

# The Compton-thick growth of Supermassive Black Holes constrained

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FONDECYT fellow

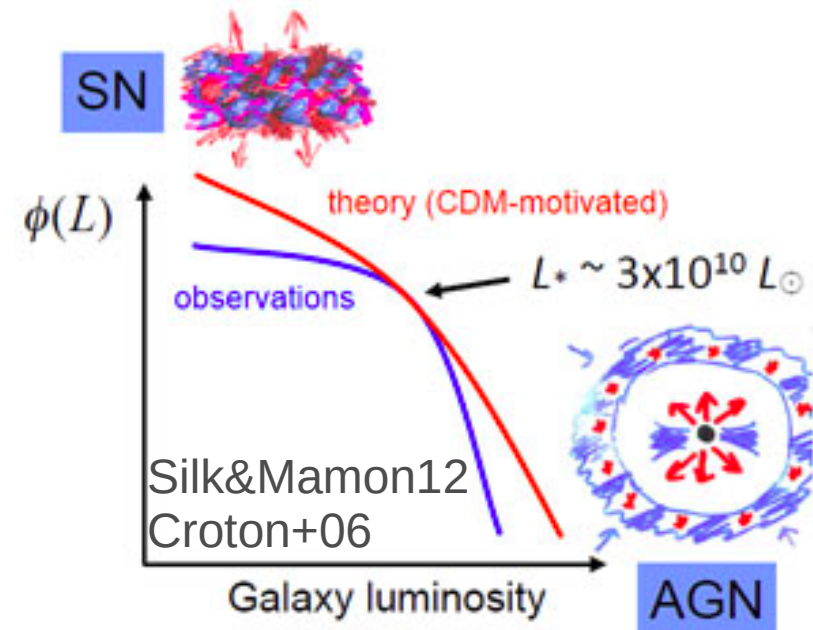
<http://astrost.at/istics/>



Collaborators: @PUC: Steve Schulze, Franz Bauer  
@MPE: A. Georgakakis, K. Nandra, M. Brightman, ML. Menzel,  
Z. Liu, L-T. Hsu, M. Salvato, C. Rangel, J. Aird, A. Merloni

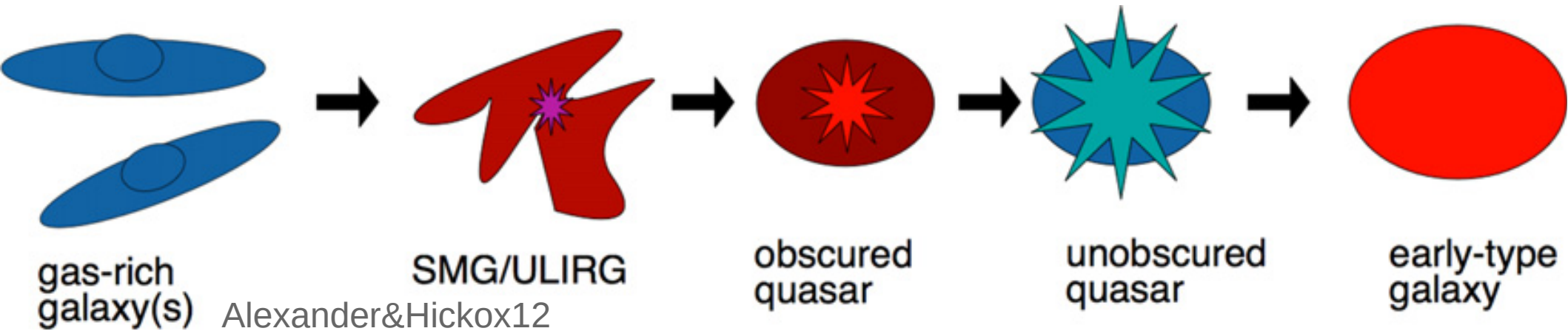
# SMBH growth

- Local Universe:  $10^{6-10} M_*$  black holes
  - How and when did they get there?
  - Interaction with hosts? As gal-form tool
- Growth mode: AGN
  - Inflow, self-heating radiates as AGN, proportional



# SMBH growth channels

- How to get 0.5% of bulge mass into  $<0.0001\%$  of the volume?
  - Angular momentum problem
  - One efficient way: major mergers
  - In any case:  
*matter feeding can be matter obscuring*



# Census of SMBH growth

Need census over cosmic time of AGN

unobscured

$$N_H = 10^{20-22}/\text{cm}^2$$

mildly obscured

$$N_H = 10^{22-24}/\text{cm}^2$$

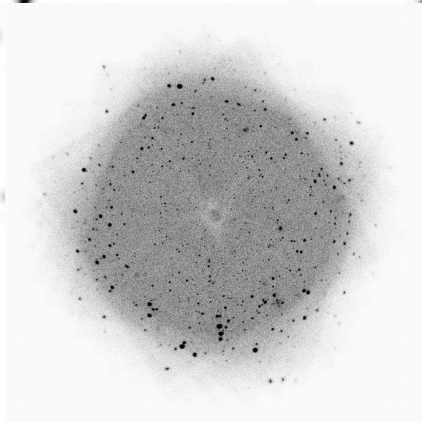
heavily obscured

$$N_H = 10^{24-26}/\text{cm}^2 \text{ (CTK)}$$

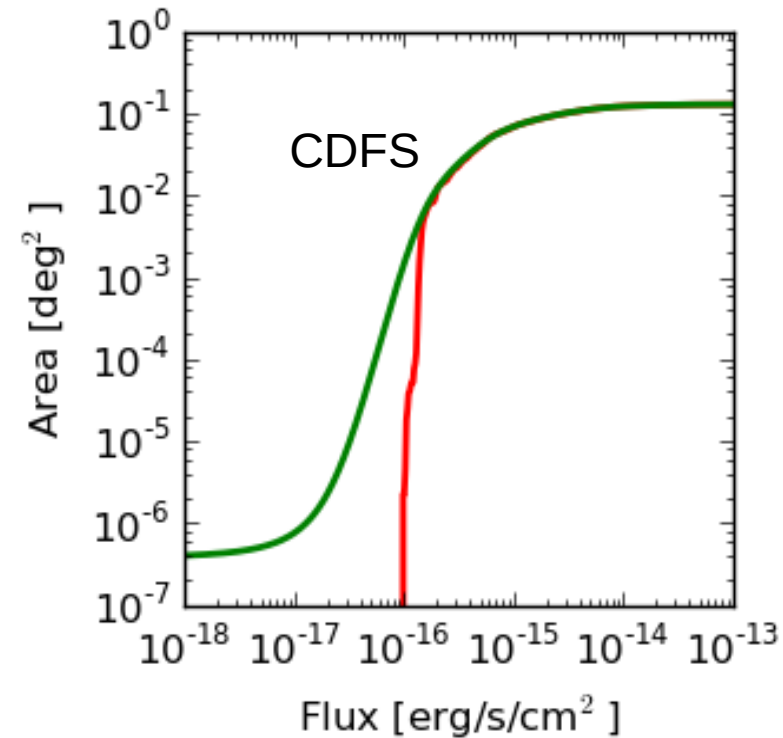
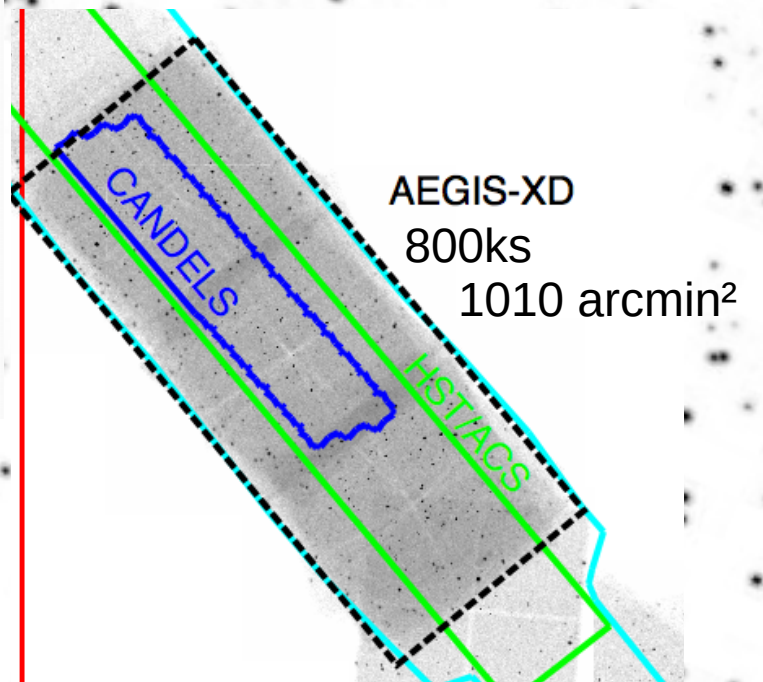
# X-ray Selection

- Why?
  - Fewer objects, longer exposures, but:
  - Selection function understood (photo-el. Abs.)
  - Little contamination from non-AGN

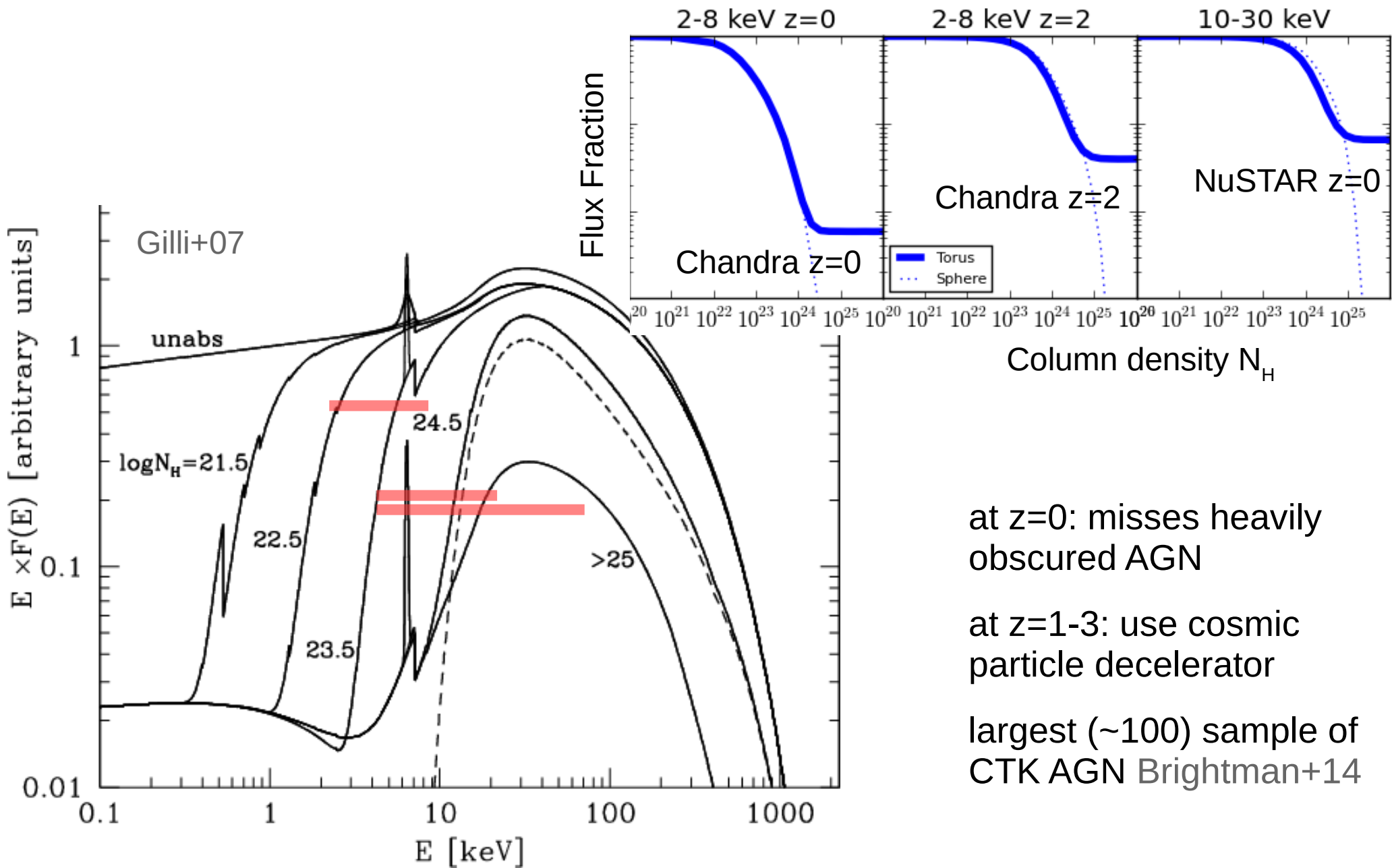
COSMOS  
160ks  
0.9deg<sup>2</sup>



CDFS  
4/7Ms  
464 arcmin<sup>2</sup>



# 2-10keV Selection



at  $z=0$ : misses heavily obscured AGN

at  $z=1-3$ : use cosmic particle decelerator

largest ( $\sim 100$ ) sample of CTK AGN Brightman+14

# Characterisation of AGN

- inflow rate  $\longleftrightarrow$  Accretion luminosity  
intrinsic (abs.-corr.)
- inflow obscuration  $\longleftrightarrow$  LOS column density
- inflow time  $\longleftrightarrow$  Redshift

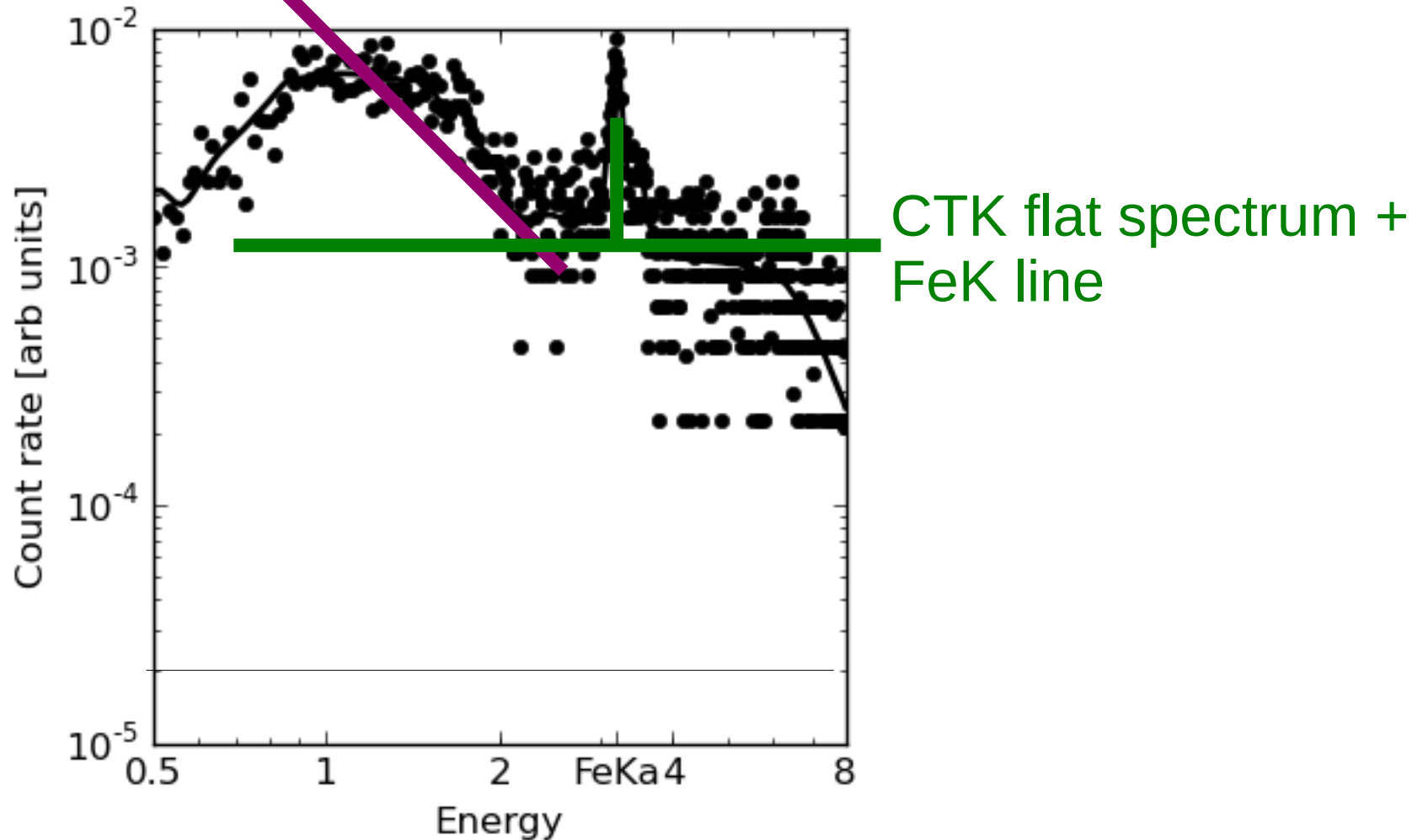
# Redshift

- Not possible from X-ray alone  
*see XZ: C. Simmonds*
- Association with multi- $\lambda$ : not trivial  
*see NWAY talk: M. Salvato*
- Redshift estimation
  - spec-z: expensive
  - photo-z: hard for AGN  $\rightarrow$  M. Salvato, LT. Hsu
- How much to trust & when not to trust a z
  - z with uncertainties, propagate
  - include sources w/o redshift *Aird+10*

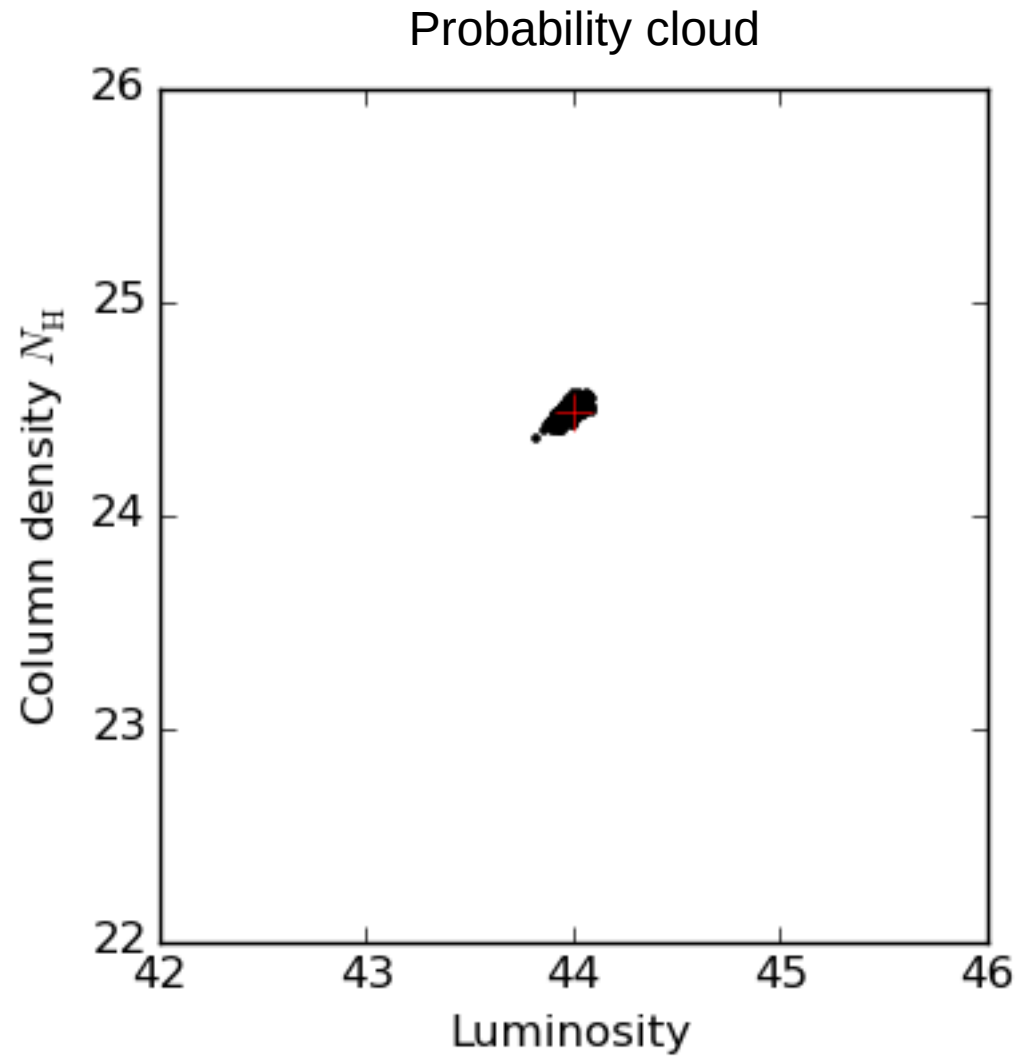
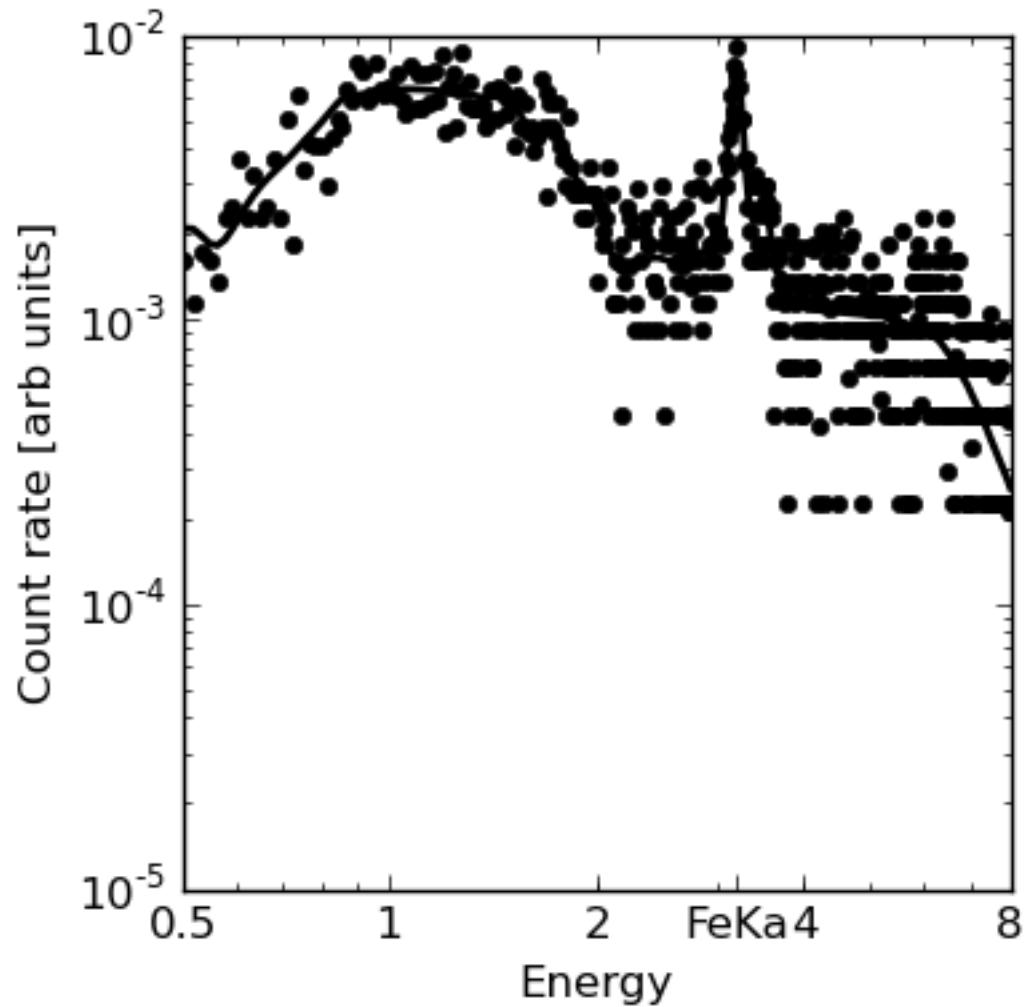


# L, $N_H$ from X-ray spectrum

Scattered Powerlaw component

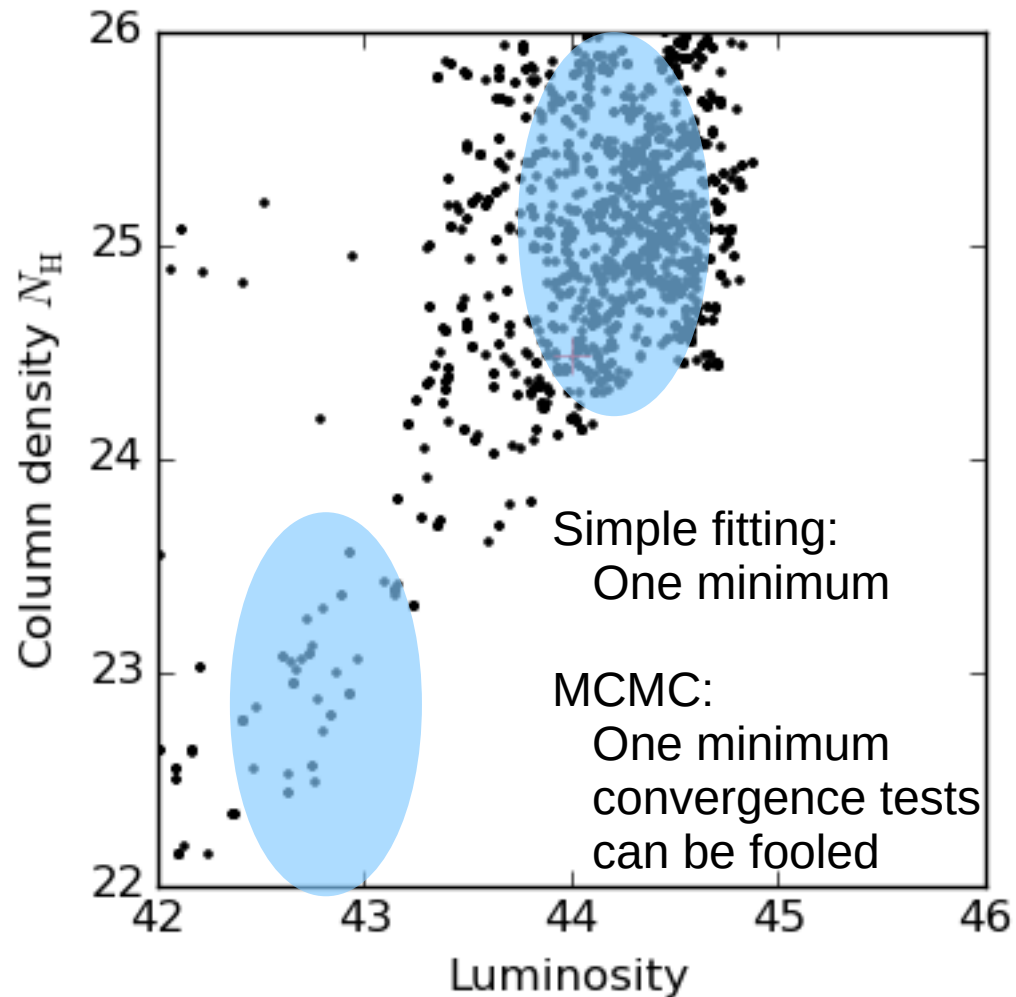


# L, $N_{\text{H}}$ from X-ray spectrum

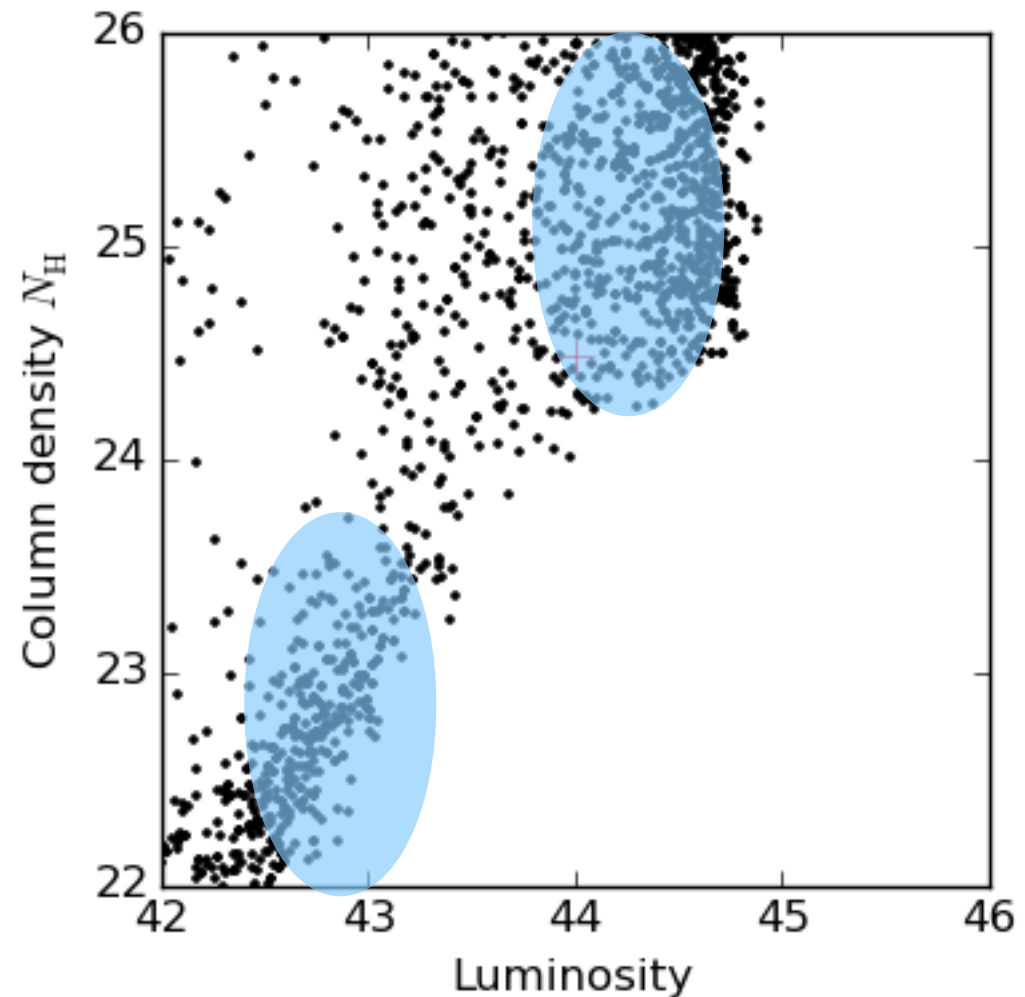


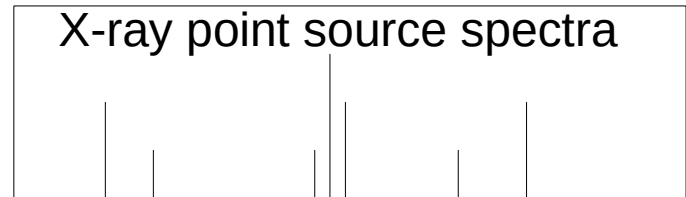
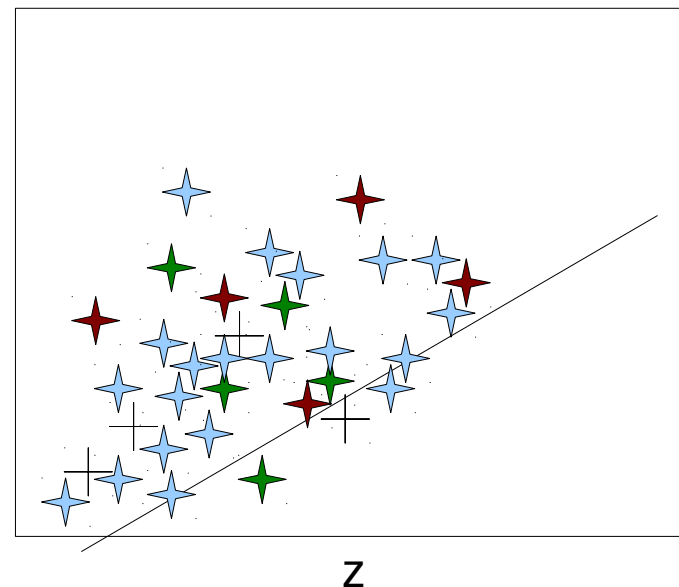
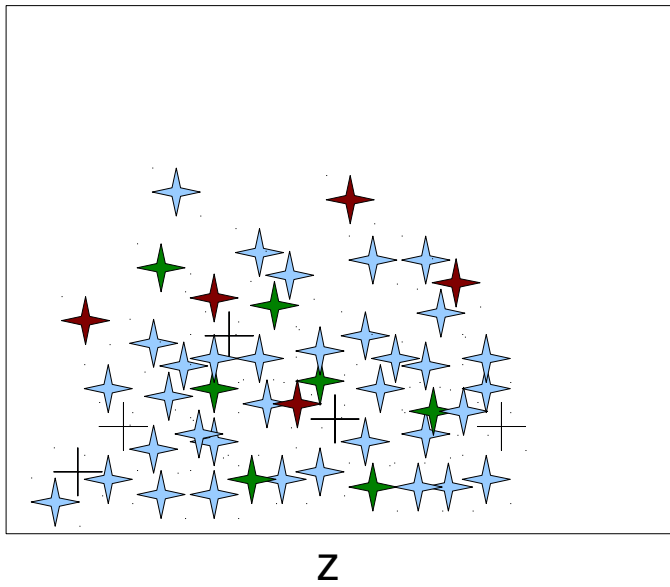
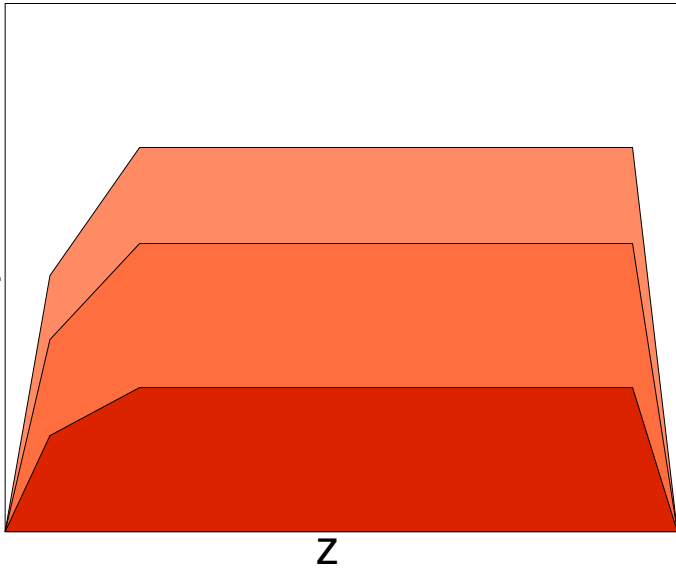
# L, $N_{\text{H}}$ from X-ray spectrum

MCMC (emcee/GW)

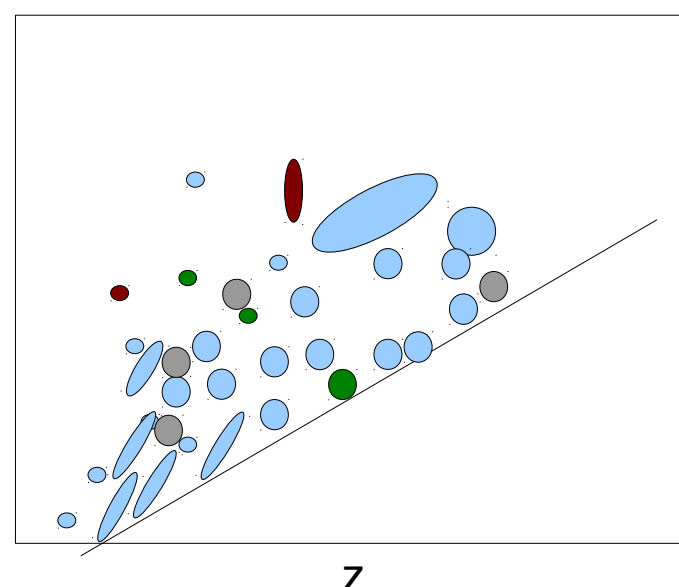
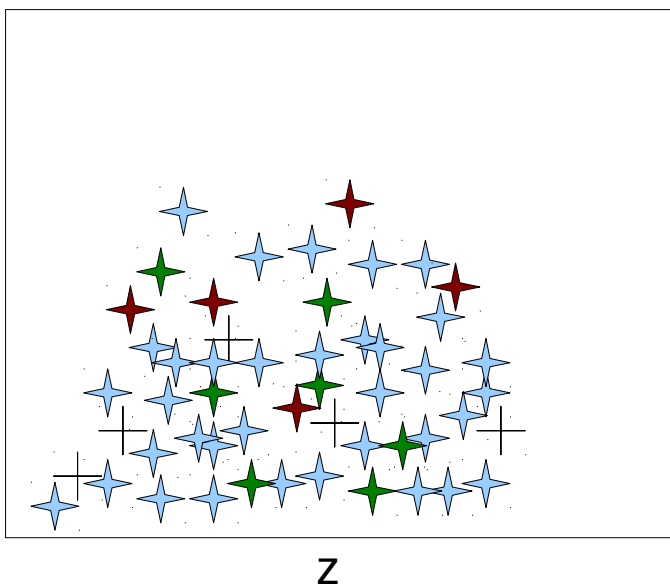
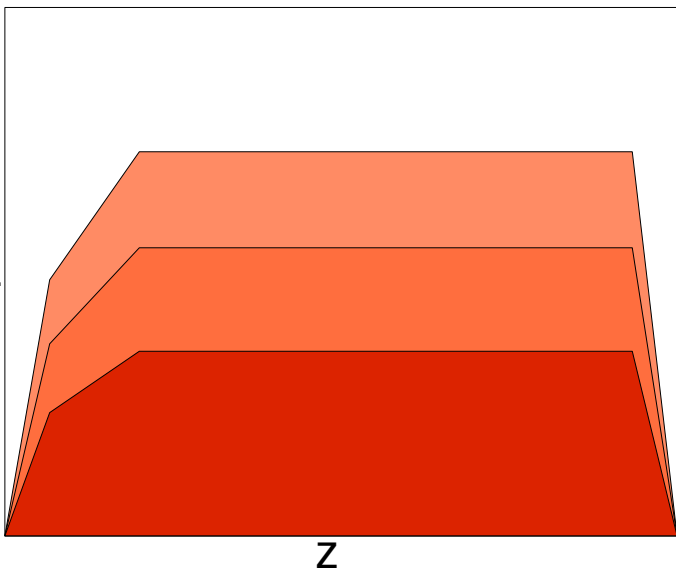


Nested Sampling (BXA/Multinest)





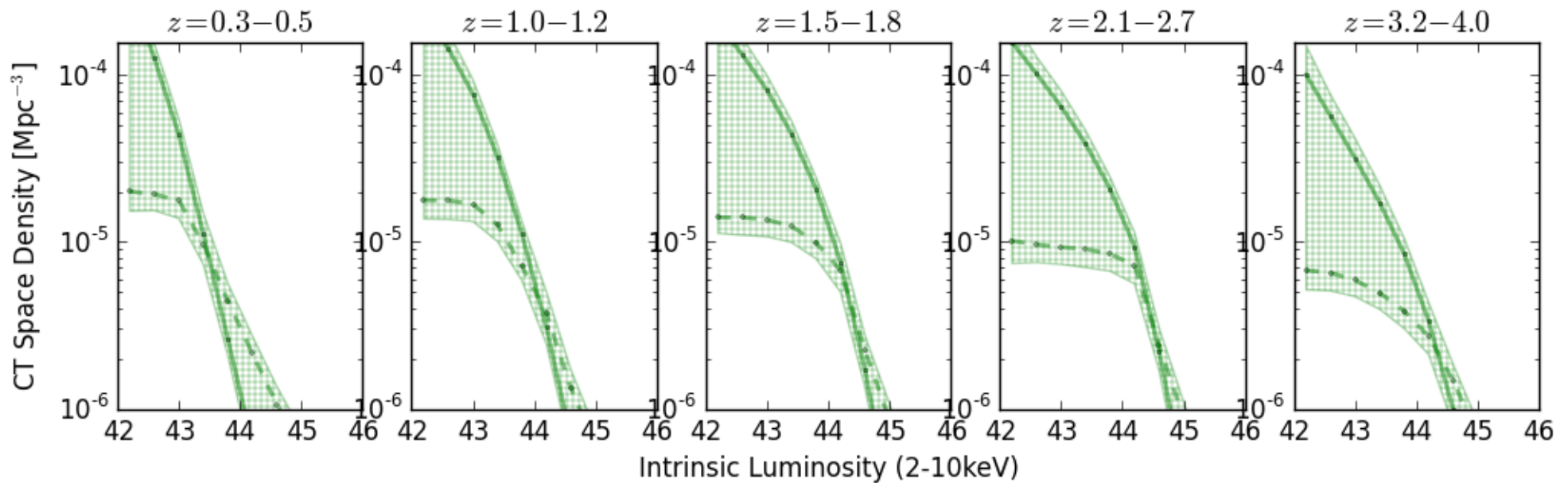
# Population inference



# Assumptions on LF shape

- Density  $\varphi(L_X, z, N_H)$
- Shift in field to verify if
  - assumed double-PL evolution is simple
  - or complex (LDDE)
- Miyaji+15      split sample, check LF in bins
- Aird+10,+15    bending PL of obsc, unobsc evolution via polynomials
- Buchner+15    smooth fields  
fewest assumptions, large uncertainties

# Compton-thick Luminosity Function



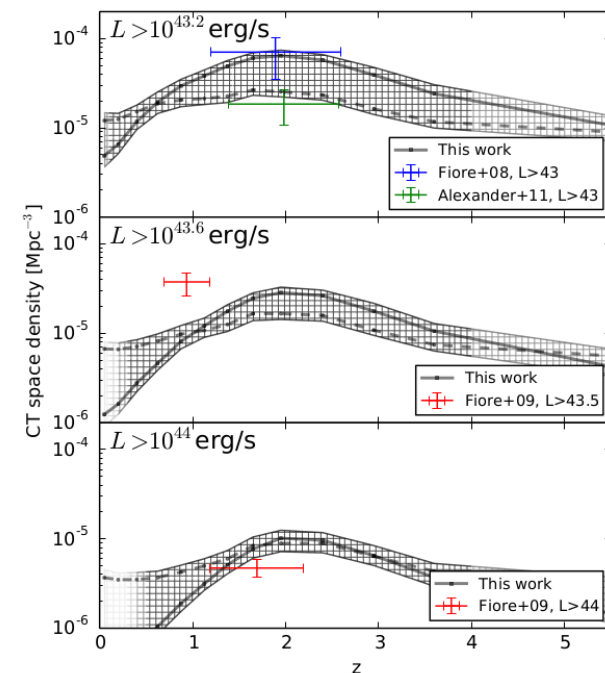
- Reconstruction of a smooth field

- Results insensitive to chosen smoothing length

0.5 mag between bins

- Consistent Cthin total LF with Ueda+14, Aird+10

Buchner+15



# Obscured fractions

Total number density

Buchner+15

- Obscured fraction:  $77^{+4}_{-5}\%$
- Compton-thick fraction:  $38^{+8}_{-7}\%$

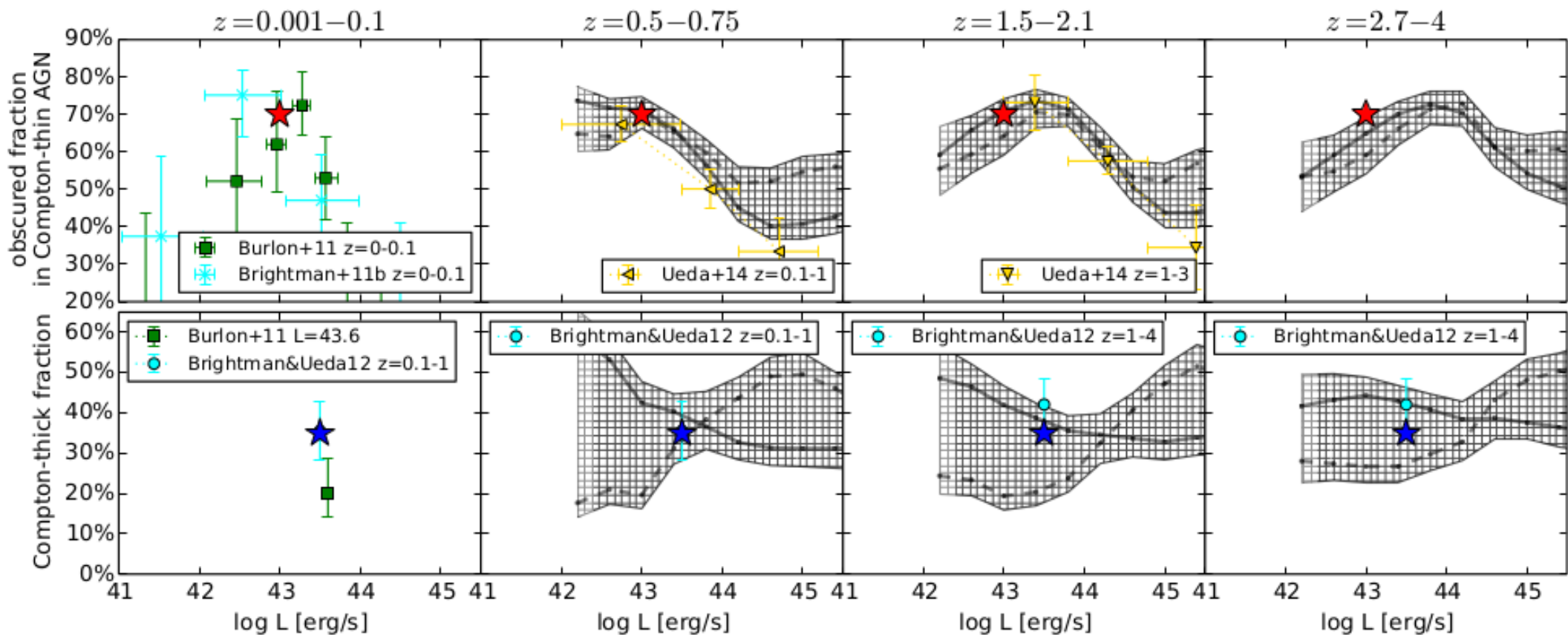
Ricci+16: Swift/BAT

Annular in prep: NuSTAR  $z=0$

Wilkes+13: Radio,  $z\sim 2$  CTK fraction  $< 40\%$

see talk Mateos+17 for upper limit  $z<1$

# Obscuration–Luminosity evolves



Buchner+15

Consensus in works correcting for selection biases:

CTK L-dep in  
local Universe:  
Ricci+16

**Evolution is**



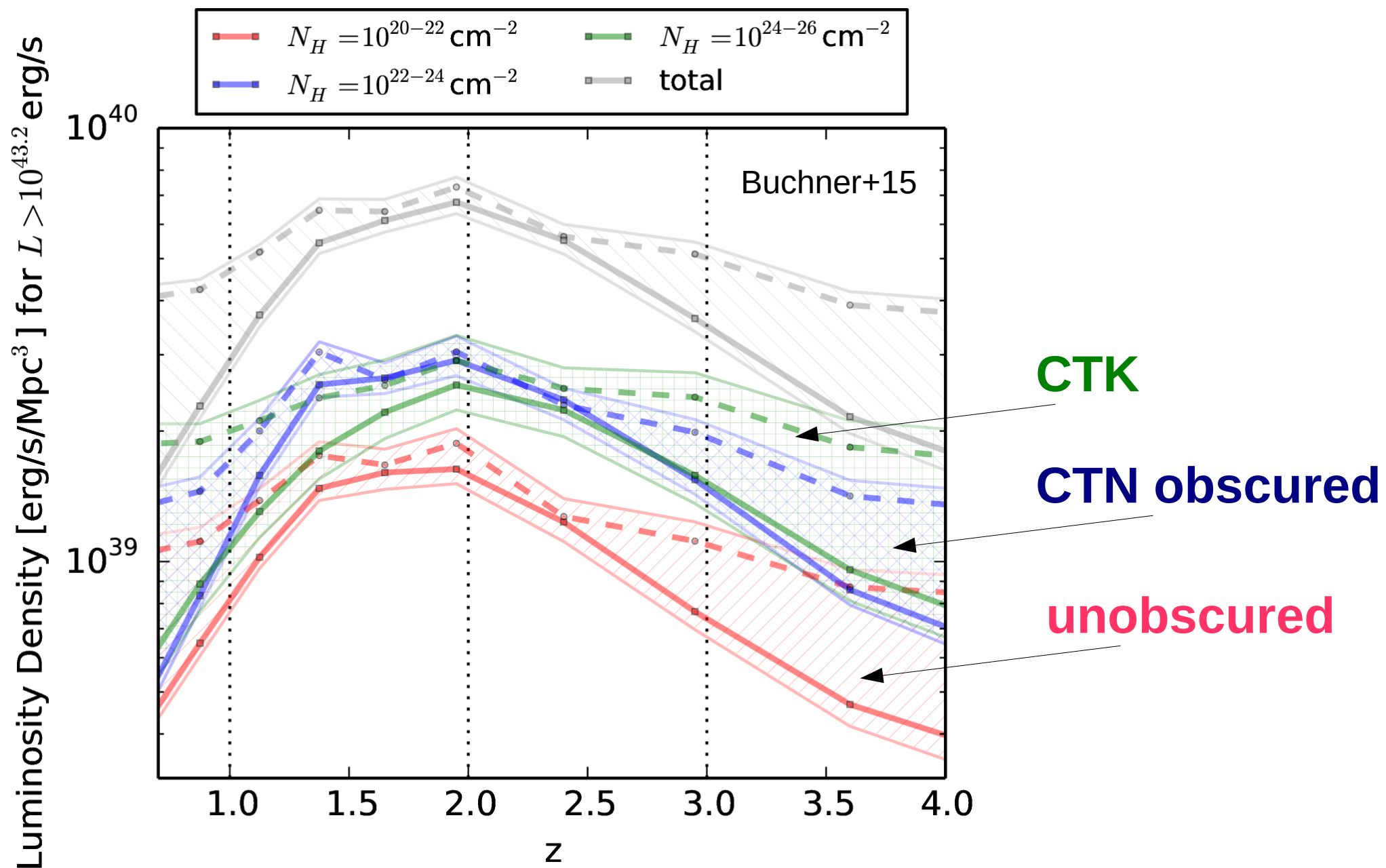
not



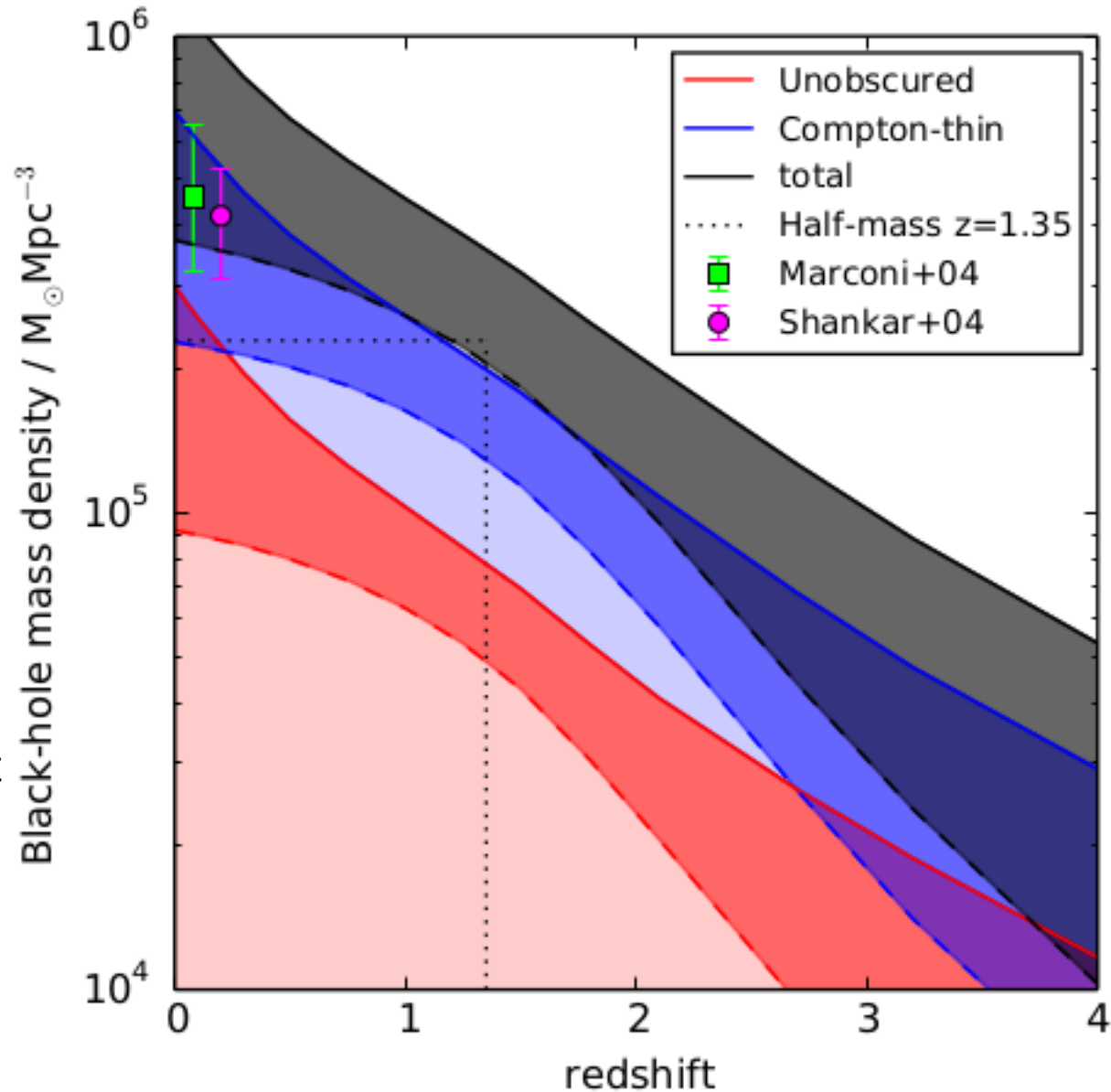
Obscurer is  
not only L-dep  
Edd-rate-dep?  
see Buchner+17b



# Total luminosity emitted



# Black Hole Mass Accretion



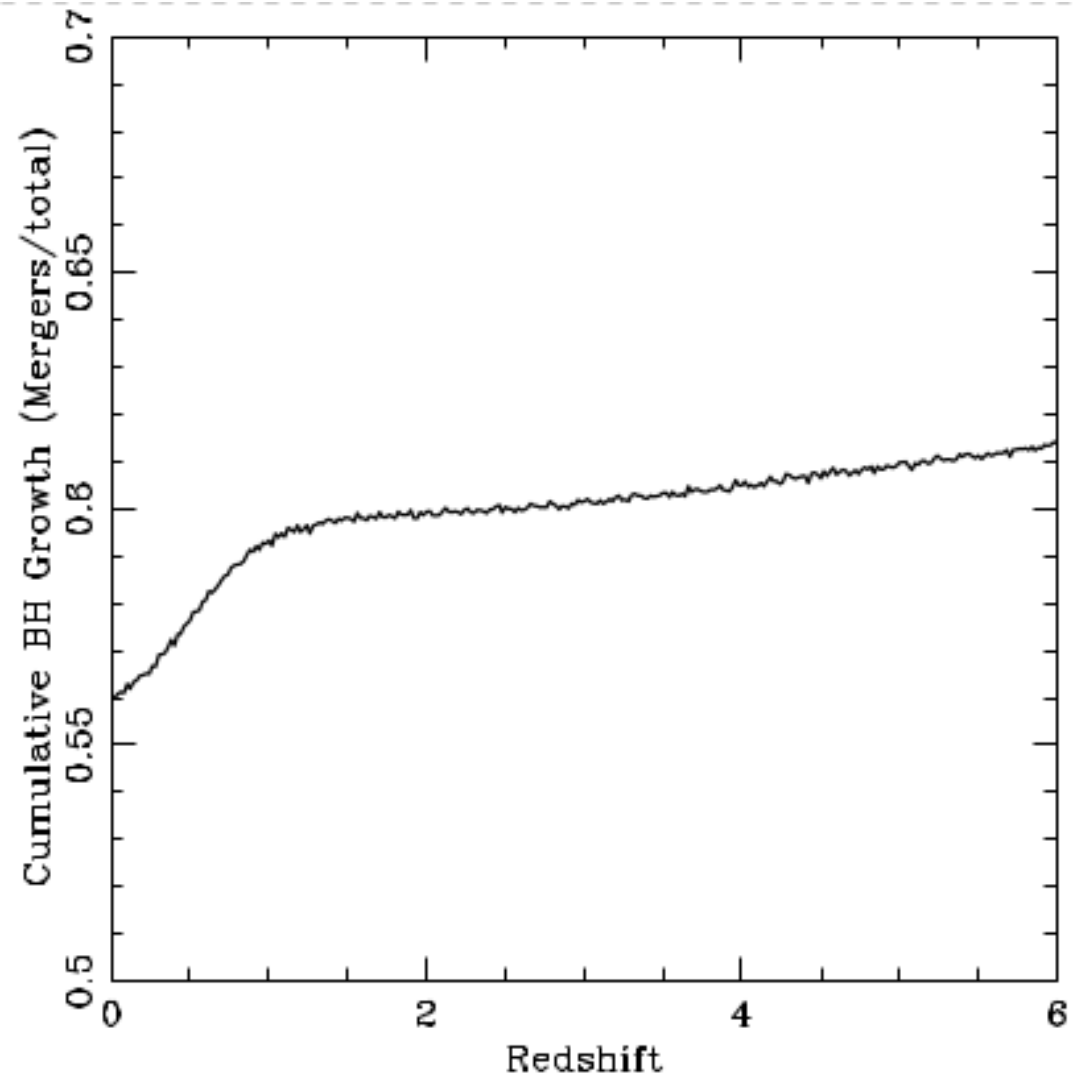
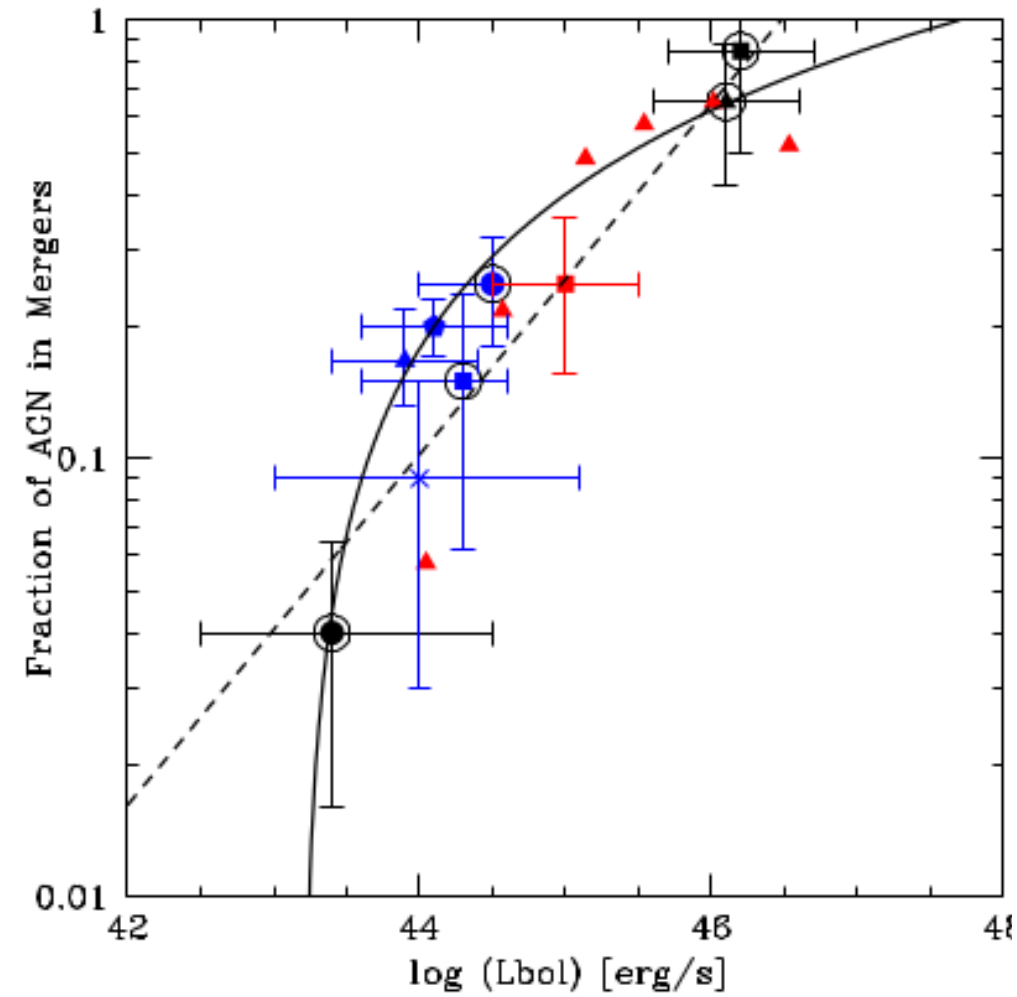
$\epsilon=10\%$

Bol. Corr.:  
Marconi+04  
not Hopkins+07

Convert to mass  
flowing into BH  
Accretion consistent  
with local BHMD

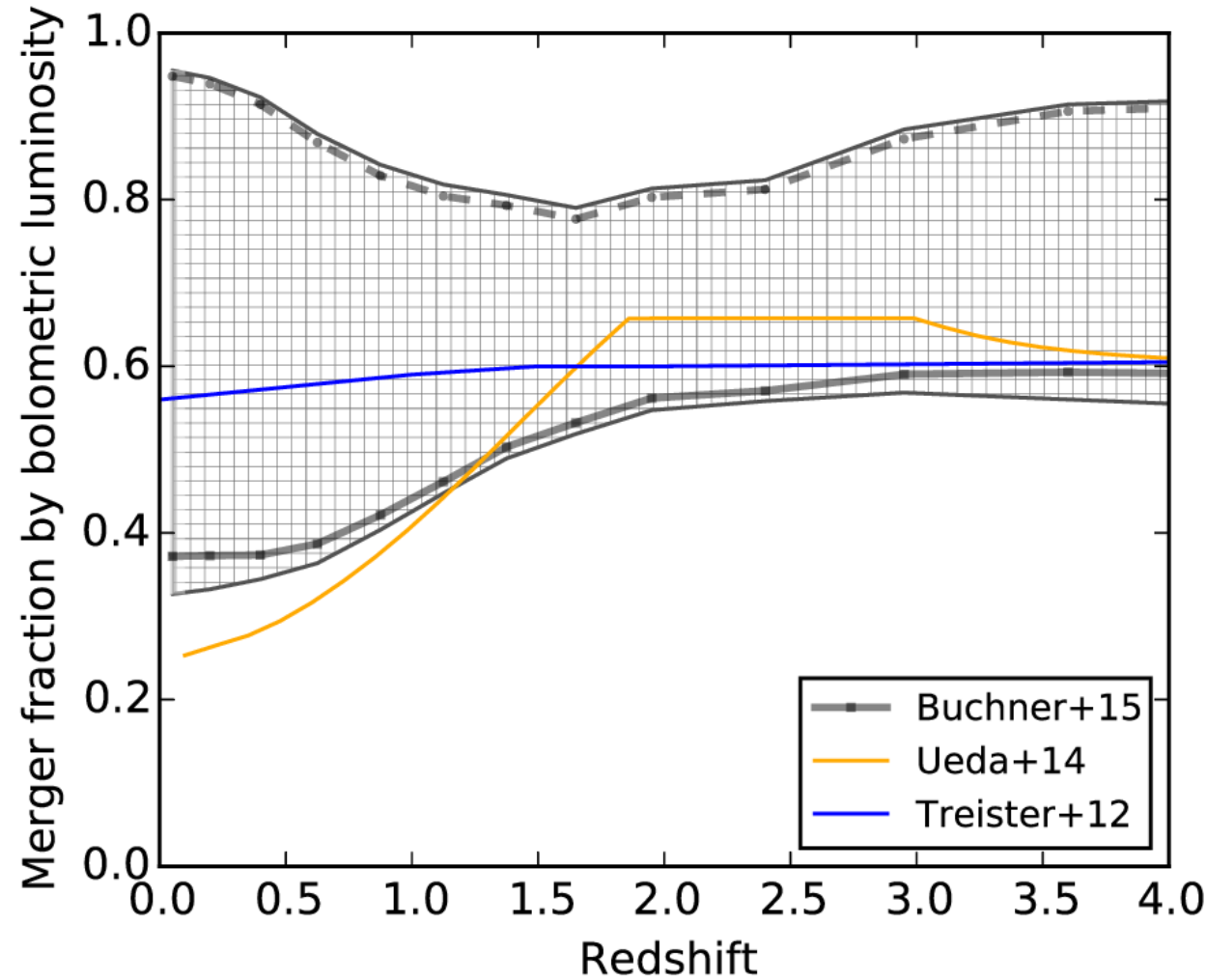
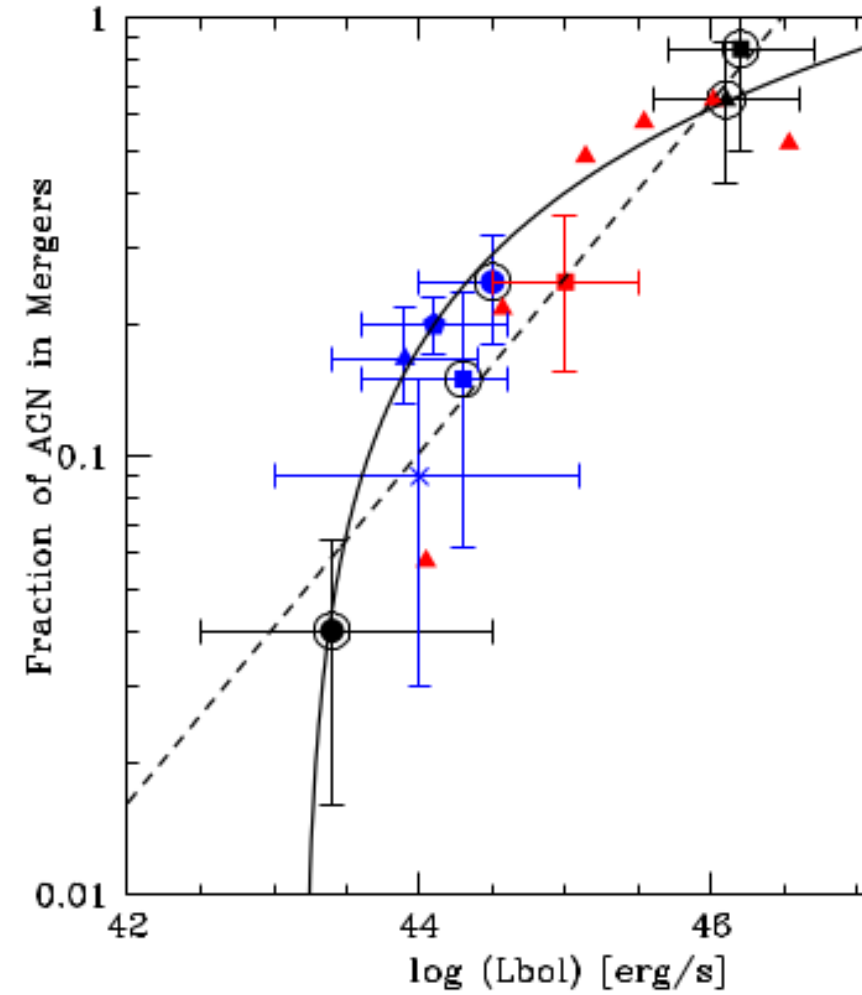
in prep., see  
also  
Merloni15

# Mergers



Treister+12

# Mergers



Treister+12

# Summary

- CTK ~ 1/3 (in number and accretion)
- Obscured ~ 3/4 (in number and accretion)
- Mergers are majority growth mode
- Beware of pitfalls of simple methods

# Summary

- CTK  $\sim 1/3$  (in number and accretion)
- Obscured  $\sim 3/4$  (in number and accretion)
- Mergers are majority growth mode
  
- Beware of pitfalls of simple methods
  
- Impact of galaxy-scale gas on obscuration?
  - Poster, Buchner+17a,b
- Poster: New CLUMPY X-ray spectral model