Debating the benefits of **Differentiable Cosmological Simulators** for weak lensing full-field inference (LSST Y10 case study)

ML - IAP/CCA - 2023

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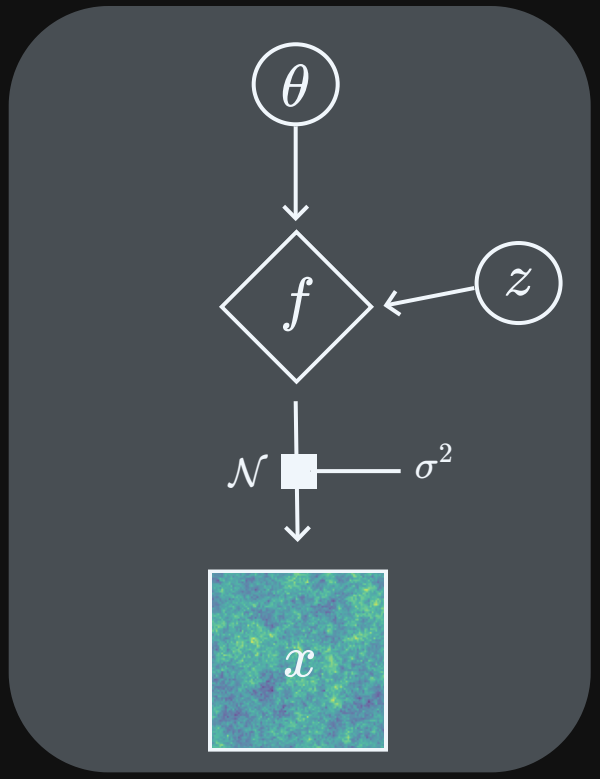
Full-field inference

Full-field inference

- Bayesian hierachical modeling

Explicit joint likelihood

$$p(x|\theta, z)$$



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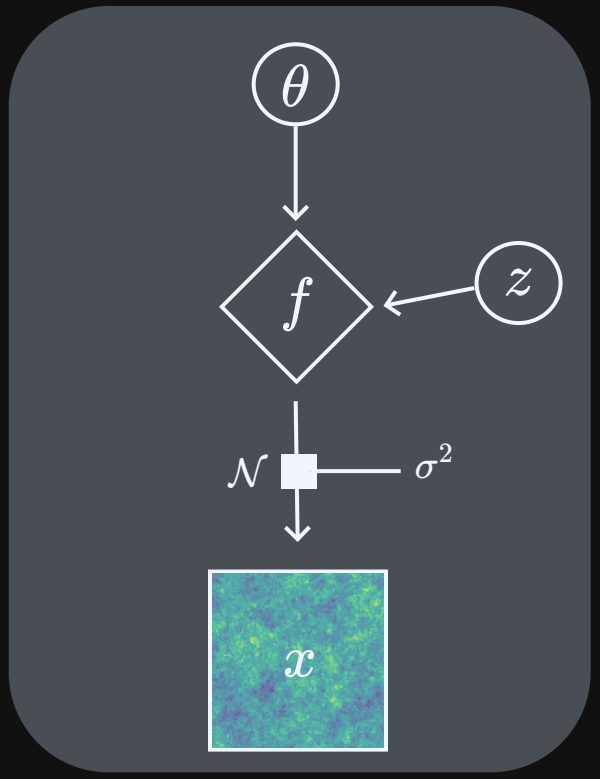

And then run an MCMC to get the posterior.

Full-field inference

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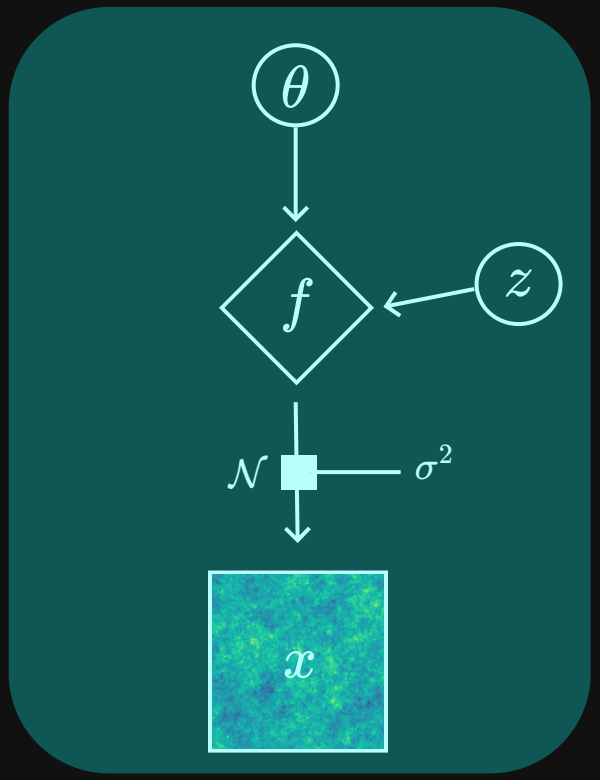


Has to be differentiable

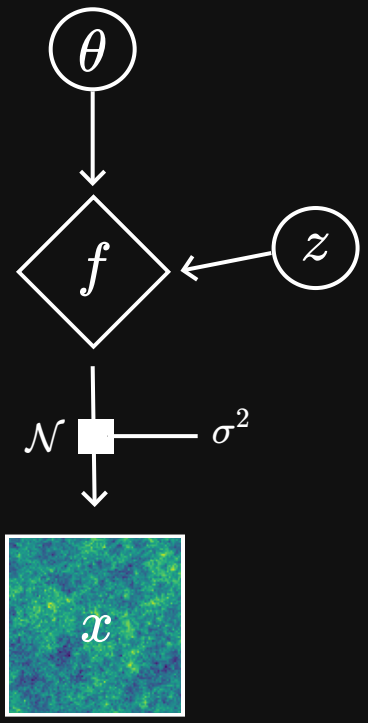
And then run an MCMC to get the posterior.

We are dealing with very high dimensional space.

$\longrightarrow$ HMC

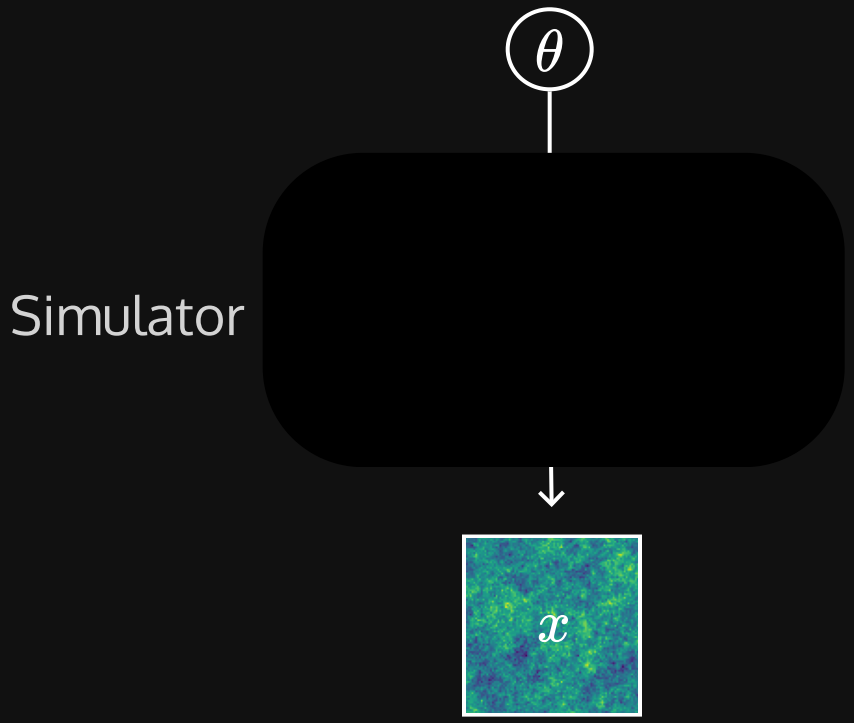
Full-field inference

- Implicit inference



Full-field inference

- Implicit inference



Full-field inference

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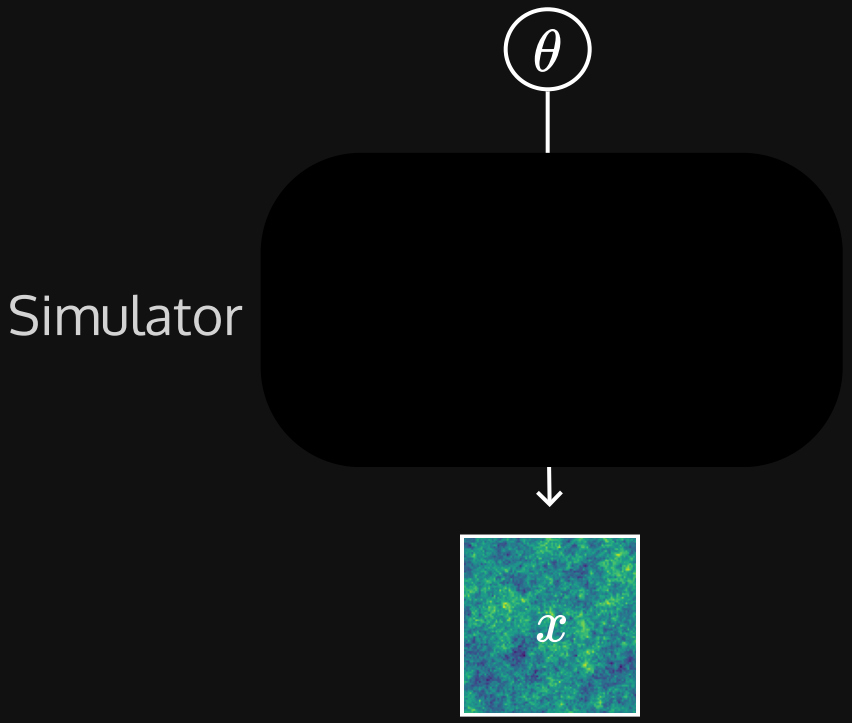
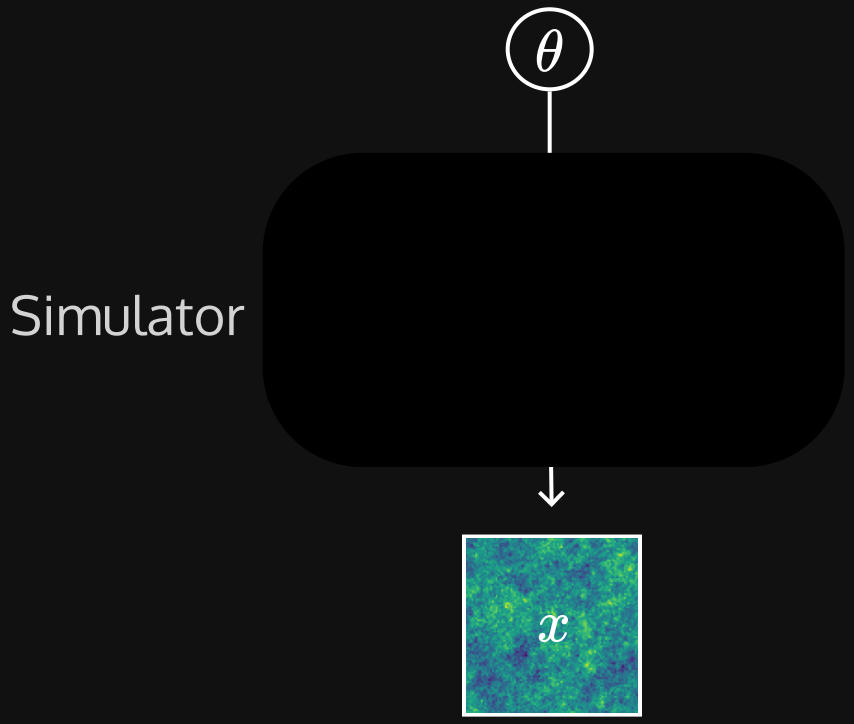


And then use an implicit inference algorithm (NPE, NLE or NRE) to approximate the posterior.

Full-field inference

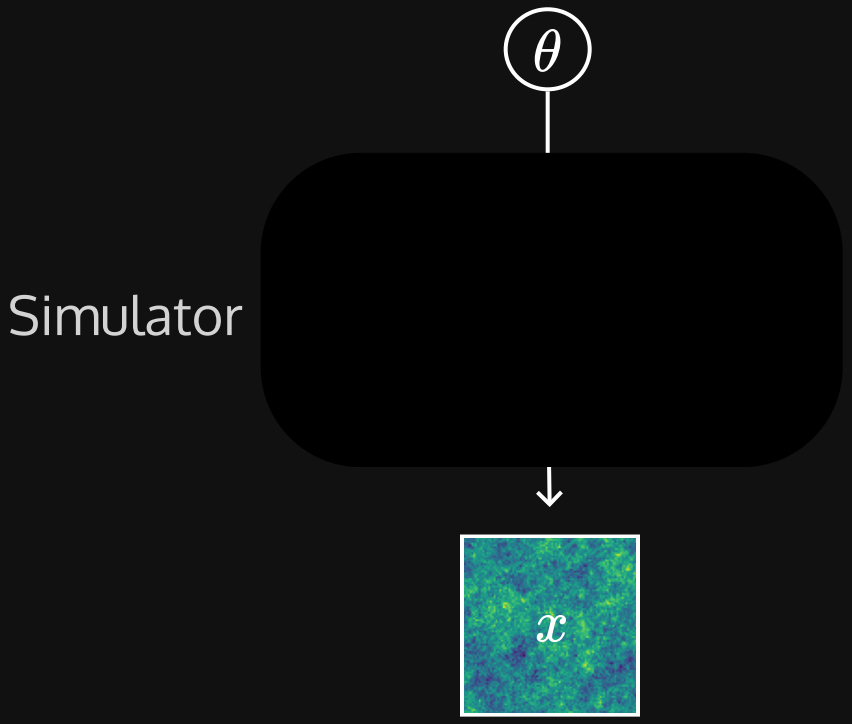
- Implicit inference



Can we extract additional information from the simulator to help reduce the number of simulations?

Full-field inference

- Implicit inference



Can we extract additional information from the simulator to help reduce the number of simulations?

Yes! The gradients $\nabla_\theta \log p(x, z|\theta)$

Full-field inference

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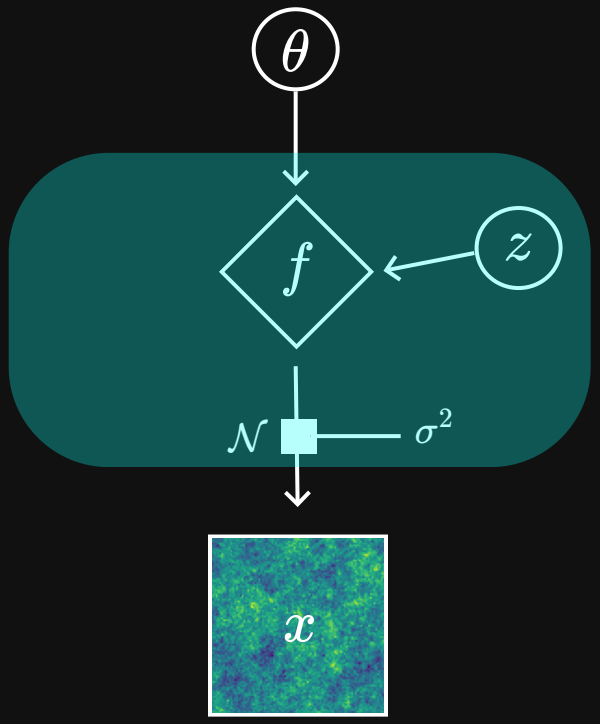
Differentiable Simulator



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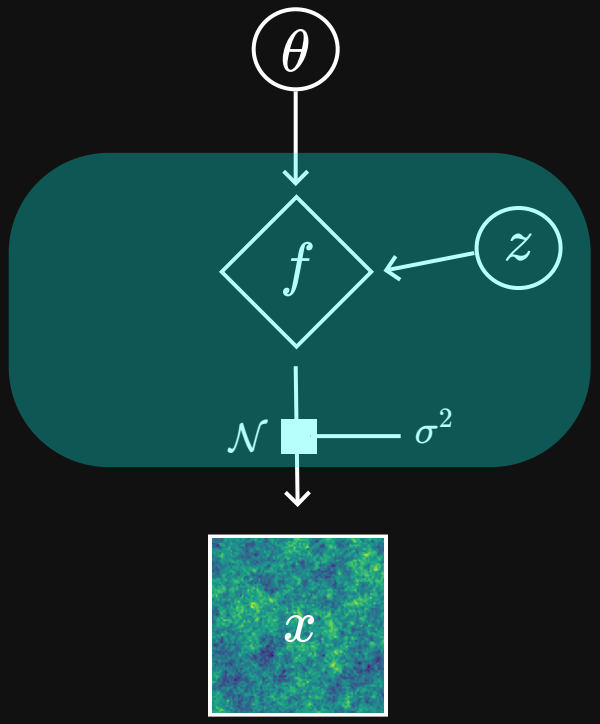
Brehmer et al. 2019 & *Zeghal et al. 2022*, introduced methods to leverage gradient information while doing NRE, NLE and NPE.

Full-field inference

- Implicit inference

Differentiable Simulator



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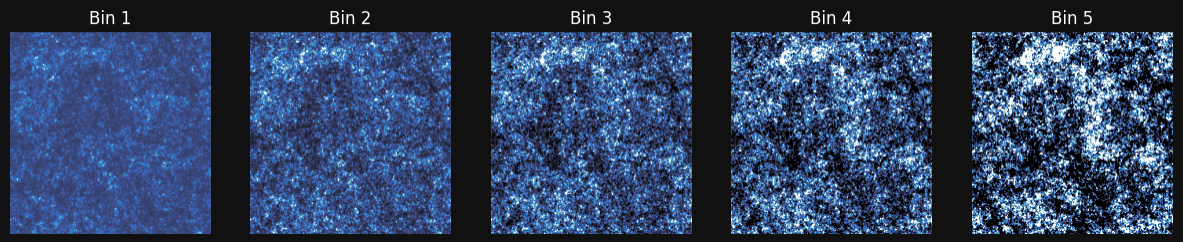
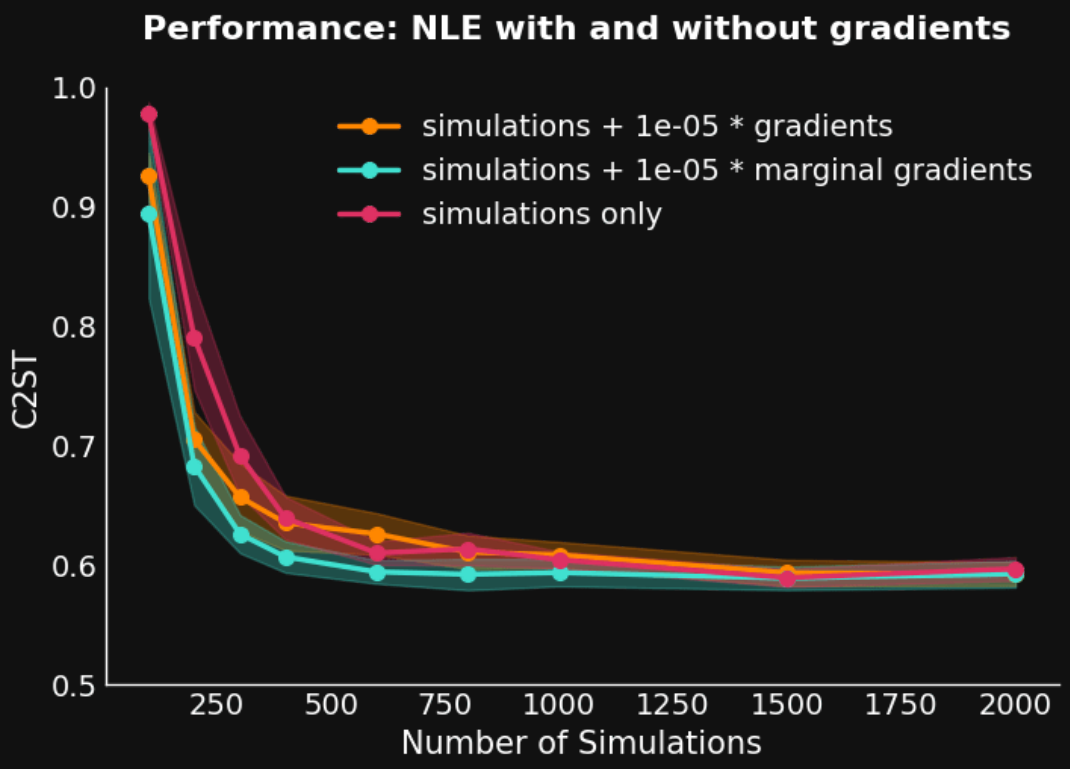
For our benchmark

`sbi_lens`

Log-normal LSST Y10 like differentiable simulator



- do gradients help implicit inference methods ?



Zeghal et al. (in prep)

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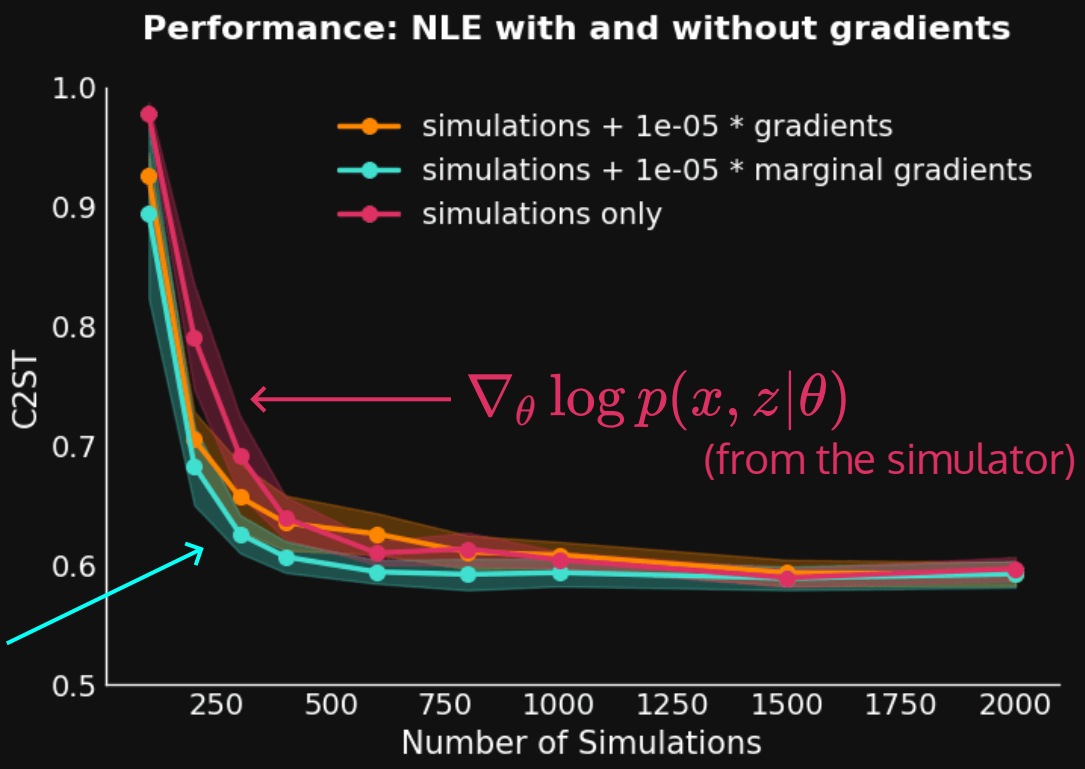

$\nabla_\theta \log p(x|\theta)$

(requires a lot of simulations to have it)

Zeghal et al. (in prep)

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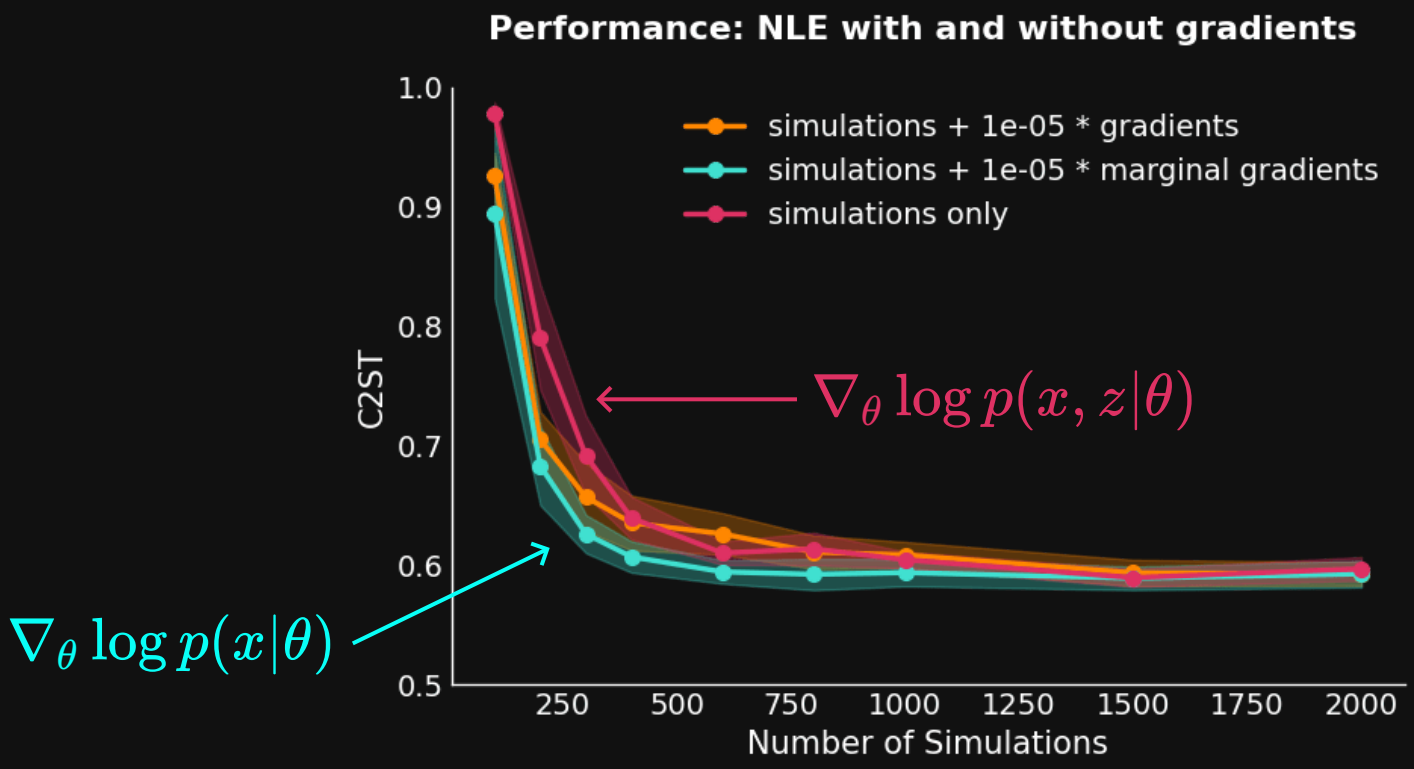
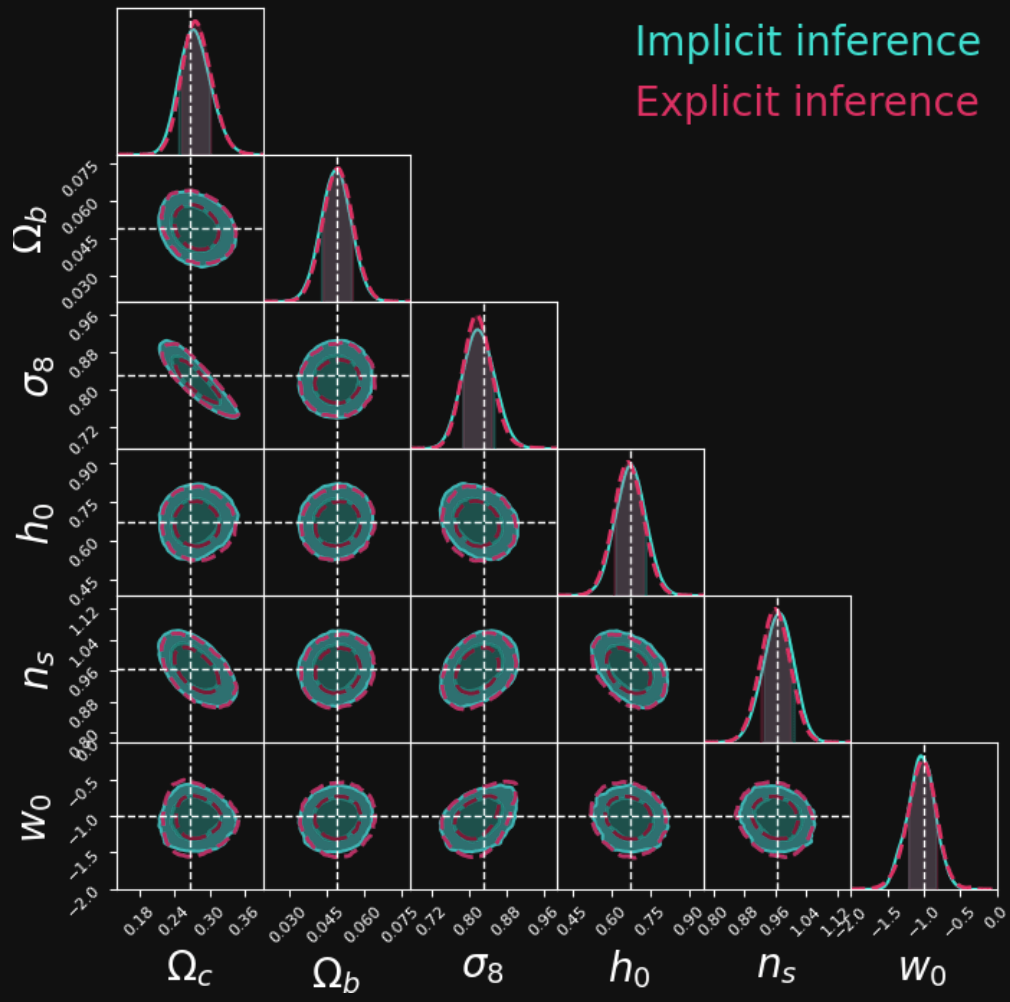


The gradients from the simulator $\nabla_\theta \log p(x, z|\theta)$ are too noisy to help.

Zeghal et al. (in prep)

- which inference method requires the fewer simulation?



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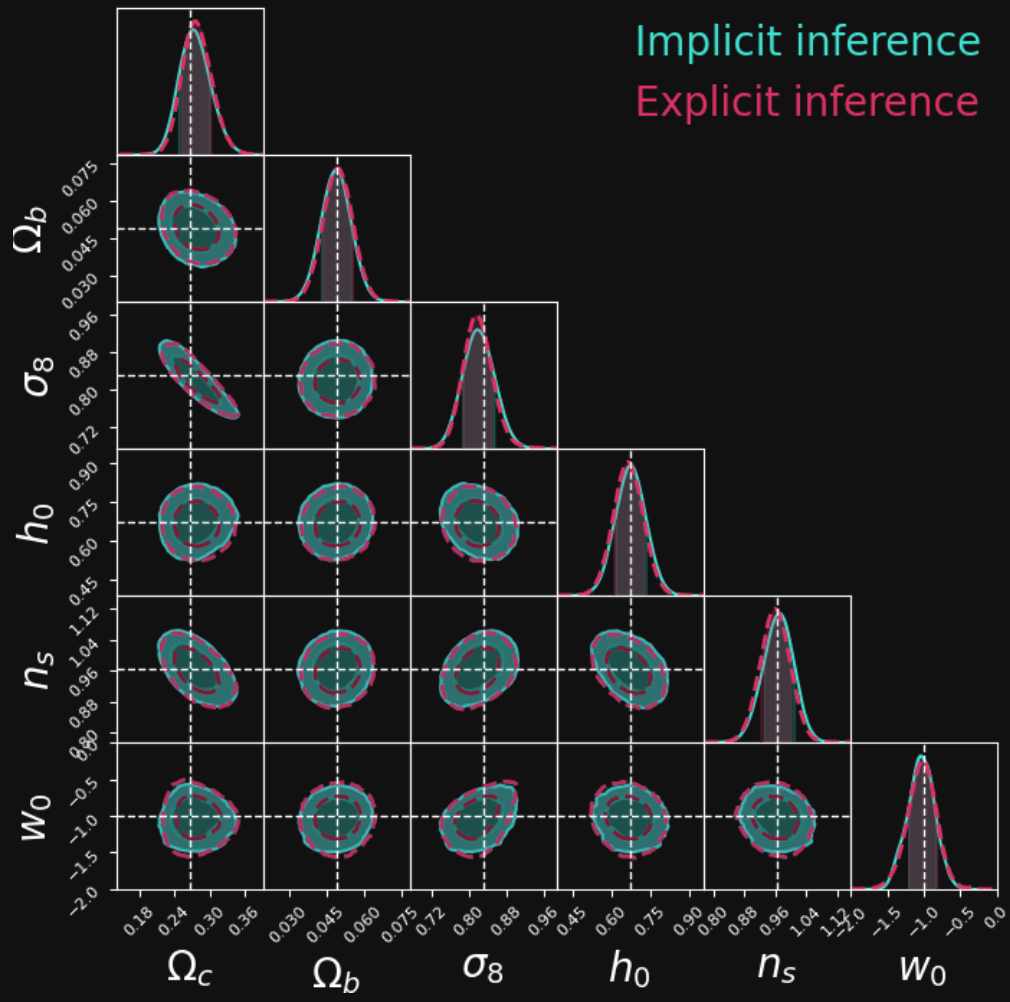

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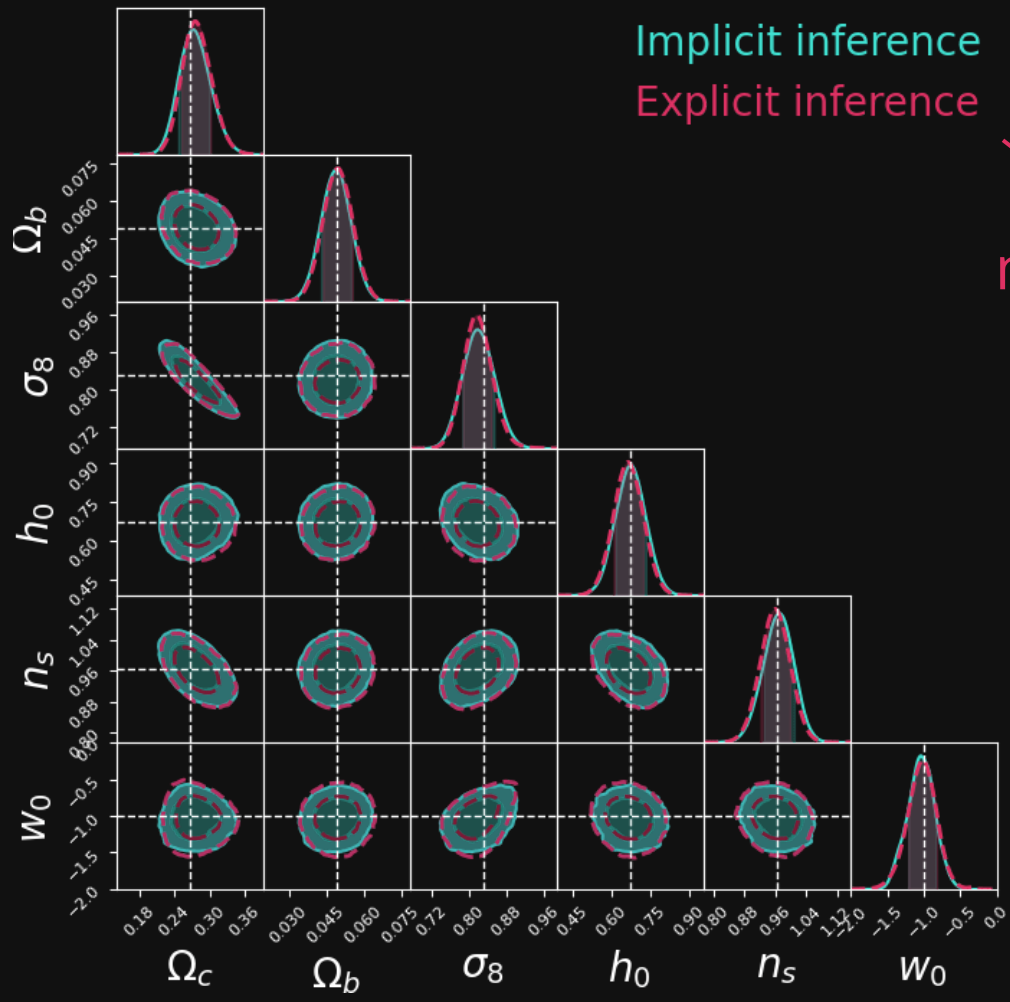


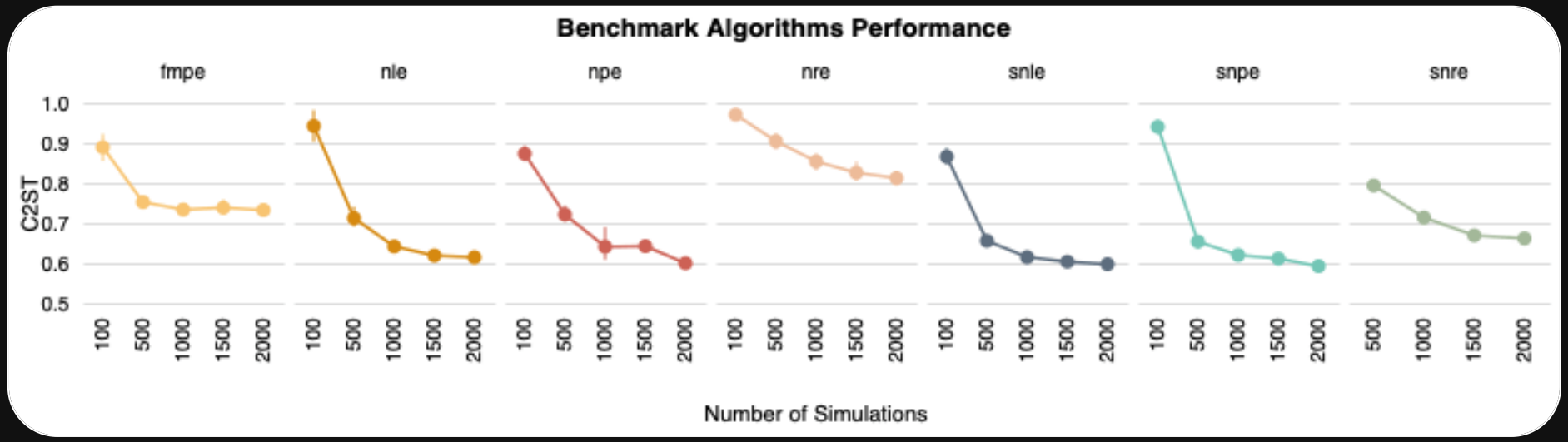
Implicit inference ⟶ 1000 simulations

Explicit inference ⟶ more than 10^6 simulations

Zeghal et al. (in prep)

- which inference method requires the fewer simulation?

  ⟶ Focus on implicit inference methods



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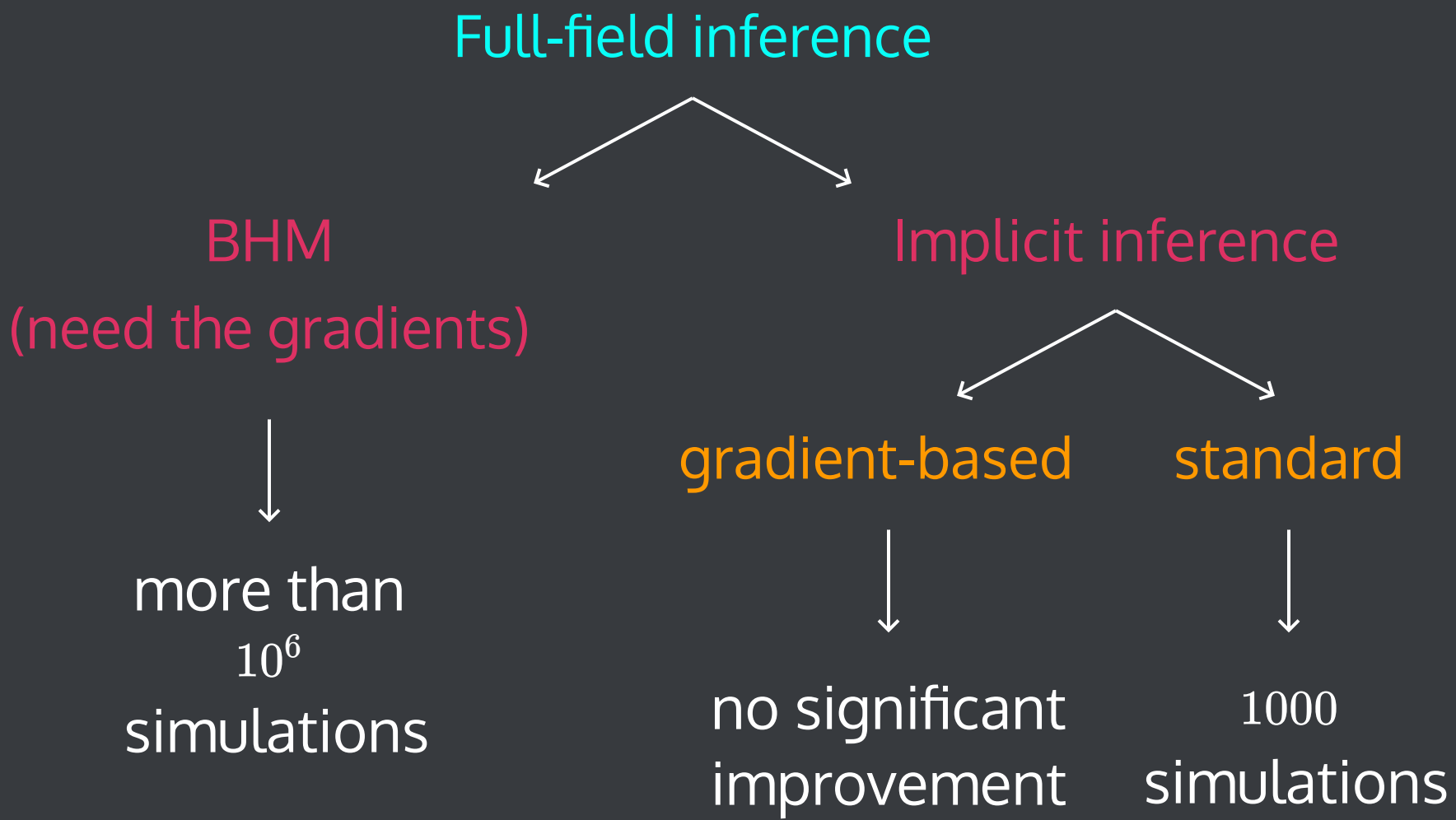
Takeaways


Full-field inference
BHM
(need the gradients)
Implicit inference
gradient-based
standard
more than
10^6
simulations
no significant
improvement
1000
simulations