AGN feedback in action:
constraints on the scaling relations between BH and galaxy at high redshift

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cospar 10
38th scientific assembly
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Excellence Cluster
Universe

Outline

- Co-evolution of stellar and SMBH mass densities: integral constraints
- Scaling relations in high redshift AGN (COSMOS/zCOSMOS)
- Future prospects

Simultaneous growth of BH and galaxies

1) AGN LF

BHAR(z) = $$\Psi_{\rm BH}(z) = \int_0^{\infty} \frac{(1-\epsilon)L_{\rm bol}(L_{\rm X})}{\epsilon c^2}\phi(L_{\rm X}, z')dL_{\rm X}$$

2) Local BH mass density

$$\frac{\rho_{\rm BH}(z)}{\rho_{\rm BH,0}} = 1 - \int_0^{z} \frac{\Psi_{\rm BH}(z)}{\rho_{\rm BH,0}}\frac{dt}{dz'}dz'$$

3) Local scaling relation and their evolution

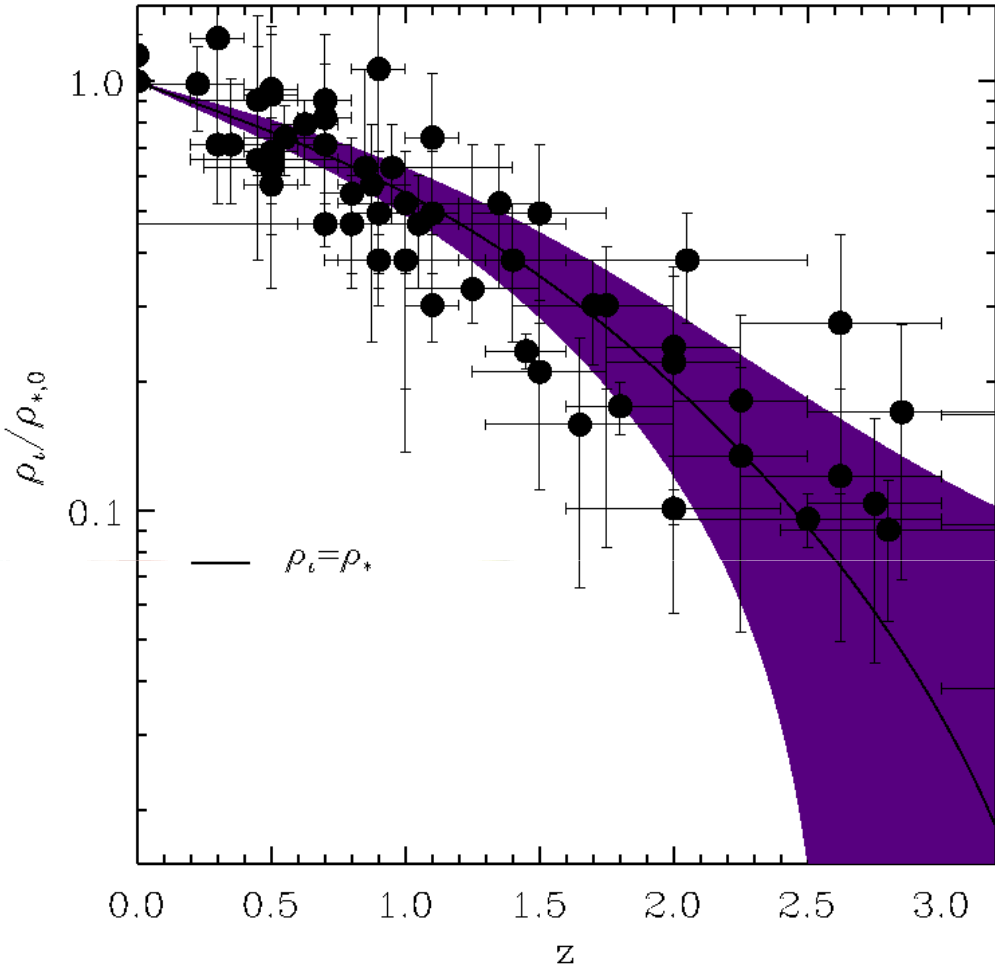
$$\rho_{\rm sph}(z) = A_0\rho_{\rm BH}(z)(1+z)^{-\alpha}$$

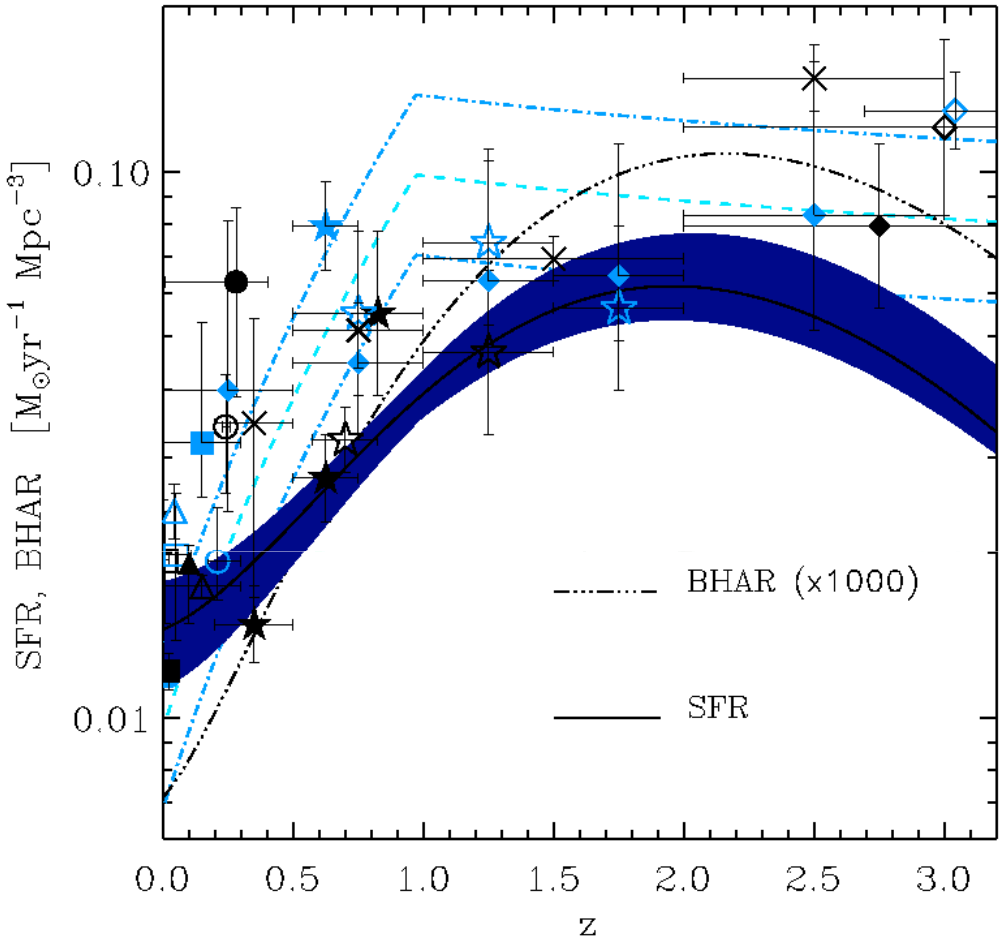
4) Link to the Hubble sequence evolution?

$$\rho_*(z) = \rho_{\rm sph}(z) + \rho_{\rm disk+irr}(z) = \rho_{\rm sph}(z)[1+\lambda(z)]$$

Fabian and Iwasawa (1999) ε~0.1; Elvis, Risaliti and Zamorani (2002) ε >0.15;
Yu and Tremaine (2002) ε>0.1; Marconi et al. (2004) 0.16> ε >0.04;
Merloni, Rudnick, Di Matteo (2004) 0.12> ε >0.04; Shankar et al. (2007) ε ~0.07

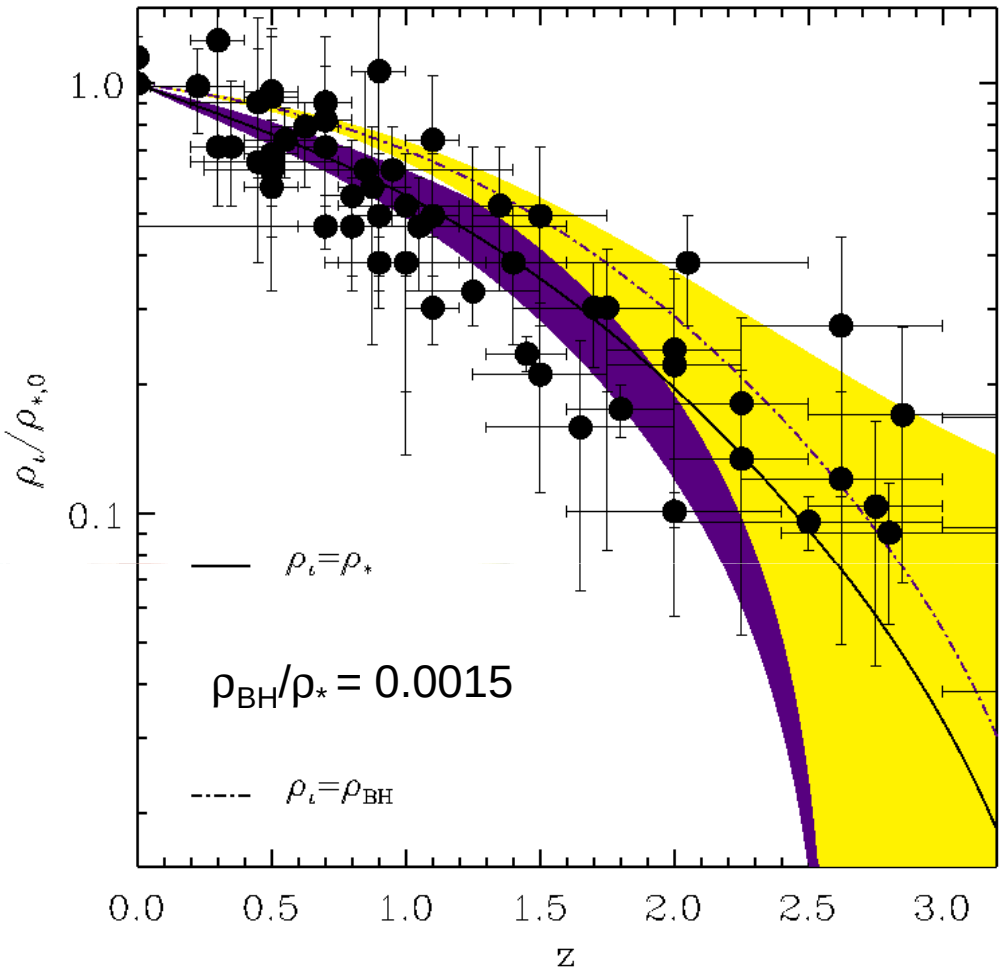
Parallel lives

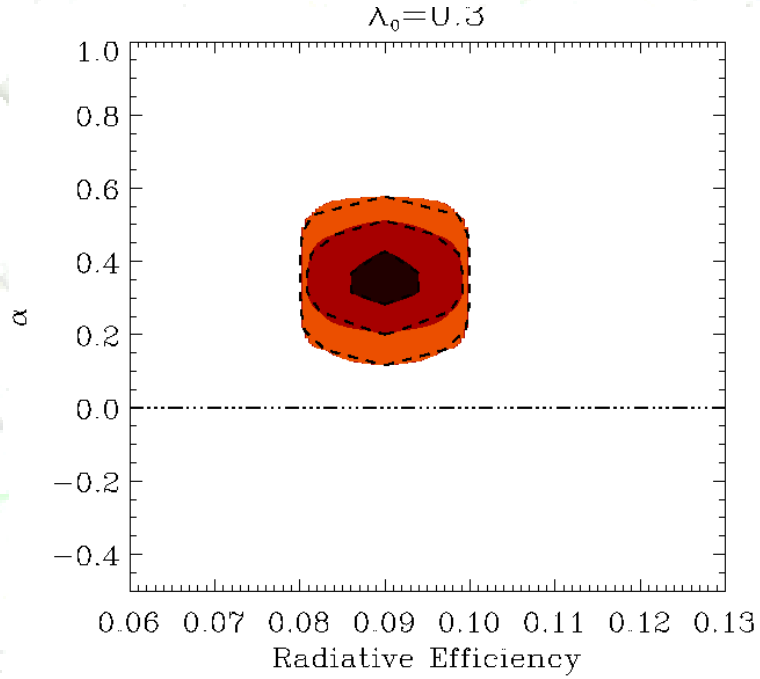




See Merloni, Rudnick, Di Matteo (2004)

Parallel lives



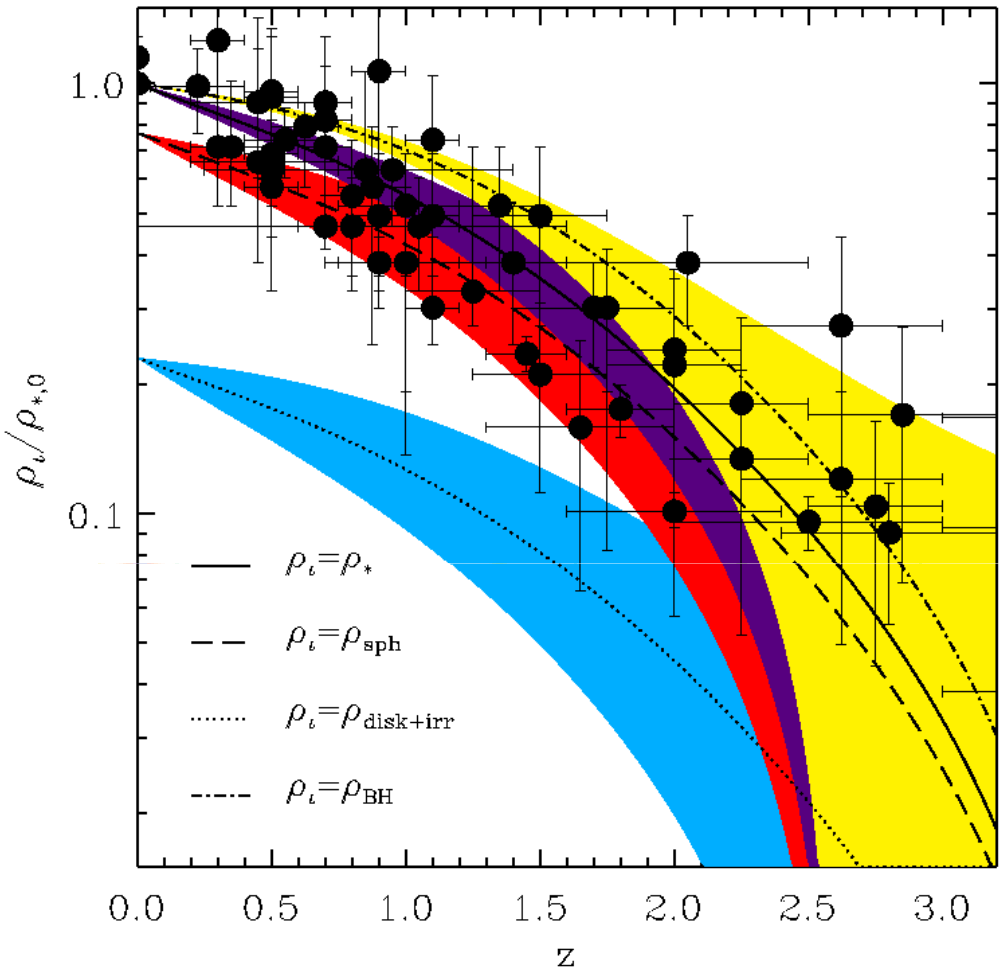


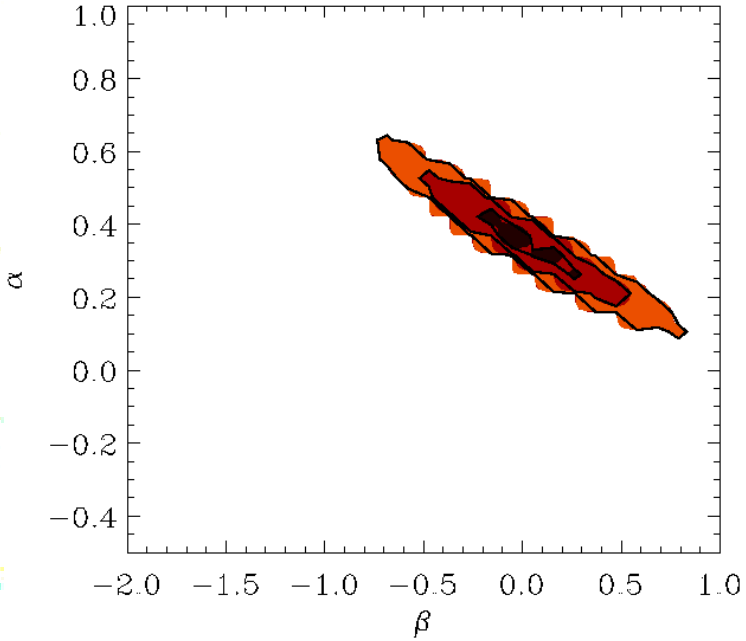
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Mild evolution $\langle M_{BH}/M_{*,bulge}\rangle \sim (1+z)^{0.4}$

Merloni, Rudnick, Di Matteo (2004); Hopkins et al. (2006)

Parallel lives





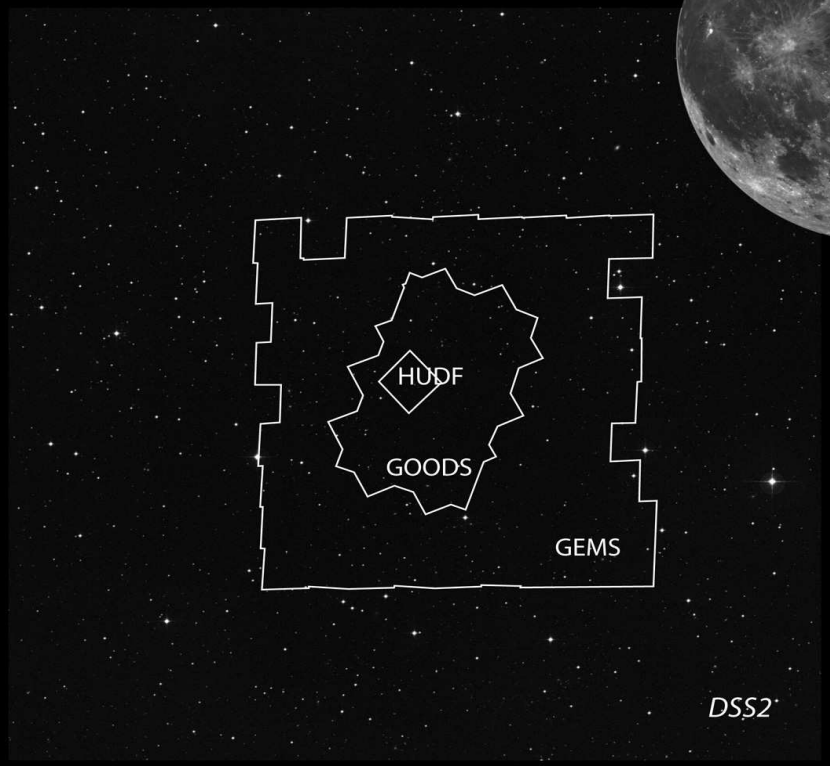
Very weak constraints on disk-spheroid ratio evolution

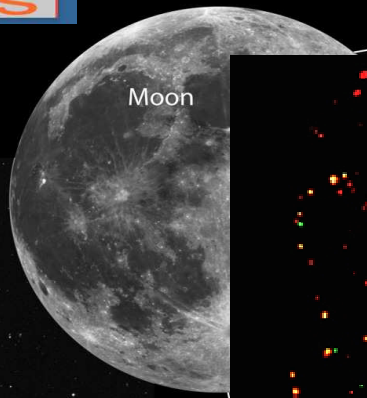
Merloni, Rudnick, Di Matteo (2004); Hopkins et al. (2006)

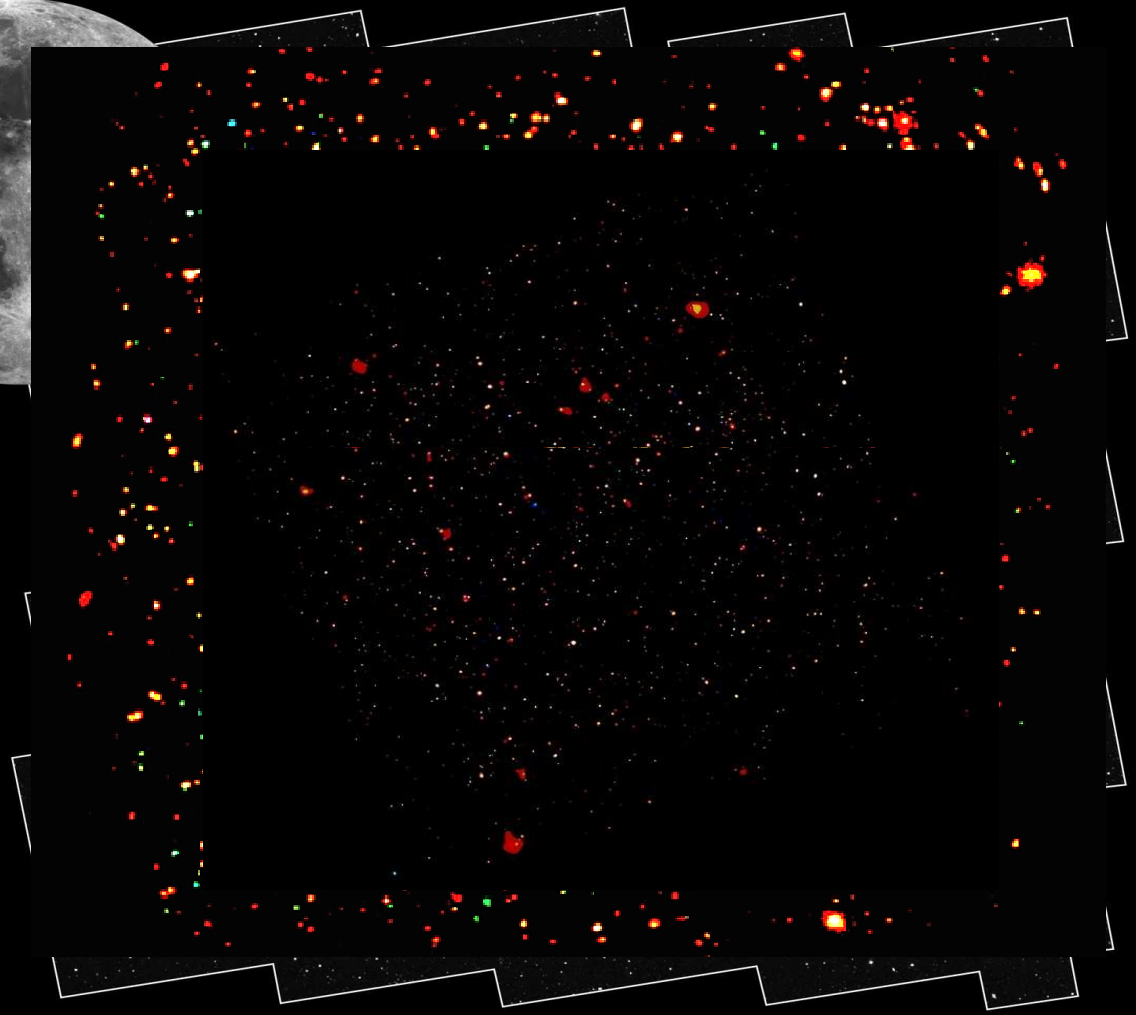
AGN in the COSMOS

COSMOS survey

Relative Sizes of *HST* ACS Surveys





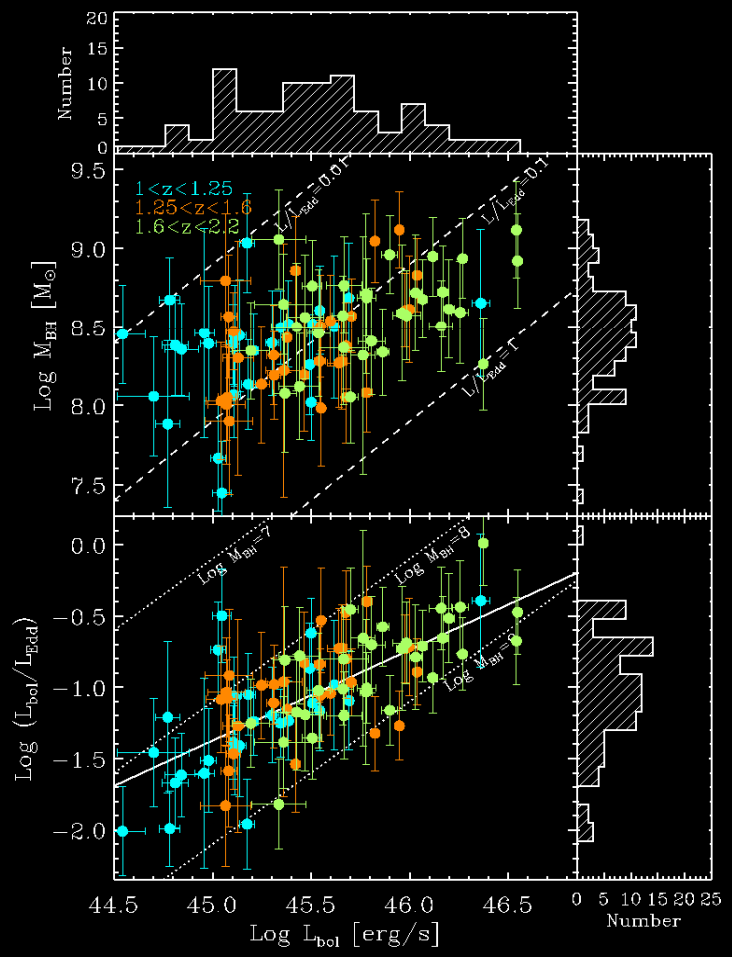


2 deg^2 equatorial
HST treasury project
Deep: ACS $i_{AB} < 27$
Similar volume as SDSS, but fainter and higher z

HST/XMM/Chandra COSMOS
[Scoville, Hasinger, Elvis]

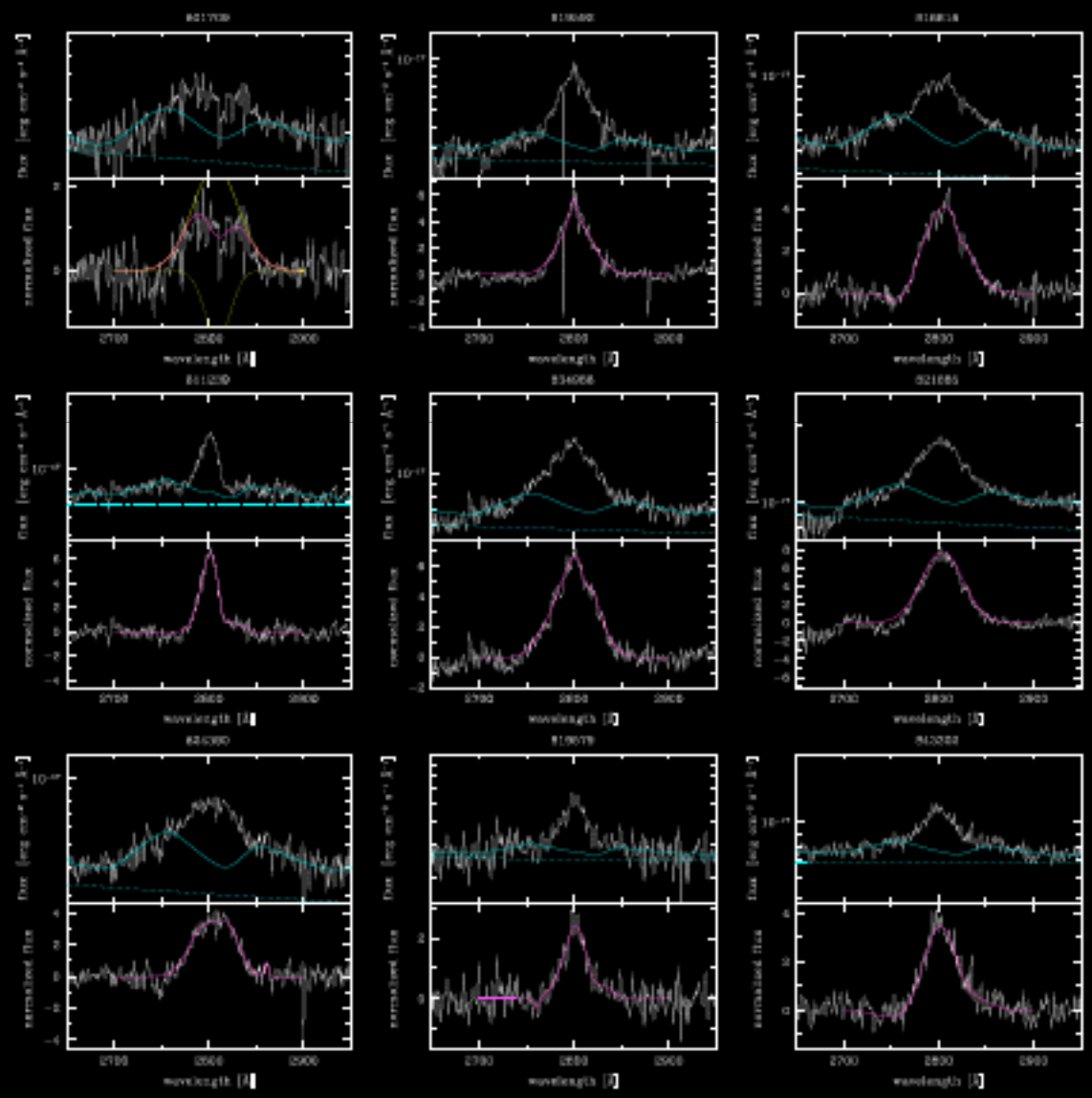
Type-1 AGN in the zCOSMOS survey

Measure BH mass using "virial" relation applied to MgII (1<z<2.2) 89 AGN

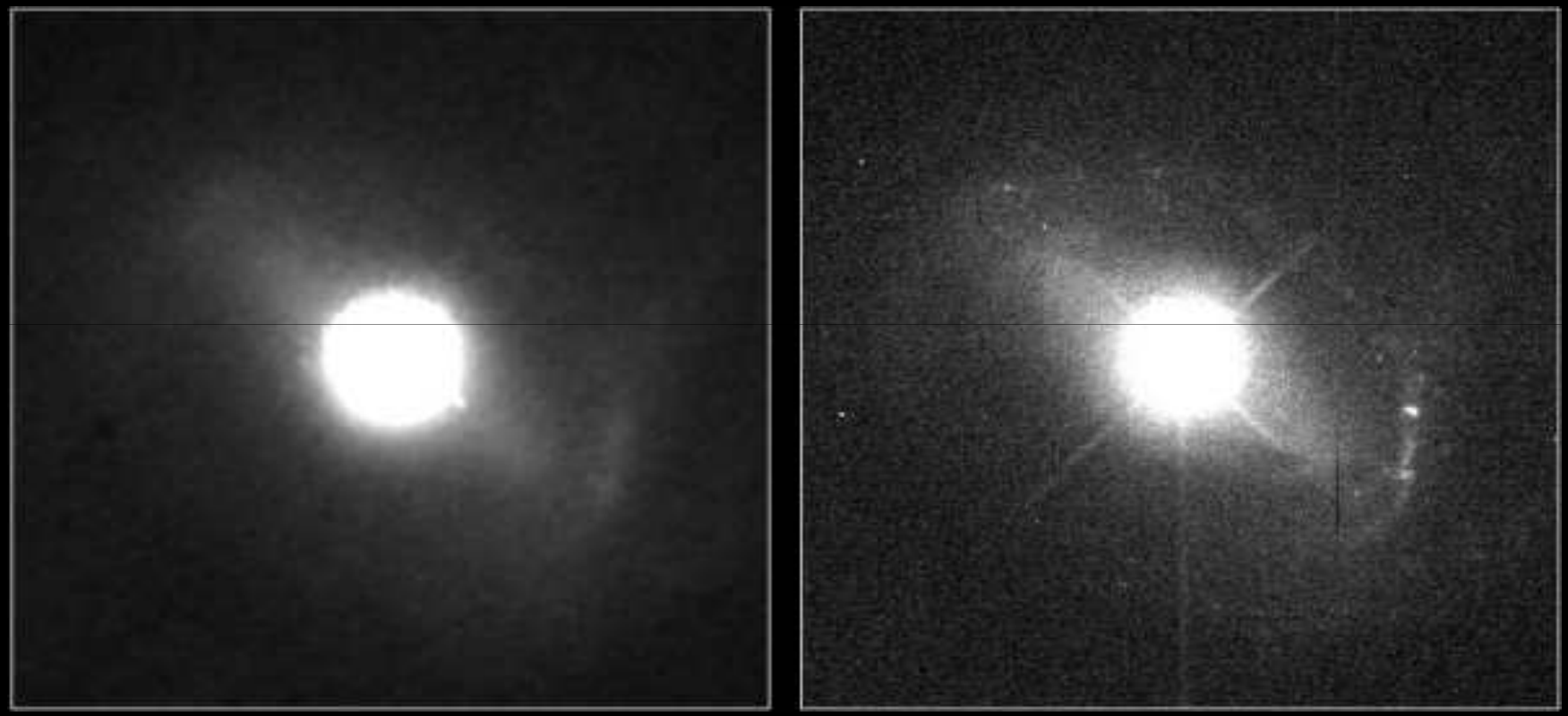


Merloni, Bongiorno et al. 2010

$$\text{Log } M_{BH} = 6.8 \text{ Log}[FWHM_{1000}^{2}\ L_{3000}^{0.47}]$$



The REAL problem:
How to obtain reliable host galaxy masses in Type I AGN?



HST image of PG 1229+204 (z=0.064)

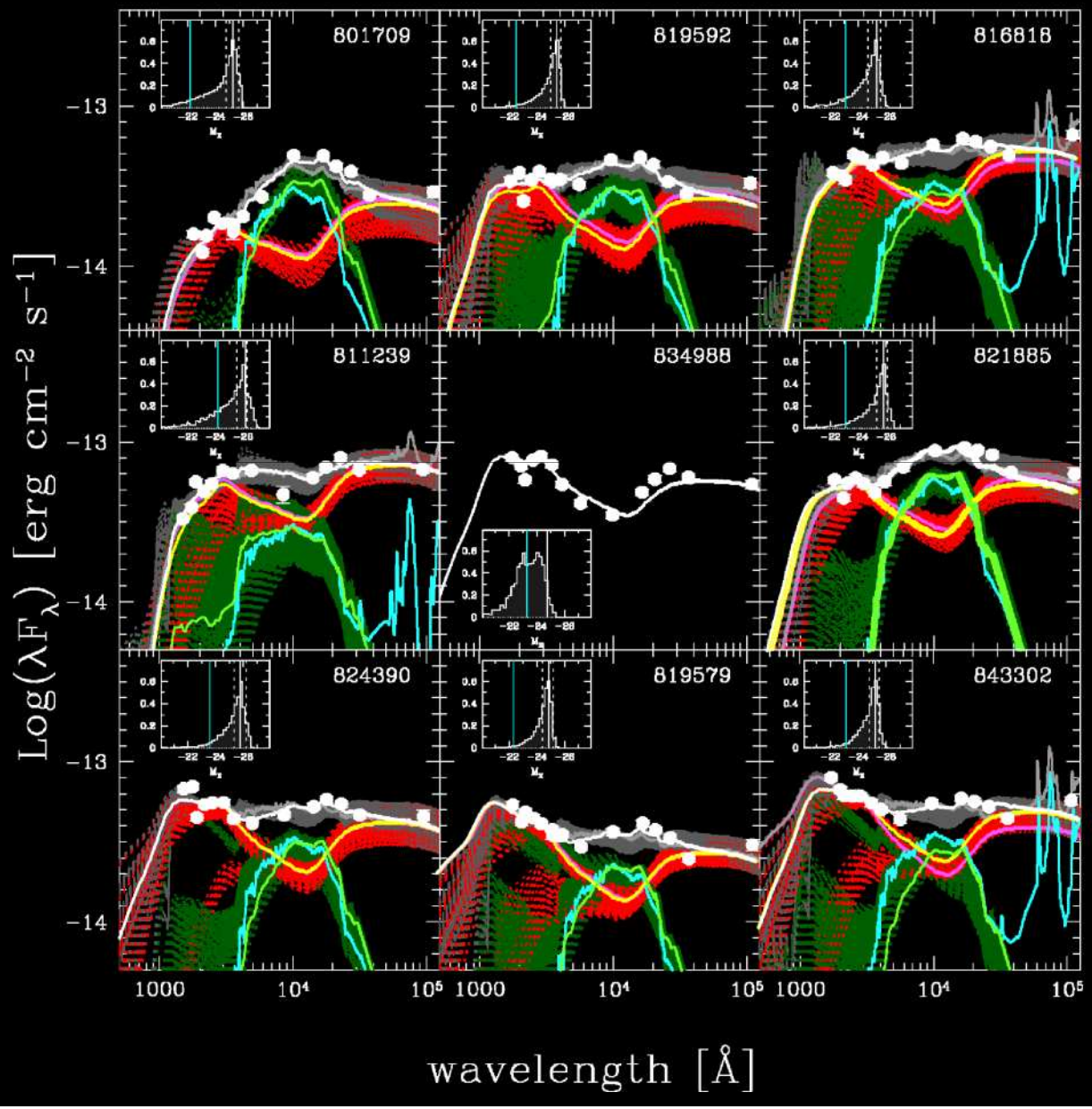
Credit: Dr. John Hutchings,Dominion Astrophysical Observatory, NASA

Unveiling AGN hosts through SED fitting

14 Bands Used
6 SUBARU bands
I + K band (CFHT)
4 Spitzer/IRAC
24mm Spitzer/MIPS

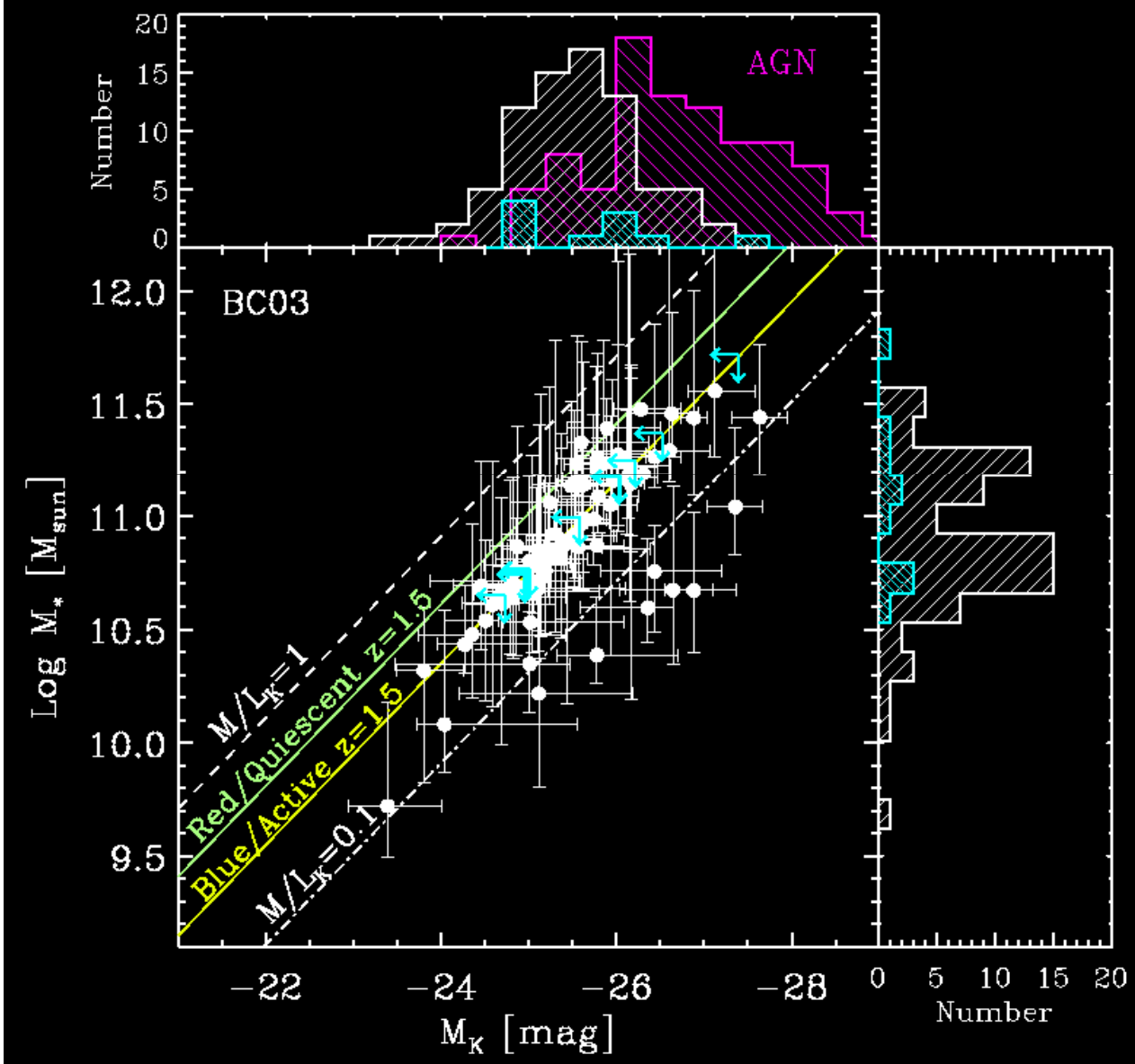
AGN templates:
- Richards et al. (2006)
- E(b-v)=0 - 0.3

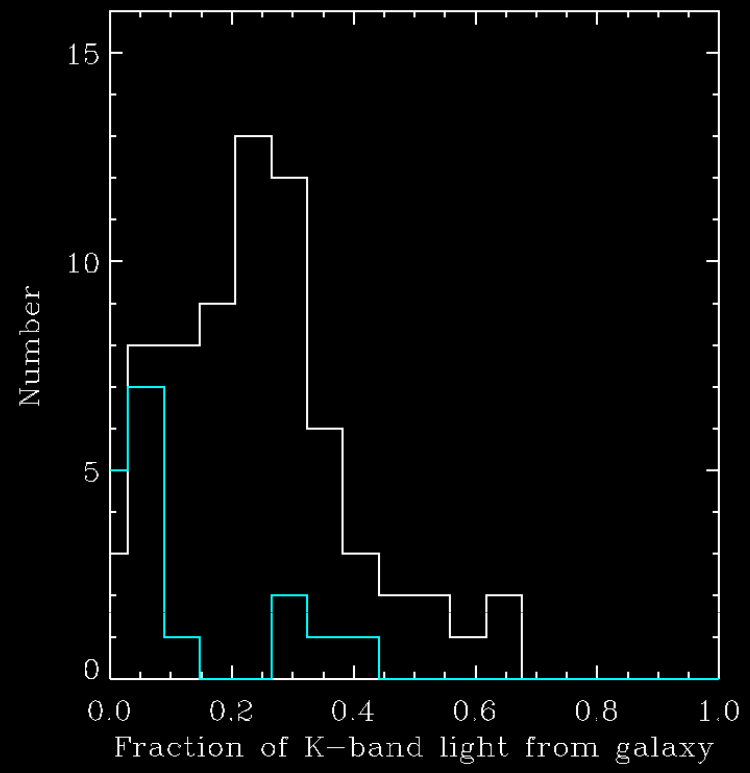
Galaxy templates:
- 14 phenomenological Polletta (2007)
- Libr. of synthetic sp. (Bruzual & Charlot)
  a) 10 declining SFH
     SFR µe-t/t
     t=[0.1-30] Gyr
     tage=[50Myr-5 Gyr]
     tage<tuniv(z)
     0 < E(B-V) <0.5
  b) 1 constant SF



Merloni, Bongiorno et al. 2010

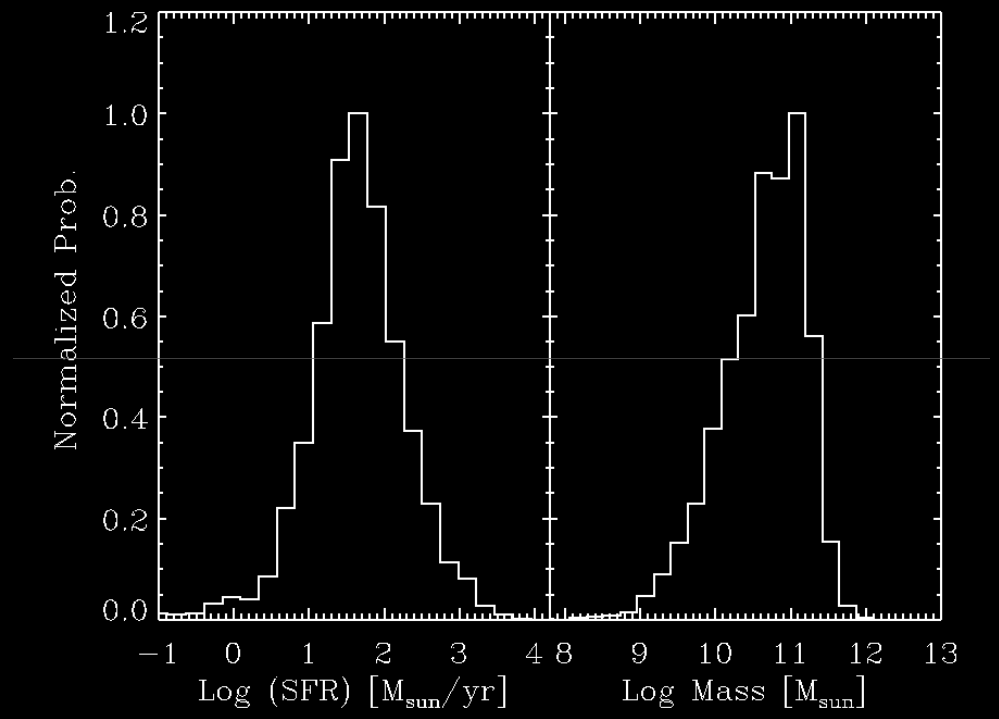
Host Galaxy properties I



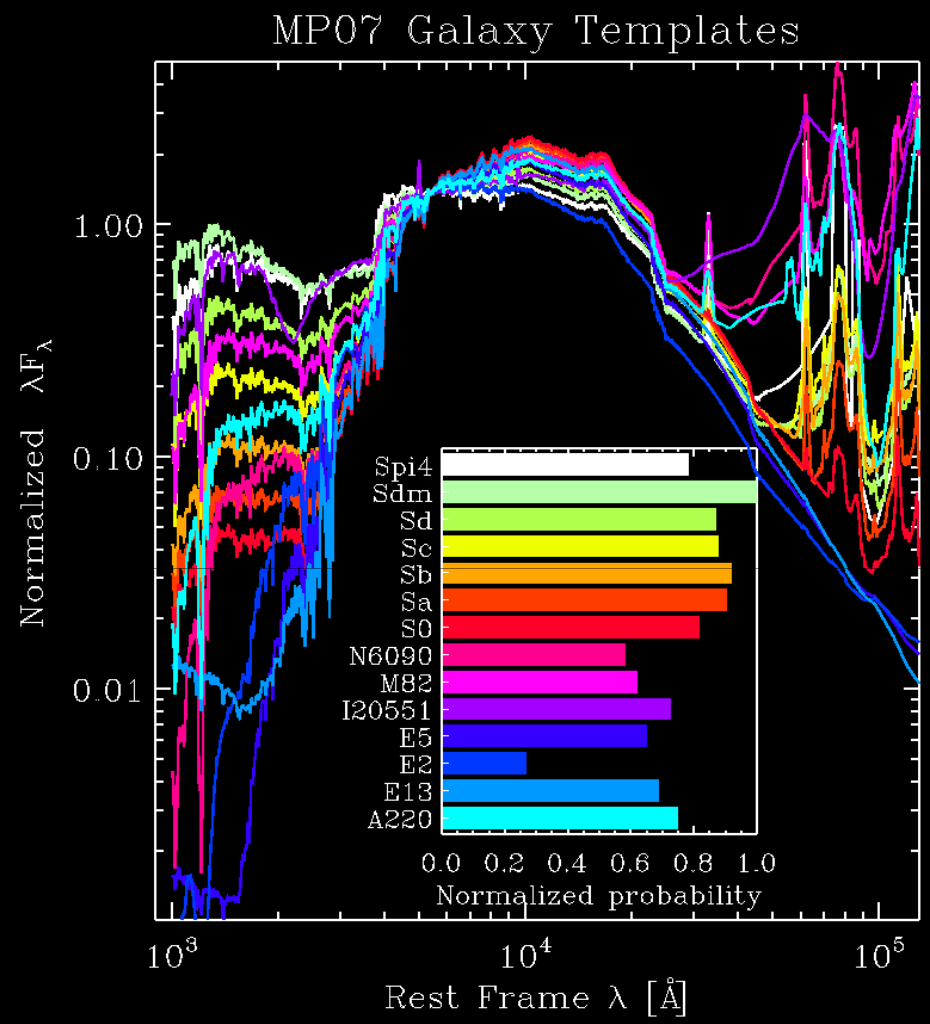


Host Galaxy Properties II

Cumulative probability distribution for SFR and total stellar mass of the HG



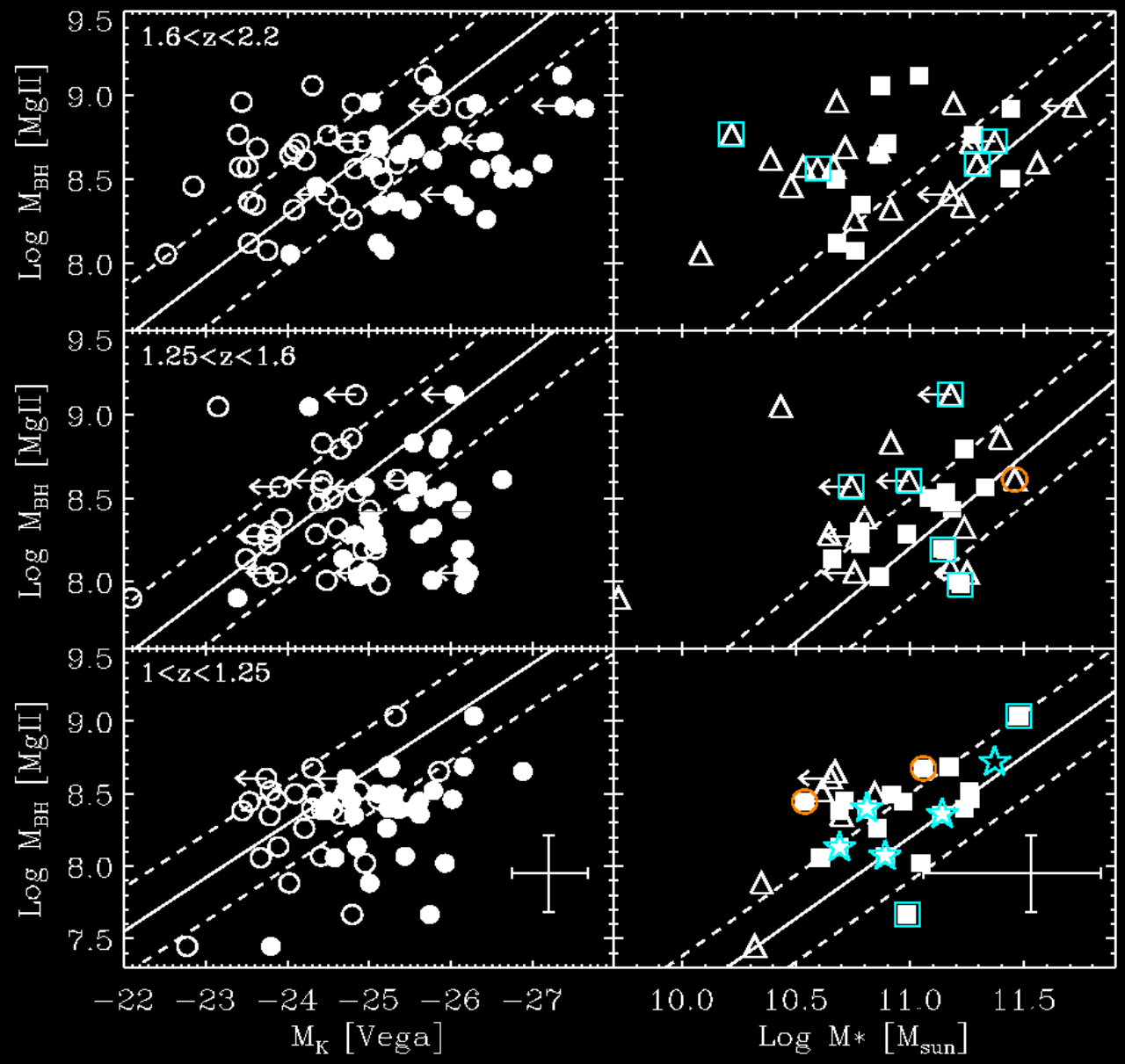
SFR= 50 M_*/yr $M_* \sim 10^{10.8}$



Our Host Galaxies are likely actively Star Forming objects

Kauffmann et al. (2003); Brammer et al. (2009); Silverman et al. (2009)

Scaling relations at 1<z<2

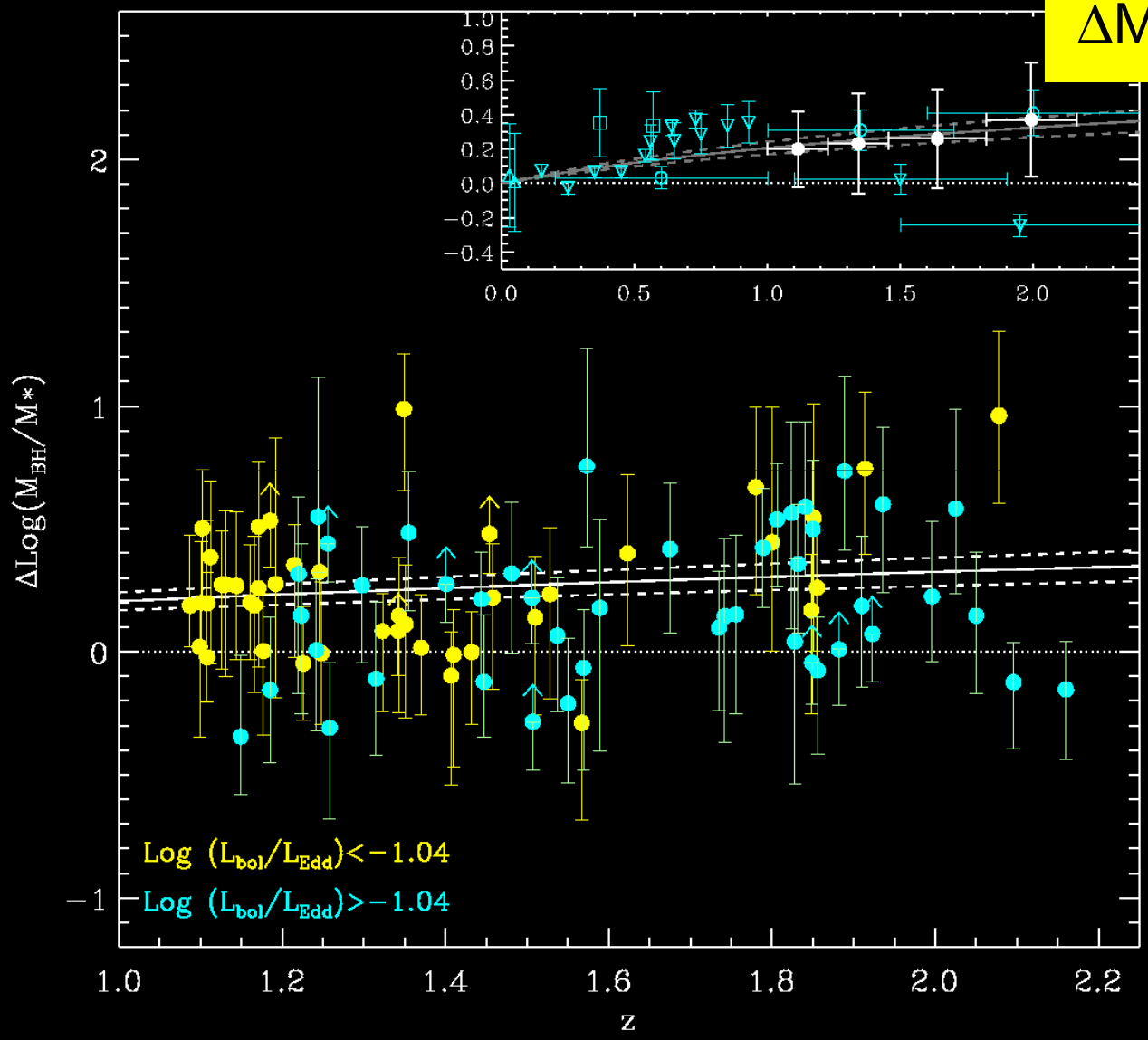


Solid line (+scatter): M_{BH}-bulge relations, z=0 (Graham et al. 2007; Haring & Rix 2004)

Merloni, Bongiorno et al. 2010

Redshift evolution of the M_{BH}-M_* relation

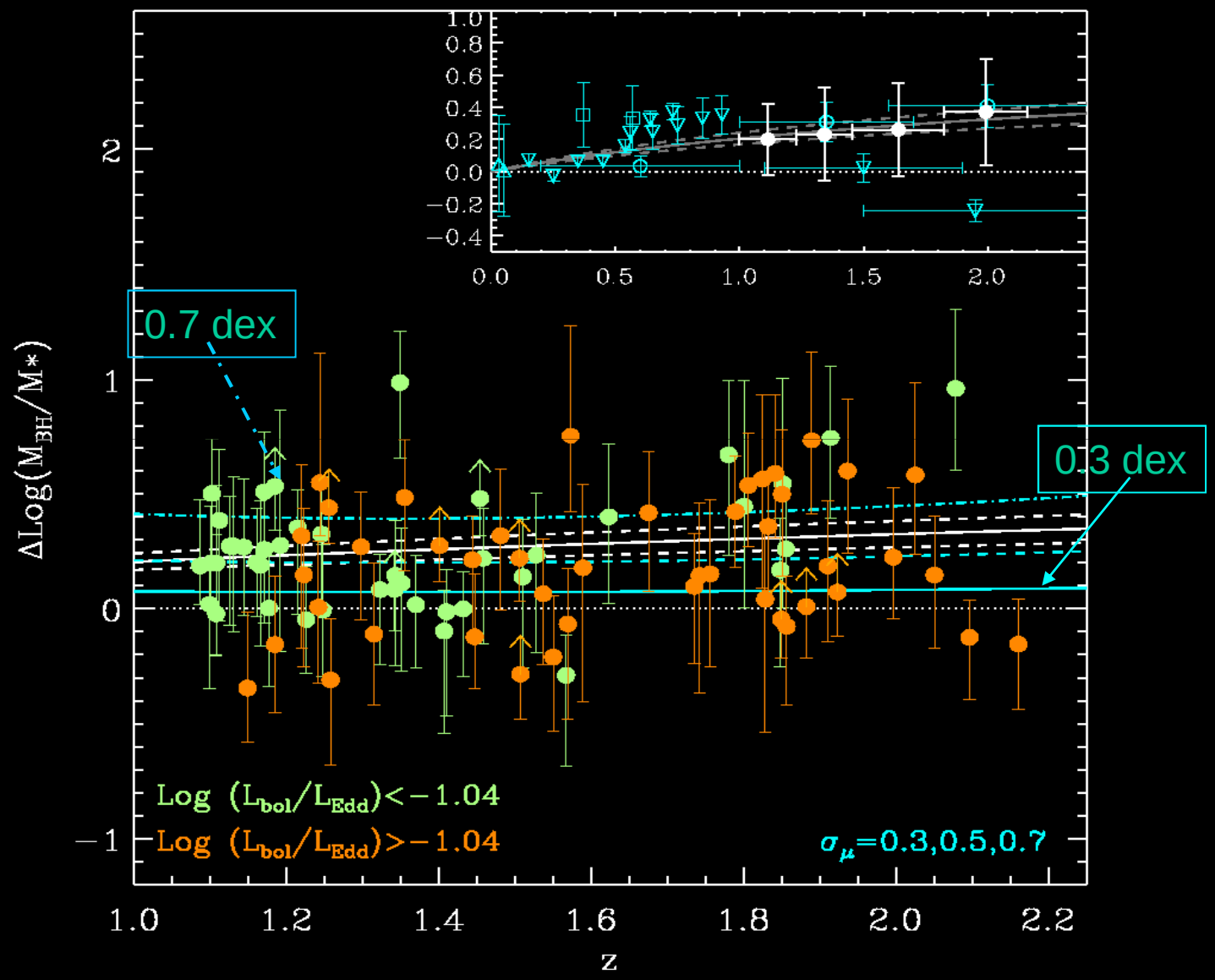
$$\Delta M_{BH}/M_* \propto (1+z)^{0.7\pm0.1^{+0.6}_{-0.3}}$$



Evolution in the Normalization?

Merloni, Bongiorno et al. 2010

Redshift evolution of the M_{BH}-M_* relation

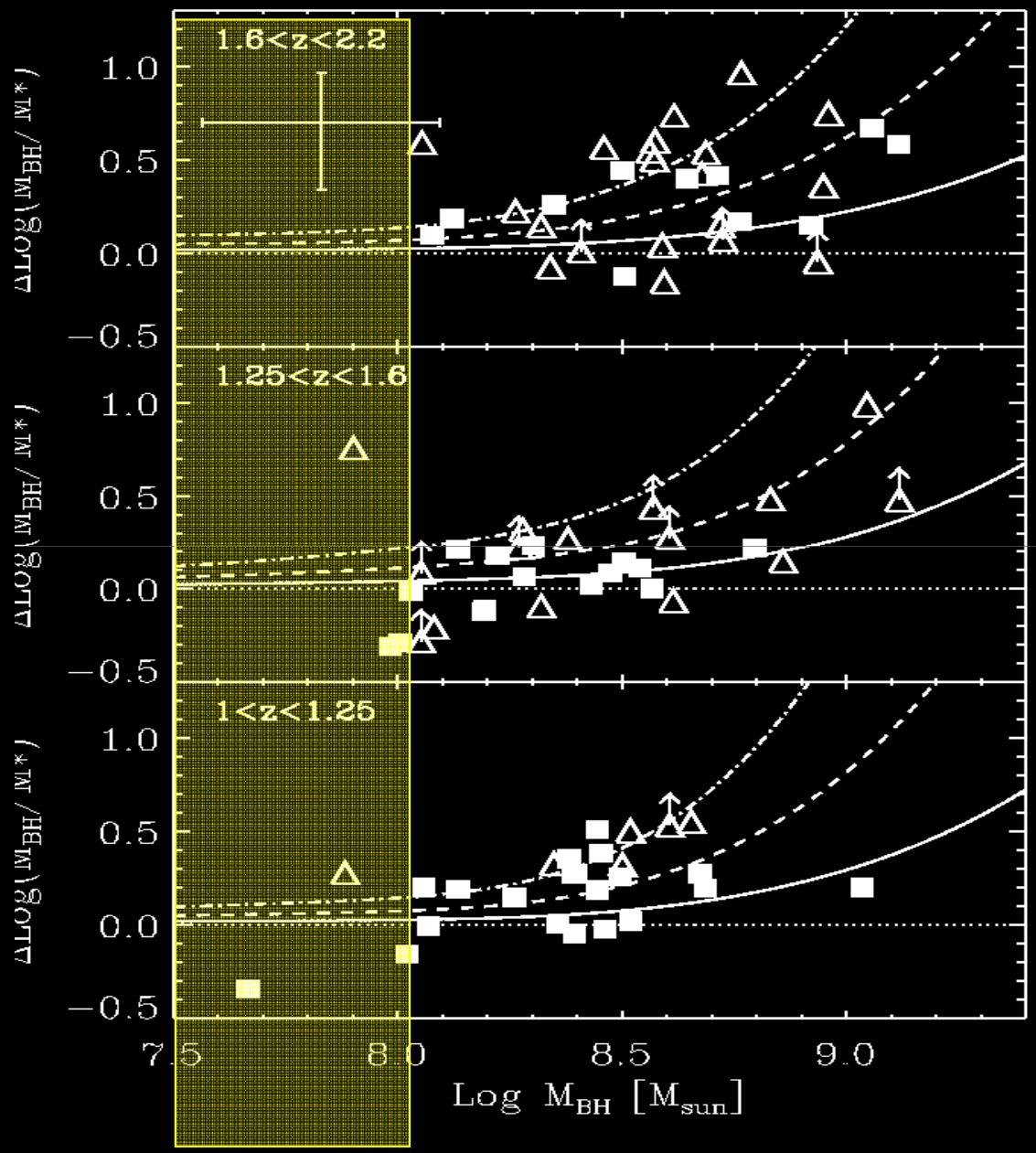


Evolution in the normalization?

Evolution in the scatter?
Significant mismatch between the typical growth times of BH and host galaxies

Merloni, Bongiorno et al. 2010

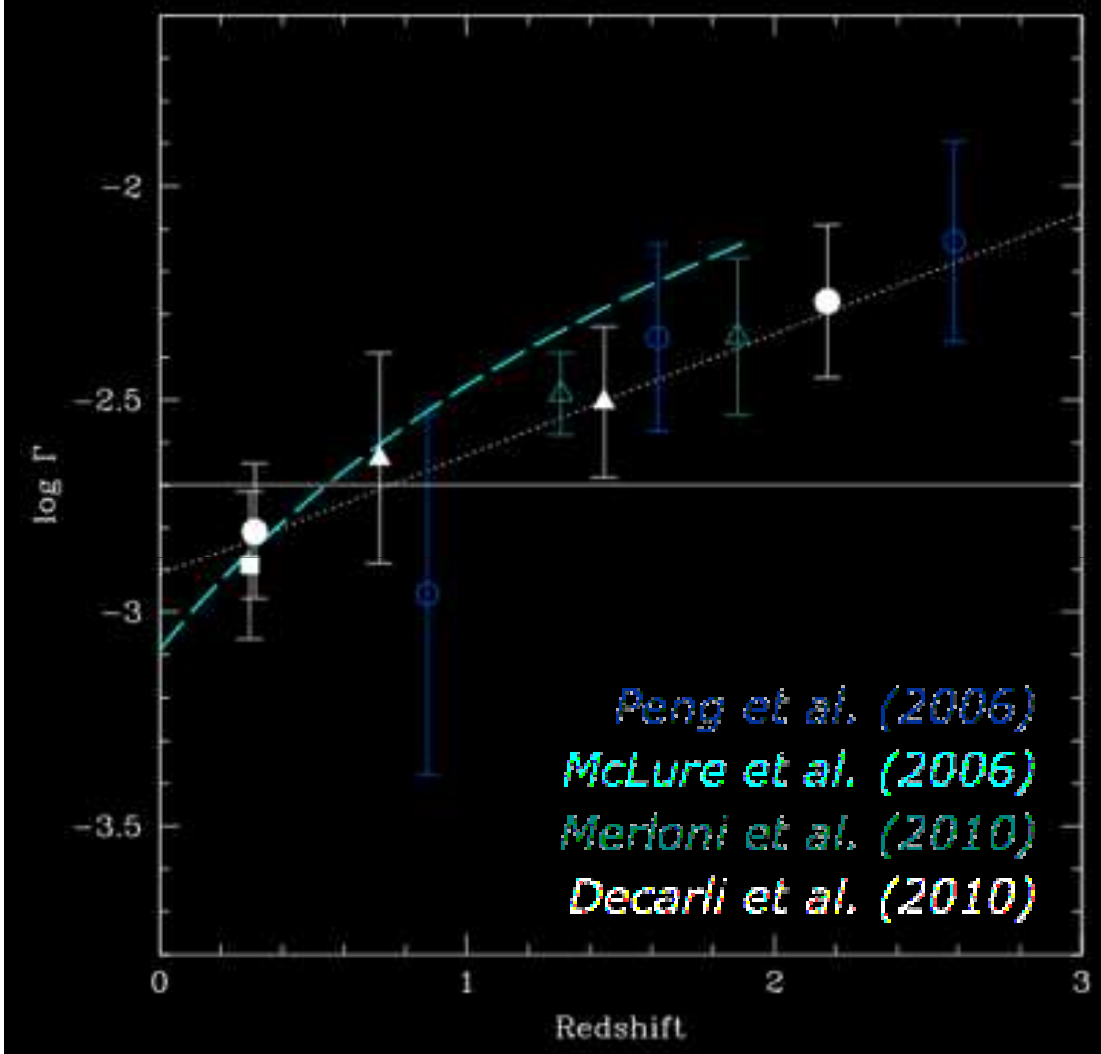
Future tests of “Luminosity bias”



for $M_{BH}<10^8$

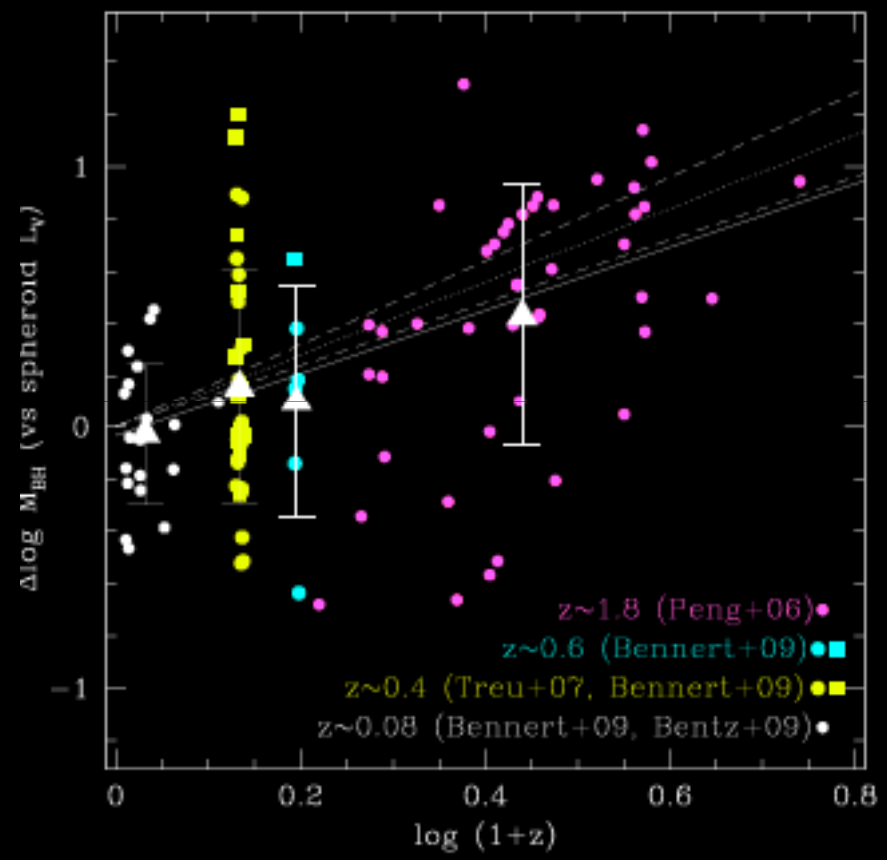
Expected bias minimal

A consistent picture?



Decarli et al. 2009

Bennert et al. 2009



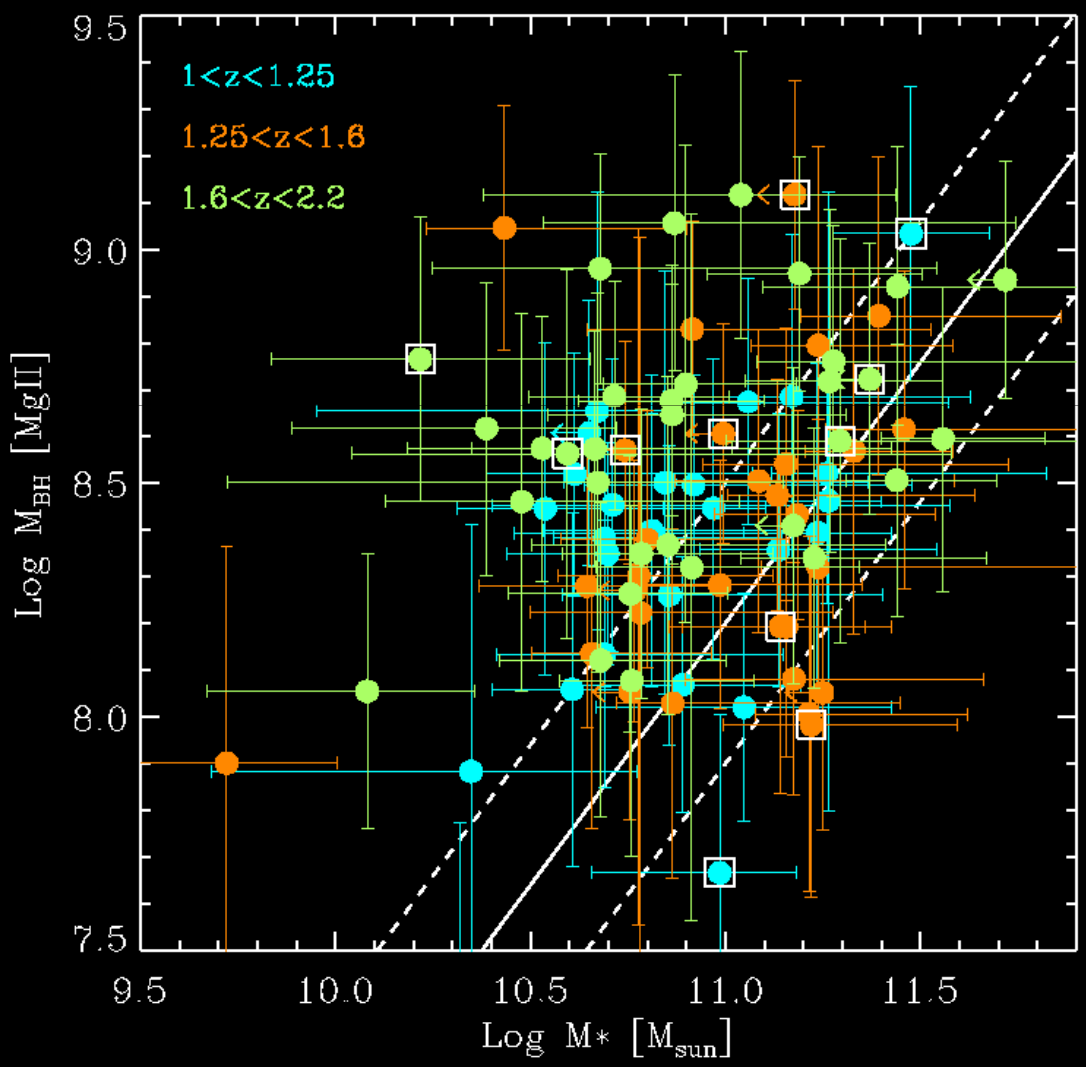
Selection, selection, selection

QuickTime™ and a
decompressor
are needed to see this picture.

Lamastra et al. (2010)

Flow patterns in the M_{BH}-M_* plane

Solid line (+scatter): M_{BH}-bulge mass relation, z=0
(Haring & Rix 2004)



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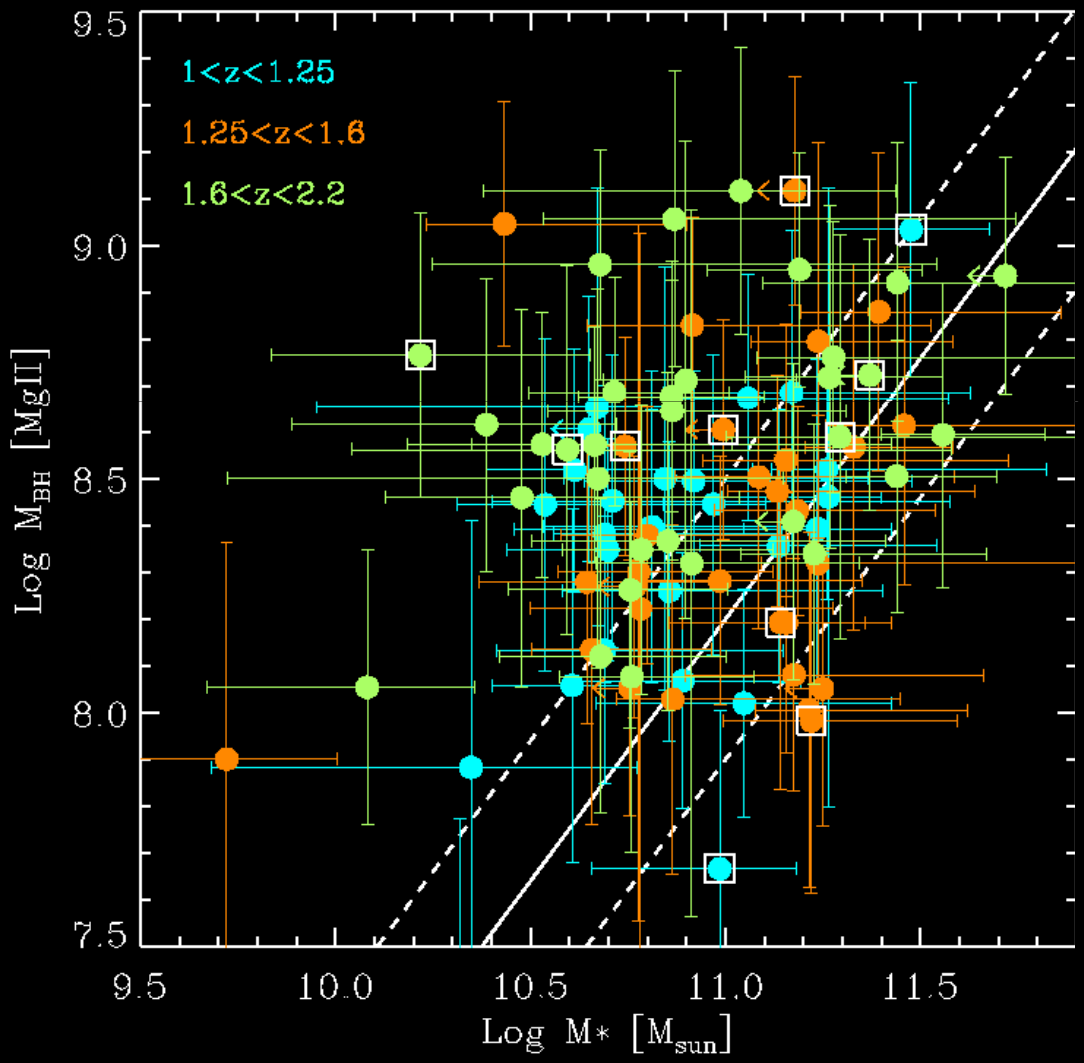

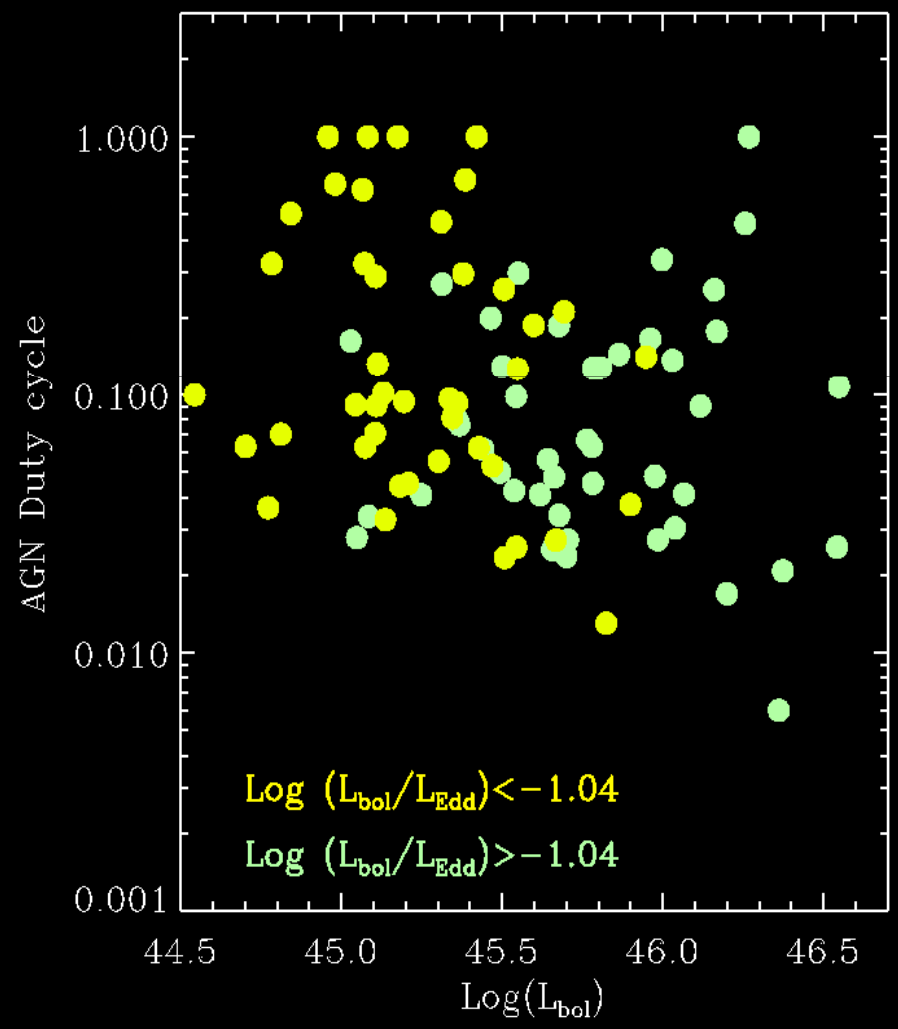

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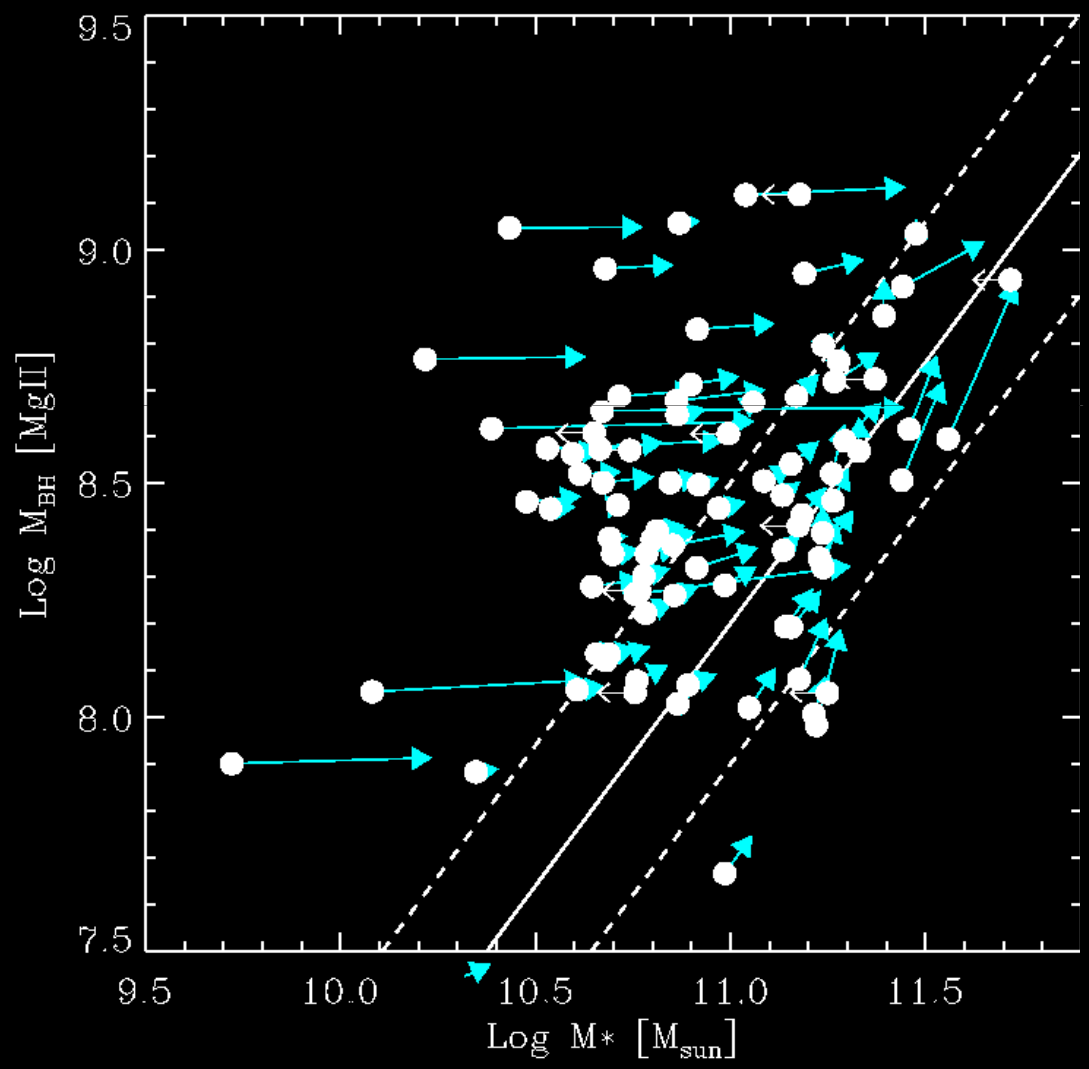

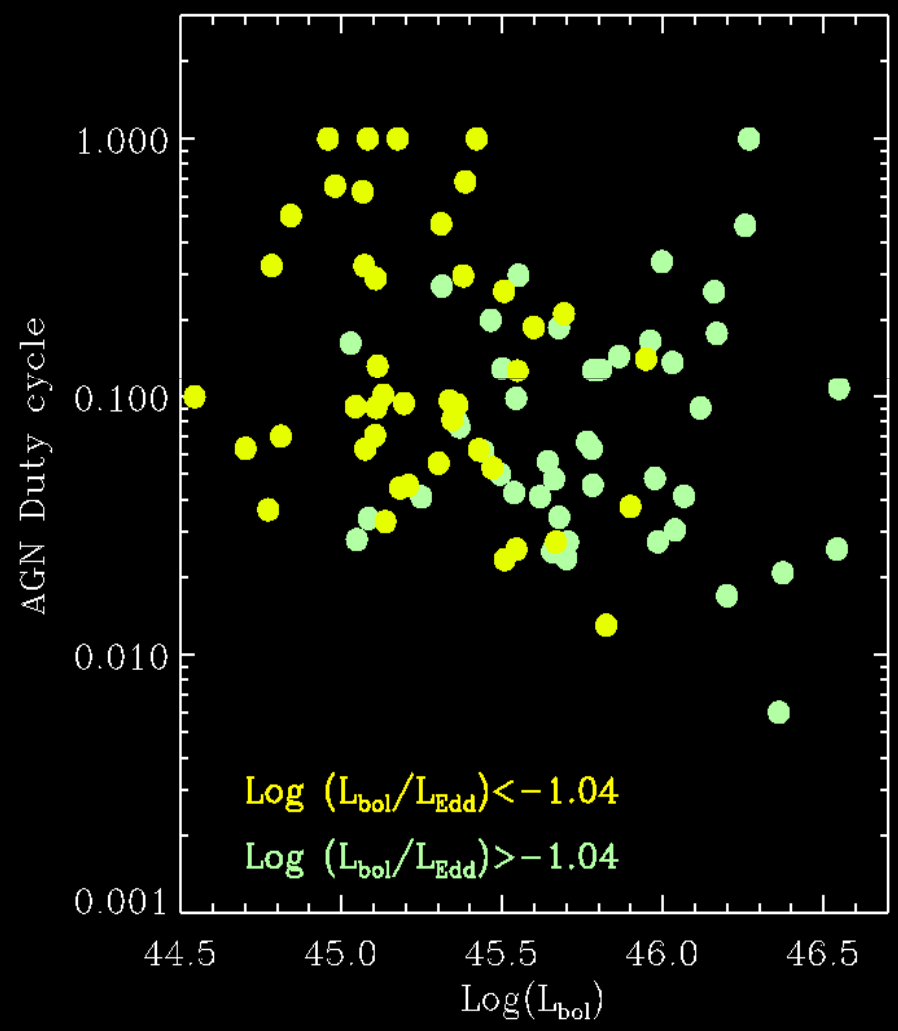

Future prospects

QuickTime™ and a
decompressor
are needed to see this picture.

Thanks to P. Rosati (ESO)

Conclusions

- AGN-galaxy co-evolution is evident in integrated quantities (masses and SFR/BHAR densities)
  - No strong evolution of $\langle M_{BH}/M_{*} \rangle$ from integral constraints
- The most rapidly growing black holes (QSOs at $1<z<4$) show an offset from the local scaling relation: for a given host BHs appear to be bigger than at $z=0$
  - This could be due to (moderate) evolution in either normalization and/or scatter in the Magorrian relation
- Strong Co-evolution and Simplest “Explosive” feedback models fail to reproduce the data.
  - Predictions about evolution of scatter are crucial
- Need BH mass estimators in (mildly) obscured AGN!!