

# Multi-fidelity emulation for high-dimensional cosmological inference

*Ming-Feng Ho*

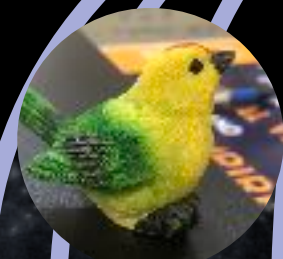
UC Riverside

NASA FINESST FI

[jibancat.github.io](https://jibancat.github.io)

*Computer science collaborators*

Bird's group:



Simeon Bird  
(UCR)



Yanhui Yang  
(UCR)



Martin A. Fernandez  
(CSU Atmospheric  
Science)



Reza Monadi  
(Cal State)



Sum(Mahdi)  
Qezlou  
(UT Austin)



Roman Garnett  
(WUSTL CS)

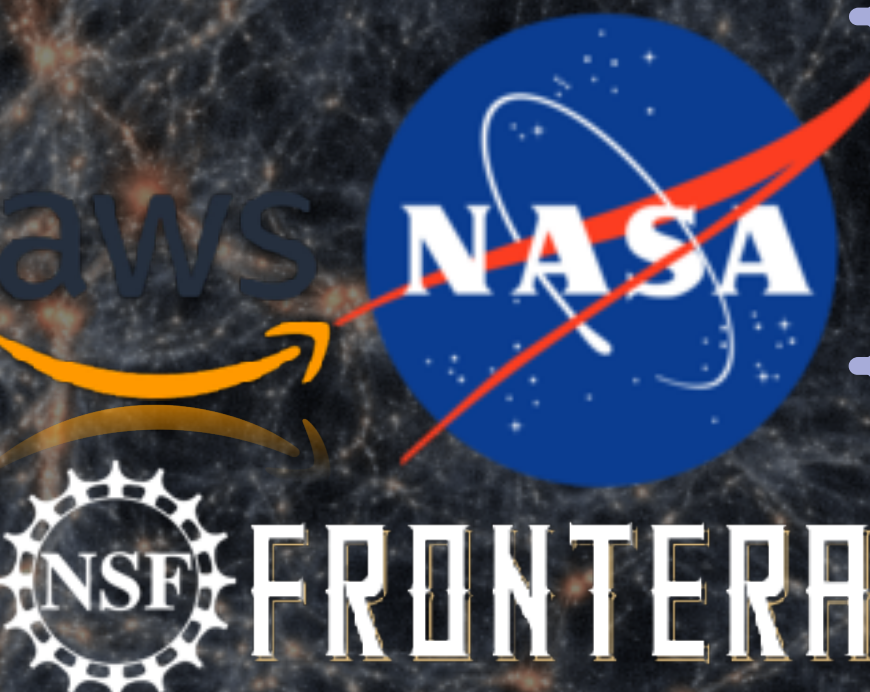


Christian Shelton  
(UCR CS)

*Astrid simulation  
collaboration:*



Yueying Ni (CfA), Nianyi Chen (CMU), Patrick Lachance (CMU), Xiaowen Zhang (CMU), James Davies (Scuola Normale Superiore), Yu Feng (Google), Tiziana Di Matteo (CMU), Rupert Croft (CMU)

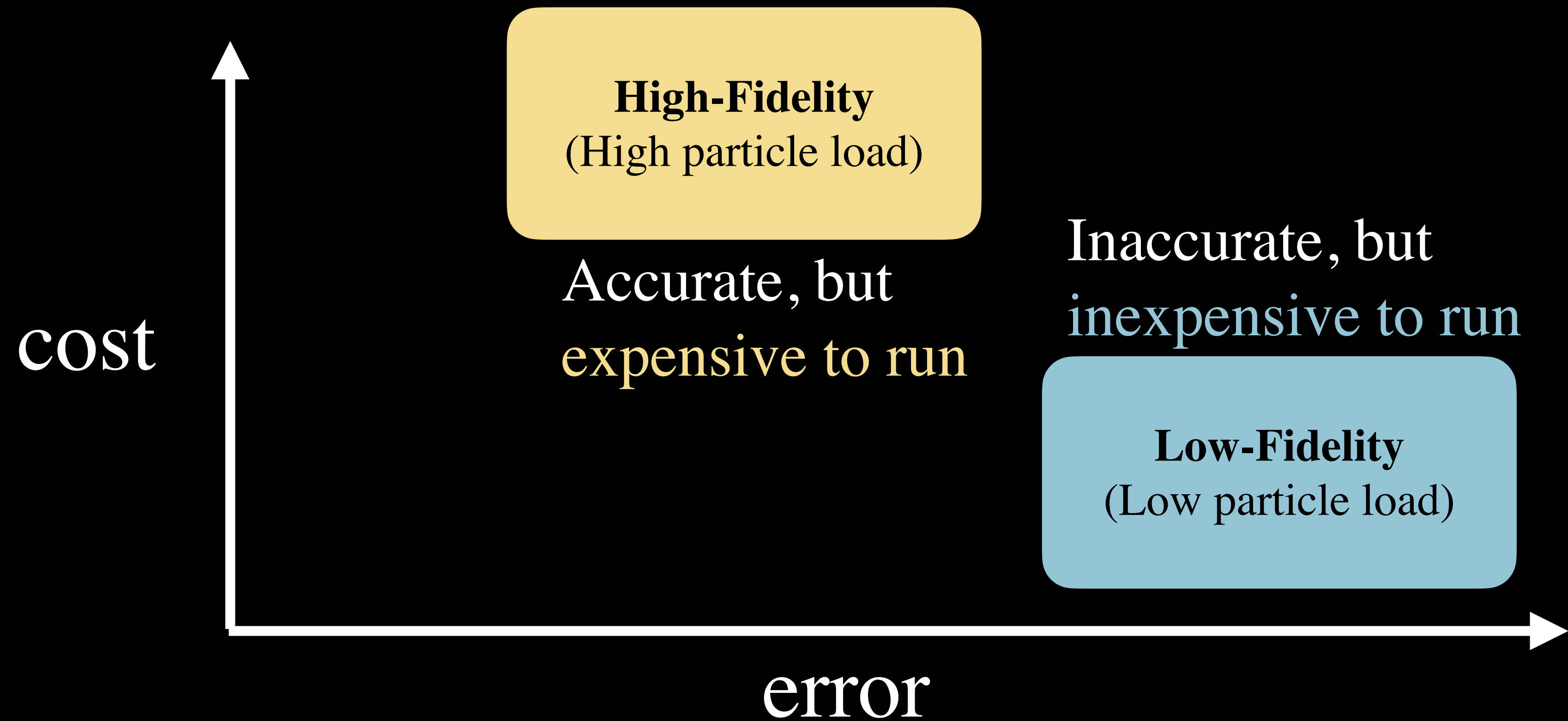


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# Motivation: Making simulations useful for future high-dimensional problems

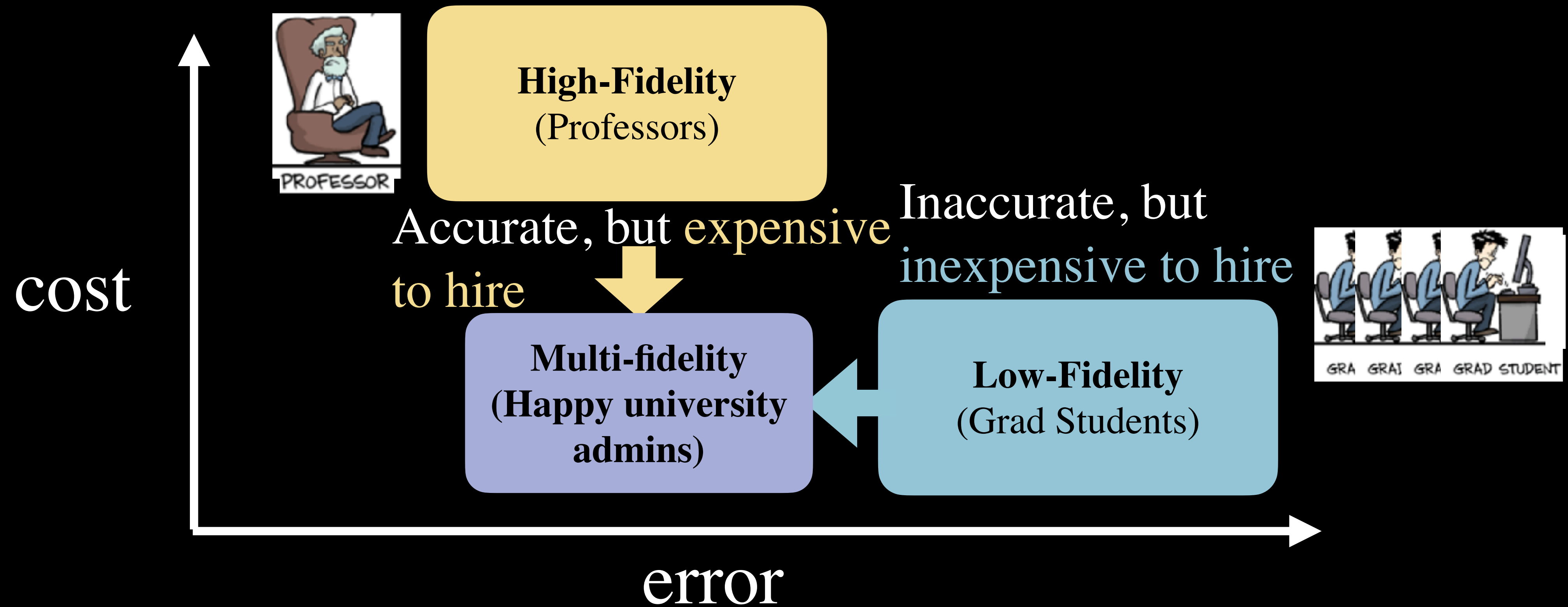
- If we want to directly use *simulations* for ...
  - Probing more beyond  $\Lambda$ CDM parameters, or
  - Marginalizing the subgrid astrophysical effects through *hydrodynamical simulations*.
- It's useful to use *emulator* approach.
- → But emulator needs *tons of simulations* to fill up the high-dim parameter space (computational bottleneck).

# Idea: Multi-fidelity emulator



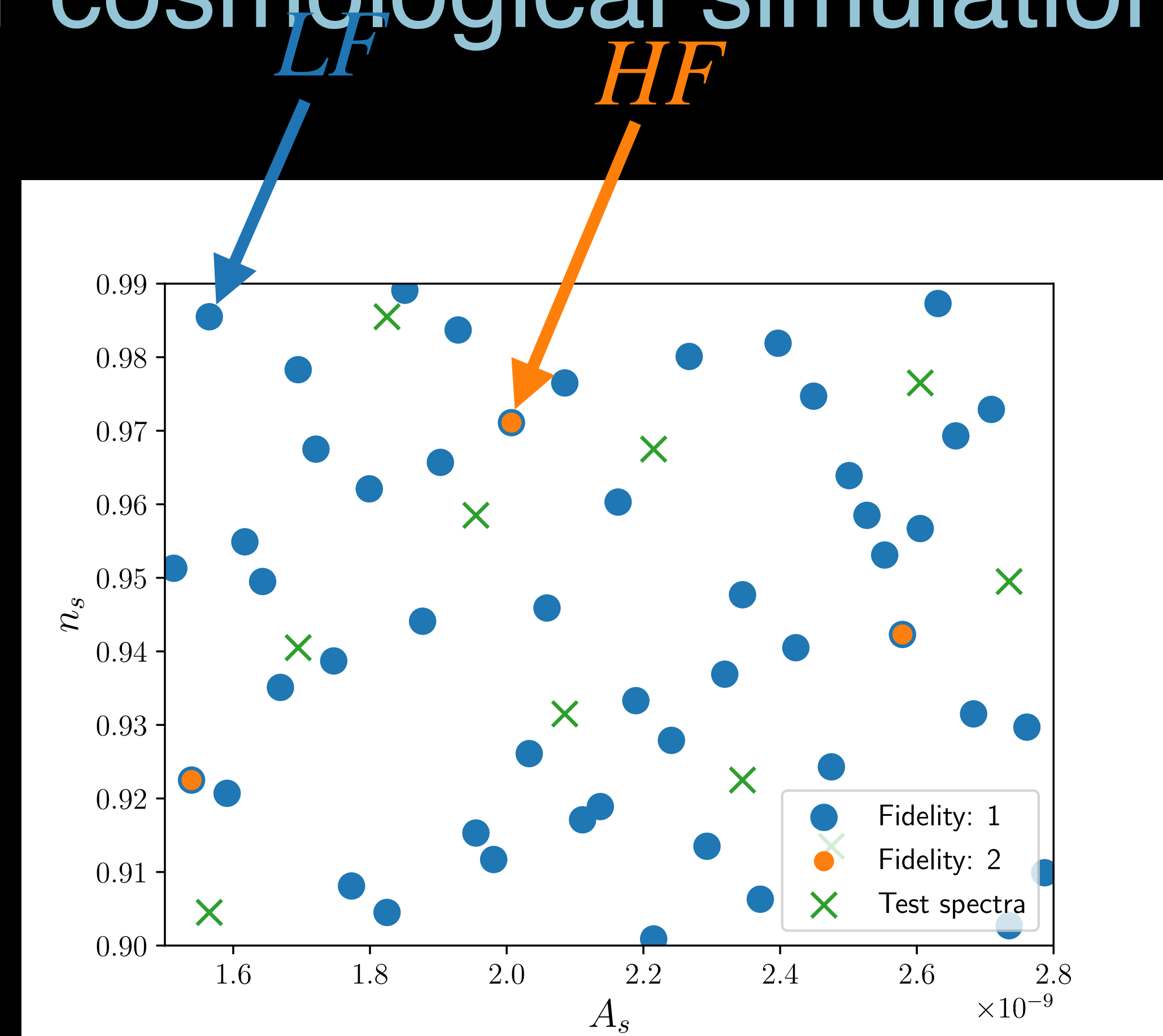
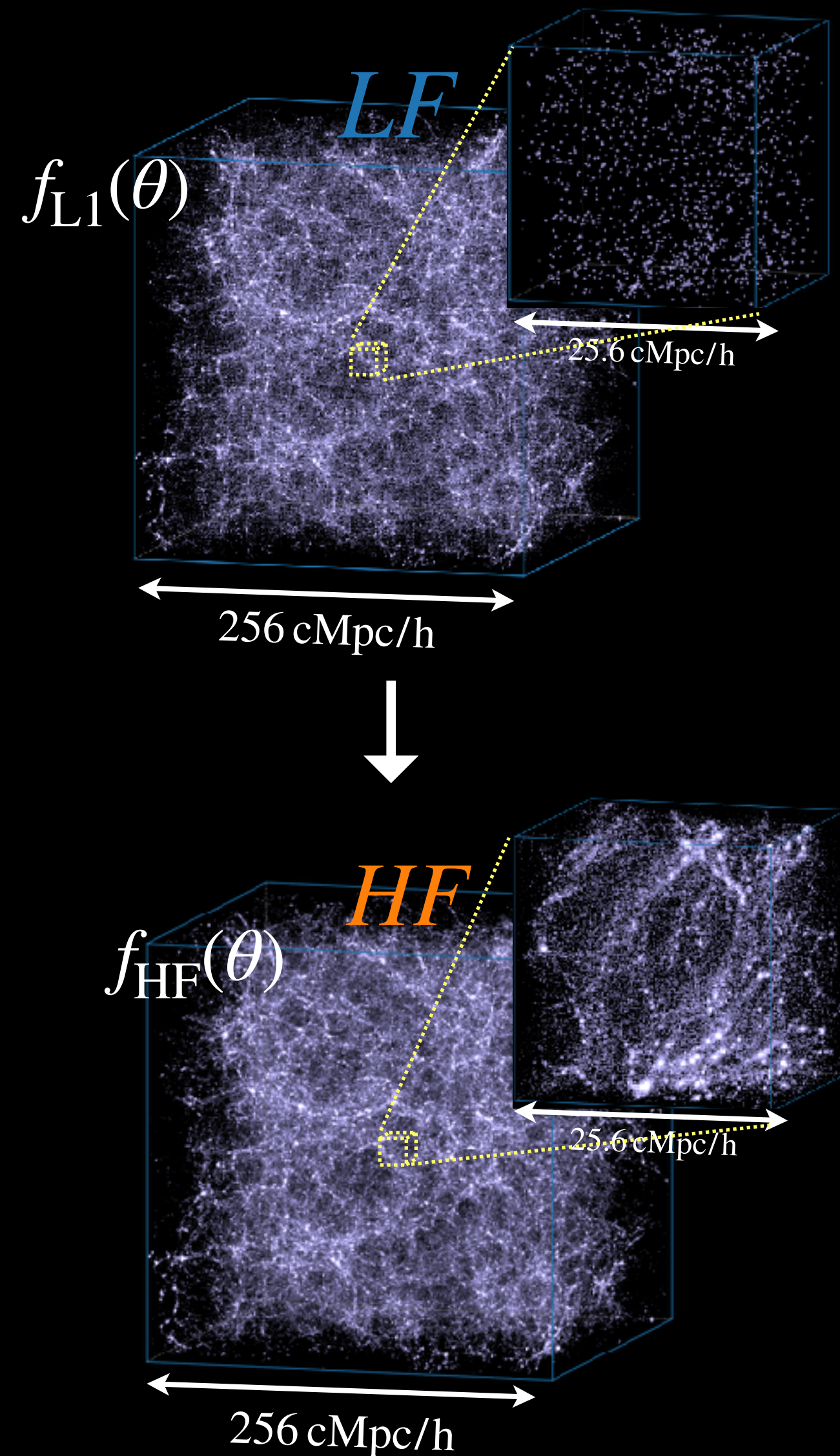
*Use tons of **Low-Fidelity** to interpolate the parameter space, use a few of **High-Fidelity** to correct the resolution.*

# Idea: Multi-fidelity emulator (Analogy)



*Idea: Many Grad Students + A few Professors = minimize the cost and maximize the accuracy.*

# MF-Emulator: Illustration for cosmological simulations

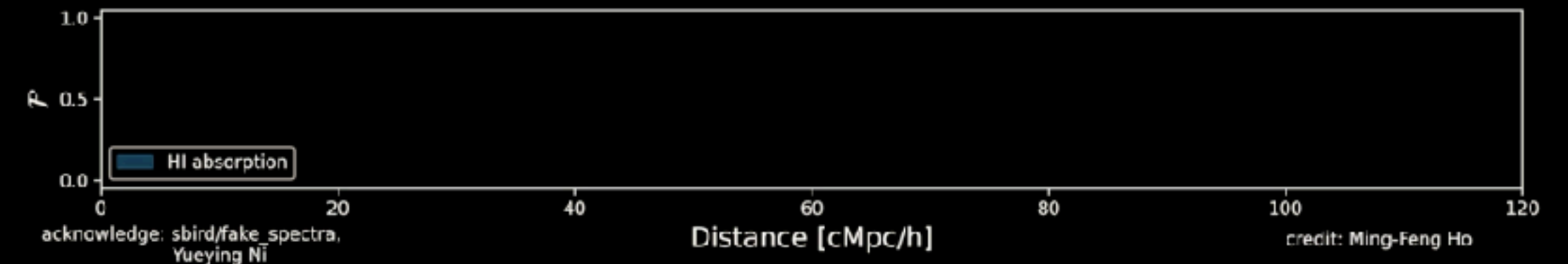
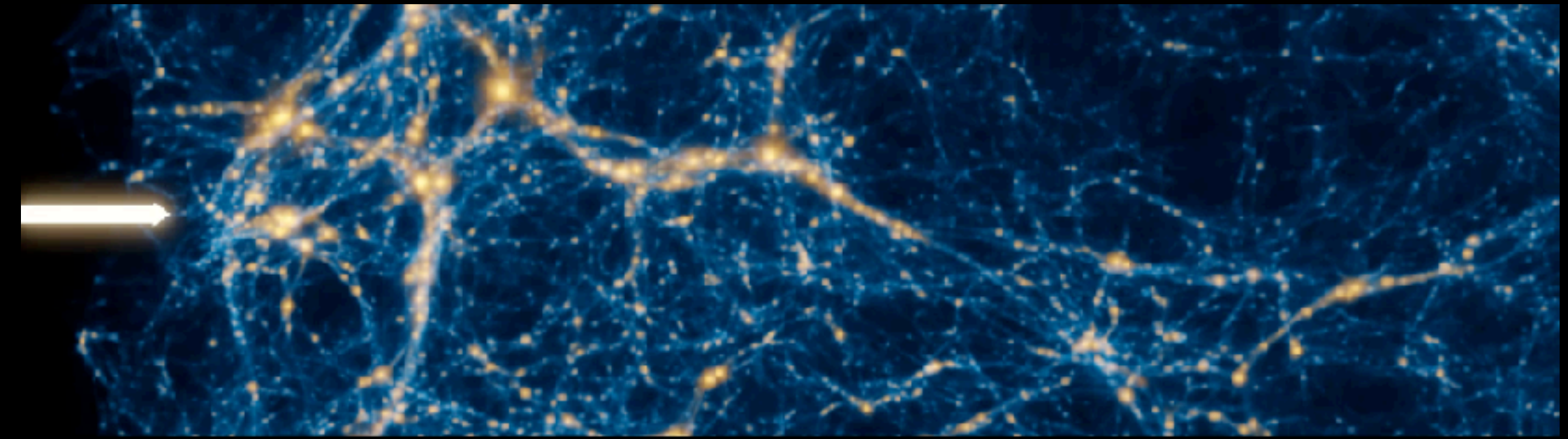
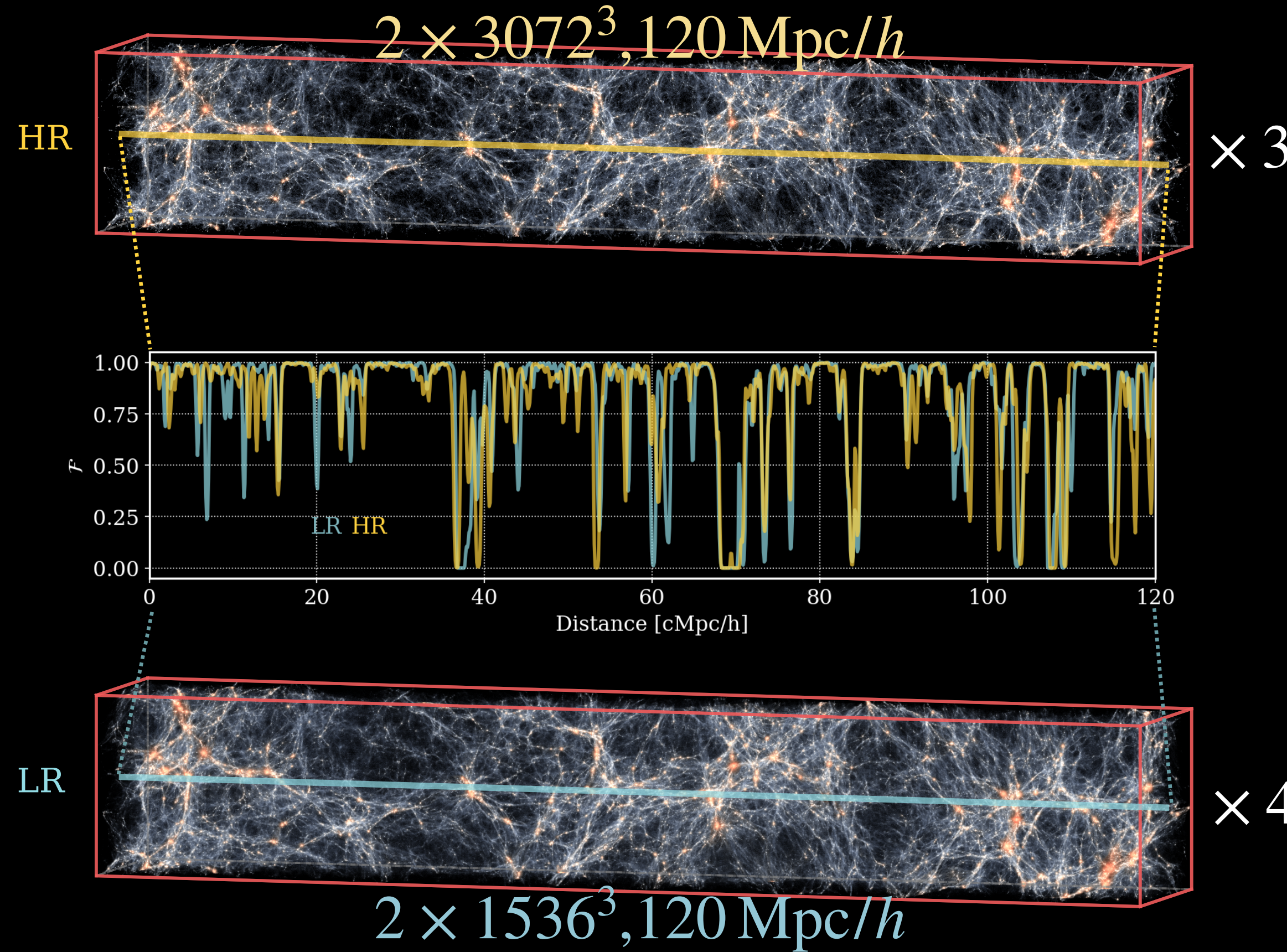


- MF benefit: Easier to fill up the hyperspace

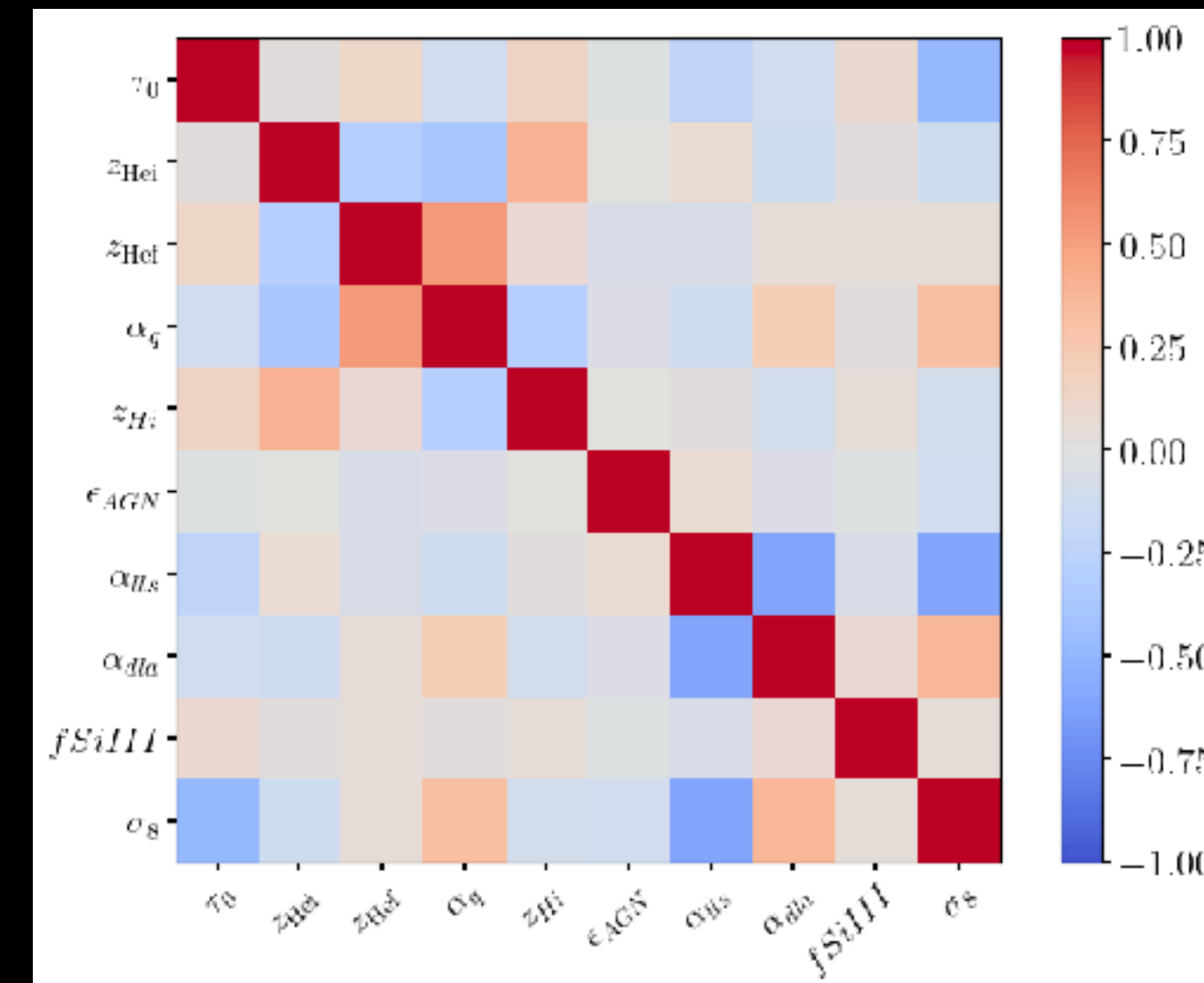
# PRIYA simulation suite for Lyman alpha forest



Martin A. Fernandez



- Cosmo ( $A_p, n_p$ ) + reionization ( $z_{\text{HI}}, \alpha_q, z_{\text{He},i,f}$ ) + AGN feedback strength ( $\epsilon_{\text{AGN}}$ )



PRIYA (Bird-Fernandez-Ho-Qezlou+; [arXiv:2306.05471](https://arxiv.org/abs/2306.05471))  
 eBOSS reanalysis paper (Fernandez-Bird-Ho; [arXiv:2309.03943](https://arxiv.org/abs/2309.03943))

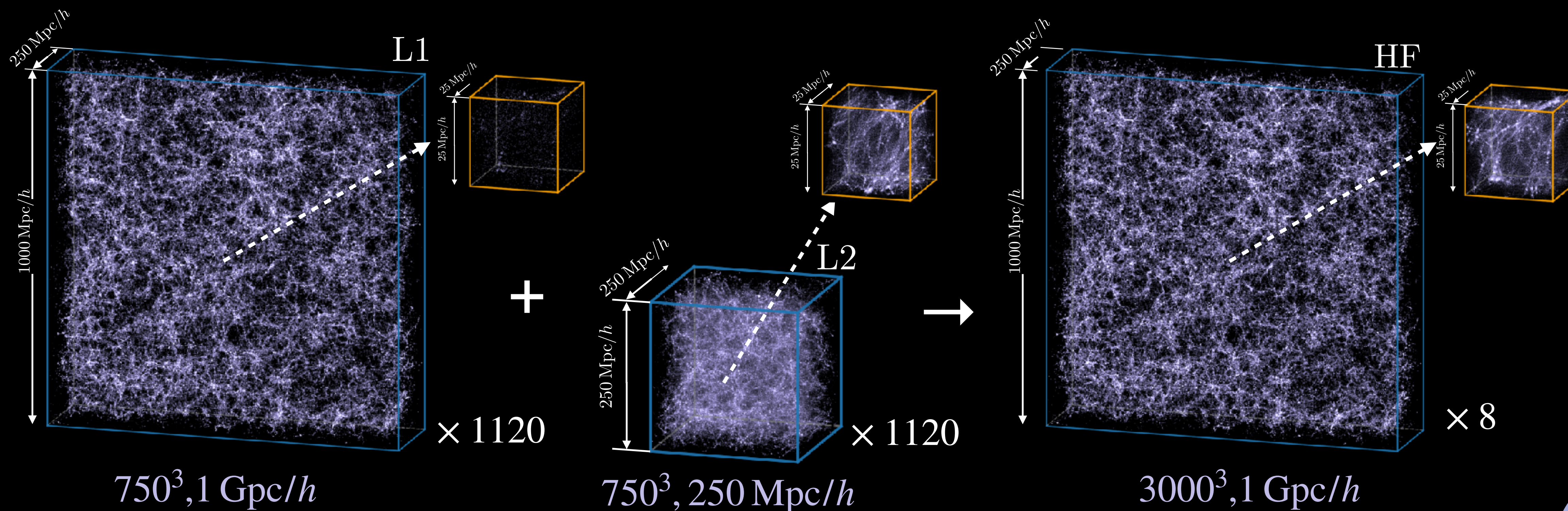


Yanhui Yang  
(UCR)

# Goku simulation suite for 11D emulation

Gravitational clustering **Over k** in an **Ultra-high** dimensional parameter space

- $w_0 w_a \text{CDM} + \sum m_\nu + N_{\text{eff}} + \alpha_S + \text{warm DM}$



# Summary

- **Multi-Fidelity:** New emulator design to efficiently expand emulator's dimensionality
- **PRIYA-MF:** a hydro sim suite for Lya forest include both astro+cosmo parameter covariance
- **Goku-MF:** a DM sim suite for beyond  $\Lambda$ CDM cosmology emulator

MF-Emulator: Ho-Bird-Shelton ([arXiv: 2105.01081](#))

MF-Box: Ho-Bird-Fernandez-Shelton ([arXiv:2306.03144](#))

PRIYA: Bird-Fernandez-Ho-Qezlou+ ([arXiv:2306.05471](#))

PRIYA-eBOSS: Fernandez-Bird-Ho ([arXiv: 2309.03943](#))

Goku: Yang-Bird-Ho: [in prep.](#)