XLSSC 122 caught in the ACT of growing up

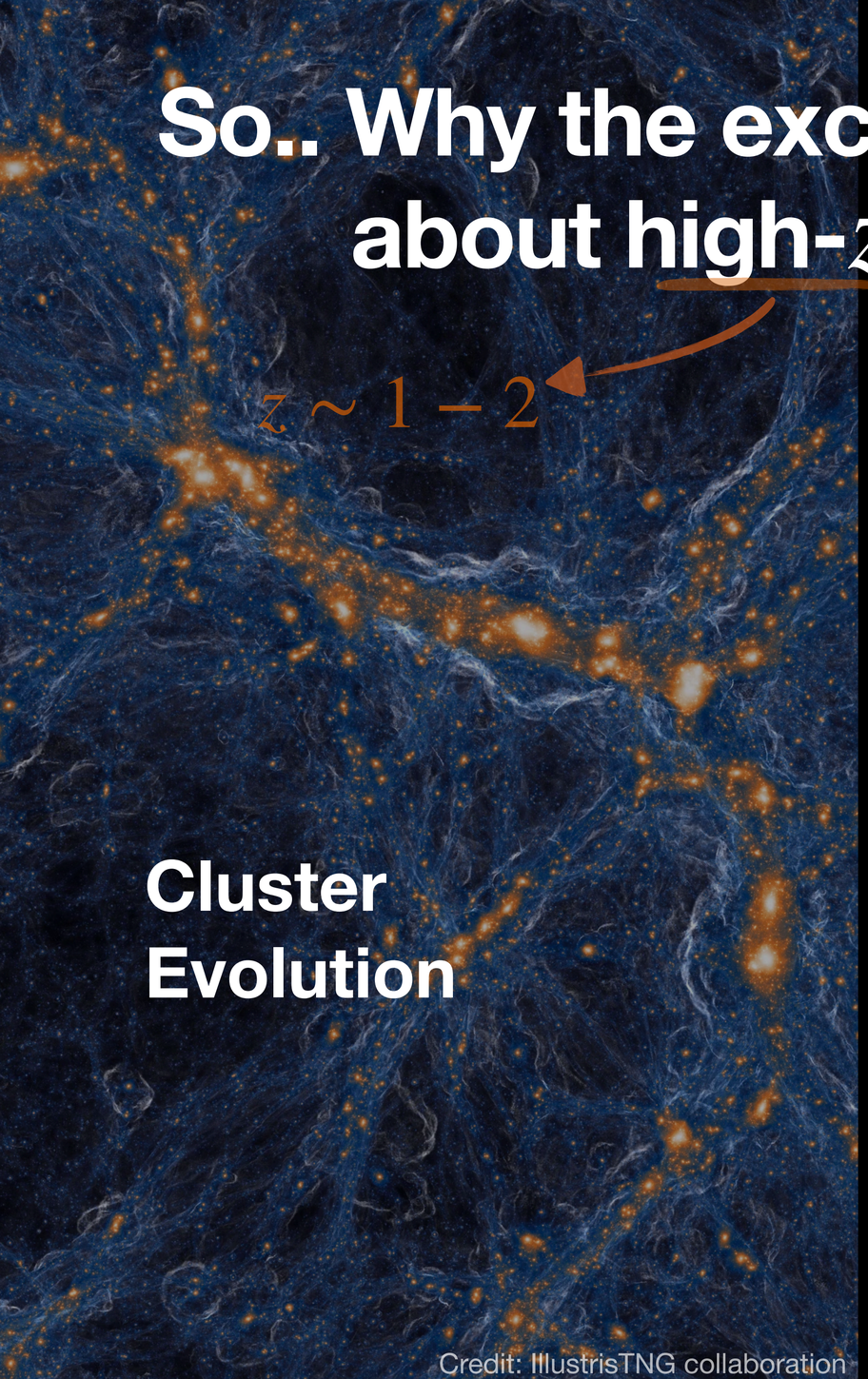
A somewhat mature cluster at $z = 1.98$

Joshiwa van Marrewijk,
Tony Mroczkowski, Luca Di Mascolo, Gergö Popping, and the ACT collaboration

So.. Why the excitement about high-z clusters?

$z \sim 1 - 2$

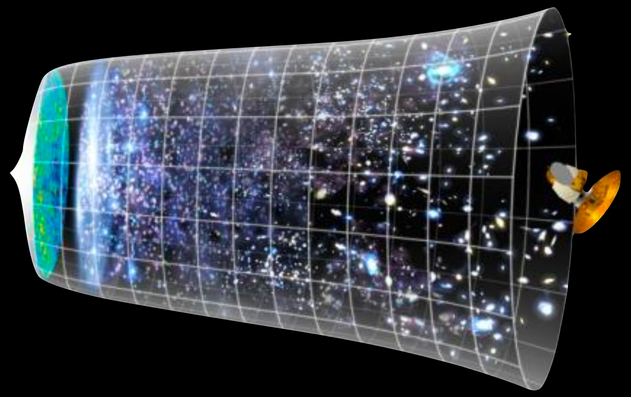
Cluster Evolution



Credit: IllustrisTNG collaboration

So.. Why the excitement about high-z clusters?

$z \sim 1 - 2$



Cluster Evolution

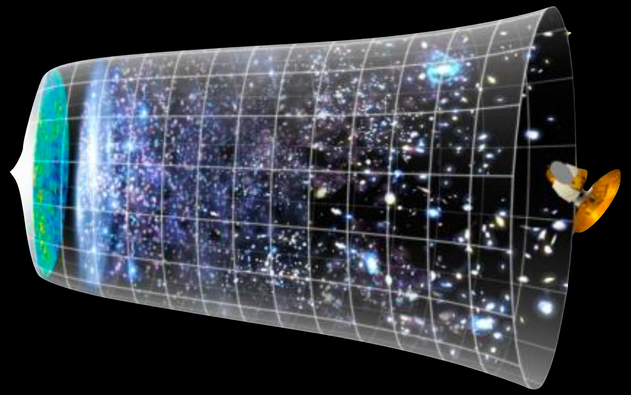
Cosmology

Credit: IllustrisTNG collaboration

So.. Why the excitement about high-z clusters?

$z \sim 1 - 2$

Cluster Evolution

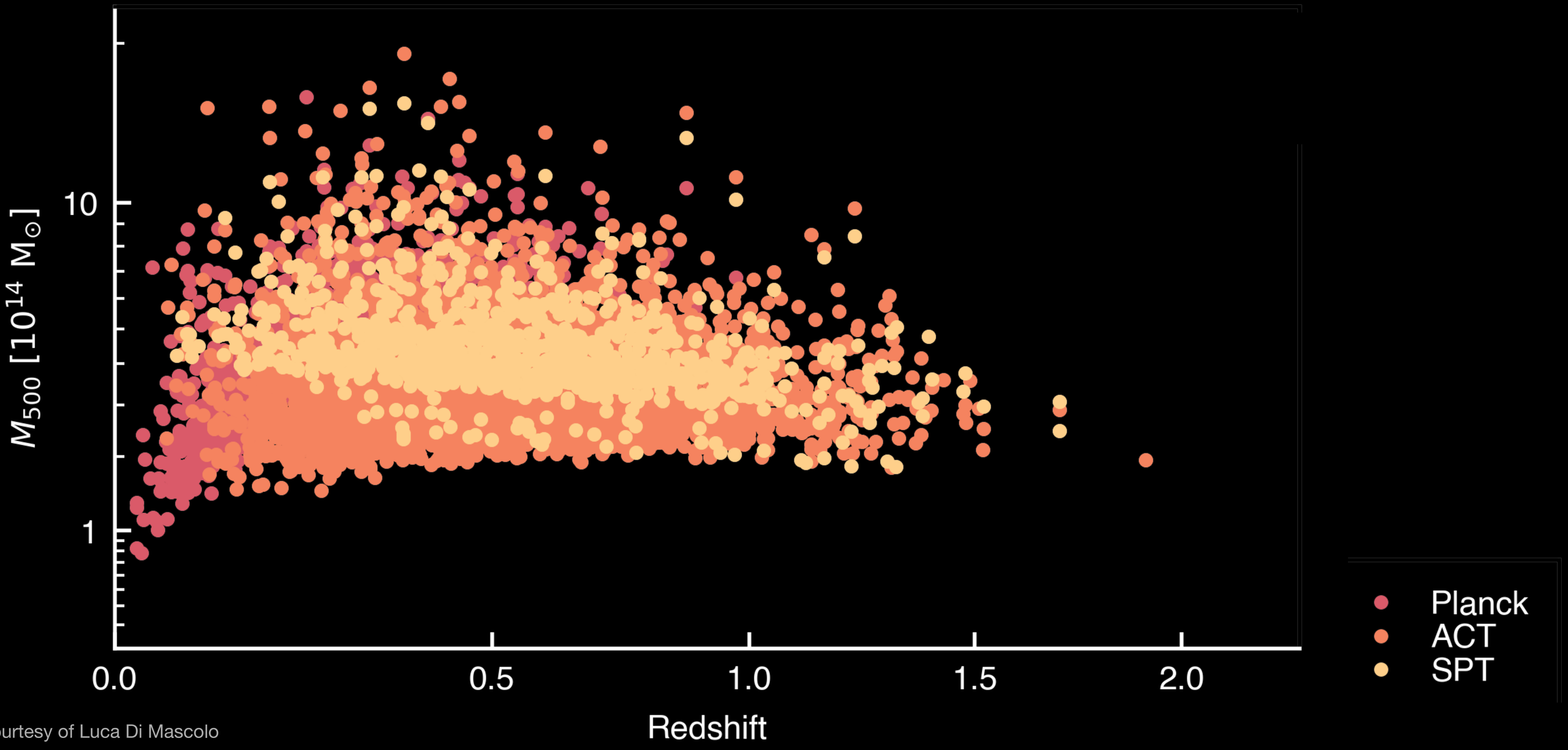


Cosmology

Upcoming Observatories

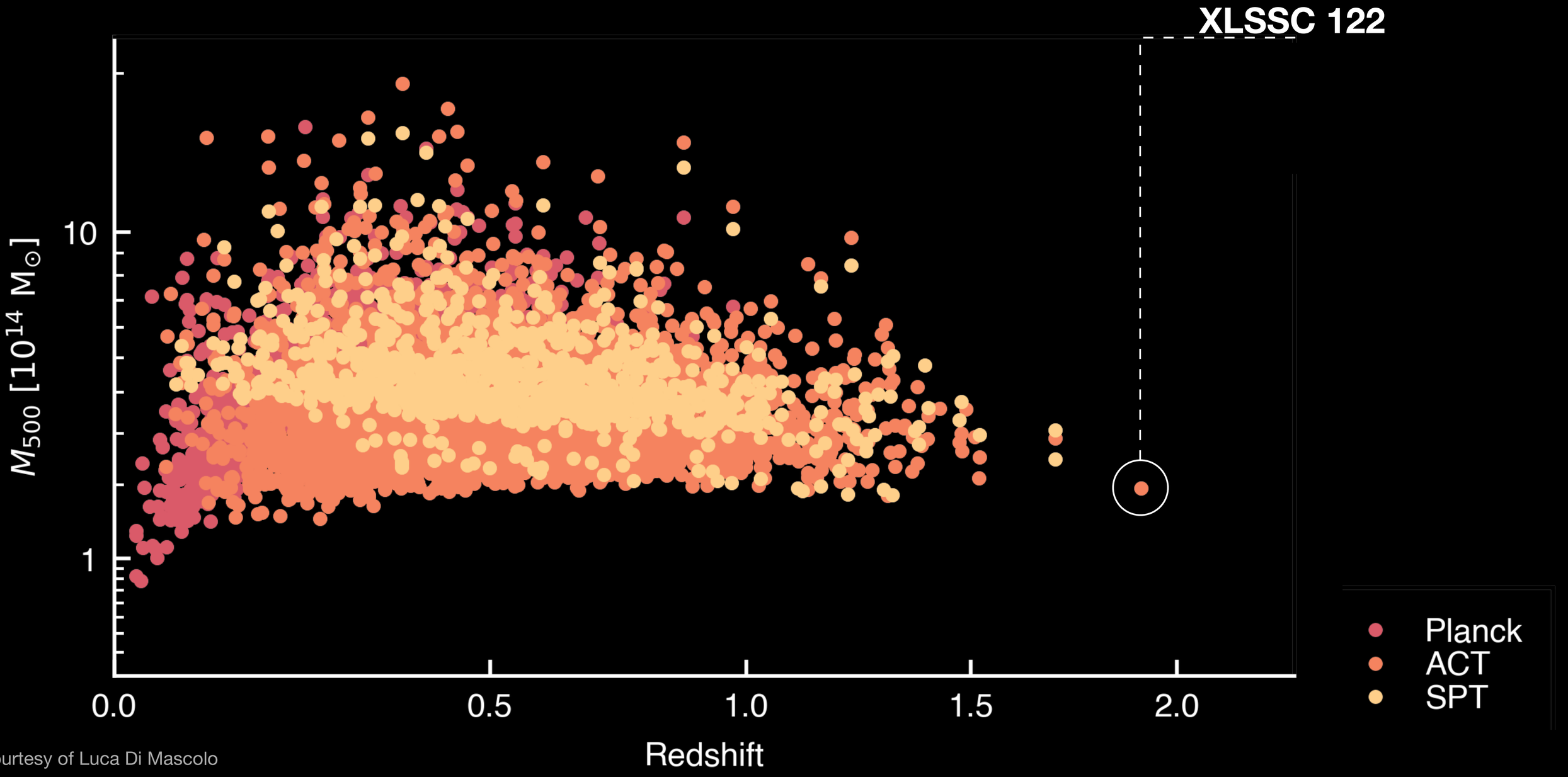
Credit: IllustrisTNG collaboration

Current status:



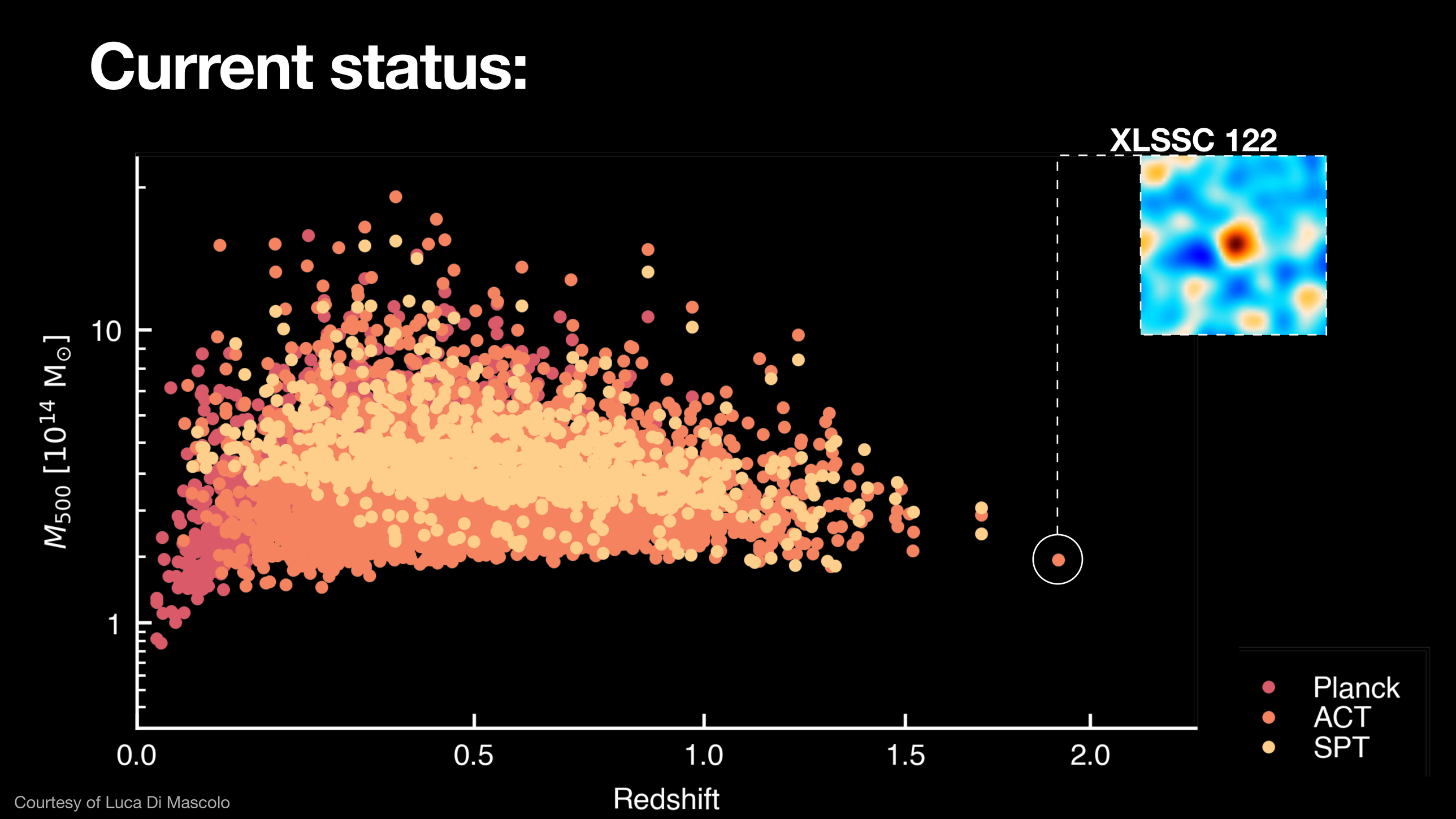
Courtesy of Luca Di Mascolo

Current status:



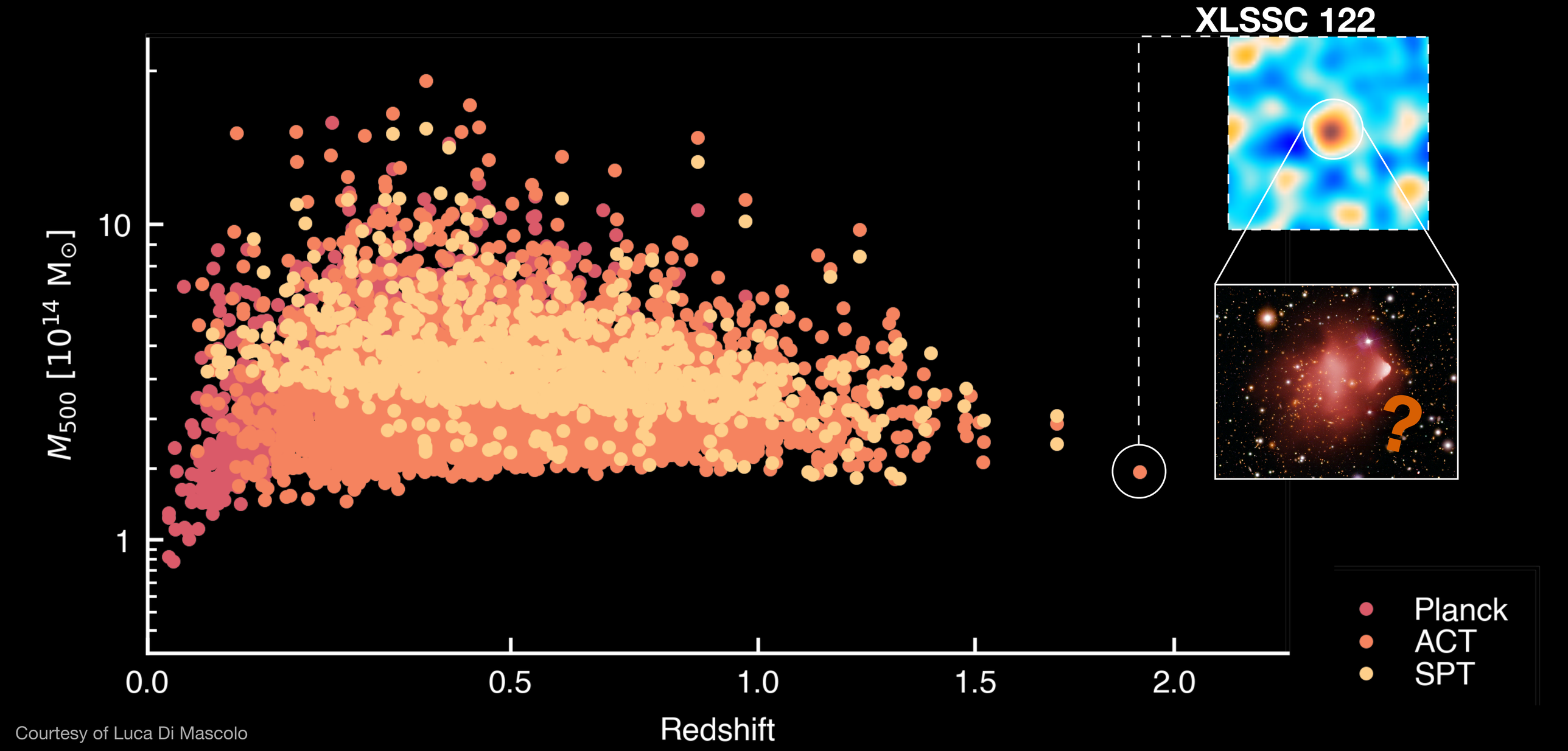
Courtesy of Luca Di Mascolo

Current status:



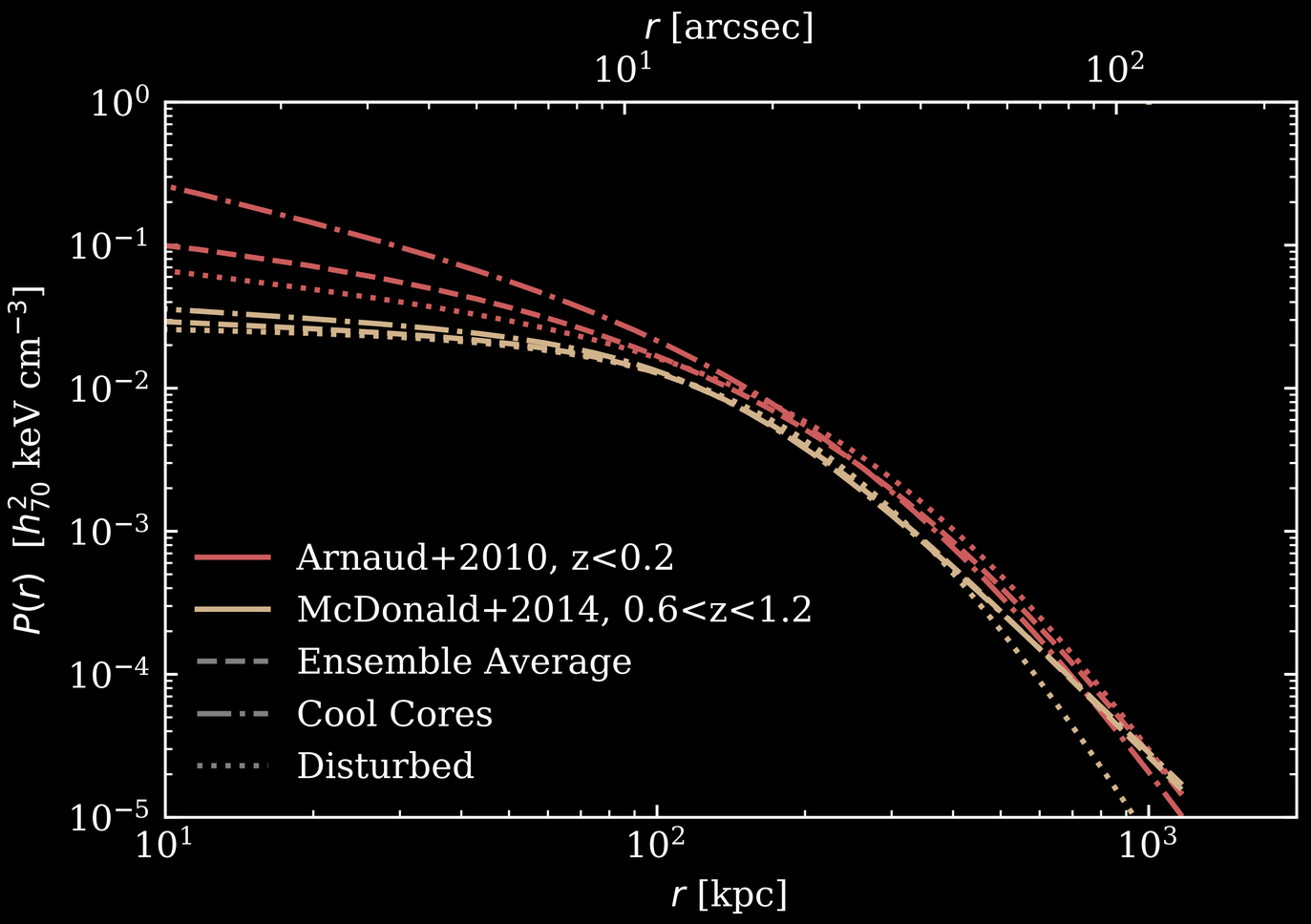
Courtesy of Luca Di Mascolo

Current status:

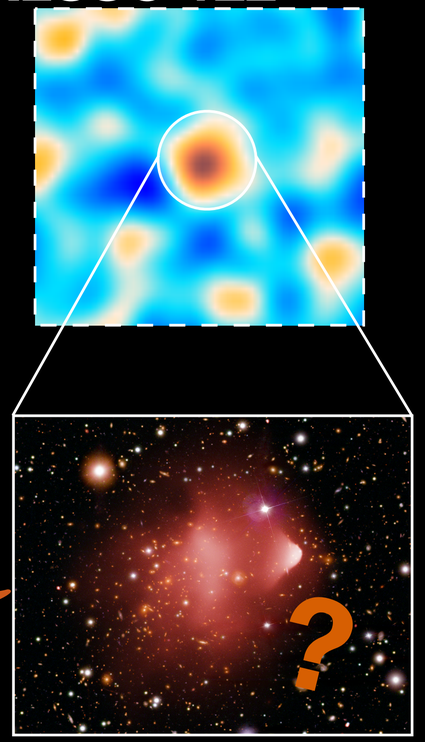


Courtesy of Luca Di Mascolo

What we want to learn:



XLSSC 122



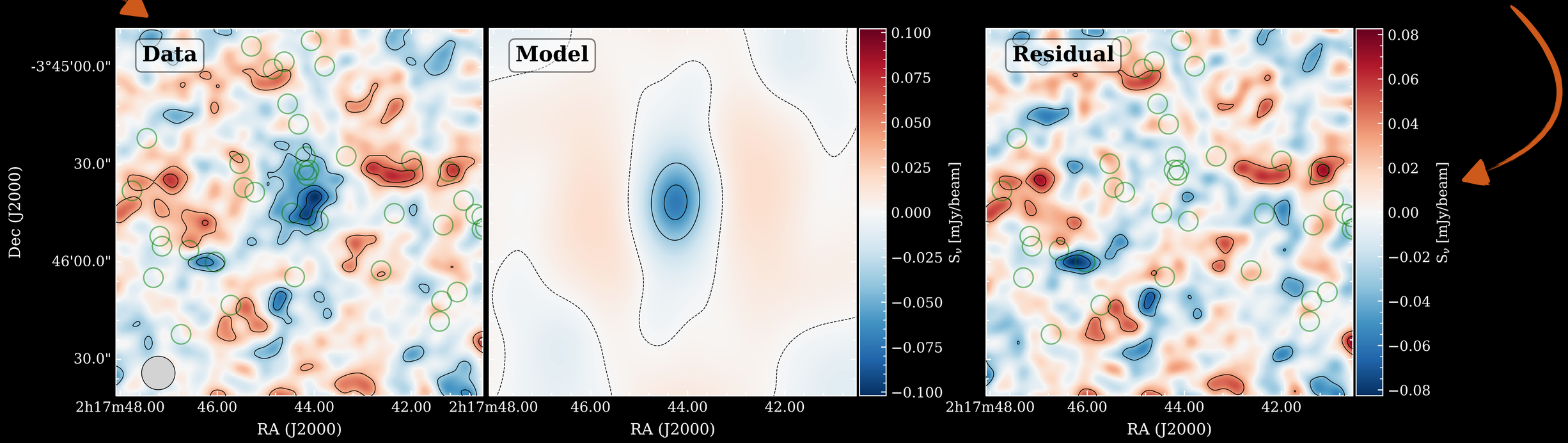
The Atacama Milimeter/ Submilimeter Array (ALMA)

Image credit: ESO

A Galaxy Cluster: XLSSC 122

Dirty Image

Imaged Residuals



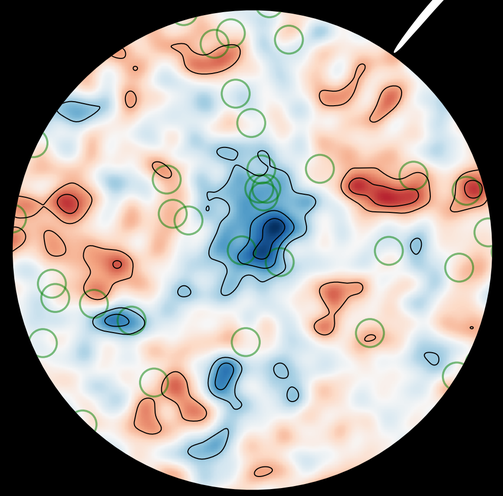
A model reconstruction Corrected for the uv-coverage

○ Cluster Members

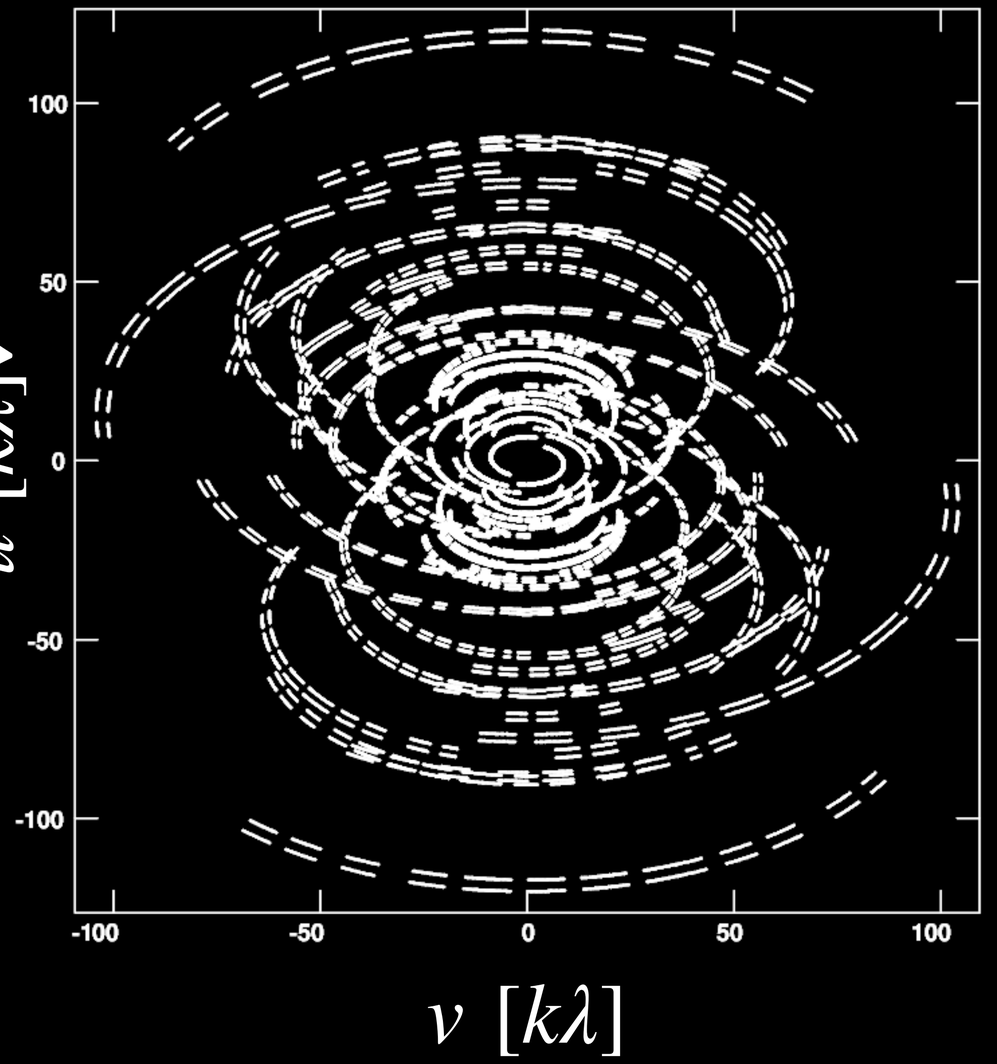
Contours are drawn at [-4.5, -3.5, -3.5, -1.5, 0, 1.5, 2.5, 3.5]-σ

J. van Marrewijk et al. (In prep)

The visibility plane

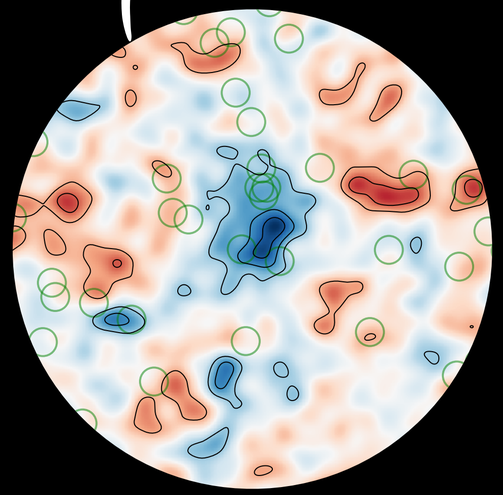


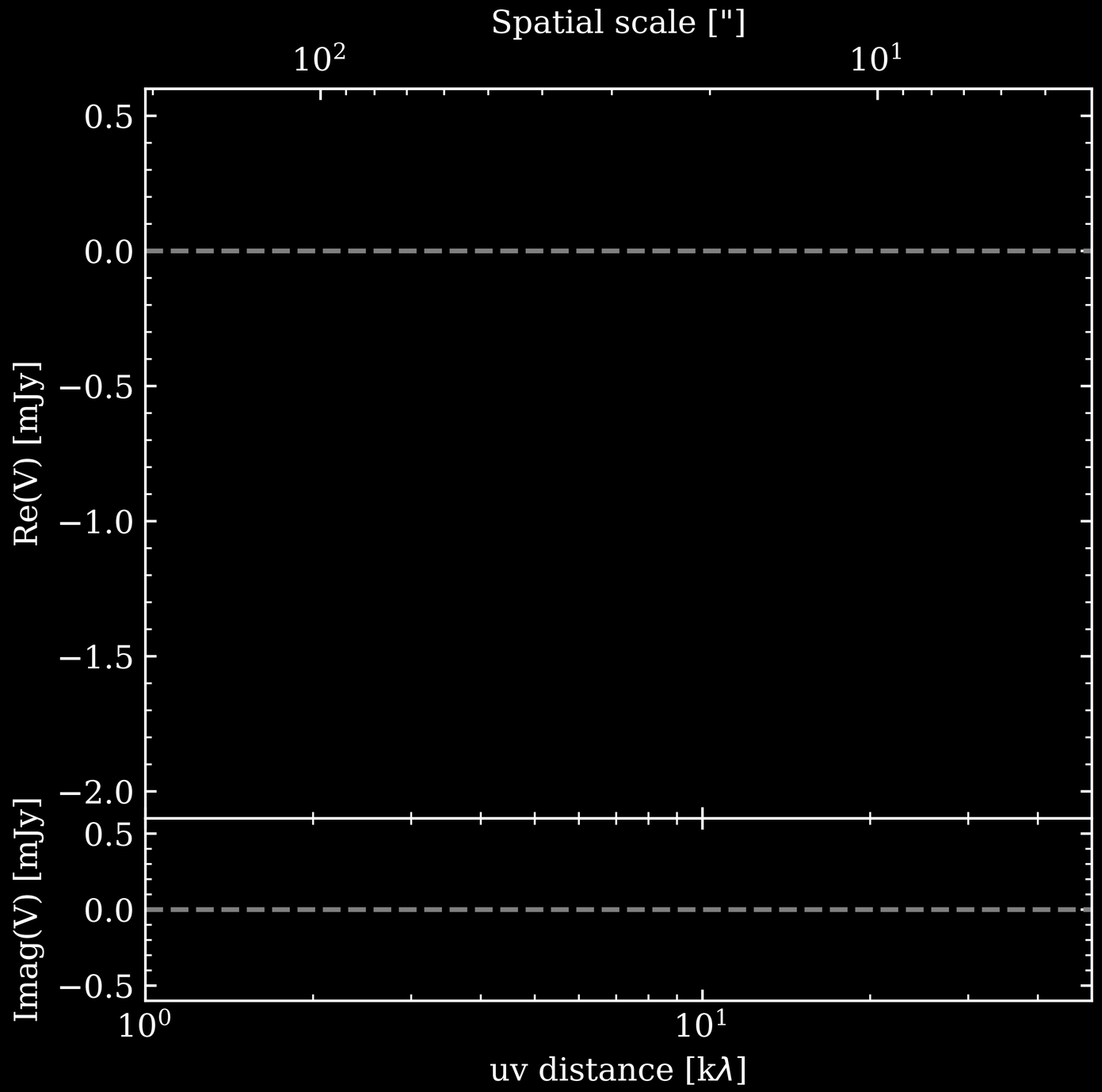
Fourier Transform



The visibility plane in 1D

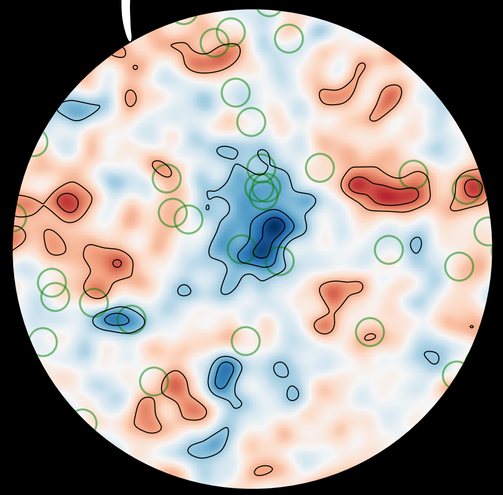
Fourier Transform

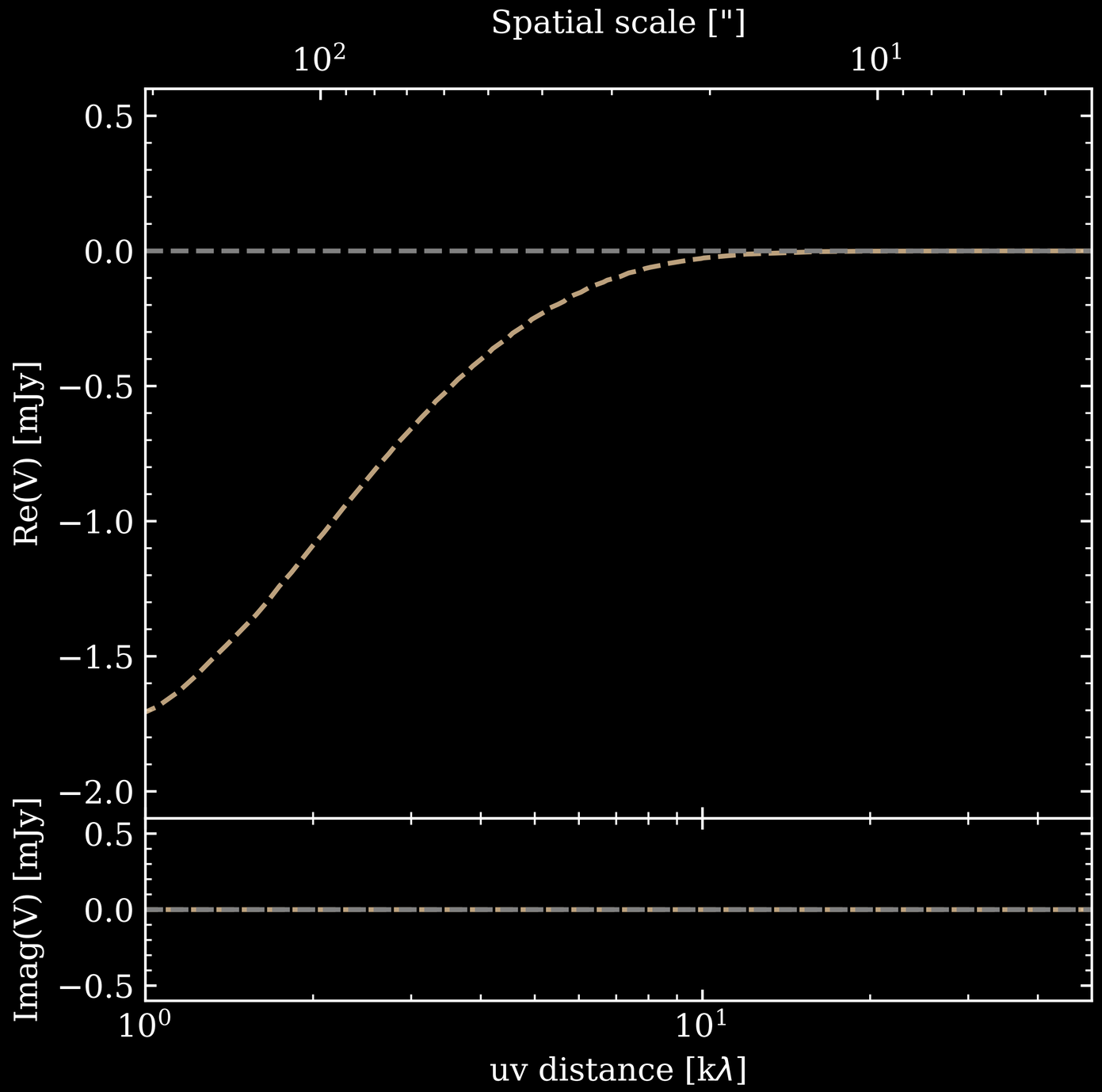




A cluster model

Fourier Transform

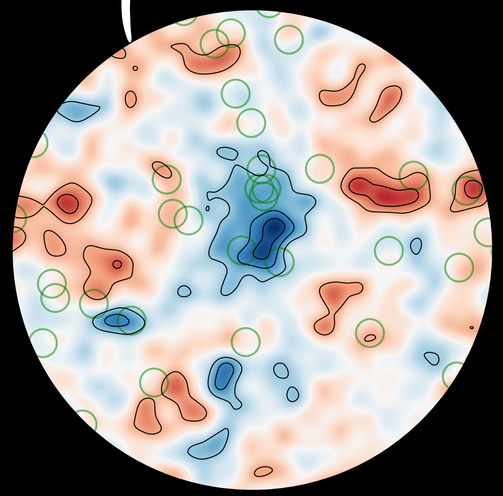


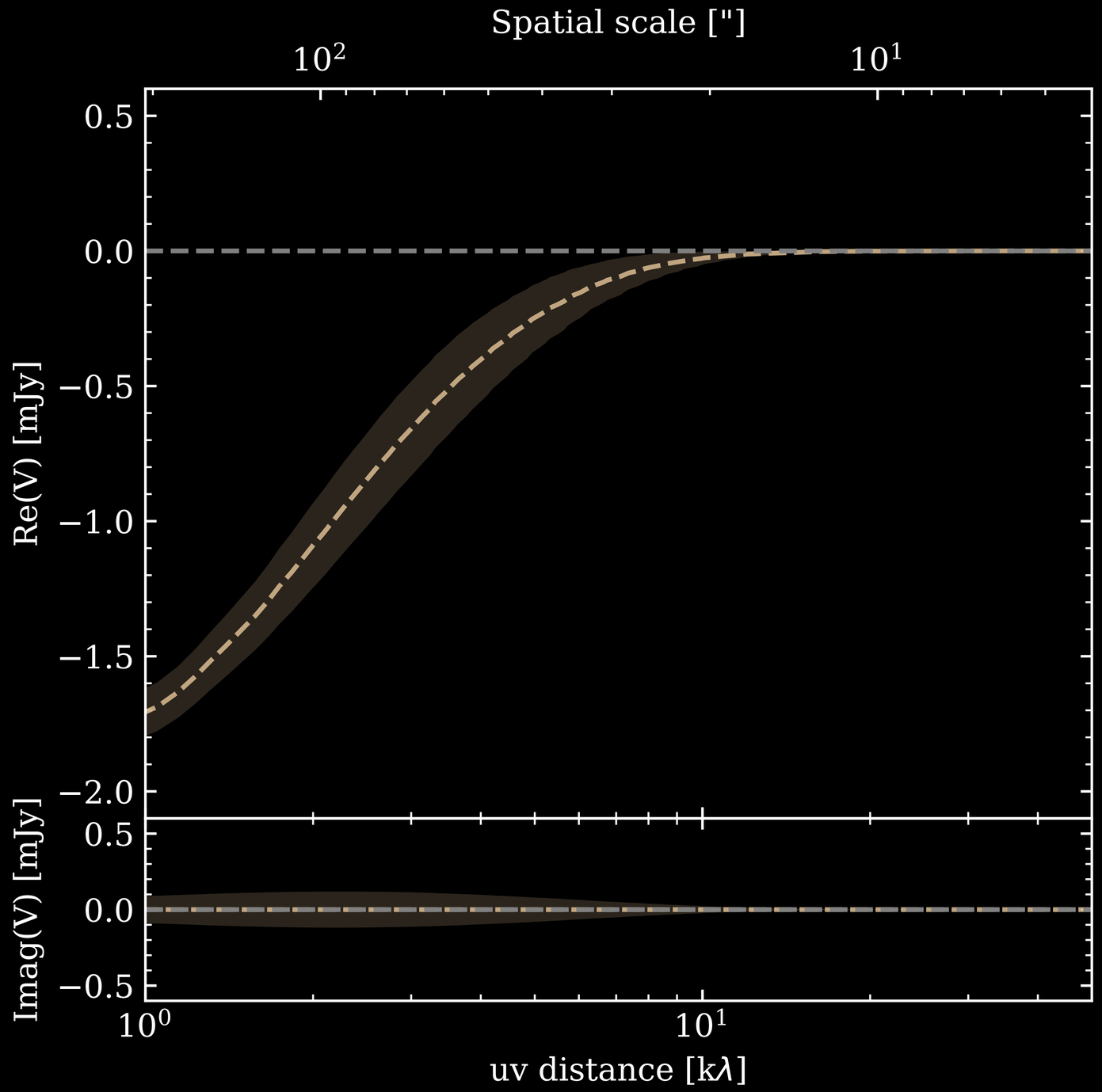


A cluster model

Introducing ellipticity

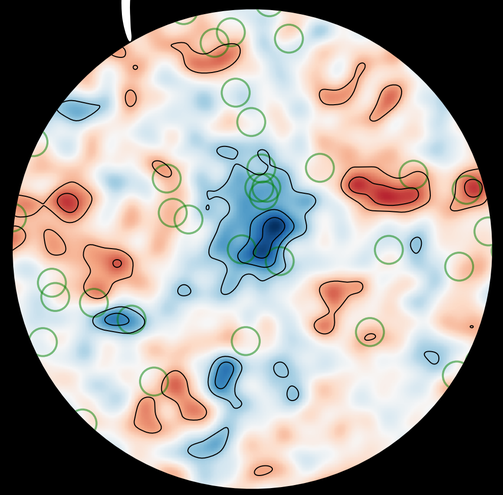
Fourier Transform

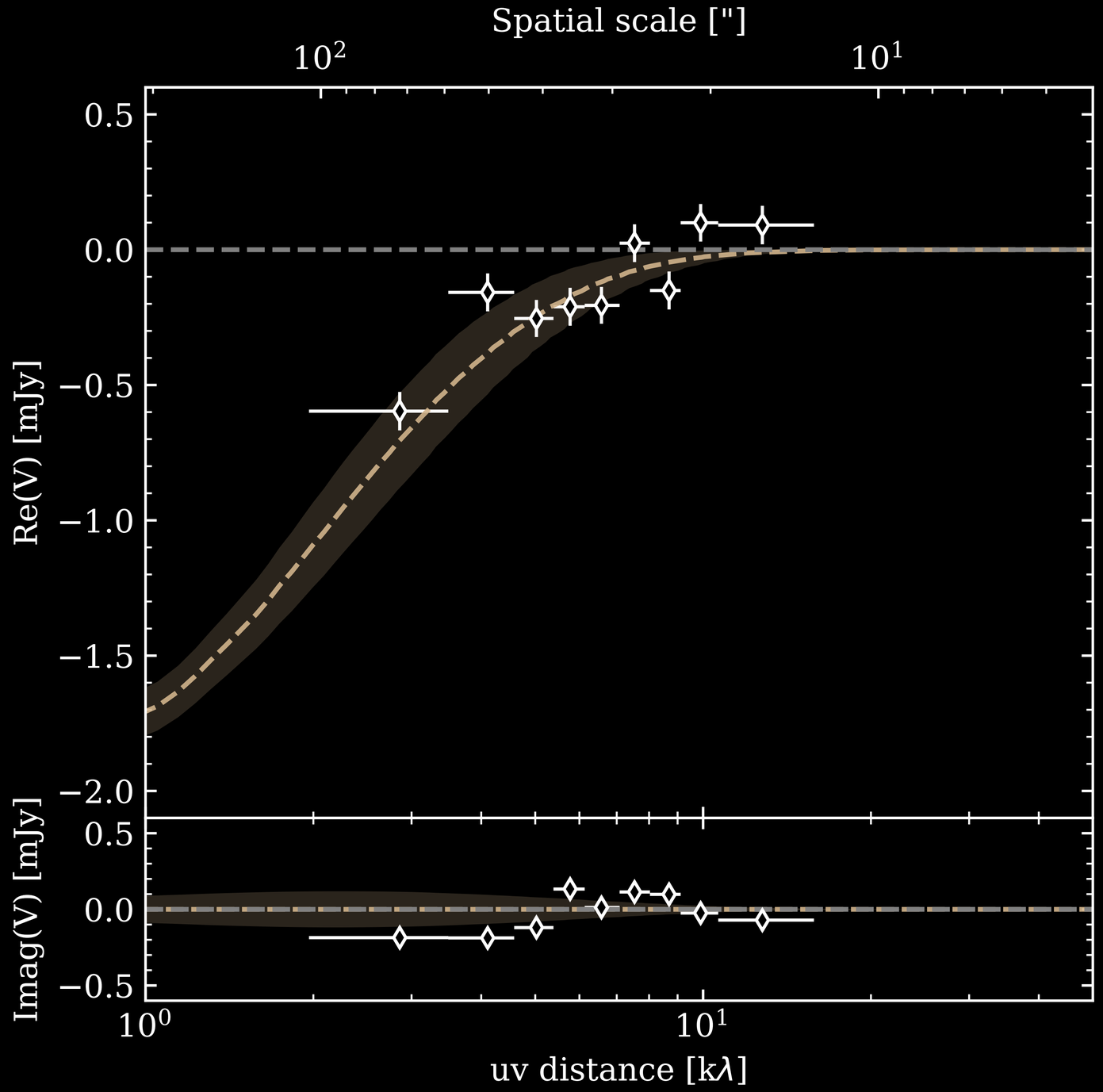




XLSSC 122

Fourier Transform

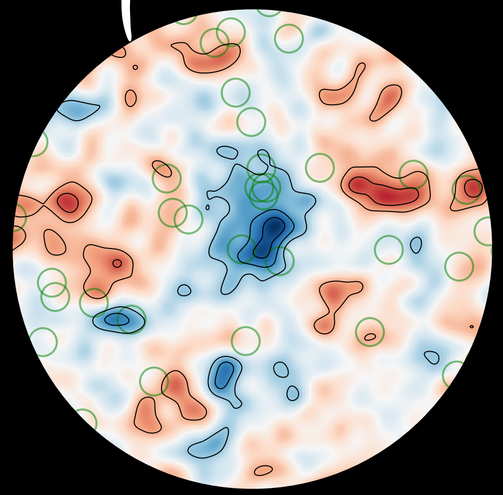


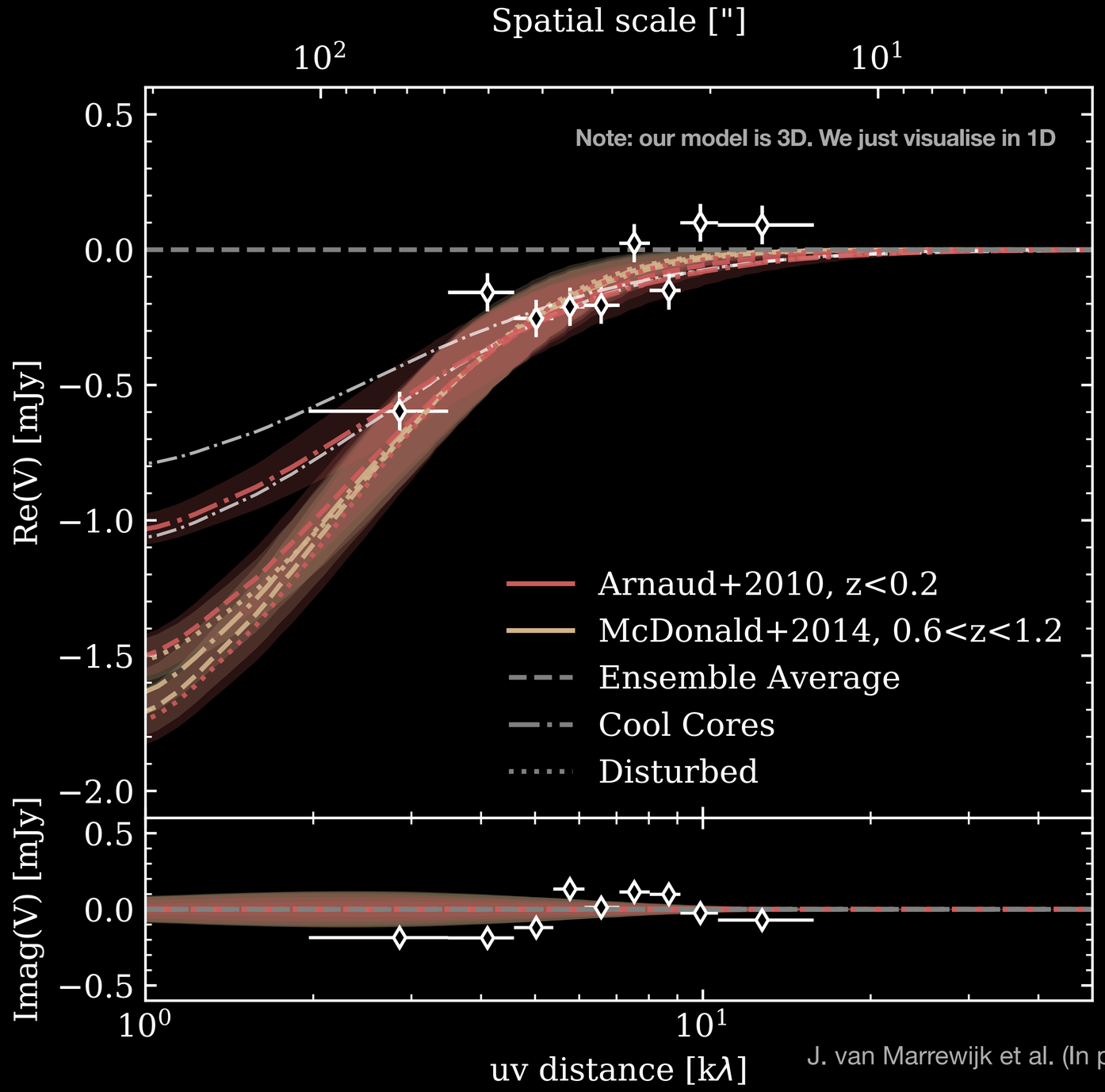


XLSSC 122

A classification based on pressure profiles is hard!

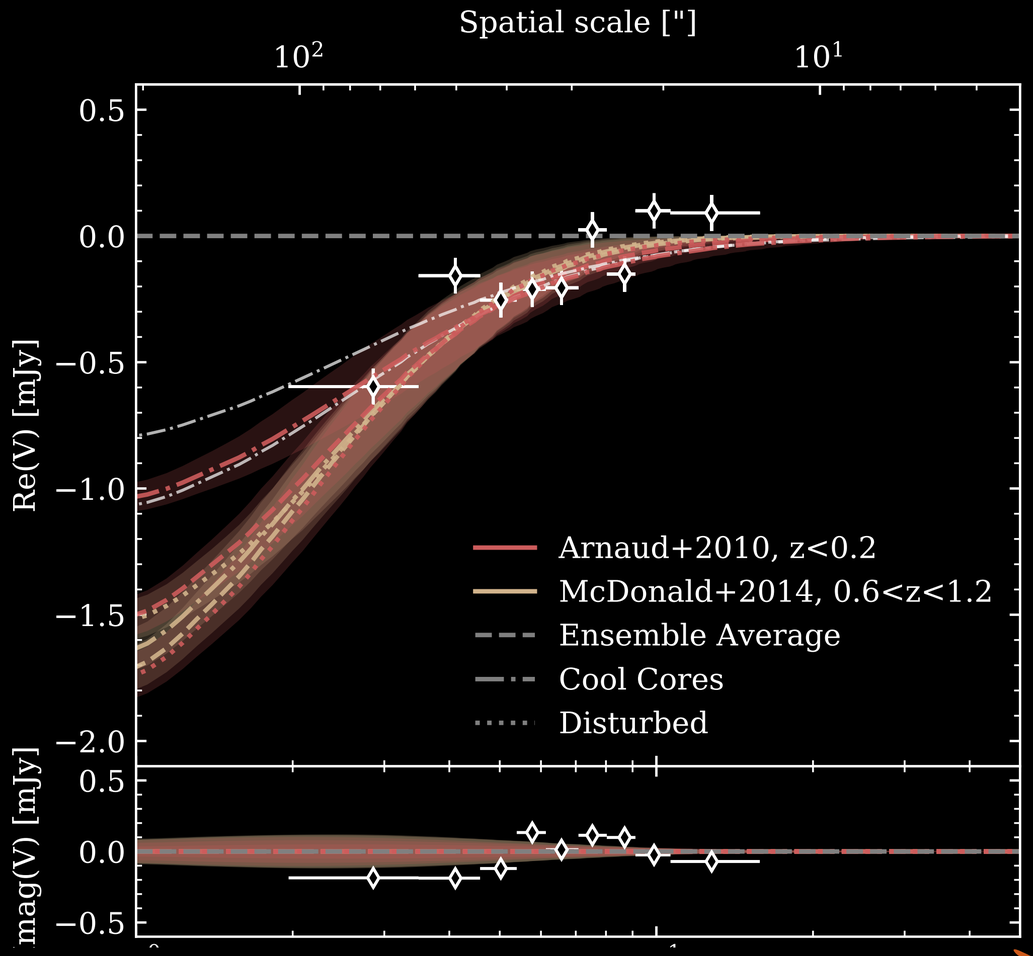
Fourier Transform

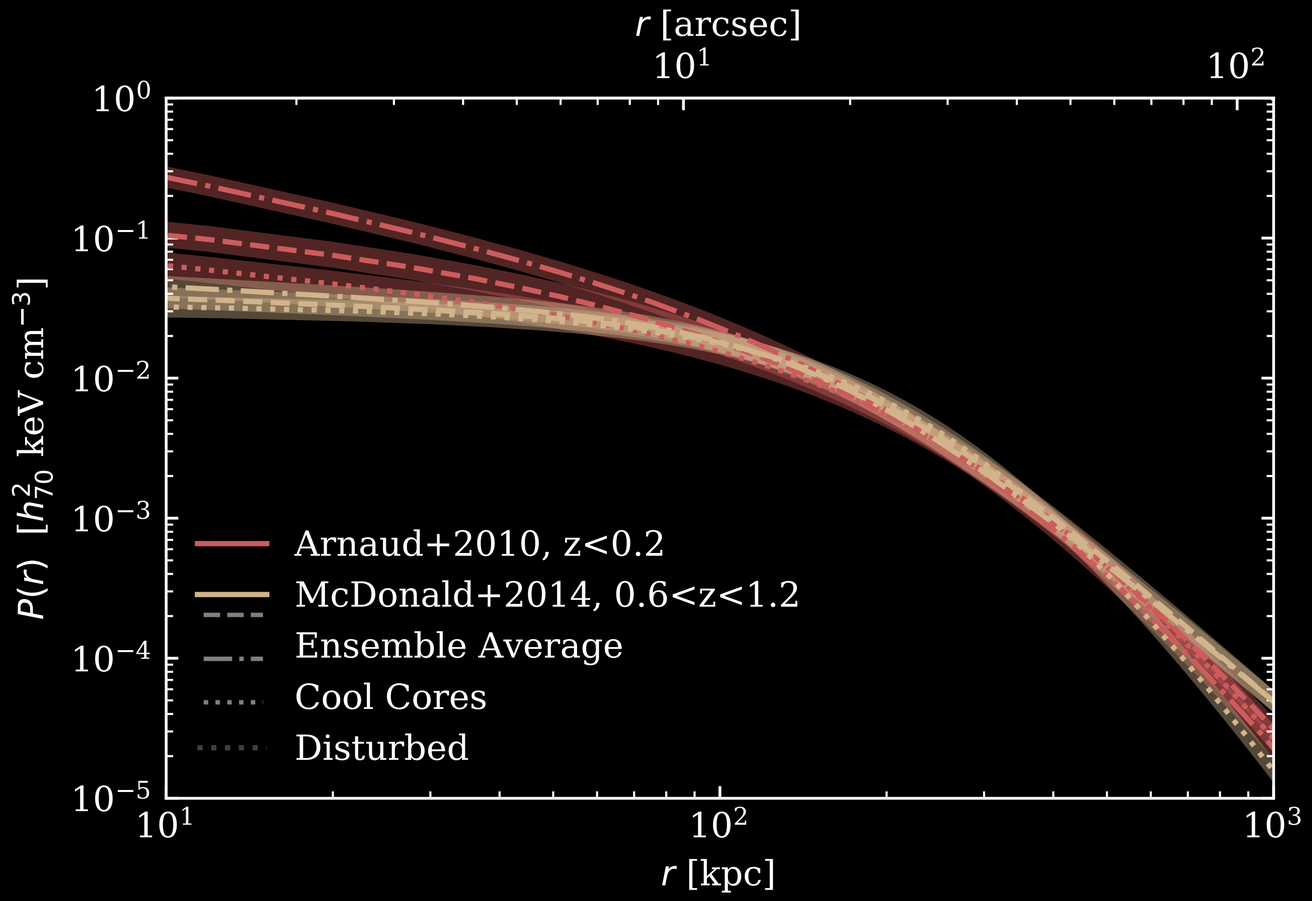




J. van Marrewijk et al. (In prep)

XLSSC 122: Pressure profiles

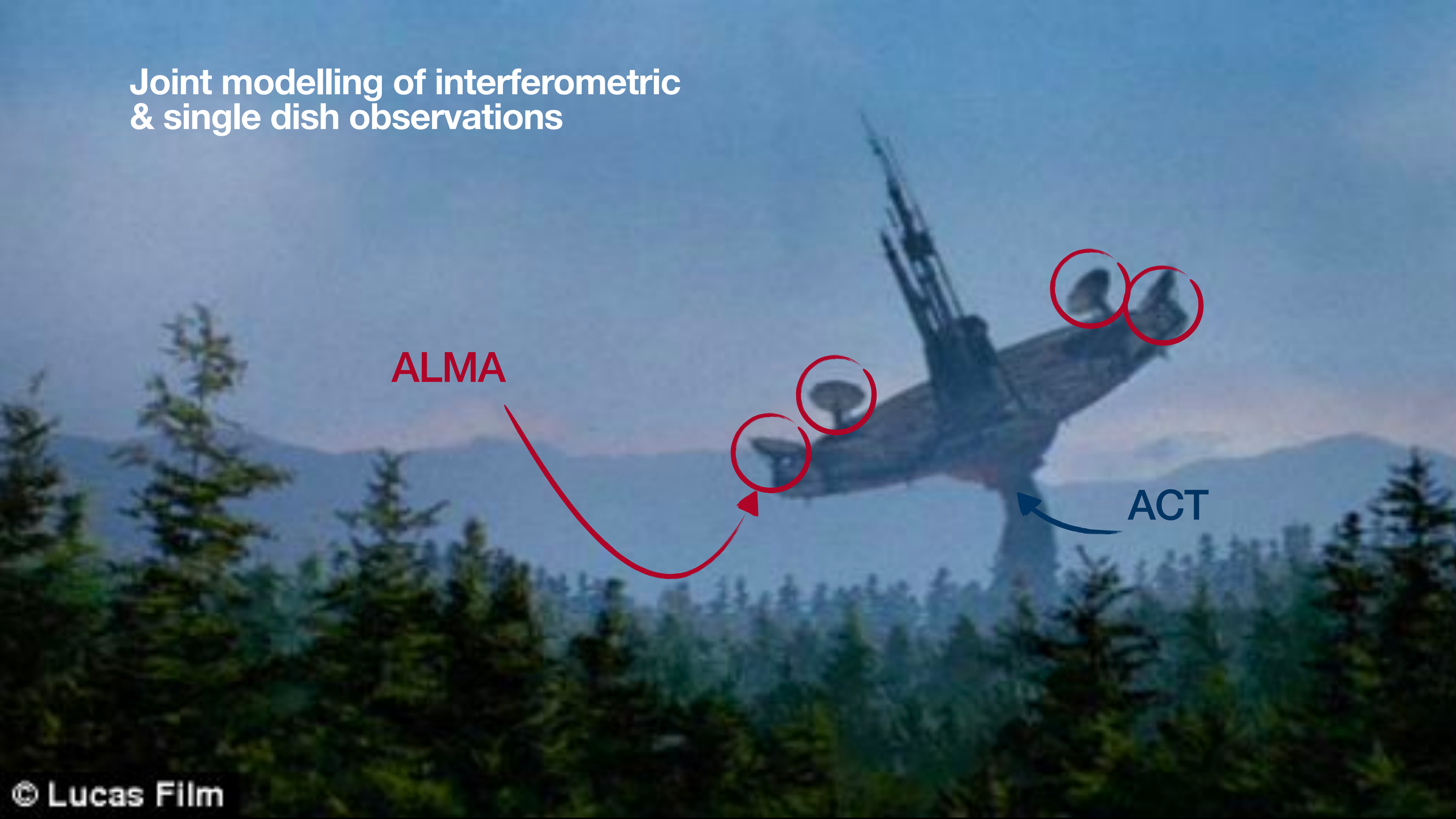




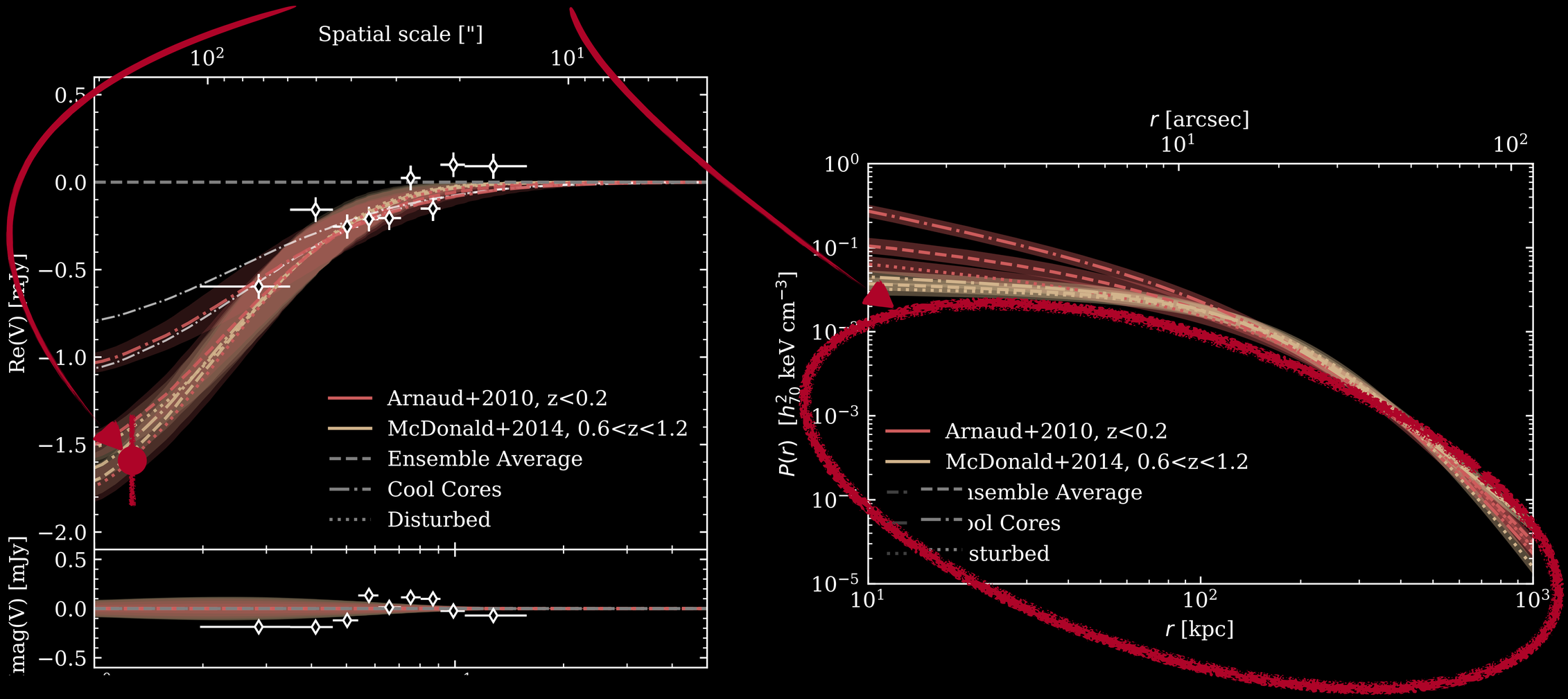
J. van Marrewijk et al. (In prep)

Image plane variant

Joint modelling of interferometric & single dish observations

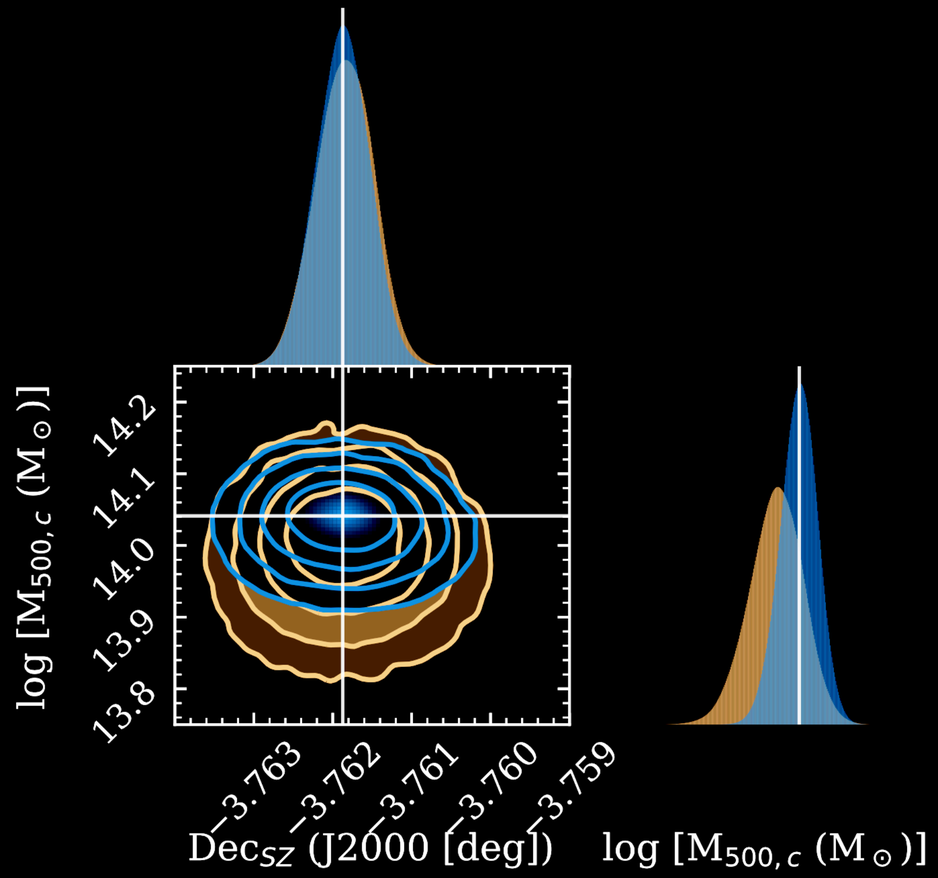


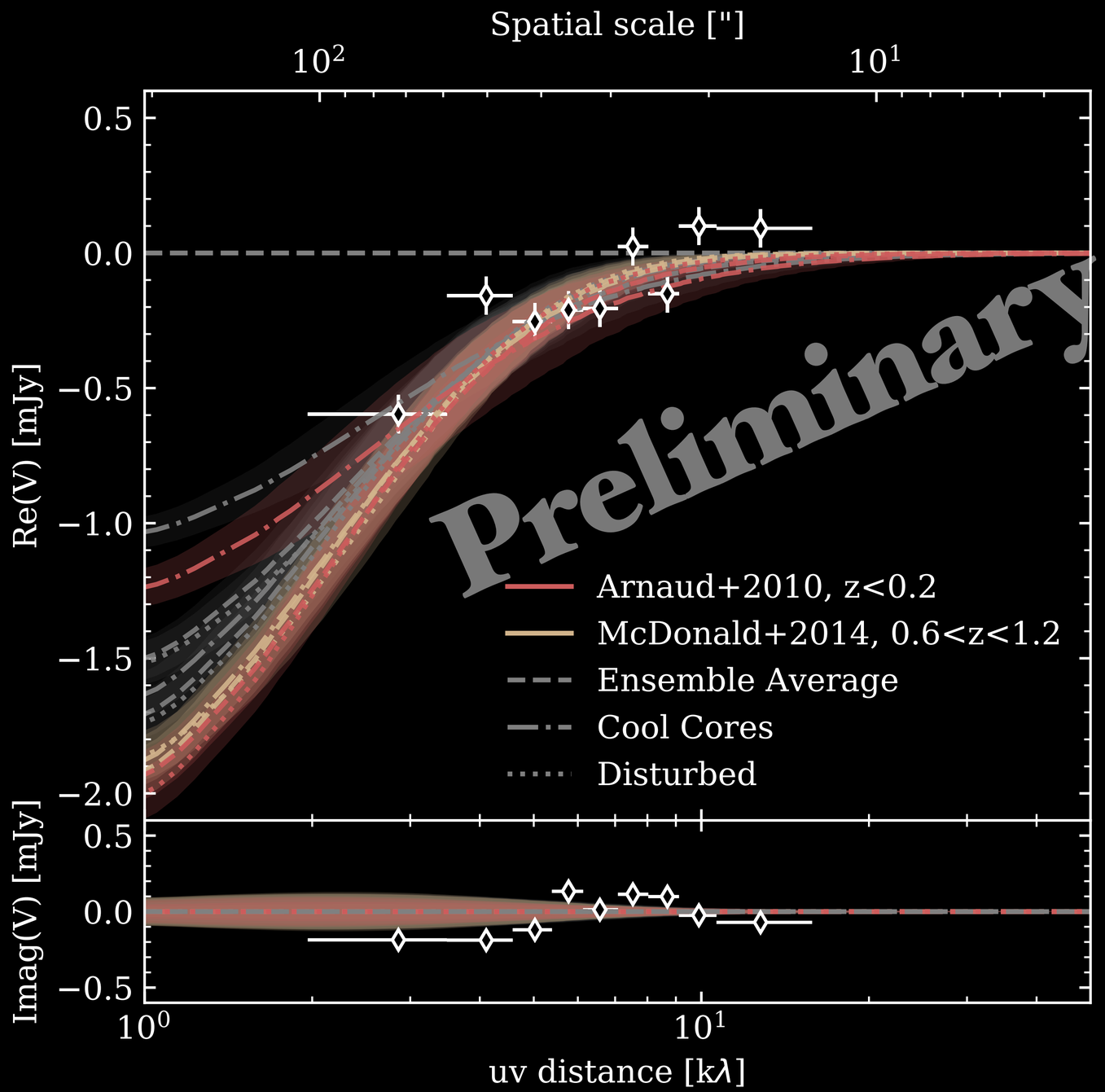
Adding additional constraining power



Ajay Gill (J. van Marrewijk+In prep)

Adding additional constraining power





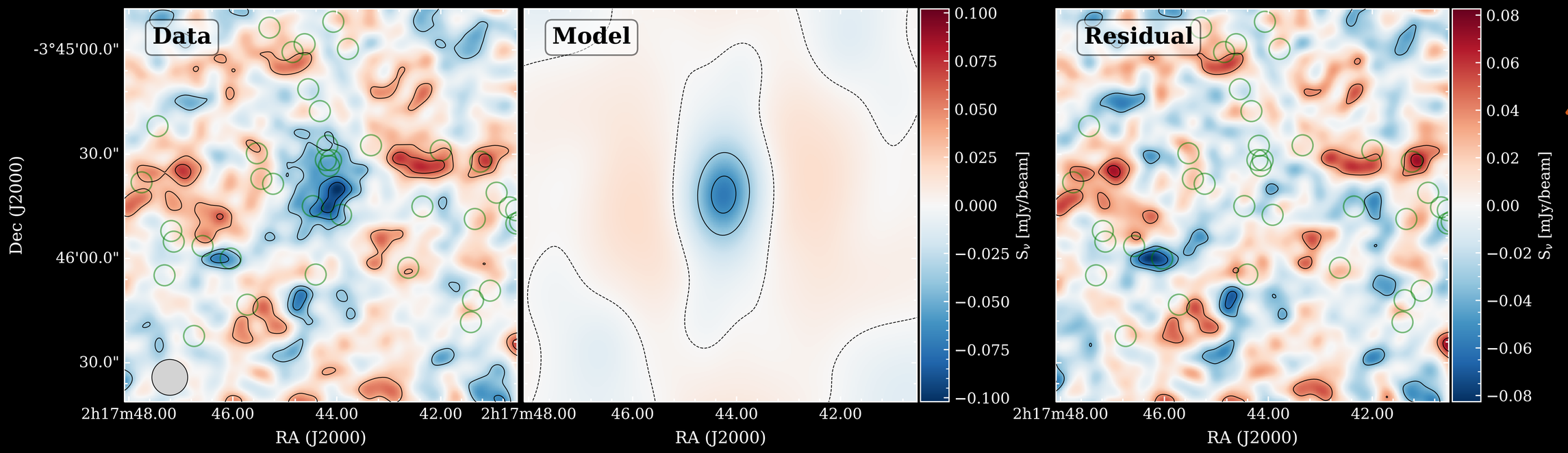
J. van Marrewijk et al. (In prep)

What does the cluster look like?

Dirty Image

A model reconstruction Corrected for the uv-coverage

Imaged Residuals



- Cluster Members

Contours are drawn at [-4.5, -3.5, -3.5, -1.5, 0, 1.5, 2.5, 3.5]-σ

J. van Marrewijk et al. (In prep)

Searching for asymmetries:

Likelihood-weighted model

⊛

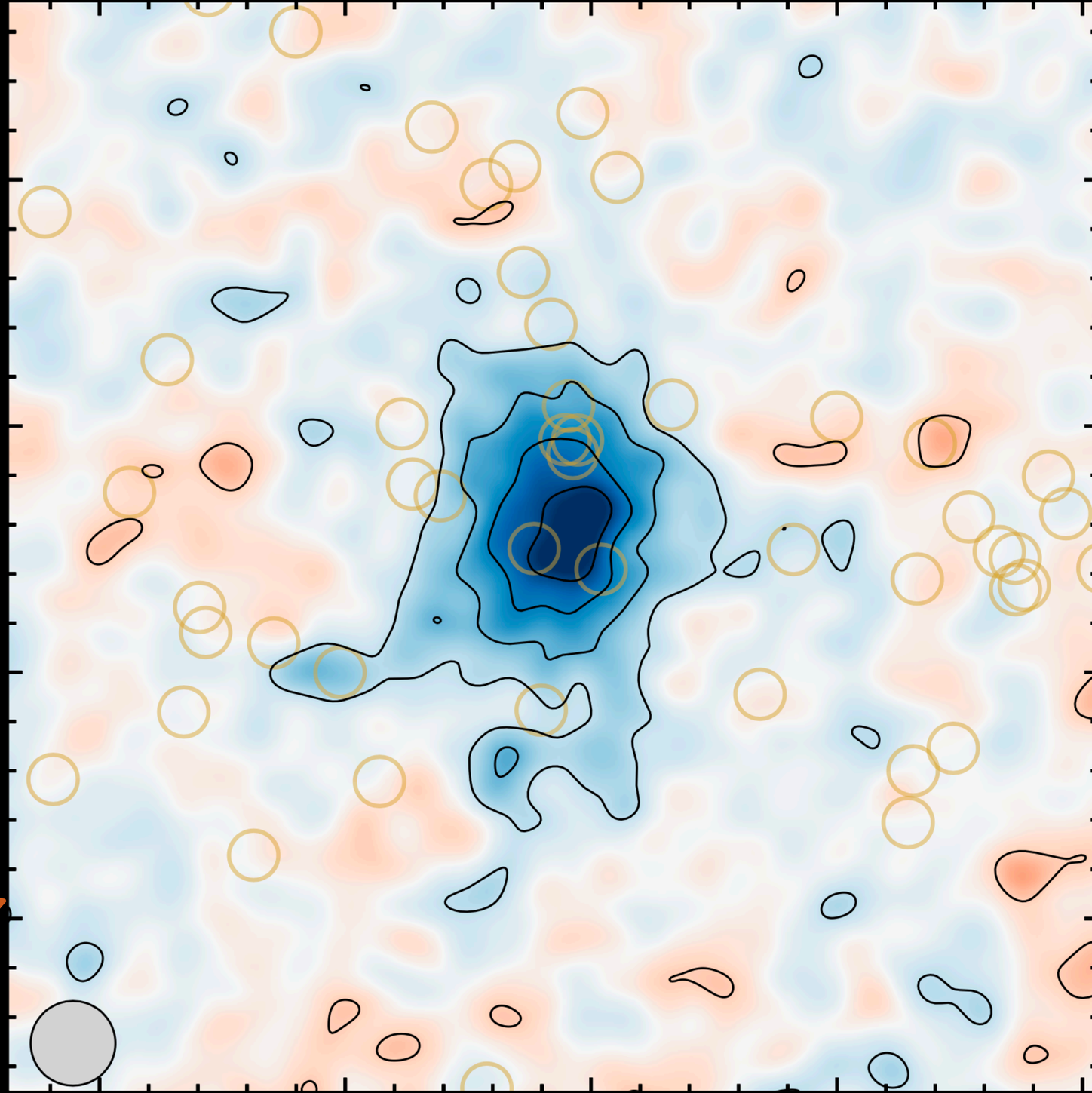
Synthesised beam

+

Residuals

=

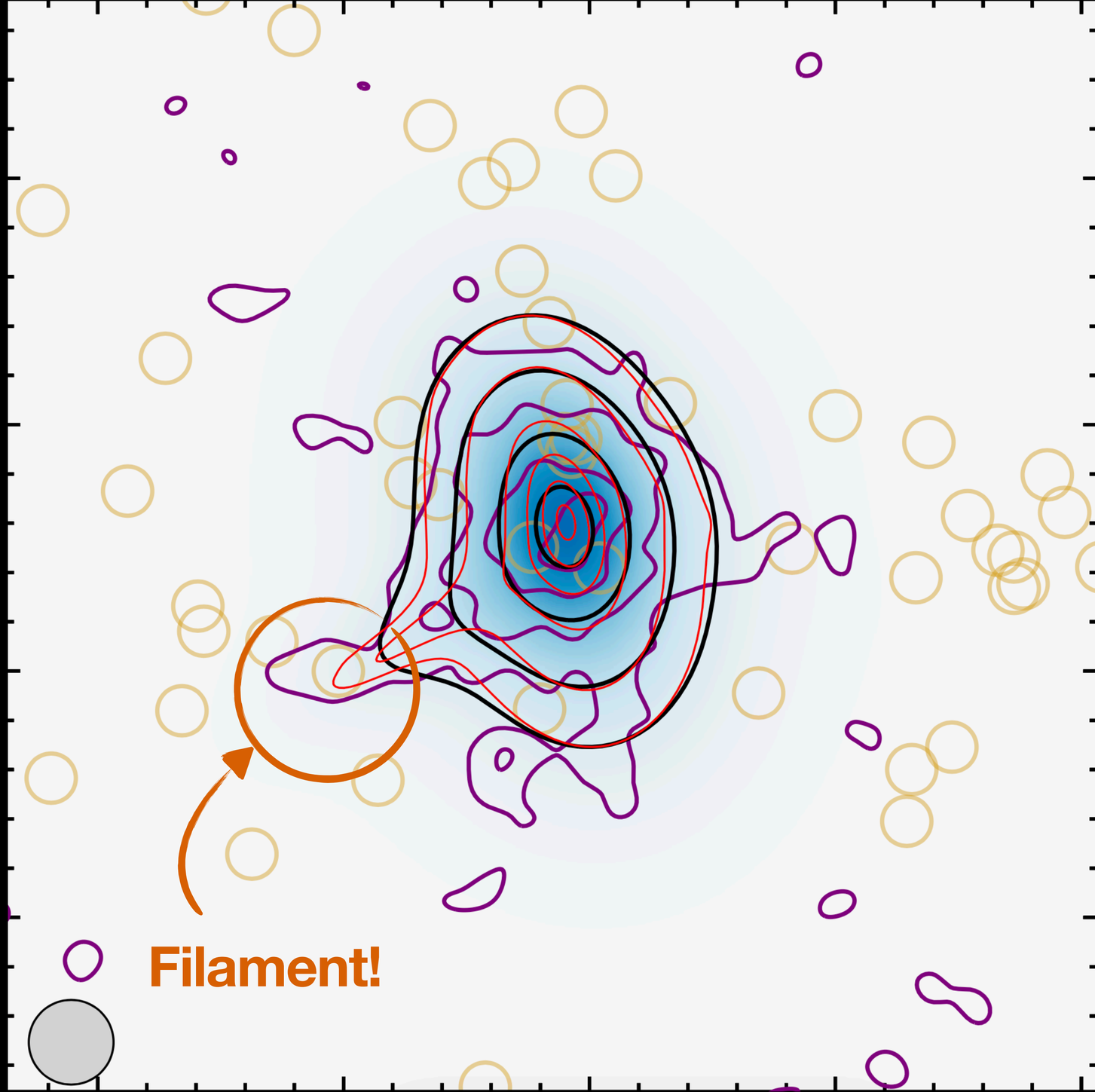
Cleaned image reconstruction



Contours are drawn at [-10, -8, -6, -4, -2, 2, 4]-σ

A 2-component likelihood-weighted model reconstruction

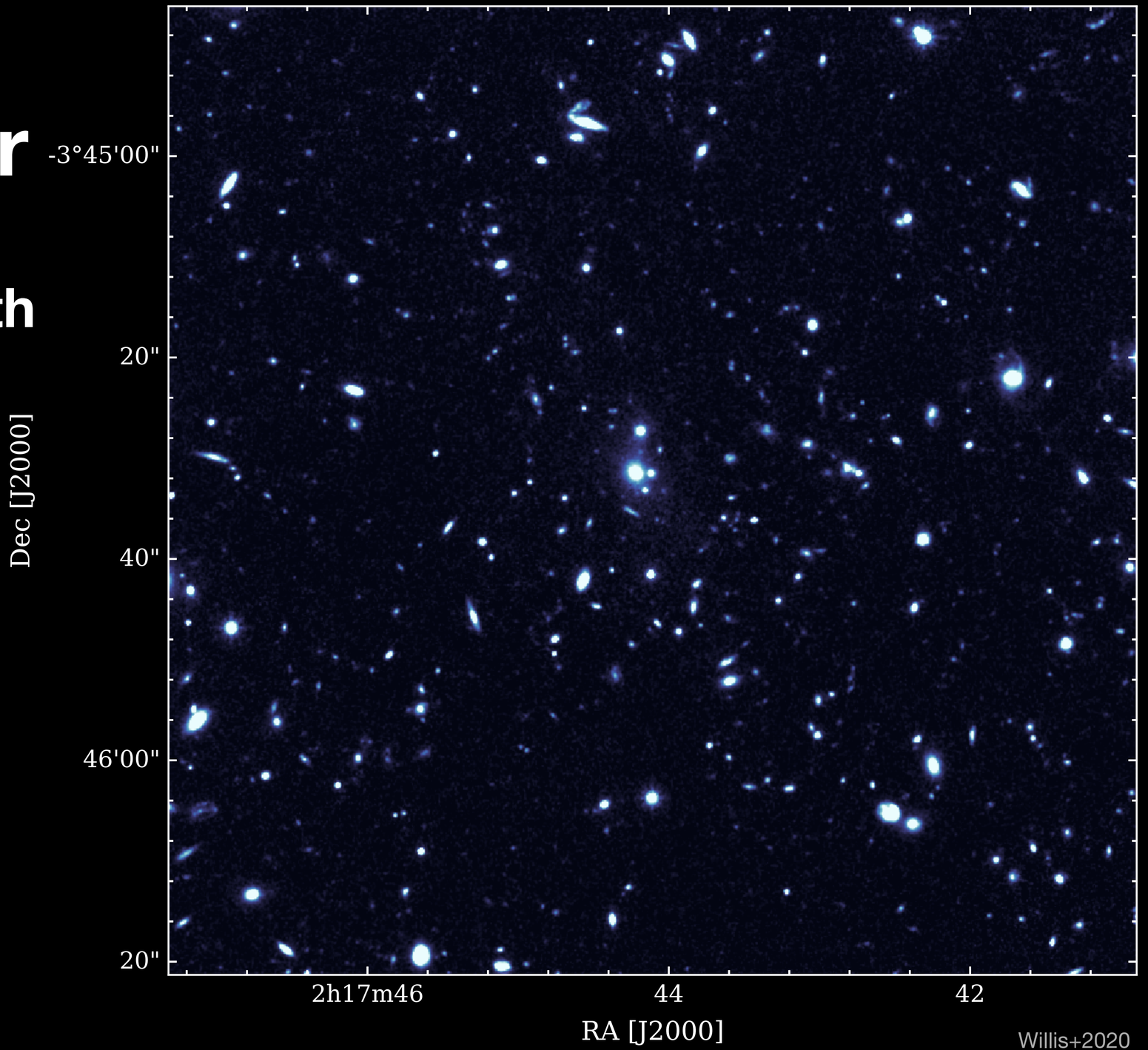
- **Equivalent to a $2.1\sigma - 3.6\sigma$ detection!**
- **A mass ratio 1:2**



Contours are drawn at [-10, -8, -6, -4, -2, 2, 4]-σ

Let us bring everything together

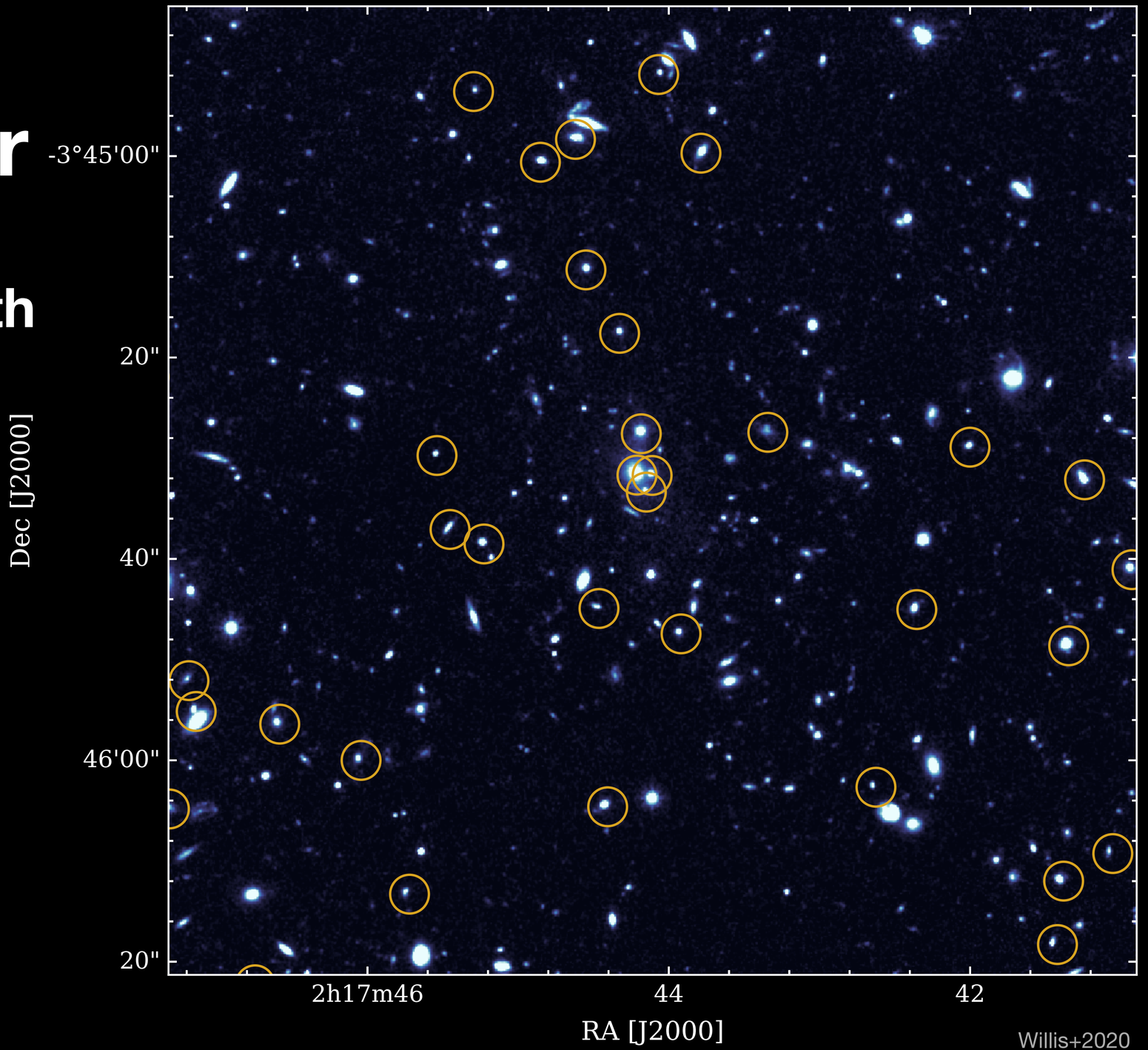
- **We need multi-wavelength information**
  - Optical



Willis+2020

Let us bring everything together

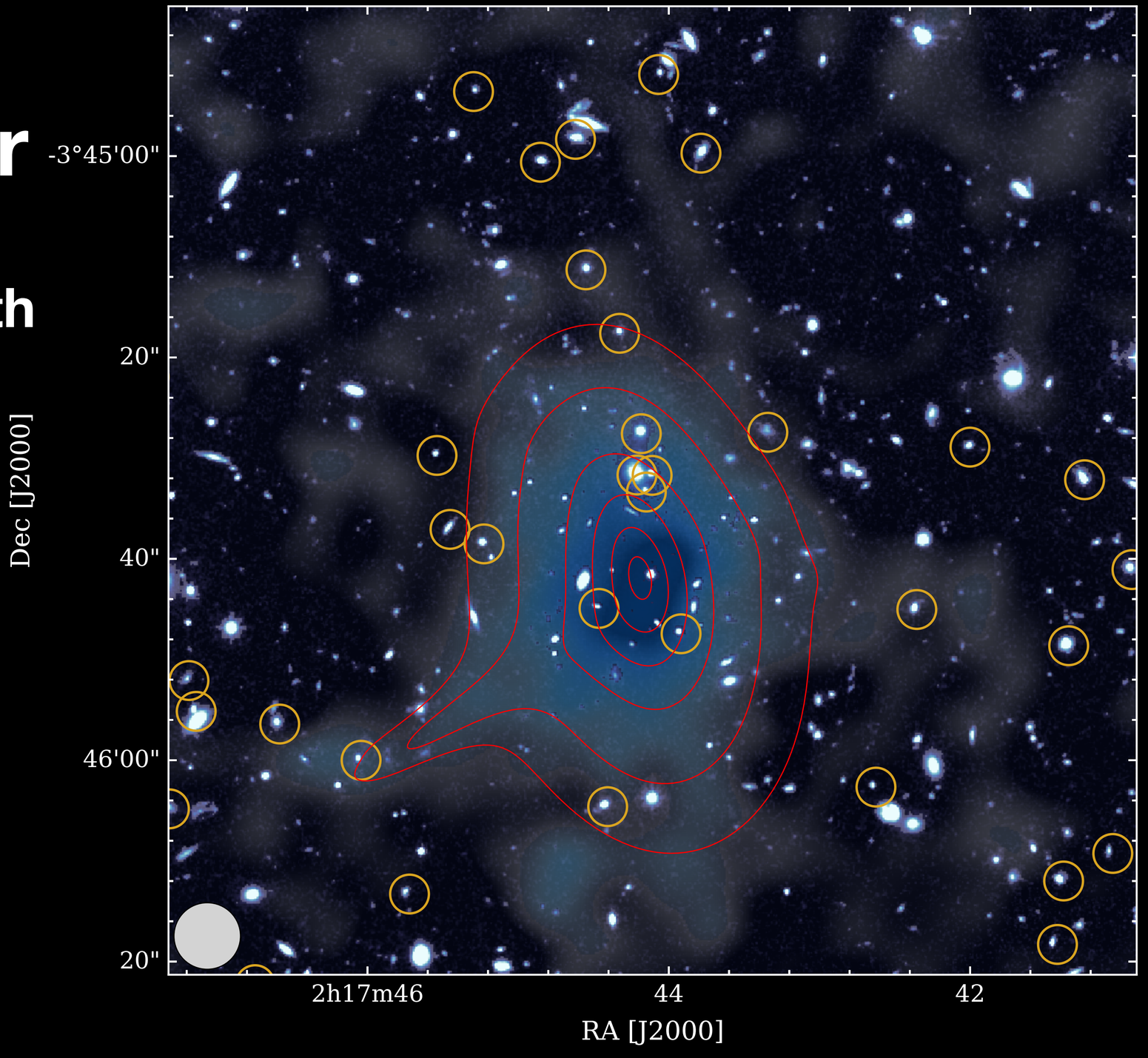
- **We need multi-wavelength information**
  - Optical
  - $H\alpha$



Willis+2020

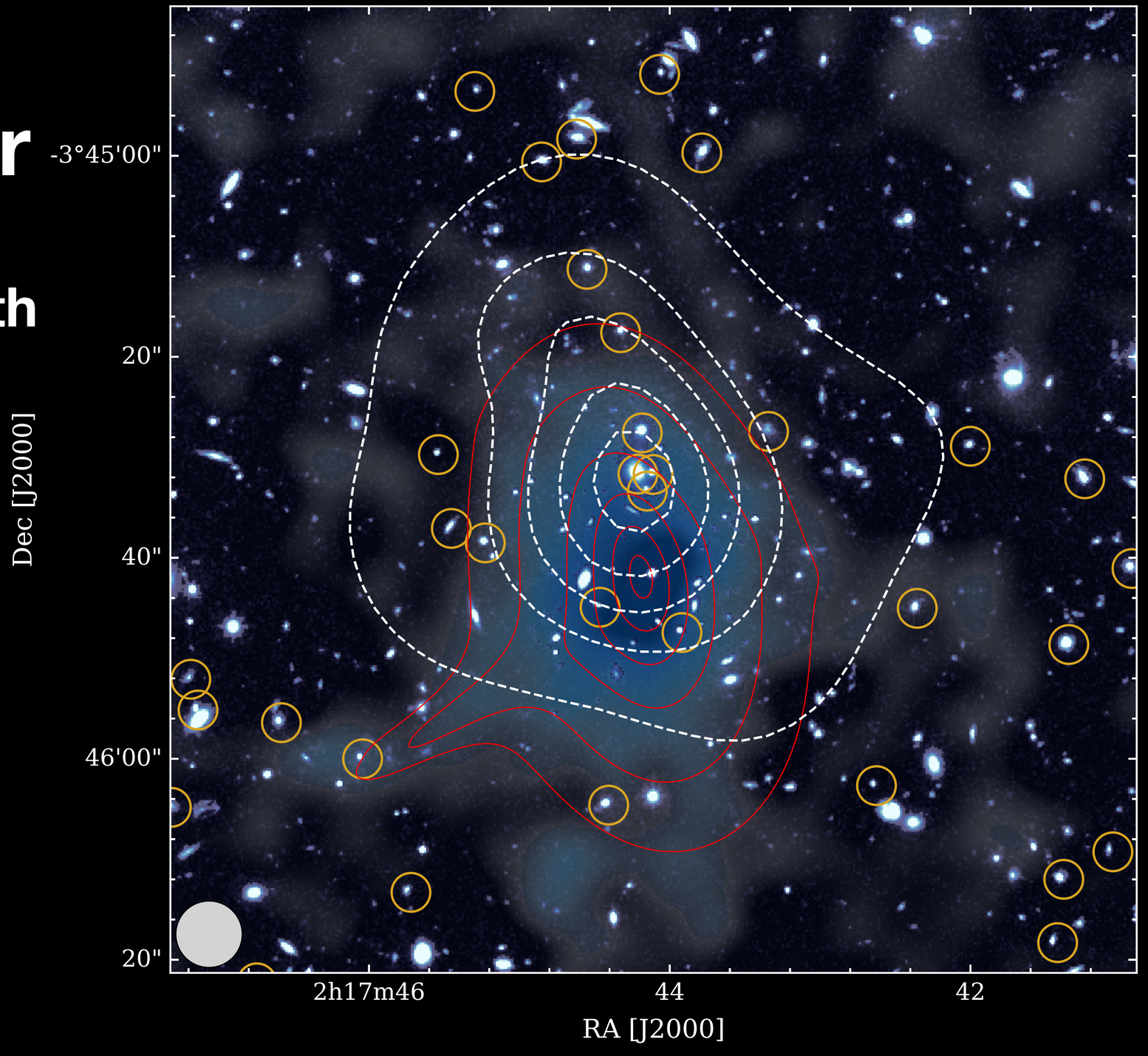
Let us bring everything together

- **We need multi-wavelength information**
  - Optical
  - $H\alpha$
  - SZ



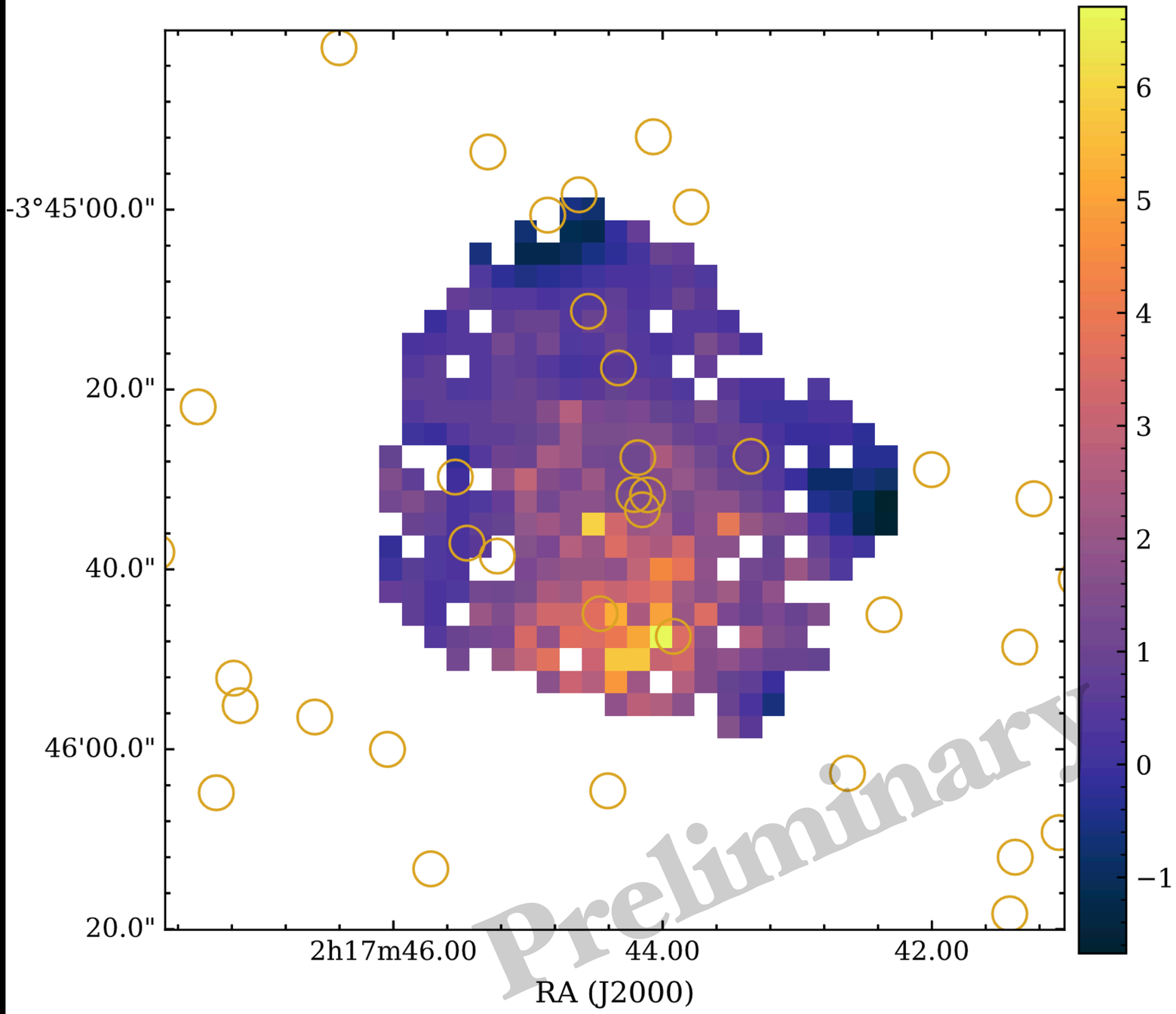
Let us bring everything together

- **We need multi-wavelength information**
  - Optical
  - $H\alpha$
  - SZ
  - X-ray



A (simplistic) X-ray + SZ view

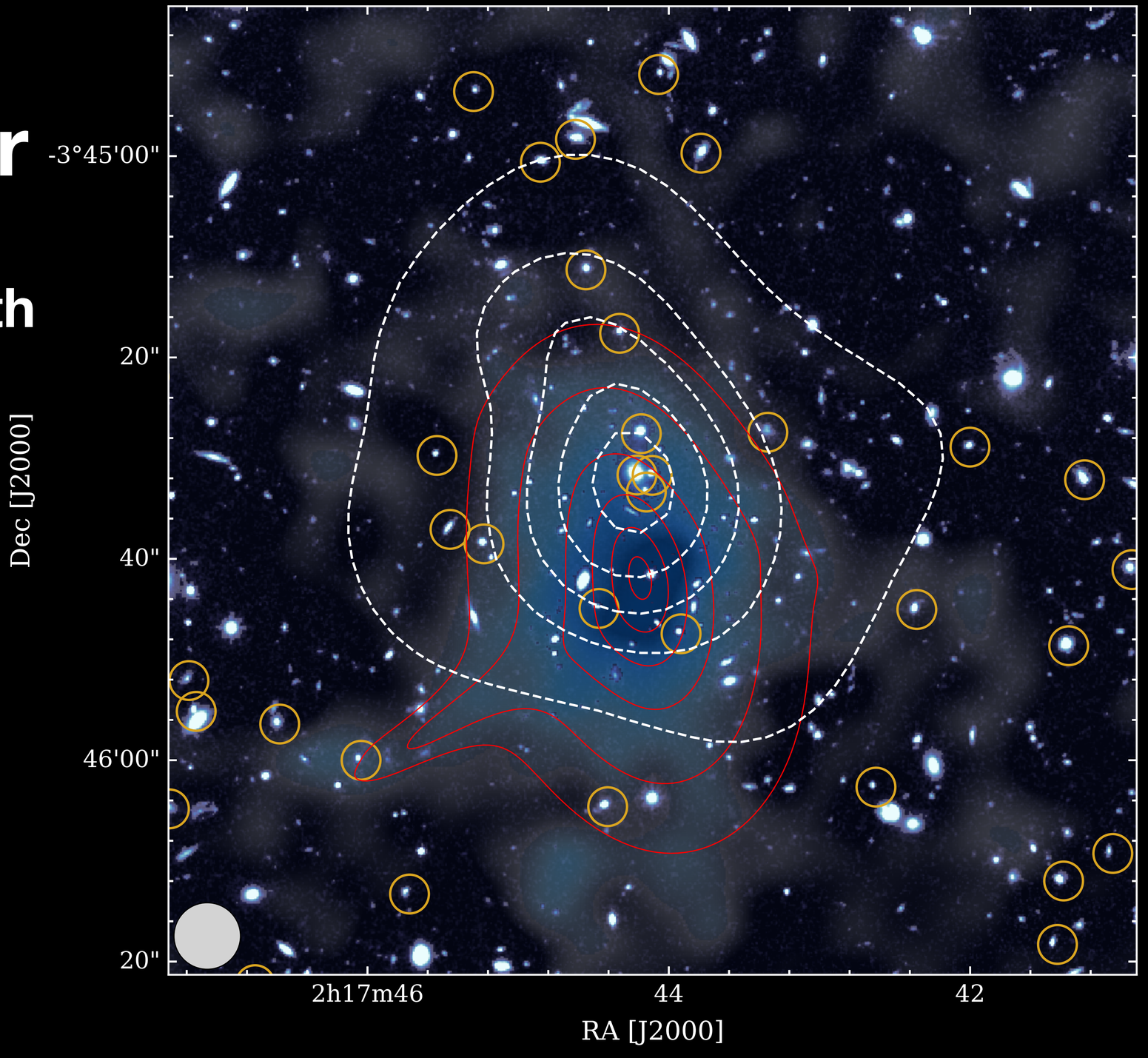
- $\propto SZ_{flux}/\sqrt{SZ_{X-ray}} \propto k_b T$



Let us bring everything together

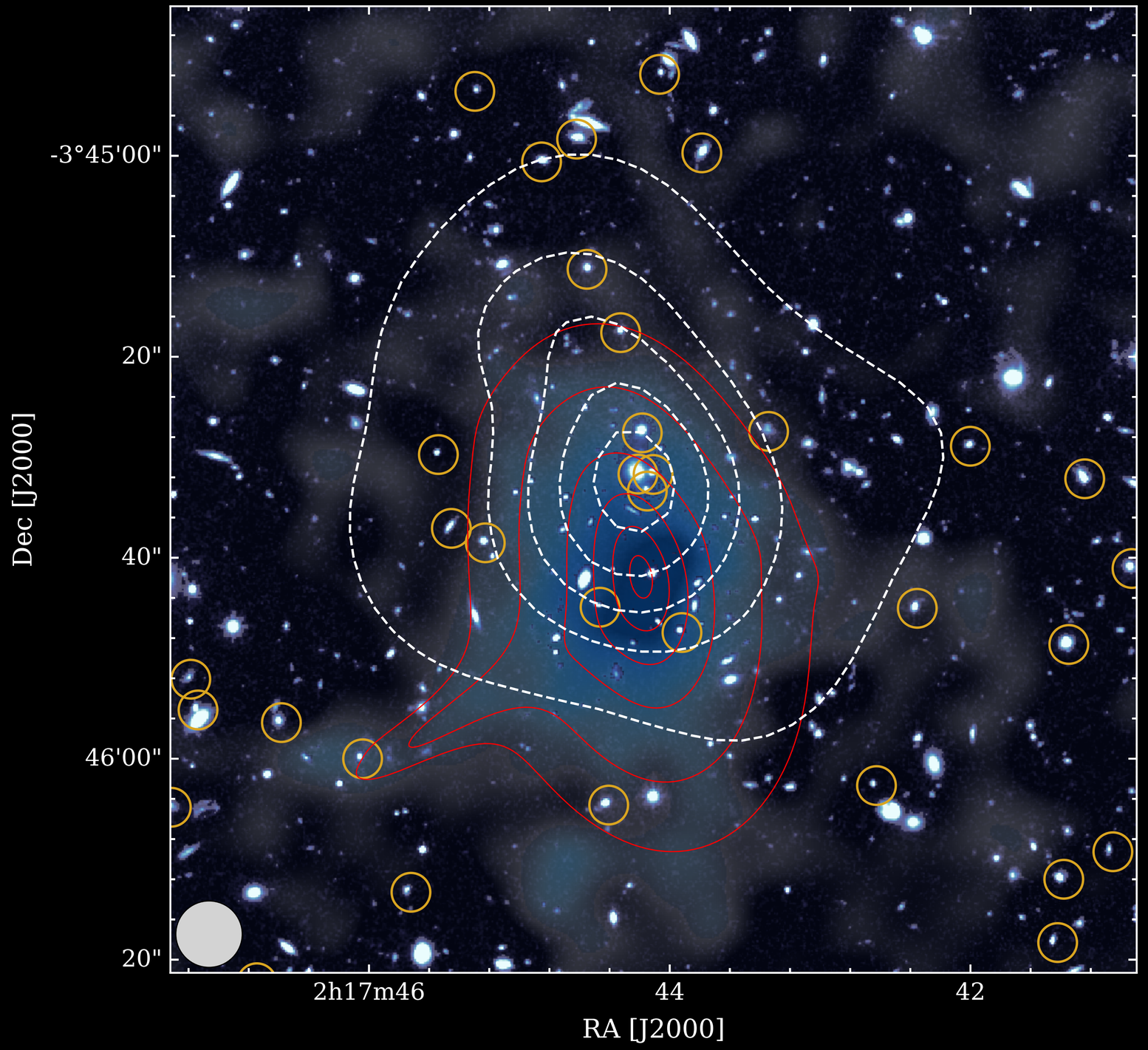
- **We need multi-wavelength information**
  - Optical
  - $H\alpha$
  - SZ
  - X-ray

- **Interpretation**
  - Low density filament/group accreting into the cluster with a Mass ratio of ~1:2.
    - Could boost and heat up the ICM
  - The cluster is still actively forming.
    - An offset between the BCG, the peak X-ray surface brightness, and the SZ-centroid.
    - ~4x larger dynamical mass



To summarise:

- We started with a single blob.
- ACA+ALMA alone weren't enough to classify the cluster based on it's pressure profile.
- However, by including ACT, we measured the pressure profile from the core till roughly the virial radius.
- The profile is consistent with a not a to extreme morphologically disturbed high-z system.

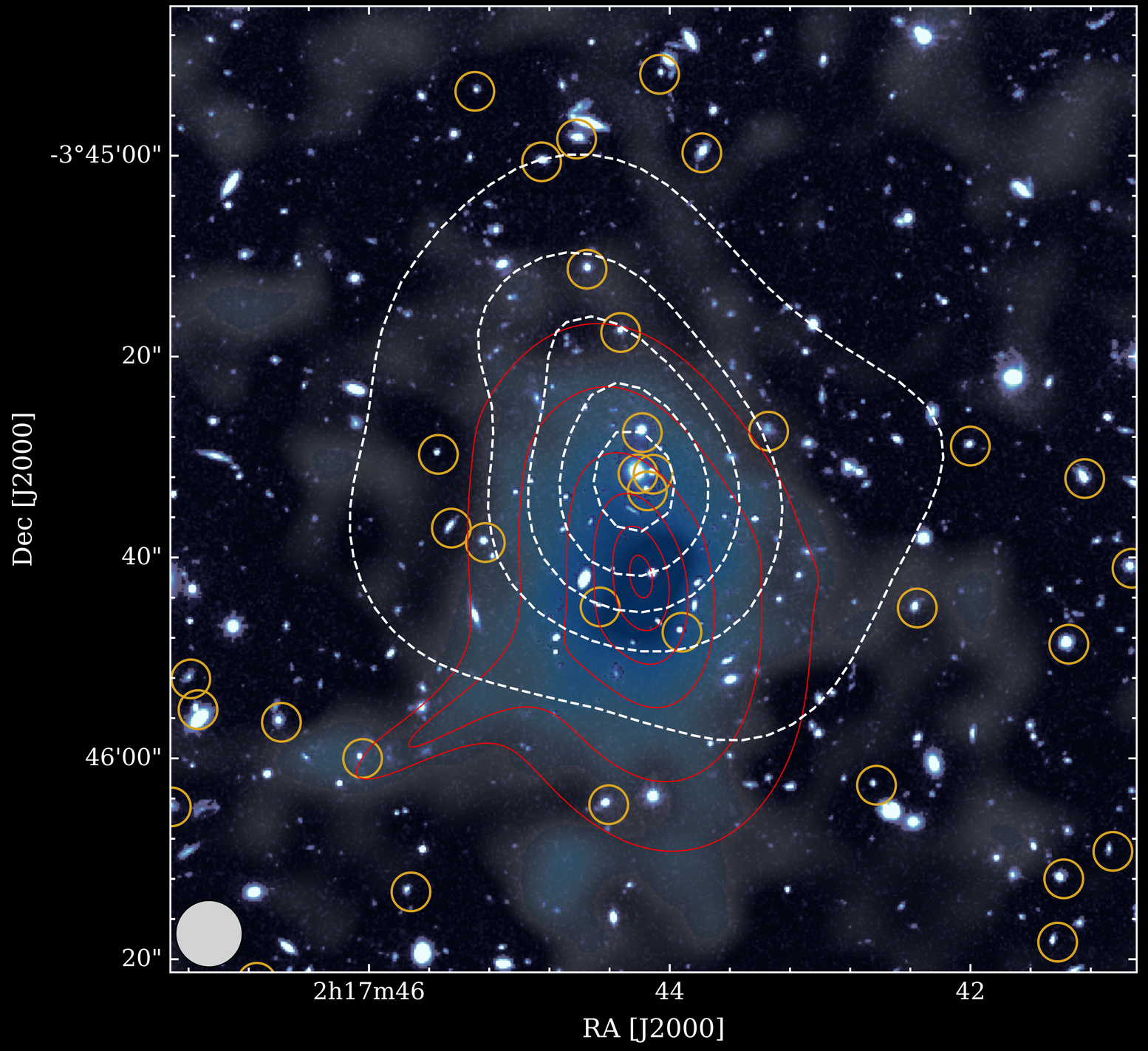


To summarise:

- We started with a single blob.
- ACA+ALMA alone weren't enough to classify the cluster based on it's pressure profile.
- However, by including ACT, we measured the pressure profile from the core till roughly the virial radius.
- The profile is consistent with a not a to extreme morphologically disturbed high-z system.

To do:

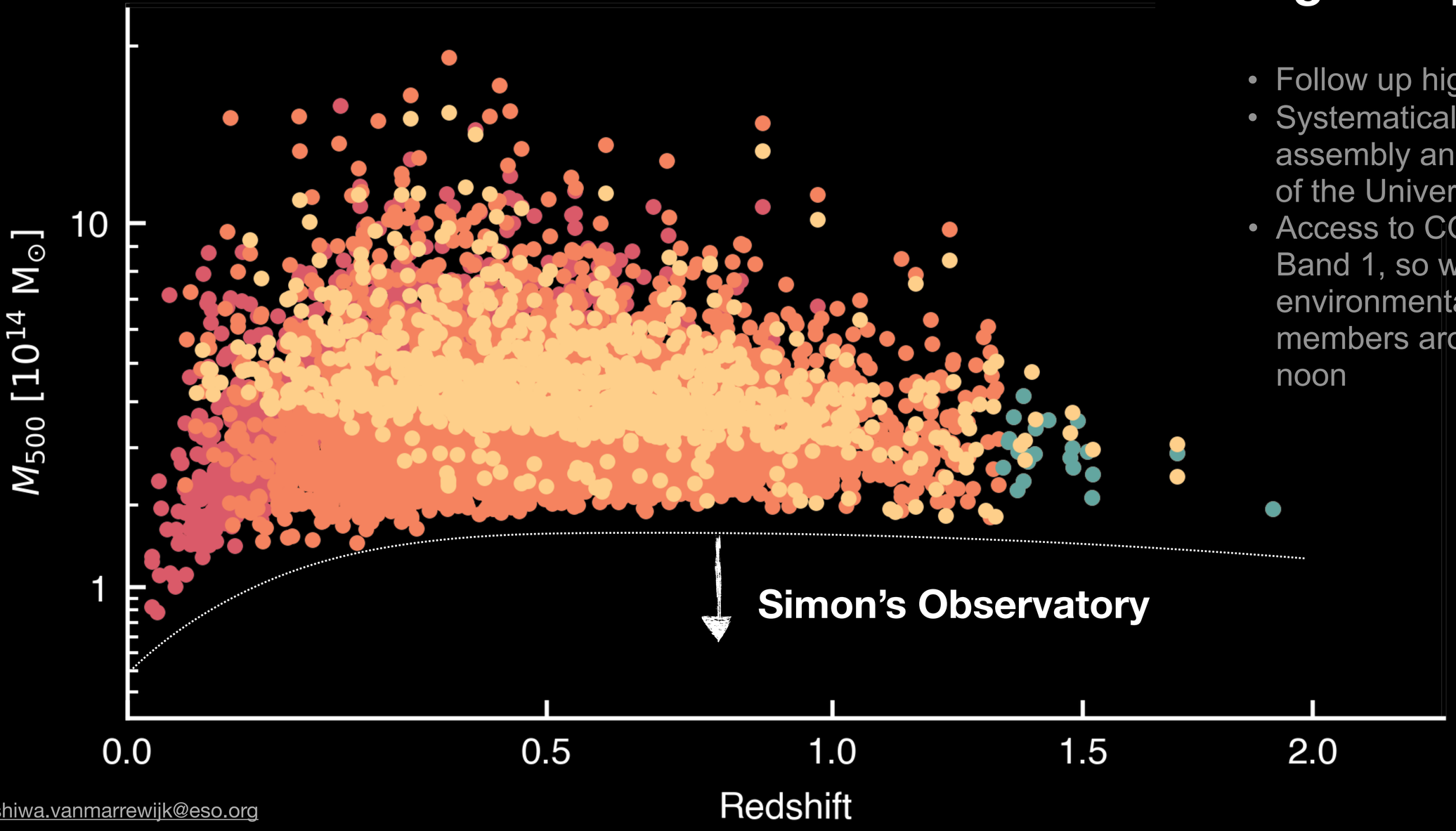
- How did the BCG form?
- How is the entropy distributed throughout the ICM?
- How to derive a cluster mass?
  - Scaling Relations?
  - Dynamical Modeling?
  - Weak Lensing?
  - CMB Lensing?



S.V. Werner et al. 2023, A. Trudeau et al. 2022

Next steps..

- **Large Project**
  - Follow up high-z clusters in ACT
  - Systematically study cluster assembly and the thermalisation of the Universe
  - Access to CO(1-0) in ALMA Band 1, so we can study environmental affects on cluster members around the cosmic noon



joshiwa.vanmarrewijk@eso.org

XLSSC 122's mass