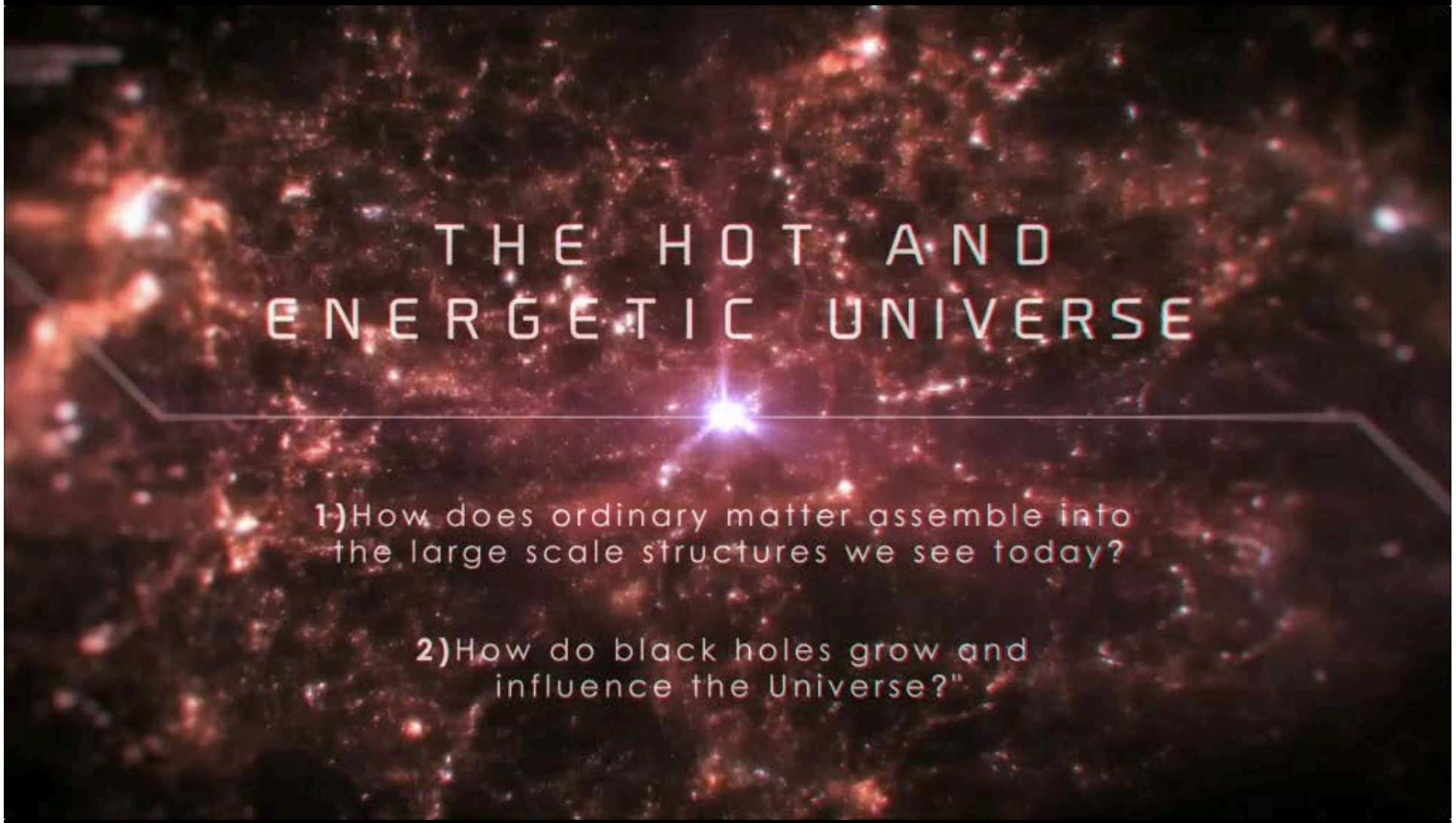
ATHENA+

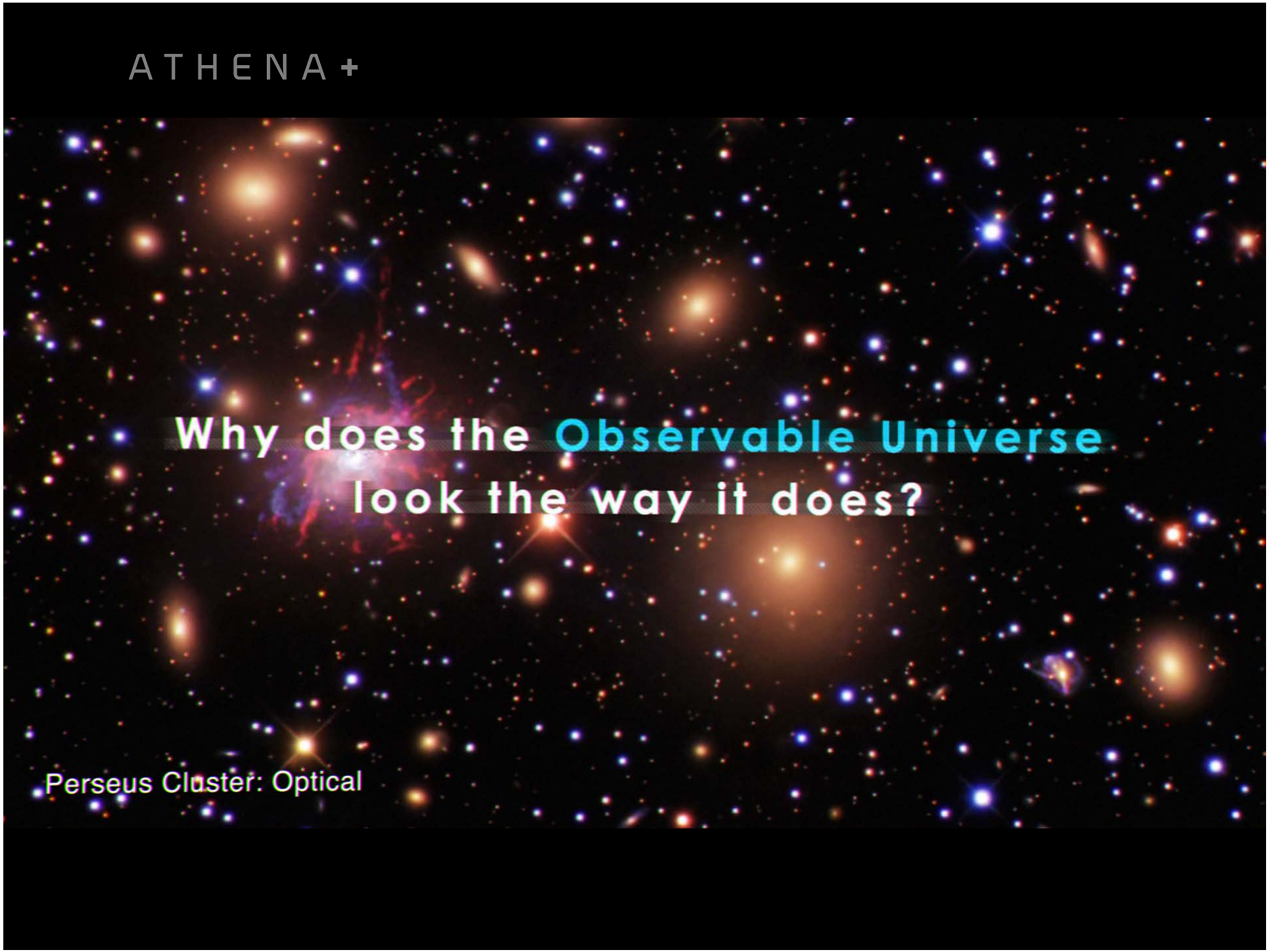


The Science Theme motivating the Athena+ mission

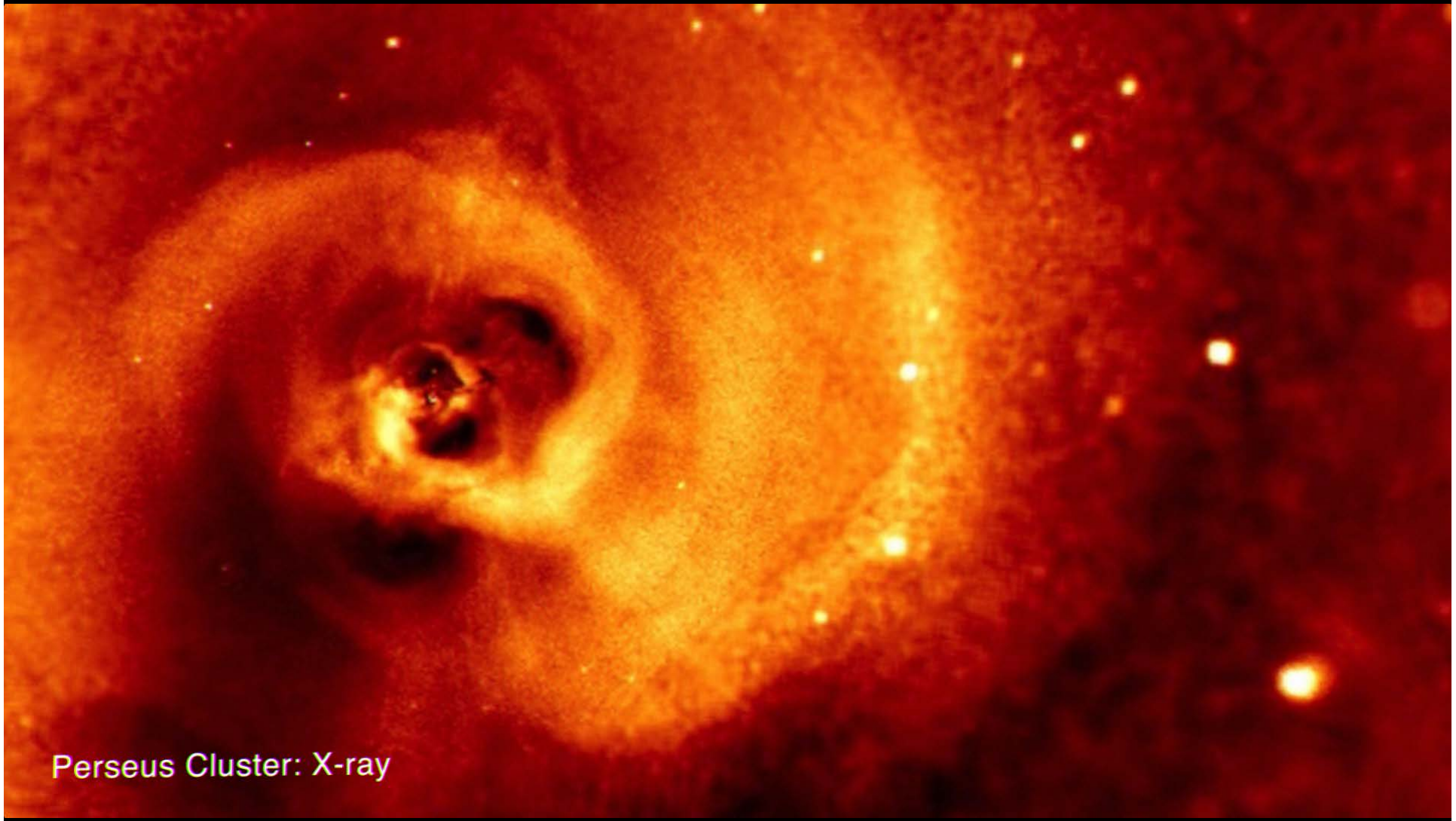
ATHENA+

Why does the Observable Universe look the way it does?

ATHENA+

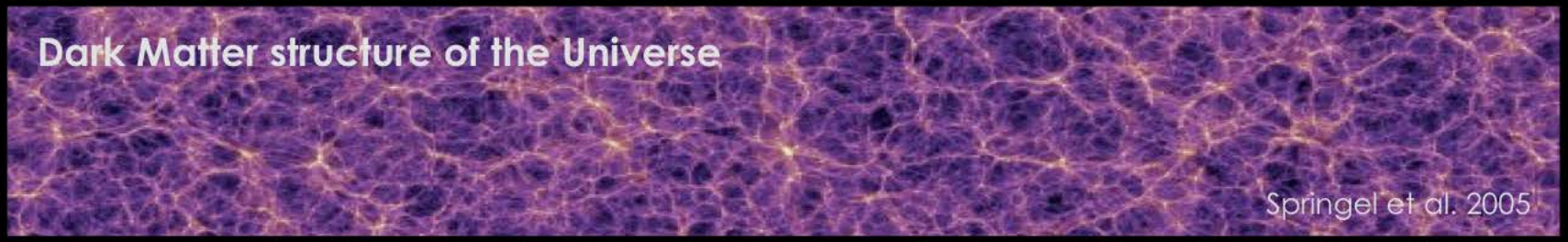

Why does the Observable Universe look the way it does?
Perseus Cluster: Optical

ATHENA+

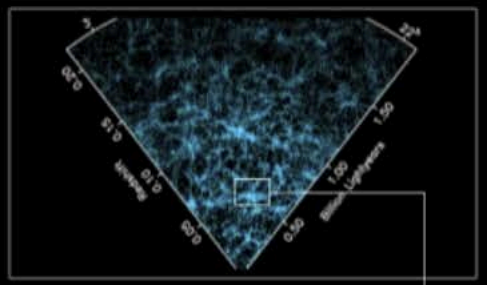


ATHENA+

Why does the observable universe look the way it does?



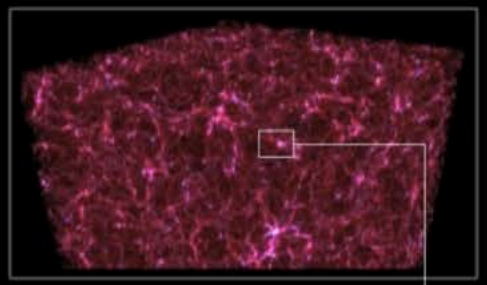
THE COLD UNIVERSE



LARGE SCALE GALAXY DISTRIBUTION

STARS AND GALAXIES

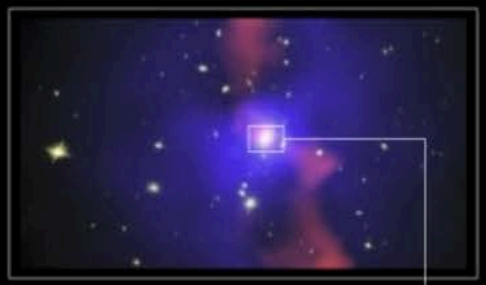
THE HOT UNIVERSE



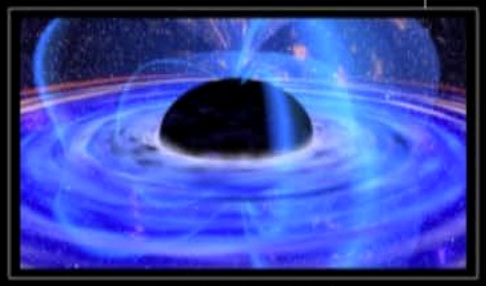
INTERGALACTIC MEDIUM

GALAXY CLUSTERS & GROUPS

THE ENERGETIC UNIVERSE



COSMIC FEEDBACK

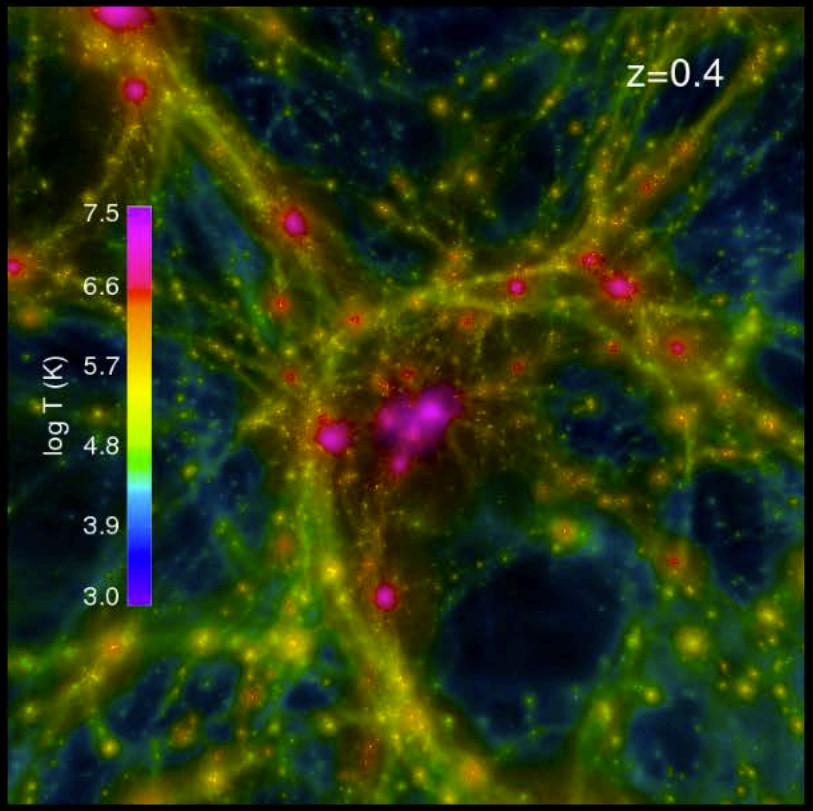


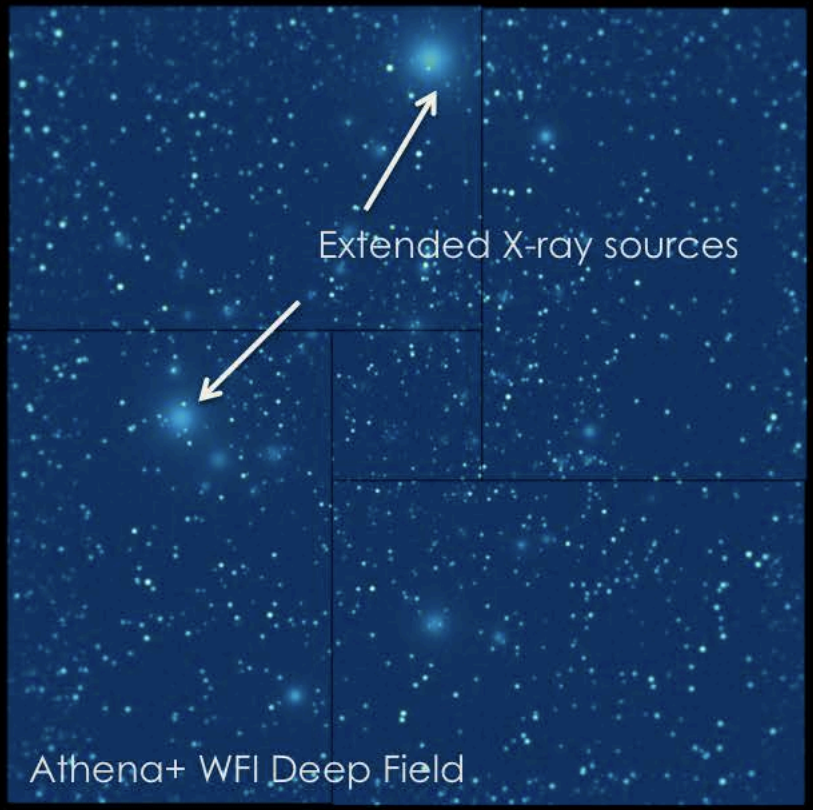
BLACK HOLES

ATHENA+

Key questions for observational astrophysics in 2028

1. How does ordinary matter assemble into the large scale structures we see today?

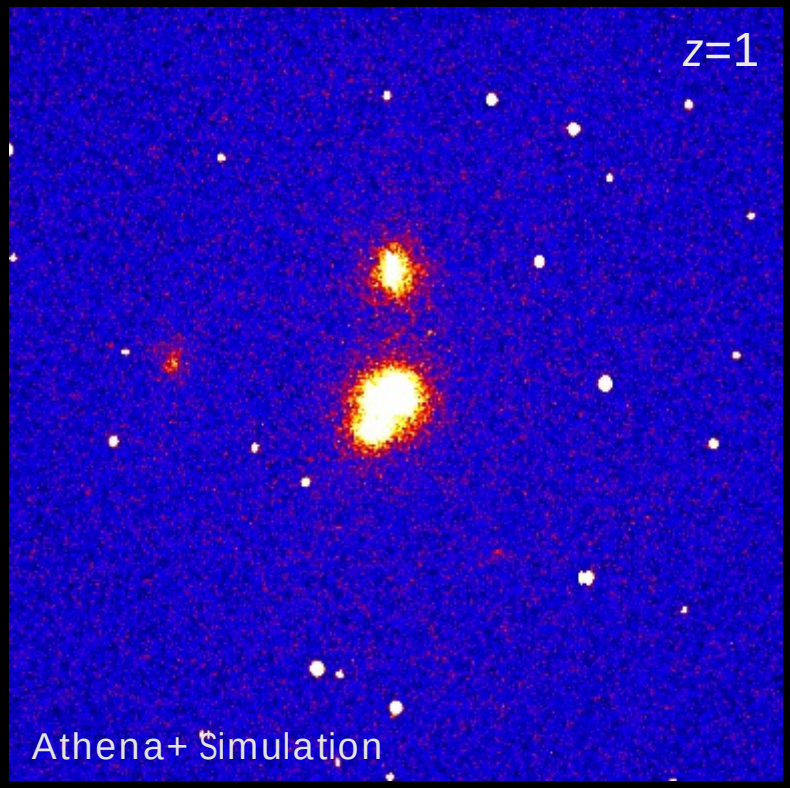




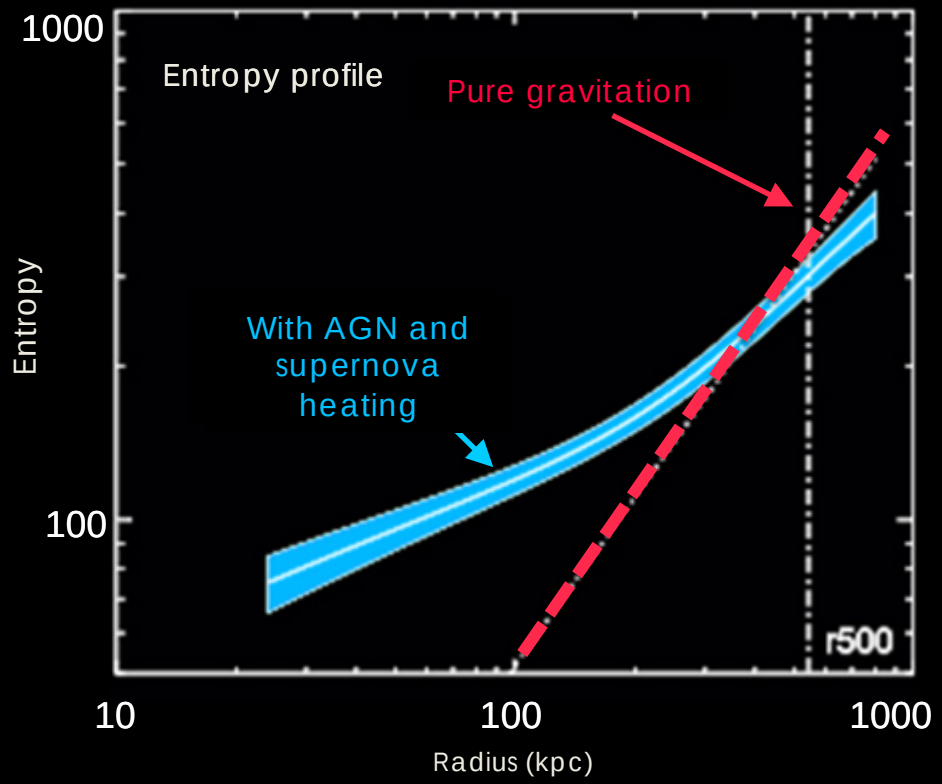
ATHENA+

The formation and evolution of clusters and groups of galaxies

How and when was the energy contained in the hot intra-cluster medium generated?



Pointecouteau, Reiprich et al., 2013 arXiv1306.2319



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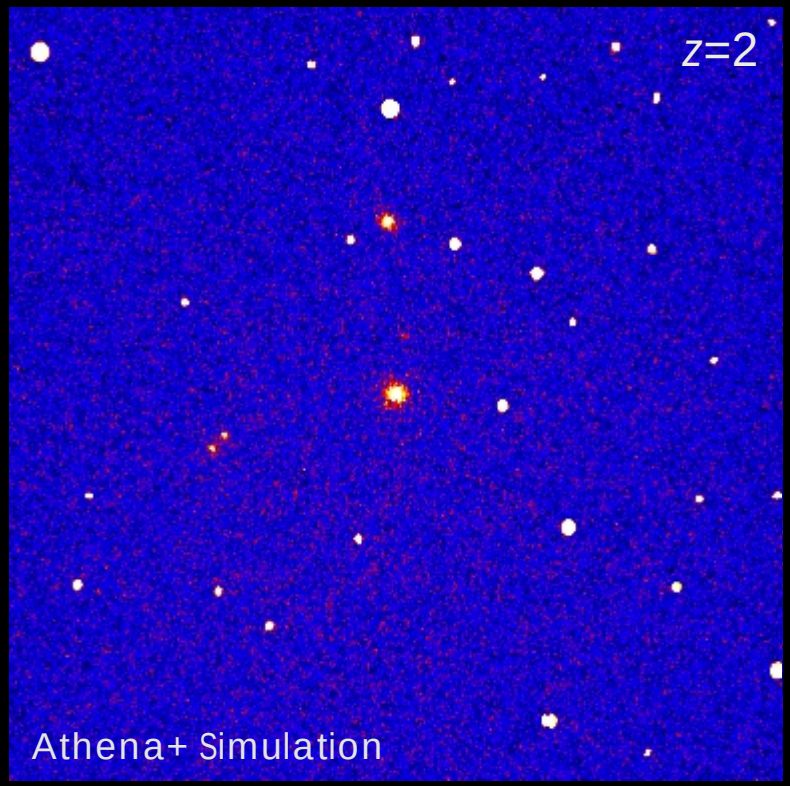
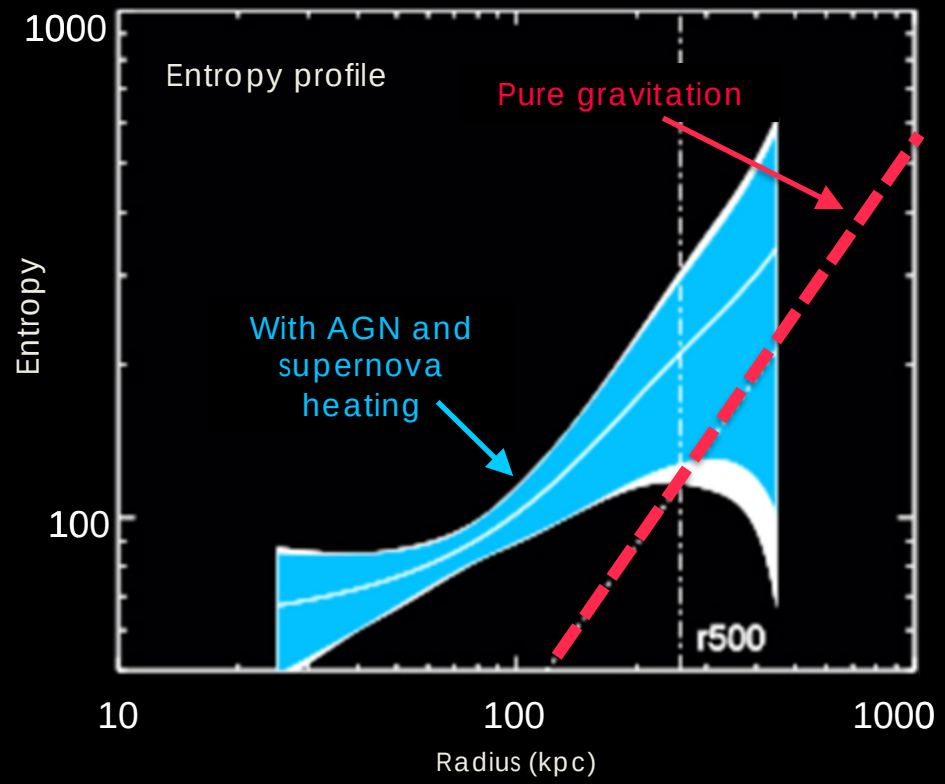


Pointecouteau, Reiprich et al., 2013 arXiv1306.2319



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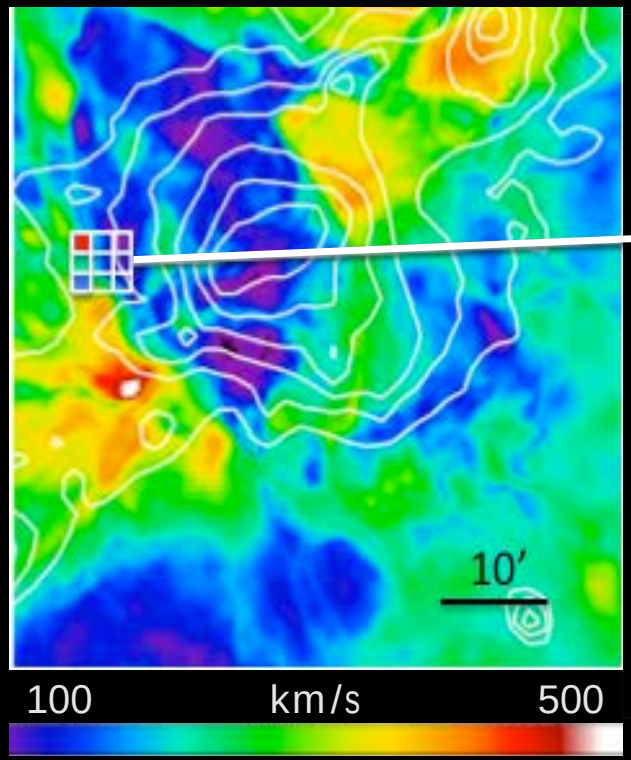
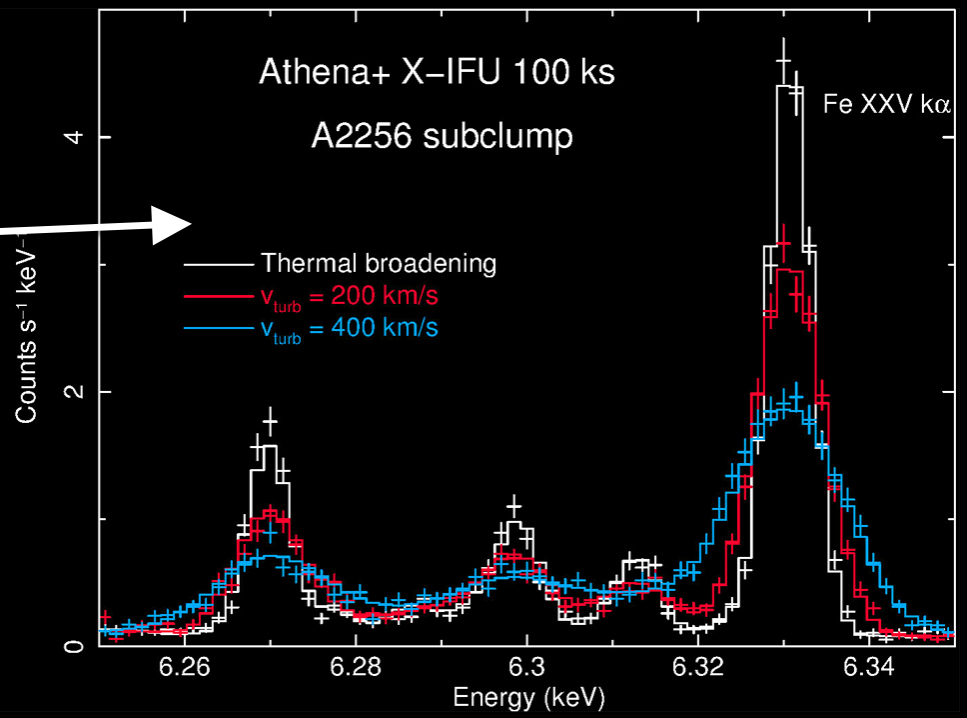
The formation and evolution of clusters and groups of galaxies

How and when was the energy contained in the hot intra-cluster medium generated?

Simulated Velocity map



Ettori, Pratt, et al., 2013 arXiv1306.2322

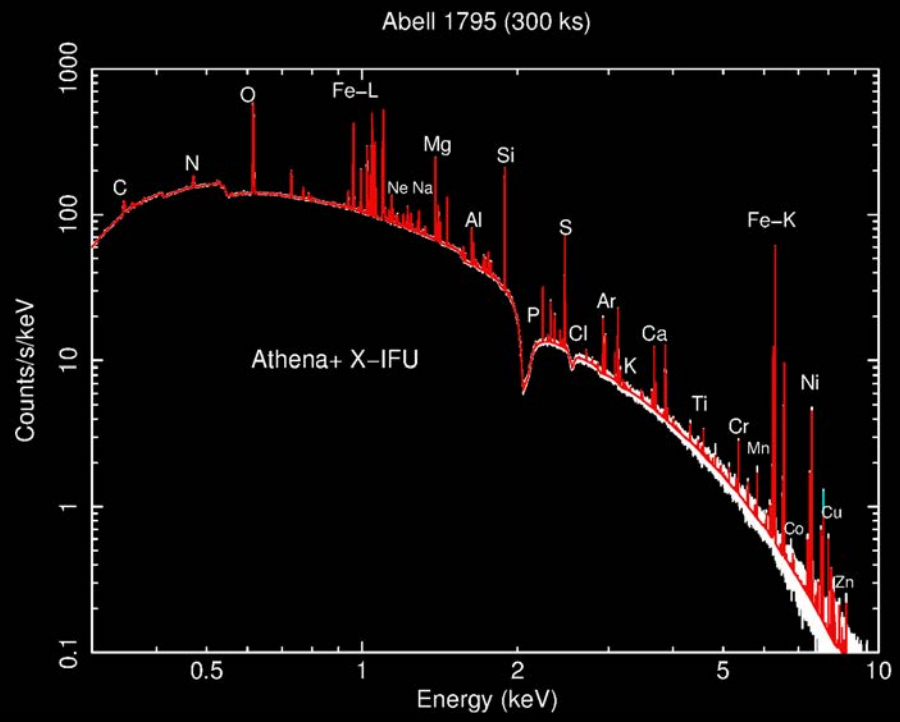


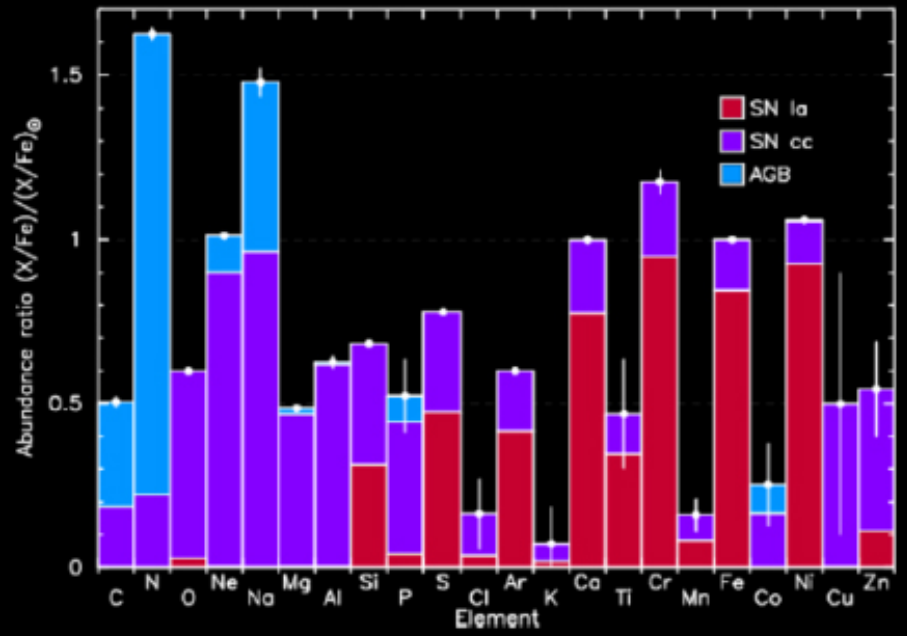
How does ordinary matter assemble into the large-scale structures that we see today?

ATHENA+

The chemical evolution of hot baryons

When and how were the largest baryon reservoirs in galaxy clusters chemically enriched?





Ettori, Pratt, et al., 2013 arXiv1306.2322

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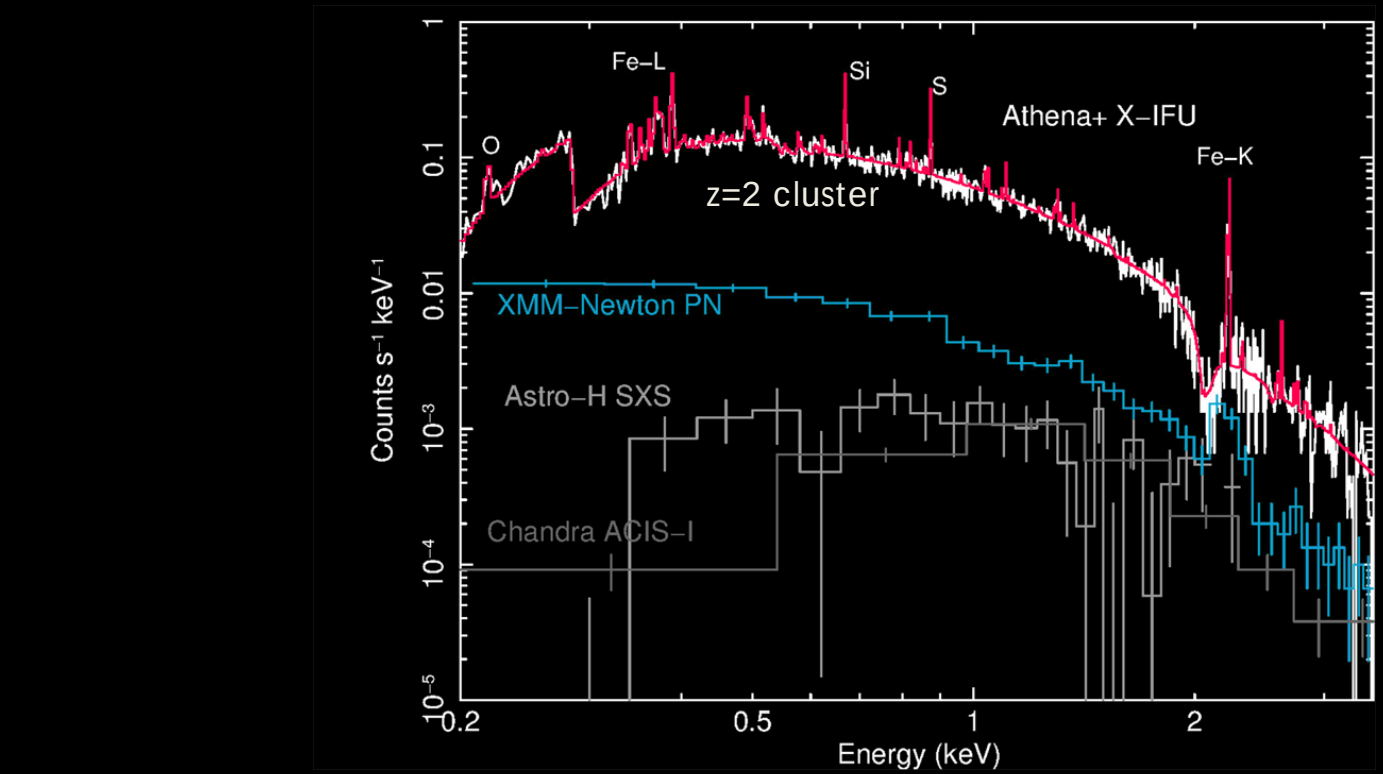


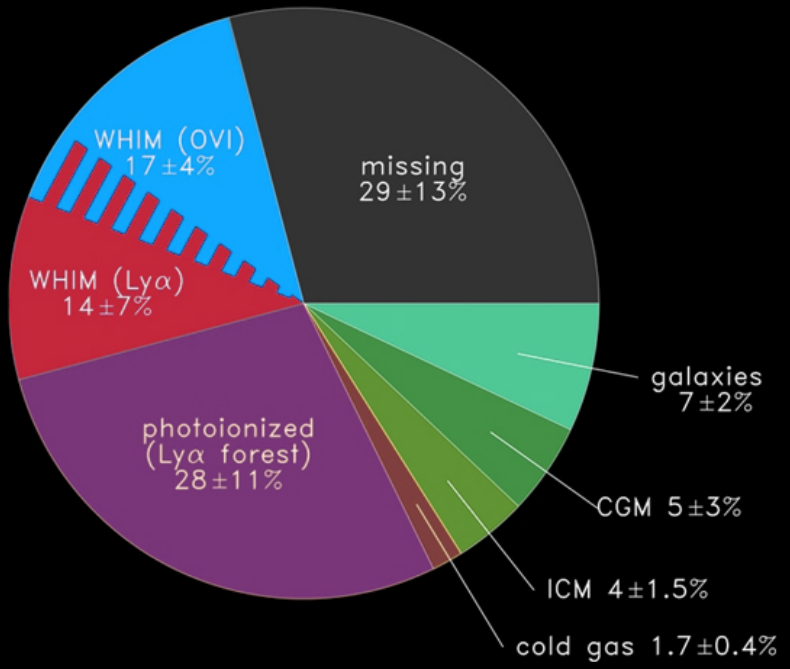
Ettori, Pratt, et al., 2013 arXiv1306.2322

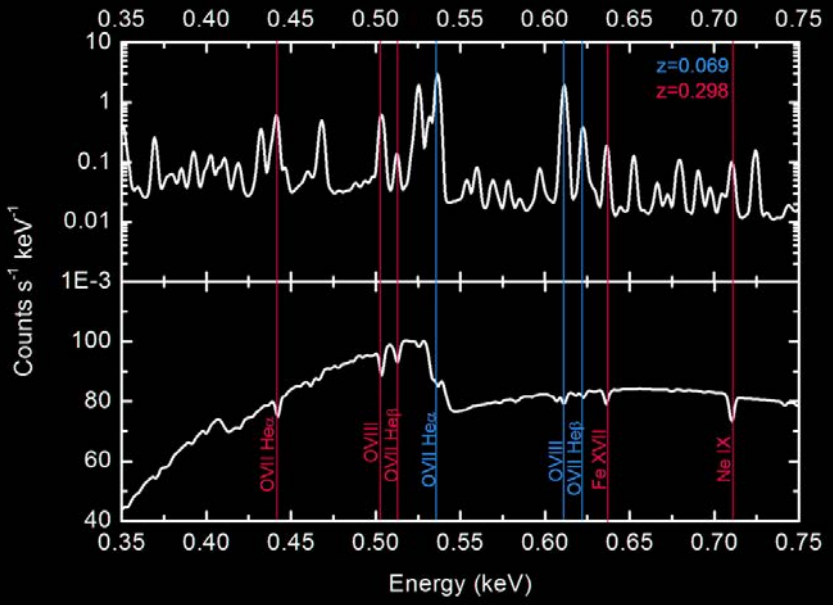
How does ordinary matter assemble into the large-scale structures that we see today?

ATHENA+

The Warm-Hot intergalactic medium (WHIM)

Where are the missing baryons in the local Universe? What is the underlying mechanism determining the distribution of the hot phase of the cosmic web?





Kaastra, Finoguenov et al., 2013 arXiv1306.2324

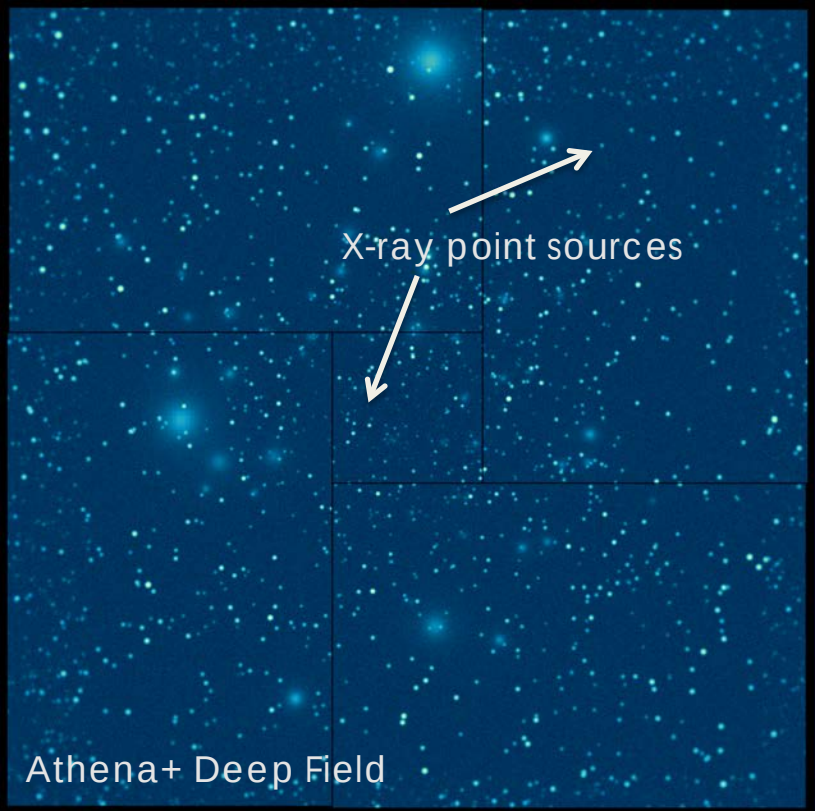
How does ordinary matter assemble into the large-scale structures that we see today?

ATHENA+

Key questions for observational astrophysics in 2028

1. How does ordinary matter assemble into the large scale structures we see today?

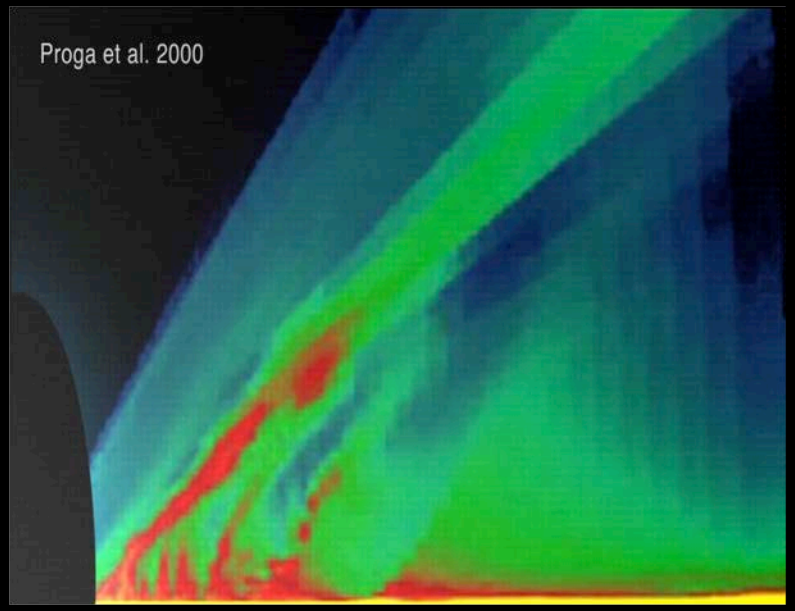
2. How do black holes grow and shape the Universe?

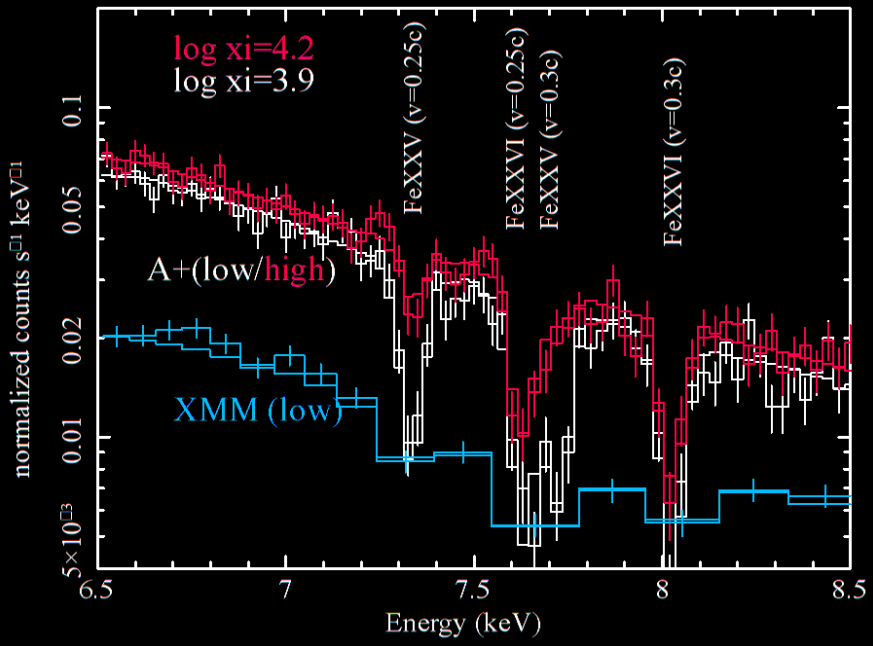


ATHENA+

Cosmic feedback: the origin of black hole winds

How do black holes launch winds and outflows?
How much energy do they carry out to larger scales?





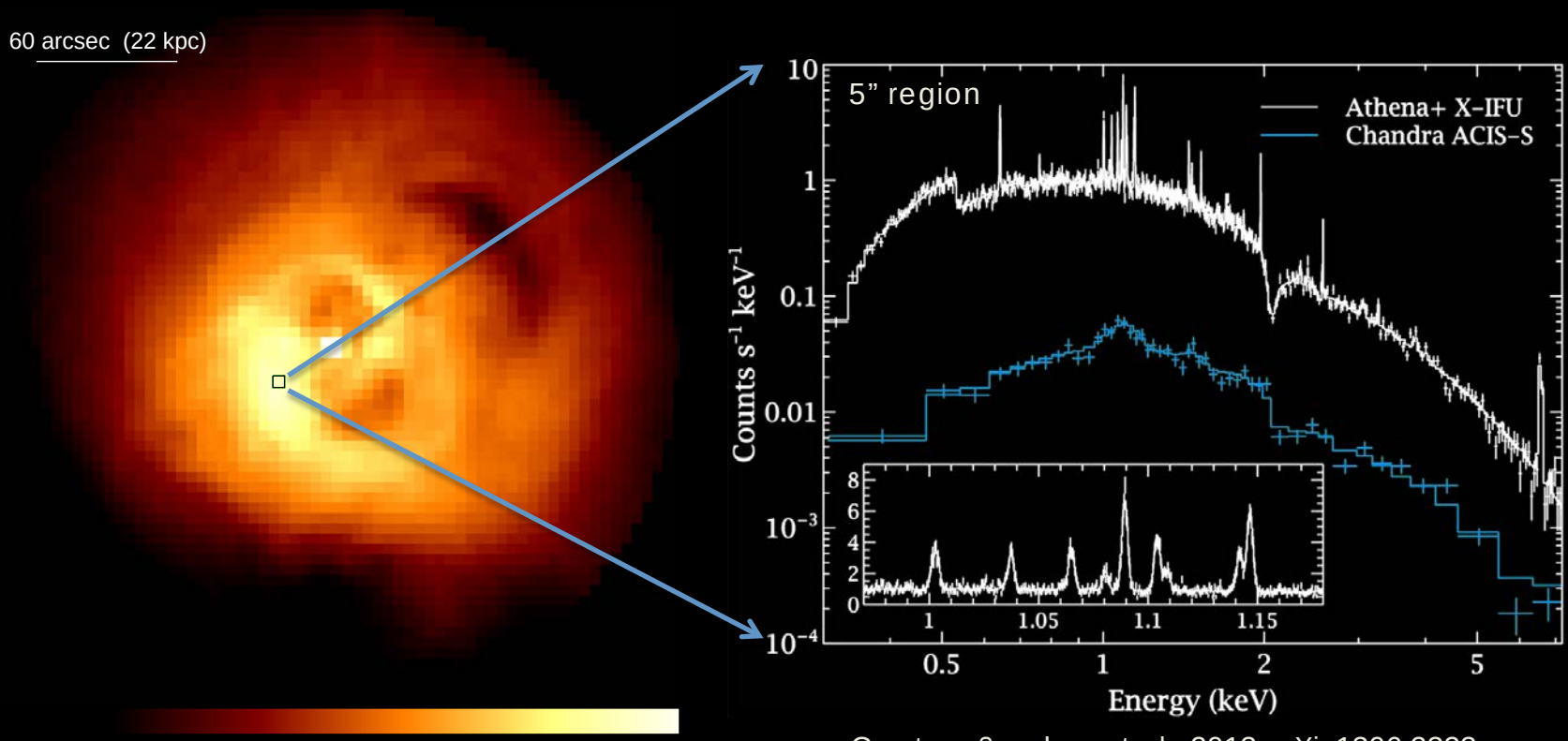
Cappi, Done et al., 2013 arXiv1306.2330
Dovciak, Matt et al., 2013 arXiv1306.2331

How do black holes grow and shape the Universe?

ATHENA+

Cosmic feedback: the impact on galaxy cluster scales

How do jets from Active Galactic Nuclei dissipate their mechanical energy in the hot intracluster medium, and how does this regulate gas cooling and black hole fuelling?



Croston, Sanders et al., 2013 arXiv1306.2323

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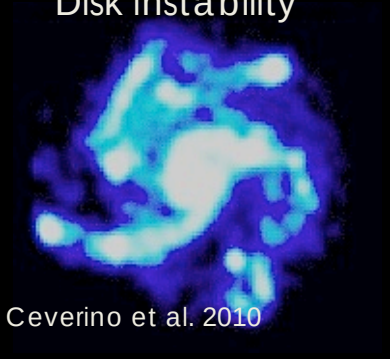
Cosmic feedback: black hole and galaxy co-evolution

How much black hole accretion occurs in the most obscured environments?
How does this relate to the evolution of the host galaxy?

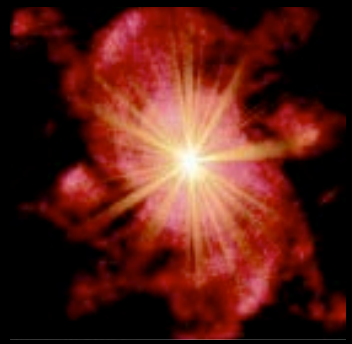
Disk instability



Ceverino et al. 2010

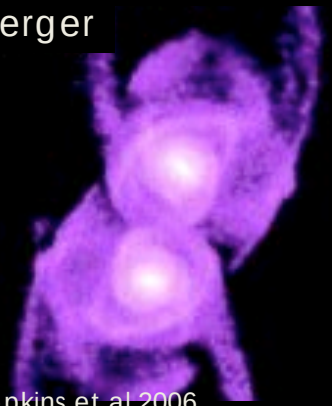
Obscured BH growth

Feedback phase

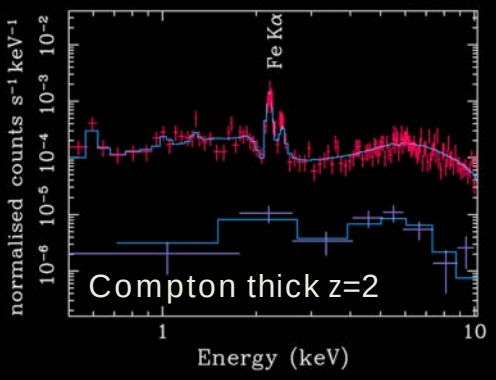


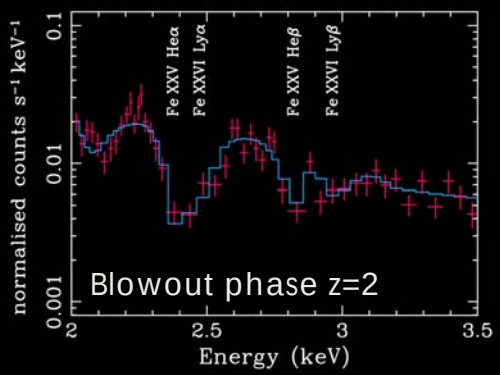
Quiescent remnant

Merger



Hopkins et al.2006





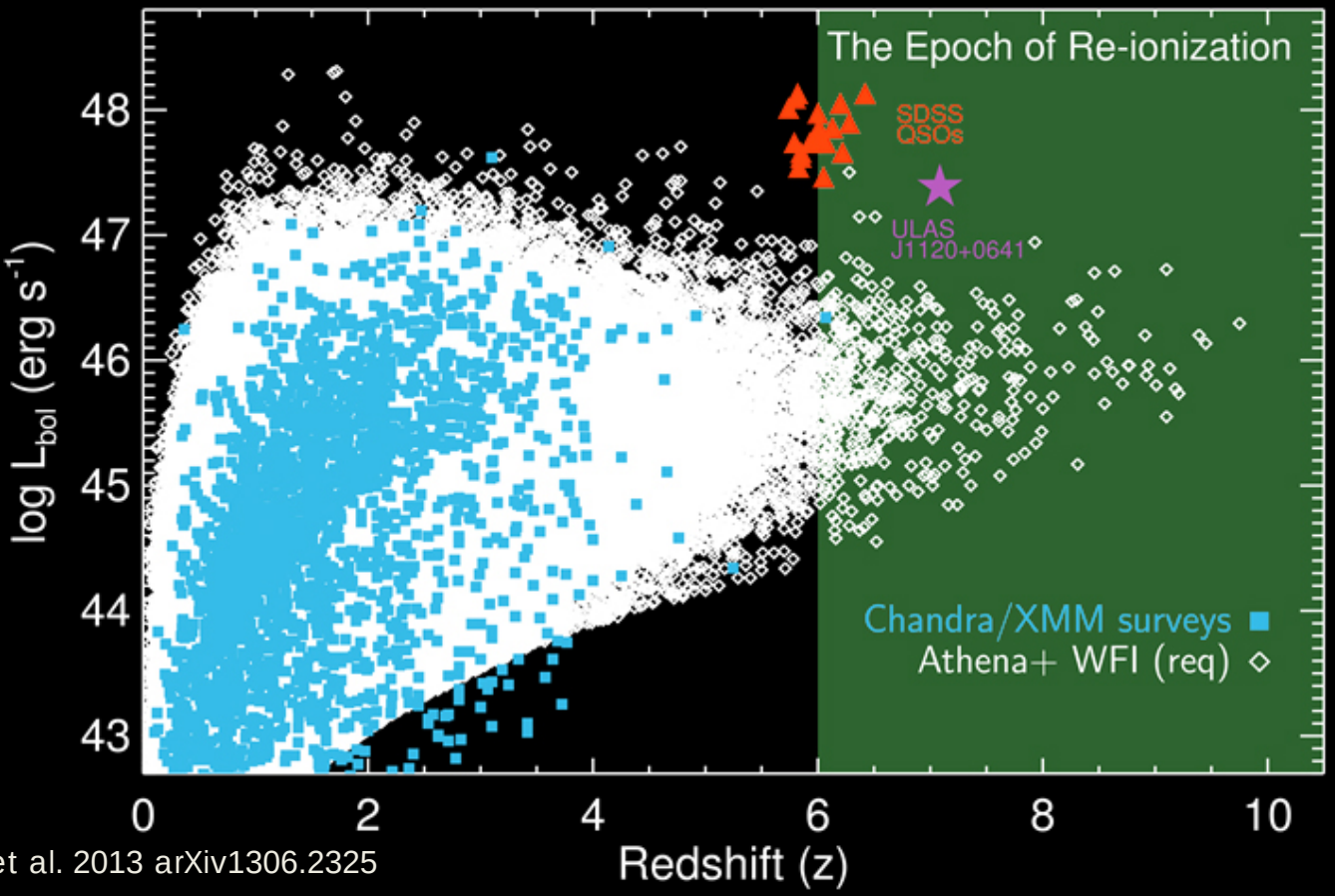
Georgakakis, Carrera et al., 2013 arXiv1306.2328

How do black holes grow and shape the Universe?

ATHENA+

Black hole growth in the early Universe

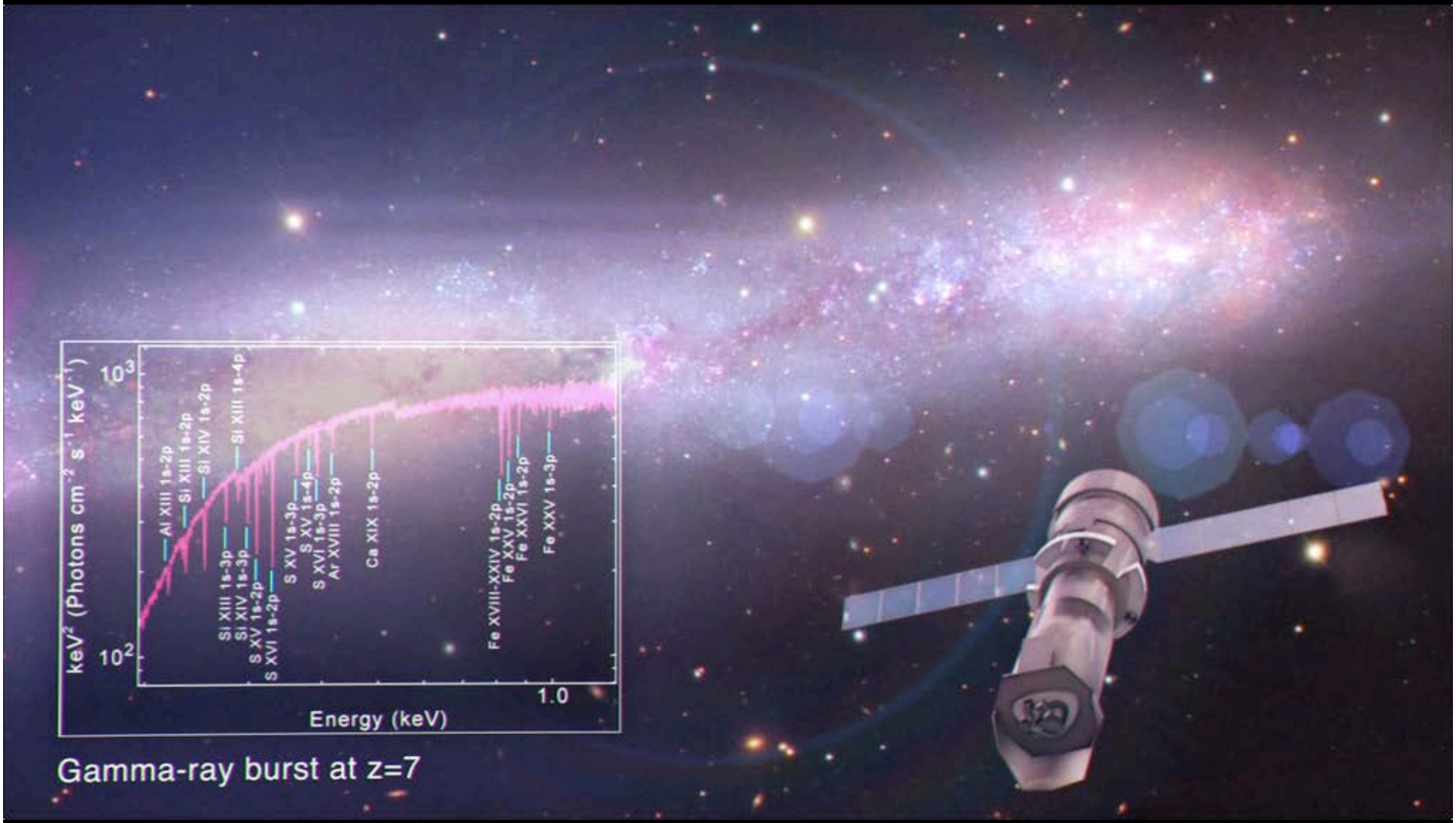
What was the growth history of black holes in the epoch of reionization?



Aird, Comastri et al. 2013 arXiv1306.2325

How do black holes grow and shape the Universe?

ATHENA+



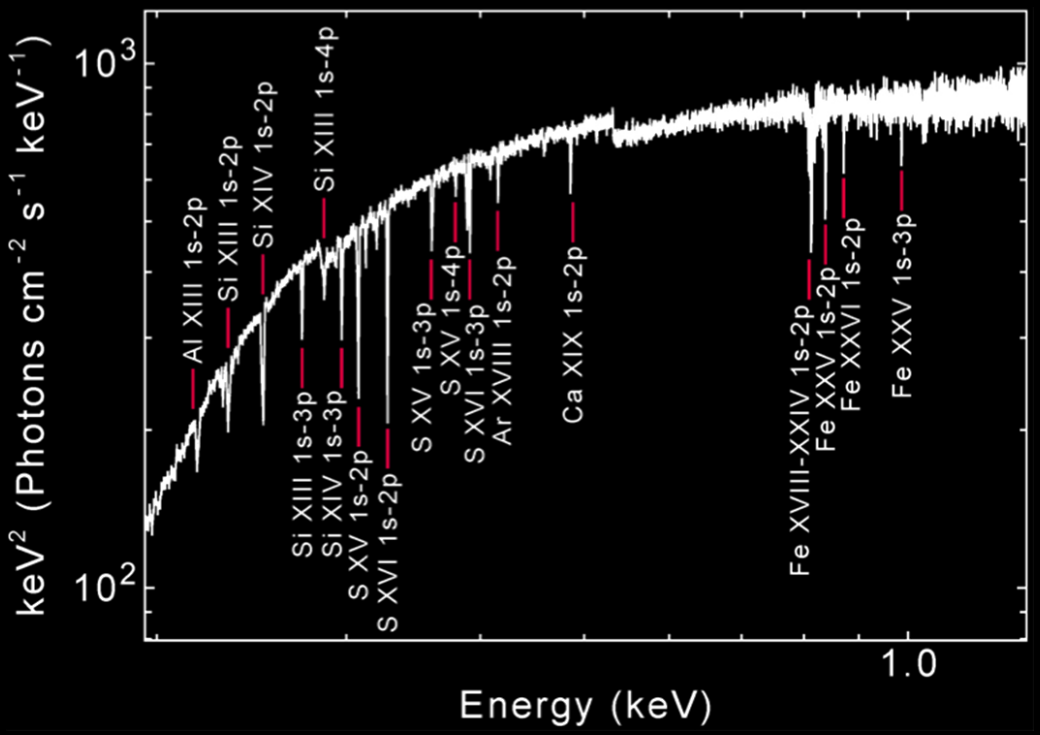
Gamma-ray burst at z=7

ATHENA+

The first stars and black holes

When did the first generation of stars explode to form the first seed black holes and disseminate the first metals in the Universe?

Gamma Ray Burst at z=7



Jonker, O'Brien et al., 2013 arXiv1306.2336

How do black holes grow and shape the Universe?

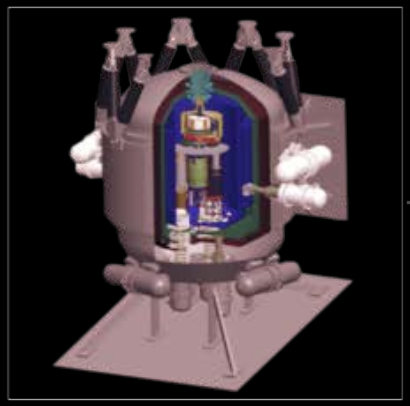

THE ATHENA+
OBSERVATORY

ATHENA+

The Athena+ Observatory

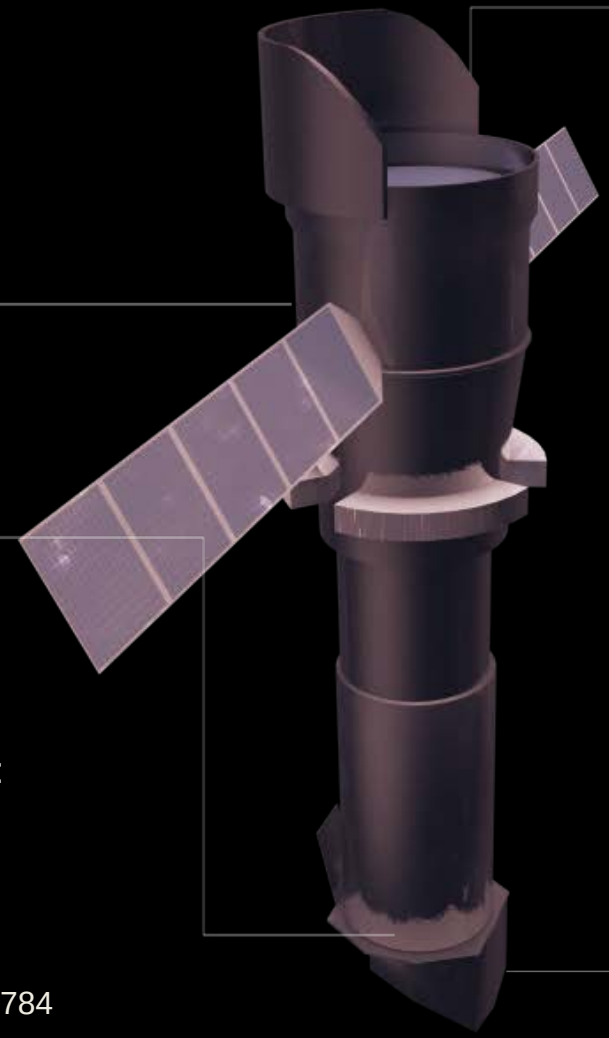
Willingale et al, 2013
arXiv1308.6785

L2 orbit Ariane V
Mass < 5100 kg
Power 2500 W
5 year mission

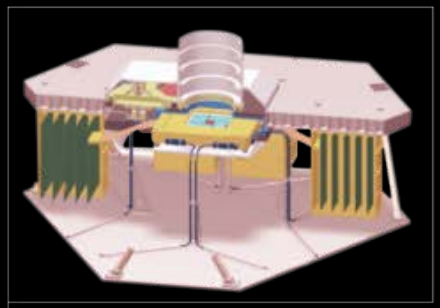


X-ray Integral Field Unit:
ΔE: 2.5 eV
Field of View: 5 arcmin
Operating temp: 50 mk

Barret et al., 2013 arXiv:1308.6784



Silicon Pore Optics:
2 m^2 at 1 keV
5 arcsec HEW
Focal length: 12 m
Sensitivity: 3 10^{-17} erg cm^{-2} s^{-1}

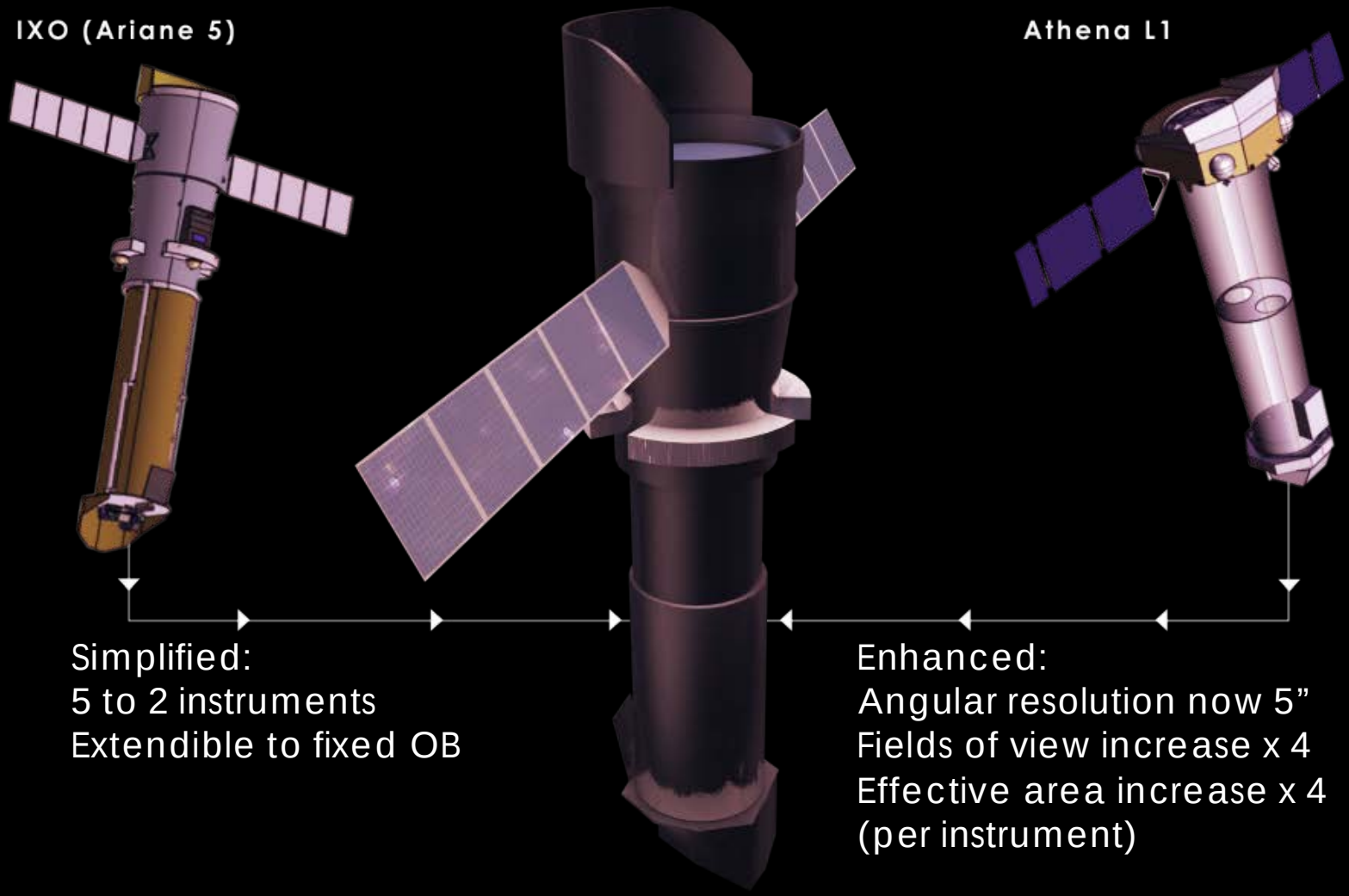


Wide Field Imager:
ΔE: 125 eV
Field of View: 40 arcmin
High countrate capability

Rau et al. 2013 arXiv1307.1709

ATHENA+

Technical Maturity



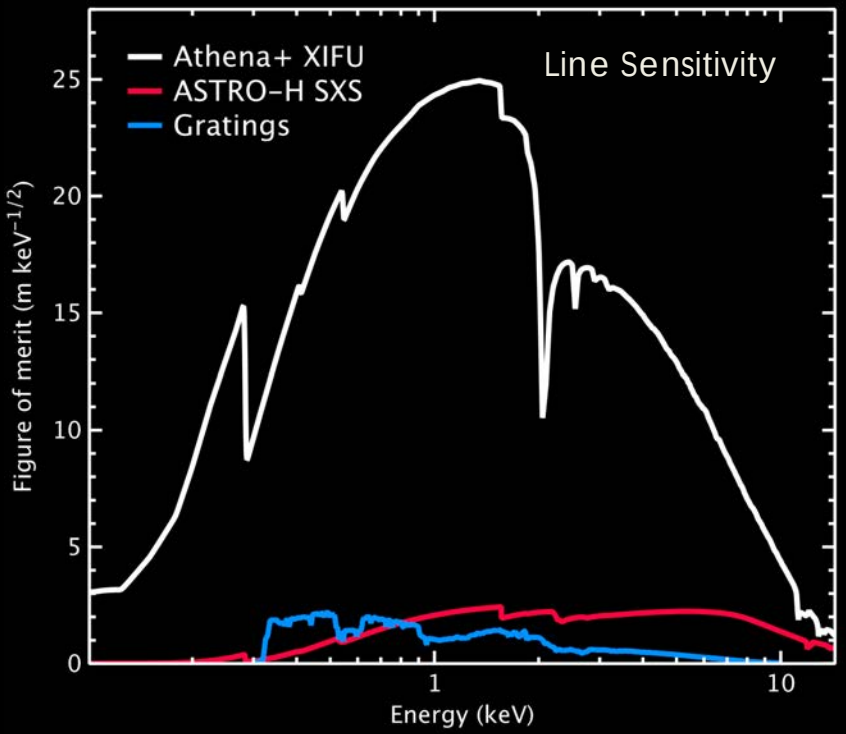
Simplified:
5 to 2 instruments
Extendible to fixed OB

Enhanced:
Angular resolution now 5”
Fields of view increase x 4
Effective area increase x 4
(per instrument)

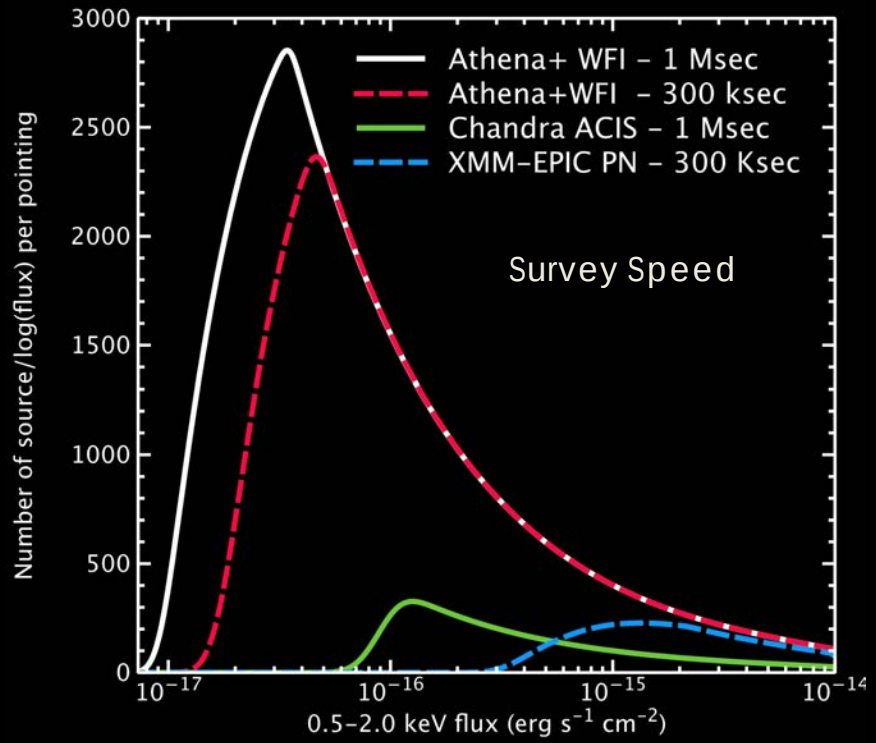
ATHENA+

The first Deep Universe X-ray Observatory

Athena+ has vastly improved capabilities compared to current or planned facilities, and will provide transformational science in virtually all areas of astrophysics



X-ray spectroscopy at the peak of the activity of the Universe



Deep survey capability into the dark ages and epoch of reionization

ATHENA+

Athena+: a powerful observatory

Planets

(interaction of solar wind with planet environment and comets)

Exoplanets

Stellar physics

Supernovae

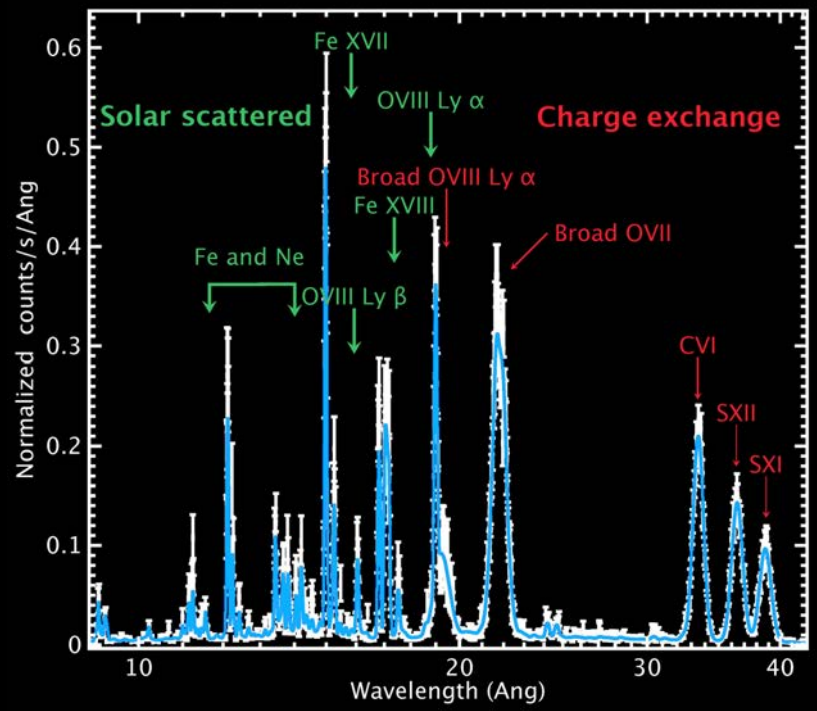
(explosion mechanism, heavy element production)

Stellar endpoints

(physics of outflows and winds in X-ray binaries)

Sgr A*

Interstellar dust and medium



Jupiter

Branduardi-Raymont, Sciortino, et al., 2013 arXiv 1306.2332; Sciortino, Rauw et al., 2013 arXiv1306.2333; Motch, Wilms, et al., 2013 arXiv1306.2334; Decourchelle, Costantini et al., 2013 arXiv1306.2335

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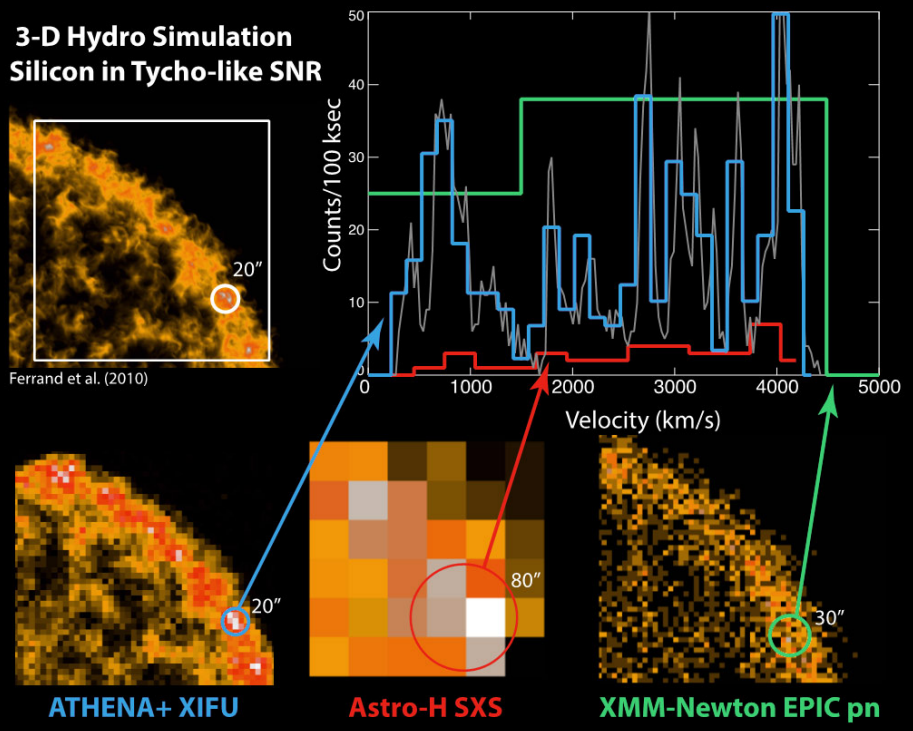

Branduardi-Raymont, Sciortino, et al., 2013 arXiv 1306.2332; Sciortino, Rauw et al., 2013 arXiv1306.2333; Motch, Wilms, et al., 2013 arXiv1306.2334; Decourchelle, Costantini et al., 2013 arXiv1306.2335

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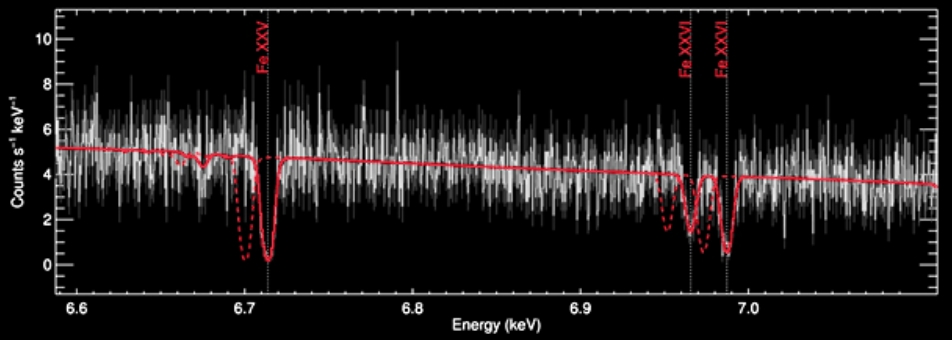
Sgr A*

Interstellar dust and medium

Outflow in X-ray binary, 10ks



Branduardi-Raymont, Sciortino, et al., 2013 arXiv 1306.2332; Sciortino, Rauw et al., 2013 arXiv1306.2333; Motch, Wilms, et al., 2013 arXiv1306.2334; Decourchelle, Costantini et al., 2013 arXiv1306.2335

ATHENA+

Athena+ science in context

Athena+ is a crucial part of the suite of large observatories needed to reach the science objectives of astronomy in the coming decades

ATHENA+

Acknowledgements

The Athena+ Co-ordination Group: Xavier Barcons (ES), Didier Barret (FR), Andy Fabian (UK), Jan-Willem den Herder (NL), Kirpal Nandra (DE), Luigi Piro (IT), Mike Watson (UK)

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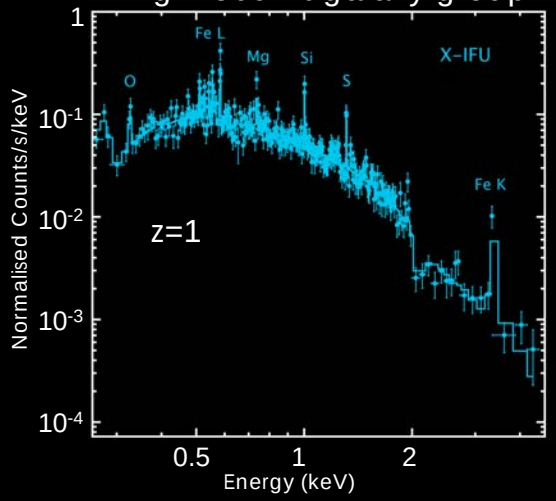
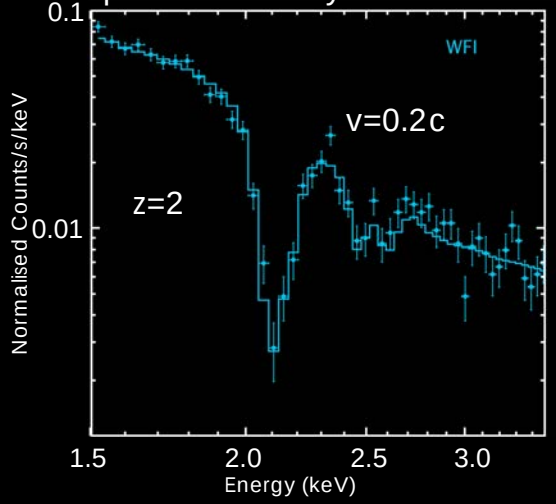
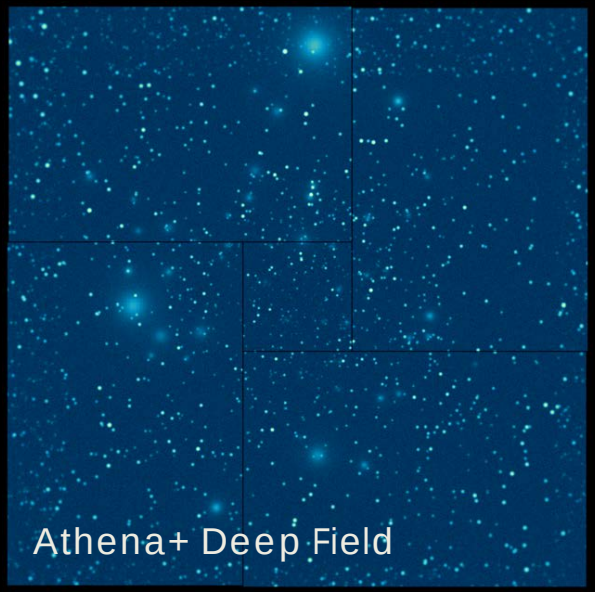


Black hole feedback at peak of activity in Universe





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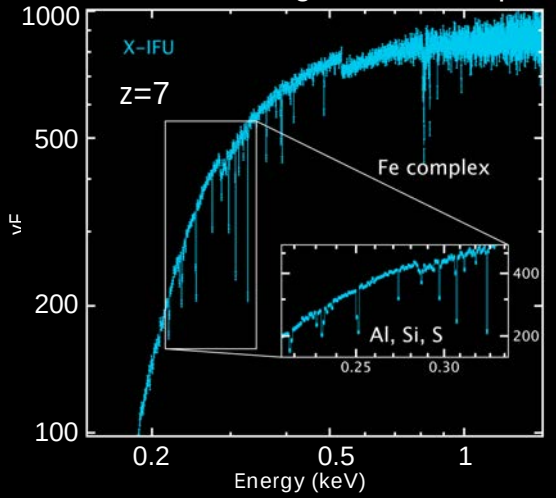

Obscured black hole in the early Universe