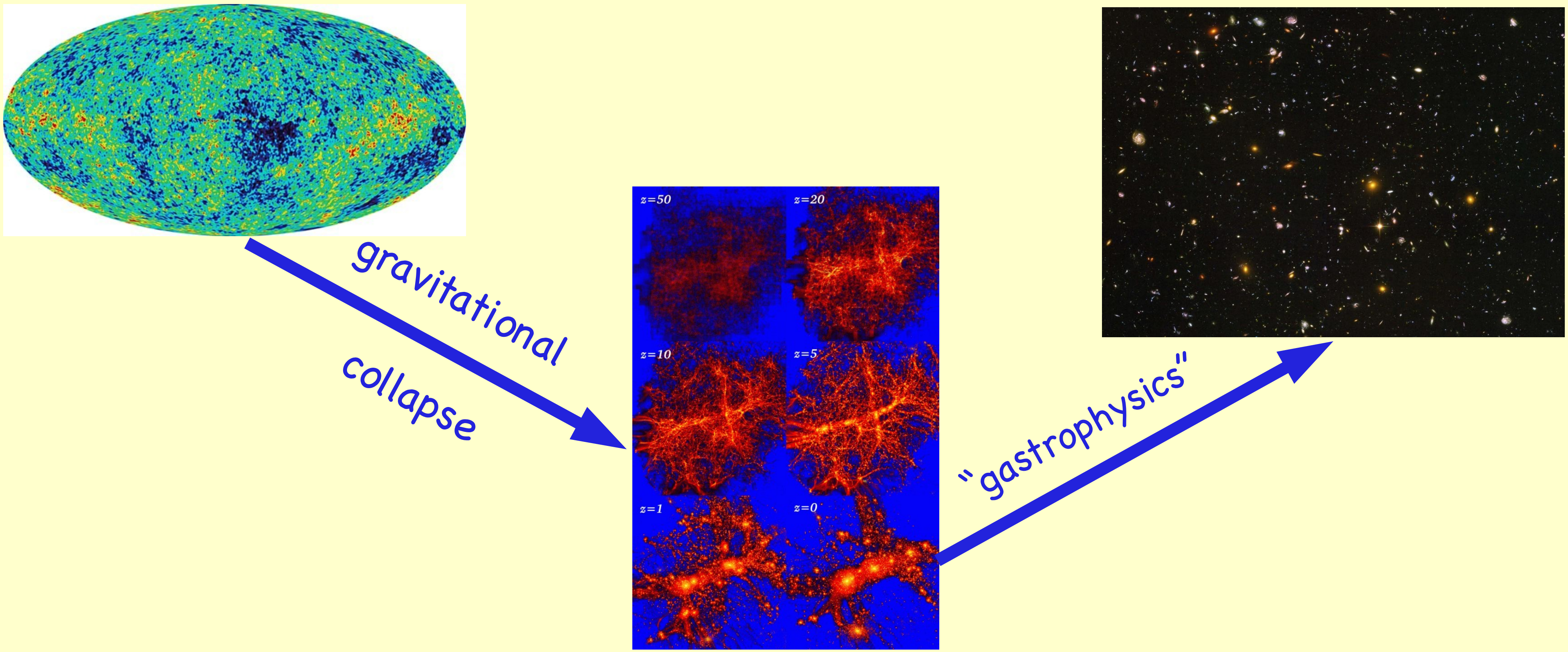
AGNs in the context of galaxy formation

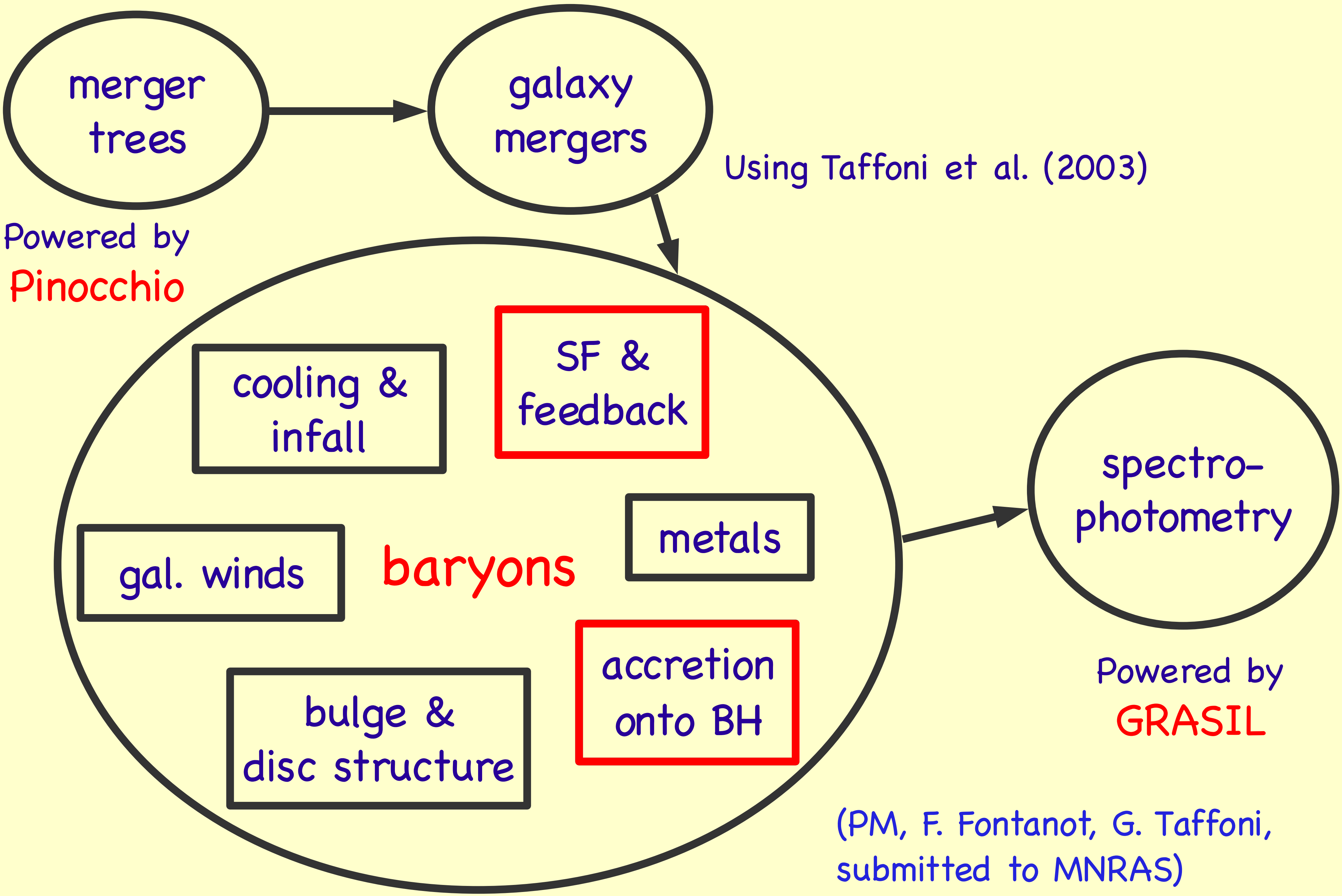
P. Monaco, Dipartimento di Astronomia, Trieste



In collaboration with:
F. Fontanot, G. Taffoni, S. Cristiani, P. Tozzi, L. Silva, M. Nonino, E. Vanzella

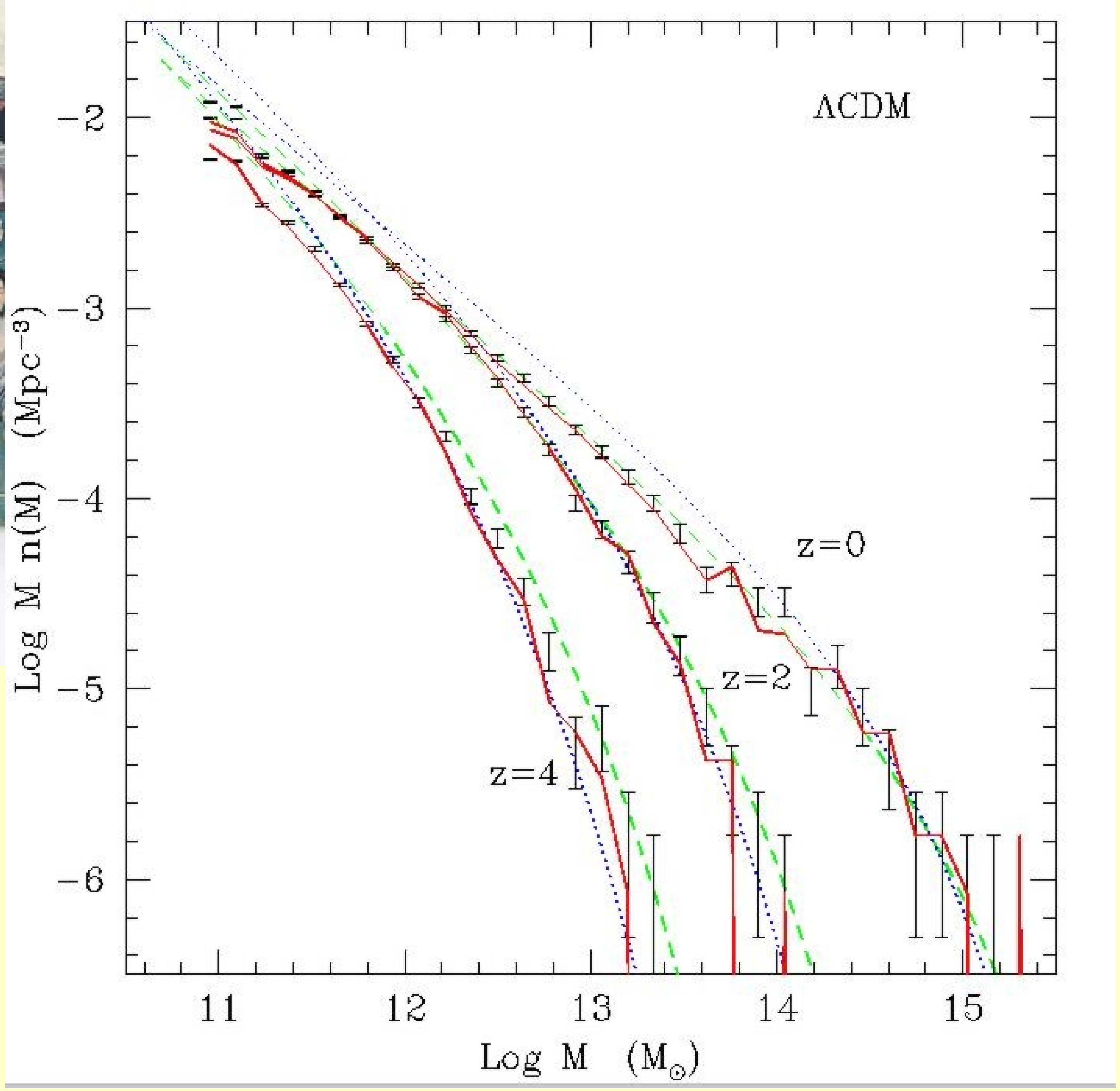
AGN7, May 2006

The GALRISE model

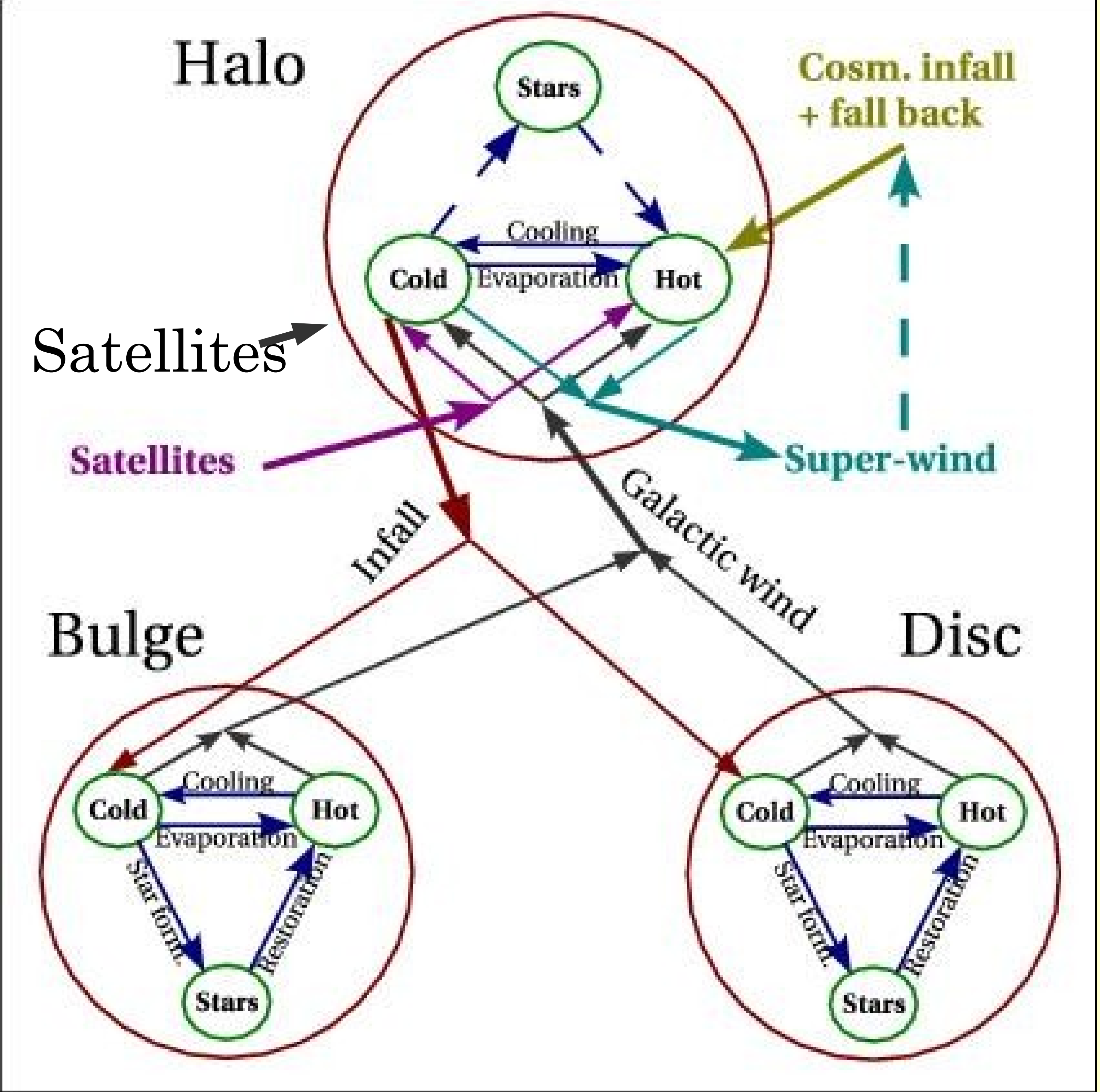


PINOCCHIO v2.1

http://adlibitum.oats.inaf.it/monaco/pinocchio/



He's cheating:
he's not N-body,
he's way too fast!



Mass flows

during the evolution

Outside the integration:

- disc instability
- major mergers
- minor mergers
- tidal stripping
- disruption
- enter cluster
- quasar wind

Feedback sources

1) correlated typeII SNe giving rise to super-bubbles sweeping the ISM

2) AGNs

Feedback types

1) thermal feedback from SNe to the ISM

2) kinetic feedback from SNe to the ISM

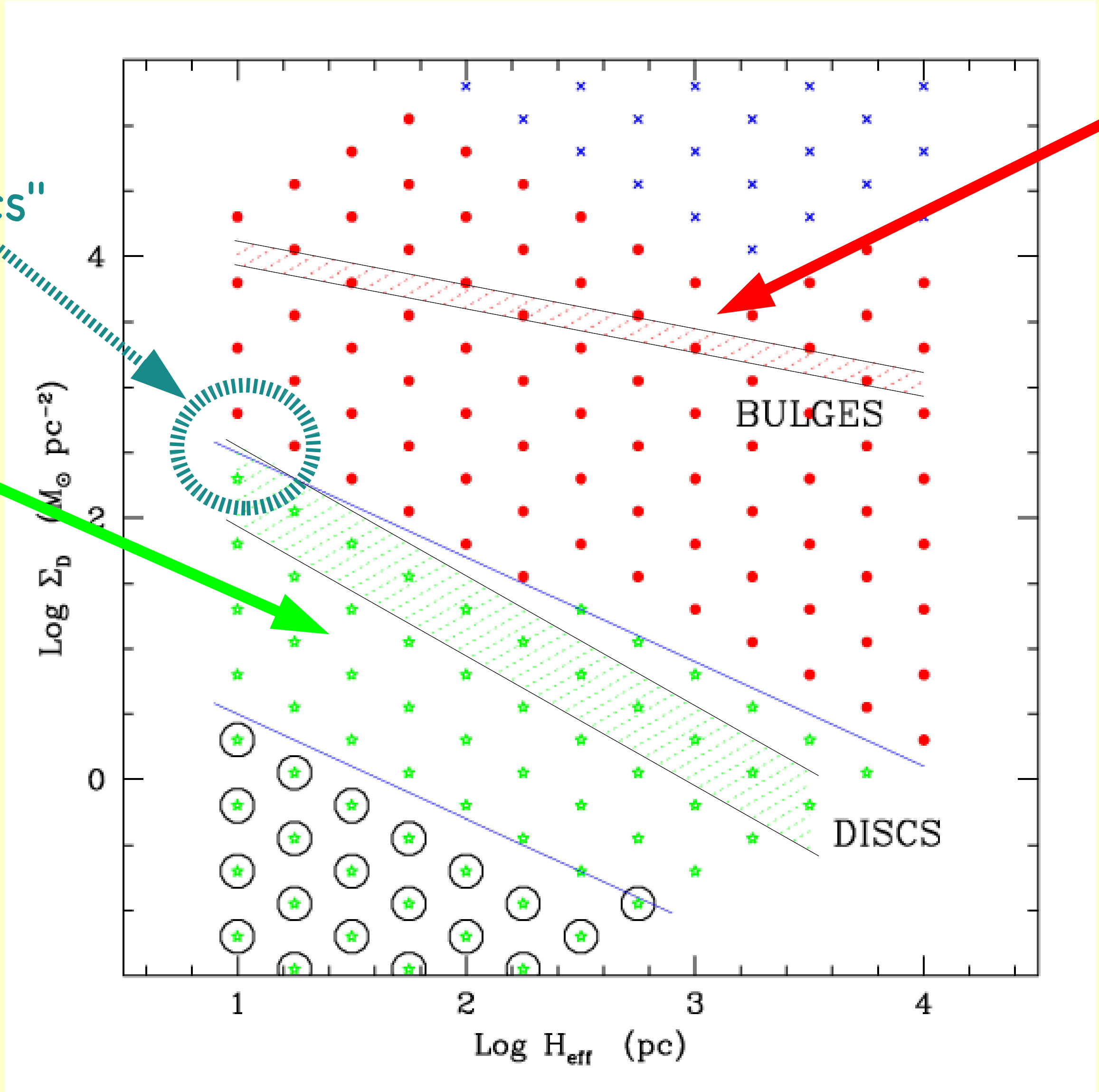
3) RE: quasar-triggered galaxy winds

4) RI: feedback from AGN jets to the ICM

Stellar feedback regimes (PM 2004)

"thick discs"

Thin systems:
super-bubbles blow out of the system
-> most energy is injected into the external halo



Thick systems:
superbubbles are confined by the pressure of the hot phase
-> most energy injected into the system

Kinetic feedback: regulating turbulence (and kicking gas off the galaxy)

Typical velocity of cold gas:

$$\dot{E}_{sn} = f_{kin} \frac{\dot{M}_{sfr}}{M_{star,sn}} E_{51}$$

$$\dot{E}_{turb} \propto \frac{-M_{cld}\sigma^3}{R_{drive}}$$

$$\frac{d}{dt}\frac{M_{cold}\sigma^2}{2} = \dot{E}_{sn} + \dot{E}_{turb} = 0$$

$$\Rightarrow \sigma = \sigma_0 t_{star,Gyr}^{-1/3}$$

Thin systems:

- energy is mostly blown out
- t_{star} is high

→σ ~ 7 km s^{-1}

Thick systems:

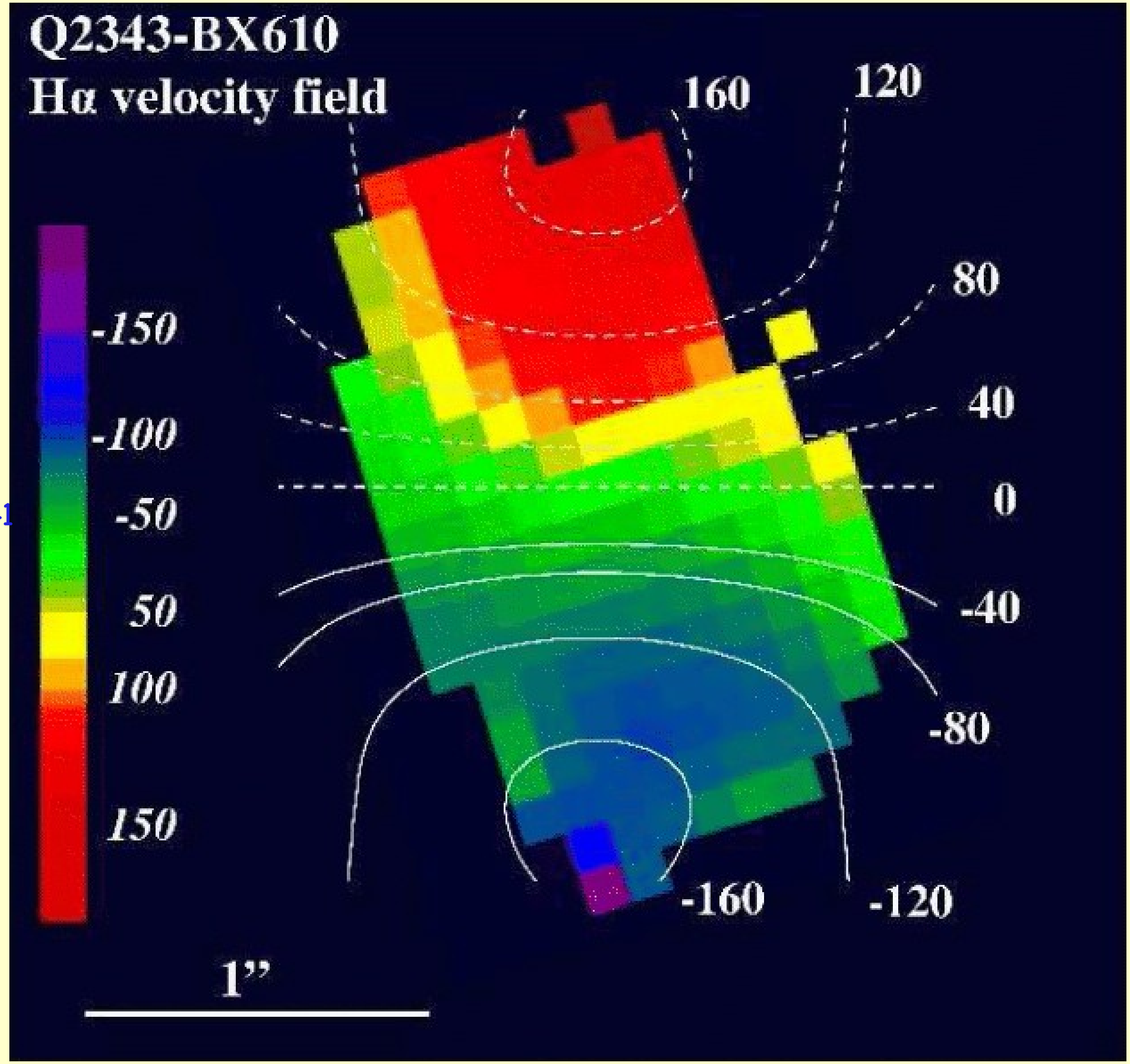
- energy is injected into ISM
- t_{star} is low

→σ can be high!

IFU observation of a z~2 starburst: a "thick disc" in action!

$V_c/\sigma \sim$ 2–4

$\sigma \sim$ 50 km s^{-1}



(Forster-Schreiber et al. 2006)

High surface density discs

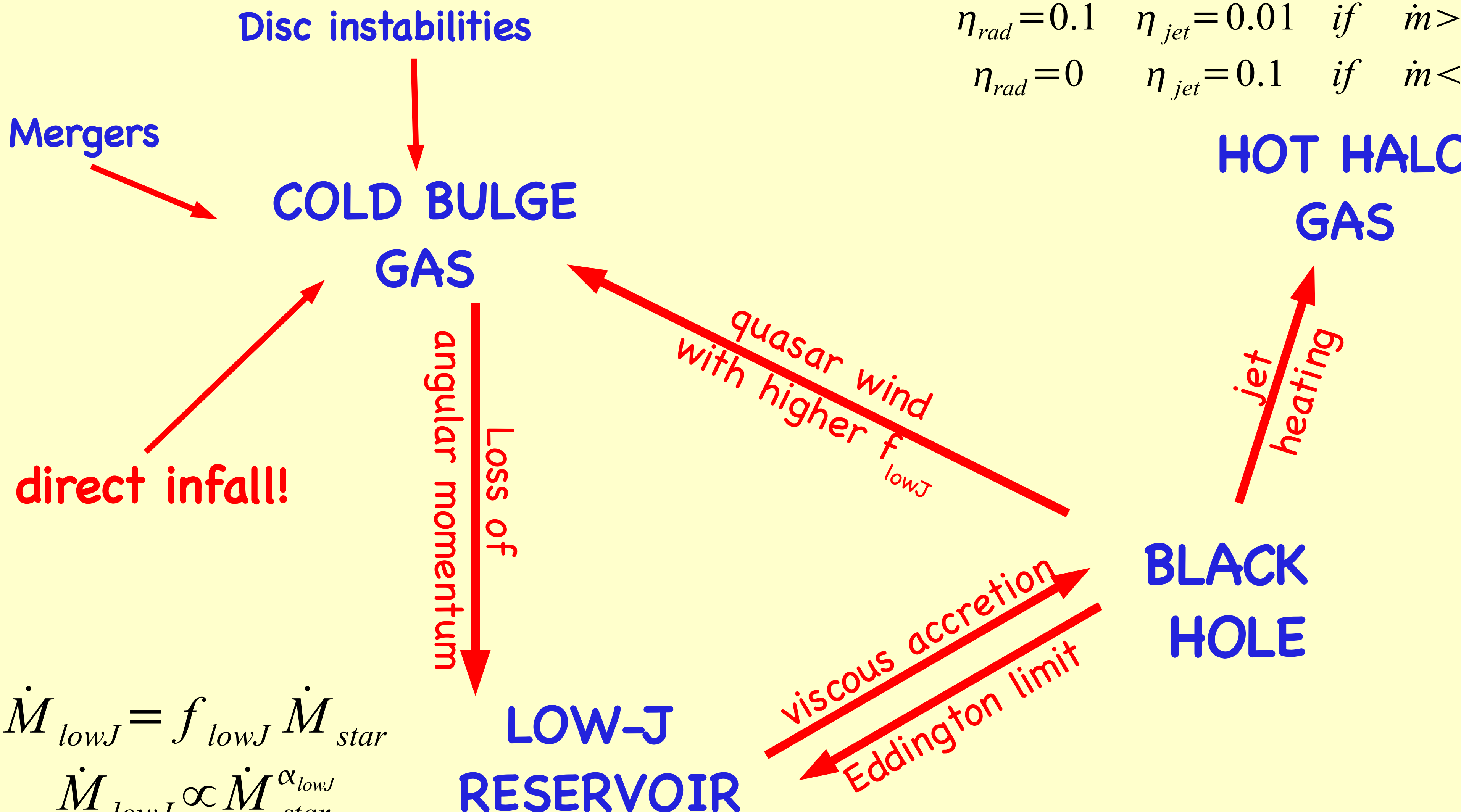
- High surface density
- High velocity dispersion of cold gas
- Loss of angular momentum
- Formation of bulges

Modeled as a disc instability when $\Sigma > \Sigma_{crit}$

Inserting accretion onto black holes

each bulge has a seed BH of $10^3\ M_\odot$

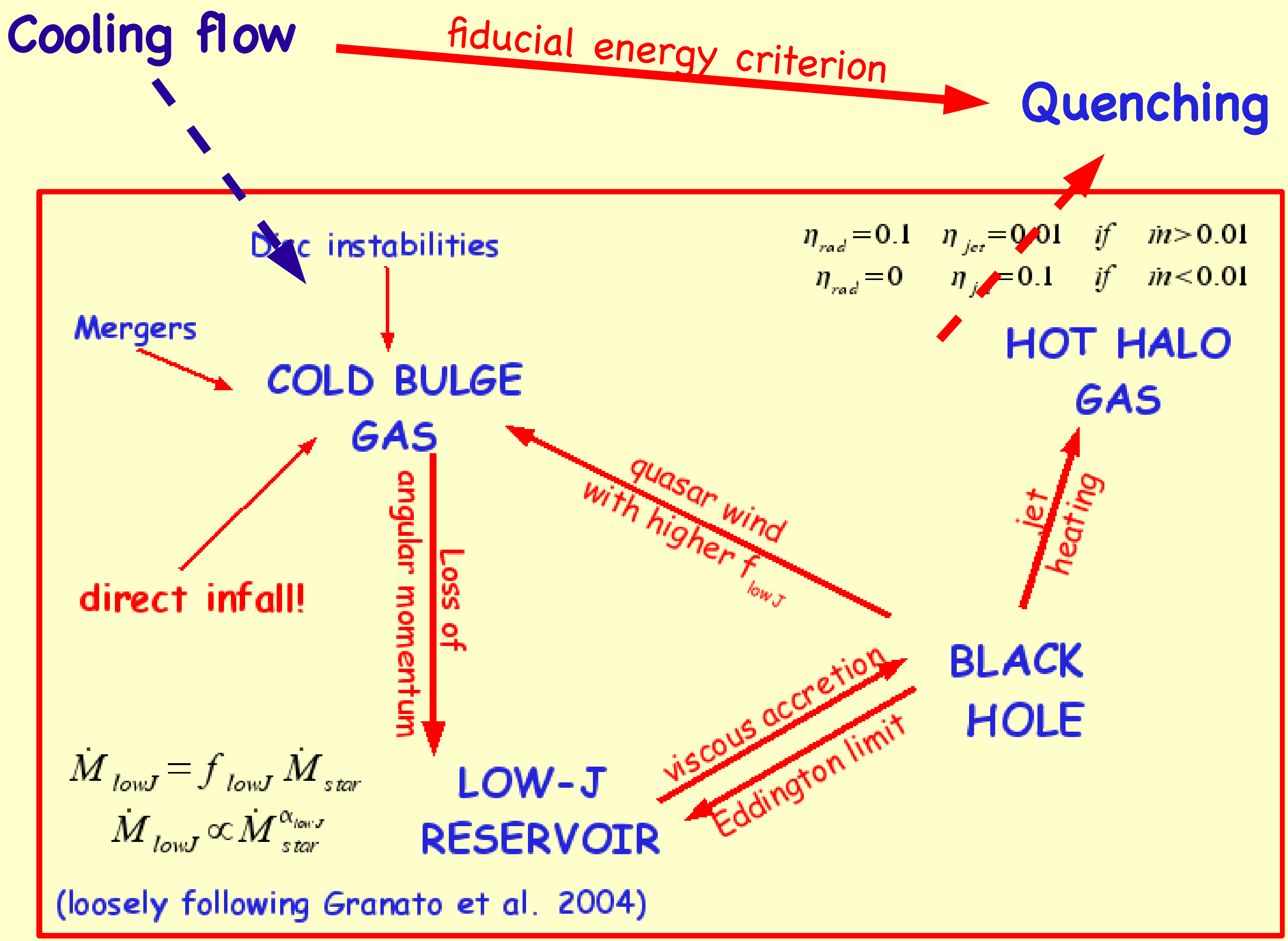
$$\eta_{rad} = 0.1 \quad \eta_{jet} = 0.01 \quad if \quad \dot{m} > 0.01$$
$$\eta_{rad} = 0 \quad \eta_{jet} = 0.1 \quad if \quad \dot{m} < 0.01$$



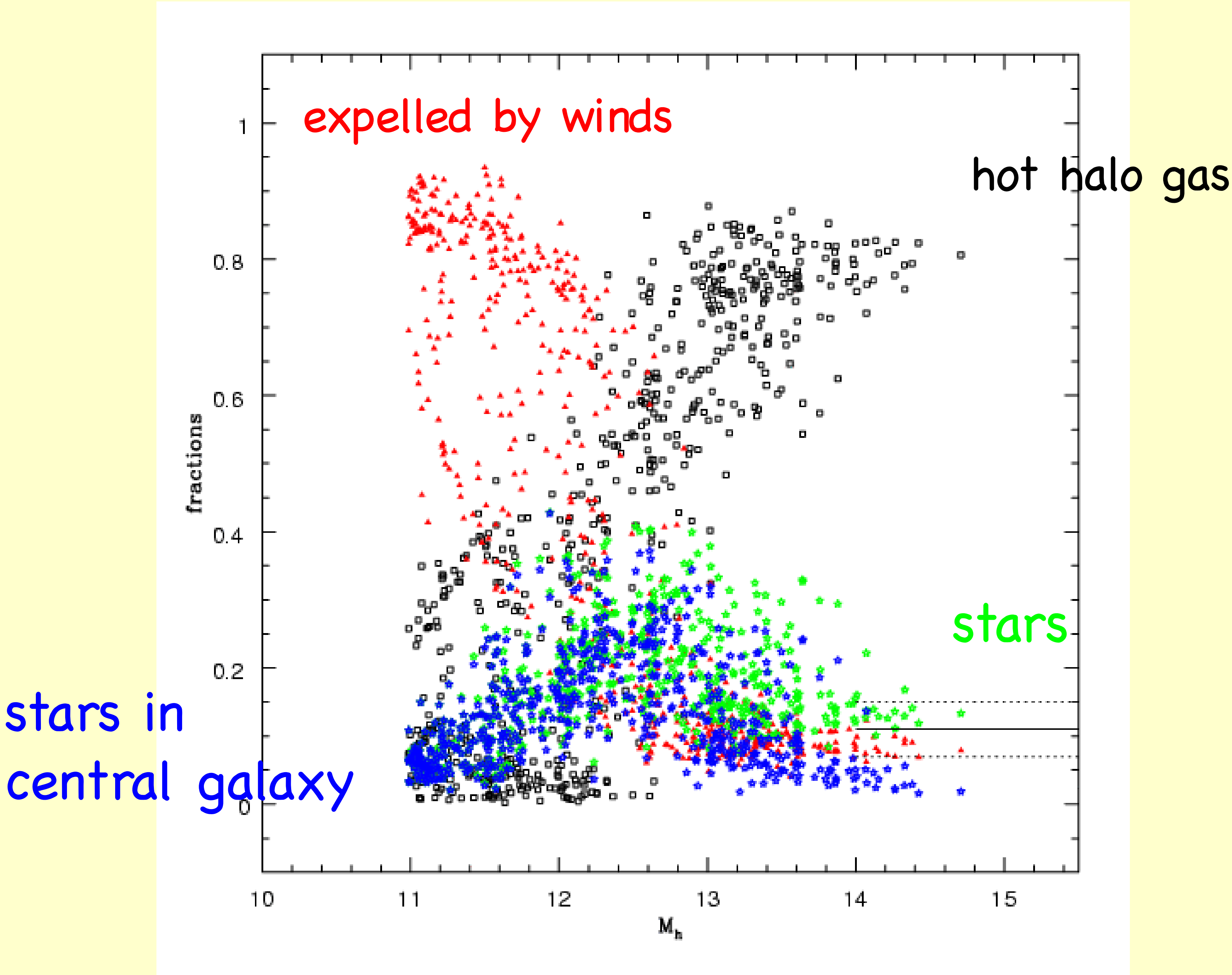
$$\dot{M}_{lowJ} = f_{lowJ}\, \dot{M}_{star}$$
$$\dot{M}_{lowJ} \propto \dot{M}_{star}^{\alpha_{lowJ}}$$

(loosely following Granato et al. 2004)

Forced quenching of the cooling flow

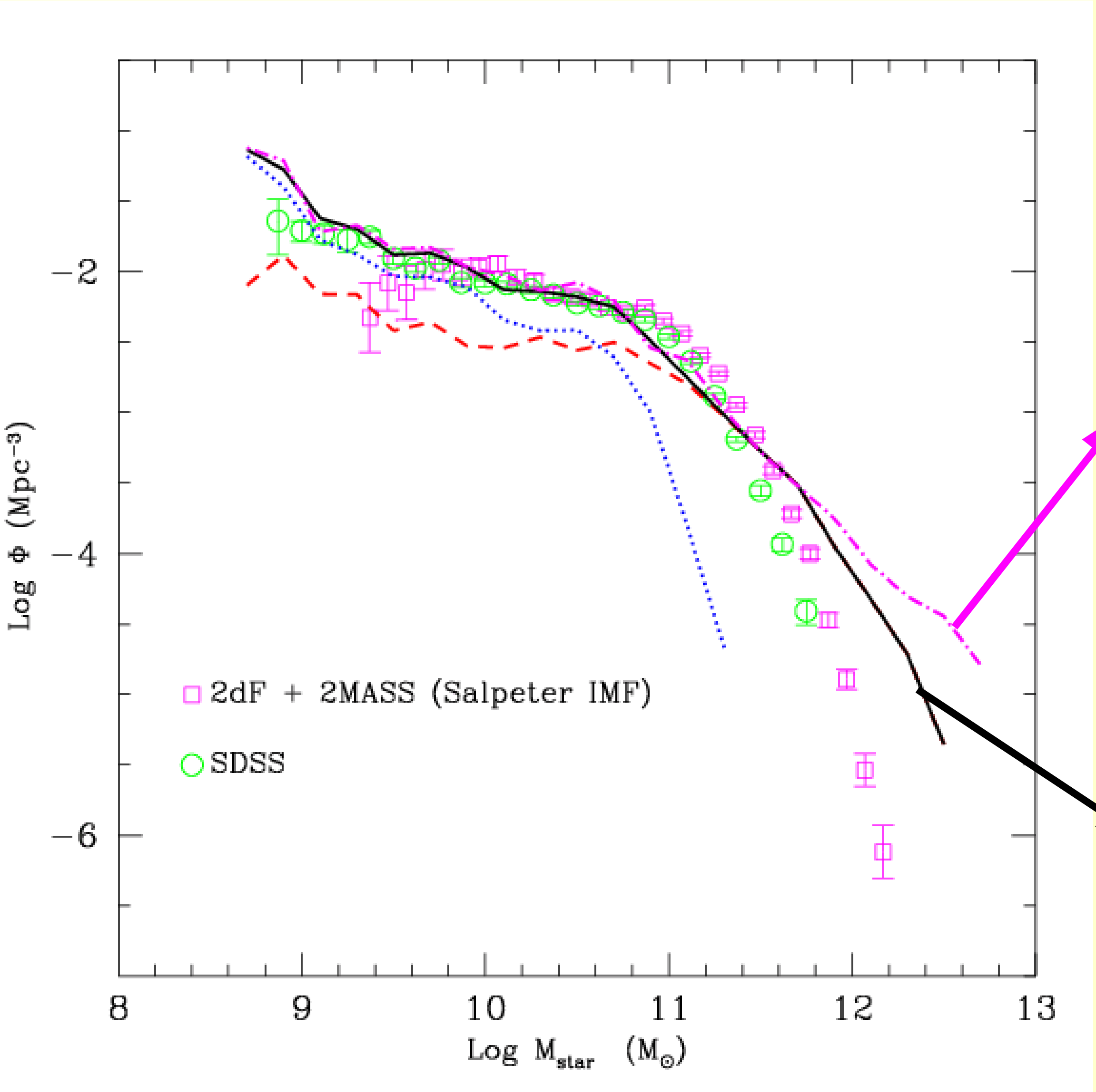


The effect of feedback in DM halos



Results: suppressing star formation in ellipticals

Box of 150 Mpc
(H_0=70 km s^{-1} Mpc^{-1})
Smallest progenitor is 1.0 x 10^{10} M_{sun}
standard cosmology



without jet feedback

with jet feedback

Results: hard X-ray LF

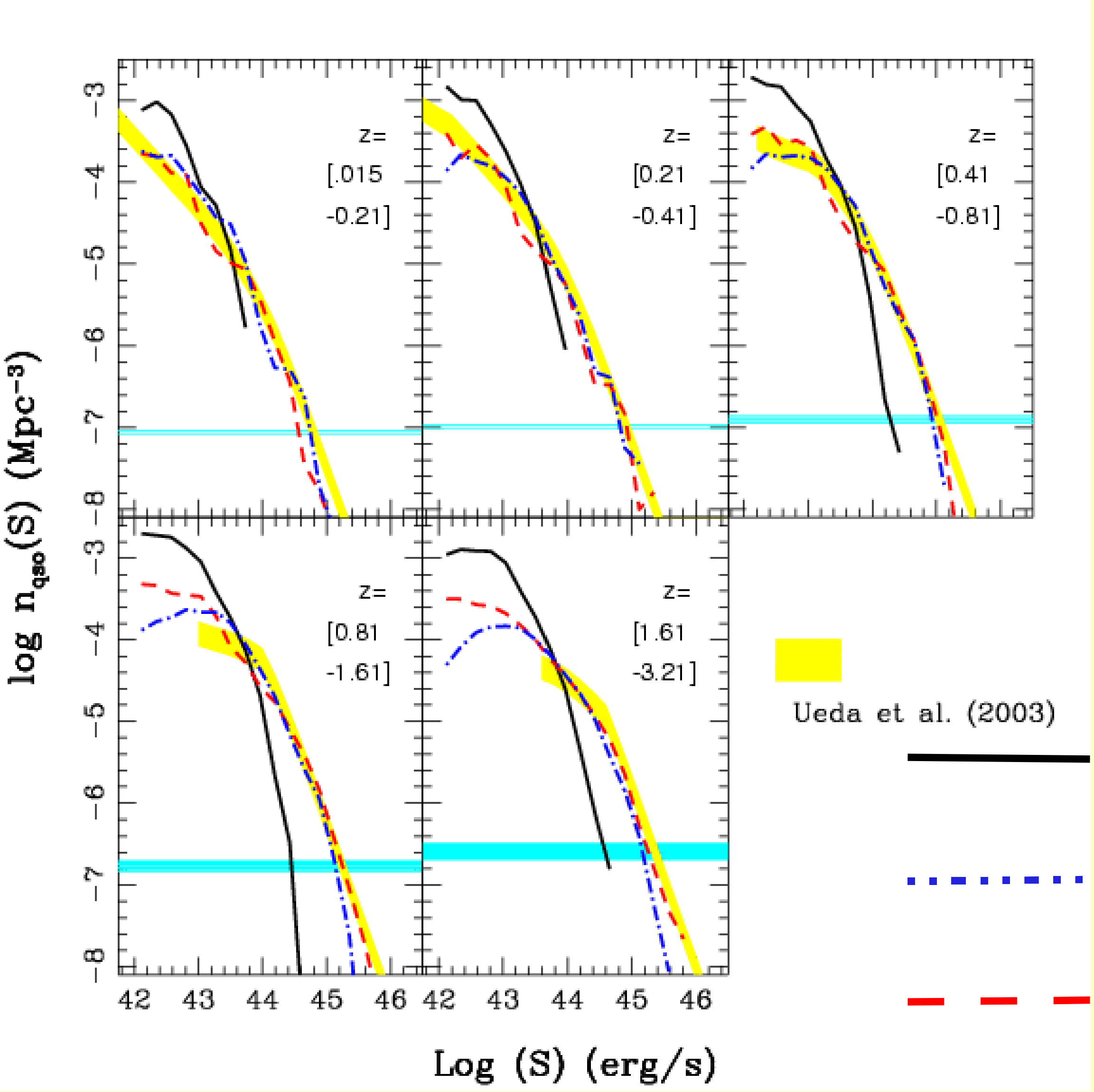
(Fontanot, PM, Cristiani, Tozzi, submitted to MNRAS)

Box of 200 Mpc (H_0=70 km s^{-1} Mpc^{-1}) smallest progenitor is 2.4 x 10^{10} M_{sun}

N_H distribution by La Franca et al. (2005)

Bolometric corrections by Marconi et al. (2005)

Optical type I/type II fraction by Simpson (2005)



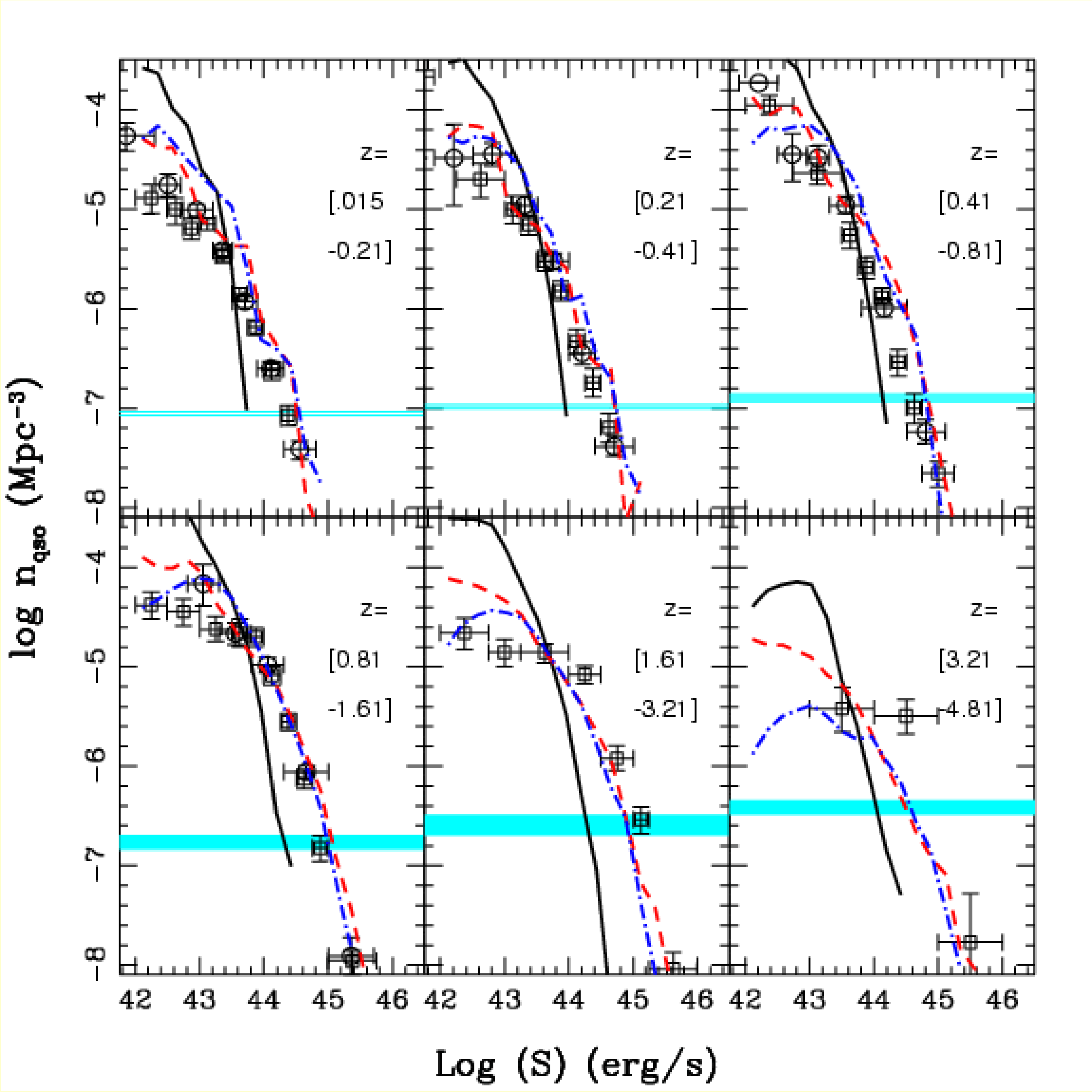
σ_0 = 60 km s^{-1}

no winds, no "thick disc"

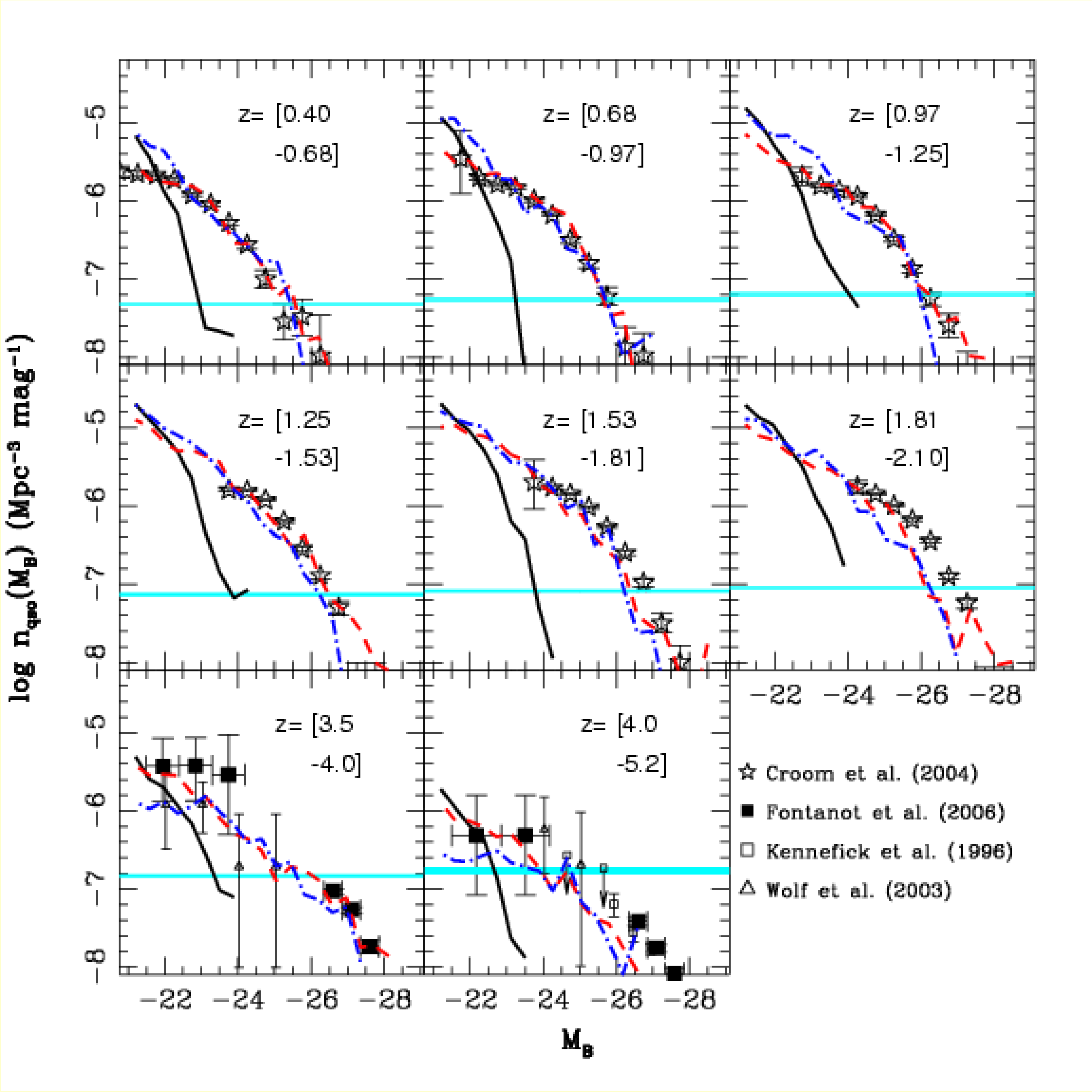
winds, α_{lowJ}=2

winds, α_{lowJ}=1, "thick disc"

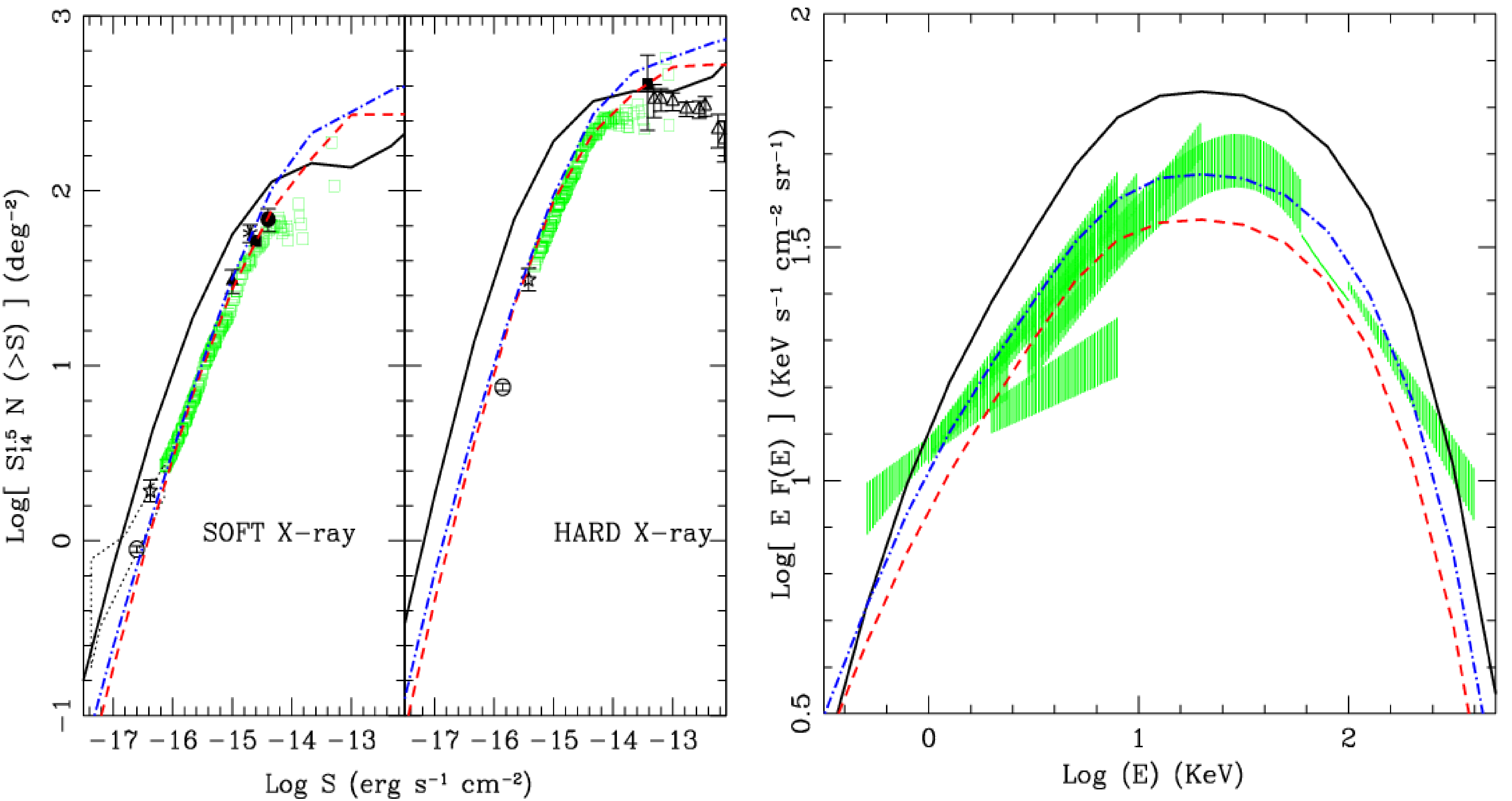
Results: soft X-ray LF



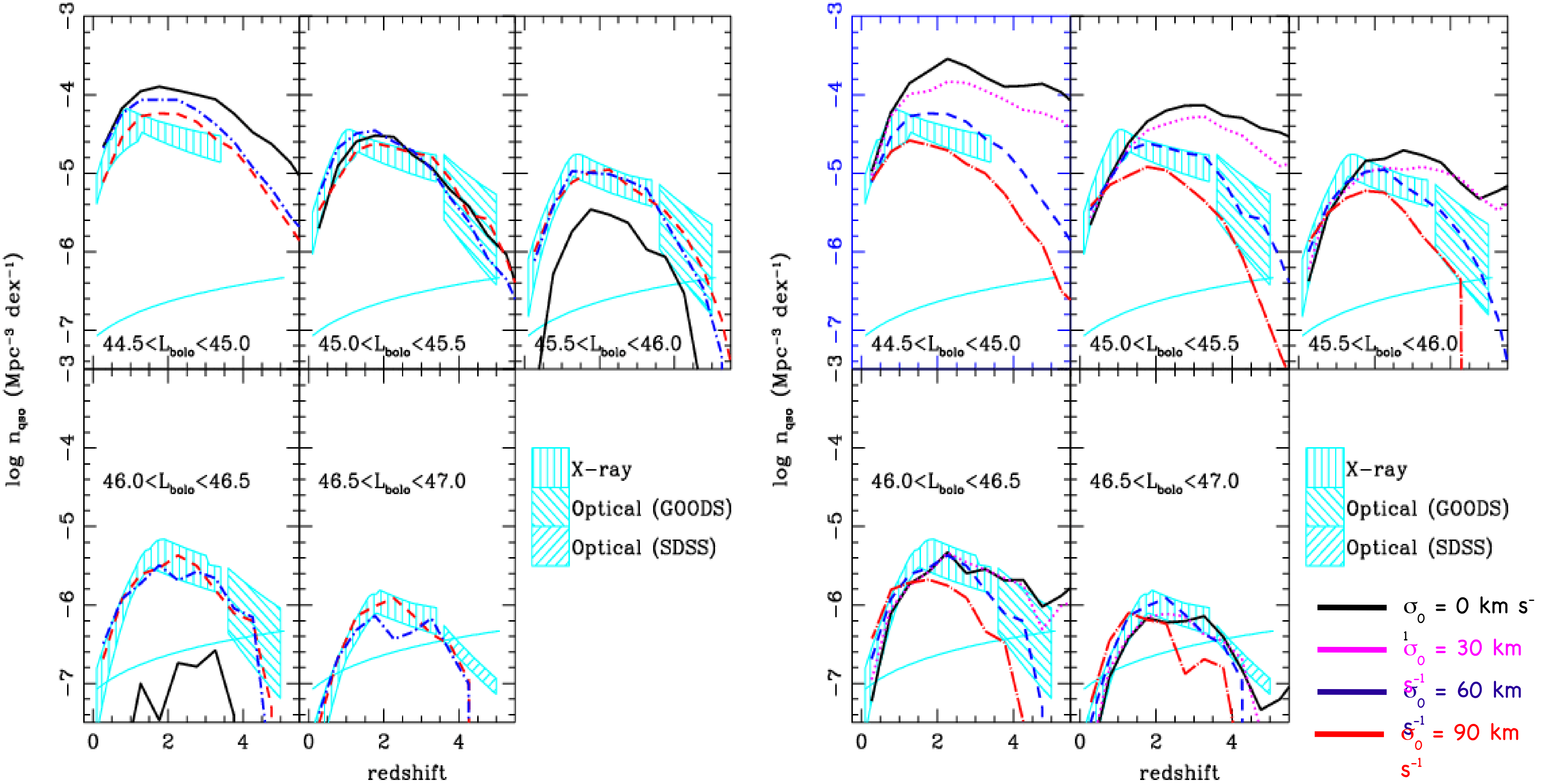
Results: optical LF



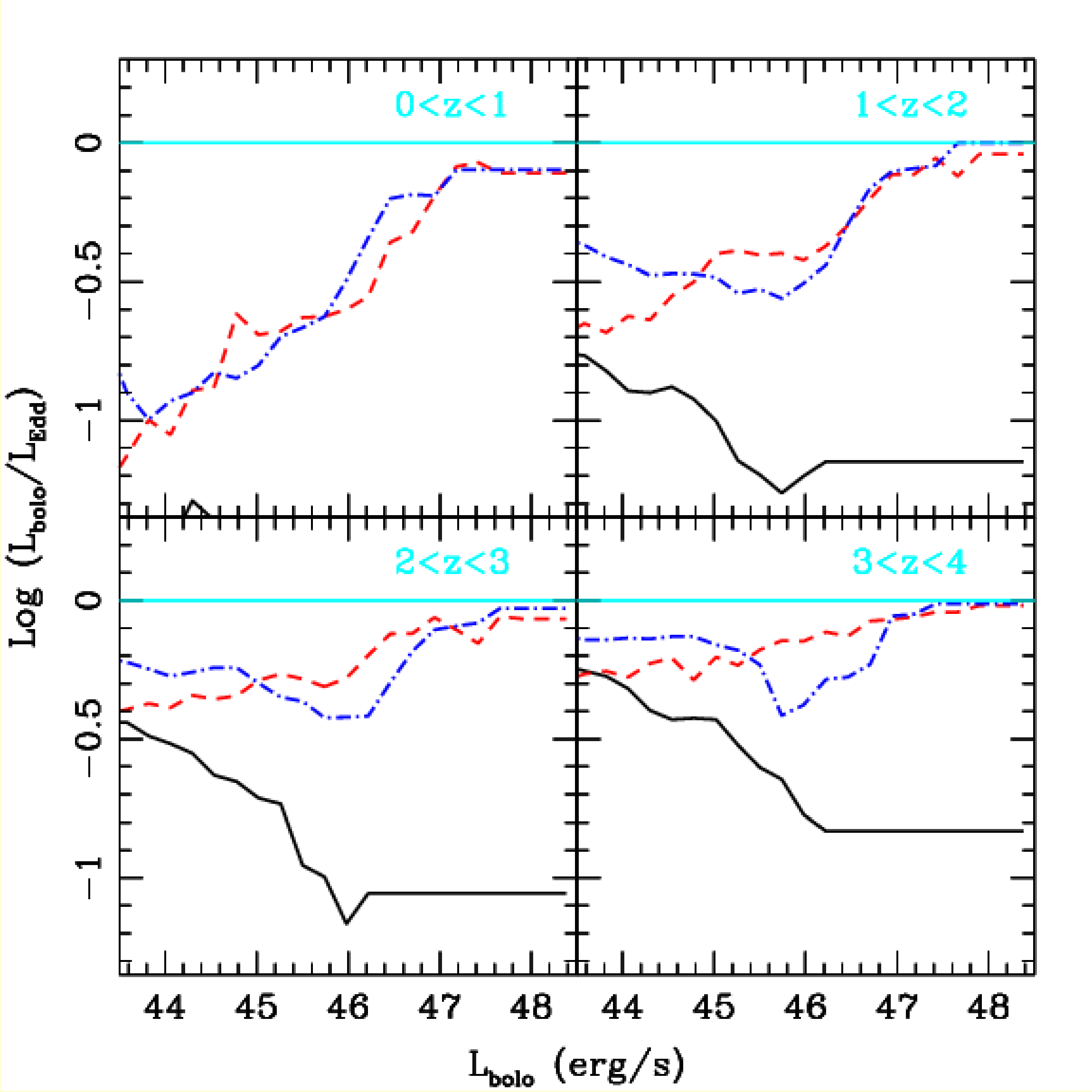
Results: X-ray counts and background



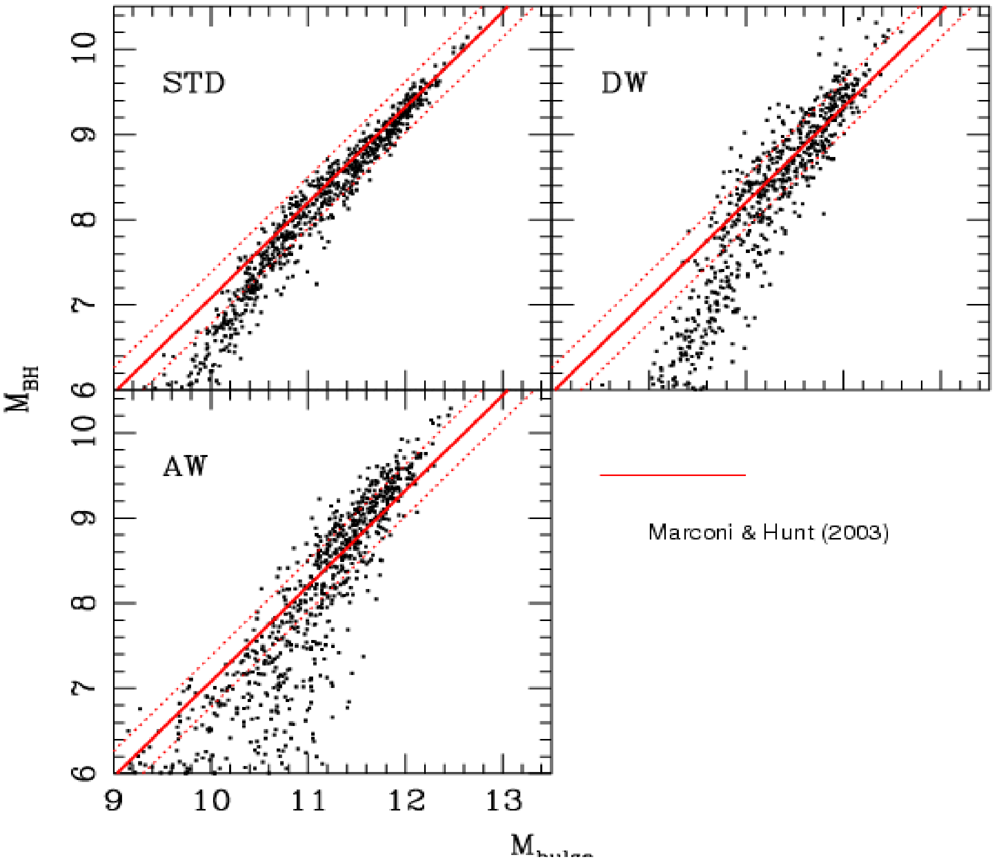
Results: downsizing

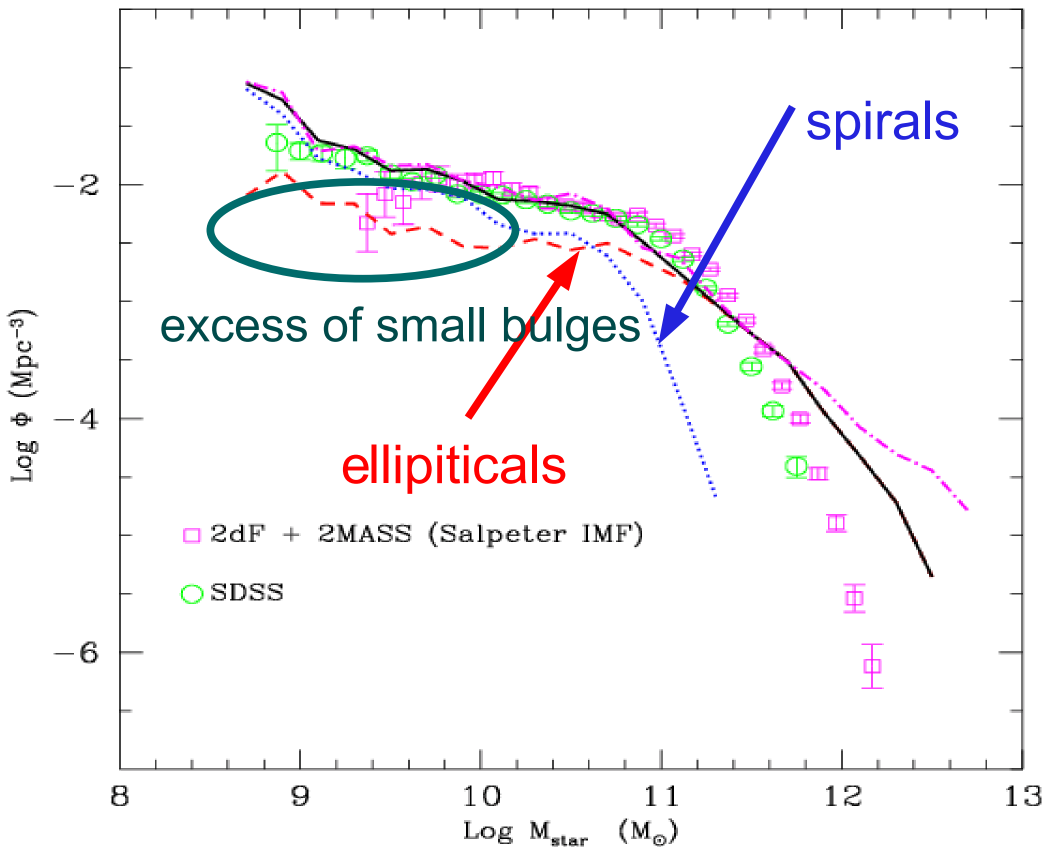


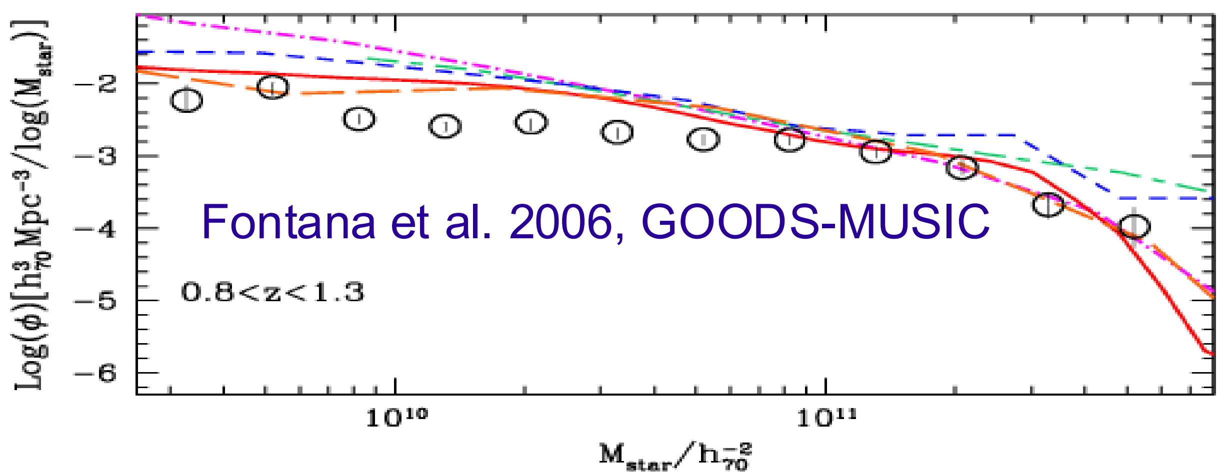
Predictions: Eddington ratio



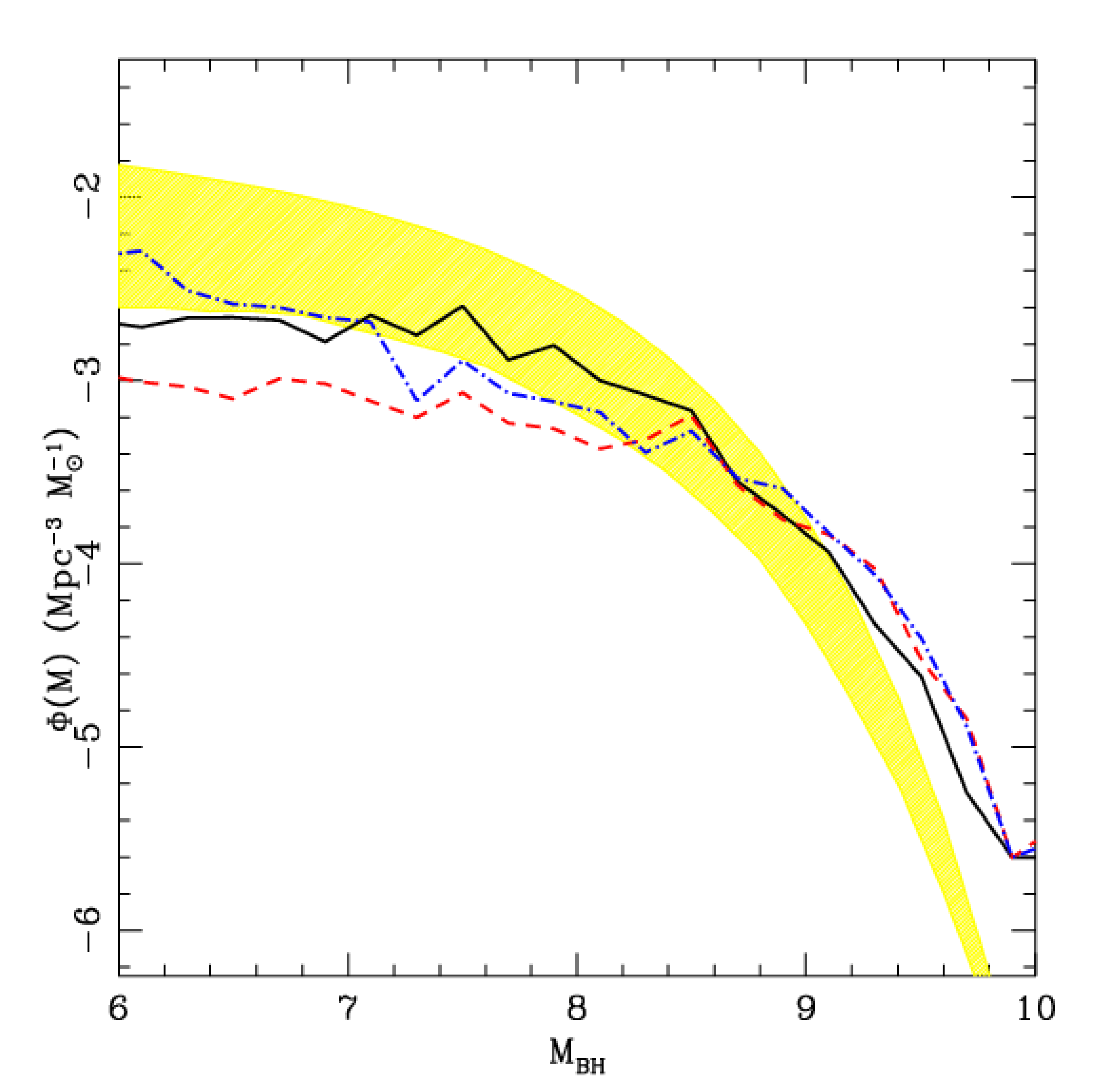
Results: BH-bulge relation





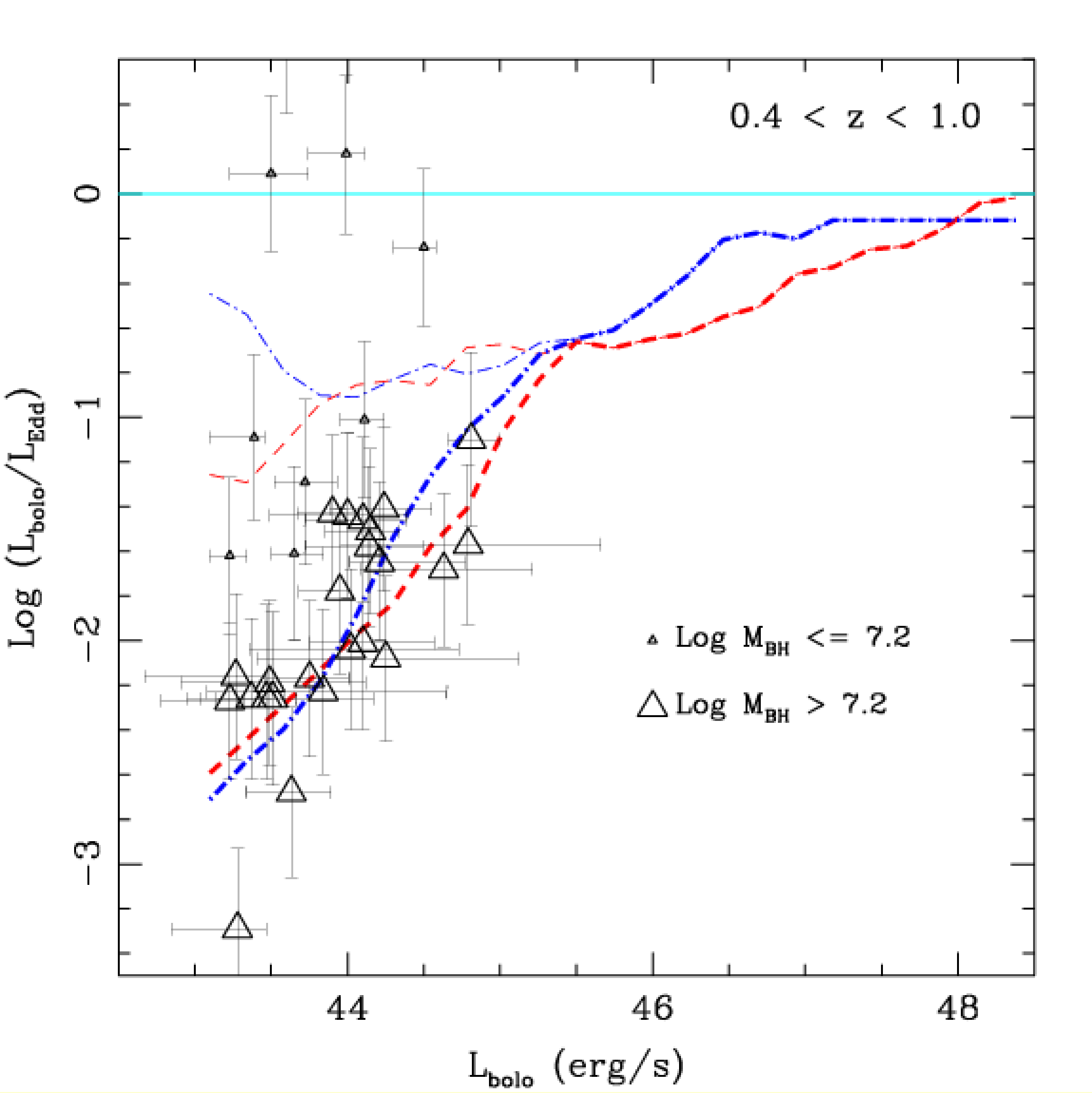


Results: MF of remnant BHs



Test: Eddington ratios

The bulk of the XRB is done by relatively large BHs accreting at low rates



GALRISE over-corrects for the excess of small bulges

Conclusions: what are we learning?

The "anti-hierarchical" AGNs are compatible with ΛCDM

Kinetic feedback, due to turbulence in star-forming bulges, is the most likely responsible for downsizing

In GALRISE quasar winds are needed to reproduce bright quasars

The parameter space of the model is too wide to obtain robust conclusions

At small stellar masses all models predict an excess of small bulges, and this must be over-corrected by feedback

Need to look at the details of feedback!

- observed relation between star formation and accretion
- quasar winds (warm/cold absorbers, Lyman- blobs)
- details of stellar feedback in starforming galaxies