One with HI: Modelling HI Intensity Mapping One-Point statistics with Systematics

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UNIVERSITÄT BIELEFELD

erc

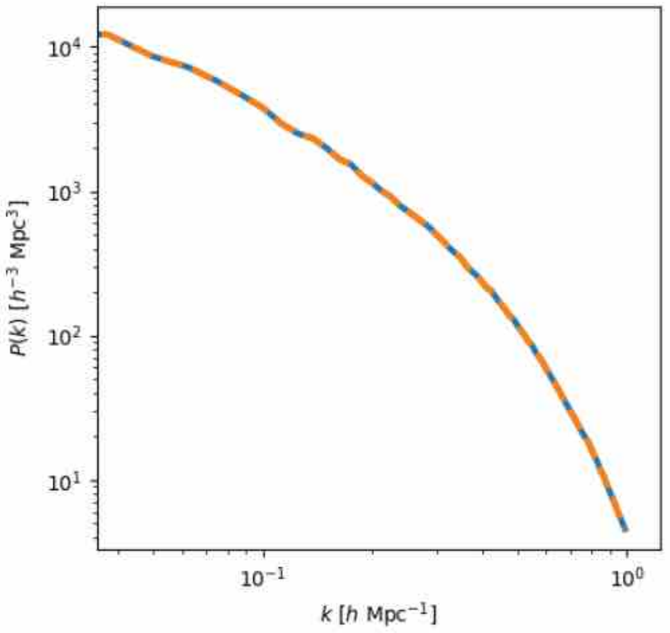
euclid consortium

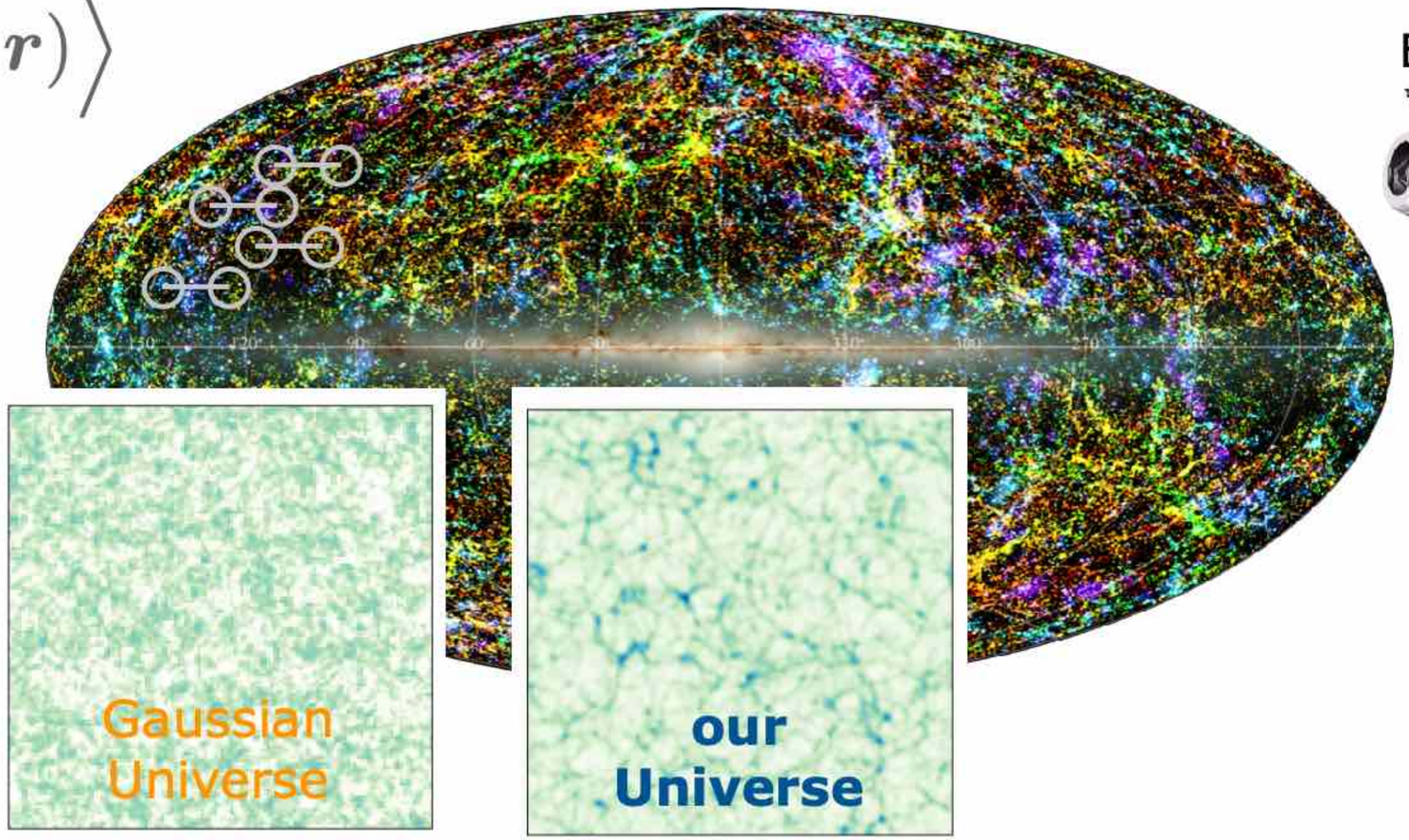
SKAO

Non-Gaussian Universe

current: 2-point correlation averages over all densities

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





Euclid

credit: Natalia Porqueres

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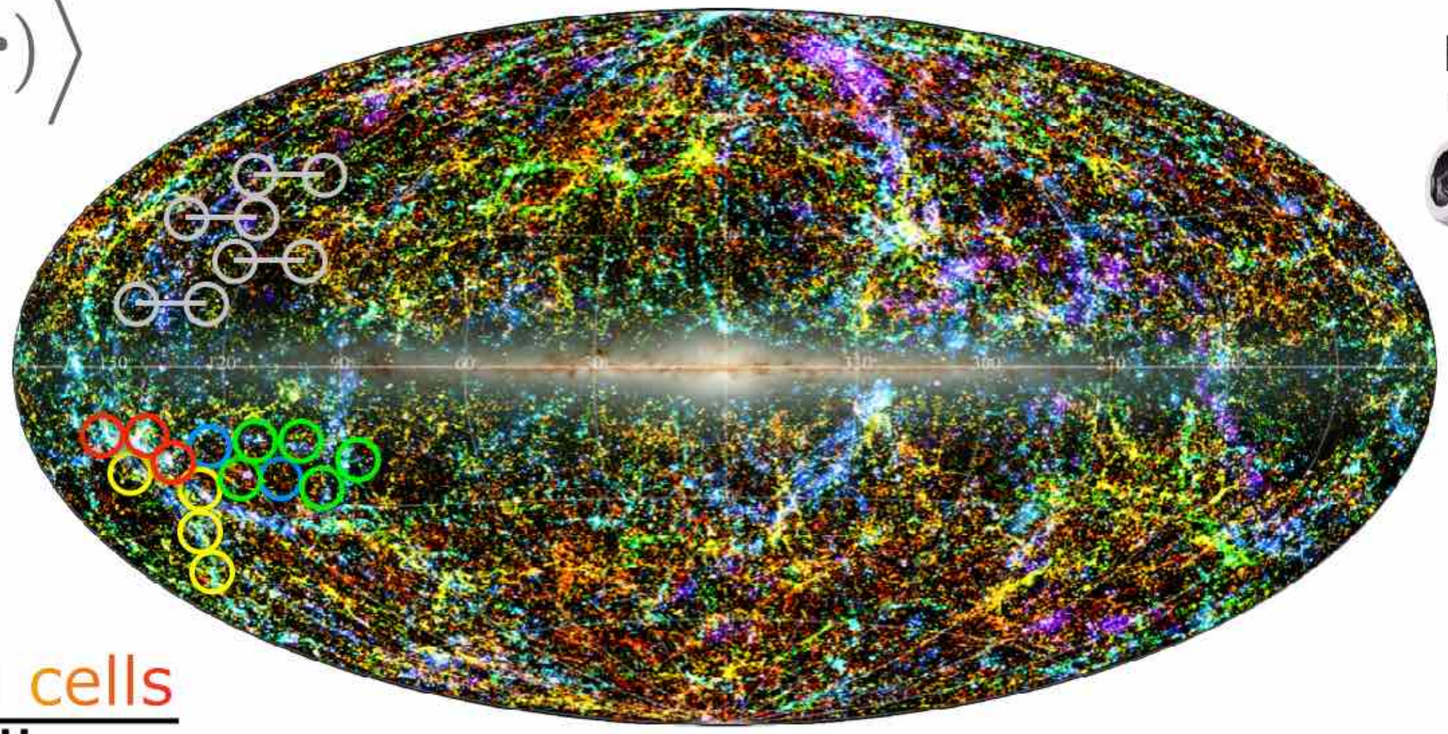
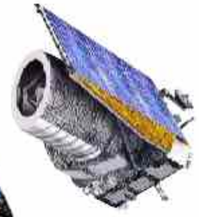


Euclid



beyond average:

1-point statistics split density environments

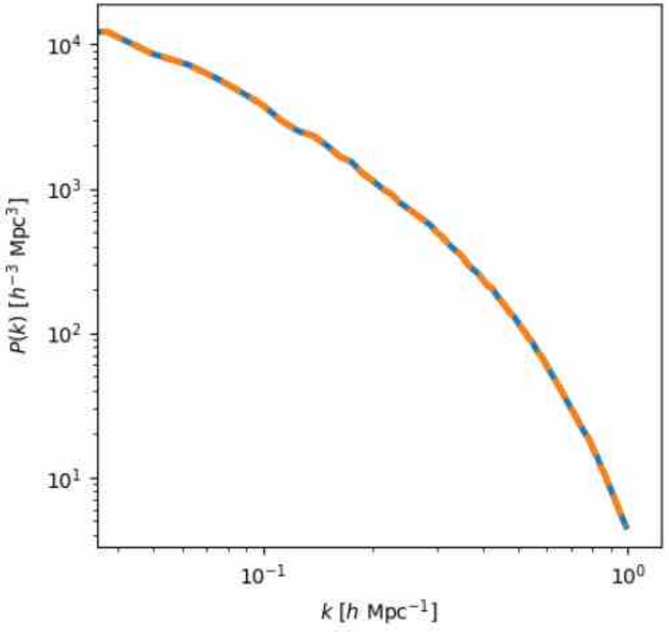
$$\mathcal{P}_R(\delta) \propto \frac{\#\text{coloured cells}}{\#\text{all cells}}$$

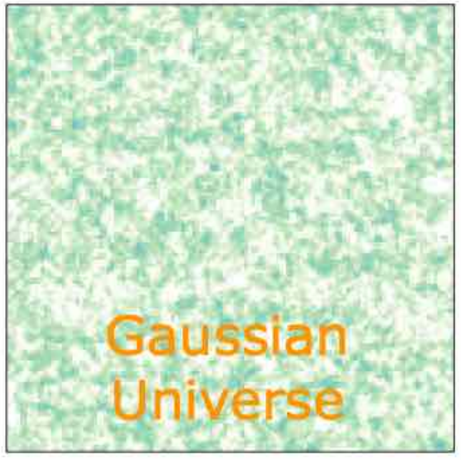
predictable on mildly nonlinear scales

Non-Gaussian Universe

CU++ ,20

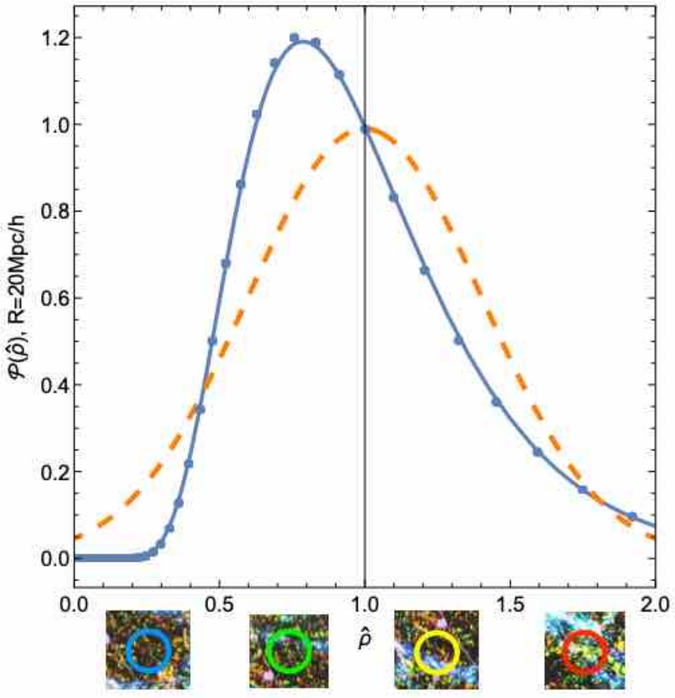
standard
2-point statistics





goal: (1+2)-point survey analysis

predictable
non-Gaussian
1-point statistics

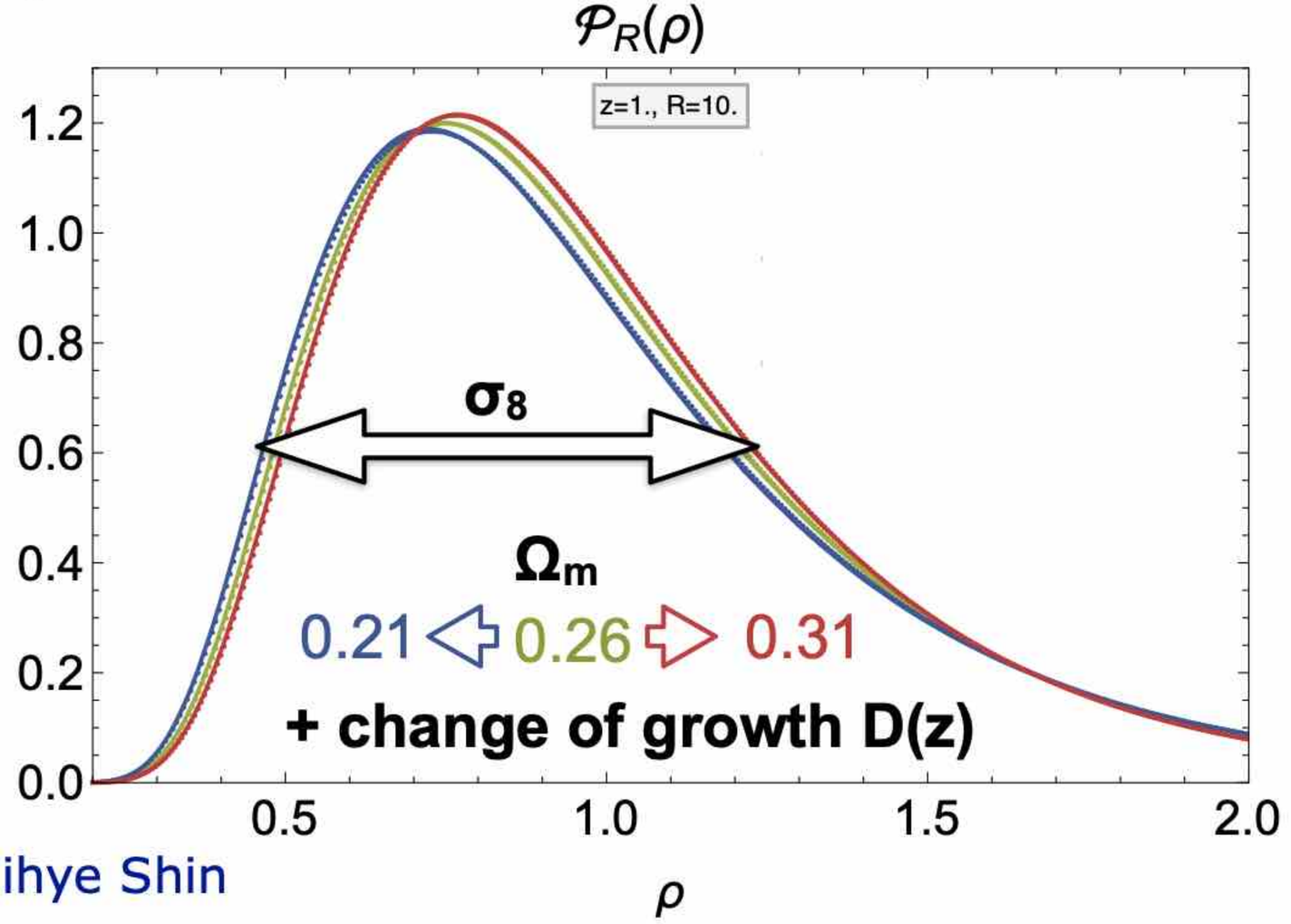


including higher-order
cumulants: skewness,…

Dark Matter 1-Point Statistics

dark matter: %-level predictions in central region, R$\gtrsim$ 10Mpc/h

cosmology dependence - σ_8 & Ω_m: width & tilt



sims: Jihye Shin

21cm (HI) Intensity Mapping

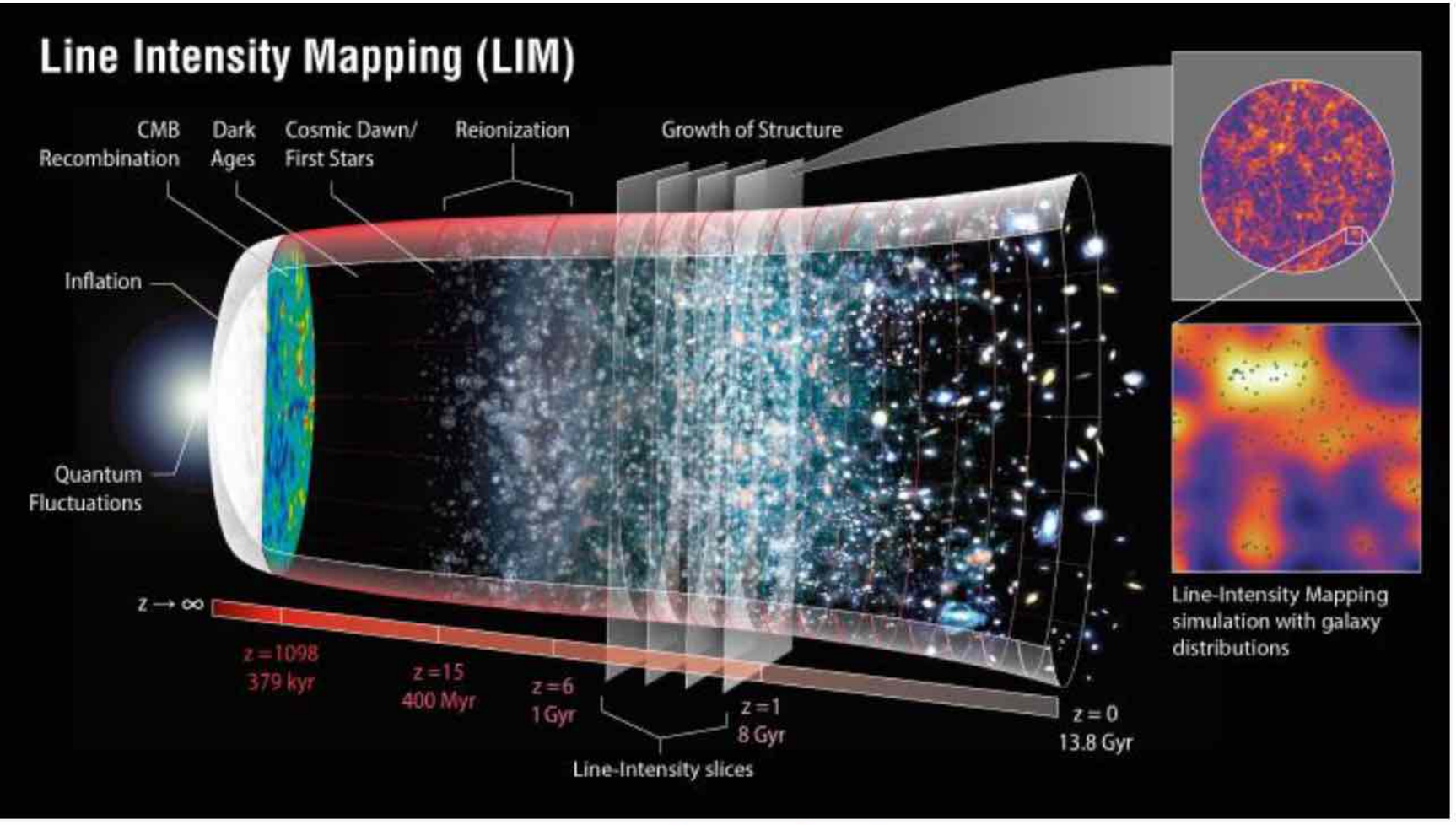


Image Credit: NASA / LAMBDA Archive Team

total emission instead of individual objects

HI via 21cm hyperfine transition

SKAO will map HI out to z~6

excellent z-resolution

for this work: single dish SKA1MID-like for low redshifts

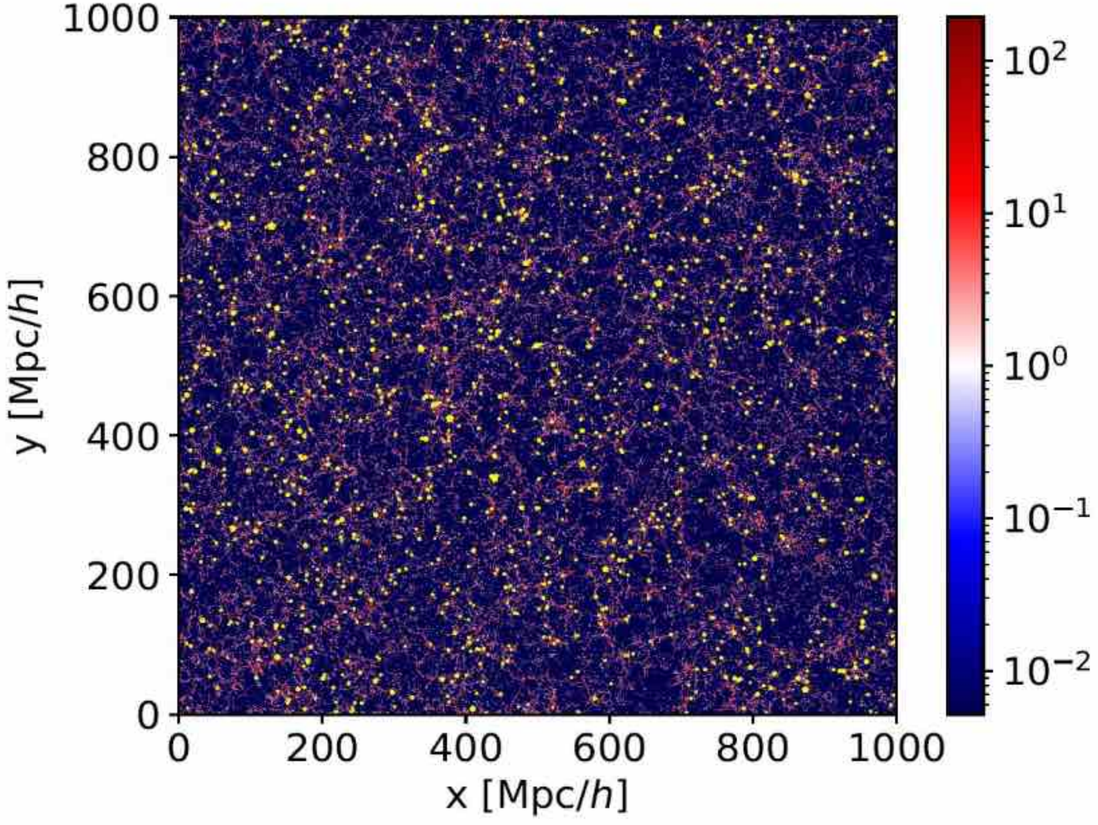
Unit Simulations

dark matter cosmological simulations Chuang++ 19

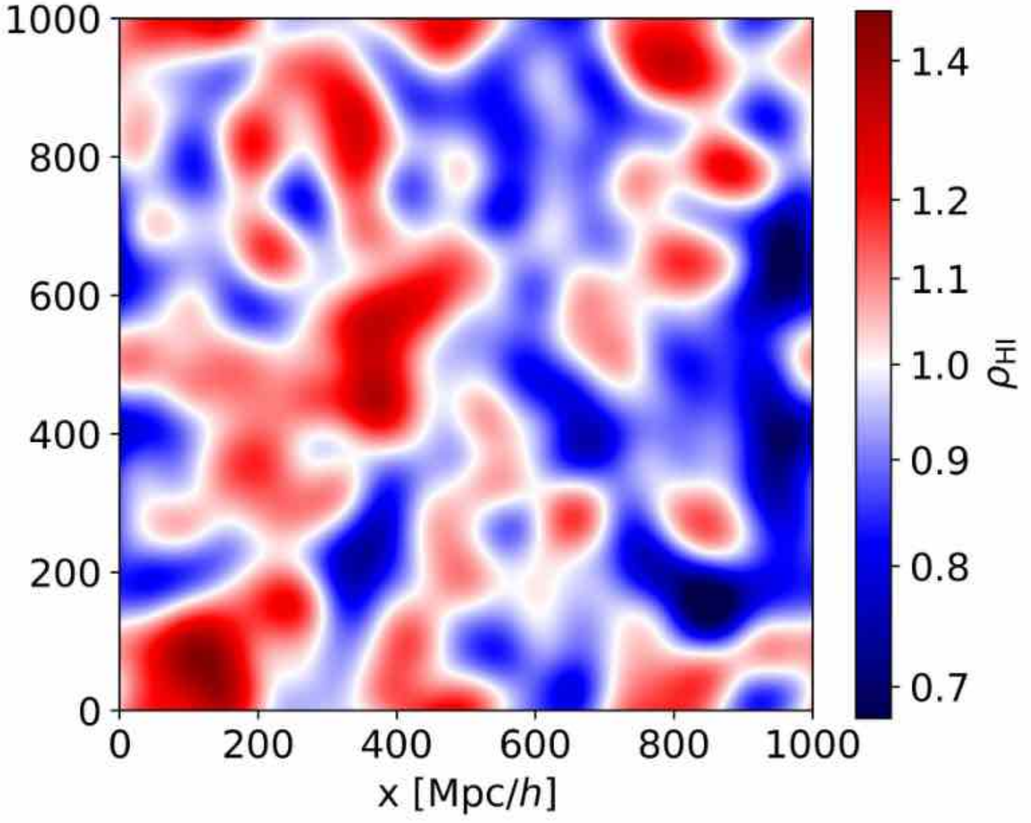
+ Semi-Analytic Model of Galaxy Evolution Croton++ 16

+ HI from cold gas distribution in 1(Mpc/h)^3 voxels Keres++ 03, Zwaan++ 05

HI Intensity @ z=1.321



Gauss beam R_b~38 Mpc/h, k_{FG}~3.6 10^{-3} h/Mpc



Intensity Mapping 1pt Statistics

HI
intensity map

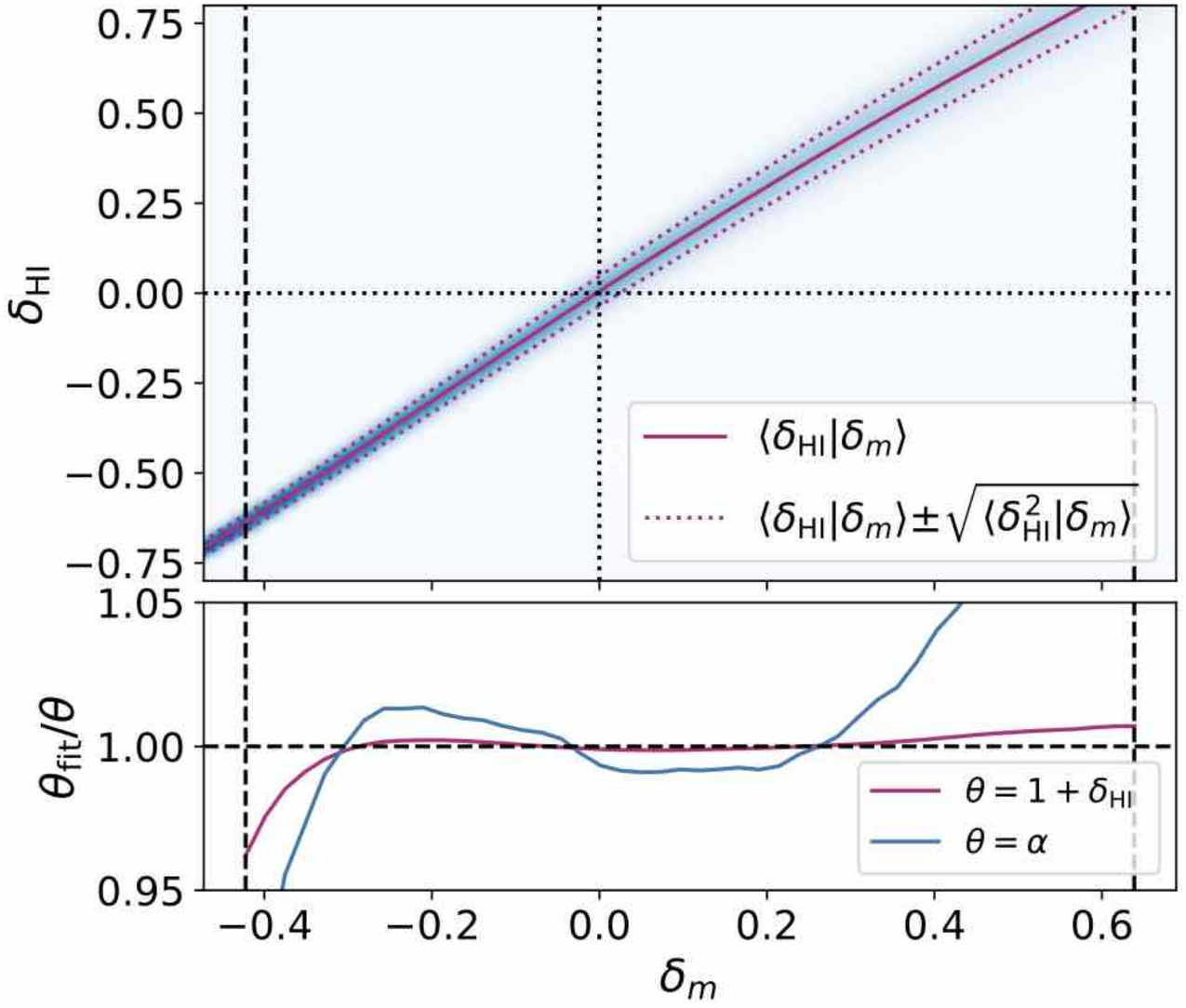
(dark) matter

$$\mathcal{P}(\delta_{\rm HI}) = \int \mathcal{P}(\delta_{\rm HI}|\delta_m)\mathcal{P}(\delta_m)d\delta_m$$

parametrise

bias $\langle\delta_{\rm HI}|\delta_m\rangle$

stochasticity $\langle\delta_{\rm HI}^2|\delta_m\rangle$



Bernhard Vos Gines & CU arXiv:2607.06526

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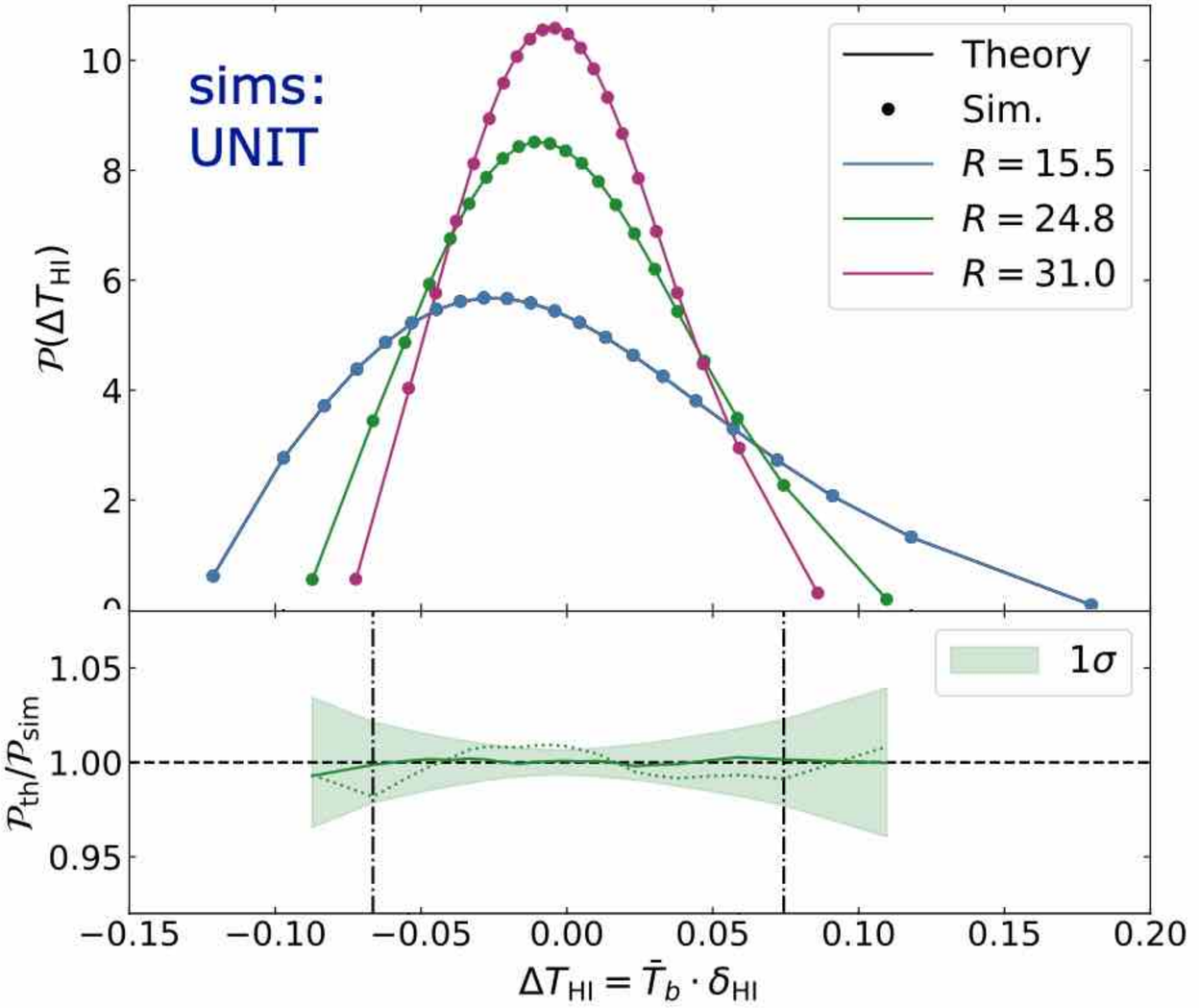

Intensity Mapping 1pt Statistics

HI
intensity map

(dark) matter

+ systematics

Gaussian beam
foreground removal
thermal noise

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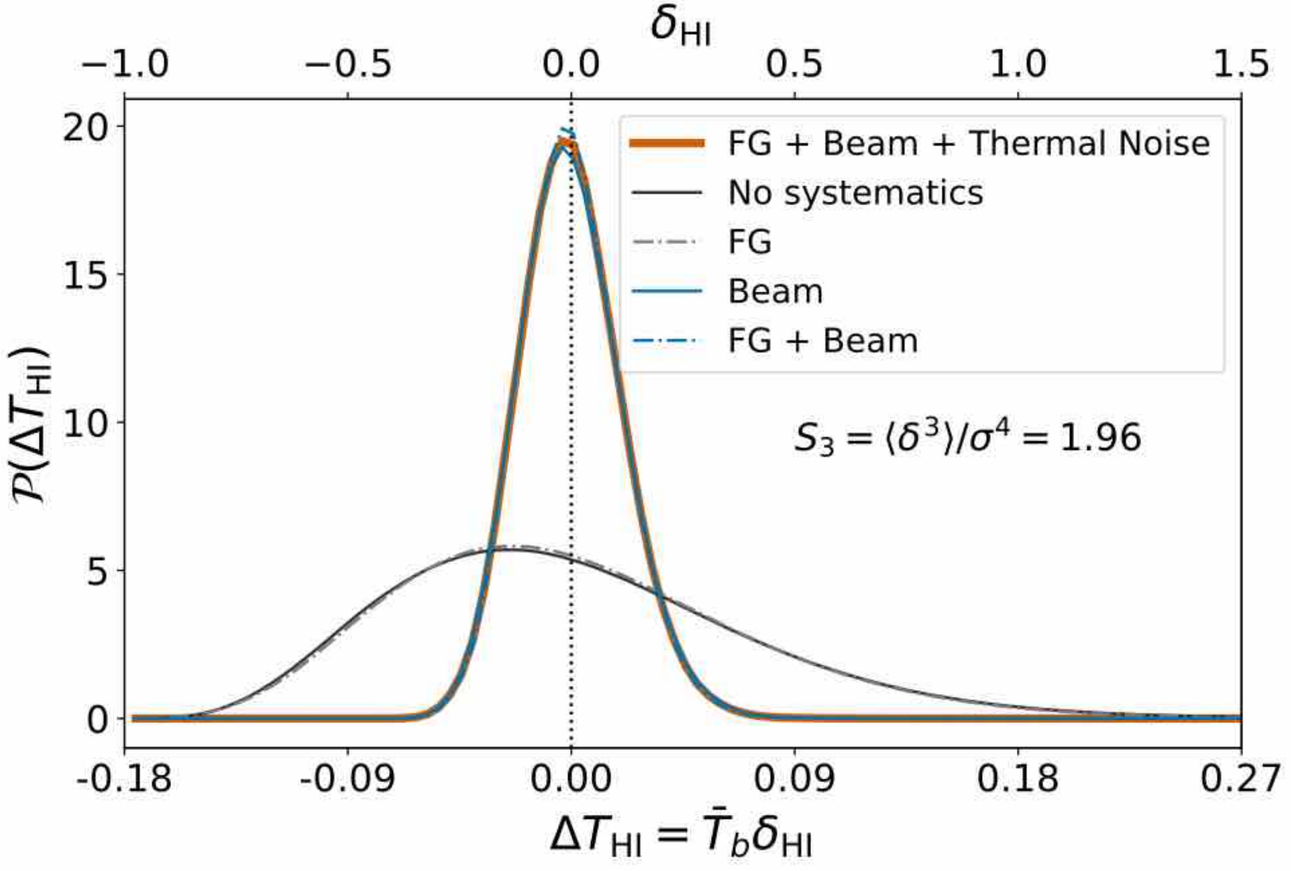

(a) $R = 15.5\ \mathrm{Mpc}/h$

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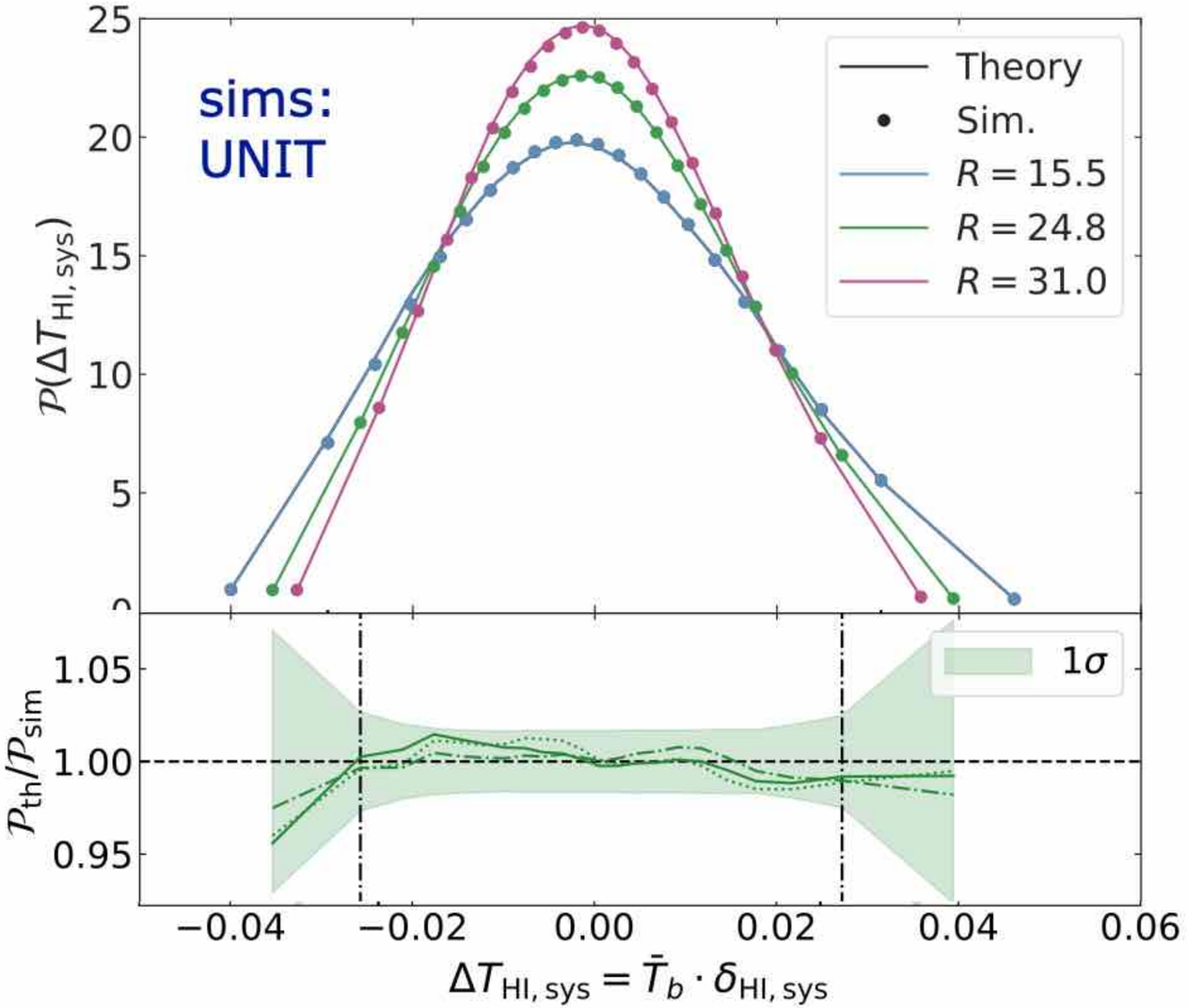


Intensity Mapping 1pt Statistics

constraining power

volume: $1(\mathrm{Gpc}/h)^3$ [SKA 16.3]

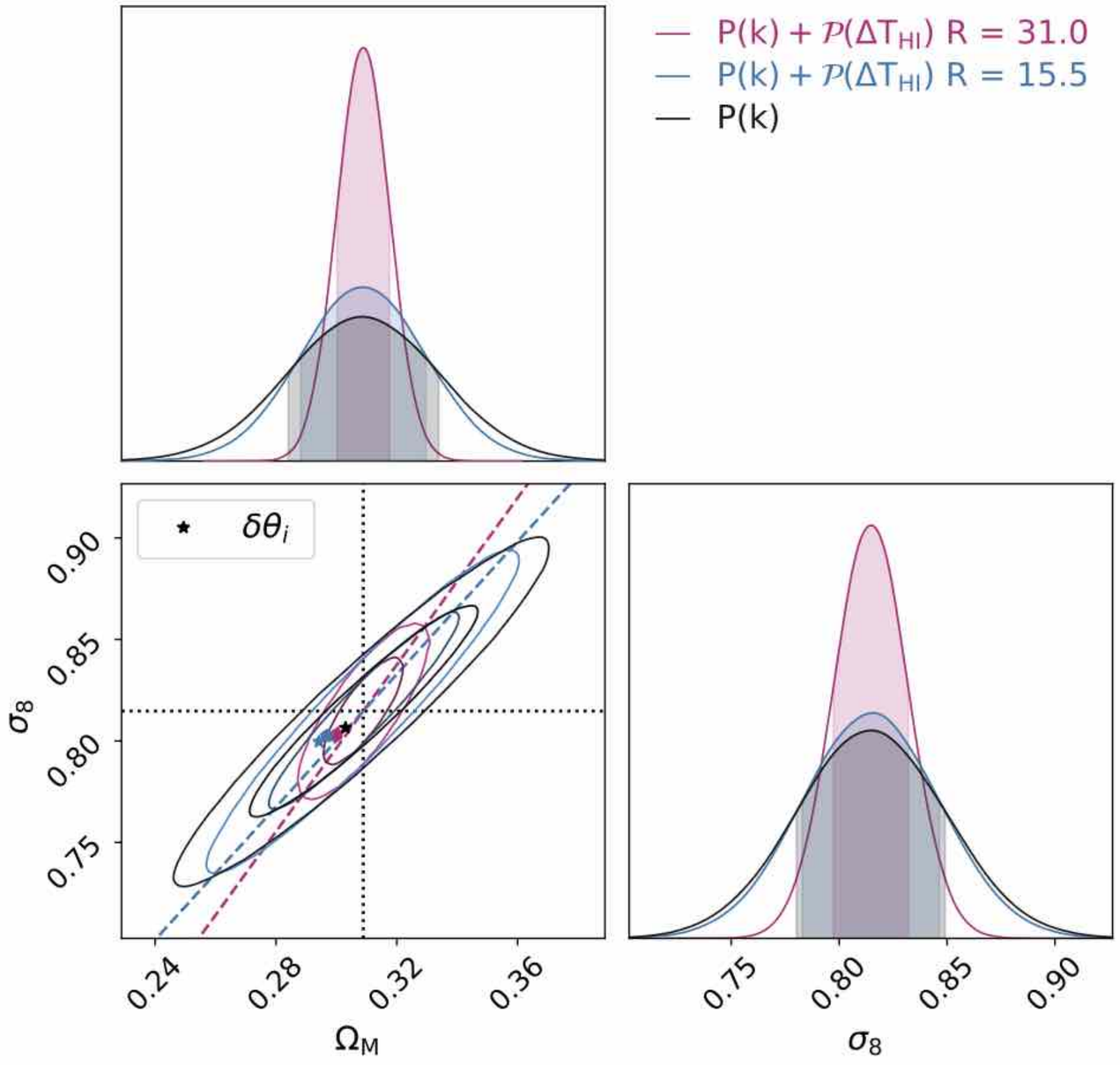
combine 2-point + 1-point
(fixed bias & stochasticity)

tightens constraints

Bernhard Vos Gines & CU
arXiv:2607.06526

AASKAII Majumdar++
arXiv:2606.30200

AASKAII Wolz++
arXiv:2607.03259



Intensity Mapping 1pt Statistics

constraining power

volume: $1(\mathrm{Gpc}/h)^3$ [SKA 16.3]

combine 2-point + 1-point
(fixed Ω_m & stochasticity)

breaks b_1-σ_8 degeneracy

Bernhard Vos Gines & CU
arXiv:2607.06526

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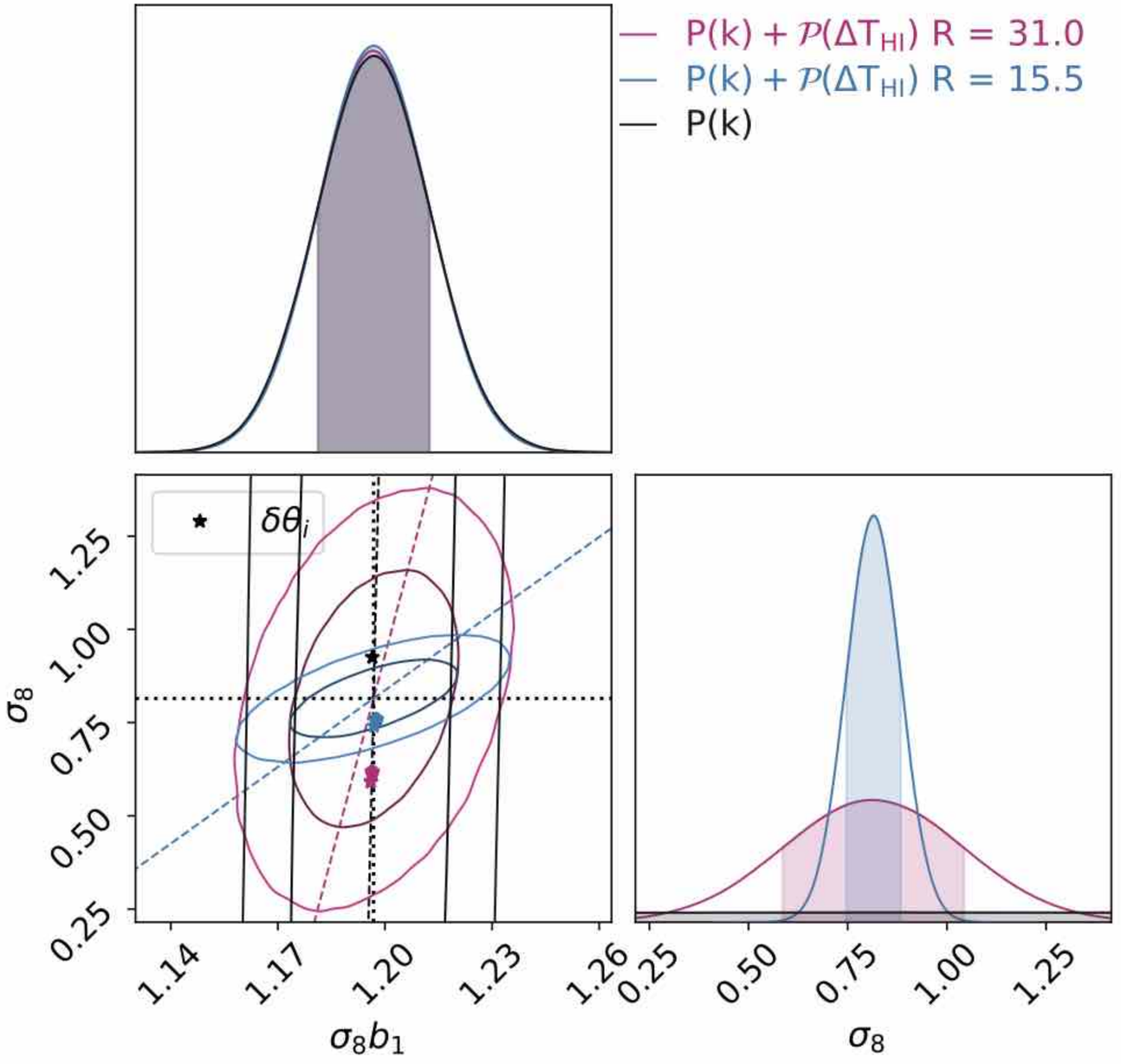

Going Below & Beyond

non-Gaussian info in 1-point

probing different mildly nonlinear densities

rich physics, including beyond SM

features

accessible, interpretable, predictable, versatile:

intensity mapping, galaxies, weak lensing

challenges

galaxy bias & stochasticity, RSD, systematics

line intensity mapping

probe cosmology with beyond 2pt statistics