XZ: X-ray spectroscopic redshifts of obscured AGN

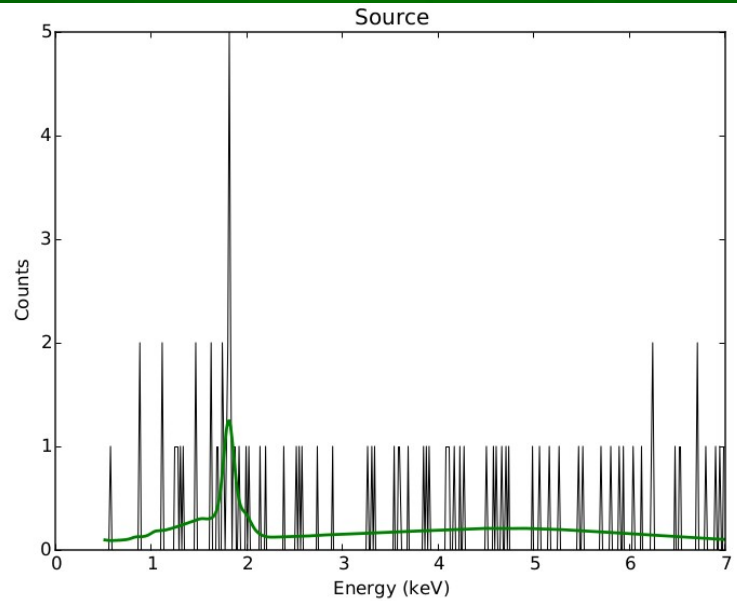
Charlotte Simmonds, Johannes Buchner, Franz Bauer
Li-Ting Hsu, Mara Salvato

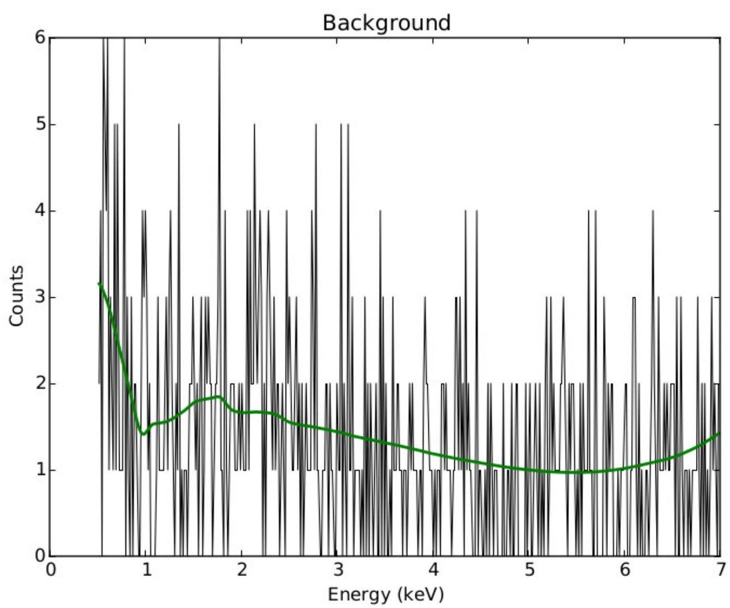
Pontificia Universidad Católica de Chile

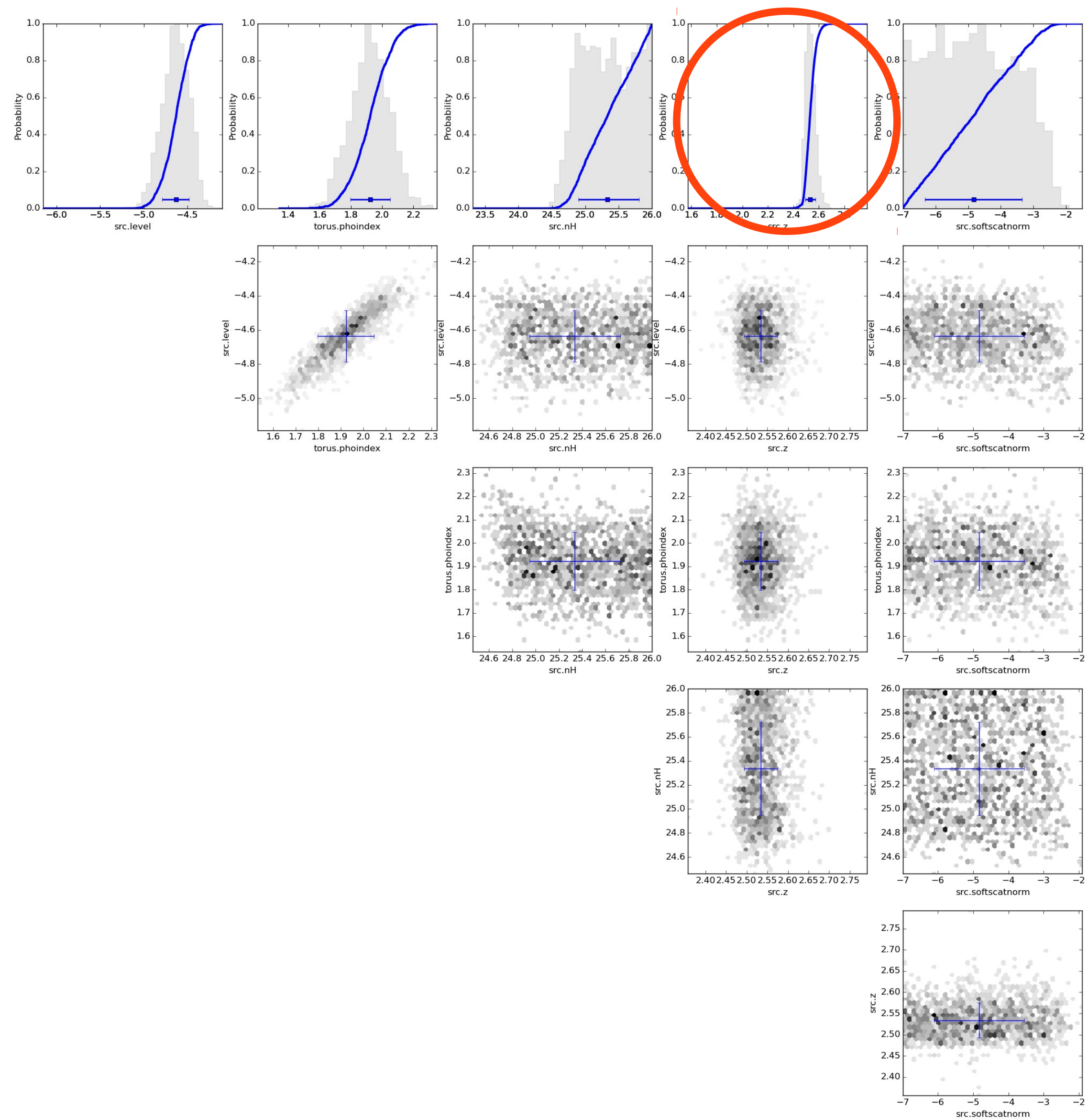
(Image credit: http://www.astro.gsu.edu)

CDF-S; ID = 77; z = 2.578; $\log_{10}(N_H)$ = 25.34 ± 0.39 cm^{-2}; cts = 121

Bayesian model fitting output







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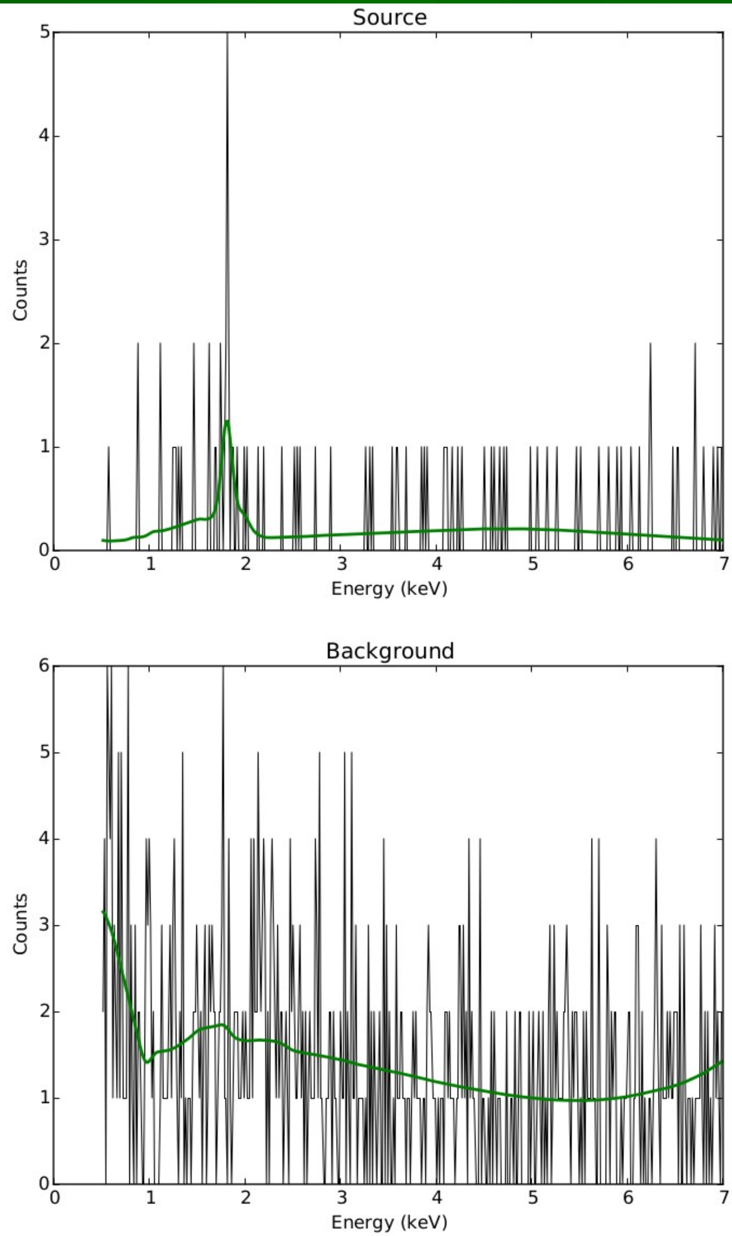

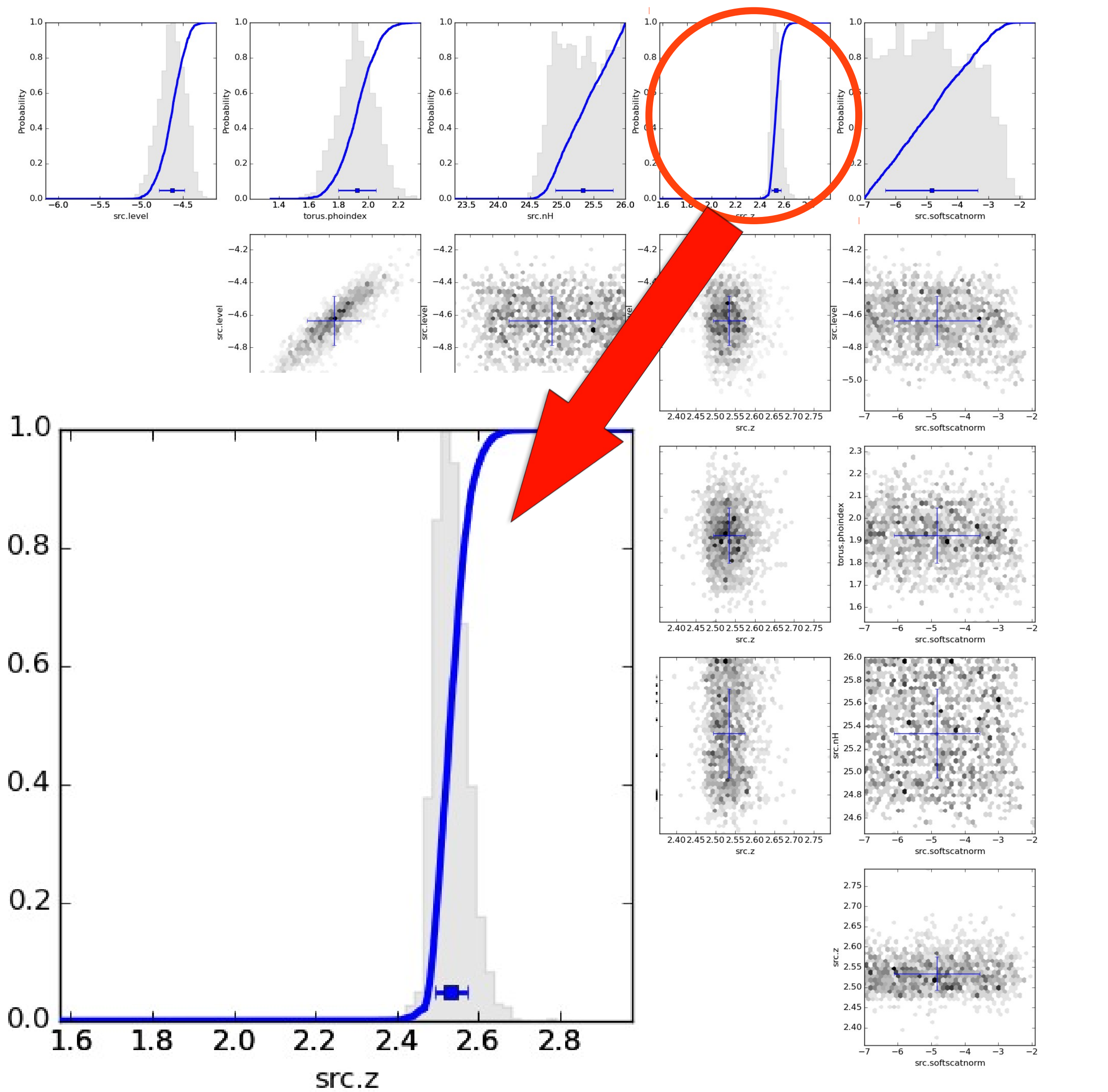

CDF-S; ID = 4; z = 0.2983; $\log_{10}(N_H)$ = 22.56 ± 0.05 cm^{-2}; cts = 5,690

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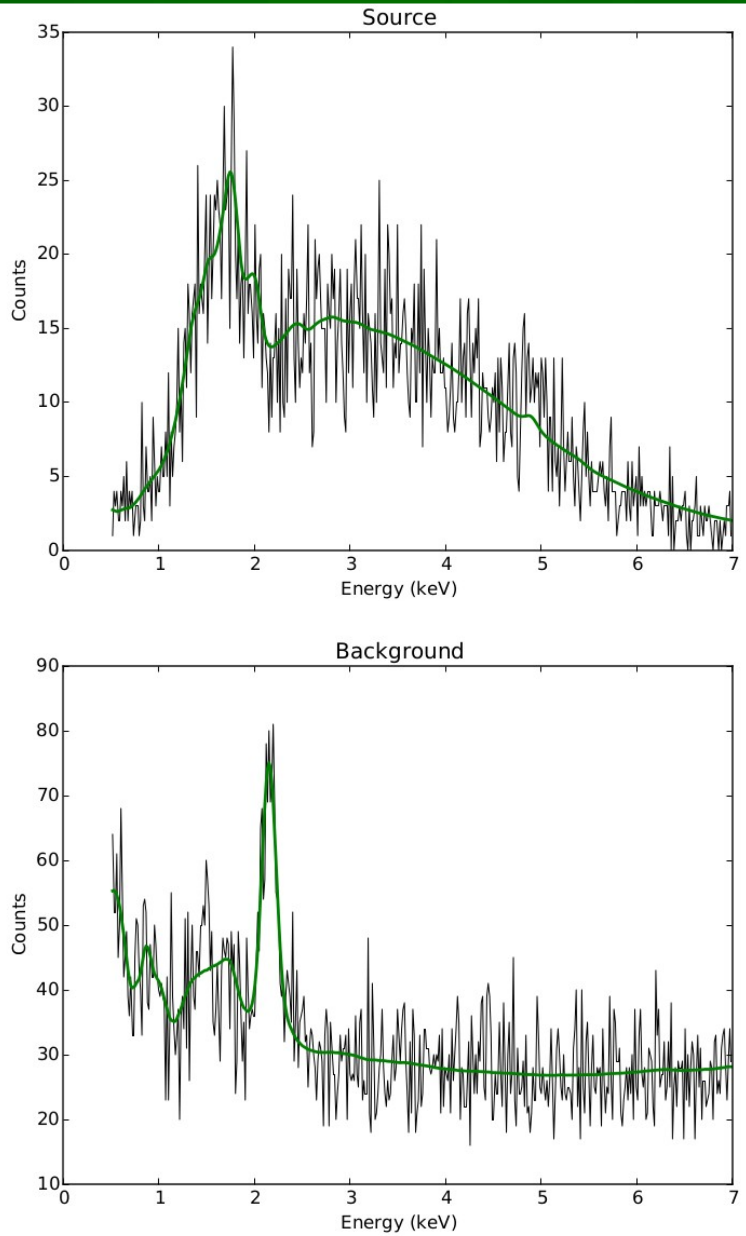

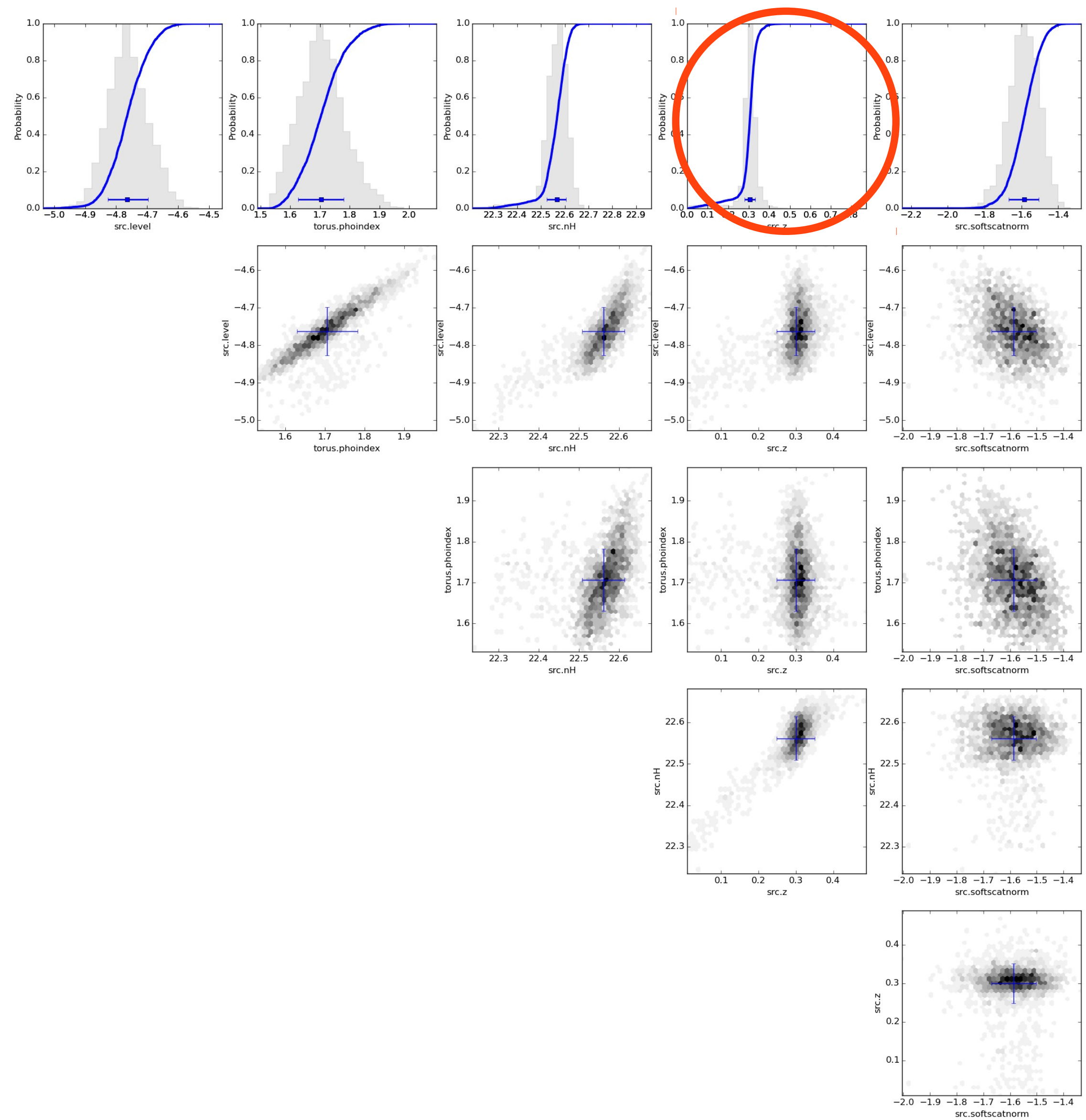

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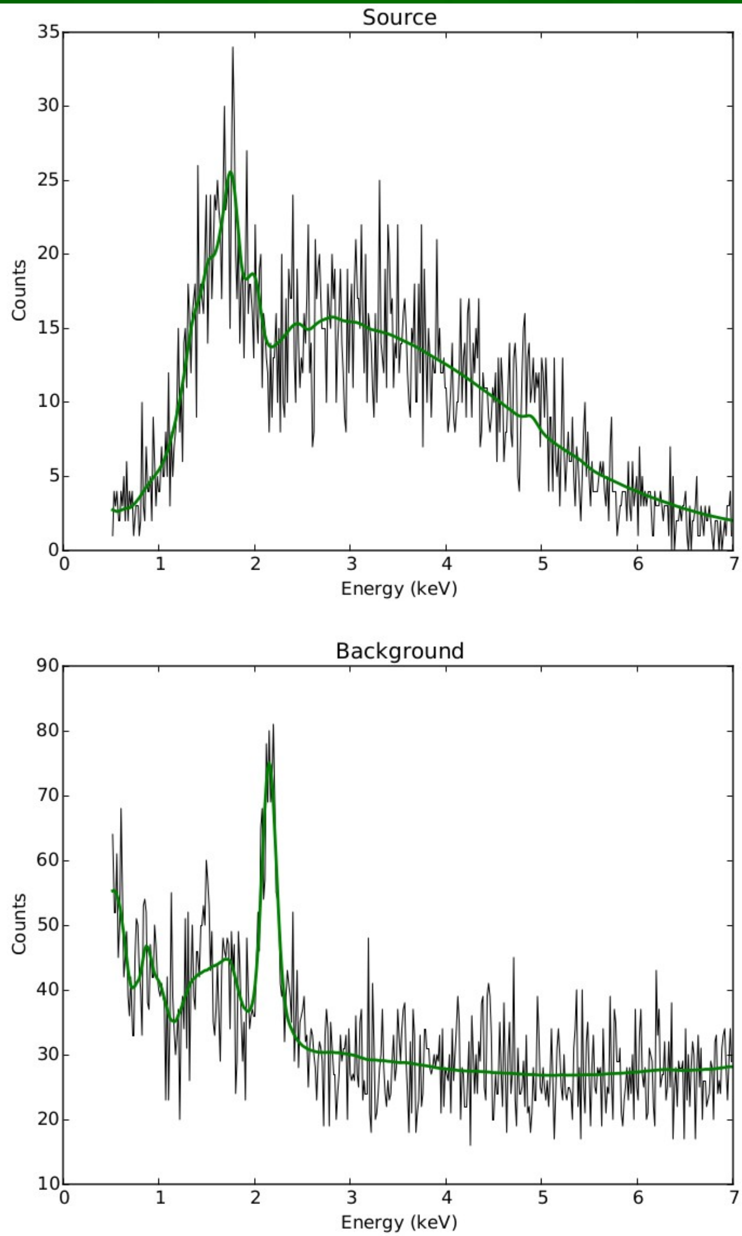
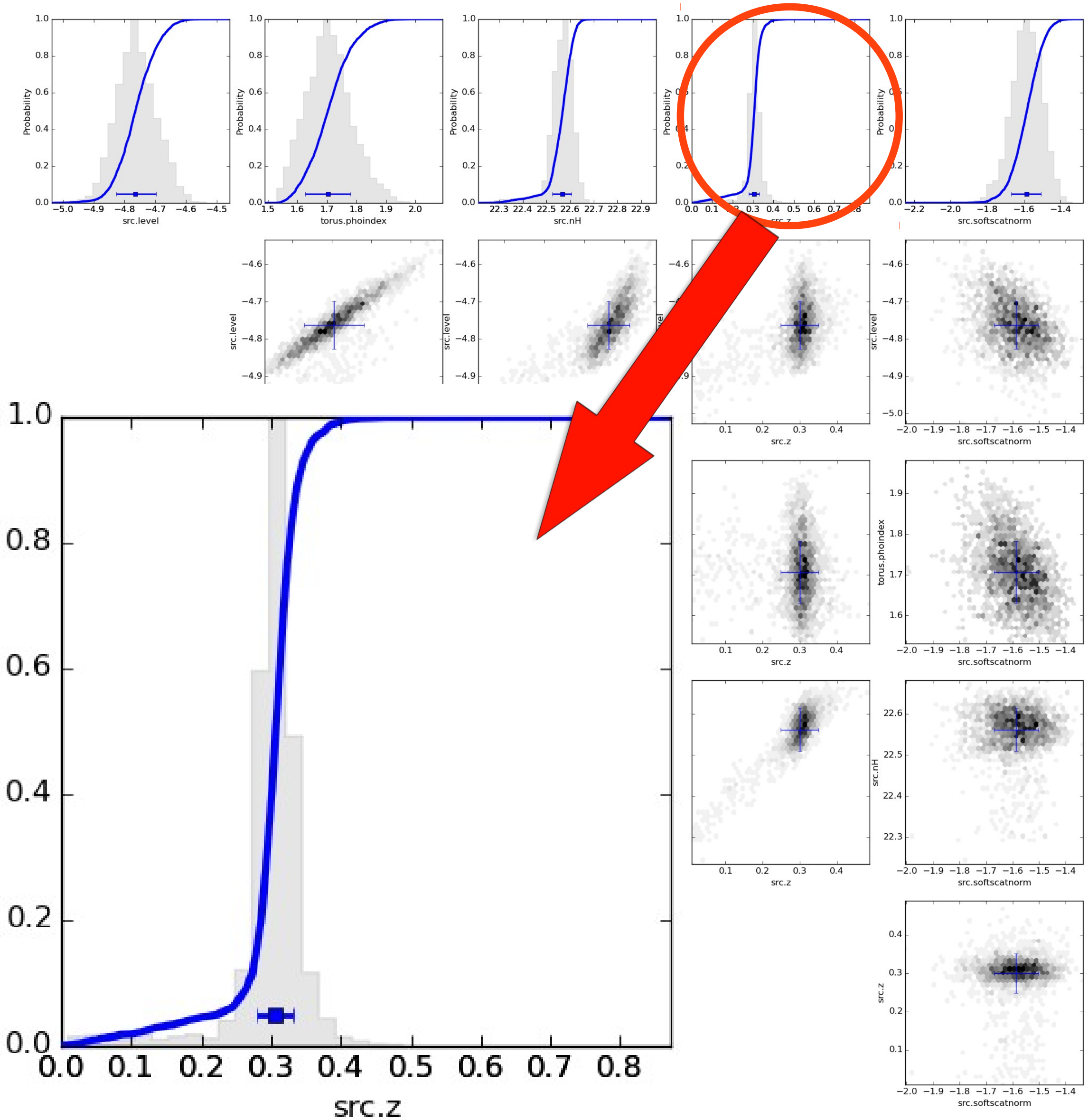




Motivation

Ambiguity in counterpart association

- Accurate redshift determination is **crucial** to correctly model galaxy evolution
- Spec-z is desirable but **expensive** and **time consuming** → photo-z
- AGN need an association with multi-wavelength data before photo-z can be calculated

Poor positioning could lead to poor counterpart associations (and there can be multiple counterparts)

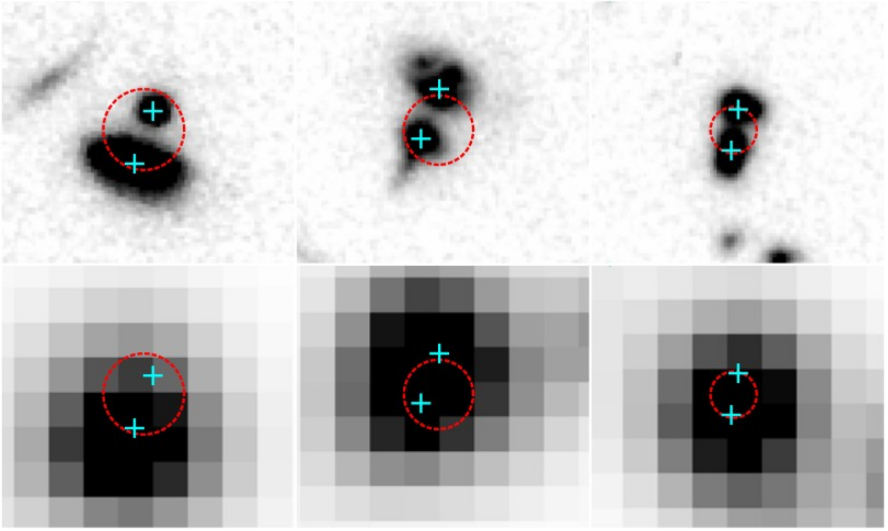


Figure 6. Three examples of multiple *H*-band associations (from left to right X-115, X-517, and X-224) in the *H* band (upper) and IRAC 3.6 μm (lower). The size of each cutout is $5'' \times 5''$. The red circles are centered at the X-ray position with the radius corresponding to the positional error. The cyan crosses indicate the positions of *H*-band detected sources from G13. These three cases have two *H*-band associations, both with probabilities greater than 0.99. The uses of deblended IRAC photometry does not help make a unique secure association.

(A color version of this figure is available in the online journal.)

Hsu et al. The Astrophysical Journal, 796:60 (2014)

Method in a nutshell

Bayesian model fitting of low-resolution spectra

We use nested sampling (MultiNest algorithm) → Advantages over MCMC

↓ Connected to X-ray spectral analysis environments Xspec/Sherpa by

BXA (Bayesian X-ray Analysis)

↓ For Bayesian Parameter Estimation and Model comparison

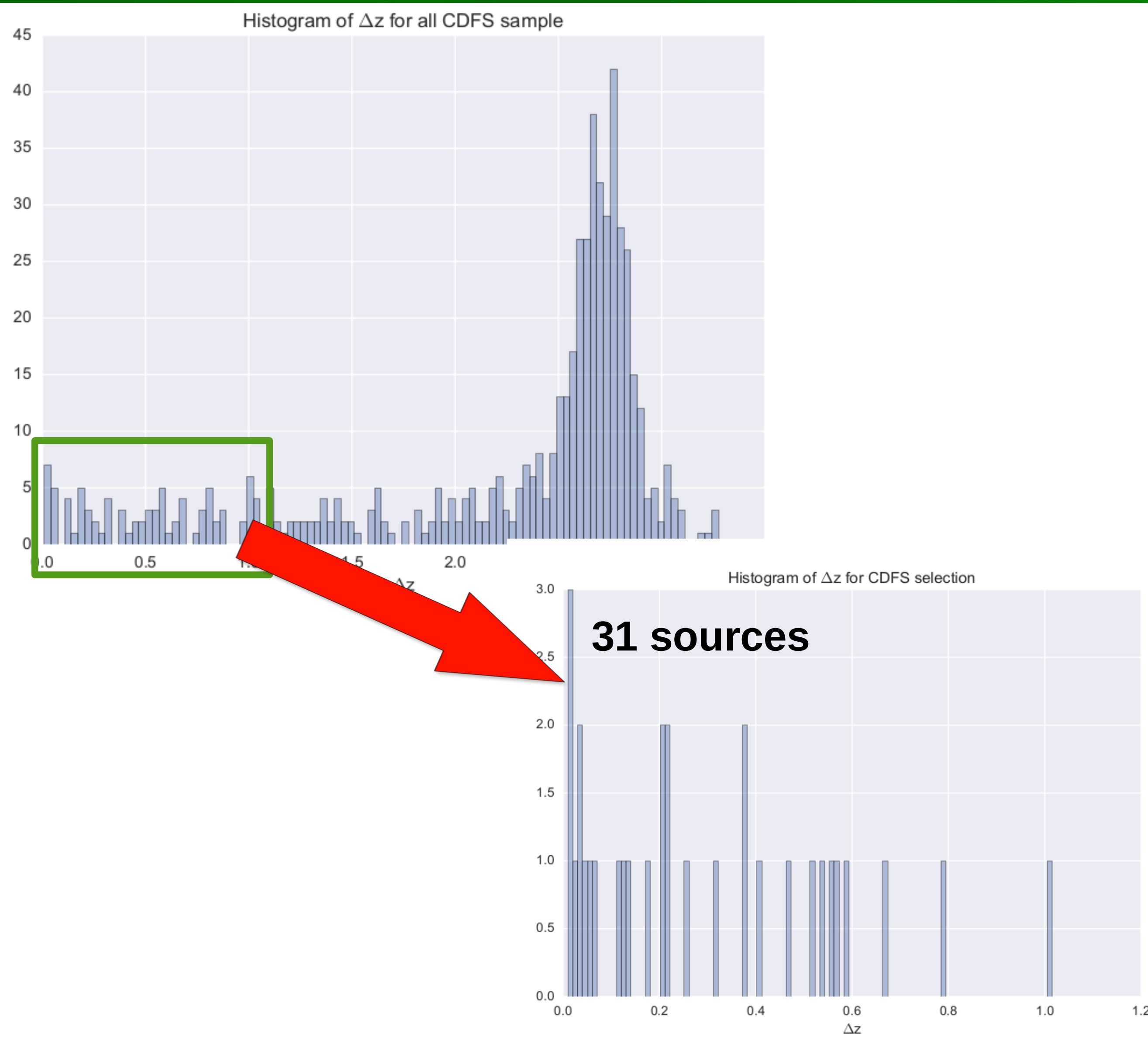
Background and source are fit simultaneously

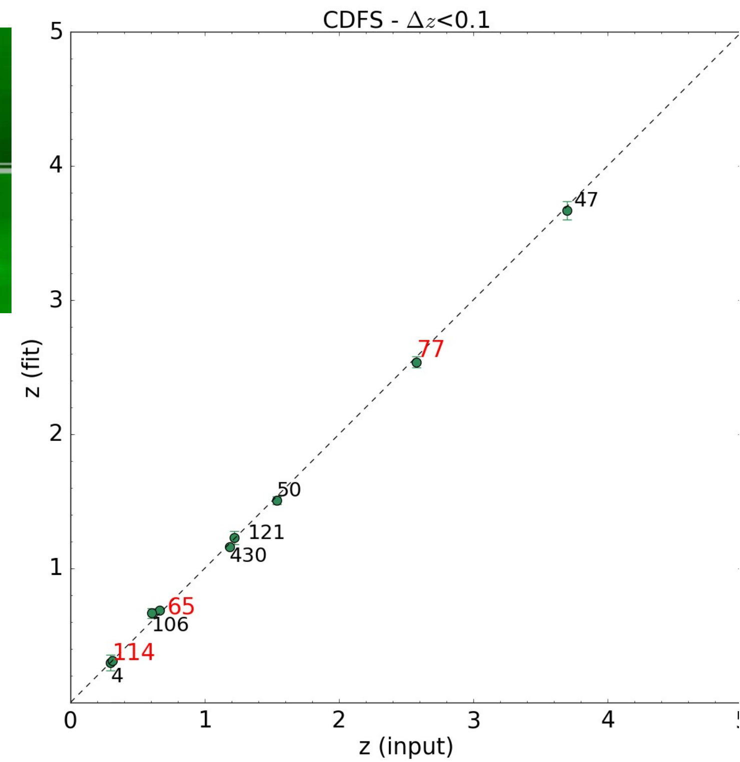
Auto background + Torus model*

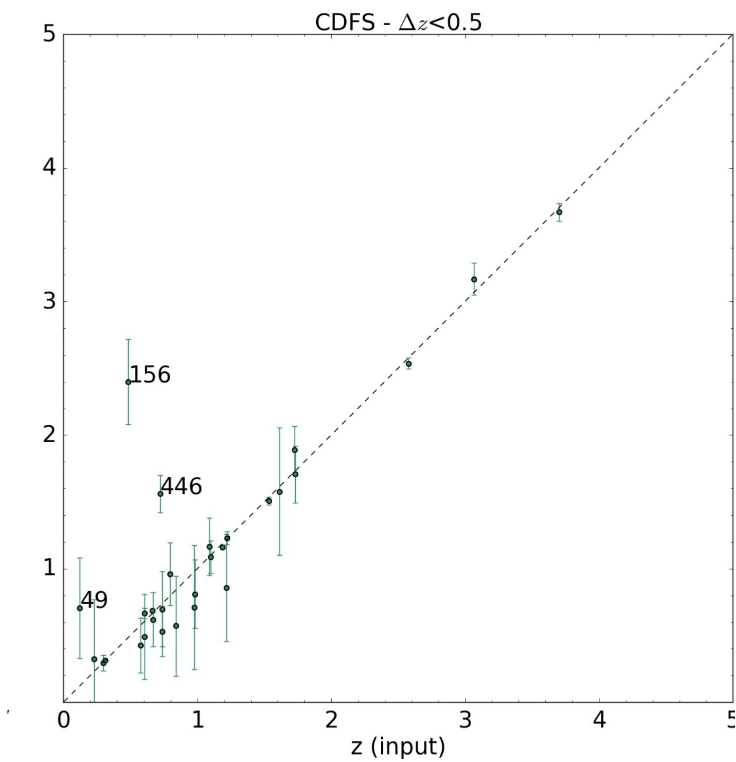
*M. Brightman (http://astro.ic.ac.uk/mbrightman/home)

4Ms CDFS data

CANDELS/GOOD-S spec-z (Hsu et al. 2014)







4Ms CDFS data

CANDELS/GOOD-S spec-z (Hsu et al. 2014)

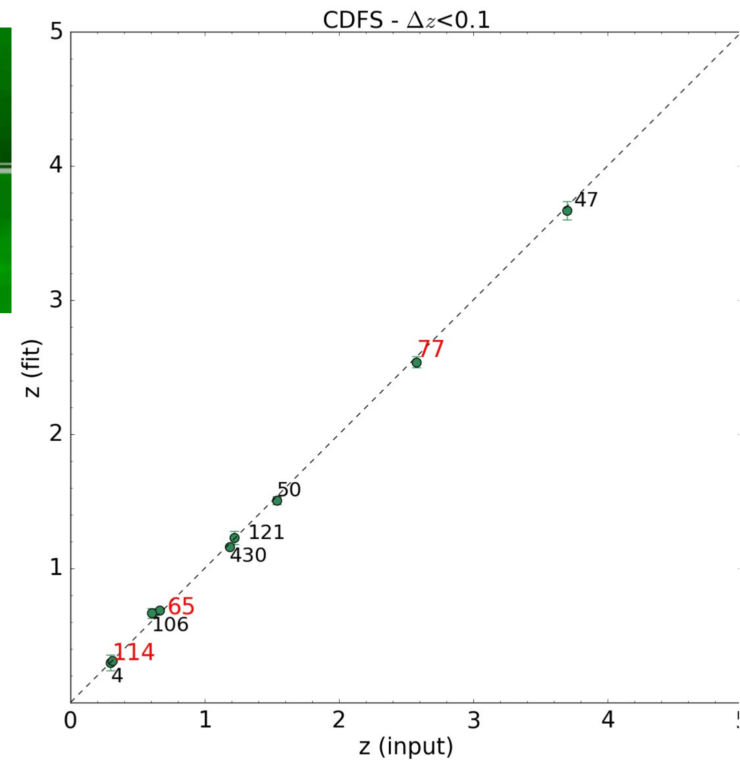
31 well constrained solutions

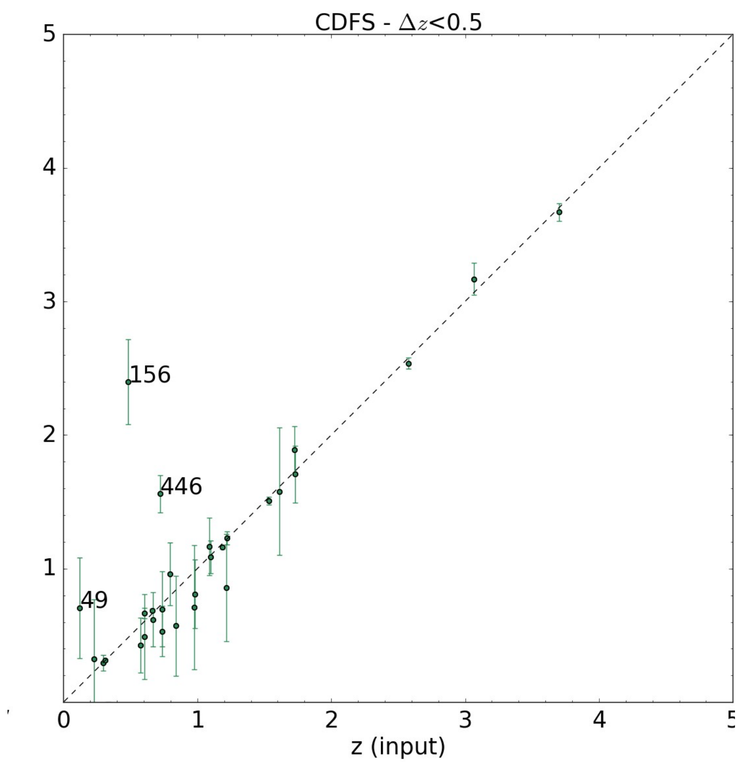
+

3 outliers

It retrieves *z* for ~90% of cases

(if we count the outliers as failures)





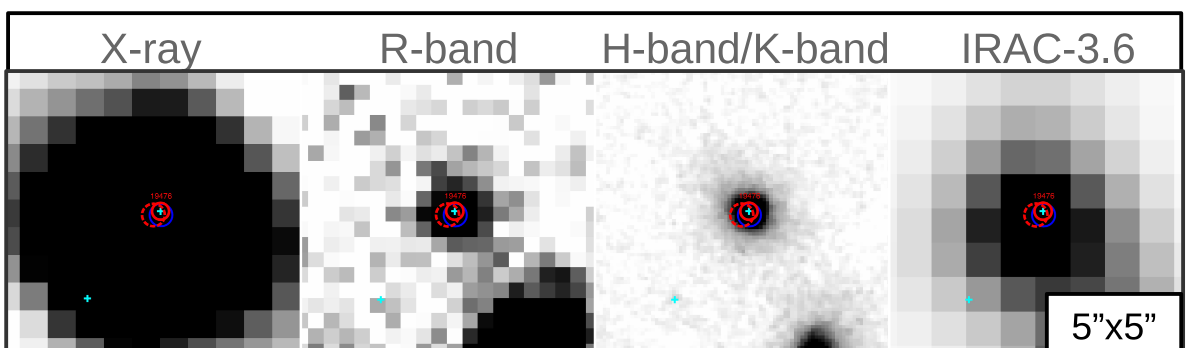
4Ms CDFS data (outliers)

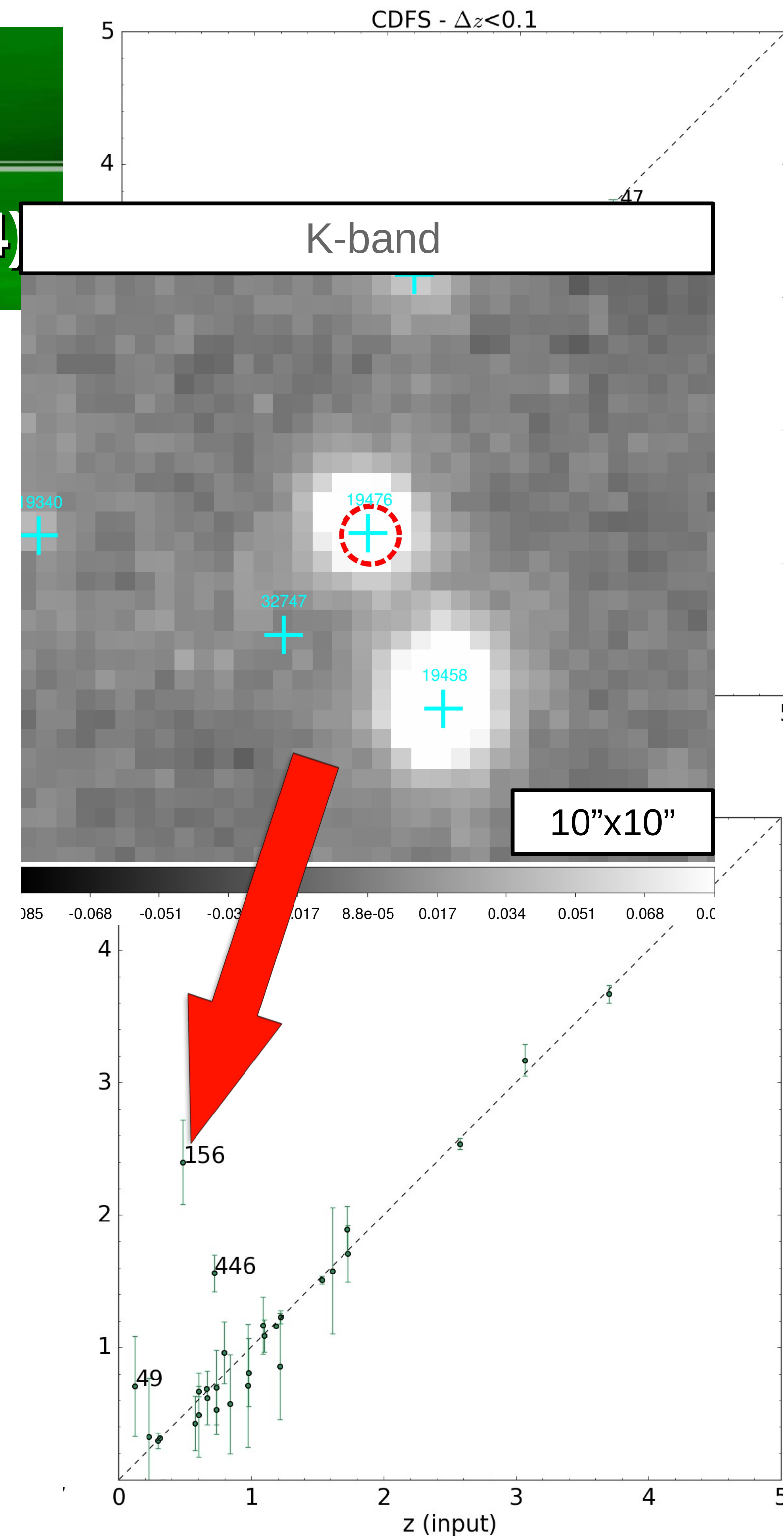
CANDELS/GOOD-S spec-z (Hsu et al. 2014)

ID	Spec-z	Photo-z
19476	0.48	1.9
19458	0.78	0.78
32747	-99	2.5

X-ray position

H-band detections

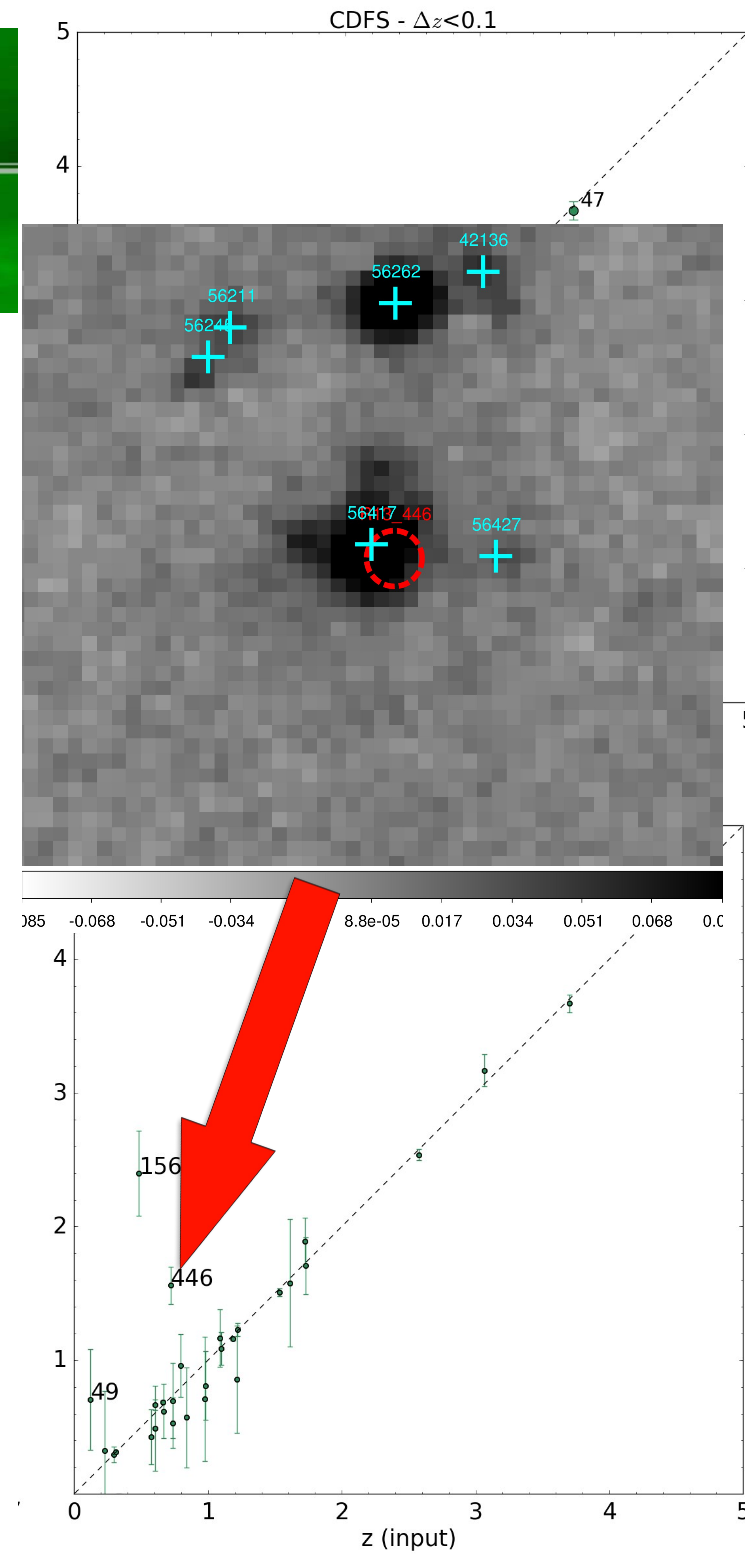




4Ms CDFS data (outliers)

CANDELS/GOOD-S spec-z (Hsu et al. 2014)

446: spectral quality is only 2 (rather than 0 or 1) → maybe we can dismiss the optical spectra. For this source we agree with the photo-z

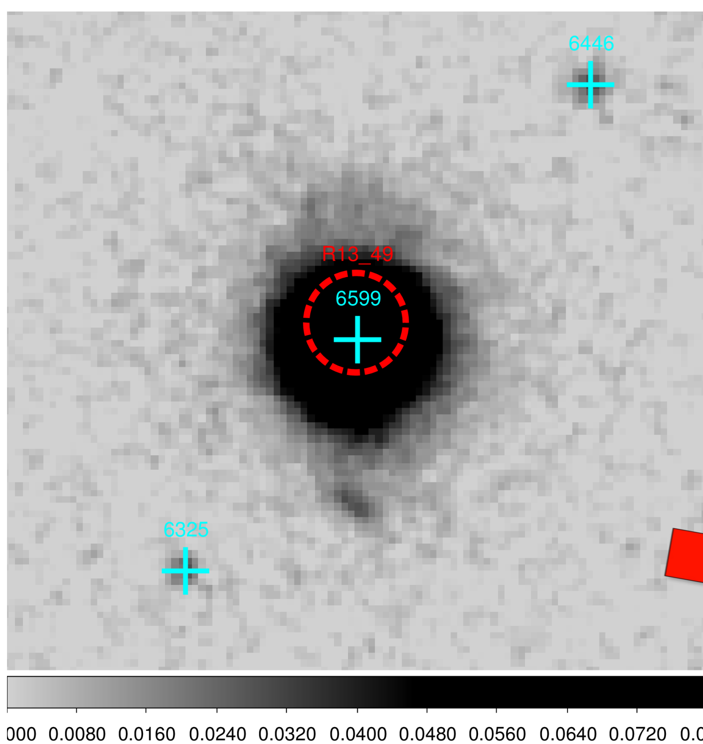


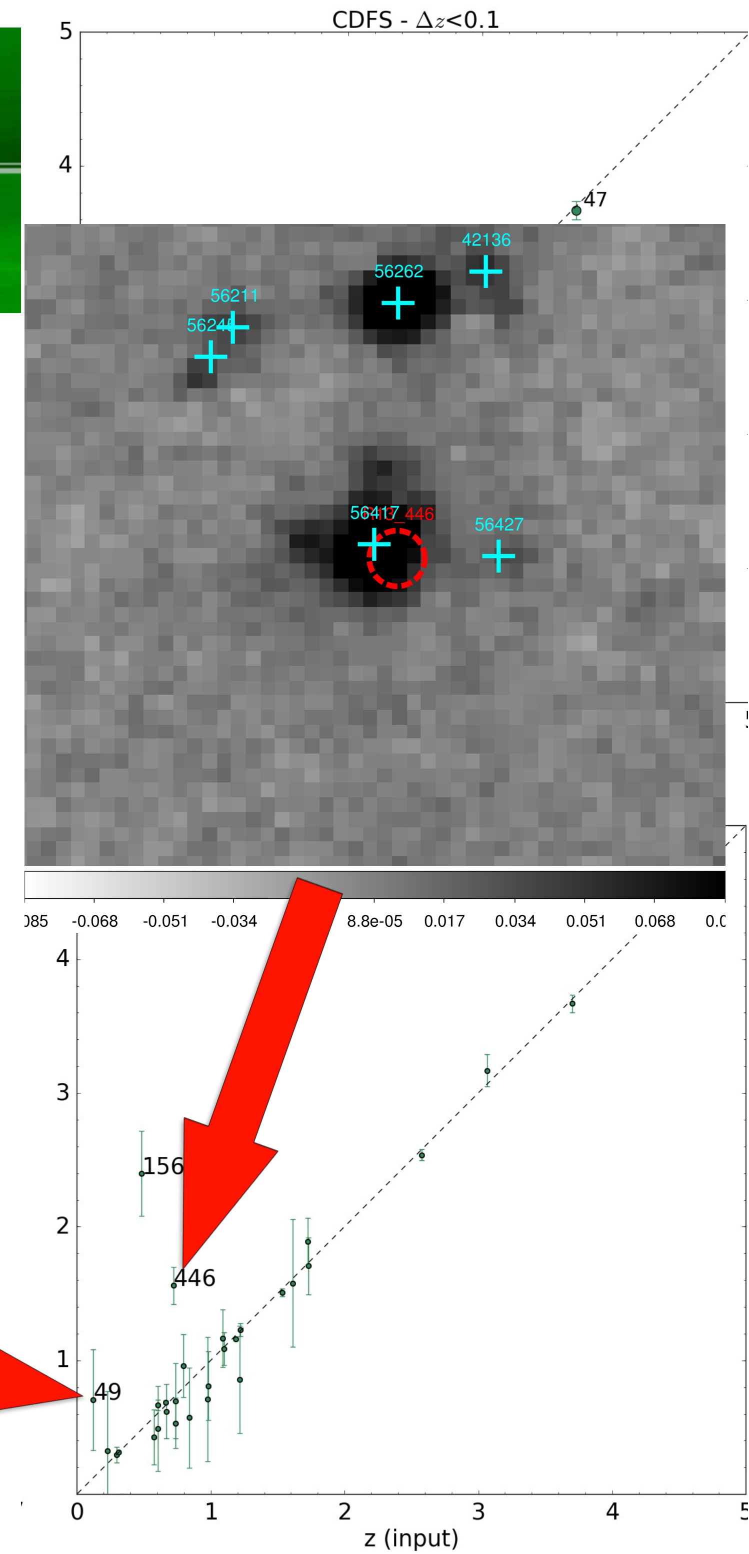
4Ms CDFS data (outliers)

CANDELS/GOOD-S spec-z (Hsu et al. 2014)

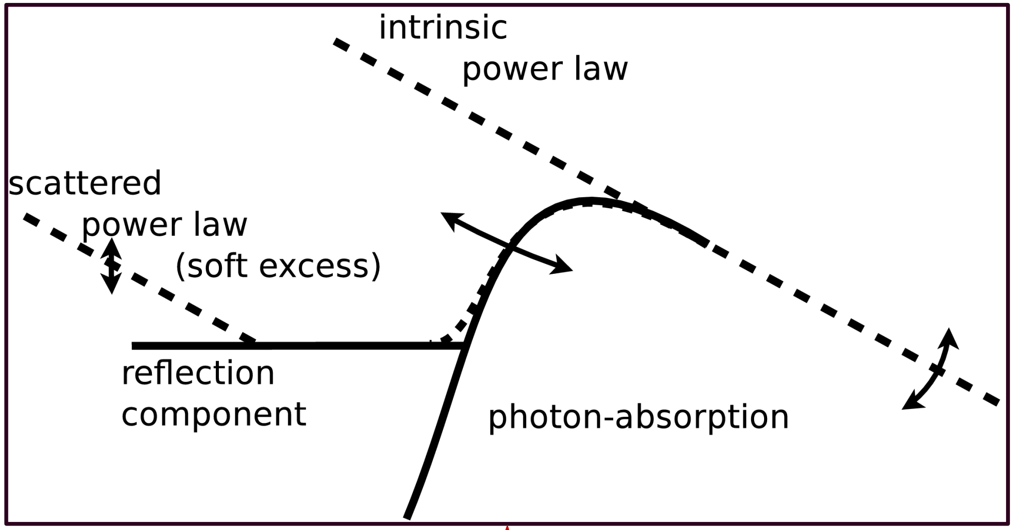
446: spectral quality is only 2 (rather than 0 or 1) → maybe we can dismiss the optical spectra. For this source we agree with the photo-z

49: Perhaps caused by low-z star formation which we do not model (yet). Adding an `apec` component takes *z* down to **0.084 +/- 0.028 (spec-z = 0.122)**



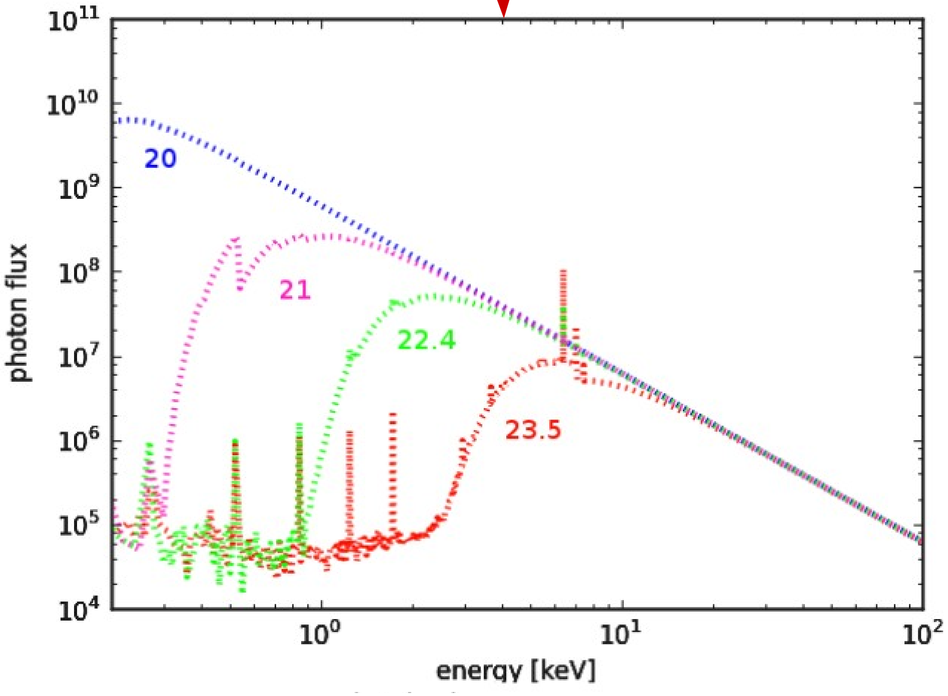


Spectrum shape according to N_H value



X-ray spectral features of the torus model with a scattering component.

Torus spectral model simulation by Brightman and Ueda (2012). The photon index was set to Γ = 2. The numbers indicate the column density of neutral hydrogen in $log_{10}(N(H) / cm^2)$.



Brightman and Ueda. MNRAS, 423:702 (2012)

Simulated data

`fake_pha(arf,rmf)`

Source

Torus model*

- $N_H = 10^{22}, 10^{23}, 10^{24}, 10^{25}$ [cm^{-2}]
- z = 0.1 – 5.0
- Γ = 1.9
- Source count number adjusted accordingly

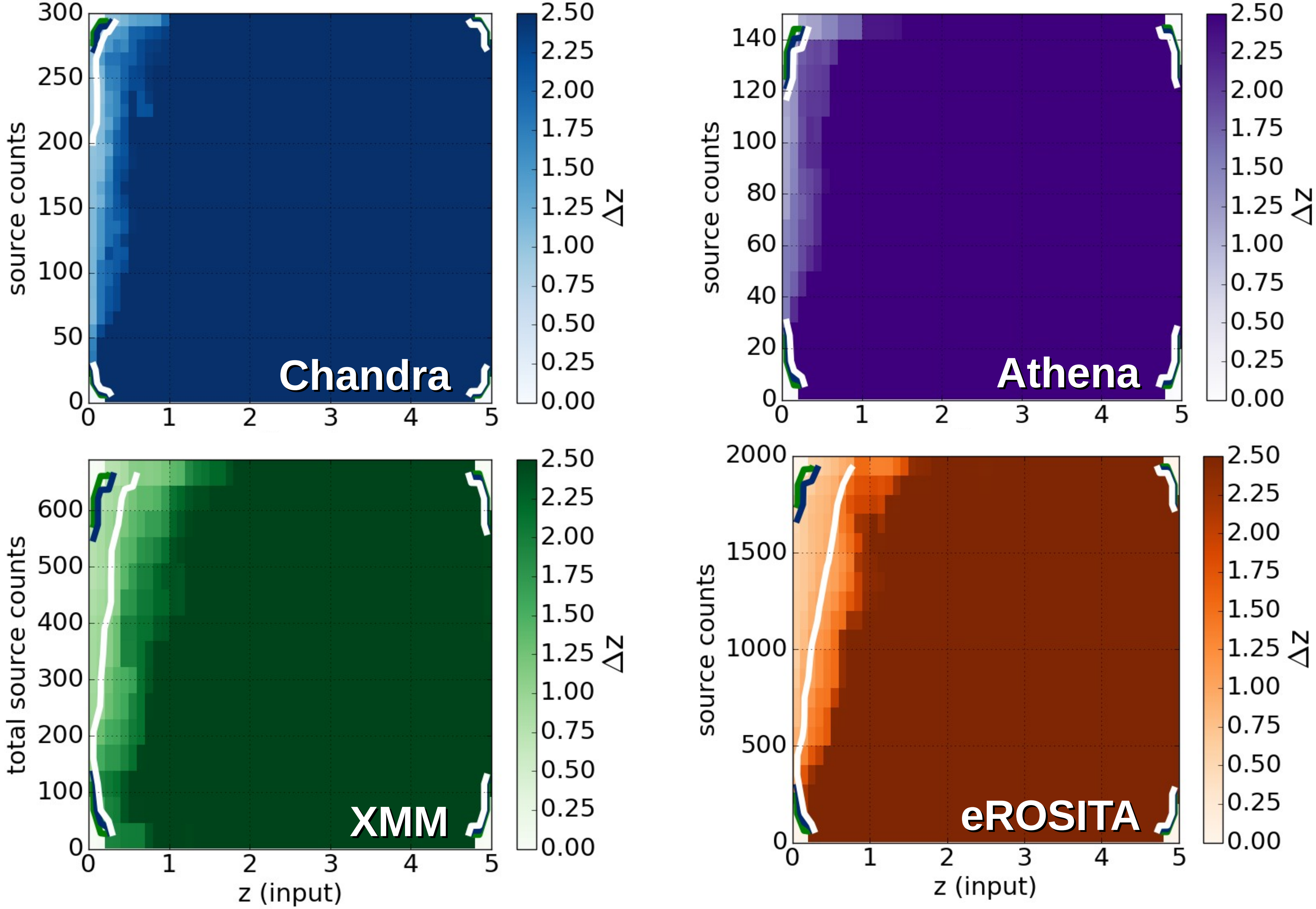
Background

Chandra / XMM	Athena / eROSITA
Auto background	Fixed background

*M. Brightman (http://astro.ic.ac.uk/mbrightman/home)

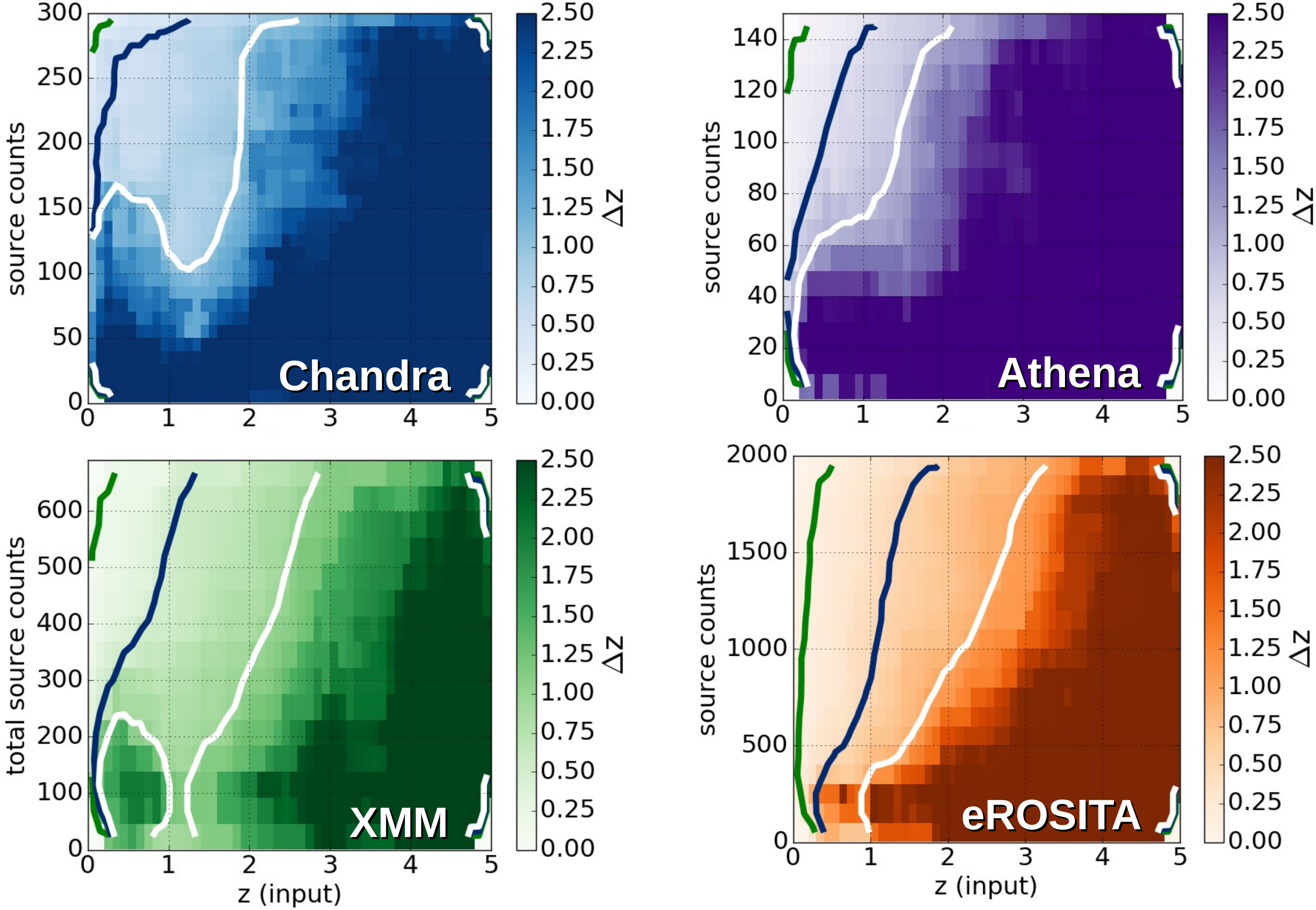
How many counts do we need? (Δz = 0.1, 0.5, 1.0)

nH = 10^{22} cm^{-2}



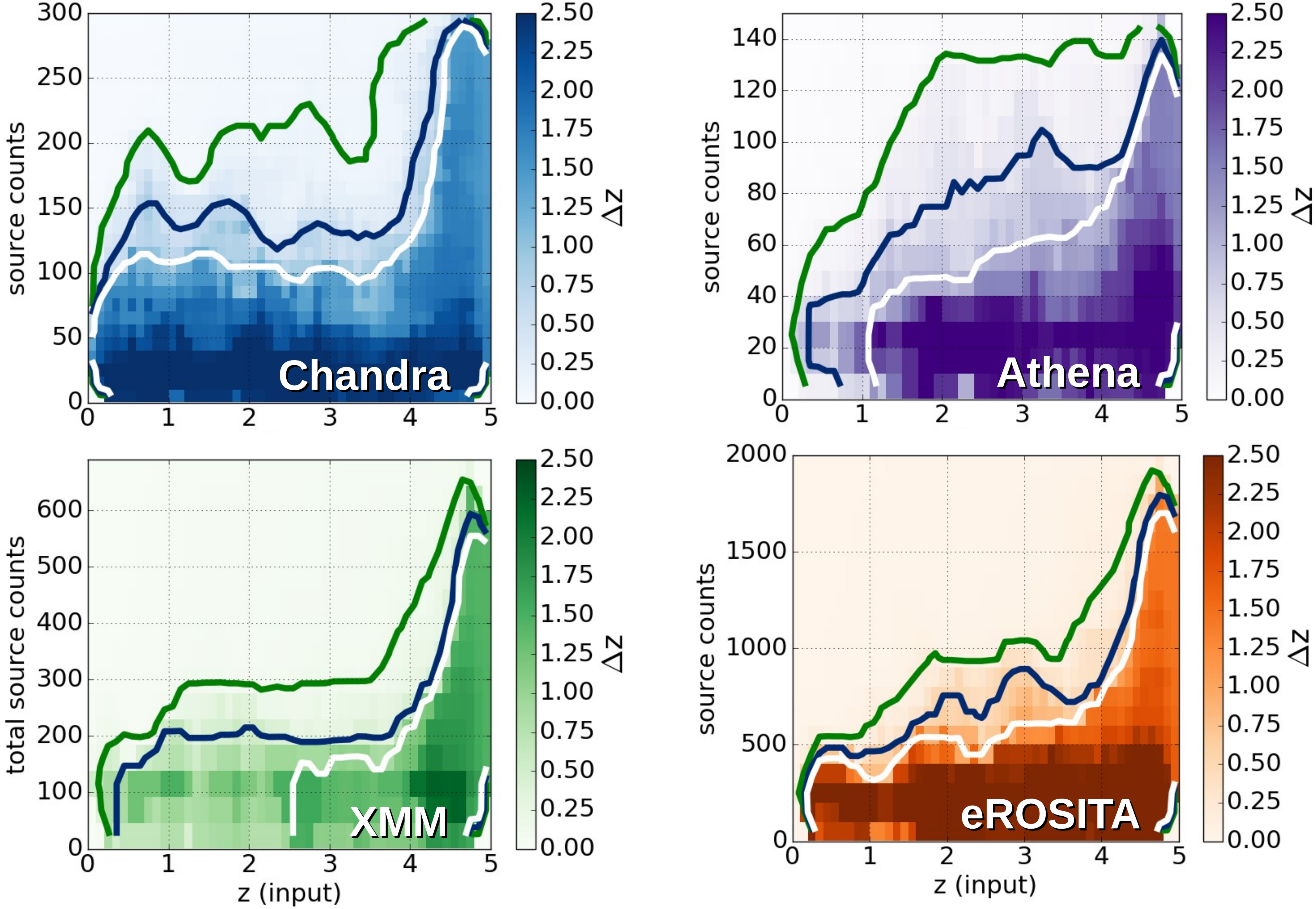
How many counts do we need? (Δz = 0.1, 0.5, 1.0)

nH = 10^{23} cm^{-2}



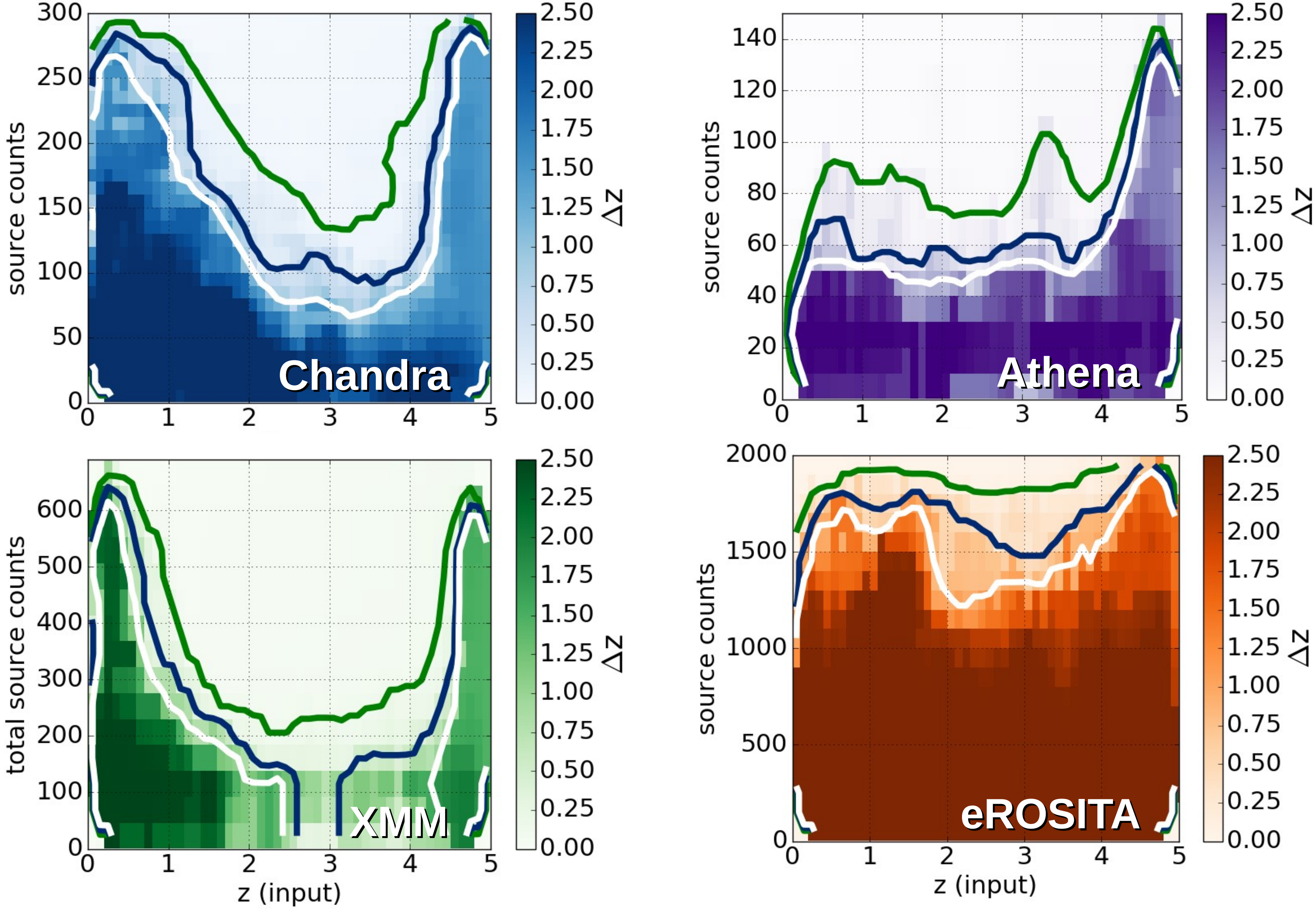
How many counts do we need? (Δz = 0.1, 0.5, 1.0)

nH = 10^{24} cm^{-2}



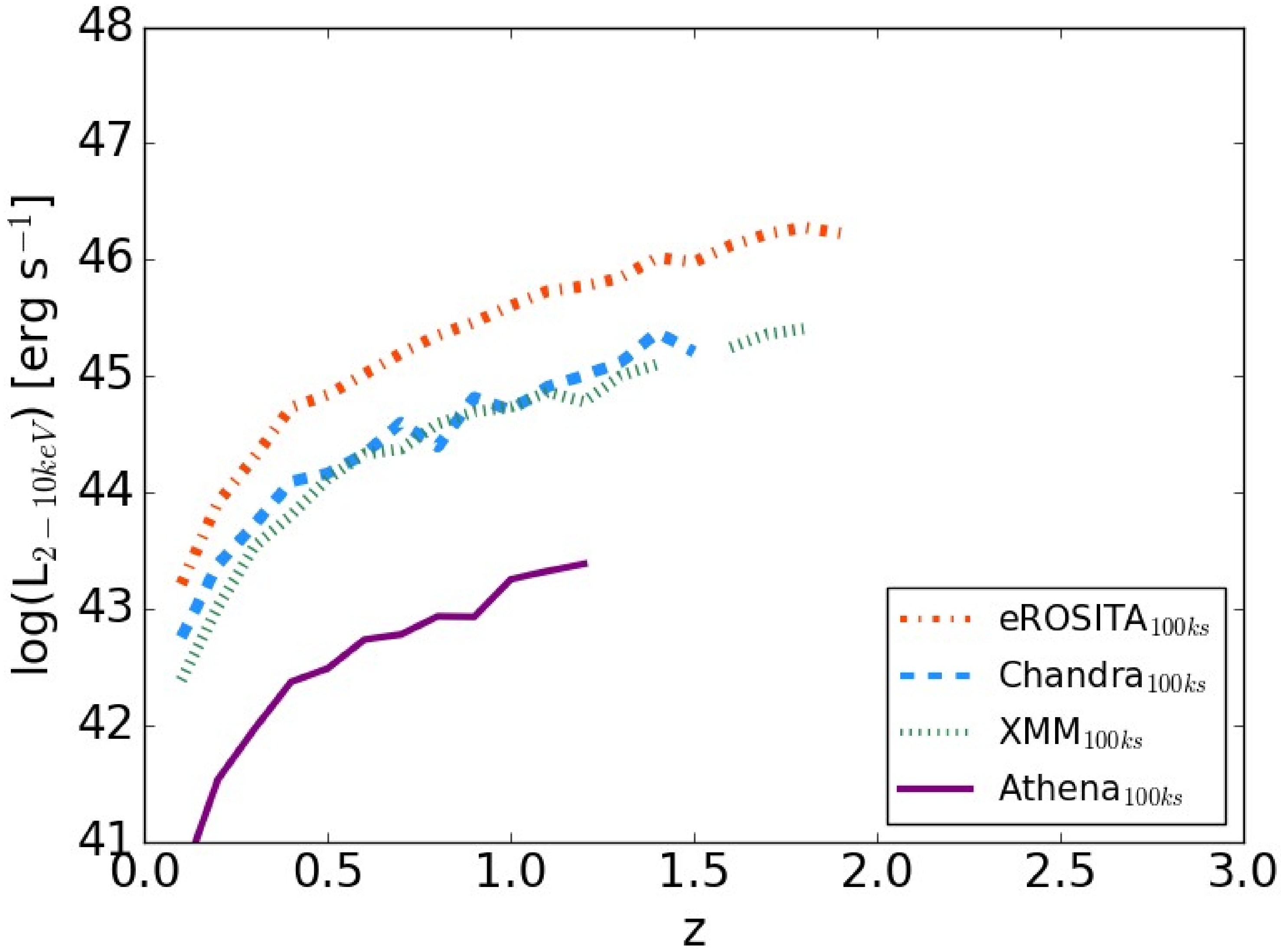
How many counts do we need? (Δz = 0.1, 0.5, 1.0)

nH = 10^{25} cm^{-2}



Sensitivity limit for our method

nH 10^{23} cm^{-2} - Normalized to 100 ks



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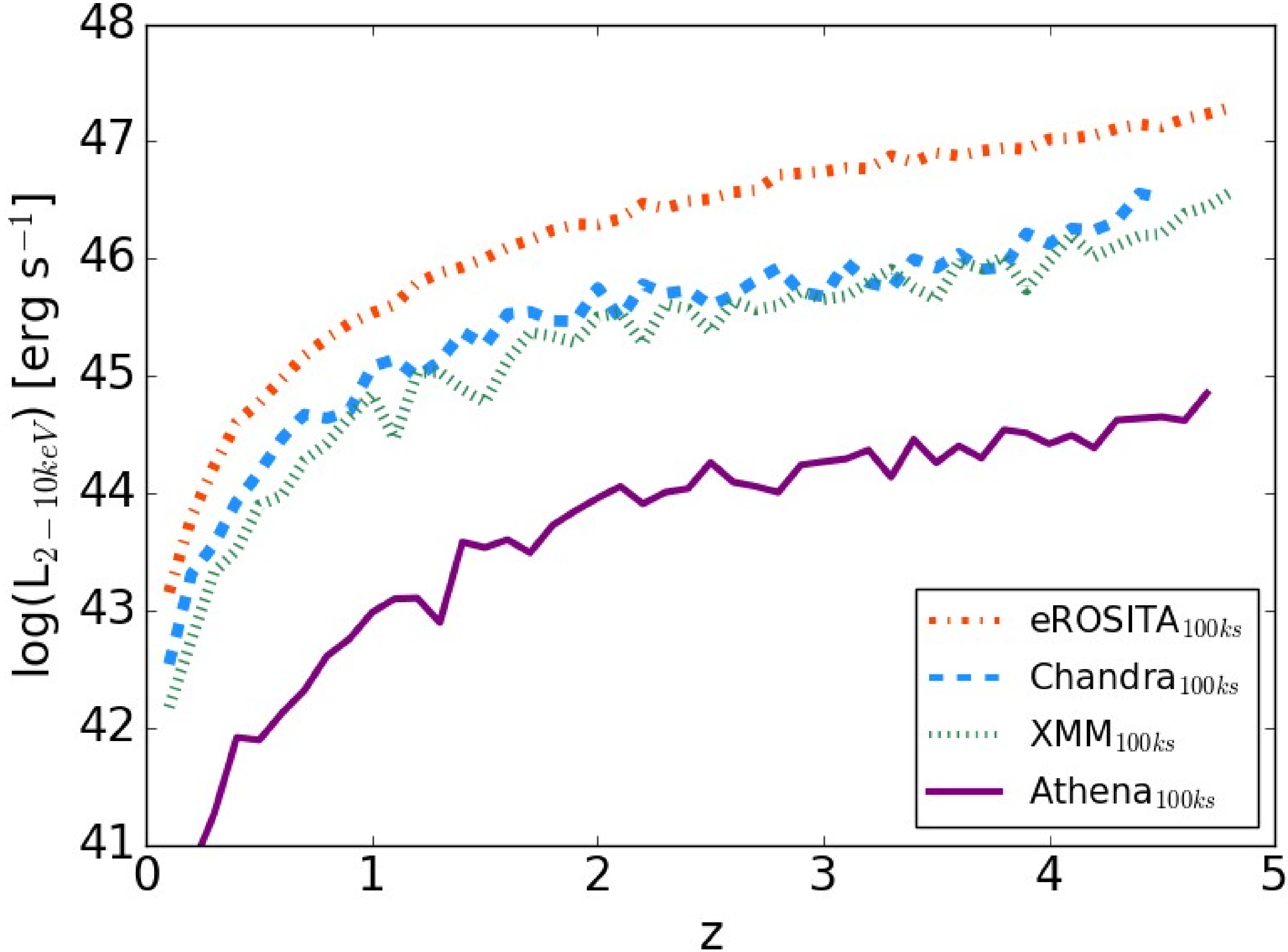

Sensitivity limit for eROSITA

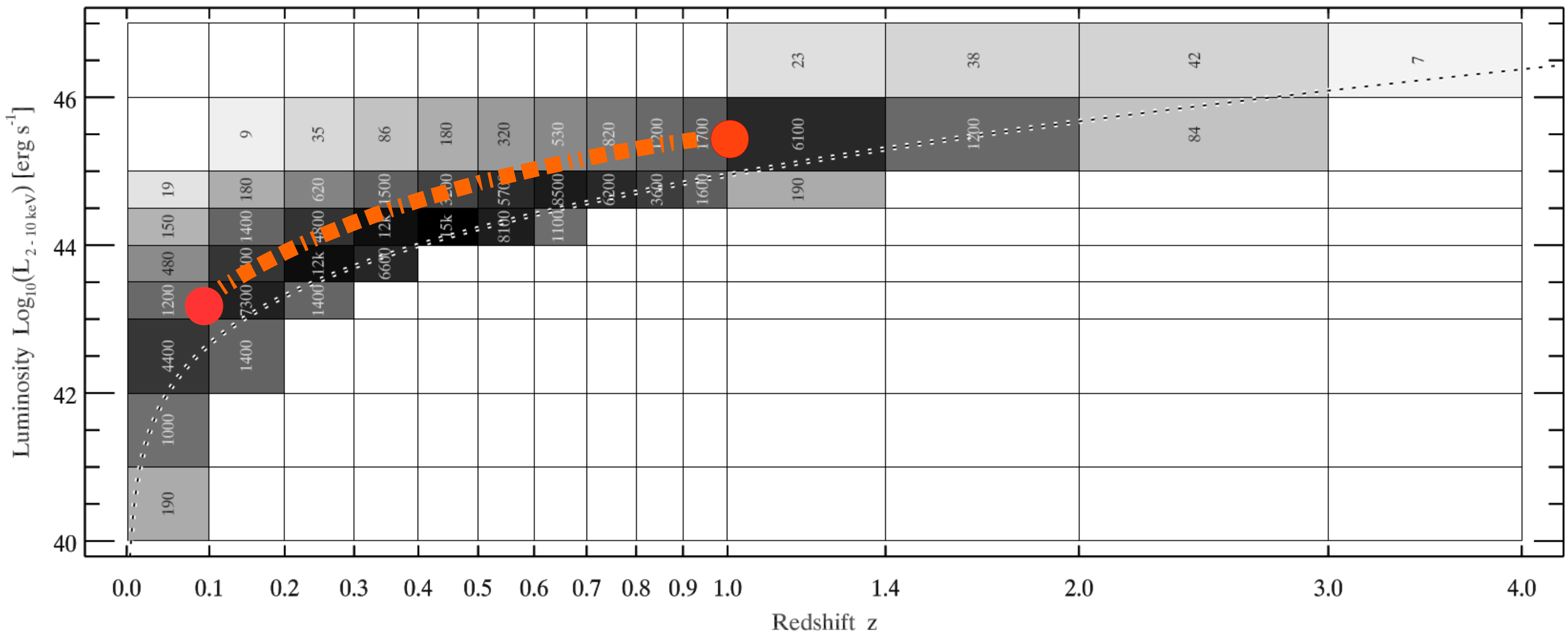

Fig. 5. Number of AGN in different redshift and luminosity bins expected to be detected in the course of the four-year survey in the soft (*top*) and hard (*bottom*) bands. White empty bins with no number correspond to zero sources. The dotted line corresponds to the detection limit of eRASS. In the soft-band plot, the numbers in brackets are for the XLF without the exponential redshift cutoff, they are given only if the difference exceeds 10%.

Kolodzig et al. A&A 558, A89 (2013)

Summary

- This method uses a **global approach** to retrieve *z* by looking for absorption edges convolved through the instrument's response

- It can give information to confirm correct counterpart (and thus *z*) for X-ray sources with ambiguous optical counterpart associations

- Other telescopes:

  NuSTAR (in process) and Swift (near future)

Thank You!