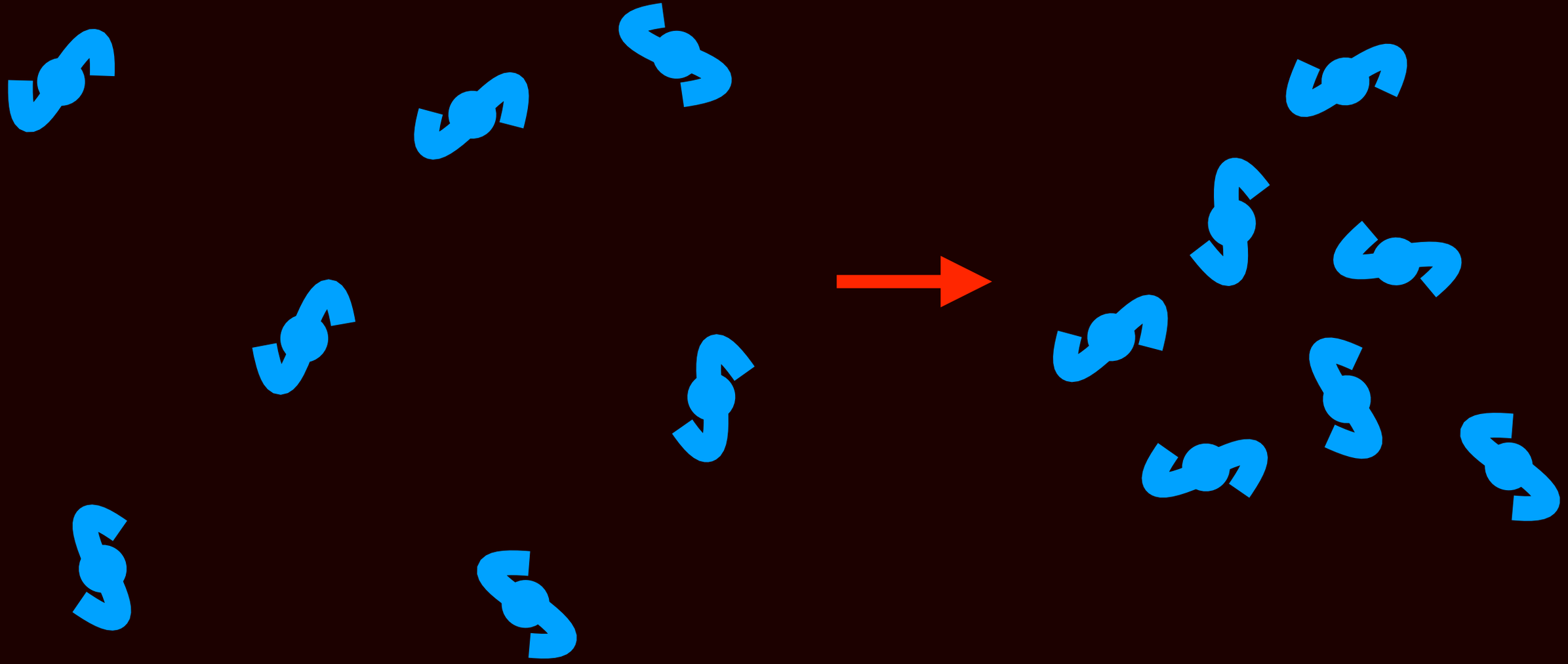
A galaxy proto-cluster seen at radio frequencies

Ryley Hill

What is a galaxy proto-cluster?

A collection of galaxies that will become a cluster at redshift 0.

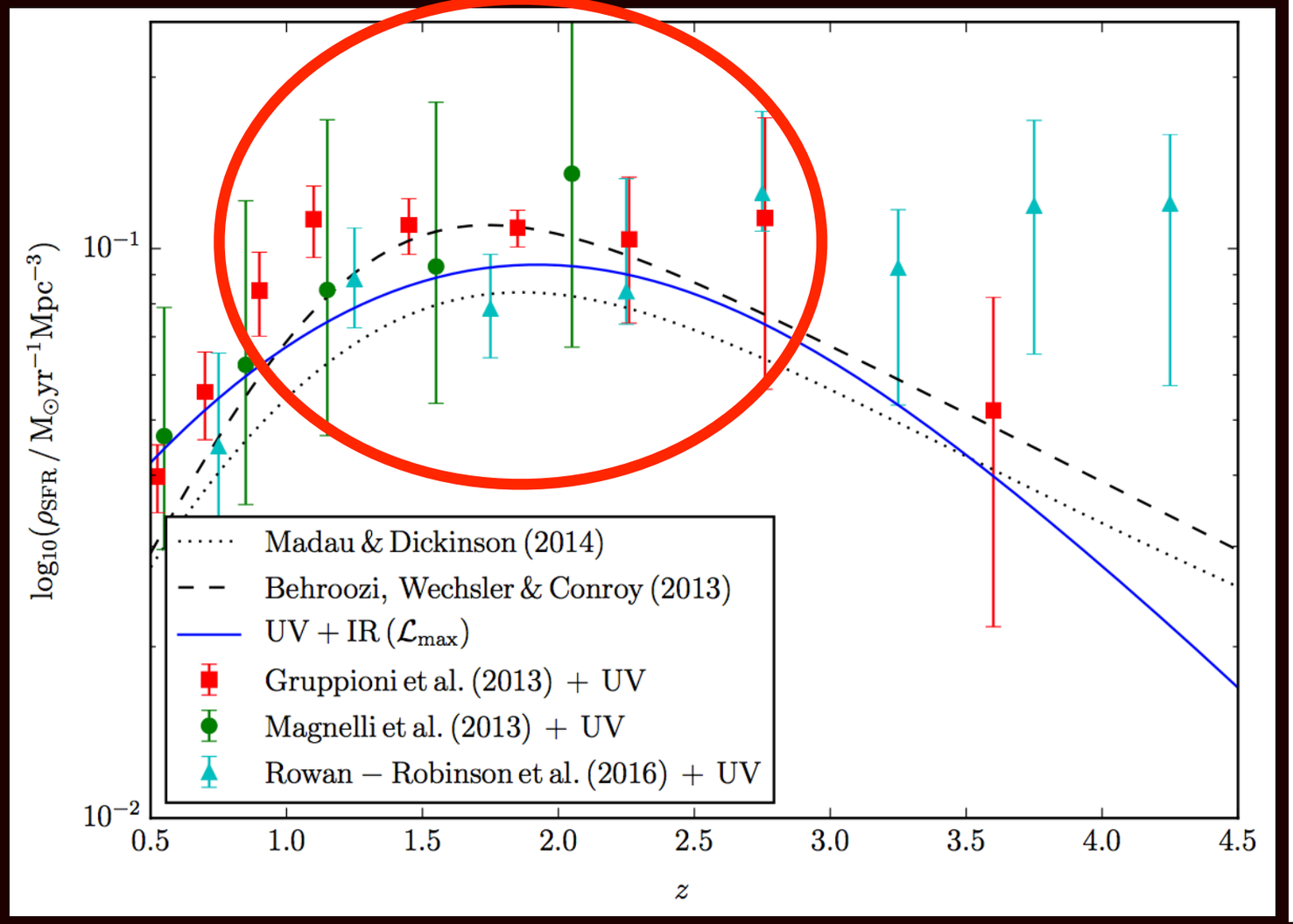


Why are galaxy proto-clusters interesting?

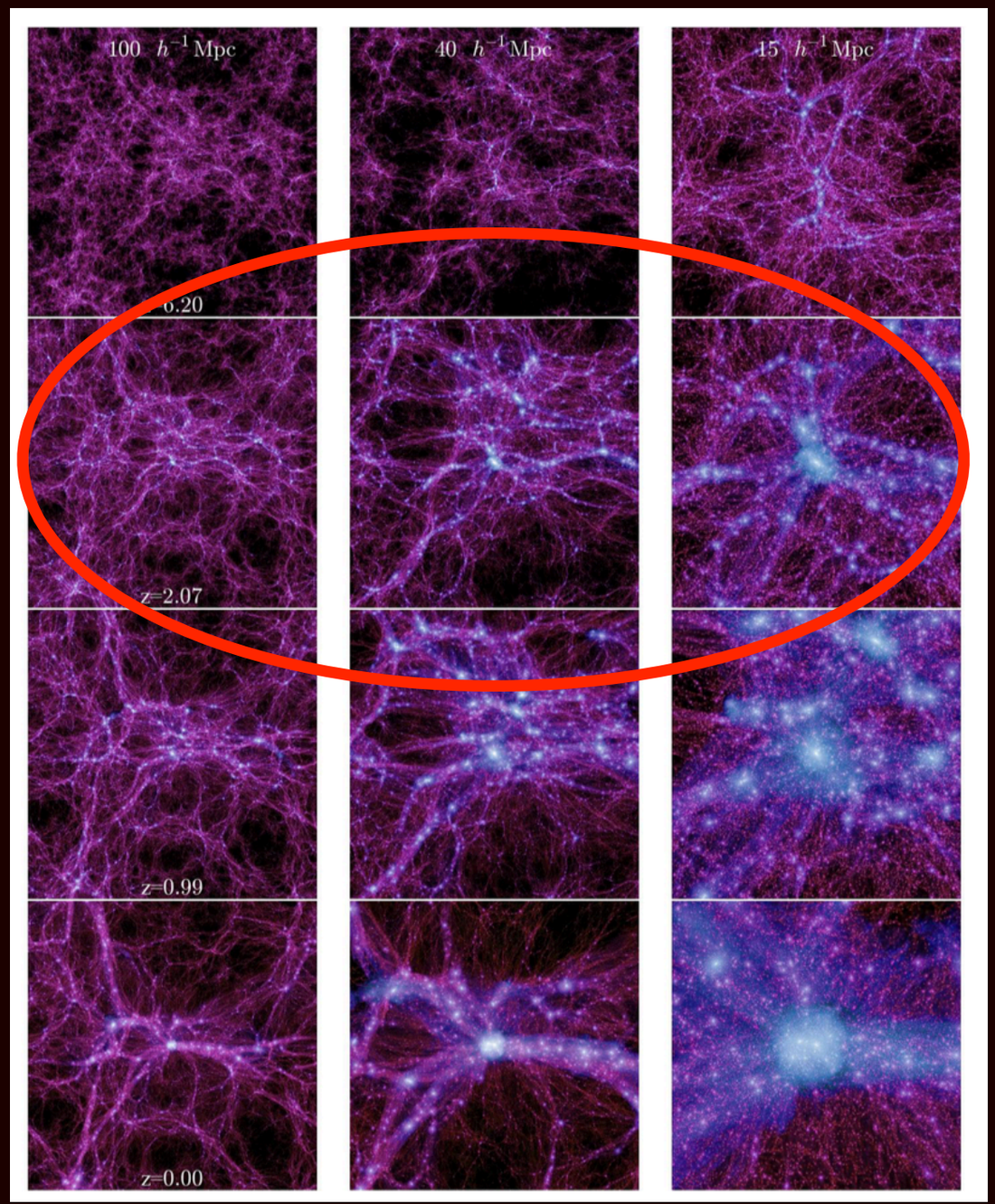
Needed to understand structure formation.

Relationship between star formation and cluster formation.

Same epoch, redshift 2!



Koprowski et al. 2017

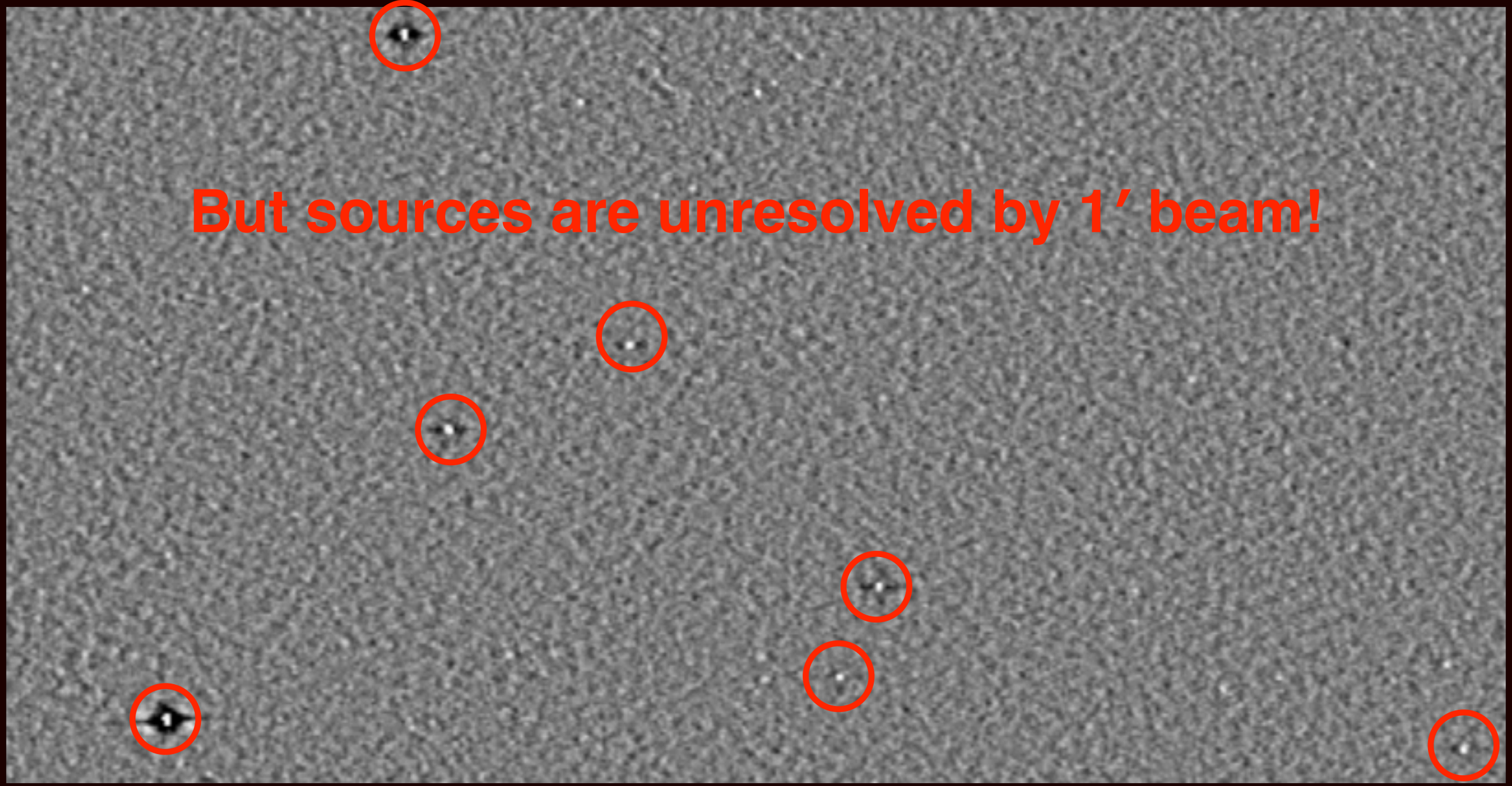


Boylan-Kolchin et al. 2009

How do you find galaxy proto-clusters?

Not virialized, can't use X-rays or SZ effect.

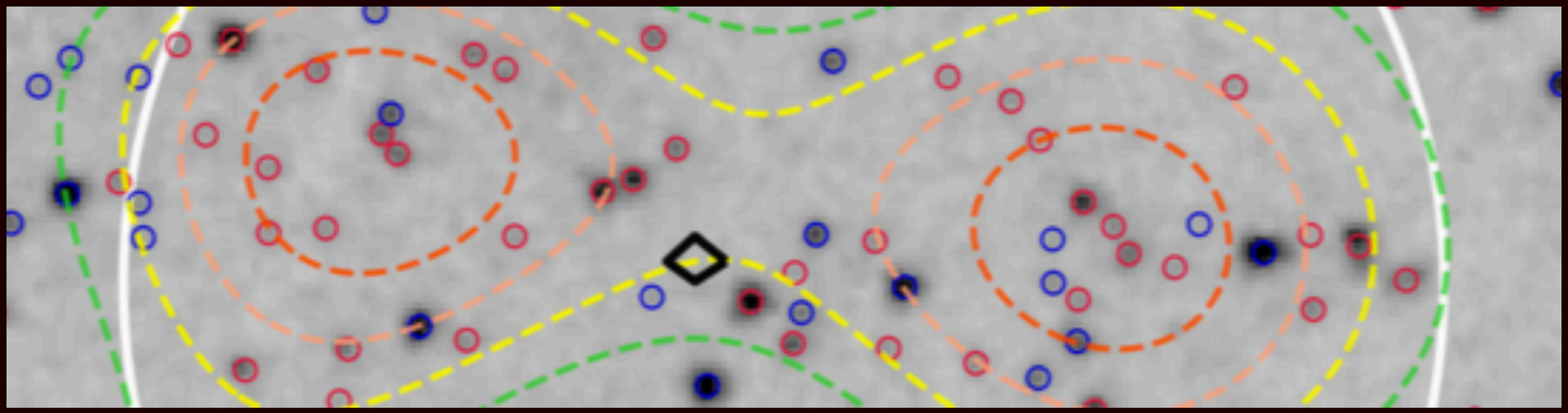
Look for bright sources in long-wavelength surveys:



South Pole Telescope; Vieira et al. 2010, Mocanu et al. 2013

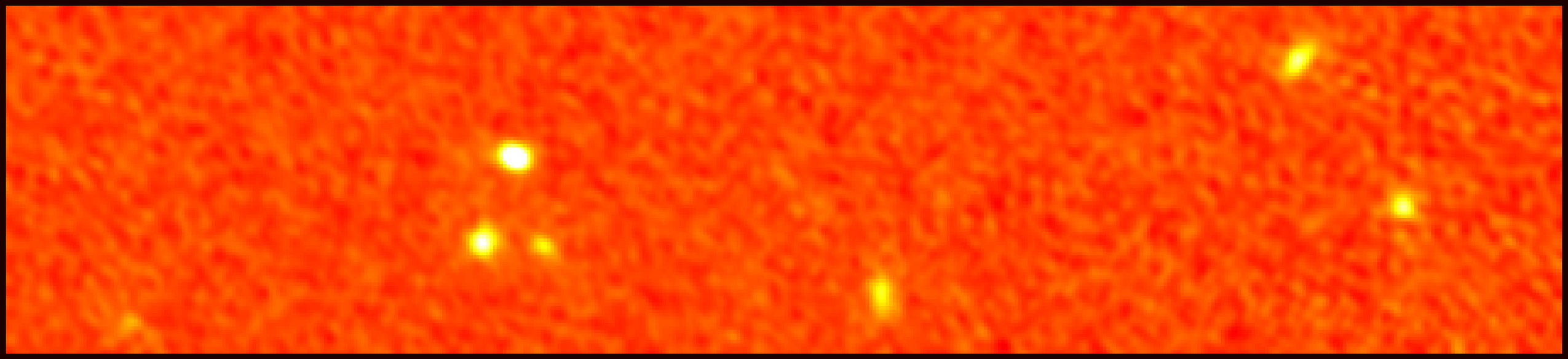
How do you find galaxy proto-clusters?

Then look for overdensities of infrared galaxies:



Martinache et al. 2018

Or resolve the sources directly:

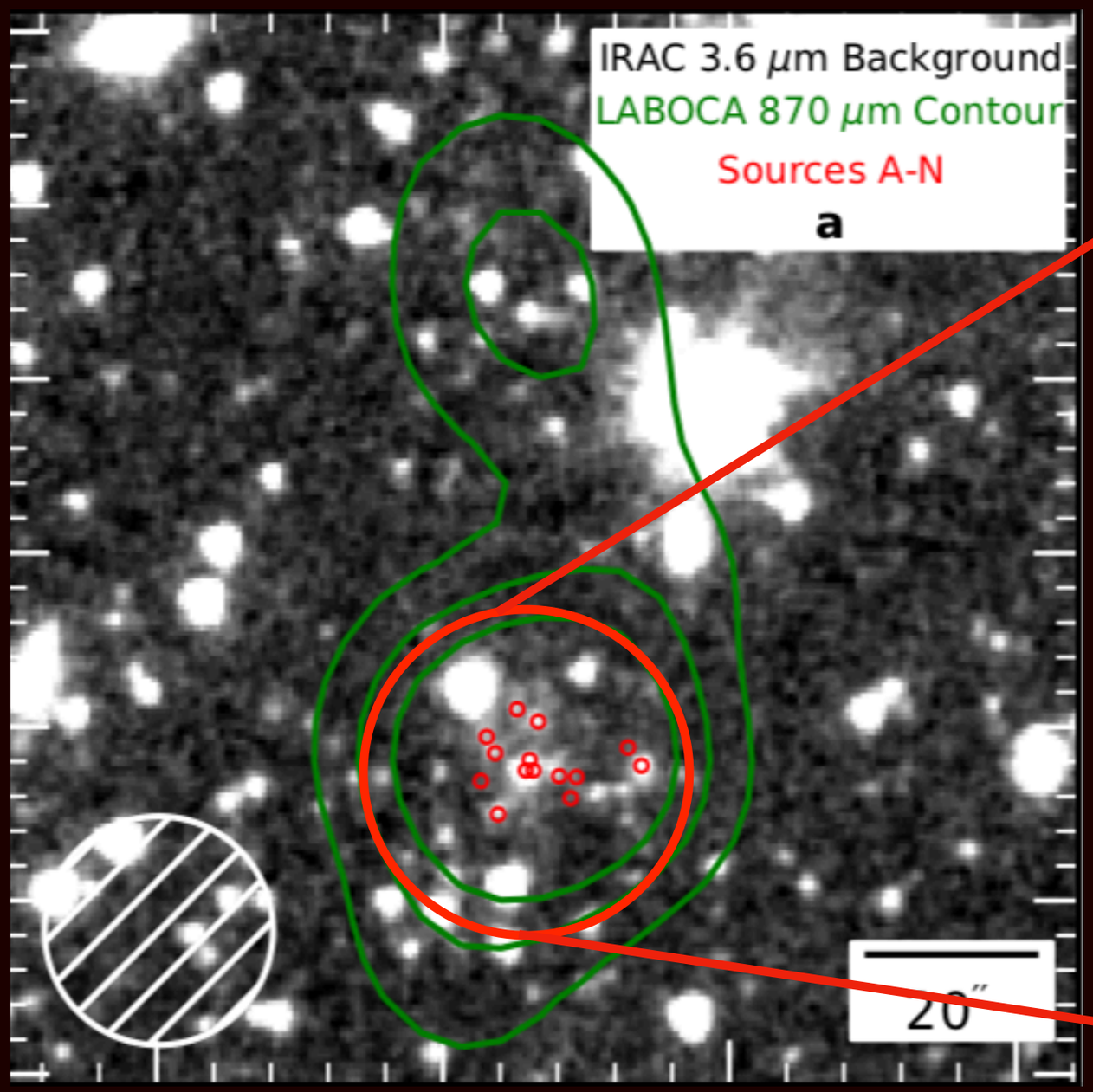


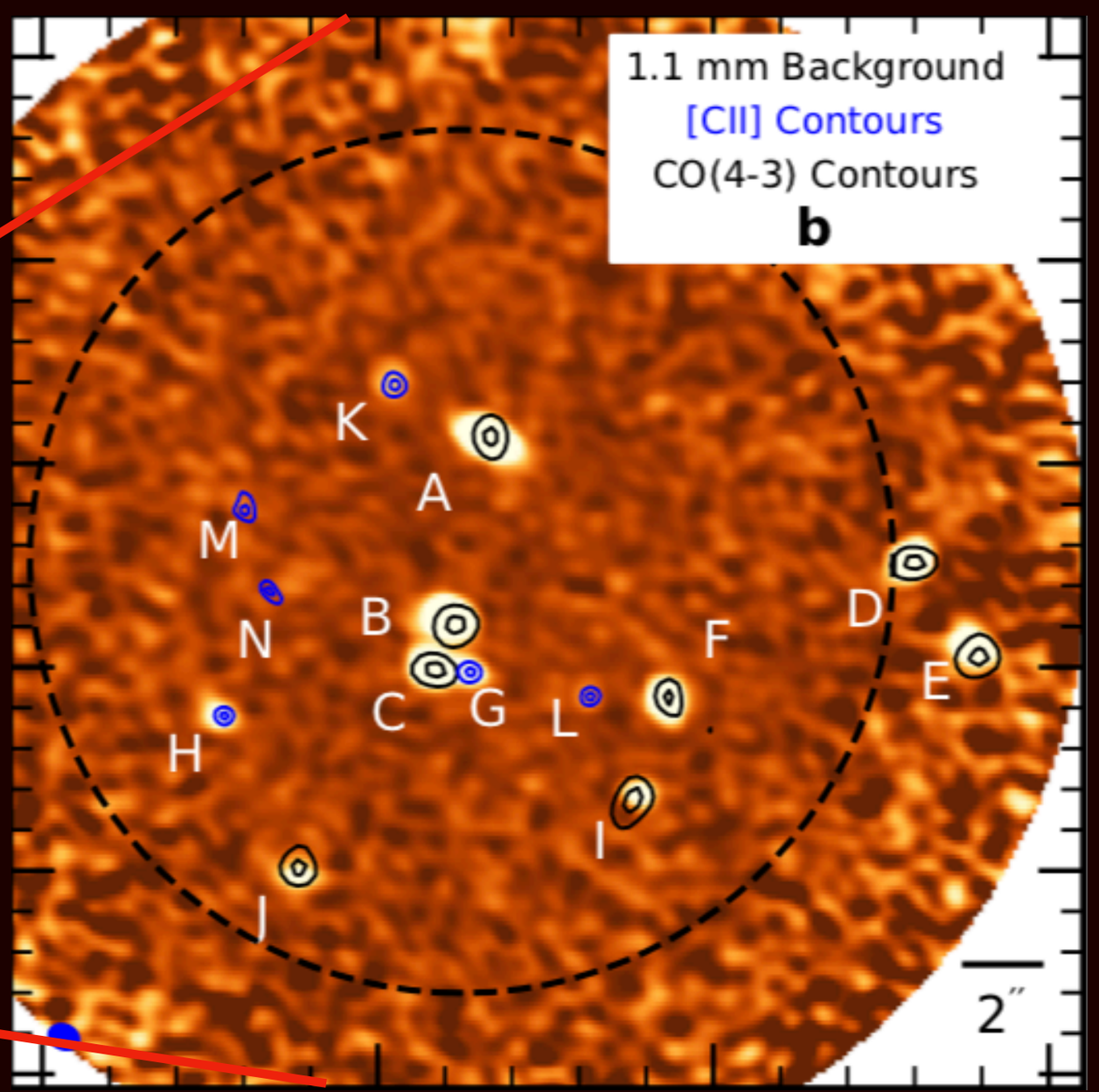
Hill et al. in prep.

SPT2349
A particularly interesting proto-cluster

Spitzer and LABOCA

ALMA



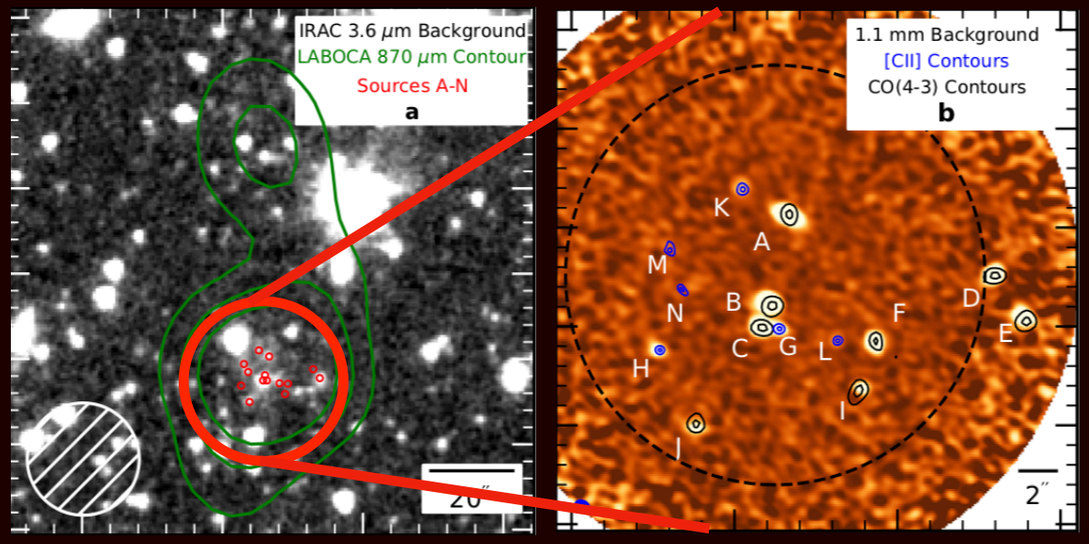


Miller et al. 2018

SPT2349
A particularly interesting proto-cluster

z=4.3, 1.5 Gyrs after the Bing Bang.

14 spectroscopically confirmed starbursting galaxies (but only 50% the total submillimetre flux!)



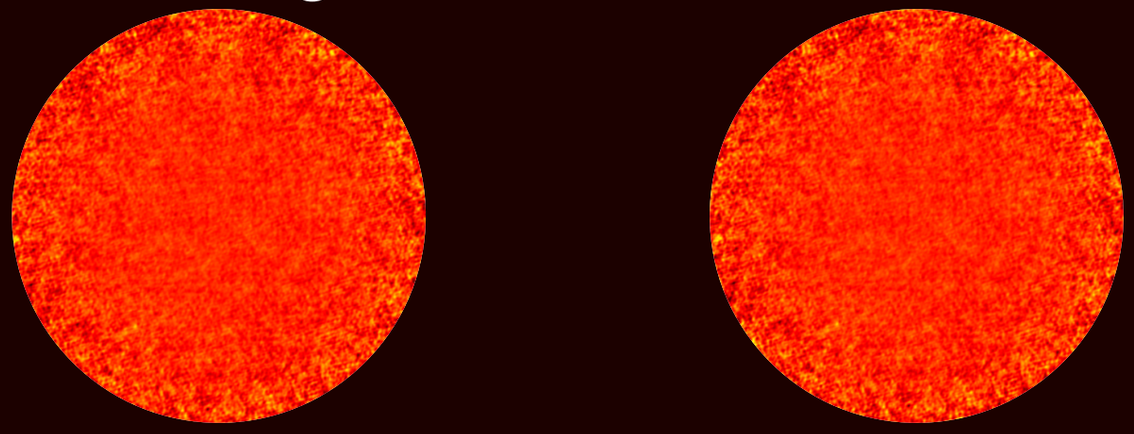
1000 times the field density.

Dynamical mass of order $10^{13}\,\mathrm{M}_{\odot}$, will become one of the most massive clusters at z=0.

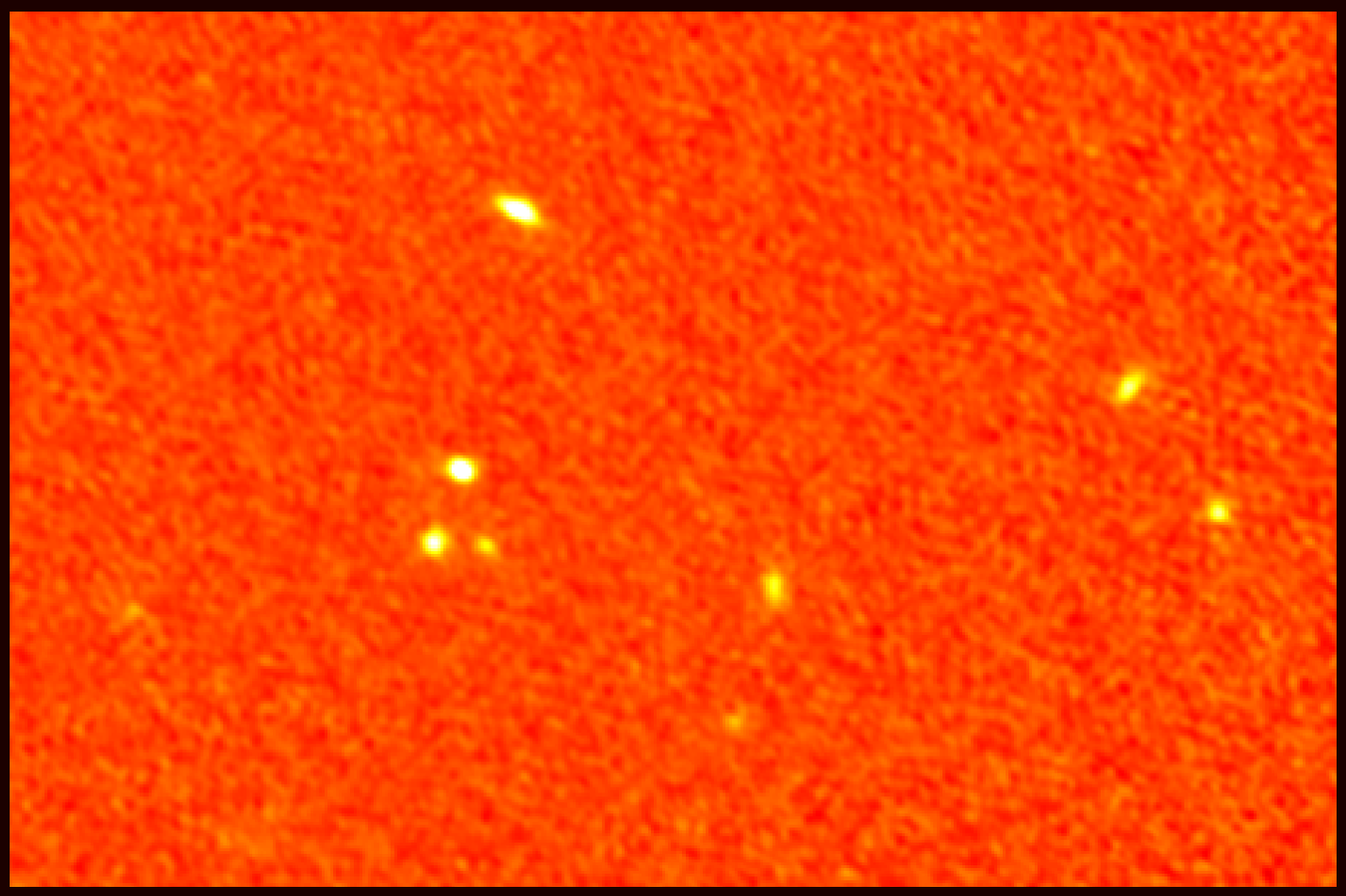
More evolved at such at such a young age than expected with simulations.

Awarded more time for Cycle 6

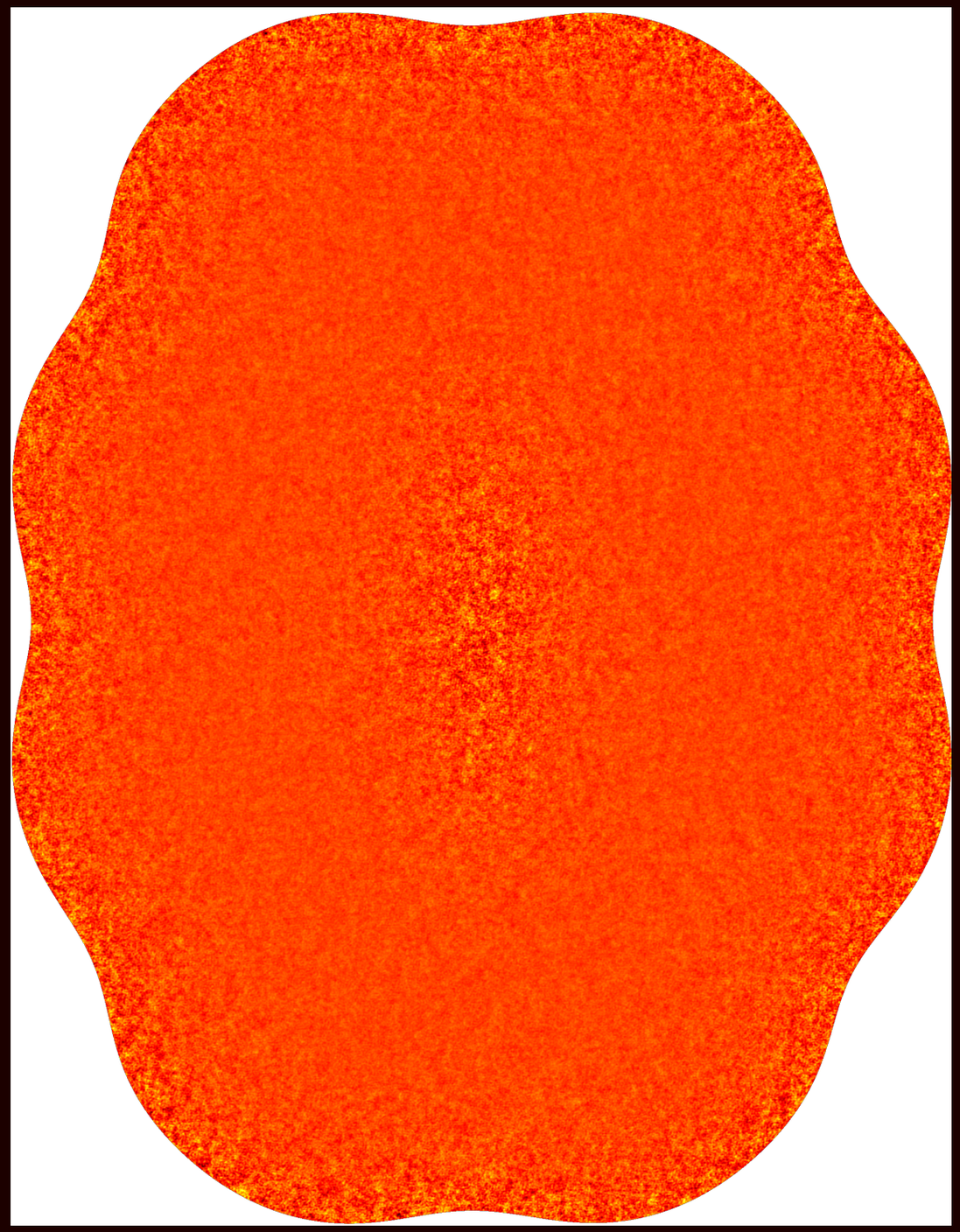
Surrounding Herschel sources at 90 GHz:



CO(7-6) mapping of core at 150 GHz:



90 GHz mosaic of outer region:



High resolution 350 GHz observation of core: Coming soon!

Awarded more time for Cycle 6

Surrounding Herschel sources at 90 GHz:

Find galaxies in associated structures with CO(4-3) lines.

90 GHz mosaic of outer region:

Combine with data from previous cycles to get a complete mosaic.

CO(7-6) mapping of core at 150 GHz:

Find more proto-cluster members with CO(4-3) lines.

Line diagnostics of the 14 confirmed proto-cluster members.

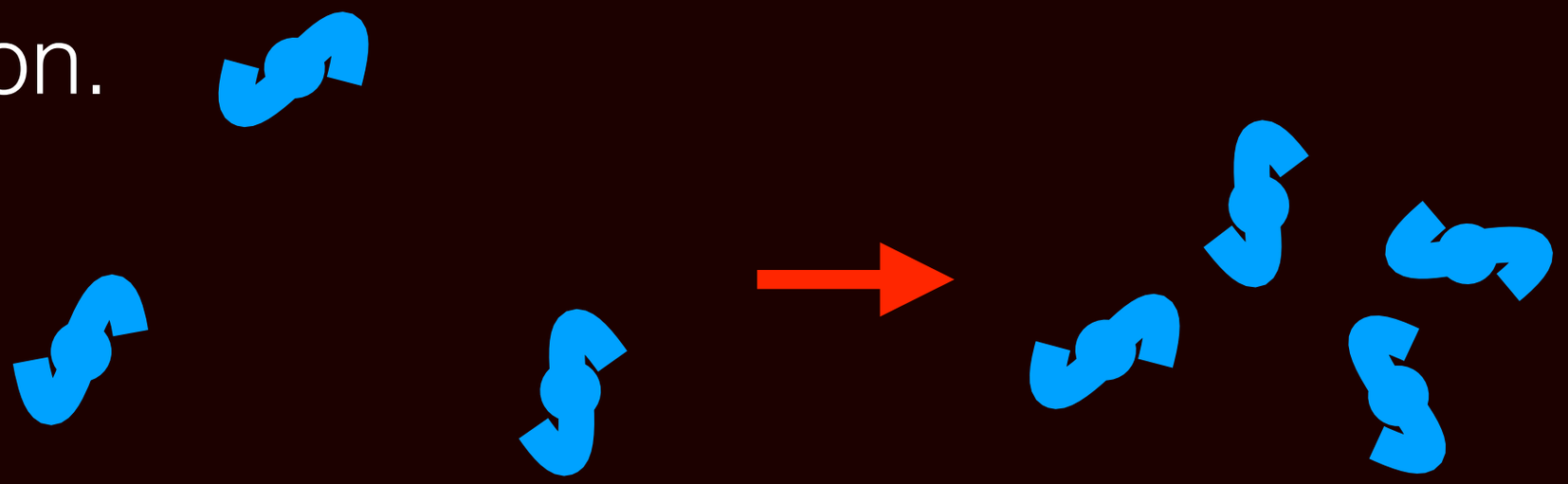
Get proto-cluster velocity dispersion and morphology.

High resolution 350 GHz observation of core:

Resolve the 14 confirmed proto-cluster members to get rotation curves.

Conclusion

Proto-clusters teach us about structure formation and evolution.



Large surveys and lots of follow-up are needed to find them.

SPT2349 is a particularly interesting proto-cluster, we are learning lots from long-wavelength observations.