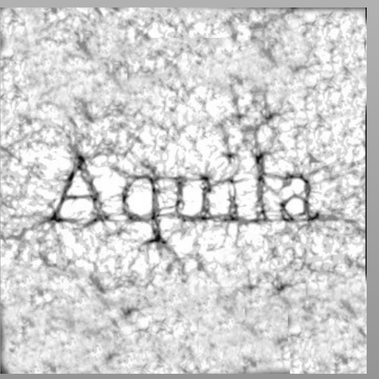
Bayesian field-level inference of primordial non-Gaussianity

Adam Andrews

Jens Jasche, Guilhem Lavaux, Fabian Schmidt

arxiv: 2203.08838



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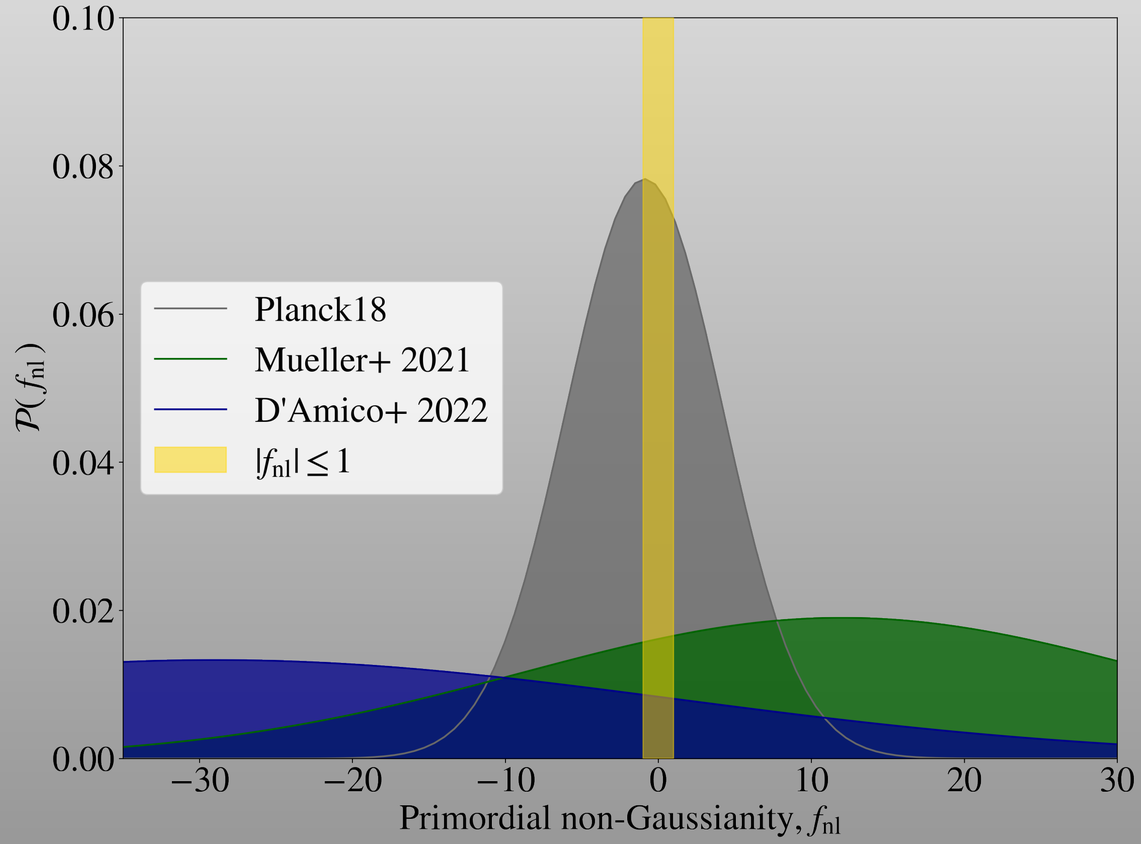

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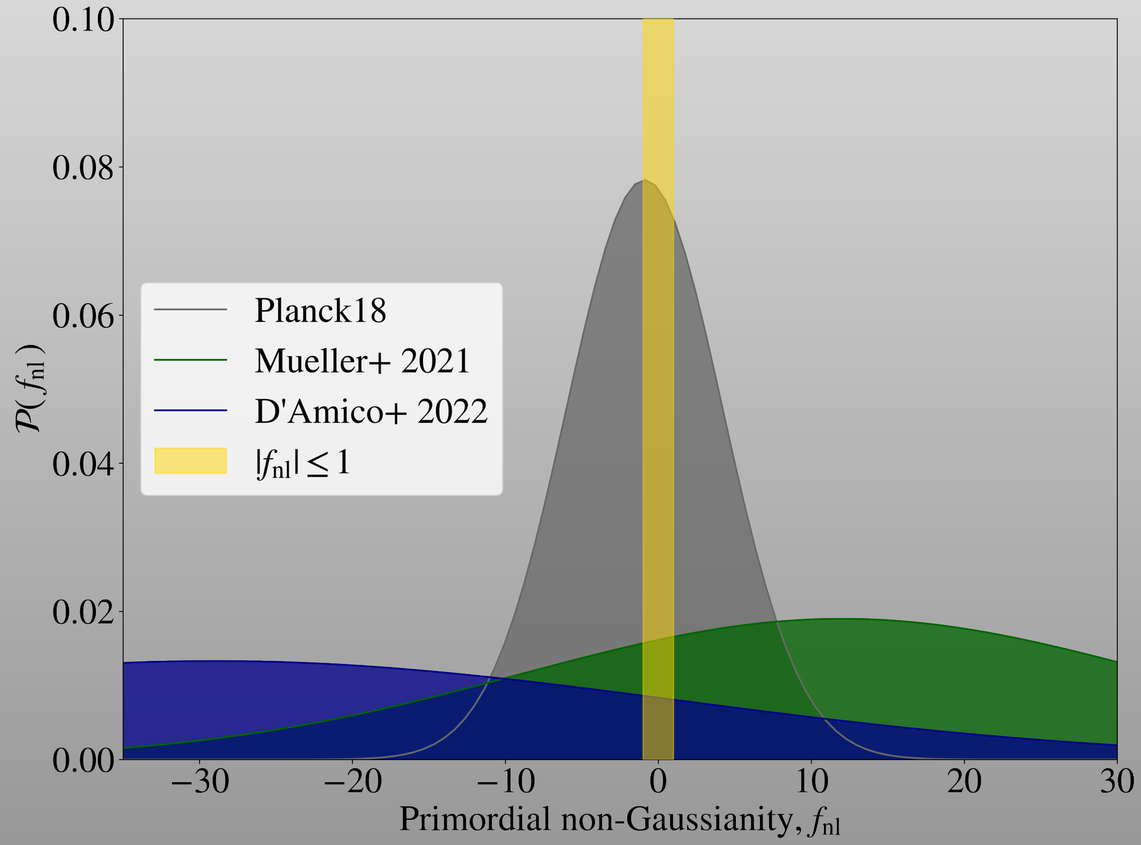

*Planck 2018

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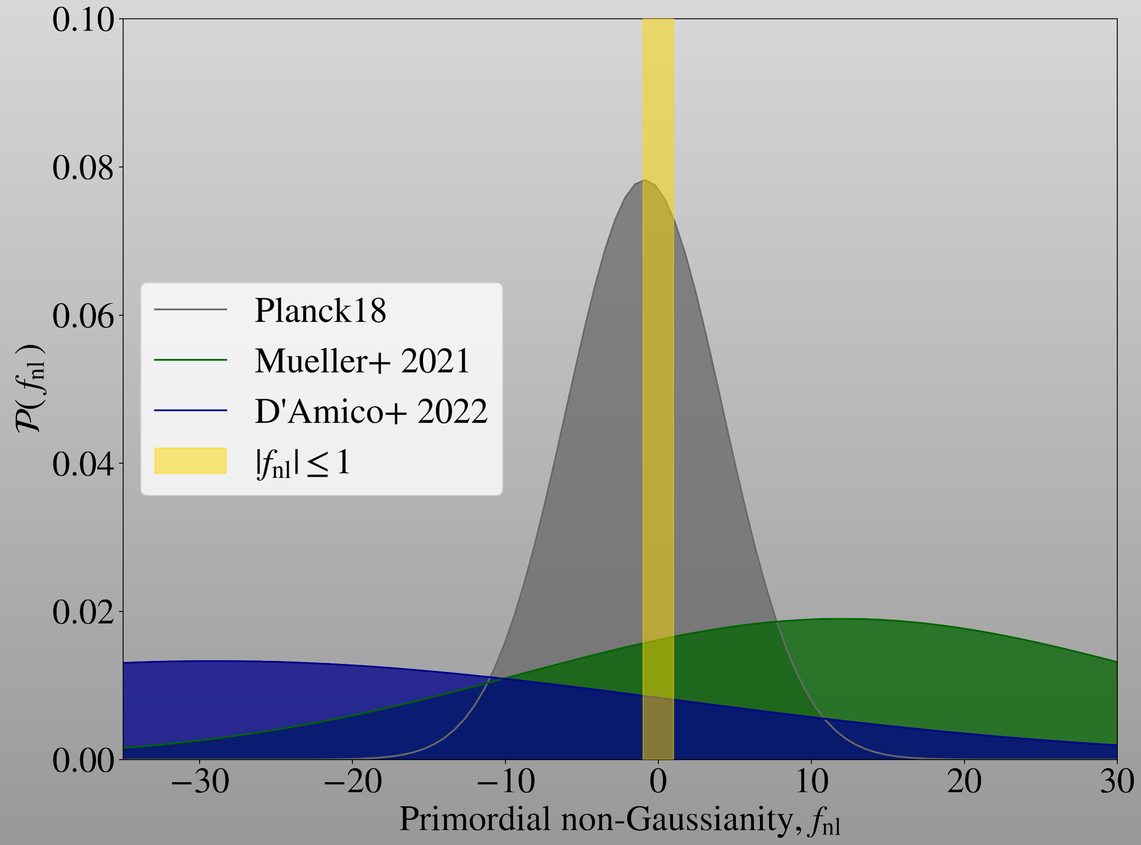

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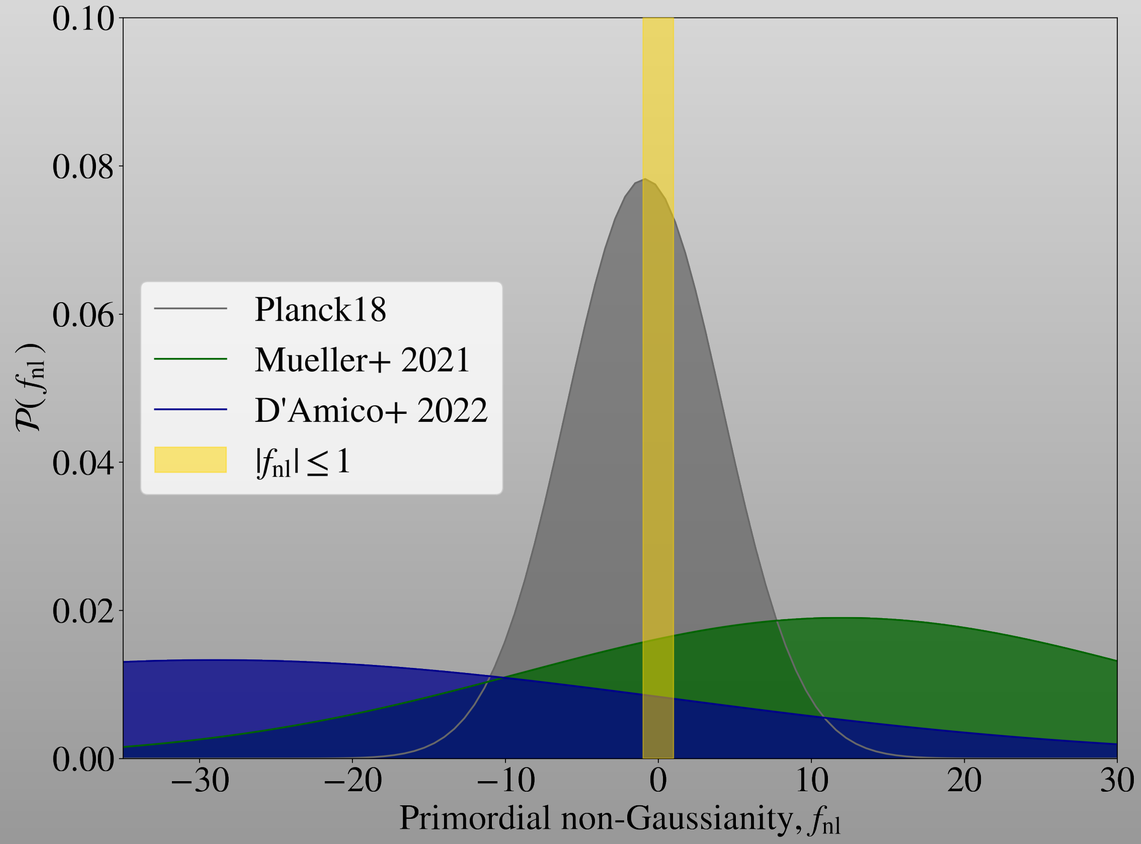

*Planck 2018 **LSST Science Book v. 2.0 & Euclid ASR

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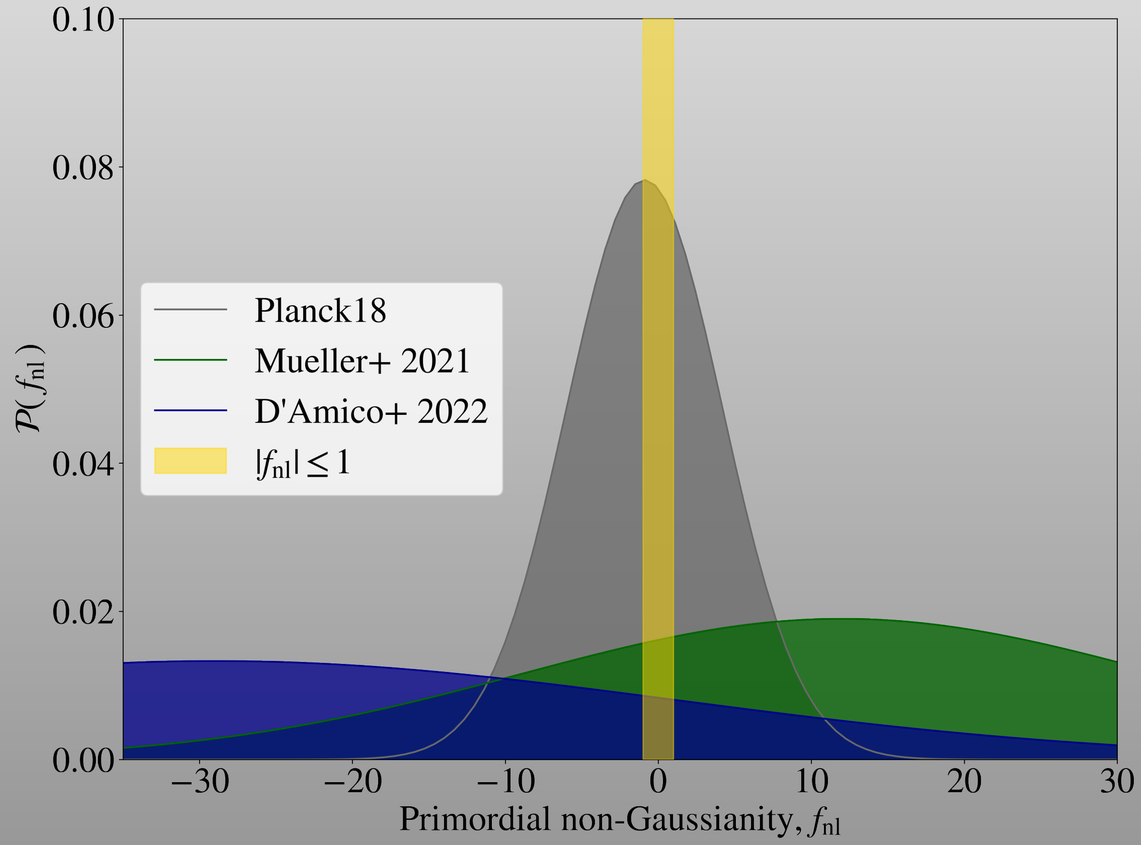
Current LSS constraints
(Bispectrum + Power spectrum)***:

SDSS3***: $f_{\rm nl} = -30 \pm 29$

SDSS4****: $f_{\rm nl} = -12 \pm 21$



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***D'Amico et al. 2022 ****Mueller et al. 2021

How does f_{nl} affect the cosmic field?

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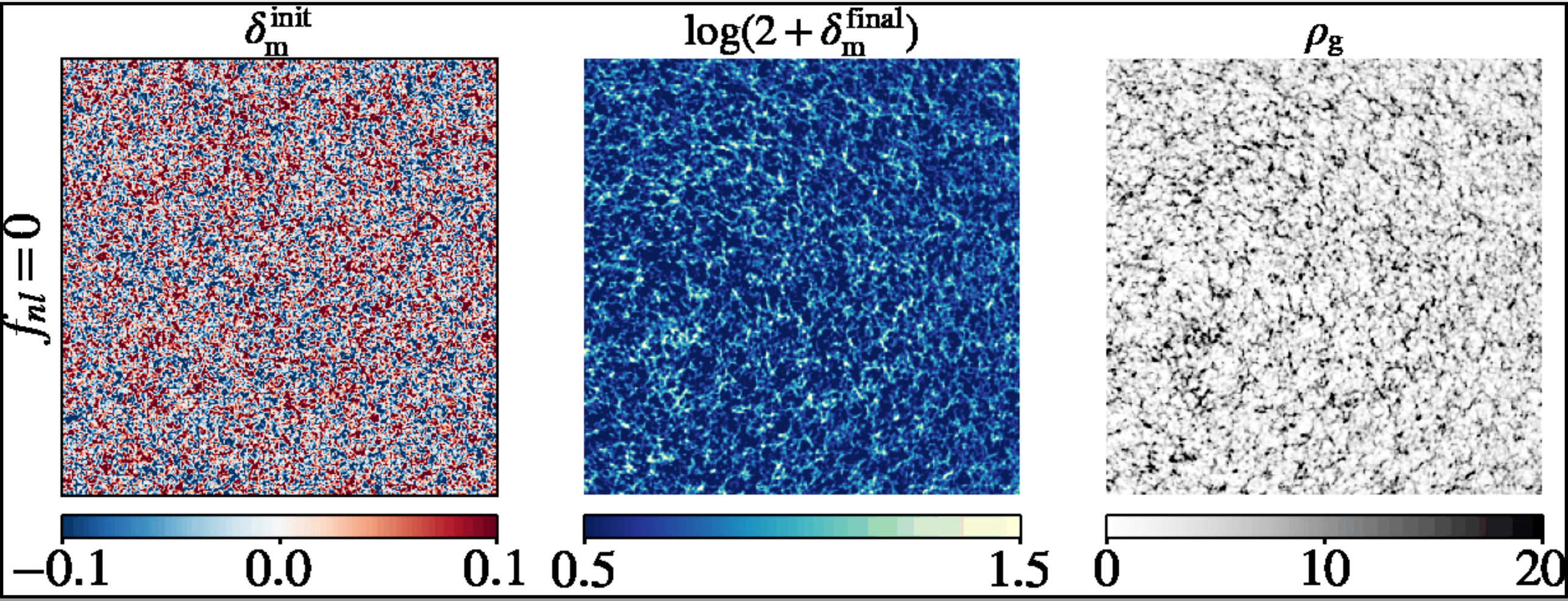

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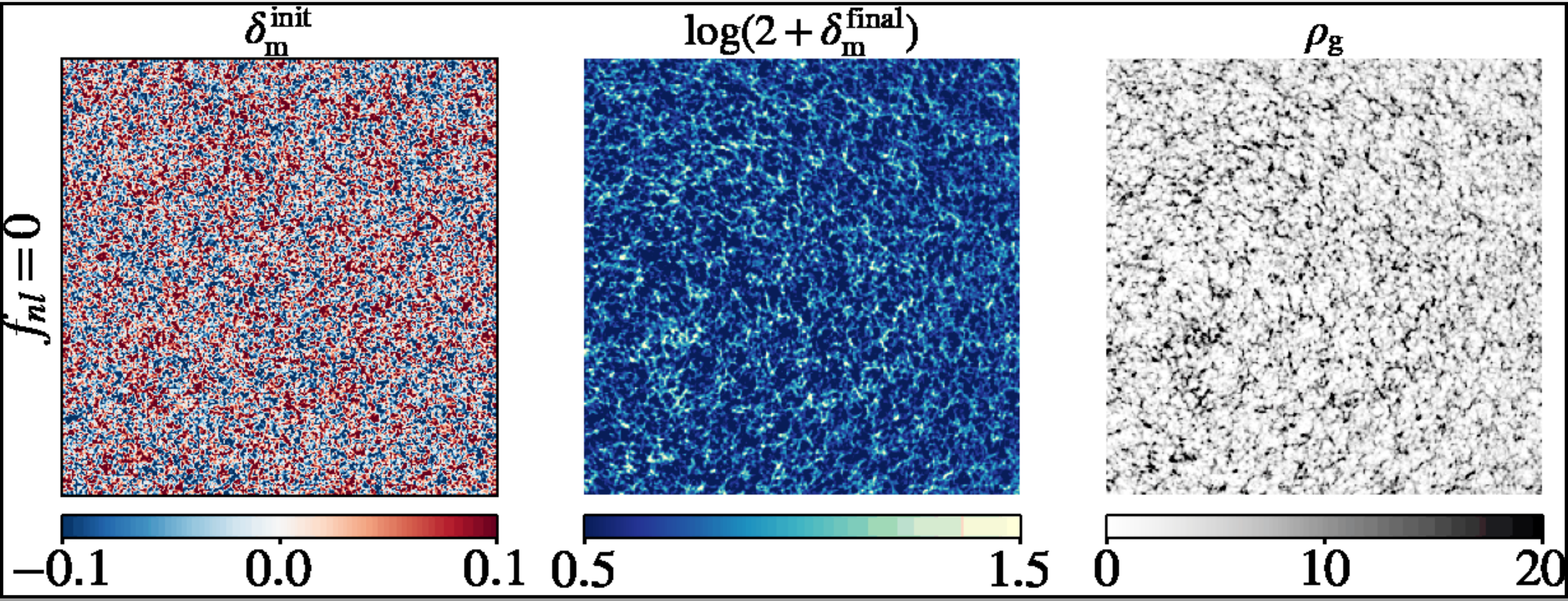

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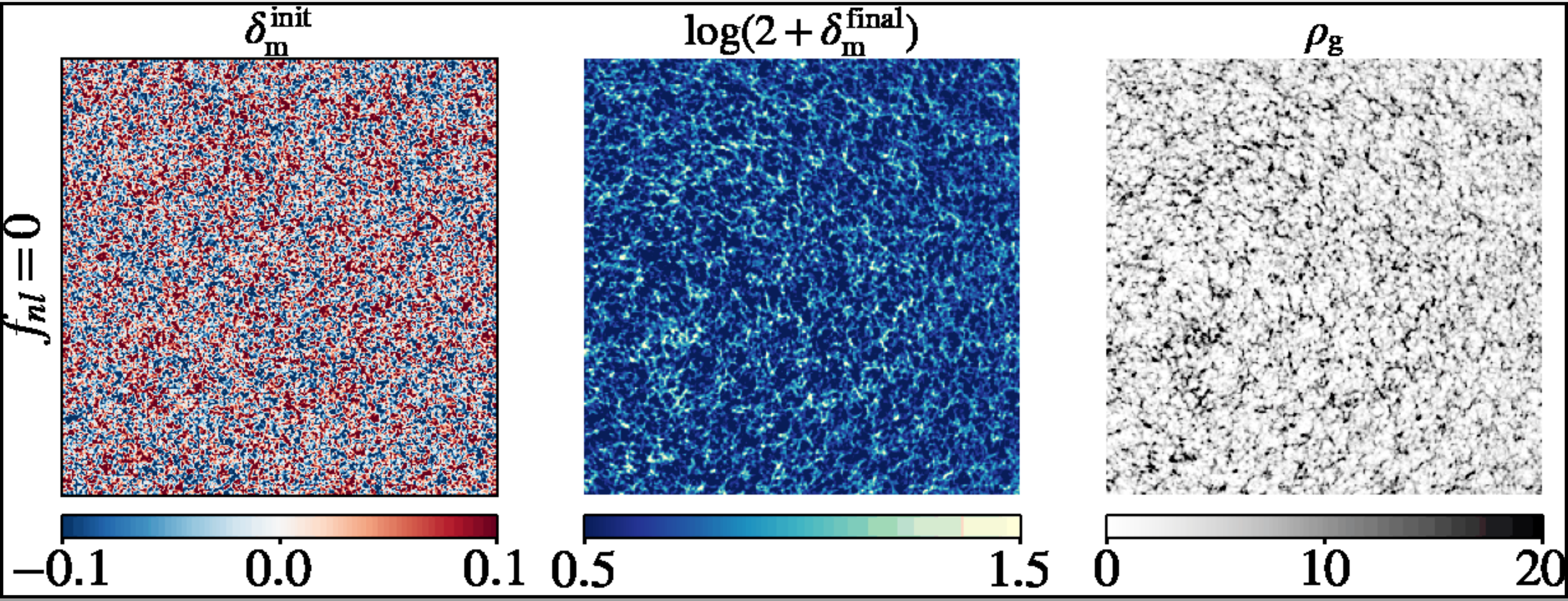

~~**Summary statistics:**~~

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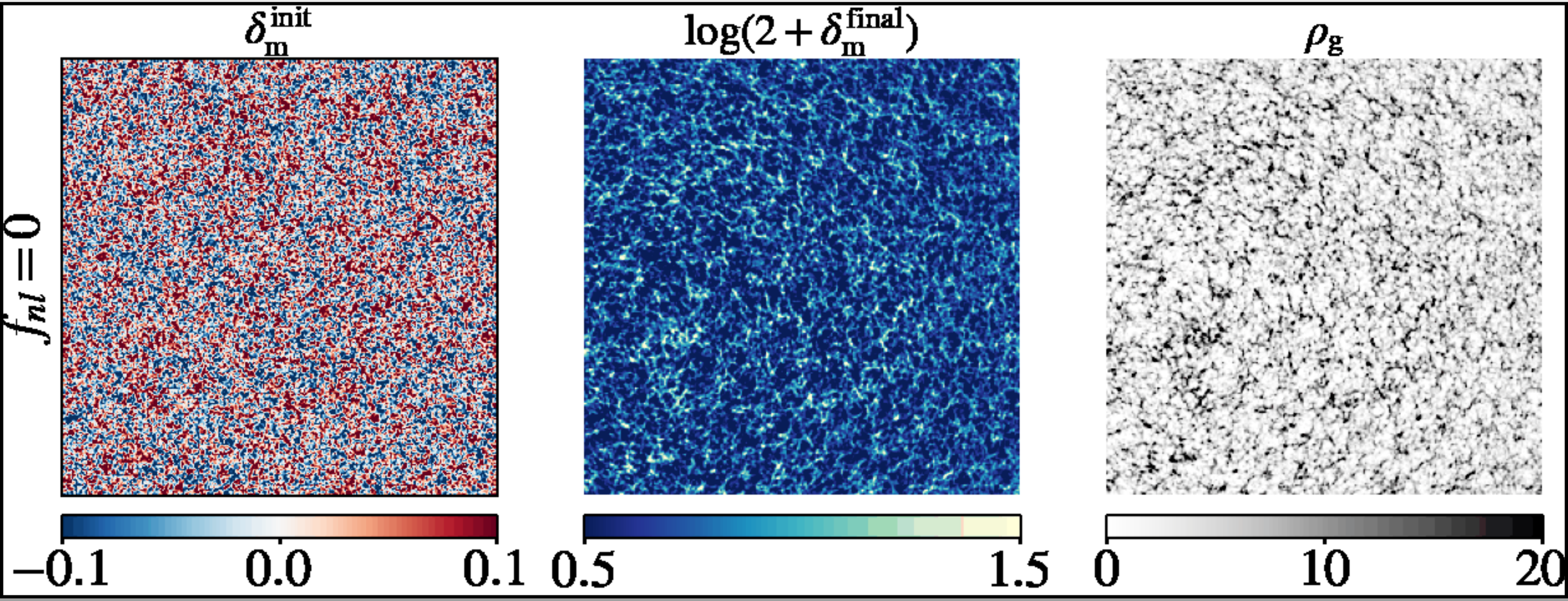

~~**Summary statistics:**~~

Goal: ***Fit the full cosmic field***

Field-level inference

1) Forward model

2) Statistical inference

Field-level inference

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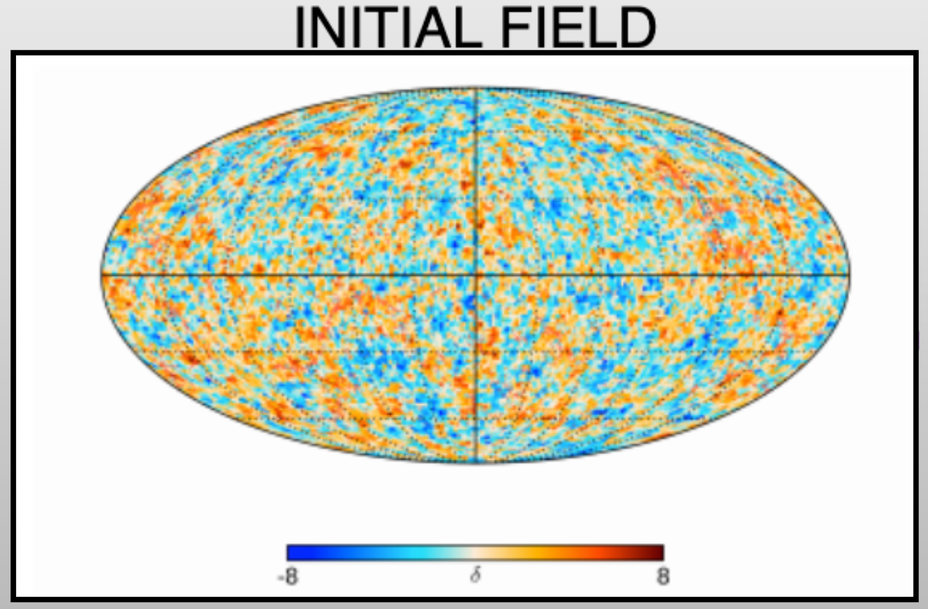

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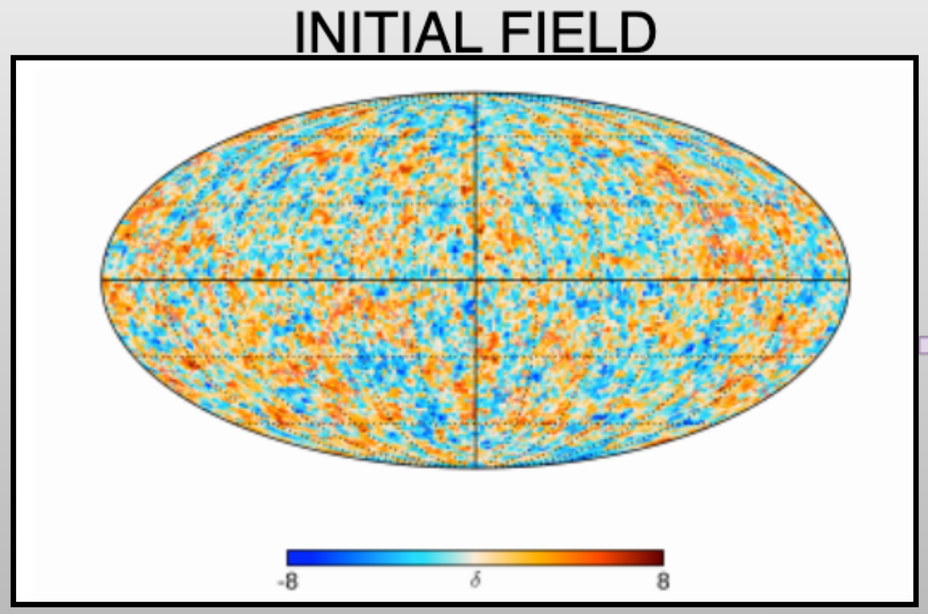

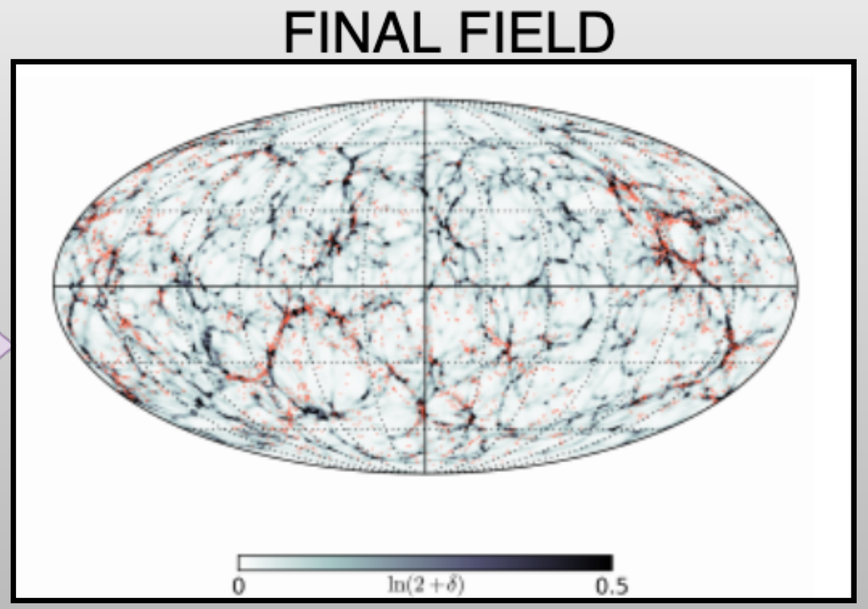

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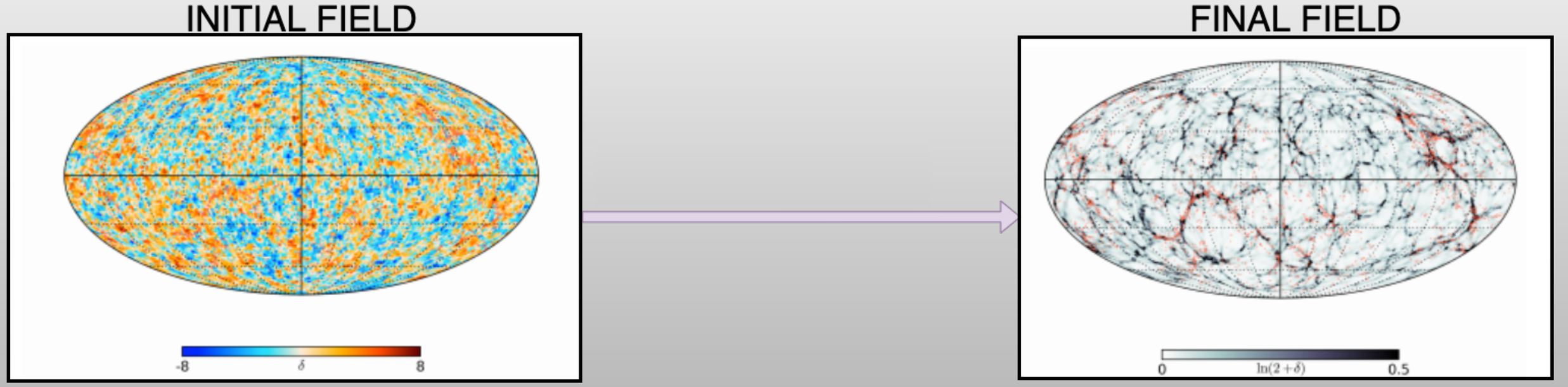

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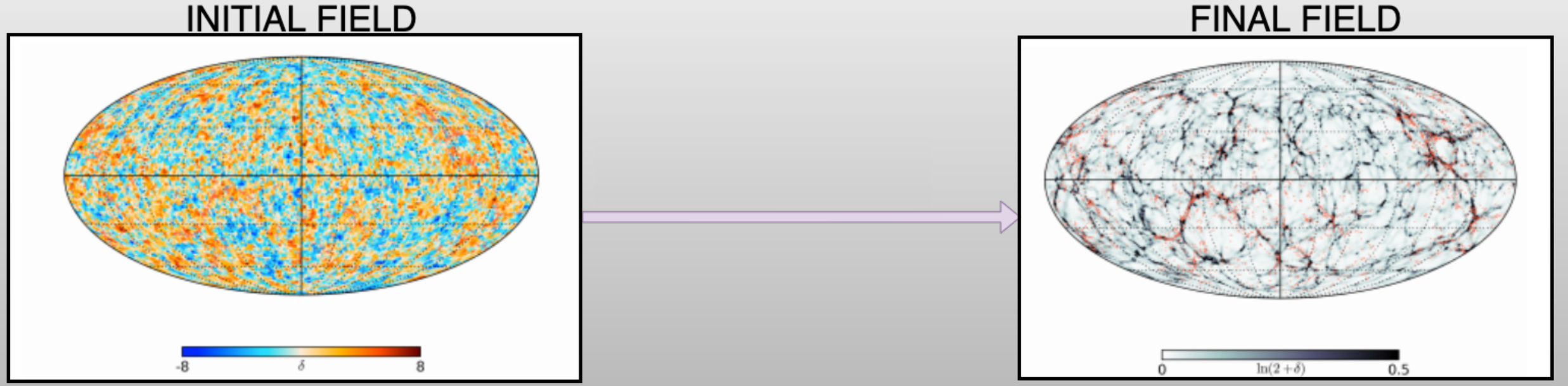

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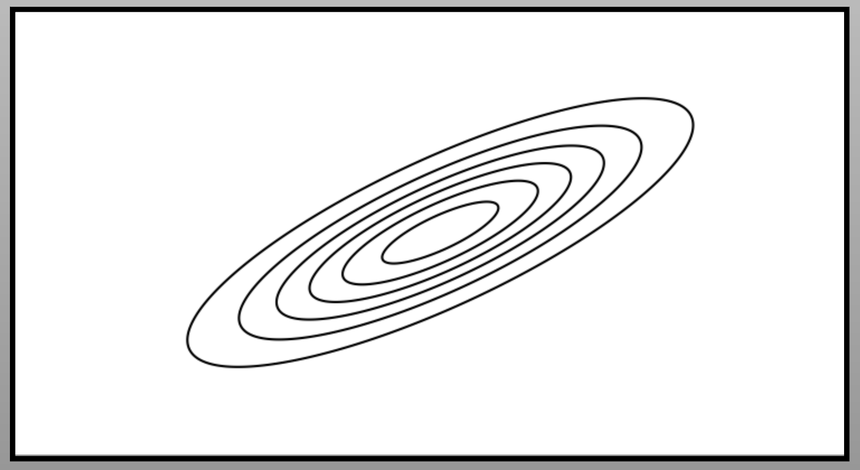

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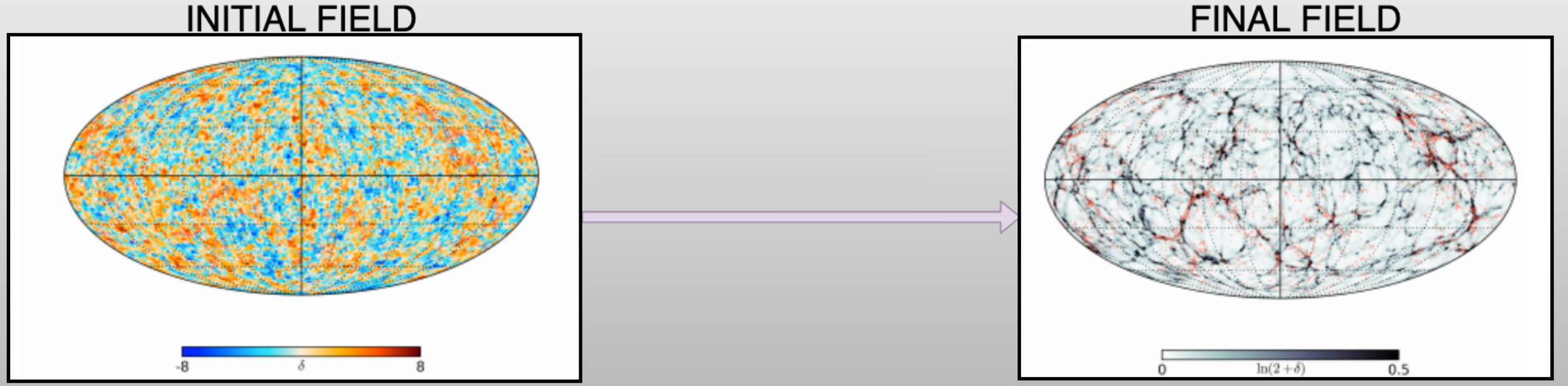

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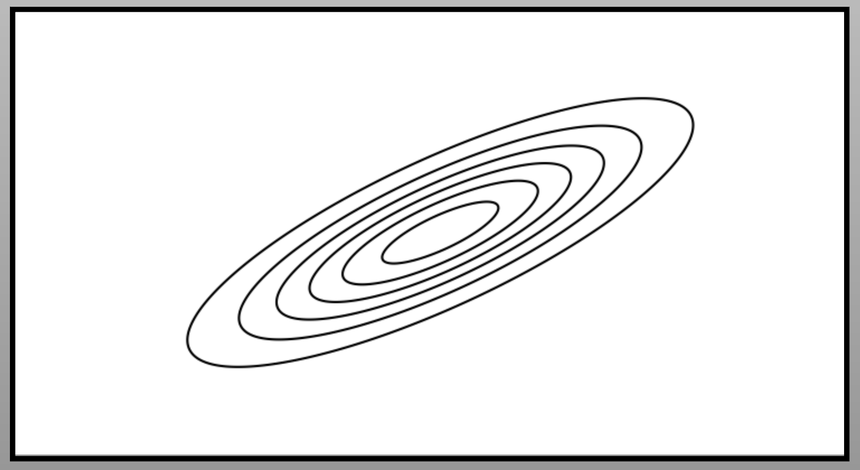

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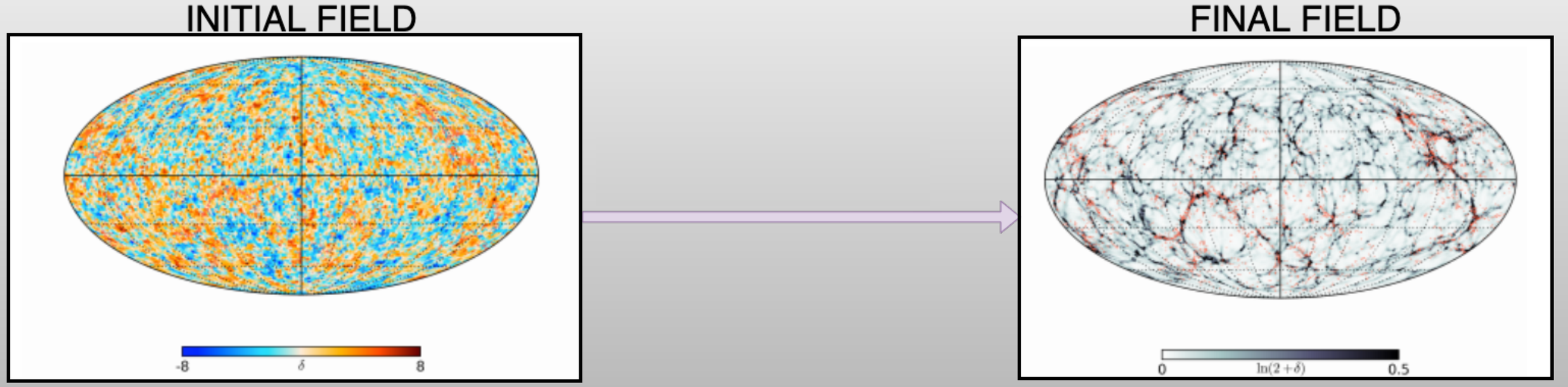

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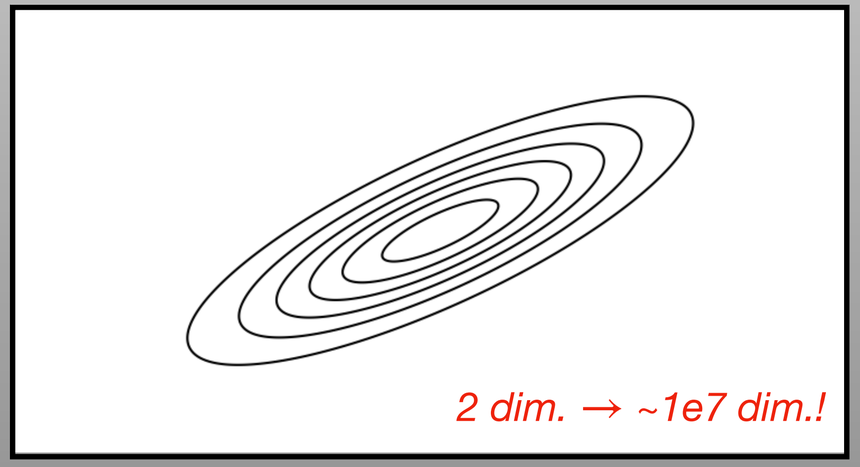

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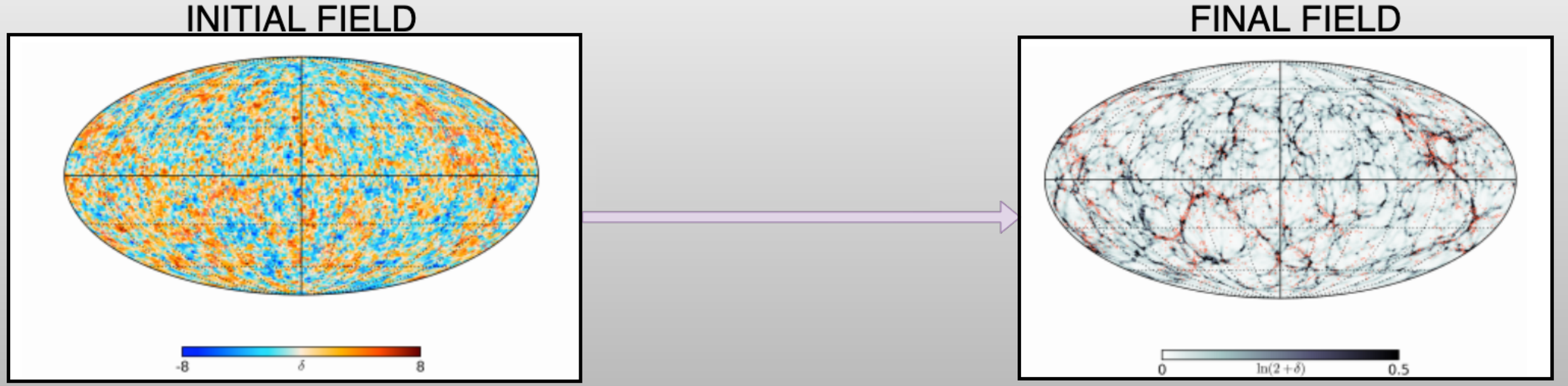

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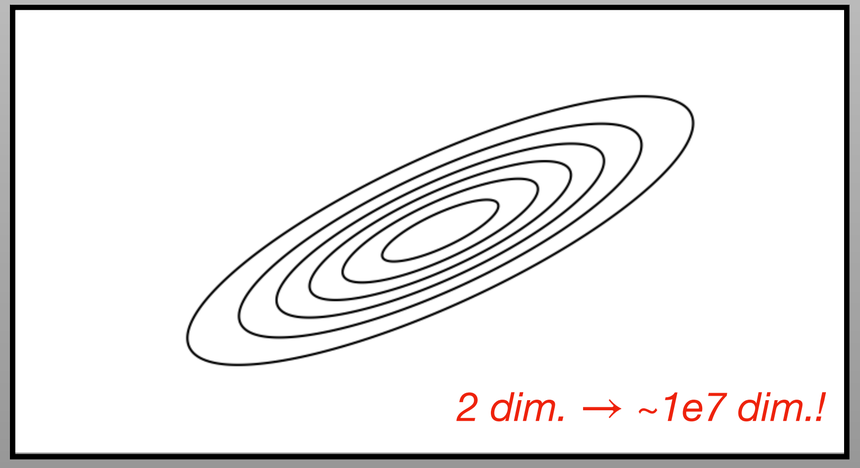

- Go beyond summary statistics
- Handle survey systematics
- Combine multiple probes
- Inference of initial conditions

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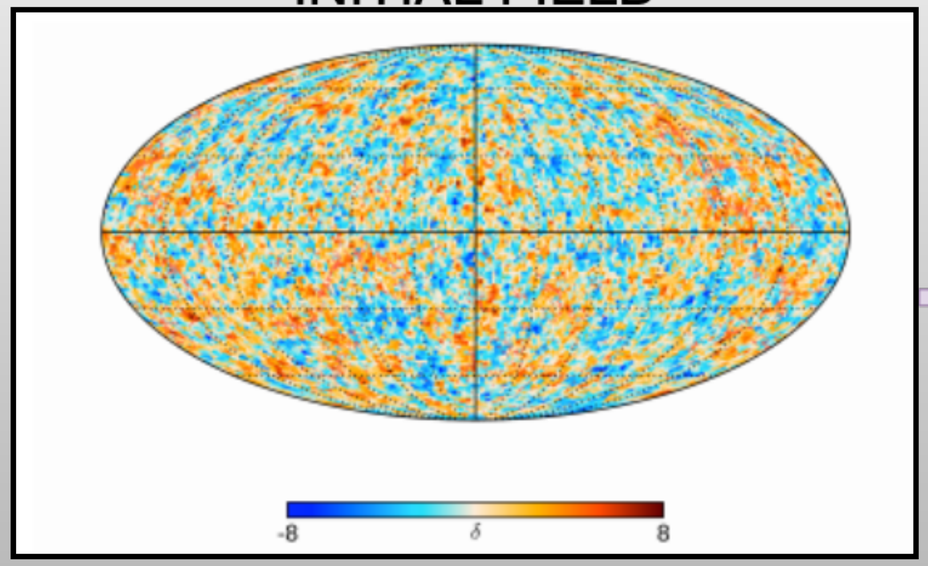
INITIAL FIELD



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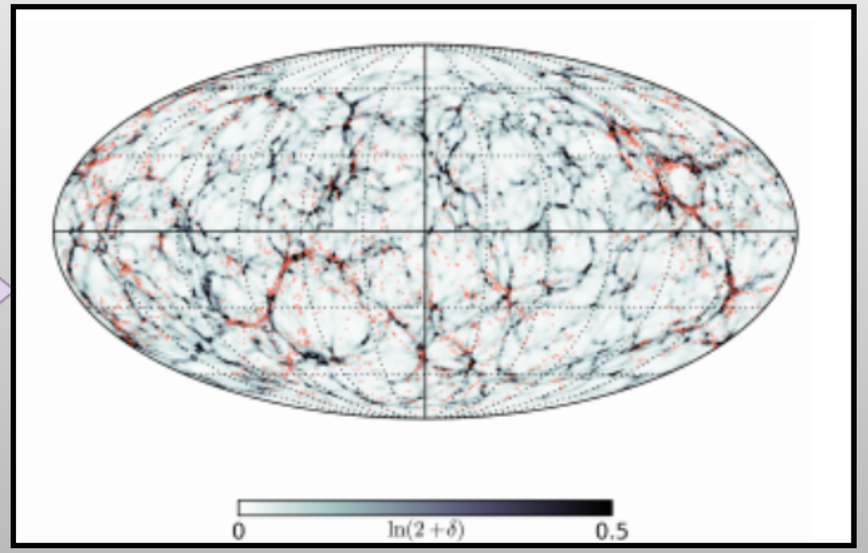

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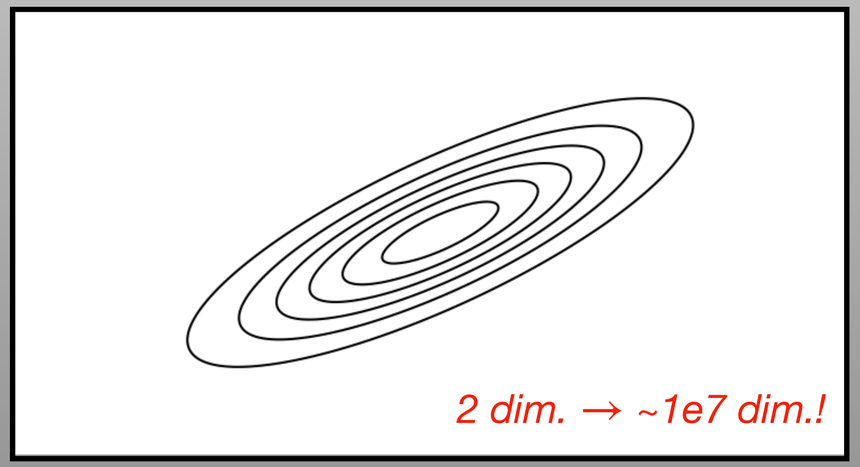

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Bayesian Origin Reconstruction from Galaxies
https://www.aquila-consortium.org/

Proof-of-Concept

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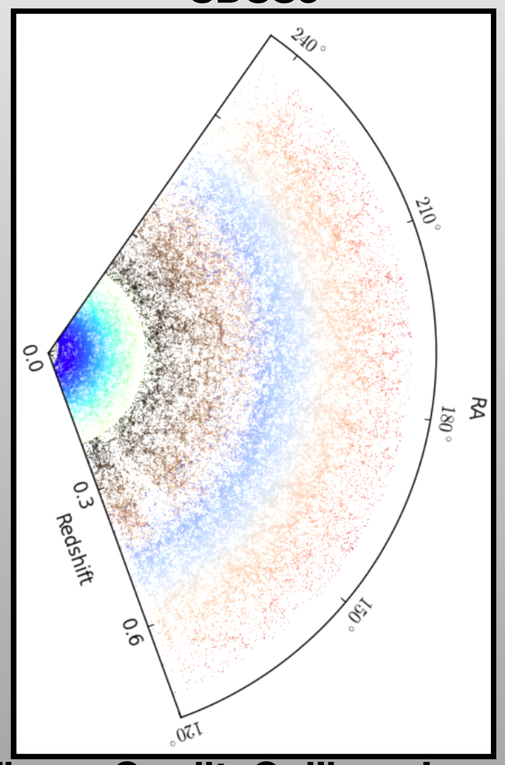

Figure Credit: Guilhem Lavaux

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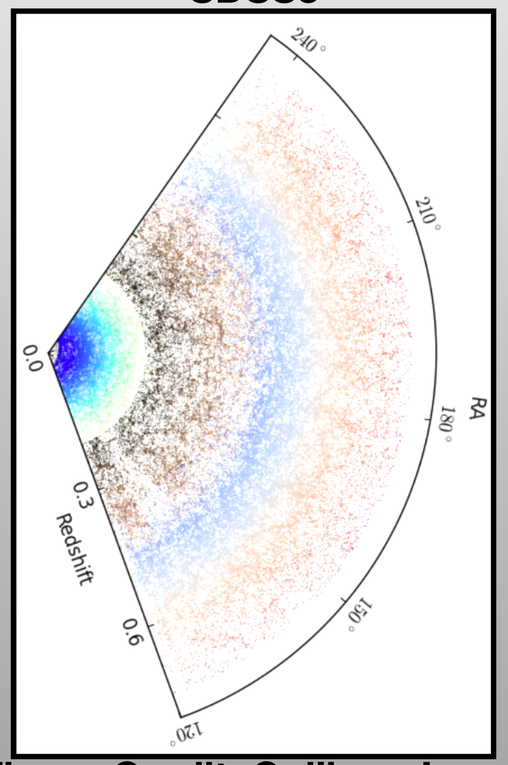

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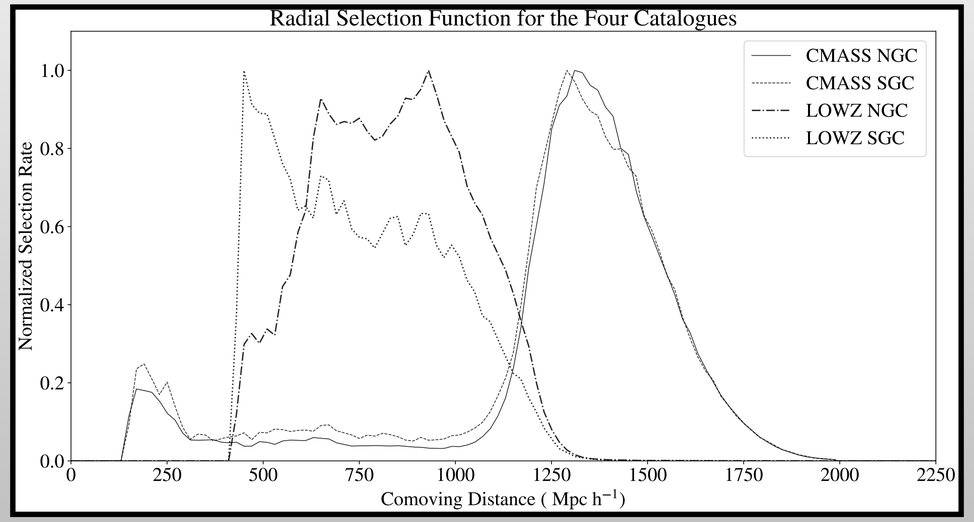
Radial Selection



Andrews et al. 2022

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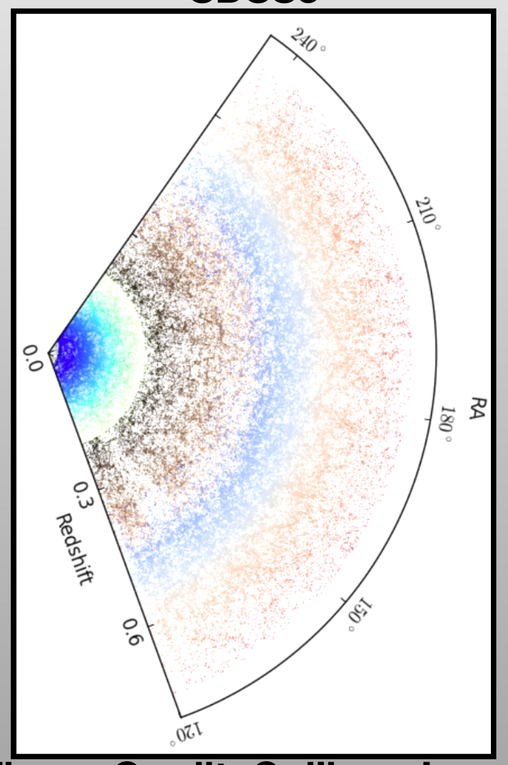

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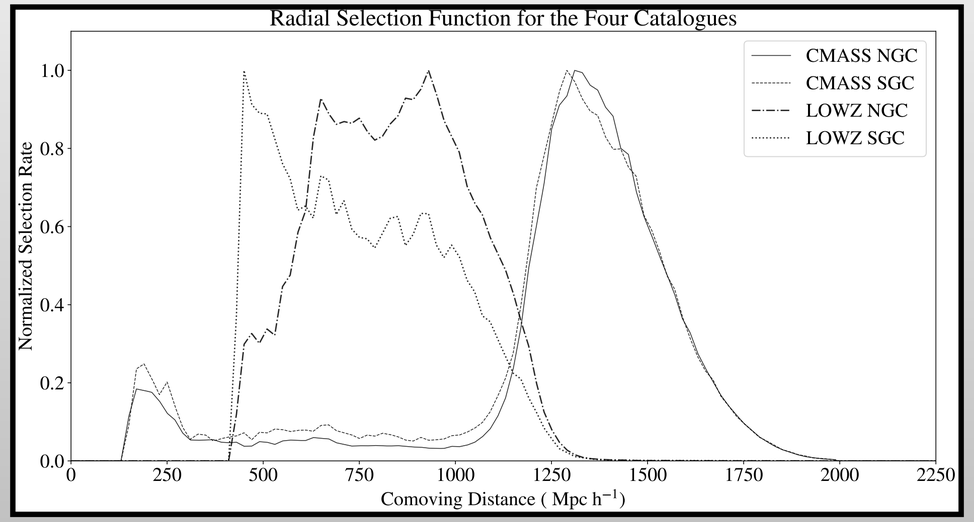

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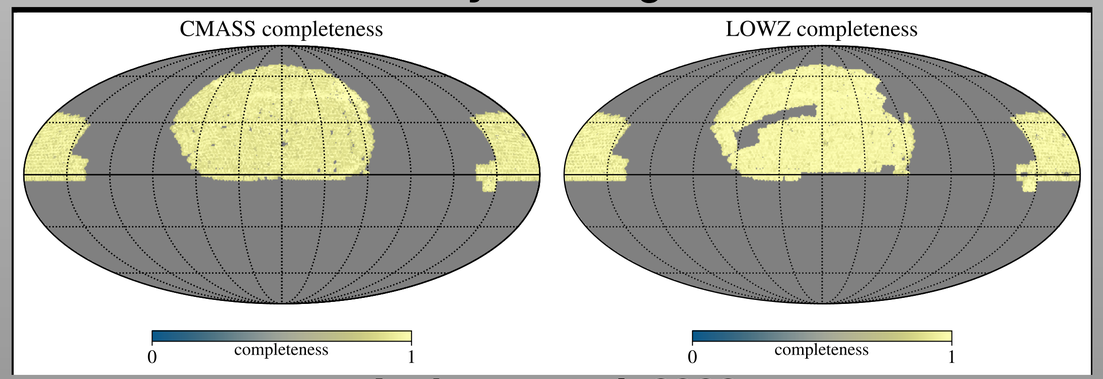
Sky Coverage



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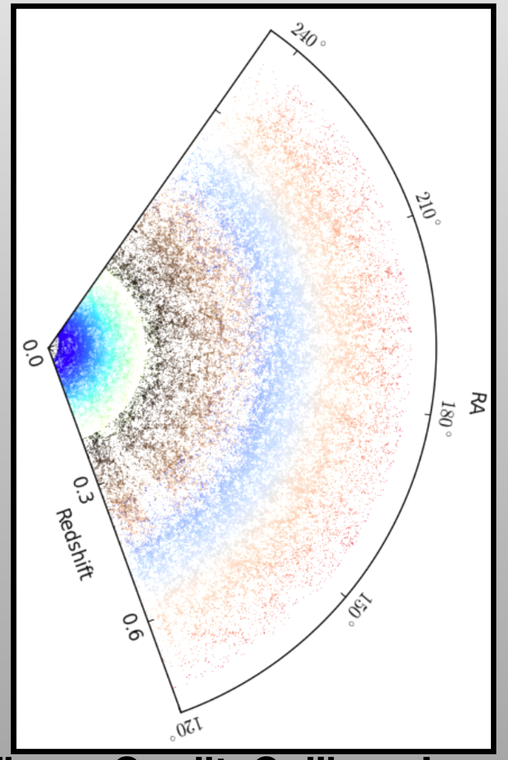

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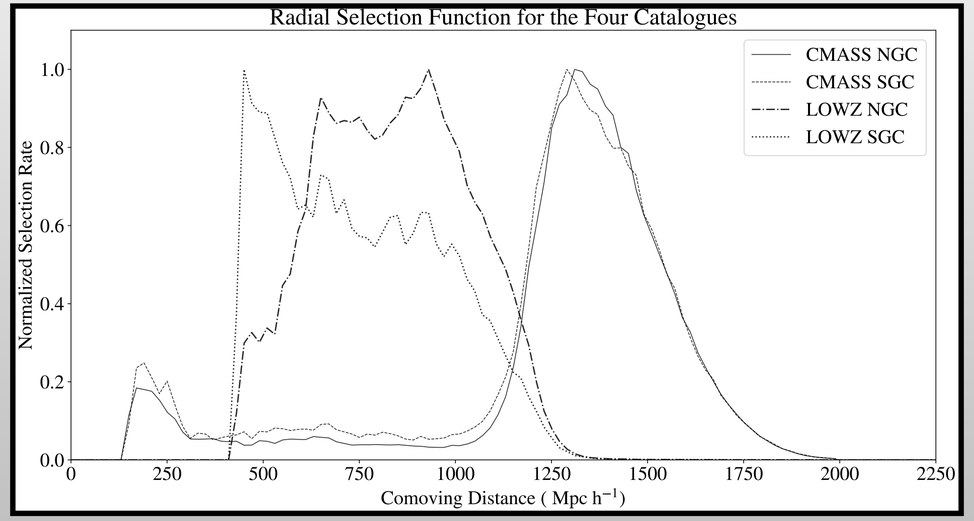

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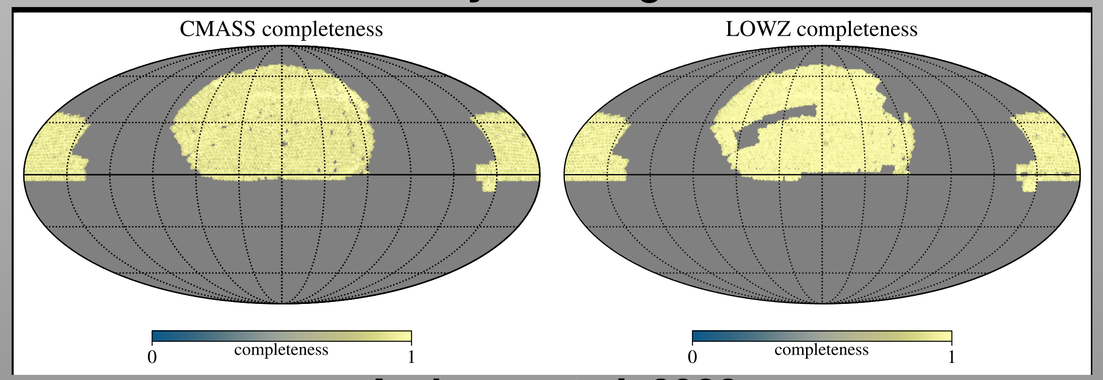

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$f_{\rm nl} = 5$

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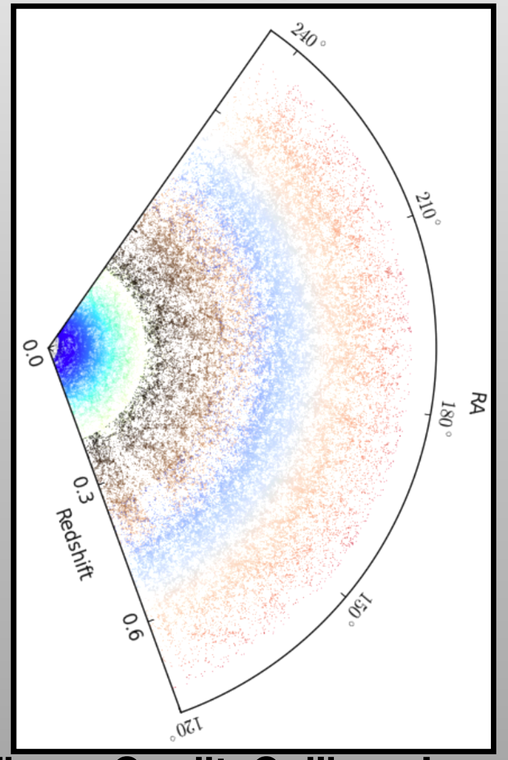

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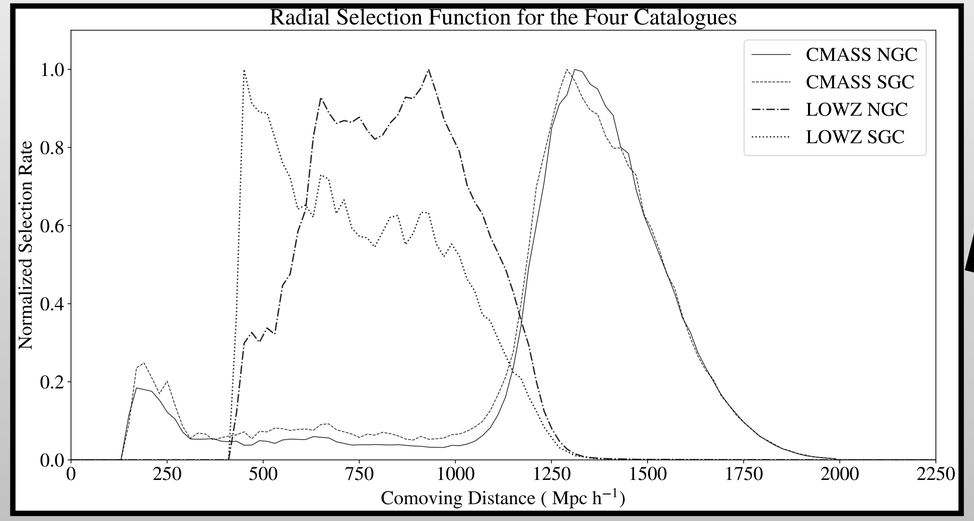

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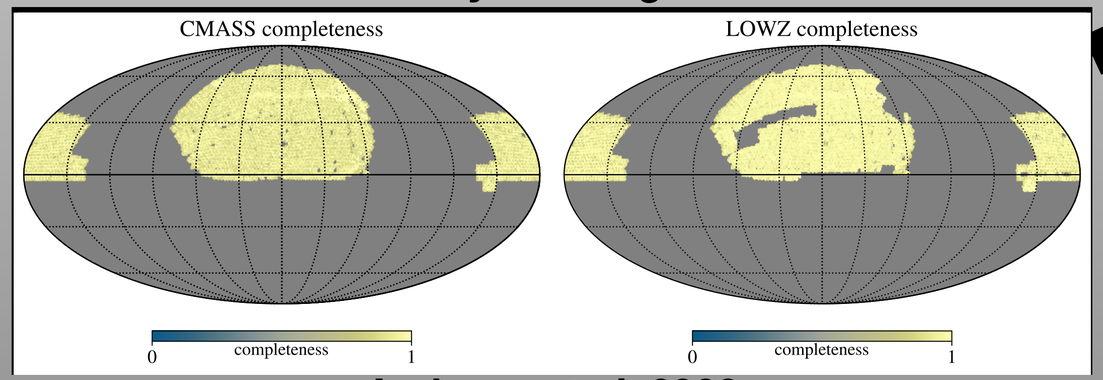

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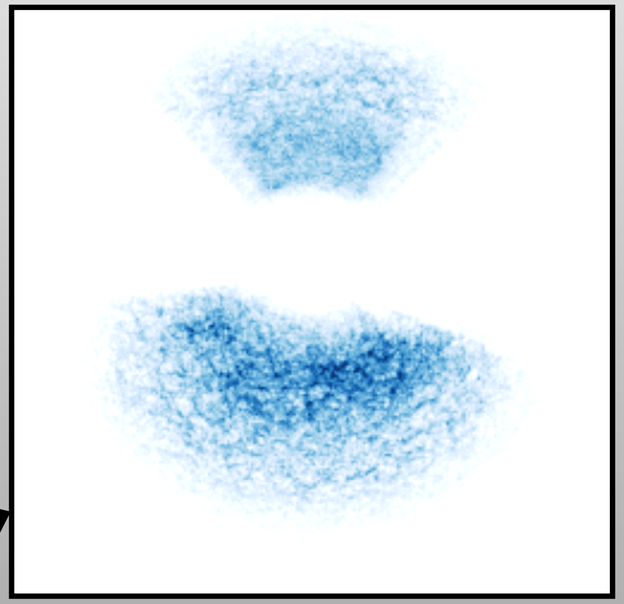
Mock Data



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Robustness of the method

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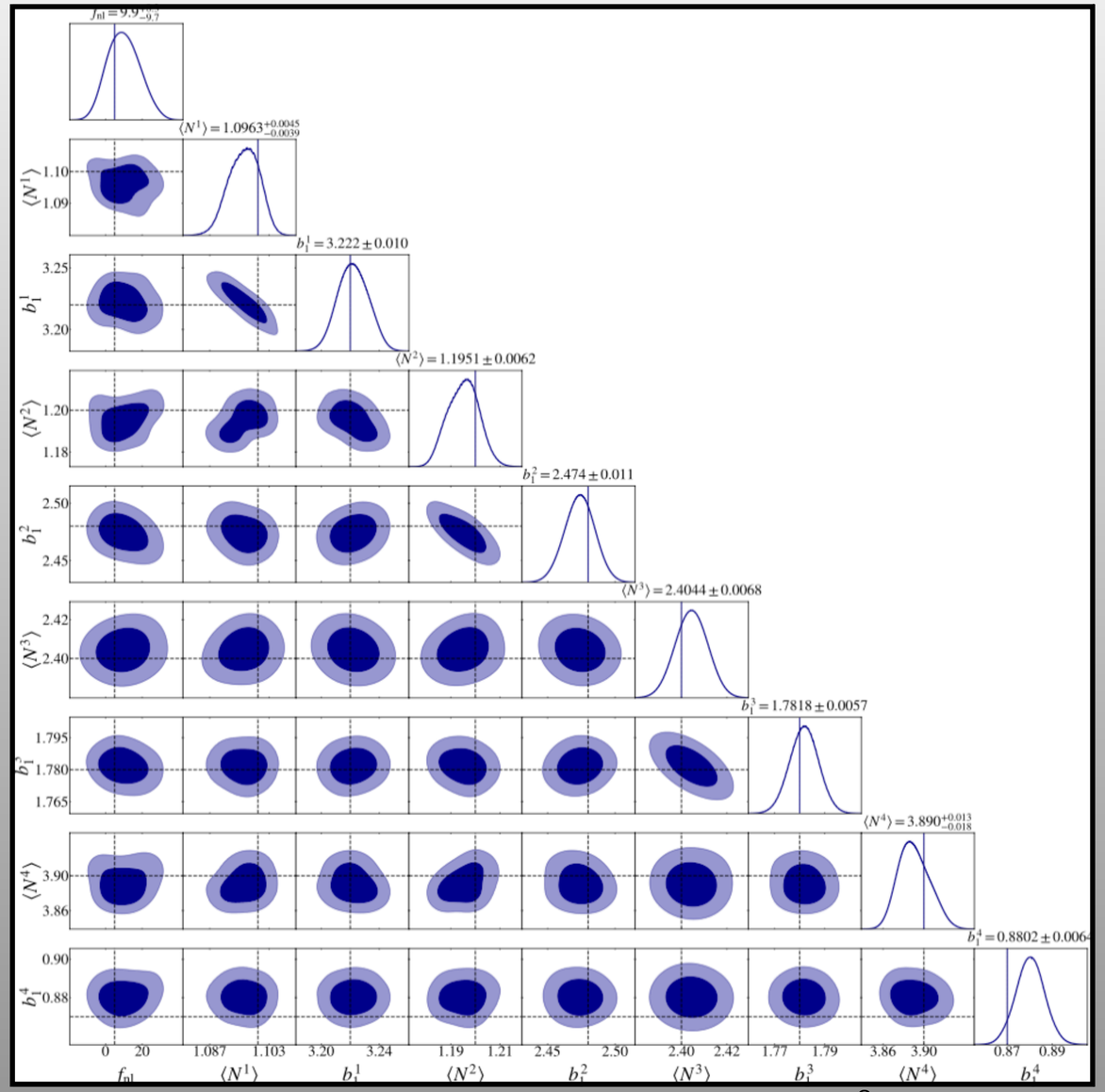

Inferring the density field

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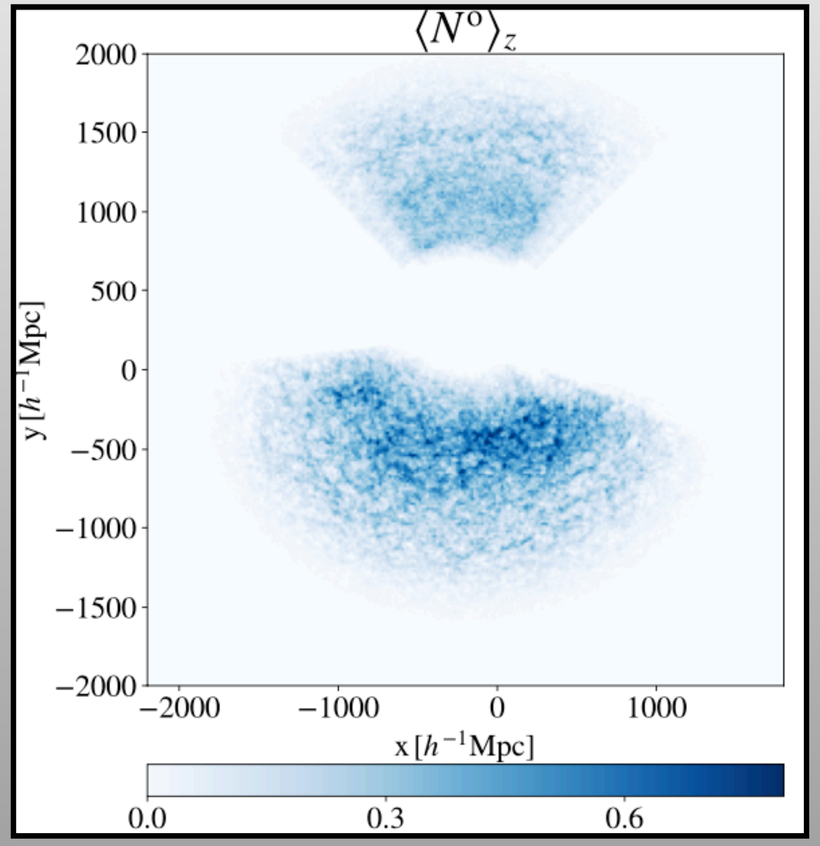

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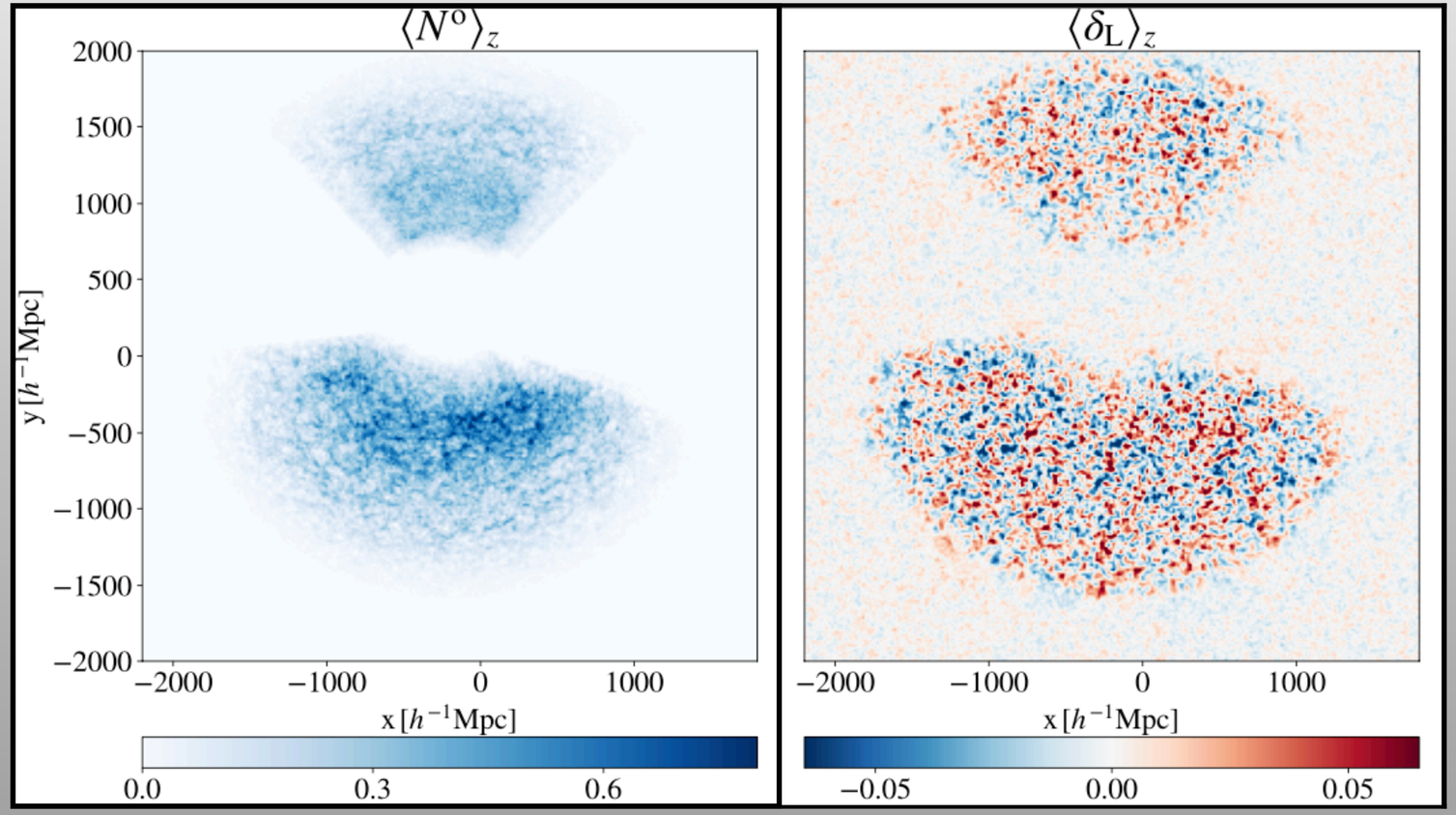

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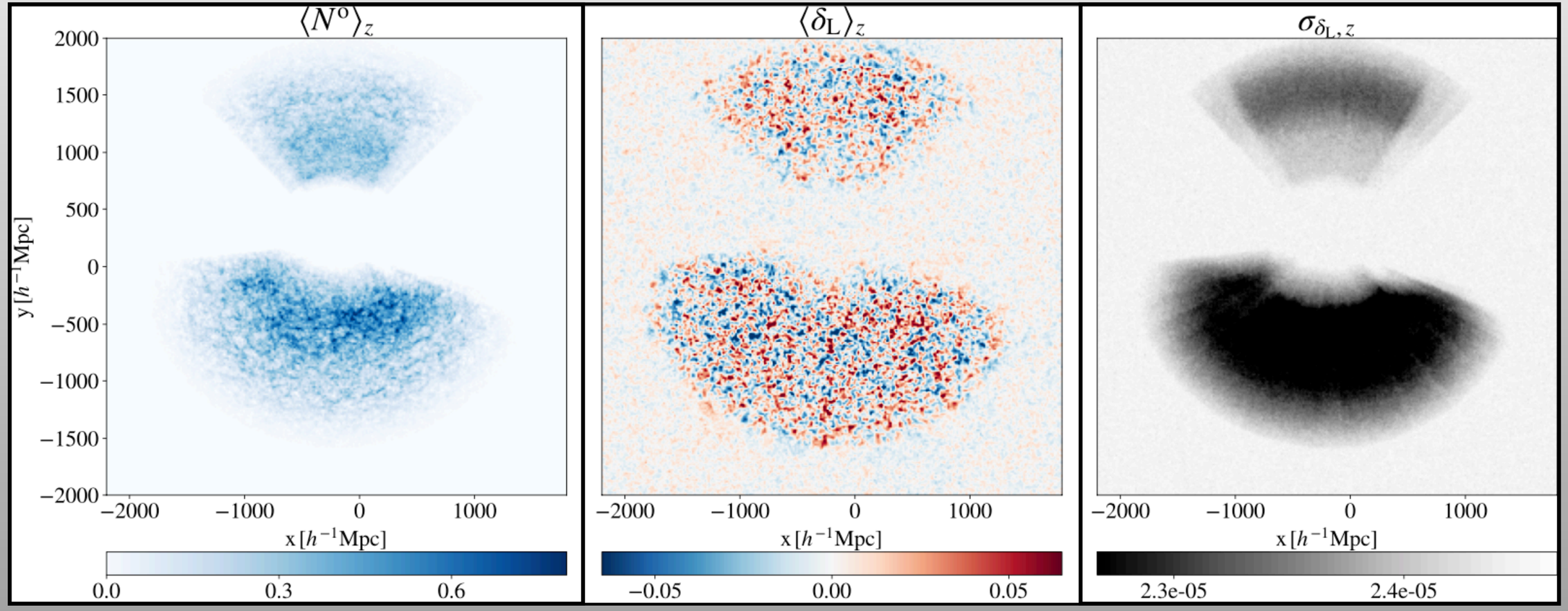

Main results

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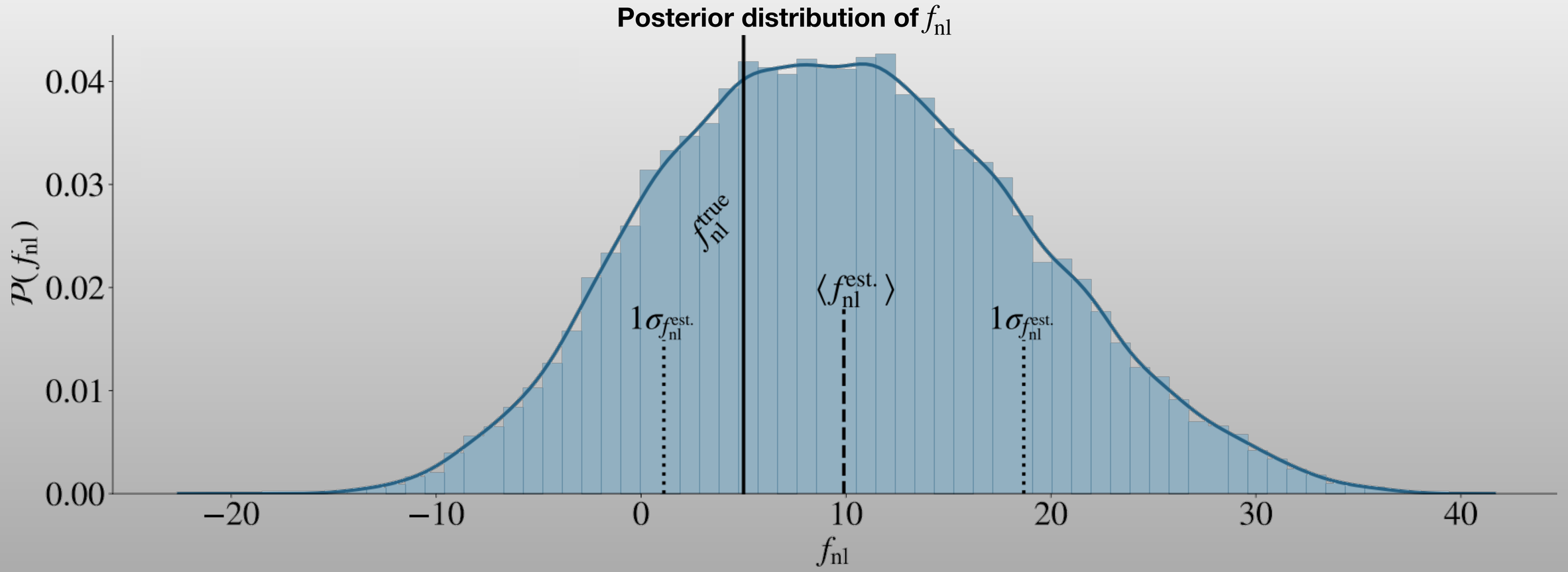
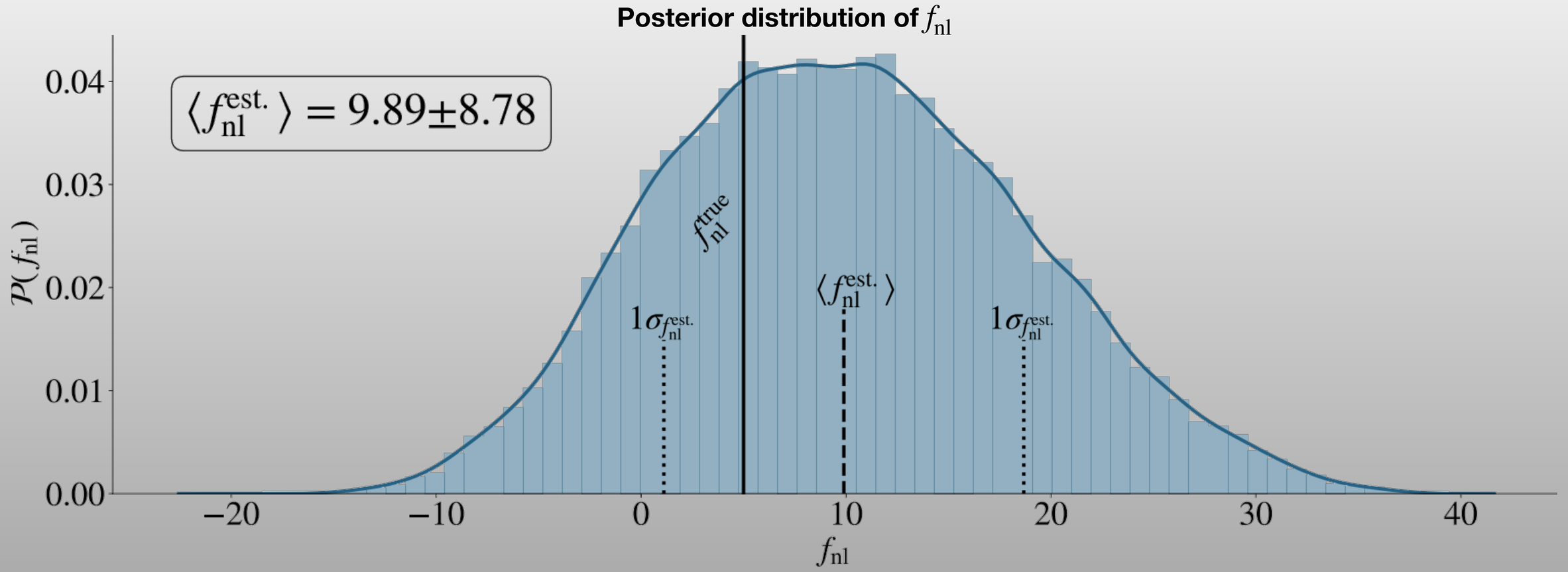
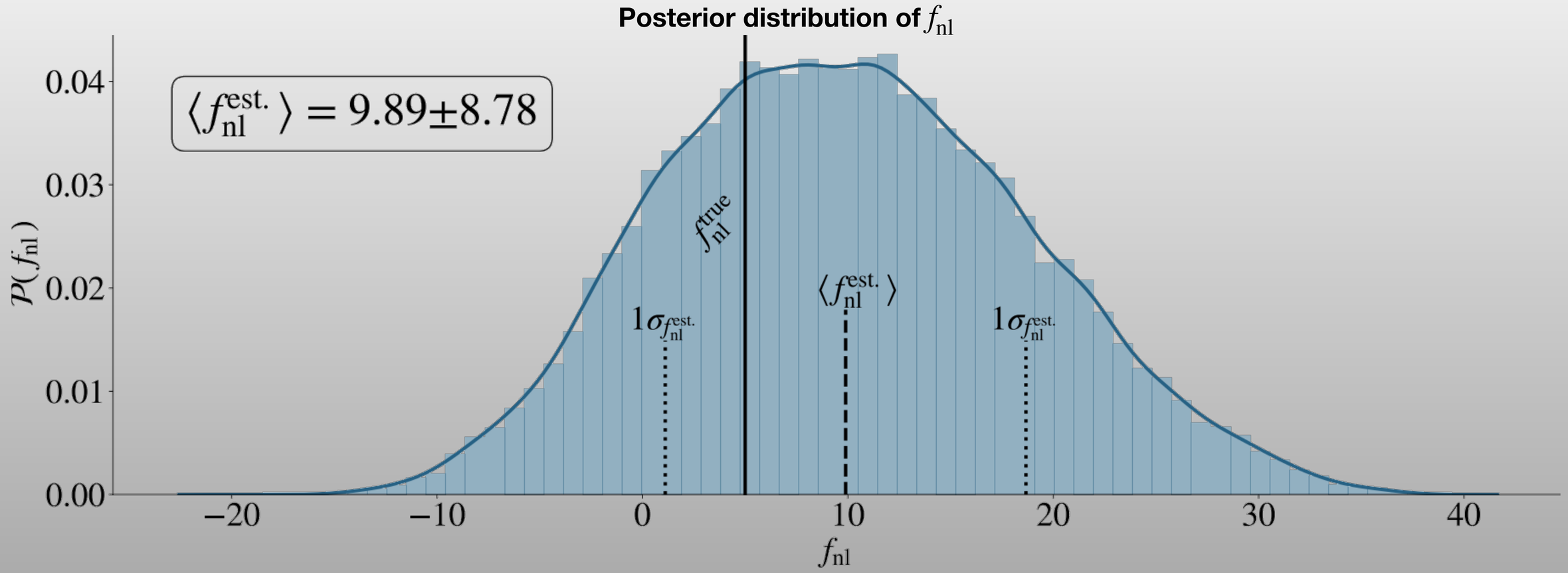


Main results

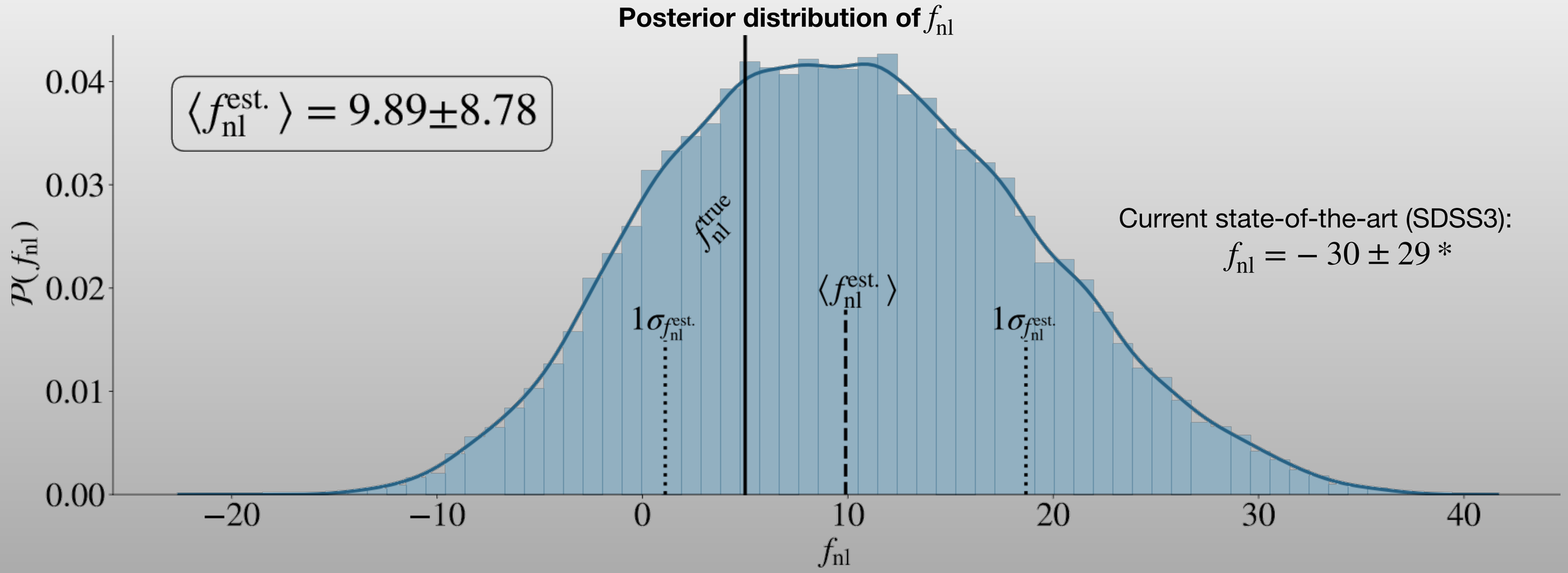


Main results



Full statement on the information content available in the data!

Main results



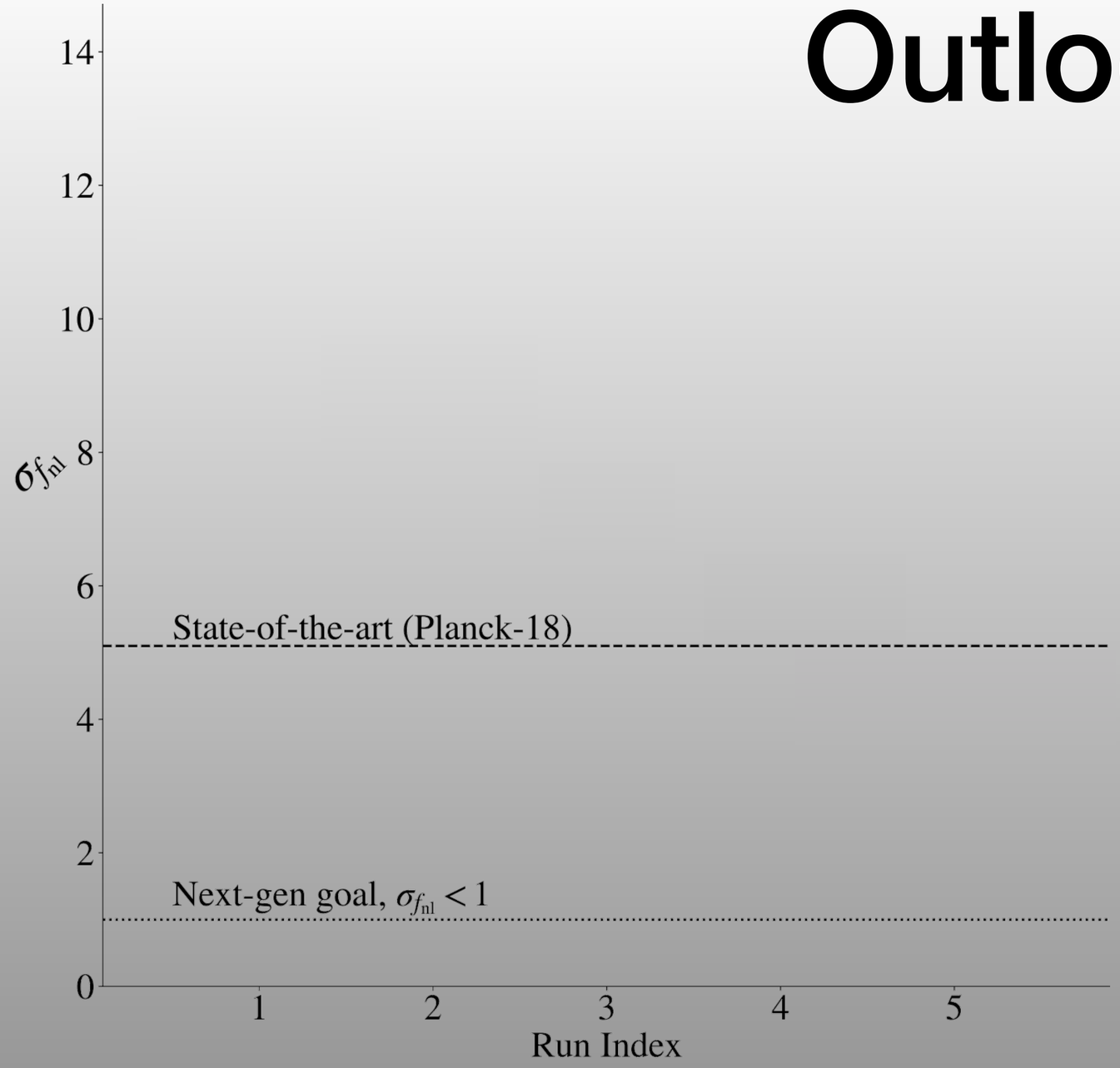
Current state-of-the-art (SDSS3):

$f_{\rm nl} = -30 \pm 29$ *

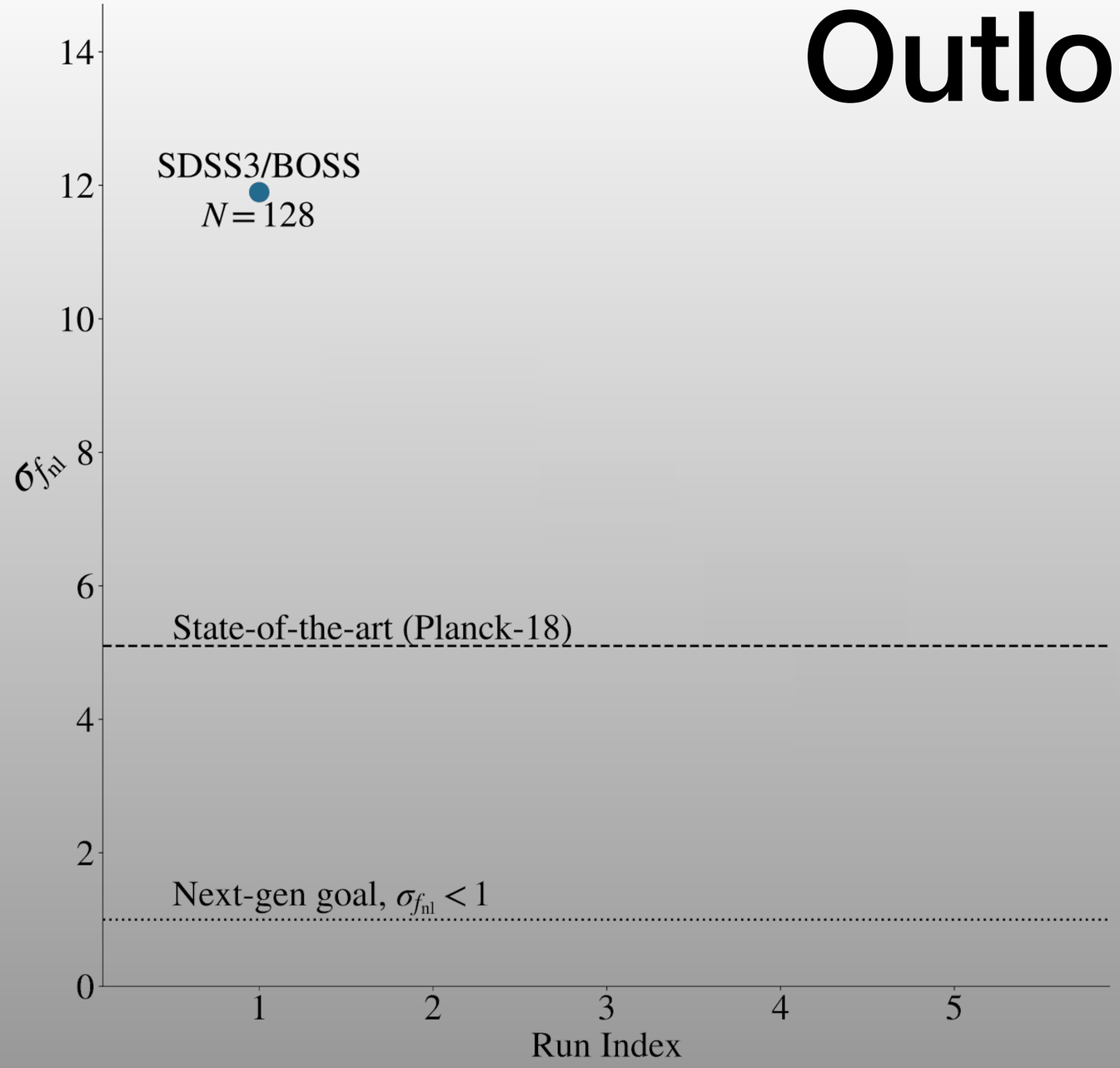
Full statement on the information content available in the data!

*D'Amico et al. 2022

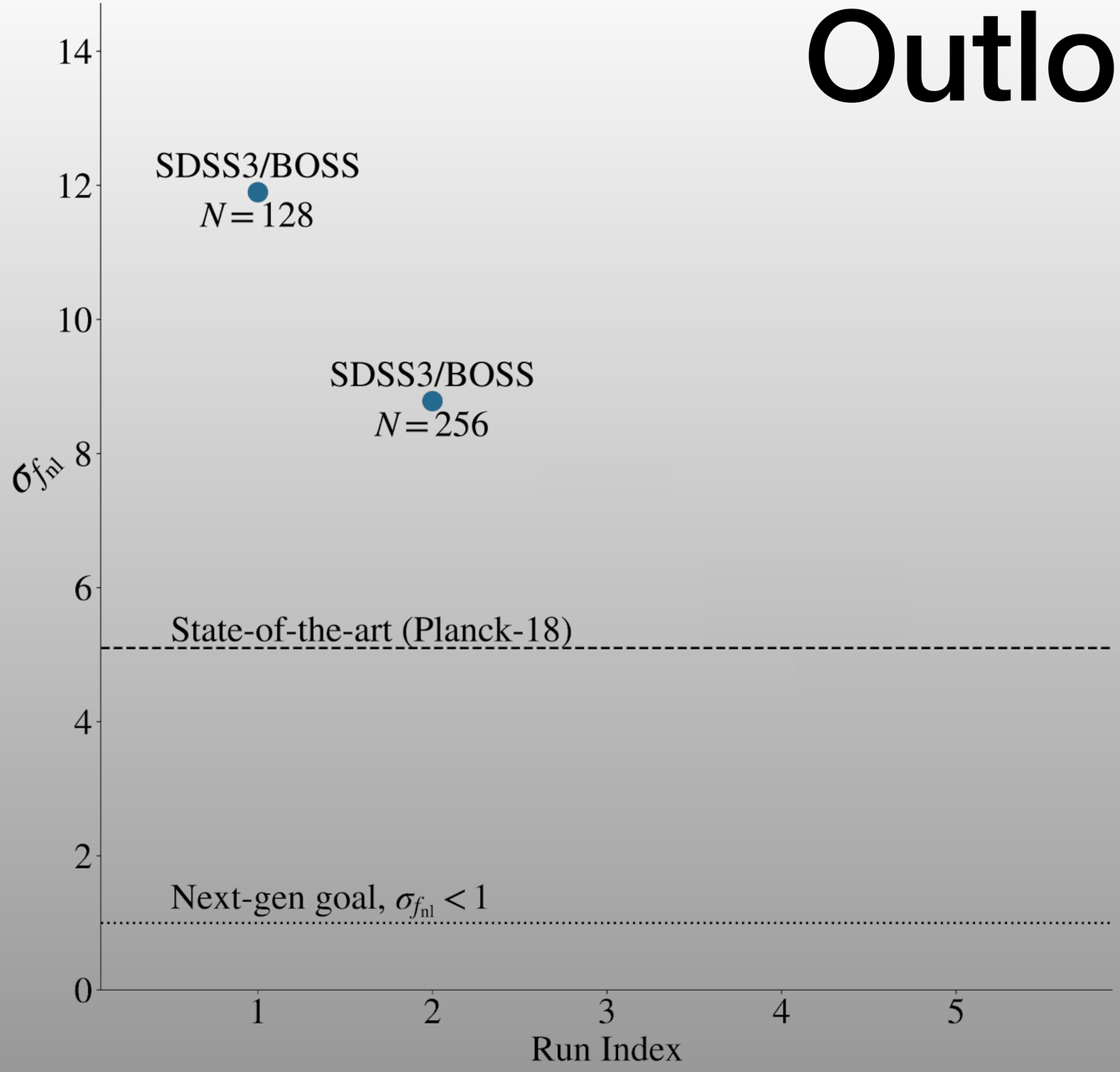
Outlook


14
12
10
8
6
4
2
0
$\sigma_{f_{\rm nl}}$
State-of-the-art (Planck-18)
Next-gen goal, $\sigma_{f_{\rm nl}} < 1$
1
2
3
4
5
Run Index

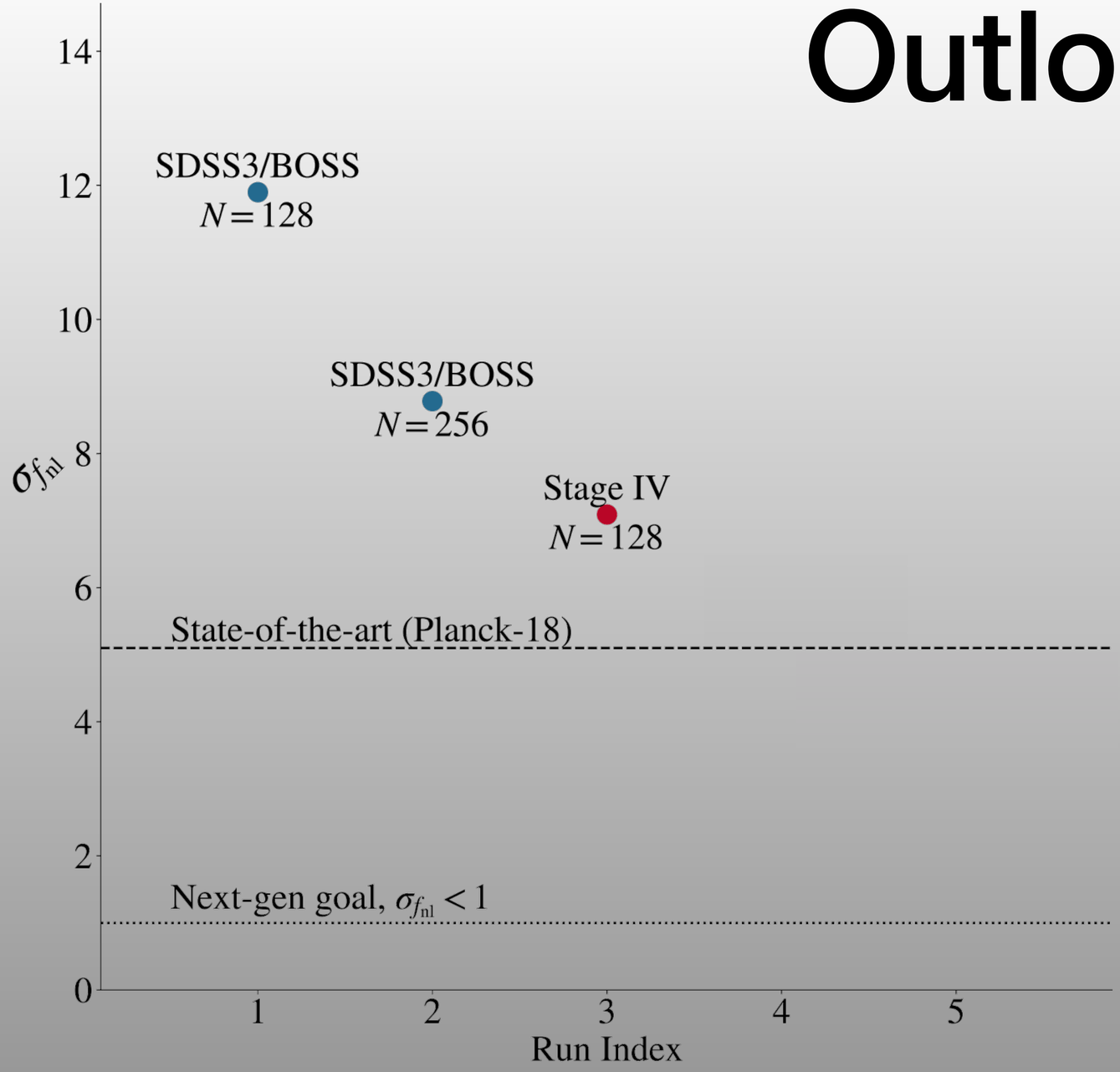
Outlook


14
12
10
8
6
4
2
0
$\sigma_{f_{nl}}$
SDSS3/BOSS
$N = 128$
State-of-the-art (Planck-18)
Next-gen goal, $\sigma_{f_{nl}} < 1$
1
2
3
4
5
Run Index

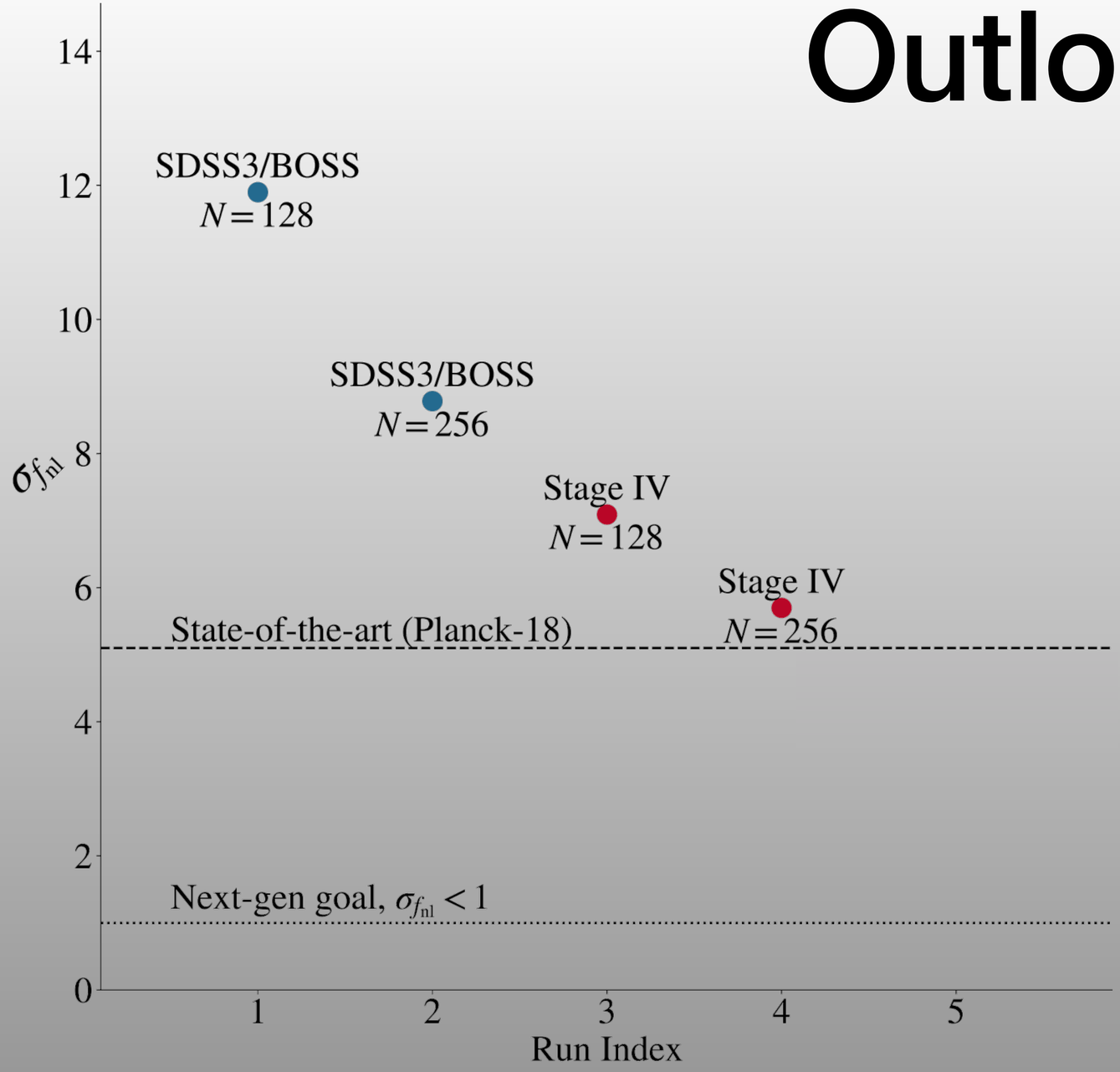
Outlook


SDSS3/BOSS
$N = 128$
SDSS3/BOSS
$N = 256$
State-of-the-art (Planck-18)
Next-gen goal, $\sigma_{f_{\rm nl}} < 1$
$\sigma_{f_{\rm nl}}$
Run Index
0
2
4
6
8
10
12
14
1
2
3
4
5

Outlook


14
12
10
8
6
4
2
0
$\sigma_{f_{nl}}$
SDSS3/BOSS
$N = 128$
SDSS3/BOSS
$N = 256$
Stage IV
$N = 128$
State-of-the-art (Planck-18)
Next-gen goal, $\sigma_{f_{nl}} < 1$
1
2
3
4
5
Run Index

Outlook


14
12
10
8
6
4
2
0
$\sigma_{f_{nl}}$
SDSS3/BOSS
$N = 128$
SDSS3/BOSS
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Stage IV
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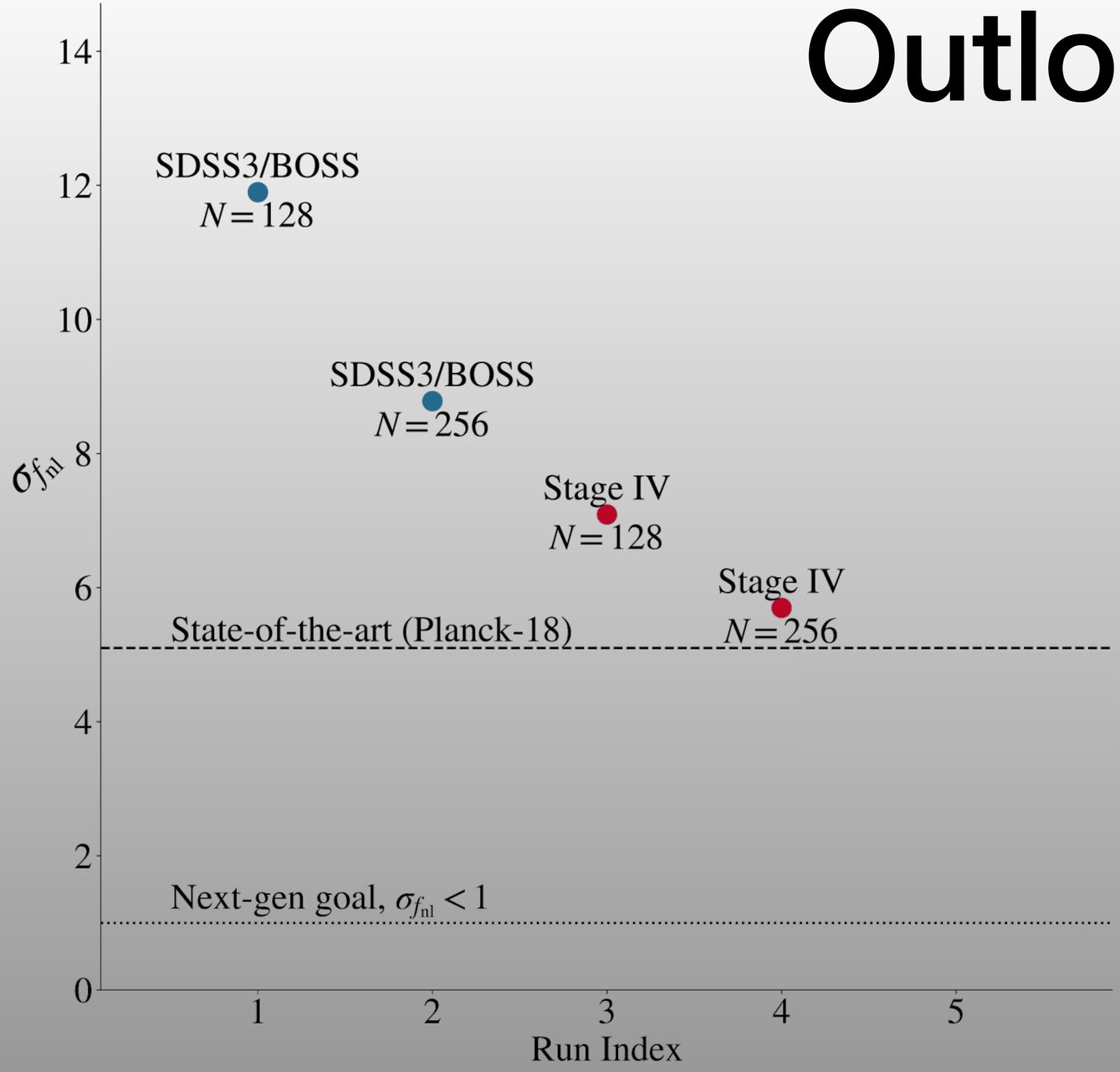
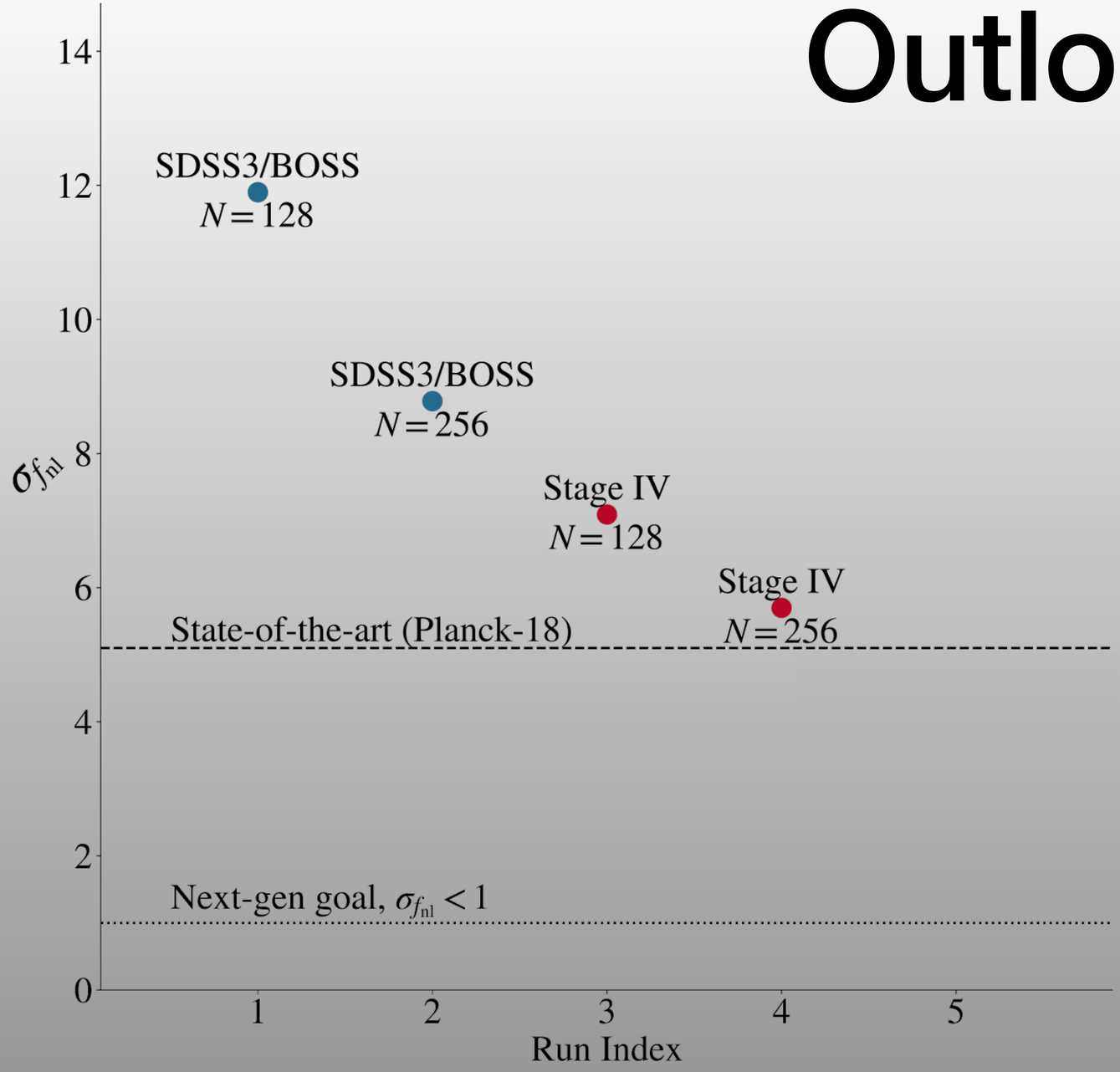
Next-gen goal, $\sigma_{f_{nl}} < 1$
1
2
3
4
5
Run Index

Outlook



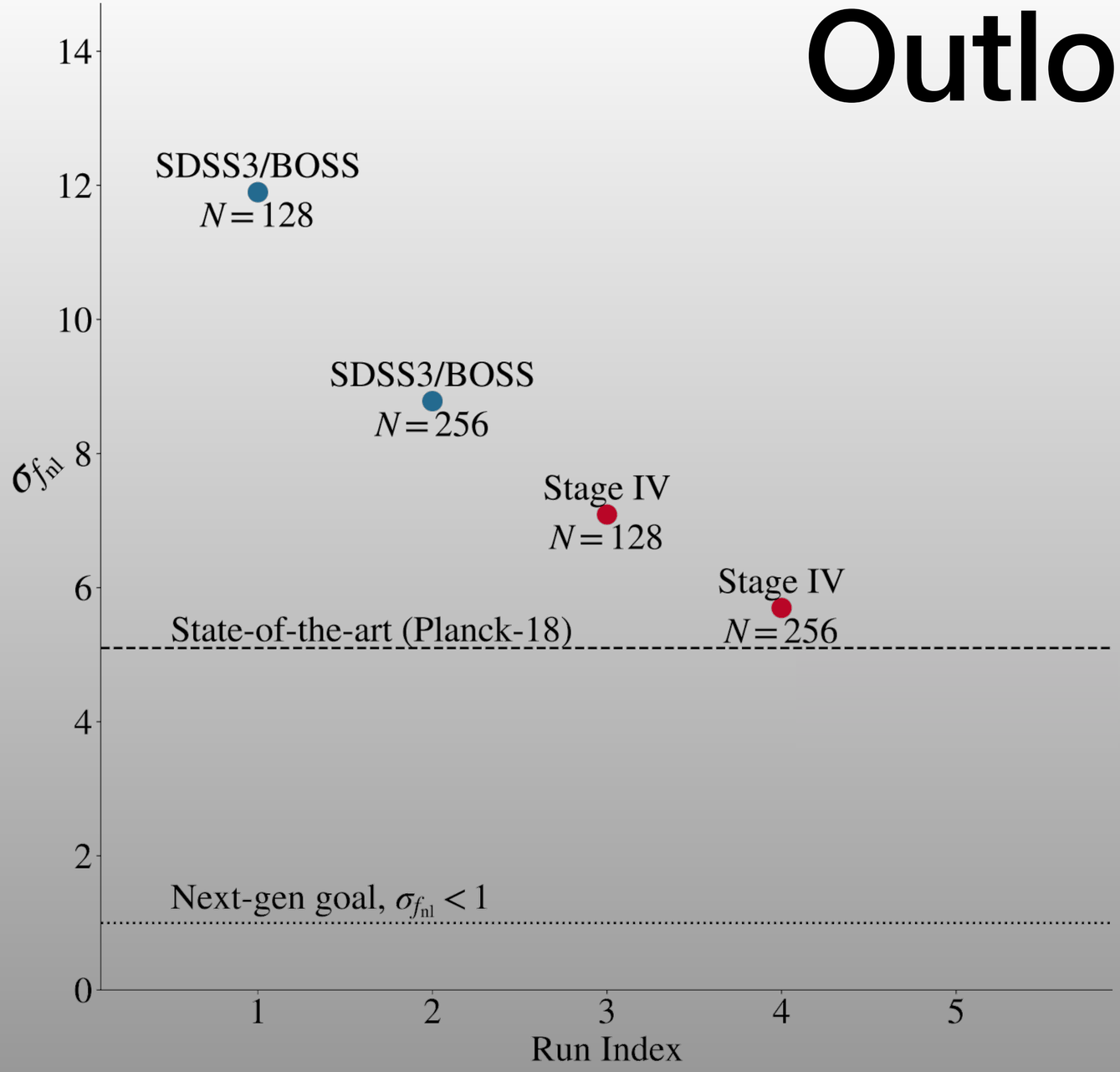
- Improvements as a function of resolution

Outlook



- Improvements as a function of resolution
- Improve the forward model
  - Structure formation
  - Scale-dependent bias model

Outlook



- Improvements as a function of resolution
- Improve the forward model
  - Structure formation
  - Scale-dependent bias model
- Prepare for Stage IV surveys

Summary

arxiv: 2203.08838
adam.andrews@fysik.su.se

Summary

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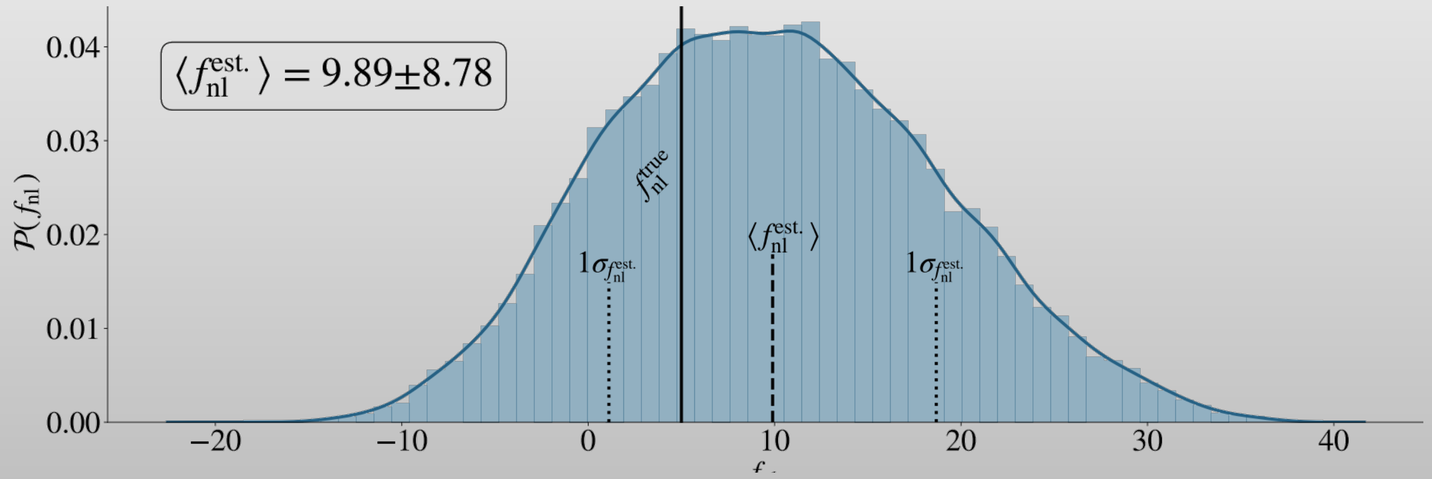
Posterior distribution of $f_{\rm nl}$



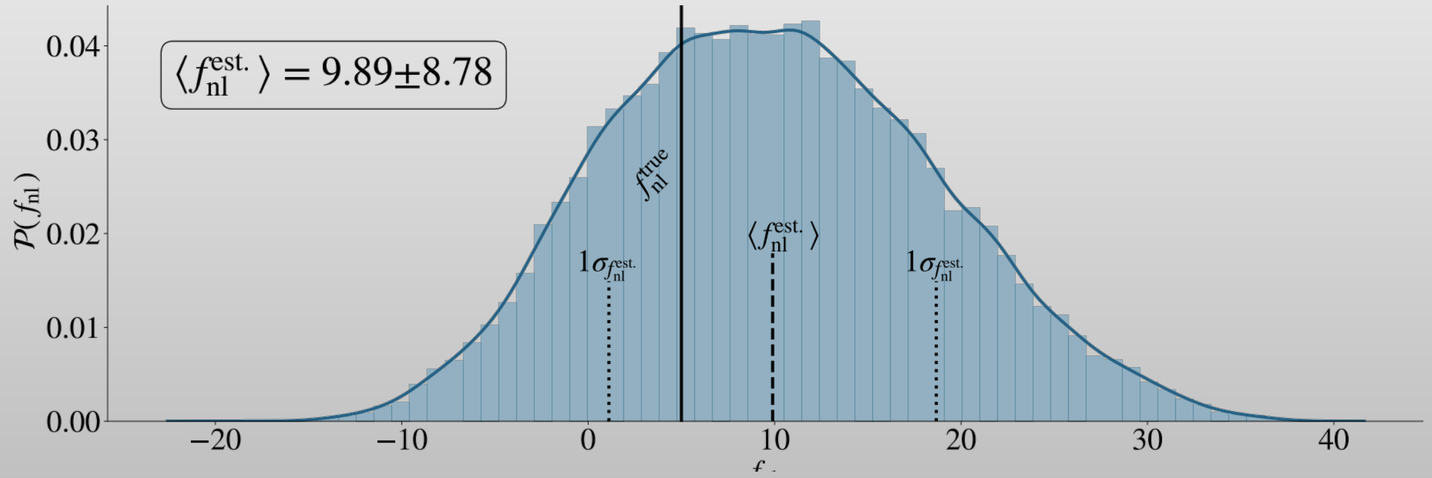
1. Developed a field-level inference which constrains $\sigma_{f_{\rm nl}} \approx 9\ (68\%)$ on SDSS3-like data

Summary

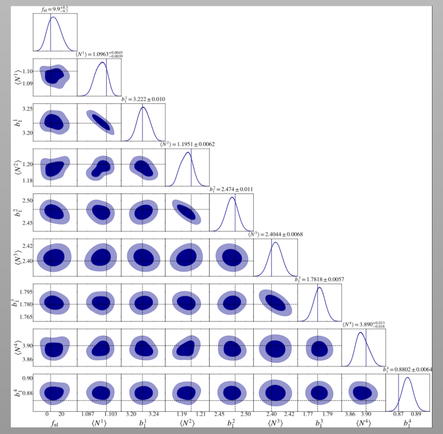
arxiv: 2203.08838
adam.andrews@fysik.su.se

1. Developed a field-level inference which constrains $\sigma_{f_{\rm nl}} \approx 9\ (68\%)$ on SDSS3-like data
2. Captures higher-order statistics and survey effects

Posterior distribution of $f_{\rm nl}$



Robustness

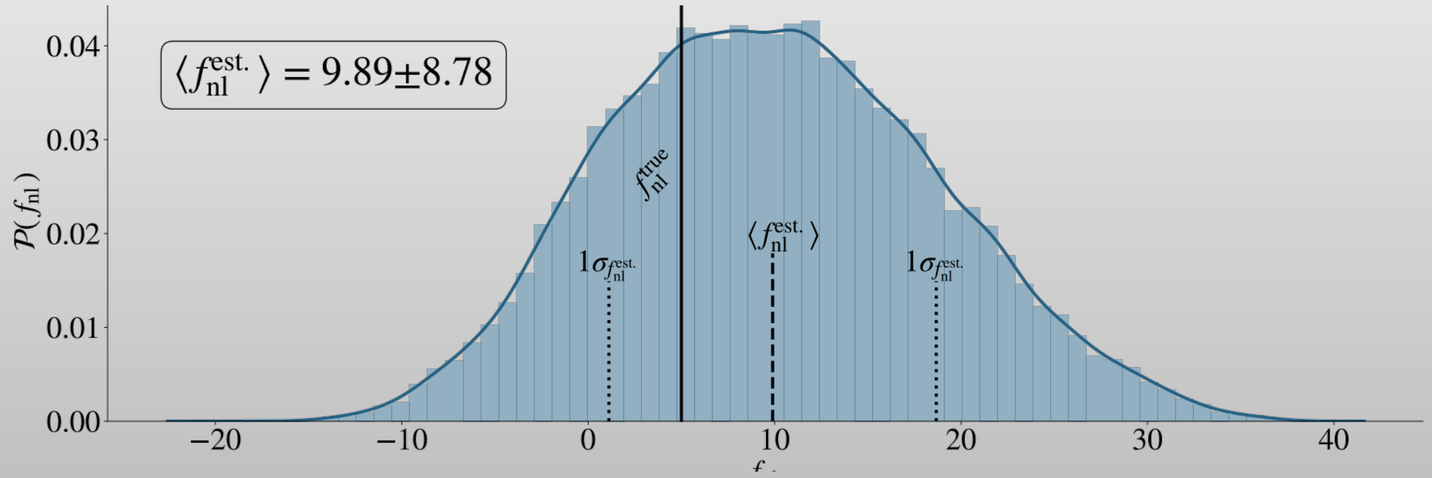


Summary

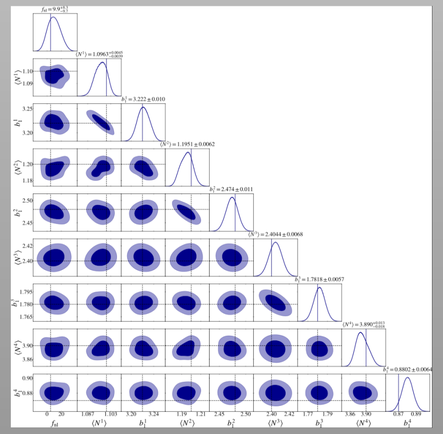
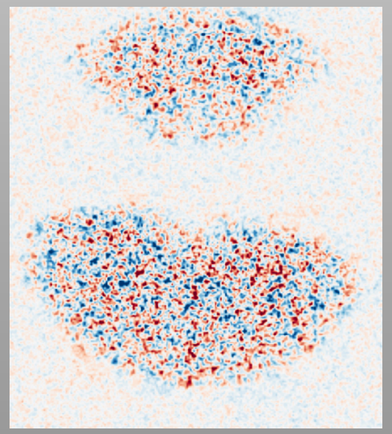
arxiv: 2203.08838
adam.andrews@fysik.su.se

1. Developed a field-level inference which constrains $\sigma_{f_{\rm nl}} \approx 9\ (68\%)$ on SDSS3-like data
2. Captures higher-order statistics and survey effects
3. Additional data products

Posterior distribution of $f_{\rm nl}$



Robustness



Inferred Density Field