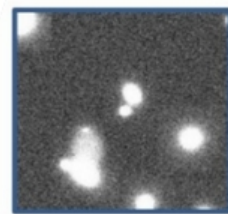
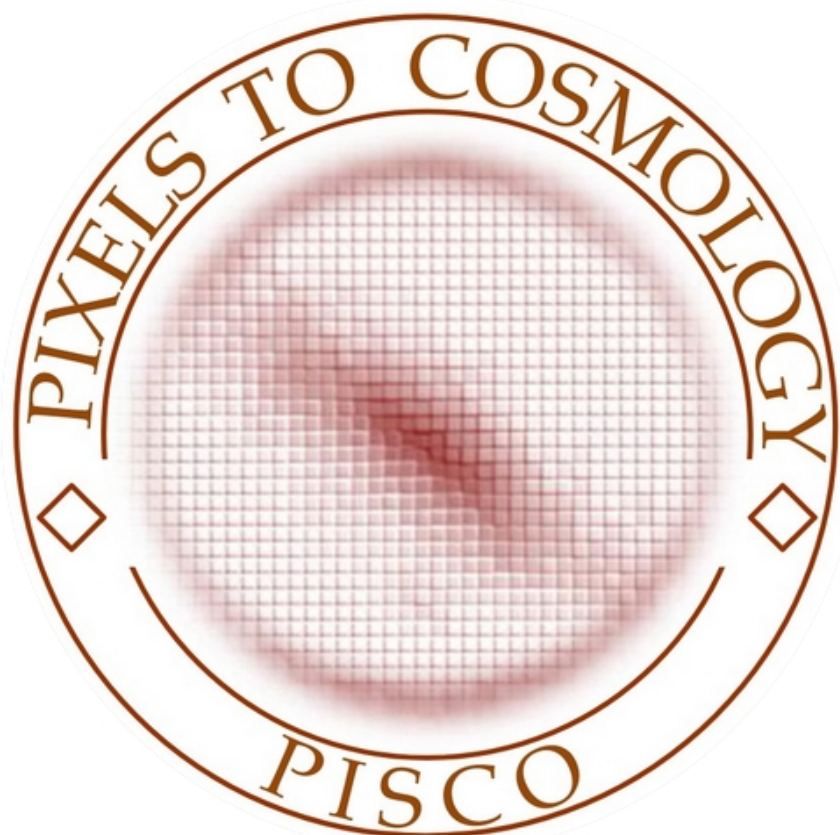


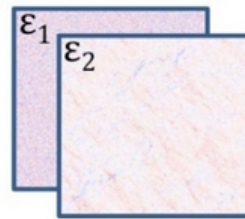
*Direct weak lensing shear
measurements with deep learning*



$\sim 0.5 \text{ arcmin}^2$



$$\begin{pmatrix} \langle \varepsilon_1 \rangle \\ \langle \varepsilon_2 \rangle \\ \frac{\mu_1}{\mu_1} \\ \vdots \\ \mu_n \end{pmatrix}$$



$\sim 100 \text{ deg}^2$



$$\begin{pmatrix} S_8 \\ w \\ \vdots \\ CP_p \\ \frac{A_{IA}}{f_B} \\ \Delta Z \\ \Delta \mu \end{pmatrix}$$



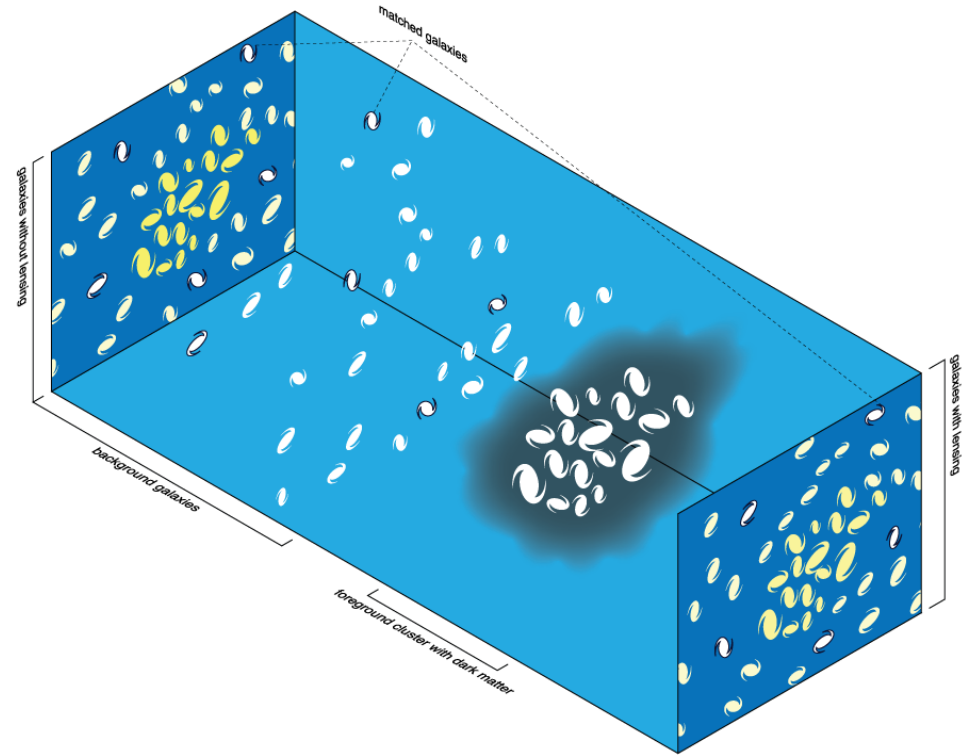
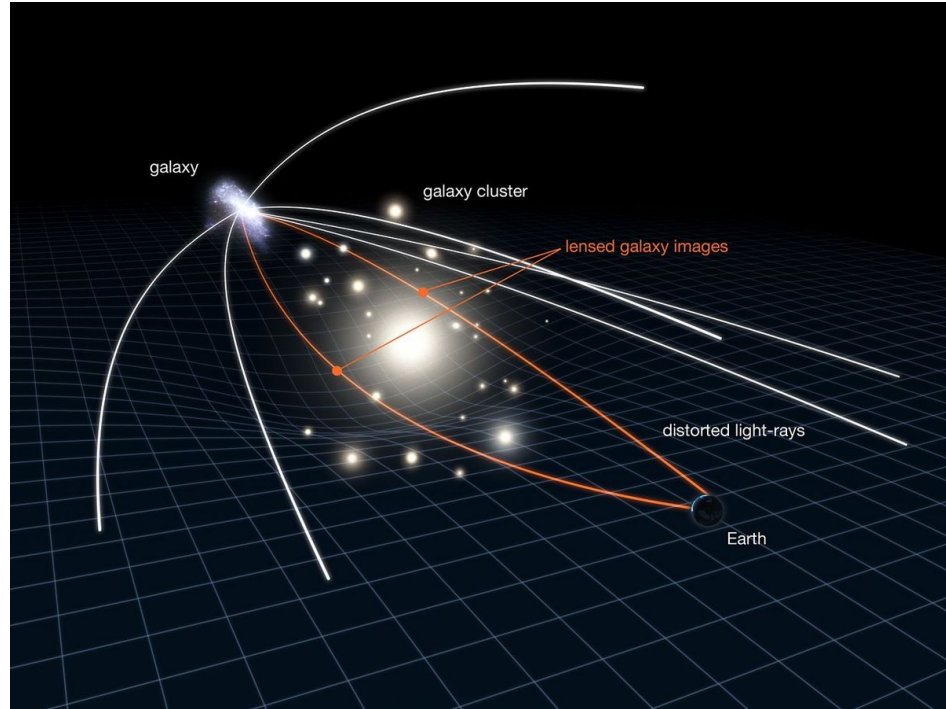
$\sim 100 \text{ deg}^2$

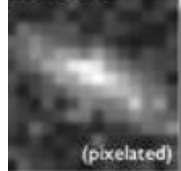


$$\begin{pmatrix} S_8 \\ w \\ \vdots \\ CP_p \\ \frac{A_{IA}}{f_B} \\ \Delta Z \\ \mu_1 \\ \vdots \\ \mu_n \end{pmatrix}$$

PISCO team : Romain BRUNET, Clara BONINI, Simone VINCIGUERRA, Nicolas MARTINET

GENERAL PHENOMENON





(Intrinsic galaxy shape) + (gravitational shear) $\otimes$ (PSF)

$$\hat{\gamma}_i = (1 + m_i)\gamma_i + c_i \quad \text{for } i = 1, 2$$

$\hat{\gamma}$ is the **measured (estimated) shear**.

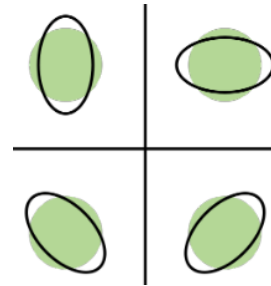
γ is the **true (cosmic) shear**.

$$|m| < 2 \times 10^{-3} \quad \& \quad |c| < 2 \times 10^{-4}$$

$$e^{\text{observed}} = \frac{e^{\text{intrinsic}} + \gamma}{1 + \gamma^* e^{\text{intrinsic}}} \approx e^{\text{intrinsic}} + \gamma$$

$$\varepsilon^{\text{obs}} = \varepsilon^{\text{int}} + \gamma$$

$$\langle \varepsilon^{\text{obs}} \rangle = \langle \gamma \rangle$$



DATABASE GALSIM LOOP

FIXED INPUTS

- pixel_scale = 0.1 arcsec
- x_size = y_size = 64 pixels (Galaxy patch size 6.4'')
- image_size = 352x352 pixels (0.59')
- zp = 24 mag
- exposure = 4 * 566 s
- gain = 3.1 e-/ADU
- sky_back = 22,35 mag/arcsec²
- galaxy = 10 per image

INDEPENDANT INPUTS

- g1 & g2 => uniform distribution
- ell1 & ell2 => gaussian distribution
- x & y => uniform distribution

SUPERVISED INPUTS

- n_sersic = [0.3, 6.2]
 - hlr = [0.1, 1.4]
 - mag = [20, 24.5]
- } w.r.t. mag
w.r.t. mag

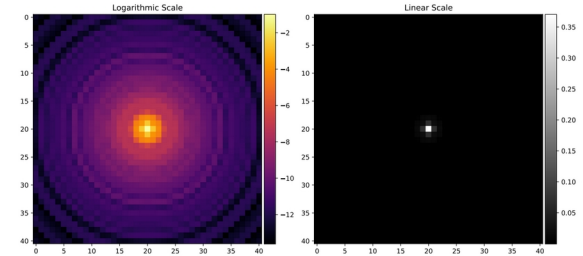
✓ Add Gaussian noise ➤ $F(\text{exposure}, \text{sky bckg}, \text{zp}, \text{nb_of_exposure}, \text{gain})$

✓ Convolve ➤ *PSF triple
airy /
euclid-like*

✓ Apply shear

✓ Apply ellipticities ➤ *Remove large ellipticity modulus (|ellips| > 0.7)*

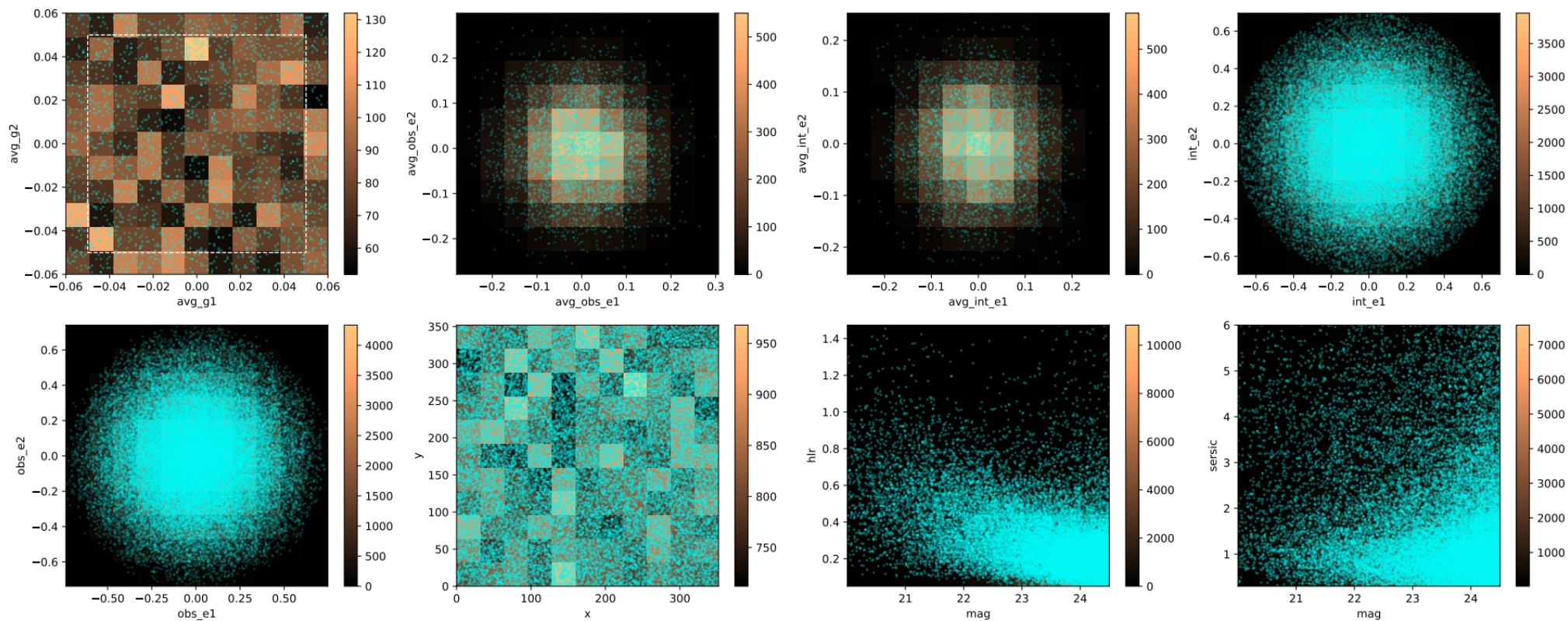
✓ Compute Sersic profile



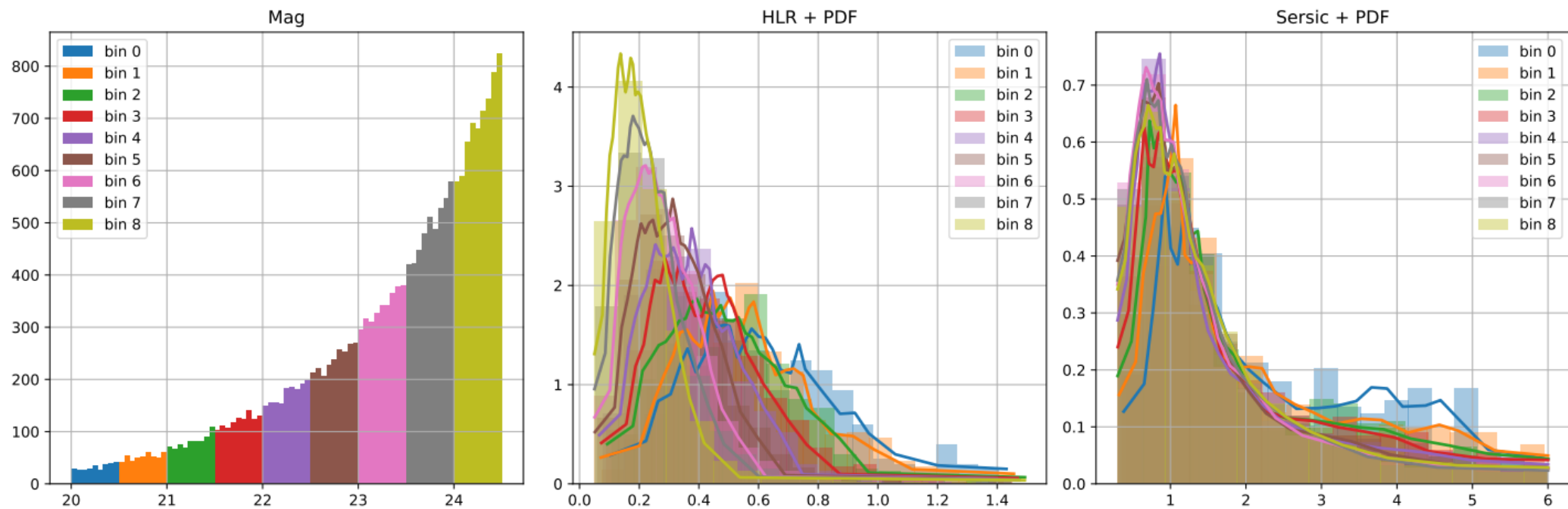
Galaxies properties

Selections of magnitude values for each galaxy based on CDF & generation of sersic and hlr based on magnitude bin

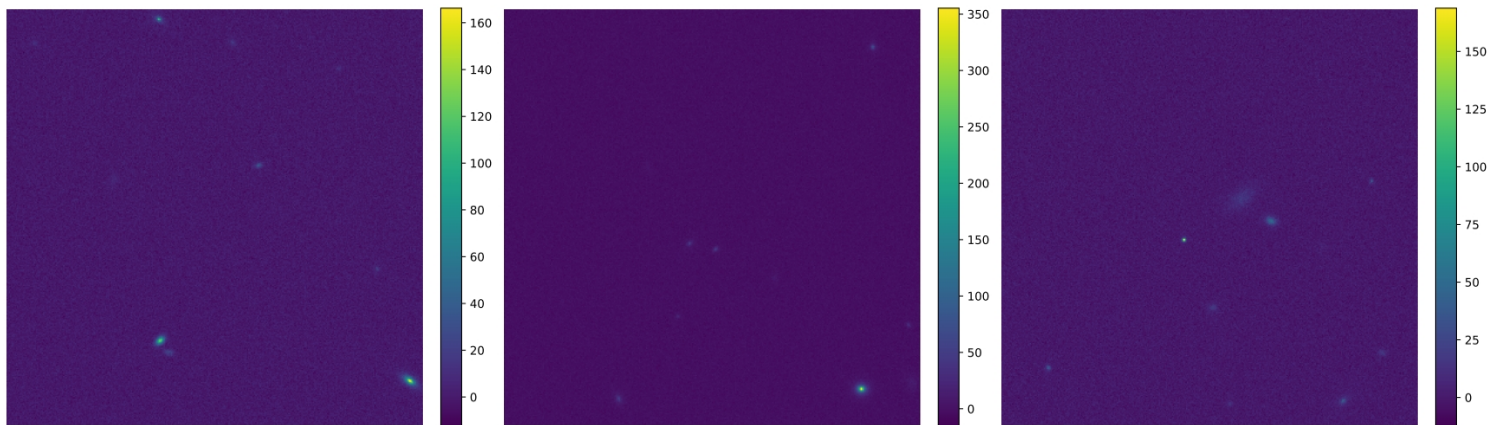
LHS FOR SIMULATION INPUTS



HST COSMOS survey distributions

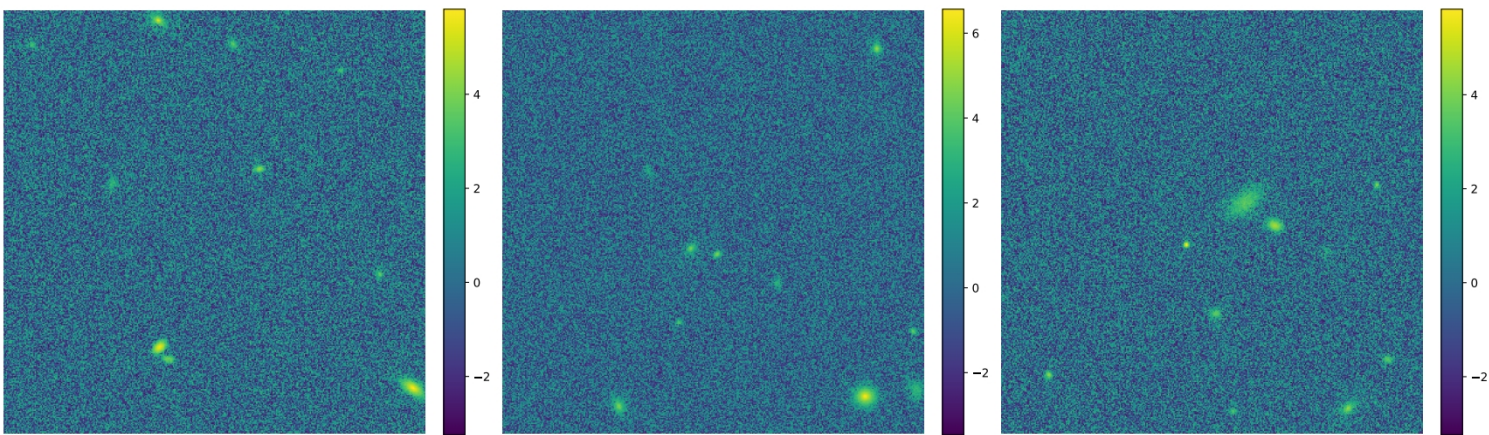


EXAMPLES

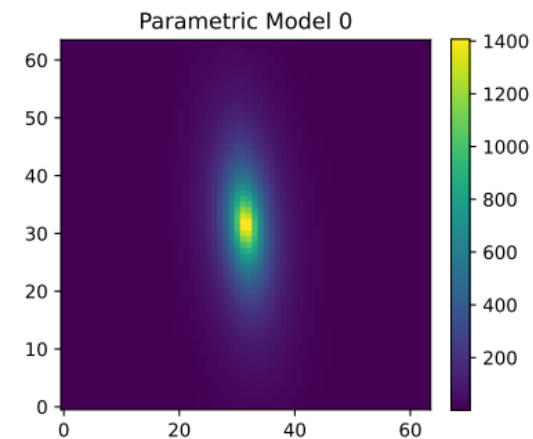
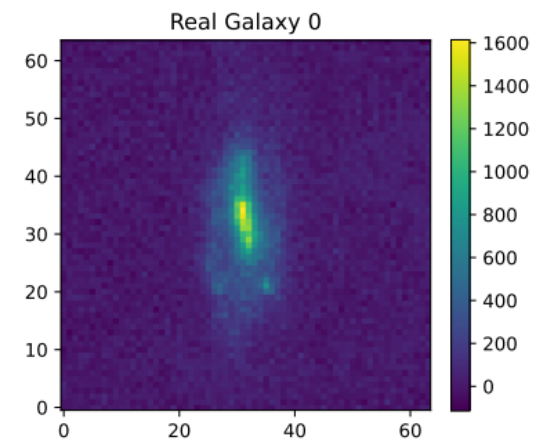
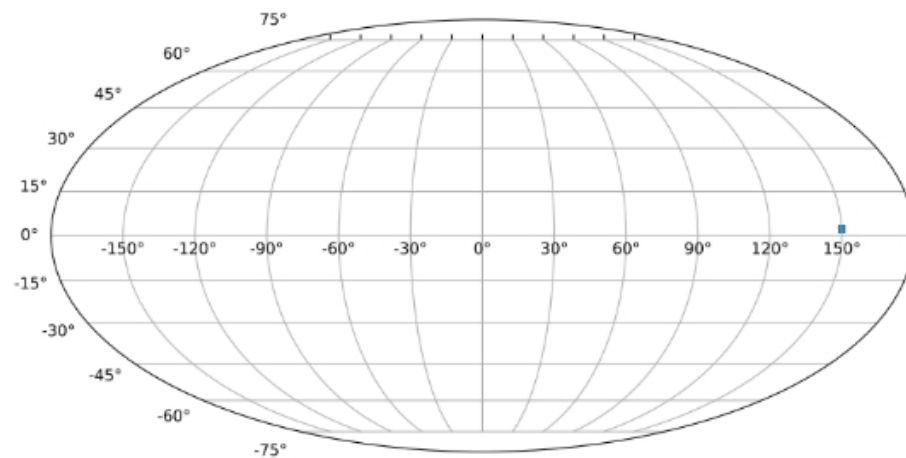
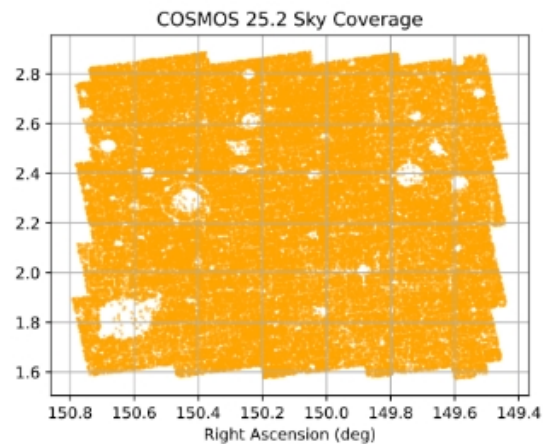
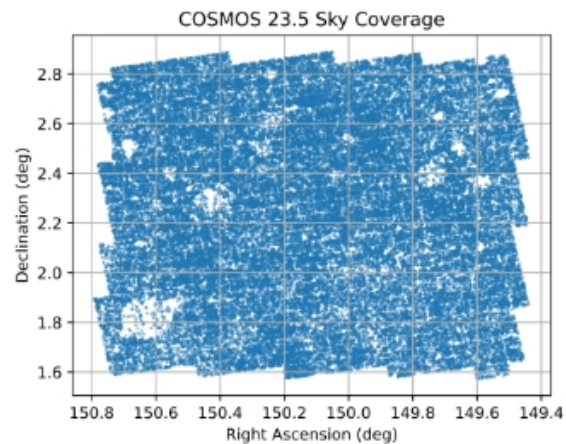


Arcsinh post-processing

Deep learning

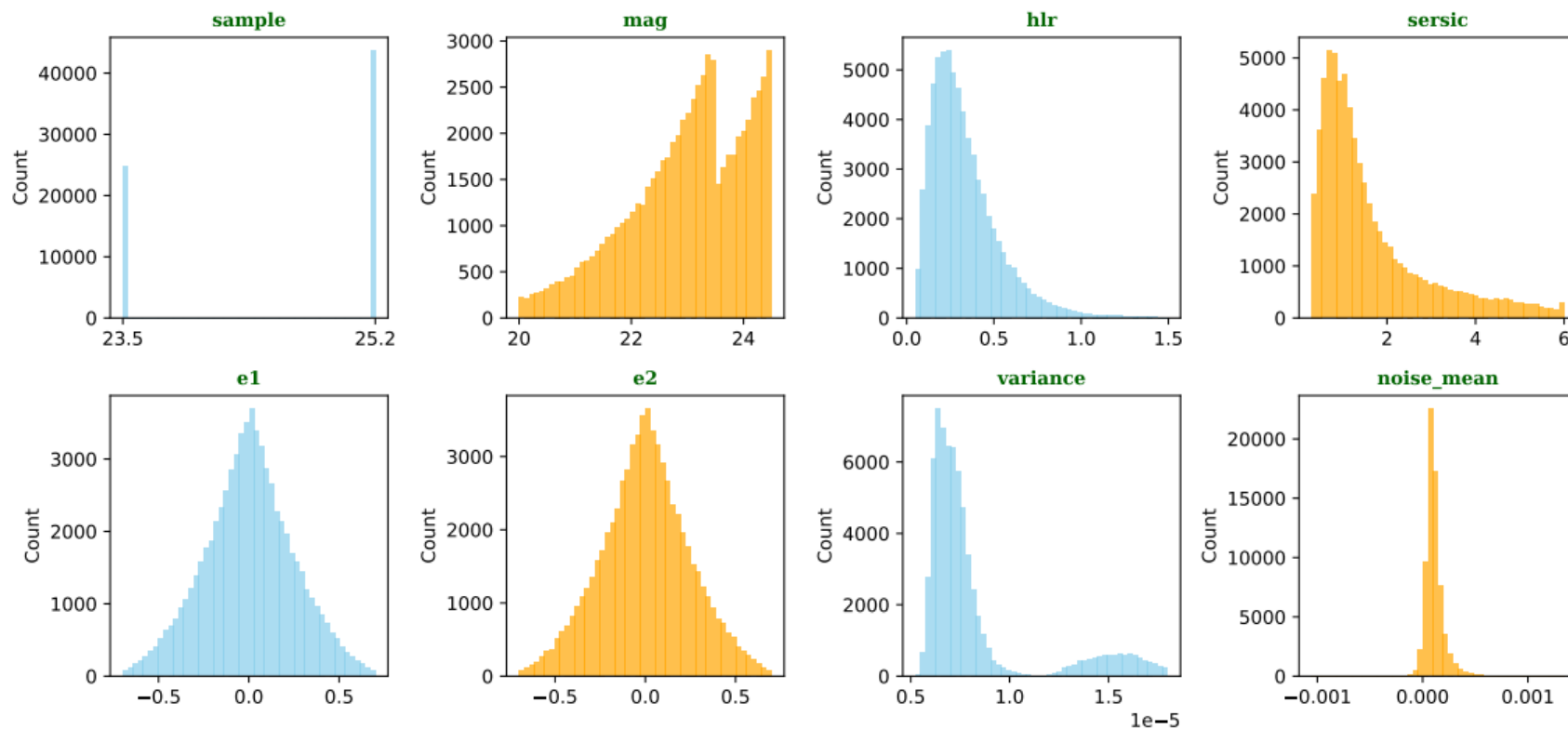


HST COSMOS survey (extracted 130k galaxies)



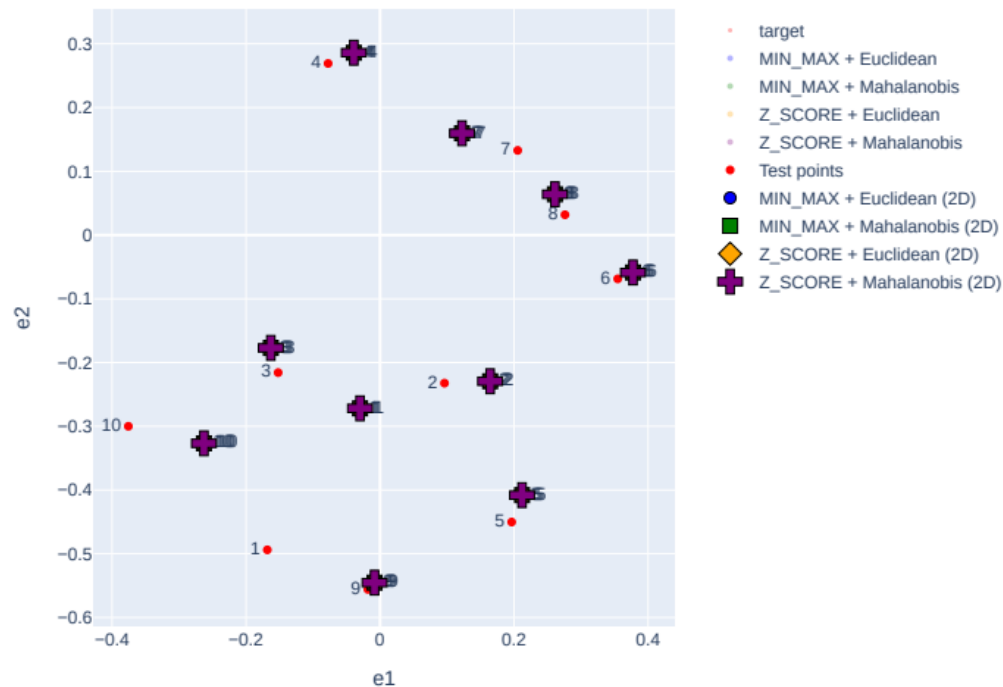
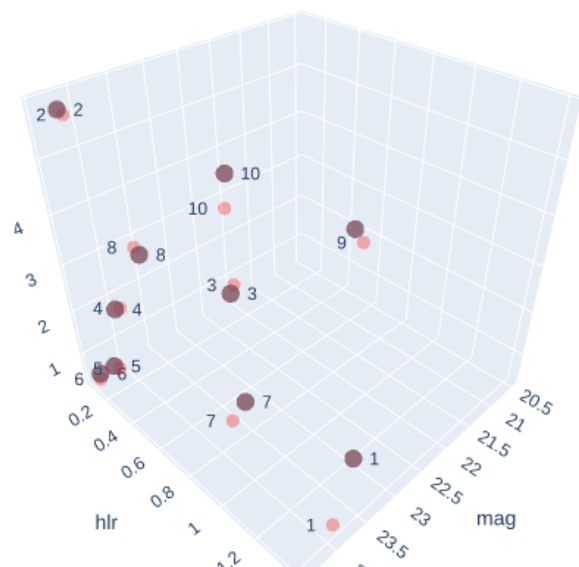
HST COSMOS survey filtered distribution

SAMPLE filtered_histos_all => 68520



➤ filter to match PISCO requirements

HST COSMOS survey picking choices



- 5D choice => avoid duplicates
- ok if not exactly picking

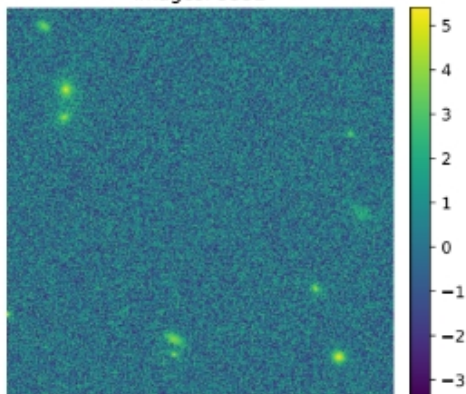
SHAPE NOISE CANCELLATION

+ noise

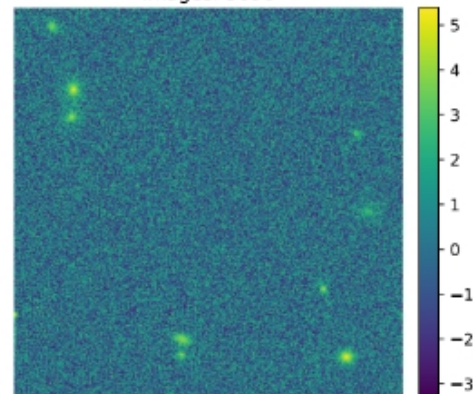
- noise

theta = 0

images: 5552

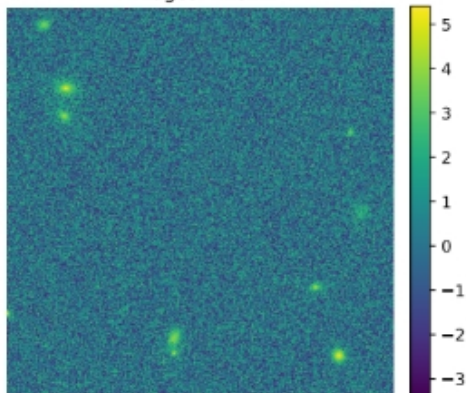


images: 5696

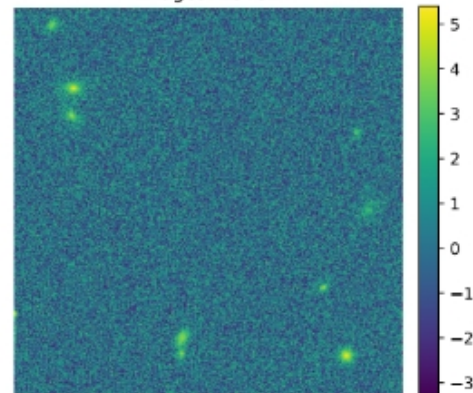


theta = 90

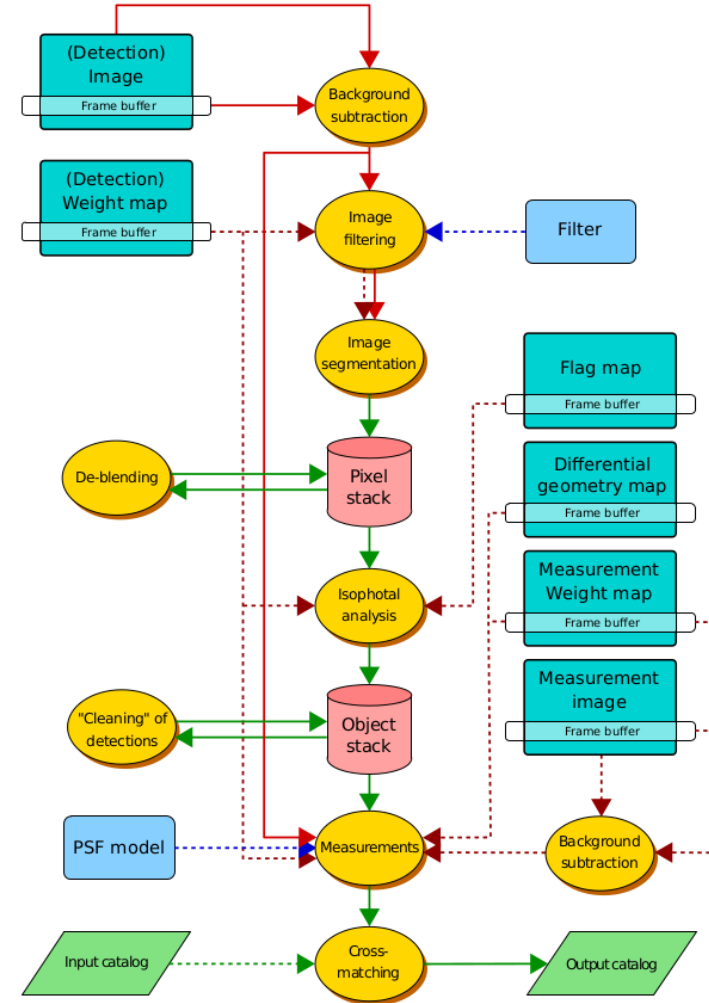
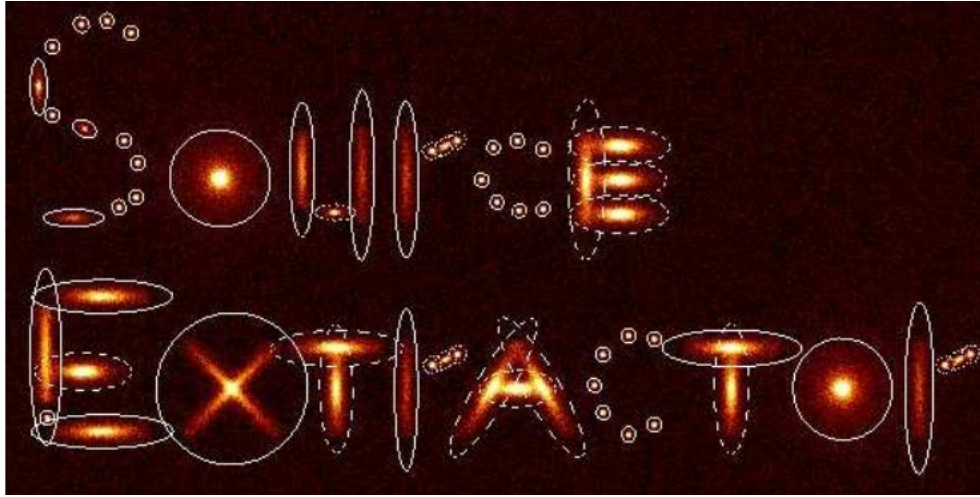
images: 11822



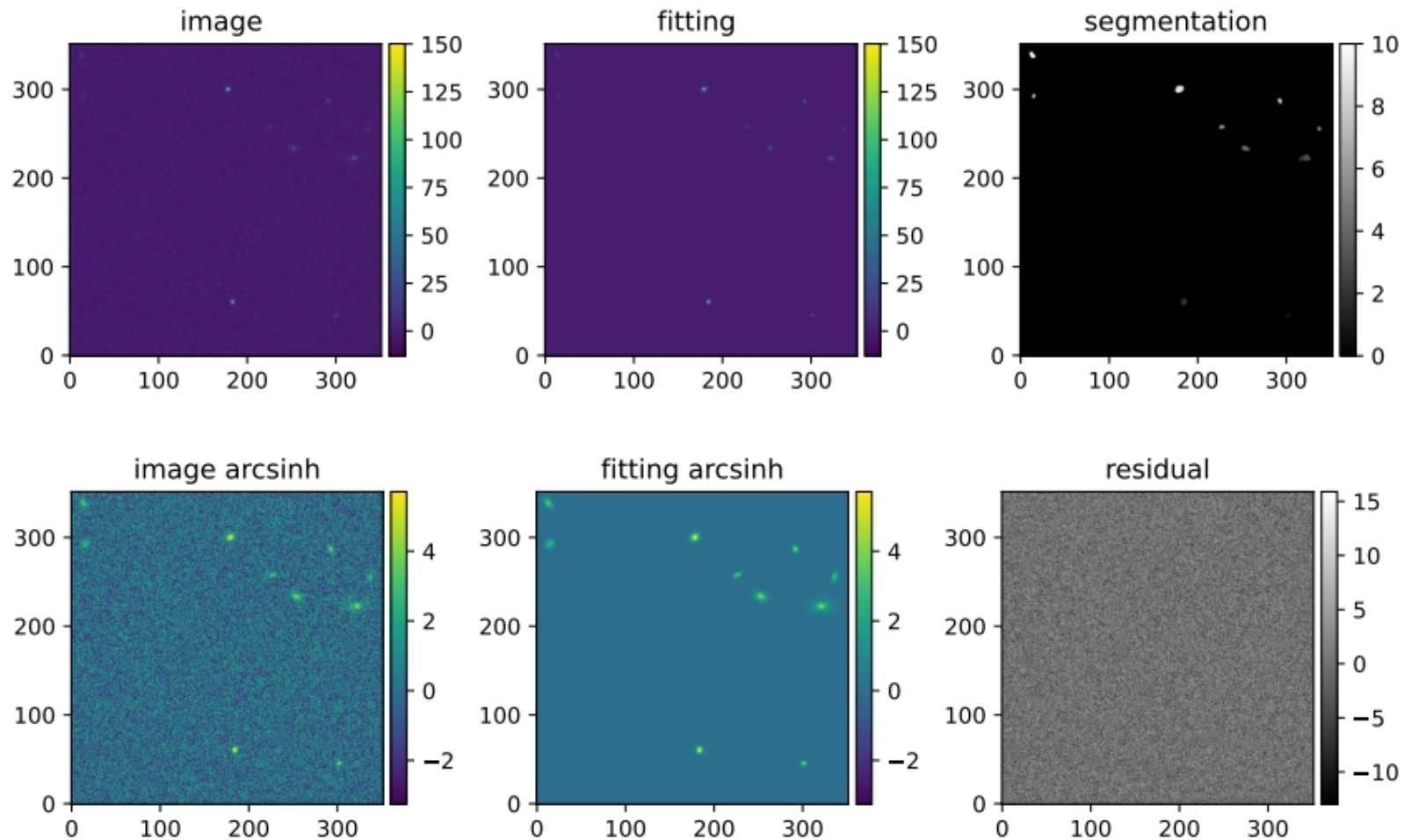
images: 15752



TRADITIONAL PIPELINE

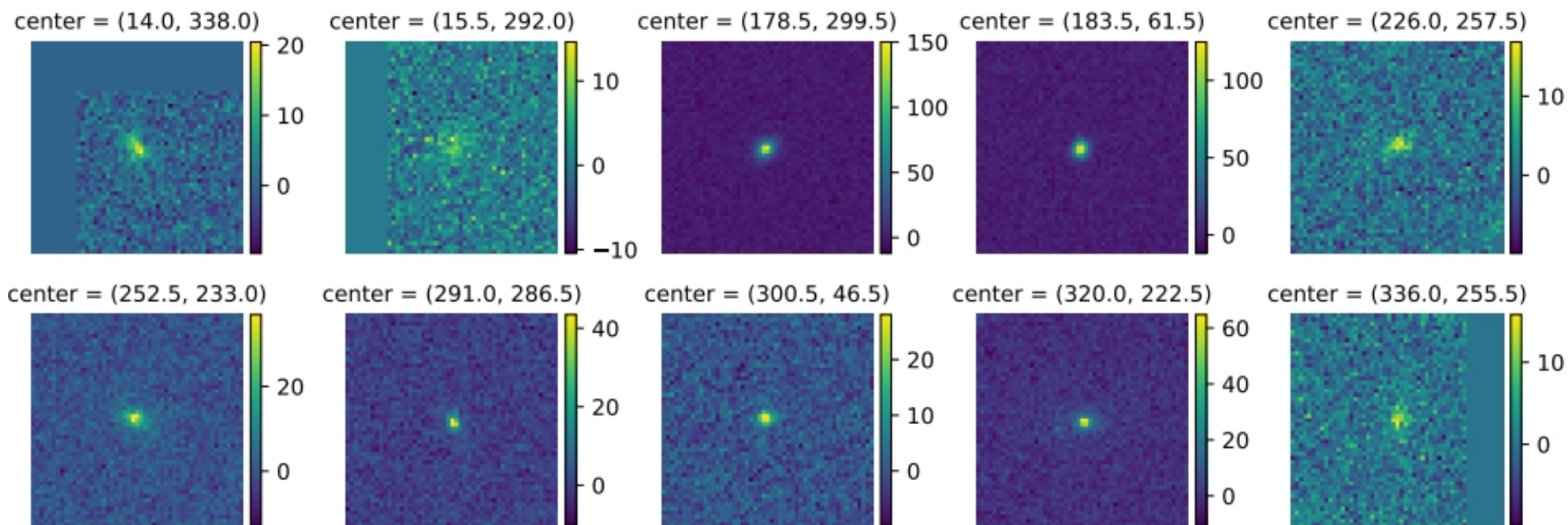


25_000*4 IMAGES (SNC)



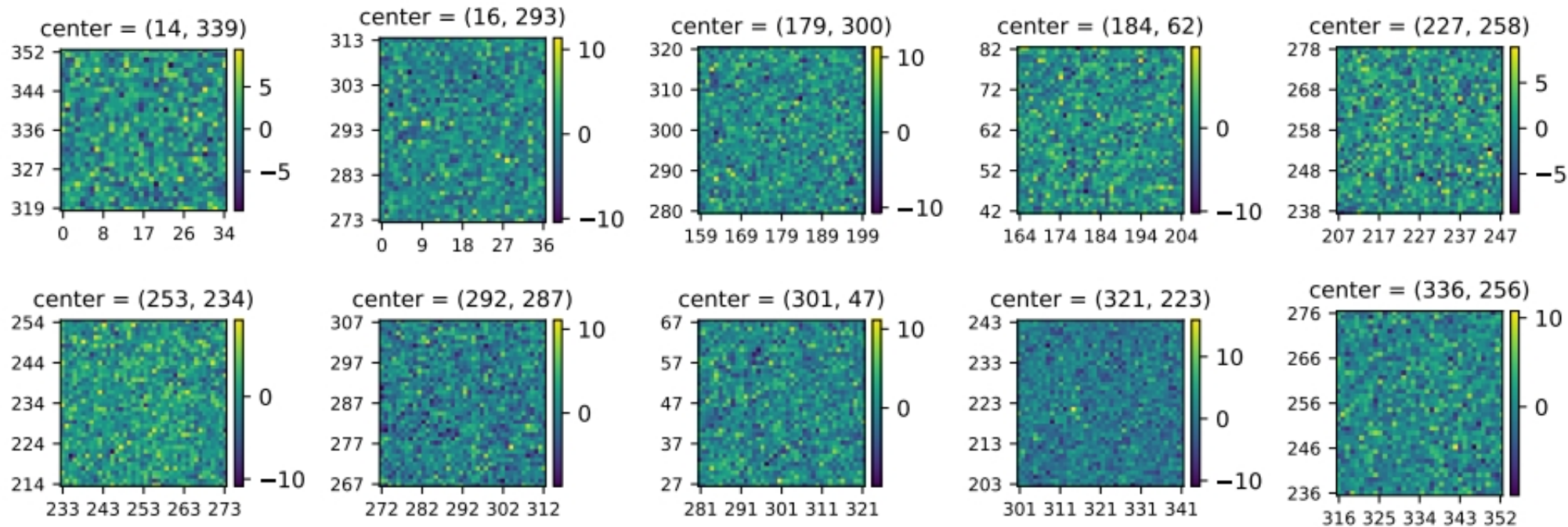
25_000*4 IMAGES (SNC)

vignettes shape 51, nb galaxies 10



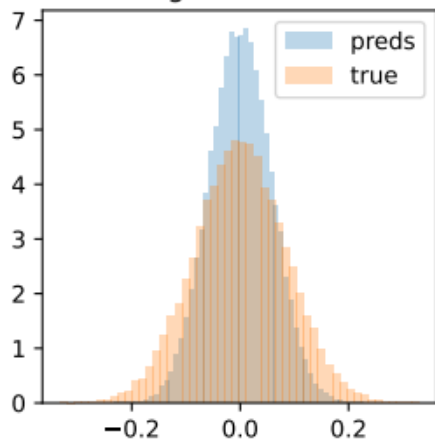
25_000*4 IMAGES (SNC)

residuals

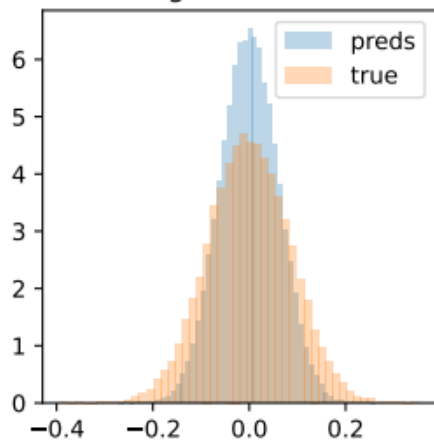


25_000*4 IMAGES (SNC)

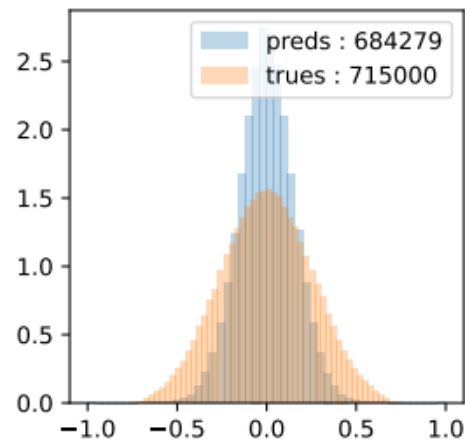
avg e1 : 71500



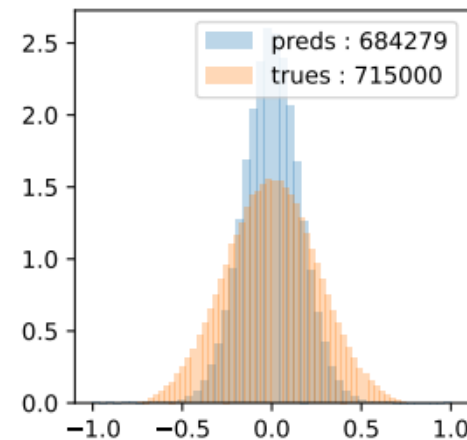
avg e2 : 71500



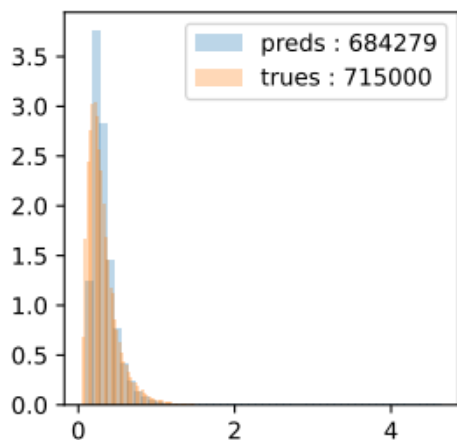
e1



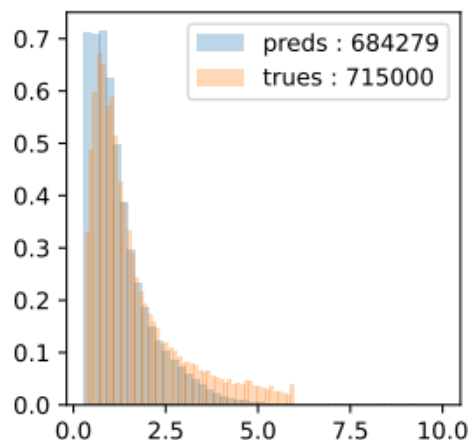
e2



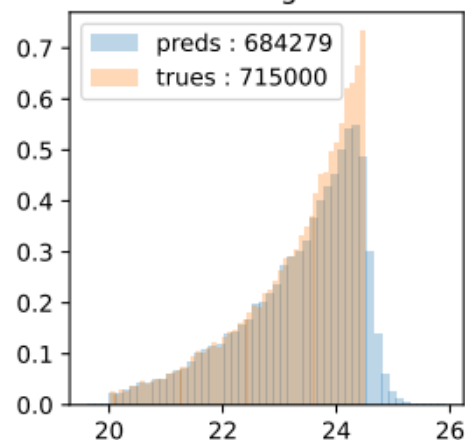
hlr



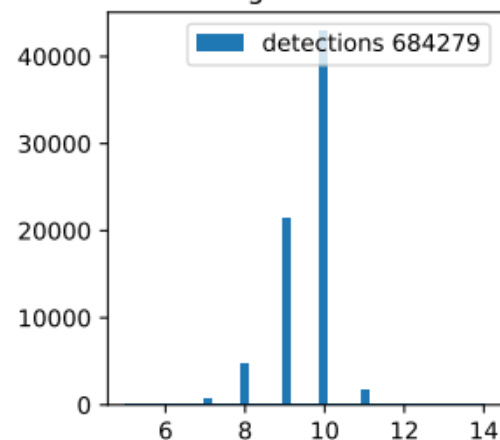
sersic



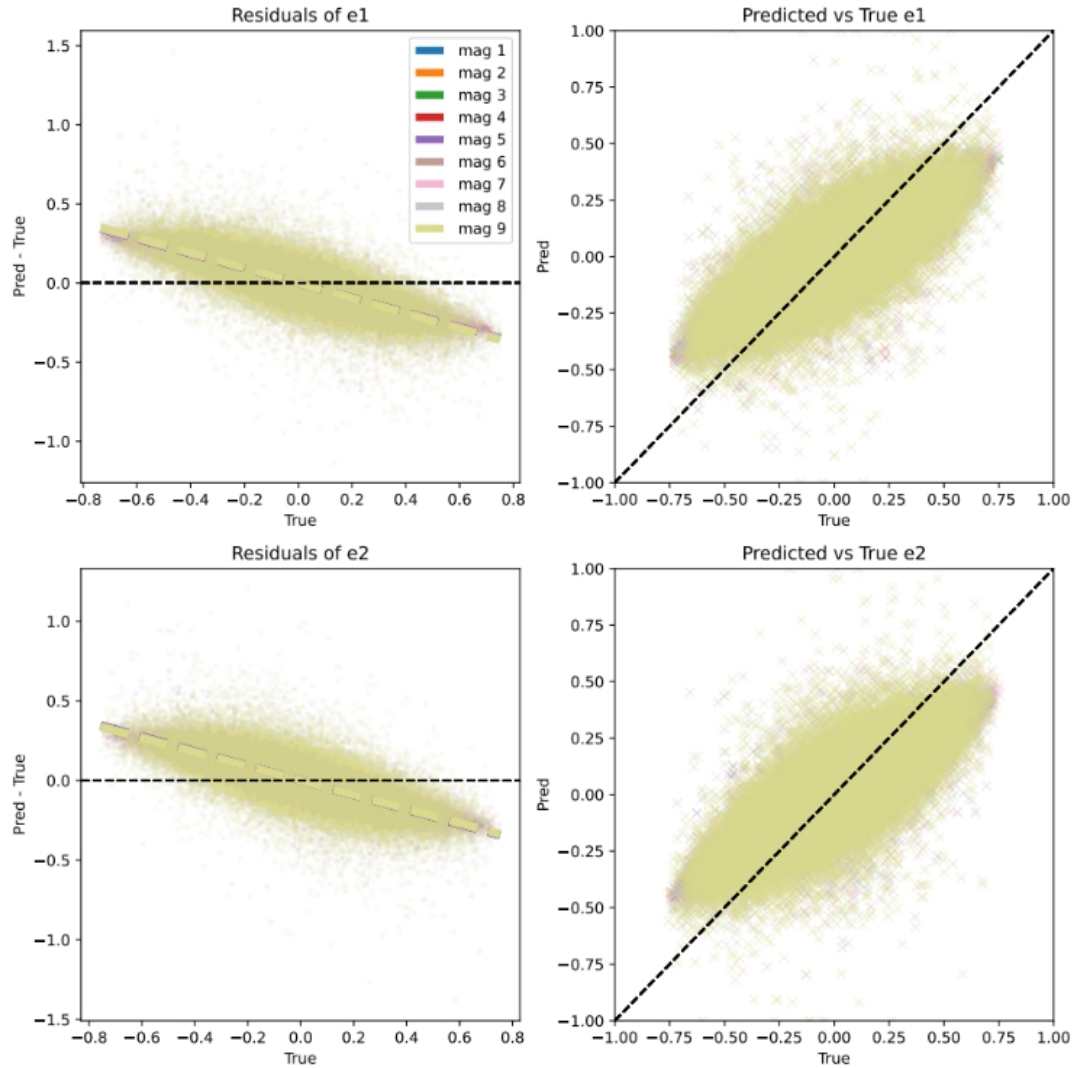
mag



galaxies

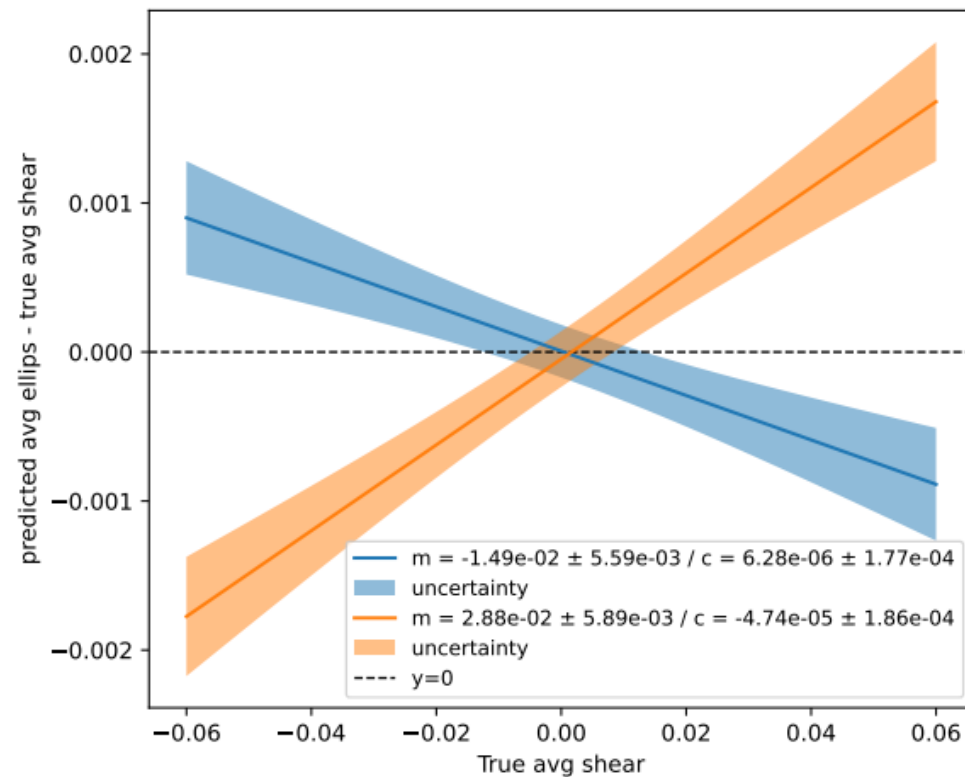
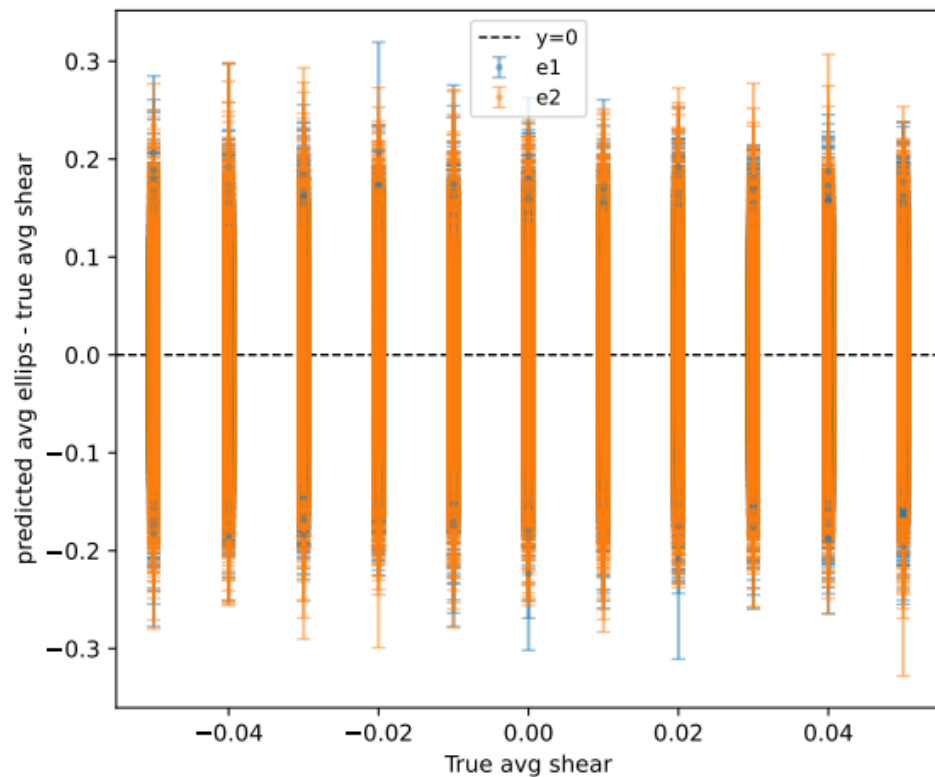


25_000*4 IMAGES (SNC)



25_000*4 IMAGES (SNC)

Results per image

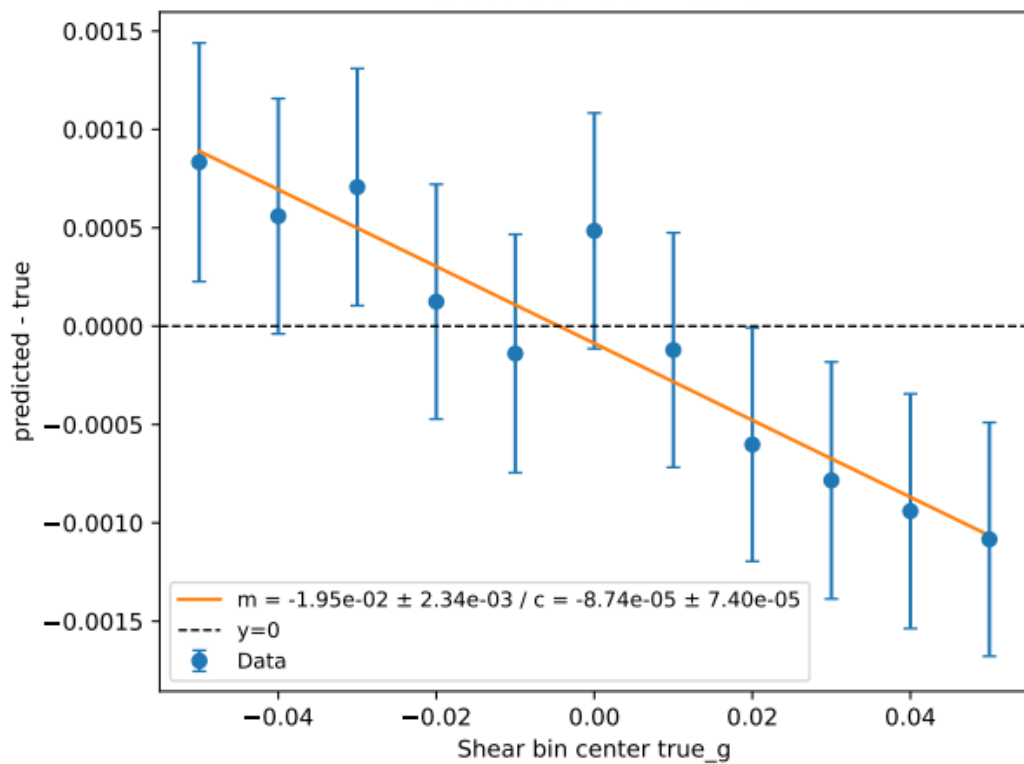


$$\hat{\gamma}_i = (1 + m_i)\gamma_i + c_i \quad \text{for } i = 1, 2$$

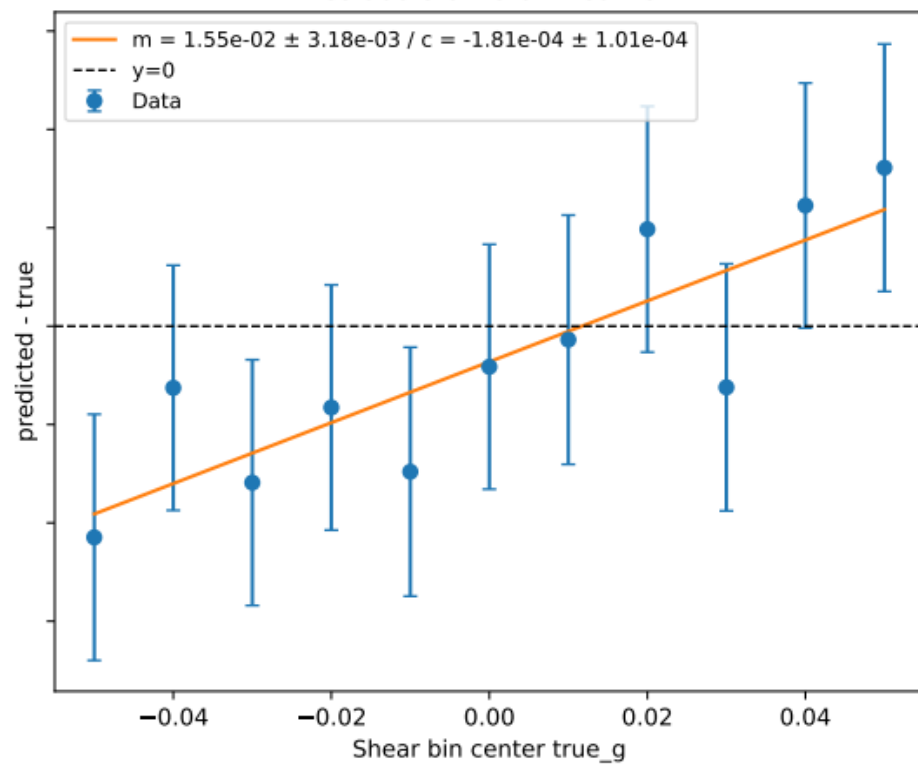
25_000*4 IMAGES (SNC)

Results shear bin

Residuals of total mean e1



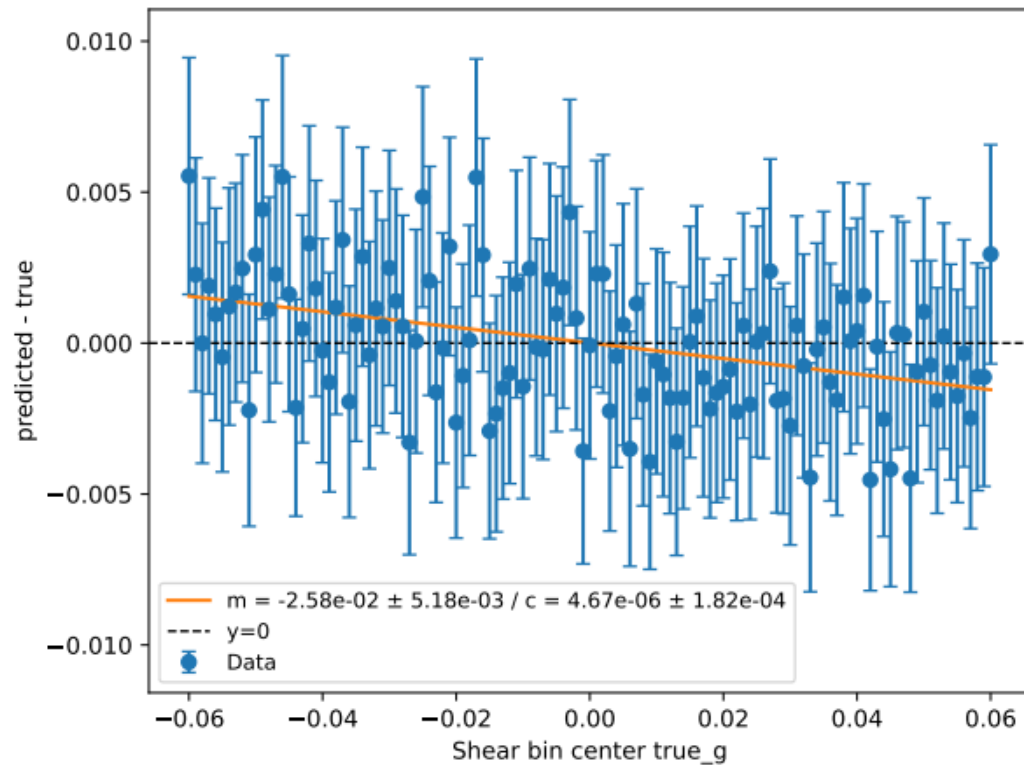
Residuals of total mean e2



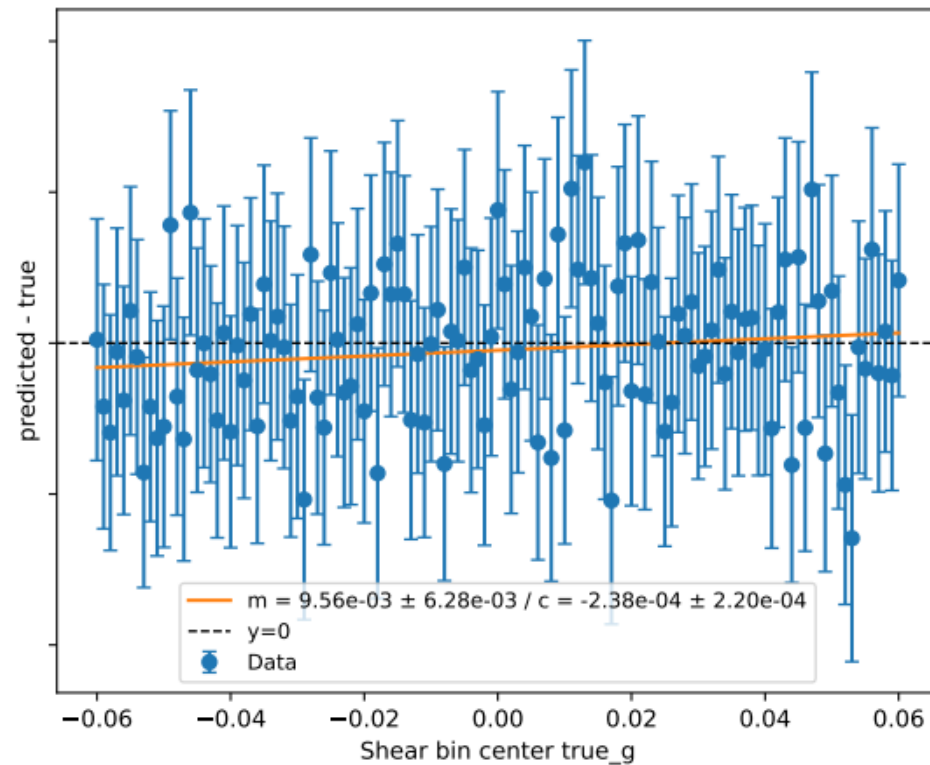
25_000*4 IMAGES (SNC)

Results shear bin

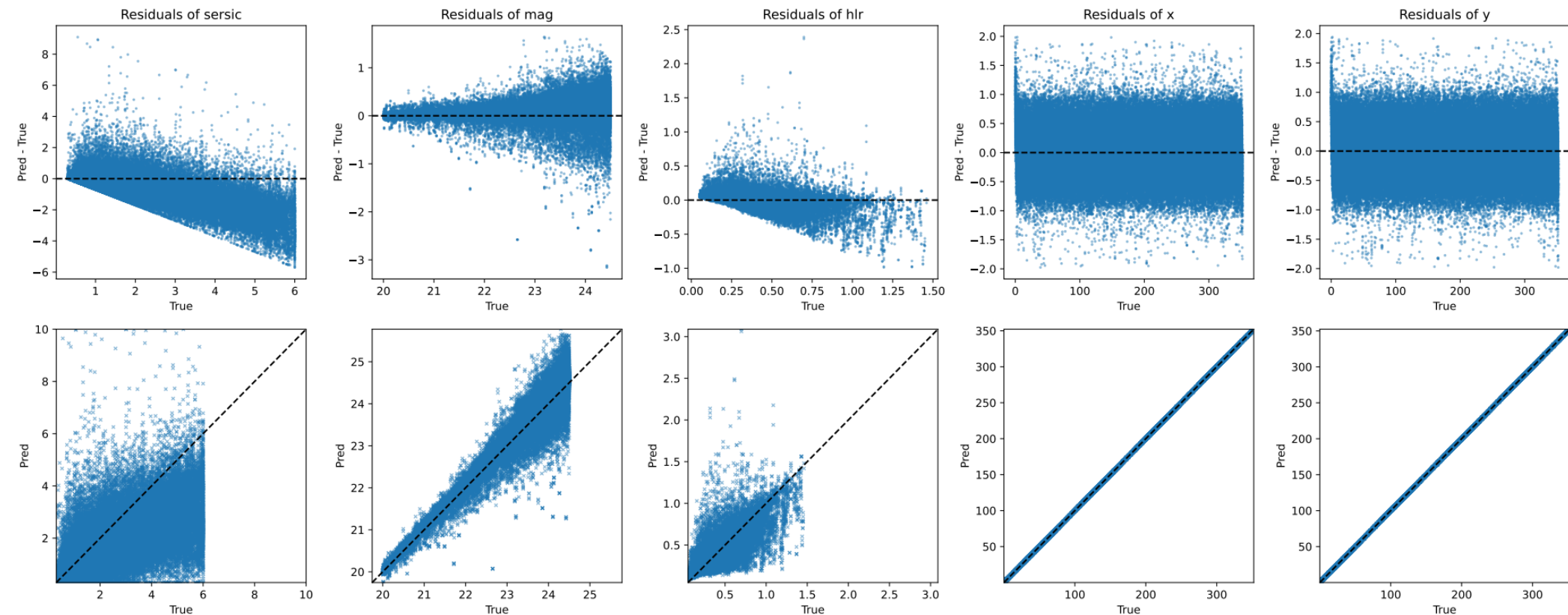
Residuals of total mean e1



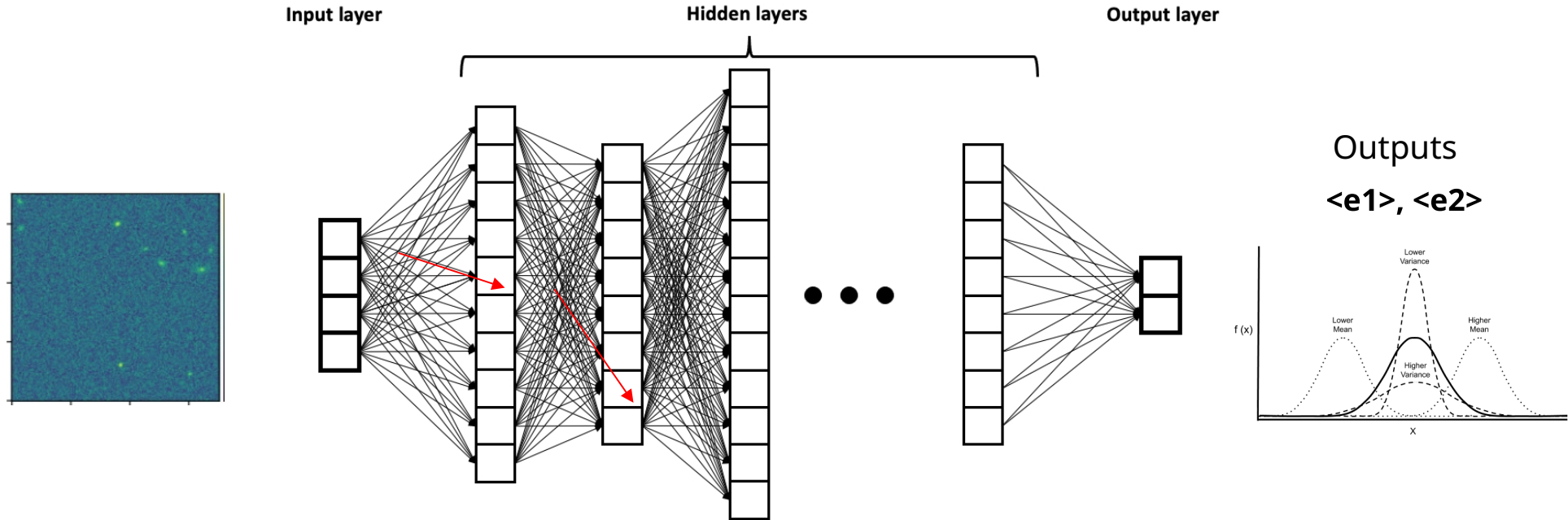
Residuals of total mean e2



25_000*4 IMAGES (SNC)



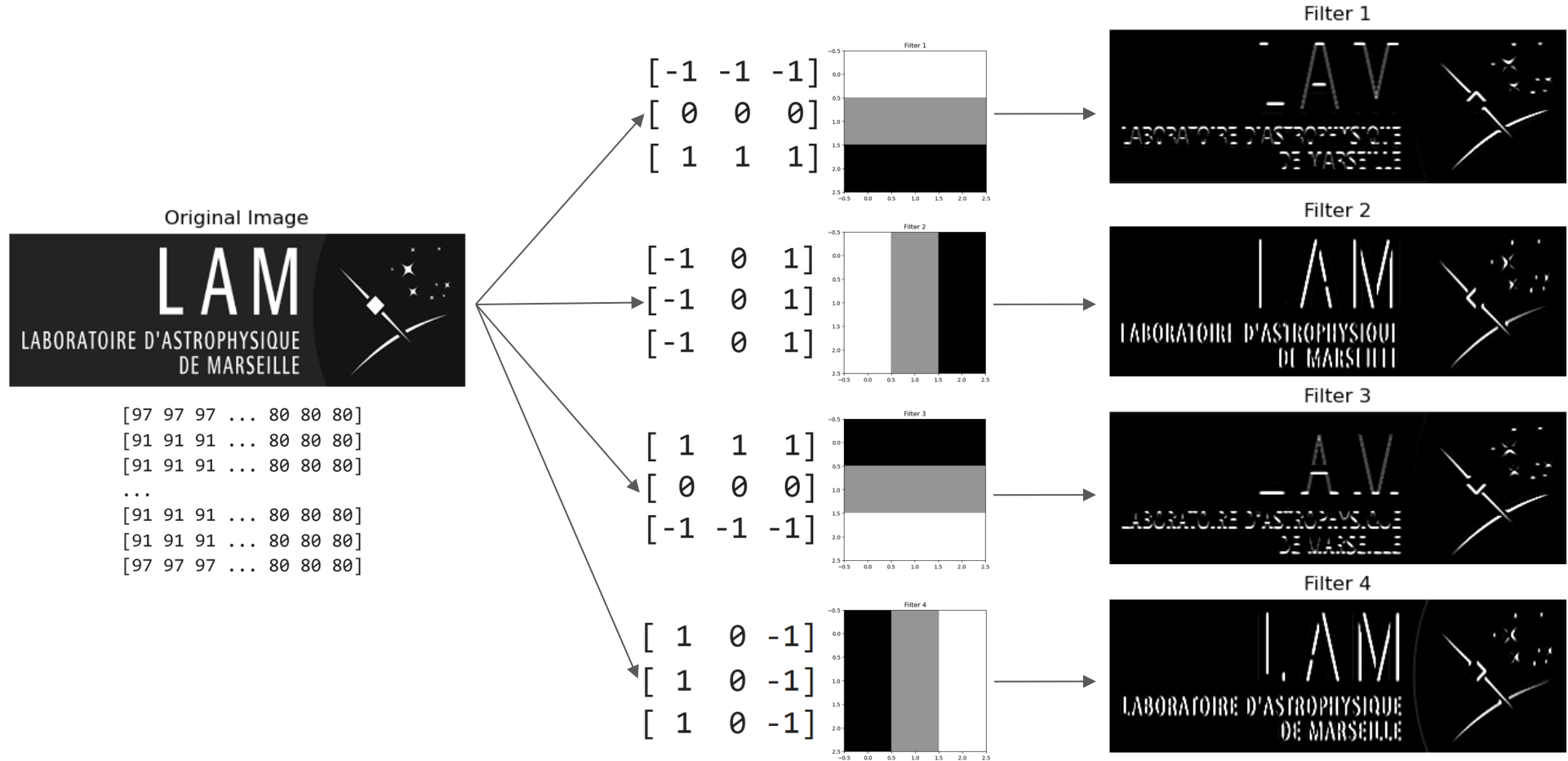
NEURAL NETWORK FOR GALAXY SHAPE



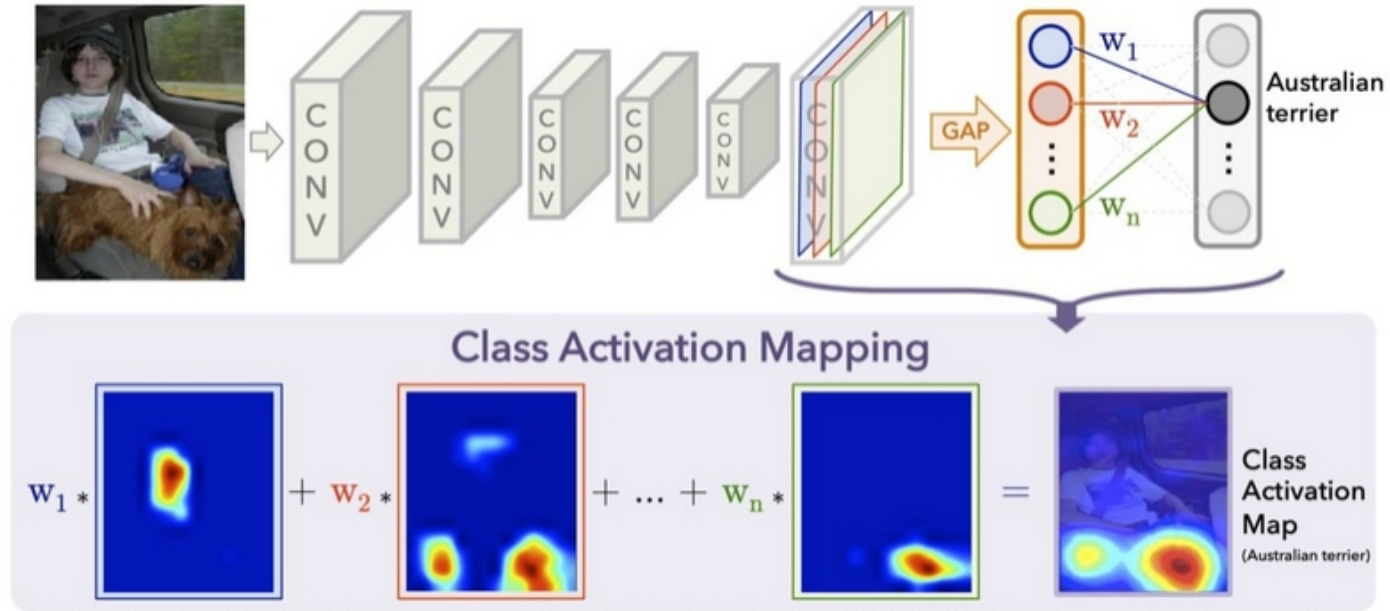
Mixture Density Network

- JAX
- Encoder : Resnet blocks & Traditional Conv/BN/ACT layers
- Reduction : two cases Maxpool & Conv with stride=2
- Outputs (probability distributions) => Distrax library
- Univariates ($g1$ & $g2$) / Multivariate ($g1+g2$) normal distributions
- Each distribution => 3 normal distributions for Multimodal cases
- skip connections layers which enables to train deep model with a lot of layers

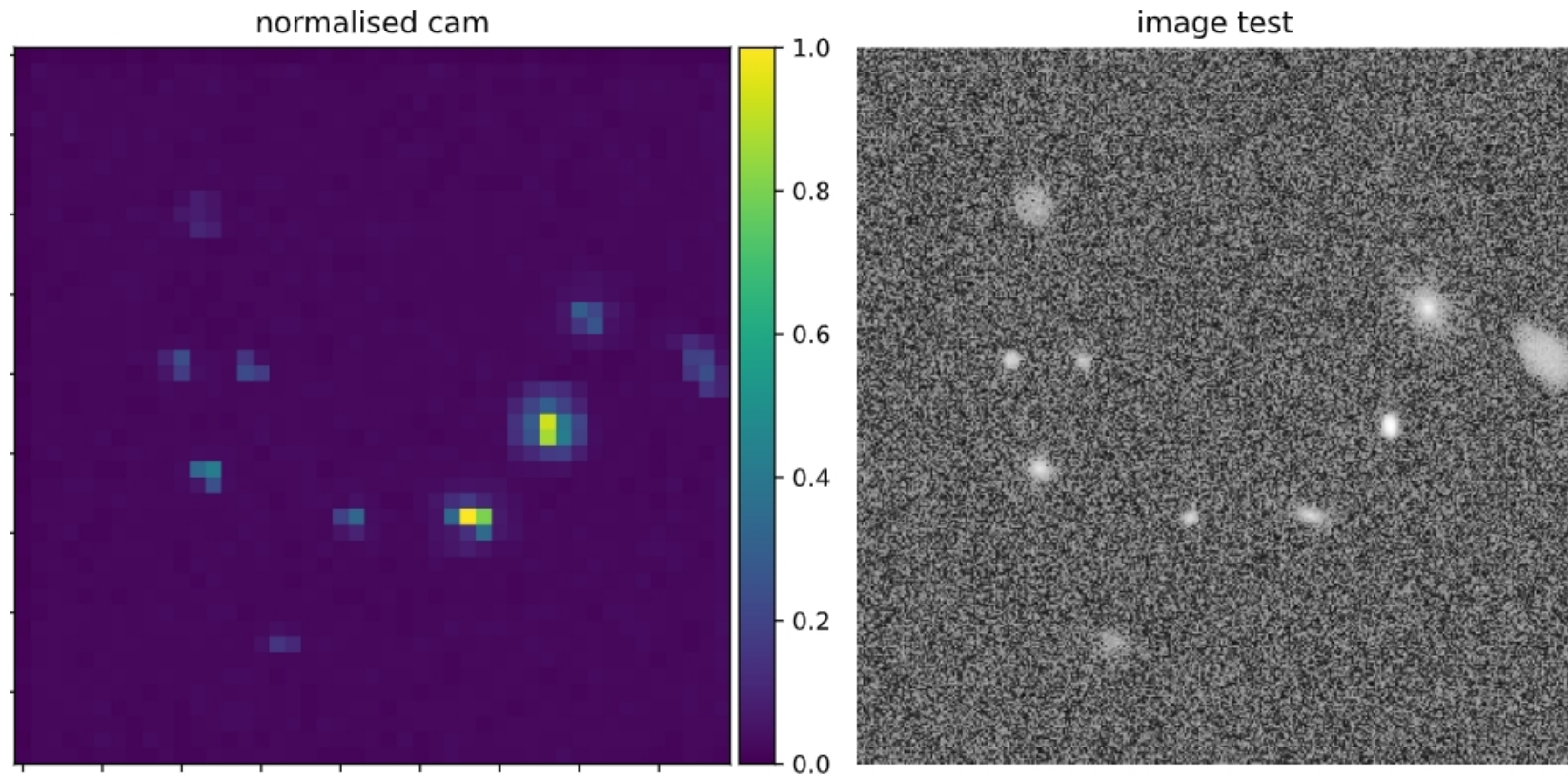
CNN



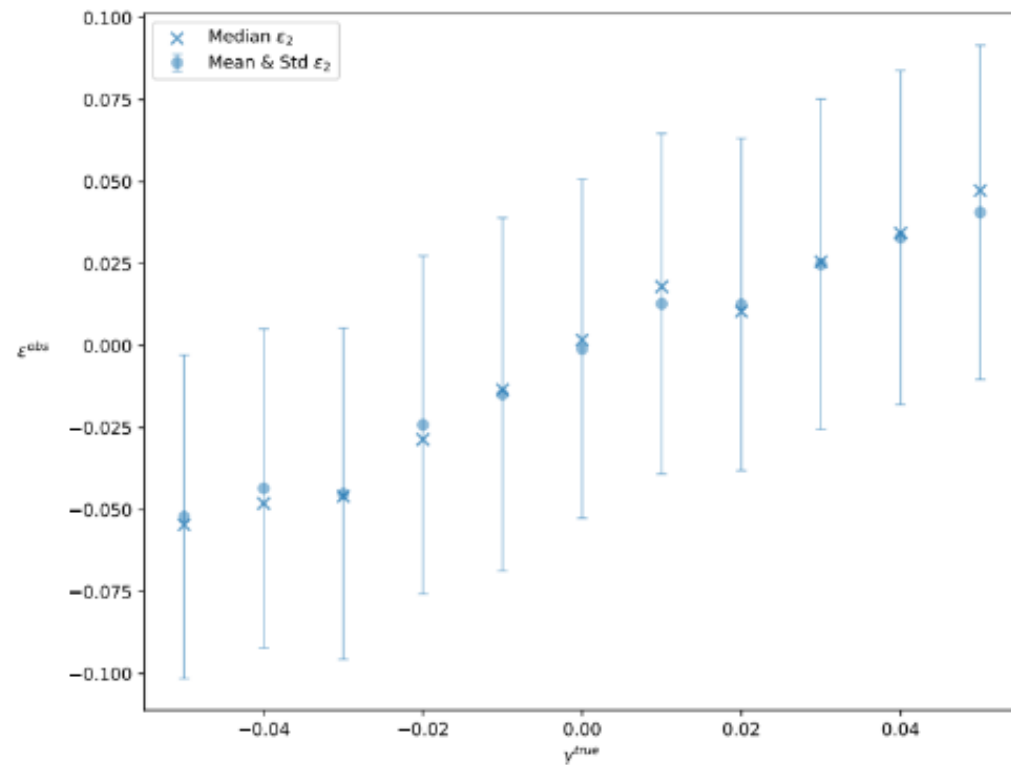
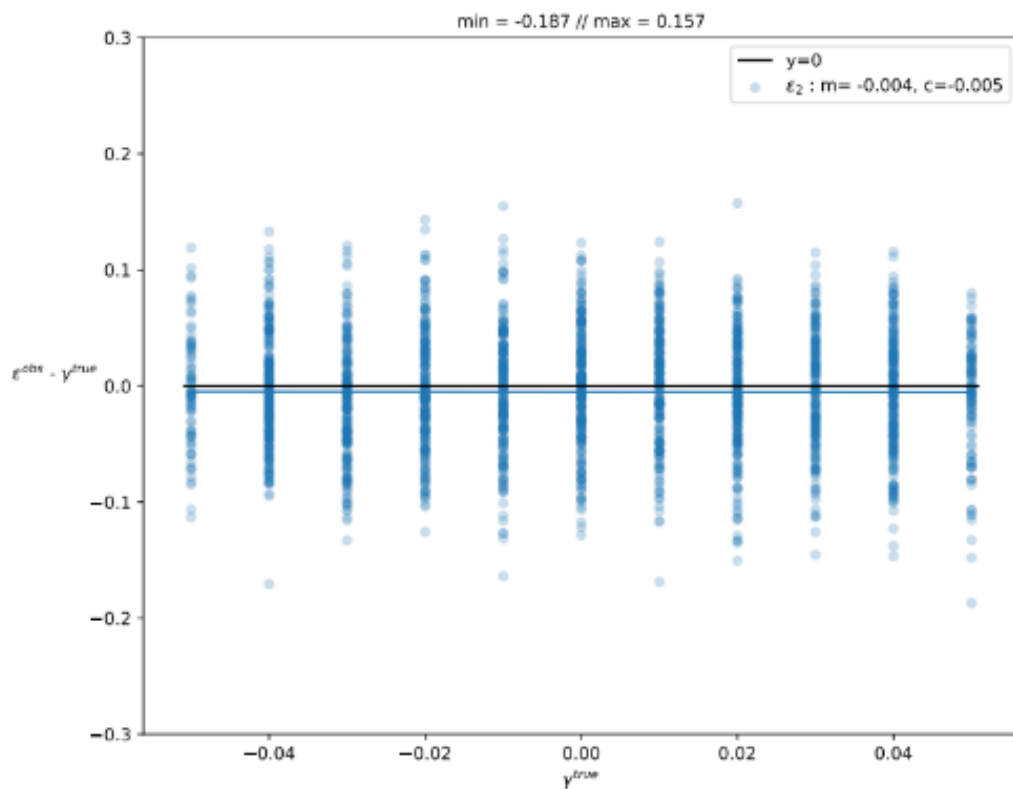
GradCam



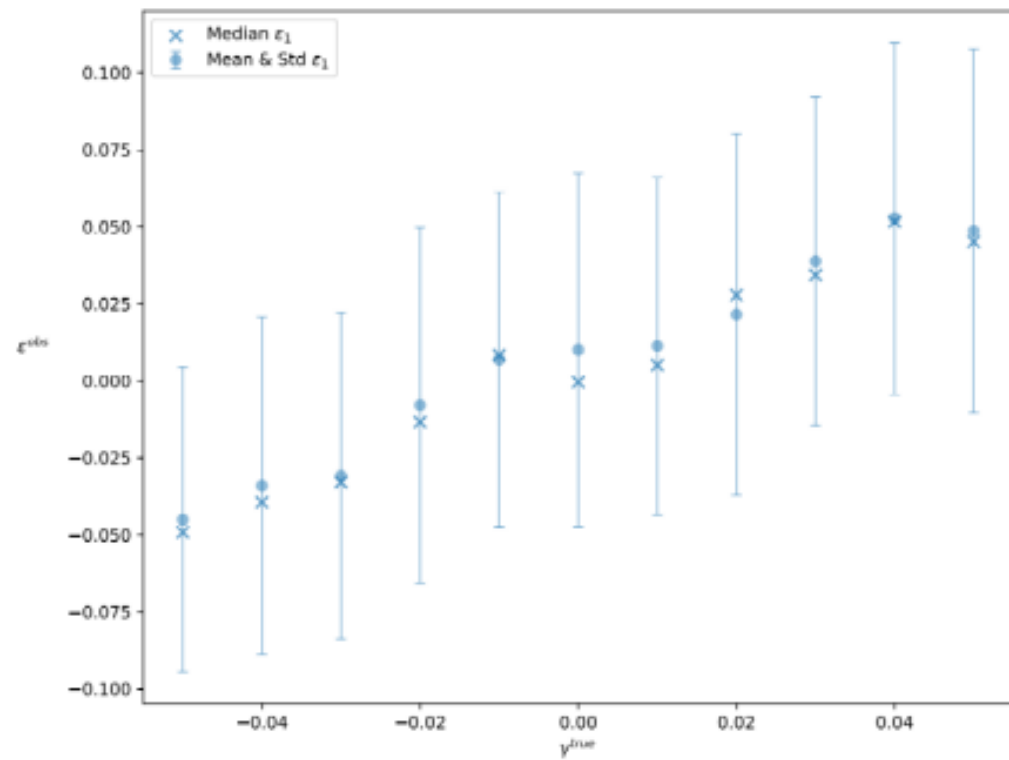
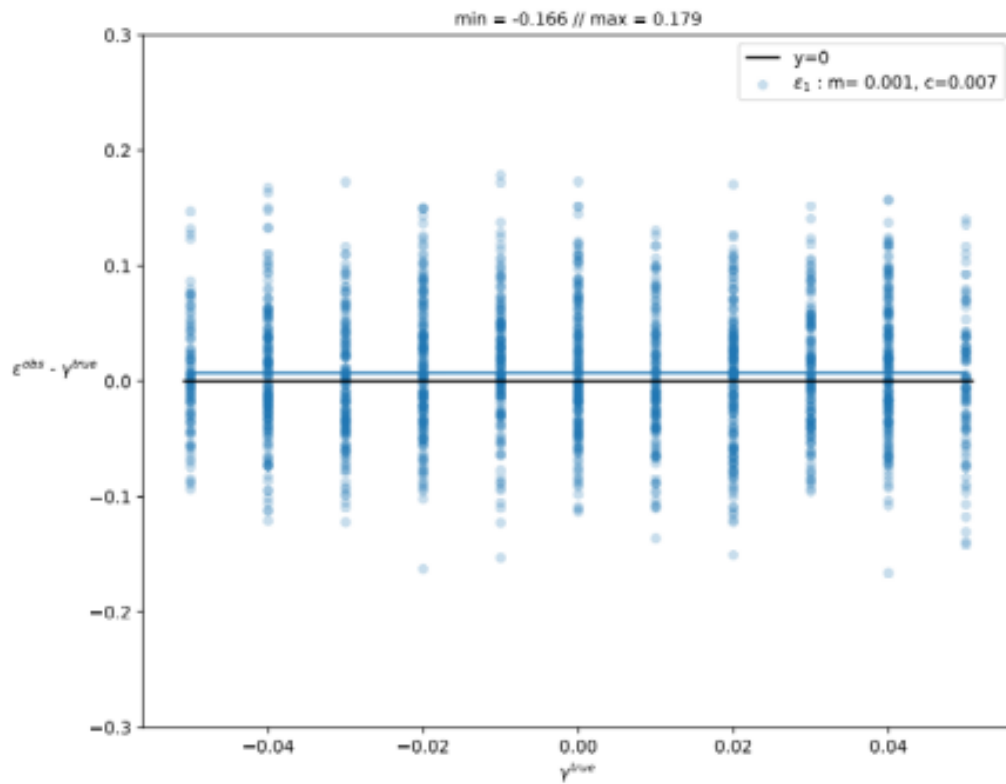
GradCam



RESULTS e1

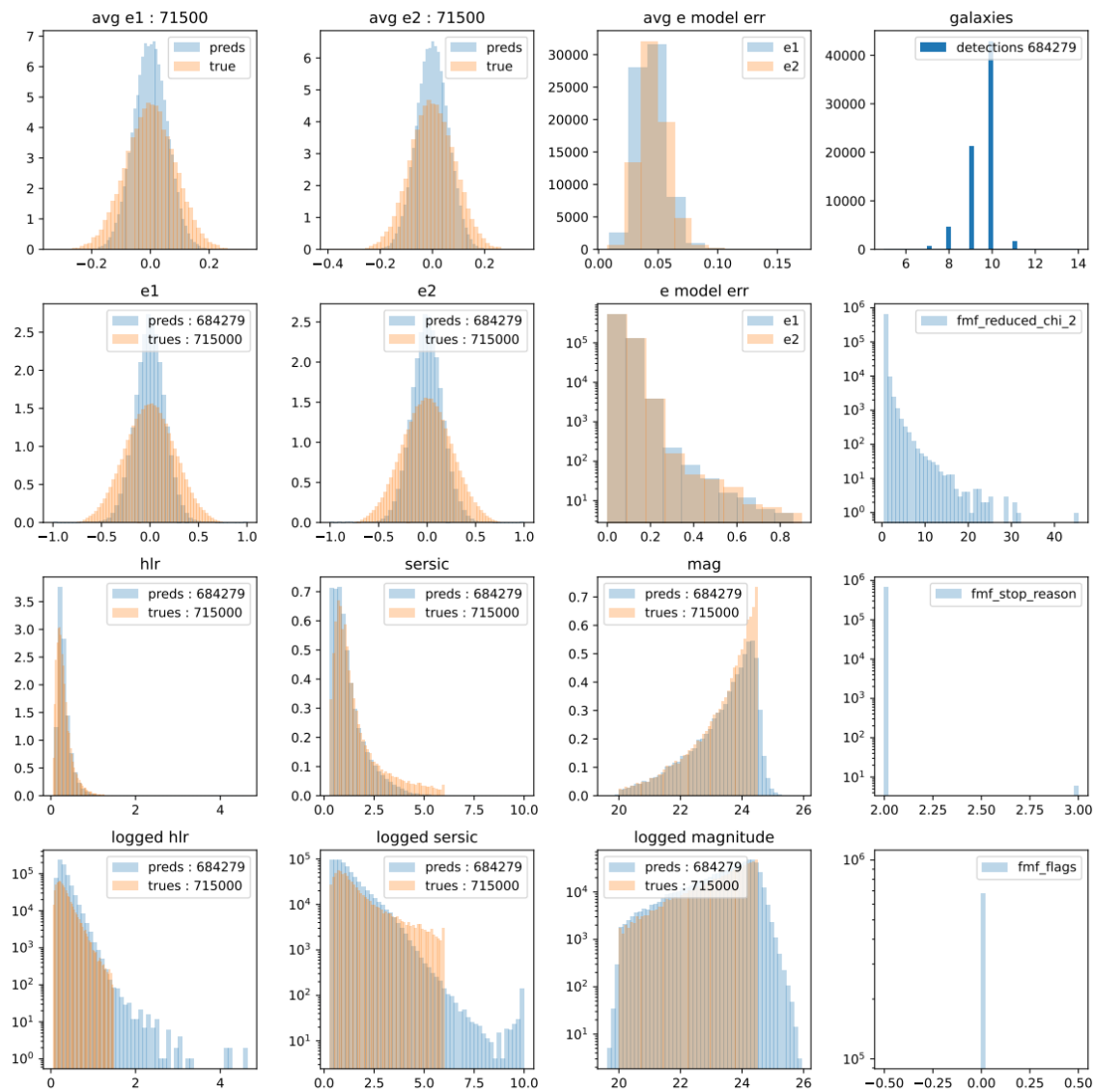


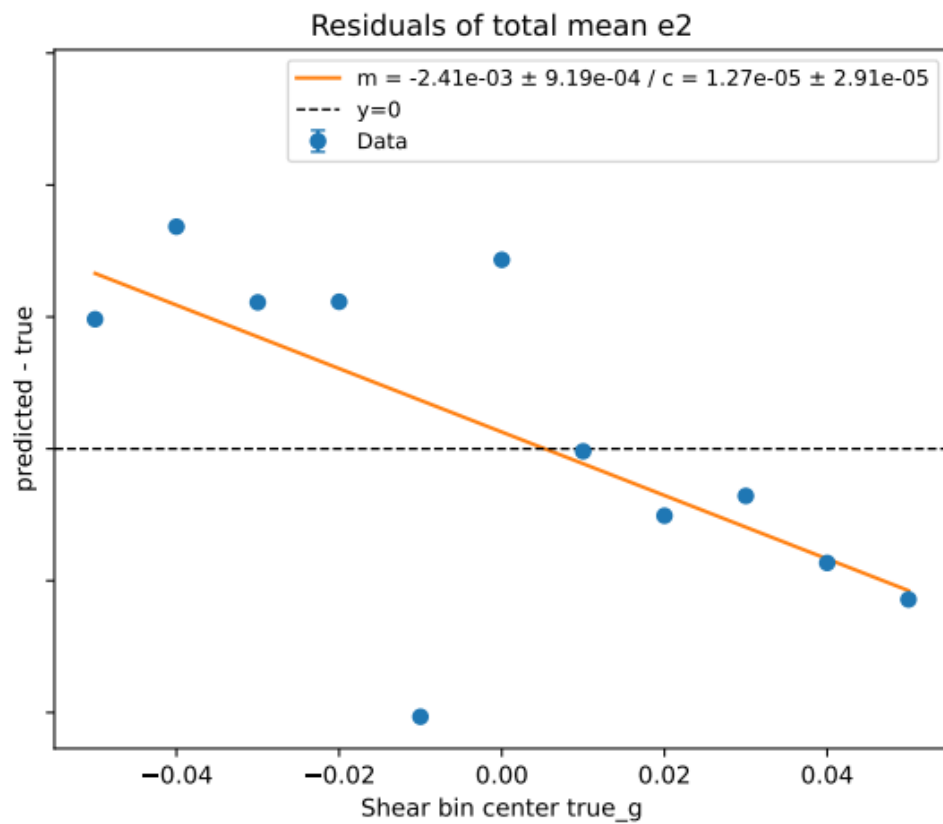
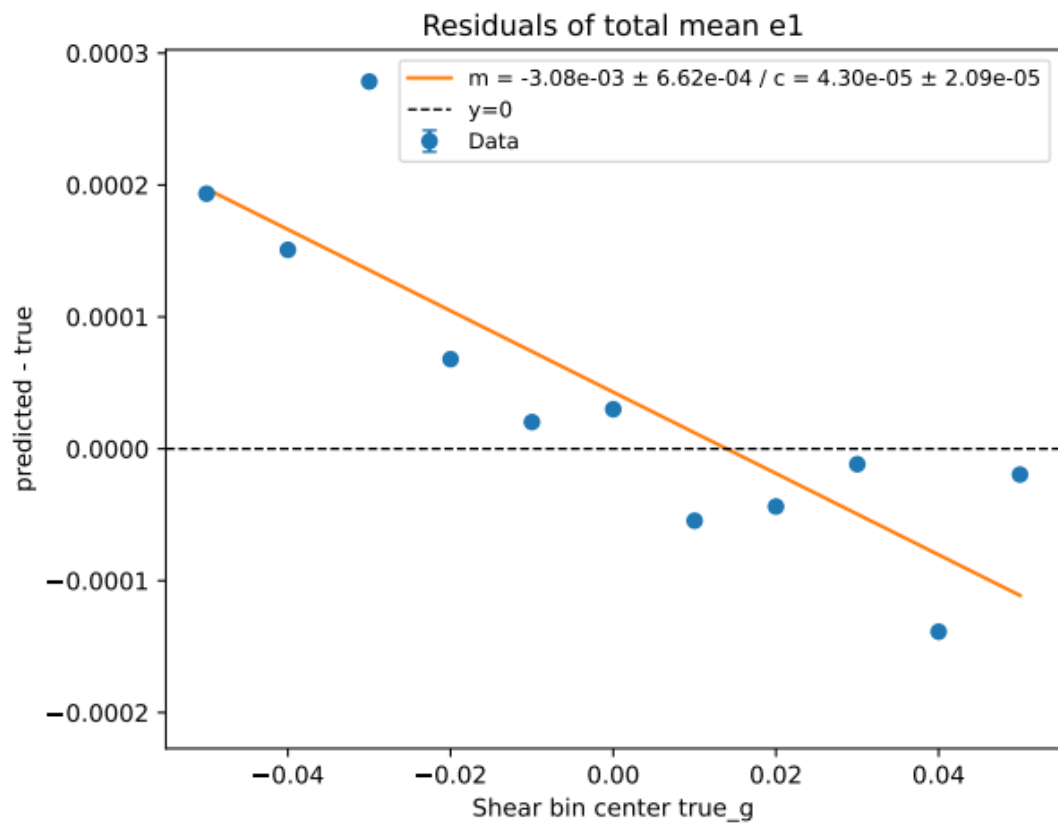
RESULTS e2



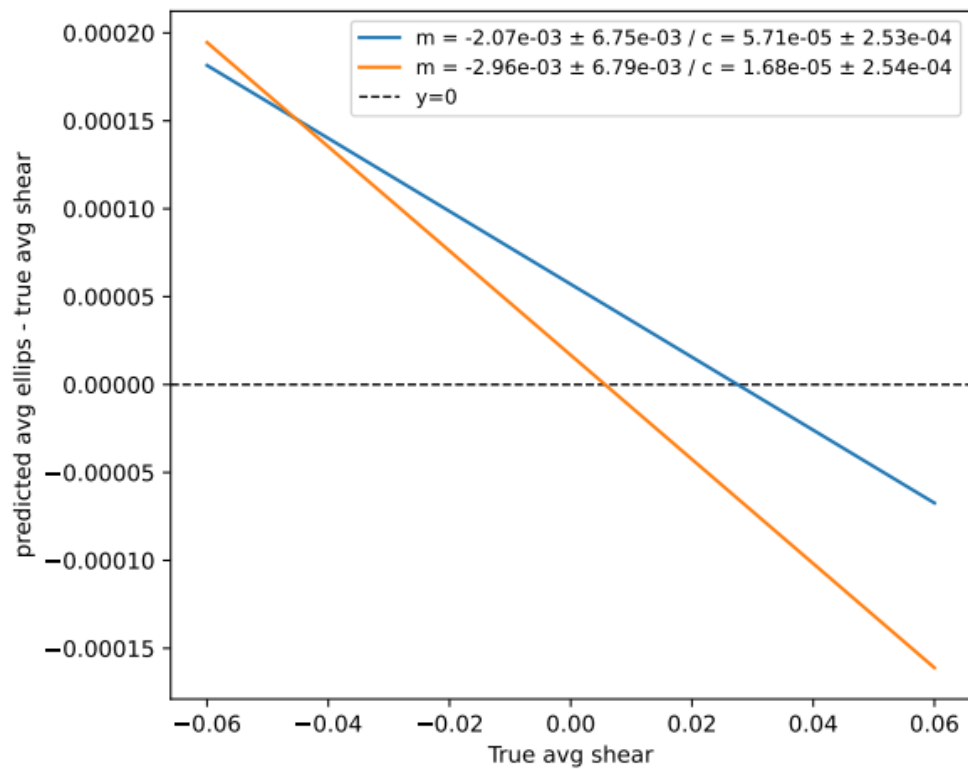
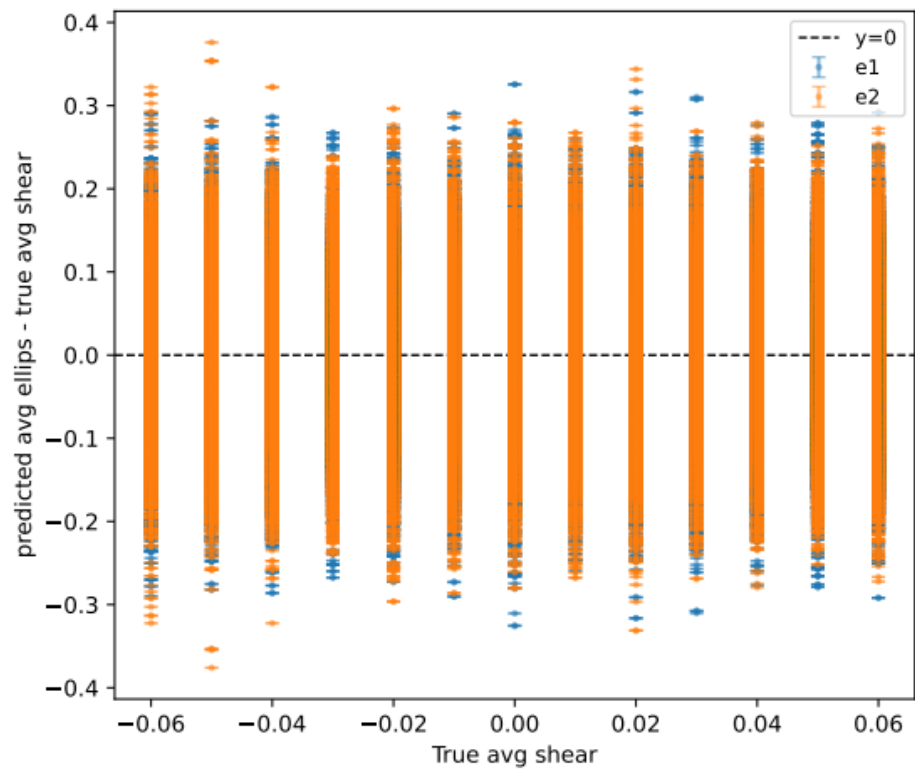
FOLLOWING

- Predict directly g_1 & g_2
- Impact of true morphologies / blending / detection biases
- Normalizing flows
- Autoencoder for more real galaxies / finetuning for univariate & flows
- Clara => finish the job
- Simone => second PISCO part

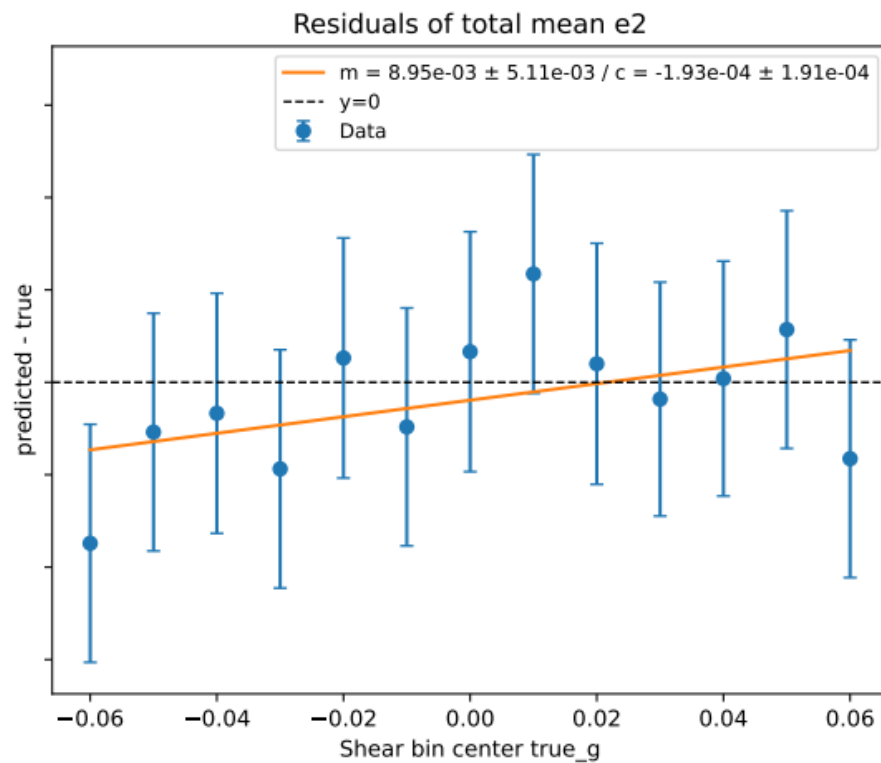
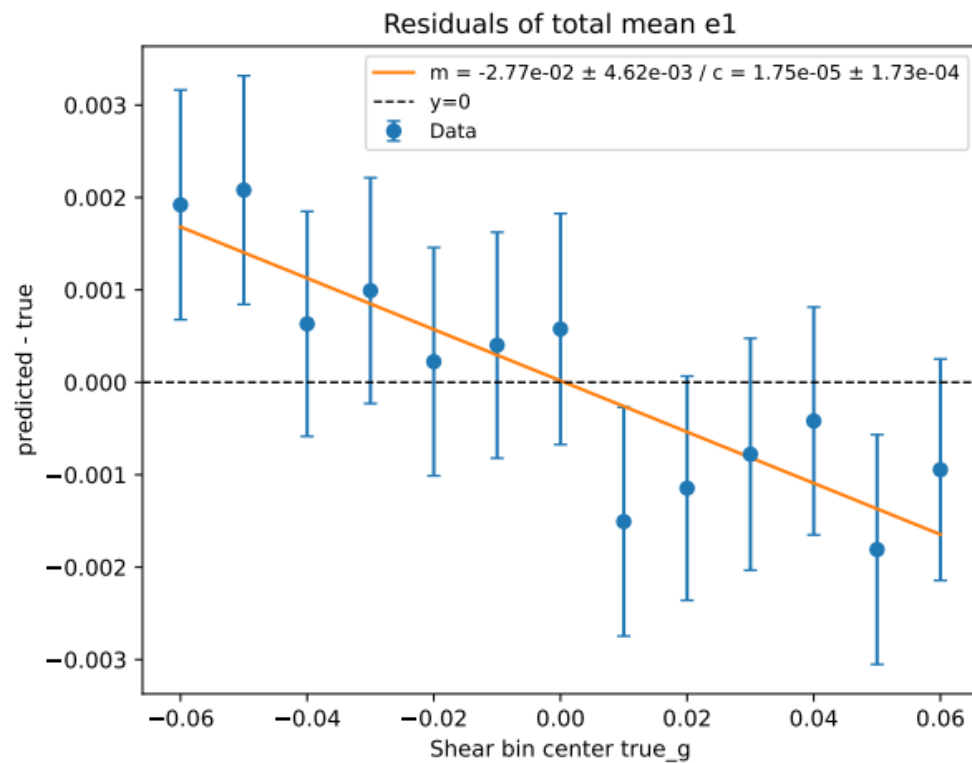




Predicted truth



Predicted truth



5000*4 images