Strong Lensing Challenge Kick-Off Meeting

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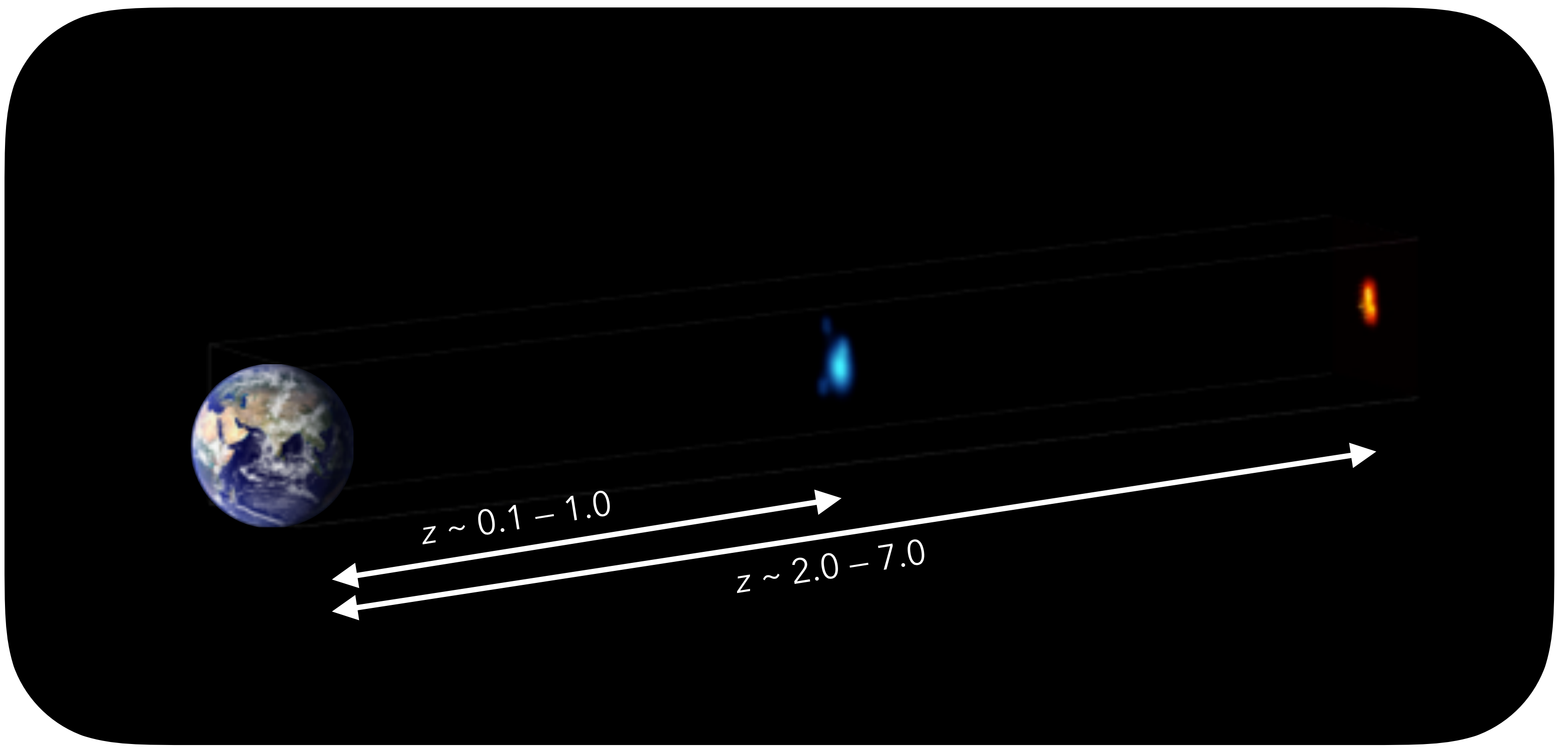
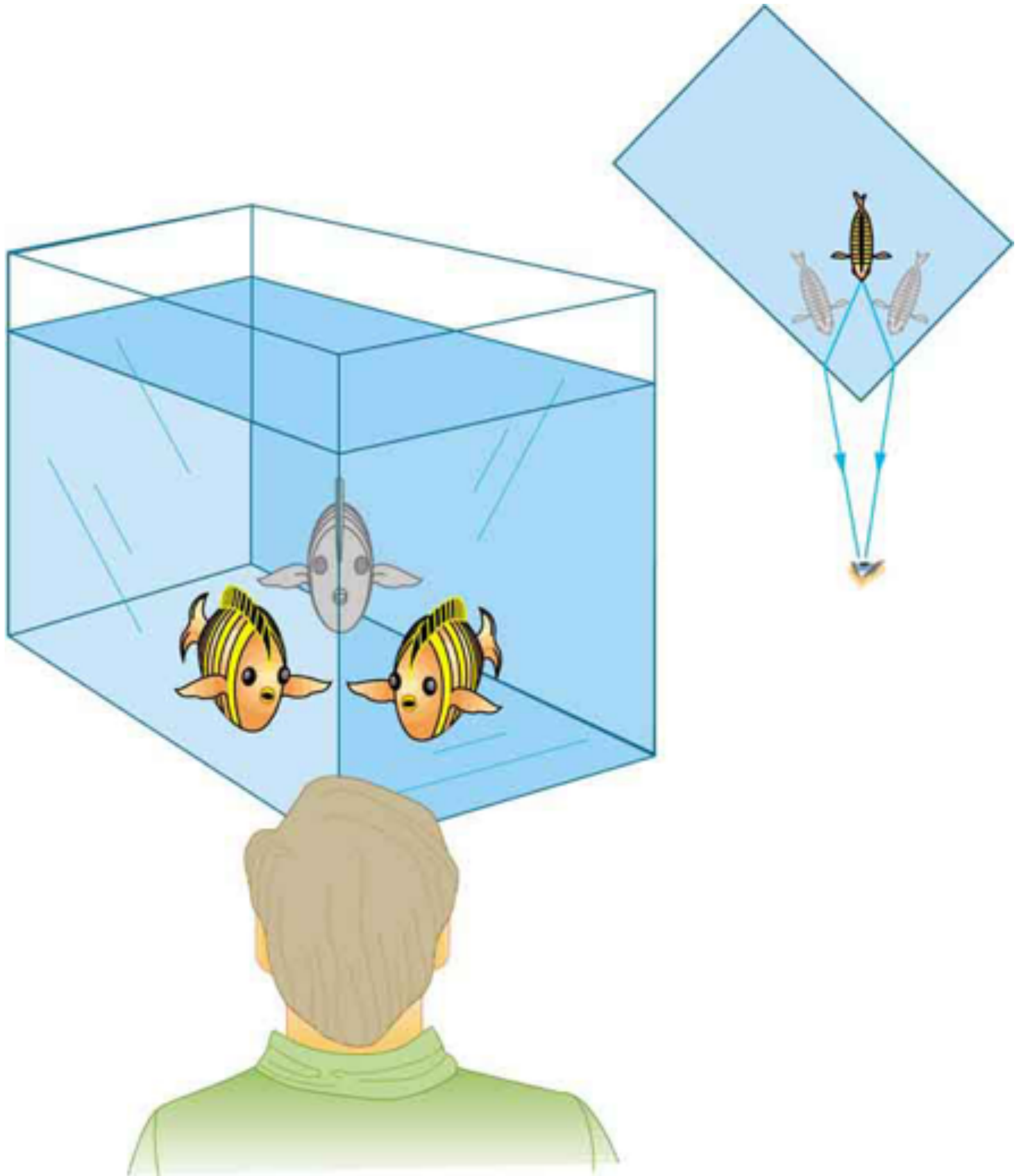
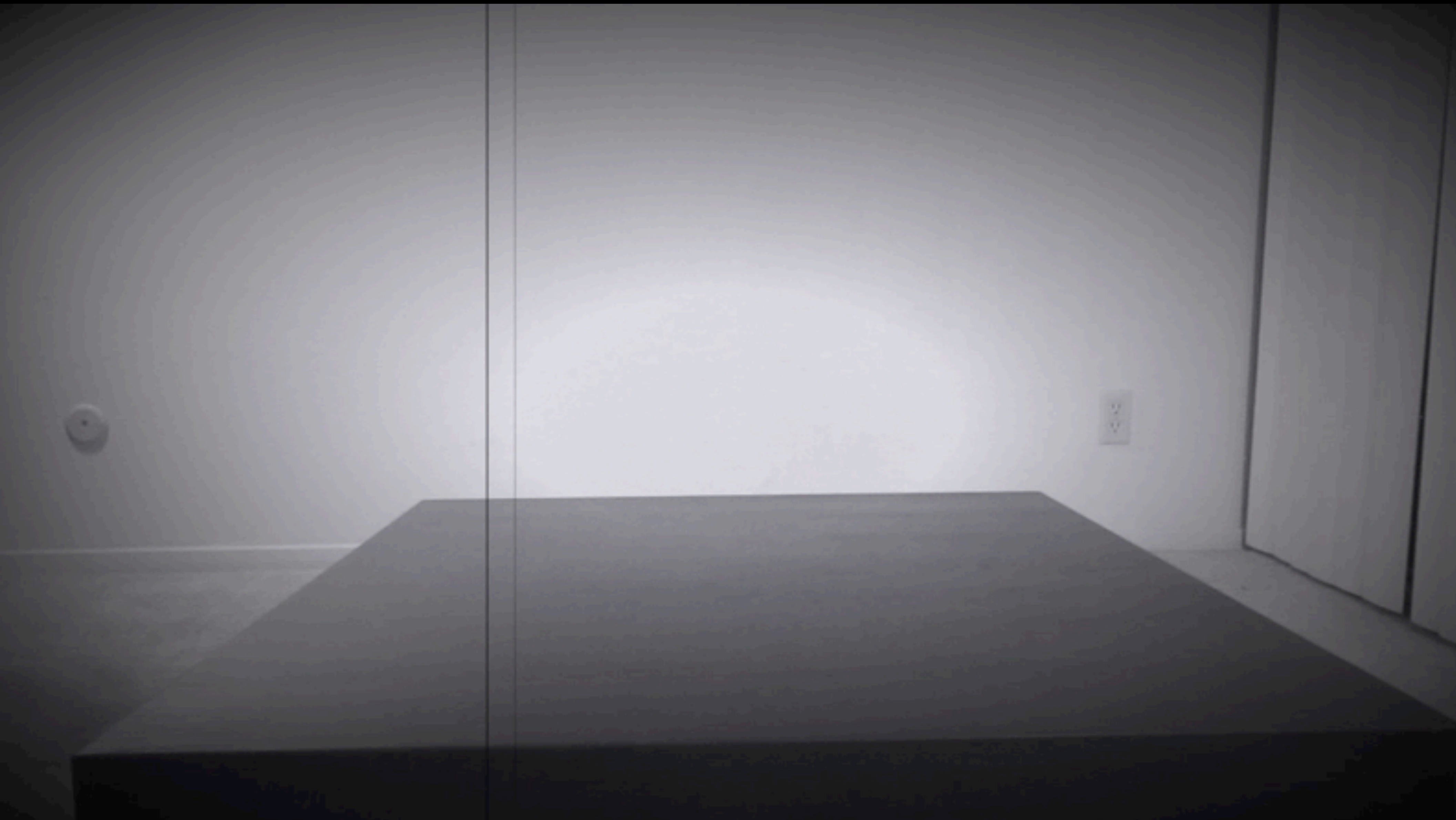
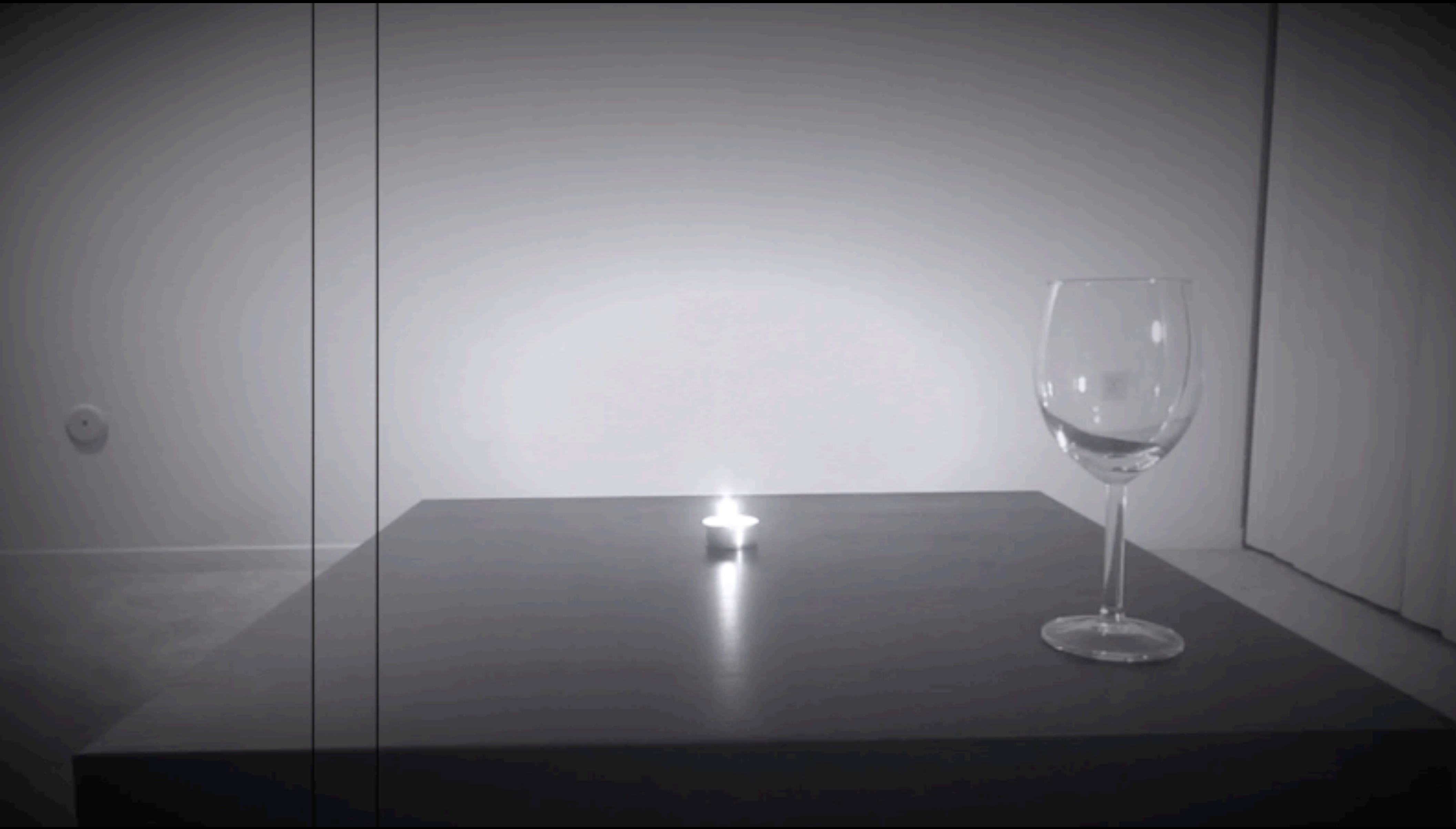
Strong Gravitational Lensing

Formation of **multiple images** of a single distant object due to the **deflection of its light** by the **gravity** of intervening structures.



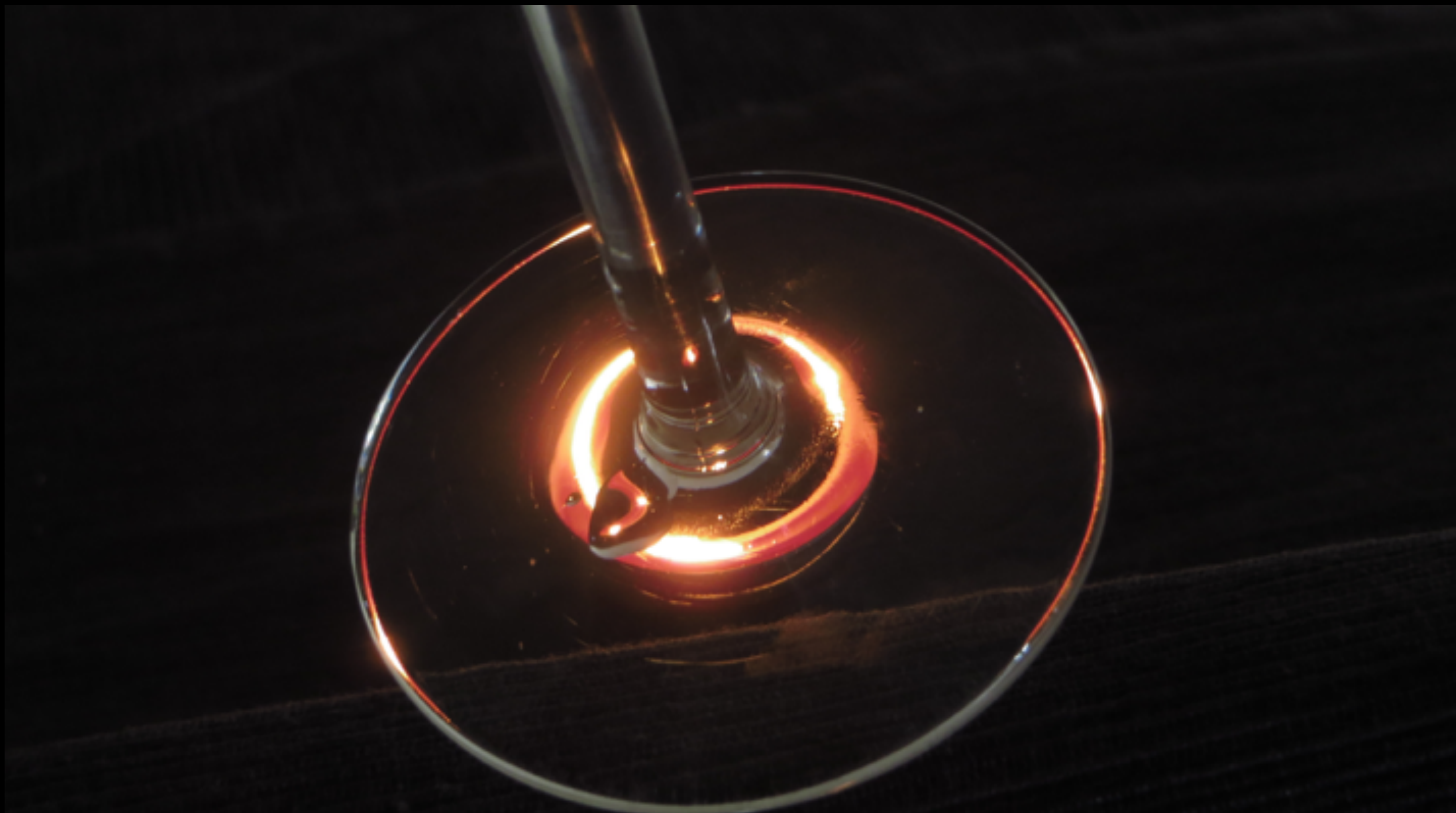


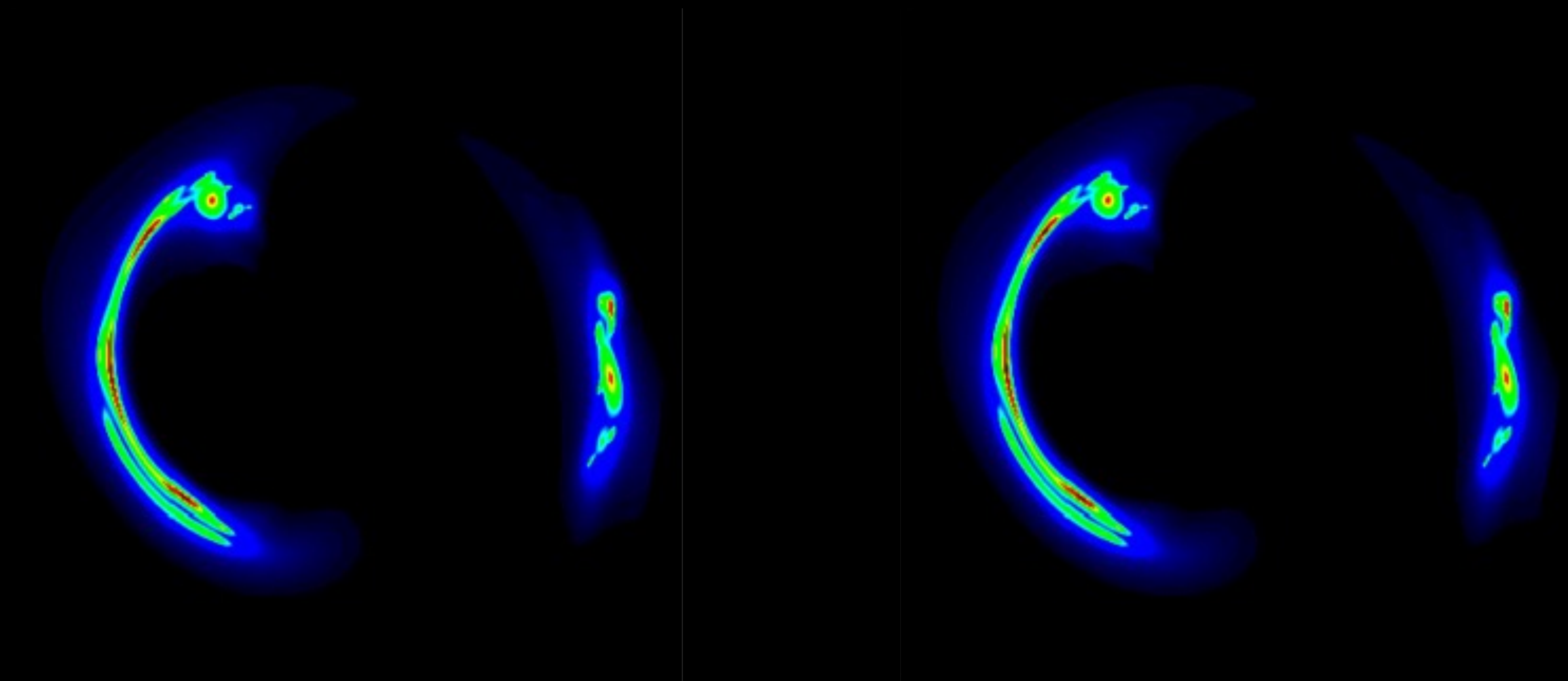


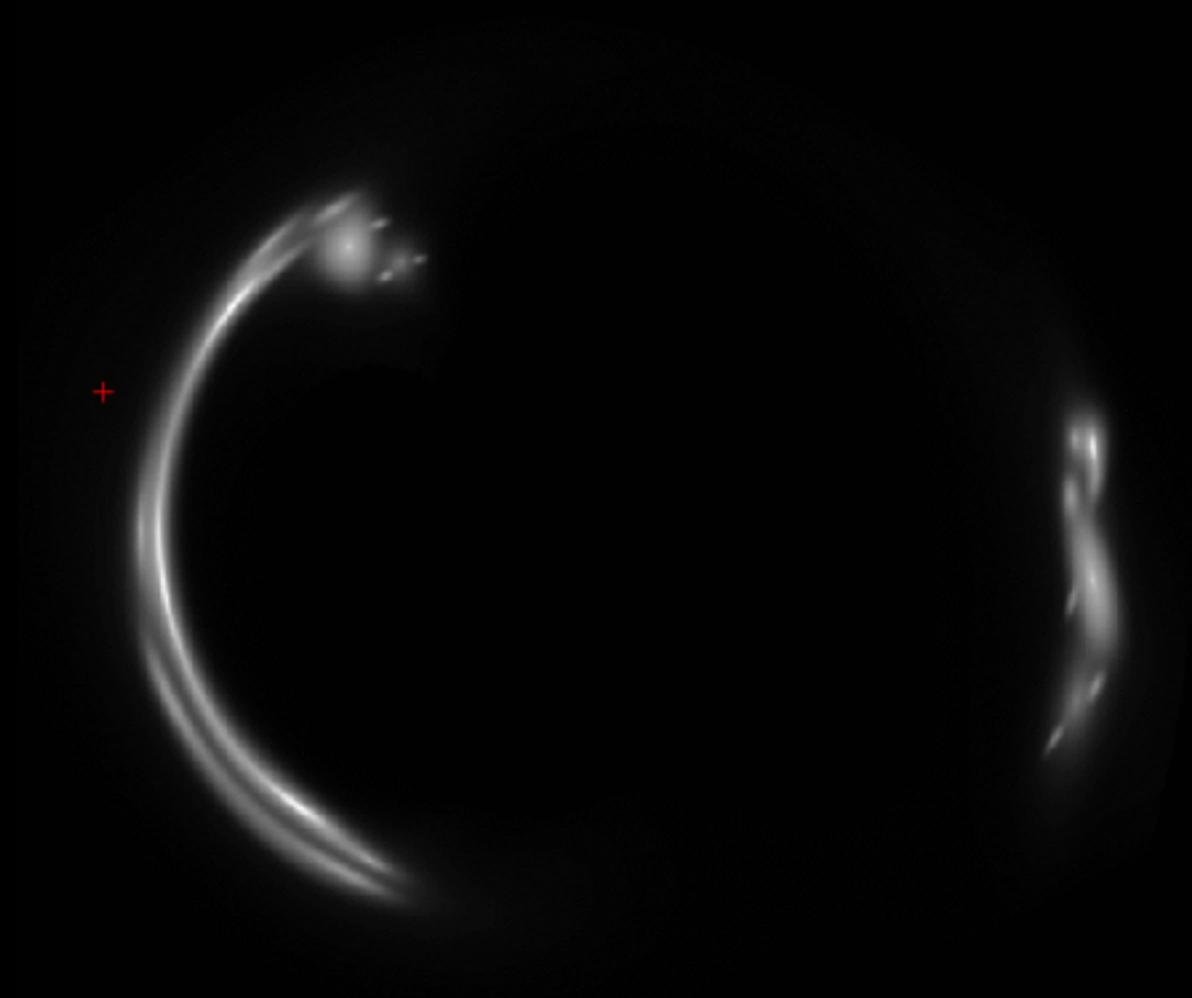


Cold Dark Matter

Warm Dark Matter







Challenge Goal

Dark Matter Substructure

Using strong lensing to map the dark matter distribution on small scales, by measuring the abundance of dark matter subhalos

Stages

0 - **Macro modeling**

Finding the overall matter distribution in the lensing galaxies (when no subhalos are present).

1- **One subhalo of fixed mass**

Find the location of a subhalo of fixed mass in strong lenses.

2- **Measure the abundance of subhalos**

A number of subhalos of a given fixed mass are present in the lens. The task is to measure the number density of subhalos (how many subhalos per unit area of the sky).

3- **measure the mass function**

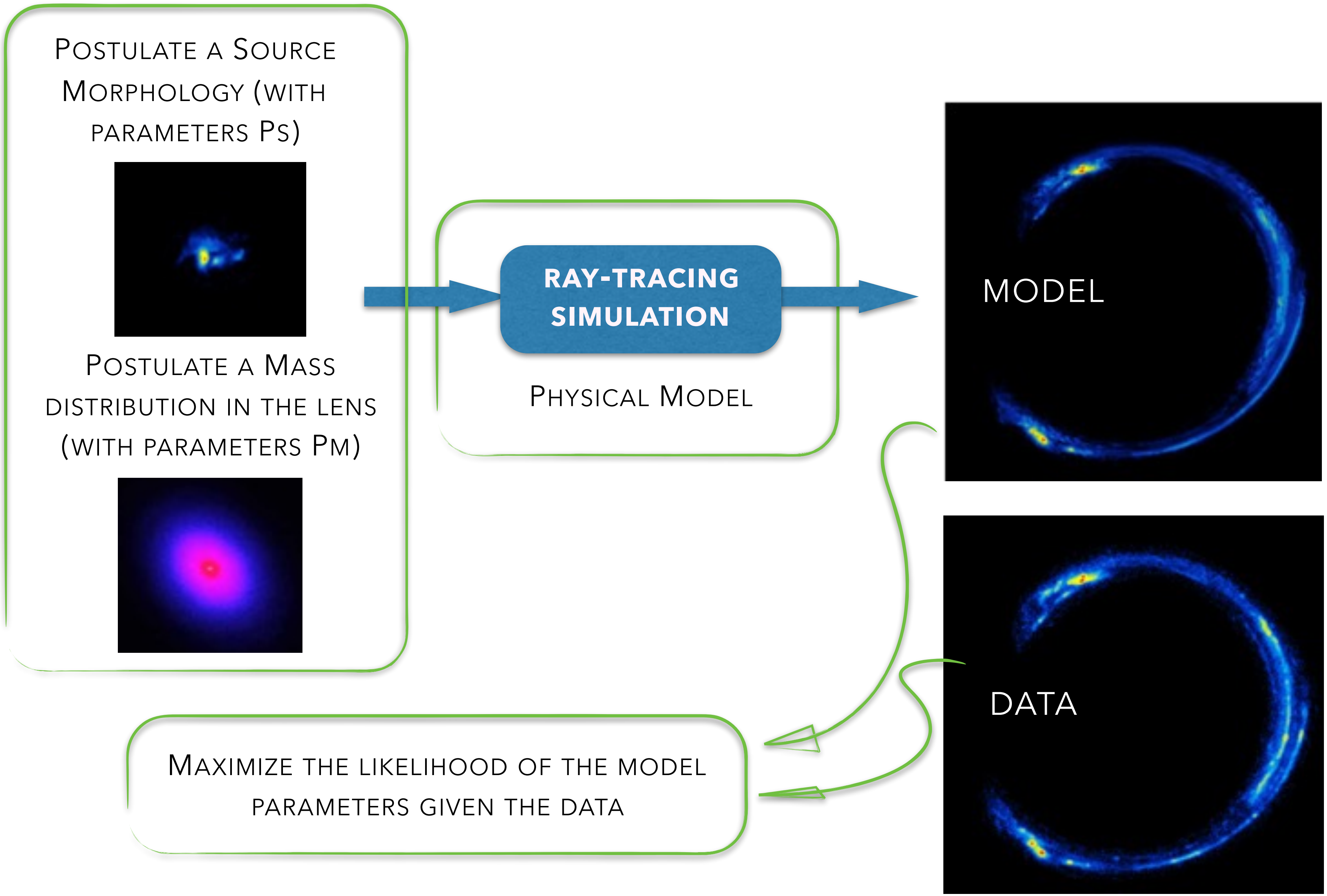
Expand stage 2 to include subhalos of different masses.

Traditional Lens Modeling:

1- How does the background source truly look like? What is the undistorted image?

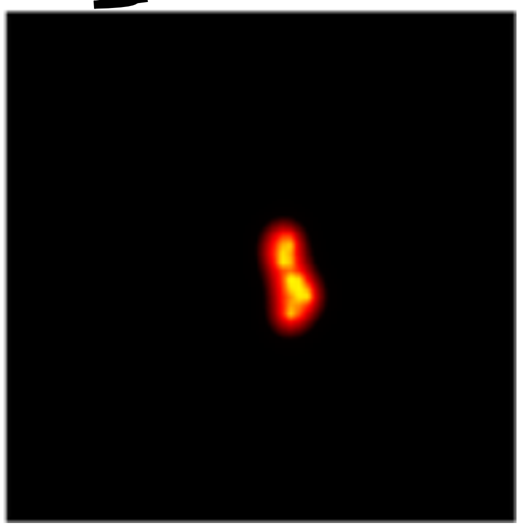
2- How is matter distributed in the lensing structure?

Maximum Likelihood Lens Modeling

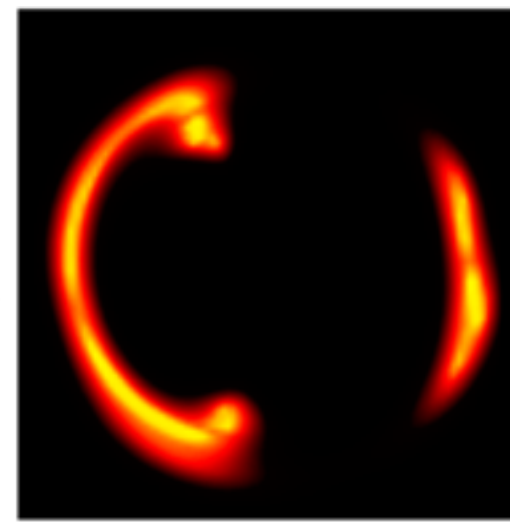


Lens Modeling Parameterization

Parameterize the light distribution in the background source with one or more analytic blobs, e.g., clumps with a Gaussian light profile.



Sky emission



Parameterize the mass distribution in the lensing galaxy with one or more analytic forms, e.g., Singular Isothermal Ellipsoid (elliptical form with radial inverse squared drop in density)

Lens Parameterization

The lenses in this challenge will follow a singular isothermal ellipsoid (SIE) + external shear profile, Parametrized by 7 parameters:

1- Einstein Radius – mass of the lens

2 - Ellipticity (x-component)

3 - Ellipticity (y-component)

4 - X - Position

5 - Y - Position

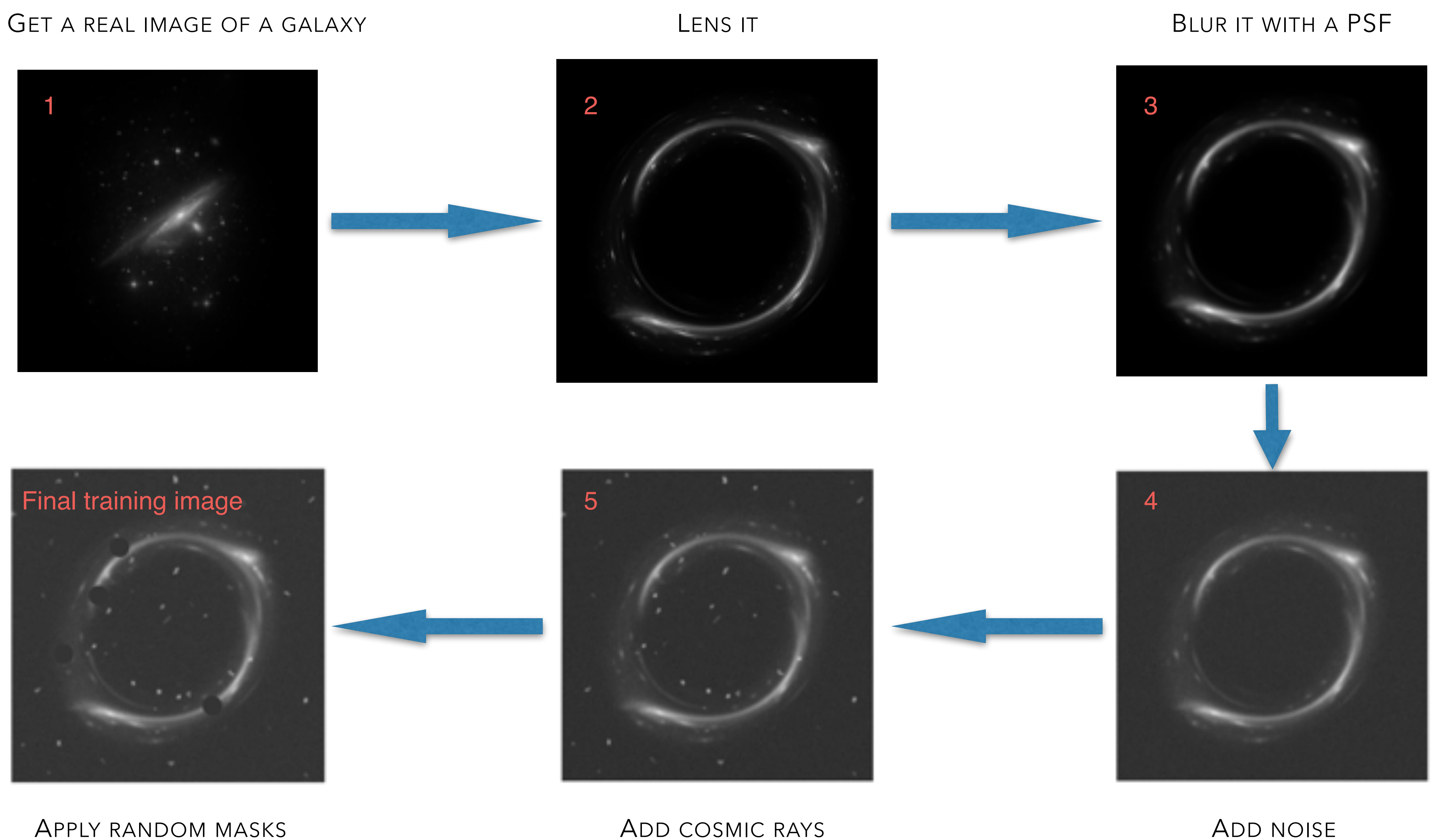
6 - External Shear (x-component) – gravitational influence of other objects outside of the main lens

7 - External Shear (Y-component) –

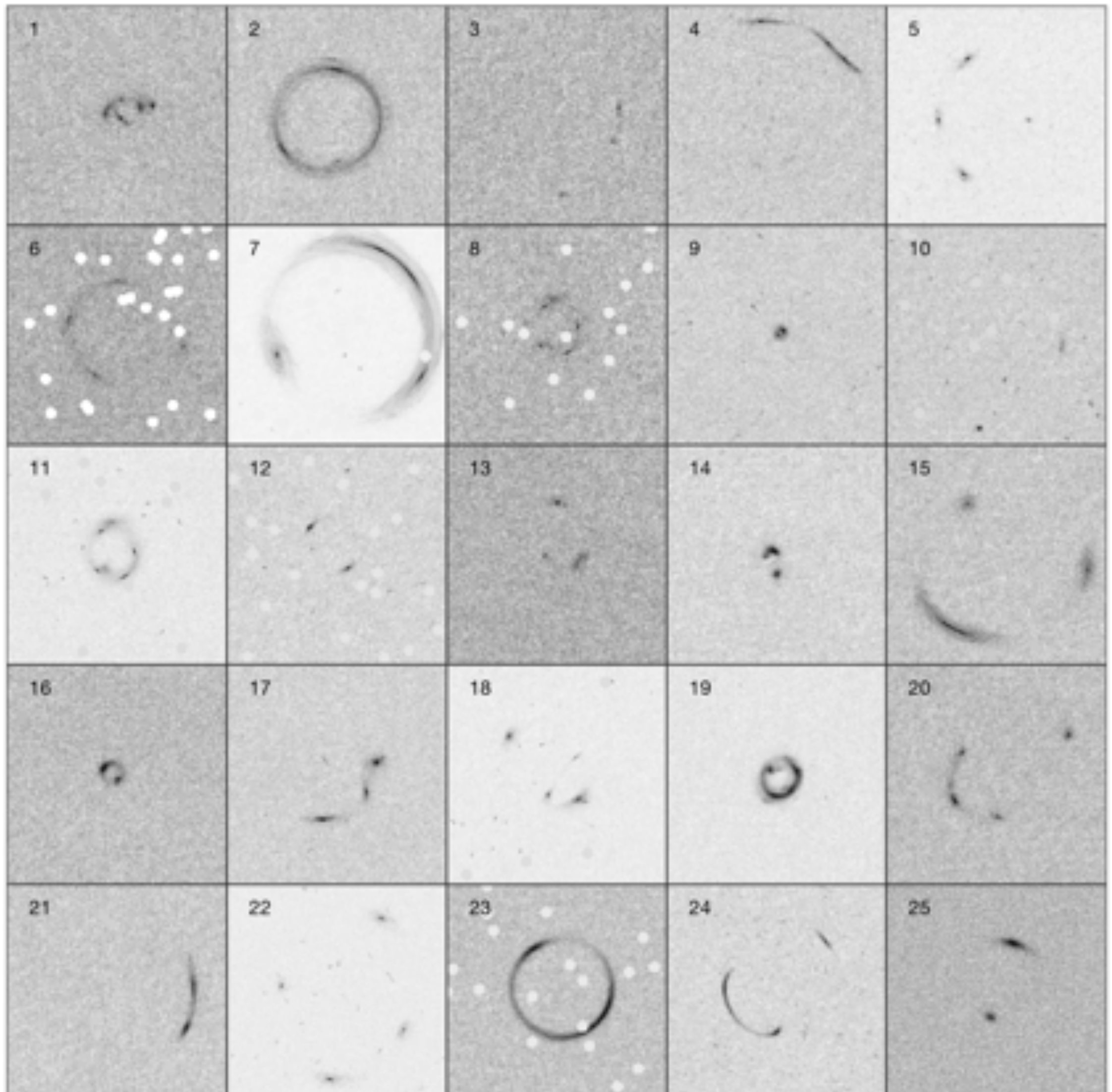
Training Data

We need a large number of training images. There are only a couple of hundred of gravitational lenses known to date. But we can simulate these images very fast.

Producing the Training Data



EXAMPLES OF SIMULATED DATA



Simulated Data

For Stage 0 : We have simulated 200 000 labeled training examples, which are available to download at:

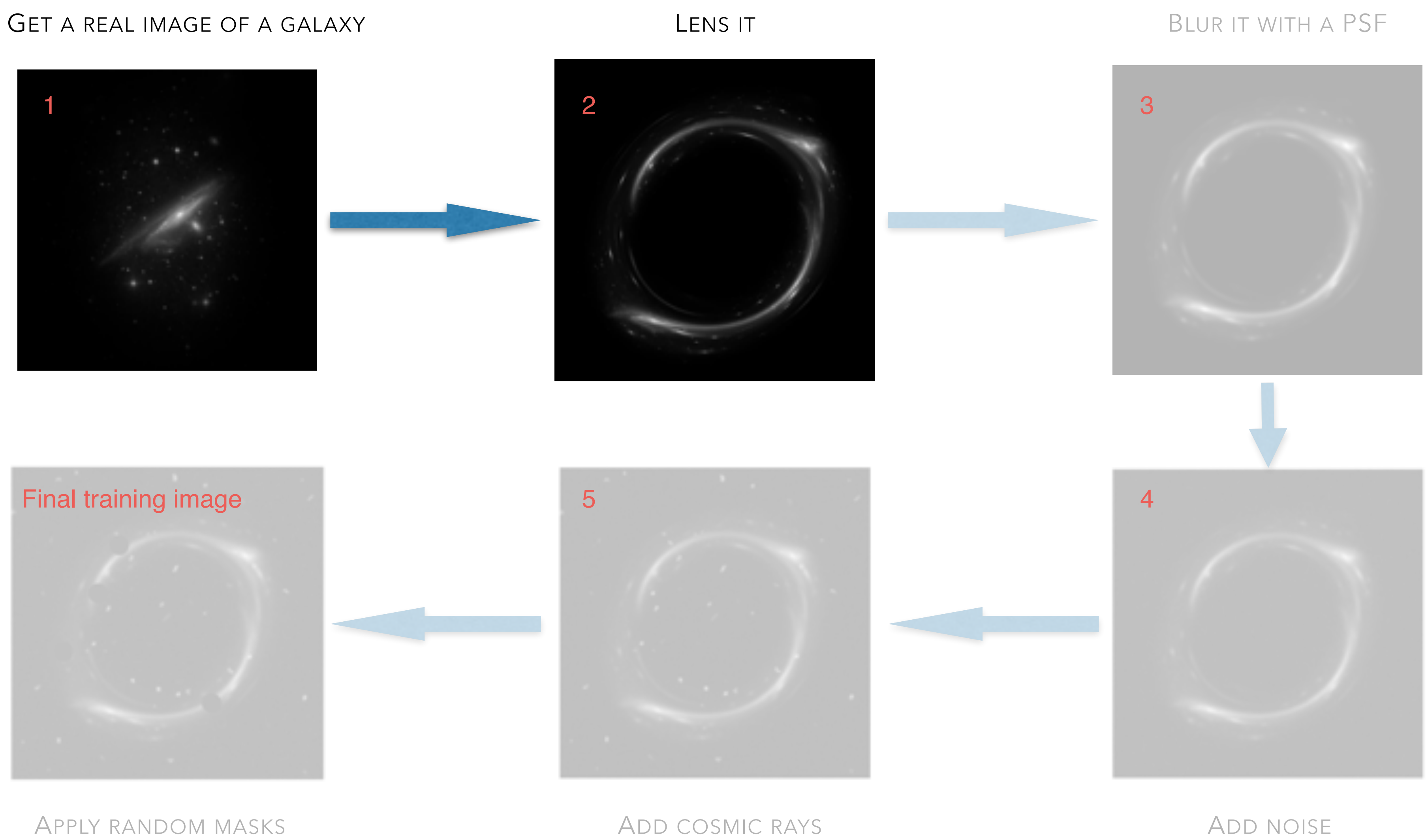
https://stanford.box.com/s/6fadk52a4zj3vnceha12dwsy6g7bm48w

The .tar file includes: 2 folders, in each folder, there is:

- 100 000 png lensed images for training
- A text file with the lens parameters (the labels) each row is a different image, the columns are, in order:
  Einstein radius, ellipticity-x, ellipticity-y, x-position, y-position, external shear- x, external shear-y
- An additional 10 000 png images for testing (labels of course not provided!)

The code for producing the training data will also be provided in a couple days (teams are welcome to produce more training data if needed).

Producing the Training Data



Metrics for Success

Accuracy: Coverage probability of the 68, 95, and 99% intervals (the proportion of the time that the interval contains the true value). We will also test for catastrophic failures.

Precision: 1) Distribution of the size of the error bars
mean and median of 1 sigma errors
2) If no uncertainties are provided, we will calculate the mean standard error

SUBMITTING RESULTS

BY EMAIL: lplevass@stanford.edu

DEADLINE: OCTOBER 31ST, 2018

At the end on the challenge, we are planning to publish the result in a paper summarizing the challenge and the results.

As suggested by Roberto last time, we're also planning on rewarding the winning team(s?) with a good bottle of wine!

Thank you