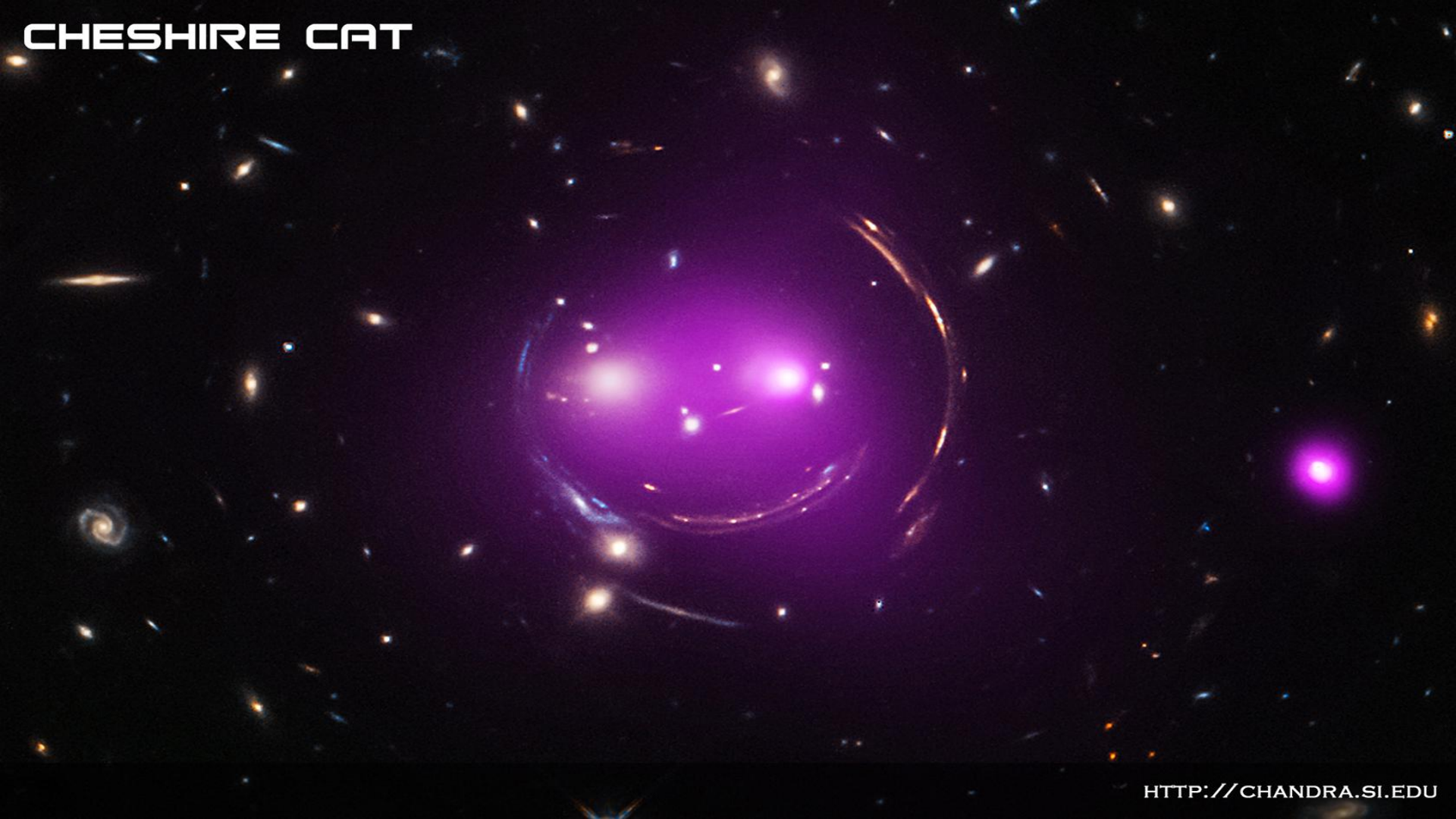
Project 01 - Strong Lensing Simulations with Lenstronomy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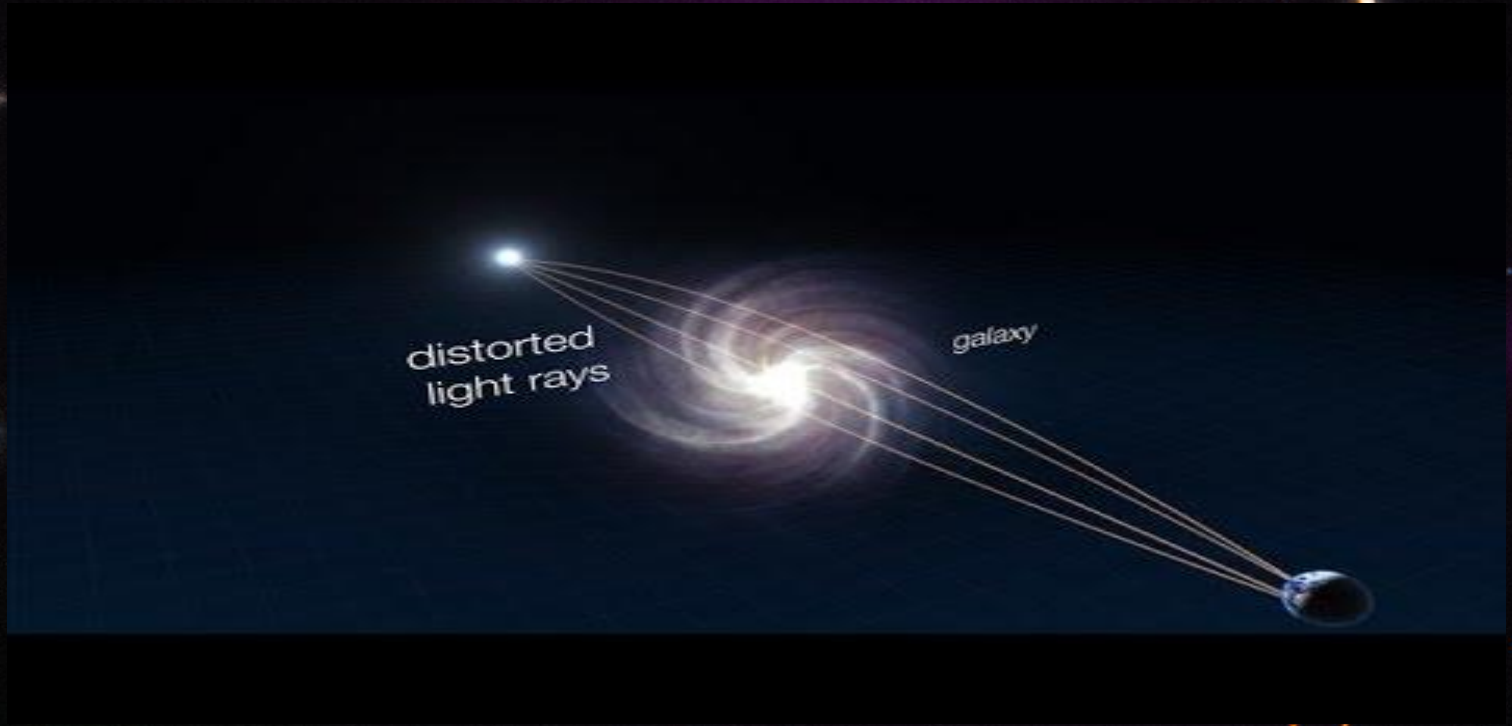
Can we create a simulated sample that look real?

- Strong Lens systems are “rare”
- Observation are expensive
- Real samples take time

Strong Lenses?



Deeplenstronomy

The configuration file (configuration_file.yaml) will have in 5 section: "DATASET", "COSMOLOGY", "SPECIES", "DISTRIBUTIONS" and "GEOMETRY".

```yaml
DATASET:
    NAME: ExampleDataset # set a name, this value is only used if you request the h5 file format
    PARAMETERS:
        SIZE: 1000 # number of images in the full dataset, I'll keep it small for this example
        OUTDIR: ExampleDataset # will be created on your system if your request to save images
        seed: 1000
```

```yaml
COSMOLOGY:
    PARAMETERS:
        H0: 74.0
        Om0: 0.3
```

Deeplenstronomy

```
SPECIES:
    GALAXY_1:  #
        NAME: SimulatedLens
        LIGHT_PROFILE_1: #
            NAME: SERSIC_ELLIPSE #
            PARAMETERS:
        MASS_PROFILE_1:
            NAME: SIE #
            PARAMETERS:


    GALAXY_2:
        NAME: SimulatedSource
        LIGHT_PROFILE_1:
        MASS_PROFILE_1:
            NAME: SIE #
            PARAMETERS:
```

Deeplenstronomy

```
GEOMETRY:
    CONFIGURATION_1:
        NAME: GalaxyGalaxySimulated # describe what's in this configuration
        FRACTION: 1
        PLANE_1: # add all objects in the first plane
            OBJECT_1: SimulatedLens # name of the object to put in this plane
            PARAMETERS:
                REDSHIFT:
                    DISTRIBUTION:
                        NAME: uniform
                        PARAMETERS:
                            minimum: 0.3
                            maximum: 1
        PLANE_2: # add all objects in the second plane
            OBJECT_1: SimulatedSource
            PARAMETERS:
                REDSHIFT:
                    DISTRIBUTION:
                        NAME: uniform
                        PARAMETERS:
                            minimum: 1.3
                            maximum: 6
```

Deeplenstronomy

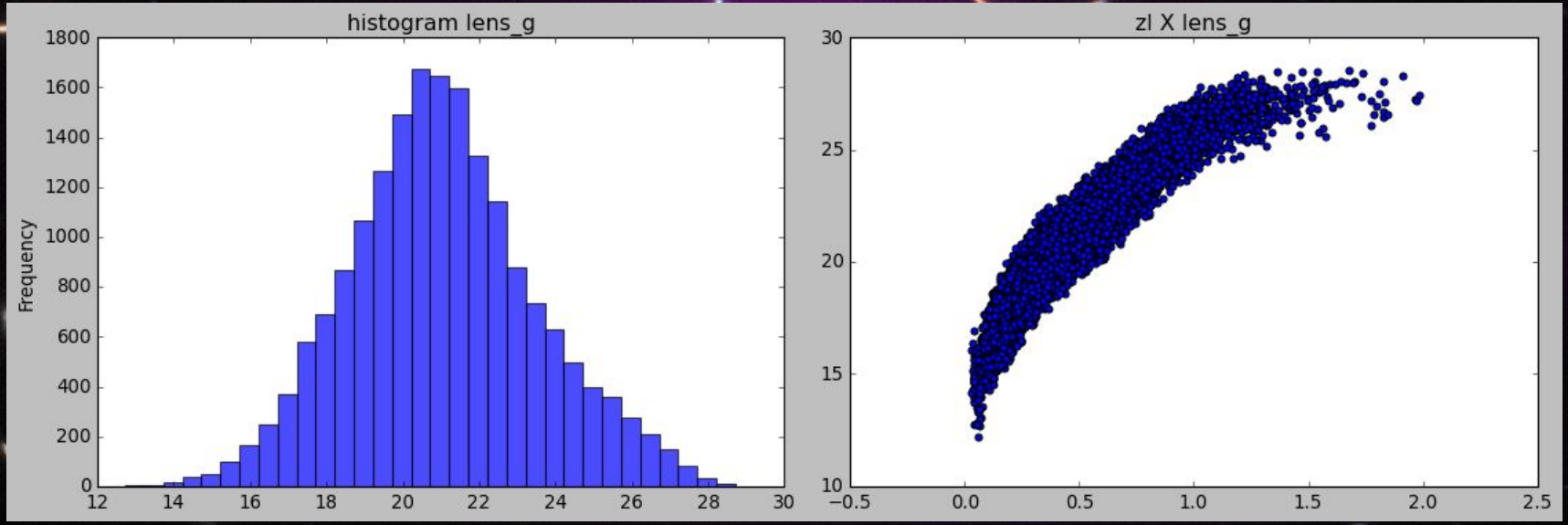
```
161 DISTRIBUTIONS:
162     USERDIST_1:
163         FILENAME: data/lens_redshifts.txt
164         MODE: sample
165     USERDIST_2:
166         FILENAME: data/mags_lens.txt
167         MODE: sample
168
```

And here start my work…

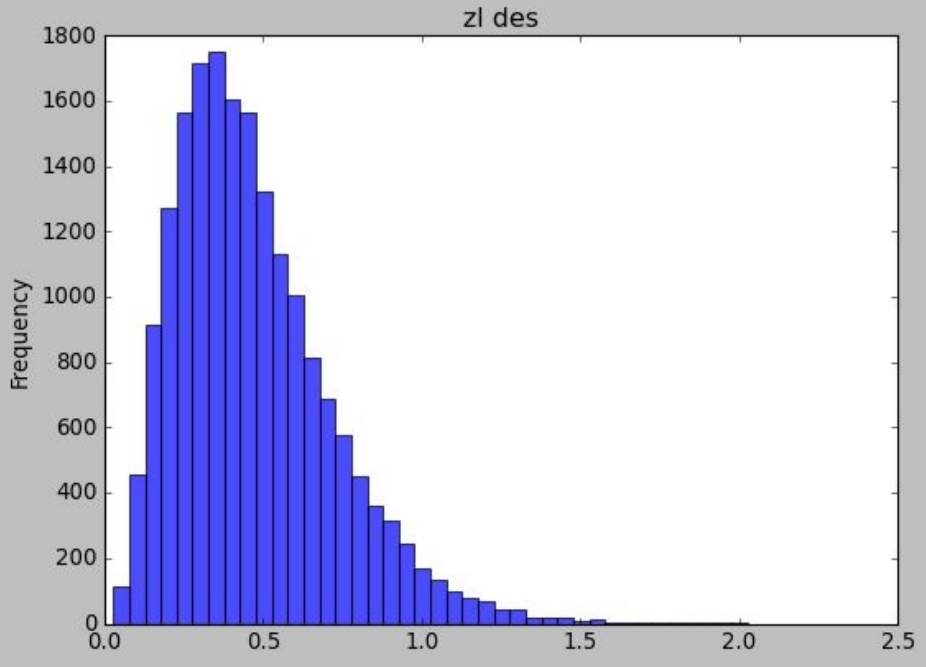
DES dataset

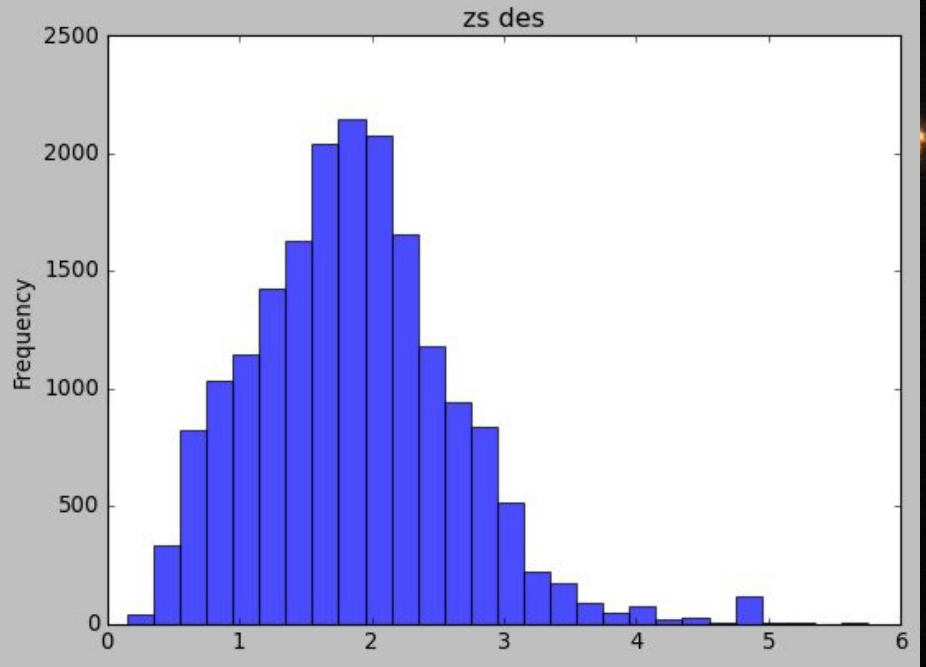
- Dark Energy Survey
- 24 fields and 18598 observation
- Let’s reproduce the magnitude distribution on band g, r and i

DES dataset


histogram lens_g
Frequency
0
200
400
600
800
1000
1200
1400
1600
1800
12
14
16
18
20
22
24
26
28
30
zl X lens_g
10
15
20
25
30
−0.5
0.0
0.5
1.0
1.5
2.0
2.5

DES dataset

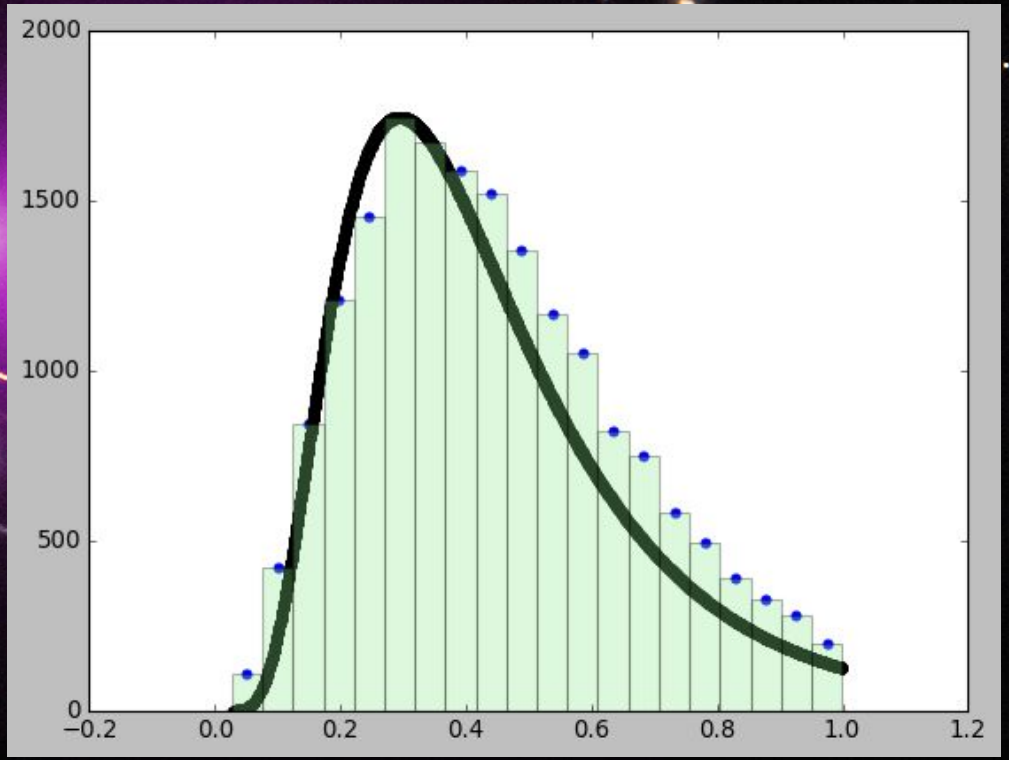

zl des
Frequency
0
200
400
600
800
1000
1200
1400
1600
1800
0.0
0.5
1.0
1.5
2.0
2.5


zs des
Frequency
0
500
1000
1500
2000
2500
0
1
2
3
4
5
6

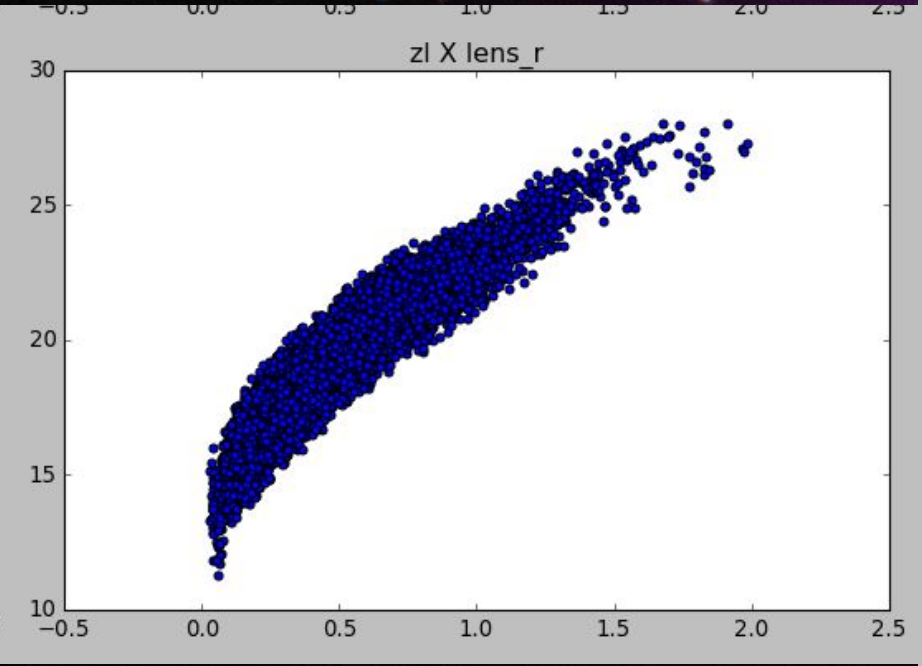
DES dataset

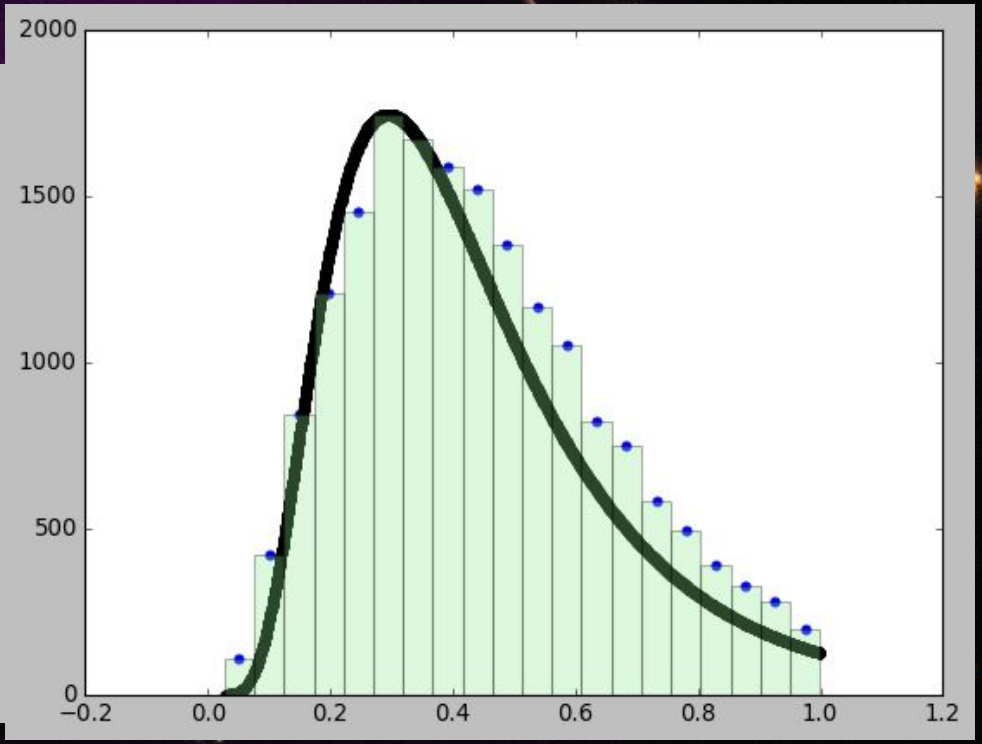
The Lognorm PDF

$$f(x, s) = \frac{1}{sx\sqrt{2\pi}} \exp\left(-\frac{\log^2(x) - \mu}{2s^2}\right)$$



DES dataset: in a summary





And the DES meet the Deeplenstronomy

```
PLANE_1-OBJECT_1-REDSHIFT WEIGHT
0.32 2.1846768603950277
0.402 1.8612869563518823
0.569 1.0247927149131326
0.18899999999999997 1.568
0.568 1.0289970602200171
0.264 2.168065315192191
0.223 1.9340115502416668
0.266 2.174058578357915
```

```
DISTRIBUTIONS:
    USERDIST_1:
        FILENAME: data/lens_redshifts.txt
        MODE: sample
    USERDIST_2:
        FILENAME: data/mags_lens.txt
        MODE: sample
```

```
CONFIGURATION_1-PLANE_1-OBJECT_1-REDSHIFT CONFIGURATION_1-PLANE_1-OBJECT_1-LIGHT_PROFILE_1-magnitude-g CONFIGURATION_1-PLANE_1-OBJECT_1-LIGHT_PROFILE_1-magnitude-r CONFIGURATION_1-PLANE_1-OBJECT_1-LIGHT_PROFILE_1-magnitude-i CONFIGURATION_1-PLANE_1-OBJECT_1-LIGHT_PROFILE_1-magnitude-z CONFIGURATION_1-PLANE_1-OBJECT_1-LIGHT_PROFILE_1-magnitude-Y WEIGHT
0.722 24.472 22.373 20.83 19.62601371 19.9975372 1.0
0.445 21.098 19.187 18.331 21.14725706 20.03470537 1.0
0.349 19.843 17.888 17.23 20.12555205 21.74764662 1.0
0.403 20.897 18.953 18.221 20.7321685 21.03293697 1.0
0.304 19.201 17.396 16.762 21.02129499 20.56705745 1.0
0.415 21.666 19.734 18.973 18.94955294 21.35908937 1.0
```

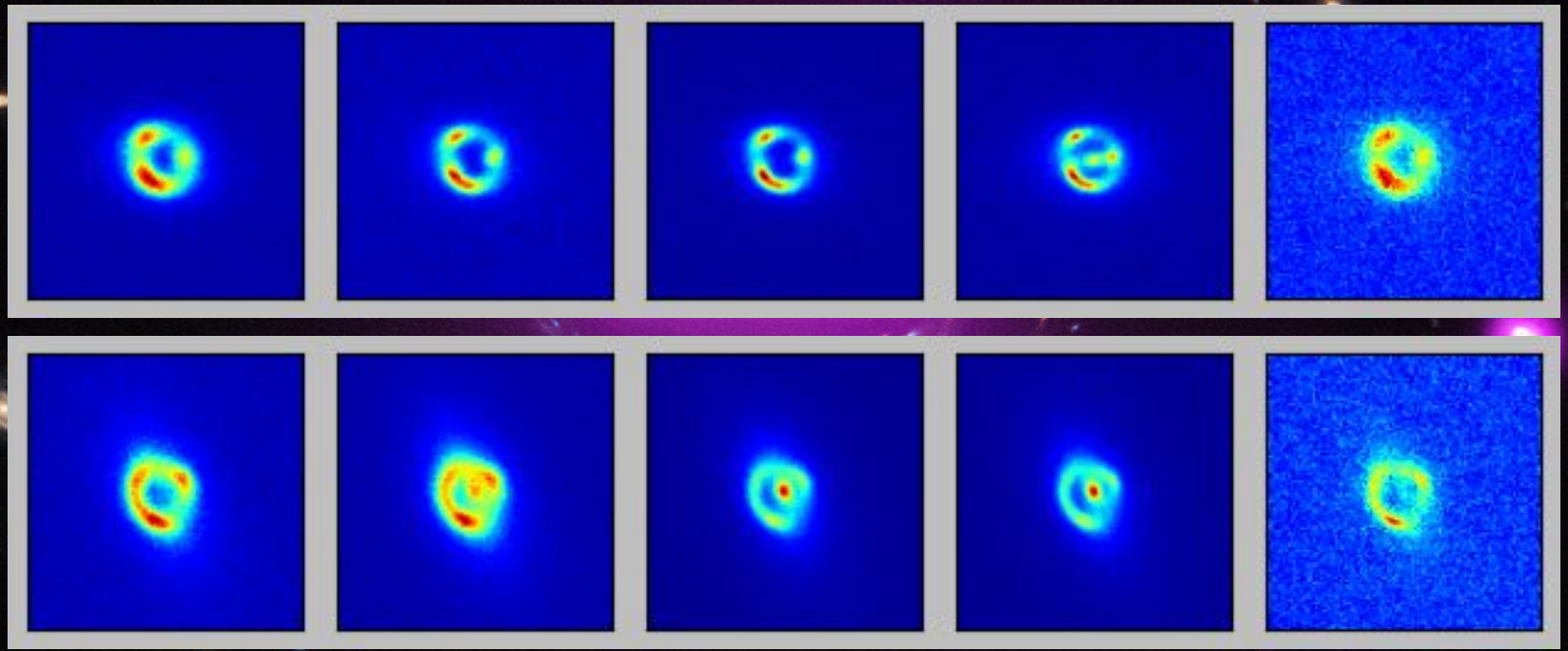
Deeplenstronomy simulation

Let's simulate

In [22]:
```
1 deeplens = dl.make_dataset('data/configuration_file.yaml', survey='des', verbose=True)
```

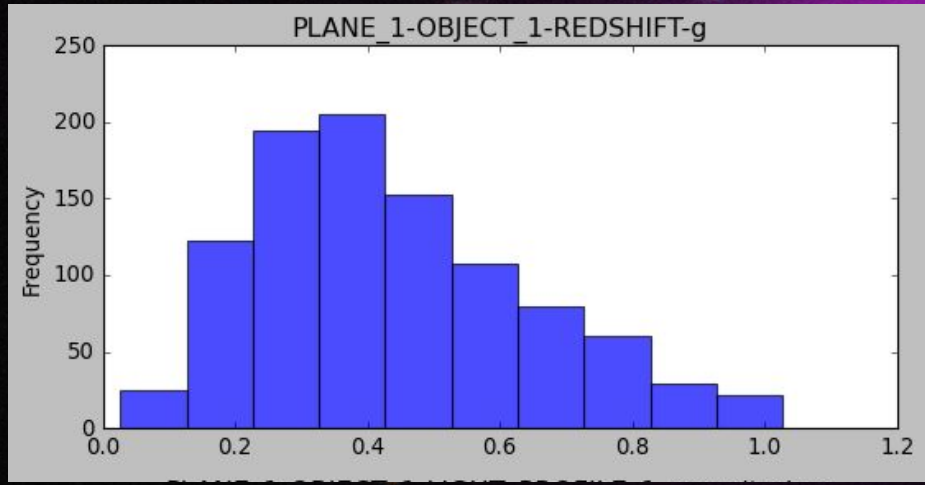
```
Entering main organization loop
Organizing CONFIGURATION_1
Generating images for CONFIGURATION_1
        Progress: 100.0 %  ---  Elapsed Time: 0 H 0 M 33 S
```

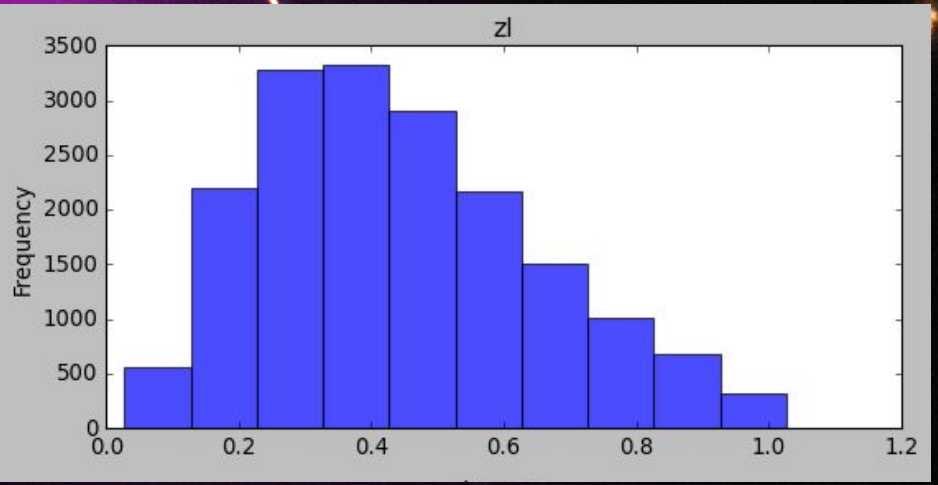
Deeplenstronomy simulation: images



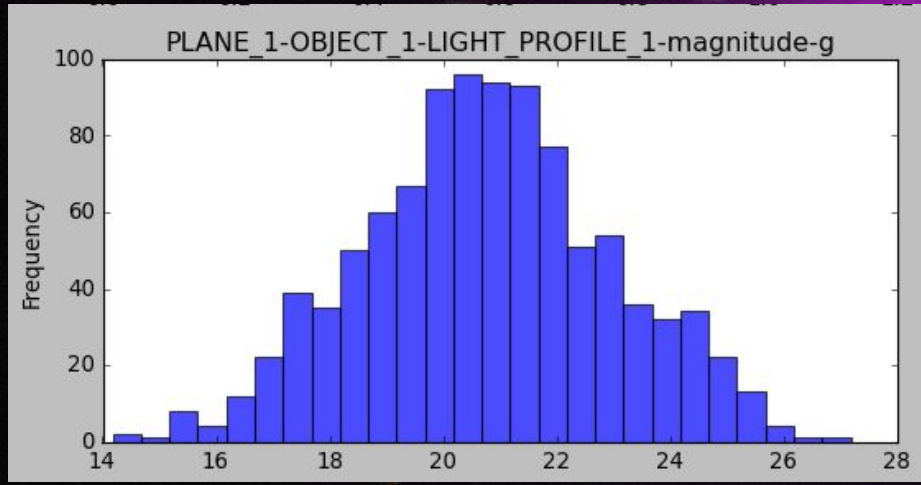
Deeplenstronomy simulation: images

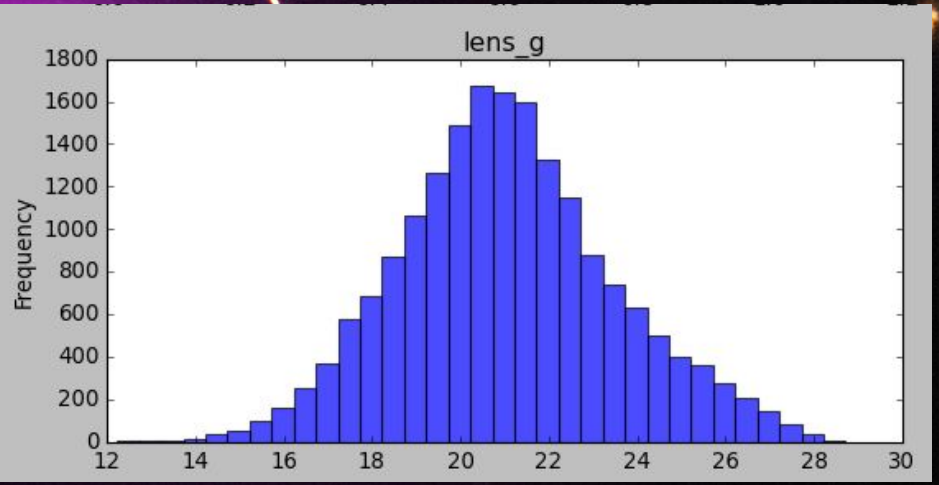
And the DES meet the Deeplenstronomy: did it work?



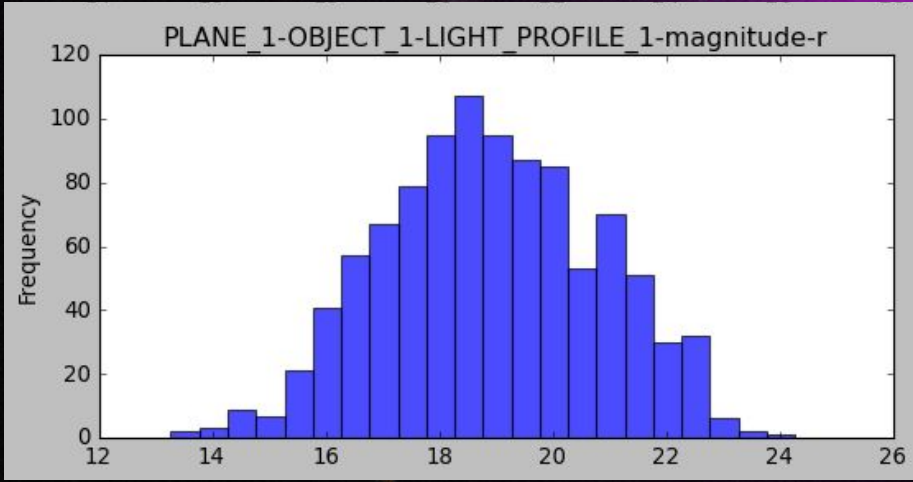


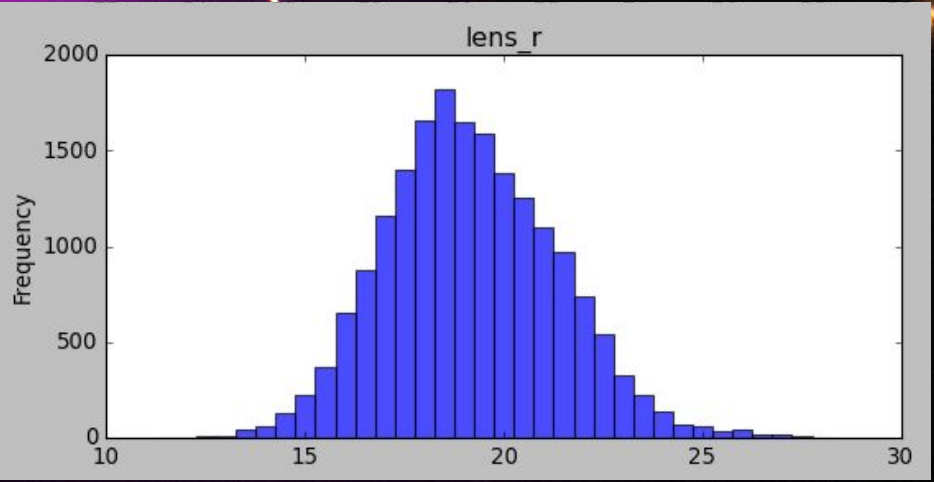
And the DES meet the Deeplenstronomy: did it work?



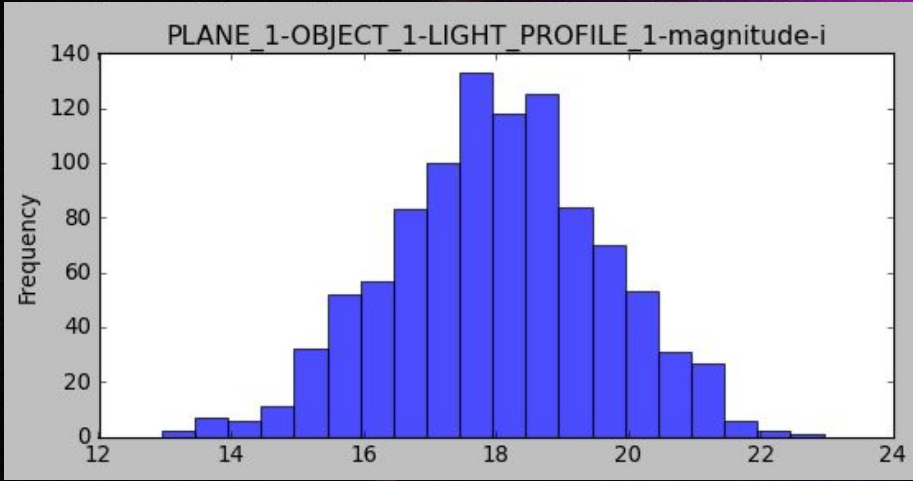


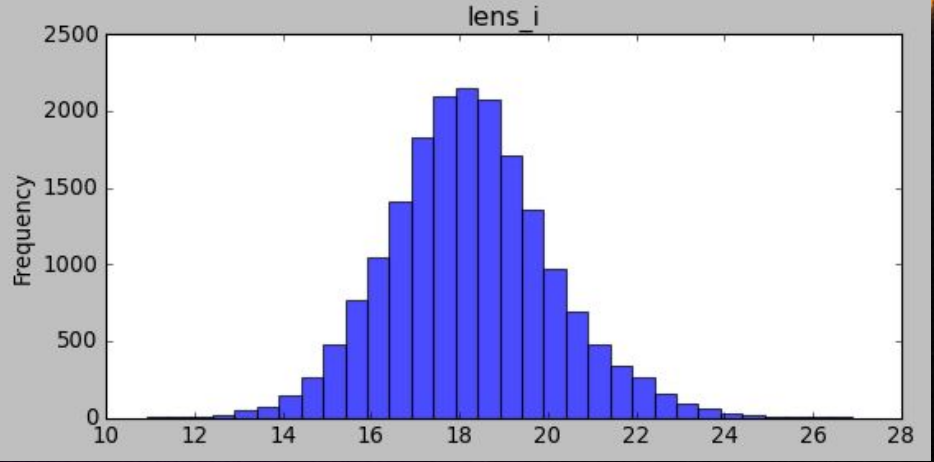
And the DES meet the Deeplenstronomy: did it work?





And the DES meet the Deeplenstronomy: did it work?





Final Considerations

- It is worth to remember that the simulated data's histogram has a thousand points while the real data's histogram has close to 20 thousand points. even though, the simulation result approach the real one.

- Simulate data will never replace observed data, but it can still offer a great help to research.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Thanks
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