Status of NεαΑθηνά

Matteo Guainazzi

NewAthena Study Scientist

Credit: IRAP, CNES, ESA & ACO

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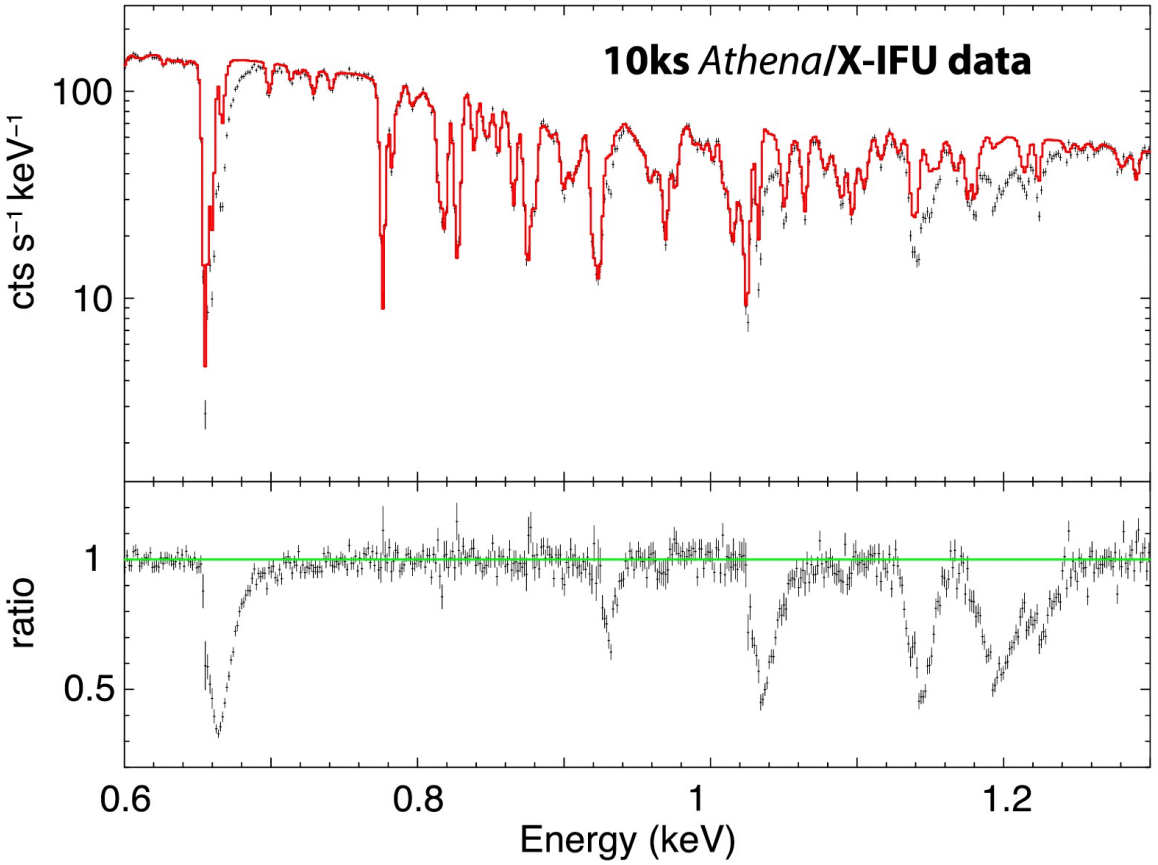
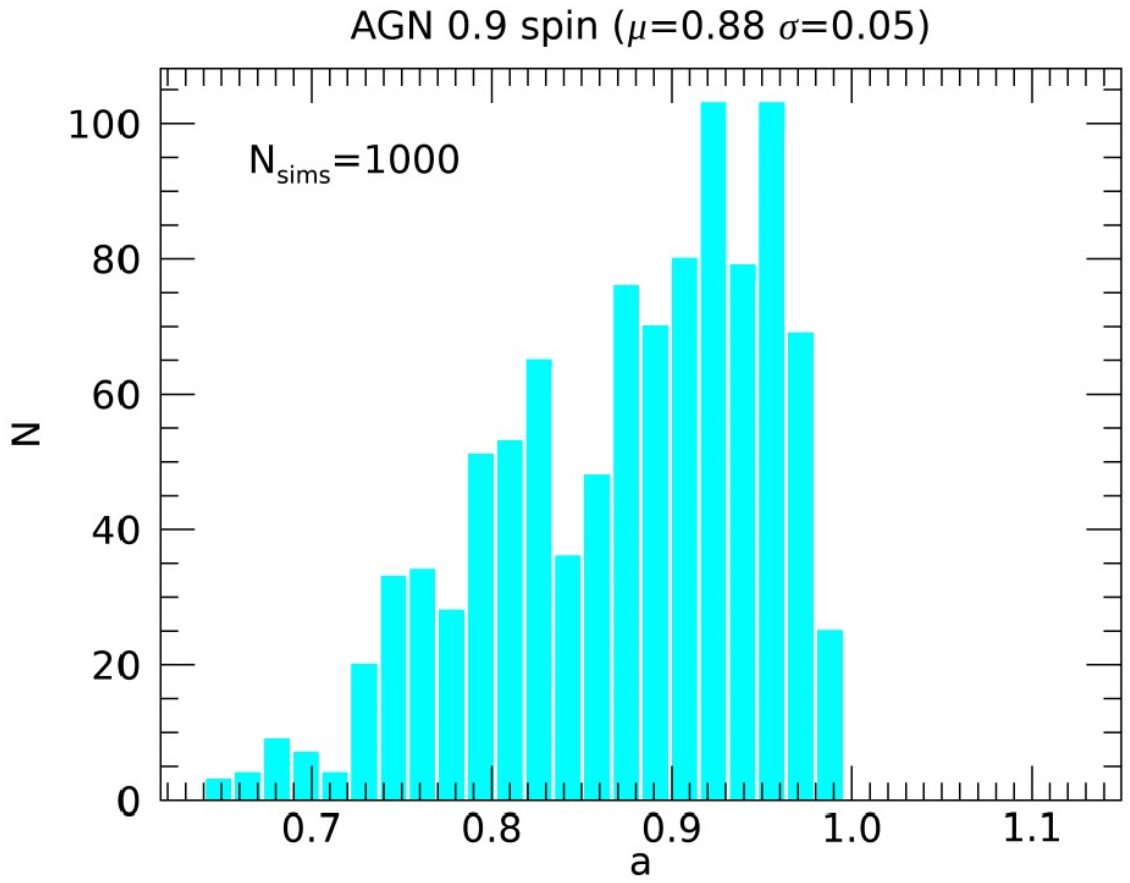
AGN physics with *Athena*

Fukumura et al., 2022, ApJ, 940, 6

Guainazzi et al., 2022, JATIS, 8, 4002



10 ks *Athena*/X-IFU simulation of an AGN with a MHD wind – removed in the residuals to show the "tell-tale" line profile

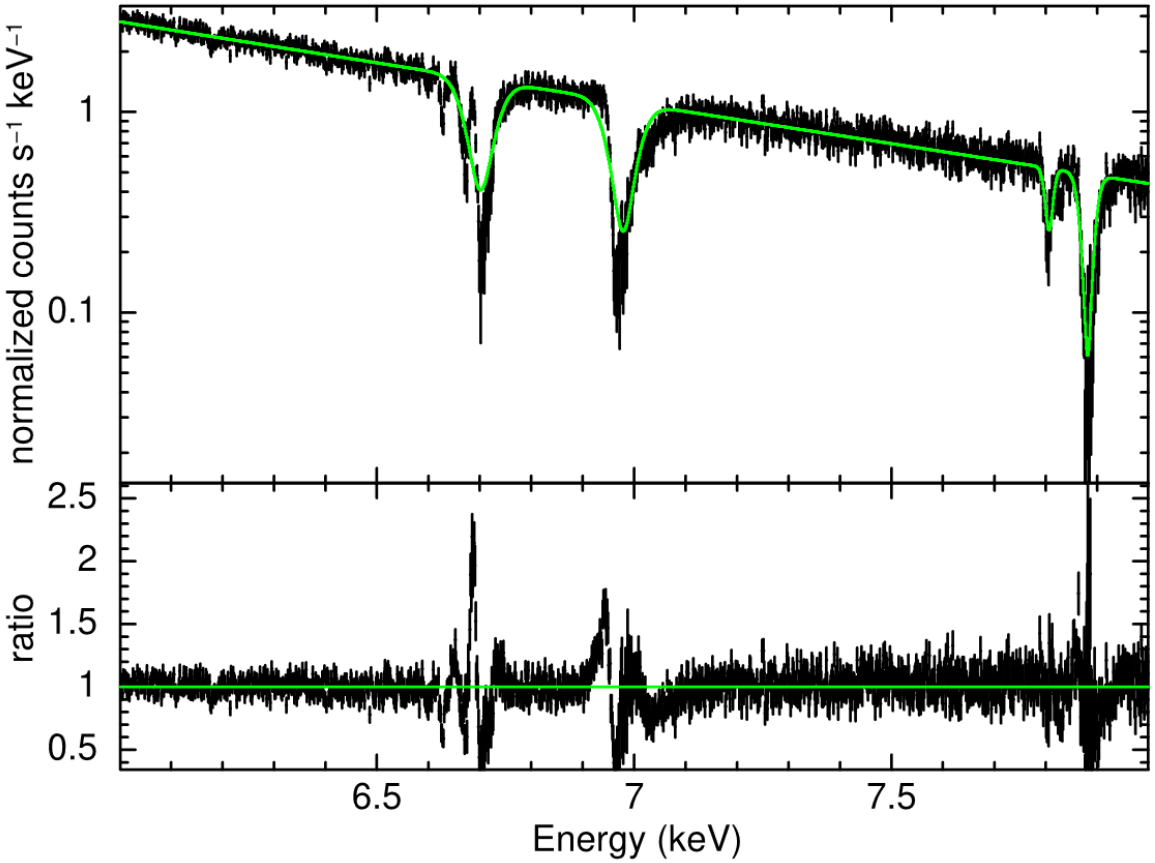


Distribution of uncertainties on the measurement of the AGN black hole spin by *Athena*/X-IFU

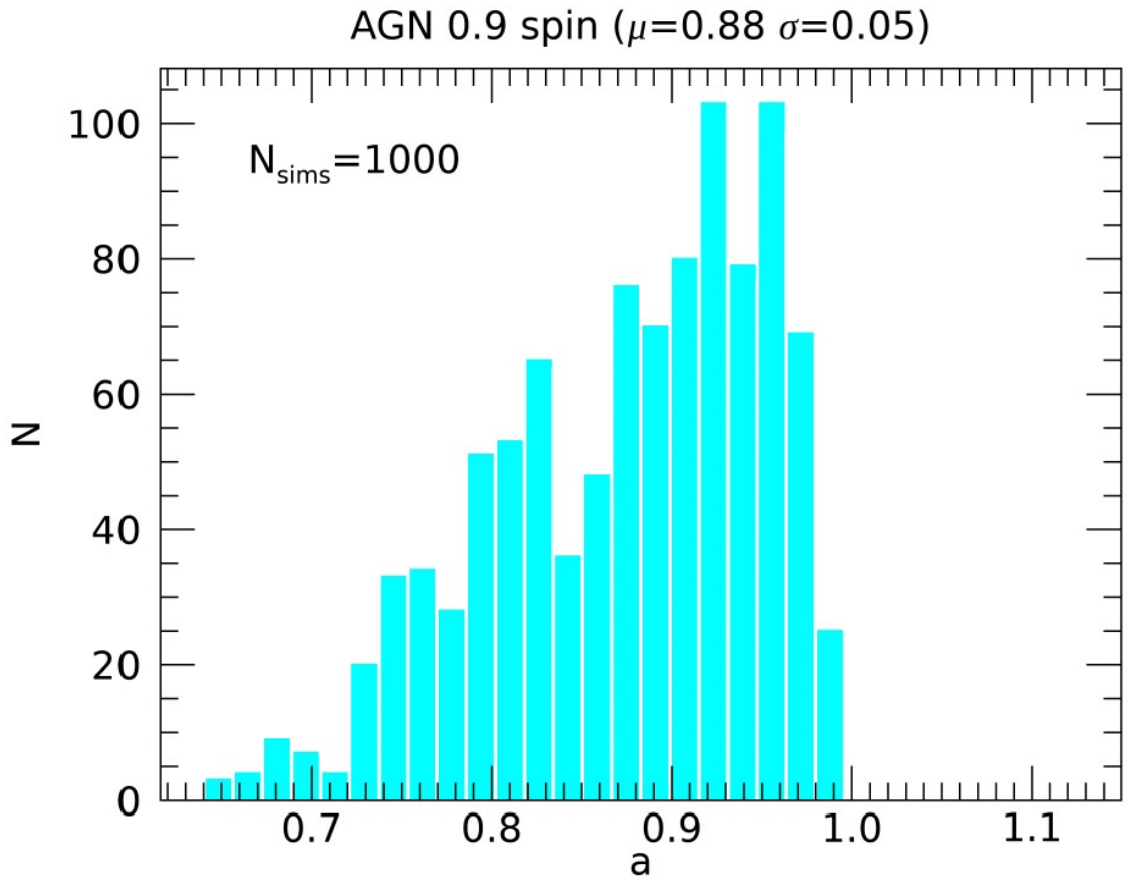
AGN & XRB physics with *Athena*

Chakravorty et al., 2022, MNRAS, 518, 1335

Guainazzi et al., 2022, JATIS, 8, 4002



X-IFU 100 ks smulation of a 100 mCrab XRB with a MHD wind

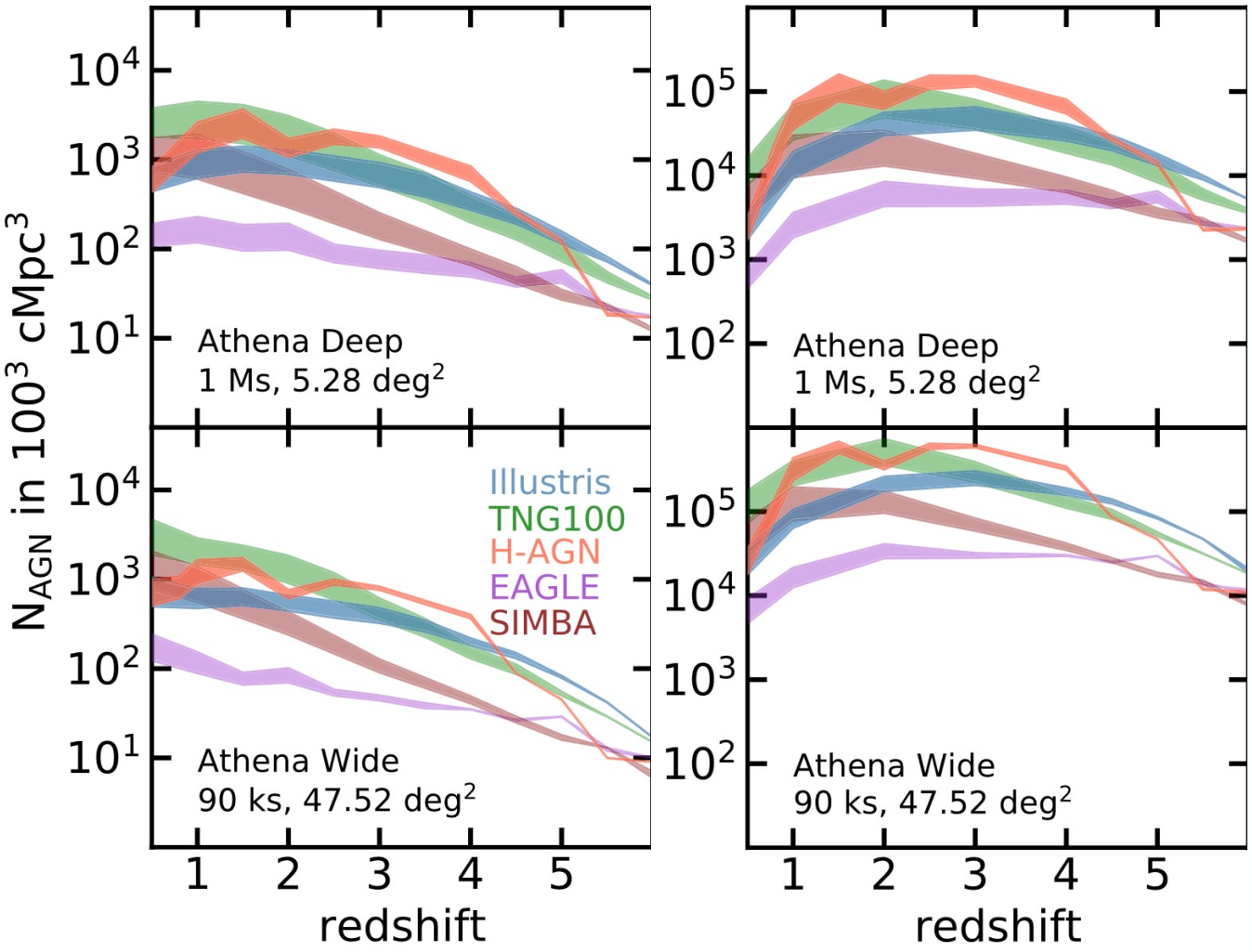


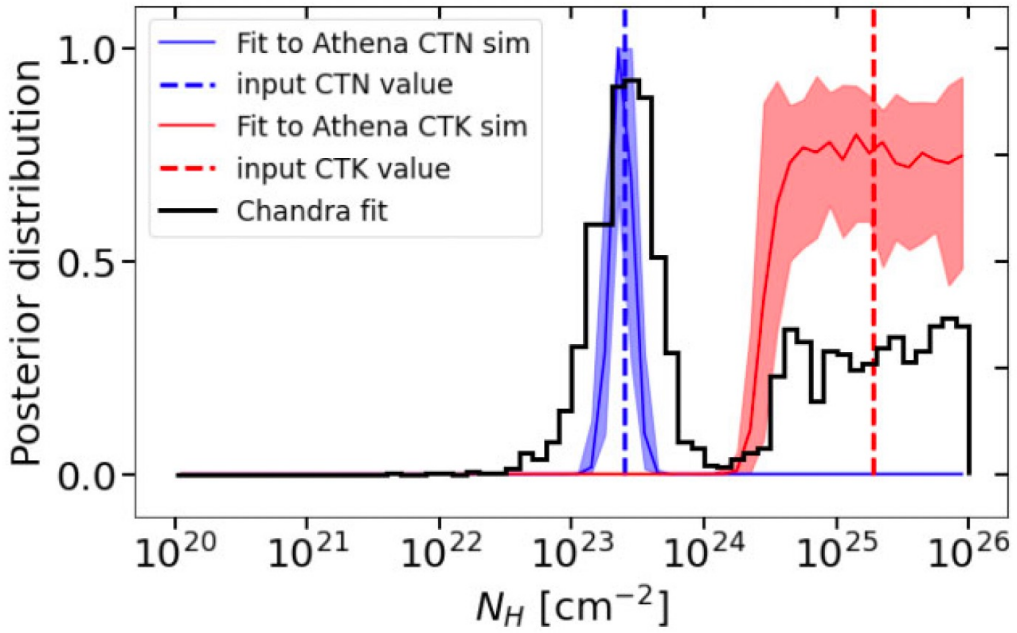
Distribution of uncertainties on the measurement of the AGN black hole spin by X-IFU

AGN population studies with *Athena*

Habouzit et al., 2022, MNRAS, 518, 1335

Laloux et al., 2023, MNRAS, 518, 2546





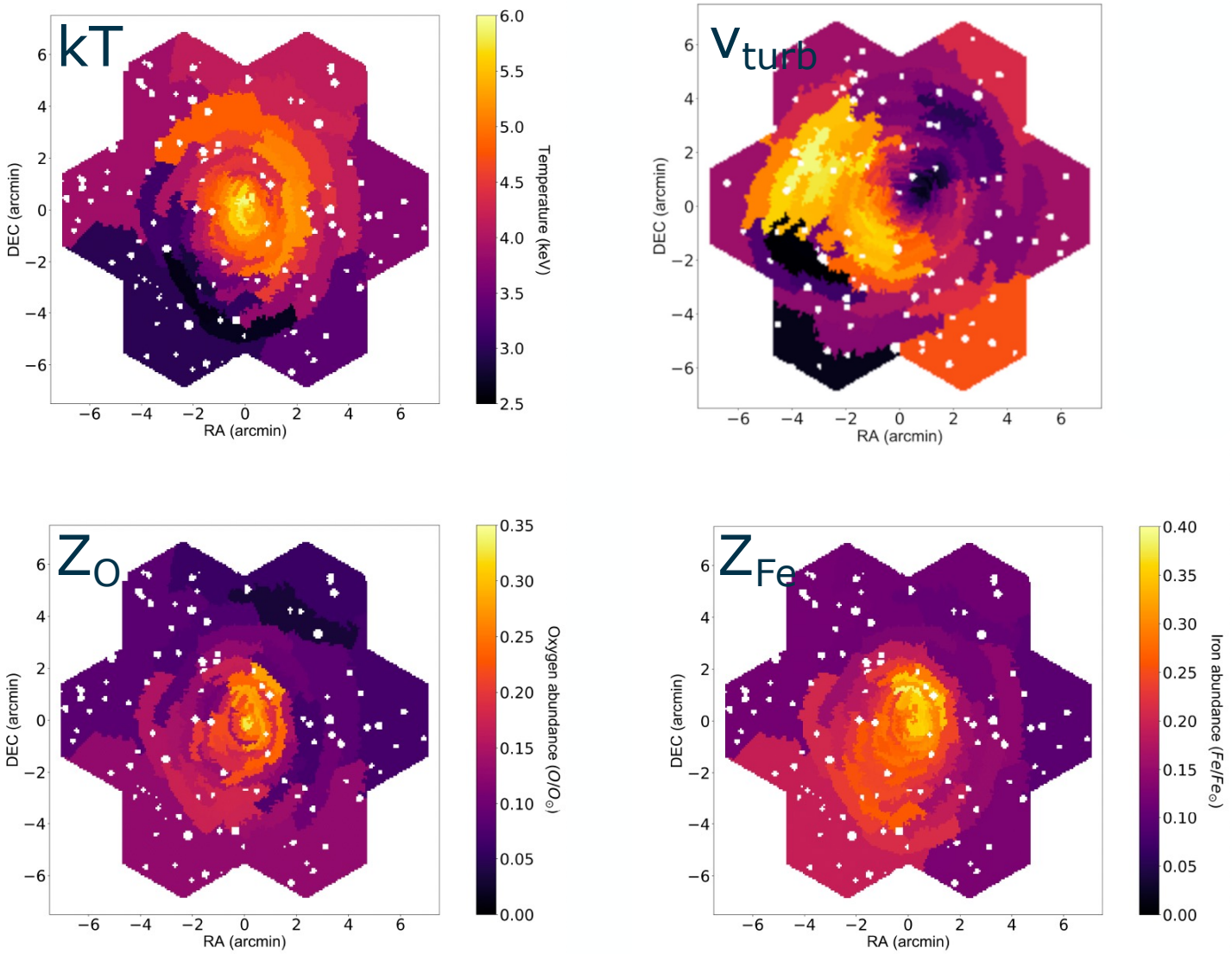
Posterior distribution for N_H of a COSMOS AGN at z=1.55 – comparison with *Chandra* (black)

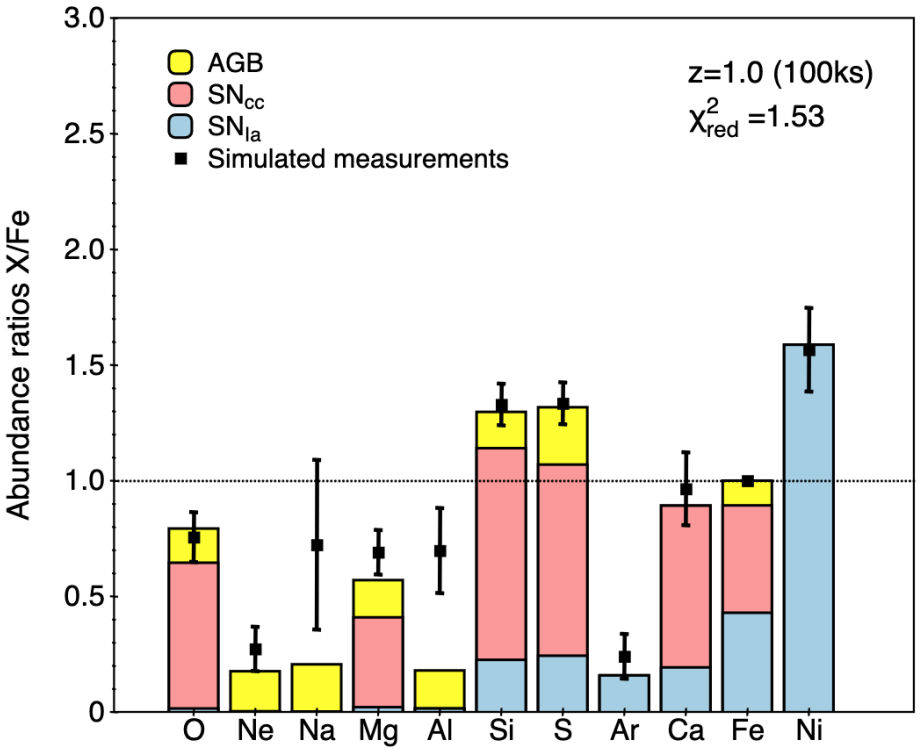
Number of AGN detection for various Athena survey tiers and cosmological simulations

Physics of the intra-cluster medium with *Athena*

Cucchetti et al., 2018, A&A, 620, 173

Mernier et al., 2020, A&A, 642, 90

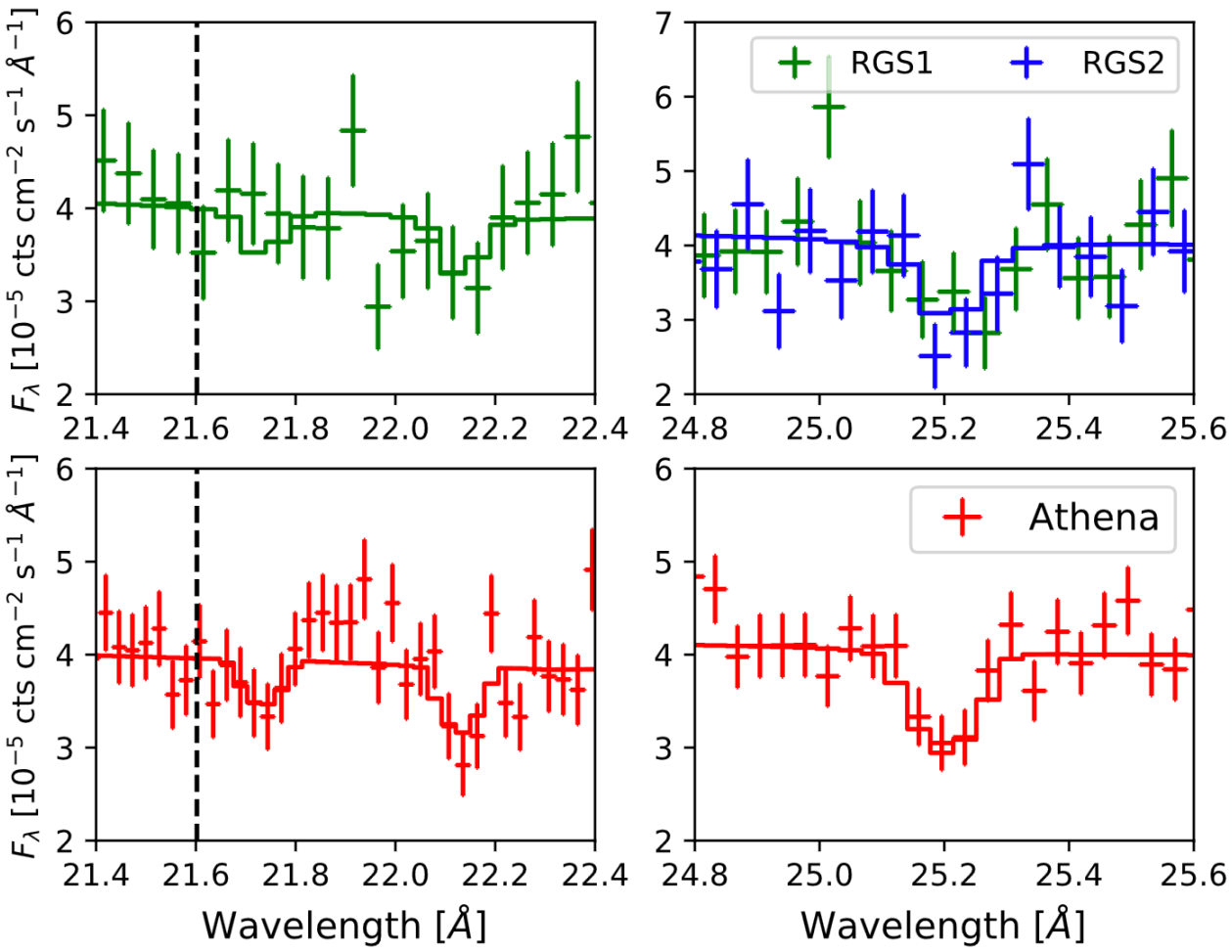


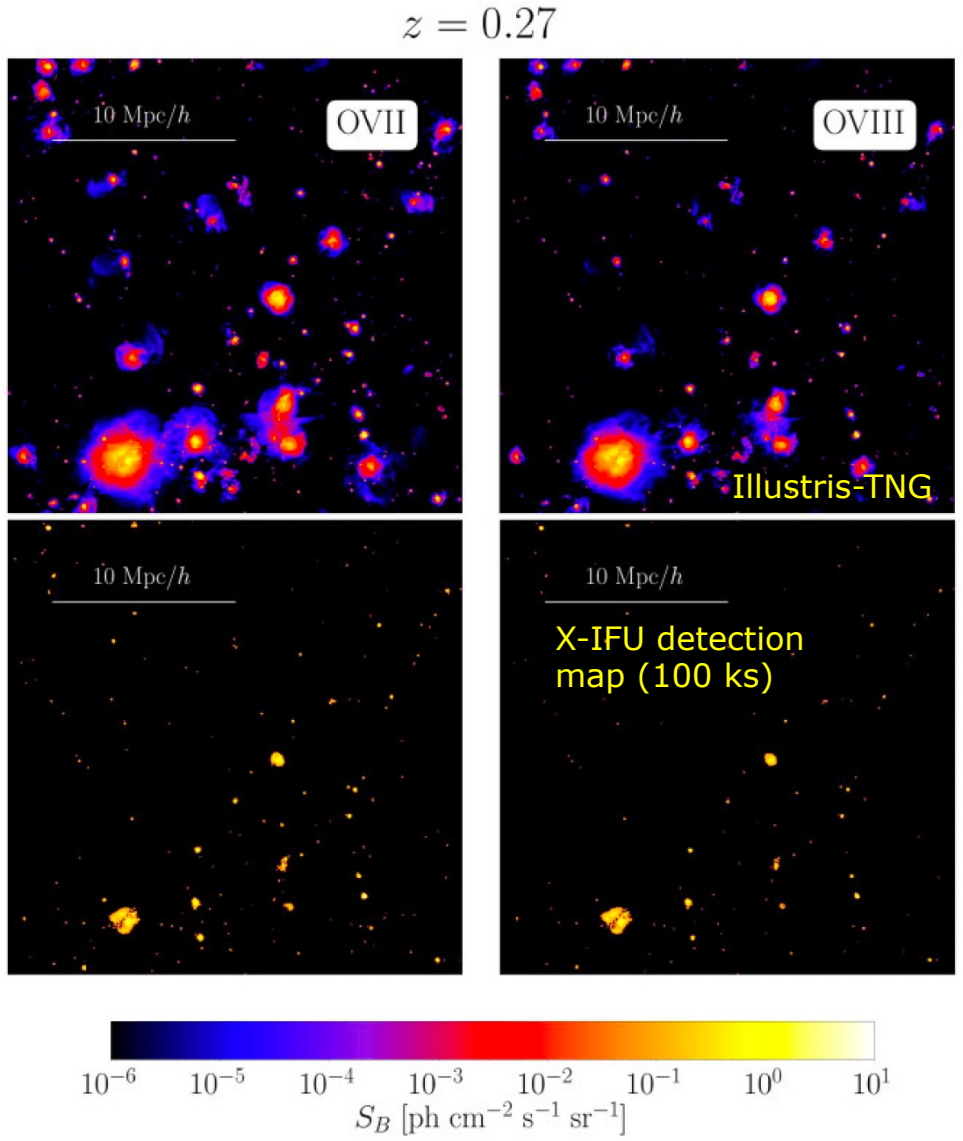


Galactic halo and WHIM studies with *Athena*

Mathur et al., 2021, ApJ, 908, 69

Parimbelli et al., 2023, MNRAS, 523, 2263

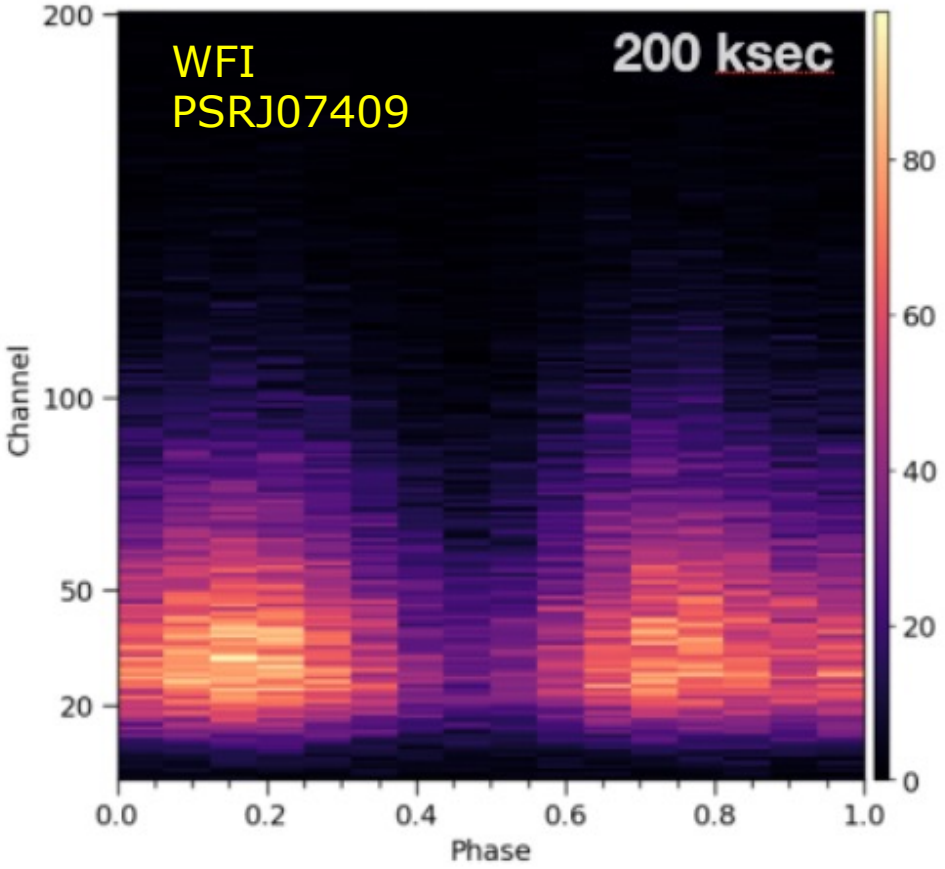




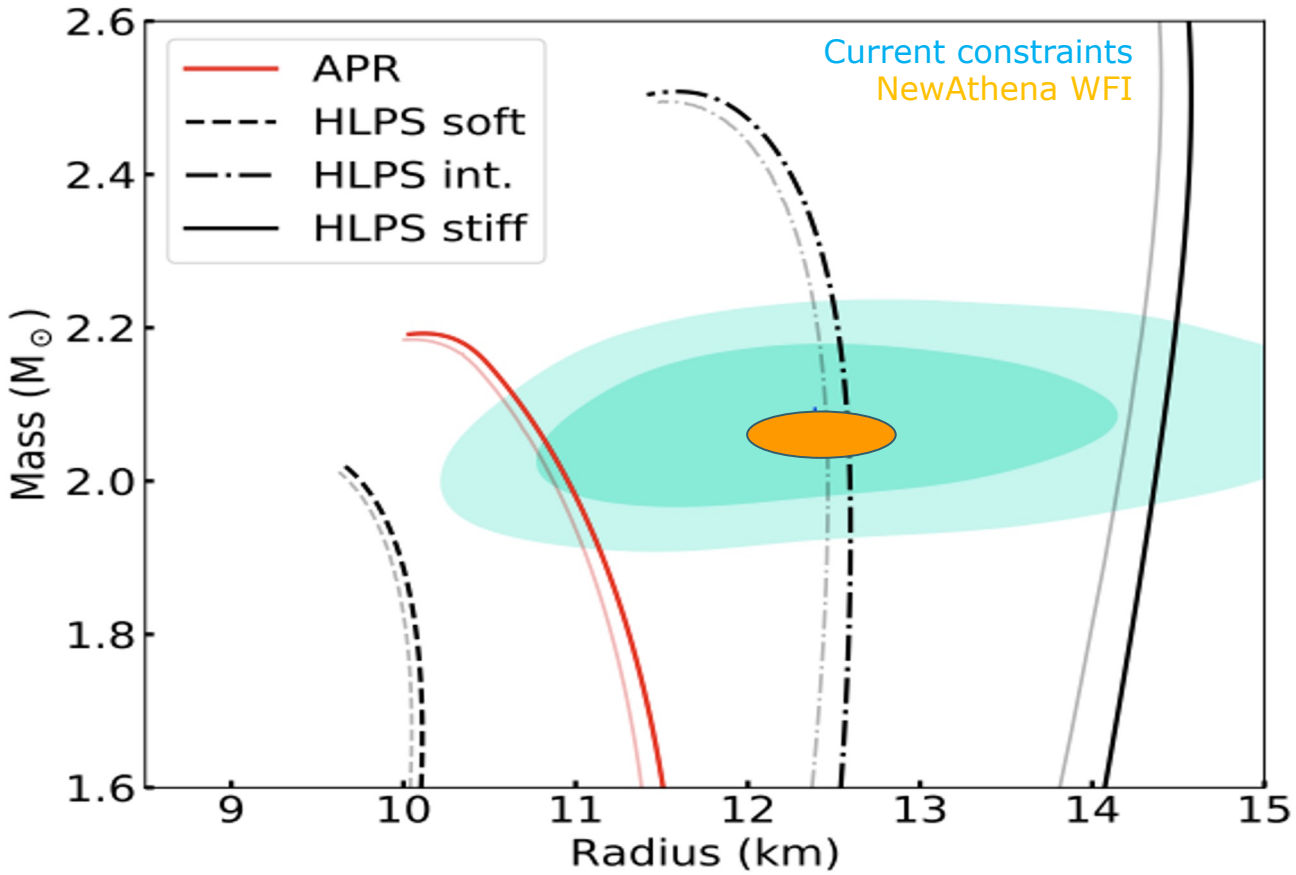
Comparison between 815 ks of XMM-Newton/RGS and 38 ks of *Athena*/X-IFU spectrum of a WHIM

Equation of State of NSs with [New]Athena

Credit: N.Rea/S. Vinciguerra/T. Salmi/S. Guillot/A. Watts



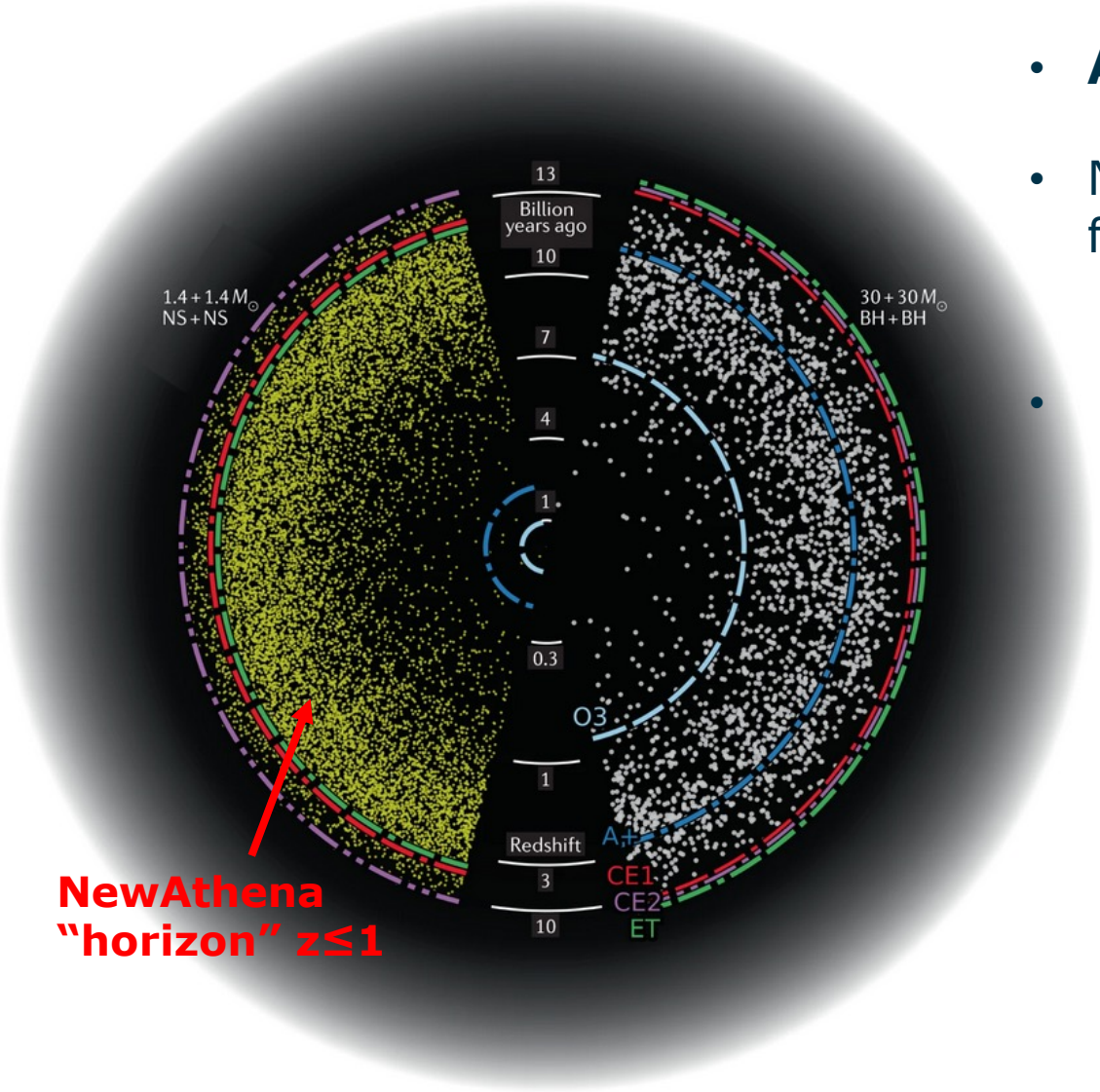
NεαΑθηνά/WFI simulation of en energy-dependent pulse profile for a msec pulsar



Comparison of the NICER/XMM-Newton versus NεαΑθηνά constraint on the NS mass/radius plane

Multi-messenger studies with *Athena*

Bailes et al., 2021, Nat.Rev.Phys., 3, 344



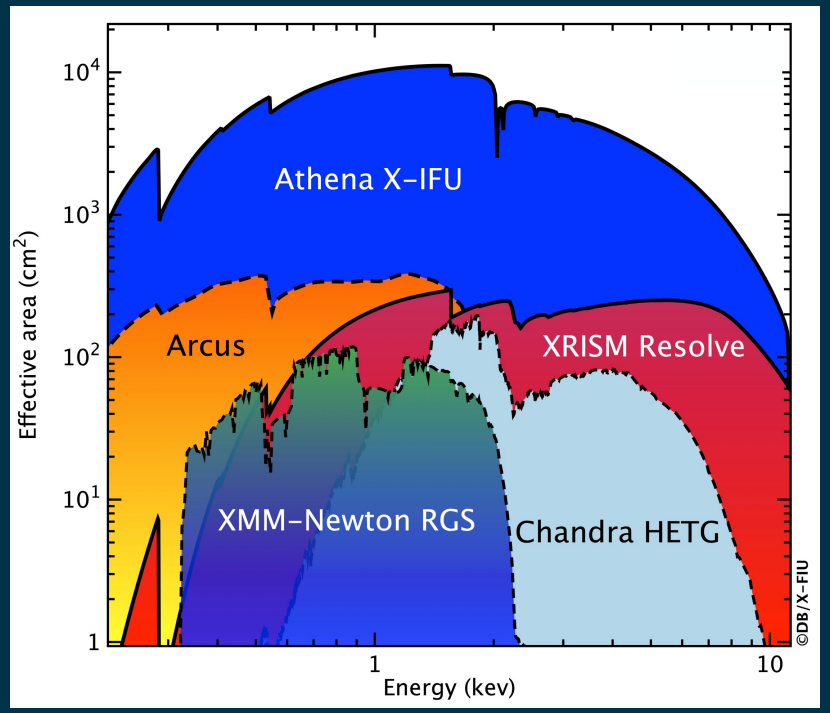
- **Accurate jet inclination for most binary systems**
- NεαΑθηνά may enable arcseconds locatization on a few targets per year
  - Number of detections: $N_{det} \sim 0.005 \varepsilon_{FOR} / \Delta t_{ToO}^{1.2}$
- Main science areas:
  - Cosmology (through joint Gravitational Wave and electromagnetic observations)
    - X-rays break the degeneracy between inclination and luminosity distance
  - Nature of the remnant compact object through X-ray variability
  - Accurate metallicity in kilonovae through disentangling non-thermal contribution

Three key innovative elements

Credit: Didier Barret (IRAP)

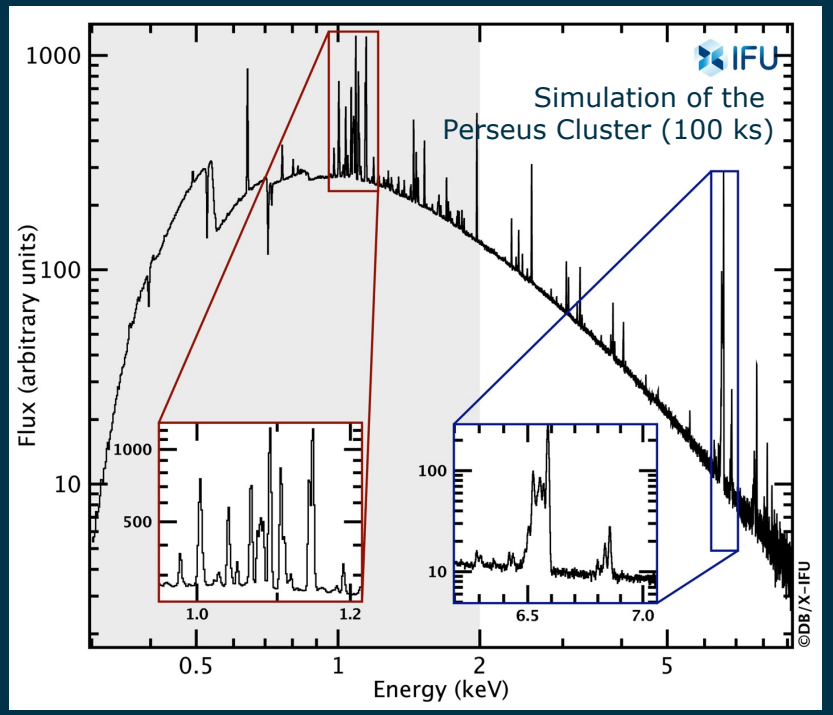
Credit: Arne Rau (MPE)

The largest X-ray mirror for astronomy ever studied



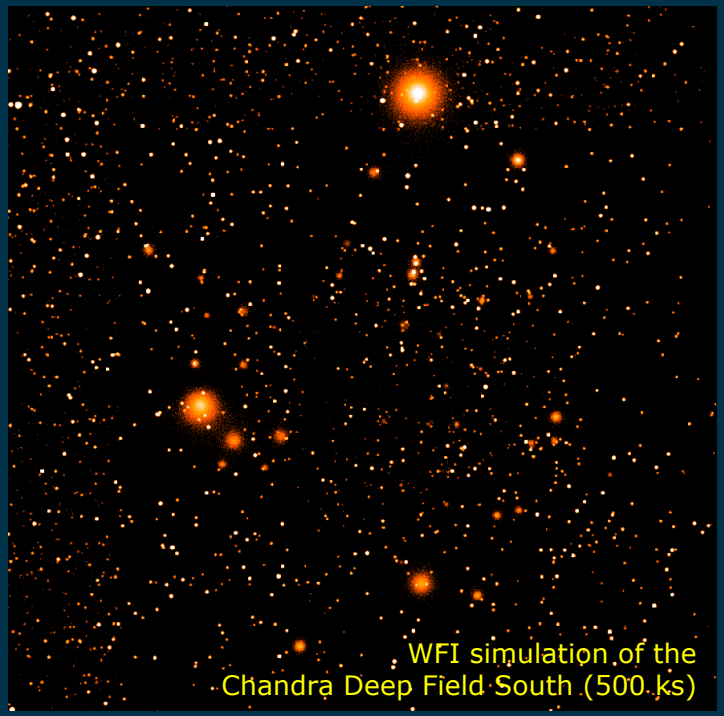
X-ray telescope based on Silicon Pore Optics technology (ESA), 5” HEW, 1.4 m^2 area @1 keV

Unprecedented X-ray spectroscopic capabilities



X-Ray Integral Field Unit (CNES/IRAP-led), ≤2.5 eV energy resolution over >3000 pixels, ~5” each (5’ effective diameter FoV)

The fastest X-ray sky survey machine



Wide Field Instrument (MPE-led), DEPFET sensor, ≤170 eV resolution @7 keV, 40’x40’ FoV

Refresher: the *Athena* science case

cf. the *Athena* Science Requirement Document. Small characters purposedly employed

- **"The Hot Universe"**
  - "*Determine how and when large-scale hot gas structures formed in the Universe and track their evolution from the formation epoch to the present day.*"
  - First galaxy groups, cluster bulk motions and turbulence, cluster entropy profile evolution, cluster chemical evolution, physics of cluster feedback, missing baryons
- **"The Energetic Universe"**
  - *"Perform a complete census of black hole growth in the Universe, determine the physical processes responsible for that growth and its influence on larger scales, and trace these and other energetic and transient phenomena to the earliest cosmic epochs."*
  - High-redshift SMBH, Complete AGN census, AGN outflows, Feedback in local AGN and star-forming galaxies, AGN spin census, GBH and NS spins and winds, black hole accretion, high-redshift GRBs, TDEs
- **"The Observatory and Discovery Science"**
  - *"Provide a unique contribution to astrophysics in the 2030s by exploring high-energy phenomena in all astrophysical contexts, including those yet to be discovered."*
  - Planetary X-ray spectroscopy, Stellar activity in exoplanets systems, Colliding winds in binaries, Magnetopheric accretion in low-mass stars, magnetic activities in ultra-cool dwarfs, mass loss in massive stars, EoS of ultradense matter, masses of accreting white dwarfs, magnetars, pulsar-wind nebulae, novae and PNe, double-degenarate binaries, SN, chemistry of the cold ISM, dust scattering halos, physics of the warm and hot ISM, Mapping of SNR, Multiwavelength synergies, Multi-messenger astrophysics, Physics beyond the Standard Model

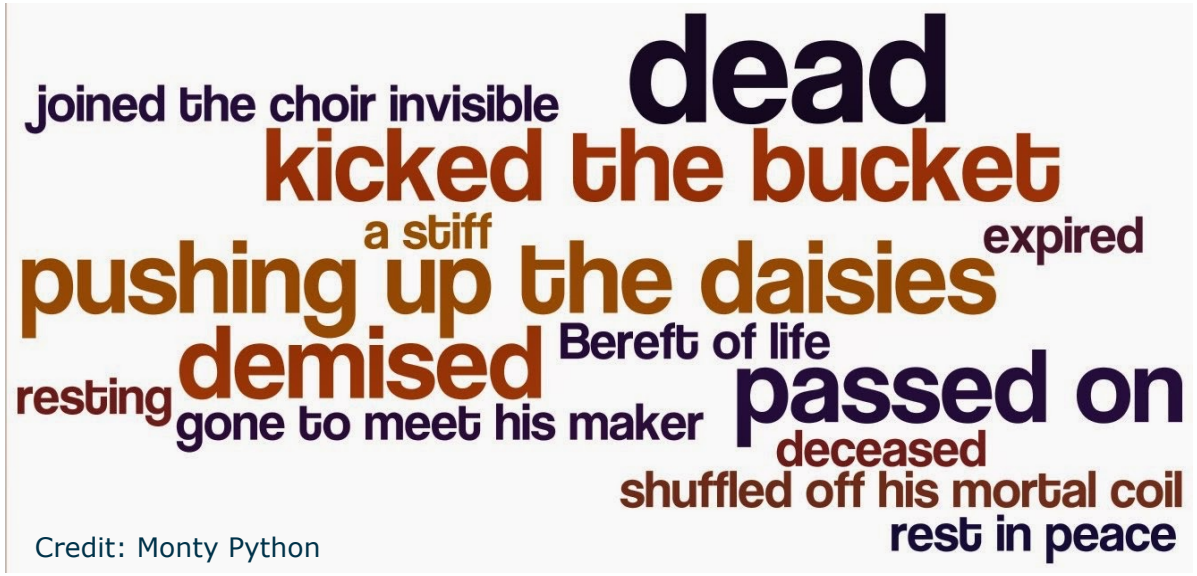
Athena was designed to be an high-energy **observatory**

Athena is no more.

Credit: ESA

- *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 (“NεαAθηνά”):
  - Consistent with a 1.3×10^9€ cap
  - Scientifically ”flagship mission”



Credit: Monty Python

Athena is no more. Long life NεαAθηνά!

Credit: ESA

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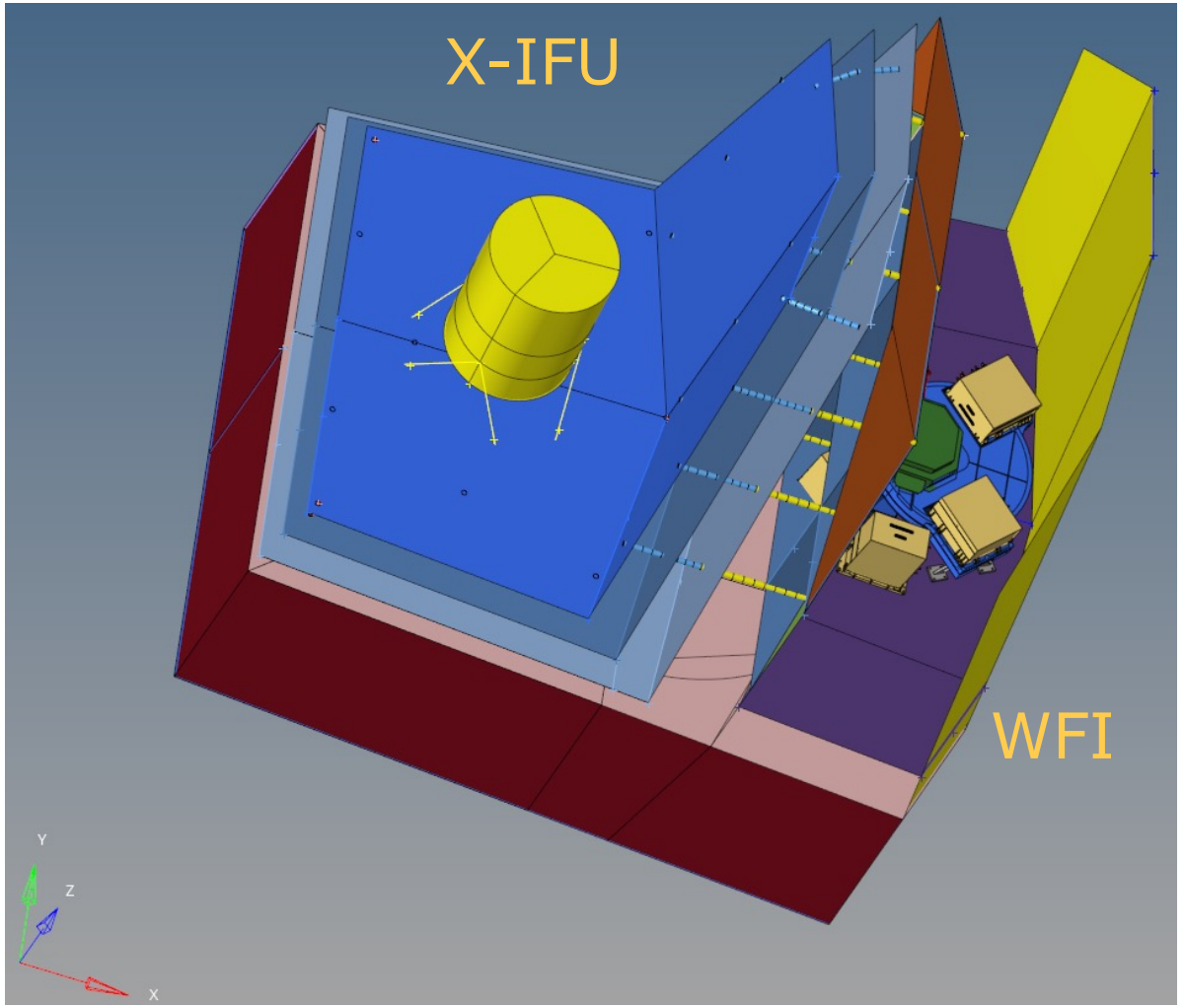
- **This concept exists!**
  - Presented to SPC in March 2023
  - Pending "programmatic consolidation"

- Decision to restart Phase A expected at the November 2023 SPC



The transition from *Athena* to ΝεαΑθηνά

ΝεαΑθηνά will achieve:

- An effective area at 1 keV 70-100% that of *Athena*
- An angular resolution (Half-Energy Width on-axis) between 5” (*Athena)* and 9”
- An X-IFU 7 keV energy resolution between 3 and 4 eV (2.5 eV in *Athena*)
- An X-IFU Field-of-View (FOV) of 4’ diameter (5’ in *Athena*)
- A WFI FoV between 40’x40’ (*Athena*) and 30’x30’
- A WFI background level between 5 (*Athena*) and 8×10^{-3} cts s^{-1} keV^{-1} cm^{-2}
- A background knowledge between ≤2% (*Athena*) and ≤5%
- A Field-of-Regard (FoR) between 34% and 40% (50% in *Athena*)
- A Target-of-Opportunity (ToO) response ≤12 hours (≤4 hours in *Athena*)

The NewAthena Science Redefinition Team (SRDT)

- Selected in November 2022 - open call for membership plus JAXA/NASA representatives
- Advise ESA on NεαΑθηνά science
  - Definition of new/revised scientific objectives
  - Assessment of the expected science performance
  - Analysis in support of the SSAC “flagship” recommedantion
- Next milestone: presentation to the **Advisory Stucture** in the fall 2023
- 2024: Science Requirement Document in support of Phase A

The NewAthena Science Redefinition Team (SRDT)

James Aird	University of Edinburgh	United Kingdom
Francisco Carrera	CSIC-Universidad de Cantabria	Spain
Elisa Costantini	SRON, Netherlands Institute for Space Research	The Netherlands
Lia Corrales	University of Michigan	USA (Deputy NASA representative)
Mike Cruise (co-Chair)	University of Birmingham	United Kingdom
Thomas Dauser	University Erlangen-Nuremberg	Germany
Dominique Eckert	University of Geneva	Switzerland
Fabio Gastaldello	INAF	Italy
Matteo Guainazzi (co-Chair)	European Space Agency	ESA
Hironori Matsumoto	University of Osaka	Japan (JAXA representative)
Rachel Osten	STScI	USA (NASA representative)
Pierre Olivier Petrucci	Institut de Planetologie et d'Astrophysqiue de Grenoble	France
Delphine Porquet	Laboratoire d'Astrophysique de Marseille	France
Gabriel Pratt	CEA Saclay - IRFU	France
Nanda Rea	Institute of Space Sciences (ICE-CSIC)	Spain
Thomas Reiprich	University of Bonn	Germany
Aurora Simionescu	SRON Netherlands Institute for Space Research	The Netherlands
Daniele Spiga	INAF	Italy
Eleonora Troja	University of Rome Tor Vergata	Italy

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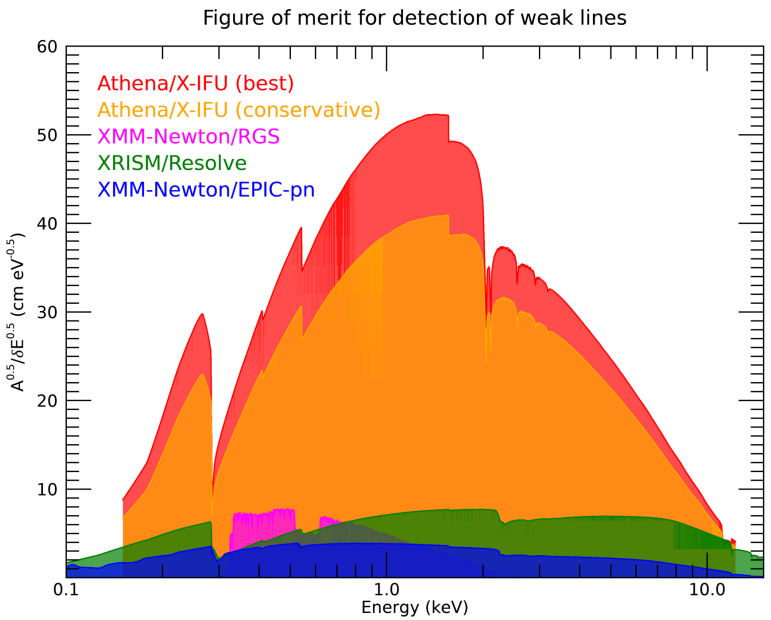
Most sciences objectives *can* be retained with ΝεαΑθηνά – some of them **revised***

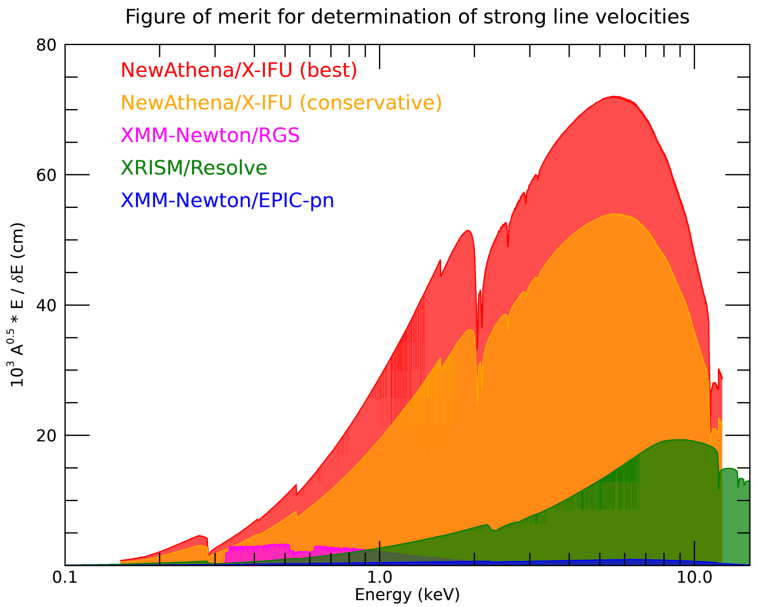
Moreover, some **new* scientific objectives** have been identified in the meantime

ΝεαΑθηνά spectroscopic performance

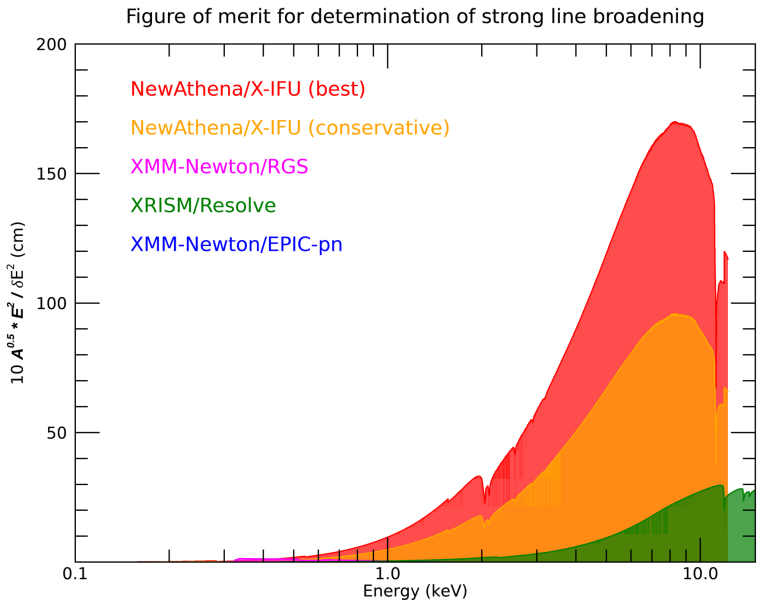
Weak line detection



Strong line velocity



Strong line broadening



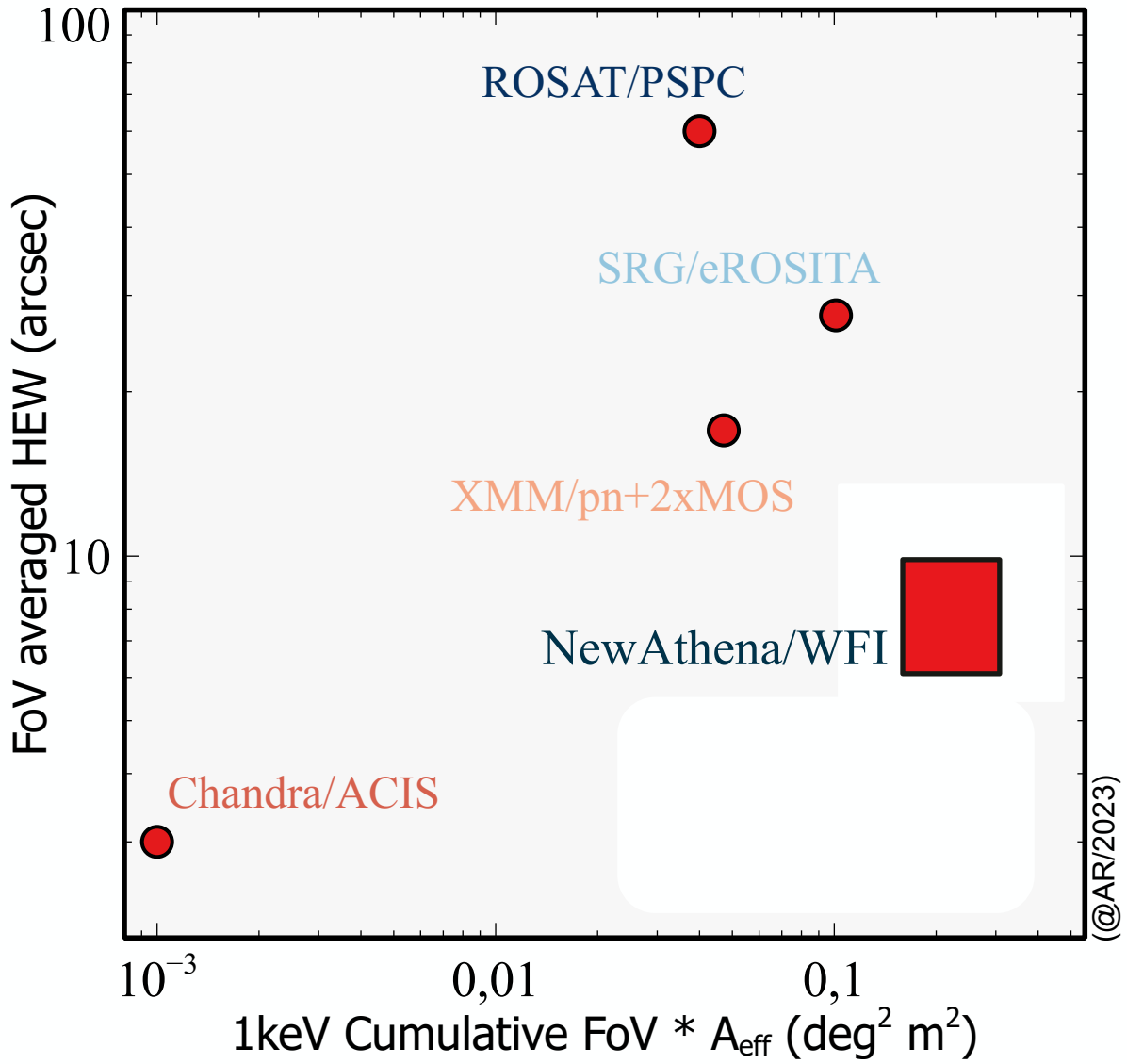
ΝεαΑθηνά /XRISM:

Weak line detection	Strong line velocity	Strong line broadening
1 keV: 6-7	1 keV: 7-11	1 keV: 17-39
6 keV: 3-5	6 keV: 4-5	6 keV: 8-16

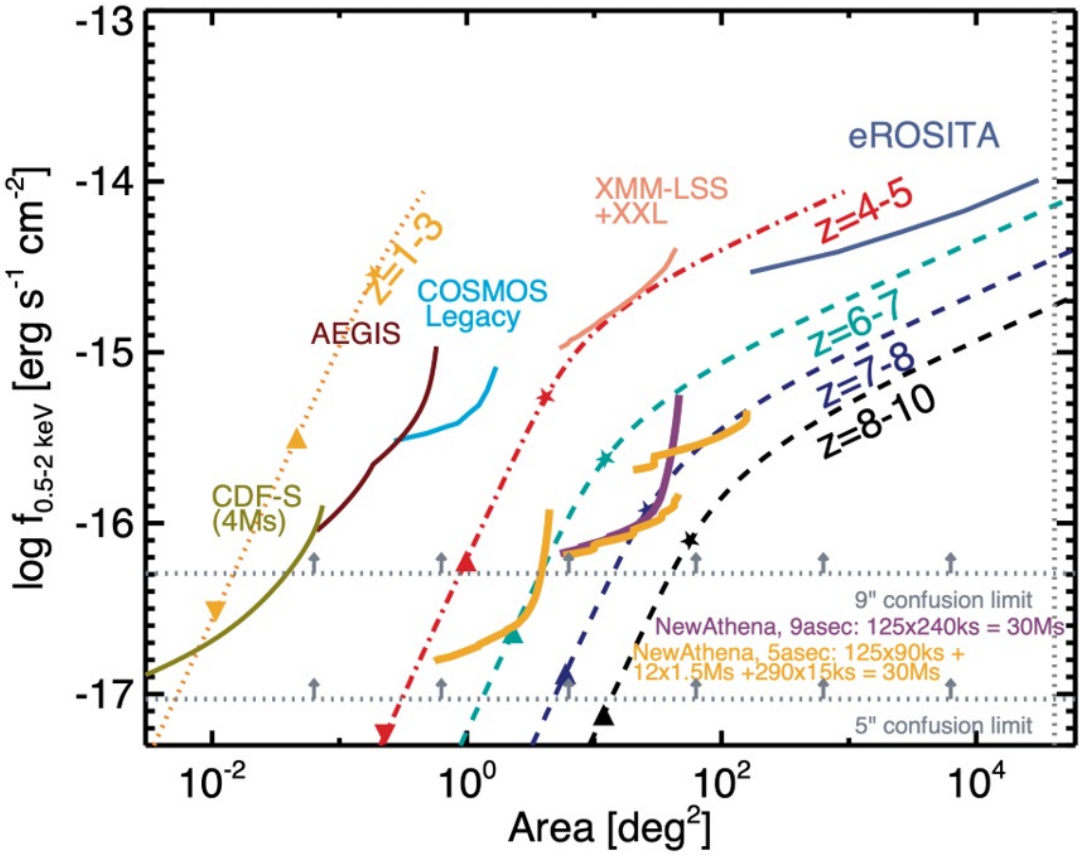
NεαΑθηνά survey performance

Credit: A. Rau (MPE), F. Carrera (IFCA)

Credit: J. Aird (UoE)



WFI sensitivity versus area in context



Scientific impact of Athena to ΝεαΑθηνά transition

- Any loss of performance (most notably, area) affects the capability to collect statistical (25 sources) or representative (10 sources) samples

- Detection and characterization of weak emission/absorption line features in non-transient sources depends on a *combination* of effective area and X-IFU energy resolution

- The increase of the confusion limit hampers science in crowded fields, *e.g.*:
  - Study of the quiescent accreting black holes in SgrA*
  - Study of stellar wind mass loss in galaxies of the Local Group

- Follow-up of transient sources require ToO capabilities *and* large Field-of-Regards

The SRDT is assessing what science can be accomodated in 4-years (5?) operations

The results to be presented to the Astronomy Working Group on October 10

ODYSSEUS' TEN-YEAR JOURNEY HOME

(POSSIBLE ROUTE ACCORDING TO PETER STRUCK, UNIVERSITY OF PENNSYLVANIA)

WORLD HISTORY ENCYCLOPEDIA

Take-home and spread-to-the-community messages

- **A financially sound, technically robust novel concept enabling to bring back Athena in the ESA Science Program exists**
- **Major achievement of all involved parties**: ESA, Instrument Consortia, International Partners
- After "programatic consolidation", **Phase A can re-start in 2024**
  - Adoption: ≤2027, 9-year implementation phase
- Scientific performance remains compelling in the spectroscopy (X-IFU) as well as in the survey (WFI) domain
- **It is the mission that the X-ray community wants!**
  - [Hint: Look at the dates of the referenced papers. If you still doubt, look at the *ADS library maintained by the ACO*]