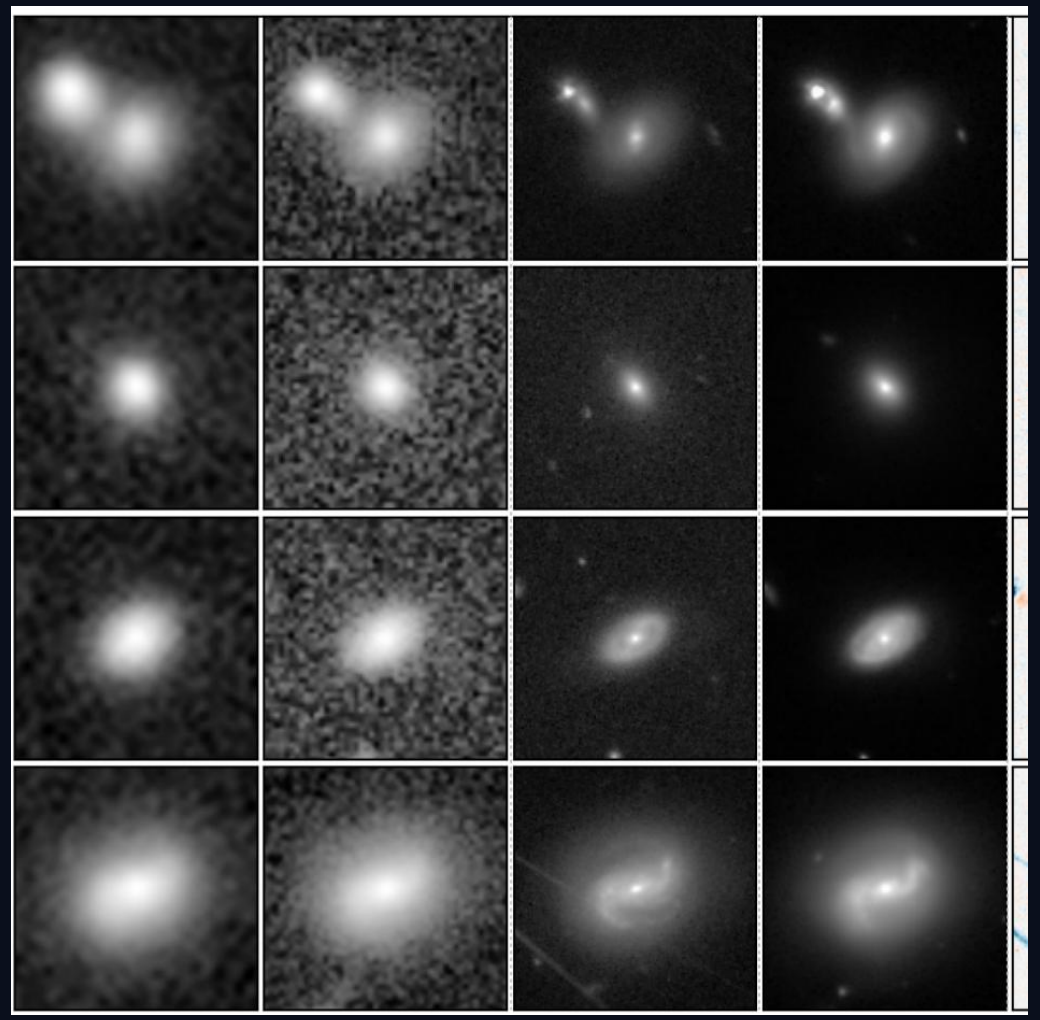
3rd international Workshop on AI + Astronomy: Models, Data, Discovery

From DESI to Euclid: A Generative Bridge to Improve Measurements of Galaxy Structure



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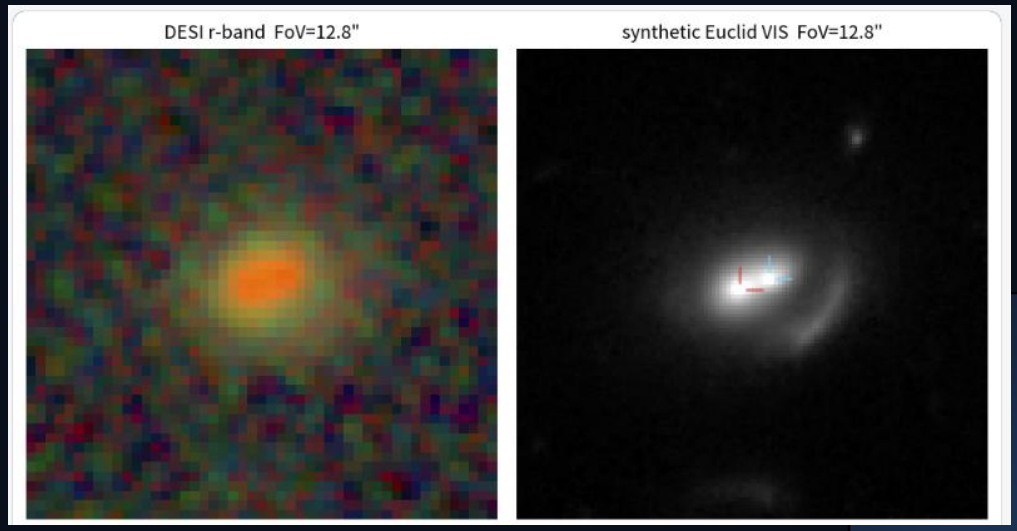
2026/10/19 Zhijiang Lab

Overview



Question: From DESI (low resolution) to Euclid (high resolution)

Classical Answer: image deconvolution problem

AI Answer: generate a high resolution image conditioned on low resolution image

MOTIVATION · RESOLUTION

The Seeing-limited Resolution Gap



The DESI Bright Galaxy Sample (BGS) supplies the largest low-redshift magnitude complete (r<19.5) galaxy sample.

milestone sample for galactic astronomy

median PSF FWHM of ~1.3 arcsec,

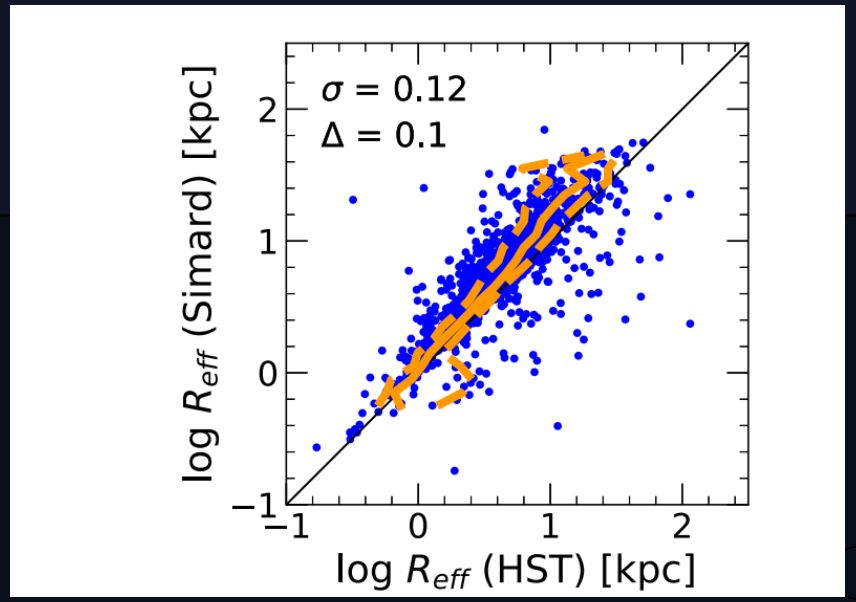
~25% of BGS cgalaxies (r50 < 1.3 arcsec) underresolved from the ground

⚠ In this regime, structural parameters acquire size-dependent systematic biases. Osborne & Salim 2024

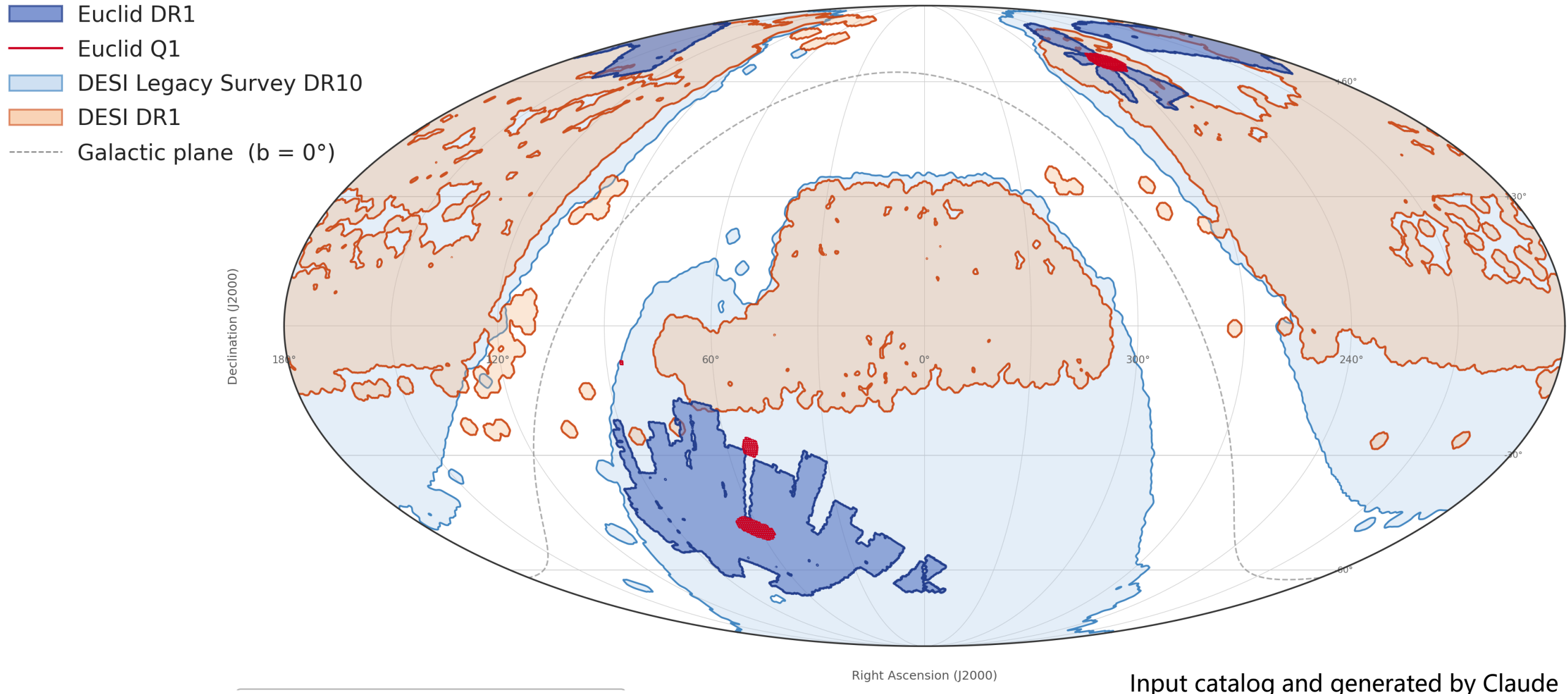
Space-based imaging survey mitigates this

0.16″ FWHM in VIS

- Currently overlaps ~ 63.1 deg²
-
-



DESI vs Euclid



Input catalog and generated by Claude

APPROACHES

Existing Approaches and the Generative Alternative

01

Analytic correction

Corrects raw Sérsic parameters for the seeing-convolved profile at the measurement stage.

Prior of seeing-free images unknown

02

Forward modeling

Convolves a parametric model with the measured PSF, then compares against observations.

03

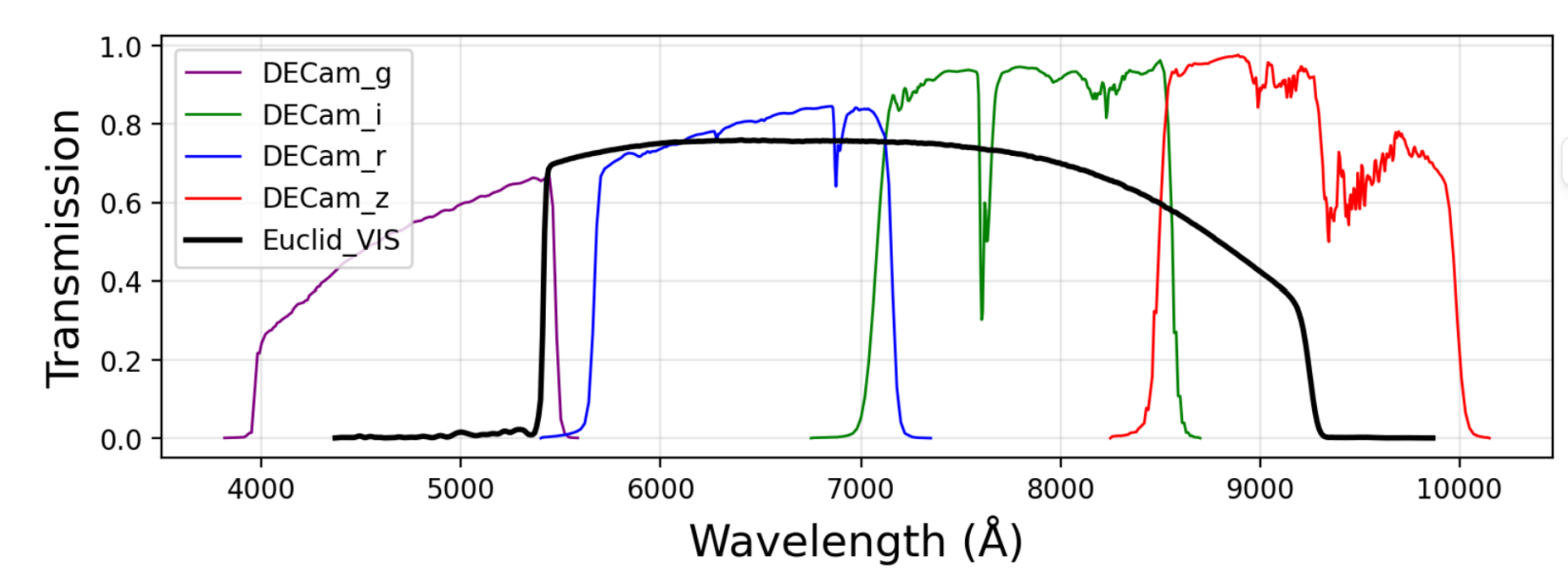
Generative alternative

Learns the conditional distribution between ground- and space-based observations instead of applying a deterministic correction.

The mapping is intrinsically underdetermined - **AI model also learns the prior of the mapping**

DATA & SAMPLE

Data: DESI Imaging and Euclid Q1 Reference



Each BGS targe（r+z） is matched to a VIS-detected source. Cutouts of 128 × 128 pixels are reprojected onto the 0.1 arcsec VIS grid.

82,830 pairs for training and validation (80:20), plus a spatially disjoint test set of 4,165 pairs — separated by sky region rather than random draw.

FRAMEWORK

A Bridge Between Two Real Observations

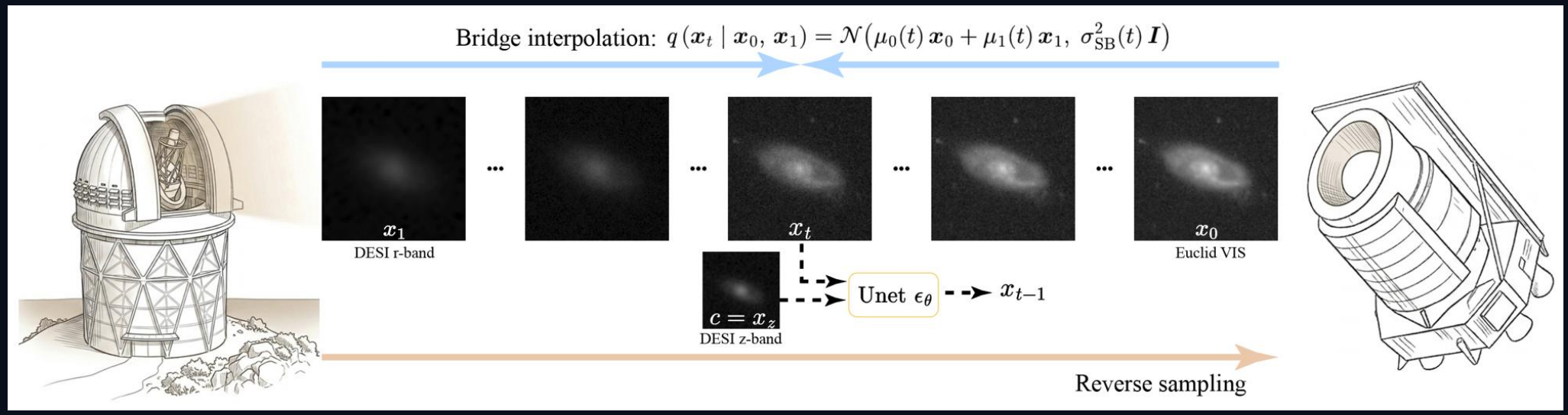
The I2SB framework connects two fixed image endpoints by a continuous path.

Euclid image
ENDPOINT

CONTINUOUS GAUSSIAN BRIDGE

→ Forward direction

DESI image
ENDPOINT



Ye & Shen 2026, ApJL 1009, L10

MODEL TRAINING & SAMPLING

Network Input, Loss, and Inference

CONDITIONING

DESI r-band defines the bridge source;z-band enters as a second channel concatenated with the current state after per-bandarcsinh stretch.

LOSS

Masked MSE with a binary validity mask, trained over 500 bridge steps.

INFERENCE

10 reverse sampling steps; three trajectories share the first 70% of steps, then diverge independently.

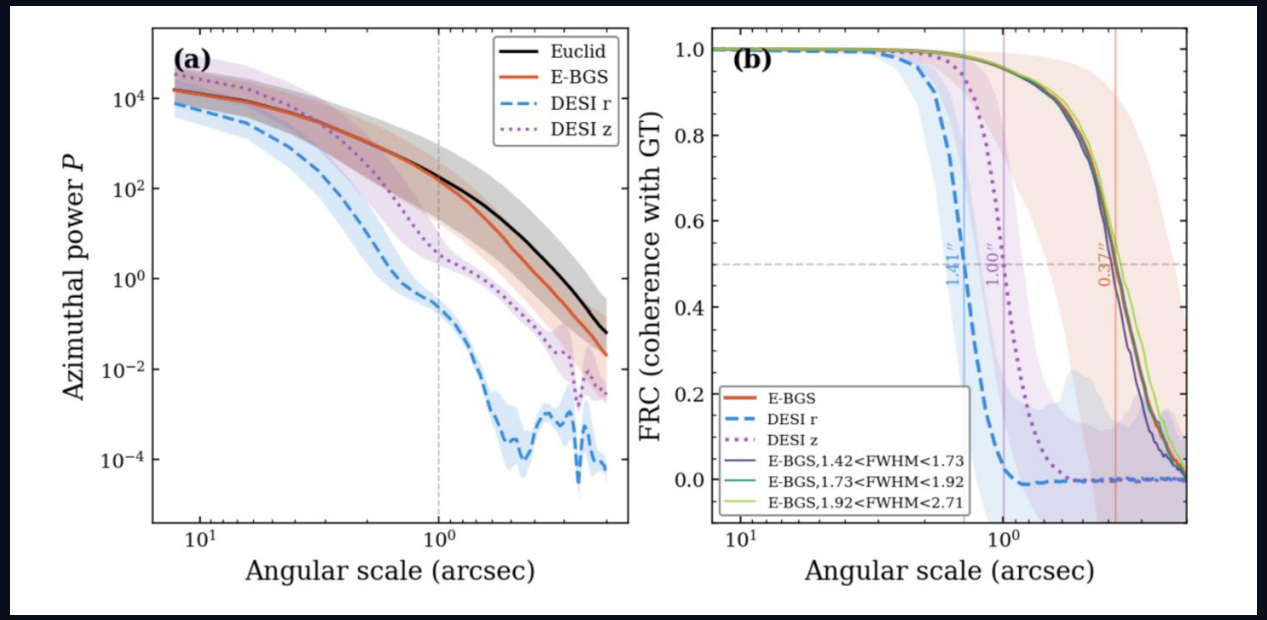
The released prediction is the mean of the three trajectories.

Ye & Shen 2026, ApJL 1009, L10

SECTION 03 · VALIDATION

Fourier-domain Structural Fidelity

Two complementary Fourier-domain diagnostics assess agreement: the azimuthally averaged power spectrum and the Fourier ring correlation.



Diagnostic	E-BGS	DESI r	DESI z
FRC 0.5 crossing (arcsec)	0.37	1.41	1.00

3.8× over DESI r

2.7× over DESI z

FRC 0.5 crossing scale

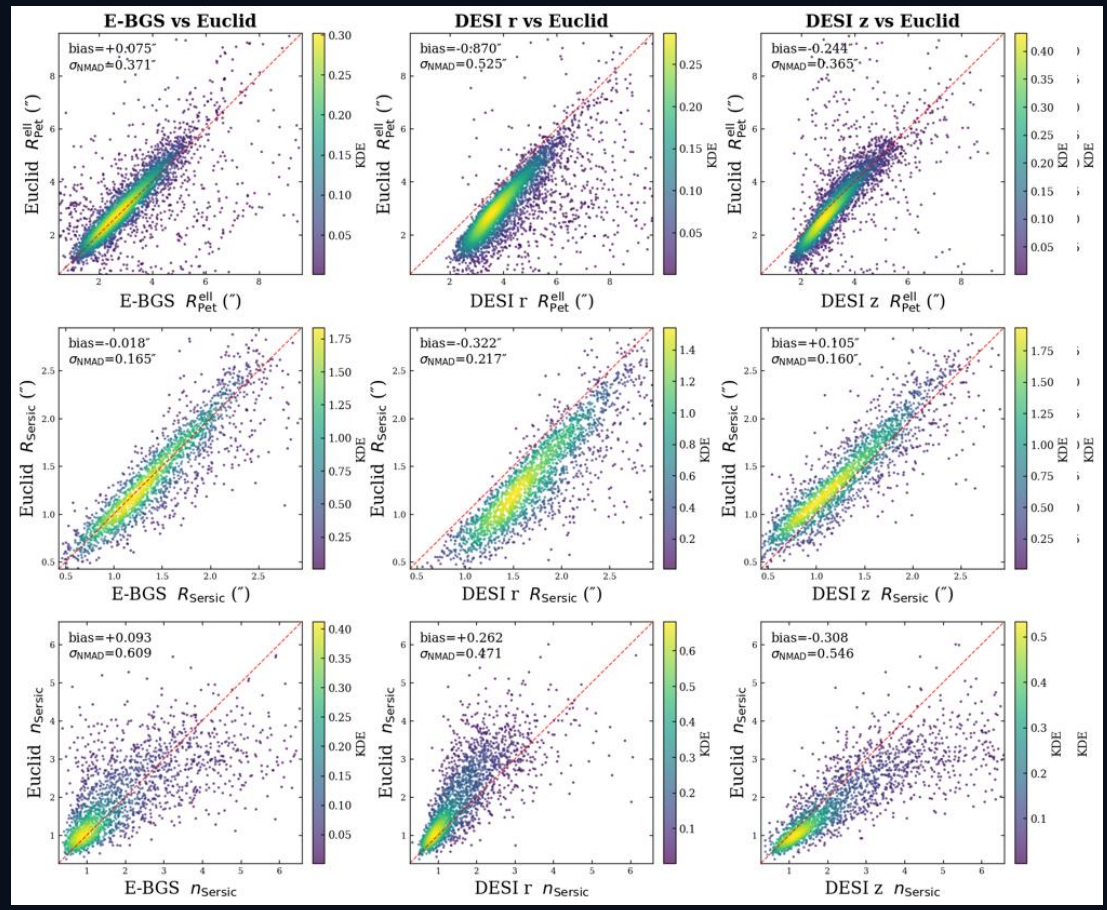
Smaller crossing = stronger Fourier correlation with Euclid on smaller angular scales

RESULTS · STRUCTURE

Structural-parameter Agreement

MEDIAN RESIDUAL, E-BGS VS. DESI r

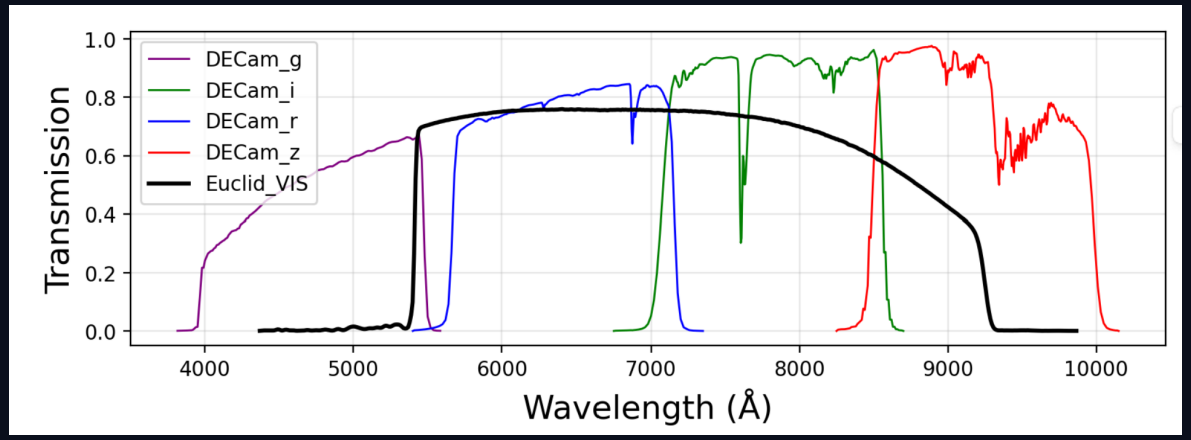
PARAMETER	E-BGS	DESI r
Petrosian radius	+0.072 ✓	−0.845
Sérsic effective radius	−0.018	−0.322
Sérsic index	+0.093	+0.262

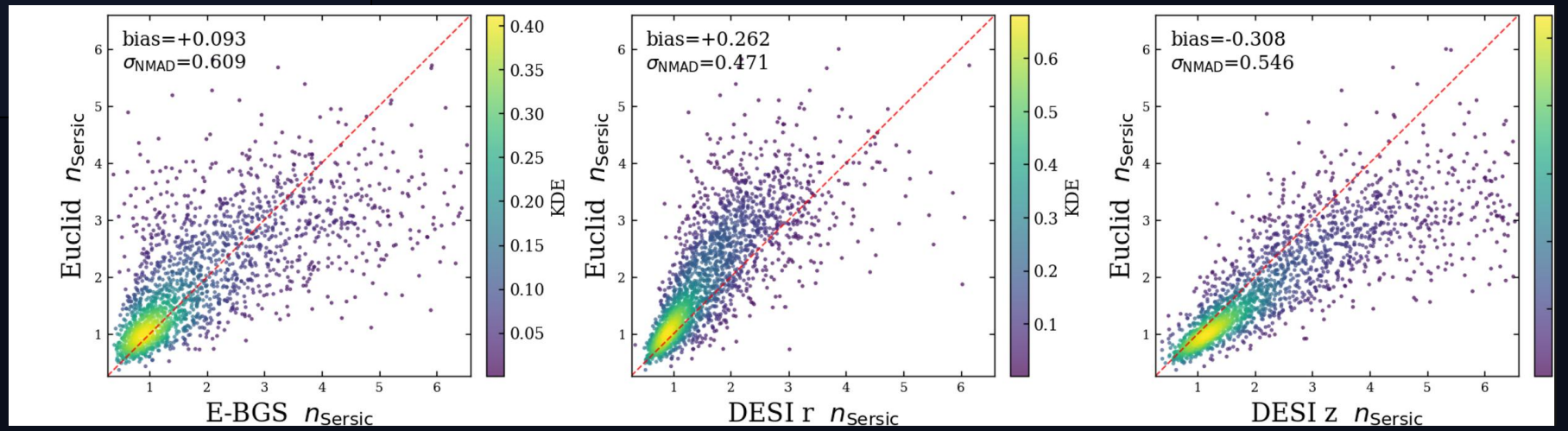


E-BGS brings all three parameters closer to observed Euclid VIS values at the sample-wide median.

Caveat

- Comparison is not strictly bandpass matched; color gradients and dust may contribute
- E-BGS does not yield the lowest scatter for Sersic index





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Published July 8, 2026 | Version v2

Dataset Open

From DESI to Euclid: A Generative Bridge to Unbiased Galaxy Structures (Part 1 of 20)

Ye, Renhao ; Shen, Shiyin

Part 1 of 20. Synthetic Euclid VIS-band galaxy images generated from DESI Legacy Imaging Surveys r,z-band cutouts using an Image-to-Image Schrödinger Bridge (I2SB) model, over the Euclid Q1 footprint.

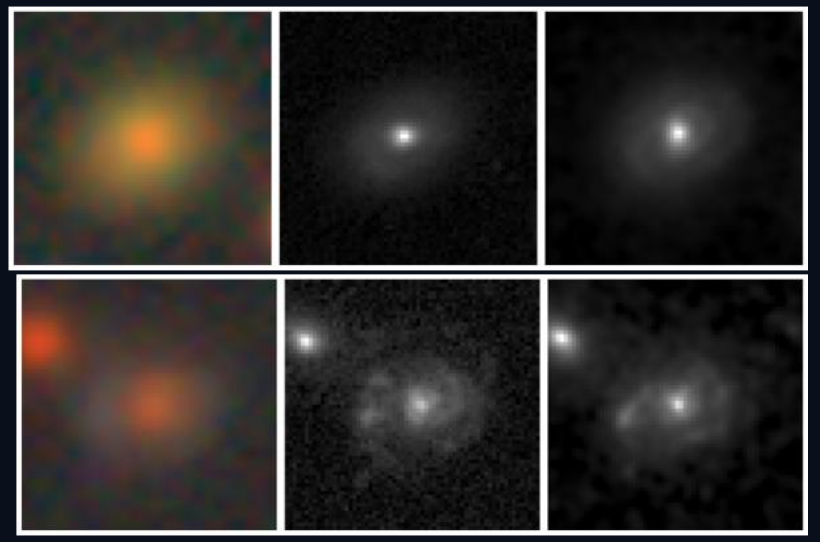
The full processed dataset covers 2,981,033 FITS cutouts packed into 1,235 tar archives grouped by HEALPix sky pixel (nside=64, NESTED ordering), ~1 GB each. Because Zenodo limits each record to 100 files and 50 GB, the full set is split across 20 records. This record publishes a 96-archive subset (RA 128.2–267.9°, Dec 52.3–79.9°).

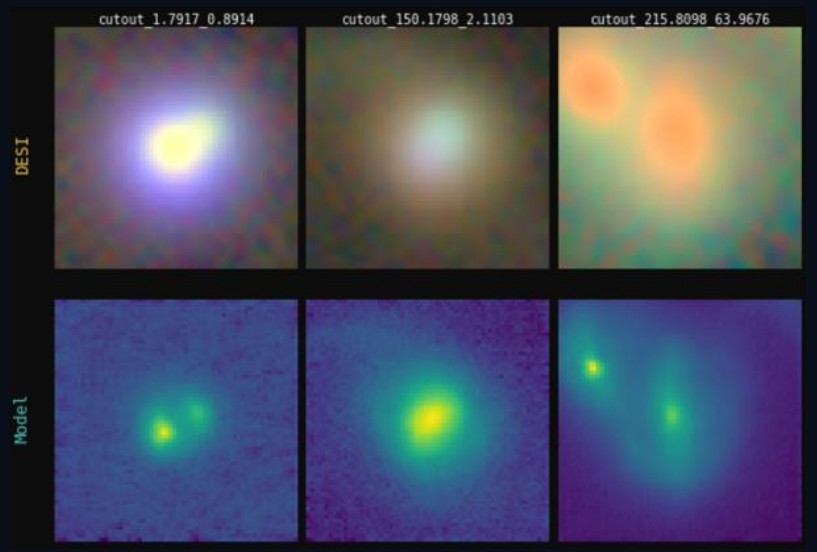
Integrity and provenance: `checksums.tsv` and `desi2euclid_index.csv` record the SHA256 of all 1,235 archives from this processing run, not just the ones published as downloadable files here. These values let this exact version of the data be independently verified in the future -- including before any analysis built on it has been published -- by recomputing an archive's SHA256 and comparing it against the recorded value, to confirm the file has not been modified, corrupted, or substituted since it was originally produced.

See `README.md` for the FITS layout (predicted VIS image, DESI g,r,z input -- of which only r,z were used to generate the prediction -- and prediction-uncertainty map), how to locate the archive for a given sky position, and how to run the integrity check.

E-BGS: DESI BGS(r<19.5) in Euclid DR1
~3 million galaxies for validation

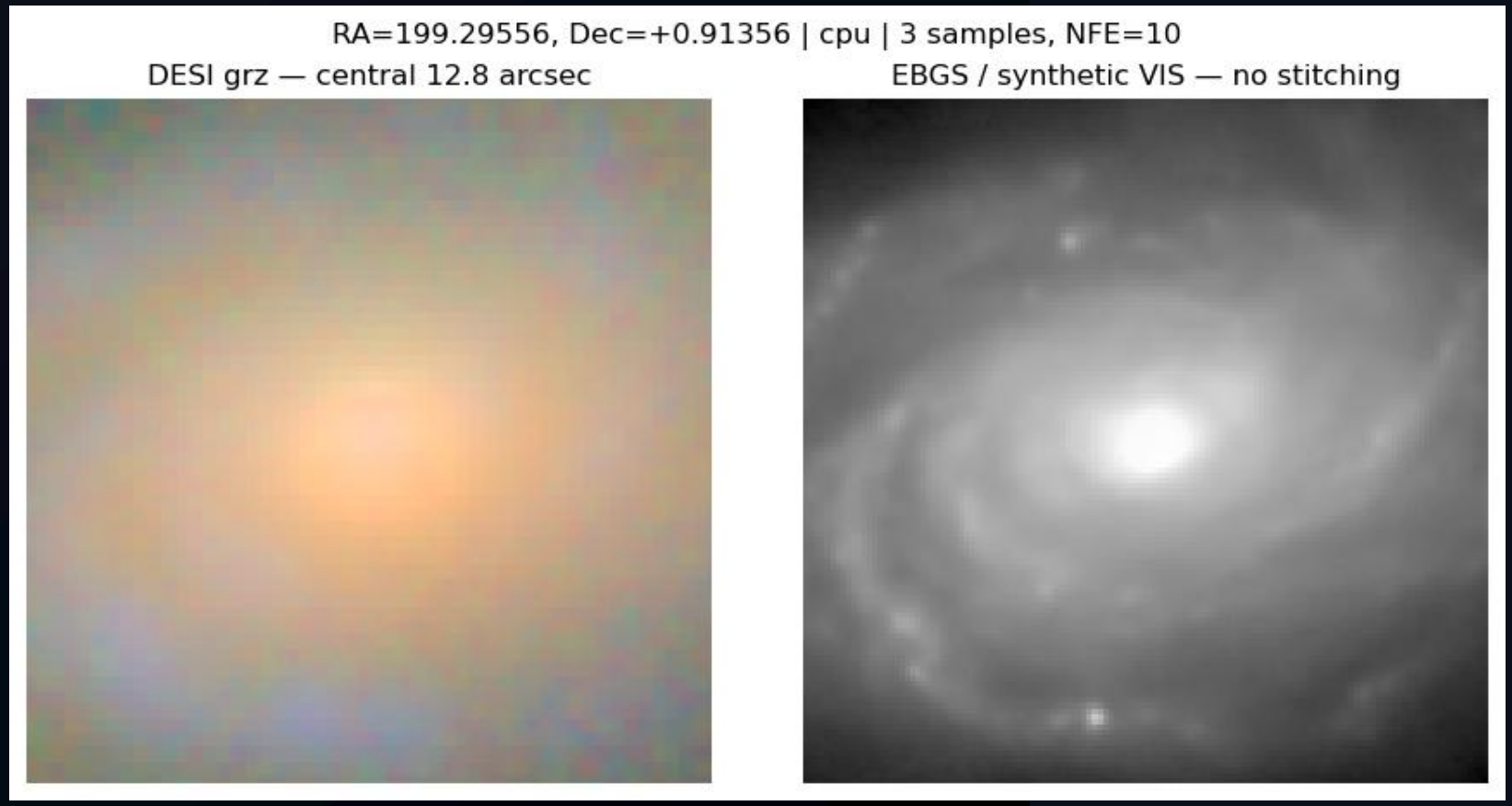
DESI Euclid Predict





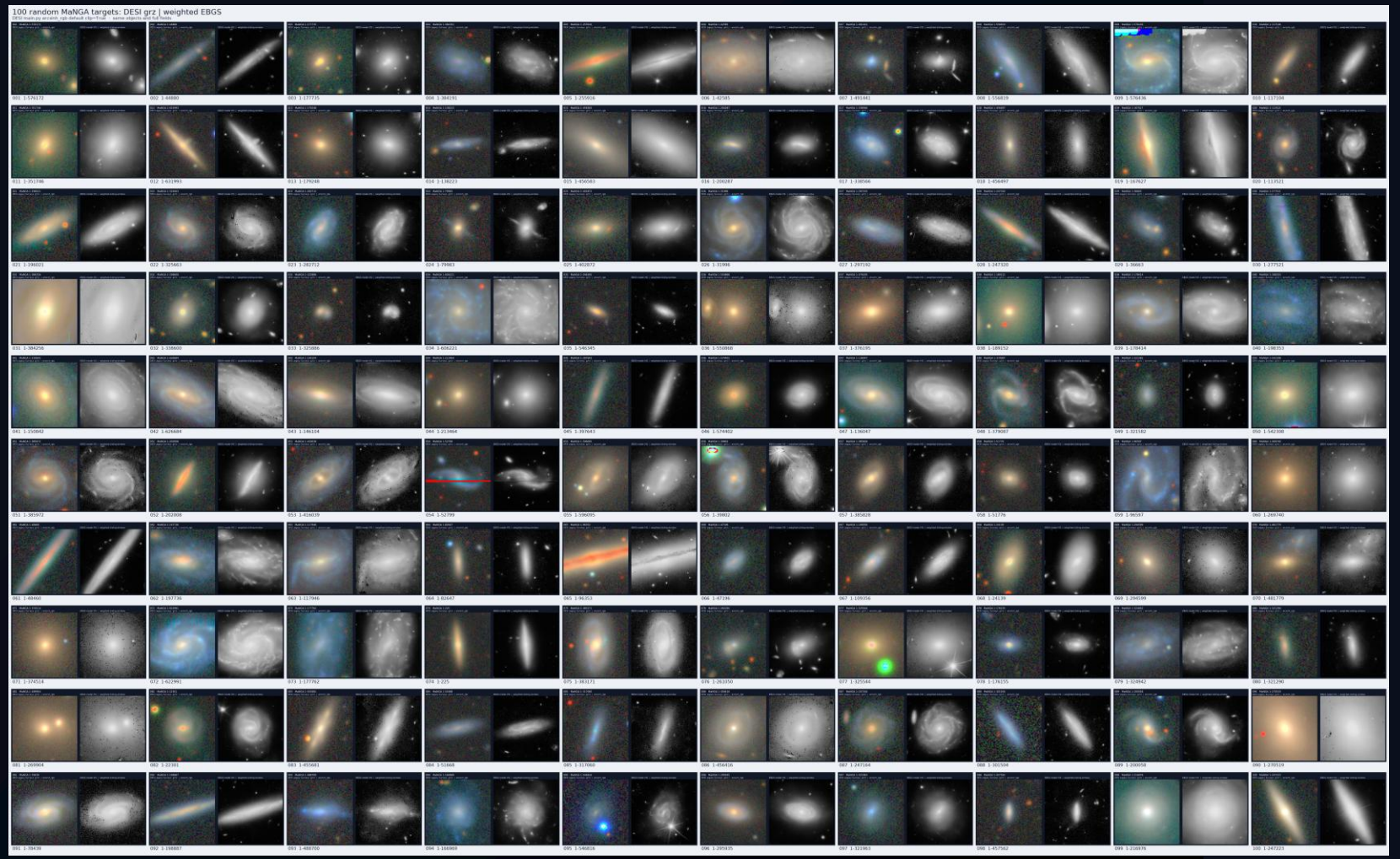
AI Euclid（from DESI） VS Real Euclid：Supernova Identification?

Eculid VIS-like image for any interested object within DESI footprint



Demo on Oct. 21: Hands-on session

large gaalxy? (our trained model: 128x128@0.1 arcsec)



Euclid VIS-like images for all MaNA galaxies 34"*34"

Simple Concatenation

Summary/outlook

- **We generate Euclid VIS-like high resoultion images for DESI bright galaxy sample (E-BGS)**
  - **scientific application qualified**

- **By learning/matching the data distribution, AI can economically and signficantly expand the sample size of those high-value data.**
  - **may also be used in time-domian study in another way**

