

# Variable Sources in the XMMSL3 Catalogue

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# The XMMSL3 Catalogue



Covers the period from launch to August 2023.

140,735 source detections of 116,598 unique sources.

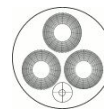
46,110 clean detections.

Median flux of detections:

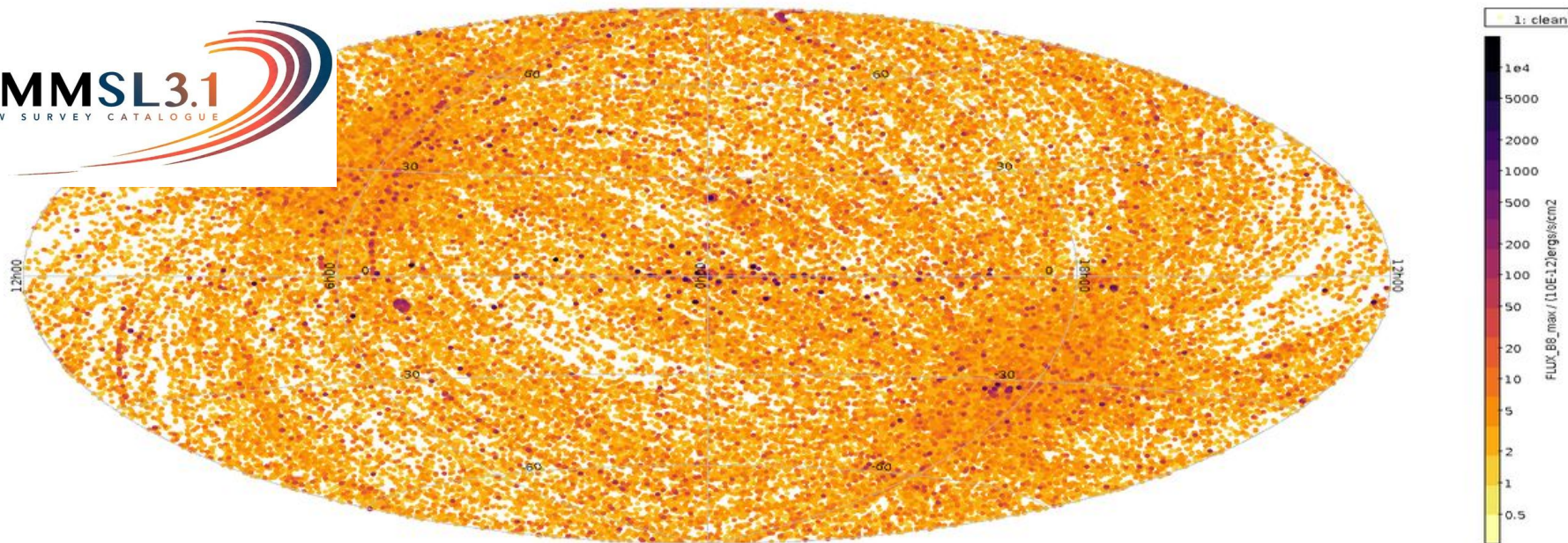
- Full band (0.2 - 12.0 keV)  $2.7 \times 10^{-12}$  erg s<sup>-1</sup>
- Soft band (0.2 - 2.0 keV)  $1.1 \times 10^{-12}$  erg s<sup>-1</sup>
- Hard band (2.0 - 12.0 keV)  $9.0 \times 10^{-12}$  erg s<sup>-1</sup>

Up to 78 repeat observations

# The XMMSL3 Catalogue



**XMM-Newton**  
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# The XMMSL3 Catalogue



## Comparison with XMMSL2

	Obs	Sky Coverage	Detections	'Clean' Dets	Unique Srcs
XMMSL2	2,114	~ 84%	72,352	29,393	63,230
XMMSL3	3,120	93.7%	140,735	46,110	116,598

# Cross-matching XSL Sources

Obs	Cat	Date	Energy	Coverage	No. Sources	Limit (erg cm <sup>-2</sup> s <sup>-1</sup> )
ROSAT	2RXS <sup>[1]</sup>	1990-91	0.1 - 2.4	All Sky	135,000	4-7 × 10 <sup>-13</sup> (obs)
	2RXP <sup>[2]</sup>	1996-99		14.5%	95,000	3 × 10 <sup>-14</sup> (77% src)
XMM Ptd	4XMM-DR14 <sup>[3]</sup>	2000-23	0.2 - 12	3%	690,000	1 × 10 <sup>-14</sup> (77% src)
XMM Slew	XMMSL3 <sup>[4]</sup>	2000-23	0.2 - 12	93.7%	117,000	5 × 10 <sup>-13</sup> (obs)
Swift XRT	2SXPS <sup>[5]</sup>	2005-18	0.3 - 10	9%	206,000	< 2 × 10 <sup>-13</sup> (obs)
eROSITA	eRASS1 main (v1.1) <sup>[6]</sup>	2019-22	0.2 - 2.3	50%	930,000	5 × 10 <sup>-14</sup> (obs)
	eRASS1 Hard <sup>[6]</sup>	2019-22	2.3 - 5	50%	5,500	
NuSTAR	NSS80 <sup>[7]</sup>	2012-19	3 - 24	0.08%	1,270	3 × 10 <sup>-14</sup> (77% src)
MAXI	3MAXI <sup>[8]</sup>	2009-16	4 - 10	100%	680	> 5.2 × 10 <sup>-12</sup> (100% src)

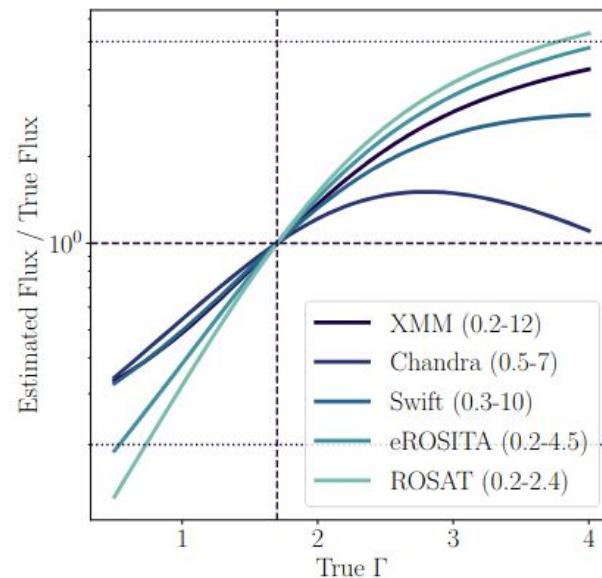
1 – Boller+ 2016, 2 – ROSAT cons.+ 2000, 3 – Webb+ 2020, 4 – Saxton+ 2008, 5 – Evans+ 2020, 6 – Merloni+ 2024, 7 – Greenwell+ 2024, 8 – Hori+ 2018.

# Flux Cross-Calibration

## Spectral Assumption

Absorbed power law  $n_{\text{H}} = 3 \times 10^{20} \text{ cm}^{-2}$ ,  $\Gamma = 1.7$

Validity examined by Quintin+ 2023



Quintin+ 2023

# Determining Variability

## Three energy bands

- Total: 0.2 - 12 keV
- Soft: 0.2 - 2 keV
  - Slew, XMM, Swift, eROSITA Main, ROSAT
- Hard: 2 - 12 keV
  - Slew, XMM, Swift, eROSITA Hard, NuSTAR, MAXI

$$Var_{\text{Con}} = \frac{\text{Max}(F_X - \sigma_{F_X})}{\text{Min}(F_X + \sigma_{F_X}, UL_{F_X})}$$

## Conservative estimate of variability

# Cross-matching Sources

~15,000 sources with multiple Slew detections

Other catalogue matching radii

- XMM Pointed, Swift - 12"
- ROSAT, eROSITA, NuSTAR, MAXI - 30"

Slew	~ 117,000
Multiple Slew	14,966
+ XMM Ptd	3,917
+ Swift	5,715
+ ROSAT Survey	16,664
+ ROSAT Ptd	3,724
+ eROSITA main	20,539
+ eROSITA hard	2,890
+ NuSTAR	42
+ MAXI	19

# The XMMSL3 Population



Unique Sources - 116,598

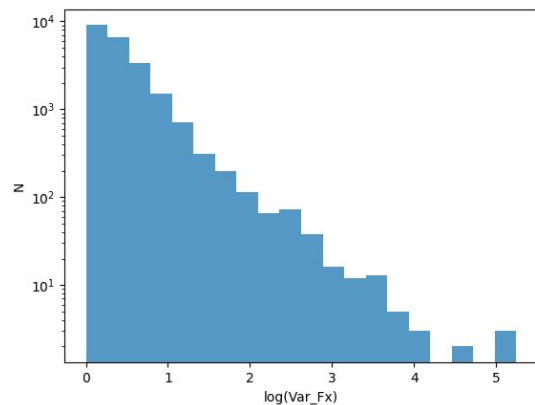
Band sources - Total: 87,724. Soft: 48,360. Hard: 33,583.

Matches for 10,000s sources to other catalogues

Cross-matches are visually examined prior to further individual analysis!

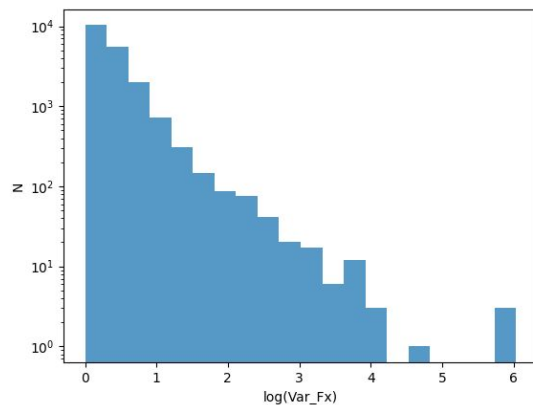
# The XMMSL3 Population

Variability by band – All sources (regardless of Slew band detection)



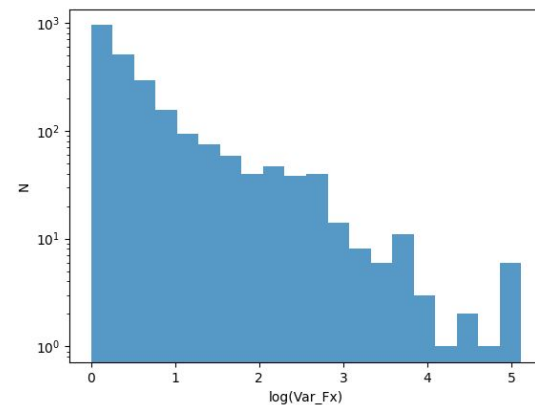
0.2 - 12.0 keV

22,064 variable. Median 2.12



0.2 - 2.0 keV

19,316 variable. Median 1.90

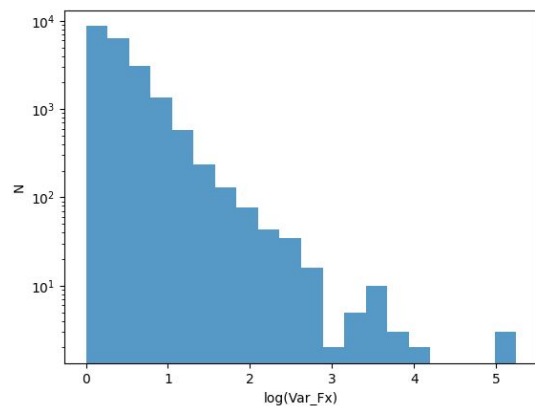


2.0 - 12.0 keV

2,350 variable. Median 2.26

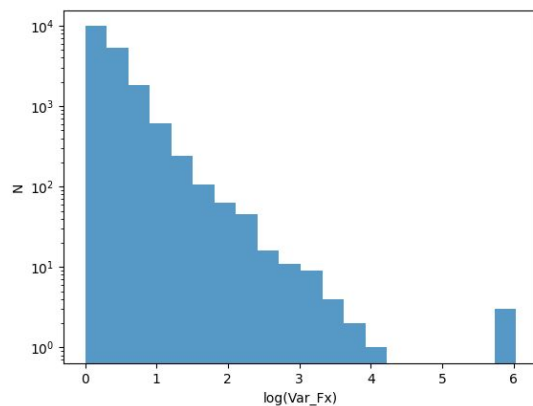
# The XMMSL3 Population

## Variability by band – Clean Slew sources (regardless of Slew band detection)



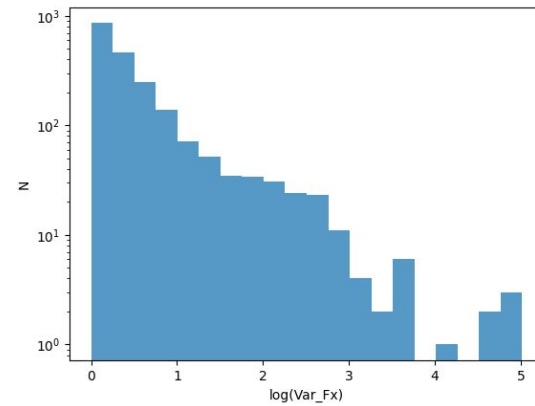
0.2 - 12.0 keV

20,617 variable. Median 2.07



0.2 - 2.0 keV

18,131 variable. Median 1.87

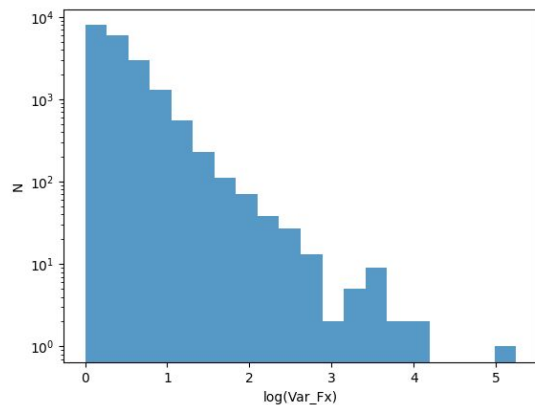


2.0 - 12.0 keV

2,009 variable. Median 2.10

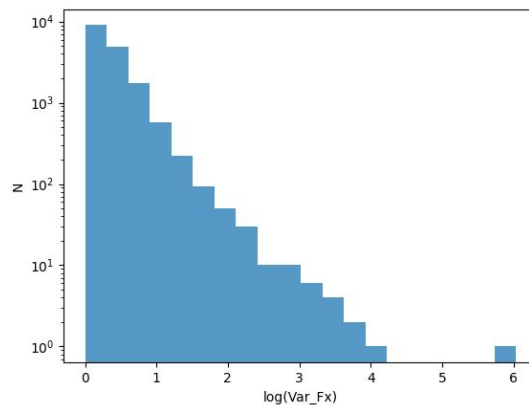
# The XMMSL3 Population

## Variability by band – Clean sources w\ Slew band detection



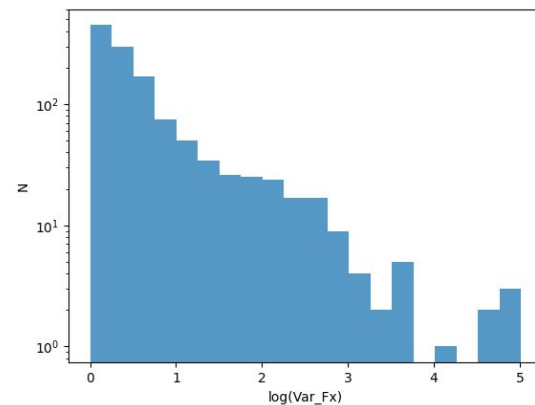
0.2 - 12.0 keV

19,255 variable. Median 2.10



0.2 - 2.0 keV

16,758 variable. Median 1.89

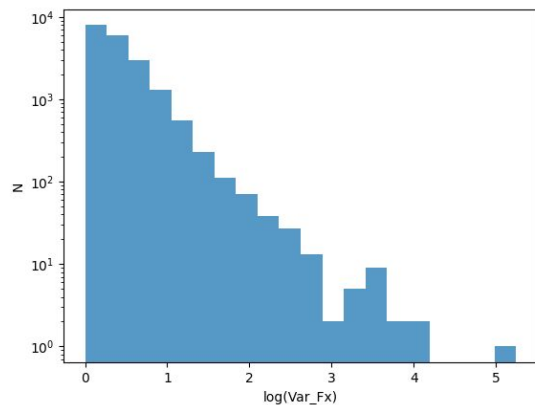


2.0 - 12.0 keV

1,208 variable. Median 2.34

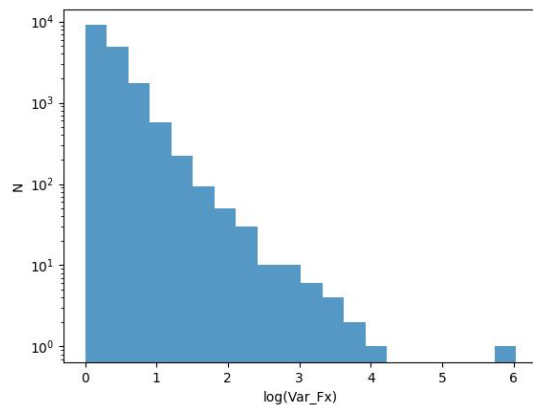
# The XMMSL3 Population

## Variability by band – Clean sources w\ Slew band detection



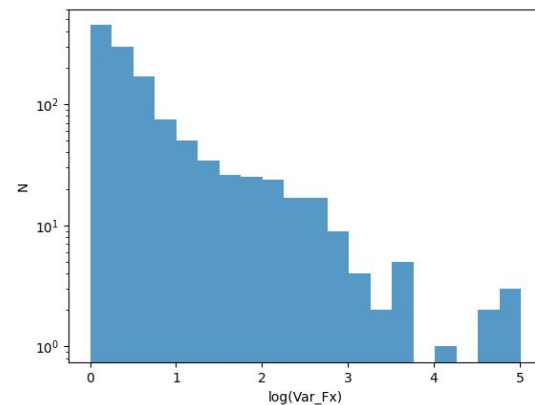
0.2 - 12.0 keV

1,243 Var\_Fx > 10



0.2 - 2.0 keV

770 Var\_Fx > 10

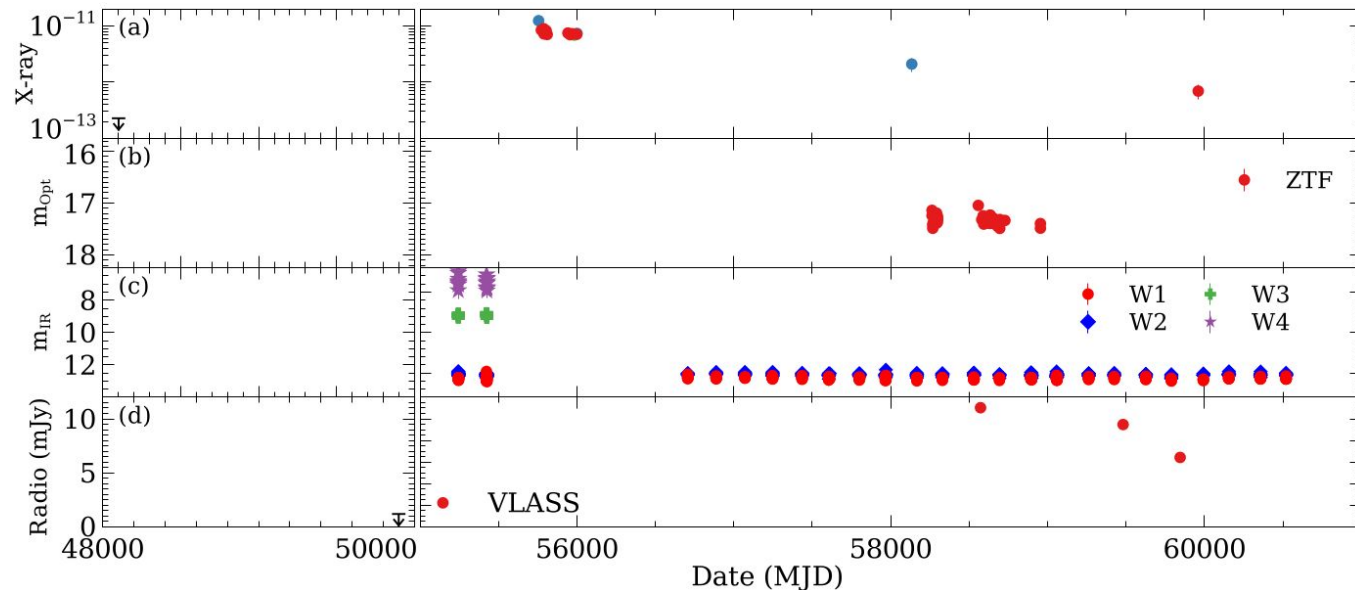


2.0 - 12.0 keV

219 Var\_Fx > 10

# Sources of Interest 1

XMMSL3 J164606.9+422737

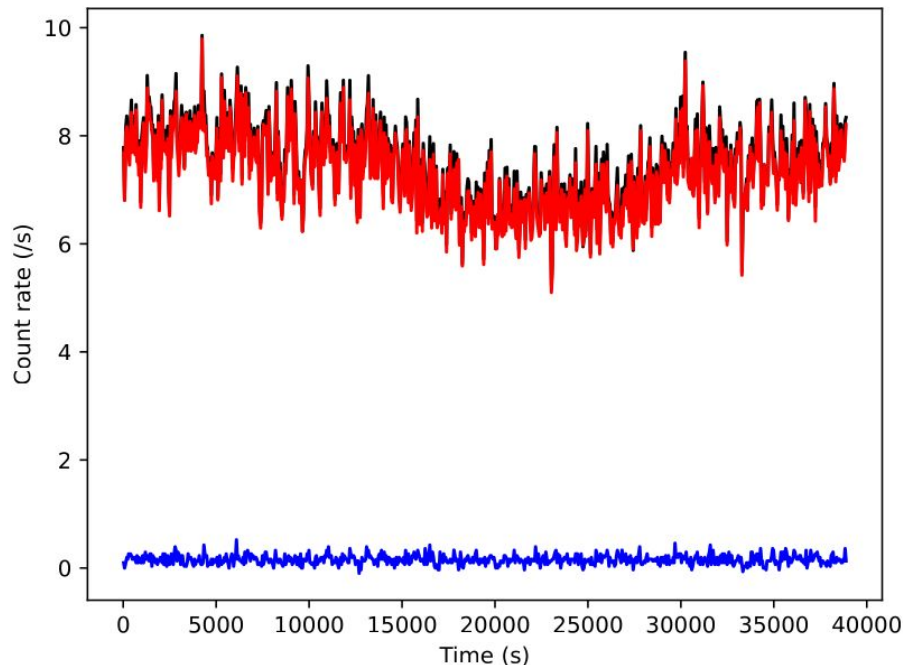


## Sources of Interest 1

Very late observed radio variability.

X-ray variability cannot be constrained for full or partial TDE.

Short-term variability also observed.







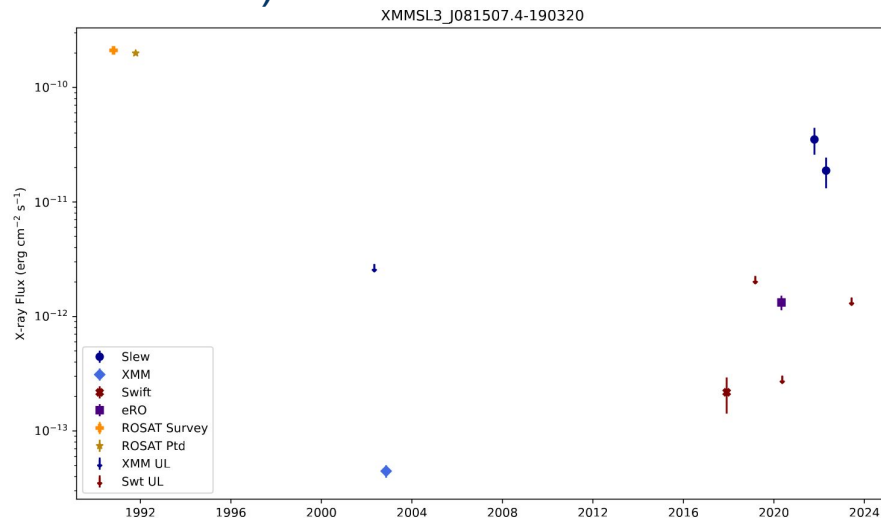
# Sources of Interest 4

XMMSL3 J081507.4-190320 - full band (0.2-12.0 keV)

V\* VV Pup

Cataclysmic Variable

Slew constrains time of new high state



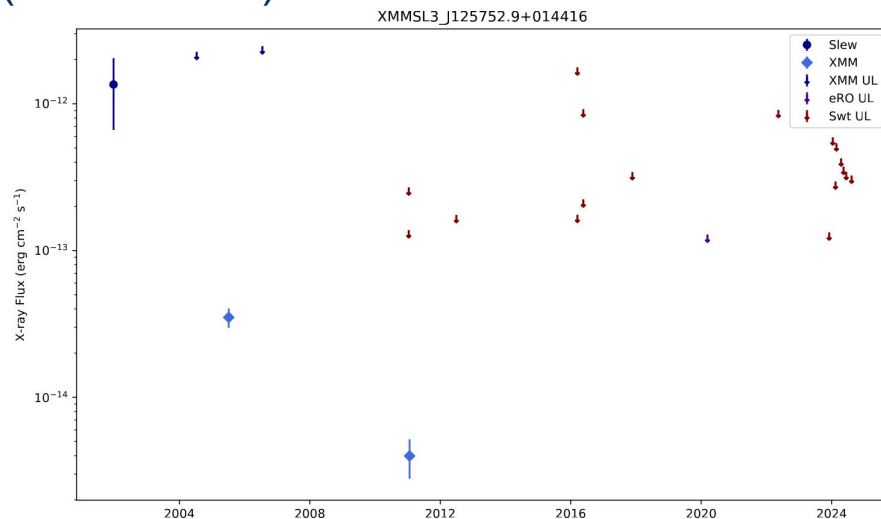
## Sources of Interest 5

XMMSL3 J125752.9+014416 - soft band (0.2-2.0 keV)

[VV2006] J125752.6+014415

QSO (or TDE?)

Peak  $L_x \sim 1 \times 10^{45}$  erg s<sup>-1</sup> at 3.7 Gpc



# Outlook for NewAthena



(Nearly) All-sky catalogue of bright sources.

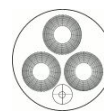
30-year baseline for long-term variability

Fast detection of new transients in NewAthena observations

Updated with new Slew Catalogues



Quick advert!



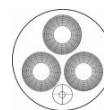
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# 5XMM-DR15

SERENDIPITOUS SOURCE CATALOGUE



Quick advert!



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# COMING SOON!!!

## 5XMM-DR15

SERENDIPITOUS SOURCE CATALOGUE

# Summary



Significant increase in numbers of sources and detections on XMMSL2

Median variability  $\sim 2$  for variable sources

Significant number of real, clean, sources with variability  $> 100$

Future plans:

Consideration of false-matching between catalogues

Detailed analysis of MCG+07-34-146, and the population of variable sources. Paper later this year!

Examination of TDE candidates by Marina Duce (Université Toulouse)

XMMSL3.1 released soon

