MODELING THE POPULATION OF HIGH-z AGNs

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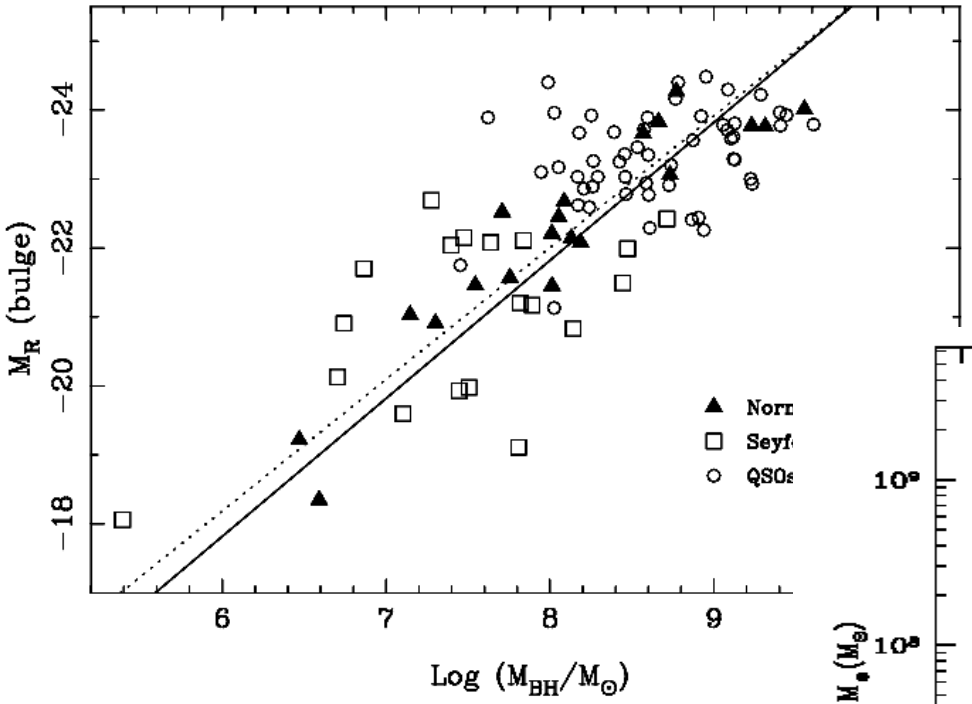
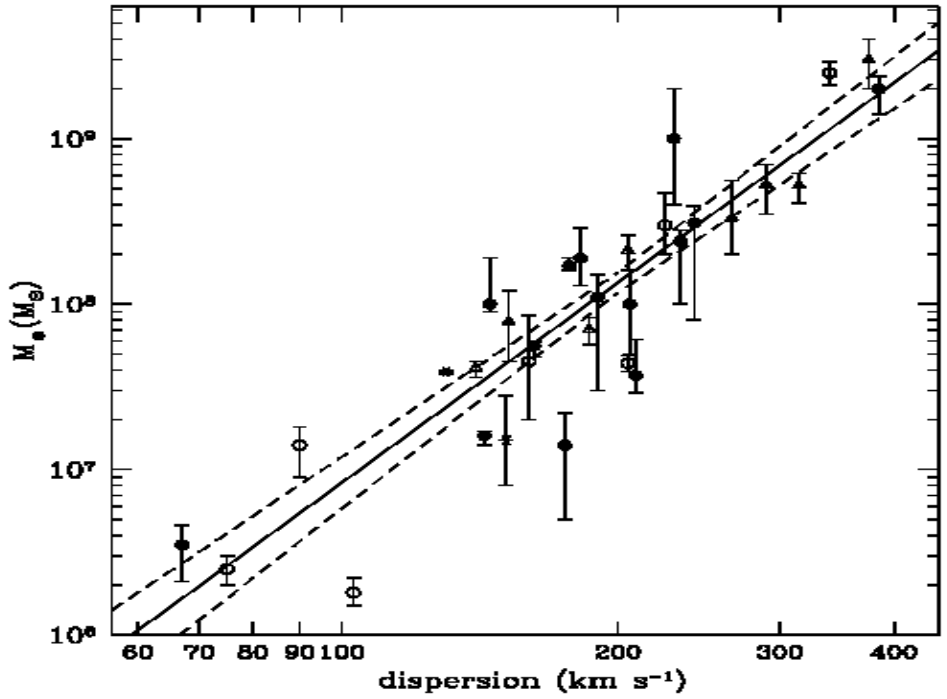
With: D. Weinberg, J. Miralda-Escudé, M. Bernardi, J. Moreno, Y. Shen, F. Marulli, R. Sheth, L. Ferrarese, S. Mei, A. Lapi, L. Danese, A. Bongiorno, E. Lusso, ….

The High Redshift Universe workshop, 5-6 June 2012

Super-Massive Black Holes→ strong link with their hosts



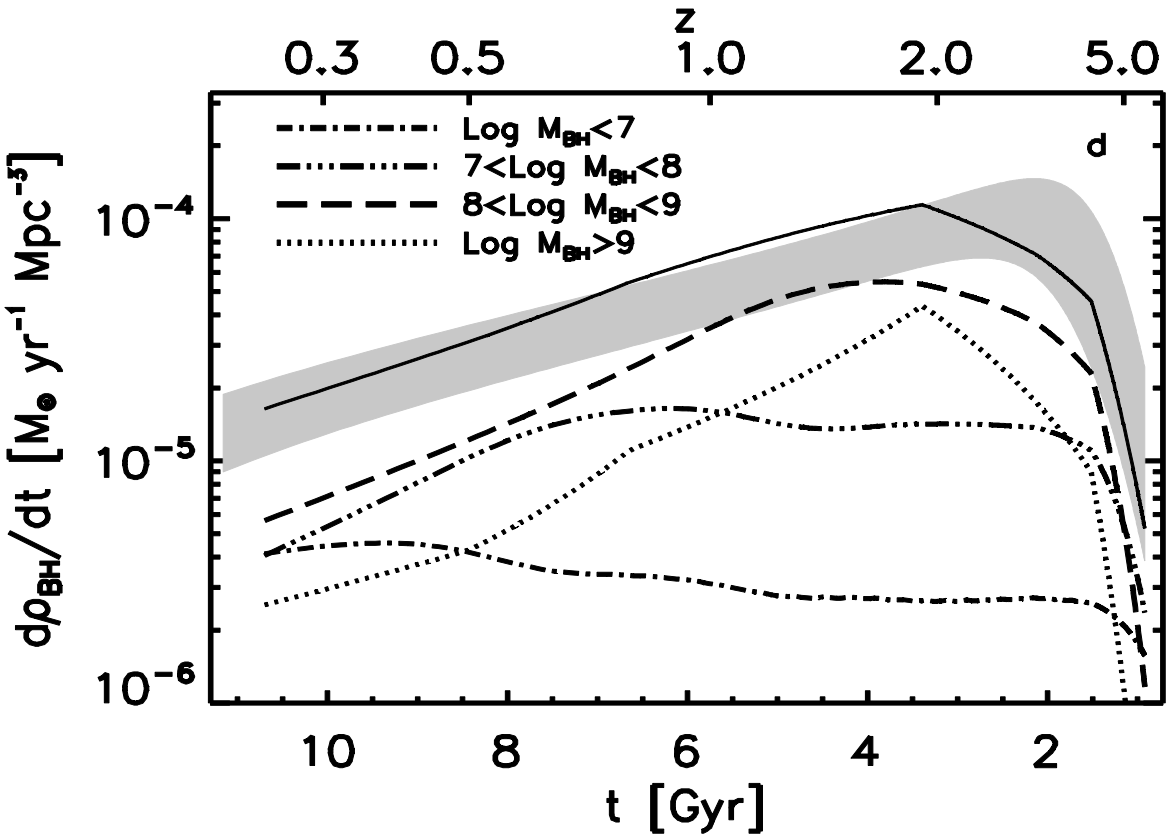


Dunlop & McLure; Magorrian et al.; Ferrarese et al.; Gebhardt et al.; Sarzi et al.; Atkinson et al.; Graham et al.; Haring & Rix; McLure, Jarvis et al.; Marconi & Hunt; FS, Ferrarese, Bernardi

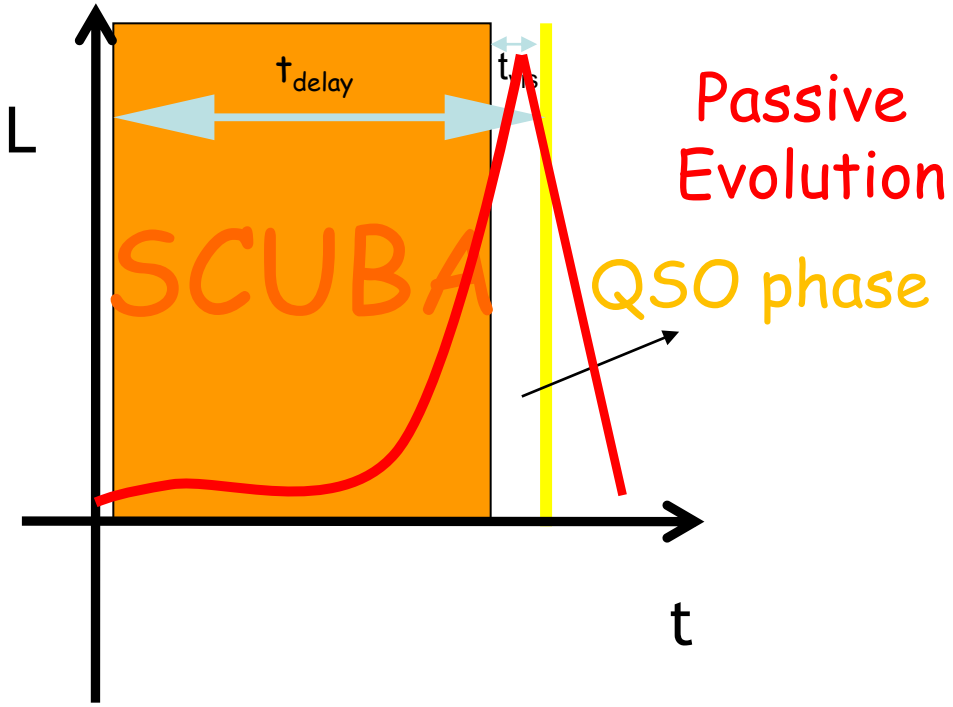
THEORETICAL MODELS 1:

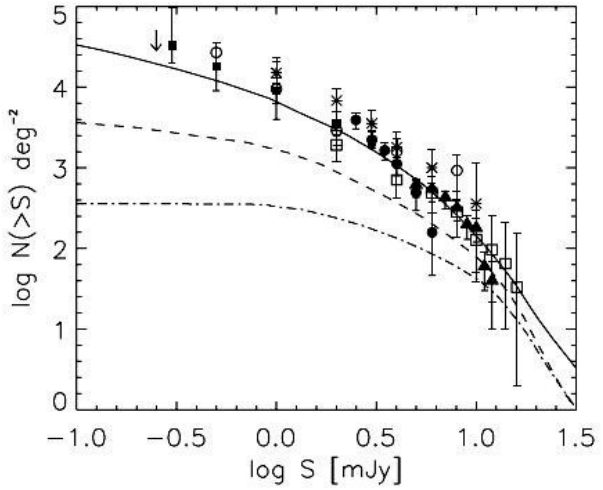
WHAT IS THE GENERAL LINK OF BHs AND GALAXIES?

BH growth and SFR broadly correlated: a first dust-enshrouded phase-role of *evolutionary* models



A two-phase BH-Galaxy co-Evolution?

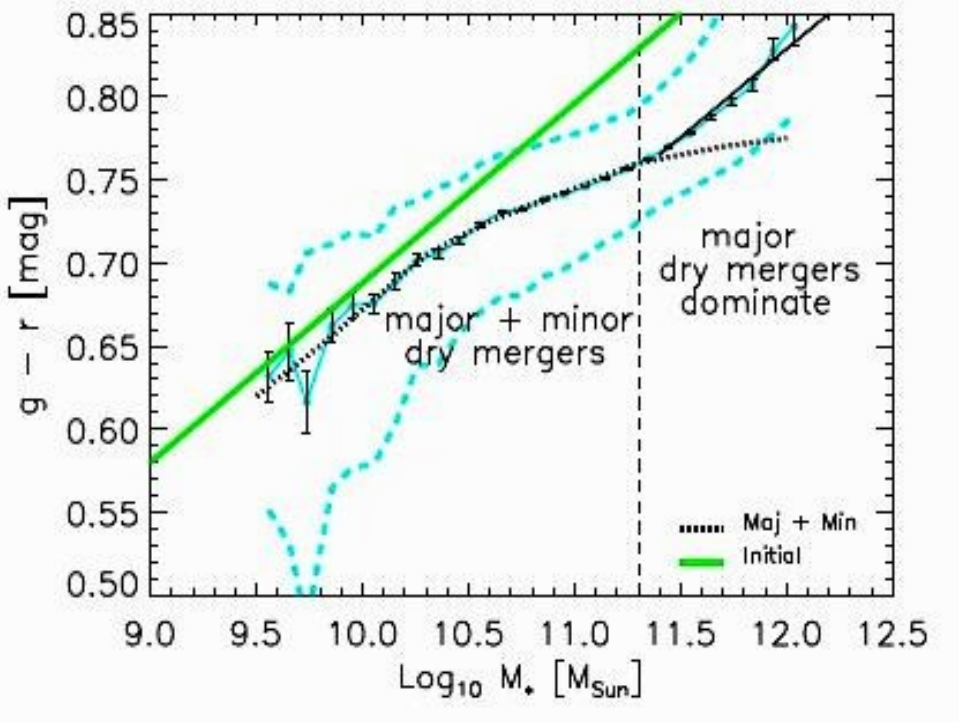




Granato et al. 2006; Lapi et al. 2006; Shankar et al. 2006; Hopkins et al. 2008

A two-phase BH-Galaxy co-Evolution?

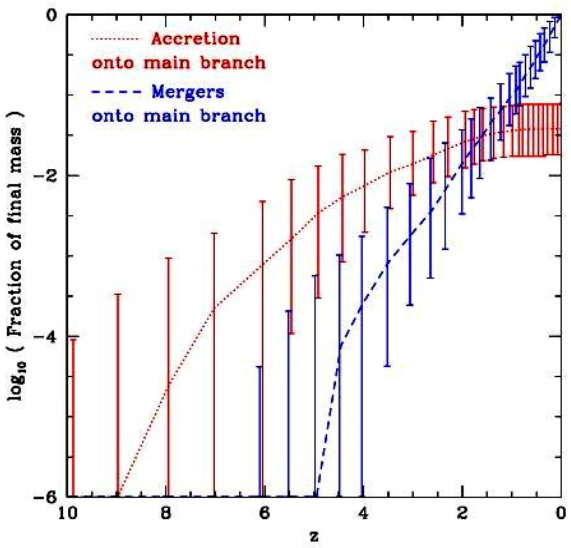
Do massive galaxies and their central BHs merge?



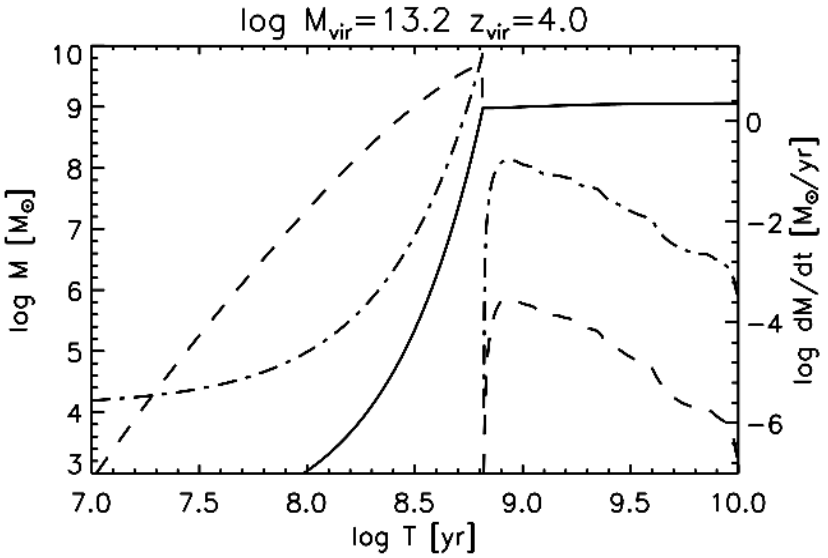
Significant *Curvature* in the Color-Magnitude relation of early-type galaxies

Granato et al. 2006; Lapi et al. 2006; Shankar et al. 2006; Hopkins et al. 2008

SAMs are working hard to understand what is going on…



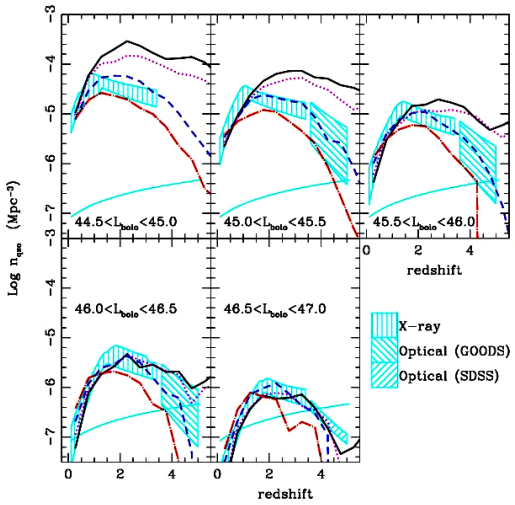
Malbon et al.



Lapi, FS, et al.

``our knowledge on the physics of accretion onto BHs and their interaction with galaxies is still poor to draw firm conclusions''

Fontanot et al.



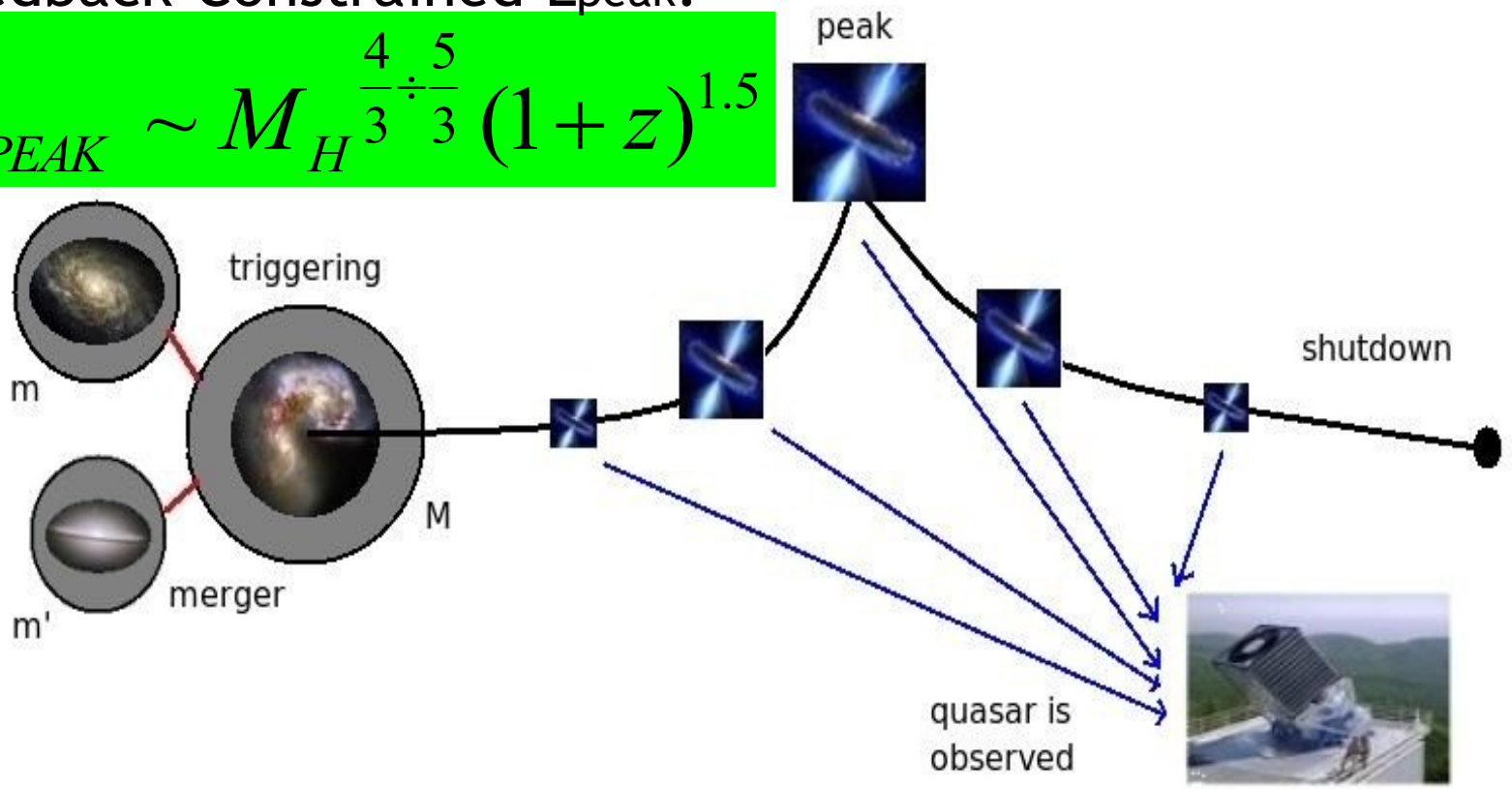
THEORETICAL MODELS 2:

MERGER MODELS, A CRITICAL REVIEW

A basic model for QSOs

Feedback-Constrained L_{peak}:

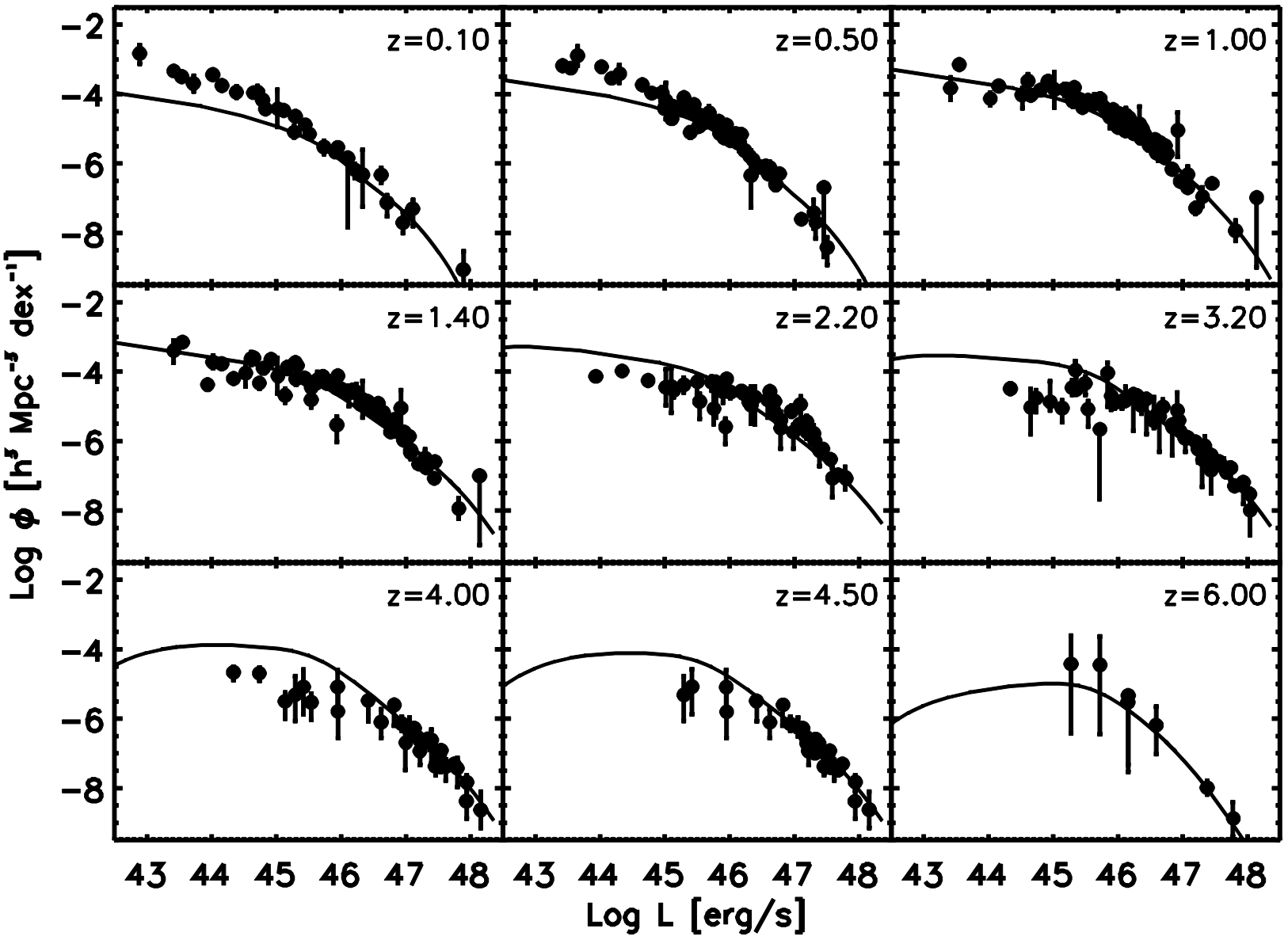
$$L_{PEAK} \sim M_H^{\frac{4}{3} \div \frac{5}{3}} (1+z)^{1.5}$$



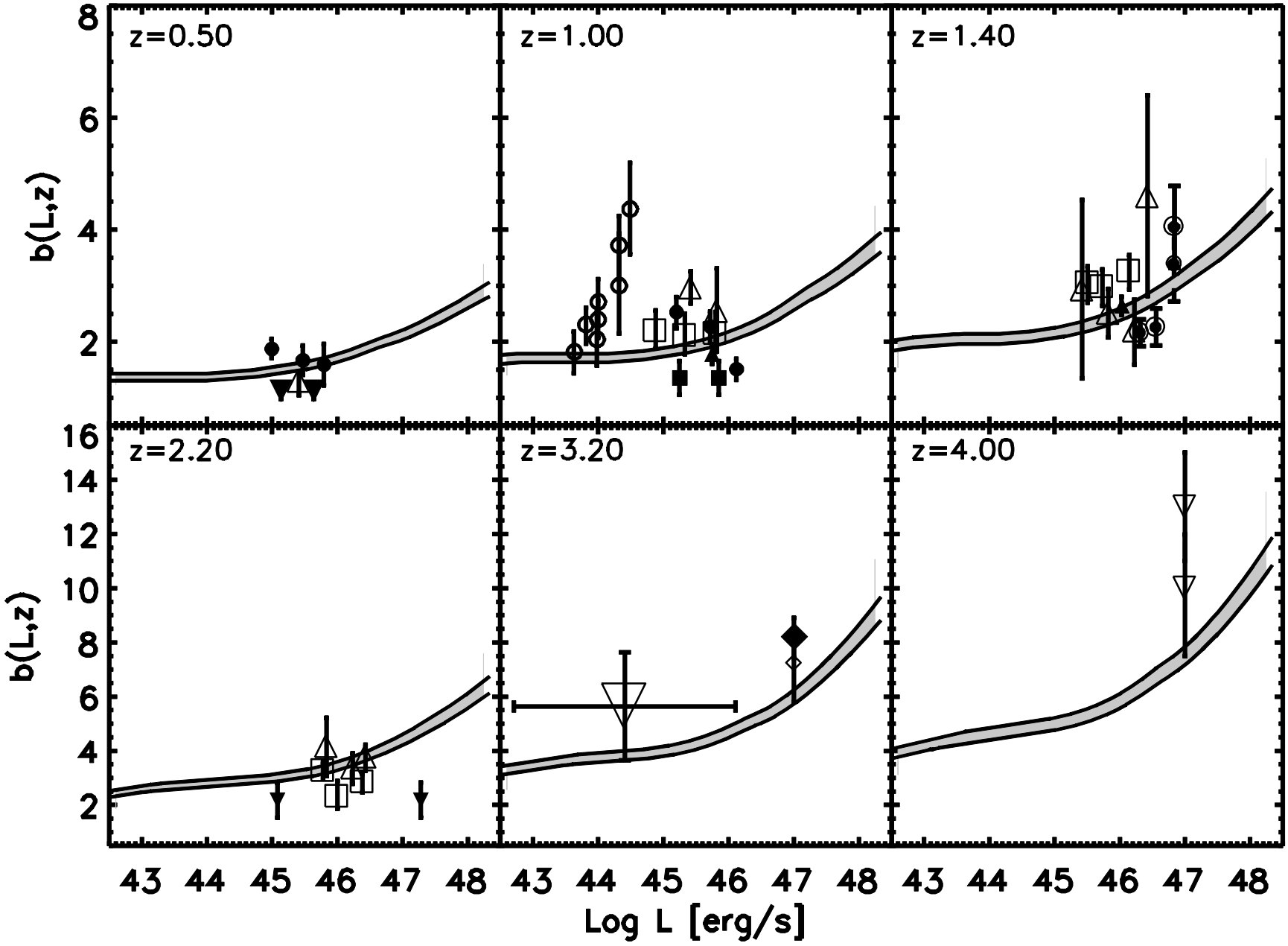
$$\Phi(L,z) = \int\int dM_H dt \frac{d^2 n_H}{dM_H dt} P[L \mid M_H, t, z]$$

See Wyithe, Loeb, Yu, Lu, Lapi, Bonoli, and others…

The luminosity function

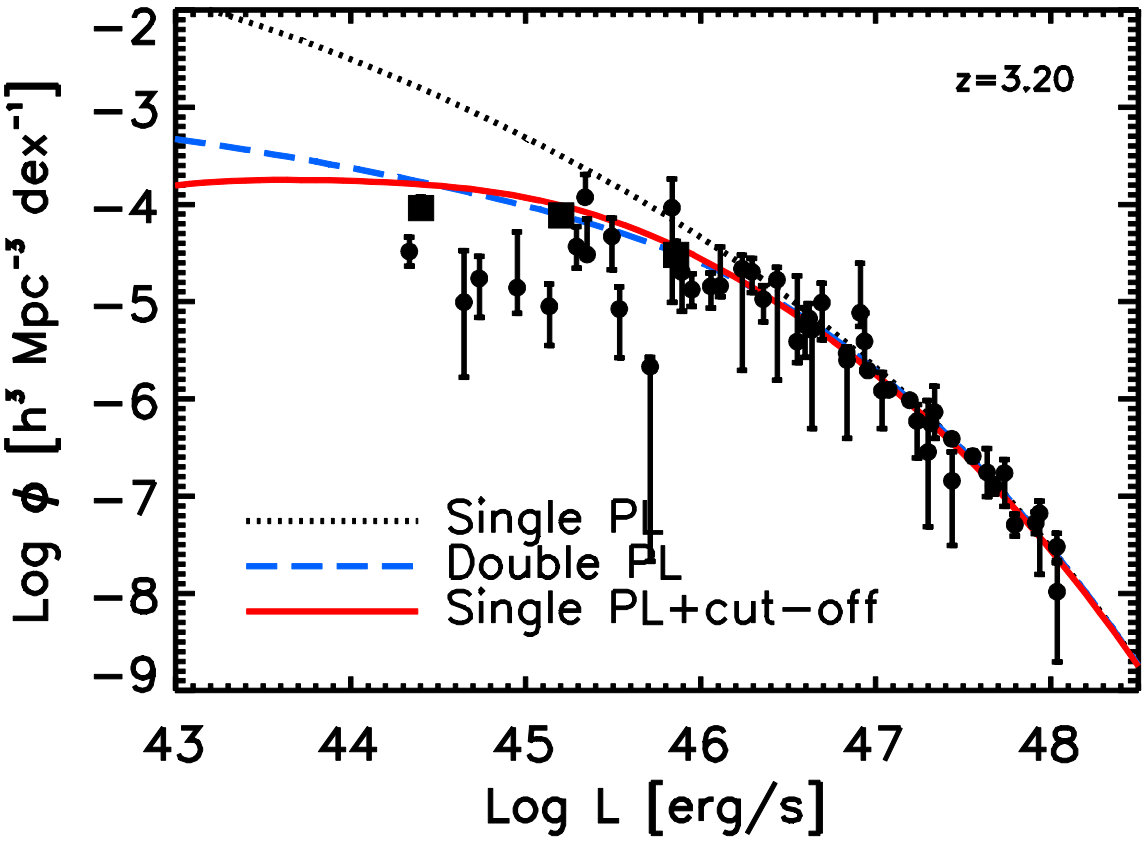


Quasar clustering



So should we be satisfied with the model?

Did we solve the problem? -> **NO**! -> Strong Degeneracies!



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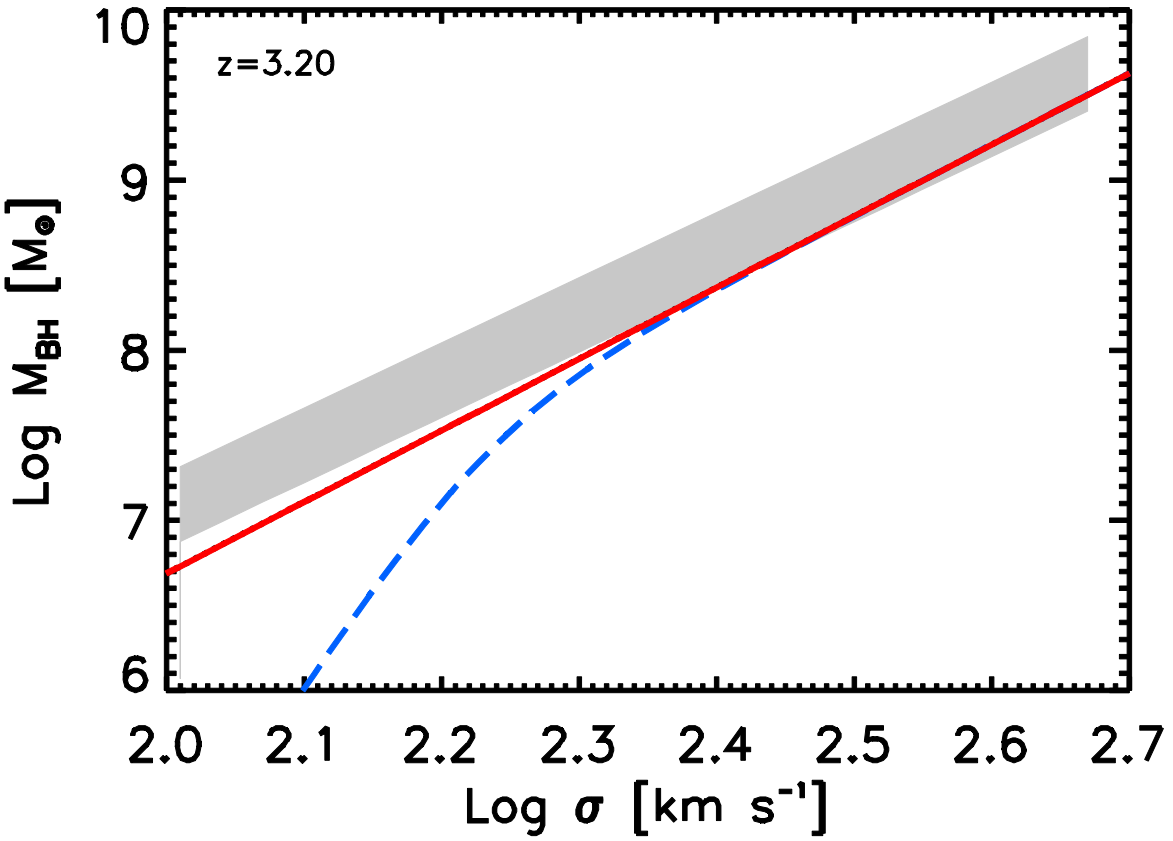

Possible signature in scaling relations but only at high-z (negligible in bias!)

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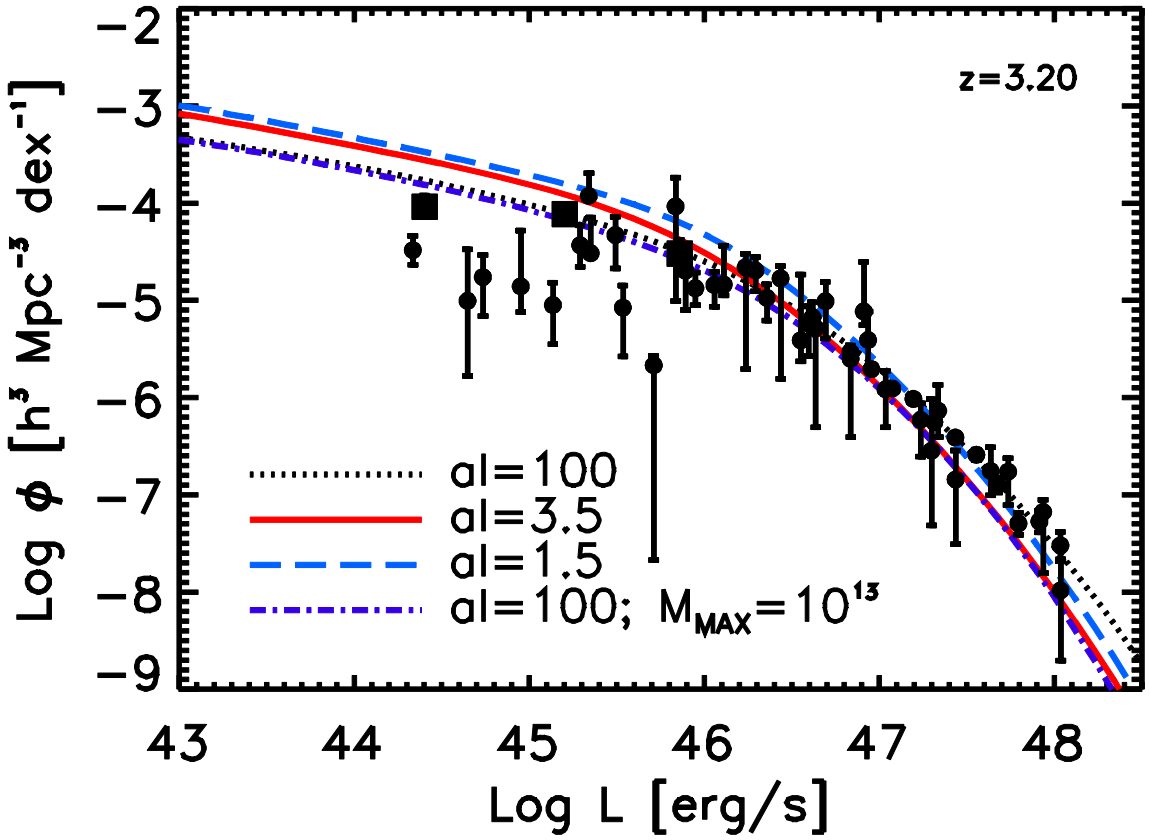
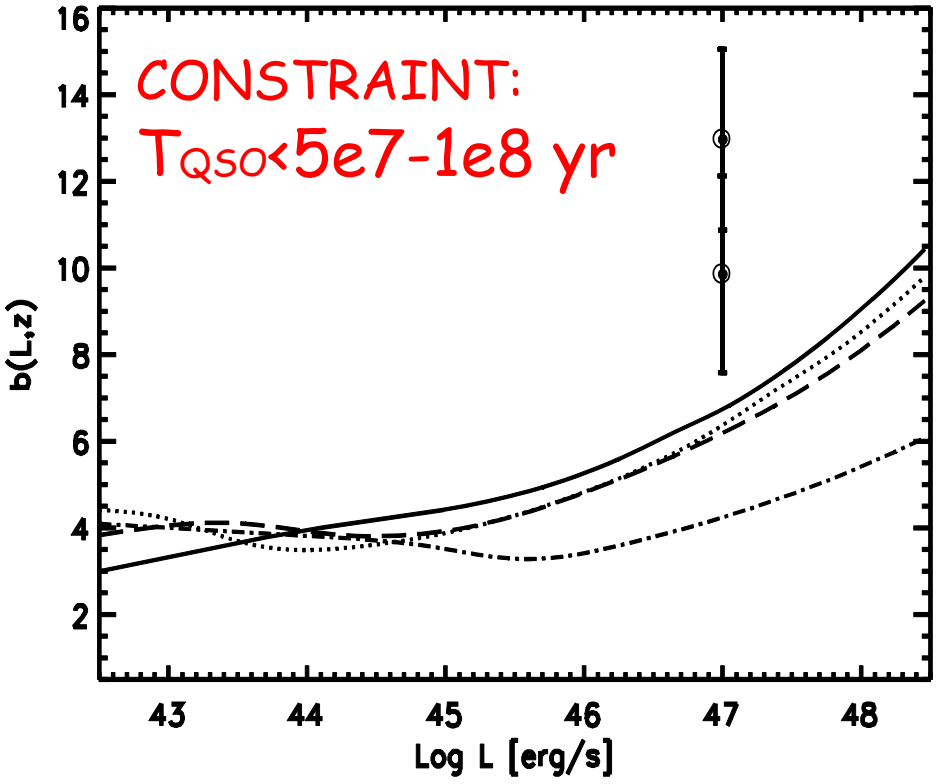


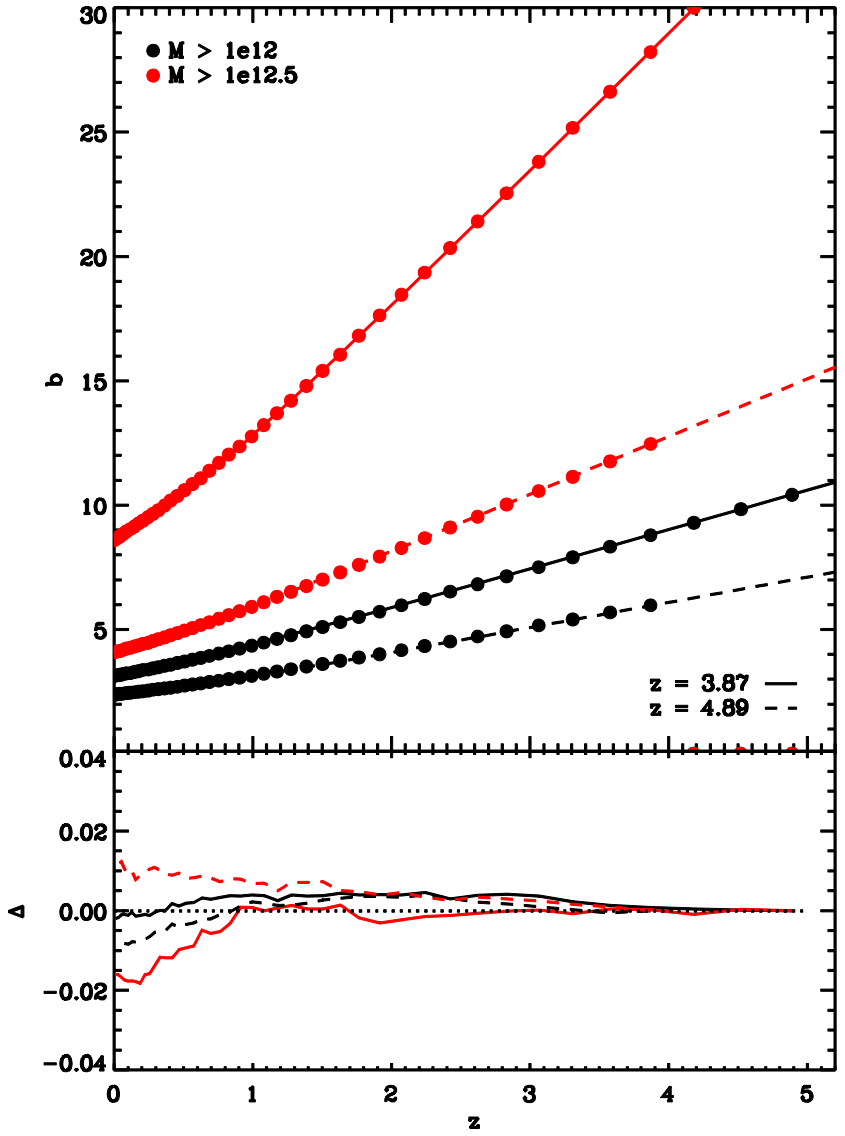
There is NO single Light Curve that can reproduce the data!

CAN'T WAIT TO HAVE AN AGN!!

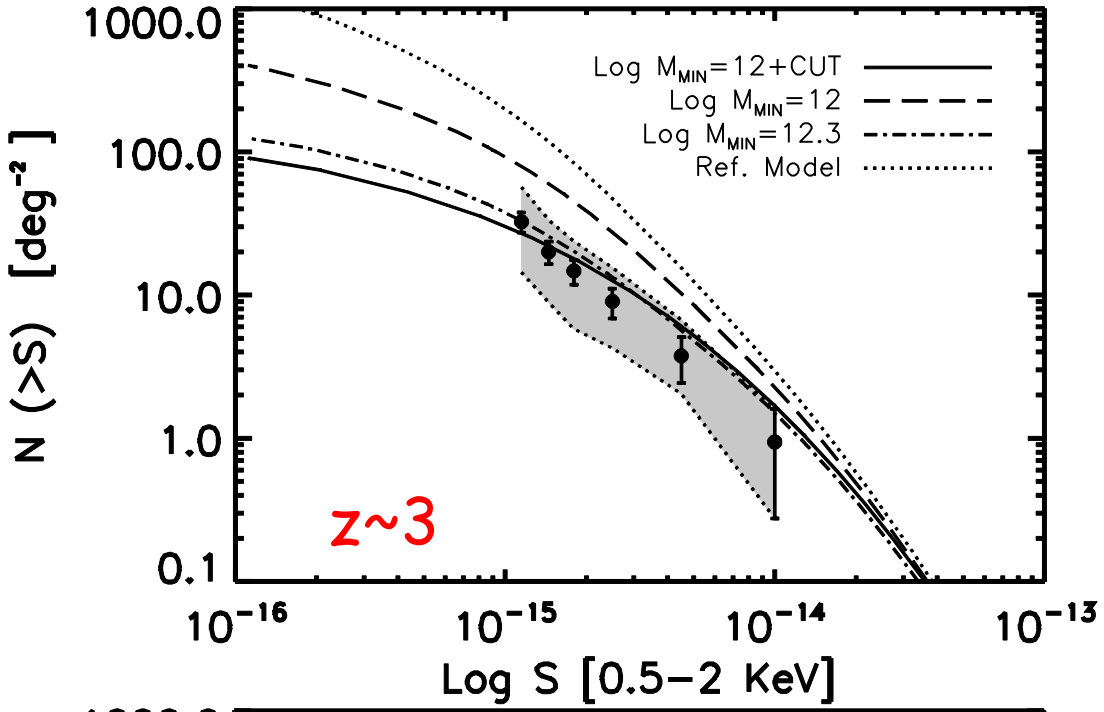
A long delay ''lowers'' the bias at the shining

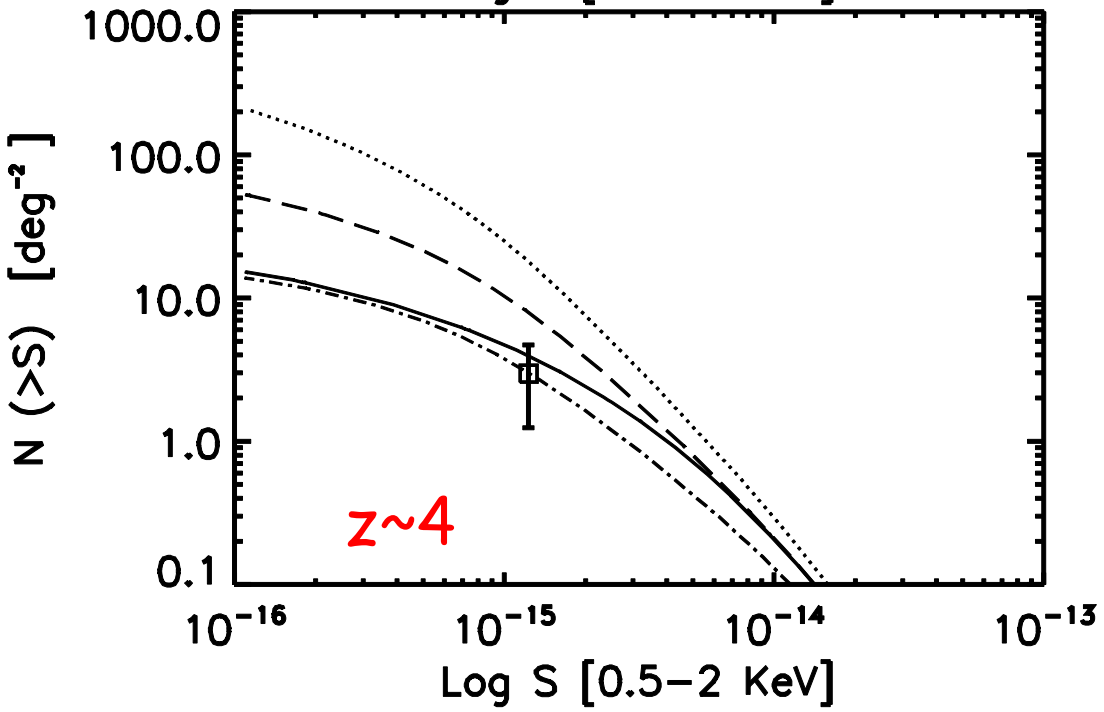


Consistent with triggering at large scales!

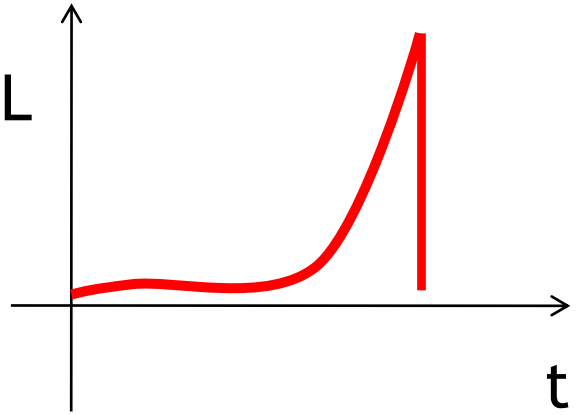


R. Angulo, M. Crocce





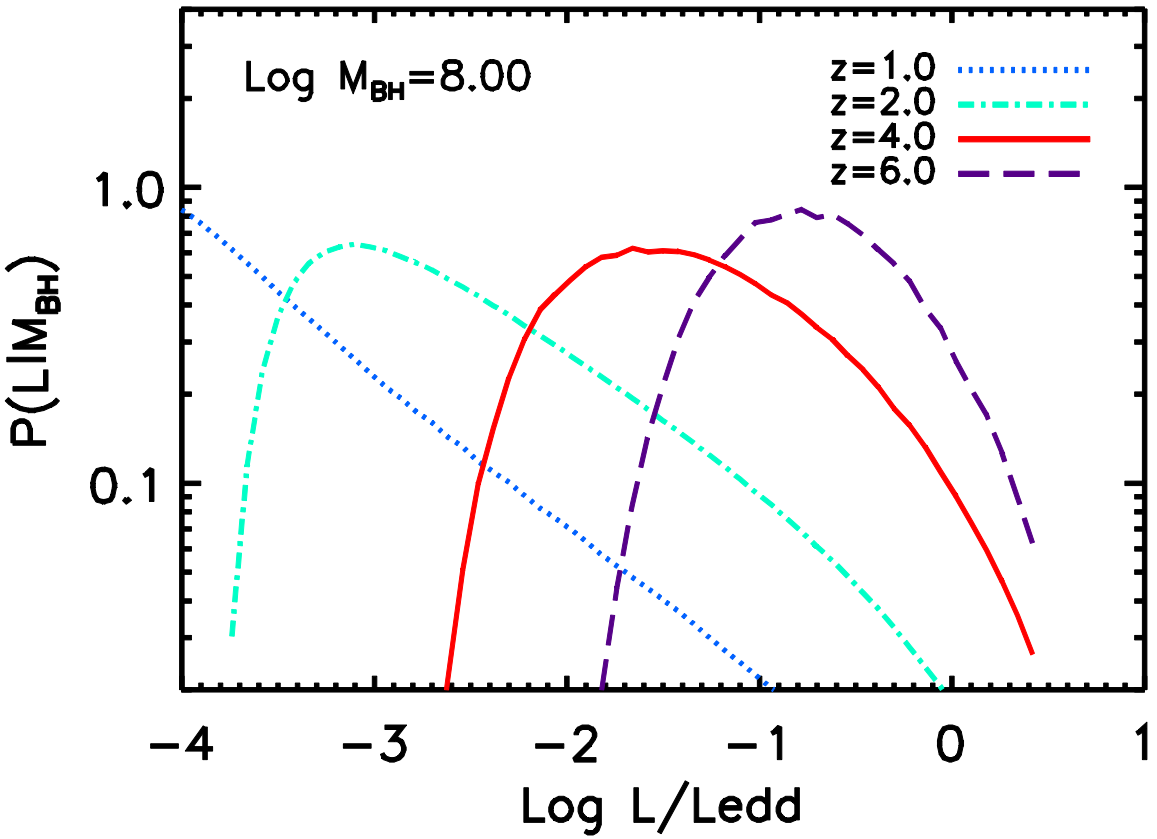
Additional constraints from deep X-ray counts: preferred *sharply declining* light curves.



Brusa+09; Civano+11

What are the predictions on Accretion properties?

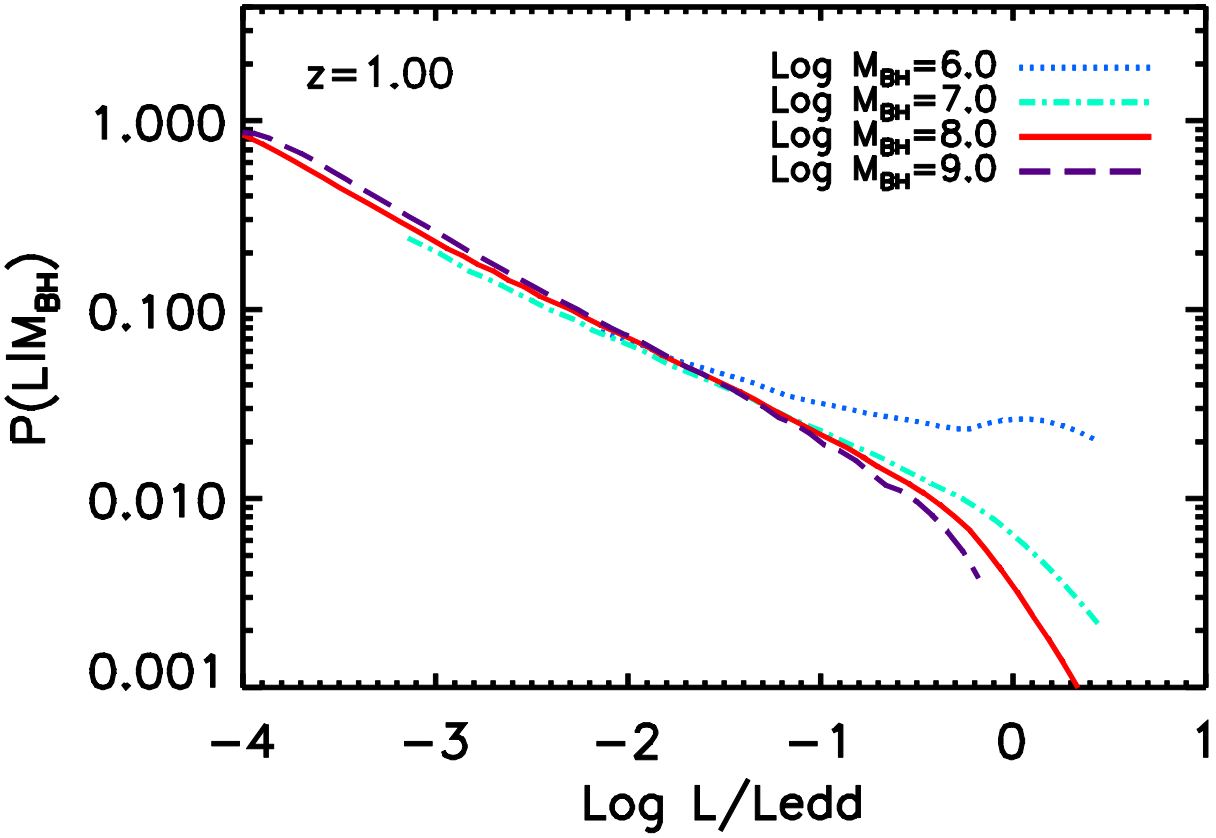
P(L/Ledd) at fixed BH mass



Declining Edd. Ratio Distributions at fixed BH mass!

What are the predictions on Accretion properties?

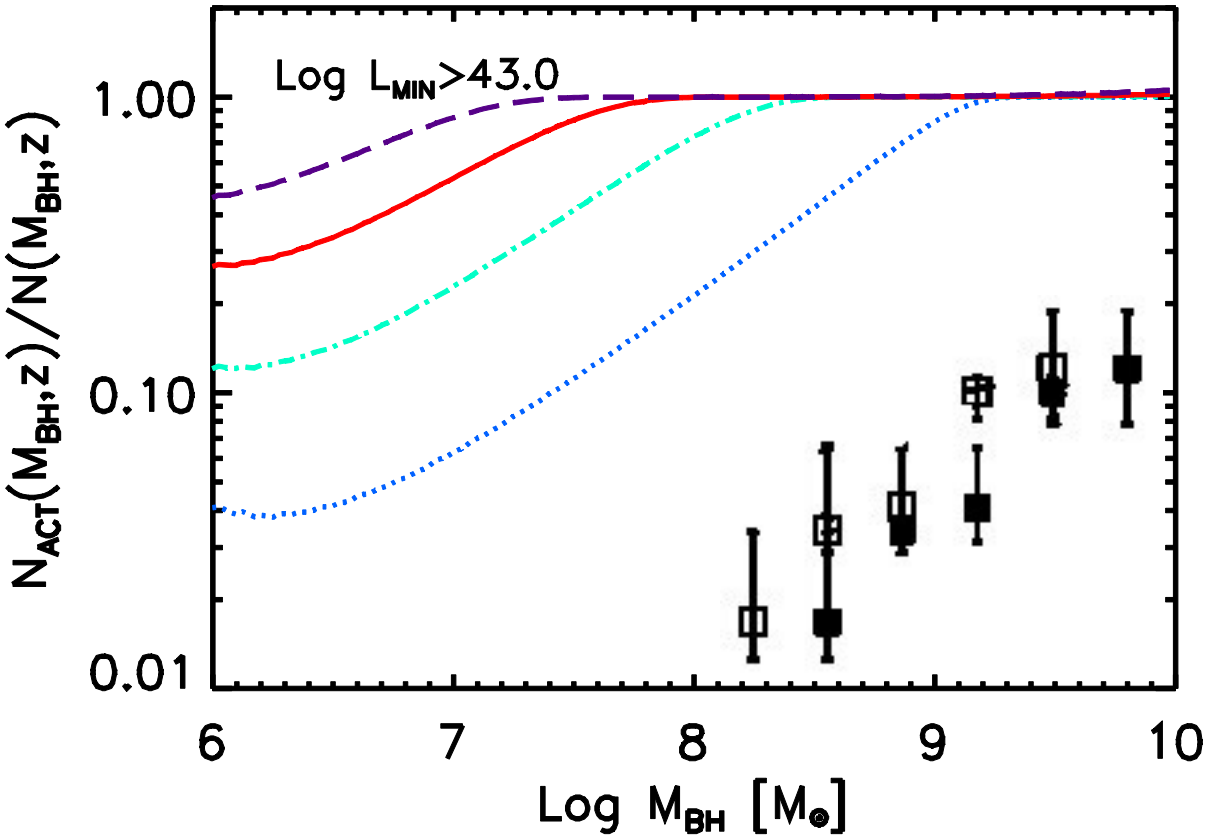
P(L/Ledd) at fixed BH mass



Declining Edd. Ratio Distribution with increasing BH mass!

Predicted Duty Cycles

Output → $U(M_{BH},t) \sim n_{ACT}(M_{BH},t)/n(M_{BH},t)$



Always increasing Duty cycle with BH mass at fixed z!

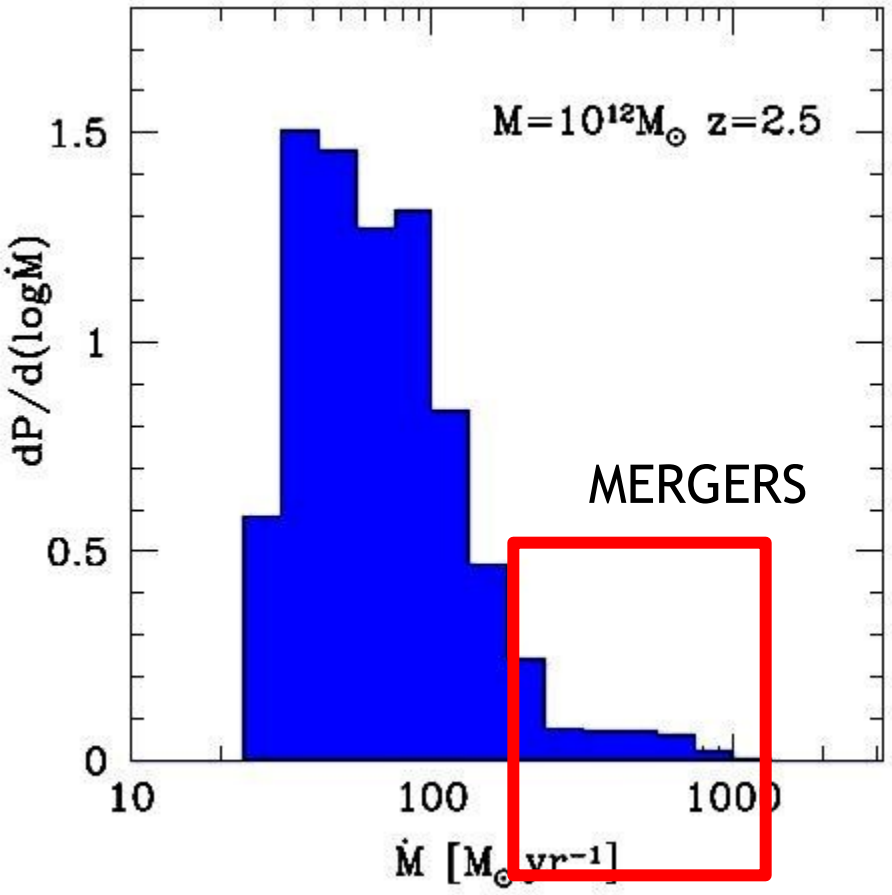
e.g., Bongiorno+, Silverman+, …

Always decreasing Duty cycle with time at fixed BH mass!

THEORETICAL MODELS 3:

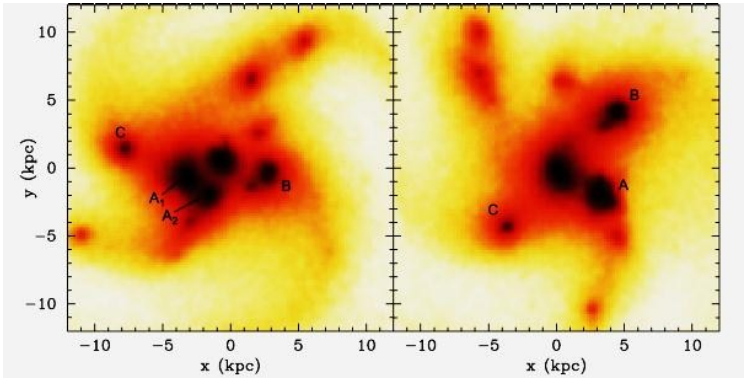
SOME ALTERNATIVES AND/OR ADDITIONS

LET's ZOOM-OUT OF MERGERS: COLD FLOWS

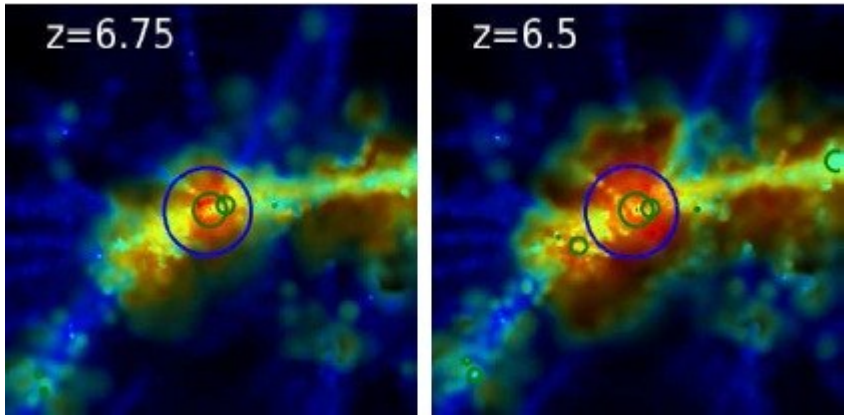


Dekel+09

Bournaud+11

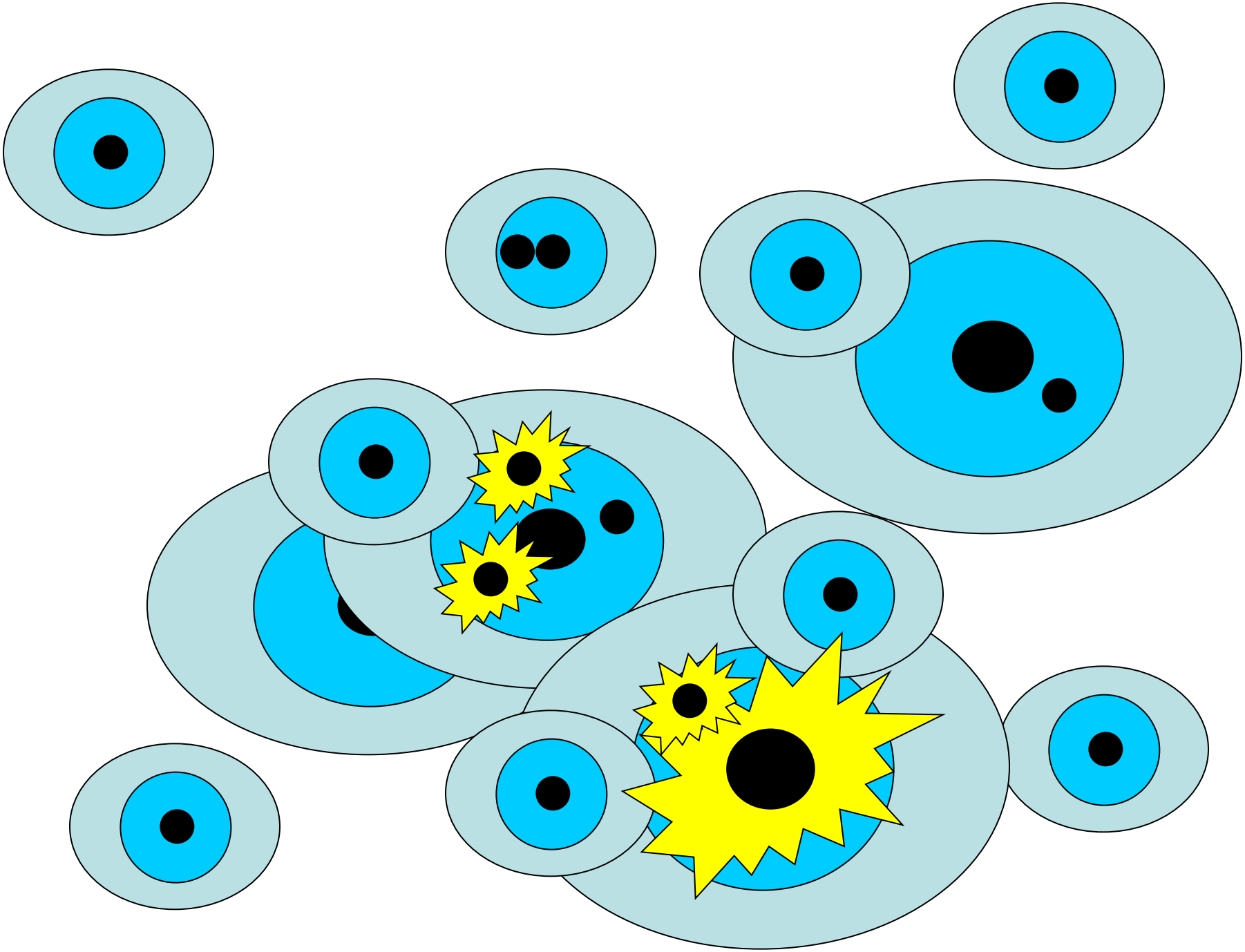


Di Matteo+12

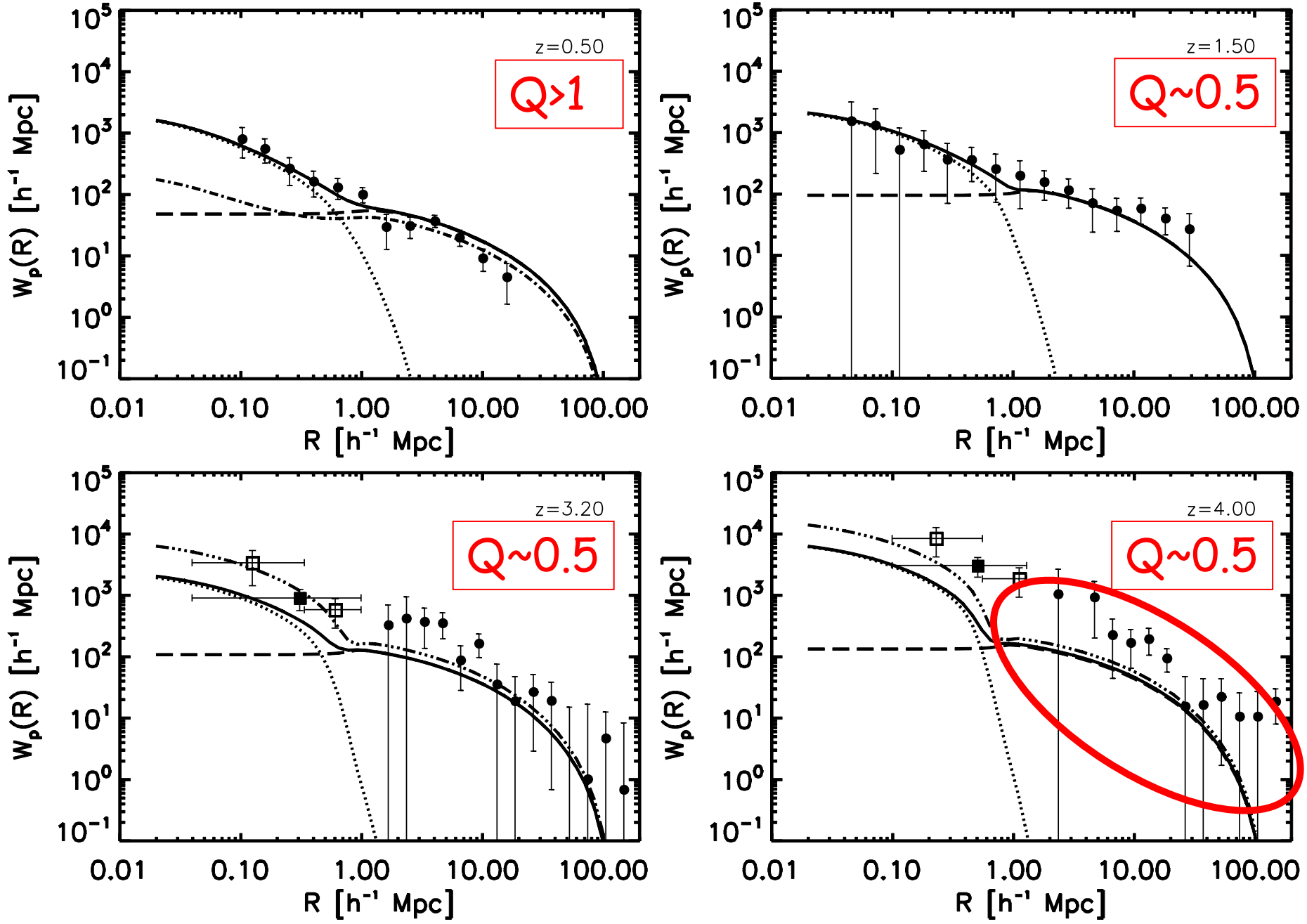


EMPIRICAL MODELS 1:

CONSTRAINTS FROM QUASAR CLUSTERING



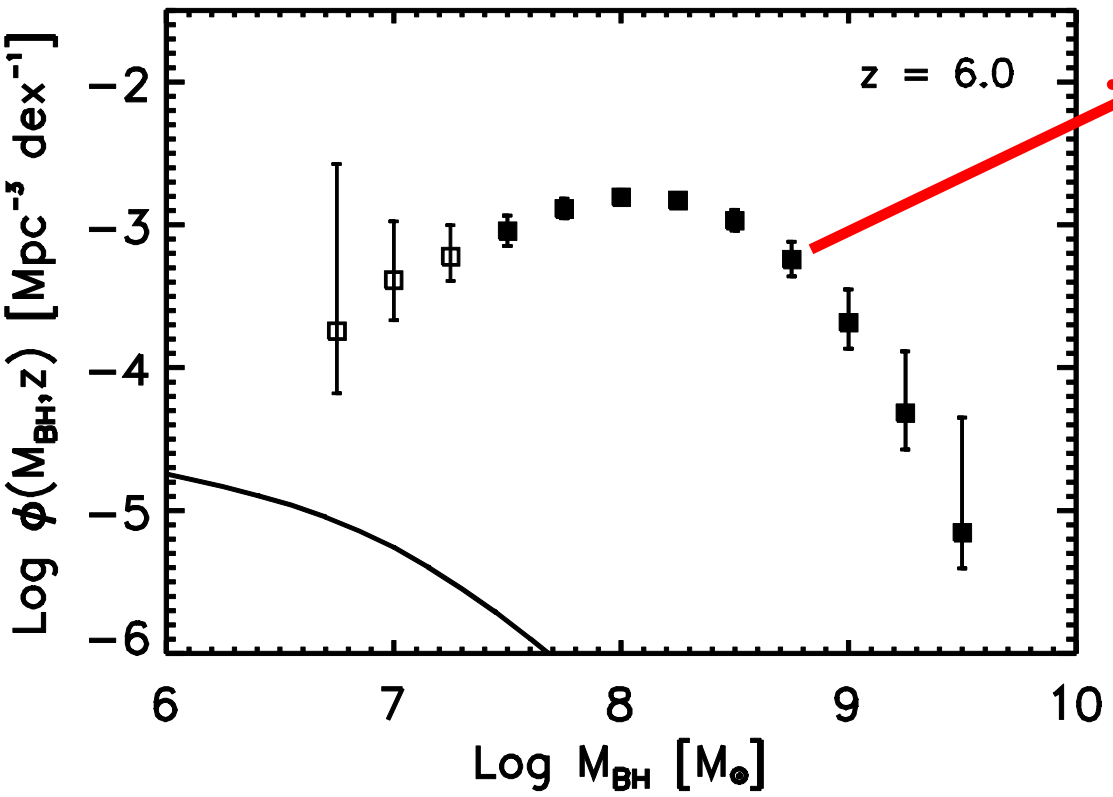
Preference for centrals being active



EMPIRICAL MODELS 2:

CONSTRAINTS FROM CONTINUITY EQUATION

Empirical results can be found with a more basic model



Local BH Mass Function

CONTINUITY EQUATION MODELS OF THE BH POPULATION

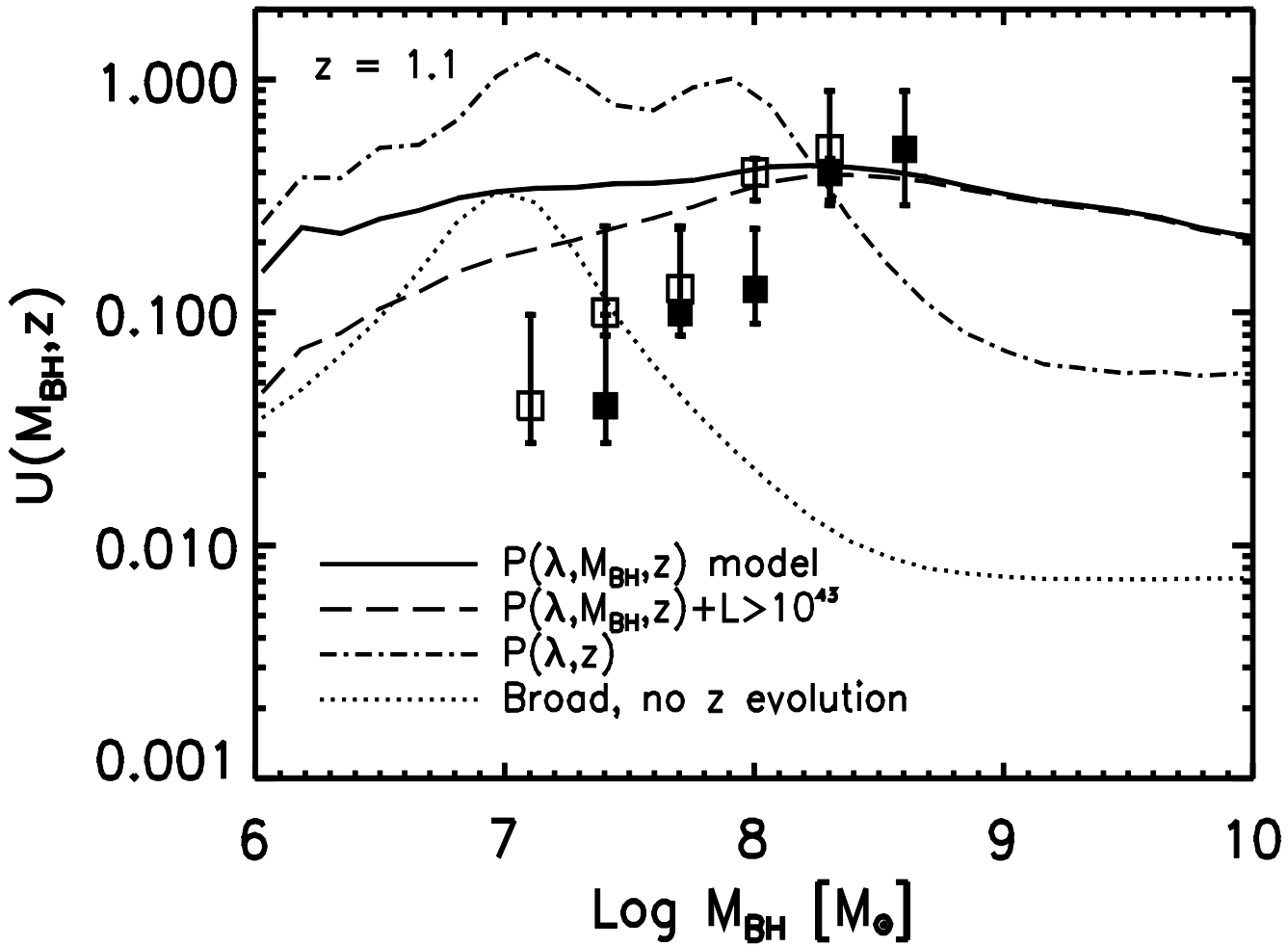
$$\frac{\partial n(M_{BH},t)}{\partial t} = -\frac{\partial}{\partial M_{BH}}\left[\left\langle \dot{M}(M_{BH},t)\right\rangle n(M_{BH},t)\right] + \dot{S}_{in}(M_{BH},t) - \dot{S}_{out}(M_{BH},t)$$

~P(L|M_{BH},z)/ε

U(M_{BH},z) as output!

FS et al. (2004, 2009, 2012)

Allowing for redshift and mass-dependent $P(L/L_{Edd}, M_{BH}, z)$ allows to match duty cycle at $z<1$!

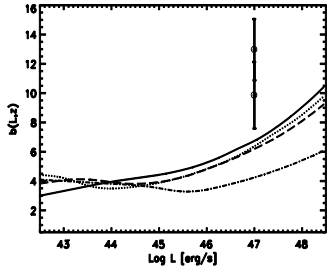


CONCLUSIONS

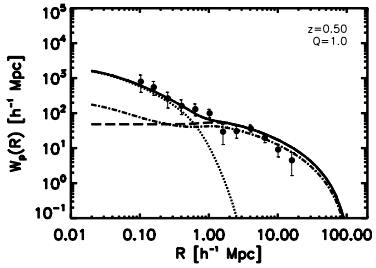
Starting from Basic Merger Models we find:

0- Strong degeneracies in the Light Curve
and some basic assumptions

1-***High clustering + Low Counts of z>3 QSOs*** :
very short delay



2-***Non-negligible*** fraction of active ***satellites***



3-***Decreasing*** characteristic L/Ledd with time