The Nature of the unresolved soft CXB:

a population synthesis model of its fluctuations

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T. Miyaji[8], F. Nicastro[9], I. Georgantopoulos[3,1] and A. Kashlinsky[10,11]

Open questions on the sources of the unresolved CXB

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Unresolved CXB contains information on all those sources that we haven't seen,... yet!

How many AGN at high-z?

AGN Number Density
at high-z

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Formation of the black hole seeds that form SMBHs

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1-few accretion episodes
2-chaotic accretion (hundreds to thousands of small accretion episodes)

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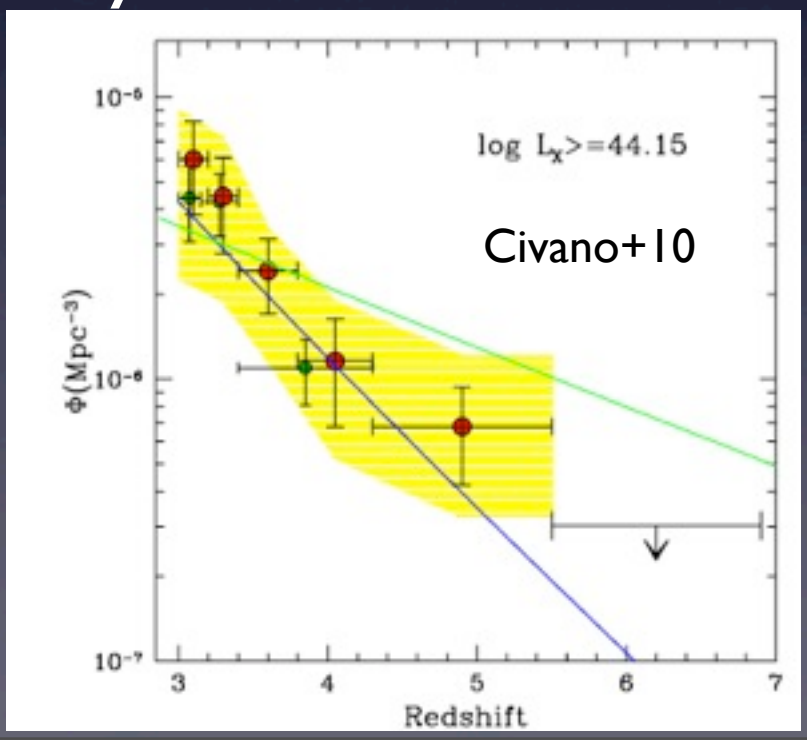

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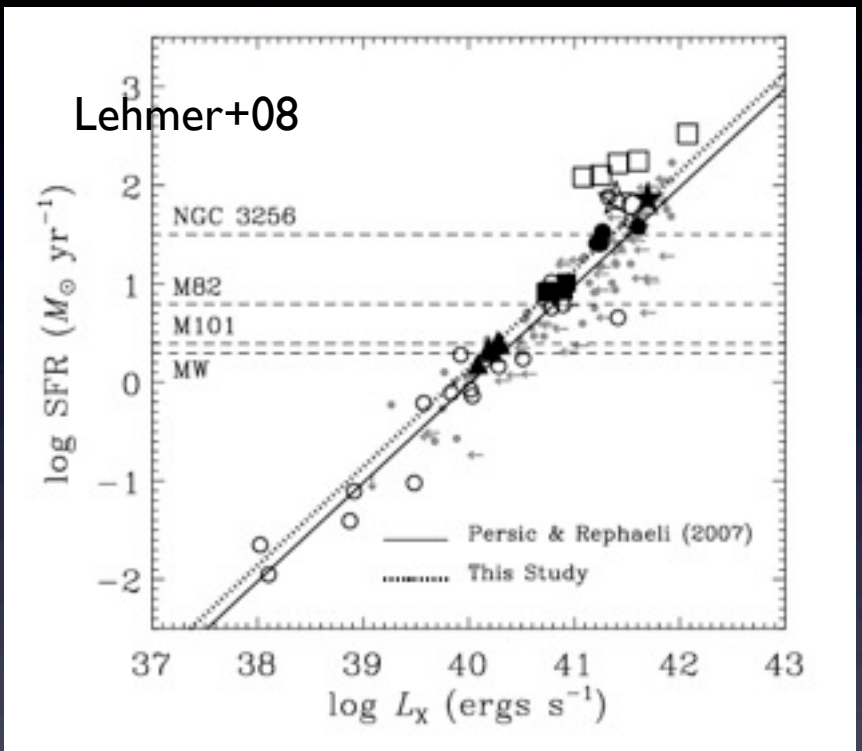
X-ray are diagnostics of SFR through X-ray: Binaries, SNr



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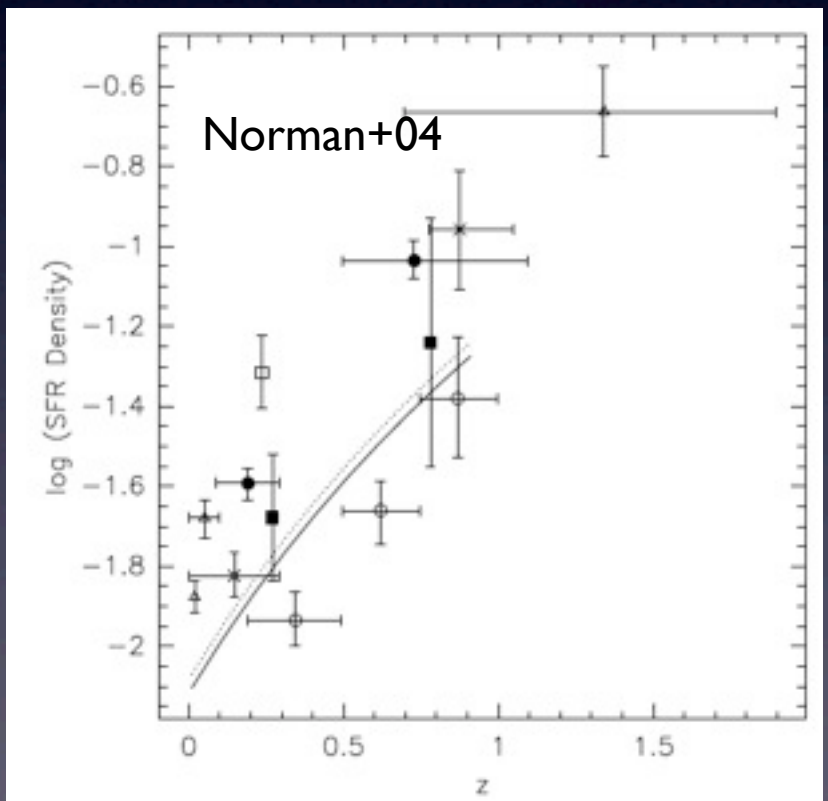

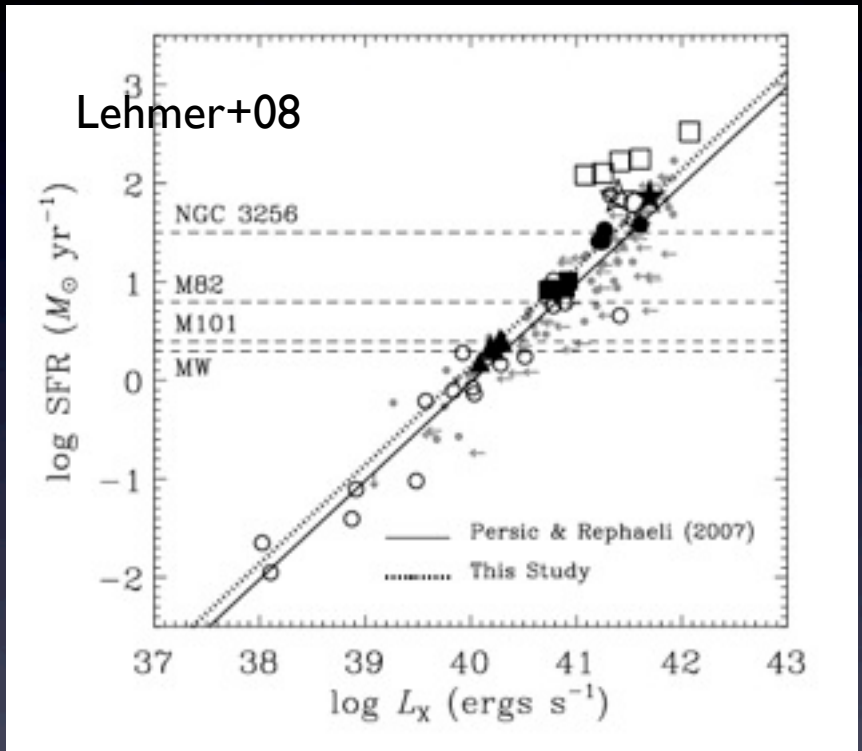

Local XLF is known, but evolution has been detected only to z~1

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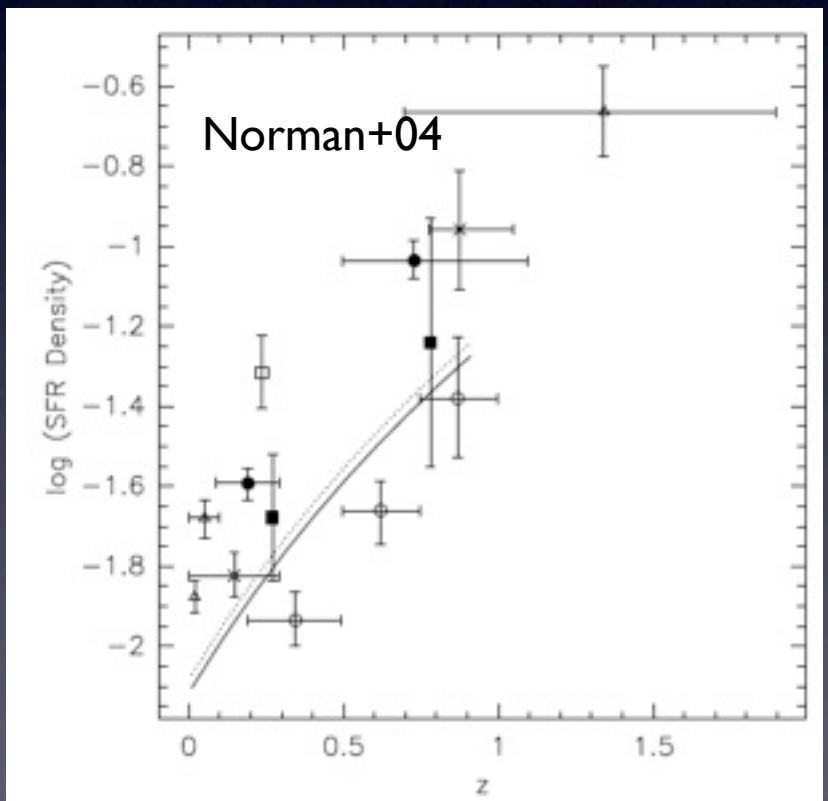

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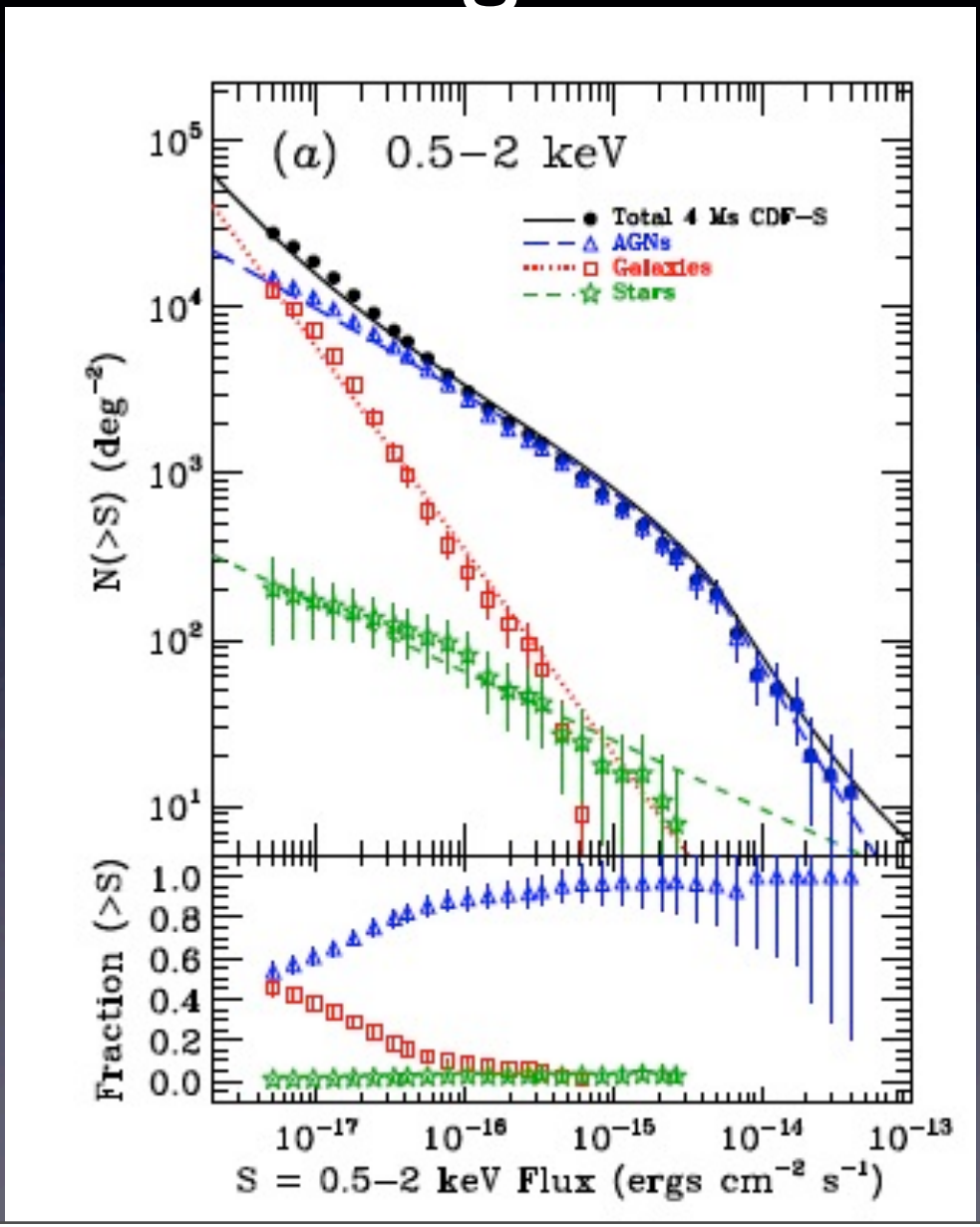
At current X-ray flux limit galaxies are as numerous as AGN
Lehmer+12



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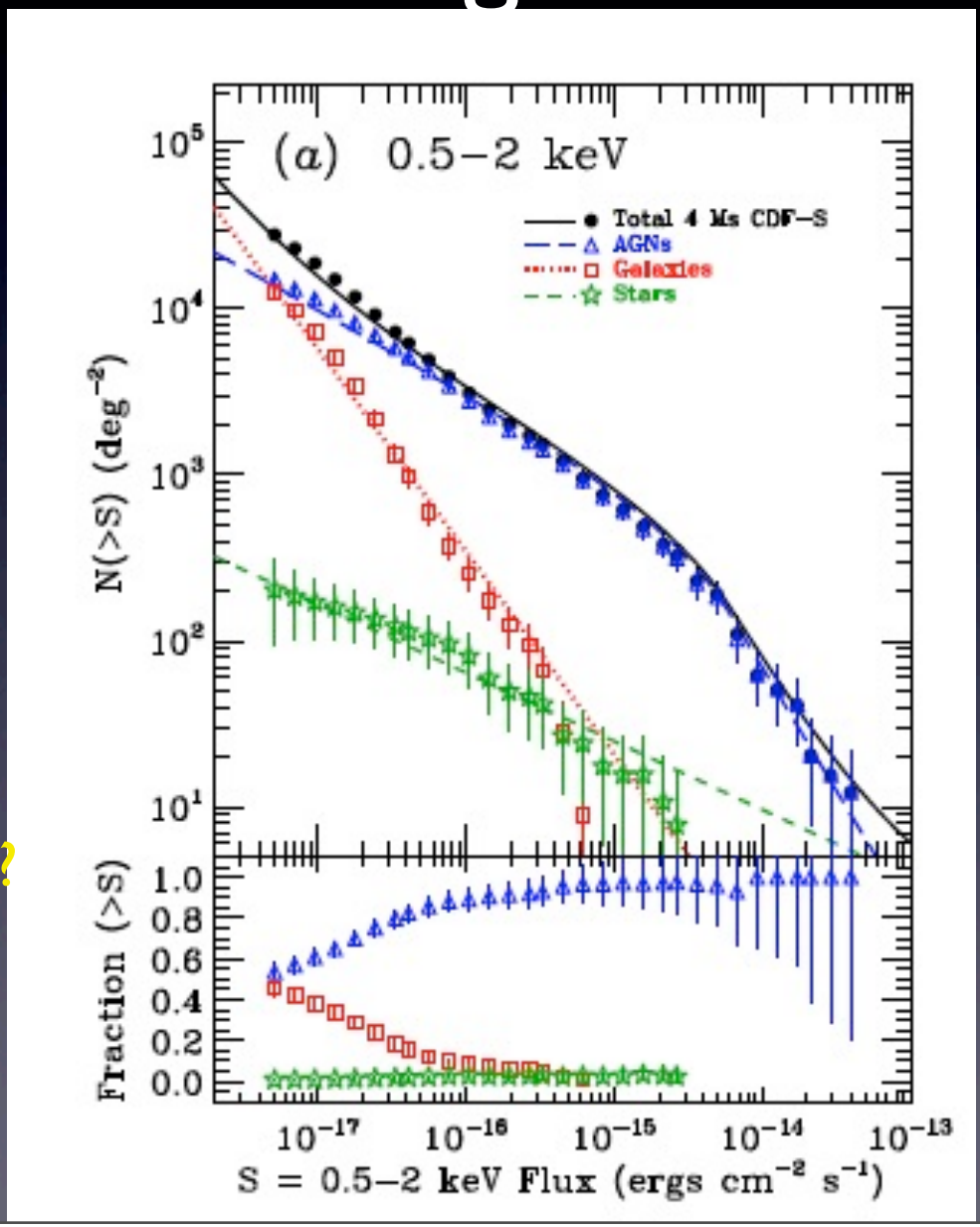
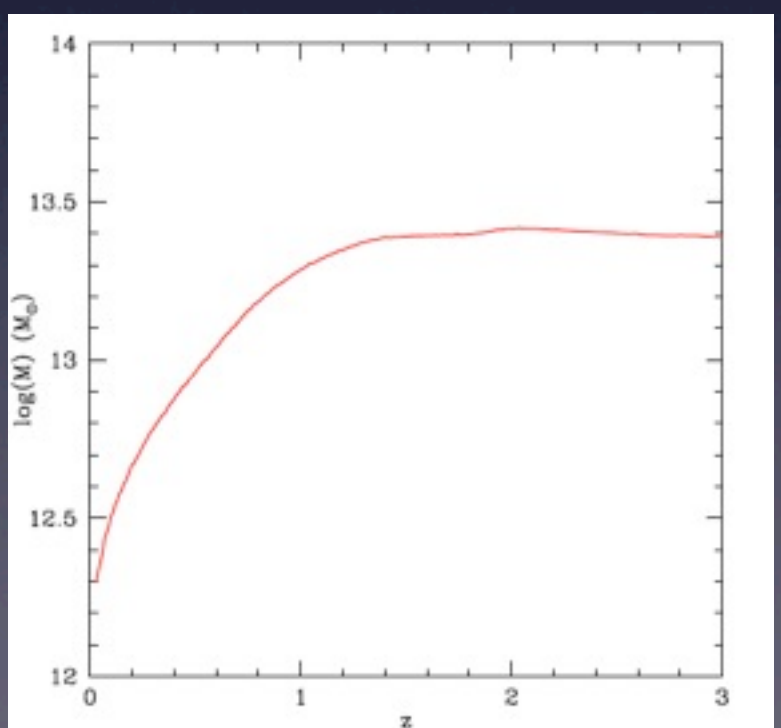
How does the X-ray emission evolve?

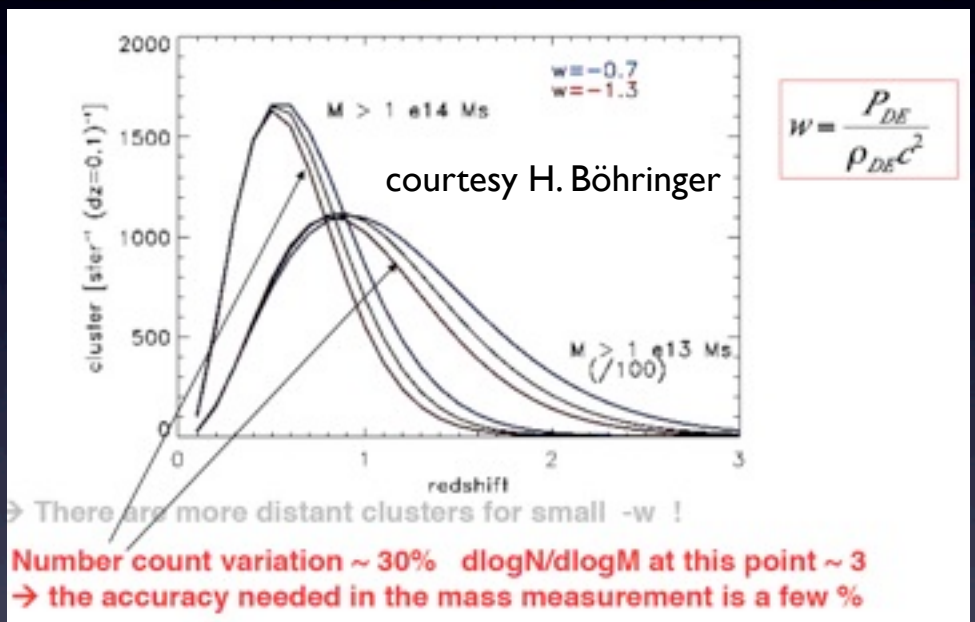


How many high-z clusters?

Is a probe of structure growth: Dark Energy

Number density of Galaxy cluster





Limits of 4 Ms CDFS

How do SMBH form?

Massive Progenitors

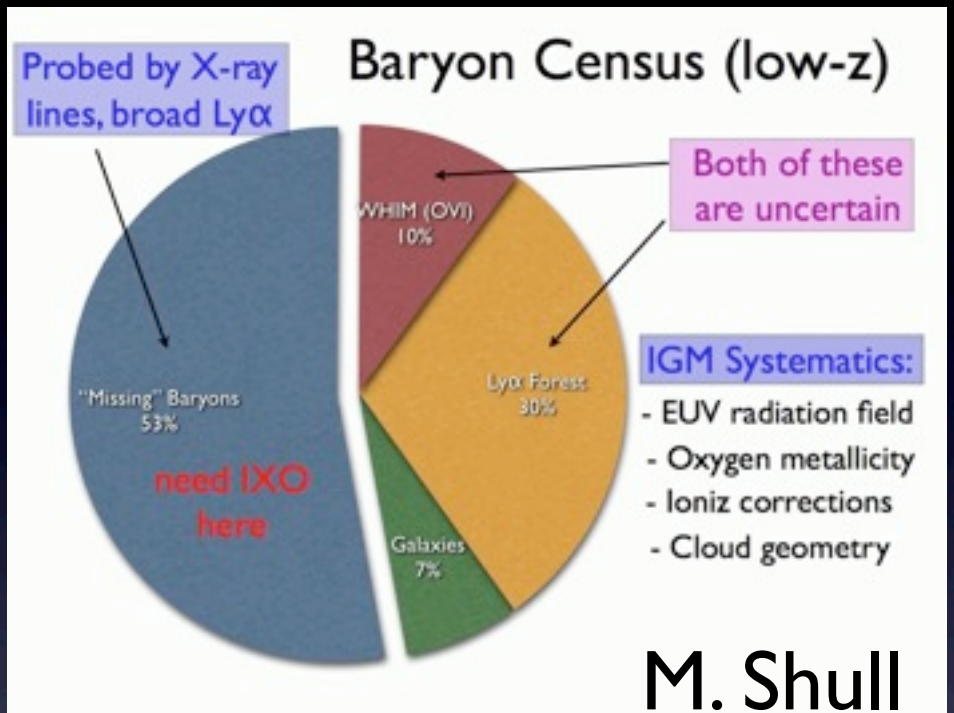
QUASI STARS
$M_{BH}=10^4$-$10^5 M_\odot$
Begelman+08

We need to explain how to make a 10^9 $M_\odot$ SMBH @z~7

POPIII, Metal free massive stars
$M_{BH}=10^2$-$10^3 M_\odot$

These sources should leave their signature in the anisotropies of Cosmic backgrounds
Kashlinsky+05,07,12

Missing Baryons (WHIM)



Half of the baryons are missing in the Local Universe wrt to z~3 and are supposed to lie in the WHIM

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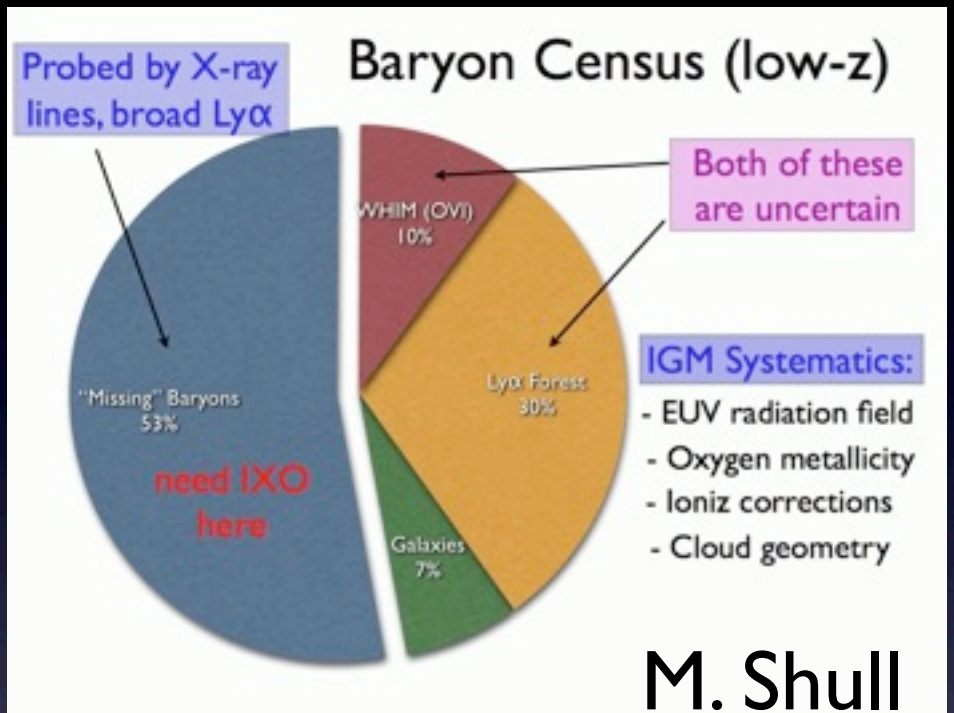

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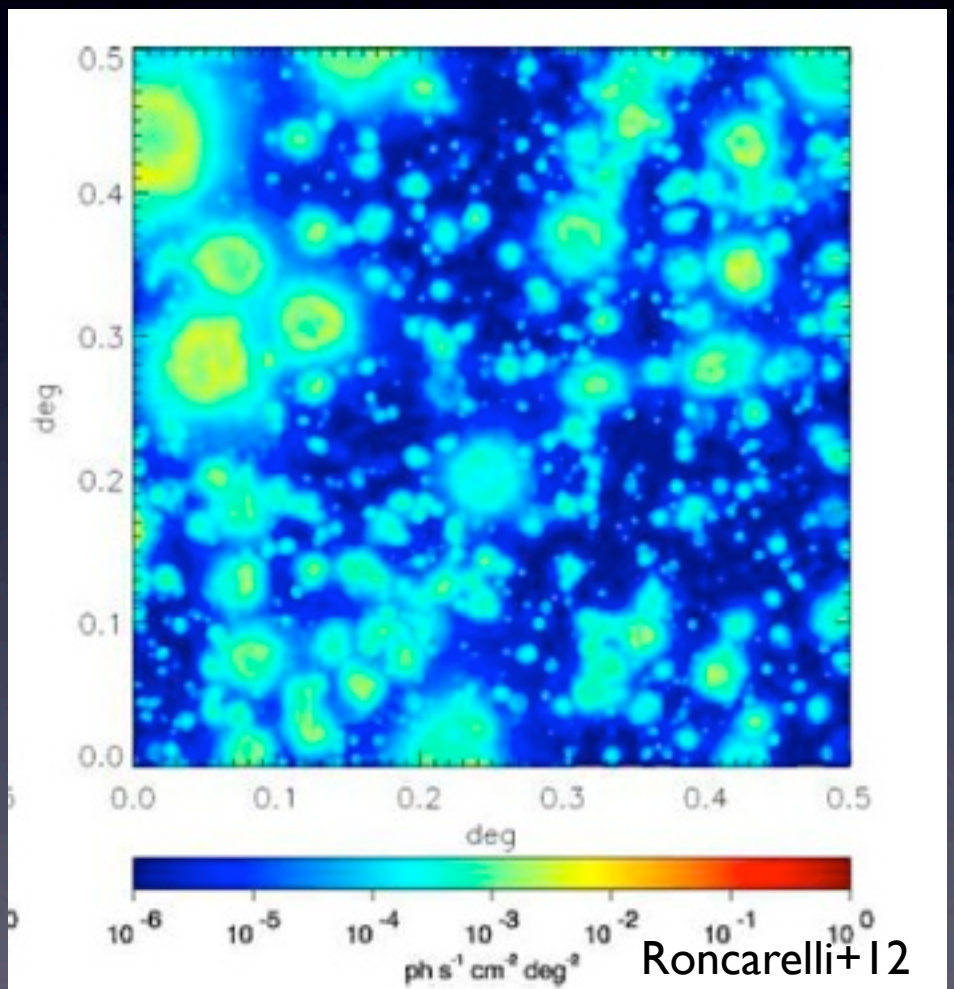
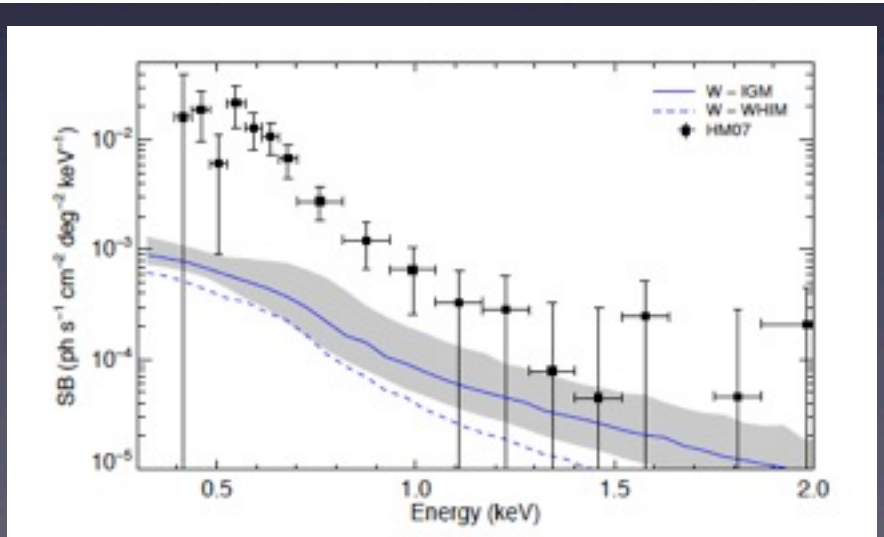
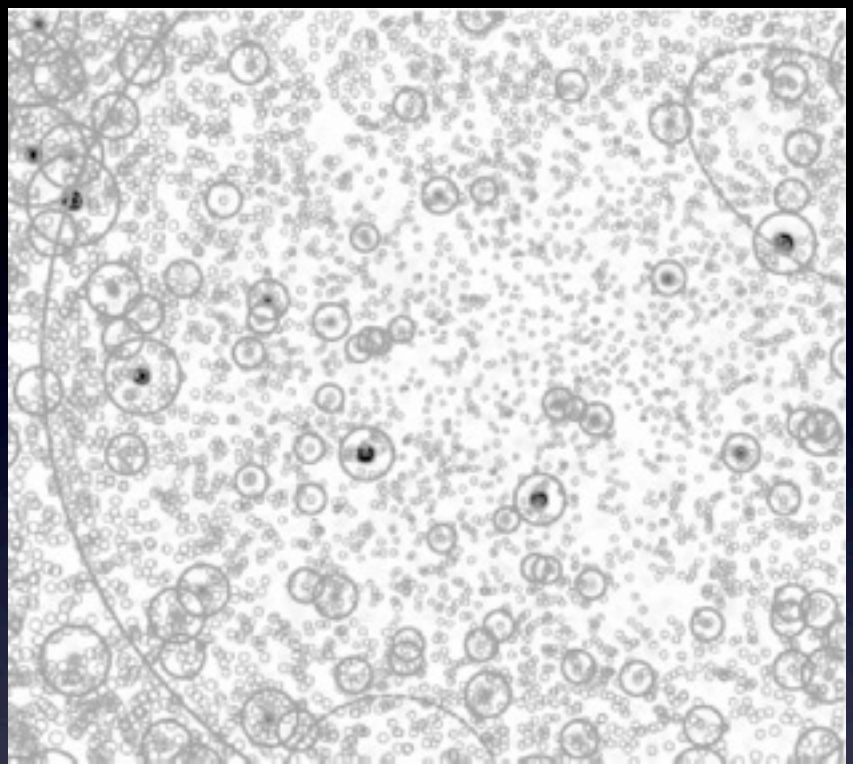


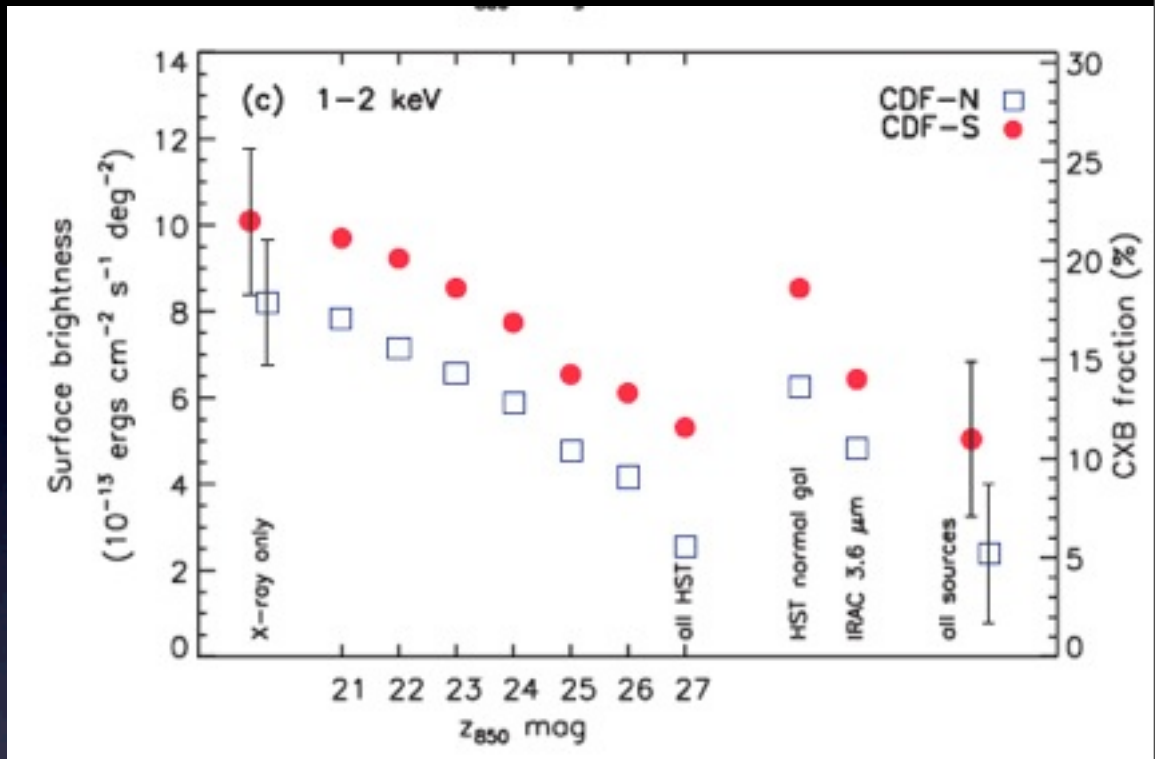


Significant contribution to the soft CXB

3-The unresolved CXB

Previous studies





Removal of HST Galaxies down to z_{850}=27 and X-ray sources in CDFS, only 50% of the soft unresolved 1-2 keV CXB is explained

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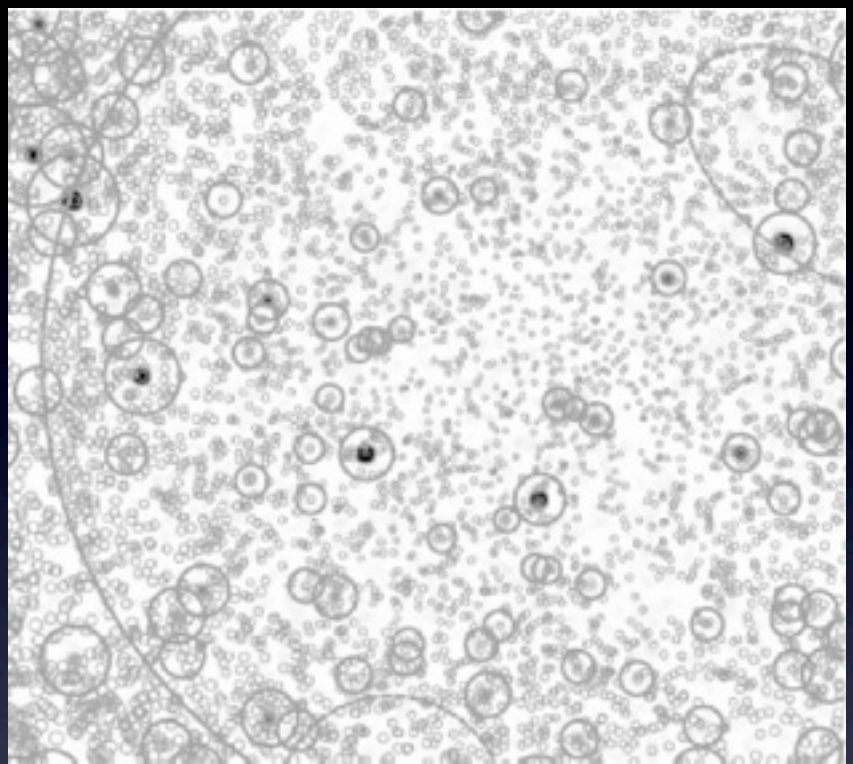

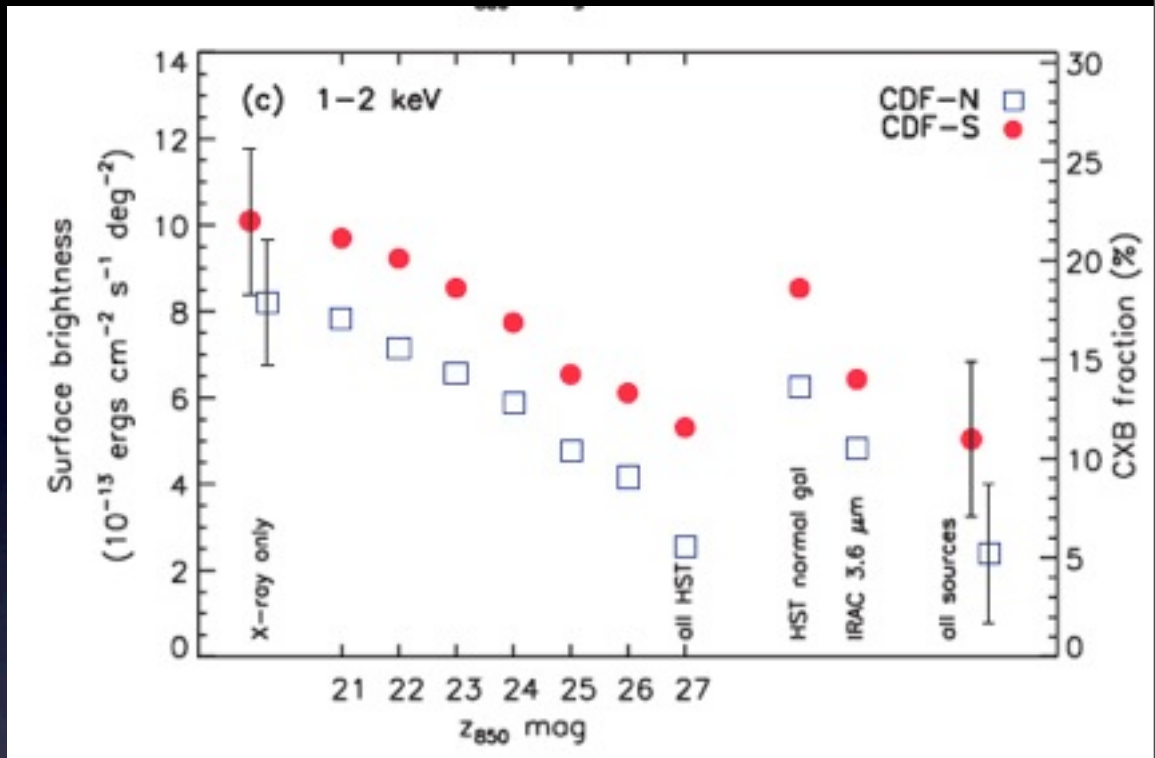

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Faint or diffuse sources should produce the remainder CXB

The Power Spectrum of fluctuations in the CDFS

- The PS contains information on both clustering and emissivity evolution of a given source population

$$P_{2,AGN}(q) = \int_0^z \left(\frac{dS}{dz}\right)^2_{AGN} \frac{P_{3,AGN}(qd_A^{-1}, z)}{c\ dt/dz\ d_A(z)^2}\ dz$$

- Shot Noise

$$P_{2,SN} = \int_0^{S_{lim}} S^2 \frac{dN_X}{dS} dS,$$

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- PS can be decomposed in additive components

$$P_{2,CXB}(q) = P_{2,SN}(q) + P_{2,AGN}(q) + P_{2,GAL}(q) + P_{2,IGM}(q)$$

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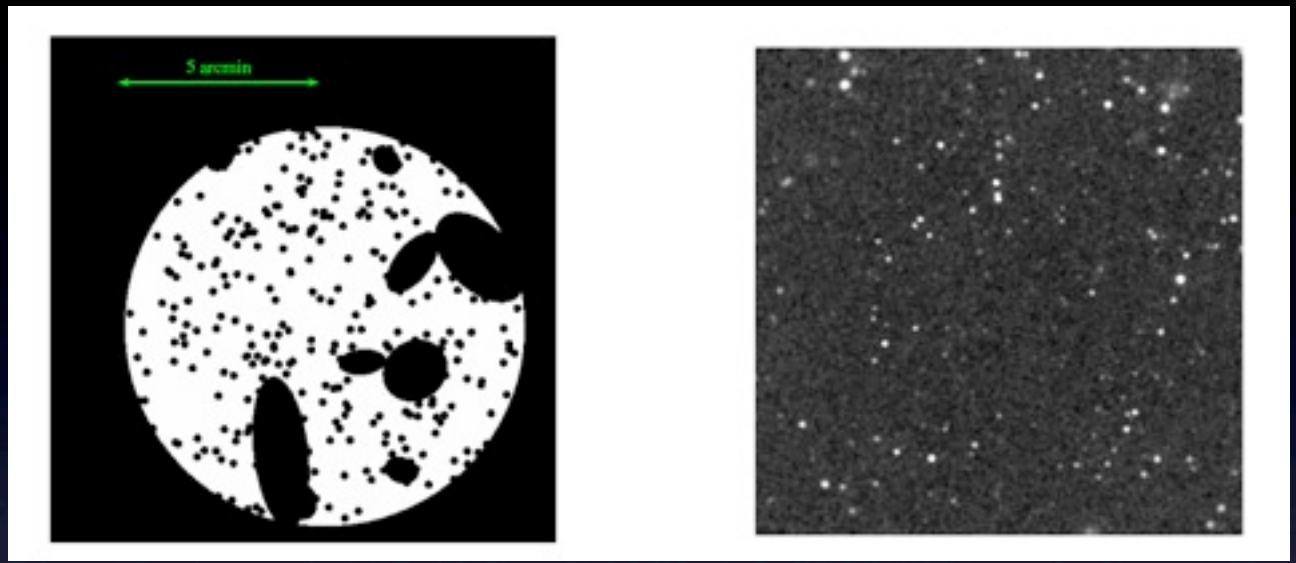
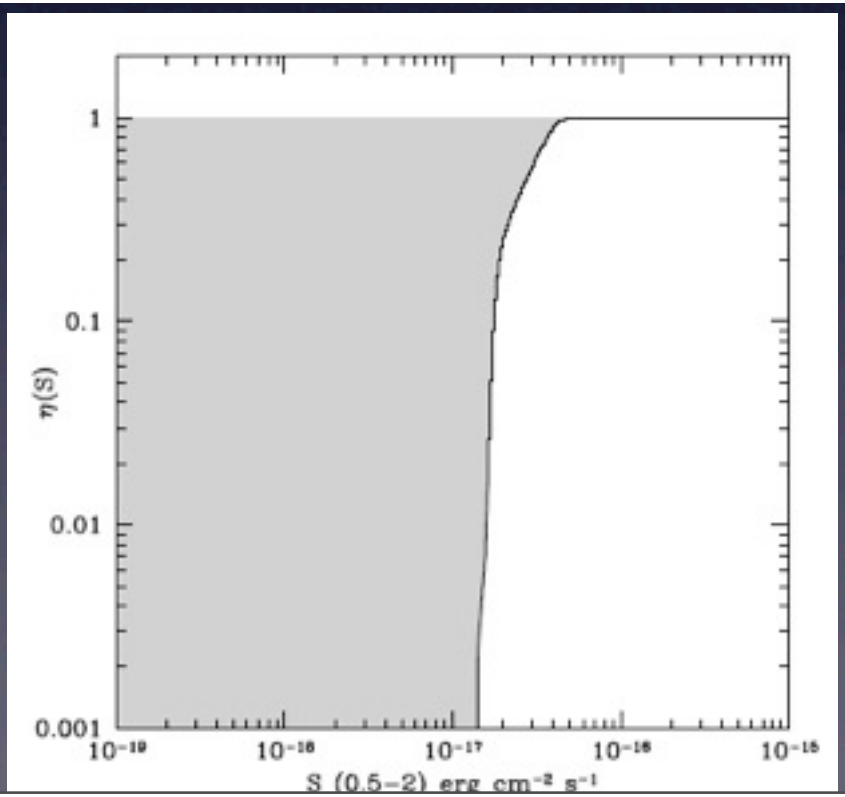
Dataset



4 Ms 0.5-2 keV
CDFS survey
Xue+11



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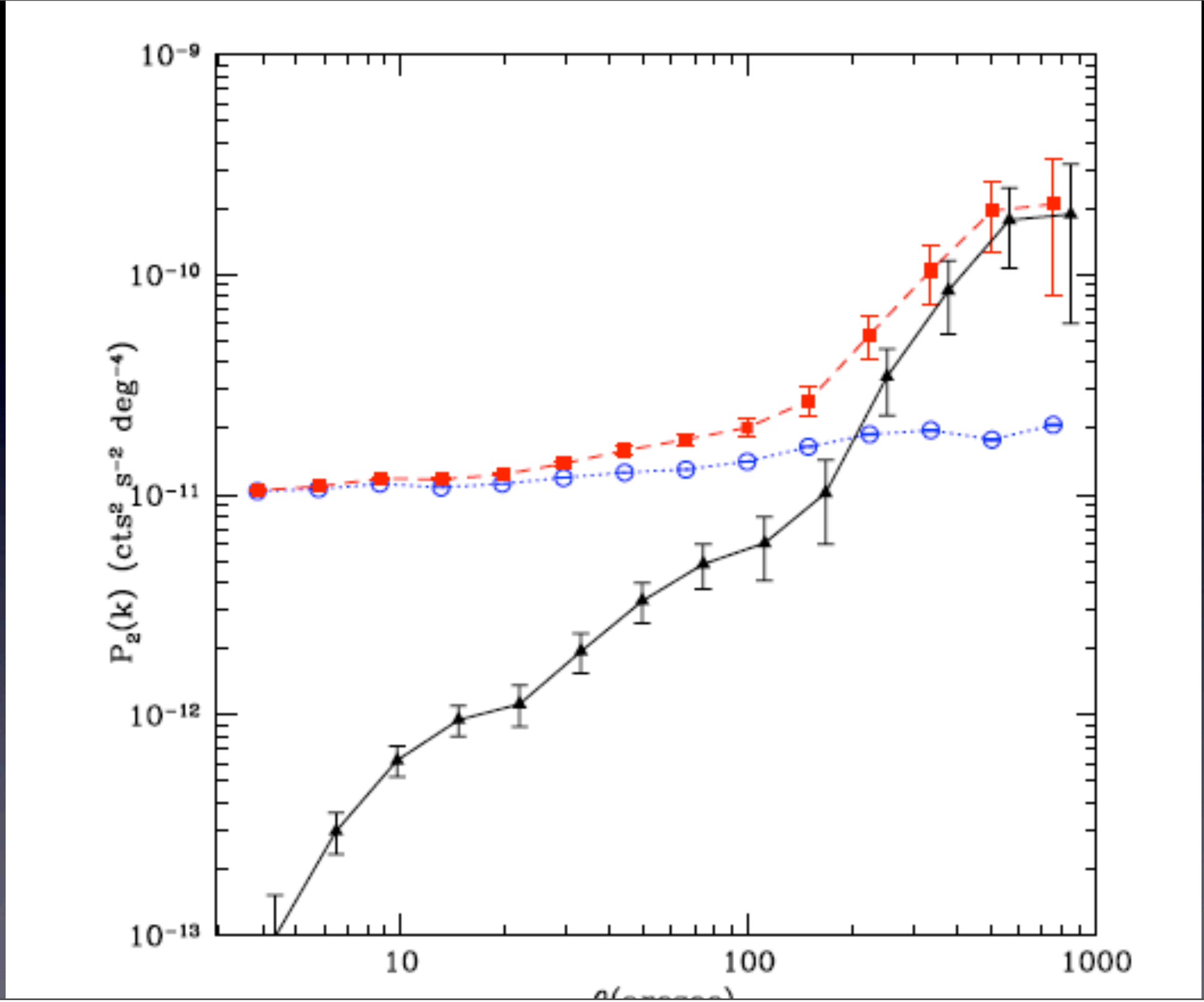

10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
$P_2(k)$ (cts^2 s^{-2} deg^{-4})
10
100
1000

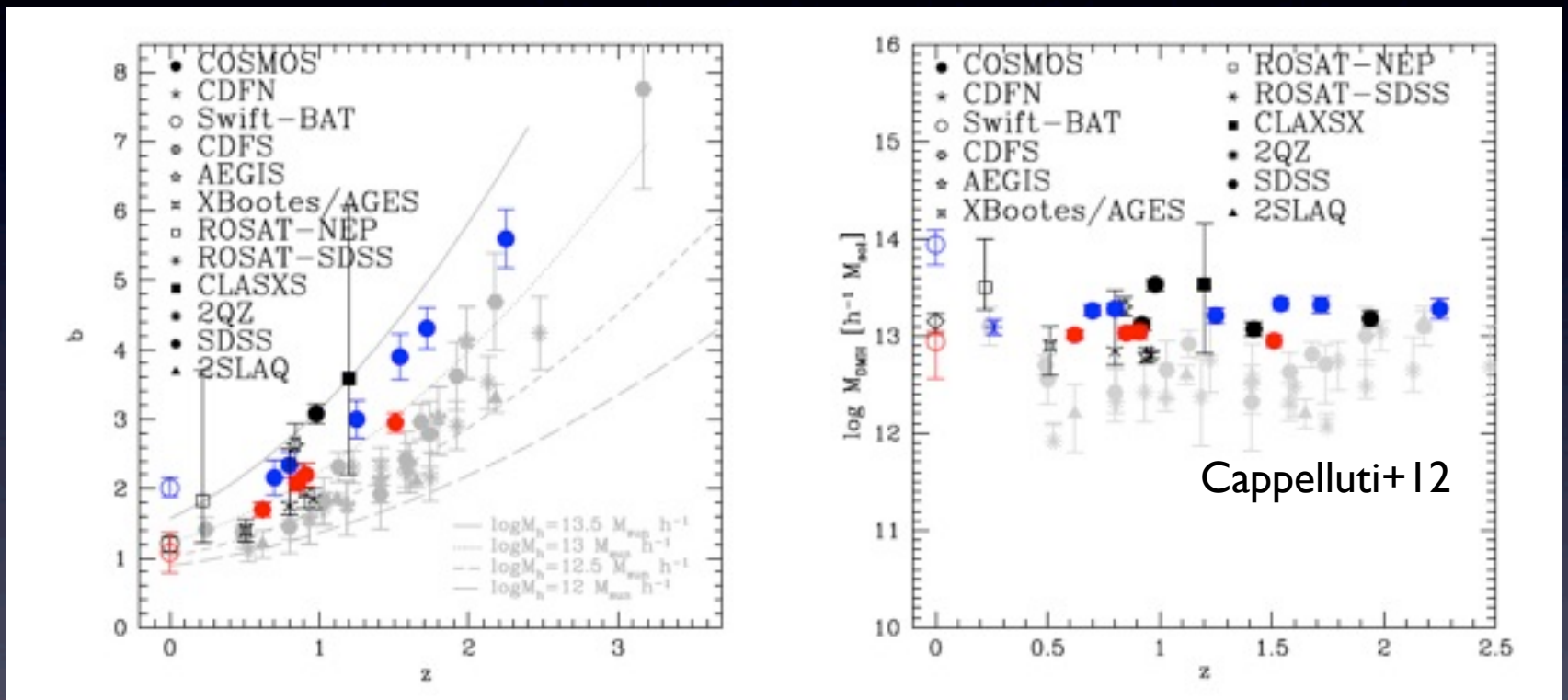
How do we explain these fluctuations?

Model of Point source

- We need to feed into the model a recipe for
- Emissivity evolution
- Bias evolution
- Cosmology... (we believe in ΛCDM)

AGN clustering

$$P_{3,AGN}(k,z) = b(z)^2 P_{3,M}(k,z),$$

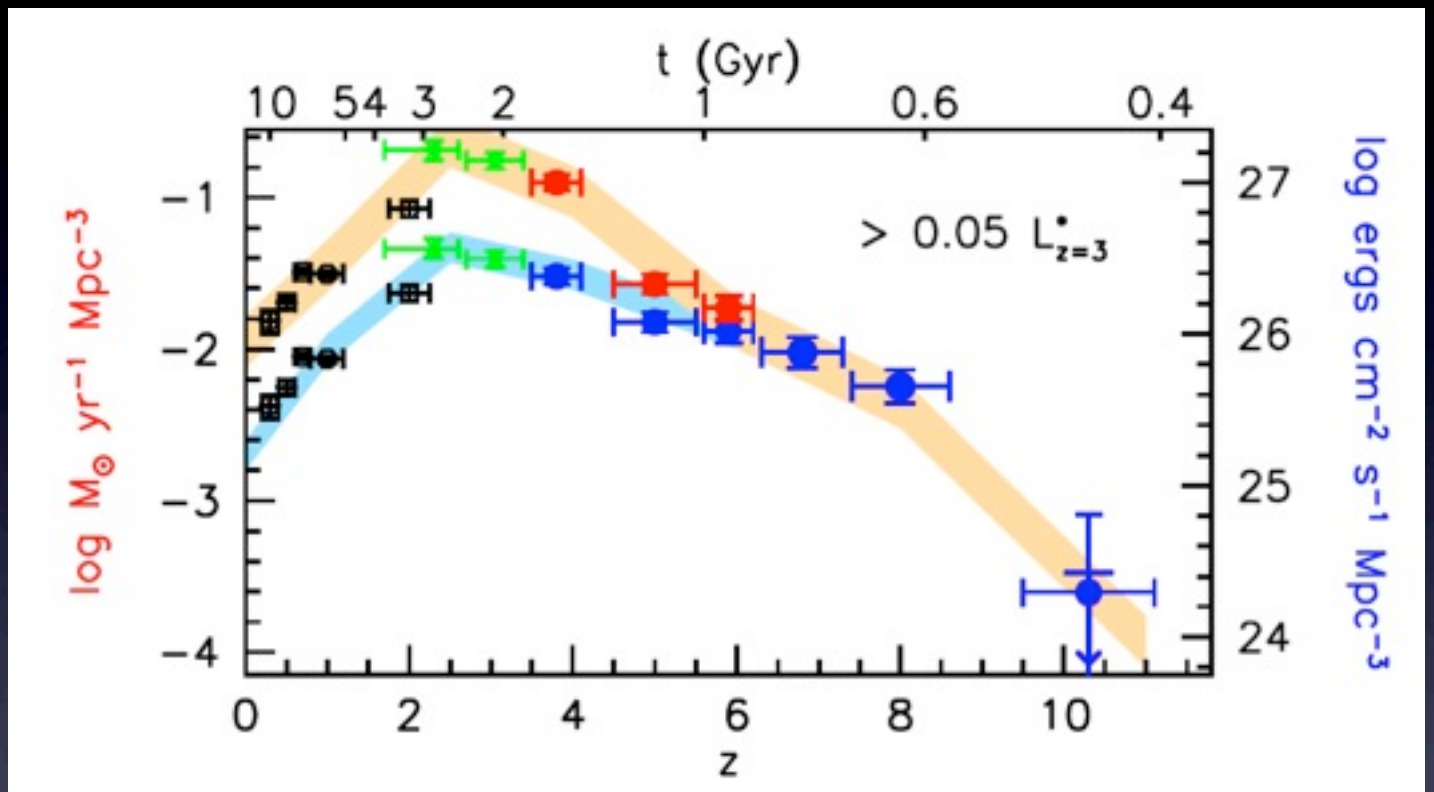


AGN follows logM~13 at all z!

AGN biasing evolution is strictly related with the AGN activation mechanisms!

Model of Galaxies

Assumption:
X-ray galaxies evolve like SFR (Bouwens+10) starting from z~0 XLF (Ranalli+06)



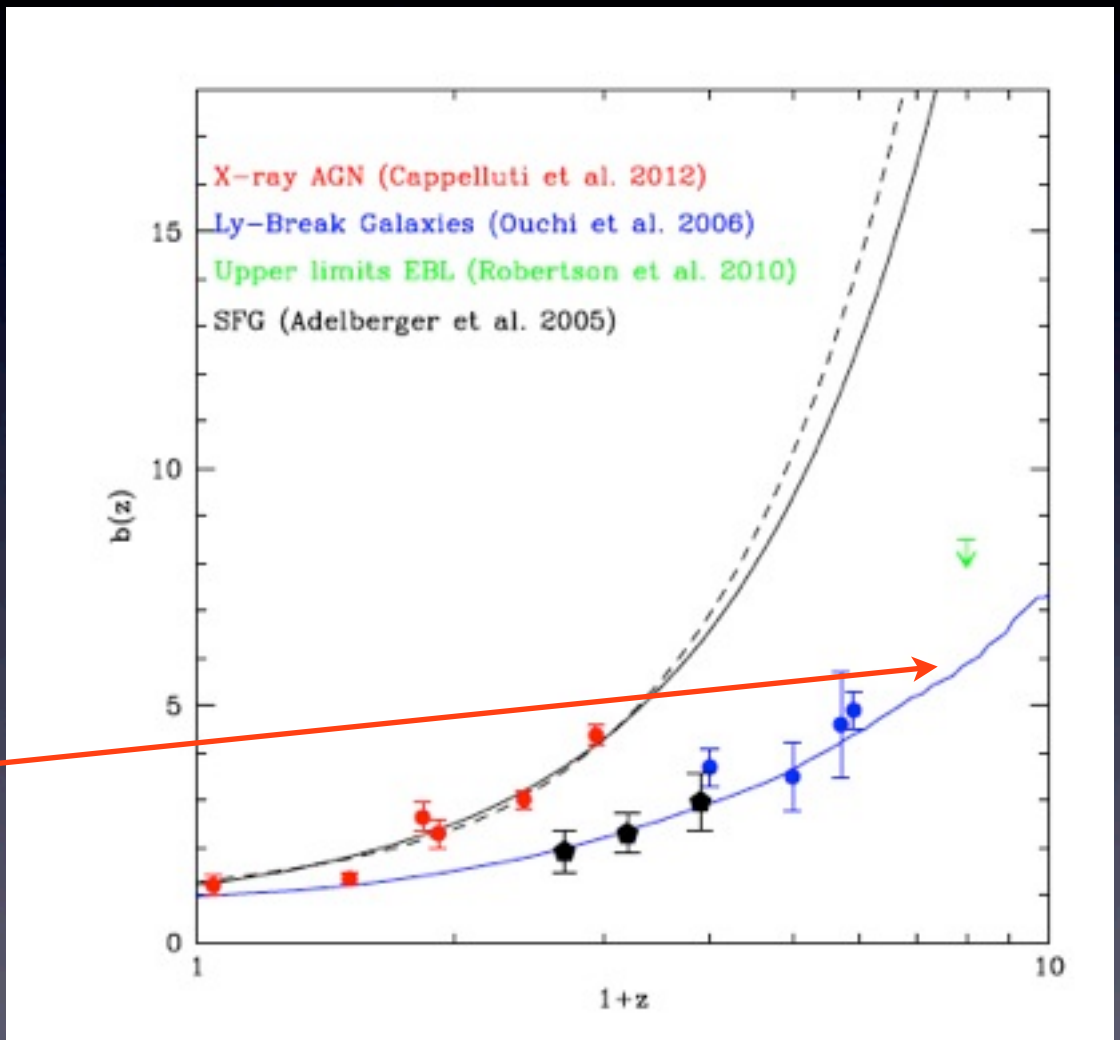
X-ray galaxies evolution is not known above z~1

Galaxies Bias

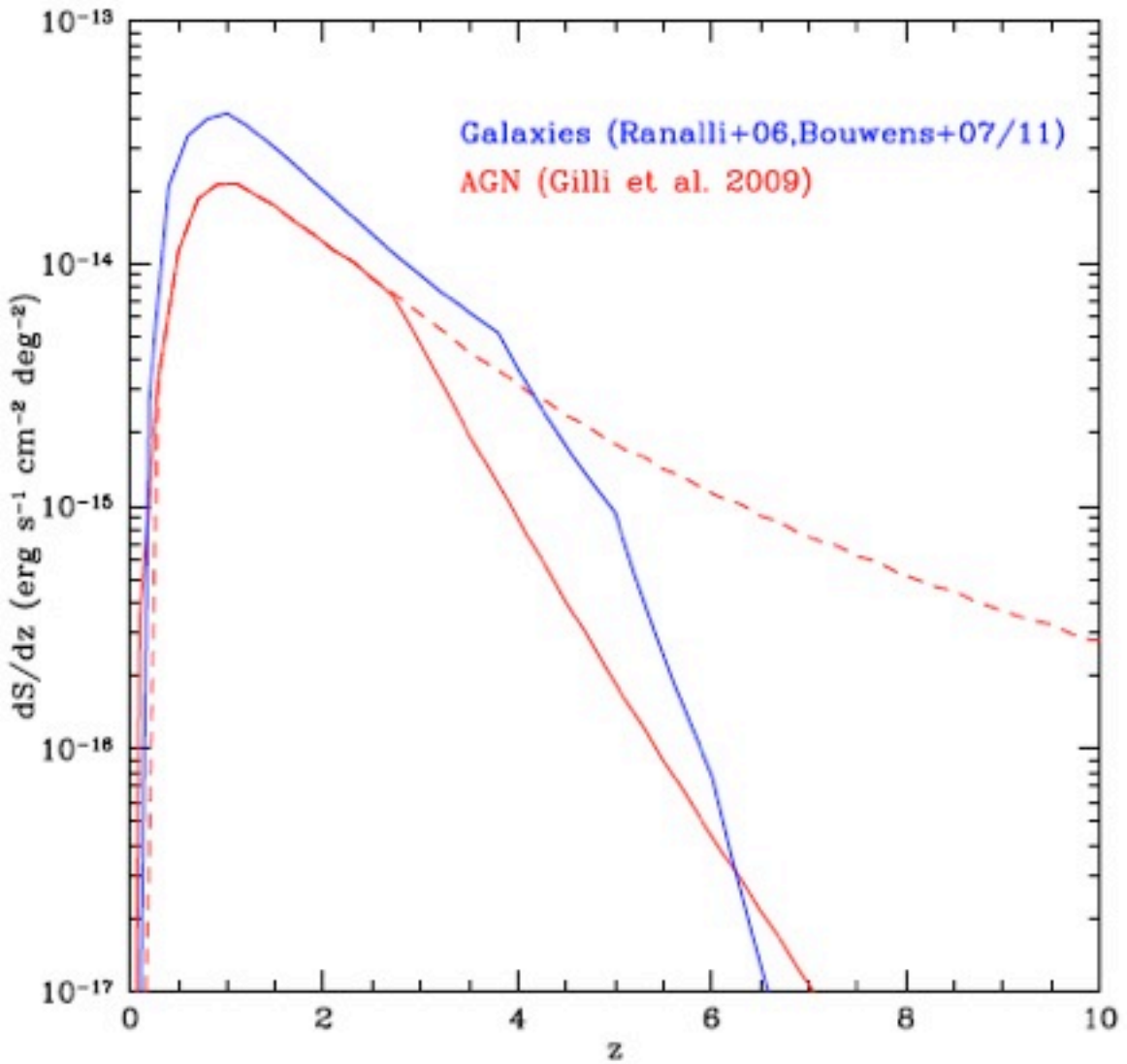
Assuming r_0=4.5 Mpc/h, γ=1.6 like for SFG

$$(\sigma_{8,G})^2 = J_2(\gamma)\left(\frac{r_0}{8Mpc/h}\right)^{\gamma}$$

$$b(z) = \sigma_{8,G}(z)/\sigma_{8,DM}(z),$$

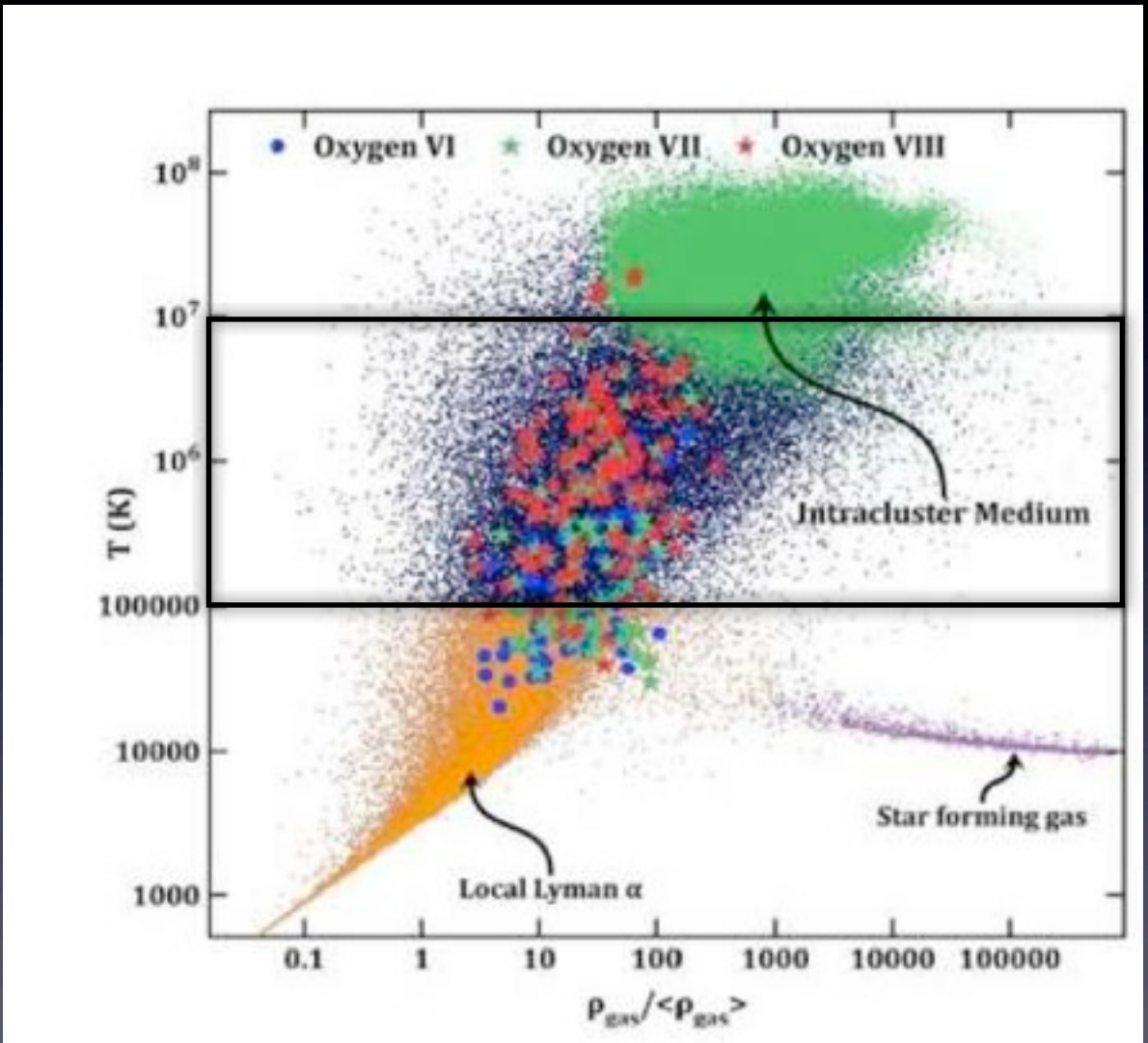


Contribution of undetected point sources to the CXB



Galaxies are the main contributors in flux and like AGN peak at z~1

Model of WHIM



WHIM is by definition whatever has $10^5 < kT < 10^7$ K

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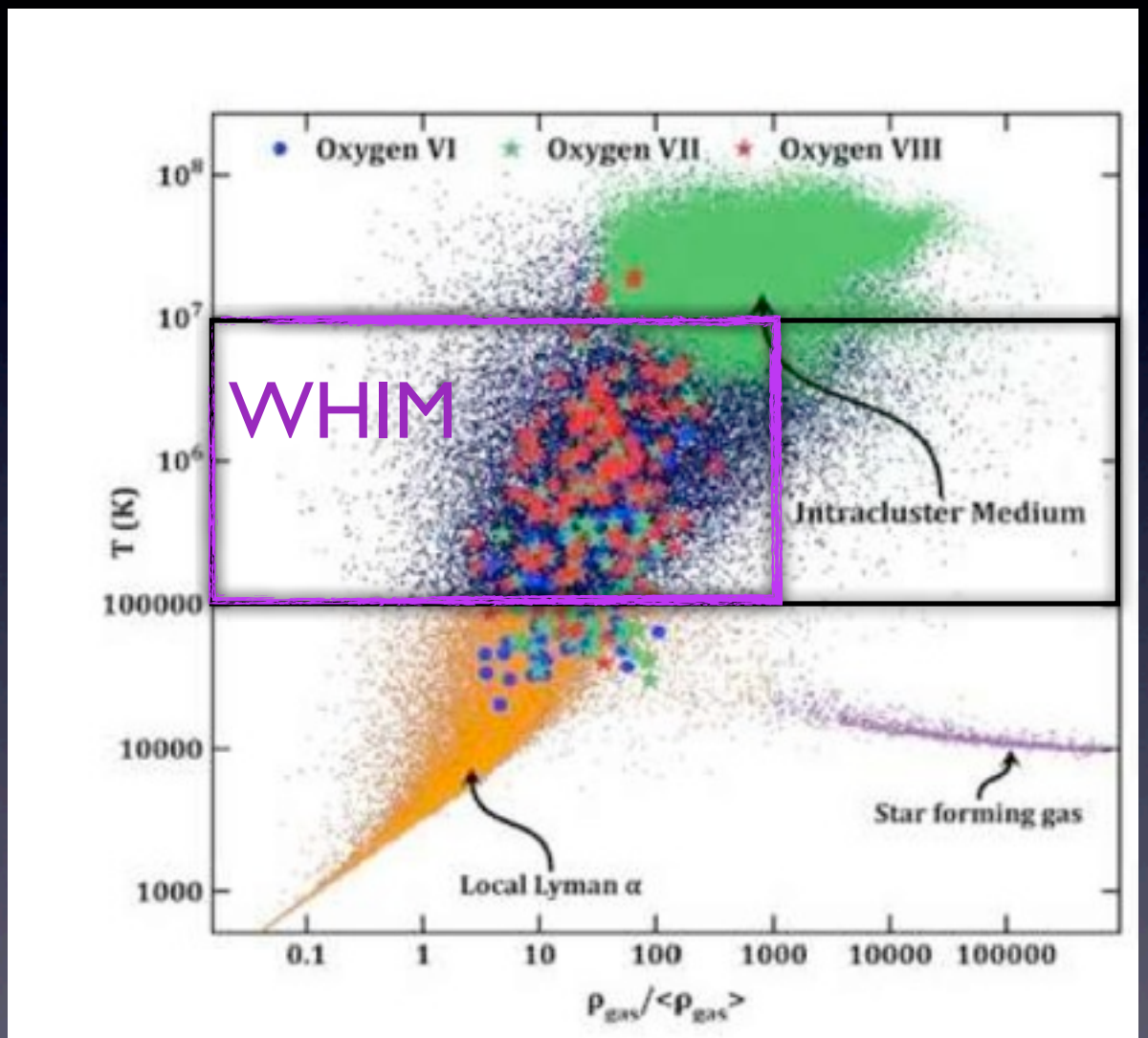


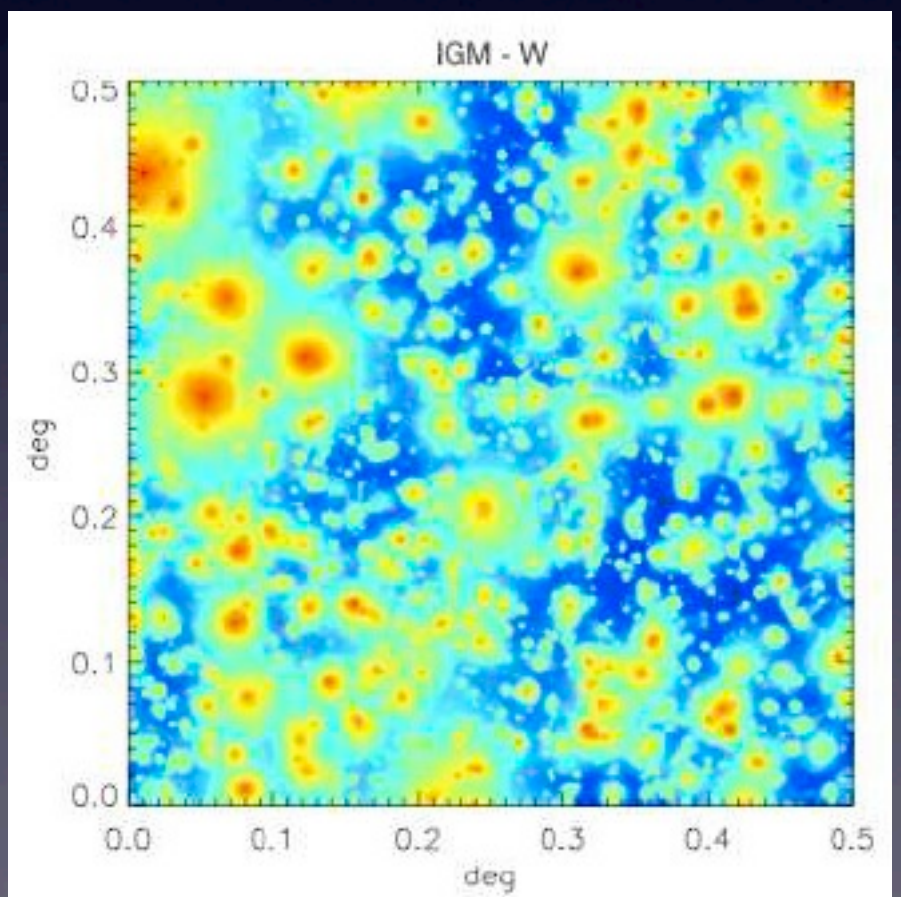
WHIM is by definition whatever has $10^5<kT<10^7$ K

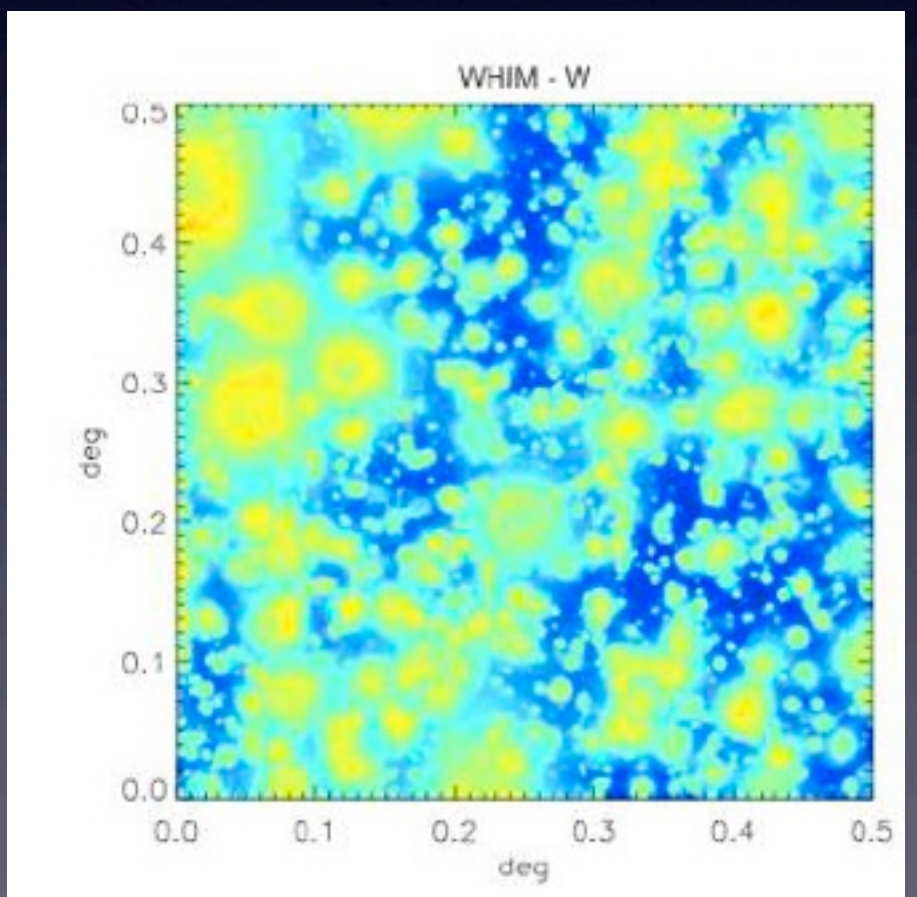
large fraction of Missing baryons are expected to lie in a medium with $10^5<kT<10^7$ K and $\delta<1000$

Needs simulations to define diffuse emission

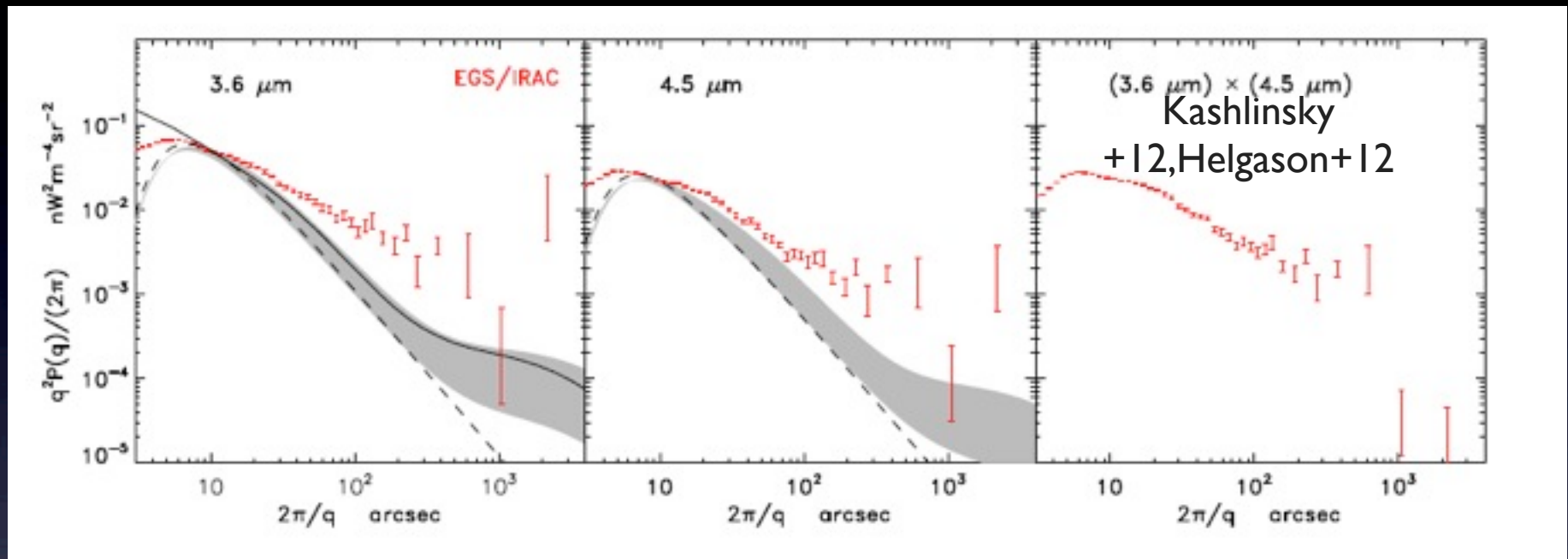
The WHIM emissivity depends the metallicity
on how the IGM is enriched of Metals

Wind Driven
feedback (Roncarelli+2012, for details)
20 simulations of 1deg2 each and averaged



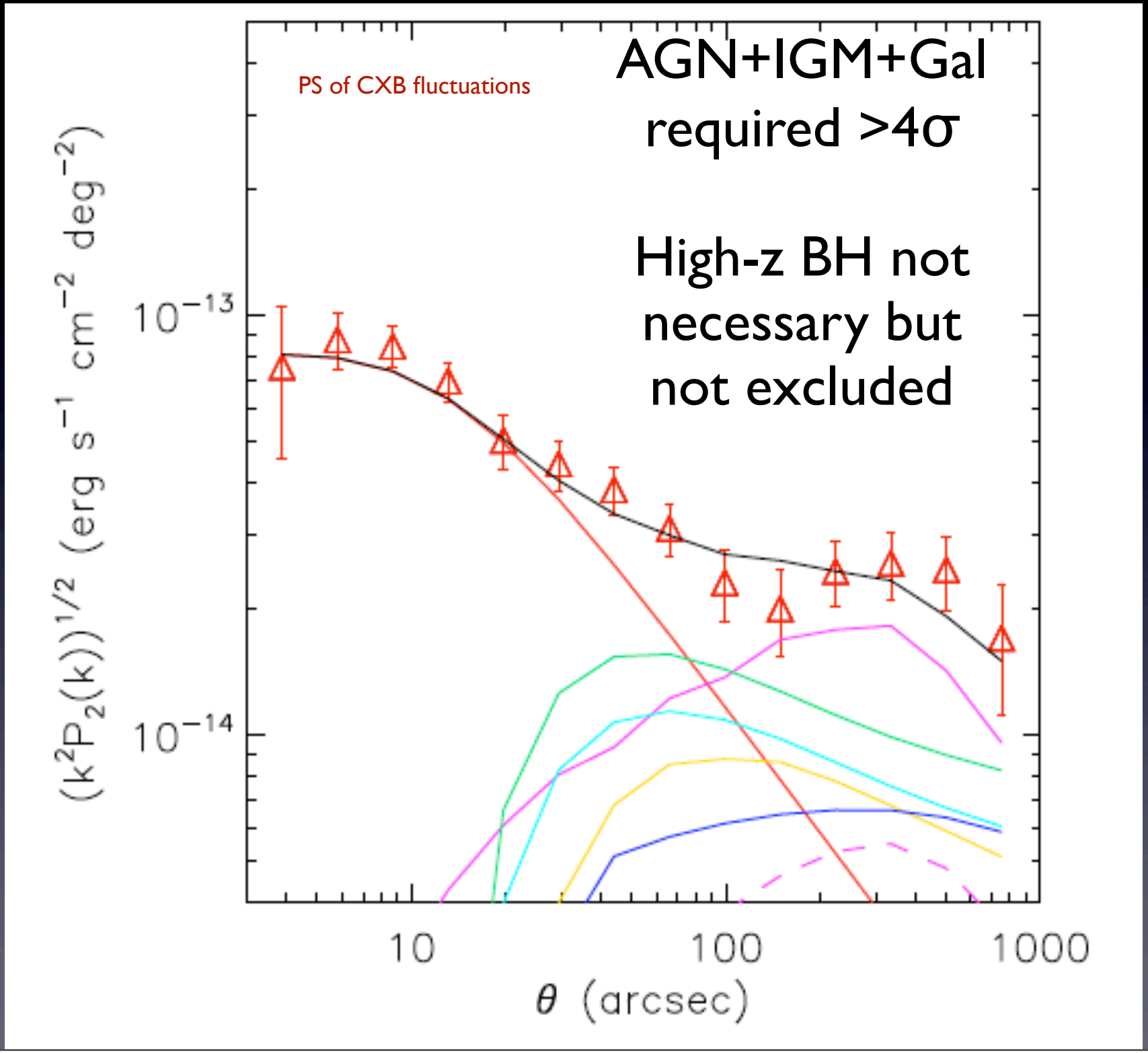


Signatures of z>7.5 sources

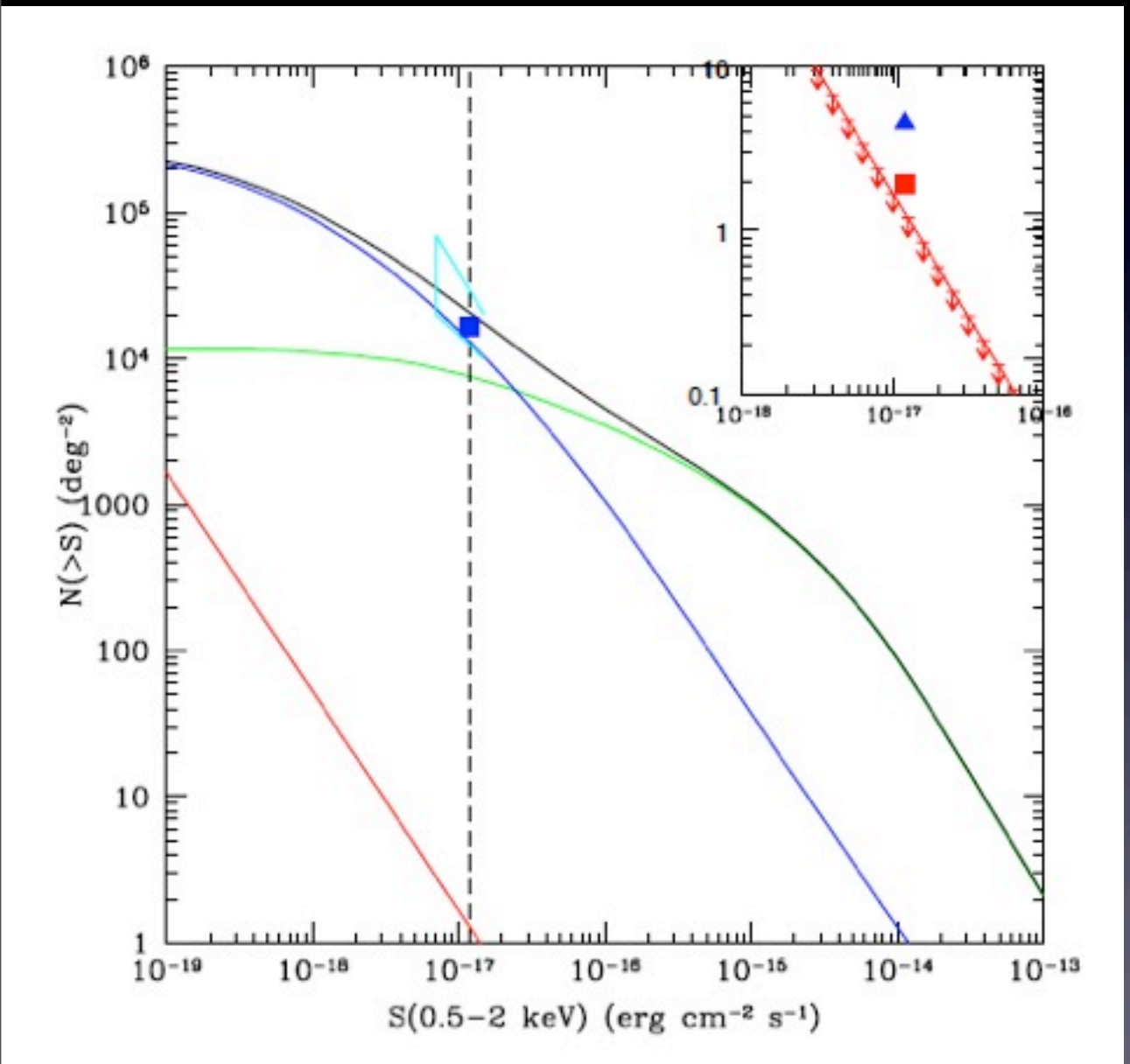


Excess power wrt to galaxies
No correlation with HST sources
z>7.5

Fluctuations from first stars/BH era


PS of CXB fluctuations
AGN+IGM+Gal
required >4σ
High-z BH not
necessary but
not excluded
$(k^2P_2(k))^{1/2}$ (erg s^{-1} cm^{-2} deg^{-2})
10^{-13}
10^{-14}
10
100
1000
θ (arcsec)

Source counts of undetected sources



Galaxies are the larger population

AGN almost "finished"

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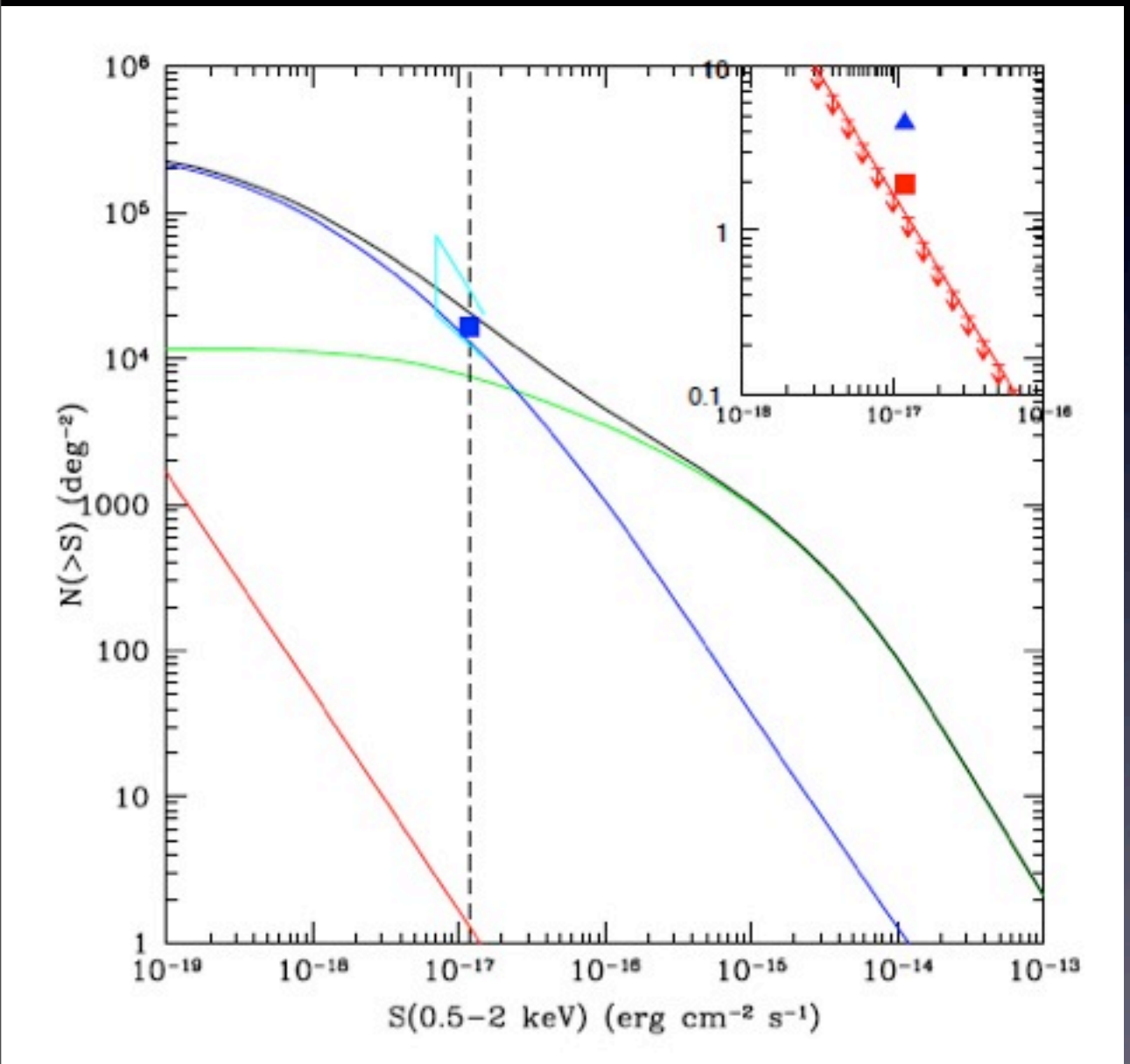

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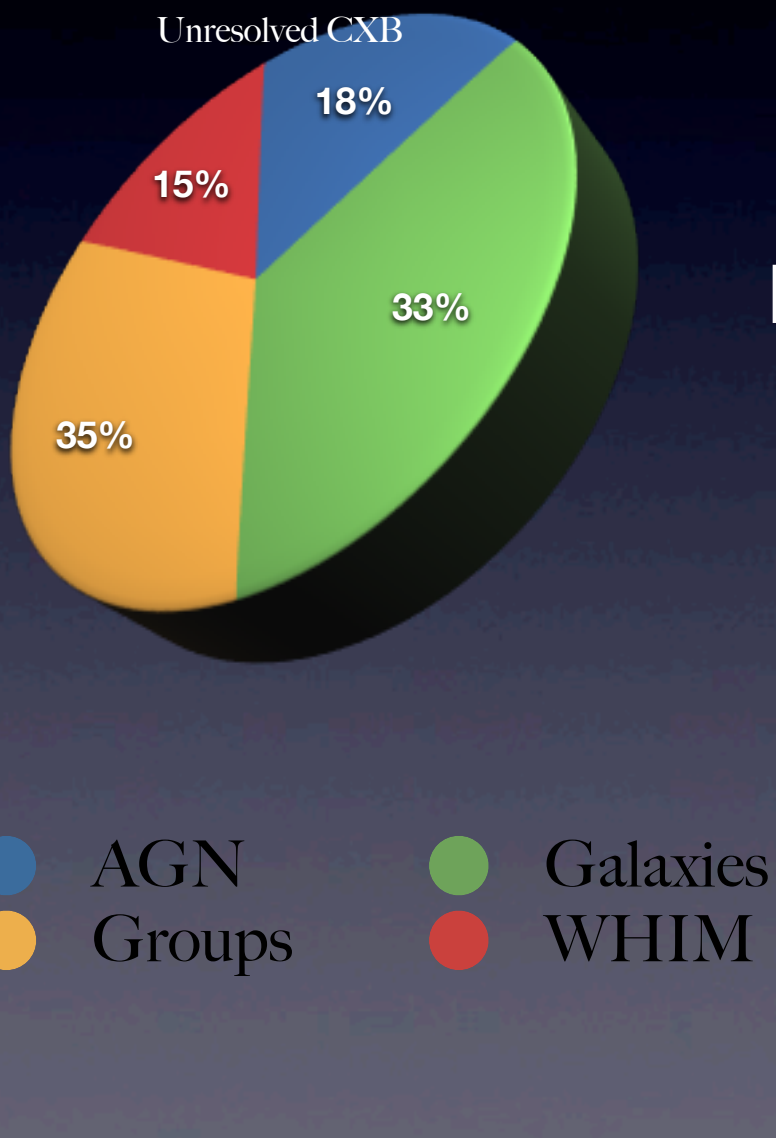
At the flux limit of future X-ray observatories possible detection of early BH

current upper limit in agreement with declining QSO

The nature of the unresolved CXB



14% of the overall CXB
MUST NOT BE CONFUSED
WITH THE QUOTED ~5%
Lehmer+12, Moretti+04