

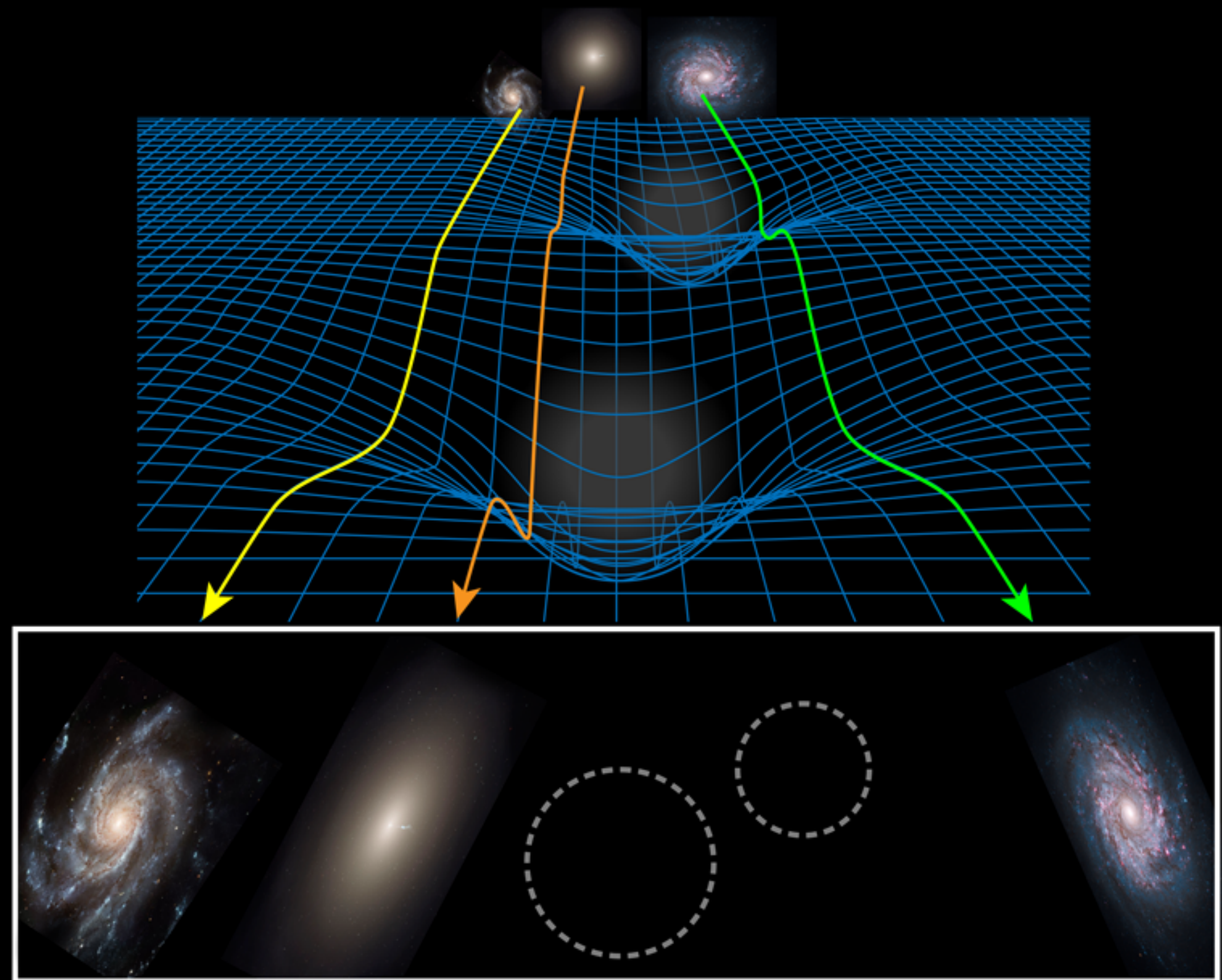
Weak Lensing ML Uncertainty Competition

Overview

Weak gravitational lensing

- The gravity of matter warps the surrounding space-time and causes distortions in the observed shapes of the background galaxies.
- Powerful probe of the matter distribution in our universe from coherent patterns of galaxy shapes.
- Numerous current and upcoming WL surveys: DES, HSC, Euclid, Rubin LSST, Roman, etc.
- Traditional analysis based on two-point correlation functions can only capture limited amount of information from the weak lensing data (2D fields similar to images).
- **AI/ML-based approaches could capture more information hidden in higher-order correlations!**

WE NEED YOU!



Weak Lensing ML Uncertainty Challenge

Competition tasks

The competition tasks will be structured into **2 phases**:

• Phase 1: Cosmological Parameter Estimation

Participants will develop models that:

- Accurately infer cosmological parameters (Ω_m, S_8) from the weak lensing image data.
- Quantify uncertainties via the 68% confidence intervals of the parameters of interest (Ω_m, S_8) .

• Phase 2: Out-of-Distribution Detection

Some test data will be generated with different physical models (OoD), leading to some distribution shifts with respect to the test data in Phase 1. Participants will develop models that:

- Identify test data samples inconsistent with the training distribution (OoD detection).
- Provide probability estimates indicating data conformity to training distributions.

Scoring metrics

KL divergence between the true Gaussian-like posterior distribution and the Gaussian distribution with the predicted mean and standard deviation.

$$\text{score}_{\text{inference}} = -\frac{1}{N_{\text{test}}} \sum_{i=0}^N \left(\frac{\left(\hat{\Omega}_m - \Omega_m^{\text{truth}} \right)^2}{\sigma_{\Omega_m}^2} + \frac{\left(\hat{S}_8 - S_8^{\text{truth}} \right)^2}{\sigma_{S_8}^2} + \log(\sigma_{\Omega_m}) + \log(\sigma_{S_8}) \right)$$

KL divergence between the posterior and the Gaussian distribution with the predicted mean and standard deviation.

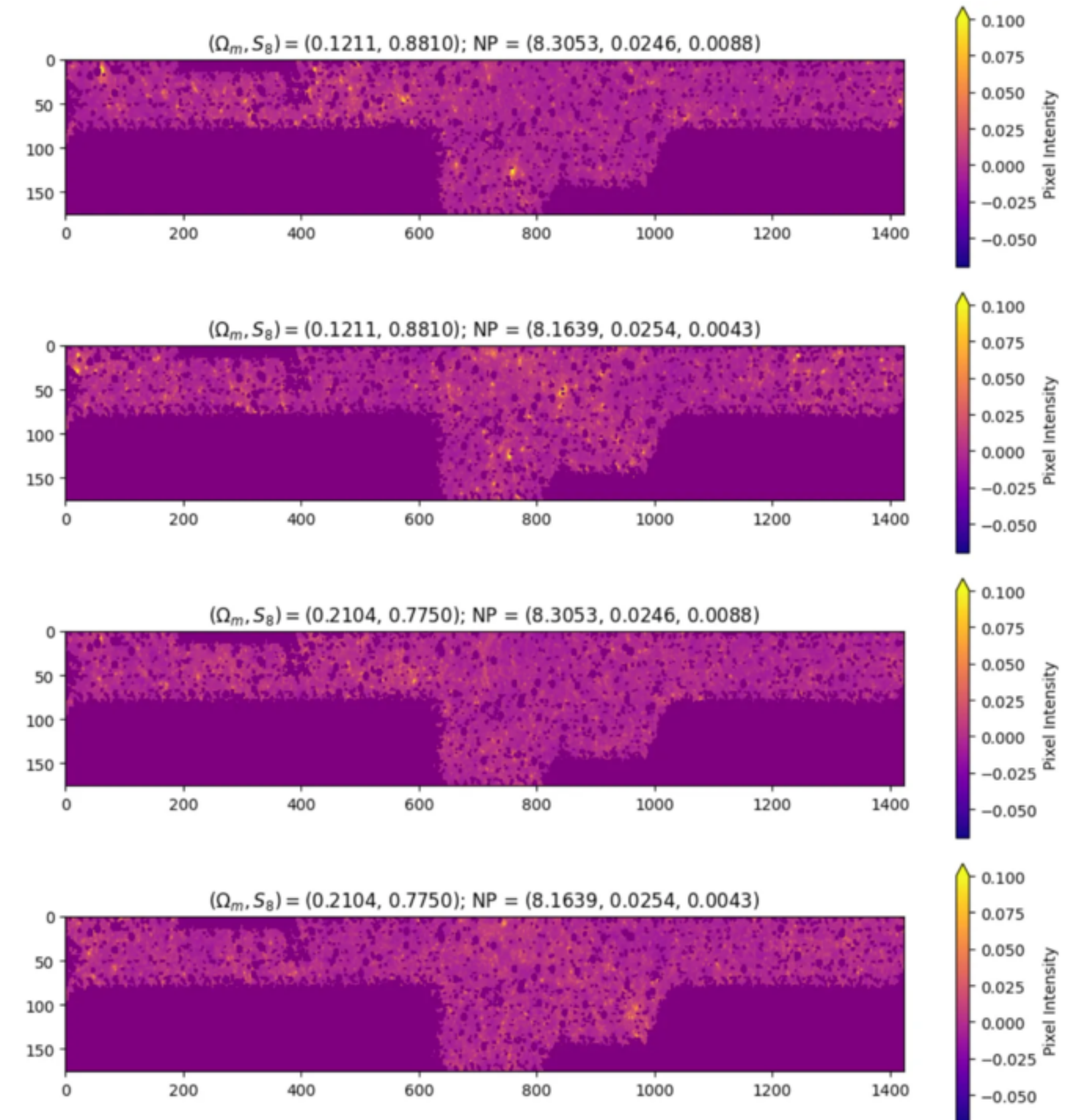
$$\text{score}_{\text{OoD}} = \frac{1}{N_{\text{test}}} \sum_{i=0}^N (y_i \log(p_i) + (1 - y_i) \log(1 - p_i))$$

where $y_i = 1$ if the dataset is InD; $y_i = 0$ if the dataset is OoD, and p_i is the probability estimates predicted by the model.

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Dataset

- Mock galaxy catalogs predicted with N-body simulations and lens algorithms at 101 cosmological parameters (Ω_m, S_8)
- Pixelized 2D weak lensing images: convergence maps
- The model must take into account the systematic uncertainties from **4 realistic systematic effects**:
 - (1) 2 baryonic effect uncertainties
 - (2) 1 photometric redshift uncertainty
 - (3) Pixel-level noises



Weak Lensing ML Uncertainty Challenge

Phase 1 Dataset

The participants will be provide with:

- **Public training set:**

- Image data; shape = (101, 256, 1424, 176)
- Label shape = (101, 256, 5)

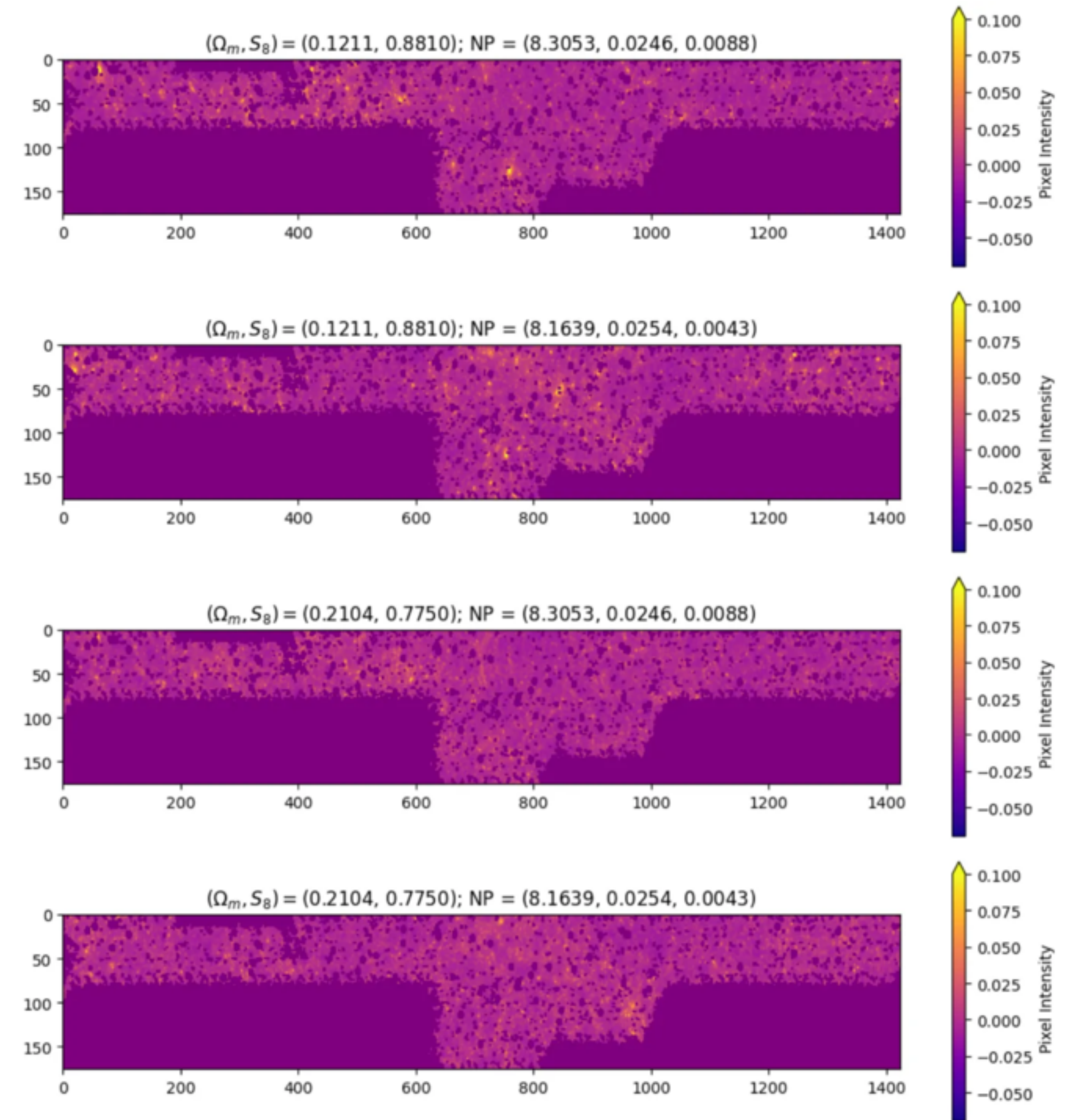
101 = Realizations of cosmological models; each characterized with 2 parameters of interest (Ω_m, S_8)

256 = 8*8*8 realizations of 3 nuisance parameters for systematic (1) and (2)

(1424, 176) = Image dimension

5 = 2 parameters of interest (Ω_m, S_8)
+ 3 nuisance parameters for systematics (1) and (2)

- **The provided training set is noiseless.** Participants can generate pixel-level noise (3) to augment their training data using a simple function we provide



Weak Lensing ML Uncertainty Challenge

Phase 1 Dataset

The participants will be provide with:

- **Public test set:**

- Image data; shape = (10000, 1424, 176)

10000 = Number of test images

(1424, 176) = Image dimension

- The test images are generated with random cosmological parameters, random nuisance parameters, and random pixel-level noises.

Evaluation

The true parameters $(\Omega_m^{\text{truth}}, S_8^{\text{truth}})$ of the public test set are unknown to the participants.

Participants will submit predictions of

- **Cosmological parameters** $(\hat{\Omega}_m, \hat{S}_8)$
- **Their uncertainties** $(\sigma_{\Omega_m}, \sigma_{S_8})$

to **Codabench** (our competition platform).

The model performance will then be evaluated with the hidden ground truth based on our scoring metrics.

Weak Lensing ML Uncertainty Challenge

Status and timeline

- This challenge has been accepted as one of the *NeurIPS 2025 competitions*.

Envisioned competition schedule		
Date	Phase	Description
Aug 2025 – End of Oct 2025	Public Phase	Start of the public phase (Phase 1 first; then Phase 2)
End of Oct 2025 – Mid Nov 2025	Final Phase	Evaluating performance on hidden dataset
Mid Nov 2025	Results	Announcement of winners

- Coming soon!** Please keep following our updates on the FAIR Universe website:
<https://fair-universe.lbl.gov/>.

