

Science With EP

BINARY ORBITAL PERIODICITY AND BLACK HOLE MASS MEASUREMENT

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□ BHs in binary systems

- 20+ firmly identified so far

- Knowing the mass

 - Stringent constraints on stellar evolution model

 - Required for BH spin measurement via continuum modeling

 - Required for BH accretion model

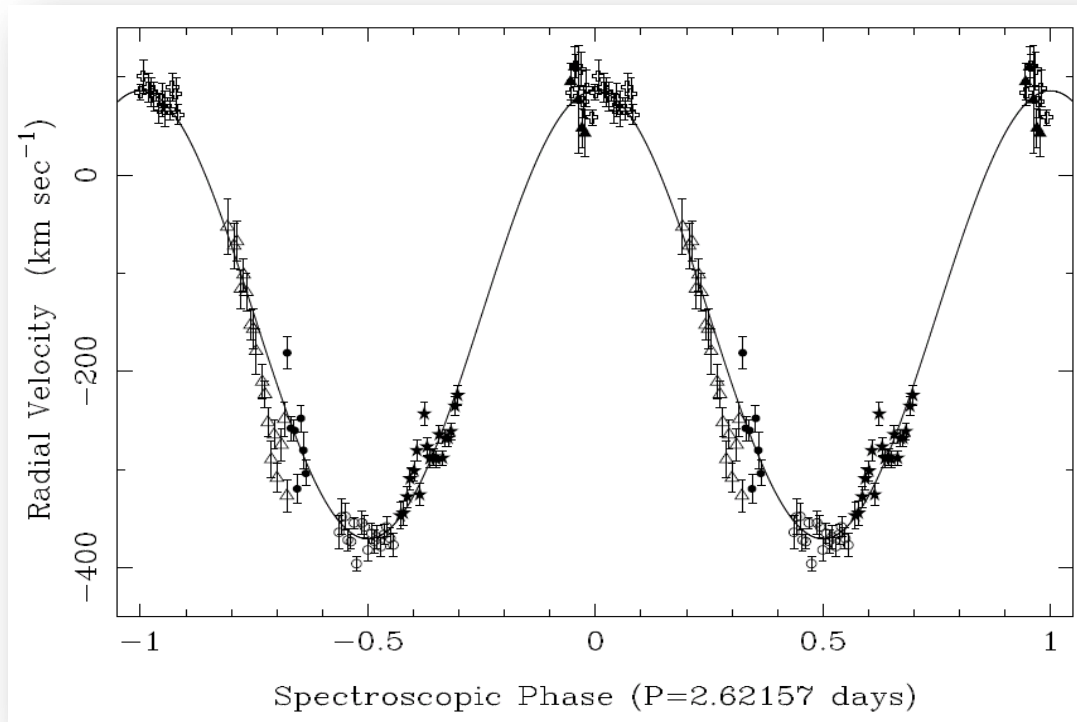
- Particularly interesting if we can

 - find low-mass BHs ($3 - 7 M_{\odot}$) and intermediate-mass BHs ($10^2 - 10^4 M_{\odot}$)

 - Largely expand the current BH sample, to ~ 100

Dynamical Mass Measurement

$$f(M) \equiv PK_2^3 / 2\pi G = M_1 \sin^3 i / (1+q)^2$$



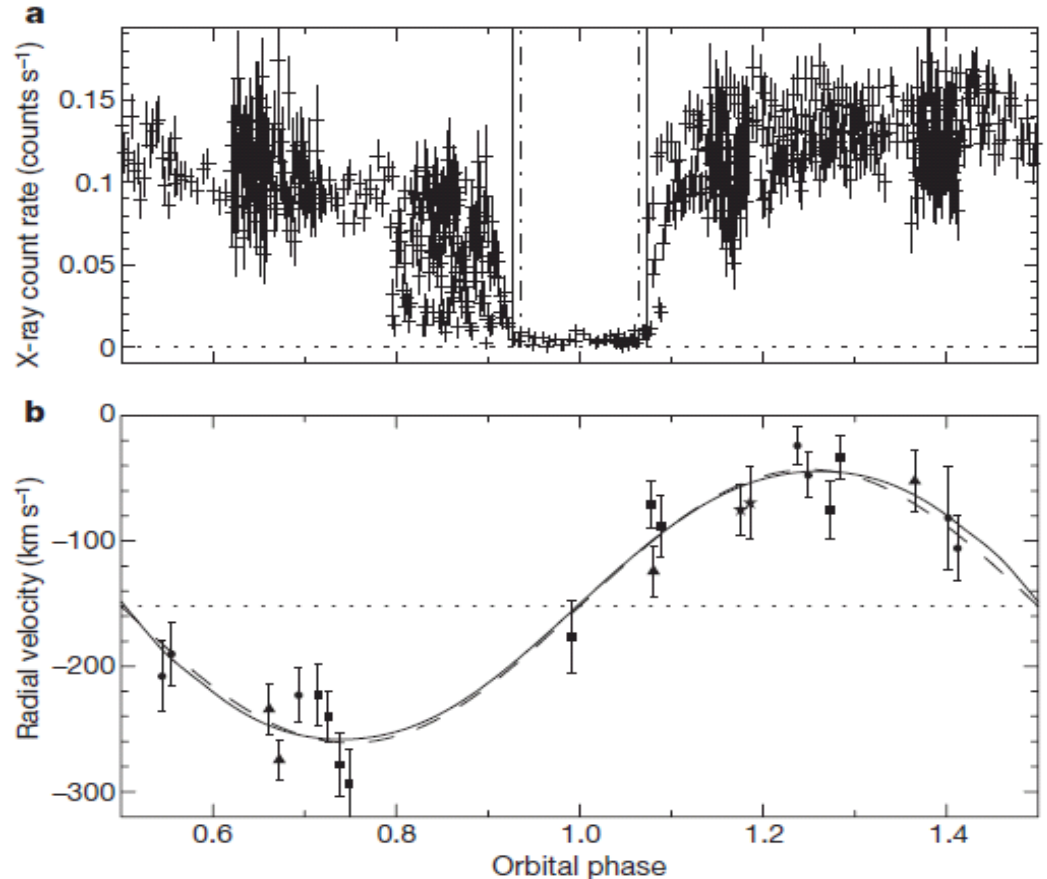
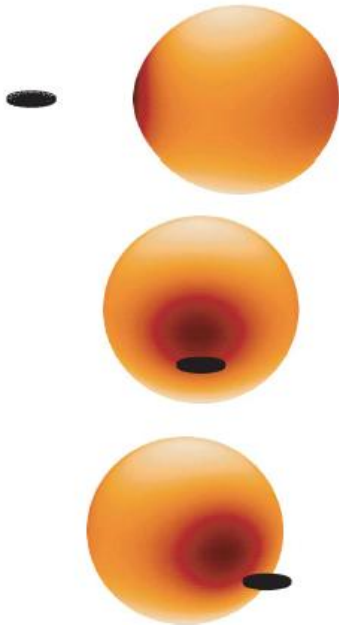
GRO J1655-40 (Orosz & Bailyn 1997)

Difficulties for extragalactic objects

- The companion is faint
 - ~a few kpc in the Milky Way
 - ~a few Mpc for nearby galaxies
 - Only detectable with large aperture telescopes, impossible for blind search
- A well defined sample is required

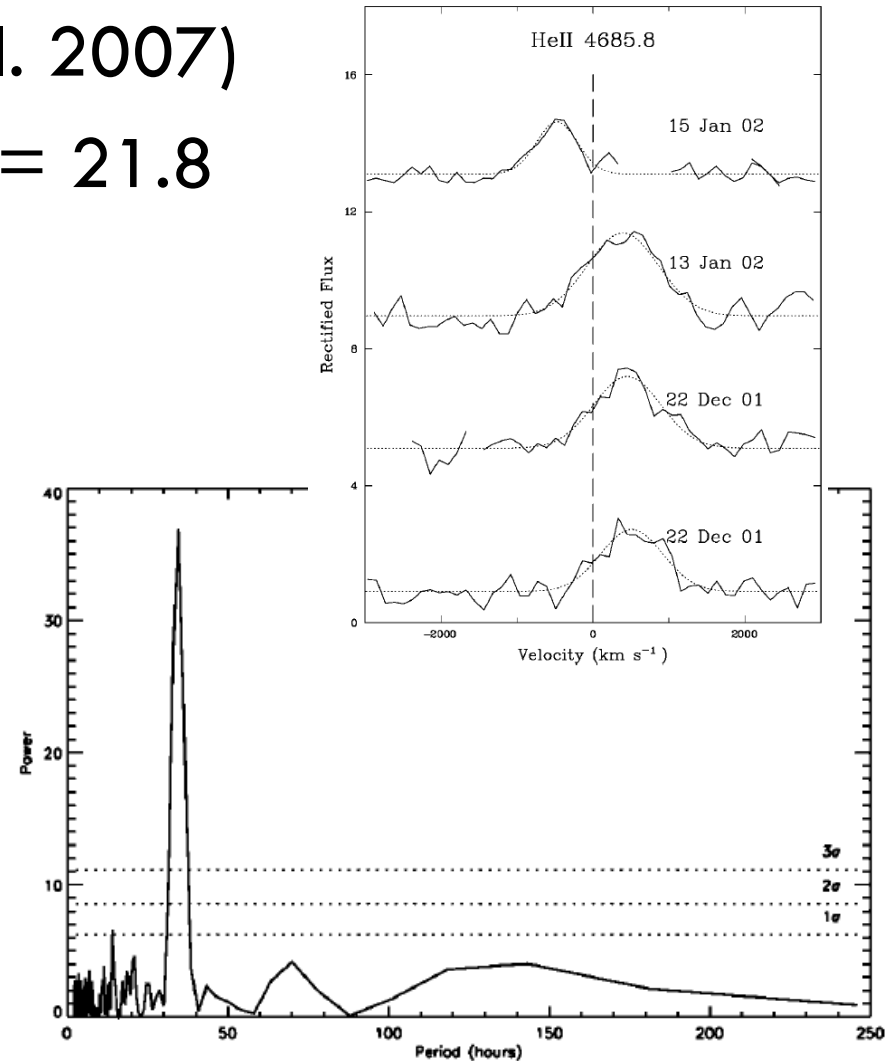
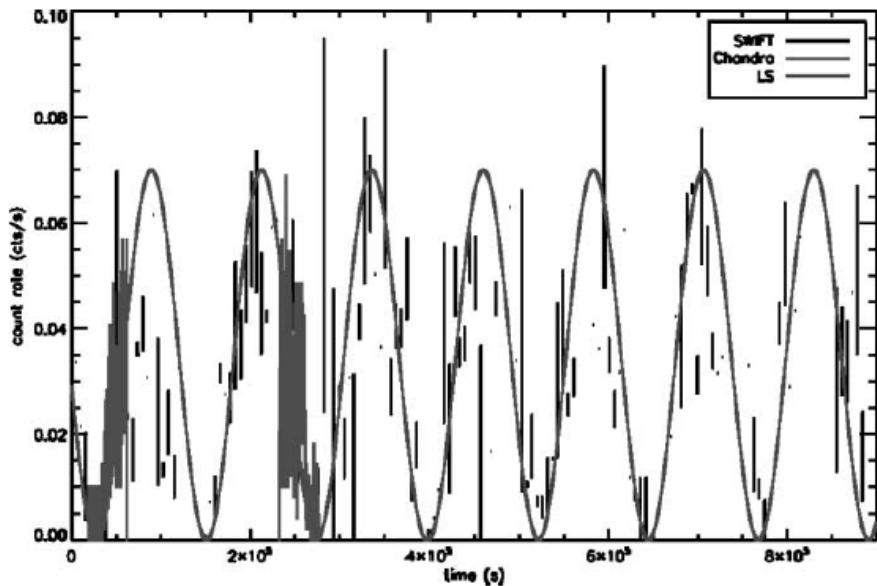
The two confirmed extragalactic BHs

- M33 X-7 (Orosz et al. 2007)
- $15.65 \pm 1.45 M_{\odot}$, 0.84 Mpc, $V=18.9$, 8.2-m Gemini North



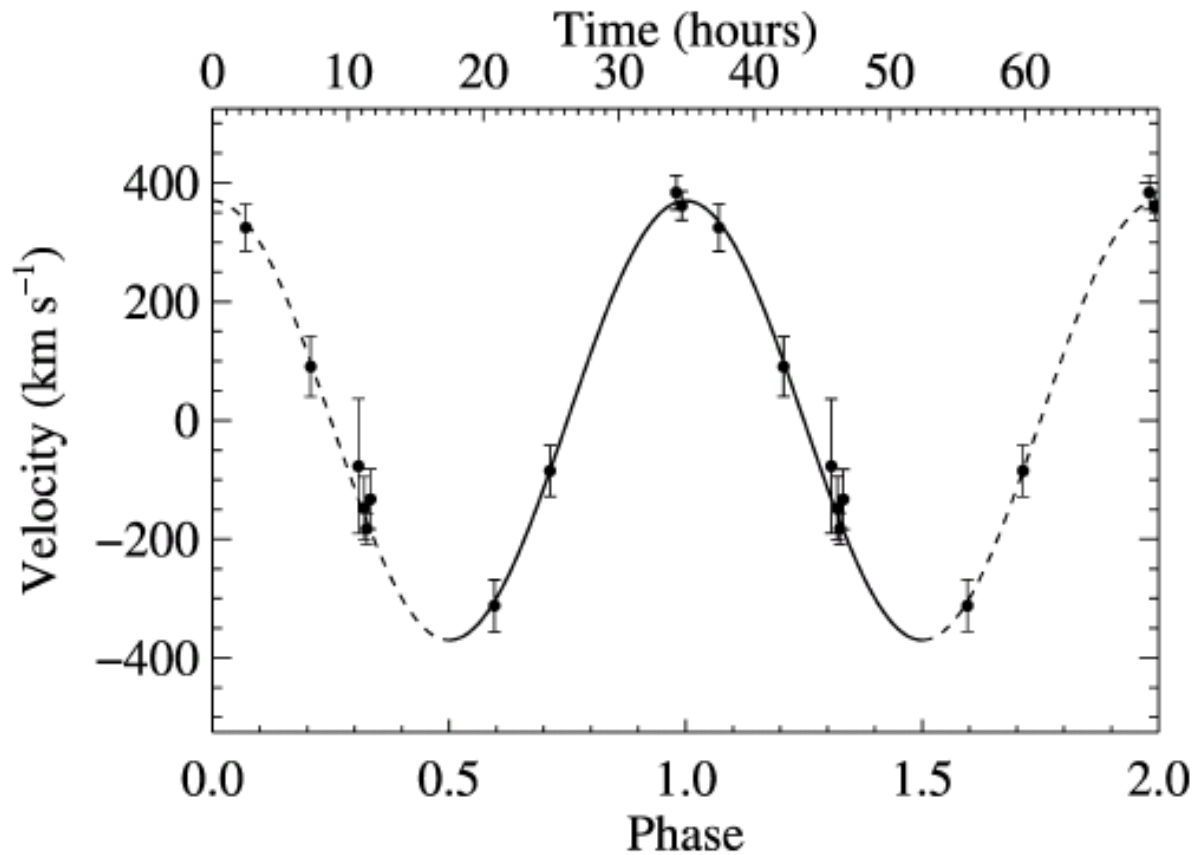
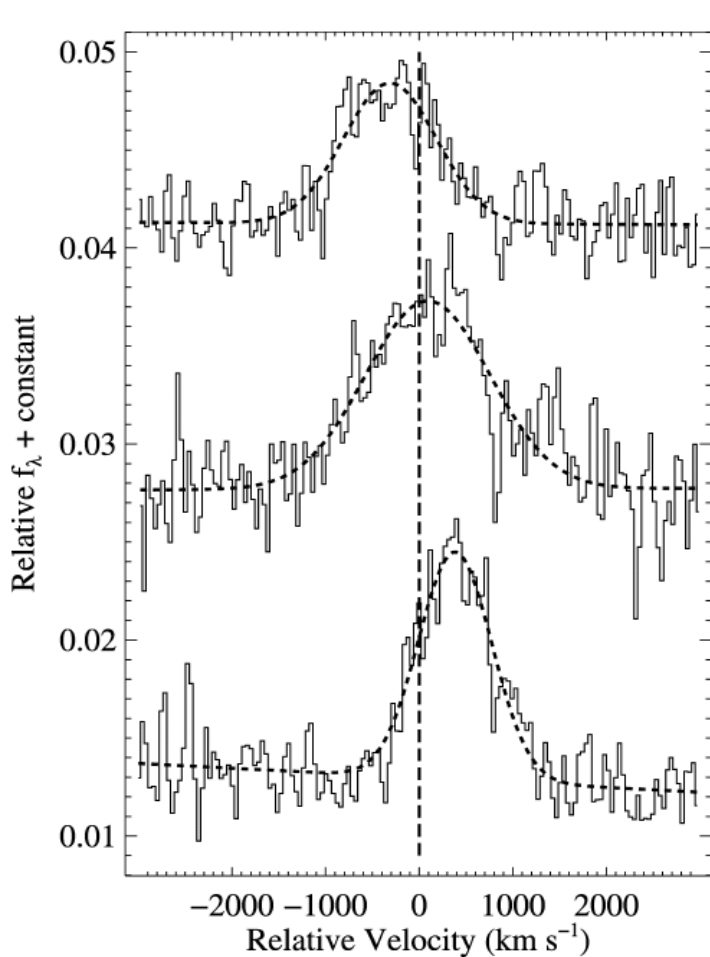
The two confirmed extragalactic BHs

- IC 10 X-1 (Prestwich et al. 2007)
- 23-38 M_{\odot} , ~ 0.8 Mpc, $V = 21.8$
- 8m-Gemini

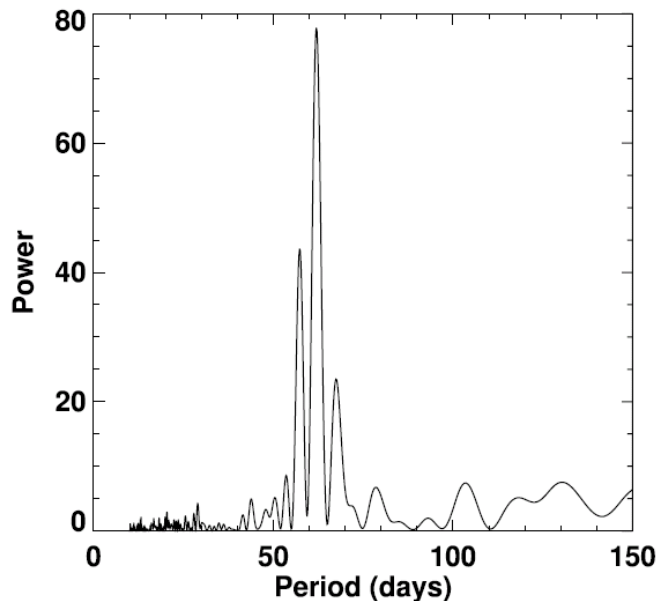
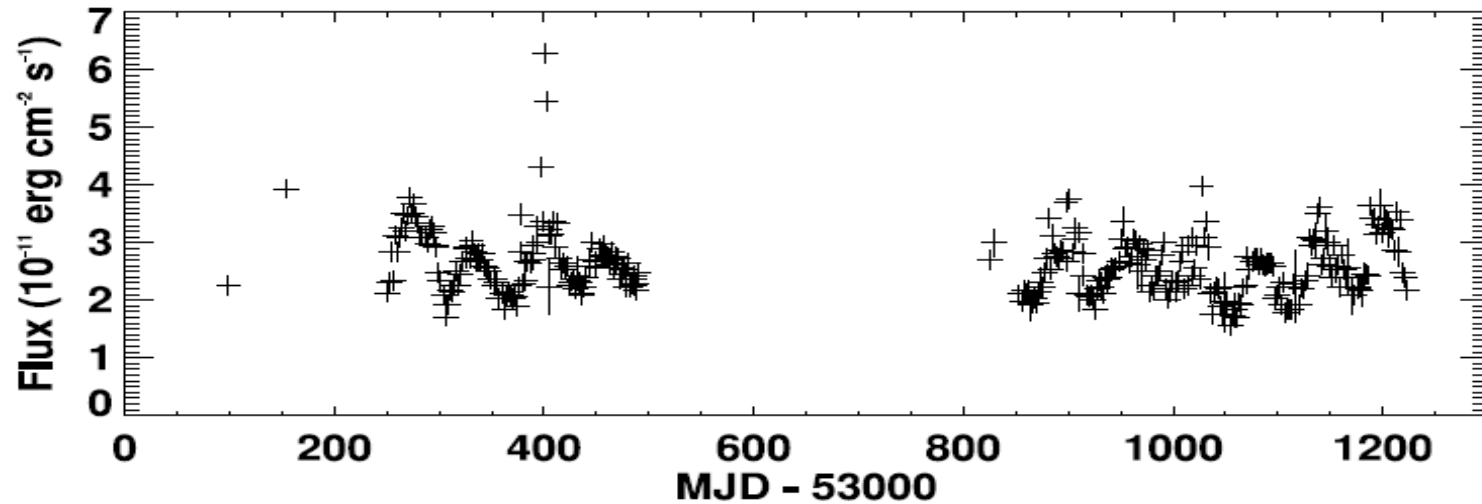


The two confirmed extragalactic BHs

□ Silverman & Filippenko (2008) 10m-Keck



Long-term X-ray periodicity found in ULXs



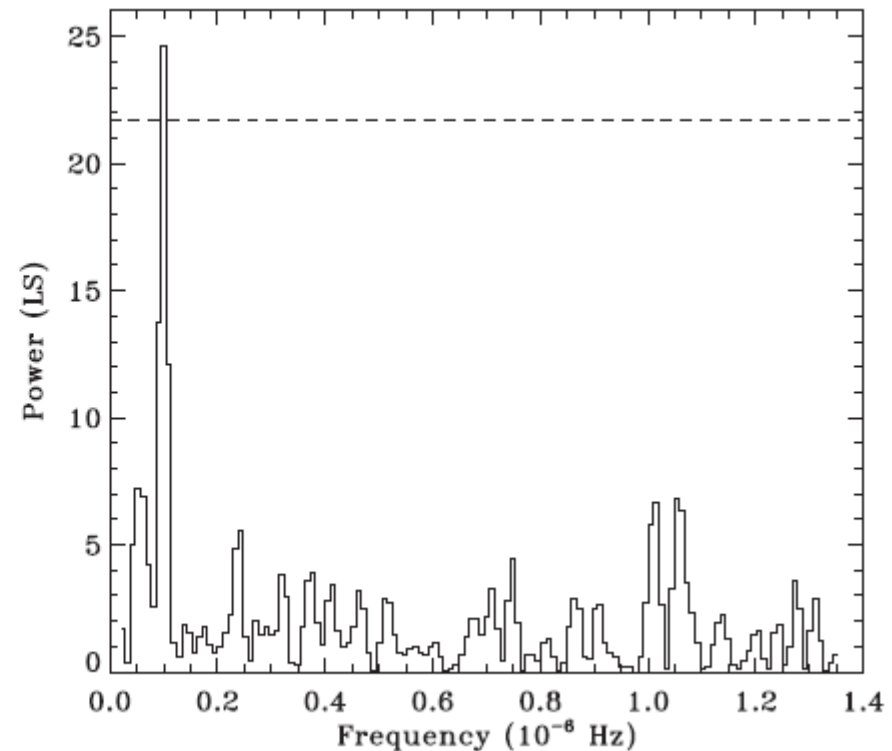
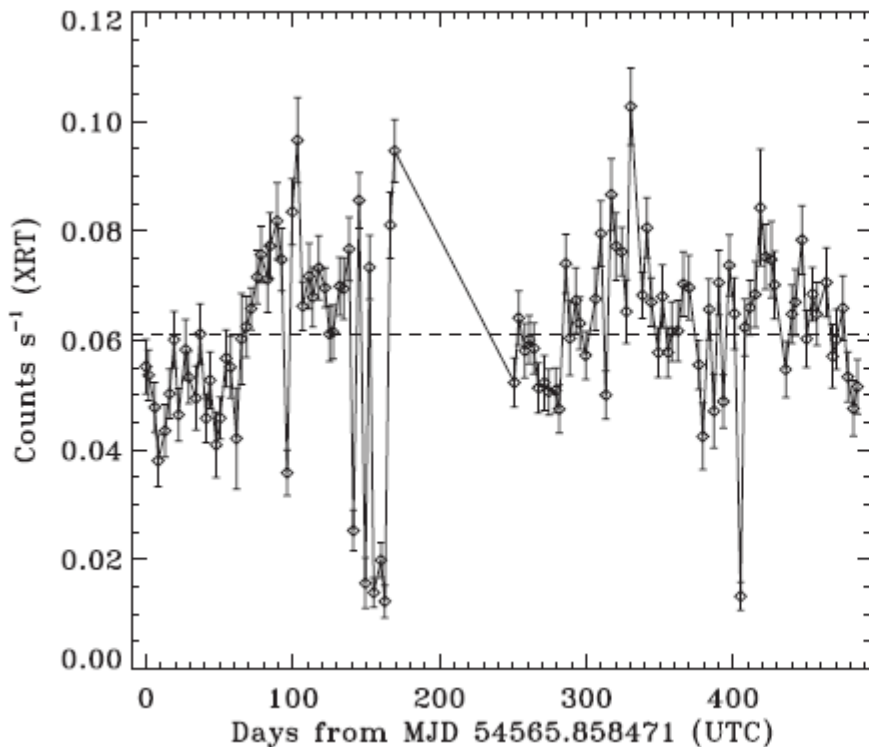
$P = 62$ day

Discovered with XTE

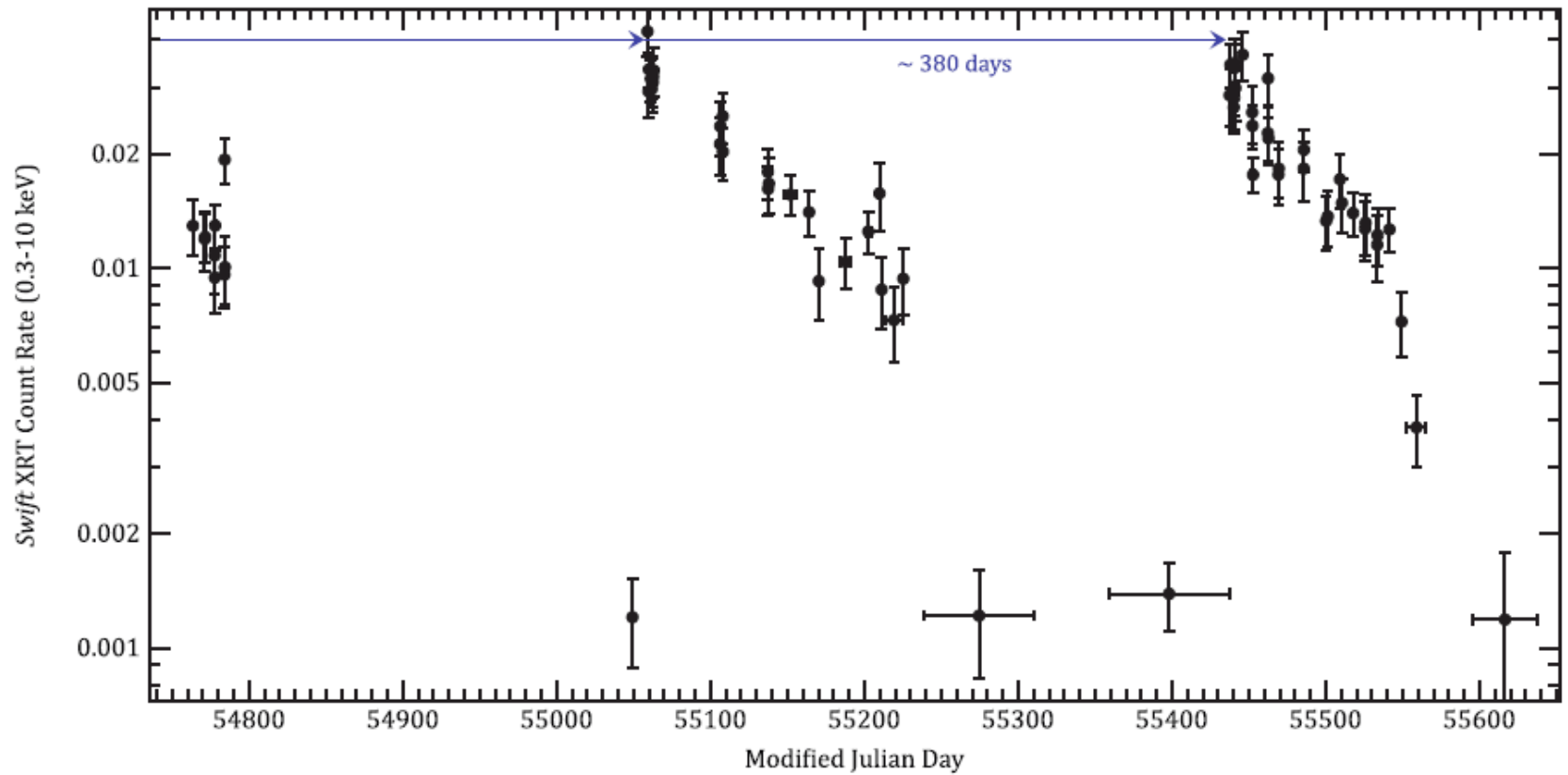
(Kaaret et al. 2006; Kaaret & Feng 2007)

Long-term X-ray periodicity found in ULXs

- NGC 5408 X-1 (Strohmayer et al. 2009), $P = 115$ day
- Unstable period, super-orbital? (Grise et al. submitted)



ESO 243-49 HLX-1



Lasota et al. 2011

Requirement for the instrument

- An extra on-axis X-ray telescope
 - ▣ Effective area a few 10^2 cm^2
 - ▣ Spatial resolution ~ 1 arcmin or better

