Searching for propeller-phase ULXs in XMM-Newton archival data

VH-ULX: a Desoutter propeller plane in Australia, 1930s (photo: Frank Walters). Not actually what we're searching for.

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ULX Pulsar Workshop, ESAC, 6-8 June 2018

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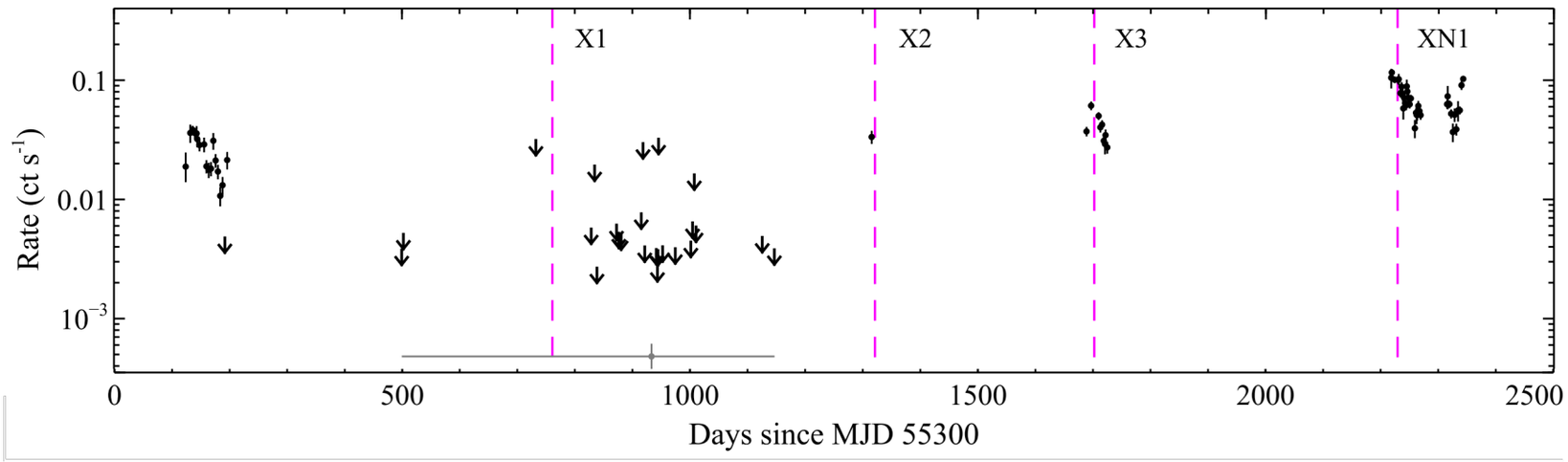
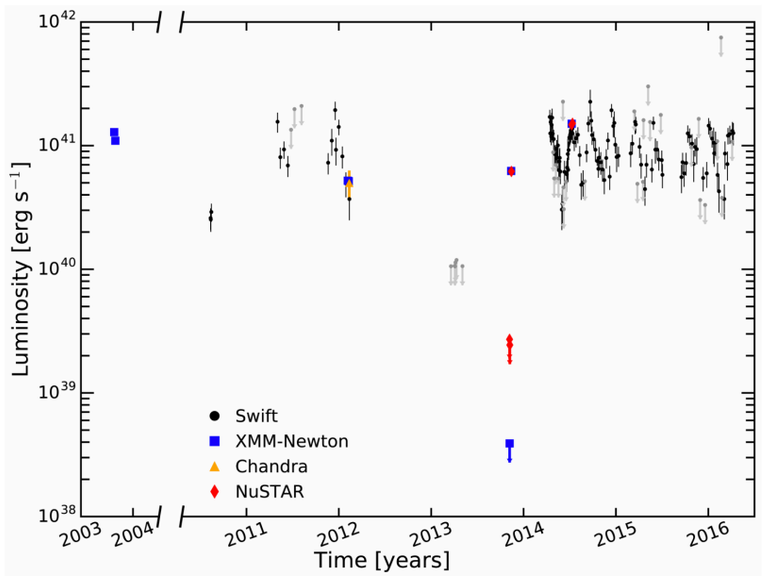
Introduction

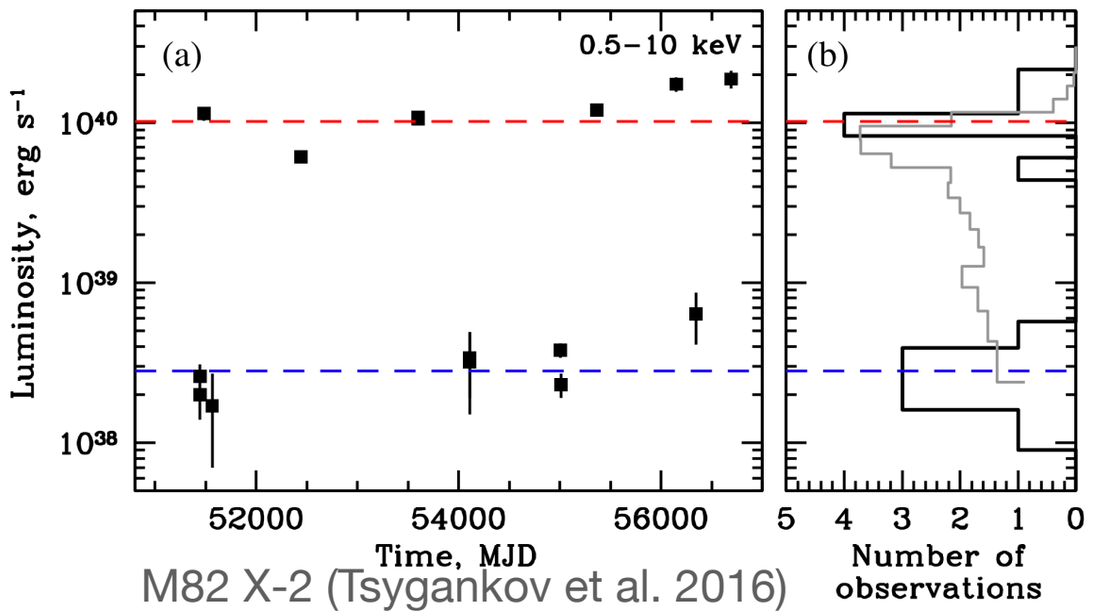
(The first three) ULXPs share a common feature of bimodal flux distributions



NGC 7793 P13
(Fürst et al. 2016)



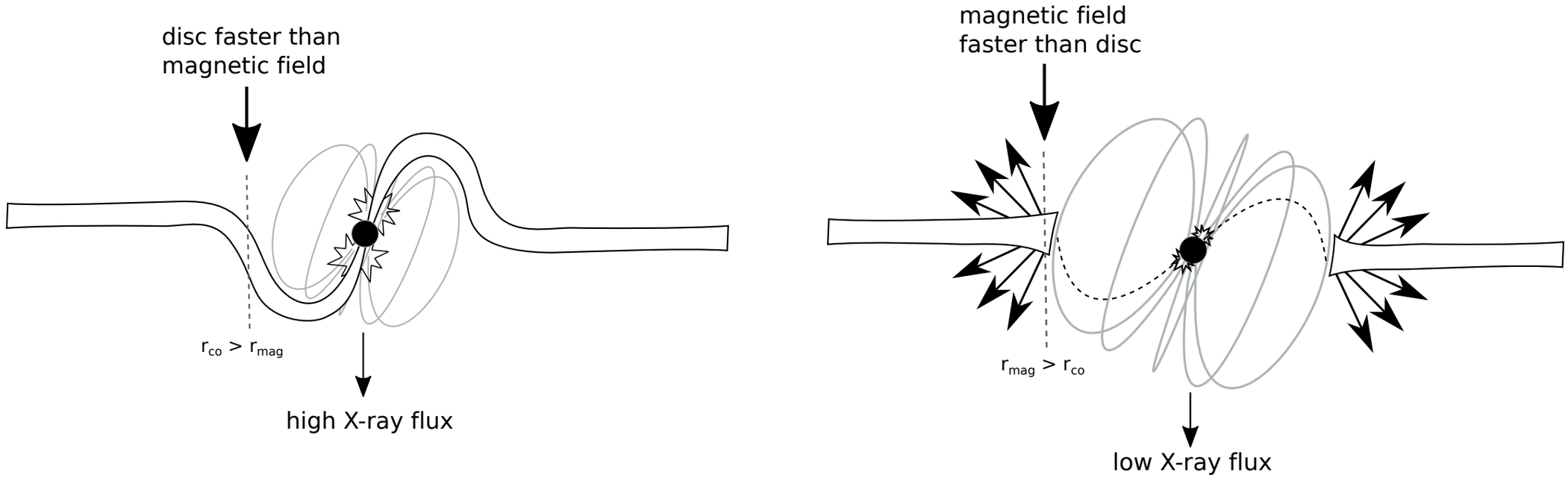
NGC 5907 ULX-1 (Israel et al. 2017)



M82 X-2 (Tsygankov et al. 2016)

Introduction

This can be attributed to the “propeller” mechanism, when the magnetosphere of the neutron star rotates faster than the accretion disc at the magnetospheric radius



Finding evidence of this propeller mechanism is a way to identify candidate neutron star ULXs in the absence of pulsations!

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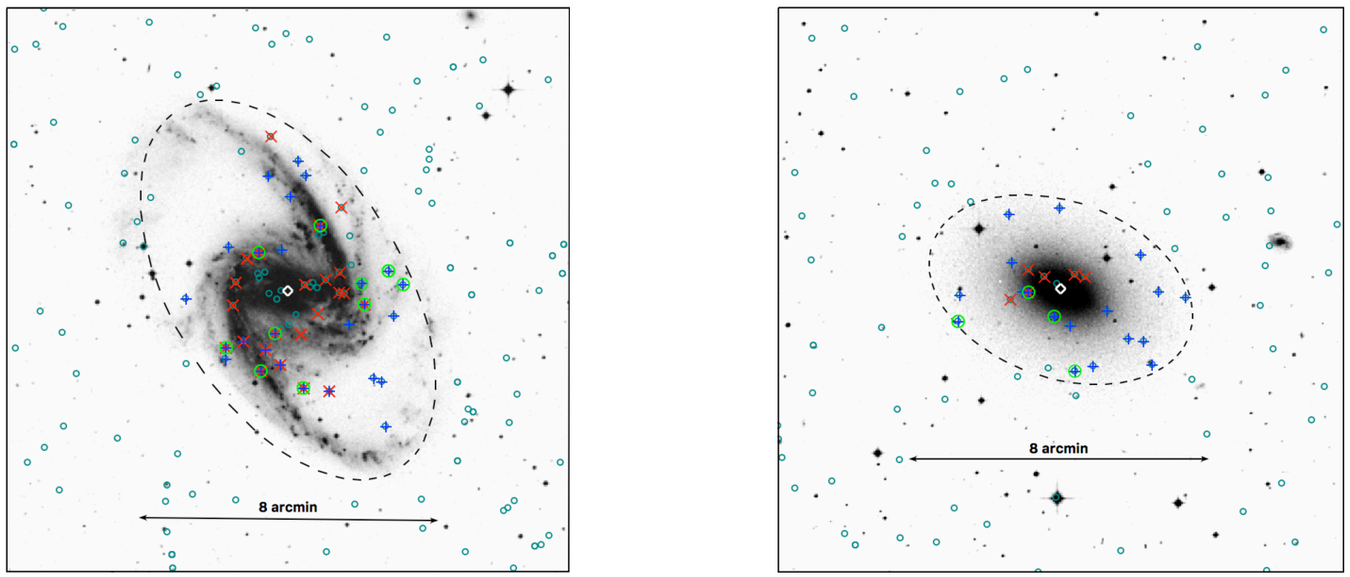
ULXs in the XMM-Newton Serendipitous Source Catalogue

We created a sample of extragalactic non-nuclear X-ray sources from the 3XMM-DR4 release of the XMM-Newton Serendipitous Source Catalogue (Earnshaw et al. submitted!!)



From the ULXs in the sample ($L_X > 10^{39}$ erg/s for at least one detection) we selected those with at least one detection or flux upper limit (from the FLIX upper limit server) with L_X at least one order of magnitude below the maximum luminosity

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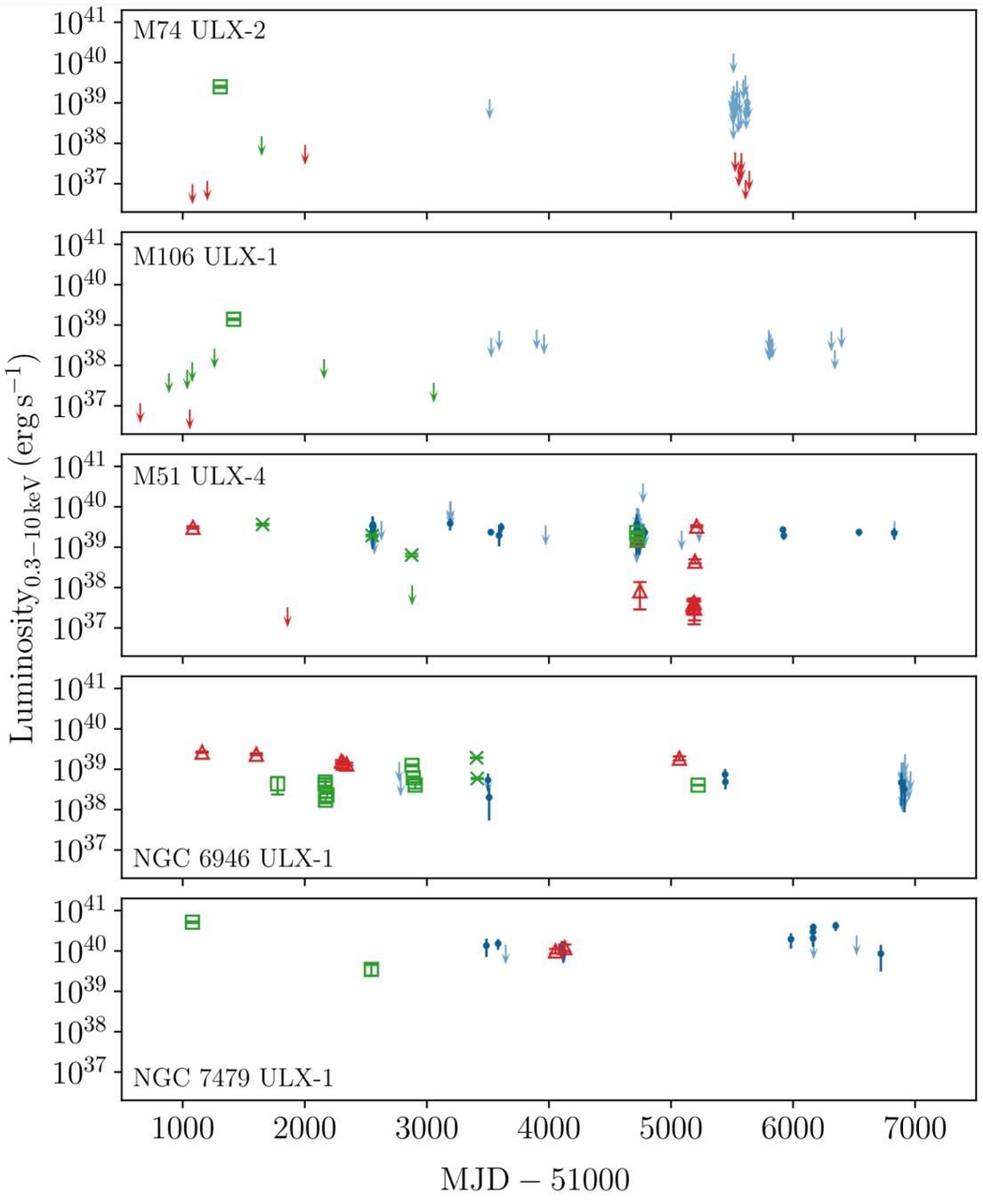
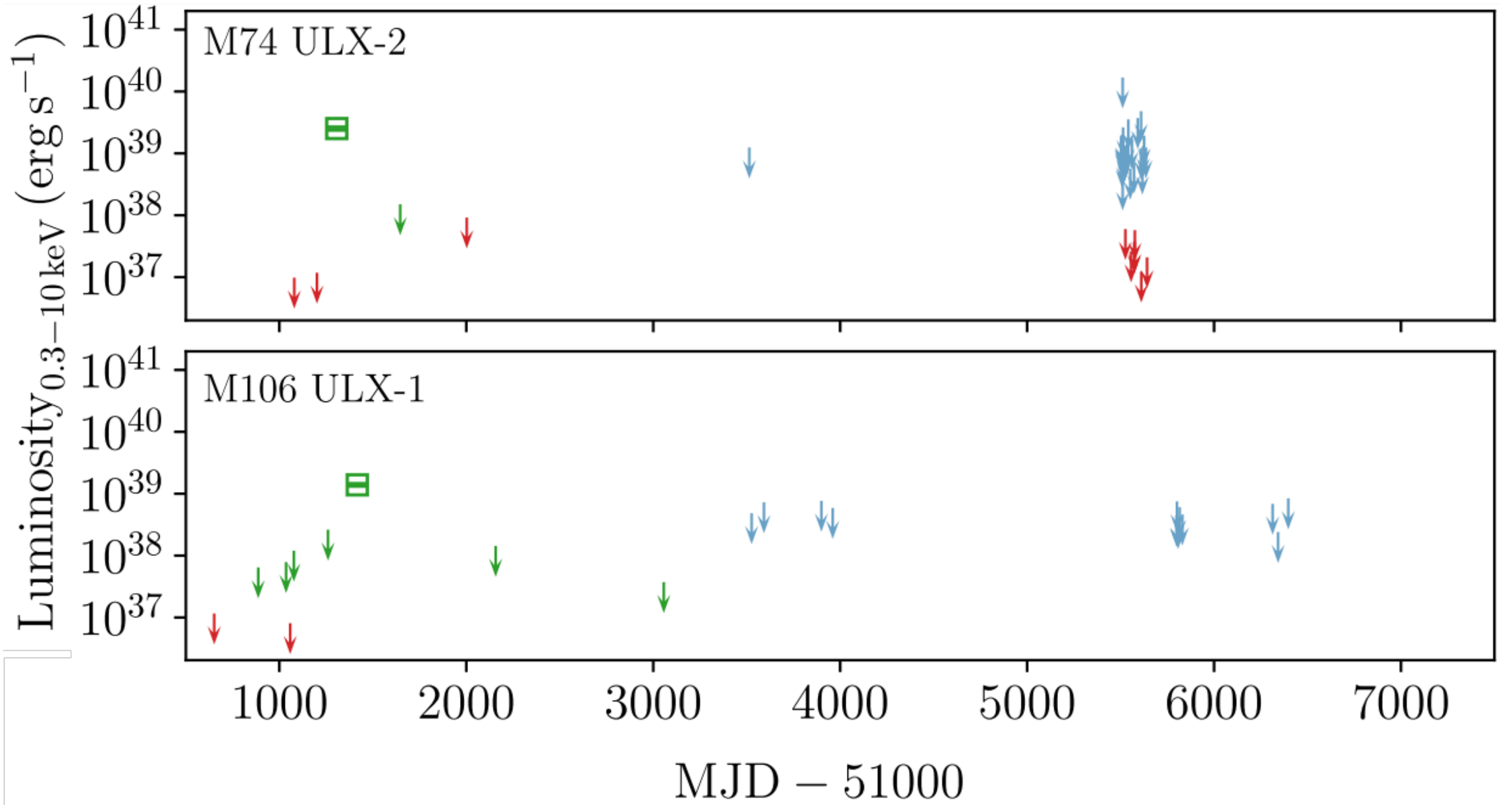
Highly variable ULXs



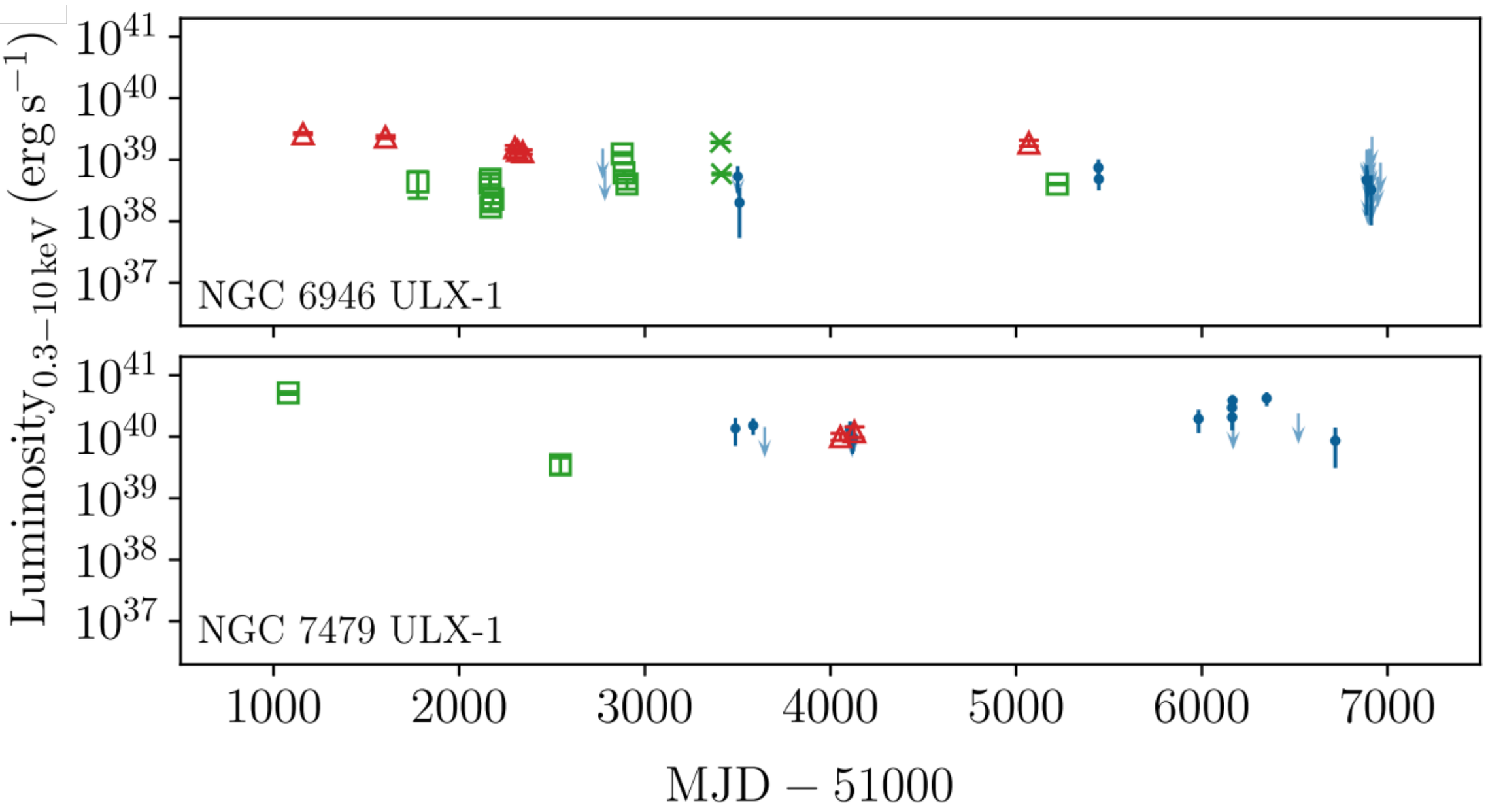
We identified five highly variable ULXs in 3XMM-DR4

We created light curves using XMM-Newton, Chandra and Swift XRT data

Earnshaw et al. (2018)

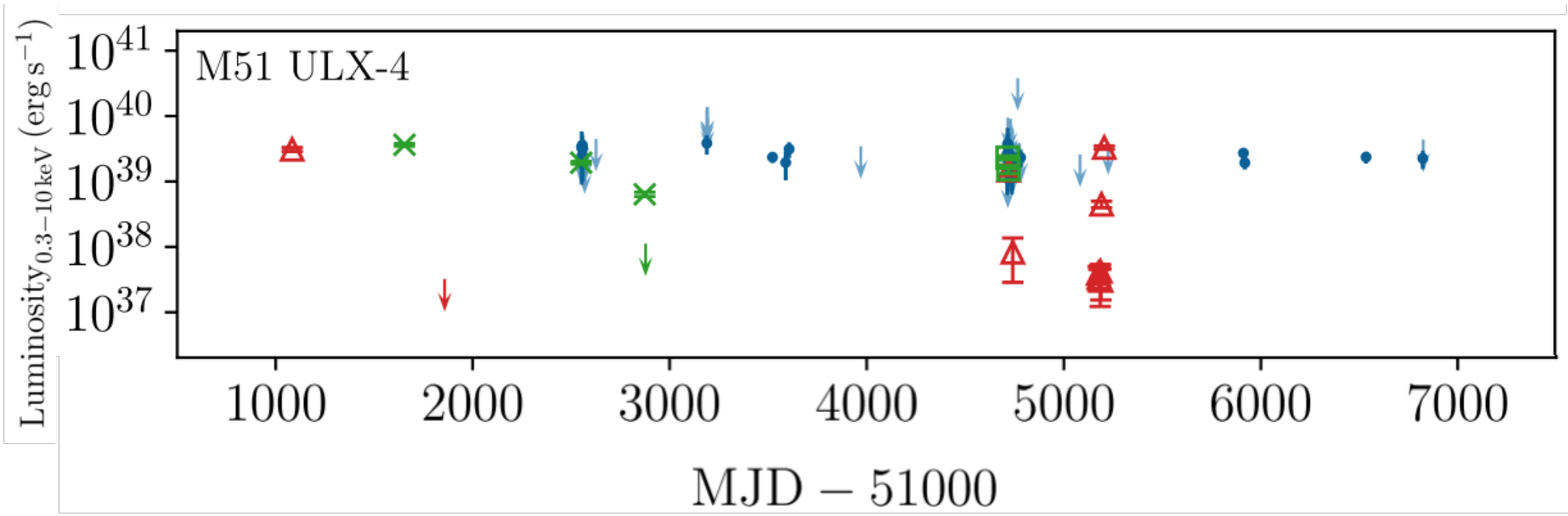


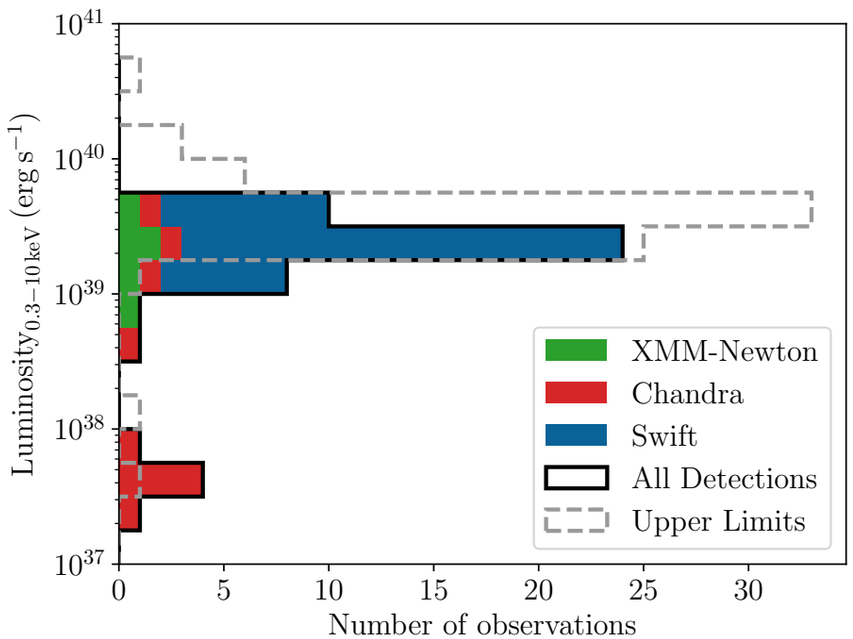
Classical transients - LMXB reaches ULX luminosities in outburst and disappears again



Persistent ULXs - flux is highly variable over time, but the source remains in or near the ULX regime

M51 ULX-4





Bimodal flux distribution - the vast majority of detections have luminosity $L_X \gtrsim 1.5 \times 10^{39}$ erg/s or $L_X \lesssim 5 \times 10^{37}$ erg/s

See Raj's poster for more details!

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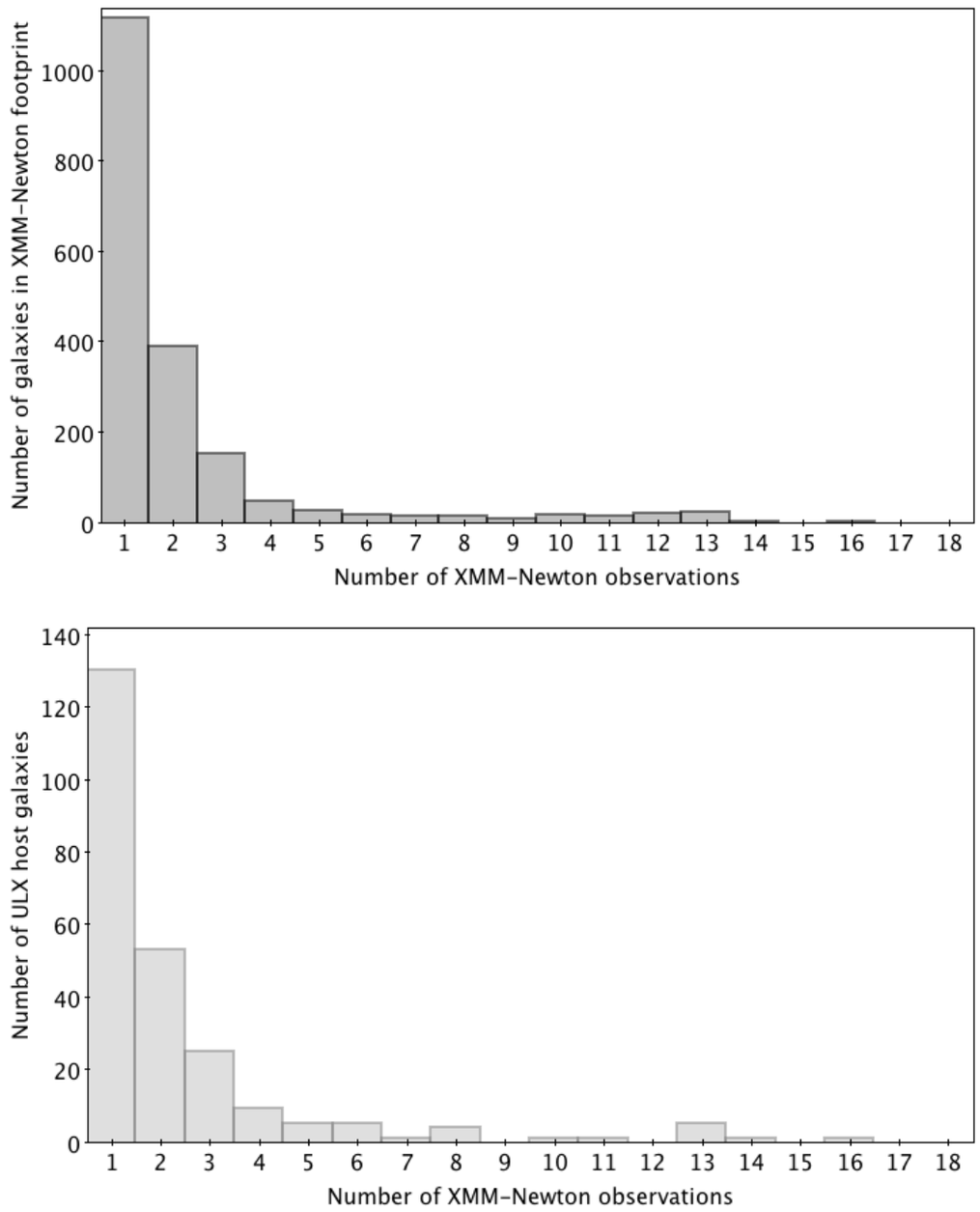
Is that it?

We see one candidate ULXP - how many are we not seeing?

Most galaxies - even those hosting ULXs - have only been observed once with XMM-Newton!

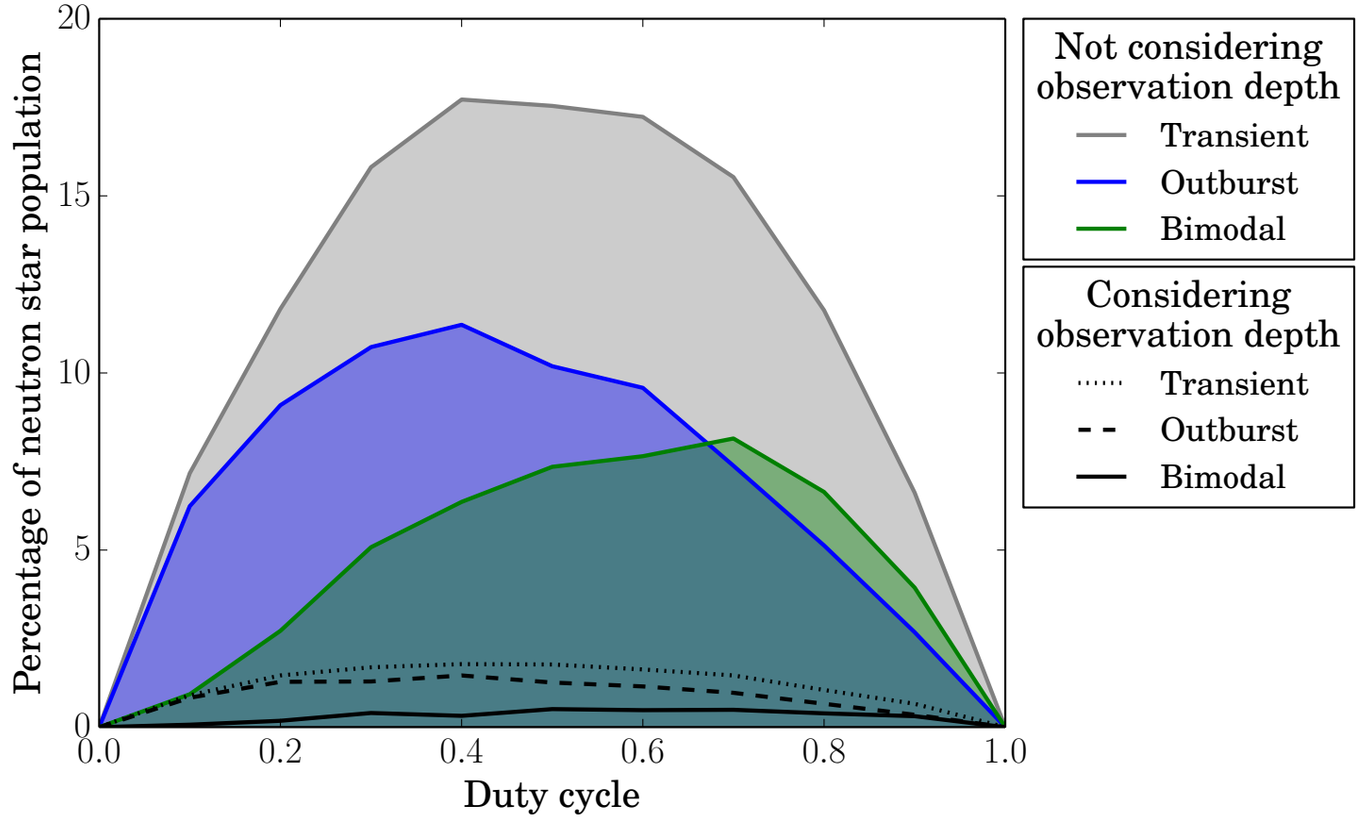
If a galaxy is only observed a few times, how likely is it that we successfully identify a bimodal source within it?



Is that it?

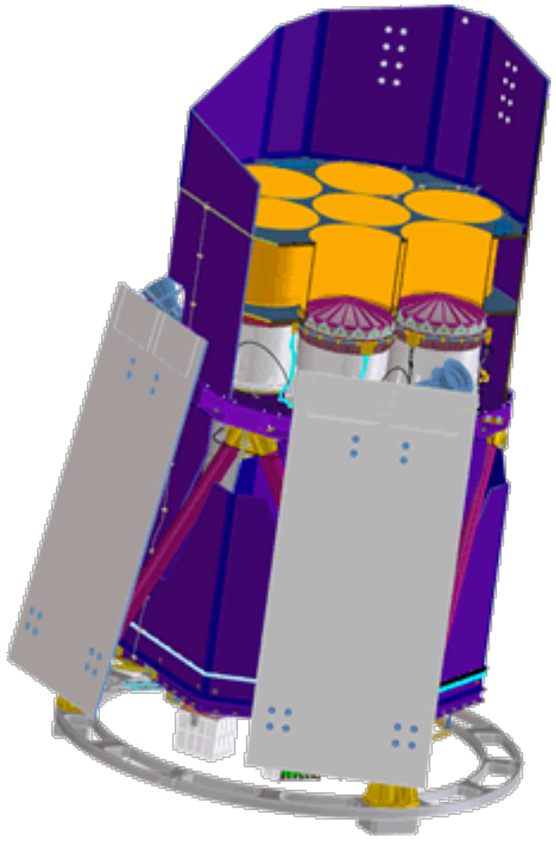
Using XMM-Newton's observing time distribution, we simulated a population of 10,000 bimodal flux sources

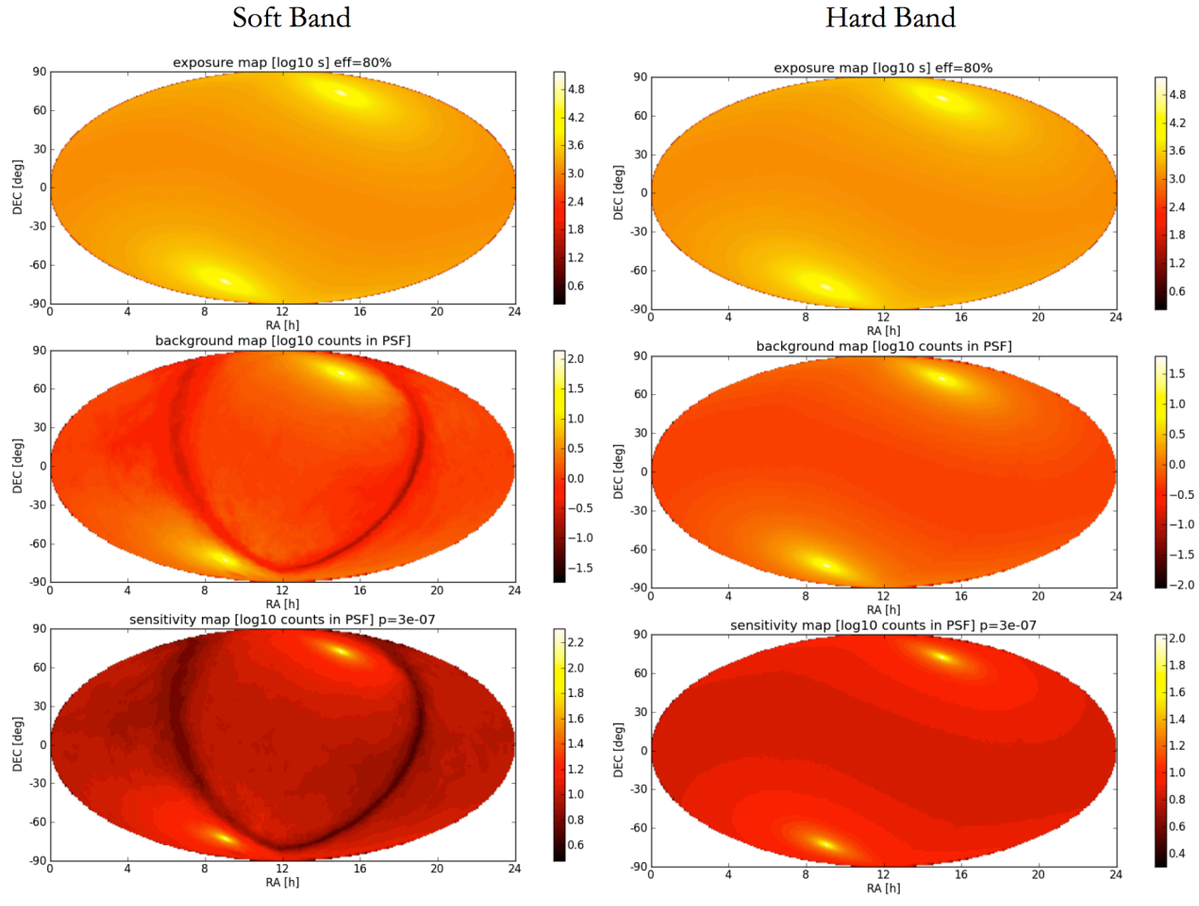
Accounting for observation depth, we only identify
1 in ~200 sources!



The potential of eROSITA

eROSITA (due to launch later this year) will scan the entire sky eight times over the course of four years => we can detect up to 96% of all bimodal ULXs… within 2.2 Mpc! (Local Group, NGC 55, NGC 300)





Summary

We successfully found a ULXP candidate in XMM-Newton archival data using this easy method!

However, the XMM-Newton archive misses most potential sources due to observing cadence and depth: there could be up to ~200 other bimodal-flux sources out there!

eROSITA presents an opportunity to discover a large proportion of very nearby bimodal ULXs, but dedicated observing campaigns will be required for the wider ULX population