How well can LSST measure neutrino masses?

in collaboration with
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Neutrino masses:

1. Solar neutrinos: SNO
2. Atmospheric neutrinos: SuperK

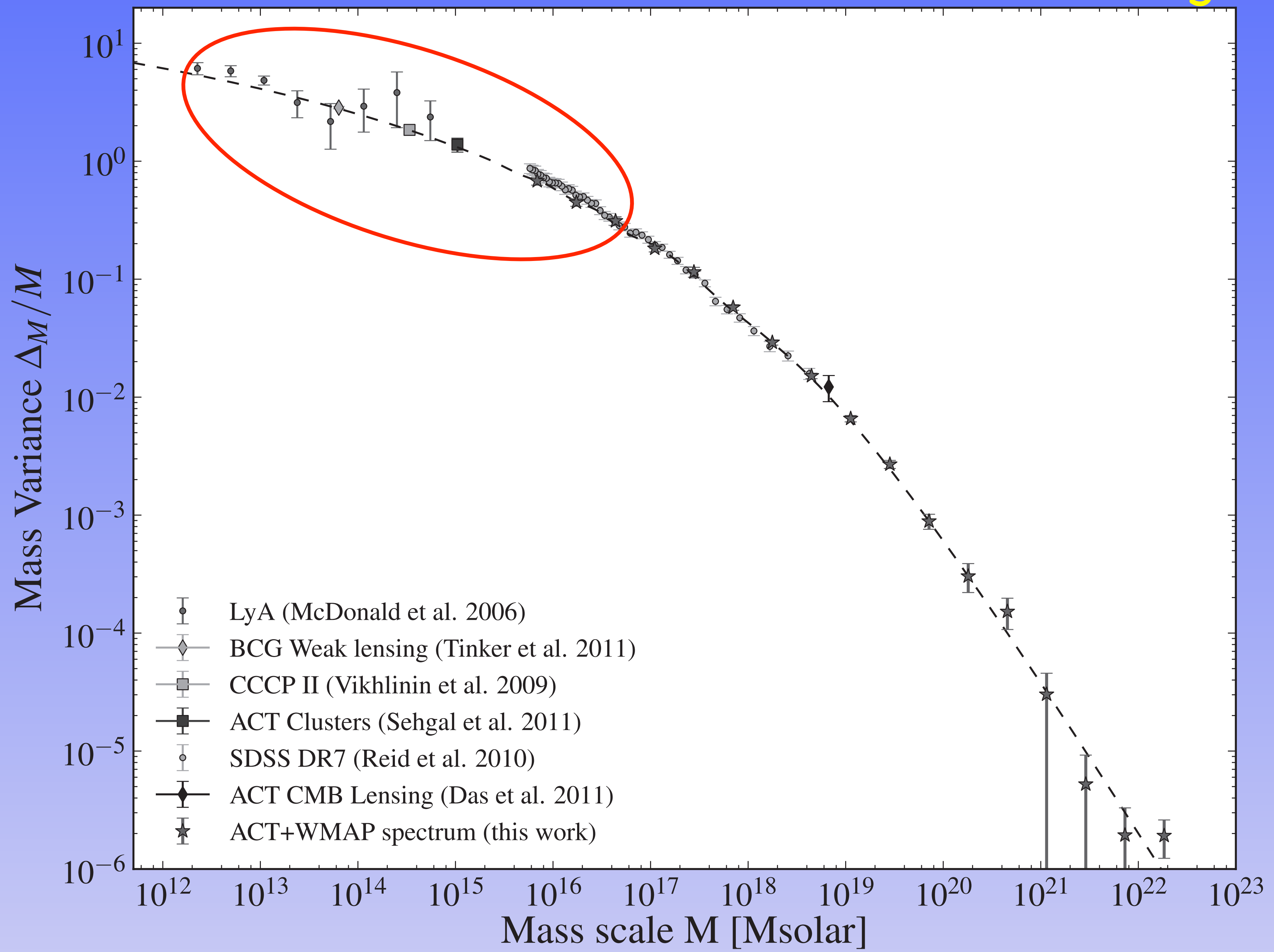
$$\Delta m^2_{21} \approx 7.6 \times 10^{-5}$$
$$\Delta m^2_{31} \approx 2.4 \times 10^{-3}\ \mathrm{eV}^2$$

mass > 0.06 eV

Neutrino masses:

Upper limits from cosmology -

Excludes neutrinos from being all the DM !



Neutrino masses:

Cosmology:

CMB + BAO (Planck) $m < 0.23$ eV (95%)

with Lyman Alpha $m < 0.17$ eV

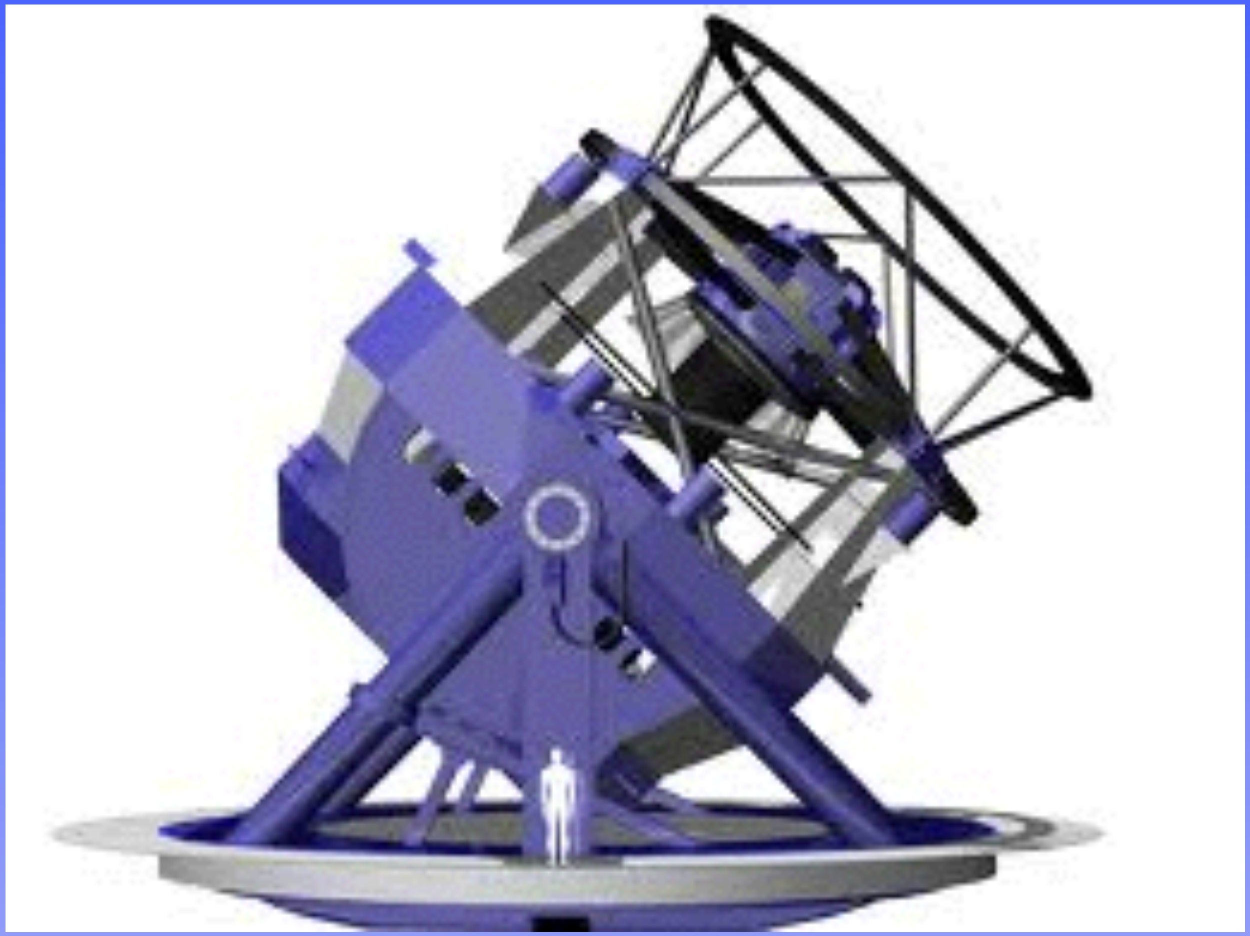
Neutrino masses:

The clustering of galaxies in the SDSS-III Baryon Oscillation Spectroscopic Survey: Signs of neutrino mass in current cosmological datasets

Florian Beutler[1⋆], Shun Saito[2], Joel R. Brownstein[3], Chia-Hsun Chuang[4], Antonio J. Cuesta[5], Will J. Percival[6], Ashley J. Ross[6], Nicholas P. Ross[7], Donald P. Schneider[8,9], Lado Samushia[6], Ariel G. Sánchez[10], Hee-Jong Seo[11], Jeremy L. Tinker[12], Christian Wagner[13], Benjamin A. Weaver[12]

Mass = 0.36 eV !!!

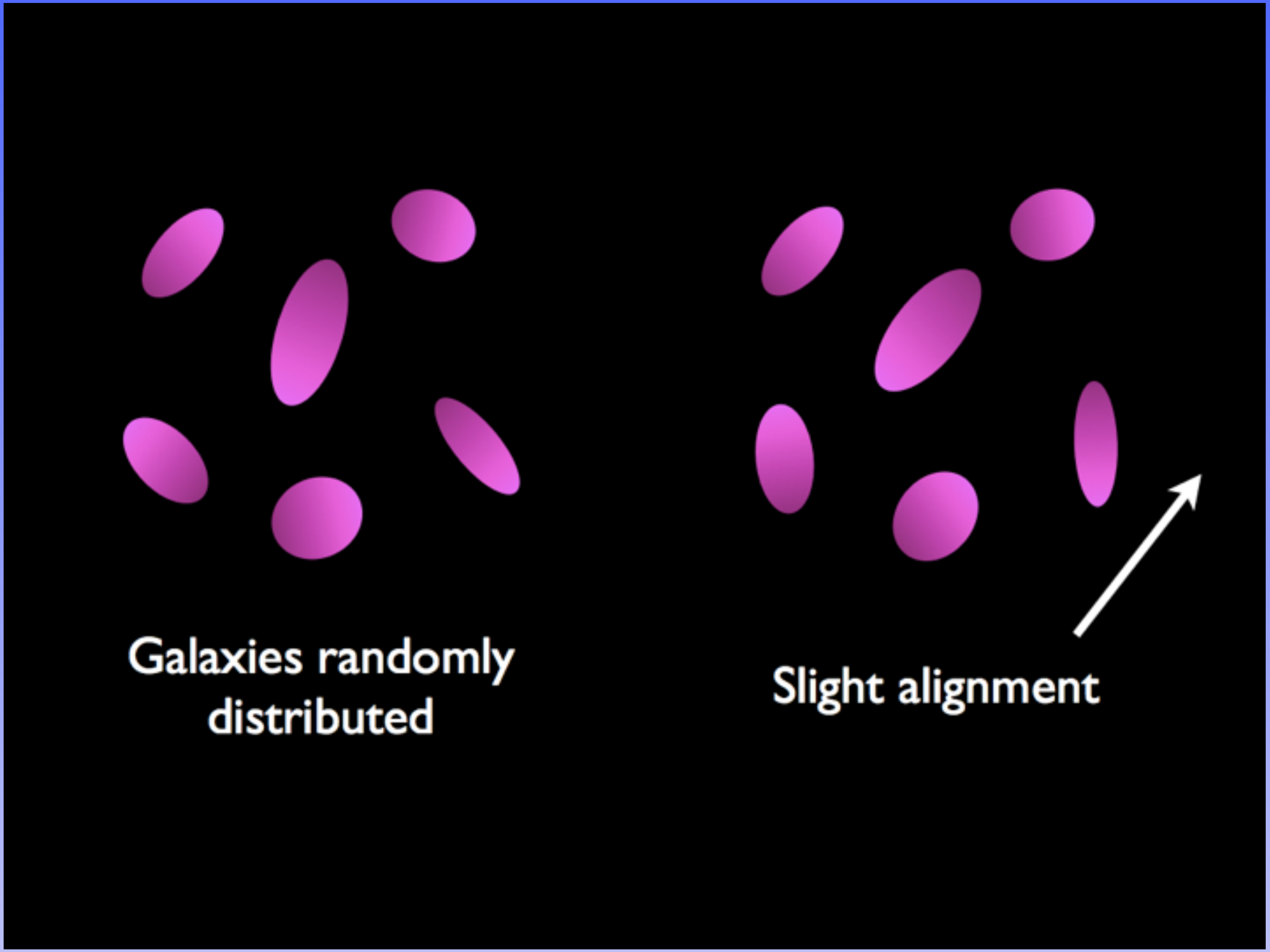
The Large Synoptic Sky Telescope



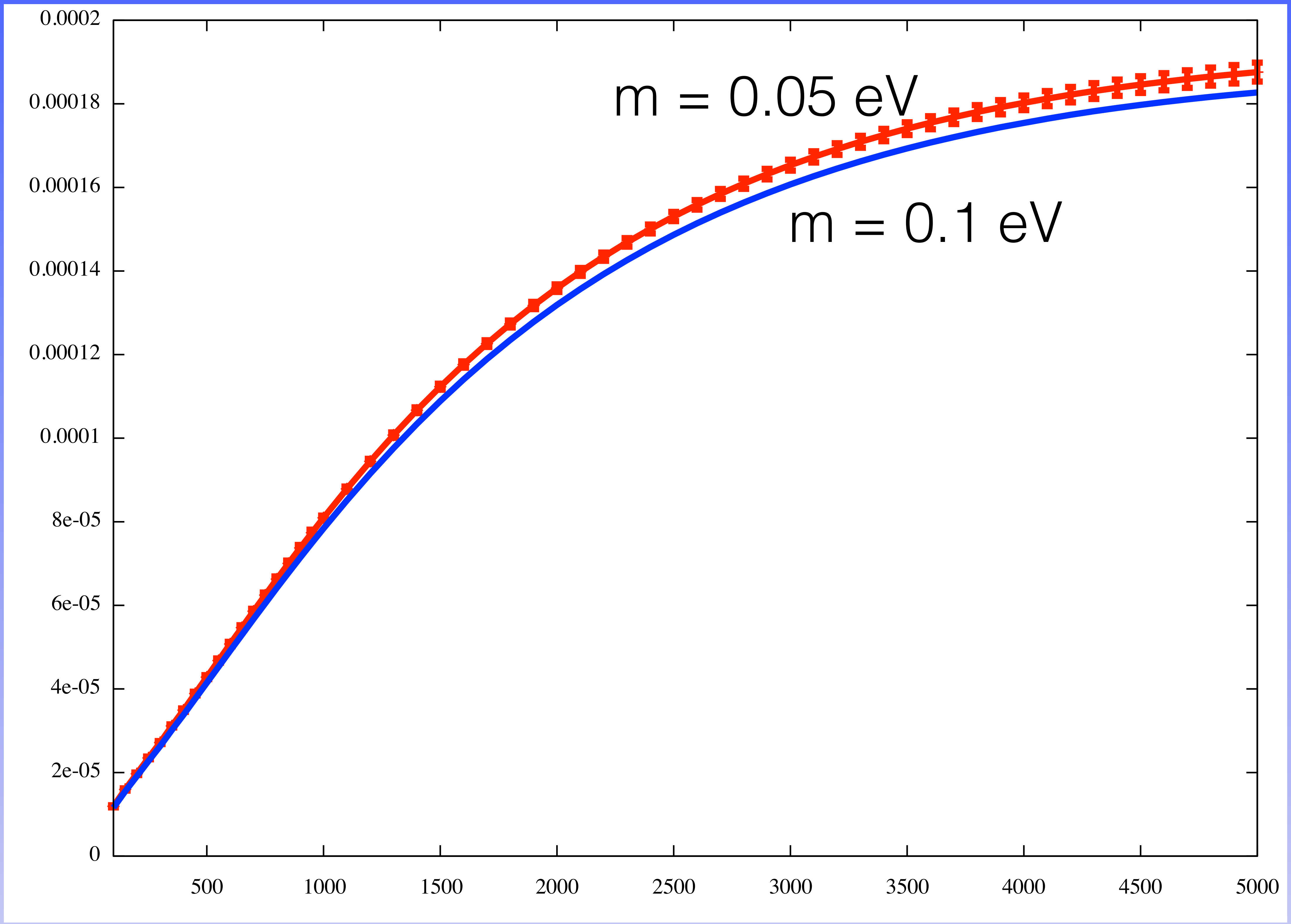
1. 3200 Megapixel camera.
2. 20 Terabytes per night!
3. Photometric data only.

LSST will measure neutrino masses very precisely!

Weak lensing -



Weak lensing -



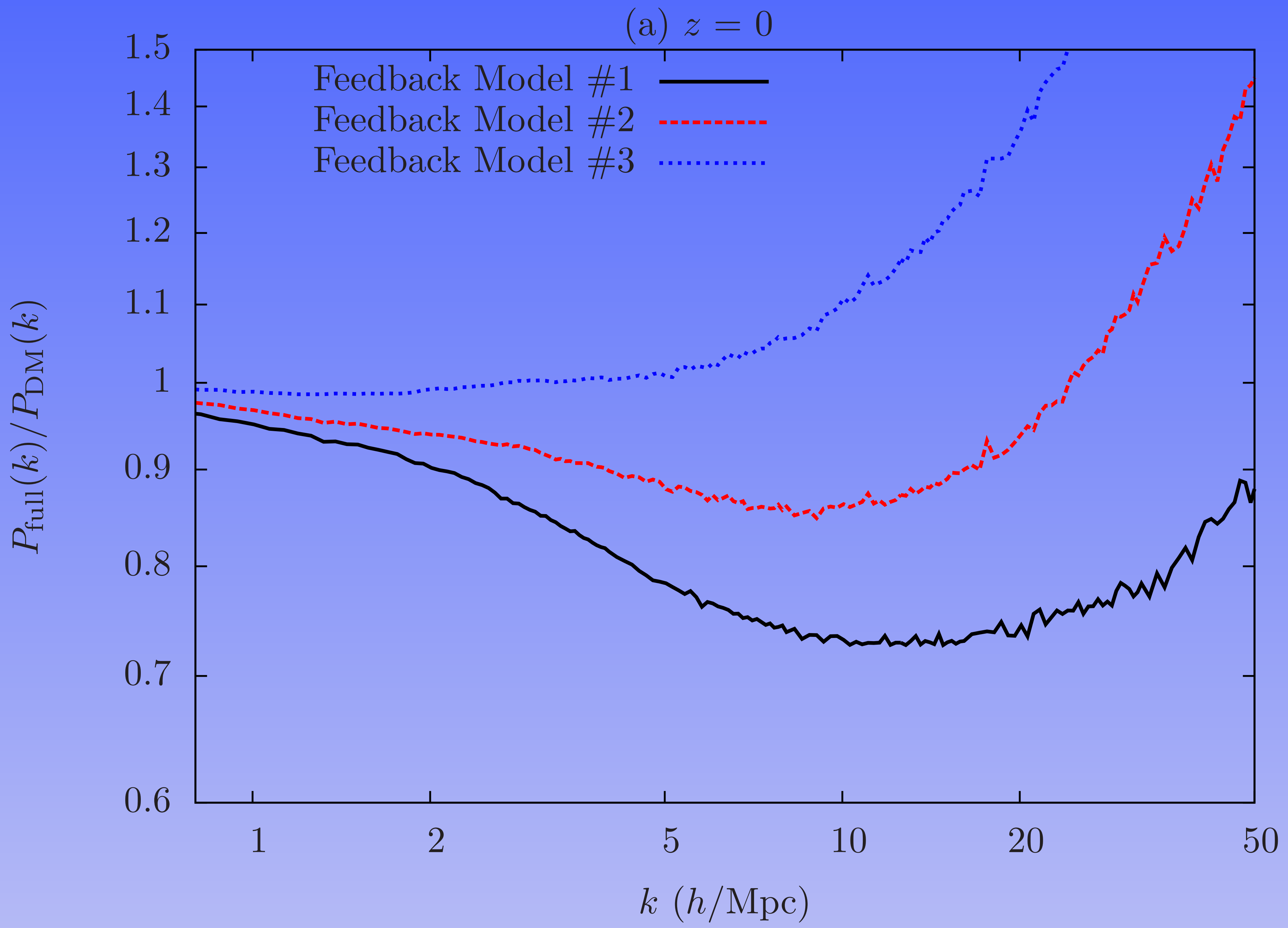
But the matter power spectrum is not well known!

Baryons cause :

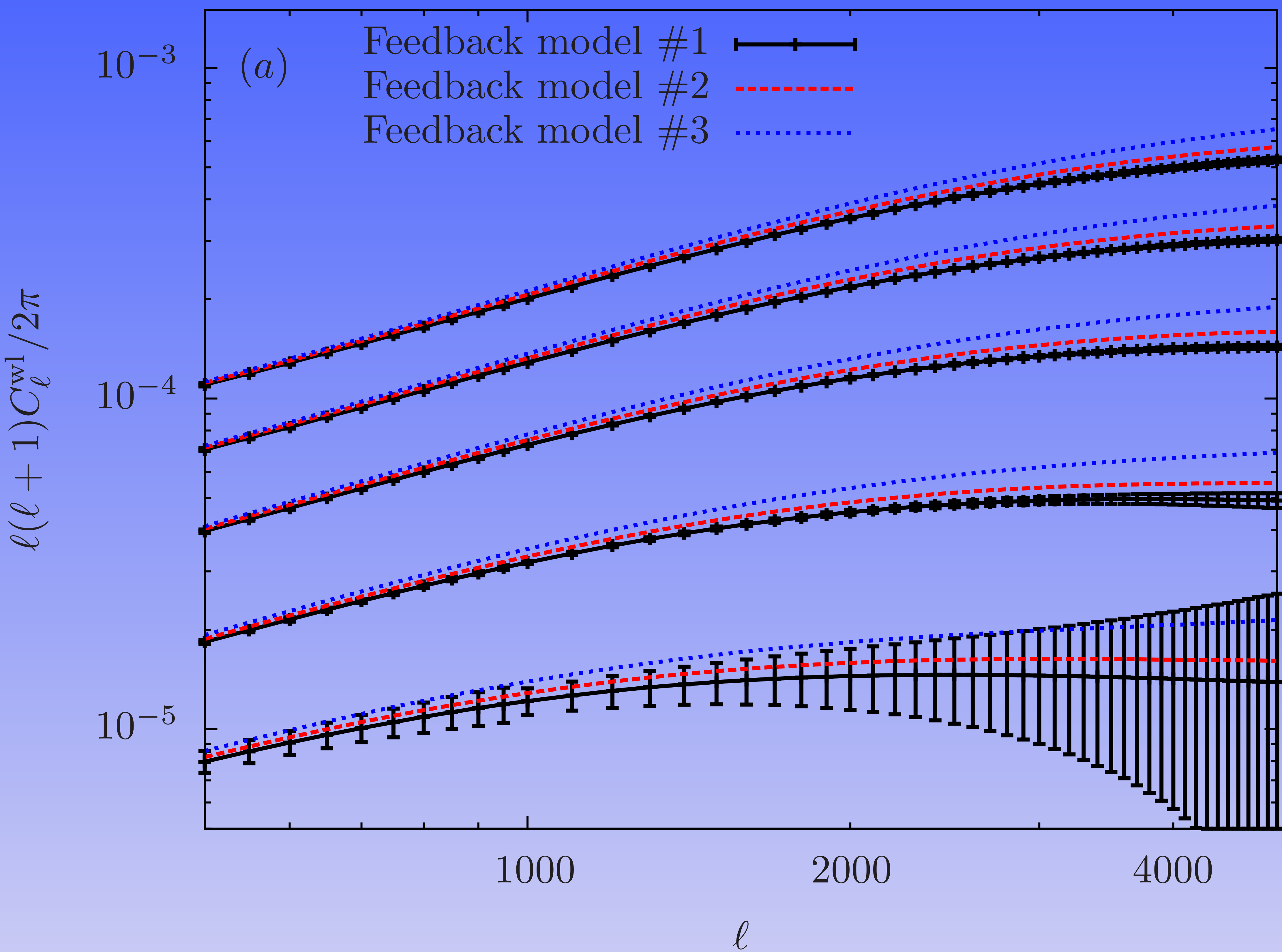
- a damping on intermediate scales.
- a boost on very small scales.

We need high res numerical simulations to study the baryon power spectrum on small scales.

But the matter power spectrum is not well known!



Distinguishing these models through weak lensing-



What is the error on the measured neutrino mass?

Fisher matrix analysis:

$$\vec{\theta} = \{\Omega_{\rm b}h^2, \Omega_{\rm c}h^2, h, 10^{9}A_{\rm s}, n_{\rm s}, m_\nu\}$$

$$\mathbf{F} = \mathbf{C}^{-1}_{\rm prior} + \sum_\ell \frac{\partial \mathbf{P}}{\partial \vec{\theta}}\,\mathbf{Cov}^{-1}\,\frac{\partial \mathbf{P}^{\rm T}}{\partial \vec{\theta}}$$

$$\sigma(\theta_i) = \sqrt{[\mathbf{F}^{-1}]_{ii}}$$

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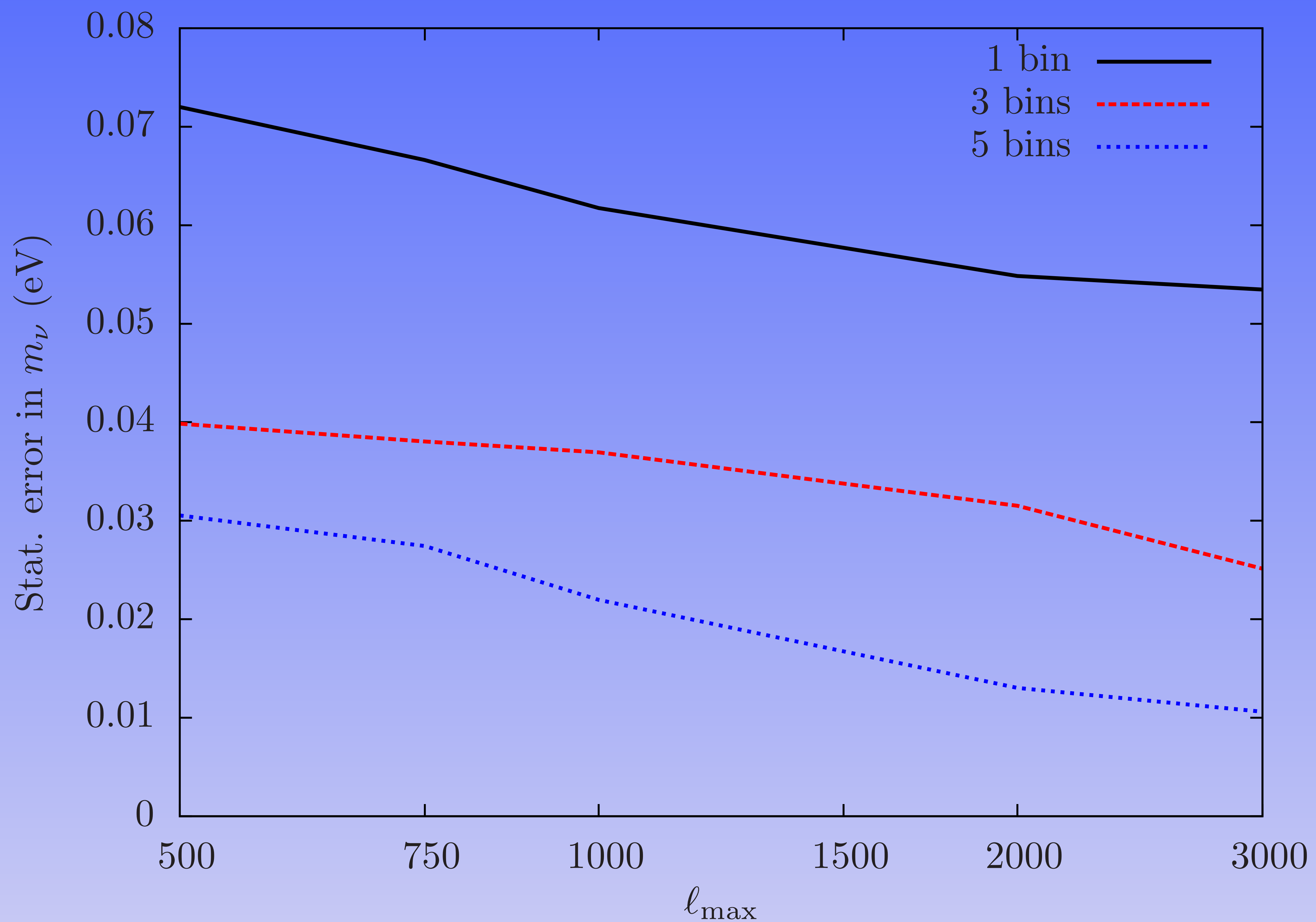
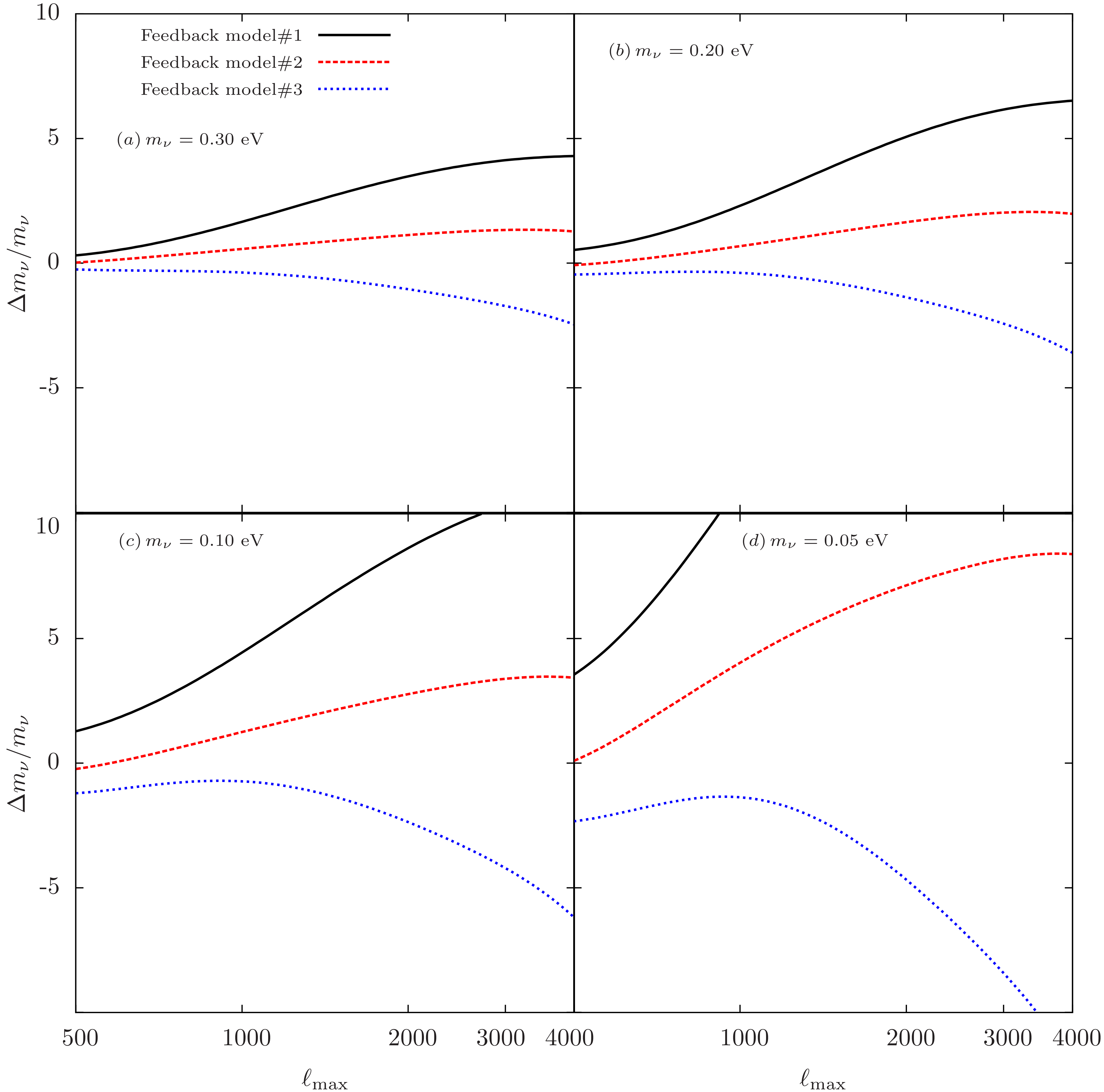
Fisher matrix analysis:



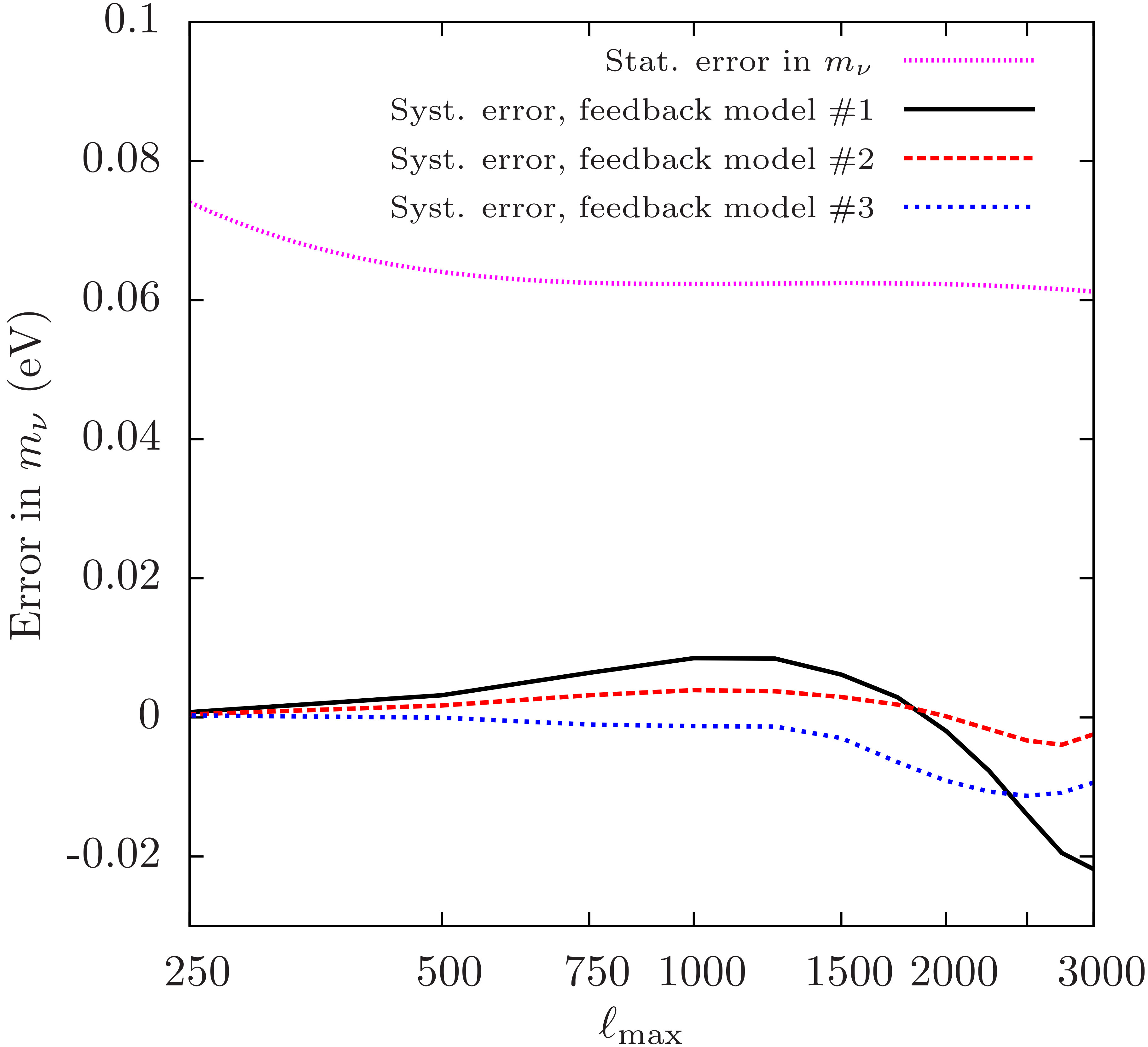
But Fisher matrix analysis also gives us systematic errors:

$$\Delta\vec{\theta} = \mathbf{F}^{-1} \sum_{\ell} \frac{\partial \mathbf{C}_\ell}{\partial \theta} \mathbf{Cov}^{-1} \Delta \mathbf{C}_\ell$$



Feedback model#1
Feedback model#2
Feedback model#3
(a) $m_\nu = 0.30$ eV
(b) $m_\nu = 0.20$ eV
(c) $m_\nu = 0.10$ eV
(d) $m_\nu = 0.05$ eV
$\Delta m_\nu / m_\nu$
$\ell_{\max}$
10
5
0
-5
500
1000
2000
3000
4000

CMB lensing can also probe neutrino masses -



Conclusions -

1. Weak Lensing is a very good probe of neutrino masses. However, it is extremely sensitive to baryonic effects!

2. The bias introduced in the neutrino mass is of order (or greater than) the neutrino mass itself. The mass inferred from weak lensing can be larger or smaller than the true mass.

3. CMB lensing is less sensitive to neutrino masses, but also less sensitive to baryonic effects.