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10 APRIL 2019

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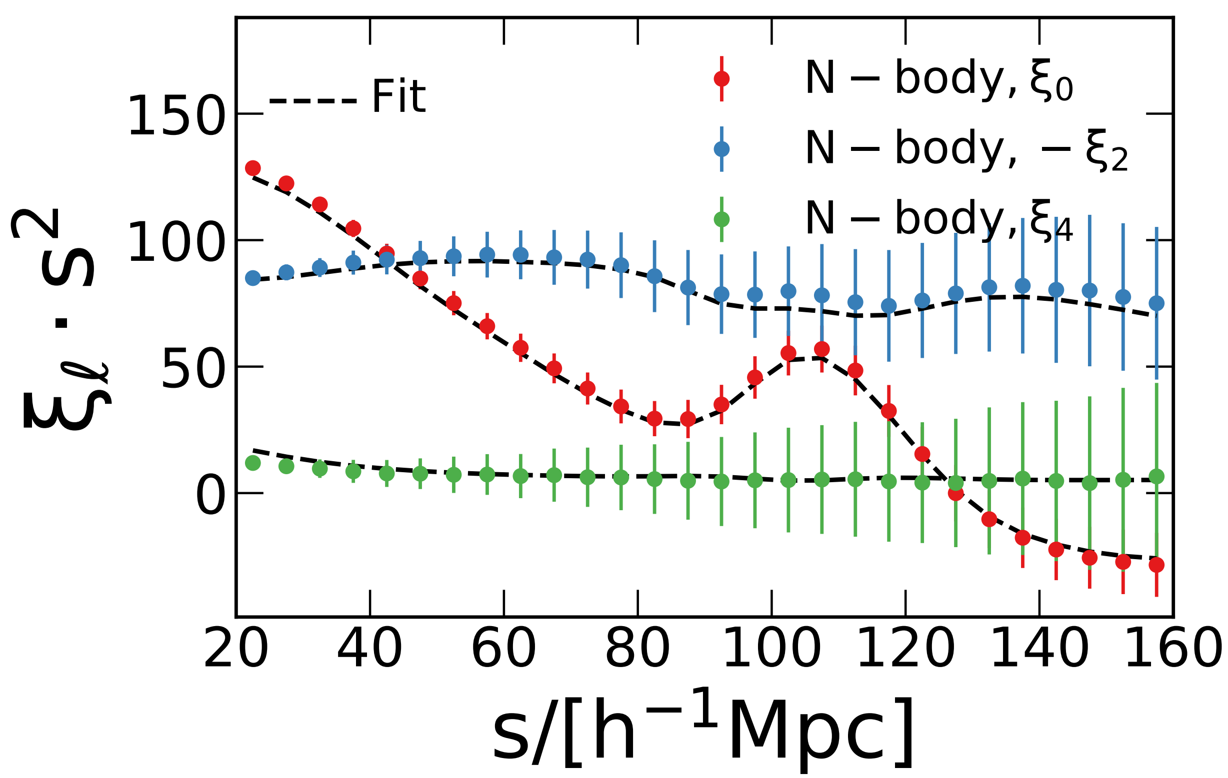
COMPARING APPROXIMATE METHODS FOR MOCK CATALOGUES AND COVARIANCE MATRICES

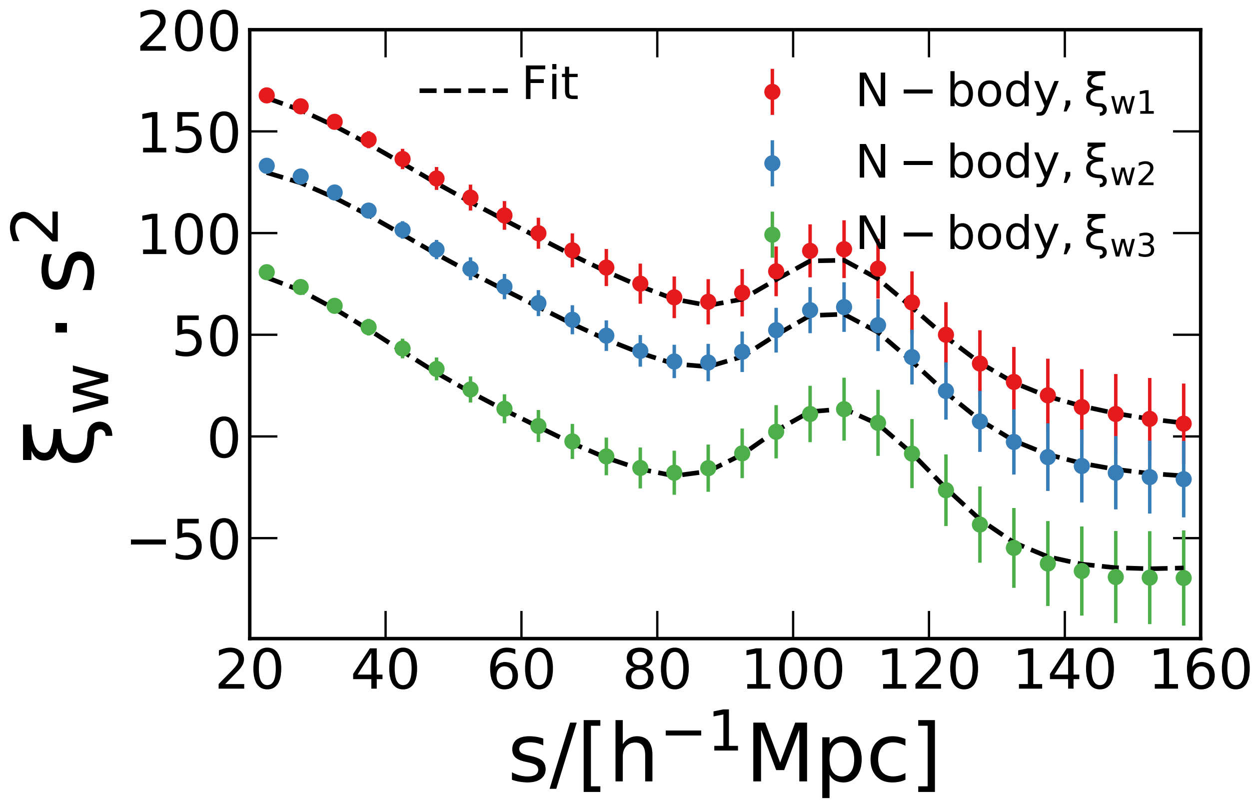
DIFFERENT CLUSTERING MEASUREMENTS

- 2-point correlation function (Lippich et al. 2019)
- Power spectrum (Blot et al. 2019)
- Bispectrum (Colavincenzo et al. 2019)

CORRELATION FUNCTION MEASUREMENTS

- Anisotropic 2-point correlation function: Legendre multipoles and clustering wedges





EXTRACTING INFORMATION FROM MEASUREMENTS

- **Model**: nonlinear gravitational evolution (gRPT, Crocce, Scoccimarro, Blas in prep.), bias and RSD

- Assume **Gaussian likelihood**

$$-2\ln\mathcal{L}(\boldsymbol{\xi}|\boldsymbol{\theta}) = (\boldsymbol{\xi} - \boldsymbol{\xi}_{theo}(\boldsymbol{\theta}))^t\,\boldsymbol{\Psi}\,(\boldsymbol{\xi} - \boldsymbol{\xi}_{theo}(\boldsymbol{\theta}))$$

$$\boldsymbol{\Psi} = C^{-1}$$

↖ **Covariance matrix**

COVARIANCE MATRIX ESTIMATION

Model	
+ no noise - need to know model, nonlinear	
Data - biases	**Simulations** - noise

COVARIANCE MATRIX ESTIMATION FROM SIMULATIONS

- Covariance matrix ***C*** estimated from ***N*****s** mock measurements

$$C_{ij} = \frac{1}{N_s - 1} \sum_{k=1}^{N_s} (\xi_{i,k} - \langle \xi_i \rangle)(\xi_{j,k} - \langle \xi_j \rangle)$$

- Depending on N_s, **C** has associated error (noise), which propagates into final constraints on cosmological parameters

→ $N_S >> N_D$

- For analysis of Euclid ~2000 - 10 000 independent realizations required!

WE NEED FAST APPROXIMATE METHODS

COMPARED METHODS

- **Reference N-body catalogues** from ***Minerva*** simulations
  300 boxes, L=1500 h^{-1}Mpc, z=1.0, ΛCDM (Grieb et al. '16)

- Approximate methods → predictive
  → calibrated
  → models of density PDF

PREDICTIVE METHODS

- **ICE-COLA** (Izard et al. '16)
- **PINOCCHIO** (Monaco et al. '13)
- **PEAKPATCH** (Bond & Myers '96)

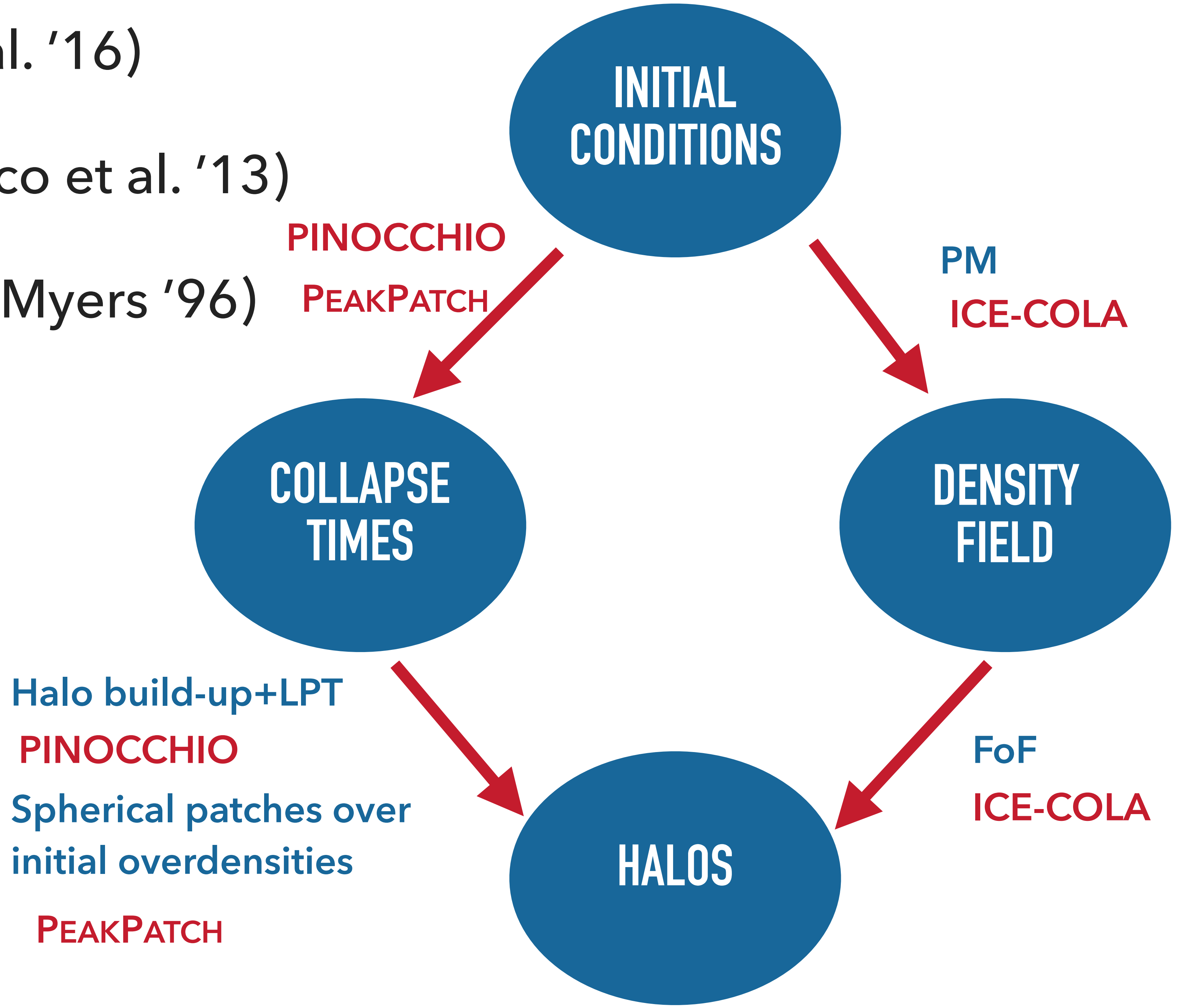


figure inspired by Chuang et al. '15

CALIBRATED METHODS

- **HALOGEN** (Avila et al. '14)
- **PATCHY** (Kitaura et al. '14a)

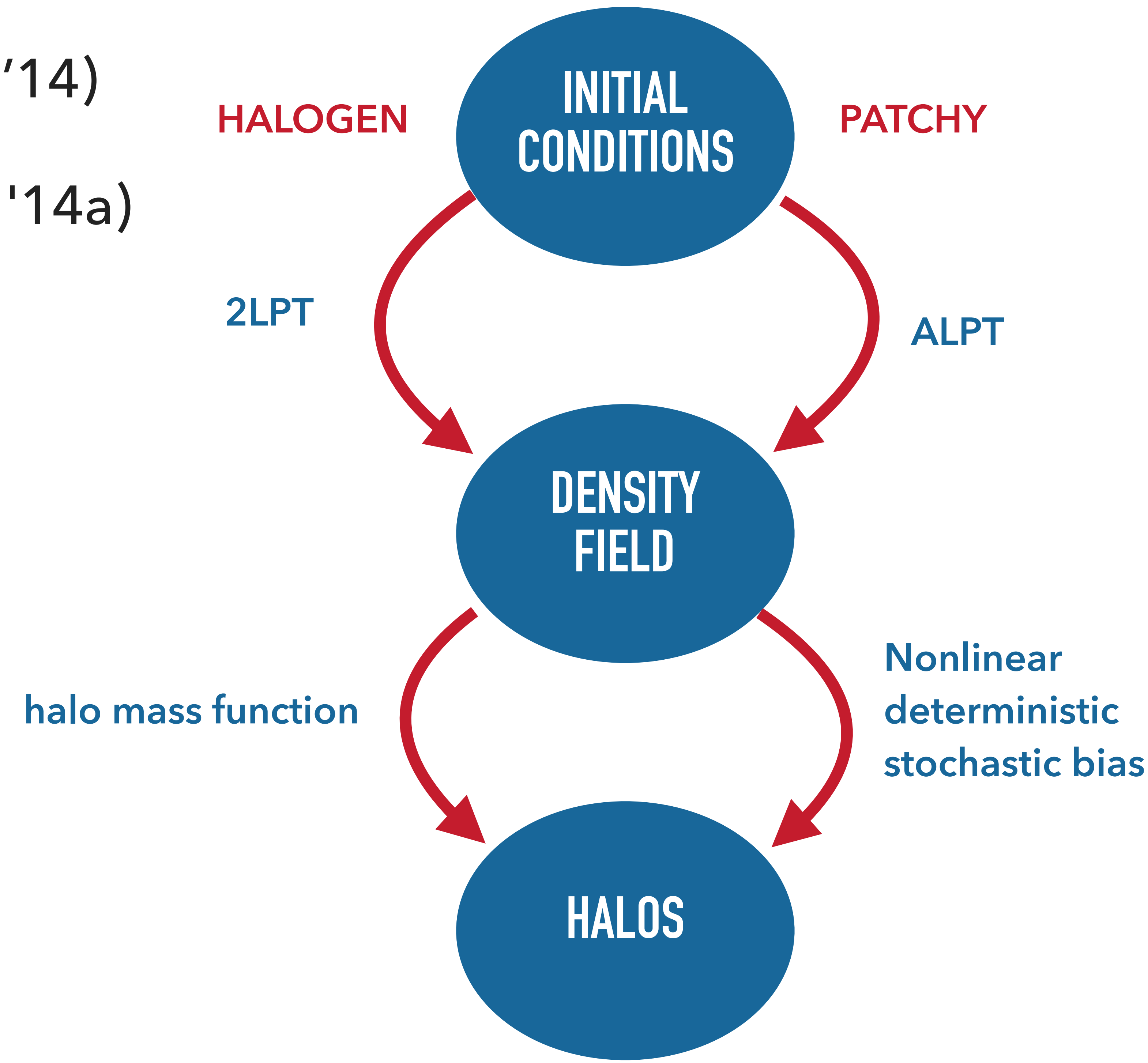


figure inspired by Chuang et al. '15

MODELS OF THE DENSITY PDF

- **Gaussian covariance model**: (Grieb et al. ’16), interpolated non-linear power spectrum as input

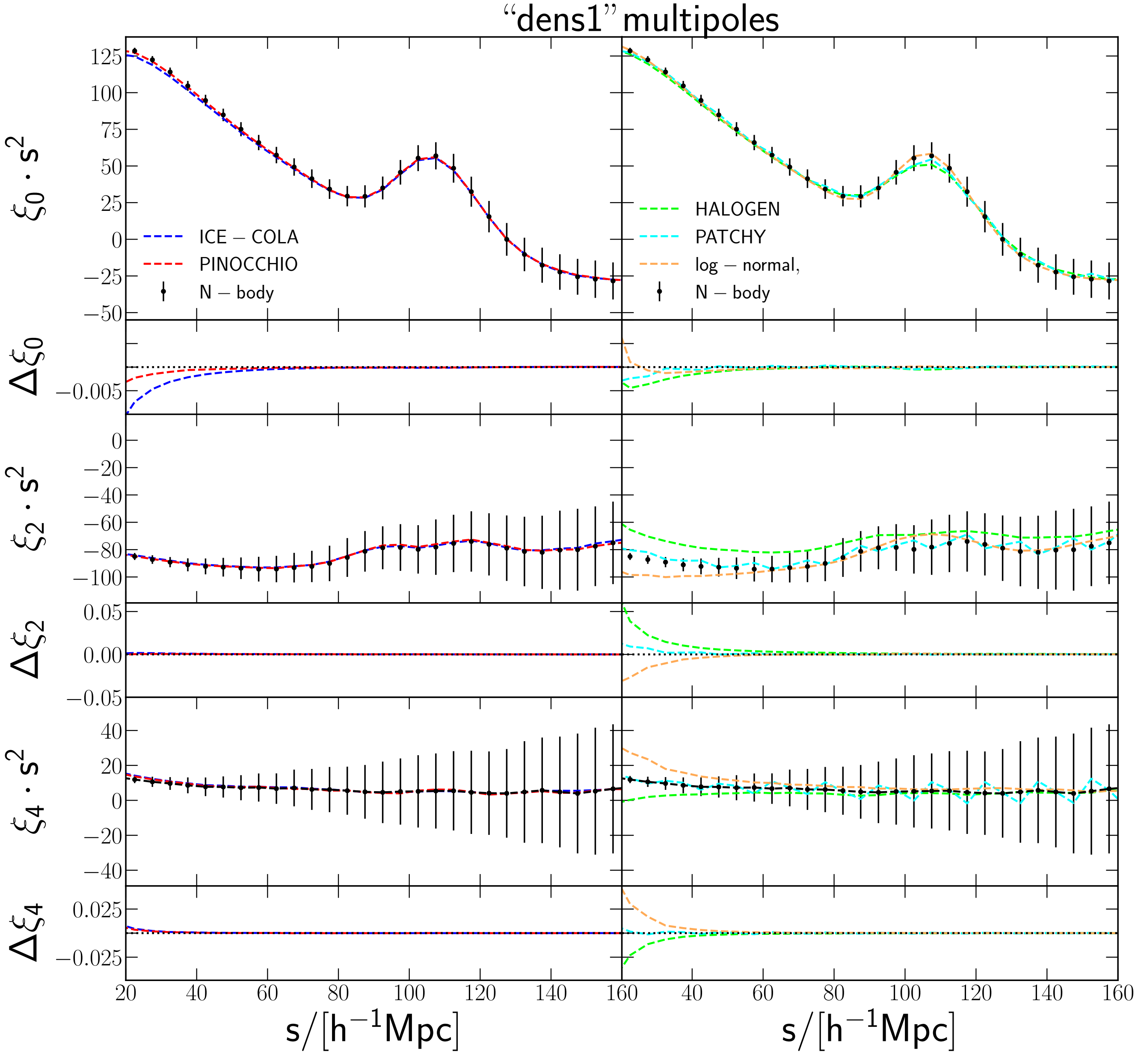
- **Log-normal**: assumes lognormal PDF of halo and matter density field (Agrawal et al. ’17)

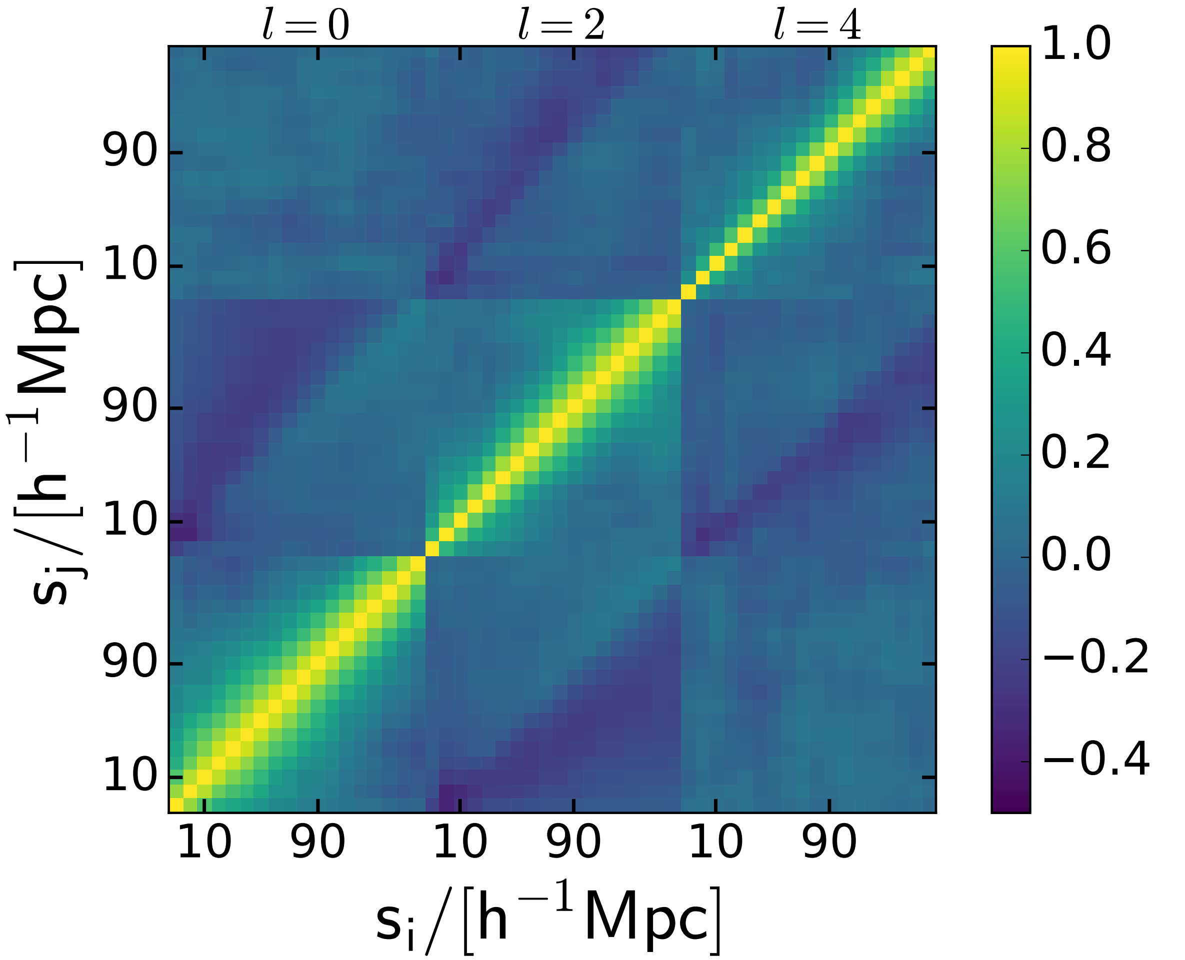
ROADMAP

1. Measure covariance matrix obtained from all methods
    - same ICs, two different mass thresholds (1.1×10^{13}, 2.7×10^{13} M_{sun}/h) with different ways of matching to N-body catalogues (mass, abundance, bias)
2. Create synthetic data using our baseline model
3. Compare performance on fits
    - Fix cosmology to that of N-body simulations
    - Constraints on Alcock-Paczynski parameters $\alpha_{\|}$, $\alpha_{\perp}$ and growth rate $f\sigma_8$

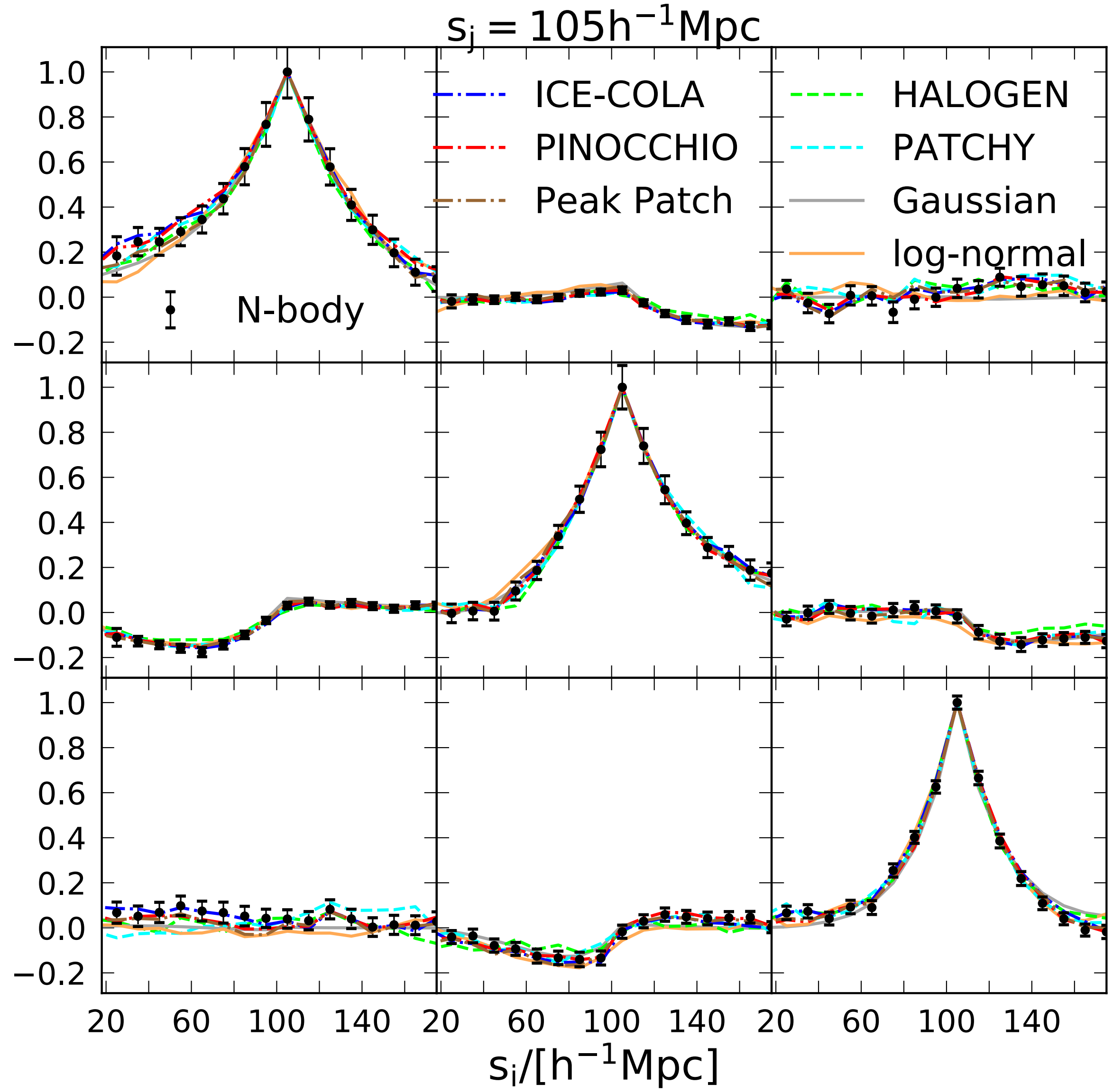
EXAMPLE:

MULTIPOLE ANALYSIS "DENSITY 1" SAMPLE





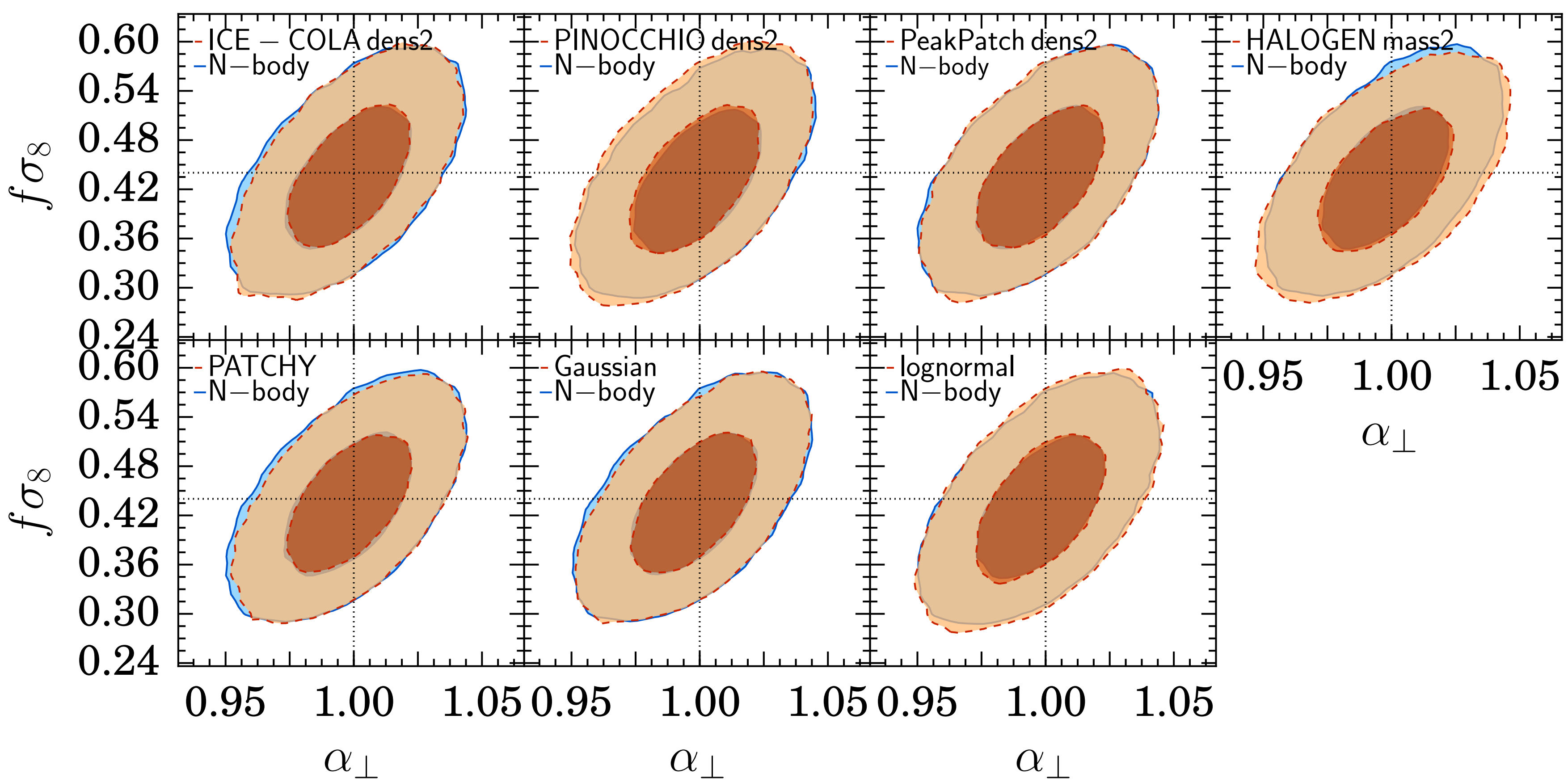
CUT THROUGH CORRELATION MATRIX



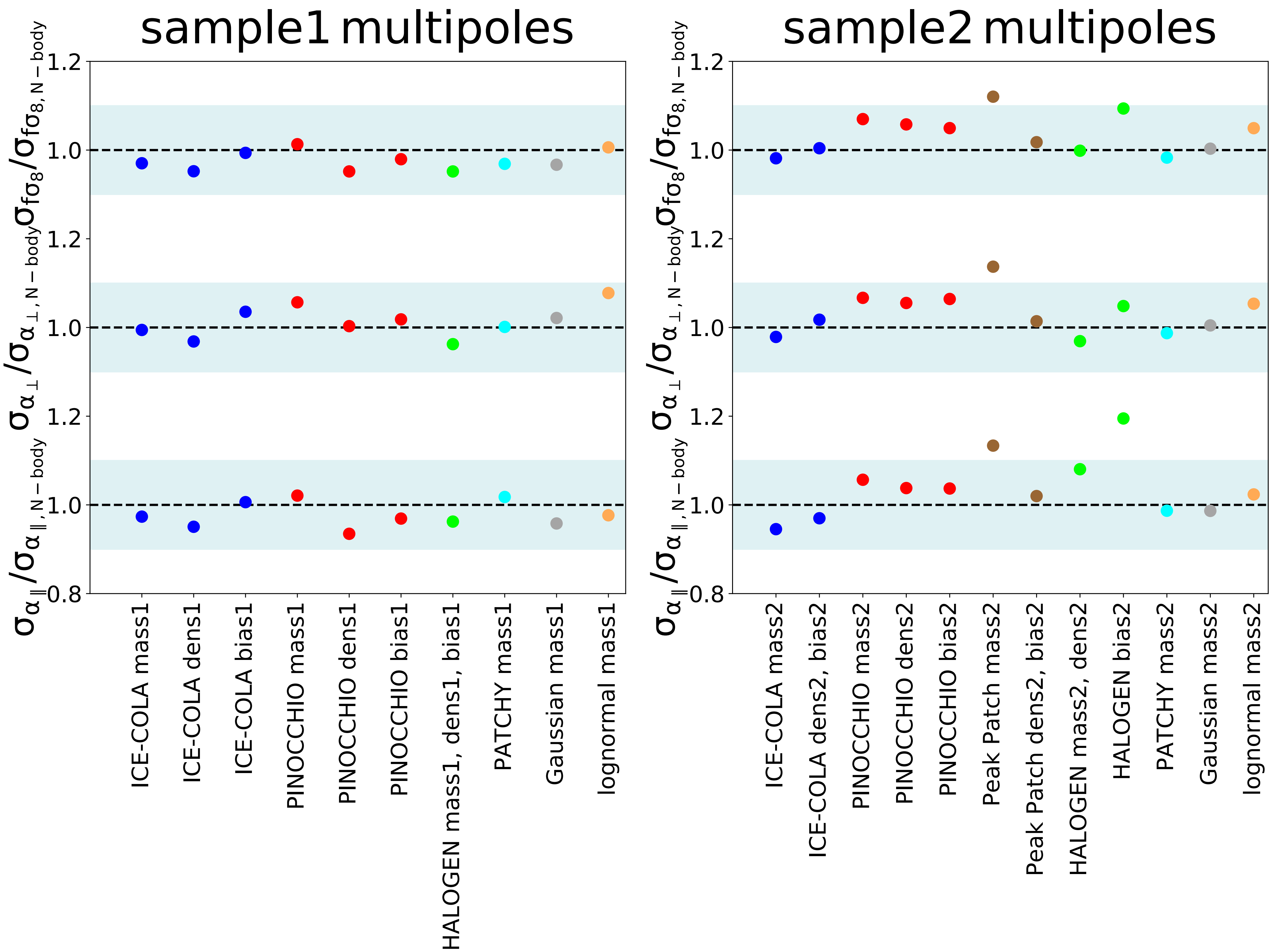
$$R_{nm} = C_{nm}[\sigma_n(s_i)\sigma_m(s_j)]^{-1}$$

PERFROMANCE COMPARISON

- Comparison of 2D constraints



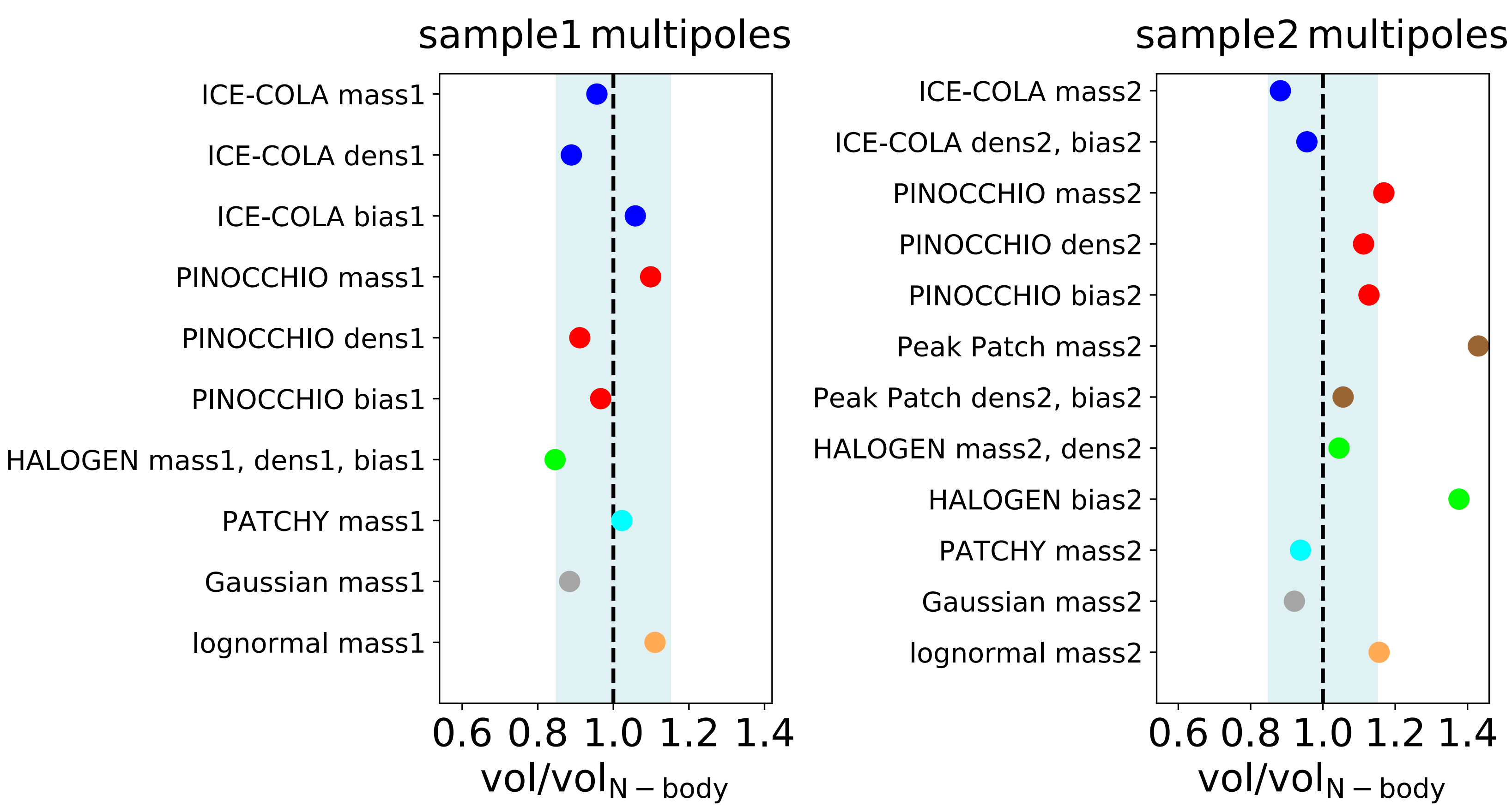
PARAMETER ERRORS CORRELATION FUNCTION



STATISTICAL PARAMETER VOLUMES

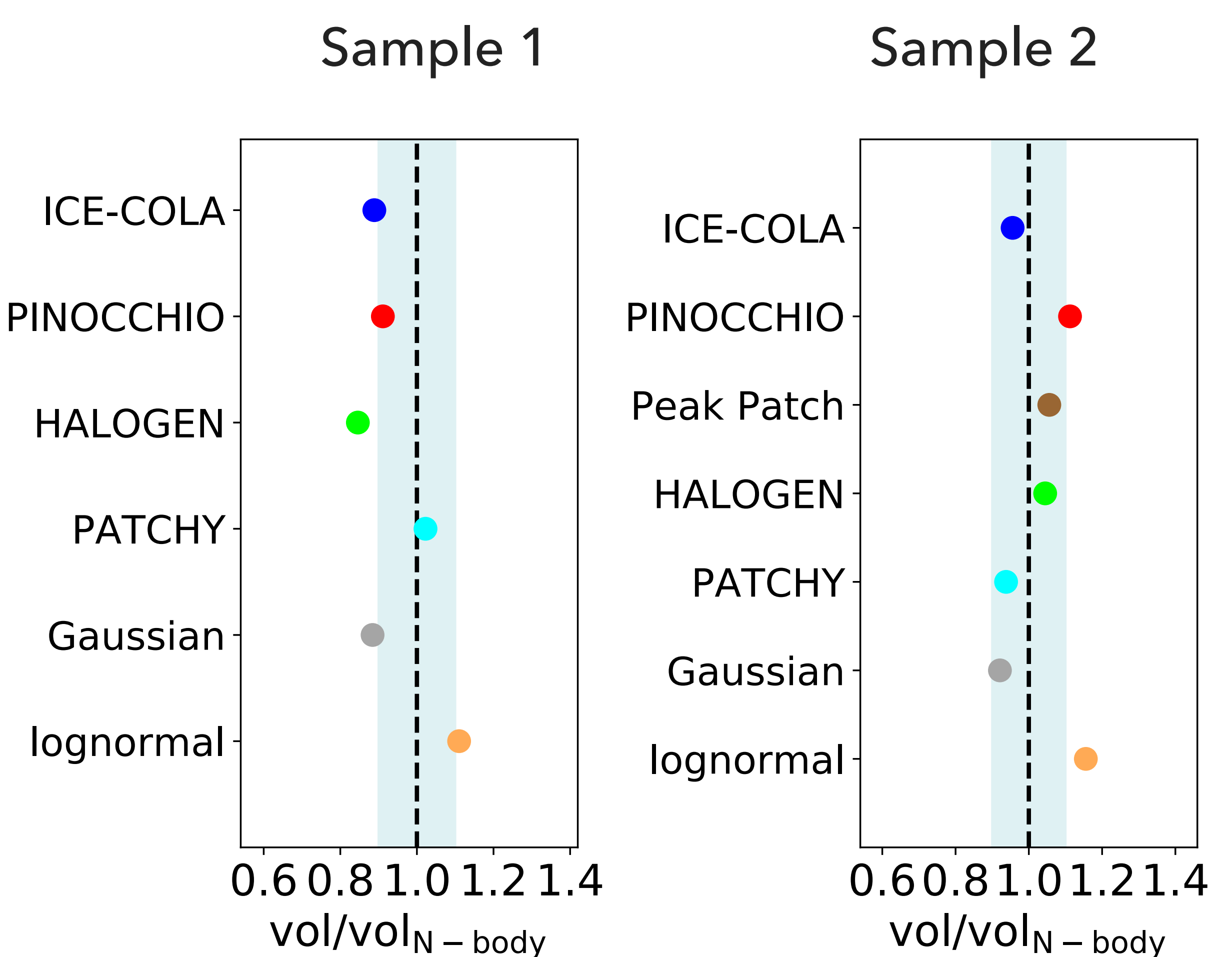
- Volume of allowed region in 3D parameter space

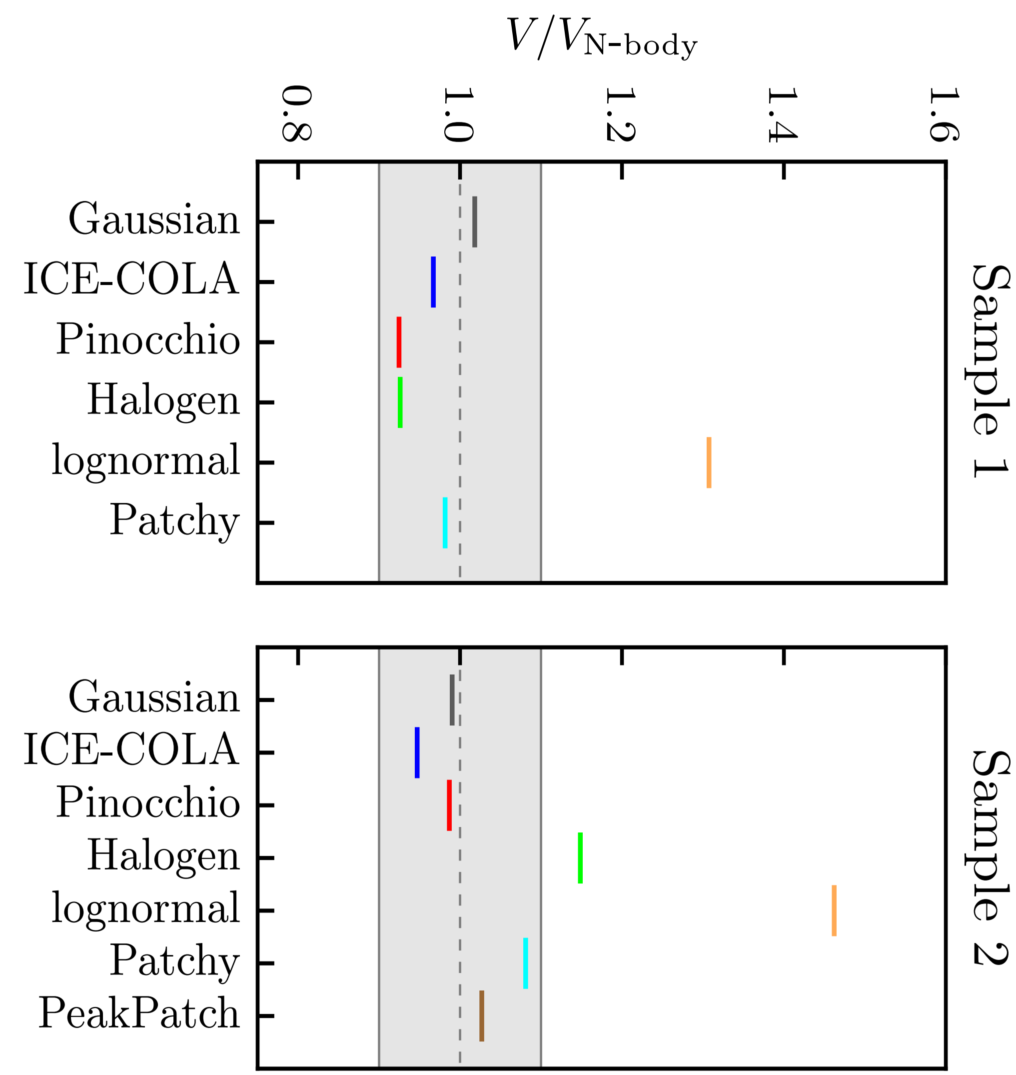
$$V = \sqrt{\det \mathrm{Cov}(\alpha_{||}, \alpha_{\perp}, f\sigma_8)}$$



COMPARISON CONFIGURATION AND FOURIER SPACE

- Comparison of volume ratios of density matched samples





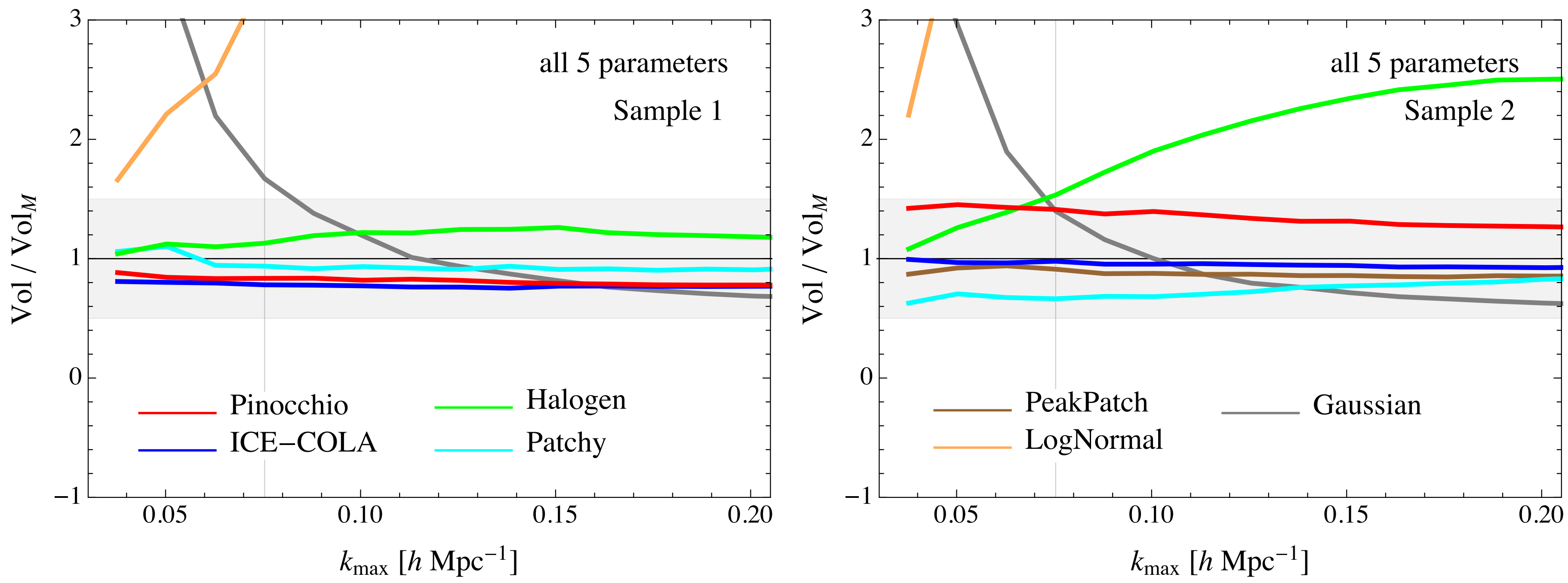
correlation function

(Lippich et al. 2019)

power spectrum

(Blot et al. 2019)

BISPECTRUM: PARAMETER VOLUMES



- Likelihood analysis with bispectrum variance
- Model of halo bispectrum = tree-level approximation in PT
- Model parameters: $\{b_1, b_2, \gamma_2, B_{SN}^{(1)}, B_{SN}^{(2)}\}$

(Colavincenzo et al. 2019)

CONCLUSIONS

- Noise from covariance matrices propagates into cosmological constraints
- Mean values of parameter constraints from approximate methods agree perfectly with N-body results
- Configuration space: no clear preference for any of the approximate methods, Gaussian works well!
- Differences between methods become more evident for power spectrum and are strongest for bispectrum