Lessons on AGN from X-ray surveys

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AGN in a cosmological framework

Argument:

1) AGN trace accretion on SMBH

2) (non-active) SMBH are ubiquitous in nearby galaxies

3) Large scale galaxies properties strongly depend on SMBH mass

AGN are key ingredient in galaxy formation

(see F. Fontanot & F. Fiore review)

population studies --> SURVEYS

details on the physics --> OBJECT by OBJECT

AGN in a cosmological framework

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AGN

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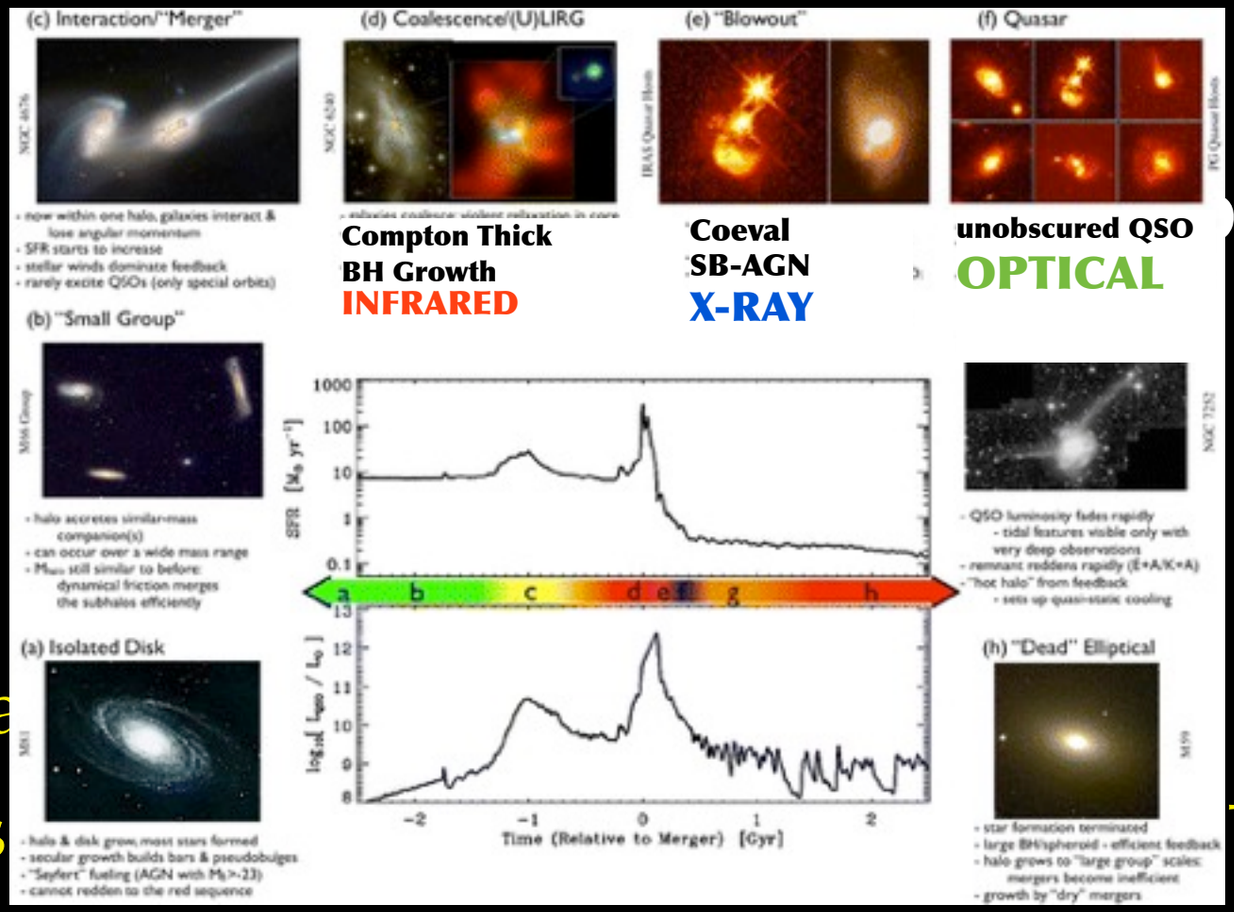


AGN emission

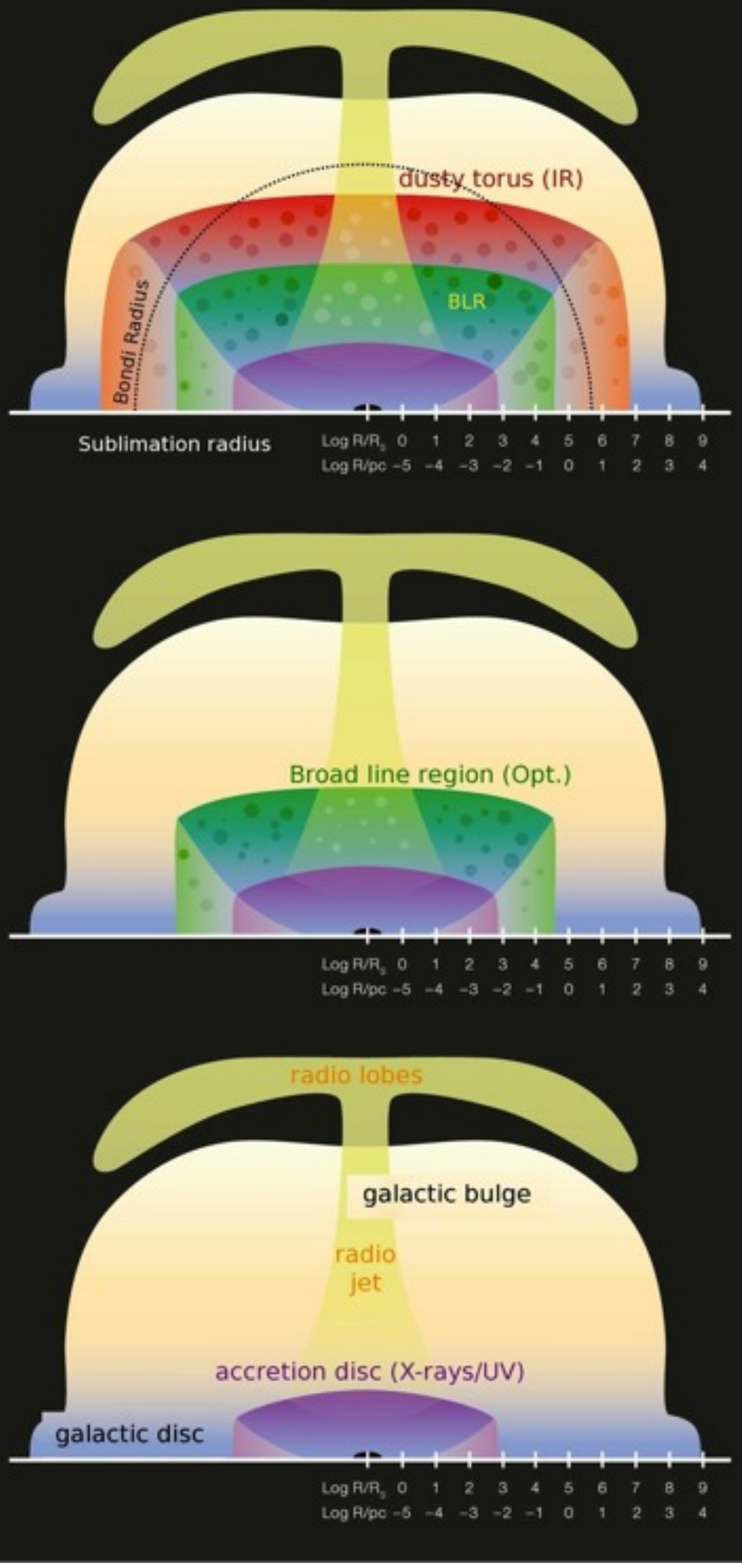
AGN emission is observed over the entire electromagnetic spectrum

Different wavelengths sample different **emission processes** and **emission regions**

X-ray emission sample the innermost regions (<10^{-2} pc, <1000 R_S)

(see F. Pozzi review for IR)

courtesy A.Merloni, S. Bonoli, ESO Graphics



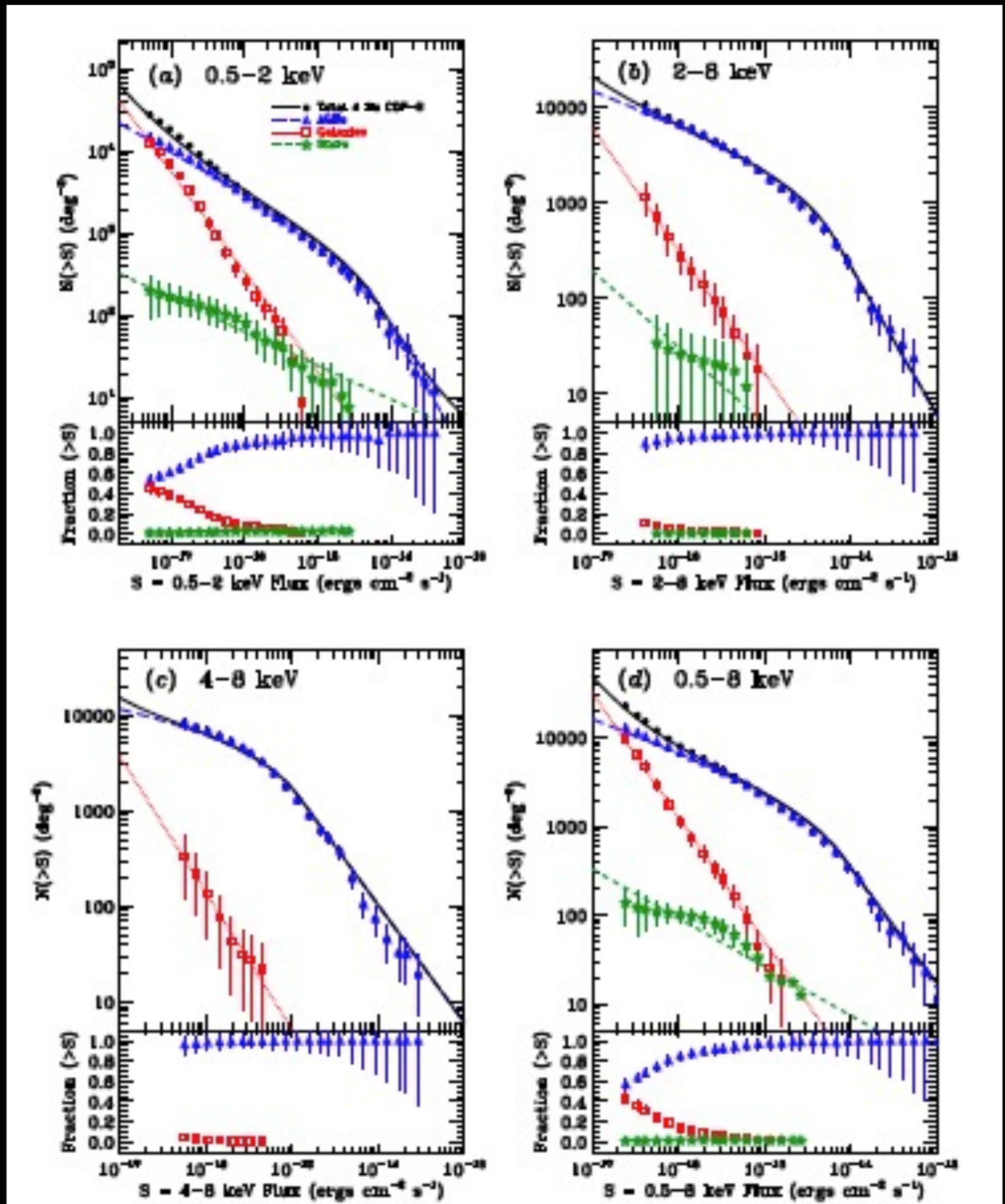
Tools:
X-ray surveys

cleanest selection

(almost no contaminants - normal galaxies and stars emerge only in deepest exposures)

combination of soft + hard samples to overcome absorption and redshifts effects

Lehmer et al. 2012, 4Ms logN-logS



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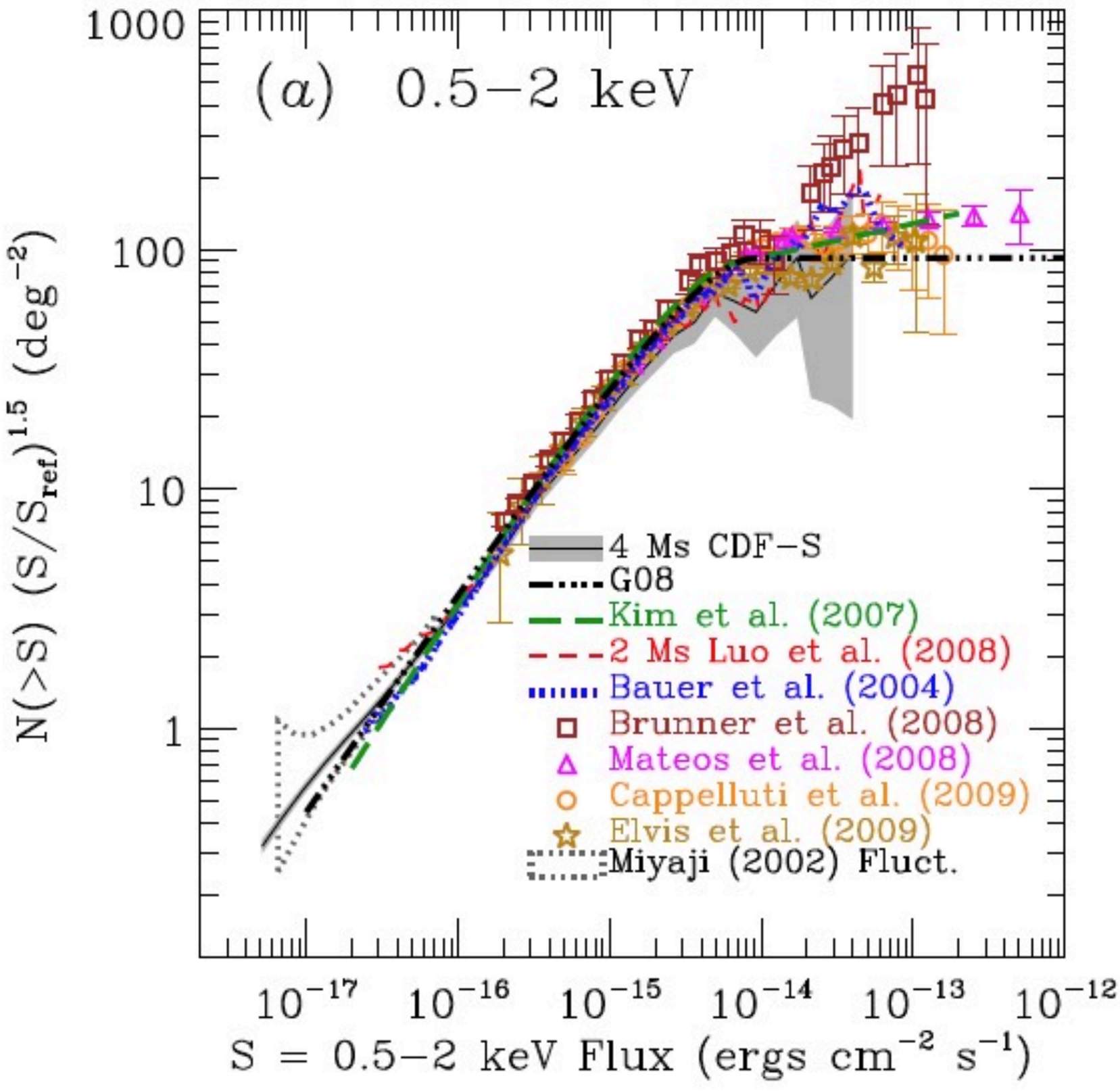


Known "missing": Compton Thick

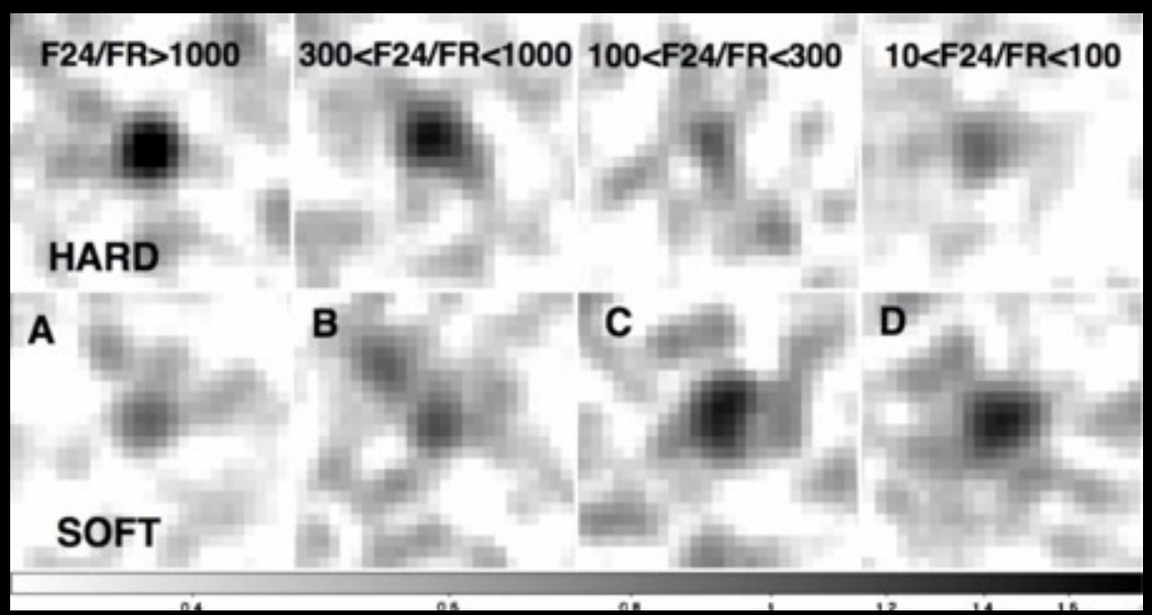
"Local" / bright (flux>1e-12 cgs) samples best studied with higher energy observatories
(Swift/BAT and INTEGRAL/IBIS - huge discovery space opened with Nustar)

High-z samples may be recovered from IR selection (absorbed radiation re-emitted in the IR) --> many criteria have been proposed since the advent of Spitzer
(Lacy+04, Stern+05, Hatziminaoglou+05, Daddi+07, Fiore+08... Luo+11, Donley+12, Severgnini+12)

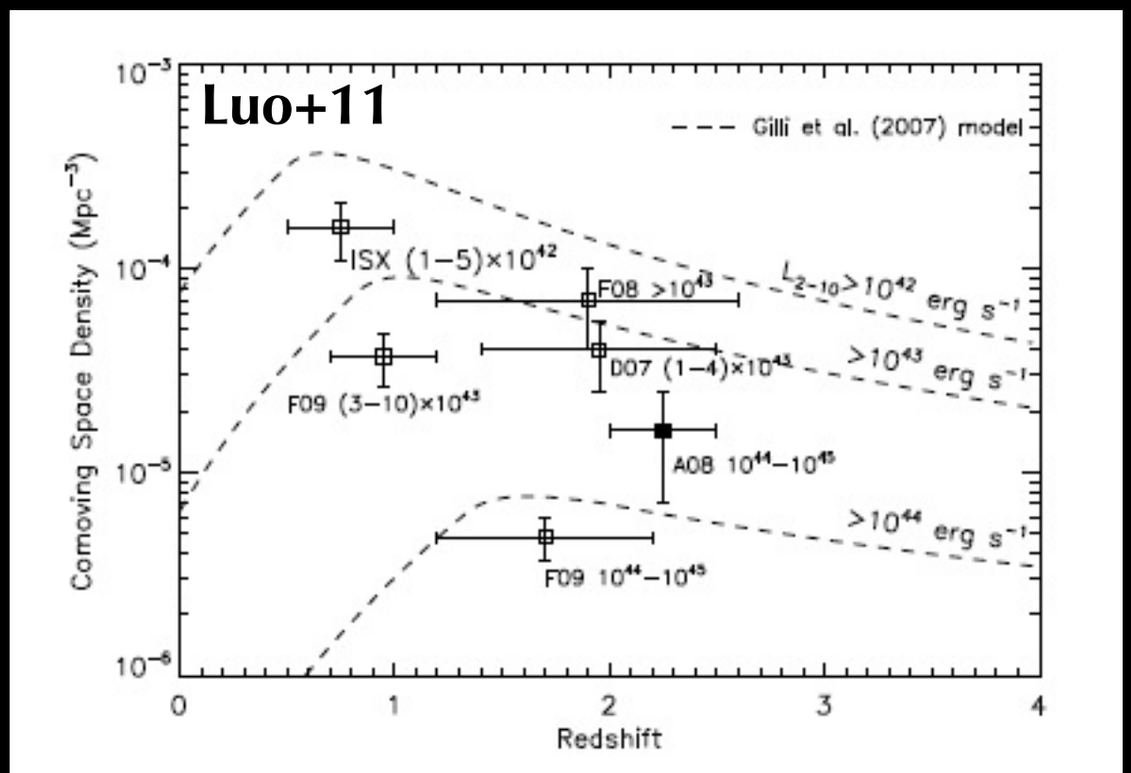
Main issue is contamination from non AGN sources (Starbursts)
Crucial role of X-ray stacking in validating the samples

Stack of Chandra images of CT candidates from MIR/optical diagnostics diagrams (Fiore+09)

from the observed HR --> CT AGN fraction

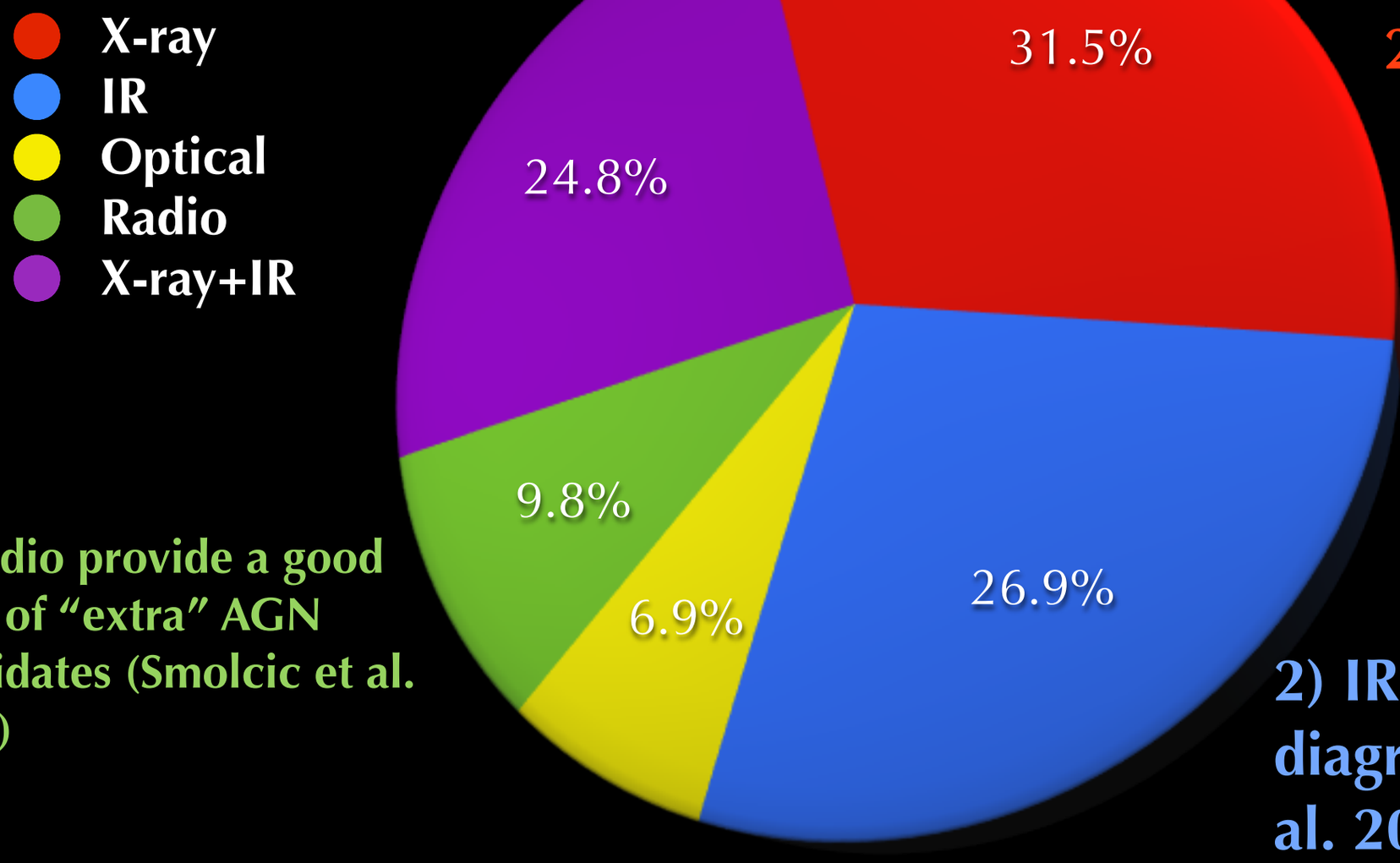


from CT AGN fraction --> CT AGN space densities
(see also G. Melini talk!)



Comparison of AGN selection

inner 0.9 deg2 COSMOS area
deeper Chandra and optical data



1) largest contribution from X-rays (Civano et al. 2012)

2) IRAC color-color diagrams (Donley et al. 2012)

3) Radio provide a good 10% of "extra" AGN candidates (Smolcic et al. 2008)

4) most of ONLY Optical sources are NL AGN from BPT diagrams (e..g Bongiorno et al. 2010)

relative contribution very sensitive to depth at different wavelengths..

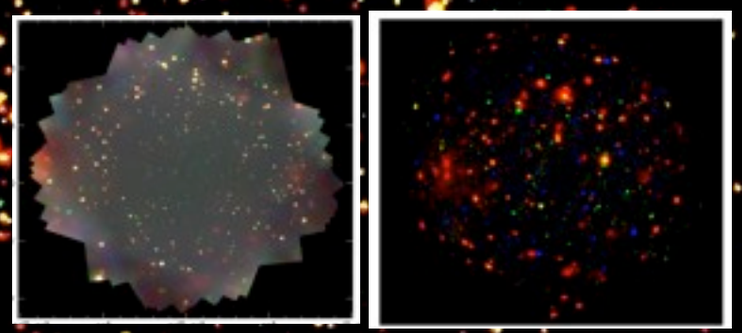
key observable

COSMOS field, 2 deg^2 (Scoville+07)

XMM 1.55 Ms (Hasinger+07, Cappelluti+07,09)
down to ~1e-15 cgs

Chandra 1.8 Ms (Elvis+09, Puccetti+09)
down to ~2e-16 cgs

CDFS 1-2-4Ms ~0.1 deg2, ~4e-17 cgs
(Giacconi+ 2002, Luo+ 2008, Xue+2011,Xue+2012)
XMM 3Ms (Comastri+2011)



- luminosity functions
  (counting)
- clustering
  (correlating)
- accretion properties
  (spectral analysis)
- host galaxies properties
  (looking at other wave)
- morphologies
  (looking at high-res)

- rare objects
  (isolating unique sources)

Only two among the many (~40) XMM & Chandra surveys in russian-doll style
(Alexander & Brandt 2010)

All wavelengths, very deep coverage available, public resources

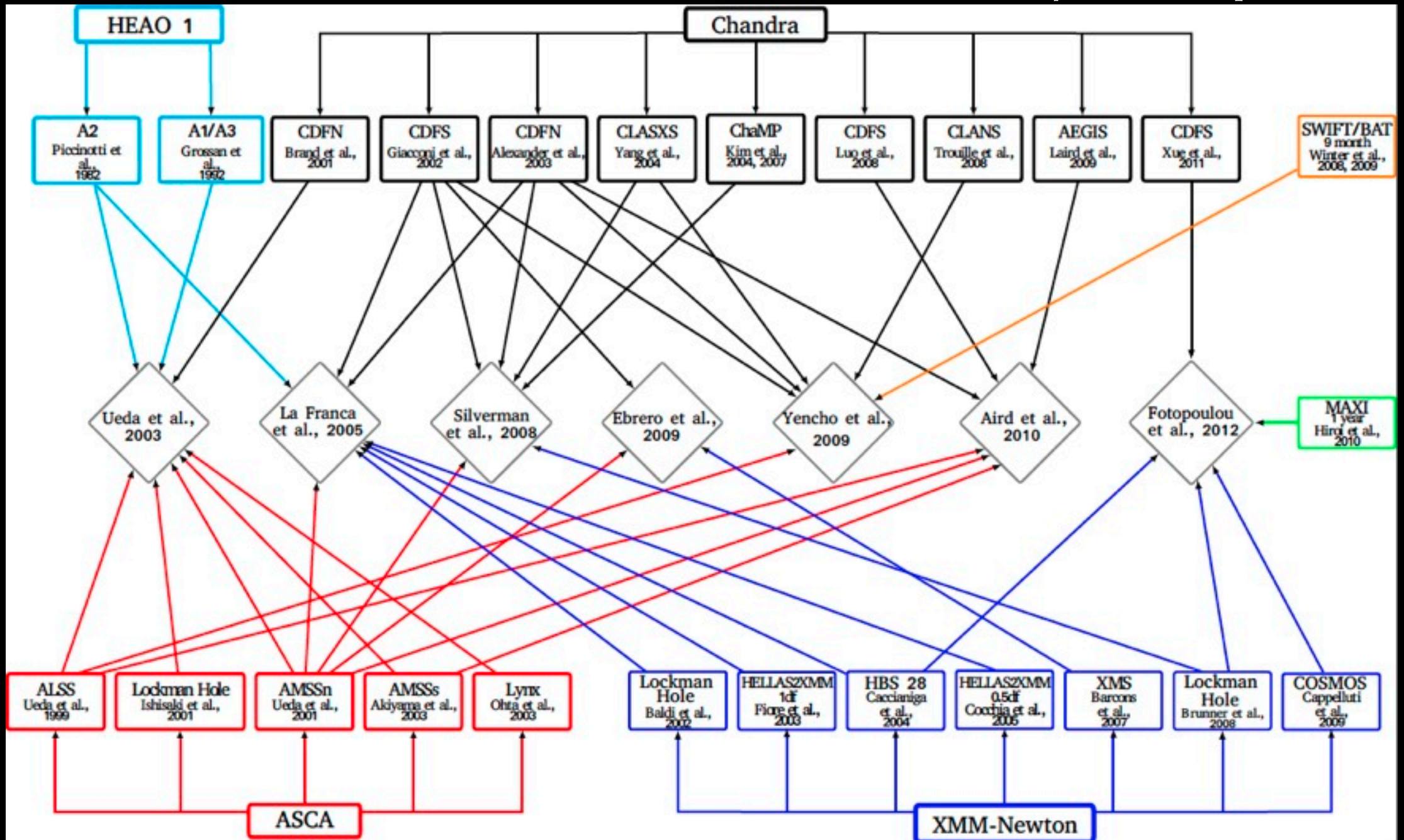
Review of results most relevant in constraining models of AGN-galaxy co-evolution

Luminosity functions (and obscured fractions)

Fotopoulou et al. 2012 **(5-10 keV)**
Burlon et al. 2011 **(Swift/BAT)**
Brusa et al. 2010 **(XMM-COSMOS)**

A decade of 2-10 keV X-ray LF

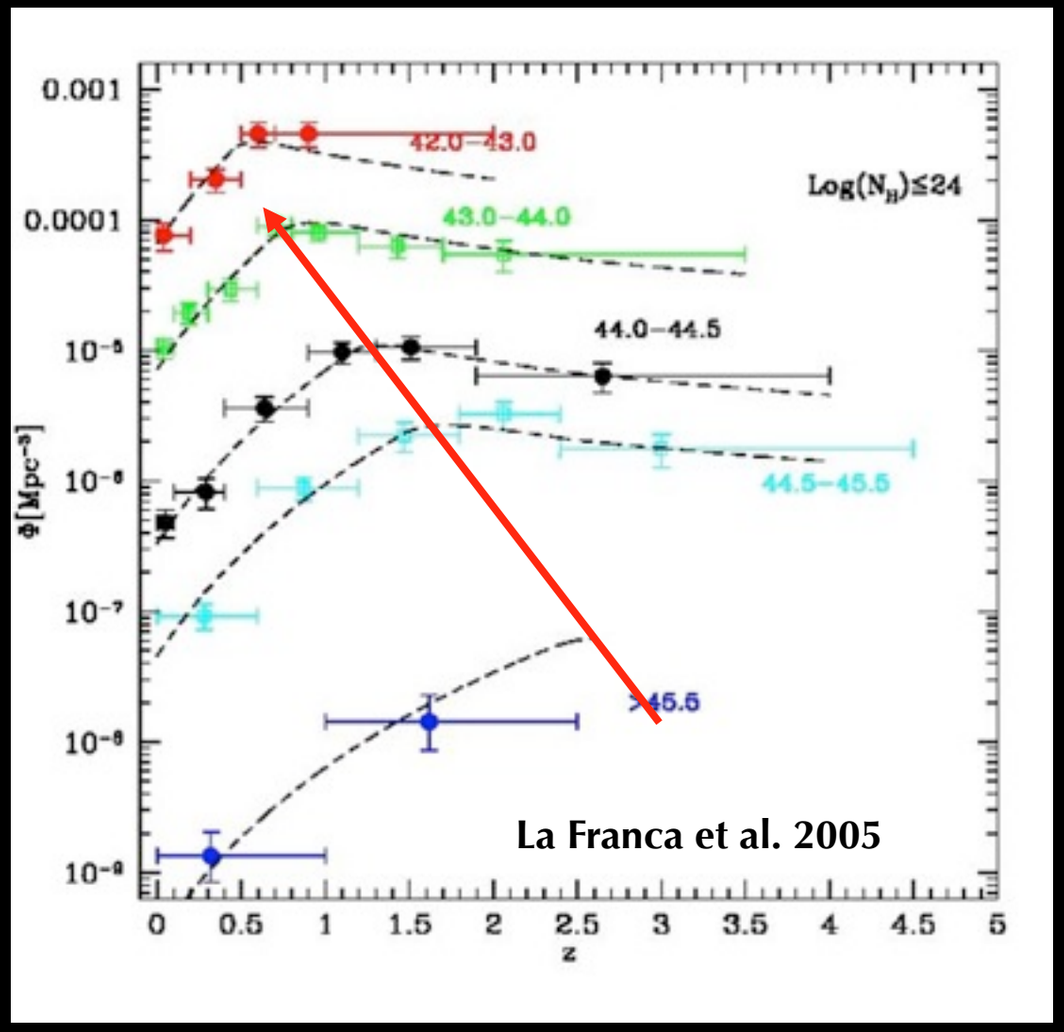
courtesy S. Fotopoulou / MPE



All LF works heavily rely on SOURCE identifications and REDSHIFT information... huge works from mw campaigns, photo-z, statistical tools for ID, etc.

Accretion and star formation histories

AGN downsizing

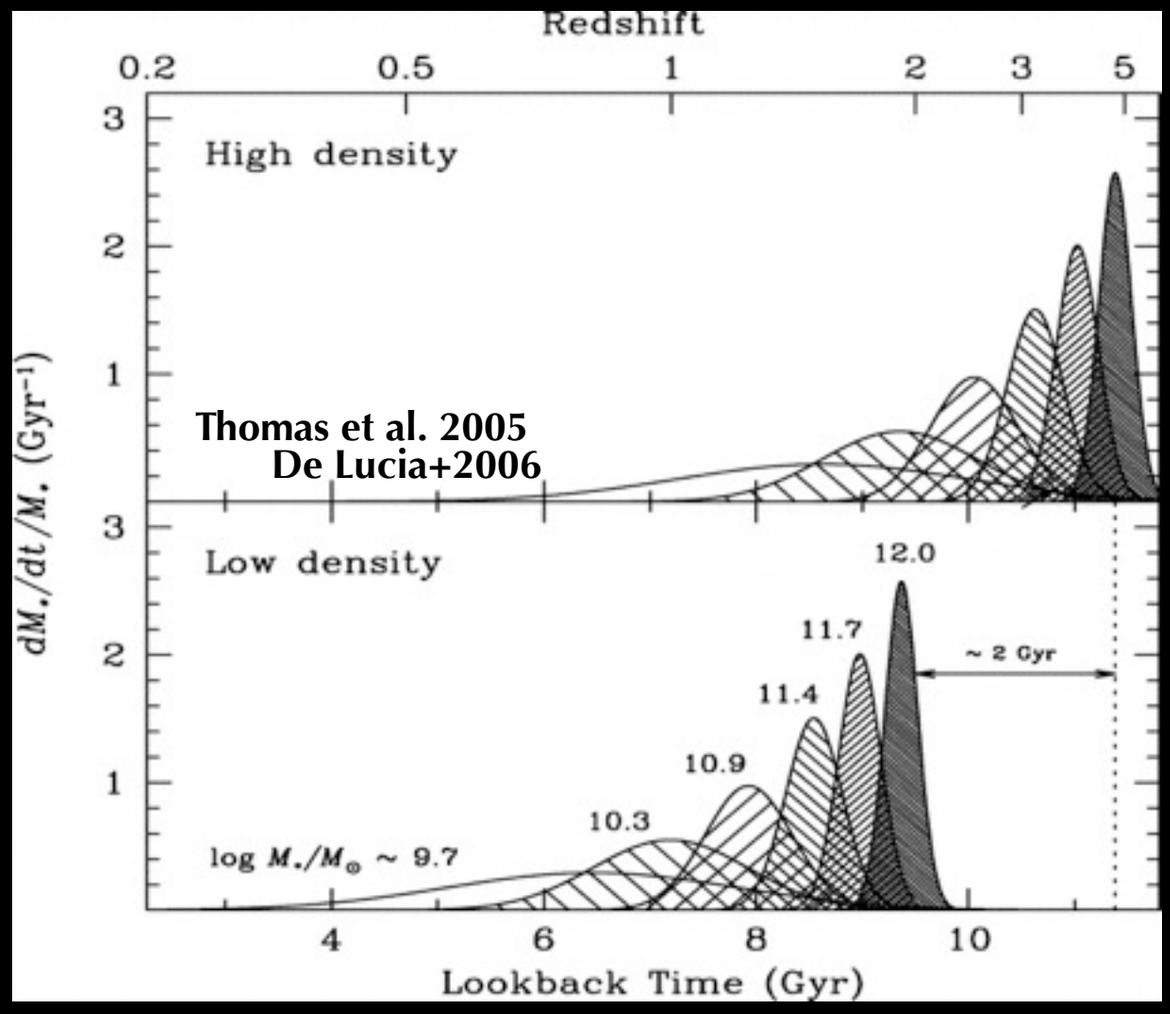


Fiore,MB+2003, A&A / La Franca et al. 2005, APJ (HELLAS2XMM)

Ueda+03; Barger+05; Hasinger+05; Silverman+05, Della Ceca+08, Ebrero+09 etc. - but see Aird+10

more luminous AGN had the peak of activity at earlier redshifts

SF downsizing



Cosmic "downsizing"

the larger the faster (Cowie et al. 1996):

"... galaxy formation took place in "downsizing", with more massive galaxies forming at higher redshift.."

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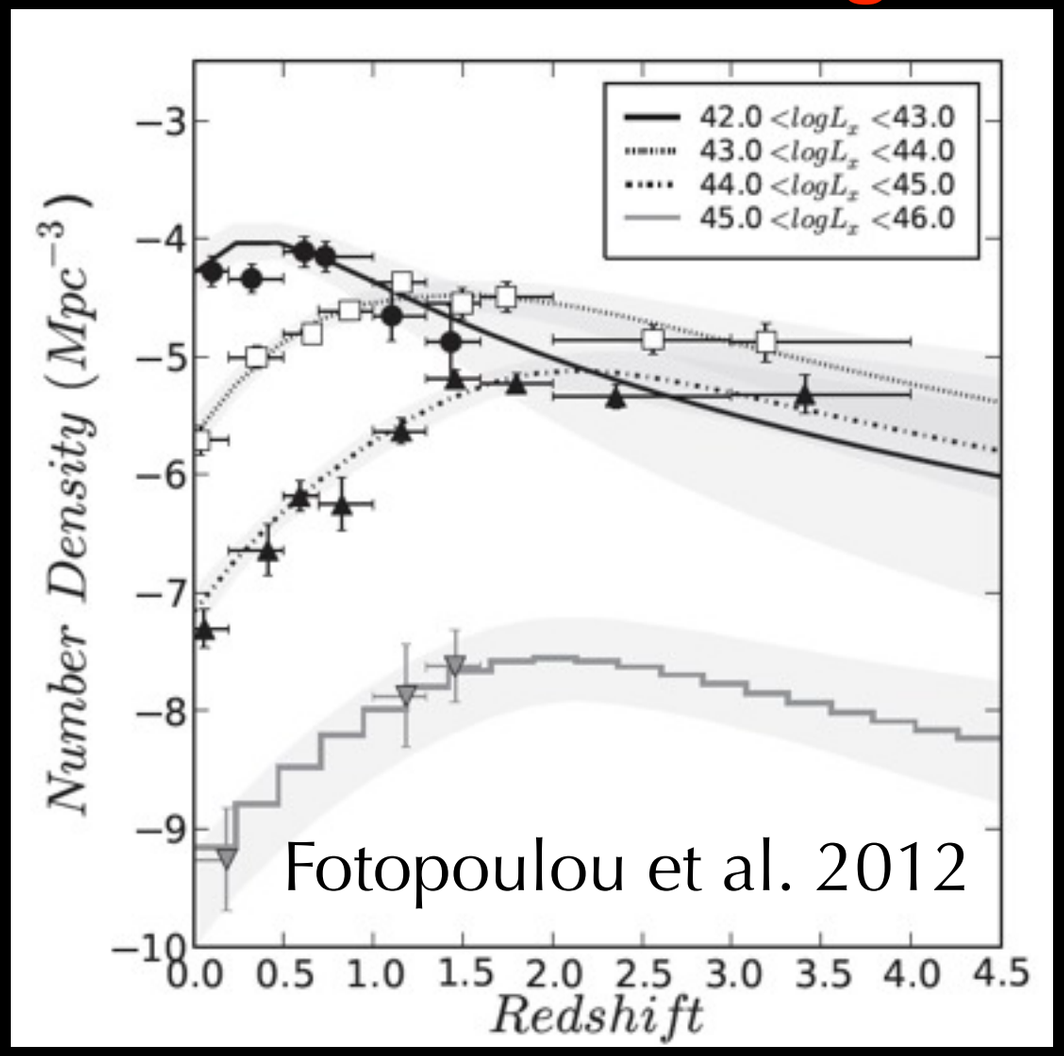

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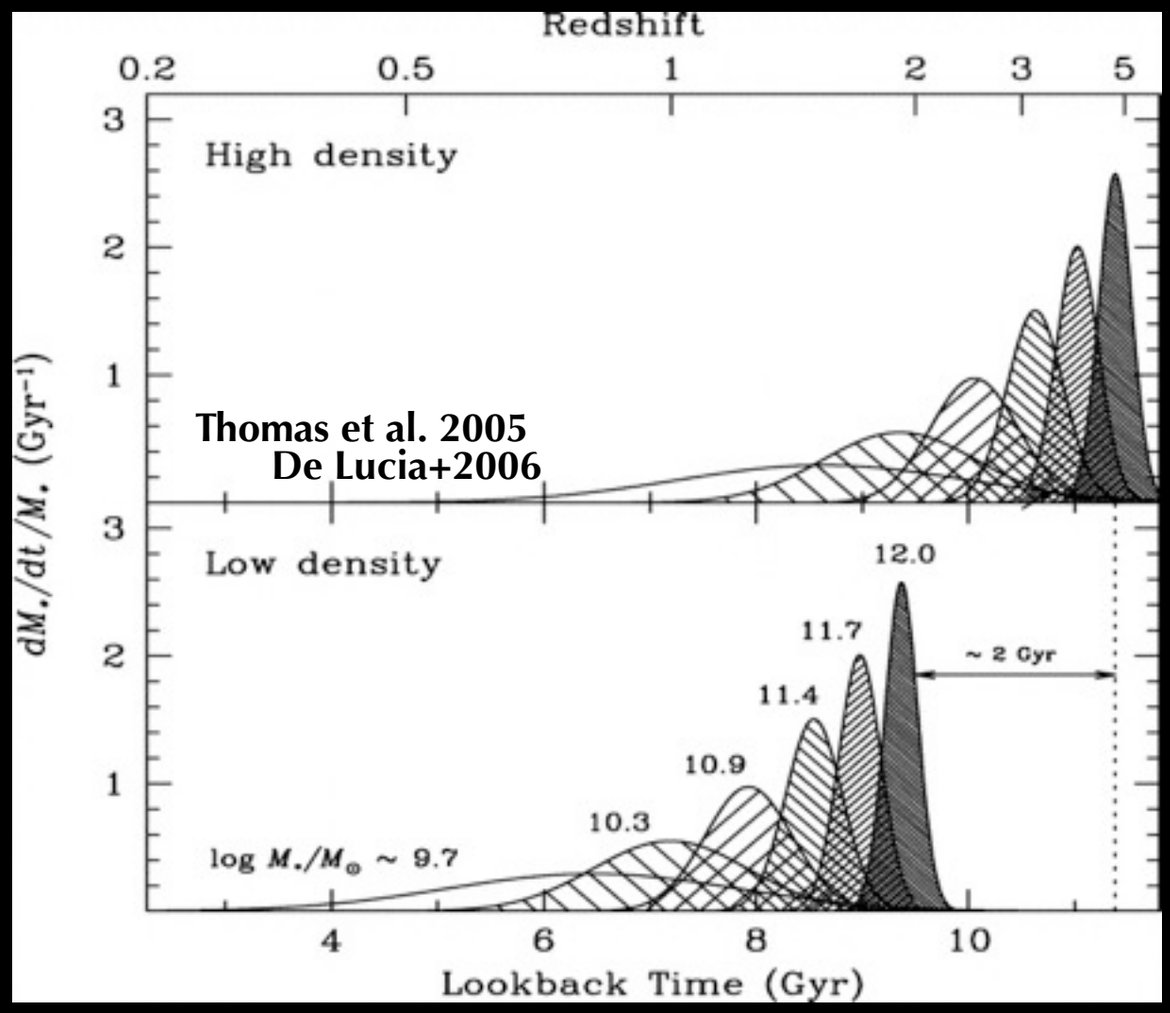

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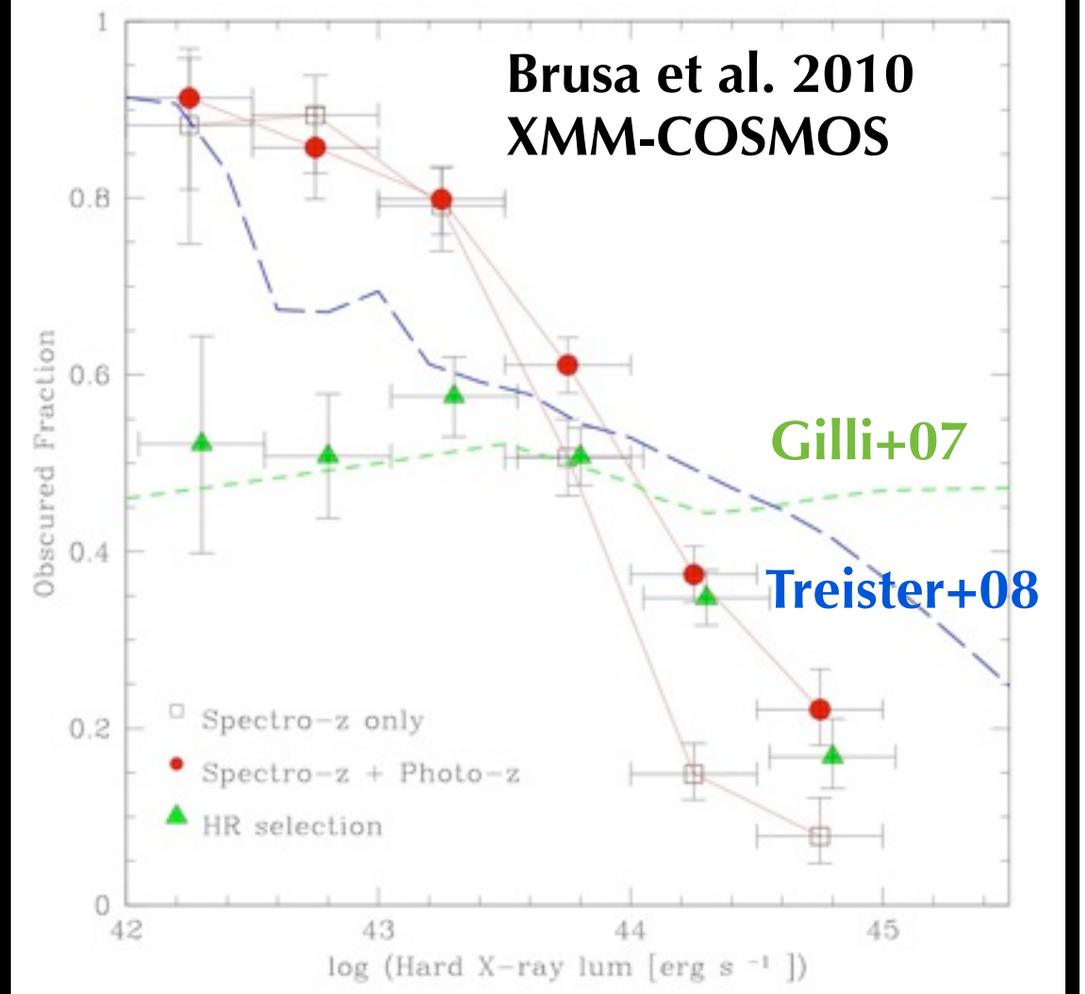
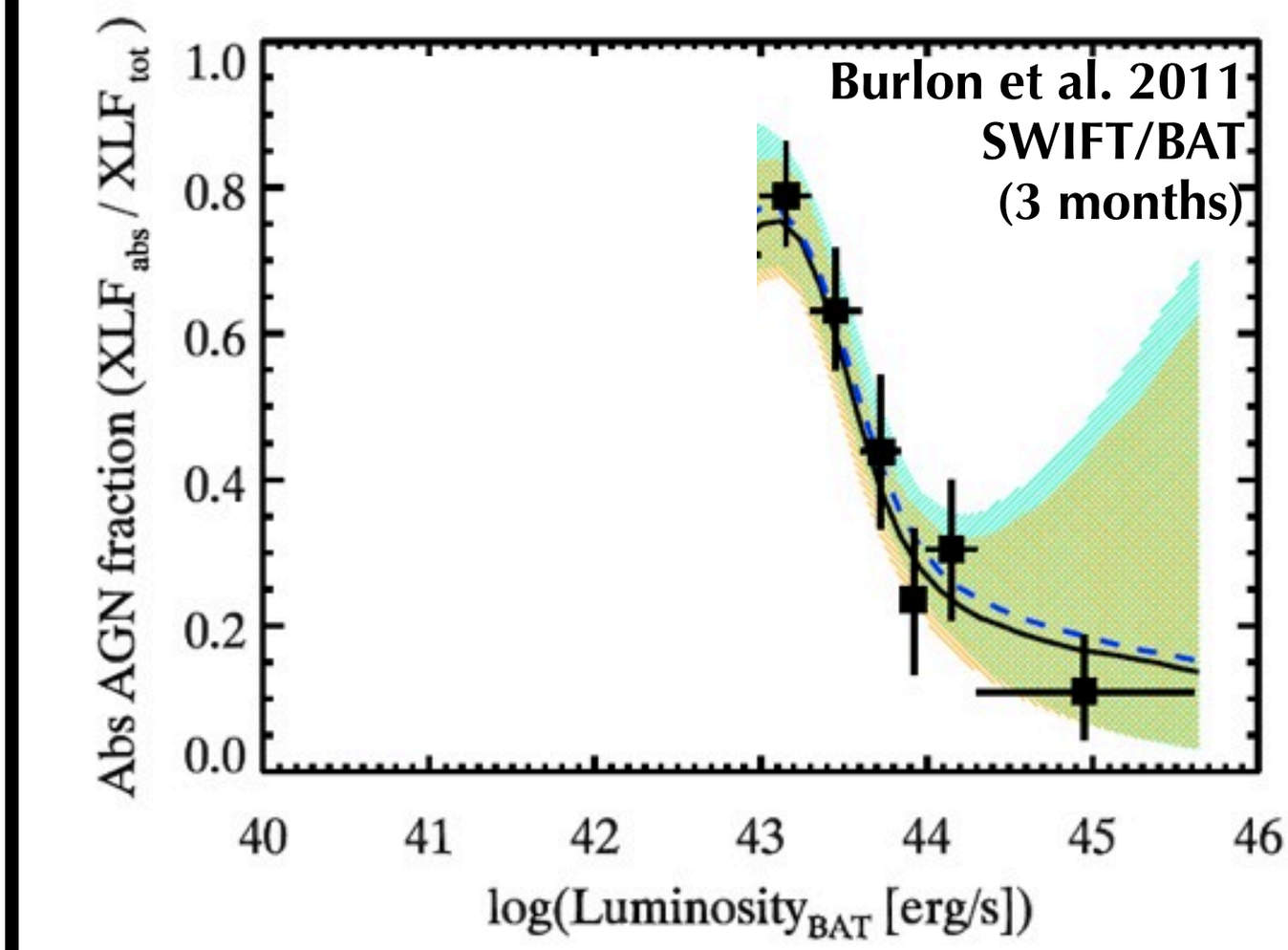
Obscured fraction as a function of L (and z)





Type 2 AGN fraction, strong function of L: less luminous, most obscured
Same results in DIFFERENT bands (Maiolino+08, Hasinger 2008, Bongiorno+10, Burlon+11, Brightman+11)

Receding torus scenario: most luminous more efficient in cleaning the environment

Type 2 AGN fraction is higher at high-z
(La Franca et al. 2005, Hasinger 2008, Fiore et al. 2012)
higher-z, more cold gas available, more obscured

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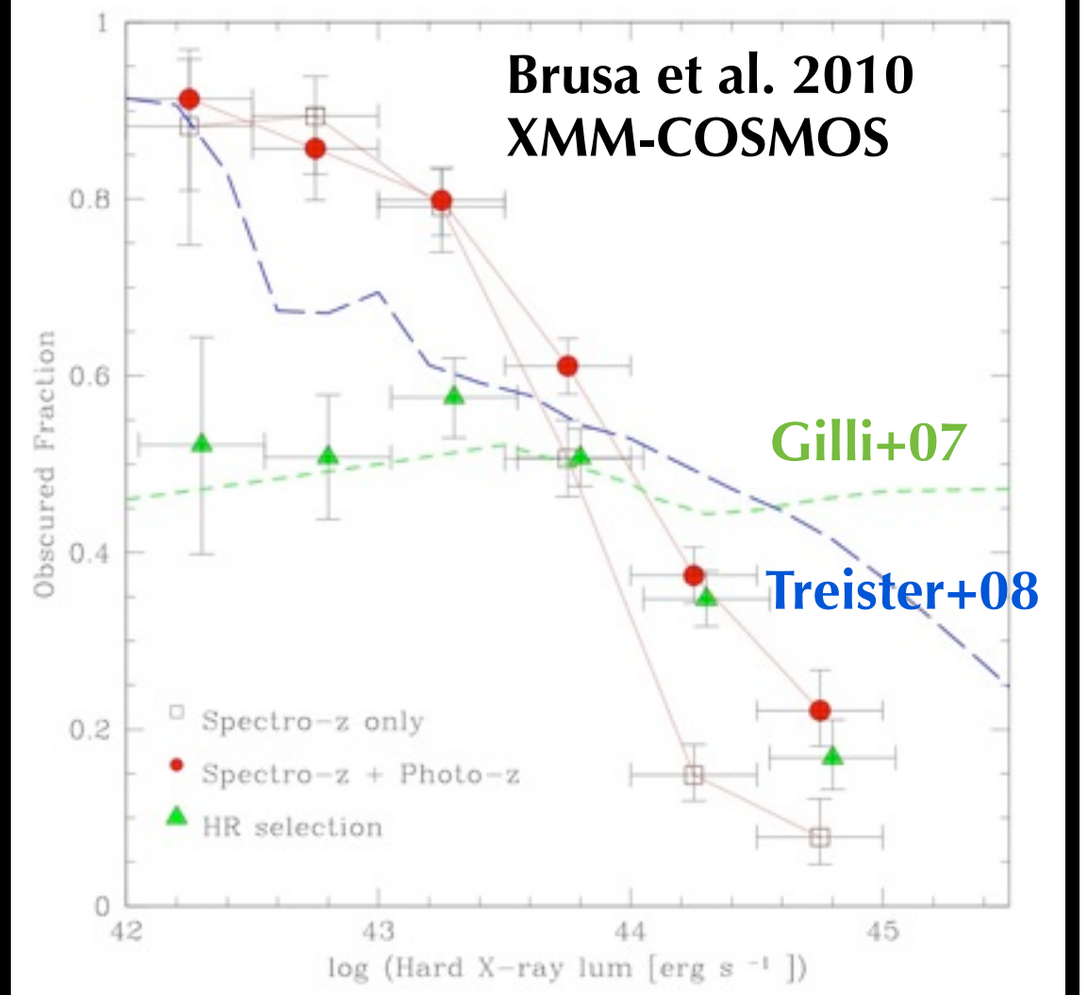

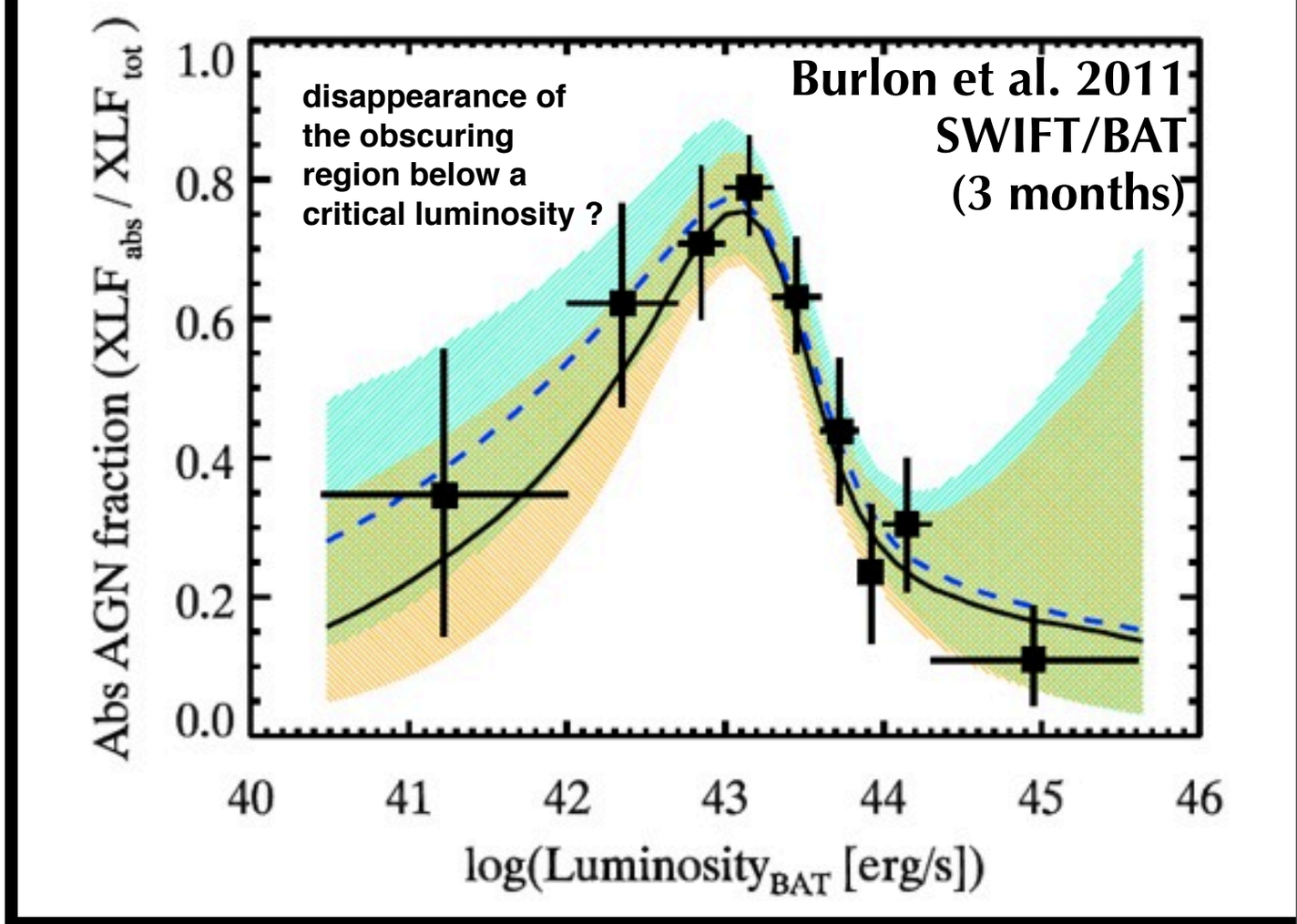

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Clustering

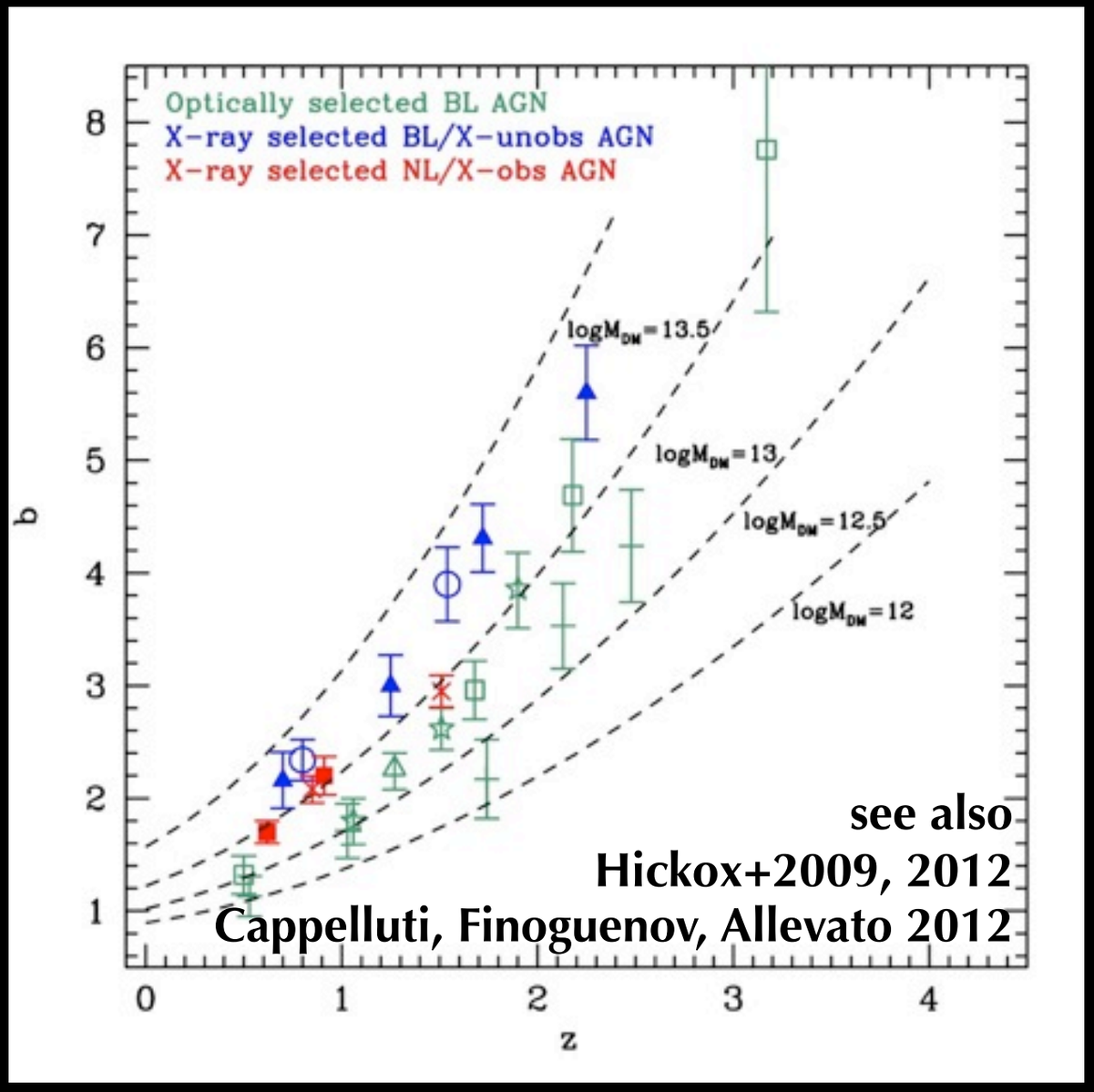
Allevato et al. 2011, 2012

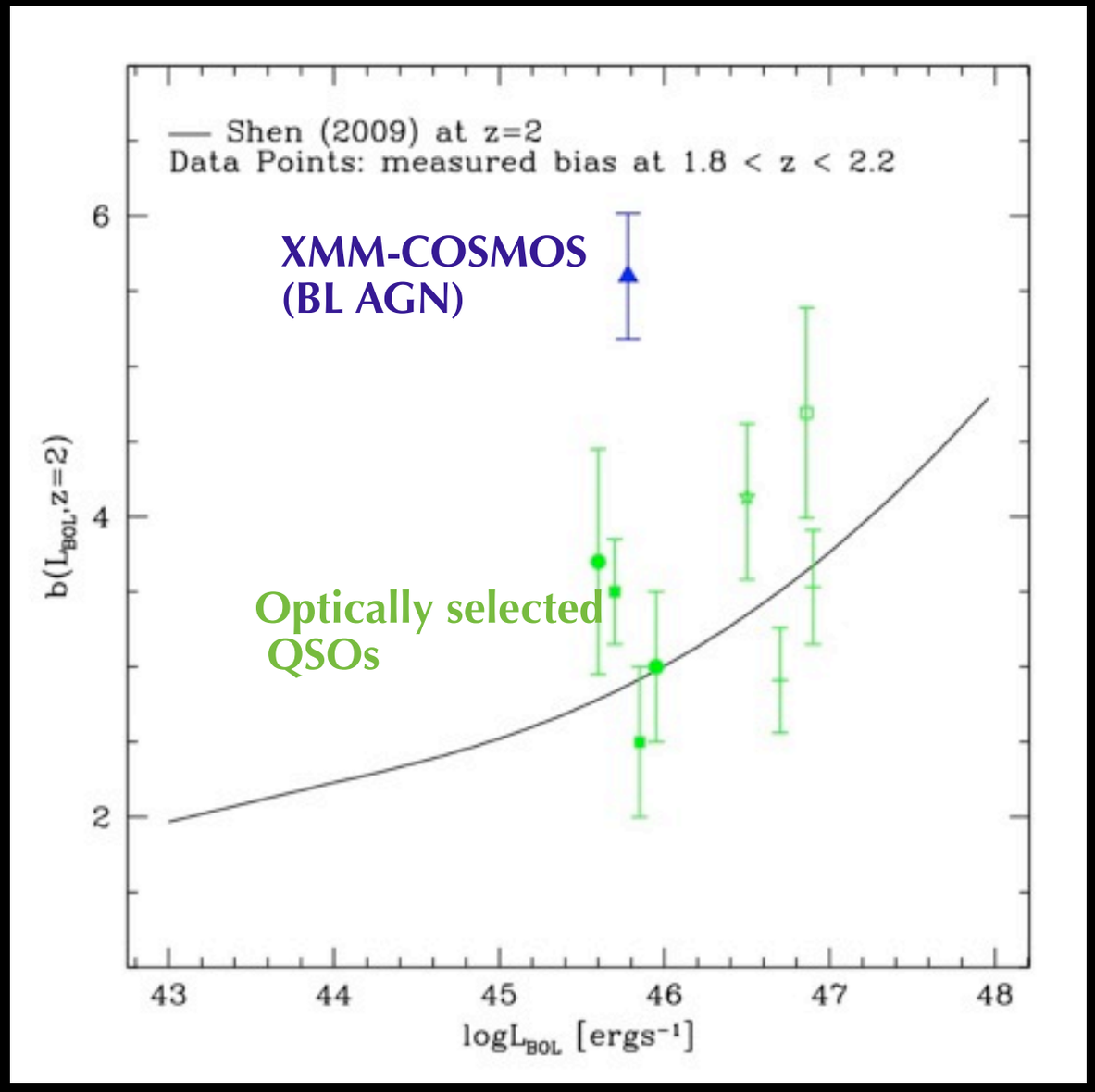
N.B. all clustering works heavily rely on SOURCE identifications and REDSHIFT information... huge works from mw campaigns, photoz-z, statistical tools for ID, etc.

AGN clustering

X-ray selected BL AGN reside in more massive halos than optically selected
<logM> ~13-13.5 (XMM)
<logM> ~12-.5-13 (optical)

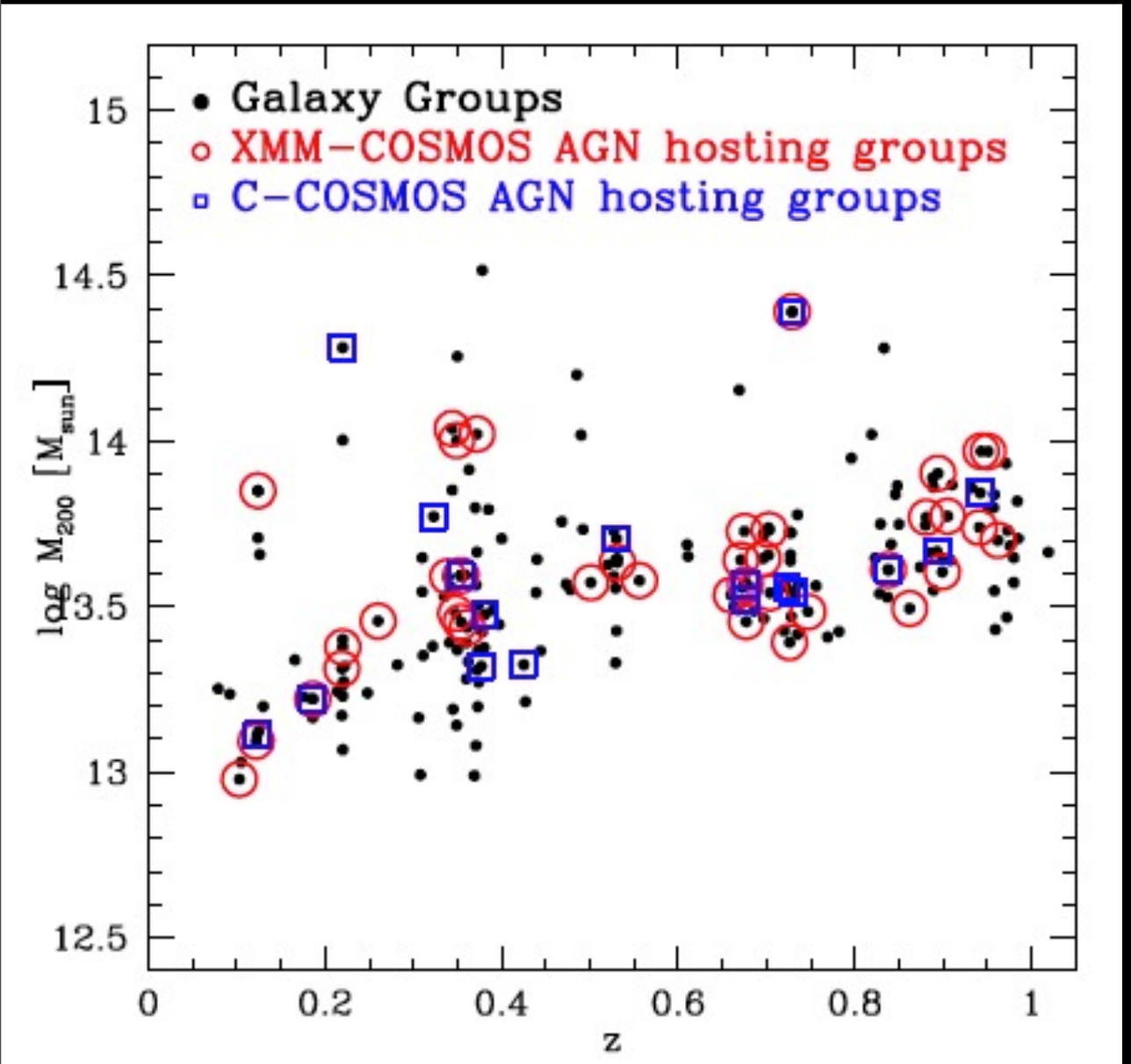
bias estimate from XMM-COSMOS **not compatible with Shen (2009) models** - major mergers triggering and flat lightcurves

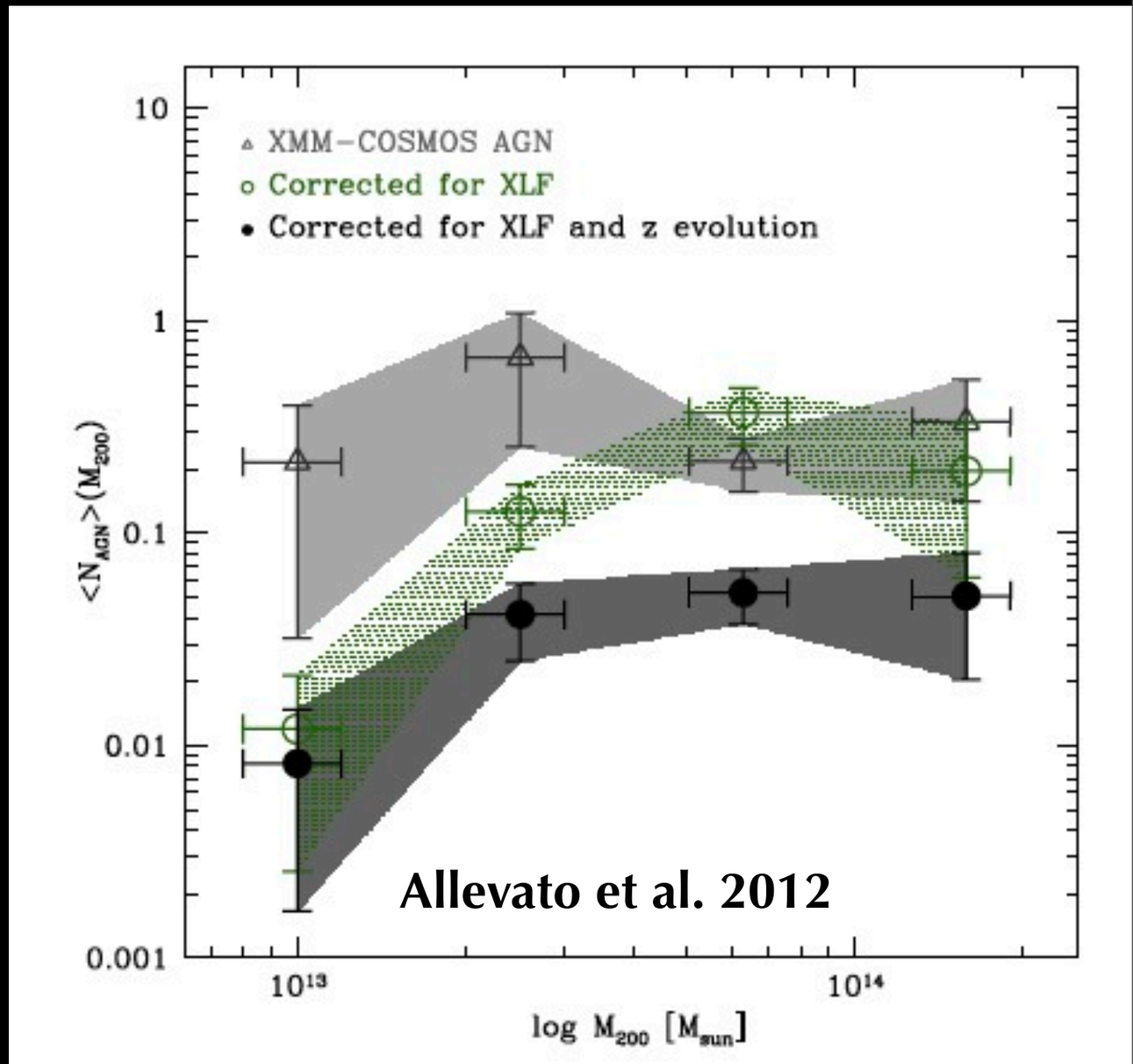




obscured and unibscured AGN have different clustering properties (zero-th order unified scheme is not enough)

AGN cross-clustering





AGN-galaxy groups cross-correlations

Group catalog: Finoguenov et al. in prep
AGN catalogs: Brusa+2010, Civano+2012

AGN occupation of galaxy groups as a function of DM halo mass

the larger, the higher
of the order of 5% at logM=13-14

SED studies (accretion and host galaxies properties)

Lusso et al. (2011,2012) - Type 1 and 2 AGN bolometric corrections
Hao et al. (2010) - Hot Dust Poor Quasars
Mainieri et al. (2011) - QSO2 in COSMOS

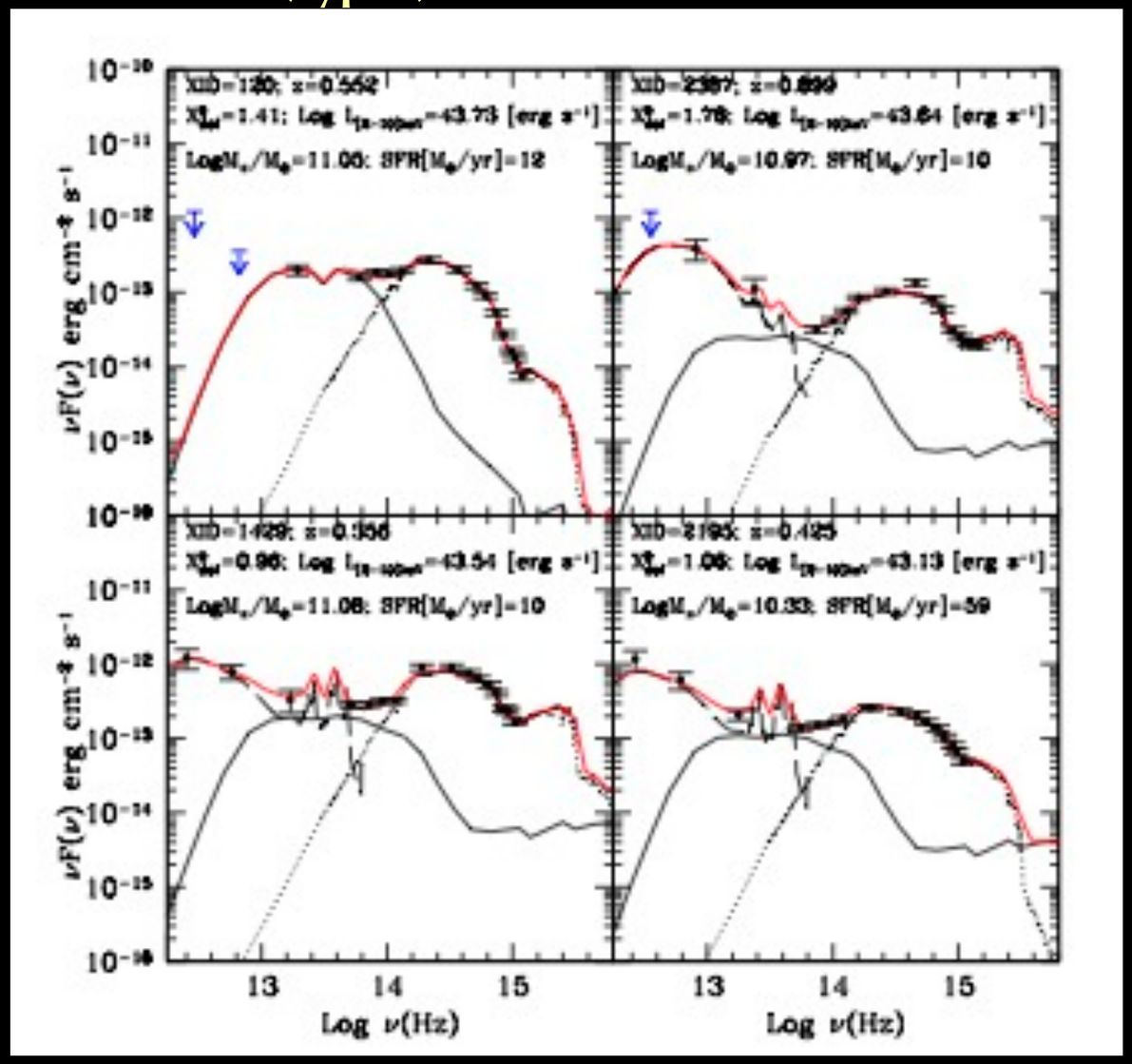
Santini et al. (2012) - PEP/Herschel data of GOODS+COSMOS AGN

Feasible thanks to complete mw information over entire electromagnetic spectrum and in particular Herschel data

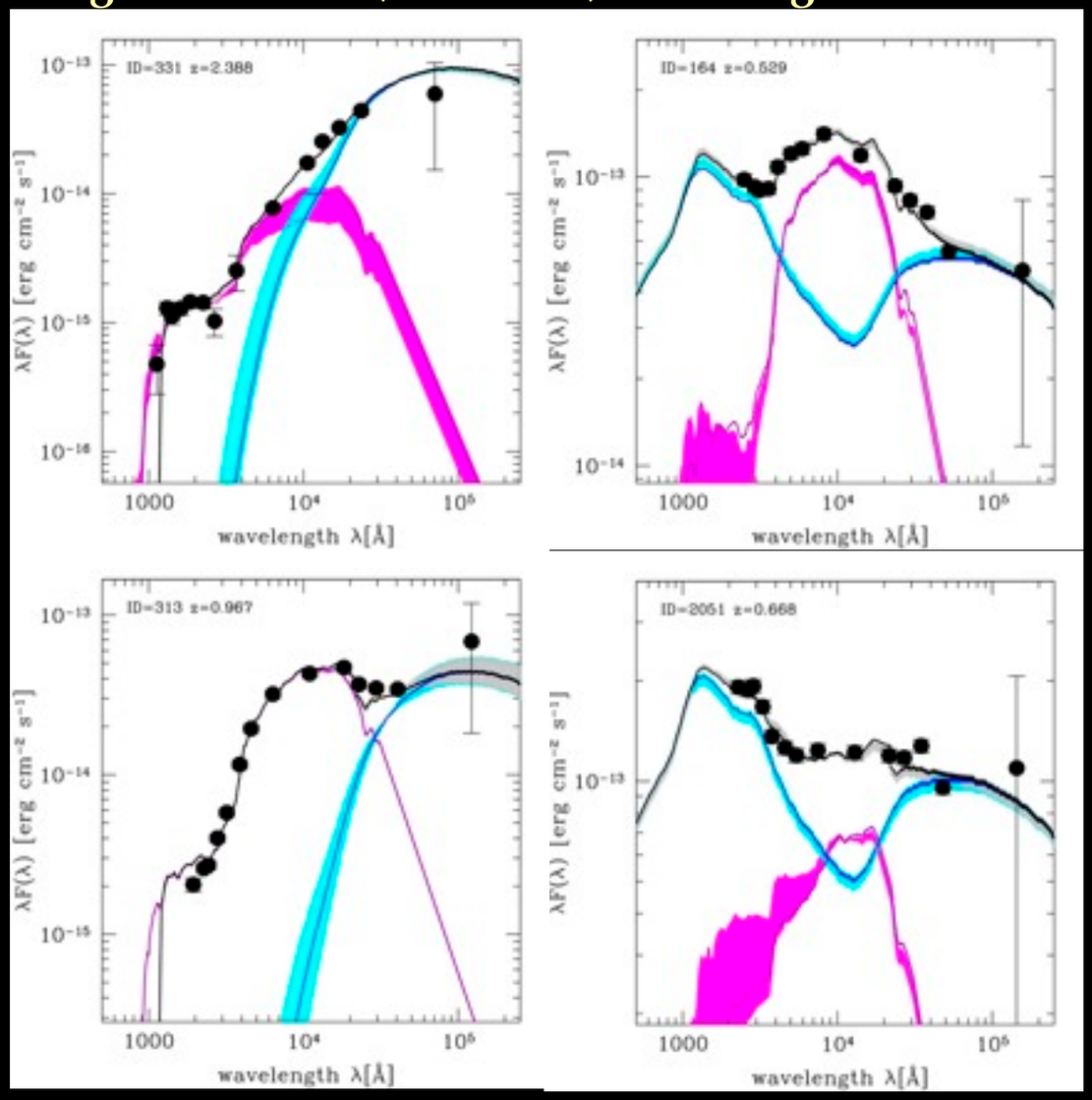
Host/AGN decomposition

(particularly) important for moderate & high-lum obscured QSO and unobs AGN (all lum) when NO FIR/Herschel information is available

Lusso+2011 (Type2)



Bongiorno+2012(full XMM) - see Angela talk!



see also Merloni+2010 (BL AGN), Pozzi+2007,2010; Gruppioni+2010; Santini+2012
Polletta+, Cardamone+2010, Rovilos+2012, Hainline+2012, Elvis+2012, Sazonov+2012

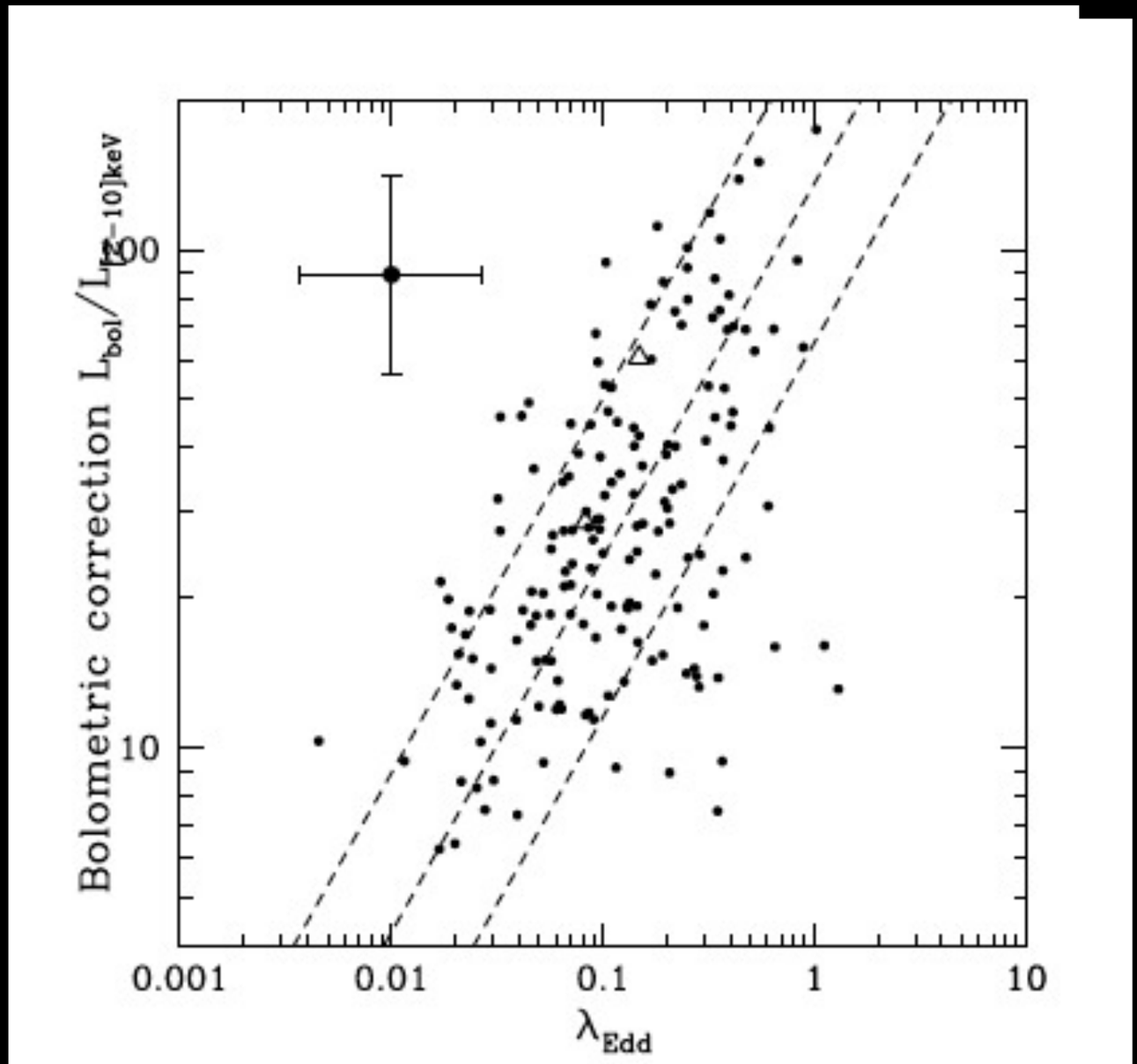
Output parameters:

HOST: M_*, SFR, colors

AGN: L_{bol}, k_{bol}, L/L_{Edd} (if BH mass vailable)

alpha_ox & bolometric corrections

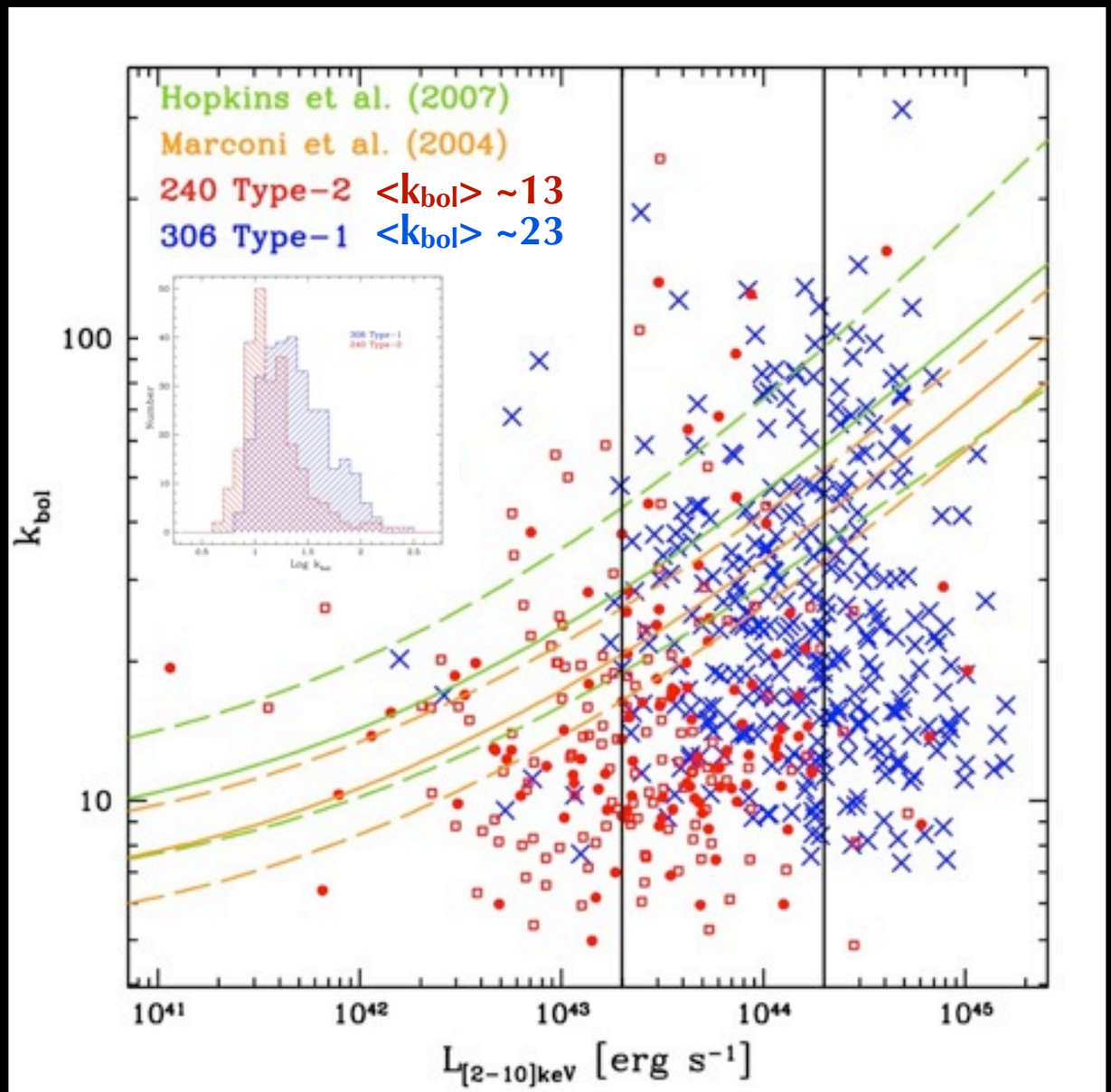
Lusso et al. 2012 (Type 1 AGN in COSMOS)



alpha_ox /Lx relation **different** for X-ray and optical selected samples (Lusso+2010)

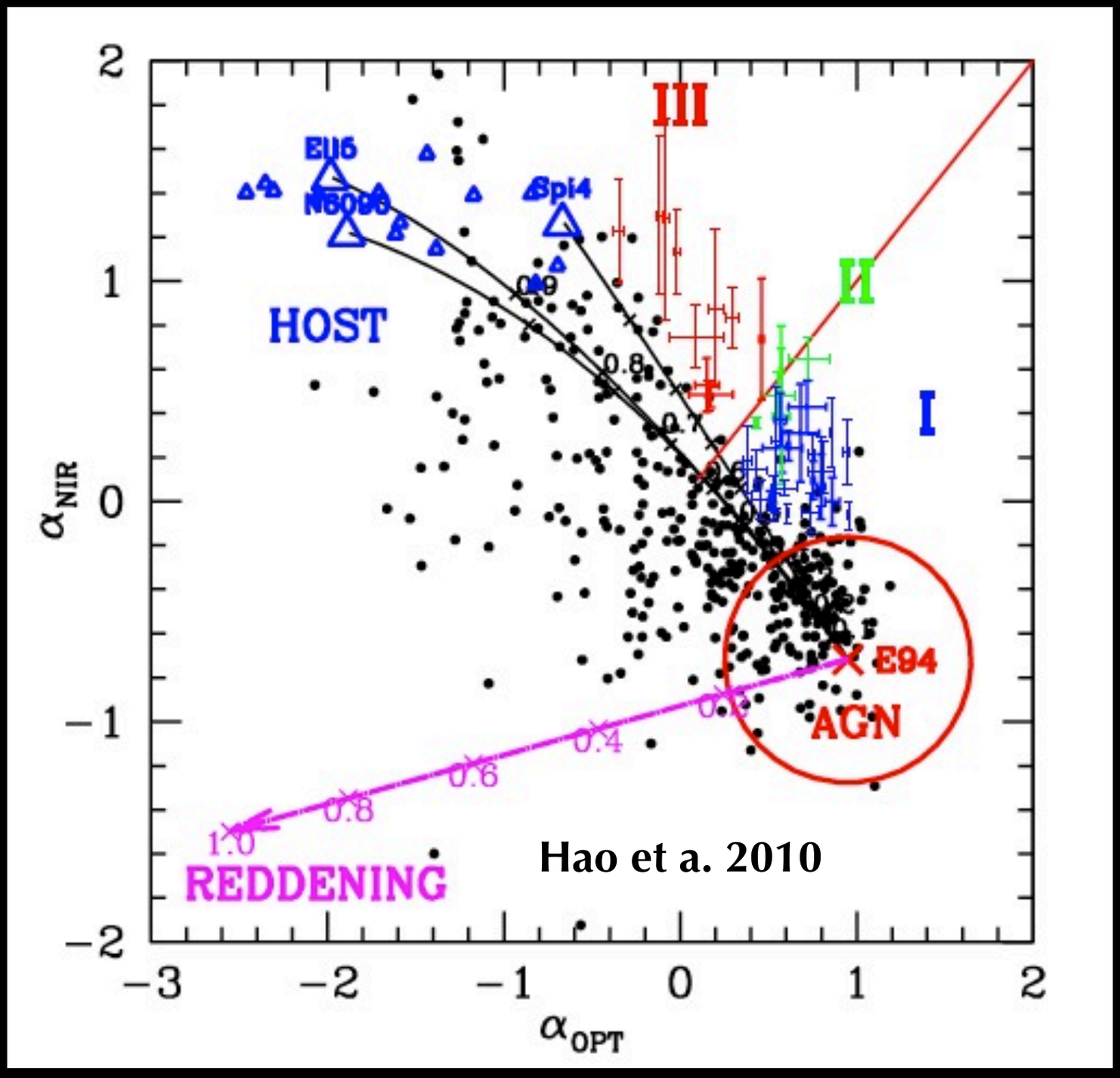
alpha_ox & k_{bol} correlates with L/L_{Edd} --> efficient accretion and more prominent big blue bump see also Marchese et al. 2012

Lusso et al. 2011 (Type 2 AGN in COSMOS)



Lower bolometric correction for Type2 AGN --> lower L/L_{Edd} for obscured AGN (see also Trump+2010)

Hot Dust Poor quasars



10% of XMM-COSMOS BL AGN have **weak NIR emission**, indicating a relative paucity of hot dust emission

Fraction increases with z up to 30%

Origin:
- Torus not yet formed?
- Effect of merger?
[Outburst after merger that can destroy innermost dust or torus]

New AGN templates with variable dust bump strengths are needed to derive accurate galaxy and BH masses!

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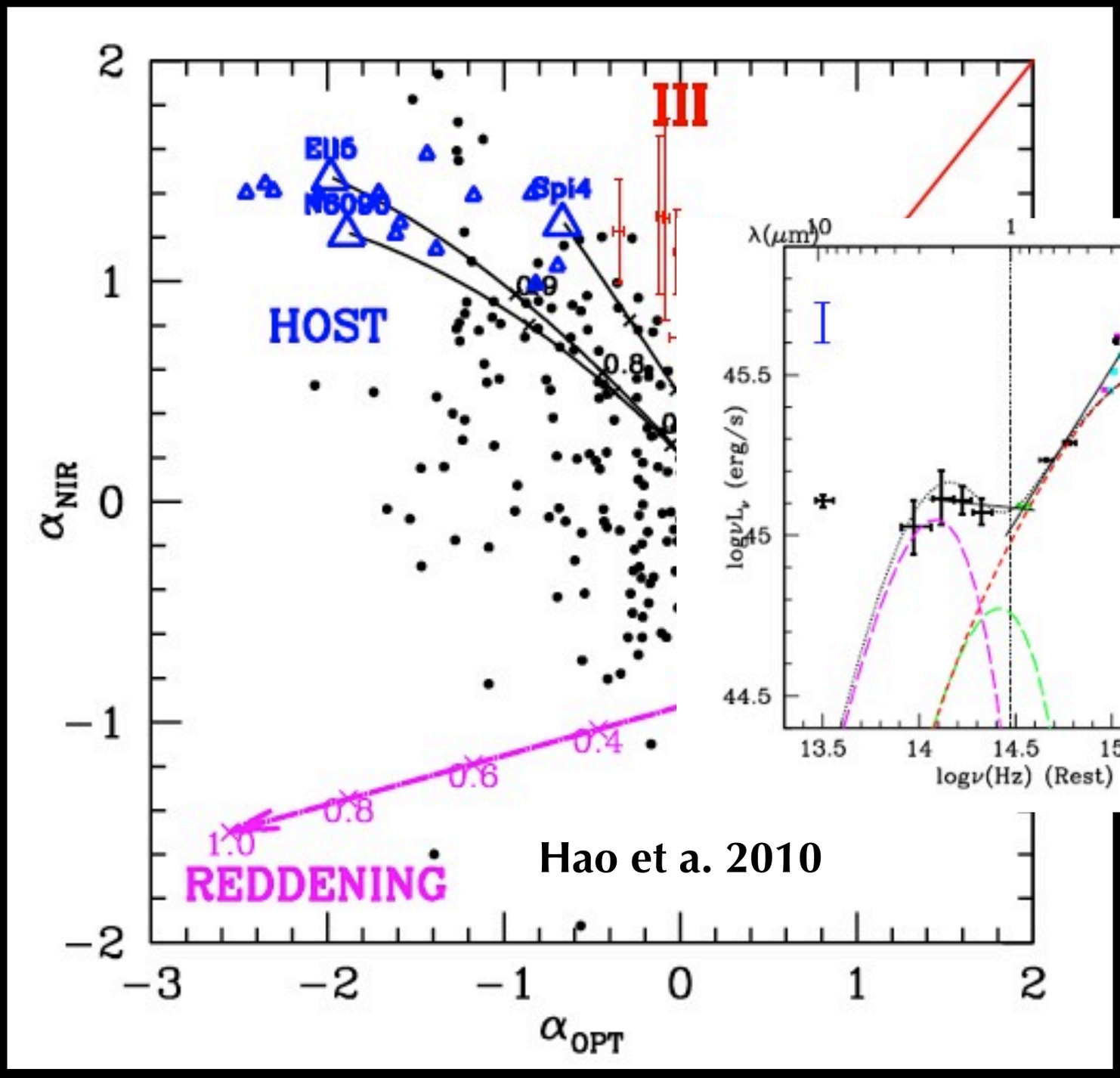

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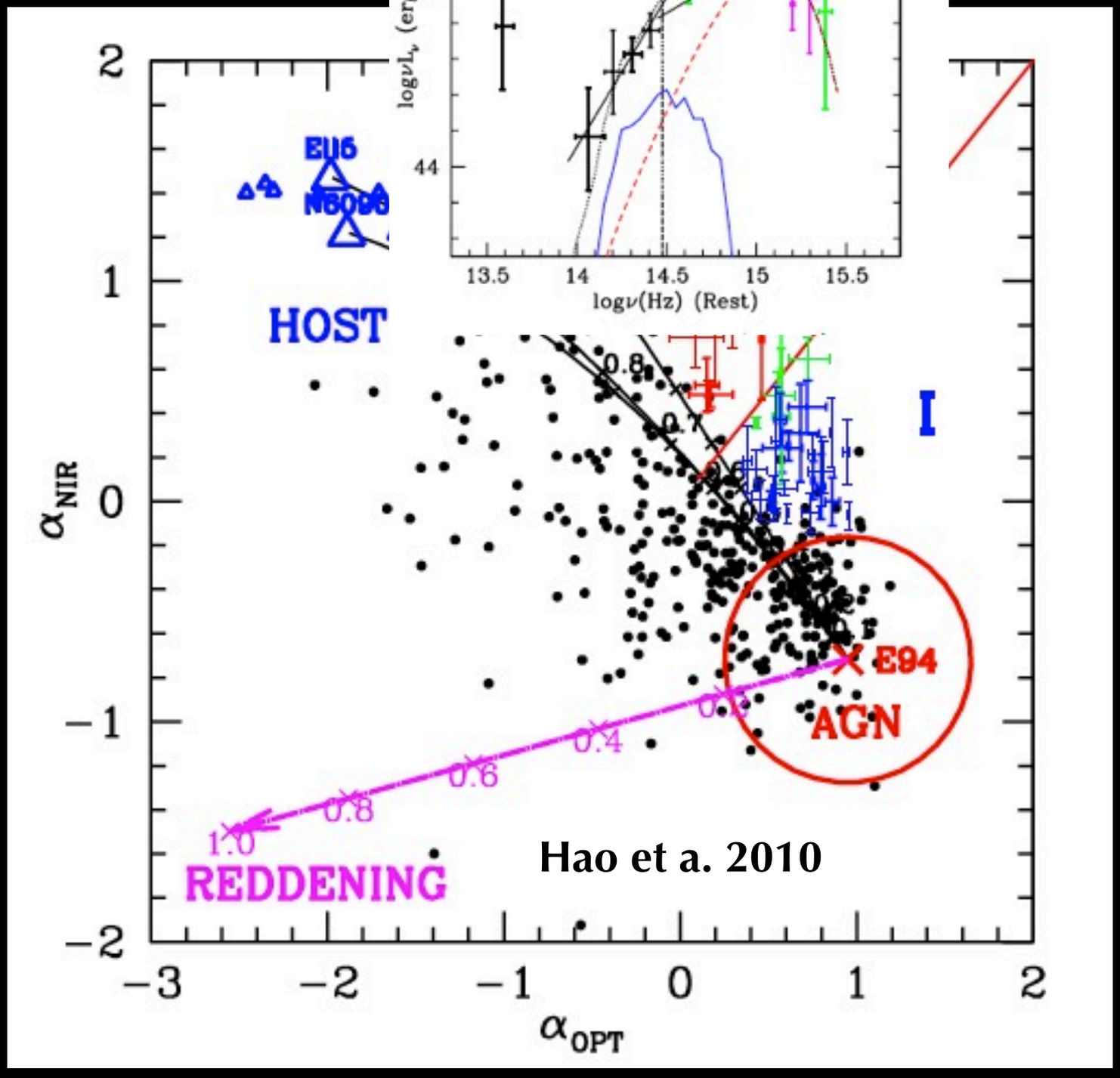

Hao et a. 2010

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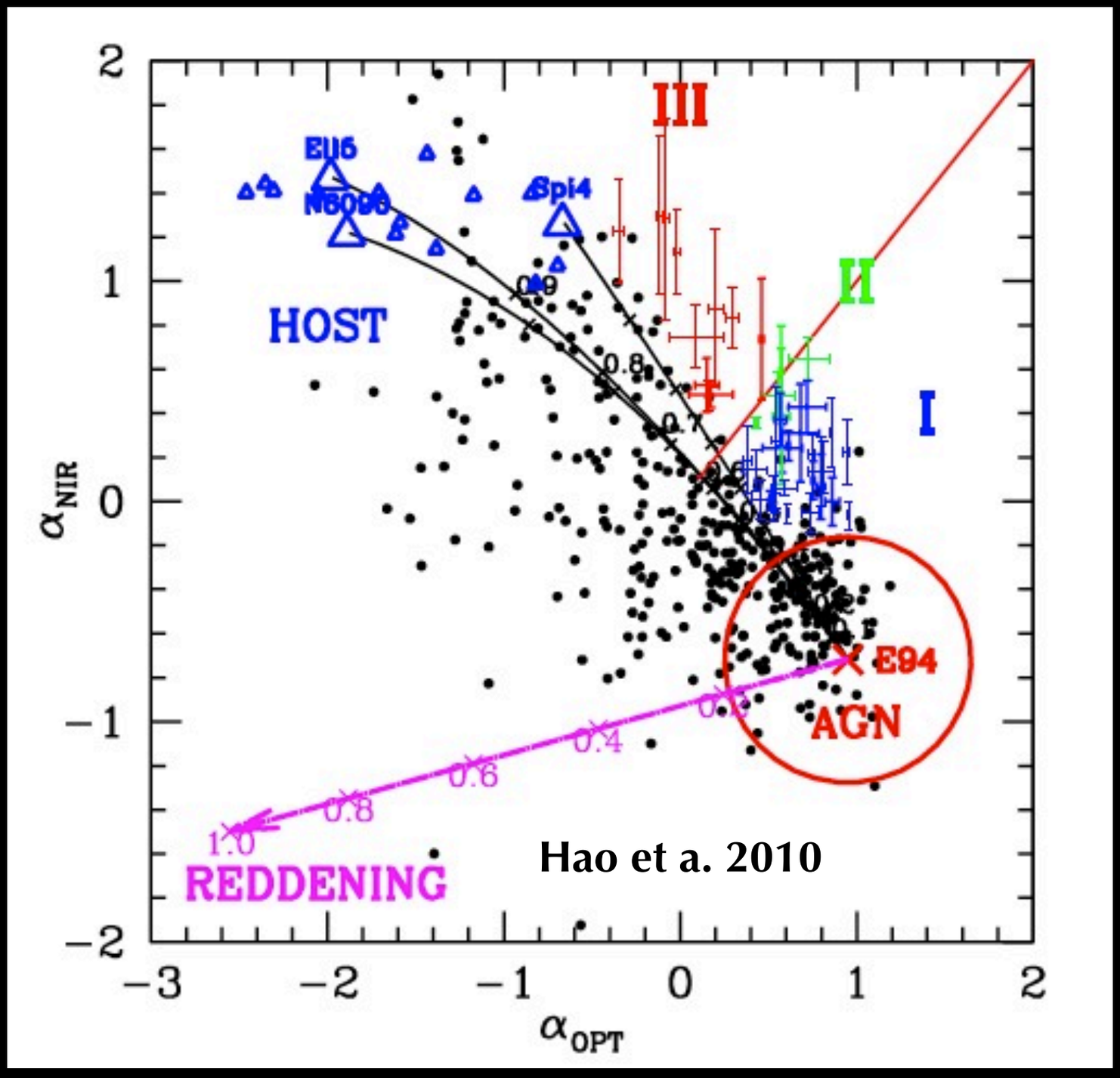

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Obscured QSO: SFR

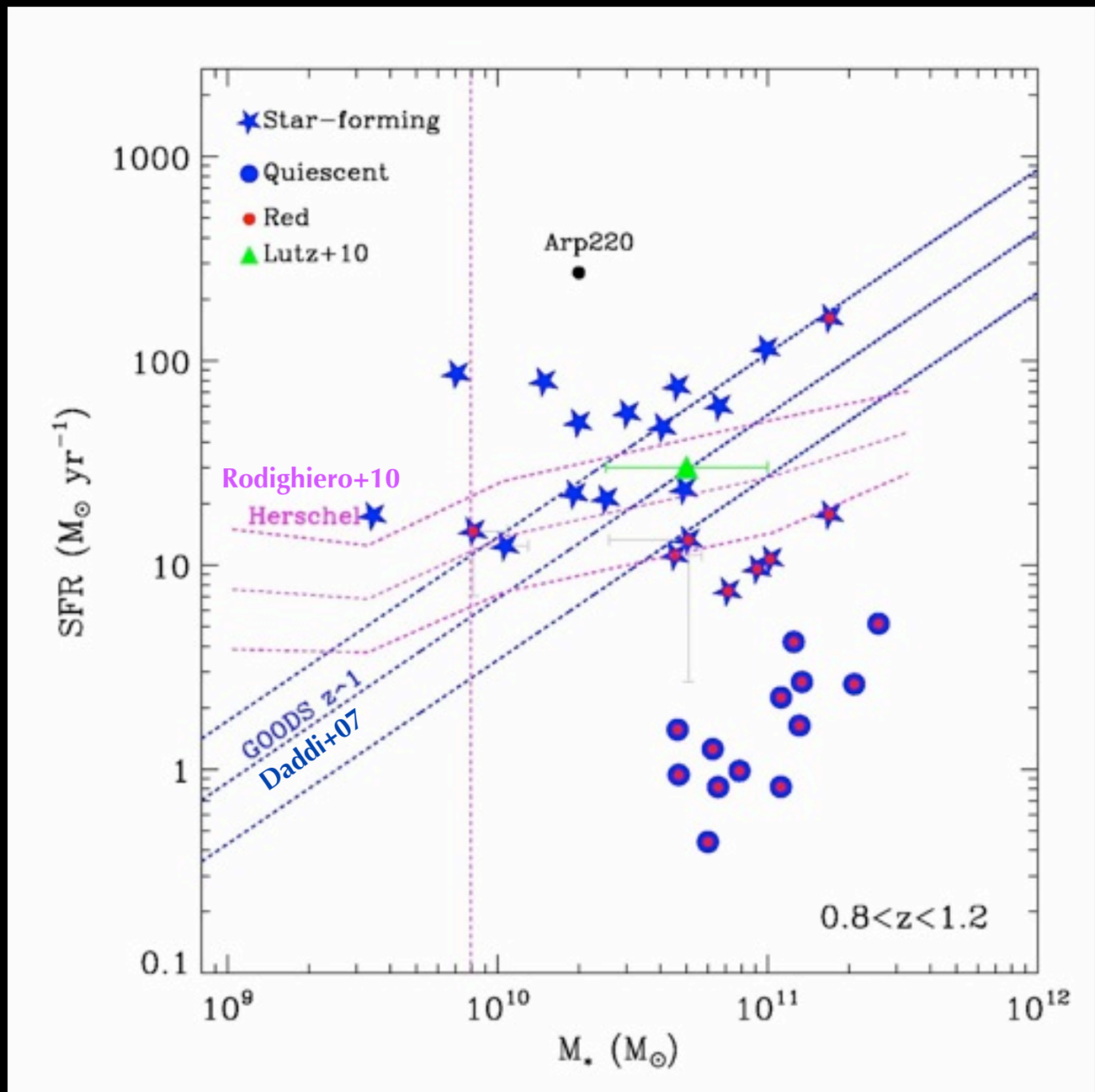
Most **luminous**, **obscured X-ray selected** sources at z>1 are red --> effect of (negative) feedback efficient in stopping star formation, or AGN is in dusty environment? Evidences for ***both*** !

Same level of starformation for"active" (AGN) and "inactive" (SF) galaxies

QSO2 hosts follow the tight correlation between SFR and M_* of blue star-forming galaxies (e.g. Noeske+07; Daddi+07; Elbaz+07; Rodighiero+10 / **Herschel)**

"Passive" population also present by studying only QSO-ULIRGs system (Rovilos et al 2012; Symeonidis et al in prep) you miss an important population!

Mainieri et al. 2011 (QSO2 in COSMOS, Lx>44) see also Brusa+2009, Lusso+2011



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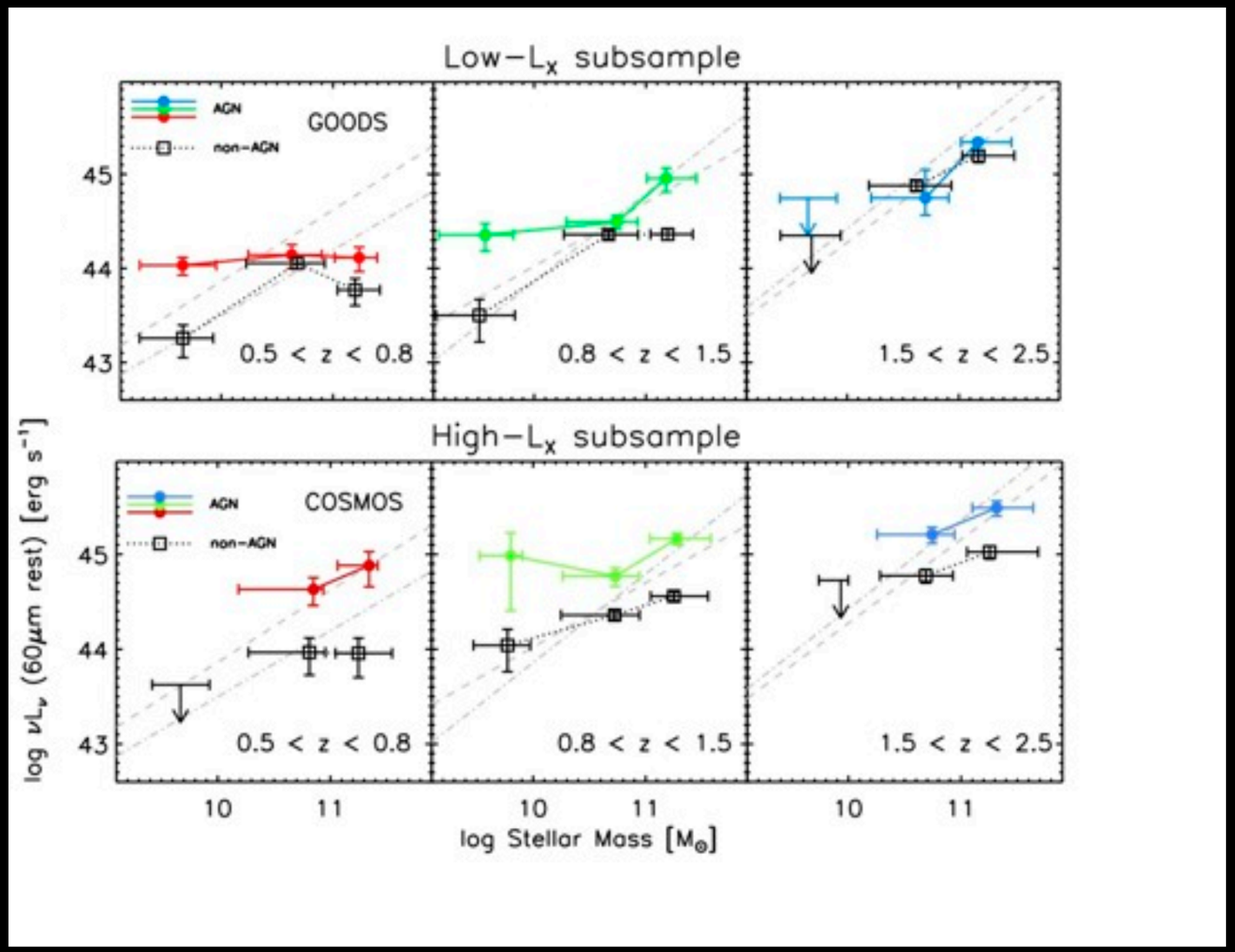
SFR should be tested/validated against FAR-IR --> Herschel/FIR data crucial!

BH masses should be higher (or the same) in passive QSO2 (subsequent phase) than in SF QSO2 --> IR (SINFONI, Xshooter, LUCIFER) spectroscopy for selected sample to observe Halpha (3 nights @X-Shooter next February)

Gas mass in SF QSO2 (still available) should be higher than in passive QSO2 (already diminished/exhausted) --> IRAM and ALMA CO luminosities vs. LIR (ALMA Cycle 1 proposal submitted)

Enhanced SFR in AGN hosts?

Santini+2012 (GOODS & COSMOS)



(see also Silverman+2009, Xue+2010, Mullaney+2011)

AGN are responsible for the reversal of the SFR-density relation (Popesso et al. 2011)

Evidence for enhancement:

- GOODS (low-Lx):

SFR in AGN hosts broadly consistent with that observed in "inactive" galaxies

(modest) enhancement observed only in low-mass samples

- COSMOS (high-Lx):

SFR in AGN hosts ~0.6 dex higher than in "inactive" galaxies, at all z/masses

different enhancements at low and at high-L consistent with two different modes of SF and BH growth

high-L: **major mergers**

low-L: **smooth accretion** (or mergers with delay in SB and AGN phases)

dall'orizzonte cosmologico all'orizzonte degli eventi

Civano et al. (2011) - High-z sources
Iwasawa et al. (2012) - Iron line stacking

“orizzonte cosmologico”

data from COSMOS survey

Brusa et al. 2009b
Civano, MB+11 ApJ

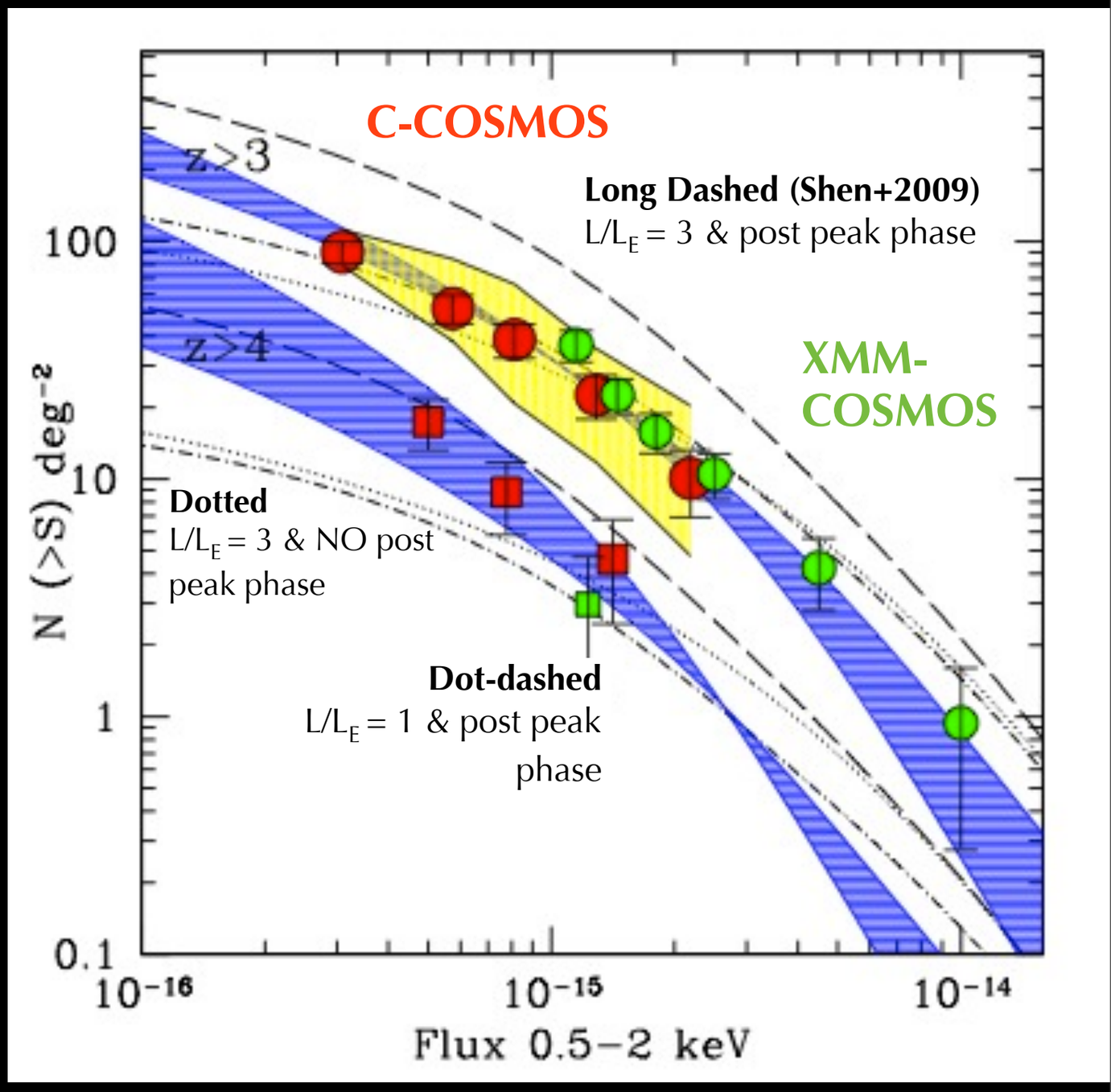
selection based on spectro-z and photoz
(from Salvato+09 & in prep)
~80 objects, 50% specz

predictions

XRB models: from **Gilli+2007**
(with a decline in the space density, following Brusa+09) and Aird+2010

SAM models:
from Shankar+2010 & in prep
different curves --> different AGN lightcurves and minimum halo mass
degeneracy within the two parameters, z dependence?

Civano, MB + 2011 (Chandra-COSMOS)
see also Fiore+2012, Hiroi et al. 2012
F. Vito talk for most recent results in CDFS



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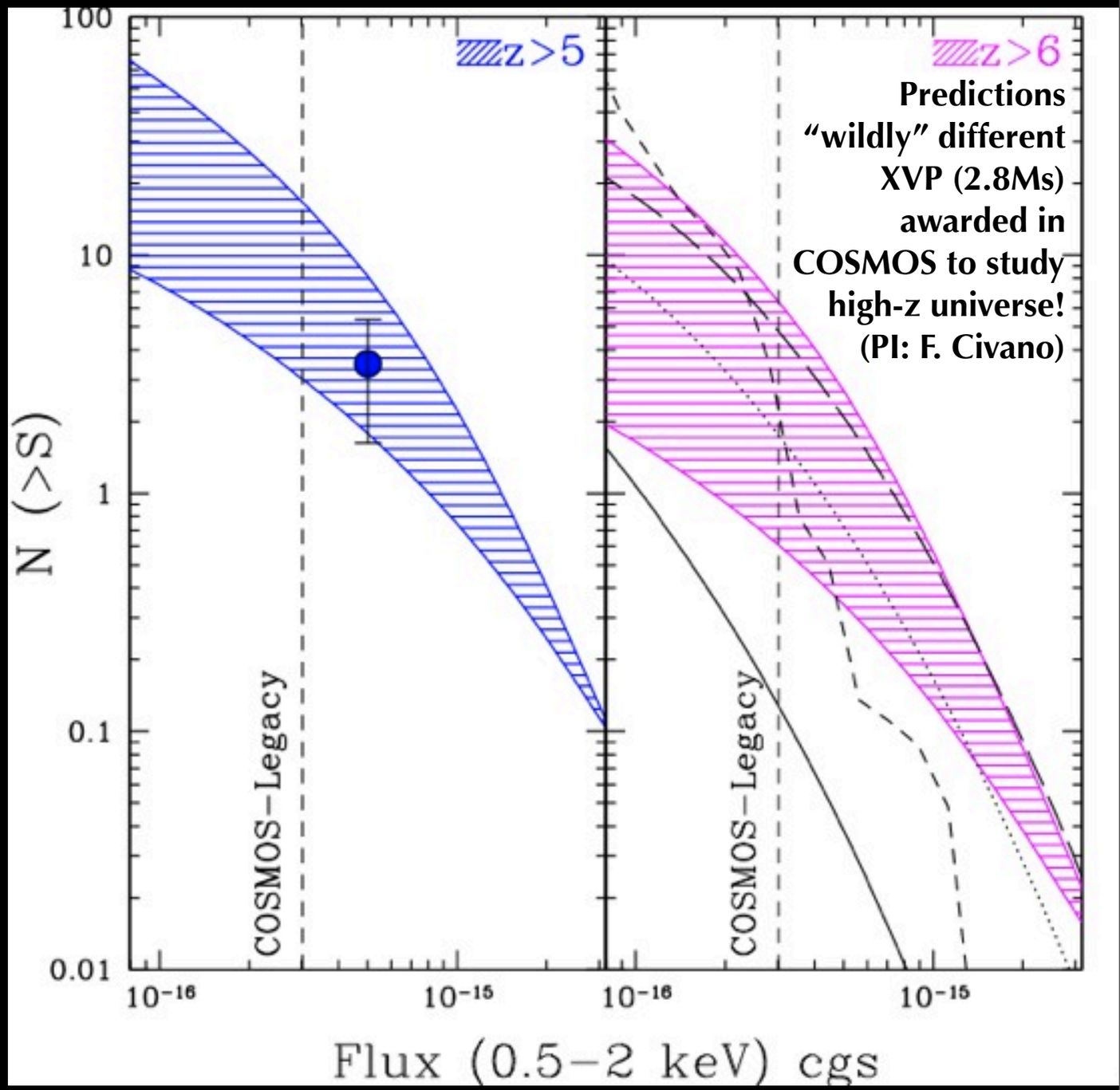
different curves --> different AGN lightcurves and minimum halo mass
degeneracy within the two parameters, z dependence?

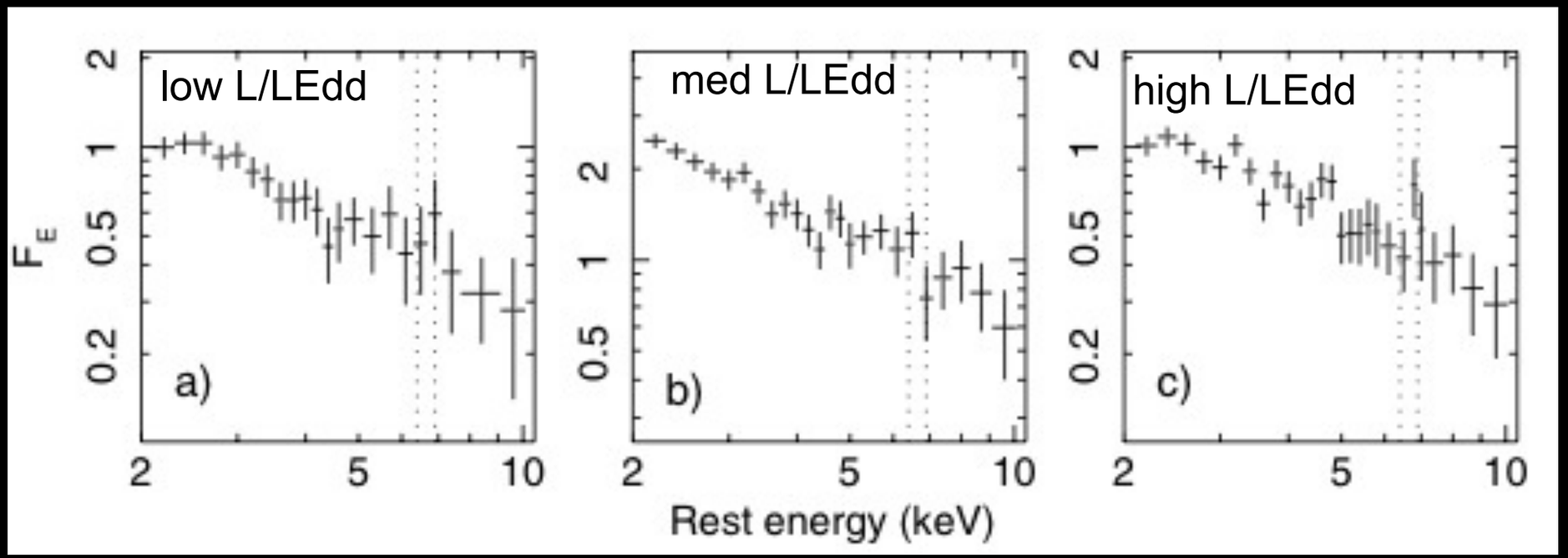
Civano, MB + 2011 (Chandra-COSMOS)
see also Fiore+2012, Hiroi et al. 2012
F. Vito talk for most recent results in CDFS



"orizzonte degli eventi"

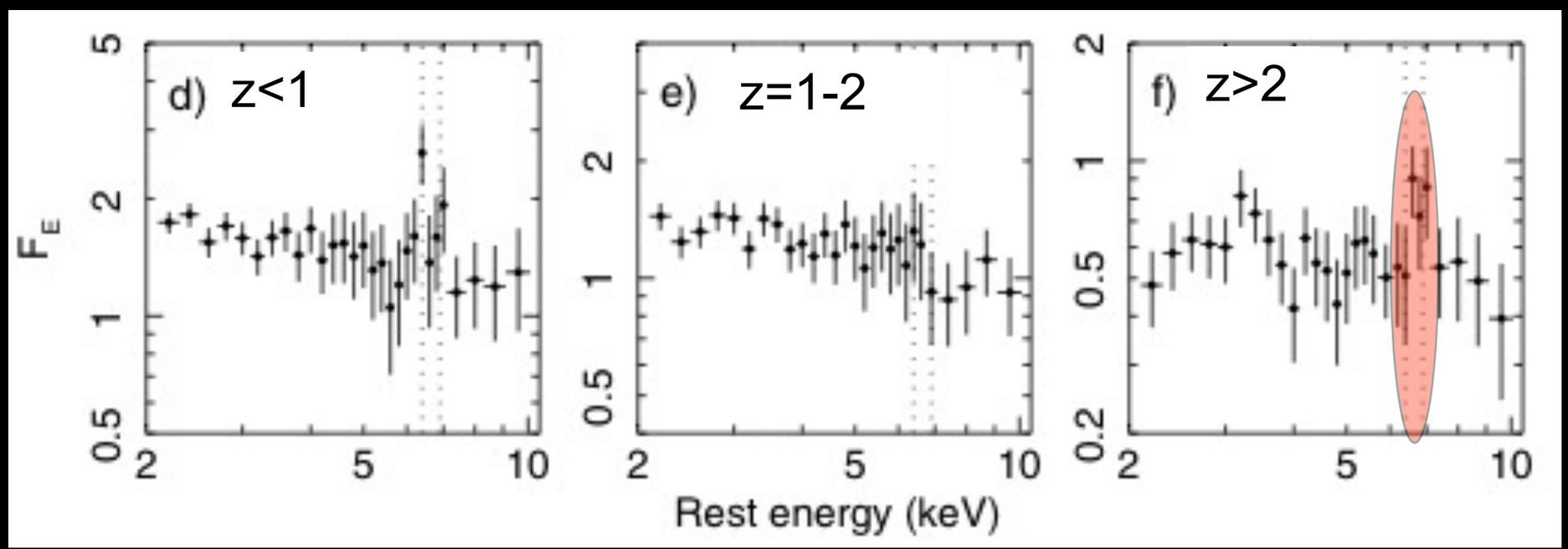
Type 1 AGN:

higher ionization lines Fe XXV and Fe XXVI pronounced, trend with accretion rates



Type 2 AGN:

at high-z (z>2) strong 6.9 keV line present (no cold iron line)



Iwasawa, Mainieri, MB et al. 2012, A&A, 537, 86

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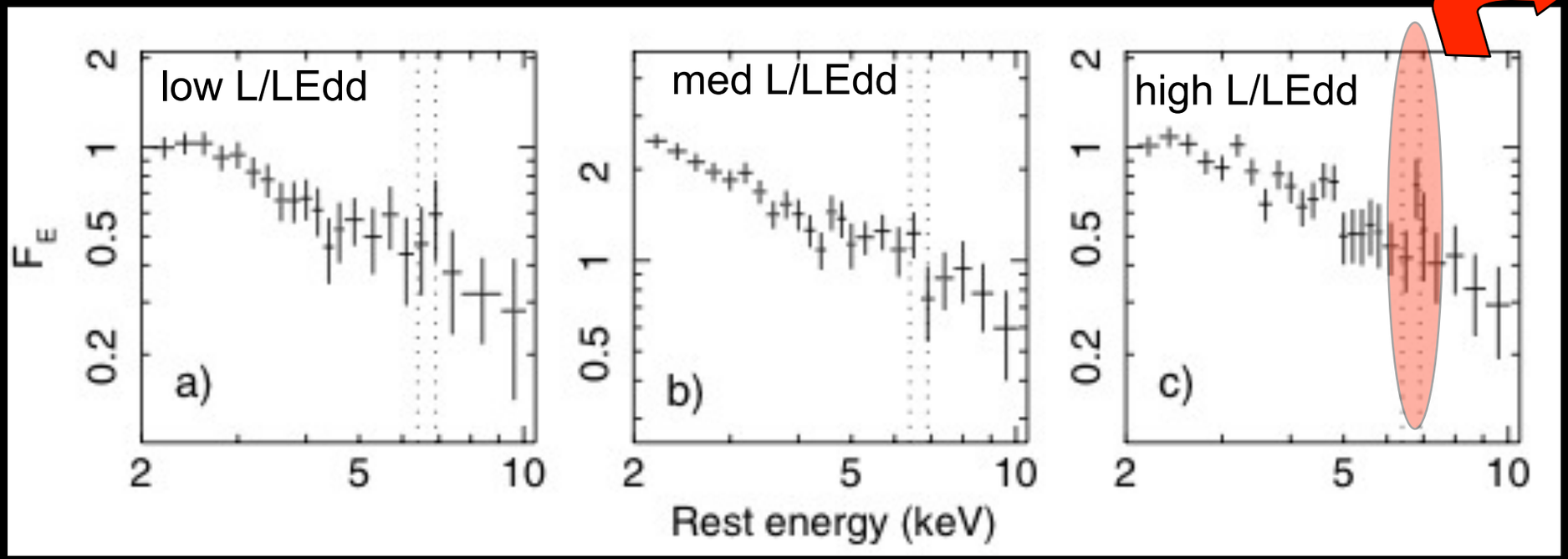

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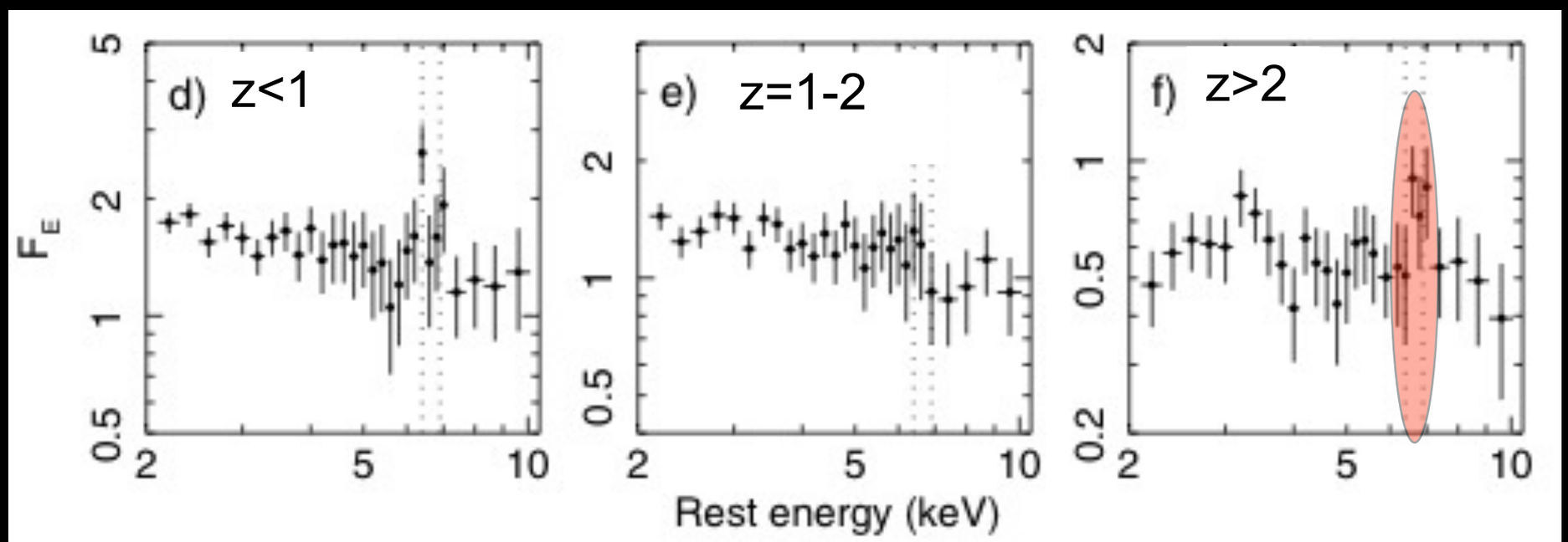

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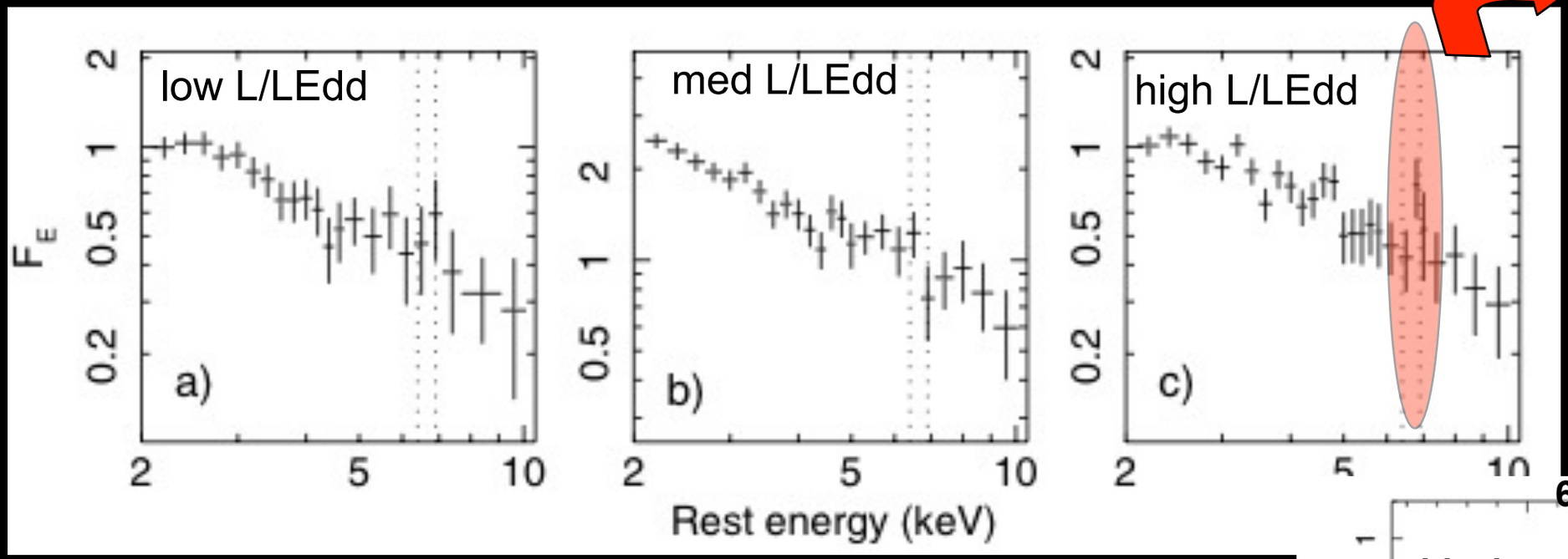

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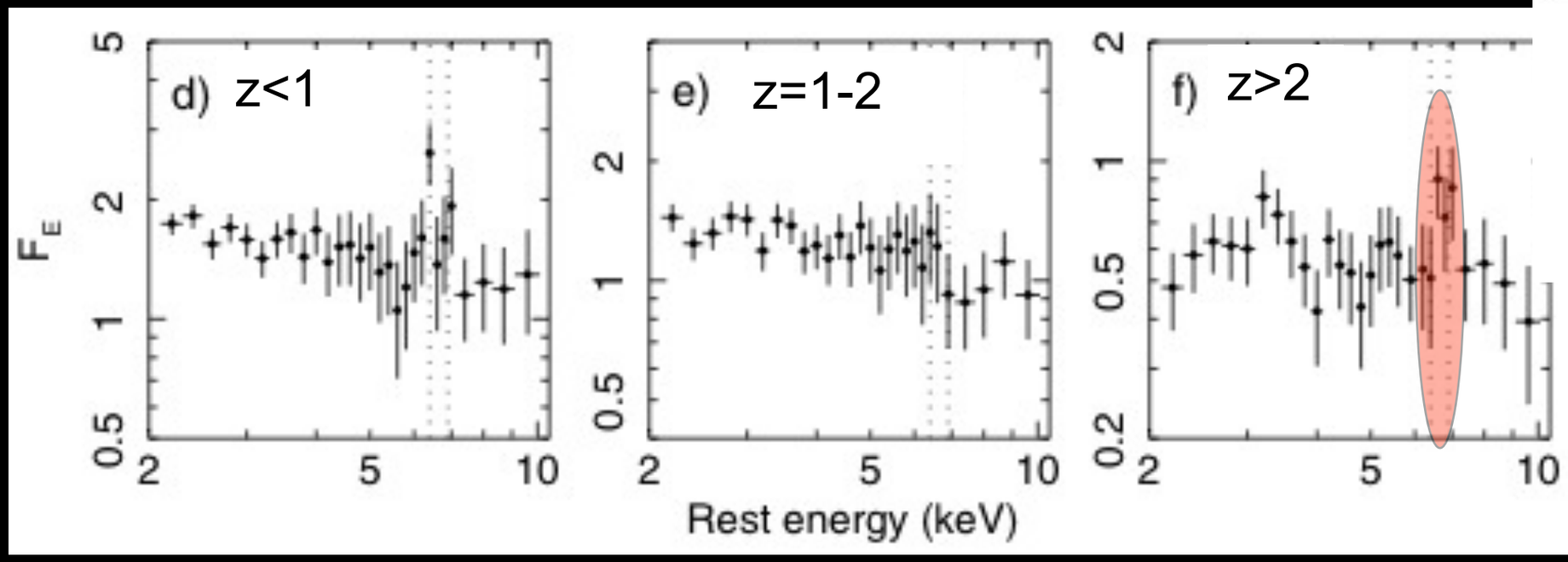

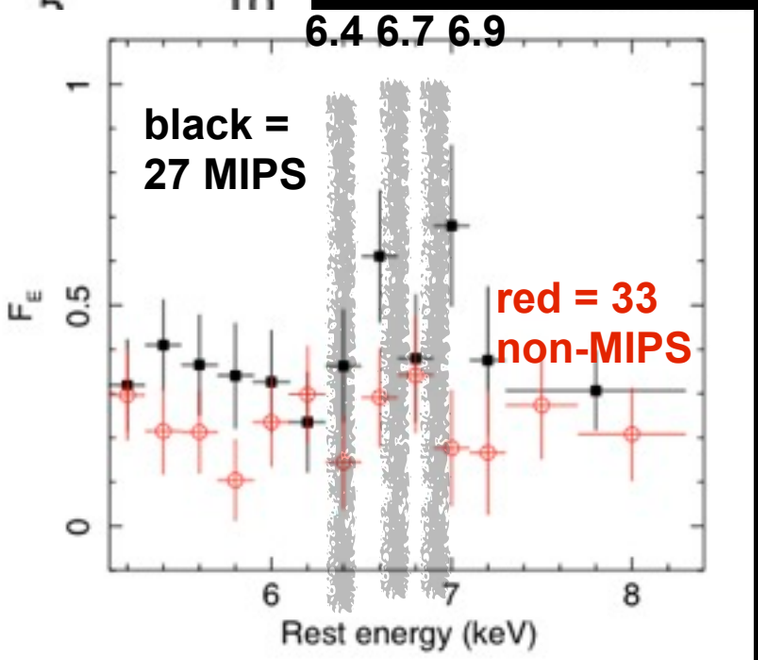

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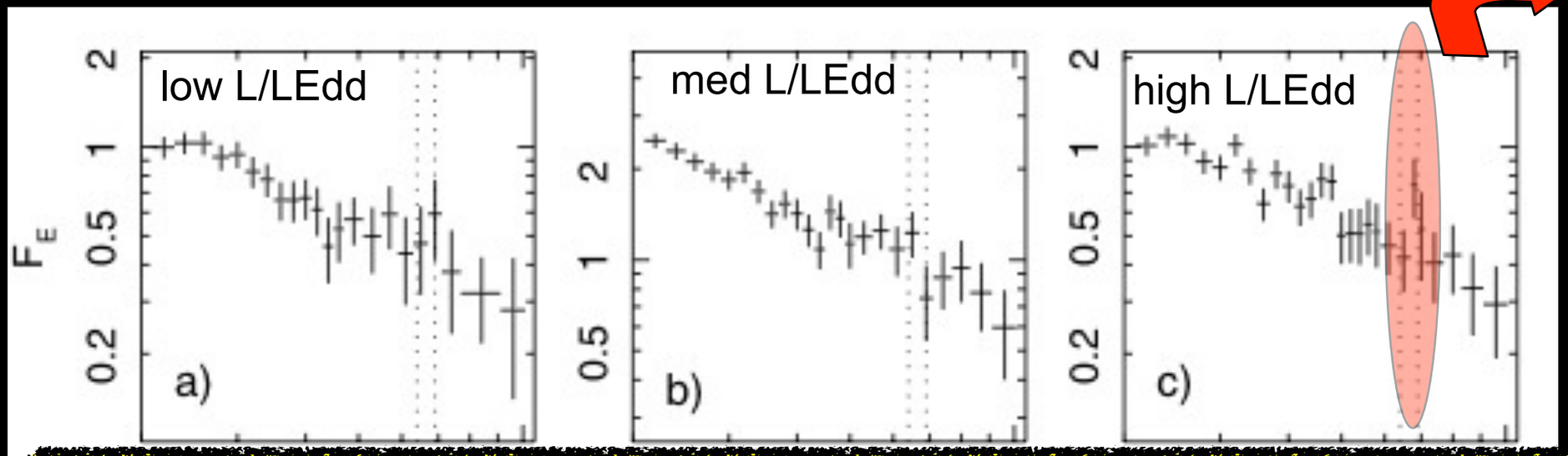


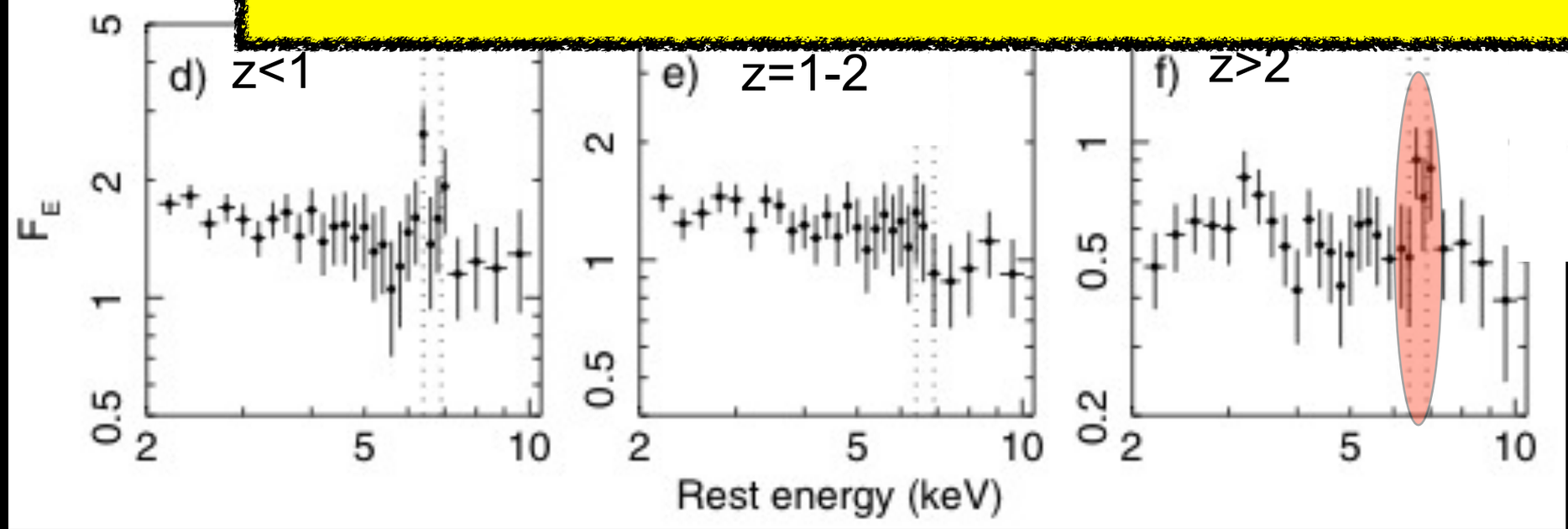
line centroid 6.9 keV

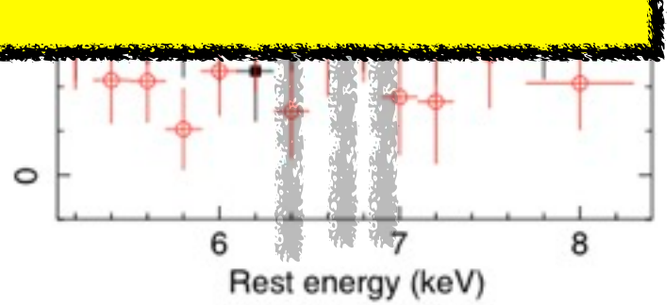
BL AGN: Higher accretion rate sources (close to Eddington) show ionized lines
NL AGN: high-ioniz lines signal from MIPS detected sources!

Higher ionization lines more common in rapidly growing BH? Link with ULIRGs

Type 2 A

at high-z





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Summary

★**X-ray selection makes up the most of AGN, multiwavelength (especially IR) essential to complete the census**

★X-ray luminosities function studies provide an **important, independent** evidence that our general BH-galaxy co-evolution picture is correct (AGN downsizing)

★Clustering studies turned out to be **crucial in fine tuning** AGN-galaxy co-evolution parameters

★detailed SED studies **essential to constrain bolometric output** (and reveal "new" populations, e.g. HDP)

★Host galaxies of z>1 obscured AGN show both **high, dust obscured starforming galaxies** and **passive ellipticals**

★**High-z (z>3) source counts and stacking results** constraints for galaxy-coevolution models; perspectives for large area and deep X-ray surveys (e.g. Chandra XVP)

★X-ray surveys future ? **Nustar** & **eROSITA (all sky)** **--> G. Matt talk**

Thanks !

“We have to remember that what we observe it is not Nature in itself, but Nature exposed to our method of questioning” (W. Heisenberg)