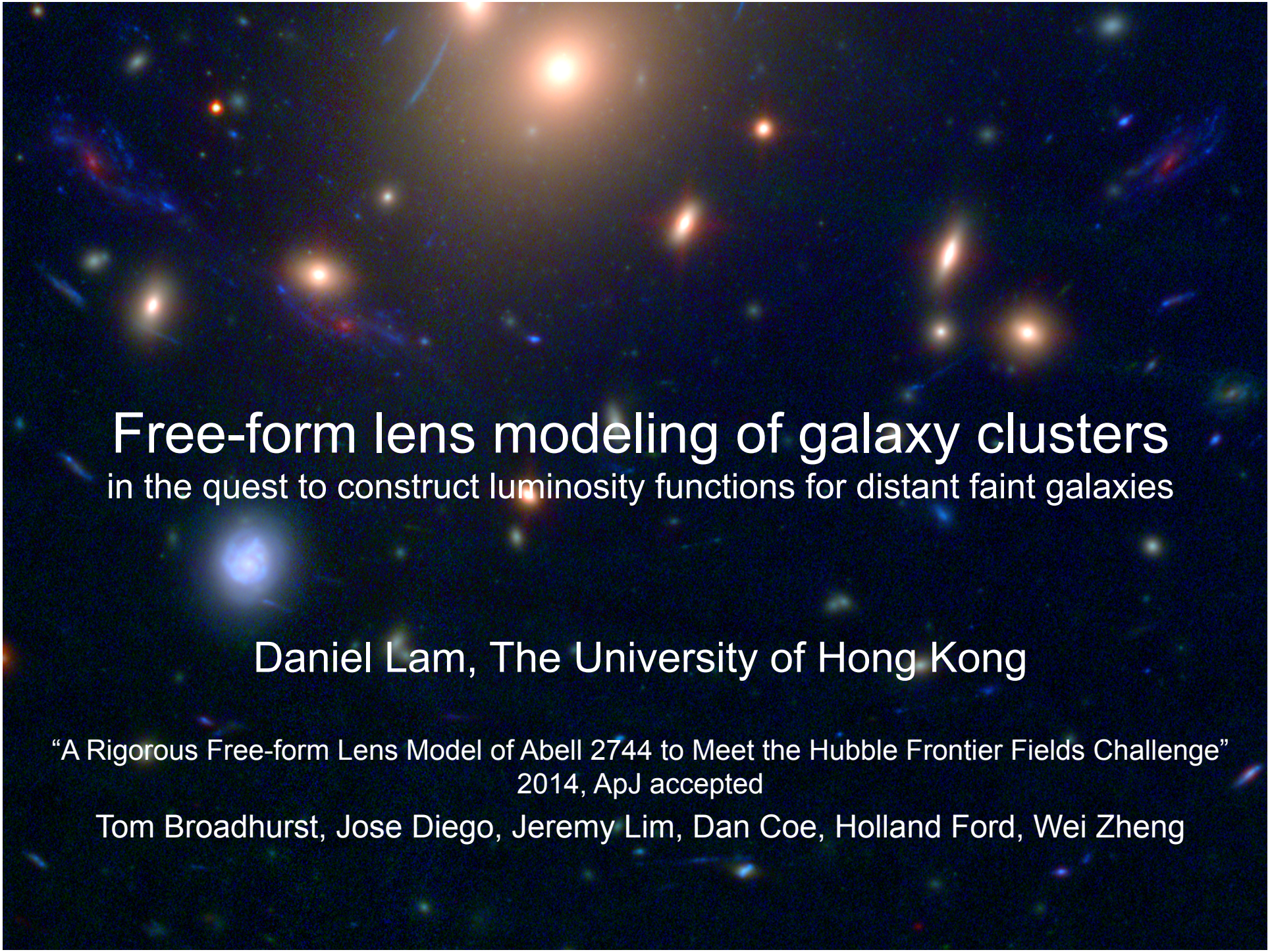


Free-form lens modeling of galaxy clusters

in the quest to construct luminosity functions for distant faint galaxies

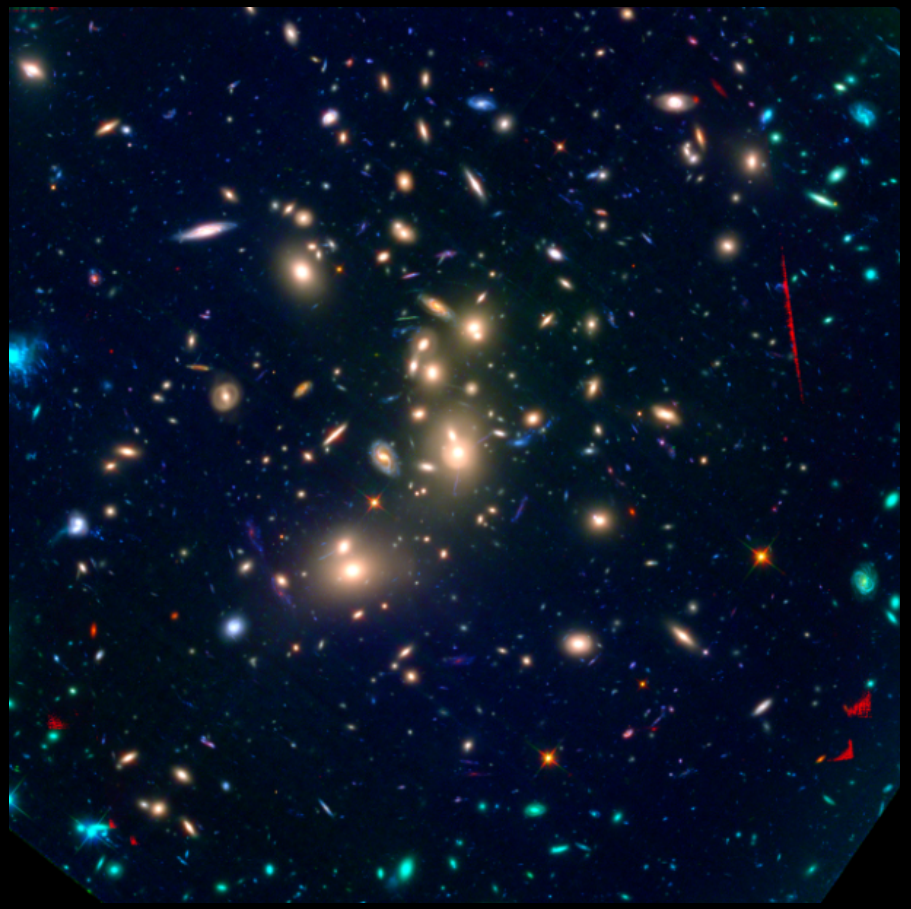
Daniel Lam, The University of Hong Kong

"A Rigorous Free-form Lens Model of Abell 2744 to Meet the Hubble Frontier Fields Challenge"
2014, ApJ accepted

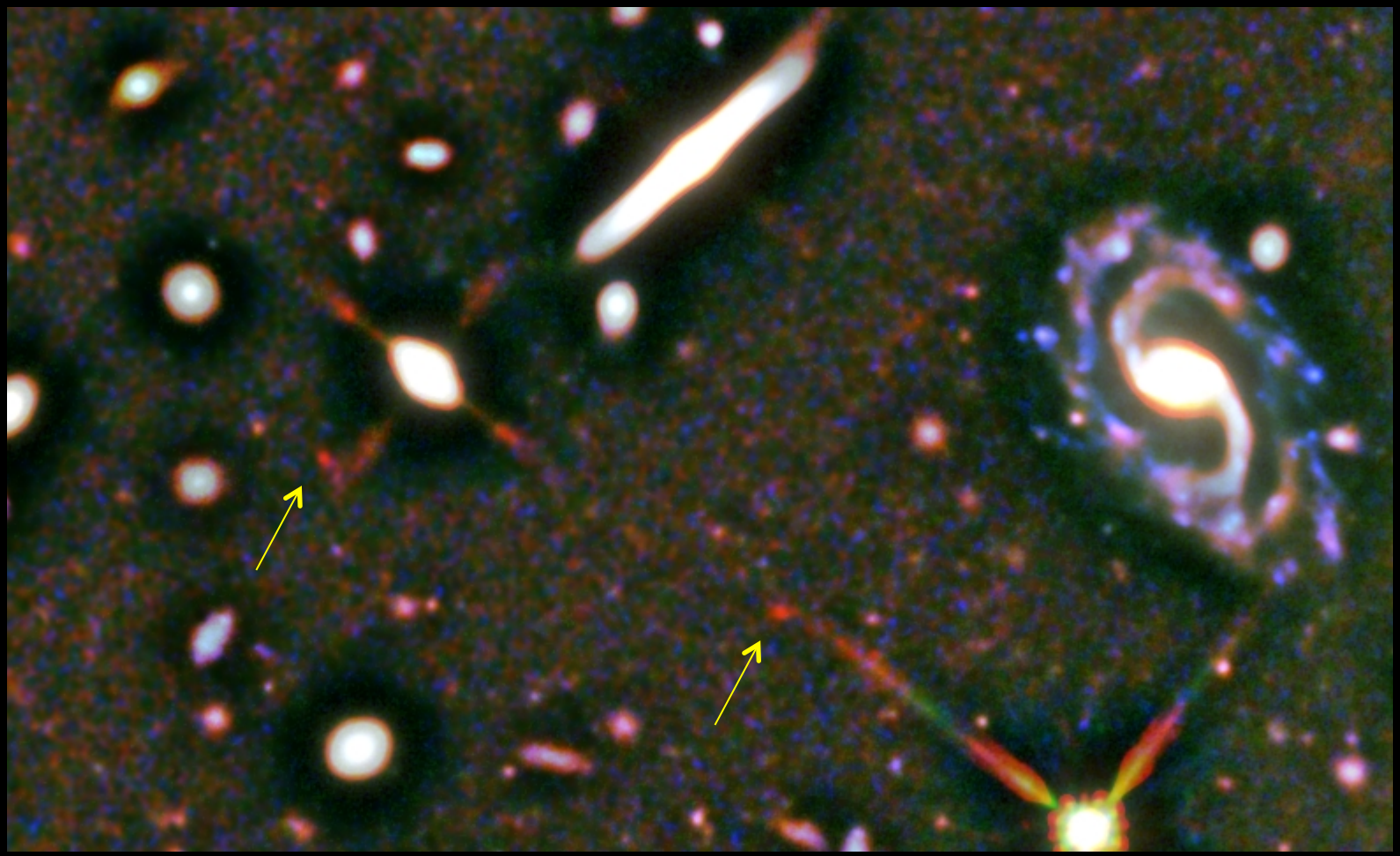
Tom Broadhurst, Jose Diego, Jeremy Lim, Dan Coe, Holland Ford, Wei Zheng

HST eXtreme Deep Field

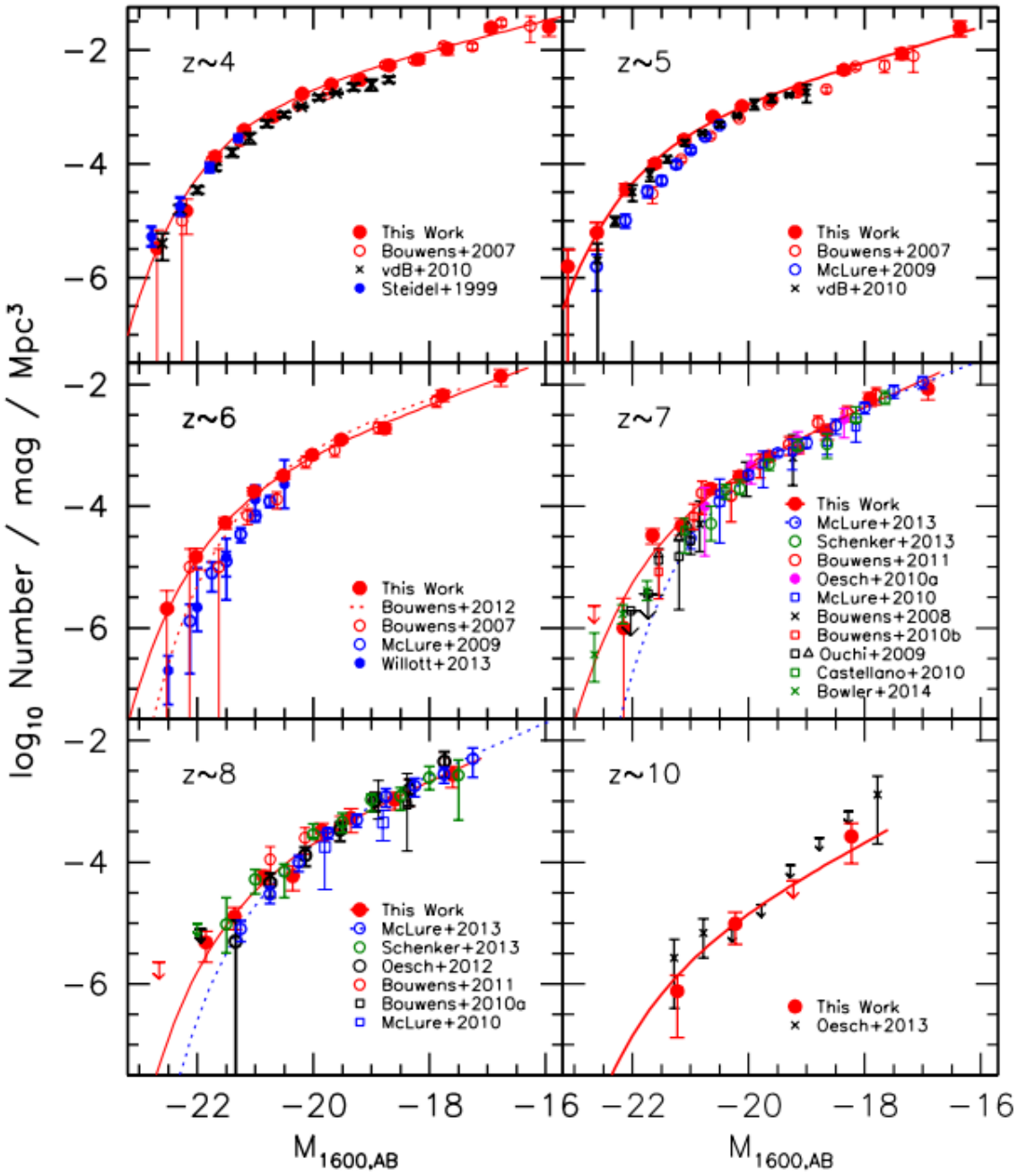
Hubble Frontier Fields



z~10 double image



Zitrin et al. 2014



Bouwens et al. 2014

1. Free-form modeling of a cluster lens

2. Model robustness

3. Predicted magnification

WSLAP+ in a Nutshell

Inputs:

1. Positions of multiple images
2. Photo-z or spec-z of images

Model components:

1. 2-D Gaussian grid
2. NFW member galaxies

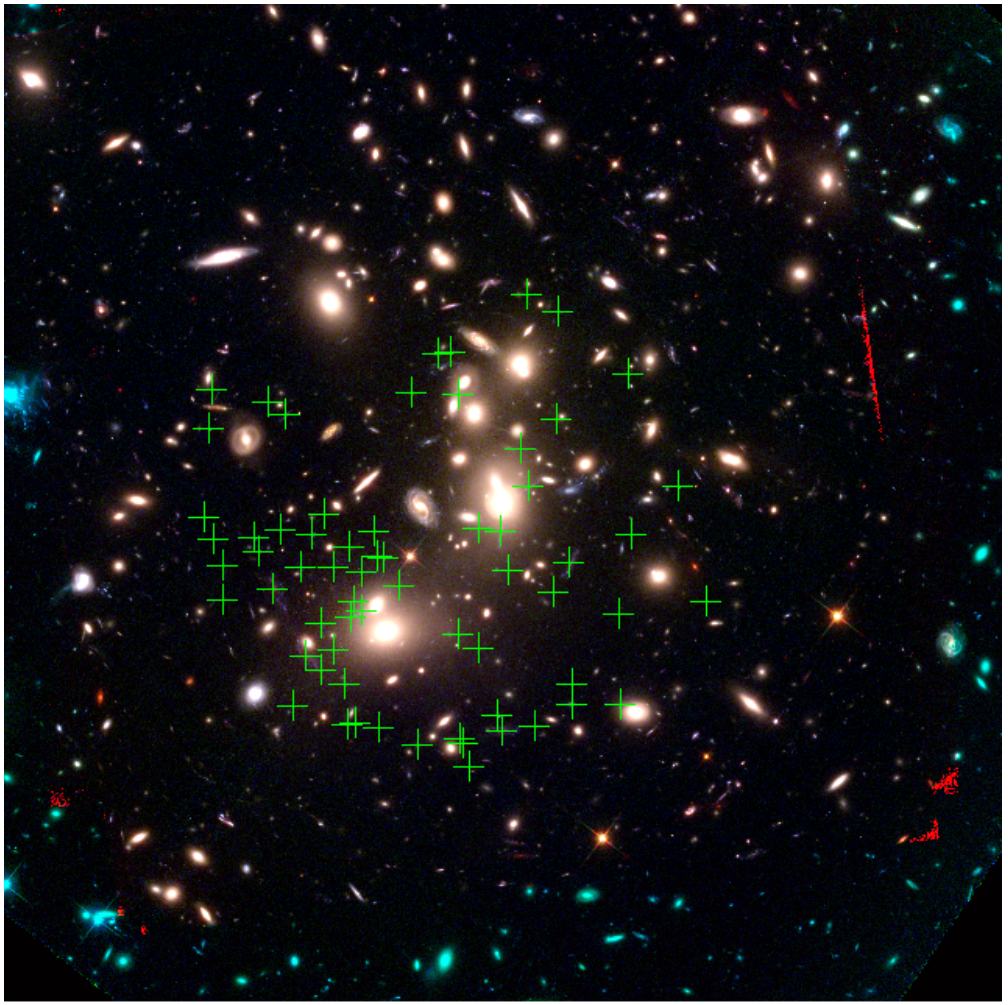
A2744

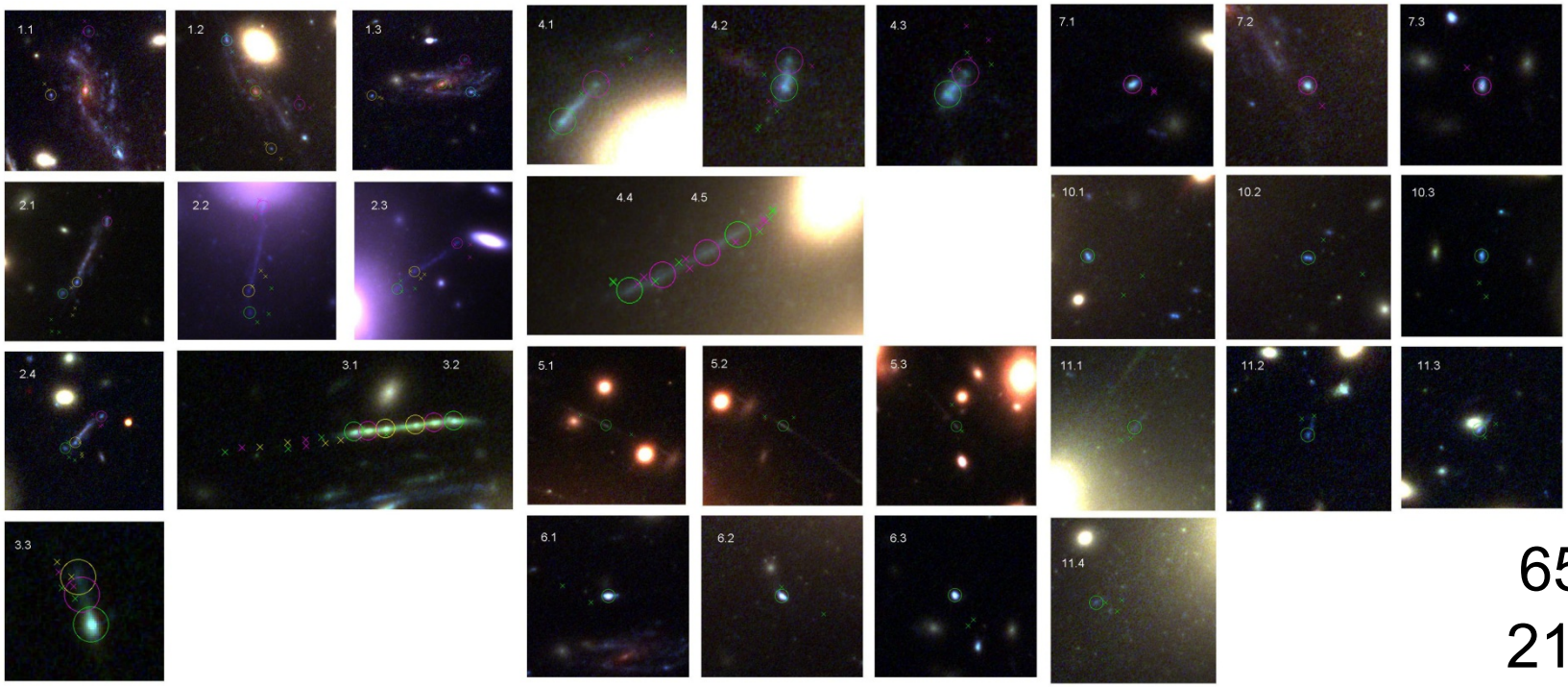
- 65 images of 21 systems
- 1.4<z<9.8
- 1024 grid cells
- 91 member galaxies, 10 groups

Obtaining lens model

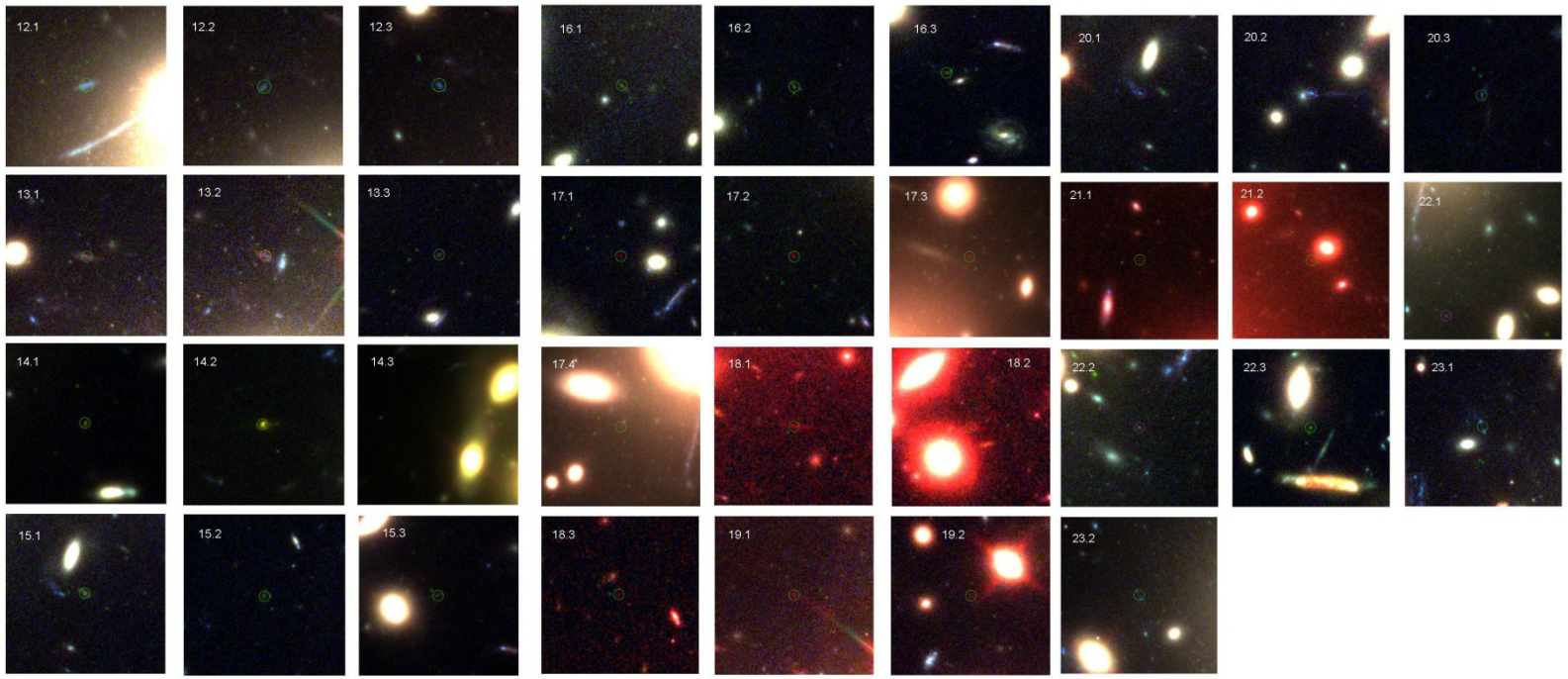
1. Converges image positions onto source plane
2. Range of models → uncertainty

* Image relative brightness NOT used as constraints

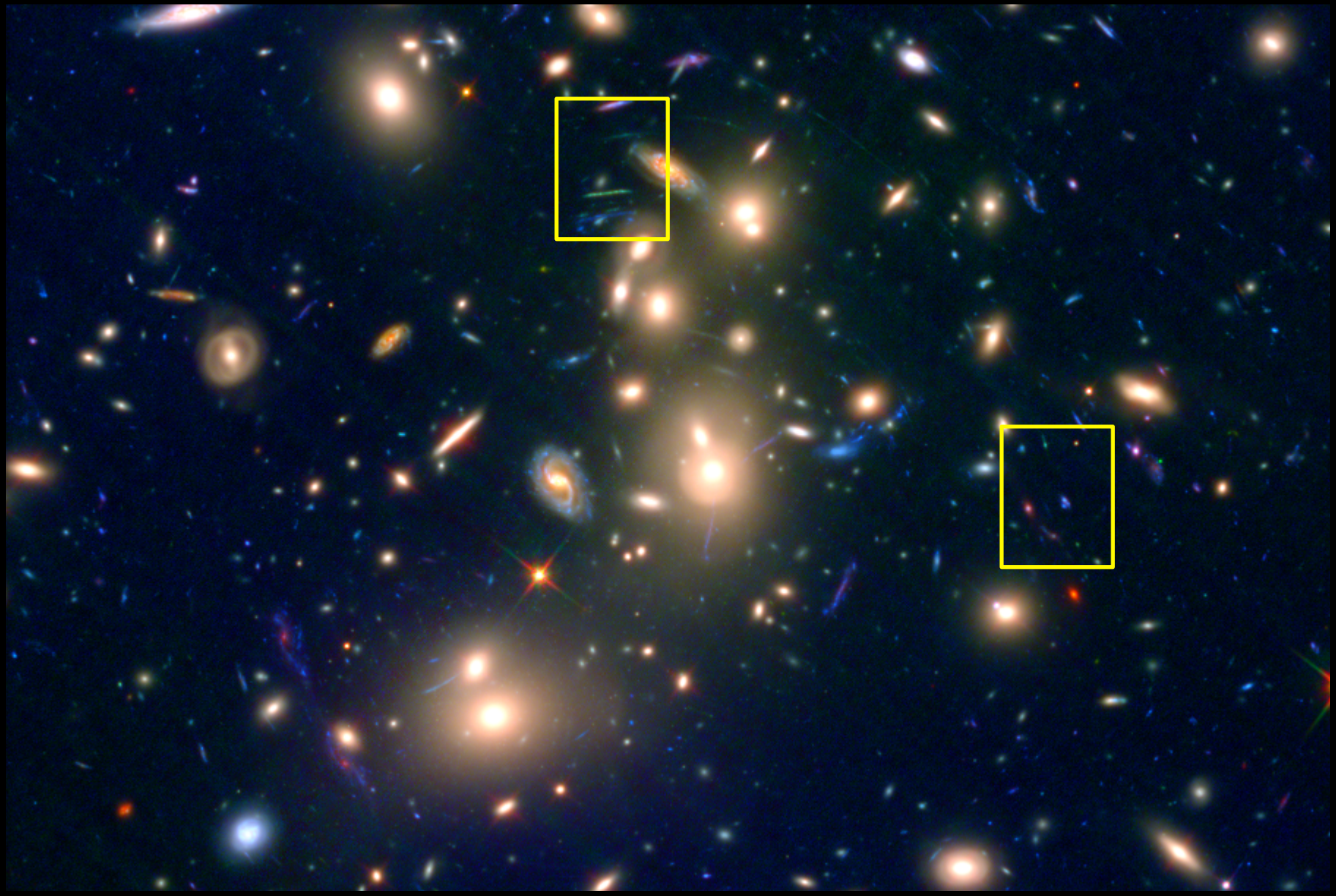




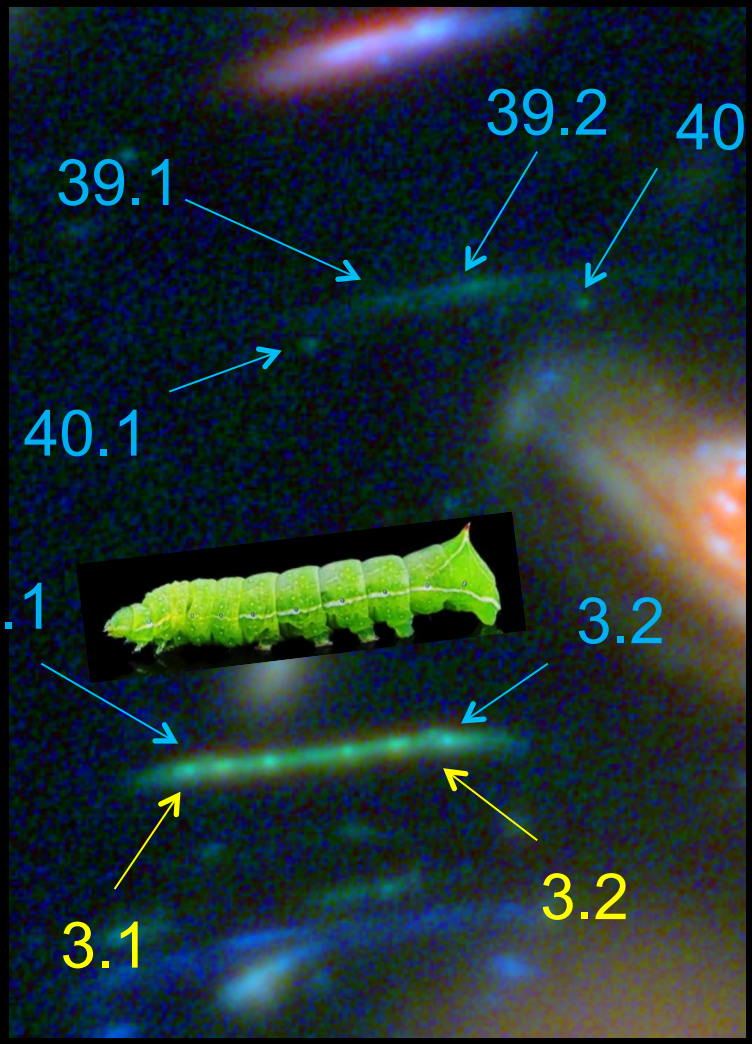
65 images
21 sources
1.4<z<9.8

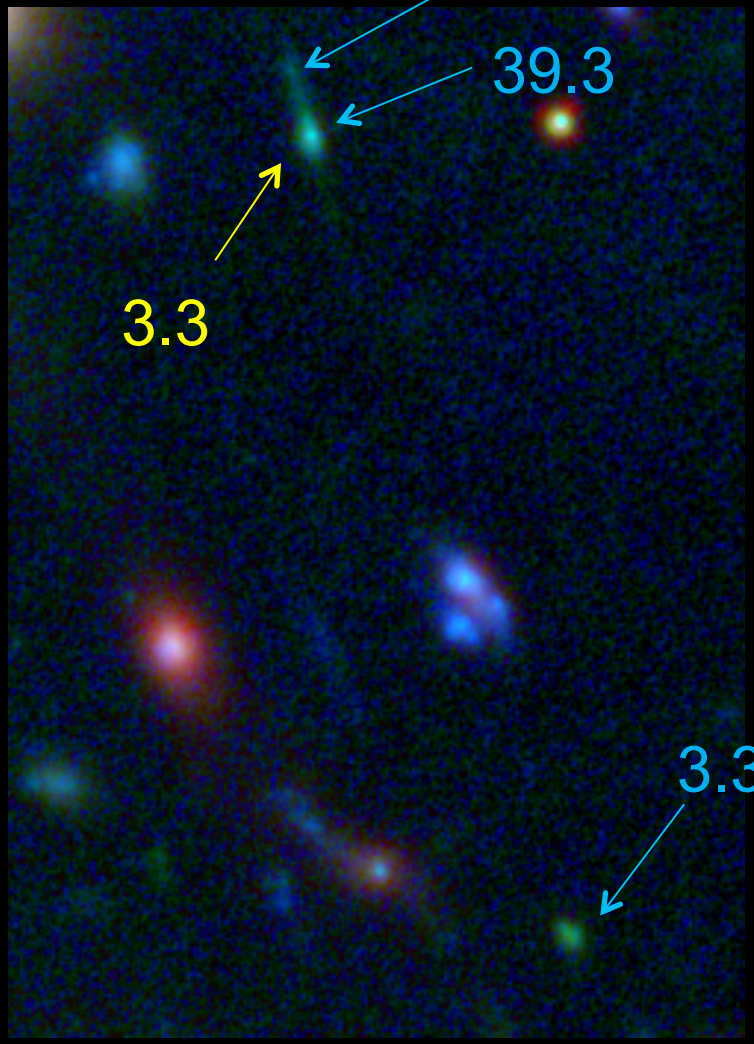


Identifying system 3



Identifying system 3





→ Jauzac et al. 2014

→ Lam et al. 2014

WSLAP+ in a Nutshell

Inputs:
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Model components:
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A2744
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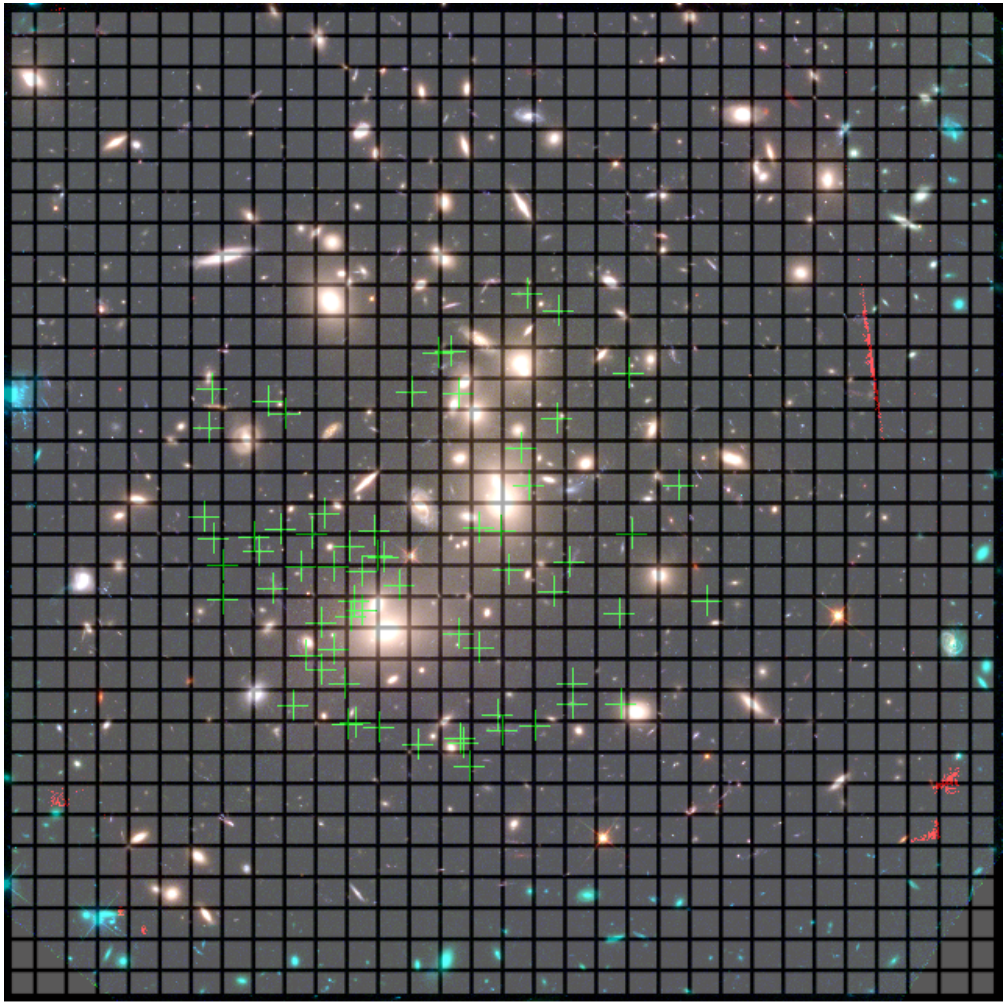
Obtaining lens model
1. Converges image positions onto source plane
2. Range of models → uncertainty

* Image relative brightness NOT used as constraints



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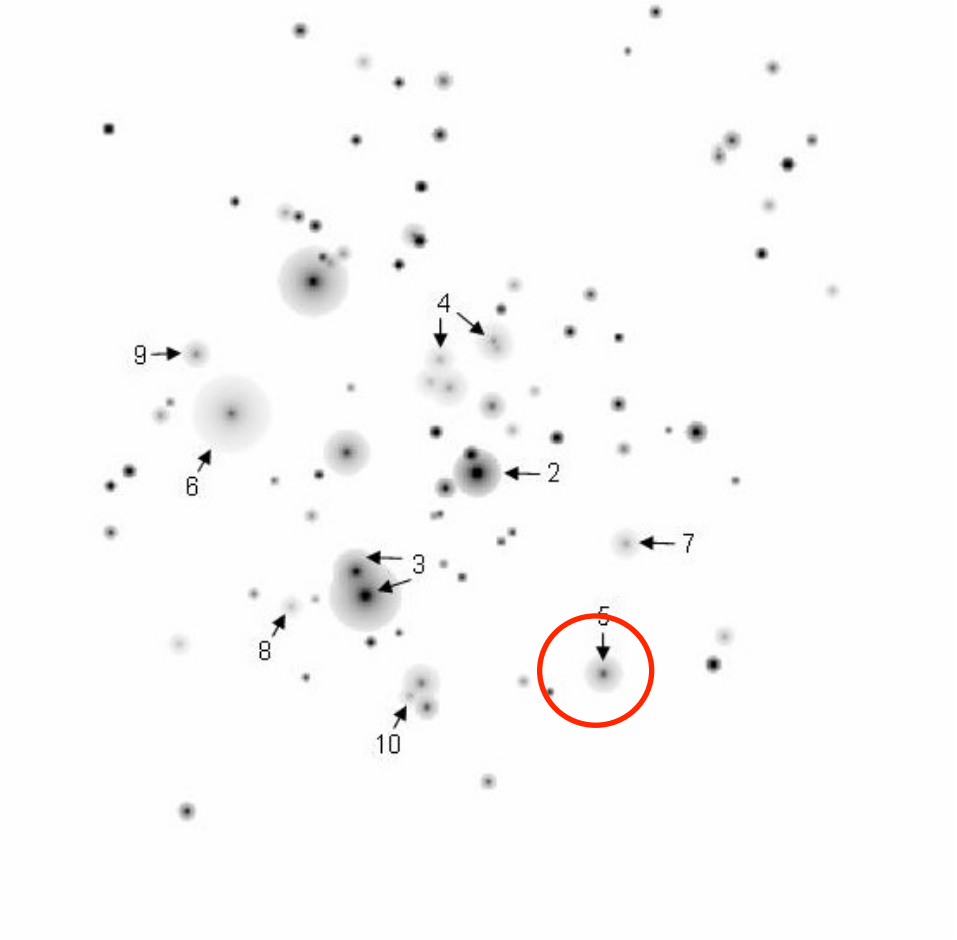

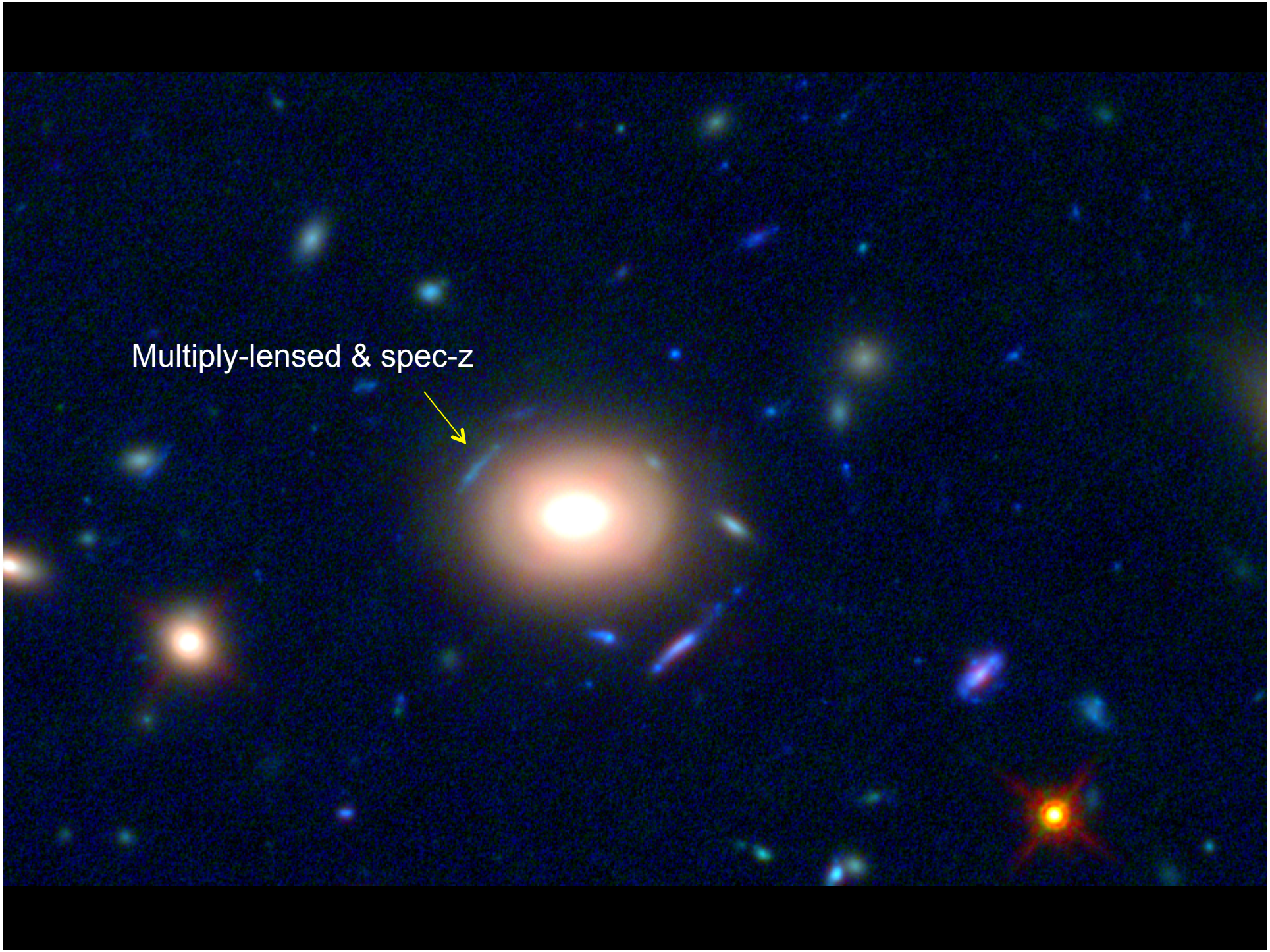
Multiply-lensed & spec-z

WSLAP+ in a Nutshell

Inputs:
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2. Photo-z or spec-z of images

Model components:
1. 2-D Gaussian grid
2. NFW member galaxies

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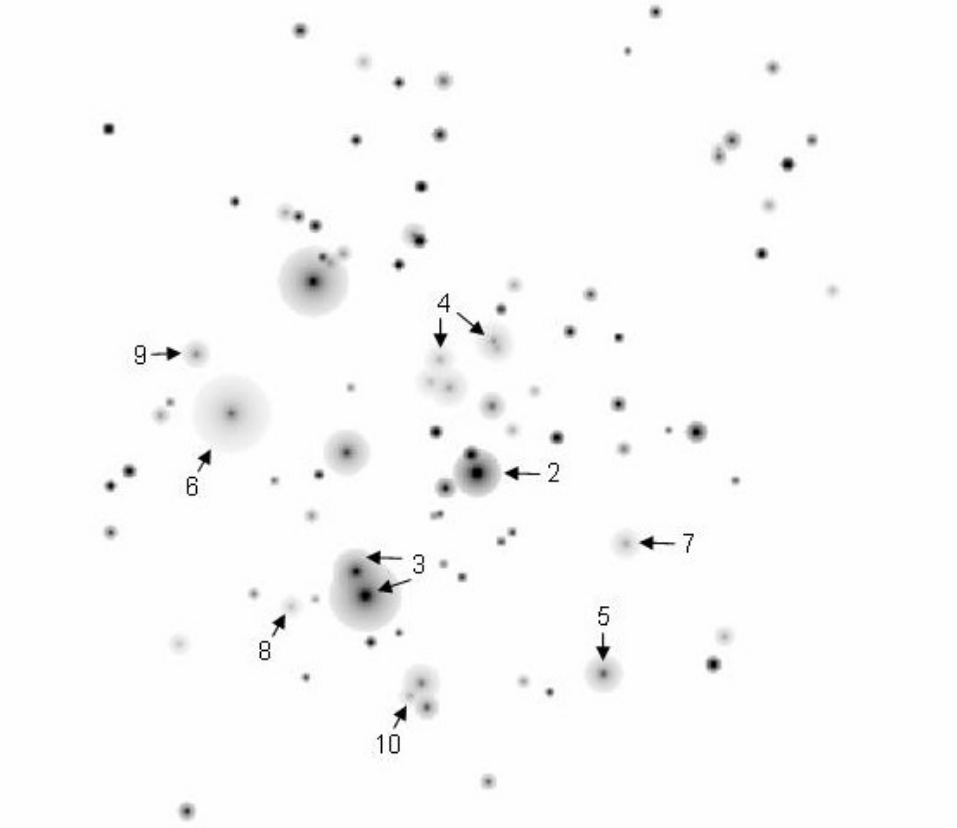
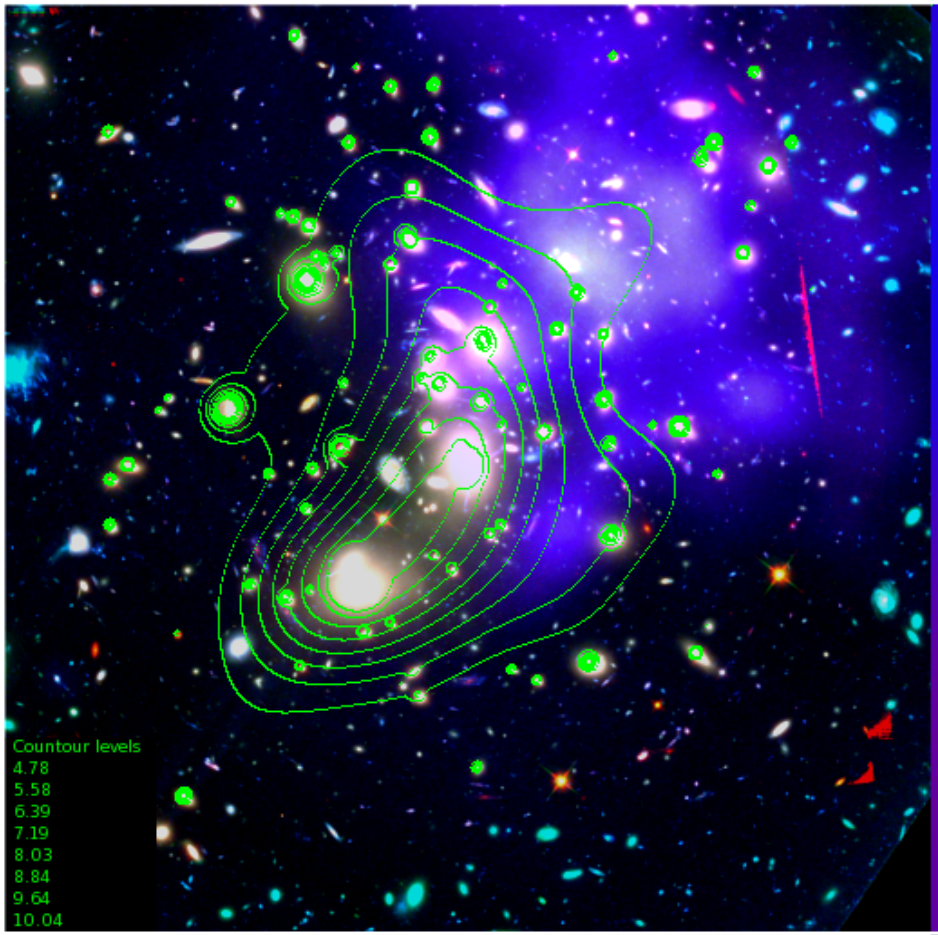
Obtaining lens model
1. Converges image positions onto source plane
2. Range of models → uncertainty

* Image relative brightness NOT used as constraints

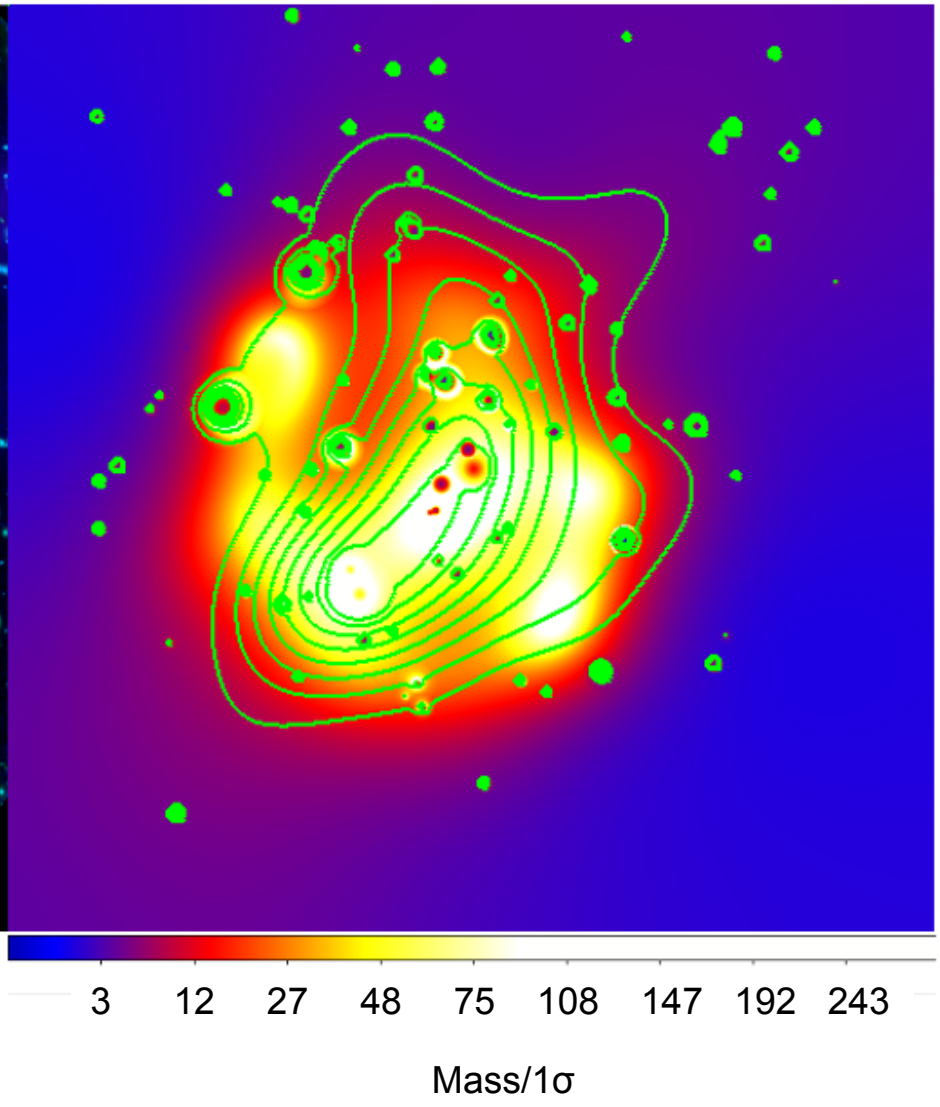


Mass model

Mass model (linear contours) & x-ray gas



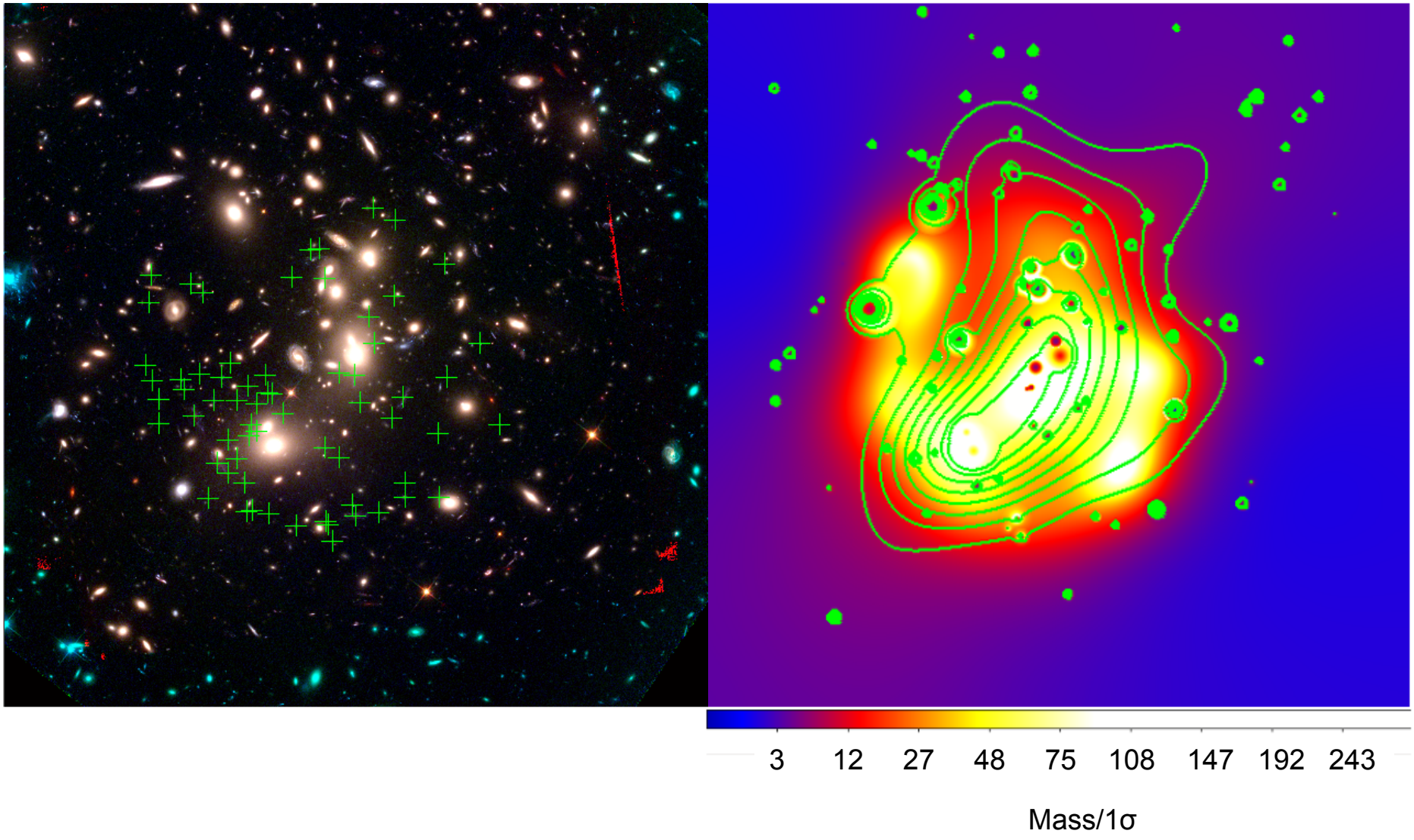
Mass model (linear contours) & Mass/1σ



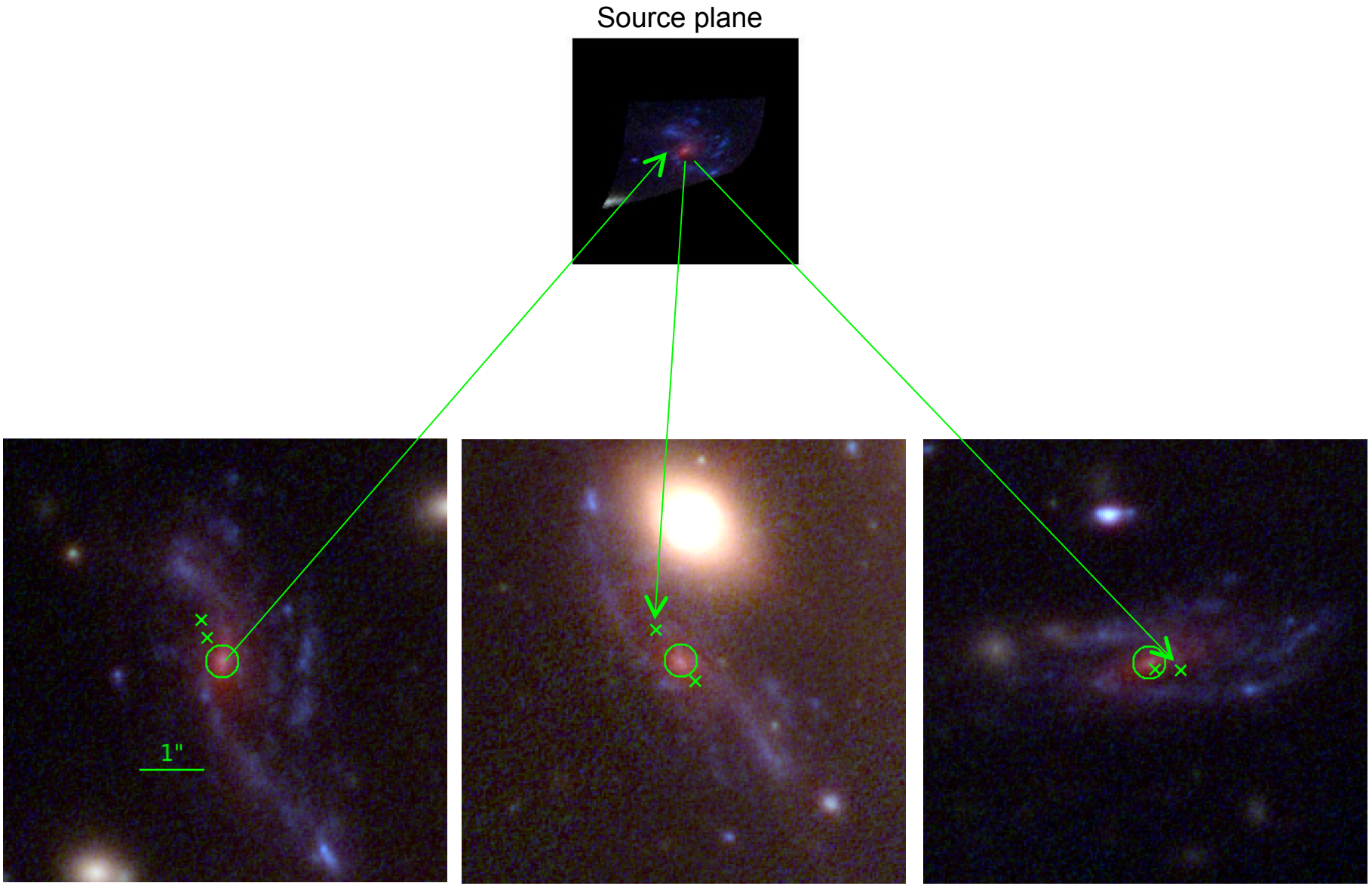
Mass model

Multiple images

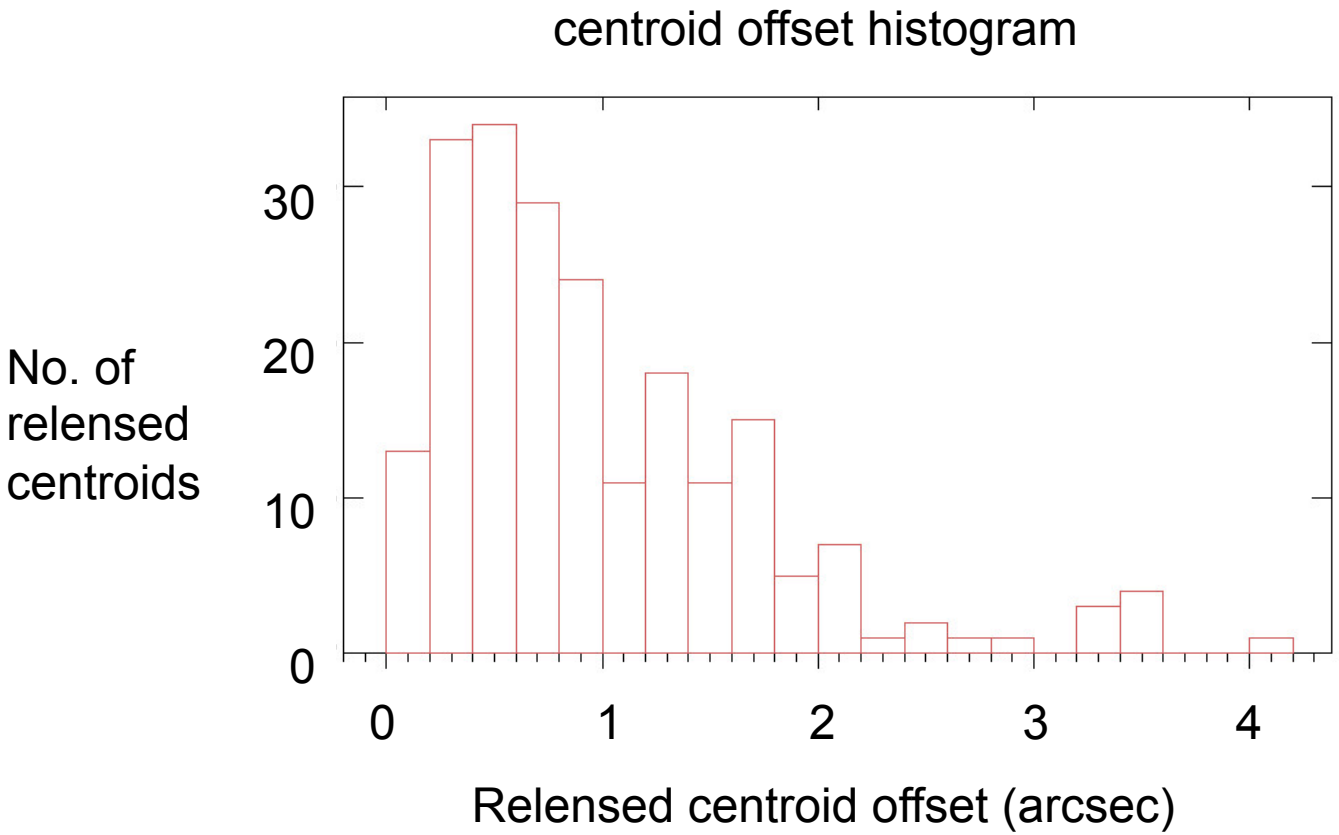
Mass model (linear contours) & Mass/1σ



Robustness 1st order check: centroid offsets

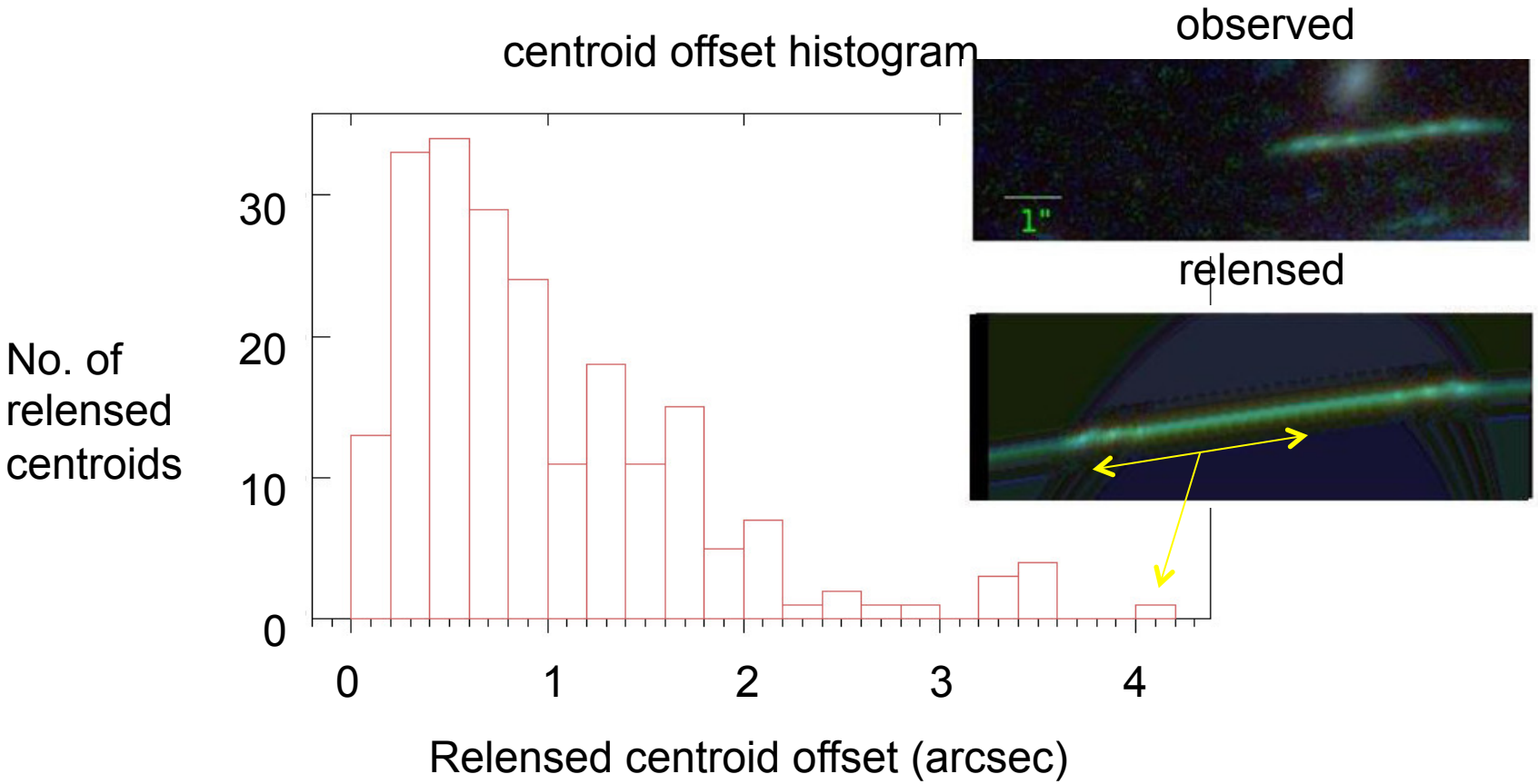


Robustness 1st order check: centroid offsets



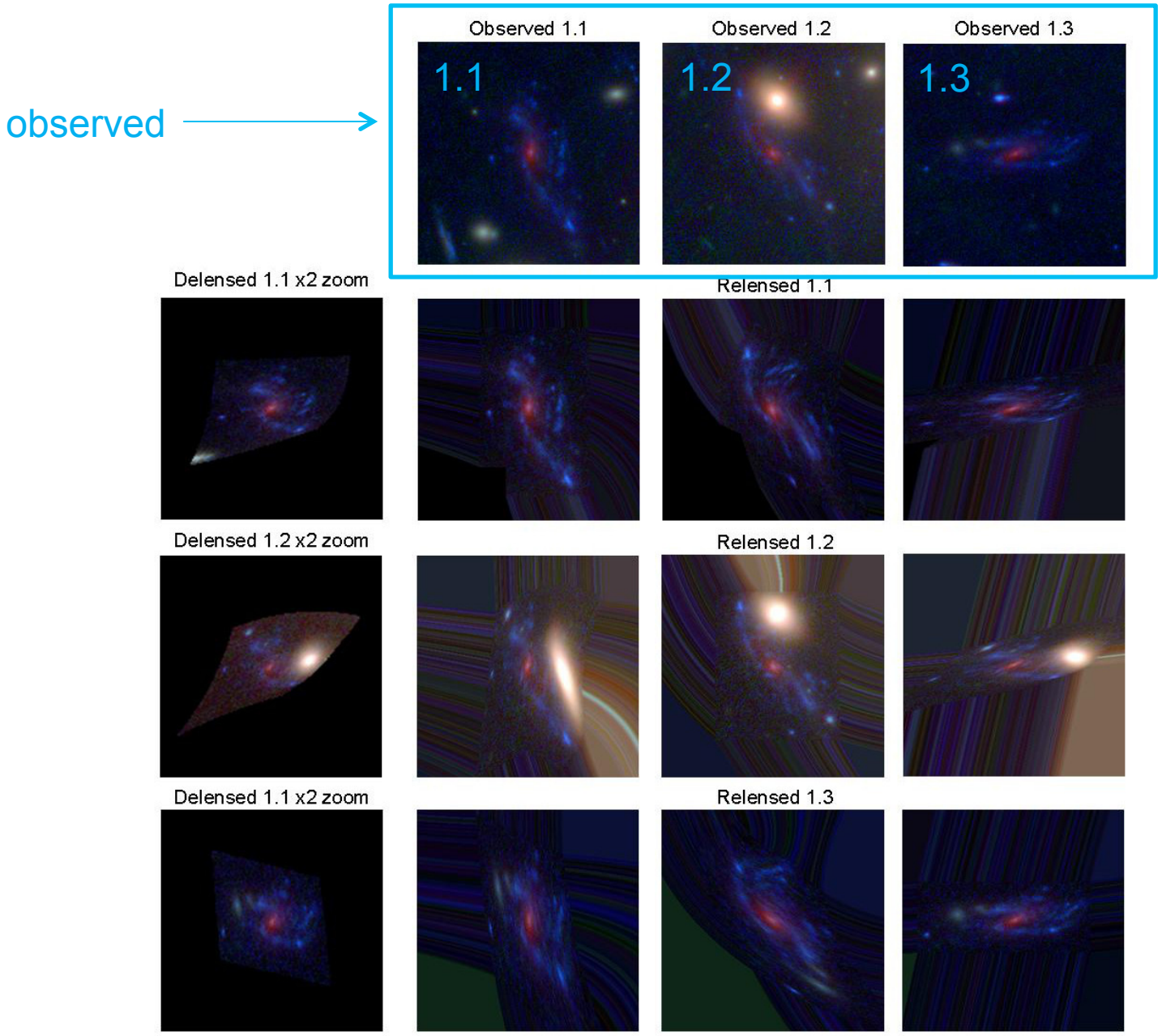
Mean 1.0” Mode 0.4” RMS 1.2”

Robustness 1st order check: centroid offsets

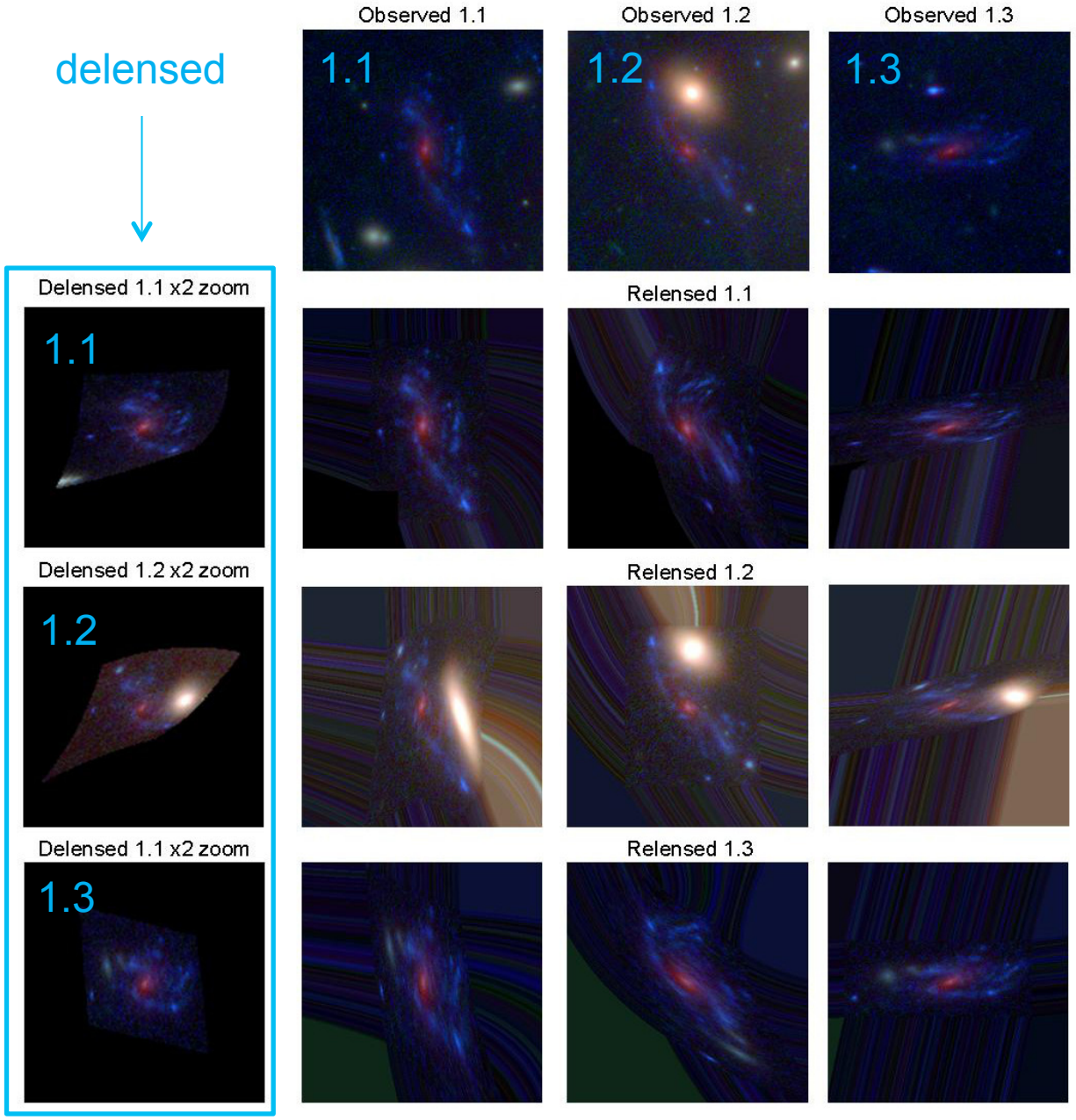


Mean 1.0” Mode 0.4” RMS 1.2”

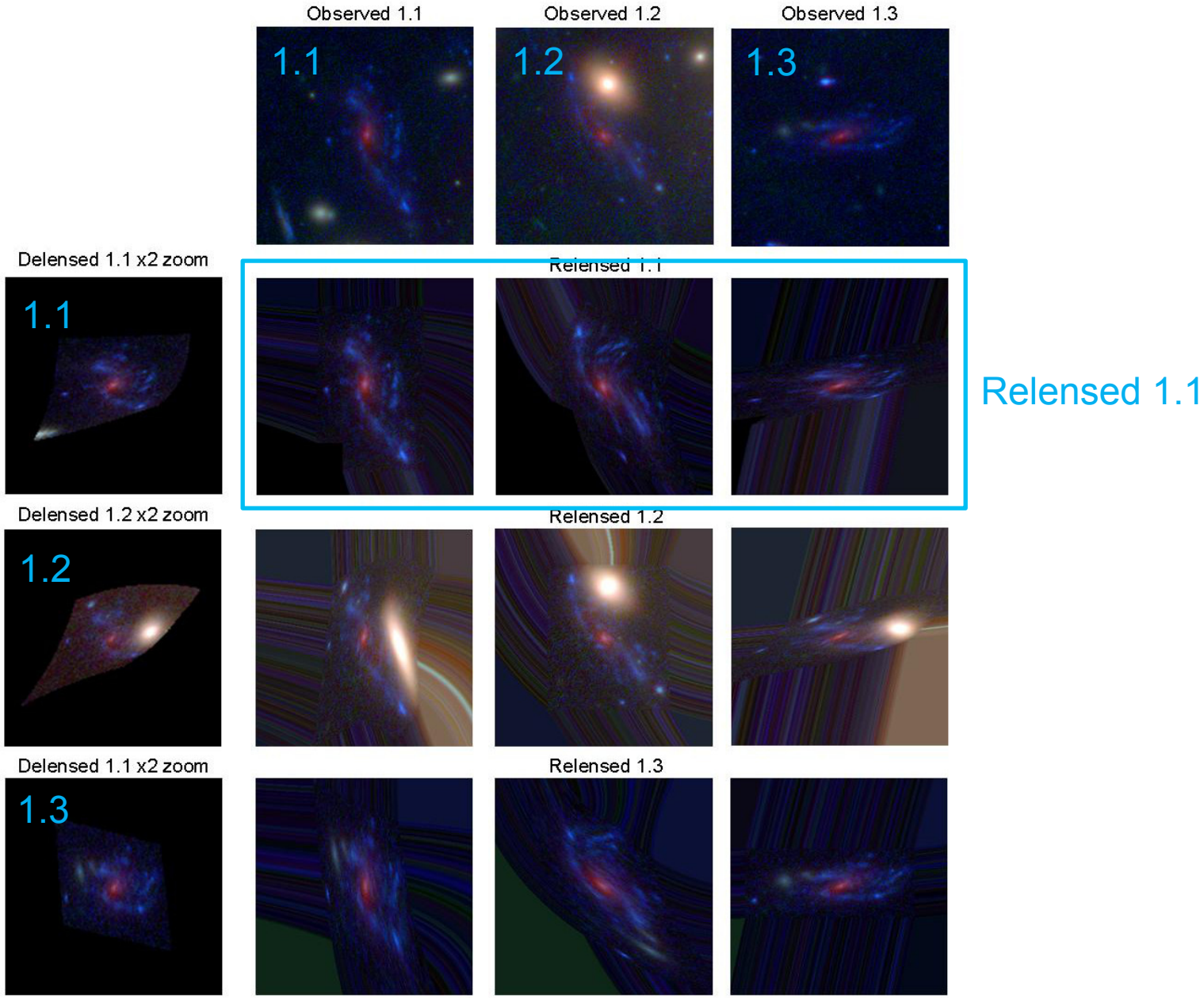
Robustness 2nd order check: internal structures



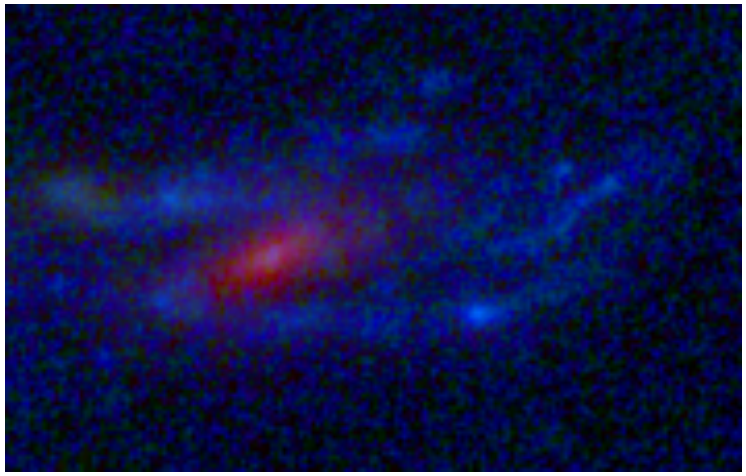
Robustness 2nd order check: internal structures



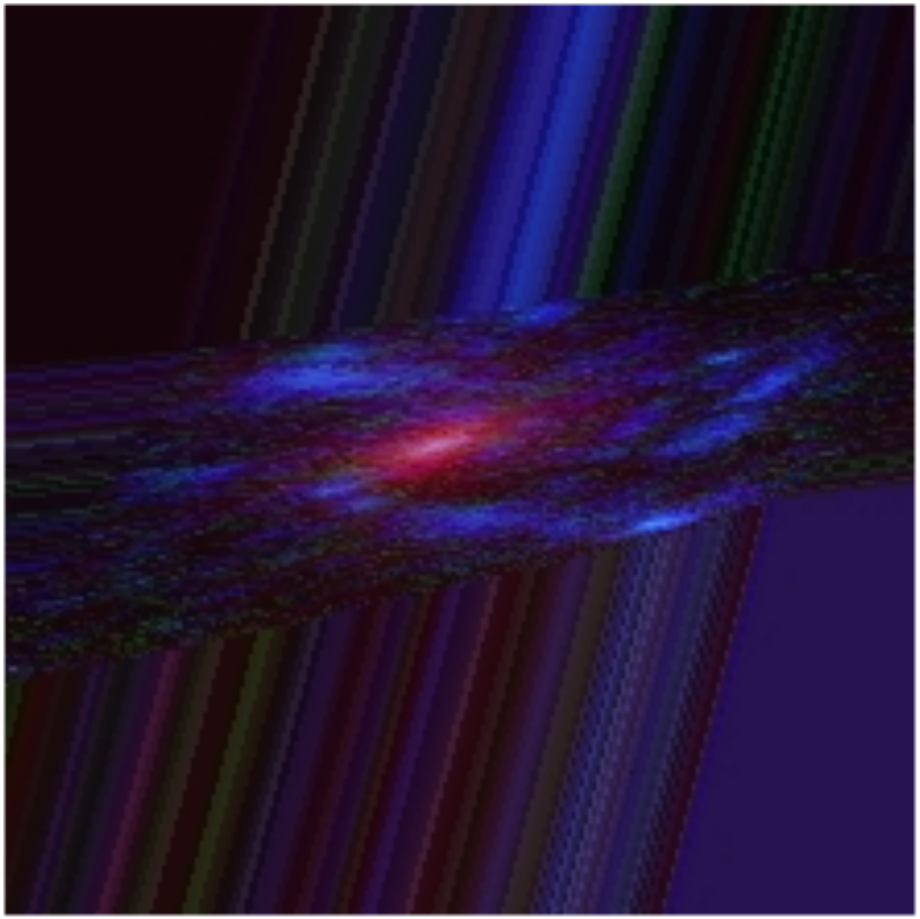
Robustness 2nd order check: internal structures



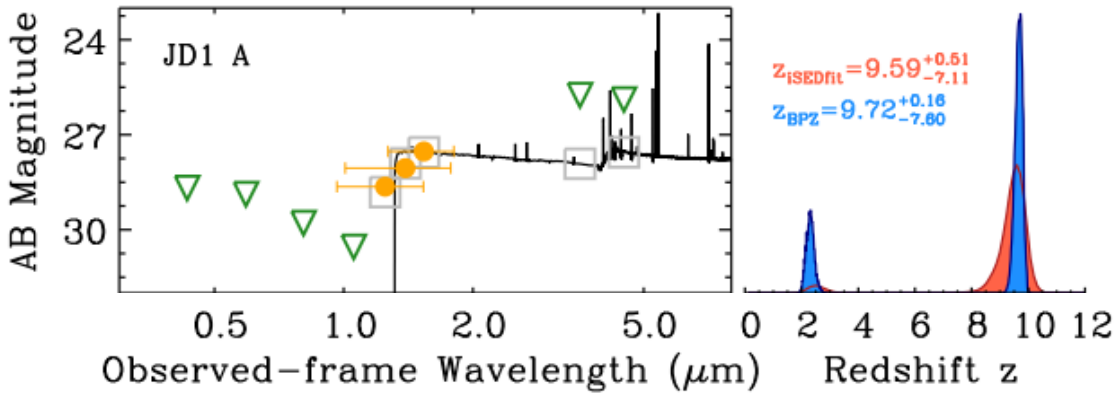
Observed 1.3

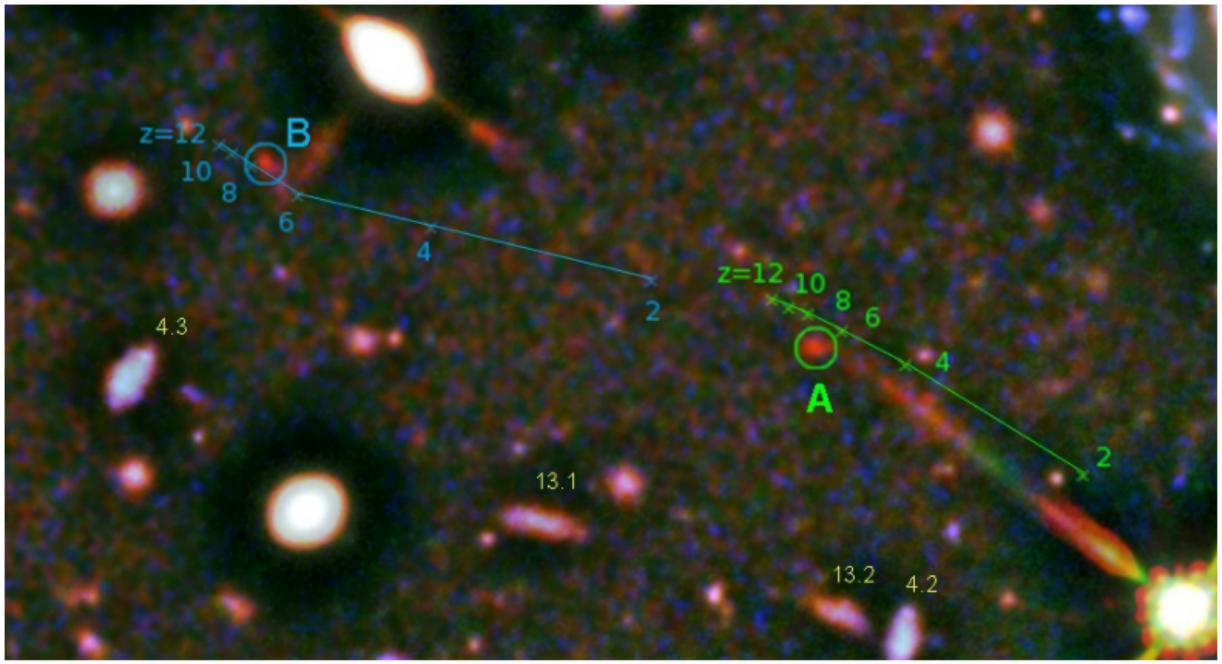


Relensed 1.1 at 1.3 location



Geometric redshift





Zitrin et al. 2014

measure m1,
model μ1

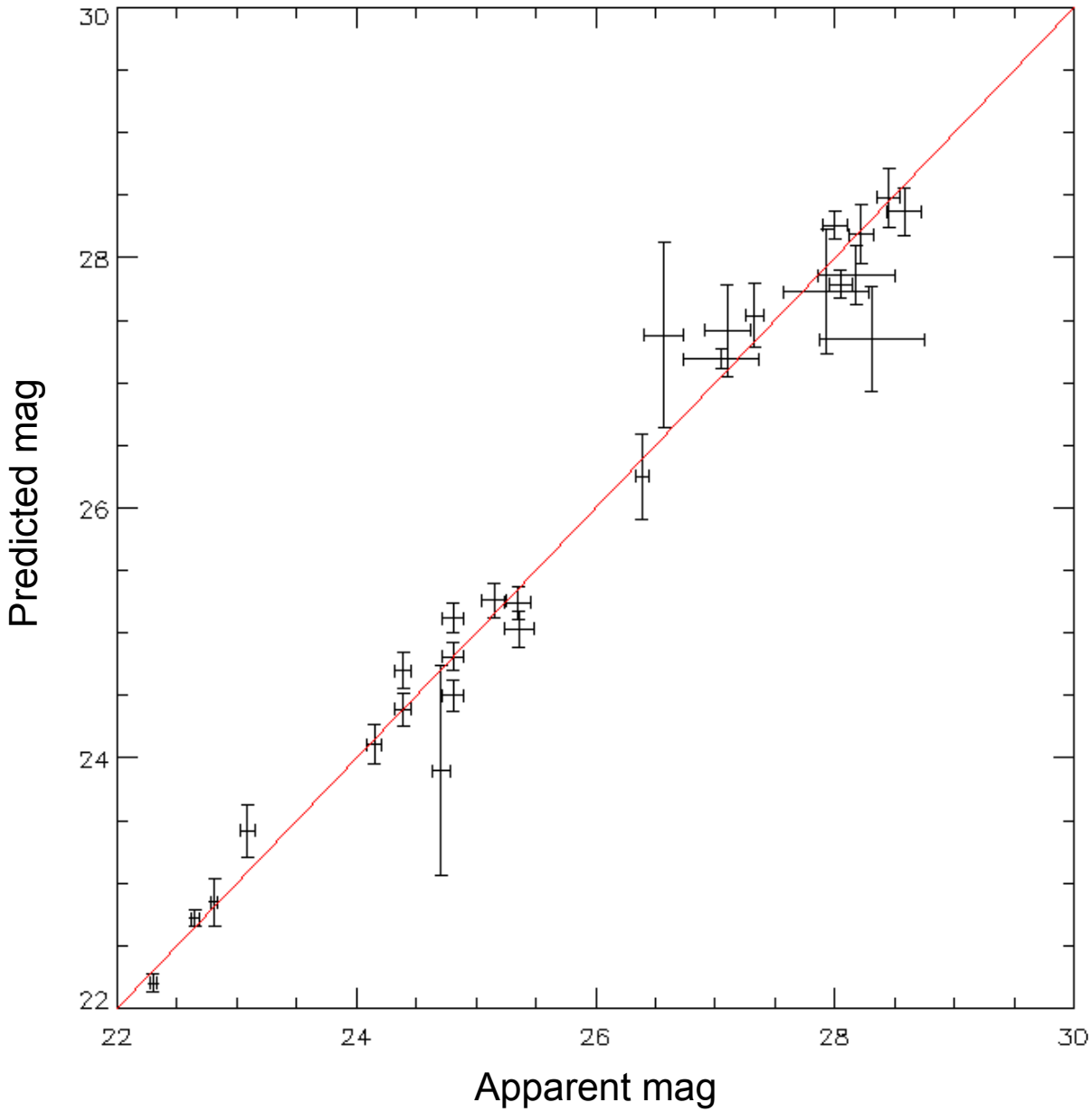
Predicted magnification

measure m3,
model μ3

Predicted magnification

All systems with more than one lensed image with photometry (27 out of 65)

1:1 line



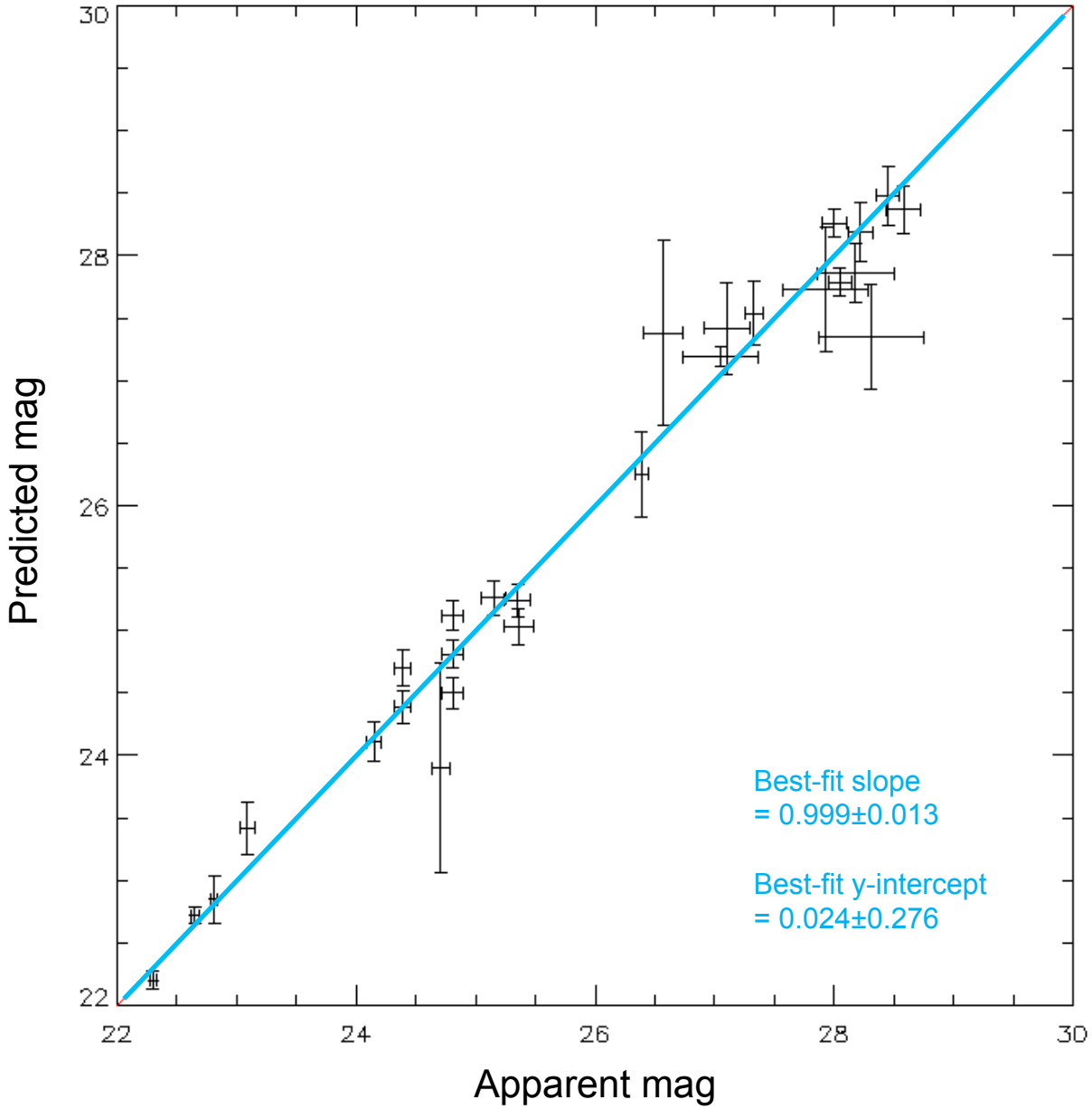
Predicted magnification

All systems with more than one lensed image with photometry (27 out of 65)

1:1 line
Best-fit line

RMS 0.25 mag

Relative images brightness NOT used as constraints



Luminosity function at z~10

Summary

- Free-form lens model: Gaussian grid + NFW haloes
- Assessing level of self-consistency:
  - Centroid offsets: mode 0.4”, mean 1.0”, RMS 1.2”
  - Compare internal structures: elongation, rotation
- Geometric redshift
- Magnification correction: RMS 0.25”