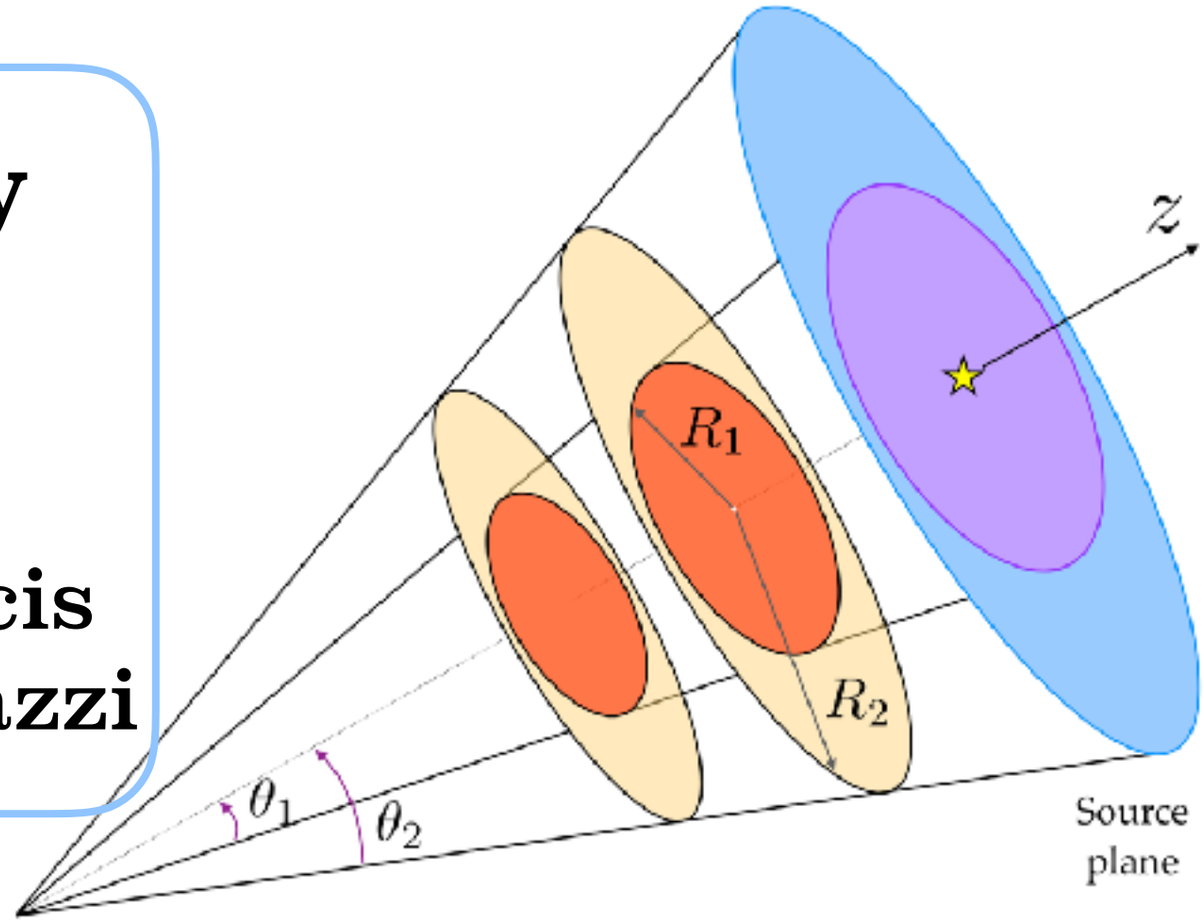
1-point statistics of the weak-lensing Aperture Mass with nulling and Large Deviation Theory

Alexandre Barthelemy

3rd year PhD student

With Sandrine Codis, Francis Bernardeau & Raphaël Gavazzi



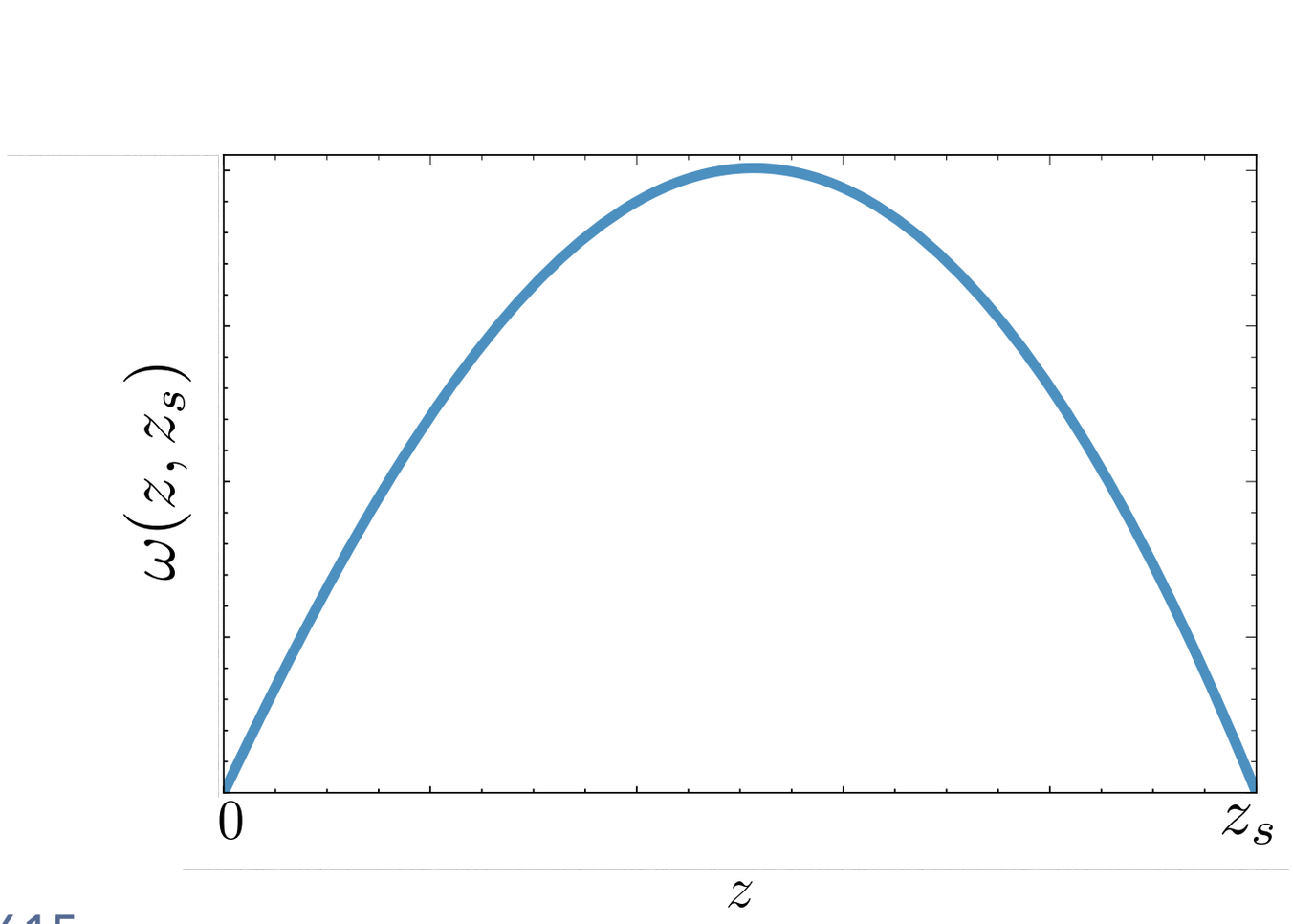
13/10/2020

RELATING LENSING QUANTITIES TO THE MATTER FIELD

The convergence field:

$$\kappa(\boldsymbol{\theta}) = \int_0^{R_s} \mathrm{d}R\, \omega\left(R, R_s\right) \delta(R, D\boldsymbol{\theta})$$

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



PDF of the convergence field: arXiv:1909.02615

RELATING LENSING QUANTITIES TO THE MATTER FIELD

The Aperture Mass: Compensated filtering of the convergence field

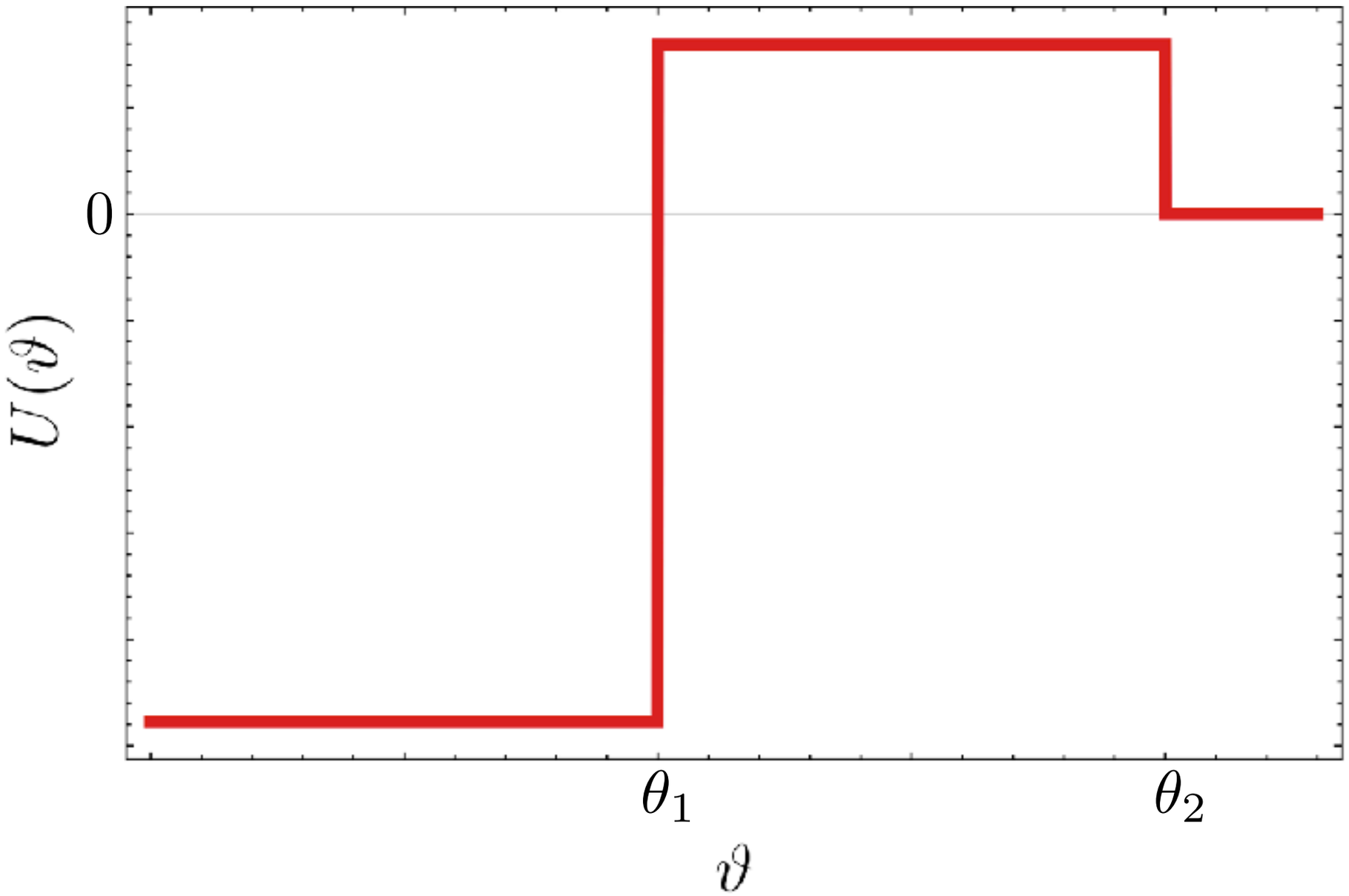
$$M_{\rm ap}(\boldsymbol{\vartheta}) = \int \mathrm{d}^2\boldsymbol{\vartheta}'\, U_\theta(\vartheta')\, \kappa(\boldsymbol{\vartheta}' - \boldsymbol{\vartheta}) \quad + \quad \int \mathrm{d}^2\boldsymbol{\vartheta}'\, U_\theta(\vartheta') = 0$$

$$\Rightarrow M_{\rm ap}(\boldsymbol{\vartheta}) = \int \mathrm{d}^2\boldsymbol{\vartheta}' Q_\theta\left(\vartheta'\right) \gamma_t\left(\boldsymbol{\vartheta} - \boldsymbol{\vartheta}'\right) \quad \left(Q_\vartheta(\vartheta) = -U_\theta(\vartheta) + \frac{2}{\vartheta^2}\int_0^\vartheta \mathrm{d}\vartheta'\,\vartheta' U_\theta\left(\vartheta'\right)\right)$$

The Aperture mass is thus directly accessible* without needed re-construction of the convergence field

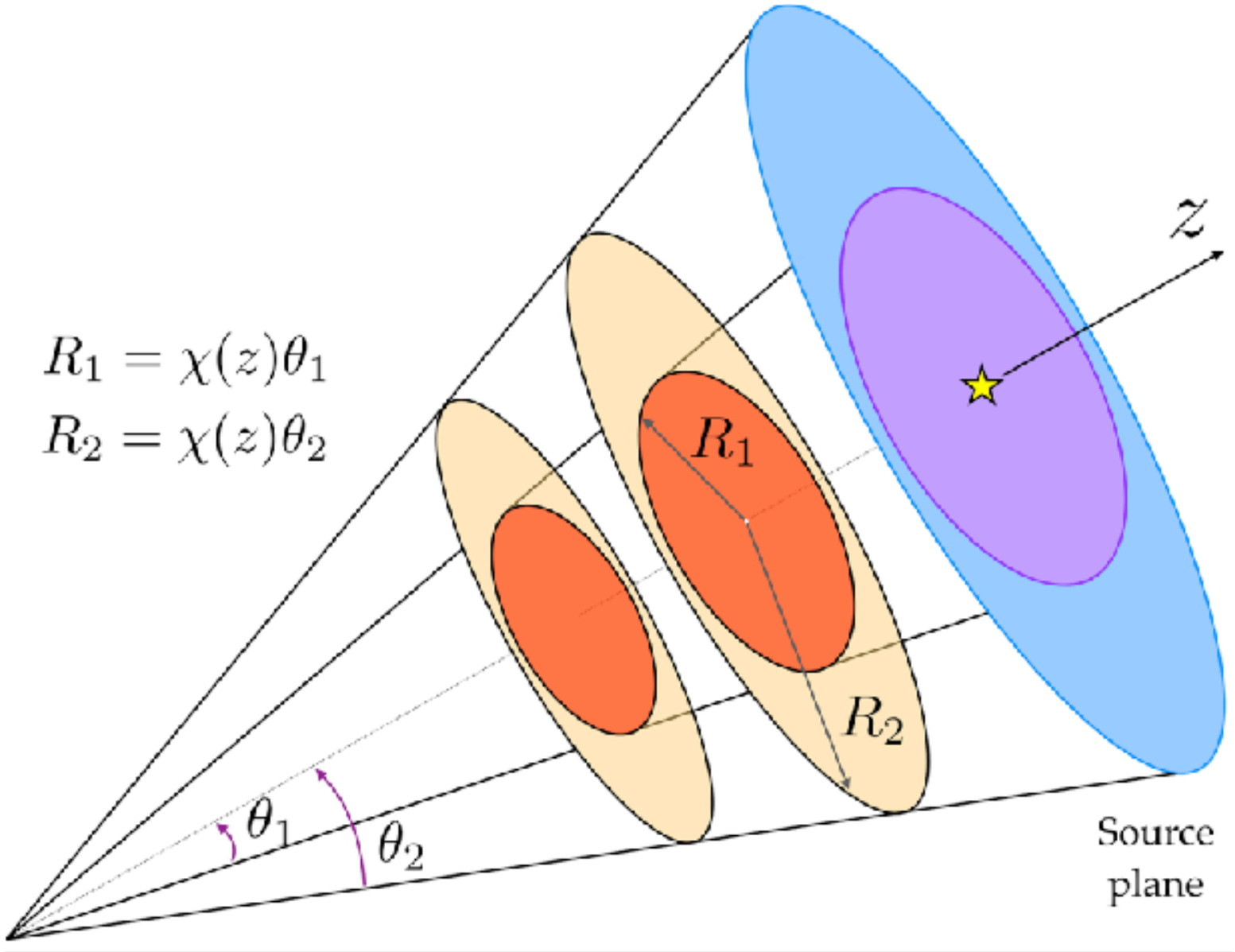
* Up to a reduced shear correction

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



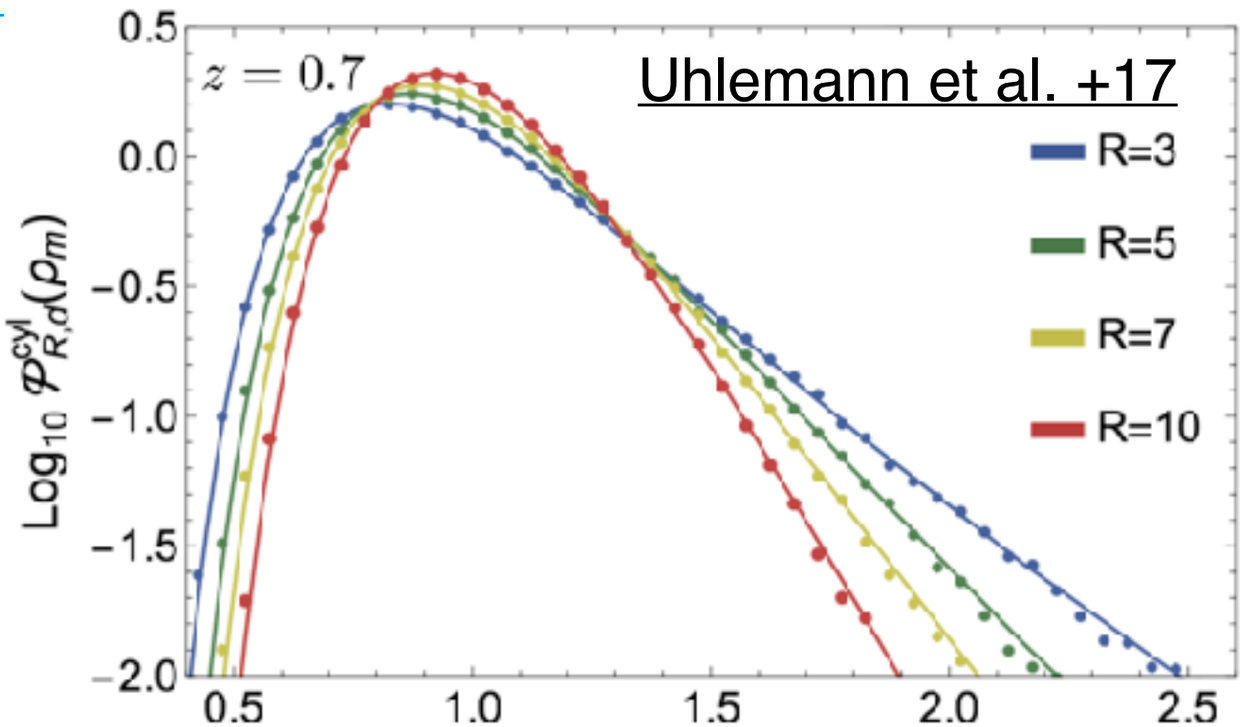
STATISTICS OF THE APERTURE MASS

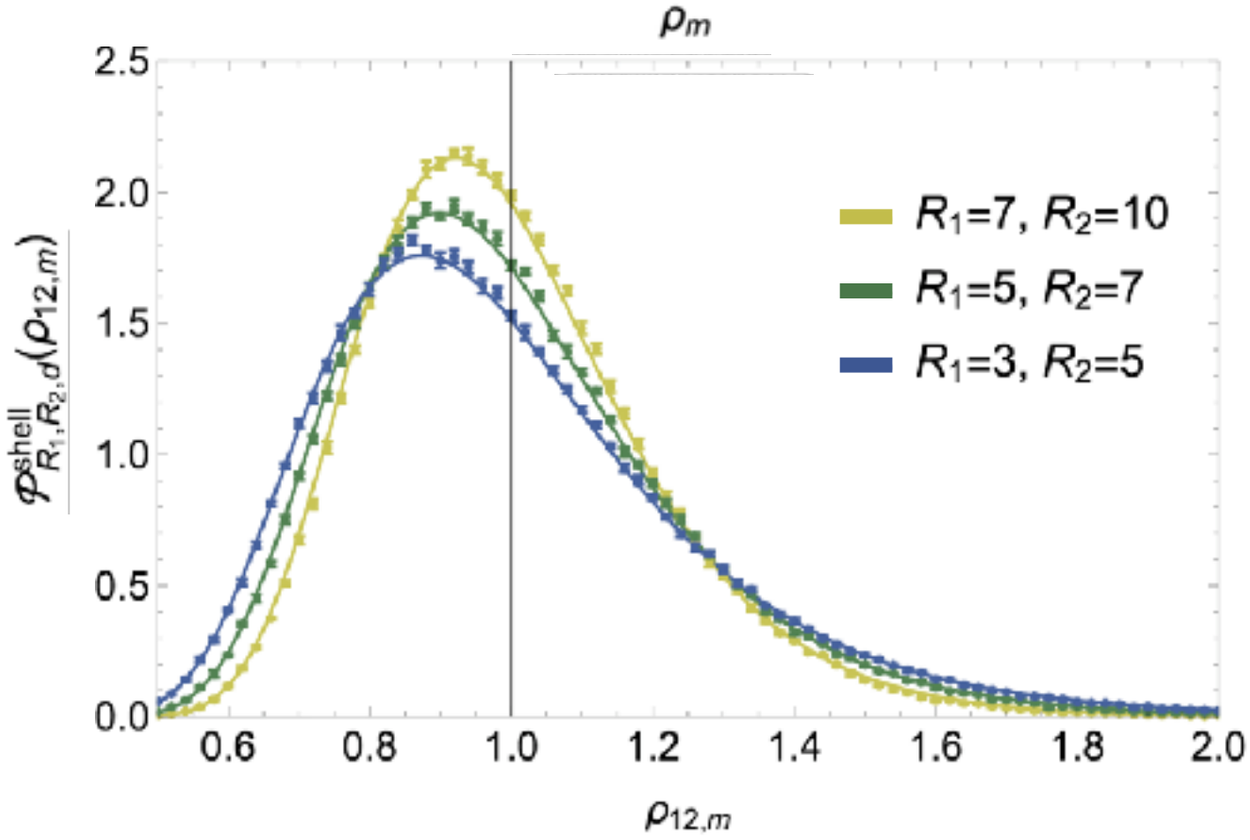
Correlations along the line of sight are negligible compared to transverse directions ➡ **Redshift slices are statistically independent** (Limber approx.)



LARGE DEVIATION THEORY IN A NUTSHELL

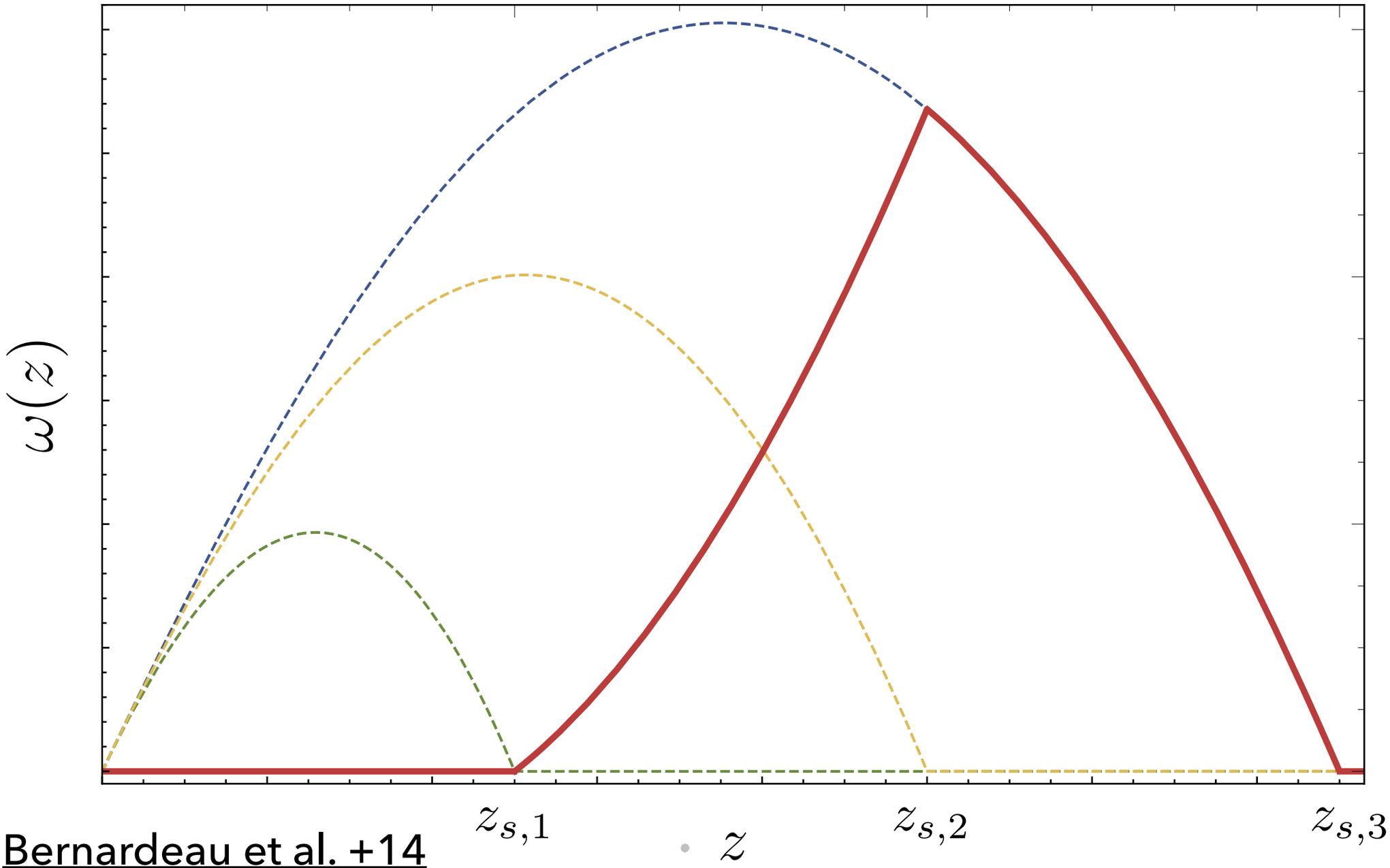
- ✦ Non-perturbative approach: non-linear dynamics of the matter field described by spherical collapse
- ✦ Equivalent to tree-order PT before filtering
- ✦ Works really well in the mildly non-linear regime





NULLING STRATEGY TO AVOID MIXING OF SCALES

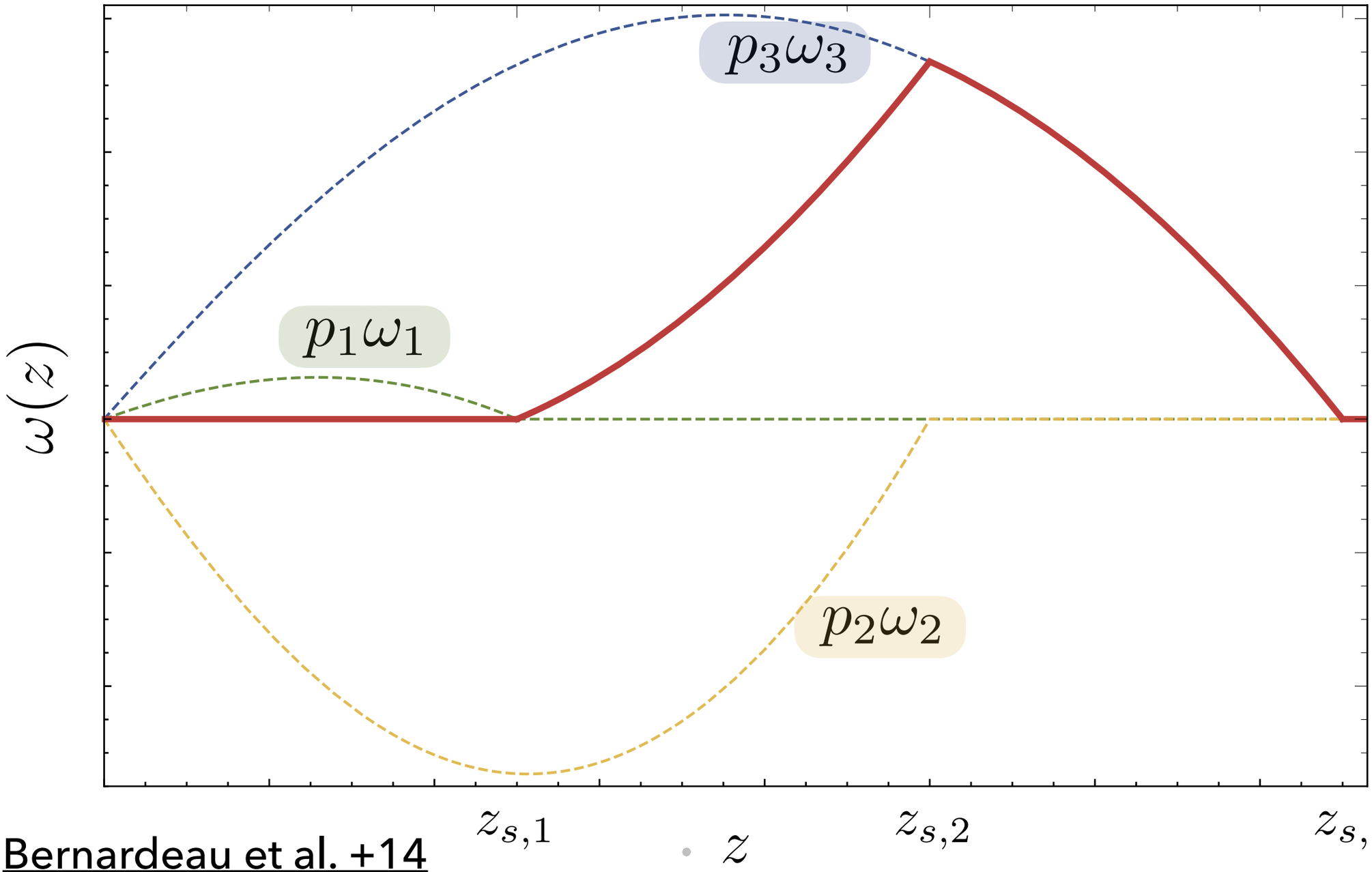
$$\kappa(\boldsymbol{\theta})_{\rm null} = \sum_i p_i \kappa_i \quad \Rightarrow \quad \omega_{\rm null}(R) = \sum_{i, R_{s,i} > R} p_i \, \omega(R, R_{s,i})$$



Bernardeau et al. +14

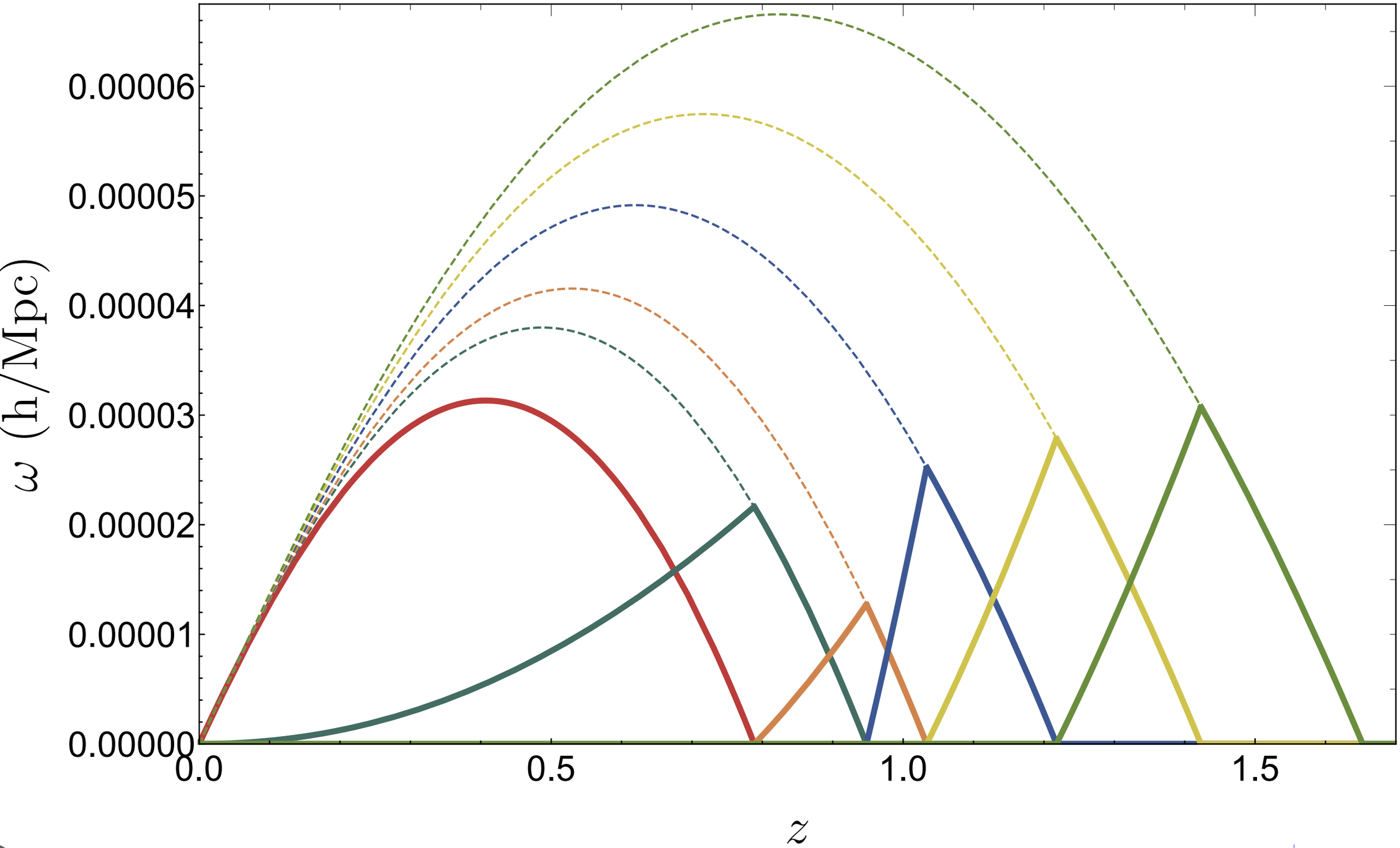
NULLING STRATEGY TO AVOID MIXING OF SCALES

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



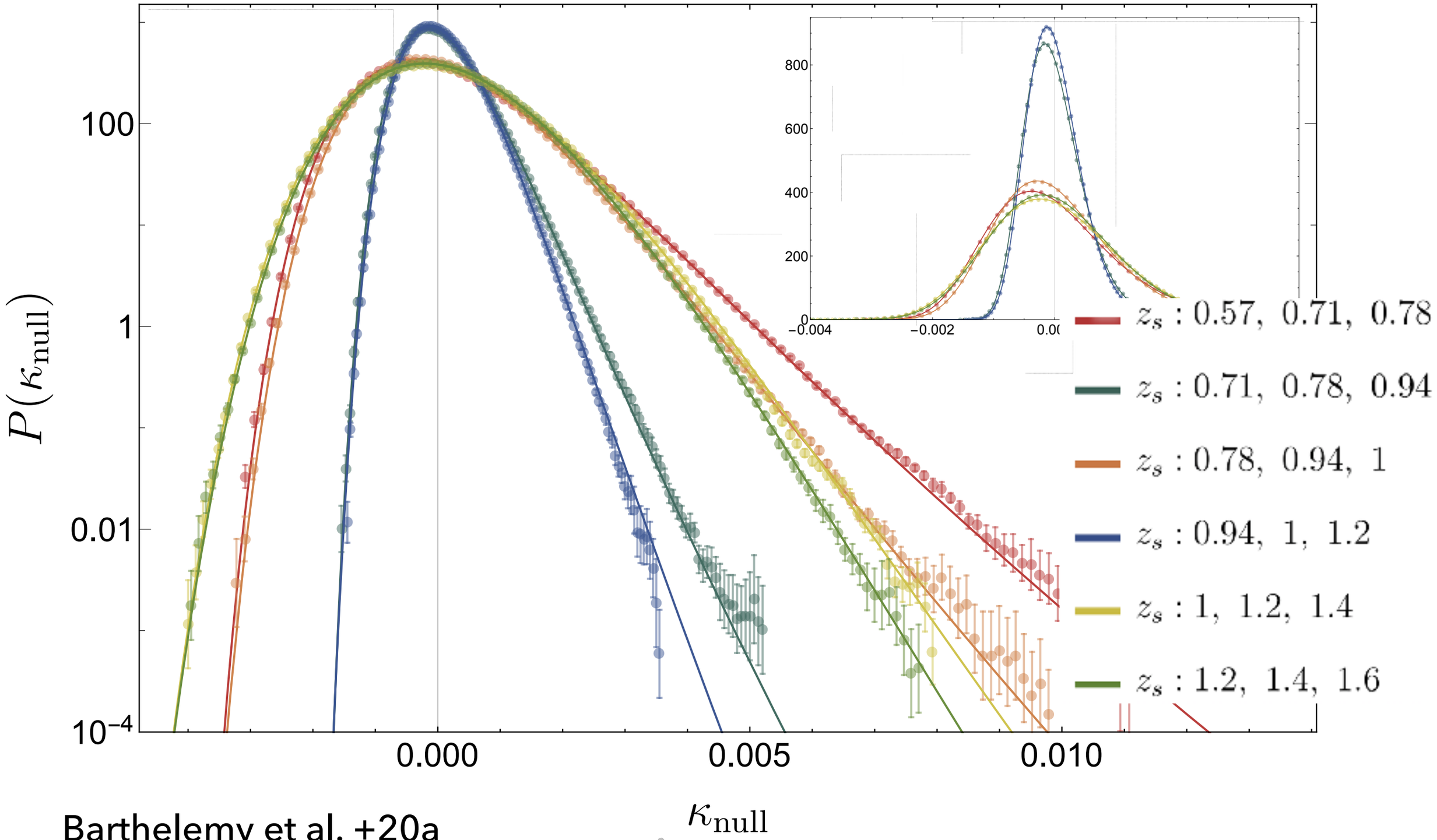
Bernardeau et al. +14

NULLING STRATEGY TO AVOID MIXING OF SCALES



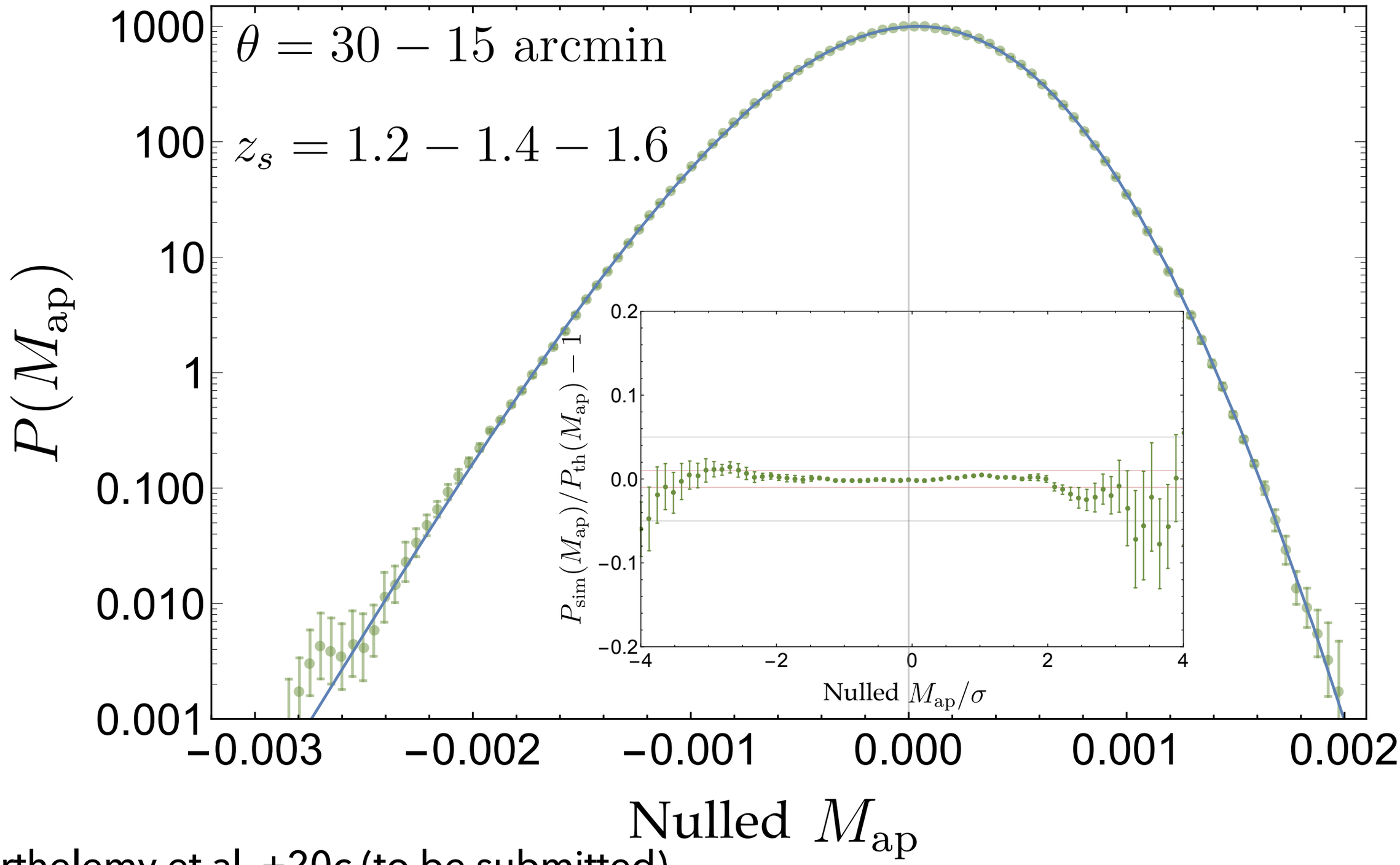
PDF OF *NULLED* CONVERGENCE

$\theta = 10$ arcmin



Barthelemy et al. +20a

PDF OF *NULLED* APERTURE MASS



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

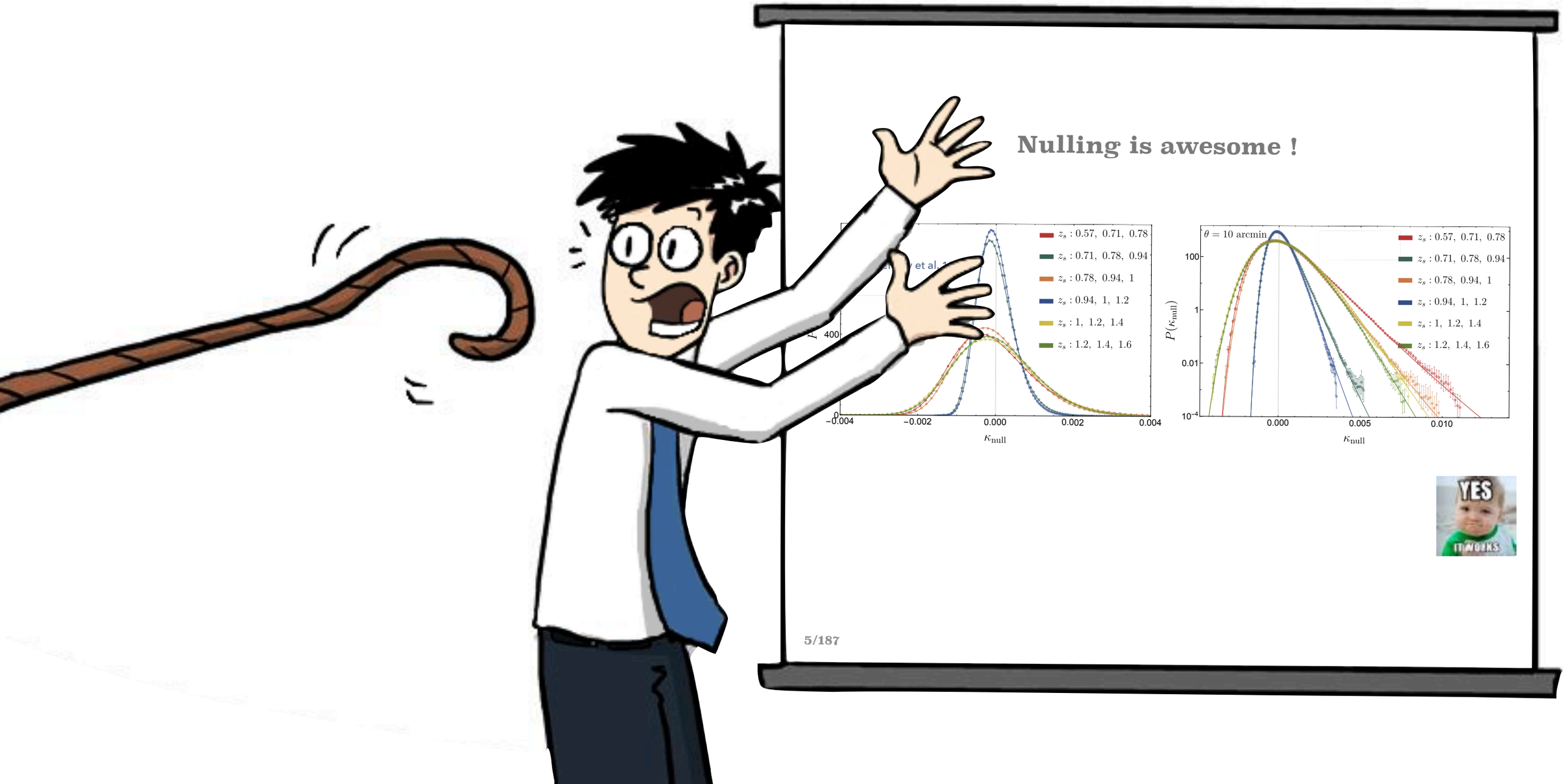
SUMMARY

- A non perturbative, from first principles approach can be used to compute the 1-point statistics of the Aperture Mass

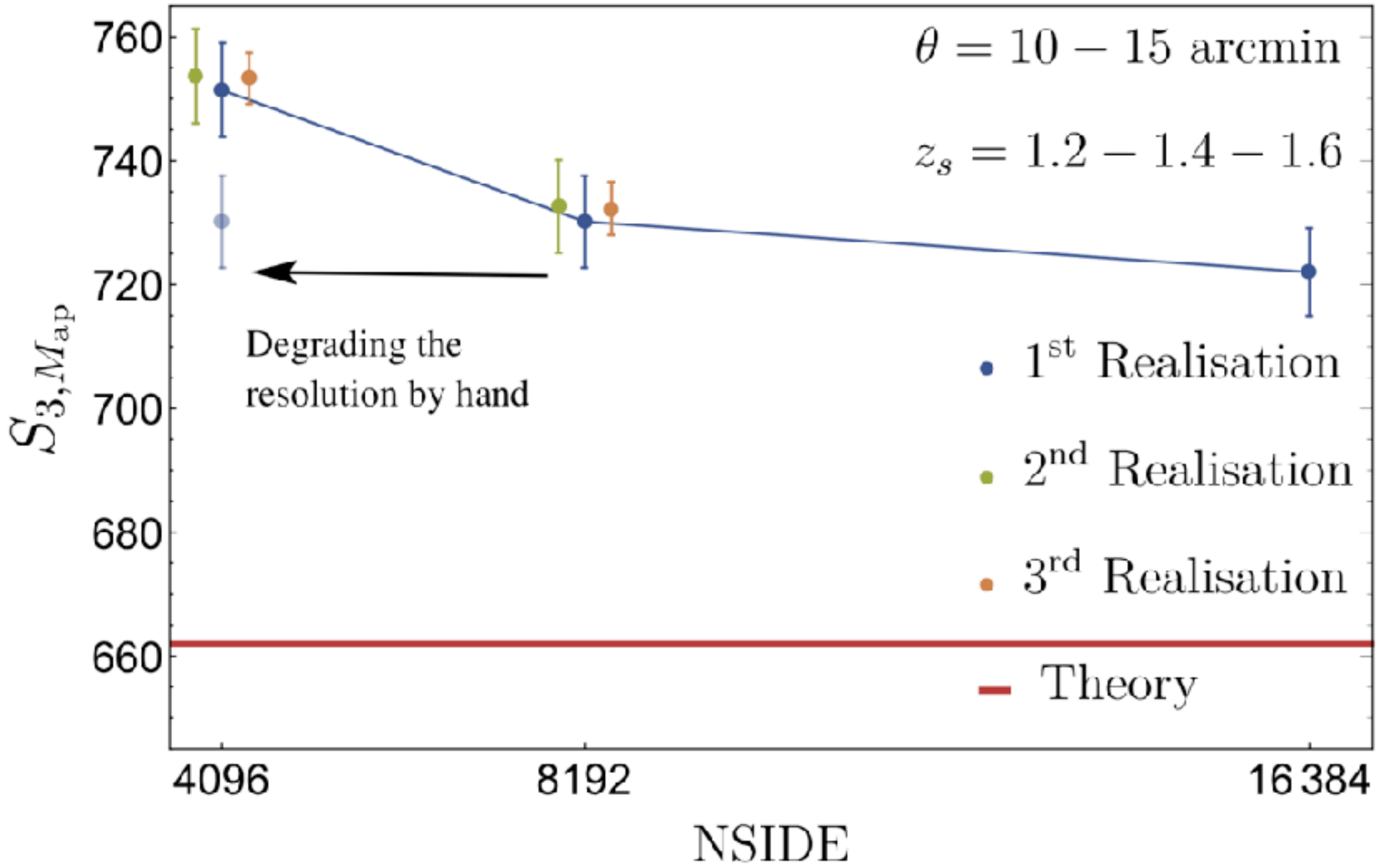
- Combined with a nulling strategy that localises the lenses/ scales contributing to the lensing effect makes the formalism precise to the percent in the PDF tails, at least in the quasi-linear regime

- 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!

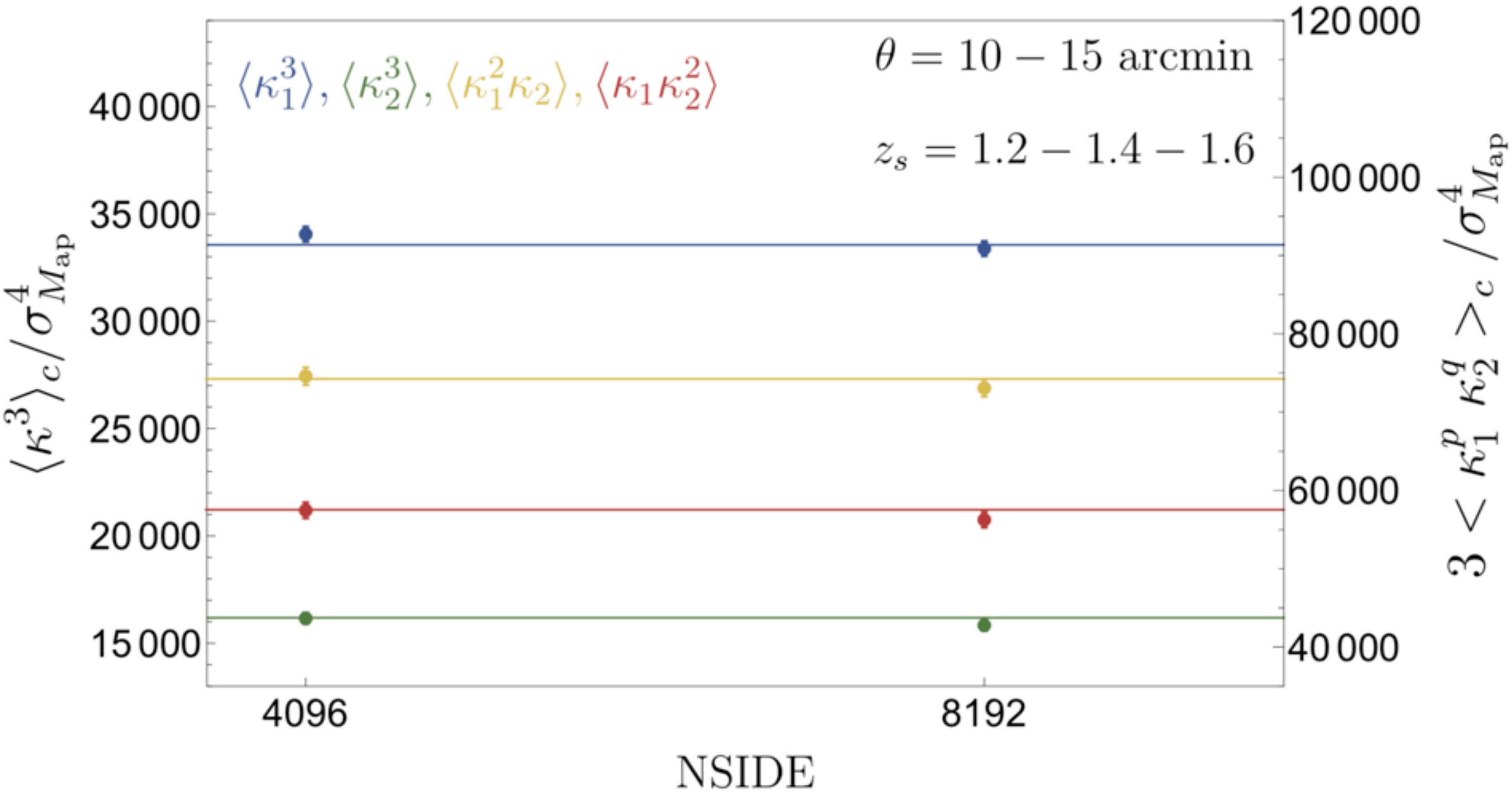


ISSUES IN NUMERICAL SIMULATIONS ?



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

ISSUES IN NUMERICAL SIMULATIONS ?



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