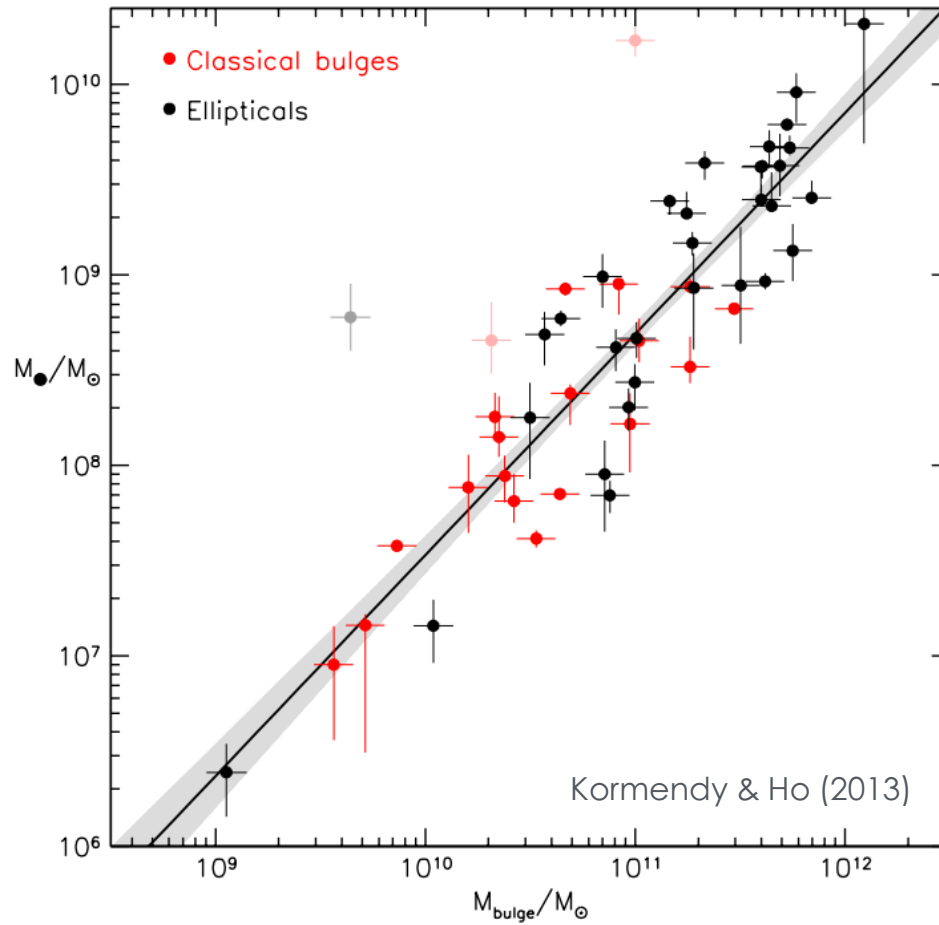


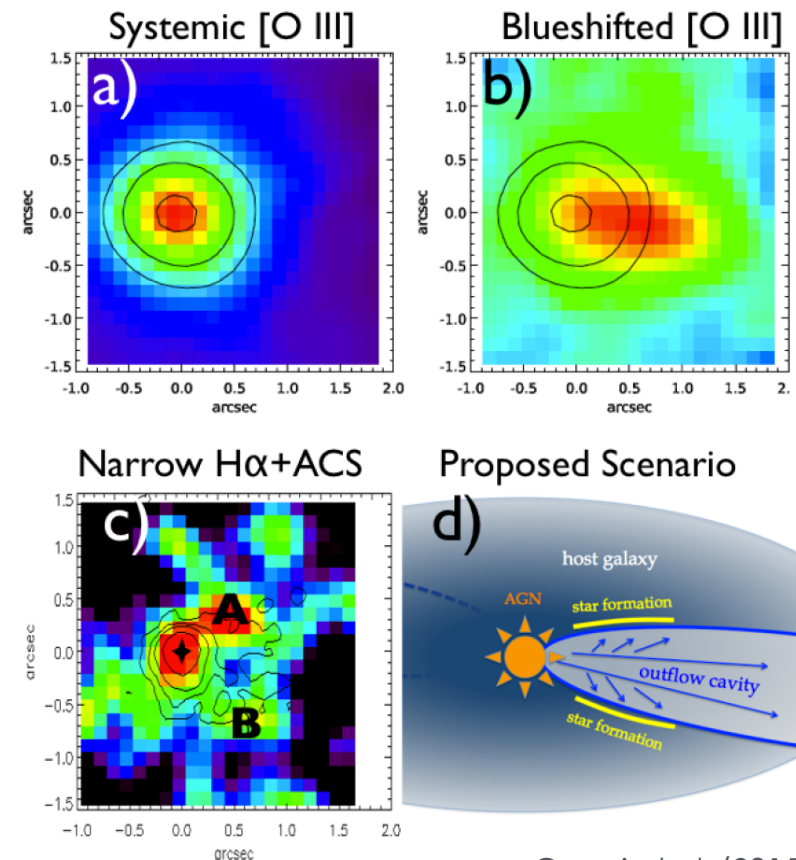
# BH-MASS vs. BULGE MASS RELATION

IS AGN-FEEDBACK THE MOST PLAUSIBLE EXPLANATION FOR THIS RELATION?



Triggering & suppression can go hand-in-hand.

(But this  $z=1.6$  obscured QSO seems to have a deficit of cold gas...)



Cresci et al. (2015)  
Brusa et al. (2015)

# BH-MASS vs. BULGE MASS RELATION

## NATURAL OUTCOME OF HIERARCHICAL MERGING?

### HOW MERGERS MAY AFFECT THE MASS SCALING RELATION BETWEEN GRAVITATIONALLY BOUND SYSTEMS

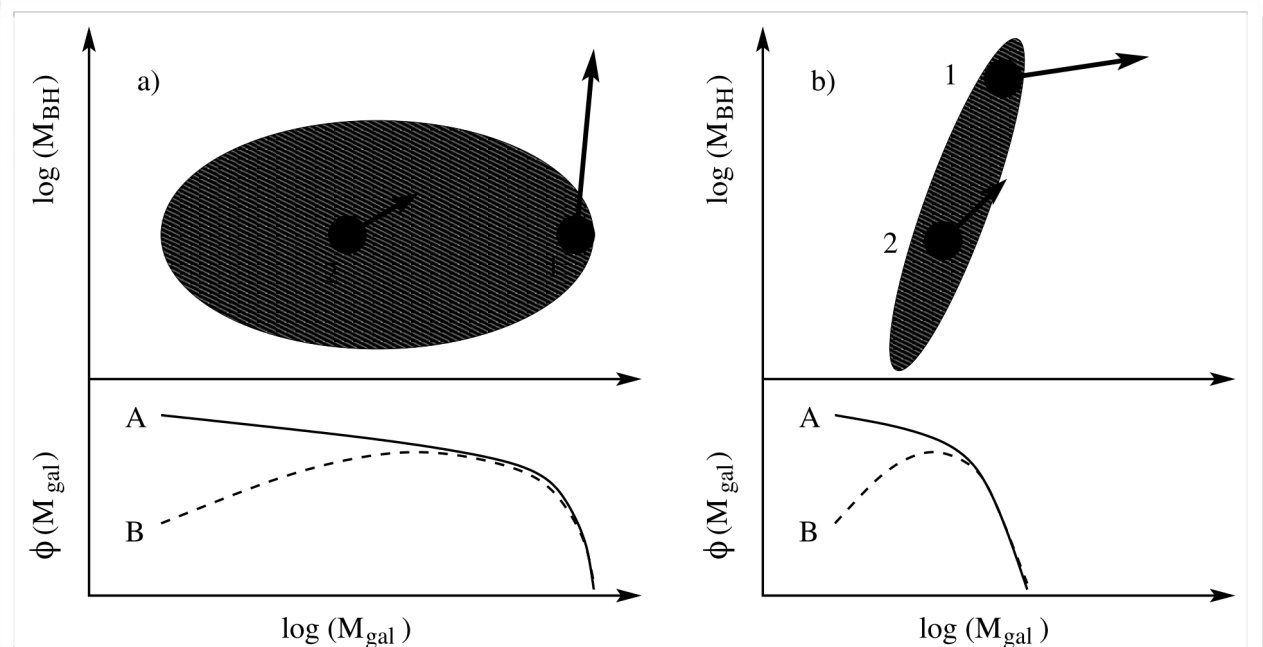
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Received 2007 March 13; accepted 2007 August 10

#### ABSTRACT

Supermassive black hole (BH) masses ( $M_{\text{BH}}$ ) are strongly correlated with galaxy stellar bulge masses ( $M_{\text{bulge}}$ ), and there are several ideas to explain the origin of this relationship. This study isolates the role of galaxy mergers from considerations of other detailed physics to more clearly show how a linear BH–galaxy mass relation ( $M_{\text{BH}}-M_{\text{gal}}$ ) can naturally emerge, regardless of how primordial BHs were seeded inside galaxies, if the galaxy mass function declines with increasing mass. Under this circumstance, the  $M_{\text{BH}}-M_{\text{gal}}$  relation is a passive attractor that eventually converges to a tight linear relation because of two basic statistical effects: a central-limit-like tendency for galaxy mergers, which is much stronger for major mergers than for minor mergers, and a convergence toward a linear relation that is due mainly to minor mergers. A curious consequence of this thought experiment is that if galaxy bulges are formed by major mergers, then merger statistics naturally show that  $M_{\text{BH}}$  will correlate more strongly with bulge dominated galaxies, because of stronger central-seeking to other physics is ultimately responsible for causing a linear relation that, counter to intuition, random merging of galaxies that weaken a preexisting, linear, correlation. This idea may be applied to other systems (e.g., galaxy clusters, galaxy groups, galaxy matter halos, compact nuclear objects) that retain their p



# BH-MASS vs. BULGE MASS RELATION

NATURAL OUTCOME OF HIERARCHICAL MERGING?

Jahnke & Maccio (2011)

## HOW MERGERS MAY AFFECT THE MASS SCALING RELATION BETWEEN GRAVITATIONALLY BOUND SYSTEMS

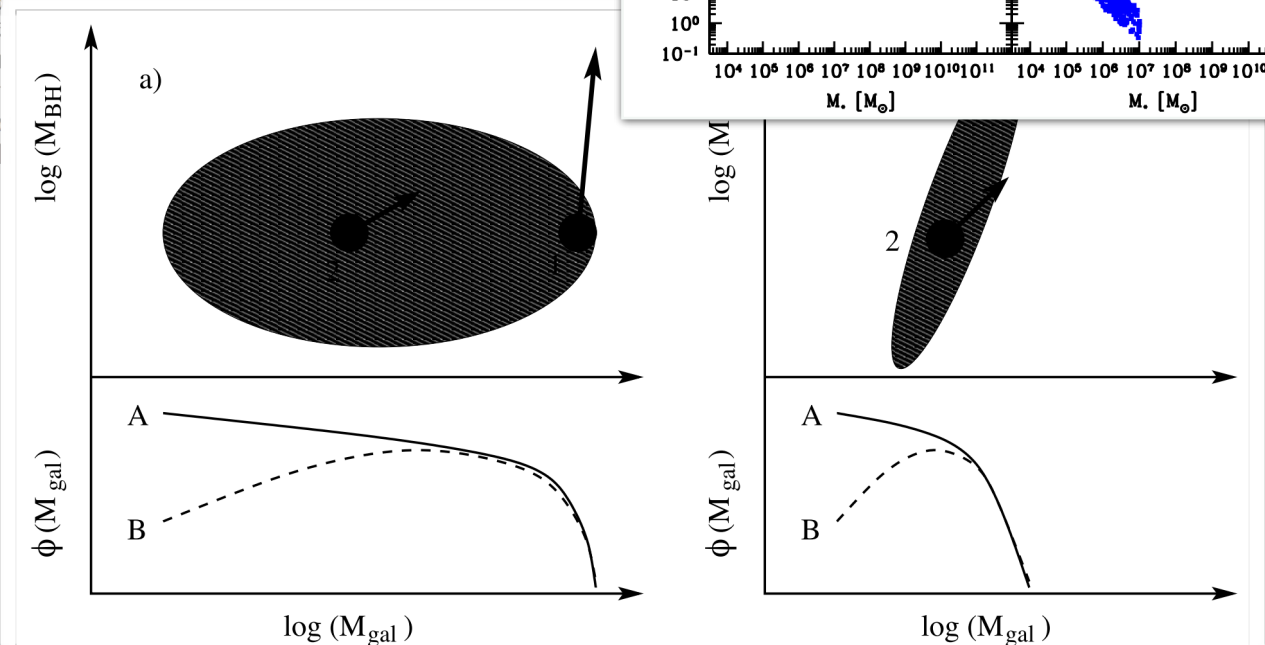
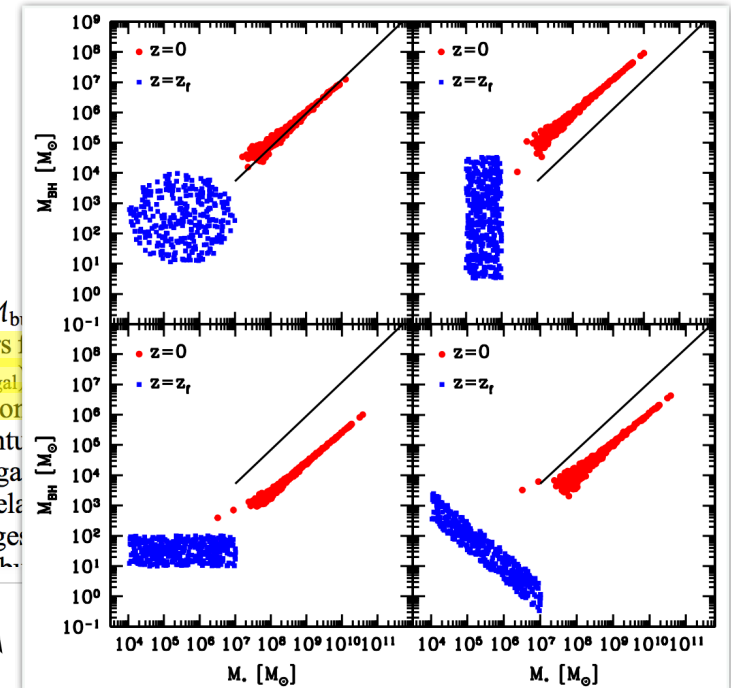
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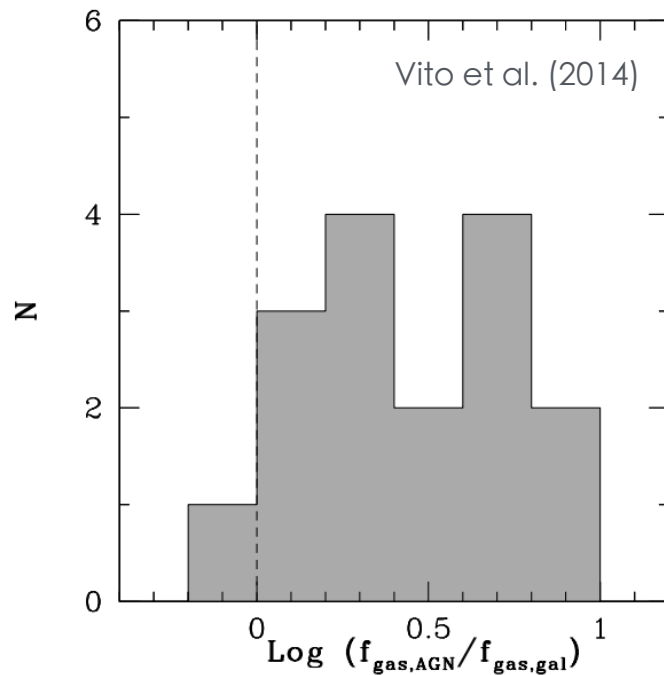


C. Peng (2007)

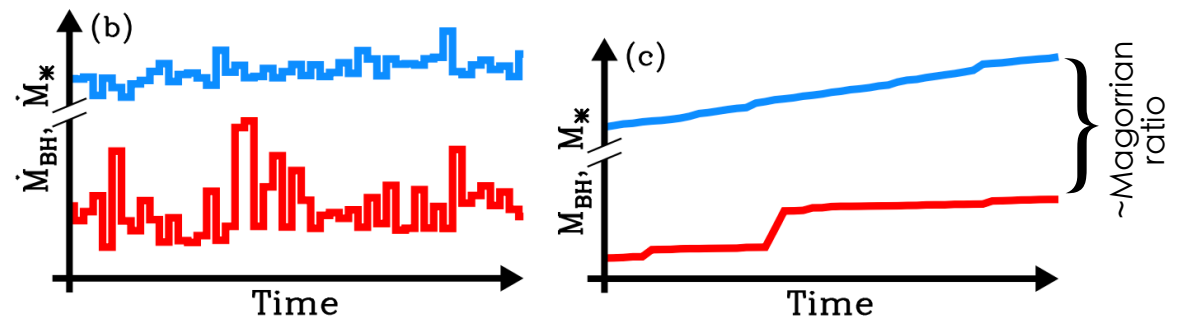
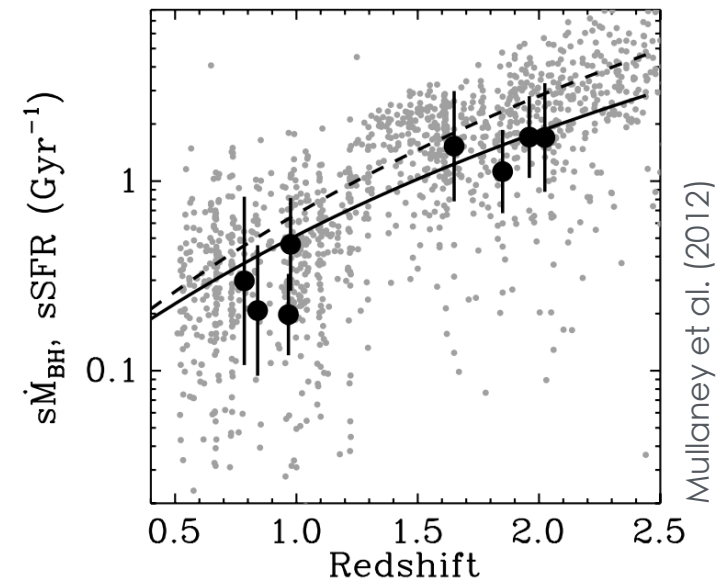
# BH-MASS vs. BULGE MASS RELATION

PARALLEL GROWTH OF BH & STELLAR BODY IN GAS-RICH STAR-FORMING GALAXIES?

Gas fraction of  $z < 1$  AGN hosts rel. to passive+ active galaxies of identical mass:

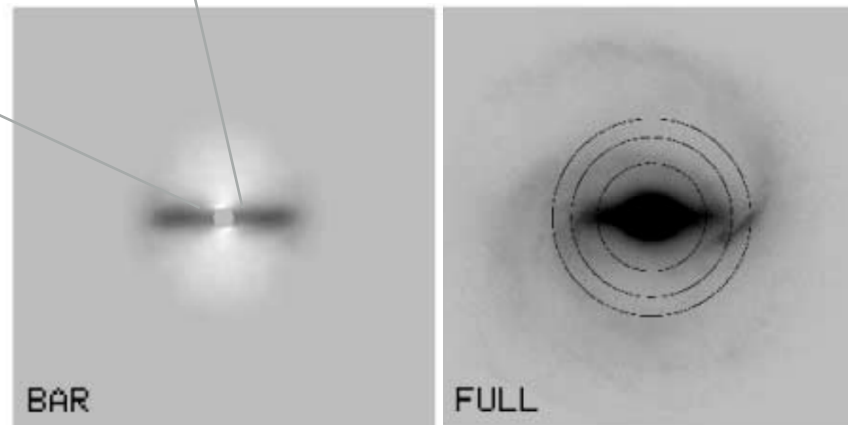
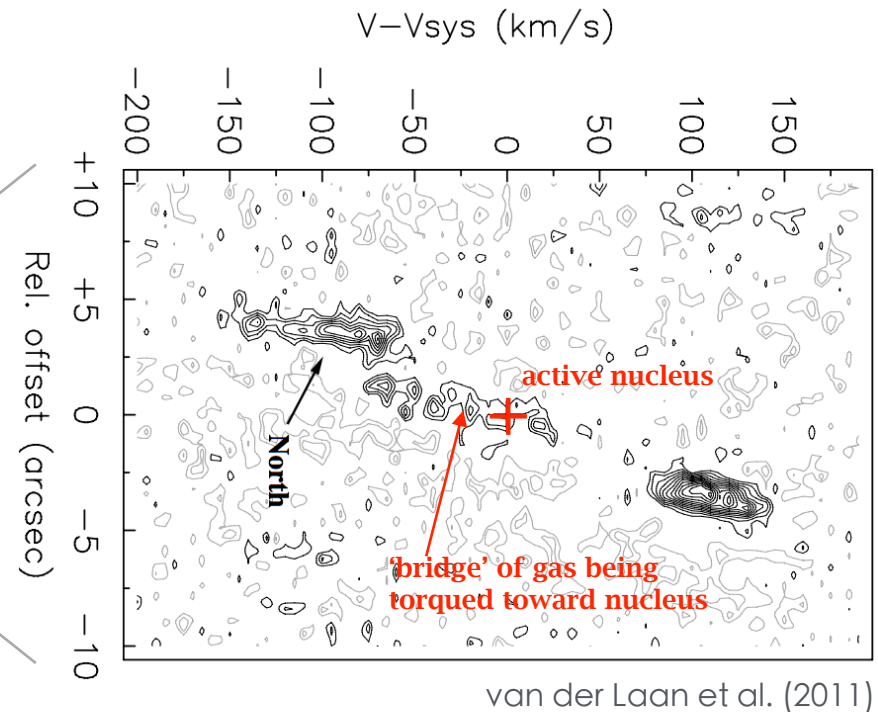
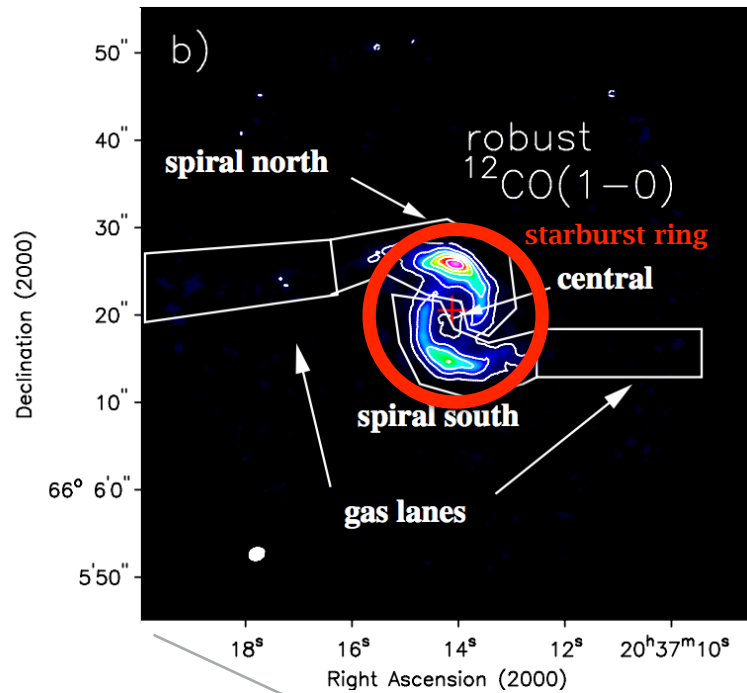


Over  $0 < z < 2$  the specific BH growth rate and the specific star formation rate have a similar slope and are offset by approx. the Magorrian ratio:



# BH-MASS vs. BULGE MASS RELATION

GETTING GAS TO THE CENTRE — SF & AGN IN GALACTIC NUCLEI (e.g. NGC6951)



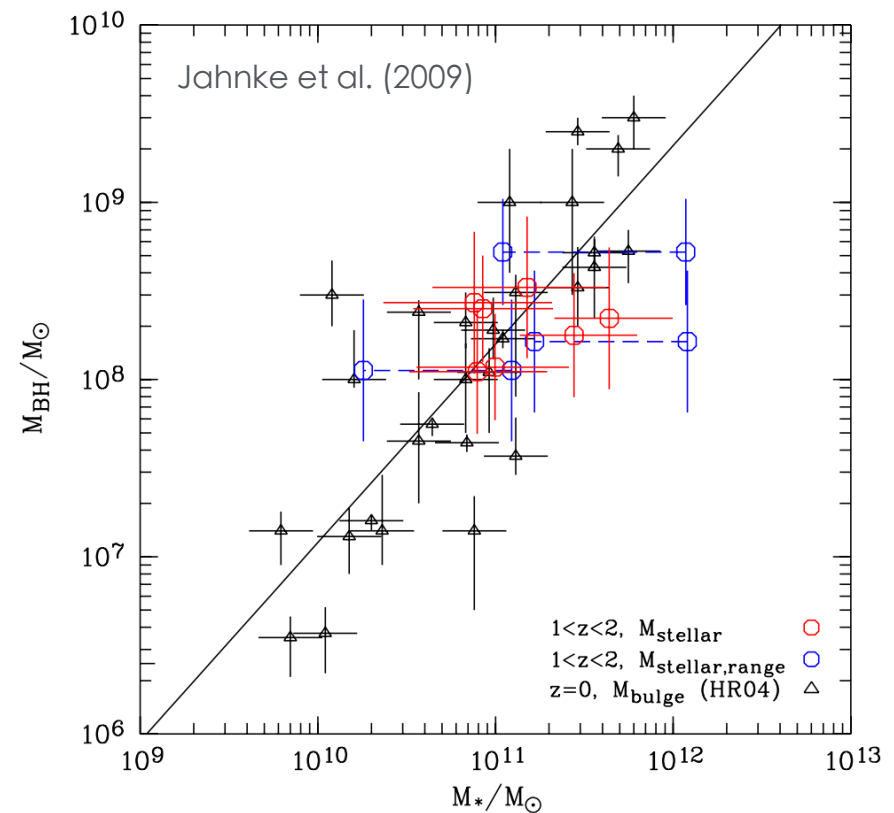
Buta et al. (2003)

# BH-MASS vs. BULGE MASS RELATION

REDSHIFT EVOLUTION - WHICH IS BUILT UP FIRST?

$z \sim 1.5$ : relation between total galaxy mass (rather than bulge mass...) and BH mass overlaps with local Magorrian relation:

(A natural consequence of co-eval growth in gas-rich star-forming galaxies? Short, merger-driven burst at  $z \sim 0$  could re-order the structure and add a low percentage of mass.)



# BH-MASS vs. BULGE MASS RELATION

REDSHIFT EVOLUTION - DO THE STARS OR THE BH COME FIRST?

