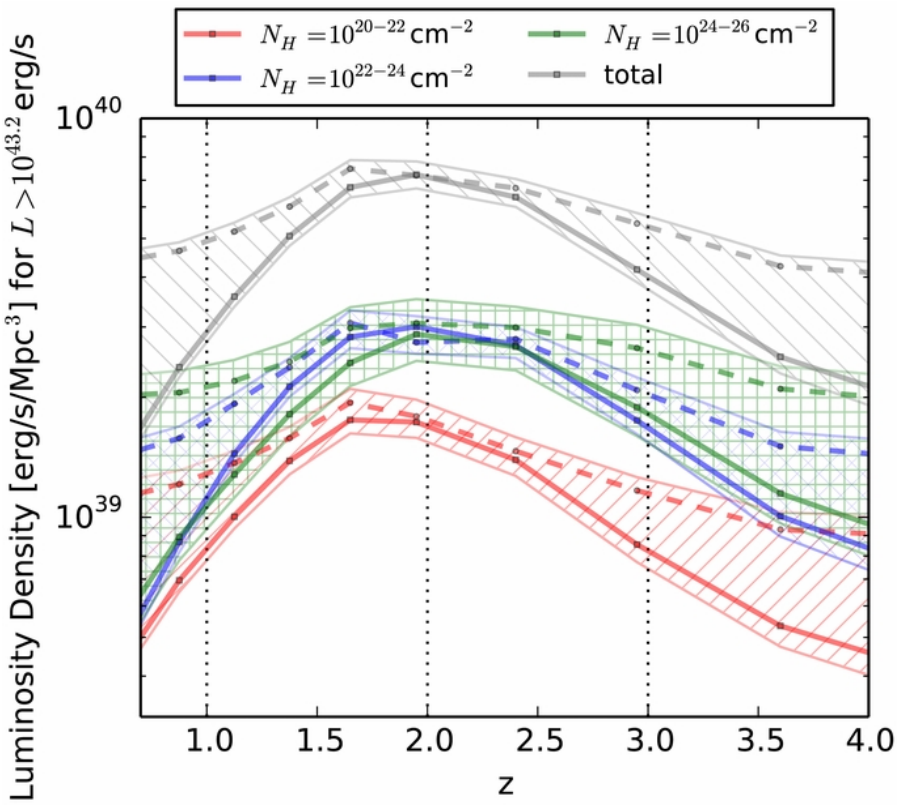
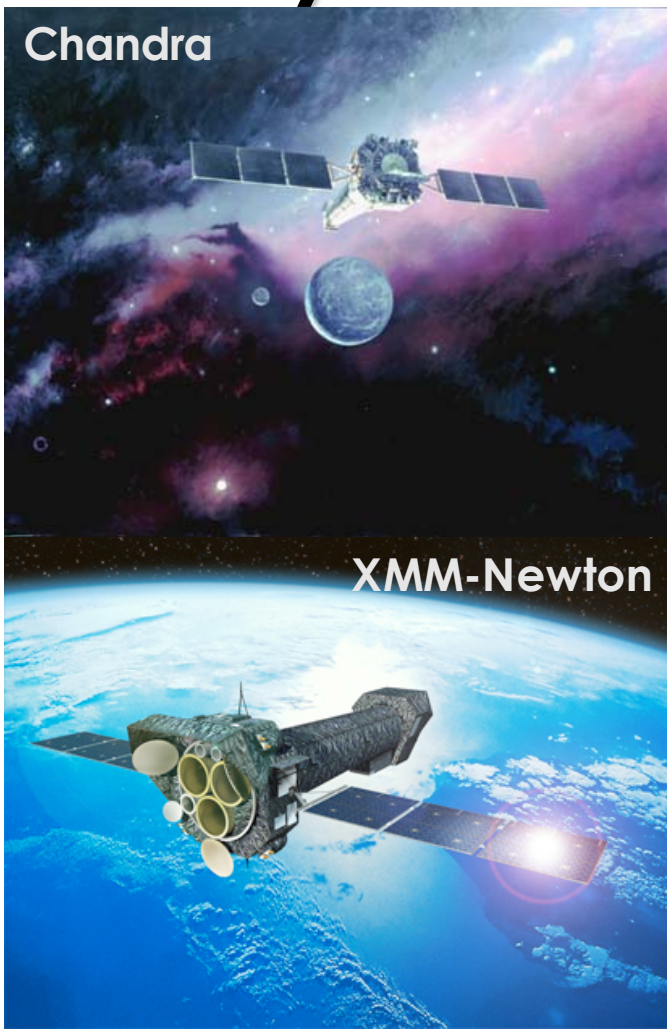
AGN Evolution from X-ray surveys in CANDELS and beyond

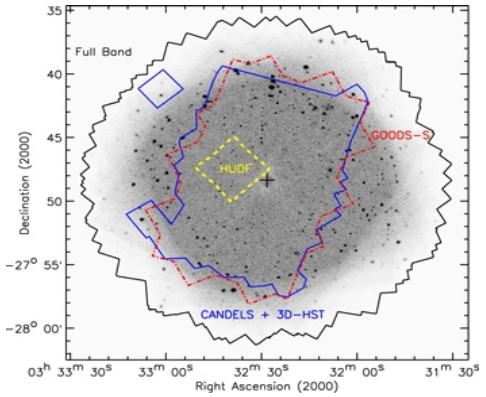




Kirpal Nandra
Max Planck Institute for Extraterrestrial Physics
With **L. Baronchelli,** M. Brightman, **J. Buchner, A. Georgakakis**, Z. Liu, M-L Menzel, A. Merloni, M. Salvato, **T. Simm (MPE),** J. Aird (Cambridge), D. Kocevski (Colby College)

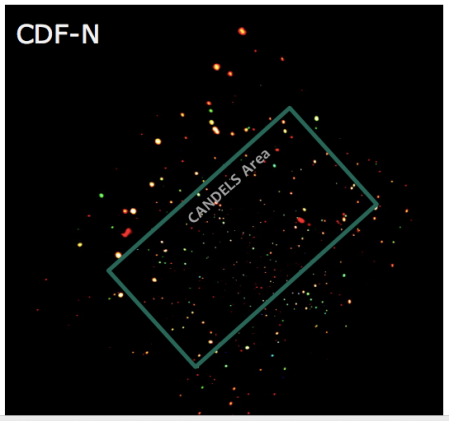
Chandra Surveys in the CANDELS Fields

GOODS-S



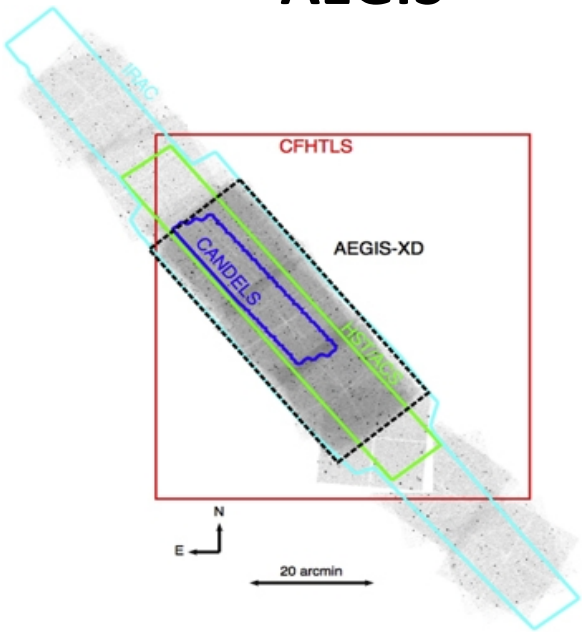
Luo et al. 2016 7Ms depth

GOODS-N



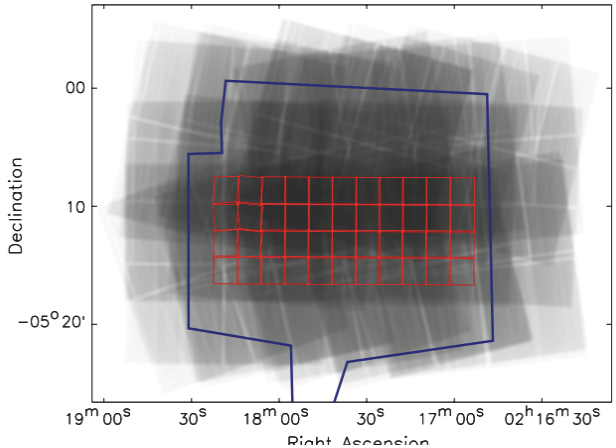
Xue et al. 2016 2Ms depth

AEGIS



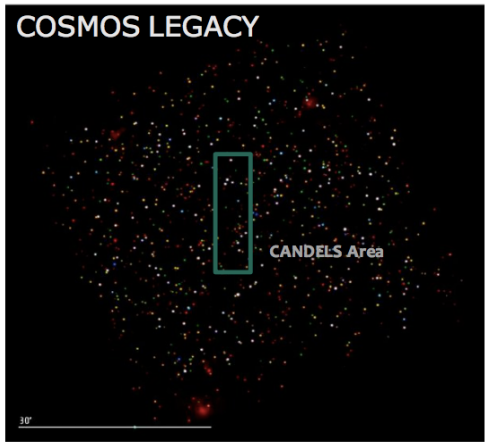
Nandra et al. 2015
800ks depth

UDS



Kocevski et al. 2017
600ks depth

COSMOS



Civano et al. 2015
160ks depth

CANDELS X-ray Status: Edinburgh 2011

FIELD	Images, Evt files	Source Catalogue	Sensitivity Map	CANDELS Cross-ID	Photom/ Photo-z	X-ray Spectra
AEGIS	✔	✔	✔	✔	✗	✔
COSMOS	✔	✗	✗	✗	✗	✗
GOODS-N	✔	✔	✔	✔	✗	✔
GOODS-S	✔	✔	✗	✔	✗	✗
UDS XMM	✗	✗	✗	✗	✗	✗

CANDELS X-ray Status: UCSC 2015

FIELD	Images, Evt files	Source Catalogue	Sensitivity Map	CANDELS Cross-ID	Photom/ Photo-z	X-ray Spectra
AEGIS	✔	✔	✔	✔	✔✔	✔✔
COSMOS	✔	✔	✔	✔	✔✔	✔✔
GOODS-N	✔	✔	✔	✔	✔✗	✔✗
GOODS-S	✔	✔	✔	✔	✔✔	✔✔
UDS	✗	✗	✗	✗	✔✗	✗✗

CANDELS X-ray Status: UCSC 2017

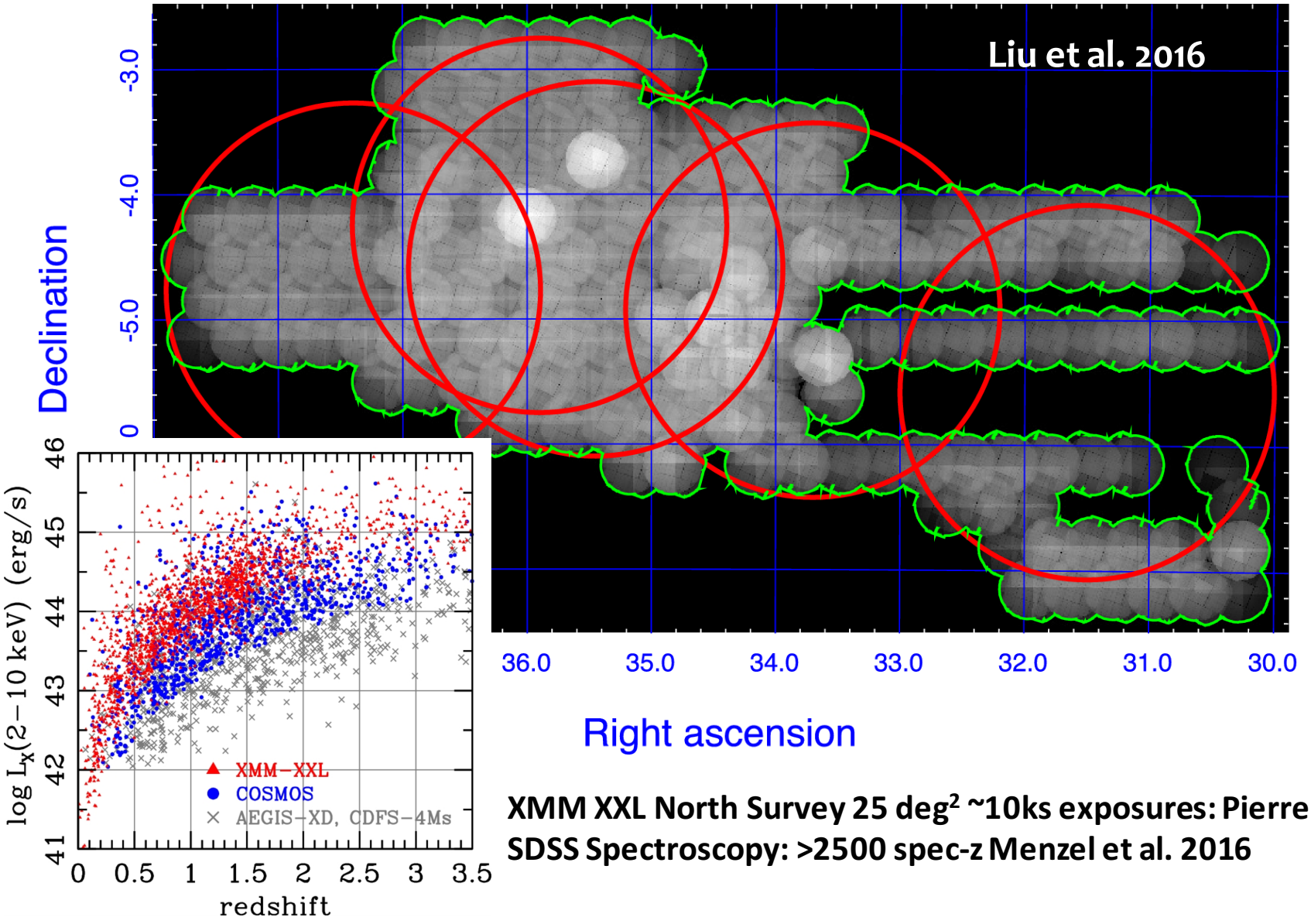
FIELD	Images, Evt files	Source* Catalogue	Sensitivity Map	CANDELS Cross-ID	Photom/ Photo-z	X-ray Spectra
AEGIS	✔	✔	✔	✔	✔✔	✔✔
COSMOS	✔	✔	✔	✔	✔✔	✔✔
GOODS-N	✔	✔	✔	✔	✔?	✔✗
GOODS-S*	✔	✔	✔	✔	✔✔	✔✔
UDS	✔	✔	✔	✔	✔?	✔✔

*Point – but extended also available

**4Ms only, 7Ms images source catalogues etc. available from Luo, Brandt et al. (PSU)*

Papers: Salvato et al. 2011, Erfanianfar et al. 2013; Rangel et al. 2013; Hsu et al. 2013; Brightman et al. 2014; Buchner et al. 2014; Buchner et al. 2015; Nandra et al. 2015; Georgakakis et al. 2015; Kocevski et al. 2017

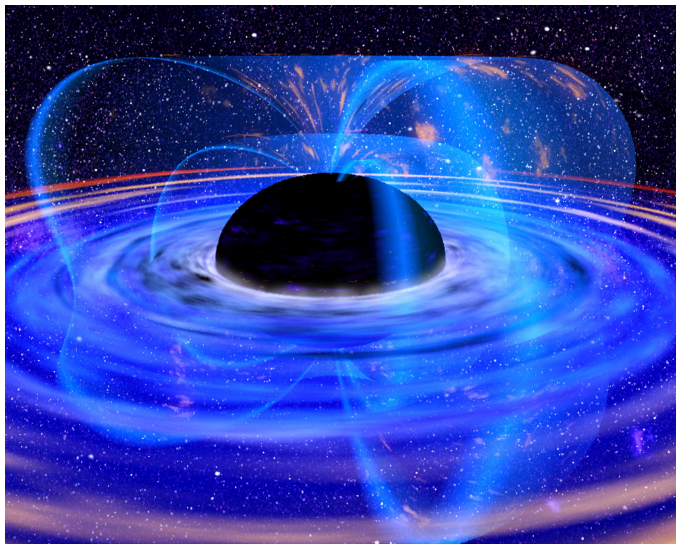
And Beyond…



XMM XXL North Survey 25 deg^2 ~10ks exposures: Pierre et al. (2016)
SDSS Spectroscopy: >2500 spec-z Menzel et al. 2016

Some Interesting Questions

- Black Hole Growth
  - What is the history of SMBH growth?
  - What fraction is obscured/Compton thick?
  - What is the accretion mode?
  - How does it compare to star formation?
  - What is the behaviour at high redshift?



- AGN/Galaxy Co-evolution
  - What are the properties of AGN hosts?
  - How do they compare to “normal” galaxies (of similar mass)?
  - What triggers black hole growth?
  - Can we see evidence for AGN feedback?

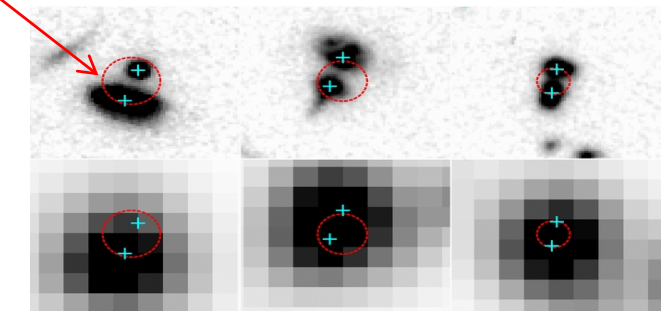
Brightman & Nandra 2014; Buchner et al. 2014; Aird et al. 2015; Buchner et al. 2015; Georgakakis et al. 2015; Georgakakis et al. 2017

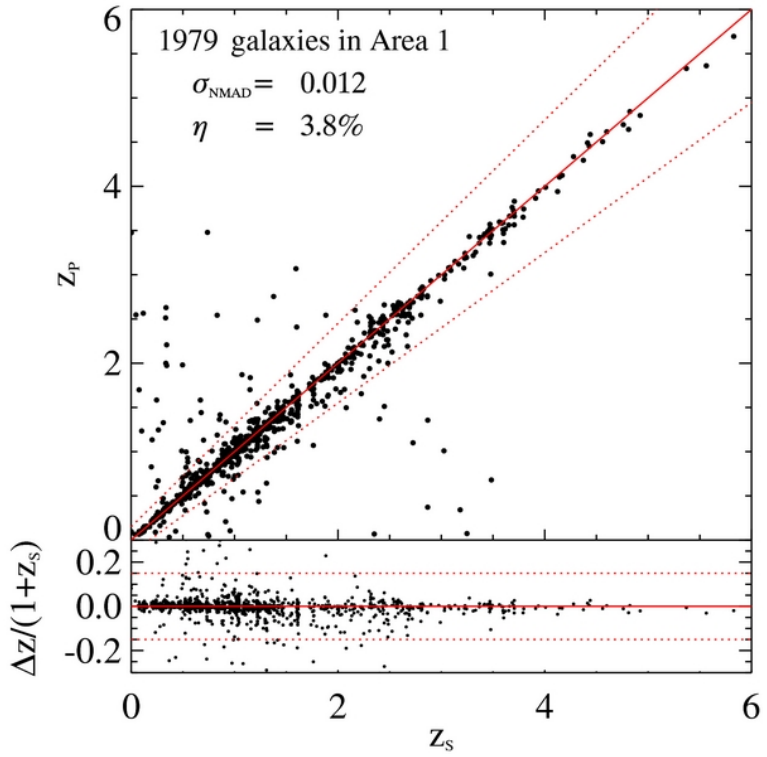
CANDELS: Identifications and Redshifts

X-ray

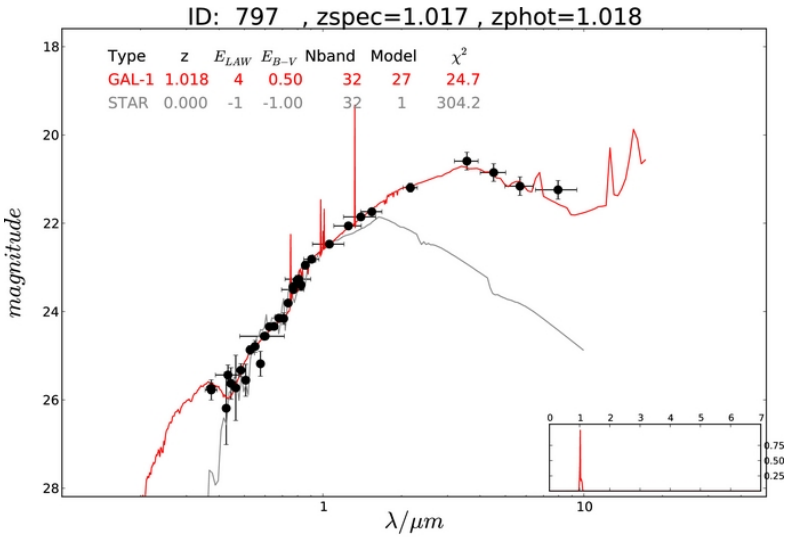
HST WFC3
H-band

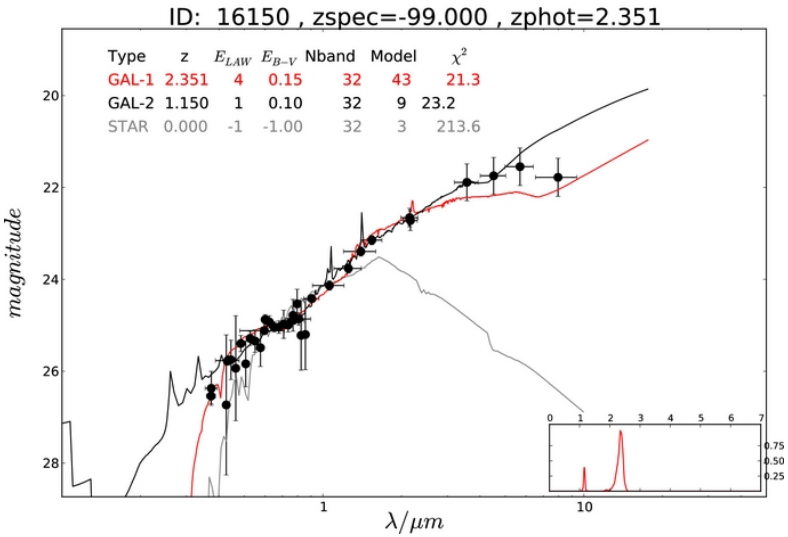
Spitzer
3.6mm





Hsu, Salvato, Nandra et al. (2013)



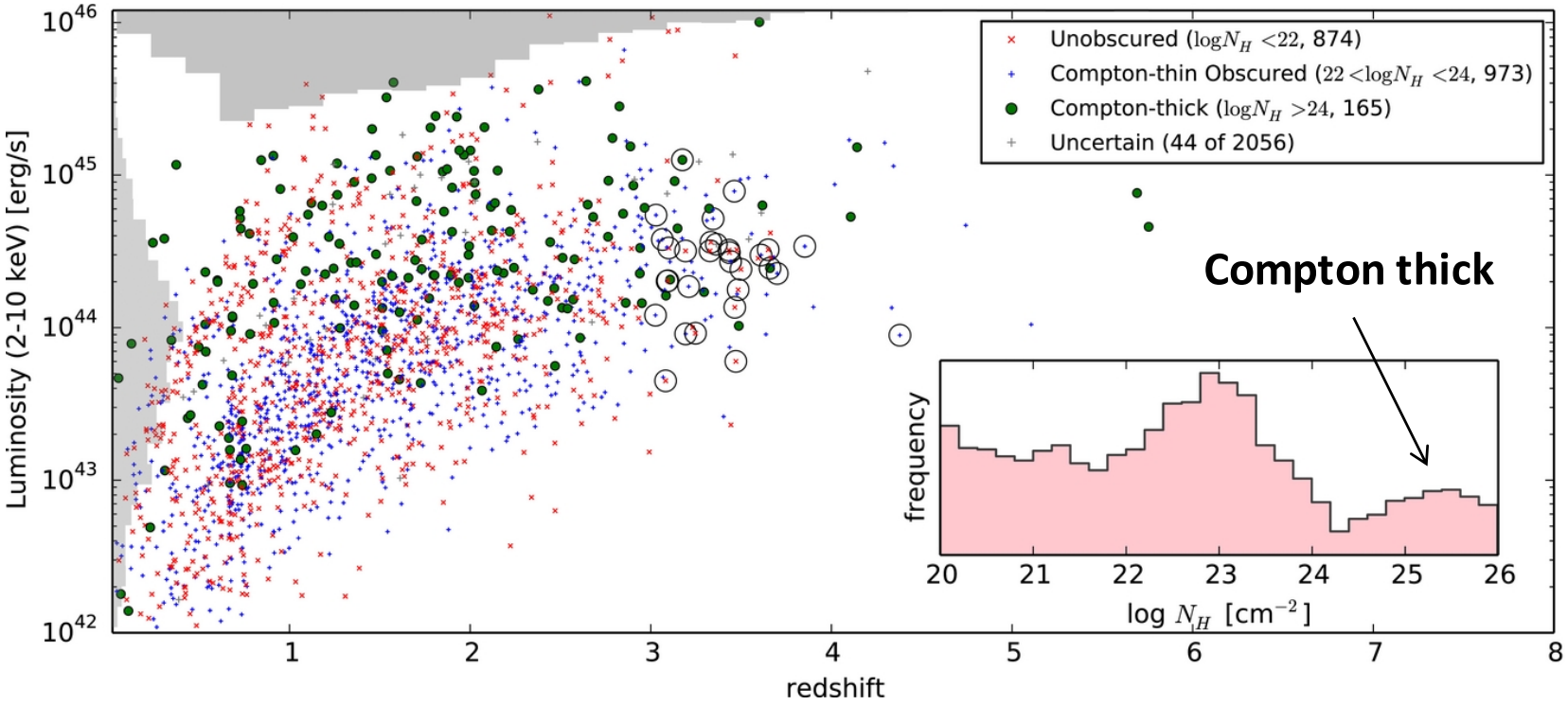


Techniques: Salvato et al. (2009, 2011)

A complete picture of SMBH evolution

Buchner, Georgakakis, Nandra et al. (2015)

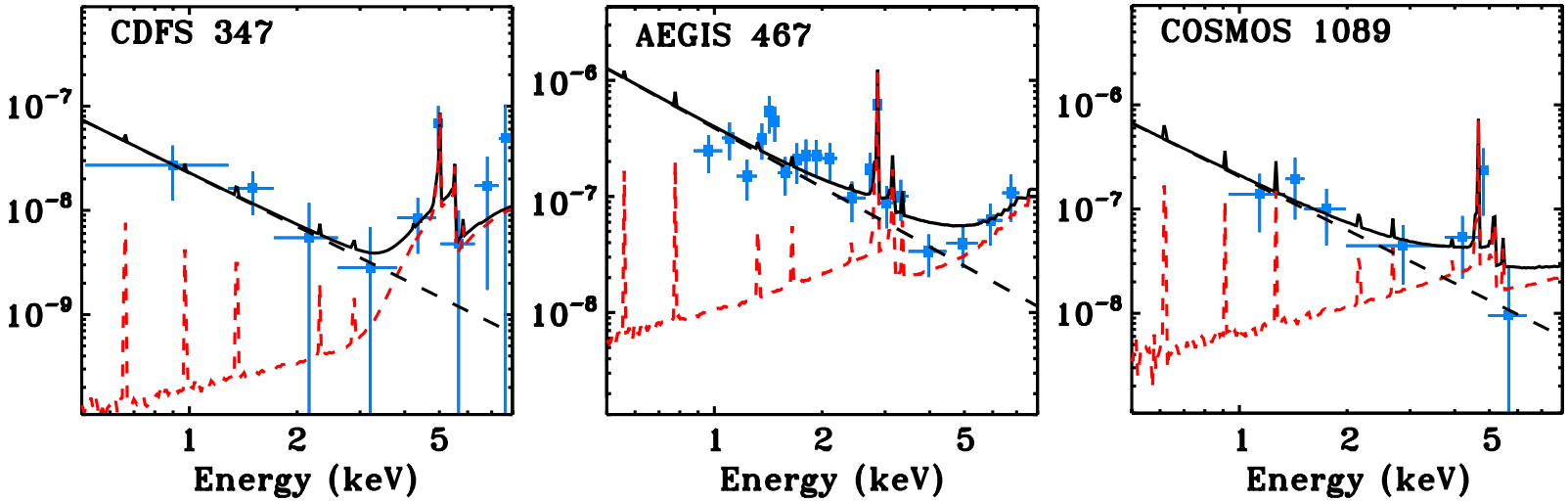
CDFS+AEGIS+COSMOS+XMM-XXL >**2000 AGN**

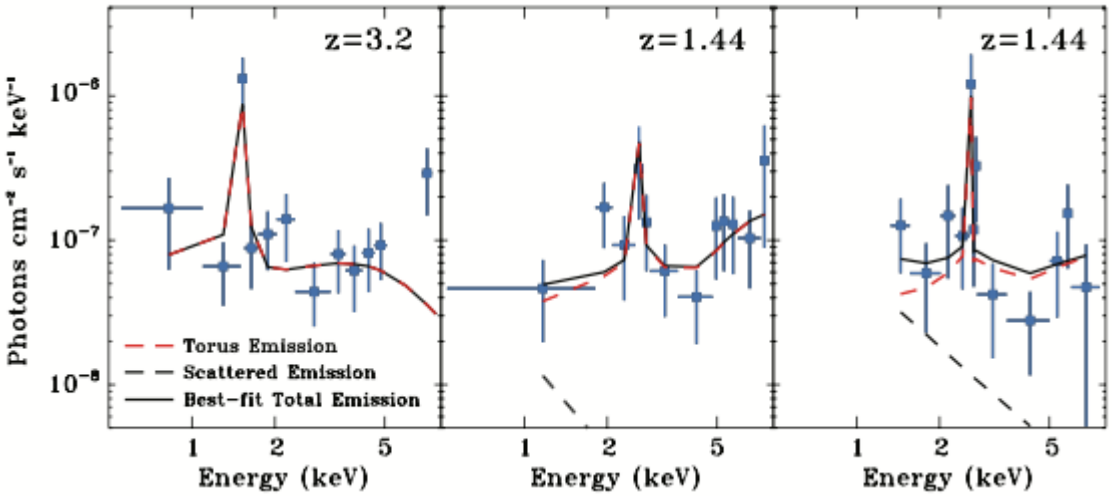


- Bayesian spectral modelling "BXA" yielding N_H and L_X PDFs
- Bayesian model selection shows significant spectral complexity
- Novel, non-parametric determination of X-ray luminosity function accounting for all uncertainties and selection effects

Compton Thick AGN in Chandra Surveys

Brightman et al. 2014: CDFS+AEGIS+COSMOS – 100 CTAGN





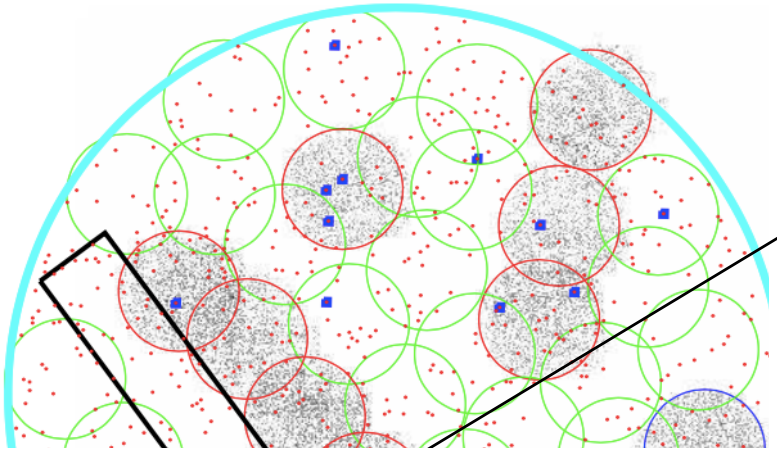
X-UDS Compton thick AGN: Kocevski et al. 2017

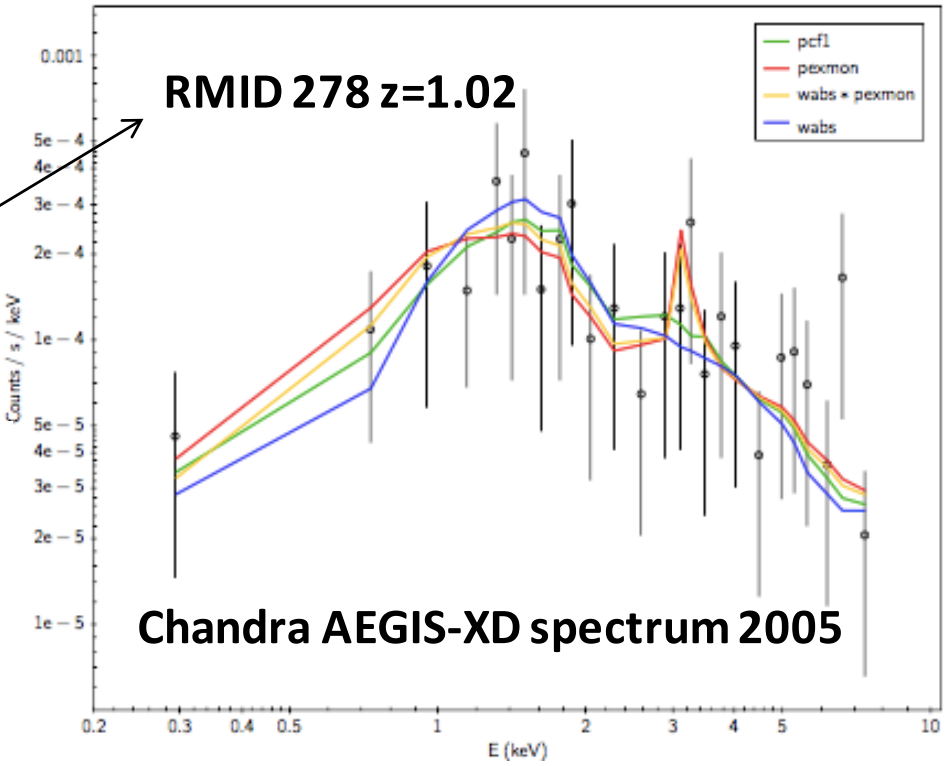
The SDSS-XMM Reverberation Mapping Field

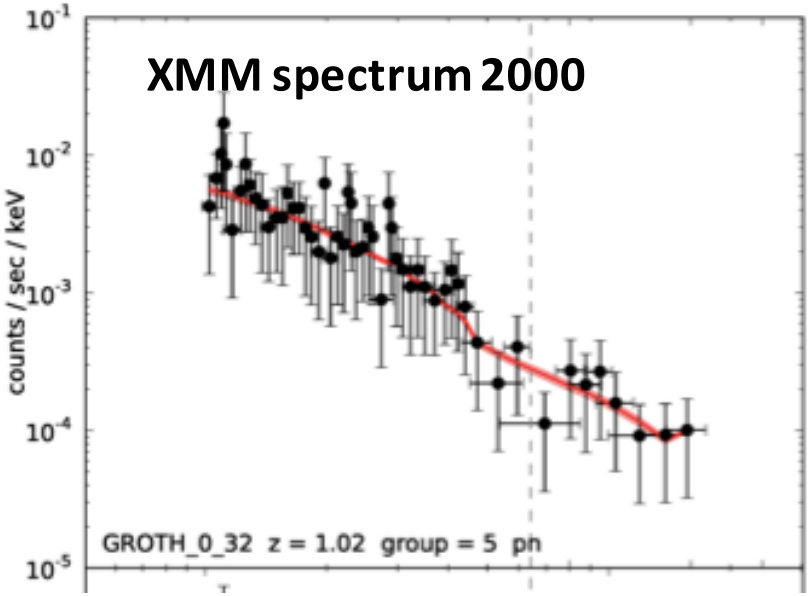
SDSS reverberation mapping of ~850 quasars at z=0.5-3: Shen et al. 2015, 2016

Successful XMM Large proposal. PI: A. Merloni

Torben Simm et al., in preparation



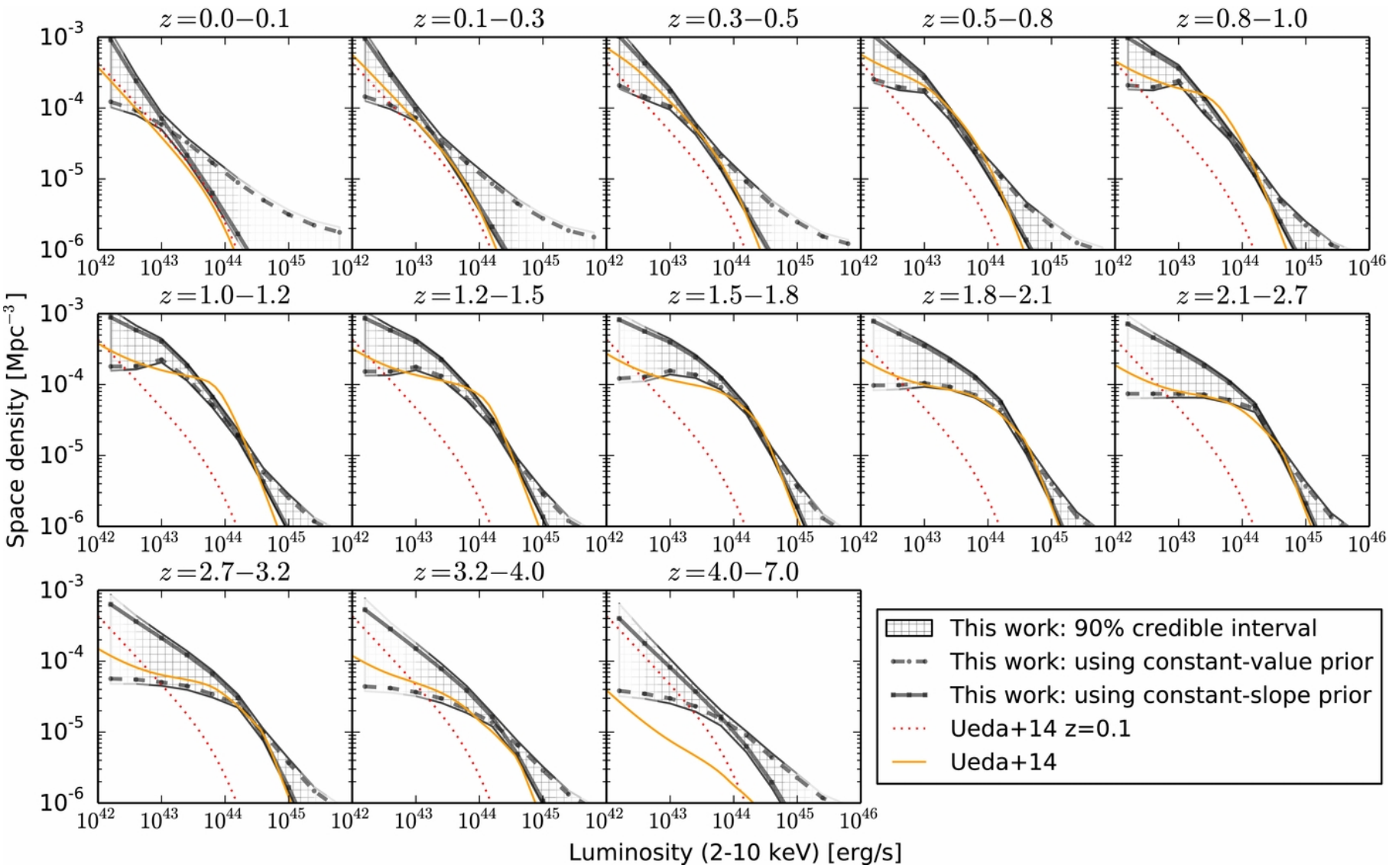




A Compton thick Type 1 QSO?

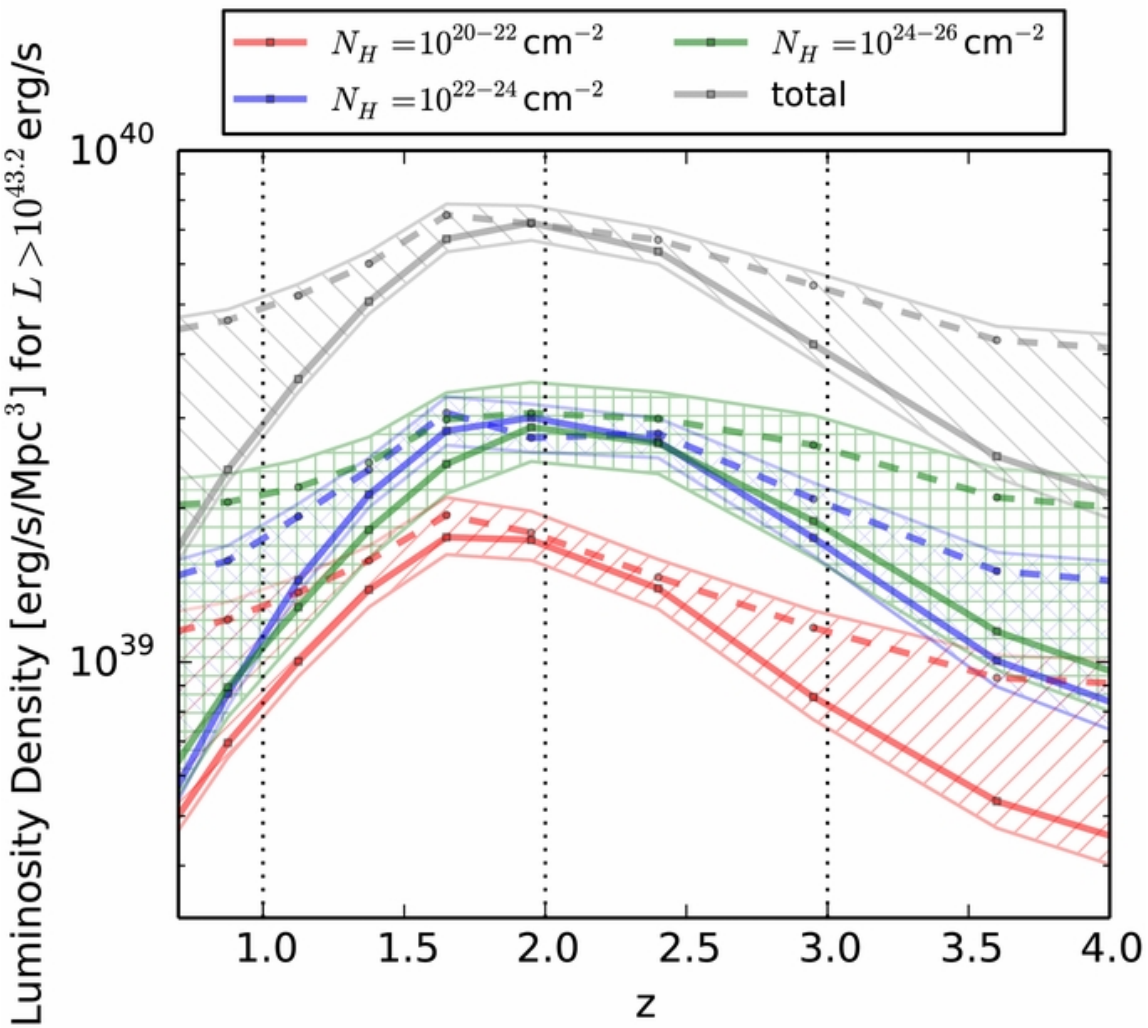
Log M_{BH}=8.3 λ_{Edd}=0.2

Evolution of the X-ray luminosity function



Buchner et al. 2015 see also Ueda et al. 2014; Aird et al. 2015; Miyaji et al. 2015

Obscuration-dependent evolution of SMBH

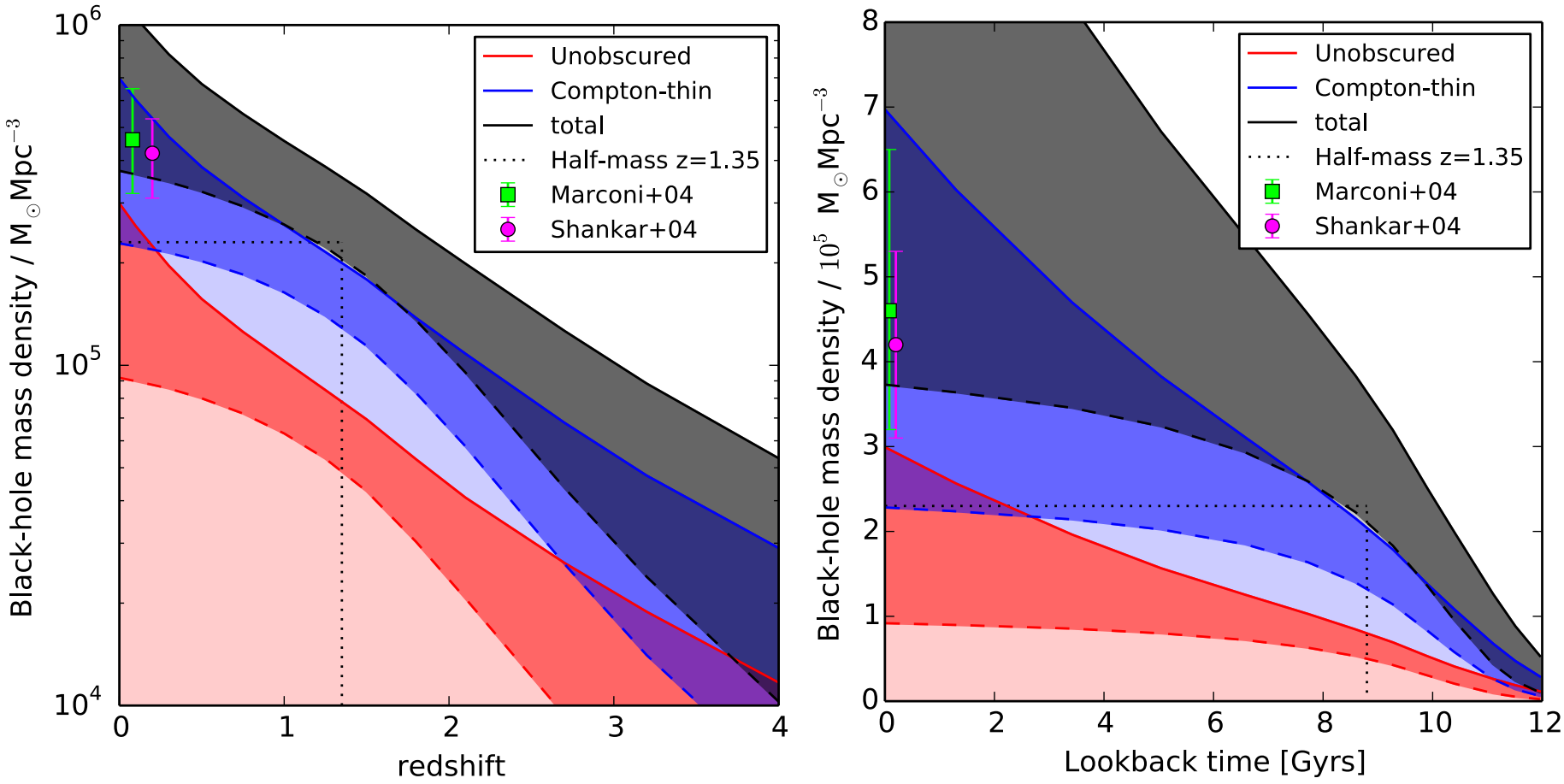


Buchner et al. 2015

- Obscured accretion accounts for ~75% of black hole growth
- Compton thick sources contribute 35-40%

Obscured black holes evolve more rapidly: dominate at z=1-3

The Accretion History

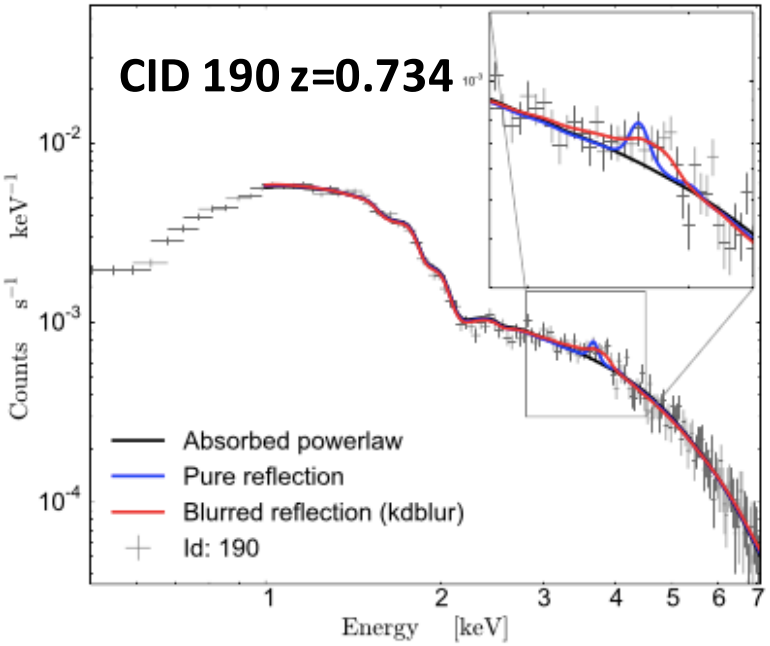


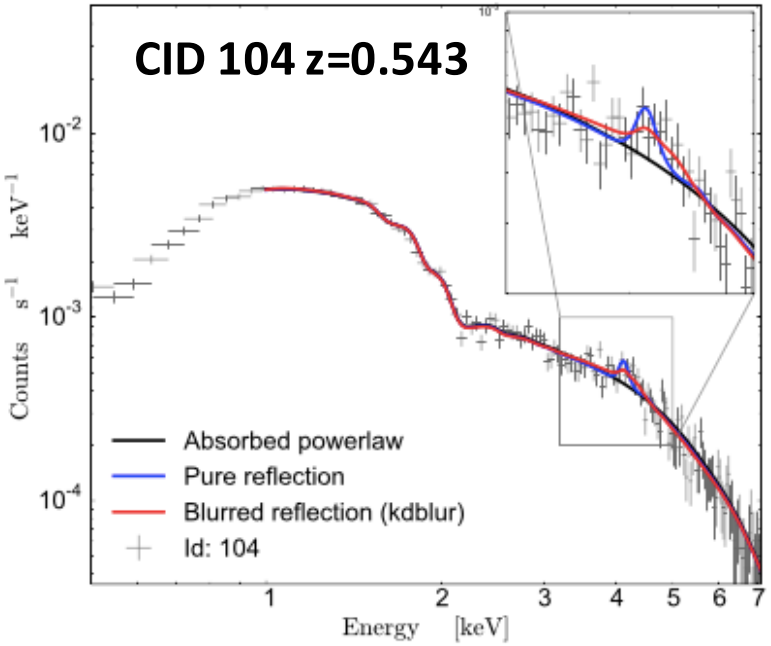
Half BH mass growth at z=1.35

Based on Buchner et al. 2015

Relativistically broadened iron Ka lines in GOODS-S

Linda Baronchelli, in preparation



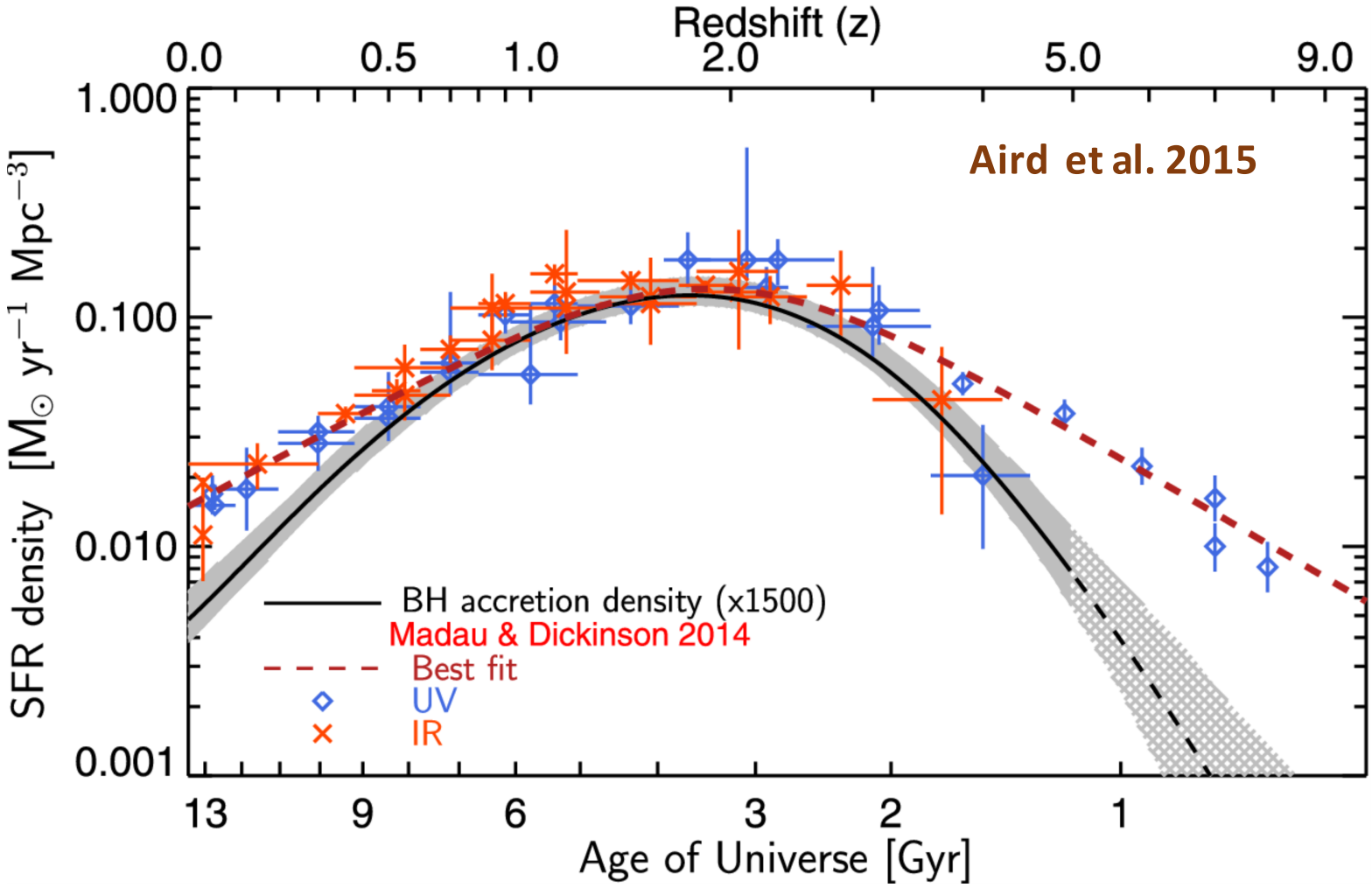


Bayesian BXA fits of 199 CDF-S X-ray spectra
Strong preference for relativistic model

Standard, radiatively efficient accretion disk must extend close to last stable orbit

Can we measure the typical spin?

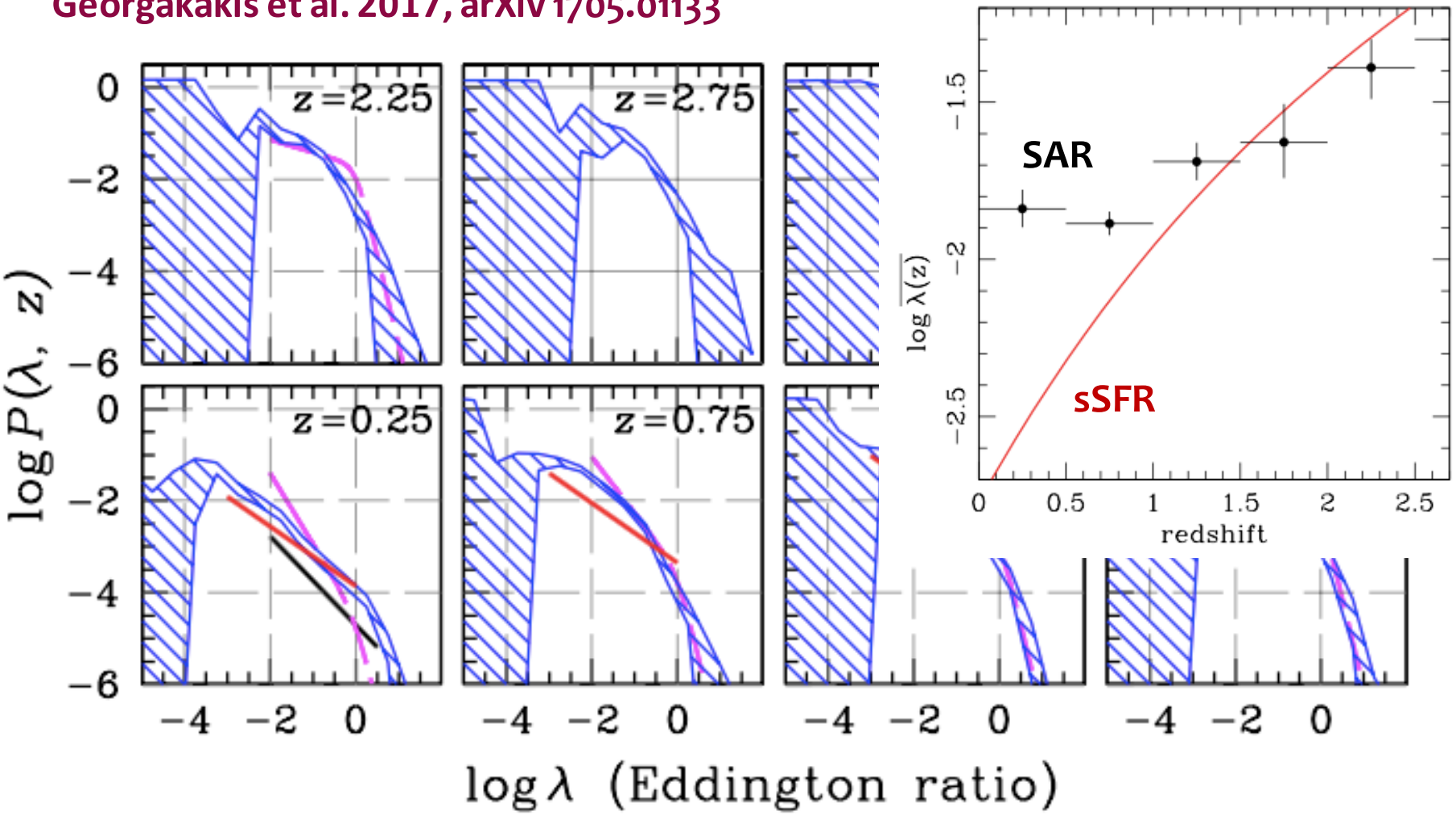
Accretion vs. Star formation history



AGN and star formation peak at the same redshift, but accretion evolves more rapidly at both higher and lower redshift

The Specific Accretion rate distribution

Georgakakis et al. 2017, arXiv 1705.01133



The decline in the accretion luminosity since z~1 is mostly due to a reduction in the AGN fraction/duty cycle rather than the typical accretion rate

X-RAY SURVEYS: THE FUTURE

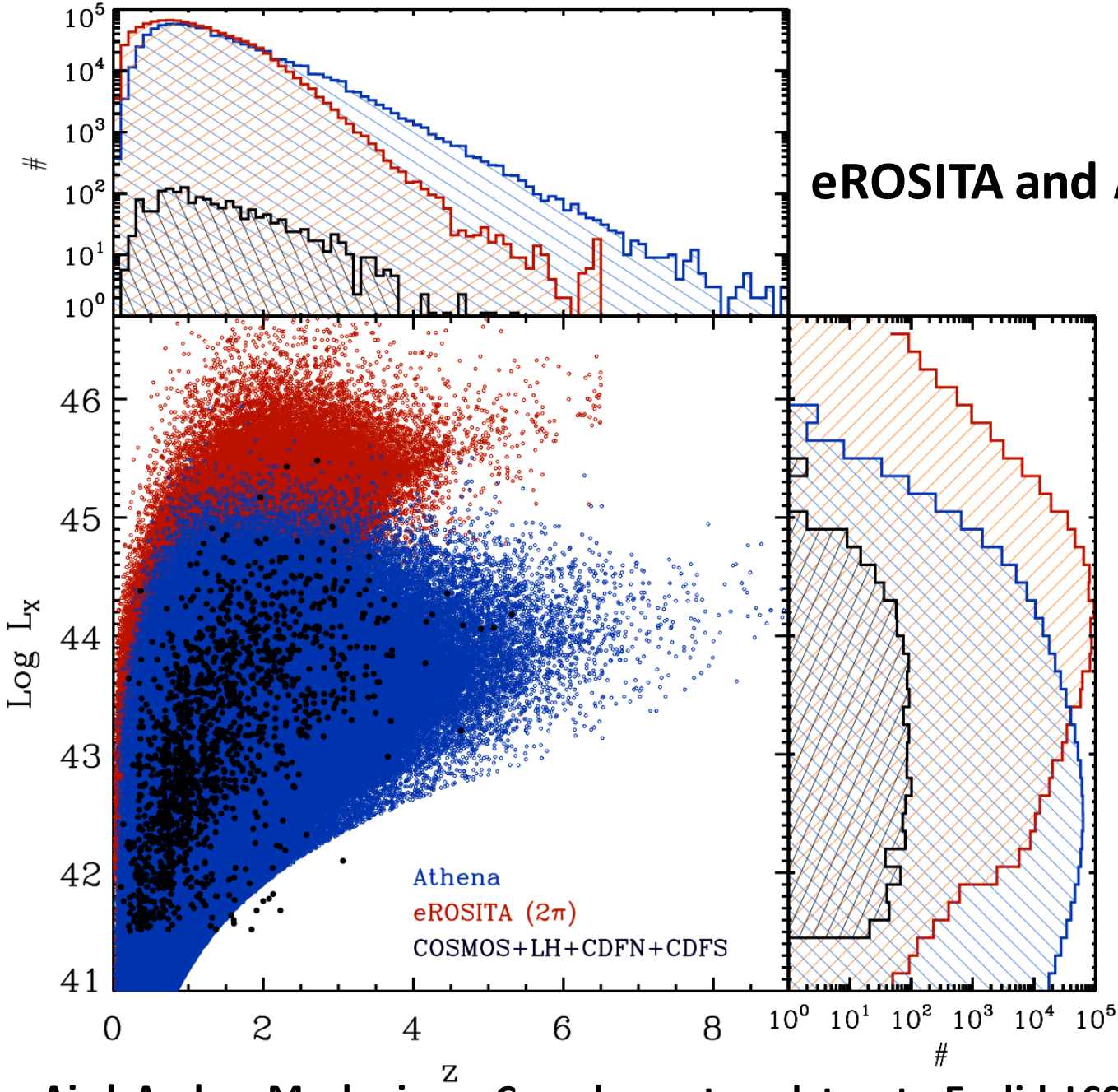
Predehl et al. 2016, SPIE, 9905
Merloni et al. et al 2012, arXiV1209.3114

All sky survey 0.2-10 keV
A_{eff} =1300cm2, HEW=15", FOV=1deg2
30-100x deeper than ROSAT/HEAO
3 Million X-ray AGN
Low z, high luminosity, high z

Nandra et al 2013, arXiV1306.2307

Europe's next large X-ray observatory
A_{eff}=1.4m2, HEW=5", FOV=40'x40'
100x Chandra speed @CDF depth
Typical AGN @z=6-8
Deep Universe X-ray spectroscopy

eROSITA and Athena



Credits: James Aird, Andrea Merloni

Complementary datasets: Euclid, LSST, WFIRST

Conclusions

- Thanks to deep X-ray surveys in CANDELS fieds and beyond we now have a good handle on the accretion history including obscured objects
- Major uncertainties remaining
  - Bright end, high z, low z (!)
  - eROSITA (and later Athena)
- Co-evolution and feedback
  - Still many open questions
  - Much work to be done consolidating results from final CANDELS catalogues