# **NewAthena** – the *next* decade of X-ray observation

*Chandra and XMM-Newton at 25 - Utilising Several Decades of X-ray observation*
UK National Astronomy Meeting, July 2025

James Aird
(University of Edinburgh)

On behalf of the
NewAthena Science Study Team (NASST)

Credit: IRAP, CNES, ESA & ACO

# *NewAthena* Science Study Team (NASST)

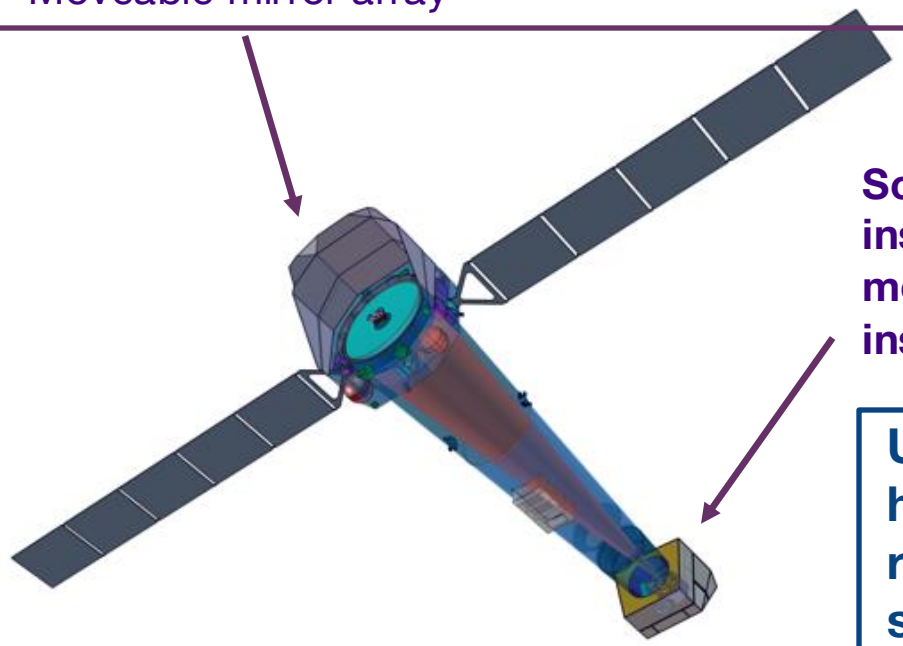
**Dr Matteo Guainazzi** - ESA project scientist - ESTEC/ESA, **Prof Didier Barret** - X-IFU PI - Institut de Recherche en Astrophysique et Planétologie, **Prof Kirpal Nandra** - WFI PI - Max-Planck-Institute für extraterrestrische Physik, **Dr James Aird** - University of Edinburgh, **Dr Laura Brenneman** - NASA representative - Harvard & Smithsonian Center for Astrophysics, **Dr Elisa Costantini** - SRON Netherlands Institute for Space Research, **Dr Thomas Dauser** - Dr. Karl Remeis-Sternwarte. Universität Erlangen-Nürnberg, **Dr Dominique Eckert** - Université de Genève, **Dr Hirofumi Noda** - JAXA representative - Astronomical Institute. Tohoku University, **Dr Ciro Pinto** - Istituto di Astrofisica Spaziale e Fisica Cosmica Palermo (INAF – IASF), **Dr Gabriel Pratt** - CEA Saclay - IRFU - Département d'Astrophysique, **Prof Nanda Rea** - Institut de Ciencies de l'Espai (ICE-CSIC), **Dr Eleonora Troja** - Università degli Studi di Roma Tor Vergata.

- Members selected following an open call (plus appointments by Instrument Consortia and partner Agencies)
- Appointed by ESA in May 2024 – in charge until *NewAthena* Adoption
- NASST mandate:
  - Define the science requirements of the mission
  - Support the ESA Study on all aspects related to the science return of NewAthena
  - Act as a focus for the interests of the broad scientific community

# *NewAthena:* three key science-enabling innovations

## Largest space-qualified X-ray mirror for astronomy

- Silicon Pore Optics technology (1.0m$^2$ area @ 1keV)
- ~9” spatial resolution (half-energy width)
- Moveable mirror array

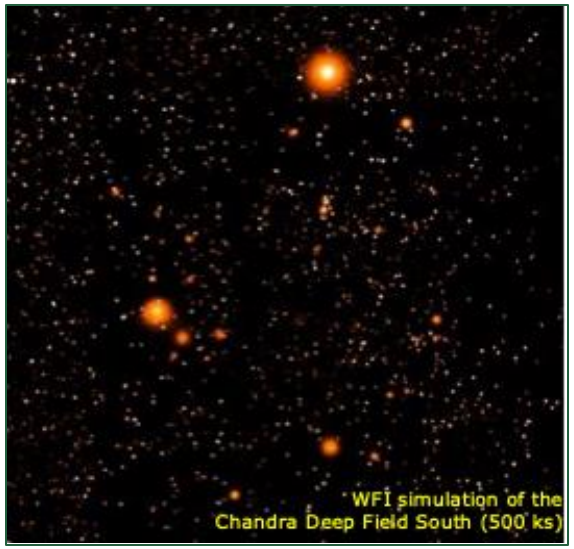


**Science instrument module, two instruments:**

## Fastest X-ray sky survey machine

- **Wide Field Imager (WFI)**
- DEPFET detector
- <170 eV energy resolution @ 7keV
- High count-rate capabiliities
- 40’x40’ field-of-view

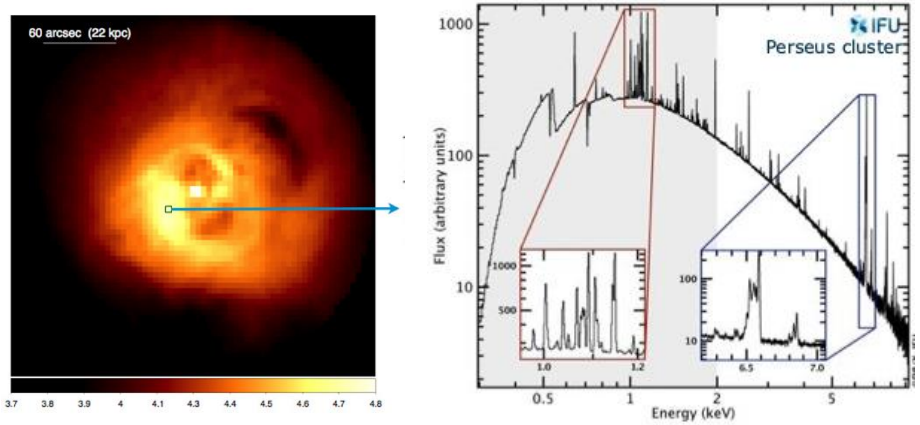
Credit: Arne Rau




## Unprecedented, high-resolution spatially resolved X-ray spectroscopy

- **X-ray Integral Field Unit (X-IFU)**
- ≤4eV energy resolution.
- >1500 pixels, 5” each.
- 4’ diameter field-of-view

Credit: Didier Barret



# *NewAthena* timeline and current status

- 2013:
  **"The Hot & Energetic Universe"** selected as the science theme for 2nd large-class (L2) mission in ESA's long-term "Cosmic Vision" plan.
- 2014:
  ***Athena*** selected as mission to address this theme.
  Entered study phase.
- 2022:
  *Athena* deemed to be too expensive for ESA. Terminated in June 2022
- ESA mandated by the Science Program Committee (SPC) to study a new concept (**"*NewAthena*"):**
  - Consistent with a 1.3billion € cap
  - Scientifically "flagship mission"

***Athena* study phase**

**N.B. non-linear scale!**

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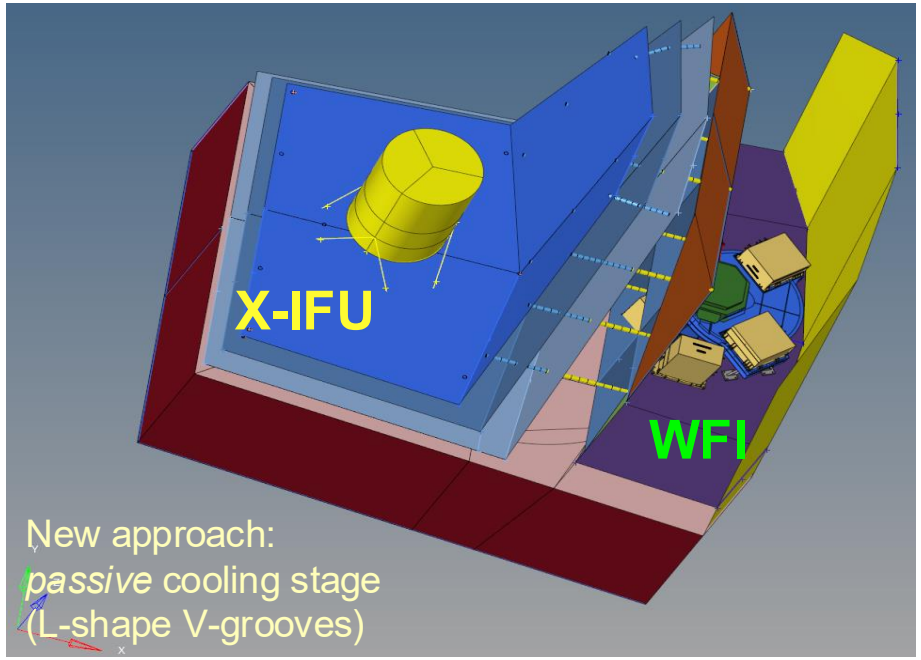


- Retain three key elements including **both instruments** sharing same focal plane

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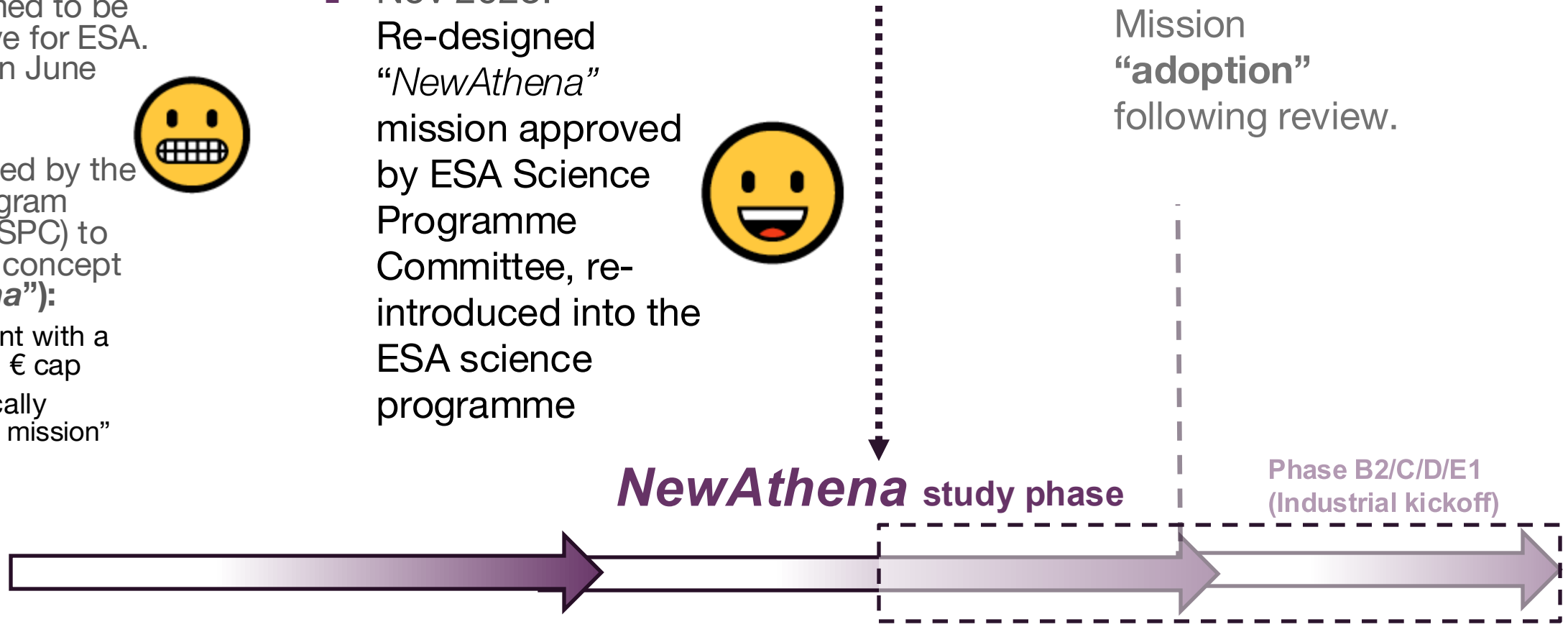


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# *NewAthena* timeline and current status

Recently completed an **Interim Review** of mission, spacecraft and instrument design

- No showstopper found for 2027 adoption.
- No significant performance deficits identified.
- Available resources sufficient e.g.mass-compliant with launcher with sufficient margin.
- Technologies at right level with risk mitigations in place.
- Programmatic risk from US contribution.
- Schedule analysis suggests feasible launch mid-2038 (TBC)
- Costs on target
- **Interim Review declared successful**

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**Launch 2038**

***NewAthena* study phase**

**Phase B2/C/D/E1 (Industrial kickoff)**

**5-year nominal mission**

N.B. non-linear scale!

# Science with NewAthena

- As part of the re-definition process, ESA appointed a *Science Re-definition Team* who **re-assessed and updated** the scientific case for the mission in light of redefined specifications.

- Concluded that an X-ray observatory matching NewAthena's specifications specifications will have a **transformational impact on most areas of modern astrophysics** and uniquely address a set of fundamental questions, including:
  - How does the stellar radiation field affect the habitability of planetary systems, and h is it in turn influenced by the presence of nearby planets?
  - What is the equation of state regulating matter in neutron stars?
  - What is the origin of the high-energy processes in the close environment of black hol
  - What distribution of supernovae and supernova explosions leads to the mixture of metals we measure in the local Universe? How are metals distributed through the cosmos?
  - What drives the cosmological co-evolution of galaxies and supermassive black holes?
  - How does SMBH feedback shape the large-scale baryon distribution?
  - How do large-scale structures in the Universe form and evolve? What physics defines their hot gas content?
  - What is the astrophysical nature of the most common celestial sources of neutrinos and gravitational waves?
  - Also defined a set of **mission-driving science objectives** that determine the mission specifications (further developed by NASST to specify NewAthena *Science Requirements Document)* and will form foundation of Study Assessment Report (Redbook)

# *NewAthena* community Working groups

| WG1 | WG2 | WG3 | WG4 |
|---|---|---|---|
| **Large-scale structure of the Universe**<br>Chair: Aurora Simionescu | **Galaxies and supermassive black holes**<br>Chair: Javier García | **Stars and their environment**<br>Chair: Marco Miceli | **Compact objects**<br>Chair: Matthew Middleton |
| Pinto, Pratt | Aird, Brenneman, Noda | Costantini | Dauser, Rea |
| **Co-chairs:**<br>Mariachiara Rossetti / François Mernier | **Co-chairs:**<br>Fancisco J. Carrera / Giovanni Miniutti | **Co-chairs:**<br>Costanza Argiroffi / Manami Sasaki | **Co-chairs:**<br>Enrico Bozzo / Sebastien Guillot |

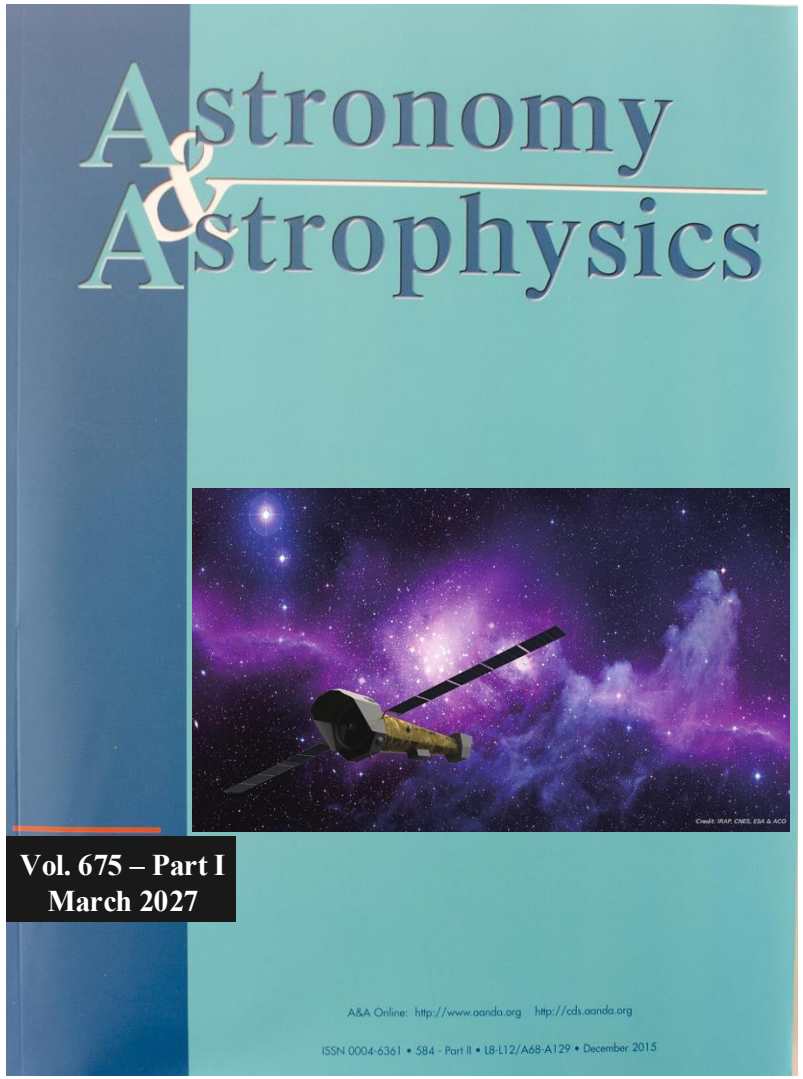
| WG5 | WG6 | WG7 |
|---|---|---|
| **Transients and multi-messenger astrophysics**<br>Chair: Carlo Ferrigno | **Cosmology and fundamental physics**<br>Chair: Esra Bulbul | **Science Support**<br>Chair: Fabio Acero |
| Troja | Eckert | Guainazzi |
| **Co-chairs:**<br>Tingting Liu / Shuo Zhang | **Co-chairs:**<br>Julia Sisk Reynes / Florian Pacaud | **Co-chairs:**<br>Iacopo Bartalucci / Liyi Gu |

*NewAthena* science community: **1130 members** following recent call (early 2025)

- 6 ”science topic” WGs, spanning *NewAthena* science
- 7th “Science support” WG on theory, simulations, synthetic observations, data analysis, systematic uncertainties.
- Each WG has **“NASST liasons”** to ensure smooth communication with the NASST

# Astronomy & Astrophysics Special Issue

- The Astronomy & Astrophysics Editorial Board has agreed to host a **Special Issue on NewAthena science**
- **Short, refereed papers demonstrating a *science topic* that may be addressed with *NewAthena*.**
- A call for abstracts will be issued in **mid-July 2025**
  (deadline 30th Sept 2025 → internal review/reconciliation of topics by WG chairs/NASST)
- Submissions warmly welcomed from *across astronomical community* (including and especially early-career researchers).
- Papers shall be prepared in the **first half of 2026**
- Lean internal review process before the formal submission to the journal (**Q3/2026**)
- Target for publication is **early 2027** → published concurrently, and in support of Adoption



# Example of a (mission-driving) *NewAthena* science objective:

Measure the space density of **moderate-luminosity, obscured** Active Galactic Nuclei (*that cannot be identified at other wavelengths*) out to *at least* z=8. Measure their luminosity **and obscuration via X-ray spectral analysis.**

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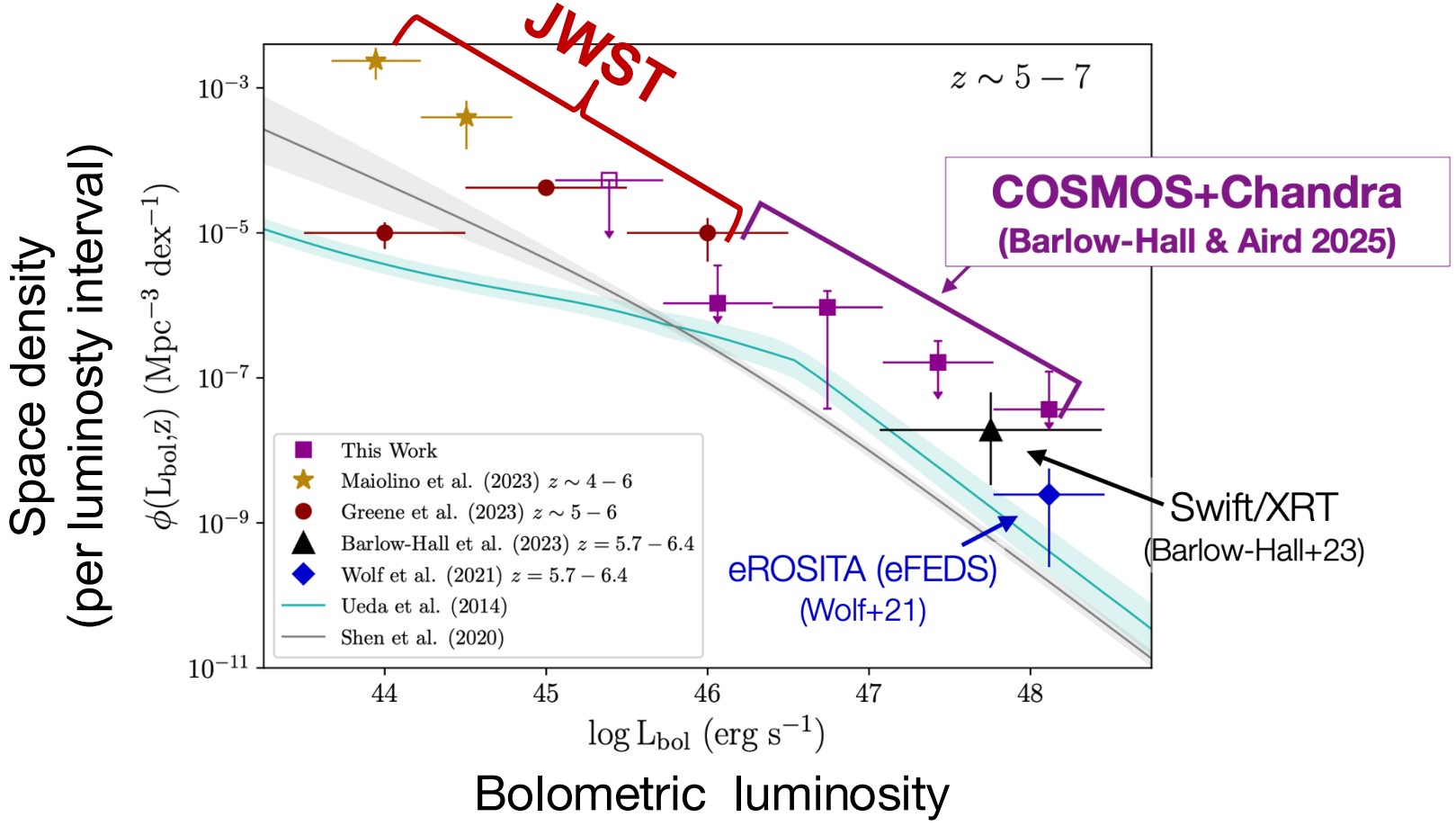
- Recent measurements suggest a high-level of supermassive black hole growth at early cosmic times (primarily via *obscured* AGN)

Cassandra Barlow-Hall



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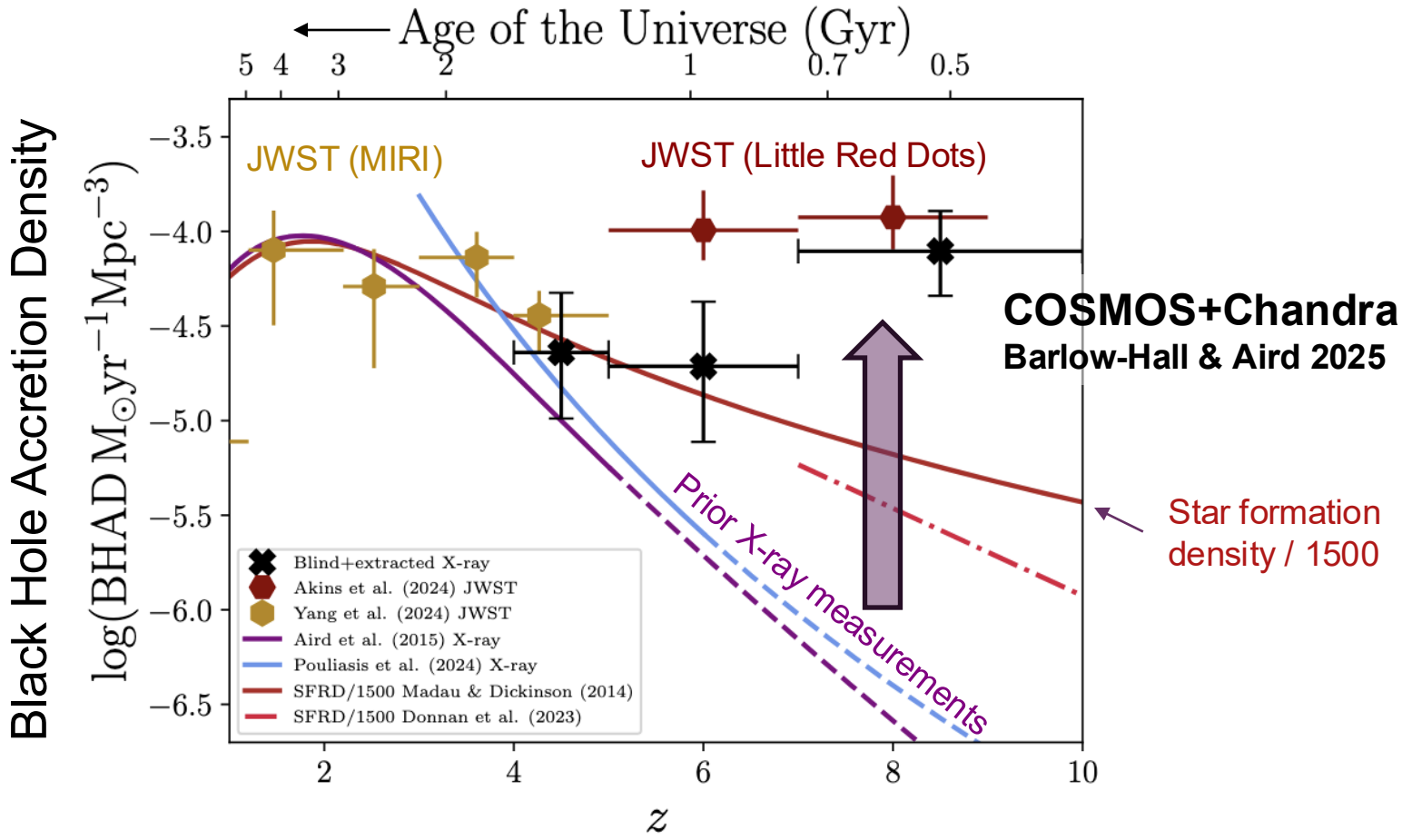

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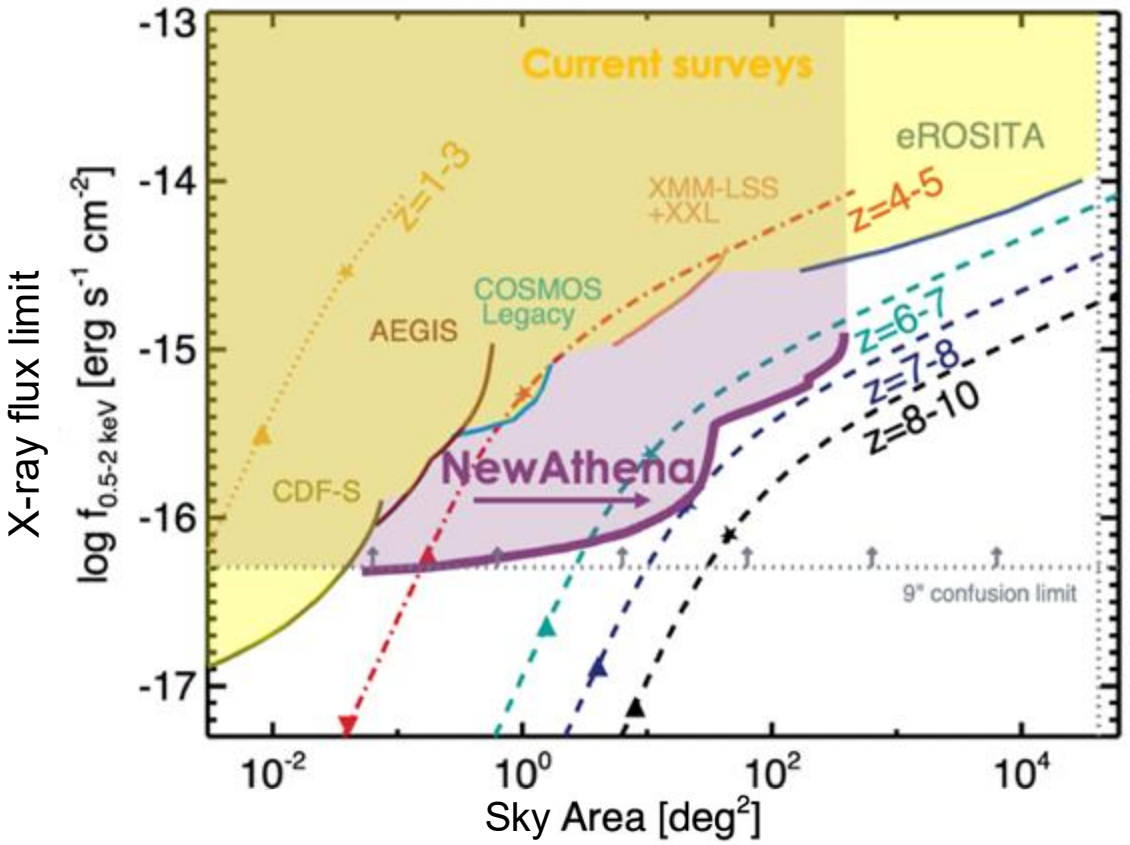
- **Motivates a deep (≥200ks), moderate-area (~50 deg$^2$) survey with WFI to identify high-z AGN**

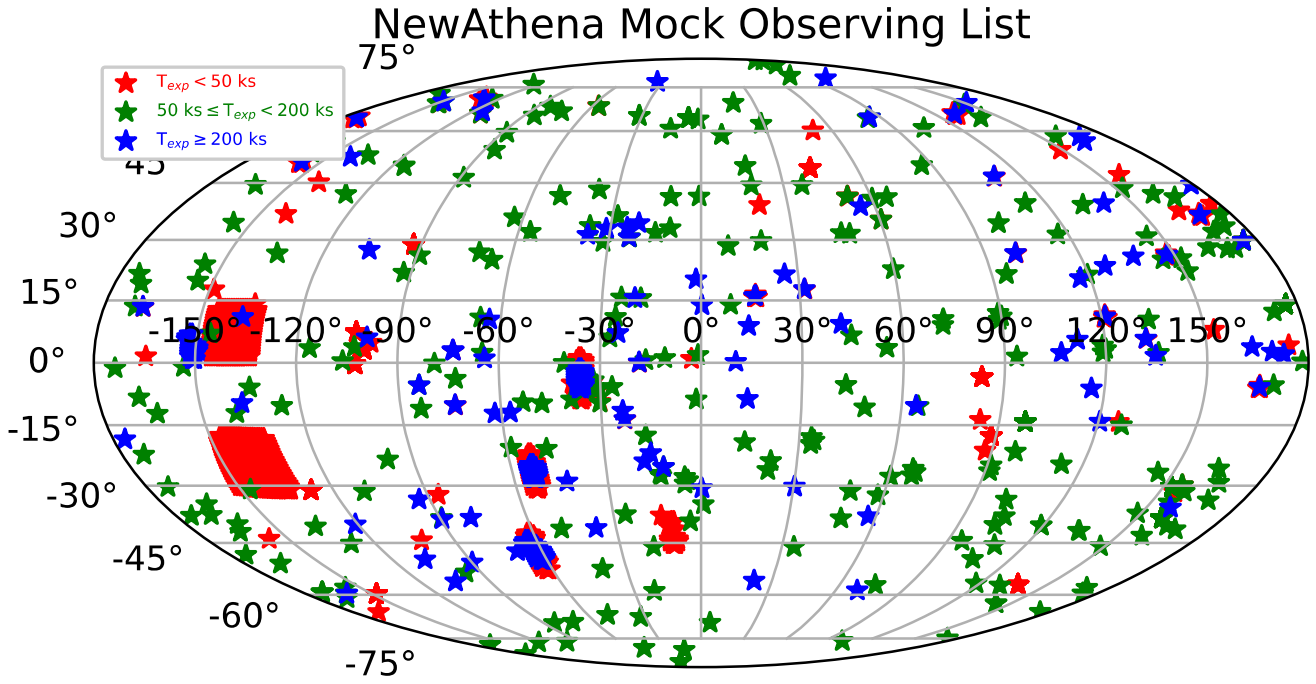



Wider/shallower component driven by distinct science objective (early groups)

**860x10ks**
**70x200ks +**
**30x300ks**
**=31.6Ms**

Deeper observations to improve spectral characterisation

# The *NewAthena* WFI survey




- Instatiation of possible observations fulfilling the SCIOBJs
- N.B. leaves **26.5%** of the 5-year operations for “Discovery science”

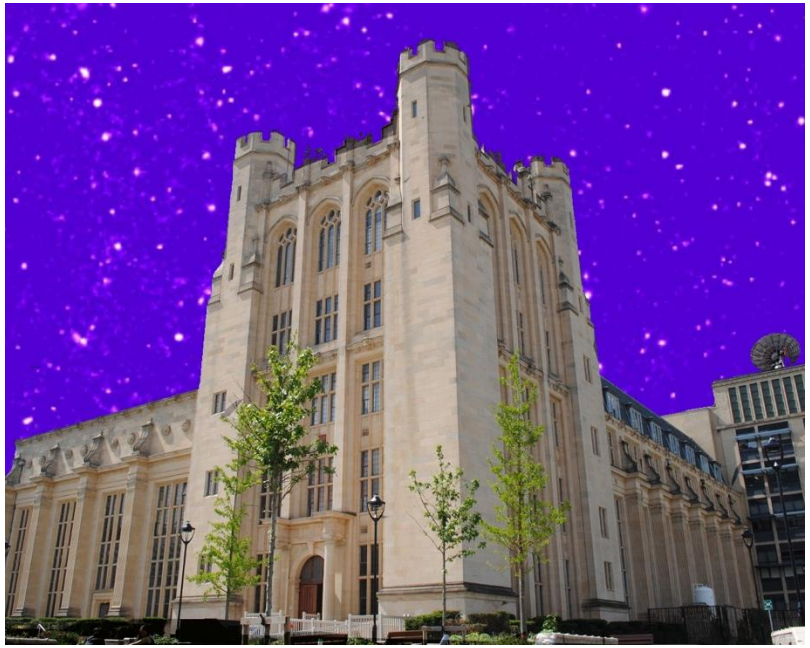
- **Includes a realisation of the 31.6 Ms WFI survey**
  - The **ultra-deep tier** should be driven by the Roman time-domain/ultra-deep/deep surveys
    - Full HLWAS ultra-deep area in COSMOS (5 deg$^2$)
    - Full HLTDS deep area in the Euclid Deep Field South (4.5 deg$^2$)
    - HLWAS deep area in XMM-LSS (2.8 deg$^2$)
  - The **deep tier** is driven by the LSST deep-drilling fields
    - COSMOS, XMM-LSS, CDFS, EDFN (total 16.4 deg$^2$)
  - The **wide tier** uses a combination of various surveys
    - Complete coverage of Southern Euclid Deep Fields (20 deg$^2$), Euclid Deep Field Fornat (23 deg$^2$), LSST Deep Drilling field (9.6 deg$^2$), XMM-LS XXL region (15 deg$^2$), EFEDs (140 deg$^2$), 4MOST-WAVES-South (157 deg$^2$)

Notes:

- The exact survey strategy does not need to be completely fixed now, but need a baseline for The Red Book
- Considering potential scheduling of the ultra-deep/deep survey to access **time domain**

# To learn more about *NewAthena*… come to Bristol in September!

- **"New Results in X-ray Astronomy" – Thurs 4th Sept**
  - Showcasing new scientific results in the field of high-energy astrophysics.
- **"NewAthena UK community science meeting" – Fri 5th Sept**
  - Invited talks on the NewAthena mission profile and science objectives.
  - Solicited talks on future facilities and synergies with NewAthena.
  - Contributed talks showcasing broad range of NewAthena-related science.
  - Discussion of UK involvement in the NewAthena project.
- Abstract submission deadline **Monday 14th July**



For more info and to register see:
**https://www.star.bris.ac.uk/meeting/new-results-2025/**

# Take-home messages

- NewAthena is ESA's large observatory to perform the next decade of X-ray observation.
  - On track for adoption into ESA science programme in 2027 and launch in 2038.
- Enables a *broad range* of science through combination of large collecting area mirror (1m$^2$) with high-resolution spatially resolved spectroscopy (X-IFU) and wide-field sensitivity (WFI).
- **Opportunities coming for members of the community to lead A&A special issue papers presenting diverse science topics.**
- Established plans for a multi-tiered survey with WFI (~31.6Ms) targeting key extragalactic fields; potential strategies to access *time domain*?

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