

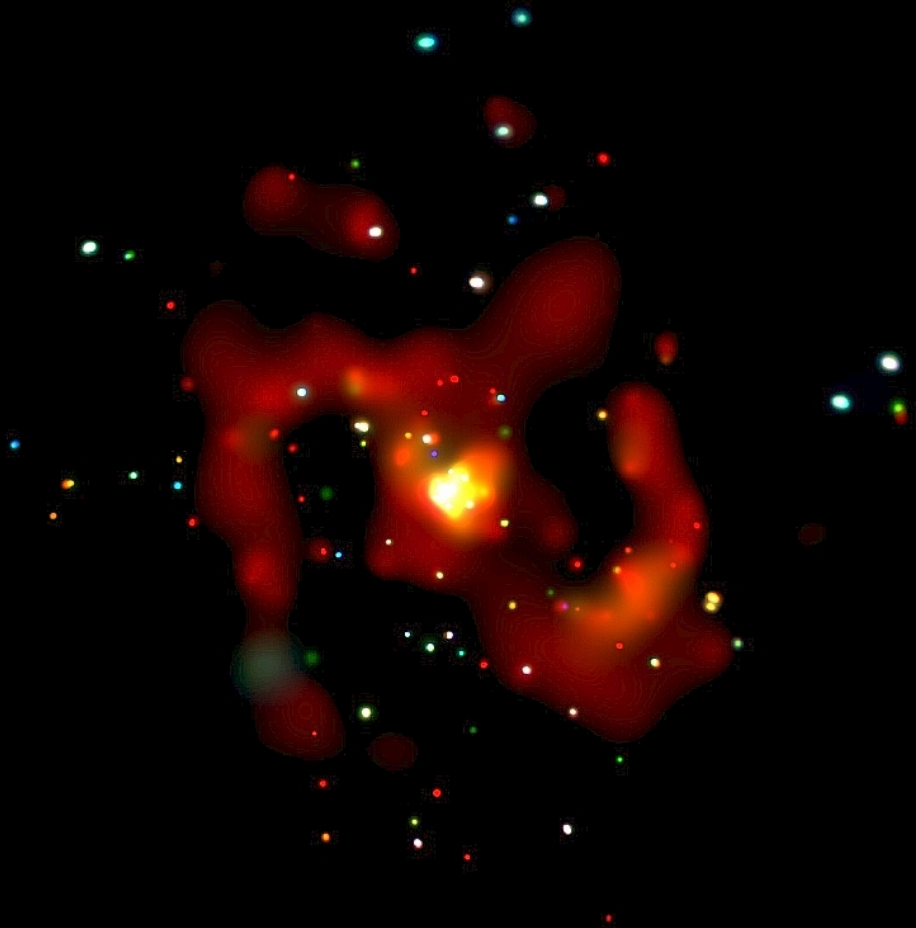
Ultraluminous X-ray Transients and Friends

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X-ray Emission from Normal Galaxies



- Accreting neutron stars and black holes (low-mass X-ray binaries, high-mass X-ray binaries and ultraluminous X-ray sources)
- Supernova remnants
- Accreting white dwarfs (supersoft X-ray sources)
- Diffuse gas
- Background AGN
- Foreground stars

Ultraluminous X-ray Sources

- bolometric luminosity $>$ Eddington limit for a $20 M_{\odot}$ black hole (2.8×10^{39} erg/s assuming isotropic emission): $M_{\text{BH}} < 20 M_{\odot}$ from “normal” stellar evolution (even from very massive stars)
- not at galaxy nucleus
- Unresolved ($< 0.6''$ with *Chandra*)

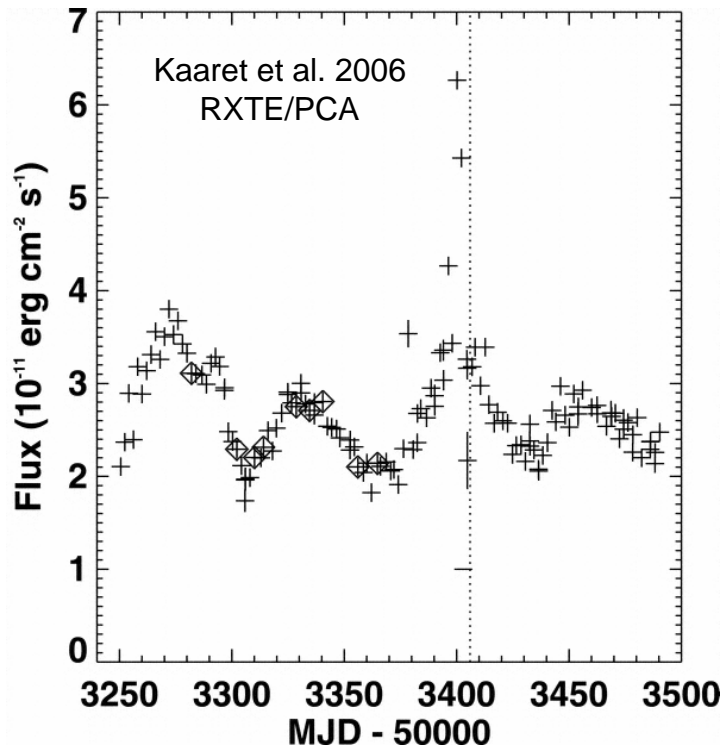
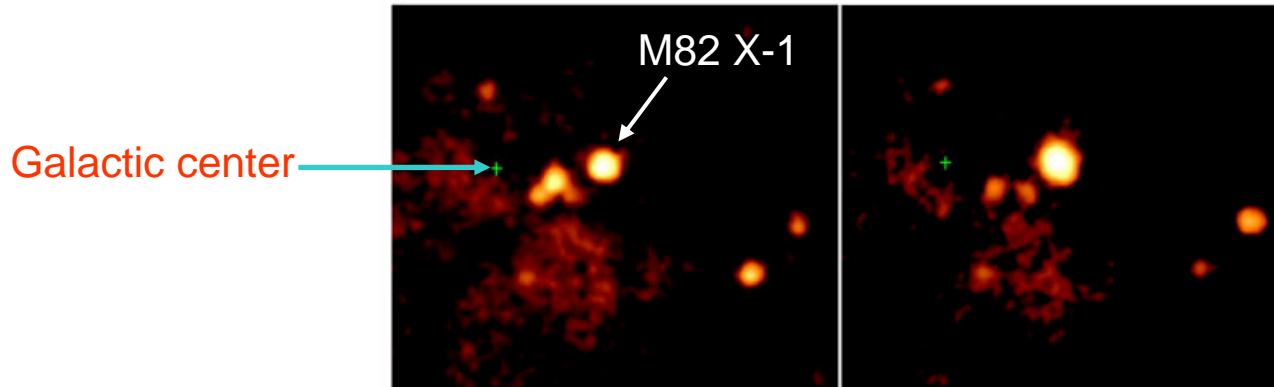
Are they intermediate-mass black holes (IMBHs)?

“ULXs” in the Milky Way and MC

- 4U 1543-37: 4.2×10^{39} erg/s
- GRS1915+105: 2.4×10^{39} erg/s
- V4641 Sgr: 6.2×10^{39} erg/s

- A0535-668: a pulsating NS in LMC with $L_x \sim 1.2 \times 10^{39}$ erg/s.

The best IMBH candidate: M82 X-1



- Very luminous: $\sim 10^{41}$ erg/s
- Not at the galactic center
- 62-d periodicity; orbital period?
- 50-100 mHz QPO
- near a young cluster
- $> 500 M_{\odot}$?

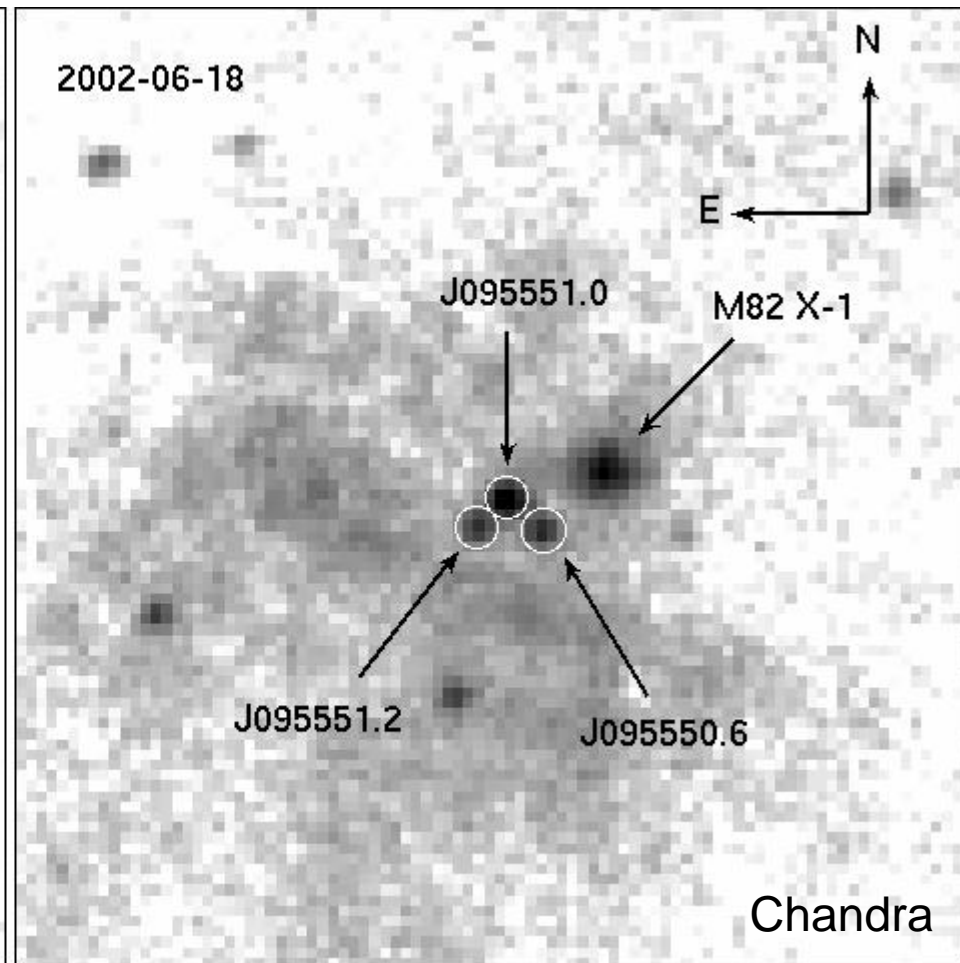
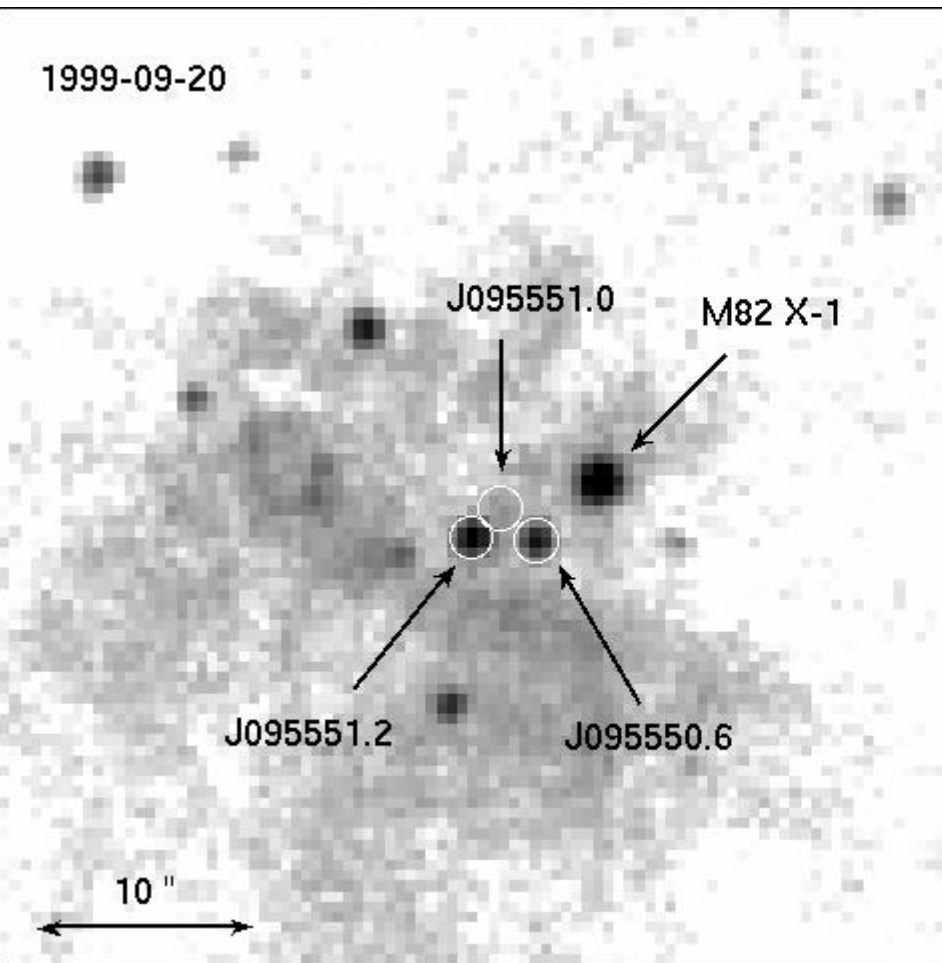
Ultraluminous X-ray Transients

- Definition: at least a factor of 10 in flux variation
- Not common in external galaxies: most ULXs are persistent sources with $<$ a factor of 3 variability over the timescales from ROSAT to XMM (Winter et al. 2006)
- Ultraluminous transients found so far: NGC 3628 (Strickland et al. 2001), M74 (Soria & Kong 2002), NGC 300 (Kong & Di Stefano 2003), NGC 253 (Bauer & Pietsch 2005), M101 (Kong et al. 2004,2005), and M82 (Kong et al. 2007)
- Some are supersoft X-ray sources (M101 & NGC 300)

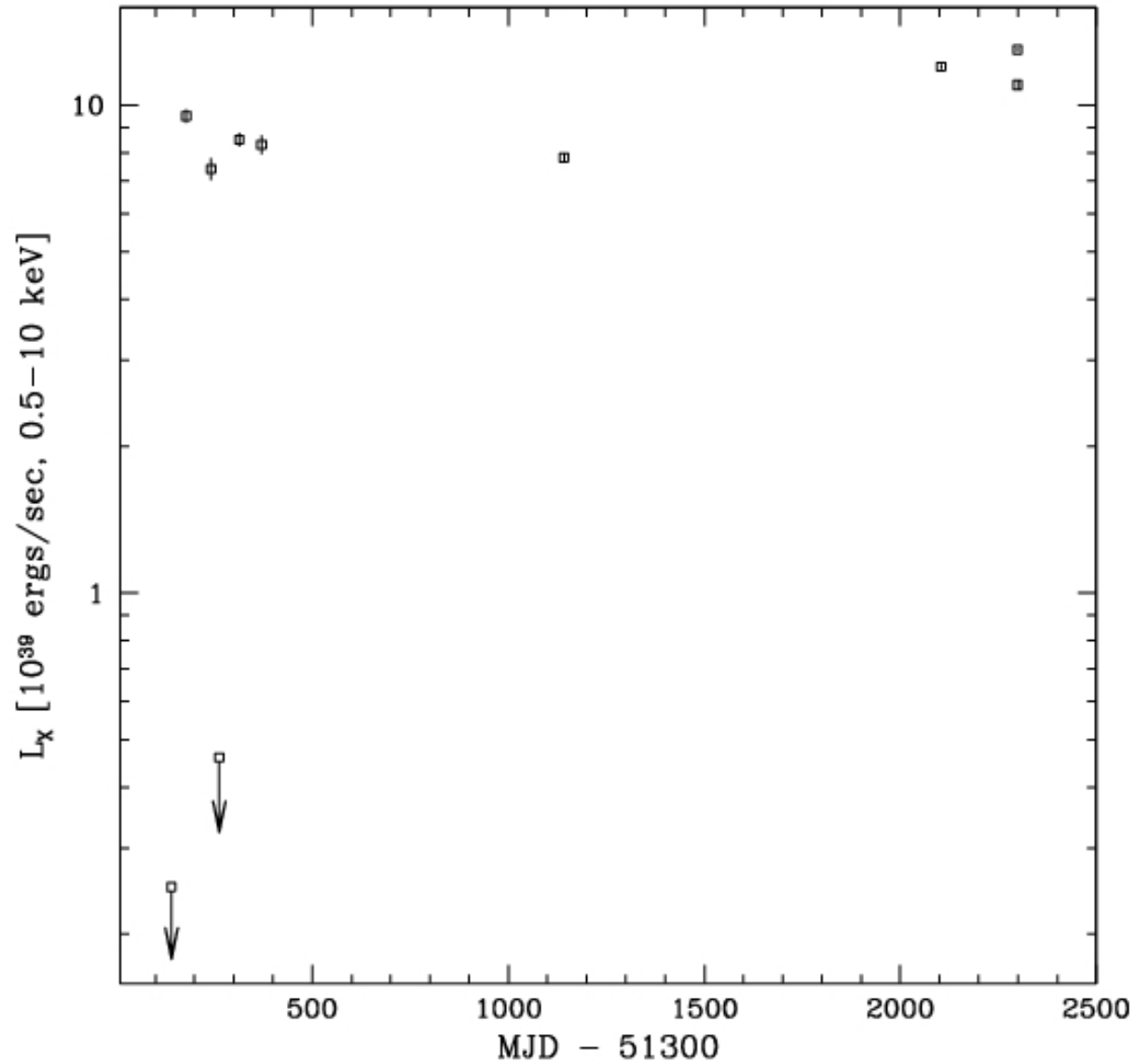
Ultraluminous transient as a probe of IMBH

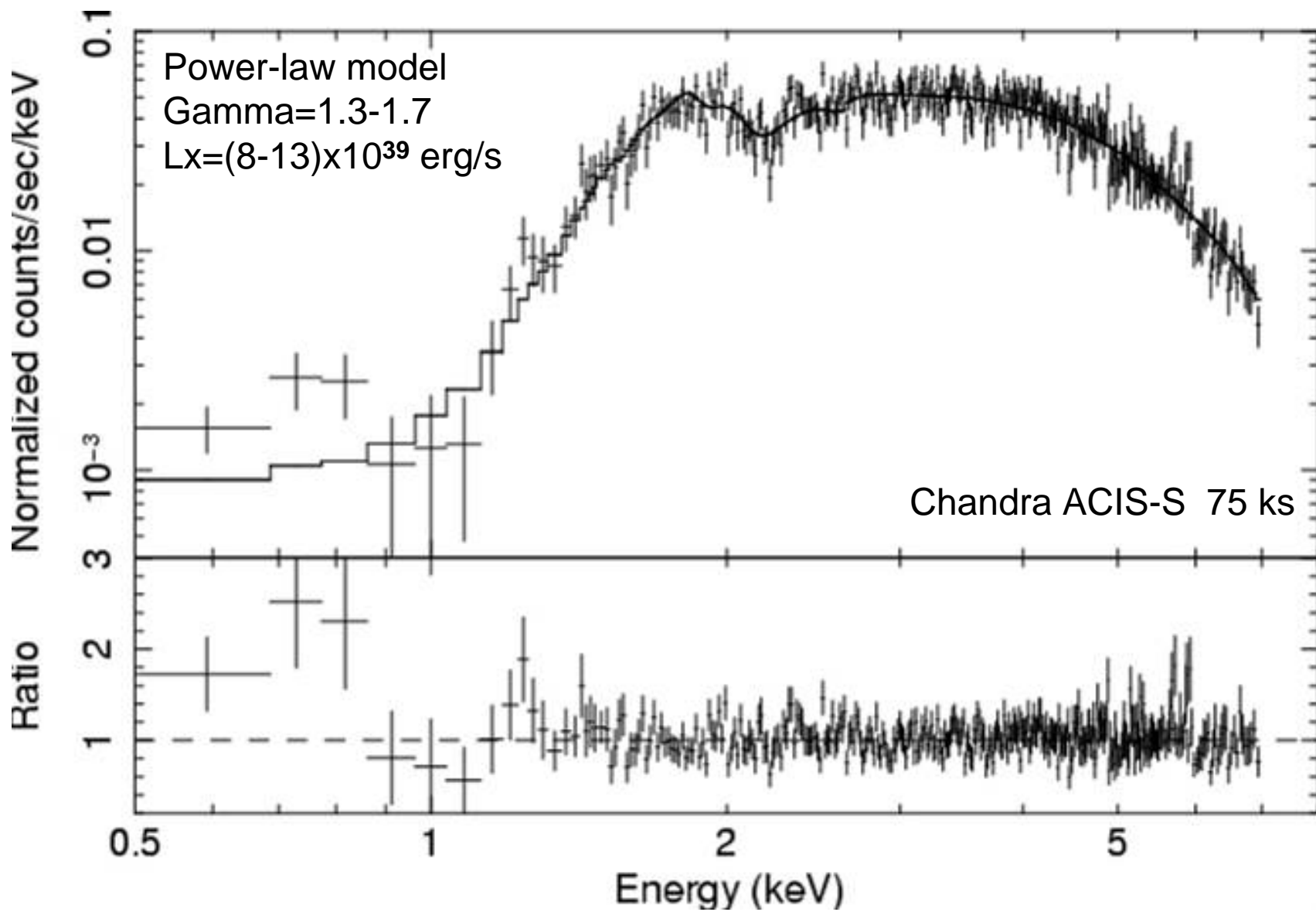
- Simulations suggest that IMBHs should be transients with low duty cycle in young clusters (Kalogera et al. 2004; Blecha et al. 2006)

An Ultraluminous X-ray Transient in M82

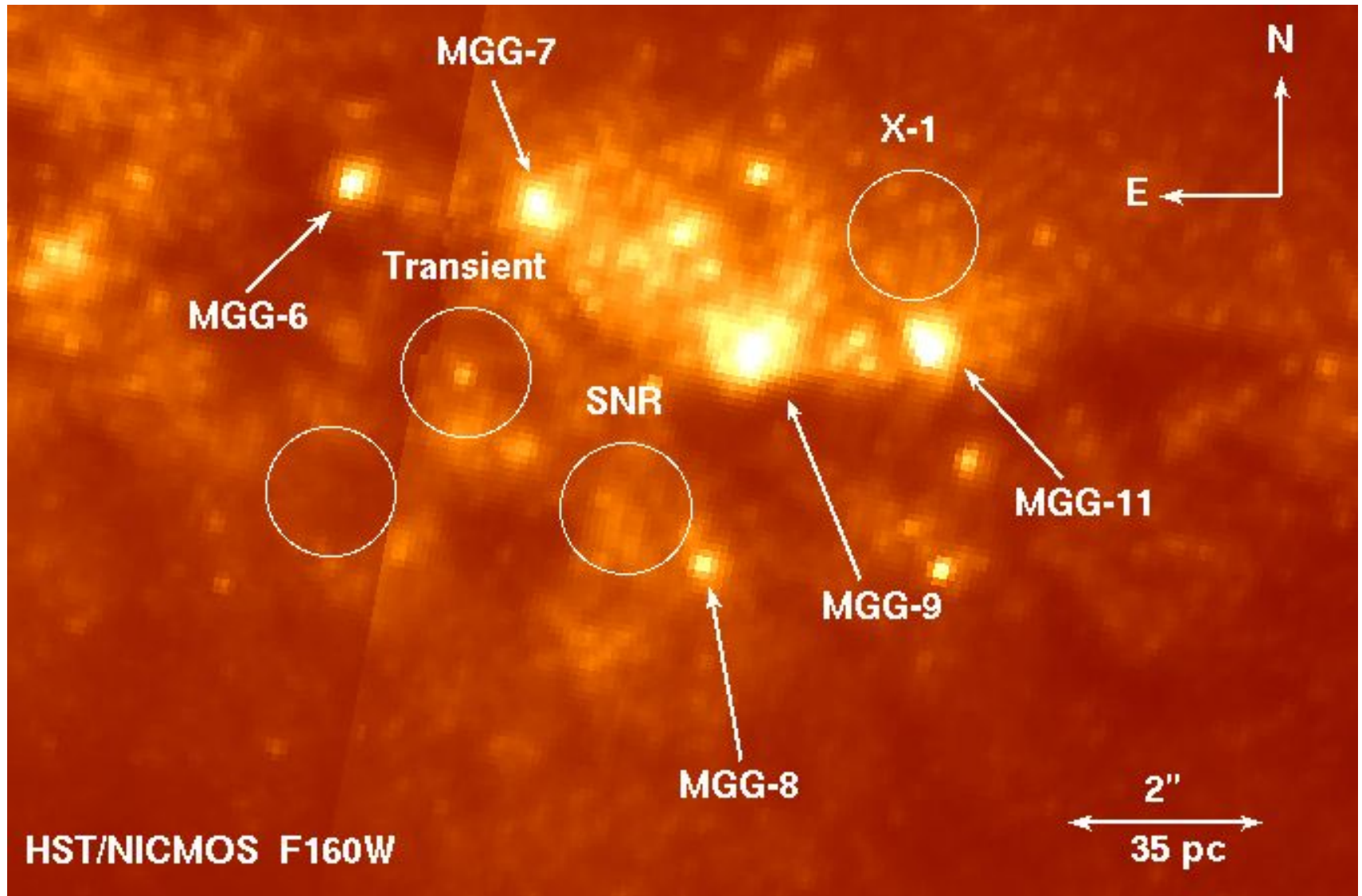


Recurrent X-ray Transient





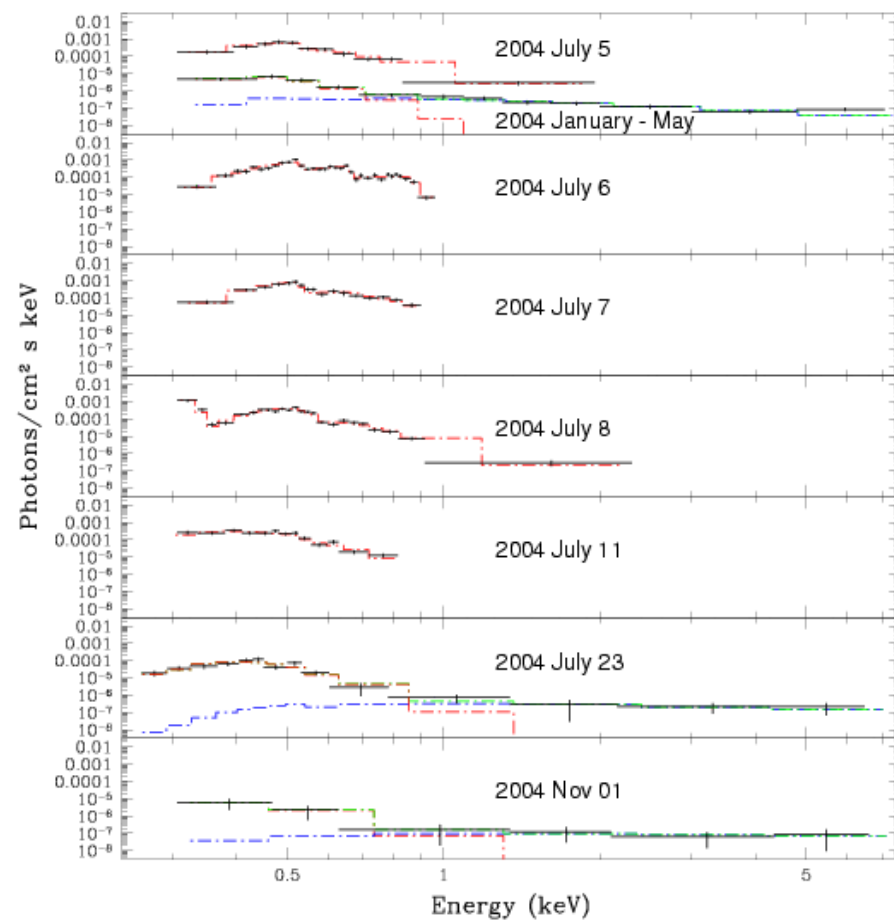
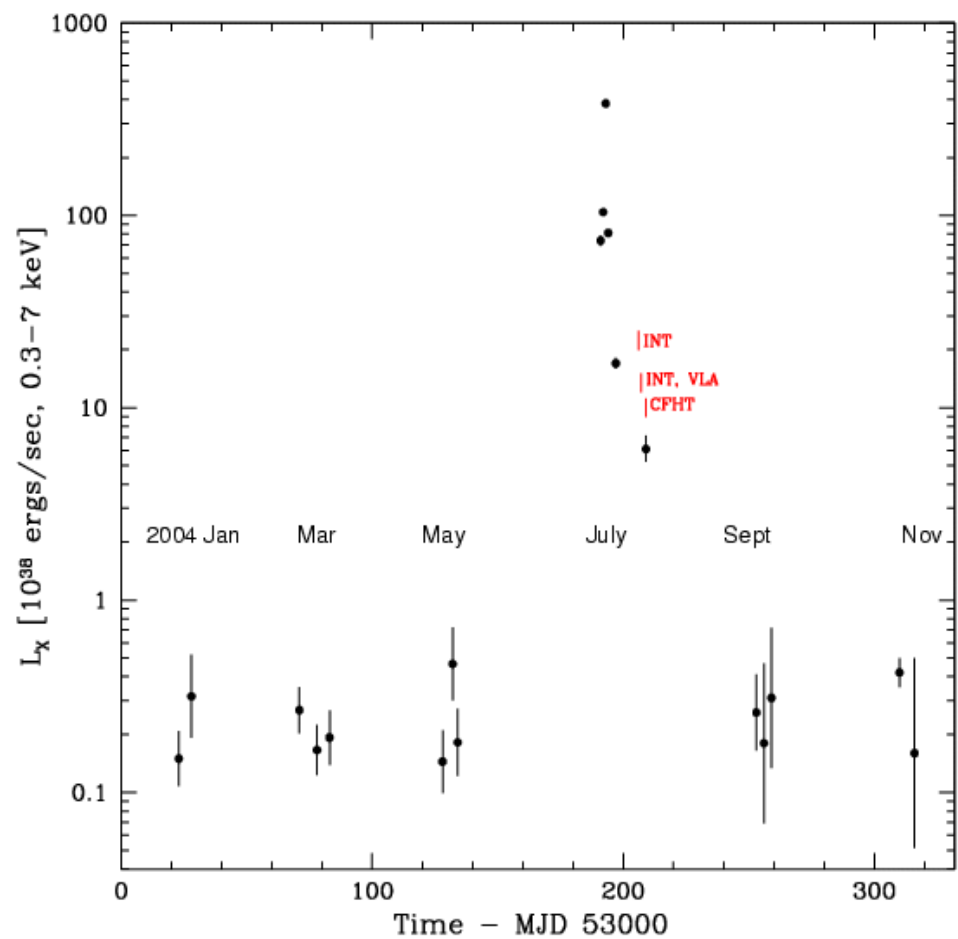
X-ray/NIR Correlation



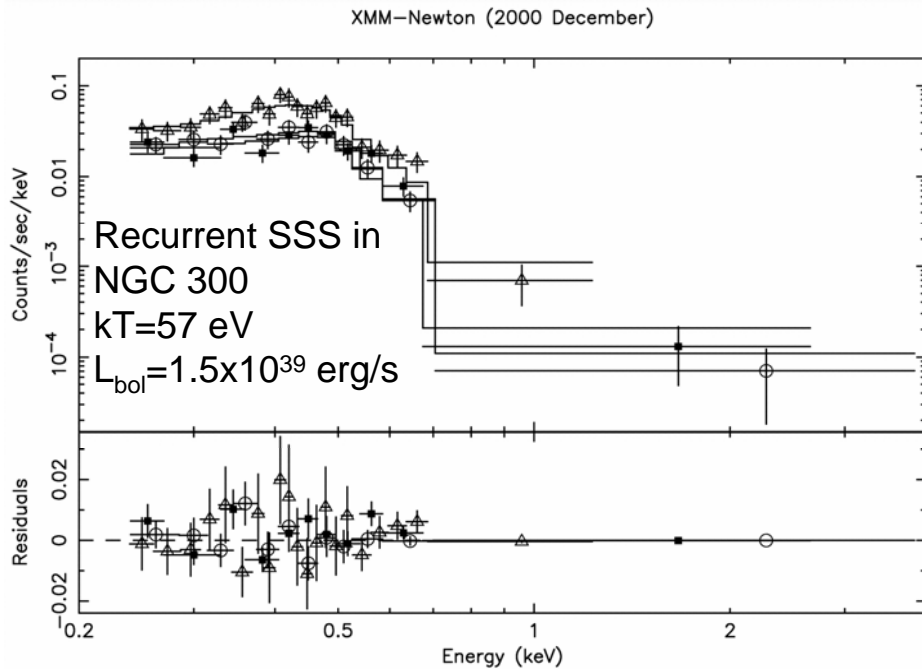
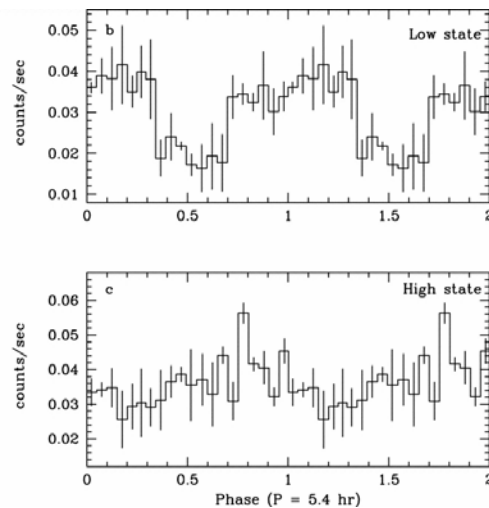
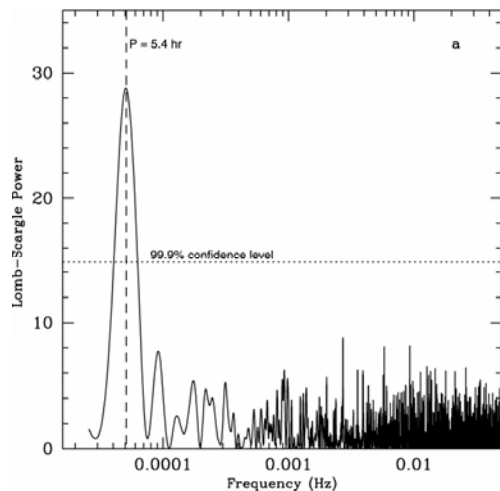
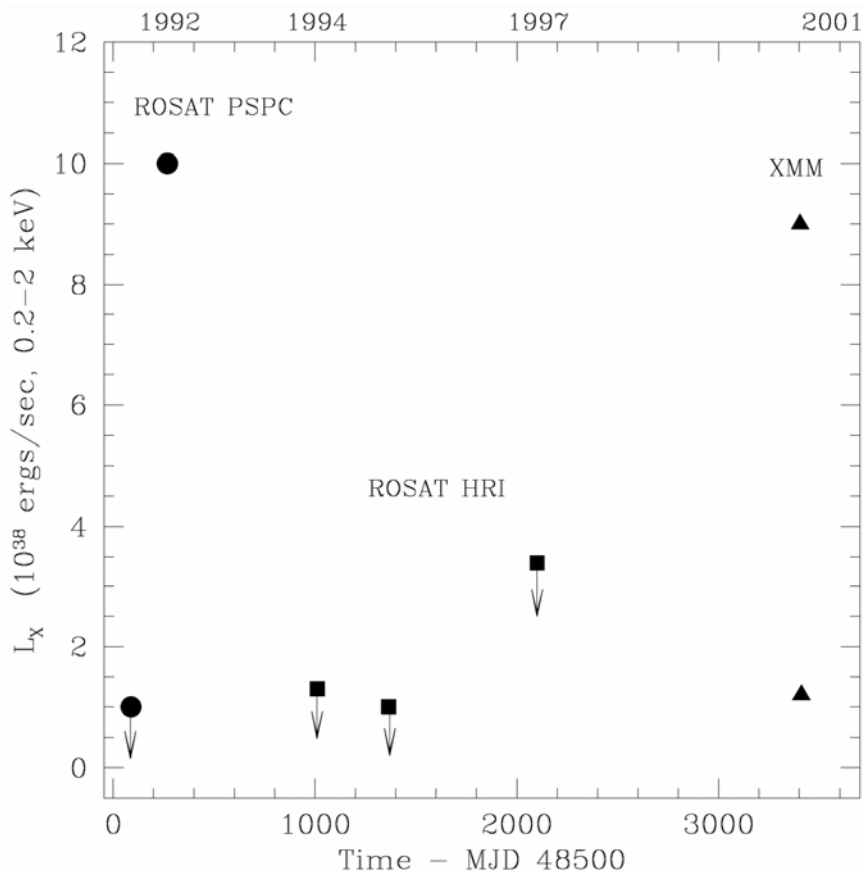
Nature of the ultraluminous transient

- Transient behavior and hard X-ray spectrum can rule out a young supernova remnant and background AGN
- The high X-ray luminosity ($\sim 10^{40}$ erg/s) => a black hole accretor
- Assuming isotropic emission => $100 M_{\odot}$ BH; IMBH
- The X-ray spectra resemble the low/hard state of black hole X-ray binaries in our Galaxy
- During the low/hard state, the X-ray luminosity is about <1%-10% of the Eddington limit => $1000-10000 M_{\odot}$ BH
- No short-term (hours) variability => relativistic beaming unlikely (Kording et al. 2002)
- No disk emission and hard spectrum => anisotropic emission (mechanical beaming) unlikely (King et al. 2001)
- Associated with a star cluster => ideal place to produce IMBHs via the collapse of very massive stars through runaway collision (Portegies Zwart et al. 2004)

A Recurrent Ultraluminous X-ray Source in M101

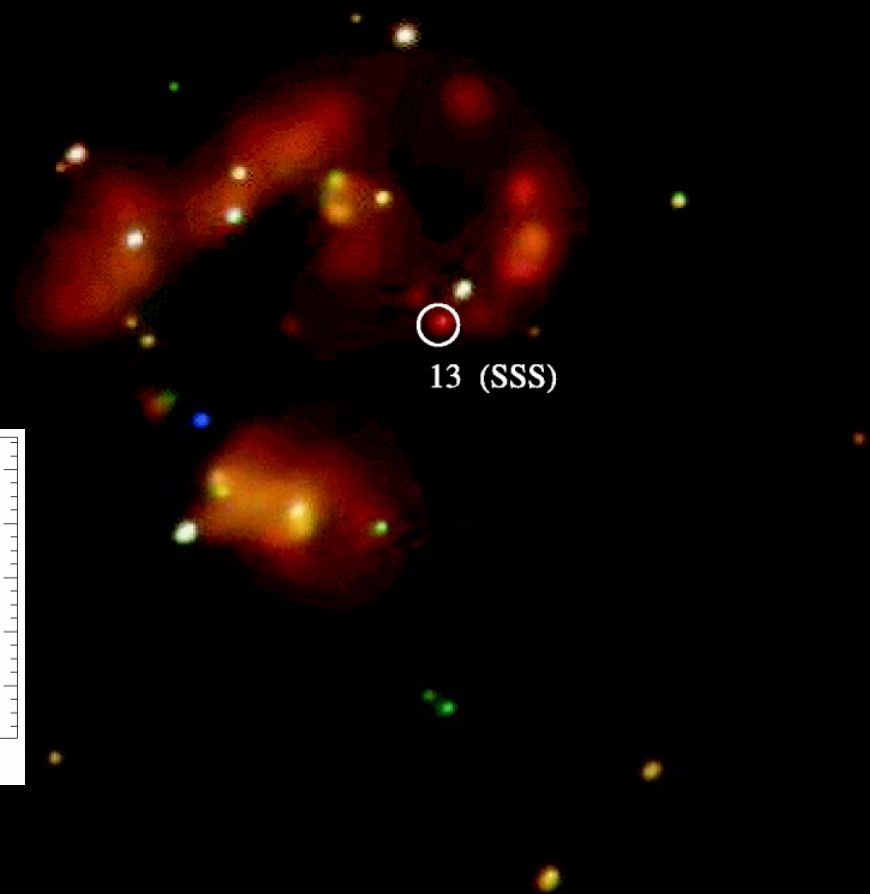
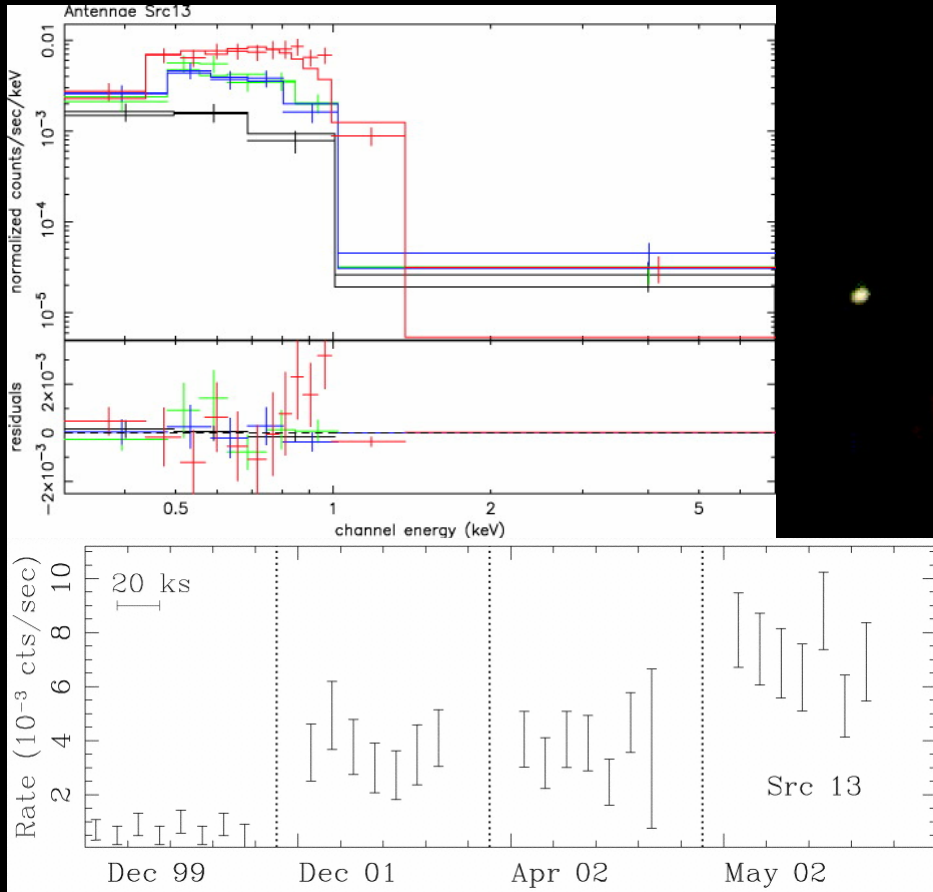


A Recurrent SSS in NGC 300



Kong & Di Stefano 2003

An ultraluminous SSS in the Antennae



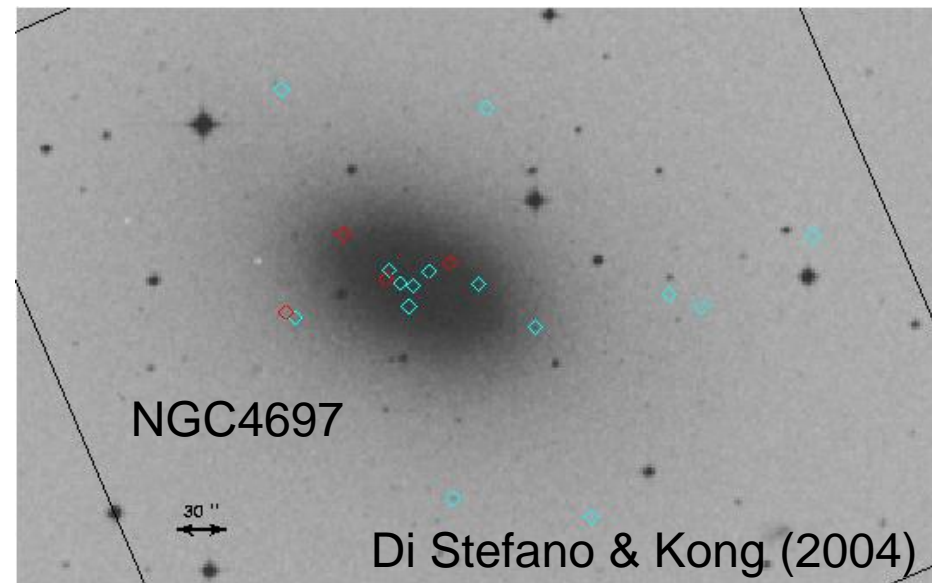
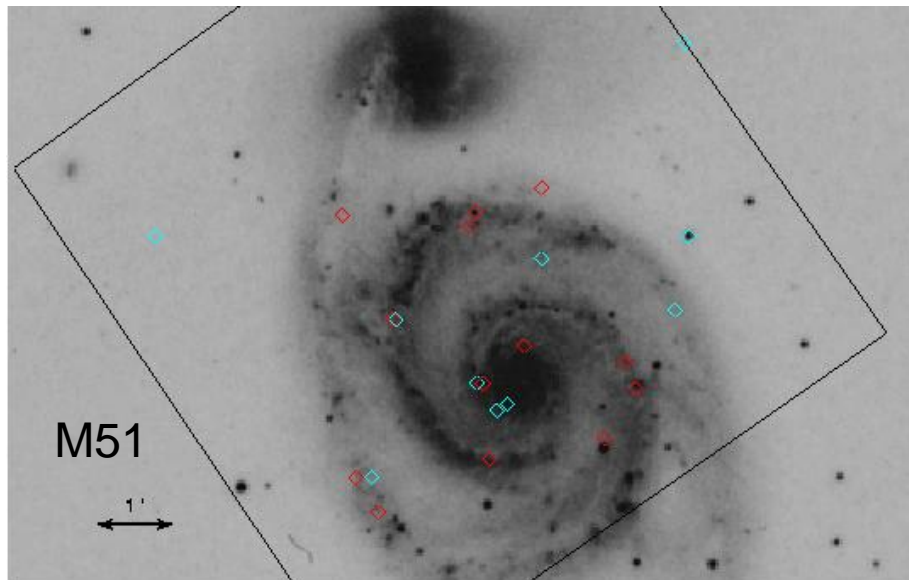
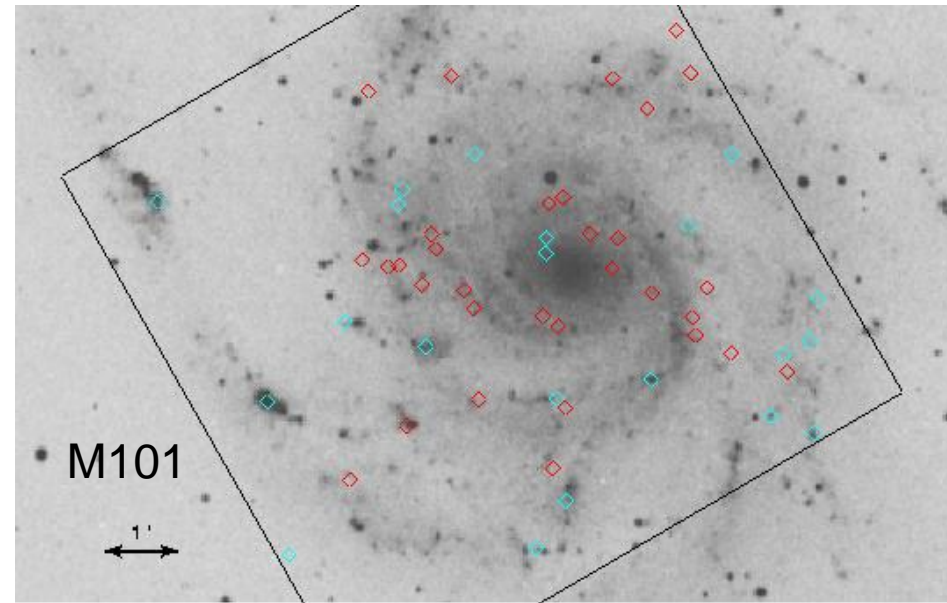
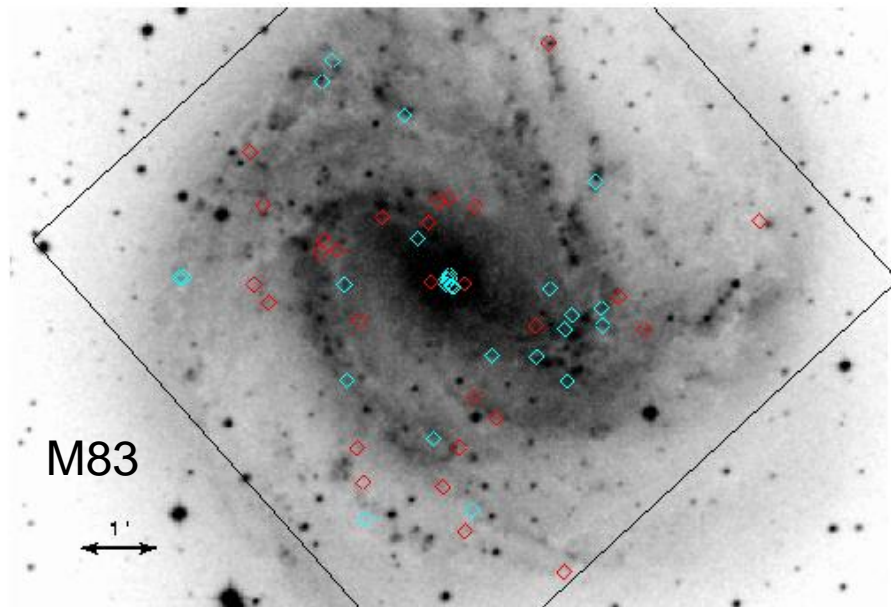
$kT=90-150$ eV

$L_x=2 \times 10^{38}-10^{40}$ erg s^{-1}

Fabbiano et al. 2003

Red: SSSs

Blue: QSSs



What are ultraluminous SSSs and QSSs?

- They may be IMBHs if their X-ray emission is isotropic.
- Stellar-mass BHs with beaming will also work.
- White dwarf models seem to be unlikely but we cannot totally excluded.
- Neutron star with extended photosphere is possible.

I need help from theorists!