STAR-X : A NEXT-GENERATION X-RAY AND UV EXPLORER TO STUDY THE RESTLESS NATURE OF AGN

Roberto Gilli
INAF - OAS Bologna

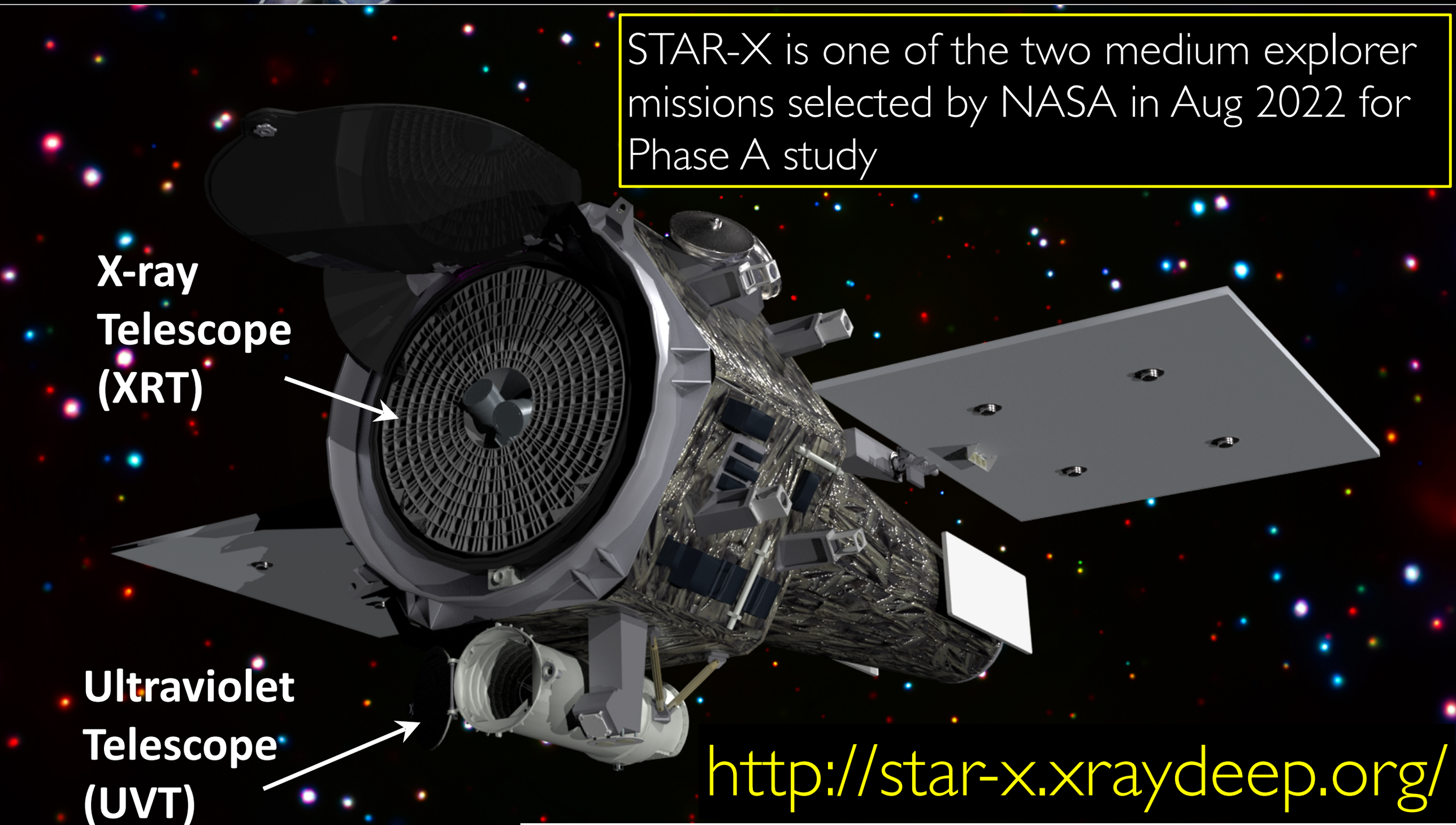
on behalf of the STAR-X team

Naples, 28 June 2023 - The Restless Nature of AGN

STAR-X

Survey and Time-domain Astrophysical Research eXplorer

STAR-X is one of the two medium explorer missions selected by NASA in Aug 2022 for Phase A study



http://star-x.xraydeep.org/

NASA Goddard Space Flight Center · Ball · Massachusetts Institute of Technology · LASP Laboratory for Atmospheric and Space Physics, University of Colorado Boulder · ASI Agenzia Spaziale Italiana · MPE

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CSR submitted to NASA
Final selection >March 2024
Launch in 2028

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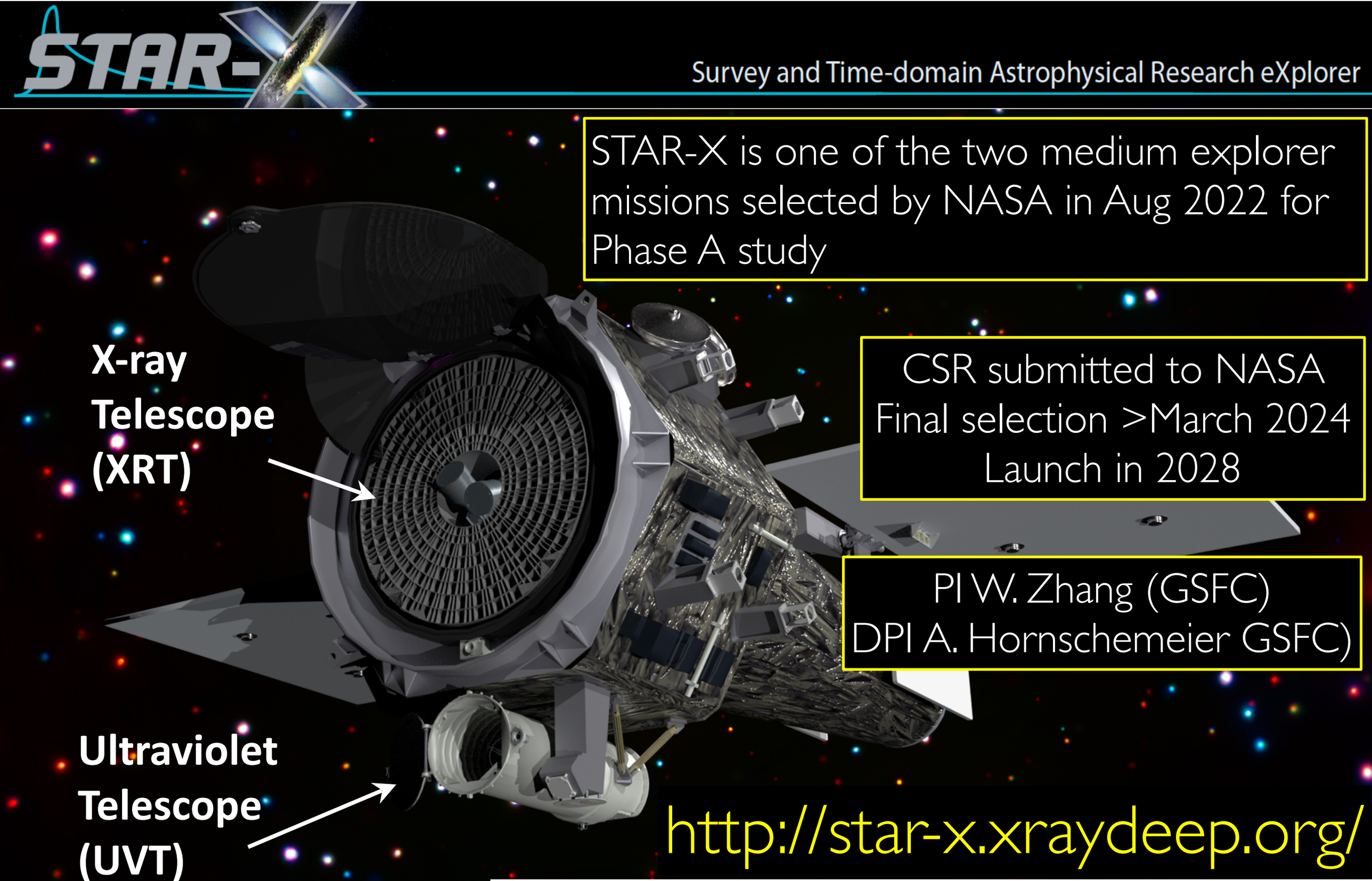

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DPI A. Hornschemeier GSFC)

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PI DPI

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Ann Hornschemeier

Antara Basu-Zych

Mark Bautz

Niel Brandt

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Maya Fishbach

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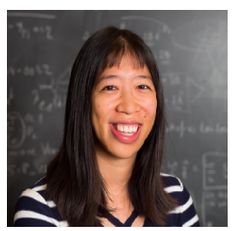
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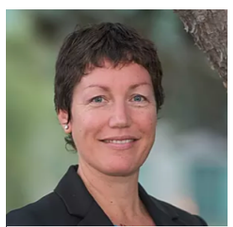
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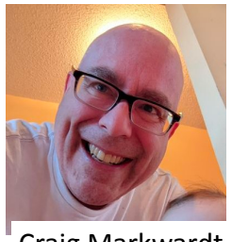
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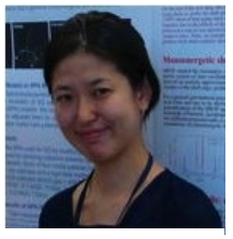
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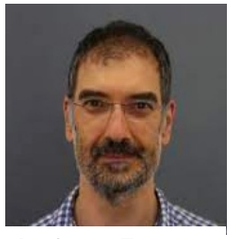
Andreas Zezas

37 members: 27 US, 5 Italy, 2 Canada, 2 Germany, 1 Greece

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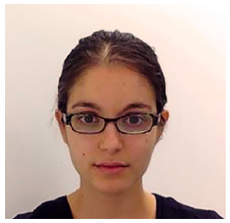
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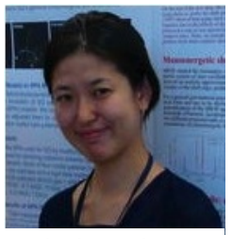
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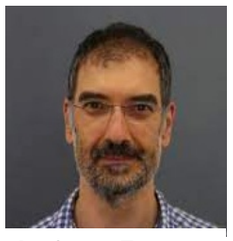
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What is STAR-X?

X-ray telescope + UV telescope + rapidly responding spacecraft

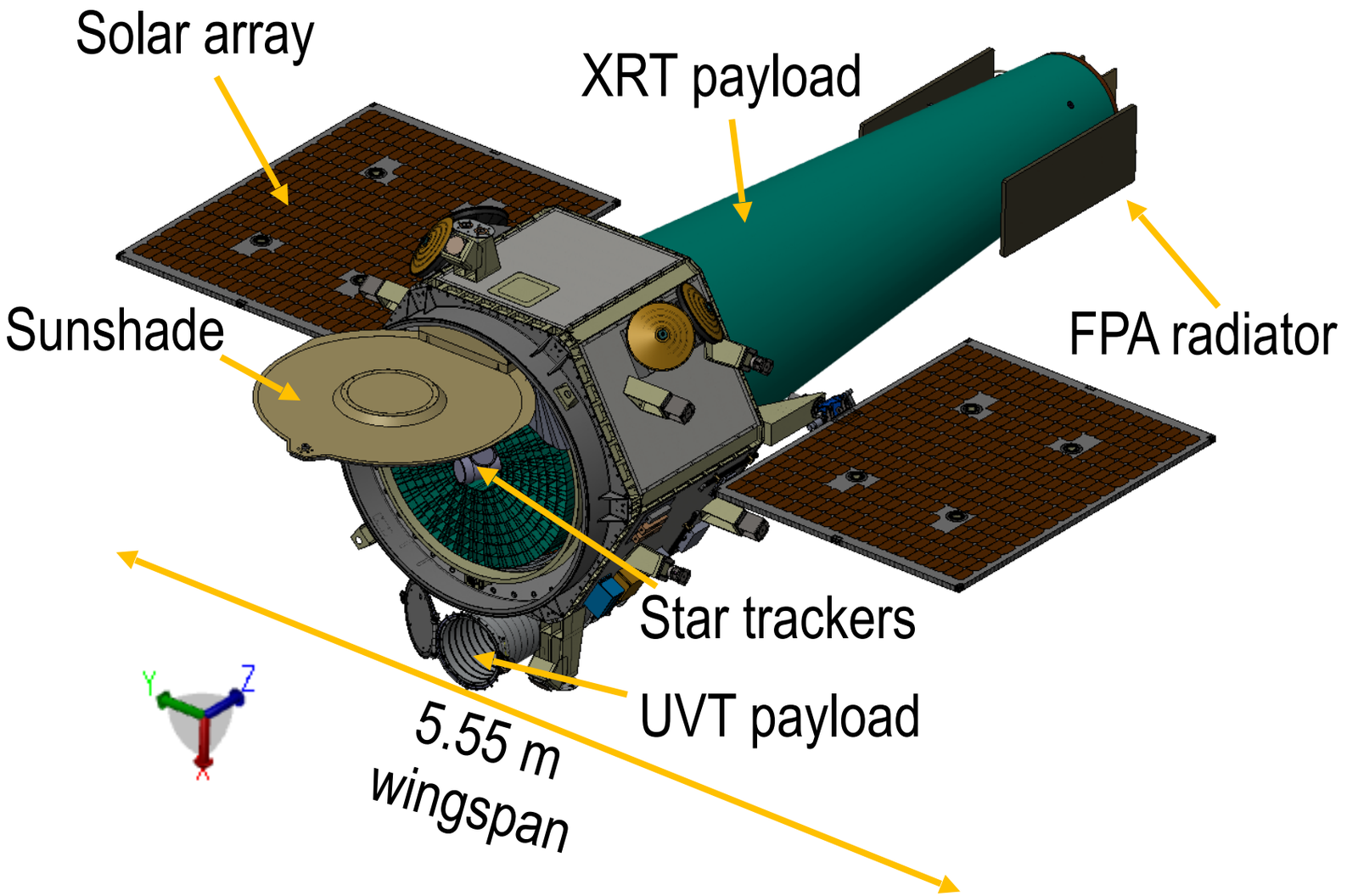
Fast-slewing

120 deg in less than 9 min
(0.5 deg in 26 sec)

Fast ToO response

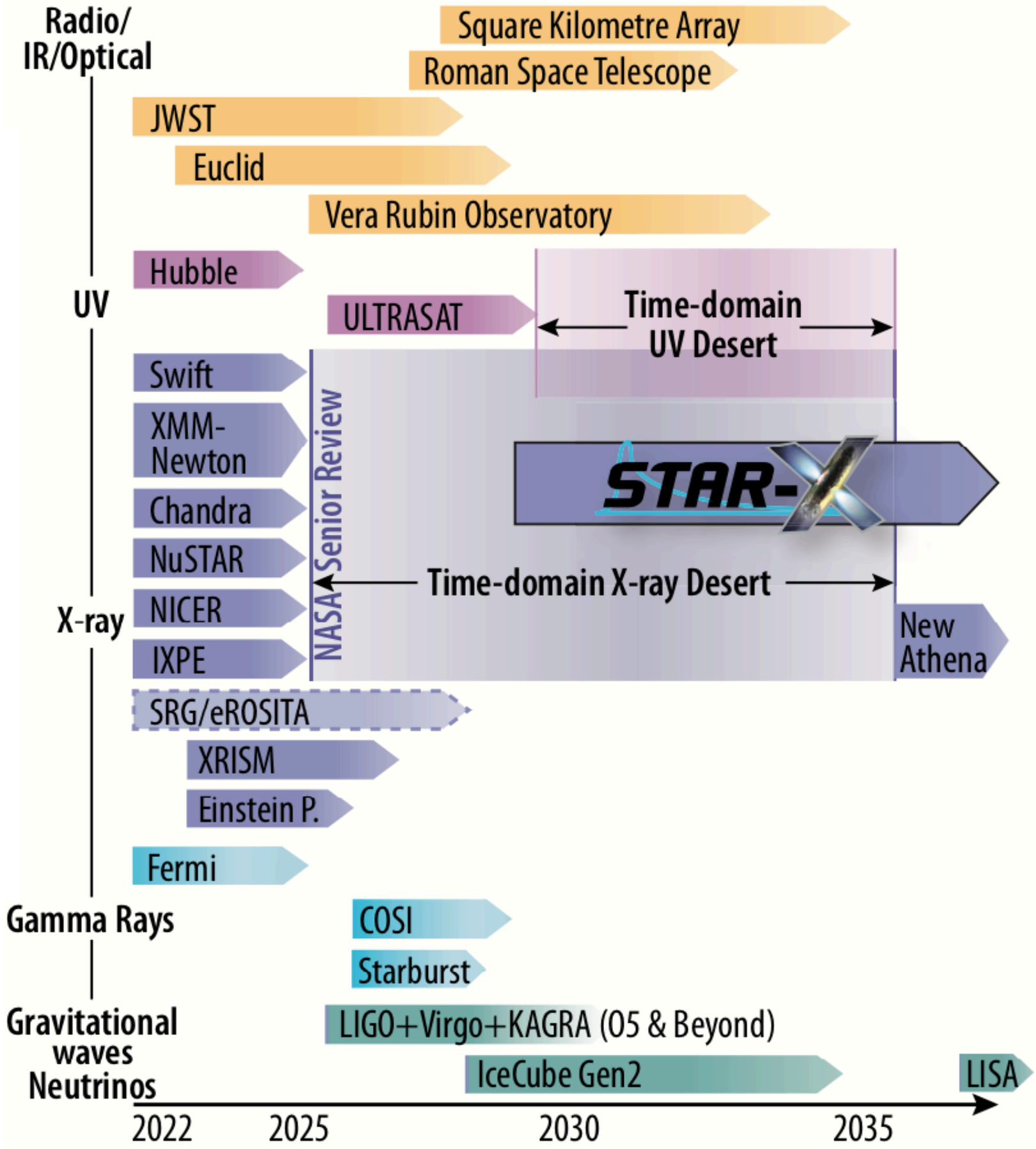
Observe ToO within
120 min 80% of the time

2-year nominal mission



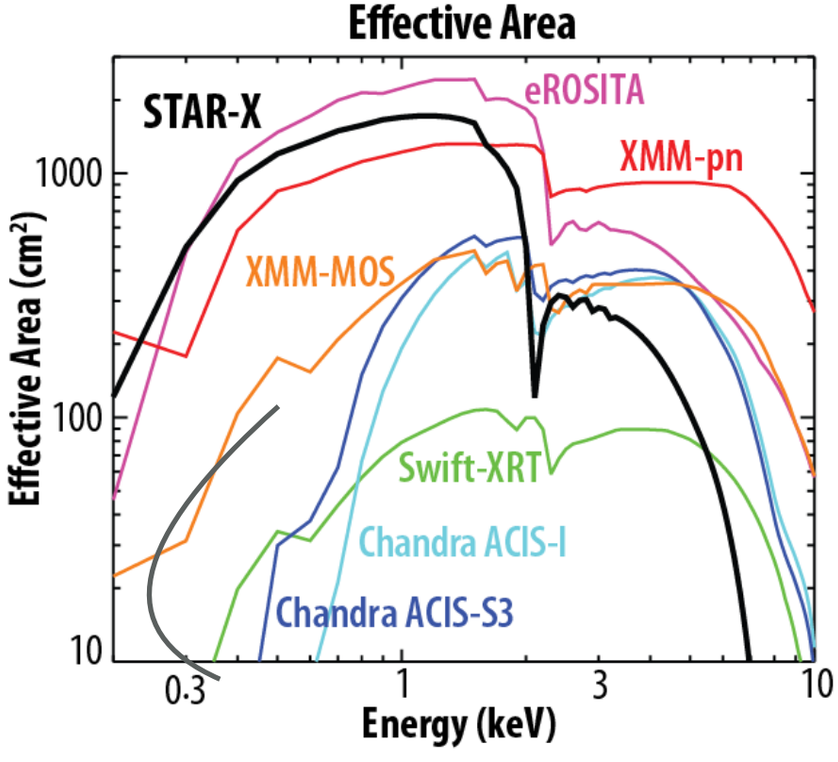
WHY STAR-X? STAR-X is a timely response to Astro2020's recommendation for a space-based, sustaining time-domain and multi-messenger program.

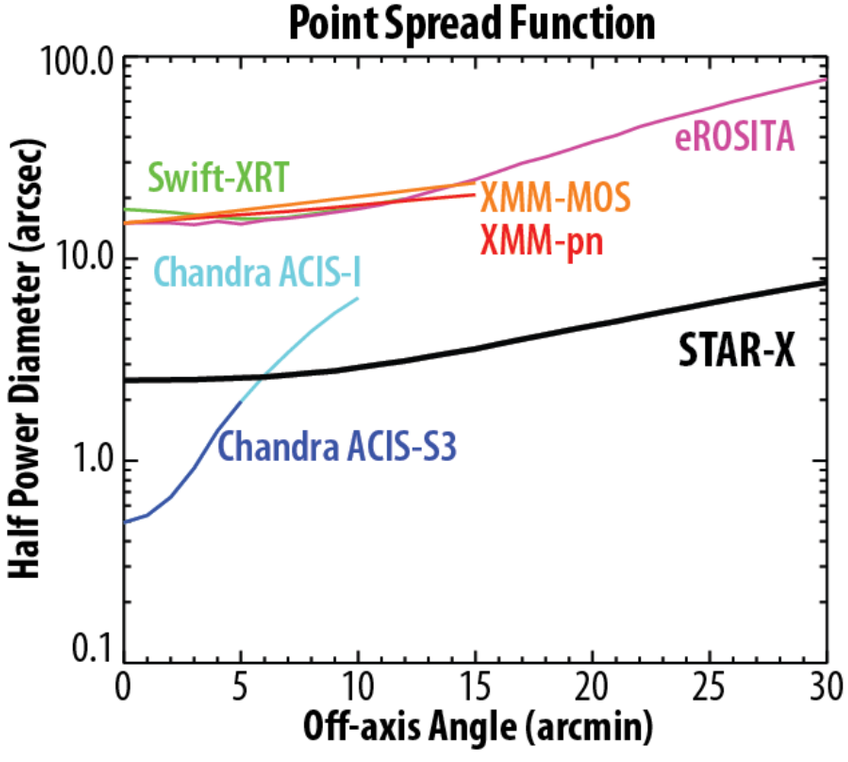
WHY NOW? STAR-X fills the gap in X-ray and UV time domain coverage in the late 2020s, providing simultaneous X-ray and UV observations that complement optical, infrared, and gravitational wave facilities.



X-ray requirements

- Bandpass: 0.2-6 keV
- Large effective area: >1,700 cm^2 at 1 keV
- Large FoV: 1 deg^2
- Excellent PSF: 2.5" on-axis, 6" FoV-averaged
- Low particle background (low-earth orbit)





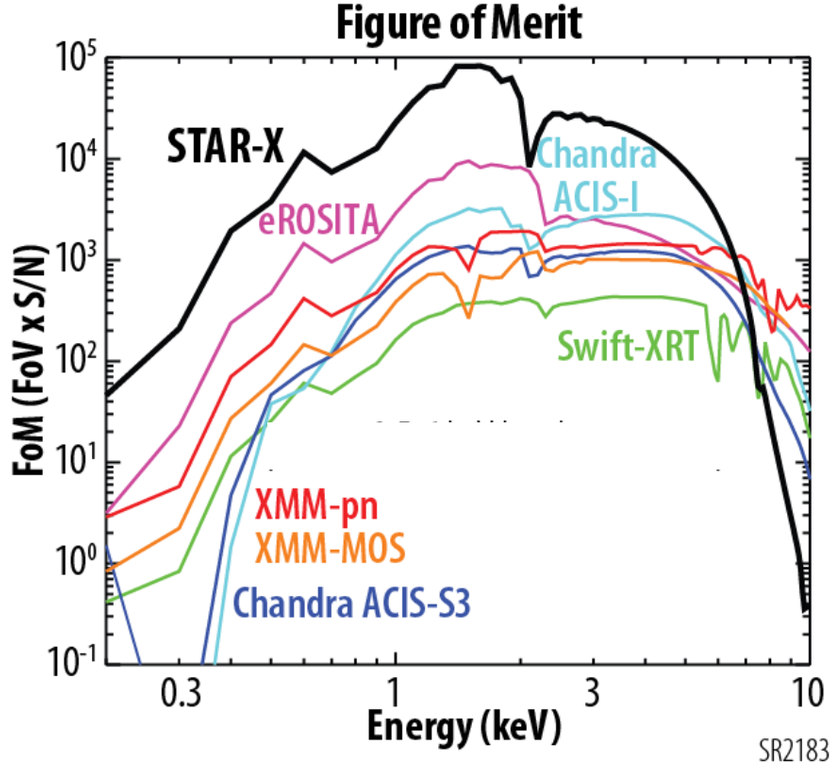
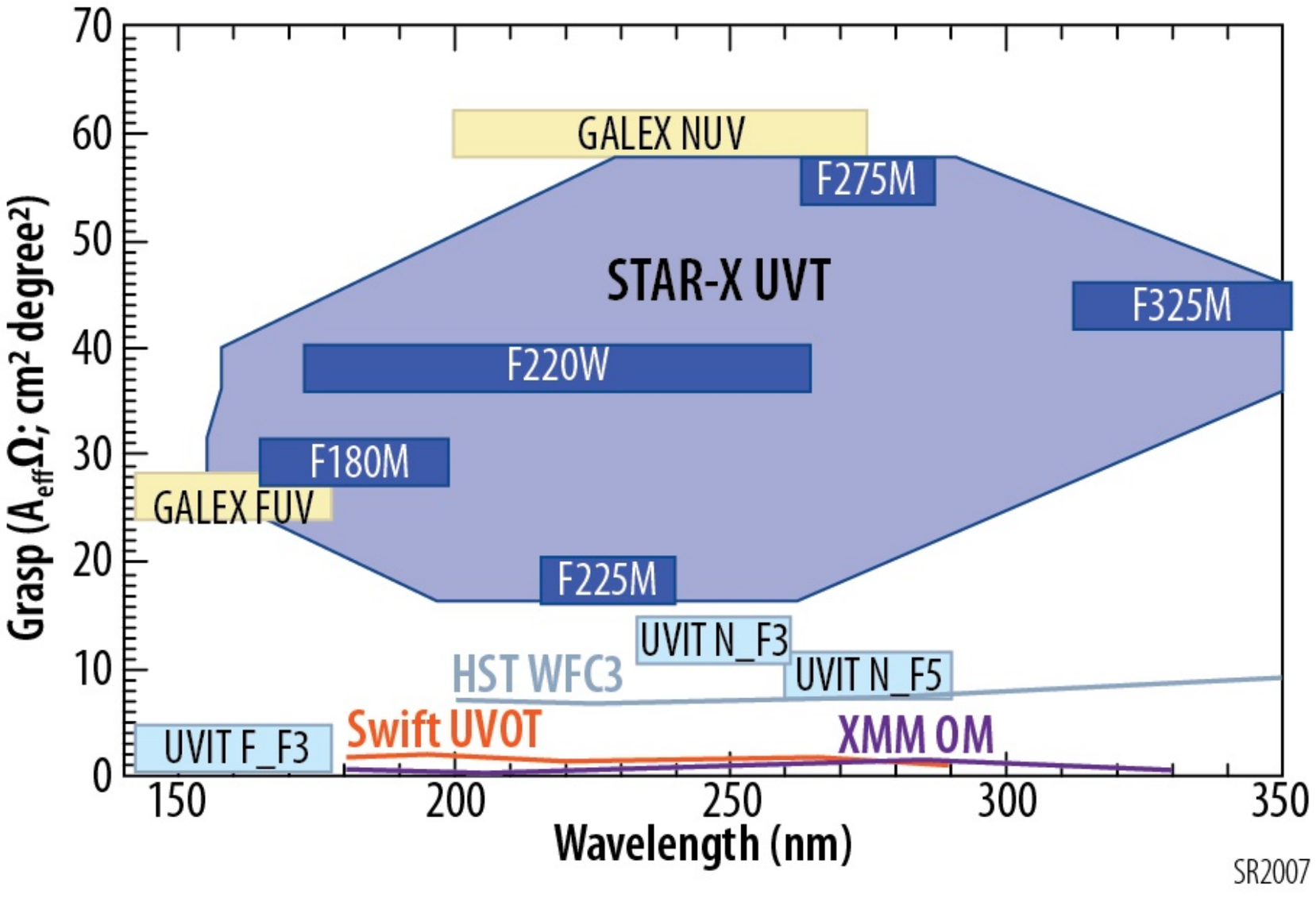


Figure of Merit to discover faint point sources (integrated S/N over FoV)

UV requirements

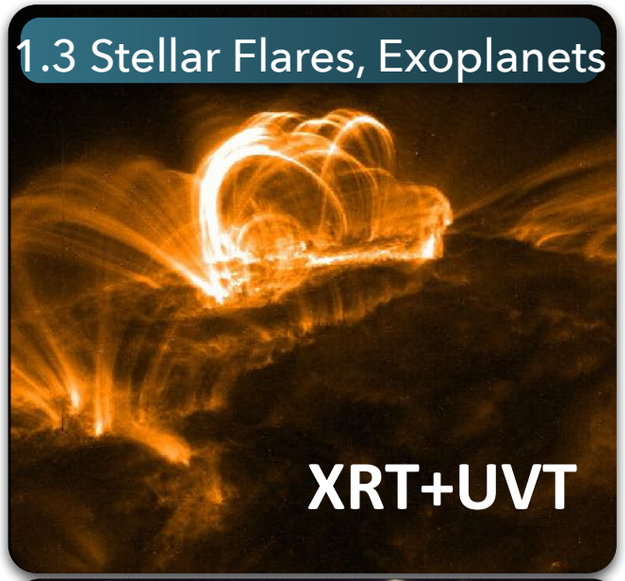


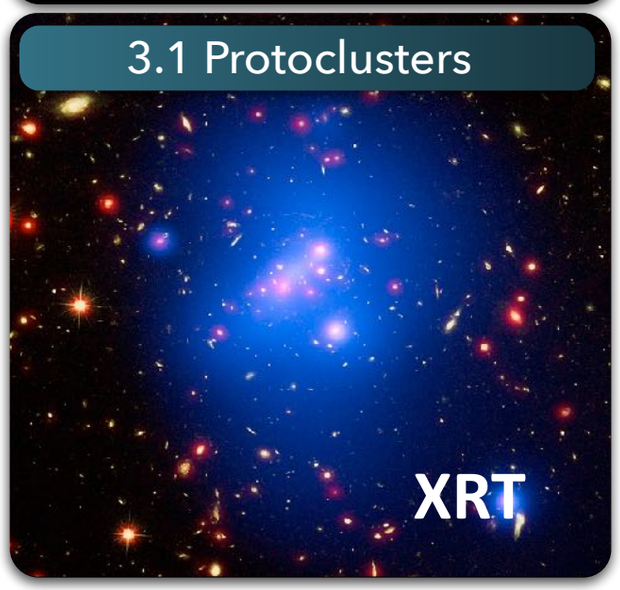
- Excellent PSF:
  5" over FOV.
- Large FOV:
  0.9 deg × 0.9 deg.
- Good effective area:
  25 – 55 cm^2.
- Five filters
  - 180 nm
  - 220 nm
  - 225 nm
  - 275 nm
  - 325 nm

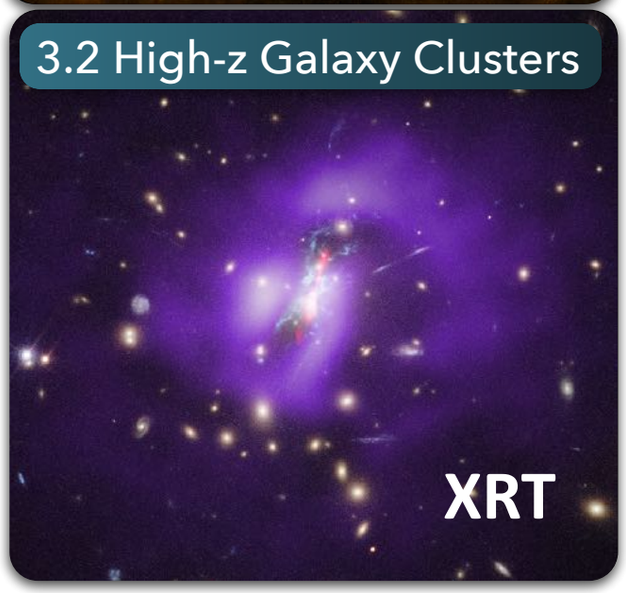
STAR-X

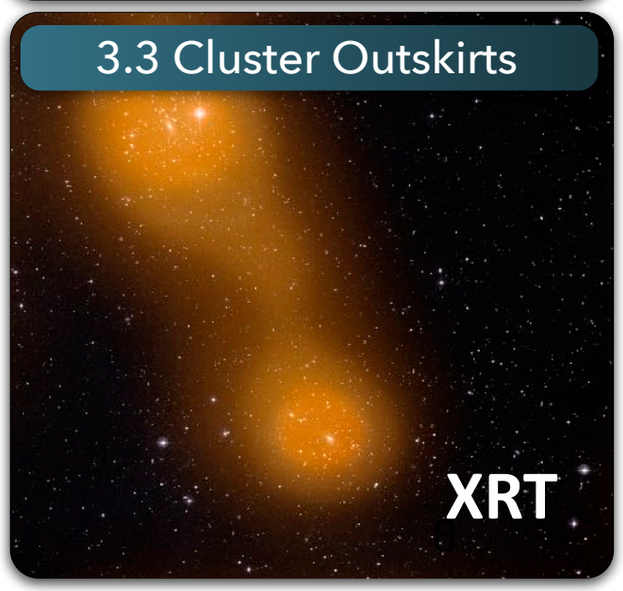
Survey and Time-domain Astrophysical Research eXplorer

STAR-X science: exploring the Fast, Furious, and Forming Universe









three goals, eight objectives

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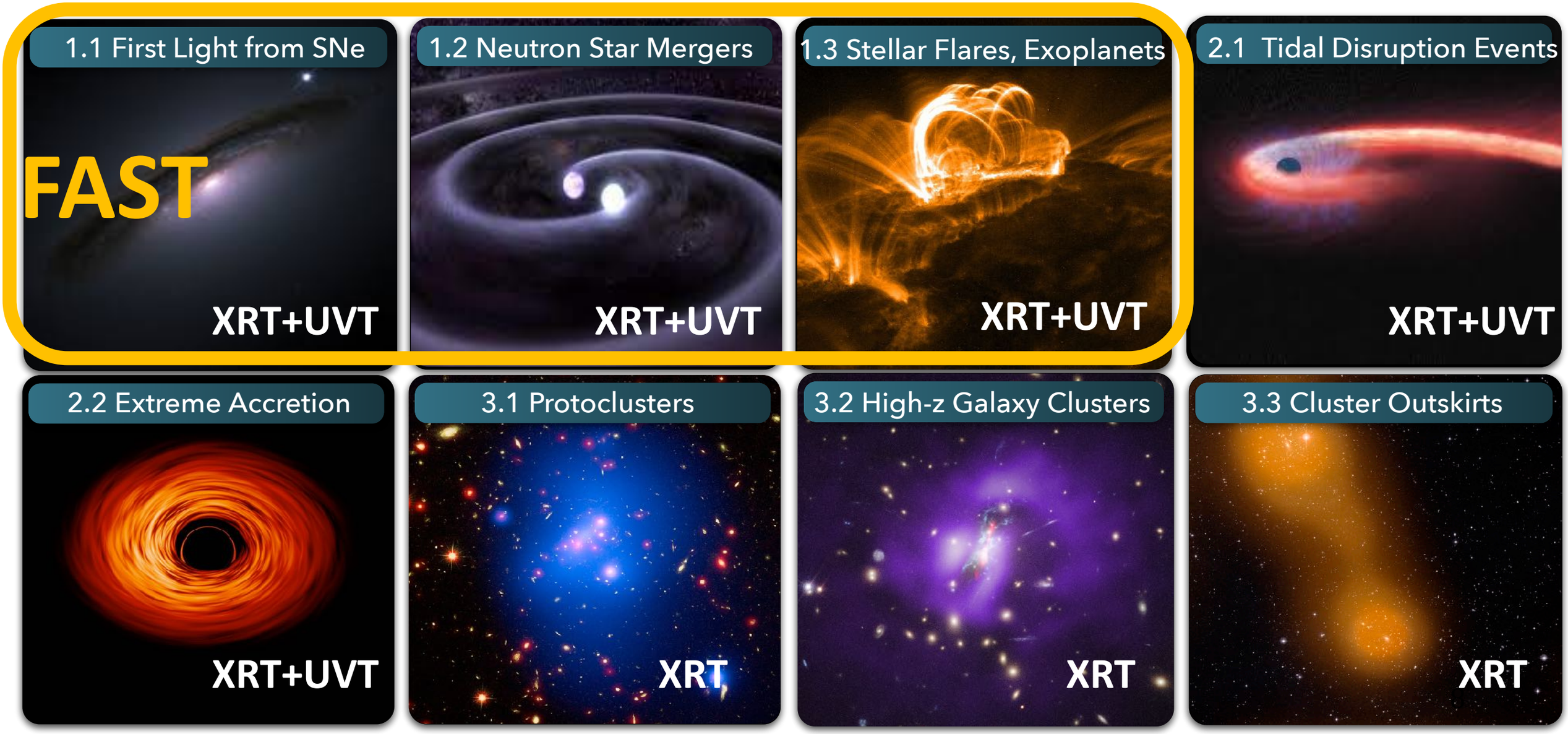

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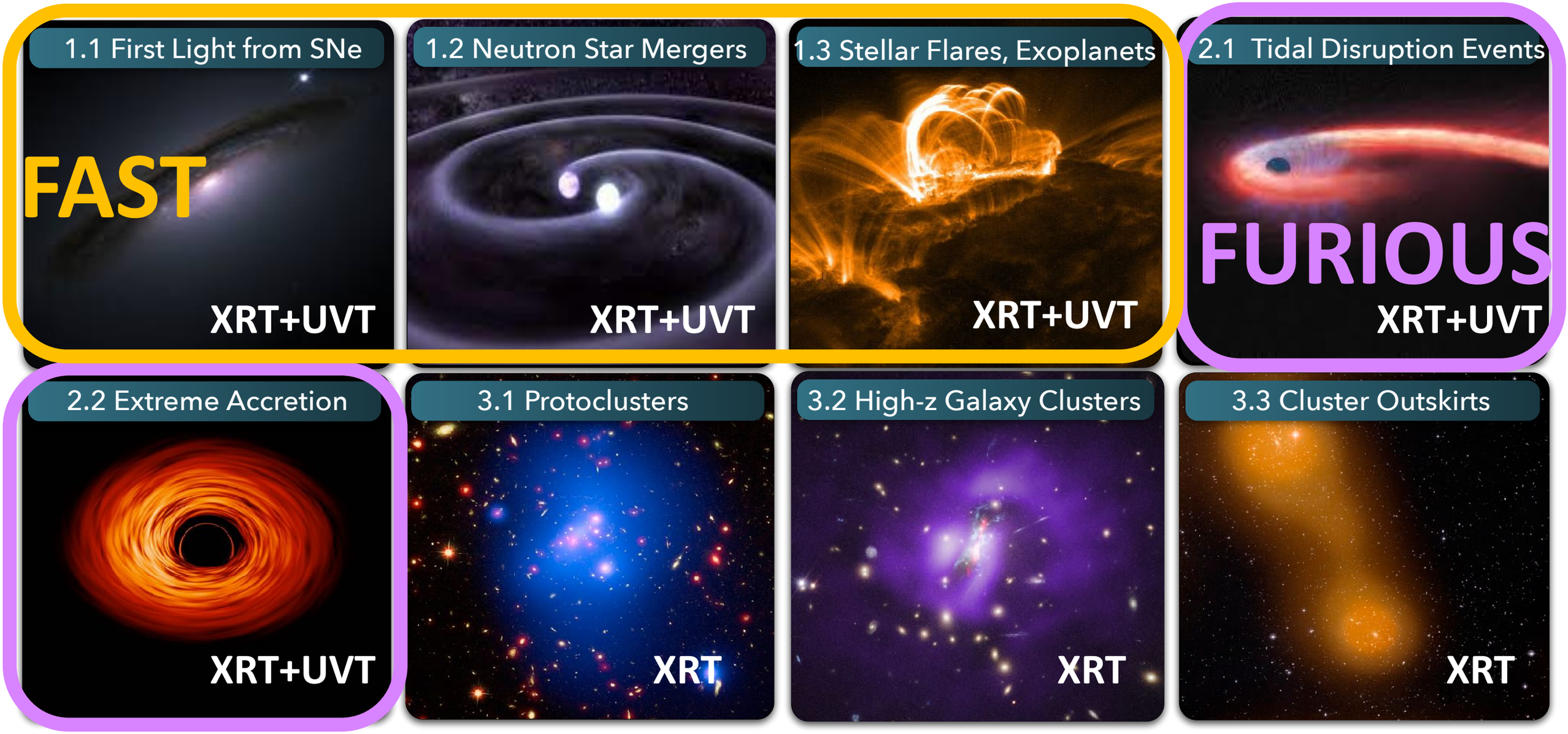

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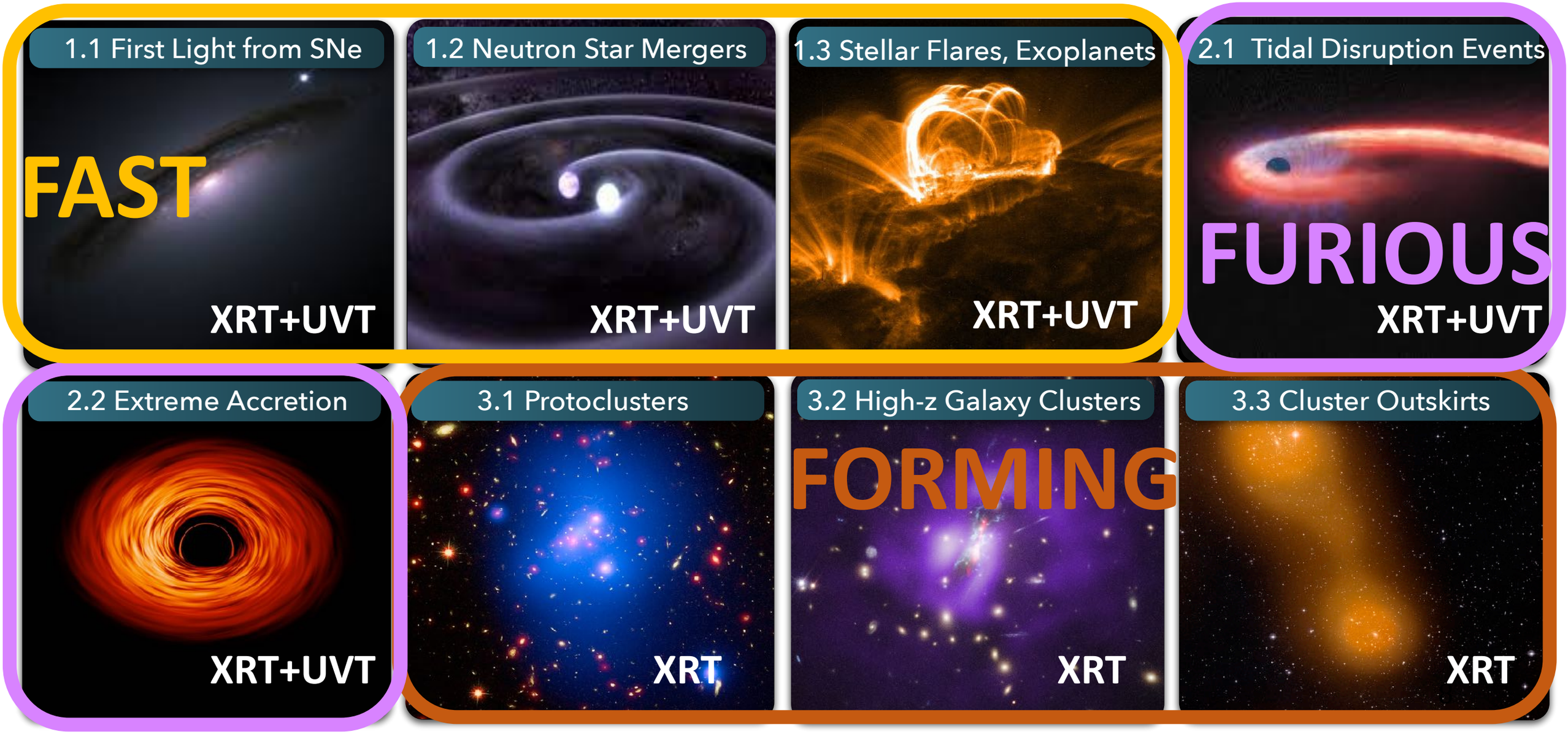

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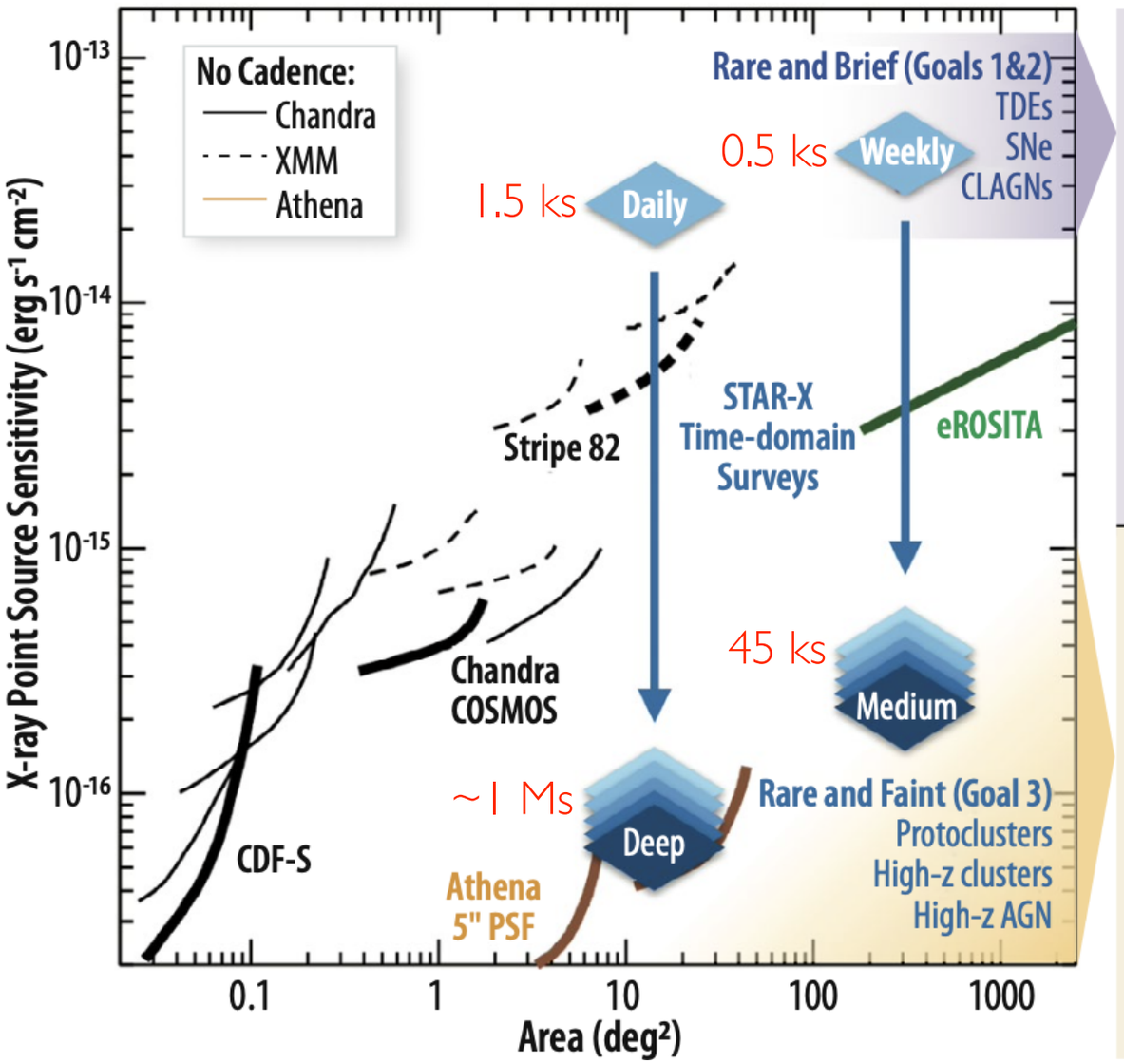
High-cadence, wide-and-deep surveys



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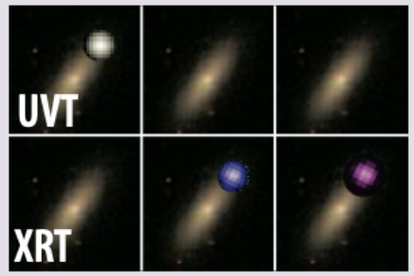
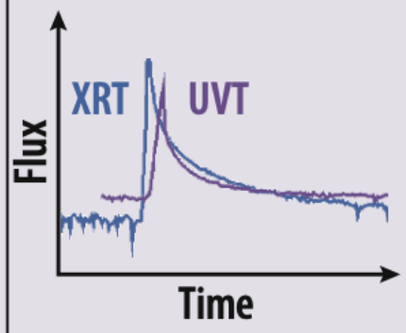


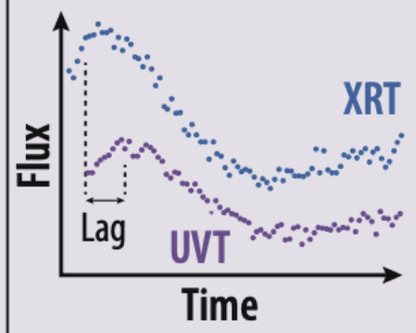
XRT discovers a shock breakout and triggers a ToO to catch cooling in the UV

2-1 Tidal Disruption



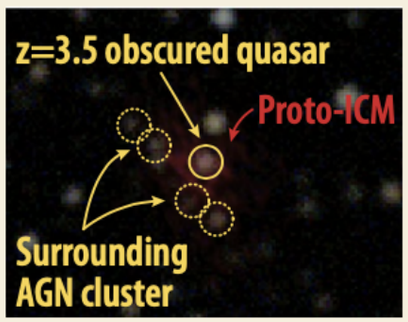
Weekly X-ray/UV monitoring rapidly reveals hundreds of new TDEs

2-2 AGN Accretion Flows



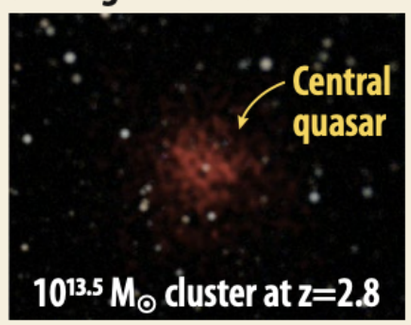
Daily X-ray/UV monitoring probes accretion disk structure via time lags

3-1 Protoclusters



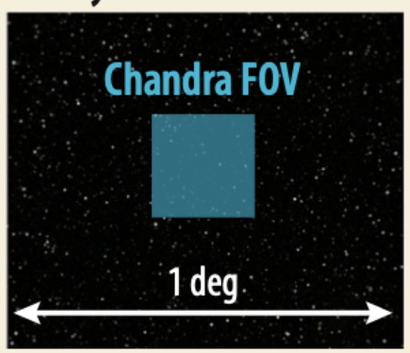
STAR-X will witness the birth of galaxy clusters at z>3 via AGN clustering and early intracluster medium

3-2 High-z Clusters



STAR-X will discover hundreds of high-z clusters to trace cluster growth over cosmic time

Survey Science: z>6 AGNs



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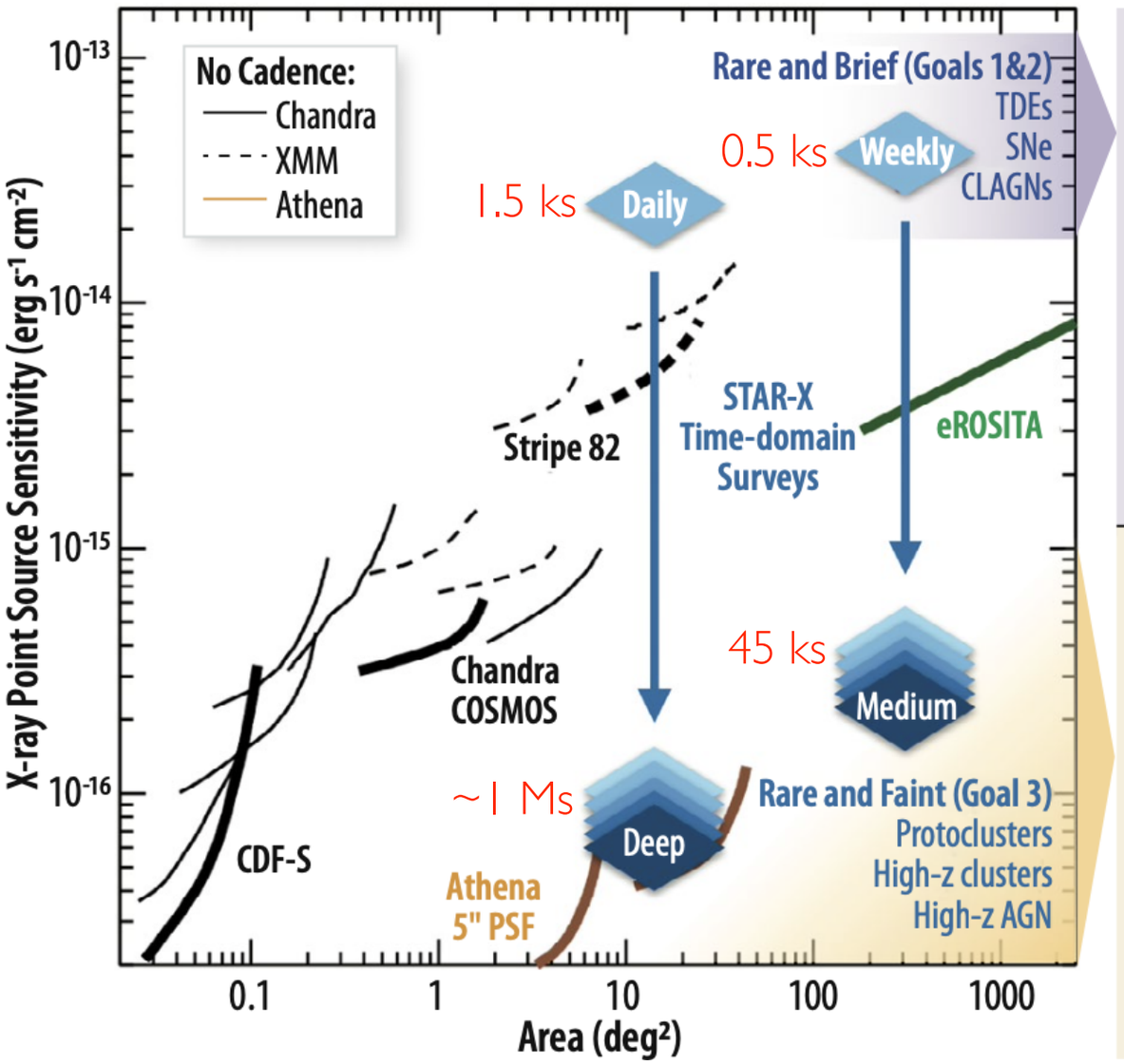
STAR-X finds rare and brief events and rare and faint high-z objects

High-cadence, wide-and-deep surveys



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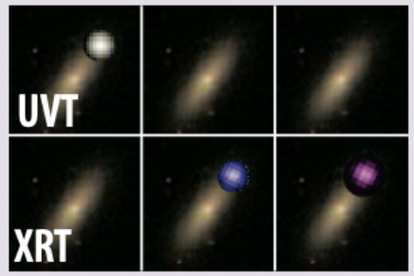

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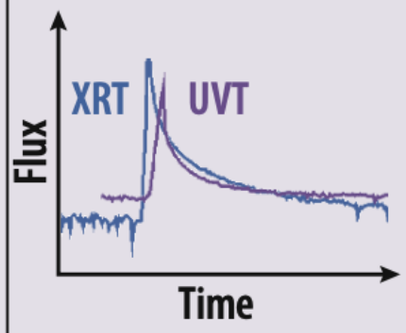

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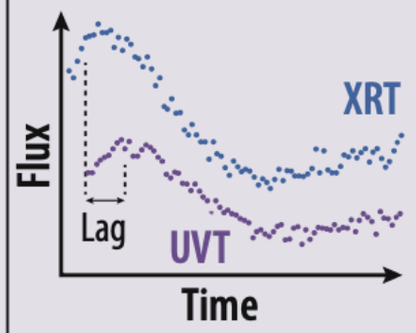

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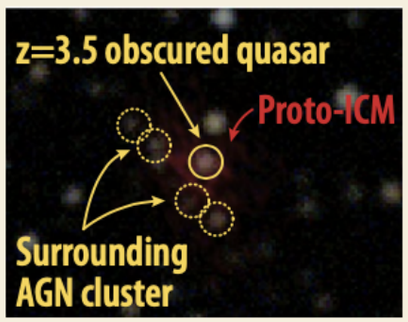

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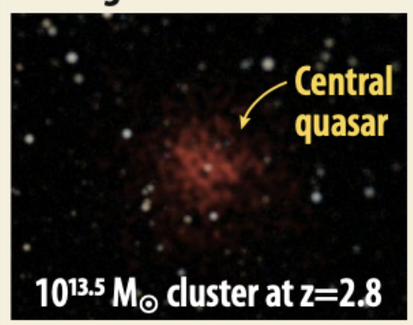

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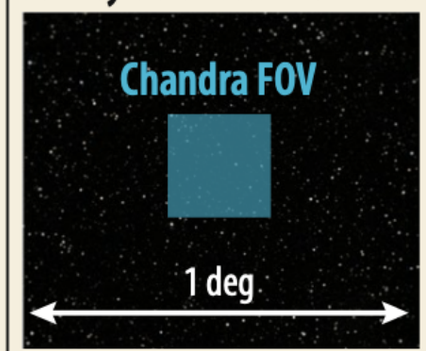

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Final depths: MEDIUM: 5×10^{-16} cgs over 350 deg^2 (>100x Chandra COSMOS Legacy)
DEEP: 9×10^{-17} cgs over 13 deg^2 (>100x 1Ms Chandra Deep Field South)

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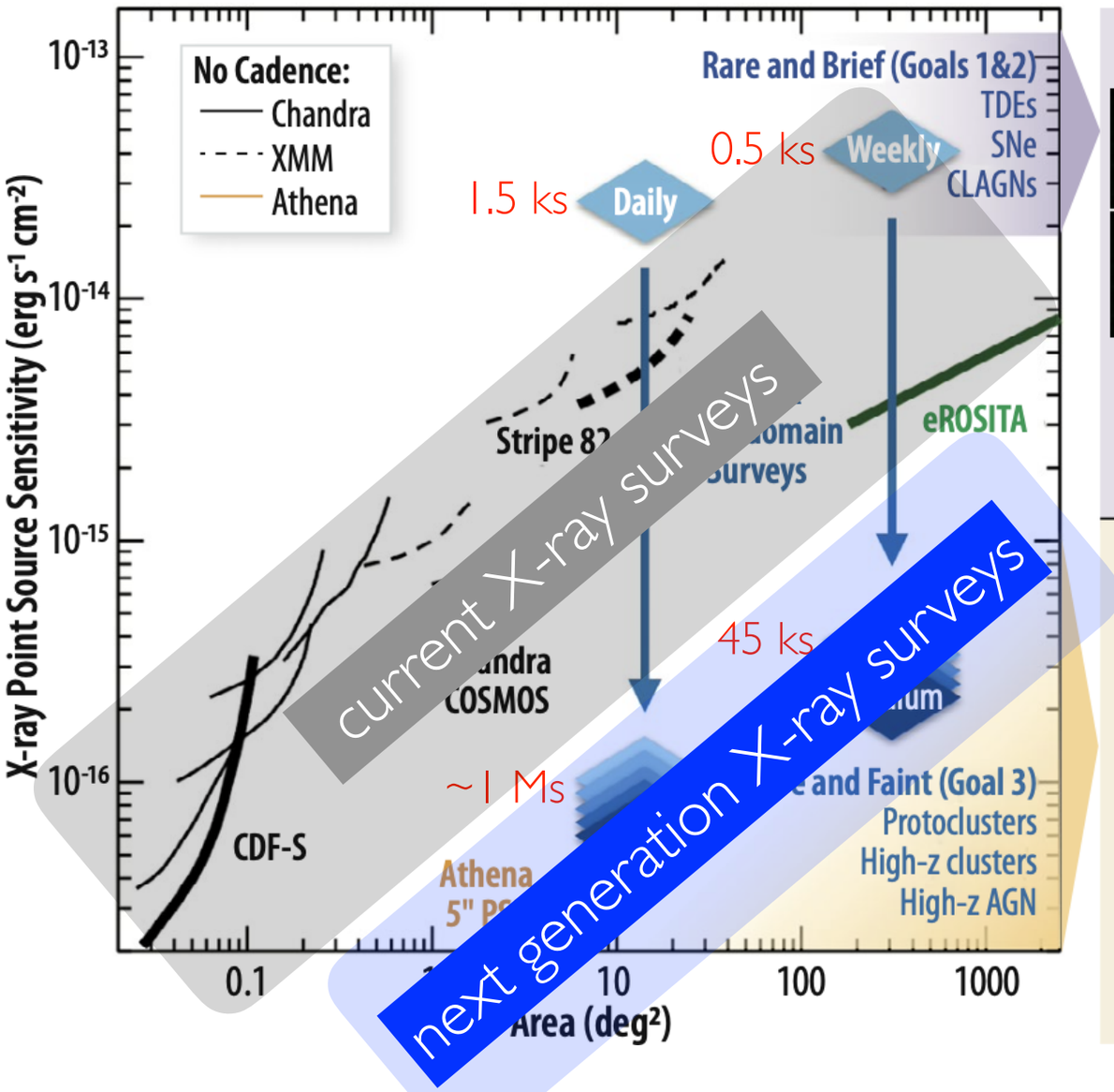

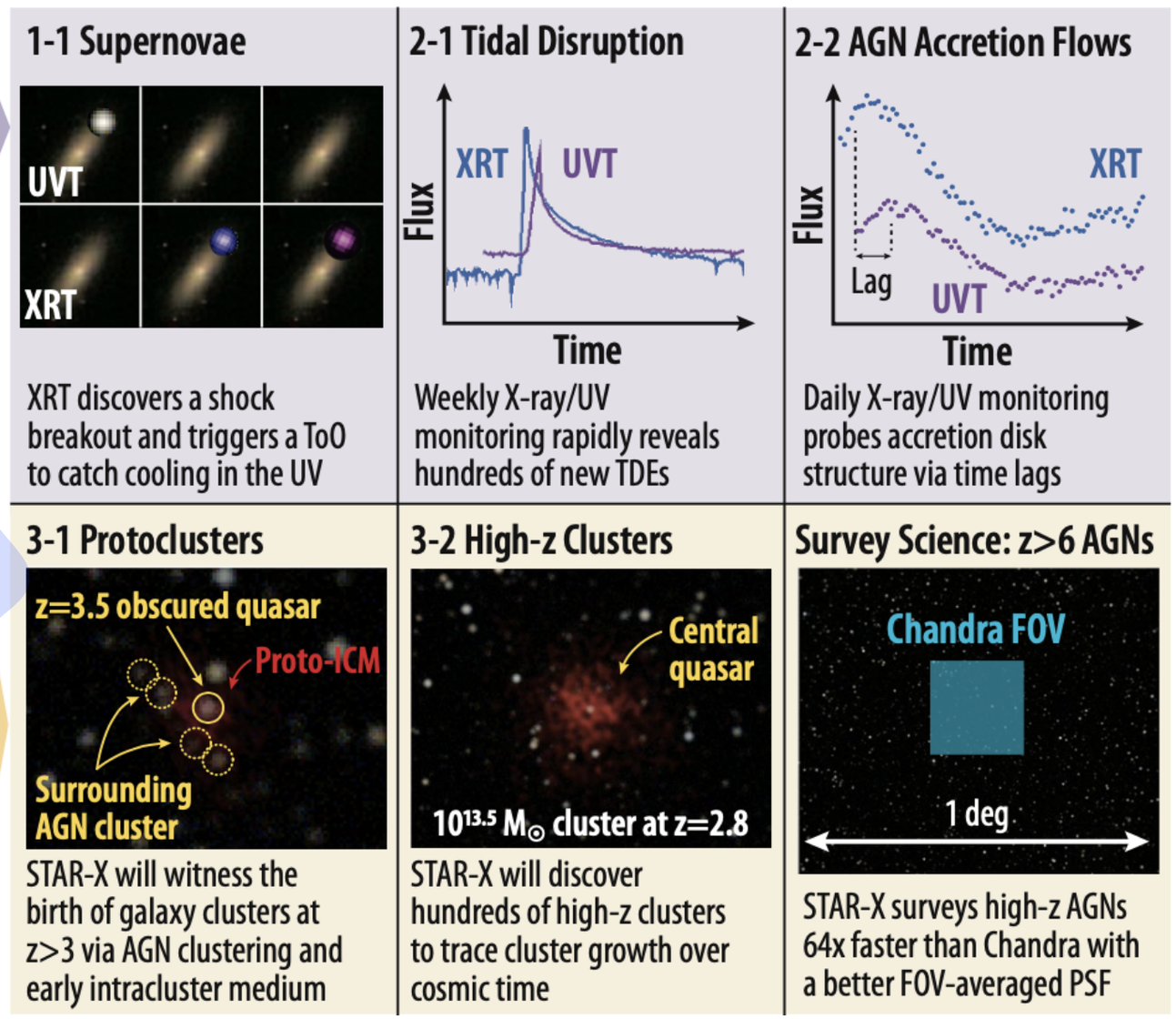

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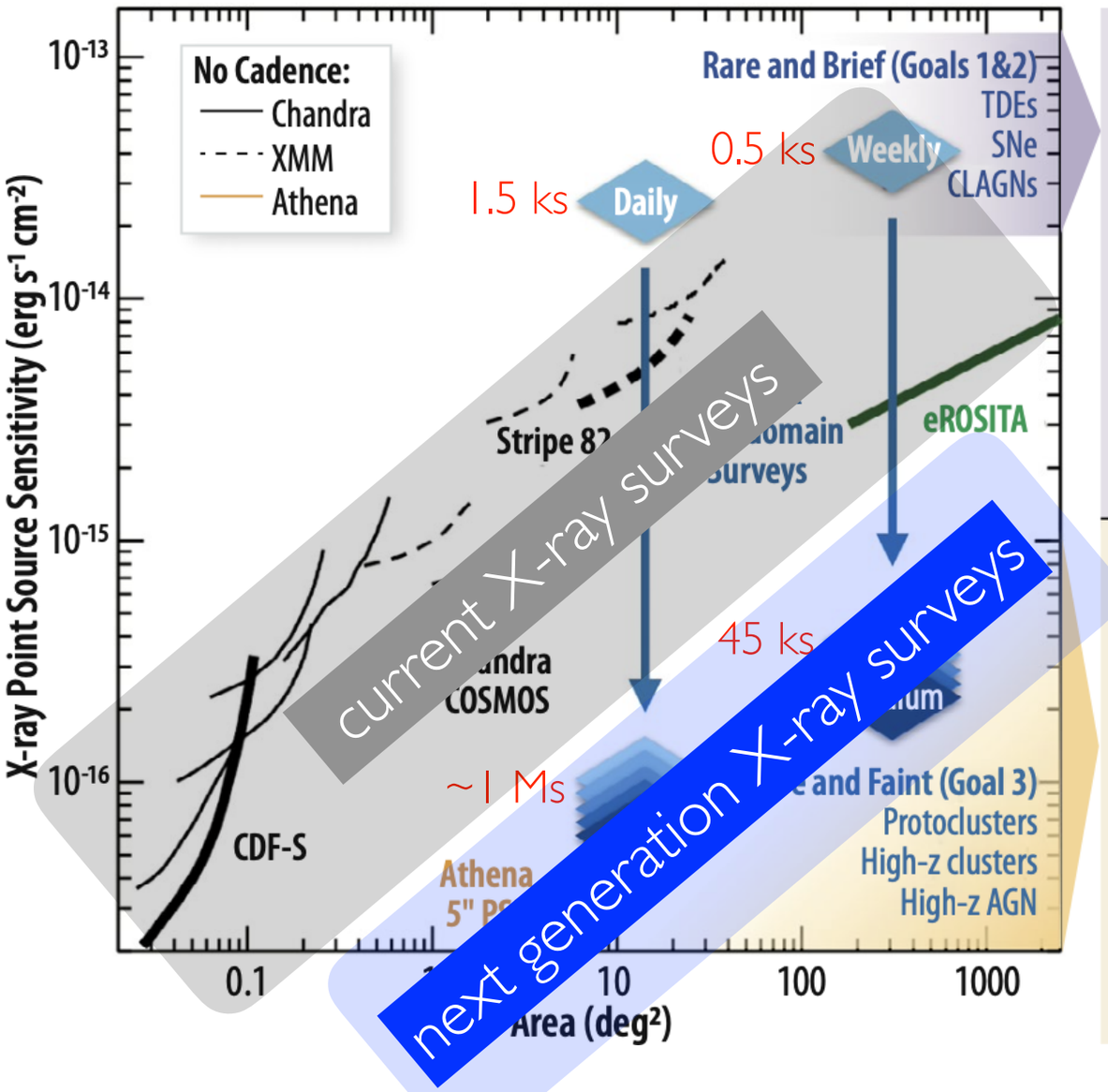

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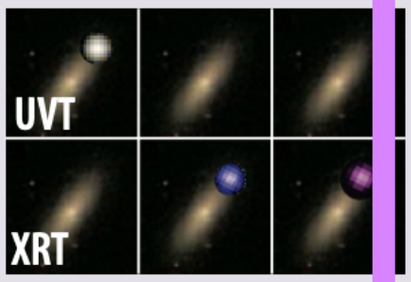

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FURIOUS

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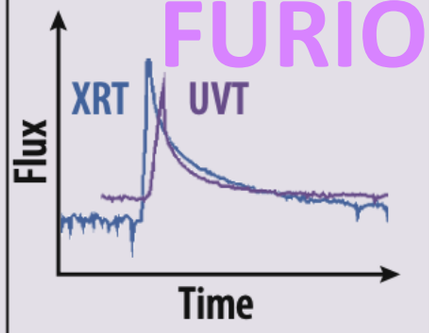
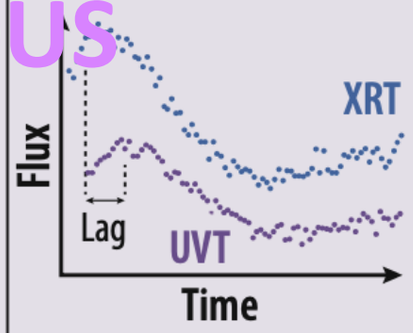


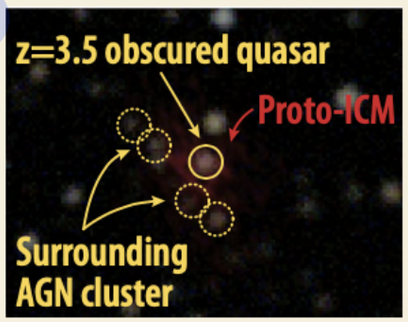
Weekly X-ray/UV monitoring rapidly reveals hundreds of new TDEs

2-2 AGN Accretion Flows



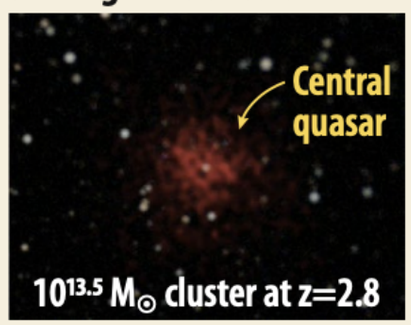
Daily X-ray/UV monitoring probes accretion disk structure via time lags

3-1 Protoclusters



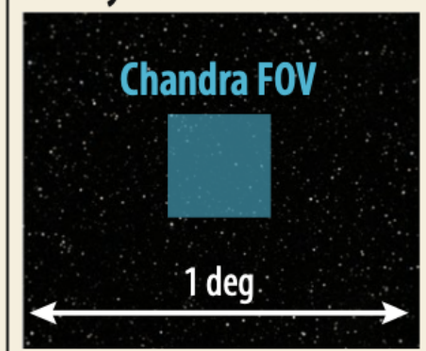
STAR-X will witness the birth of galaxy clusters at z>3 via AGN clustering and early intracluster medium

3-2 High-z Clusters



STAR-X will discover hundreds of high-z clusters to trace cluster growth over cosmic time

Survey Science: z>6 AGNs

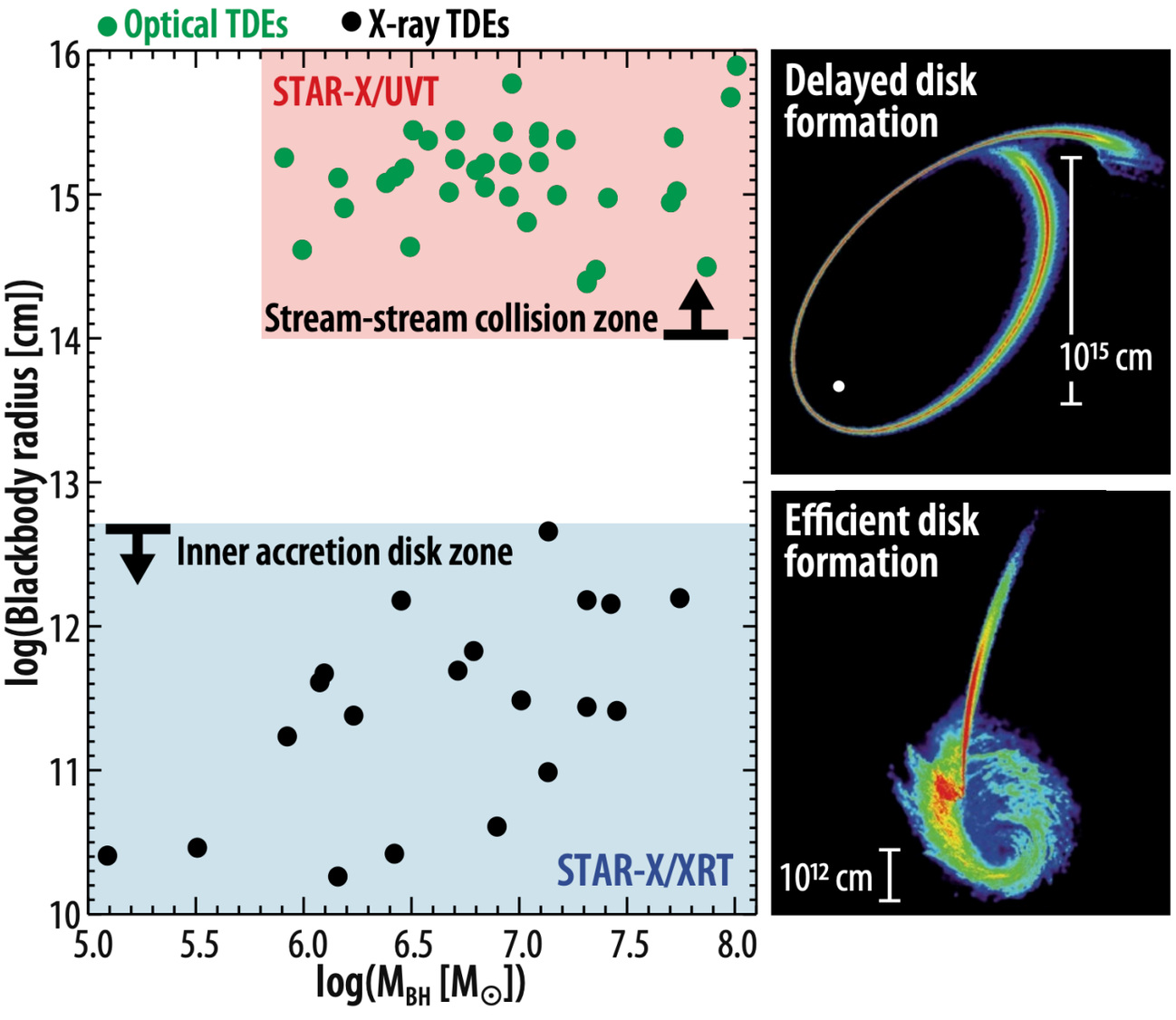


STAR-X surveys high-z AGNs 64x faster than Chandra with a better FOV-averaged PSF

STAR-X finds rare and brief events and rare and faint high-z objects

Final depths: MEDIUM: 5×10^{-16} cgs over 350 deg^2 (>100x Chandra COSMOS Legacy)
DEEP: 9×10^{-17} cgs over 13 deg^2 (>100x 1Ms Chandra Deep Field South)

2.1- Determine how stellar debris accretes onto black holes in X-ray selected TDEs



Vast majority of TDEs discovered in the optical, emission process uncertain

X-ray TDEs probe newly formed disks

Major questions:

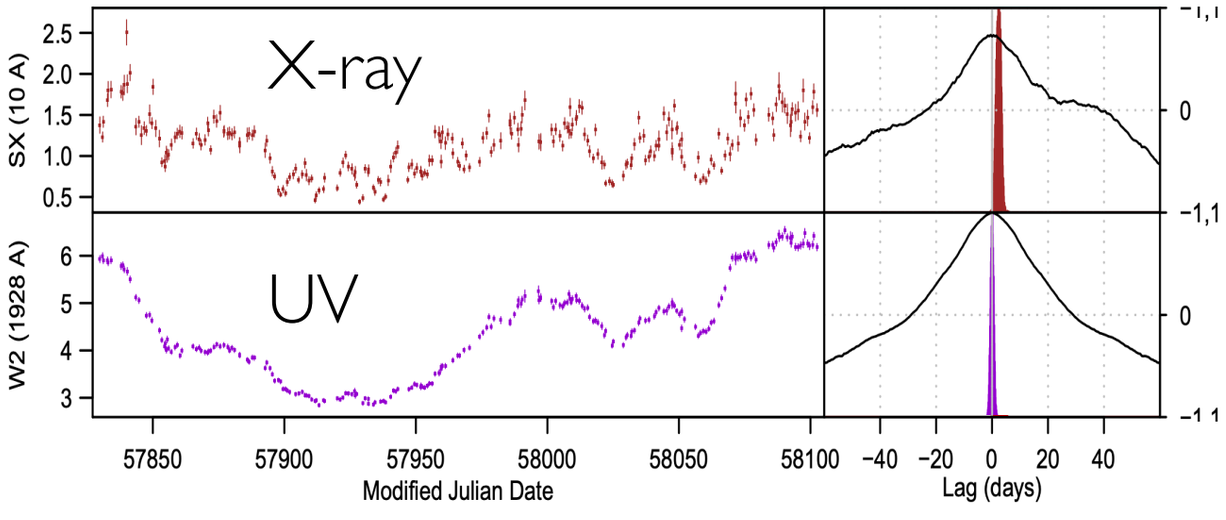
- What are the timescales for the formation of the accretion disk (and corona and jet/outflow)?
- What processes rule X-ray and UV emission?

STAR-X will discover and monitor hundreds of new TDEs in the X-rays and UV to definitively answer this questions, and enable measurements of BH masses and accretion rates

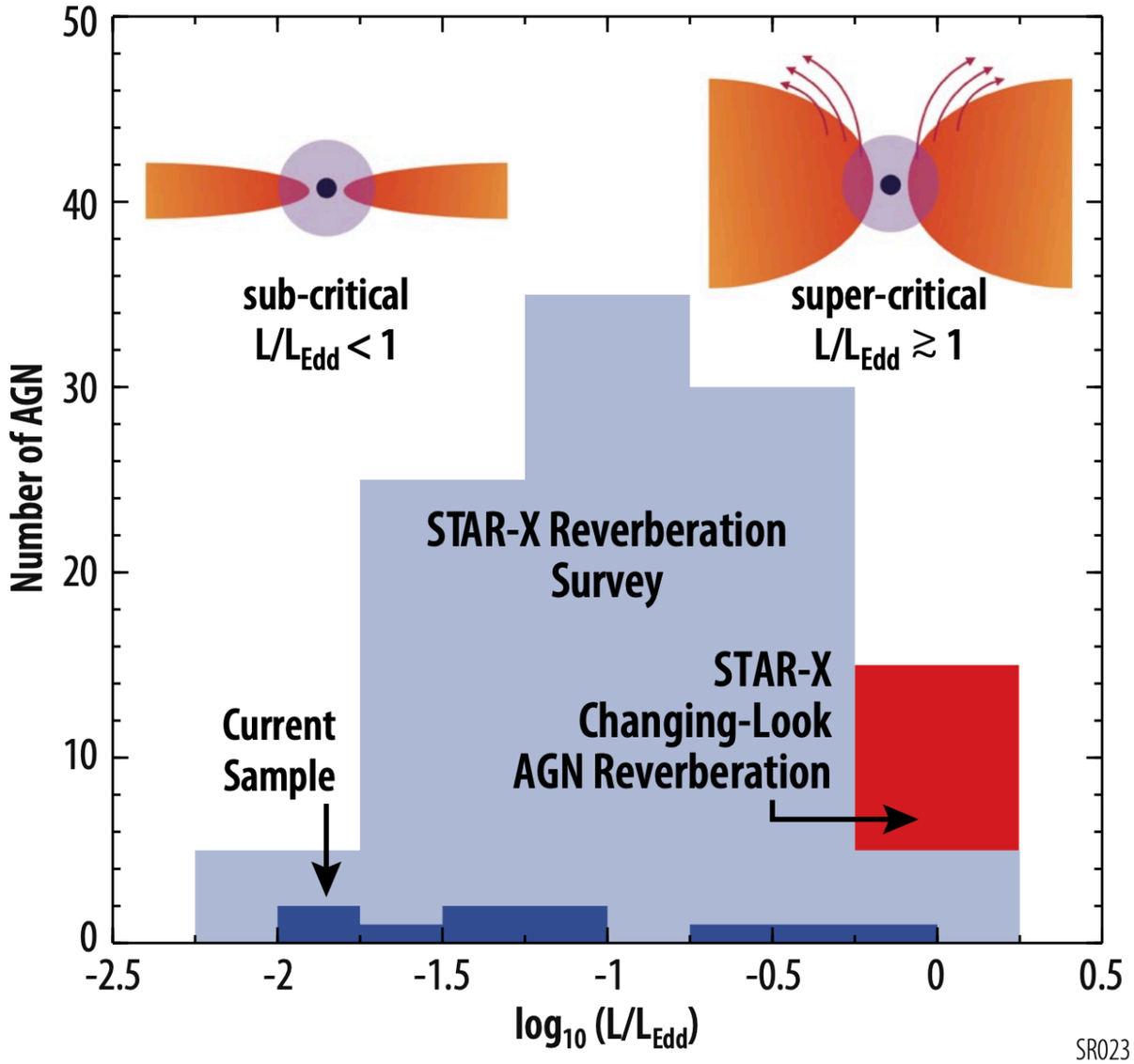
2.2 - Discover how the accretion flow geometry depends on the accretion rate: first X-ray/UV AGN Reverberation Mapping Survey

Deep, daily-cadenced surveys with STAR-X will enable X-ray/UV reverberation mapping for >70 AGN and determine:

- the causal connection between the accretion disk and the corona (and/or jet base)
- the structure of the disk as a function of Eddington ratio



Swift UV/X-ray campaign; Edelson et al., 2019



CONCLUSIONS

- STAR-X represents an unmatched opportunity to realize near-term cadenced, wide-and-deep X-ray and UV surveys.

- Major advances expected over a broad range of science themes, ranging from SNe, to AGN, to galaxy clusters. AGN time-domain studies are one of the three major science goals.

- Spring 2024: final decision on selection for Phase B, for a launch expected before 2030.

- Fills-in the gap in sensitive X-ray and UV instrumentation in the next decade.