eROSITA: synergies between Chandra and the next-generation all-sky X-ray survey

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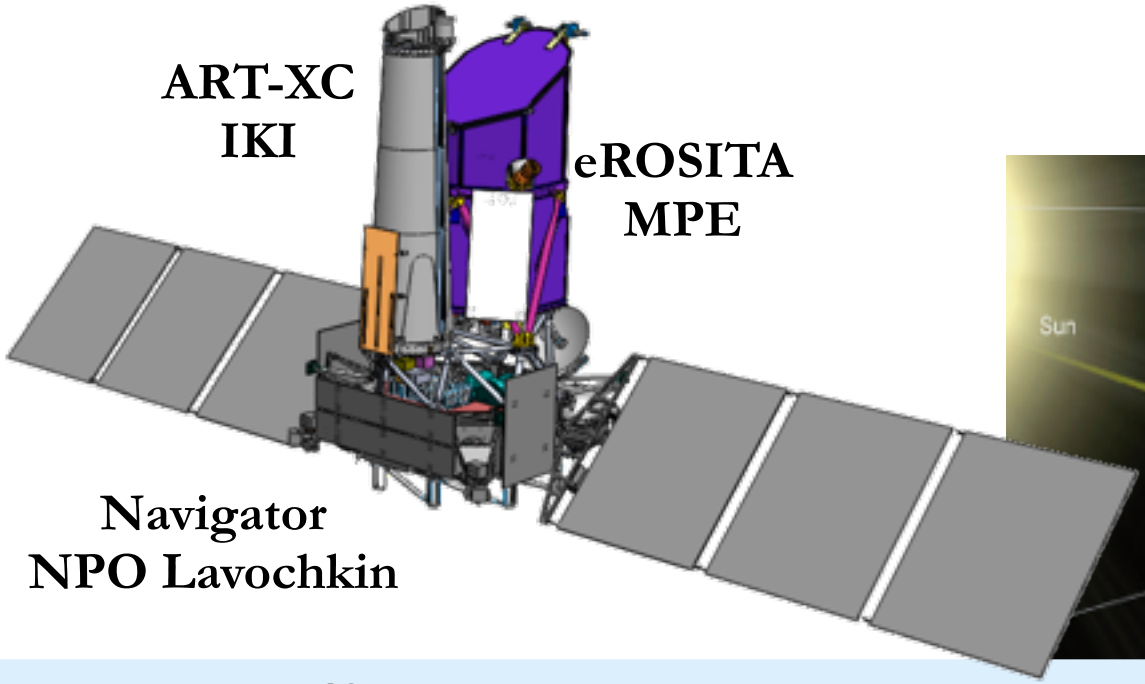
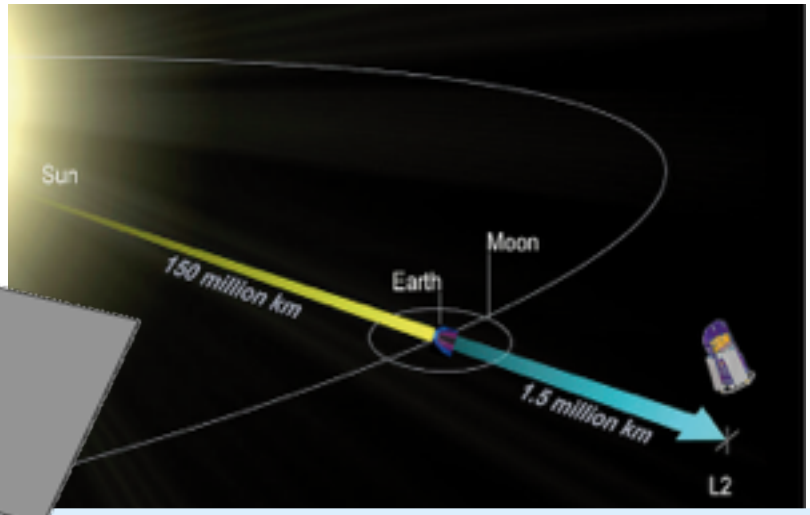
On behalf of Peter Predehl (eROSITA PI), Andrea Merloni (eROSITA Project Scientist) and the eROSITA collaboration

The Spectrum-RG Mission





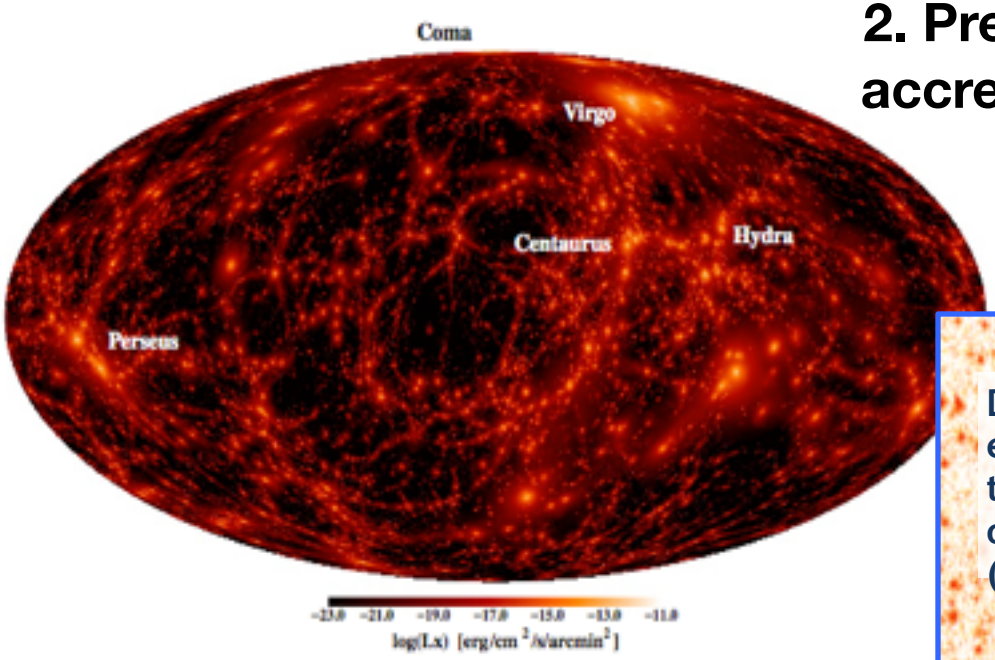
- Joint Russian/German Mission
- Scheduled Launch: late 2017 from Baykonour to L2 with Zenit/Fregat
- 4 yrs: 8 all sky surveys (scanning: 6 rotations/day, 1 degree advance per day)
- 3.5 years: pointed observation phase, including ~20% of GTO. 1 AO per year
- Proprietary data: shared 50/50 between MPE (Germany) and IKI (Russia)
- German (MPE) half: proprietary period 2 yrs
- Periodic release of German all-sky data
- External and Group Collaboration possibilities with eROSITA_DE

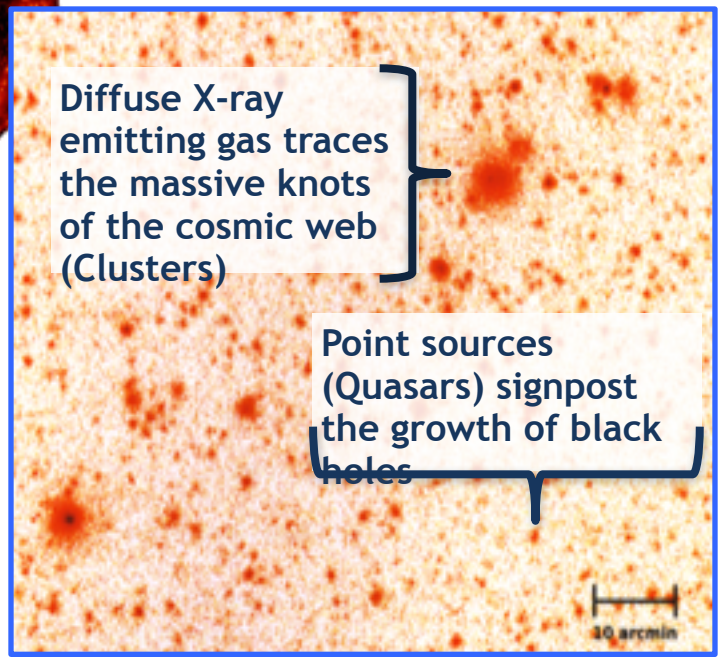
eROSITA: Scientific Problems

1. Trace the growth of cosmic structure using the largest gravitationally-bound systems

2. Precision measurement of the accretion history of the Universe

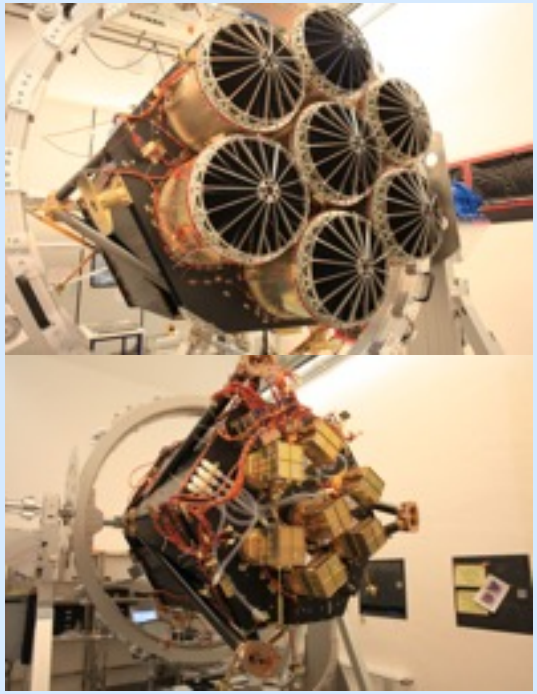
3. Find out what (else) is out there in the X-ray Universe



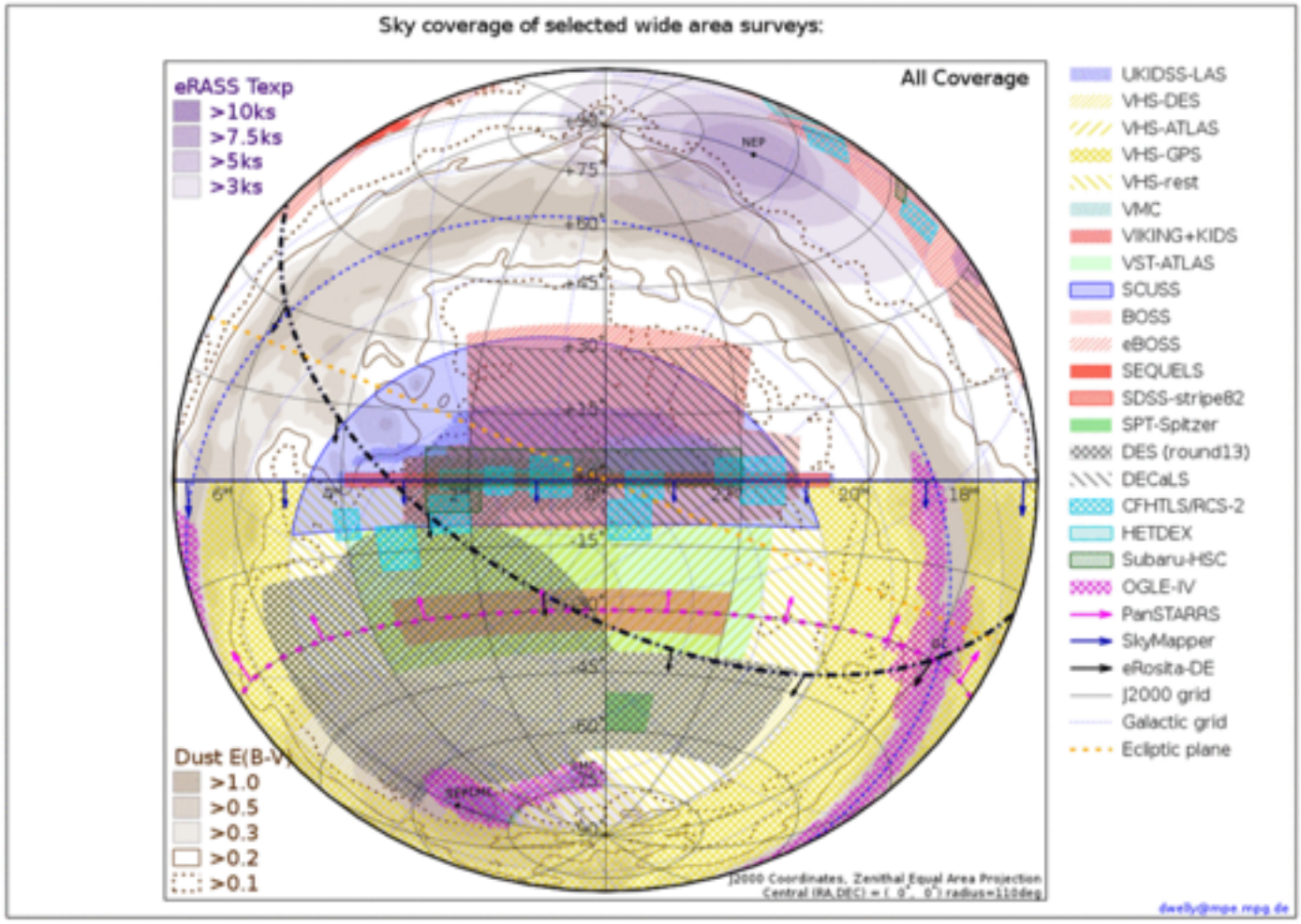


eROSITA/SRG Status and Schedule

- *Next generation all sky X-ray survey*
  - *7 telescopes: 1 deg^2 FOV, 15" PSF, A_{eff}=1300 cm^2@1 keV*
  - *7 pnCCD cameras: 0.3-10 keV, E/ΔE=20-50*
  - *0.5-2 keV: 30x deeper than ROSAT*
  - *2-10 keV: 100x HEAO-1*
  - *Consortium led by MPE (PI: P. Predehl)*
  - *Launch aboard Russian SRG mission*
- *Status:*
  - *Integration complete*
  - *Final (end-to-end) test starts Aug 29th*
  - *Shipping date to Russia Oct 25 2016*
  - *Scheduled SRG launch Nov/Dec 2017*

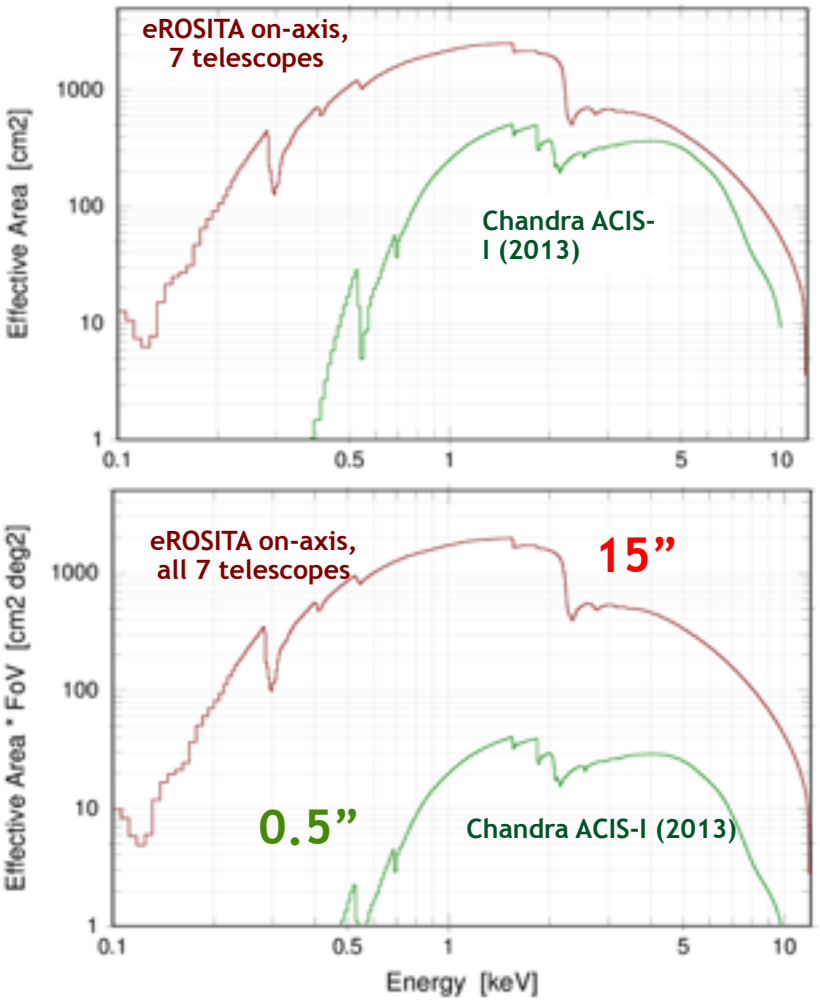


The eROSITA sky



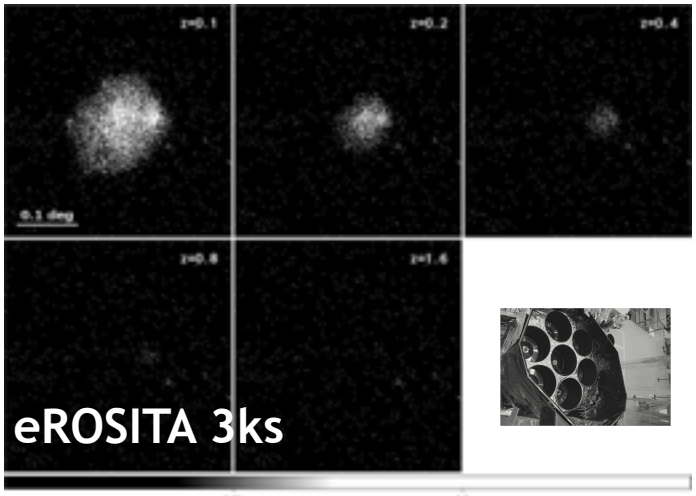
Periodic data releases for “German sky” e.g. 6, 18, 48 months + 2 years
External Collaborations via eROSITA_DE working groups
Open AO after survey phase

eROSITA/Chandra Capabilities



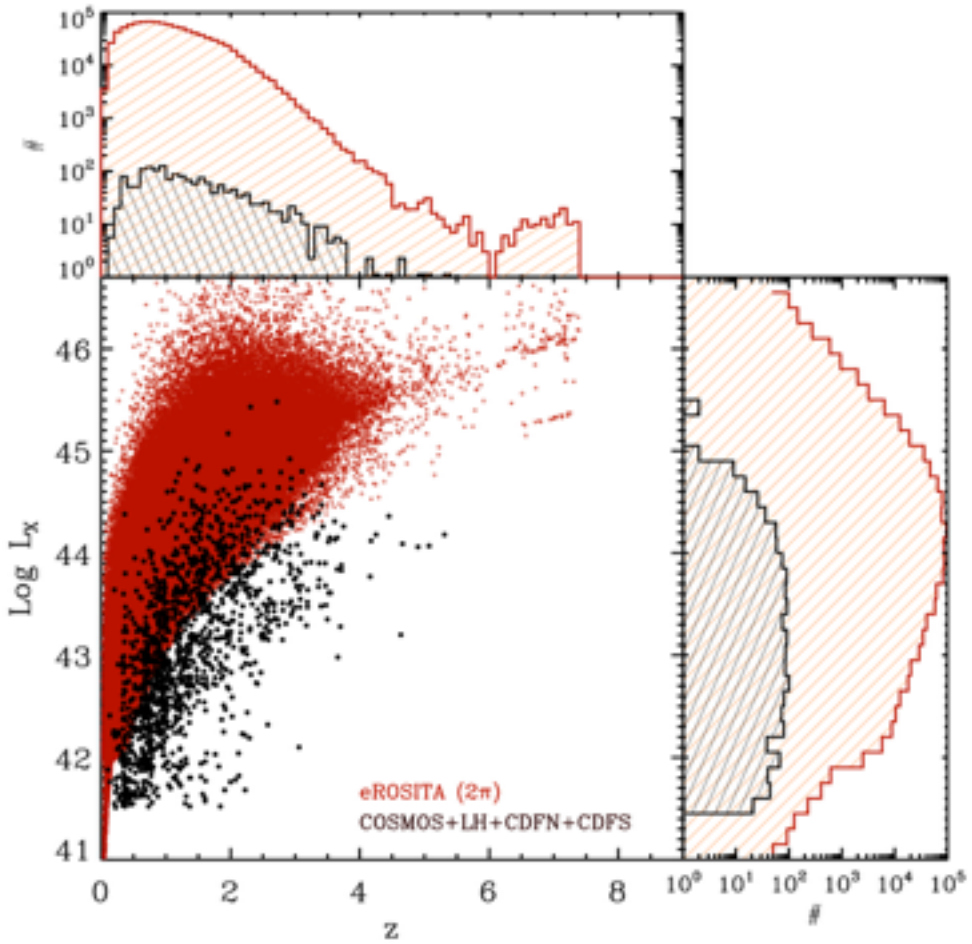
Konrad Dennerl

Markevitch et al. 2004



Hoffmann et al. 2016

eROSITA/Chandra Complementarity



Chandra/XMM

eROSITA

Luminosity-redshift plane for accreting supermassive black holes

eROSITA/Chandra Synergy

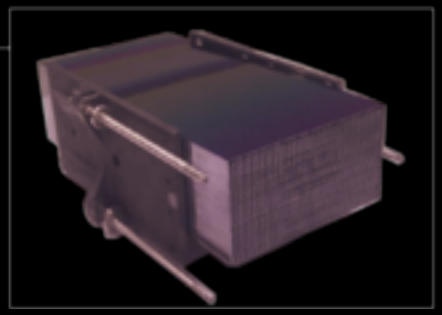
- *eROSITA will provide unprecedented samples:*
  - *100k clusters, 3 M AGN, 500k active stars, accreting binaries, transients and unknowns*
  - *Flux range 10^{-12} – 10^{-15} erg cm^{-2} s^{-1}*
- *Chandra followup of selected eROSITA sources*
  - *Clusters: cosmological calibration and physics*
  - *AGN: environmental studies to high redshift*
  - *Binaries, transients: spectroscopy*

The Hot and Energetic Universe:
Nandra, Barret, Barcons, Fabian, den Herder, Piro, Watson et al. 2013 arXiv 1306.2307

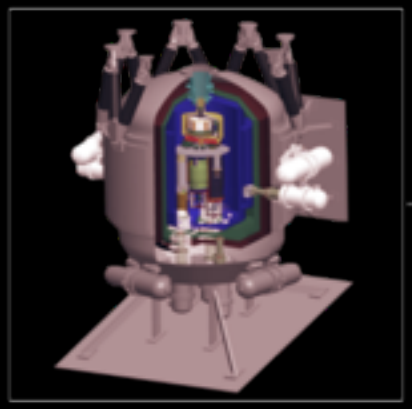
The Athena Observatory

Willingale et al, 2013
arXiv1308.6785

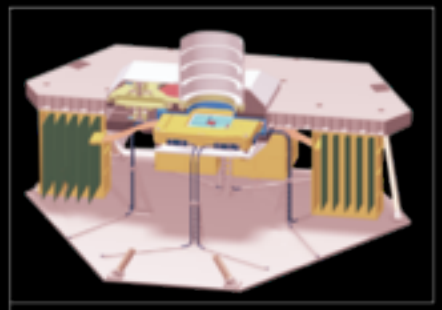
L2 orbit Ariane V
Mass 6000 kg
Power 2500 W
5 year mission



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}



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



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

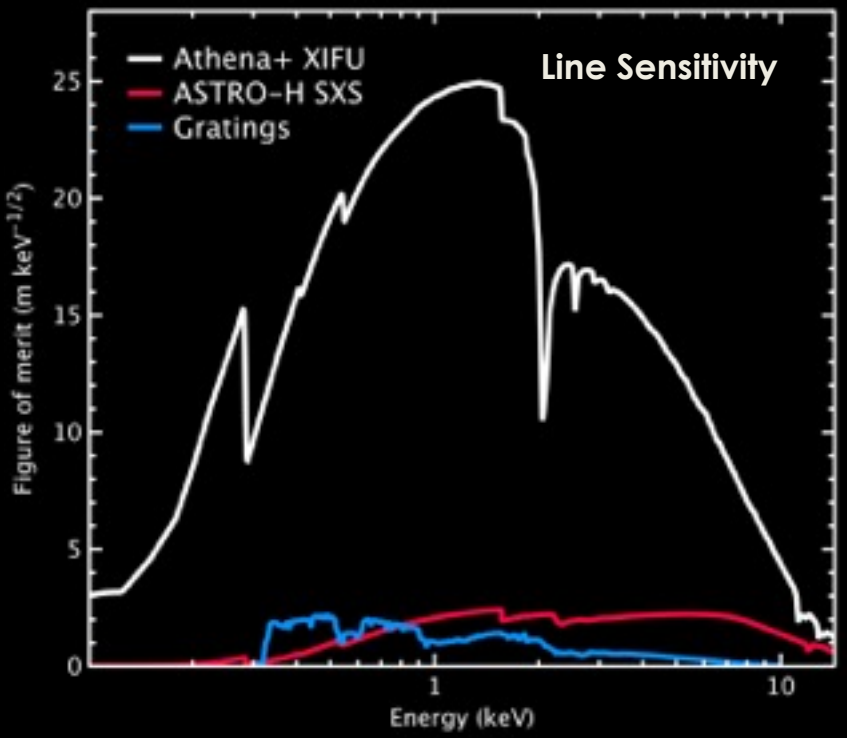
Barret et al., 2013 arXiv:1308.6784

Rau et al. 2013 arXiv1307.1709

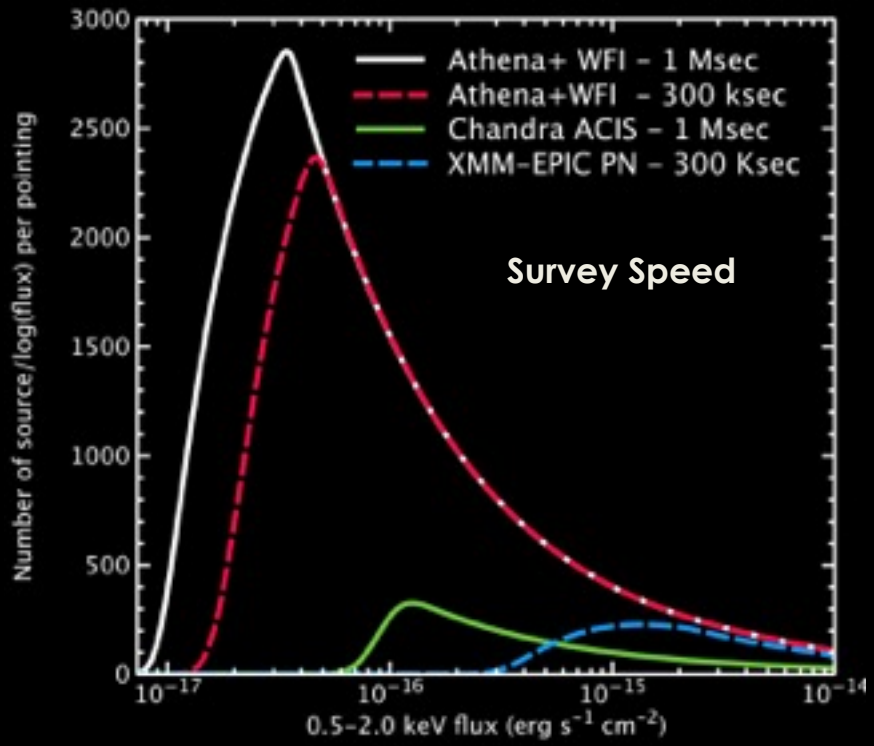
In Phase A for launch in 2028

Athena capabilities

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

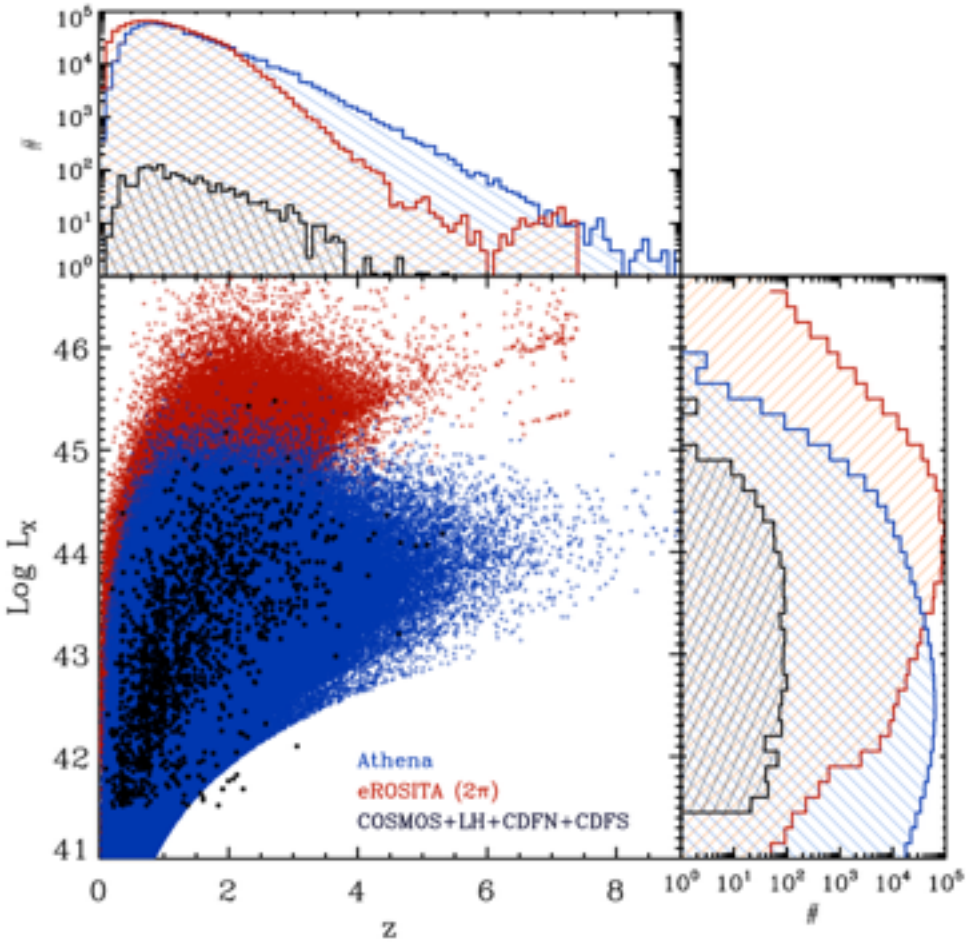


X-ray spectroscopy at the peak of the activity of the Universe



Deep survey capability into the dark ages and epoch of reionization

Athena/ChandraComplementarity



Chandra/XMM

eROSITA

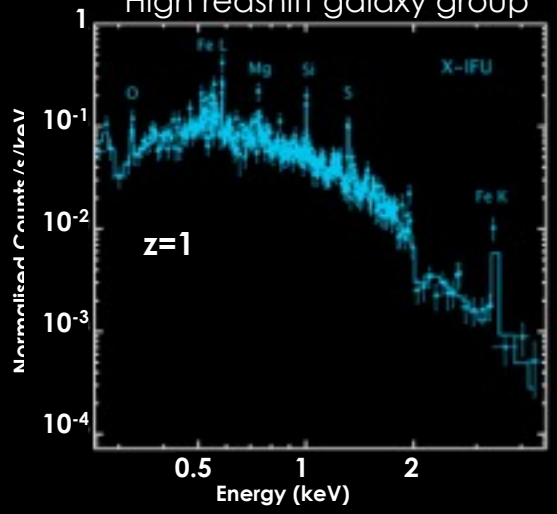
Athena

Luminosity-redshift plane for accreting supermassive black holes

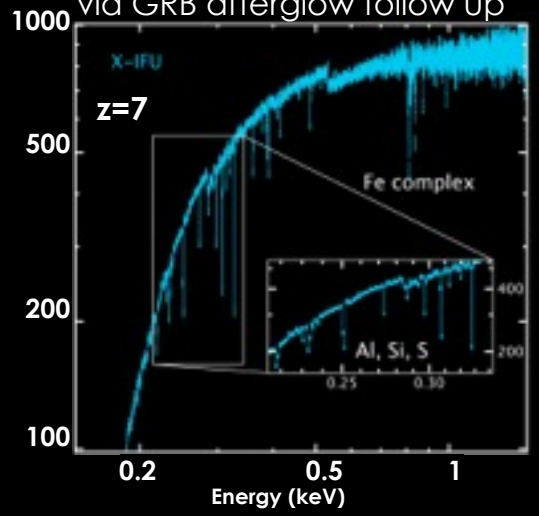
ATHENA+

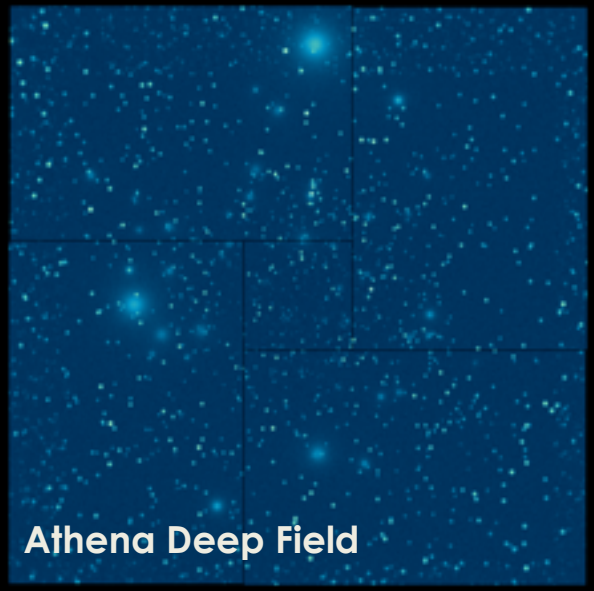
Athena
Exploring the Hot and Energetic Universe

High redshift galaxy group

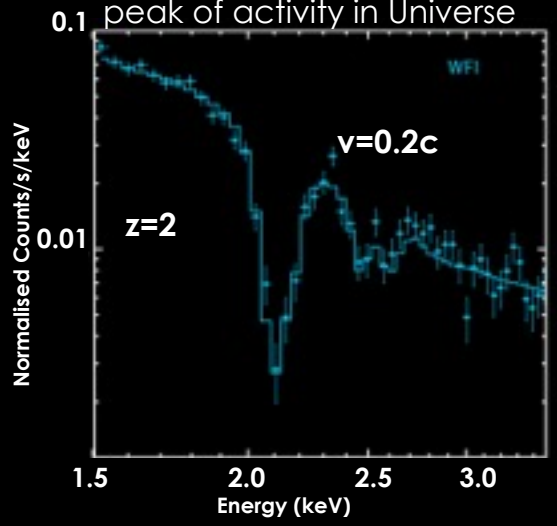


Primordial stellar populations via GRB afterglow follow up

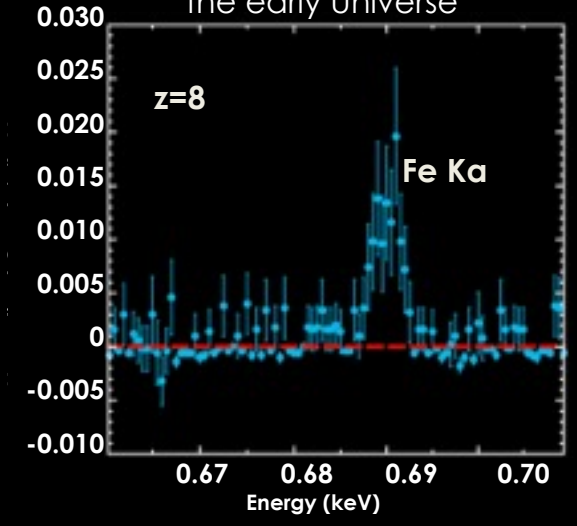




Black hole feedback at peak of activity in Universe



Obscured black hole in the early Universe



Nandra, Barret, Barcons, Fabian, den Herder, Piro, Watson et al. 2013 arXiv 1306.2307

BACKUP

eROSITA data rights and policies

- ***eROSITA is a PI instrument*** http://www.mpe.mpg.de/eROSITA
  - *Data split 50% MPE and 50% IKI West/East*
  - *German data public after 2 years, periodic releases e.g. eRASS1, 3, 8*
  - *Proprietary access via eROSITA_DE consortium*
  - *Projects/papers regulated by working groups*
- ***Working Groups:***
  - ***Science:*** *Clusters/Cosmology, AGN, Normal galaxies, Compact objects, Diffuse emission/SNR, Stars, Solar System*
  - ***Infrastructure:*** *Time Domain, Data analysis and catalogues, Multi-wavelength follow-up, Calibration, Background*
- ***Collaboration policy:***
  - *Individual External Collaborations (proposal to WGs)*
  - *Group External Collaborations (team-to-team MoUs)*

Multi-λ, X-ray followup

- *Ground based imaging:*
  - *AGN to r_{AB}~24 all sky*
  - *DES, PanStarrs, DECALS*
  - *NIR for high-z clusters*
  - *Future: LSST, Euclid*
- *Spectroscopy*
  - *Current: SDSS*
  - *Future: 4MOST, WEAVE, DES*
- *XMM, Chandra, NuSTAR followup*
  - *Keep going!*
- *Astro-H, Athena*
  - *Spectroscopy, Spectral Imaging*