Black Hole Masses and Eddington Ratios of AGNs at 0.4<z<1: evidence of retriggering

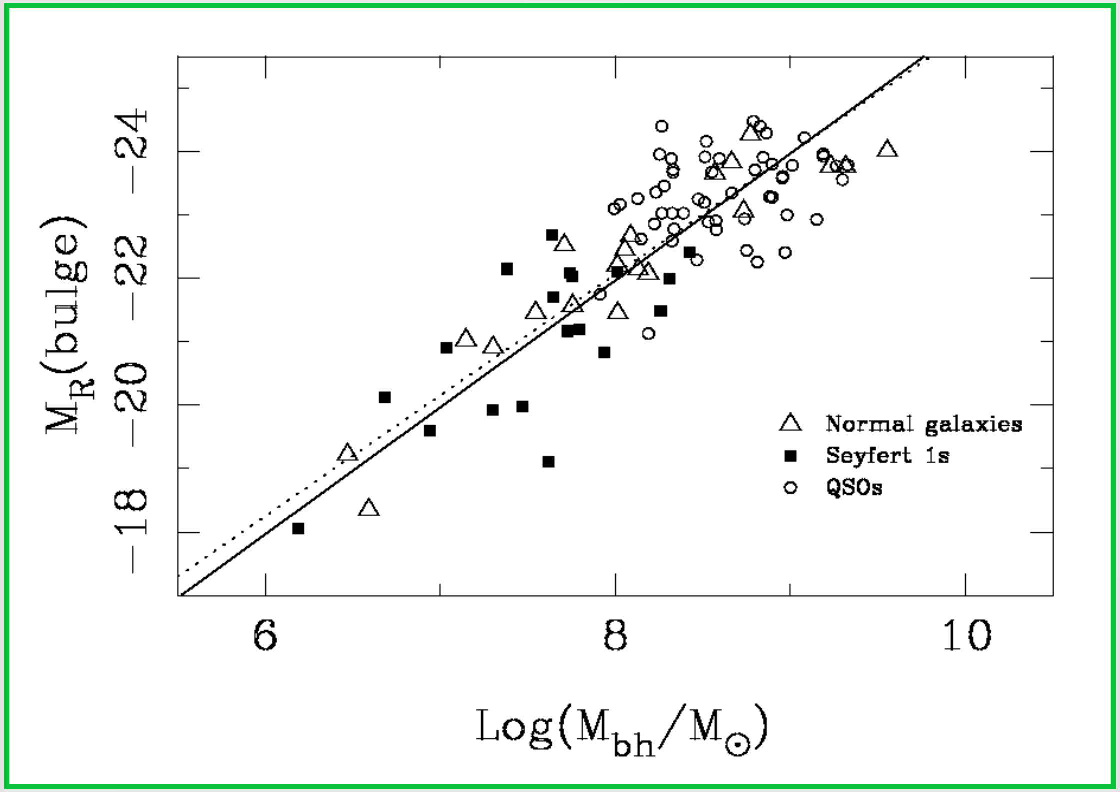
Lucia Ballo

S. Cristiani (OAT), F. Fontanot (DAUT), P. Monaco (OAT, DAUT),
M. Nonino (OAT), P. Tozzi (OAT), E. Vanzella (OAT), L. Danese (SISSA)

Nucleus vs host

- ✓ SMBHs ubiquitous at the centers of local spheroids *(Richstone et al. 1998)*
- ✓ Tight correlations between M_{BH} & host properties → coevolution
- ✓ local SMBHs = relics of past AGN activity (transient phase of galaxy evolution)

(e.g. Brandt & Hasinger 2005)



(McLure & Dunlop 2002)

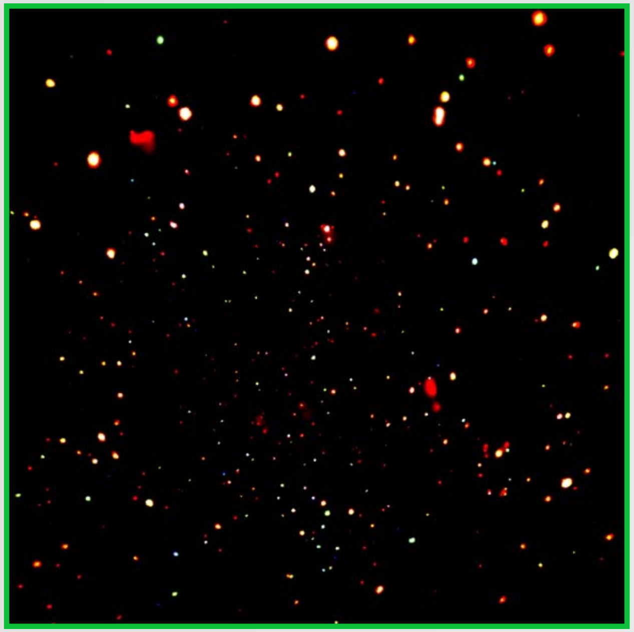
OSS

- M_{BH} vs σ

  0.2 dex
- M_{BH} vs M_R(bulge)

  0.42 dex (ACTIVE)
- Found for INACTIVE and LOCAL galaxies; confirmed for ACTIVE and LOCAL galaxies

Accretion and Background X



CDFN image (Alexander, Bauer, Brandt et al.)

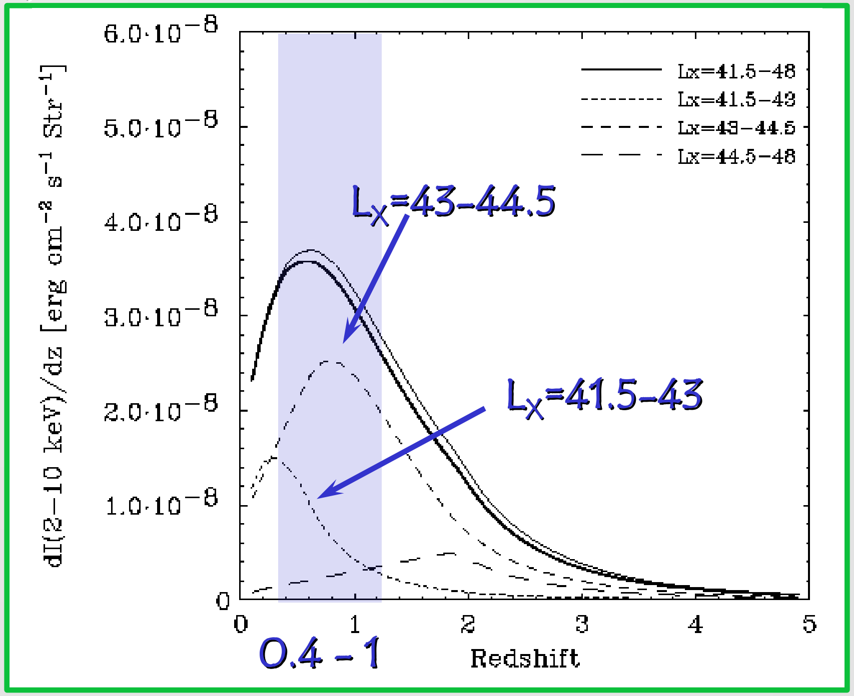
Deep X-ray surveys → more than 80-90% from extragalactic point sources *(Brandt et al. 2001, Rosati et al. 2002, Hasinger et al. 2001)*

Optical spectroscopic identification → mix of absorbed and unabsorbed AGNs *(Szokoly et al. 2004, Barger et al. 2003)*

The bulk of XRB (2-10 keV)

- ✓ in a narrow range of redshift ($0.5 < z < 2$) peaking at $z \sim 1$
- ✓ by AGNs with X-ray luminosity between $\sim 10^{42}$ and 10^{45} erg s^{-1}

(Ueda et al. 2003)

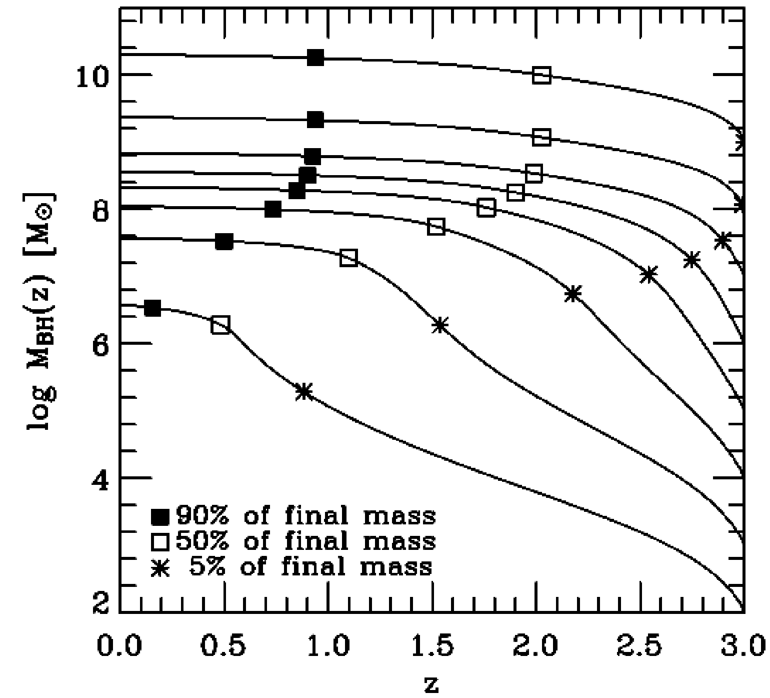


Evolution models

e.g. Granato et al. 2001, 2004

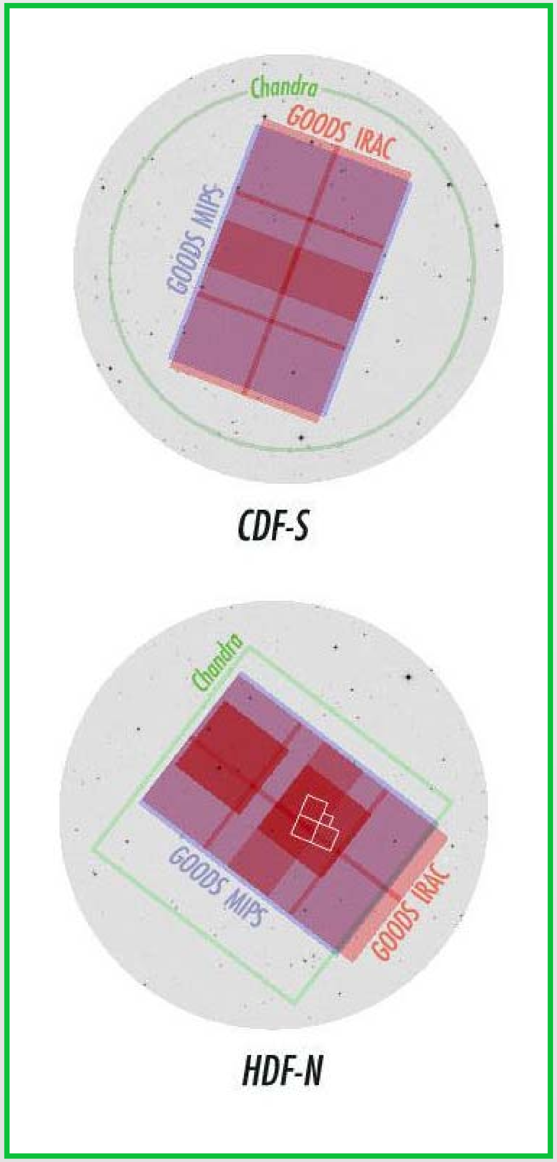
- ✓ Big BHs form in deeper potential wells ⟶ grow faster.
- ✓ Smaller BHs form in shallower potential wells ⟶ take more time to grow.

The AGNs making the X-ray background could probe the lower end of the BH mass function.



(Marconi et al. 2003)

The multiwavelength advantage: GOODS overview



- ✓ Study galaxy formation and evolution over a very wide range of cosmic lookback time
- ✓ Multi Wavelength Survey

  Area: 2 × 160 $arcmin^2$ fields (HDFN and CDFS)

Space Based:

ACS on HST

Spitzer

Chandra

XMM-Newton

GALEX

Ground Based:

VLT/ESO

Keck

Gemini

Subaru

NOAO

ATCA

VLA

SCUBA

MAMBO

(ApJL special issue 2004 January 10)

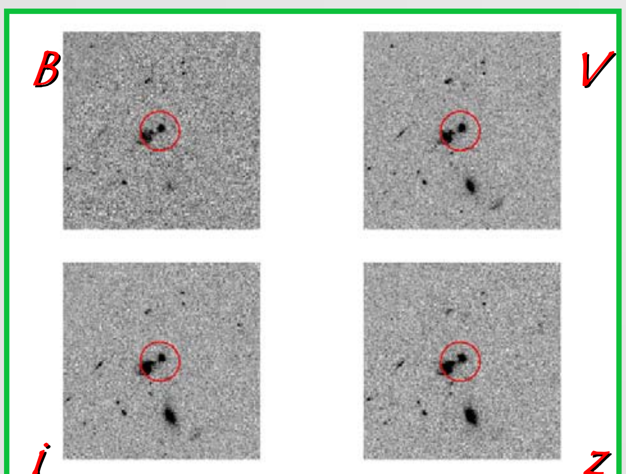
Sample selection

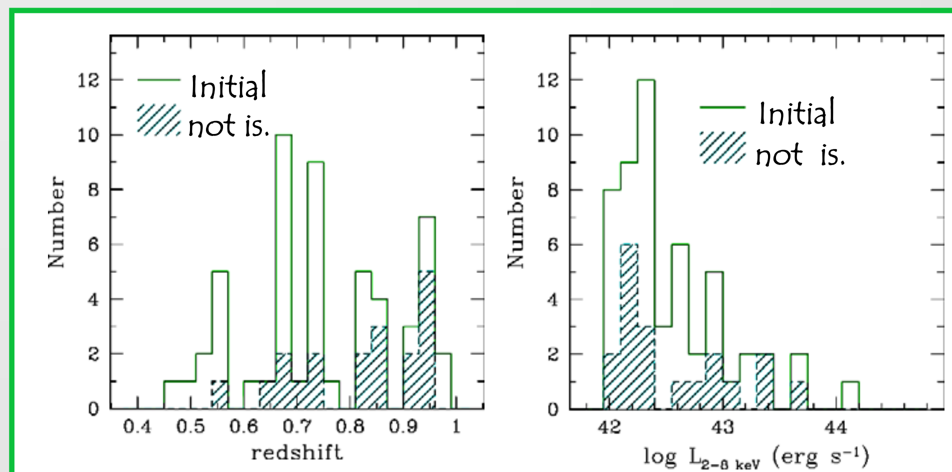
✓ X-ray selected sources with 0.4<z<1 (spectroscopic + photometric)

✓ Selection in luminosity (AGN) Log $L_{2-8\ keV}$ > 42 erg s^{-1}

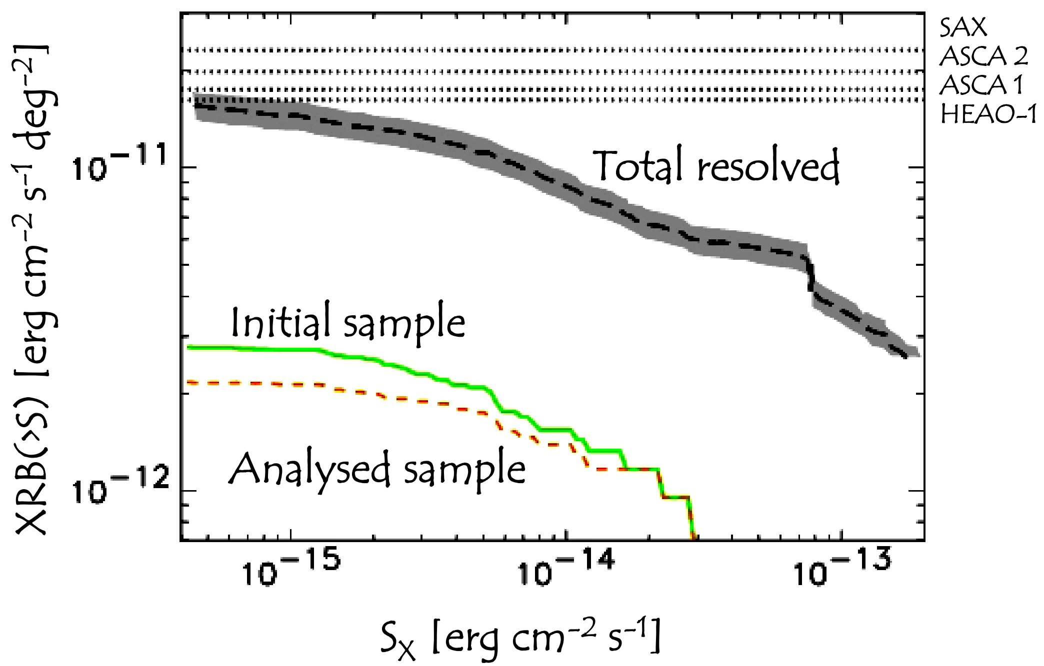
✓ ALL cutouts OK: 23+2 (CDFS) - 25+3 (HDFN) ⇒ Initial sample

✓ Not isolated (projected radius ~ 2″ ≈ 13 kpc at the mean redshift)



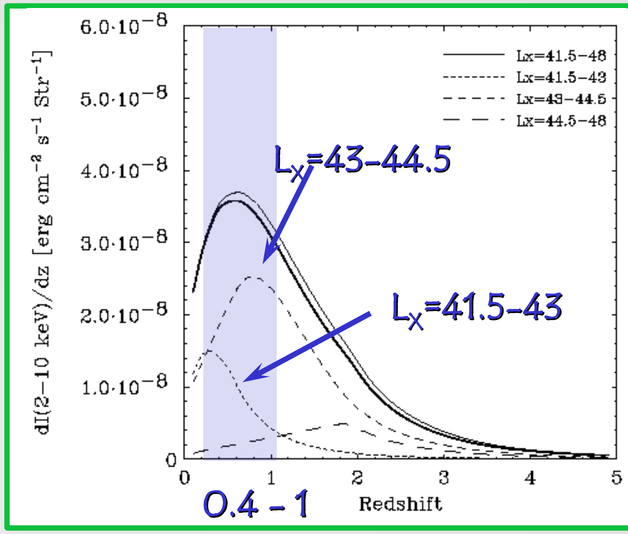


19 sources out of 53 ⇒ ~ 39%

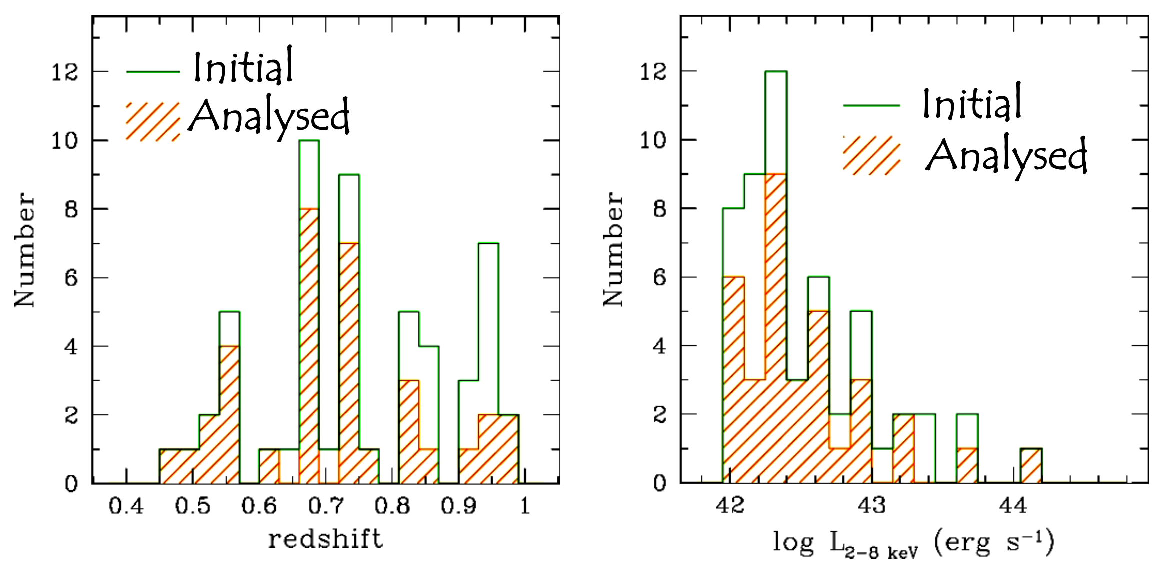


The analysed sample:

19 CDFS 15 HDFN



~16% of hard XRB

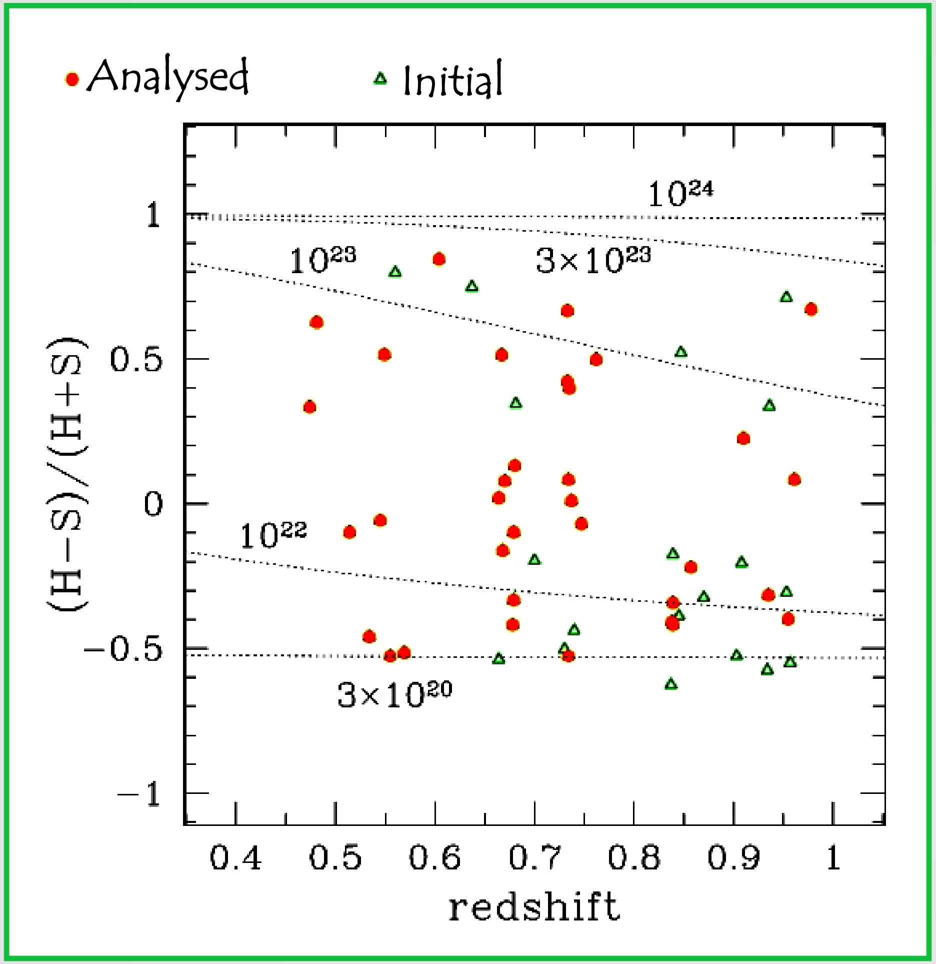


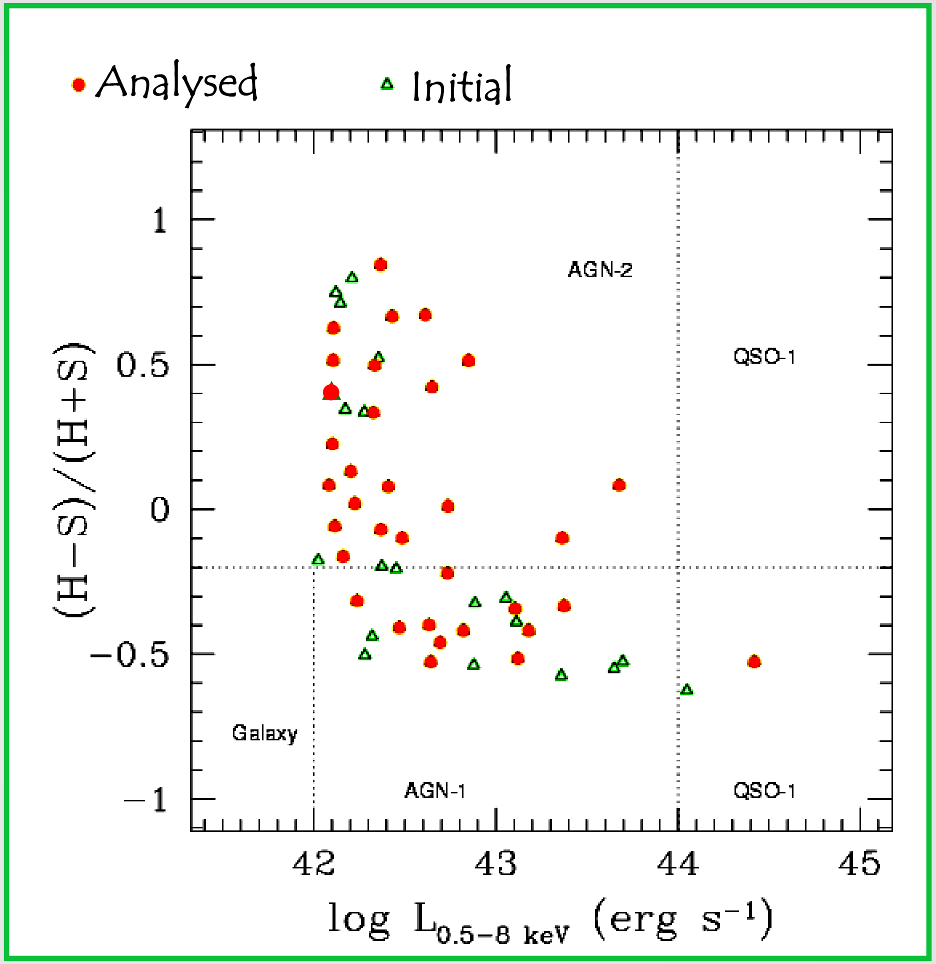
TOTAL RESOLVED HARD XRB:

Tozzi and the CDFS team

astroph/0111036

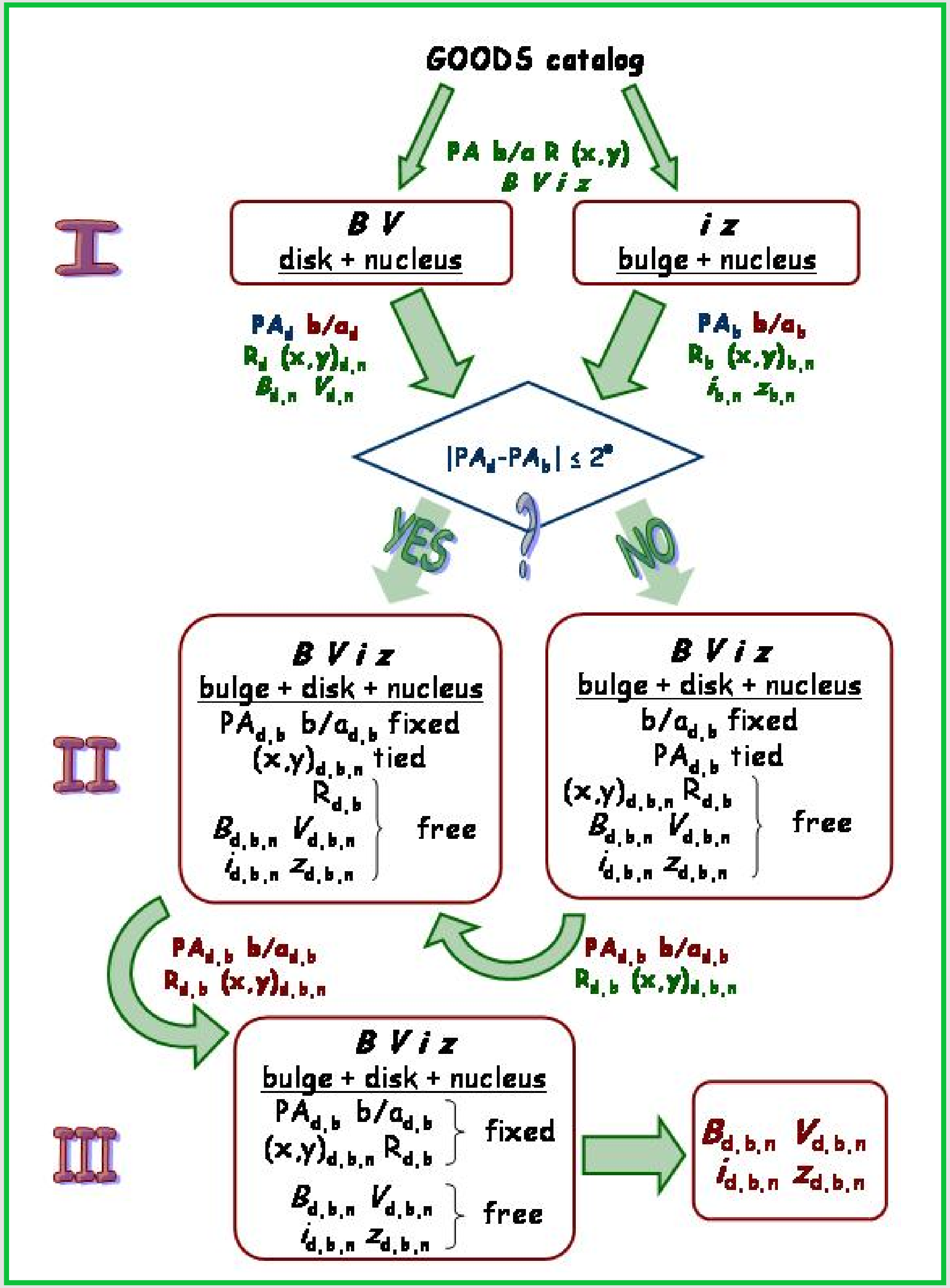
The nature of our sample: diagnostic diagrams





S = 0.5 – 2 keV counts s^{-1}
H = 2 – 8 keV counts s^{-1}

(H-S)/(H+S)=Hardness Ratio: absorption indicator



The Analysis

Image preprocessing & PSF derivation

Bidimensional deconvolution
GALFIT
(Peng et al. 2002)

nucleus – bulge – disk

Errors: $m_i + \Delta m_i$ fixed
new fit
until $\Delta\chi^2=1$

CDFS

source 34 (I)

redshift = 0.839 i_{GOODS}=22.19

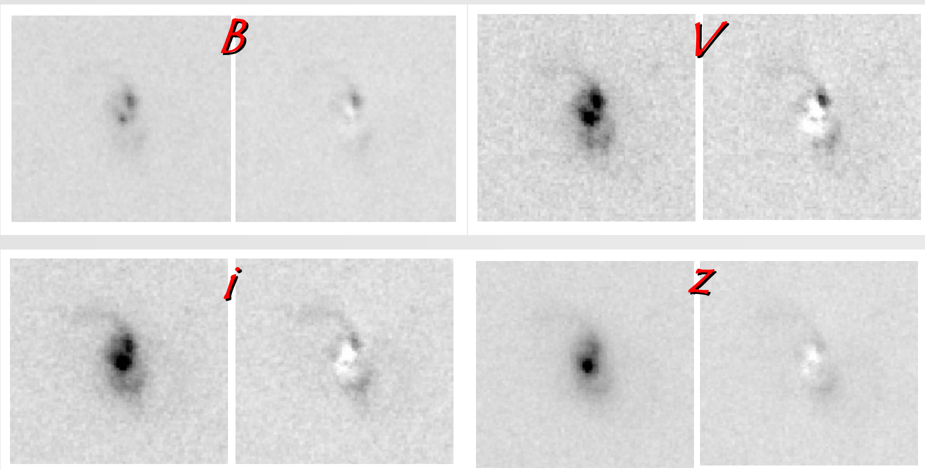
Γ = 1.58 $N_H = 6.4 \cdot 10^{21}$ cm^{-2}

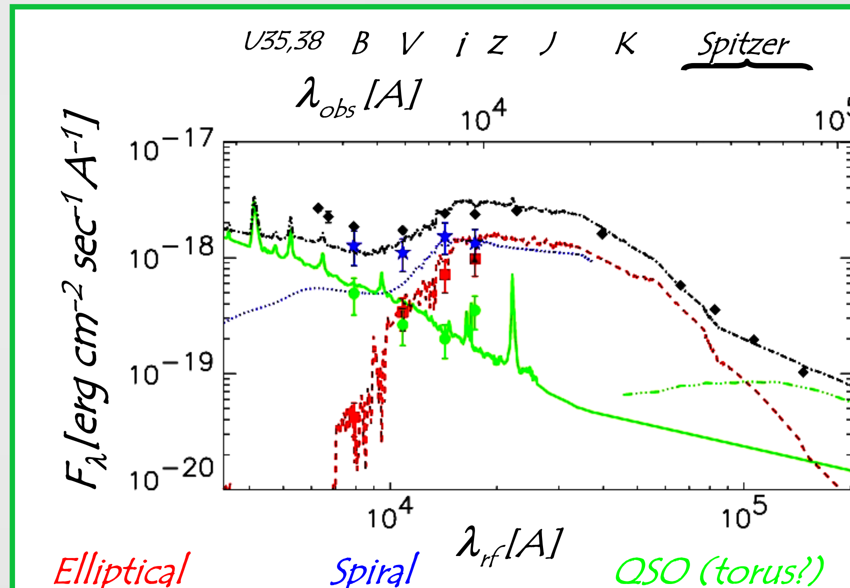
HR = -0.34 C-thin

$L_{2-8\,keV} = 8.5 \cdot 10^{42}$ erg s^{-1}

$L_{0.5-2\,keV} = 5.20 \cdot 10^{42}$ erg s^{-1}

(Tozzi et al. 2006)





	z	i	V	B
	r(″)	PA(°)	b/a	
Nuc	23.85 –	24.89 –	25.18 –	25.20
Disk	22.40 0.17	22.68 -7.22	23.63 0.48	24.17
Bulge	22.74 0.60	23.51 -6.22	24.92 0.46	27.87

Host-dom.
(6 obj)

Nucleus-dom.
(2 obj)

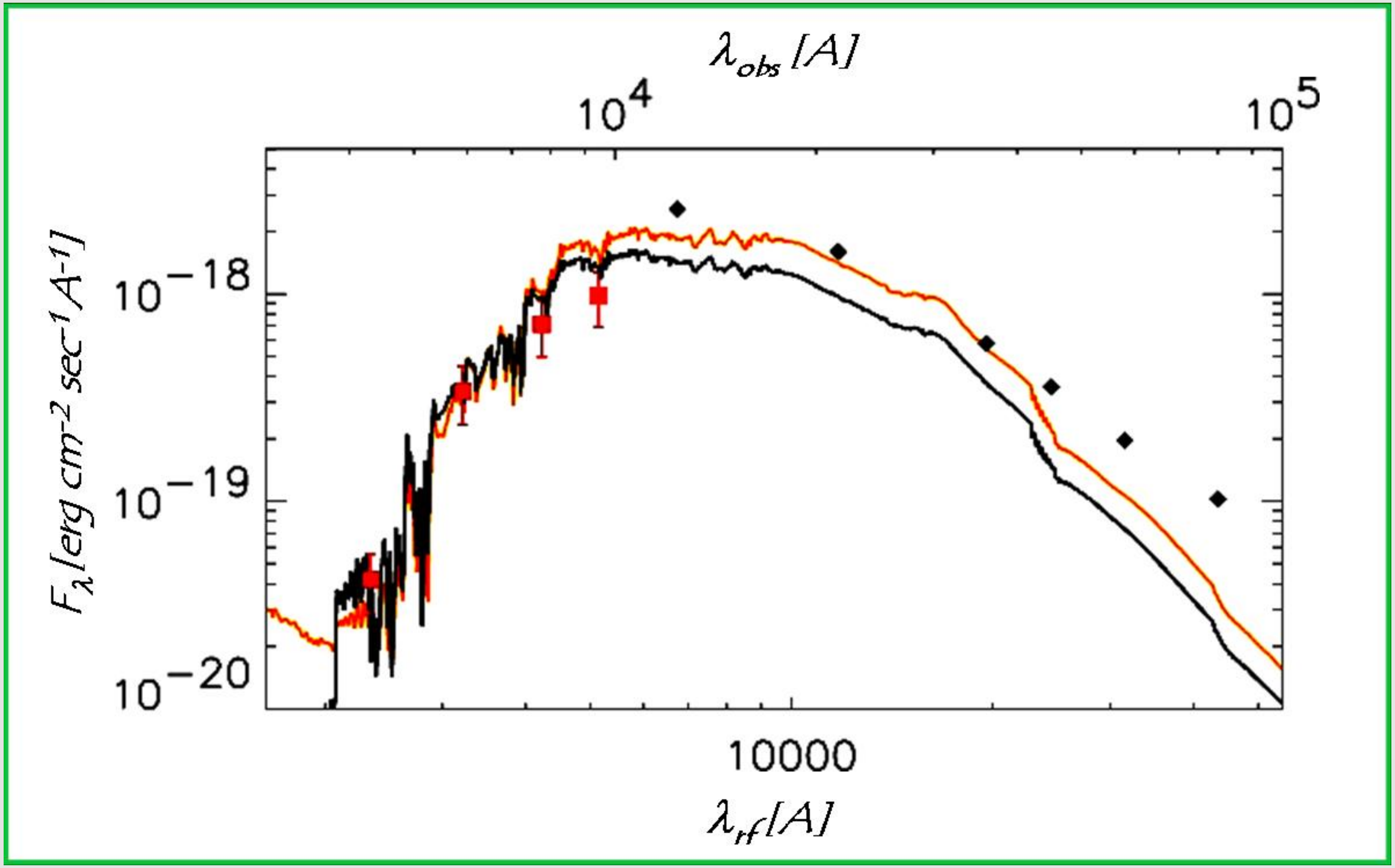
CDFS source 34 (II)

bulge magnitudes
+
Elliptical template
+
passive evolution

→ $M_{R,bulge}$

$\text{Log } M_{BH} = -0.50 \cdot M_{R,bulge} - 2.69$

(McLure & Dunlop 2002)



<u>Errors</u>:
Δnorm
until $\Delta\chi^2$=1

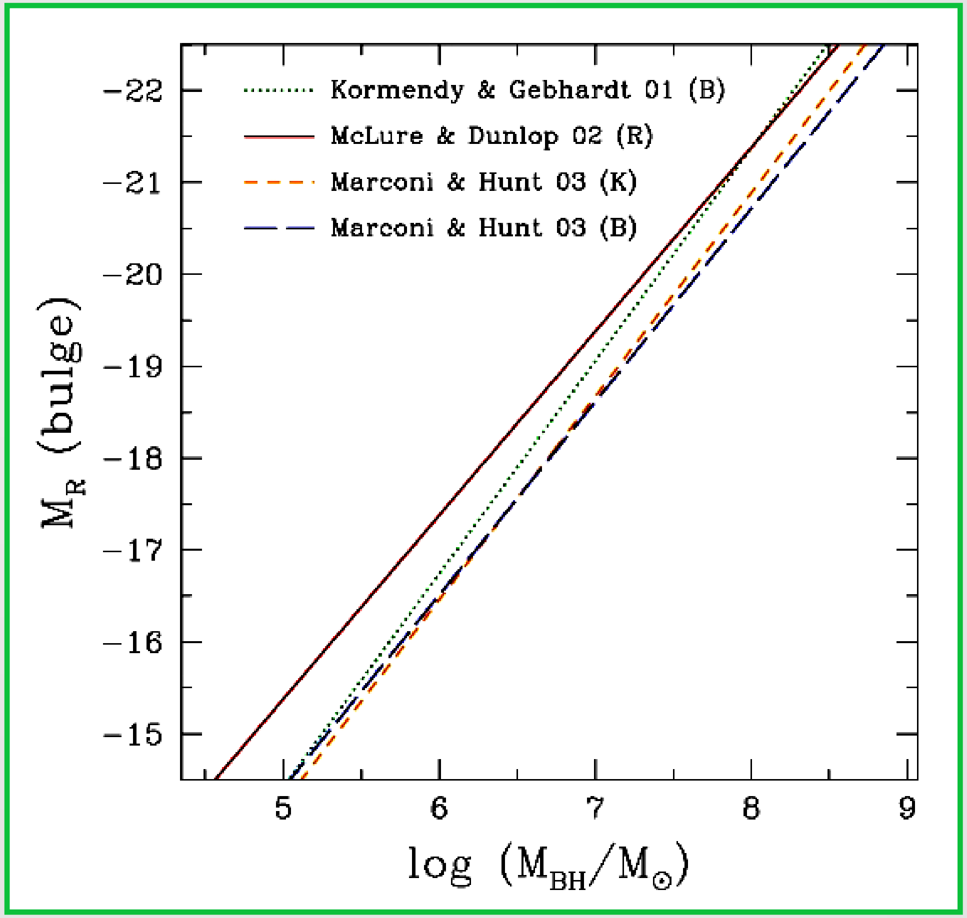
✓Strict coevolution M_{bulge}/M_{BH}:

- BH stops at z, bulge evolves in M
  ⟹ M_{BH} *lower* limit
- M_{bulge} formed at z, BH accretes
  ⟹ M_{BH} *upper* limit

BUT: how to reach the correlation?

✓M_{BH} vs bulge: different norm.

R-band: lower limit

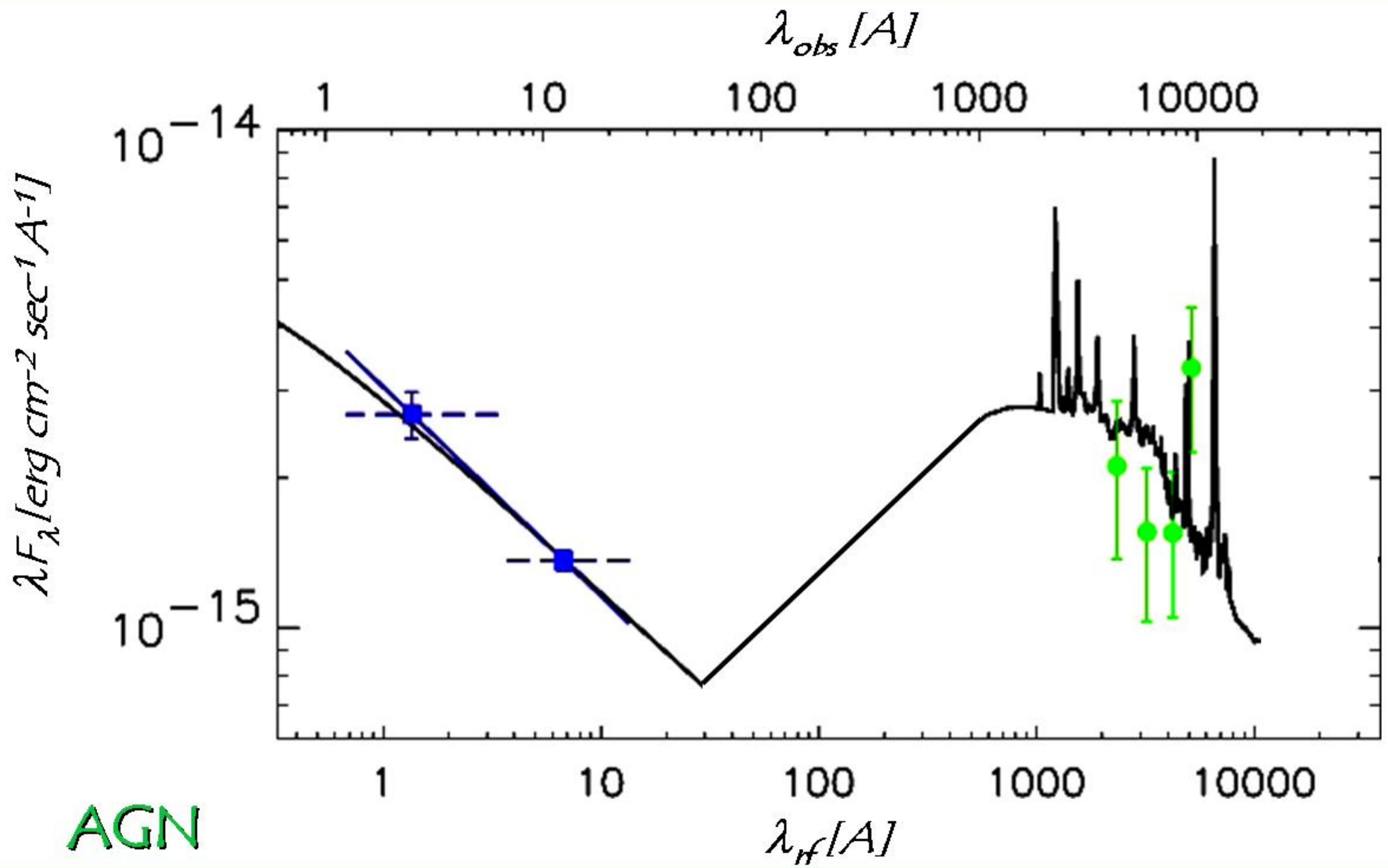


CDFS source 34 (III)

intrinsic X-ray emission
+
B, V, i, z nuclear optical magnitudes
+
QSO template (mean SDSS QSO)

→ L_{BOL}

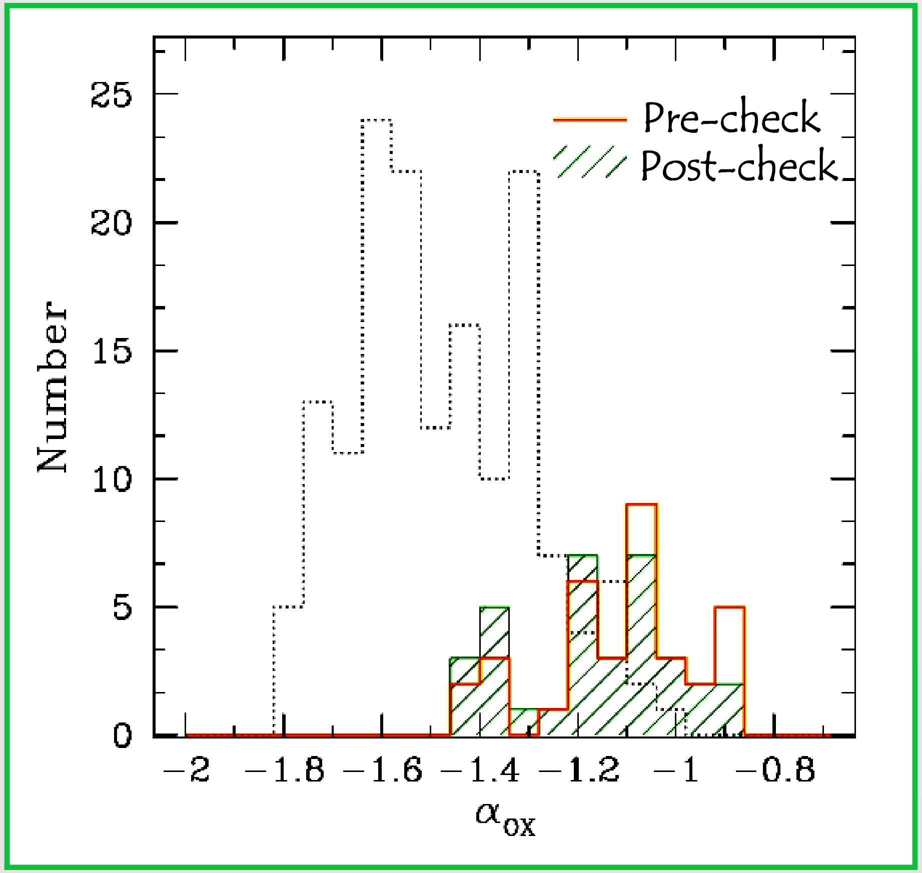
(Unified Model)



Errors:
Δnorm until $\Delta\chi^2$=1

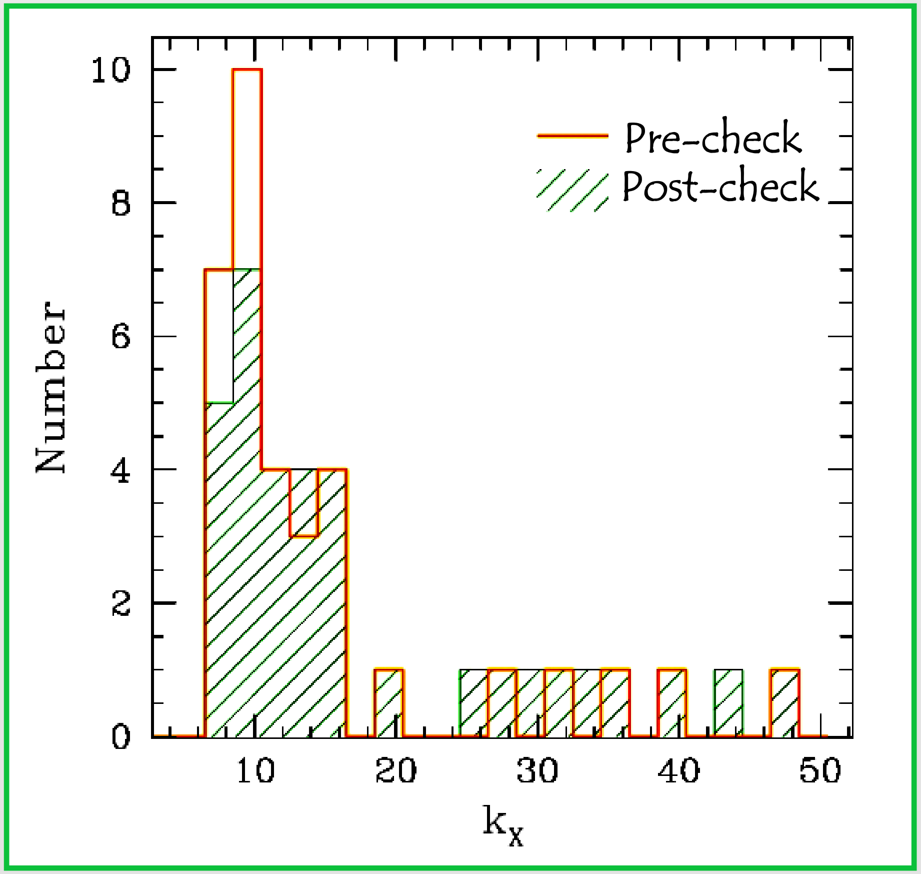
AGN

RESULTS: α_{OX} and k_X



α_{OX} = log ($L_{\nu[2500\ Ang]}/L_{\nu[1\ keV]}$) / log ($\nu_{[2500\ Ang]}/\nu_{[1\ keV]}$)

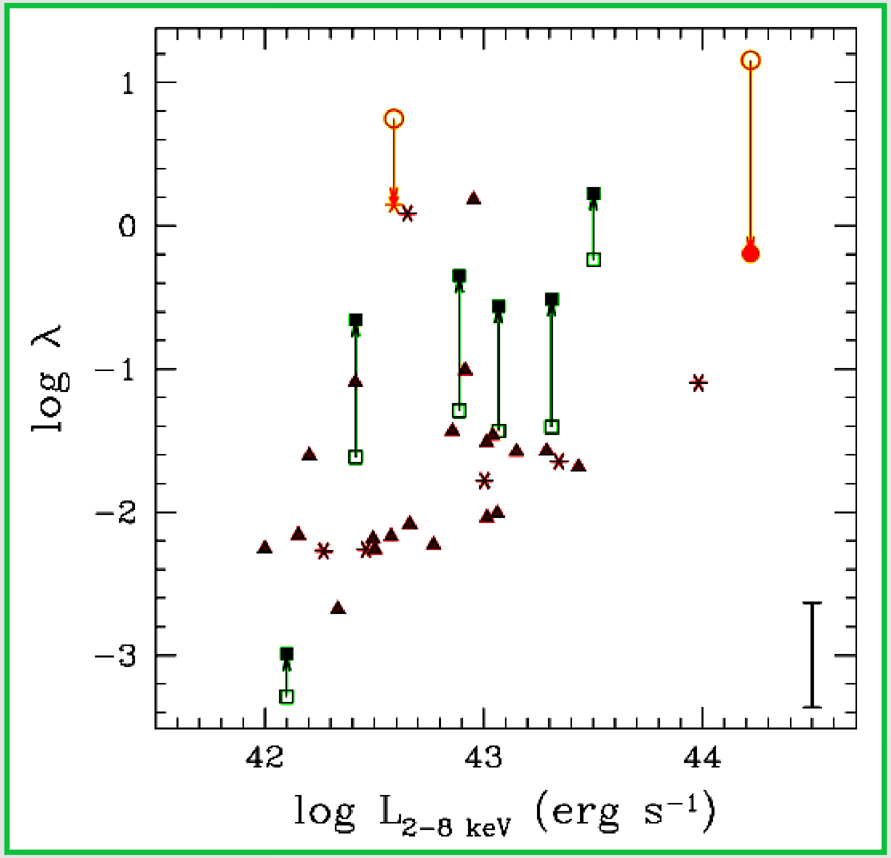
$k_X = L_{BOL}/L_X$

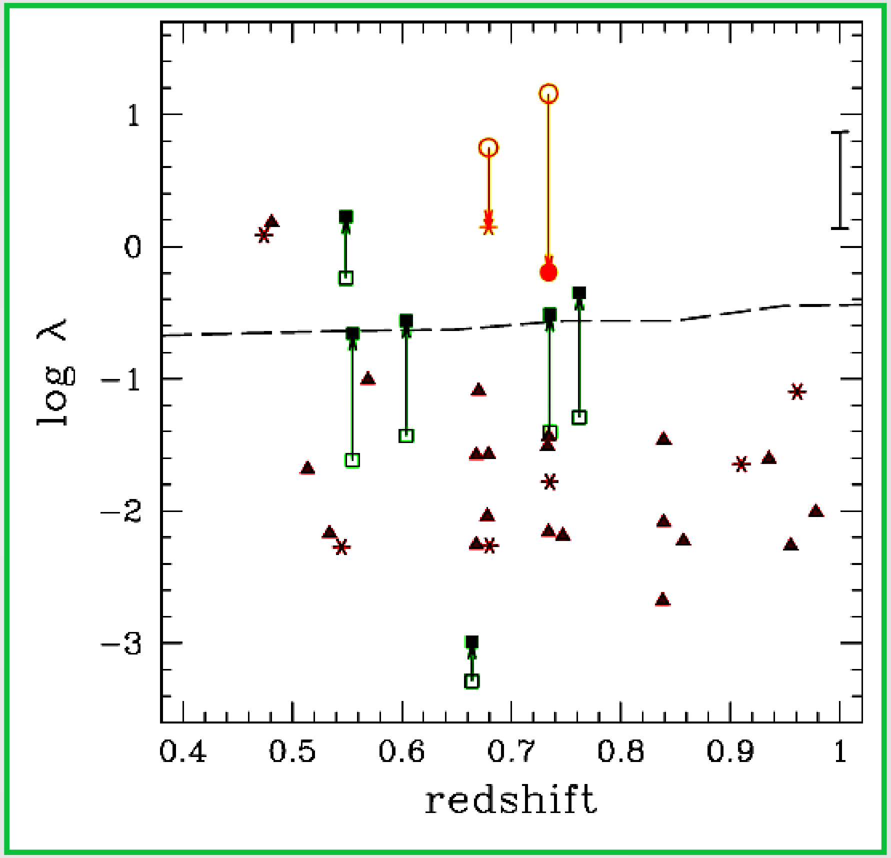


vs QSO sample

(Strateva et al. 2005)

RESULTS: M_{BH}, L_{bol} & Eddington ratios (I)



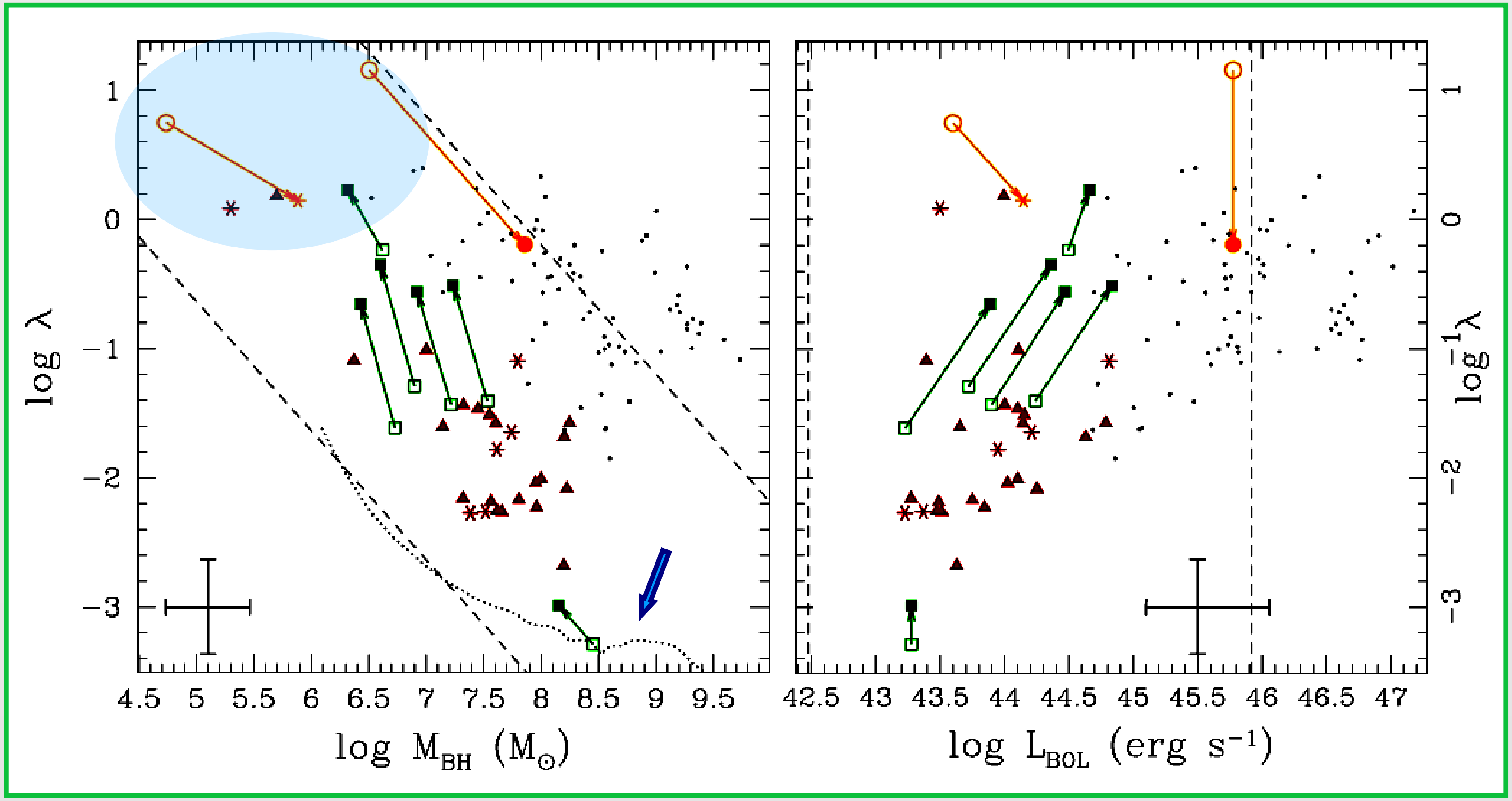


vs QSO sample

(McLure & Dunlop 2004)

$\lambda = L_{bol}[\mathrm{erg\ s^{-1}}]/1.3 \cdot 10^{38} M_{BH}[M_{SUN}]$

RESULTS: M_{BH}, L_{bol} & Eddington ratios (II)



vs QSO sample *(Vestergaard et al. 2006)*

$\lambda = L_{bol}[\text{erg s}^{-1}] / 1.3 \cdot 10^{38} M_{BH}[M_{SUN}]$

CONCLUSIONS

Different from optically selected samples.

It seems that these objects do not host a strong accretion associated with a phase of formation.

It seems more likely that this accretion phase is tied to a re-ignition.

It is not clear why there should be a preferential redshift (0.4-1) range for such events.

FUTURE WORKS

Increase the sample.

Perform a detailed study of the morphology.

Possible check of our method?