

GRAVITATIONAL LENSING

LENS MODELLING II

R. Benton Metcalf
2022-2023

MODELLING GALAXY CLUSTERS

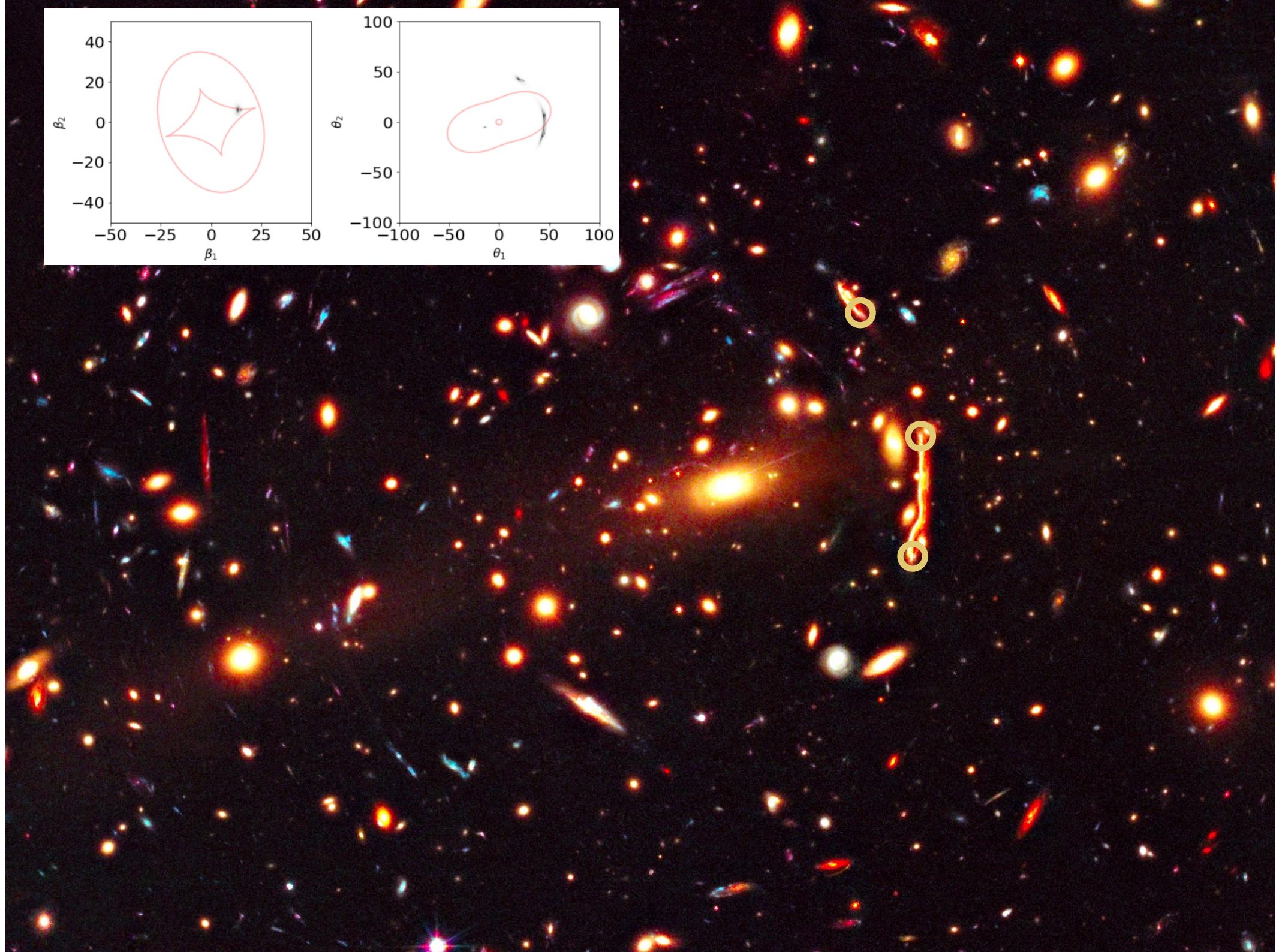
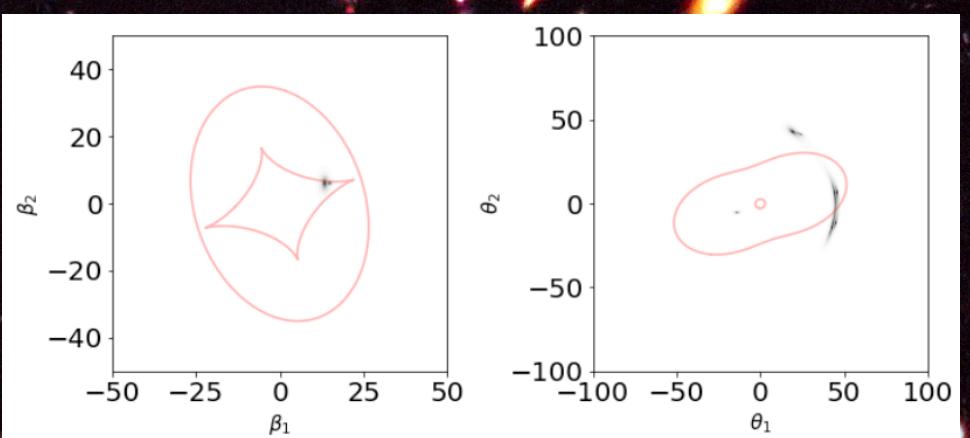
- Galaxy clusters are much more complex than galaxies
- Need to include many mass components
- Many free parameters
- Possibility to have many lensed sources at the same time
- Possibility to use lensing to recover the mass distribution over a large range of distances from the lens center (e.g. combining strong and weak lensing).

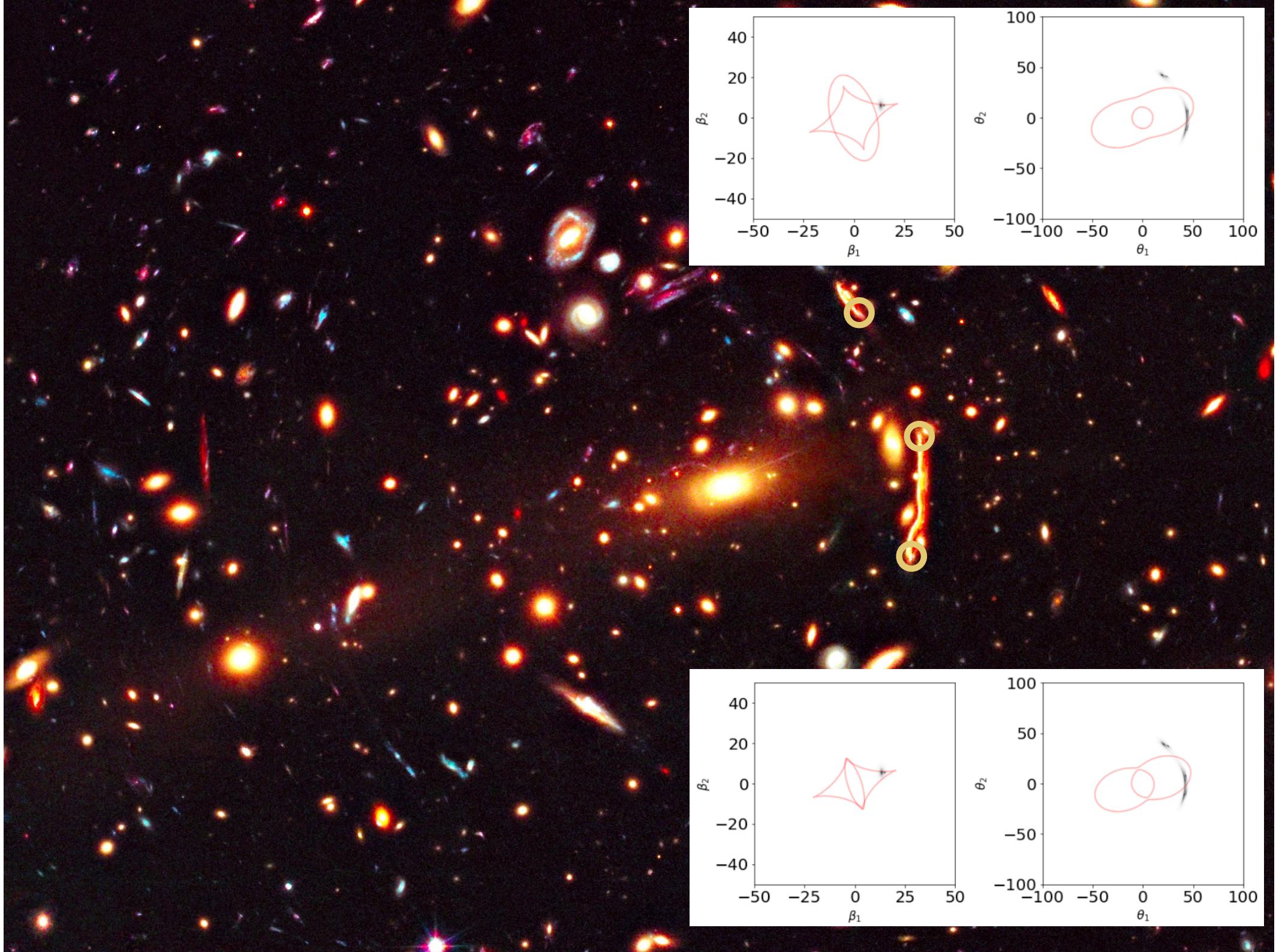
FINDING MULTIPLE IMAGES IN A GALAXY CLUSTER

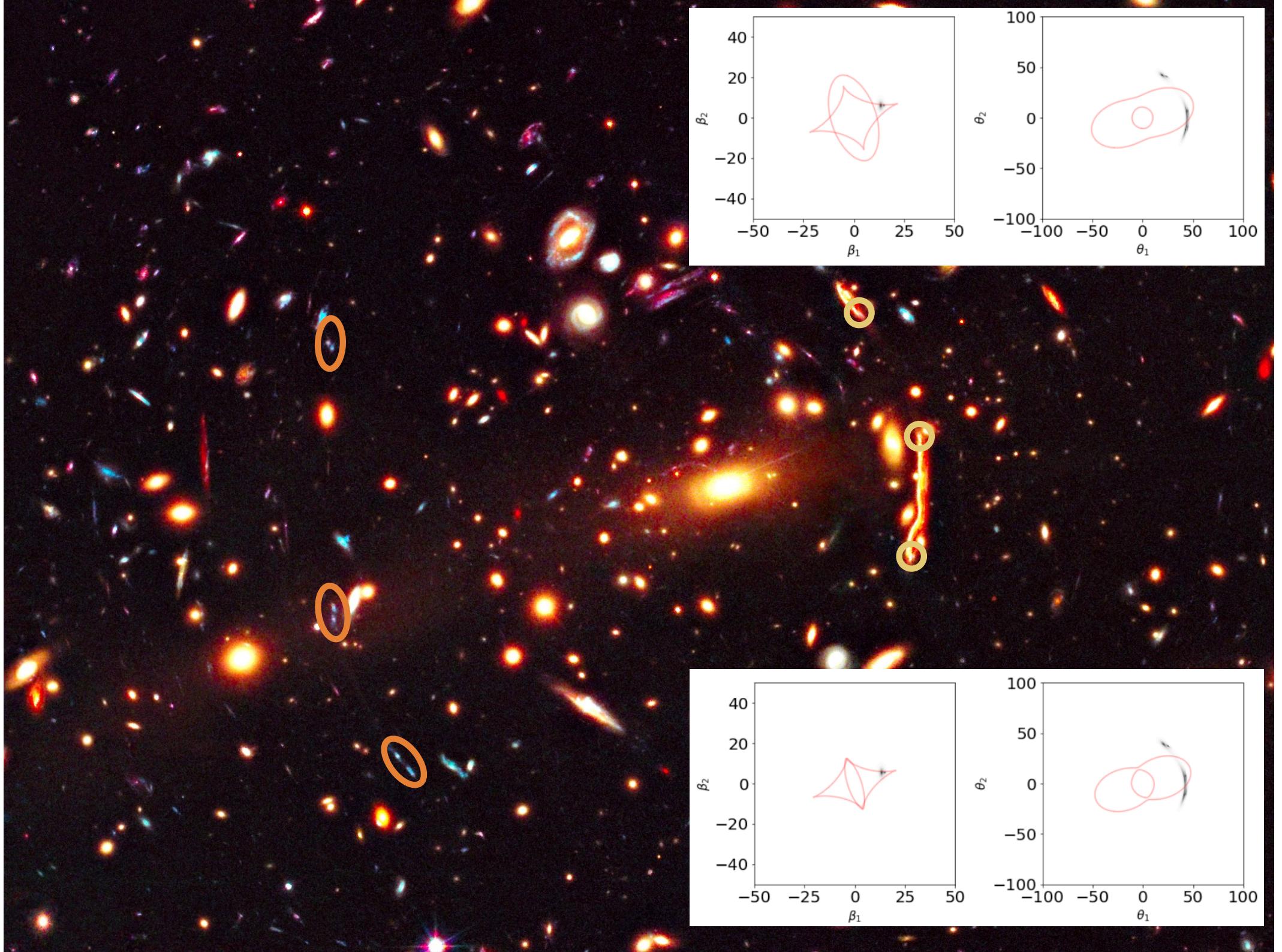
- In order to build a strong lensing model of a galaxy cluster, we must first find **families of multiple images** to use as constraints
- For this, it is very important to have **high resolution imaging data** (at the moment, the only option is **HST**):
 - Images of extended sources typically have **features** that can be identified in the multiple images
 - The **parity** changes help recognising conjugate images
- **Colors** also help separating the lensed sources from the cluster galaxies:
 - Cluster galaxies are typically red elliptical galaxies (but not only)
 - Background galaxies typically have different spectro-morphological types (colors)

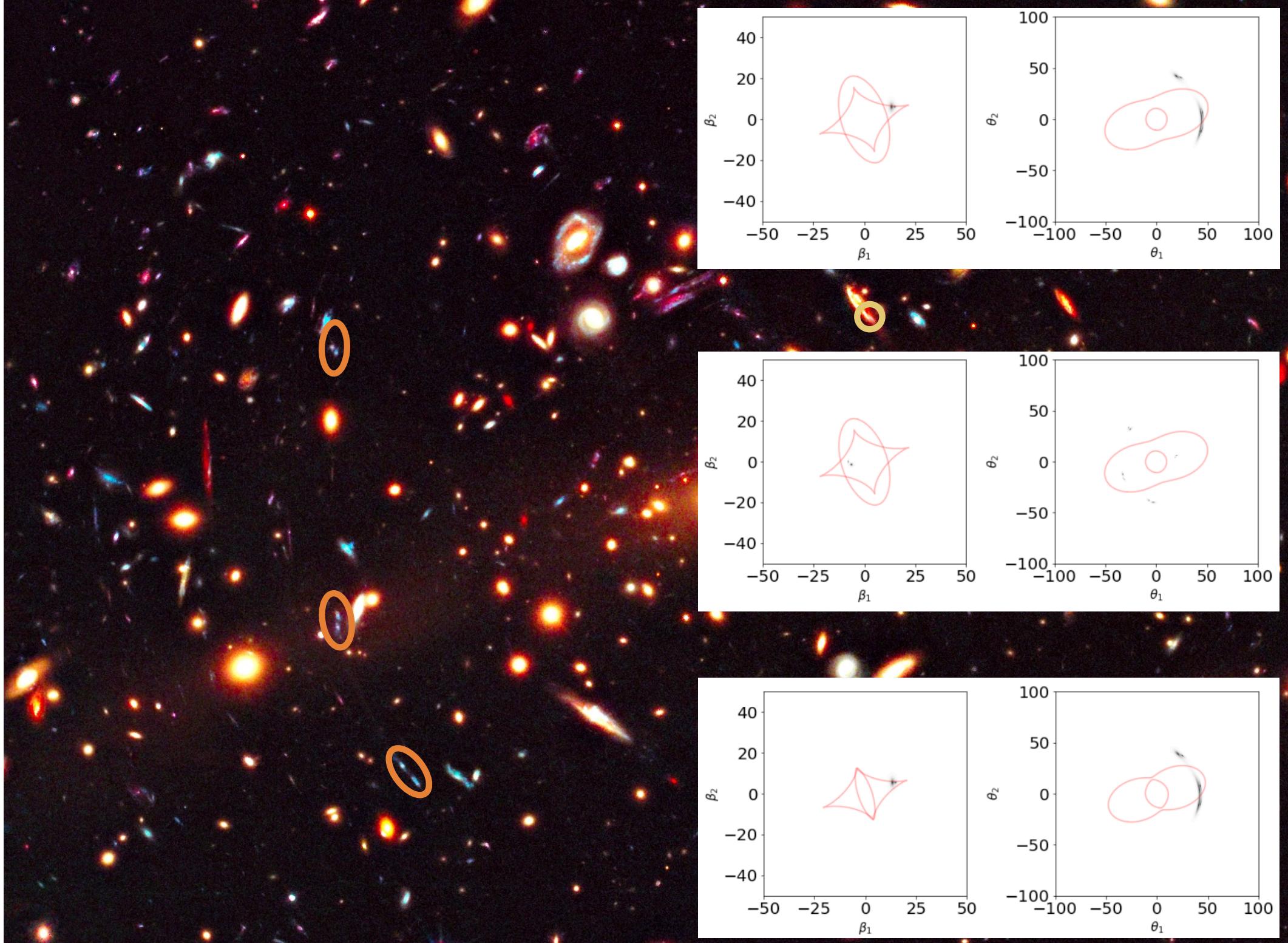


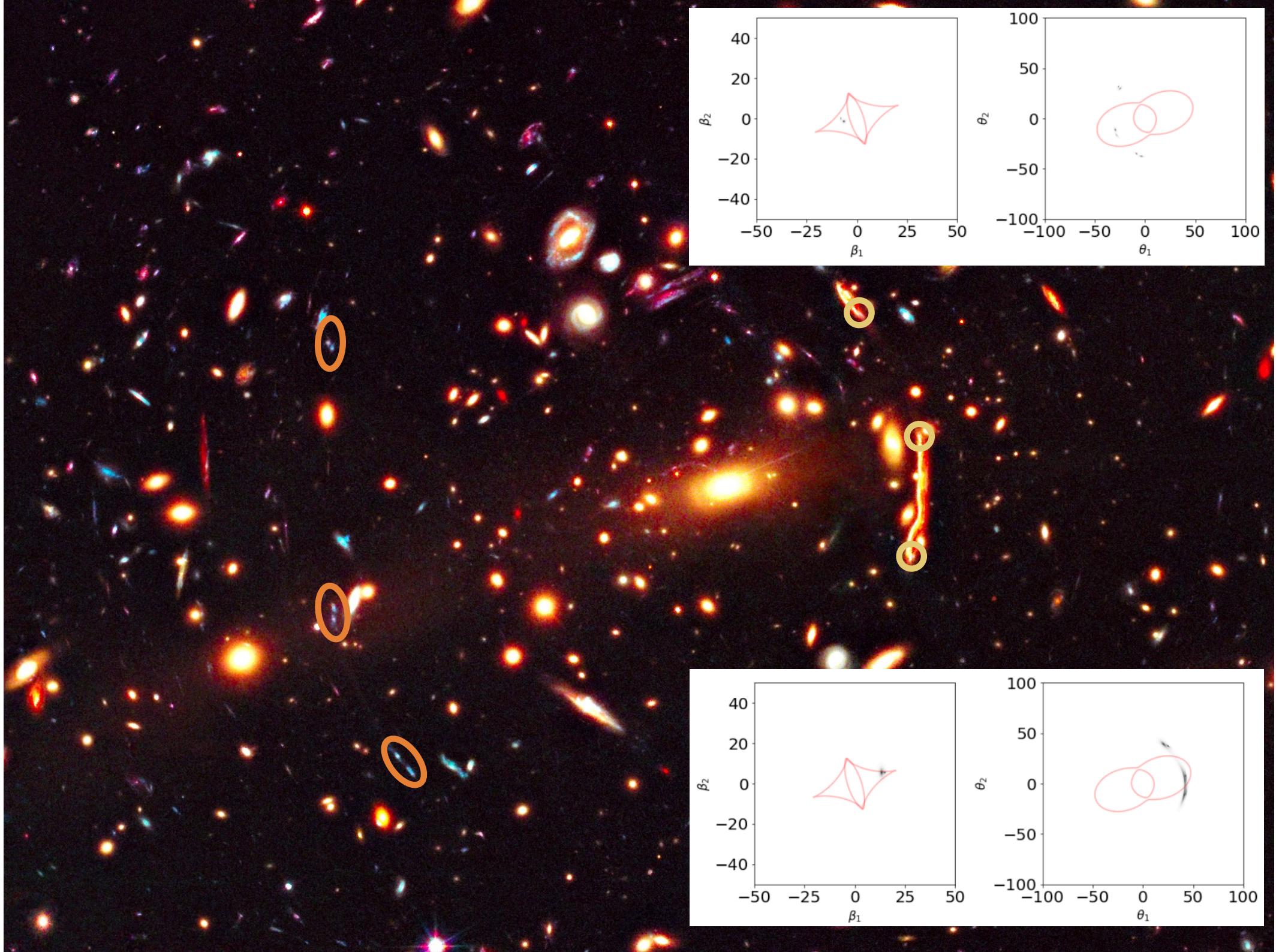


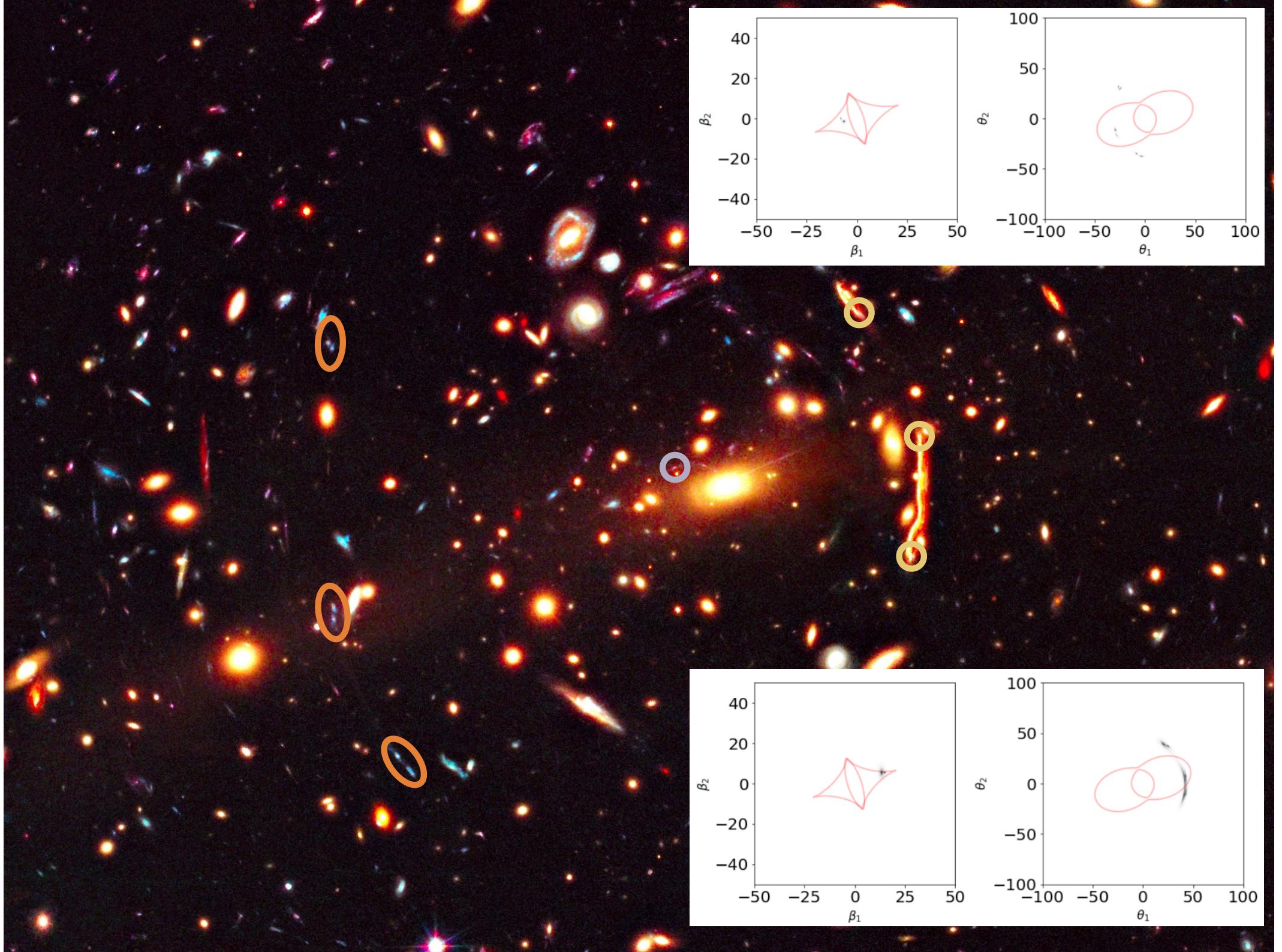


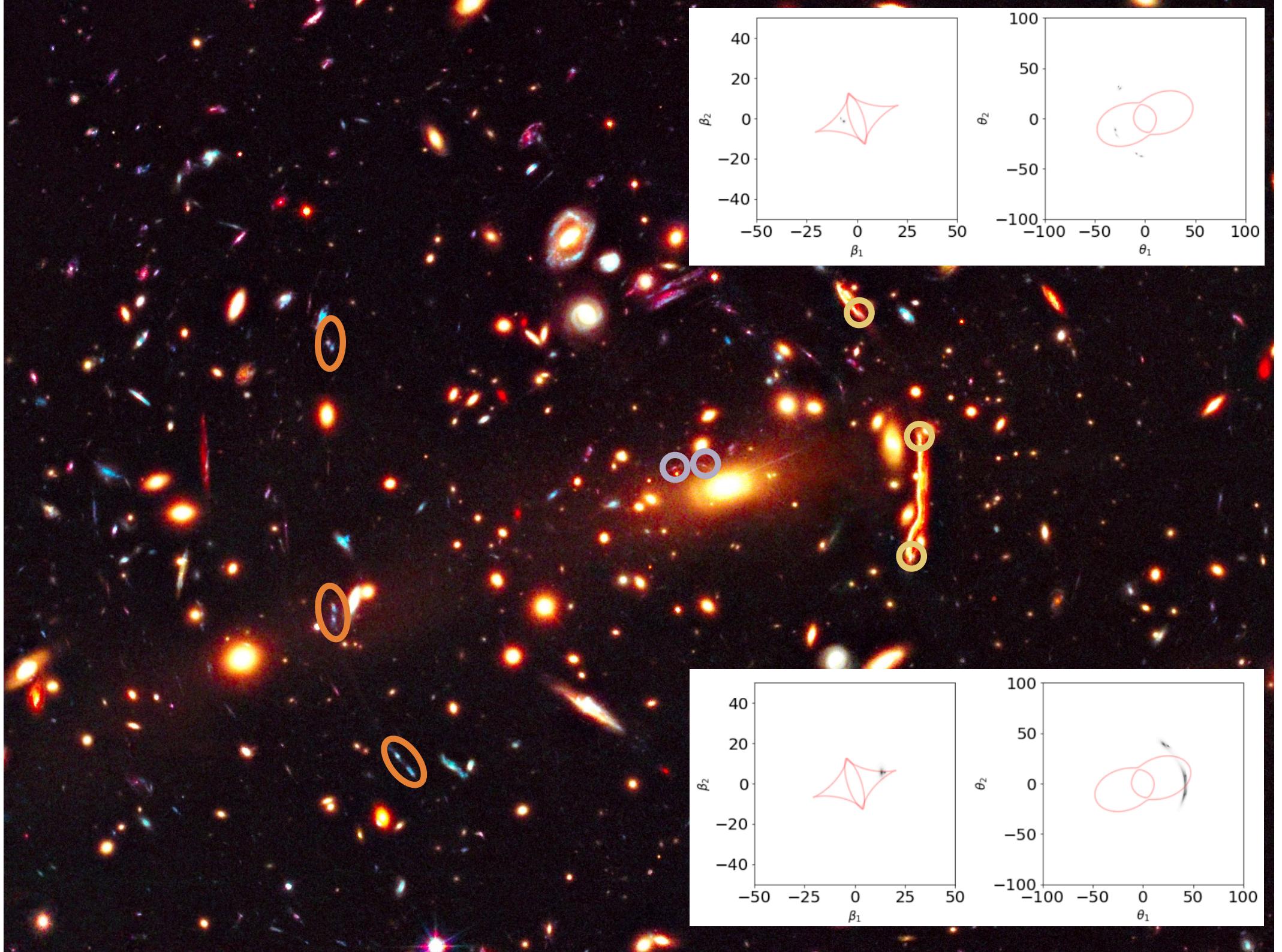


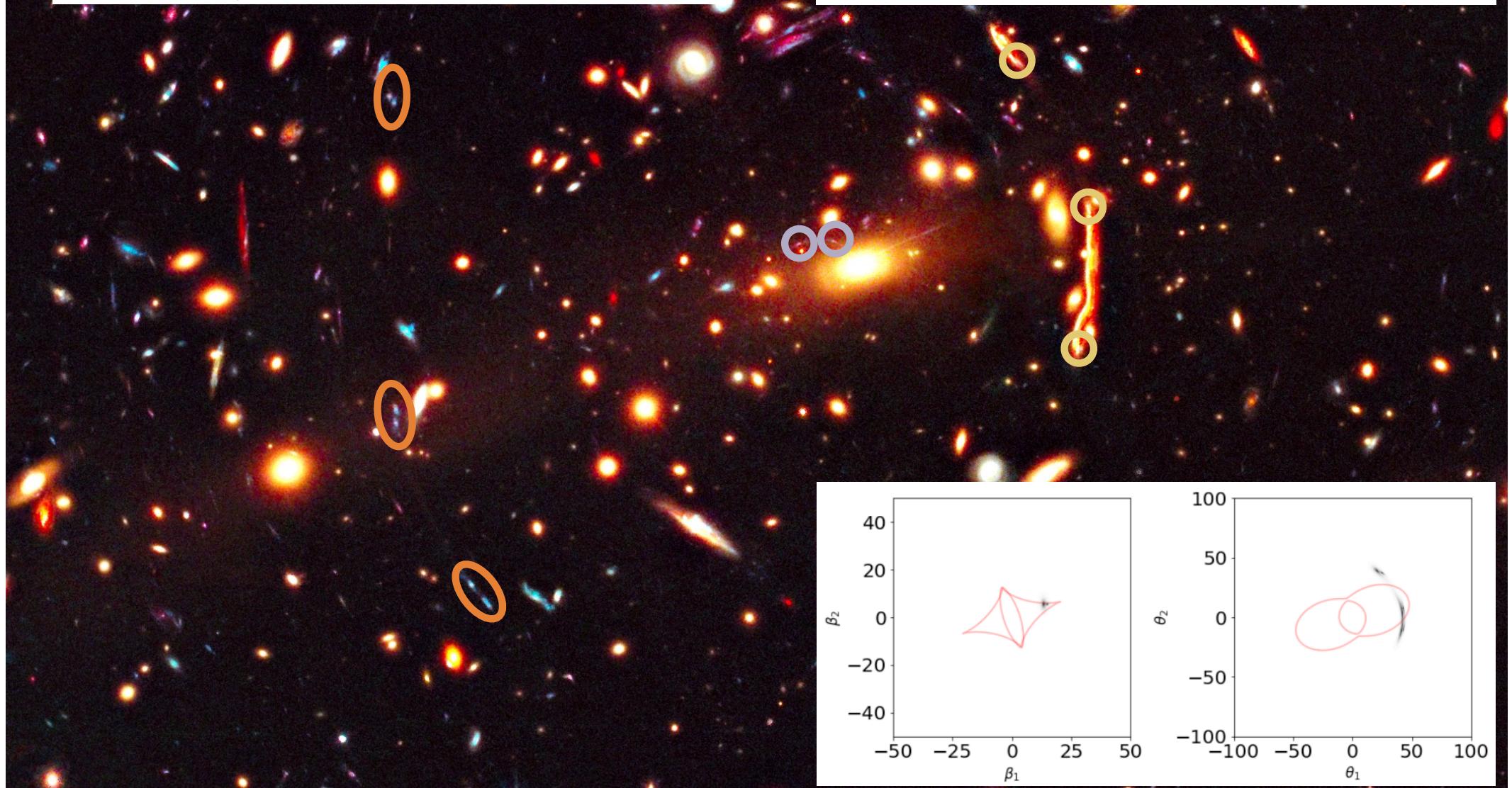
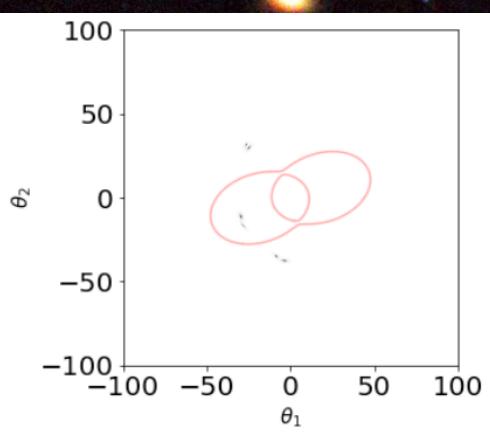
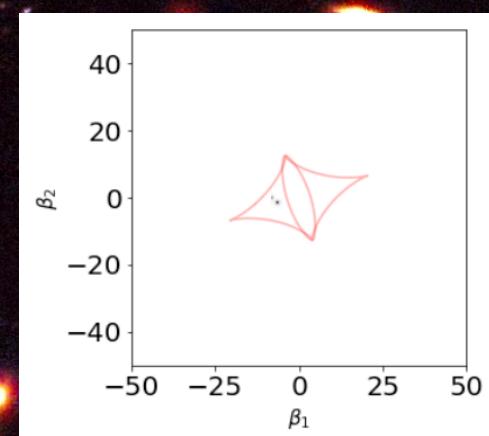
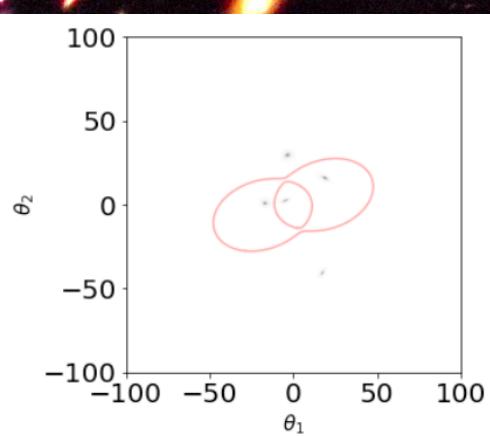
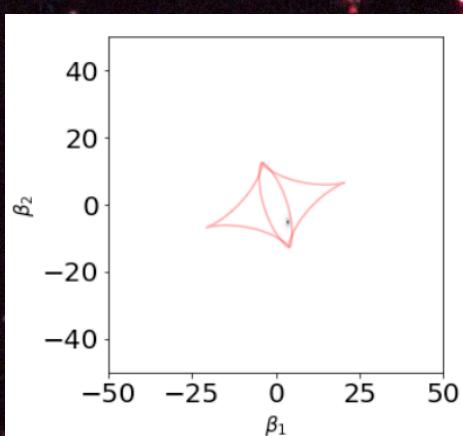


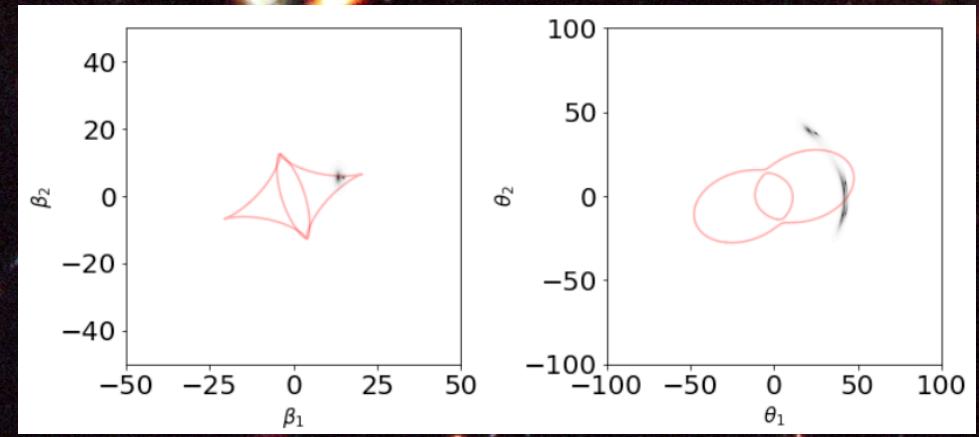
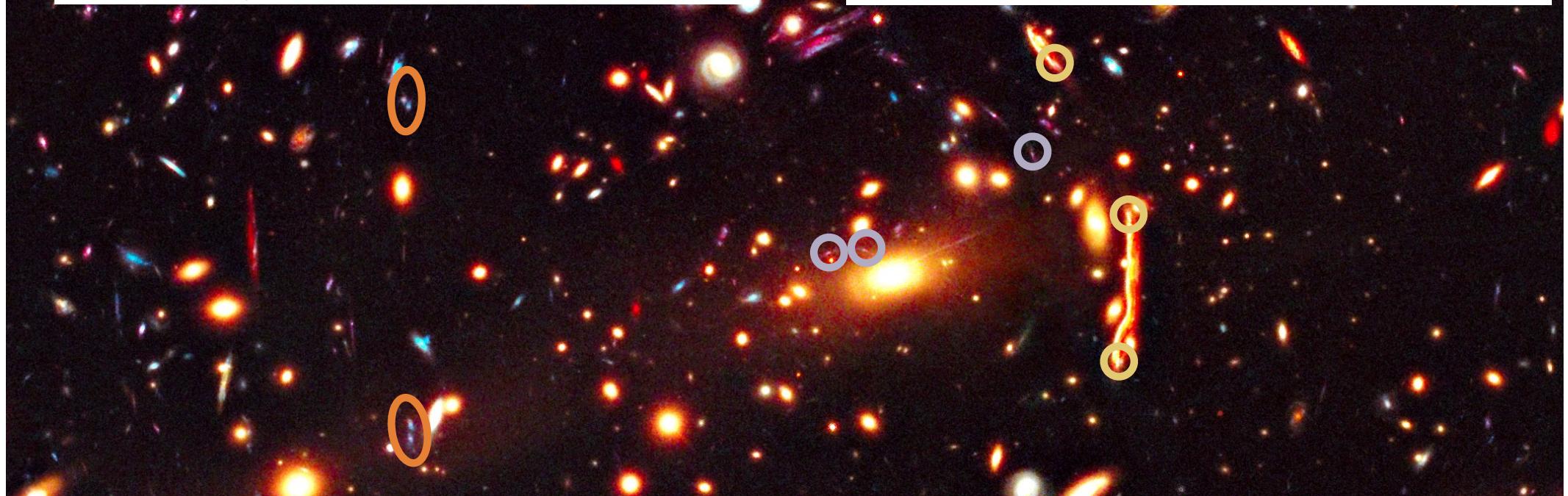
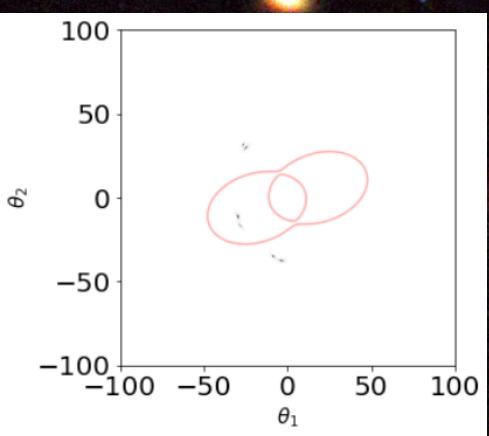
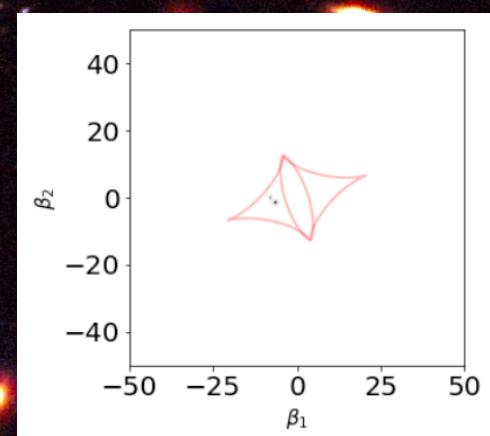
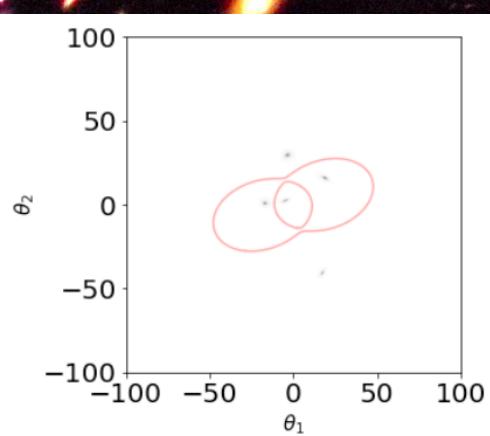
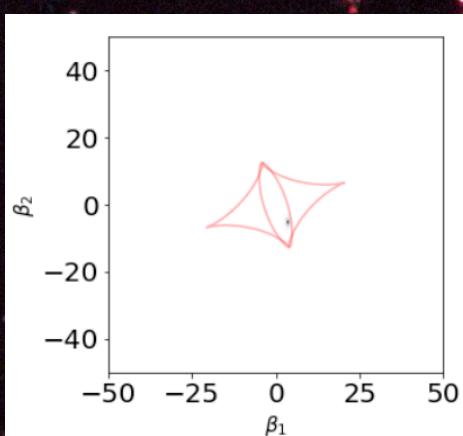


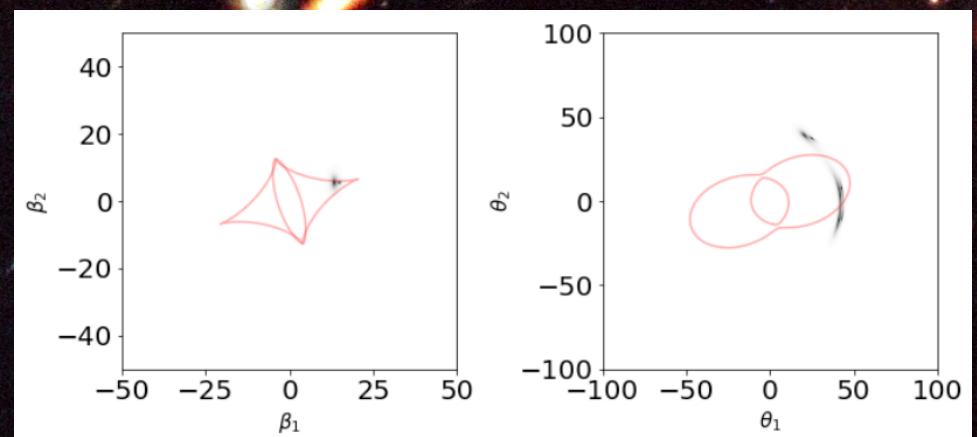
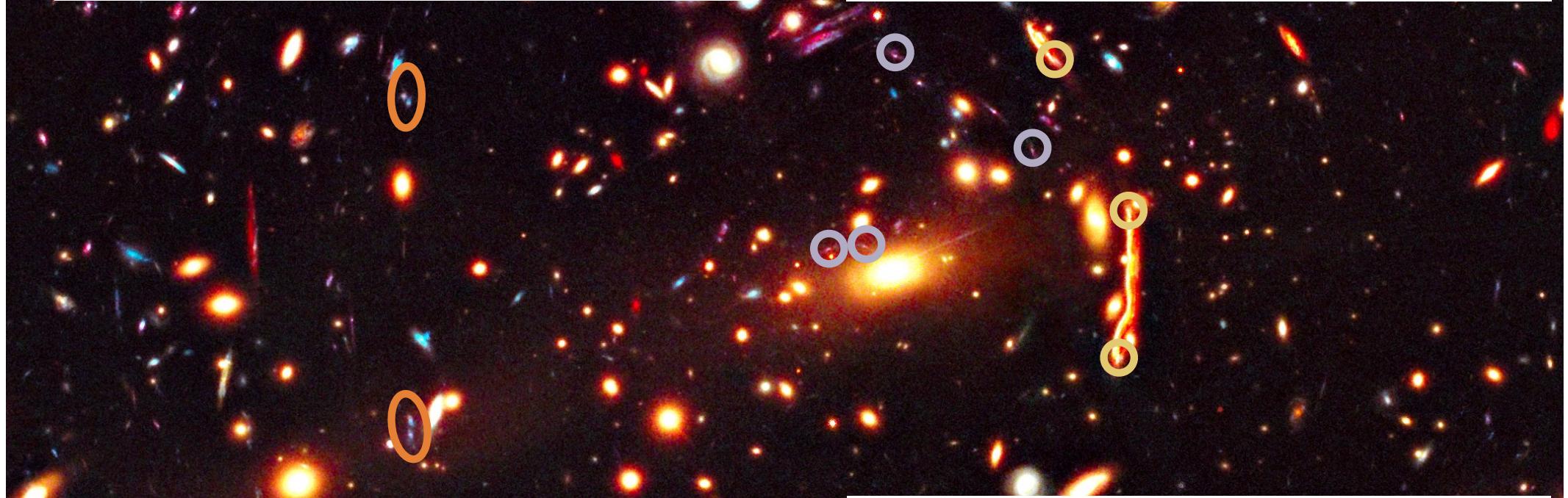
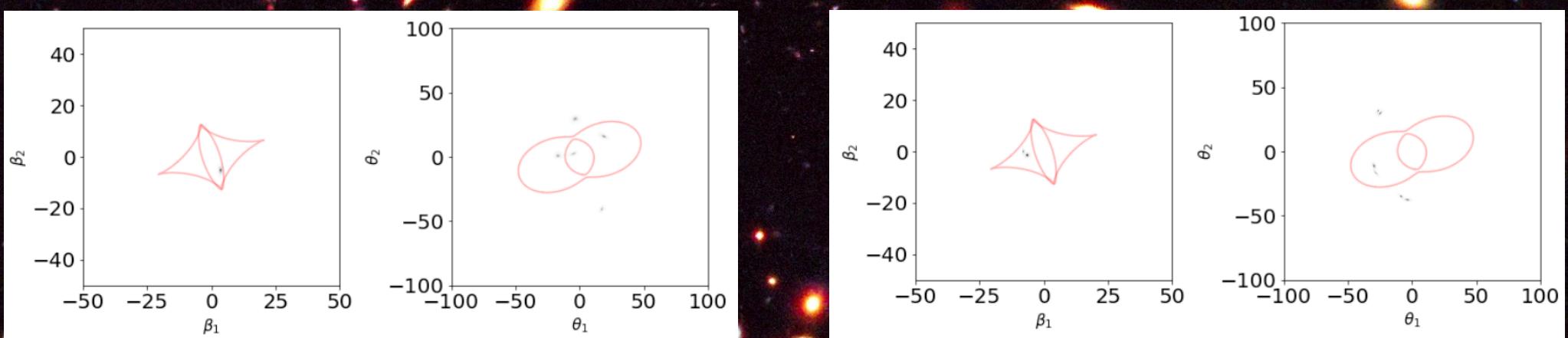


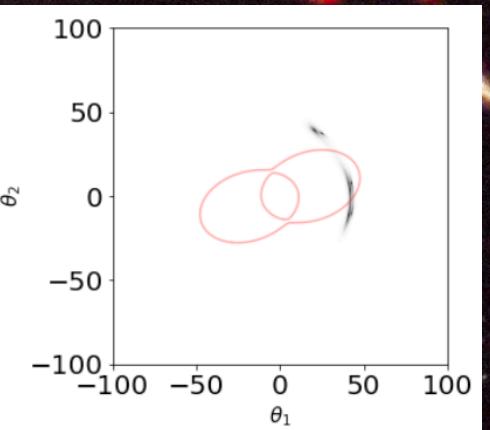
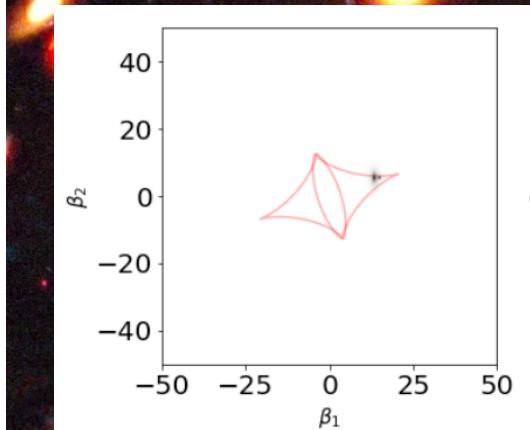
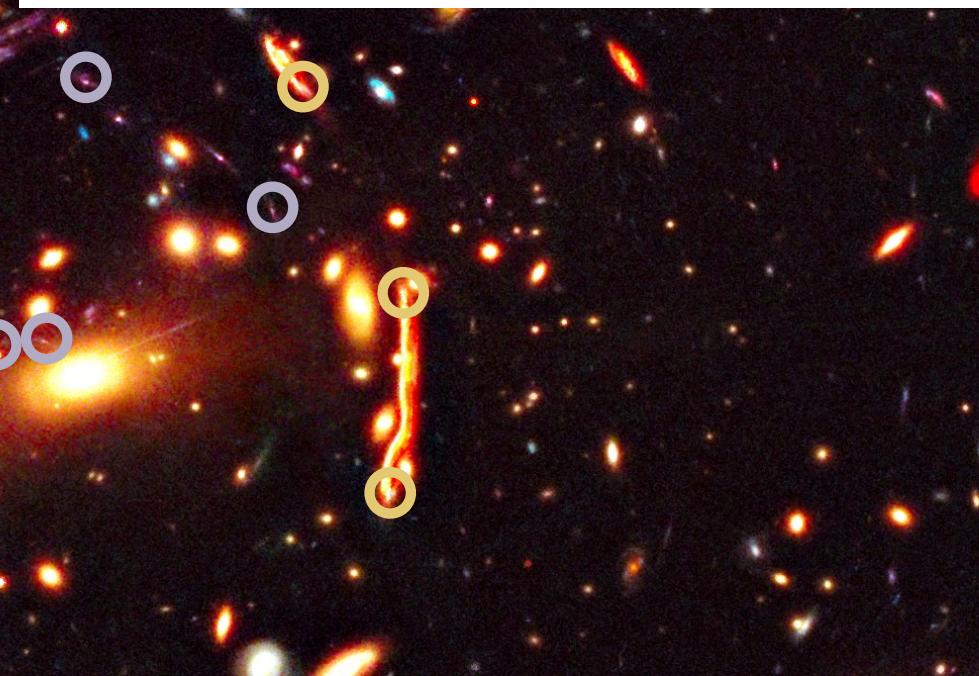
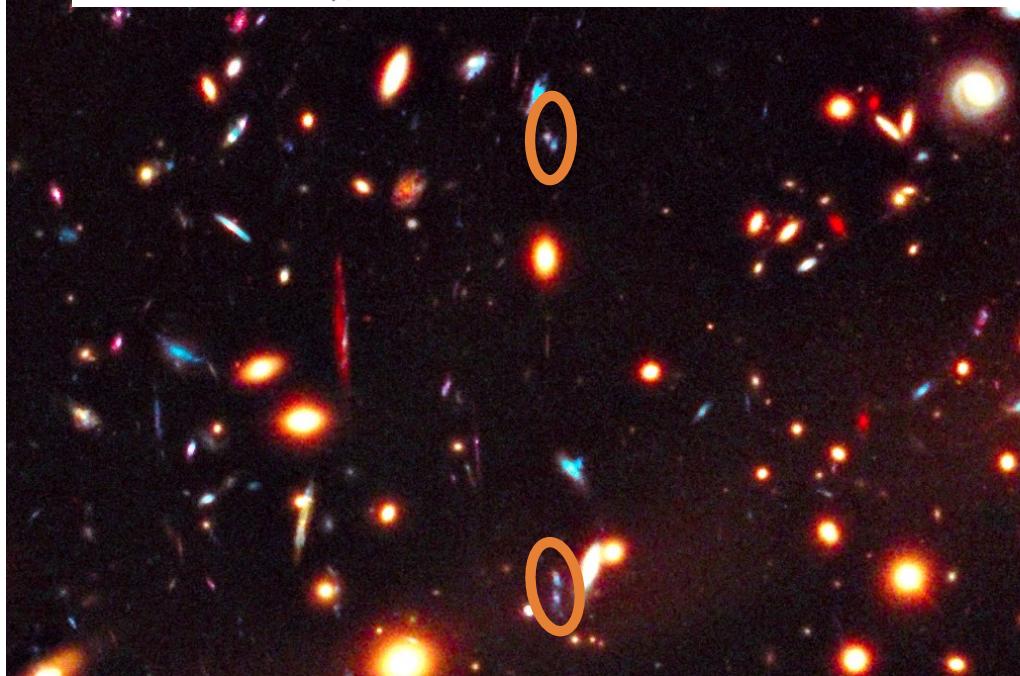
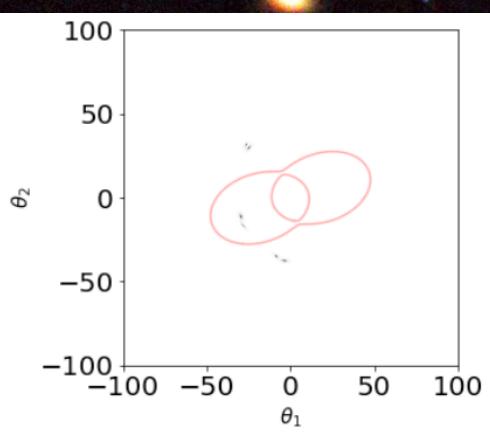
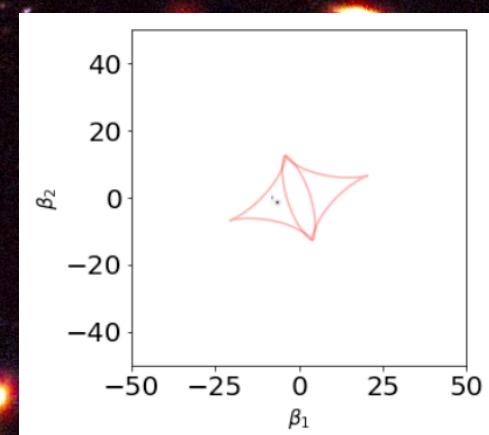
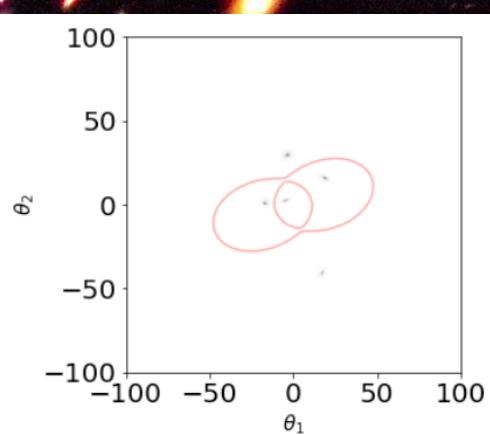
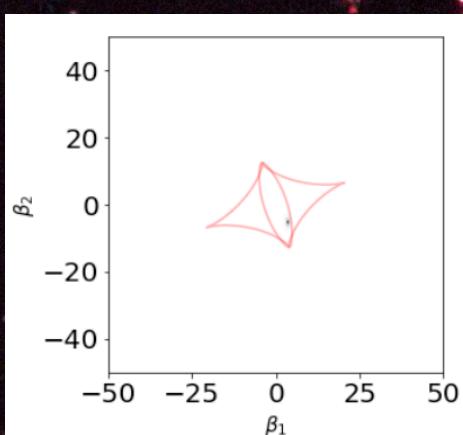


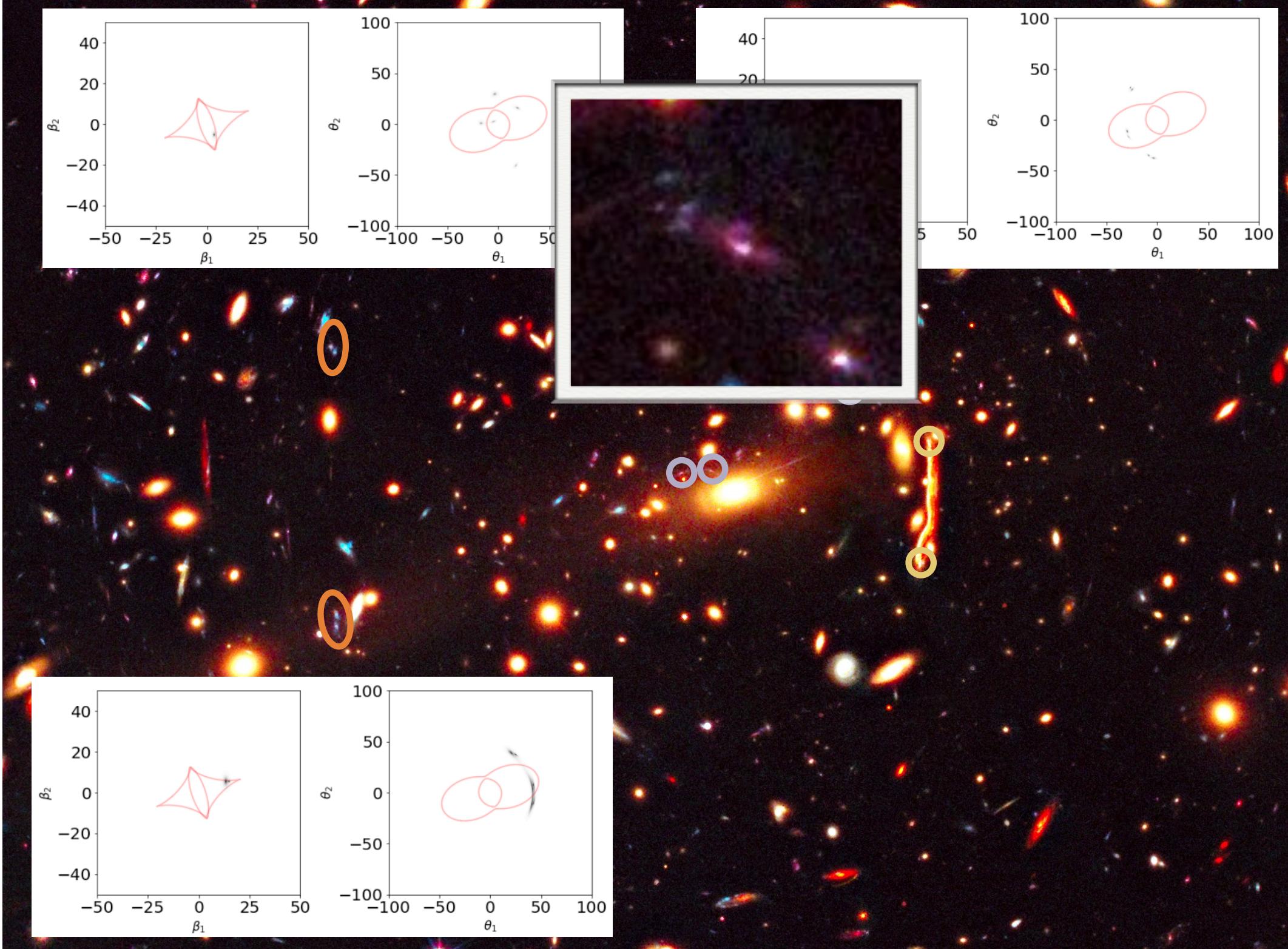


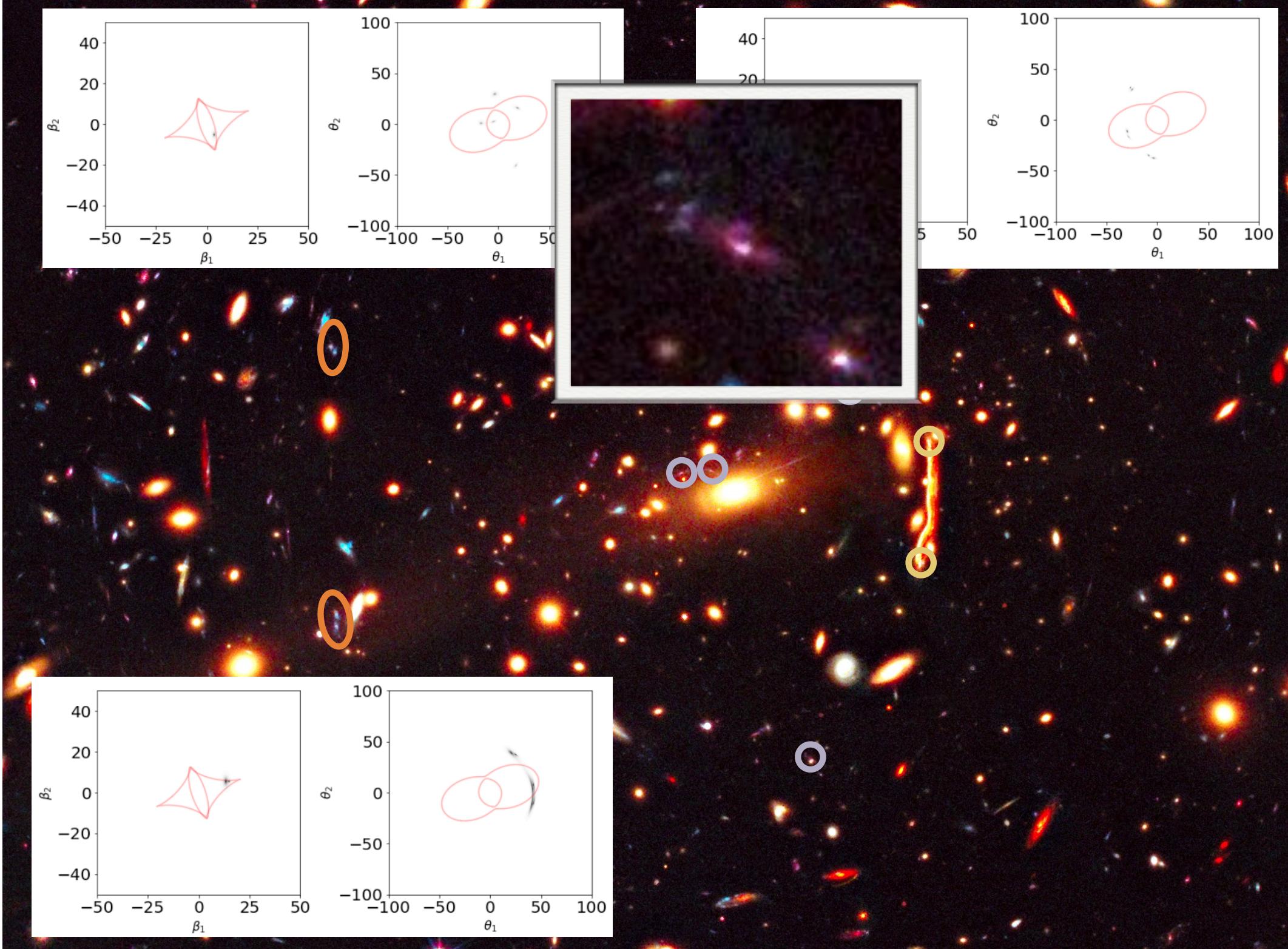


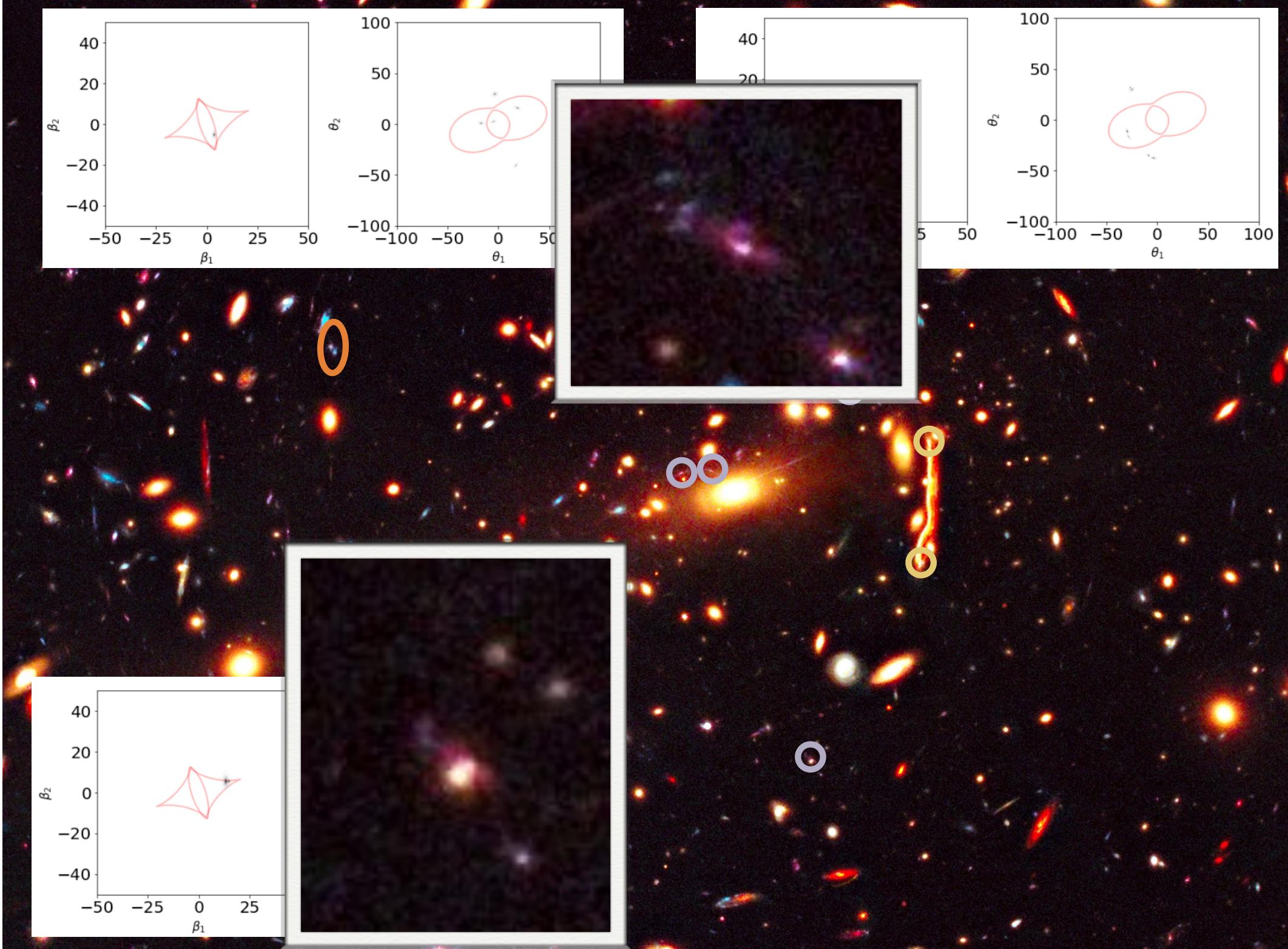






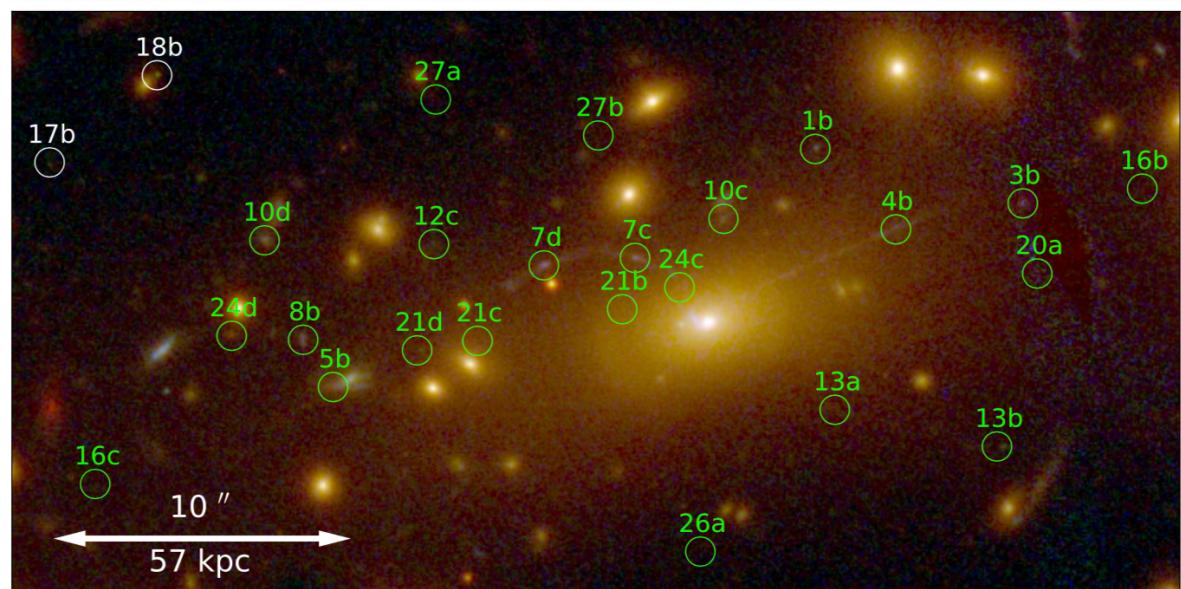
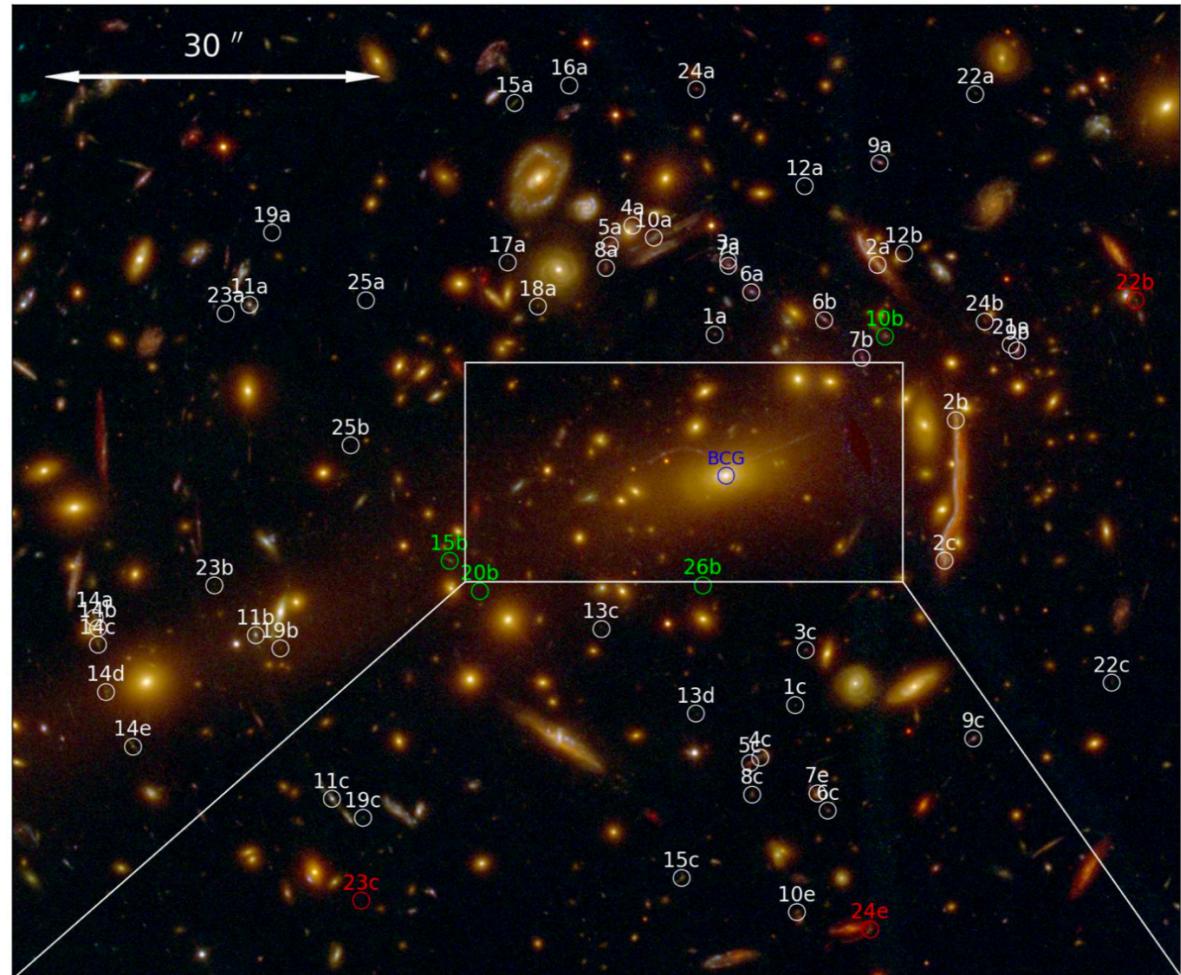






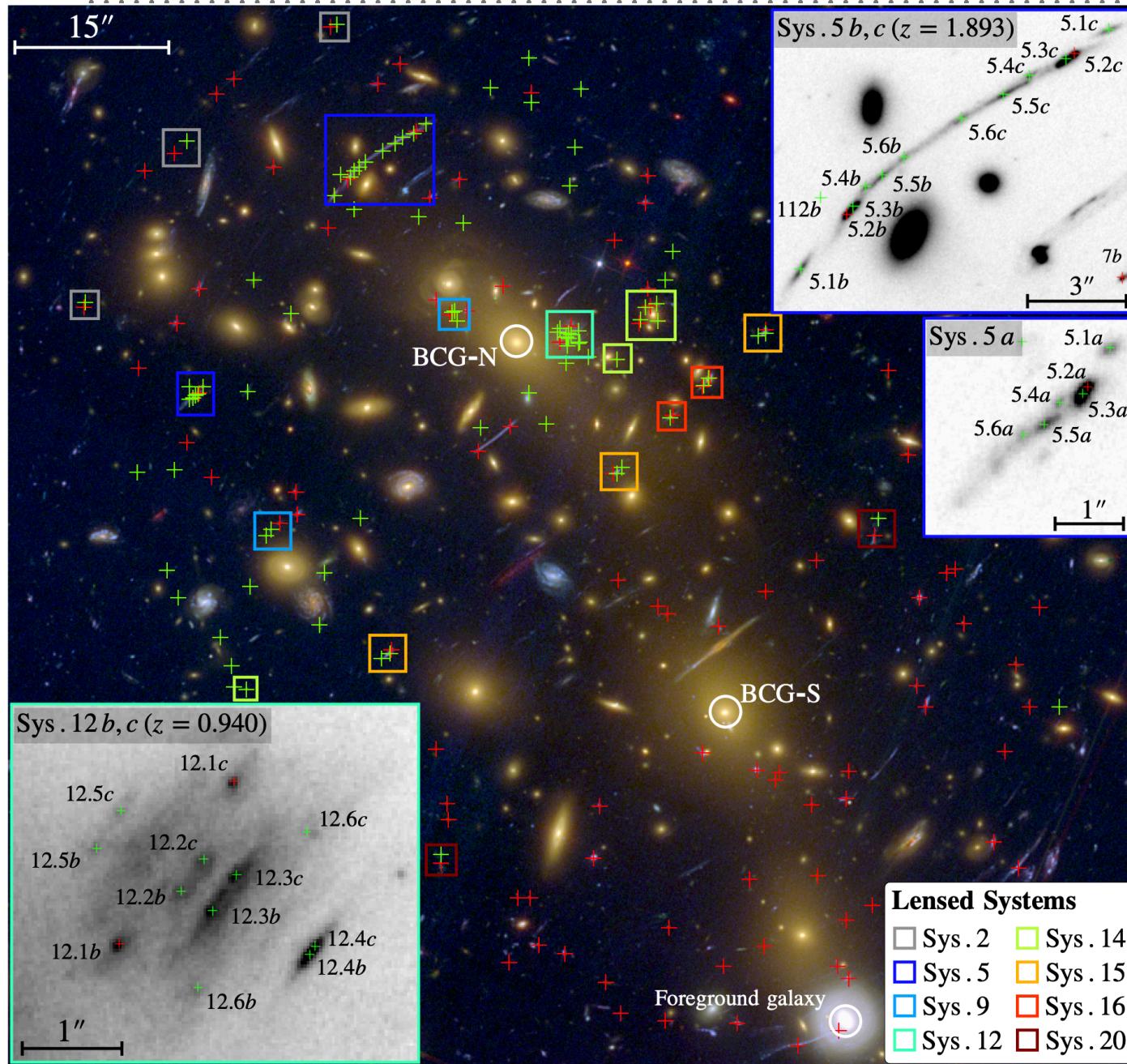
MACSJ1206

- 27 families of multiple images; 82 multiple images in total
- $z=[1.0-6.1]$
- Cluster redshift: $z=0.44$



Caminha et al. 2018

MULTIPLE KNOTS IN THE SAME SOURCE



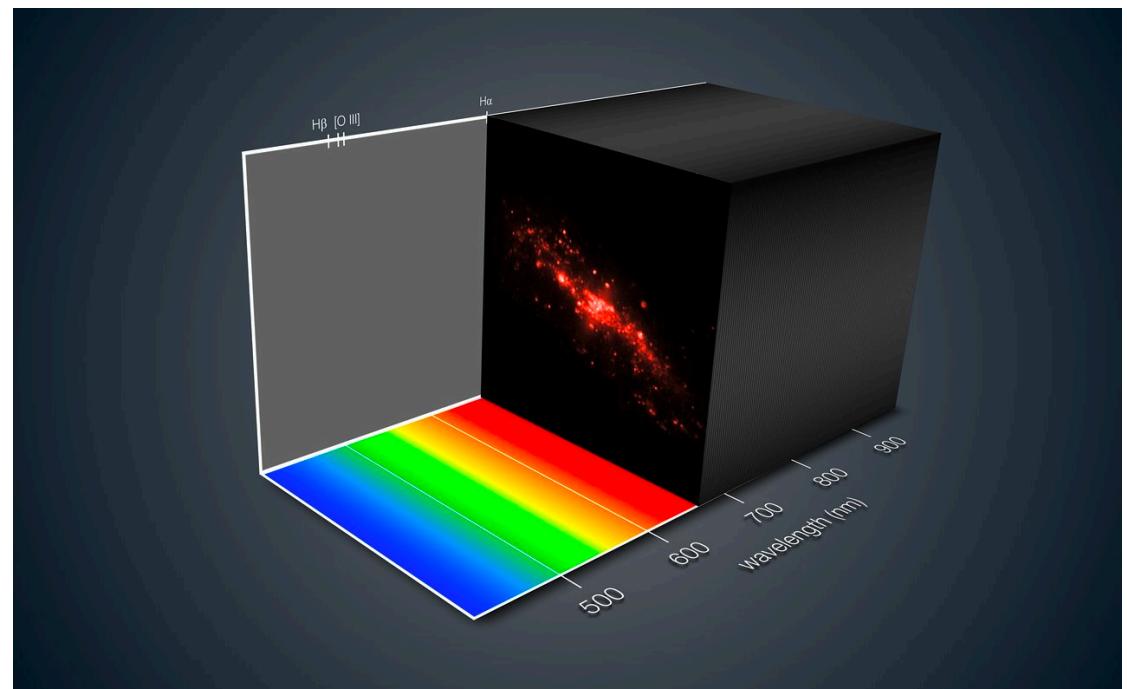
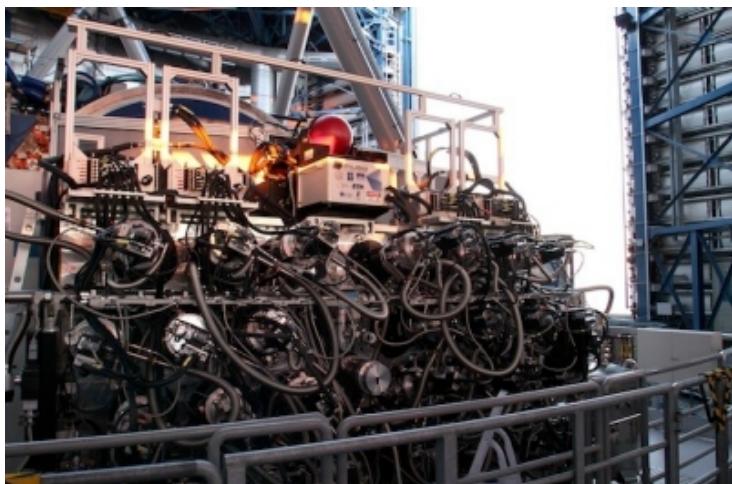
Knots (e.g. compact star formation regions, globular clusters, etc) within the same source can be used as additional constraints to build the model

MACSJ0416

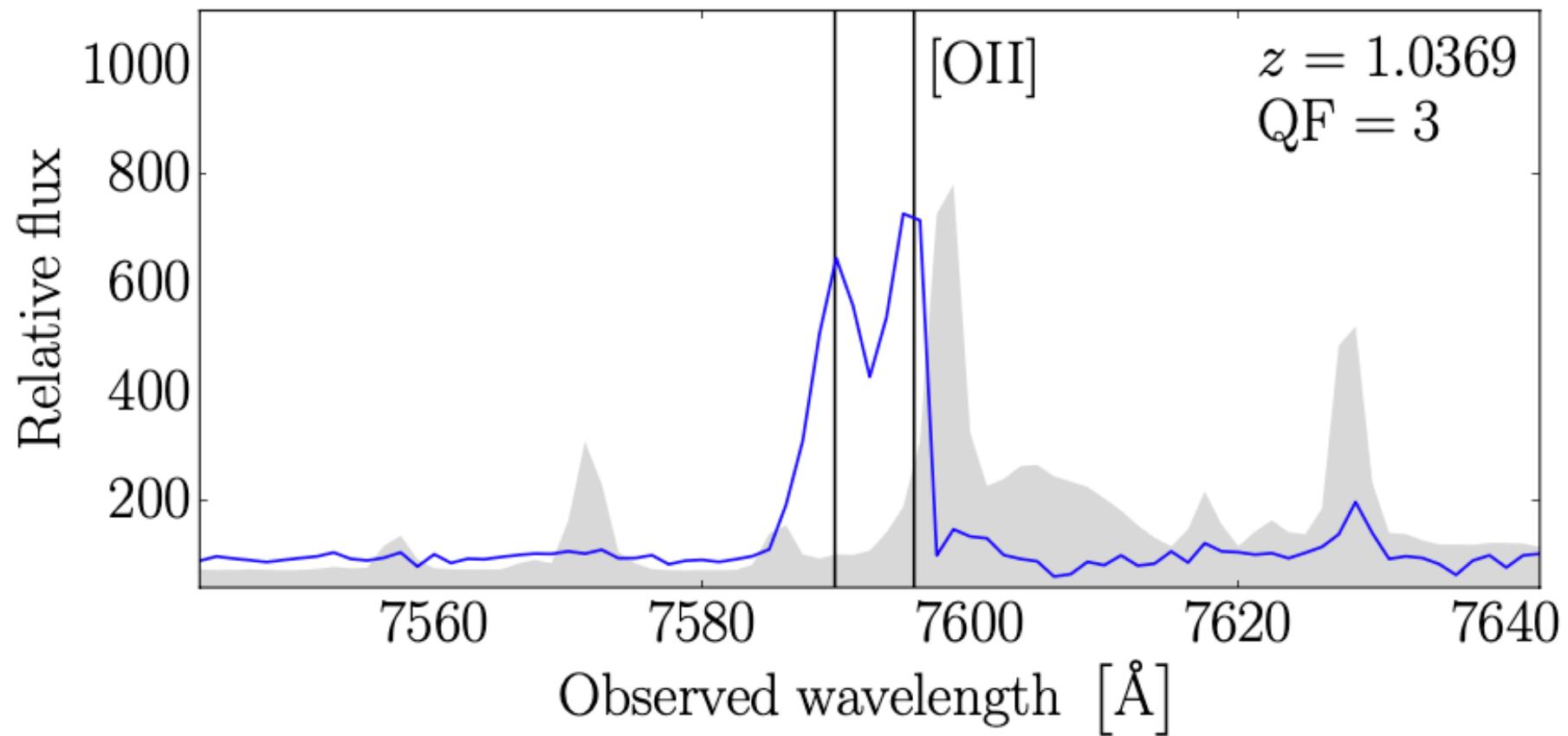
Bergamini et al. 2020

RECENT ADVANCEMENTS: MUSE (THE MULTI-UNIT SPECTROSCOPIC EXPLORER) @VLT

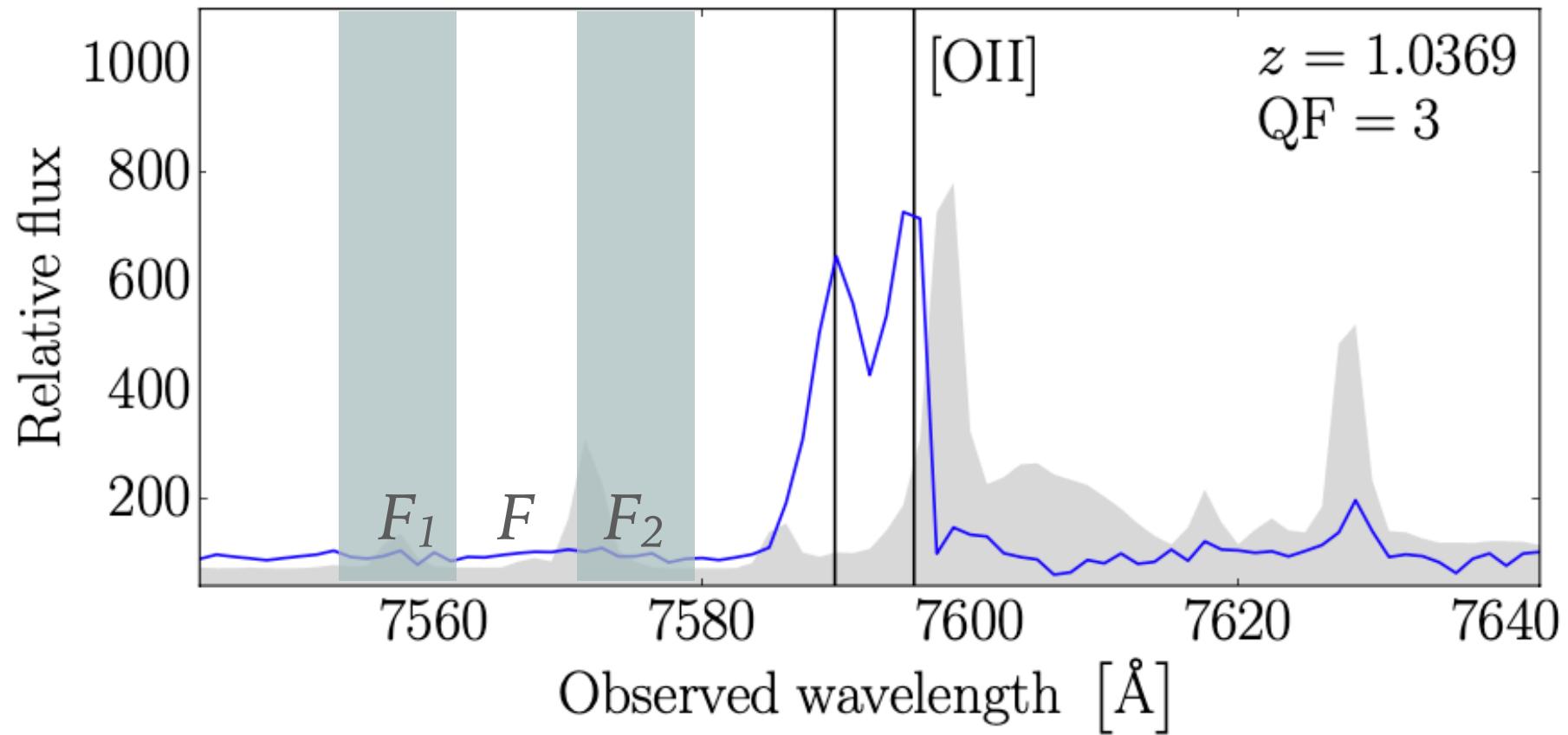
- an Integral Field Spectrograph located at the Nasmyth B focus of Yepun, the VLT UT4 telescope.
- It has a modular structure composed of 24 identical IFU modules that together sample, in Wide Field Mode (WFM), a near-contiguous 1 squared arcmin field of view.
- Spectrally the instrument samples almost the full optical domain with a mean resolution of 3000.
- Spatially, the instrument samples the sky with 0.2 arcseconds spatial pixels in the currently offered Wide Field Mode with natural seeing (WFM-noAO).
- E.g. Ly-a emission up to $z=6.5$



EXAMPLE

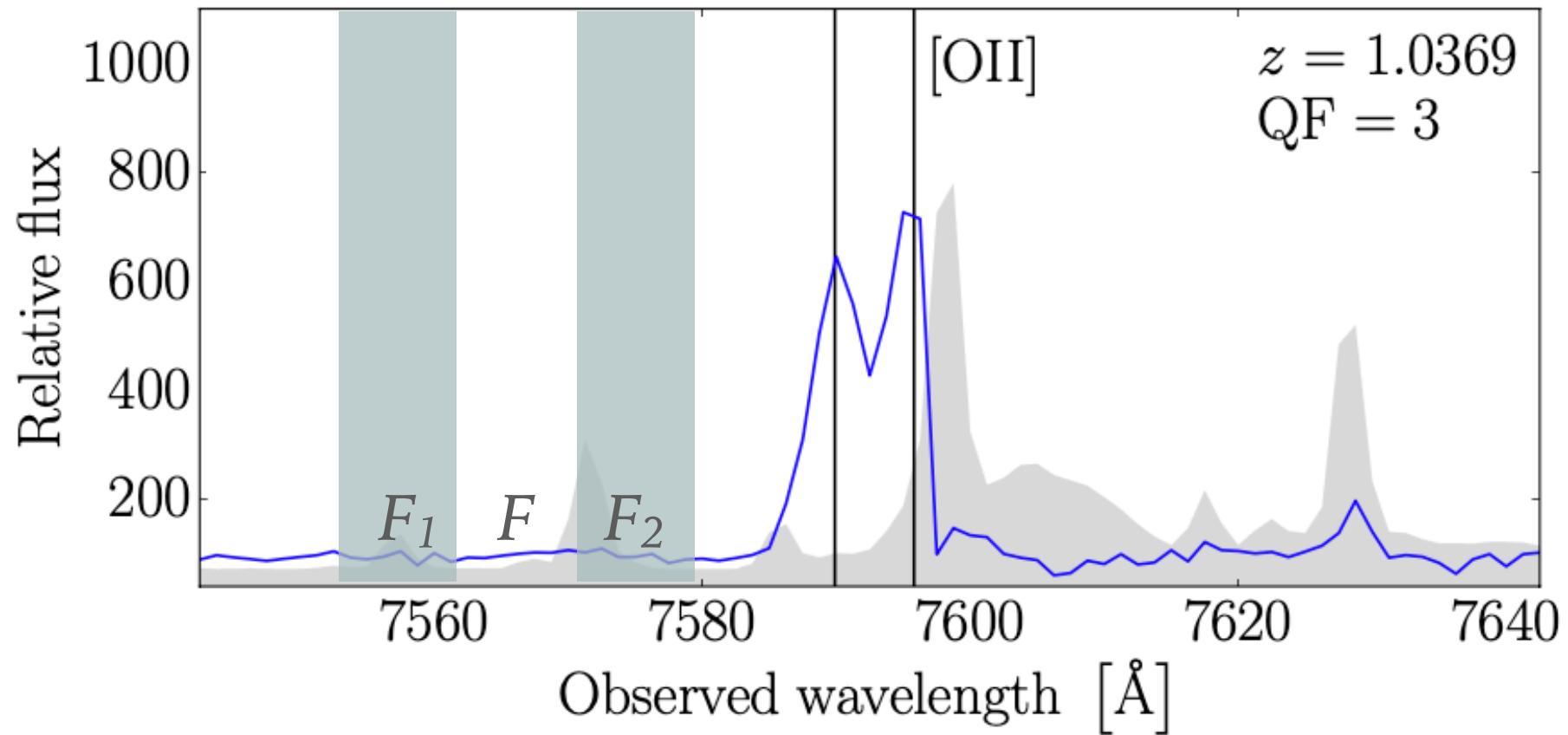


EXAMPLE



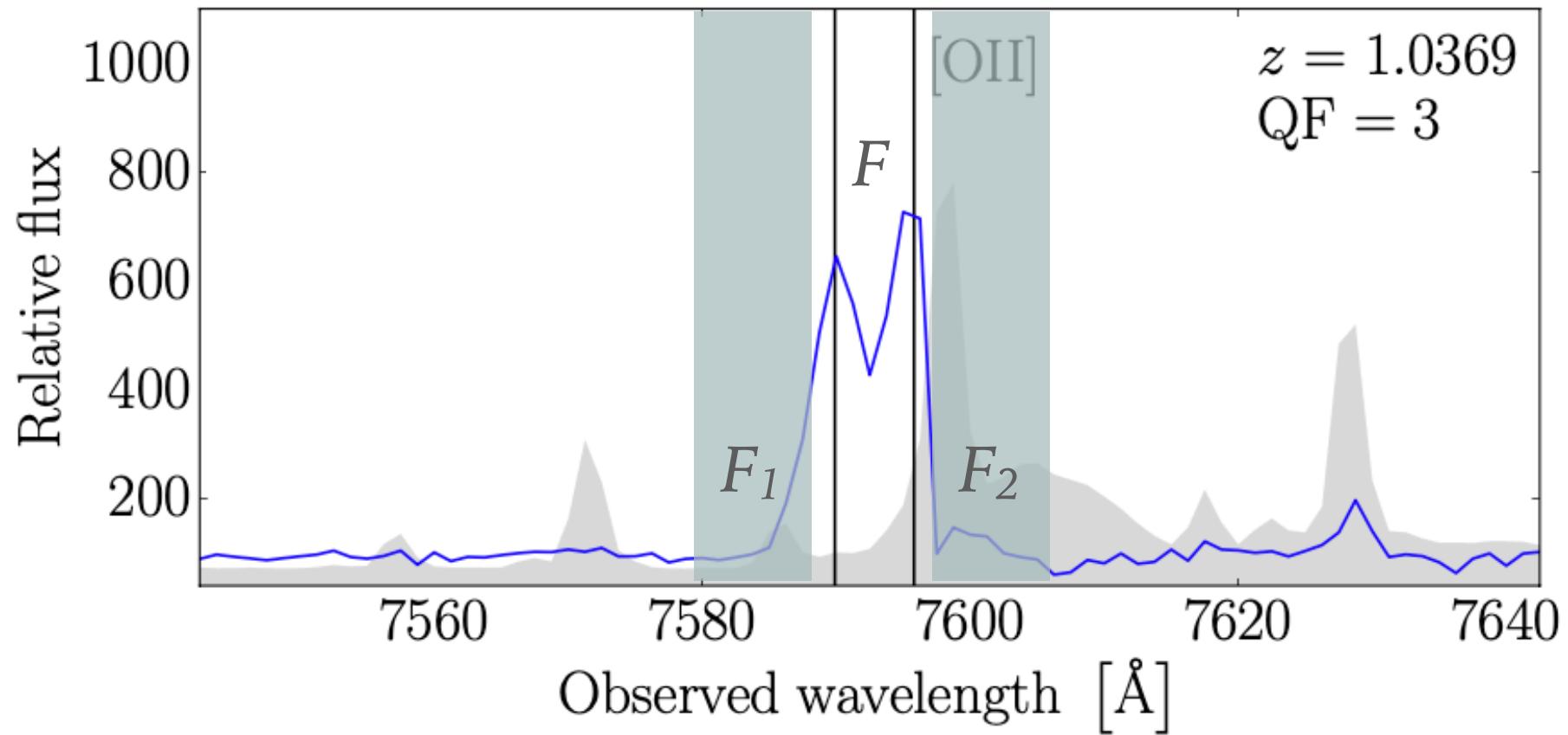
$$F - \frac{(F_1 + F_2)}{2} \simeq ?$$

EXAMPLE



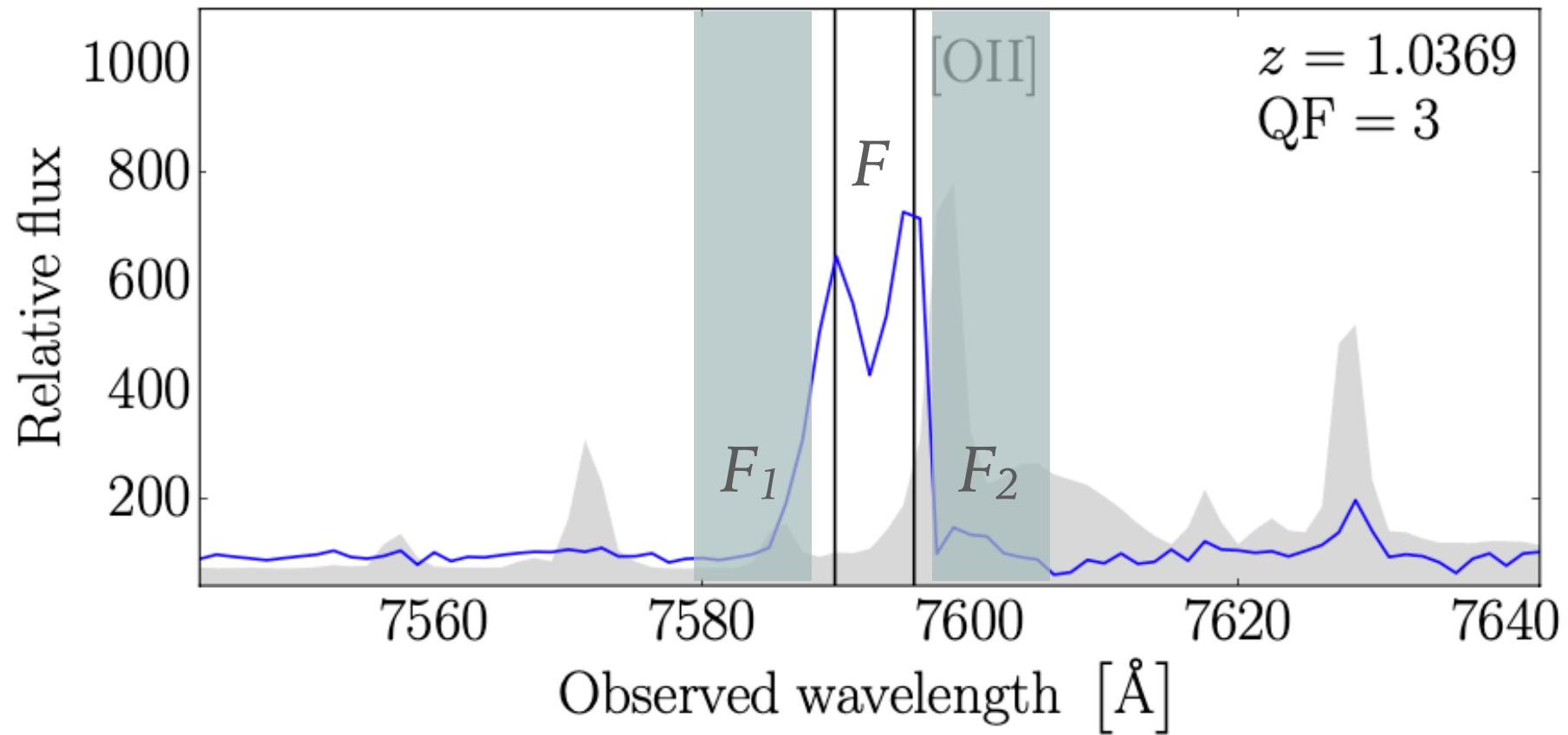
$$F - \frac{(F_1 + F_2)}{2} \approx 0$$

EXAMPLE



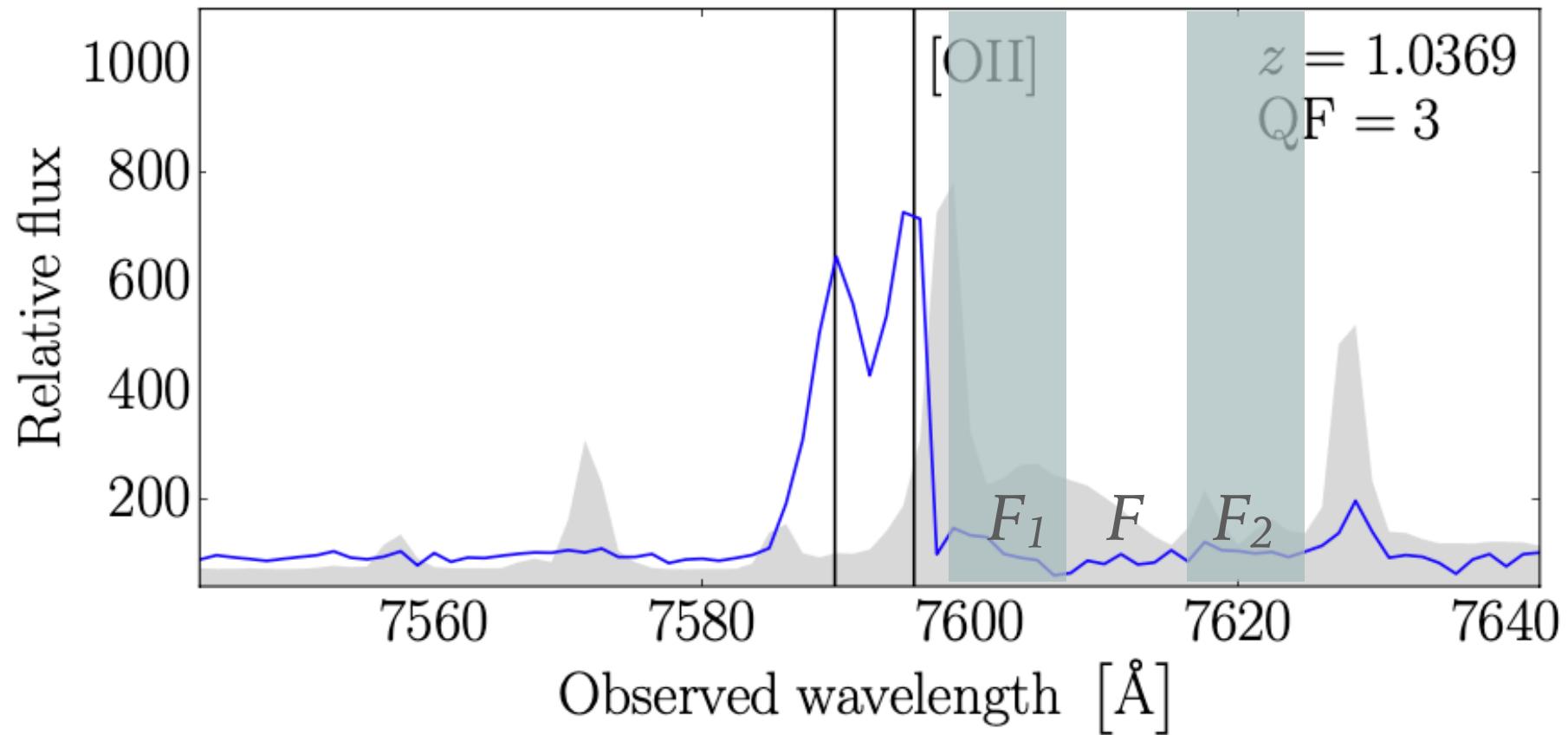
$$F - \frac{(F_1 + F_2)}{2} \simeq ?$$

EXAMPLE



$$F - \frac{(F_1 + F_2)}{2} > 0$$

EXAMPLE



$$F - \frac{(F_1 + F_2)}{2} \approx 0$$

