Insights from cosmological hydrodynamical simulations

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Outline

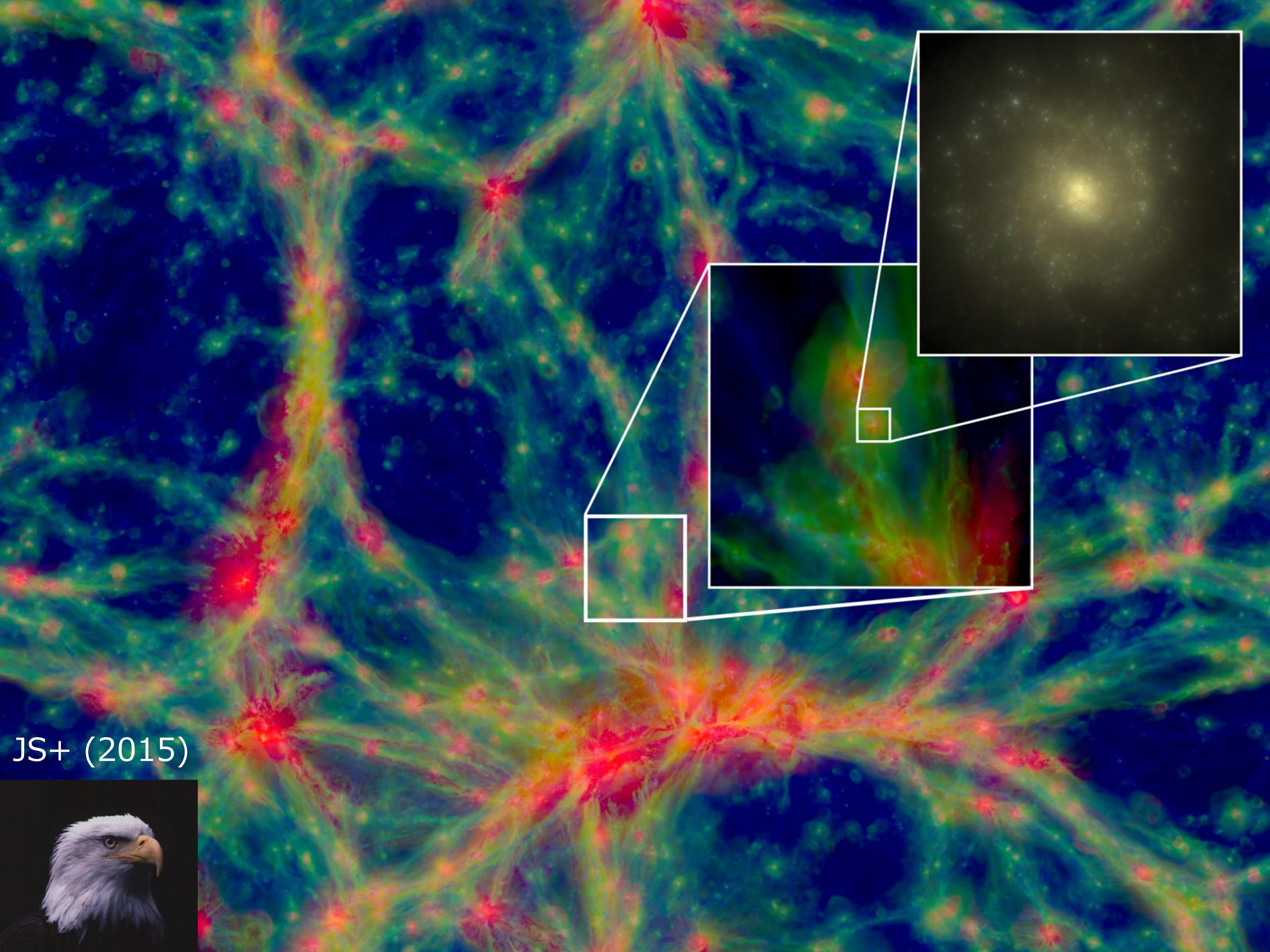
1. Cosmological hydro
    a) General considerations
    b) EAGLE
    c) OWLS, Cosmo-OWLS and BAHAMAS
2. Results
    a) Matter power spectrum
    b) Cosmic shear
    c) Halo mass function
    d) Subhalo clustering
    e) SHAM
    f) Alignments
    g) Matter outside haloes

Starting points

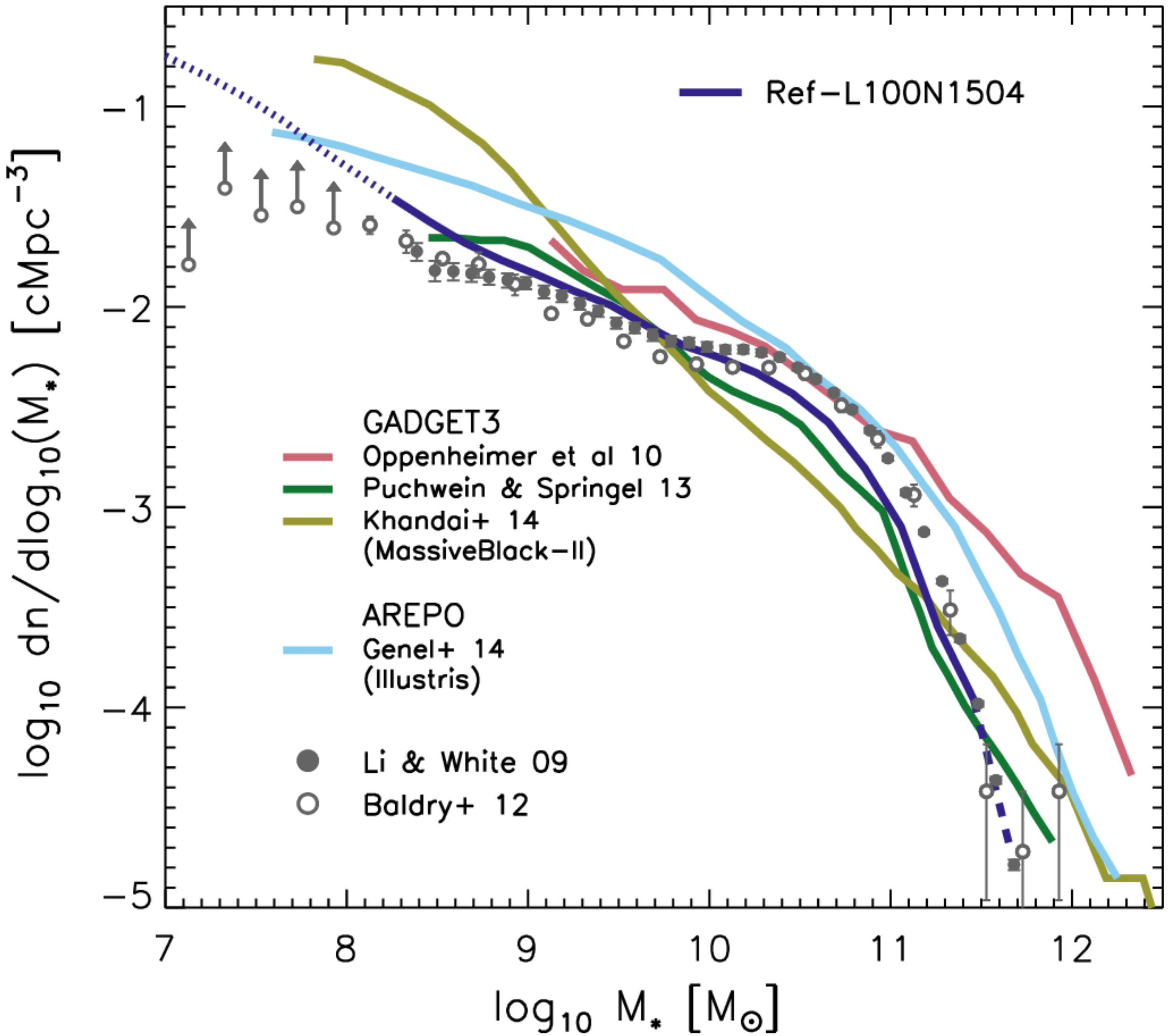
- Strong outflows at high redshift are necessary to obtain agreement with a diverse set of observations
- Cosmological hydro simulations cannot predict radiative losses and momentum cancellation in the ISM
- Cannot predict stellar masses, black hole masses and gas fractions from first principles
- Calibration necessary → need to compare to *relevant* observations

Starting points

- For testing observational cosmology, it is not necessarily better to use simulations that
  - Include more physics
  - Have higher resolution
  - Agree better with *some* observations
- Don't ask what solver/resolution/physics was used, ask to see a comparison with the *relevant* observations!

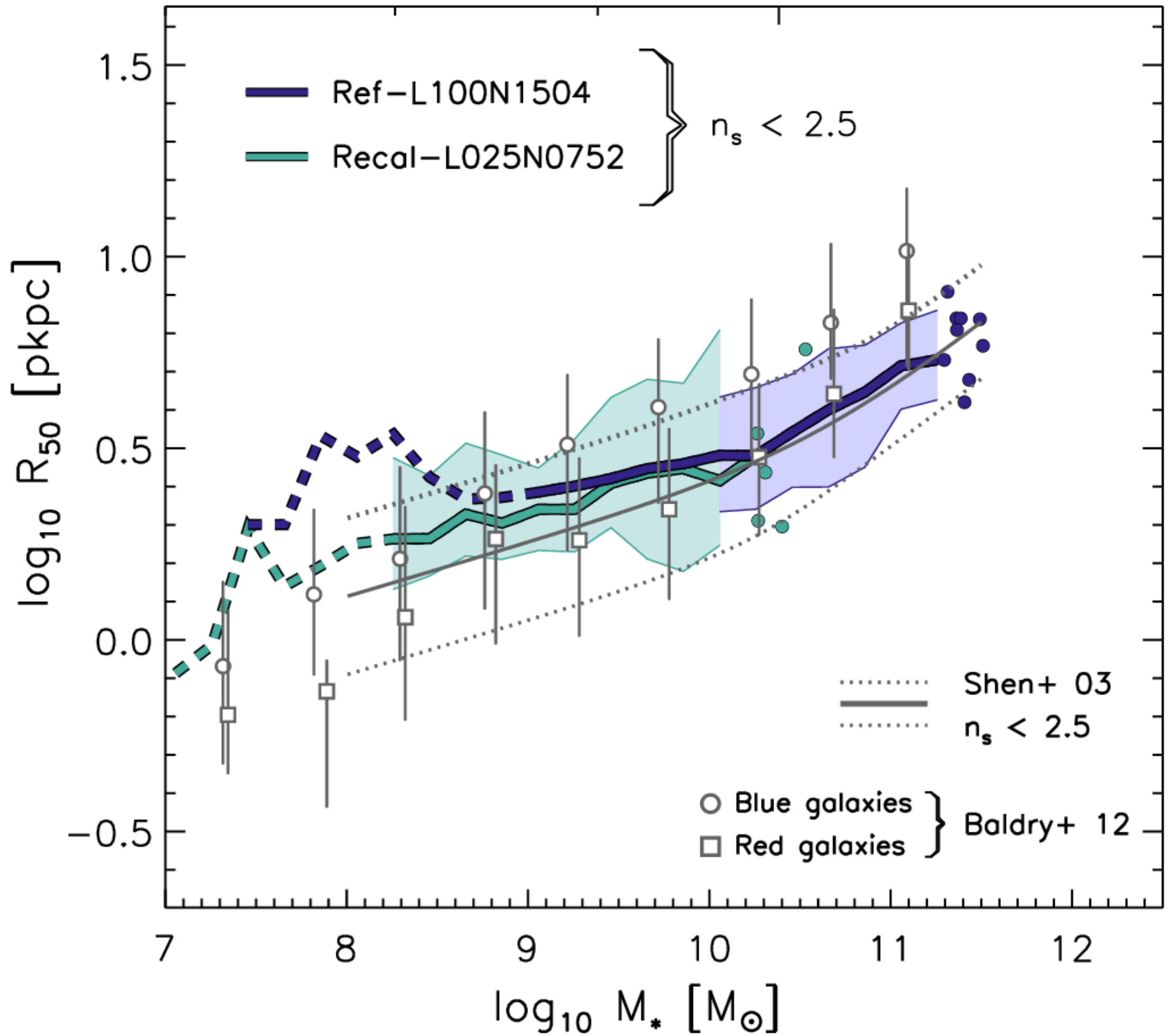

JS+ (2015)

Galaxy stellar mass function



JS, Crain, Bower, et al. (2015)

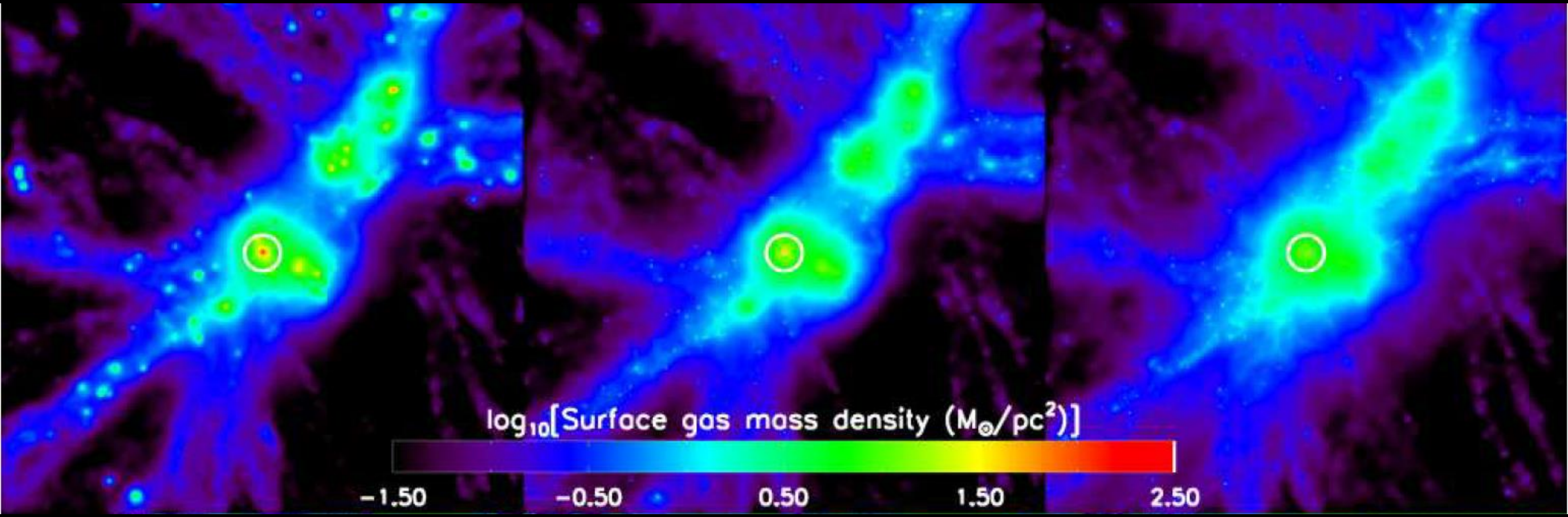
Galaxy sizes



JS, Crain, Bower, et al. (2015)

The effect of baryons on the distribution of matter

Adiabatic | Cooling, SF, SN | Cooling, SF, SN, AGN



10 Mpc/h

McCarthy, JS+ (2011)

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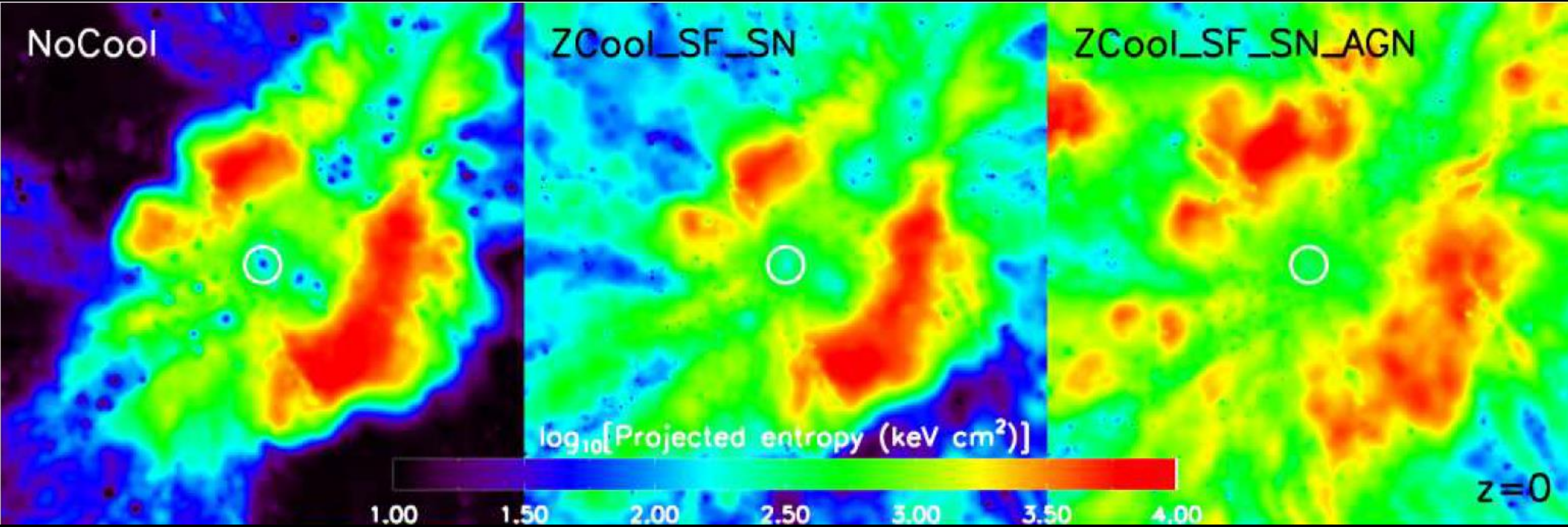
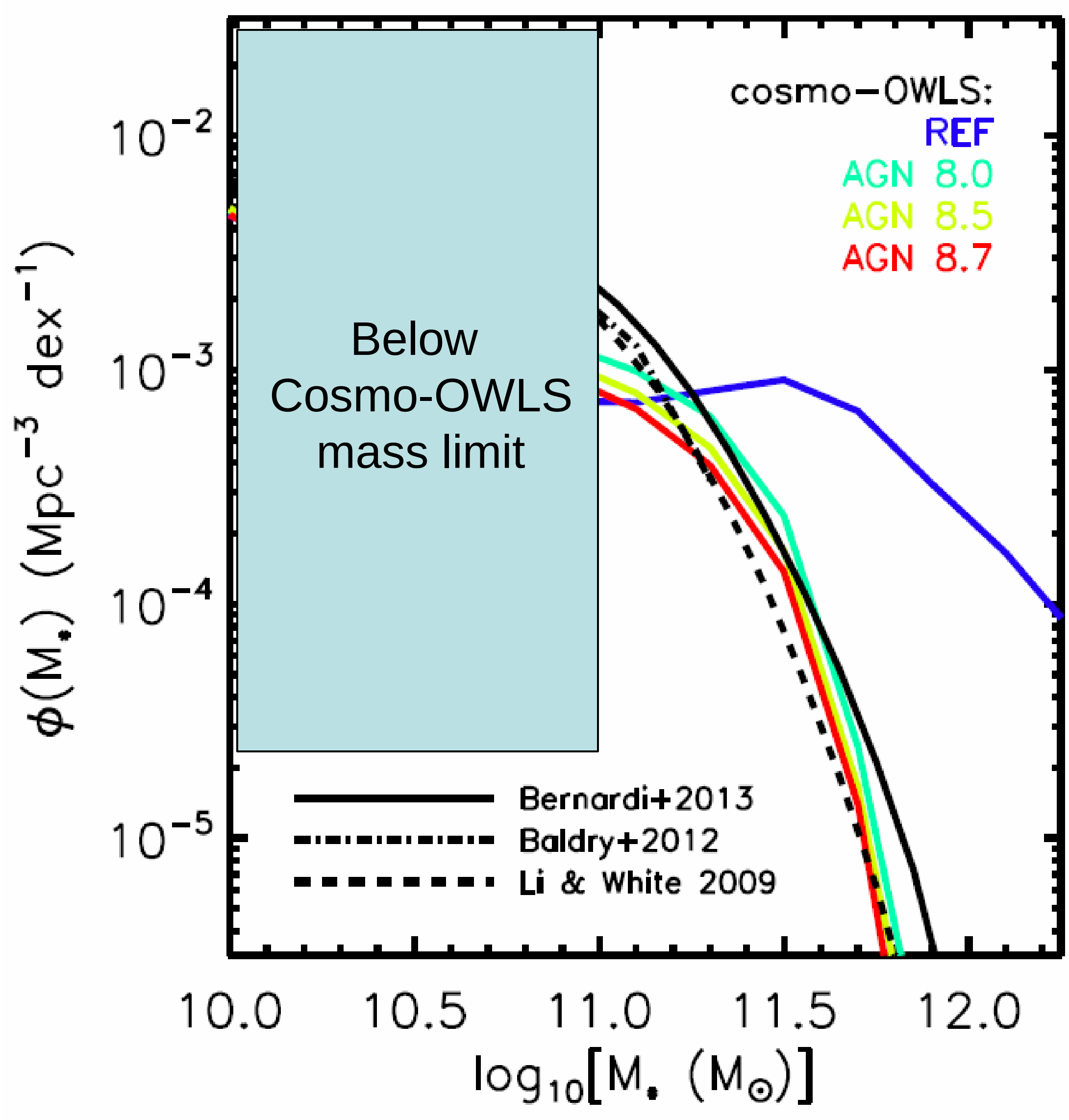


← 10 Mpc/h →

McCarthy, JS+ (2011)

Cosmo-OWLS: Stellar mass function



Le Brun, McCarthy, JS, Ponman (2014)

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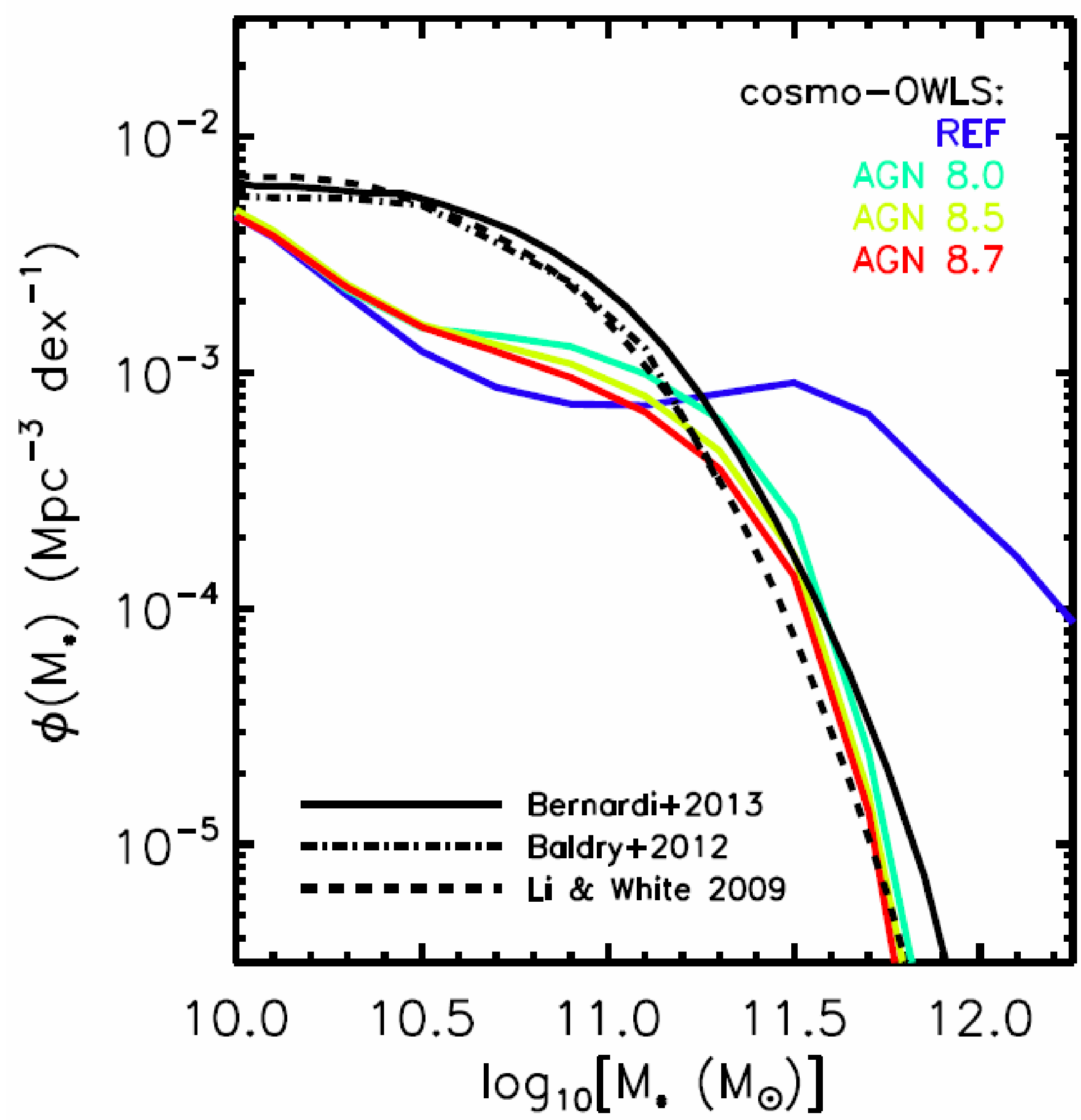
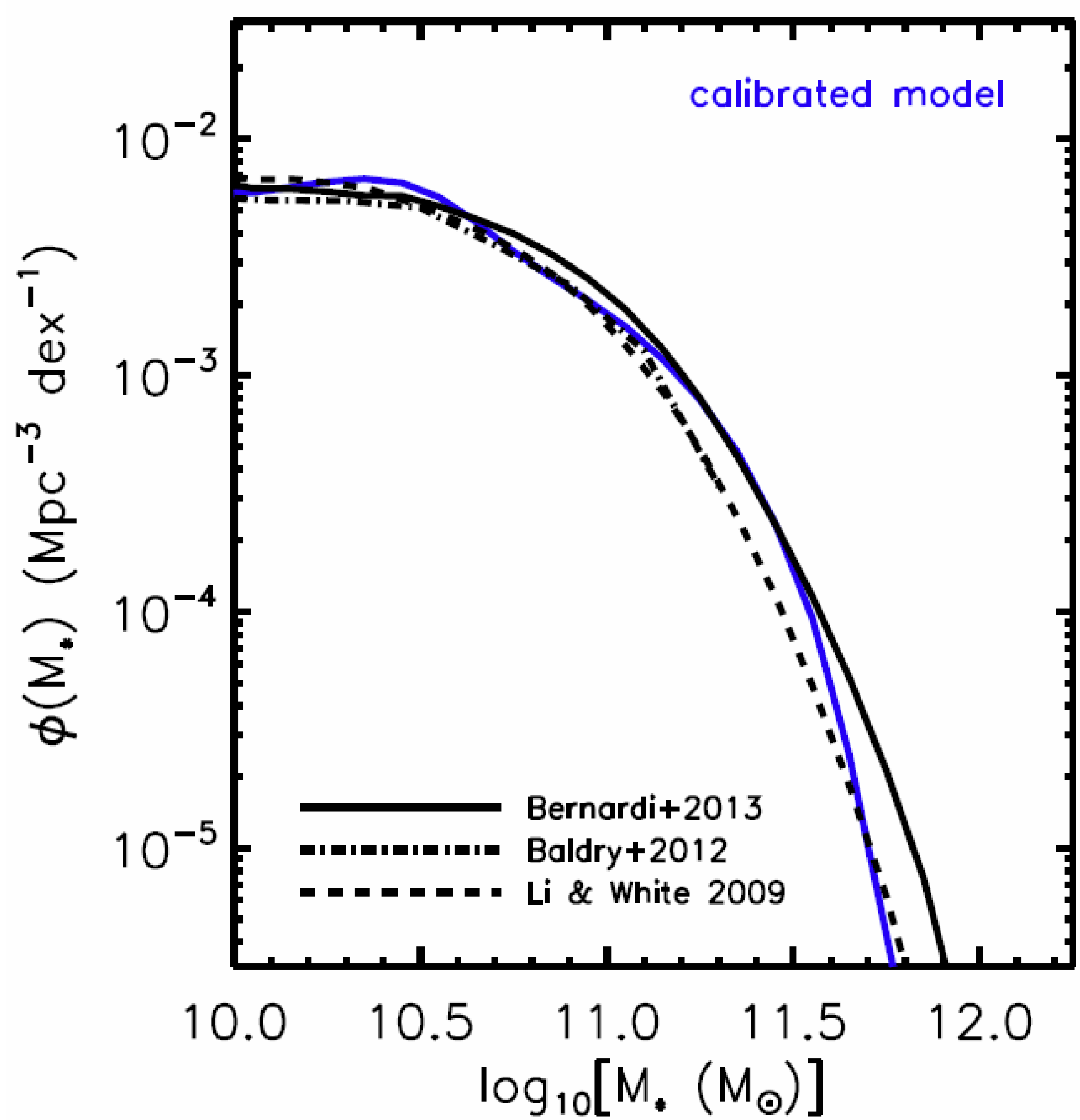


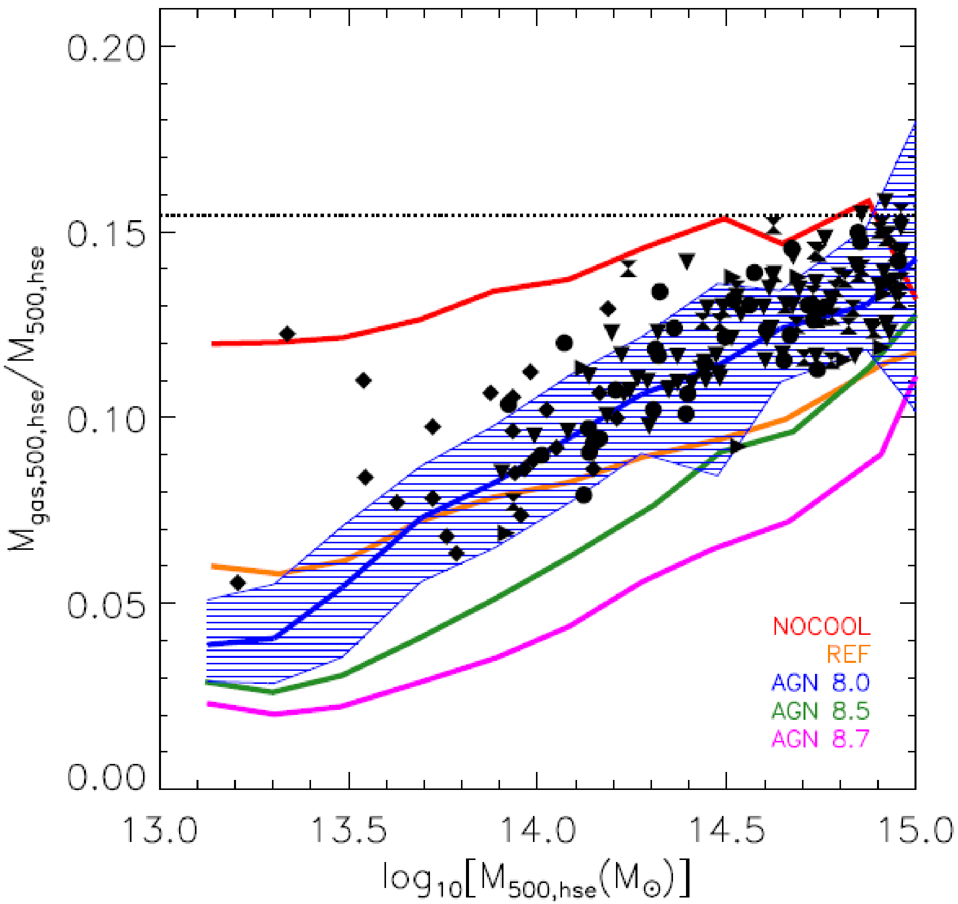
Le Brun, McCarthy, JS, Ponman (2014)

BAHAMAS: Stellar mass function

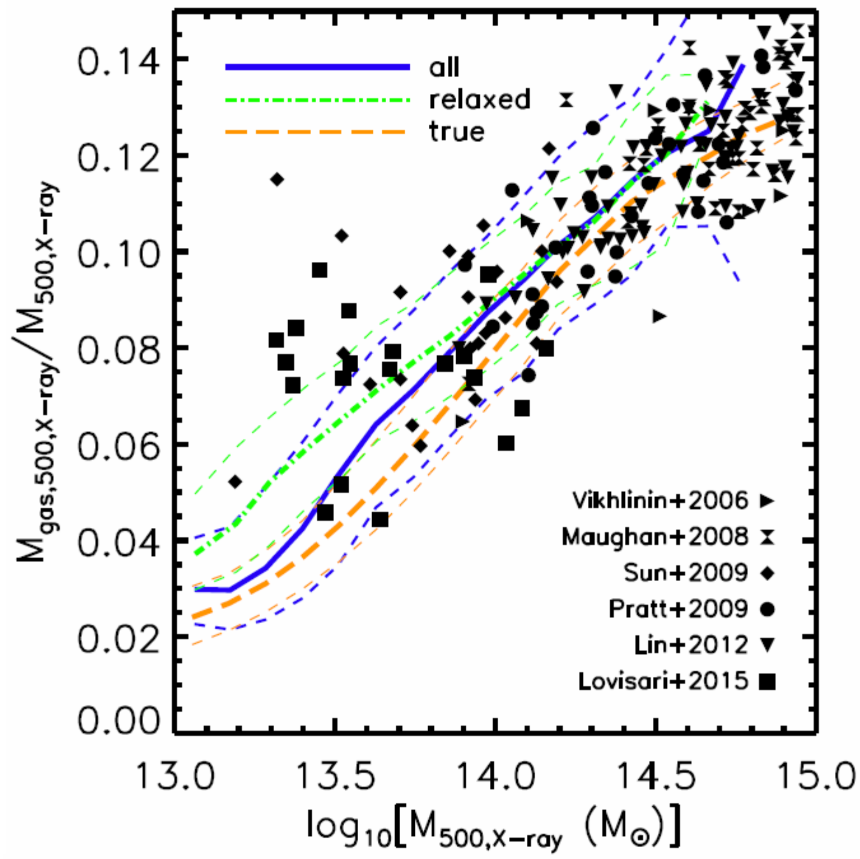


McCarthy, JS+ (in prep)

Cosmo-OWLS: gas fractions



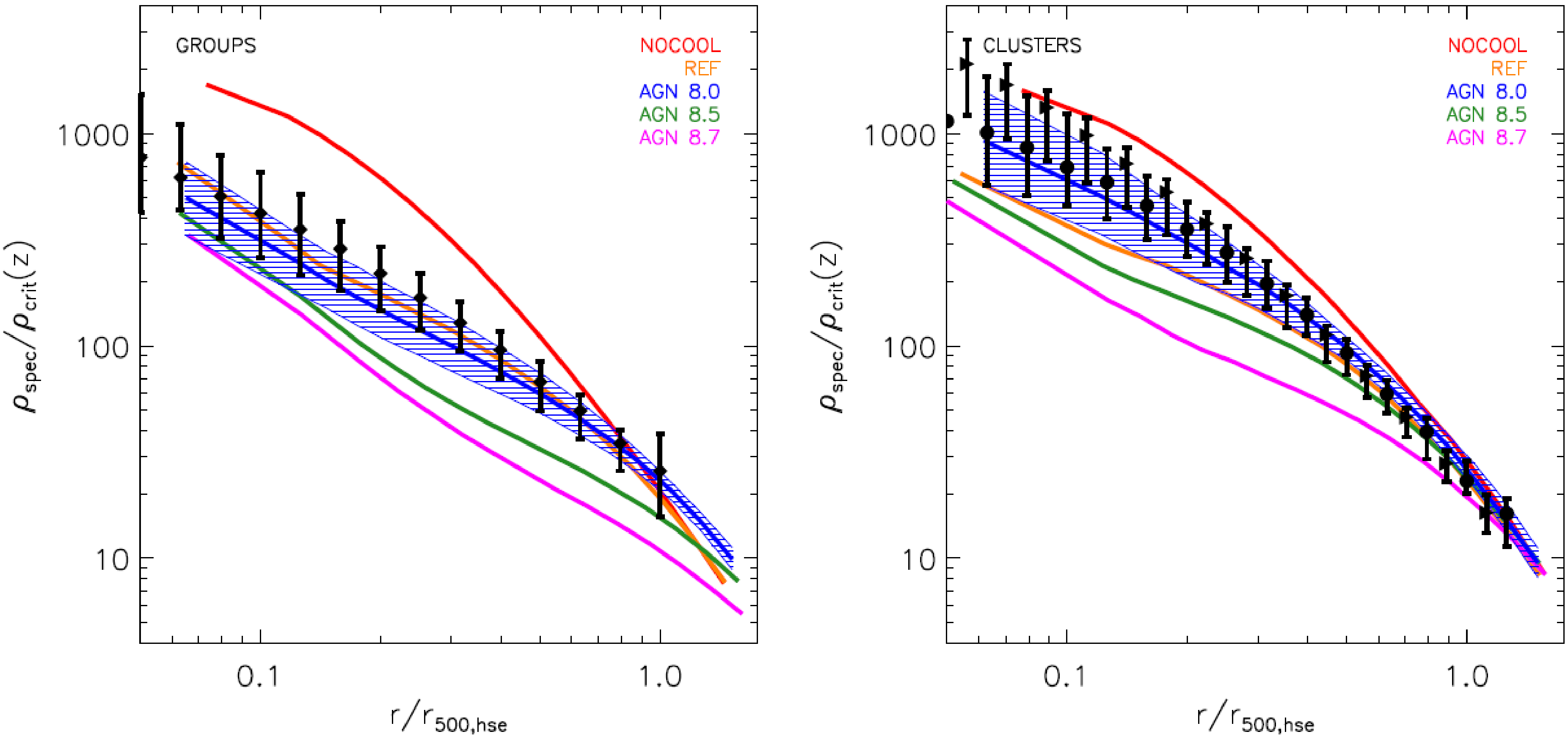
BAHAMAS:



Le Brun, McCarthy, JS, Ponman (2014)

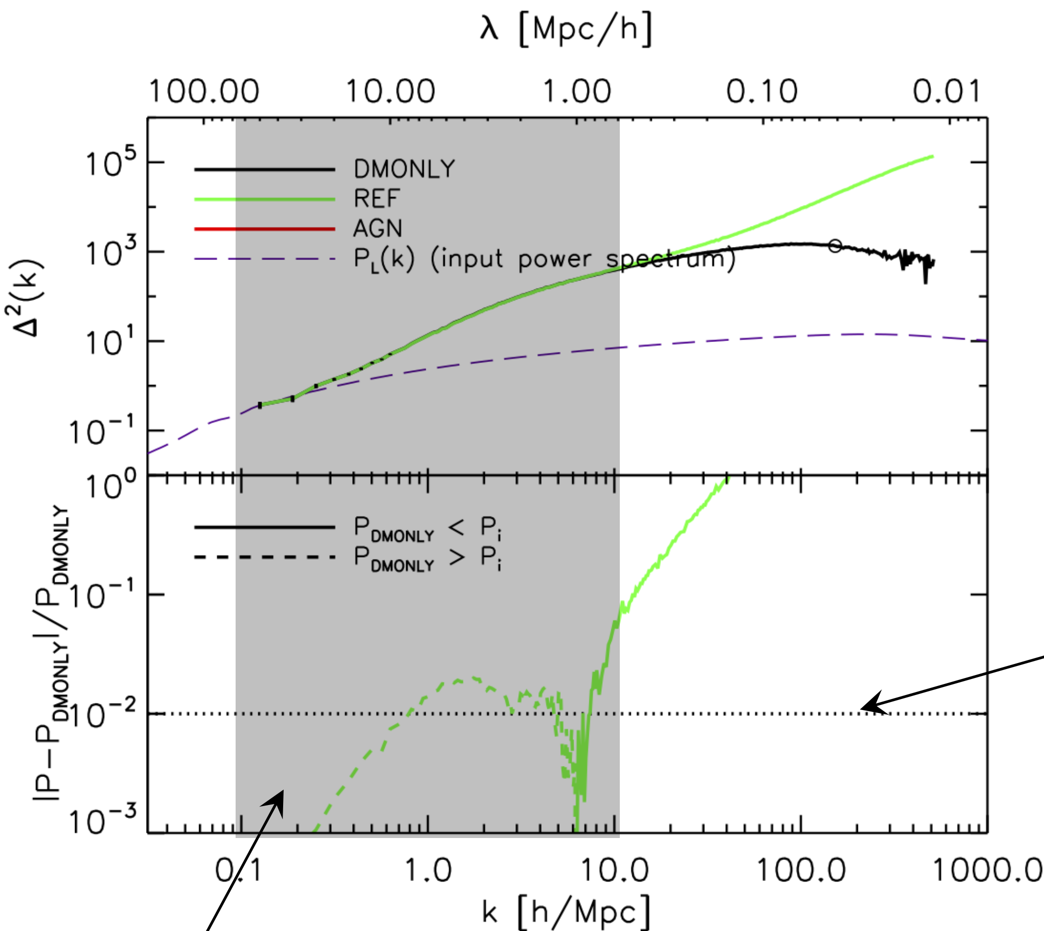
McCarthy, JS+ (in prep)

Cosmo-OWLS: Density profiles



Le Brun, McCarthy, JS, Ponman (2014)

Baryons and the matter power spectrum

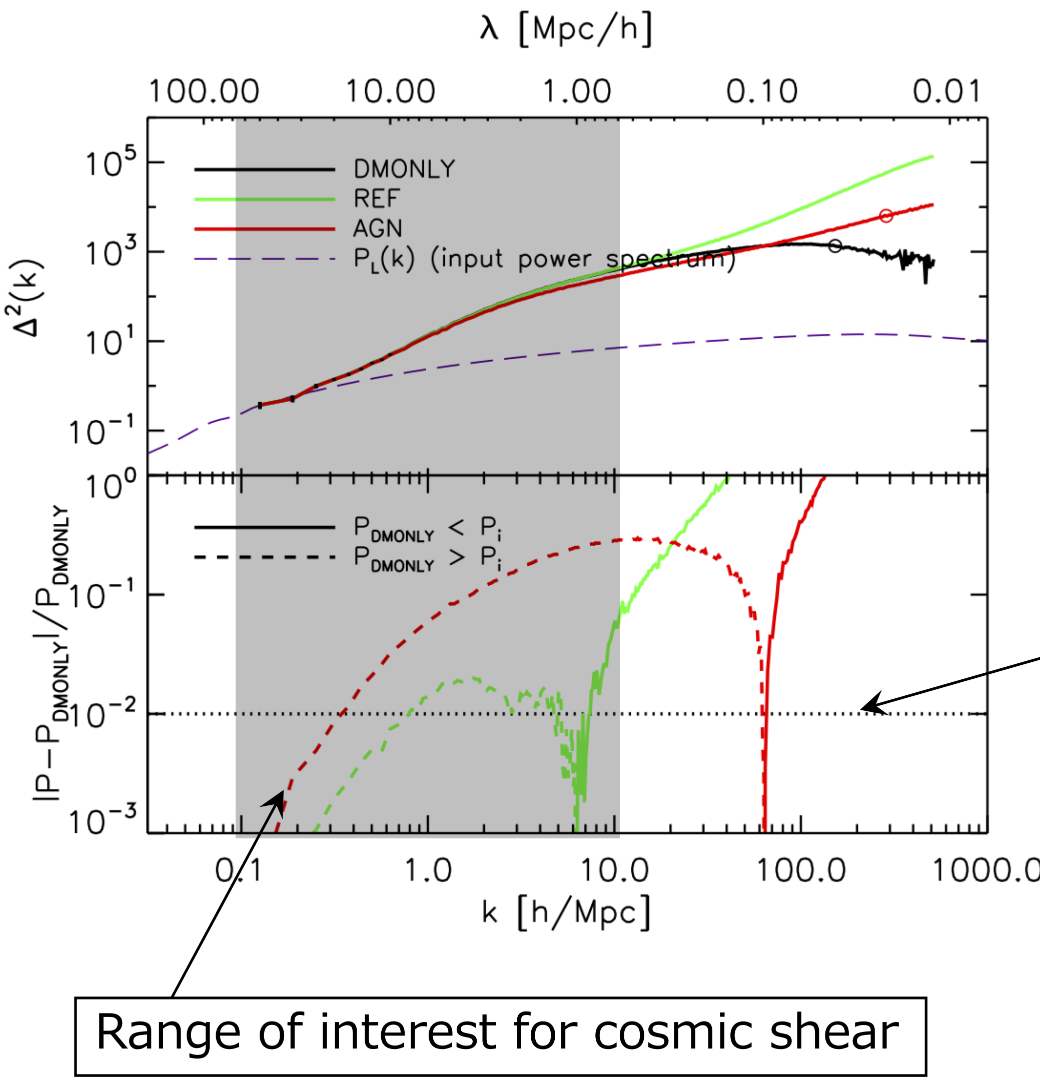


1% difference wrt dark matter only

Range of interest for cosmic shear

Van Daalen, JS+ '11

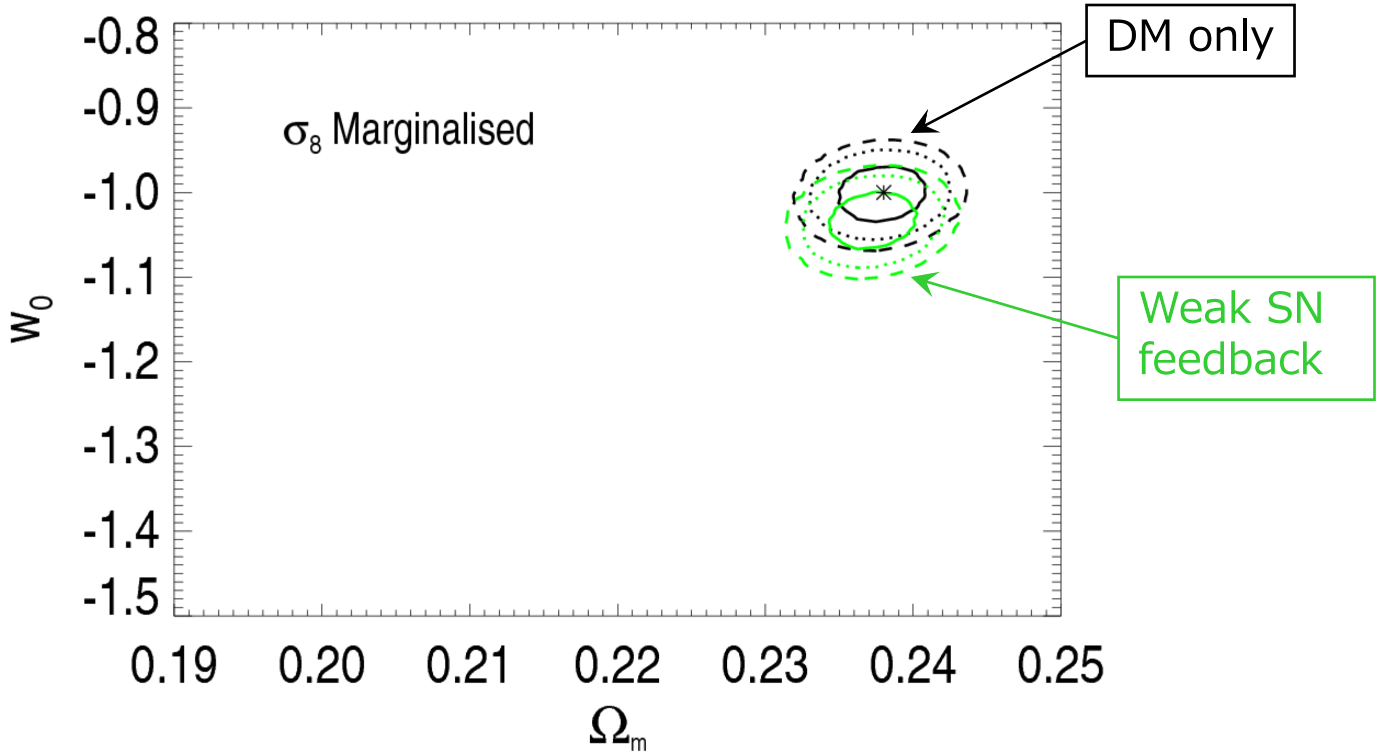
Baryons and the matter power spectrum



The feedback required to solve the overcooling problem suppresses power on large scales

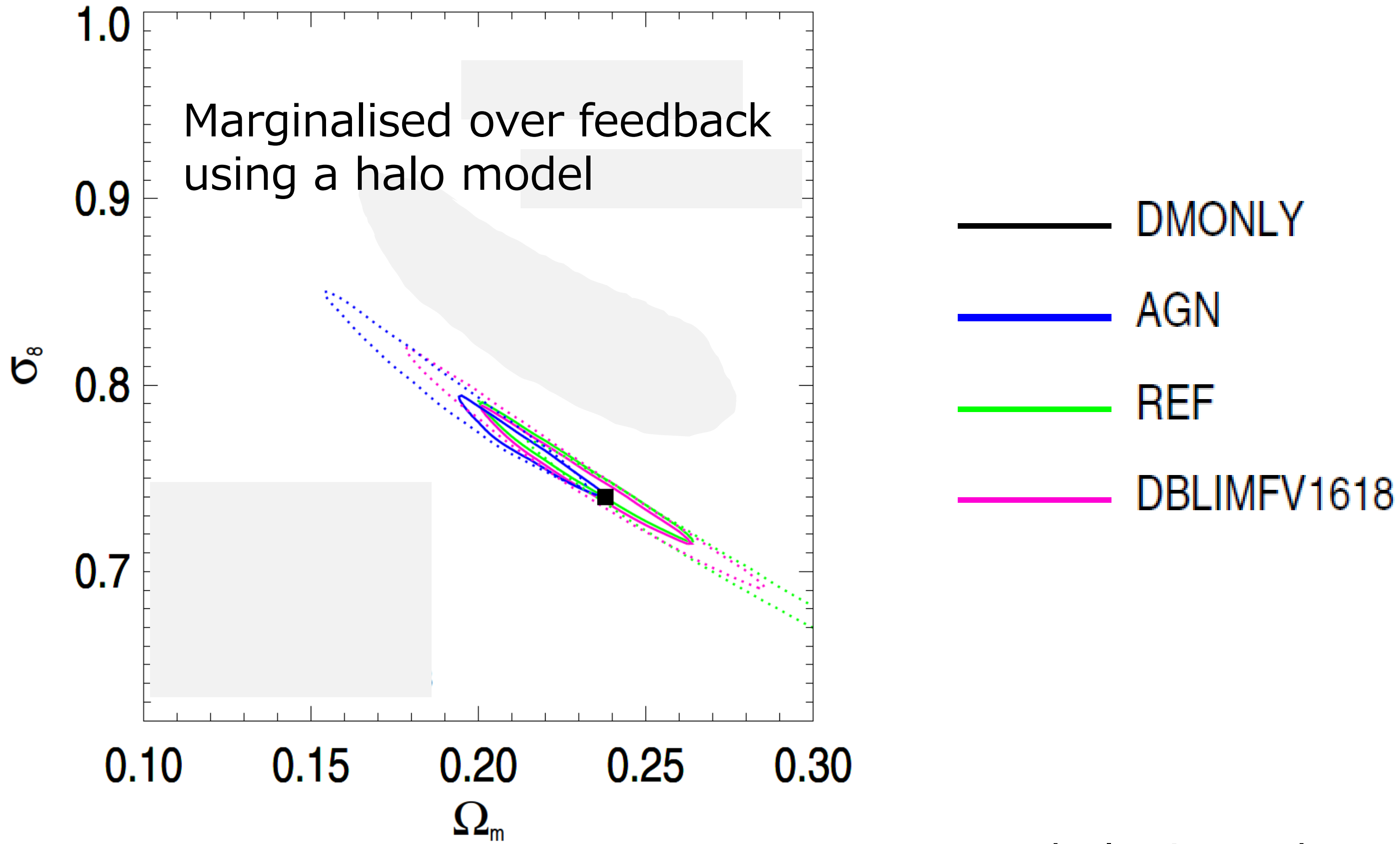
Van Daalen, JS+ '11

Biases due to galaxy formation for a Euclid-like weak lensing survey



Semboloni, Hoekstra, JS, et al. (2011)

Two and three point statistics

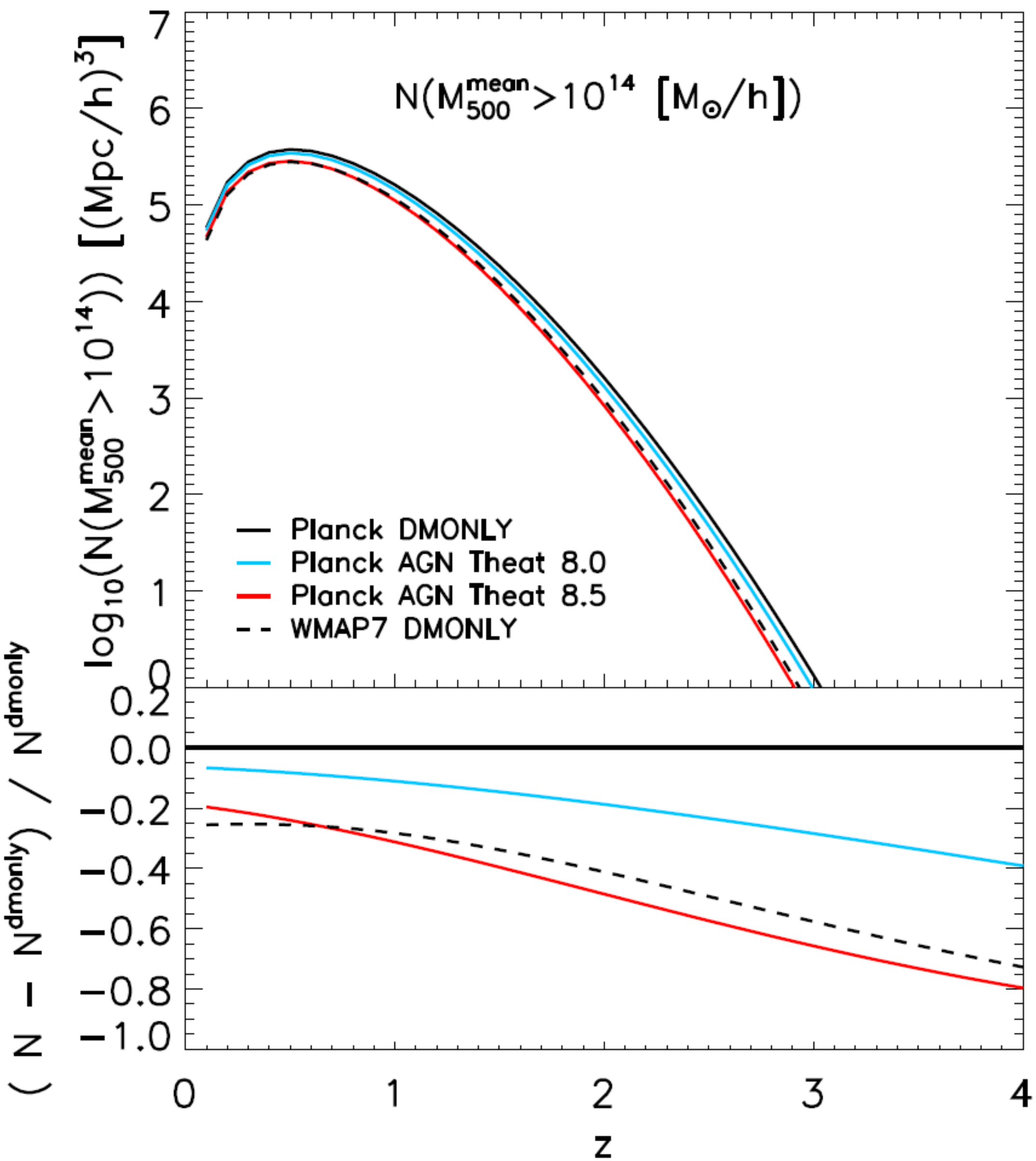


Semboloni, Hoekstra, JS '13

Euclid

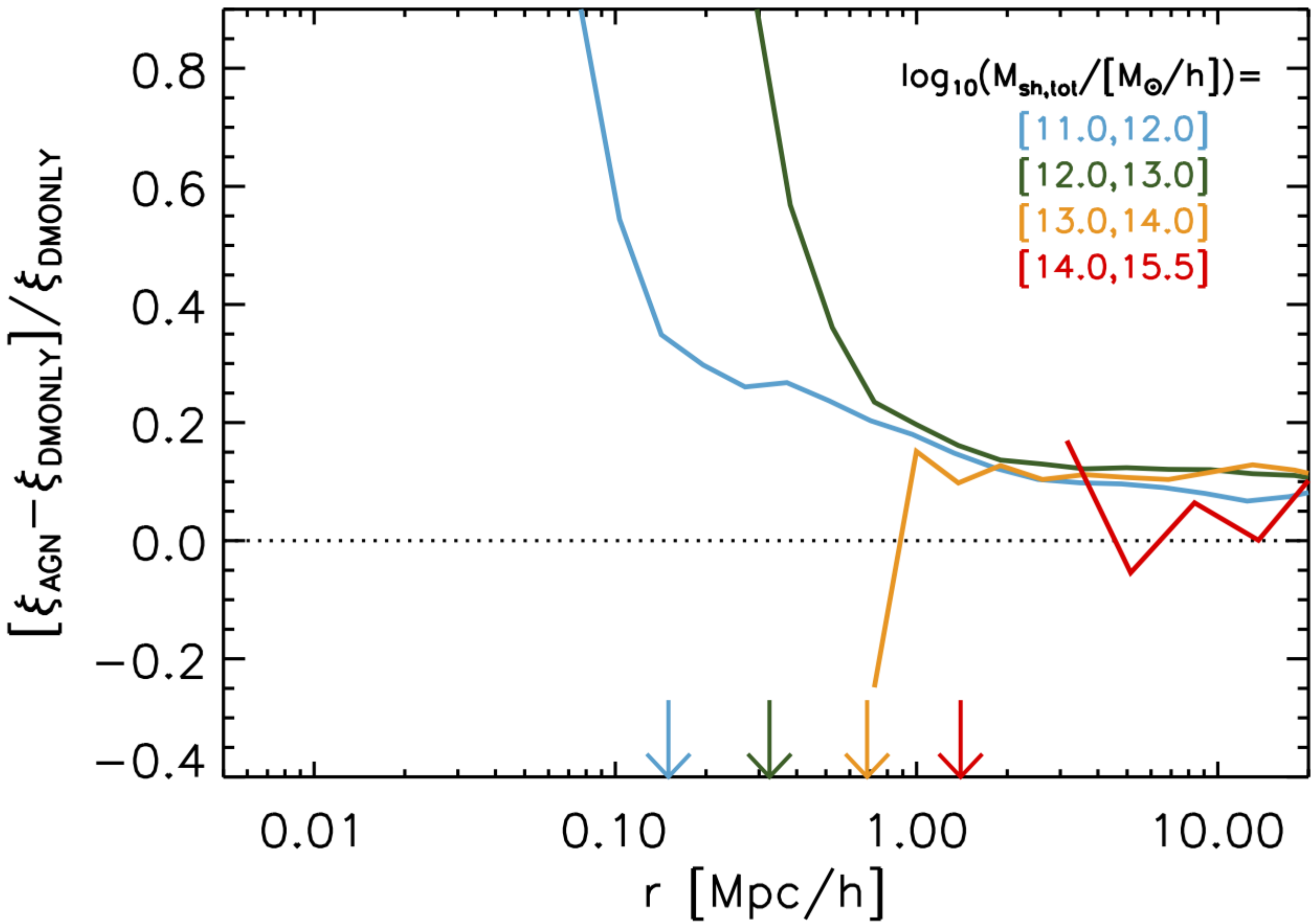
w_0 marginalised

Halo mass function



Velliscig, van Daalen, JS, et al. (2014)

Subhalo autocorrelation: AGN vs DMONLY



Van Daalen, JS+ (2014)

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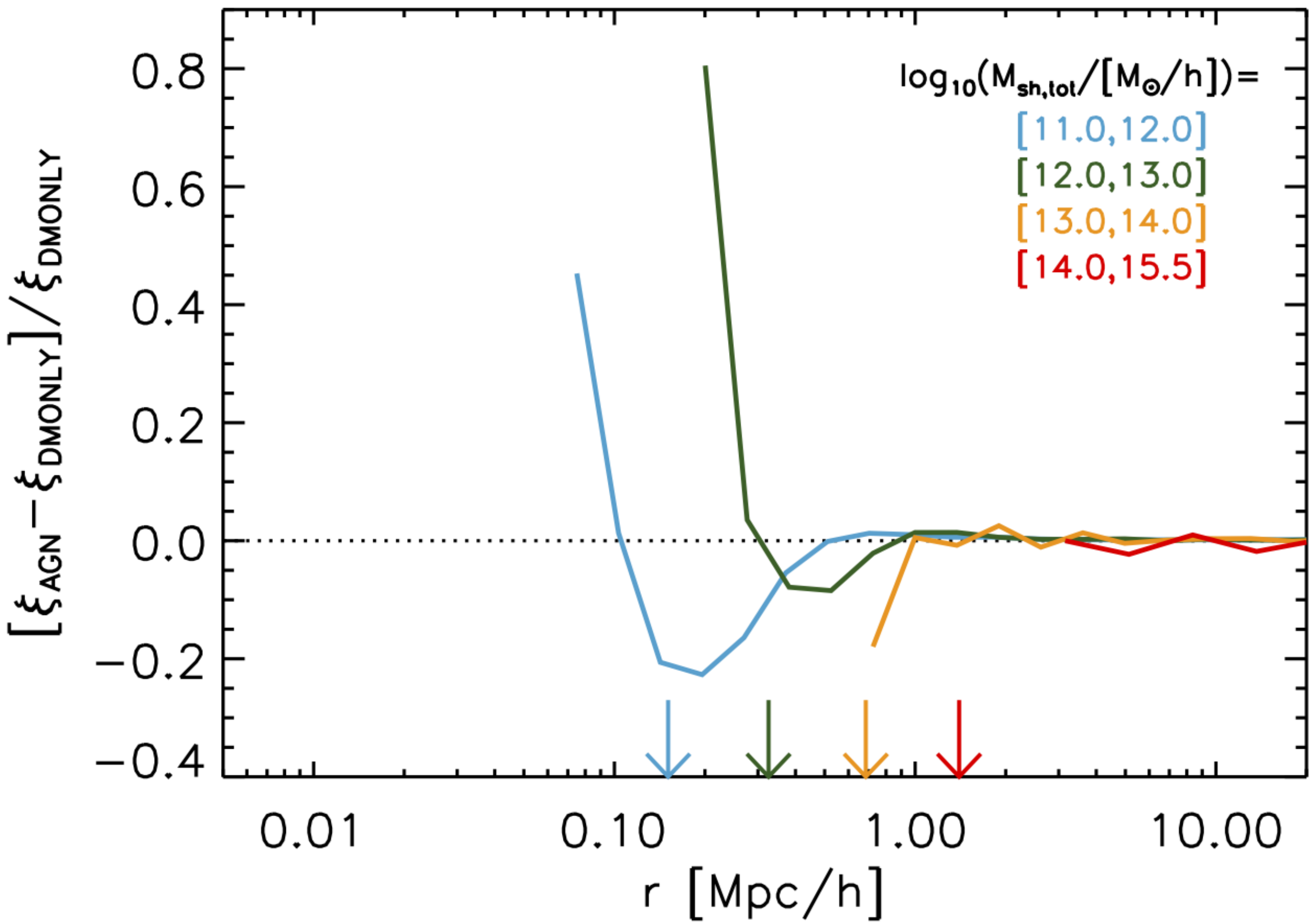
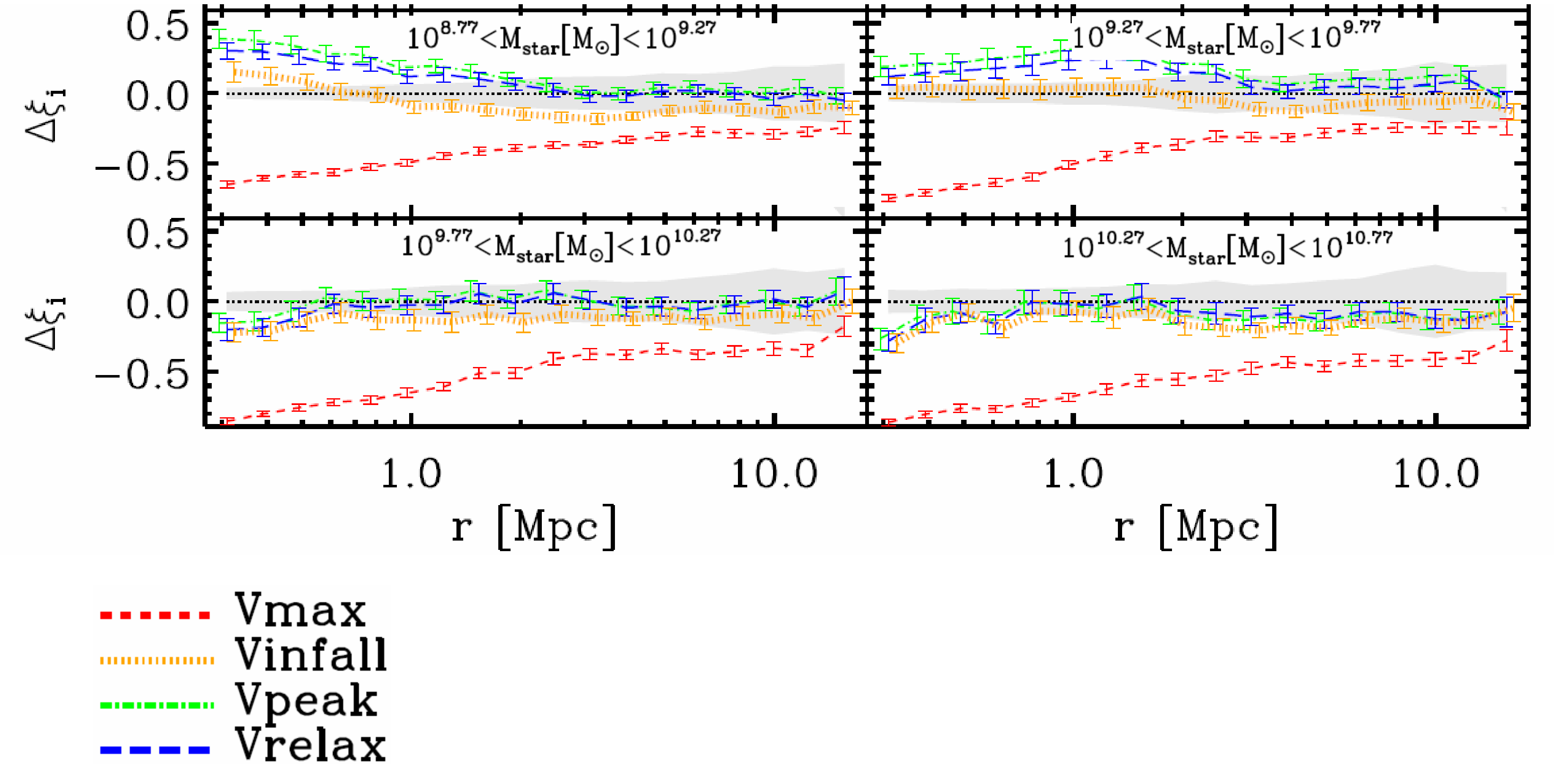


Linked subhaloes only

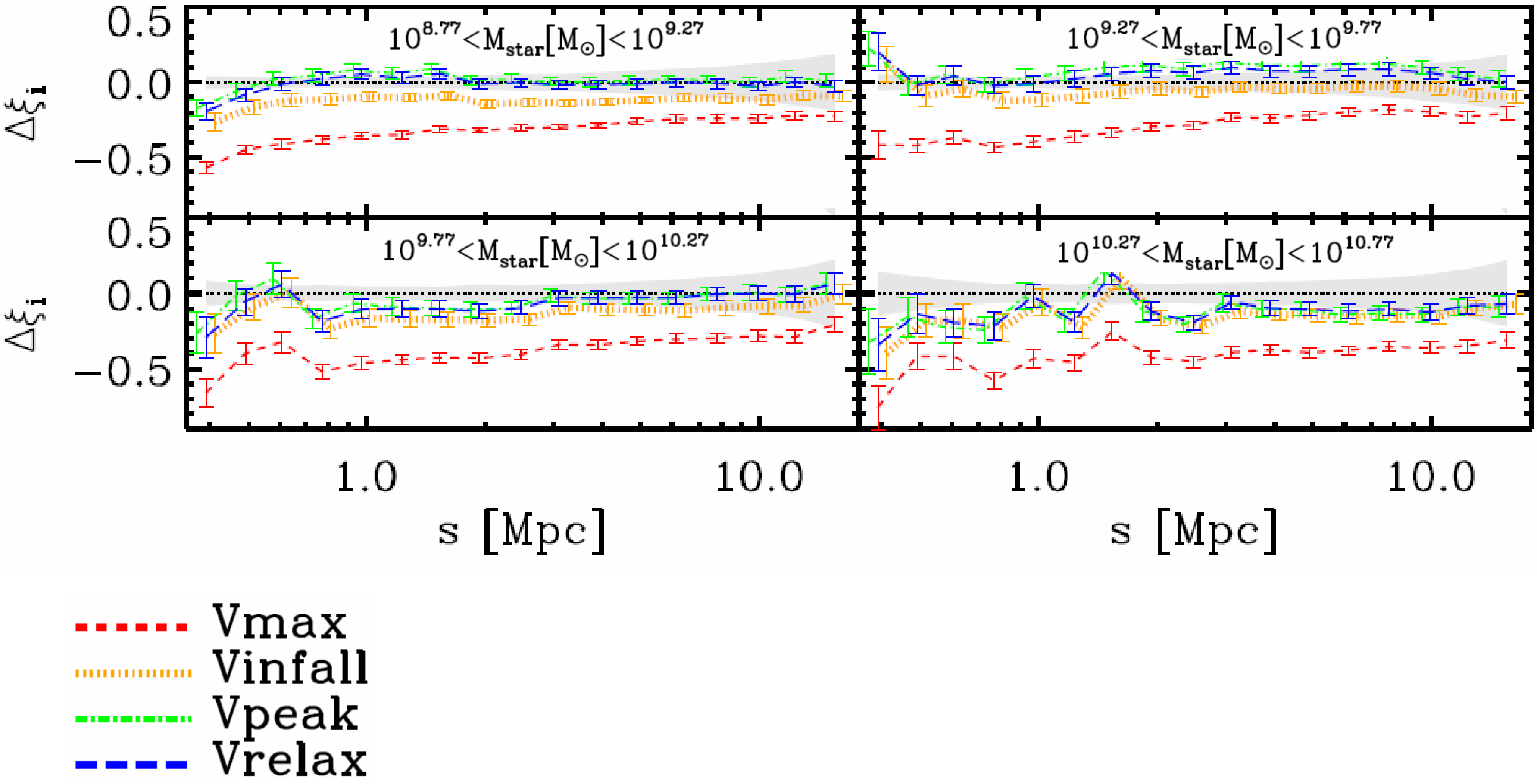
Van Daalen, JS+ (2014)

Real space clustering: relative error



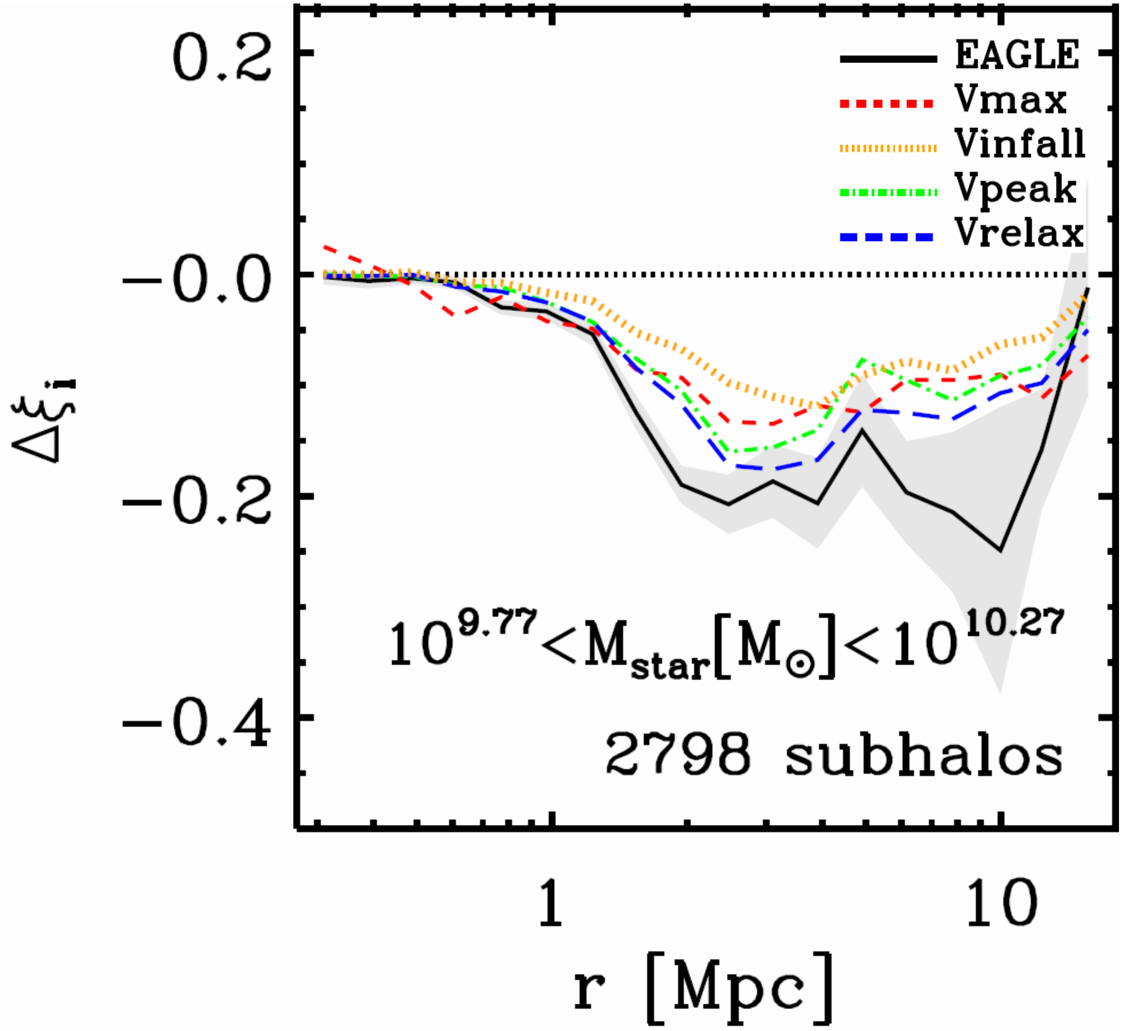
Chavez-Montero, Angulo, JS, et al. (2015)

Redshift space clustering: rel. error



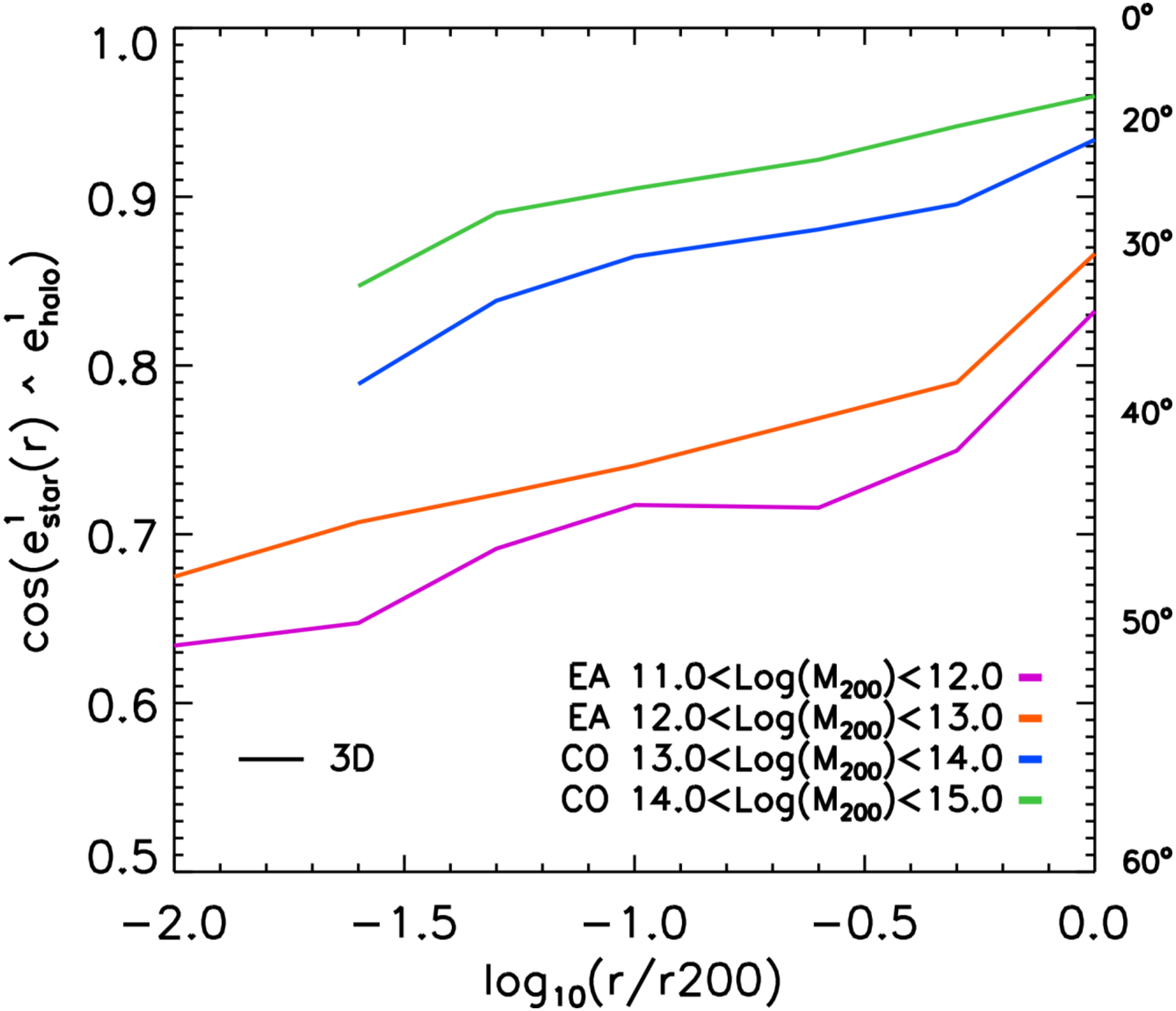
Chavez-Montero, Angulo, JS, et al. (2015)

Assembly bias:
Effect of reshuffling haloes



Chavez-Montero, Angulo, JS, et al. (2015)

Stellar(<r)-halo alignment



Velliscig, Cacciato, JS, et al. (2015)

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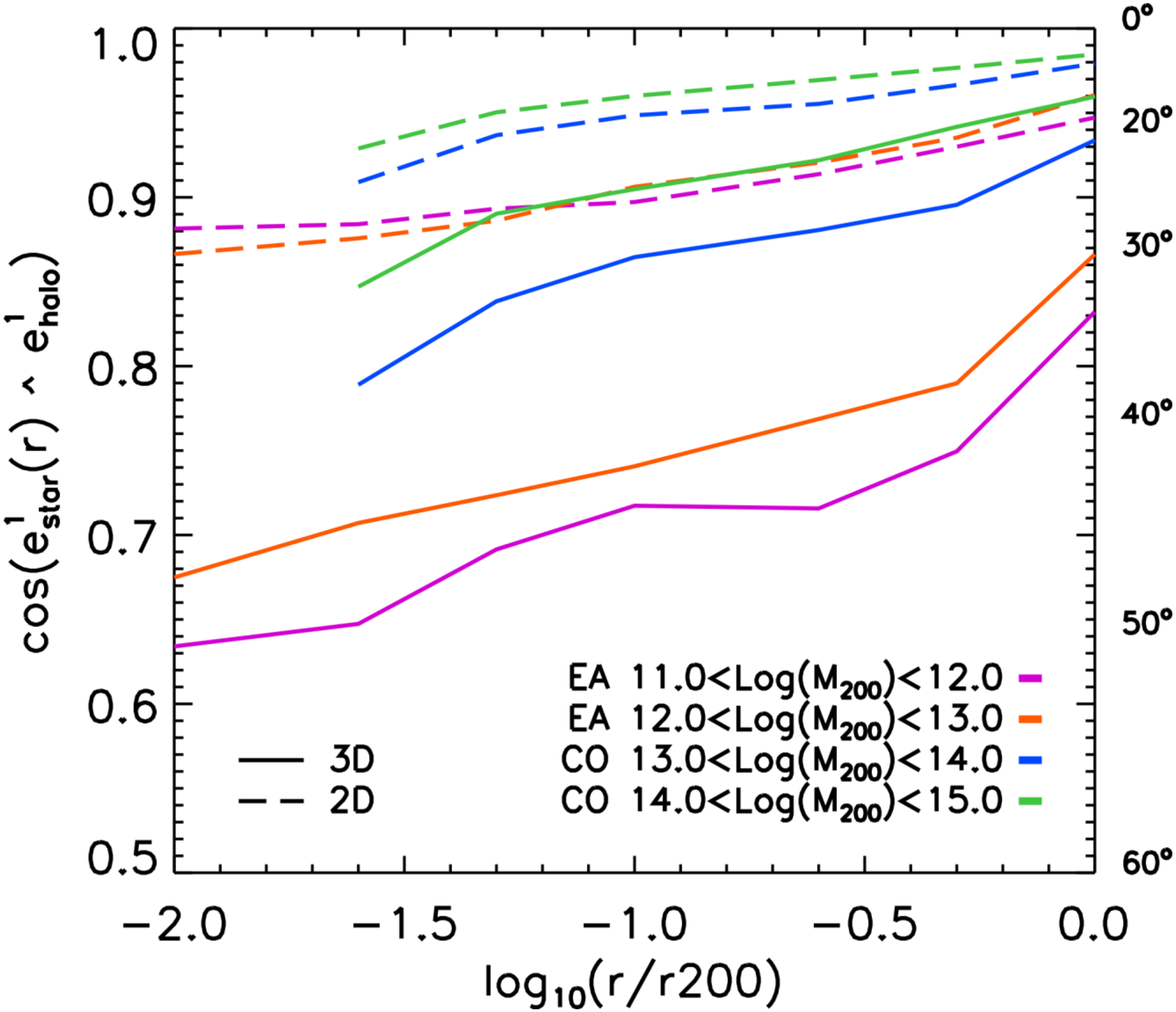
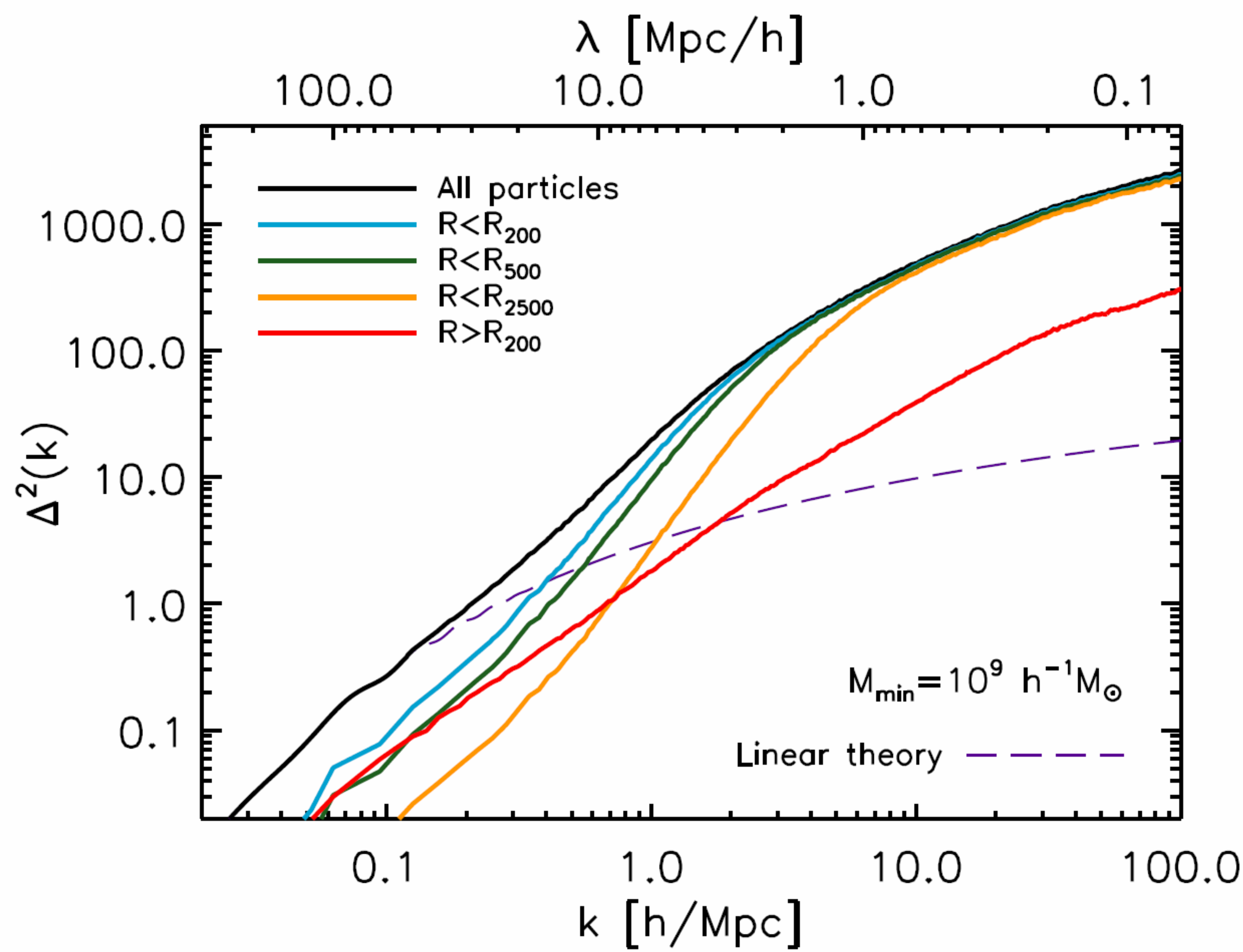


Velliscig, Cacciato, JS, et al. (2015)

Halo contribution to the power spectrum



Van Daalen & JS (2015)

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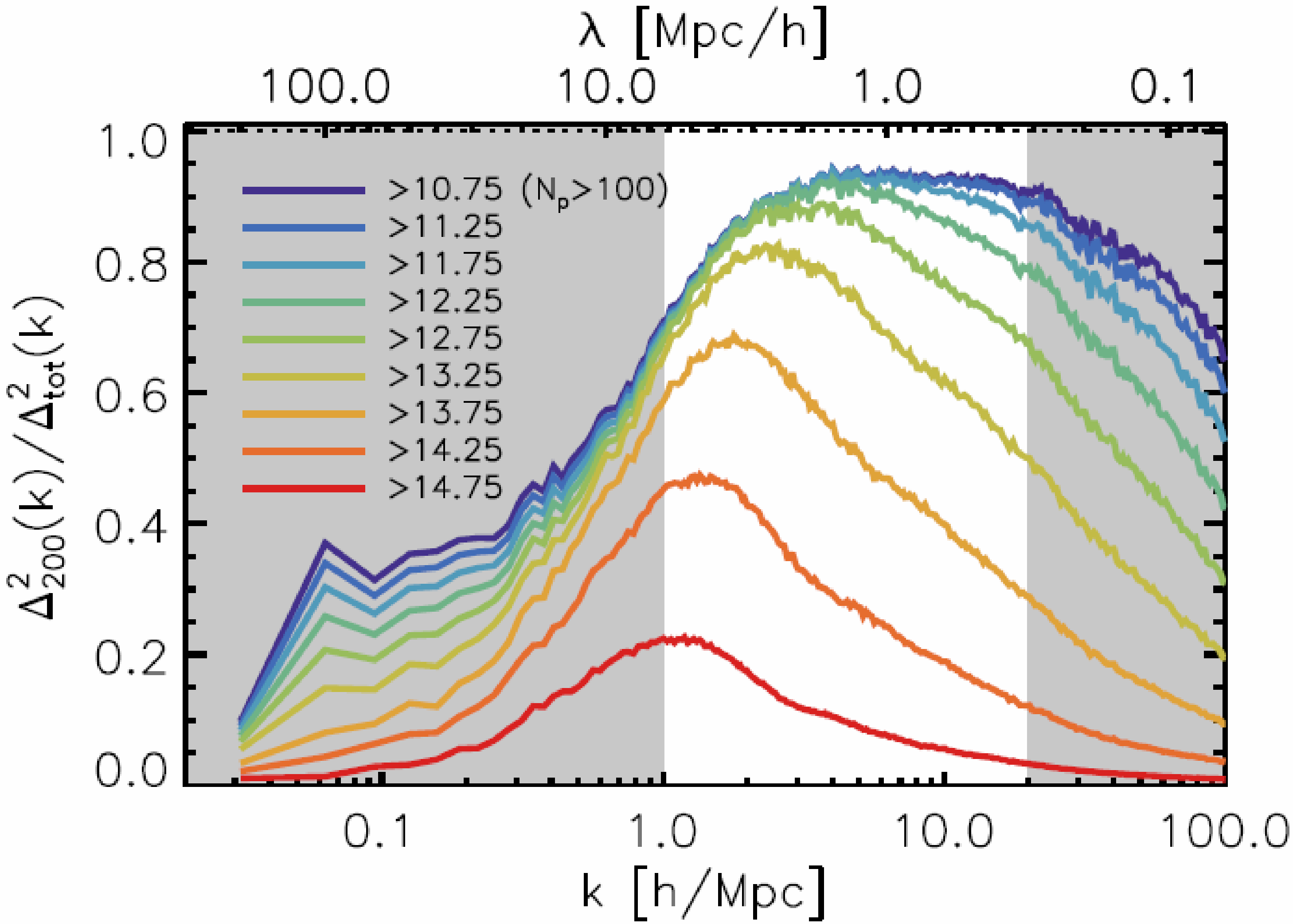

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Van Daalen & JS (2015)

Conclusions

- Subgrid models for stellar feedback and BHs need calibration
- To estimate the effects of baryons, we should use simulations that fit observations (rather than the "most physics" or "highest resolution")
- Baryons, particularly their ejection, are important for:
  - Power spectrum ($k > 0.3$ h/Mpc)
  - Cosmic shear ($\theta < 60$ arcmin)
  - Halo mass function ($M < 10^{15}\ M_\odot$ for perfect estimator)
  - Clustering at fixed mass (all scales)
  - Clustering at fixed number density (< 1 Mpc)
  - Galaxy-halo misalignment
- SHAM works relatively well, but not high precision (Vrelax)
- Matter outside haloes matters