

# The Nature of Star-formation in powerful AGN

with help and support from members of  
PEP  
COSMOS  
GOODS-Herschel  
CANDELS  
+ Hagai Netzer, Benny Trakhtenbrot

The view from the FIR

DAVID ROSARIO

MAX PLANCK INSTITUTE FOR EXTRATERRESTRIAL PHYSICS

@ AGN vs. SF,  
Durham



# The Nature of Star-formation in powerful AGN

+ some new stuff

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The view from the FIR

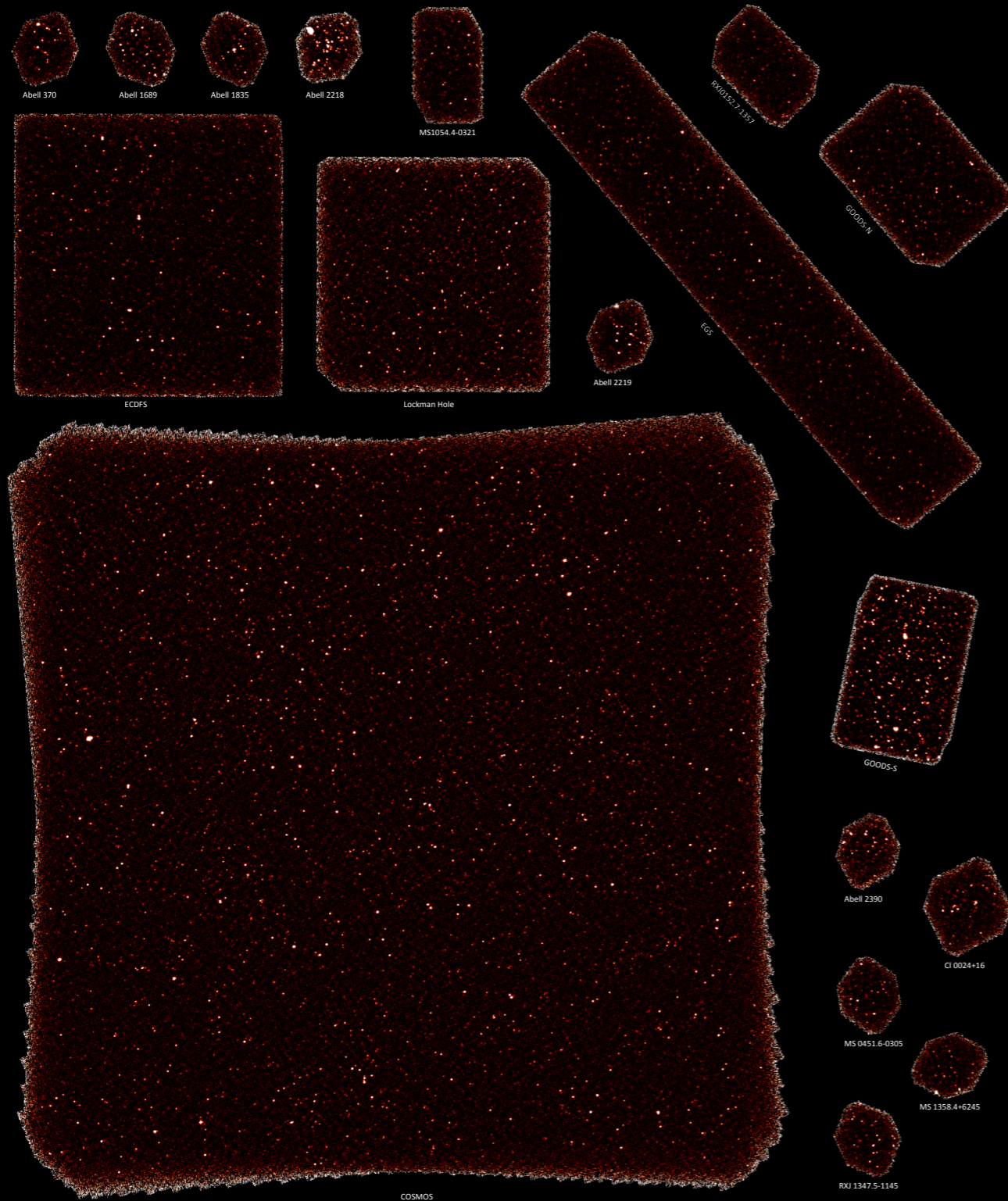
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PEP surveys the far-infrared sky with Herschel-PACS



# PEP

## The PACS EVOLUTIONARY PROBE

Herschel GTO survey covering six key  
survey fields and several massive galaxy  
cluster fields

LUTZ+ 2011, A&A, 523, 90

FULLY PUBLIC AT:

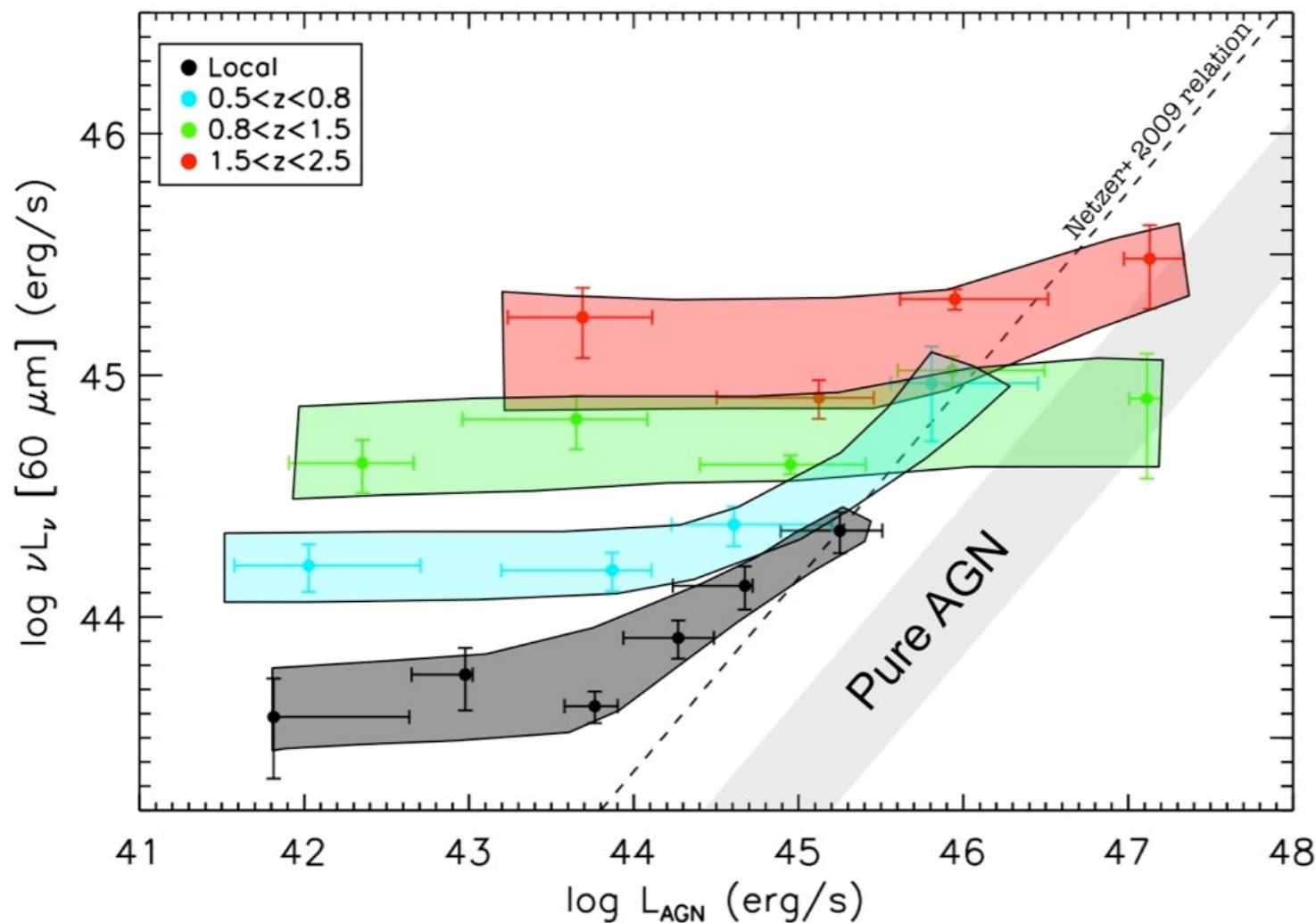
[www.mpe.mpg.de/ir/Research/PEP/public\\_data\\_releases.html](http://www.mpe.mpg.de/ir/Research/PEP/public_data_releases.html)





# STAR-FORMATION ACROSS AGN LUMINOSITY

ROSARIO+ 2012



The mean FIR luminosity is not strongly dependent on AGN luminosity, especially at  $z > 1$ .

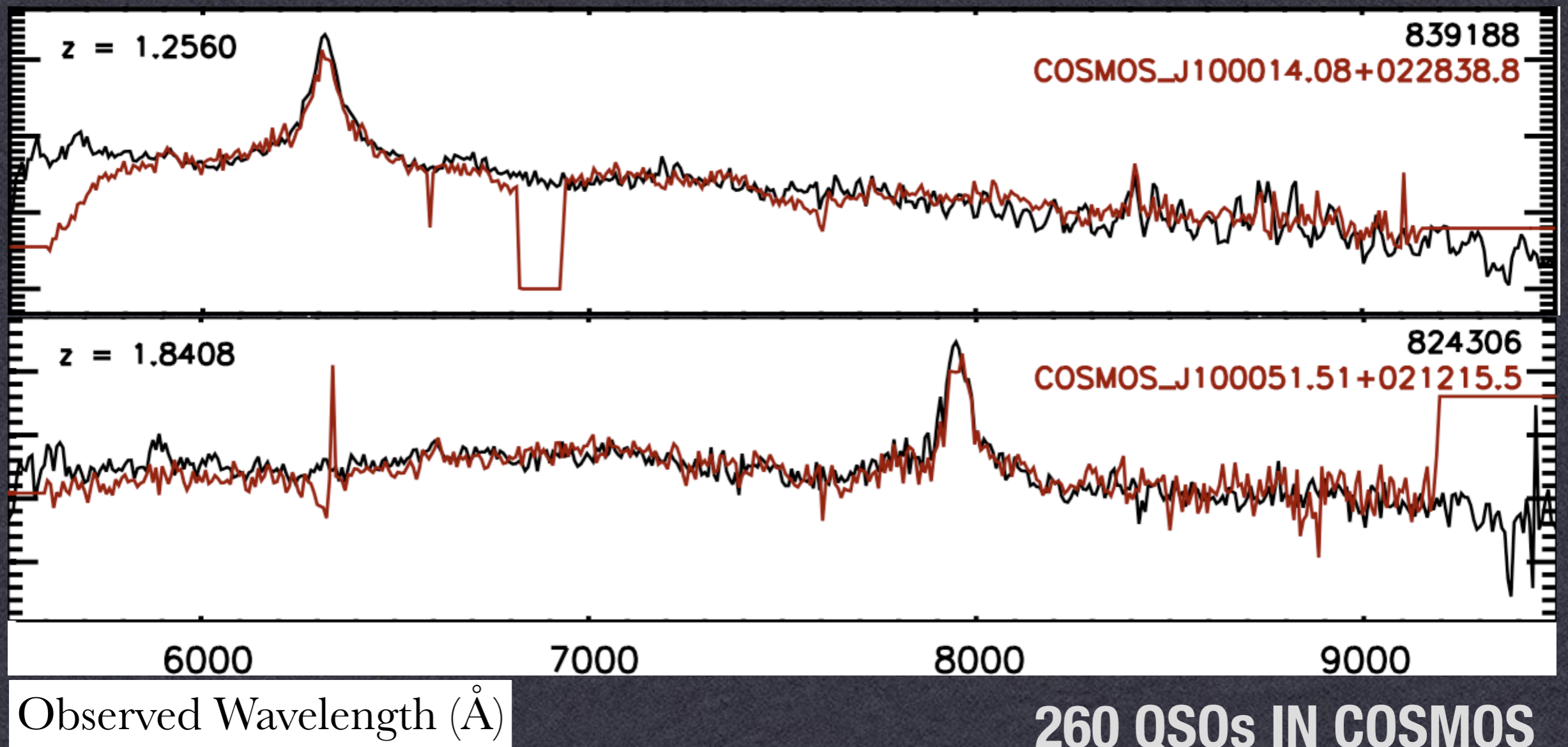
**Page+ 2012 vs.  
Harrison+ 2012  
for uncertainties and  
role of cosmic variance.**

Also see Lutz+ 2010, Shao+ 2010, Hatziminaoglou+ 2010, Pozzi+ 2012, Mullaney+ 2012



# STAR FORMATION IN QSOs FROM $z=0$ TO $z=2$

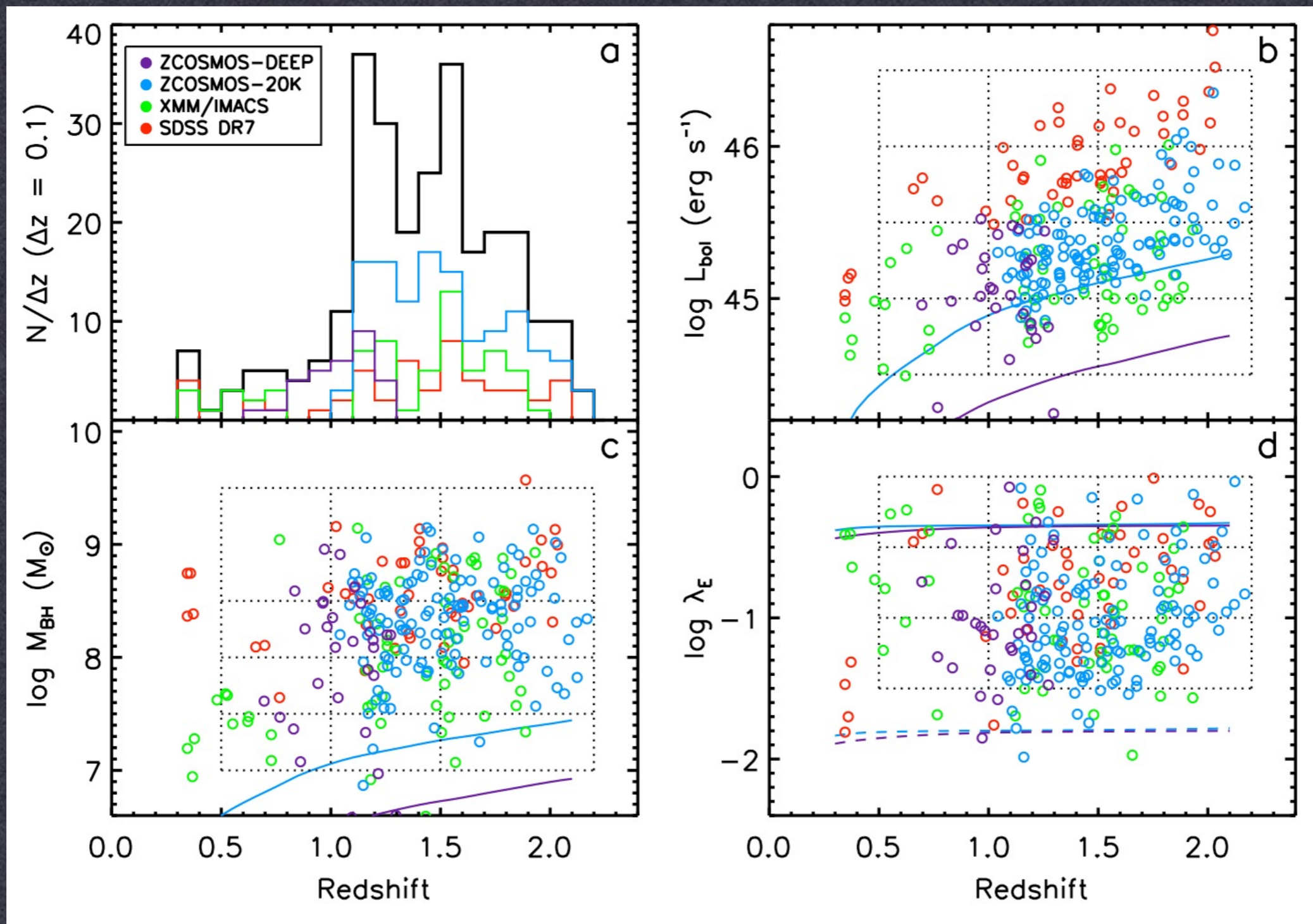
ROSARIO+ 2013 C



with B. Trakhtenbrot, D. Lutz, H. Netzer, J. Silverman,  
PEP/COSMOS collaborators



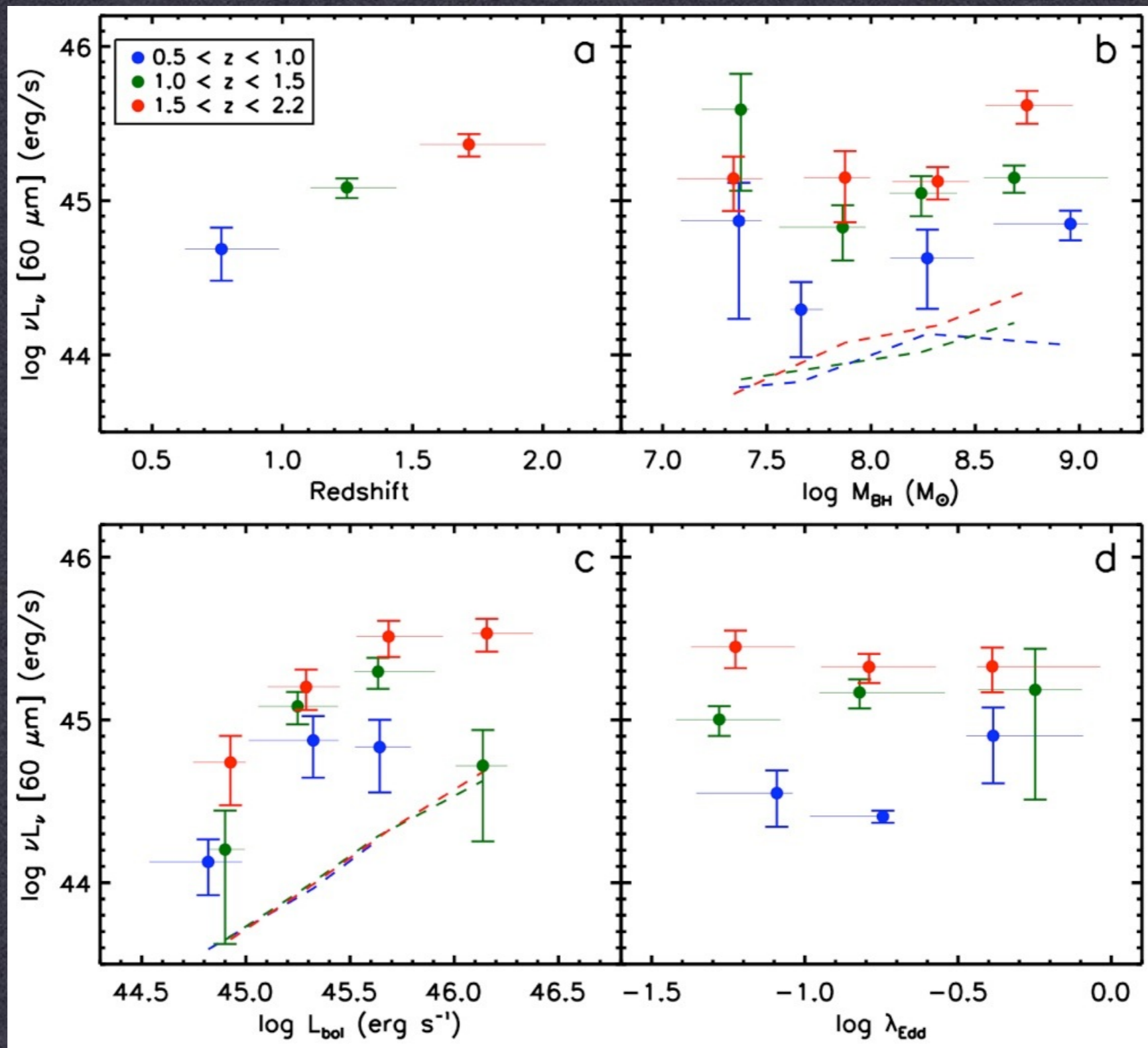
Four spectral datasets (z-COSMOS 20K/Deep, XMM-IMACS, SDSS DR7)  
Uniform measurements of SMBH mass/AGN luminosity,  
Herschel PACS photometry and stacking



**The largest sample of high-z QSOs with uniform, deep FIR photometry**

*Two orders of magnitude in  $L_{bol}$ ,  $M_{BH}$  and Eddington ratio ( $\lambda_E$ )*



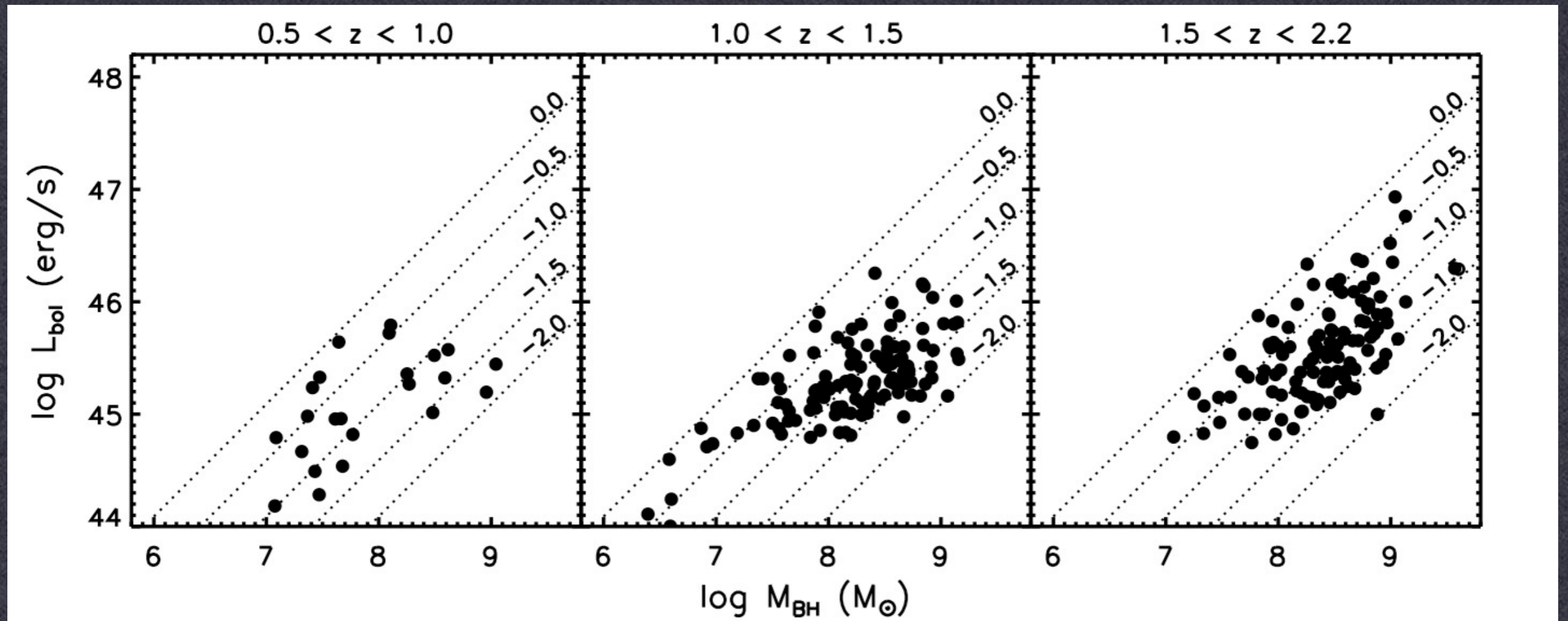


## Trends with SMBH parameters

*But modeling is needed to account for selection effects.*



# RAPIDLY ACCRETING BLACK HOLES

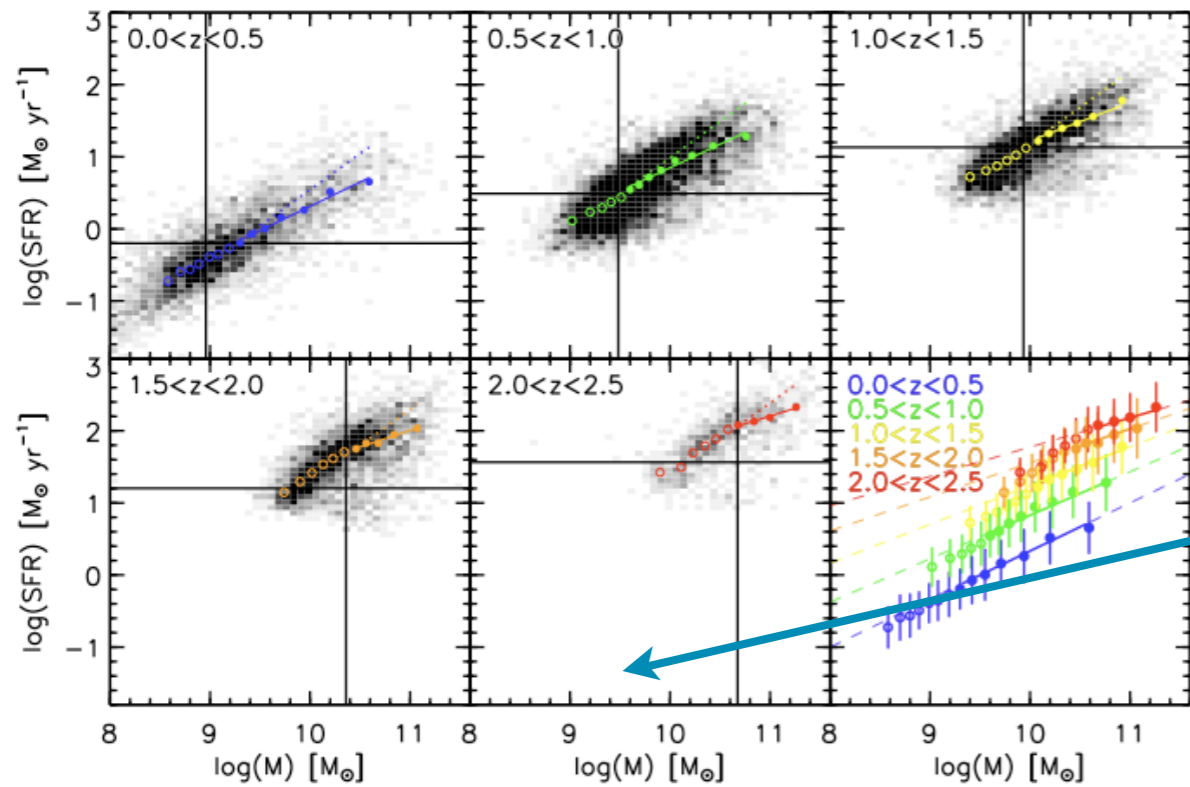


**Selection effects are critical**

Fast accreting AGN tend to be lower mass, due to flux limits  
+ dropoff in BHAR function at low and high end



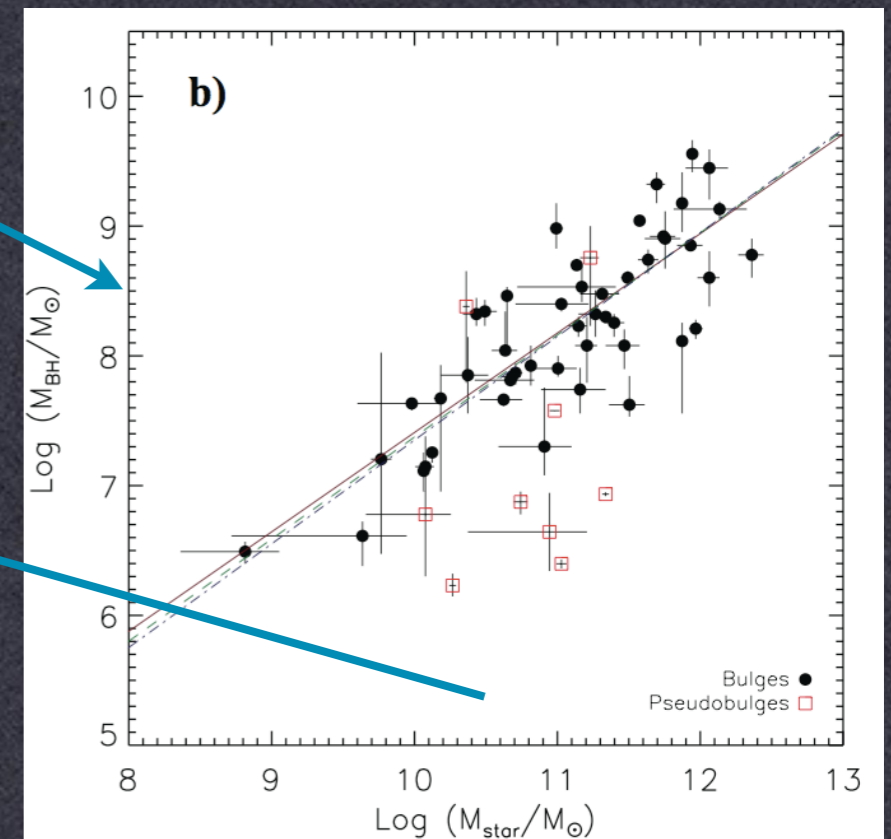
# SIMPLE MODELLING OF SELECTION EFFECTS



SFR -  $M_*$  RELATION CALIBRATED FROM SF GALAXIES (WHITAKER+ 2012)

$M_{BH}$

$M_*$



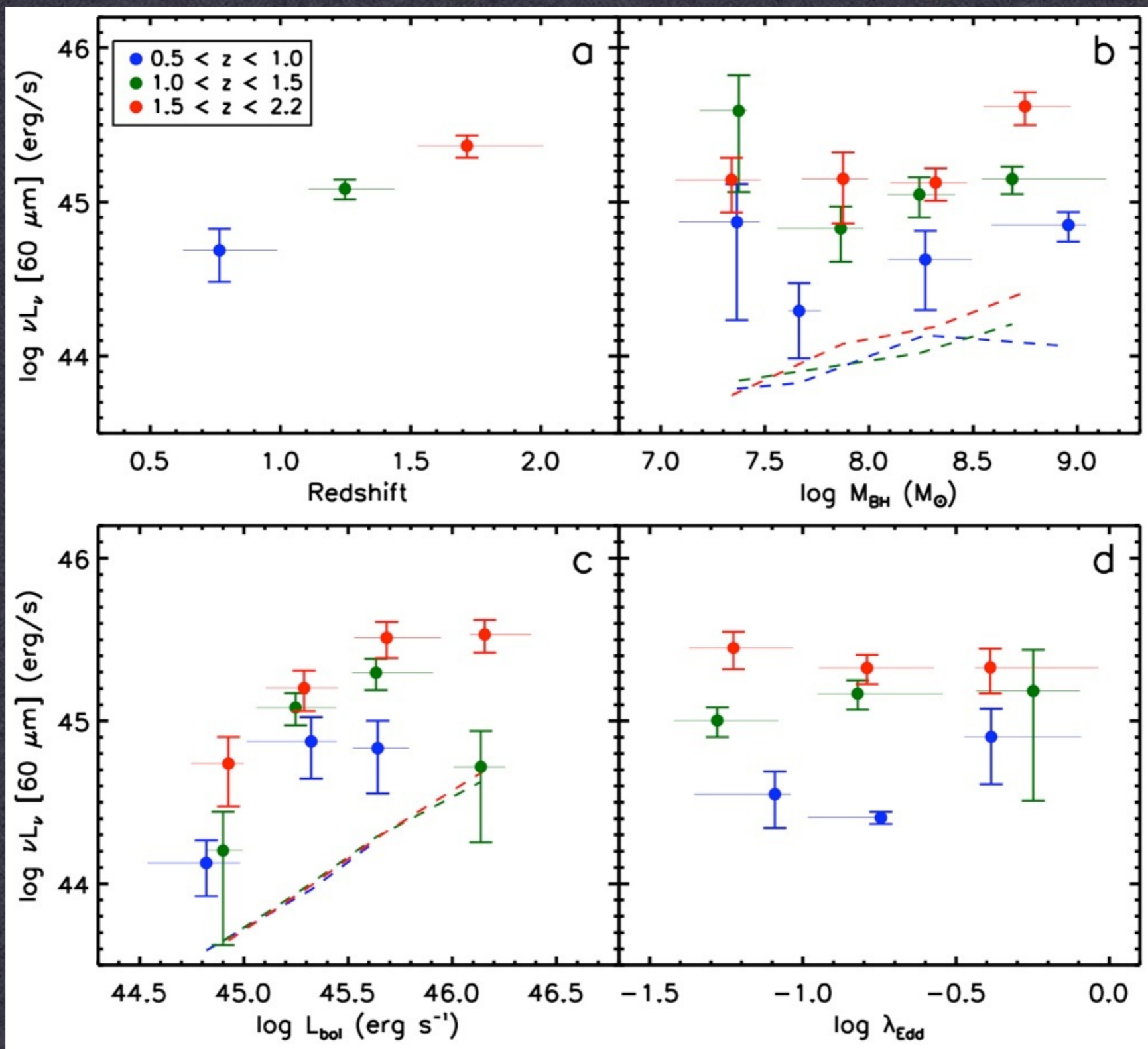
LOCAL  $M_{BH}$  -  $M_*$  RELATION (SANI+ 2011)

No evolution in  $M_{BH}$  -  $M_*$

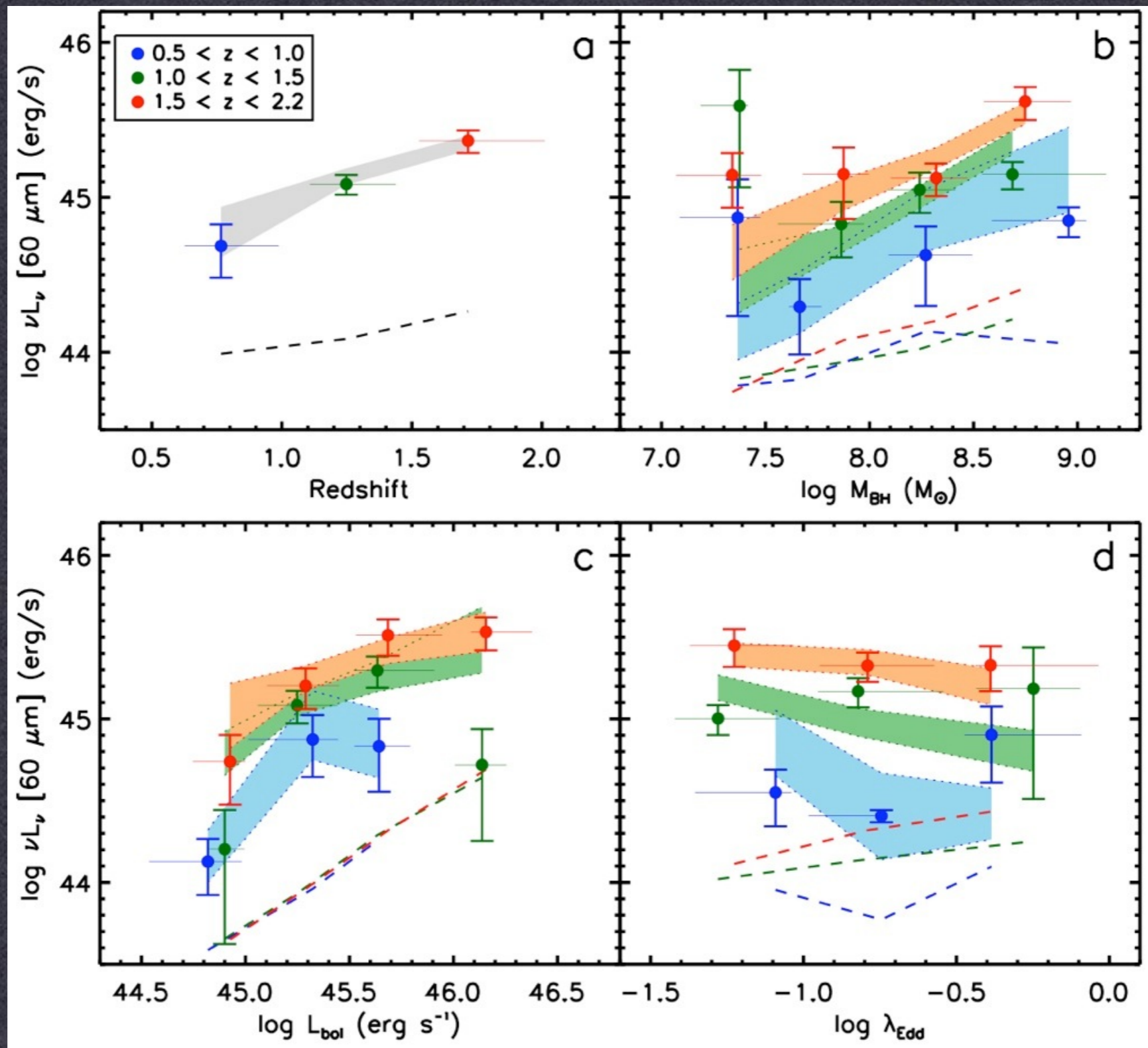
Scatter in all relations accounted for using Monte-Carlo bootstrapping

Small correction for AGN emission in the FIR (unimportant at high  $z$ )









**Trends fit remarkably well!**

*The scatter is also generally reproduced*



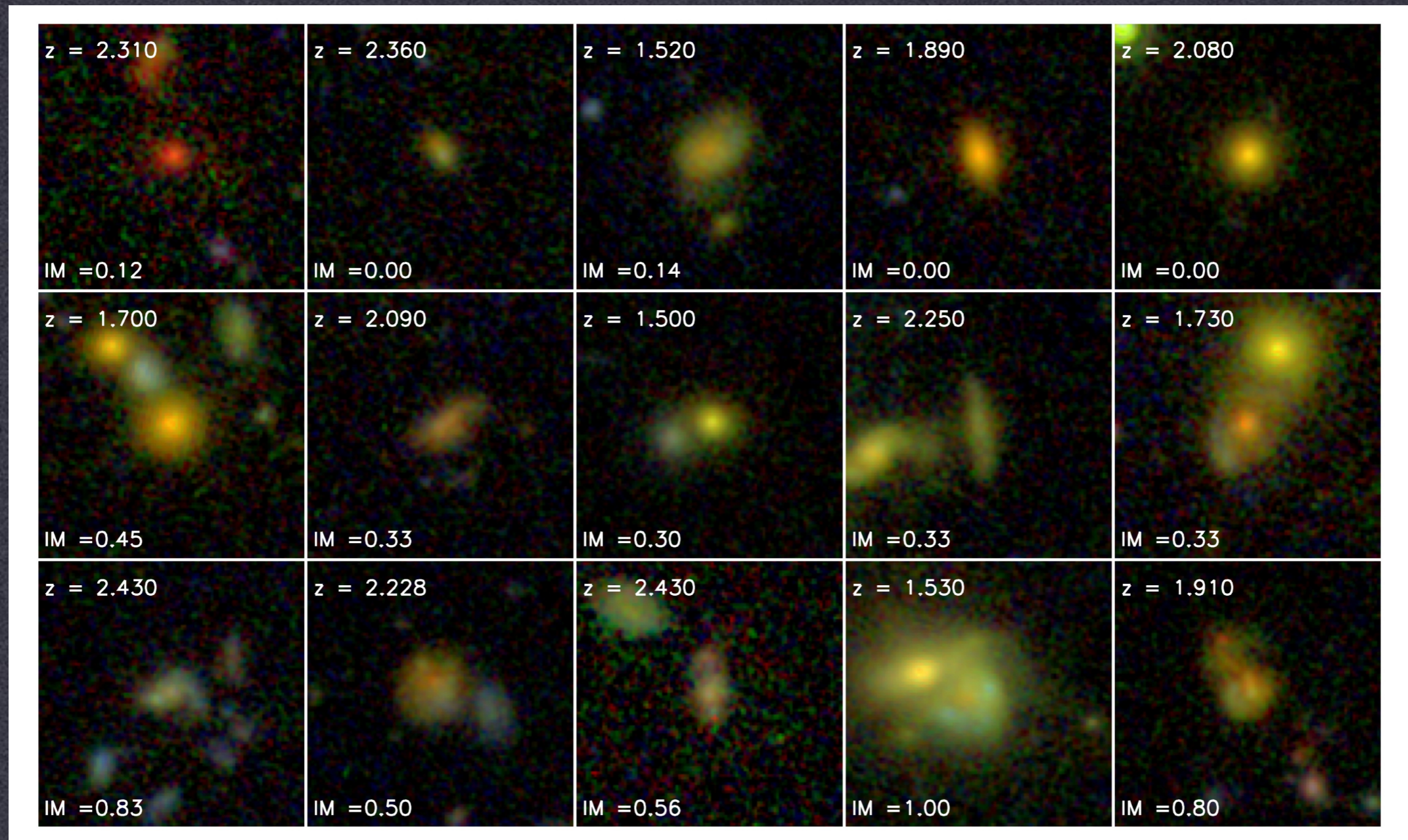
# TAKE AWAY MESSAGE

**This study suggests that  
high-redshift QSOs, are mostly in  
normal, massive, SF galaxies.**



# STAR-FORMATION AND HOST STRUCTURE

ROSARIO+ 2014 A (SUBMITTED)



A CANDELS, PEP/GOODS-Herschel collaborative work

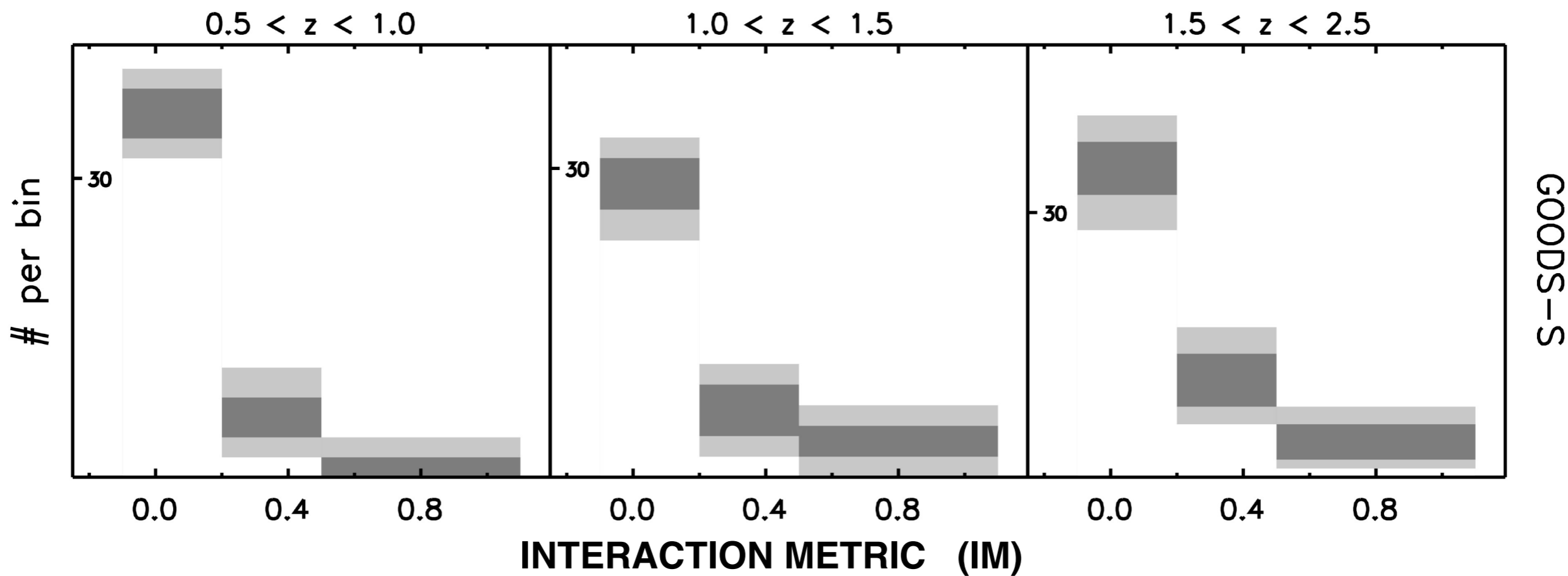


# BOOTSTRAPPING “ALL THE GALAXIES”

There are many more **massive inactive galaxies** than AGN in any deep field.

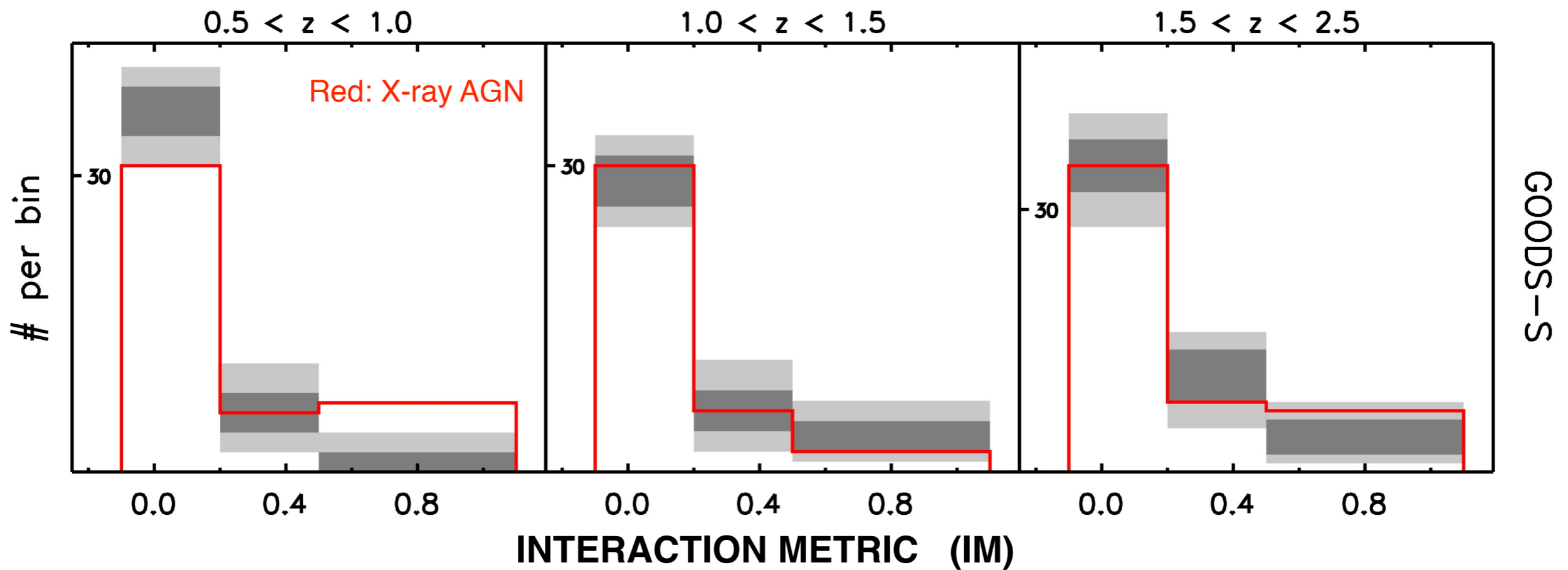
Do AGN share the structural and SF distributions and relationships shown by inactive galaxies?





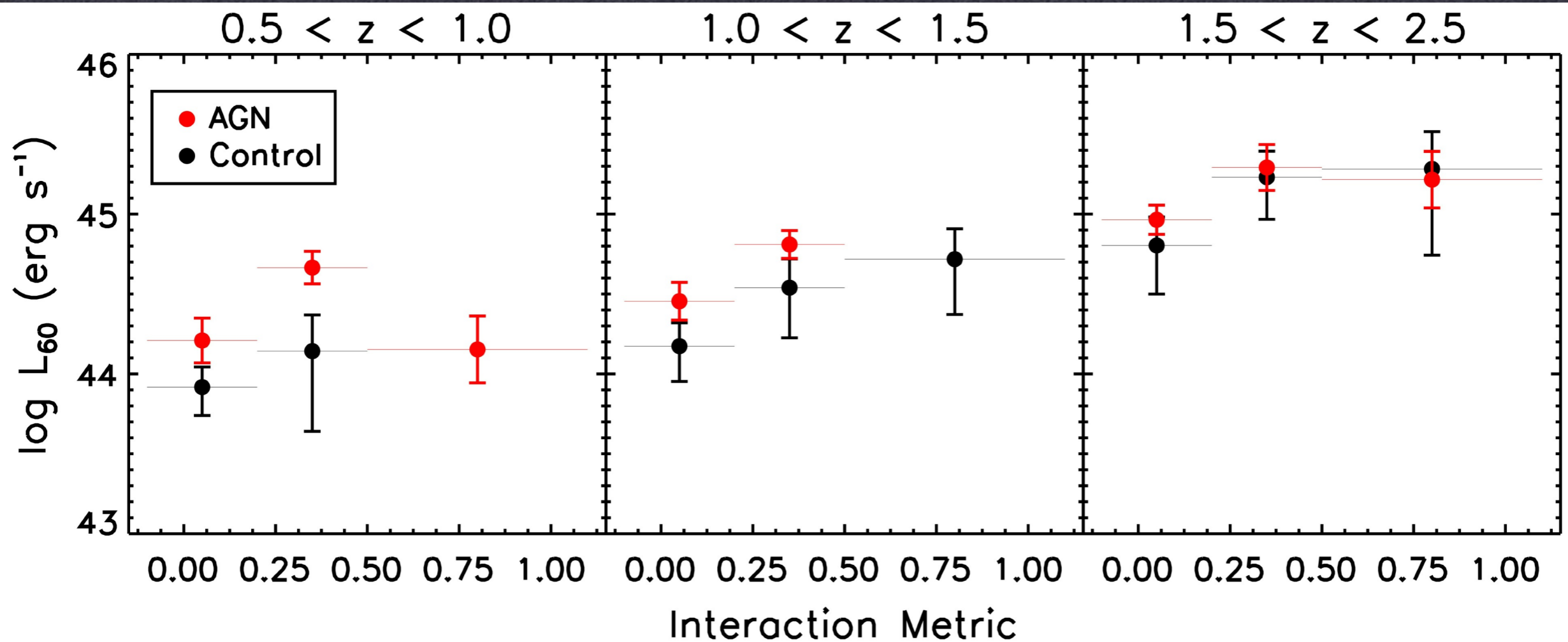
**Distributions of IM for mass-matched inactive control samples**





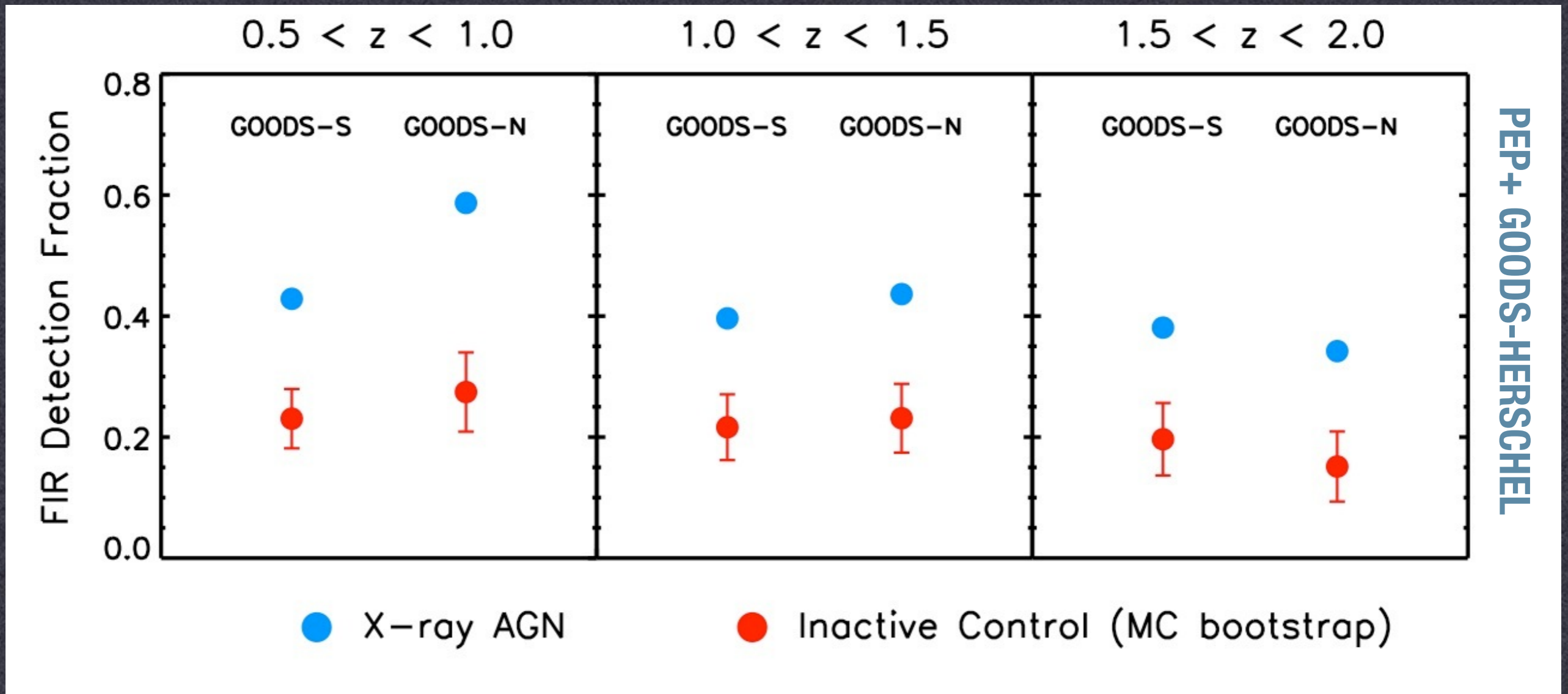
**AGN have a higher interaction fraction at  $z \sim 1$**





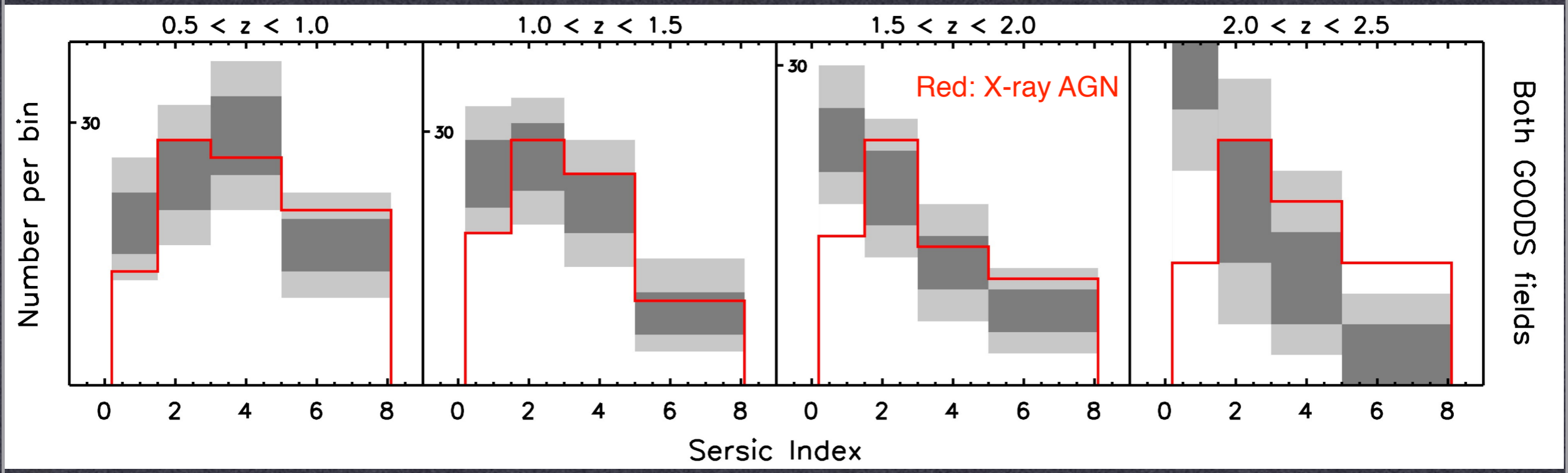
The mean FIR luminosity of AGN is enhanced in interacting, **as well as in isolated**, hosts.





Higher **gas fractions** in AGN (also see Fabio Vito's talk).





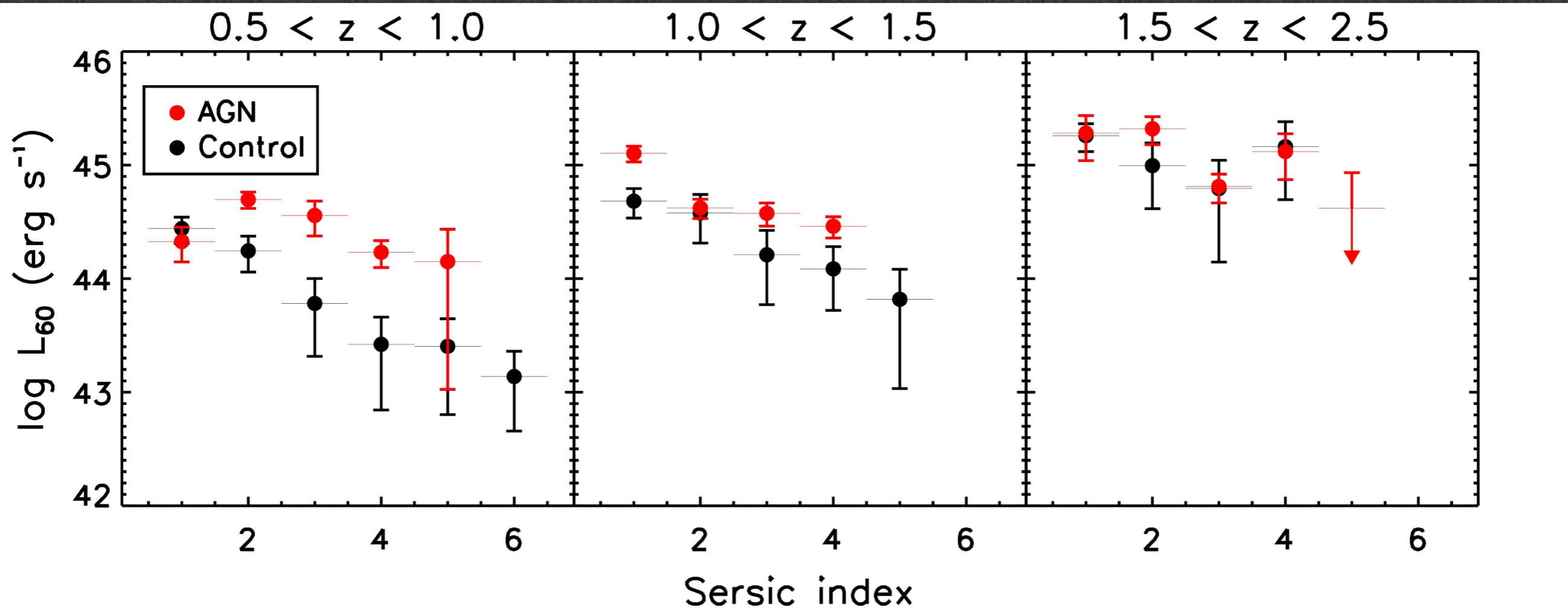
**AGN have steeper light profiles at  $z \sim 2$**



- \* The light excess is at least as red as the rest of the galaxy, if not redder.
- \* At the moderate X-ray luminosities in the CDFs, point sources with  $> 10\%$  of the galaxy light are difficult to produce if they are extinguished, even modestly.
- \* Two-component GALFIT fits show a light excess over a pure Sersic profile in both AGN and inactive galaxies.

The central excess is due to a **more pronounced bulge** in AGN hosts at  $z \sim 2$





**The mean FIR luminosity of AGN is enhanced in bulgier galaxies but only at  $z \sim 1$**



# SUMMARY THOUGHTS

- \* QSOs in normal SF hosts - secular processes fuel luminous AGN? Or are many mergers not starbursts?
- \* Moderate luminosity X-ray AGN have a marginally higher interaction fraction at  $z \sim 1$ , but not at  $z \sim 2$ .
- \* Higher SFR in bulgy AGN at  $z < 1$ . Remaining gas accretion in post-mergers? Gas streamer accretion in dense environments?



# FOLLOWING RYAN'S SUMMARY

- \* Cold gas is the main modulator of both average AGN activity and SFR in galaxies.
- \* Accretion modes: mergers, secular evolution, etc, are second order. For e.g.; gas rich mergers fuel more AGN than gas poor mergers.
- \* We now know how gas behaves in galaxies to high redshift (Saintonge's talk).