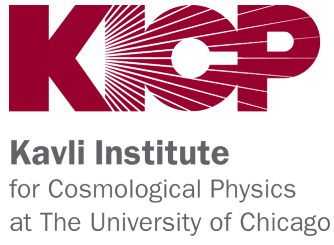
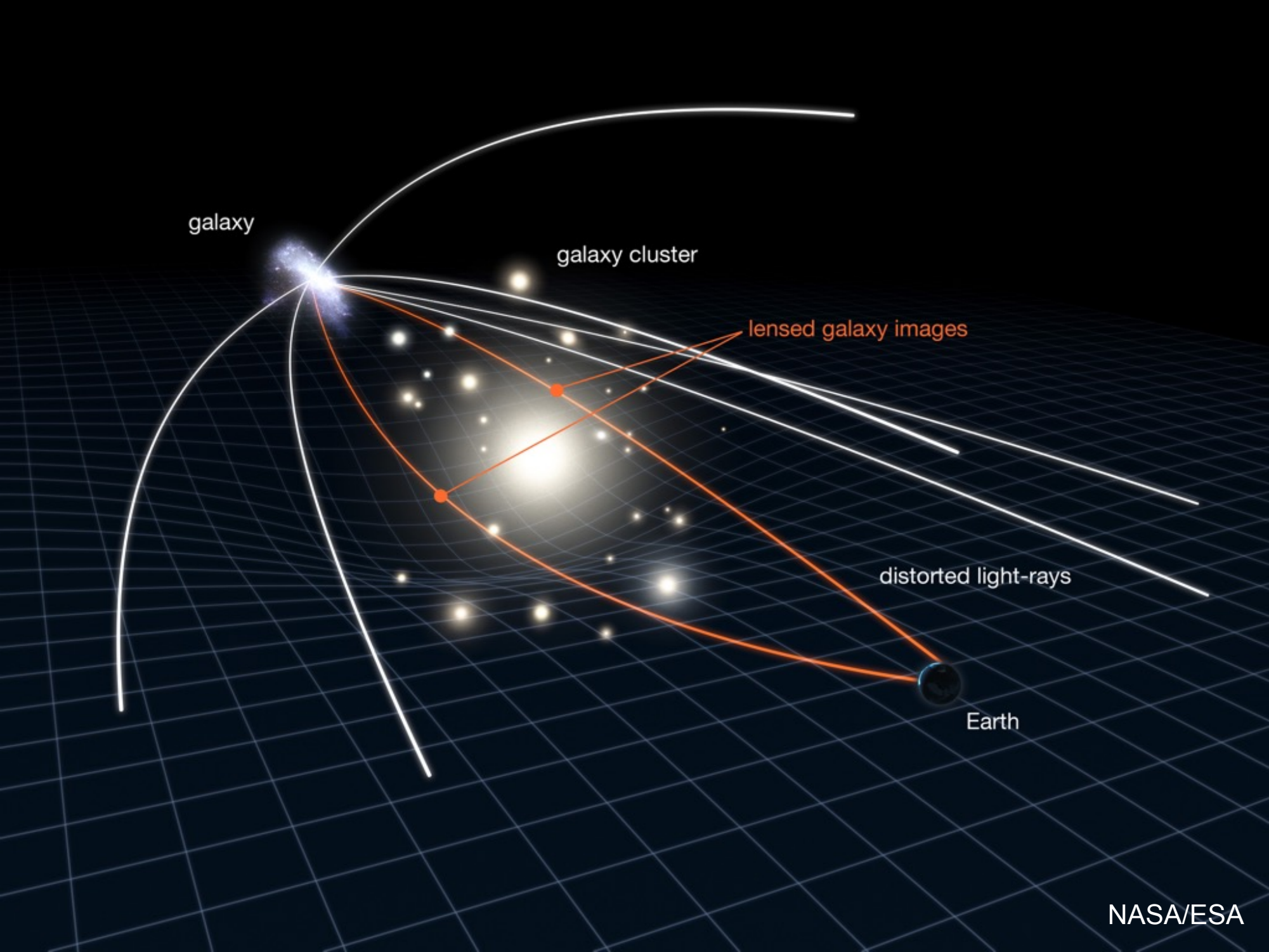
Simulations of Strong Lensing

SF15, 07/15/2015

Nan Li (ANL & KICP)



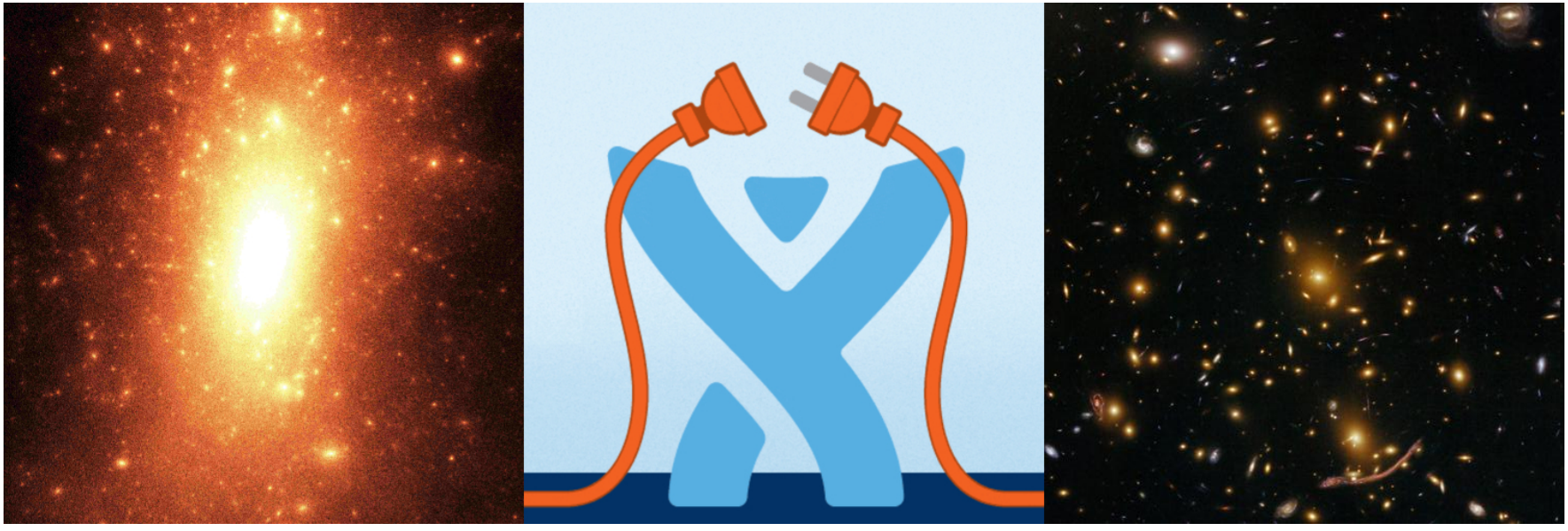
In collaboration with:
Salman Habib, Mike Gladders, Katrin Heitmann, Steve Rangel, Lindsey Bleem, Michael Florian, Hilary Child, Patricia Fasel.


galaxy
galaxy cluster
lensed galaxy images
distorted light-rays
Earth
NASA/ESA


ga
/s
NASA/ESA

Simulations of Gravitational Lensing

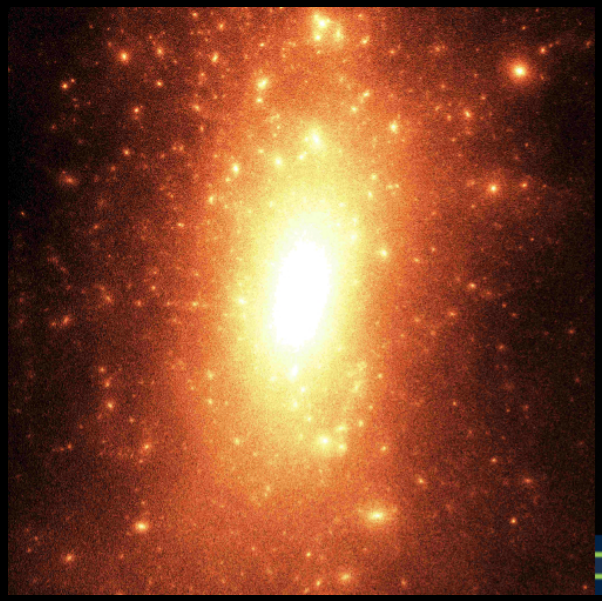
What will happen?

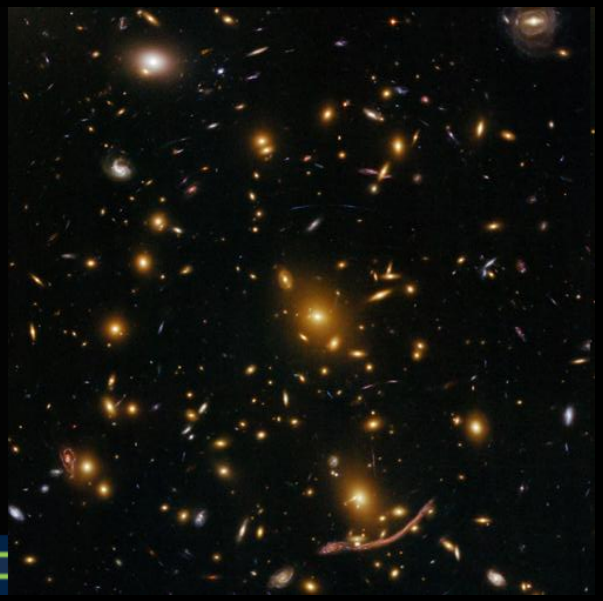


Modified from figures on https://www.atlassian.com.

Simulations of Gravitational Lensing

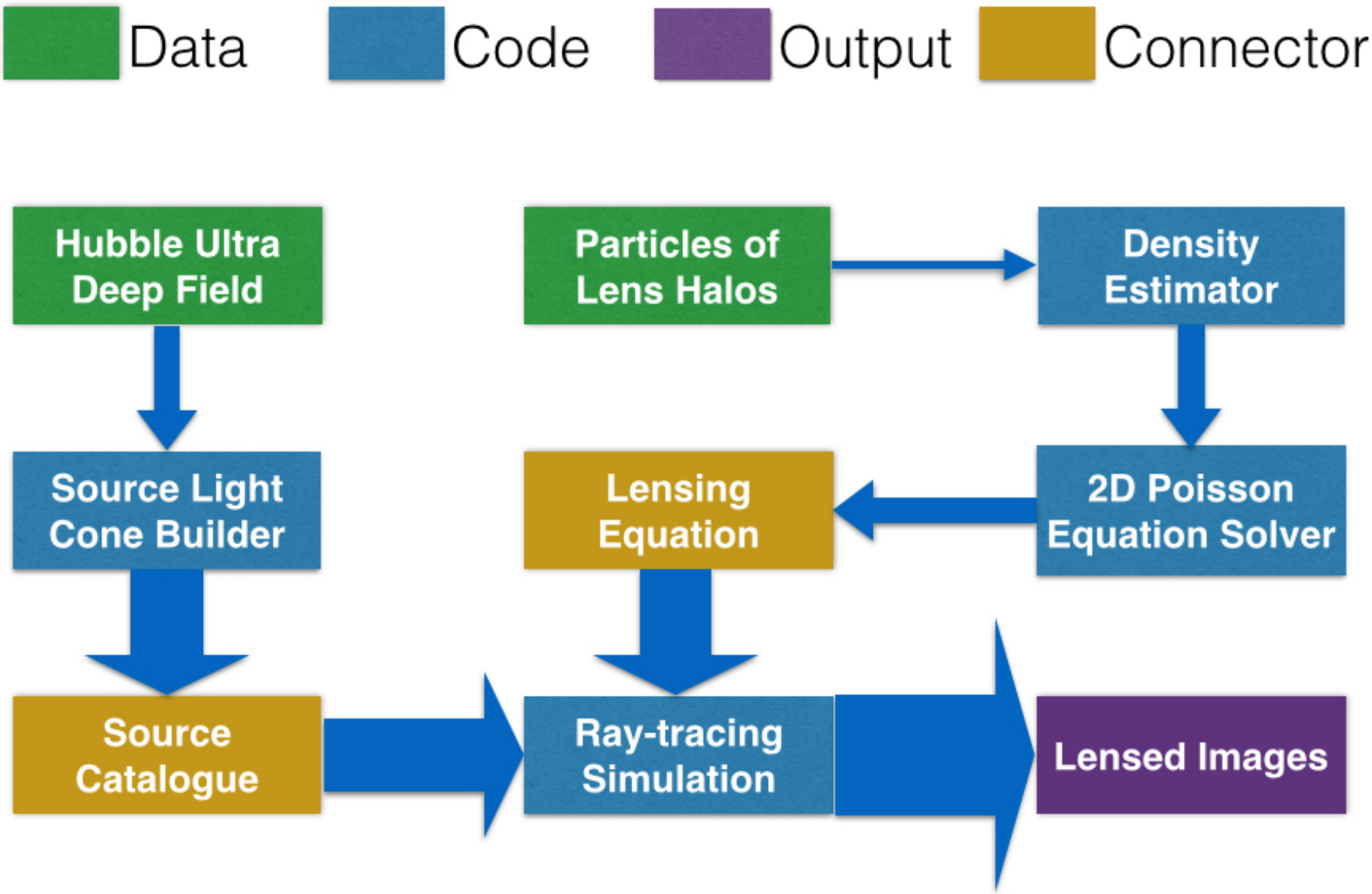
What will happen?



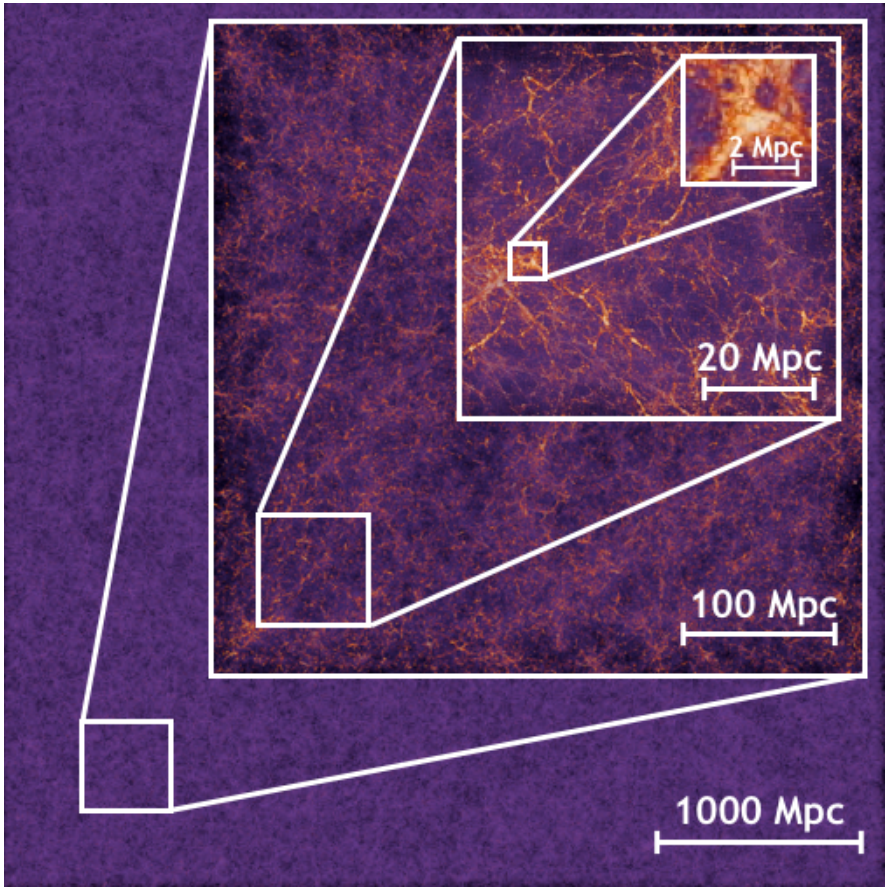


Modified from figures on https://www.atlassian.com.

Producing Lensed Images



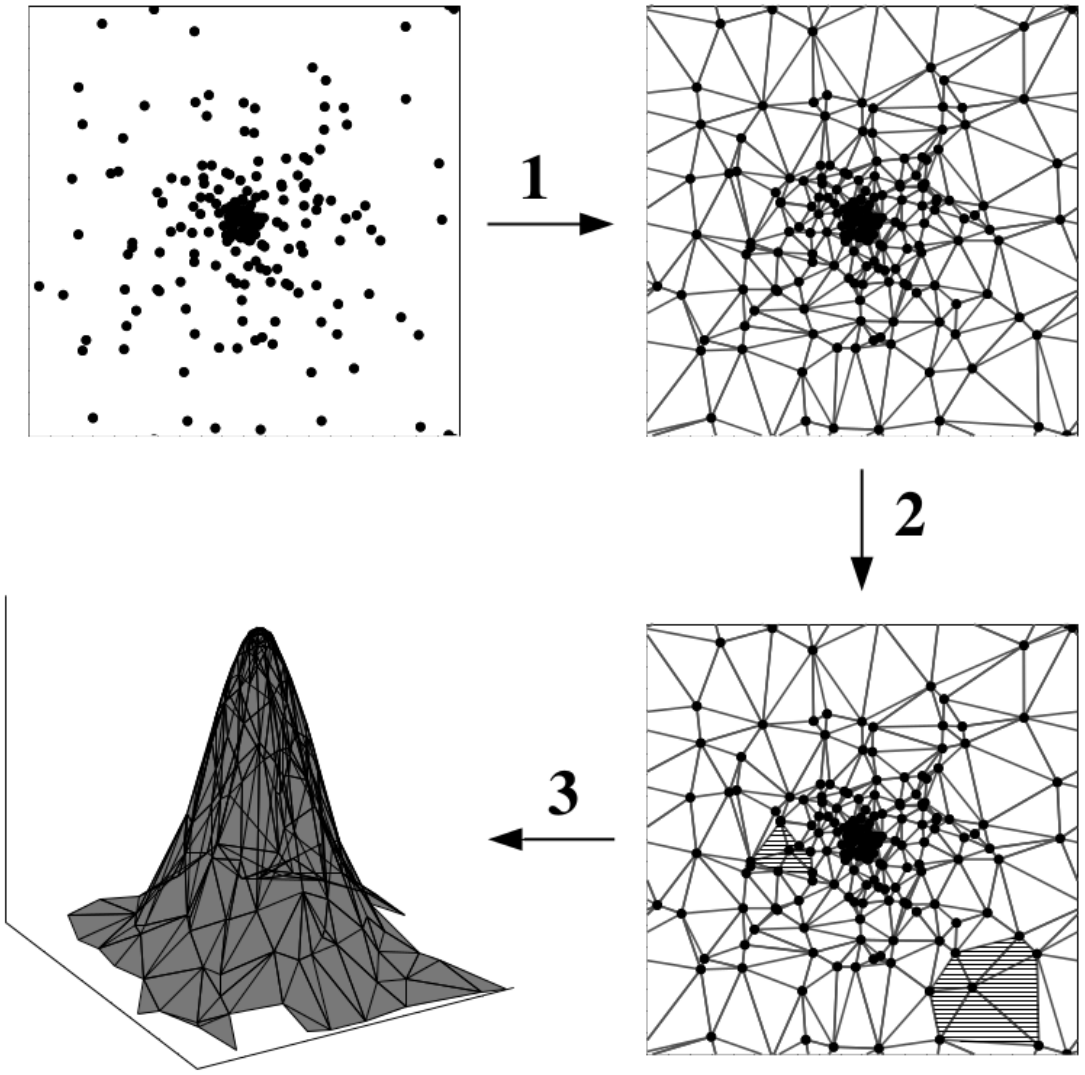
The Outer Rim Simulation



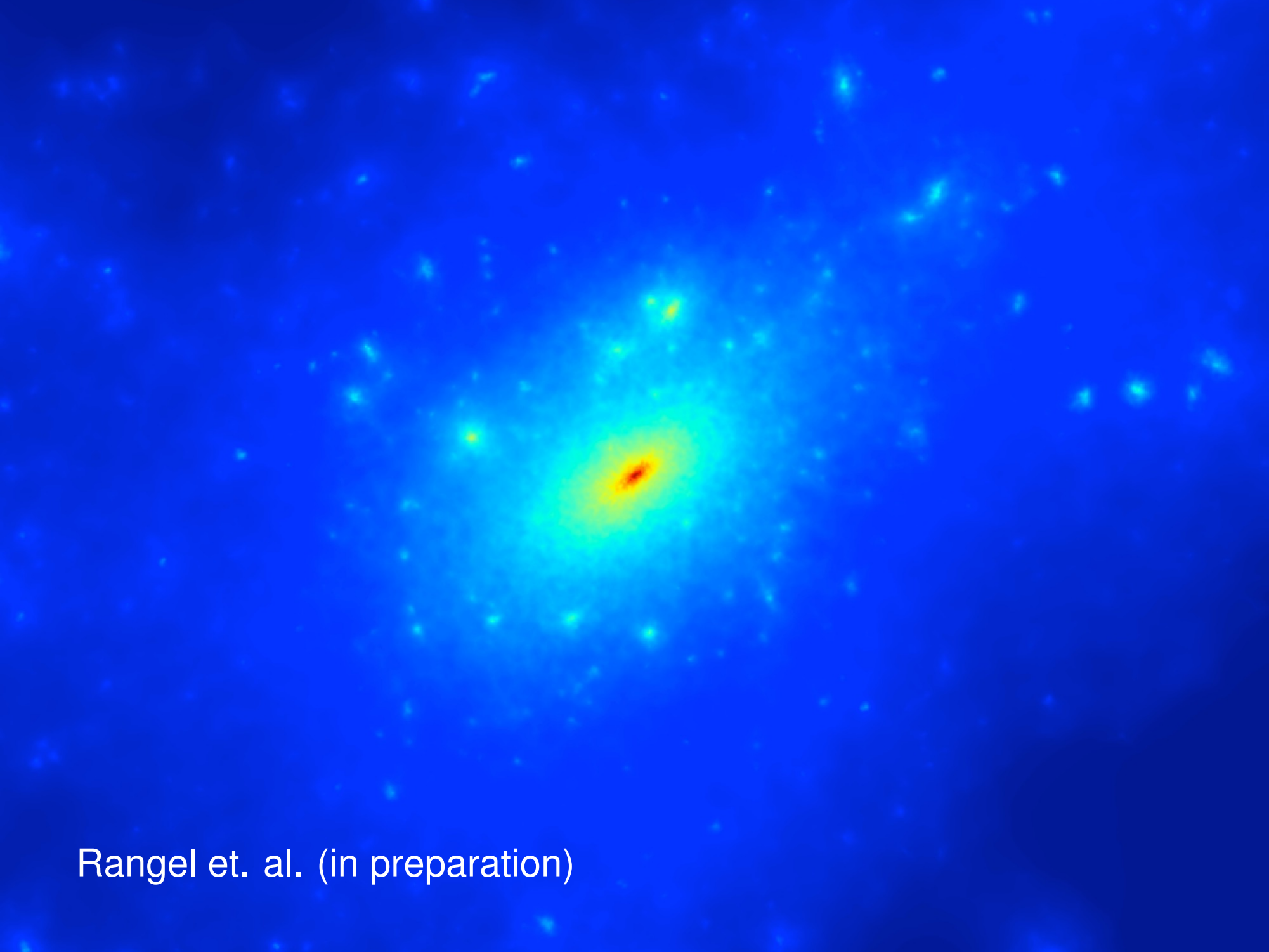
- $V_{\rm box} = (3h^{-1}{\rm Gpc})^3$.
- $M_{\rm p} = 1.85 \times 10^9 h^{-1} M_\odot$.
- $N_{\rm p} = 10240^3$.
- 100 snapshots (z = [10, 0]).

The Q Continuum Simulation is with higher mass resolution. Heitmann et.al. (2014) arXiv:1411.3396

Density Estimation

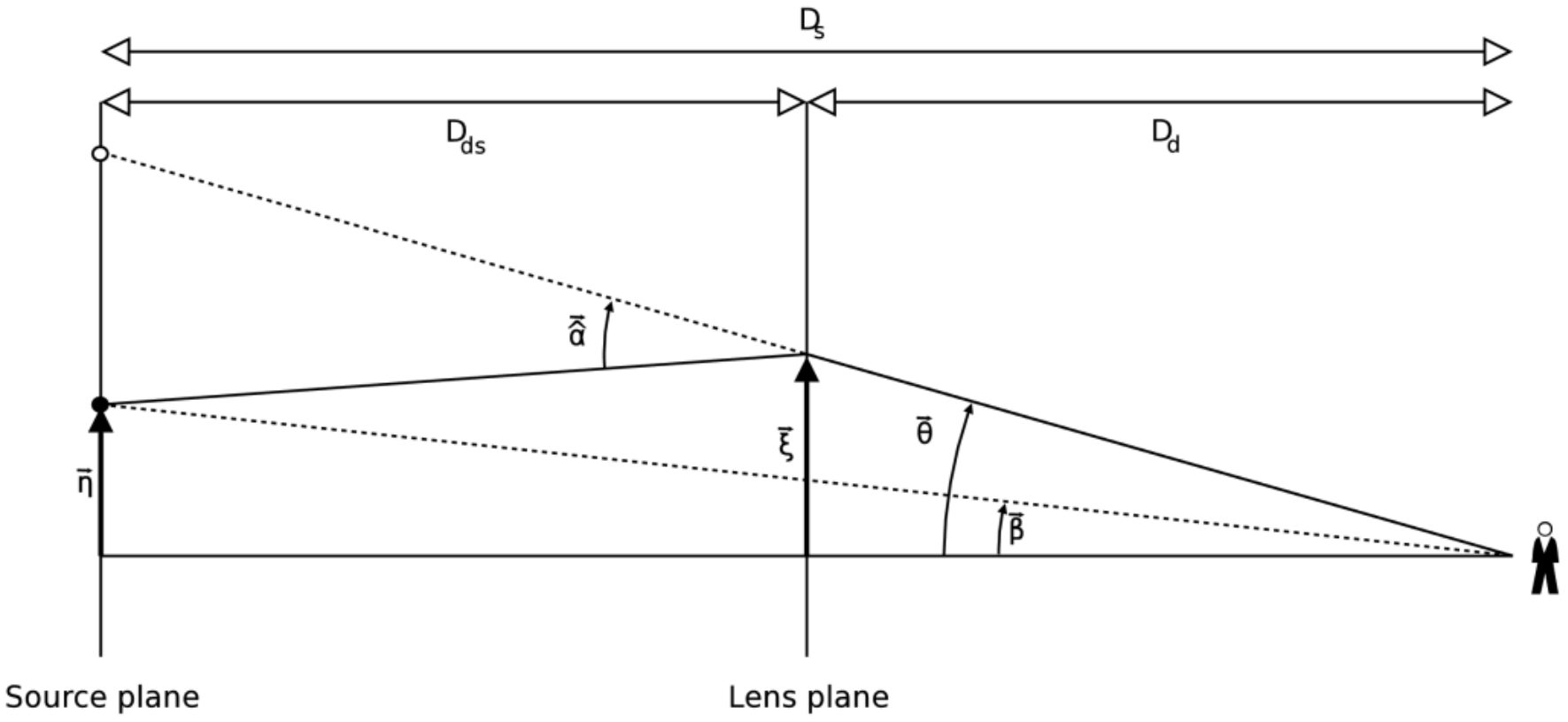


Schaap et. al. (2007)

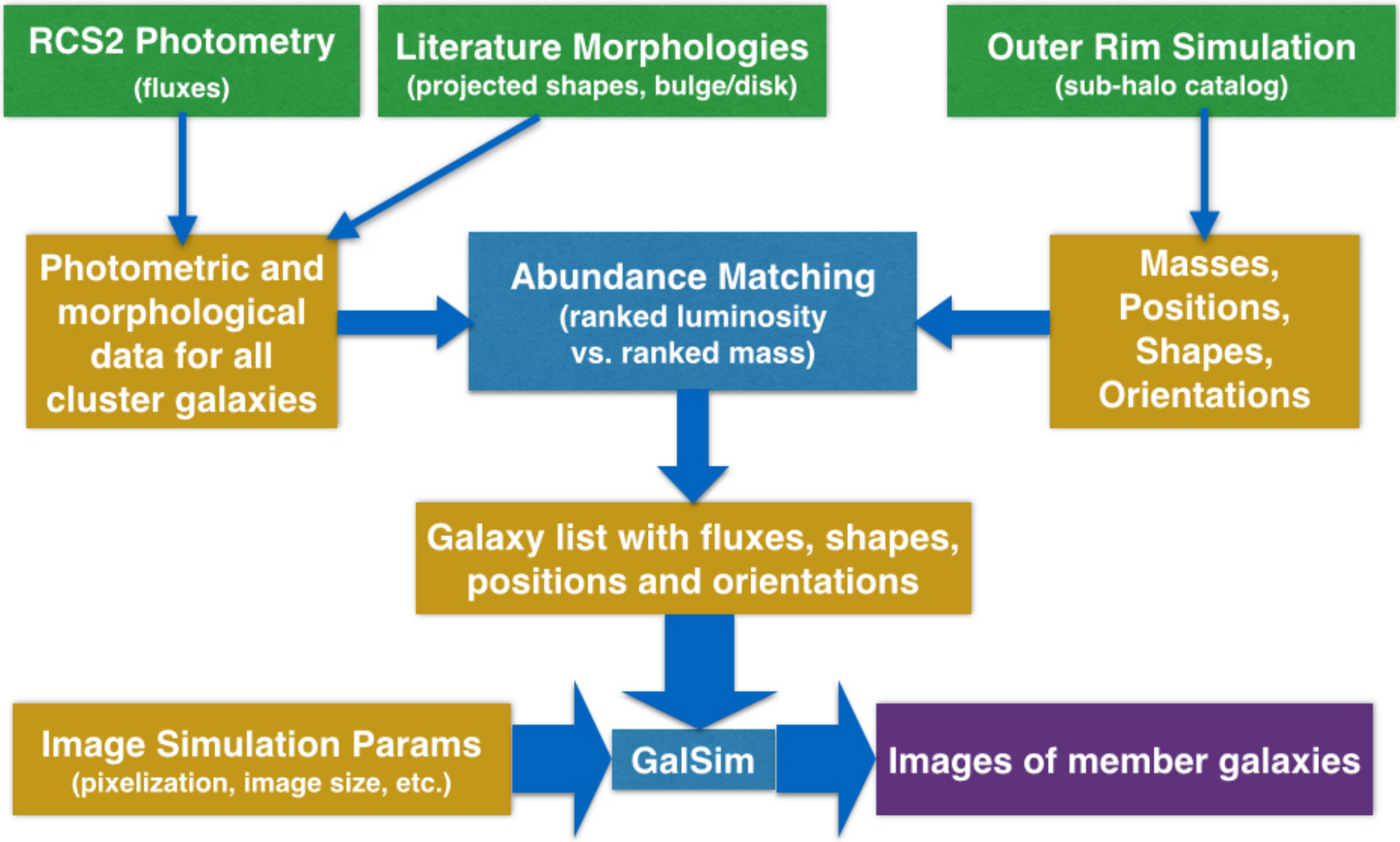

Rangel et. al. (in preparation)

Building Lensing Equation

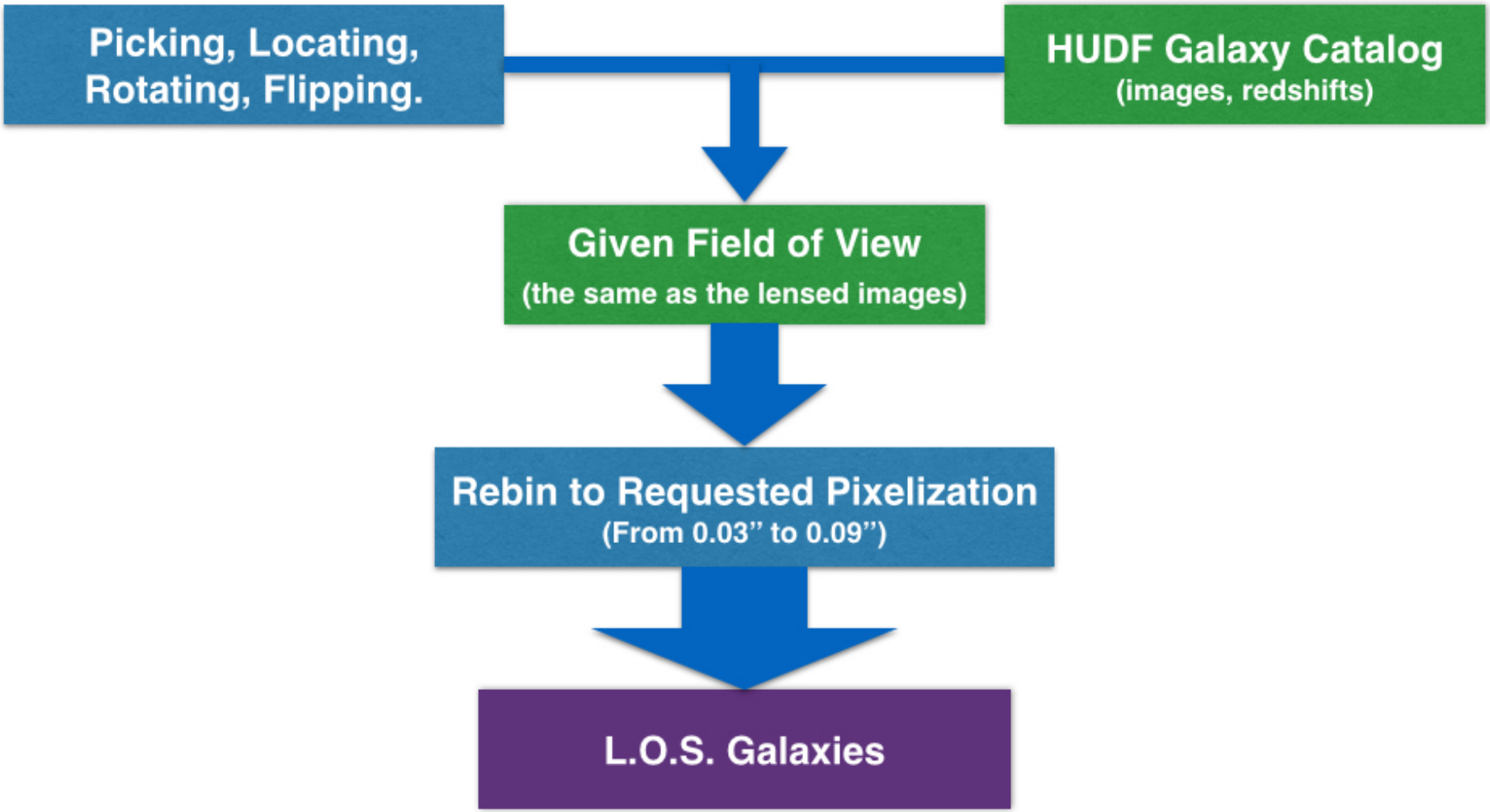
- $\vec{\alpha}(\vec{\theta}) = \frac{1}{\pi} \int \mathrm{d}^2\vec{\theta}'\, \kappa(\vec{\theta}')\, \frac{\vec{\theta} - \vec{\theta}'}{|\vec{\theta} - \vec{\theta}'|^2}\,.$
- $\beta = \theta - \alpha(\theta).$

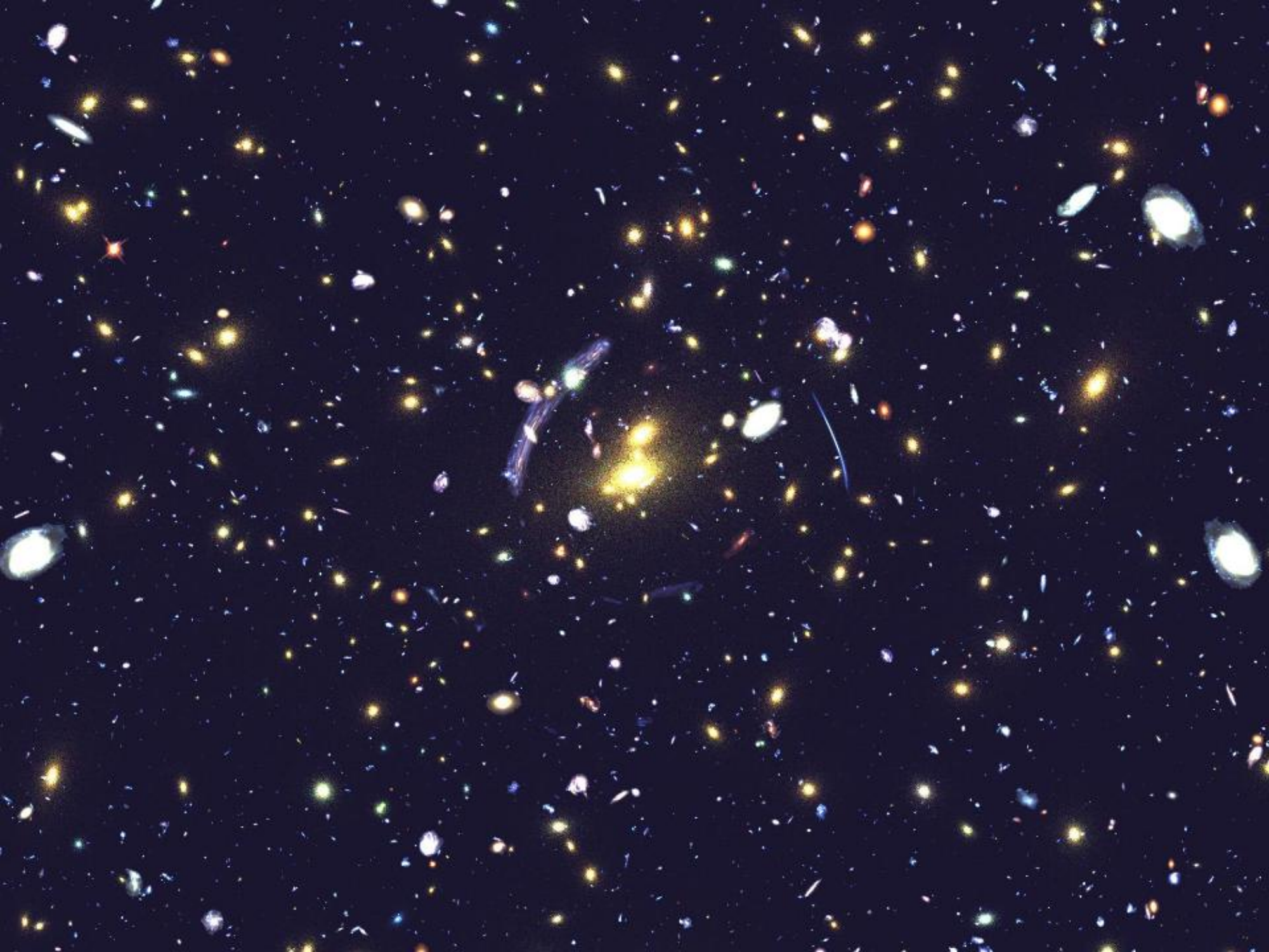


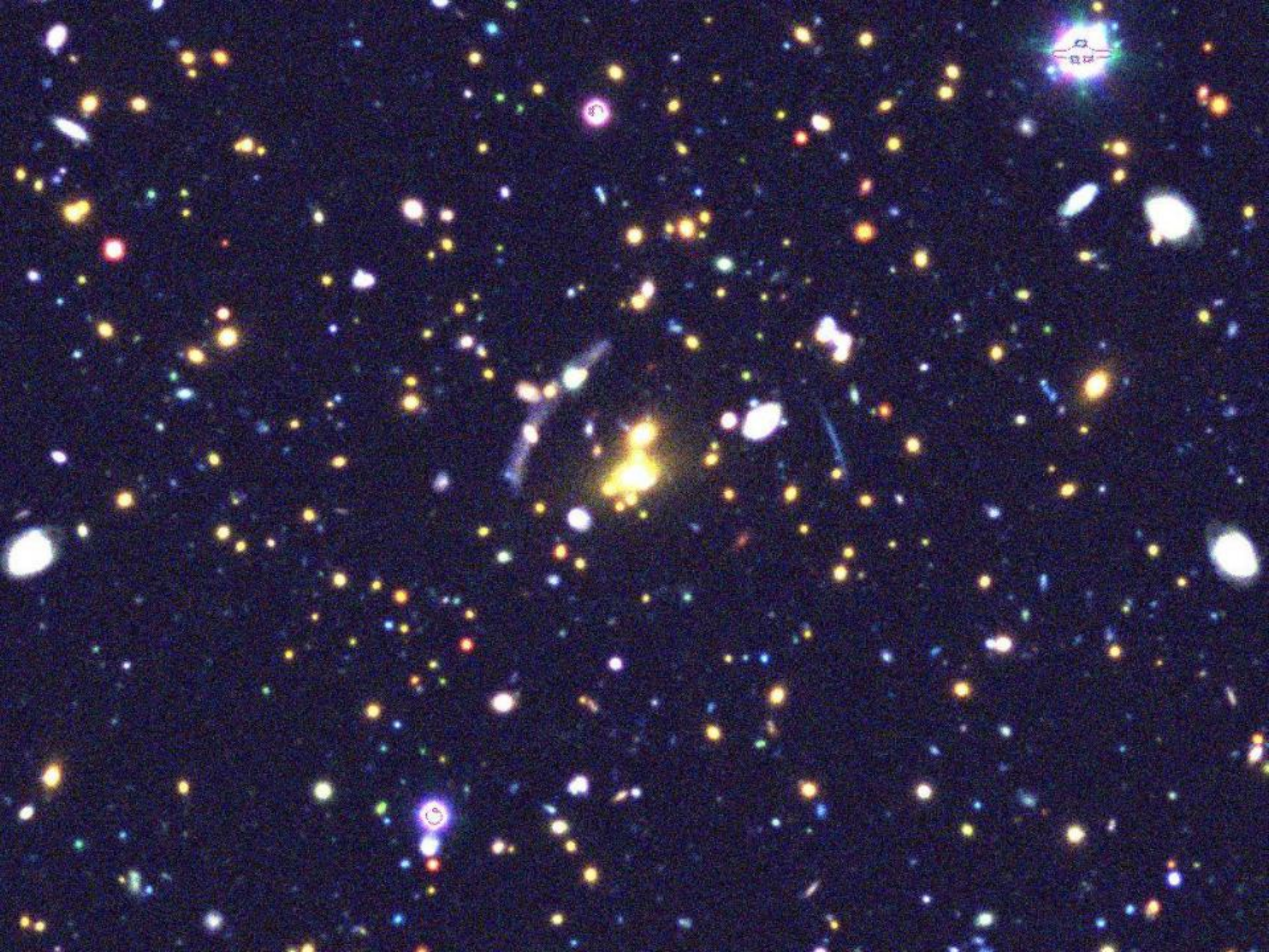
Producing Images of Member Galaxies



Producing Images of L.O.S. Galaxies







Obs?

Sims?

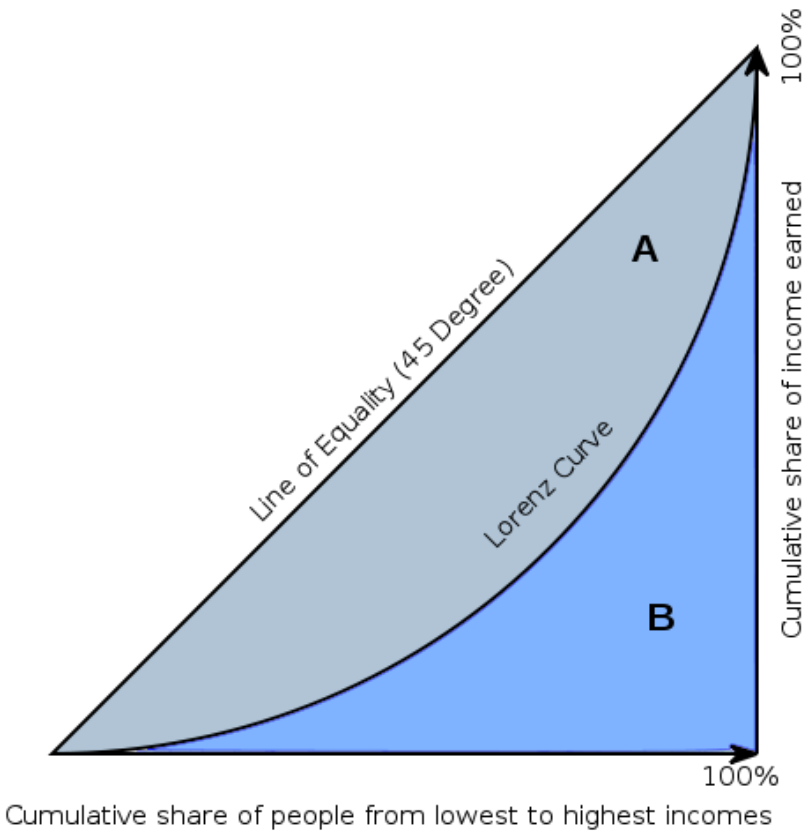
Sims?

Obs?

Current and Future Work

1. Lensing effects on the morphology distribution of the background source galaxies. (Florian+ in preparation)

Gini Coefficient



- The Gini coefficient shows the inequality of light distribution. $(A/(A+B))$
- It reflects some information on properties of galaxies, e.g., type, evolution.
- Gini Coefficient of the galaxies can be used to improve lensing modeling.

Florian et al in preparation

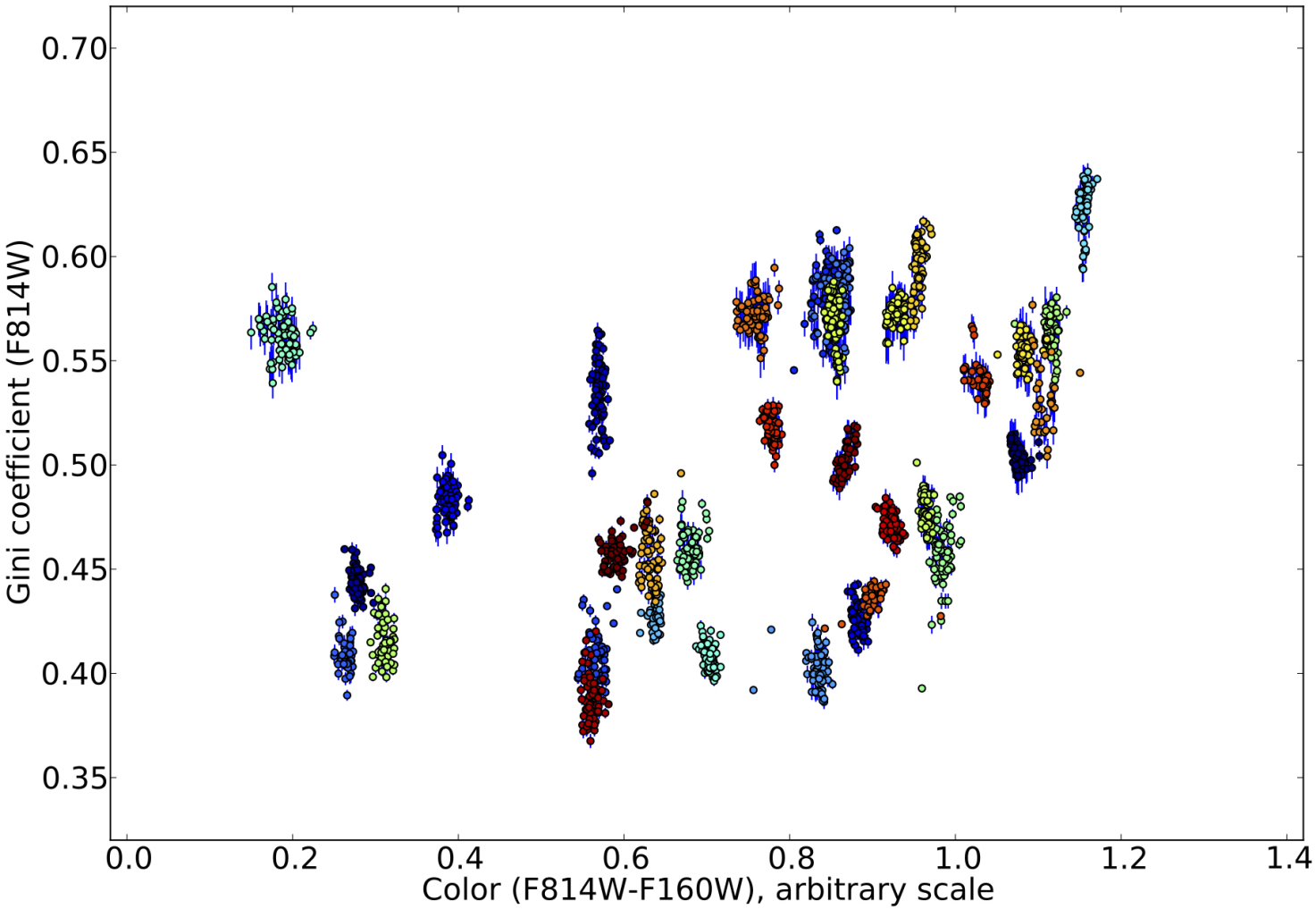


FIG. 1.— The Gini coefficient in the F814W filter plotted against the F814W-F160W color. The points are color-coded by source the source galaxy that was used to make each simulated arc (ie. all points of the same color are different arcs created by lensing the same source galaxy, but at different positions relative to the caustics). Arcs from the same source galaxy tend to clump together in this space.

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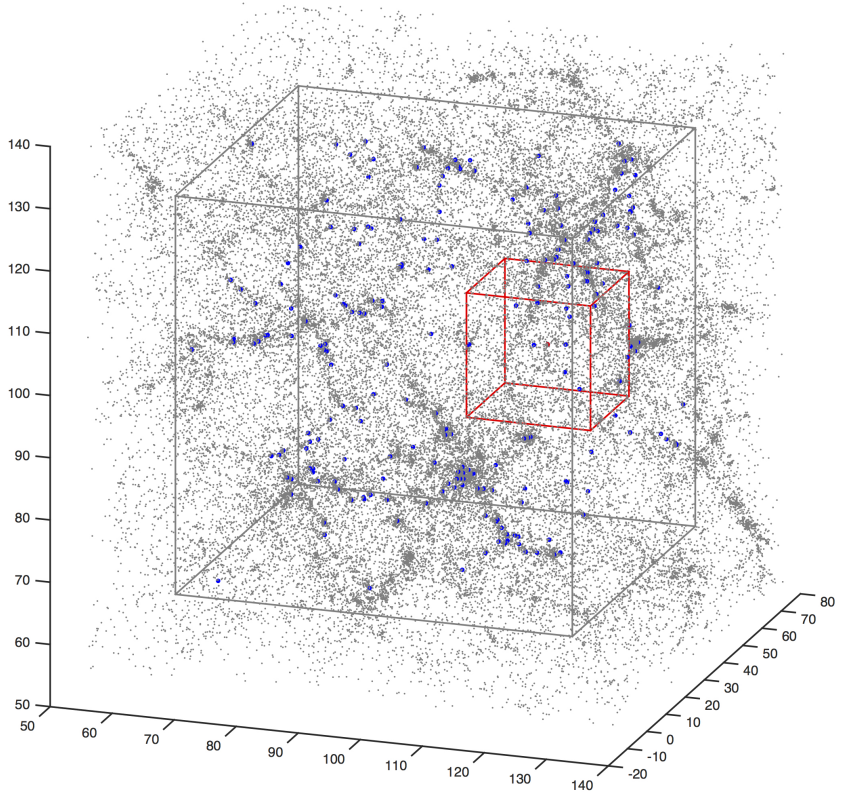
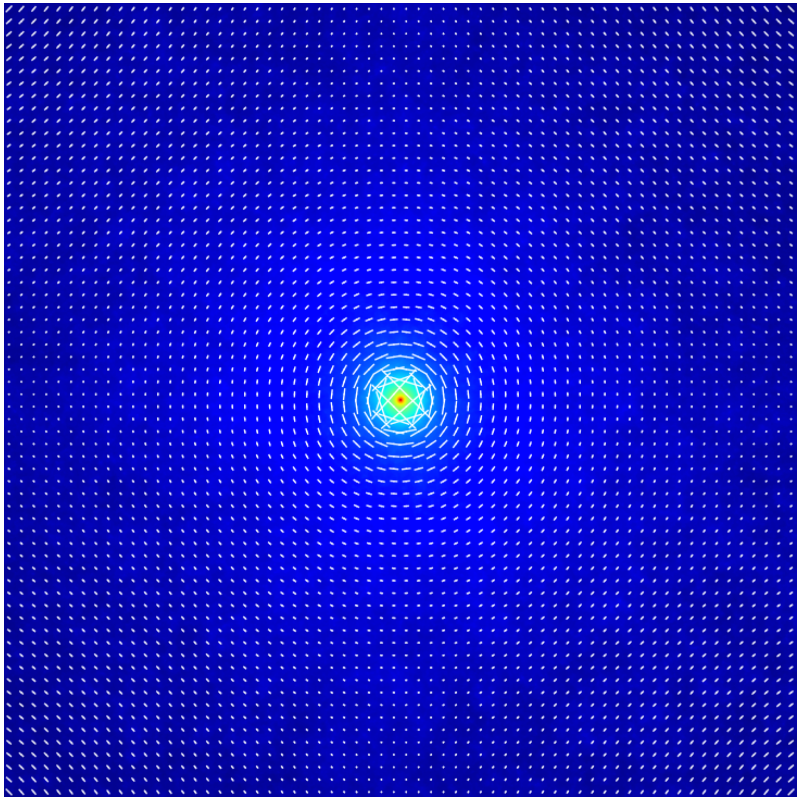
2. Simulations of structure detecting and reconstructing using galaxy-galaxy lensing. (Rangel+ in progress)

Galaxy-Galaxy Lensing





Rangel et al in preparation

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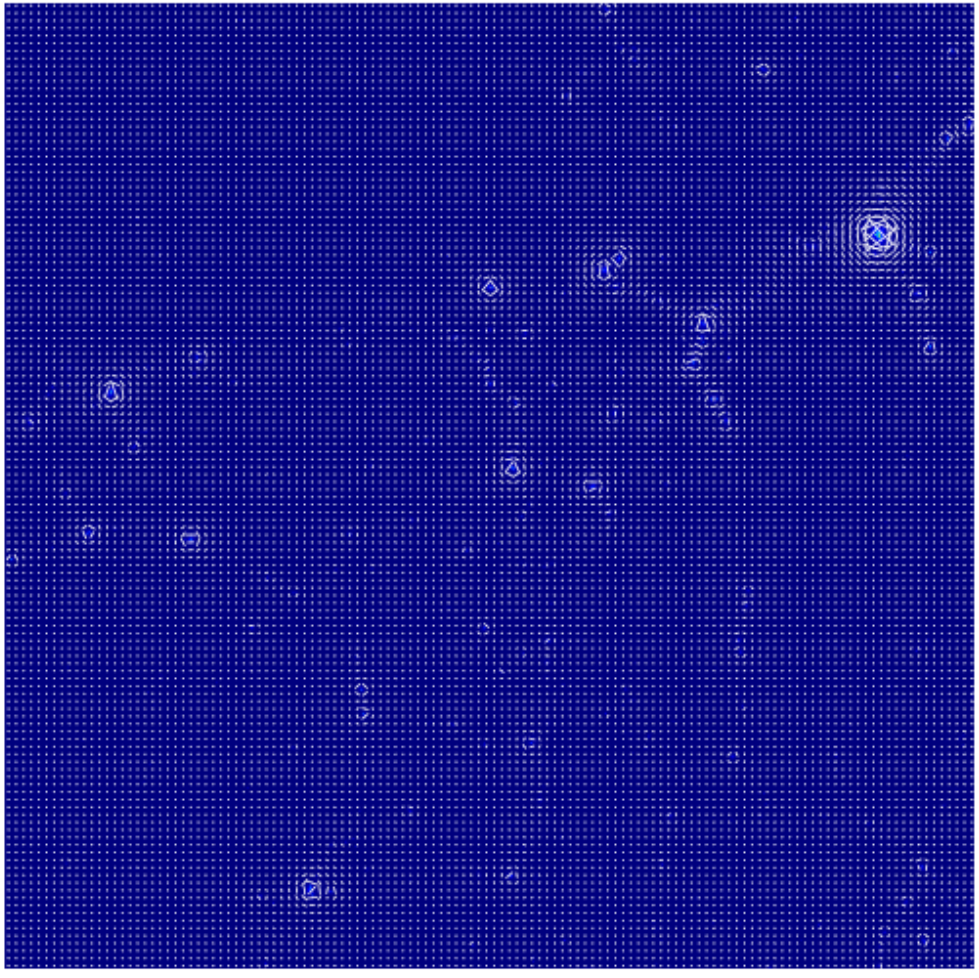

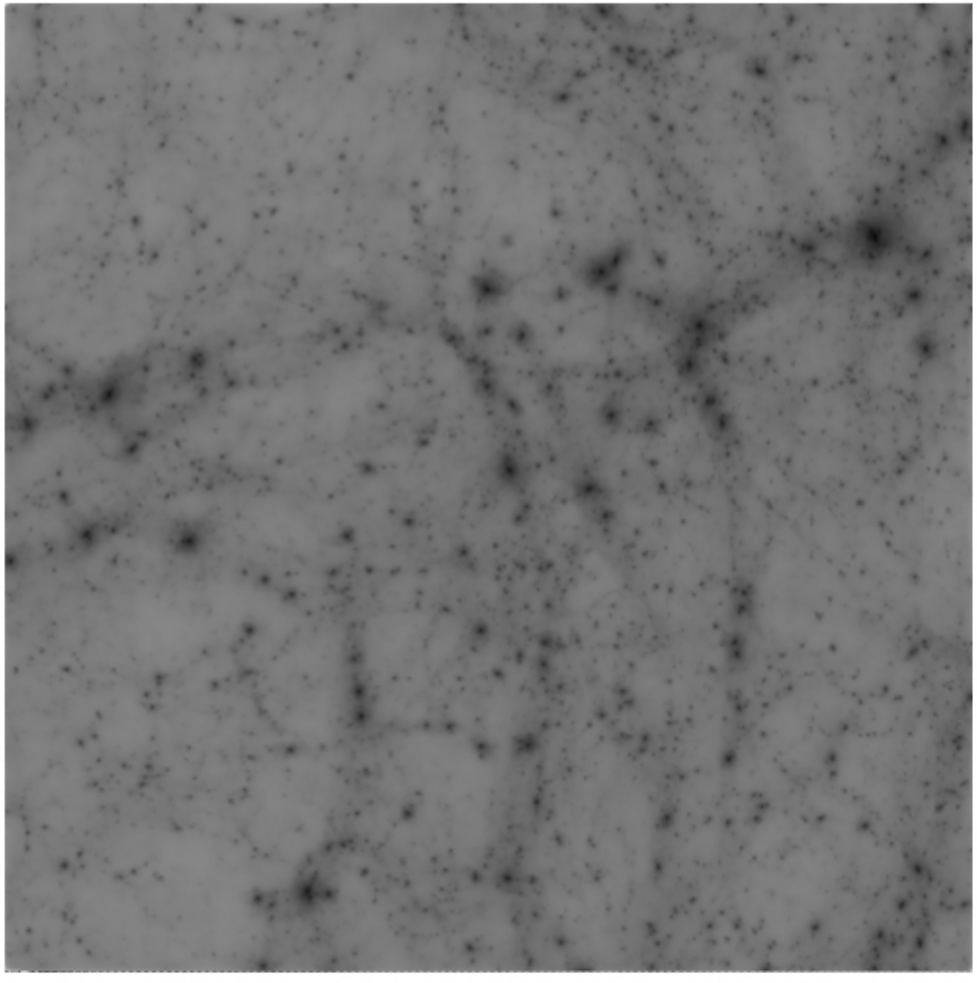

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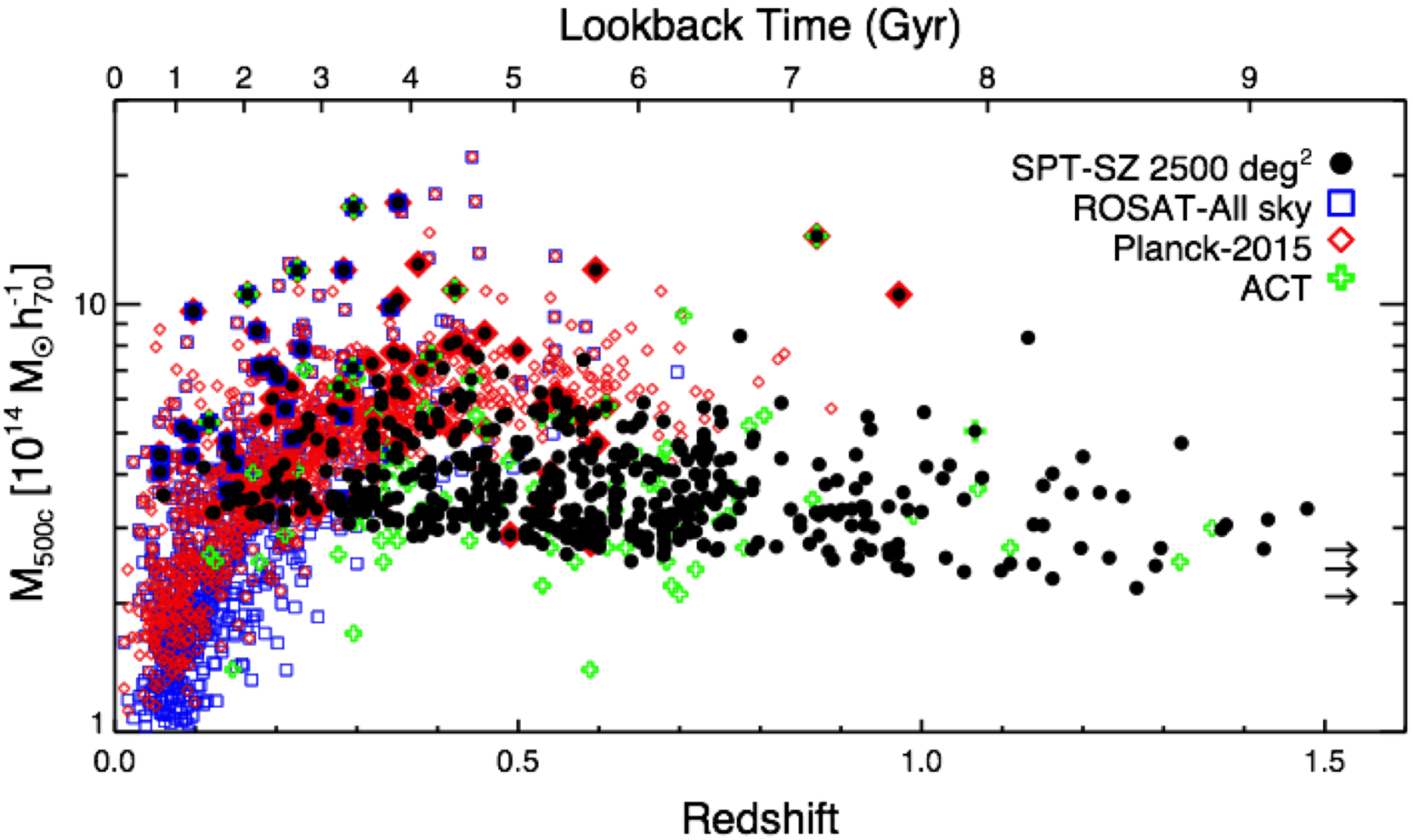
3. Arc statistics : a comparison to strong lensing in the SPT cluster catalog. (Li+ in progress, Bleem+ in progress)

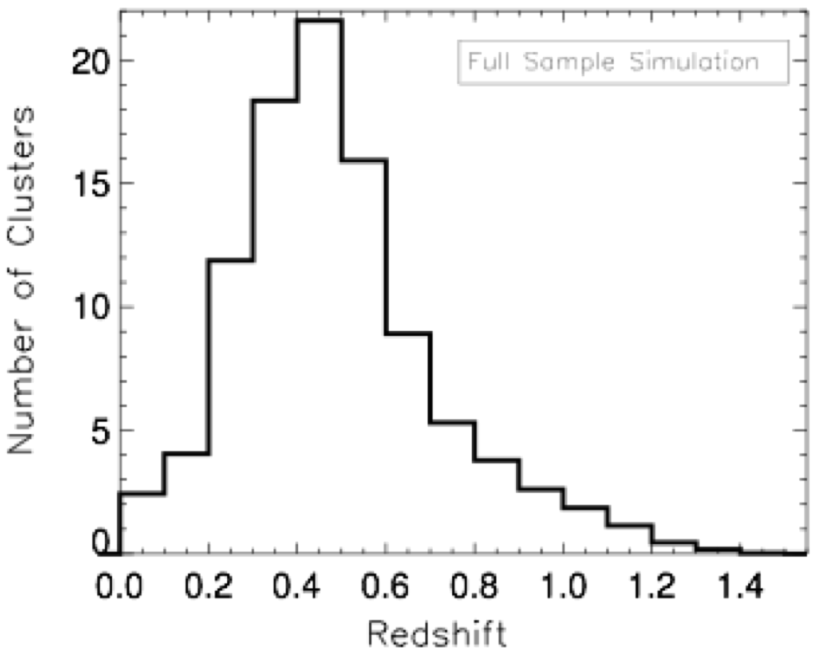
The 2500d SPT-SZ Cluster Sample



Bleem et al., ApJS, 216, 27 (2015)

Strong Lensing in SPT Cluster Catalog

Preliminary Predicted Lens Redshift Distribution.



Li et al in progress

- Expect >100 strong lenses with reasonable $(< 0.75")$ ground-based imaging.
- Will be possible to constrain the c-m relation of massive halos to $\sigma \sim 10\%$.
- On-going observational efforts with SPT collaborators: Imaging Program, Spectroscopic Followup.

Pretty Pictures…

Bleem+

~100 SPT clusters observed in good seeing

Current and Future Work

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3. Arc statistics : a comparison to strong lensing in the SPT cluster catalog. (Li+ in progress, Bleem+ in progress)

4. Algorithm of automatically arc-finding in simulated images and future image surveys, e.g., LSST, WFIRST. (Li+ in progress)