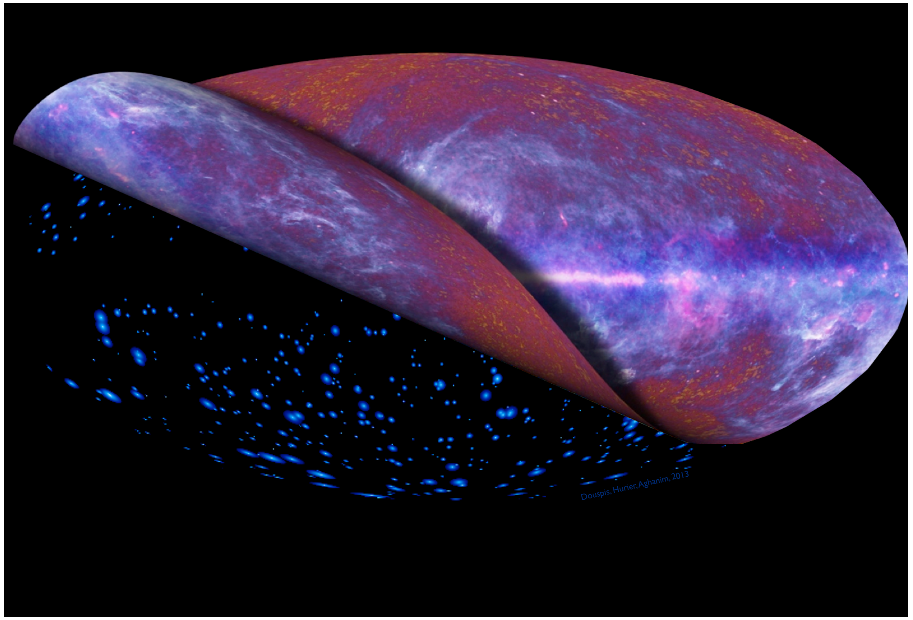
Cosmology with *Planck* SZ cluster counts



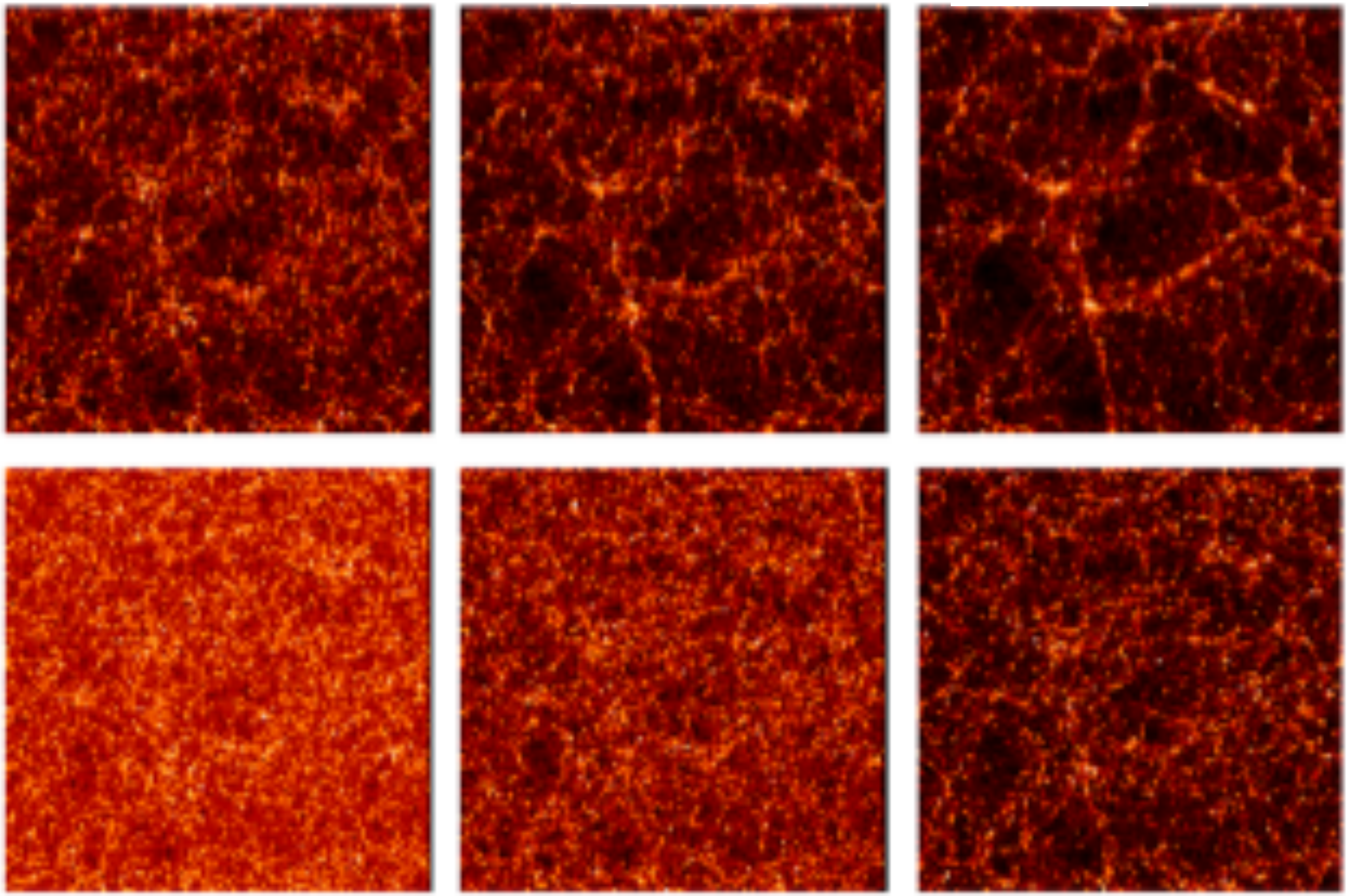
Anna Bonaldi (Jodrell Bank Centre for Astrophysics)

for the *Planck* Collaboration

z=3 z=1 z=0

ΛCDM

SCDM



Cluster number counts

NEW!

2D

$$\frac{dN}{dzdq} = \int d\Omega \int dM_{500} \frac{dN}{dzdM_{500}d\Omega} P[q|\bar{q}_{\rm m}(z, M_{500}, l, b)],$$

q=detection signal-to-noise

Mass function
Reference: Tinker et al. 2008

distribution of q given the mean model signal-to-noise (z, M500, l,b)

1D

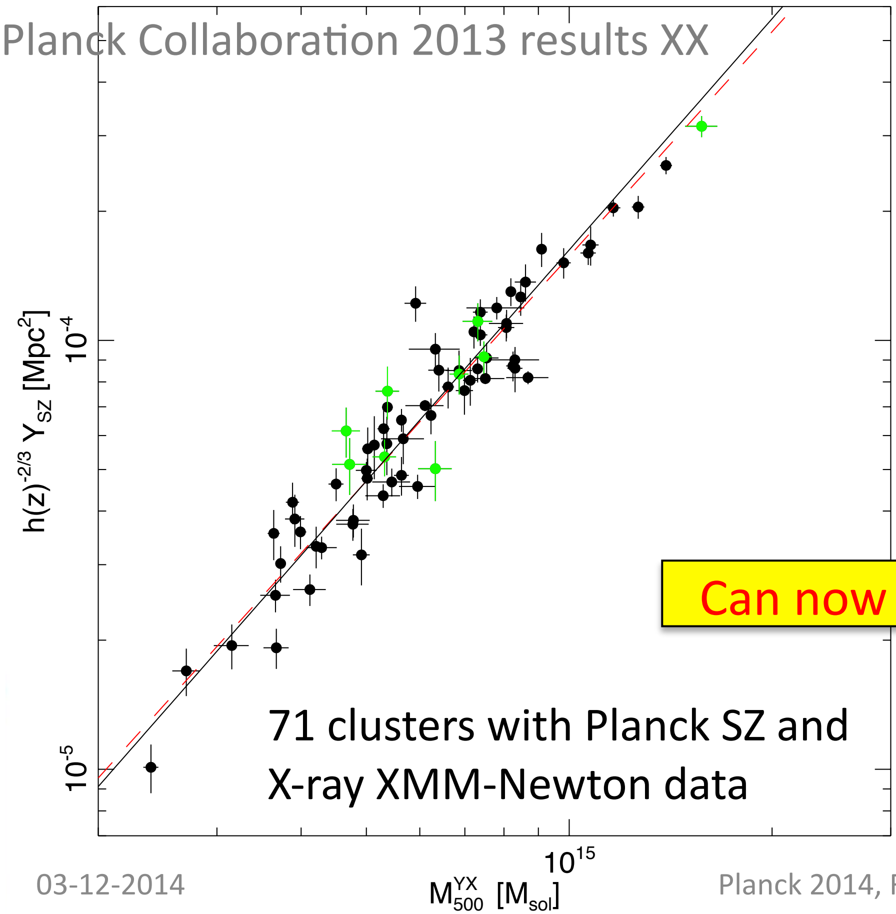
Same as 2013

$$\frac{dN}{dz}(q > q_{\rm cat}) = \int_{q_{\rm cat}}^{\infty} dq \frac{dN}{dzdq}$$

Y-M relation

$$[E(z)]^{-2/3}\frac{[D_{\rm A}(z)]^2 Y_{500}}{10^{-4}\,{\rm Mpc}^2} = Y_\star \left(\frac{h}{0.7}\right)^{-2+\alpha}\left[\frac{(1-b)M_{500}}{6\times 10^{14} M_{\rm sun}}\right]^\alpha$$

Planck Collaboration 2013 results XX



71 clusters with Planck SZ and X-ray XMM-Newton data

Same as 2013

$$\log Y_* = -0.19 \pm 0.02$$

Can now relax this

$$\alpha = 1.79 \pm 0.08$$

$$\sigma_{\log Y} = = 0.075 \pm 0.01$$

Y-M bias

- (1-b) $=M^X_{500}/M_{500}$ (calibration of mass from X rays)
  – hydrostatic mass bias
  – X-ray flux calibration
  – it's the main uncertainty in our analysis!

- Use priors:
  – external priors (gravitational shear):
    - 1-b=0.80 ± 0.05 (stat) ±0.06 (sys) (CCCP) Hoekstra et al. 2015
    - 1-b=0.688 ± 0.072 (WtG) von der Linden 2014
  – internal priors:
    - 1/(1-b)=1.07 +- 0.19 (cluster CMB lensing measurement of Planck clusters) Melin & Bartlett 2014

PSZ2 cluster detection

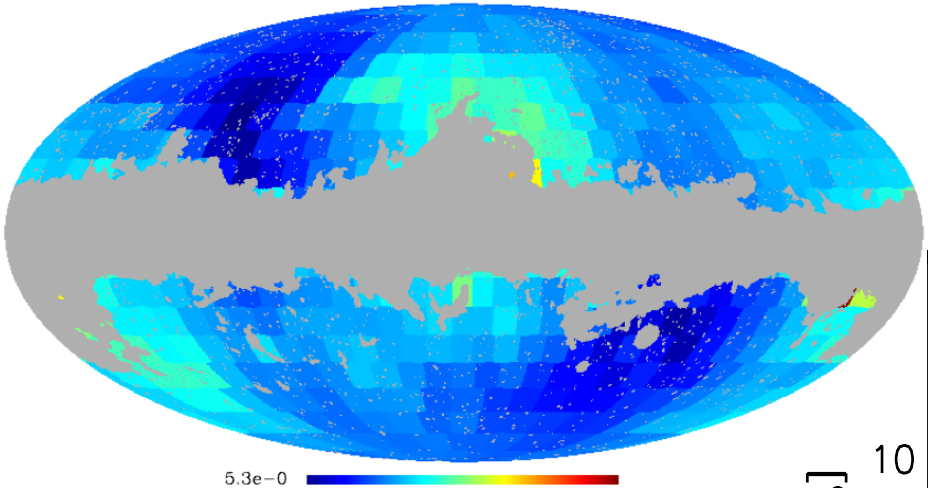
see M. Rossetti's talk….

- Three detection methods: MMF1, MMF3, PwS
  - exploit frequency dependence of SZ effect and information on cluster profiles
  - applied to 100-857 GHz maps
- Full catalogue:1651 clusters and candidates
  - 1110 confirmed
  - 715 new detections wrt PSZ1
- **Cosmo sample: subset with S/N>6**
  - **438 clusters (MMF3)**
  - **z in [0,1], M in [1,20]10^{14} M_{sun}**

Preliminary

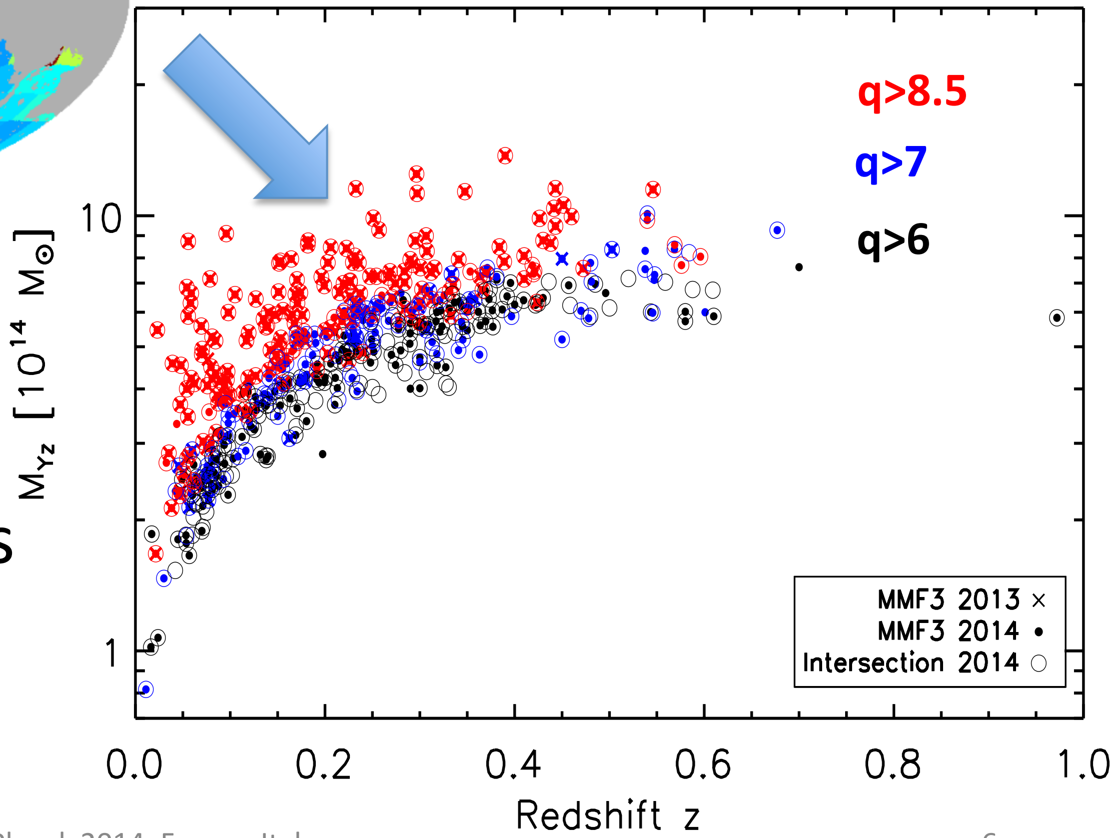
Selection function

Preliminary



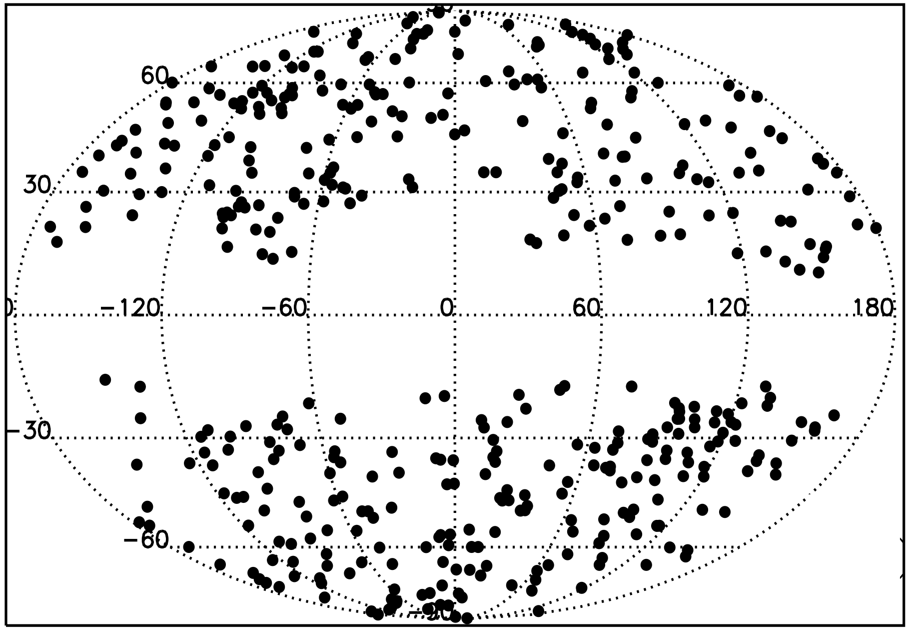
σ_{Y500} [arcmin-2] for
θ=1.7 arcmin

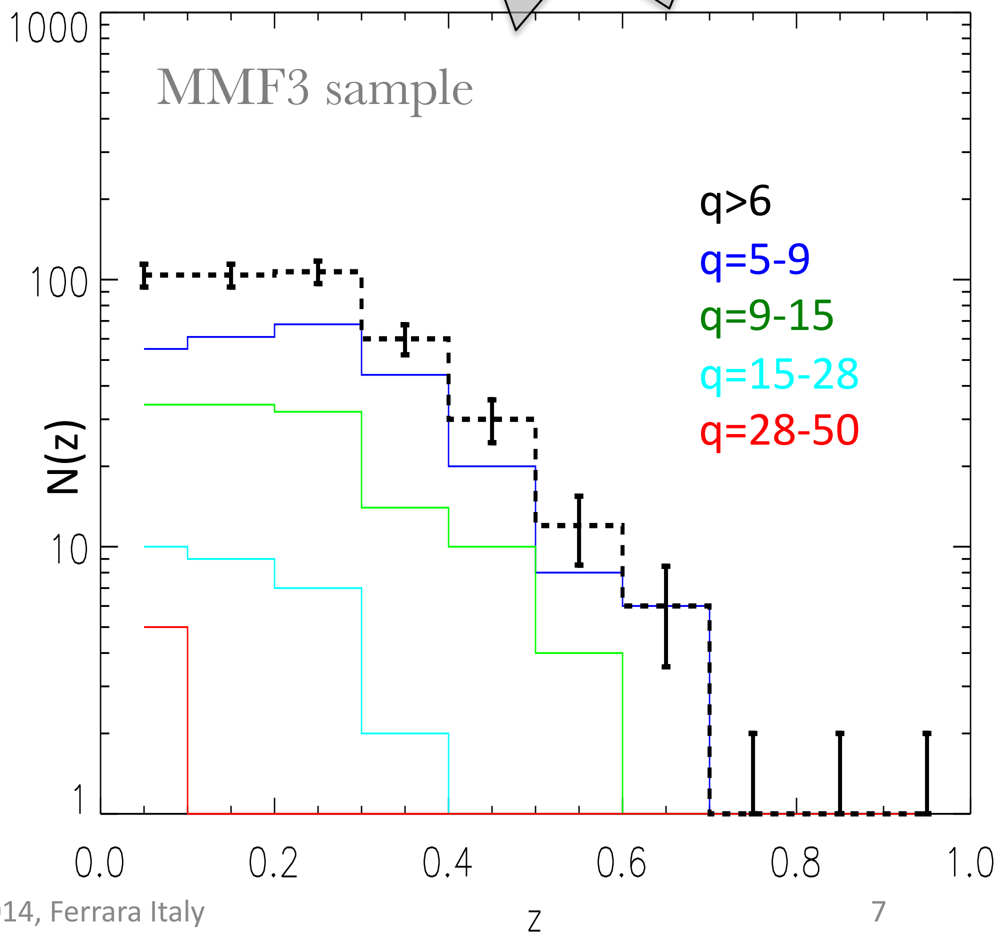
- Noise map from MMF3 for all detection patches
- Threshold in q=S/N
- 65% of sky



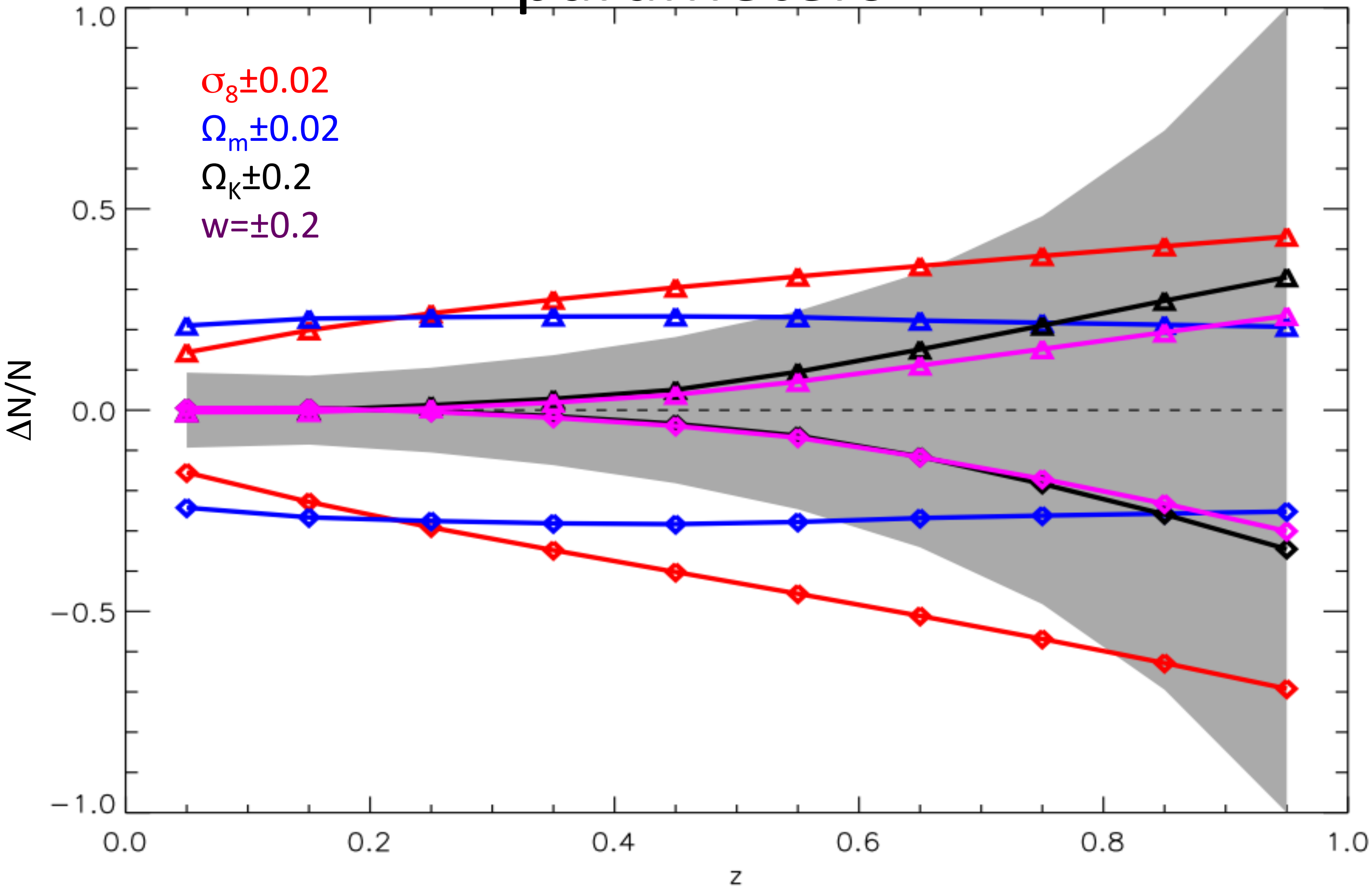
Cosmological sample

Preliminary





Dependence on cosmological parameters



Likelihood

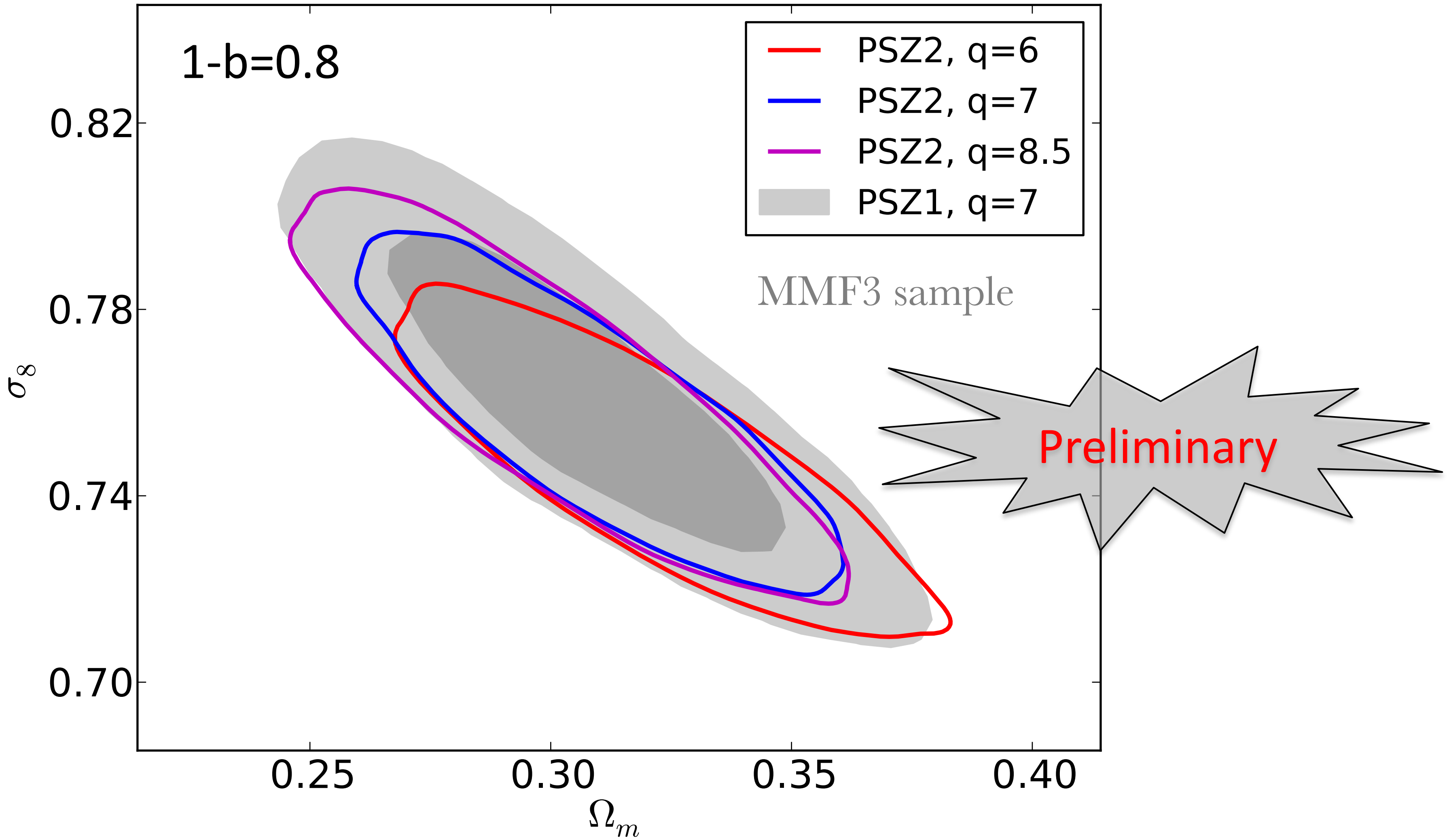
- SZ likelihood: Cash-C statistics

$$\ln L = \sum_{i,j}^{N_z N_q} \left[N_{ij} \ln \bar{N}_{ij} - \bar{N}_{ij} - \ln[N_{ij}!] \right]$$

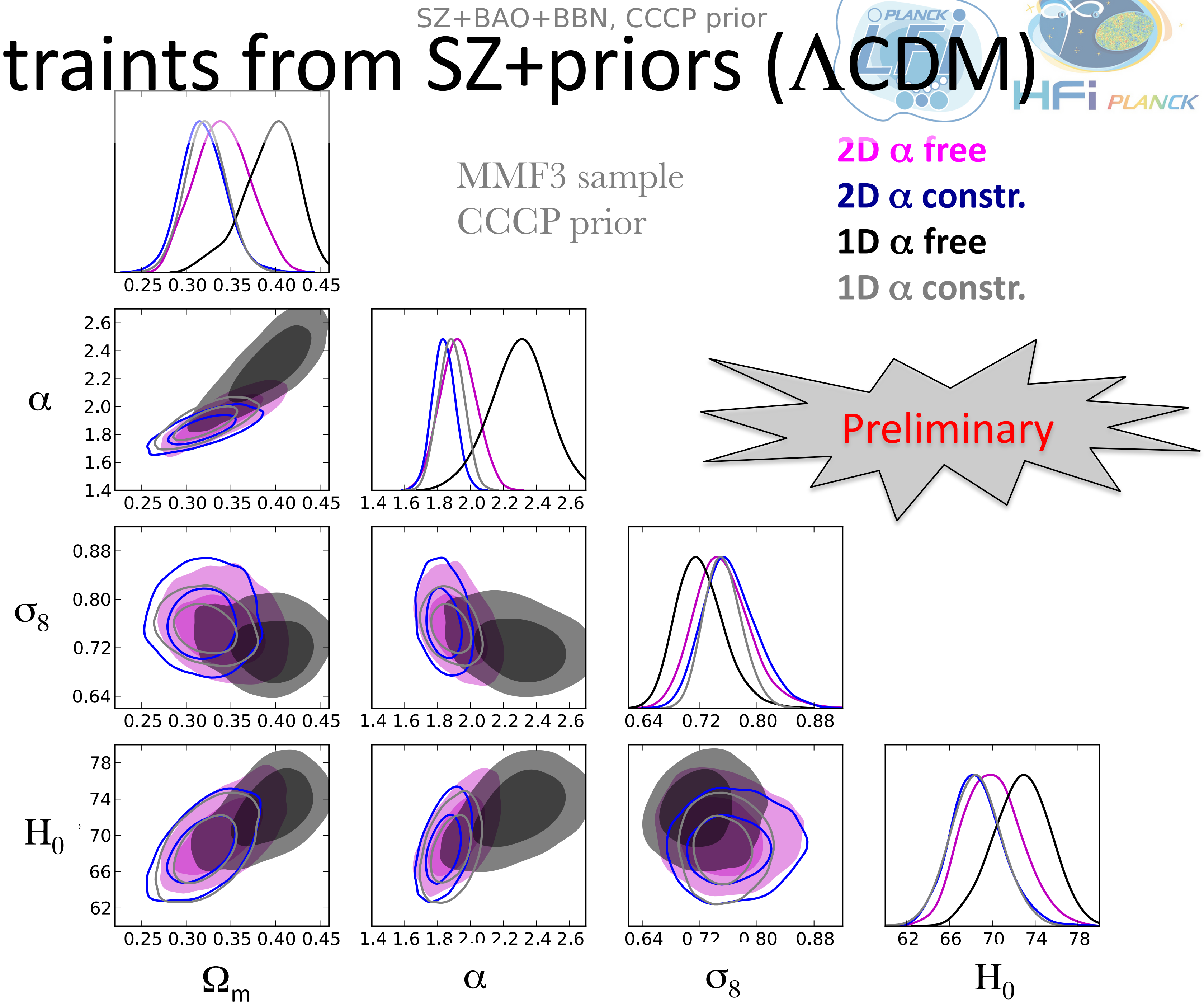
catalogue counts
theory counts

- Additional information:
  - BBN $\Omega_b h^2 = 0.022 \pm 0.002$ (Steigman 2008)
  - BAO to constrain H_0 (Beutler et al. 2011, Padmanabhan at al. 2012, Anderson et al. 2012, 2014)
  - Planck CMB prior on $n_s = 0.9624 \pm 0.014$ (Planck 2013 results XVI)

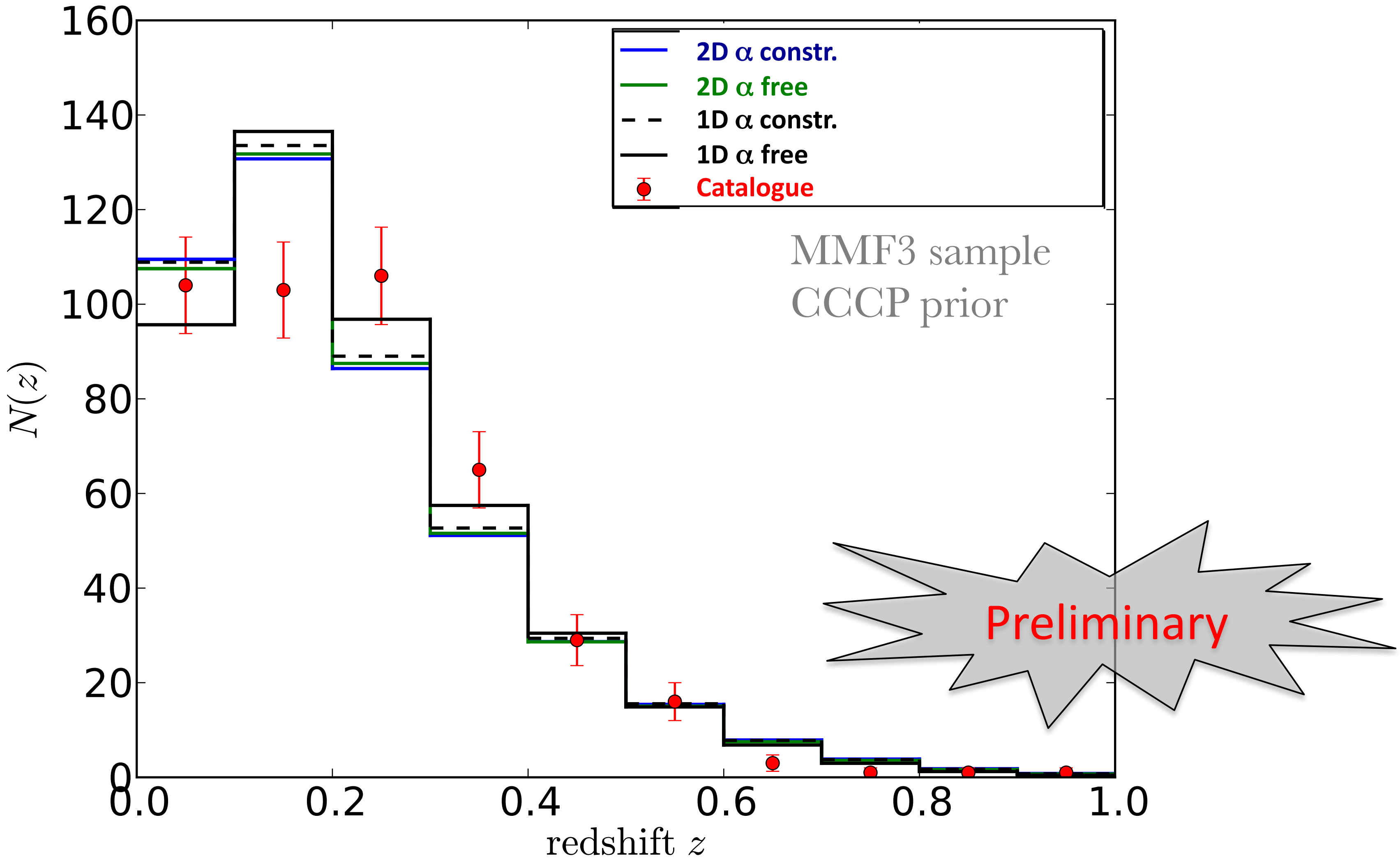
Comparison with PSZ1



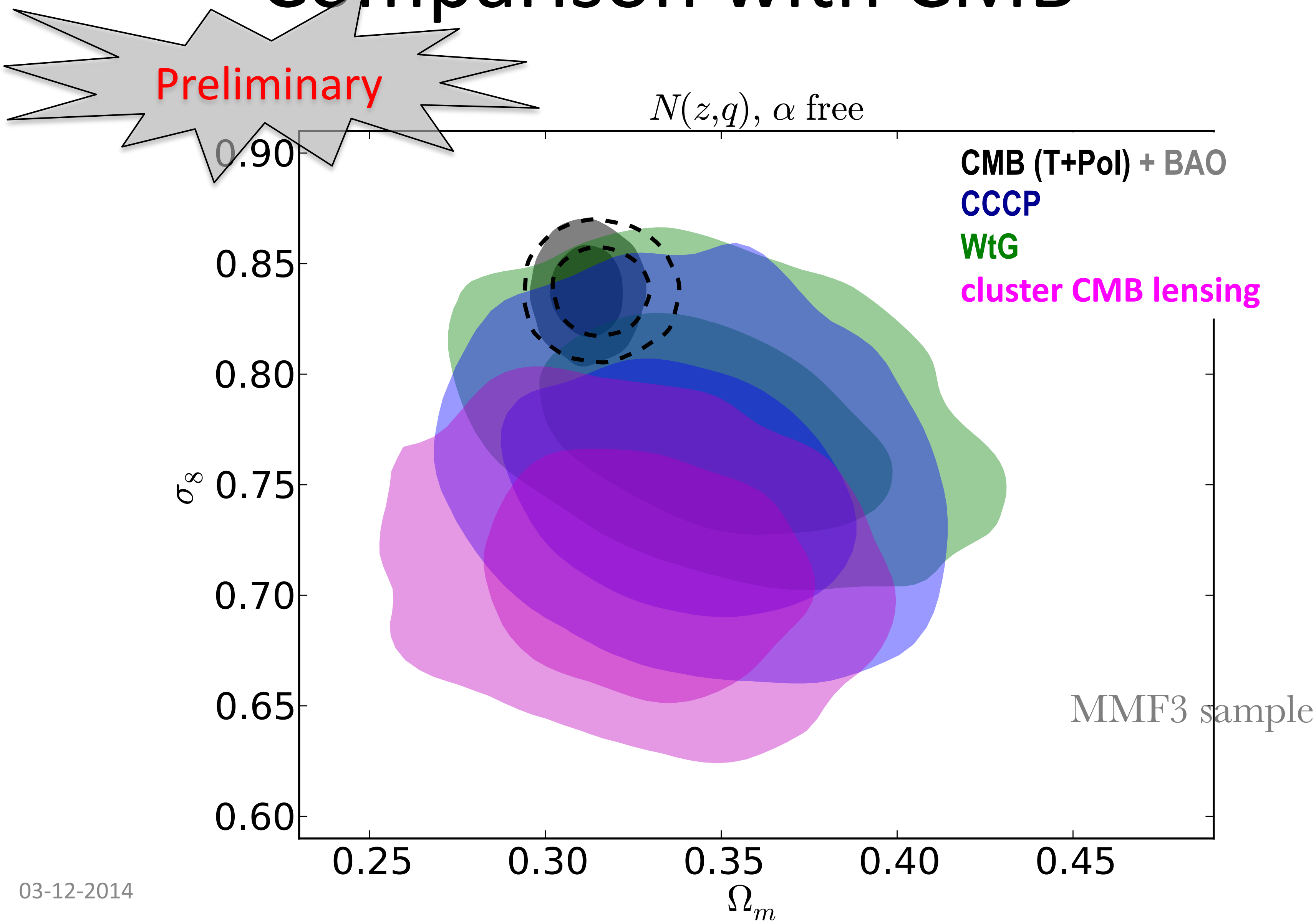
Constraints from SZ+priors (ΛCDM)



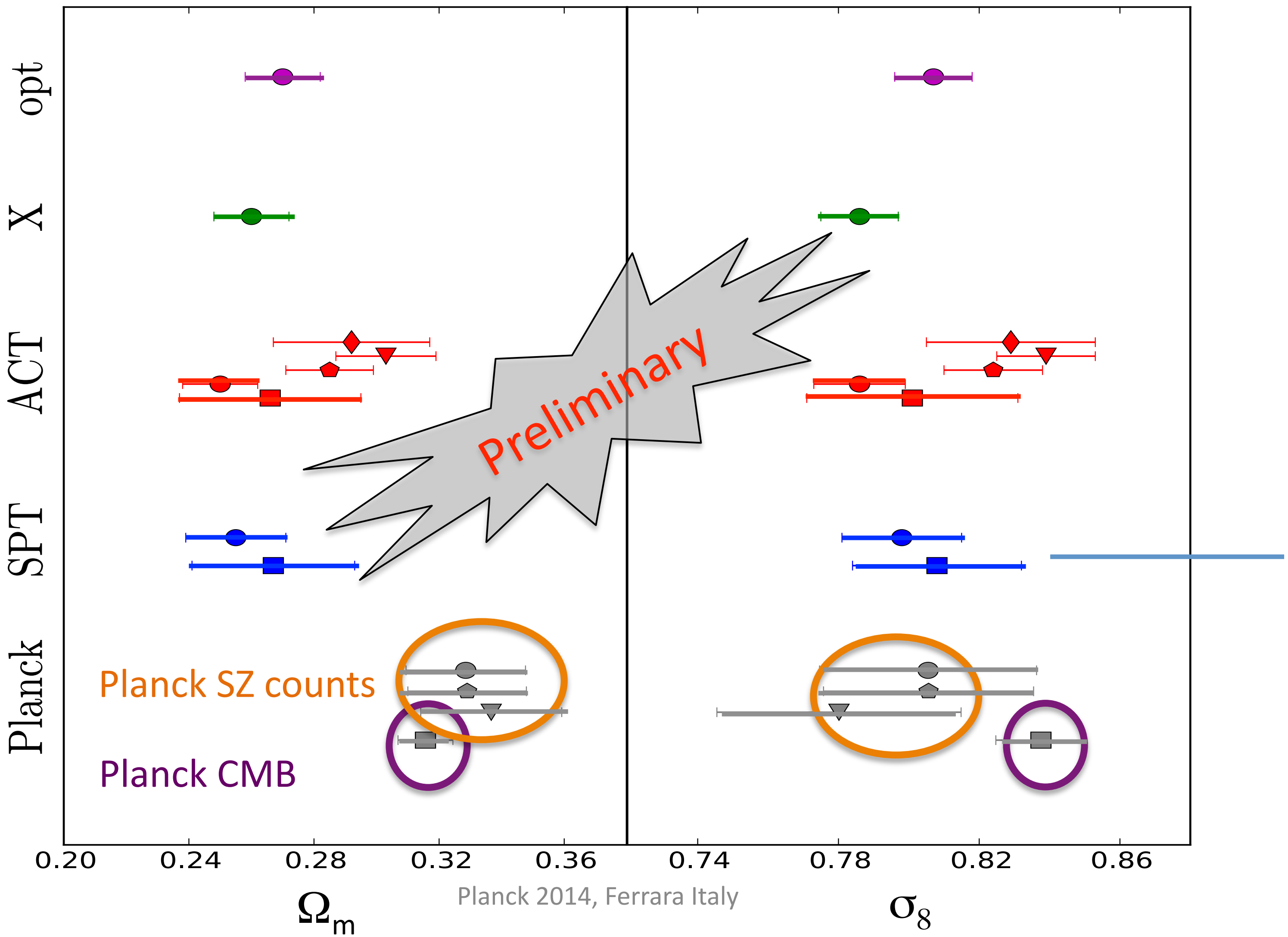
Counts for best-fit models



Comparison with CMB

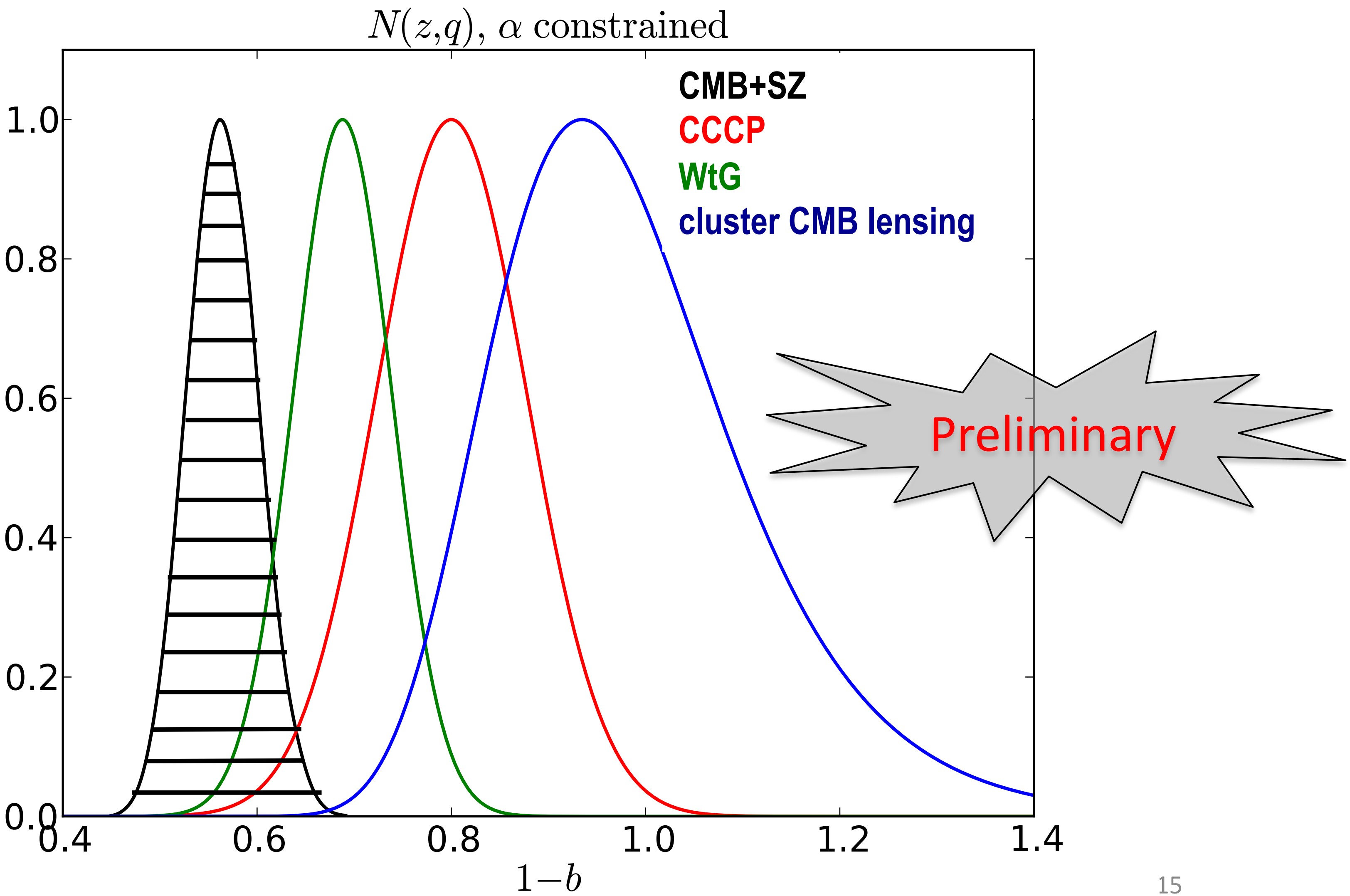


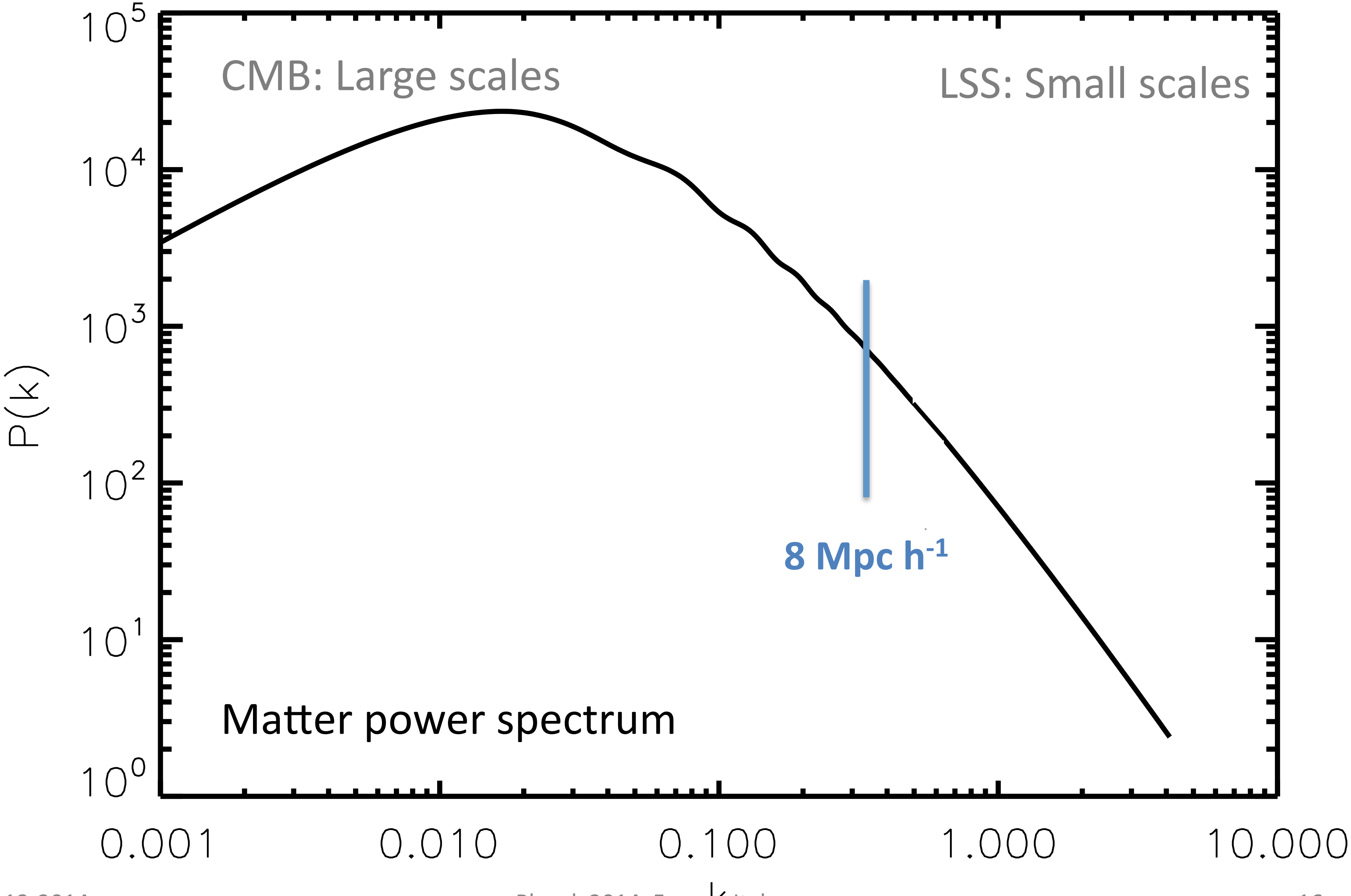
Comparison to other measurements



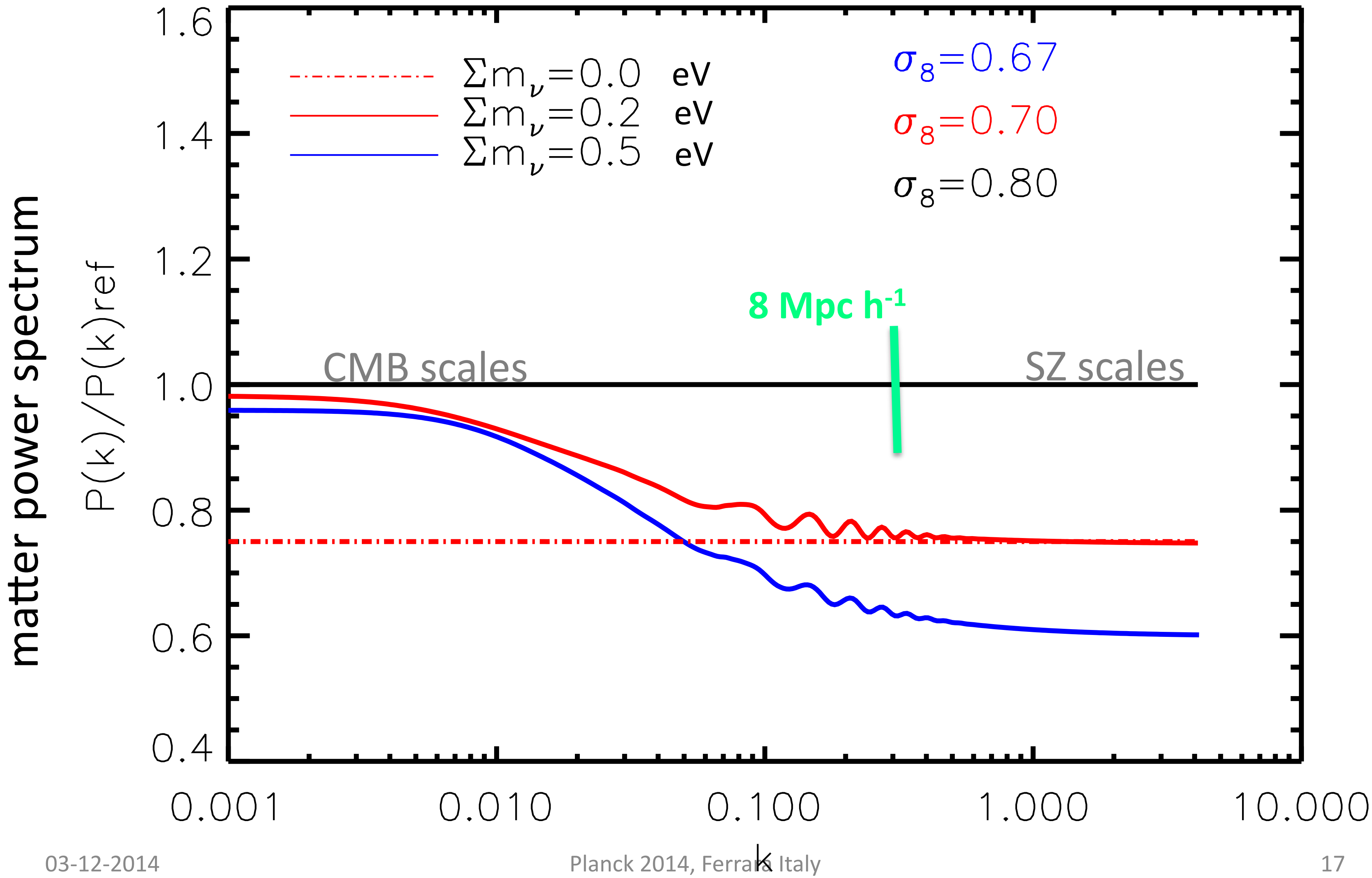
Impact of mass bias

MMF3 sample

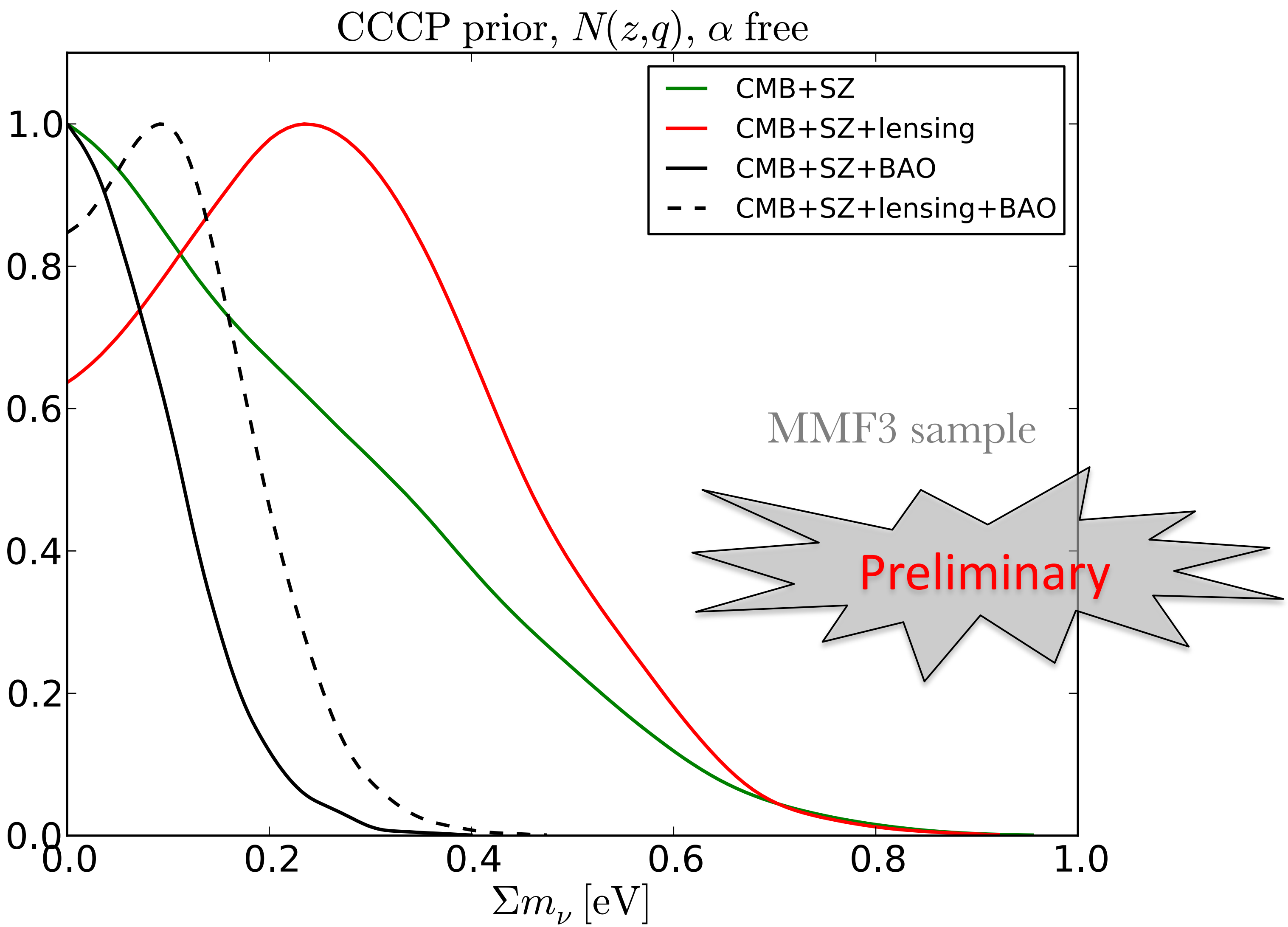



CMB: Large scales
LSS: Small scales
8 Mpc h-1
Matter power spectrum
P(k)
k
0.001
0.010
0.100
1.000
10.000

Impact of massive neutrinos



Fit for massive neutrinos



Preliminary

Conclusions

- Cosmology with 438 SZ clusters having S/N>6
- Improvements wrt our previous work:
  - larger sample (438 vs 189)
  - priors on (1-b): galaxy lensing and cluster CMB lensing
  - improved 2D likelihood -> relaxing prior on Y-M slope
- Results in agreement with our previous analysis
- Tension with primary CMB on σ_8
  - requires 1-b~0.56 -> smaller than WtG prior
  - higher 1-b and combination with lensing power spectrum and/or BAOs favours non-minimal neutrino masses (may conflict with other data)

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asdc ASI Science Data Center