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DE L'ÉCOLE NORMALE SUPÉRIEURE

Single frequency CMB B-mode inference with realistic foregrounds from a single training image

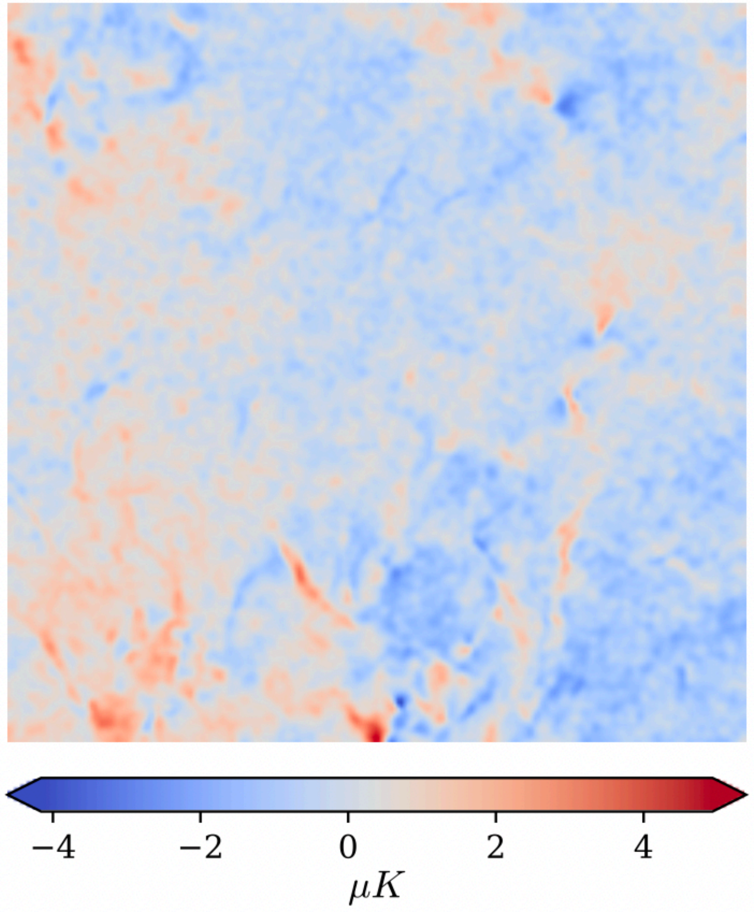
Niall Jeffrey

François Boulanger, Benjamin Wandelt,
Bruno Regaldo-Saint Blancard, Erwan Allys, François Levrier

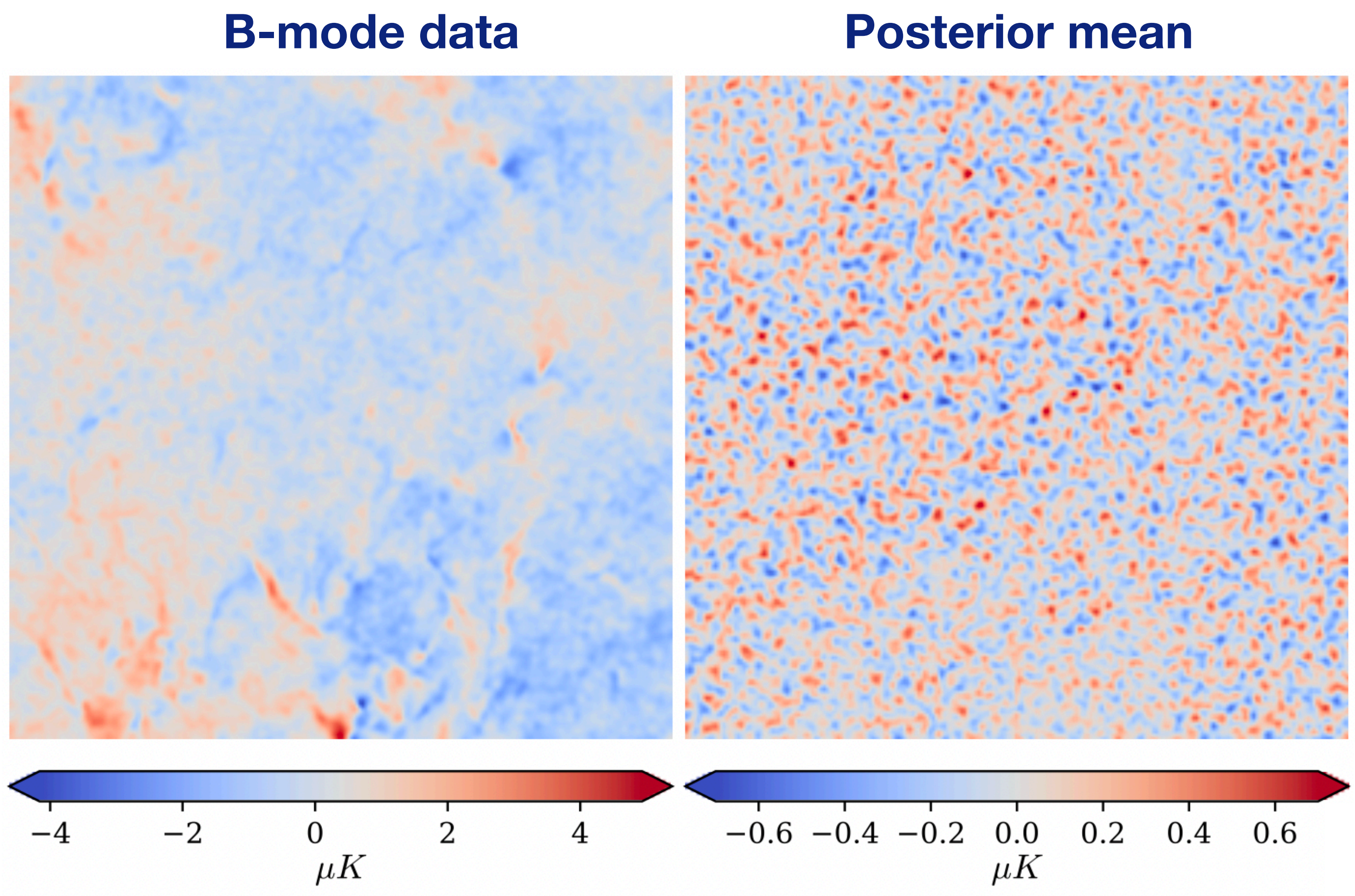
ENS | PSL UNIVERSITÉ PARIS
cnrs
SORBONNE UNIVERSITÉ
Université de Paris

B-mode inference

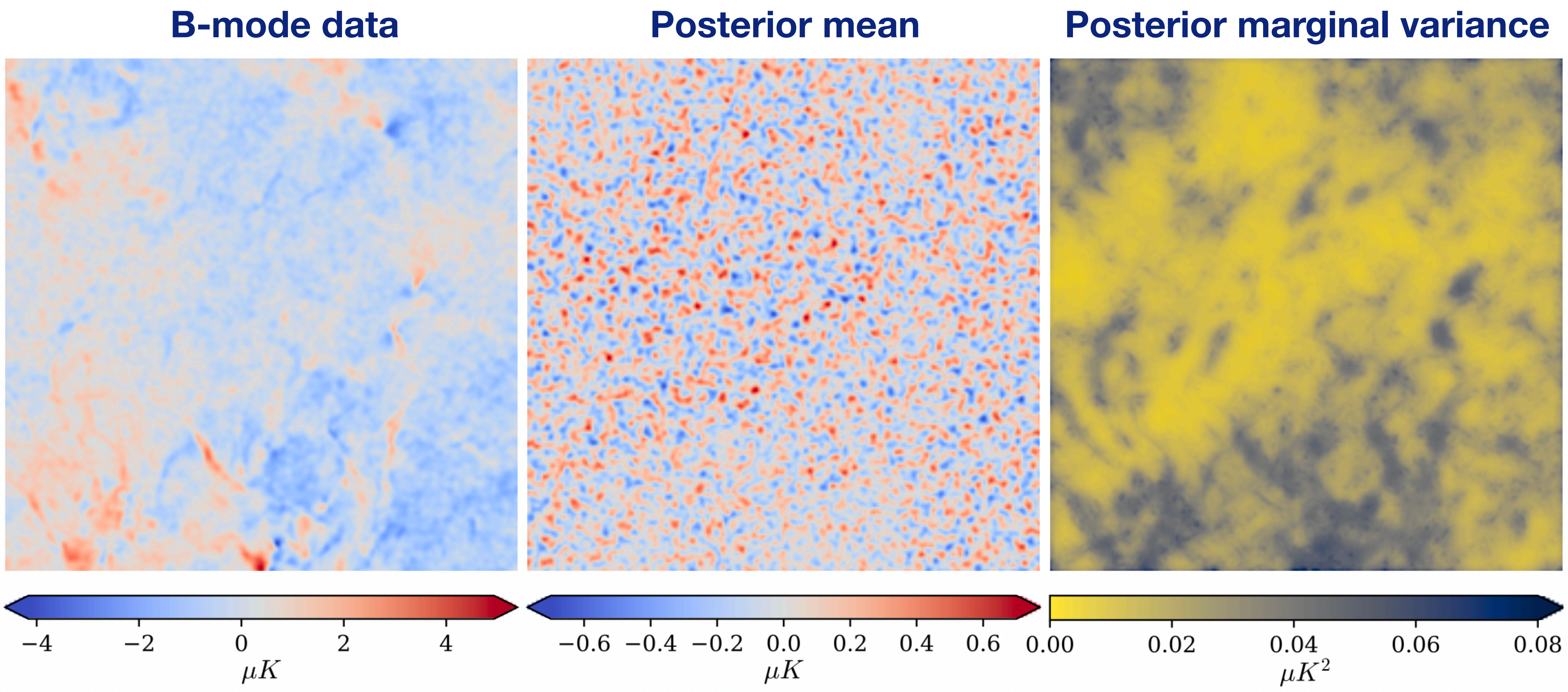
B-mode data



B-mode inference



B-mode inference



Outline

1. ***High-dimensional likelihood-free inference***

2. ***Realistic forward model***

3. ***Posterior validation***

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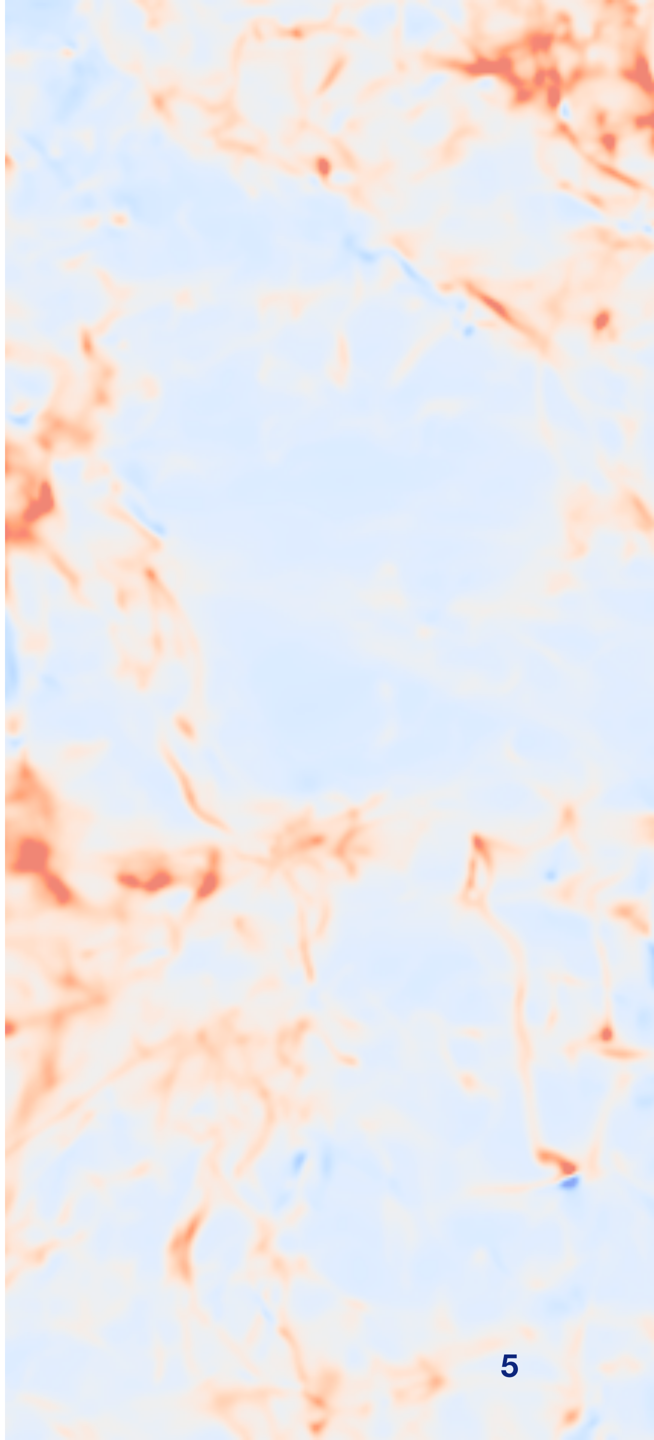

01

High-dimensional likelihood-free:
Moment Networks

Parameter inference

1. Possible "data" $\mathbf{d}$

2. Unknown parameters: $\mathbf{s}$ signal

$$p(\mathbf{s} \,|\, \mathbf{d}) \propto p(\mathbf{d} \,|\, \mathbf{s})\; p(\mathbf{s})$$

Moment Network:
side-step density estimation problem

NJ & Wandelt 2011.05991

Moment Network:
side-step density estimation problem

I. Hierarchy of Networks

II. Optimization objective use square loss

$$J_0 = \int ||\boldsymbol{s} - \mathcal{F}(\boldsymbol{d})||^2 p(\boldsymbol{d}, \boldsymbol{s}) \, \mathrm{d}\boldsymbol{d} \, \mathrm{d}\boldsymbol{s}$$

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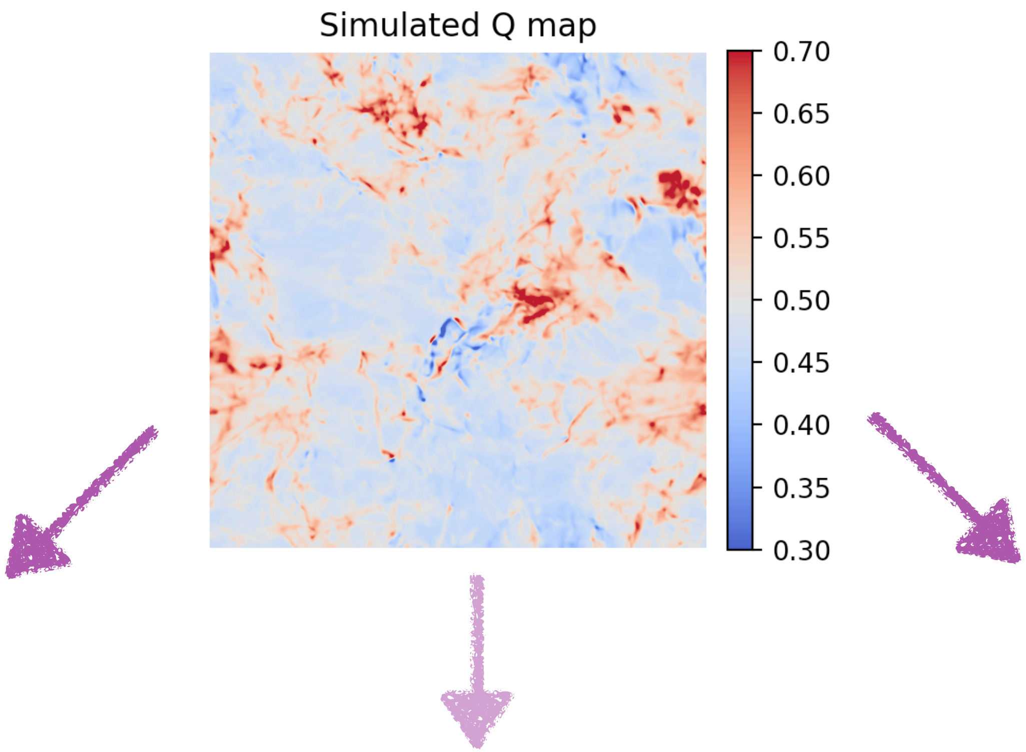
$$J_0 = \int ||\boldsymbol{s} - \mathcal{F}(\boldsymbol{d})||^2 p(\boldsymbol{d}, \boldsymbol{s}) \, \mathrm{d}\boldsymbol{d} \, \mathrm{d}\boldsymbol{s}$$

$$J_1 = \int ||(\boldsymbol{s} - \mathcal{F}_{\mathrm{fixed}}(\boldsymbol{d}))^2 - \mathcal{G}(\boldsymbol{d})||^2 p(\boldsymbol{d}, \boldsymbol{s}) \, \mathrm{d}\boldsymbol{d} \, \mathrm{d}\boldsymbol{s}$$

02

Forward model & B-mode inference

Generative model for data?



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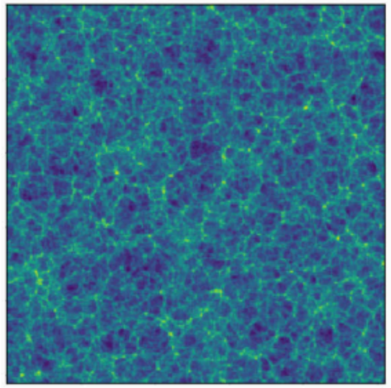
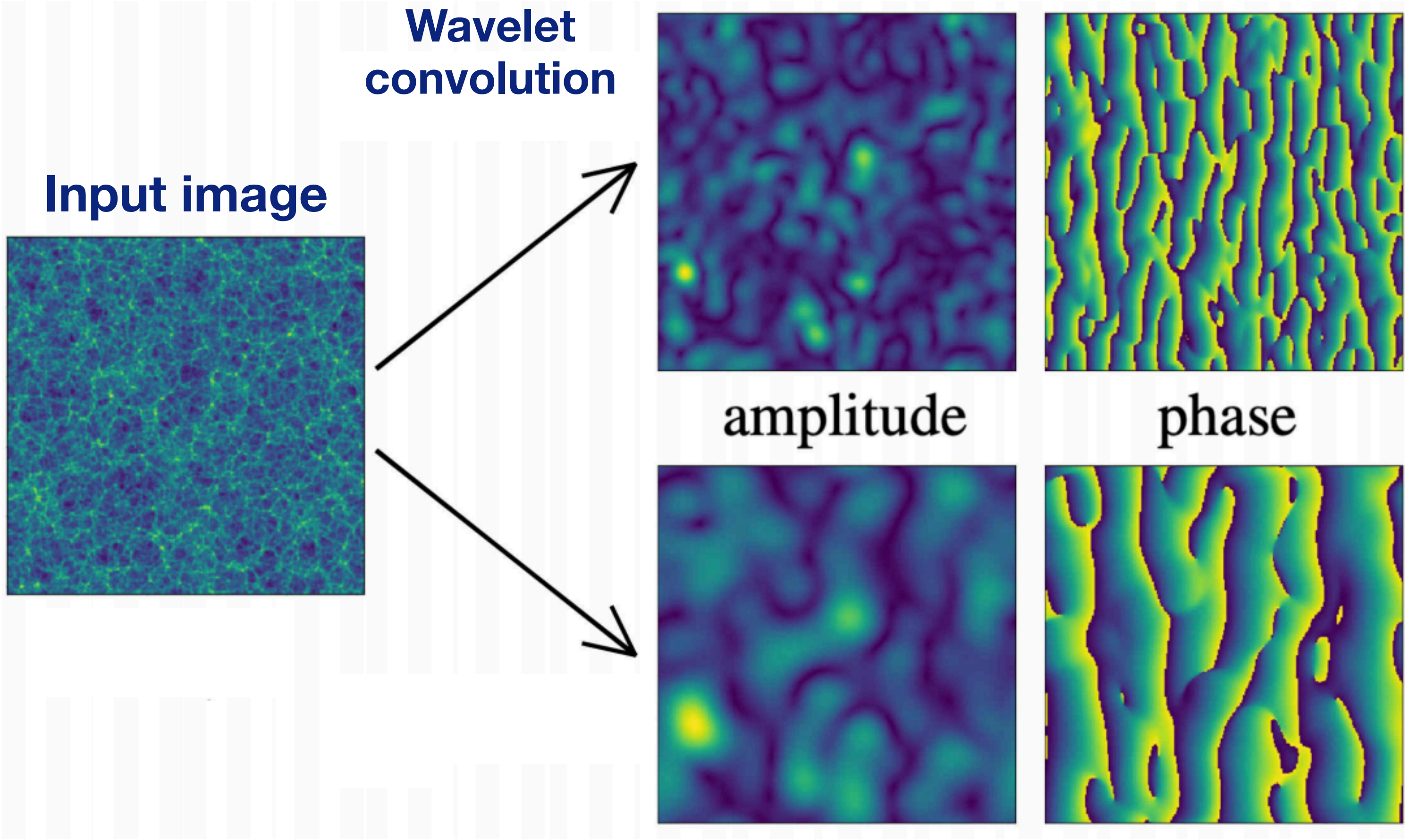
Wavelet Phase Harmonics

Input image

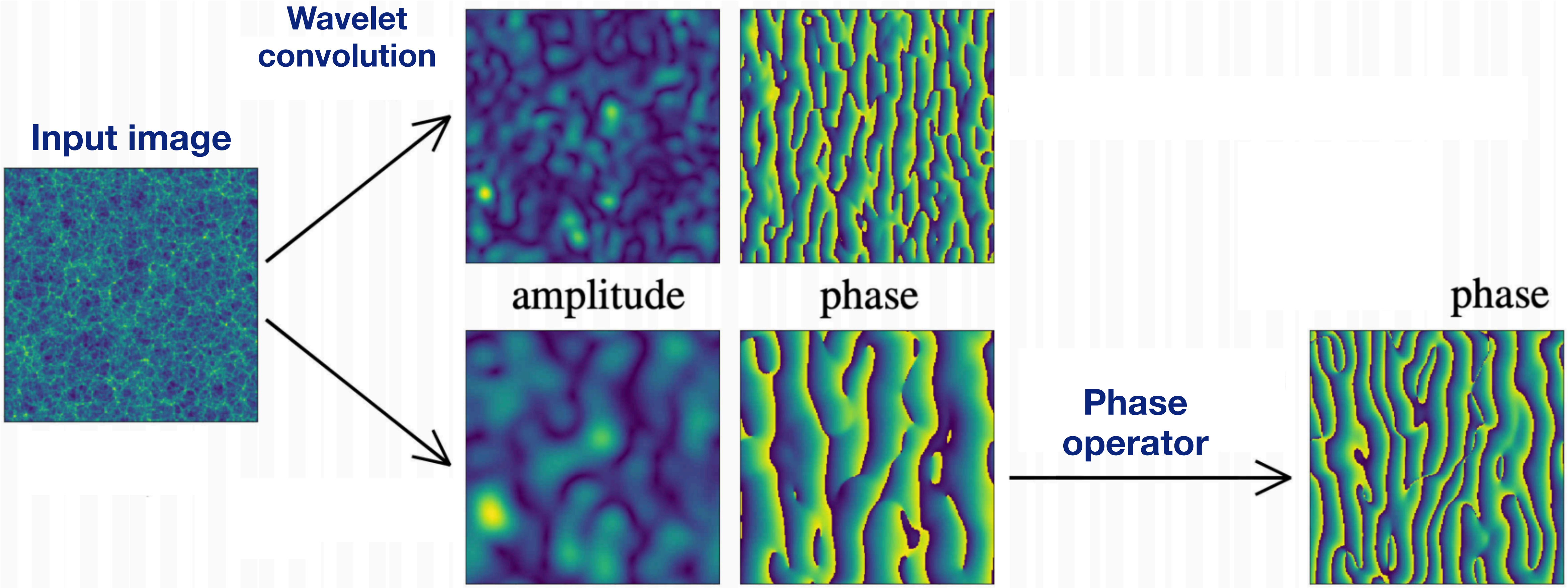


Wavelet Phase Harmonics



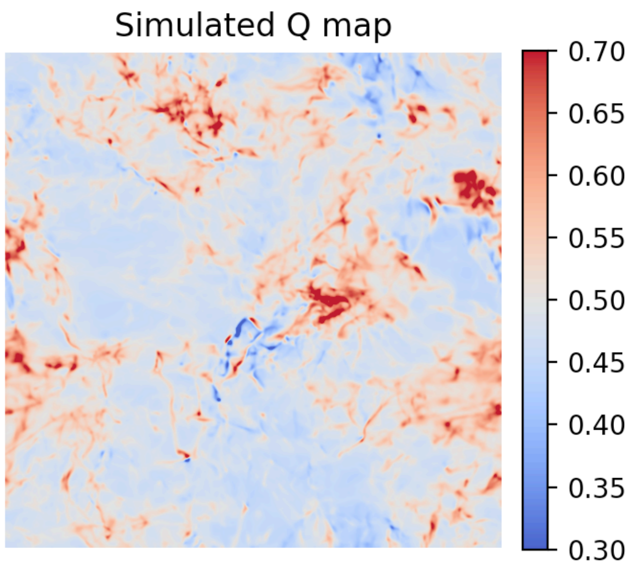
(adapted from Allys++ 2006.06298)

Wavelet Phase Harmonics

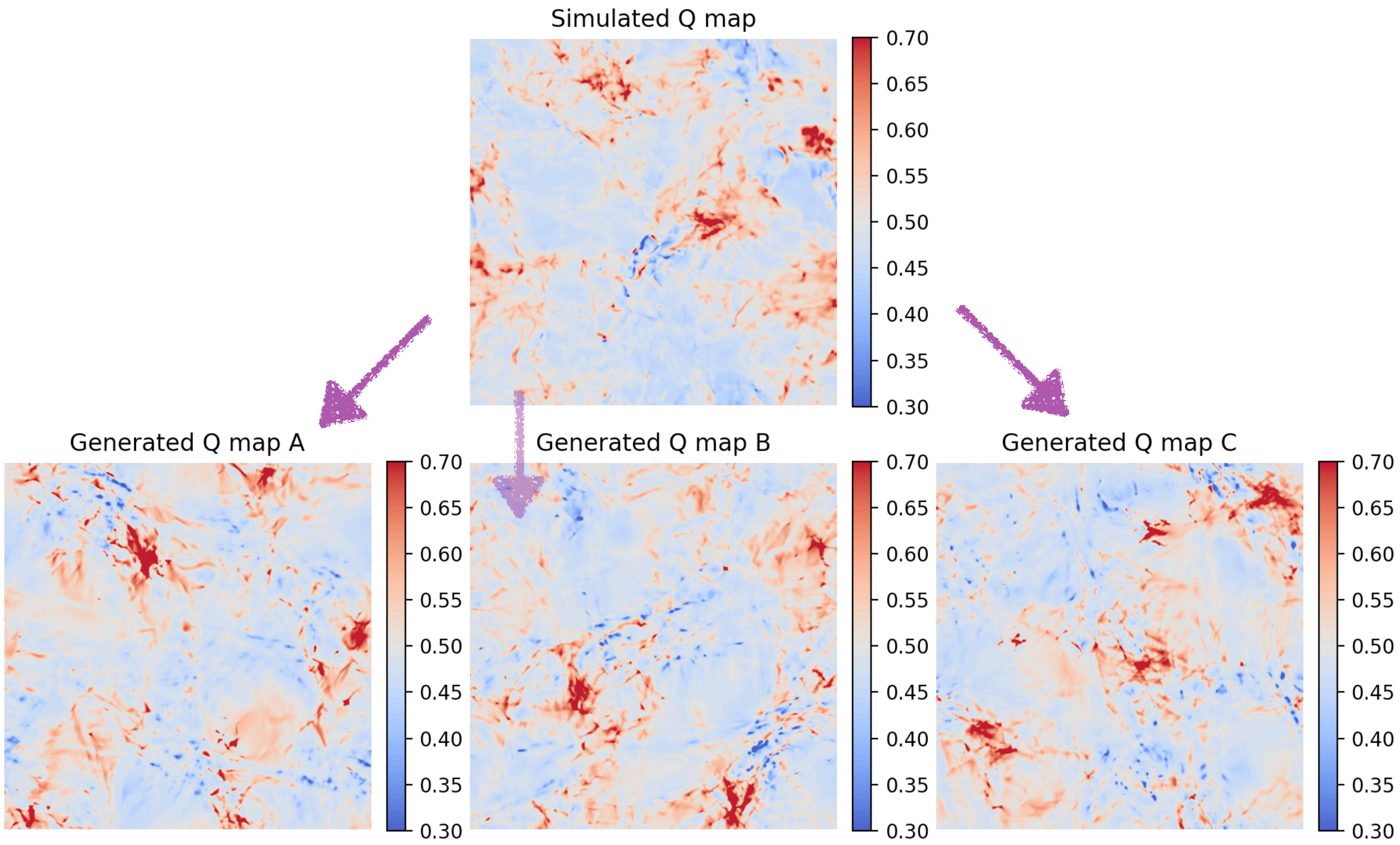


(adapted from Allys++ 2006.06298)

Generative model for data



Generative model for data



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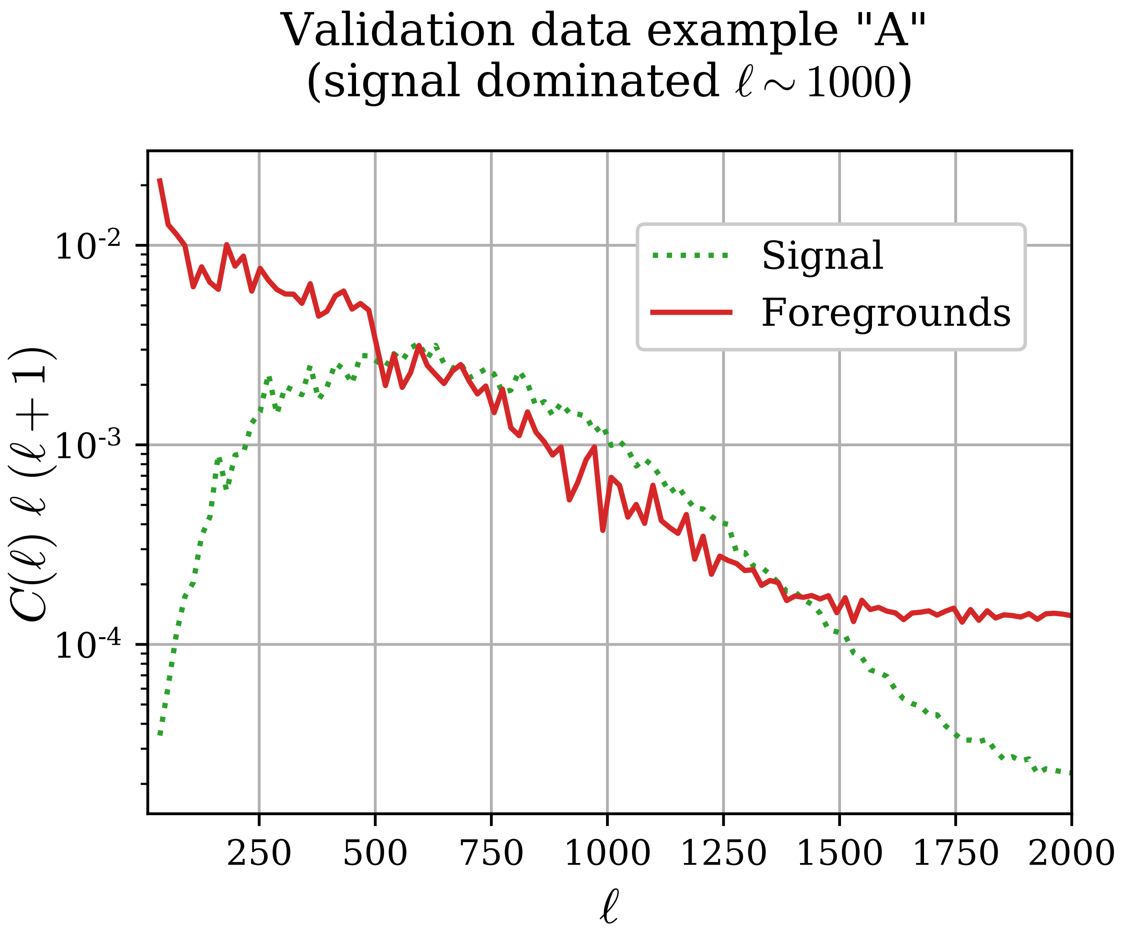
Model parameters from prior



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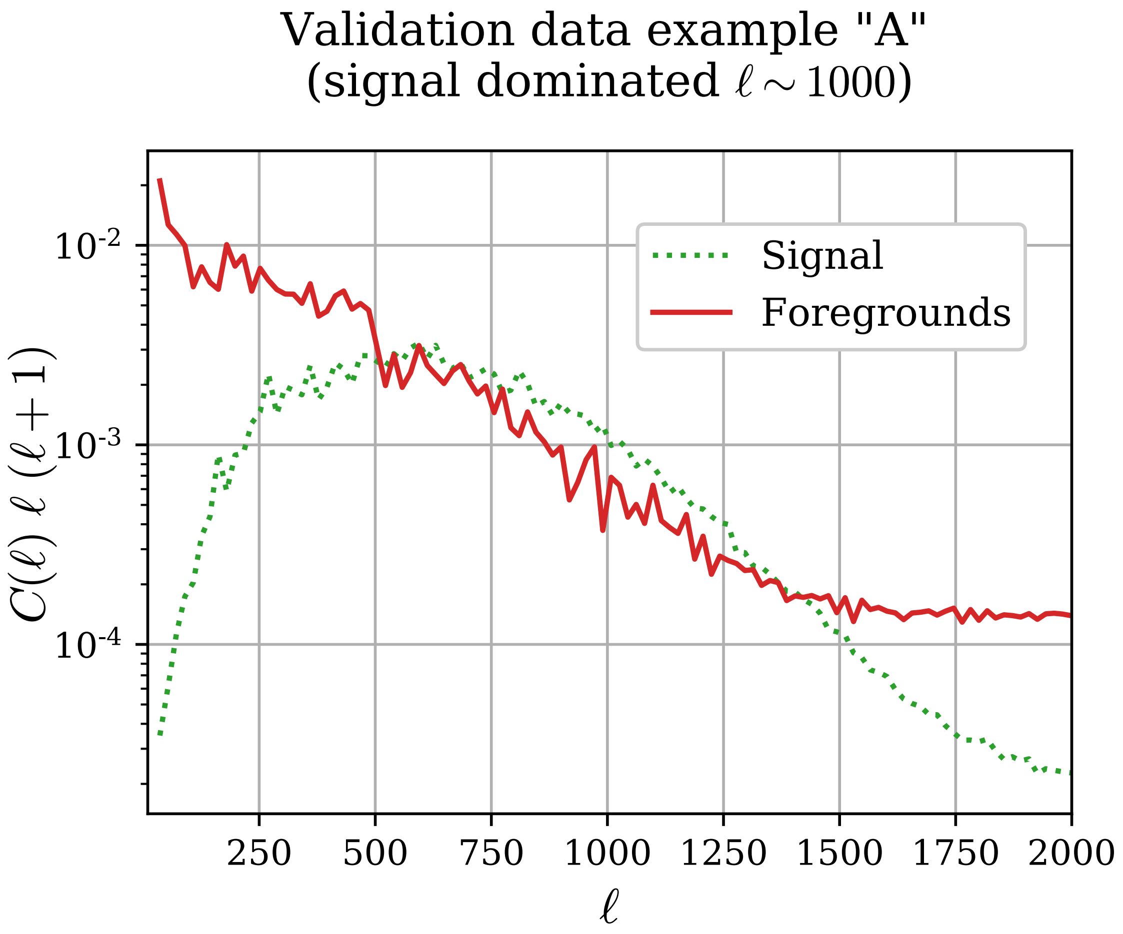
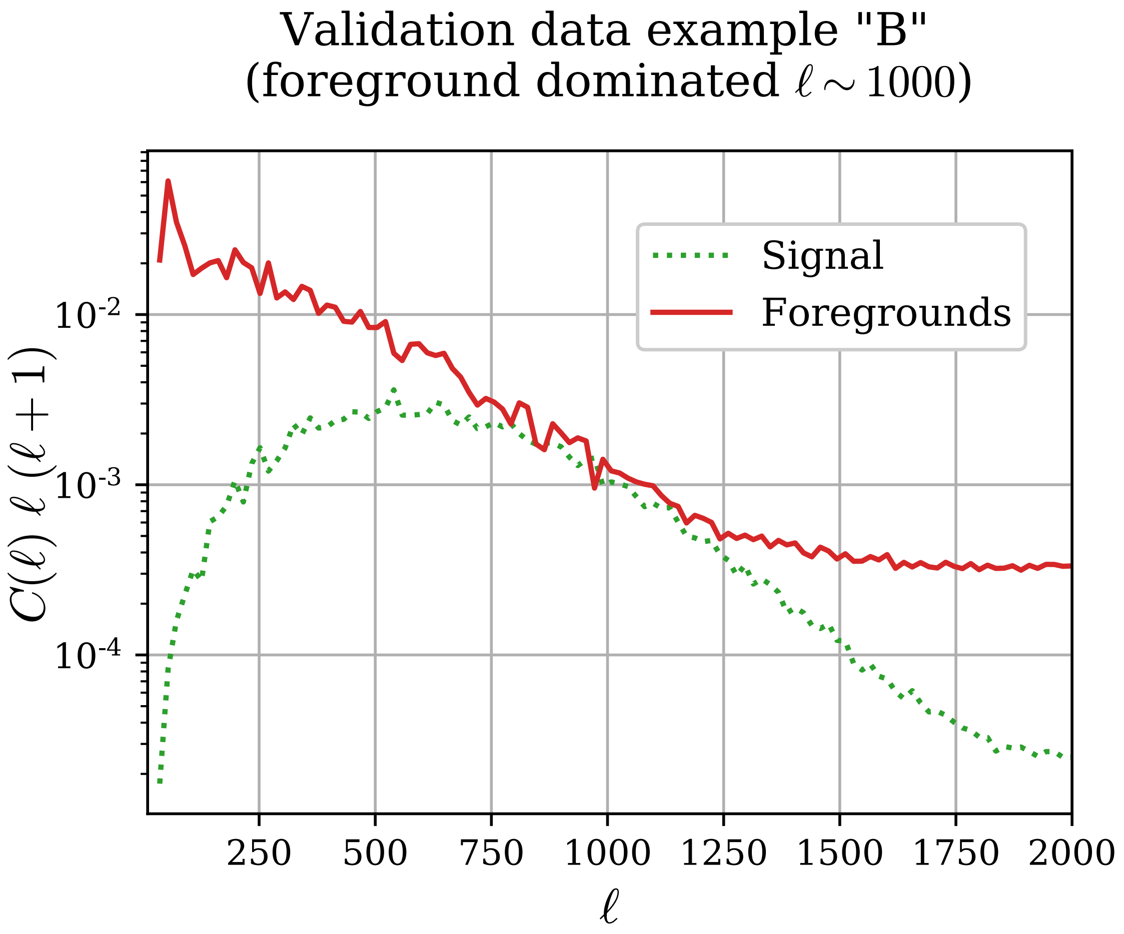
Model parameters from prior





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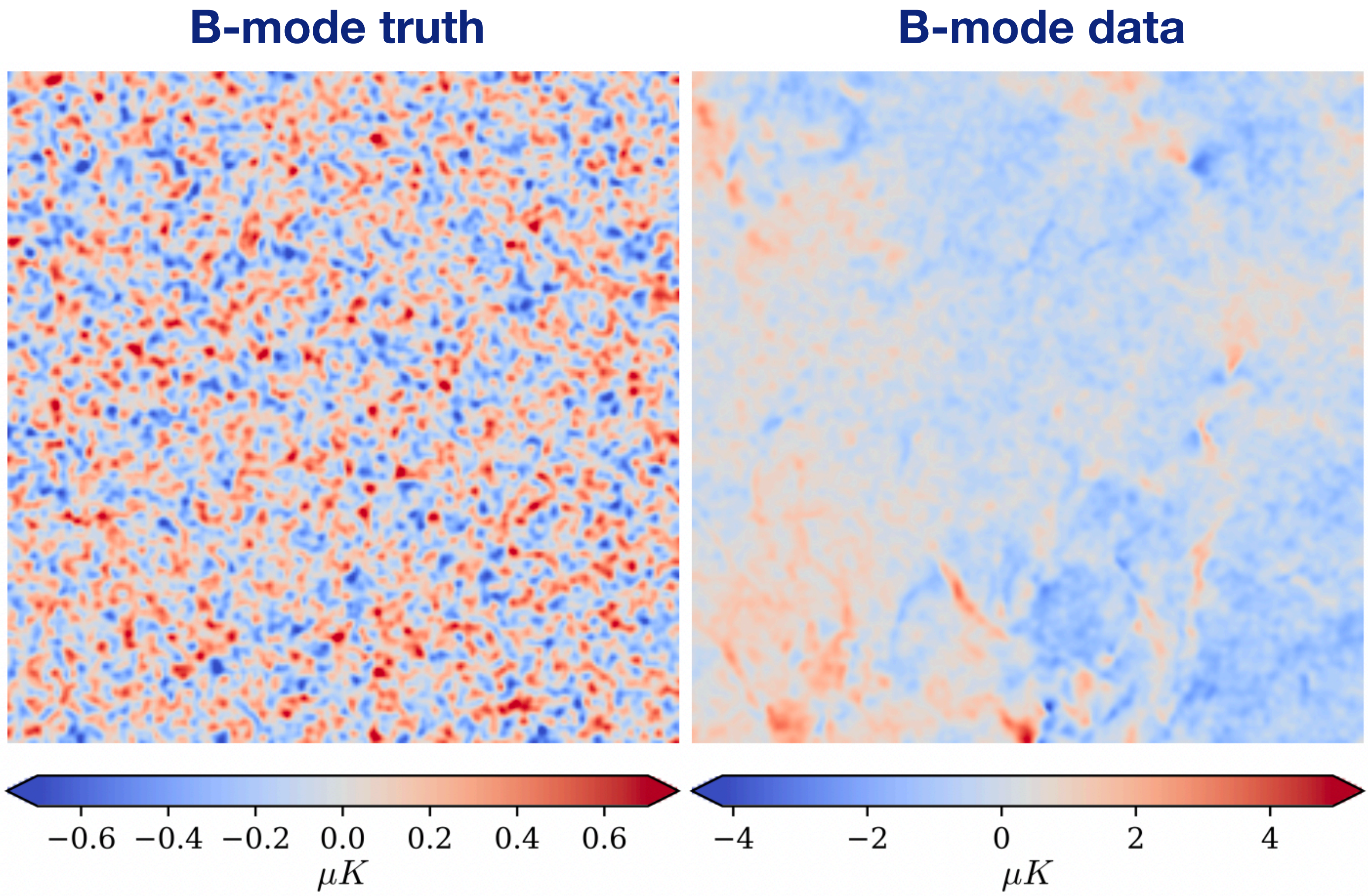
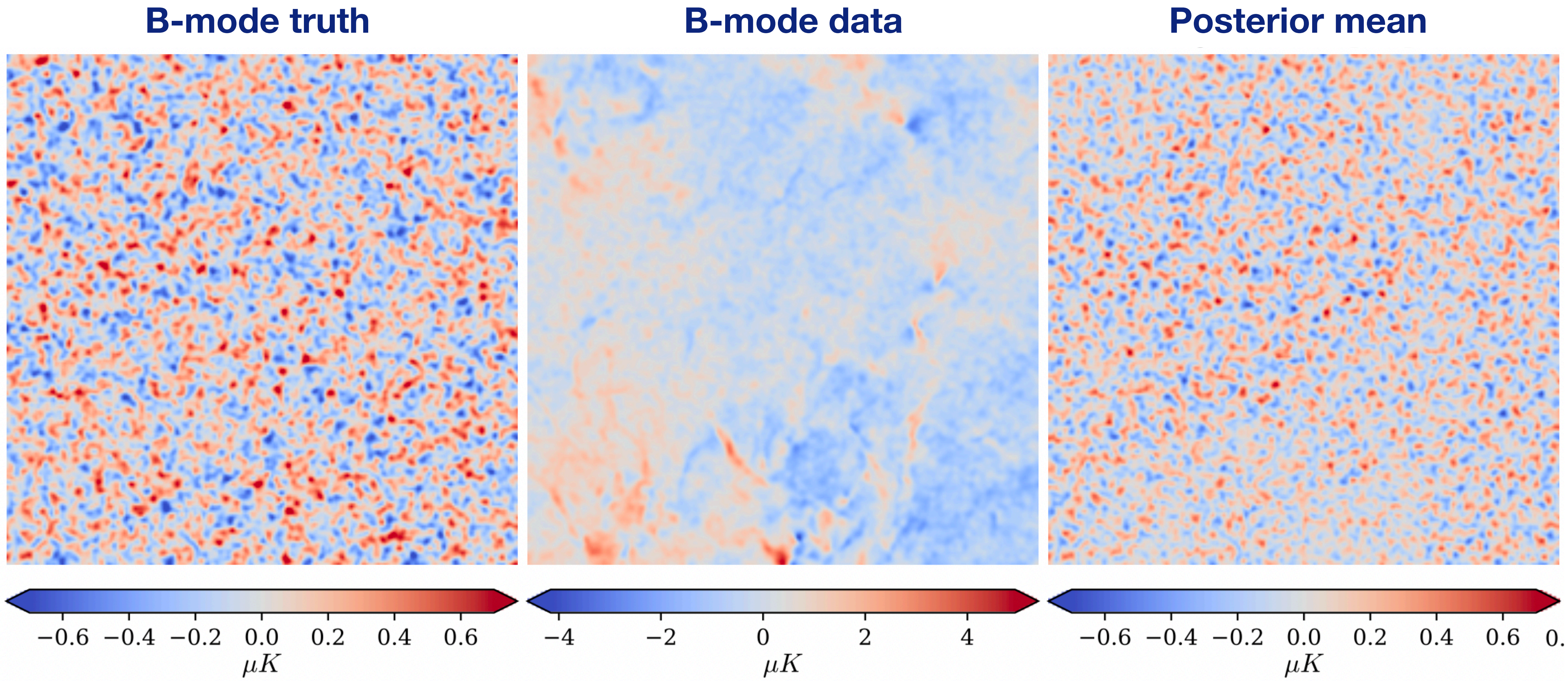
B-mode inference



B-mode inference



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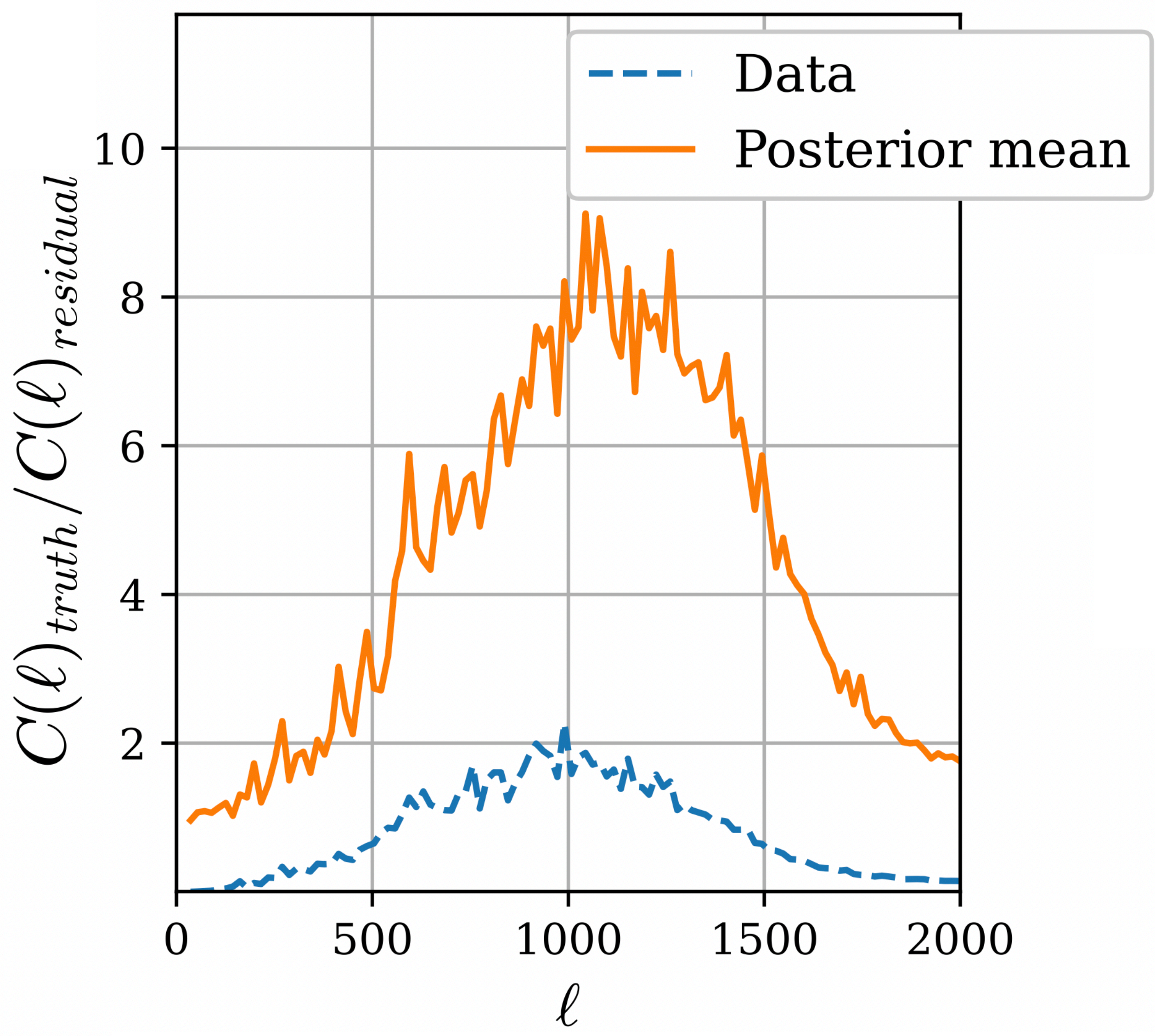
Recovered "signal-to-noise"



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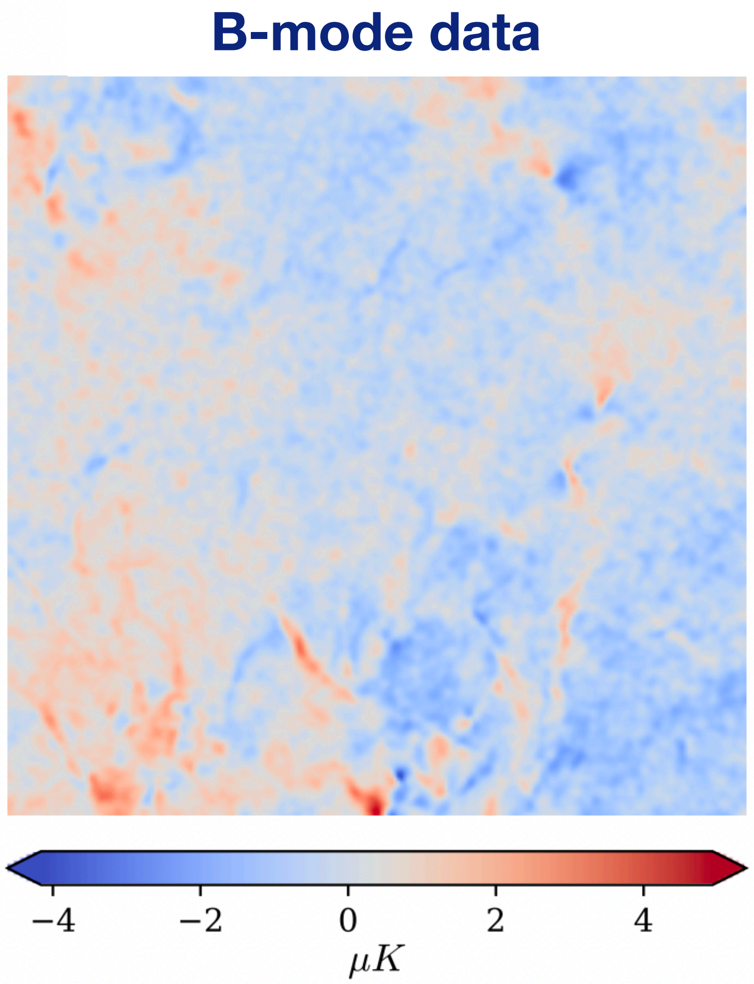
03 *Posterior validation*

How can we test the posterior?

What does the “wrong” answer look like…

Naive Gaussian model:



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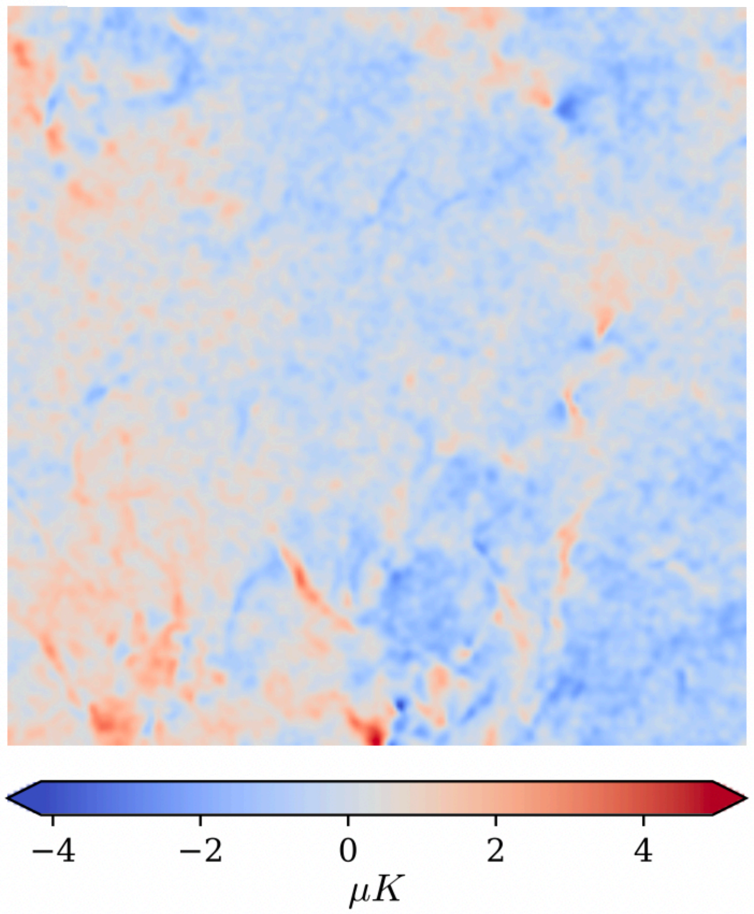
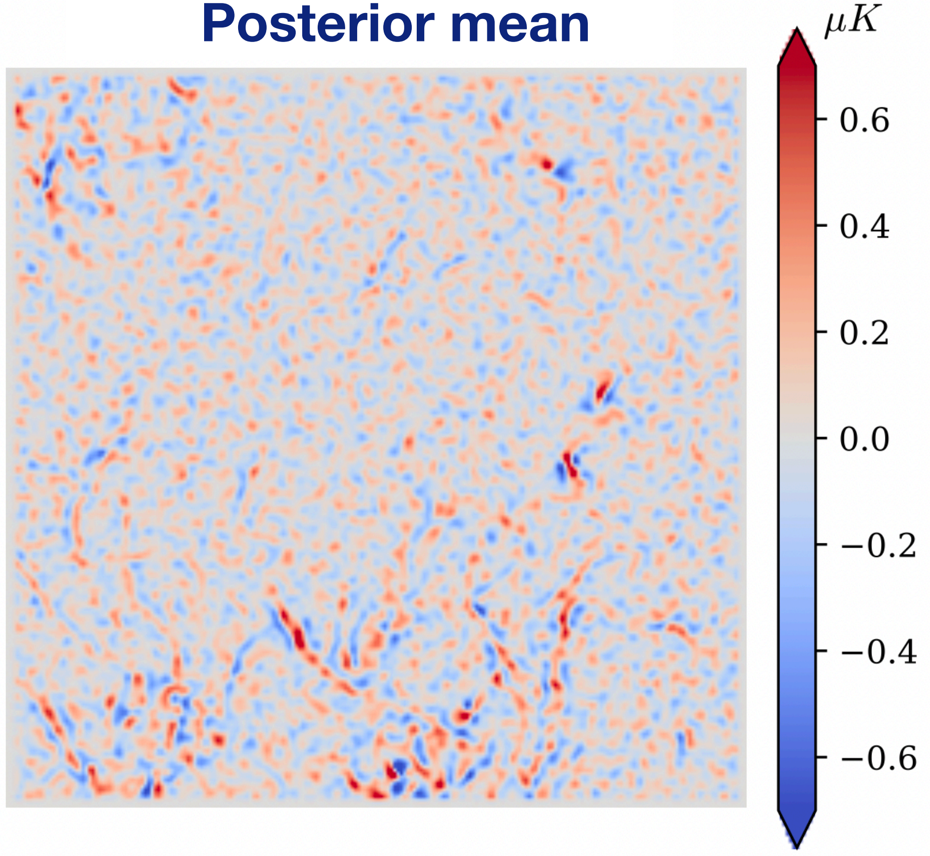
Naive Gaussian model:

B-mode data

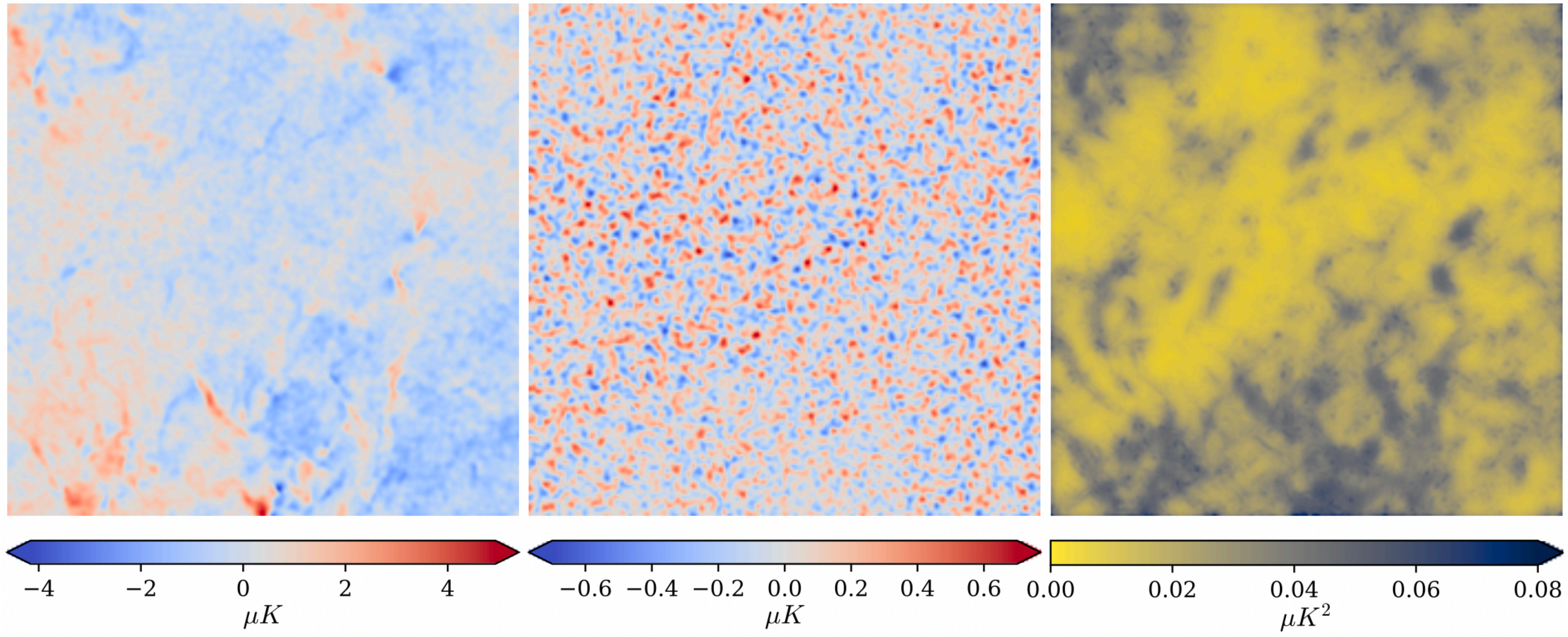


Posterior mean



Validation of posterior

B-mode data | **Posterior mean** | **Posterior marginal variance**



Rescaled residuals

$$(\mu_B - s_B)/\sigma_B$$

POSTERIOR MEAN

TRUE PIXEL VALUE

POSTERIOR VARIANCE

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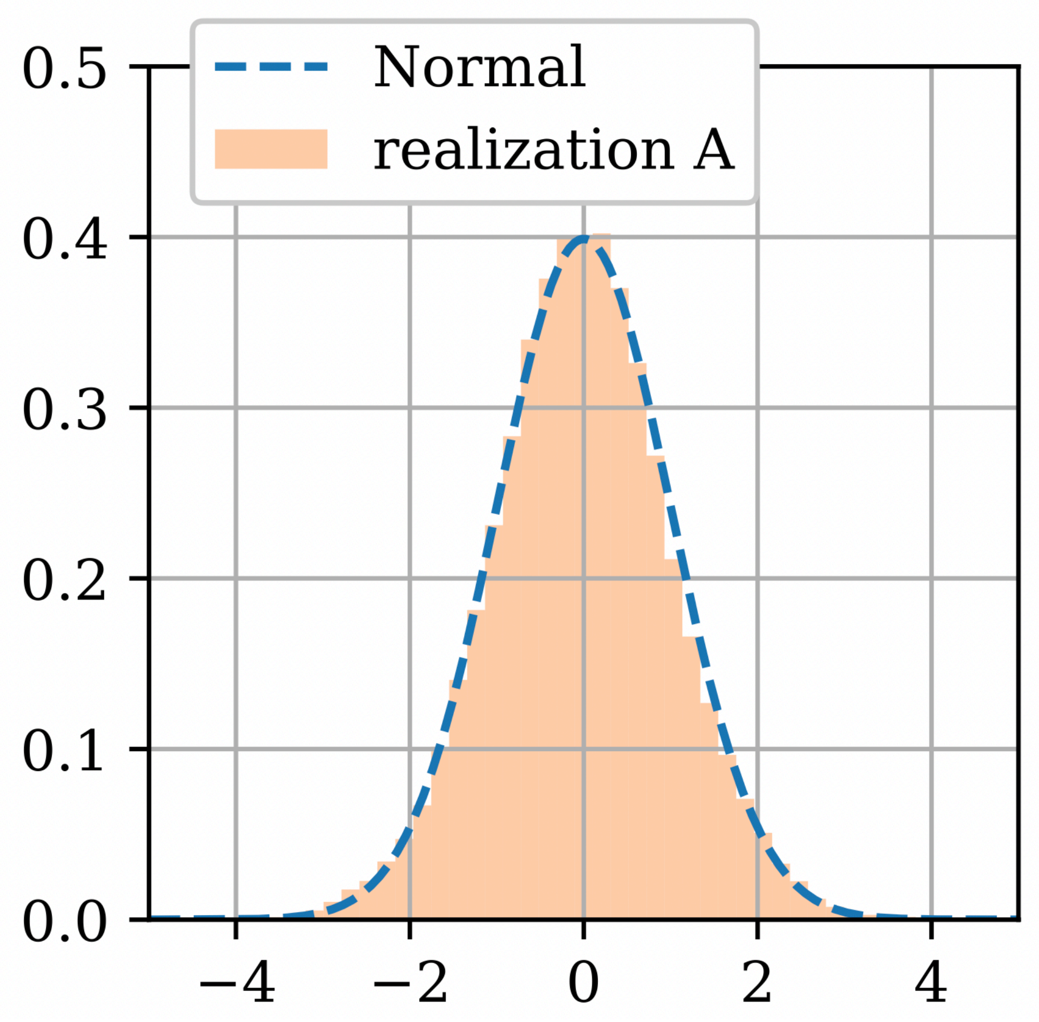
Rescaled residuals



$$(\mu_B - s_B)/\sigma_B$$

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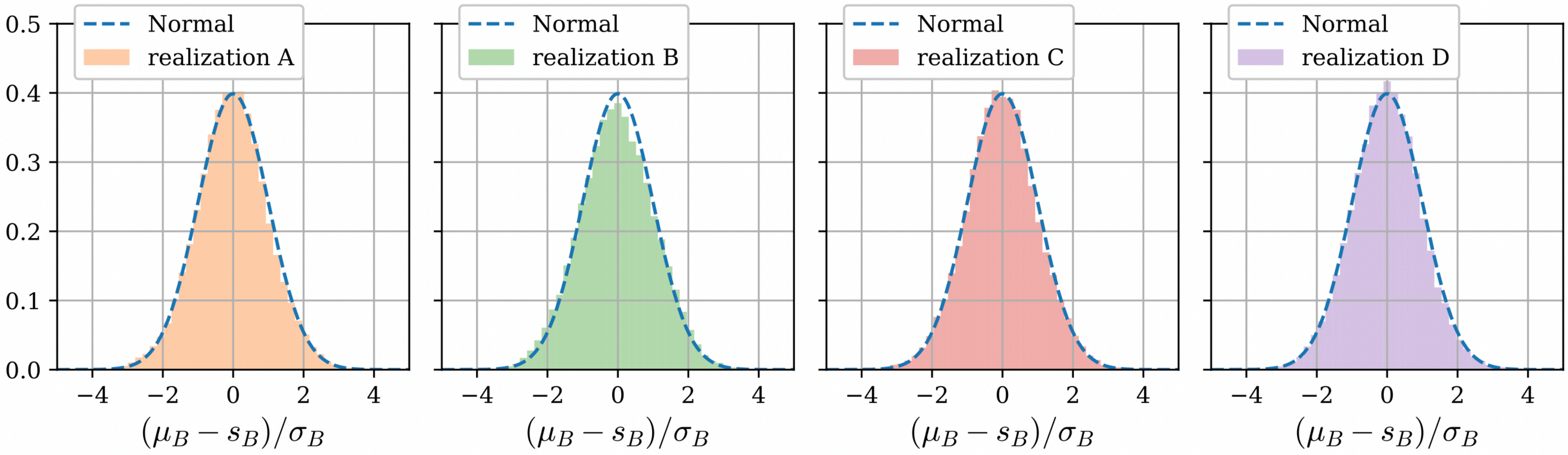
Posterior estimates are excellent:



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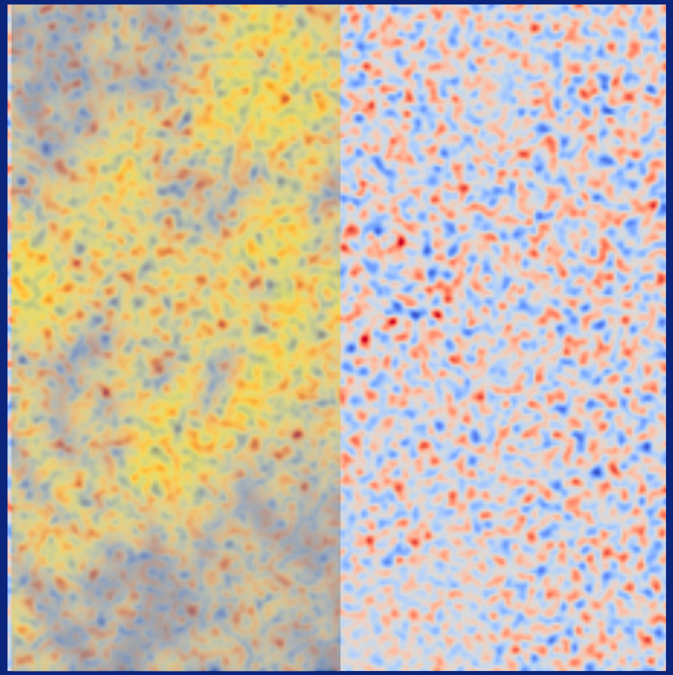
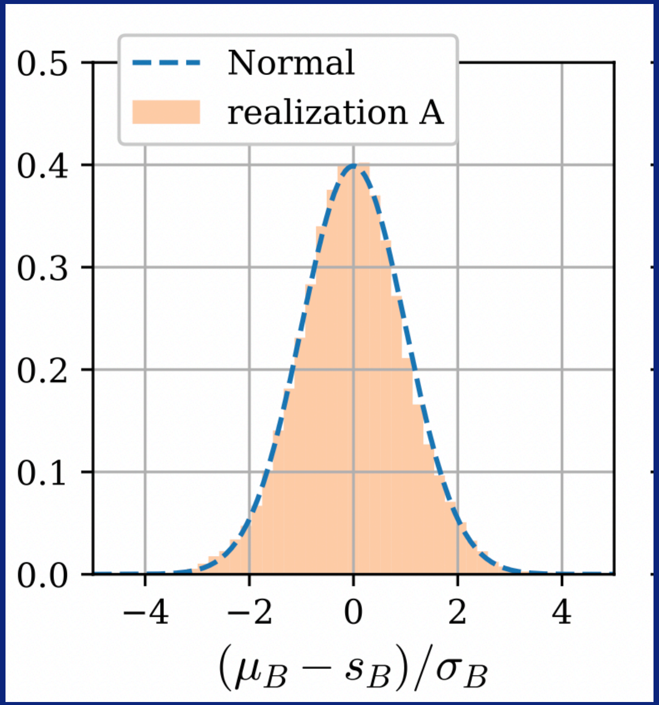


Merci !



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