Field-level inference using forward modeling of weak lensing magnification

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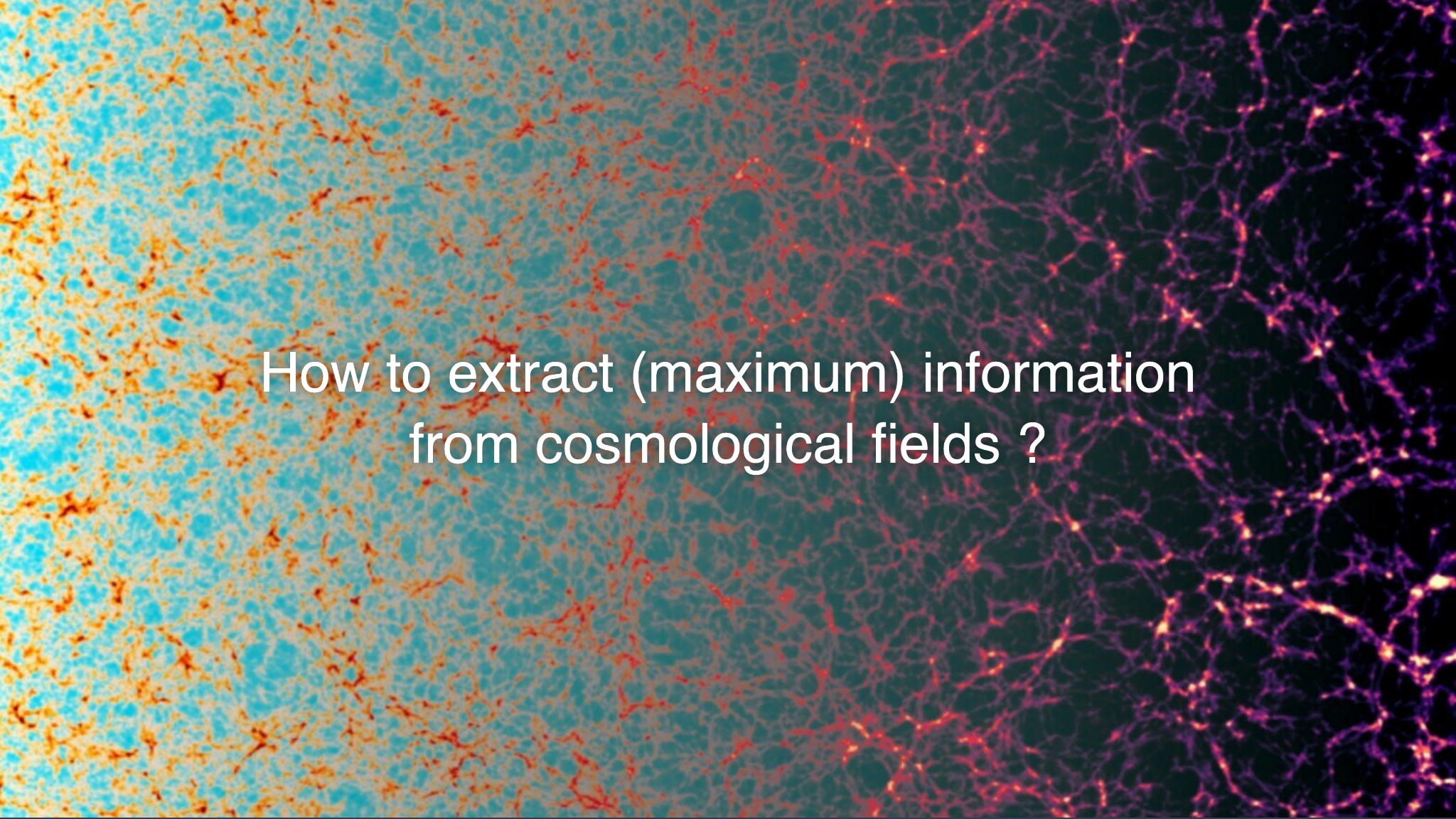
Future Cosmology - IESC Cargèse 2023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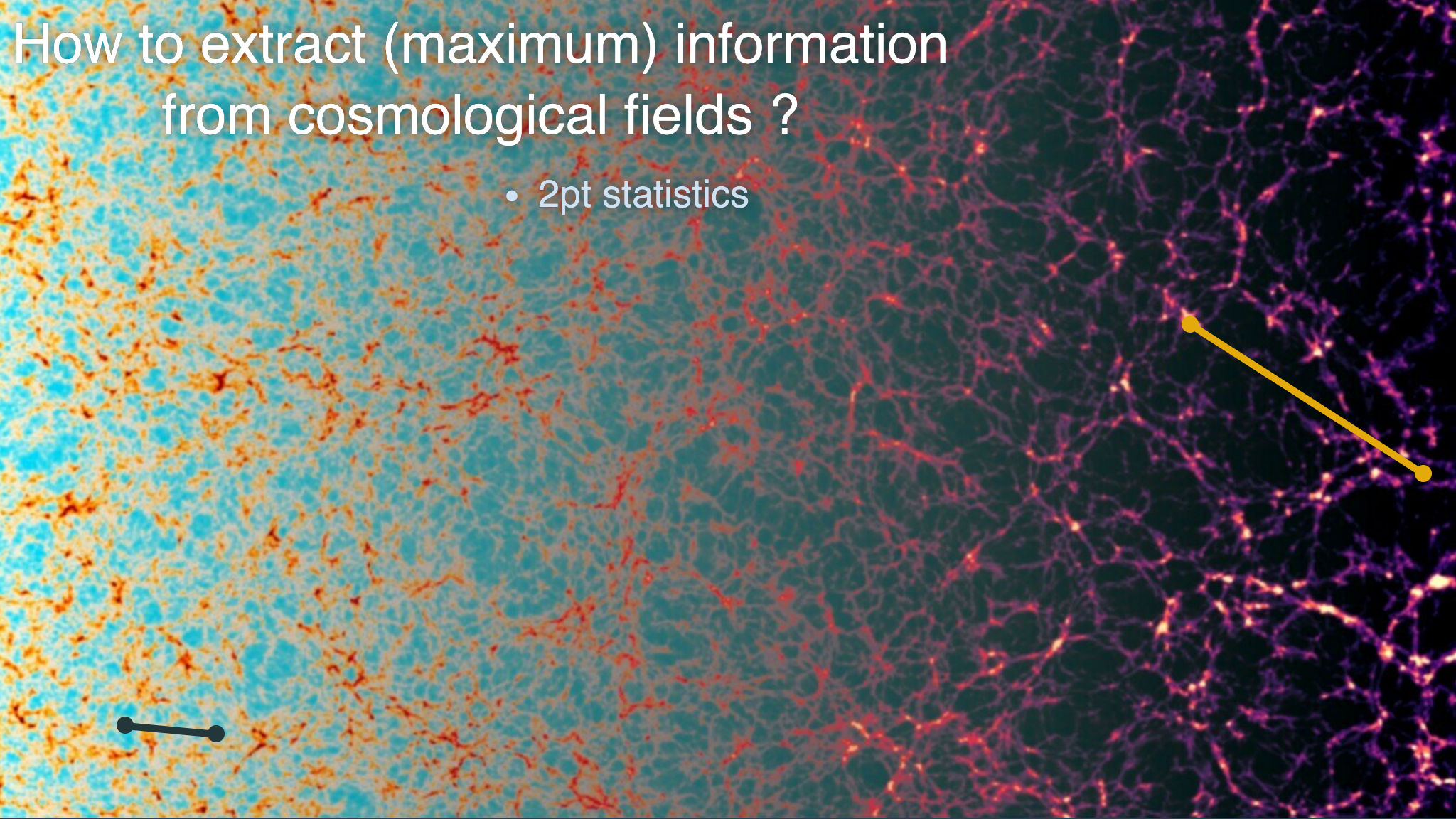
- 2pt statistics



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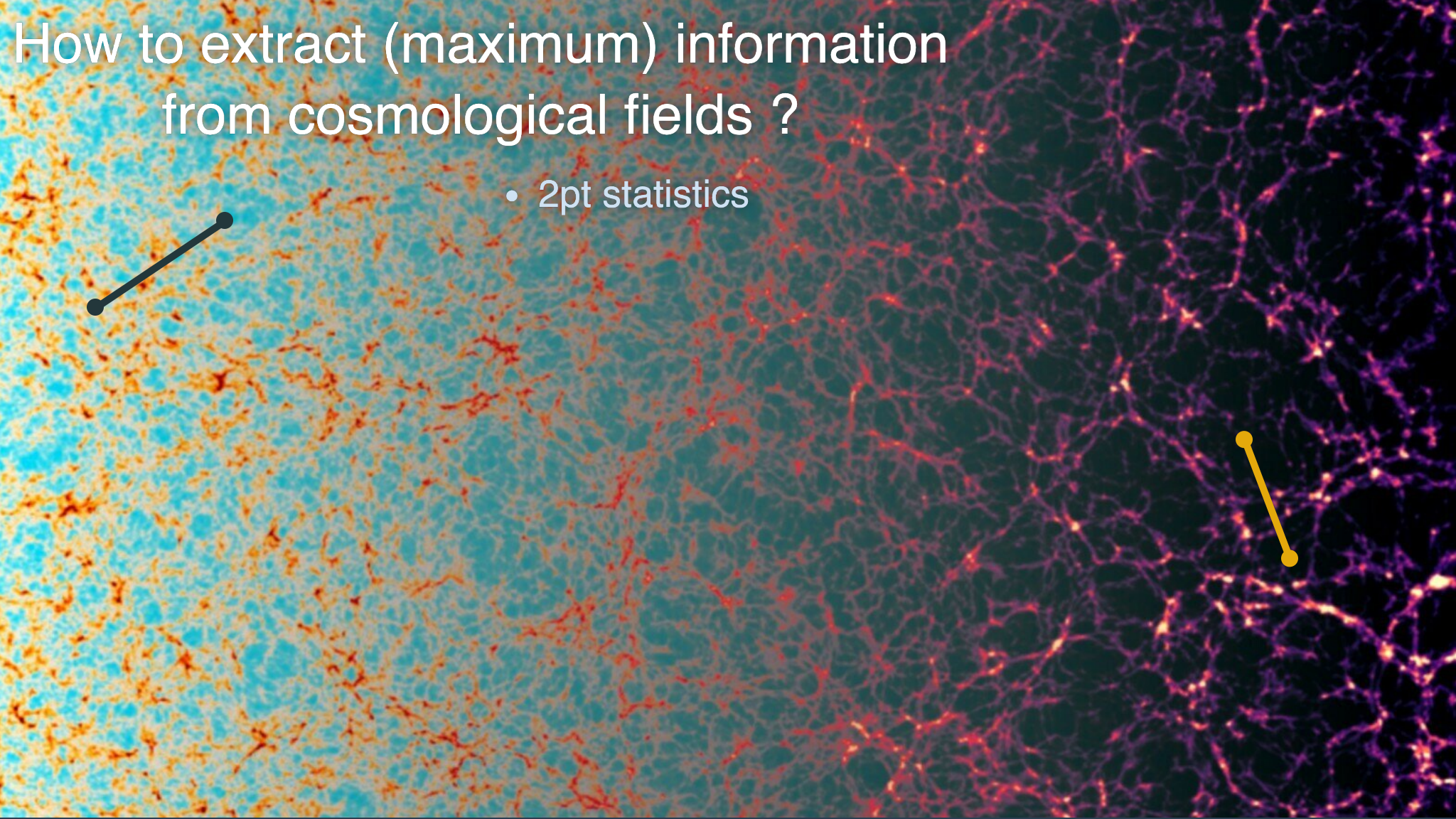

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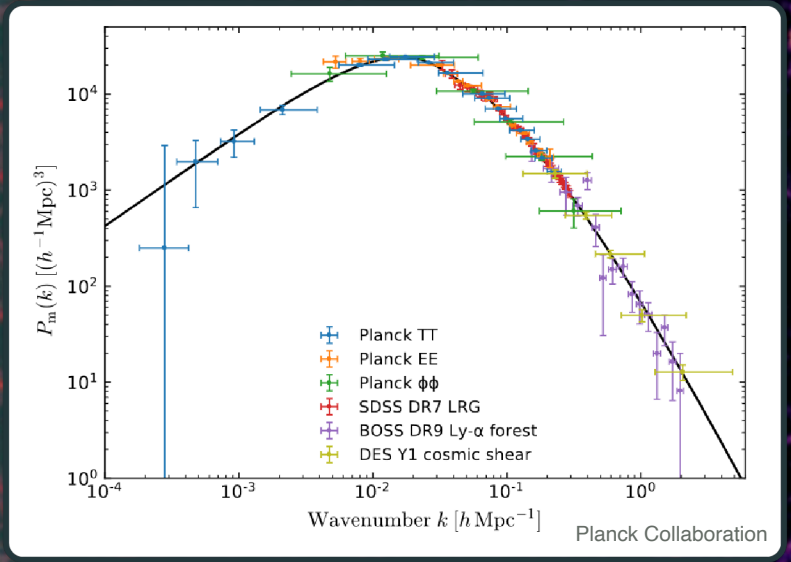
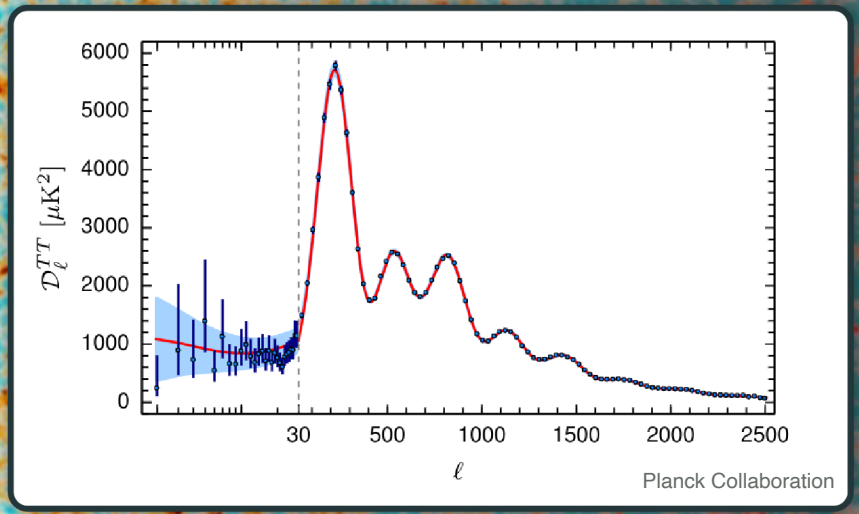
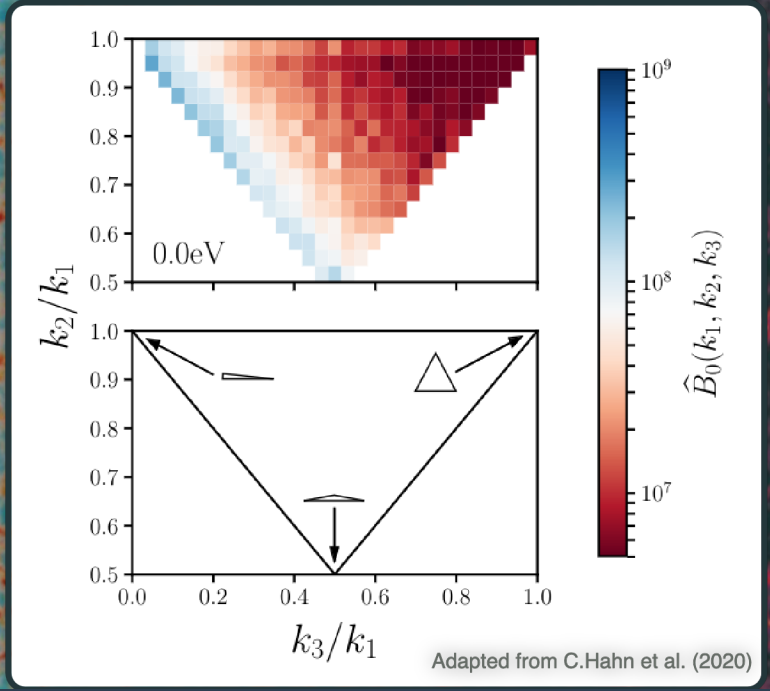




How to extract (maximum) information from cosmological fields ?

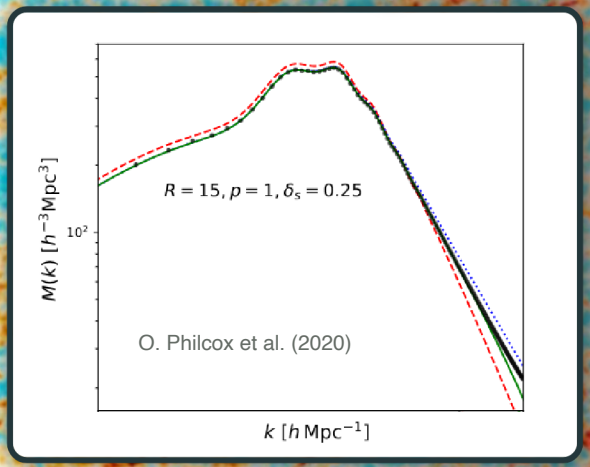
- ~~2pt statistics~~
- 3pt statistics...



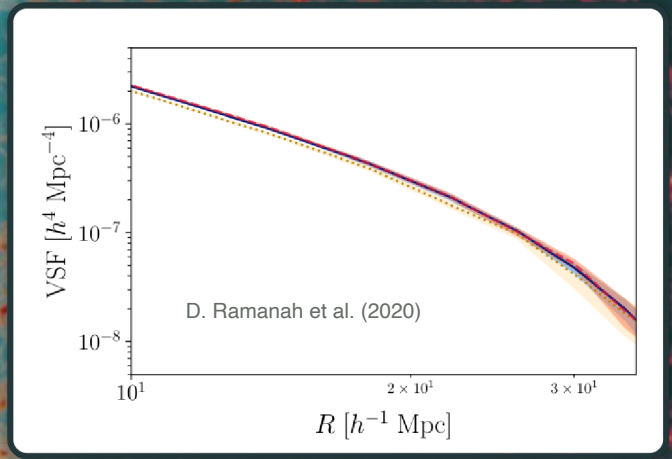
How to extract (maximum) information from cosmological fields ?

- ~~2pt statistics~~
- ~~3pt statistics~~... other summaries

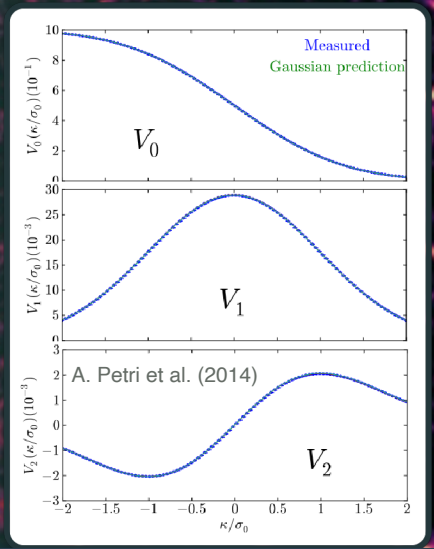
Marked Power Spectrum



Void Size Function



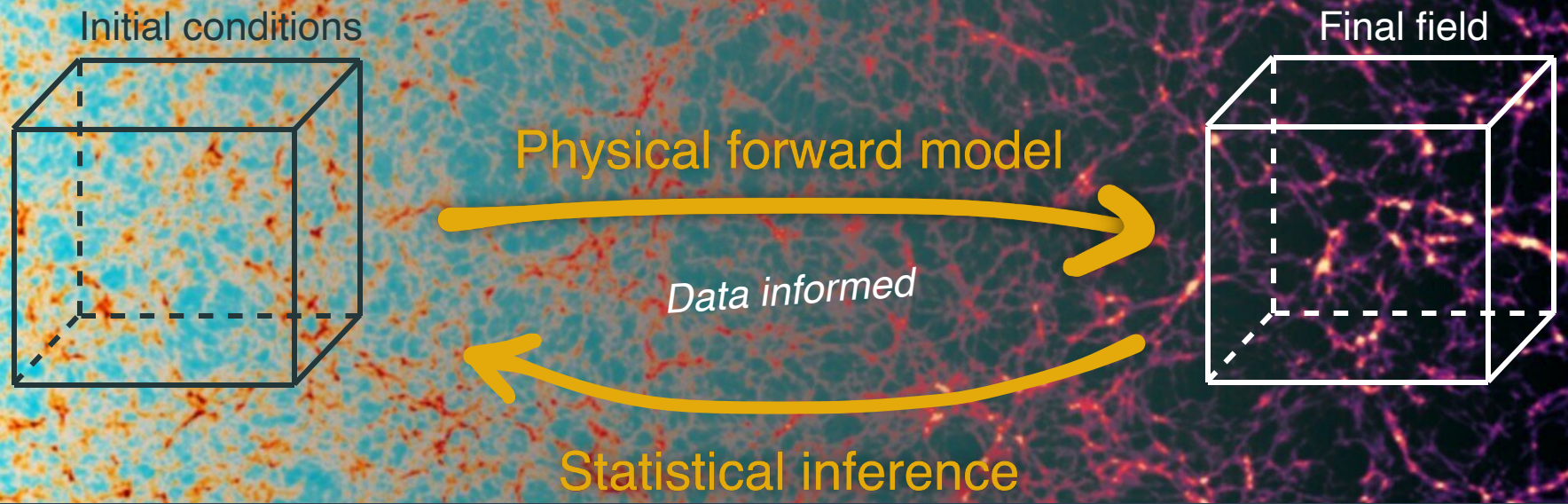
Minkowski Functionals



...

How to extract (maximum) information from cosmological fields ?

- ~~2pt statistics~~
- ~~3pt statistics~~... ~~other summaries~~
- **Field level inference**



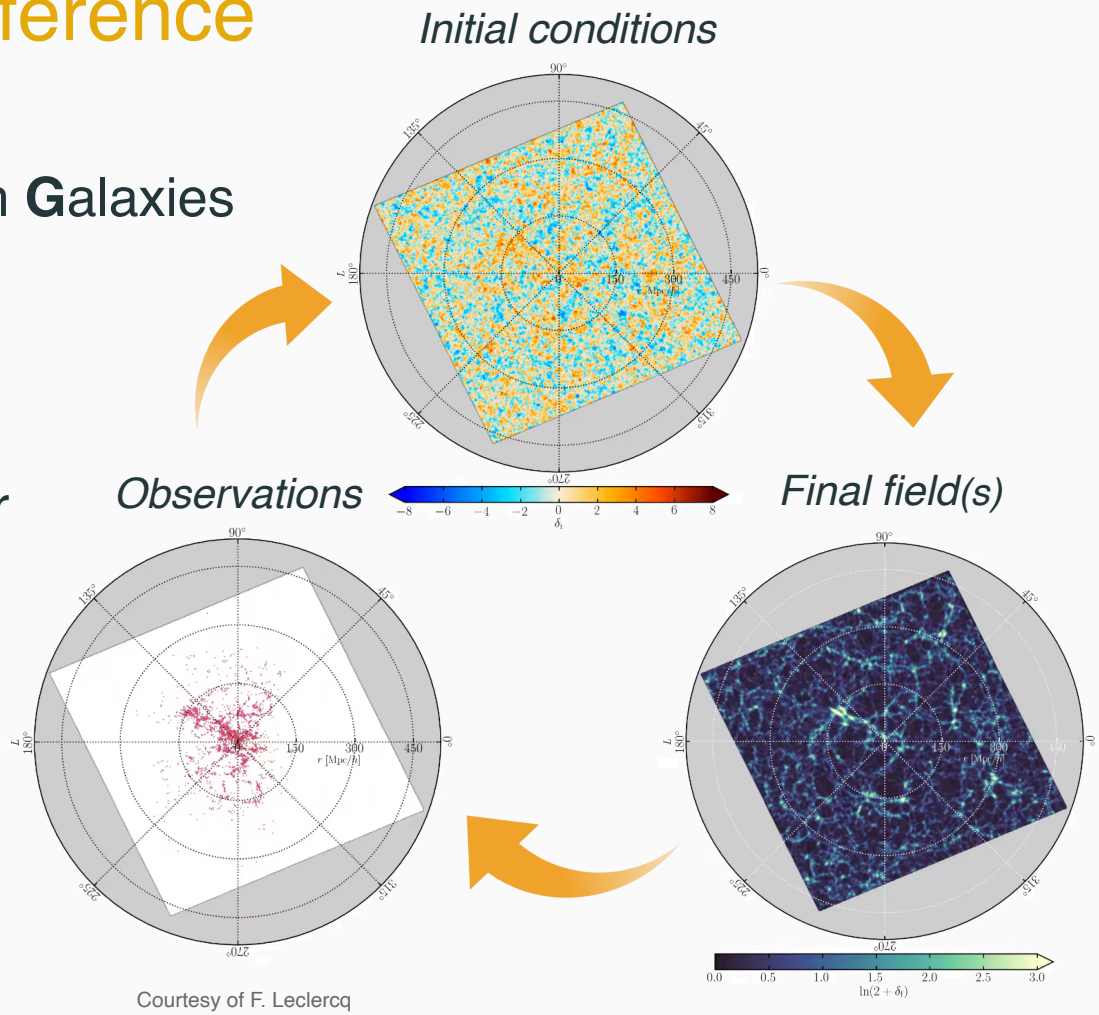
Field-level cosmological inference

Bayesian **O**rigin **R**econstruction from **G**alaxies *(BORG)*

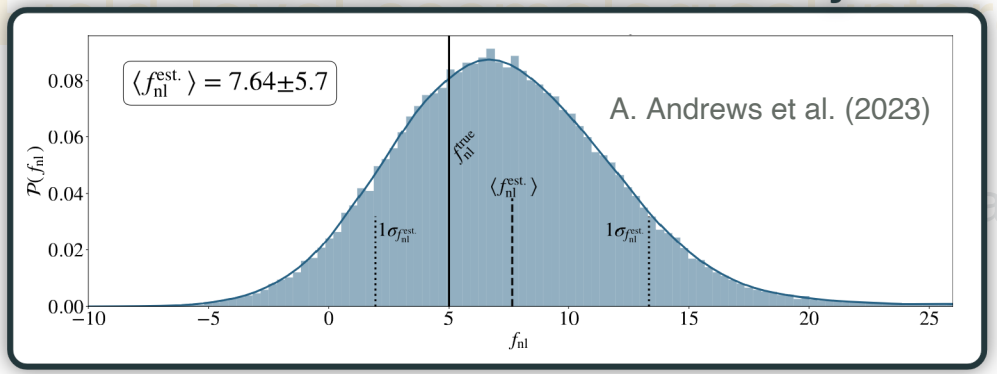
- Differentiable forward model
- Hamiltonian Monte Carlo sampler

BORG infers:

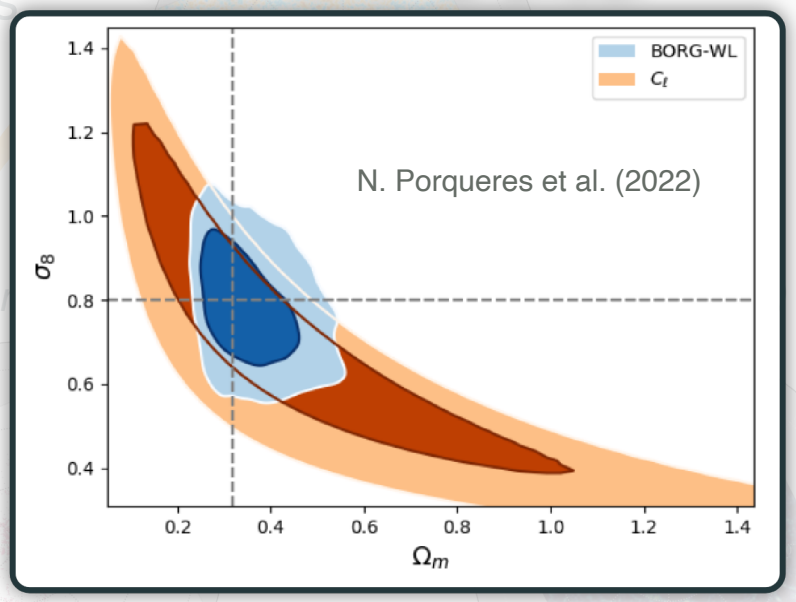
1. Initial conditions
2. Bias parameters
3. Cosmological parameters



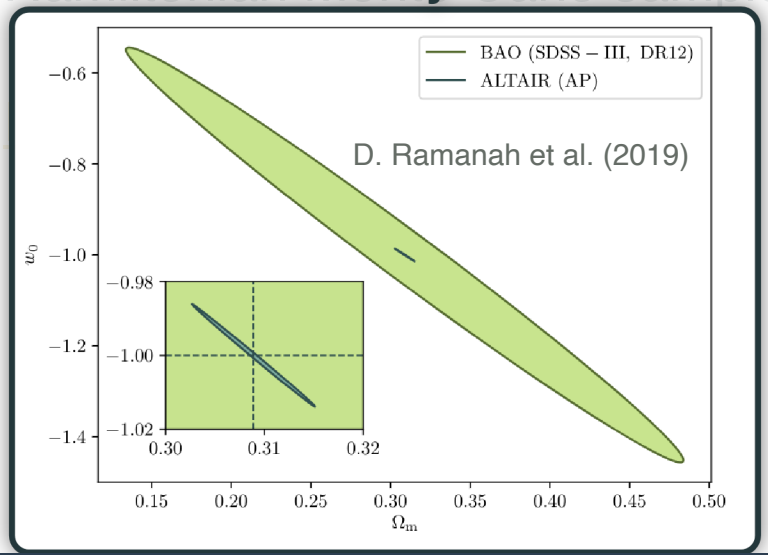
Primordial non-Gaussianity



Gravitational shear



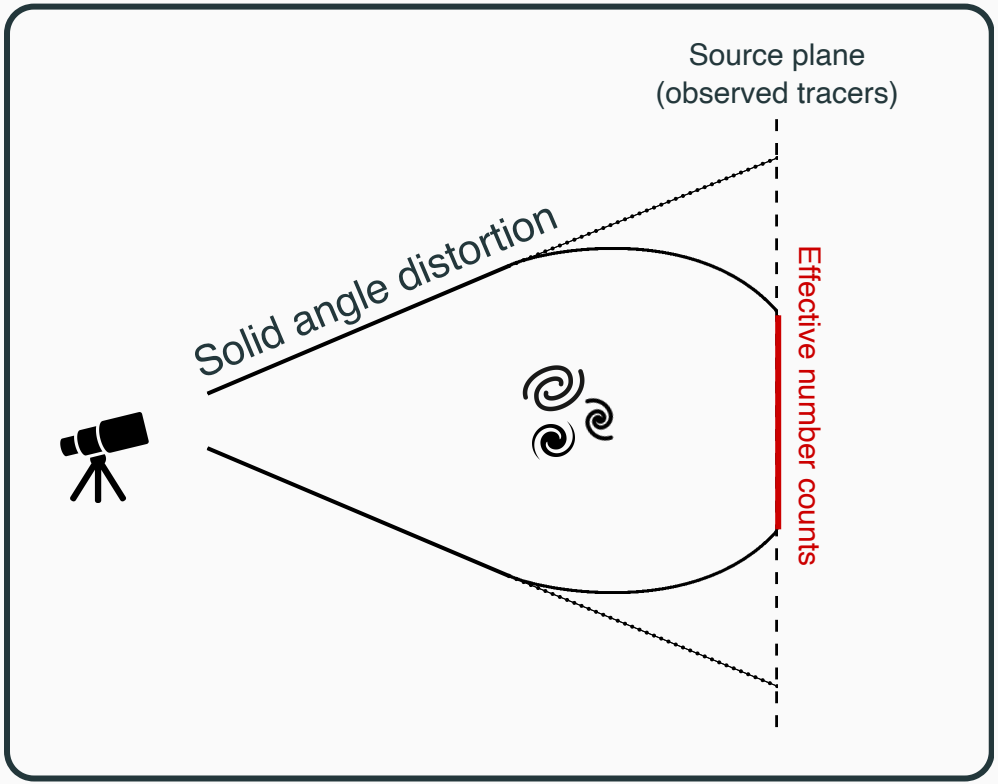
Alcock-Paczyński test



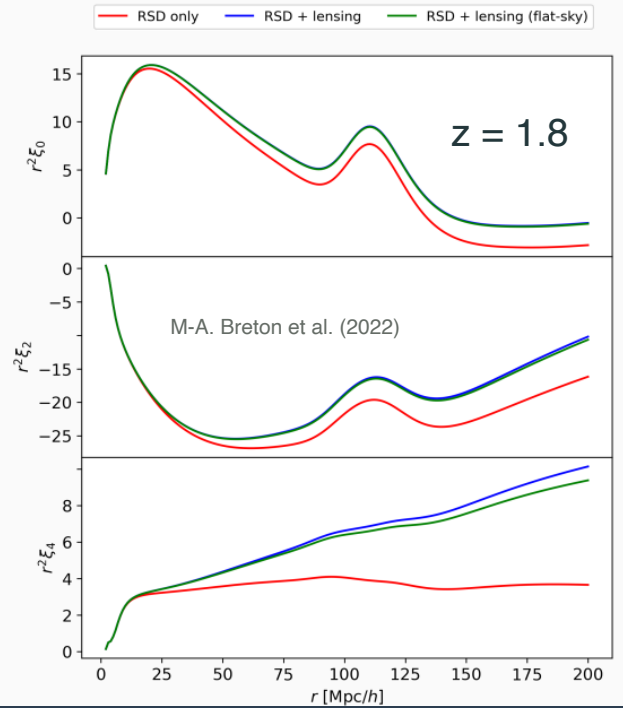
... and many more !

https://www.aquila-consortium.org/publications/

Weak lensing magnification



- Deflection of distant tracers
  - Order of the arcmin at z~1
- Coherent signal over degree-sized scales



➡ Magnification bias

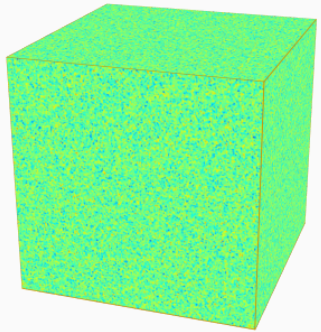
(Geometrical part)

Lensing forward model

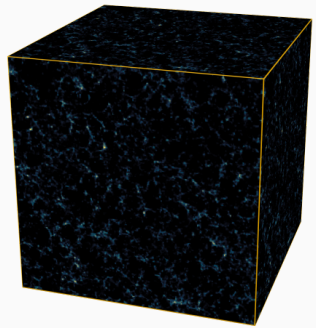
Cosmolog
Uniform prior

$$\Omega_m, \Omega_b$$
$$\Omega_\Lambda, H_0$$
$$\sigma_8, n_s$$

Initial conditions
Gaussian prior



Final density



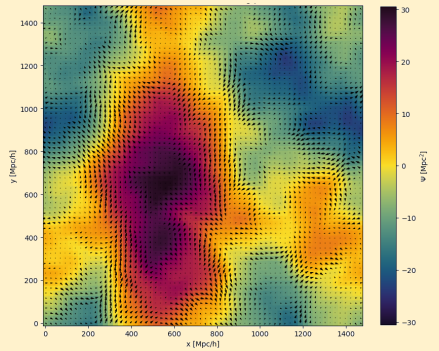
Gravity

- *2LPT*
- *Lightcone*

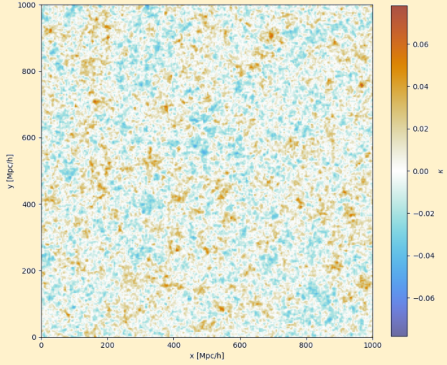
Lensing

- *Flat sky*
- *Born approximation*
- *Autodiff gradients*

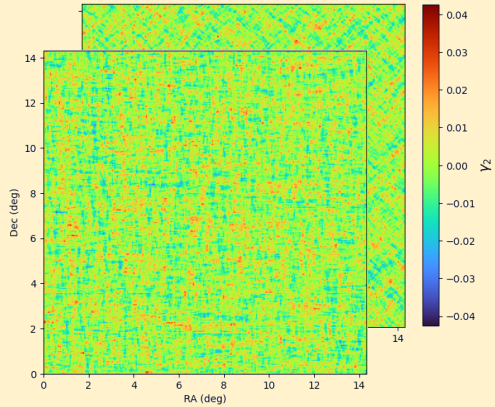
Deflection field



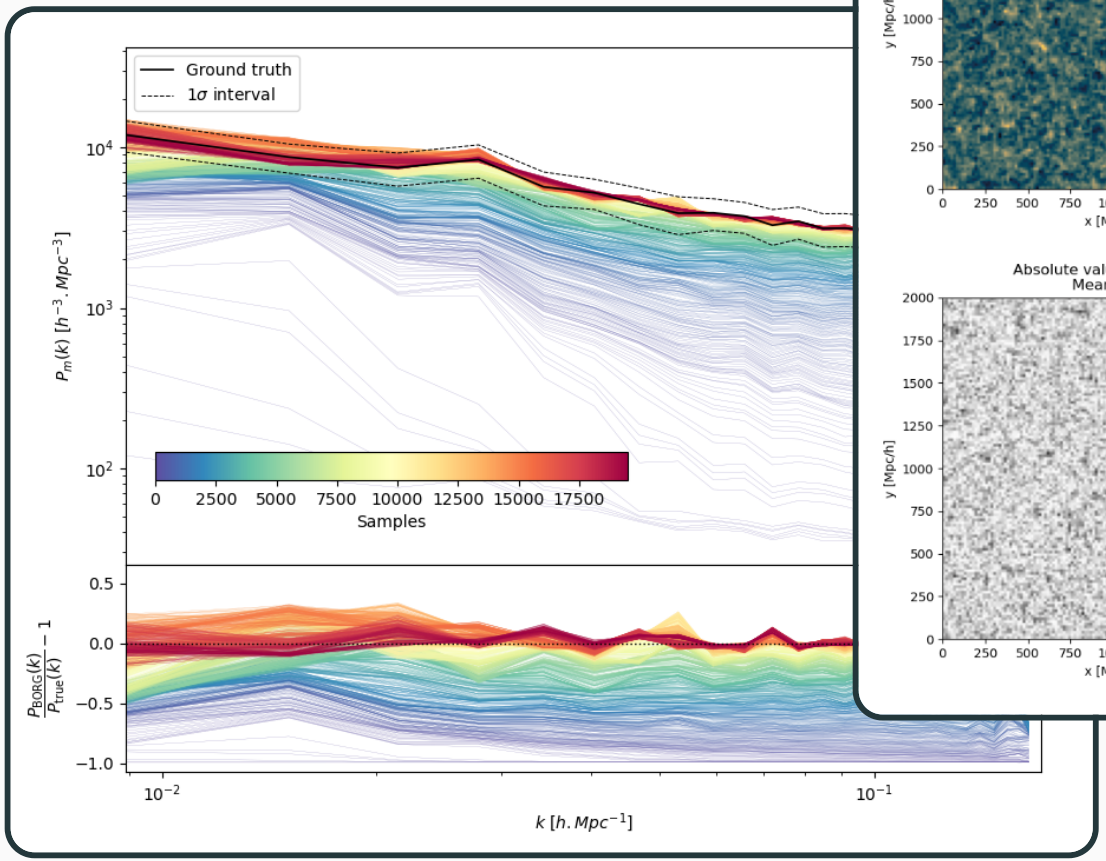
Convergence field

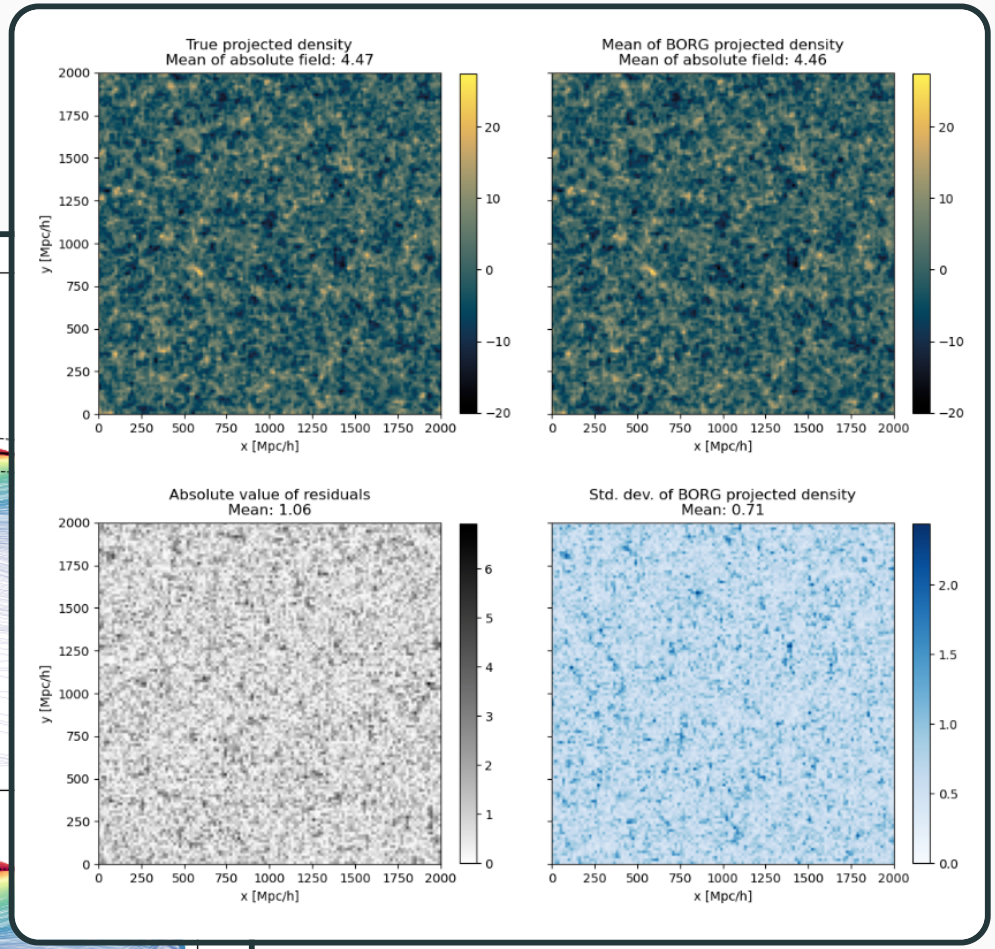


Shear fields



Reconstruction





- Informative signal
- Recovers 2pt and field properties

Take-aways

Contact: *axel.lapel@iap.fr*

- **Field-level** inference for optimal information extraction enables:
  - Reconstructing the **initial conditions** of the Universe
  - Constraining **cosmological parameters**

- Developments and applications:
  - Differentiable **magnification** and **shear simulator**
  - Lensing magnification for cosmological field reconstruction
    - Comparable constraining power to cosmic shear

- Ongoing research:
  - Investigating constraints on **cosmological parameters**