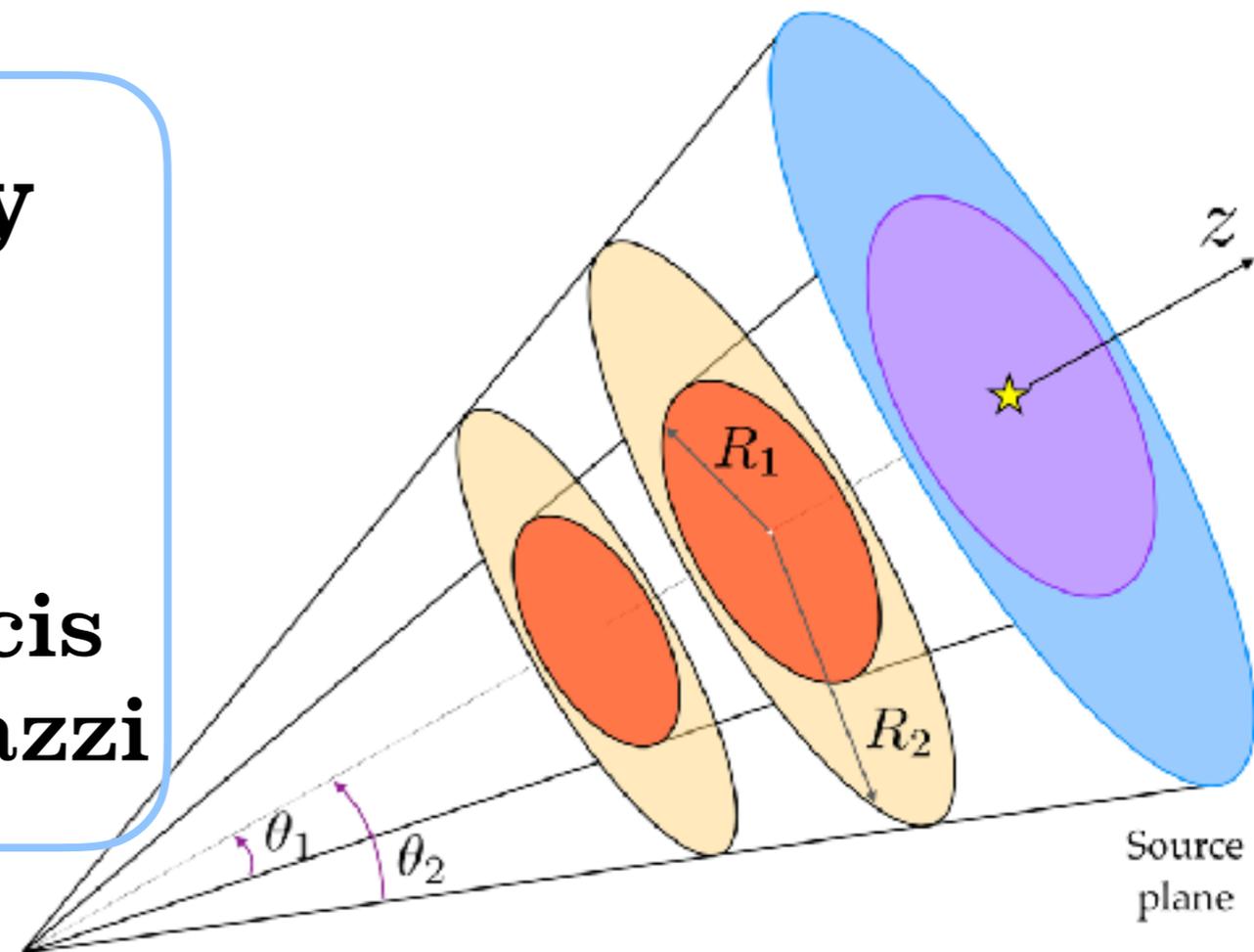


# 1-point statistics of the weak-lensing Aperture Mass with nulling and Large Deviation Theory

**Alexandre Barthelemy**

3rd year PhD student

With Sandrine Codis, Francis  
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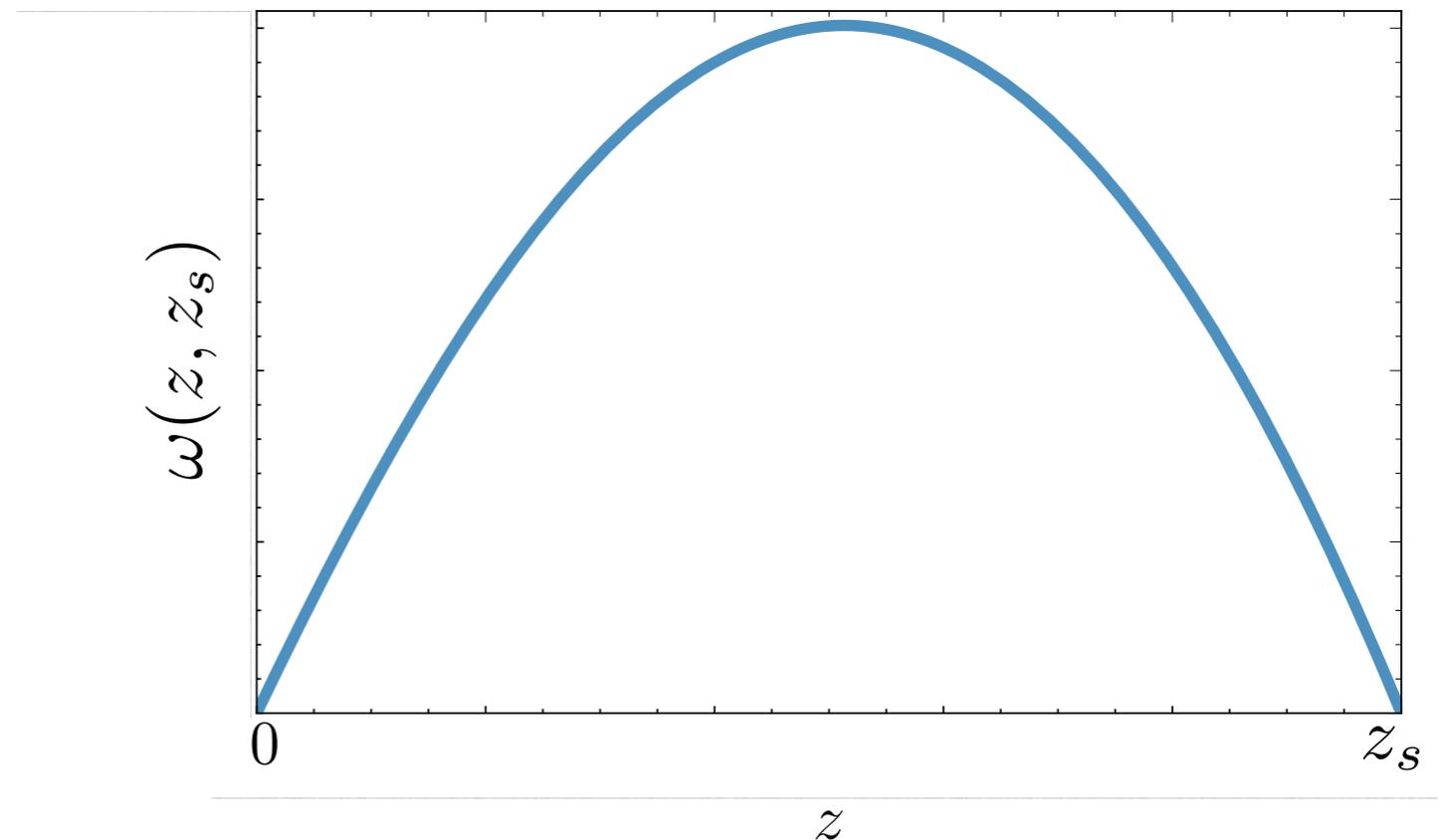
# RELATING LENSING QUANTITIES TO THE MATTER FIELD

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The convergence field:

$$\kappa(\boldsymbol{\theta}) = \int_0^{R_s} dR \omega(R, R_s) \delta(R, D\boldsymbol{\theta})$$

- Comoving radial distance
- Lens efficiency kernel
- Matter density contrast field



PDF of the convergence field: [arXiv:1909.02615](https://arxiv.org/abs/1909.02615)

# RELATING LENSING QUANTITIES TO THE MATTER FIELD

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The Aperture Mass: **Compensated filtering** of the **convergence** field

$$M_{\text{ap}}(\vartheta) = \int d^2\vartheta' U_{\theta}(\vartheta') \kappa(\vartheta' - \vartheta) + \int d^2\vartheta' U_{\theta}(\vartheta') = 0$$

➔ 
$$M_{\text{ap}}(\vartheta) = \int d^2\vartheta' Q_{\theta}(\vartheta') \gamma_t(\vartheta - \vartheta') \left( Q_{\theta}(\vartheta) = -U_{\theta}(\vartheta) + \frac{2}{\vartheta^2} \int_0^{\vartheta} d\vartheta' \vartheta' U_{\theta}(\vartheta') \right)$$

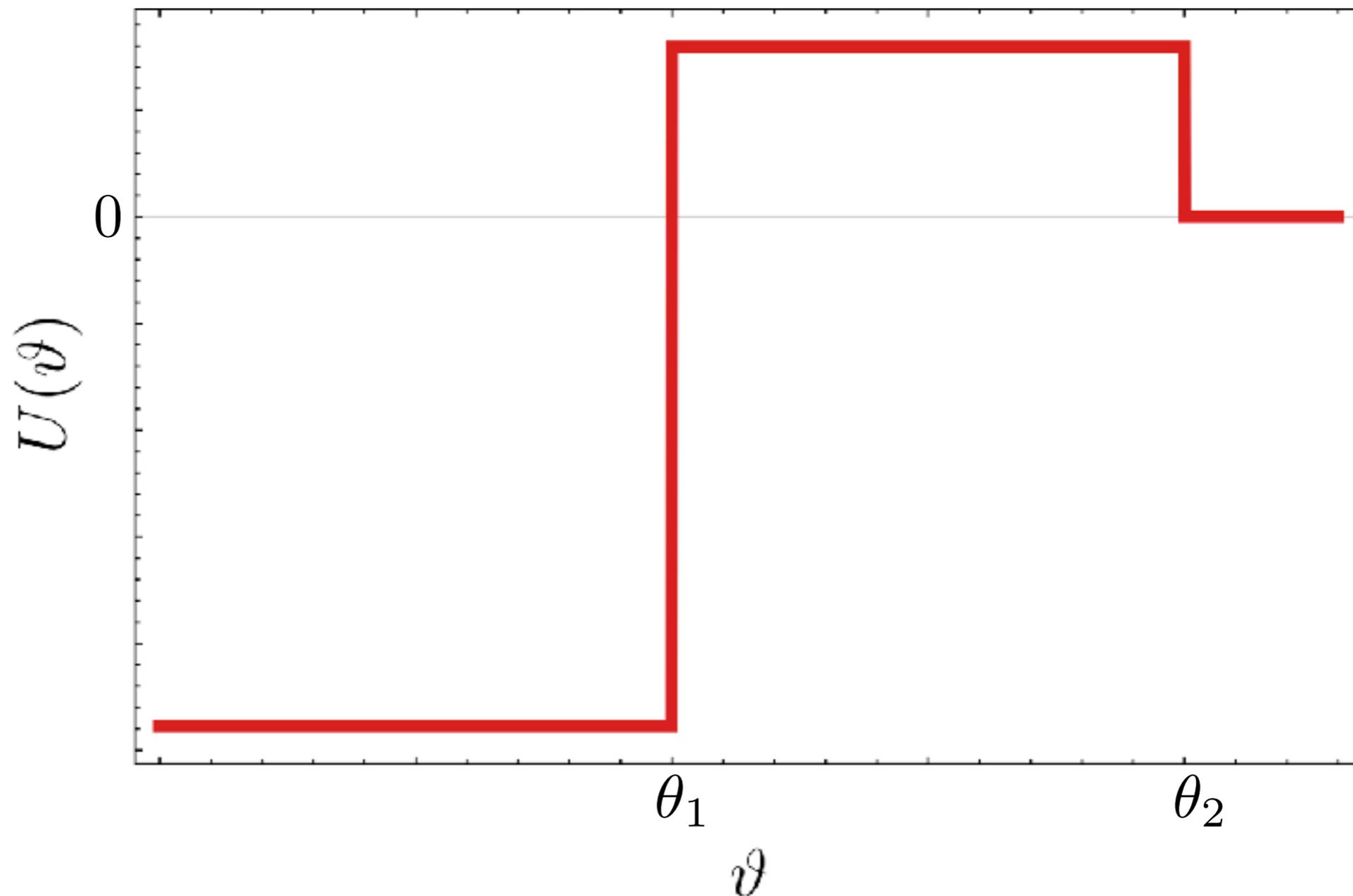
The Aperture mass is thus directly accessible\* without needed reconstruction of the convergence field

\* Up to a reduced shear correction

# RELATING LENSING QUANTITIES TO THE MATTER FIELD

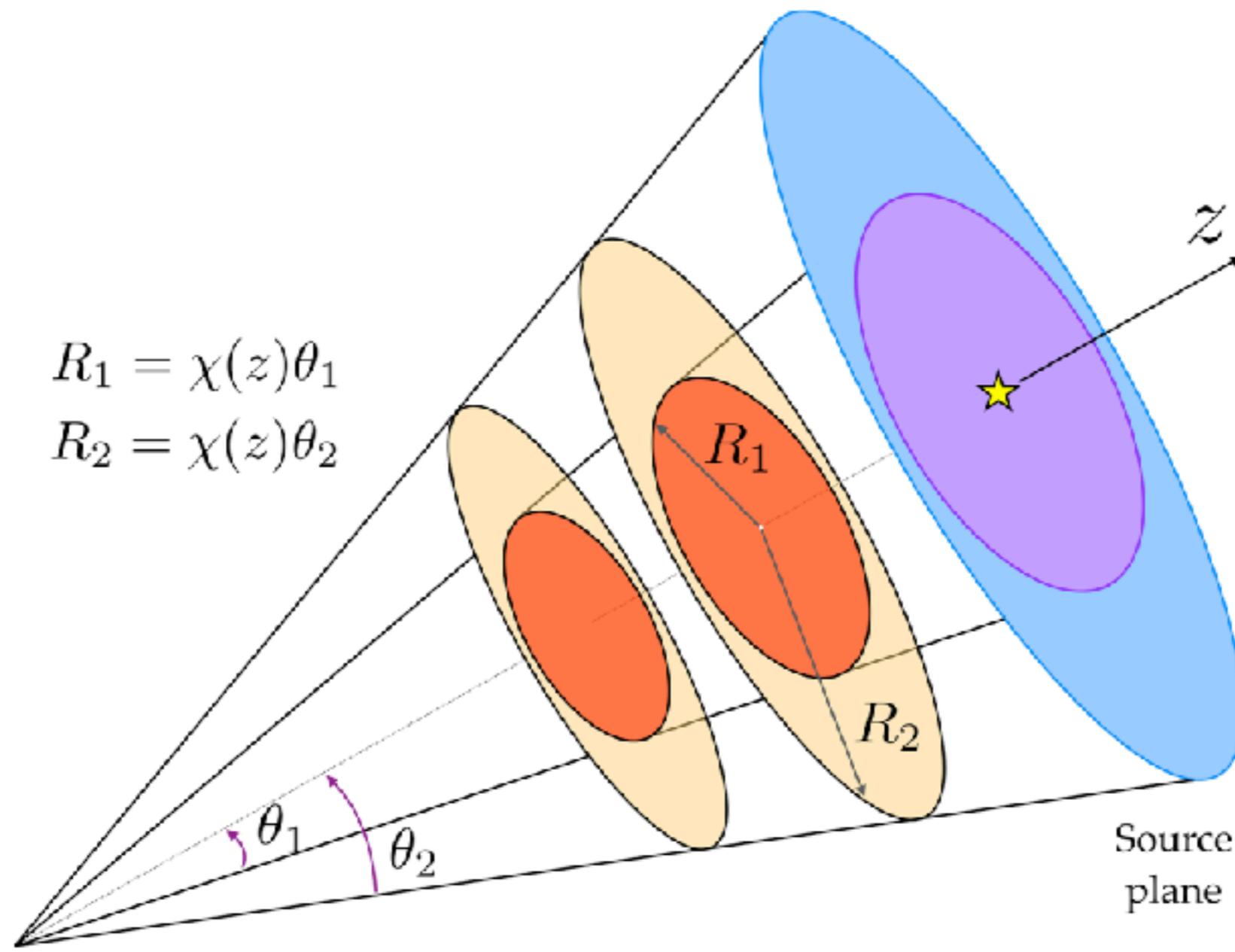
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Compensated filter: Difference of two top-hat windows of different radii



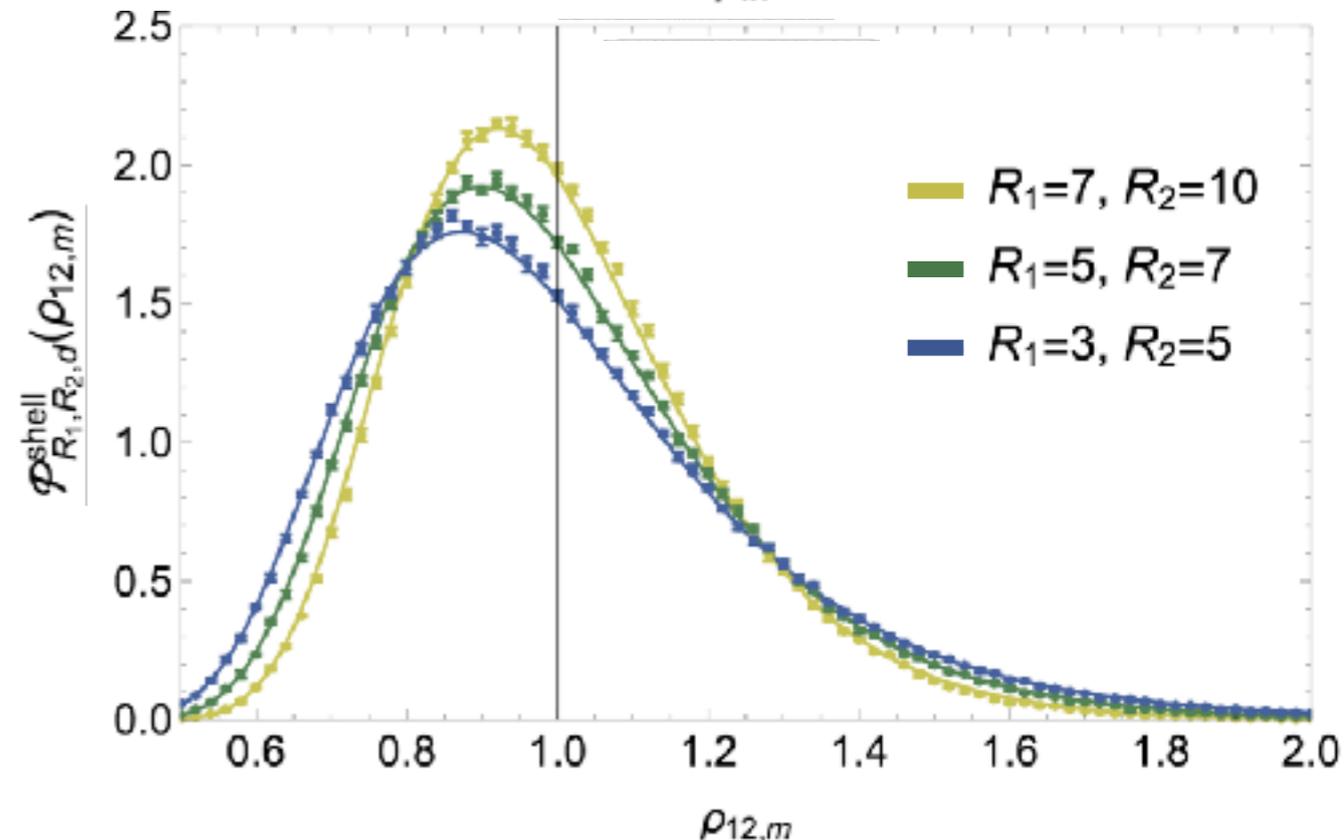
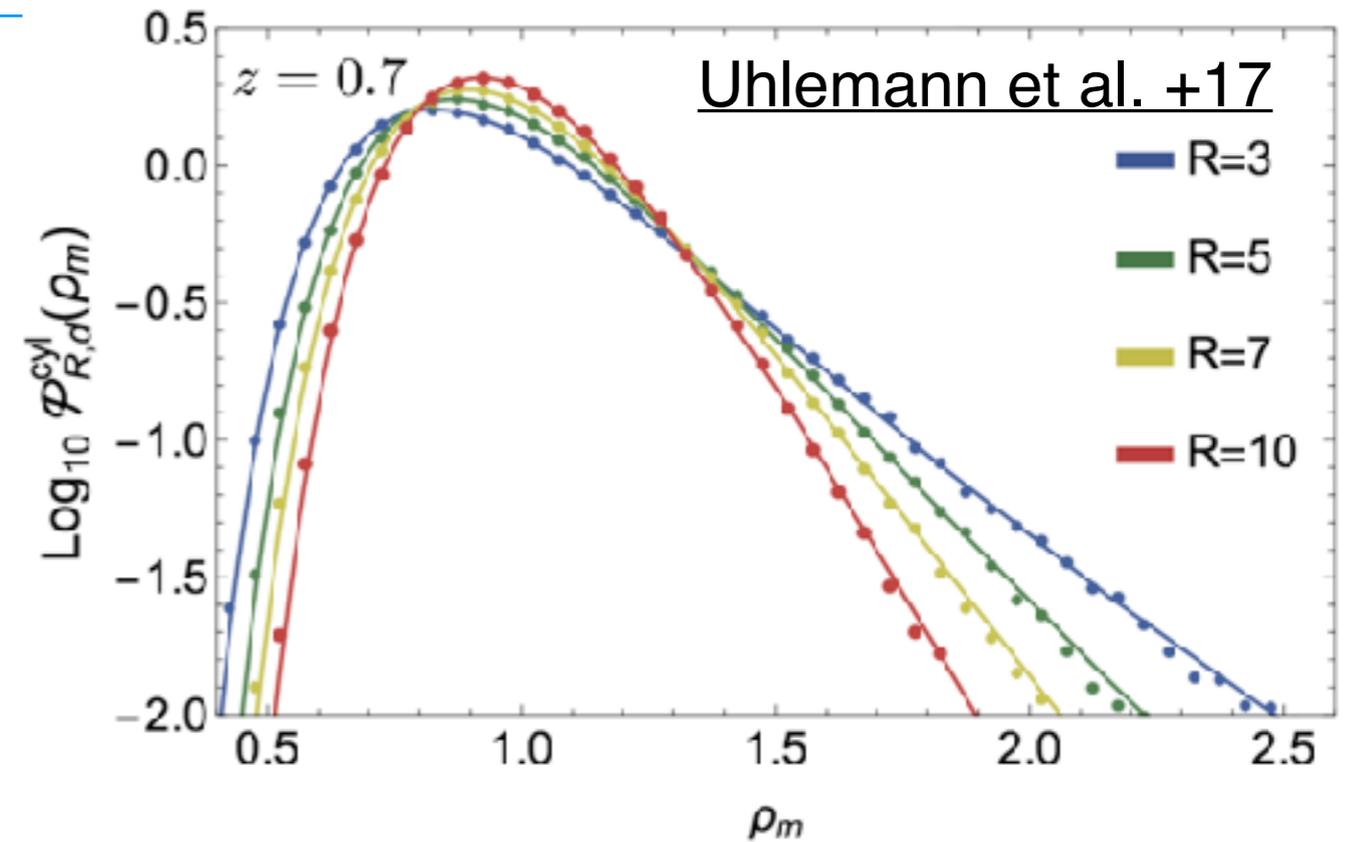
# STATISTICS OF THE APERTURE MASS

Correlations along the line of sight are negligible compared to transverse directions → **Redshift slices are statistically independent (Limber approx.)**



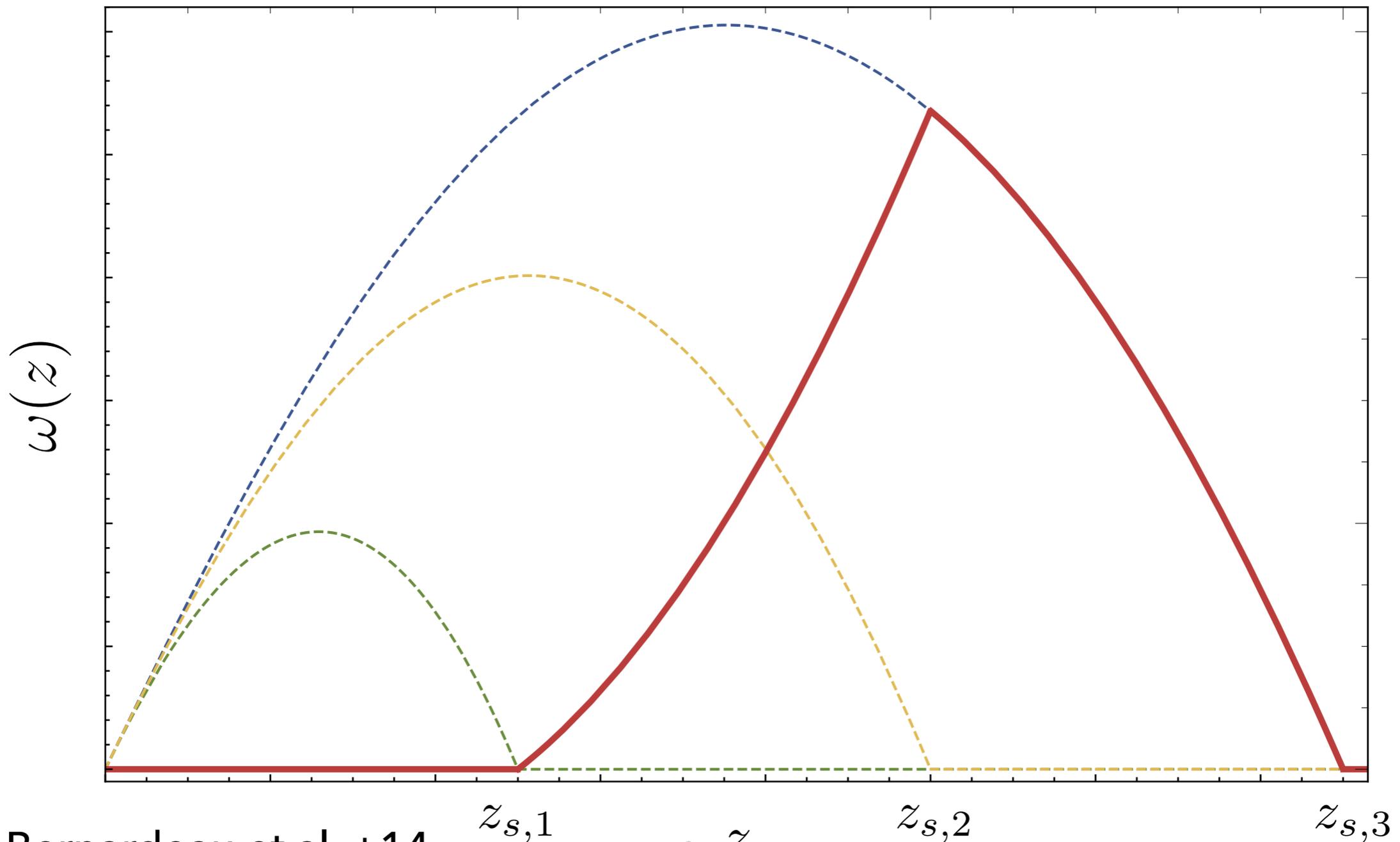
# LARGE DEVIATION THEORY IN A NUTSHELL

- ◆ Non-perturbative approach: non-linear dynamics of the matter field described by spherical collapse
- ◆ Equivalent to tree-order PT before filtering
- ◆ Works really well in the mildly non-linear regime



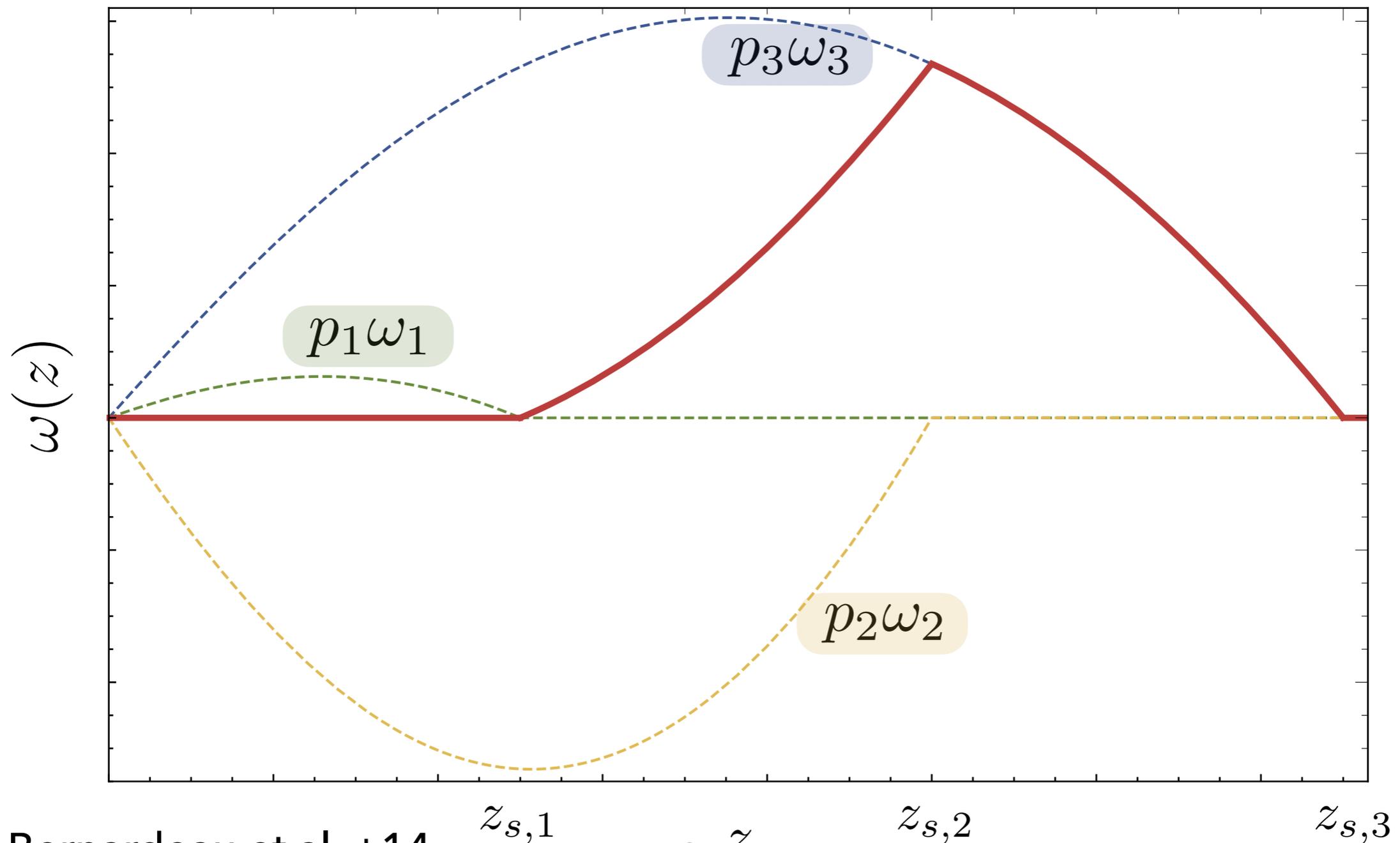
# NULLING STRATEGY TO AVOID MIXING OF SCALES

$$\kappa(\boldsymbol{\theta})_{\text{null}} = \sum_i p_i \kappa_i \quad \longrightarrow \quad \omega_{\text{null}}(R) = \sum_{i, R_{s,i} > R} p_i \omega(R, R_{s,i})$$

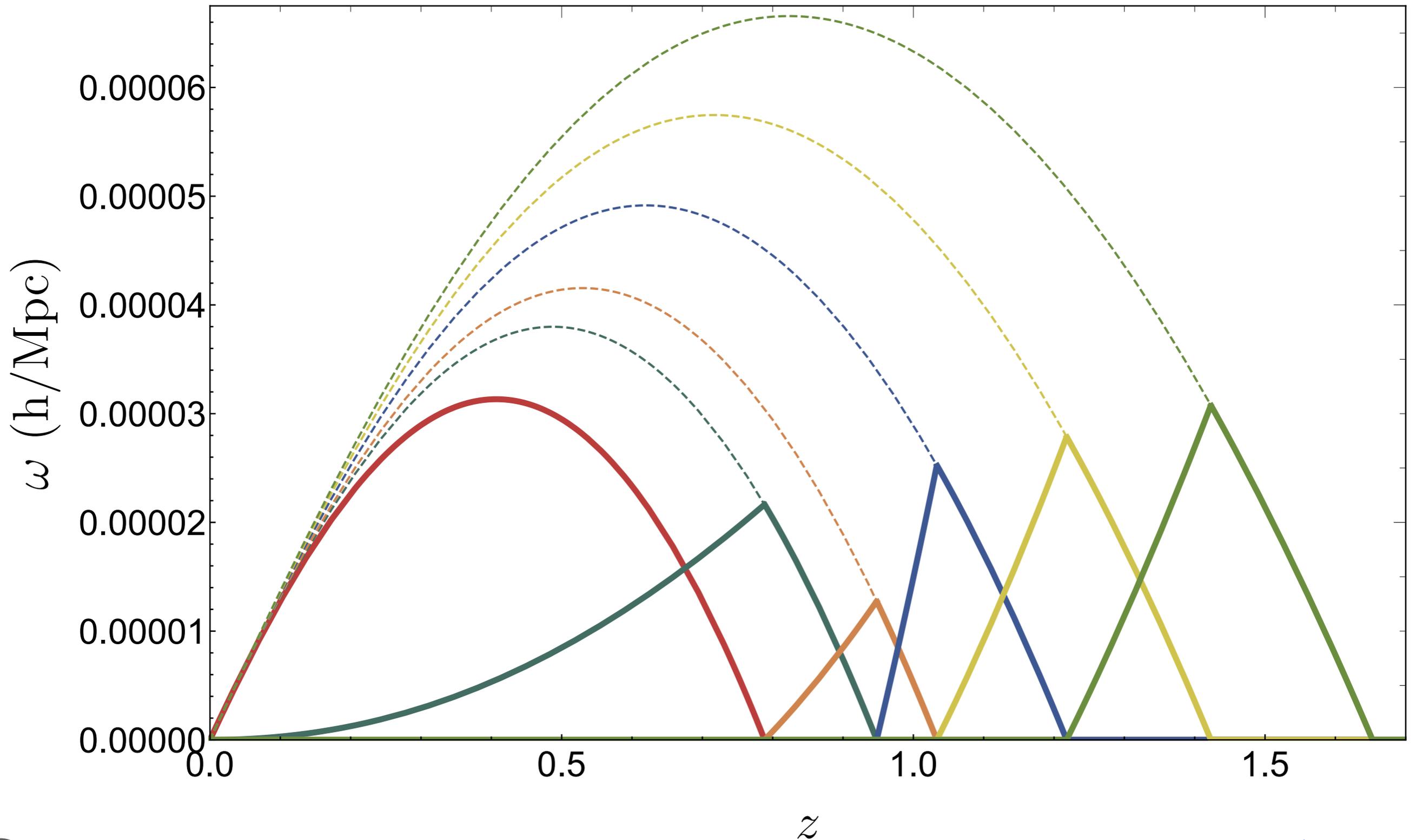


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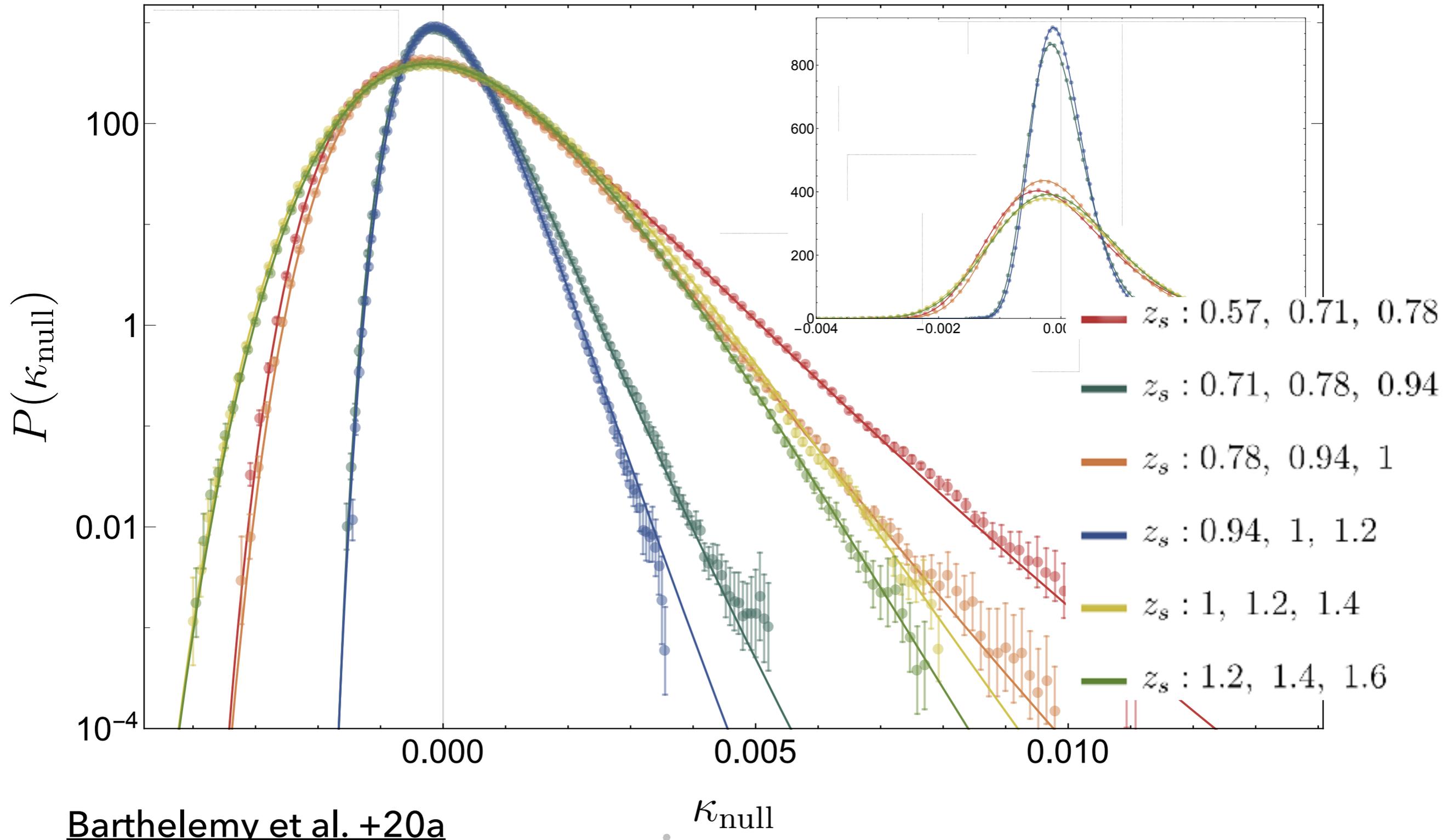


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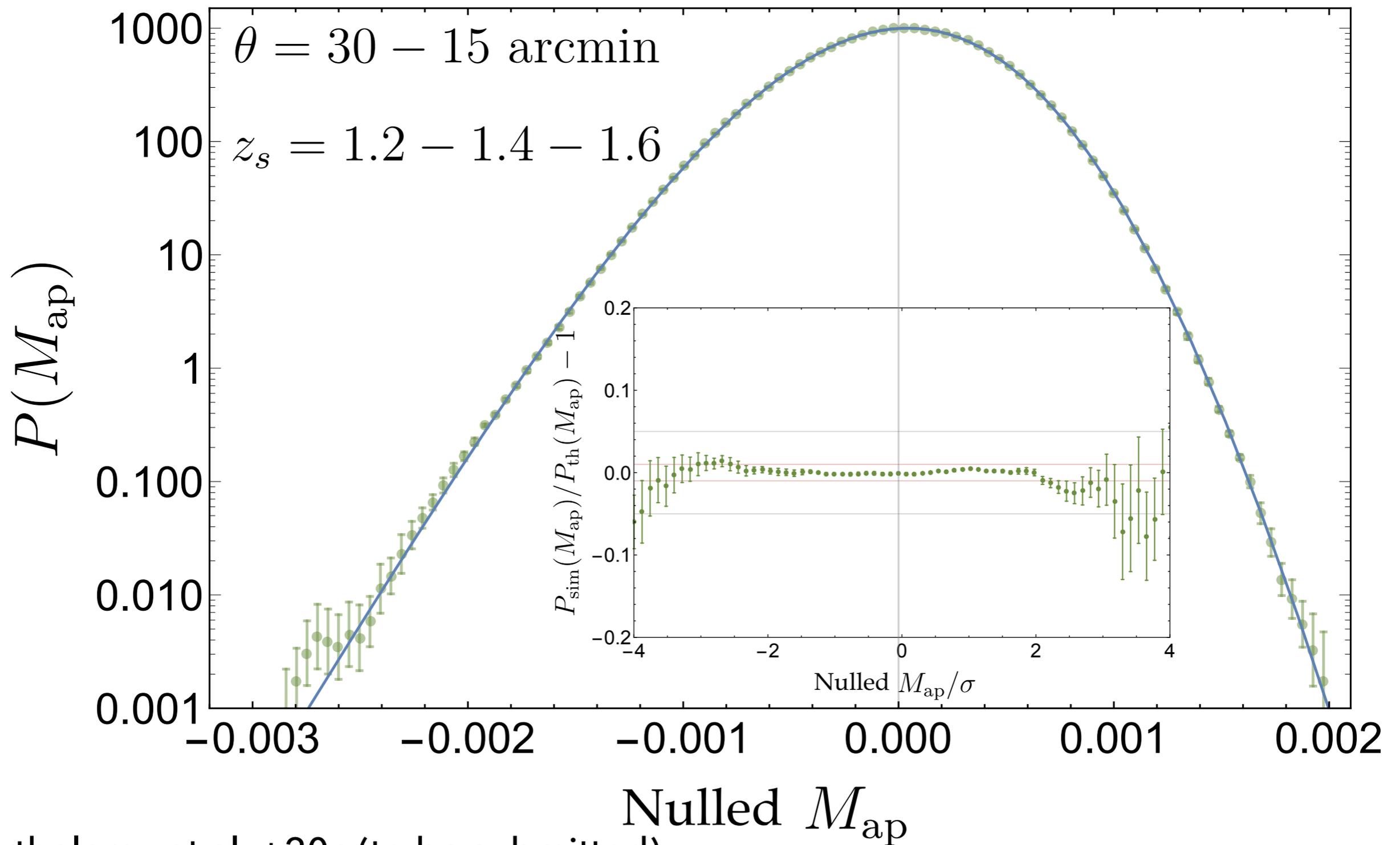
# PDF OF *NULLED* CONVERGENCE

$\theta = 10$  arcmin



Barthelemy et al. +20a

# PDF OF *NULLED* APERTURE MASS



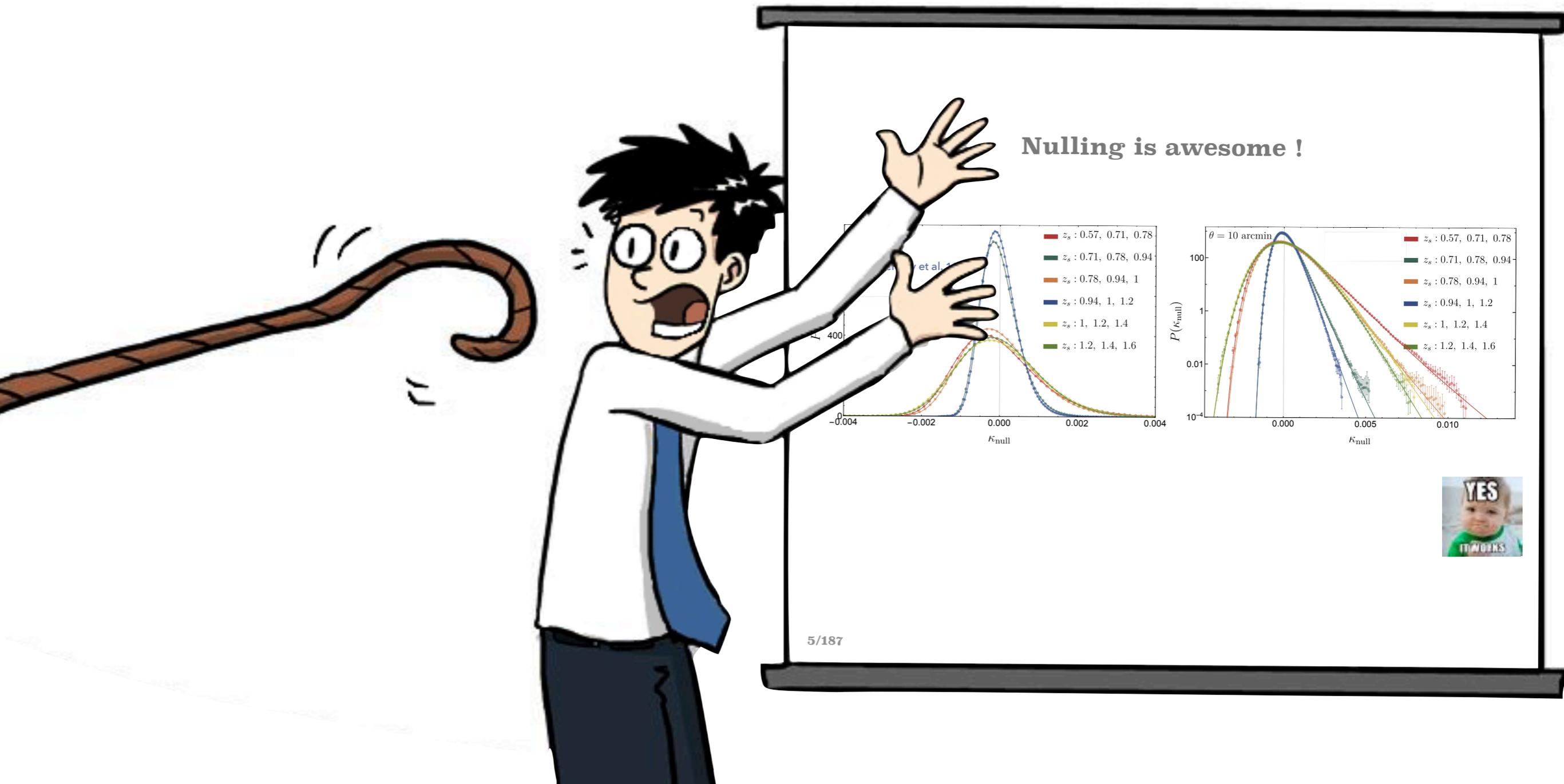
Barthelemy et al. +20c (to be submitted).

# SUMMARY

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- A non perturbative, from first principles approach can be used to compute the 1-point statistics of the Aperture Mass
- Combined with a nulling strategy that localises the lenses/scales contributing to the lensing effect makes the formalism precise to the percent in the PDF tails, at least in the quasi-linear regime
- The Aperture Mass is not, yet, well probed by numerical simulations and this formalism could help to perform more checks

# Thank you for your attention!



A cartoon illustration of a man with glasses, a white shirt, and a blue tie, pointing enthusiastically at a presentation slide. A large, thick, brown, curved redaction bar obscures the left side of the slide. The slide content includes the title 'Nulling is awesome!', two plots of  $P(\kappa_{null})$  vs  $\kappa_{null}$ , a legend for redshift ranges, and a small meme image of a baby saying 'YES IT WORKS'.

**Nulling is awesome !**

$P(\kappa_{null})$  vs  $\kappa_{null}$  (Left Plot):

- $z_s : 0.57, 0.71, 0.78$  (Red)
- $z_s : 0.71, 0.78, 0.94$  (Green)
- $z_s : 0.78, 0.94, 1$  (Orange)
- $z_s : 0.94, 1, 1.2$  (Blue)
- $z_s : 1, 1.2, 1.4$  (Yellow)
- $z_s : 1.2, 1.4, 1.6$  (Purple)

$P(\kappa_{null})$  vs  $\kappa_{null}$  (Right Plot):

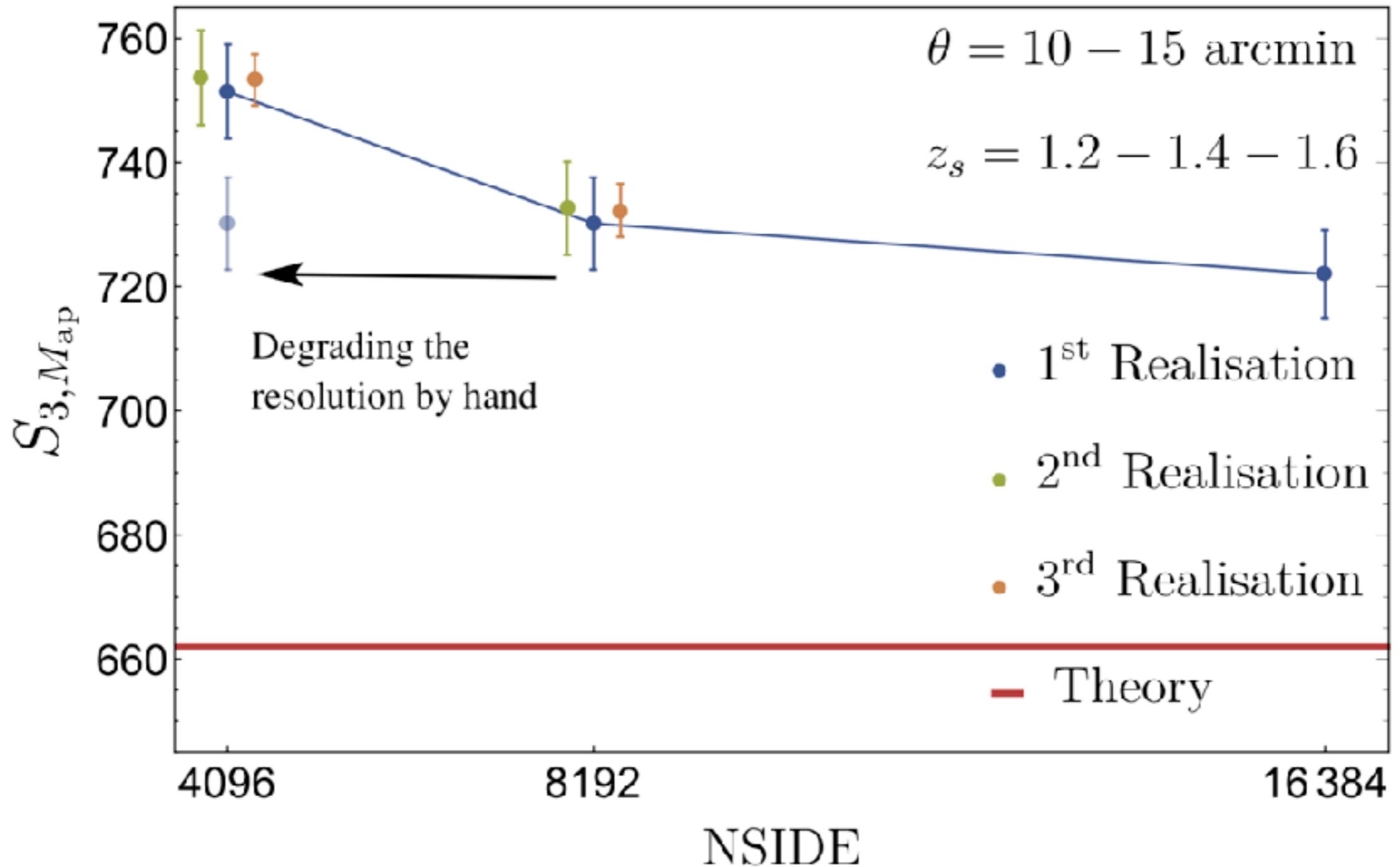
- $z_s : 0.57, 0.71, 0.78$  (Red)
- $z_s : 0.71, 0.78, 0.94$  (Green)
- $z_s : 0.78, 0.94, 1$  (Orange)
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$\theta = 10$  arcmin

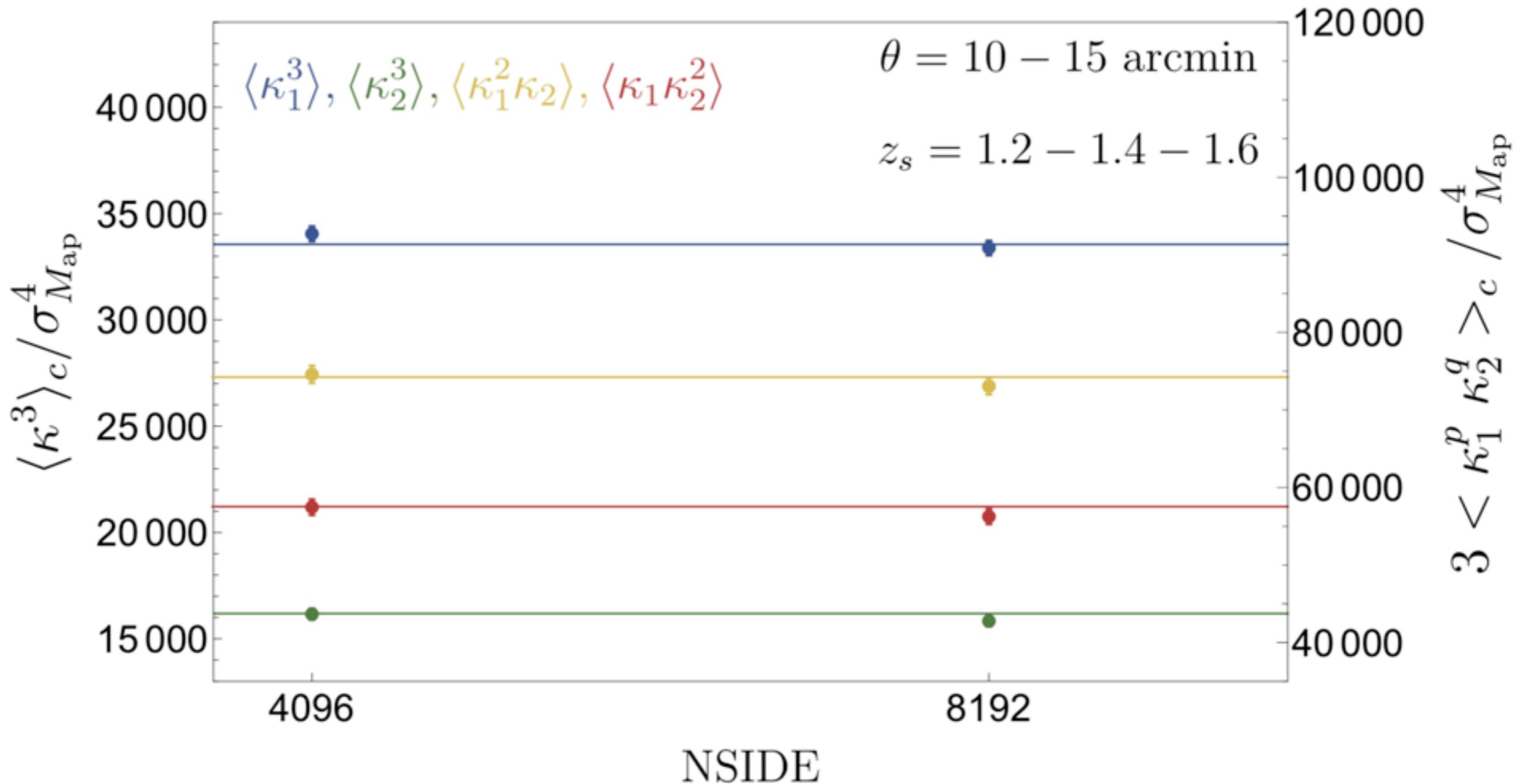
**YES IT WORKS**

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# ISSUES IN NUMERICAL SIMULATIONS ?



# ISSUES IN NUMERICAL SIMULATIONS ?



Barthelemy et al. +20c (to be submitted)