The evolution of obscured accretion

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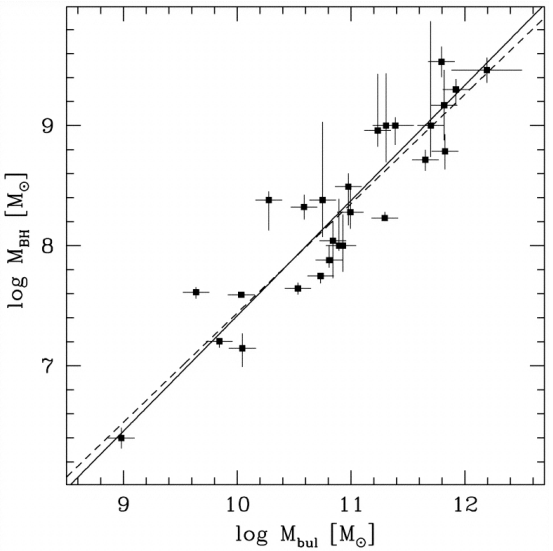
+ COSMOS and CDFS teams

Outline

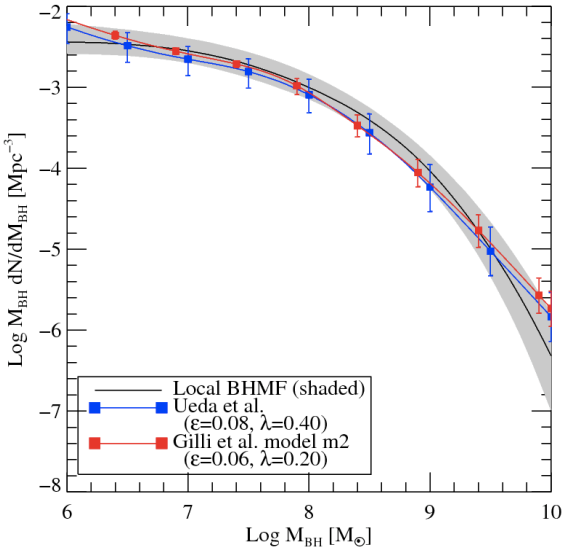
- the BH-galaxy coevolution scenario
- cosmic history of obscured accretion:
  models vs observations
- elusive heavily obscured AGN:
  selection and number density
- propects for future surveys

AGN is a key phase of a galaxy lifetime

Scaling relations between BH mass and host galaxy properties (stellar bulge mass, luminosity, velocity dispersion)



Super Massive Black Holes in the local galaxies mainly grow through active accretion phases



AGN and galaxies closely tied
➔ co-evolution

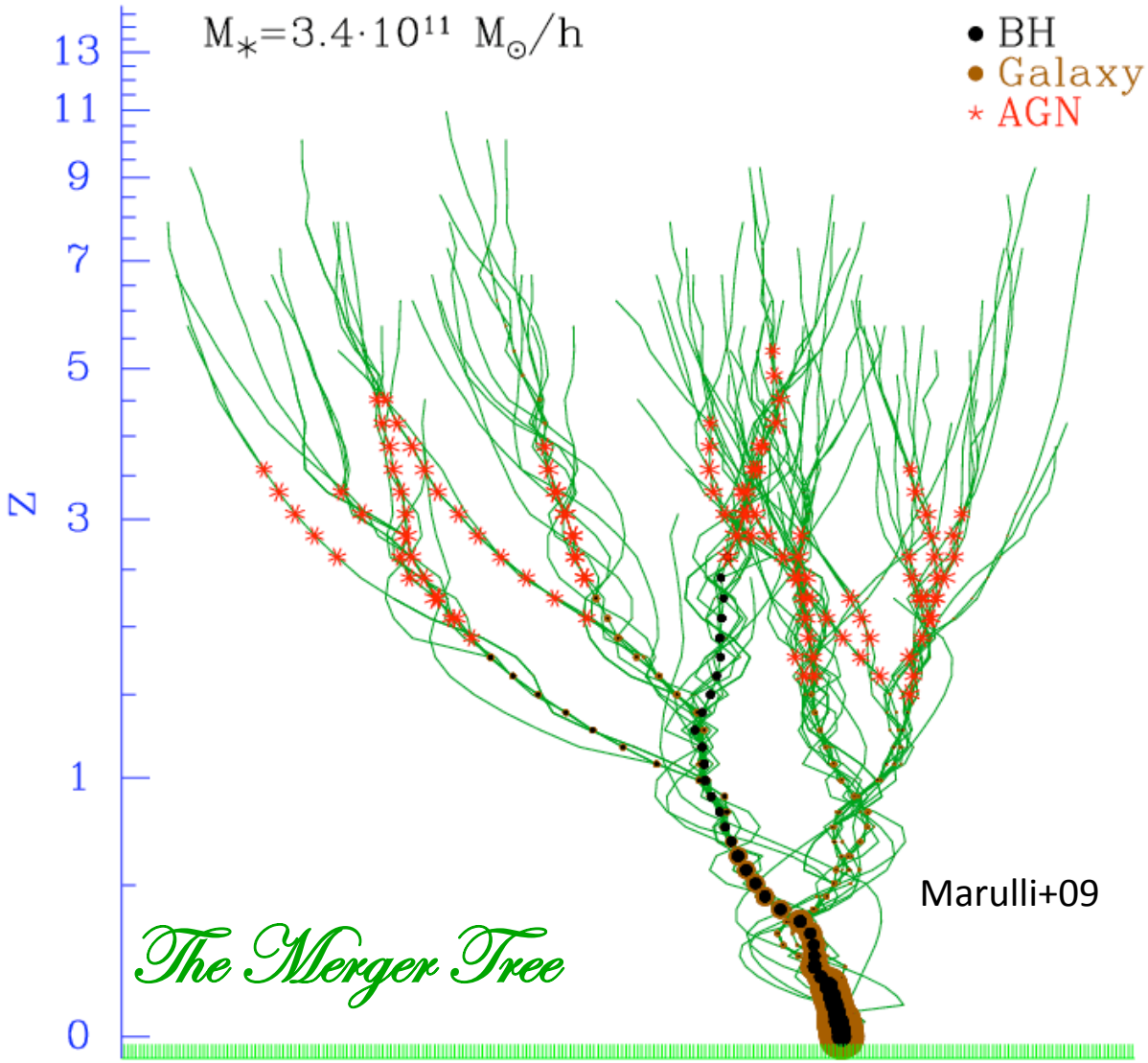
Semi analytic models of BH/galaxy co-evolution

e.g: Kauffmann+98, Volonteri+06, Salvaterra+06, Rhook&Haehnelt08, Hopkins+08, Menci+08, Marulli+09

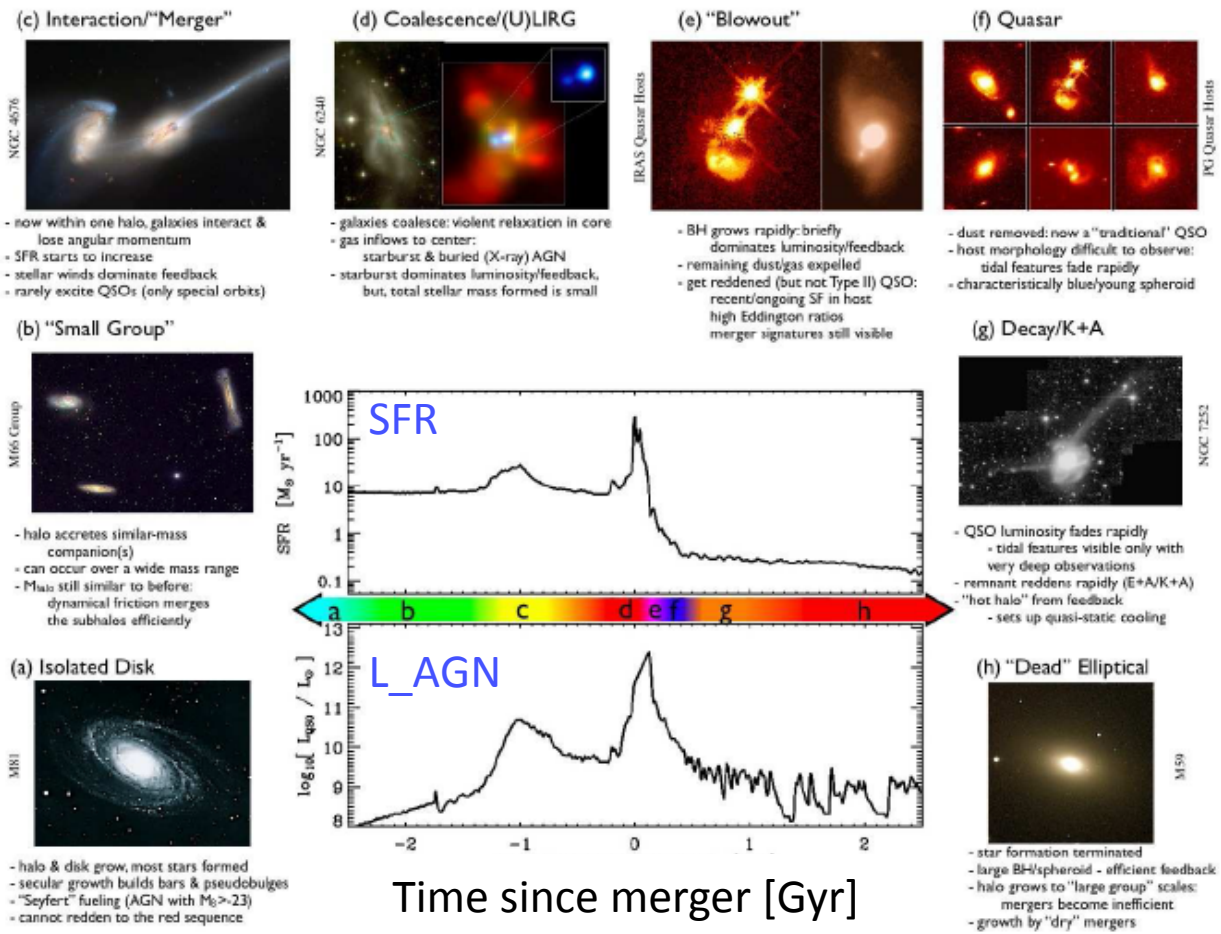
These follow the evolution and merging of Dark Matter Halos with cosmic time and use analytic recipes to treat baryon physics.

Ansatz:

nuclear trigger at merging



The BH/galaxy evolutionary sequence



Hopkins+08

mergers

⬇

SF/ obscured accretion

⬇

"clean" accretion (QSO)

⬇

transition (green valley) object

⬇

passive red galaxy

Can explain many observables:

* local BH/galaxy scaling rel.
* local BH mass function
* QSO luminosity function
* QSO clustering
* host galaxy colors

Evolution of obscuration

An obscured accretion phase is expected to preceed a clean accretion phase, at least in bright QSOs / massive objects:

Do we expect that the fraction of obscured AGN (f_{abs}) was higher in the past?

This depends on many things, e.g.:
physical scale of the absorbing gas and how this is driven towards the BH
timescales of the abs/unabs phases
abs-to-unabs transition true also in low-mass/low-lum. objects (Seyferts)?

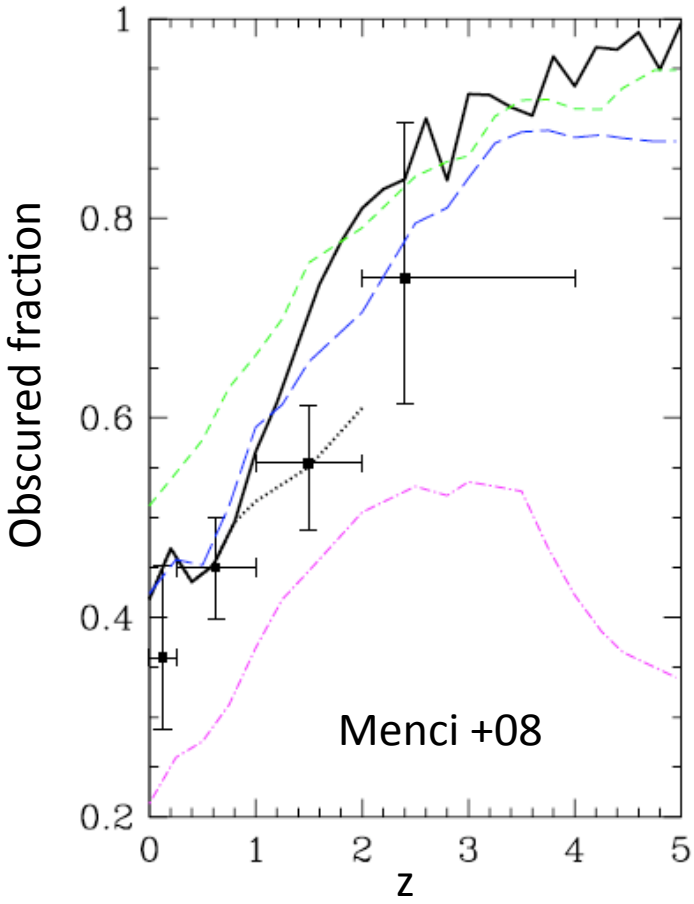
What are the model predictions (e.g. for X-ray surveys)?

And what is the observed trend?

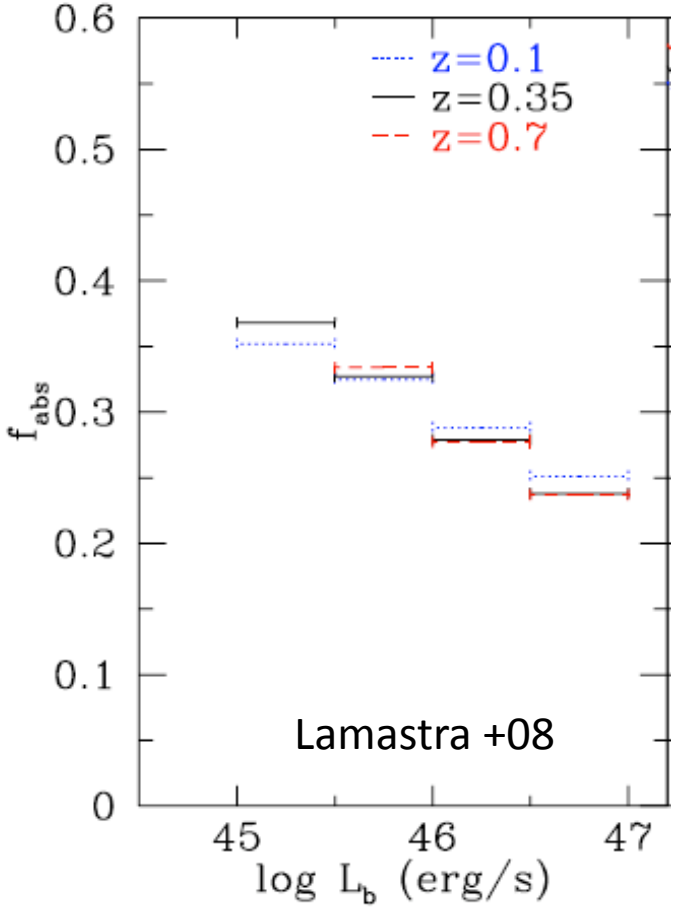
Evolution of f_{abs} with redshift: model predictions

Not many predictions..

Increase with z found by some models



not found by others

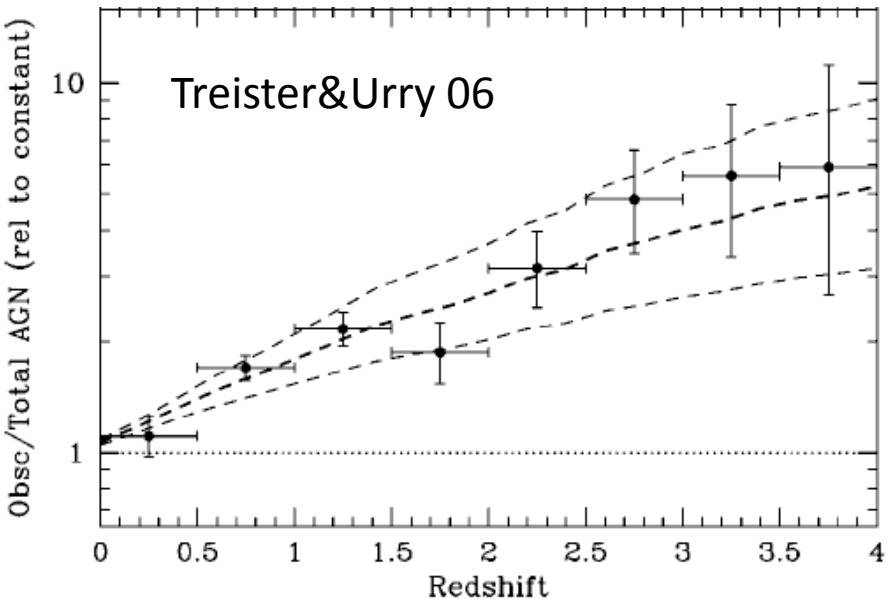


Blast wave: $t_{abs} \approx L$ and M_{gas}

$L/L_{EDD} \approx z$ and M_{BH} ; $f_{abs} \approx M_{BH}$

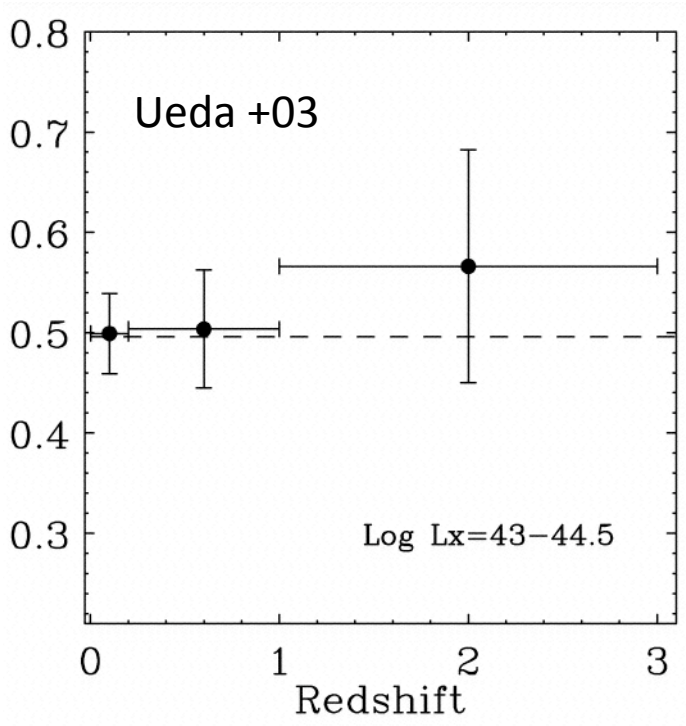
Evolution of f_{abs} with redshift: observations

Increase with z found in some data



see also La Franca +05, Hasinger08, Trump+08

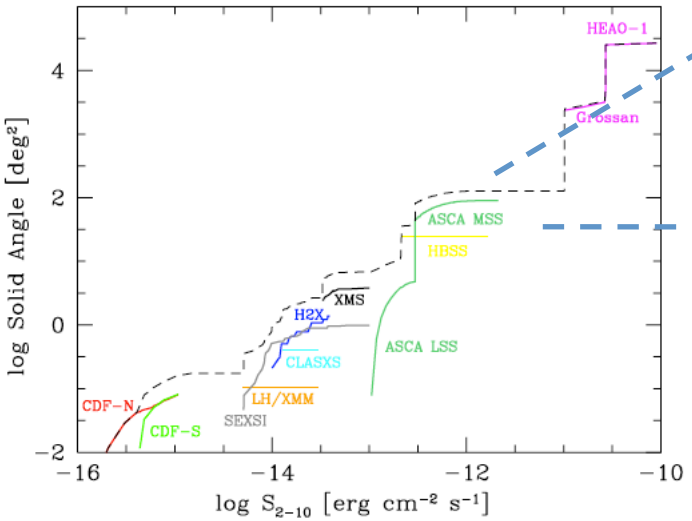
not found in others

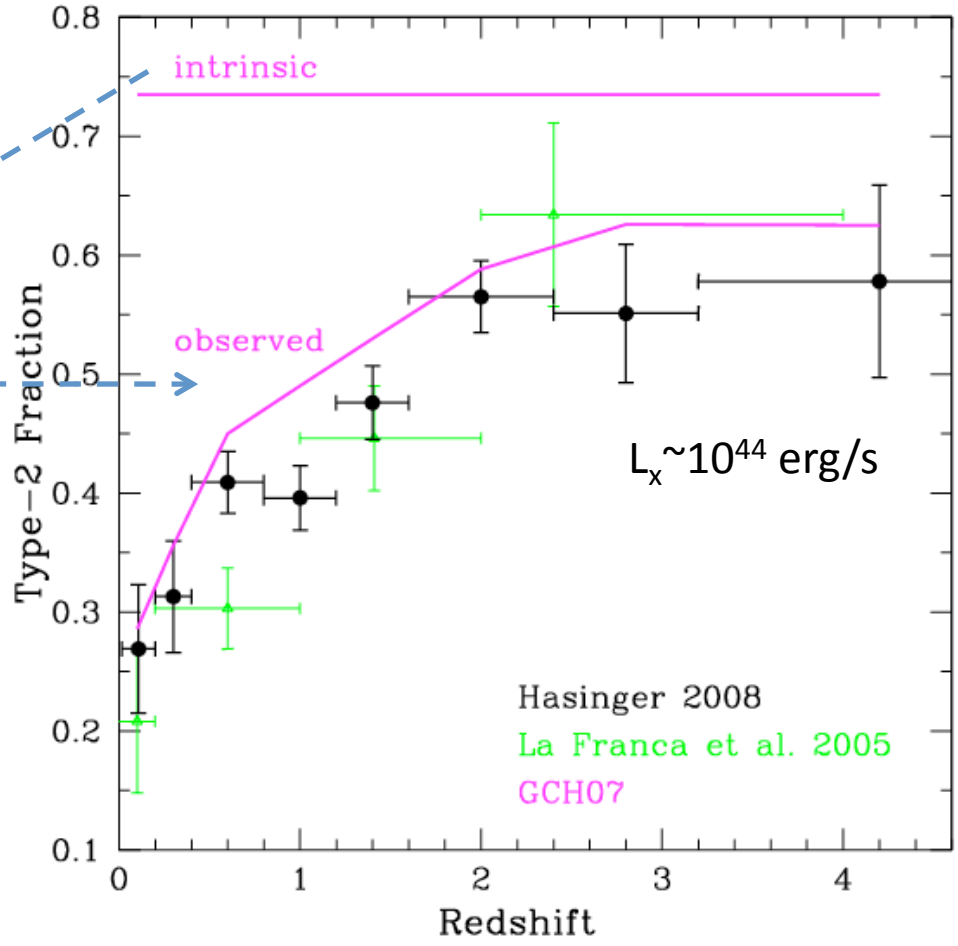


see also Dwelly&Page06, GCH07

Fraction of obscured AGN: selection effects

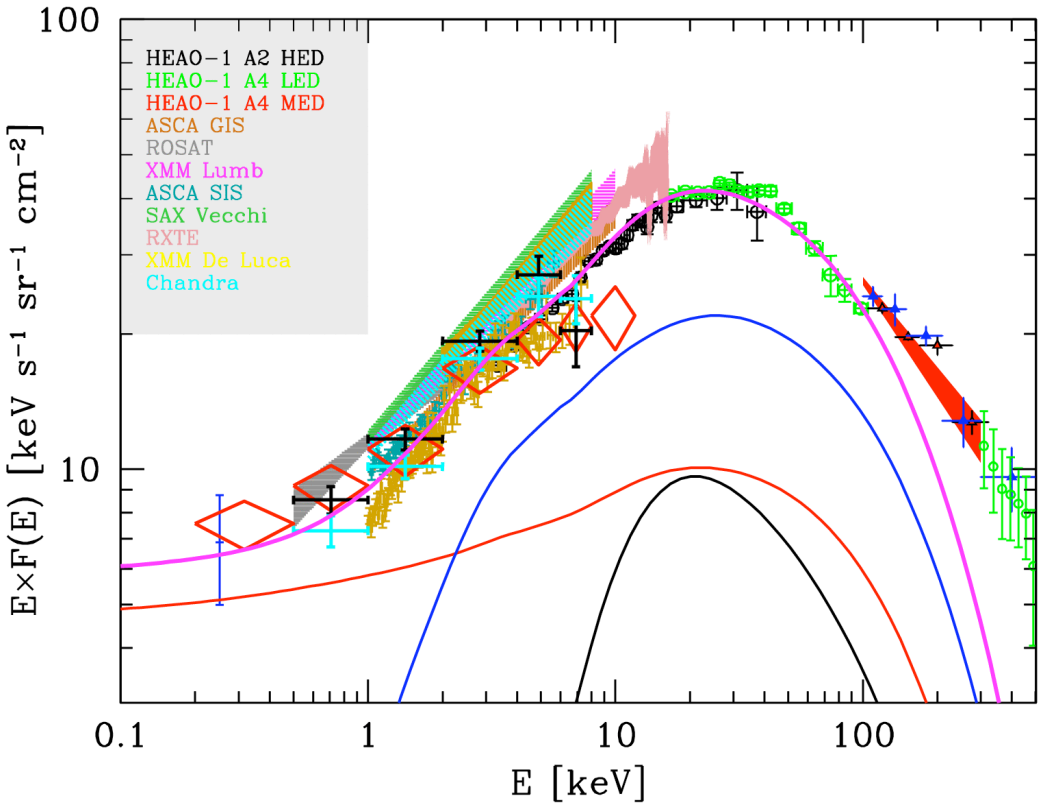
Sky coverage of Hasinger08





In Hasinger08 the increase of f_{abs} with z can be almost entirely explained by selection effects (K-correction)

The most heavily obscured AGN



C-thick AGN at z~1 invoked to explain the 30 keV XRB. (~25-30% contribution, but see Treister+09 who suggest a smaller value).

Their XLF and evolution completely unknown

About 50 *bona fide* Compton-thick AGN known, mostly at z<0.1 (Comastri04, Della Ceca 08). What about high-z?

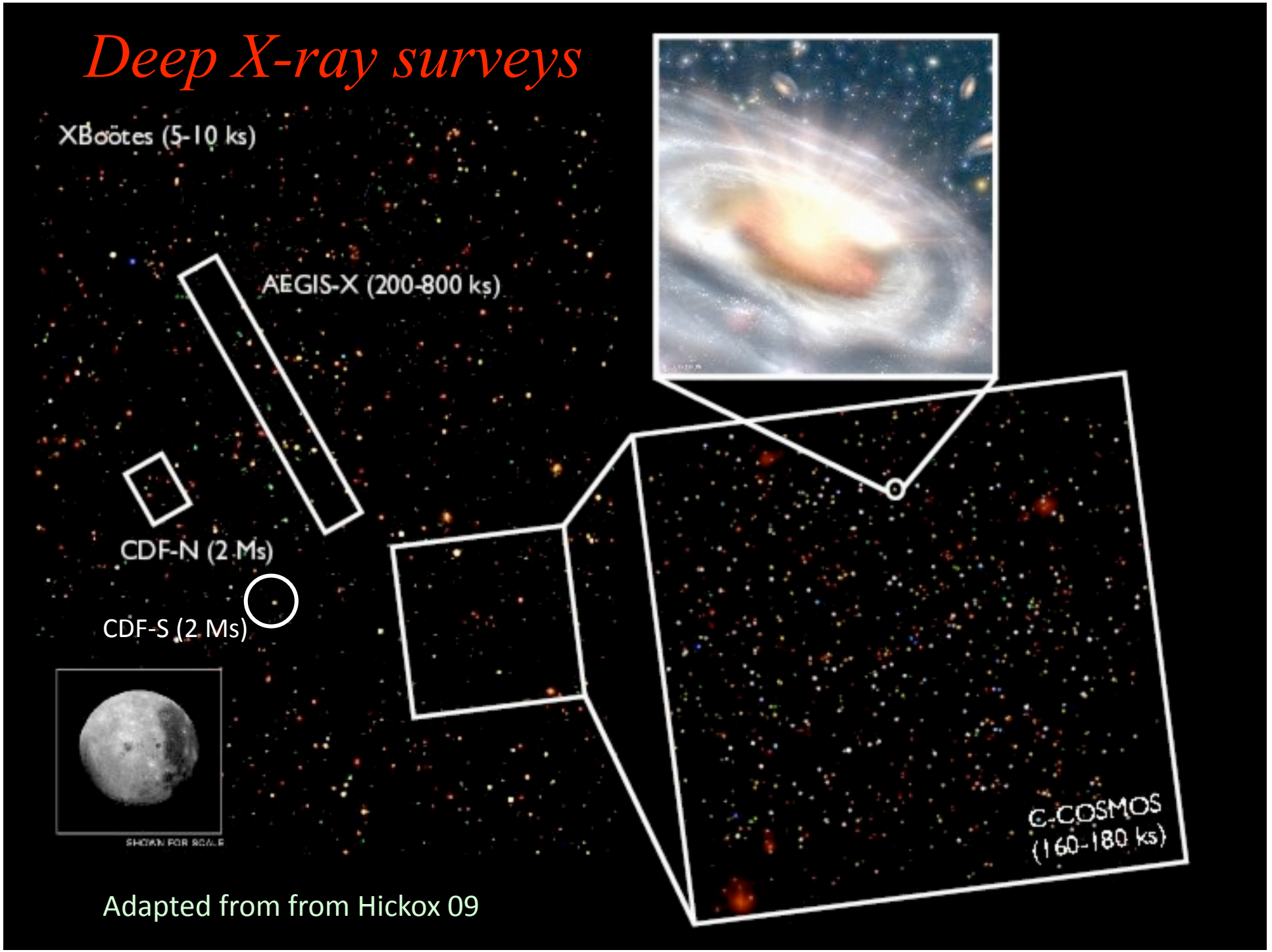
The search for heavily obscured AGN

Heavily obscured accretion mostly unconstrained beyond the local Universe

Selection techniques:

- Hard (>10 keV) X-ray surveys (peak of X-ray spectrum; only local Universe)
  INTEGRAL/Swift (see talks by Beckmann, Mushotzky, Winter)
- Deep X-ray surveys: X-ray reflected emission
  (e.g. CDFS-CDFN: Tozzi +06, Georgantopoulos +07,09)
- IR-surveys: reprocessed emission, heated dust
  (Polletta +06, Daddi+07; see also talks by Fiore, Alexander, Georgakakis)
- Spectroscopic surveys: high-ionization emission lines like
  [OIII]5007 (Maiolino +98, Risaliti +99, Zakamska +03, Vignali +06,09, +many others)
  [OIV]26um (Spitzer/IRS, local Universe; Diamond-Stanic +09, Rigby +09)
  [NeV]3426 (this talk)

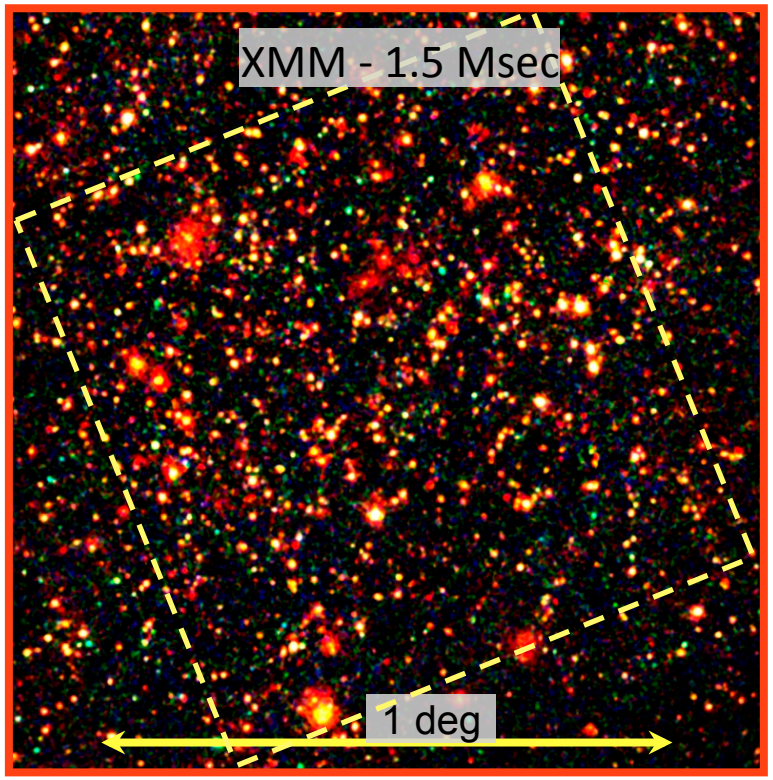
Deep X-ray surveys

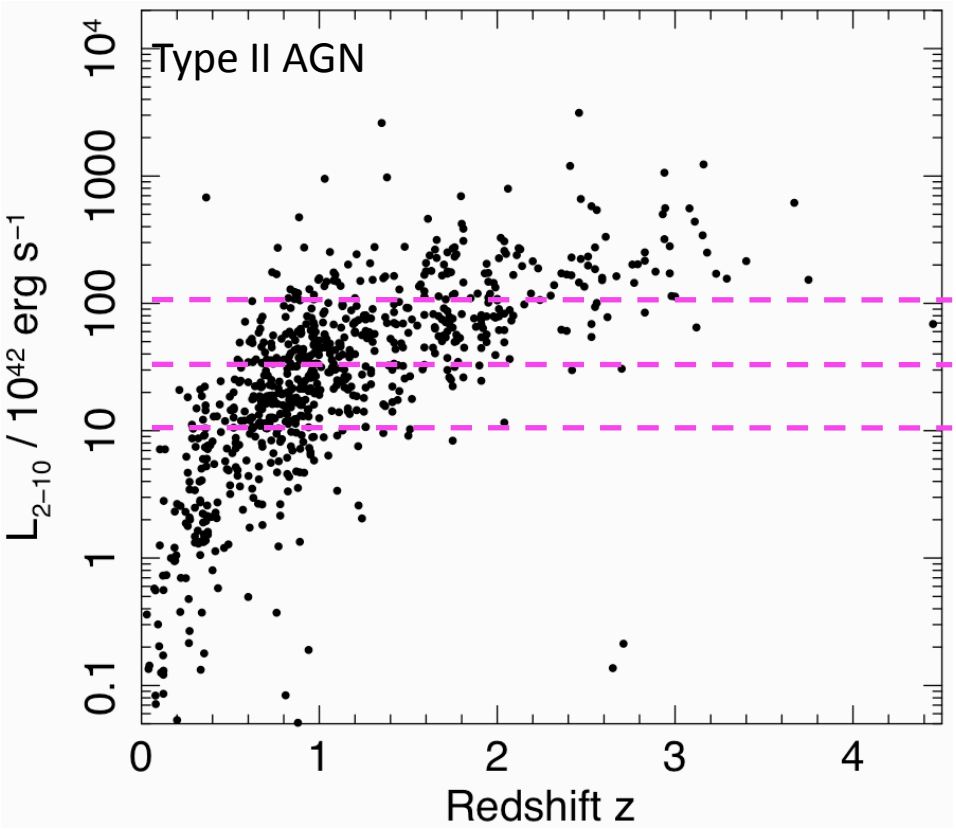


Adapted from from Hickox 09

XMM-COSMOS: Type-2 sample properties

~1900 X-ray sources over 2 deg^2 (Cappelluti et al. 2009)



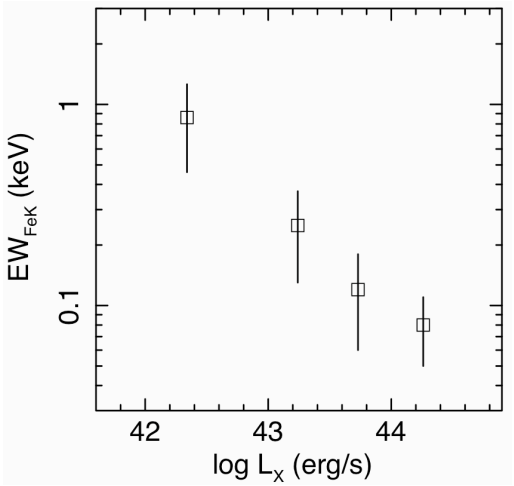


Flux cut	z measure	N	Total
> 20 ct	Spectro-z	206	
	Photo-z	295	501

See also poster by Mainieri+ (P.7.45)
on XMM-COSMOS spectral analysis

XMM-COSMOS: Type II AGN in four L_X ranges

Iwasawa et al. 09 in prep

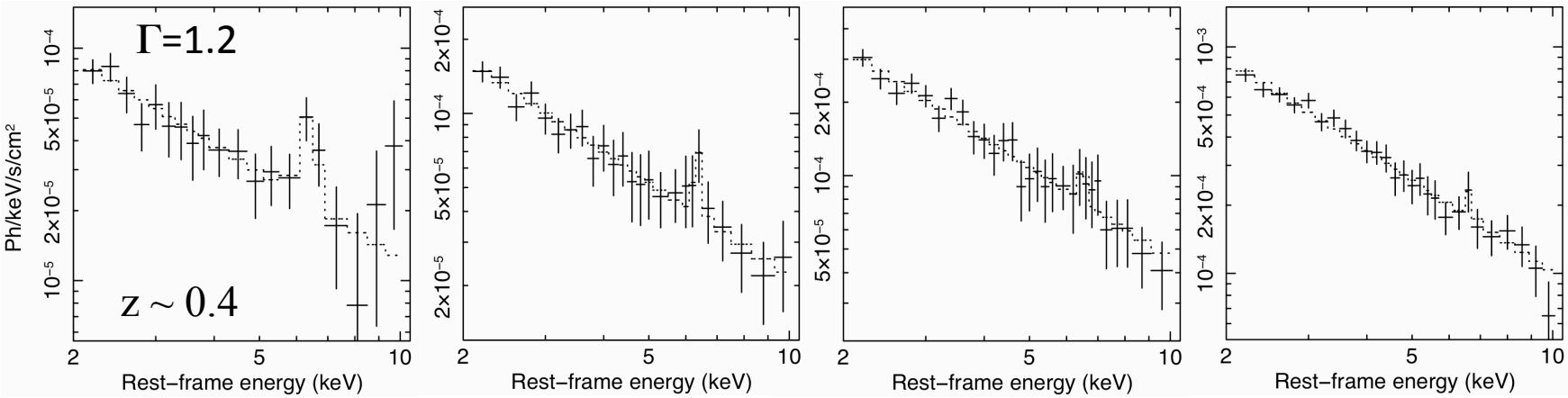


Very strong Fe K line in the lowest luminosities

➡ Substantial number of heavily obscured AGN

See also Chaudary+ poster (P.7.7)on 2XMM

Higher L_X



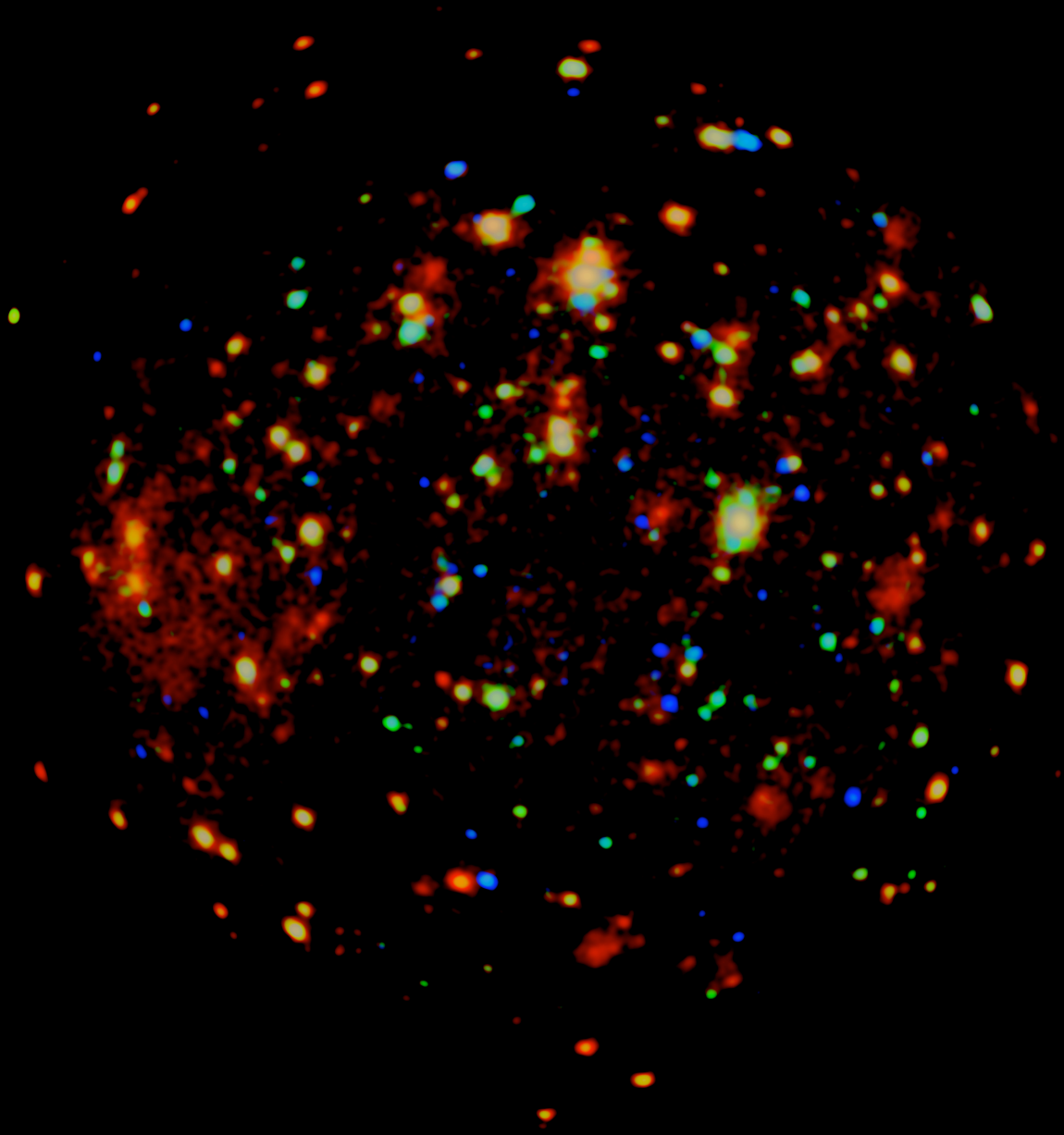
The XMM-CDFS

cleaned expo:

1.4 Ms analyzed
(AO7 + archive)

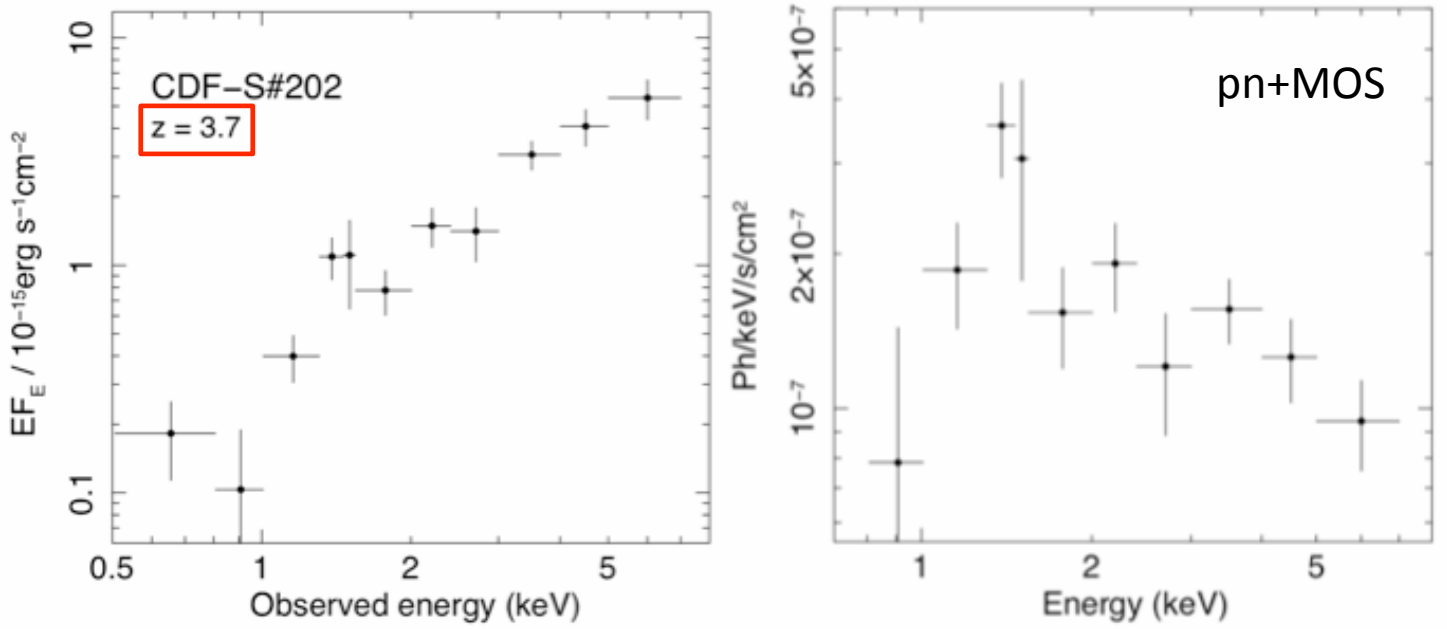
1.8 Ms observed

2.5 Ms by Feb 2010
(AO7+AO8+archive)



P.I. A. Comastri

CDFS-202: a famous type-2 QSO (Norman+02)

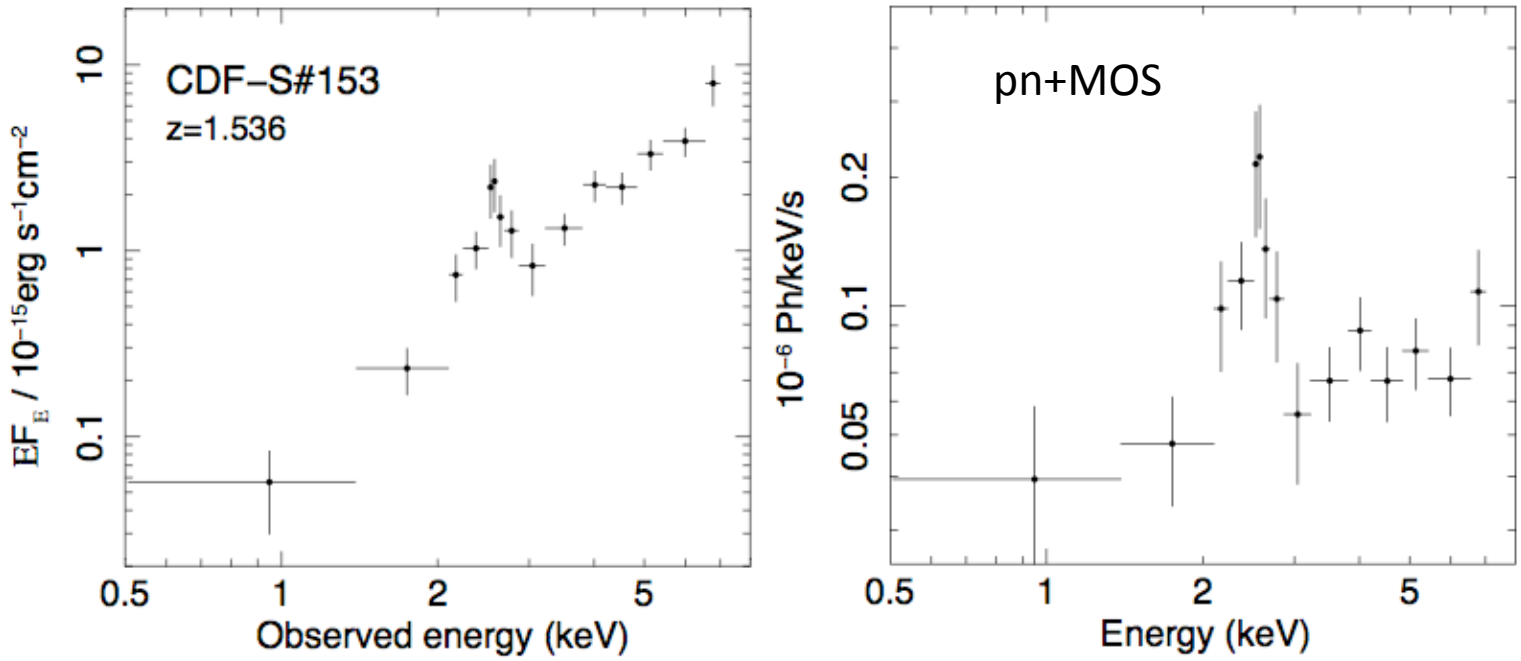


F_x~2.5 10^{-15} cgs , ~900 photons, S/N~20

N_H>~10^{24} cm^{-2}

L_{obs} = 3 10^{43} → L_{int}>10^{44} erg/s

CDFS-153: a C-thick AGN at z=1.5 *(Tozzi+06)*

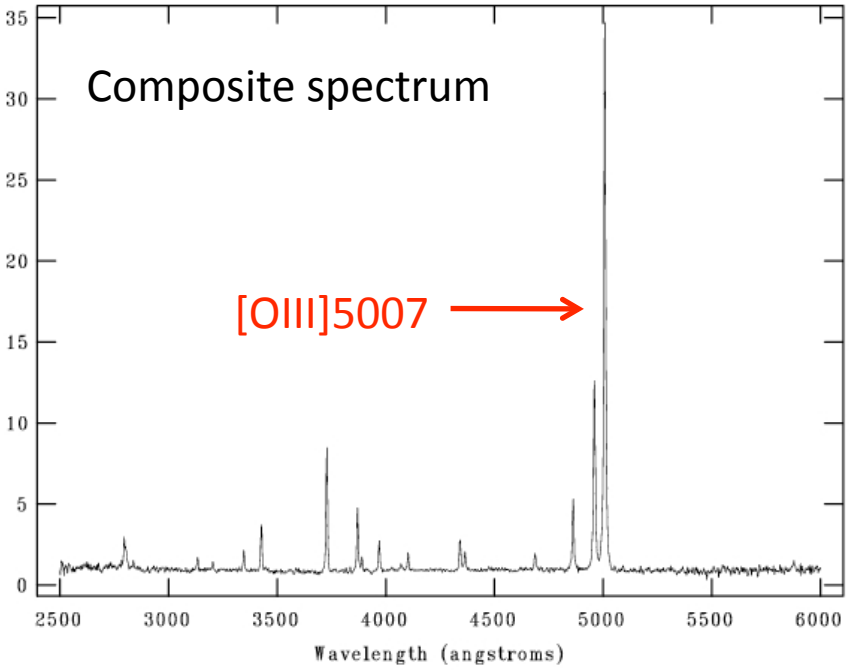


Fx~8 10-15 cgs, N_H>~10^{24} cm^{-2}

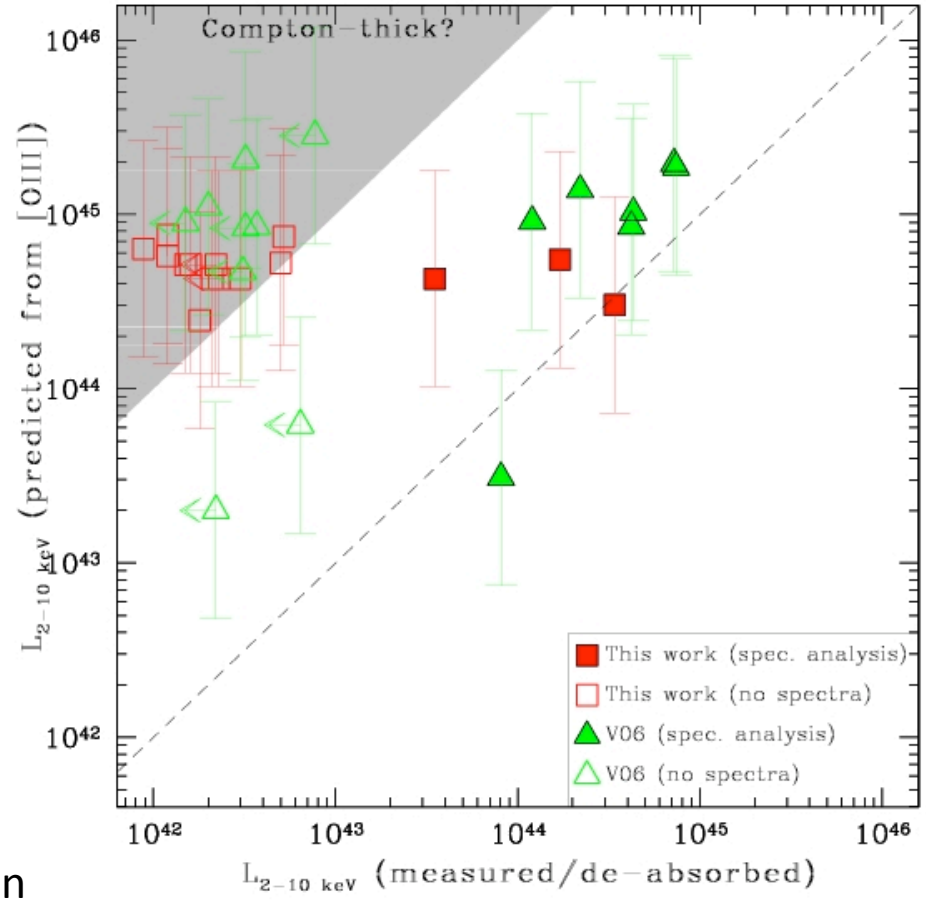
XMM is sampling the C-thick population at z~1-2
where the bulk of the accretion is produced

Spectroscopic surveys: [OIII] selection

X-ray observations of 30 SDSS QSO-2
from Zakamska +03 at z=0.4-0.7



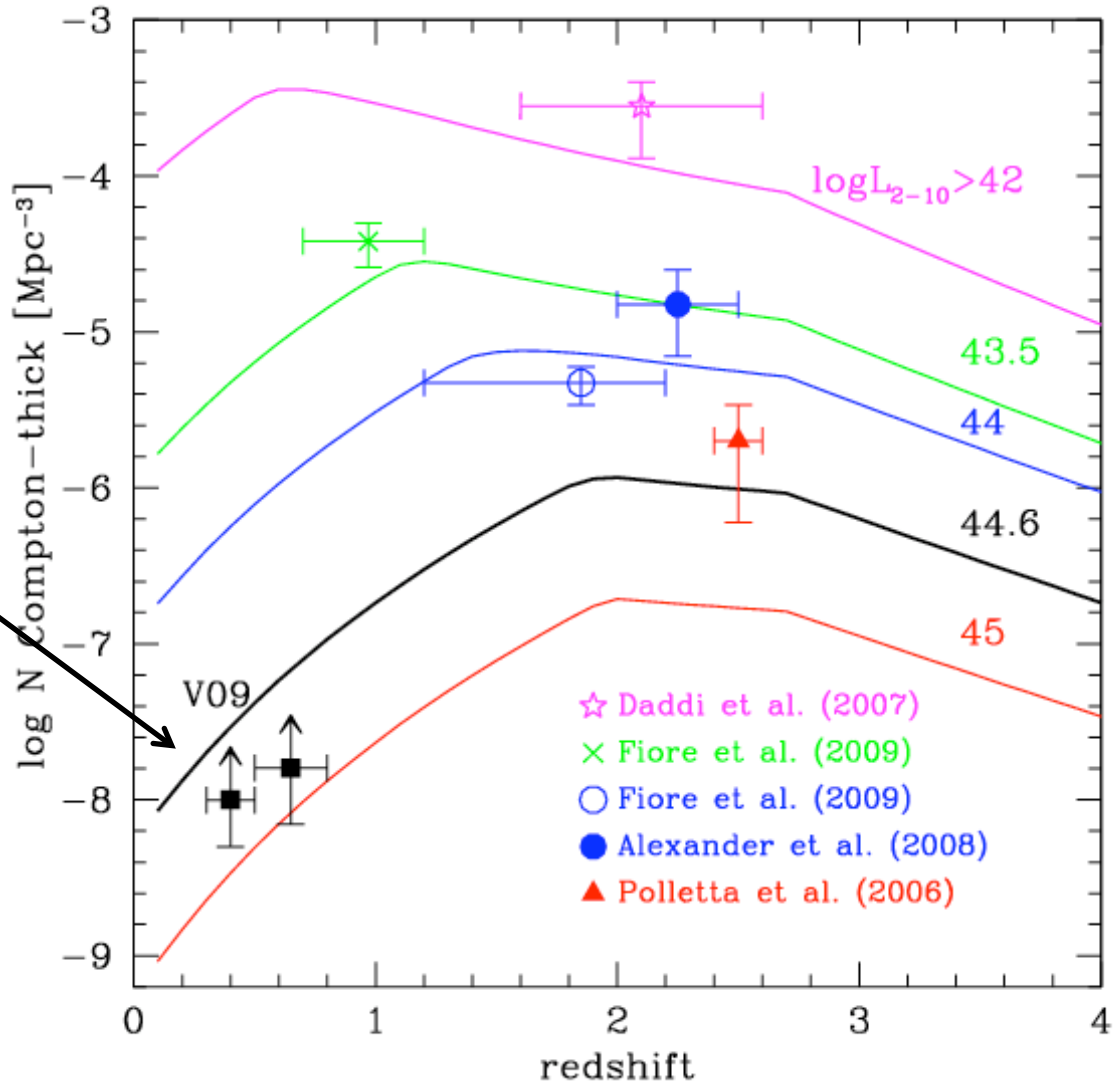
Vignali +09 MNRAS submitted



~50% have Lx/LOIII a factor of 100 lower than expected ➔ candidate C-thick QSOs

Space density of C-thick AGN

derived by applying
50% C-thick fraction to
QSO2 optical LF
of Reyes +08



Spectroscopic surveys: [NeV]3426 selection

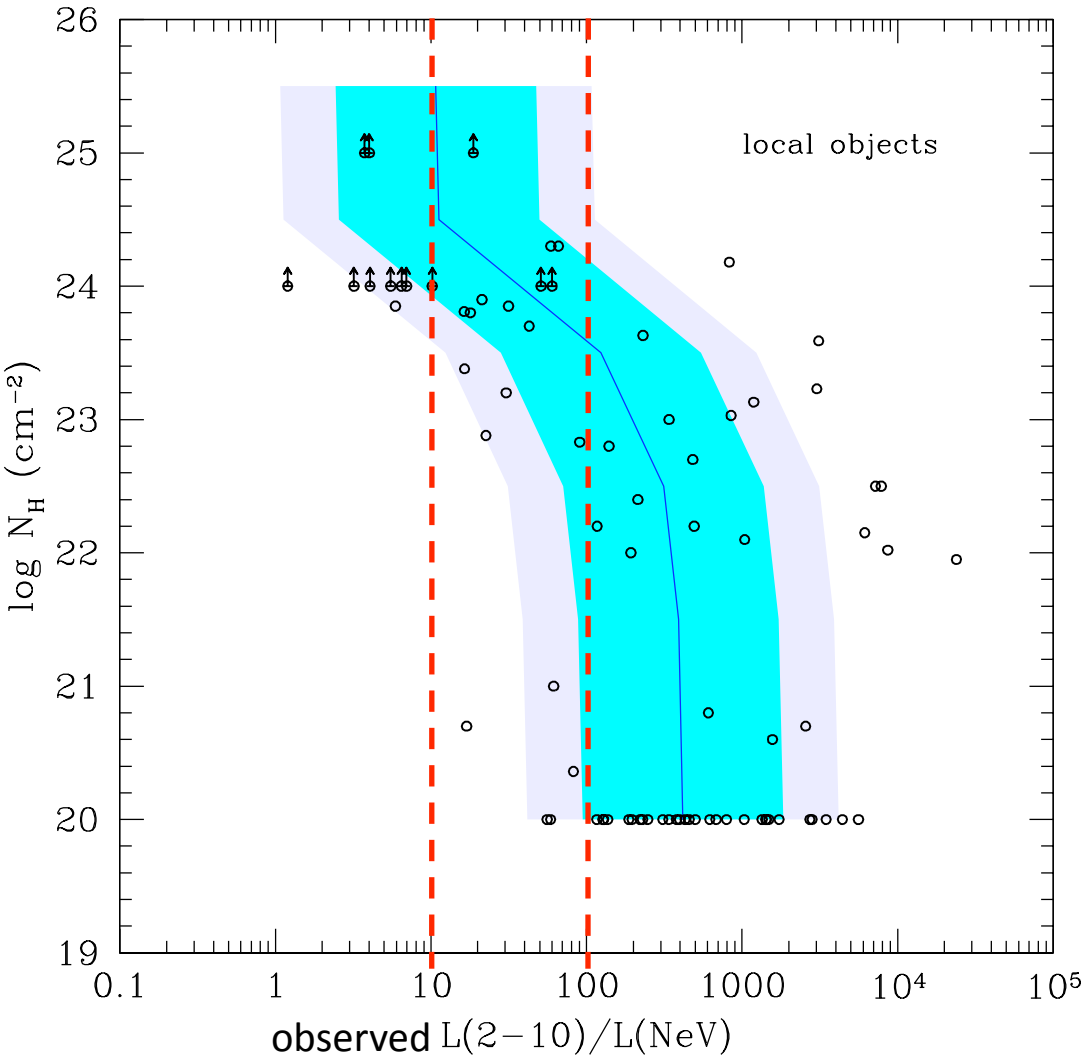
[NeV] cons

*It is a factor of ~9 weaker than [OIII] and suffers from heavier extinction ➔ selects only objects with "clean" NLR

[NeV] pros

*unambiguous AGN marker (E_{ion} >~0.1 keV)

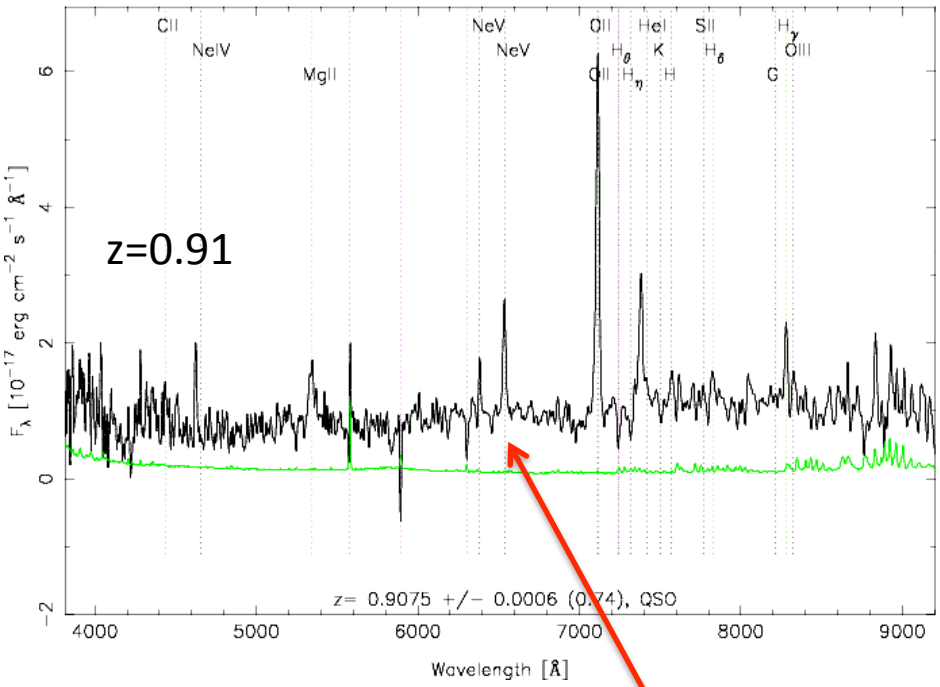
*visible up to z~1.6, while [OIII] up to z~0.8



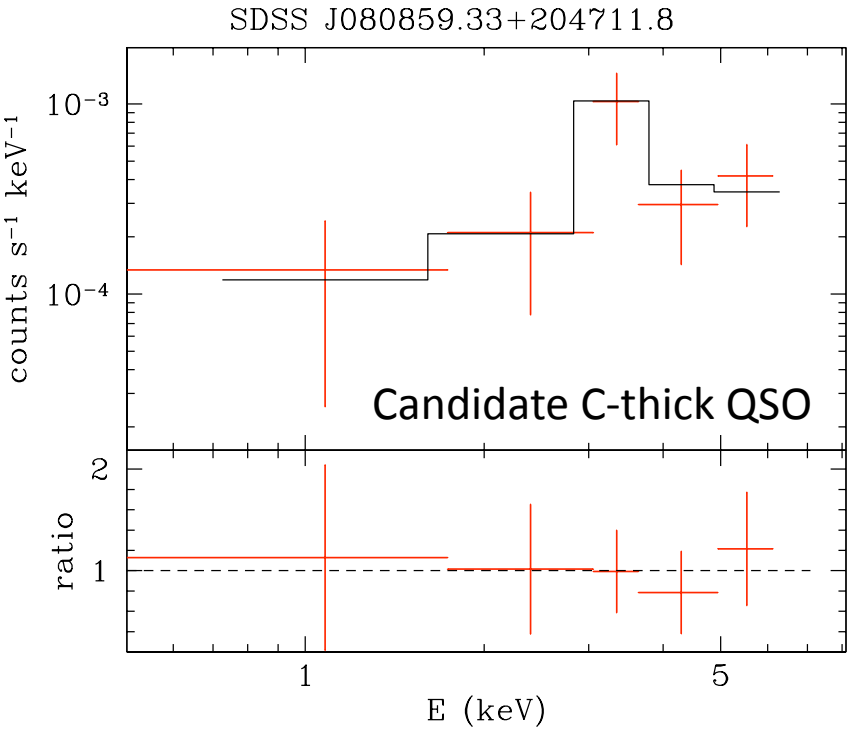
See similar plots for [OIII]
by Maiolino +98, Cappi +06, Panessa +06)

Spectroscopic surveys: [NeV] selection

Chandra 10 ks observations of 9 SDSS type2 QSO candidates at z=0.85-1.30 (beyond [OIII] limit) based on rest EW_{NeV} > 4 Angstrom



[NeV]3426

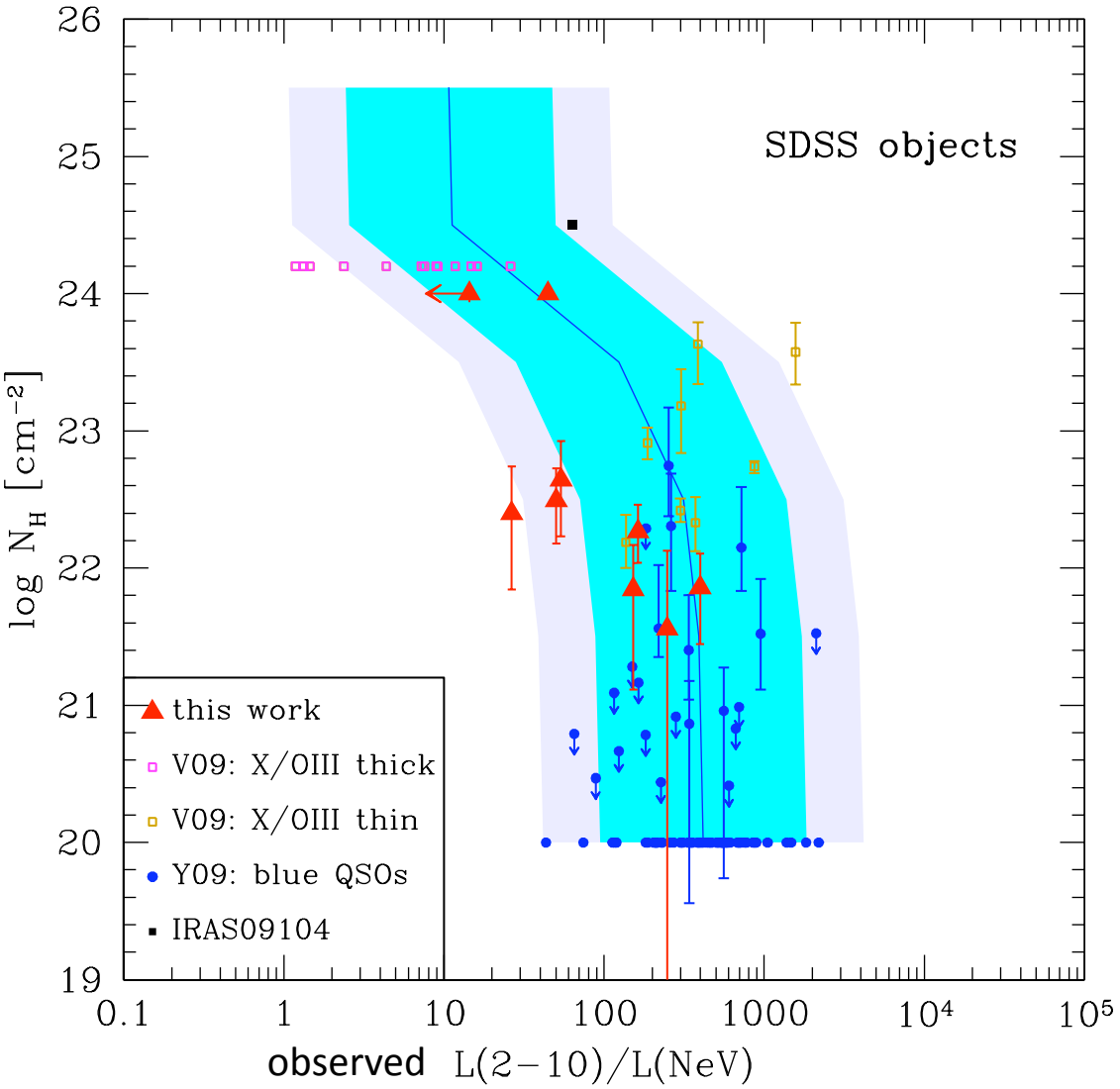


Γ = -1.2

EW > 0.7 keV

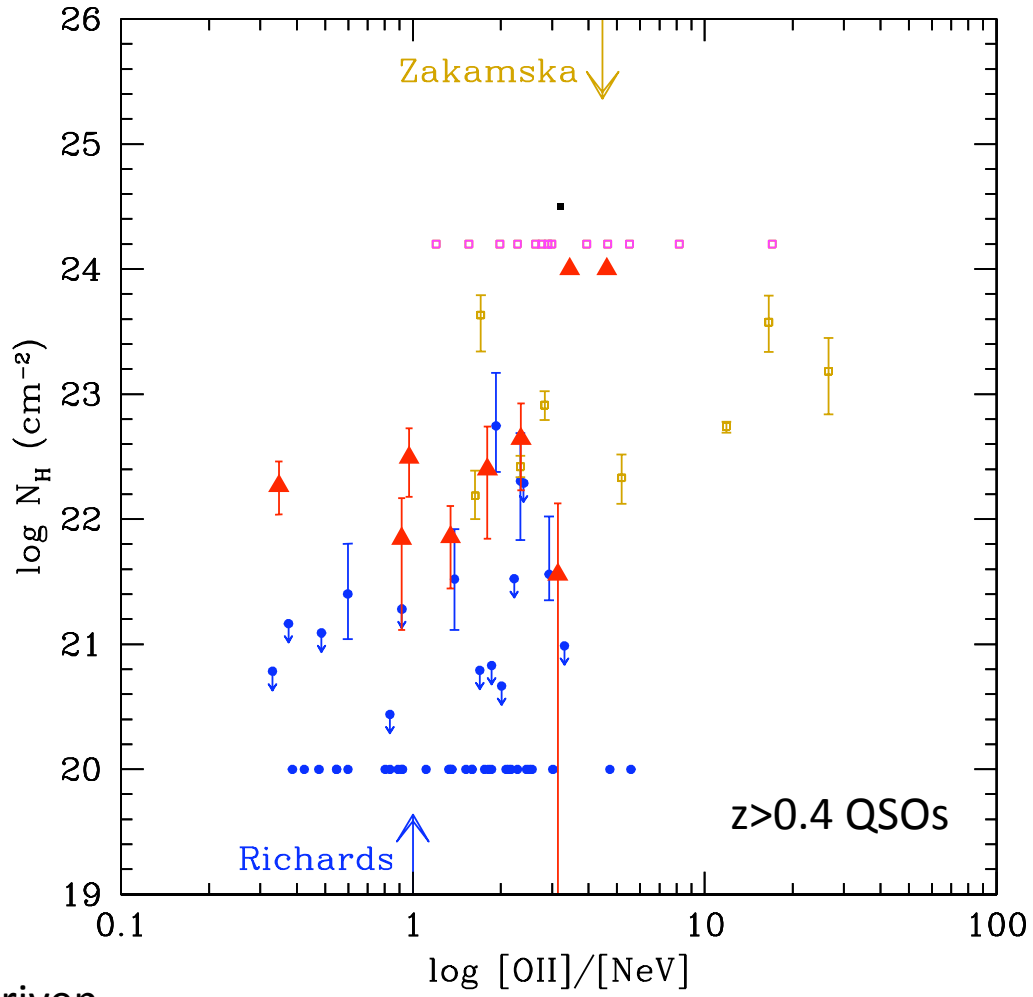
$L_{(2\text{-}10)}$ obs. = 10^{44} erg/s

Optical emission lines: [NeV]



Spectroscopic surveys: [NeV] selection

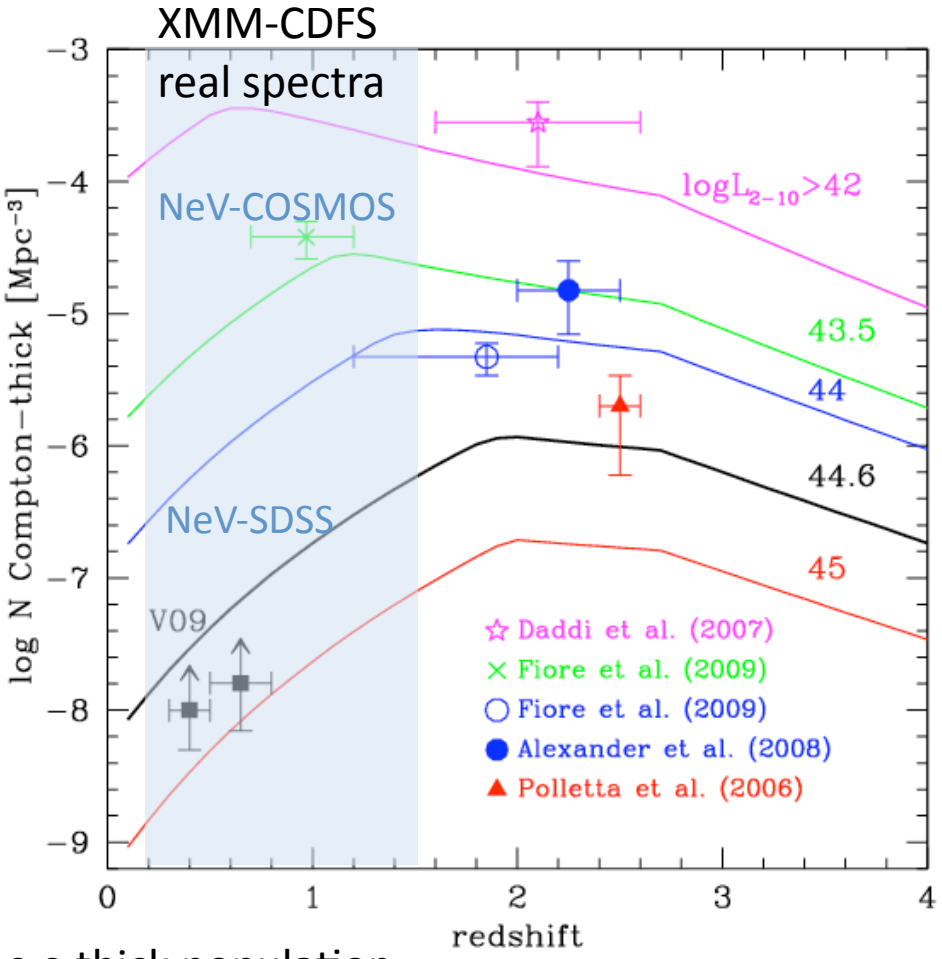
With optical (e.g. [NeV]) selection [OII]3727 (i.e. AGN+SF) for free



Evidence for enhanced star formation with increasing absorption in z>0.4 QSOs? (see also Kim+06)

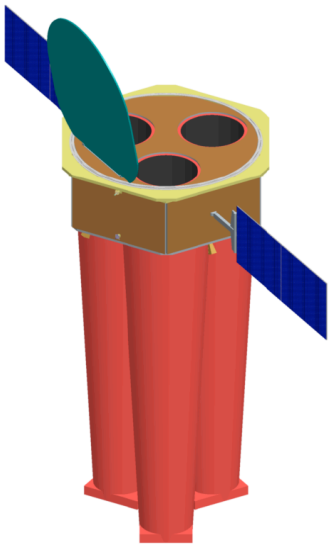
Consistent with merger-driven evolutionary sequence

Space density of C-thick AGN



Most attempts to
determine the size of the c-thick population
at z>0 rely on indirect evidence

Deep/wide surveys with WFXT



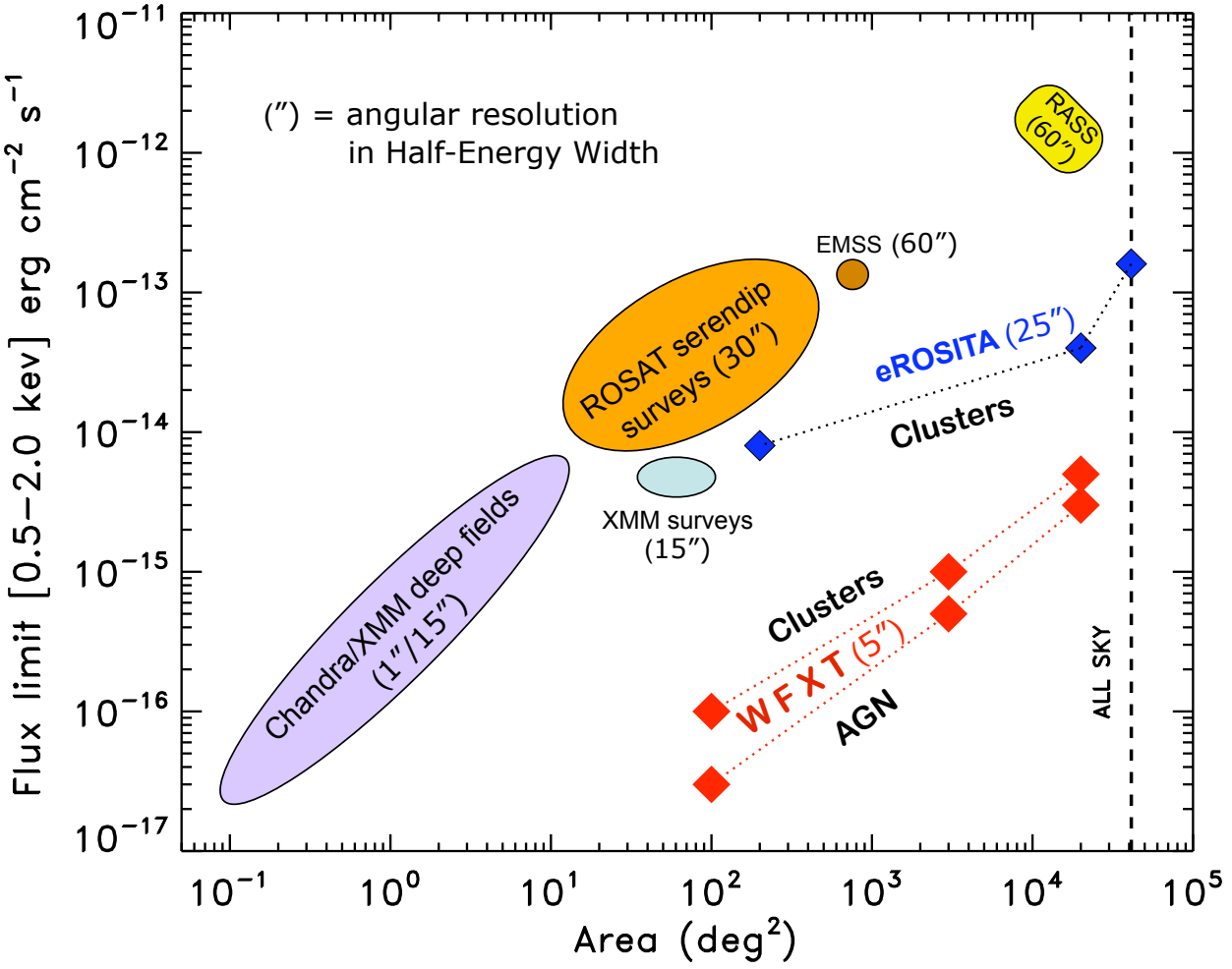
http://wfxt.pha.jhu.edu

FOV=1 deg^2

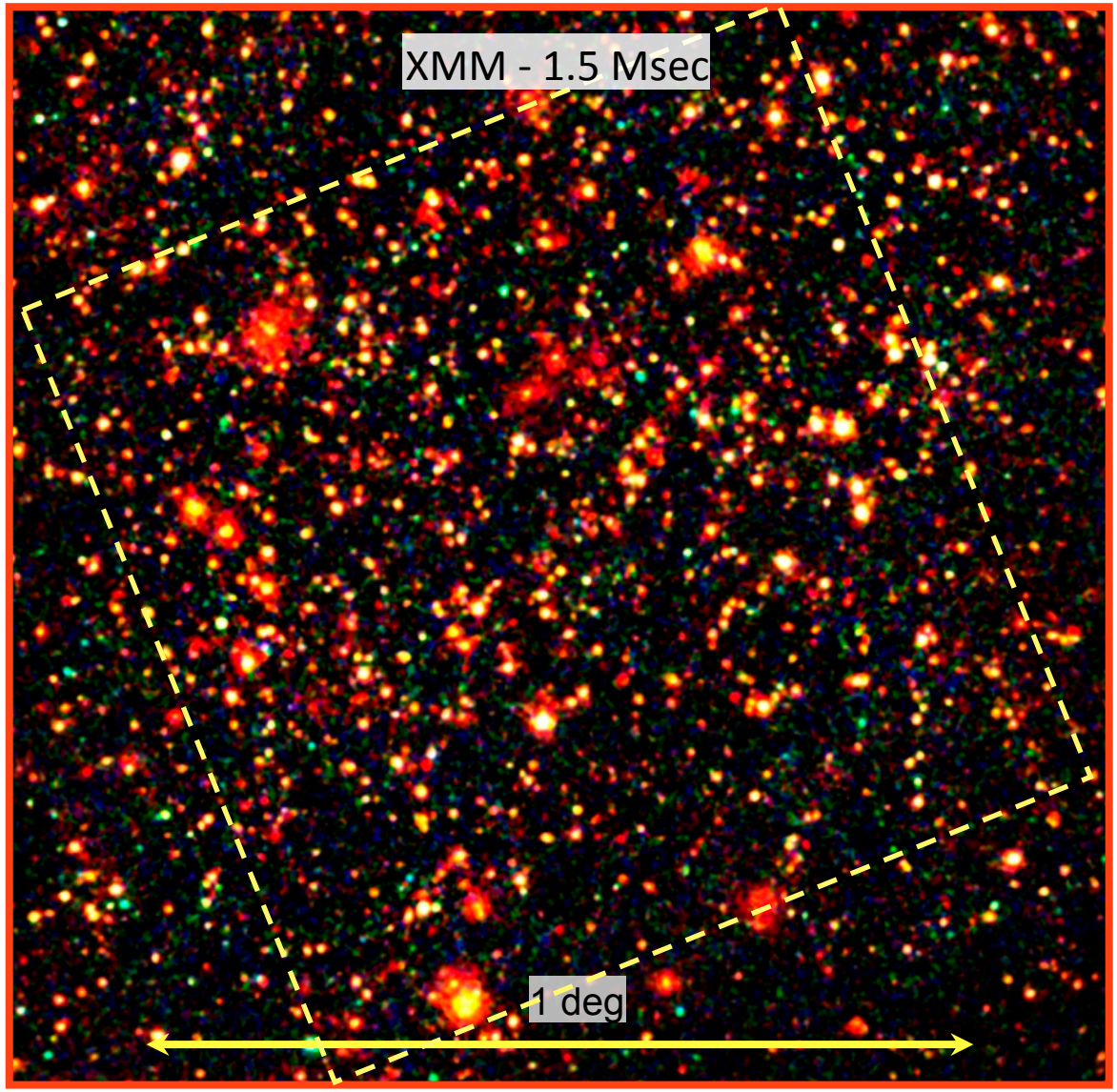
A_{eff}=1m^2 @1.5 keV →

Large GRASP=FOVxA_{eff}

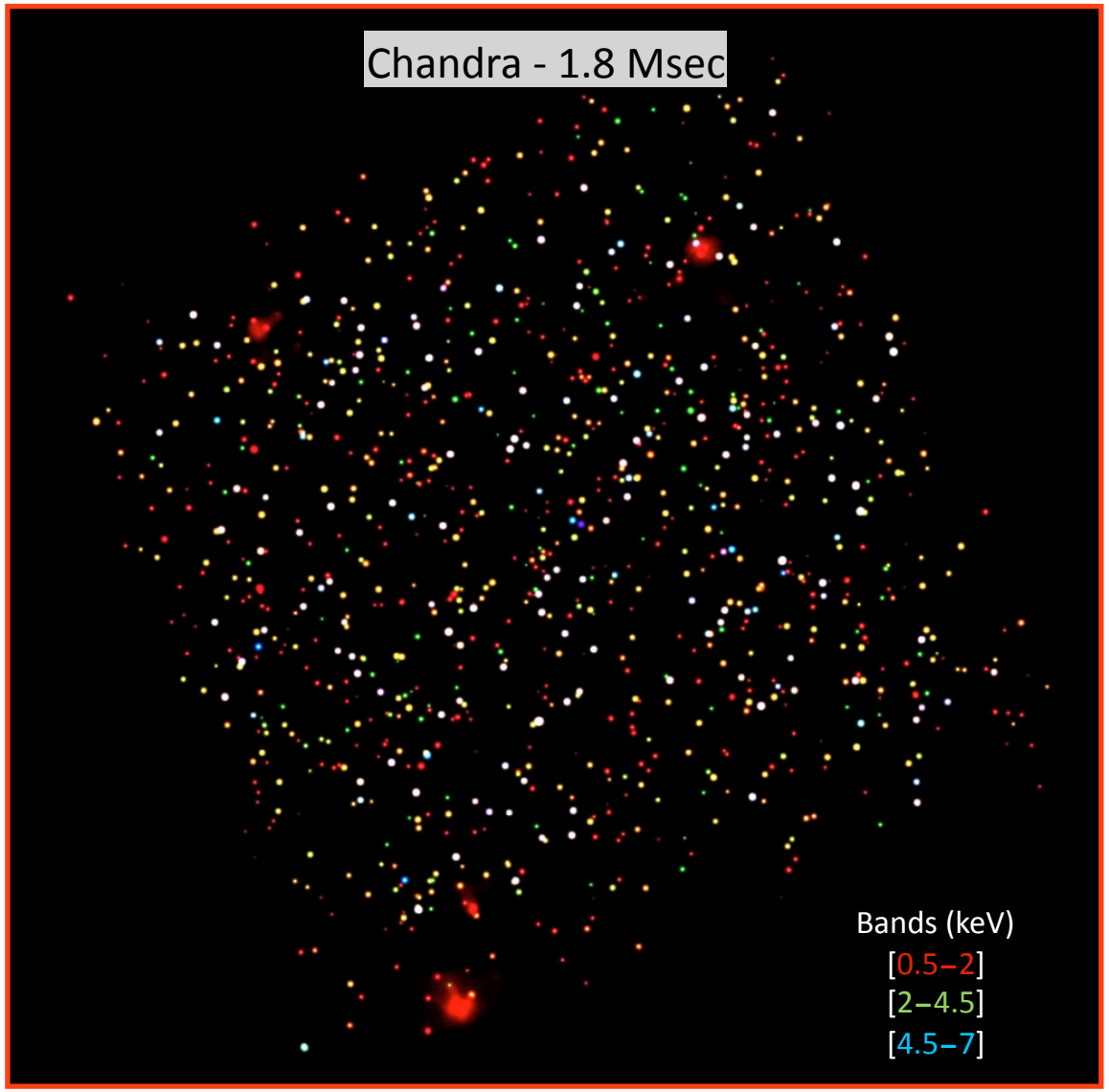
PSF= 5-10” HEW



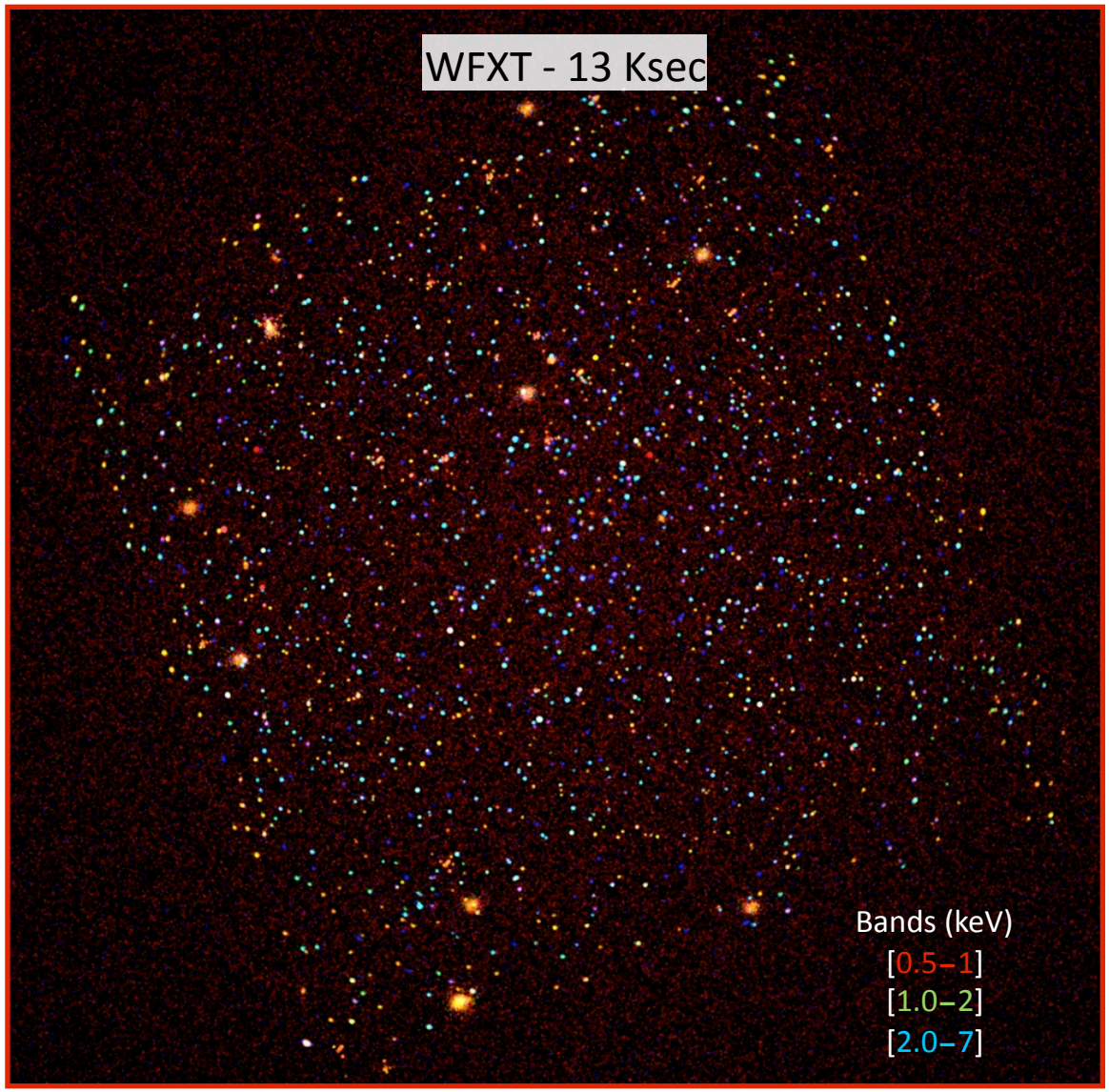
XMM COSMOS survey (2 deg^2) (Cappelluti et al. 2009)



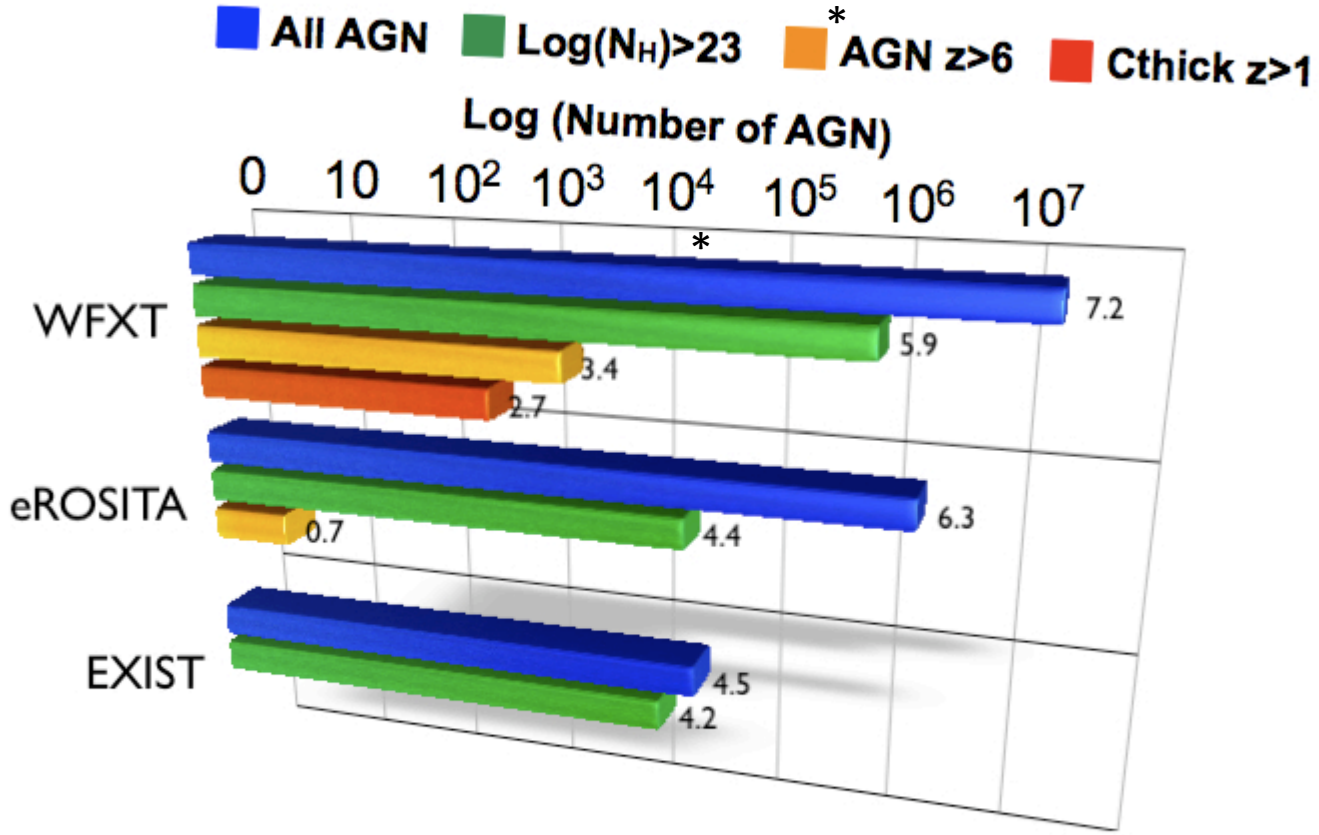
Chandra COSMOS survey (1 deg^2) (Elvis et al. 2009)



WFXT simulation (one tile from the medium survey) using the Chandra catalog



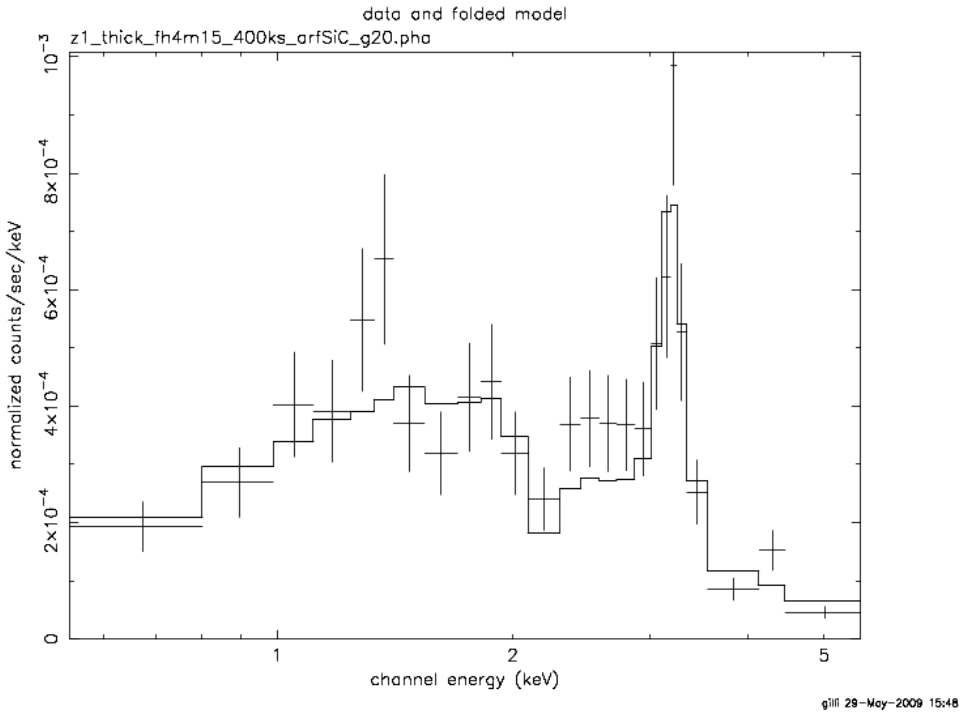
Comparison with other missions



WFXT will provide a large sample of high-z objects for statistical studies (BH formation, evolution),

*assuming a decline

Simulated C-thick QSO with intrinsic logLx ~ 44.5 at z=1 in WFXT deep (400ks)



F(2-10) = 4 10^{-15} cgs, 500 cts > 0.5 keV
Line EW ~ 1 keV , err=25%
Err. on line centroid = 1%

About 500 objects like this expected at z>1 in the 100 deg^2 Deep Survey, enough for XLF studies

Here c-thick nature established source by source from the X-ray spectrum. In principle no need for identification (z from the Fe line)

z >	Number
1	500
2	270
3	60
4	12

Summary

How (obscured) accretion evolves with cosmic time still to be fully determined. Observations of SDSS QSOs are consistent with merger-driven evolutionary sequence

Major uncertainties on the most heavily obscured, C-thick objects: deep X-ray surveys and optical emission line surveys, combined with X-ray data, are effective in selecting C-thick AGN beyond the local Universe.

Measurements so far indicate an abundant population of C-thick AGN at different redshifts. However, need real X-ray spectra to get rid of systematics. Future wide/deep X-ray surveys should do the job.