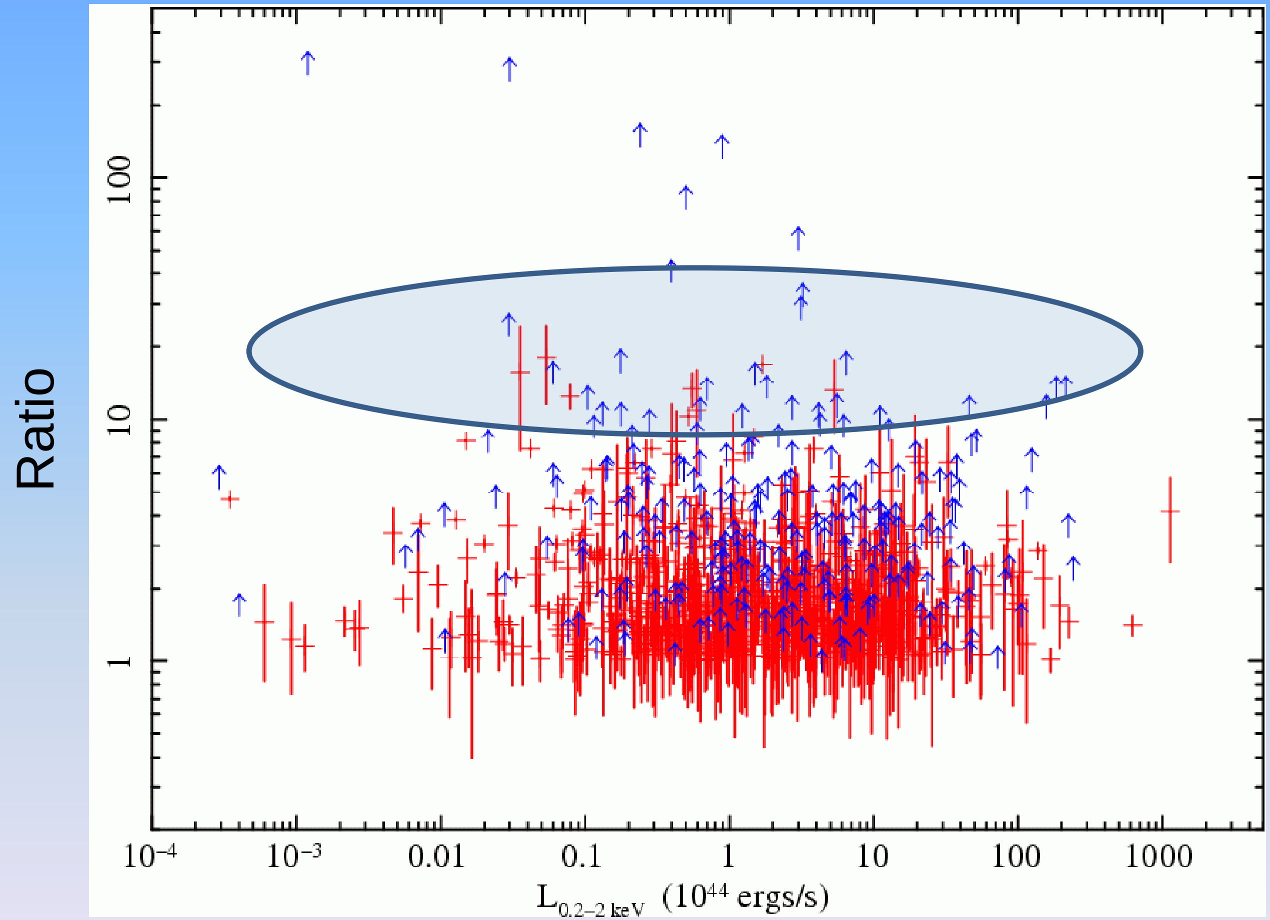
Massive, long-duration, soft X-ray flares from Galactic nuclei

Richard Saxton,

Stefanie Komossa, Andy Read, Sara Motta, Pedro Rodriguez, Pilar Esquej, Dirk Grupe, Giovanni Miniutti, Rhaana Starling, Nora Strotjohann

XMM – ROSAT extragalactic variability



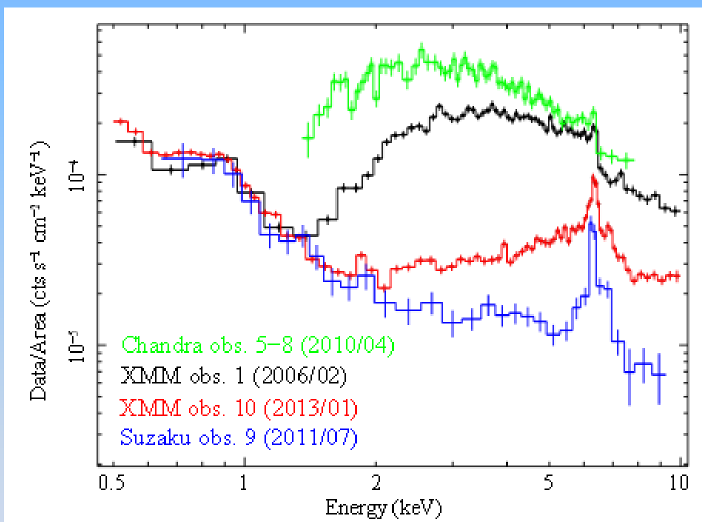
Ratio of XMM / ROSAT 0.2-2 keV flux

Small number of high variability galaxies

Medium -strong variability: Absorption and Reflection

ESO 323-G77 (NGC 1365)

Absorption

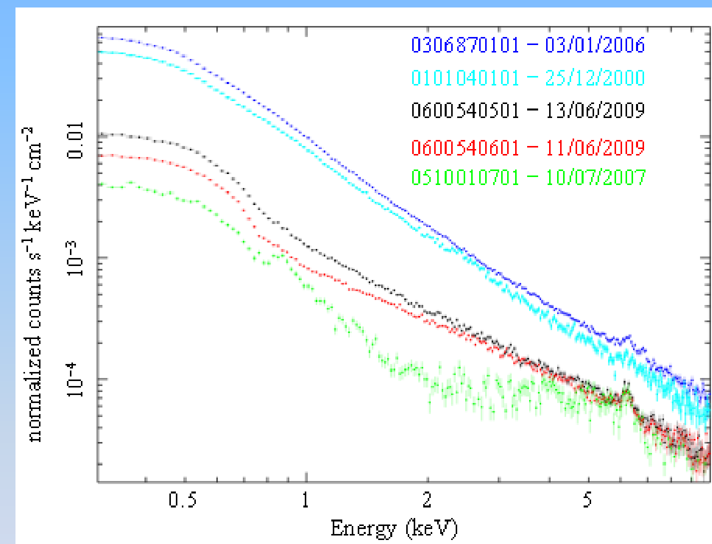


Miniutti et al. 2013
Risaliti et al. 2005, 09
Agis-Gonzalez et al. 2013
Walton et al. 2014

-

MRK 335

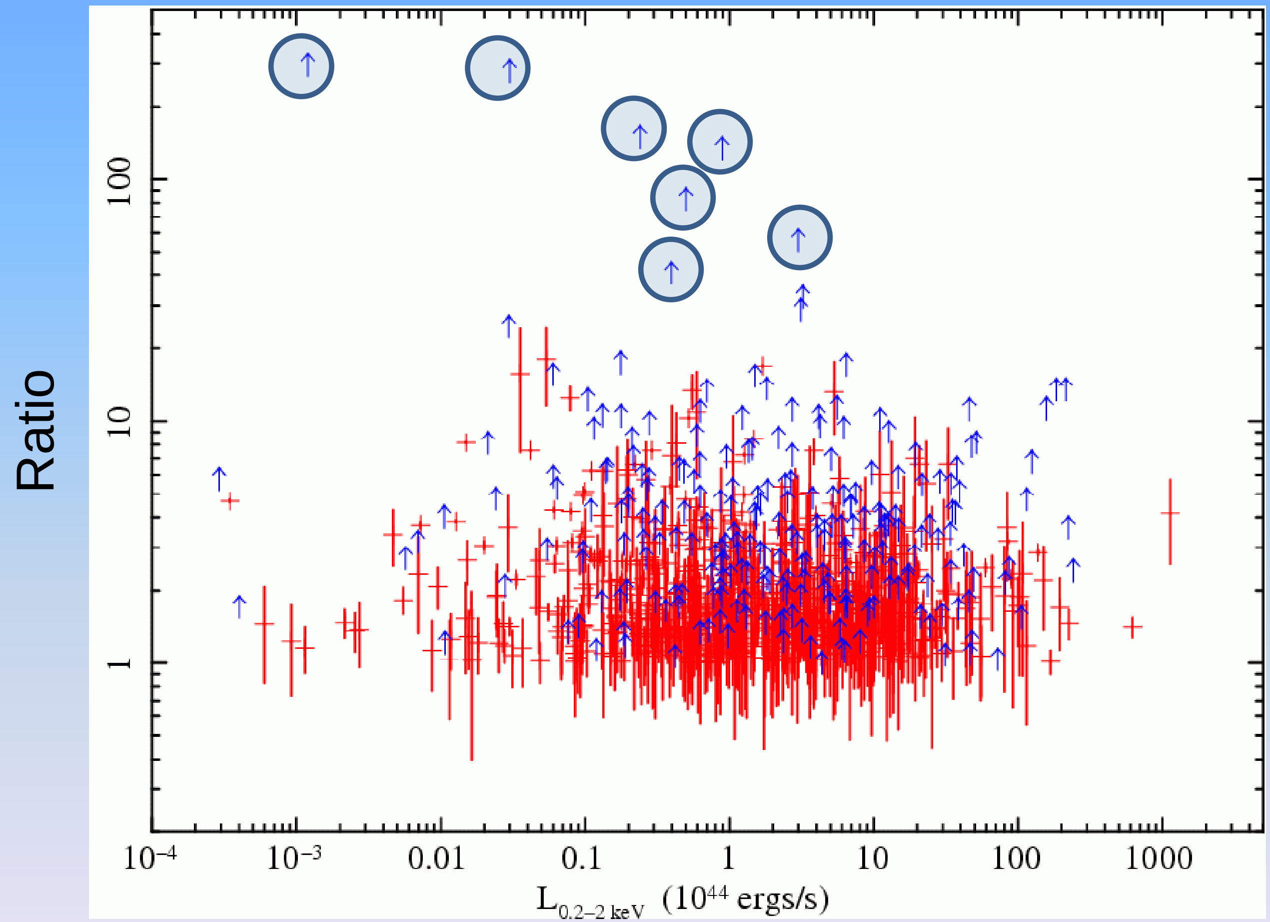
Reflection



Longinotti et al. 2013
Grupe et al. 2013
Gallo et al. 2013, 2015

See Poster D09 by Starling et al.

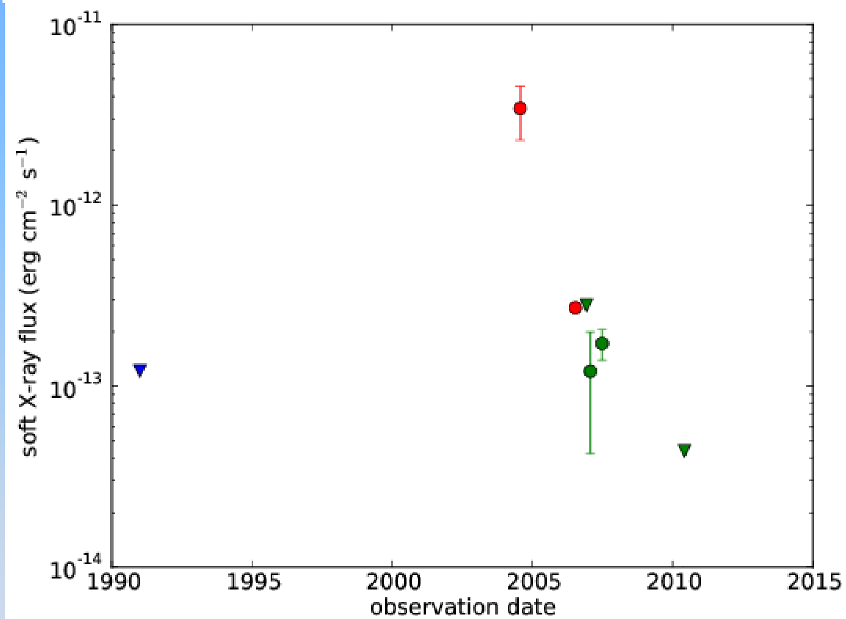
XMM – ROSAT extragalactic variability

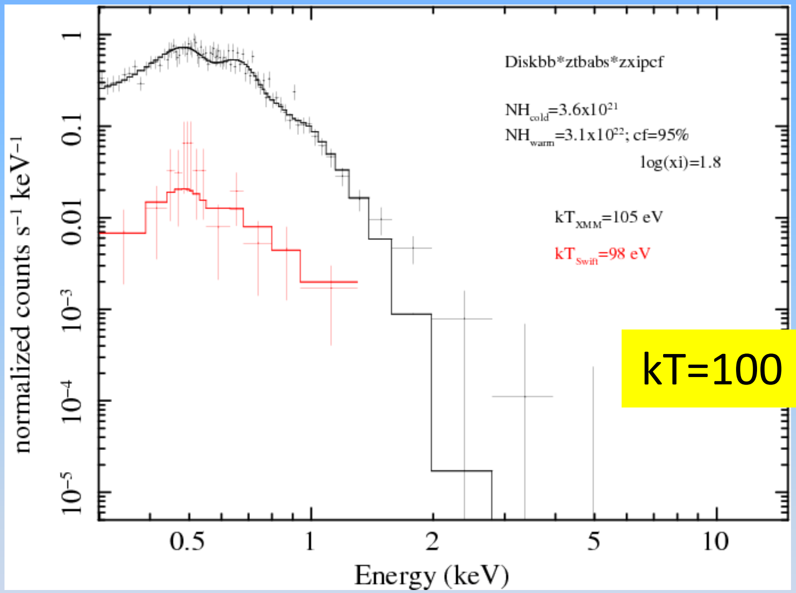


Small number of very high variability galaxies – <1% factors 50-300

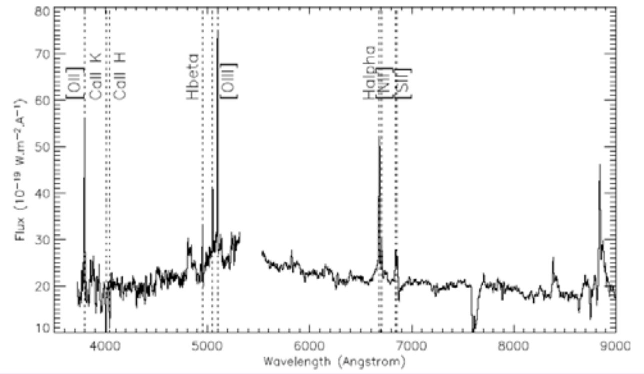
Thermal emission from lower-mass BH

SDSS J0249-0412





kT=100 eV



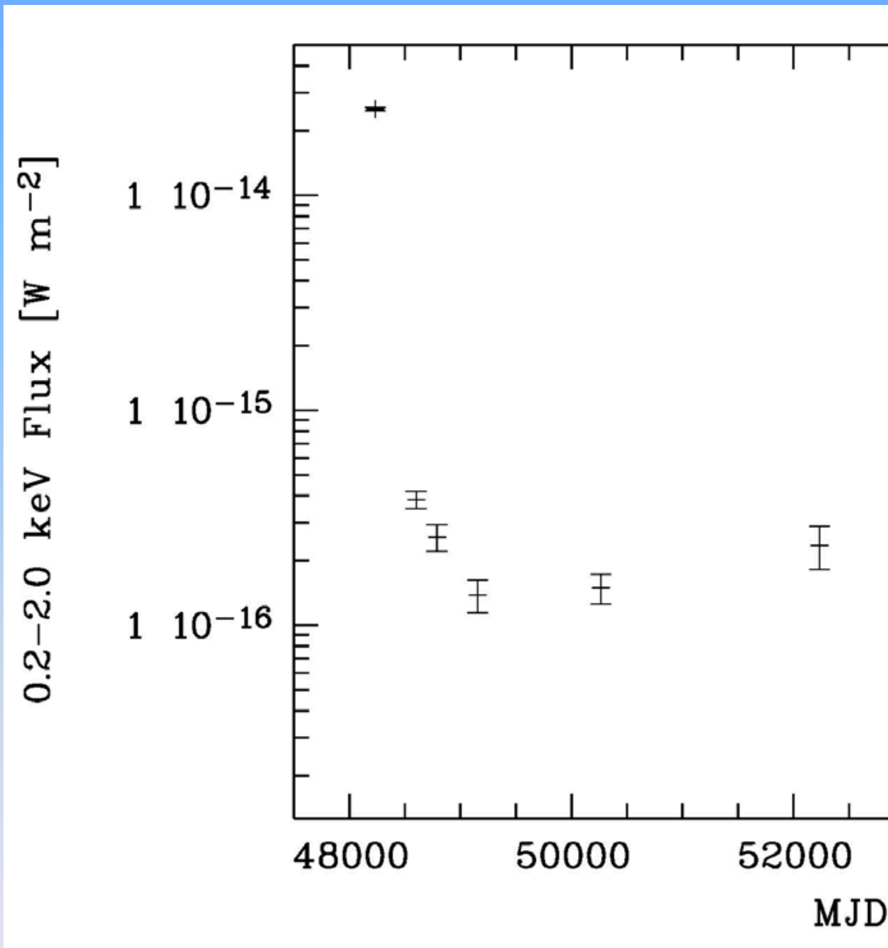
- Seyfert 1.9
- M_{BH} = 5-10 x 10^5 $M_{\odot}$
- Probable AGN variability

Strotjohann et al. in prep

Candidate Tidal Disruption Event (TDE)

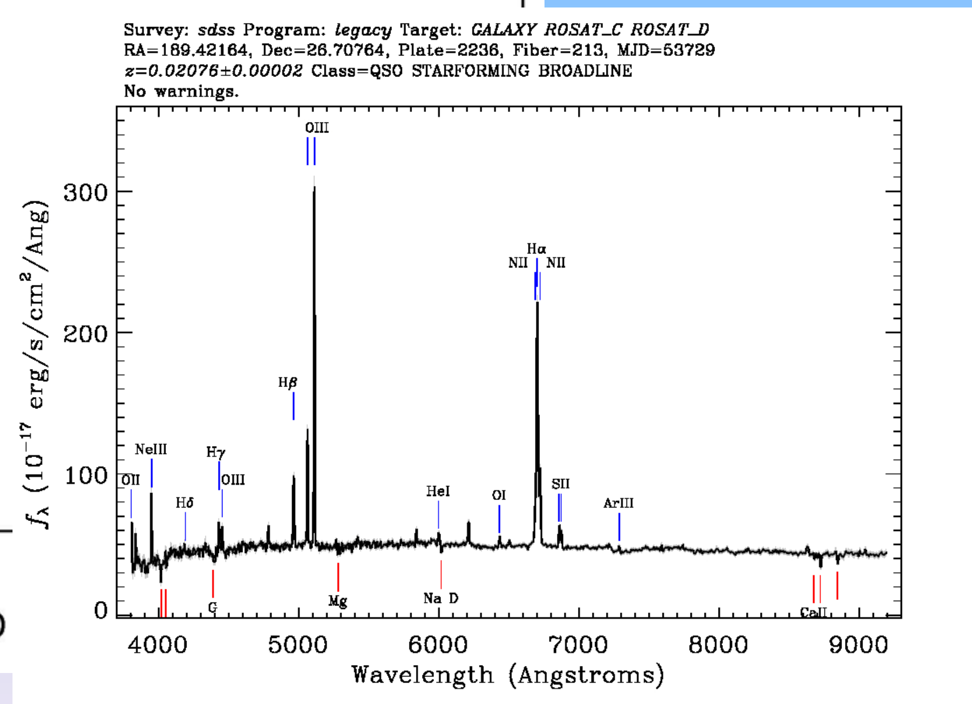
Esquej et al. 07

IC3599 – a sibling from ROSAT



IC 3599 long-term X-ray light curve

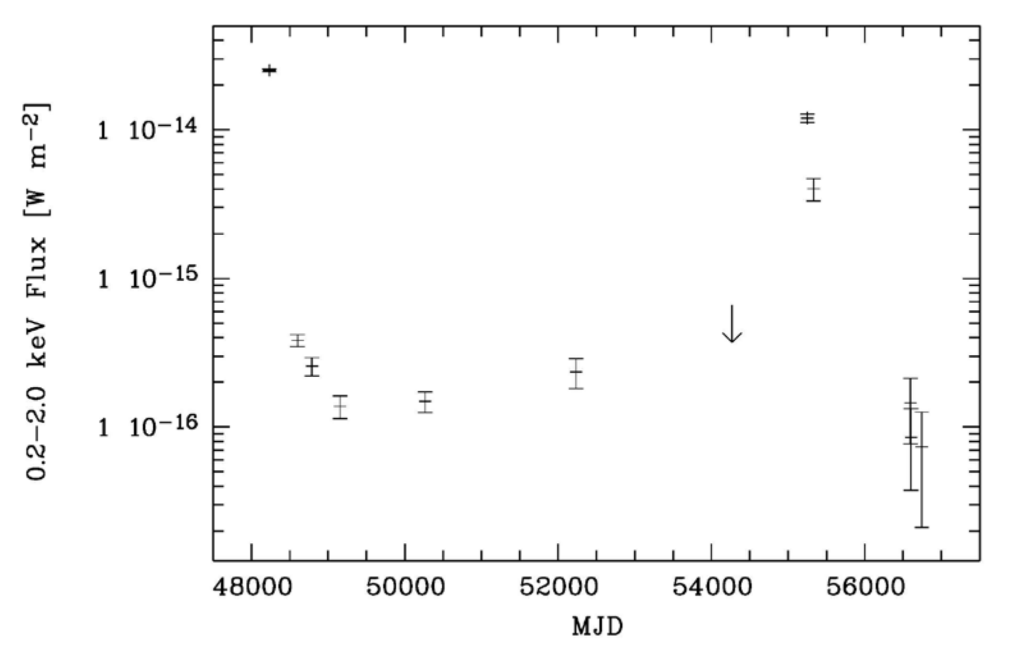
Soft X-ray spectrum,
Weak power-law plus
90 eV black-body

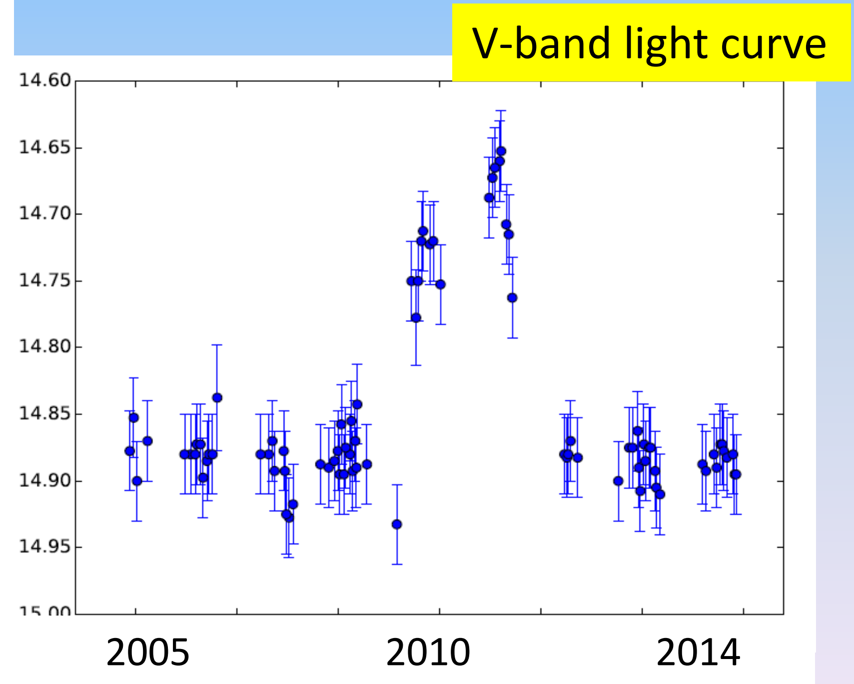


Optical spectrum – Sy 1.9

not sure if AGN or TDE (+AGN)

IC3599 – recent light curve





Catalina long-term light curve

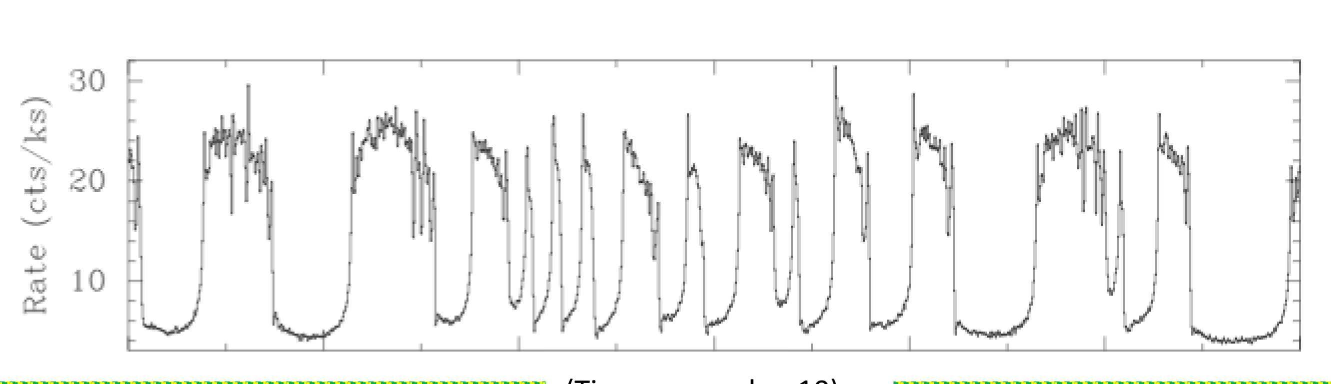
Repeat flare after 20 years

Rise time = 2.4-17 months

Grupe, Komossa & Saxton 2015 : AGN activity

Campana et al. 2015 : repeat tidal stripping

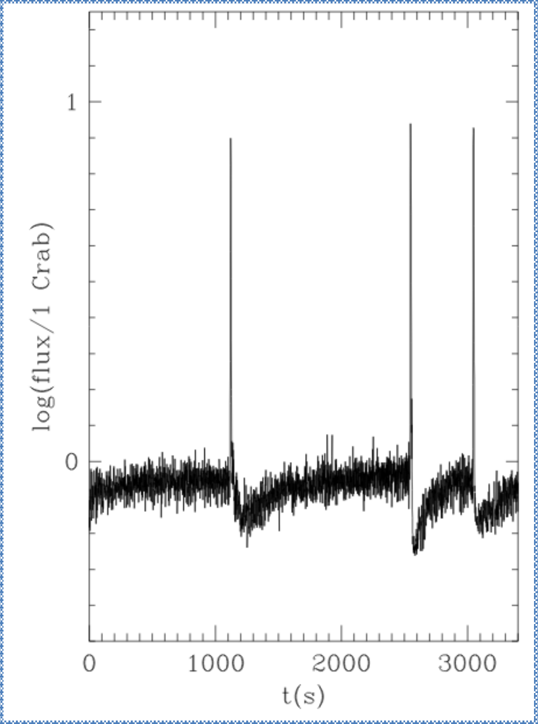
IC3599 – BBH similarities



(Time - seconds x 10)

GRS 1915+105

Belloni et al. 1997



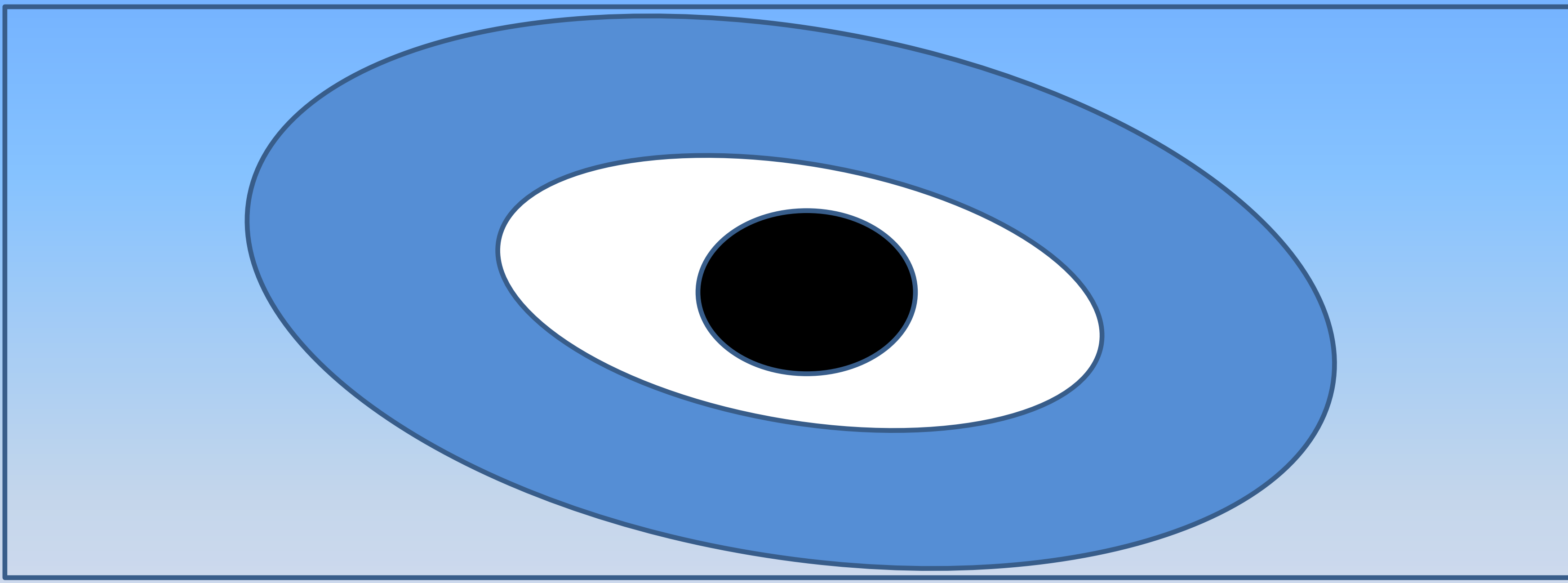
GRO J1744-28

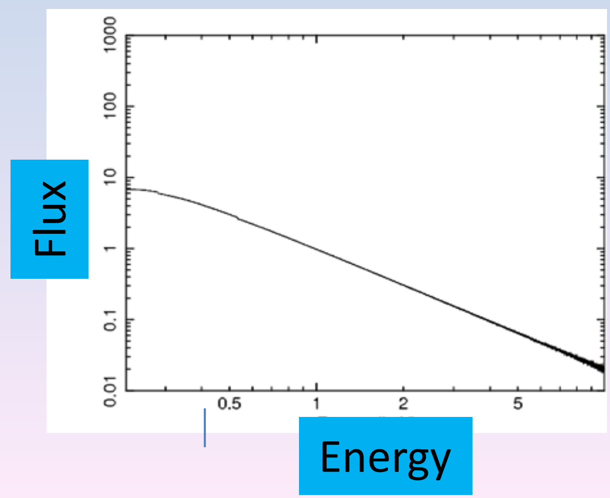
Cannizzo 1996

Lightman-Eardley

instability

Truncated Disk | Viscous infall | Radiation pressure instability | Heating of inner disk | Increased Accretion | Emptying of inner disk





Truncated Disk

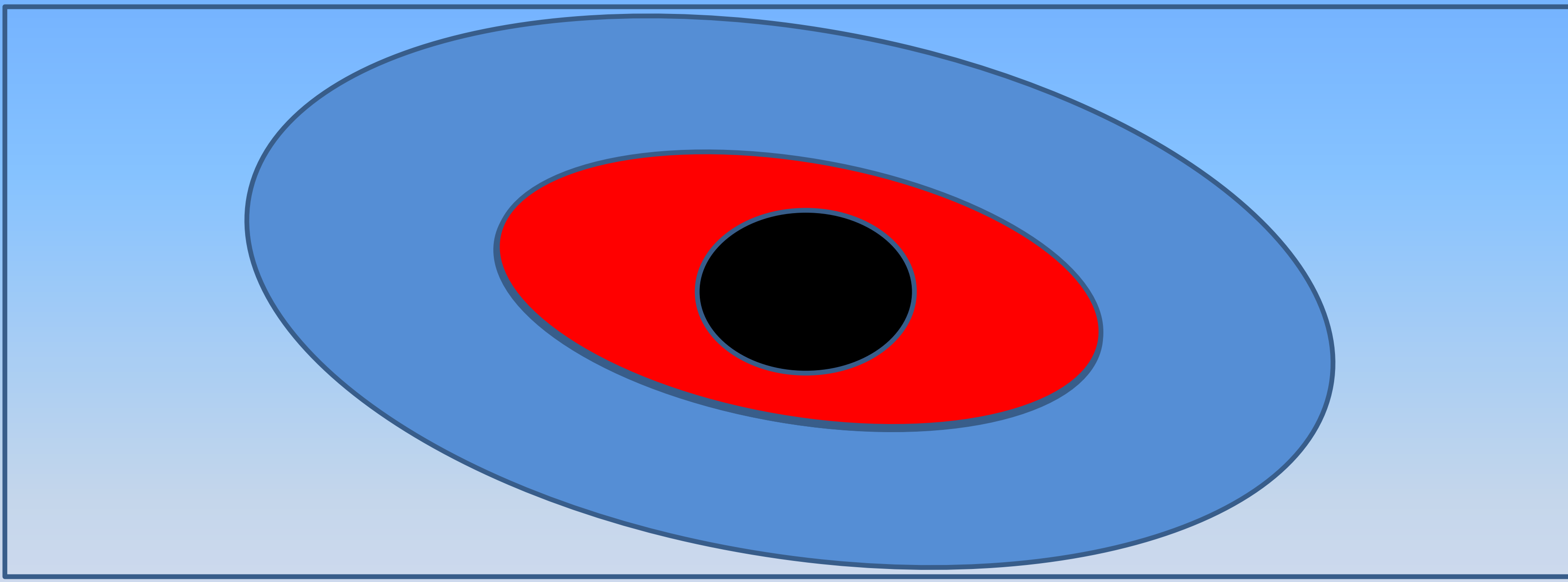
Viscous infall

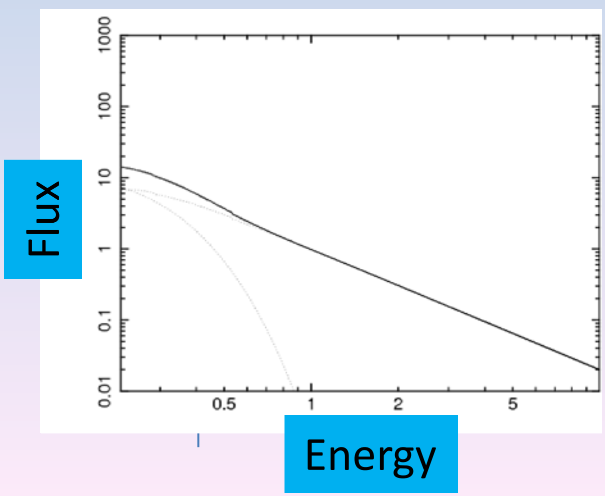
Radiation pressure instability

Heating of inner disk

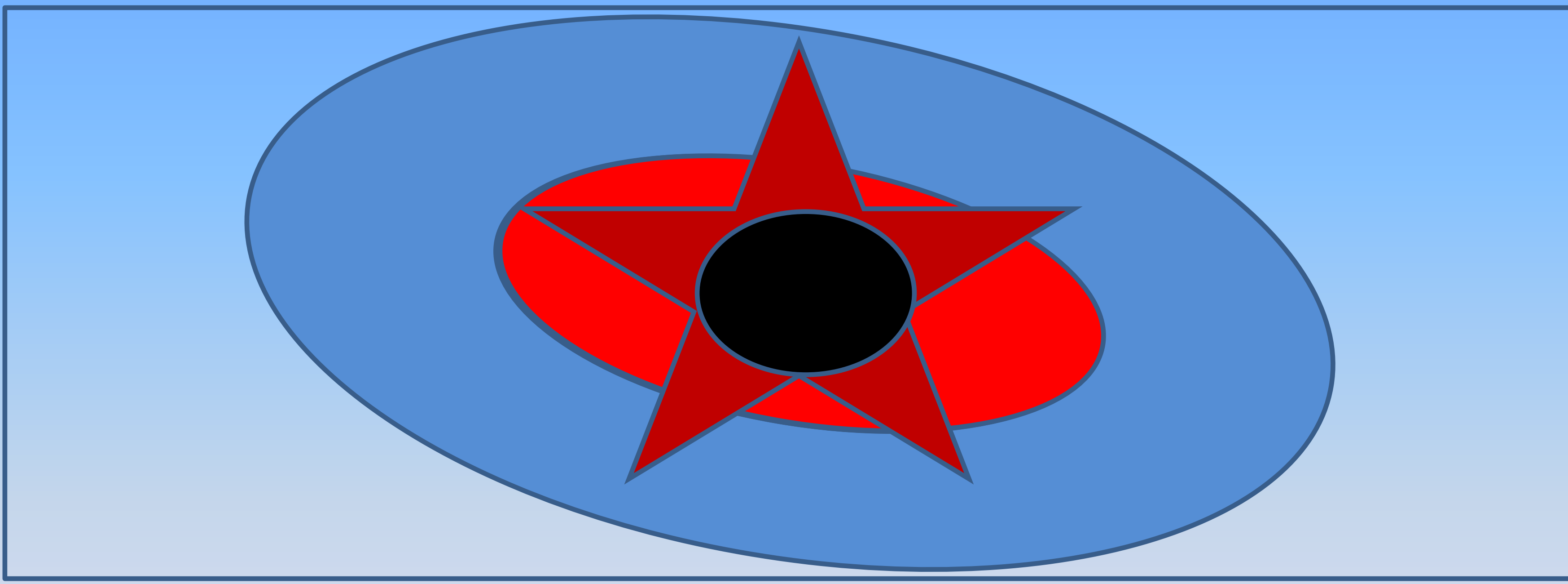
Increased Accretion

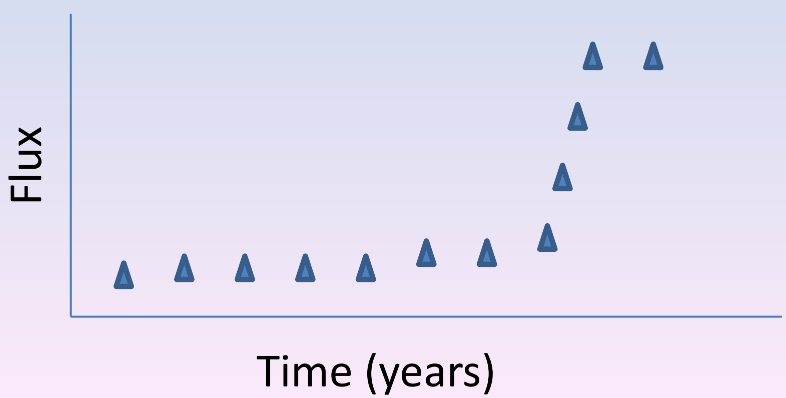
Emptying of inner disk

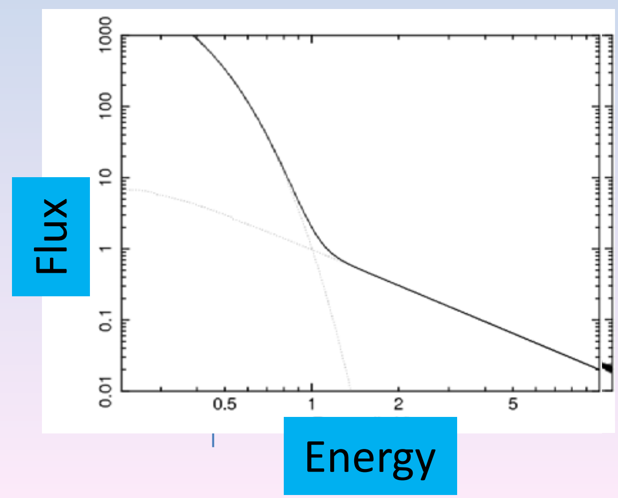




Truncated Disk | Viscous infall | Radiation pressure instability | Heating of inner disk | Increased Accretion | Emptying of inner disk







Truncated Disk

Viscous infall

Radiation pressure instability

Heating of inner disk

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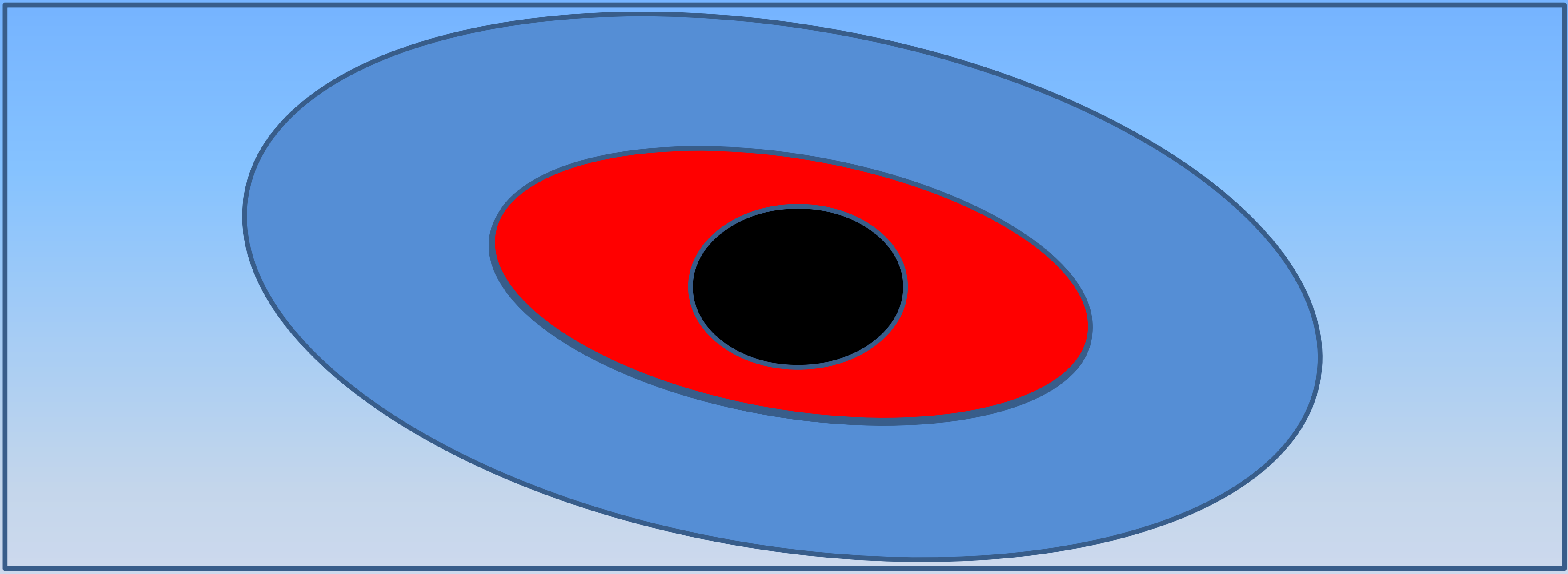
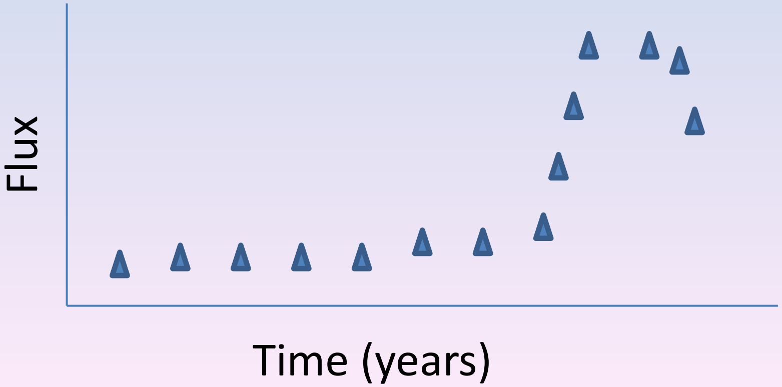
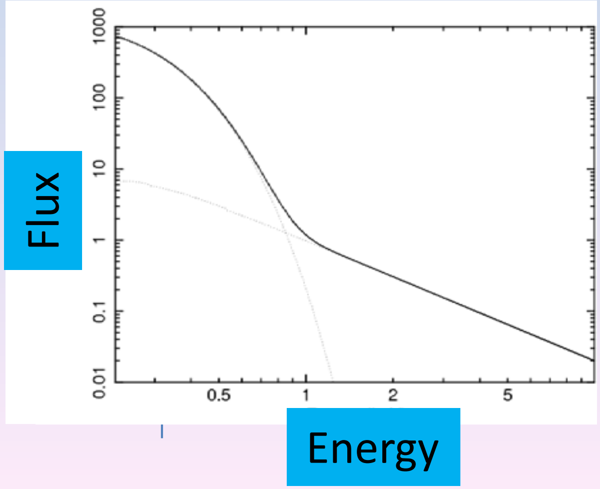
Emptying of inner disk







Truncated Disk

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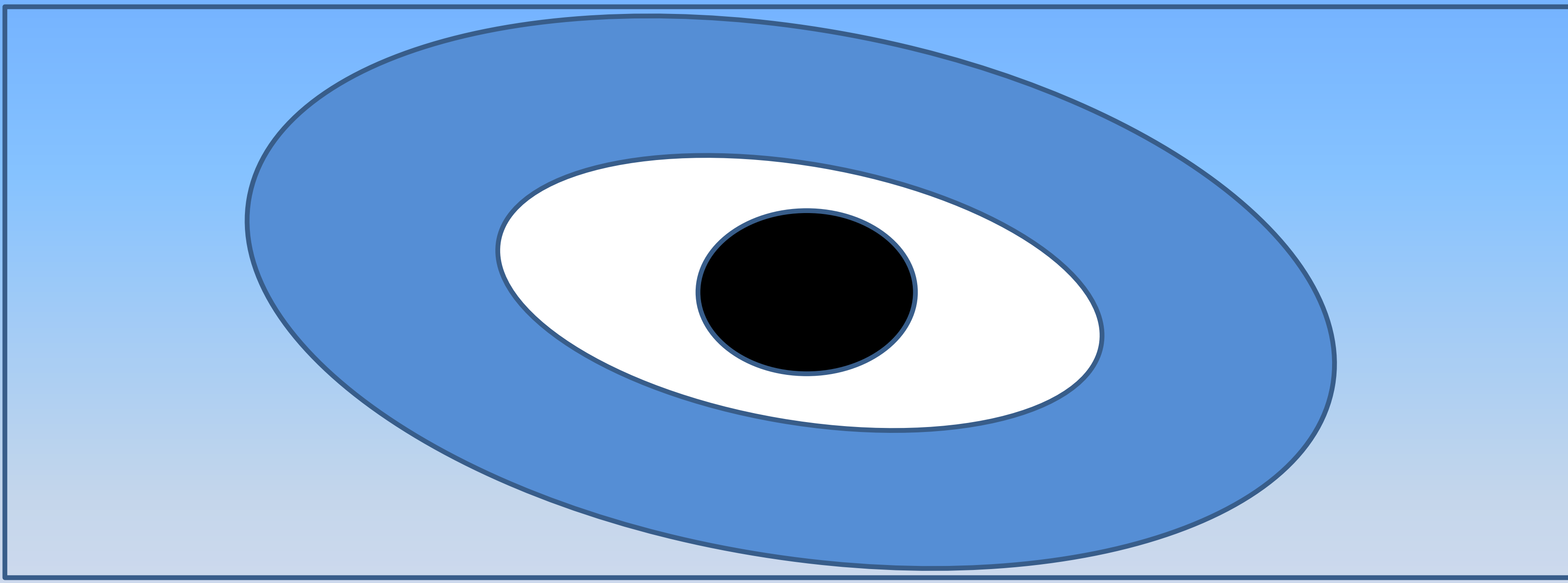
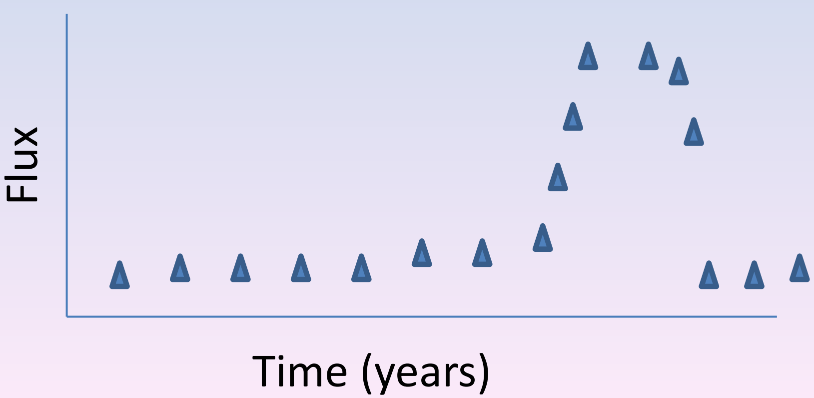
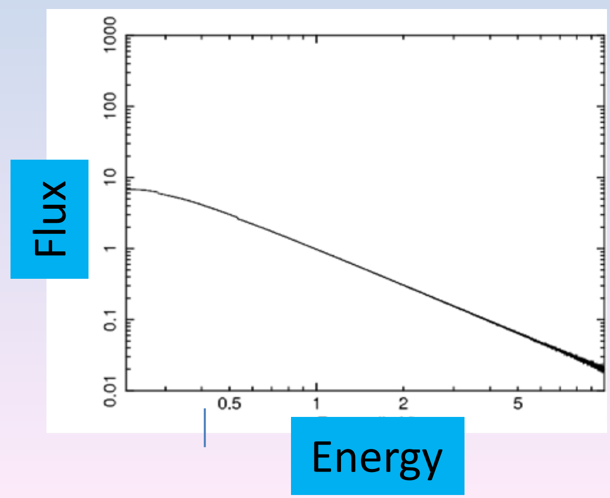
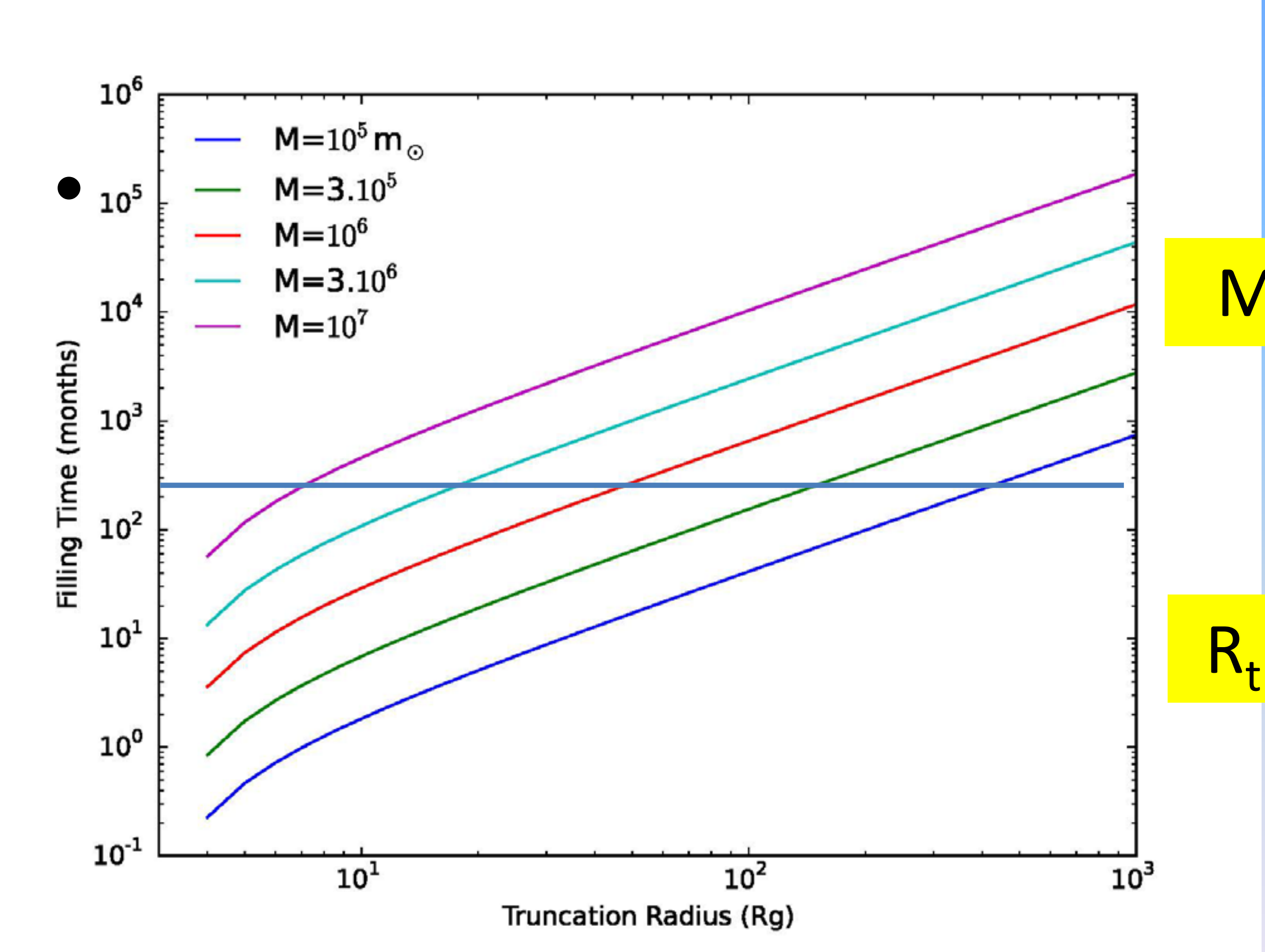






Infall timescales

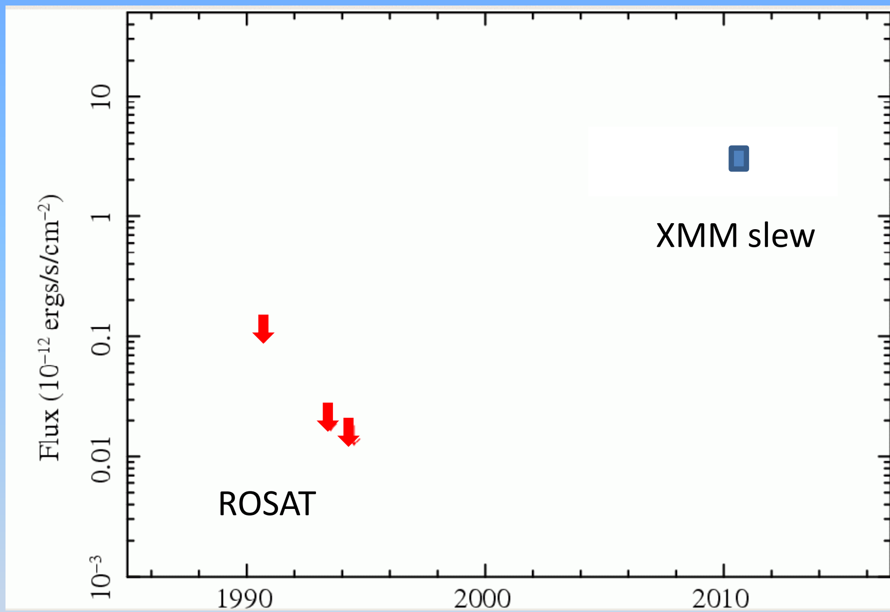


M_{BH}=1-5x10^6 $M_\odot$

R_{trunc} = 10-40 R_g

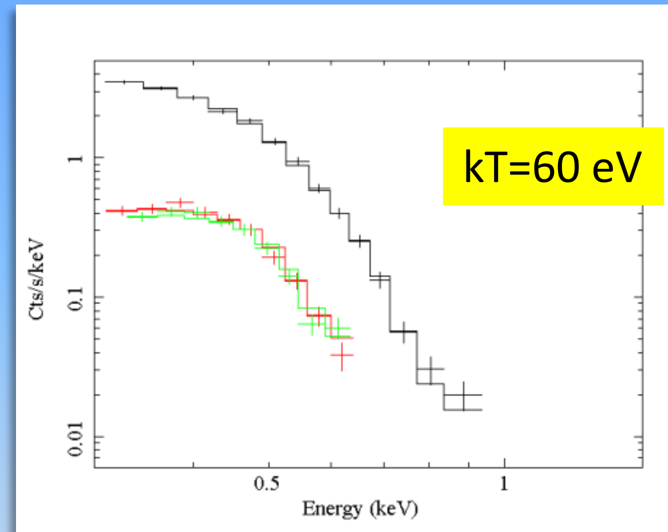
Next IC 3599 flare in ~2030 – great early target for Athena !

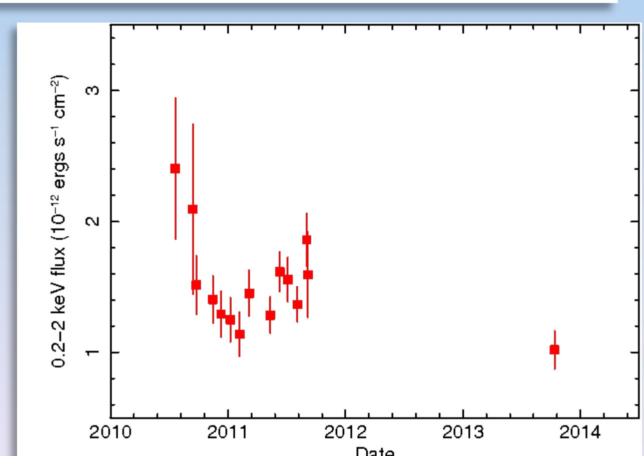
Another example: GSN 069



Miniutti et al. 2013

- Radical change in flux between 1994 and 2010
- In stable high state from 2010-2014





Monitoring over 3 years with Swift and XMM shows X-ray flux now stable within factor 2-3. $F_{0.2\text{-}2}$~$2\text{x}10^{12}$ ergs/s/cm^2

Why so rare?

The duty cycle in IC 3599 is ~10% and yet they are very rare in ROSAT and XMM where thousands of $M_{BH}<5x10^6\ M_\odot$ galaxies have been observed.

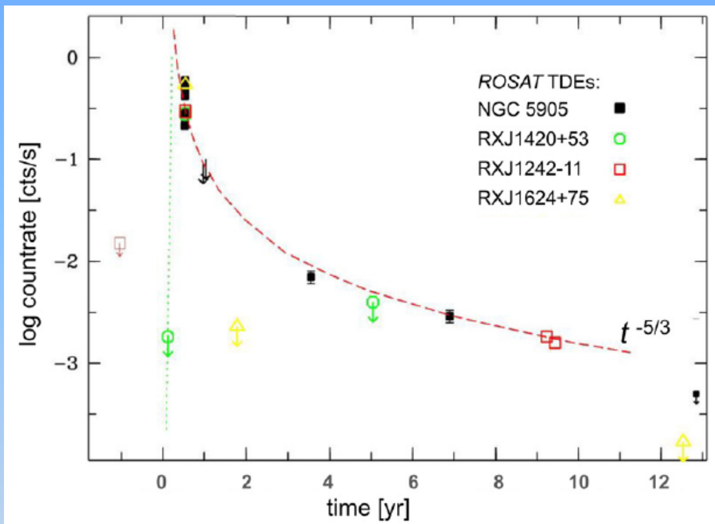
Must be a rare accretion mode.

eRosita should increase numbers by factor of 10s or so.

Tidal Disruption Events (TDE)

Credit: James Guillochon

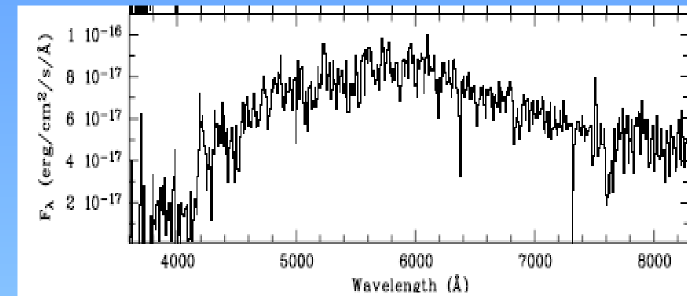
ROSAT Tidal Disruption Events



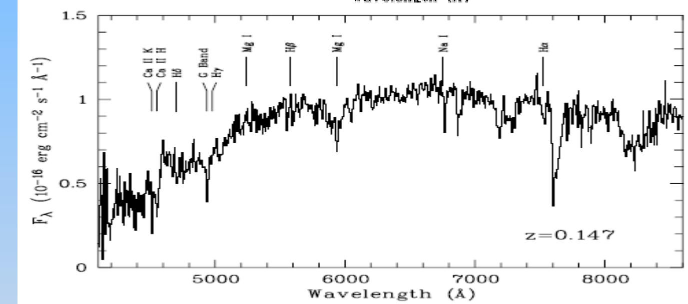
Komossa 2012

Rosat discovered several quiescent galaxies with soft X-ray flux variations > 100. Light curve decay roughly compatible with $t^{-5/3}$. Dropping by factors of 1000s in some cases.

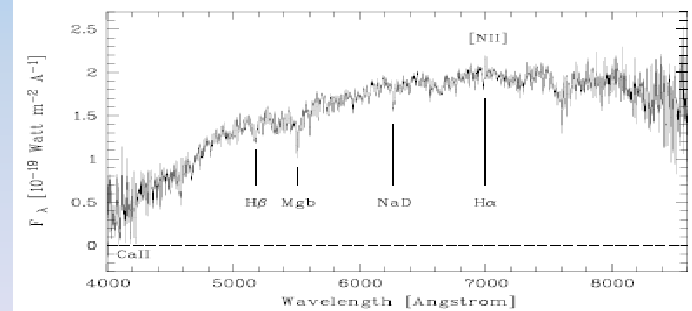
RXJ 1242.6-1119
Komossa & Greiner 1999



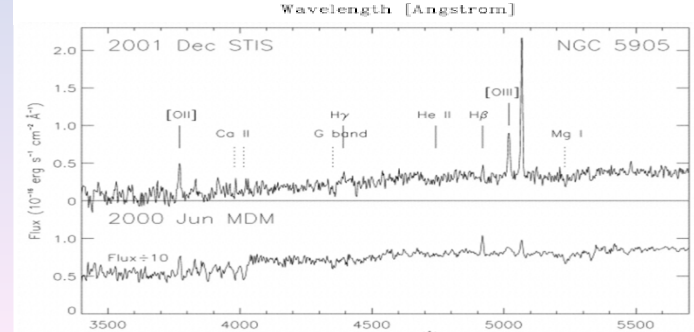
RXJ 1420.4+5534
Greiner+ 2000



RXJ 1624.9+7554
Grupe, Thomas & Leighly 1999

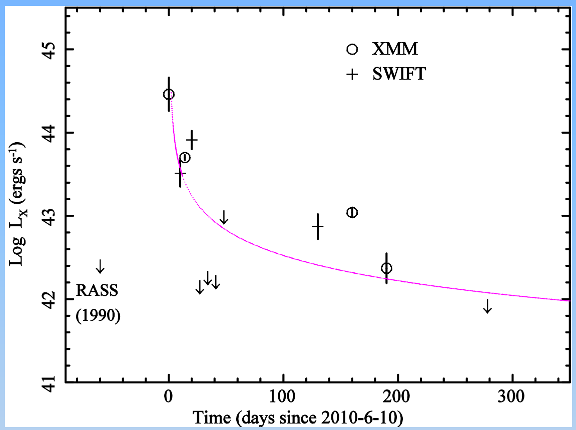


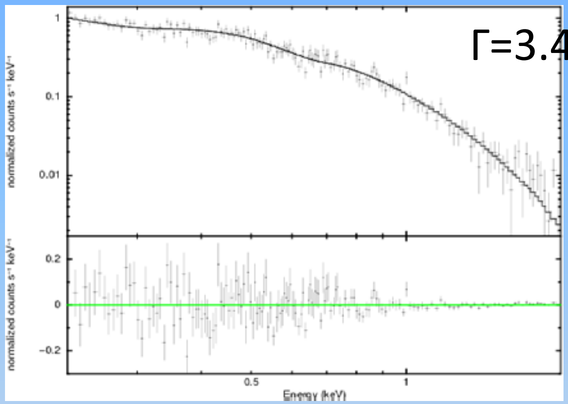
NGC 5905
Bade, Komossa & Dahlem 1996; Gezari+ 2003

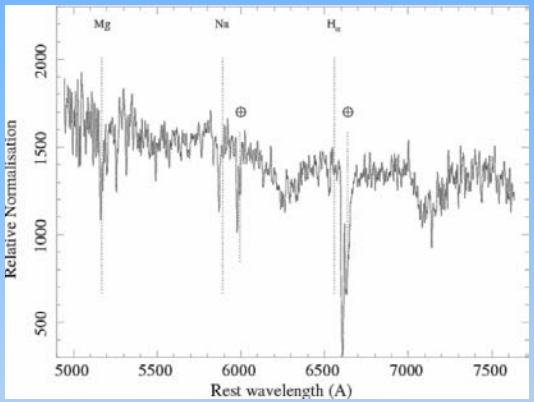


XMM - TDE

SDSS J1201+30

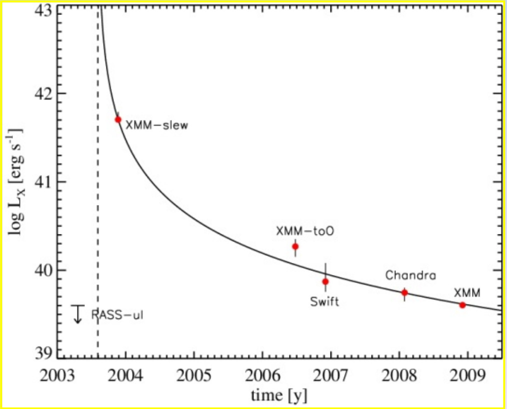


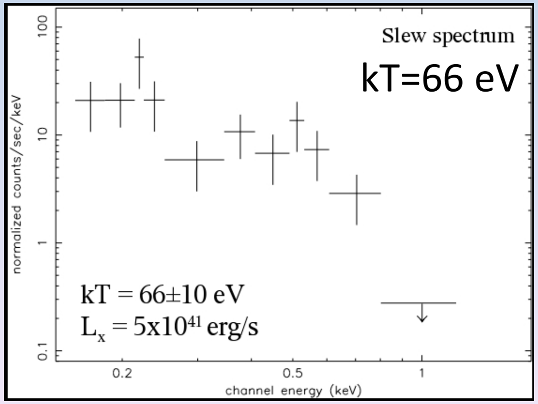


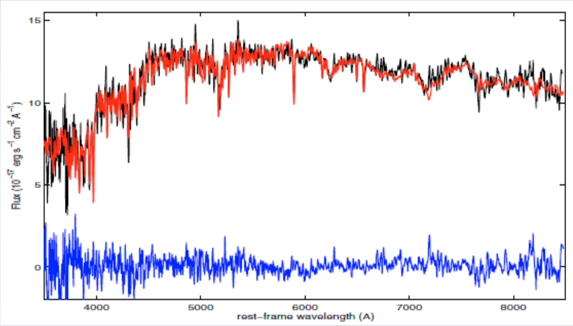


Saxton et al. 2012

SDSS J1323+43







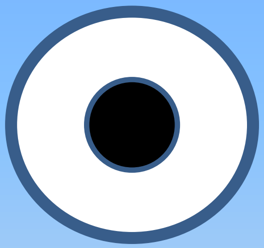
Esquej et al. 2007,08

Also a few from pointed XMM obs: Maksym, 2010, 2013; Lin 2013

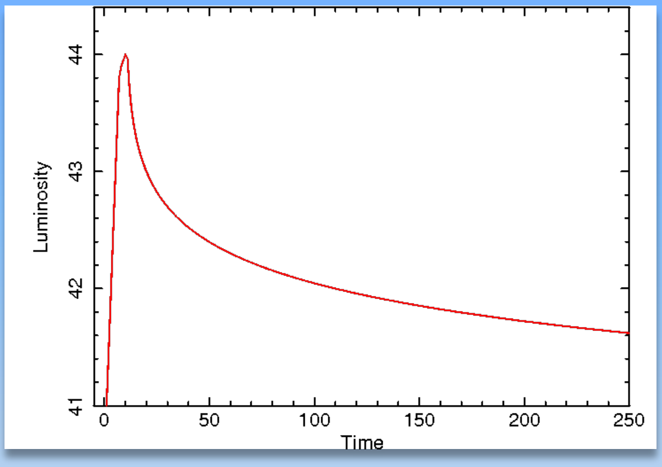
TDE theory – light curves

Classical

Rees 1988

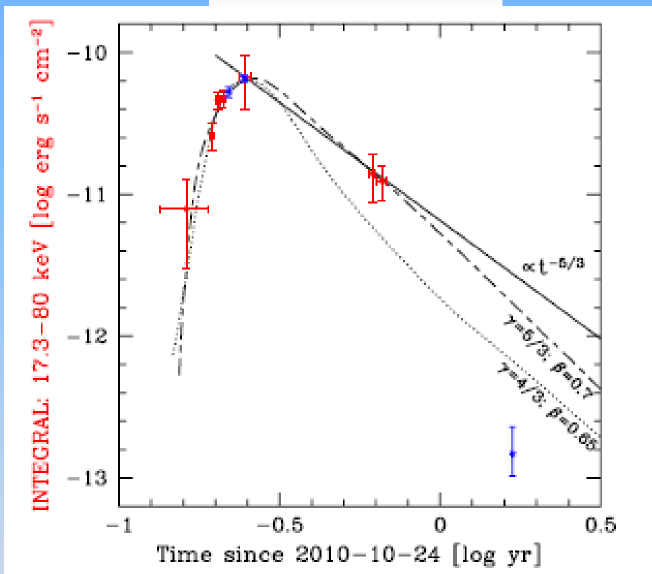


Fast, close circularisation



TDE – Fast Rise events

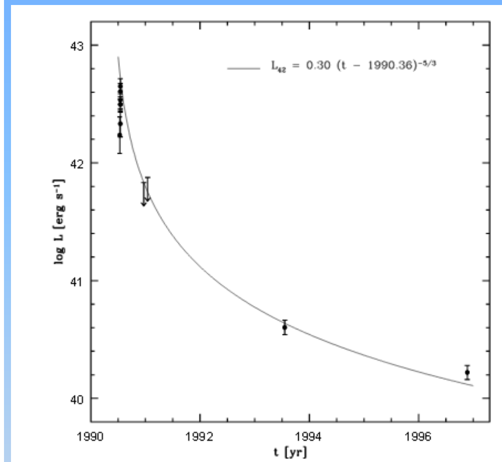
NGC 4845



Nikolajok & Walter 2013

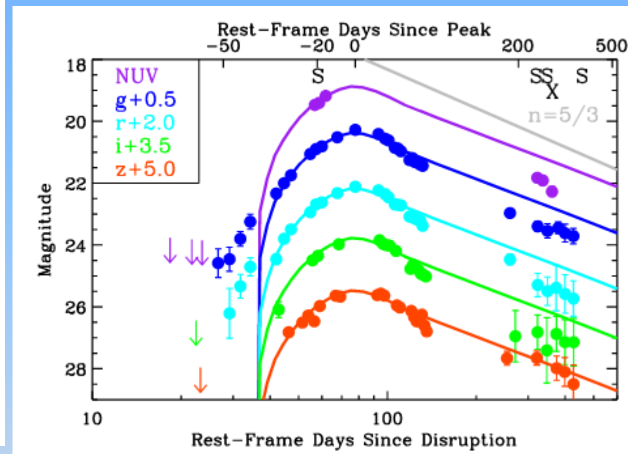
Factor 500 X-ray flux decline
In 1.5 years

NGC 5905



Komossa & Bade 98
Li et al. 2002

PS1-10jh



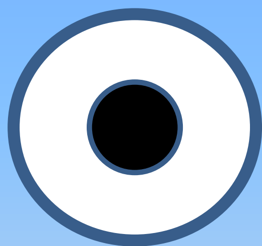
Gezari et al. 2012

When the rise is caught it is invariably fast – few weeks.

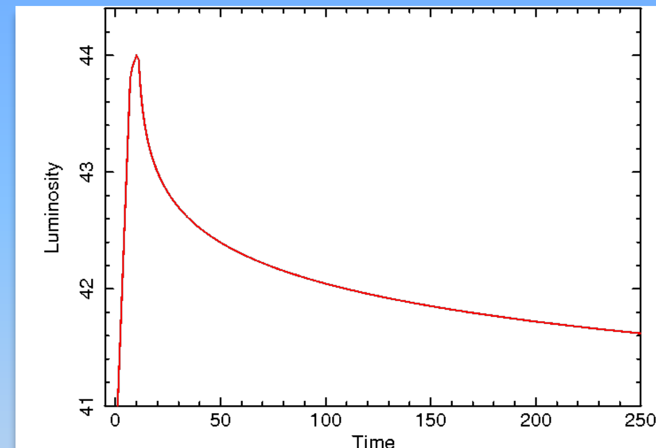
TDE theory – light curves

Classical

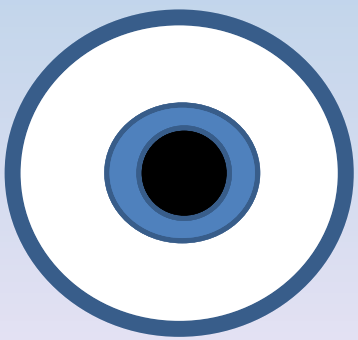
Rees 1988

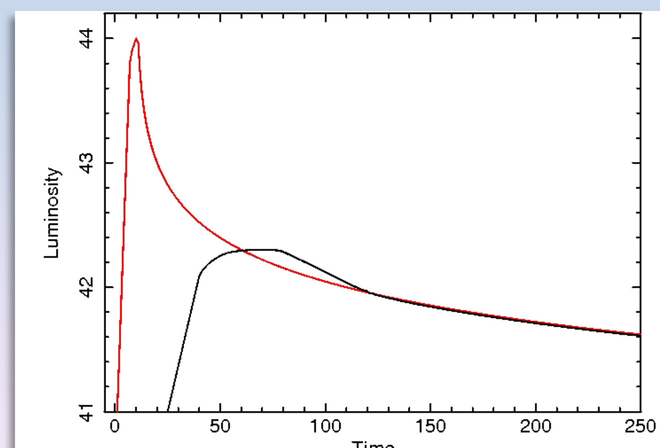


Fast, close circularisation



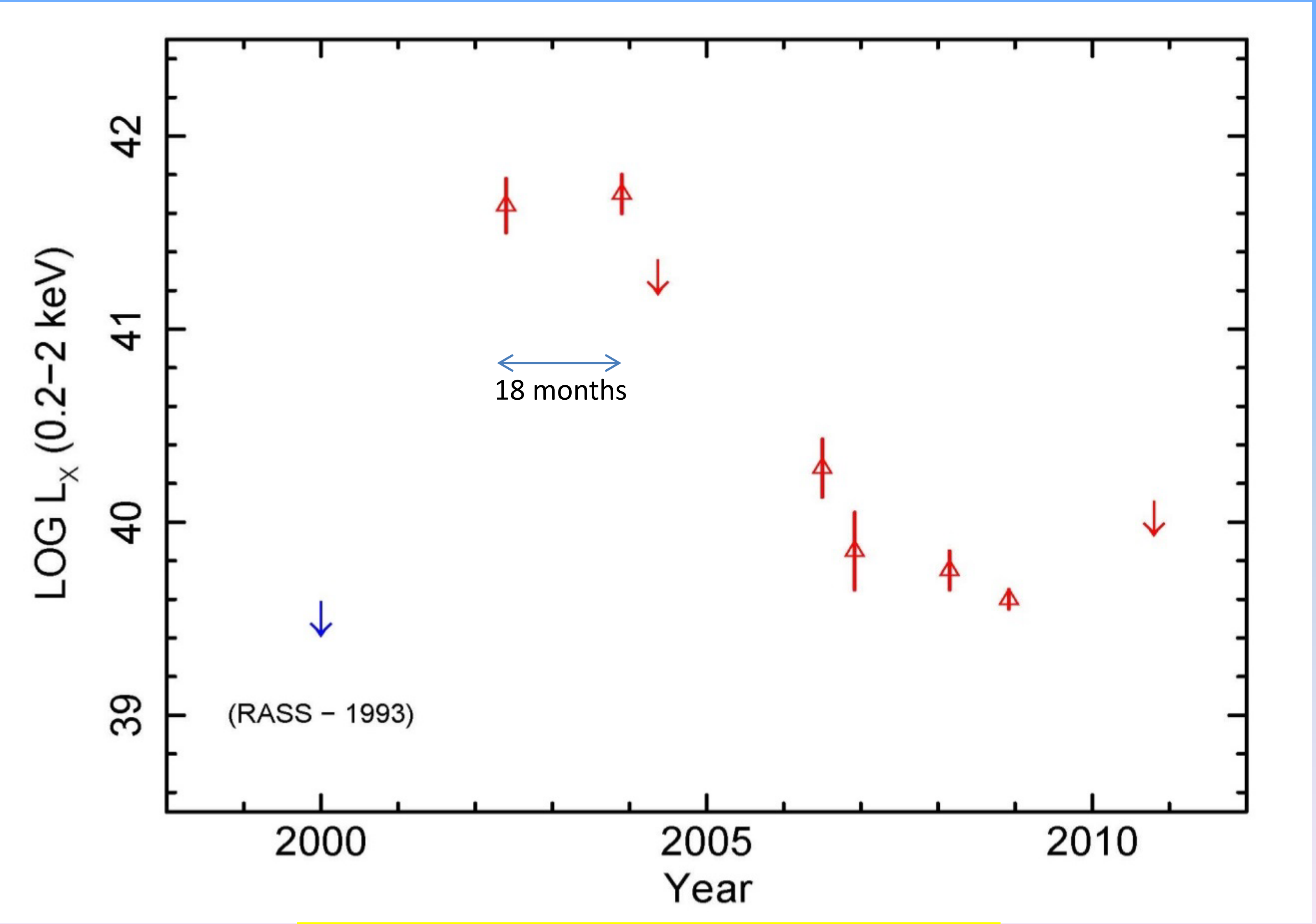
Guillochon & Ruiz-Ramirez 2015
Shiokawa et al. 2015
Hayasaki, Stone & Loeb 2015
Bonnerot et al. 2015





Recent numerical simulations, show that the Circularisation is usually later and more distant

NGC 3599 – delayed TDE ?



Long-term, X-ray light curve of NGC 3599

Conclusions

- Some AGN show evidence for large variability which may be due to a disc instability but why so few ?
- *Delayed* TDE may be more common than the *Prompt* TDE that we have discovered so far and can be found by comparing surveys over many years. Is NGC 3599 an example ?
- eRosita should (by end of survey) increase the numbers of these rare events by factor of 10s.