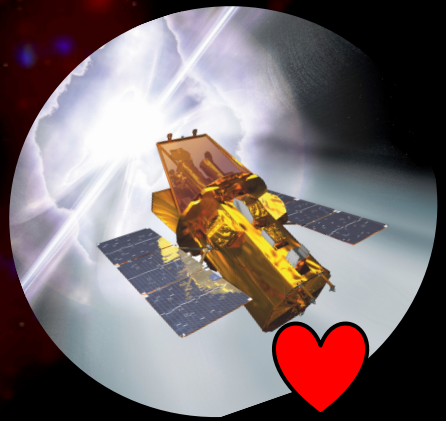
Completing 20 years of Swift/XRT Monitoring of the Galactic Center



Nathalie Degenaar (University of Amsterdam)

Jamie Kennea, Mark Reynolds, Rudy Wijnands, Jon Miller + collaboration

Factsheet Swift/XRT Campaign

~25 arcmin / ~60 pc

Start:
2006 February

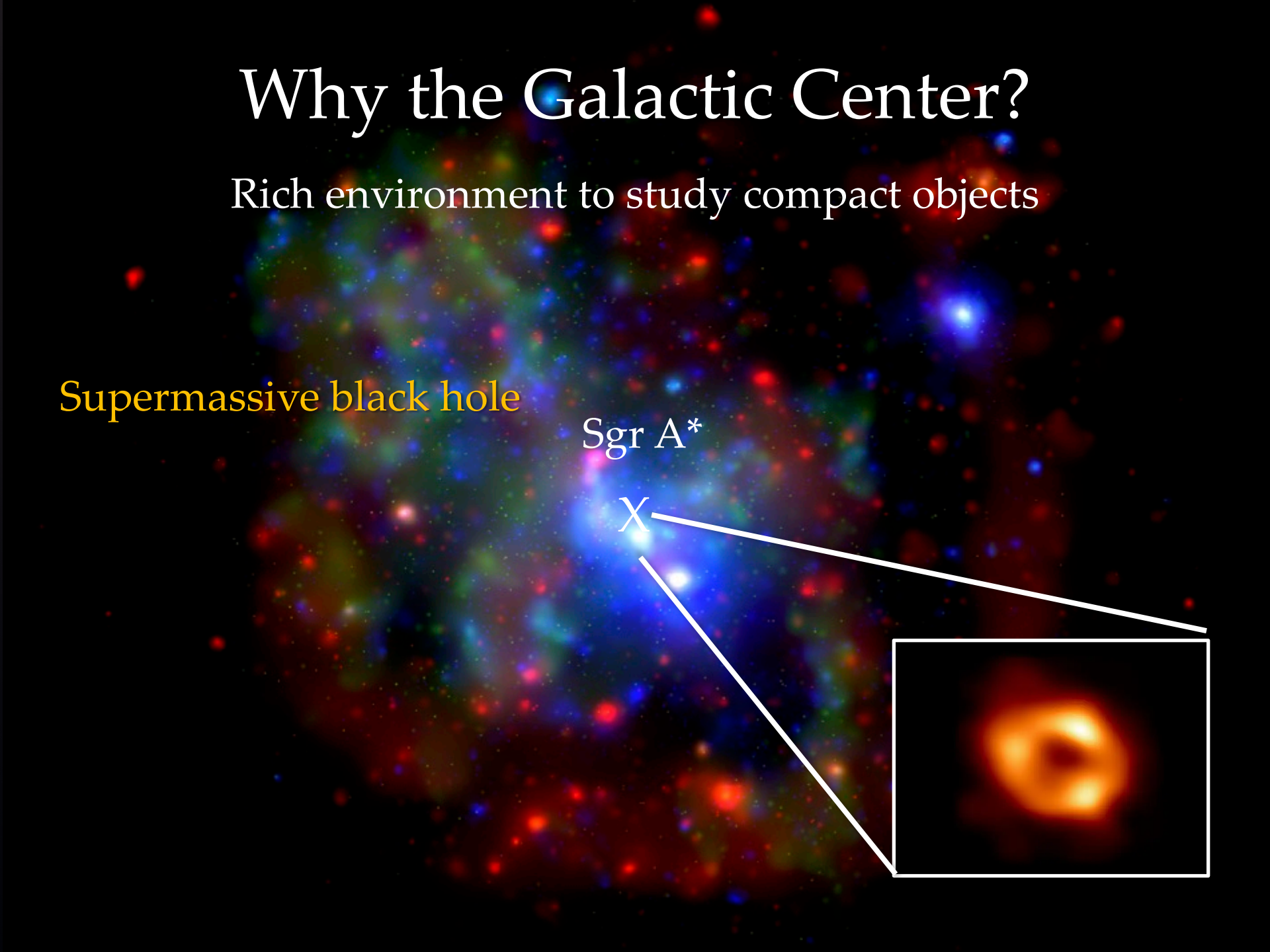
Cadence:
1 ks / day

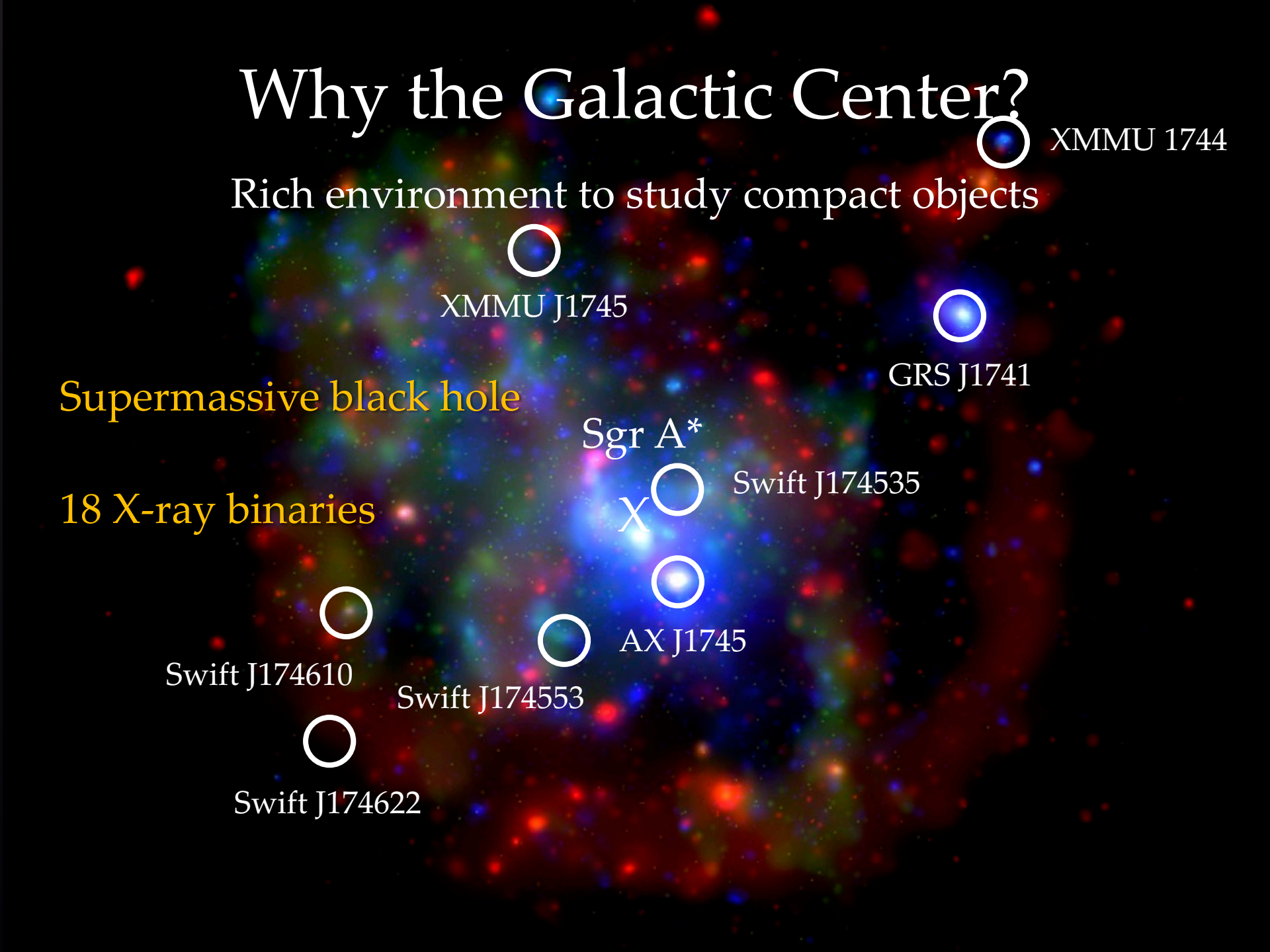
Sensitivity:
L_x~5x10^{33} erg s^{-1}

So far:
3550 pointings (3.3 Ms)

Why the Galactic Center?

Rich environment to study compact objects




Why the Galactic Center?
XMMU 1744
Rich environment to study compact objects
XMMU J1745
GRS J1741
Supermassive black hole
Sgr A*
Swift J174535
18 X-ray binaries
AX J1745
Swift J174610
Swift J174553
Swift J174622

Why the Galactic Center?

XMMU 1744

Rich environment to study compact objects

XMMU J1745

GRS J1741

Supermassive black hole

Sgr A*

18 X-ray binaries

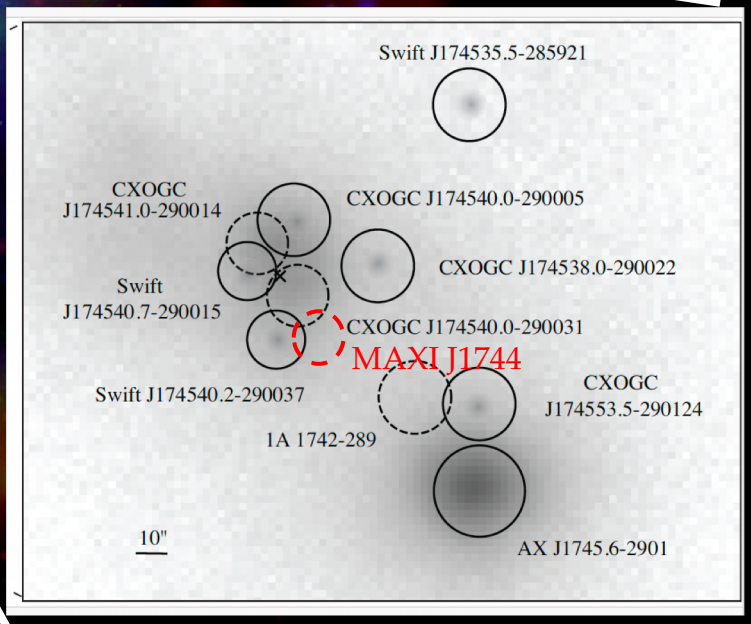
10 within central 10 pc

AX J1745

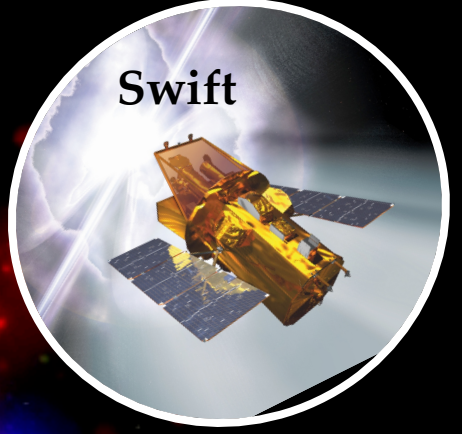
Swift J174610

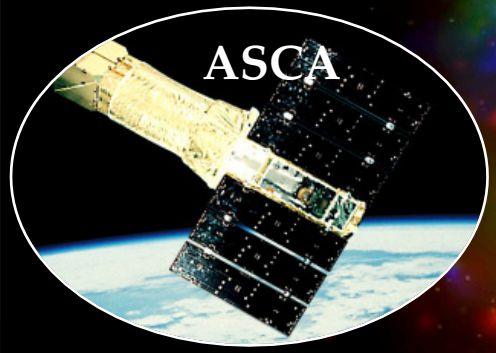
Swift J174553

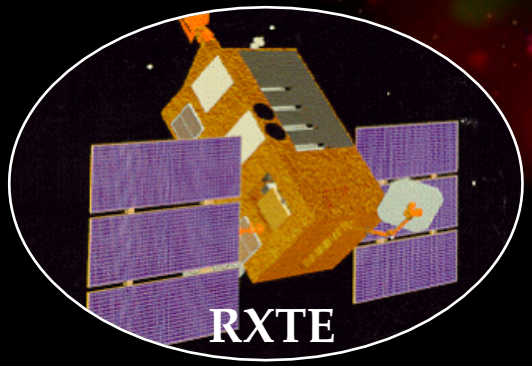
Swift J174622

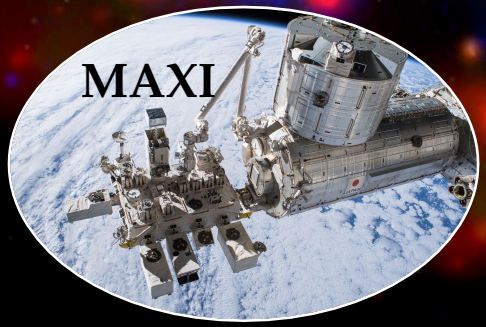


Why Swift/XRT?





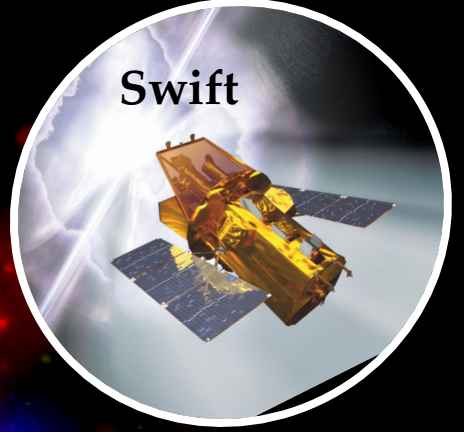


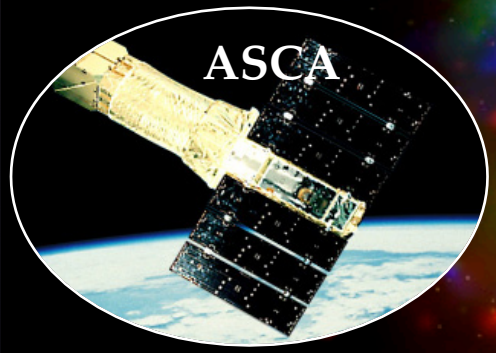


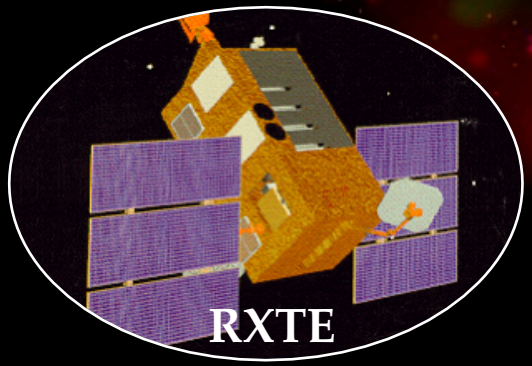
Why Swift/XRT?

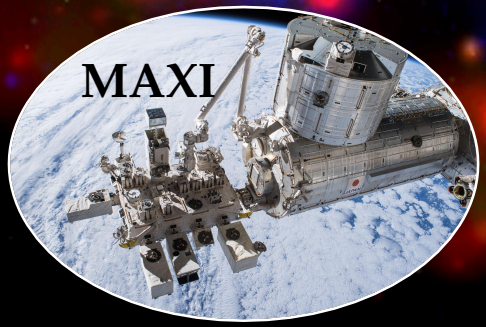
Resolution, sensitivity, flexibility

Swift









Why Swift/XRT?

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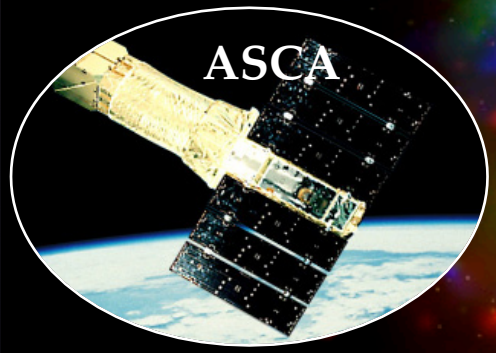
Swift

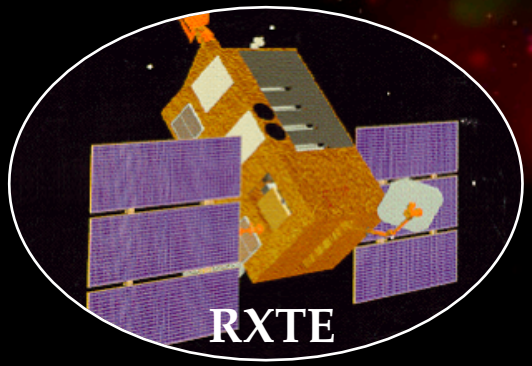
$L_x > 5x10^{33}$ erg s^{-1}

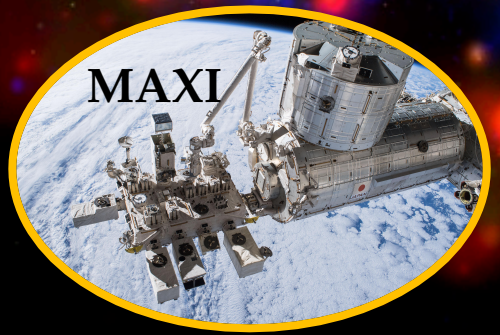


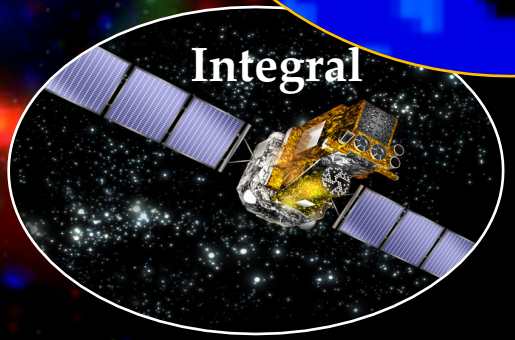
VS

MAXI

$L_x >x\ 1x10^{36}$ erg s^{-1}







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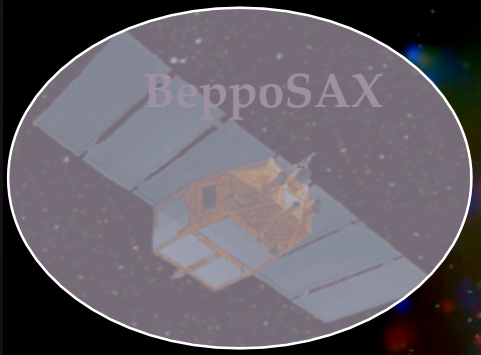
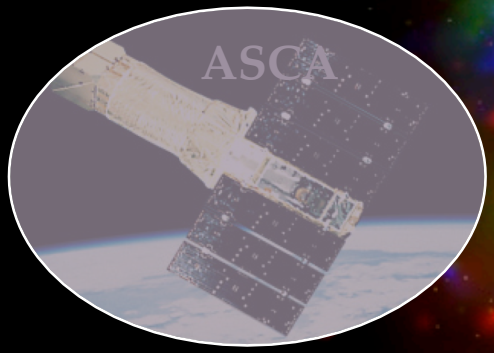
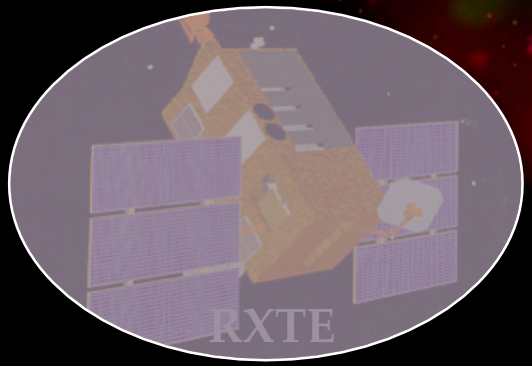
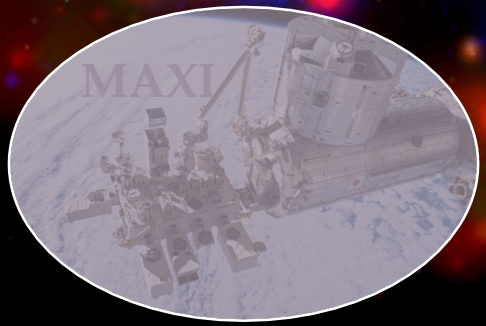
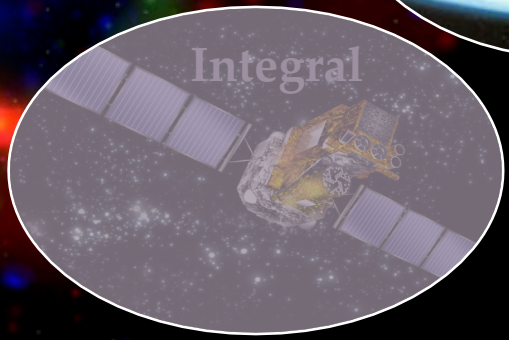
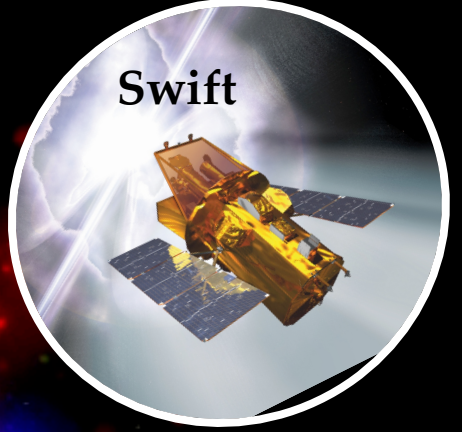




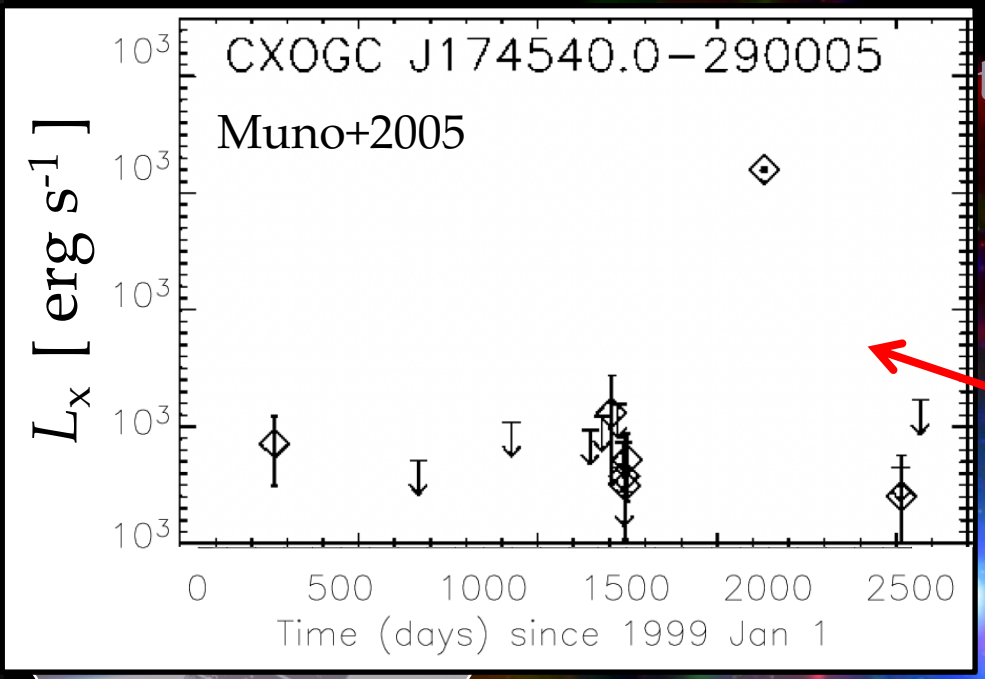






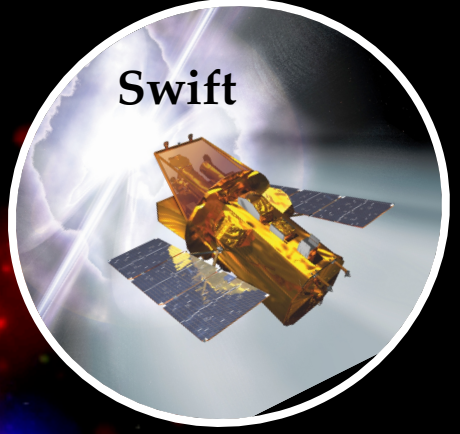


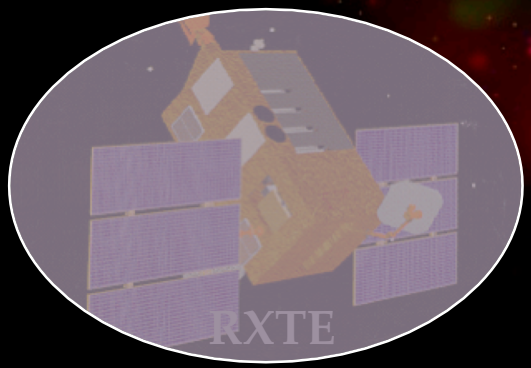
Why Swift/XRT?

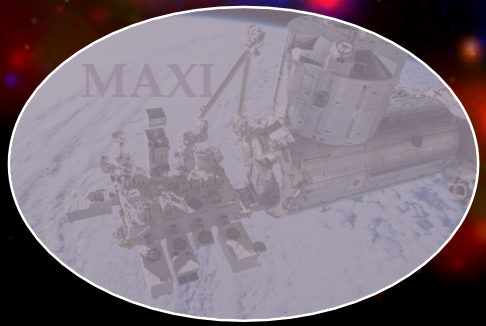


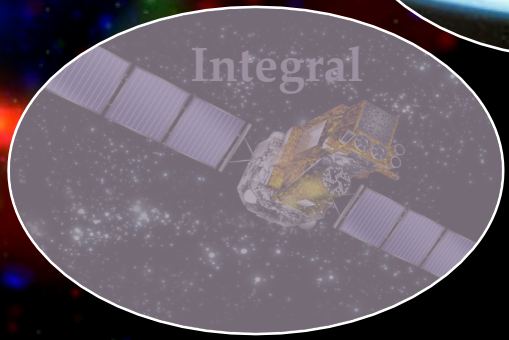
tivity, flexibility

Chandra



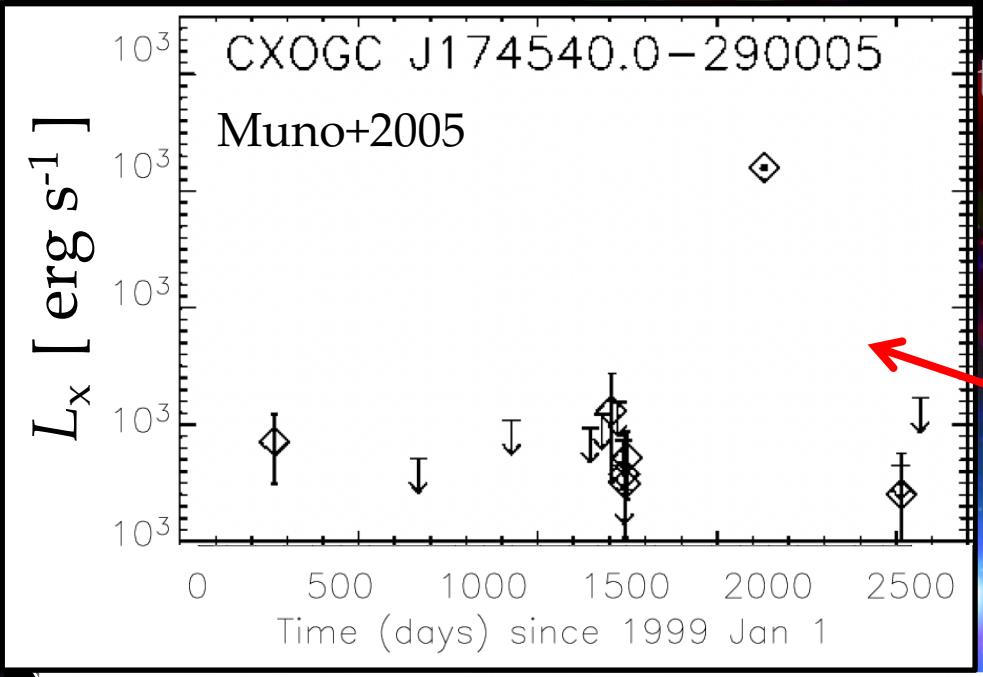






Why Swift/XRT?

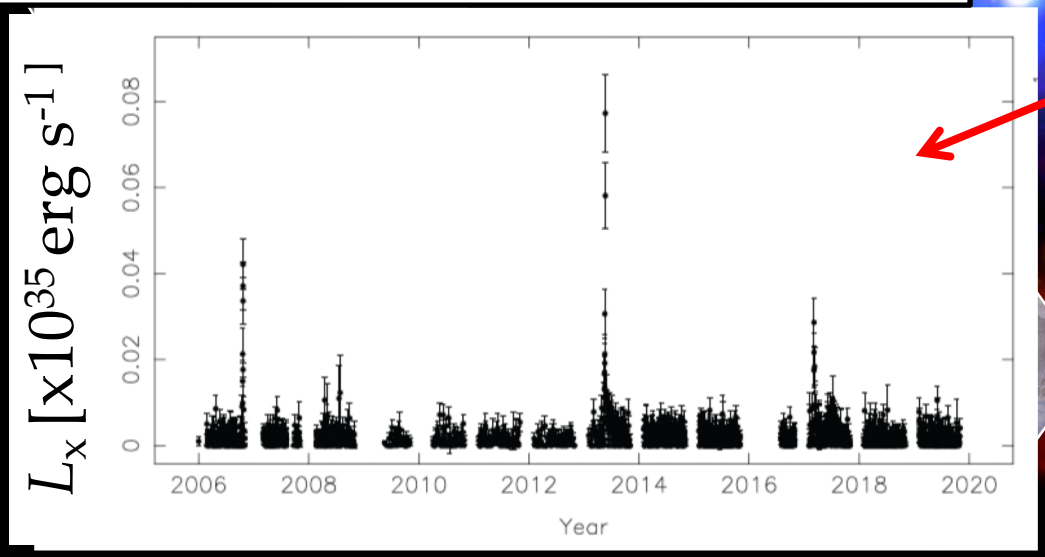
tivity, flexibility

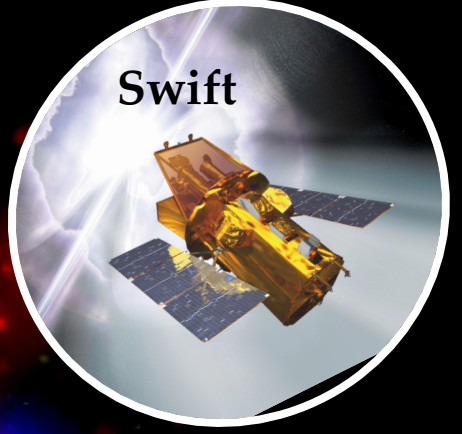


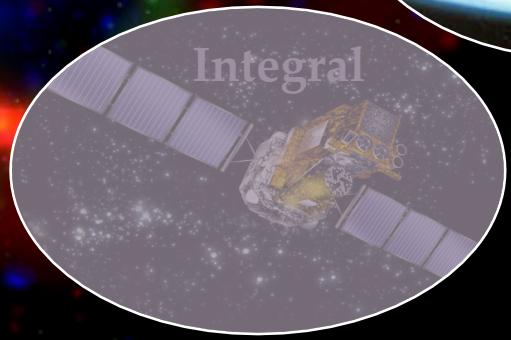
Chandra

VS

Swift

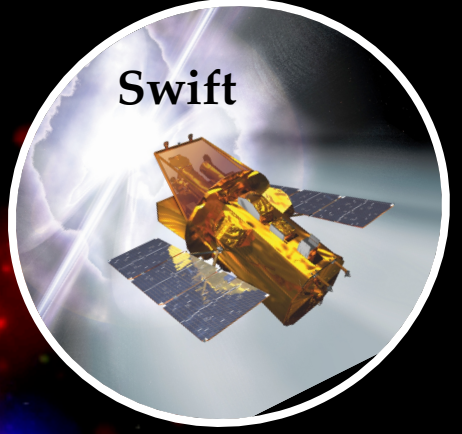




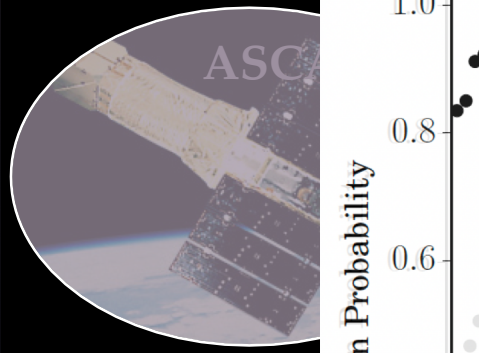


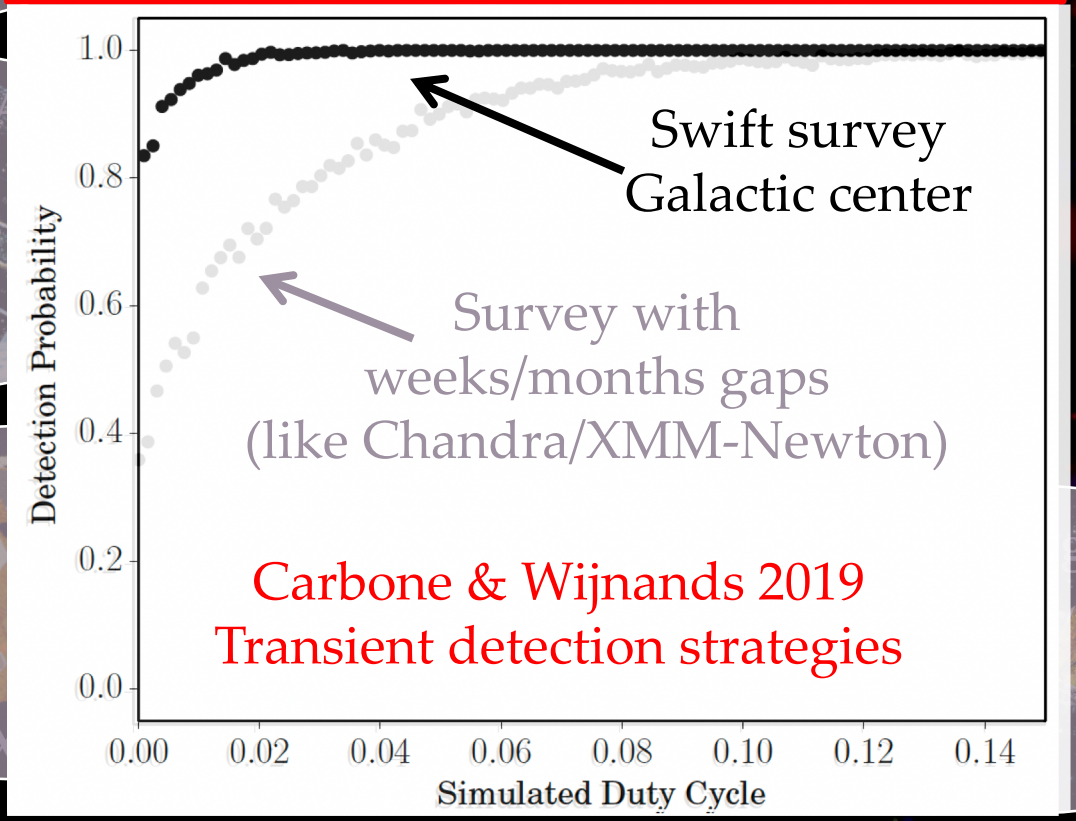
Why Swift/XRT?

Resolution, sensitivity, flexibility

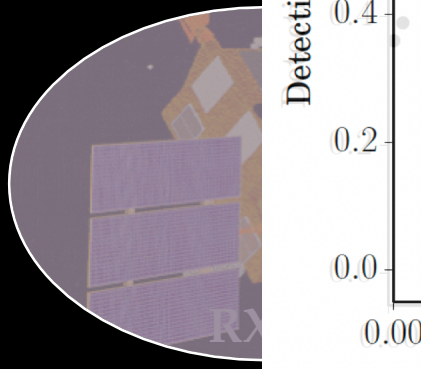


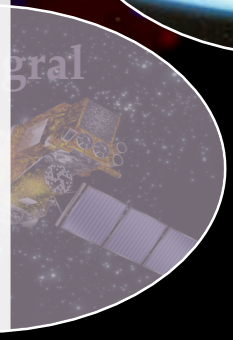
High observing cadence → highest chance to detect brief events





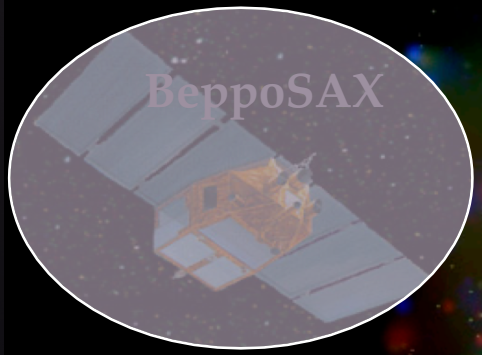
Carbone & Wijnands 2019
Transient detection strategies

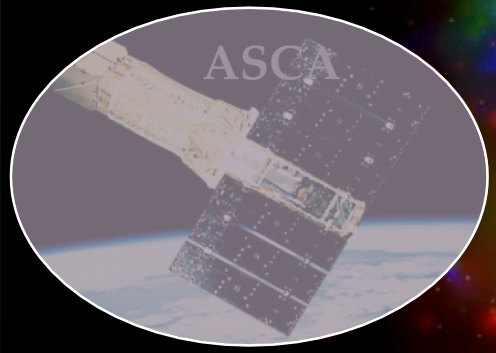


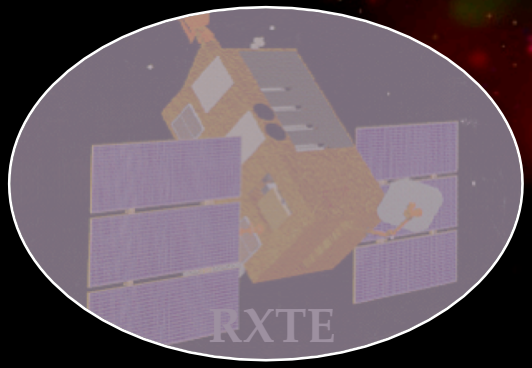


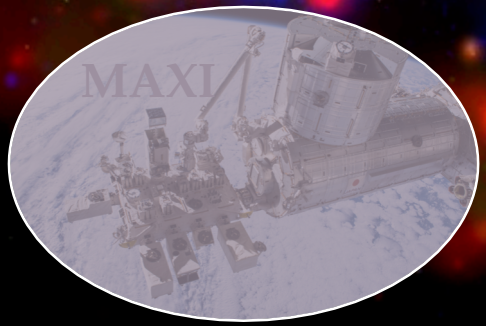
Why Swift/XRT?

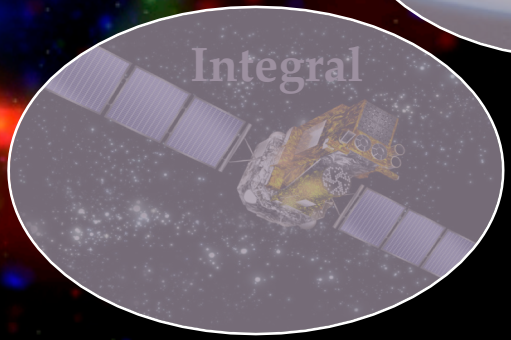
Resolution, sensitivity, flexibility











- Resolve transients in crowded region
- Detect 100-1000x fainter transients
- Detection rate of short-lived transients

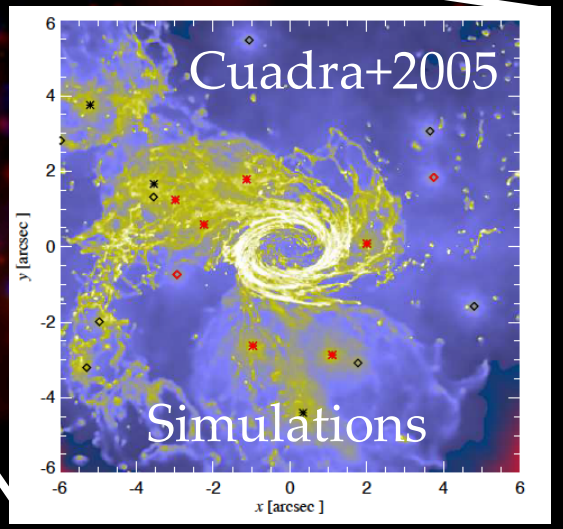
Science Highlight I: Our supermassive black hole

Accretion from stellar winds nuclear star cluster

Low accretion rate / luminosity

L_x~10^{33} erg/s

Sgr A*



Science Highlight I: Our supermassive black hole

Low accretion rate / luminosity

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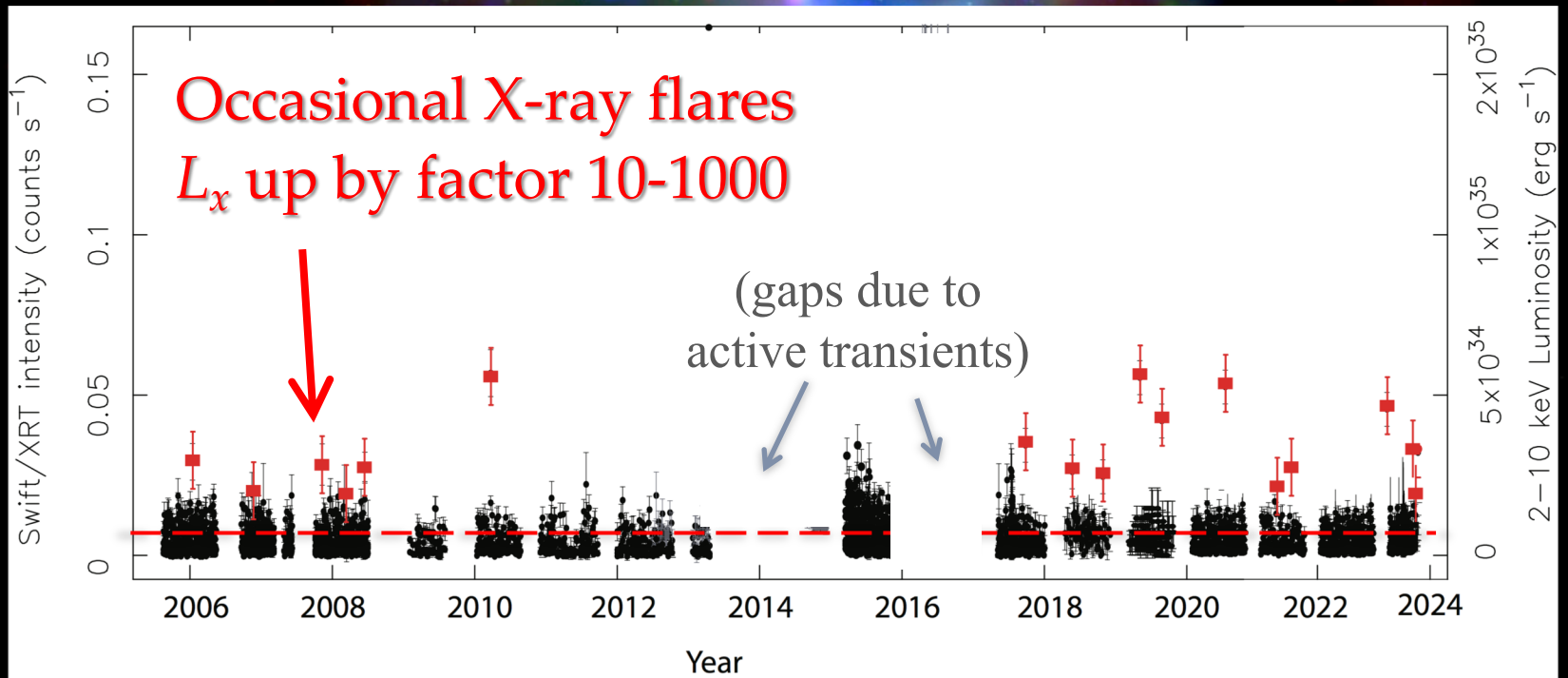

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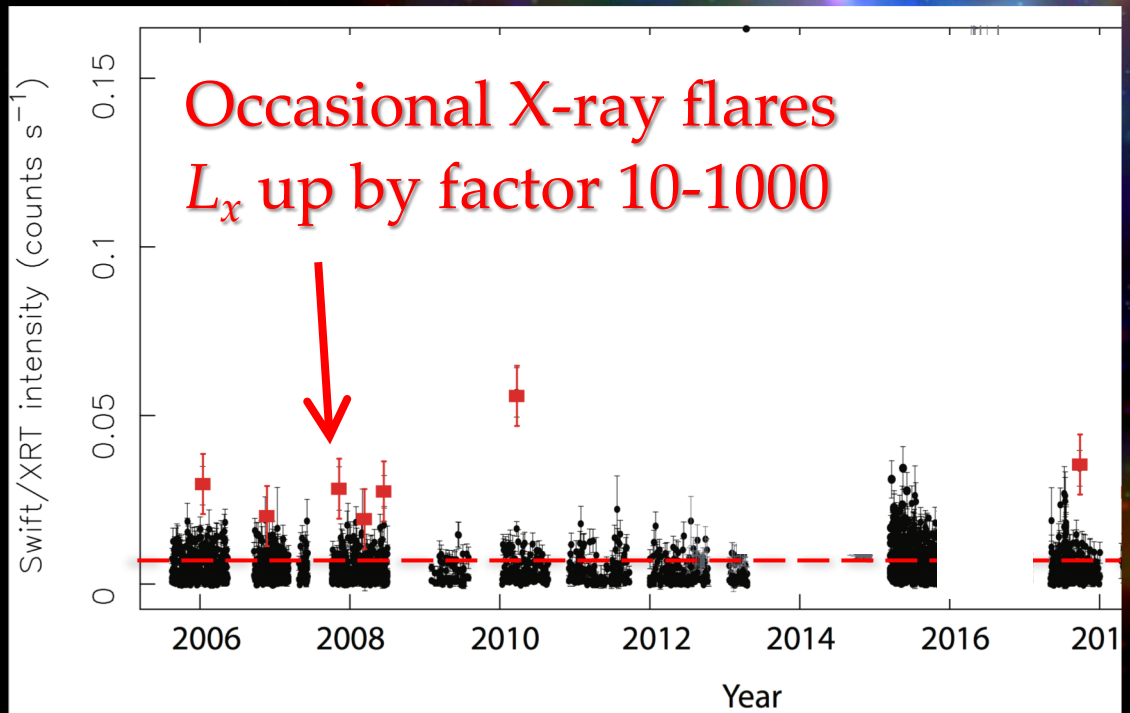


Cause of X-ray flares = open question

Magnetic reconnection?

Accretion of comets?

Blobs accretion stream?

Important role Swift

Detecting them →

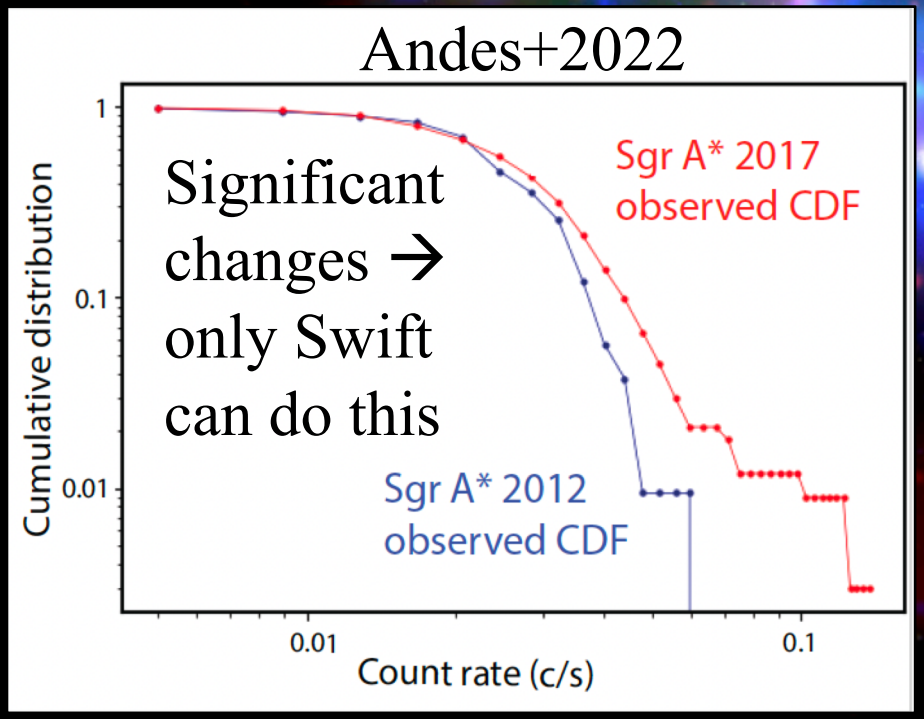
Last hours, easily missed

Science Highlight I: Our supermassive black hole

Low accretion rate / luminosity

L_x~10^{33} erg/s

Sgr A*



Cause of X-ray flares = open question

Magnetic reconnection?

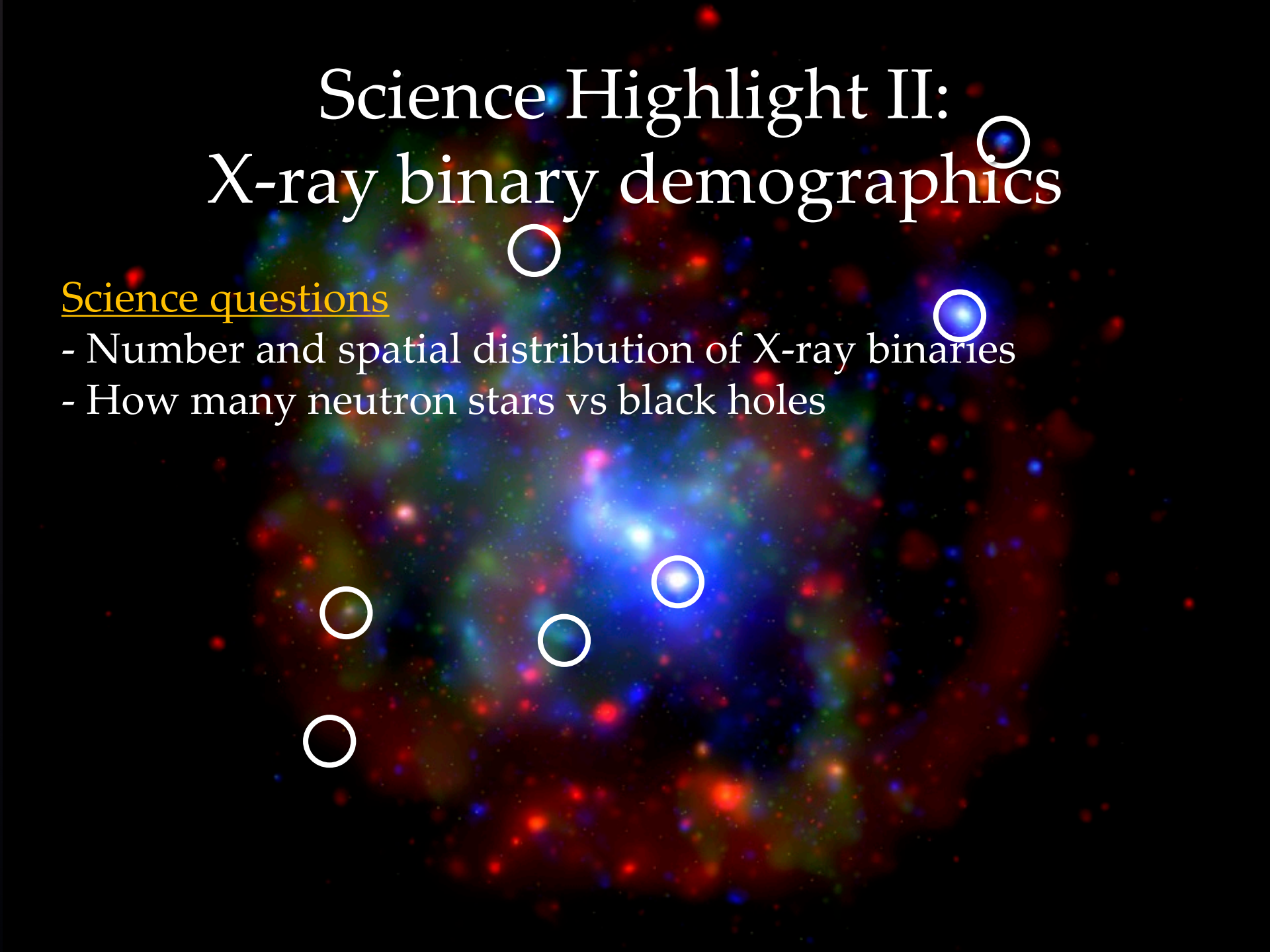
Accretion of comets?

Blobs accretion stream?

Important role Swift

Detecting them → flaring rate + changes in flaring rate

Science Highlight II: X-ray binary demographics



Science questions

- Number and spatial distribution of X-ray binaries
- How many neutron stars vs black holes

Science Highlight II: X-ray binary demographics

Science questions

- Number and spatial distribution of X-ray binaries
- How many neutron stars vs black holes

Important for

- Binary formation in dense environments
- Supernova physics
- Rates of GW mergers in galactic nuclei

Science Highlight II: X-ray binary demographics

Science questions

- Number and spatial distribution of X-ray binaries
- How many neutron stars vs black holes

Important for

- Binary formation in dense environments
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- Rates of GW mergers in galactic nuclei

Role Swift

- Detecting + characterizing
- Building up statistics

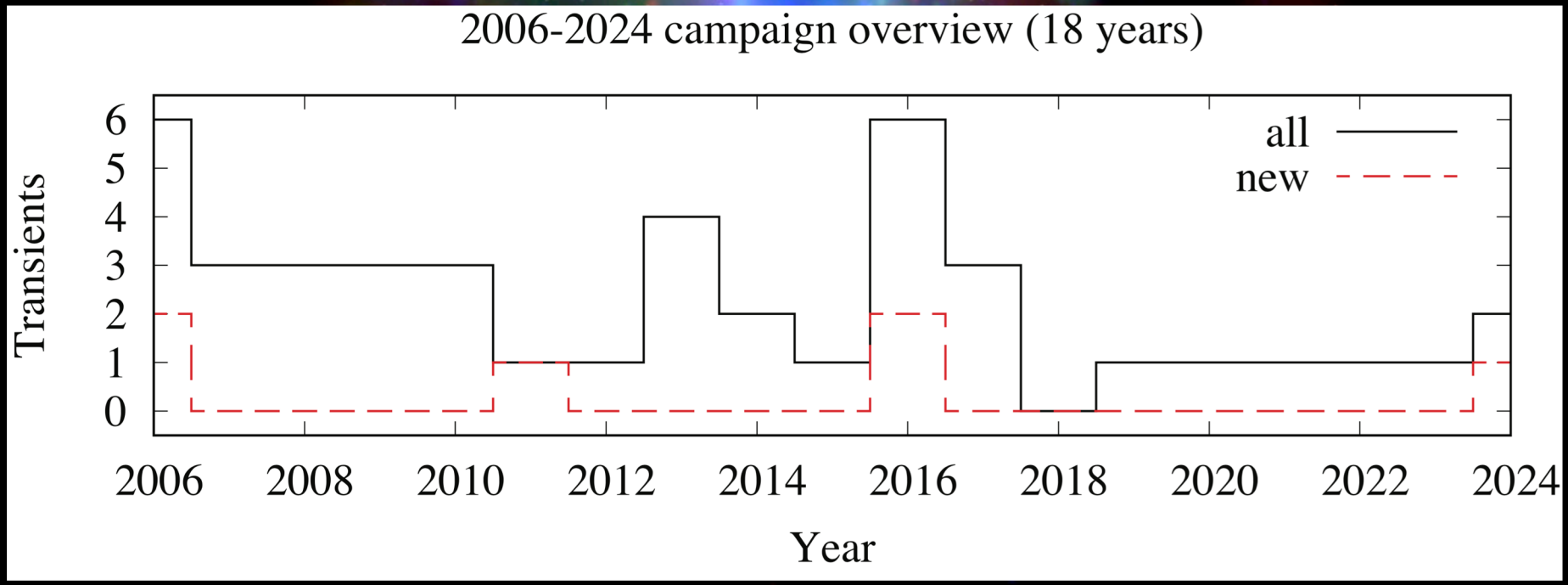
Science Highlight II: X-ray binary demographics

49 outbursts from 13 transient X-ray binaries

7 new transients

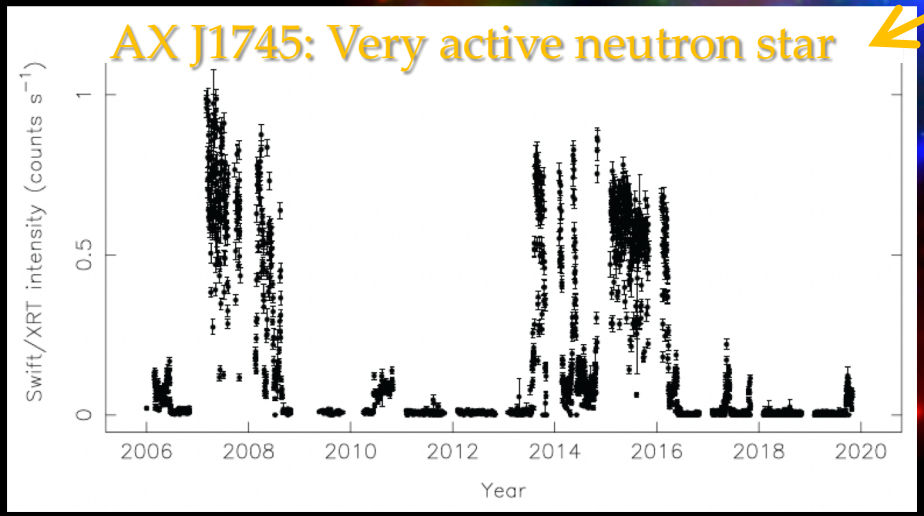
2.5 outbursts per year, one new source every ~2.5 yr

60% of outbursts are faint ($<10^{36}$ erg/s)

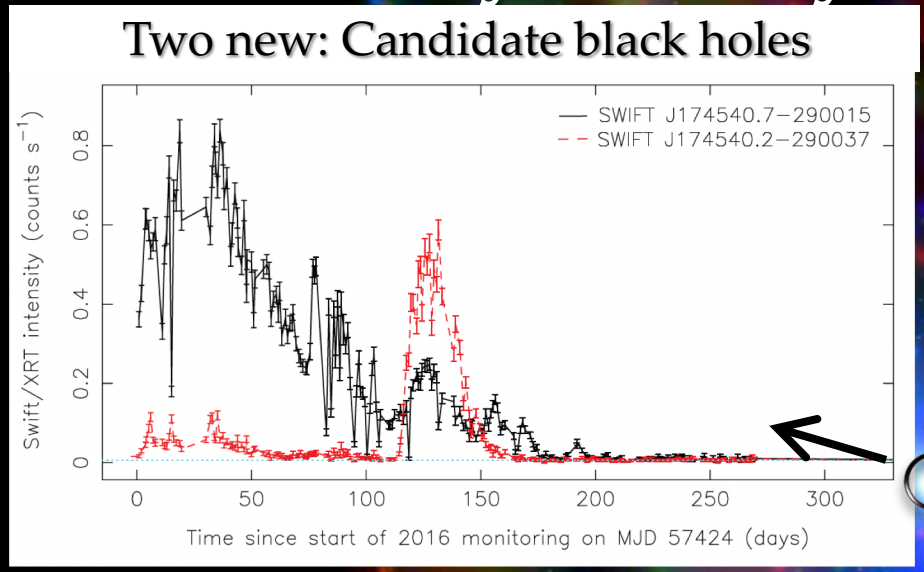


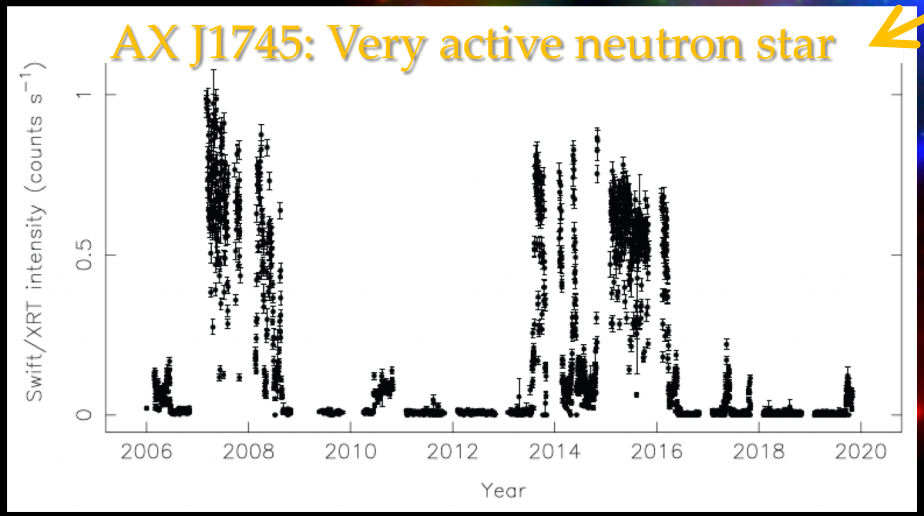
Science Highlight II: X-ray binary demographics

Swift detection + characterization of transient X-ray binaries



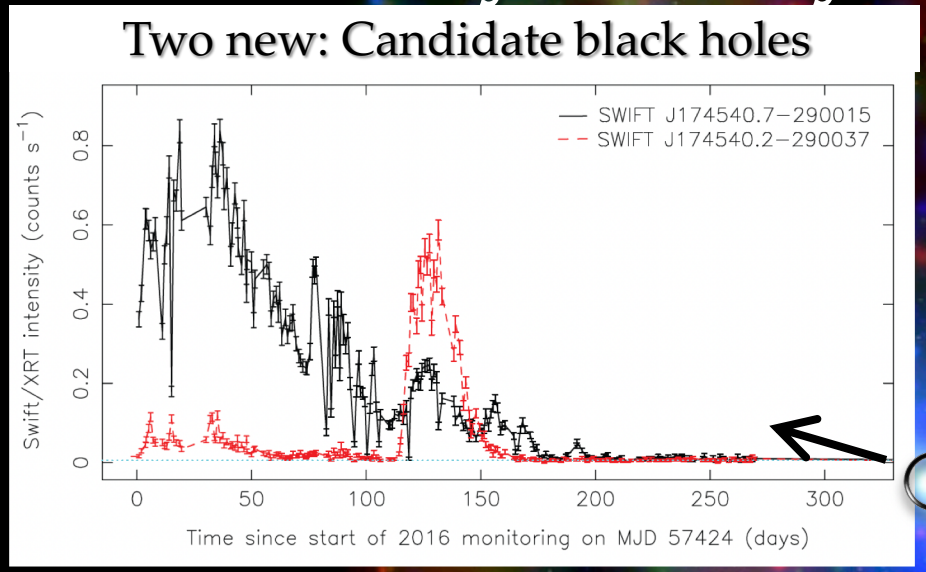
Science Highlight II: X-ray binary demographics





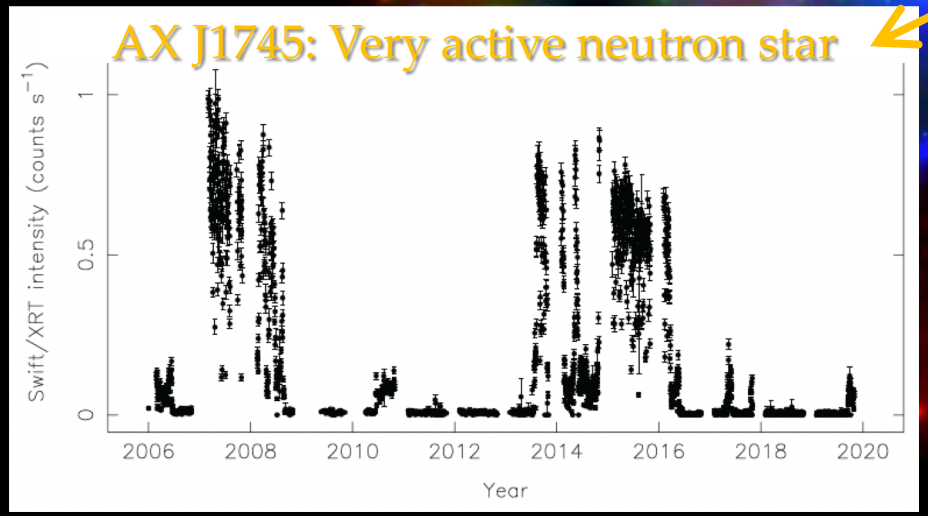
Swift detection + characterization of transient X-ray binaries

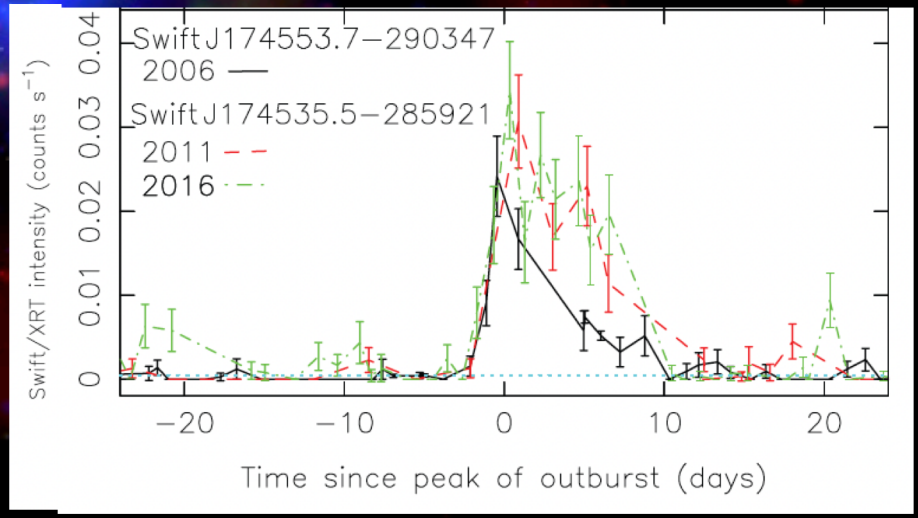
Science Highlight II: X-ray binary demographics



Swift detection + characterization of transient X-ray binaries

Only Swift can do this
~1-2 weeks
~10^{34}-10^{35} erg/s





Science Highlight II: X-ray binary demographics

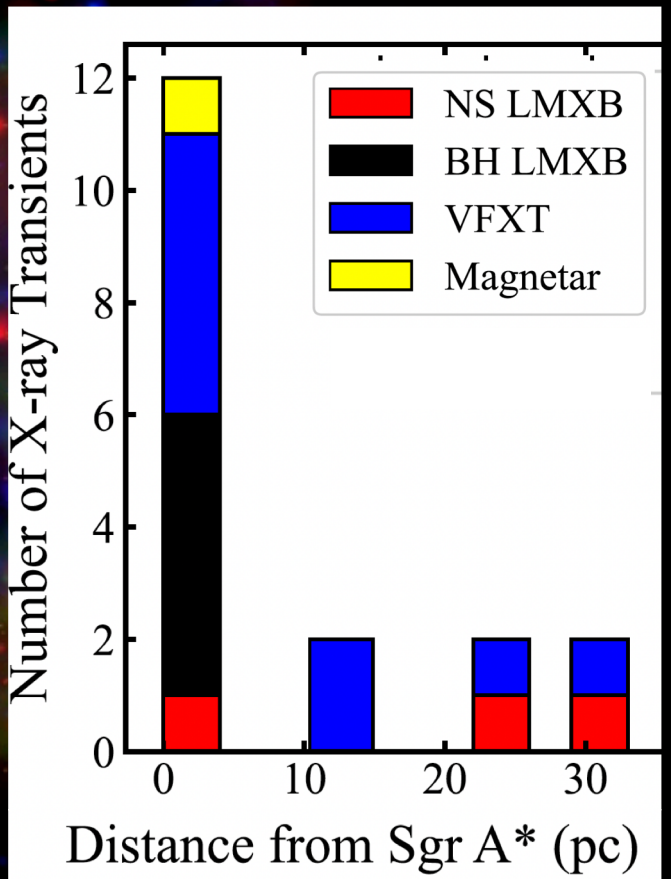
Science questions
- Number and spatial distribution
- Neutron stars vs black holes

Important for
- Binary formation
- Supernova physics
- Rates of GW mergers

Role Swift
- Detecting + characterizing
- Building up statistics

(only accessible to Swift)

Mori+2021



Summary of 18 years (going strong)

Main science topics

Flares Sgr A*

X-ray binary demographics

Outputs

20+ refereed papers

50+ ATels

15+ student projects

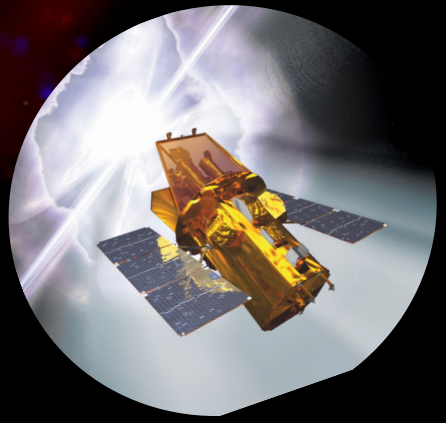
Trigger for many other observatories

Serendipitous science

Arches massive star cluster

magnetars

transitional millisecond pulsars



Three Take-Away Points

1) Why Galactic center

Extremely rich to study compact objects

2) Why Swift

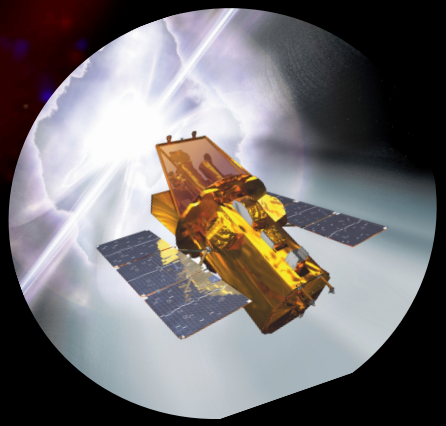
Crowded region, many short-lived, faint events

3) Many different science results

Supermassive black hole, X-ray binaries

Other (rare) transients

Rich data set, still lots to explore

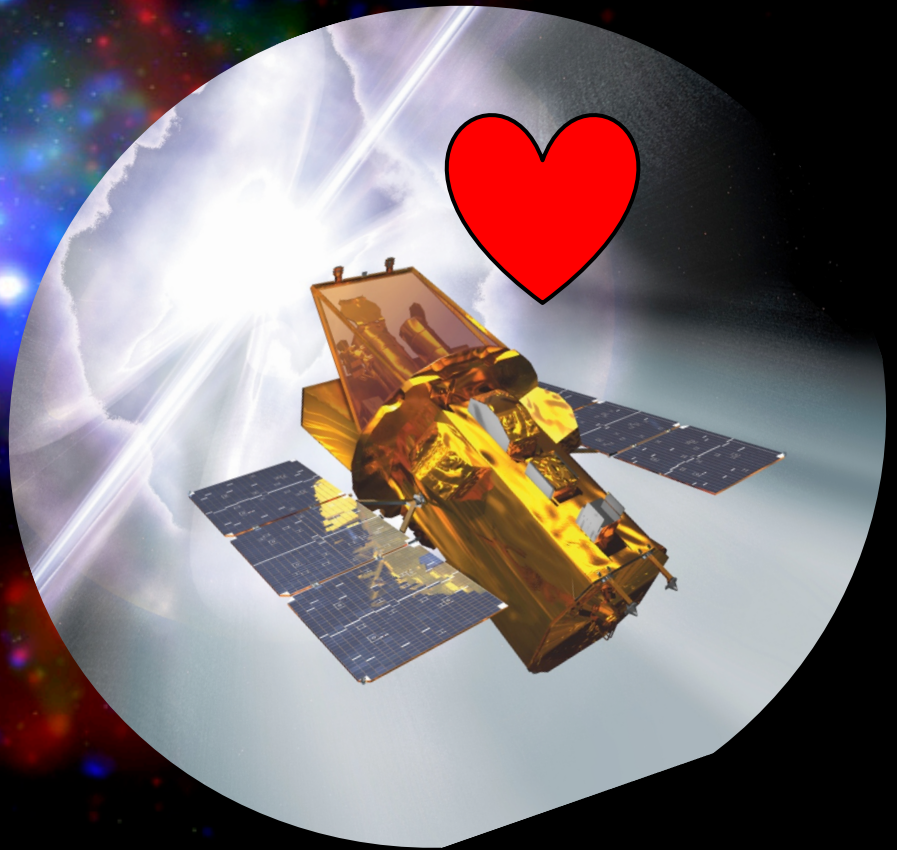


Three Take-Away Points

1) Swift is awesome

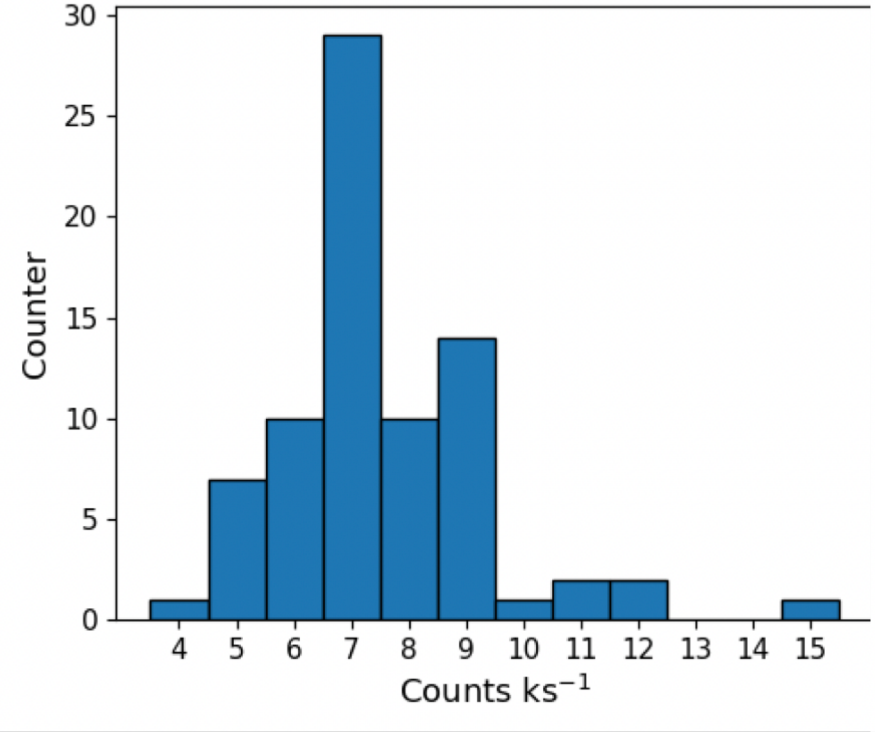
2) Swift is awesome

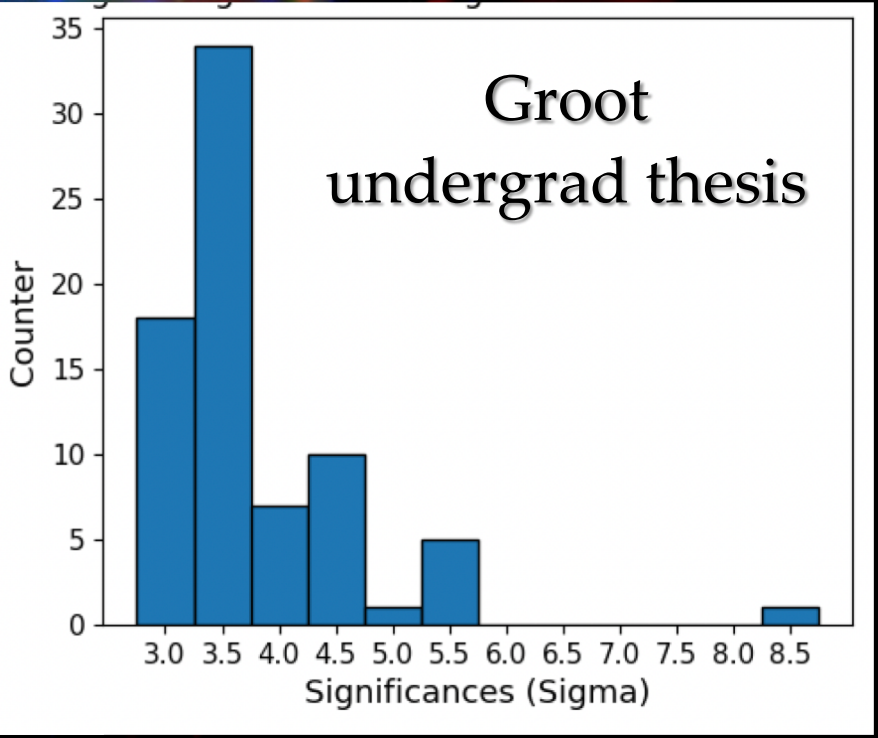
3) Swift is awesome



Deleted scenes

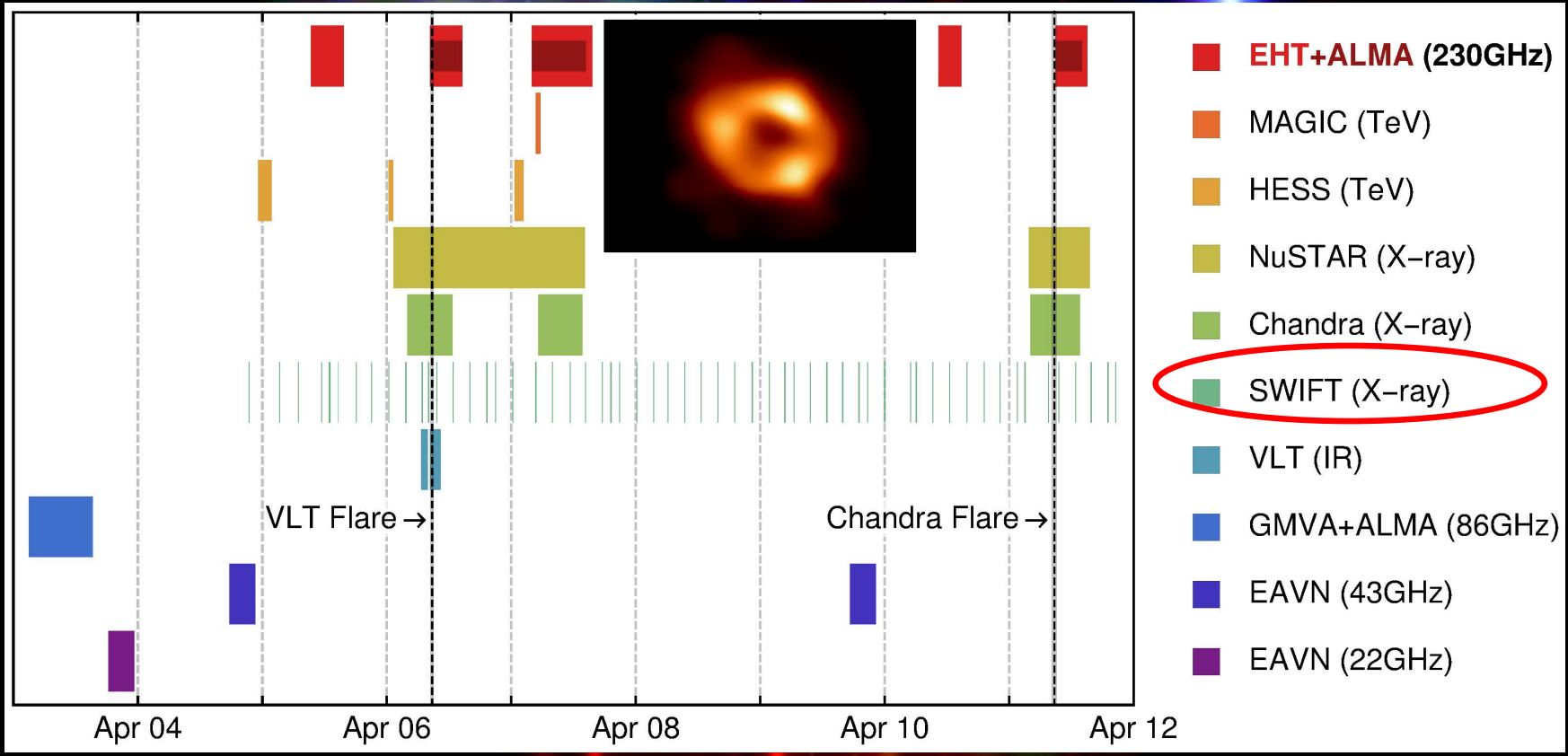
Serendipitous Science: Flares from the Arches Cluster





Swift & Event Horizon Telescope

Detecting flares essential for EHT imaging → role Swift

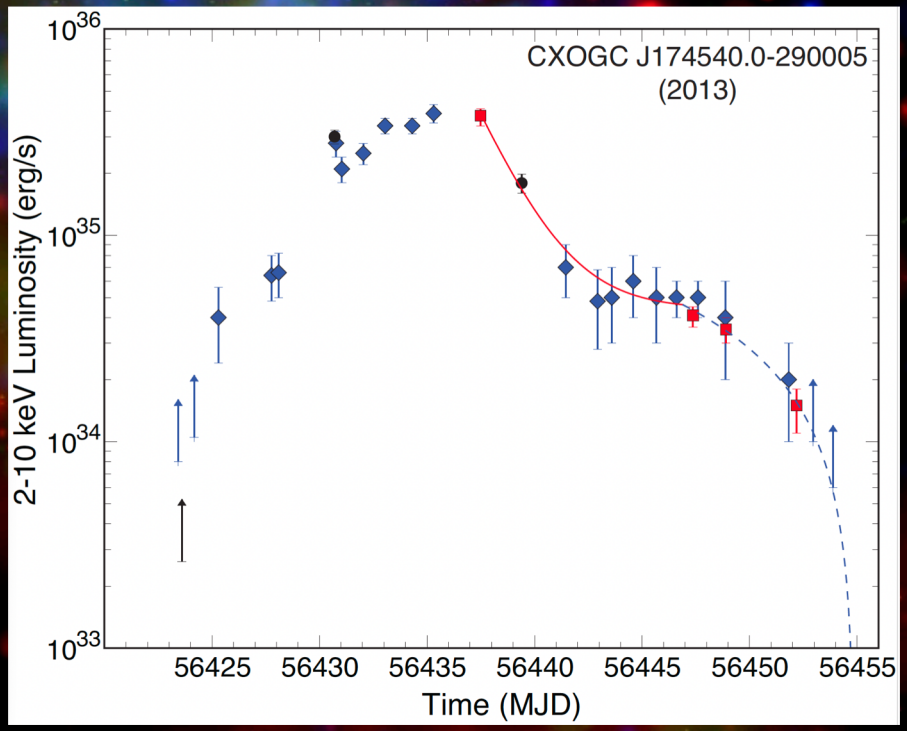


Multi-wavelength coverage Sgr A* during EHT operations 2017

Very-faint X-ray binaries

Model outbursts with accretion disk models

→ Evidence for small disks = small orbital periods

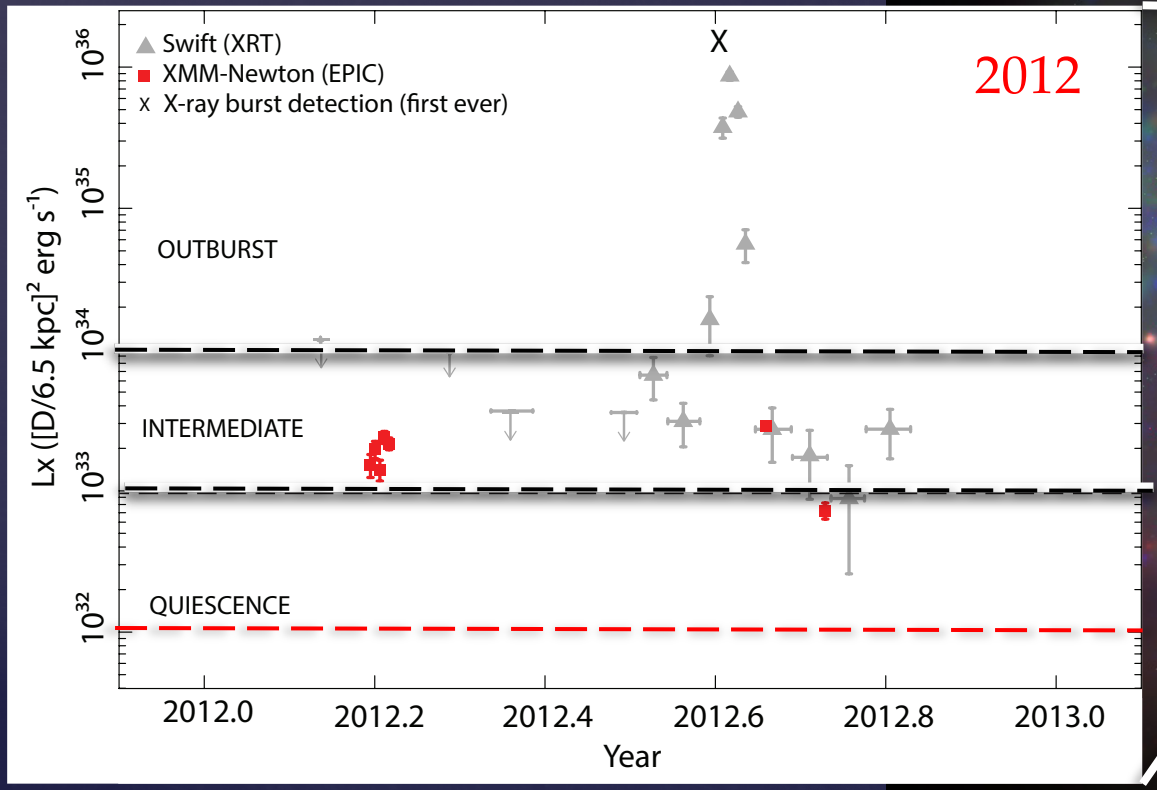


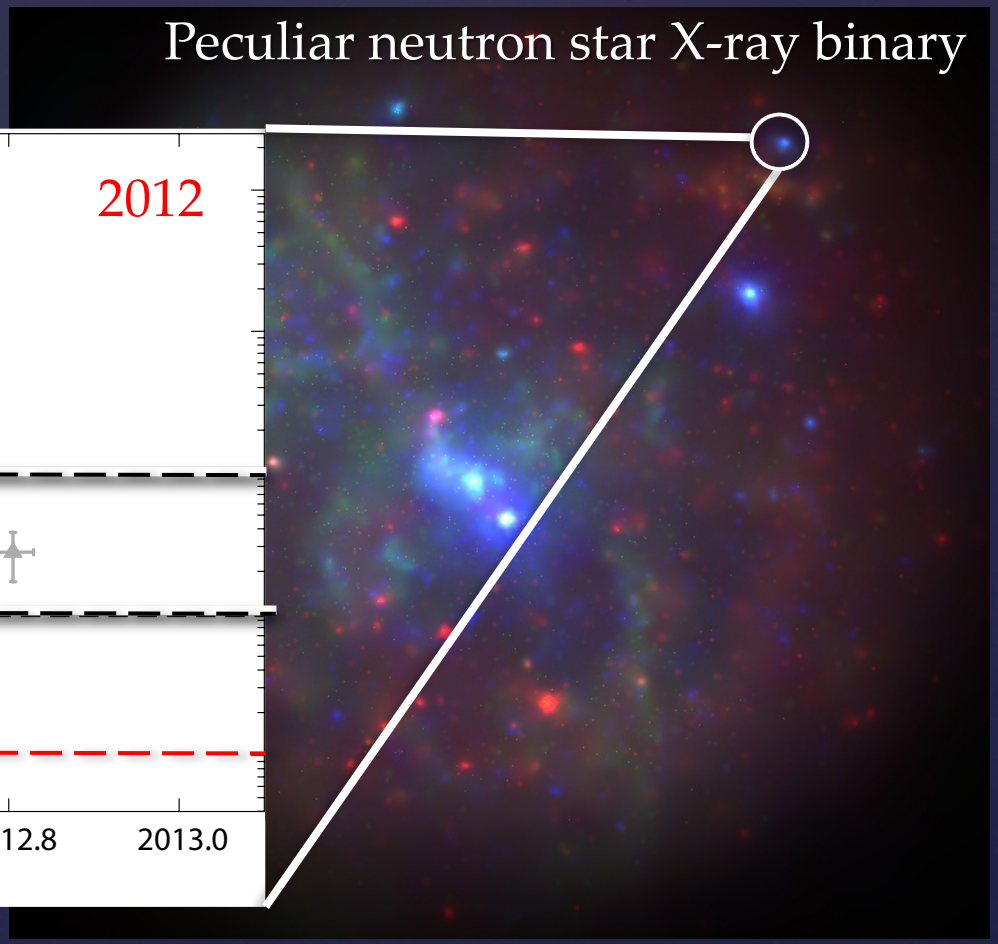
Swift Transient X-ray binaries

Extended low-intensity states

XMM J174457-2850.3

Peculiar neutron star X-ray binary



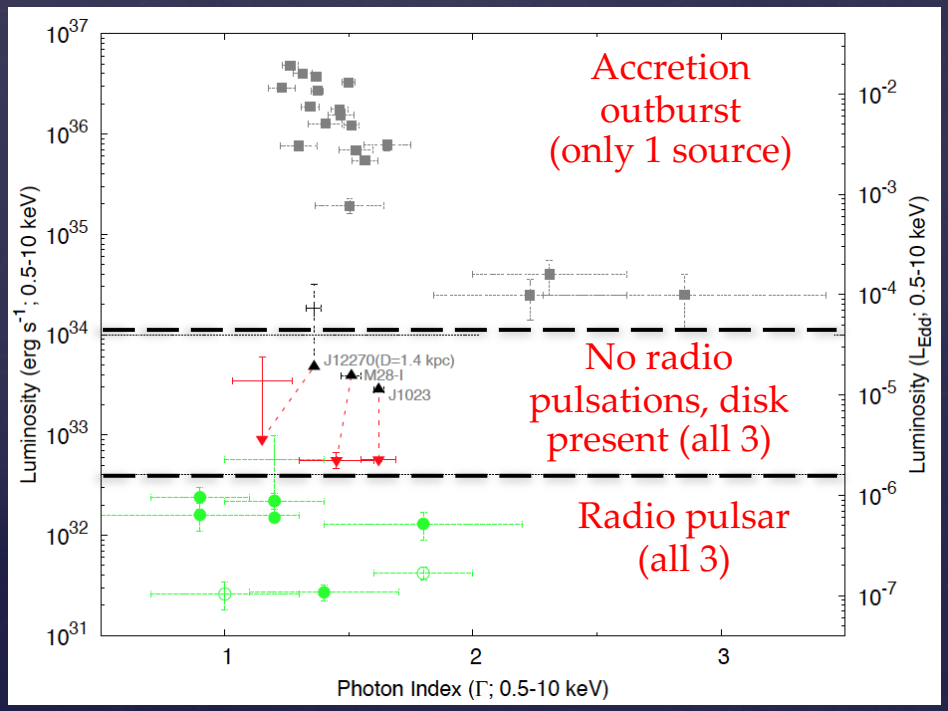


Degenaar+2014

Peculiar XMM J174457-2850.3: Similar to Transitional Objects?

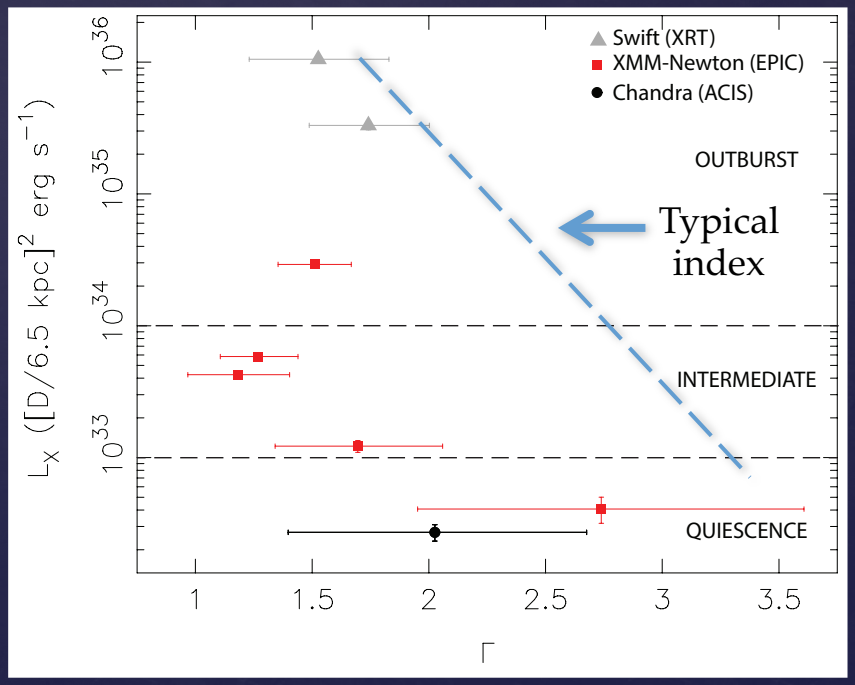
Neutron stars switching between X-ray binary / Radio Pulsar
Swift source: Same Lx states(?), hard spectrum, little variation

3 Transitional X-ray Binaries / Radio Pulsars



Linares 2014

XMM J174457-2850.3



Degenaar+2014

Science Highlight I: Our supermassive black hole

Signs of a glorious past

Will it re-activate?

Sgr A*

Predictions evolution Sgr A*