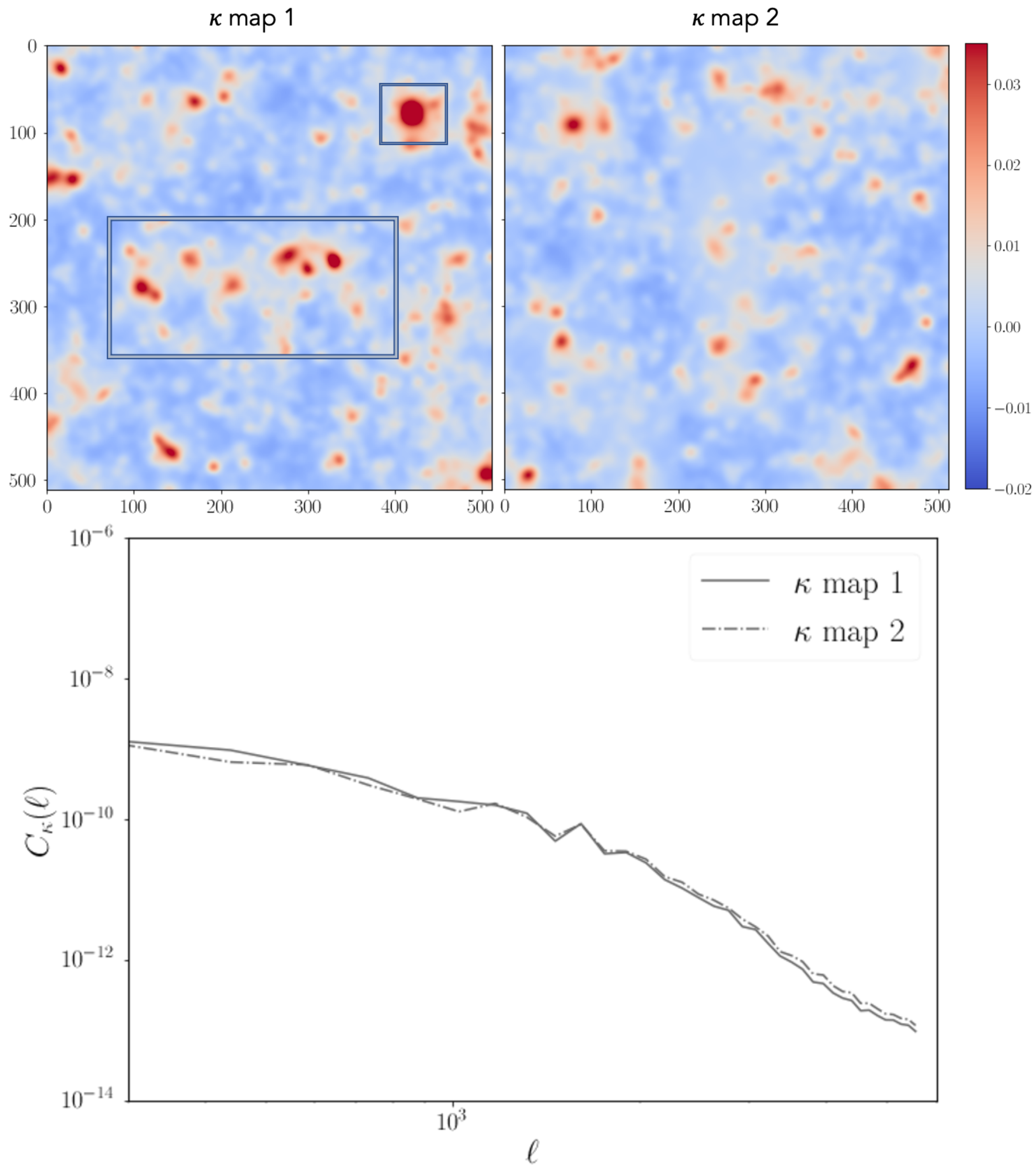
Forecasting the power of Higher Order Weak Lensing Statistics with automatically differentiable simulations

Denise Lanzieri

Supervisors: François Lanusse, Jean-Luc Starck

ML-IAP, 19/10 2021



κ map 1
κ map 2
0
100
200
300
400
500
0.03
0.02
0.01
0.00
−0.01
−0.02
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{-14}
$C_\kappa(\ell)$
10^3
ℓ

Some simulation-based inference approaches proposed to access the non-Gaussian information:

- Lifting weak lensing degeneracies with a field-based likelihood, *(Natalia Porqueres, Alan Heavens, et al. (2021))*
- Mining gold from implicit models to improve likelihood-free inference *(Johann Brehmer, Gilles Louppe et al. (2018))*

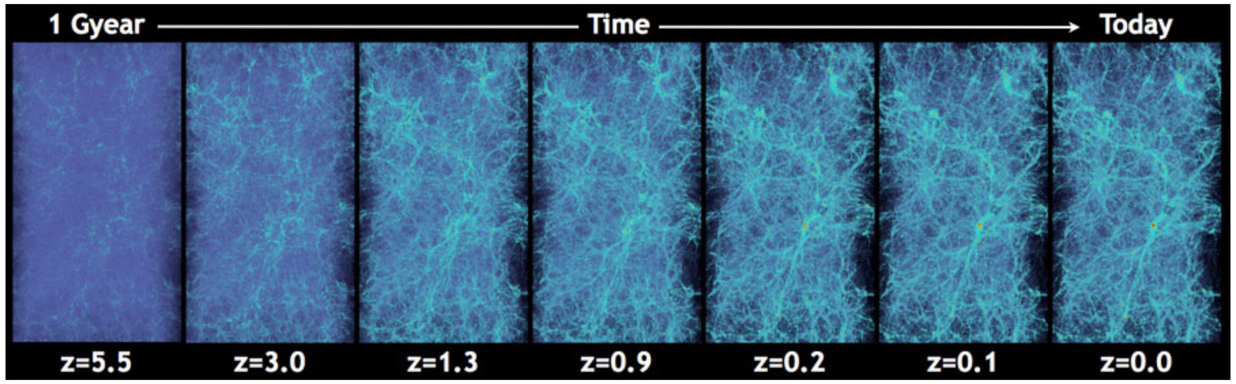
MAIN LIMITATIONS:

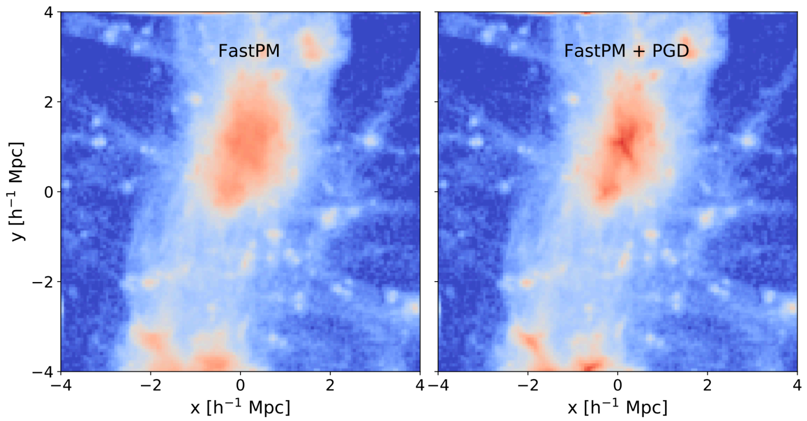
- Gradient-based
- Costly as they require a large number of simulations
- Intractable for more than 3 or 4 cosmological parameters.

$$\left.\frac{df(x)}{dx}\right|_{x_1} \approx \frac{f(x_1+h)-f(x_1)}{h}$$

DLL (Differentiable lensing light cone) → **TensorFlow**-based weak gravitational lensing package

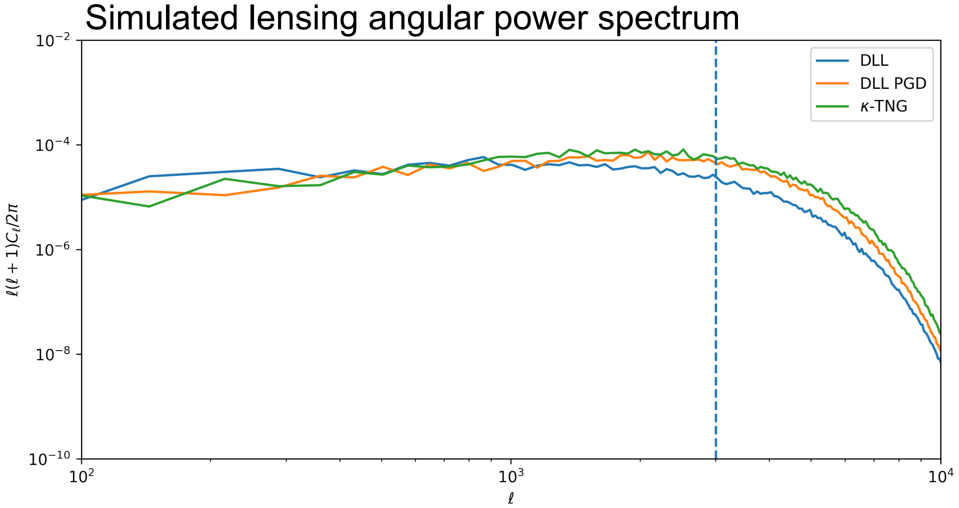
- **N-body** simulation (particle-mesh solver)
- Fills the gap in the accuracy-speed space through the PGD scheme
- Provides derivatives with respect to cosmological and nuisance parameters through automatic differentiation





Biwei Dai et al. 2018

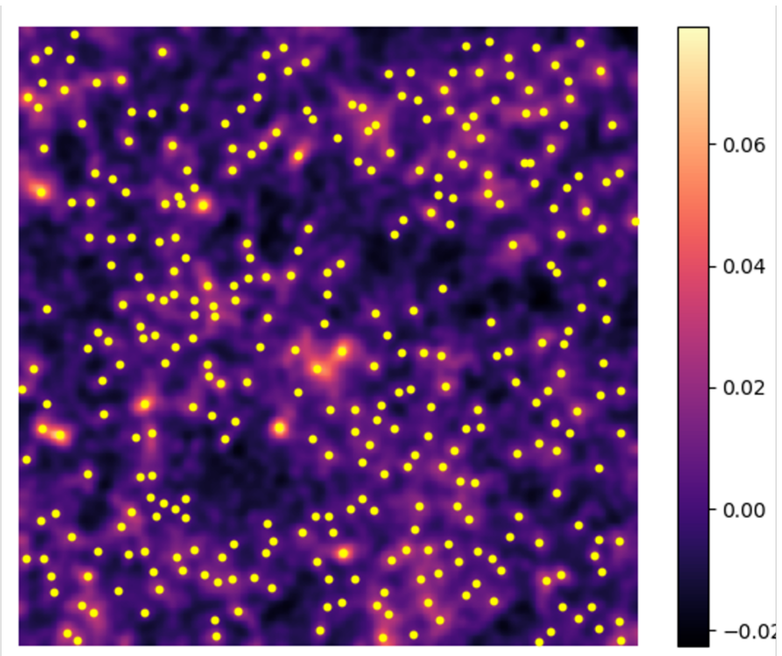
Simulated lensing angular power spectrum



https://github.com/DifferentiableUniverseInitiative/flowpm

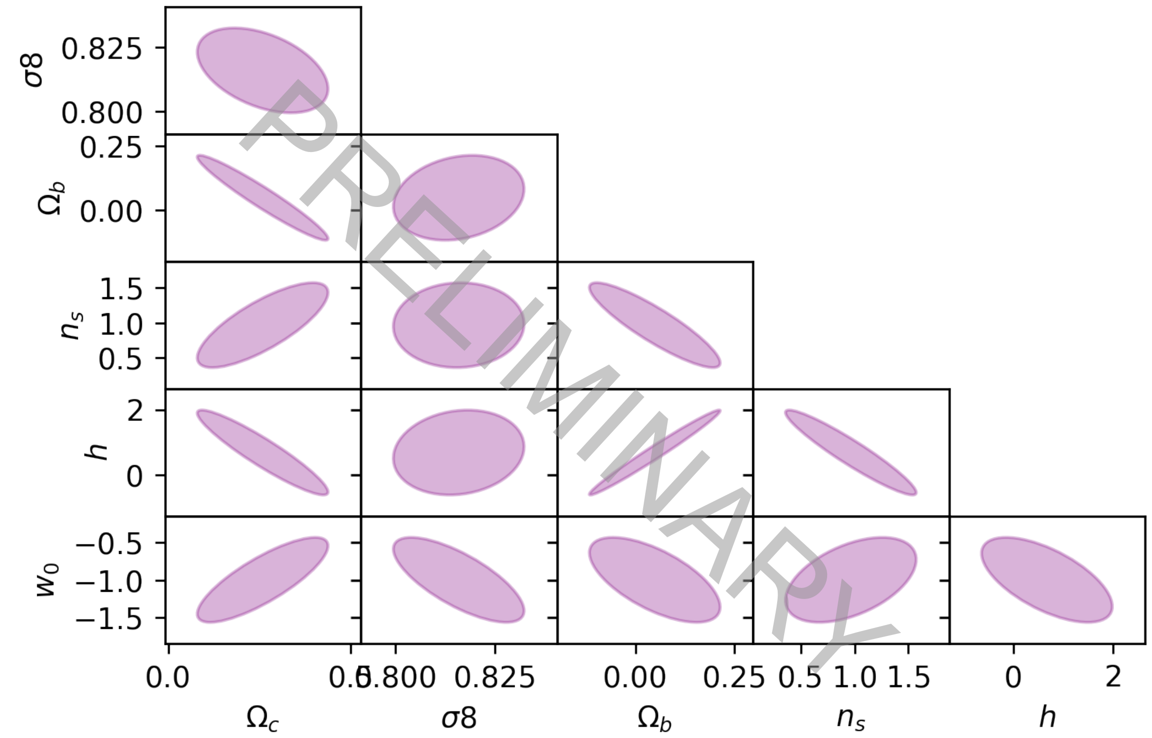
https://github.com/LSSTDESC/DifferentiableHOS

Peak counts (local maxima)



κ map

$$F_{\alpha,\beta} = \sum_{i,j} \frac{d\mu_i}{d\theta_\alpha} C^{-1}_{i,j} \frac{d\mu_j}{d\theta_\beta}$$



- Forecast for any map-based statistics (Scattering transform, l1norm, neural compression, etc)

Denise Lanzieri

Next step

- Simulation based inference, made efficient by very fast lensing lightcone and having access to gradient

Everyone is most welcome to join! How to get in touch:

- GitHub repo: https://github.com/LSSTDESC/DifferentiableHOS

  https://github.com/DifferentiableUniverseInitiative/flowpm

Thank you!