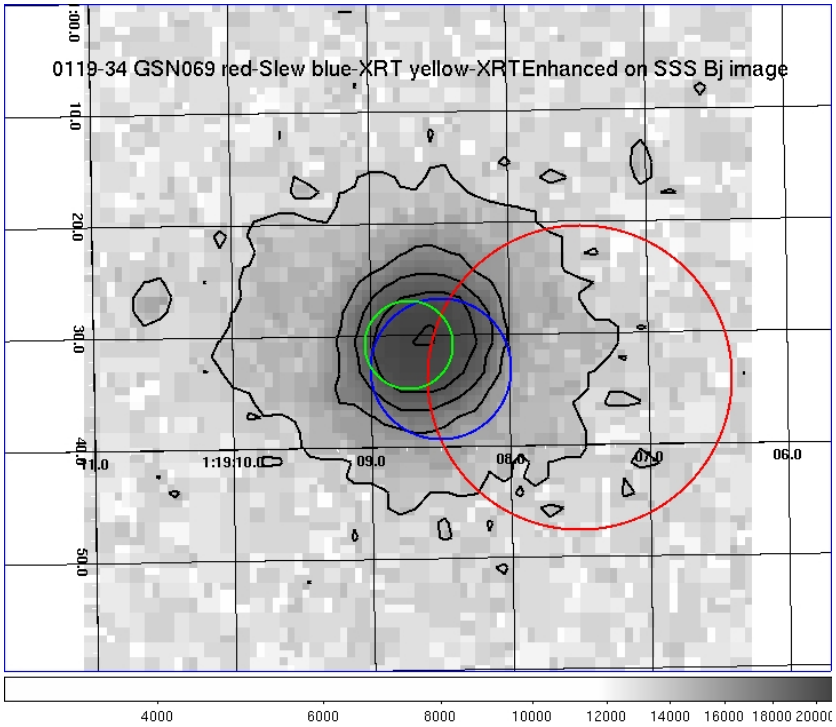


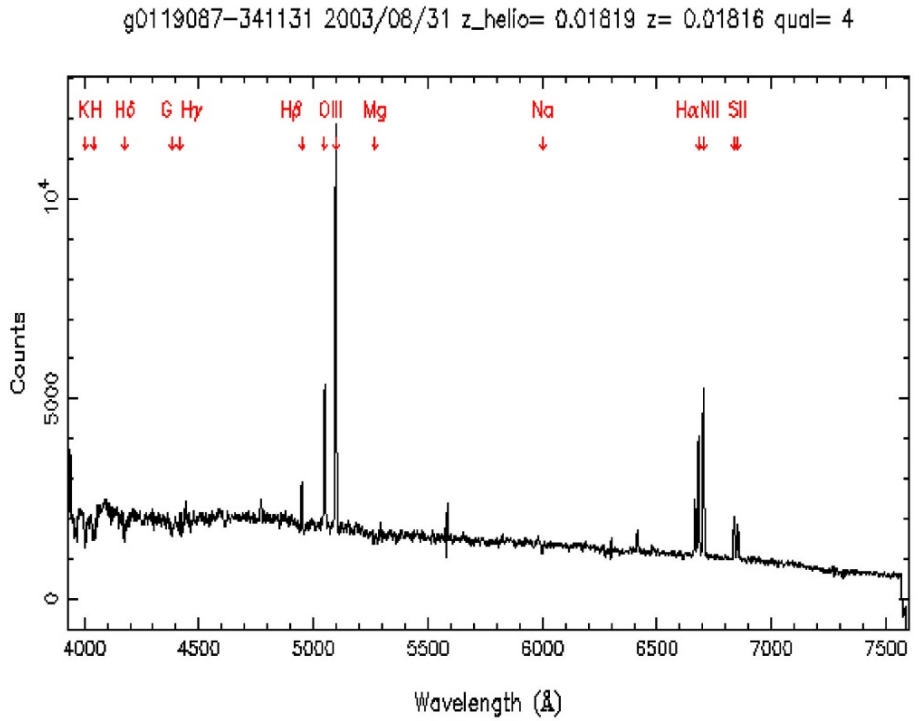
1 well-monitored source raises questions – t-series and spectrum more complex than expected – but is this a one-off ?

100 well-monitored sources should give answers

Can give real information on how accretion disks form …….

AGN: Soft slew flare from GSN 069

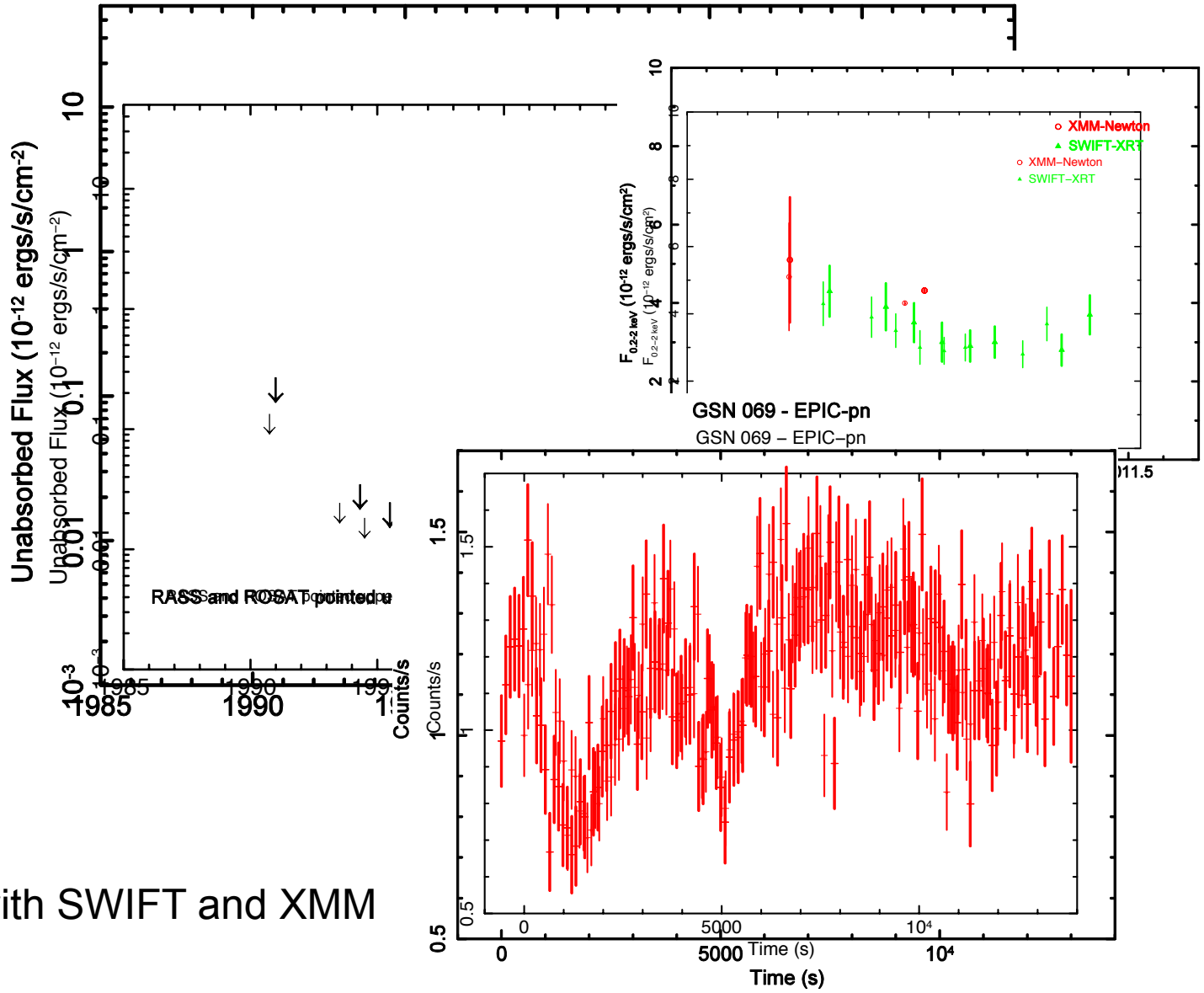




Low-luminosity Seyfert 2

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

GSN 069 – X-ray light curve

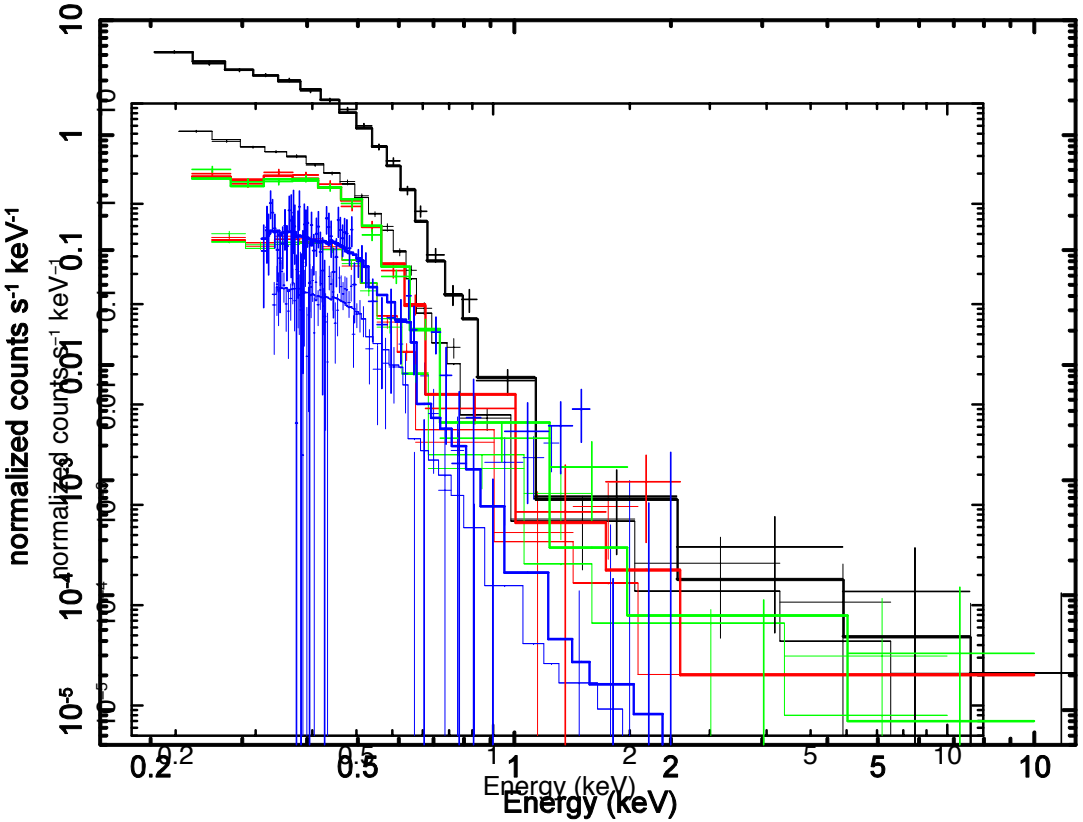


Monitoring with SWIFT and XMM

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

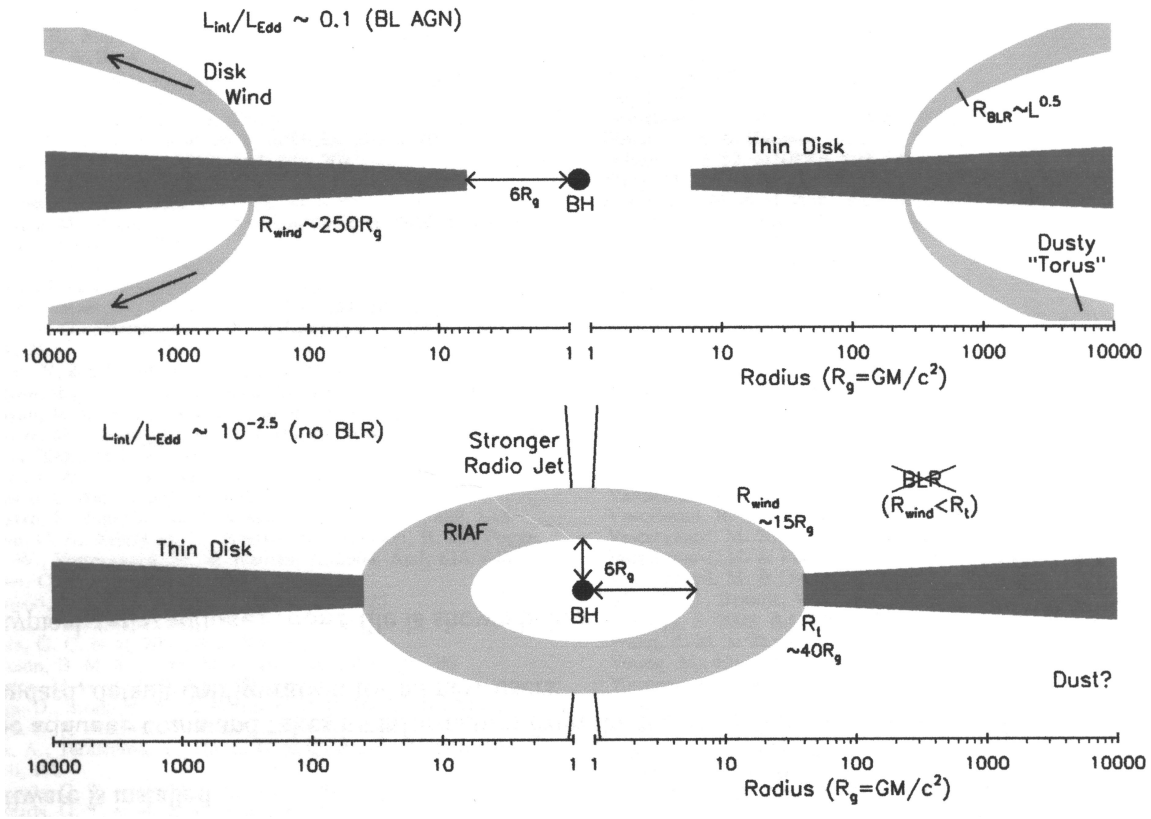


DISKBB(71.5±1.eV) * EDGE * $N_{H,Gal}$

L_{2-10}=10^{40} ergs/s;
L_{bol} / Lx ~1000

$L_{0.2-2}$=4.6x10^{-12} = 5x10^{42}; L_{bol}~10^{43}

GSN 069 – disk scenario



Trump et al. 2011

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

High X-ray variability galaxies seen to date

Tidal Disruption Events		AGN (>100x variability)
NGC 5905 (Bade, Komossa & Dahlem 96) RXJ 1242.6-111 (Komossa & Greiner 99) RXJ 1624+755 (Grupe,Thomas&Leighly 99)	**ROSAT**	WPVS 007 (Grupe+ 95) IC 3599 (Brandt, Pounds & Fink 95) IRAS 13224-3809 (Otani+ 96)
NGC 3599 (Esquej+ 07) SDSS J1323+48 (Esquej+ 07) SDSS J1201+30 (Saxton+ submitted)	**XMM slew**	GSN 069 (Miniutti+ *in prep*) MCG+07 (Read+ *in prep*)
Abell 3571 (Capelluti+ 09) Abell 1689 (Maksym+ 10) IC 4765-f01-1504 (Lin+ 11)	**XMM pntd**	PHL 1092 (Miniutti+ 09)
SWIFT J1644+57 (Burrows+ 11) SWIFT J2058+05 (Cenko+ 11)	**SWIFT**	

What eRosita will see

XMM-slew sees 1 TDE or high-var AGN in 4000-6000 deg^2 to a limit of 6E-12 cgs

Single eRosita survey sees 2.5x lower count rate in the 0.2-2 keV band, for these very soft sources (current response), than XMM slew but with 40x more exposure.

-> 16x more source photons = 4x deeper (?) [bckgnd dept]

eRosita in **first** all-sky survey pass will see the same ~ **6 -10 events**

eRosita in **second** all-sky survey pass will see **18 – 30 events**

eRosita in **third** all-sky survey pass will see **30 – 50 events**

By third year sees $4^{1.5}$ more galaxies per deg^2 -> **50-80 events in 6 months**

i.e. **1 TDE per week + 1 high-var AGN per week.**

XMM-slew flare exploitation issues

- Team size – 3-5 is barely enough to handle 1 event per 6 months
- Follow-ups / TOOs - pre-arranged if possible
- ATELs, circulars or on-the-fly TOOs ?
- AGN can be treated leisurely, Tidal Disruptions have to be followed-up immediately

Summary

- Flares give another window onto galactic nuclei accretion
- eRosita mission is a magnificent tidal disruption detector ; has the potential to see 10x more events than we have seen to date
- Finding 100 more TDEs gives nothing – need to follow them up
- If caught in time can give real information about the accretion process, but needs:
  - Working group of dedicated staff (correctly sized)
  - Pre-arranged, short-notice response time on X-ray, optical (and radio) facilities.

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