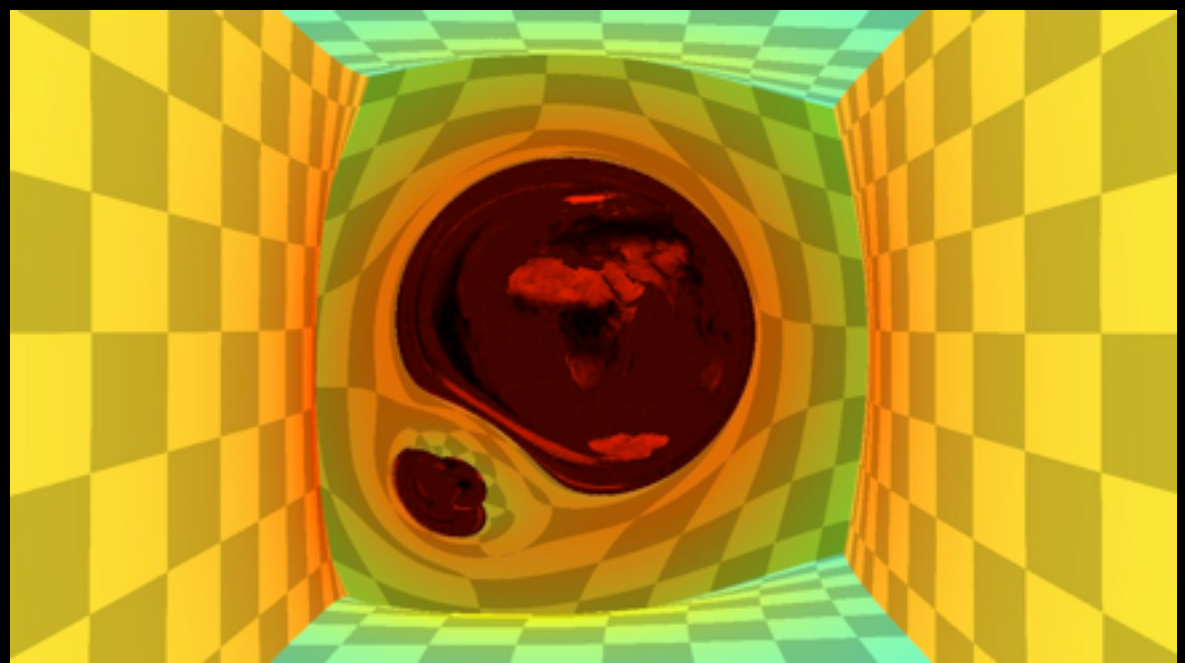
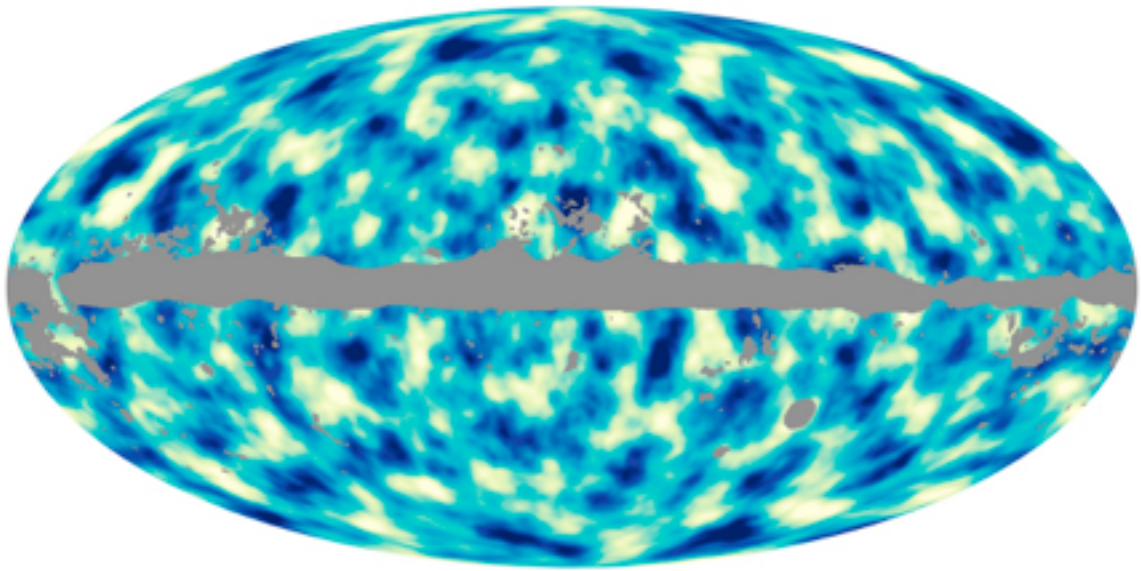
Galaxy lensing and modified gravity: digging into non-linear scales

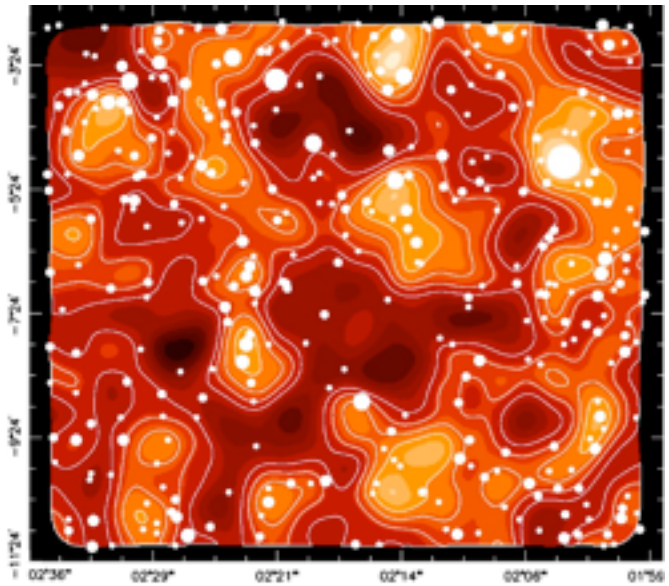


L. Van Waerbeke
(UBC/CIfAR)

SFU-UBC ModGrav january 17th 2015



Planck CMB lensing



CFHTLenS mass map

CMB lensing significance: Planck full sky ~25 σ

CMB lensing significance: SPT/ACT ~600 sq.deg. ~6 σ

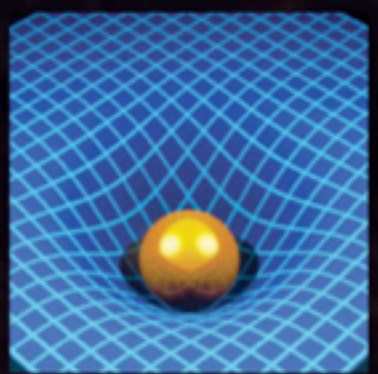
CFHTLenS lensing significance: 150 sq.deg. ~30 σ

DES or KiDS lensing significance over 100 σ

LSST or Euclid lensing significance over 400 σ

Beyond-Einstein gravity theories

$$ds^2 = (1+2\Phi)dt^2 - a^2(1-2\Psi)dx^2$$



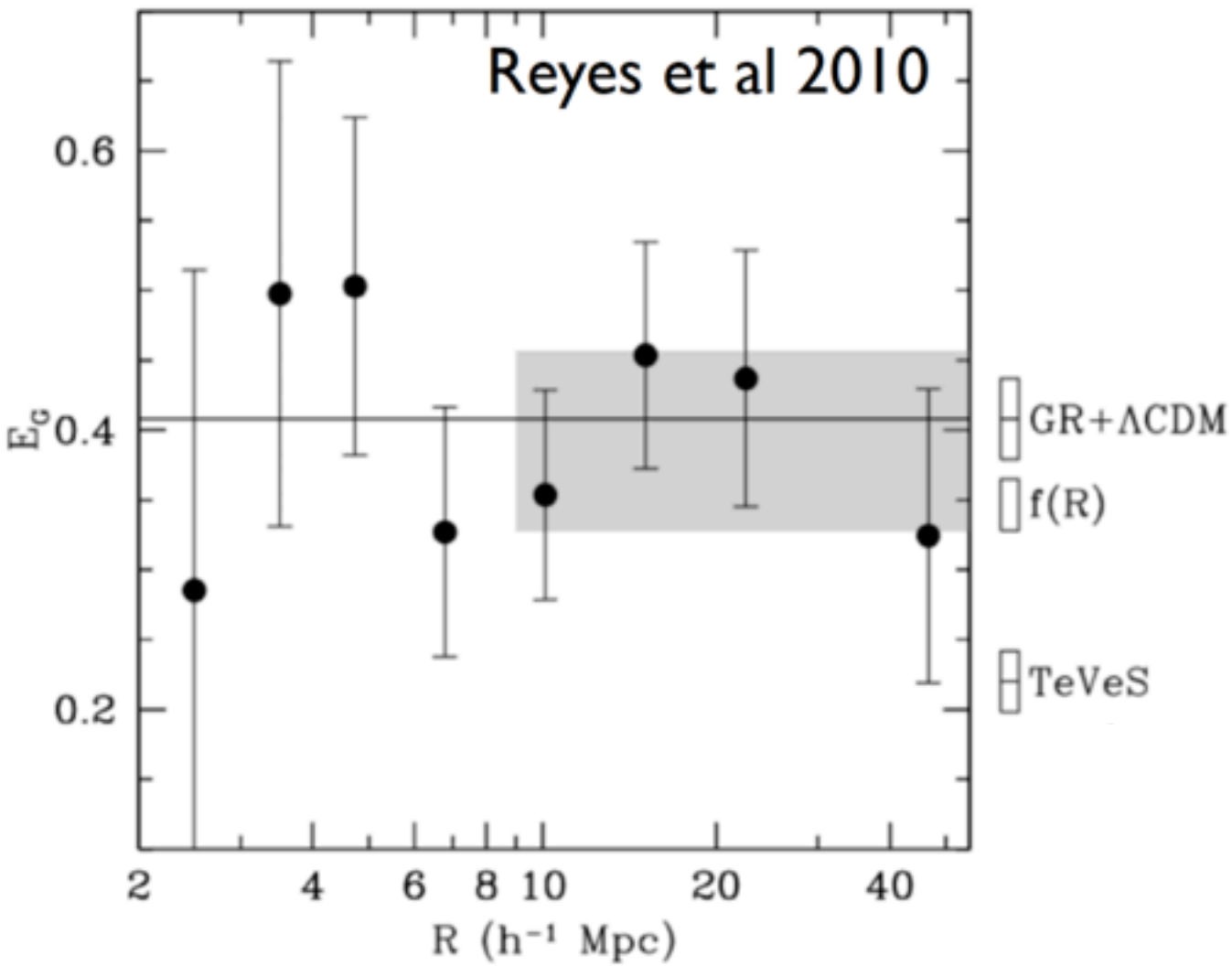
Gravitational Potential

Curvature Potential

Poissons Equation $\nabla^2\Phi = 4\,\pi G a^2\,\bar{\rho}\delta$

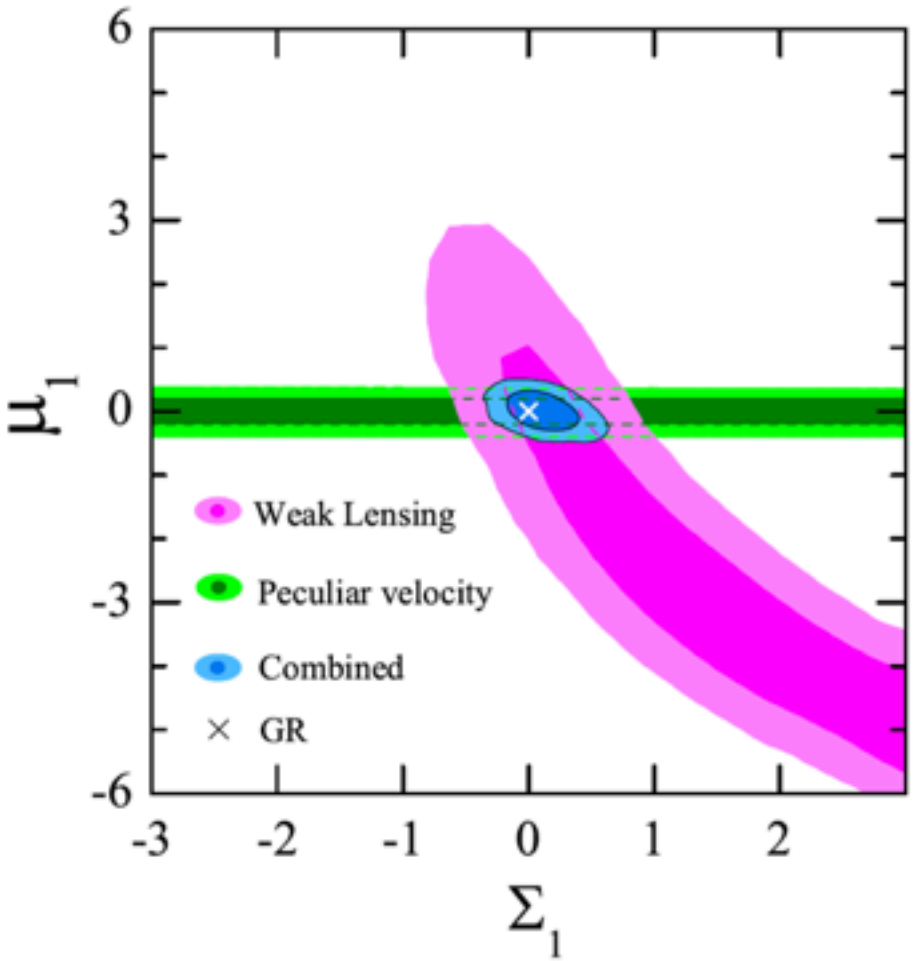
GR fully tested on solar system scales, so any modification must be length or time dependent

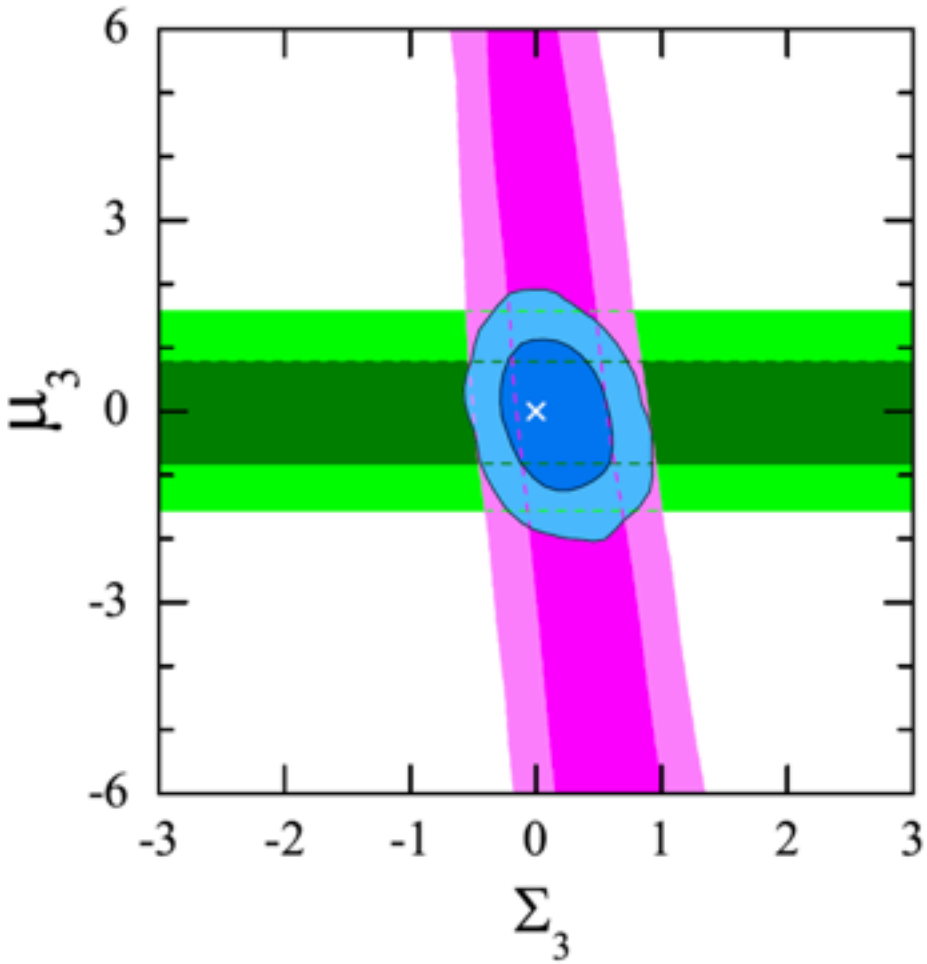
Combining redshift survey and gravitational lensing



$$E_G(R) = \frac{1}{\beta}\frac{\Upsilon_{gm}(R)}{\Upsilon_{gg}(R)}$$

Combining redshift space distortion and gravitational lensing



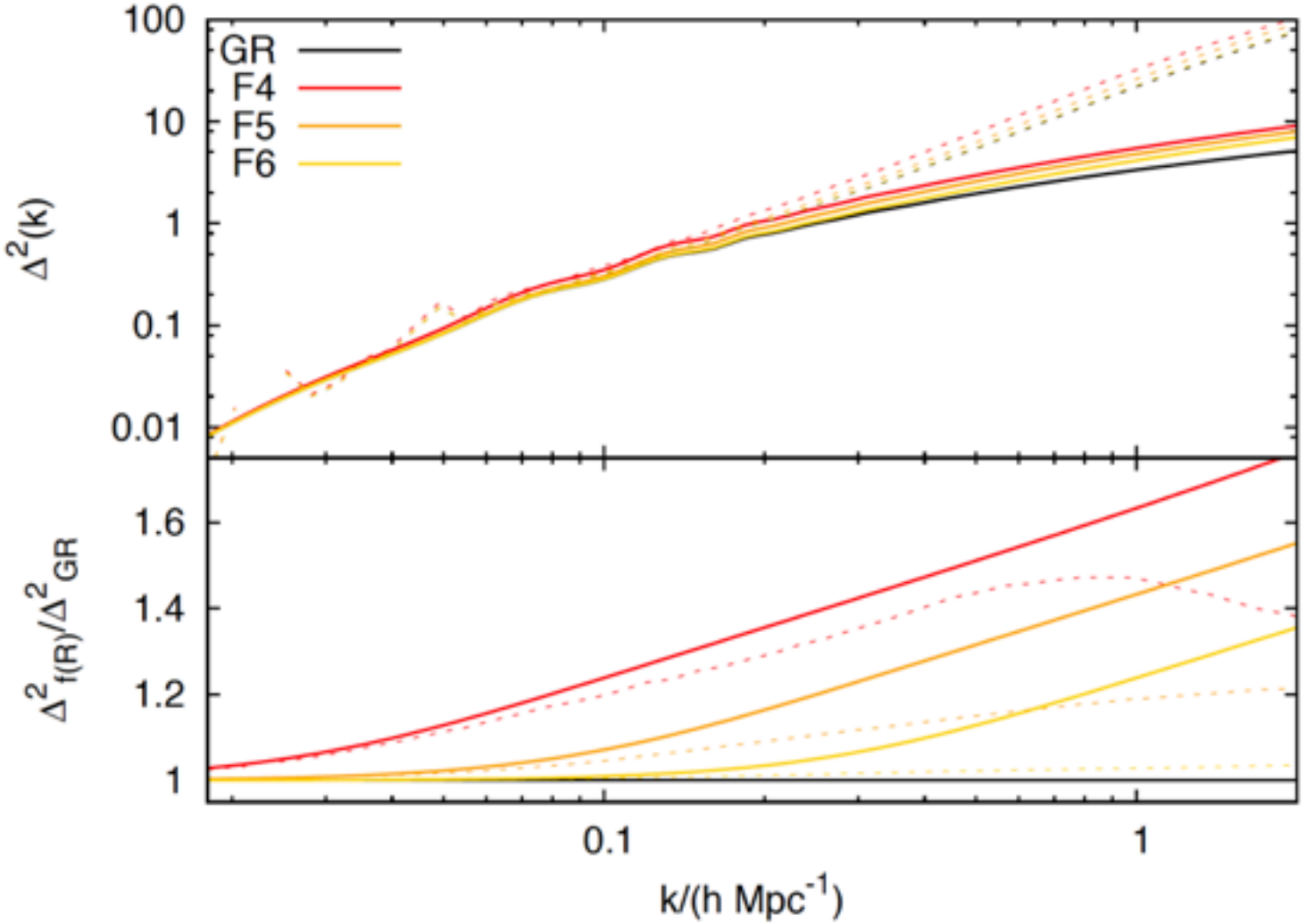


Song, Zhao, Bacon, et al. 2010
(CFHTLenS large scale+SDSS)
scale>30 arcmin

$$k^2\Psi = -4\pi G a^2 \mu(k,a)\rho\delta,$$
$$k^2(\Phi-\Psi) = 8\pi G a^2 \Sigma(k,a)\rho\delta,$$

$$\Sigma = 1+\Sigma_s a^s, \quad \mu = 1+\mu_s a^s$$

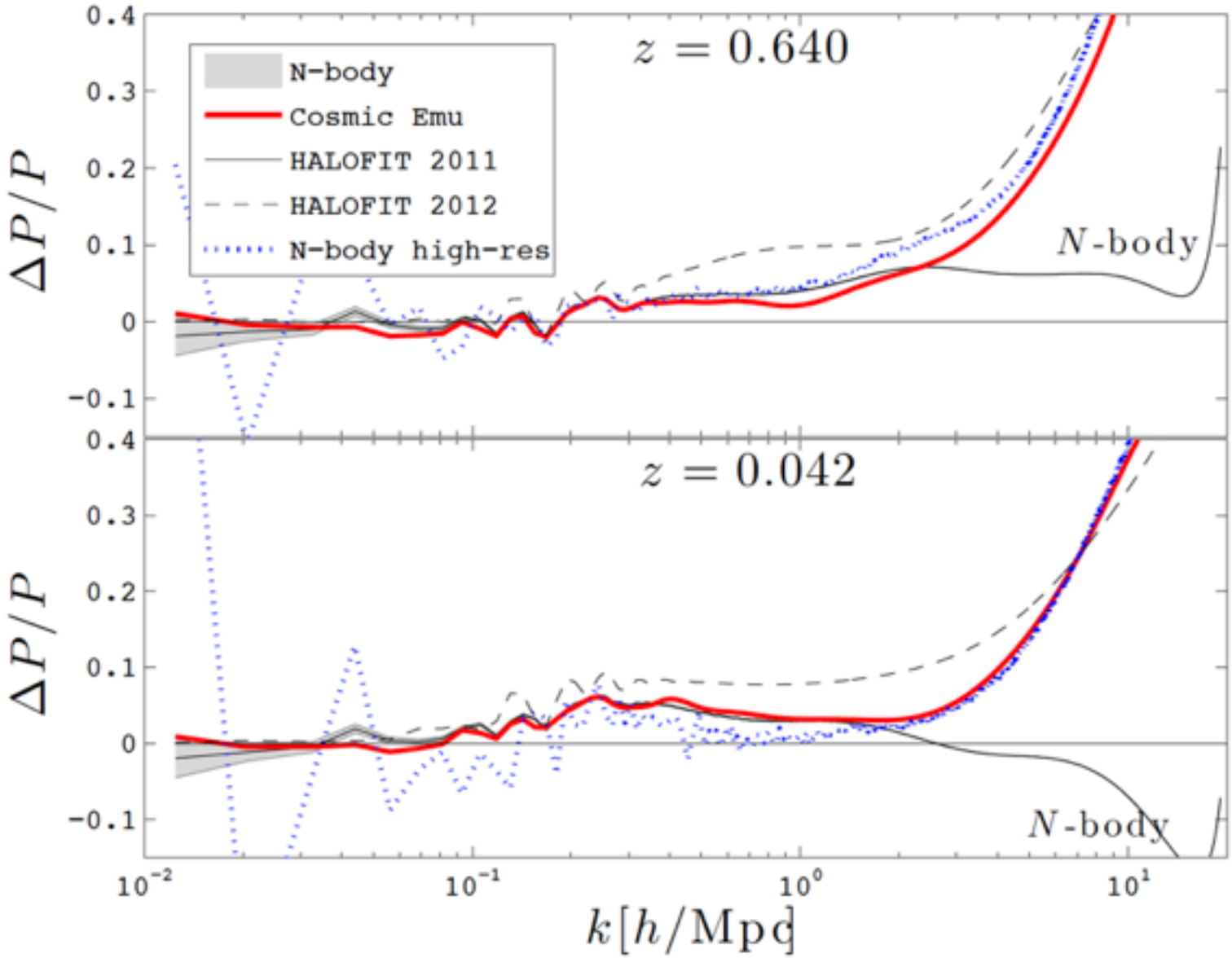
f(R) theories and matter power spectrum



Simulation	n	f_{R0}
GR	-	-
F6	1	-10^{-6}
F5	1	-10^{-5}
F4	1	-10^{-4}

Mead et al. 2014
arXiv:1412.5195

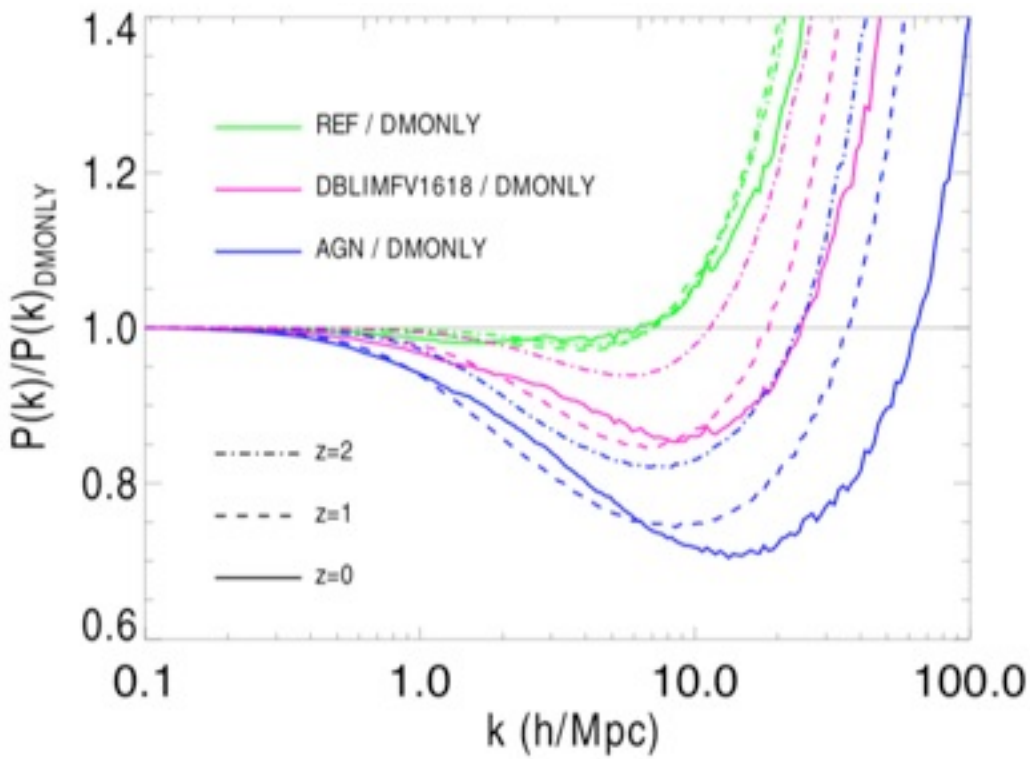
Digging into non-linear scales I: theoretical predictions



Harnois-Deraps and Van Waerbeke 2014, arXiv:1406.0543

The effects of galaxy formation on the matter power spectrum

Marcel van Daalen, Joop Schaye, Craig Booth & Claudio Dalla Vecchia



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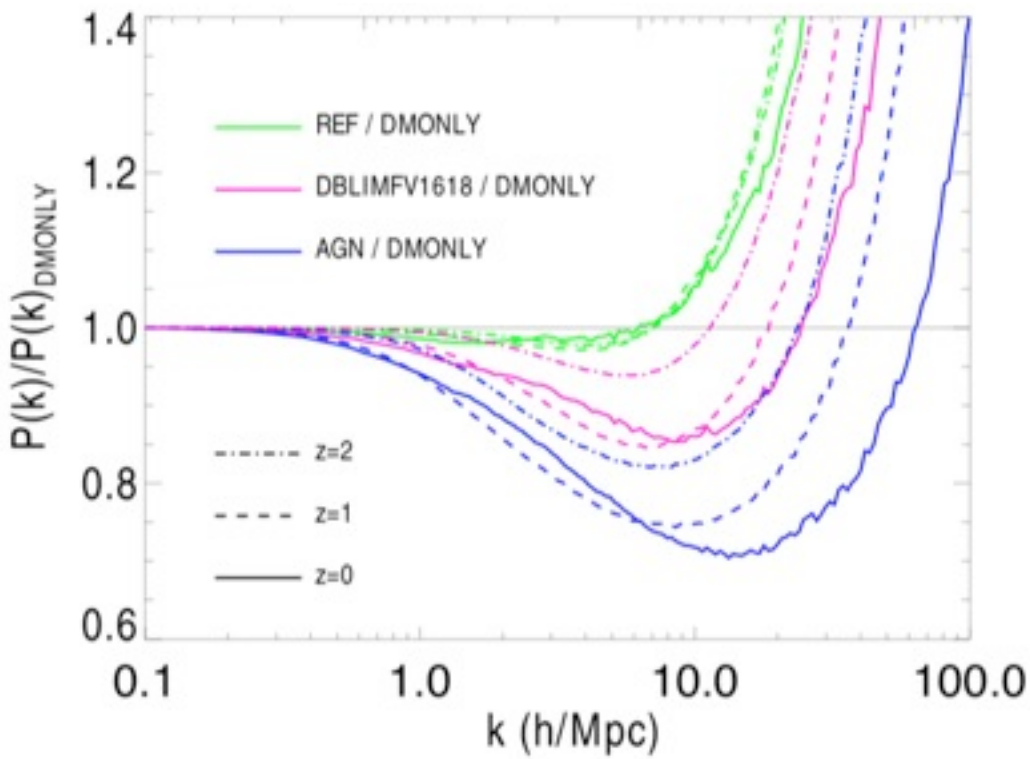

Van Daalen et al, 2011
Semboloni et al, 2011,2012

The effects of galaxy formation on the matter power spectrum

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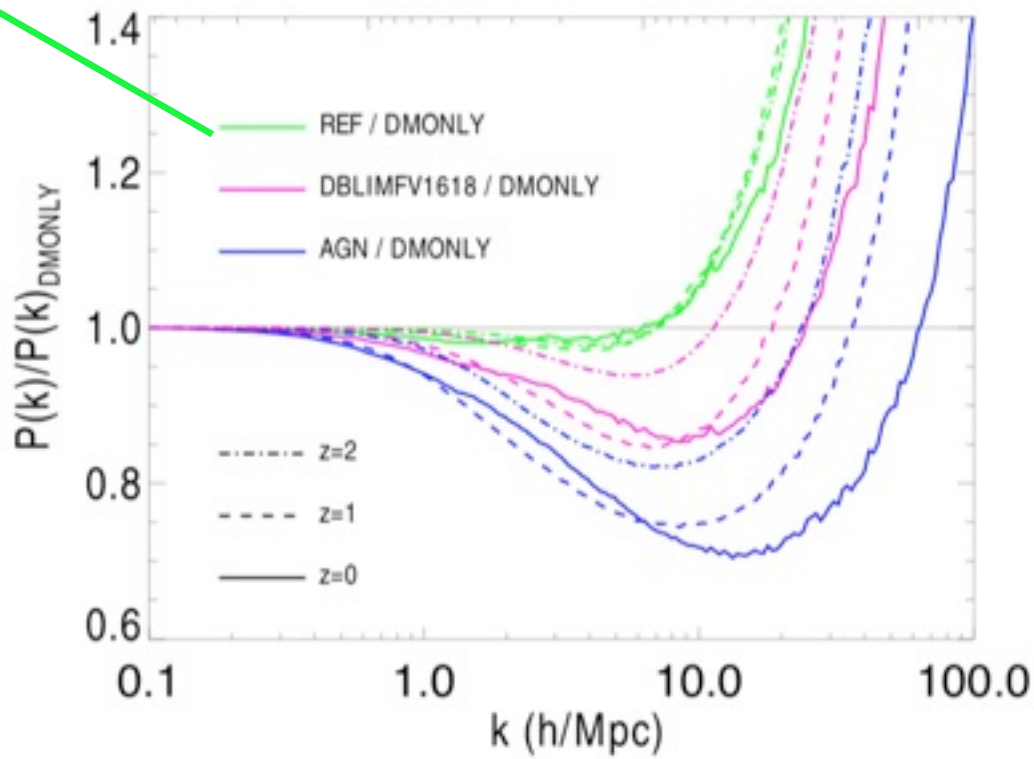
REF: SN winds, cooling, SF,…
No AGN feedback
baryon1



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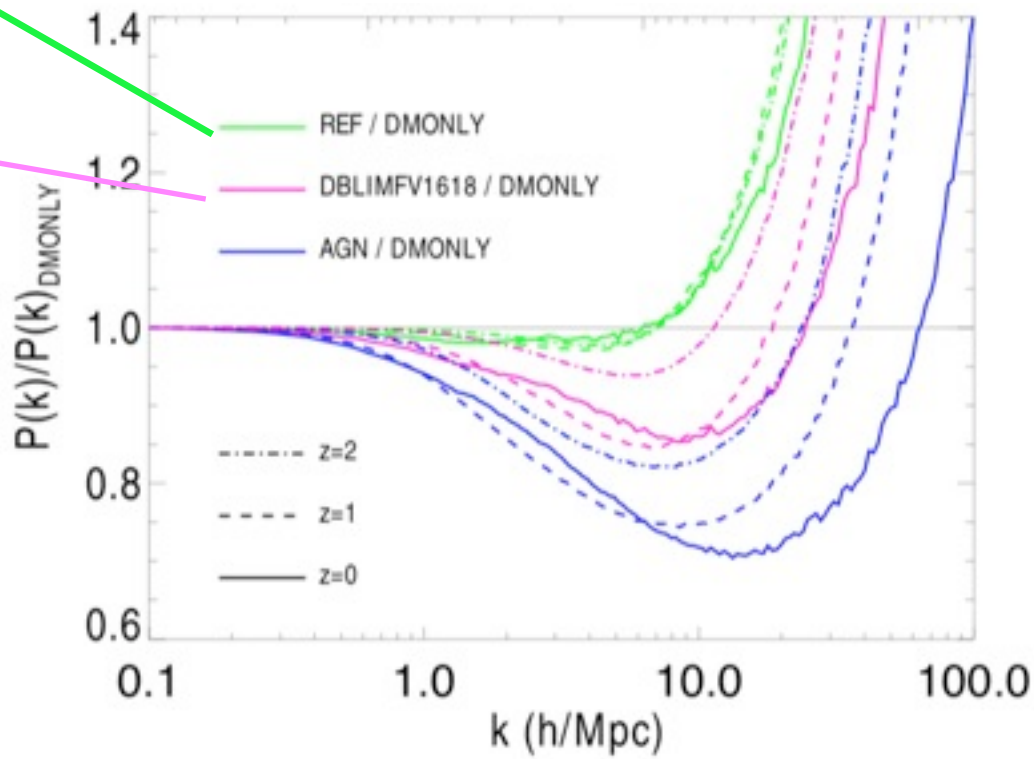
baryon1

DBLIM: Top heavy IMF
baryon2



Van Daalen et al, 2011
Semboloni et al, 2011,2012

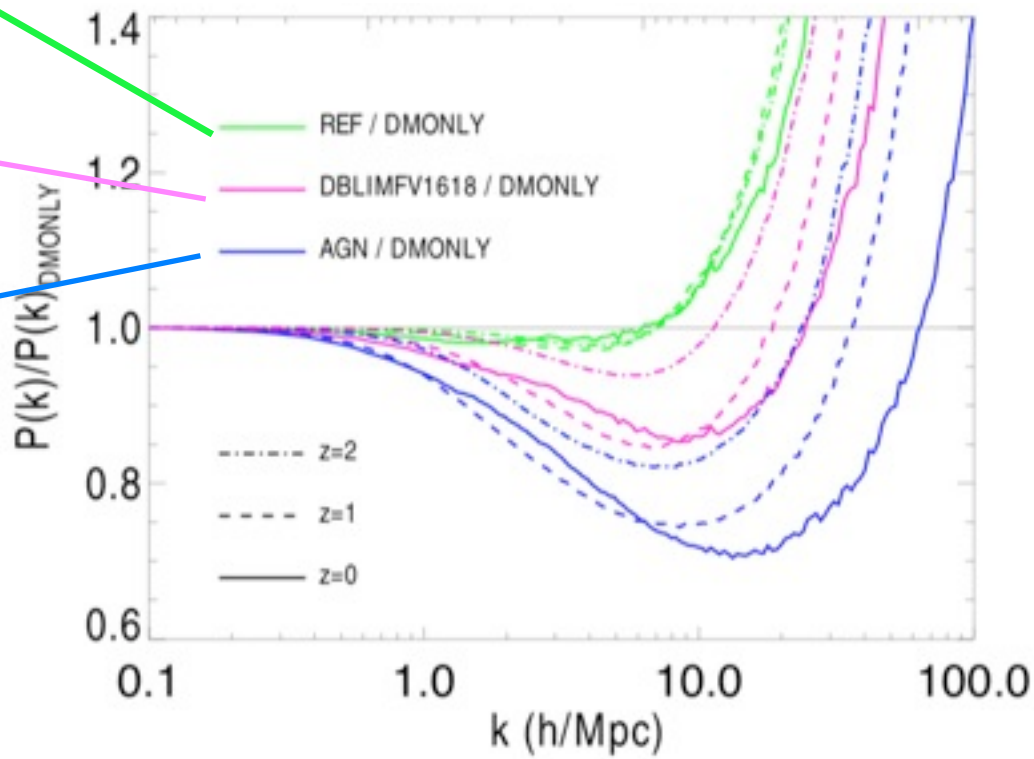
The effects of galaxy formation on the matter power spectrum

Marcel van Daalen, Joop Schaye, Craig Booth & Claudio Dalla Vecchia

REF: SN winds, cooling, SF,…
No AGN feedback
baryon1

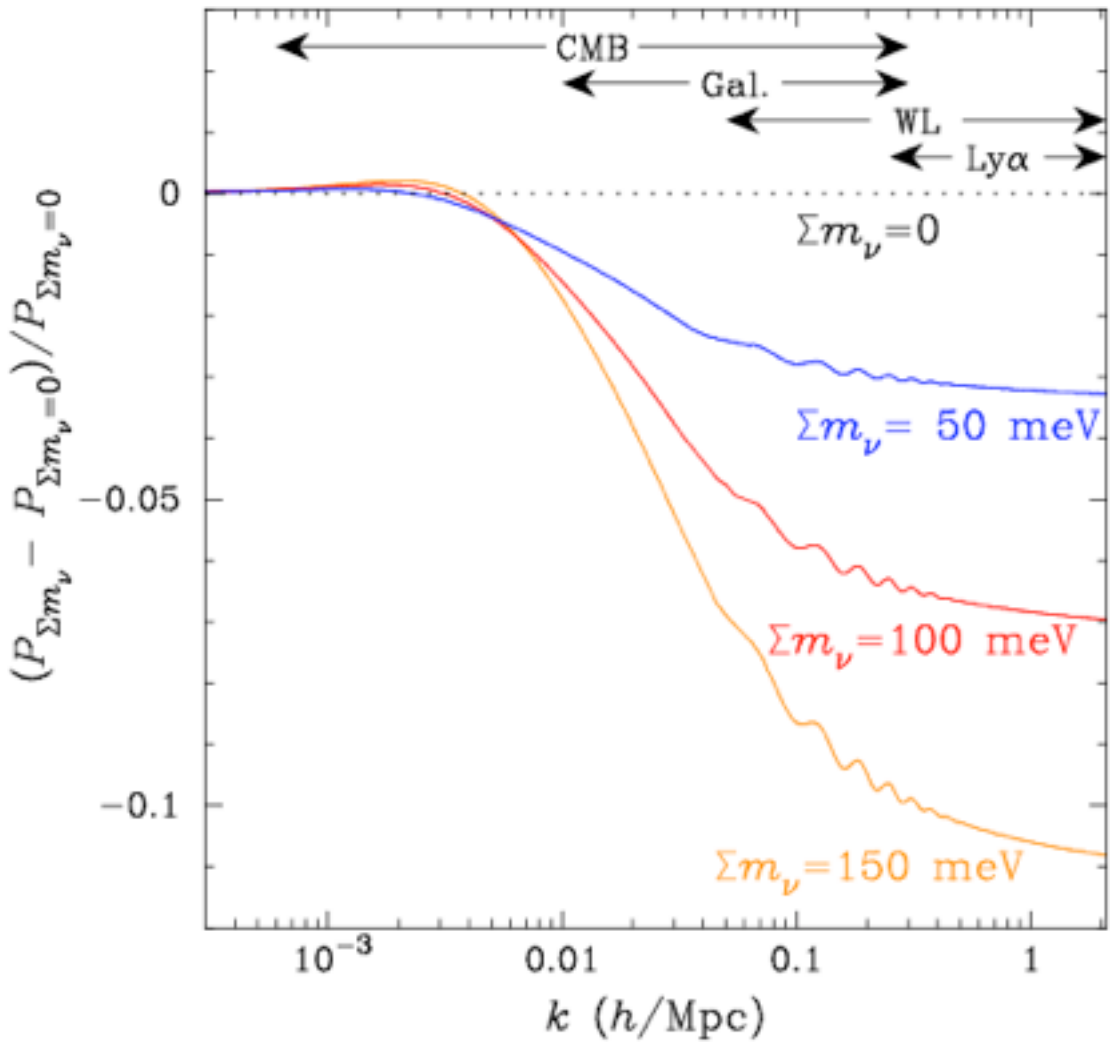
DBLIM: Top heavy IMF
baryon2

REF+AGN (Booth & Shaye 2009)
baryon3



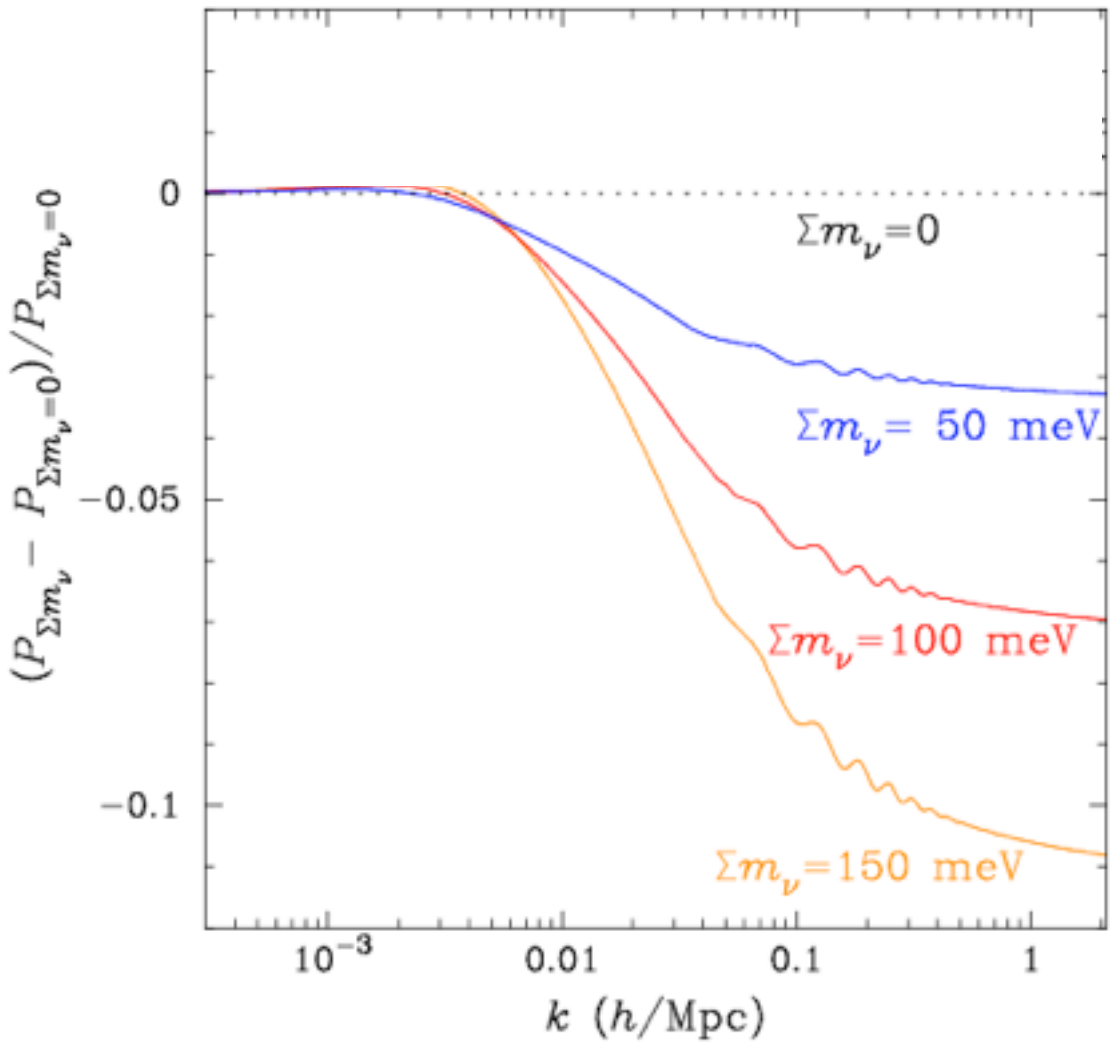
Van Daalen et al, 2011
Semboloni et al, 2011,2012

Effect of neutrino mass on the mass power spectrum



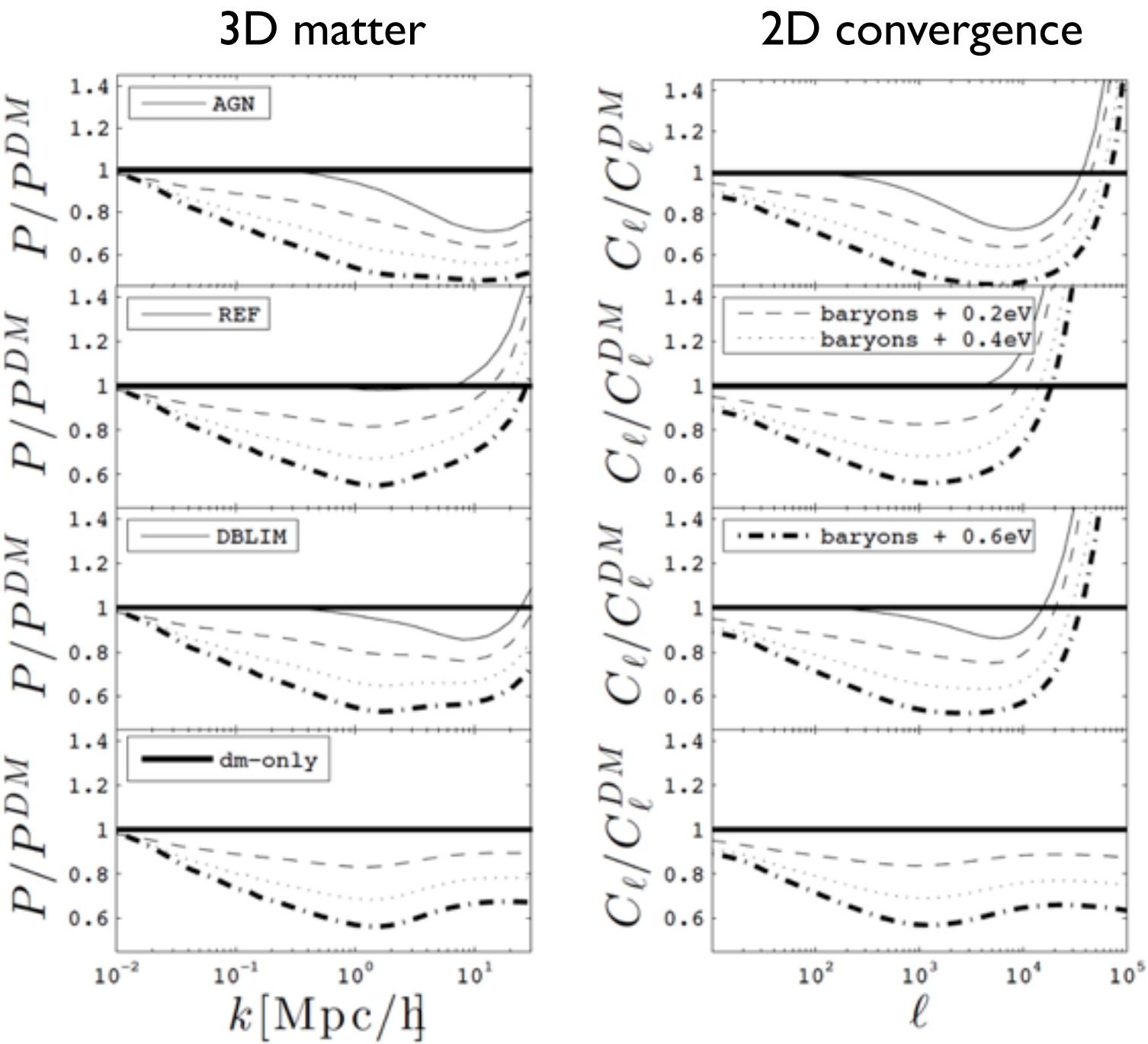
(Abzajian et al 2014)

Effect of neutrino mass on the mass power spectrum



(Abzajian et al 2014)

Impact of baryons+neutrino on the 3D and 2D power spectra

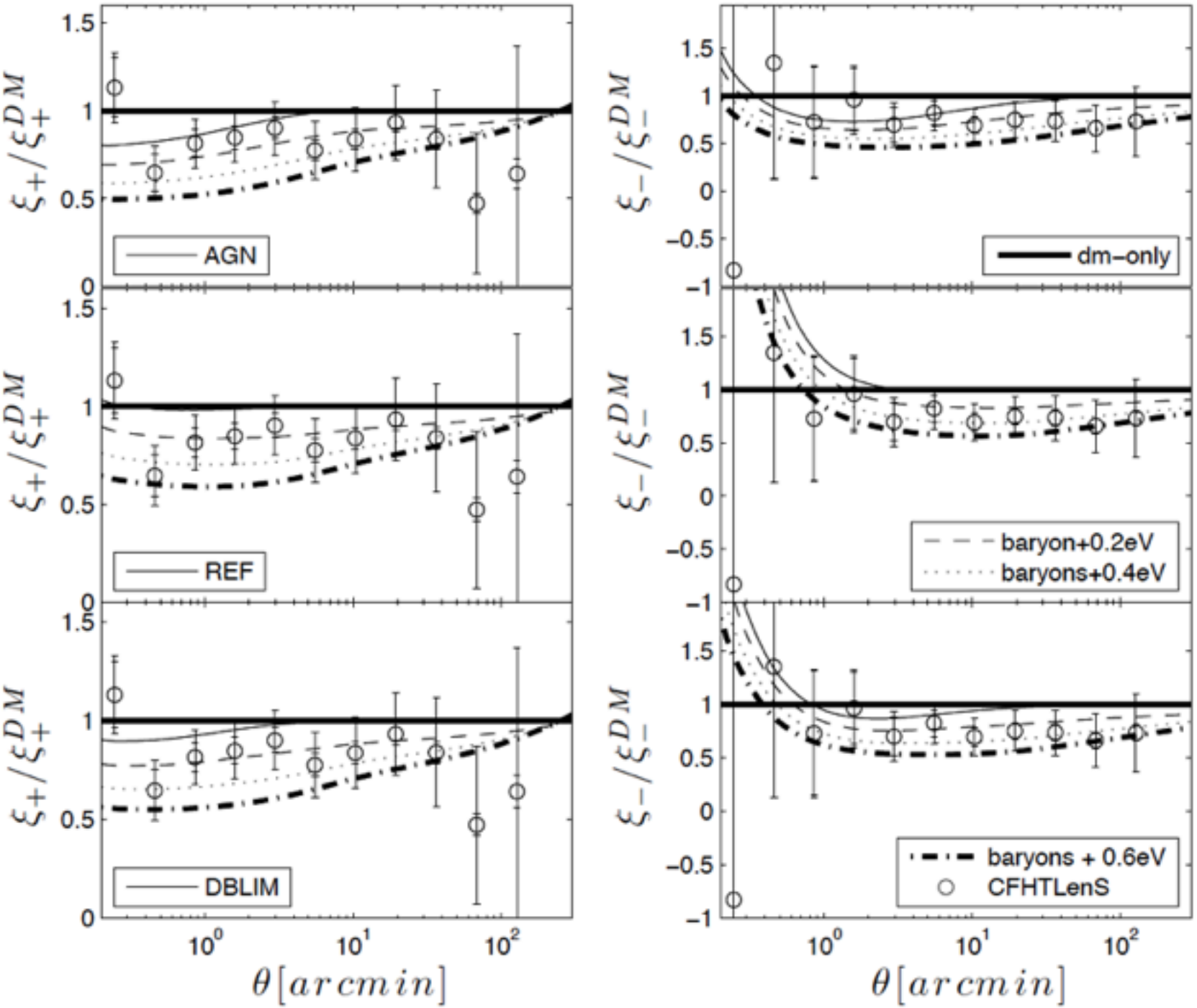


CFHTLenS
+simLenS

baryons 3

baryons 1

baryons 2

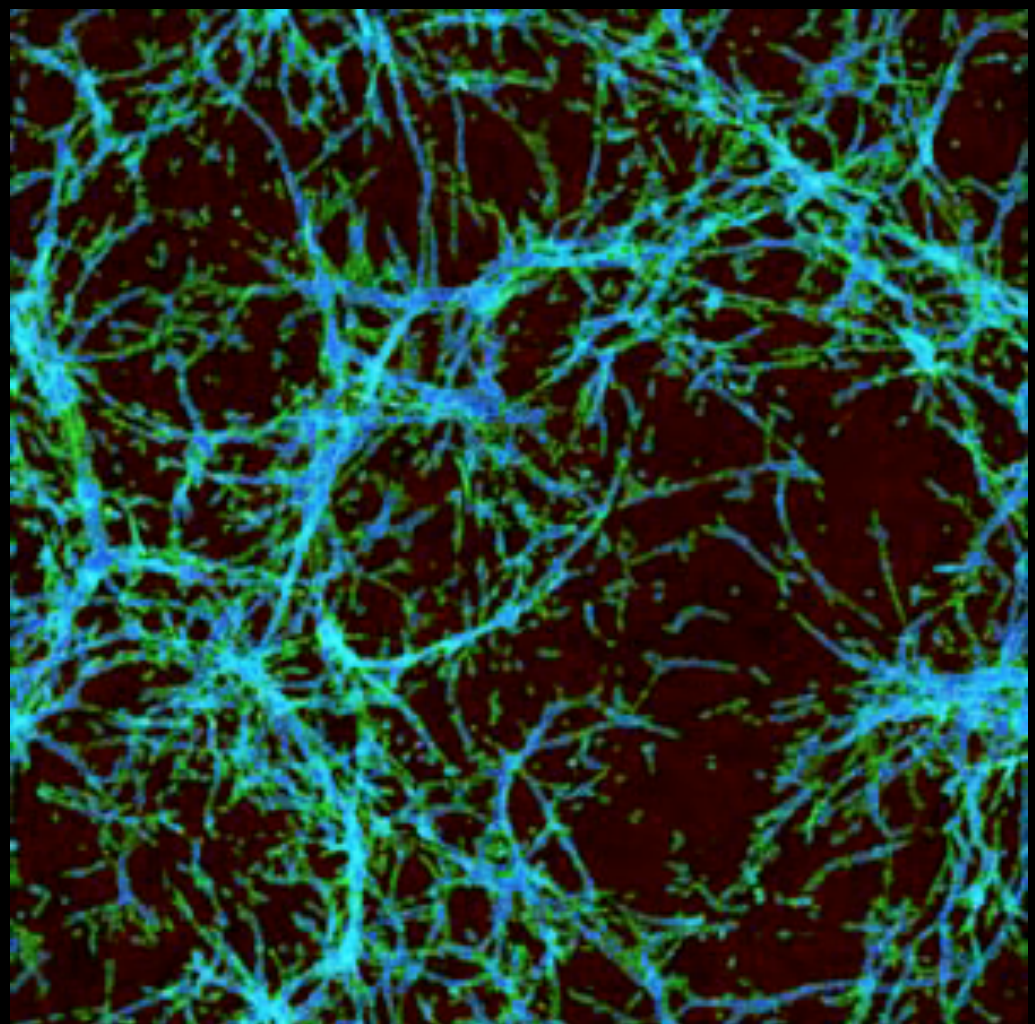


Harnois-Deraps et al. arXiv:1407.4301

Main results (Harnois-Deraps et al. arXiv:1407.4301)

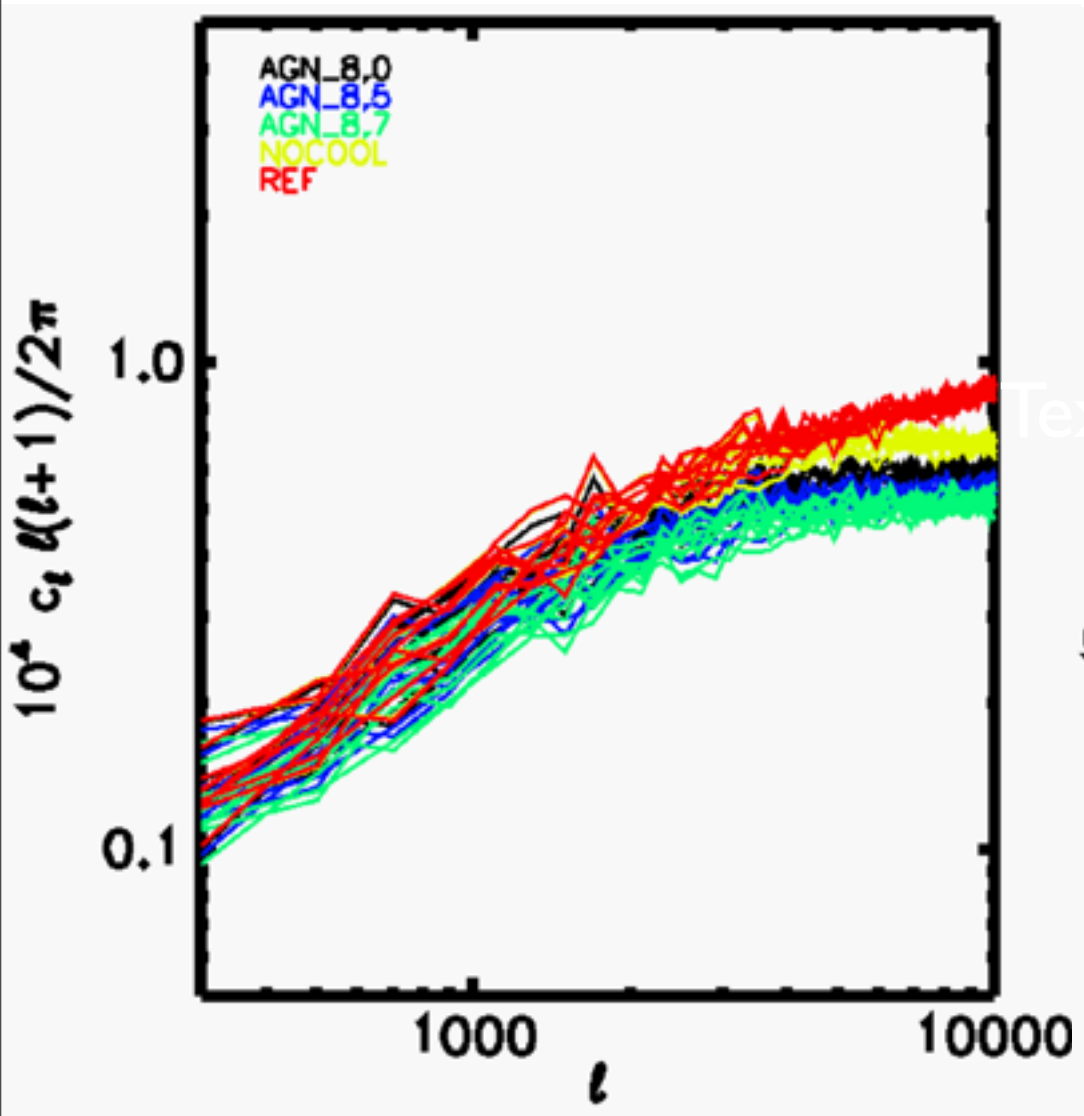
	ξ_+ alone				ξ_+ and ξ_- combined			
M_ν	0.0eV	0.2eV	0.4eV	0.6eV	0.0eV	0.2eV	0.4eV	0.6eV
DM-only	**0.036**	0.158	0.267	0.230	**0.037**	0.278	0.621	0.760
AGN	0.110	0.222	0.209	0.120	0.168	0.476	0.659	0.675
REF	**0.050**	0.189	0.289	0.235	**0.030**	0.234	0.571	0.728
DBLIM	**0.092**	0.245	0.283	0.191	0.109	0.438	0.695	0.756

Can we constrain baryonic physics accurately?

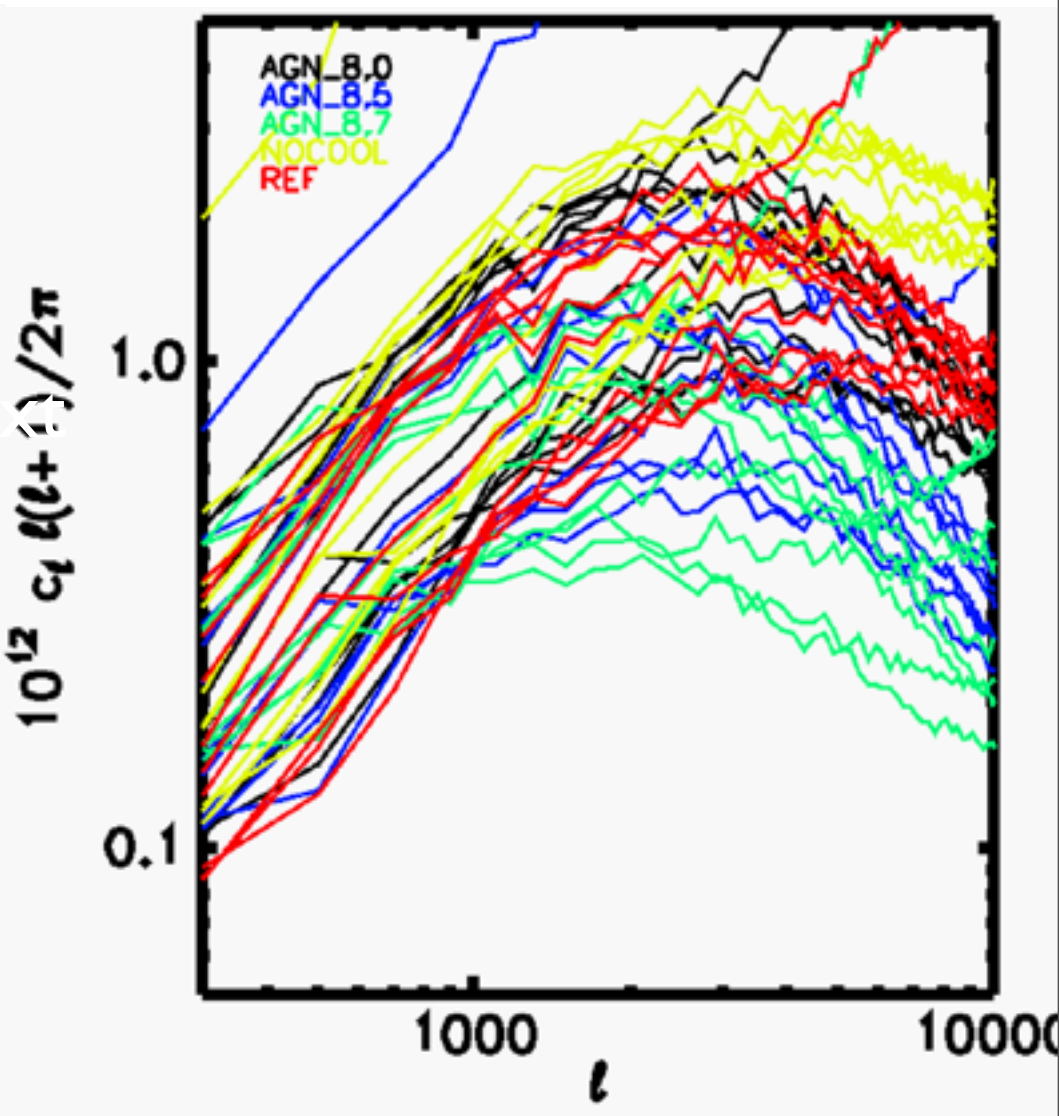


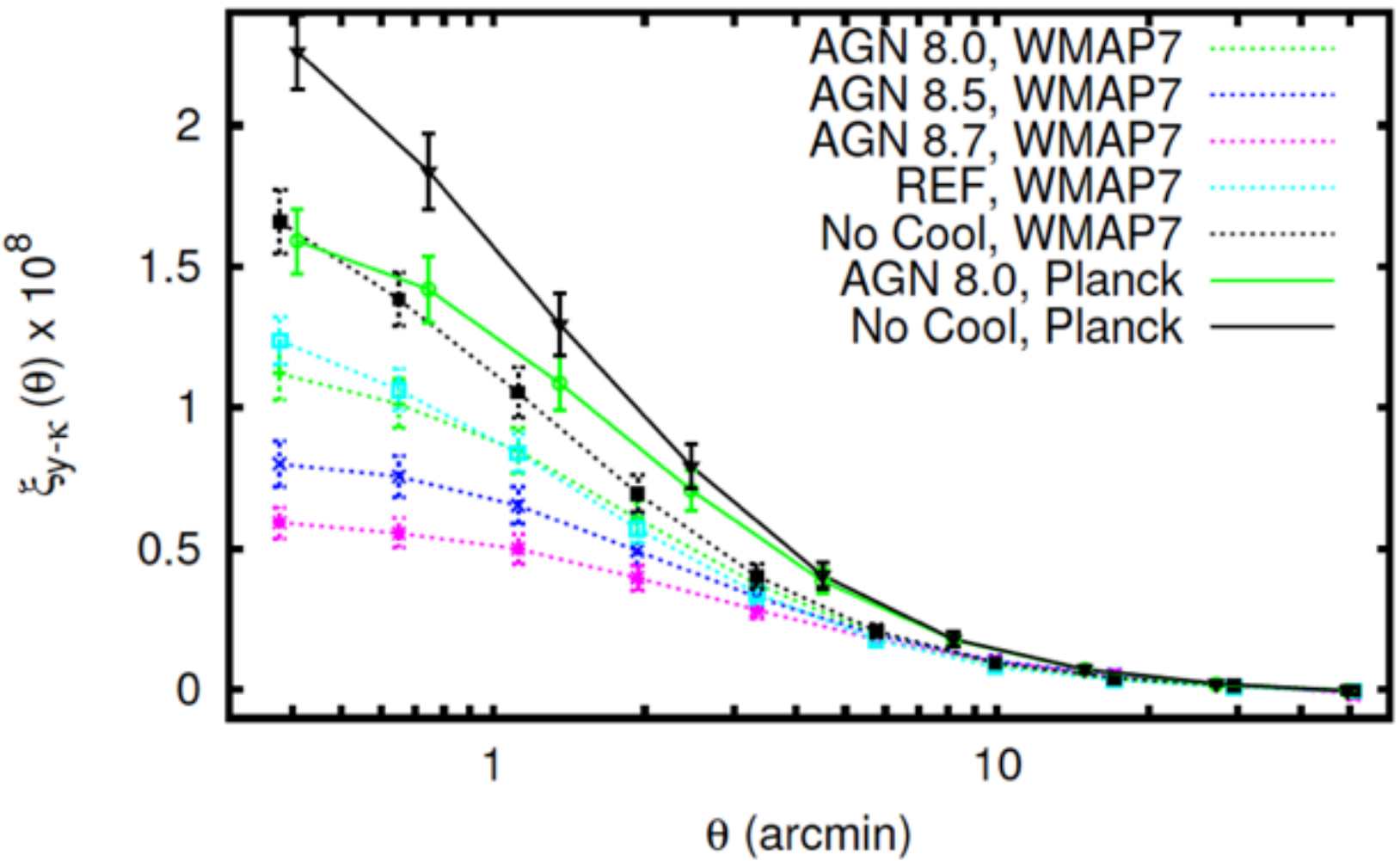
Hydro simulations with feedback (McCarthy et al)

K-K (CFHTLenS dndz)



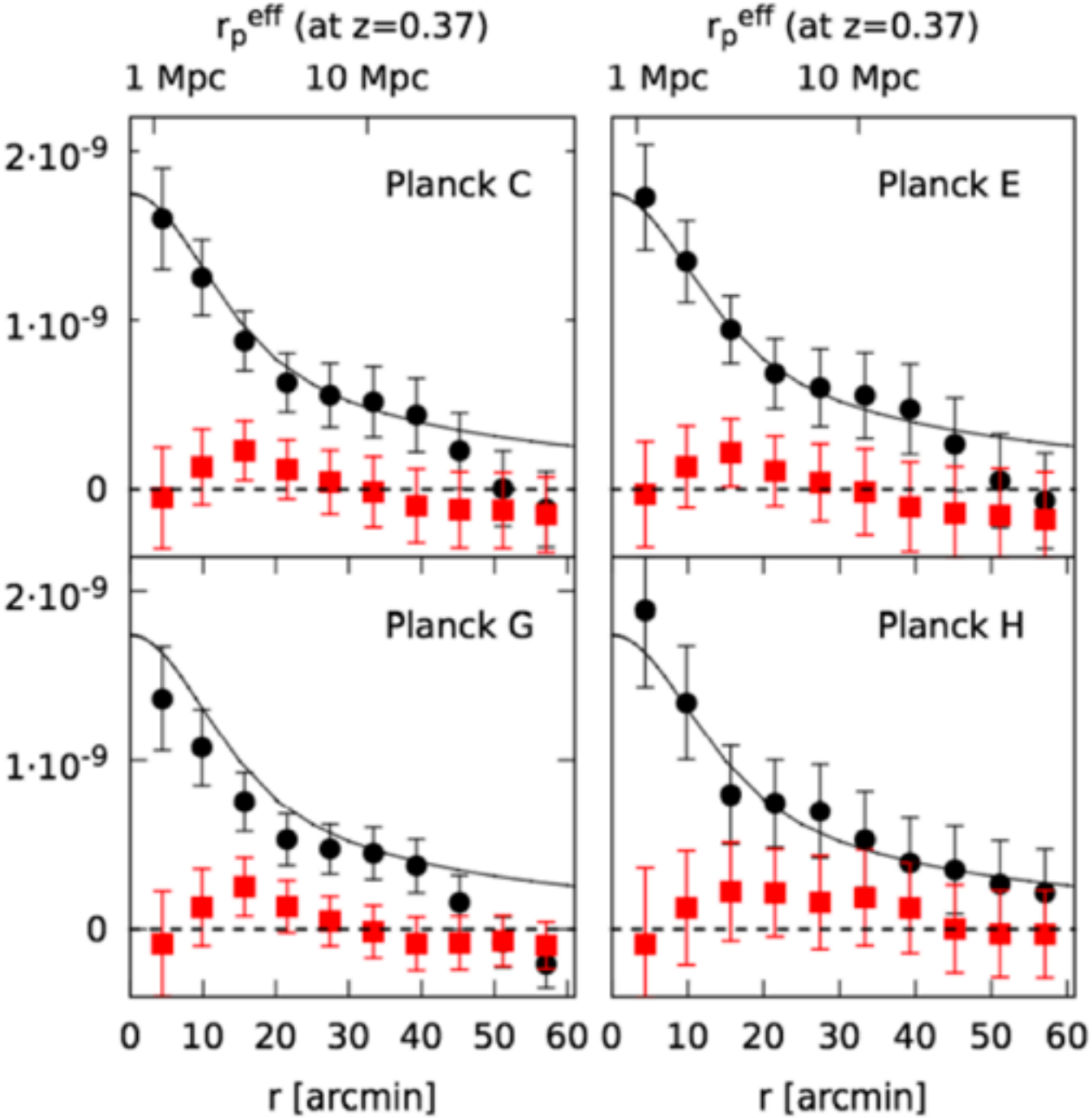
y-y (CFHTLenS) dndz





Hojjati et al. 2014, **arXiv:1412.6051**

Lensing maps-SZ cross-correlations (LVW, Hinshaw, Murray, 2014)



Conclusion

-Challenging modified theories of gravity using non-linear scales is possible

-None of the theoretical and technical difficulties are show stopper, but none can be ignored, as they could conspire to mimic LCDM.

Neutrino (k>0.01)
Baryonic physics (k>0.1 strong at k>1)
Intrinsic alignment, source clustering (all k)

All have specific angular and redshift dependence (i.e. additional information in high order statistics and tomography).