star formation feedback in galaxy formation models

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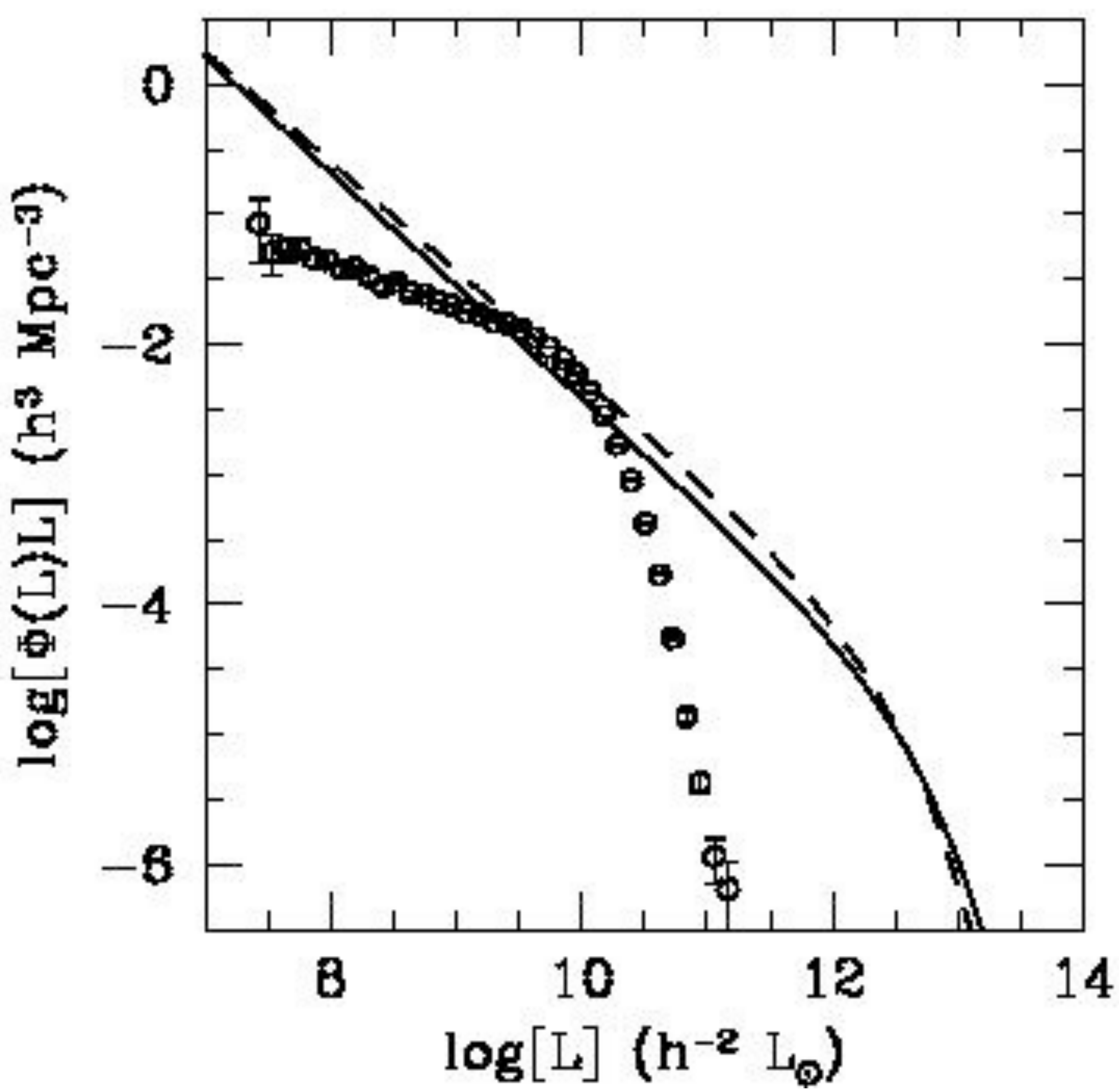
CDM galaxy formation

- galaxies form in dark matter halos
- CDM model predicts too many low-mass and high-mass halos
- “feedback” is needed to explain galaxy LFs.



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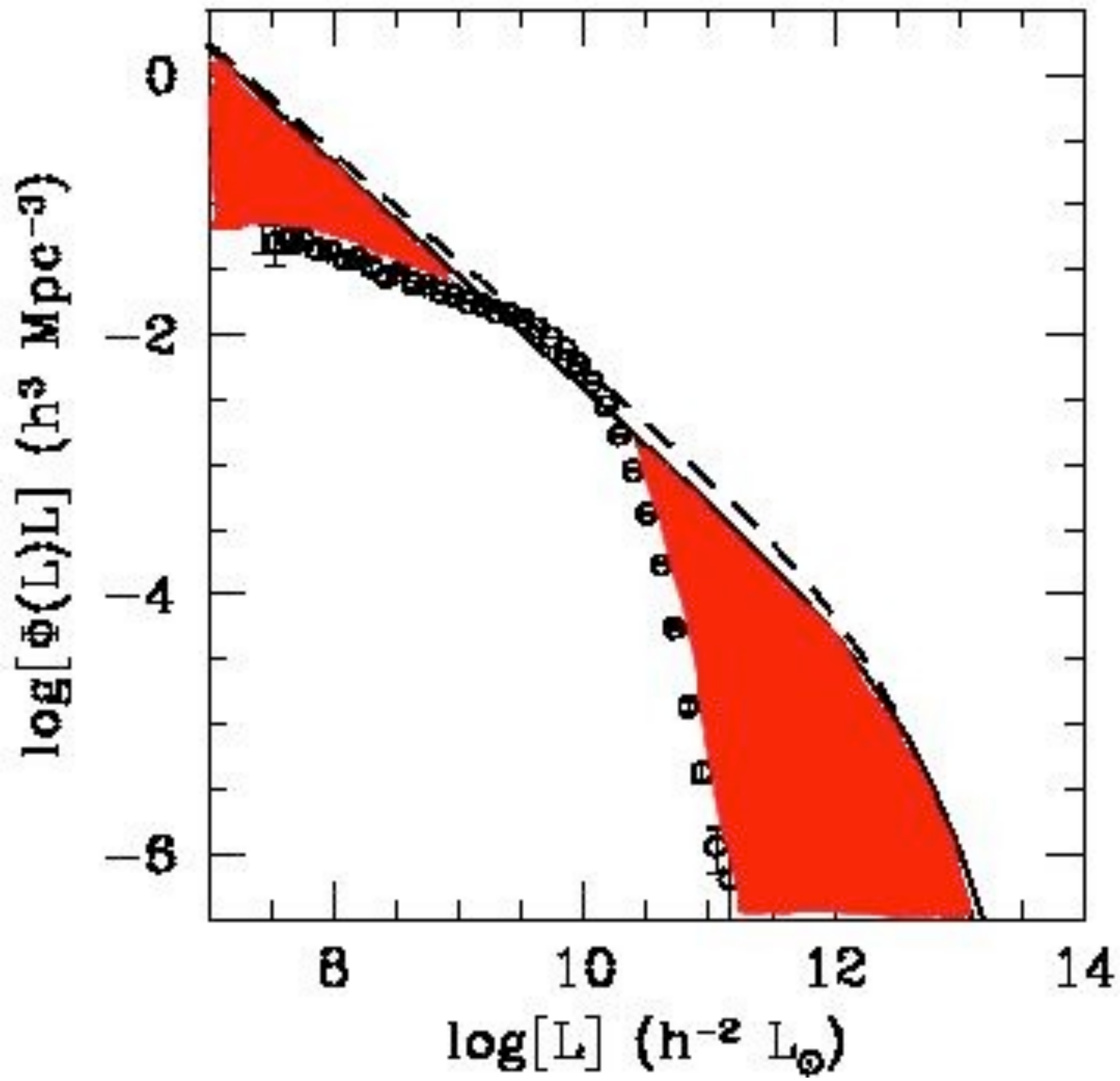

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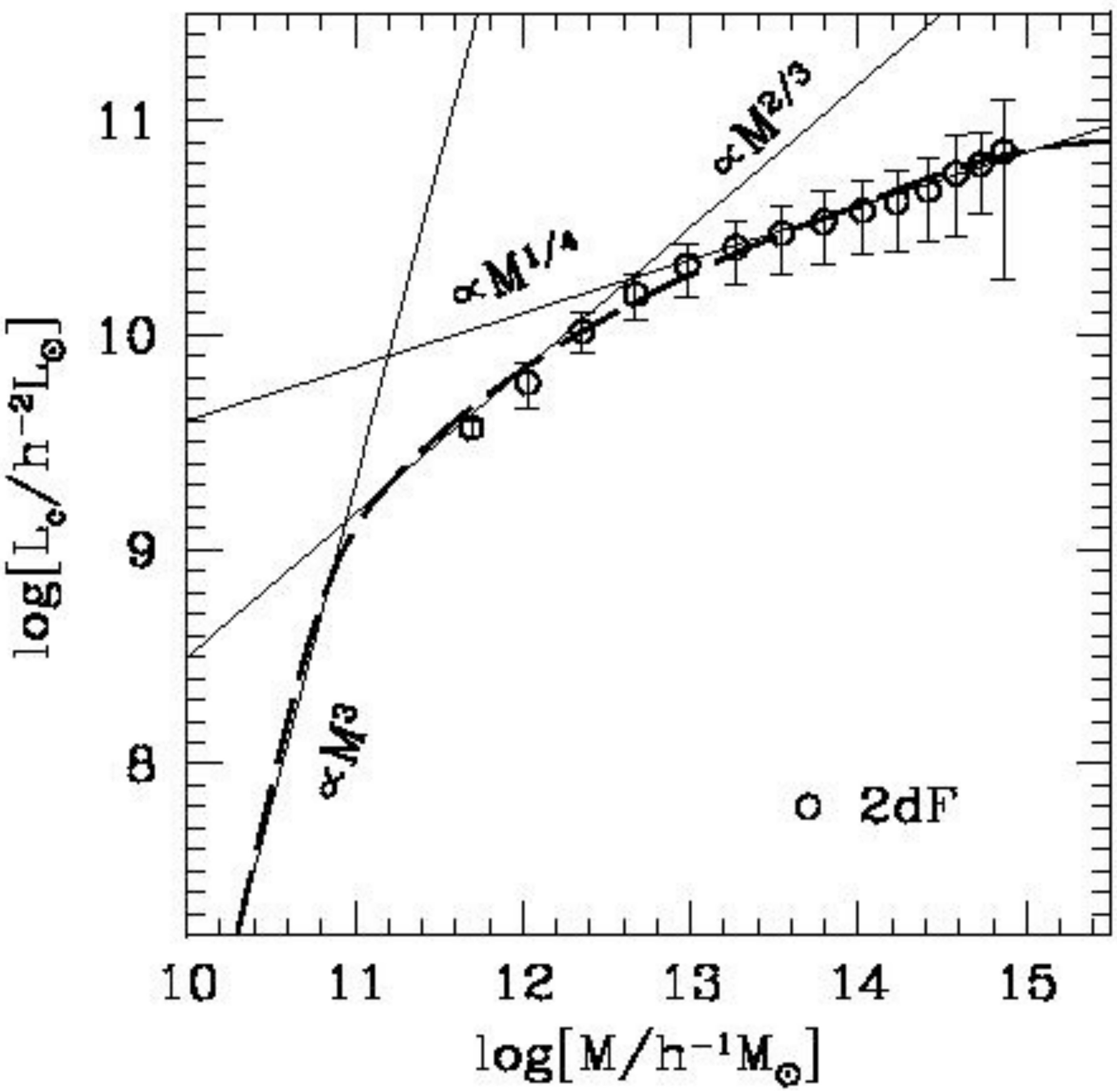
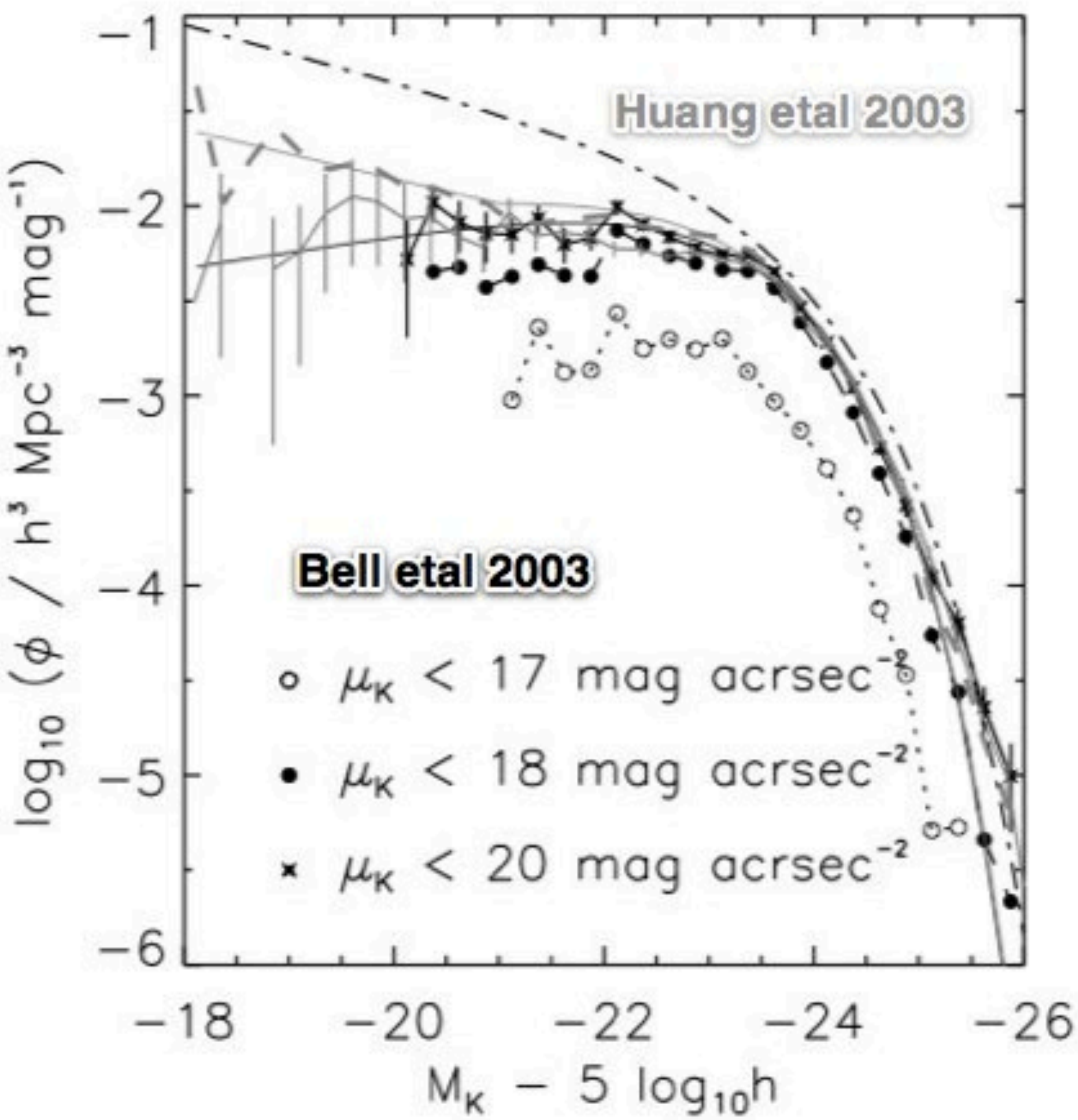
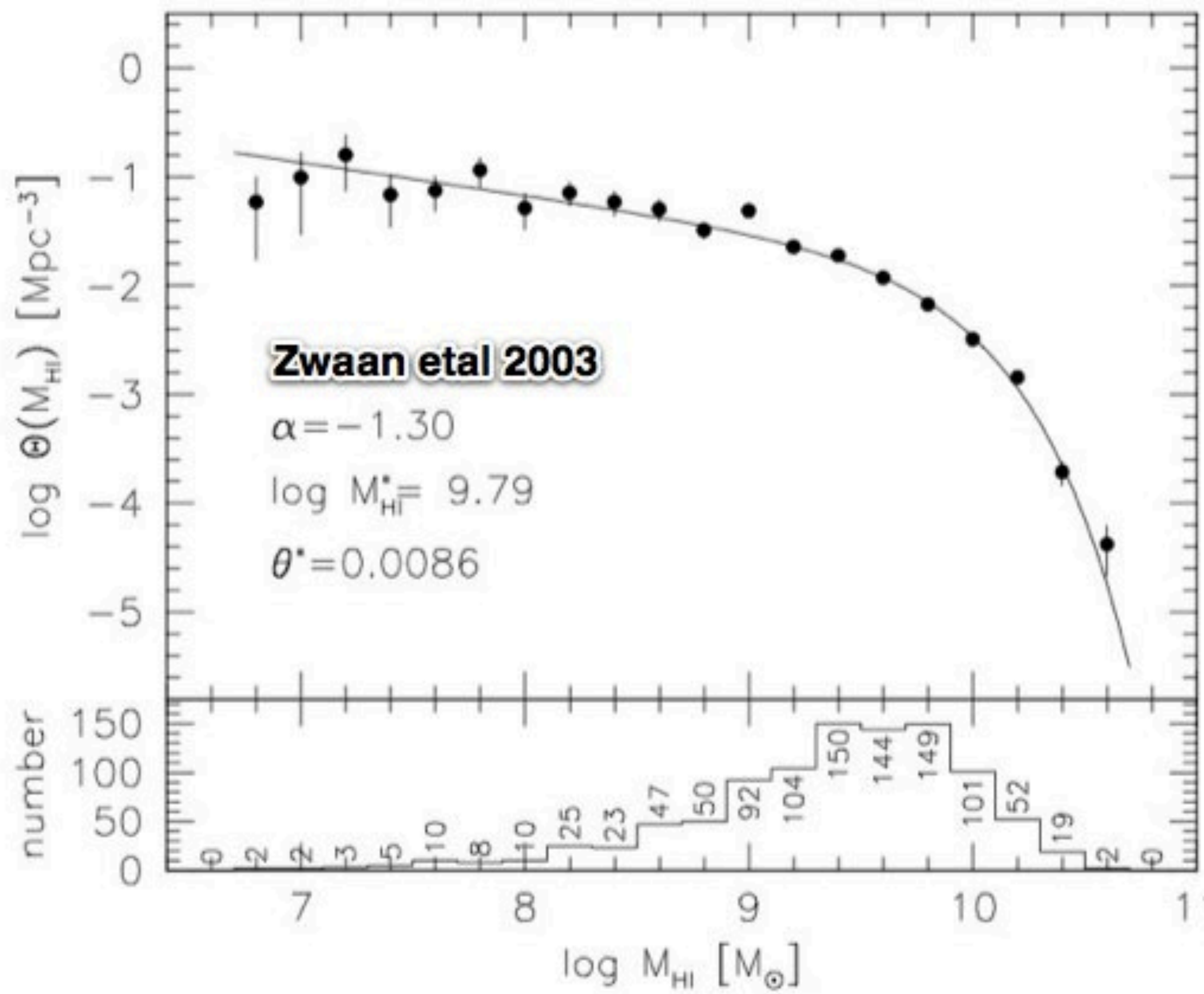
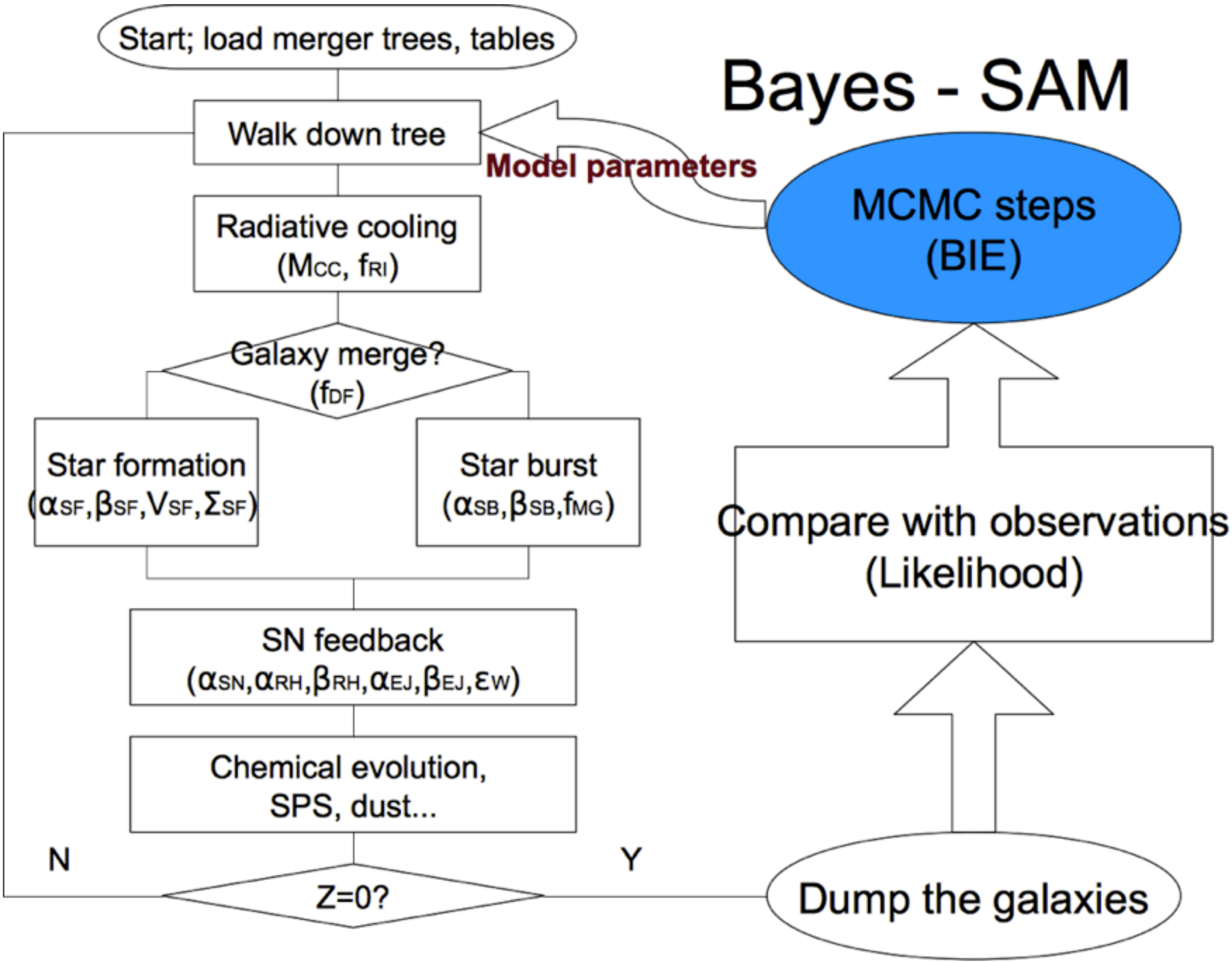


K-band LF

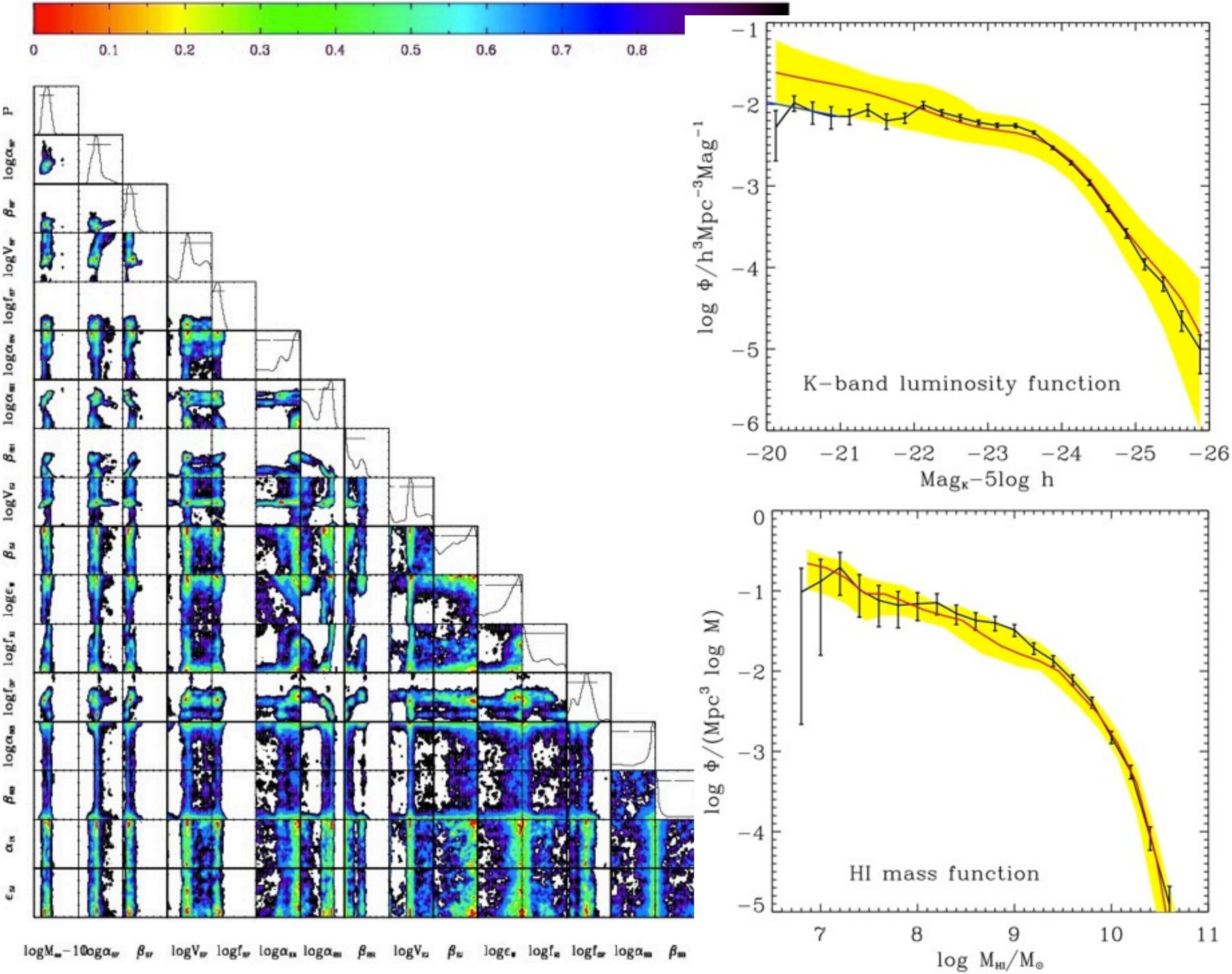


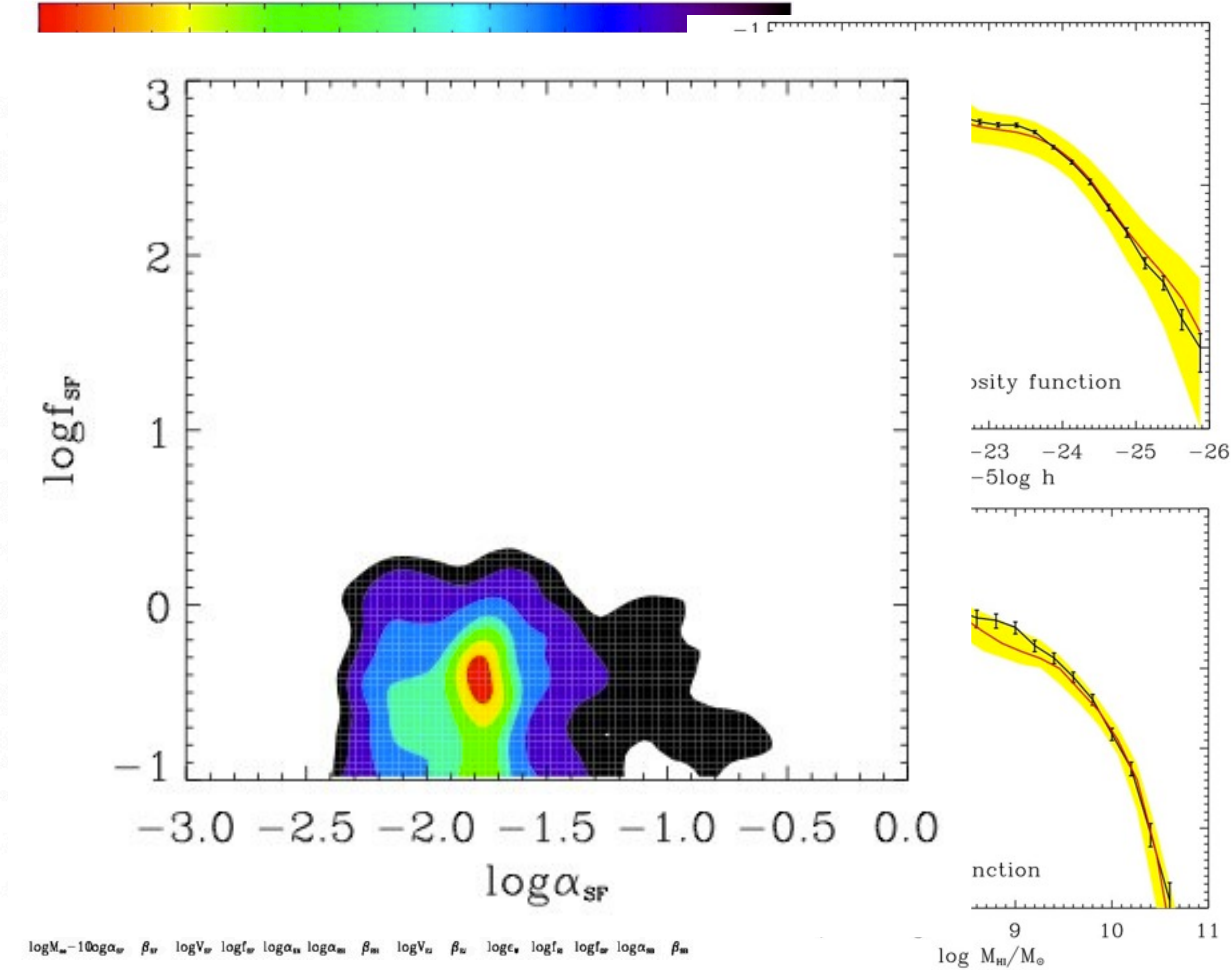
HI MF



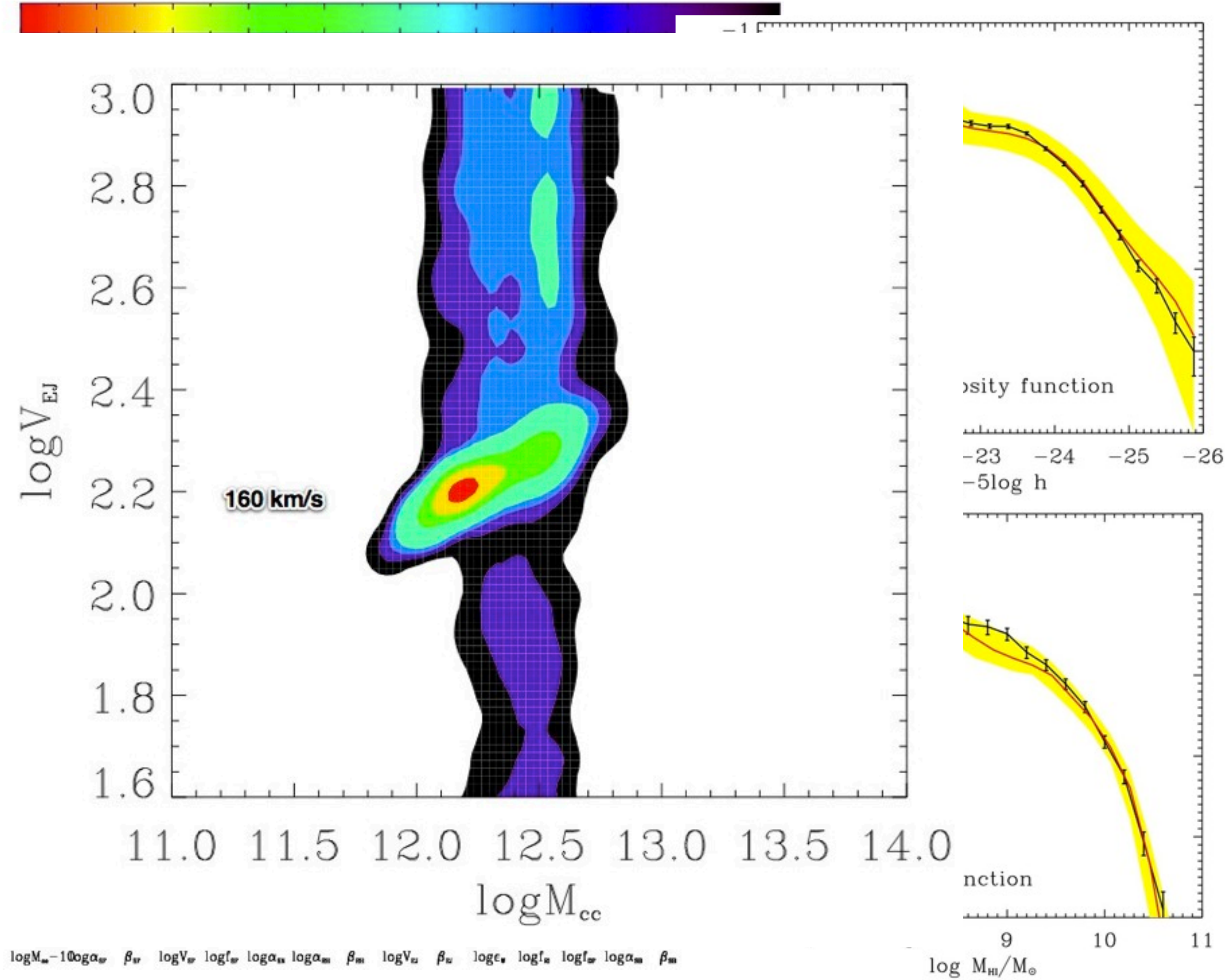


Start; load merger trees, tables
Bayes - SAM
Walk down tree
Model parameters
MCMC steps
(BIE)
Radiative cooling
(M_{CC}, f_{RI})
Galaxy merge?
(f_{DF})
Star formation
(α_{SF},β_{SF},V_{SF},Σ_{SF})
Star burst
(α_{SB},β_{SB},f_{MG})
Compare with observations
(Likelihood)
SN feedback
(α_{SN},α_{RH},β_{RH},α_{EJ},β_{EJ},ϵ_{W})
Chemical evolution,
SPS, dust...
N
Y
Z=0?
Dump the galaxies


K-band luminosity function
log Φ/h³Mpc⁻³Mag⁻¹
Mag_K−5log h
HI mass function
log Φ/(Mpc³ log M)
log M_HI/M_⊙
logM − 10 logα β logV logf logα logα β logV β logε logf logf logα β



3
2
1
0
−1
log f_SF
−3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.0
log α_SF
osity function
−23 −24 −25 −26
−5log h
nction
9 10 11
log M_HI/M_⊙



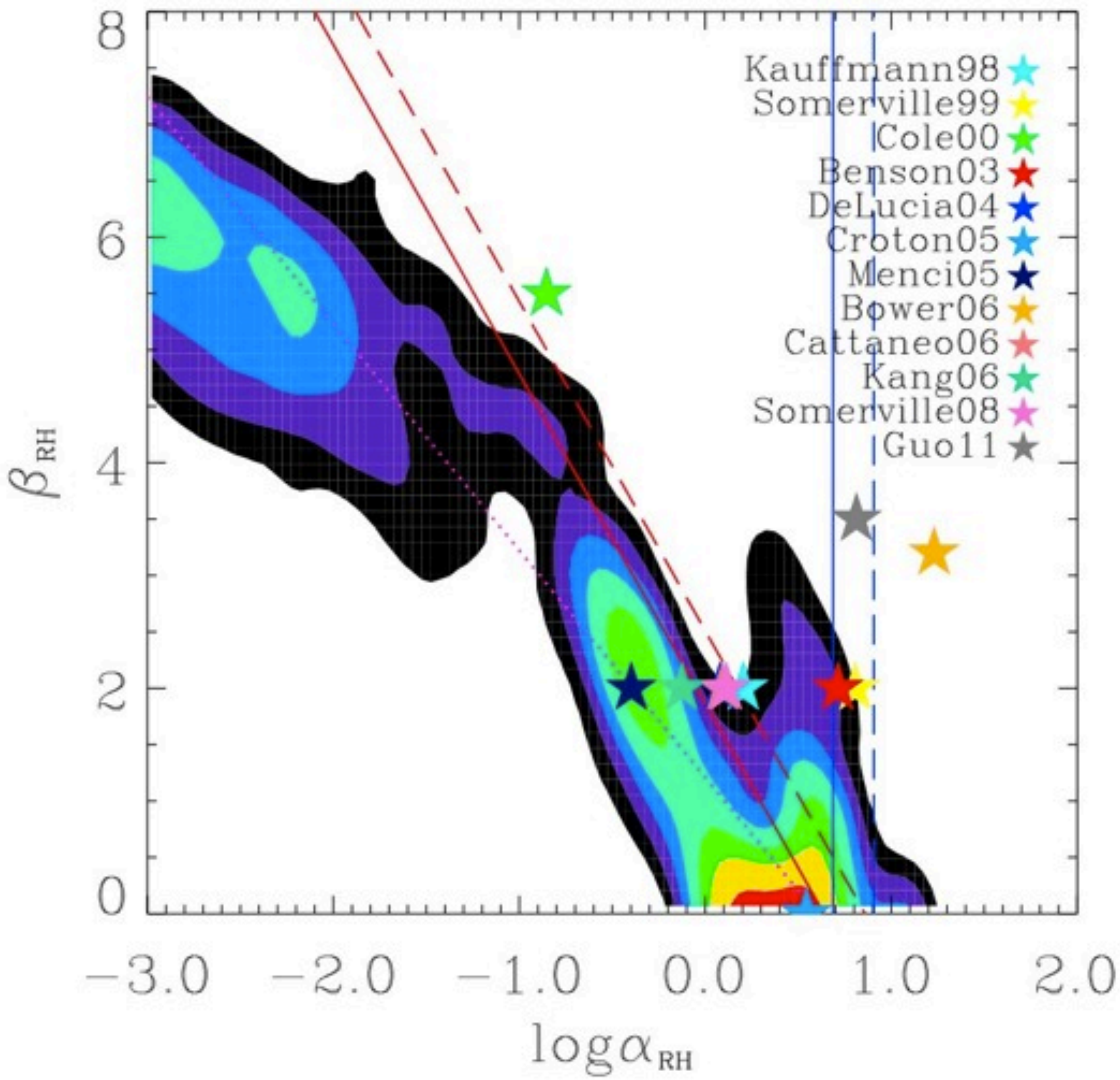
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
logV_EJ
160 km/s
11.0 11.5 12.0 12.5 13.0 13.5 14.0
logM_cc
osity function
−23 −24 −25 −26
−5log h
nction
9 10 11
log M_HI/M_⊙

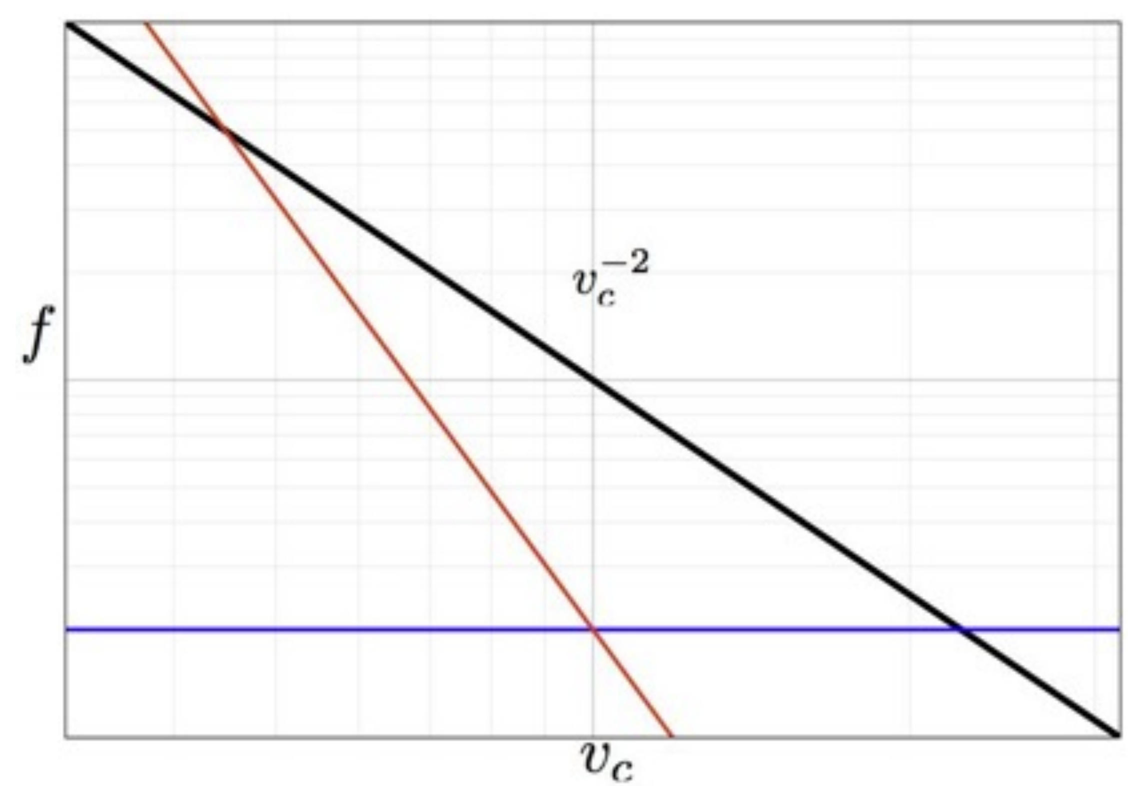
$$\Delta M_{out} = \alpha_{\rm RH}\left(\frac{200km/s}{V_{\rm c}}\right)^{\beta_{\rm RH}}\Delta M_*$$

$$\Delta E_{out} = \begin{cases} \frac{1}{2}\Delta M_{out} V_{\rm esc}^2 & \text{ejection;} \\ \frac{5}{4}\Delta M_{out} V_{\rm c}^2 & \text{reheating.} \end{cases} .$$

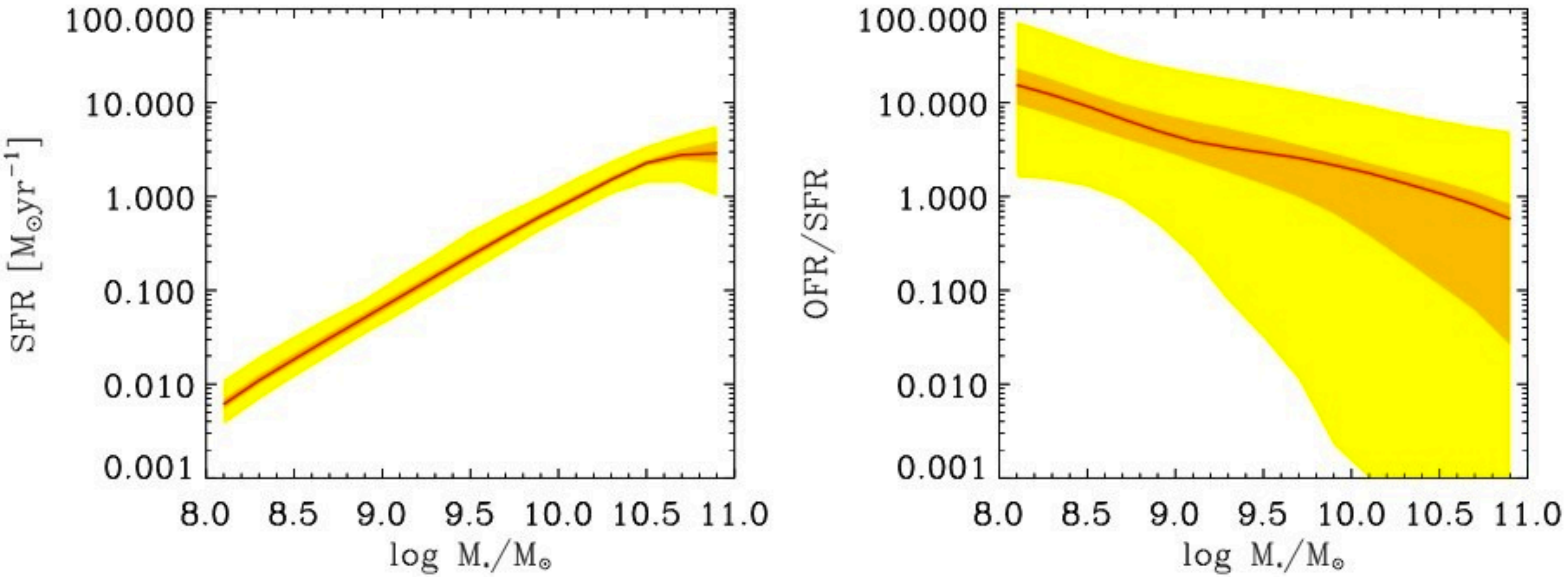
$$\Delta E_{\rm FB} = \epsilon_{FB}\eta_{\rm SN}E_{\rm SN}\Delta m_*$$

$$\Delta E_{\rm FB} \geq \Delta E_{out}$$

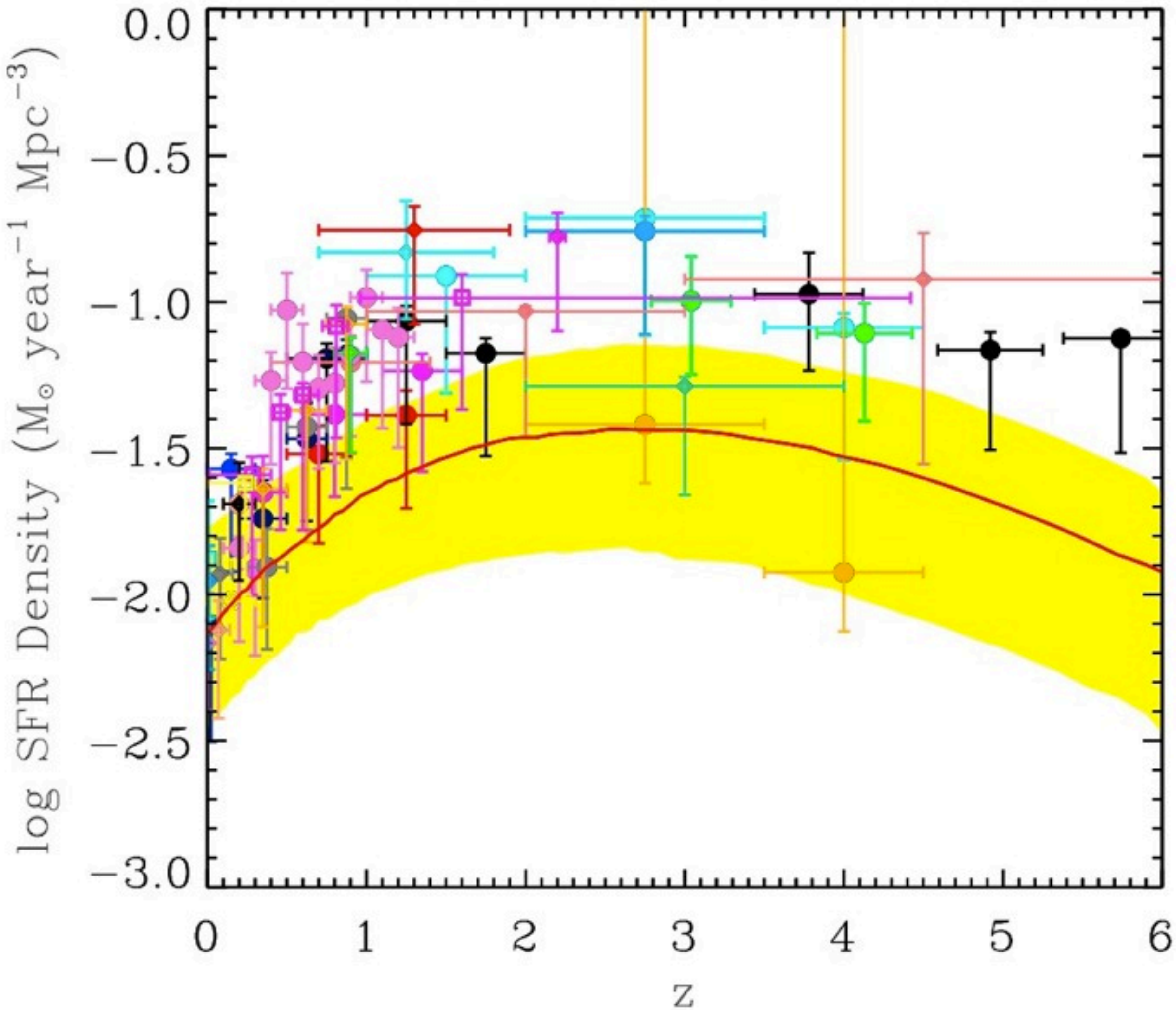




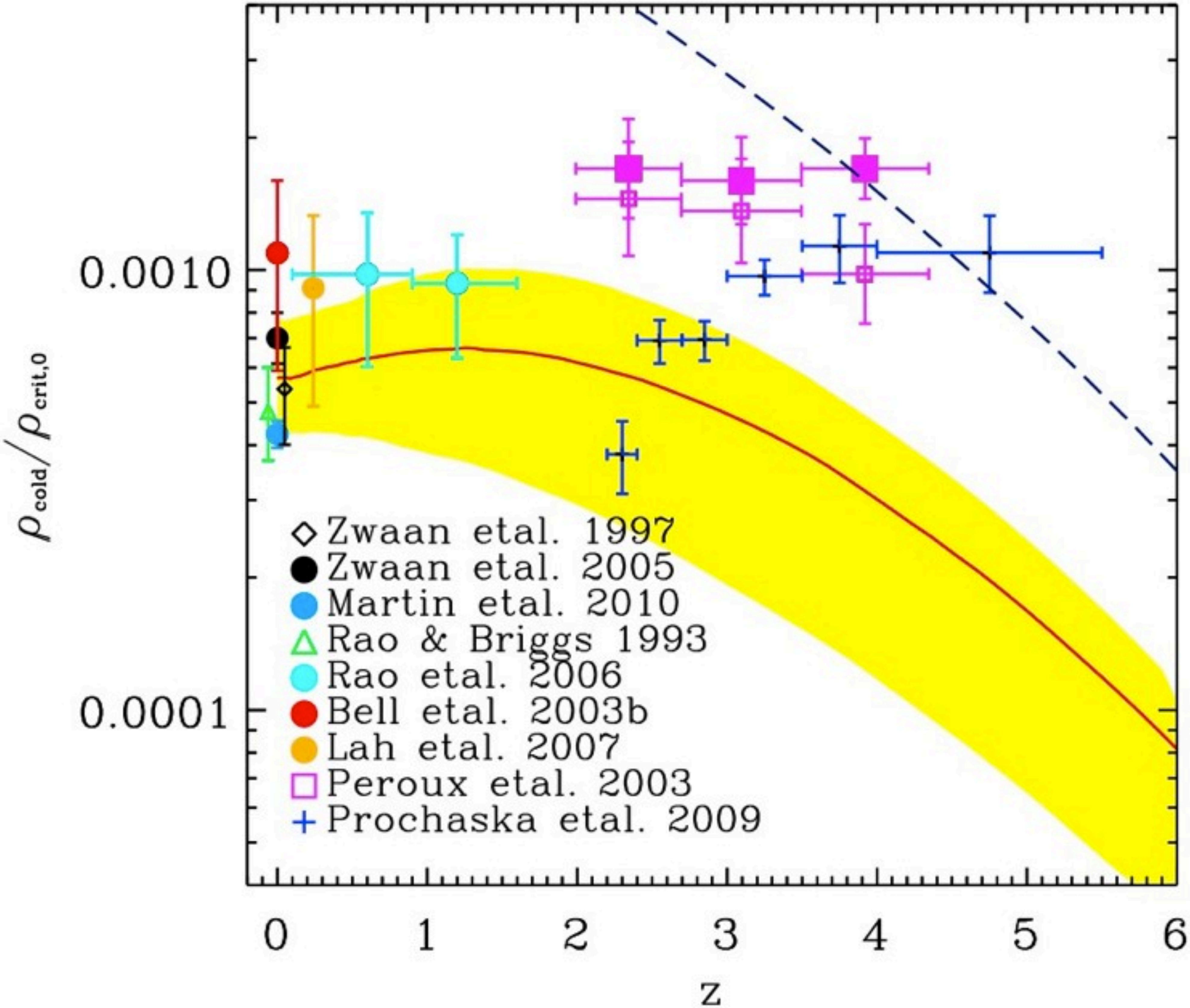
Star formation rate and outflow rate



- observations show (Martin etal 2006):
  - OFR ~ SFR
  - outflow rates in the cold component of the wind is of the order of 10% of the star formation rate



log SFR Density (M$_\odot$ year^{-1} Mpc^{-3})
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
0
1
2
3
4
5
6
z



0.0010
0.0001
$\rho_{\rm cold}/\rho_{\rm crit,0}$
0 1 2 3 4 5 6
z
Zwaan etal. 1997
Zwaan etal. 2005
Martin etal. 2010
Rao & Briggs 1993
Rao etal. 2006
Bell etal. 2003b
Lah etal. 2007
Peroux etal. 2003
Prochaska etal. 2009

conclusions

- To explain the LF and HI MF, strong feedback is needed. If halos accrete baryons with the universal baryon fraction, SN energy has to be efficiently used to drive super galactic winds. Radiation pressure provides more energy.
- The high mass loading factor of outflow required by present-day low-mass galaxies predicts mass outflow rates that are too high.
- The surface density threshold for star formation is much lower than what current observations suggest.
- Galaxy formation at high redshifts is also suppressed in the strong outflow model. The predictions for high-z are inconsistent with existing data.
- The physics of quenching star formation in low-mass halos needs to be understood.