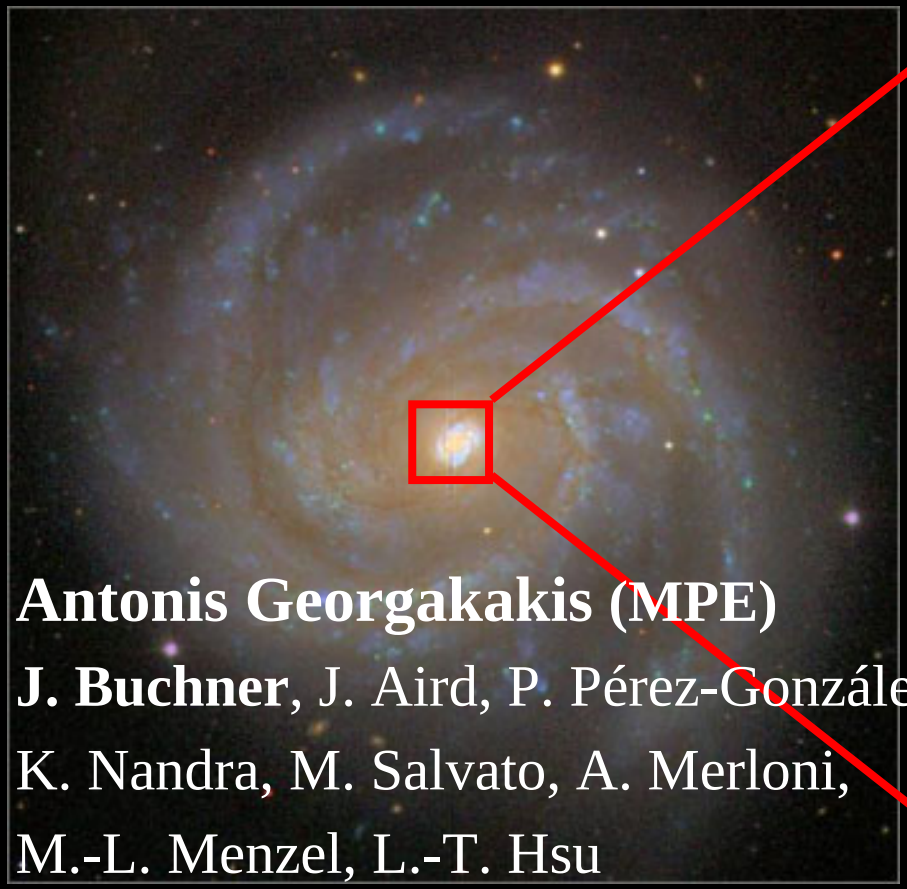
The evolution of Active Galactic Nuclei across cosmic time



Antonis Georgakakis (MPE)

J. Buchner, J. Aird, P. Pérez-González, K. Nandra, M. Salvato, A. Merloni, M.-L. Menzel, L.-T. Hsu

Motivation

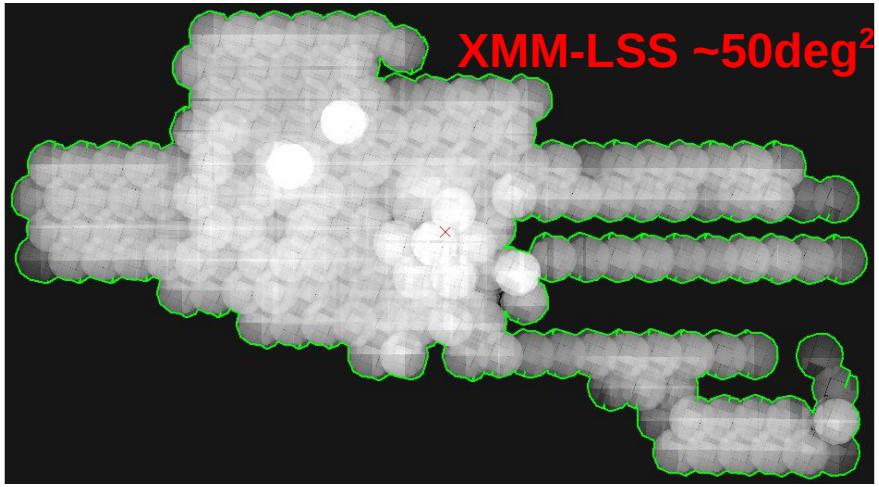
AGN space density as a function of redshift, luminosity and obscuration (luminosity function)

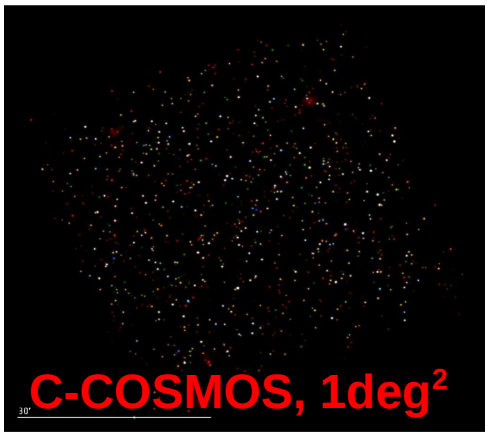
- Accretion history of the Universe
- Relation between BH accretion and galaxy evolution
- Geometry of the obscuring material in the vicinity of the BH

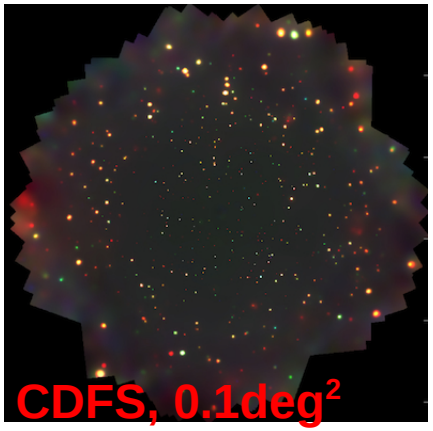
Multi-wavelength surveys

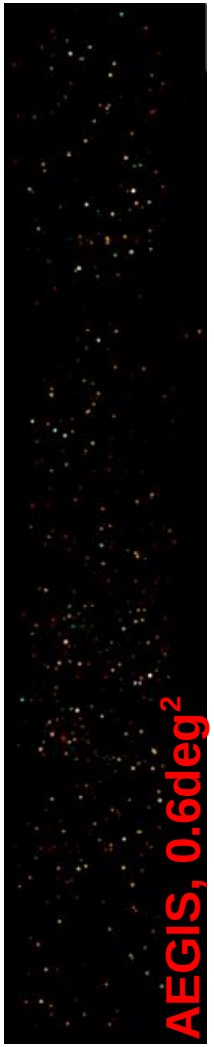
Explosion in quality and quantity of X-ray survey data:

- ✓ Chandra X-ray
- ✓ Optical/near-IR SEDs
- ✓ Large spec-z surveys
- ✓ HST (morphology)
- ✓ Spitzer mid/far-IR
- ✓ Herschel far-IR





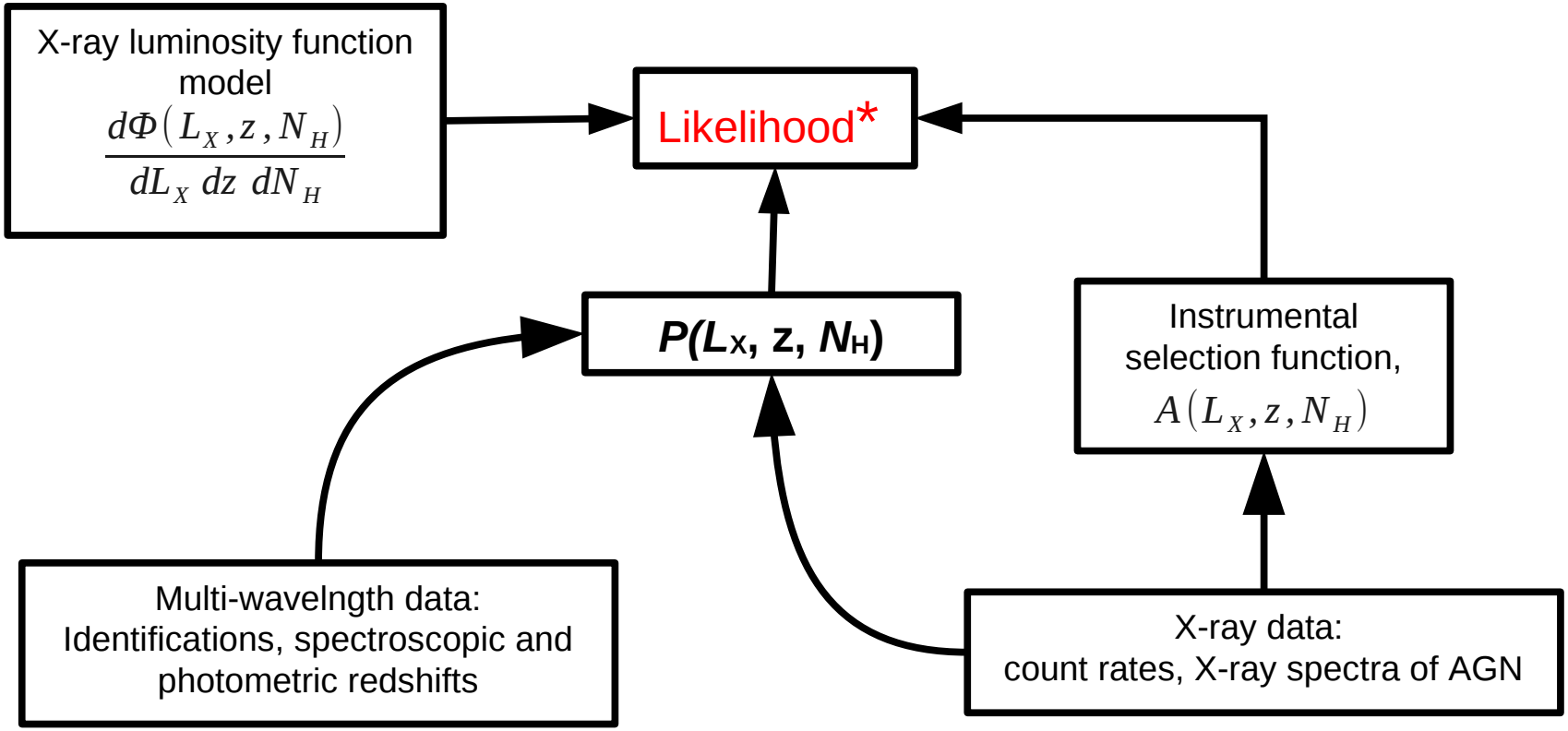




Last comprehensive XLF measurement: Ueda+03

Past year 5 publications on XLF (Ueda et al. 2014, Miyaji et al. 2015, Aird et al. 2015, Buchner et al. 2015, Georgakakis et al. 2015).

Modeling the X-ray luminosity function



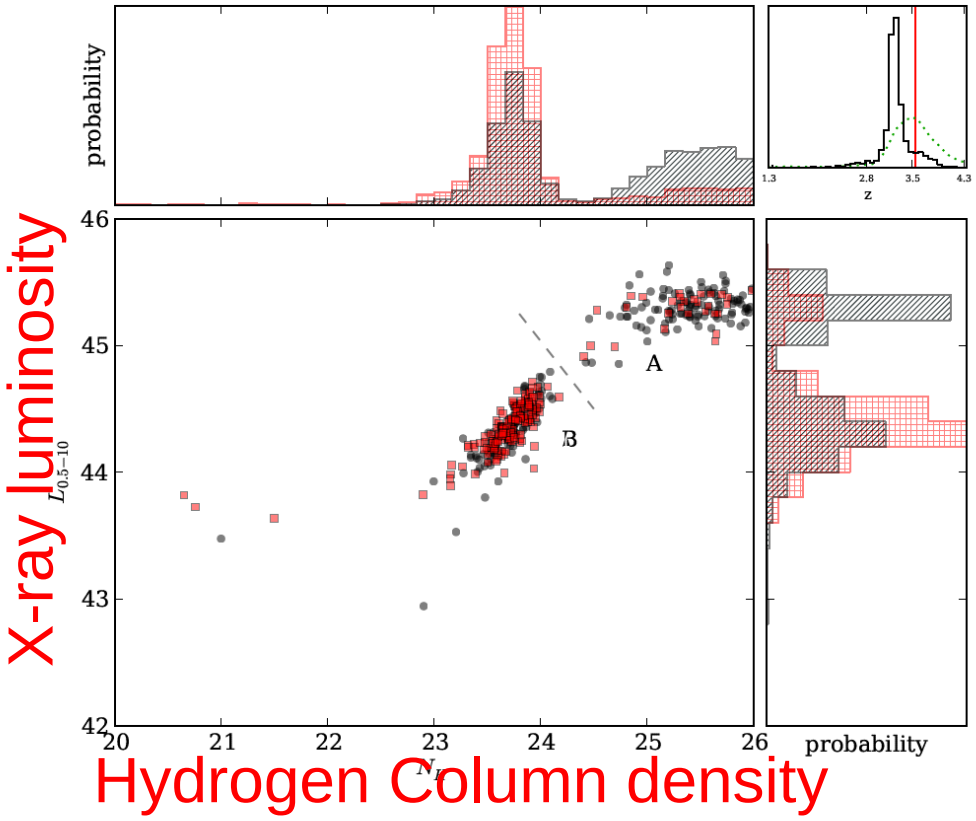
$$* \log(Likelihood) = -\lambda + \sum_i \int \Phi(L_X, z, N_H)\, P(L_X, z, N_H)\, \frac{dV}{dz}\, dz\ dlogL_X\ dlogN_H,$$

$$where \quad \lambda = \int A(L_X, z, N_H)\, \Phi(L_X, z, N_H)\, \frac{dV}{dz}\, dz\ dlogL_X\ dlogN_H,$$

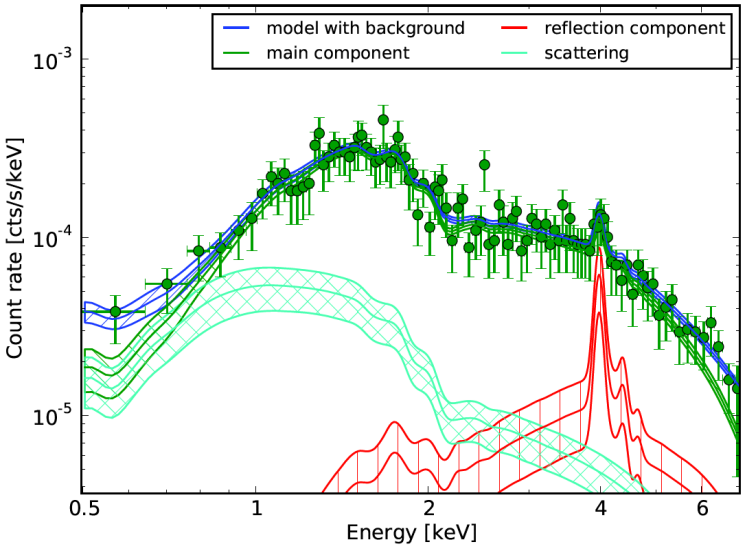
$A(L_X, z, N_H)$ *selection function*

Bayesian X-ray spectral analysis approach

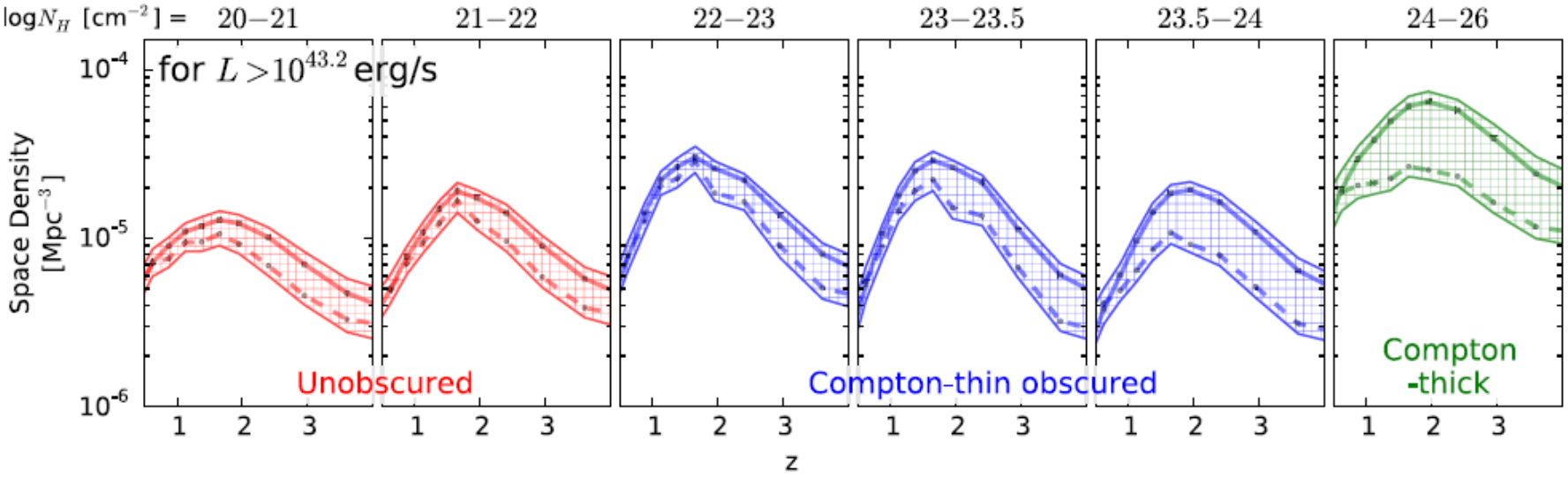
Buchner+14



Estimate full probability distribution function of inferred parameters, i.e. N_H, L_X



AGN space density vs obscuration



see Poster A1

Buchner+15:

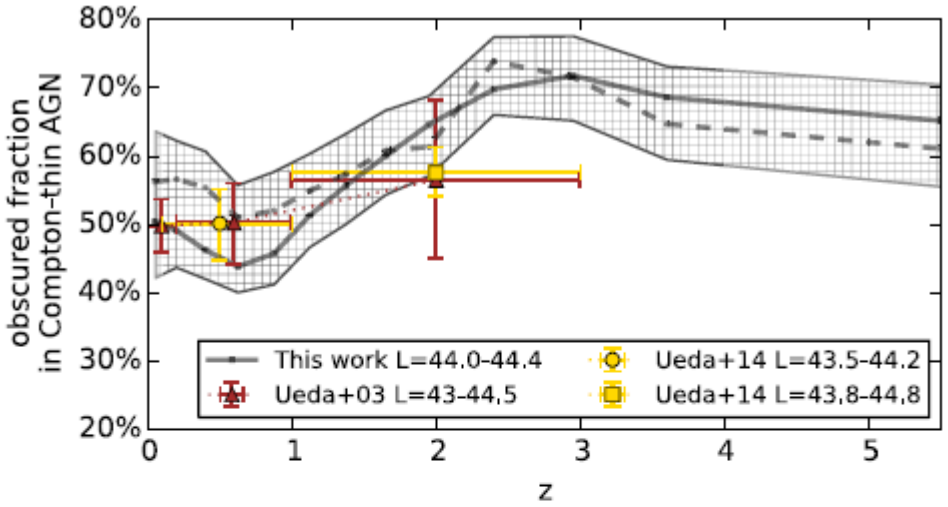
(a) ~2000 X-ray AGN.

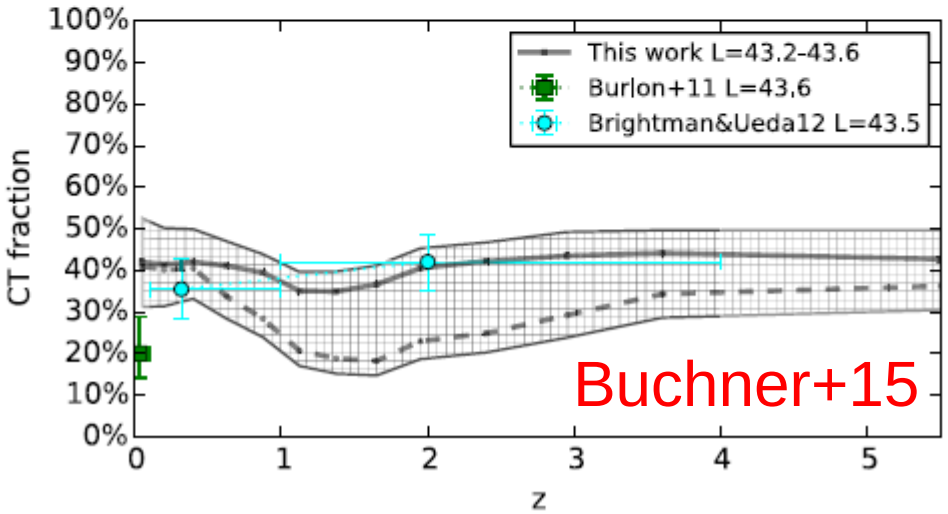
(b) X-ray spectral analysis

(c) Propagation of uncertainties

(d) Non-parametric approach

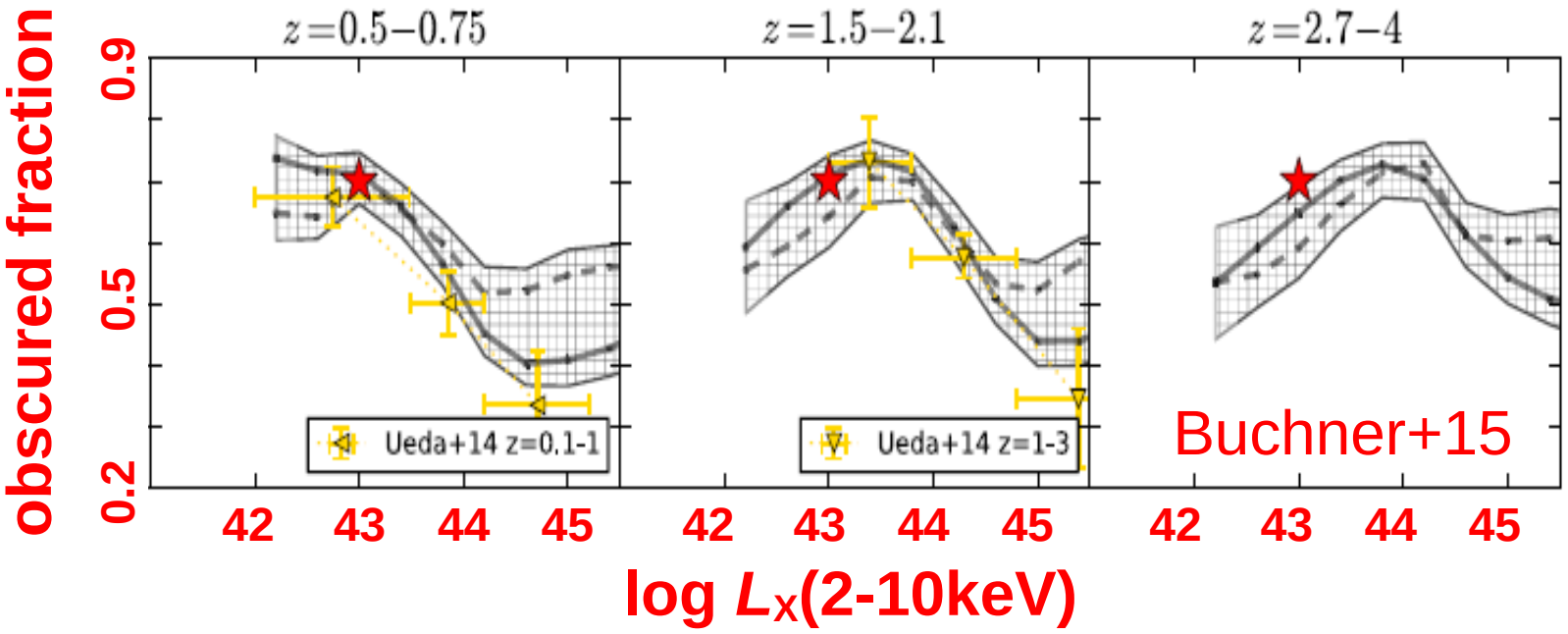
Obscured AGN fraction vs redshift

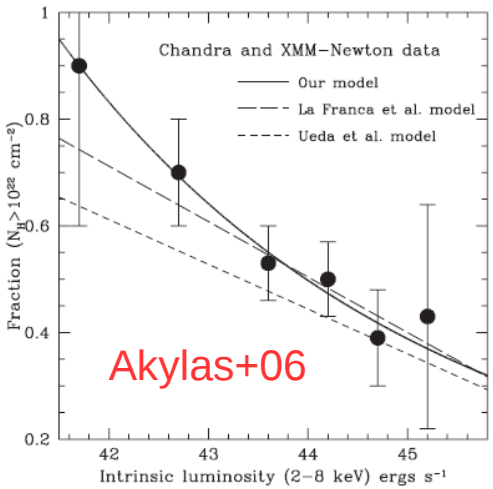




- Obscured AGN fraction increases with redshift
- Compton thick AGN fraction constant with redshift, global average ~35%.

Obscured AGN fraction vs luminosity

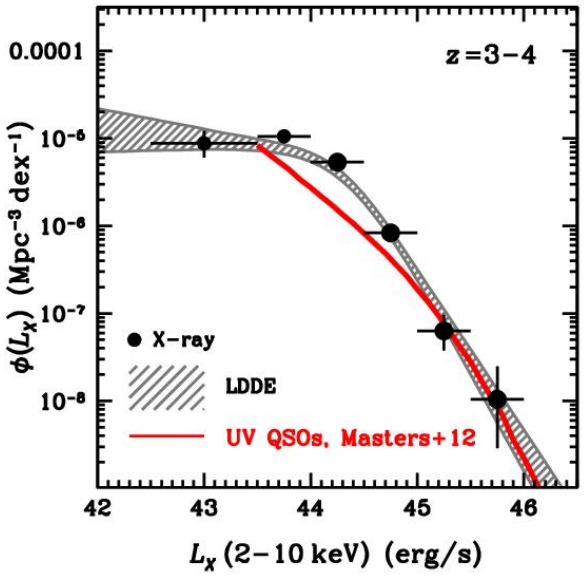


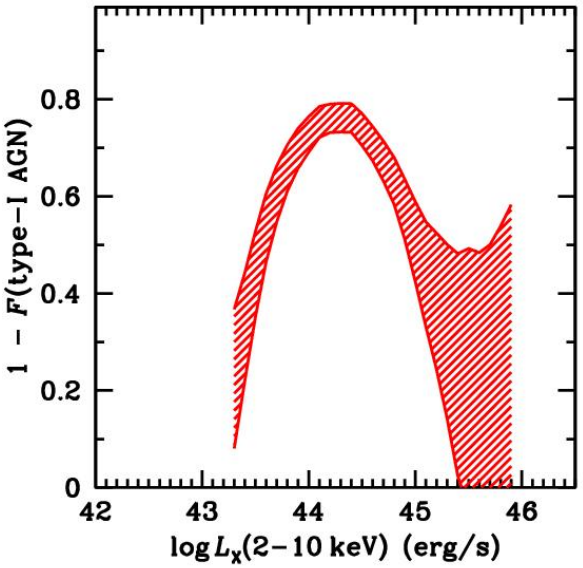


- Non-monotonic relation between obscured fraction and luminosity
- Contradicts previous studies (e.g. Ueda+03, Akylas+06)

Obscured AGN fraction vs luminosity

Georgakakis+15: combining X-ray with UV/optical LF





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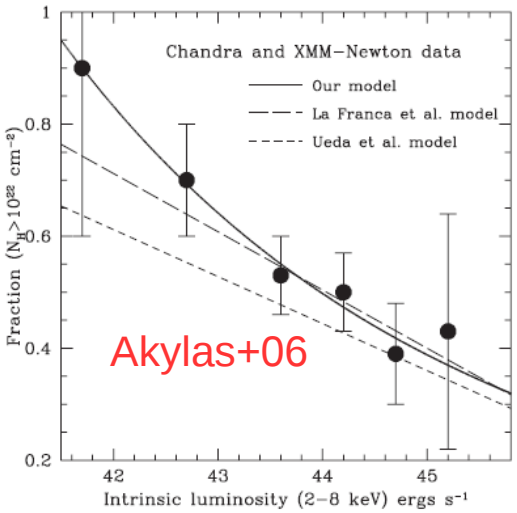
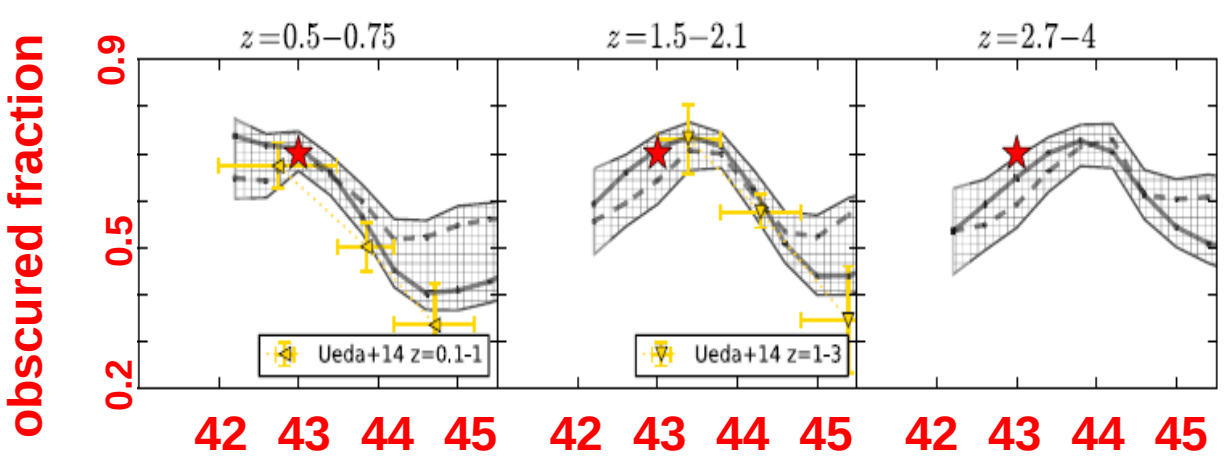
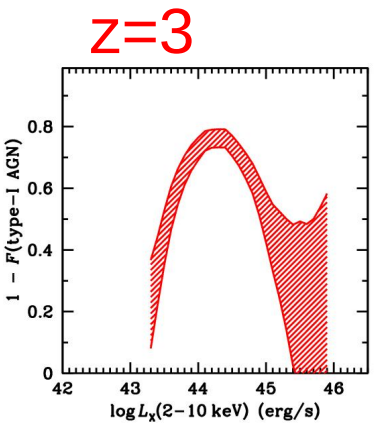


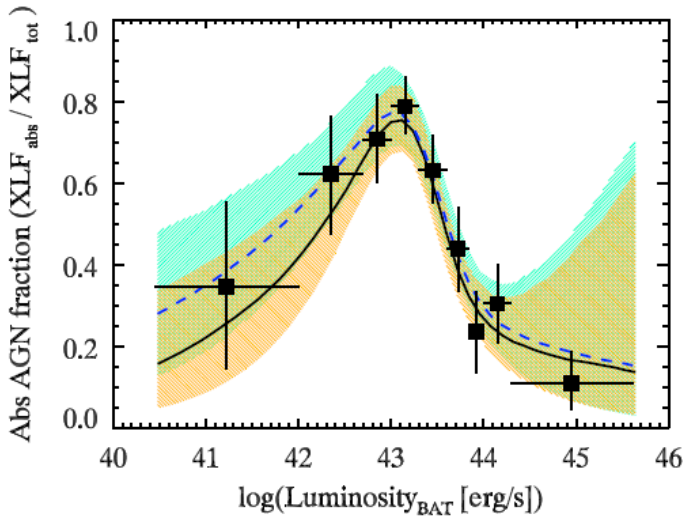
- XLF z>3: total of 340 X-ray sources (largest sample to date)
- Compare with UV QSO LF

Obscured AGN fraction vs luminosity





Local Universe: Burlon+11, Brightman+11

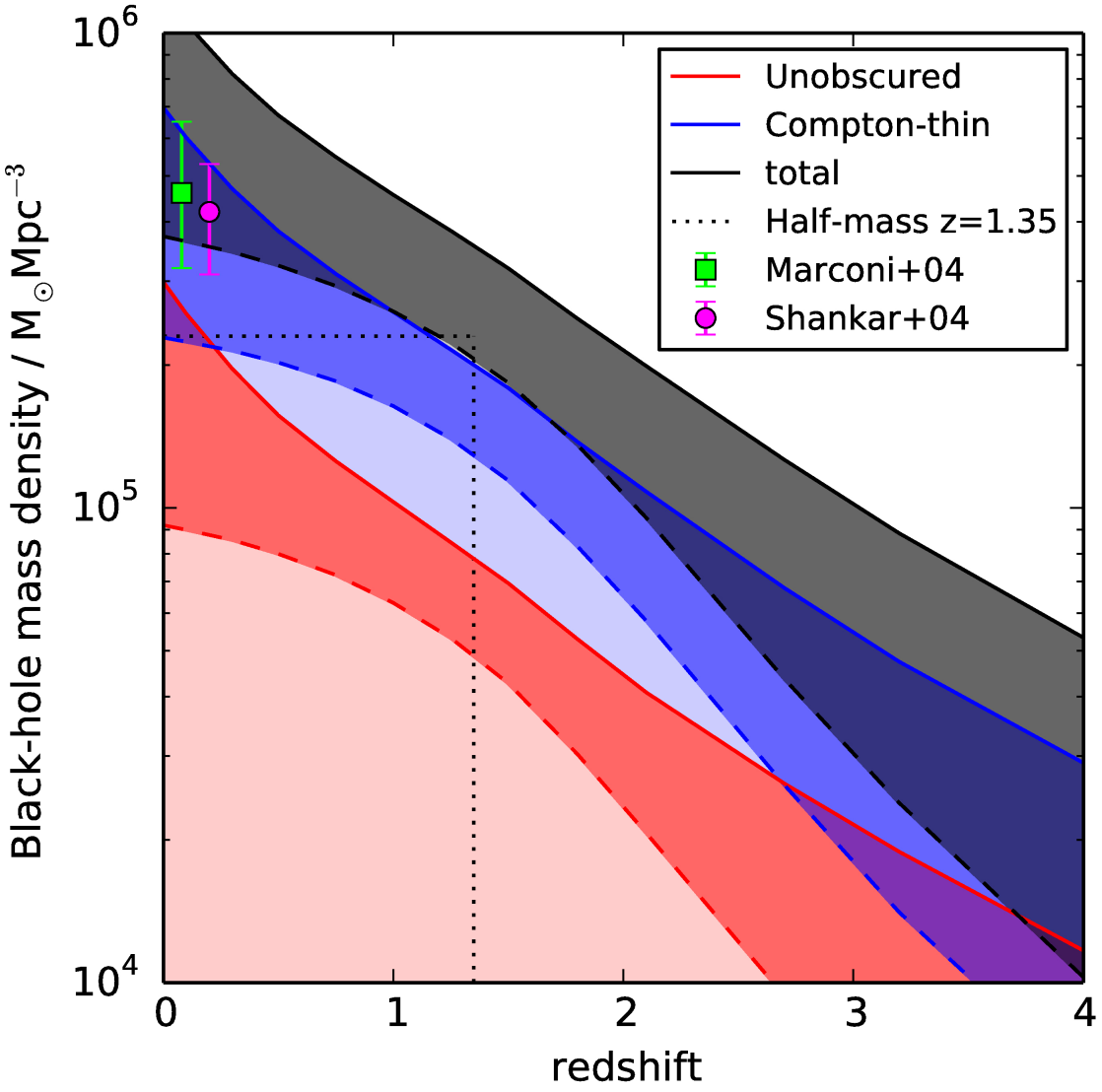


- ~~Receding torus~~
- Bright luminosities: regulation via AGN outflows
- Faint luminosities: disk wind cloud production model (Elitzur+08, also Laor+03).

Summary

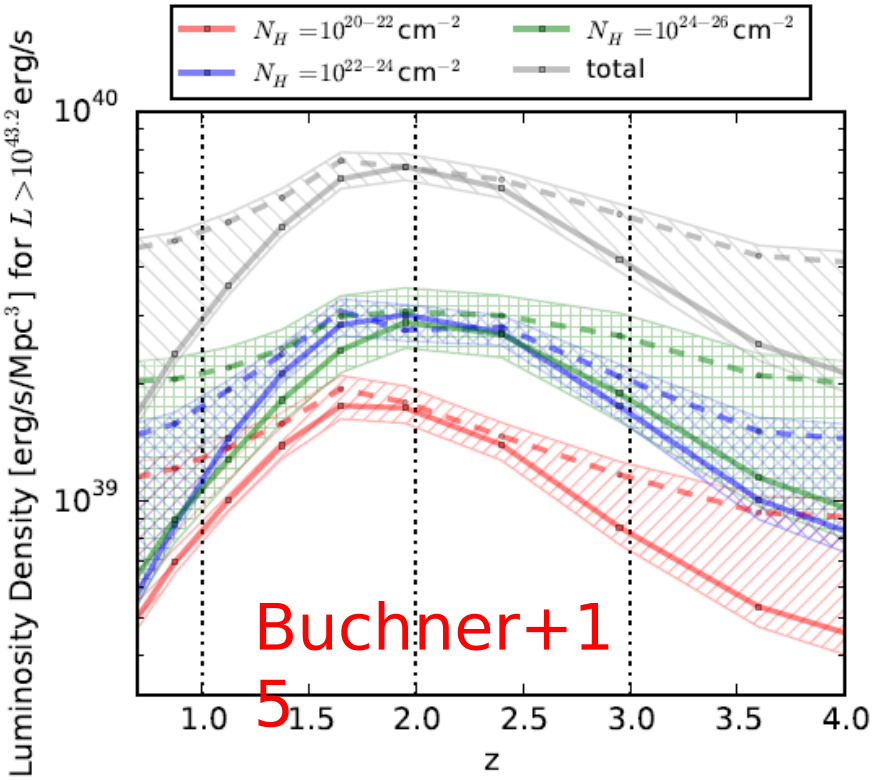
- Obscured AGN fraction increases with redshift, 70% at z~3.
- Compton thick AGN fraction is ~35% independent of redshift.
- Non-monotonic luminosity dependence of the obscured AGN fraction.

Black hole mass density vs redshift



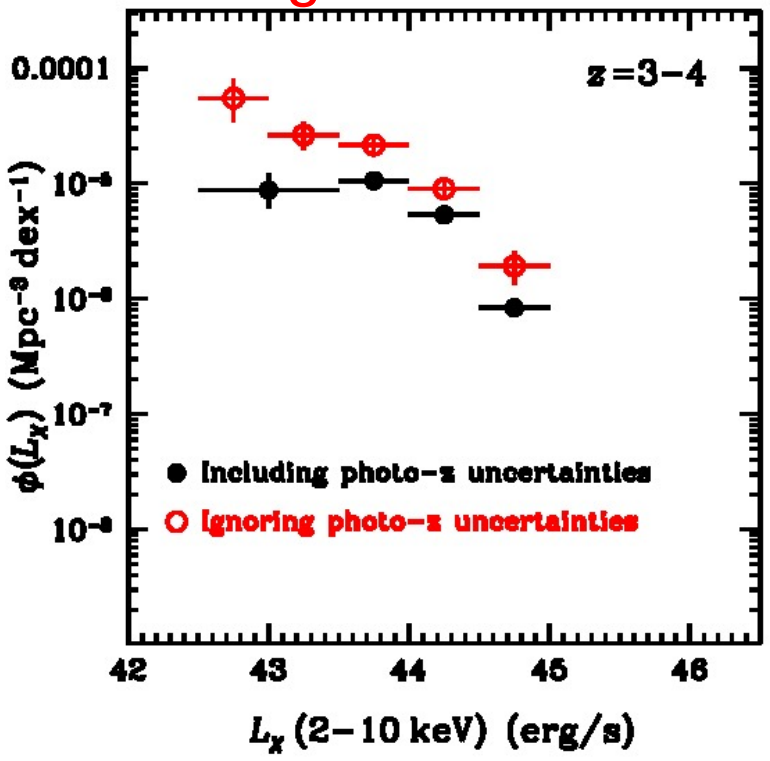
Buchner+15

X-ray luminosity density of the Universe



- Rapid decline since *z*~1
- Broad plateau at z~1-3
- Decline at z>3
- Obscured and Compton thick AGN dominate
- Obscured and Compton similar contribution

X-ray luminosity function: importance of error propagation

Ignoring uncertainties (e.g. photo-zs) leads to biases in XLF estimation

Georgakakis+15