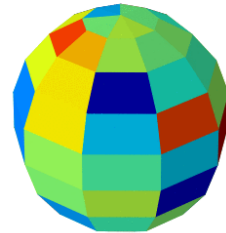


Simulating **non-Gaussian** CMB foregrounds in a **stochastic** way, basing on **GAN**

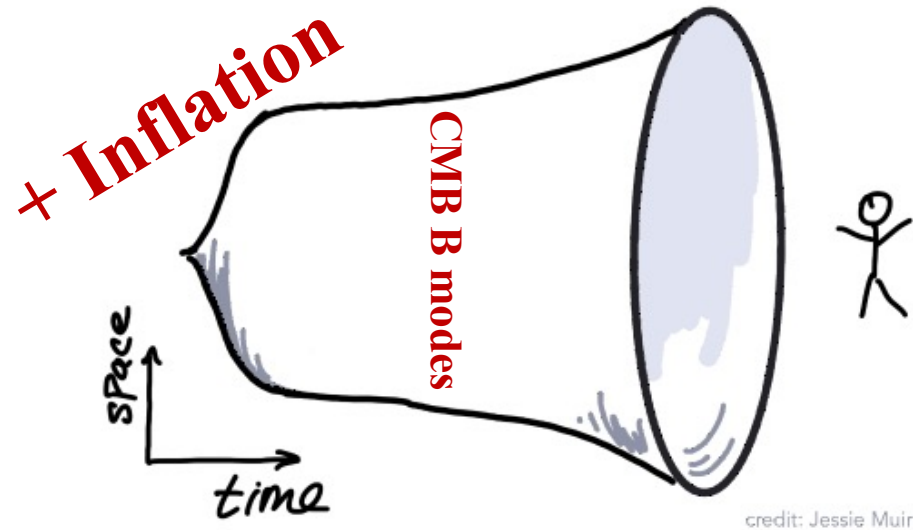


Jian Yao, 姚健
PhD, SISSA

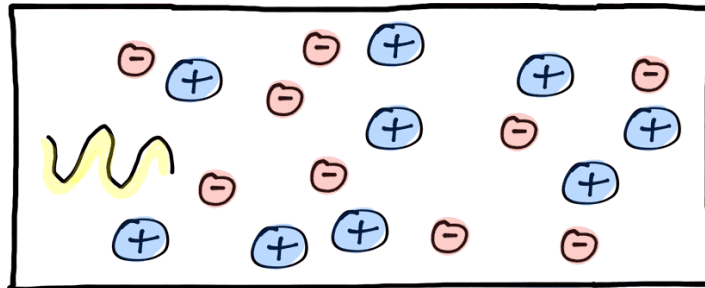
Nicoletta Krachmalnicoff, Marianna Foschi, Giuseppe Puglisi, Carlo Baccigalupi

Based on Yao et al., arXiv:2406.14519, A&A, 686, A290 (2024)

Λ CDM: standard model of cosmology

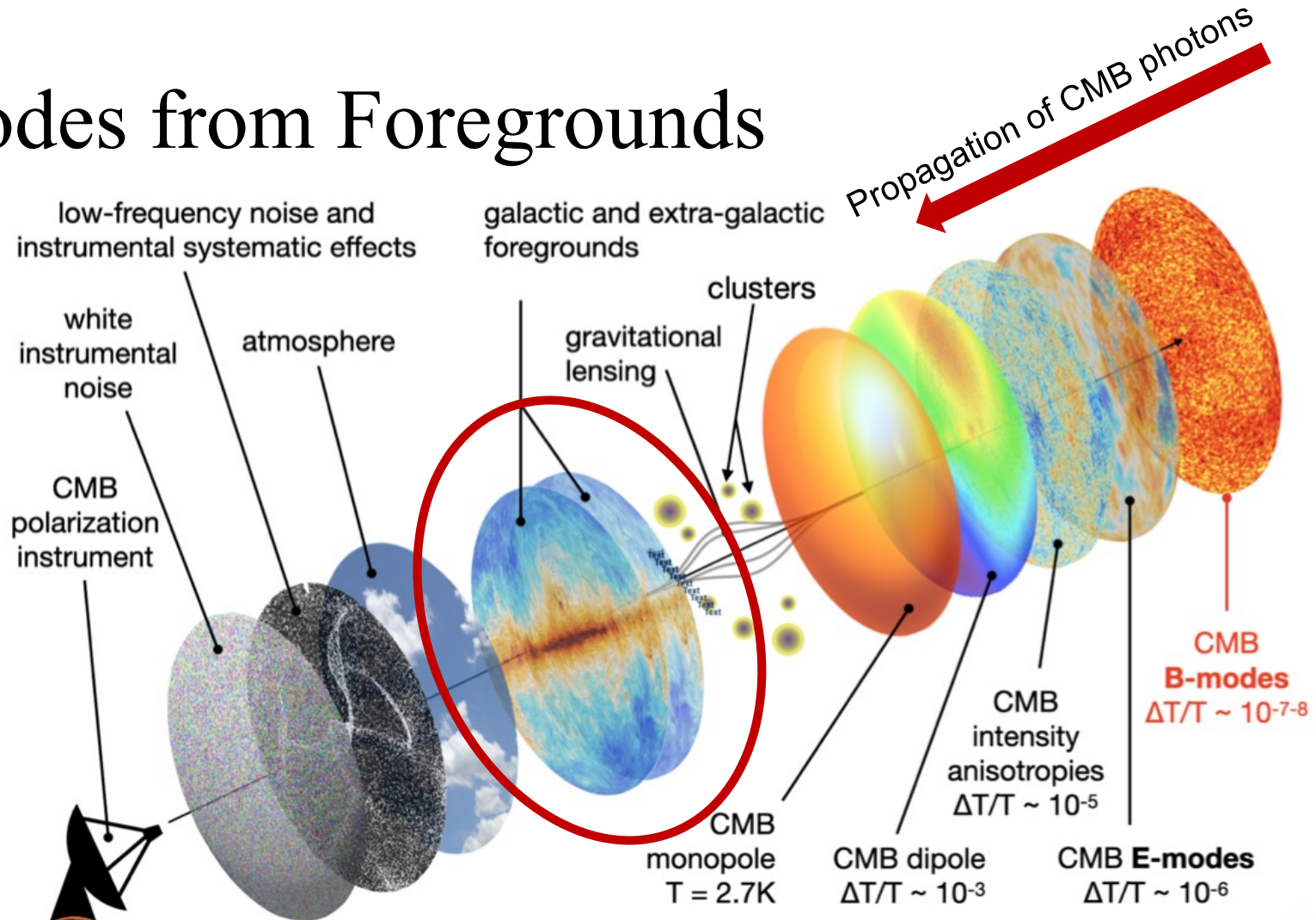


t = 380000
years



Test Inflation:
Primordial CMB B modes

B modes from Foregrounds



B modes from Lensing

Lensing B-modes (small-scales)

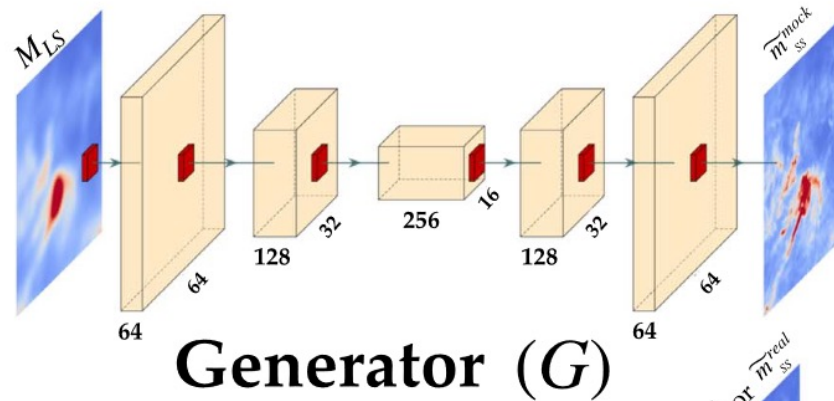
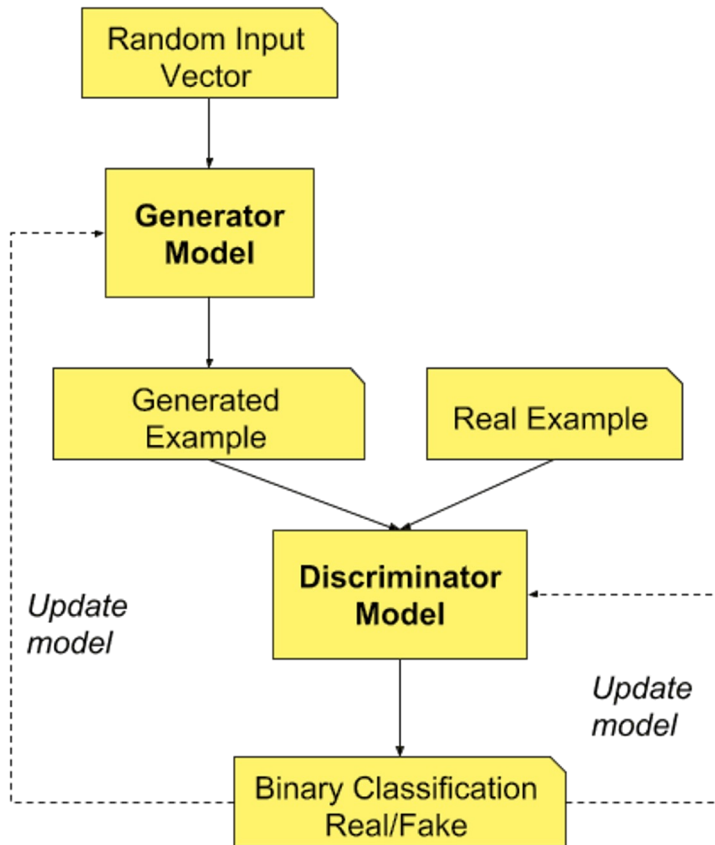
- CMB lensing: distort path of CMB photons (a few arcminutes)
- Lensing reconstruction (and delensing) : all about searching for **non-Gaussianity** in CMB

Non-Gaussian small-scale foregrounds

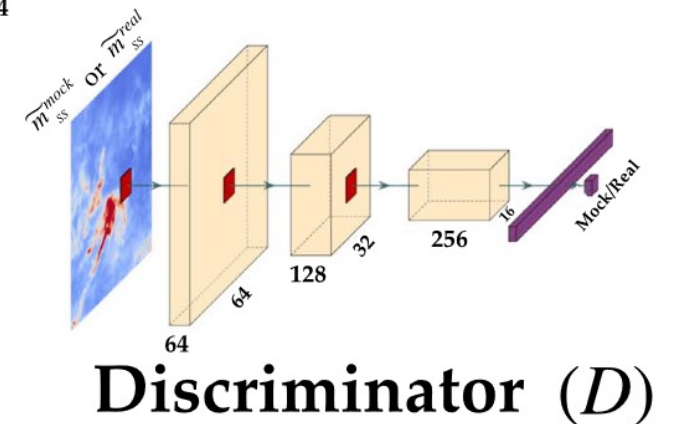
- Impact on CMB Lensing reconstruction, delensing, measurement of CMB B modes (r)

- Problem: No enough data of **polarized** foregrounds at arcminutes (up to $\sim 1^\circ$). **Intensity** map is better.
- Task:
 - Simulate **Non-Gaussian**, polarized, arcminute-scale foreground
- Method:
 - Turn to Machine Learning (focusing on thermal dust emission)

Generative adversarial networks (GAN)

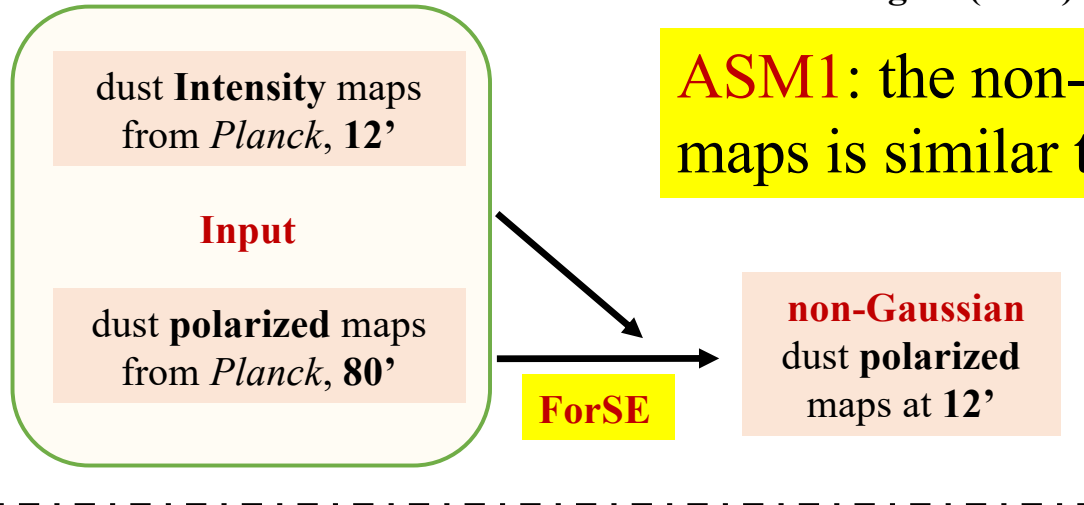


Krachmalnicoff & Puglisi, 2021



Planck GNILC dust maps at 353GHz

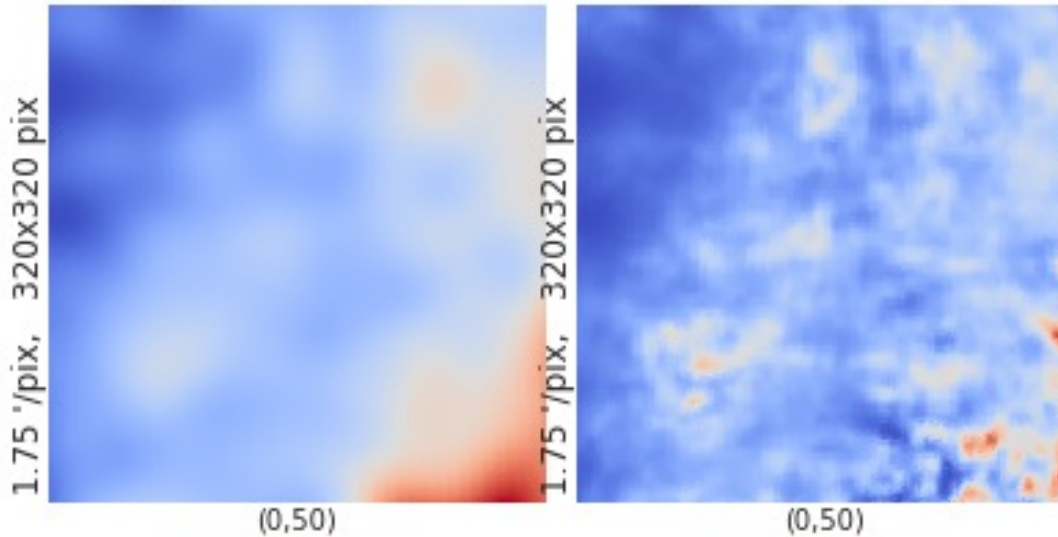
Krachmalnicoff & Puglisi (2021)



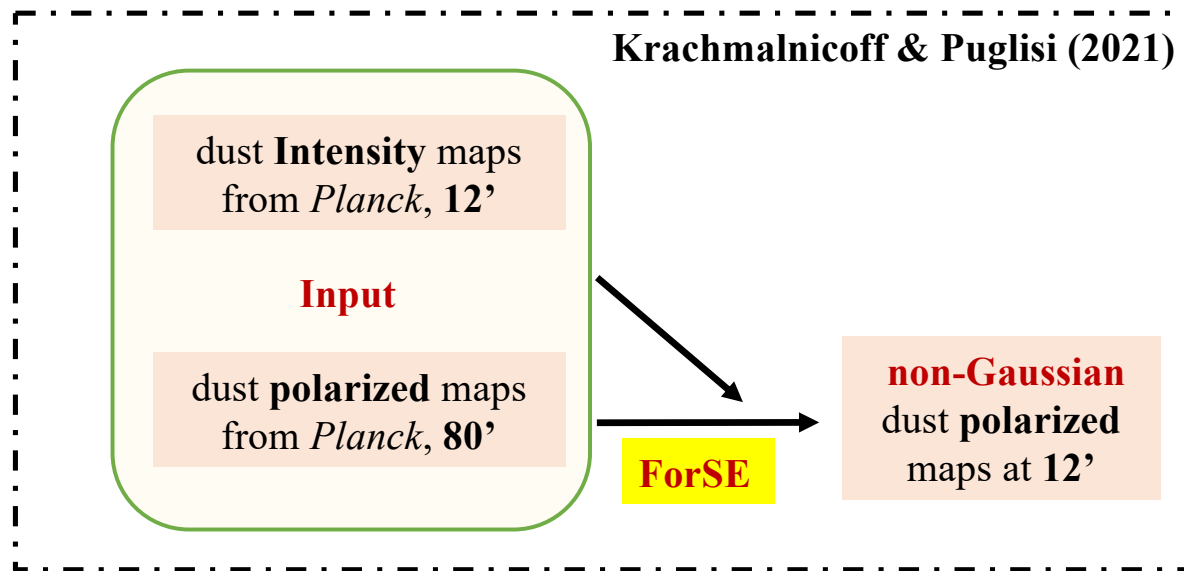
ASM1: the non-Gaussianity in the polarized maps is similar to that in the intensity maps

Q at 80amin

Q at 12amin



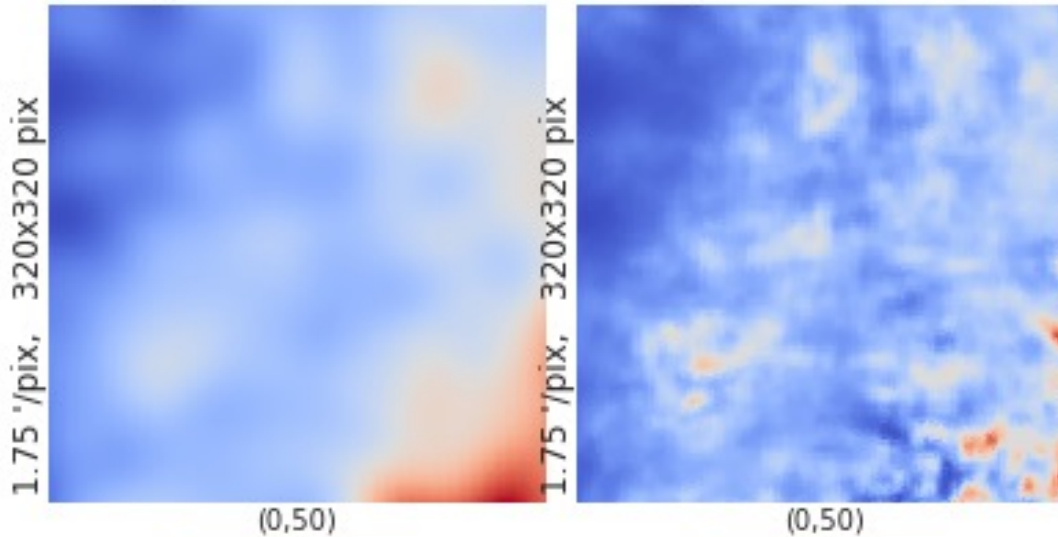
Planck GNILC dust maps at 353GHz



No data
at 3'

Q at 80amin

Q at 12amin

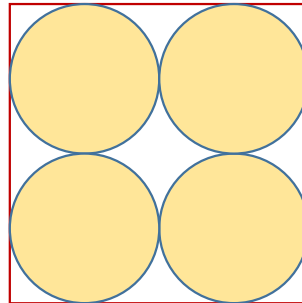


Map at 3'?

Image resolution: pixels per unit length

Pixels: 2

physical length: 2 cm
resolution: 1 cm^{-1}

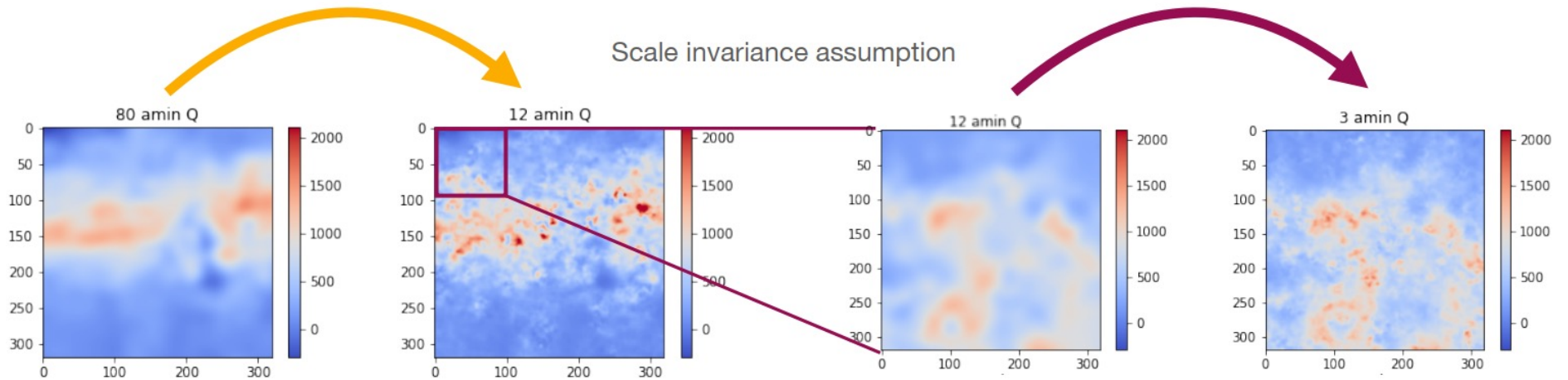
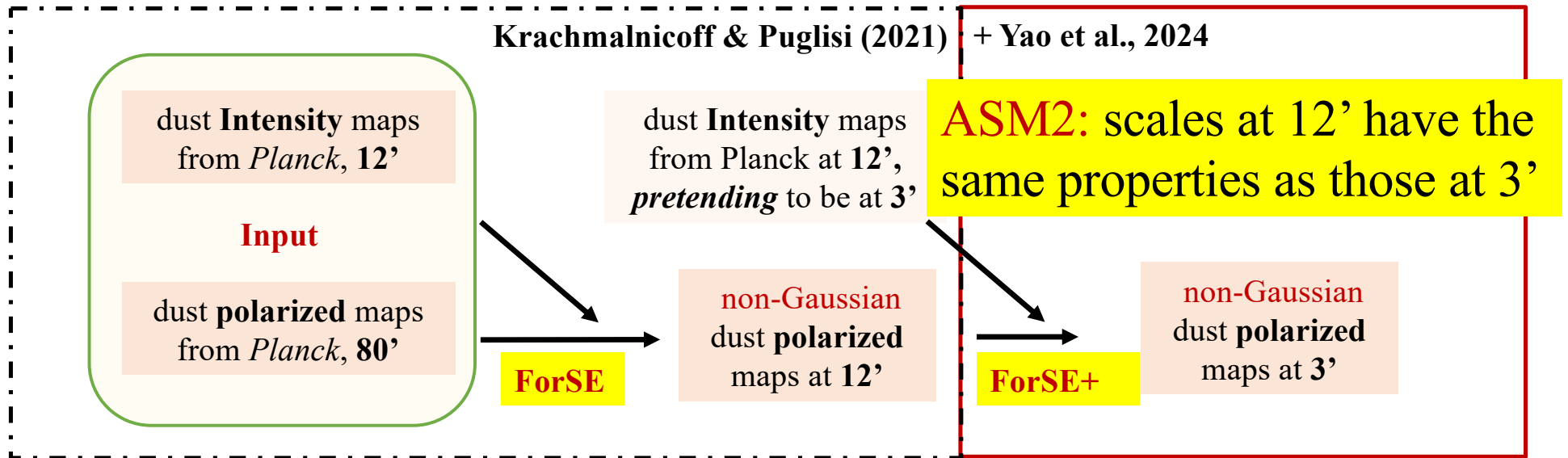


if L: 1 cm
then r: $? \text{ cm}^{-1}$

NNs don't have the sense of physical length

label the side length with a smaller value \rightarrow image with higher resolutions.

Planck GNILC dust maps at 353GHz



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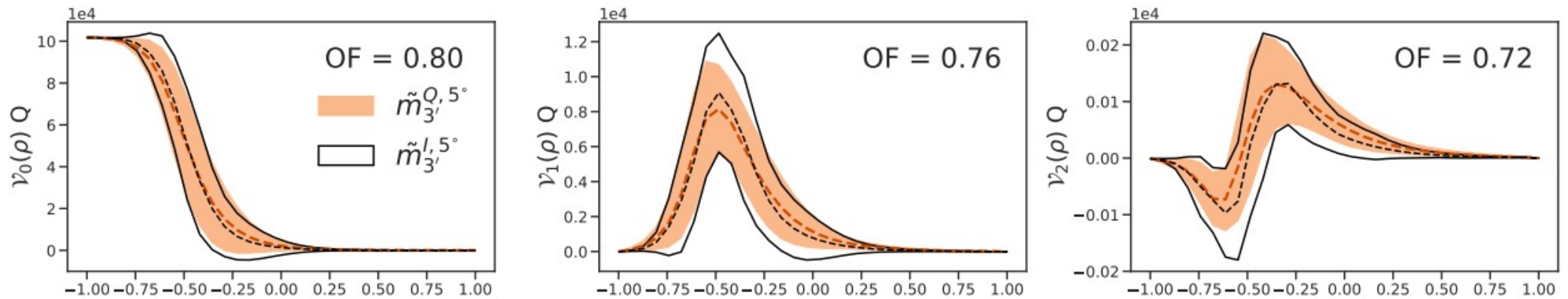
First NN iteration

Second NN iteration 11

Non-Gaussianity: Minkowski functionals of generated small scales

Yao et al., 2024

1σ variation of MFs across whole sky patches



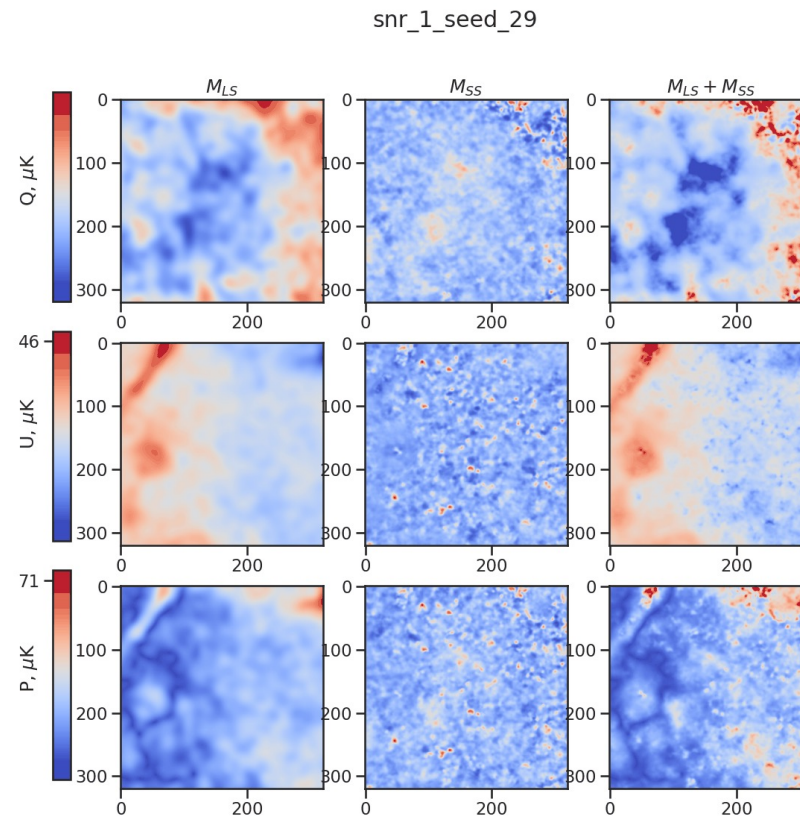
7/17/24

Jian Yao, jyao@sissa.it | ML4ASTRO2, Catania

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Different realizations at 12'

Yao et al., 2024



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Jian Yao, jyao@sissa.it | ML4ASTRO2, Catania

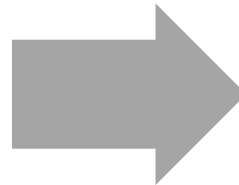
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Conclusions

<https://github.com/yaojian95/ForSEplus>

ForSE+ models are able to produce small-scale foregrounds with

- Non-Gaussianity
- Stochasticity!



Useful for studying the impact of foregrounds on:

- CMB Lensing reconstruction
- Delensing
- Estimation of r