XMM2ATHENA

Long-term transient alerts

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004168

INTRODUCTION

Long-term variability

- Already >17200 observations with XMM-Newton
- Sources vary on the long term, no systematic study made in X-ray
- Some sources already detected >90 times
- Some sources observed and not detected
- Time domain astronomy becoming important
- XMM-Newton could continue until 2030s and could provide transient alerts

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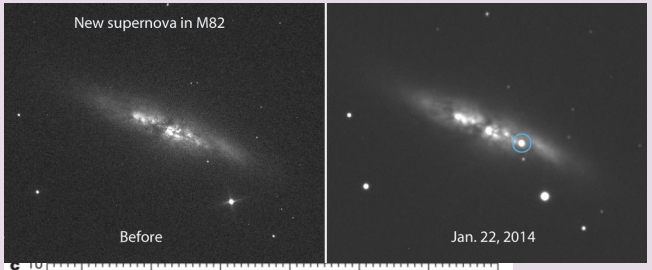
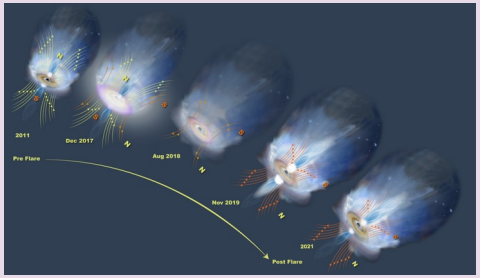
INTRODUCTION

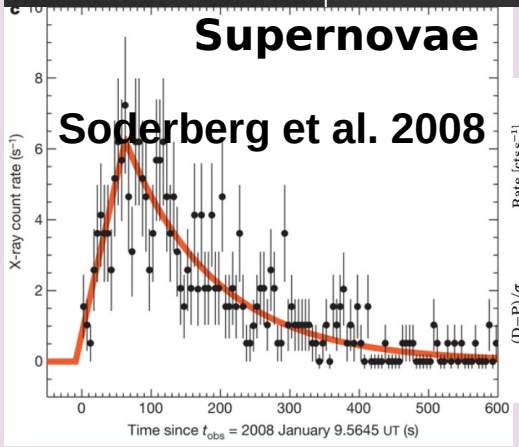
Long-term variability



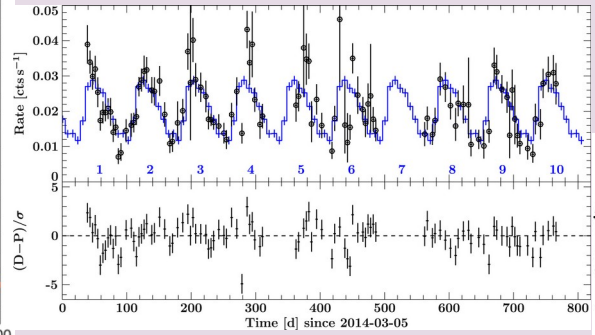


Supernovae

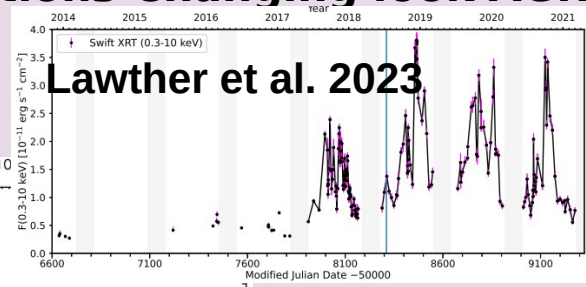
Soderberg et al. 2008



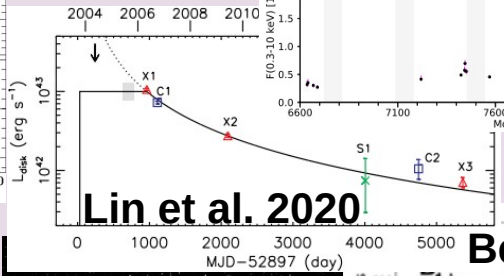
ULX state changes Tidal disruptions Changing look AGN



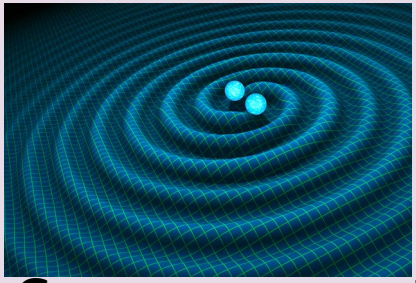
Walton et al. 2016



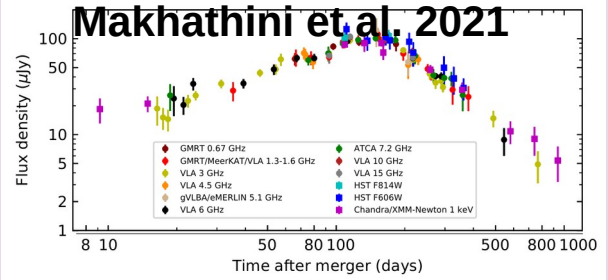
Lawther et al. 2023



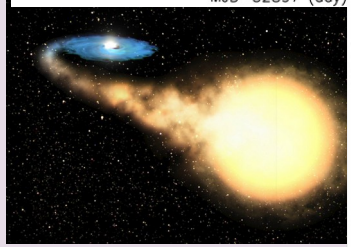
Lin et al. 2020

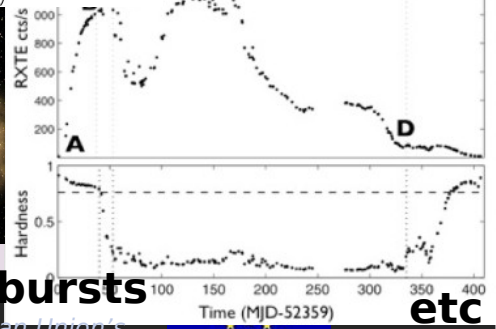


Makhathini et al. 2021



Belloni et al. 2005





Grav. wave events

X-ray binary/ CV outbursts etc

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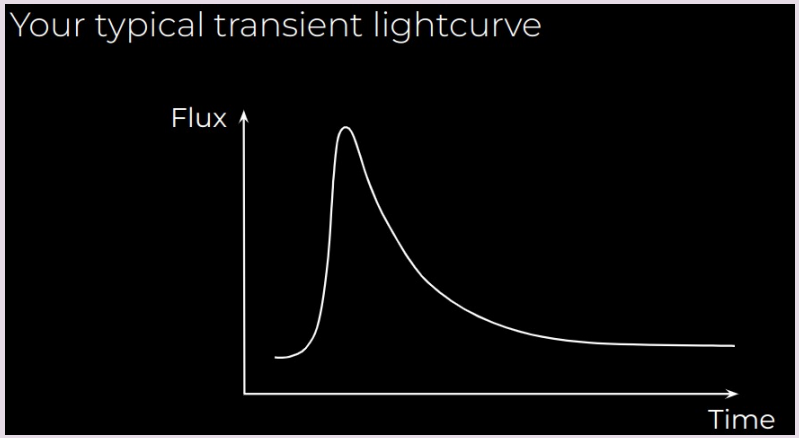
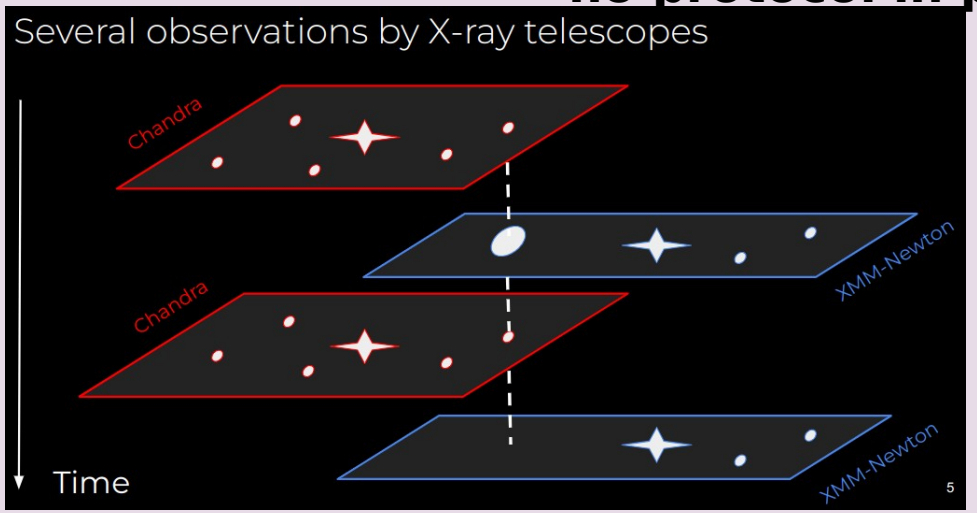
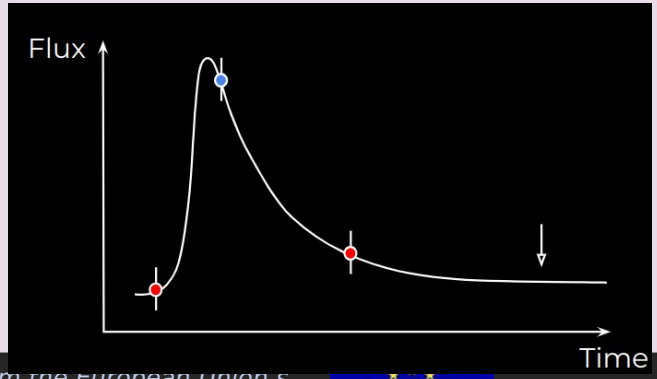
LONG TERM VARIABILITY



- **Code developed to identify long-term variability (Quintin et al. 2024)**
- **Identifies factor >5 variation in flux**
- **Expected to send to screener to validate source then push to public**
- **Code placed in ACDS pipeline – Reco. 2023-05-11/11 - but not activated as no protocol in place for send to IRAP**





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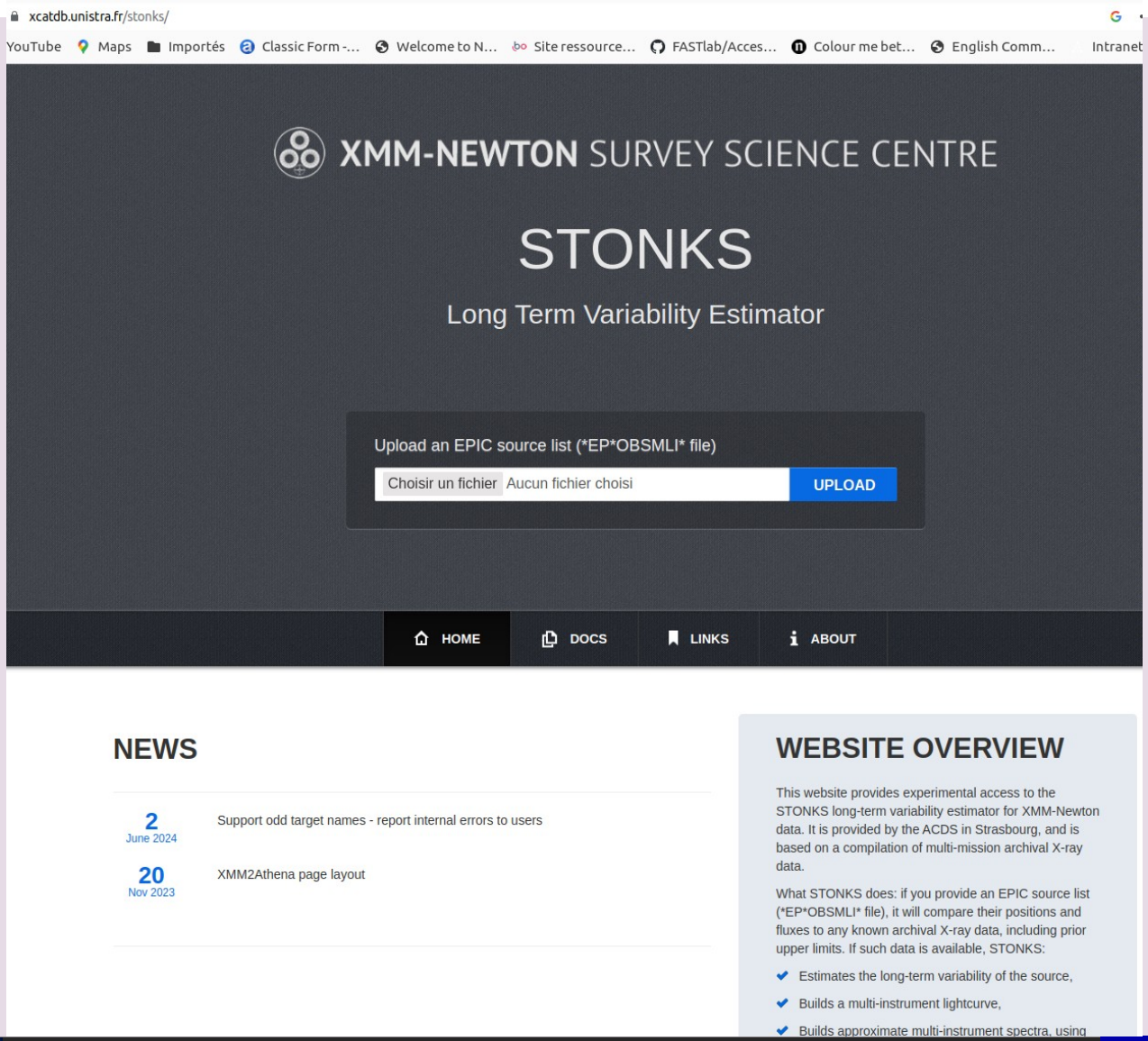
ONLINE INTERFACE



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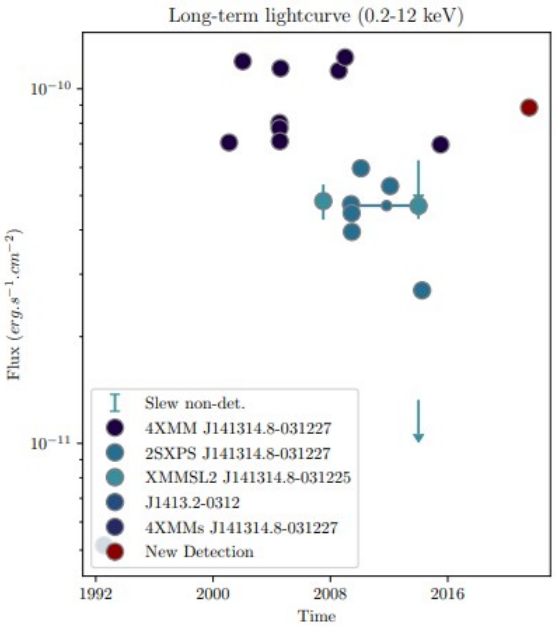
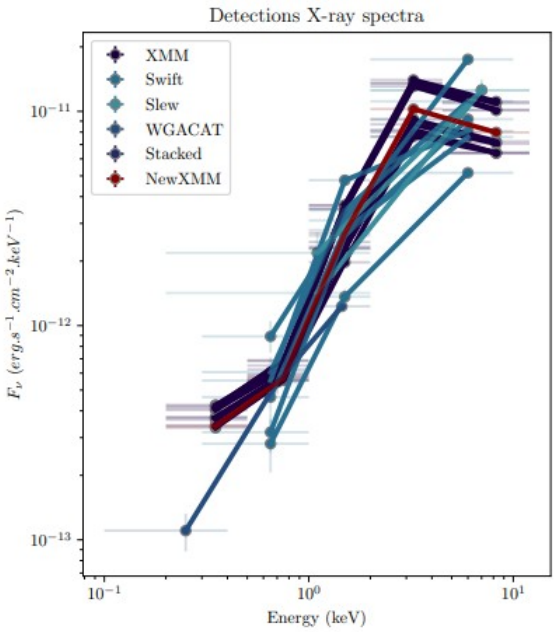
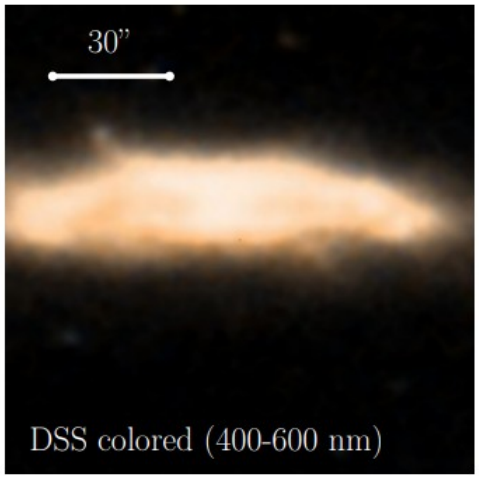
STONKS OUTPUT







ObsID 0880550401
Date Obs 2021-07-22T09:59:21
Target Name ..... NGC 5506
Exposure Time ..... 56946 s

SRCNUM 1
Source RA ..... 213.31 / 14:13:15
Source Dec ..... -3.21 / -03:12:27
Position Error ..... 0.01”
Off-axis Angles ..... PN: 1.2’, M1: 0.2’, M2: 1.2’
Instruments DetML .....
PN: 1860208.9, M1: nan, M2: nan, EP: 1860208.9

Type of Alert ..... Past Variability
Long-term Variability 14.1
Short-term Variability ..... True
Simbad ..... Unknown ([MRN2004] NGC 5506 B2)

!!! Warning: extreme spectrum might impact variability !!!

JSON file to push to web:

- > 0bsID
- > Date Obs
- > Exposure Time
- > SRCNUM
- > Source RA, Dec
- > Position Error
- > *_DETML
- > *_OFFAX
- > VarAmplitude
- > LastFlux, LastFluxErr
- > LastHR
- > ArchivalShortTermVar
- > Simbad id
- > SpectralWarning
- > AlertType:
    1. High Flux State
    2. Low Flux State
    3. Past Variability:
    4. First detection

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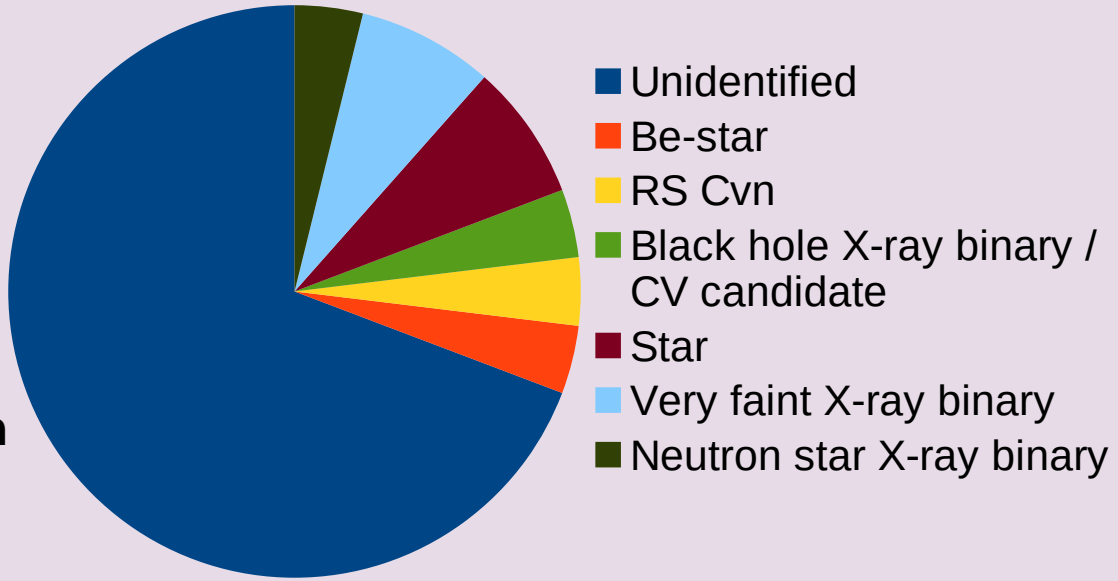
TESTING ALERTS WITH THE MULTI-YEAR HERITAGE PROGRAMME (MYHP)

- **Considered data from July 2023 onwards from Gabriele Ponti MYHP Galactic plane survey (only programme currently available)**
- **87 observations, 4 with no detections**
- **67 alerts raised**
- **38 alerts were false detections mostly due Galactic plane containing many bright sources giving rise to reflection rings**
- **Of the 29 good alerts :**
  - **First ever detection : 14**
  - **High state : 7**
  - **Low state : 7**
  - **Past variability : 1**
- **4 showed extreme spectra**
- **Only 3 sources in Simbad (stars)**



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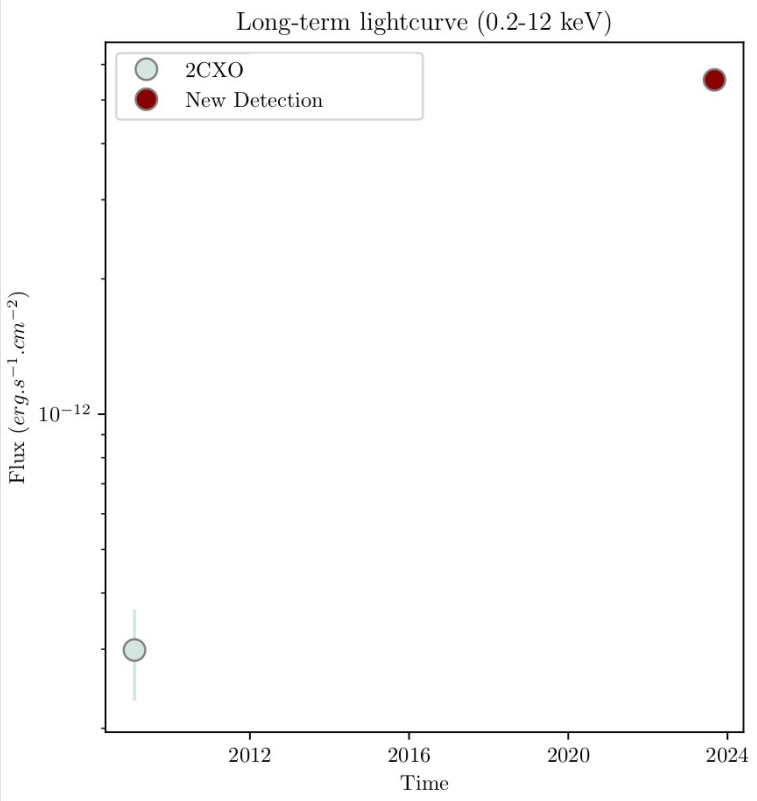
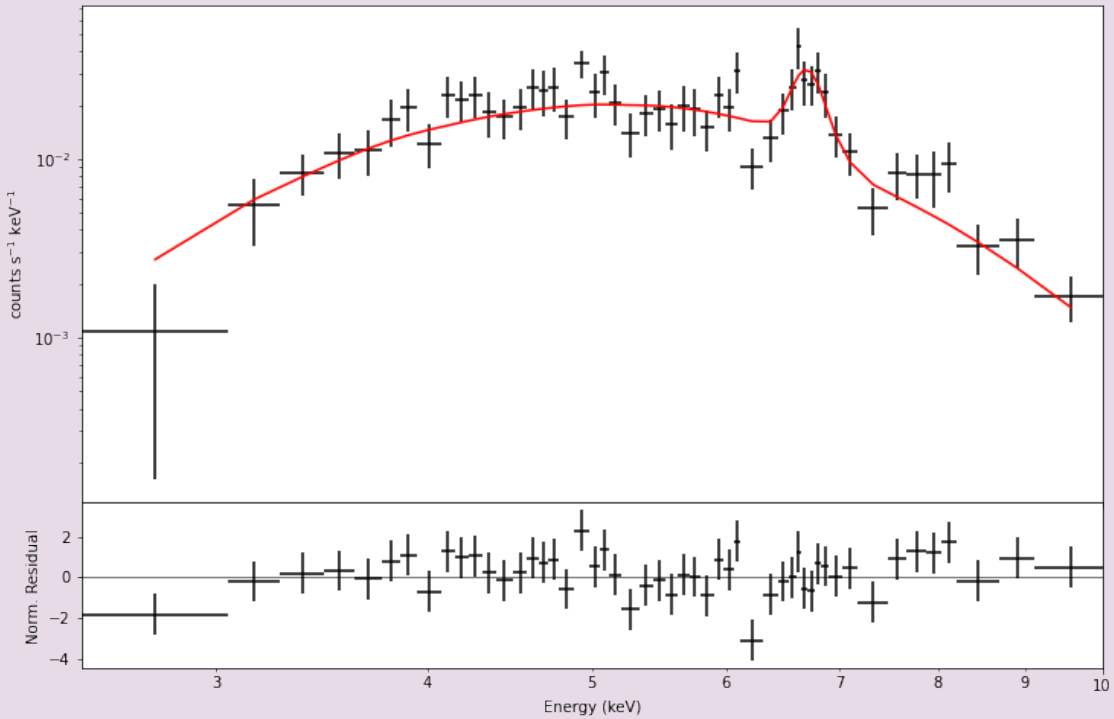
EXAMPLES OF DETECTED VARIABLE SOURCES

- **L ~3x10^{34} erg s^{-1} if at Galactic centre (given absorption and no optical counterpart)**
- **Possible very faint X-ray binary (Wijnands et al. 2006) – small / symbiotic system**





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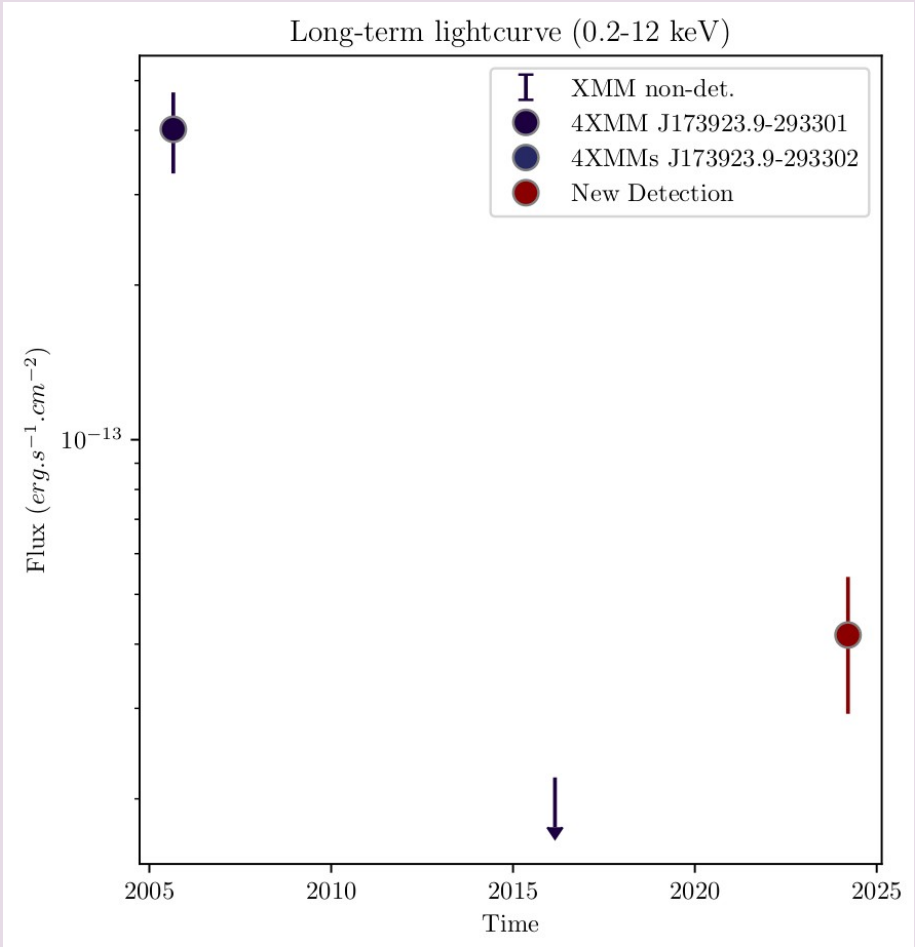
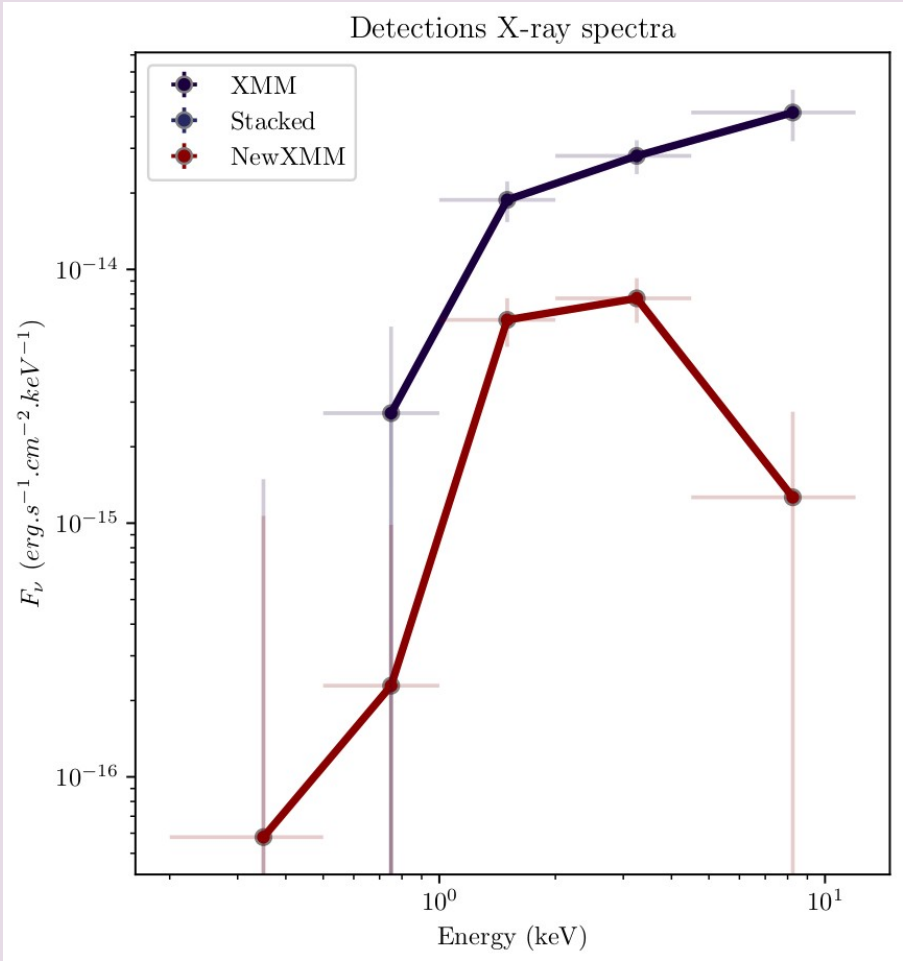
EXAMPLES OF DETECTED VARIABLE SOURCES

- **Candidate neutron star very faint X-ray binary close to Galactic centre**





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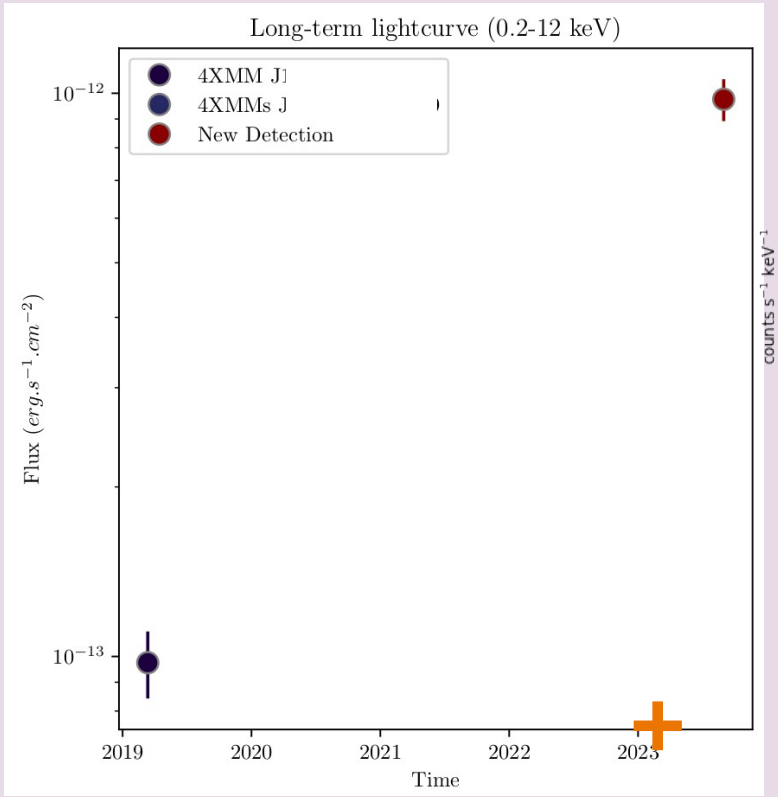
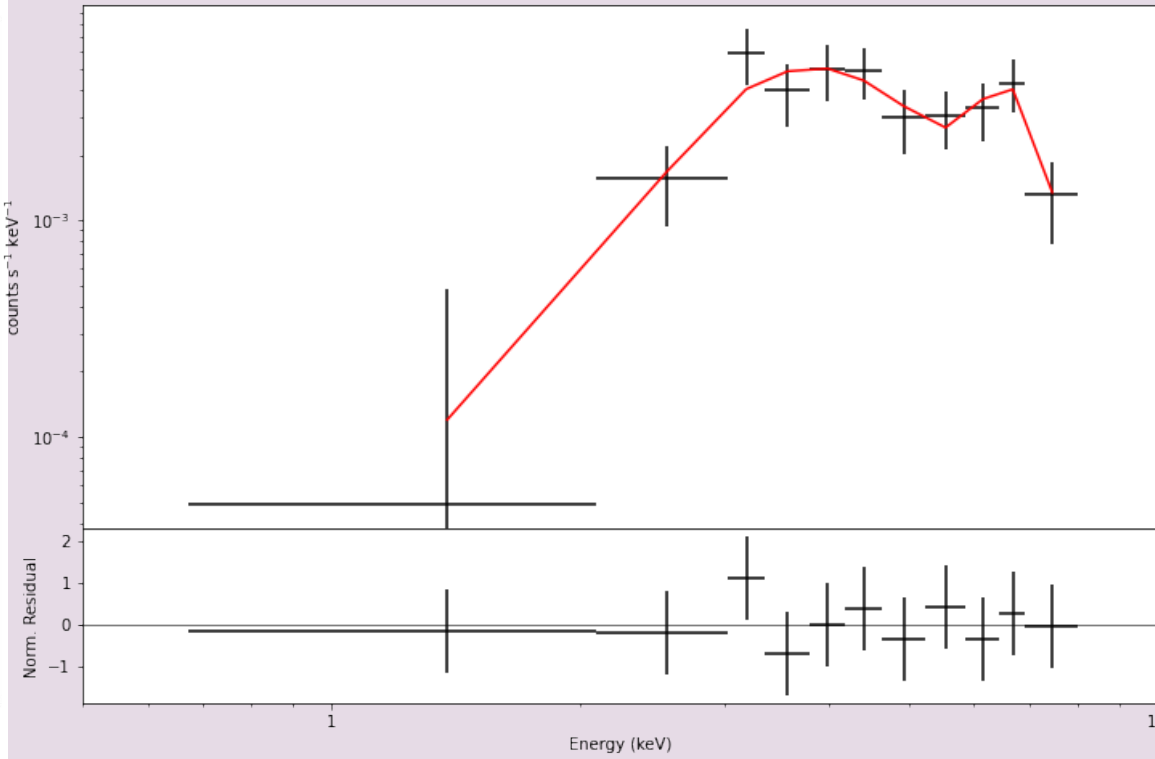
EXAMPLES OF DETECTED VARIABLE SOURCES

- **New black hole X-ray binary/ cataclysmic variable**
- **L ~8x10^{33} erg s^{-1} if at Galactic centre**





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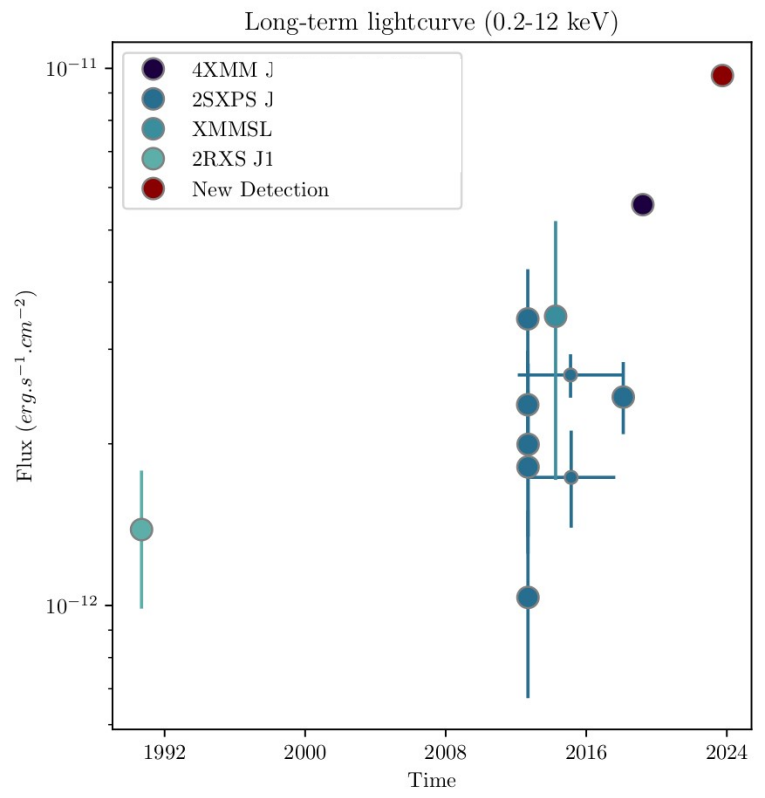
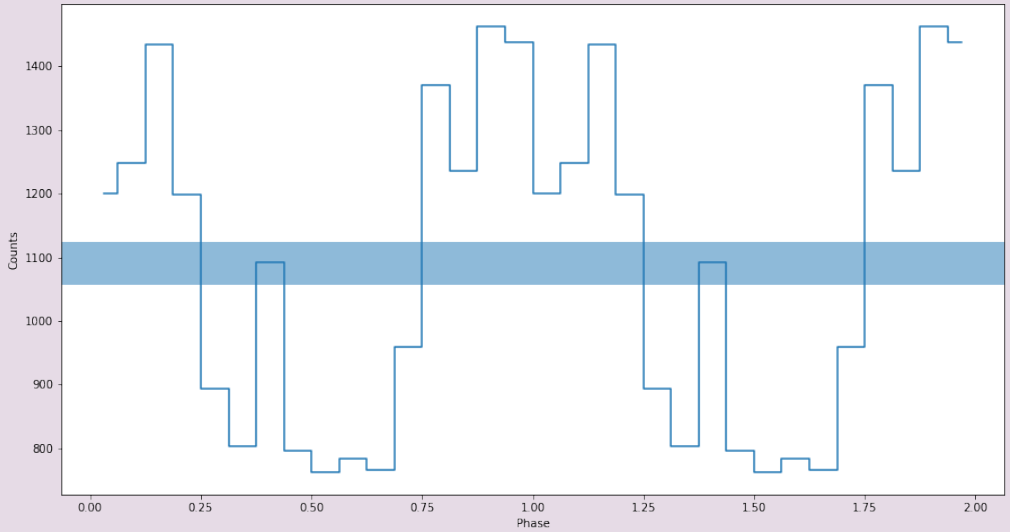
EXAMPLES OF DETECTED VARIABLE SOURCES

- **New Be X-ray binary @1.8 kpc, 7980 s period, pulsed fraction : 0.29**
- **L ~4x10^{33} erg s^{-1} - persistant system showing variability**
- **Hard power law spectrum (Γ ~ 1.4) + line @ 6.7 keV (σ ~ 0.33)**





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NEXT STEPS

- **New extra-galactic MYHP starting - should allow longer term transients such as TDEs, supernovae, ULXs, changing look AGN, to be detected (and followed up), but also gravitational wave counterparts etc**
- **Screening with EPIC data essential for weeding out problems (screeners?)**
- **If not possible, protocol to be developed for sending to SOC & IRAP**
- **Web server developed at IRAP to go live to house alerts and send to interested parties**
- **Modify phase I (or II) to allow PI to uncheck a box when responding to AO if not happy about basic data made public about serendipitous transient**

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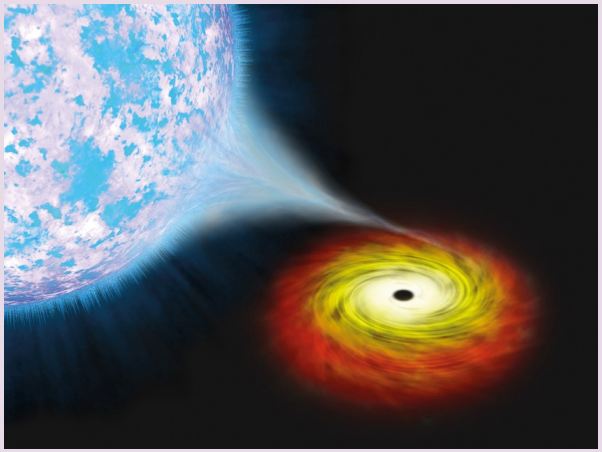
DISCOVERIES OF RARE SOURCES WITH THE SOFTWARE



- Origin of the very high luminosity observed from ultra luminous X-ray (ULX) sources unclear
- 7 show accelerating pulsations => neutron star (NS) compact object
- 8th candidate NS ULX found in galaxy with another NS ULX (Quintin et al. 2021)
- Supports idea that many ULXs may host NS, implying emission is beamed and generated through fan beam geometry (Gnedin & Sunyaev, 1973)

- Quasi periodic eruptions (QPEs) discovered from massive black holes (Miniutti et al. 2019)
- Five systems known, two associated with tidal disruption events (TDEs)
- New good candidate found (Quintin et al. 2023), associated with TDE
- Suggests TDEs may be at the origin of QPEs and data gives constraints on the time from TDE to QPE
- Data helps understand the form of the eruption profile

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