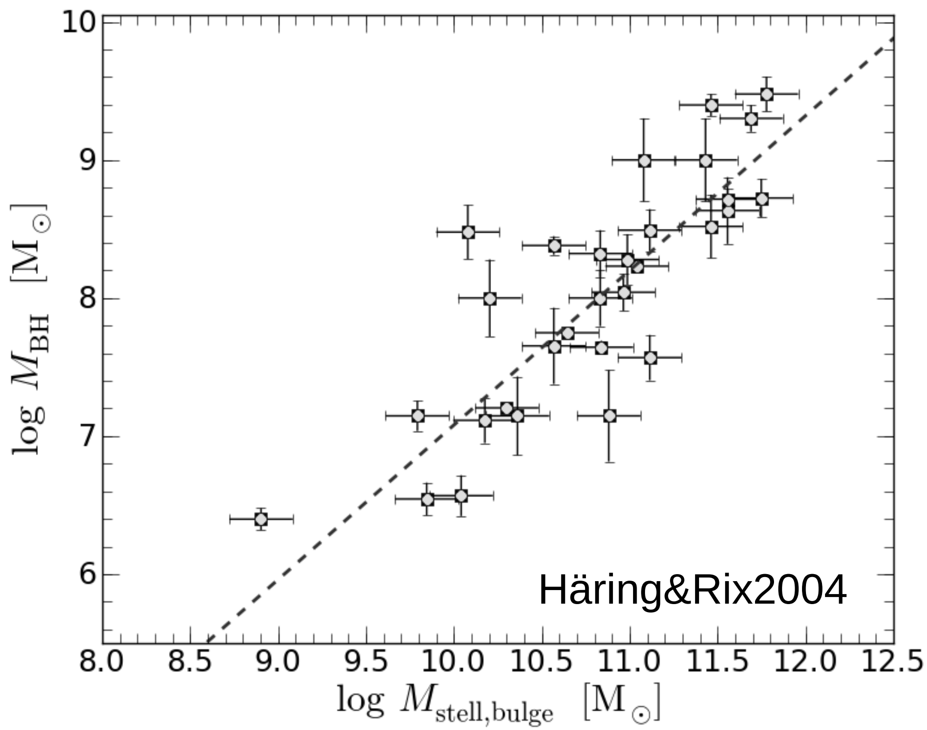
BH-Galaxy Co-Evolution at z=3:
Latest Results from SUBARU & ALMA

Malte Schramm NAOJ

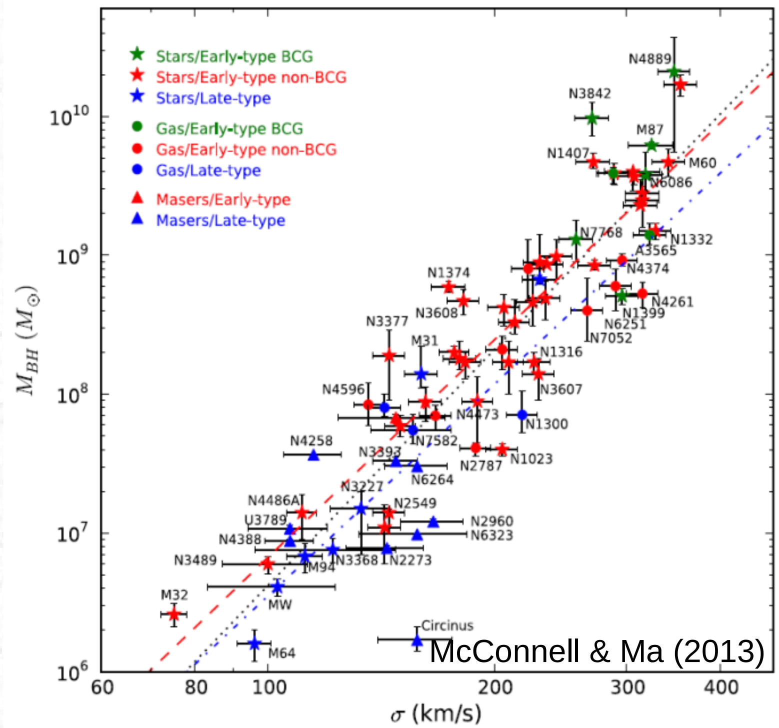
EA-AGN 2016

Motivation I

- Strong relations observed between BH mass and host properties



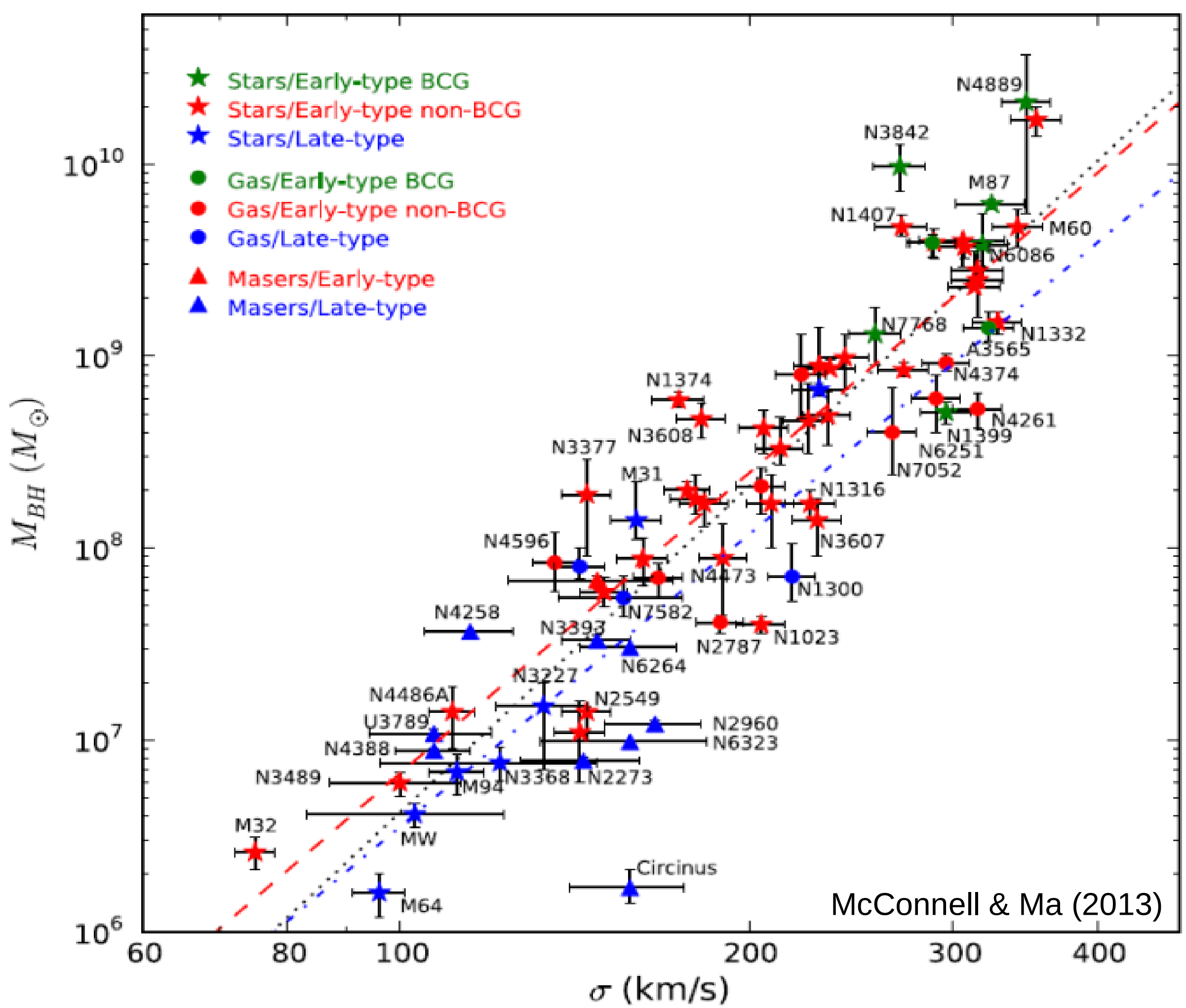
BH mass



bulge velocity dispersion

So far: M-sigma only at z<1

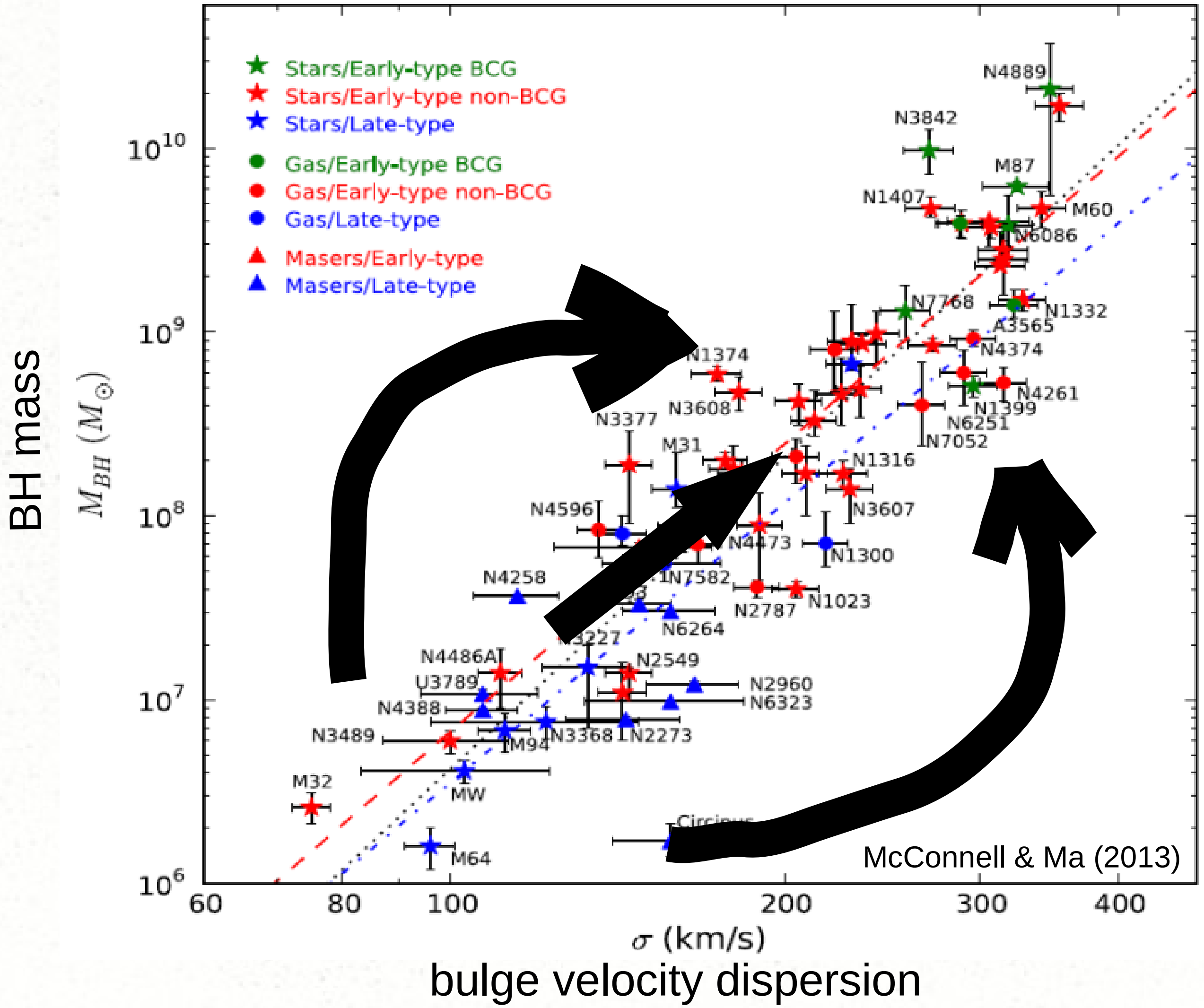
Motivation II



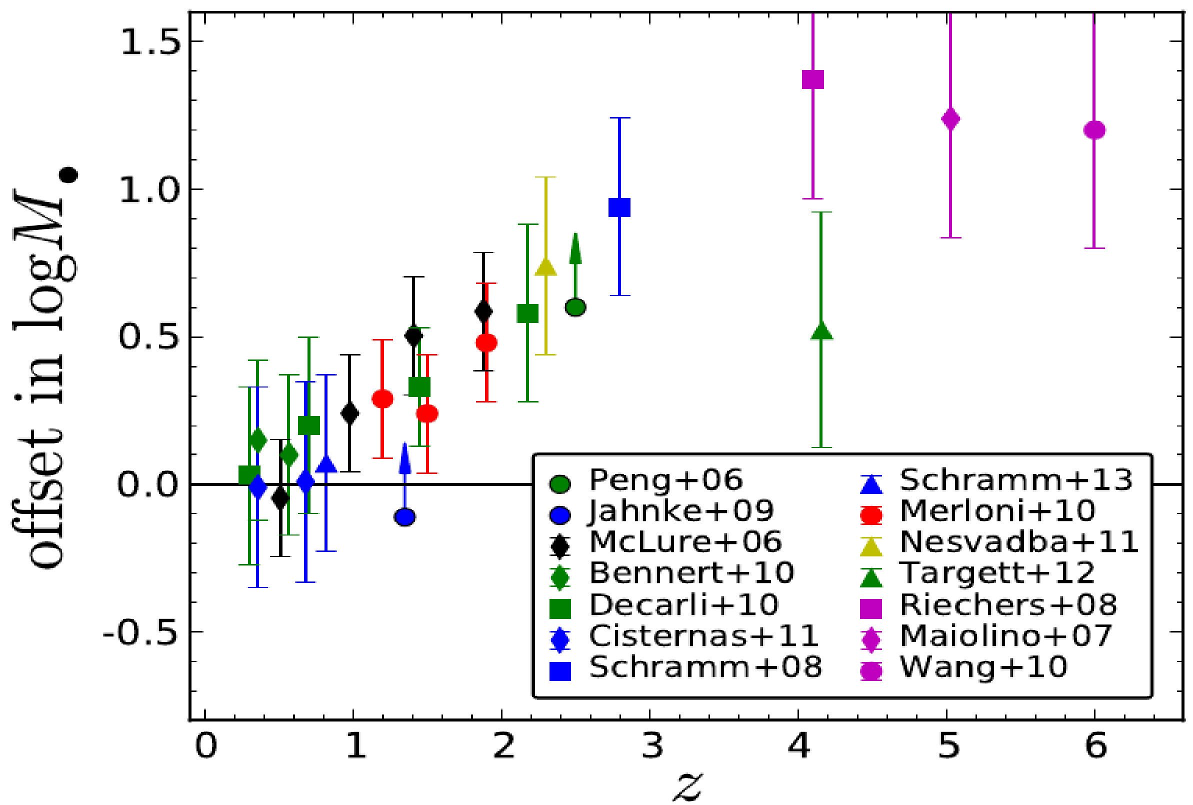
BH mass

bulge velocity dispersion

Who comes first BH or Host Galaxy?



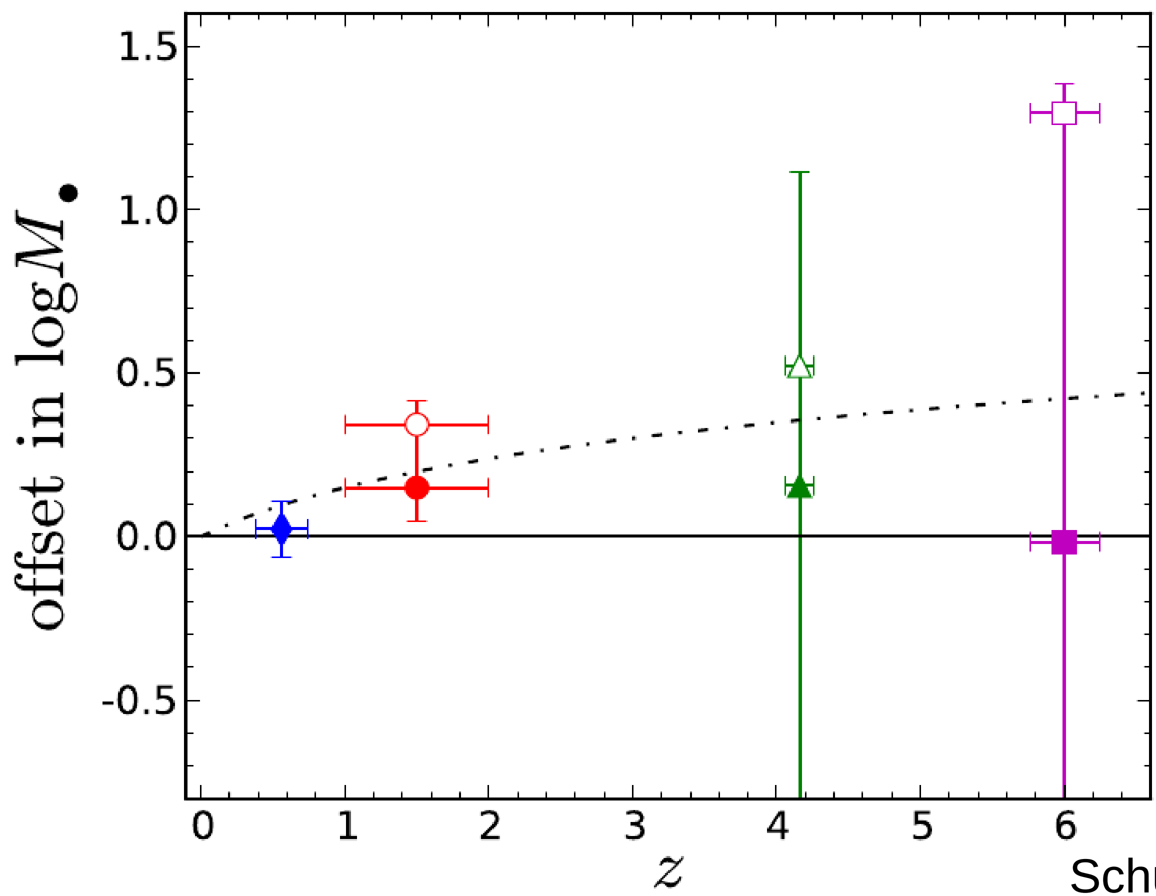
Apparent Cosmic Eolution of M_{BH}/M_{BULGE} relation



Schulze&Wisotzki 2014

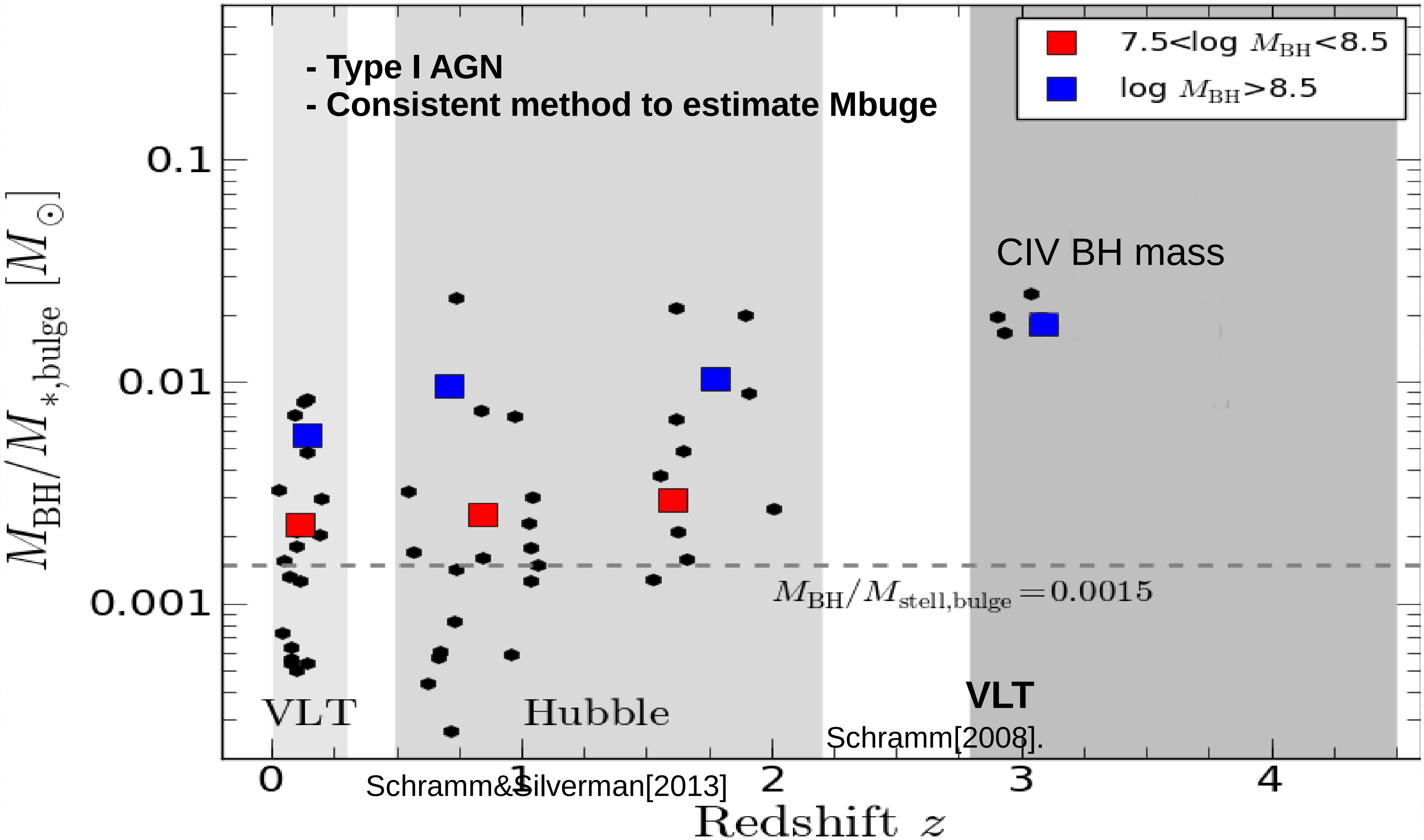
BEWARE: Selection Effects

No strong trend after accounting for selection effects



Schulze&Wisotzki 2014

My Approach: Probing the redshift evolution of the BH mass – bulge mass relation



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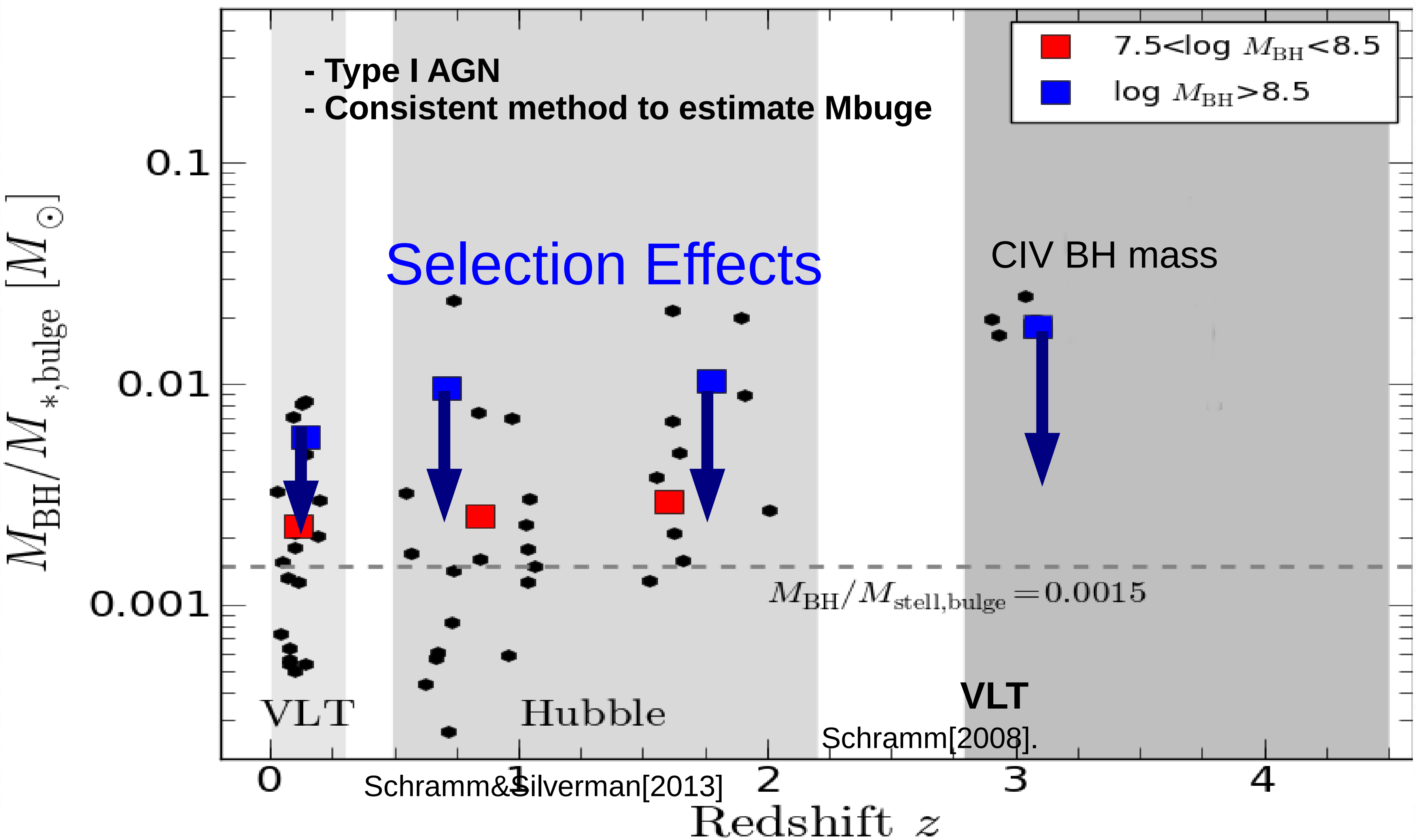
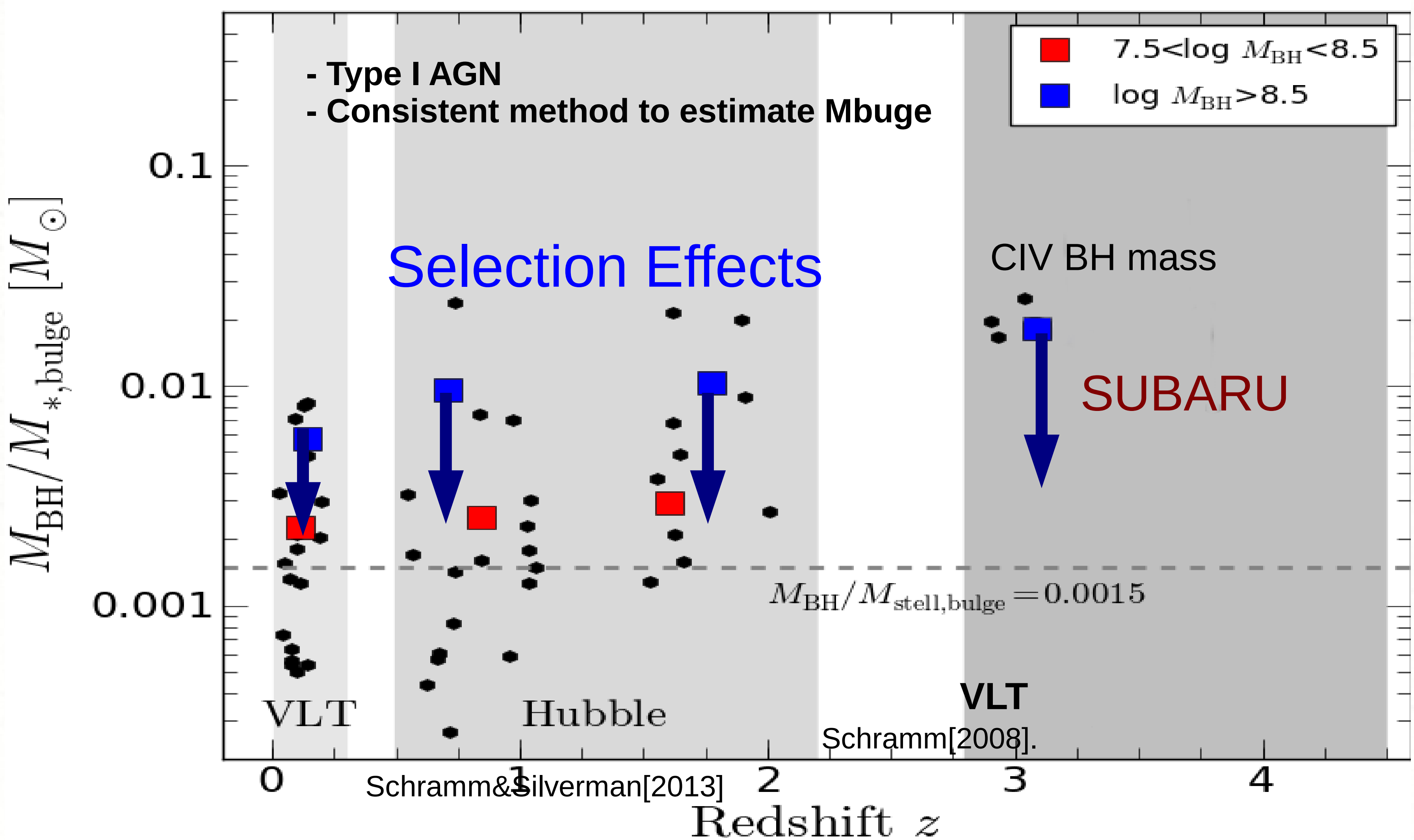
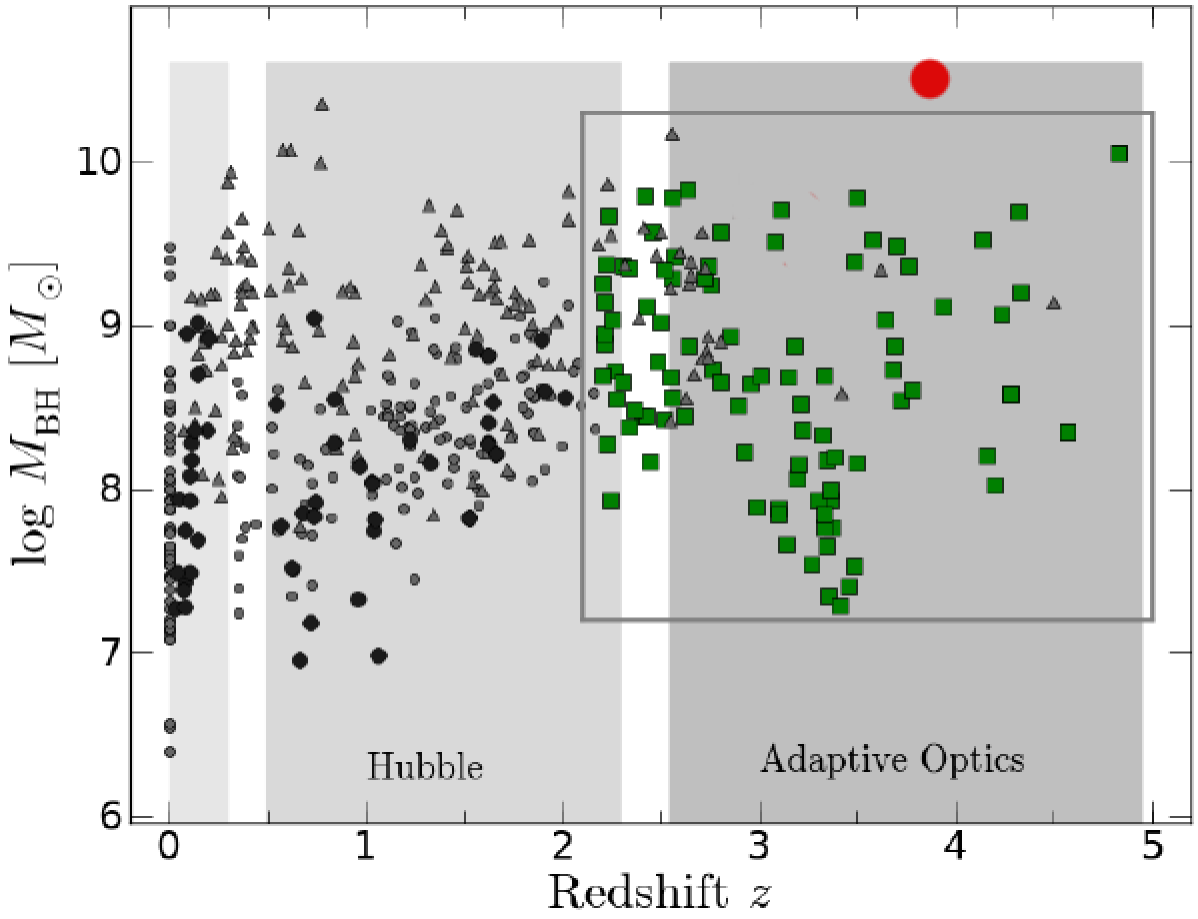


My Approach: Probing the redshift evolution of the BH mass – bulge mass relation

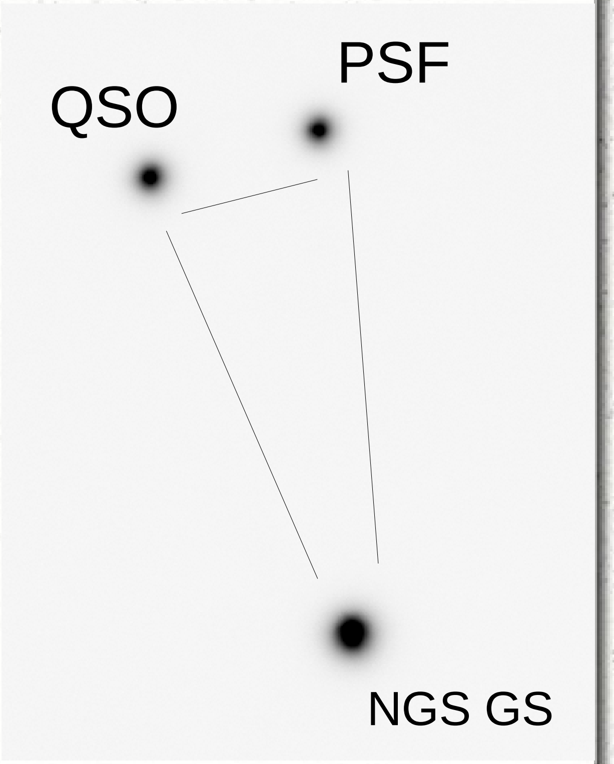


SUBRU IRCS+AO observations of high-z SDSS QSOs

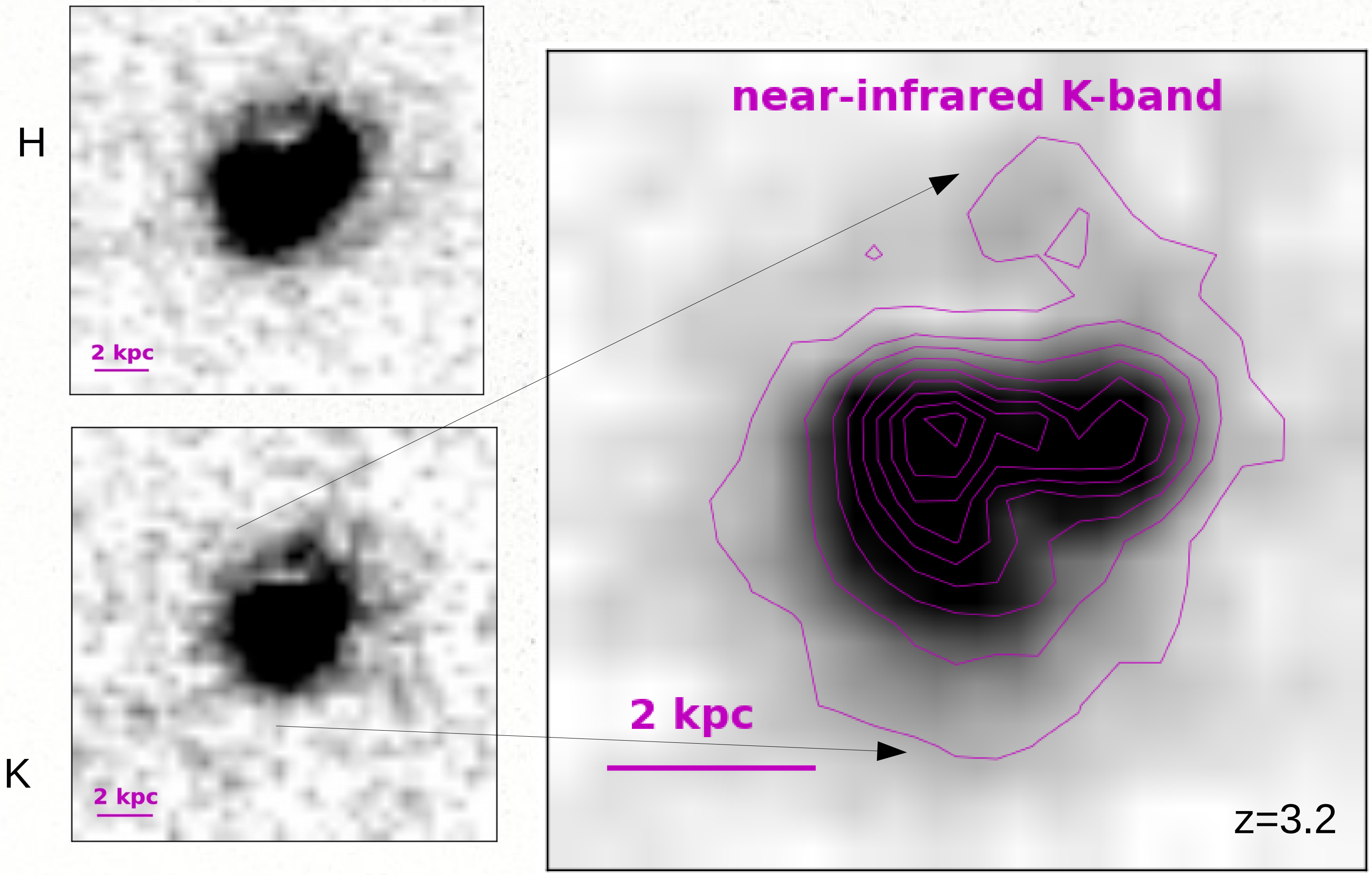


Lets try to be consistent with low-z!

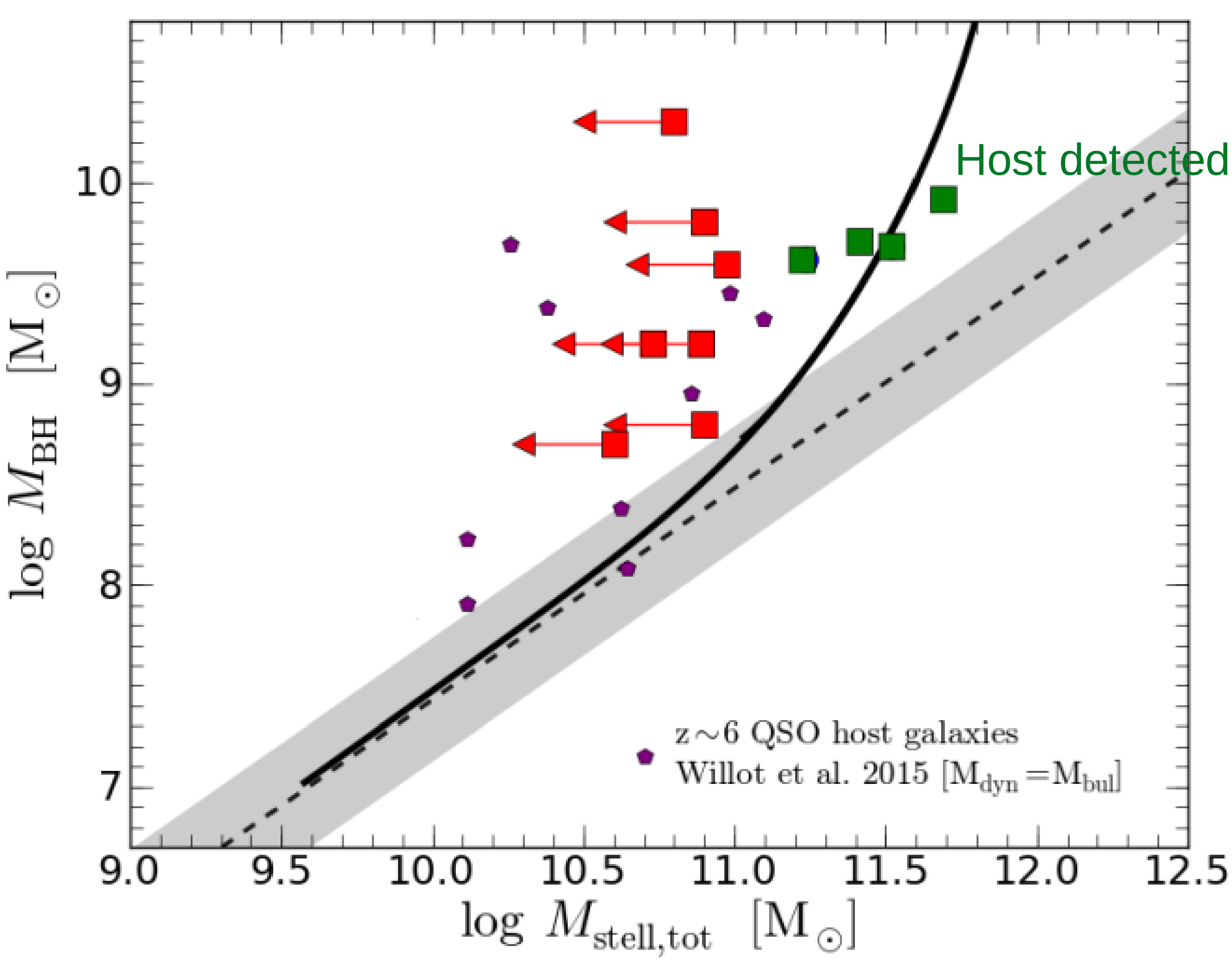
- Better BH mass (than SDSS CIV) estimates from Hbeta
- Better spatial resolution (0.1-0.3 arcsec) using SUBARU IRCS+AO188
- Have good control over the PSF using a favorable GS-PSF-QSO configuration
- Probe rest-frame B-V for consistent M/L estimates



AGN host galaxy at z=3.2 wAO



Scaling Relation at z=3



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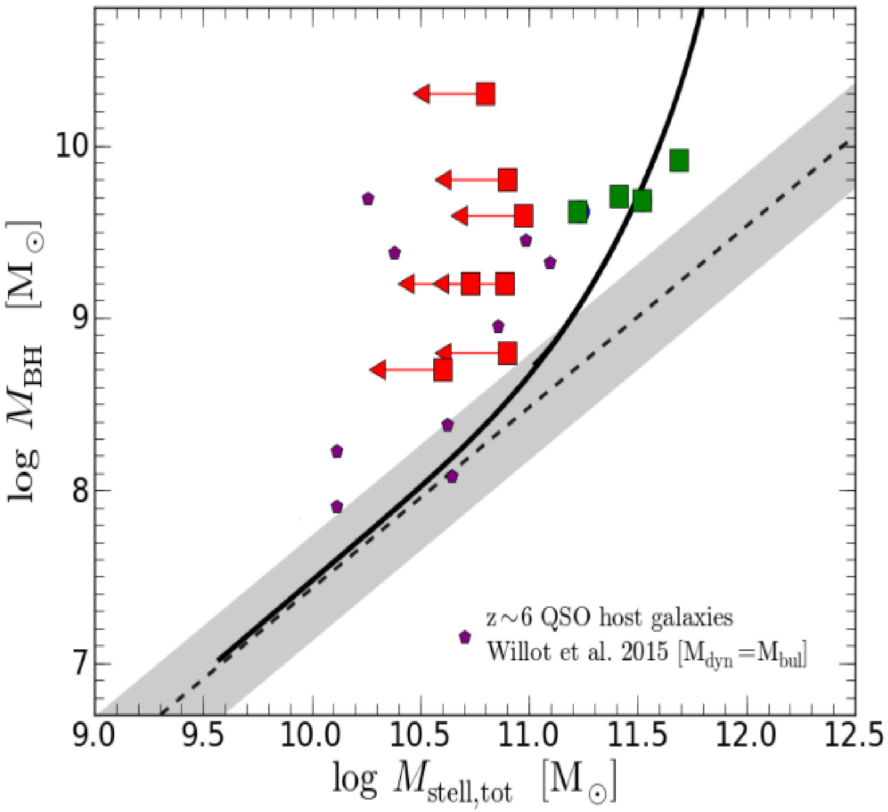
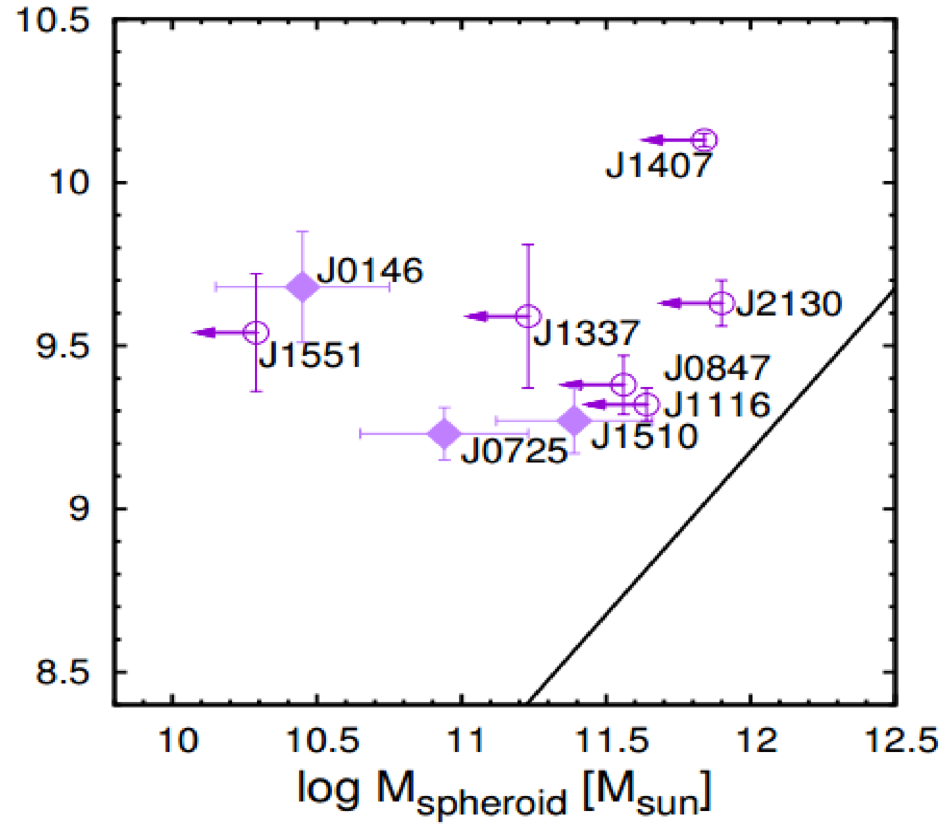


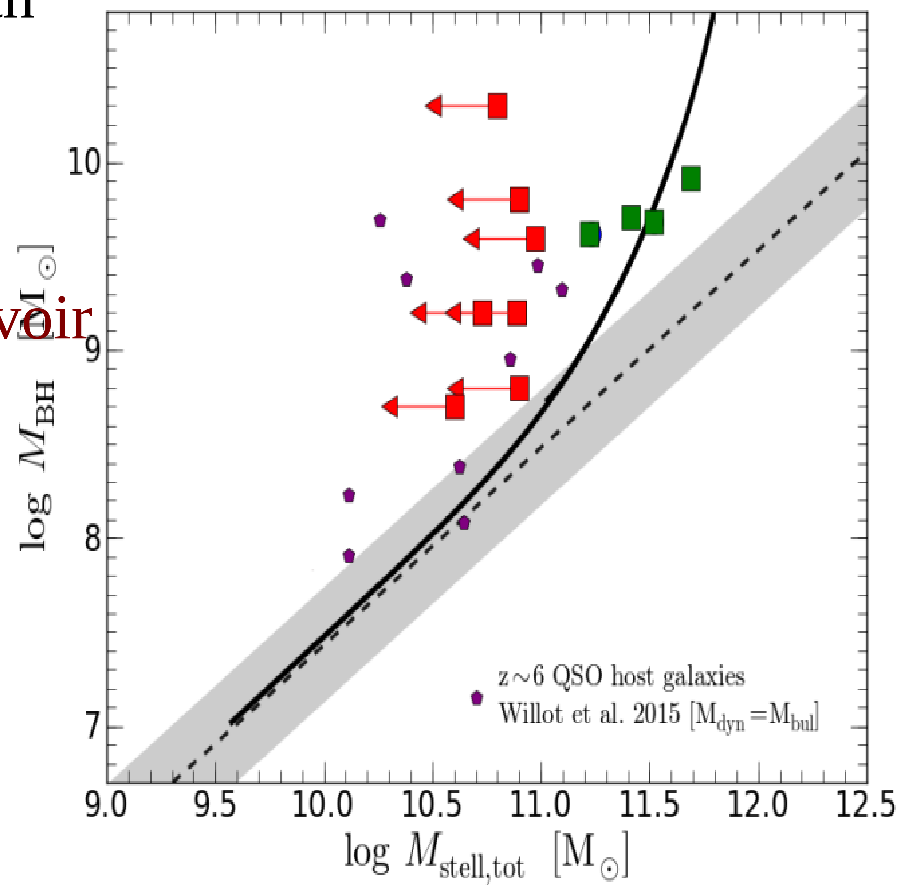
Similar result from different group



Yuriko Saito's PHD Thesis

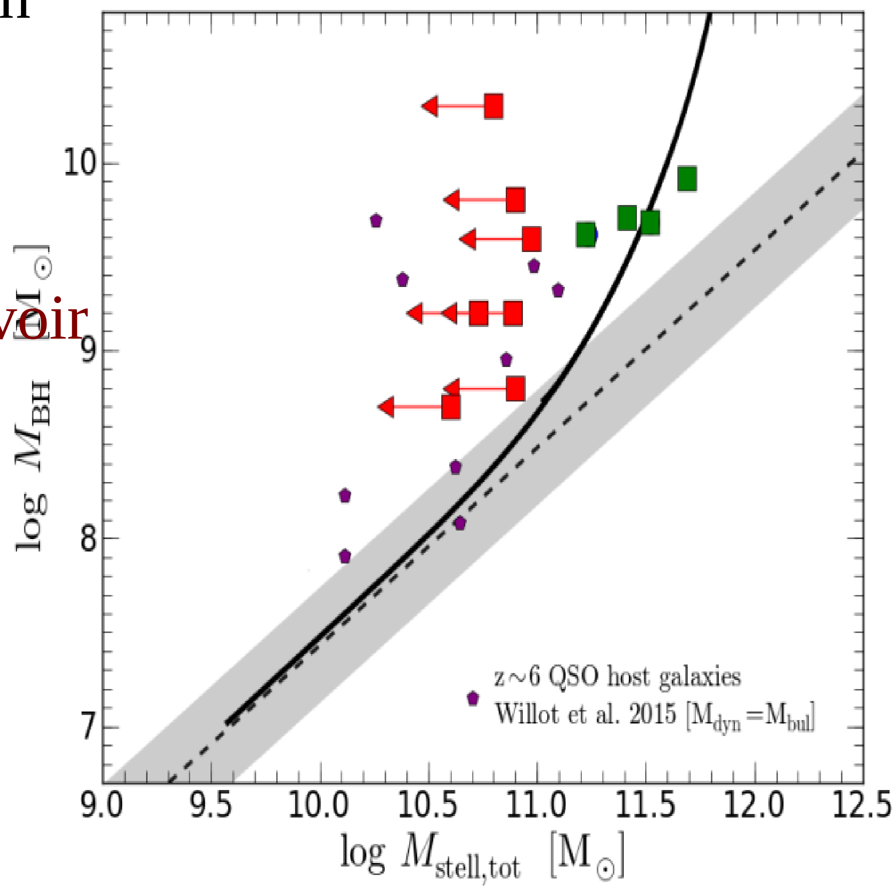
The next step: ALMA

- Successful Cycle 3 ALMA program to look at 4 QSOs with NO host detection in band 3 to detect CO
- Our assumption: 'no' stars but massive BH → large gas reservoir

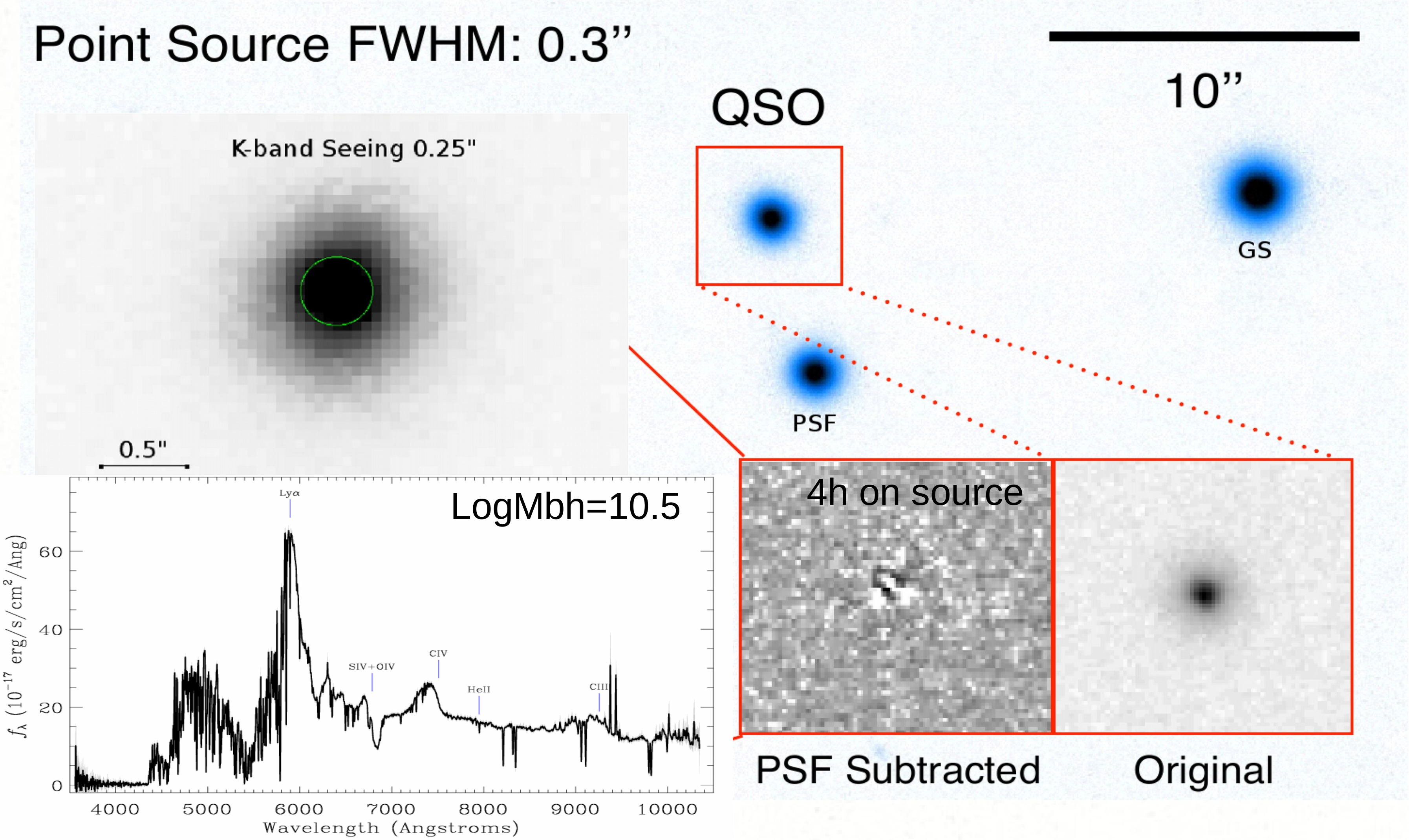


The next step: ALMA

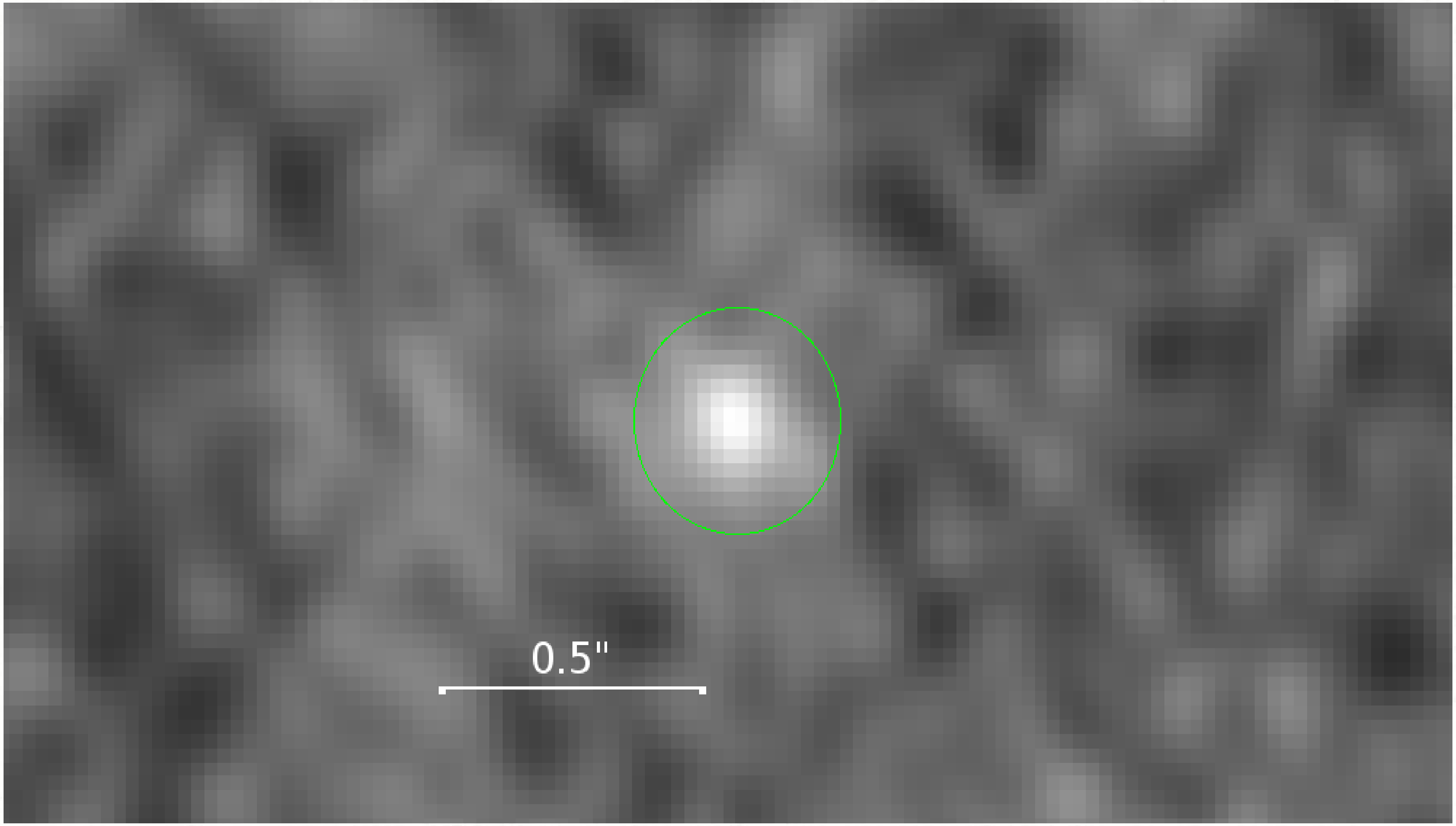
- Successful Cycle 3 ALMA program to look at 4 QSOs with NO host detection in band 3 to detect CO
- Our assumption: 'no' stars but massive BH → large gas reservoir
- What we got were mostly non-detections but 1 exception



Case study of J16+28 at z=3.8



ALMA reveals the gas!

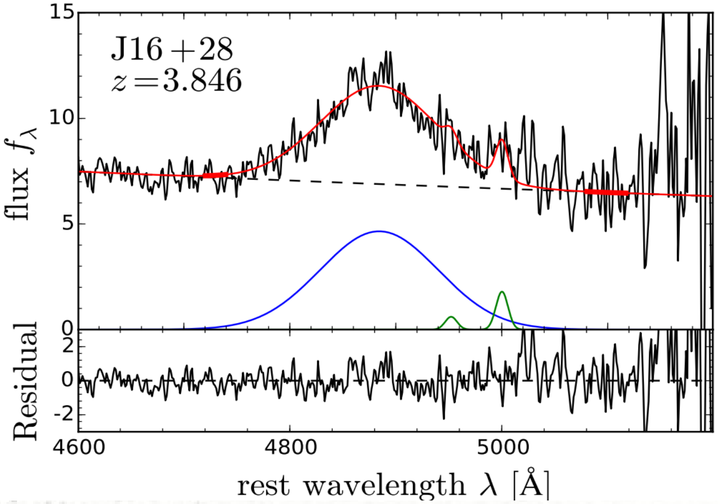


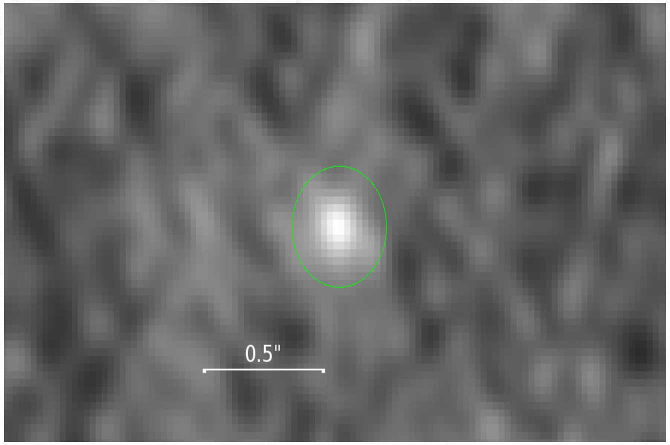
ALMA reveals very compact CO4-3 (<1.5 kpc) ALMA resolution <0.1”

J16+28 character sheet

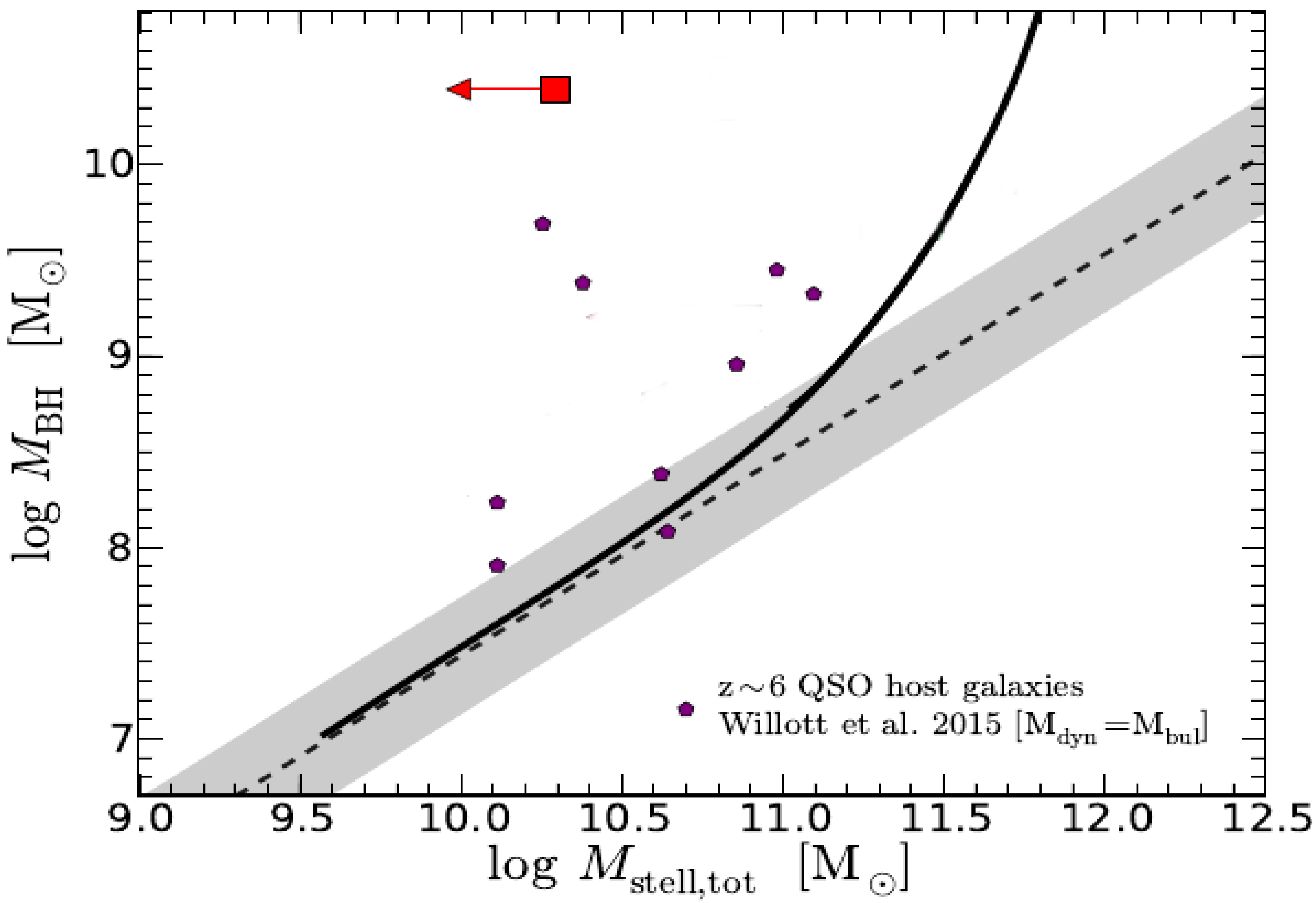
- BH mass: log MBH=10.4 Msun from Hb consistent with CIV
- ER: 60%
- Upper limit of the stellar component logM*<10.8 Msun
- Gas mass logMgas=10.3 Msun
- limit on dynamical mass logMdyn=10.8 (i~50°) from CO (~450 km/s)

  => in this case BH accounts for 40% of Mdyn
- => BH+gas account for 75% of Mdyn





Stellar Mass limit from Mdyn



How to interpret this?

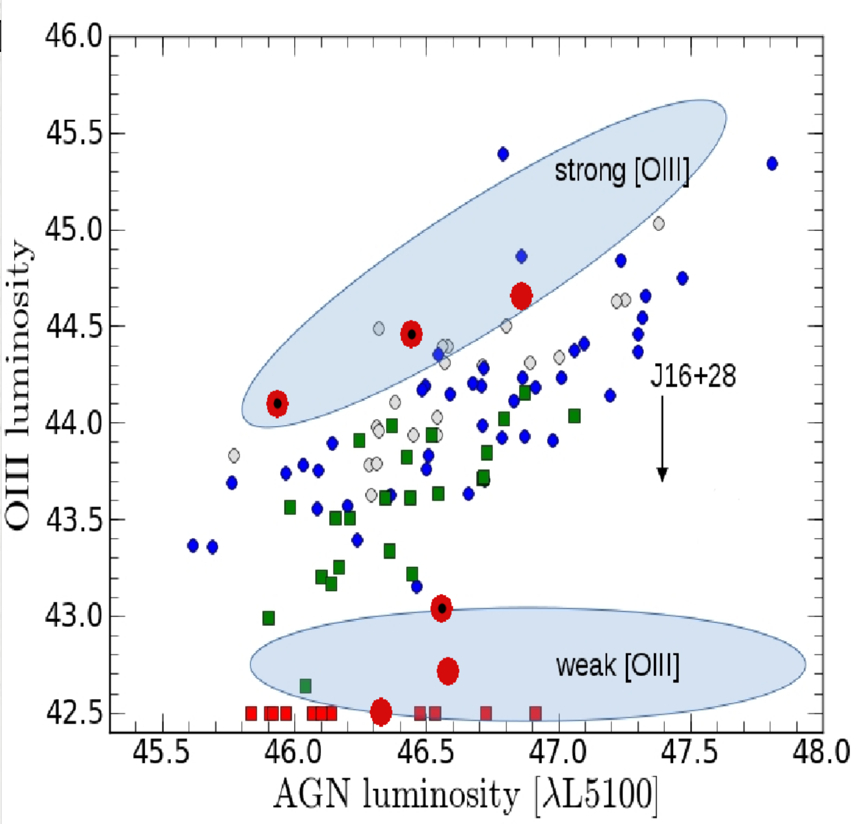
- Currently no way to gain some weight for the host – factor 2 at best

  Is there gas hidden somewhere?

- Maybe ionized gas on larger scale?

  Needs to be tested (preliminary results reveal no large scale ionized gas in Lya on ~30 kpc scale)

- * also OIII is weak



How to interpret this?

- We can still hide some gas → (tested only CO(4-3), and need to test Lya on 100 kpc scale)
- If no further gas is found: this might be an interesting case study for very efficient accretion
- Also our other 3 QSOs seem gas poor but difficult to interpret since we have no detection – could be sb issue

Future

- Plan to extend this study in ALMA Cycle 4 with another 4 QSOs (in this case some with detections for comparison) with different OIII strengths

Indication of extended OIII from IRCS+AO NB imaging in some QSOs