Demography of obscured and unobscured AGN

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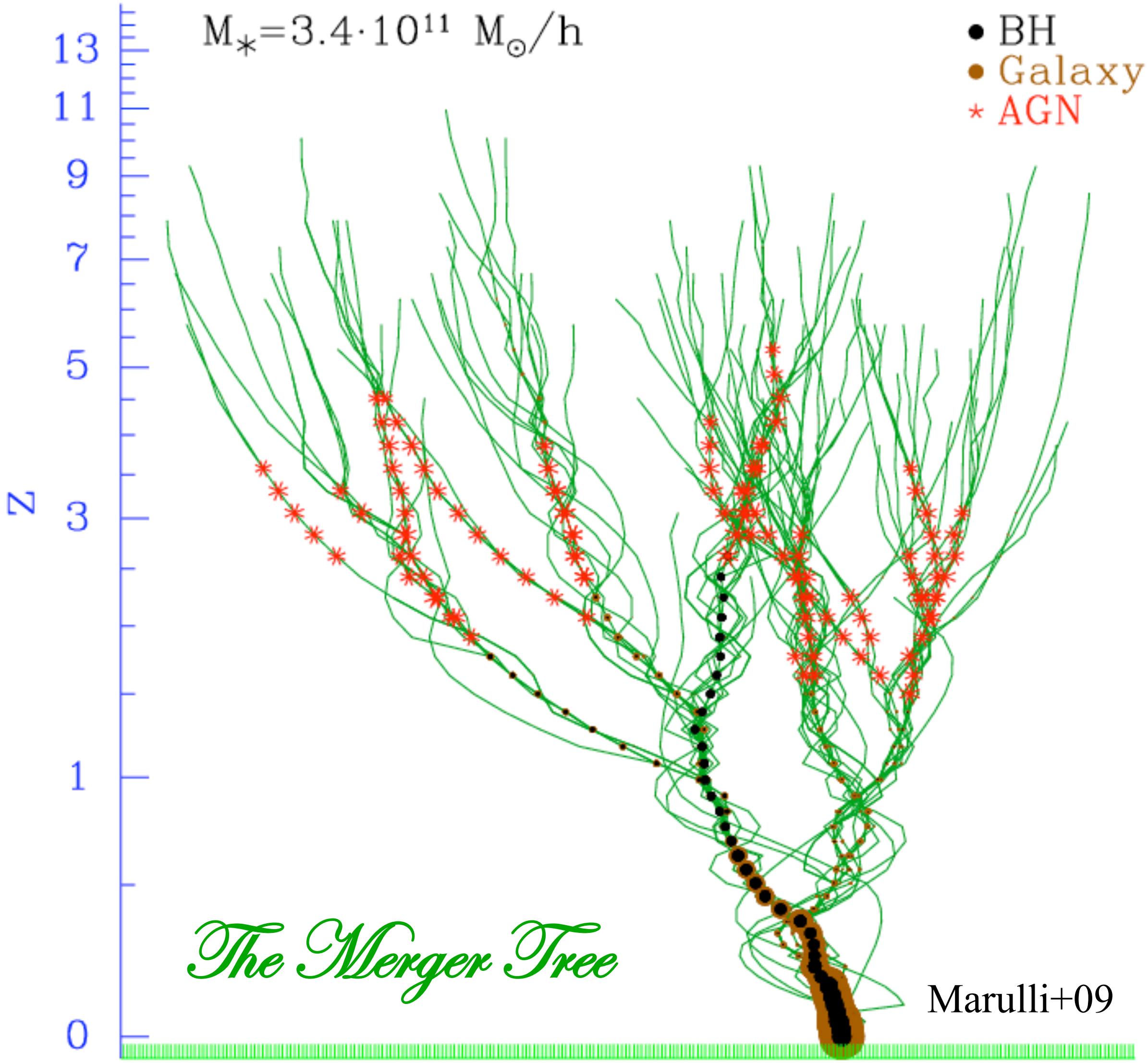
BH/galaxy co-evolution: semi-analytic models (SAMs)

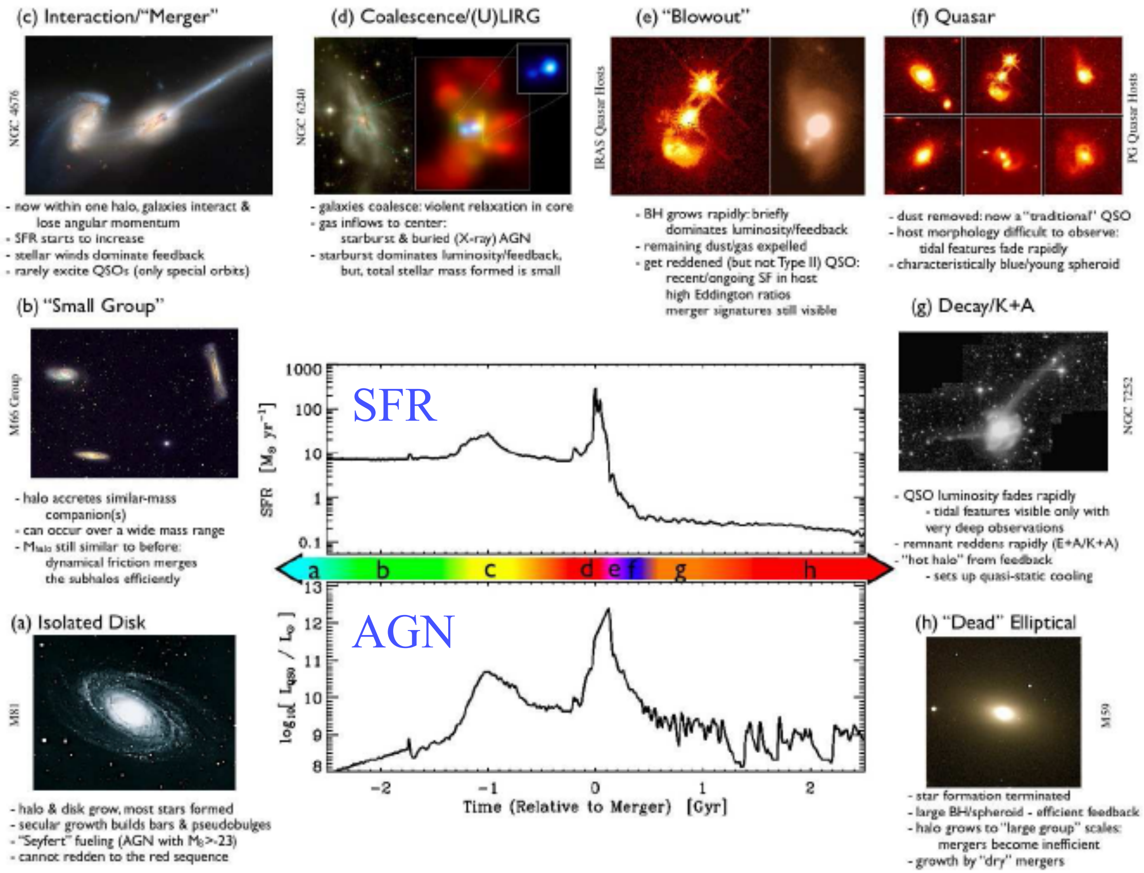
These follow the evolution and merging of Dark Matter Halos with cosmic time and use analytic recipes to treat baryon physics.

Ansatz:
nuclear trigger at merging



Marulli+09

The merger-driven BH/galaxy evolutionary scheme



Hopkins+08

mergers

↓

SF/ obscured accretion

↓

"clean" accretion (QSO)

↓

transition (green valley) object

↓

passive red galaxy

Can explain several observables:

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

Missing pieces in BH/galaxy co-evolution

Many fundamental pieces missing:

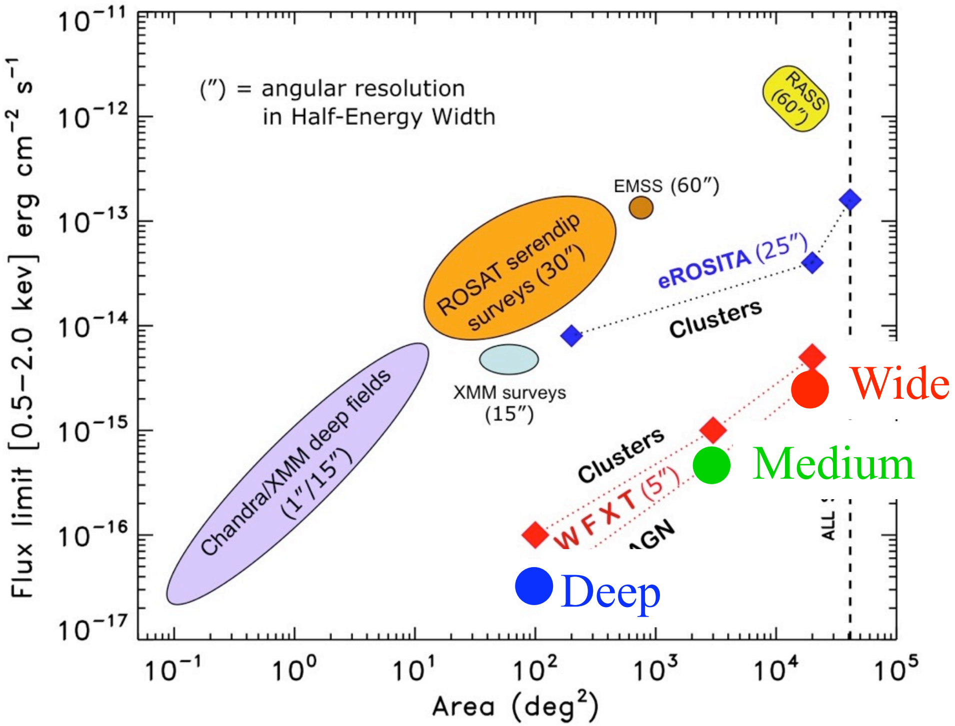
1) BH/galaxy co-evolution at very high-z ($z>6$ or so)

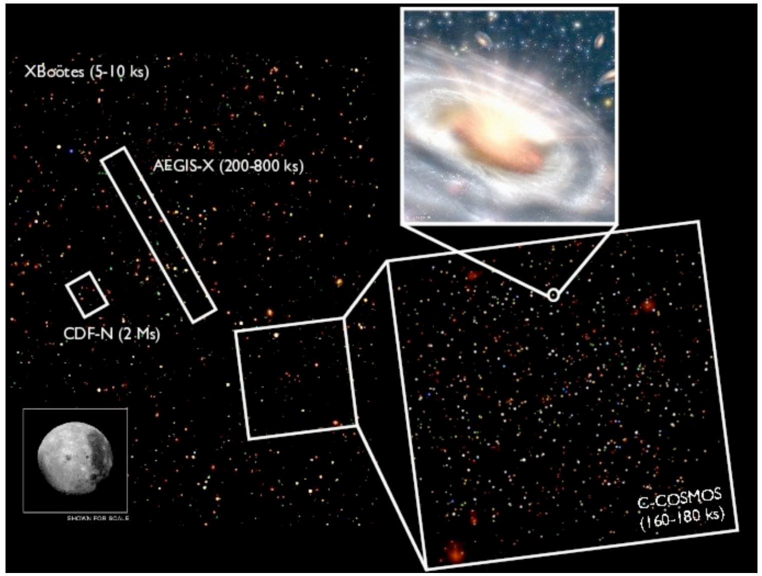
2) Cosmological evolution of obscuration

3) Environmental dependence of nuclear activity
➔ Clustering as a function of AGN properties

These require sensitive large area X-ray surveys

AGN demography with WFXT





Wide ~ 2000 x XBootes ~ 2000 x 3300 ~ 6.6 millions AGN

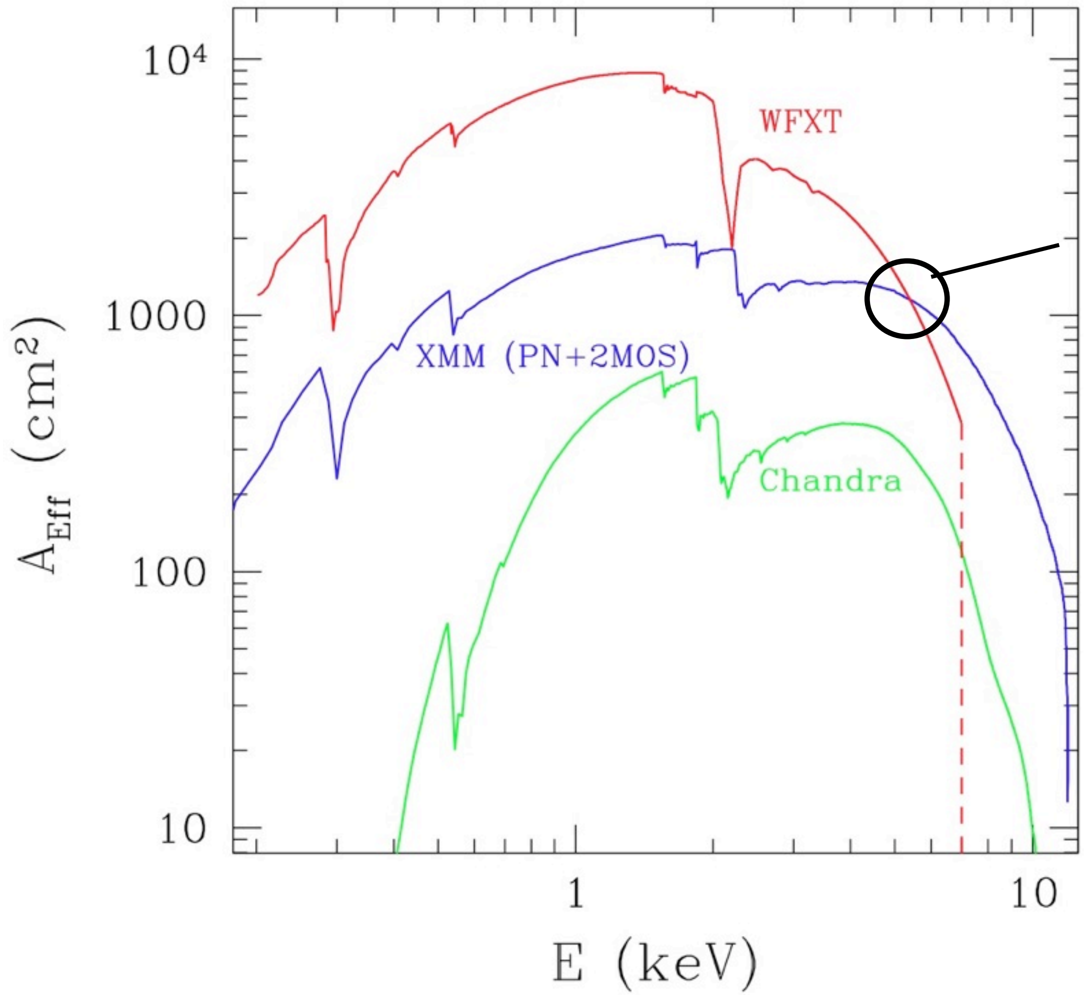
Medium ~ 3000 x C-Cosmos ~ 3000 x 1700 ~ 5.1 millions AGN

Deep ~ 1000 x CDFS ~ 1000 x 450 ~ 0.5 millions AGN

total > 10 millions AGN

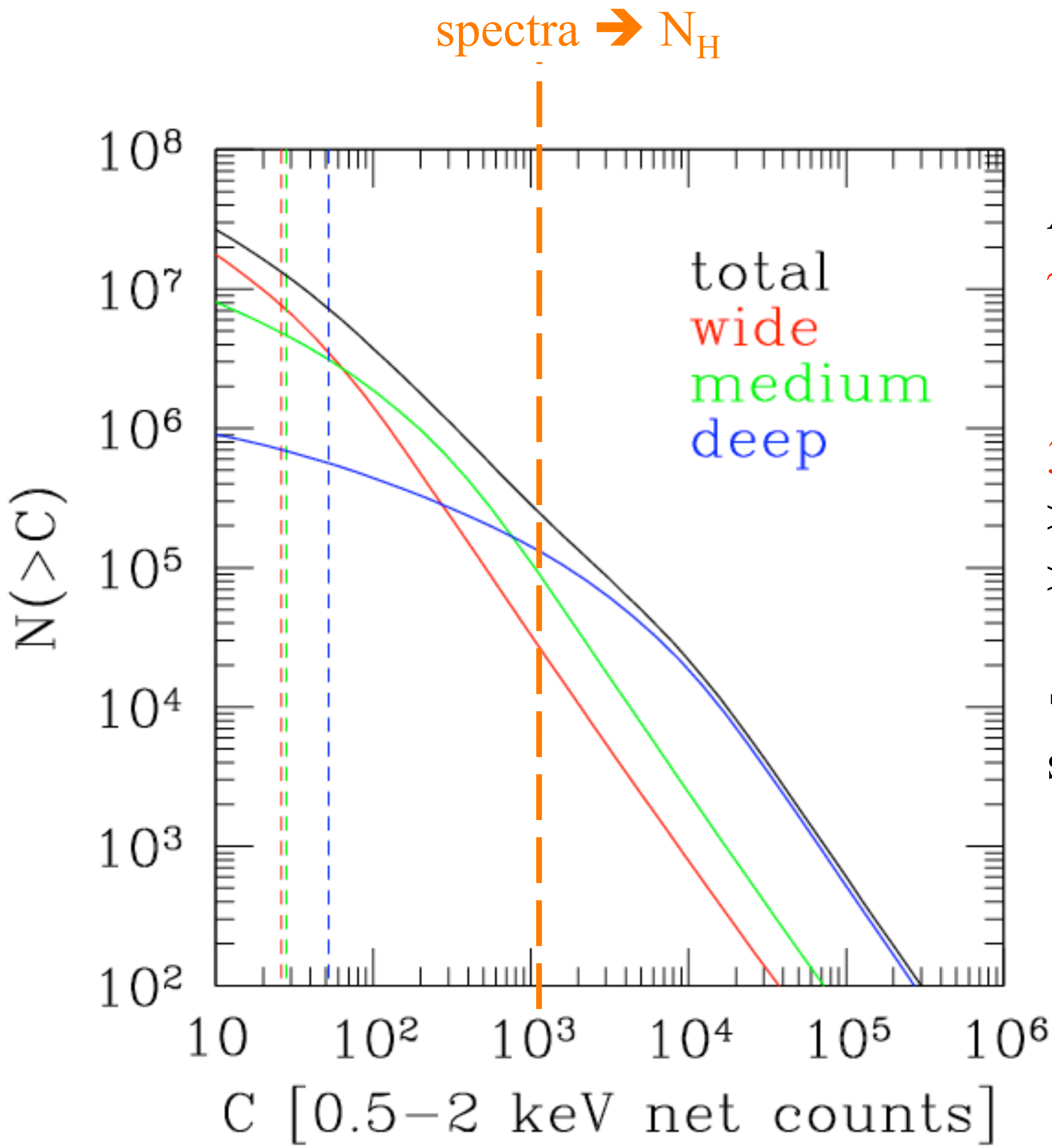
Spectral characterization

WFXT does not really "die" at 4 keV.



Goal eff. area @ 5 keV equal to XMM

AGN demography and spectral characterization

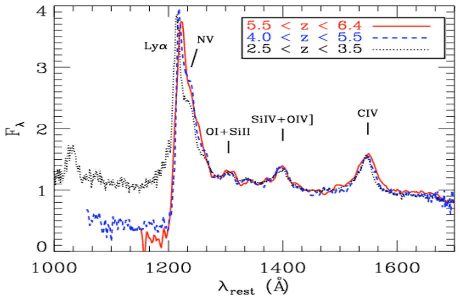


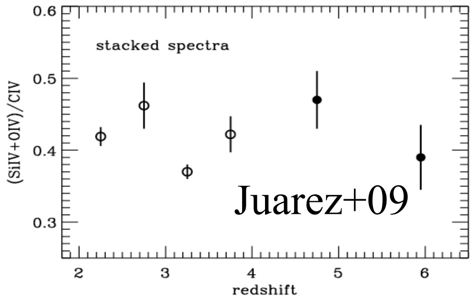
AGN detections:
~15 millions 0.5-2 keV band
~4 millions 2-7 keV band

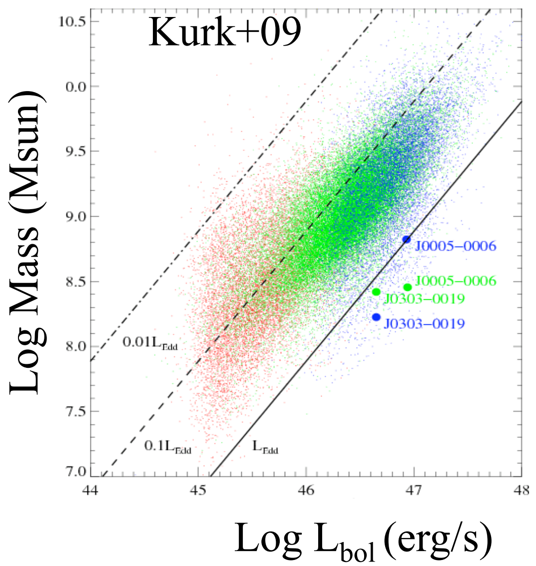
300,000 with good X-ray spectra:
>1000 cts 0.5-2 keV band
>1300 cts 0.5-7 keV band

➔ Accurate N_H for very large sample

QSOs at z>6: where do we stand







About 40 QSOs at z>5.6, ~15 at z>6, mostly from SDSS which traces the brightest QSOs (logLx~45, $\log L_{bol}$~46.5)

SDSS objects at z~6 are already "mature":
high metallicity and large 10^8-10^9 Msun BH masses
(Juarez +09, Kurk +09)

Multiple mergers of gas-rich galaxies starting at z>14 and fueling Eddington limited accretion might explain both BH and host galaxy properties of SDSS QSOs at z>6:

OK: metal abundances, BH mass and L/L_{Edd}

?: M_{BH}/M_*~0.002, as in the local Universe, while observations suggest M_{BH}/M_*~ 0.1

But SDSS QSOs likely NOT representative of whole z>6 pop.

Some key questions on the high-z Universe

How and when the bulk of the first BHs form and grow?

What formed first, BH or galaxy?

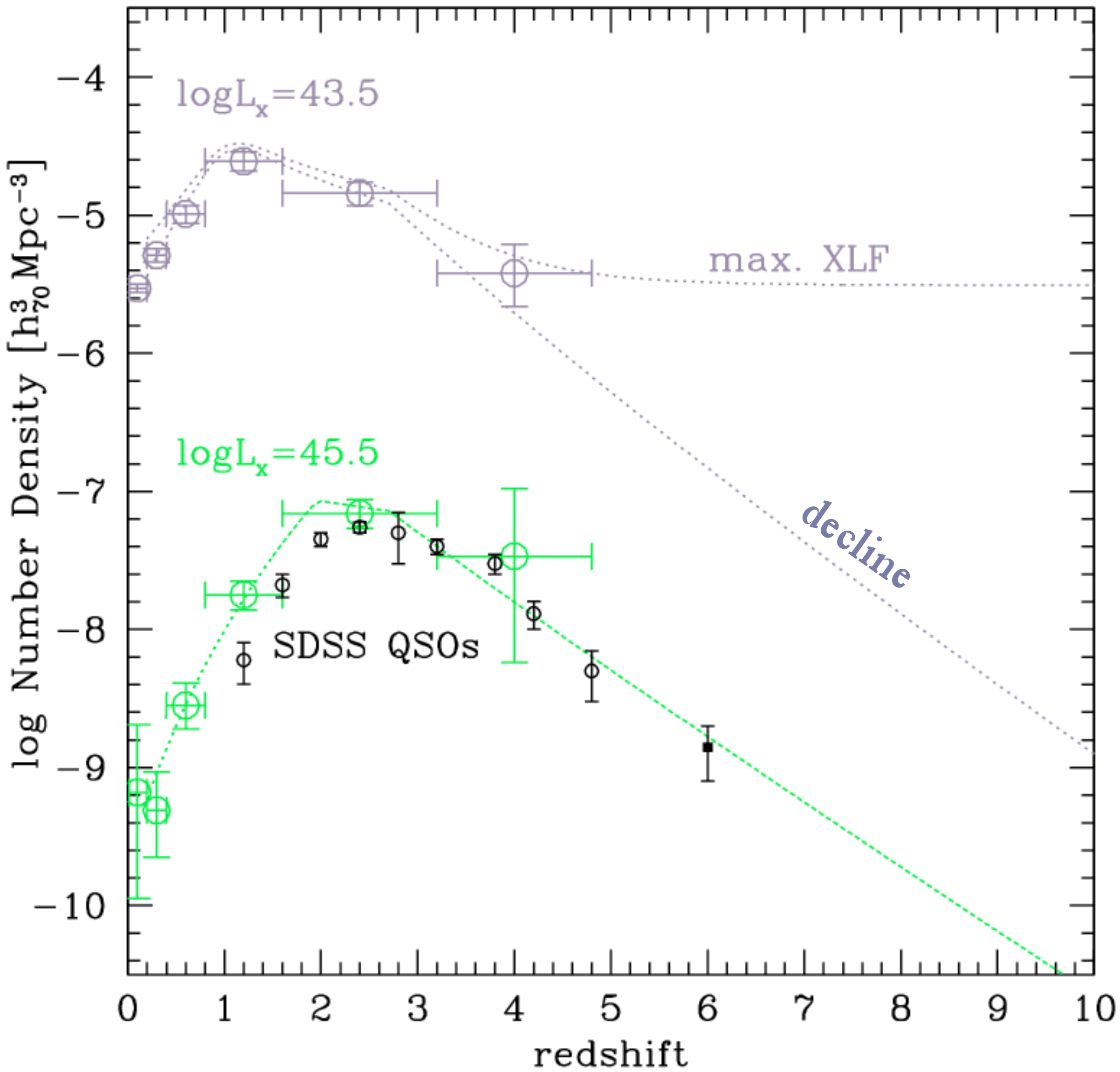
What are the scaling relations between BH and host galaxy properties
at high-z (but also at all z)?

What is the high-z BH mass function?

How do accretion modes evolve? [radiative efficiency, L/L_{Edd}, SED(α_{ox})]

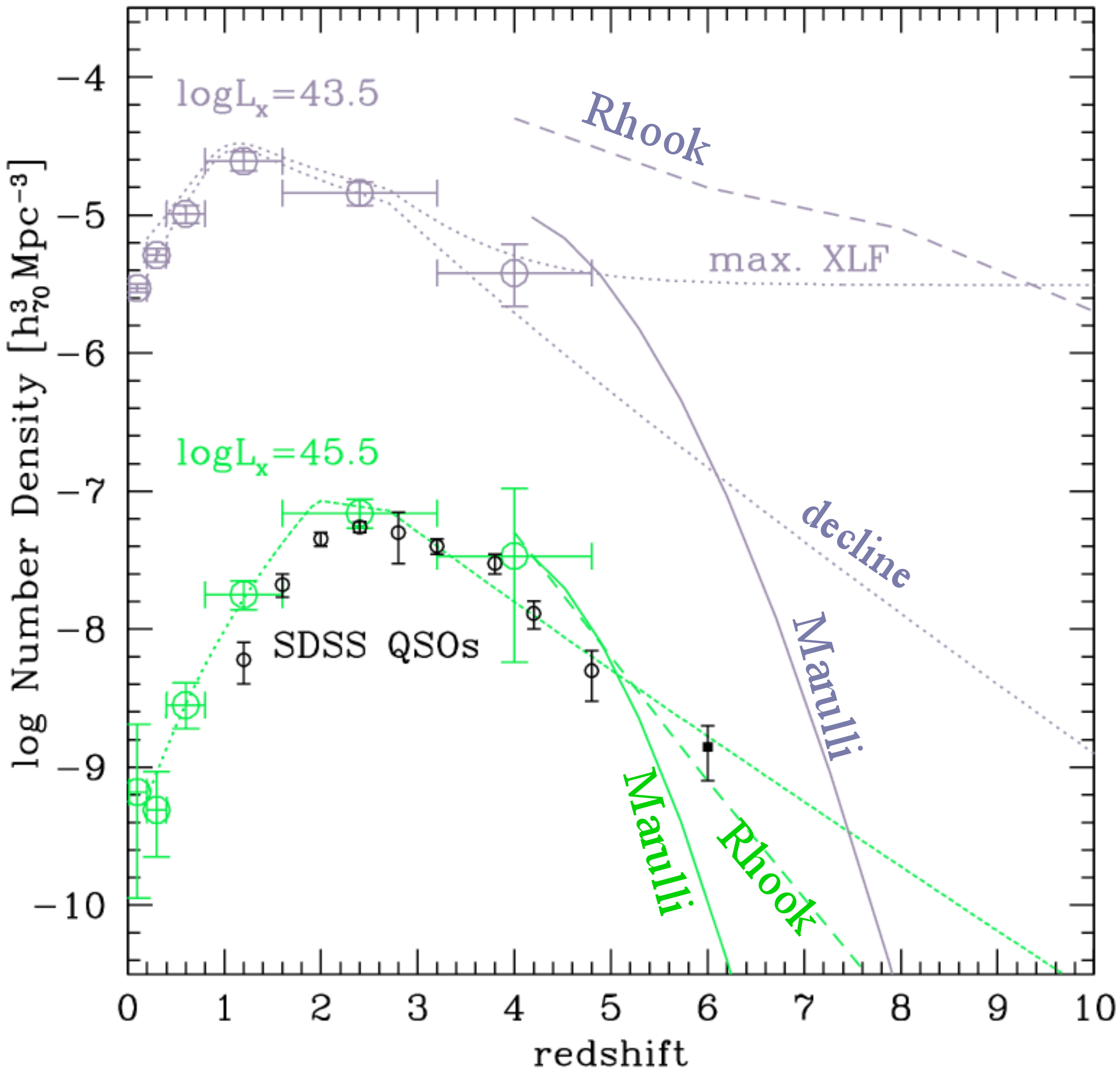
All above issues need object statistics

How many WFXT will see? Extrapolations of known XLF



max. XLF:
XLF that predicts the maximum number of high-z AGN while being in agreement with current data.

How many WFXT will see? SAMs of early BH growth

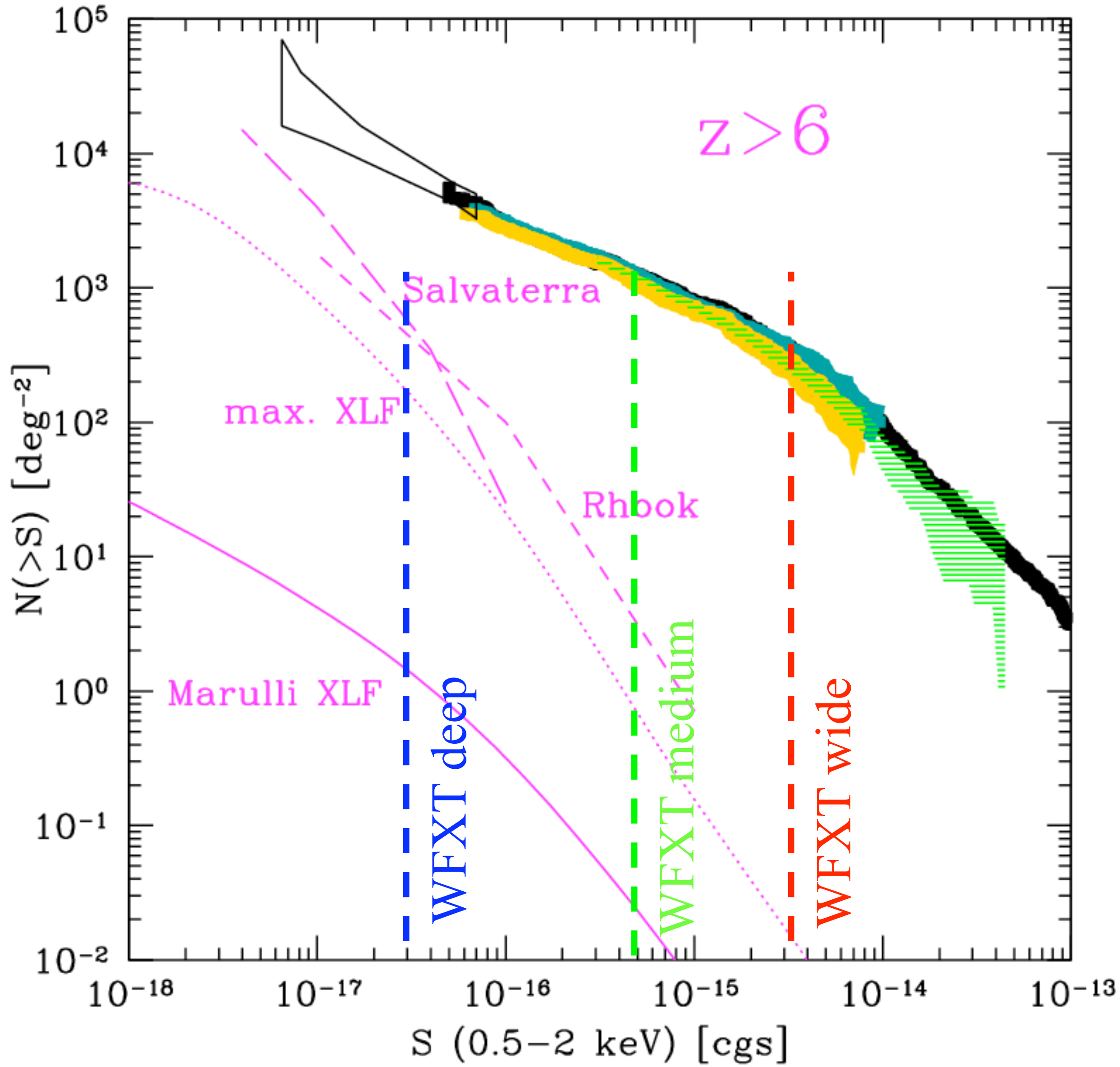


Completely uncharted territory: predictions for high-z Universe very uncertain, even by a few orders of magnitude

Some free parameters of SAMs:

- BH seed mass and location (Nσ peaks)
- Accretion recipes
- Room for internal processes

AGN at $T_{Universe}$ < 1 Gyr



Very wild range of predictions for z>6 AGN:

Observations of significant samples at z>6 would constrain the physics of early BH formation disentangling between several scenarios

How many WFXT will see?

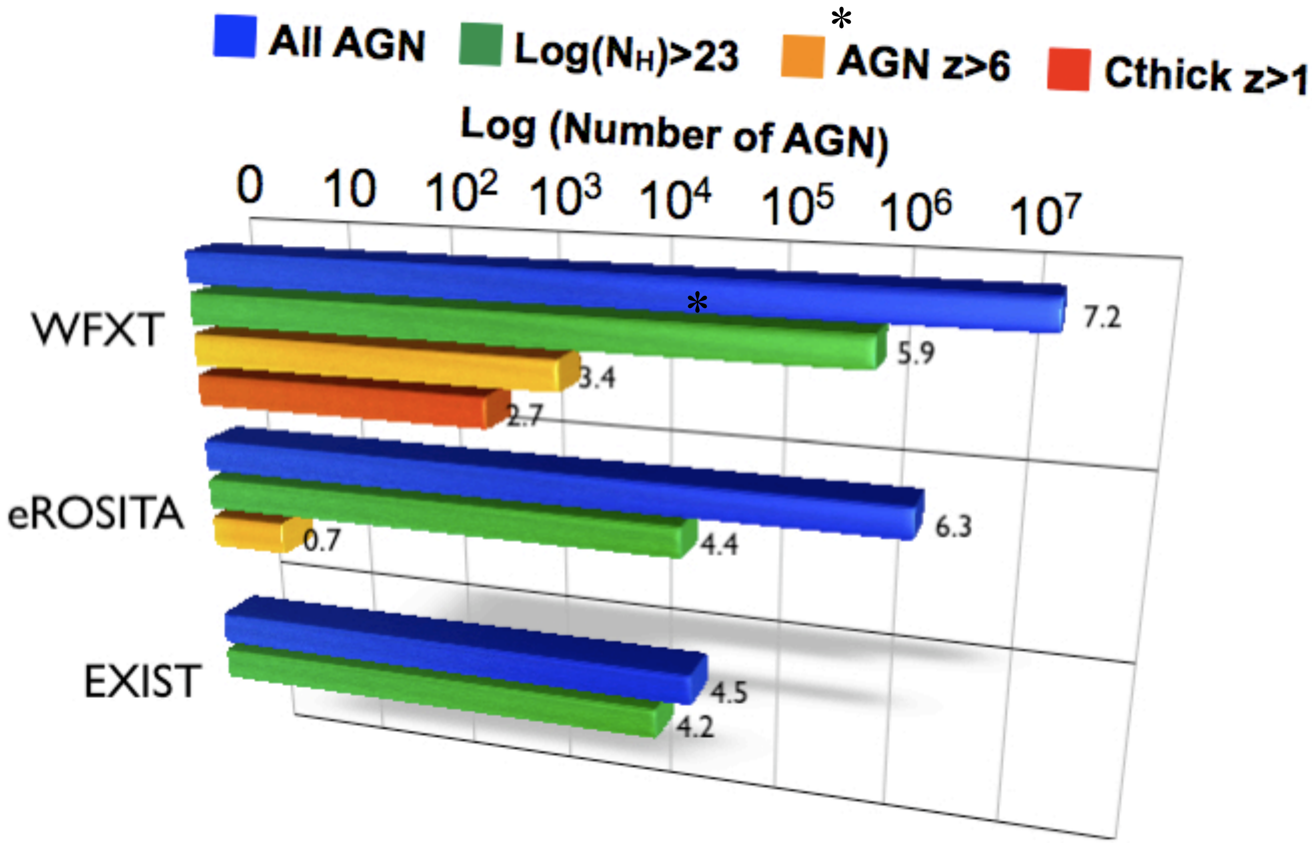
The expected number of AGN

Sample	Wide	Medium	Deep	Total
z>4 decline	30600	38000	6100	74700
z>4 maxlf	31300	54100	43600	1.3e5
z>4 SAM*	55600	84000	34600	1.7e5
z>6 decline	660	1350	310	2320
z>6 maxlf	680	3650	11950	16280
z>6 SAM	30	105	110	245
z>8 decline	22	59	19	100
z>8 maxlf	20	400	3270	3690
z>8 SAM	2e-5	4e-4	3.6e-3	4e-3
z>4, Lx>6e43	30600	30000	1000	61600
z>4, Lx>6e44	6600	1000	33	7600
z>6, Lx>1e45 (sdss)	126	20	1	147
logNH>23	1.9e5	4.1e5	1.8e5	7.8e5
Total AGN	1.0e7	4.0e6	5.0e5	1.5e7

Statistics large enough to determine the XLF of z>6 AGN

* Semi-analytic model by Marulli+08

Comparison with other missions



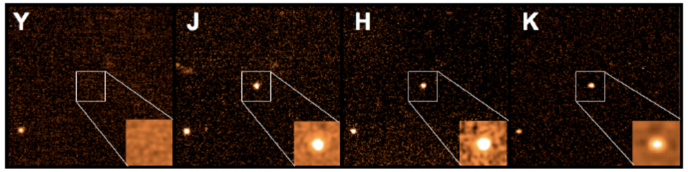
WFXT will provide a large sample of high-z objects for statistical studies (BH formation, evolution)

science case unique to WFXT

*assuming a decline

AGN at $T_{Universe}$ < 0.65 Gyr

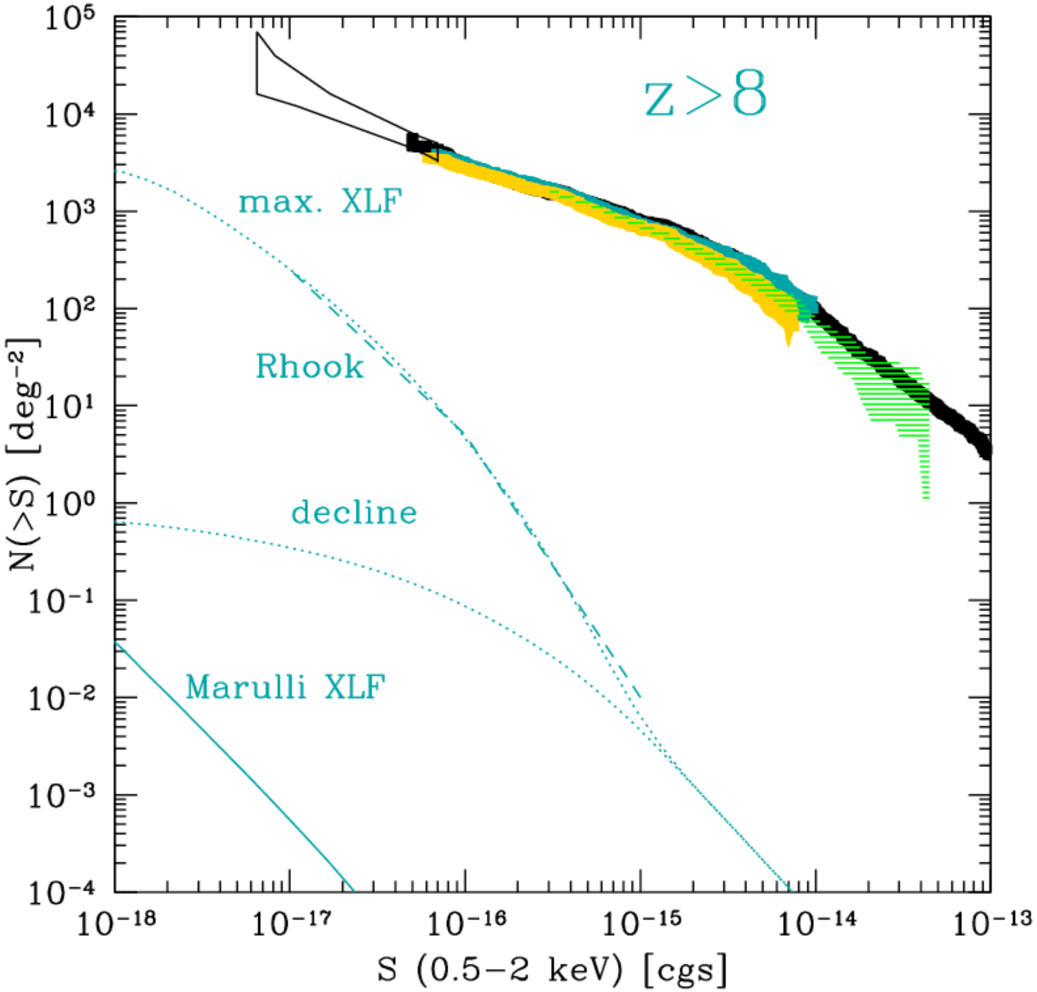
23 April 2009: GRB discovered
at redshift z=8.26; Y-band dropout



Tanvir+09, Salvaterra+09

~100 AGN at z>8 expected
in WFXT surveys:
22 wide
59 medium
19 deep

(based on the "decline"
scenario, the relative fractions
among WFXT surveys change
with the assumed evolution)



Evolution of the obscuration

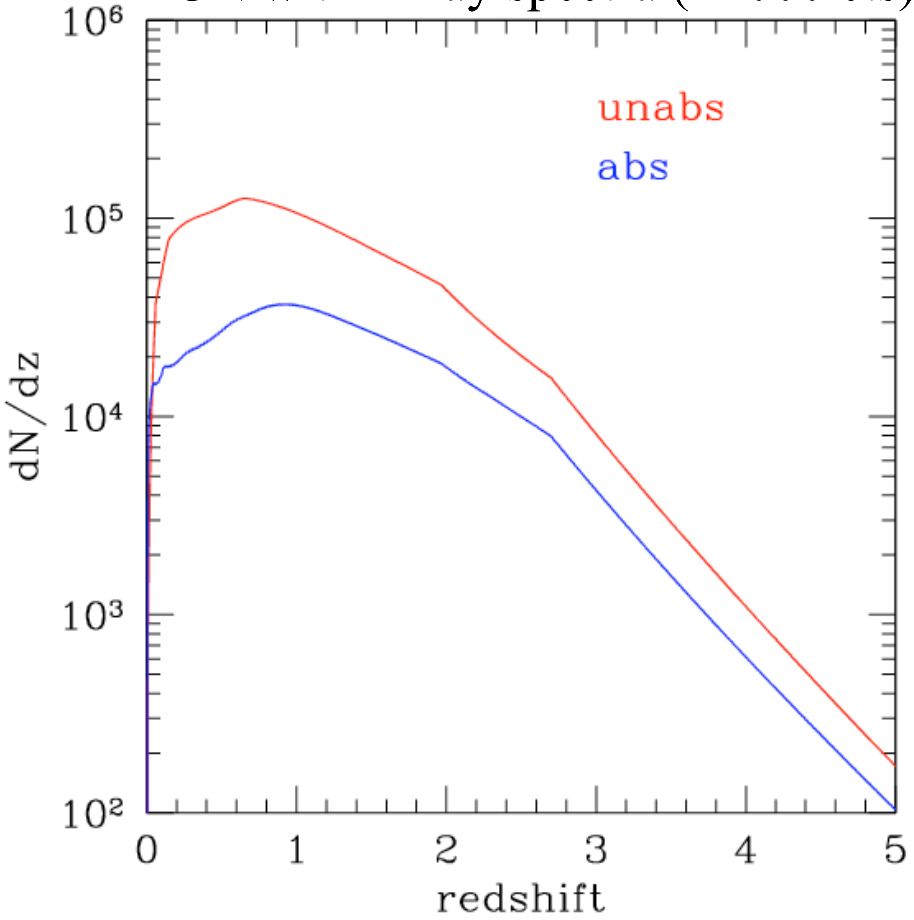
Current XLFs contain <~ 2000 AGN (Hasinger+08, Aird+09, Yencho+09)

N_H mostly comes from HR or low quality spectra. What is the XLF and evolution of obscured AGN?

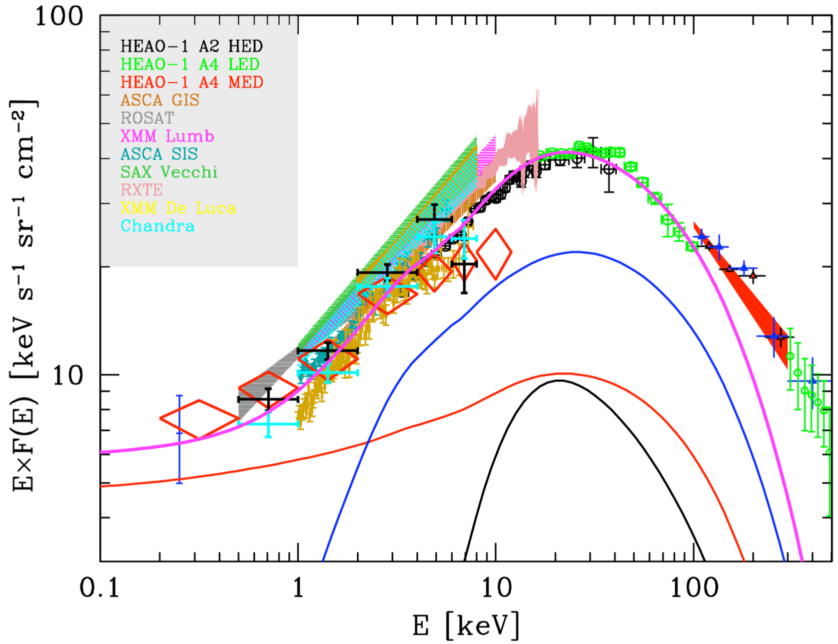
With WFXT:
300,000 AGN with X-ray spectra at z=[0-5]
200,000 unabsorbed
100,000 absorbed

➔evolution of obscuration measured (provided spectro-z or photo-z are available)

AGN with X-ray spectra (>1000 cts)

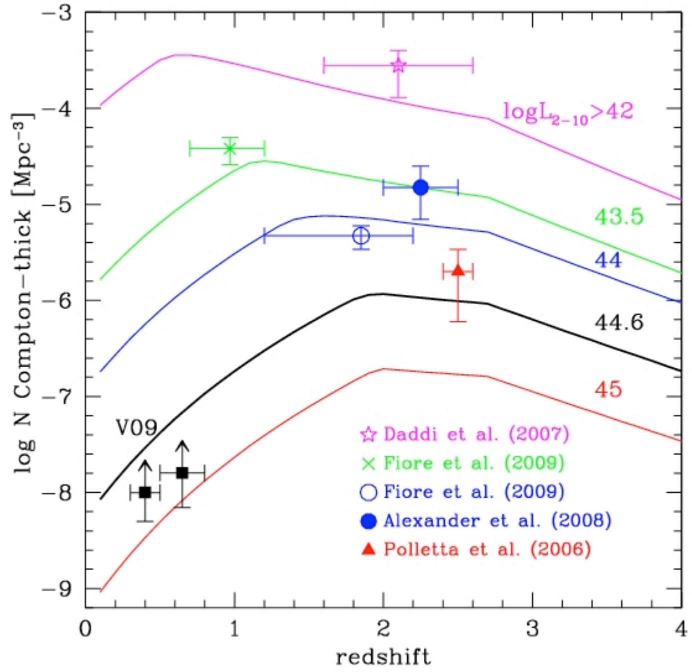


The most obscured objects: Compton thick AGNs



C-thick AGN at z~1 invoked to explain the 30 keV XRB, however their XLF and evolution completely unknown

Vignali+09

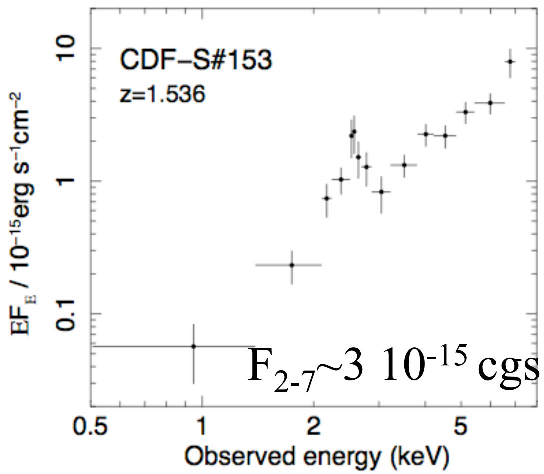


About 50 *bona fide* C-thick AGN known, mostly at z<0.1. Recent attempts to determine the size of the C-thick population rely on X-ray stacking of IR selected objects or X-ray/[OIII] ratio, i.e. no direct measurement

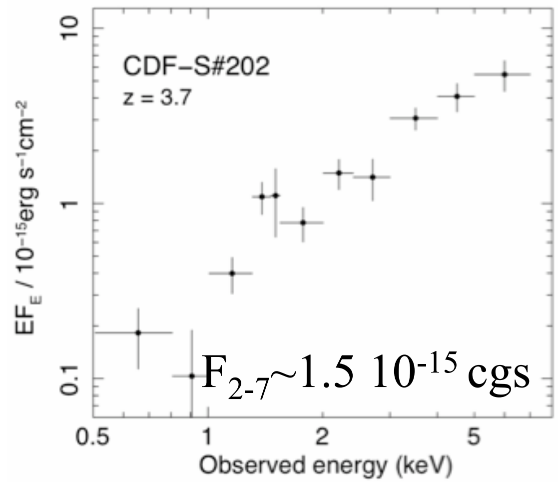
Plotted errorbars are statistics, but in fact systematics dominate the uncertainties

Two examples of distant Compton-thick AGN

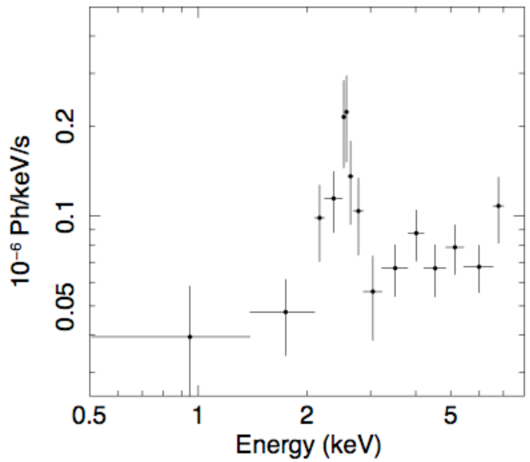
CDFS-153, z=1.5 XMM 1.8 Msec spectra CDFS-202, z=3.7



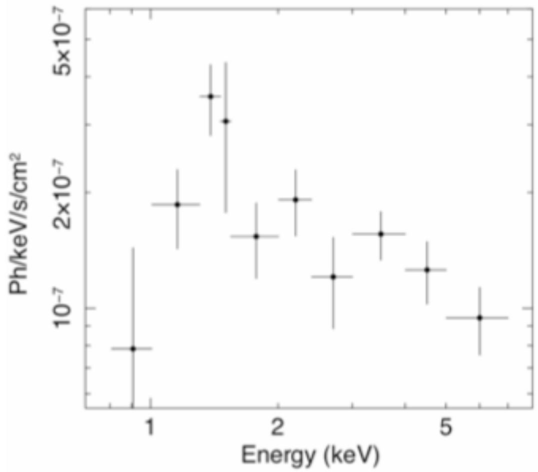
F_{2-7}~3 10^{-15} cgs



F_{2-7}~1.5 10^{-15} cgs



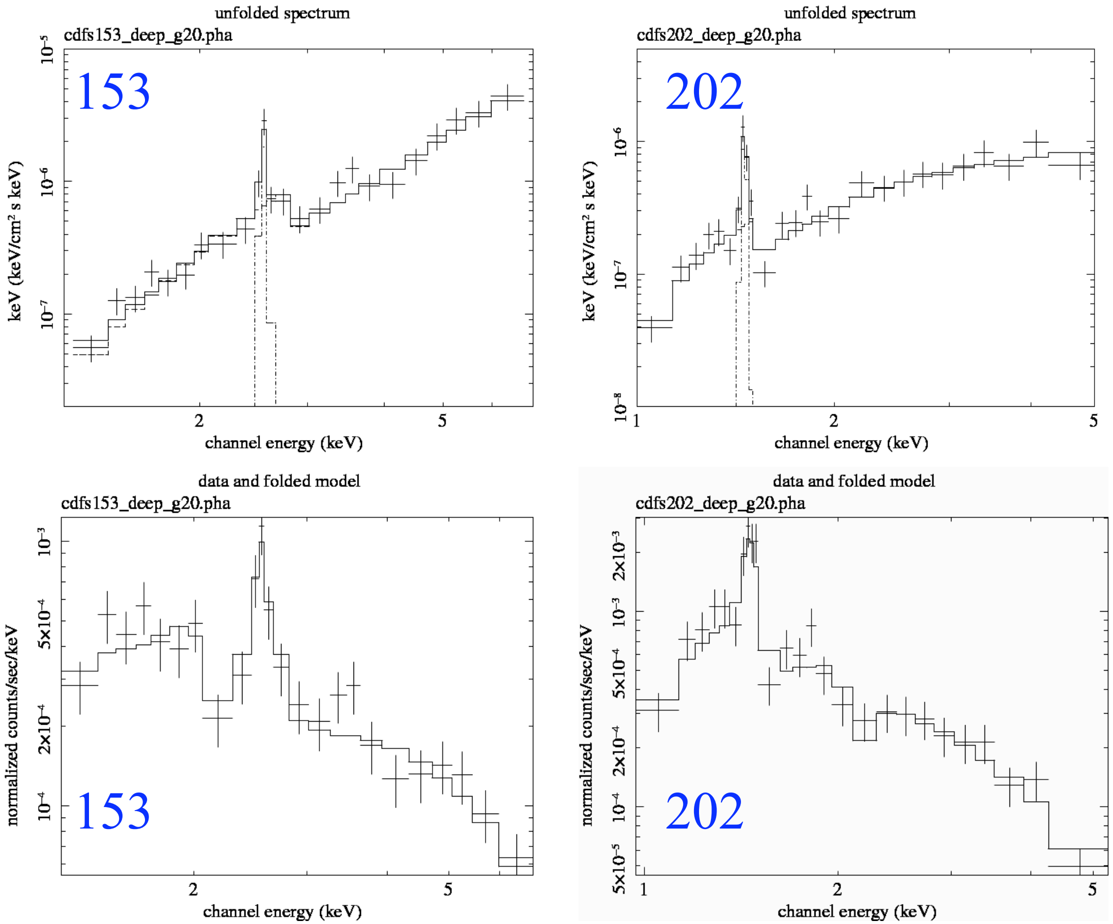
~650 net cts



~320 net cts

CDFS-153 and CDFS-202 in the WFXT Deep (100deg^2, 400ks) survey

~500 cts 0.5-7 keV



About 500 objects like these expected at z > 1, enough for population studies ← UNIQUE

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

No bkg in the spectral simulations, but few (~ 10-20) bkg counts expected at E > 1 keV

Final remarks

- ~15 millions AGN detected by WFXT; 300,000 with more than 1000 net cts, i.e. accurate N_H ➔ evolution of obscured AGN, e.g. abs/unabs vs z

- WFXT will break through the high-z Universe: >2000 AGN at z>6 ➔ AGN population studies at z>6 * UNIQUE *

- ~500 *bona fide* C-thick AGN at z>1 in the WFXT deep survey ➔ Evolution of high-z C-thick population * UNIQUE *