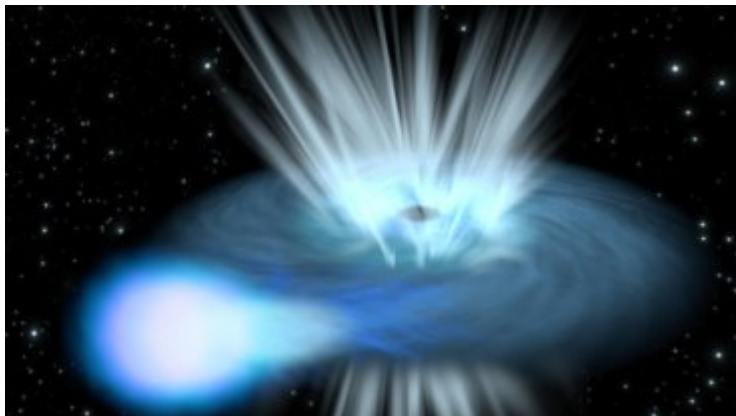




Durham
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A new catalogue of ultraluminous X-ray sources (and more!)



Tim Roberts

*Presented by Dom Walton
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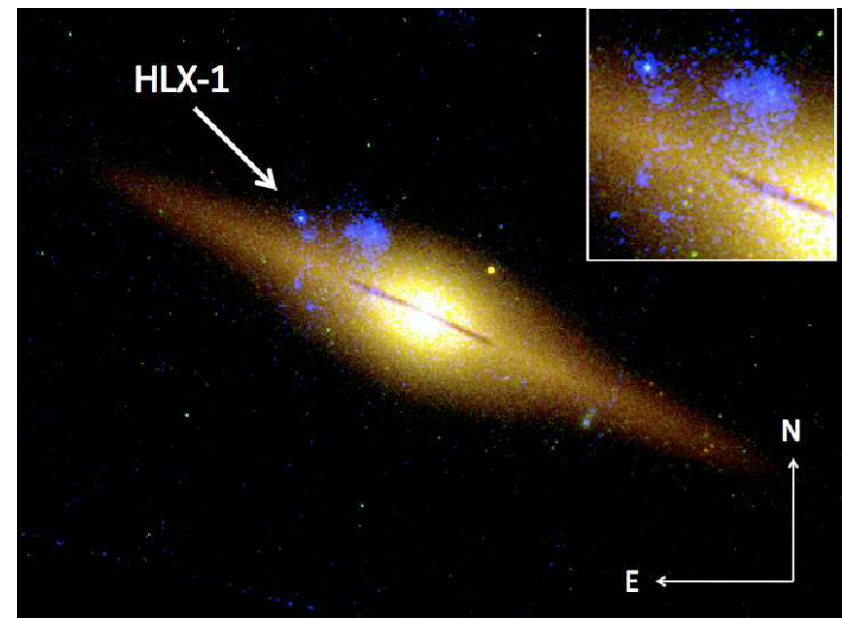
Matt Middleton (Southampton)

Silvia Mateos (IFCA)

Ultraluminous X-ray sources

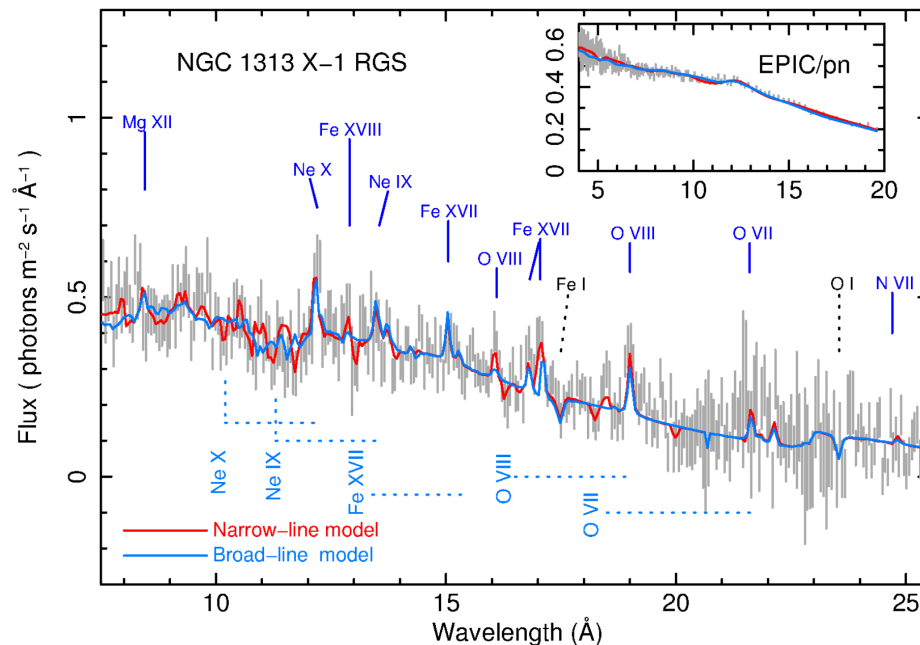
Kaaret, Feng & Roberts (2017)

- Eddington limit is
 $L_{Edd} = 1.3 \times 10^{38} (M/M_{Sun}) \text{ erg s}^{-1}$
- **ULXs**: point sources in nearby galaxies with
 $L_x > 10^{39} \text{ erg s}^{-1}$
- **Implies big black holes; or super-Eddington accretion**
- IMBHs now thought to be a minority of ULXs



The optical/UV counterpart of ESO 243-49 HLX-1, a good IMBH candidate (Mapelli et al. 2013)

Super-Eddington accretion



Detection of an outflowing, fast ($v = 0.2 c$) wind in NGC 1313 X-1 (Pinto et al. 2016)

□ Observational evidence includes:

- Optical nebulae (e.g. Pakull & Mirioni 2003)
- X-ray behaviour (e.g. Gladstone et al. 2009; Sutton et al. 2013)
- Outflowing material in wind (Middleton et al. 2015; Pinto et al. 2016, 2017)
- Pulsations – 3 neutron star ULXs! (e.g. Bachetti et al. 2014; Israel et al. 2017)

ULX catalogues

□ Long heritage

- *ROSAT* HRI (e.g. Roberts & Warwick 2000, Colbert & Ptak 2002)
- *Chandra* ACIS (e.g. Swartz et al. 2004, Liu et al. 2011)
- *XMM-Newton* EPIC (e.g. Walton et al. 2011)

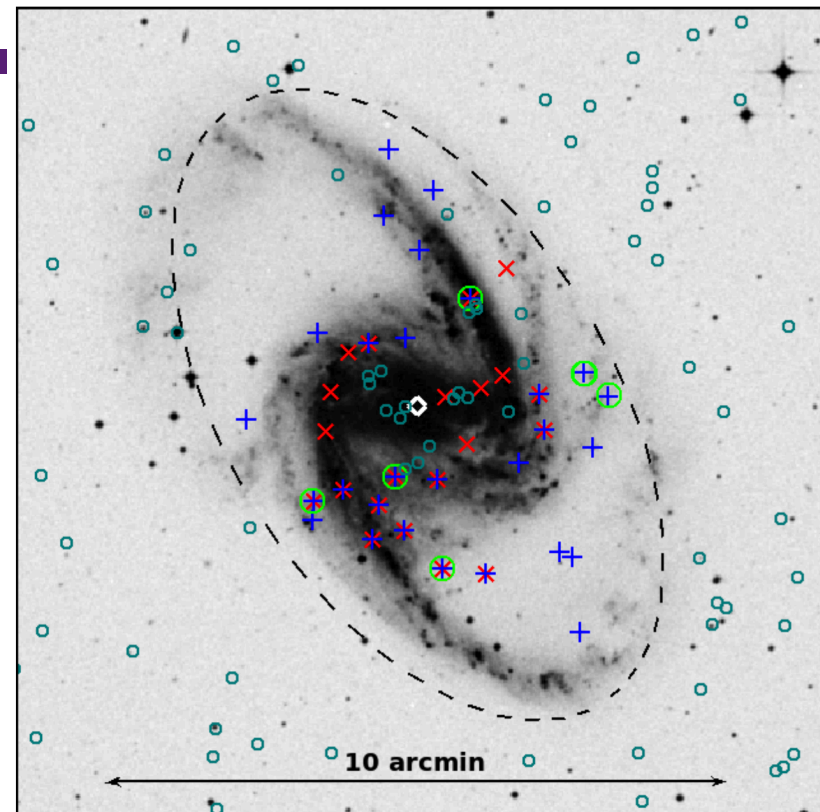
□ Critical enabler for science

- Statistical samples – population studies
- Comparative source properties
- Outliers (e.g. brightest, most variable...)

A new catalogue

- Take 3XMM-DR4 and cross-correlate with RC3 & Catalogue of Neighbouring Galaxies (Karachentsev et al. 2004)
 - ~2000 galaxies covered
- Follow method of Walton et al. (2011), with some improvements

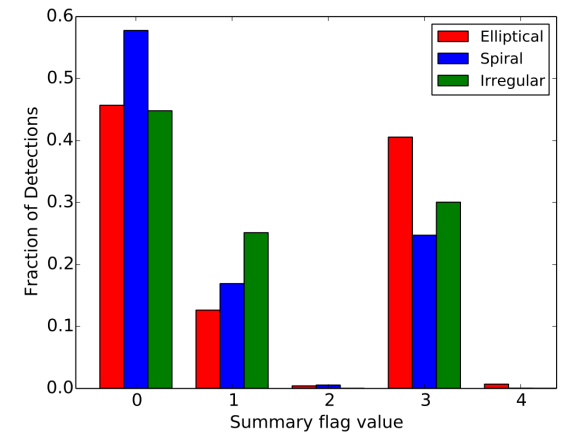
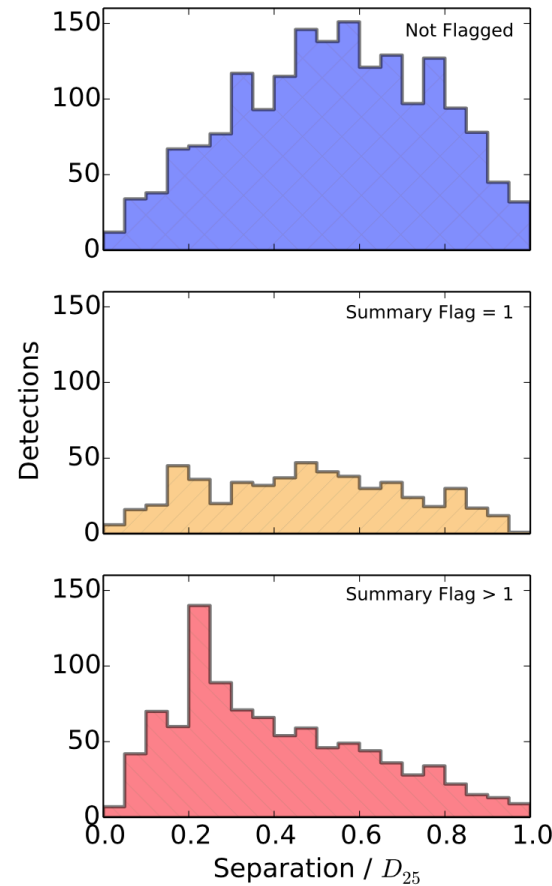
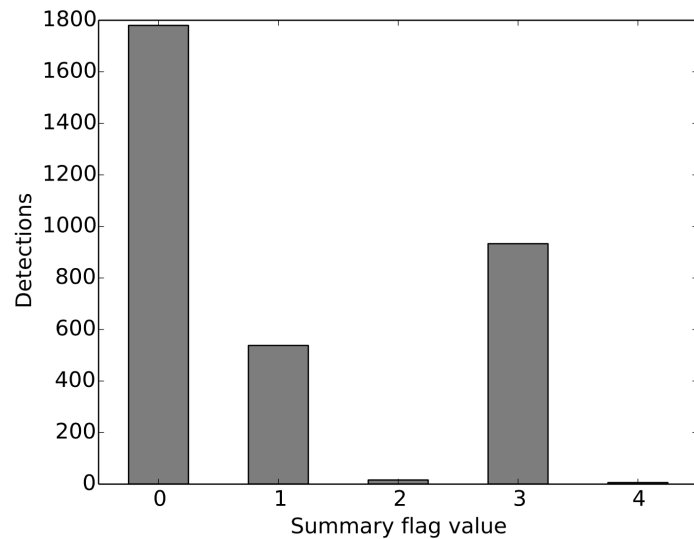
Earnshaw et al. (in prep.)



NGC 1365. Cyan circles – 3XMM detections; green circles – ULXs; blue pluses – unflagged detections; red crosses – flagged detections

Source flags

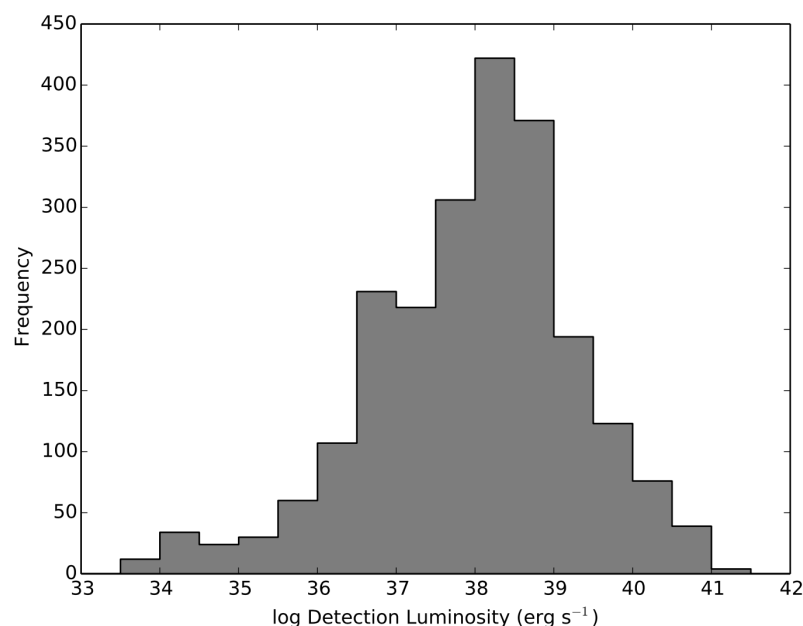
- 0 – good source
- 1 – risk of poor source parameterisation
- 2-4 – possible spurious sources



Keep 0 & 1

Remove 2-4; affects sources near centres of galaxies and/or in elliptical galaxies most.

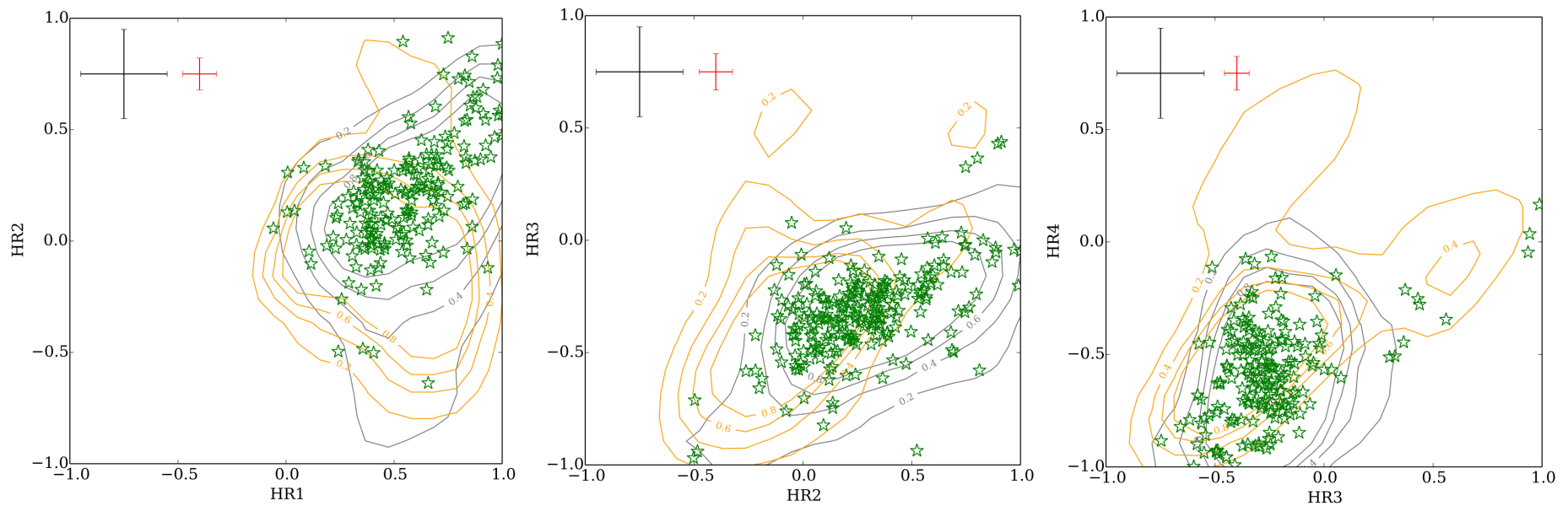
New catalogue: numbers



*Luminosity distribution of
detections*

- 2256 detections of 1464 sources in 349 galaxies
- 539 detections of 372 ULXs in 248 galaxies
- Complete subset: 298 detections of 227 ULXs in 122 galaxies
- Contamination ~ 20%

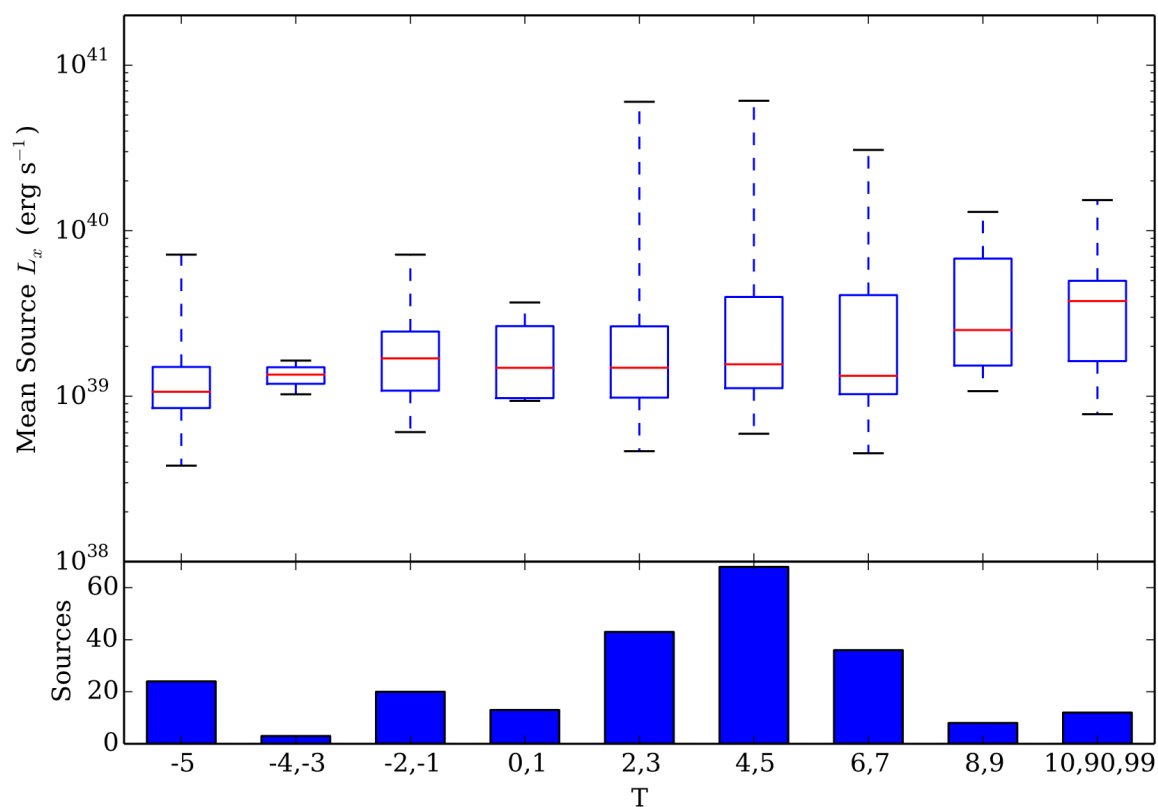
X-ray colours



Standard 3XMM bands (0.2-0.5; 0.5-1; 1-2; 2-4.5; 4.5-12 keV) converted into colours using $HR_n = (RATE_b - RATE_a)/(RATE_b + RATE_a)$.

Complete ULX sample is green stars; grey contours from sub-ULX sample; orange contours from nuclear sources (AGN candidates)

Luminosity versus host type

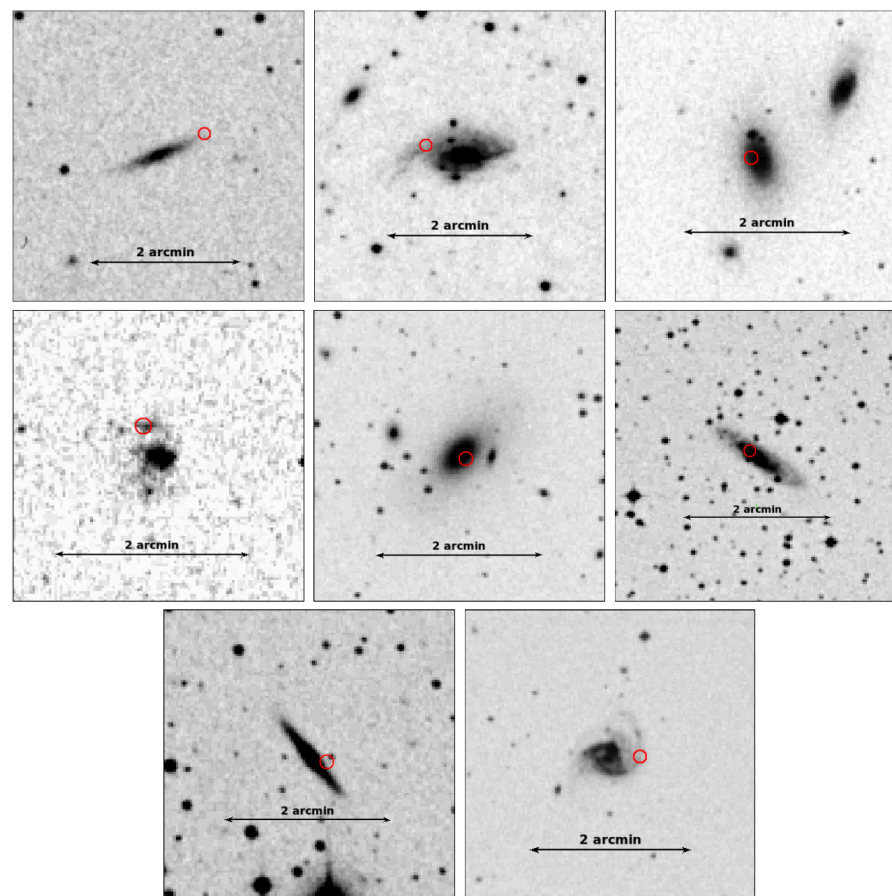


*Tentative upwards trend
in luminosity towards
later type galaxies?*

*Cf. established theoretical
& observational links to
metallicity (e.g. Prestwich
et al. 2011, Linden et al.
2010, Marchant et al.
2017) - more XRBs, and
bigger BHs.*

New IMBH candidates

- 22 sources with ≥ 1 detection above 5×10^{40} erg s⁻¹
- 4 well-known (incl. IMBH & PULX); 10 rejected as known or suspected AGNs
- 8 new IMBH candidates (see right, on DSS images)

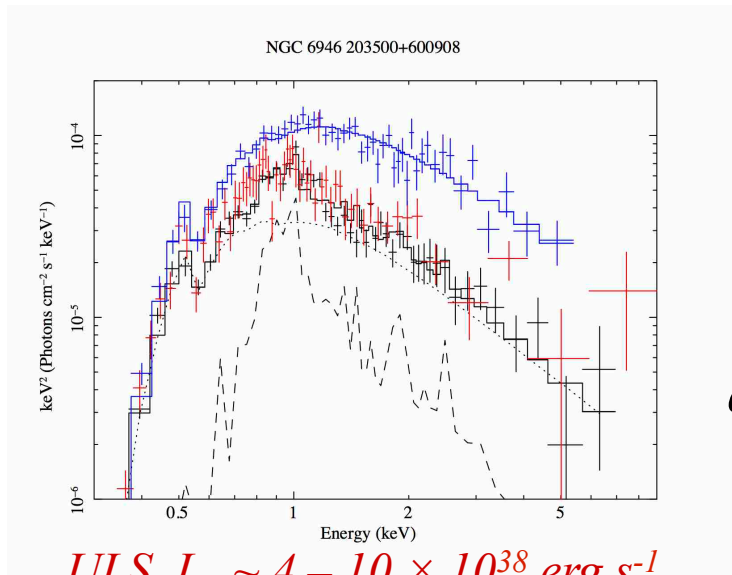


The Eddington Threshold

- Star-forming galaxy XLFs flat – so emit most (>80%) of energy (radiative & mechanical) in HMXBs with luminosities above 10^{38} erg s⁻¹.
- Bulk of output in $1 - 30 \times 10^{38}$ erg s⁻¹ regime (*Eddington Threshold*)
- (Far) more binaries created in early Universe
- Feedback impacts on young galaxies
- **Cosmologically important regime!**

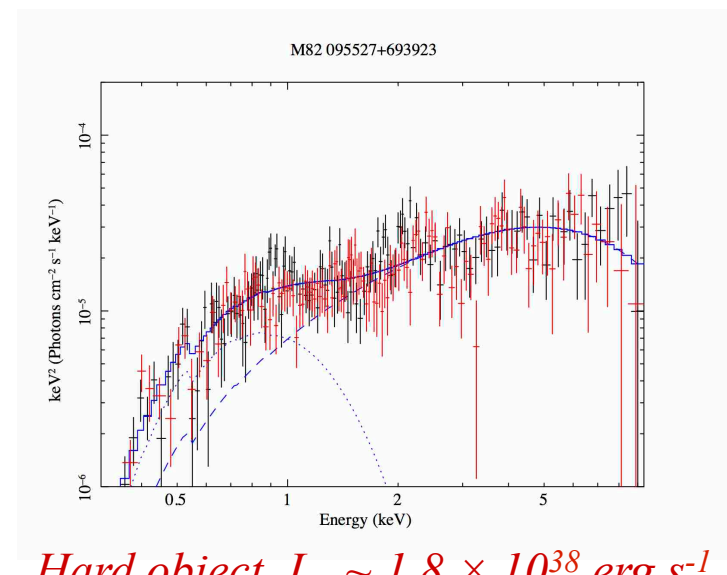
Important – but poorly understood

- Observational constraints poor
- *Athena* science; pilot studies with *XMM-Newton*
 - E.g. Earnshaw & Roberts (2017) – 4 objects



*U*LX, $L_X \sim 4 - 10 \times 10^{38} \text{ erg s}^{-1}$

*Stacked spectra
(Roberts et al. in prep.)*



Hard object, $L_X \sim 1.8 \times 10^{38} \text{ erg s}^{-1}$

Summary

- ULXs are heterogeneous – but super-Eddington emission appears common
- ULX catalogues an important resource
- Derived a new catalogue from 3XMM-DR4, including 372 ULXs & > 1000 less luminous objects in nearby galaxies
- Science: X-ray colours, luminosity as a function of host, extreme objects, Eddington Threshold, etc...