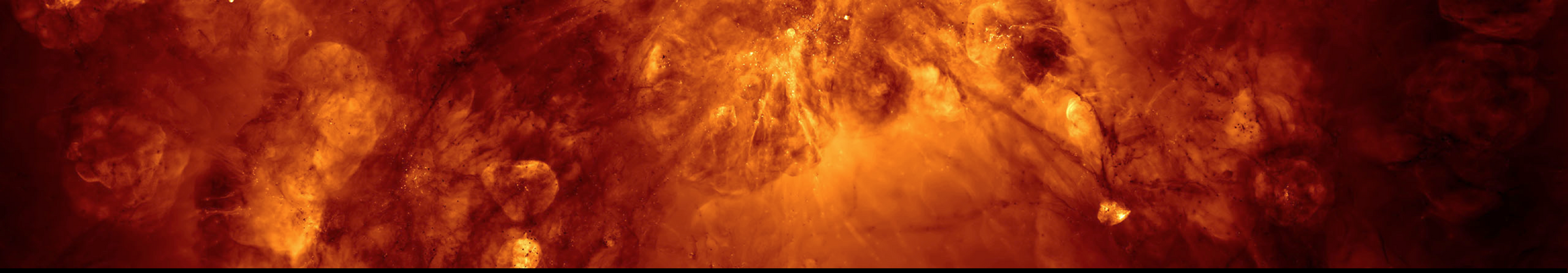


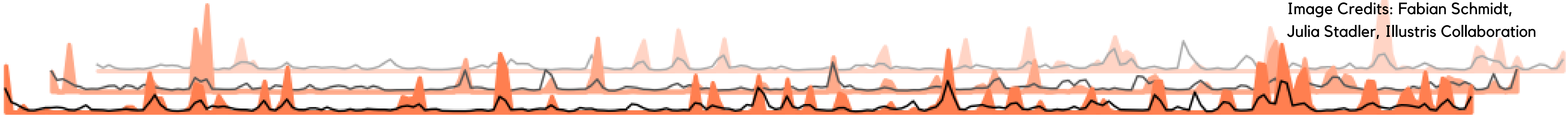
EFTofLSS meets simulation-based inference: σ_8 from biased tracers

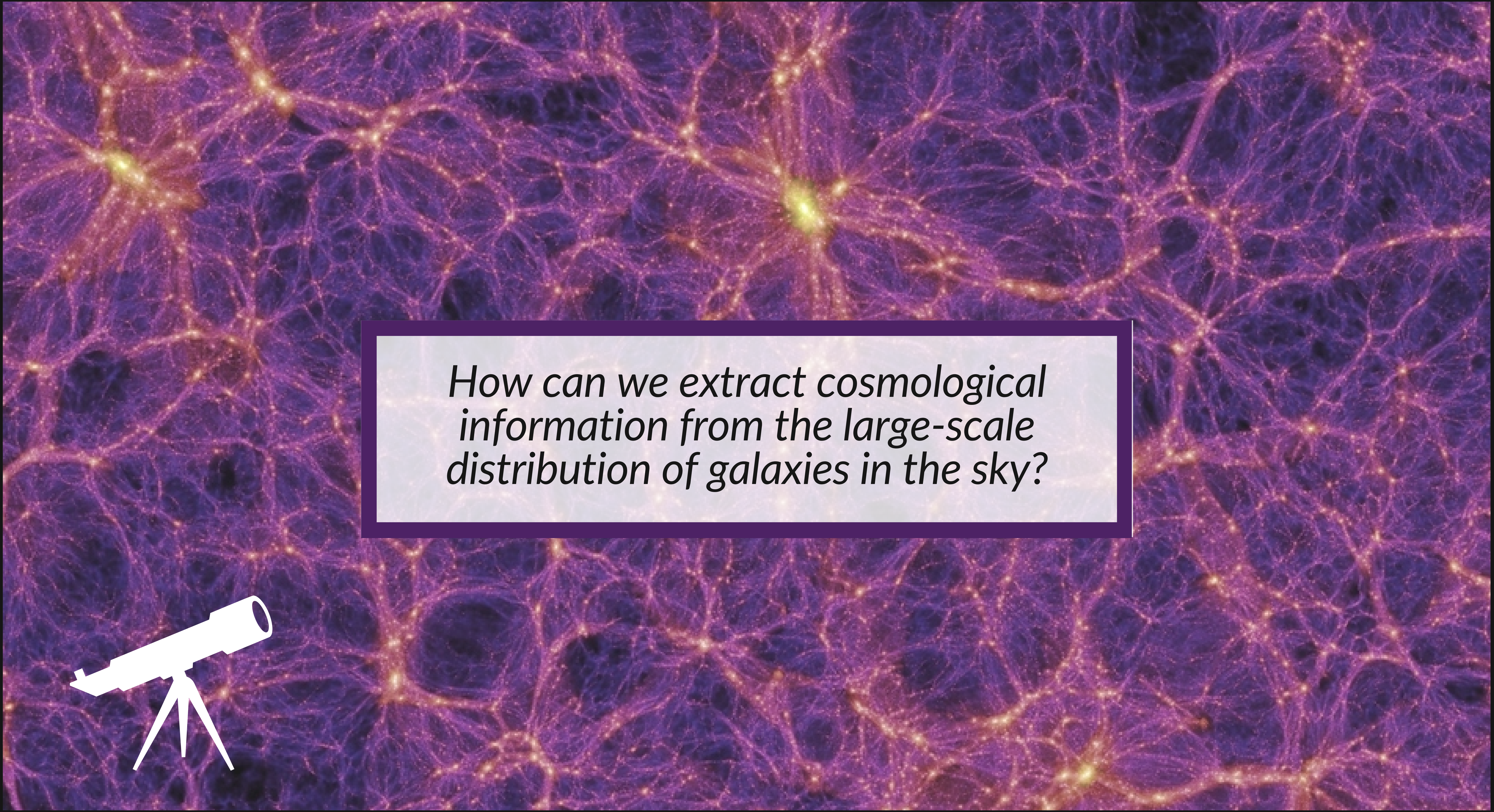
Beatriz Tucci | PhD Student at MPA
Supervisor: Fabian Schmidt

LEFTfield

MAX-PLANCK-INSTITUT FÜR ASTROPHYSIK

Image Credits: Fabian Schmidt, Julia Stadler, Illustris Collaboration





How can we extract cosmological information from the large-scale distribution of galaxies in the sky?

The Millennium Simulation Project

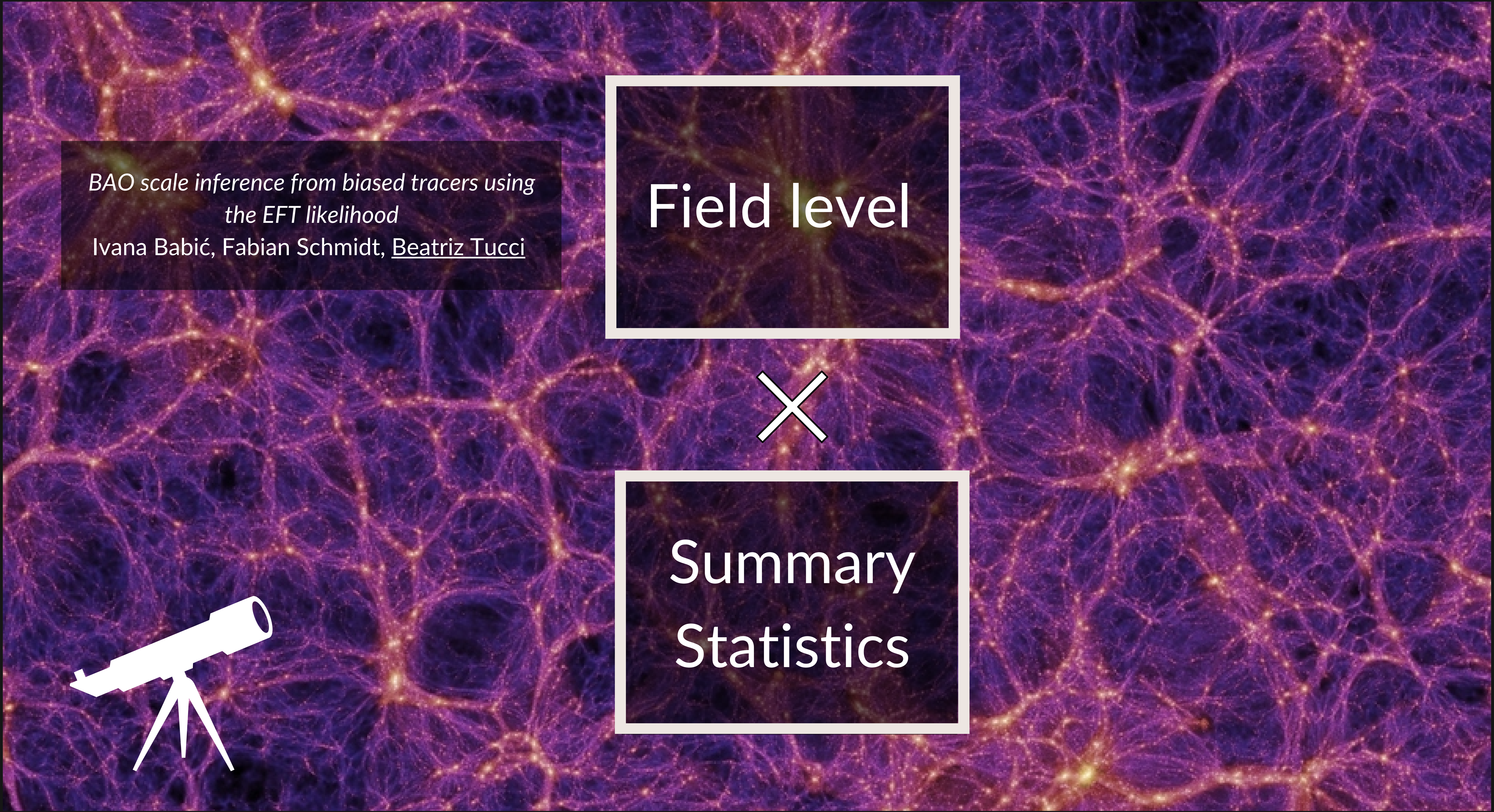
BAO scale inference from biased tracers using the EFT likelihood

Ivana Babić, Fabian Schmidt, Beatriz Tucci

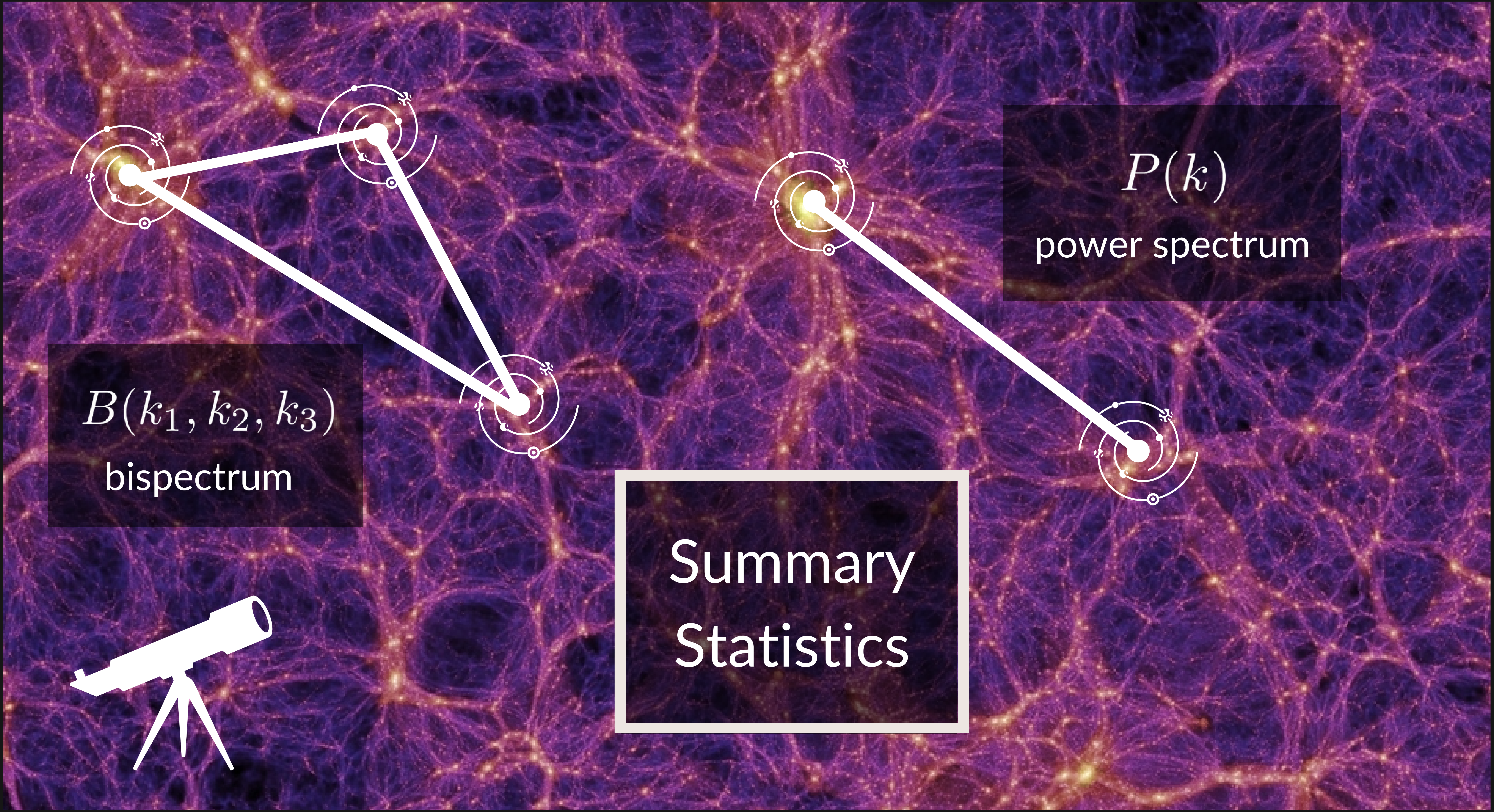
Field level

×

Summary Statistics



The Millennium Simulation Project

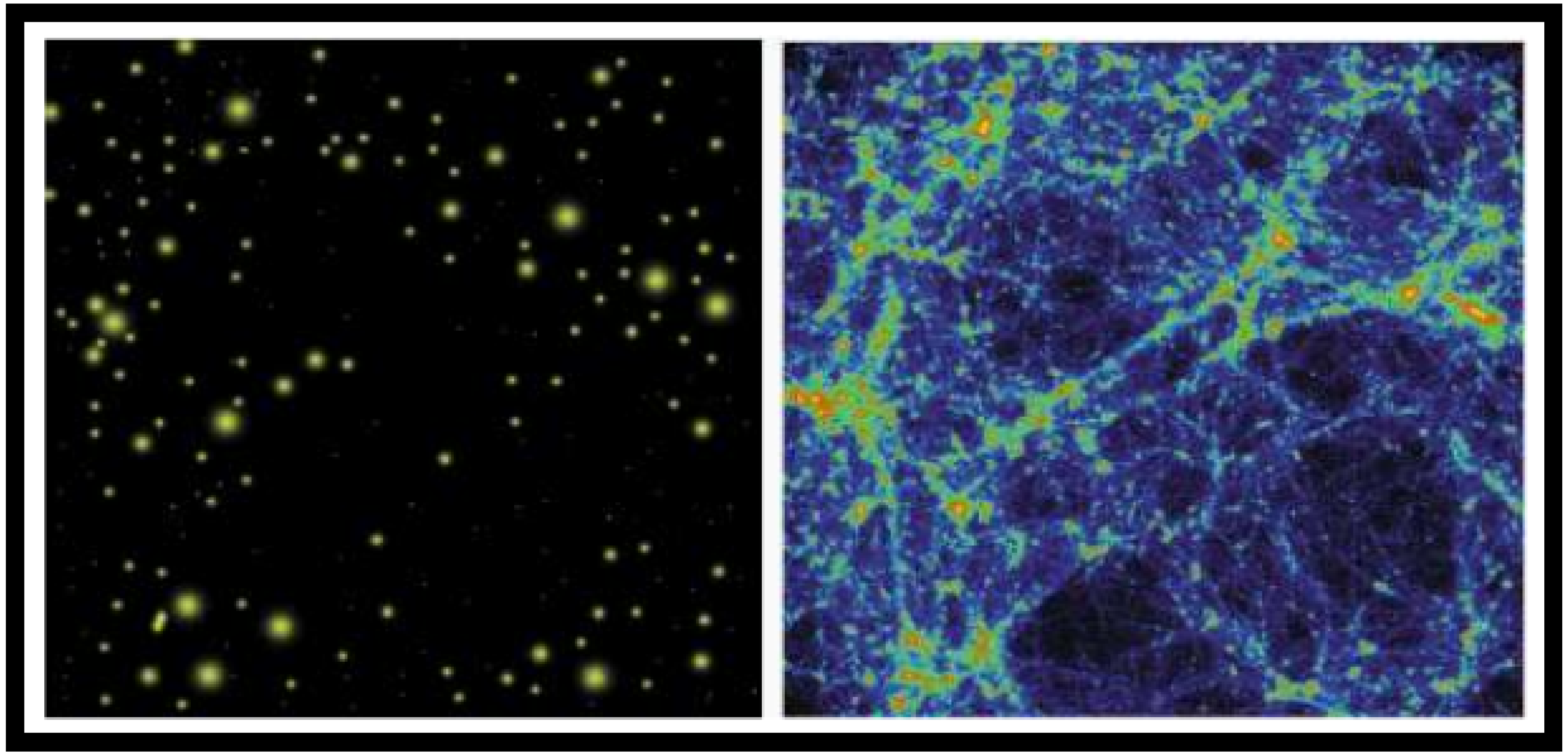


The Millennium Simulation Project

The bias expansion

Cooray & Sheth (2002)

Cosmological tracers



Matter distribution

$$\delta_g(\mathbf{x},\tau) = \sum_{\mathcal{O}} b_{\mathcal{O}}(\tau)\mathcal{O}(\mathbf{x},\tau) + \varepsilon(\mathbf{x},\tau) + \sum_{\mathcal{O}} \varepsilon_{\mathcal{O}}(\mathbf{x},\tau)\mathcal{O}(\mathbf{x},\tau)$$

For a review, see:
Desjacques, Jeong & Schmidt (2016)

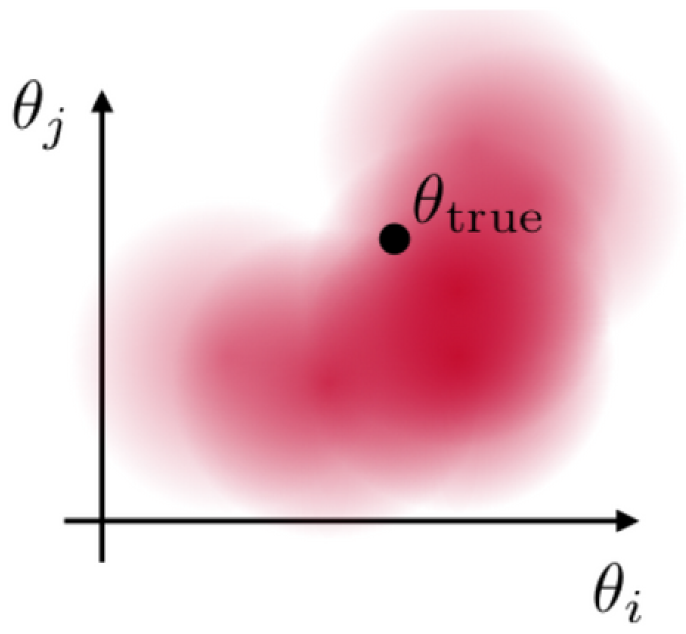
Standard inference in cosmology

Parameters posterior

Likelihood

Prior over the parameters

$$p(\boldsymbol{\theta}|\boldsymbol{x}) \propto \mathcal{L}(\boldsymbol{x}|\boldsymbol{\theta})\mathcal{P}(\boldsymbol{\theta})$$



Standard inference in cosmology

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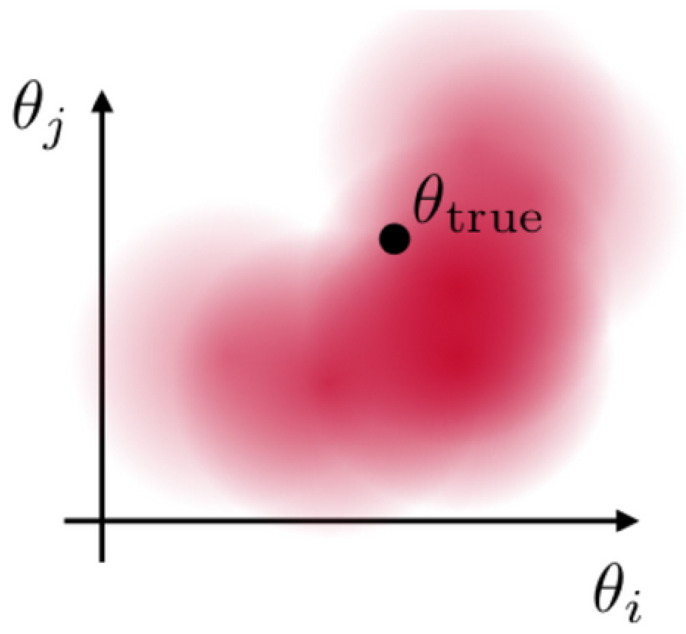


PROBLEMS:

- Analytical approximations (when available)
- Cumbersome covariance estimations

Superconfident posteriors!
(Underestimation of errors)

Simulation-based inference

Parameters posterior

Likelihood

Prior over the parameters

$$p(\boldsymbol{\theta}|\boldsymbol{x}) \propto \mathcal{L}(\boldsymbol{x}|\boldsymbol{\theta})\mathcal{P}(\boldsymbol{\theta})$$

$$\boldsymbol{x} \sim \mathrm{simulator}(\boldsymbol{\theta})$$

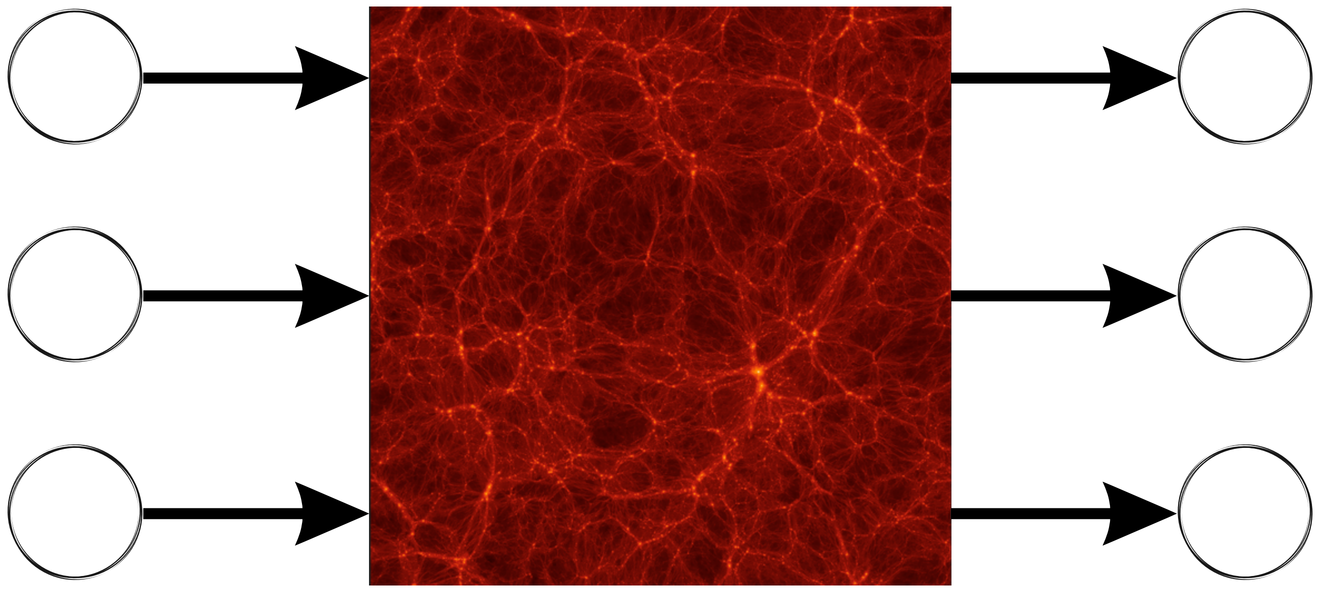
Simulation-based inference

TWO INGREDIENTS:

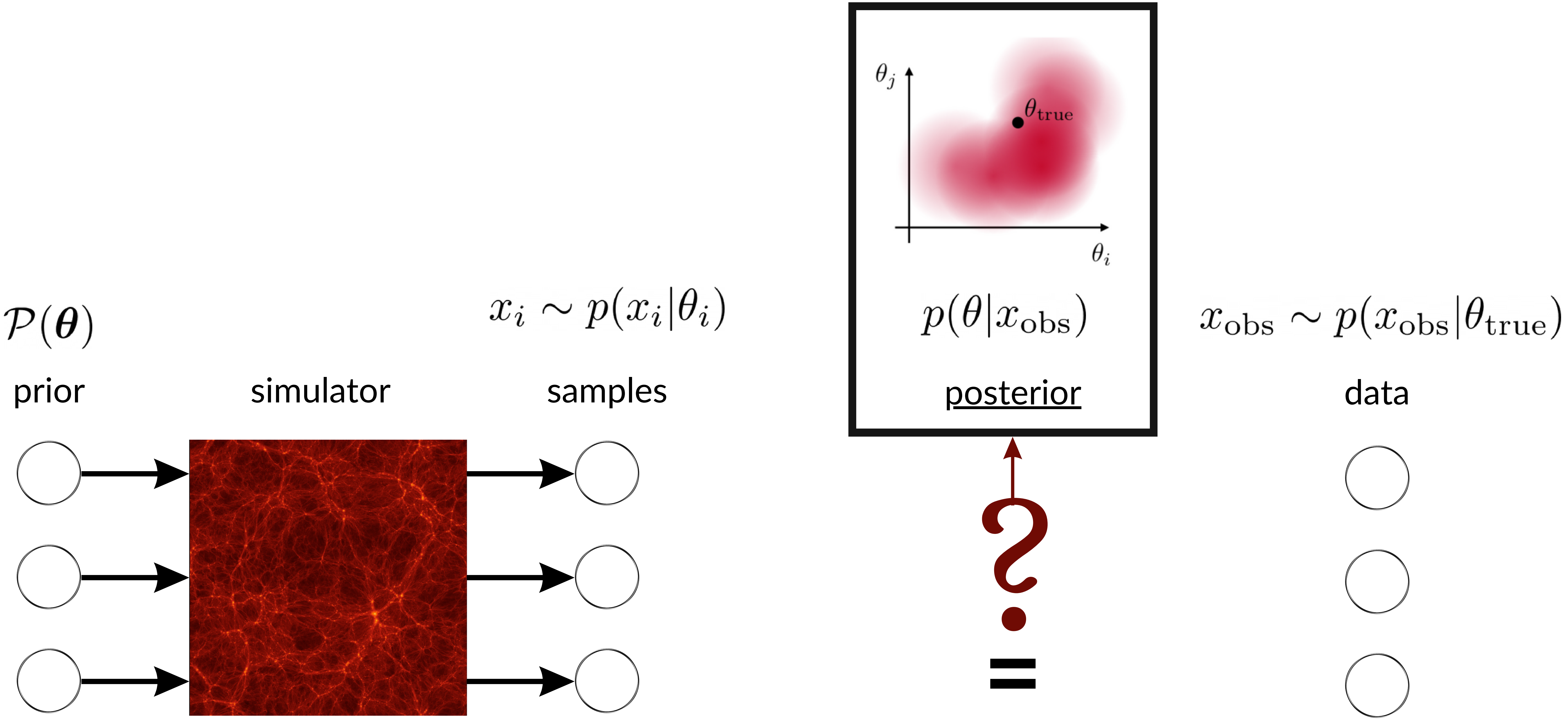
- A simulator that can generate samples
- A prior over the parameters

$\mathcal{P}(\boldsymbol{\theta})$ $\quad x_i \sim p(x_i|\theta_i)$

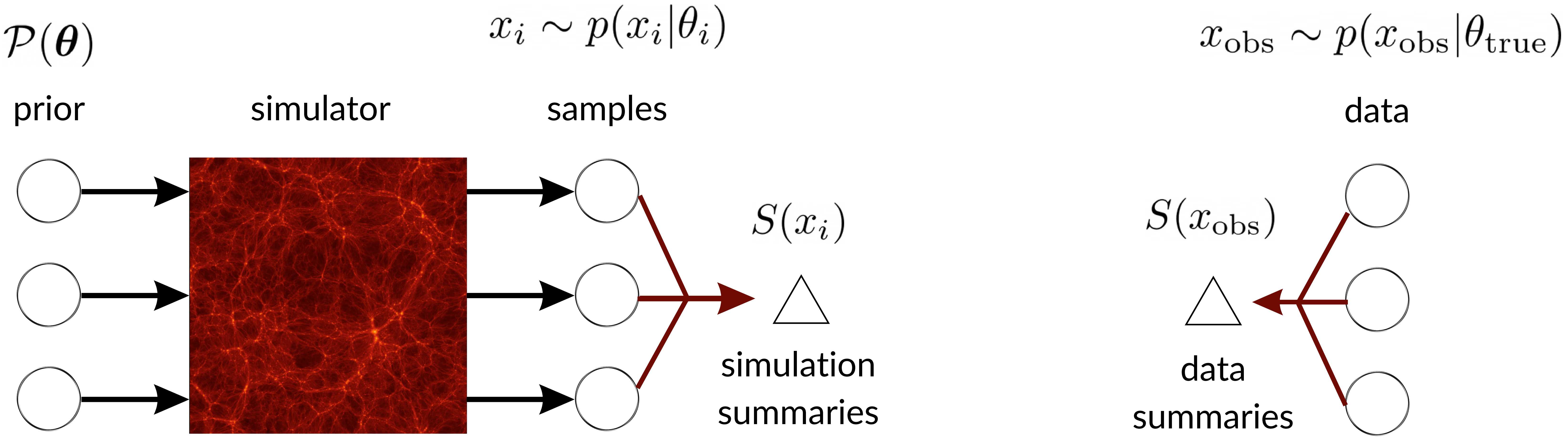
prior simulator samples



Simulation-based inference

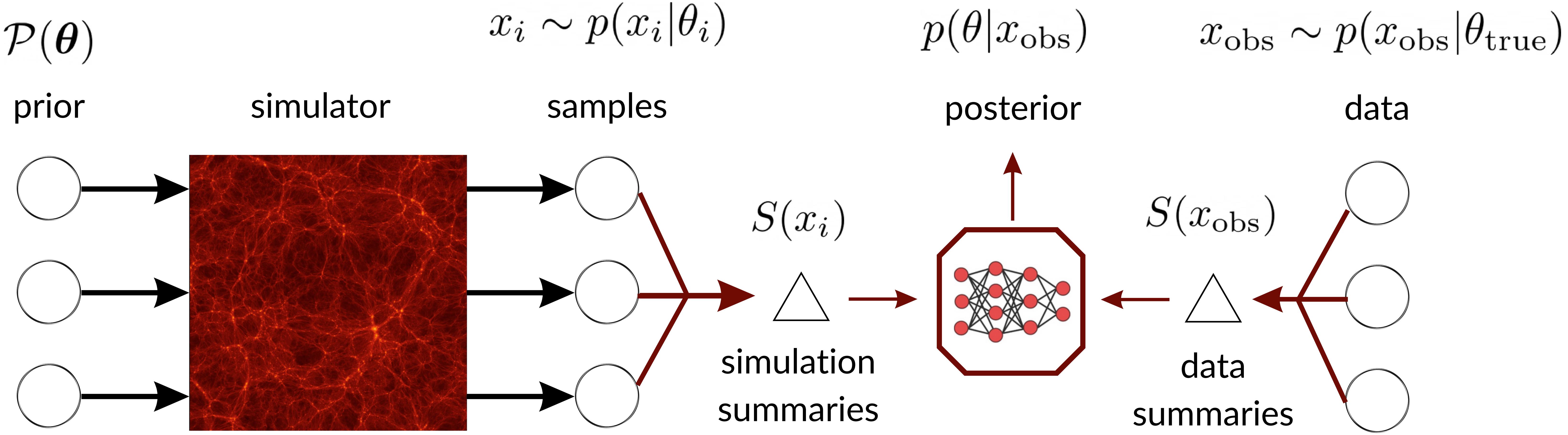


Simulation-based inference



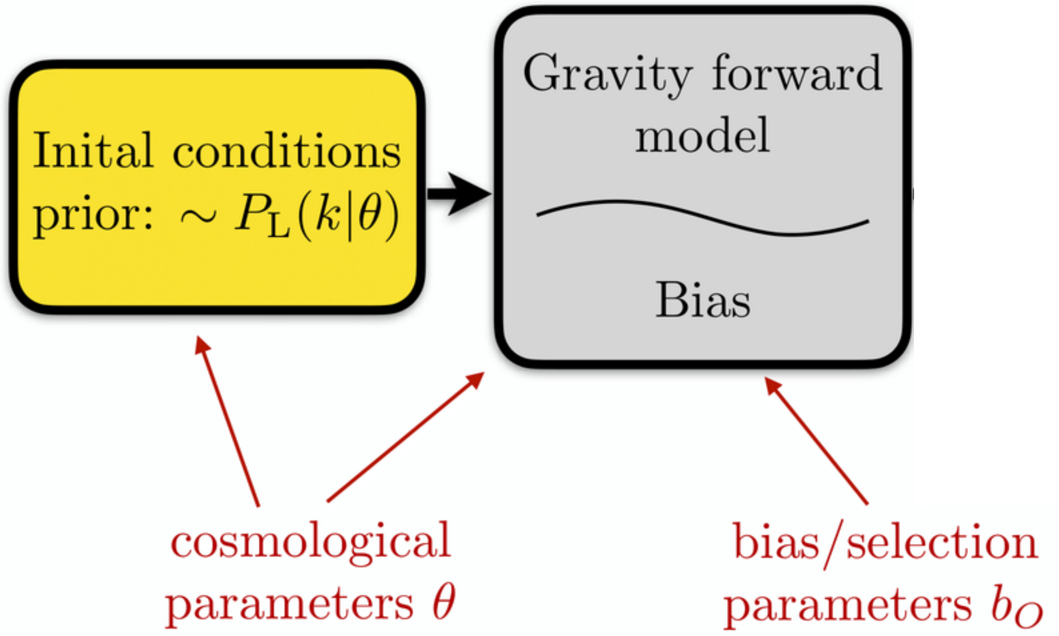
Neural Density Estimators

sbi: A toolkit for simulation-based inference
Tejero-Cantero et al. (2020)



LEFTfield | forward model

EFTofLSS based approach



An n-th order Lagrangian Forward Model for Large-Scale Structure
Fabian Schmidt (2021)

Lagrangian Perturbation Theory

$$\mathbf{x}(\tau) = \mathbf{q} + \mathbf{s}(\mathbf{x}, \tau)$$

$$M_{ij}^{(n)} = \partial_i s_j^{(n)}$$

↓

Lagrangian Bias Operators

$$\delta^L_{g,\mathrm{det}}(\mathbf{q}, \tau) = \sum_{\mathcal{O}^L} b_{\mathcal{O}^L}(\tau)\mathcal{O}^L(\mathbf{q}, \tau)$$

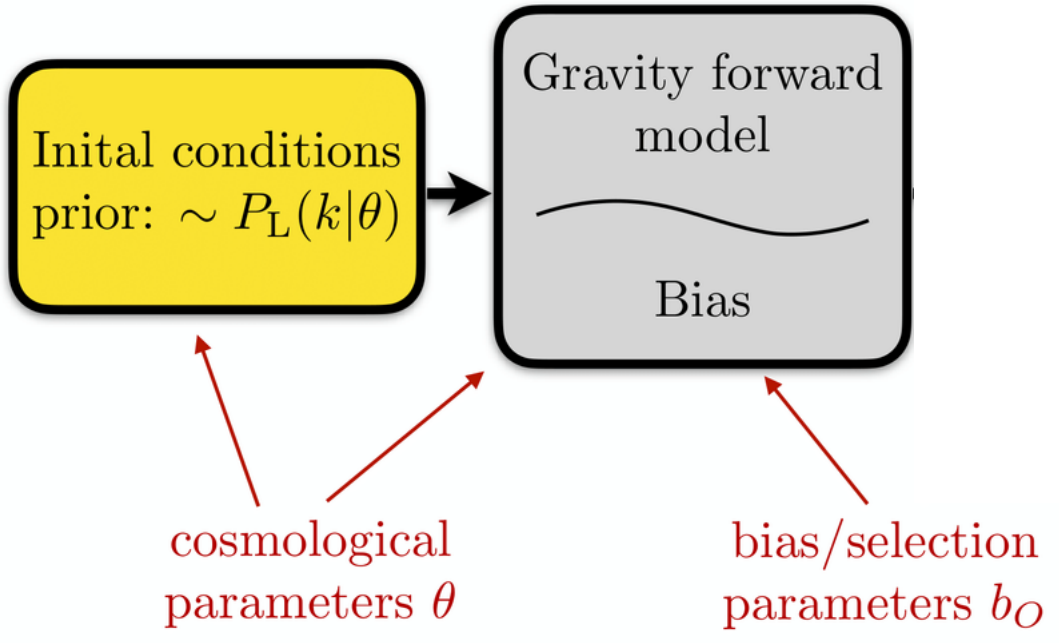
1^{st}	$\mathrm{tr}[M^{(1)}]$
2^{nd}	$\mathrm{tr}[(M^{(1)})^2]$, $(\mathrm{tr}[M^{(1)}])^2$

↓ displacement (CIC)

$$\delta_g(\mathbf{x}, \tau) = \delta_{g,\mathrm{det}}(\mathbf{x}, \tau) + \varepsilon(\mathbf{x}, \tau) + \sigma_{\varepsilon\delta}(\tau)\varepsilon(\mathbf{x}, \tau)\delta(\mathbf{x}, \tau) + c_\varepsilon^{\mathrm{NG}}(\tau)\varepsilon^2(\mathbf{x}, \tau)$$

LEFTfield | forward model

EFTofLSS based approach



An n-th order Lagrangian Forward Model for Large-Scale Structure
Fabian Schmidt (2021)

$$\varepsilon \sim \mathcal{N}(0, \sigma_\varepsilon)$$

Perturbation Theory

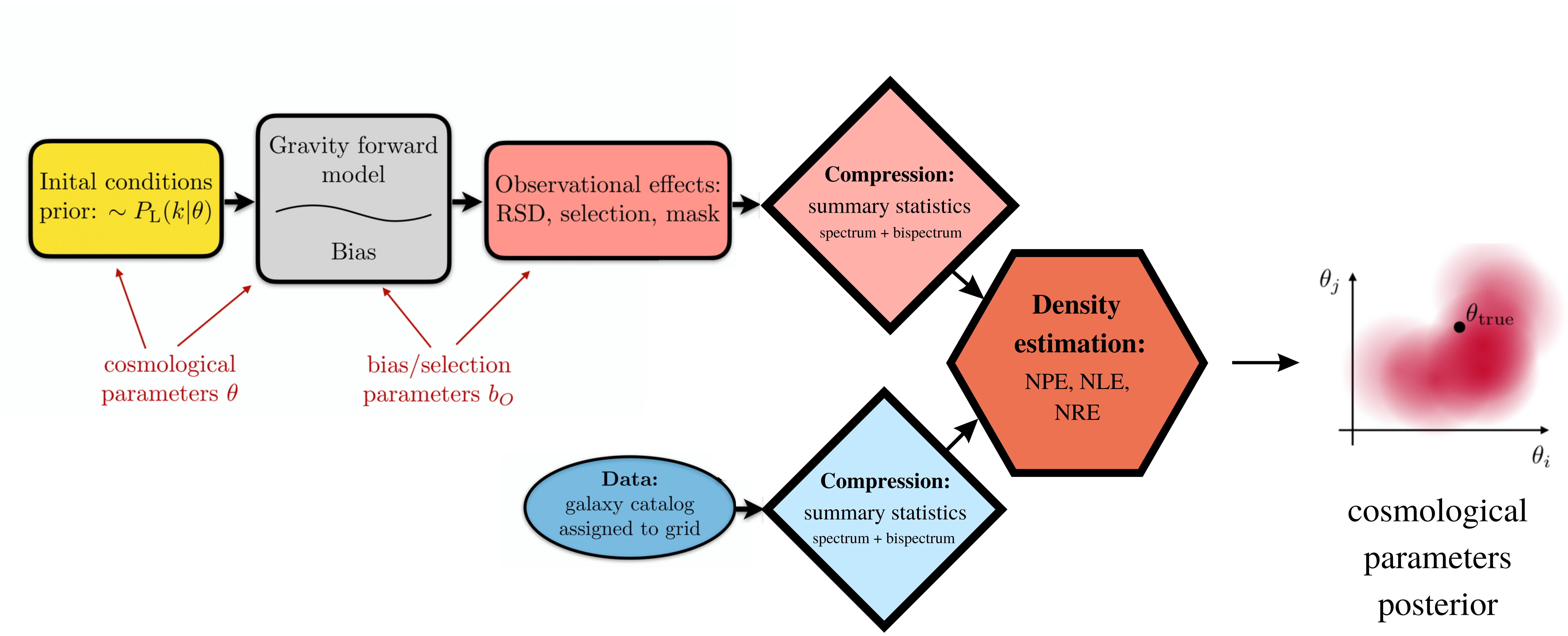
$$\langle \delta_g(k_1)\delta_g(k_2)\delta_g(k_3)\rangle'^{\text{LO}}_{\text{stoch}} = B_\varepsilon + 2b_1 P_{\varepsilon\varepsilon_\delta}(P_{\text{m}}(k_1) + 2\text{ perm.})$$

Forward Model

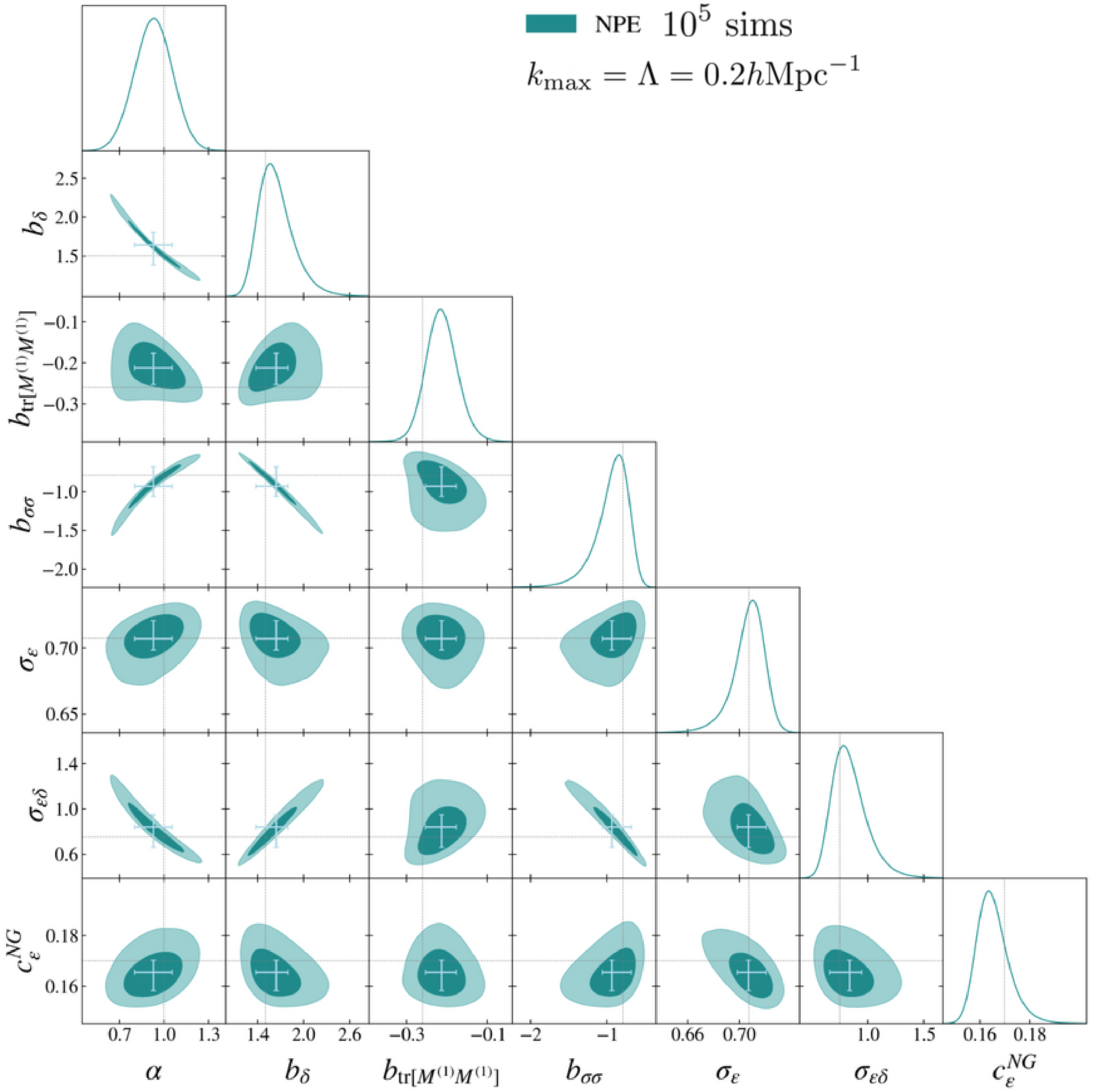
$$\langle \delta_g(k_1)\delta_g(k_2)\delta_g(k_3)\rangle'^{\text{LO}}_{\text{stoch}} = 6c_\varepsilon^{\text{NG}} P_\varepsilon^2 + 2b_1 P_\varepsilon \sigma_{\varepsilon\delta}(P_{\text{m}}(k_1) + 2\text{ perm.})$$

$$\delta_g(\mathbf{x}, \tau) = \delta_{g,\text{det}}(\mathbf{x}, \tau) + \varepsilon(\mathbf{x}, \tau) + \sigma_{\varepsilon\delta}(\tau)\varepsilon(\mathbf{x}, \tau)\delta(\mathbf{x}, \tau) + c_\varepsilon^{\text{NG}}(\tau)\varepsilon^2(\mathbf{x}, \tau)$$

LEFTI | LEFTfield & LFI



Euclid | 2LPT, 2nd order bias expansion



$$\alpha = \sigma_8/\sigma_8^{\text{fid}}$$

PRELIMINARY!

Thank you!

Beatriz Tucci | PhD Student at MPA
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