CONSTRAINING BLACK HOLE AND GALAXY EVOLUTION

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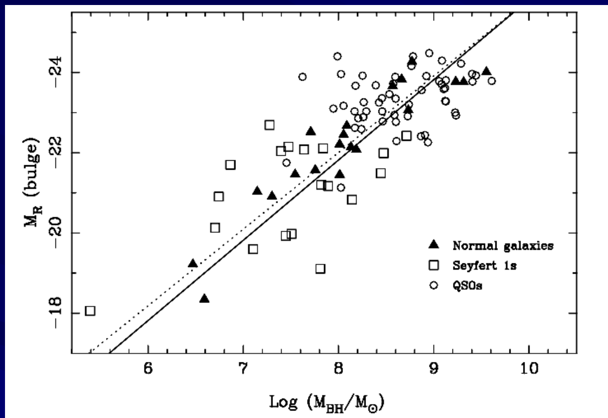
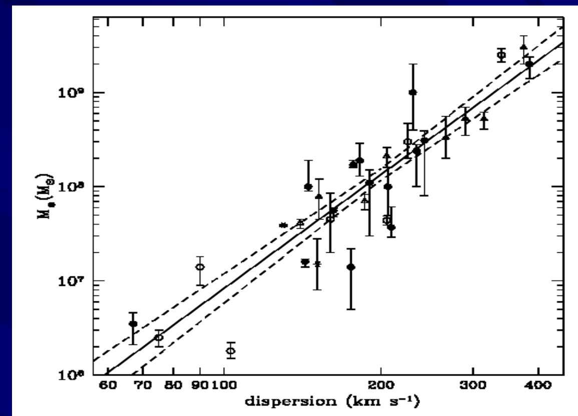
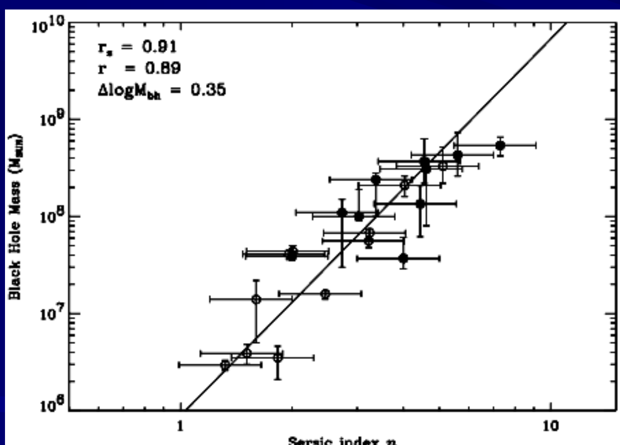
OAT 22/04/09

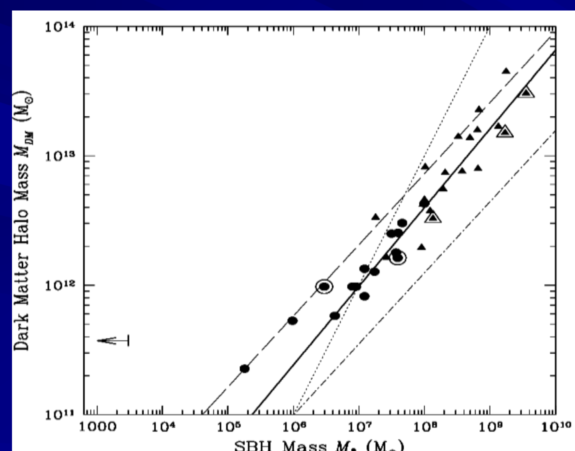
Massive Dark Objects → observed in all bulged-galaxies
→ strong link with the host spheroid M/n/σ





Dunlop & McLure; Ferrarese et al.; Gebhardt et al.; Graham et al.; Haring & Rix; Lauer et al.; Magorrian et al.; Marconi & Hunt; FS & L. Ferrarese 2009a,b





$$\sigma = k \times V_c$$

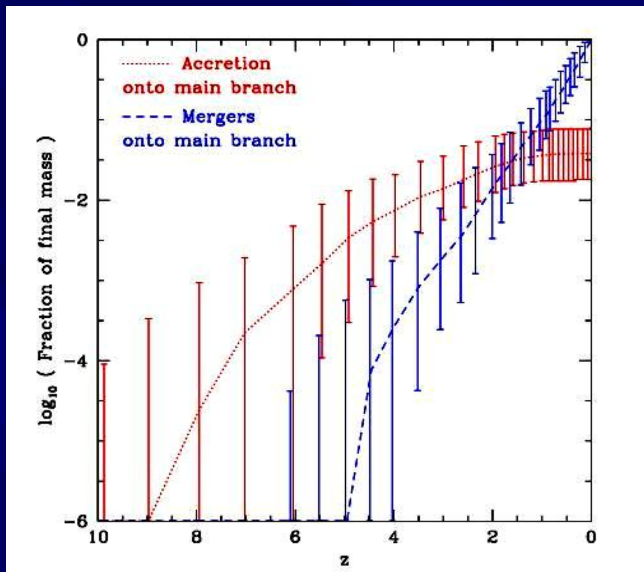
+

V_C+DM profile →

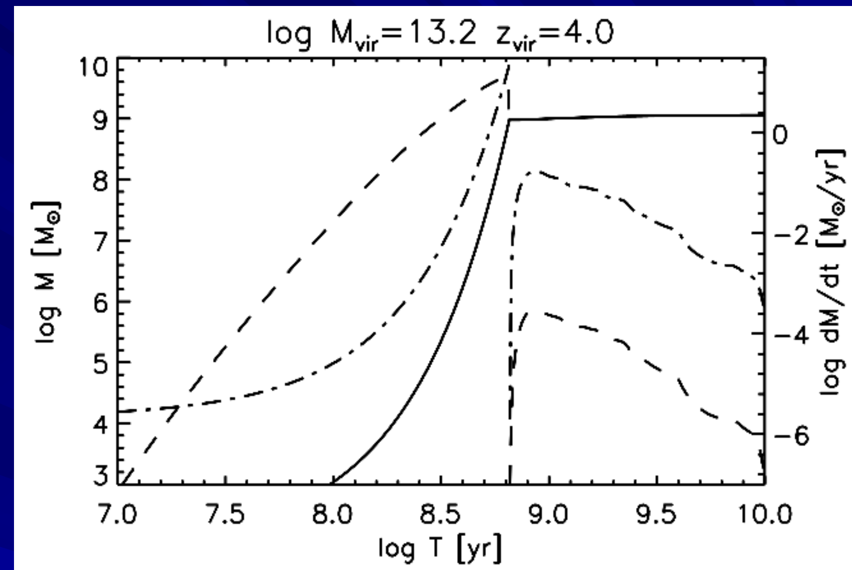
$V_{VIR}(z_{vir}=0) \propto (M_{vir})^{1/3}$

What are MDOs? How and why are they connected with spheroids and DM? What is their role in shaping galaxies?

SAMs are working hard to understand what is going on…

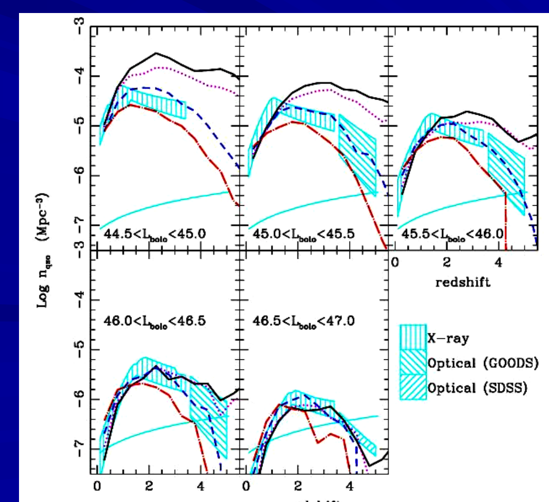


Malbon et al.



Lapi et al.

Fontanot et al.



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

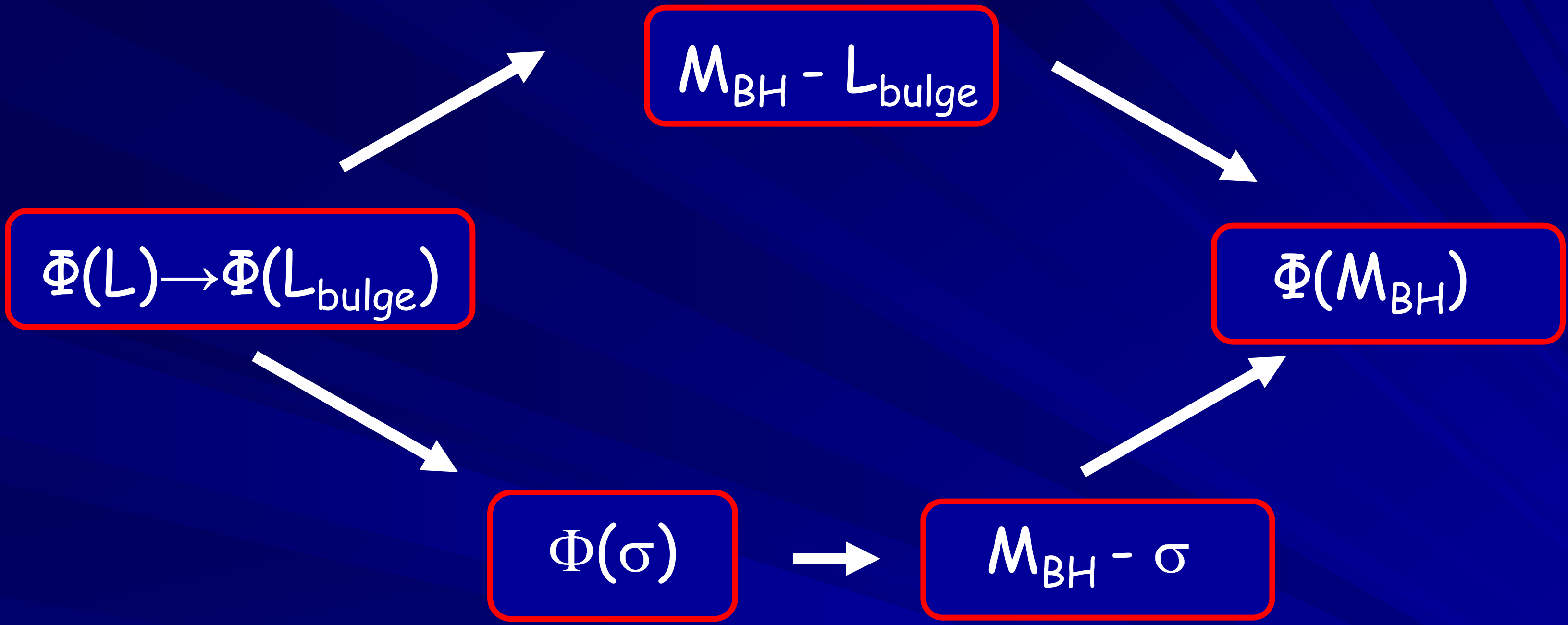
GOAL:

- **EMPIRICALLY** CONSTRAIN BLACK HOLE EVOLUTION IN A *STATISTICAL* SENSE

TOOLS:

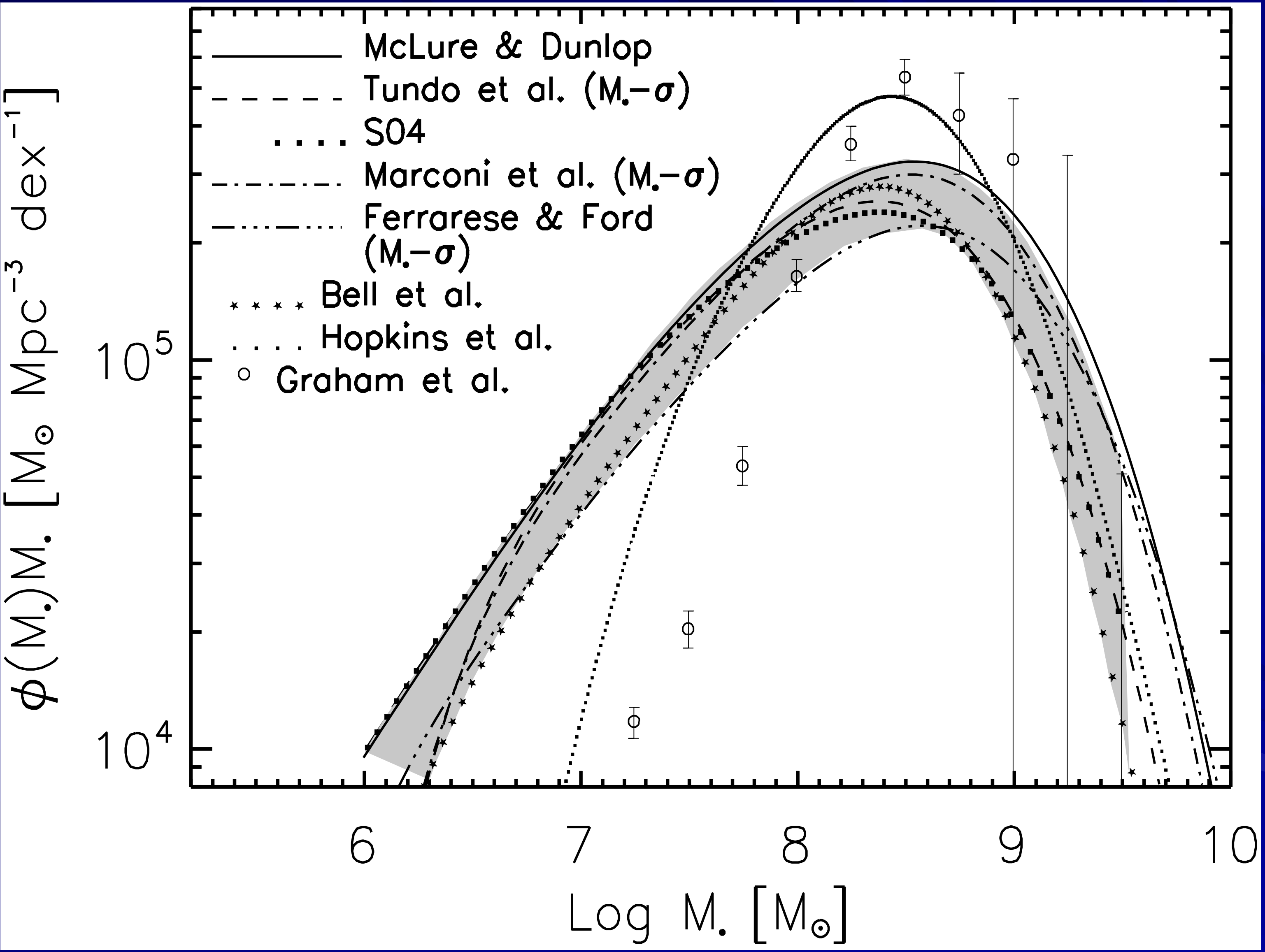
- WE USE:
  - -LOCAL BH MASS FUNCTION
  - -AGN BOL. LUM. FUNCTION
  - - AGN CLUSTERING
  - - OBSERVED DUTY CYCLE

First Step: How many SMBH?How Massive?

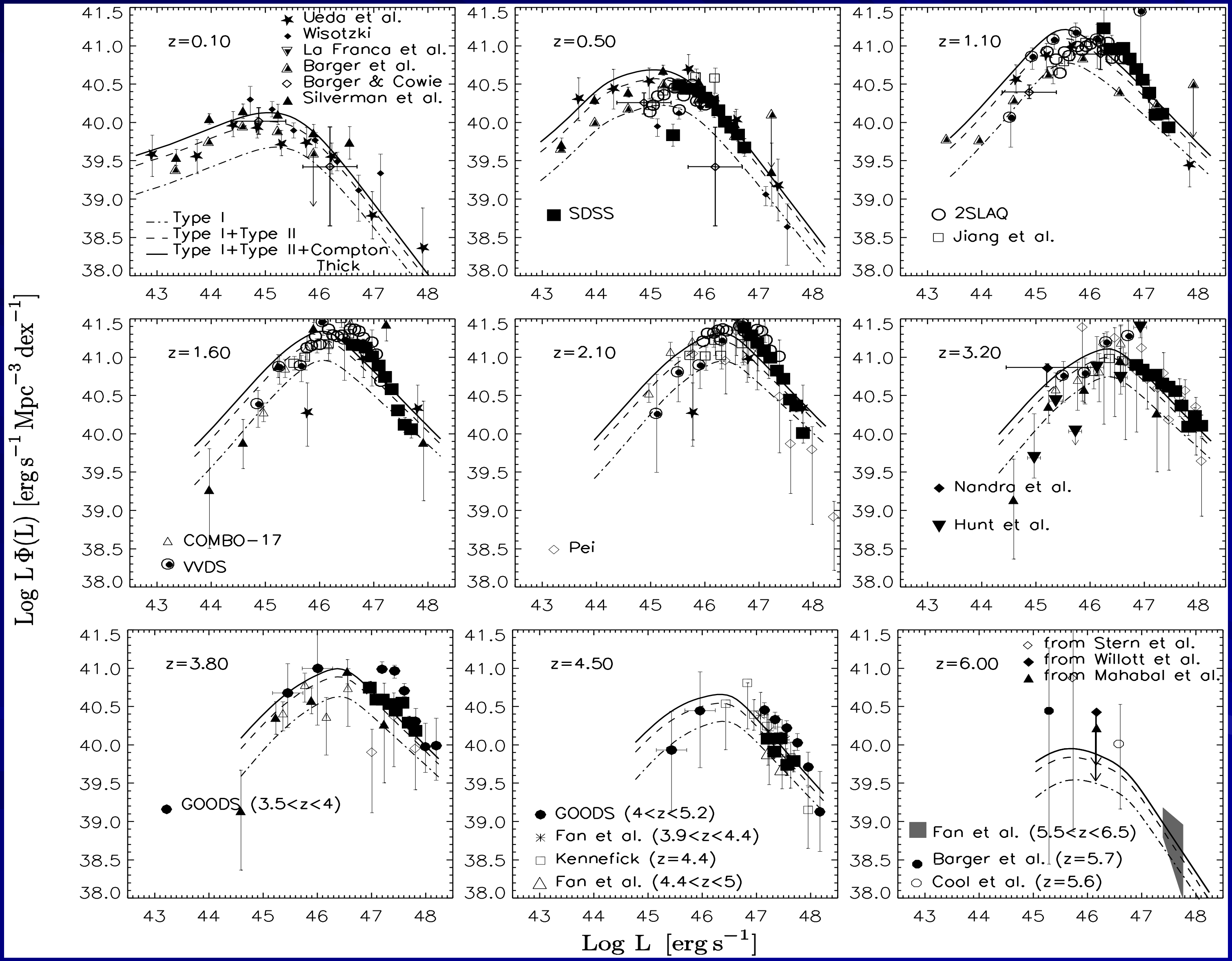


For all relations used I convolve with a Gaussian weight to account for intrinsic scatter !

Results: systematic uncertainties!



THE ACTIVE EVOLUTION OF BLACK HOLES: THE AGN LUMINOSITY FUNCTION

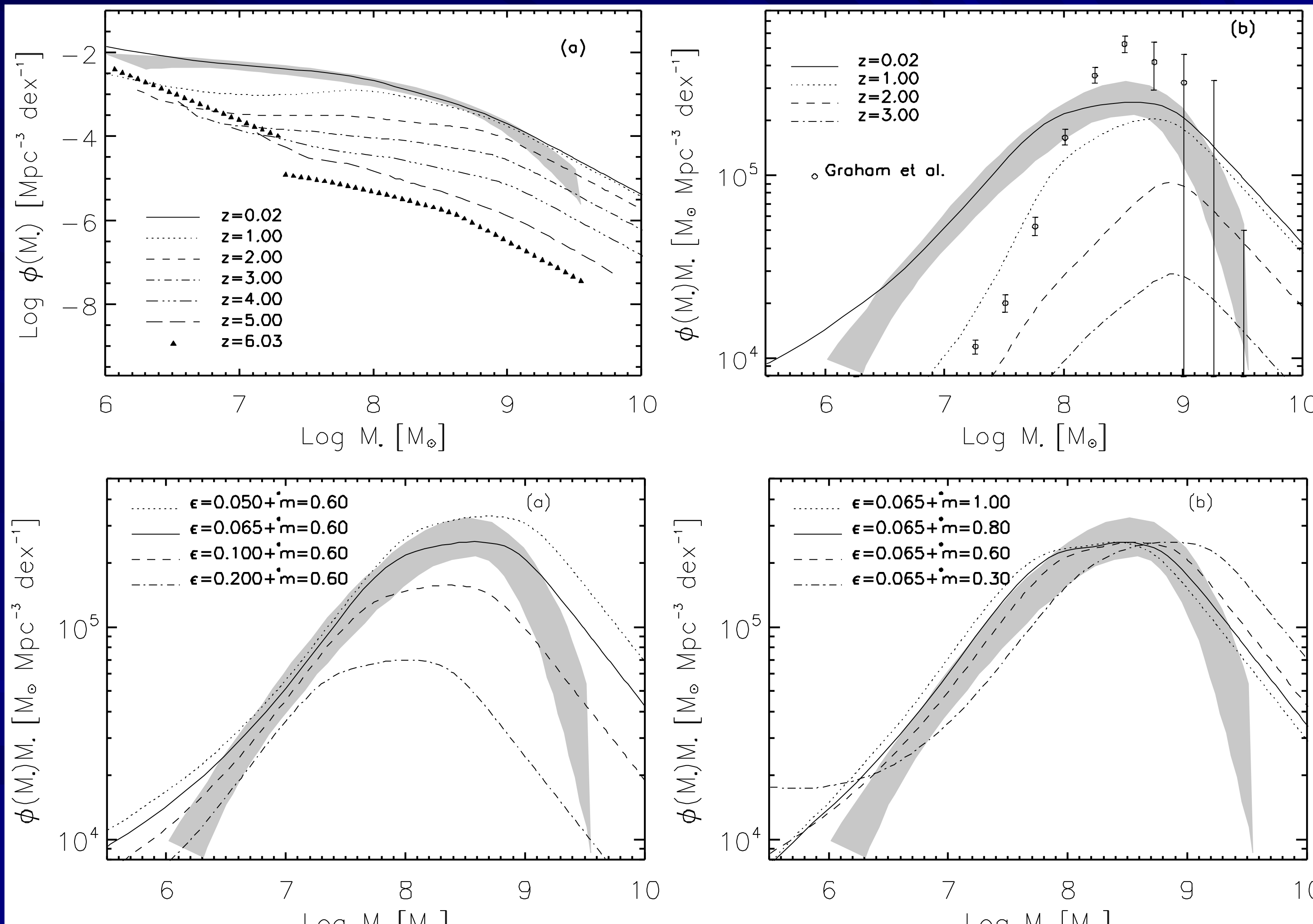


$$\Phi(M_{BH},t) = -\frac{1}{t_{ef}\ln(10)}\int \frac{\partial\Phi(L,z)}{\partial \log L}\frac{dt}{dz}\,dz$$

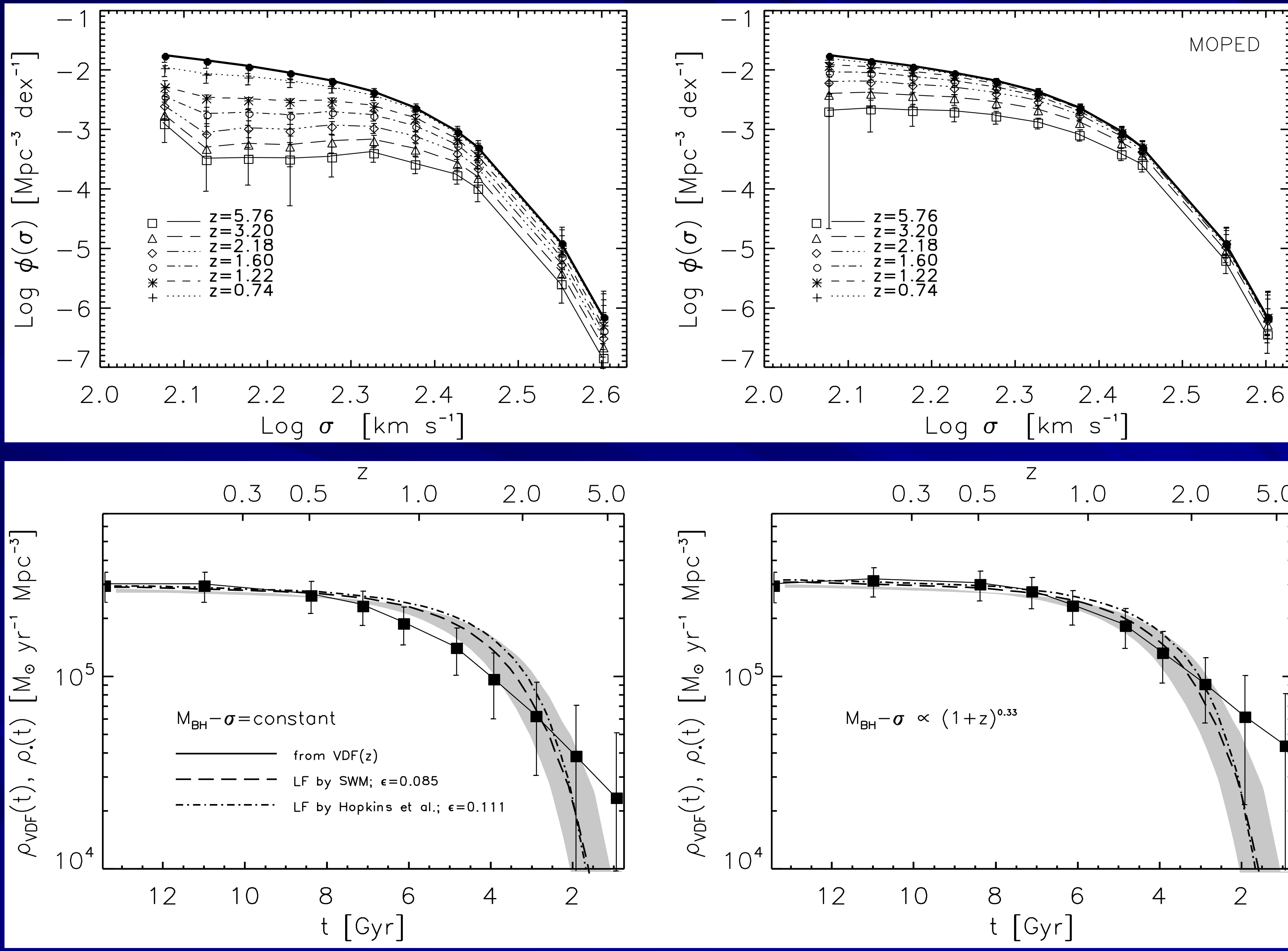
$L = \lambda L_{Edd}(M_{BH})$

$L_{Edd} = 1.3e38 \times (M_{BH}/M_{sun})$ erg/s

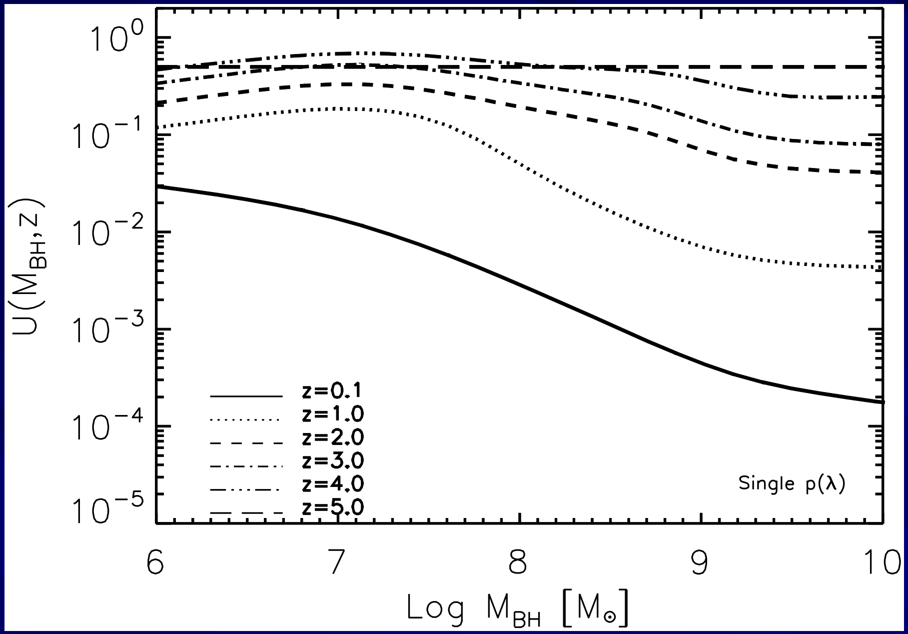
$t_{ef} \propto \varepsilon/\lambda$



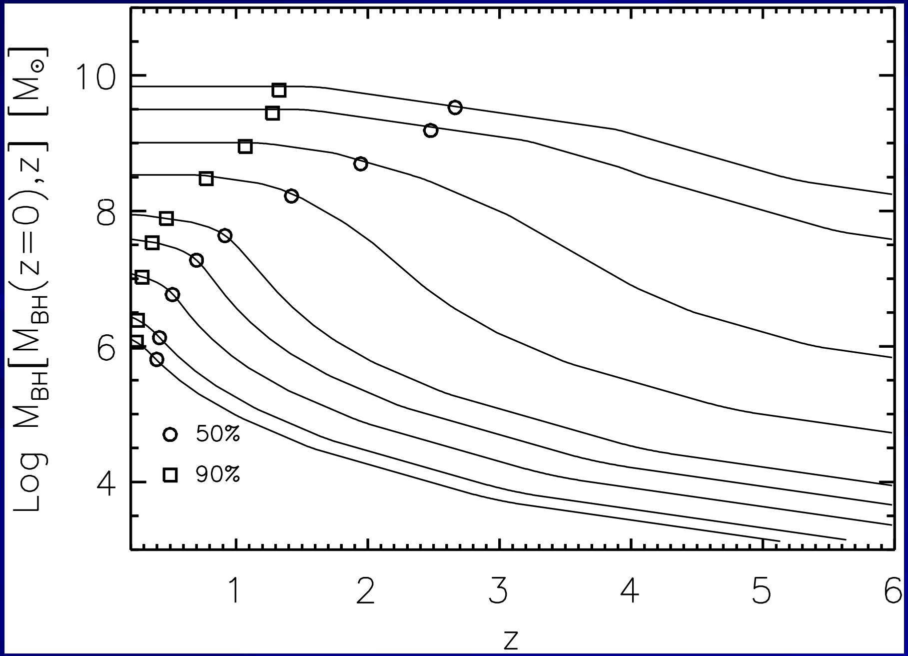
Do The Relations Evolve with Redshift?



FS, Bernardi, Haiman 2008

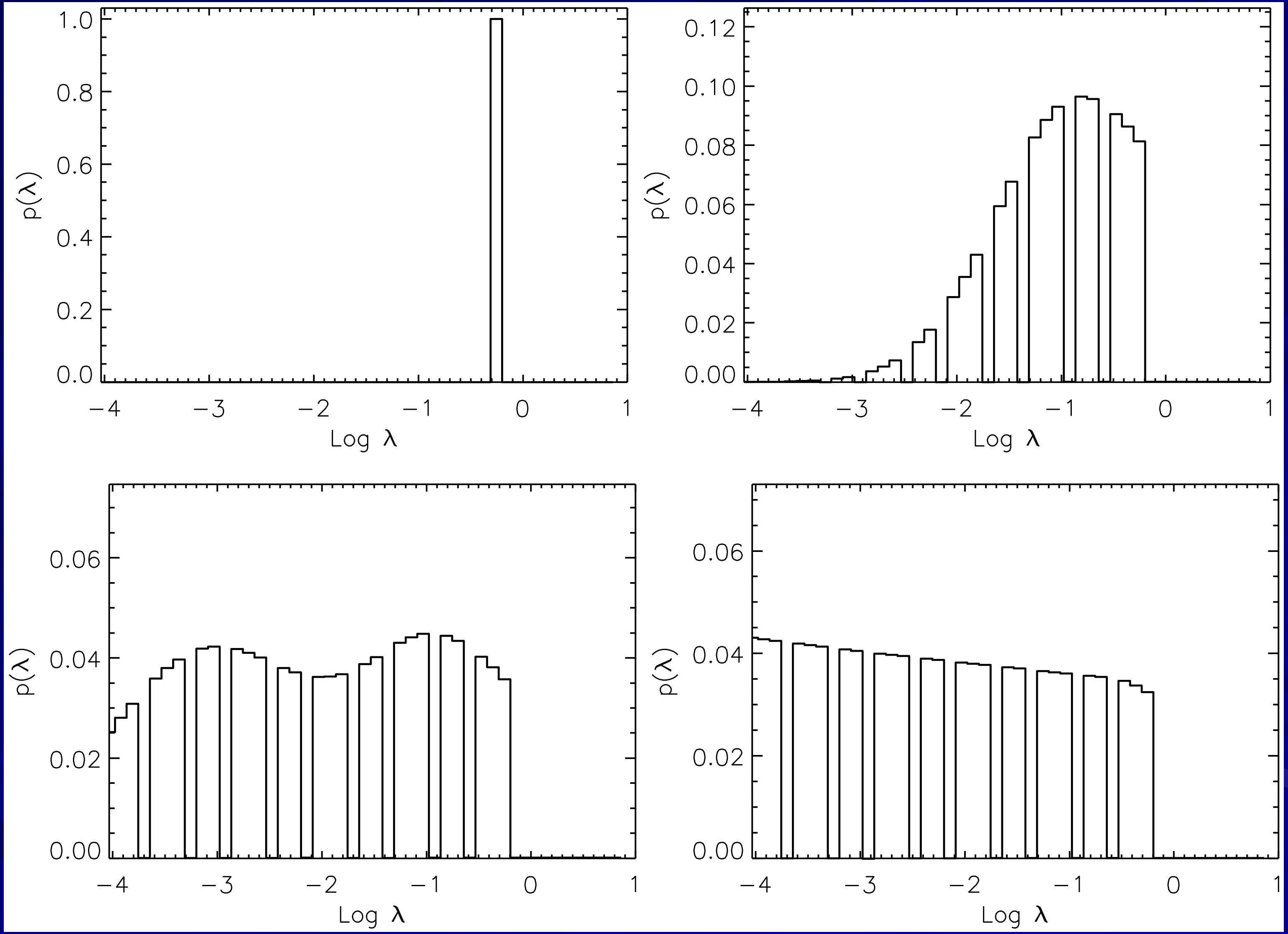


Duty cycles:
$U(M_{bh},z)=\Phi(L,z)/n(M_{bh}[L],z)$



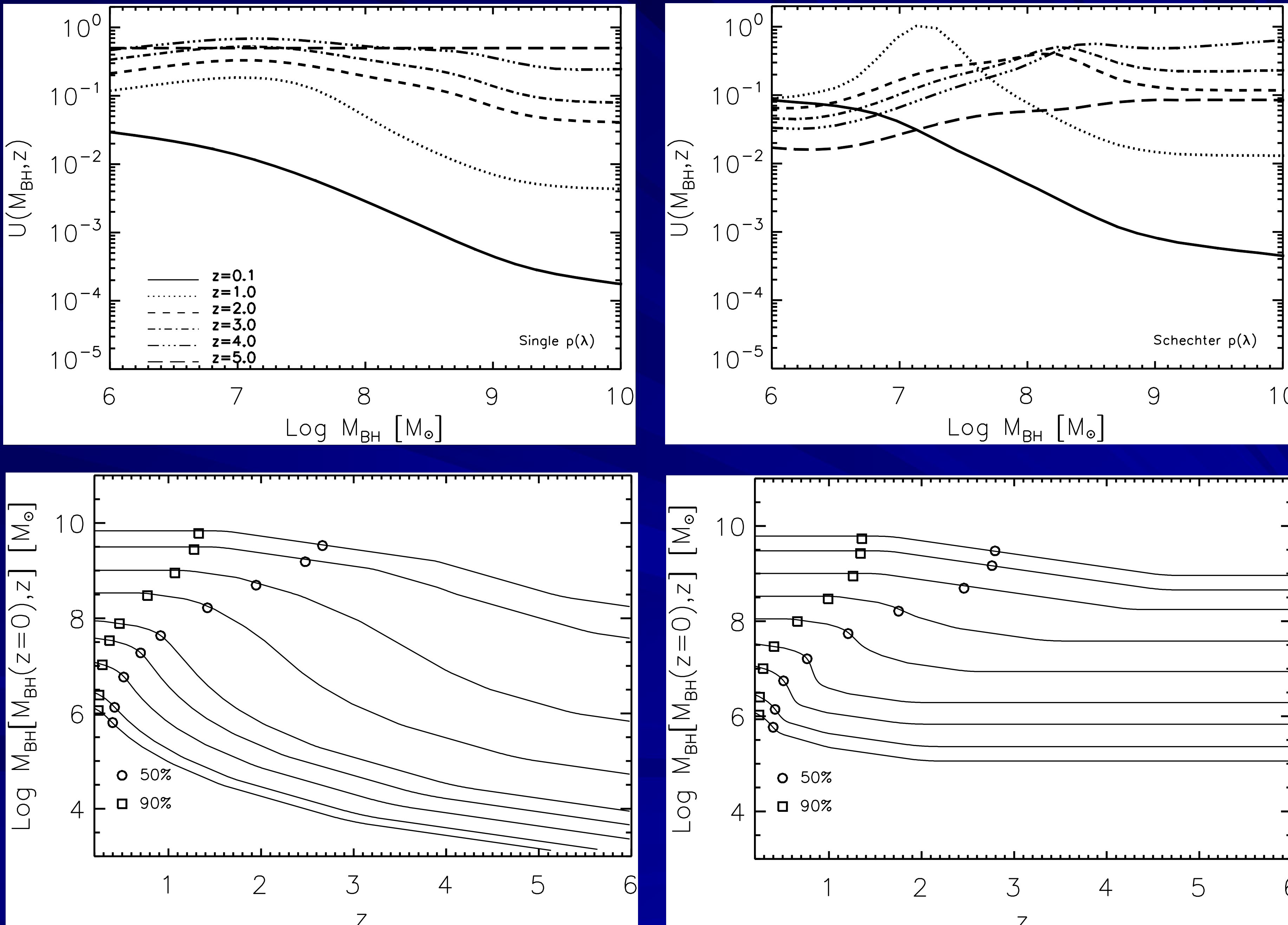
Mean Mass Accretion Histories:
Evidence for downsizing

Broad Eddington ratio Distributions I

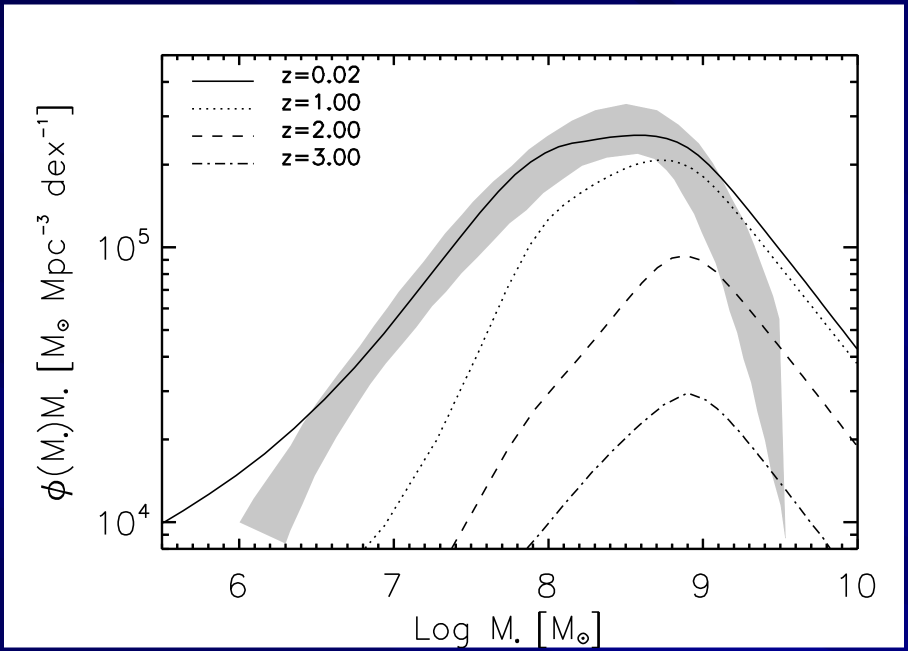


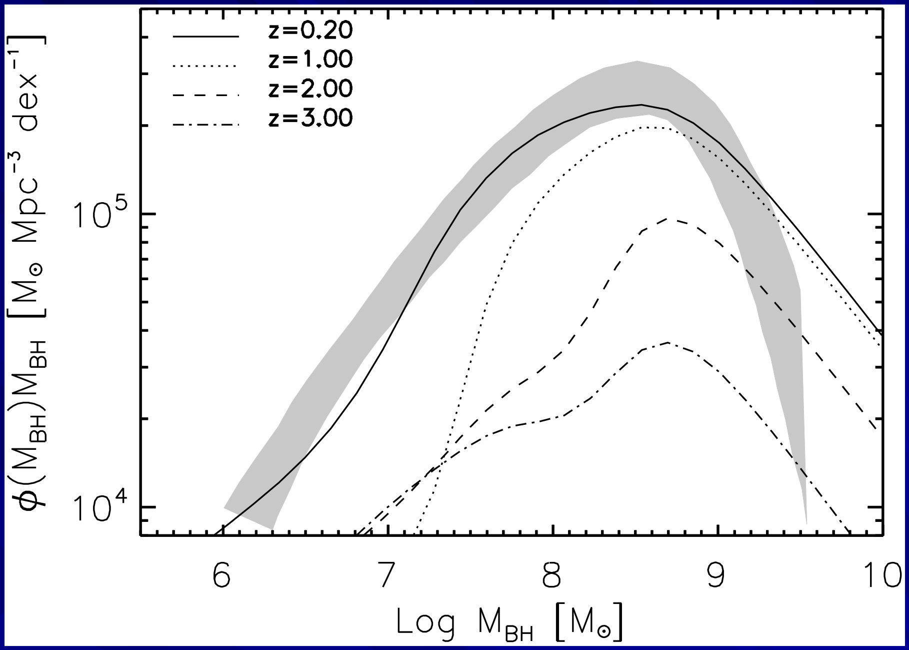
FS, D. Weinberg, J. Miralda-Escude' 2009a

...Same DOWNSIZING....



Broad Eddington ratio Distributions II

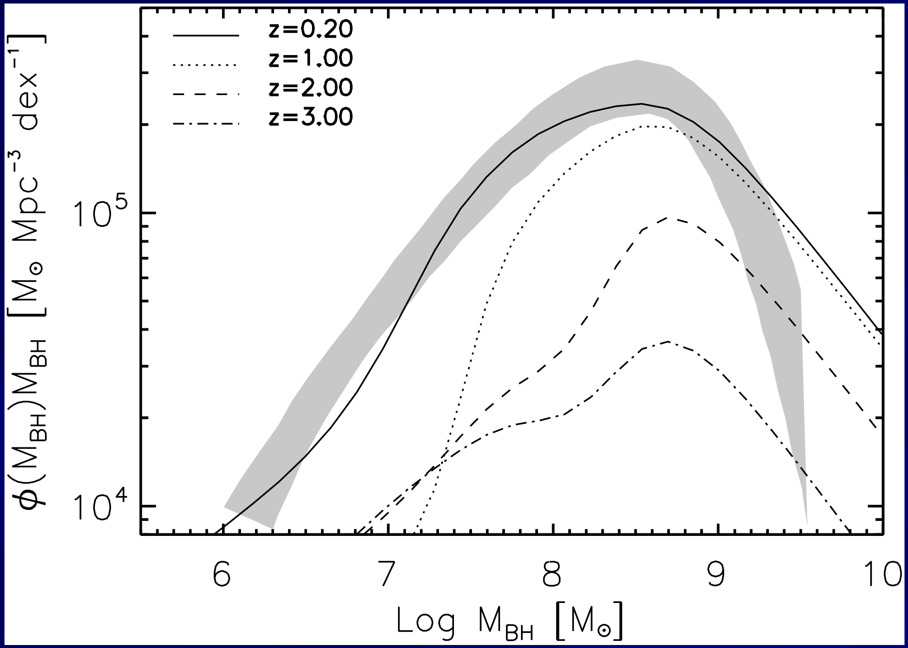


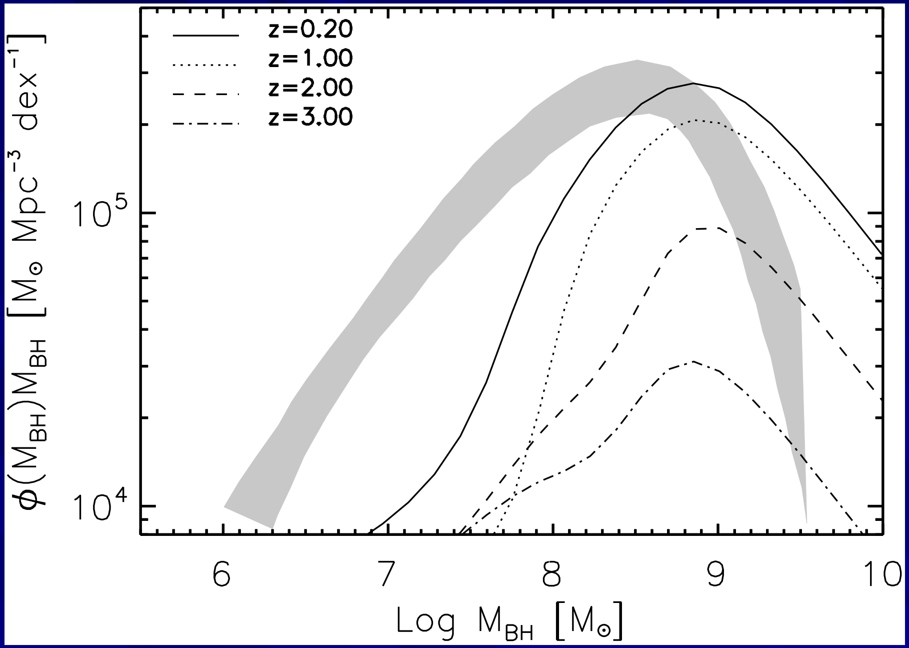


Very Narrow p(λ)

Very Broad p(λ)

Broad Eddington ratio Distributions III

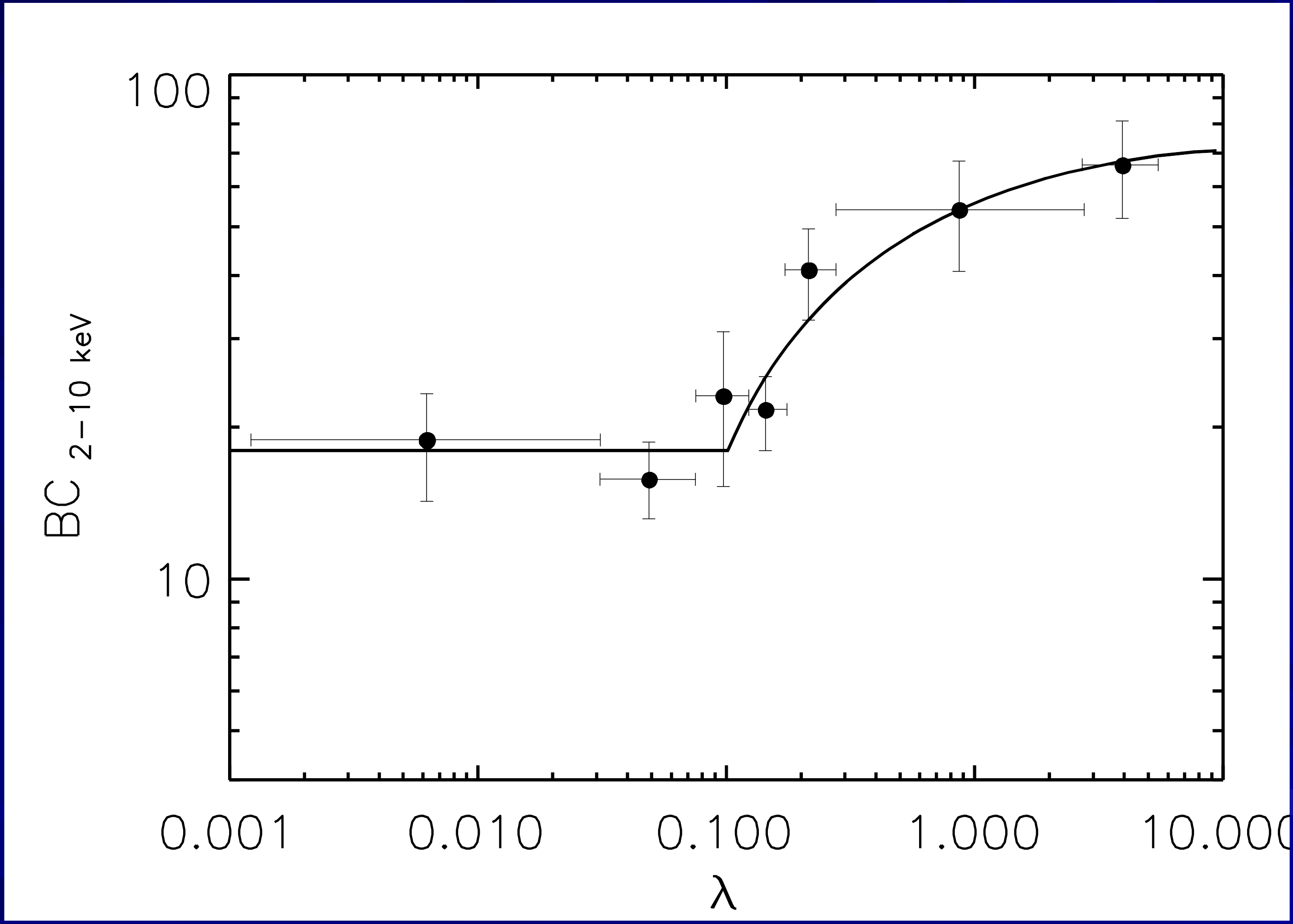




Very Broad $p(\lambda)$

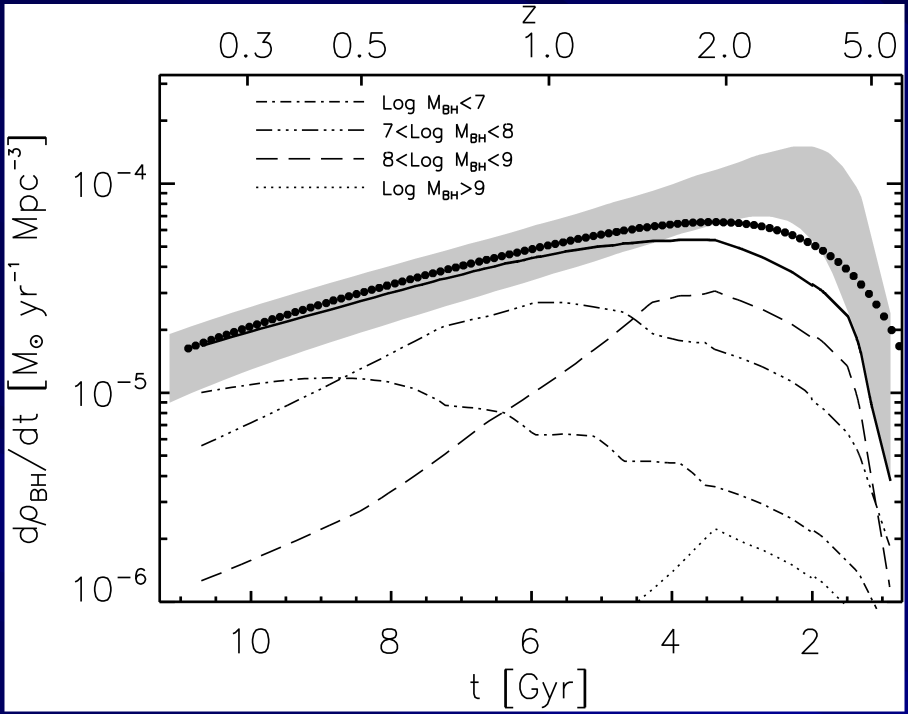
Very Broad $p(\lambda)+f(z)$

SPECIAL MODELS: λ-dependent Bolometric Correction

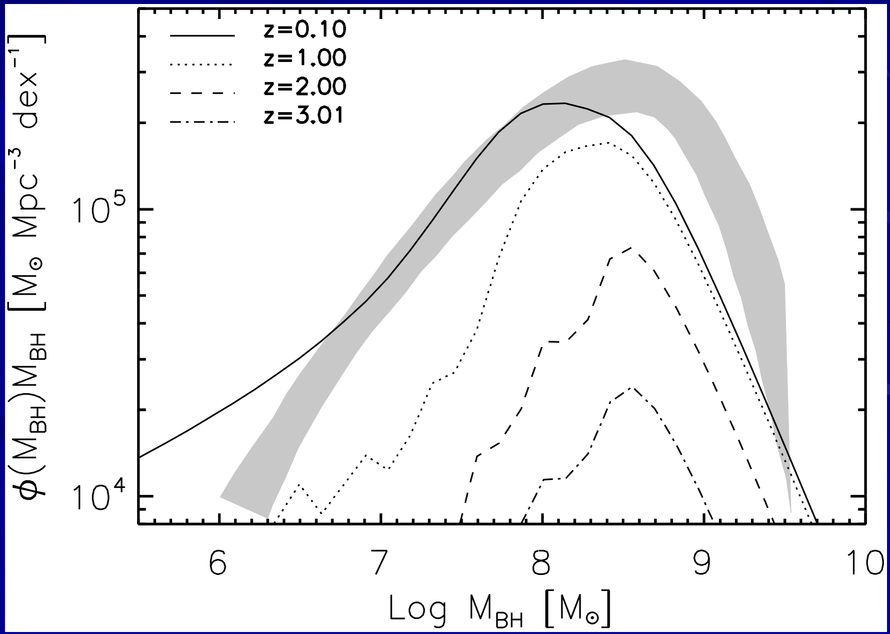


Vasudevan & Fabian 2007

Low Radiative Efficiency+Low Eddington ratios

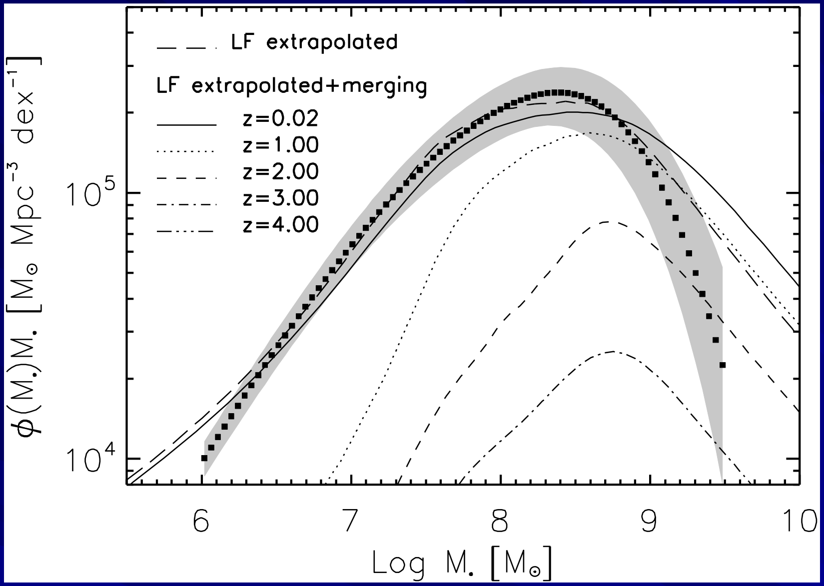


Similar Downsizing

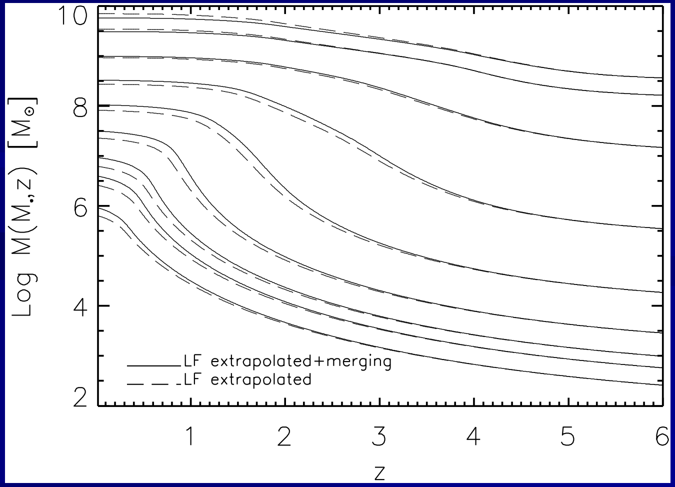


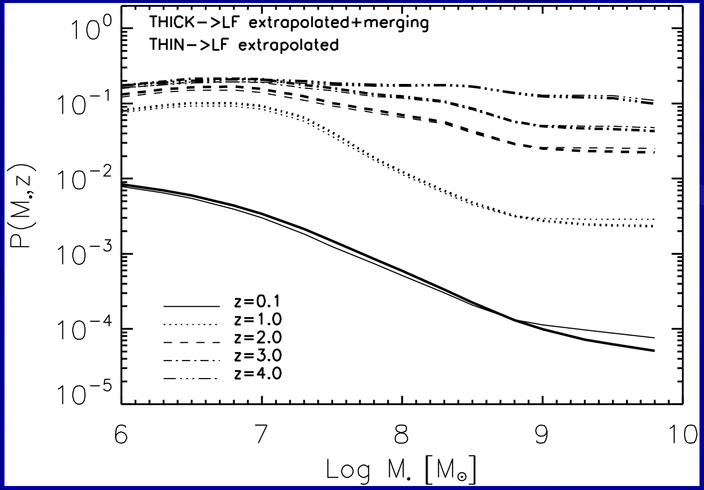
Harder to match the local BHMF: $\lambda<0.1$; $\varepsilon<0.06$

The Effect of SMBH Merging…

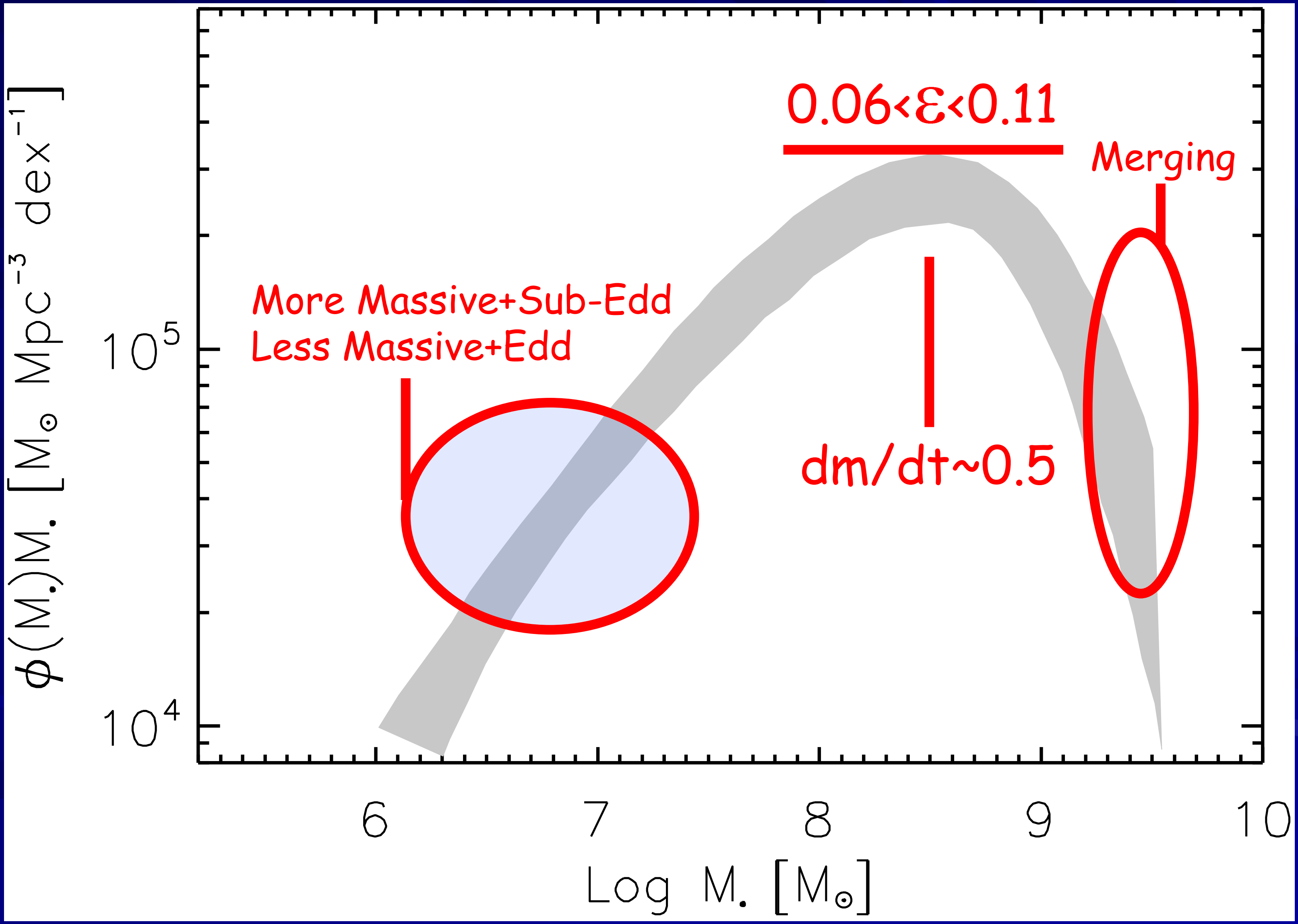


Negligible effect on accretion histories and duty cycles:

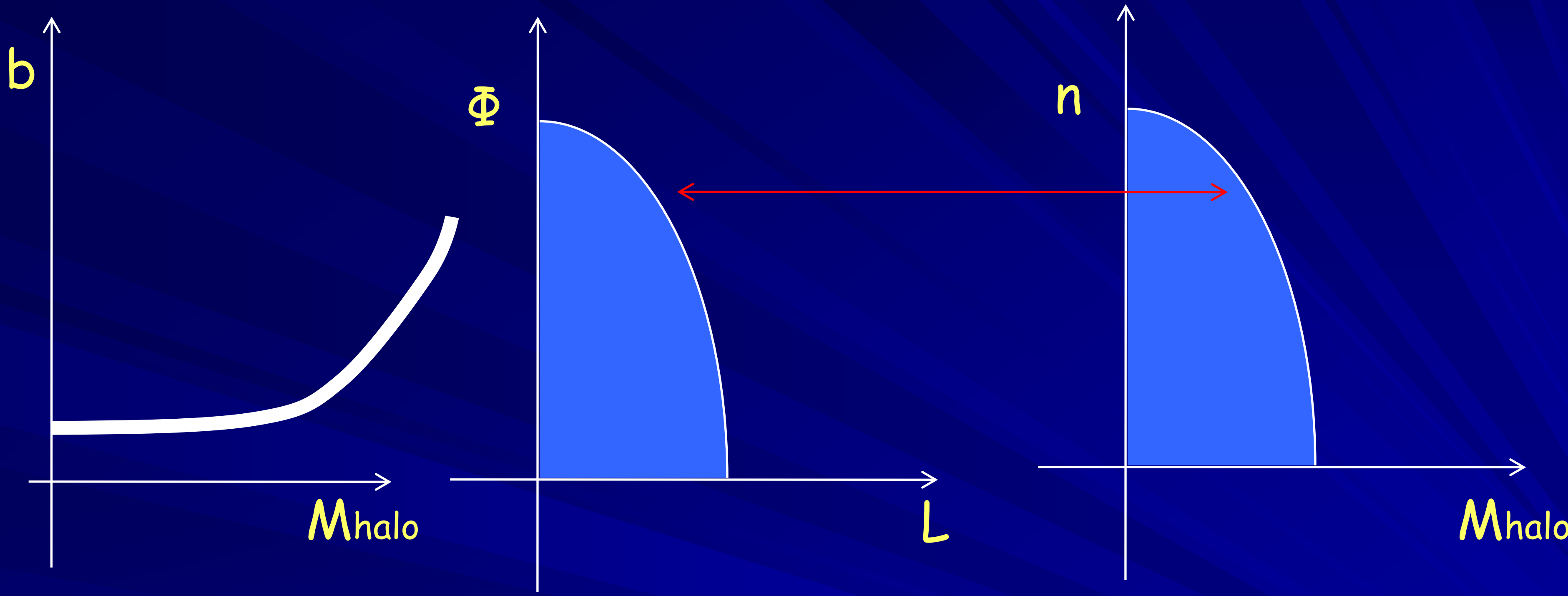




CONCLUDING on THE LMF



How to link Clustering to Accretion



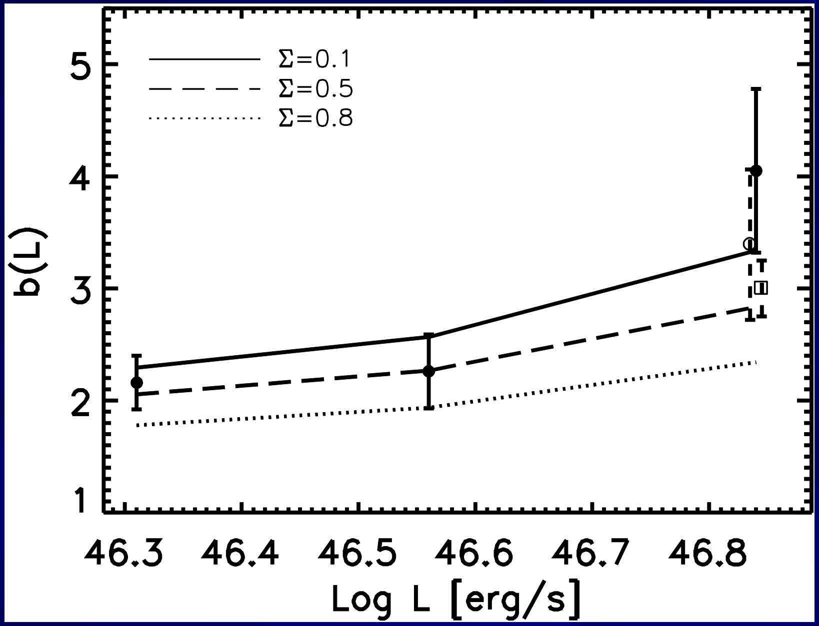
$$\int_{L_{MIN}}^{\infty} \Phi(L)dL = \int_{0}^{\infty} W_{GAUSS} f_{AGN} n(M_{HALO})dM_{HALO}$$

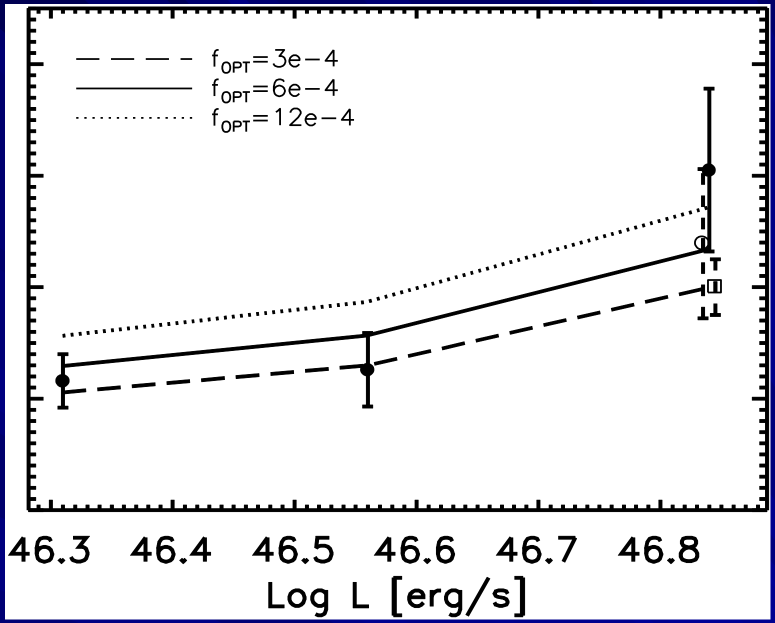
From matching the bias in output duty cycle f_{AGN}

Rule of thumb: at fixed scatter, high duty cycle massive halos low numbers

Martini & Weinberg 2001; Haiman & Hui 2001

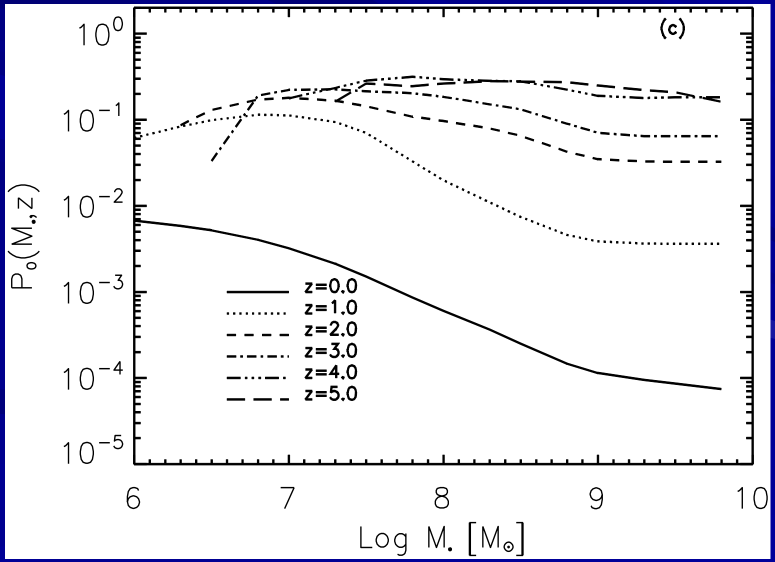
An Application: The SDSS z~1.5 quasar clustering





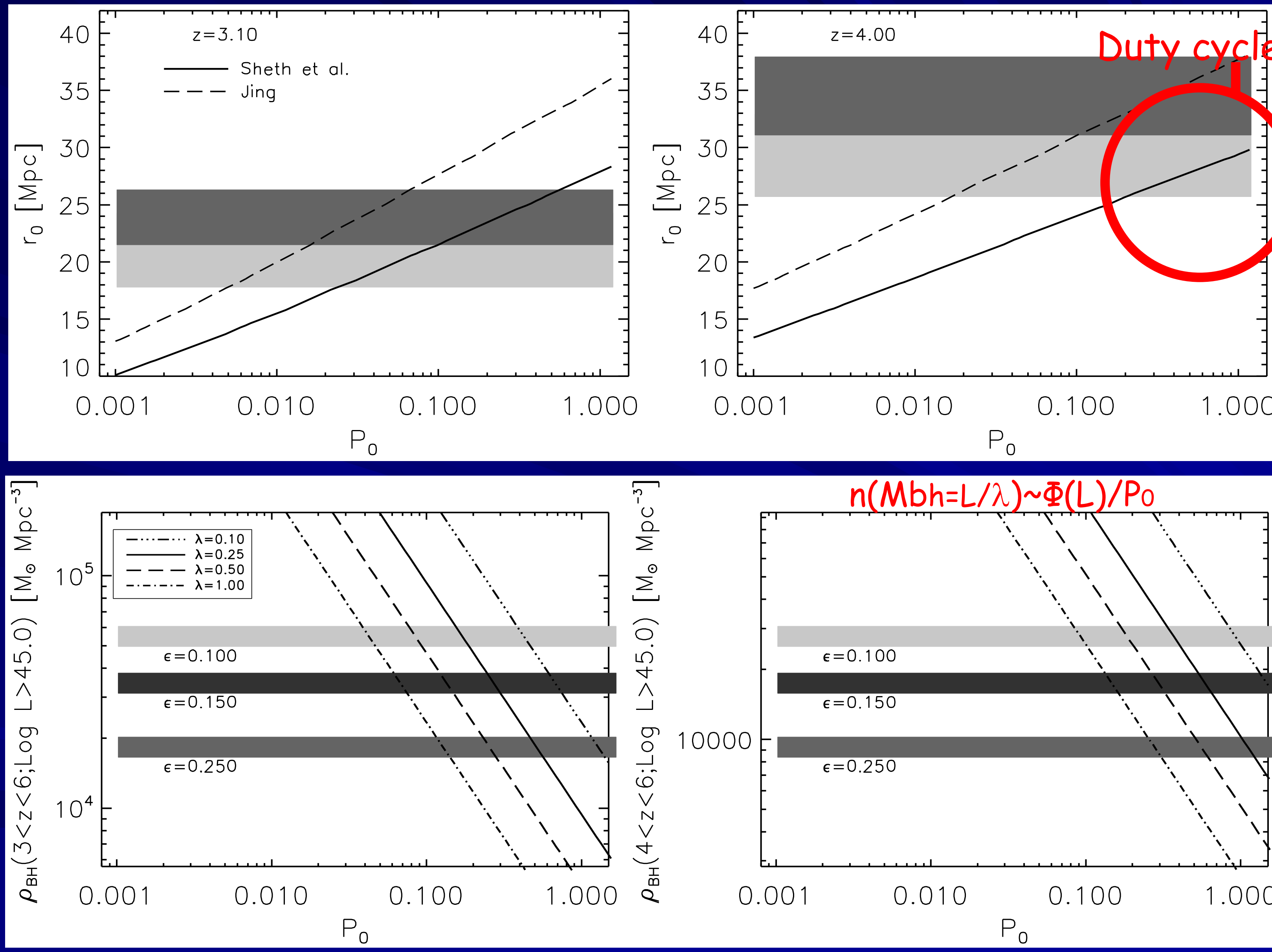
Coupling with duty cycle from Continuity Equation breaks some degeneracies!

First Results: large scatter!



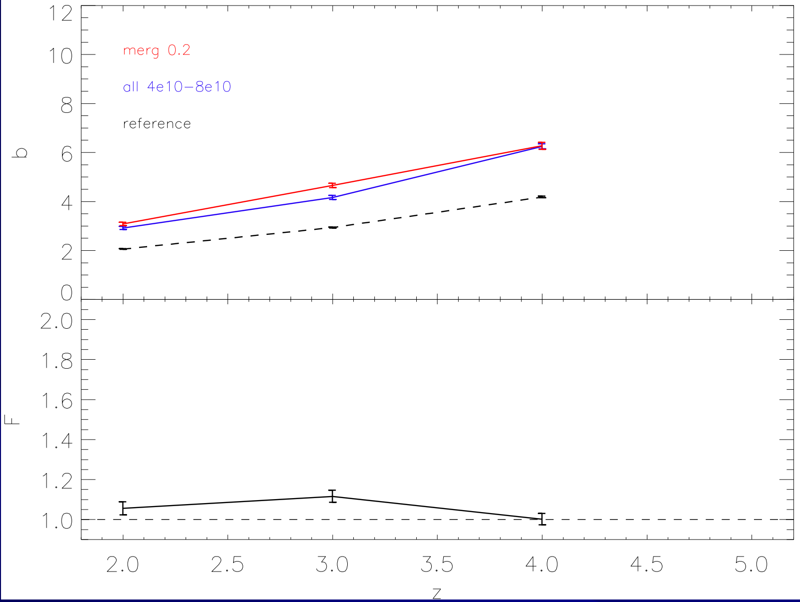
FS, Shen, Weinberg, et al. 2009

Another Application: The SDSS z>3 Quasar Clustering

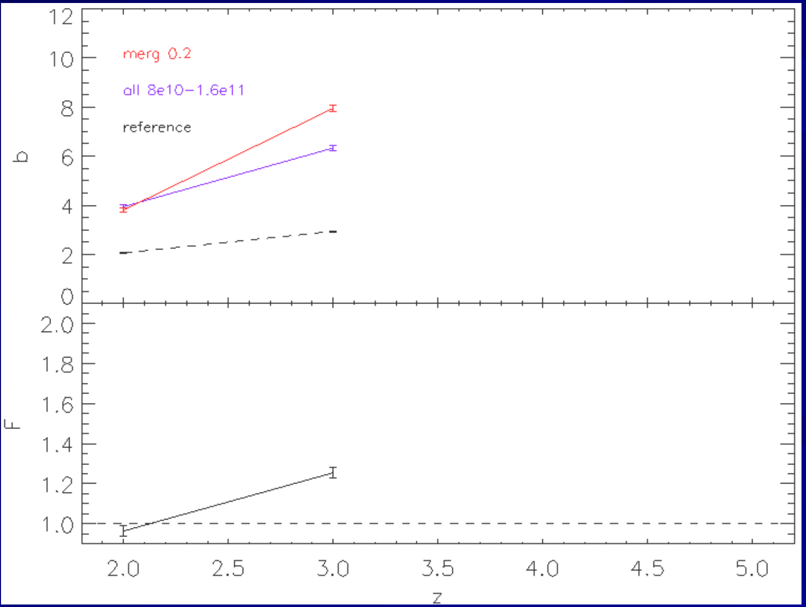


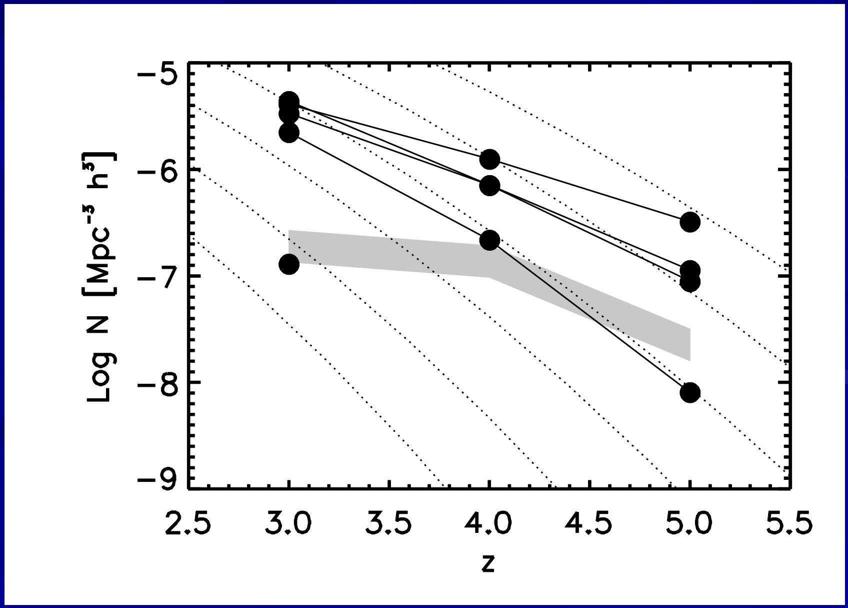
FS, M. Crocce, J. Miralda-Escude', P. Fosalba, D. Weinberg 2008

The Clustering of “MERGING” Halos



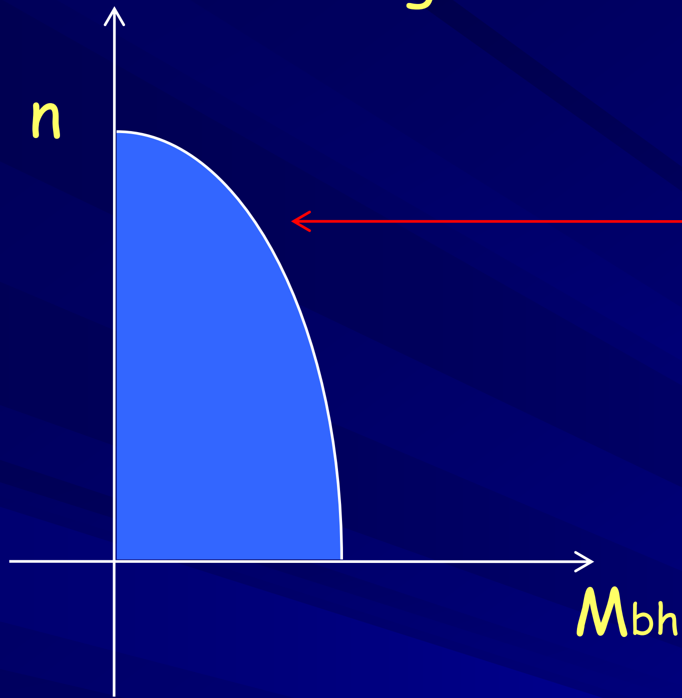
We select the halos from the MS which have recently merged

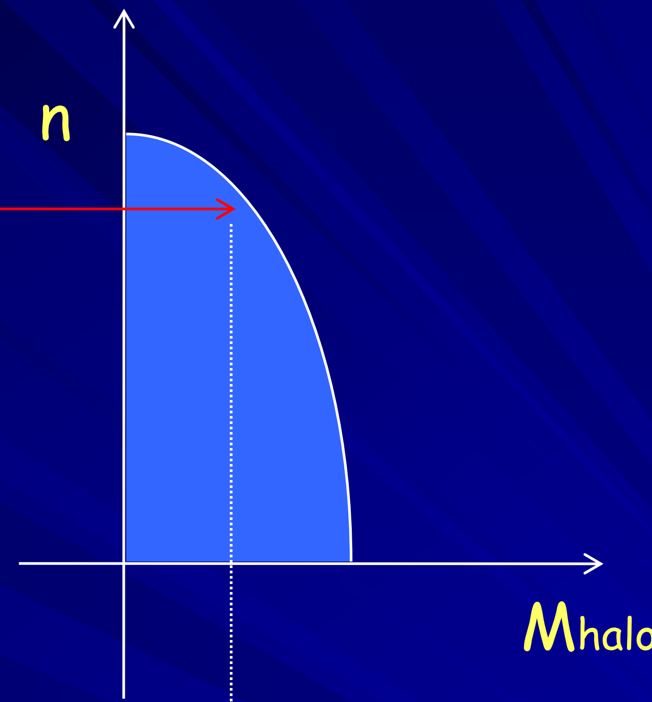




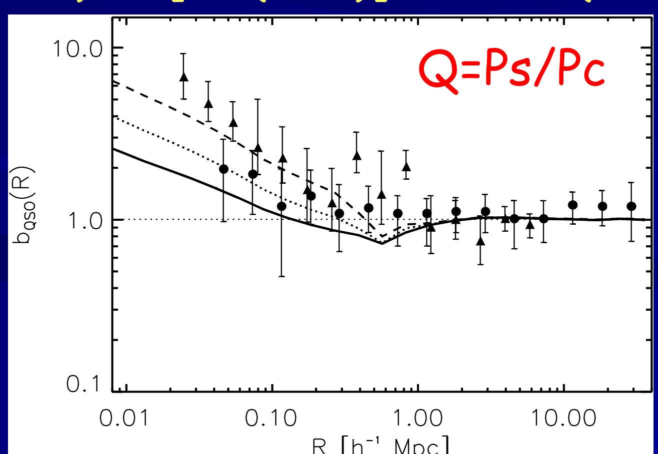
S. Bonoli, FS, S. White 2009

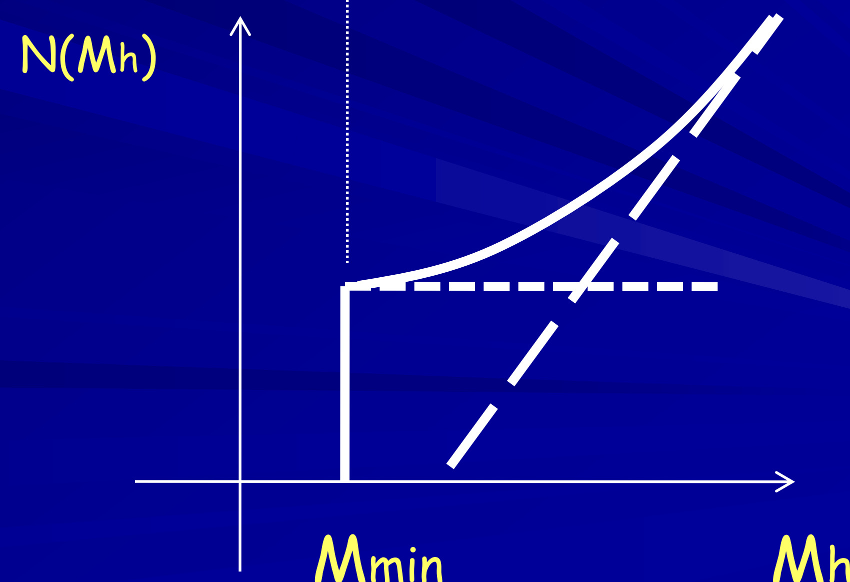
Seeding Central and Satellite Halos with BHs





$P_c(M_{bh})\, N_c[M_h(M_{bh})]/N_{tot} +$
$P_s(M_{bh})\, N_s[M_h(M_{bh})]/N_{tot} = U(M_{bh}, z)$





FS, D. Weinberg, J. Miralda-Escude' 2009b

SO…WHAT DID WE LEARN ABOUT HOW BHs EVOLVE?

- ***<u>ACCRETION:</u>*** can reproduce the local BH mass function; preferred parameters are $0.5<\lambda<1$ and $0.07<\varepsilon<0.1$. Multi Edd. Ratios do not change Accreted BHMF.

- The ***<u>Quasar clustering</u>***, independent constraints on duty cycle, mean L-Mhalo relation, and scatter, small-scales constraints on the BH triggering mechanisms

- Constraints are independent of specific models and can then be used in SAMs