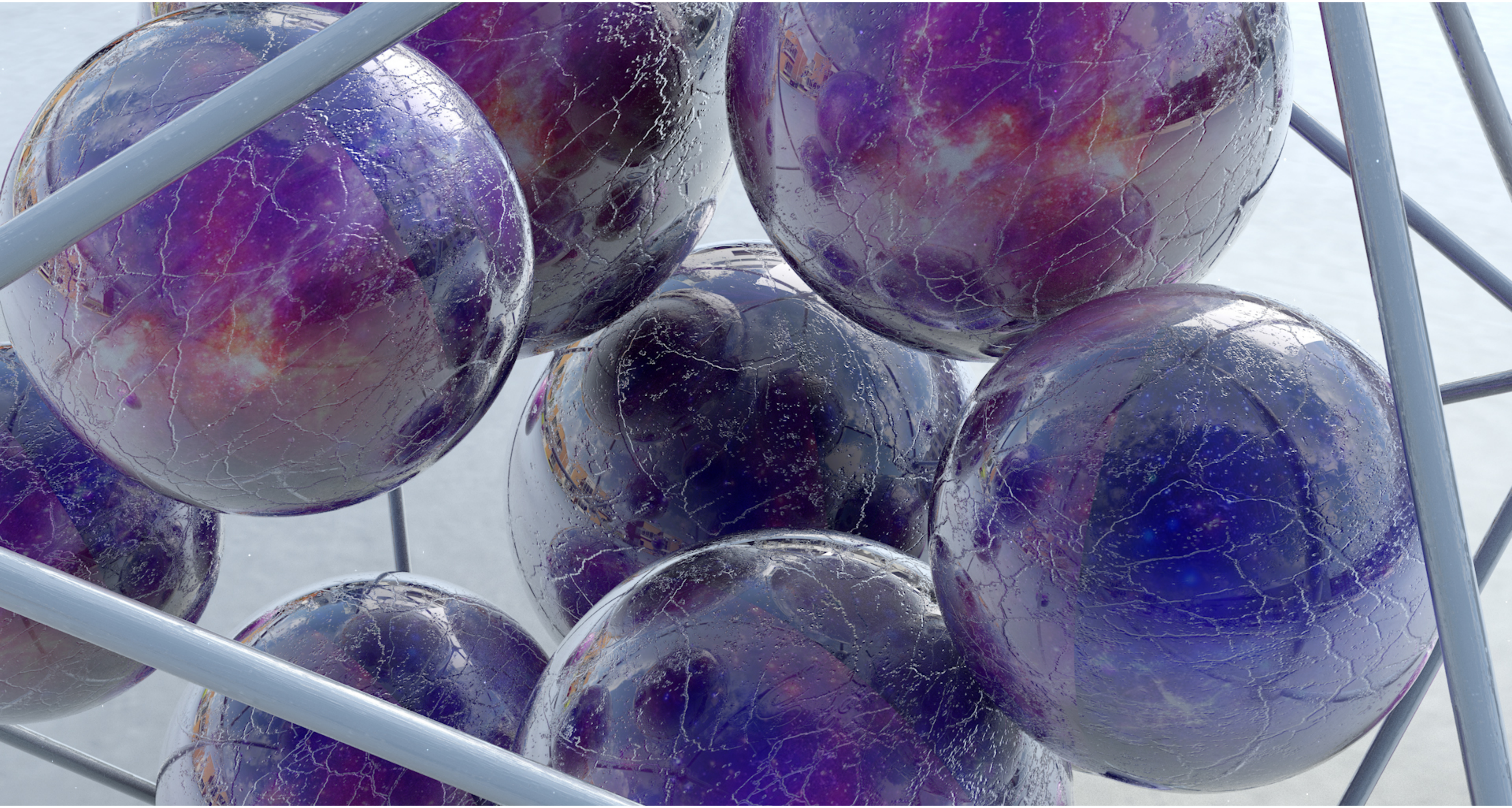
Nuw Cosmology beyond the average with ATLAS



Newcastle University

Cora Uhlemann

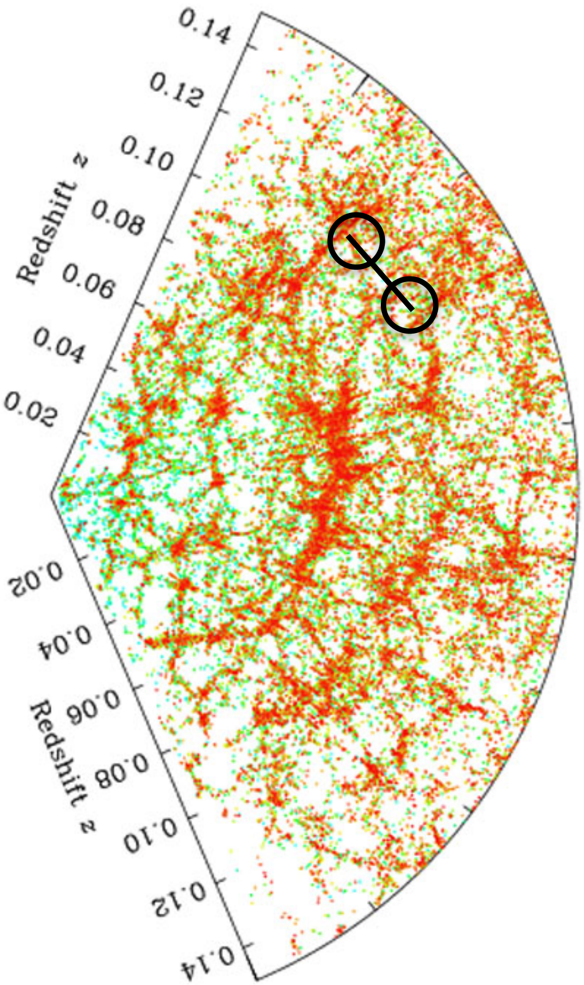
Massively Parallel Large Area Spectroscopy from Space, June 2021

Good Old Days -> Future

CMB: one snapshot
linear, almost Gaussian

LSS: motion picture
nonlinear, non-Gaussian

TRADITIONAL STATISTICS

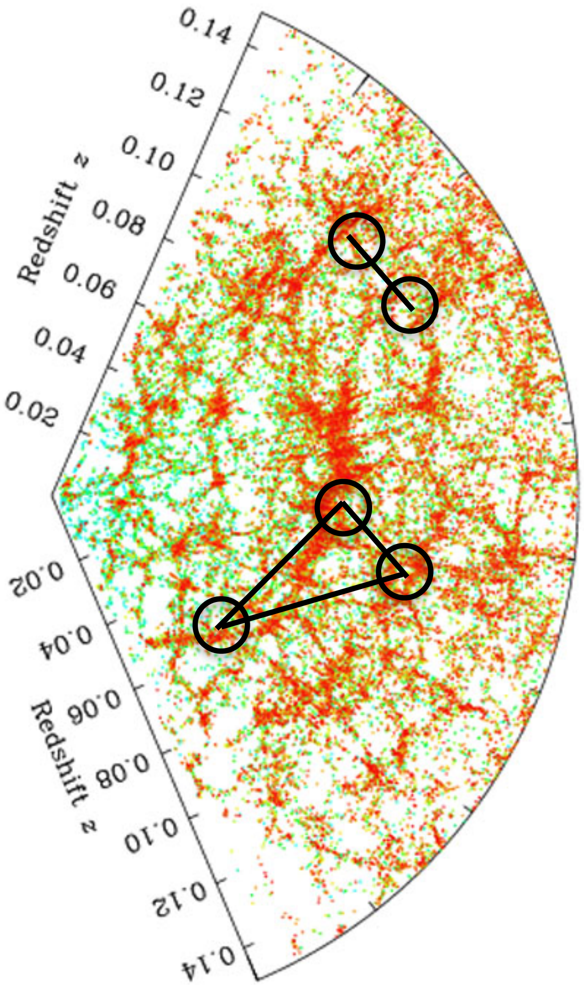


Gaussian: 2-pt correlation

$$\xi(r) = \langle \delta(\boldsymbol{x})\delta(\boldsymbol{x}+\boldsymbol{r}) \rangle$$

nonlinear → non-Gaussian

TRADITIONAL STATISTICS



Gaussian: 2-pt correlation

$$\xi(r) = \langle \delta(\boldsymbol{x}) \delta(\boldsymbol{x} + \boldsymbol{r}) \rangle$$

nonlinear → non-Gaussian

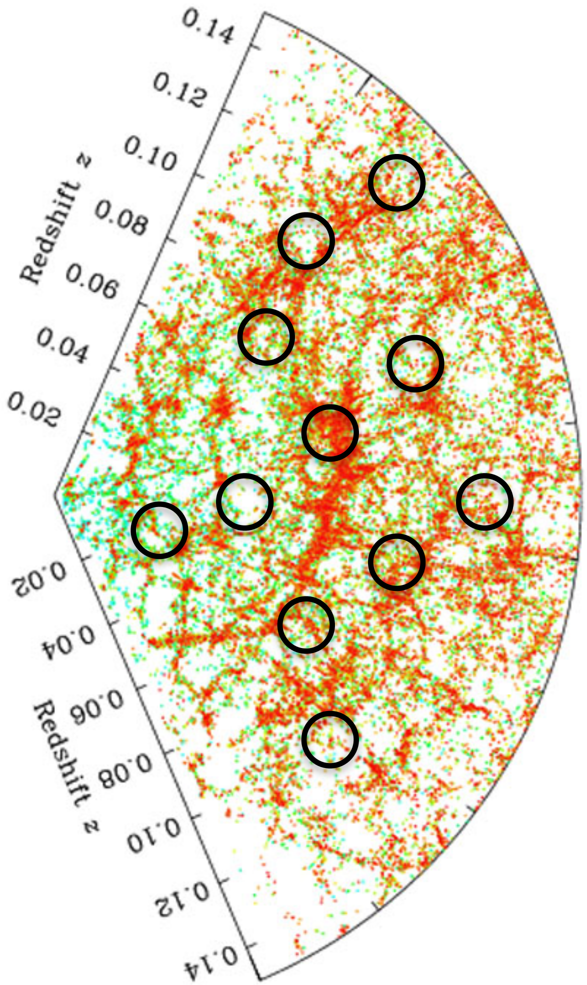
Higher N-pt correlations

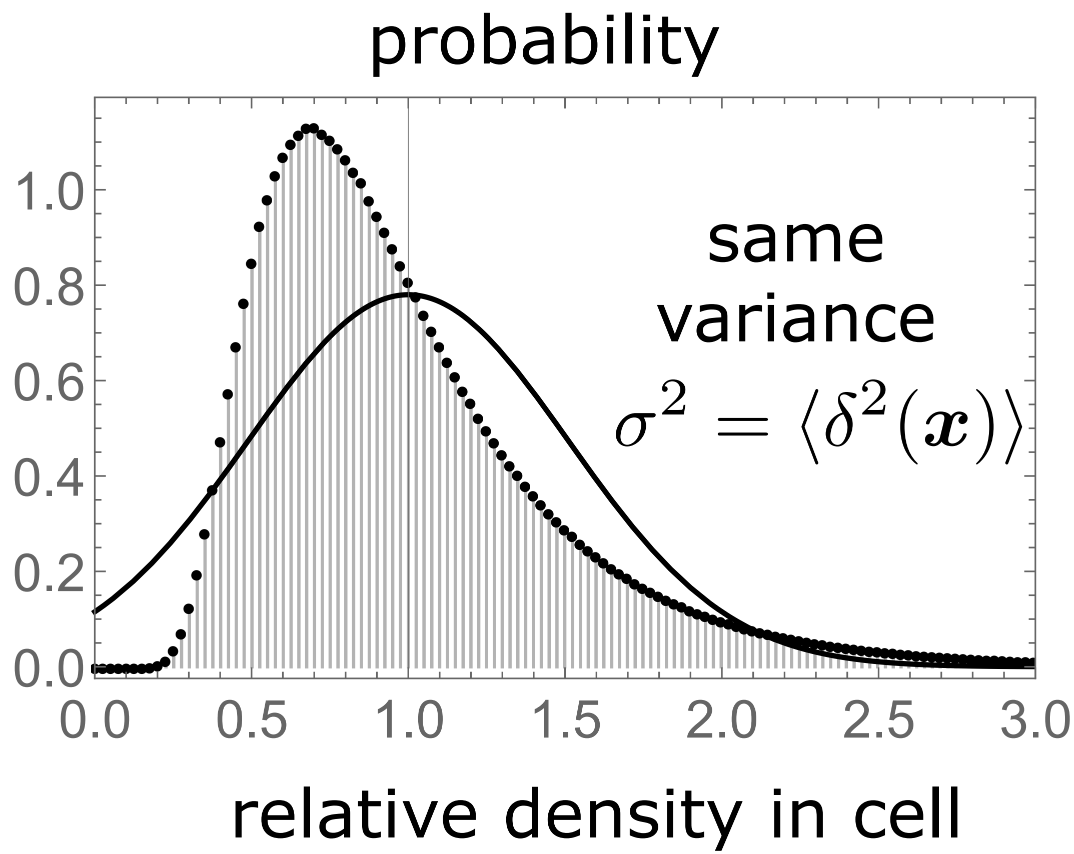
N≥3 hard to measure

EFFICIENT STATISTICS

My approach: 1-point PDF

capture non-Gaussian info





Counts-in-Cells Theory

Large-deviation statistics

symmetry statistics ↔ dynamics

spherical collapse

$$\mathcal{P}_{R,z}(\rho) \sim \exp\left[-\frac{\delta_L(\rho)^2}{2\sigma_L^2(z, r(R,\rho))}\frac{\sigma_L^2}{\sigma_{\rm NL}^2}\right]$$

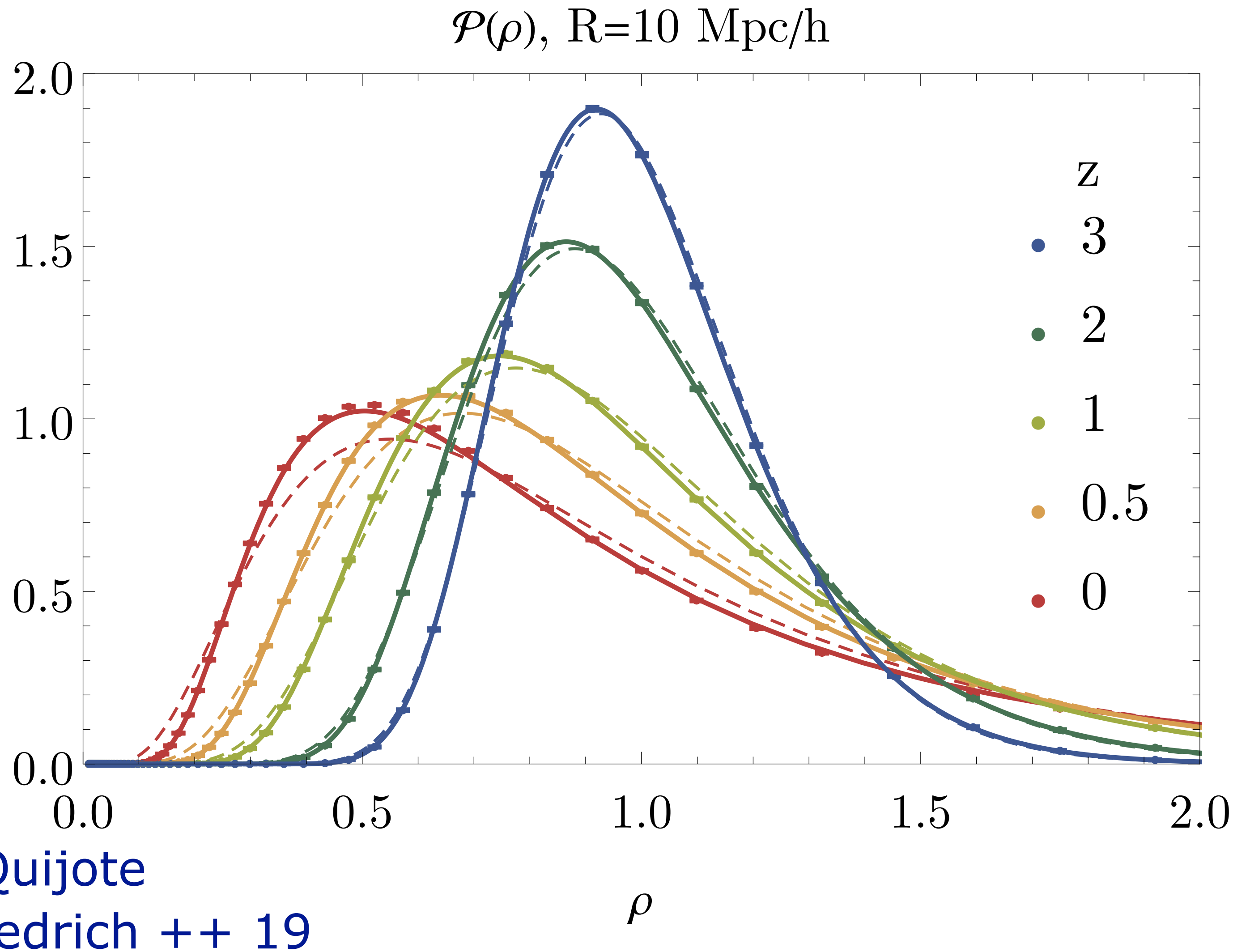
Bernardeau 94
CU++ 16

linear variance & growth

nonlinear variance

Matter Counts-in-Cells

accurate PDF from first principles, not lognormal

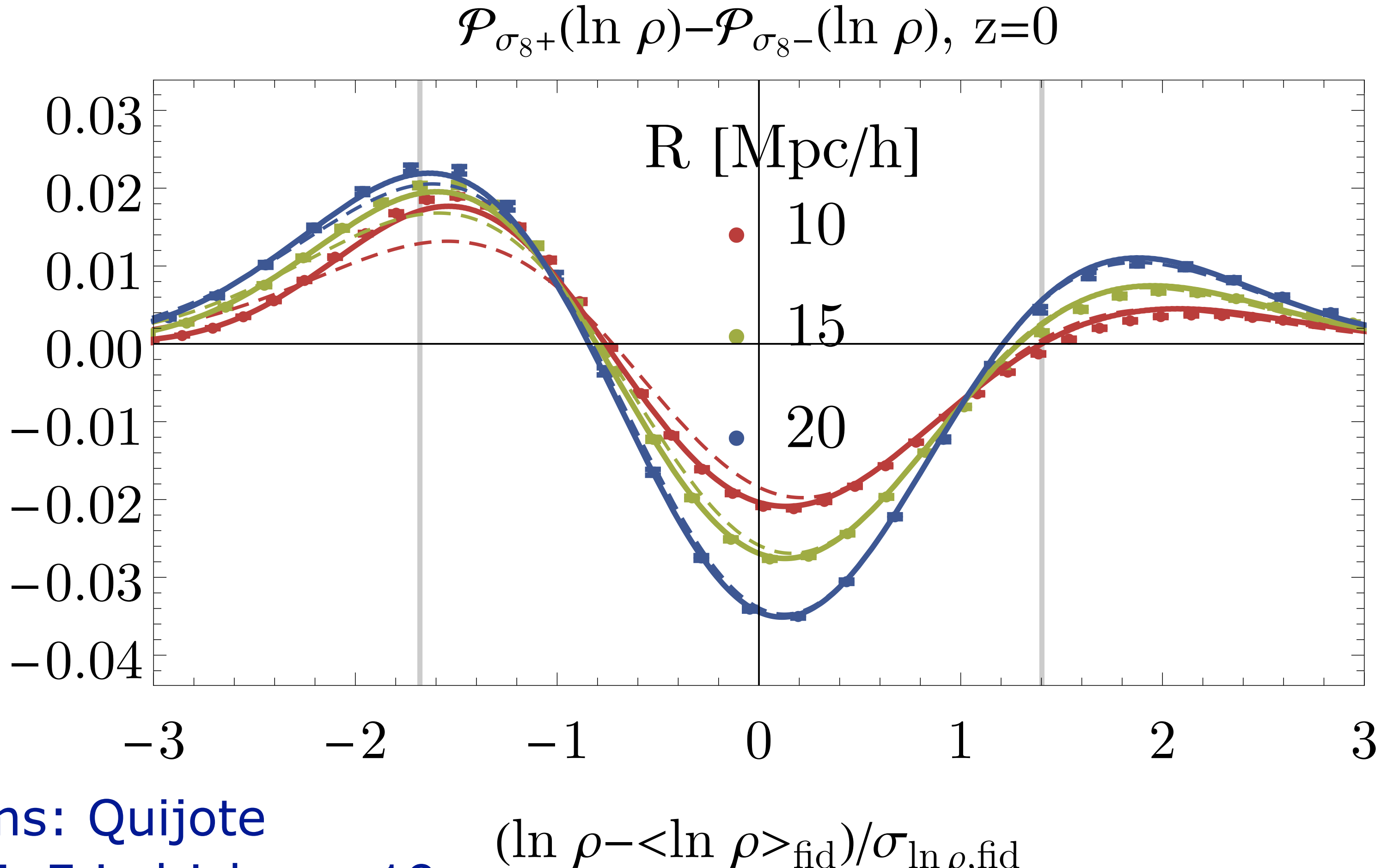


sims: Quijote

CU, Friedrich ++ 19

Matter Counts-in-Cells

width: clustering amplitude σ_8

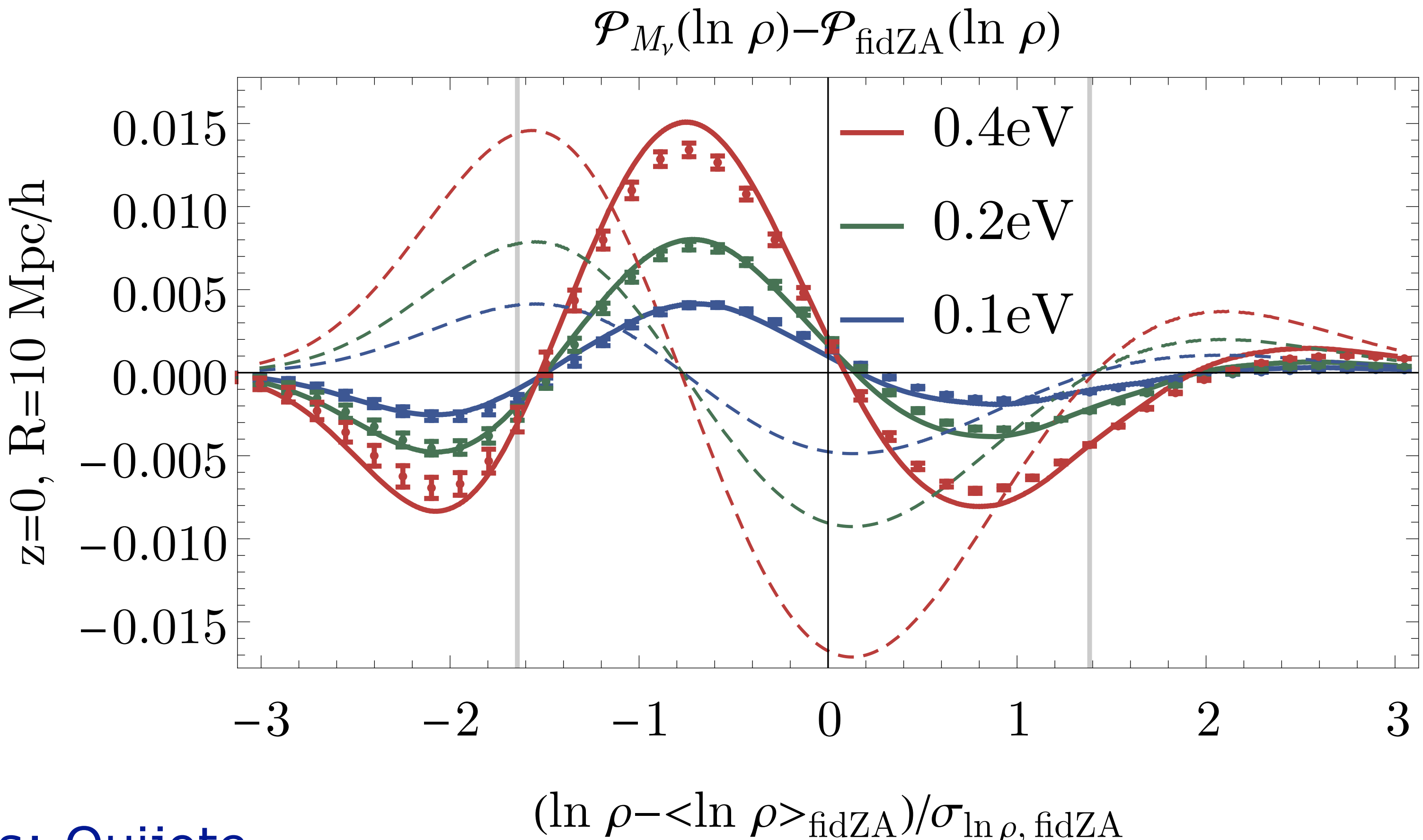


sims: Quijote

CU, Friedrich ++ 19

Matter Counts-in-Cells

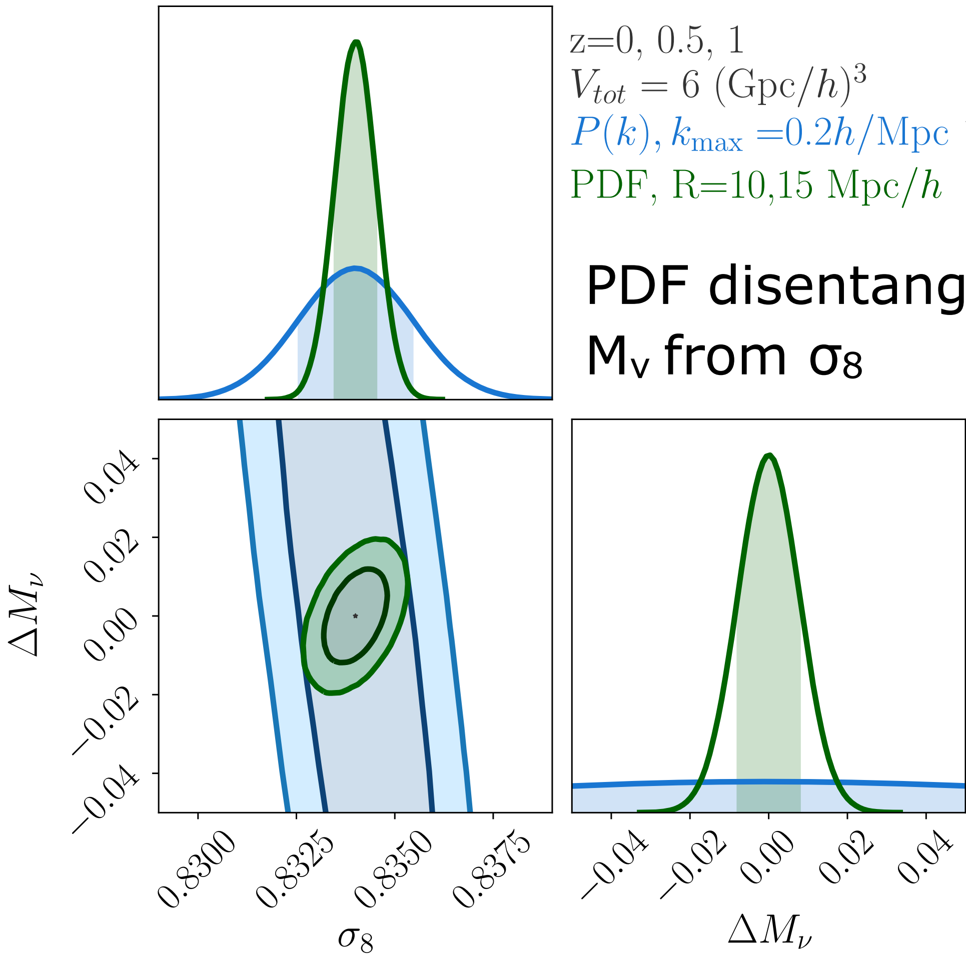
environment-dependence: M_ν



sims: Quijote

CU, Friedrich ++ 19

Matter Counts-in-Cells



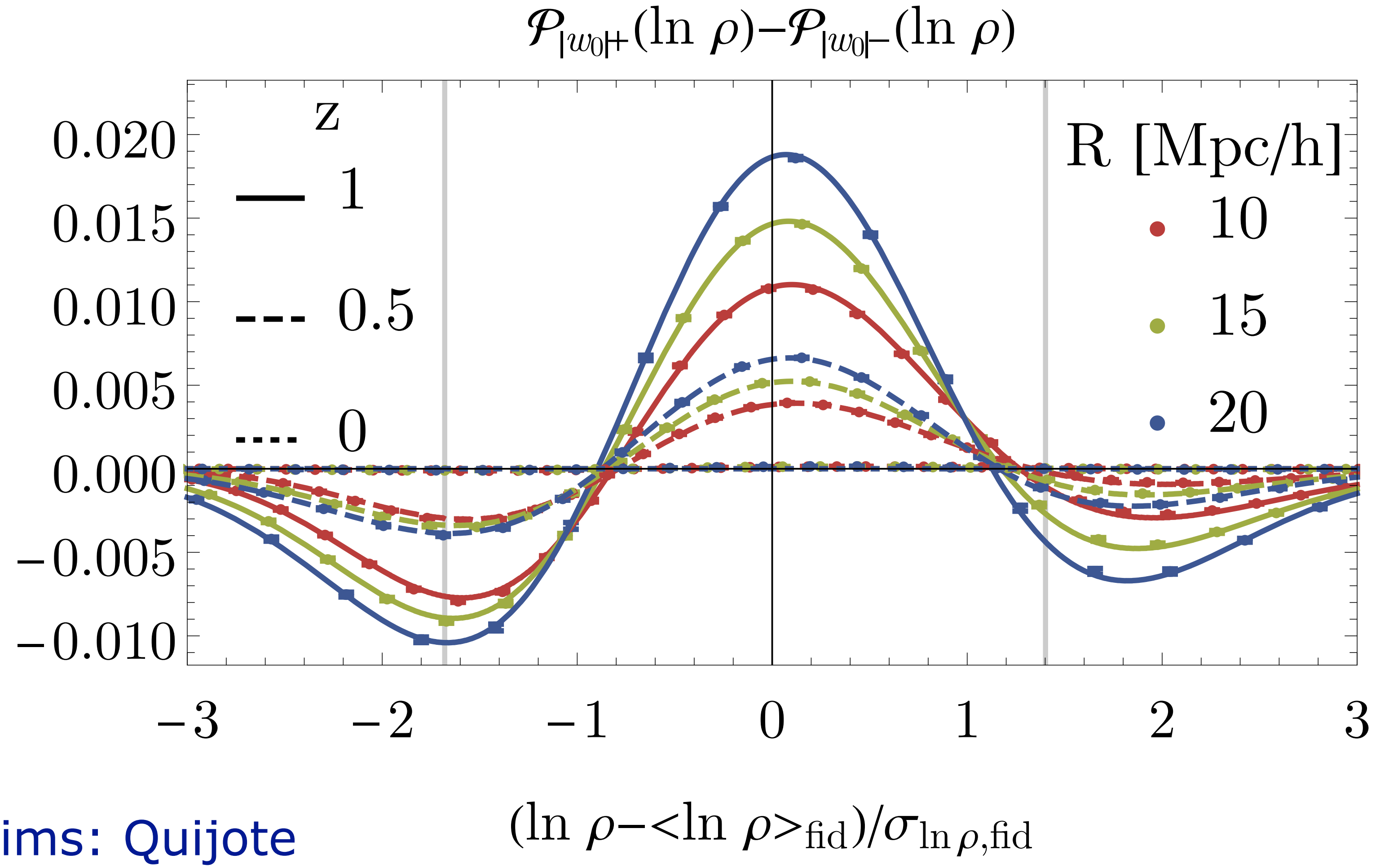
PDF disentangles M_ν from σ_8

sims: Quijote

CU, Friedrich ++ 19

Matter Counts-in-Cells

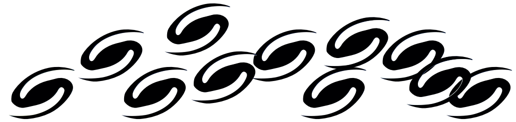
growth: dark energy e.o.s. w_0/w_a



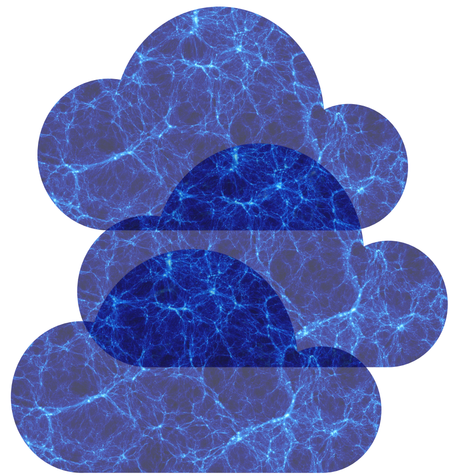
sims: Quijote

Weak Lensing & Tracers

source galaxies



(dark) matter



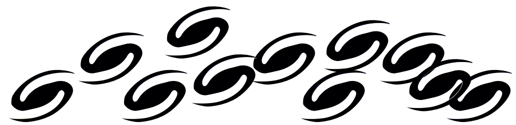
galaxy shapes

convergence κ

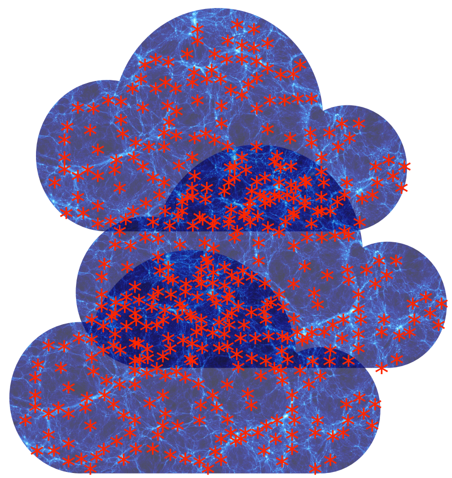
& shear

Weak Lensing & Tracers

source galaxies



(dark) matter



lens galaxies

galaxy shapes

convergence κ

& shear

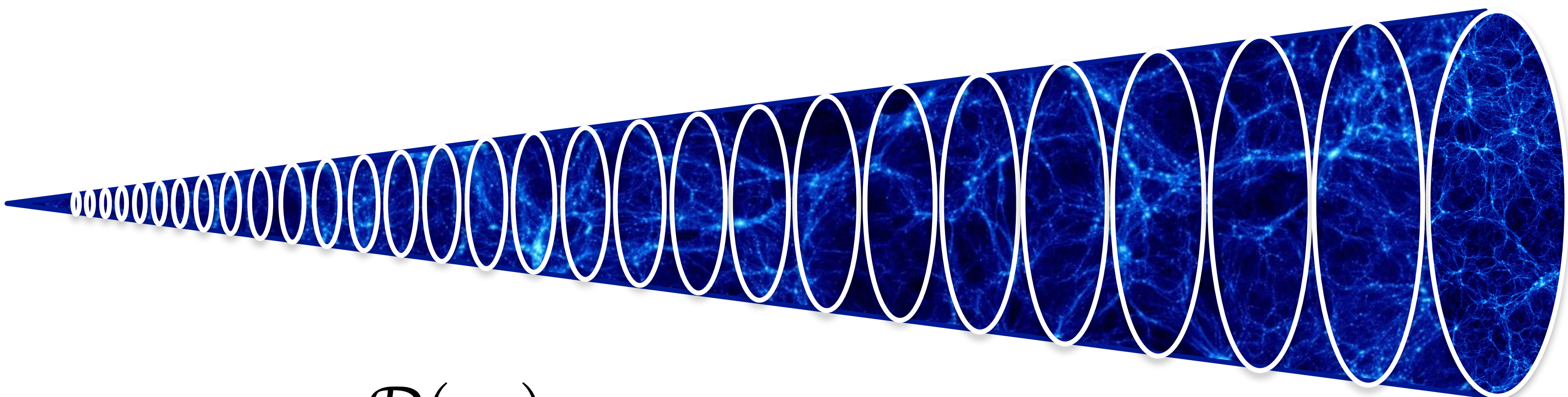
galaxy counts

density δ_g

spec & photo-z

Weak Lensing-in-Cells

convergence: projected matter density



$$\kappa_{<\theta} = \int_0^{\mathcal{D}(z_s)} d\mathcal{D}(z)\, \delta^{\rm disk}_{<\theta\mathcal{D}(z)}\, w(z, z_s)$$

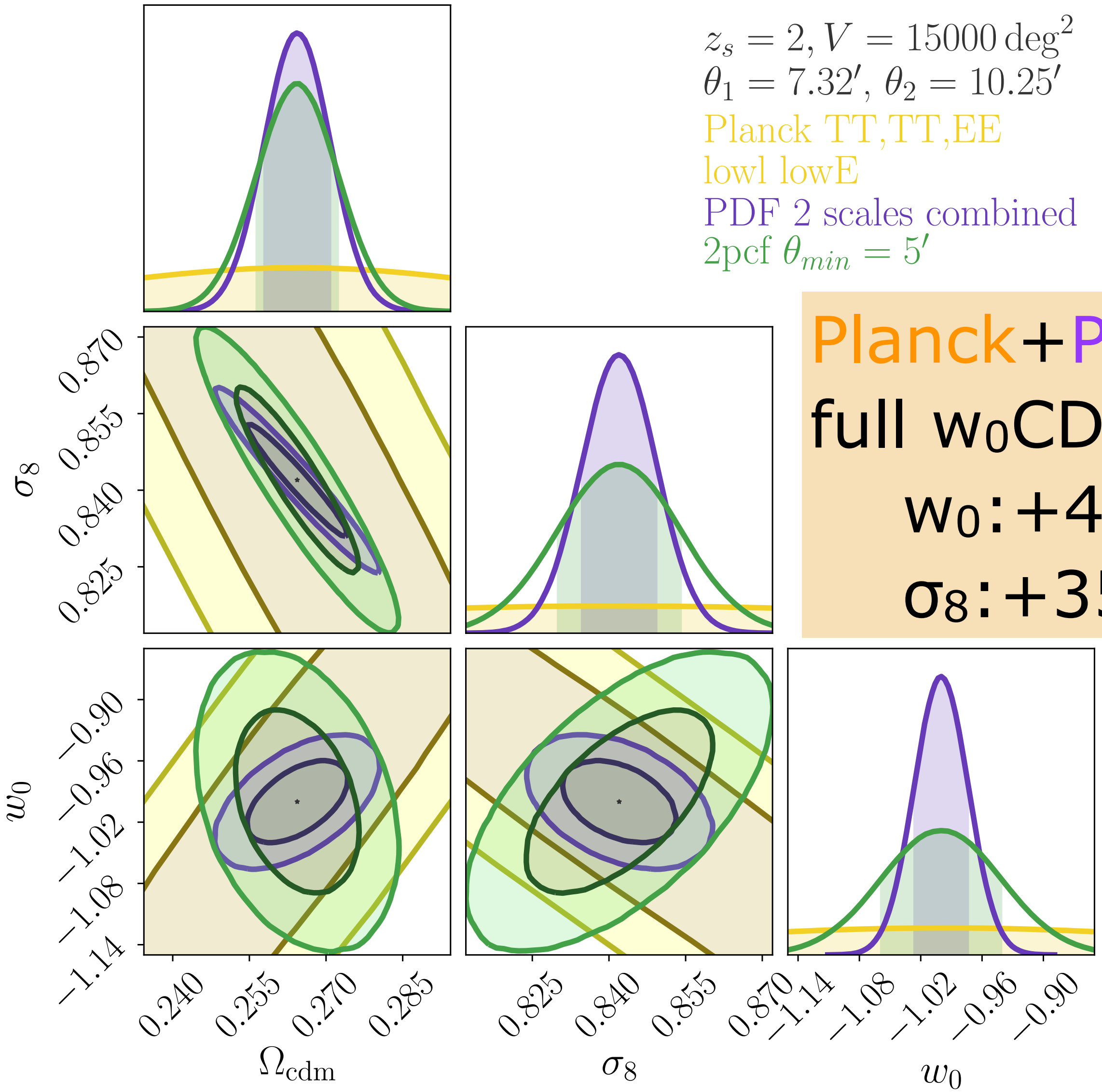
cylindrical collapse

weight

→ construct PDF

Bernardeau & Valageas `00
Barthelemy, Codis, **CU**++ 19

Weak Lensing-in-Cells



complements CMB & 2pt correlation

Planck+PDF vs. Planck+2pcf

full w_0CDM/νLCDM:

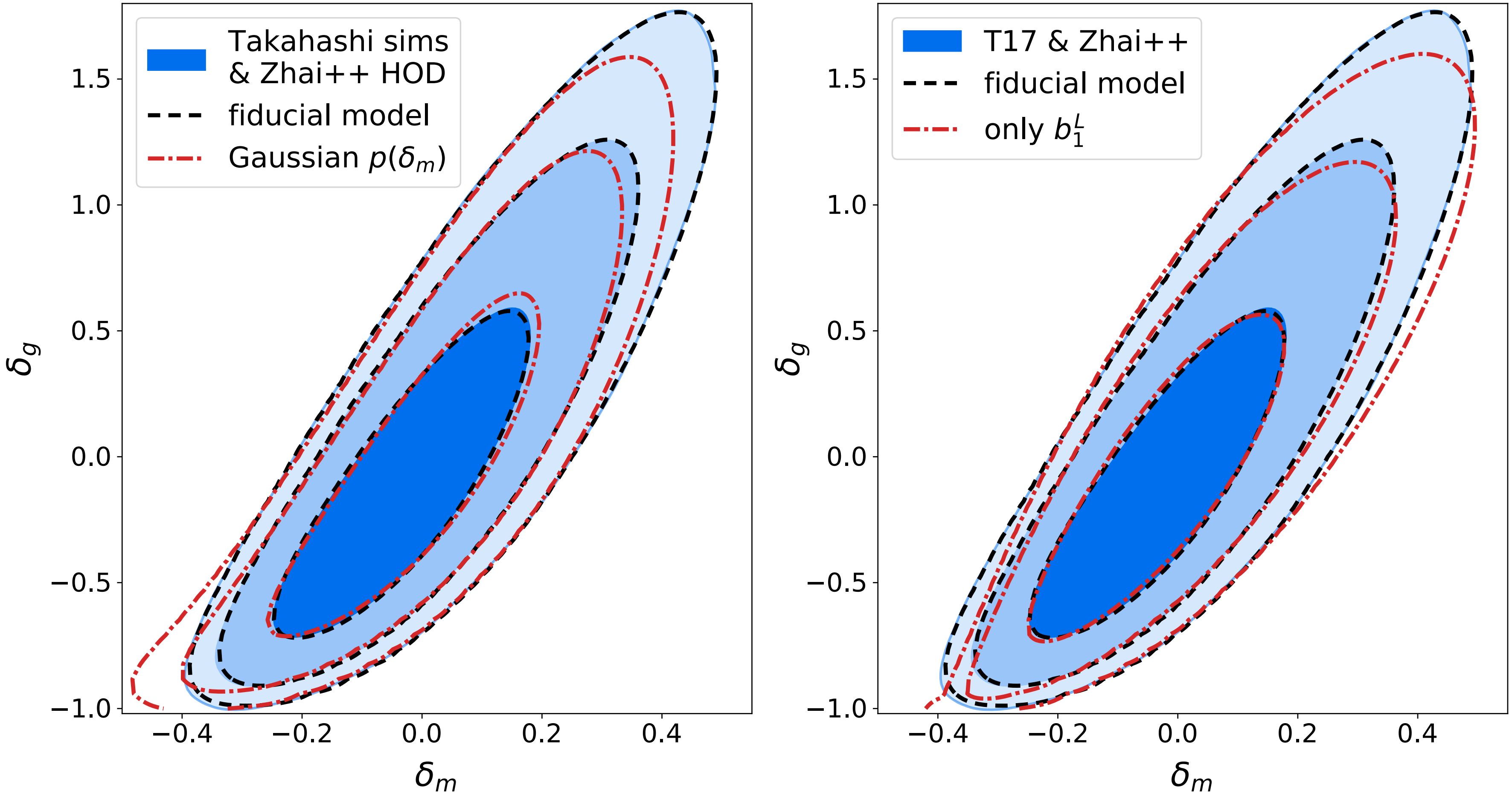
w_0:+40% M_ν:+27%

σ_8:+35% / +32%

Boyle, **CU** ++ 20

Galaxy Counts-in-Cells

with Lagrangian bias (2pt-compatible) & shot noise



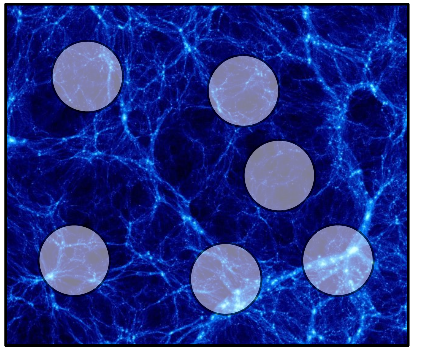
computed with CosMomentum code Friedrich +**CU**+ *in prep*

Nuw Cosmo Beyond Average

PDFs=Powerful non-Gaussian statistics

robust & accurate predictions

different density environments



Ideal: Matter density PDF

$\Omega_m, \sigma_8, M_\nu, f_{NL}$ **CU**, Friedrich ++ 19 Friedrich, **CU** ++ 19

$w_{0,a}, \Omega_{rc}, f_{R0}$ *Matteo Cataneo, Alex Gough & CU in prep*

Real: weak lensing & galaxy counts PDF

lensing convergence: $\Omega_m, \sigma_8, w_0, M_\nu$ Boyle, **CU** ++ 20

galaxies: Lagrangian bias + shot noise Friedrich +**CU**+ *in prep*