The XMM-LSS/CDFS luminosity functions

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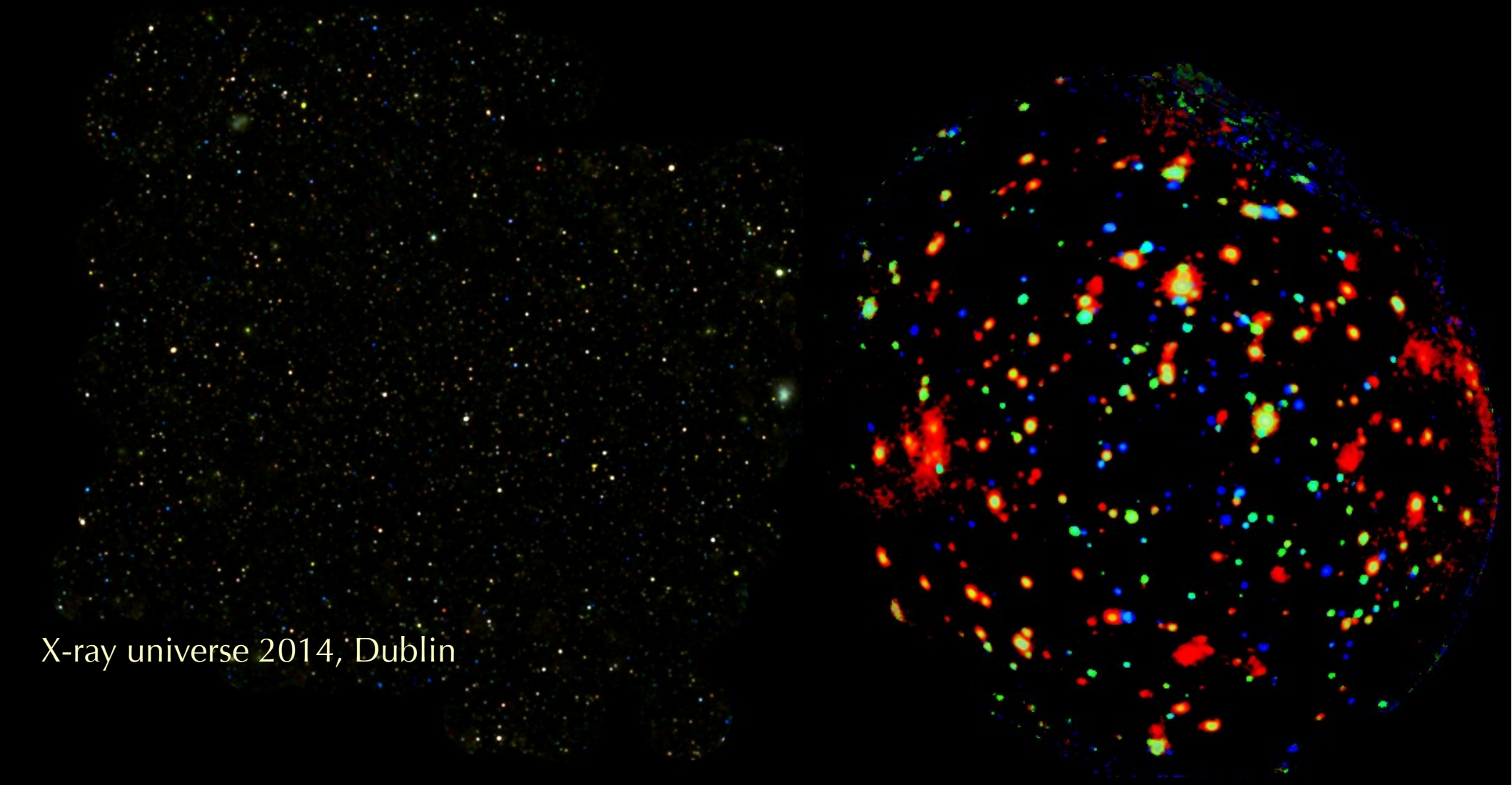


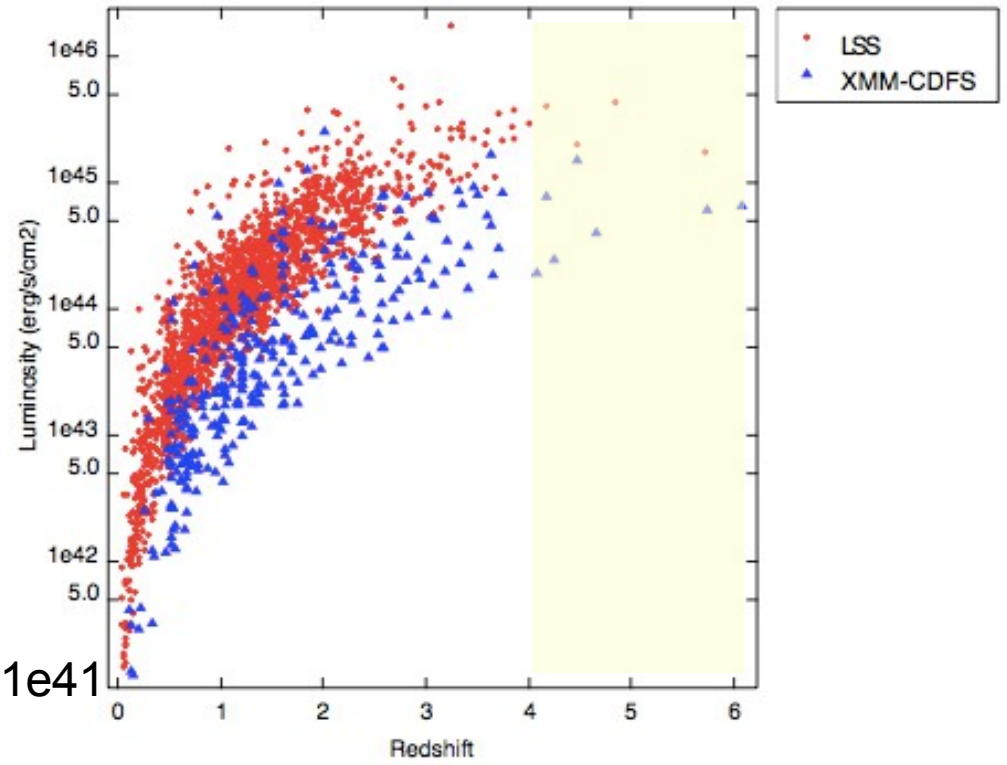
X-ray universe 2014, Dublin

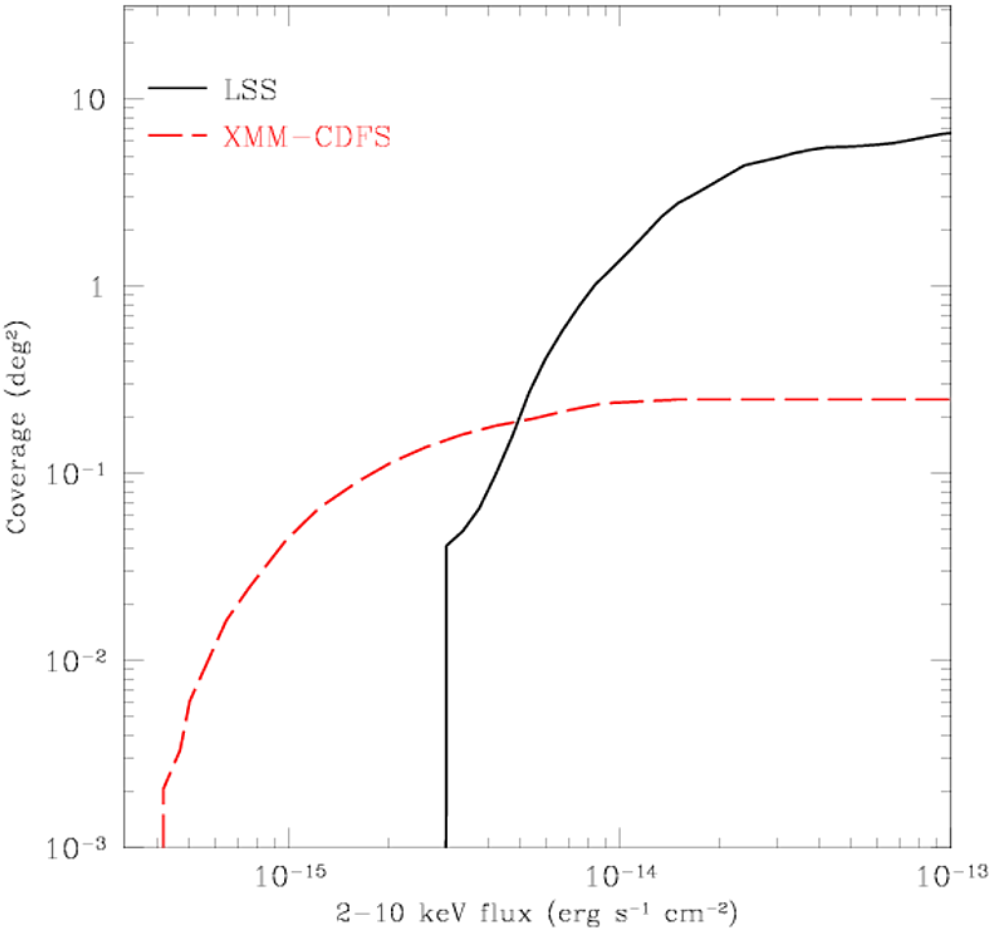
XMM/LSS

10 deg^2 x 10 ks; now part of the 5x larger XXL (see talk by M. Pierre)

flux limit at 10% area:
5 x 10^{-15} erg/s/cm^2

includes small sub-area with
larger exposure

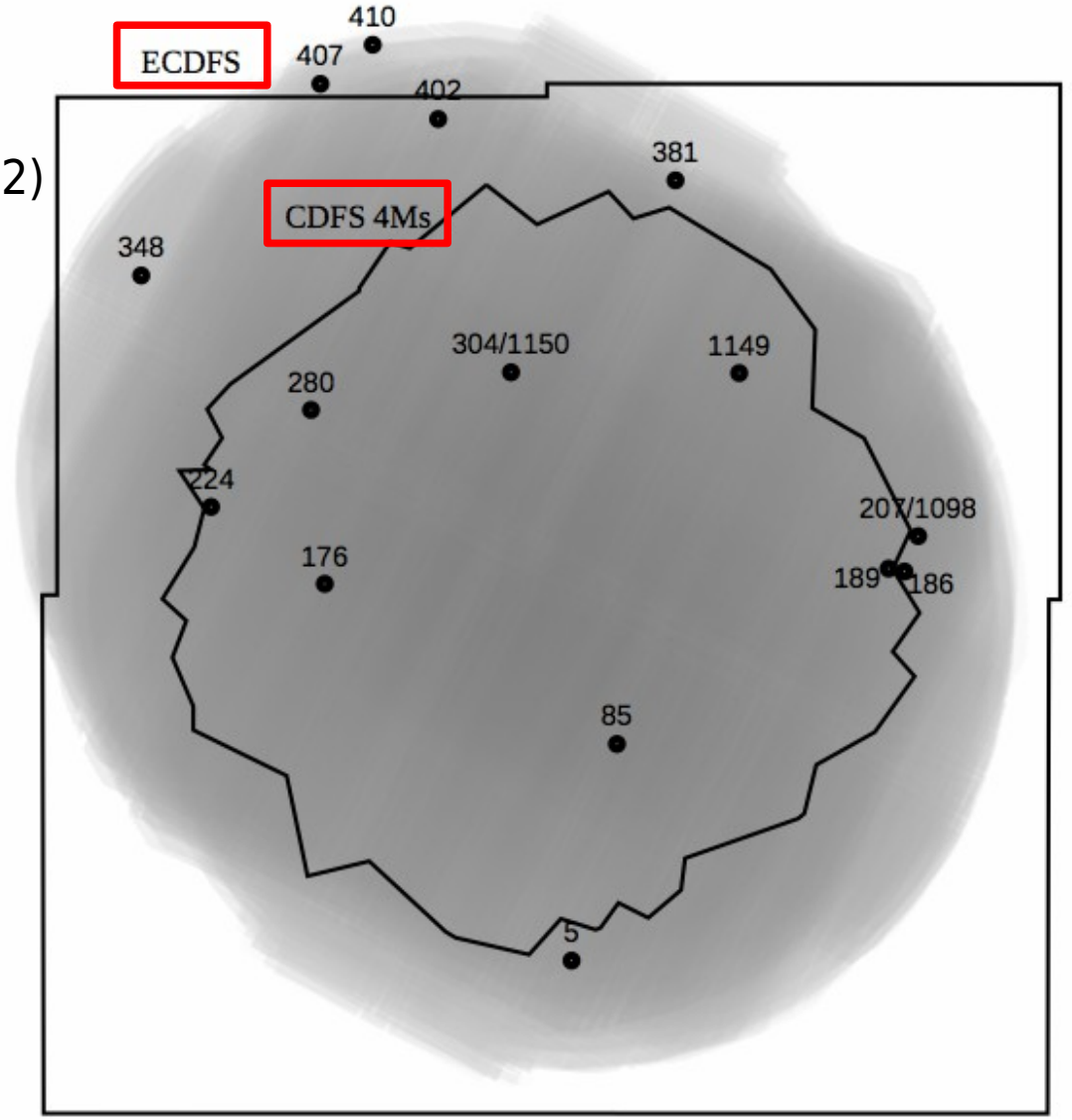




XMM-CDFS covers an area similar to ECDFS
and is a bit elongated because of different pointing coordinates in 2001
but area of highest exposure coincides with 4 Ms CDFS

always meant as a spectroscopic complement to Chandra-CDFS (see talk by C. Vignali)
(XMM is background dominated, Chandra is still photon-limited at 4Ms)

but in hard bands (2-10, 5-10 keV)
the larger effective area still
allows to detect faint (~10-15 erg/s/cm2)
sources



339 objects in 2-10 keV band,
97% redshift completeness

catalogue: Ranalli et al. 2013

photo-z from Hsu et al. 2014
(see her poster)

XMM/LSS: Numbers

only considering 2-10 keV detections:

2573 objects with hard X-ray flux, point-like
1846 with redshift (specz or photoz)
459 with spec-z (12 with only spec-z, no photo-z)
1834 with photo-z (1383 with only photo-z, no spec-z)

1520 (i.e. 82% of 1846) have X-ray/optical match probability > 95%

catalogue: Chiappetti et al. 2013
photo-z by N. Formanoit (Geneva)

XMM/LSS: Numbers

only considering 2-10 keV detections:

2573 objects with hard X-ray flux, point-like
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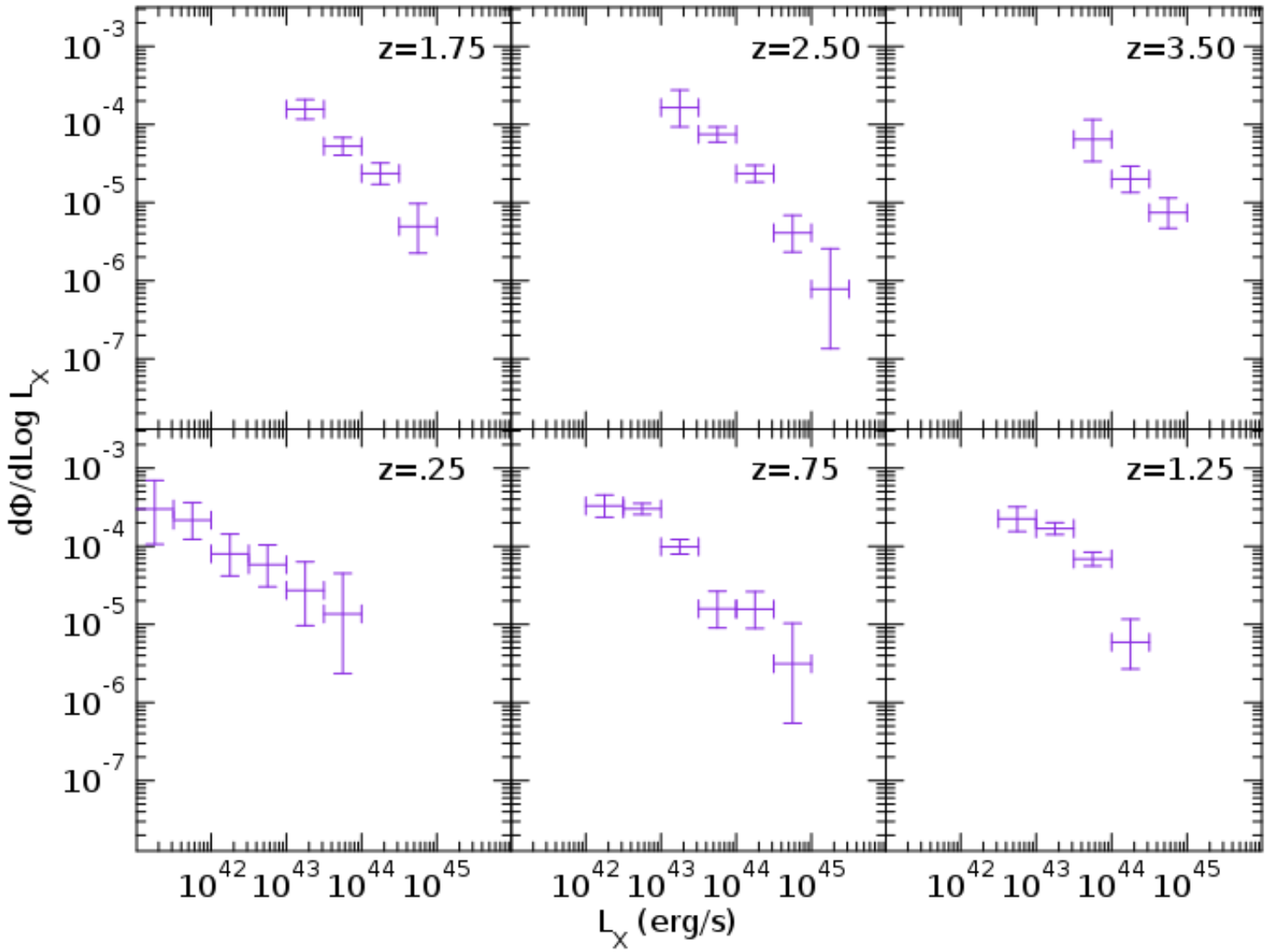
Largest samples already used for LF determination:

Ueda+2014: 1791 AGN;
XMM-COSMOS: 826 AGN;
LaFranca+2005 508 AGN; Ebrero+2009: 435 AGN;
Ueda+2003: 247 AGN; Aird+2010: 416 AGN;
Yencho+2009: 782 AGN (spectro-z only, no N_H correction)

XMM-CDFS luminosity function

(binned LF, following Page & Carrera)



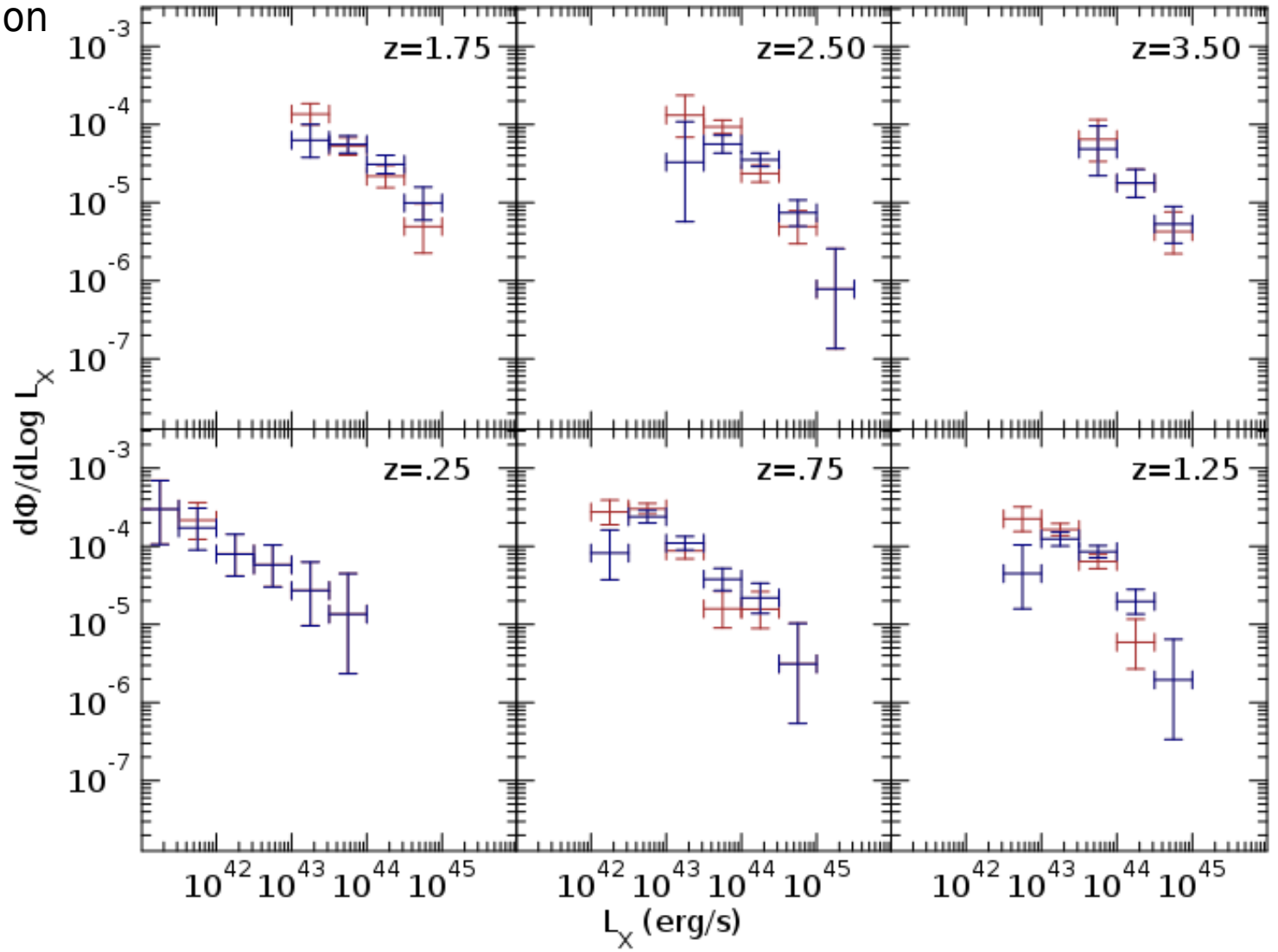
XMM-CDFS luminosity function

(binned LF, following Page & Carrera)

photo-z considered with their probability density functions (PDFs)

corrected for absorption

corrected
not corrected



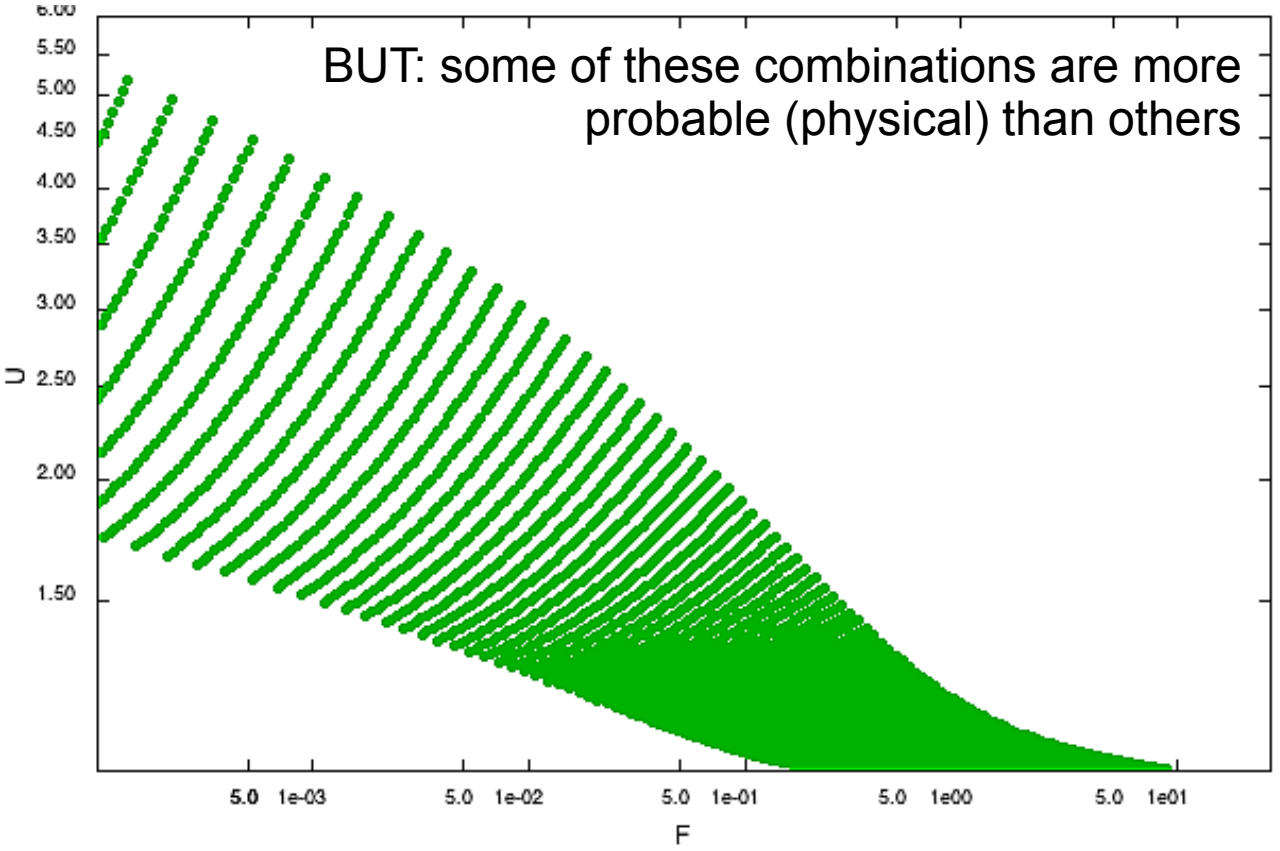
Corrections for intrinsic absorption

based on soft/hard flux ratio

U=unabsorbed/absorbed flux ratio
F=soft/hard flux ratio

F is in catalogue; we need U

relation can be derived assuming spectral model: absorbed powerlaw, various Γ and NH, on a grid of redshifts



Corrections for intrinsic absorption

based on soft/hard flux ratio

relation can be derived assuming spectral model: absorbed powerlaw, various Γ and NH

U=unabsorbed/absorbed flux ratio
SH=soft/hard flux ratio

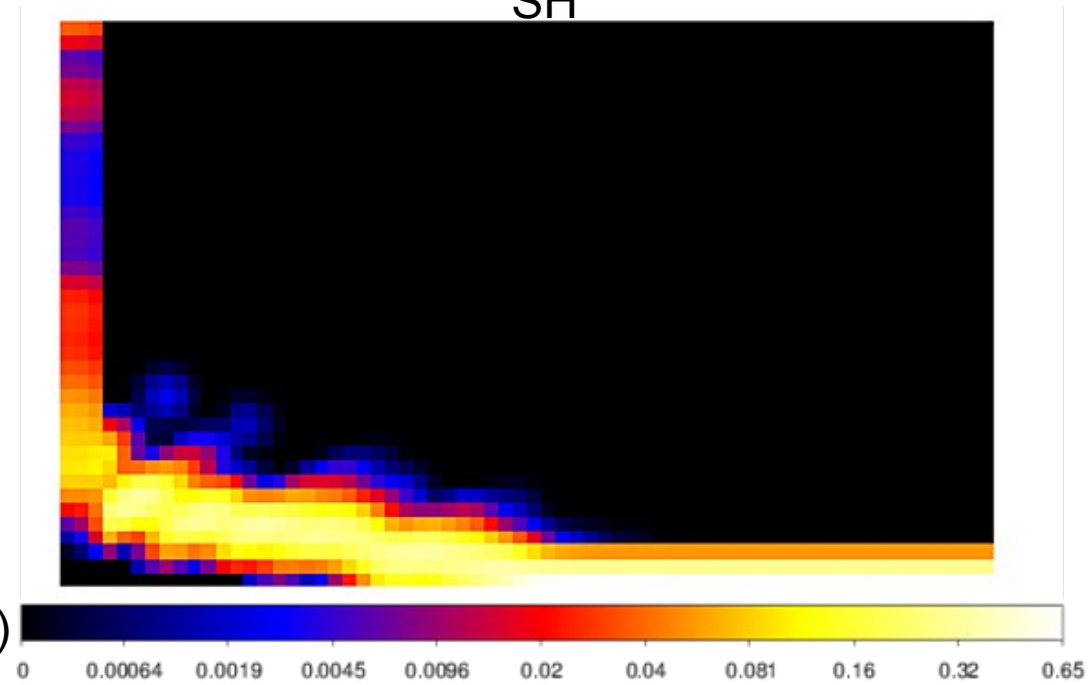
SH is in catalogue; we need U

taken from Burlon et al. 2011: we need a (Γ,NH) distribution

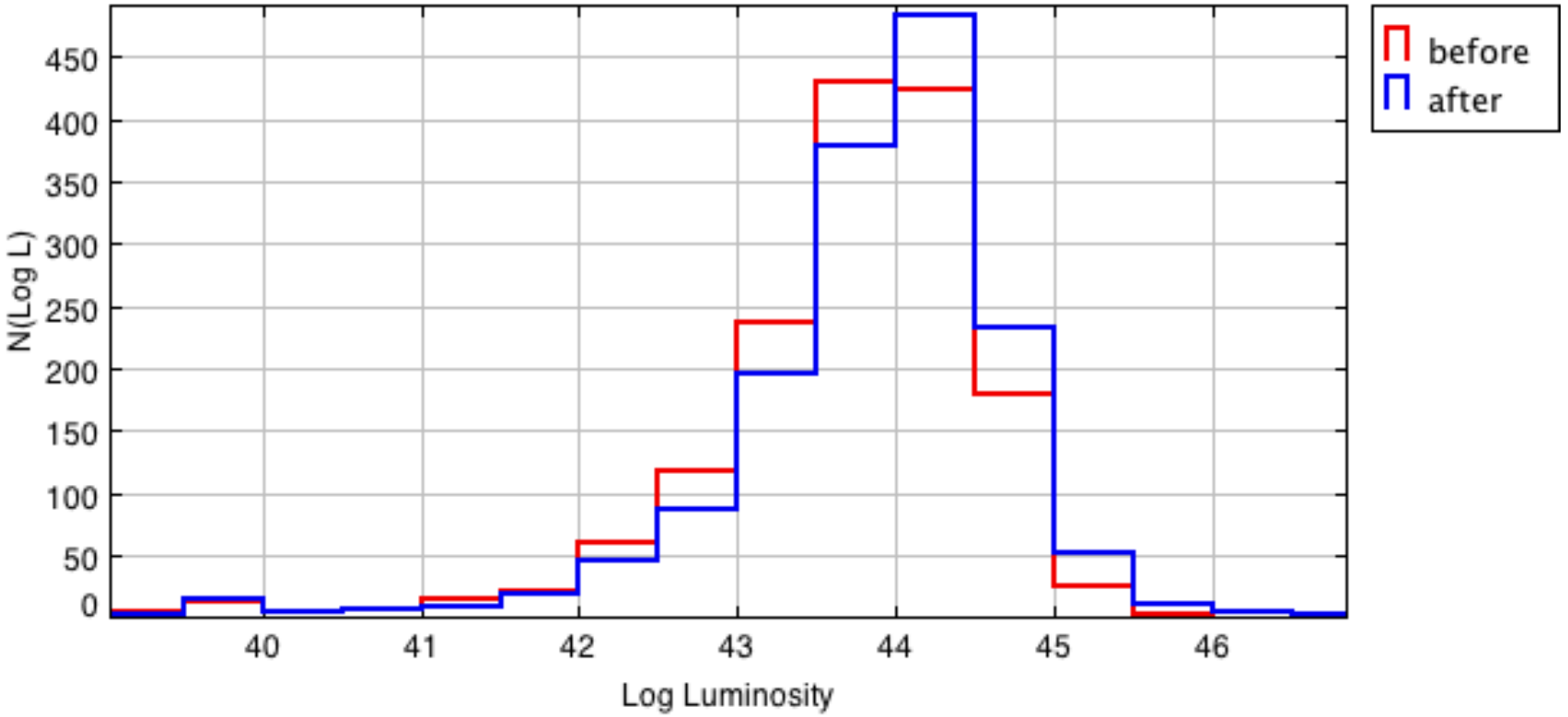
$$P(U|SH)=\frac{P(U\cap SH)}{P(SH)}$$

normalization

this is calculated
for a grid of redshifts



Corrections for intrinsic absorption



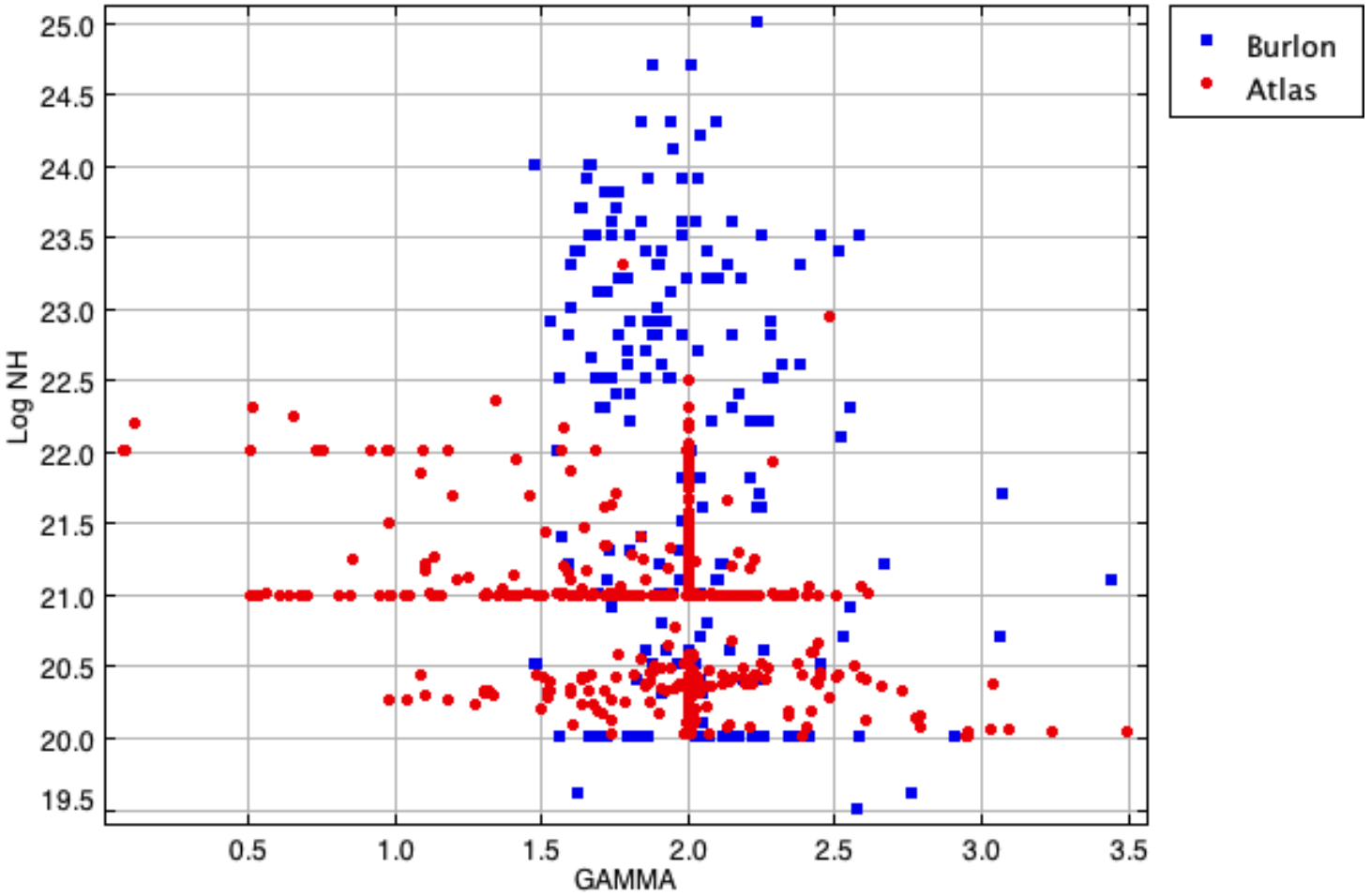
the average luminosity is increased by a factor ~1.5

How representative is the Burlon sample?

- complete sample, selected on hard X-rays from Swift/BAT => should favour flat spectra?

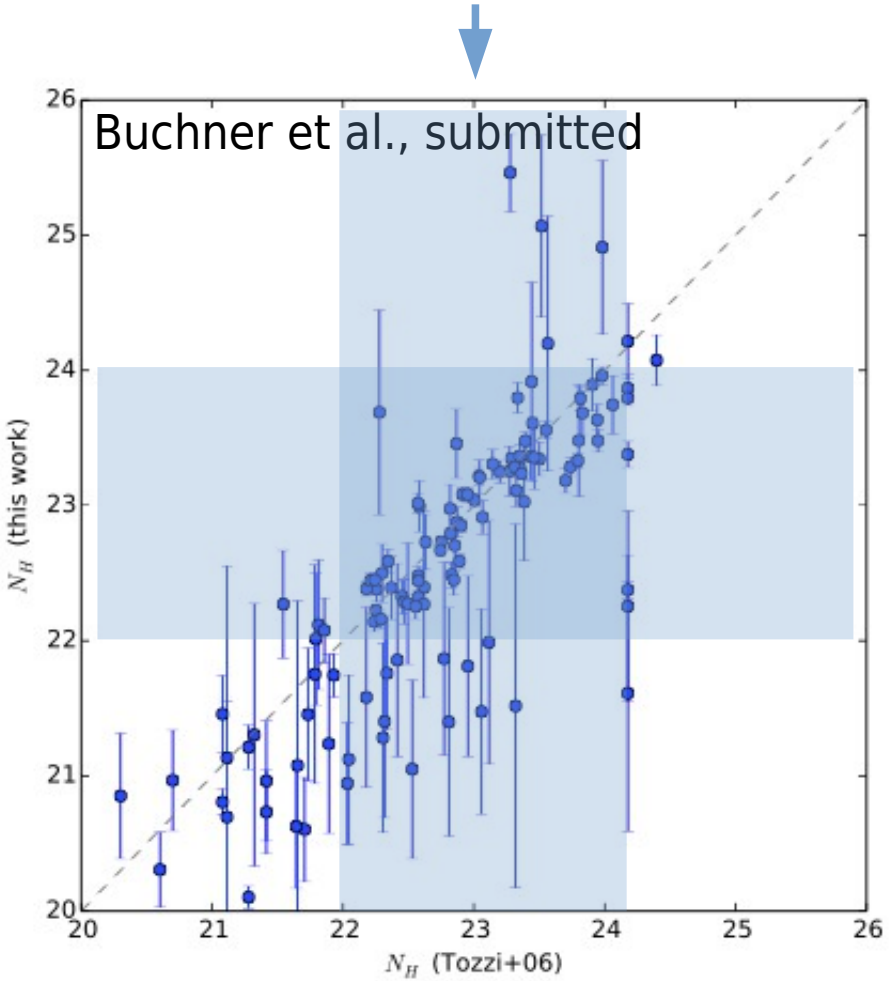
- compare with XMM-Atlas (very preliminary)

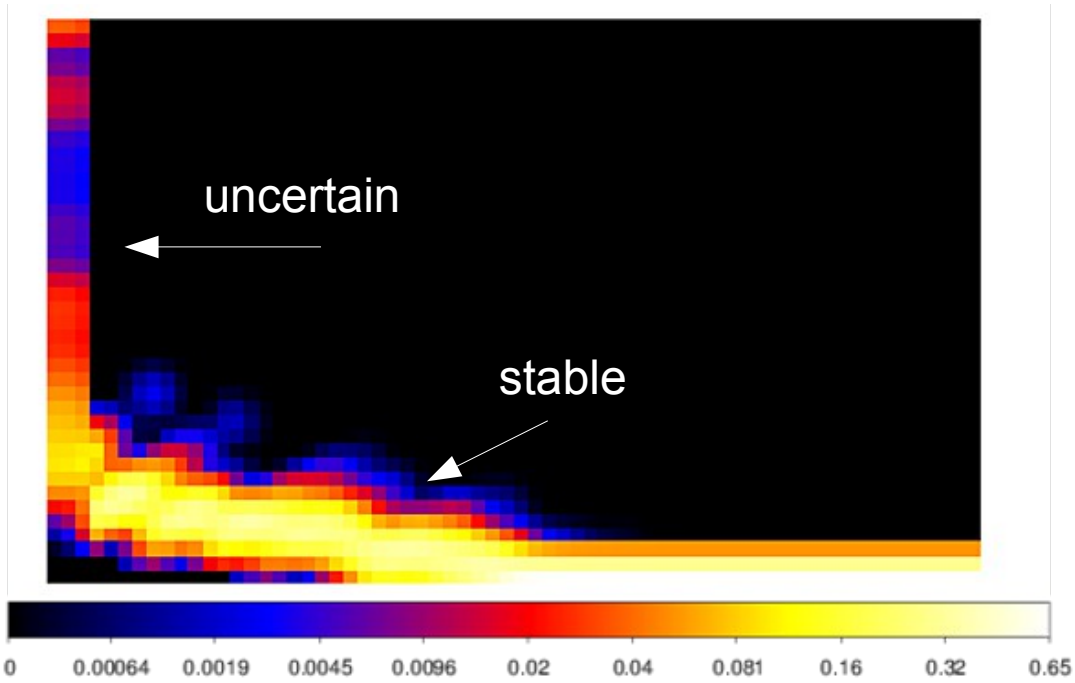
- in the near future, compare or use XXL 1000 AGN



NH determinations are sensitive to methodology and redshift:

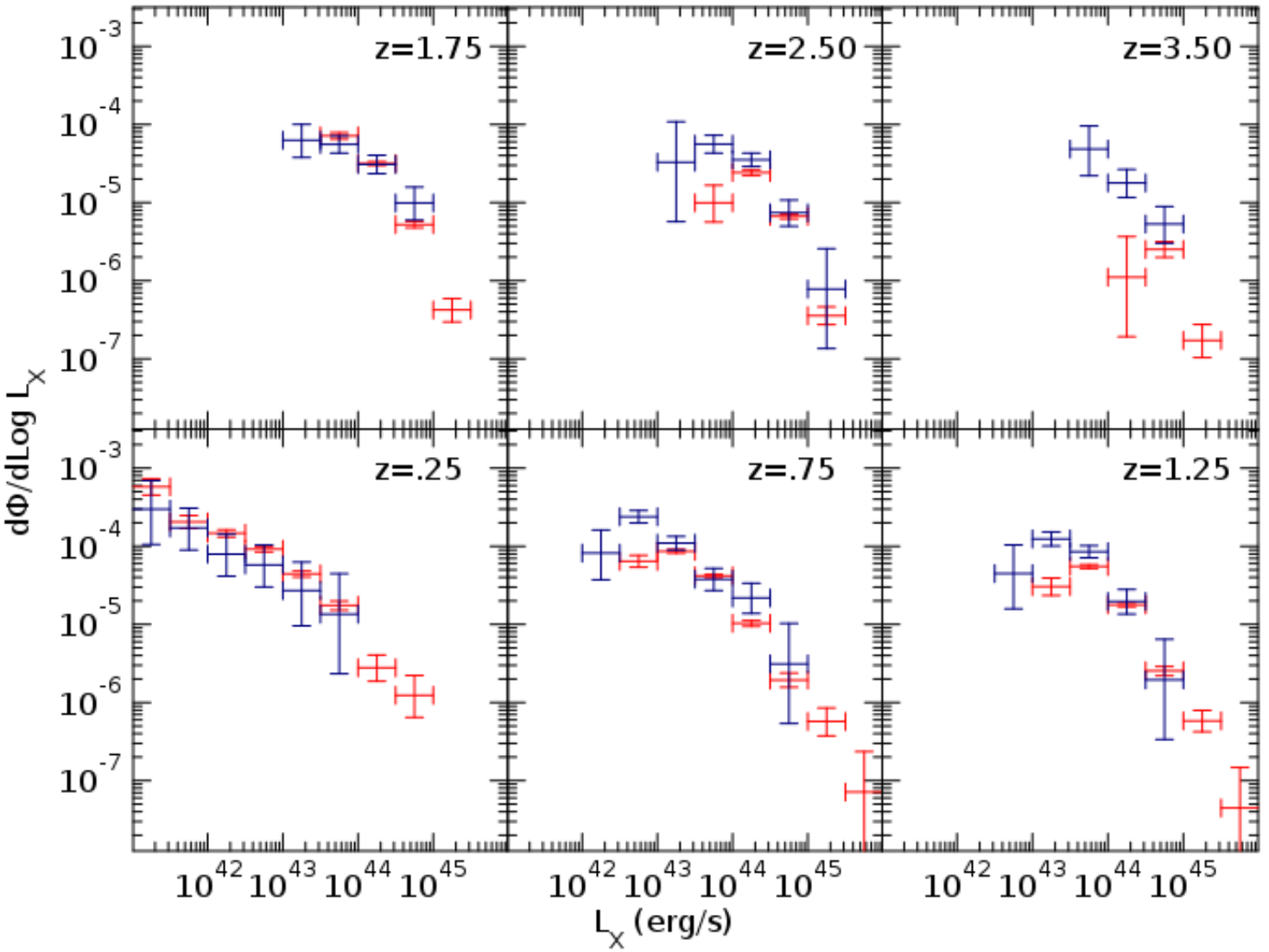
this is the NH region which affects most the corrections





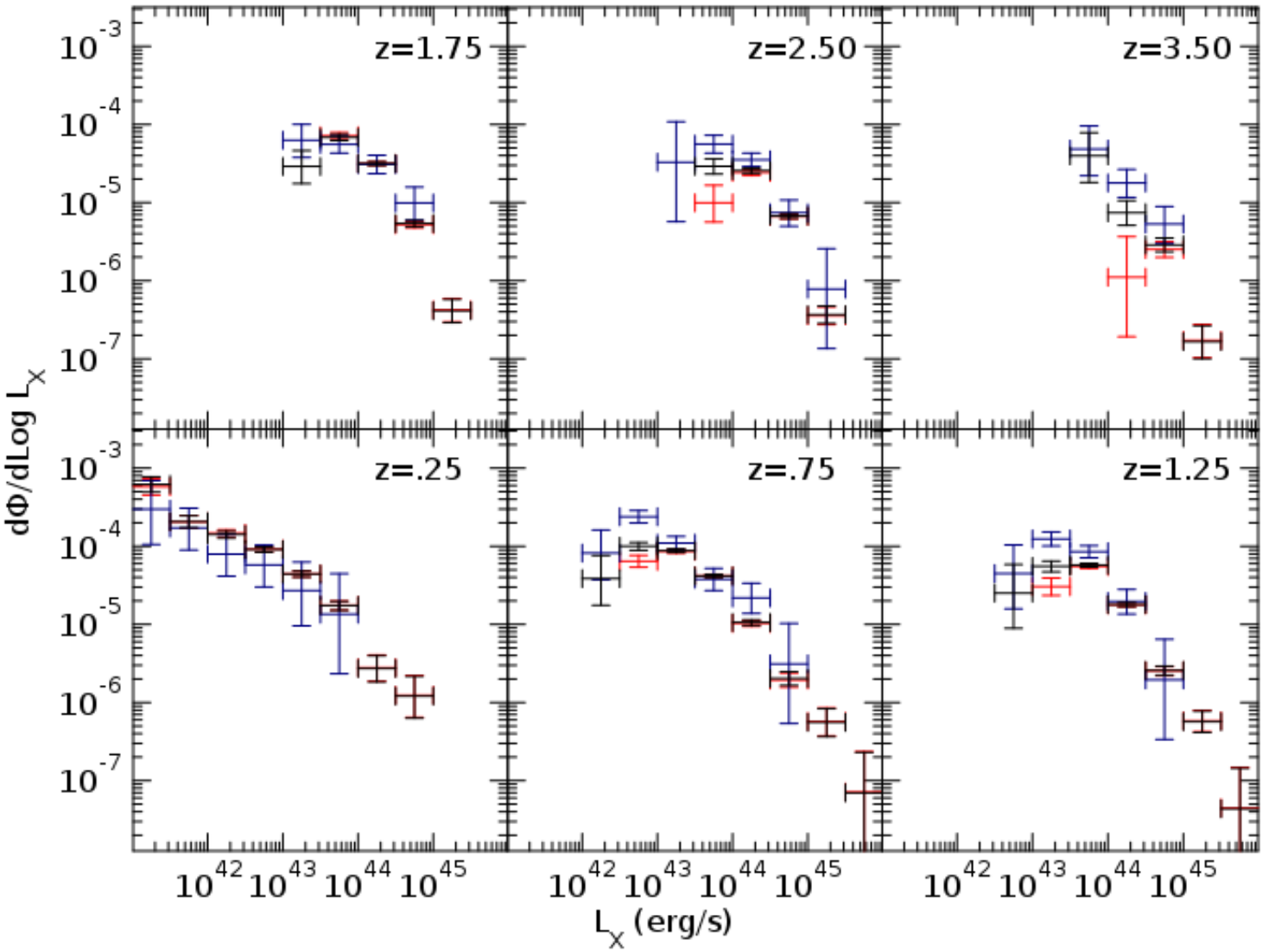
XMM-CDFS & LSS luminosity function

LSS
CDFS



XMM-CDFS & LSS luminosity function

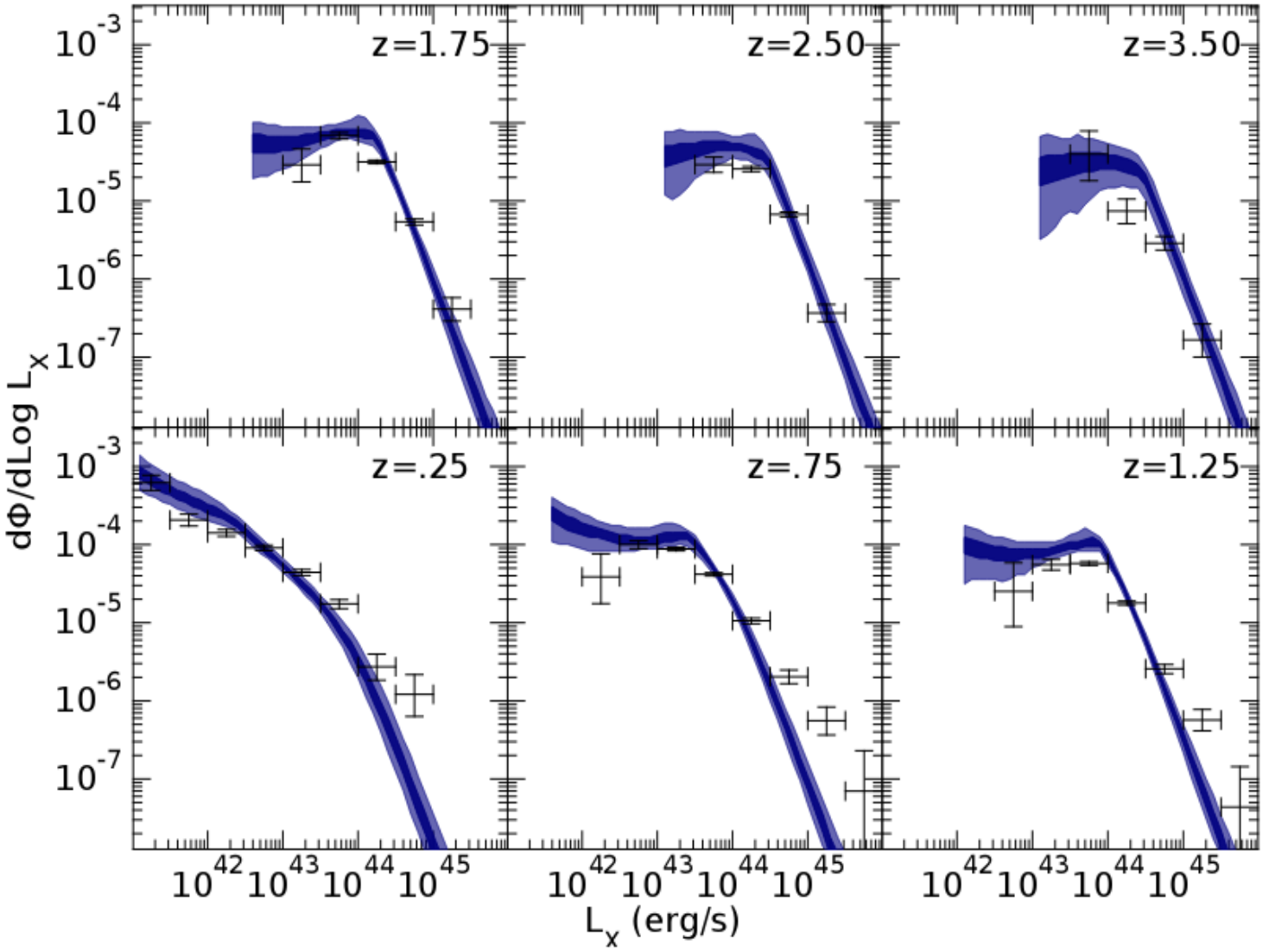
LSS
CDFS
both



XMM-CDFS & LSS luminosity function

LDDE model

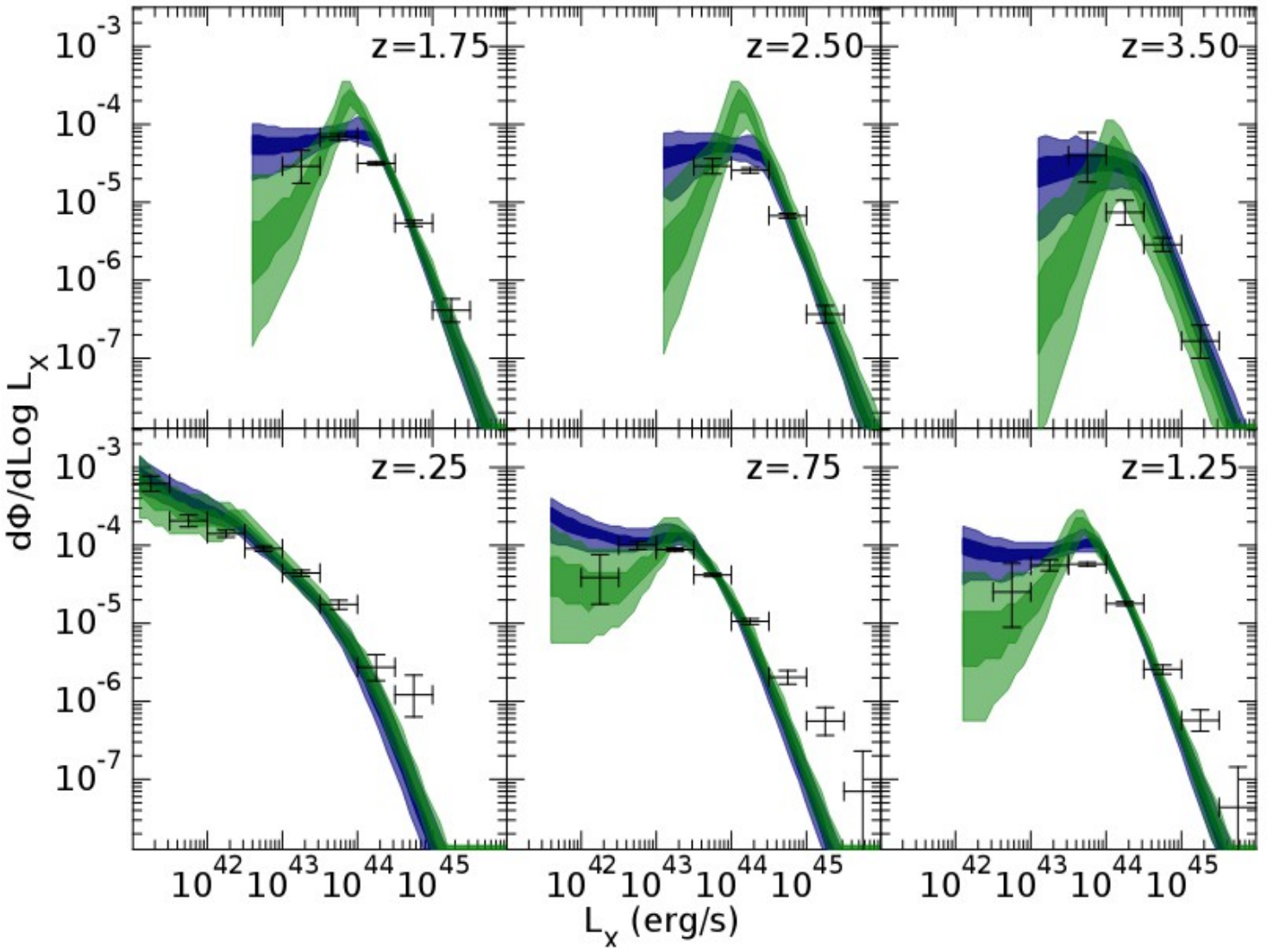
LSS+CDFS



XMM-CDFS & LSS luminosity function

LDDE model

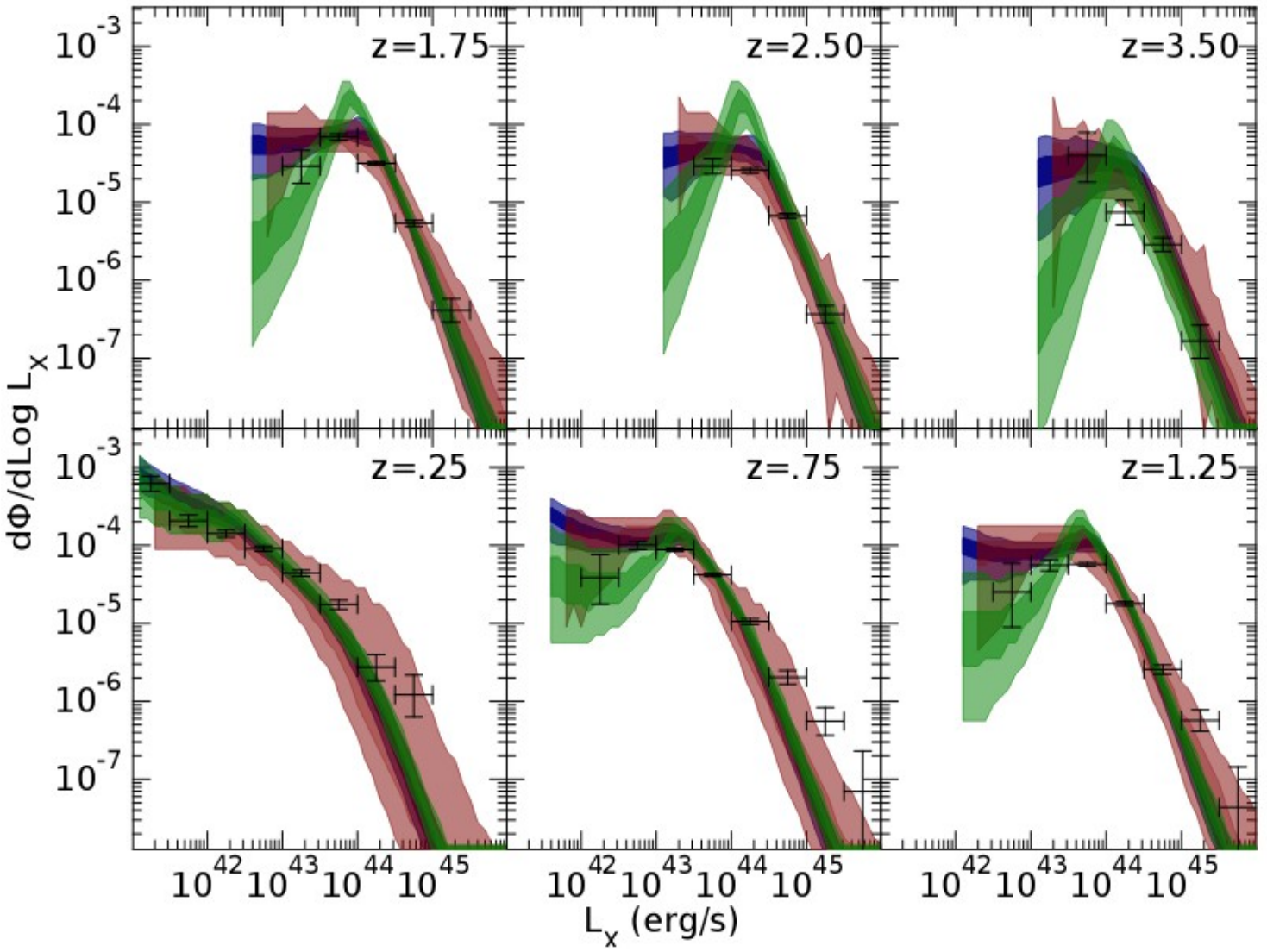
LSS+CDFS
LSS



XMM-CDFS & LSS luminosity function

LDDE model

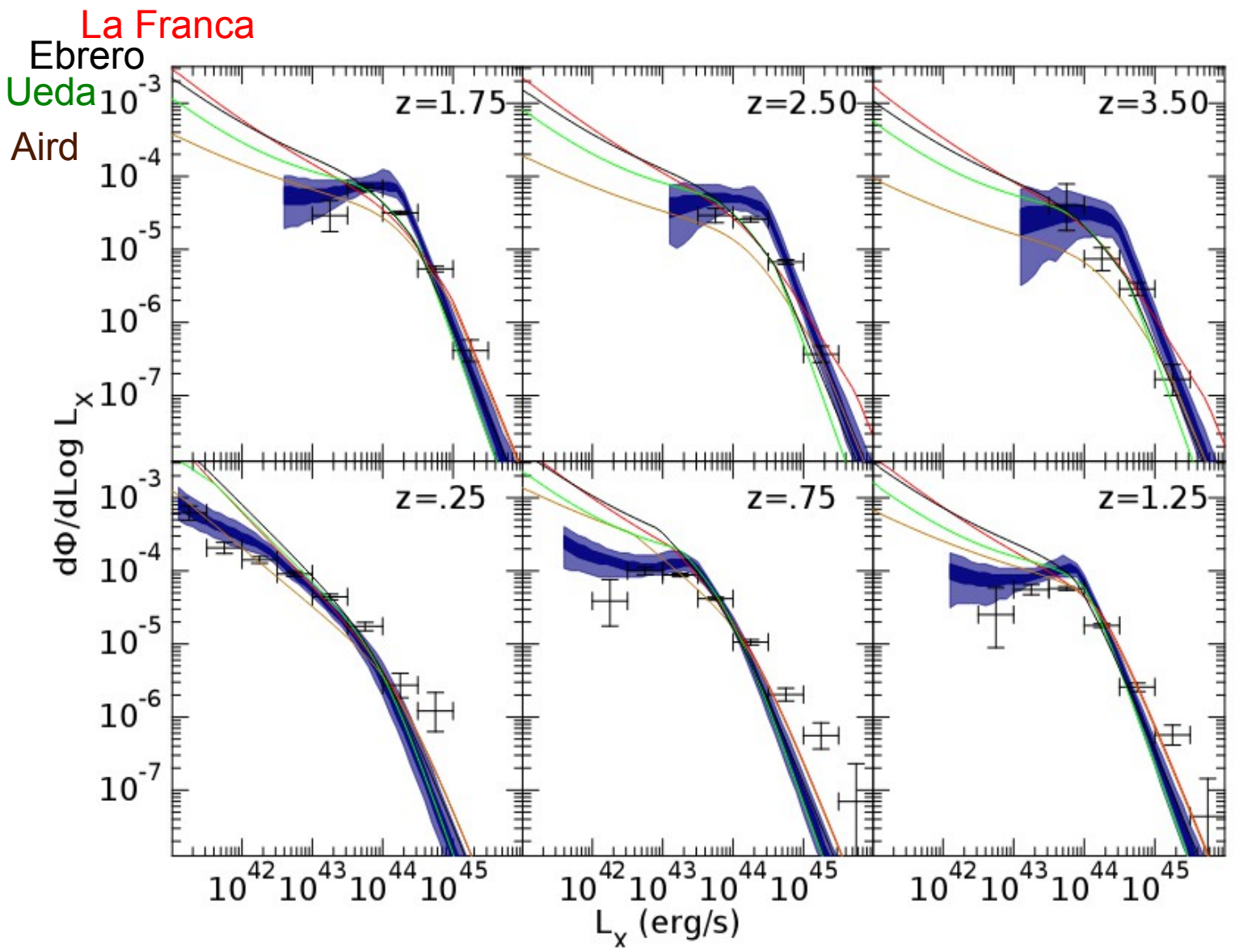
LSS+CDFS
LSS
CDFS



XMM-CDFS & LSS luminosity function

LDDE model

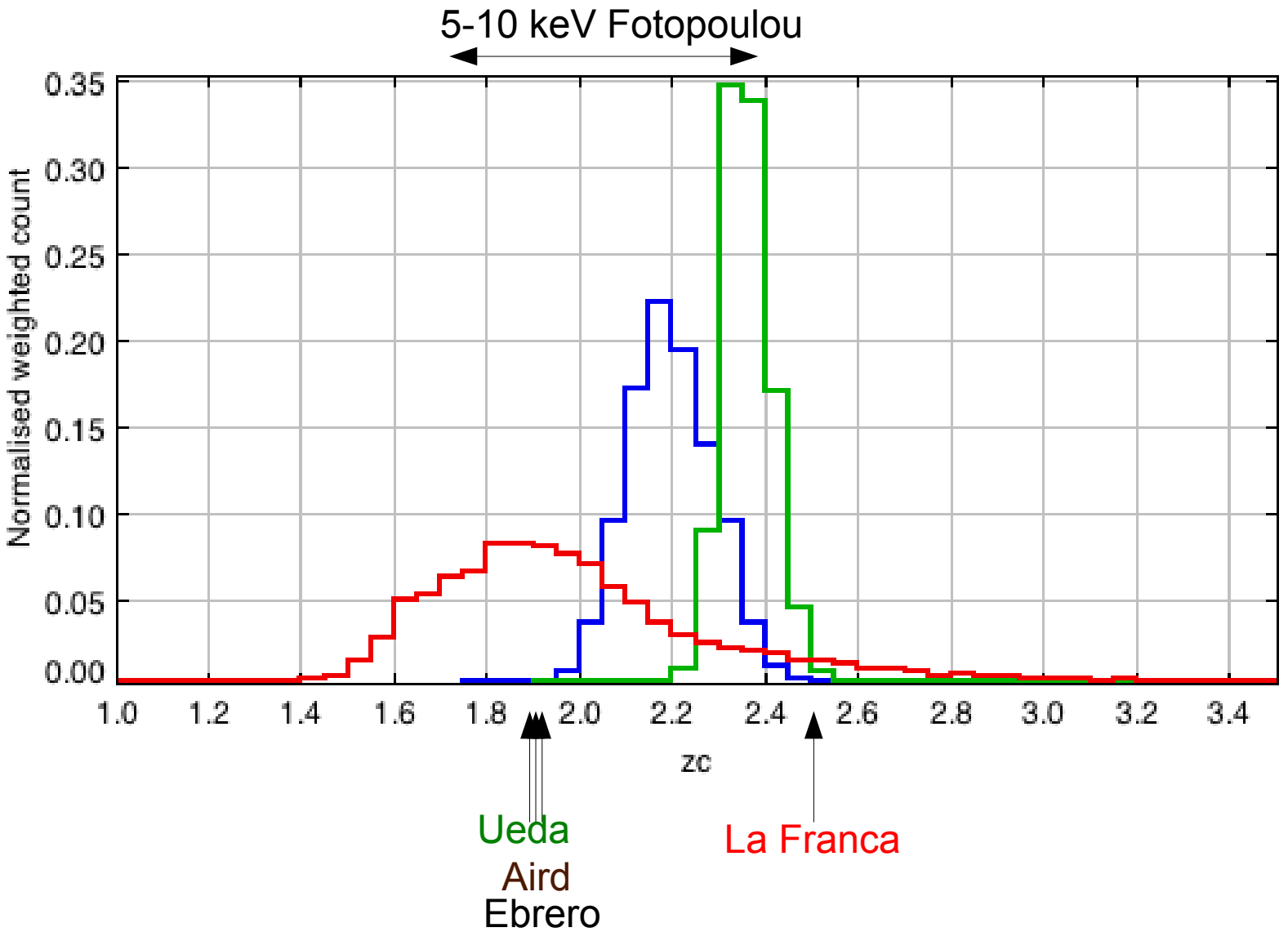
LSS+CDFS



XMM-CDFS & LSS luminosity function

LDDE model

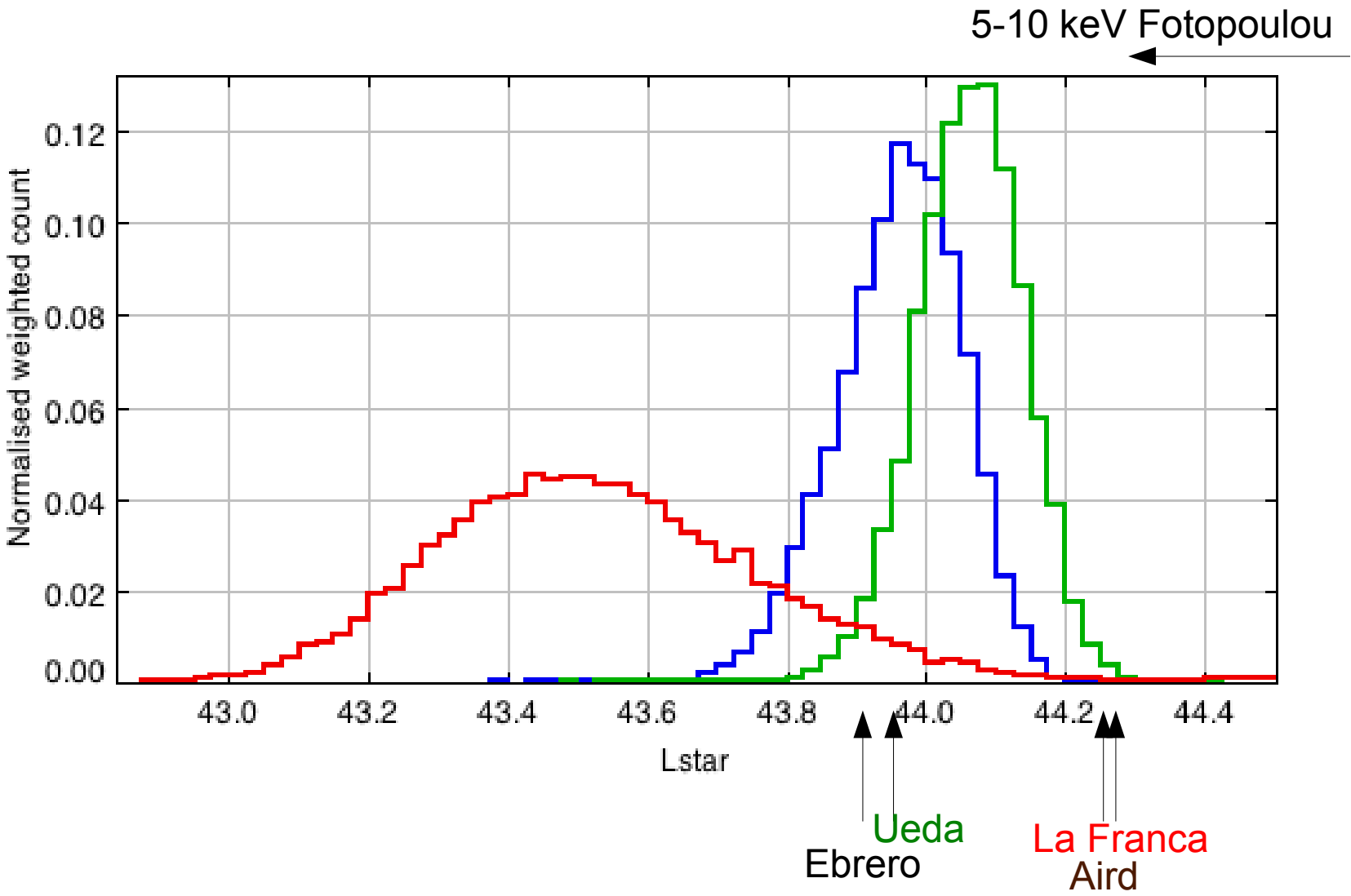
LSS+CDFS
LSS
CDFS



XMM-CDFS & LSS luminosity function

LDDE model

LSS+CDFS
LSS
CDFS

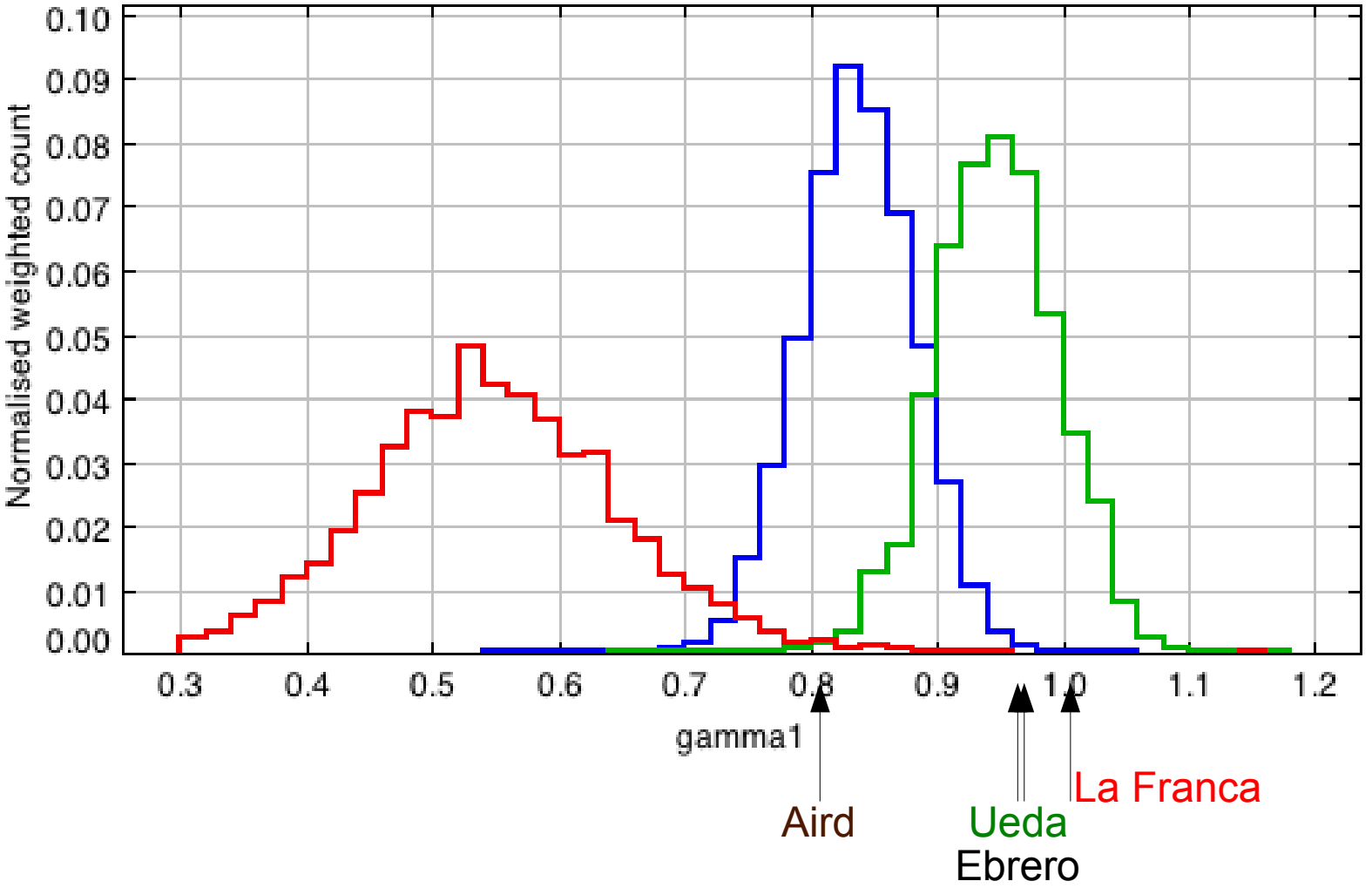


XMM-CDFS & LSS luminosity function

LDDE model

LSS+CDFS
LSS
CDFS

5-10 keV Fotopoulou:
1.3-1.5



XMM-CDFS & LSS luminosity function

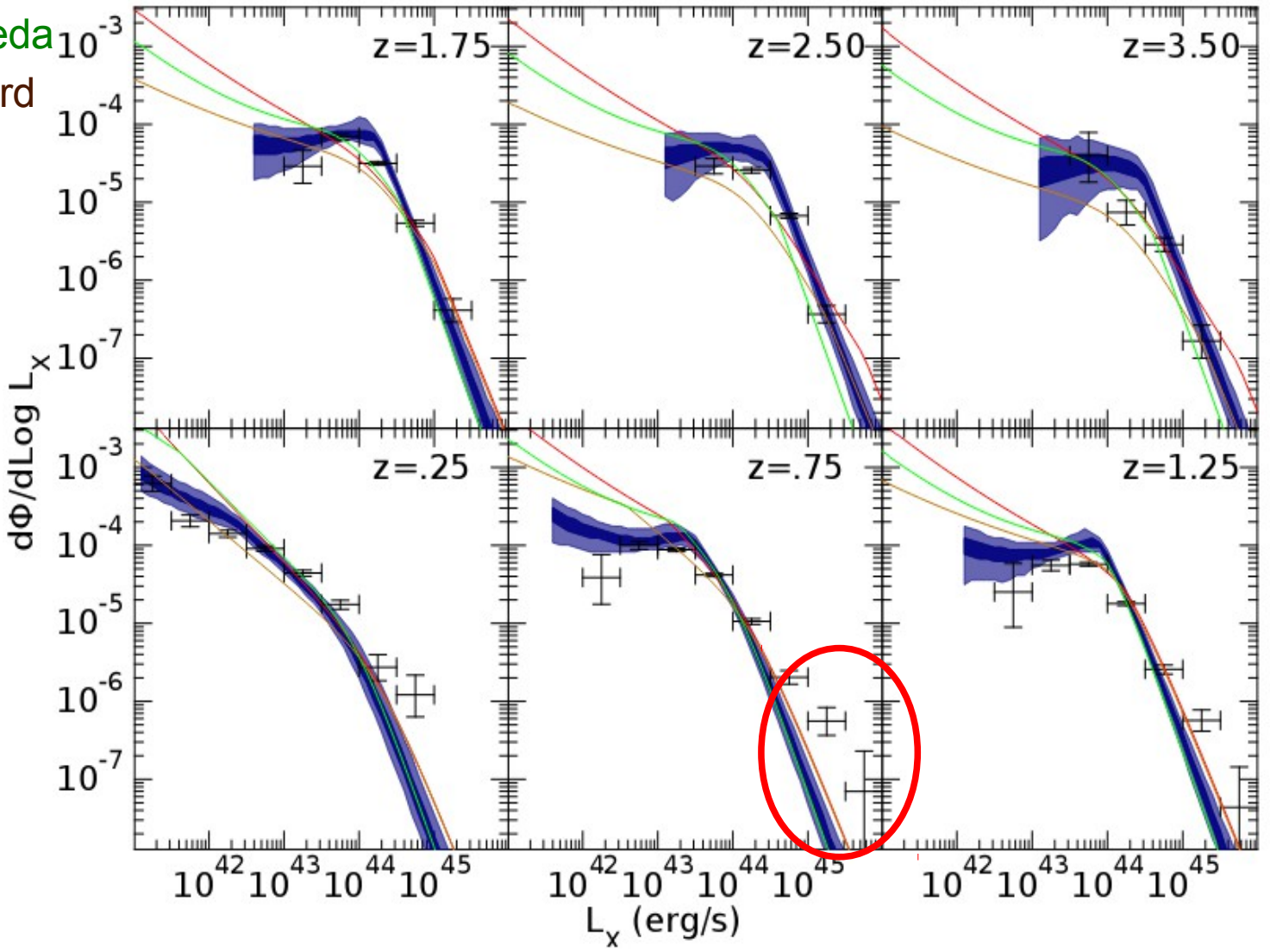
LDDE model

LSS+CDFS

La Franca

Ueda

Aird



there seems to be an excess of luminous AGN at medium z

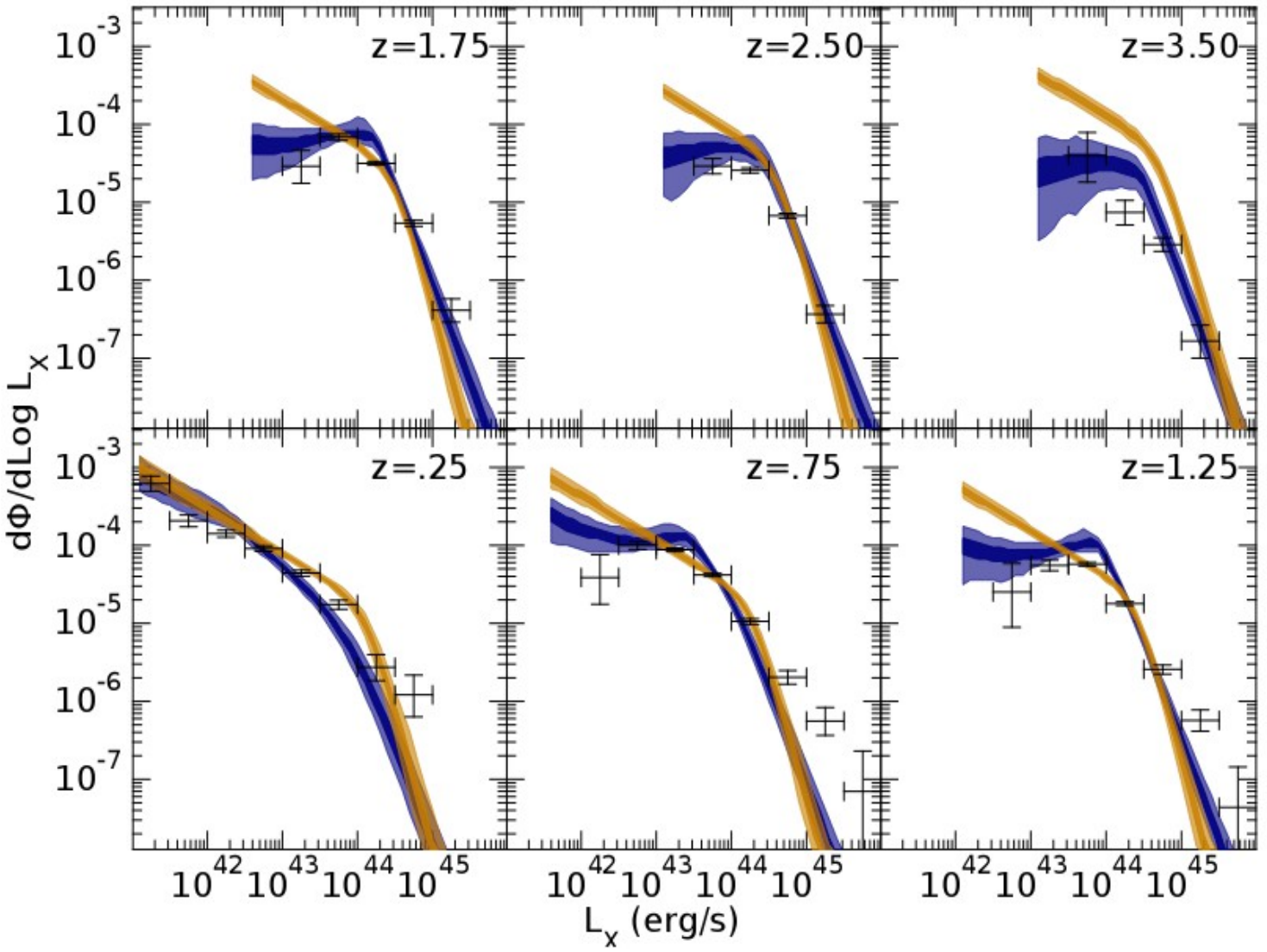
but this is strongly dependent on the absorption corrections

XMM-CDFS & LSS luminosity function

LDDE model

LSS+CDFS: LDDE
LADE

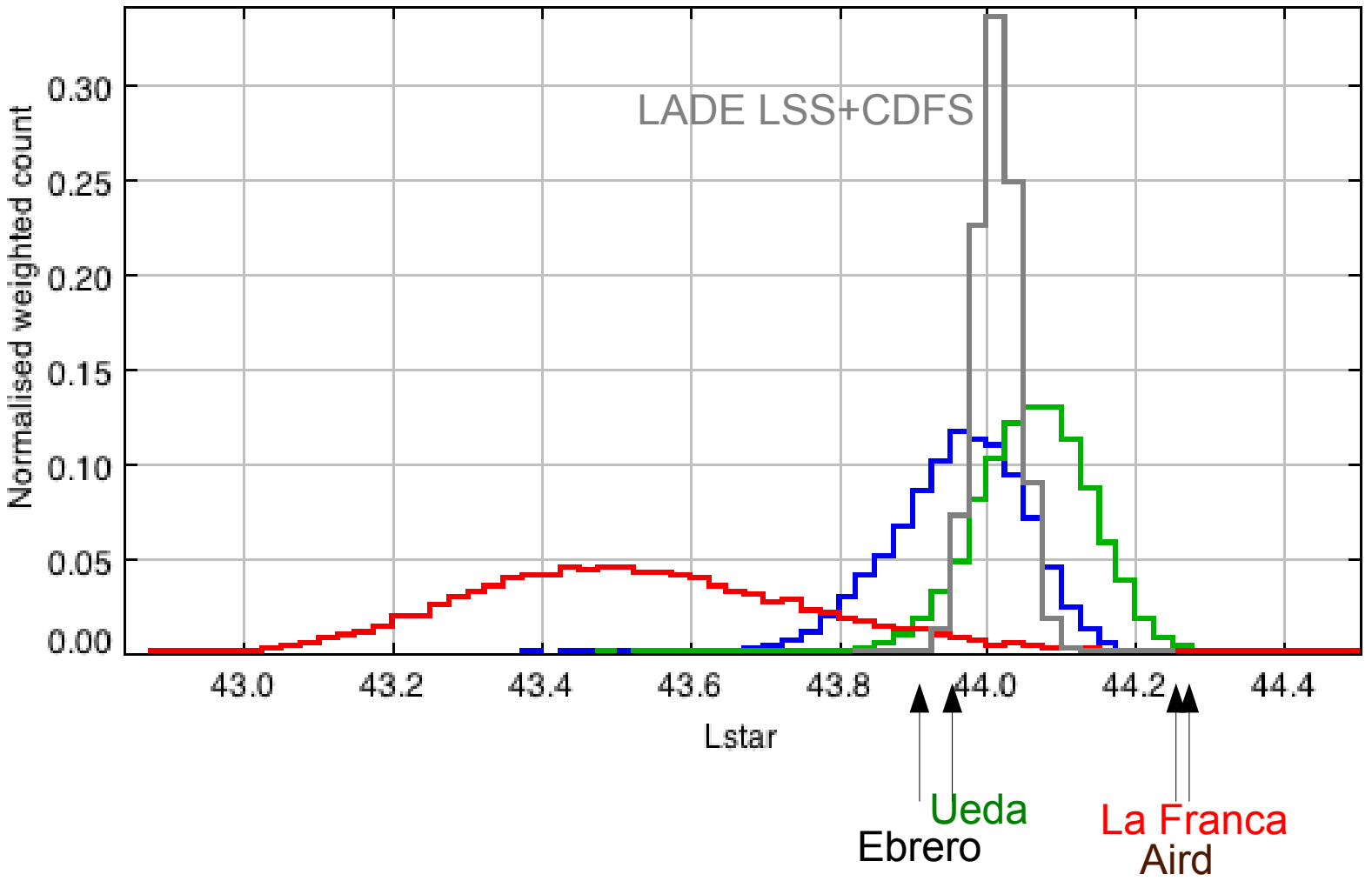
LDDE seems to perform better; next step is quantifying it (BIC, AIC, ...)



XMM-CDFS & LSS luminosity function

LDDE model

LSS+CDFS
LSS
CDFS



A note on software

The LF code will be released when the paper is submitted. The aim is to produce a general-purpose package including:

- a sample corrector, applying photoz-pdf and NH corrections
- a binned LF integrator, following the Page&Carrera method modified to work on the corrected samples
- a likelihood function, to be used in:
  - a maximum-likelihood fitter using Minuit
  - a Bayesian integrator using MultiNest

Everything is in OO Fortran 2008!

See my poster about this and other useful programmes!

Conclusions

- XMM-CDFS is the deepest XMM survey, at 3 Ms, providing good quality spectroscopy and clean samples of 2—10 and 5—10 keV sources, with 97% redshift completeness;
- XMM-LSS is among the widest area XMM surveys, at 11 deg^2, but redshift completeness among reliable optical counterparts is ~65%

- LF was determined with different methods:
  - binned
  - ML (not shown today)
  - Bayesian

- corrections for absorption are important, but the robustness of the method must be checked (NH/Gamma degeneracy, redshift, fitting method...)

- CDFS seems to require lower L*, lower zcut, flatter gamma1