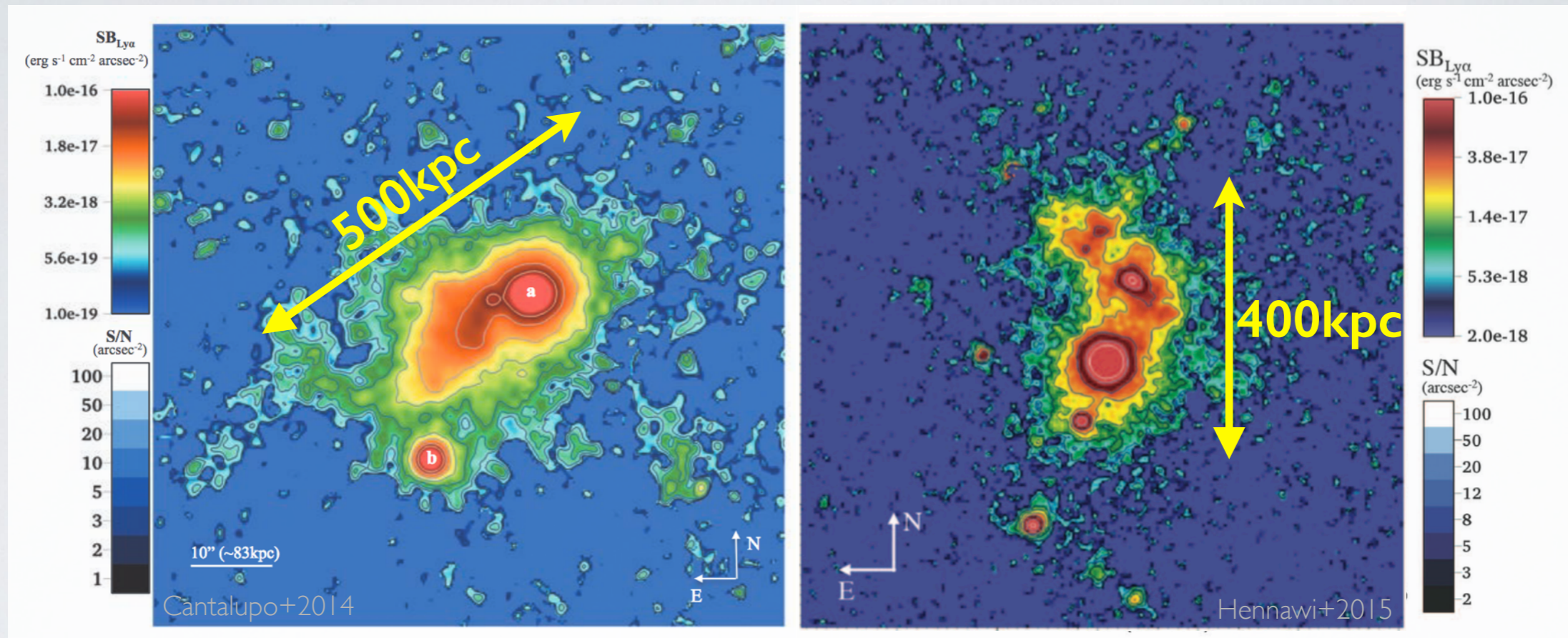


Unveiling Dust Emission Associated with Extended Quasar Nebulae at $z=2\sim 3$



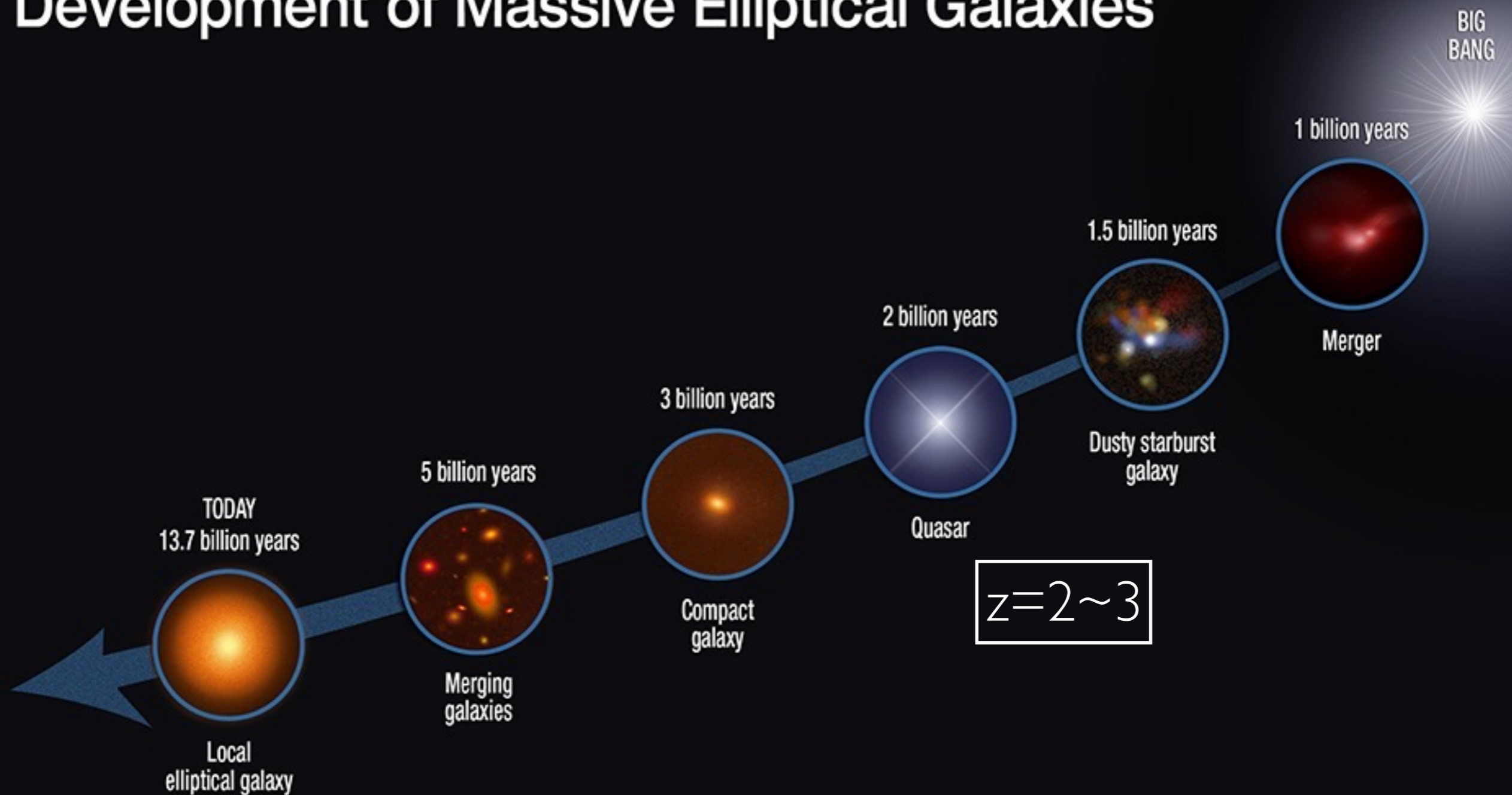
Chian-Chou Chen or T.C. (ASIAA)

Fabrizio Arrigoni Battaia (MPA); M. Fumagalli (Durham); I. Smail (Durham); Y. Yang (KASI)

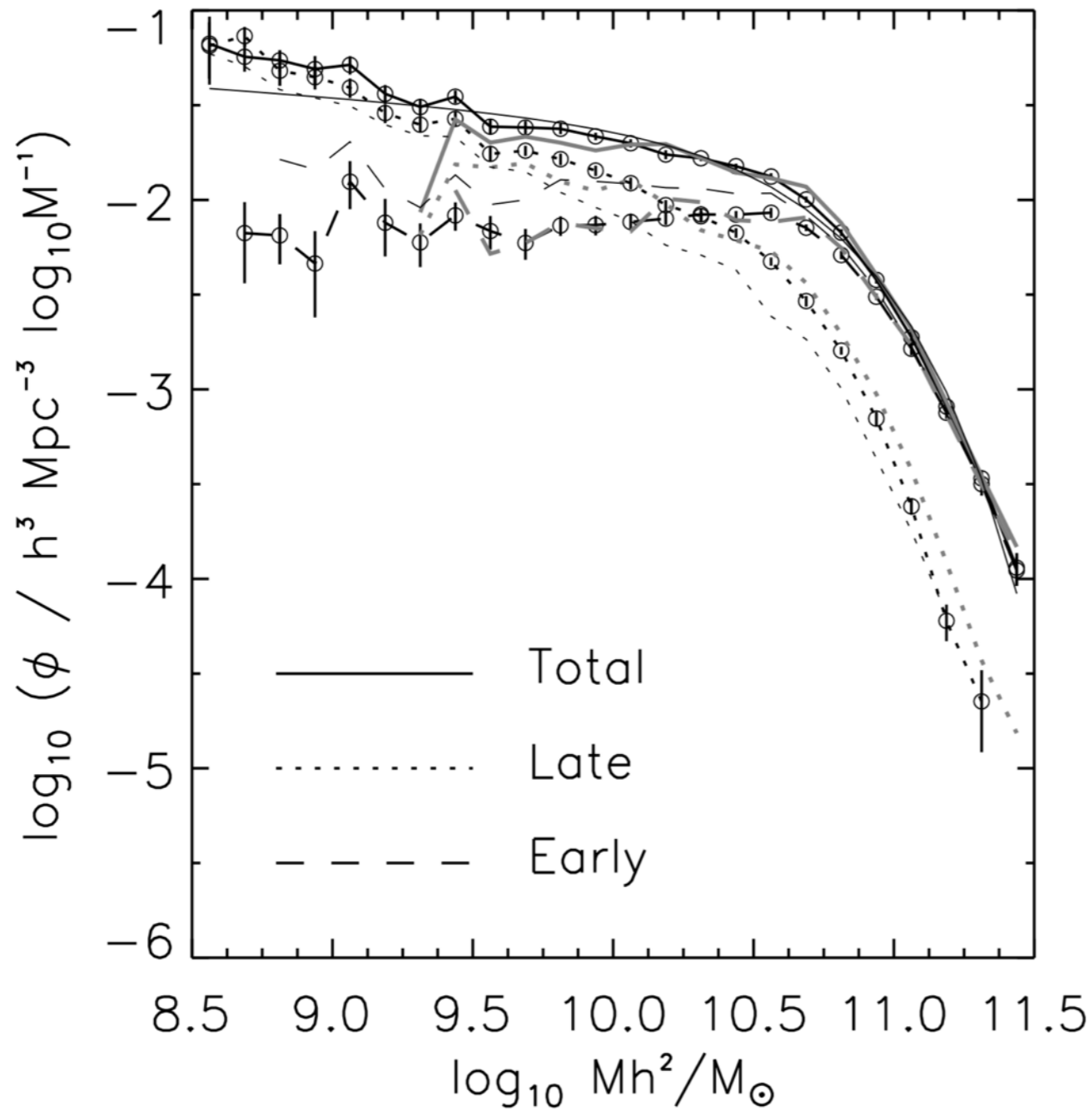


Quasars play a key role in galaxy evolution

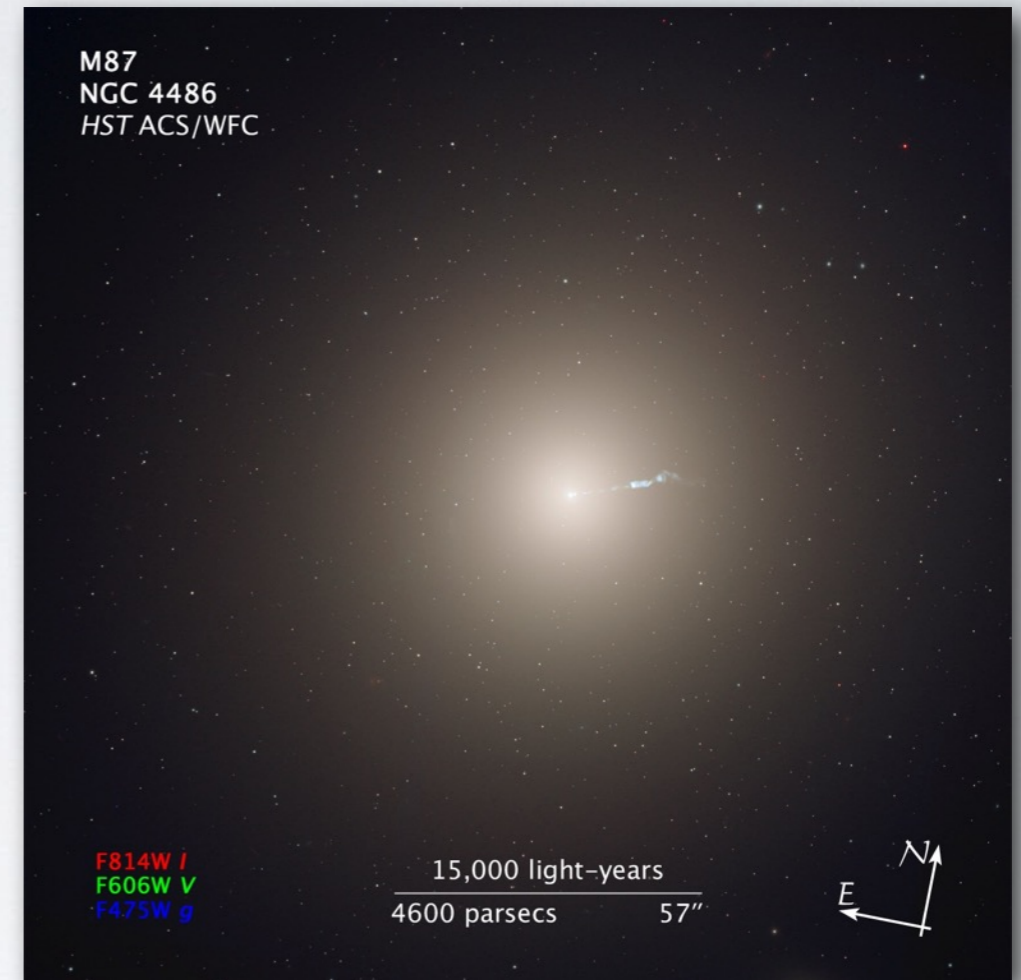
Development of Massive Elliptical Galaxies



Local Massive Ellipticals

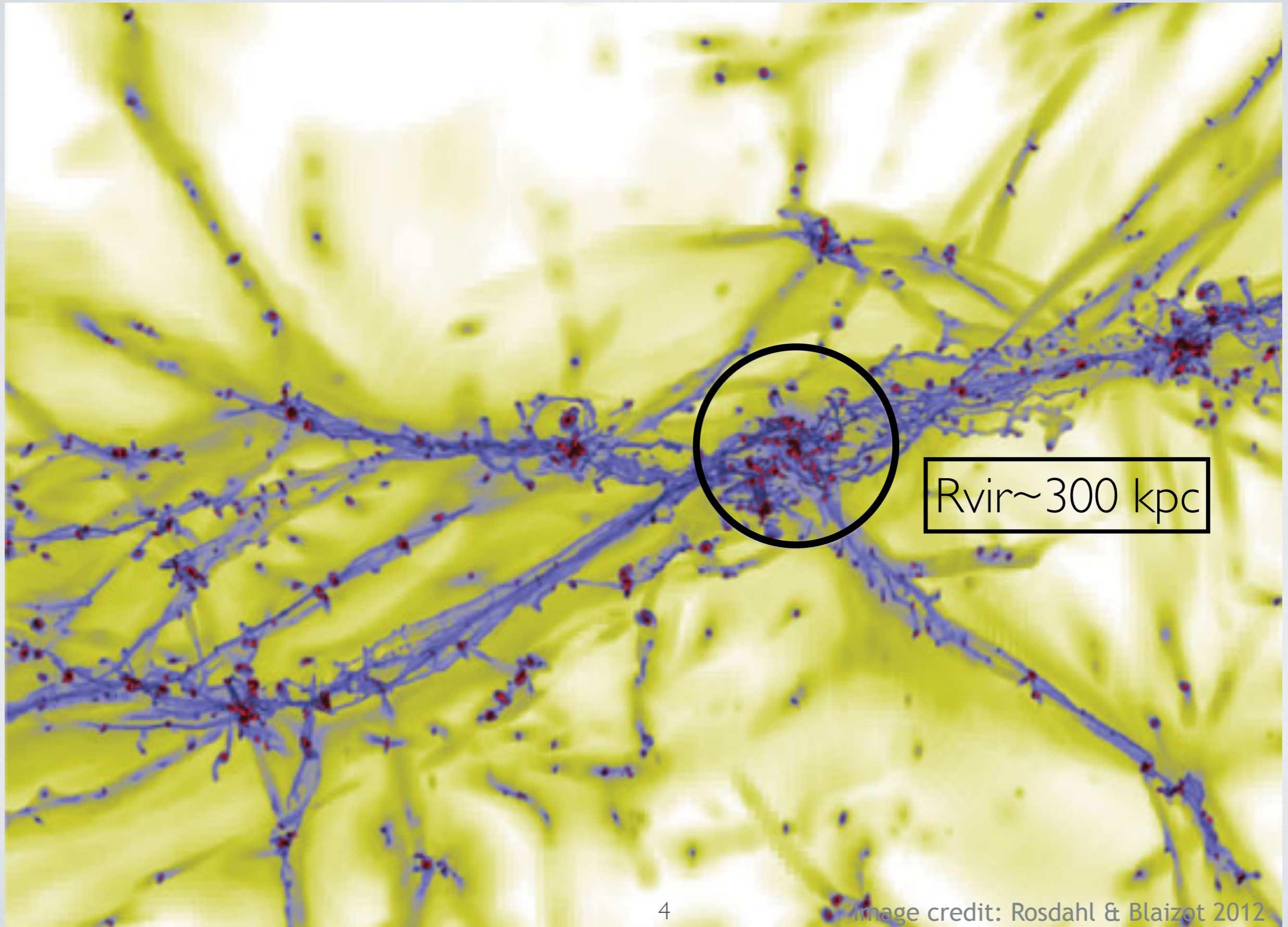


Bell et al. 2003

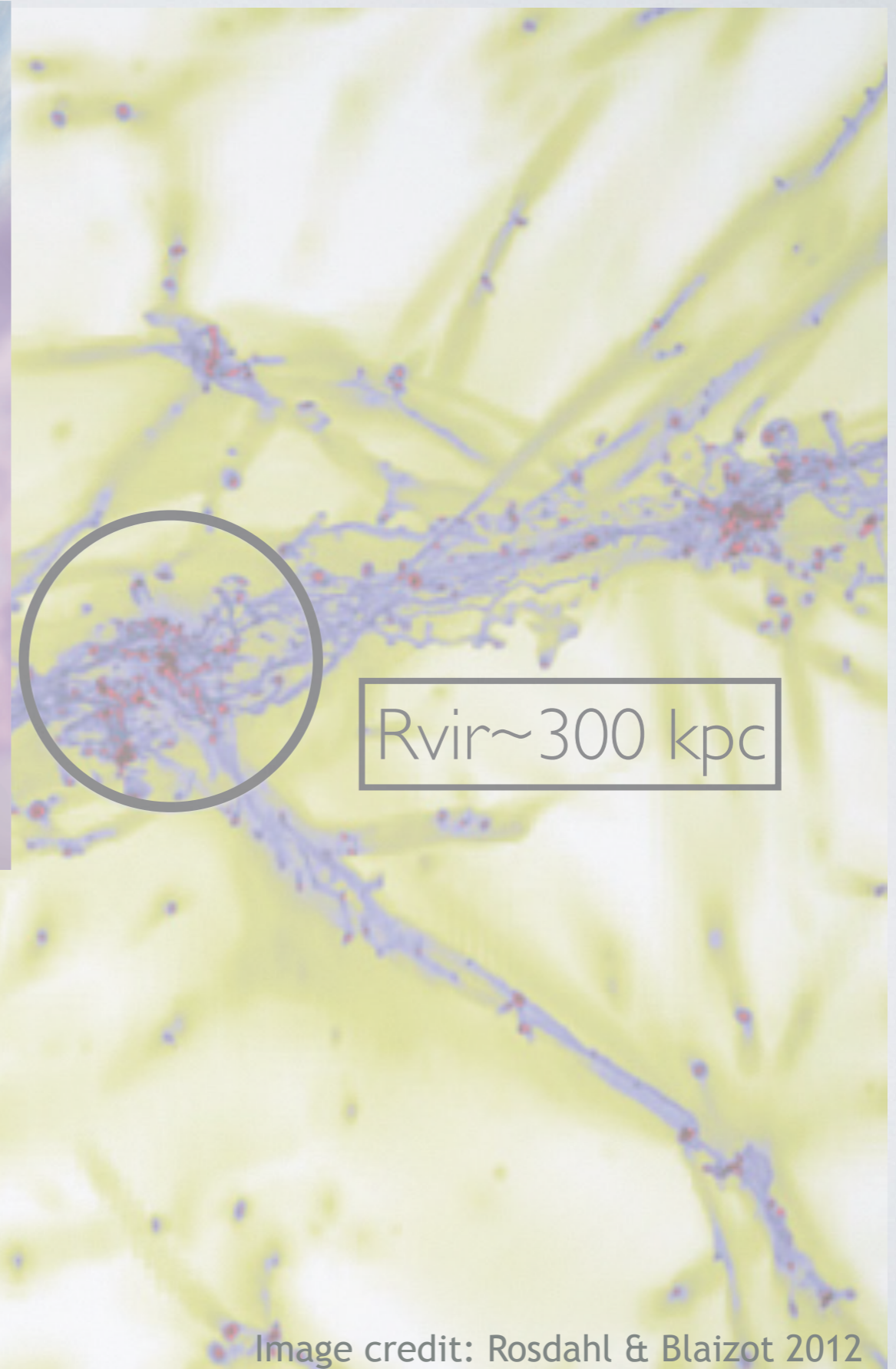
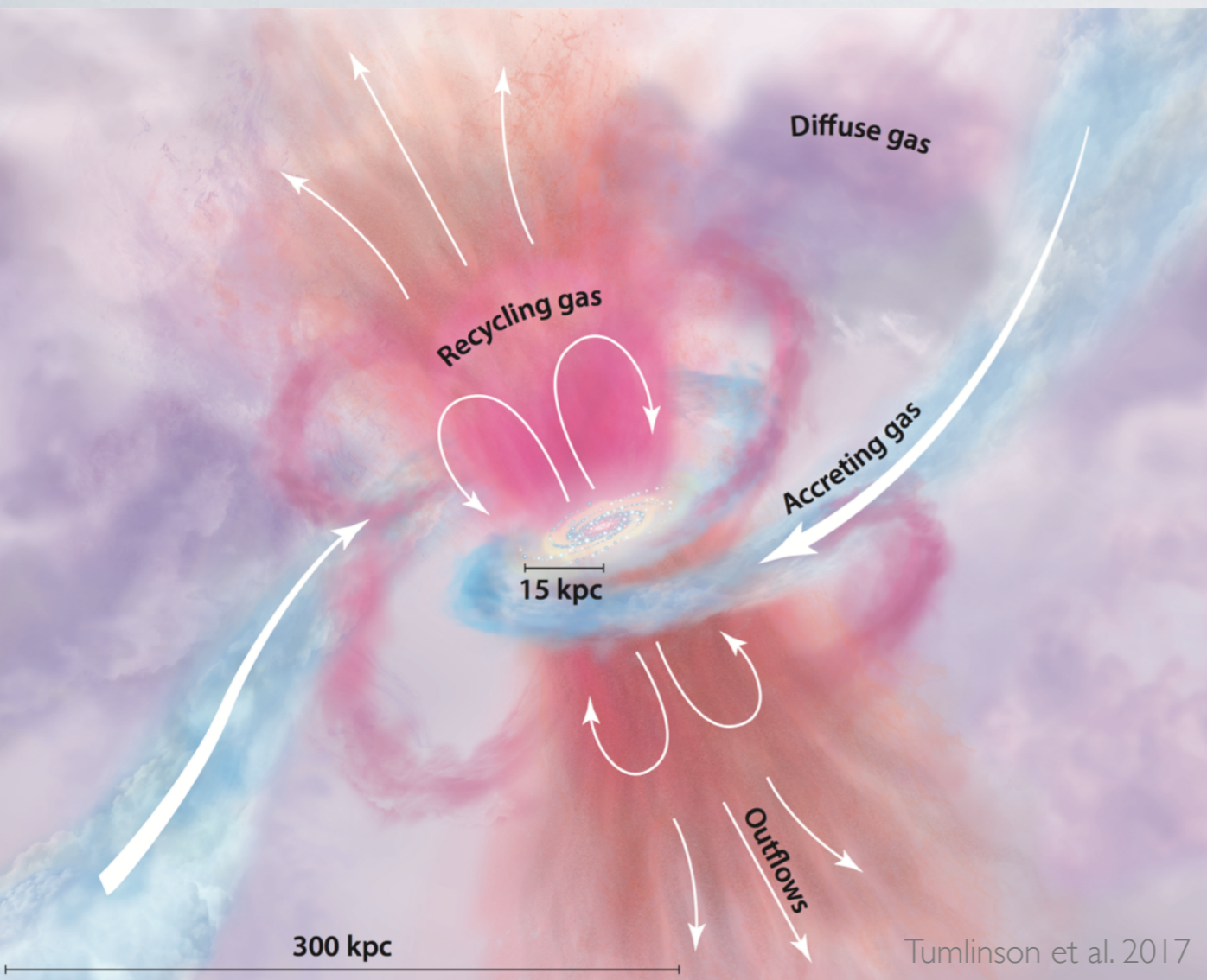


...they dominate the mass budget in the local Universe

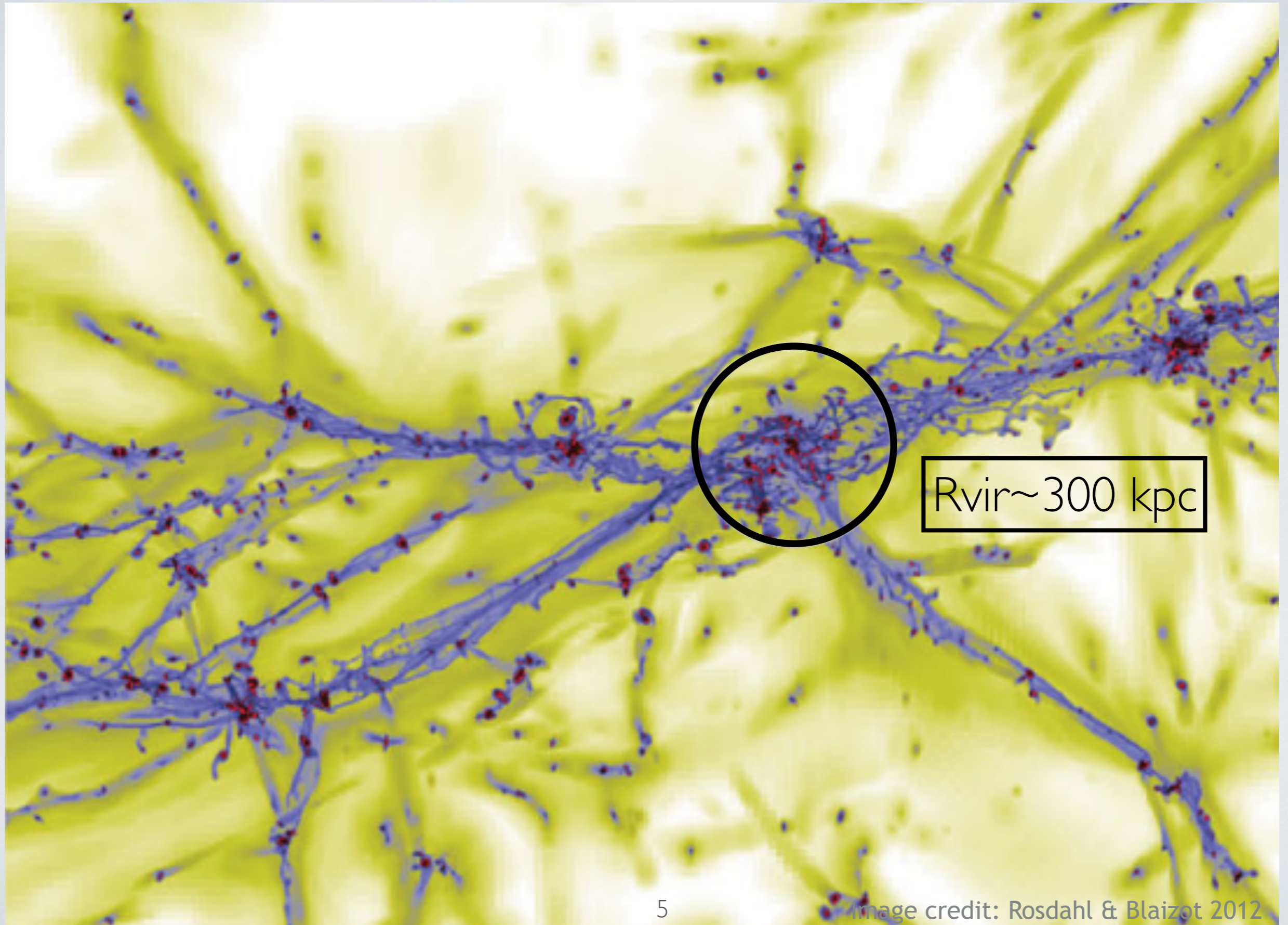
Quasars at $z=2\sim 3$ live in massive halos



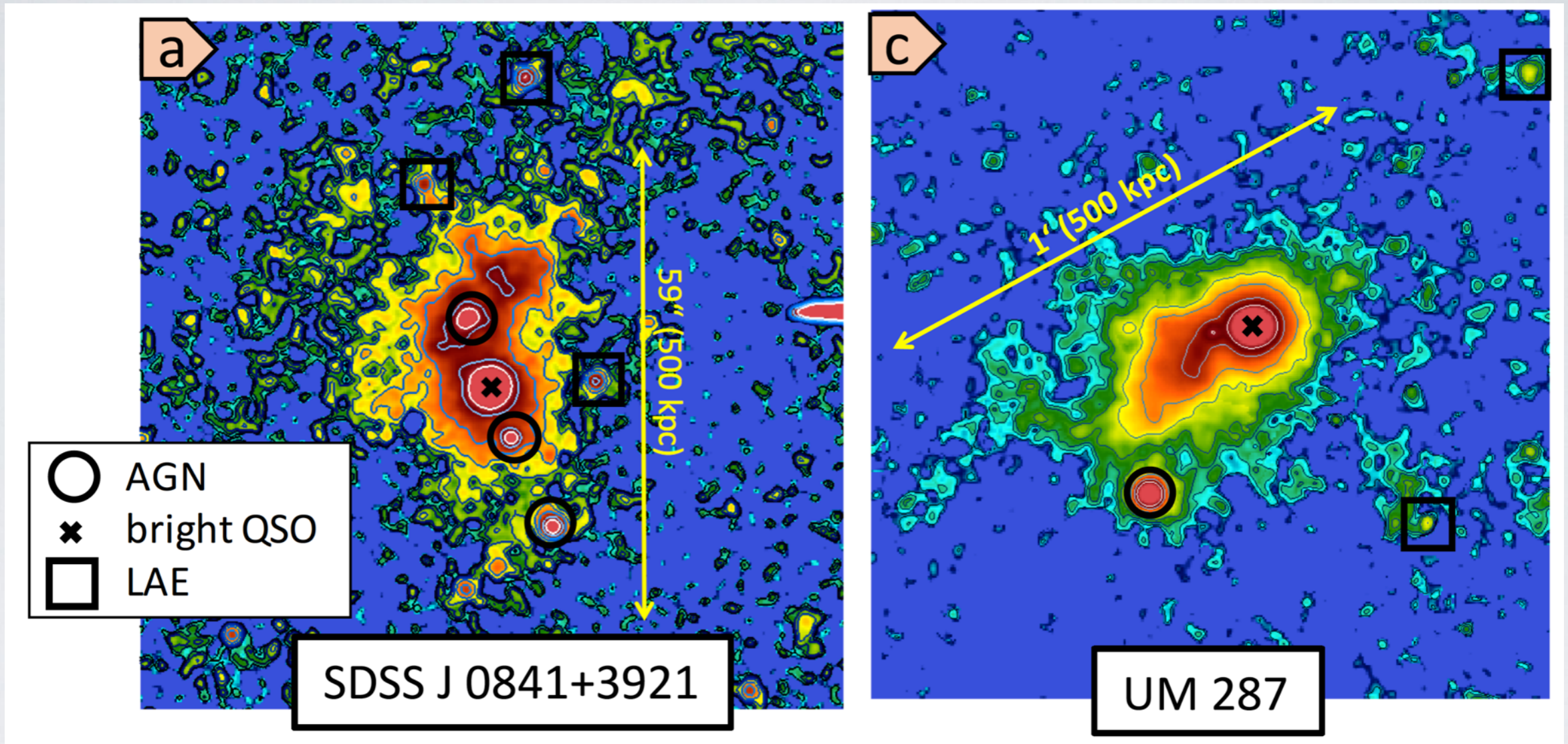
Quasars at $z=2\sim 3$ live in massive halos



Quasars at $z=2\sim 3$ live in massive halos



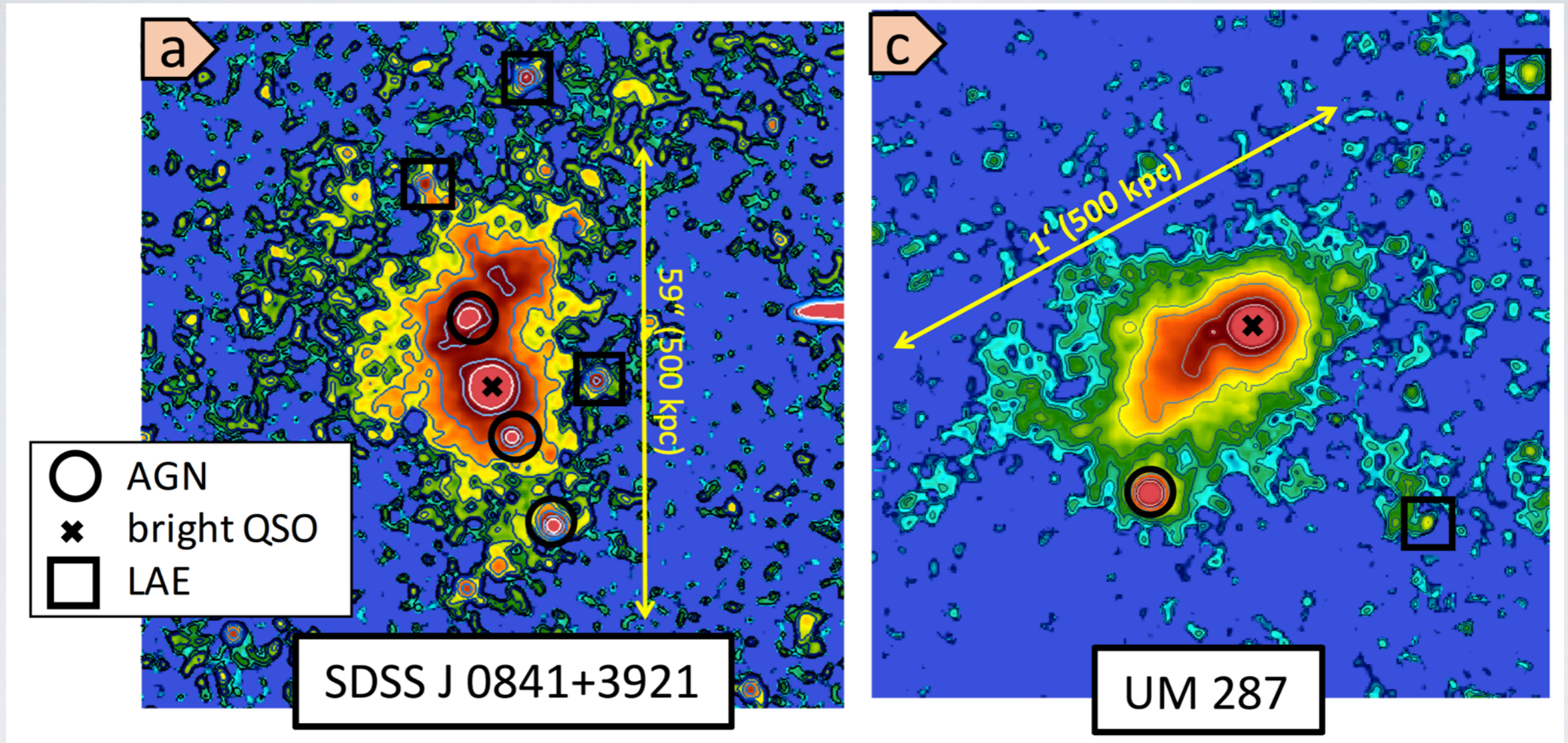
Enormous Lyman-alpha nebula (ELAN) - Lyman-alpha emission across > 100 kpc



Hennawi+2014

Cantalupo+2014

Enormous Lyman-alpha nebula (ELAN) - Lyman-alpha emission across > 100 kpc

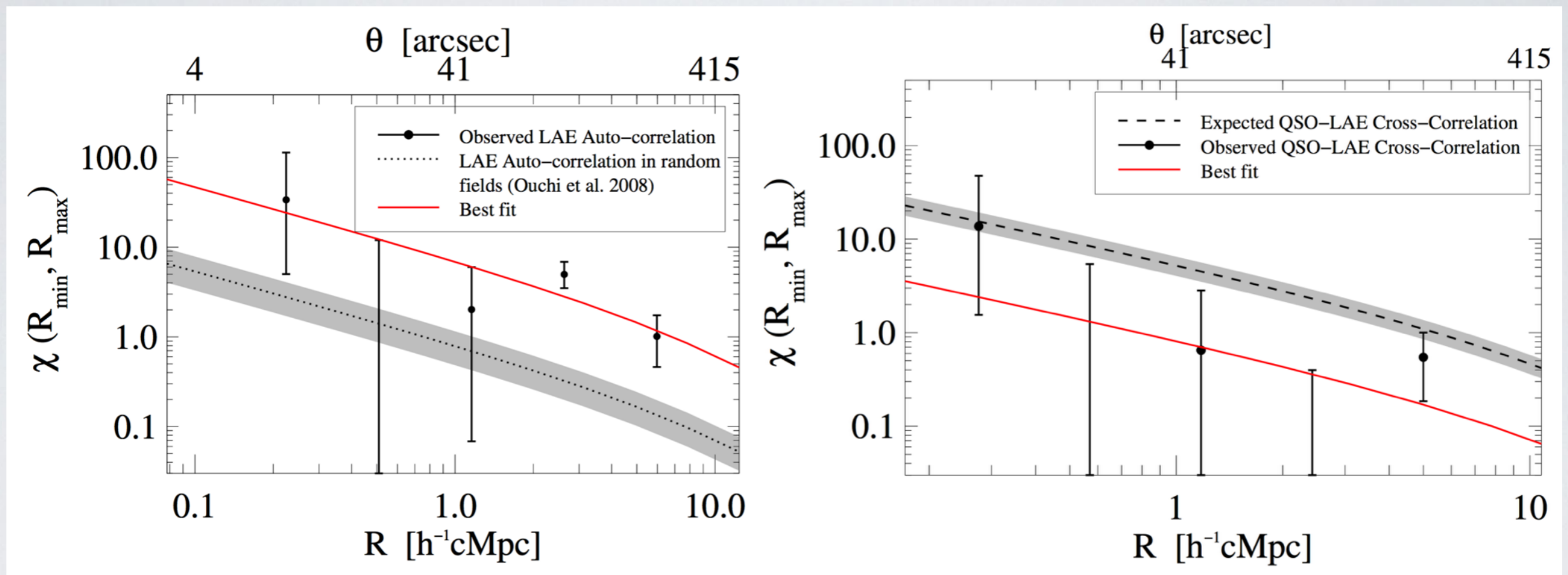


Hennawi+2014

Cantalupo+2014

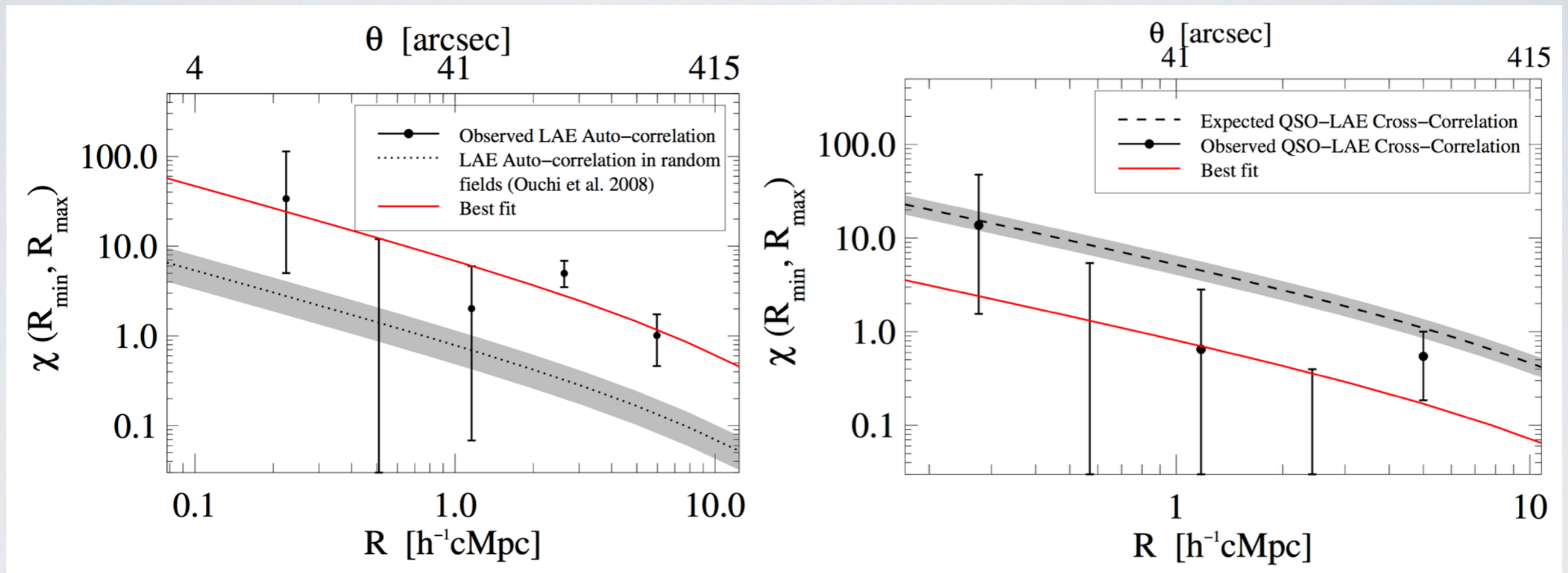
Multiple galaxies within the quasar halo - extremely dense!

On a larger scale - over densities of optical galaxies around QSO



Garcia-Vergara +2017/2019

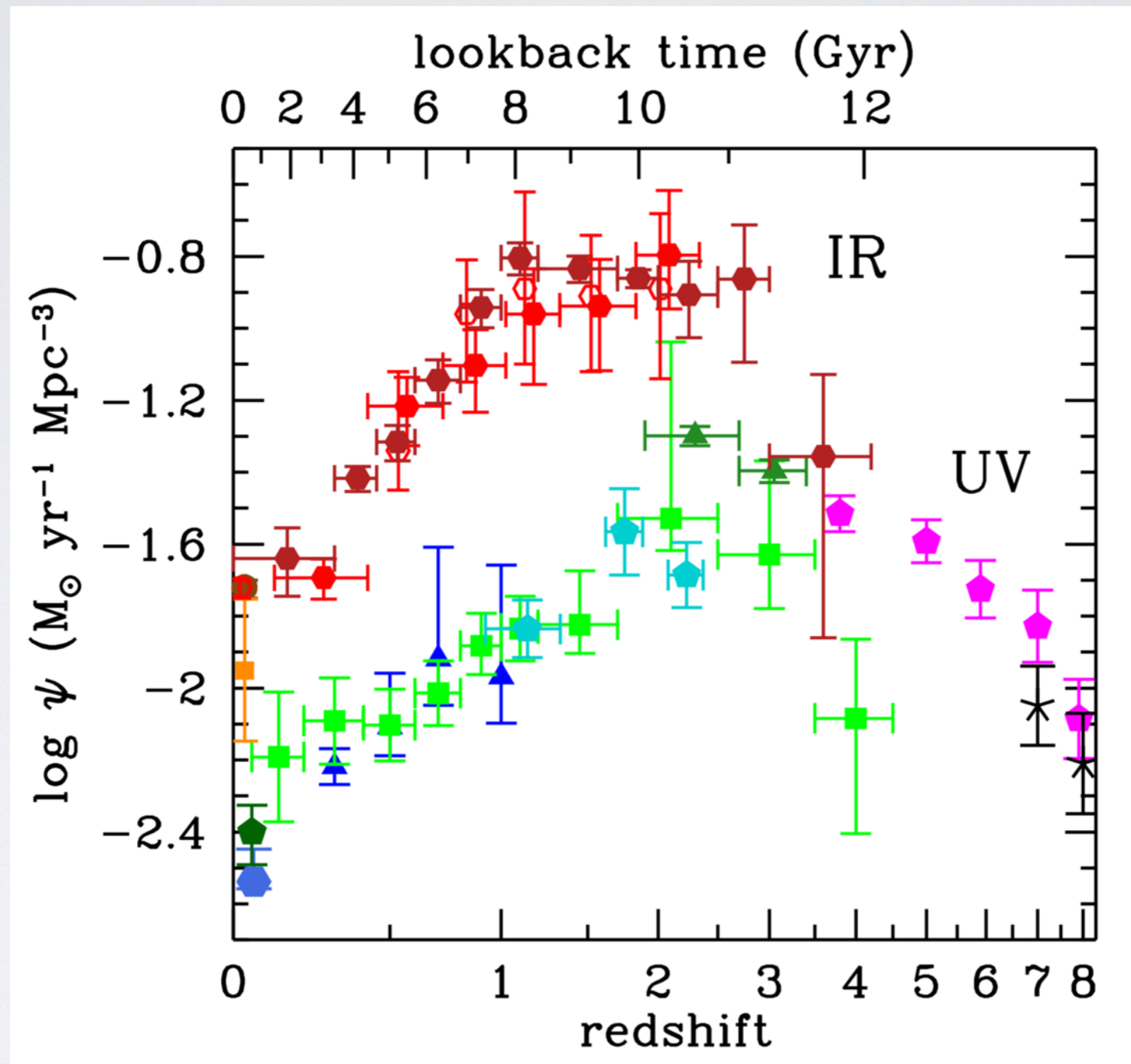
On a larger scale - over densities of optical galaxies around QSO



Garcia-Vergara +2017/2019

Not as much as expected - prevalence of dust around quasars?

Cosmic noon - SFR density dominated in IR

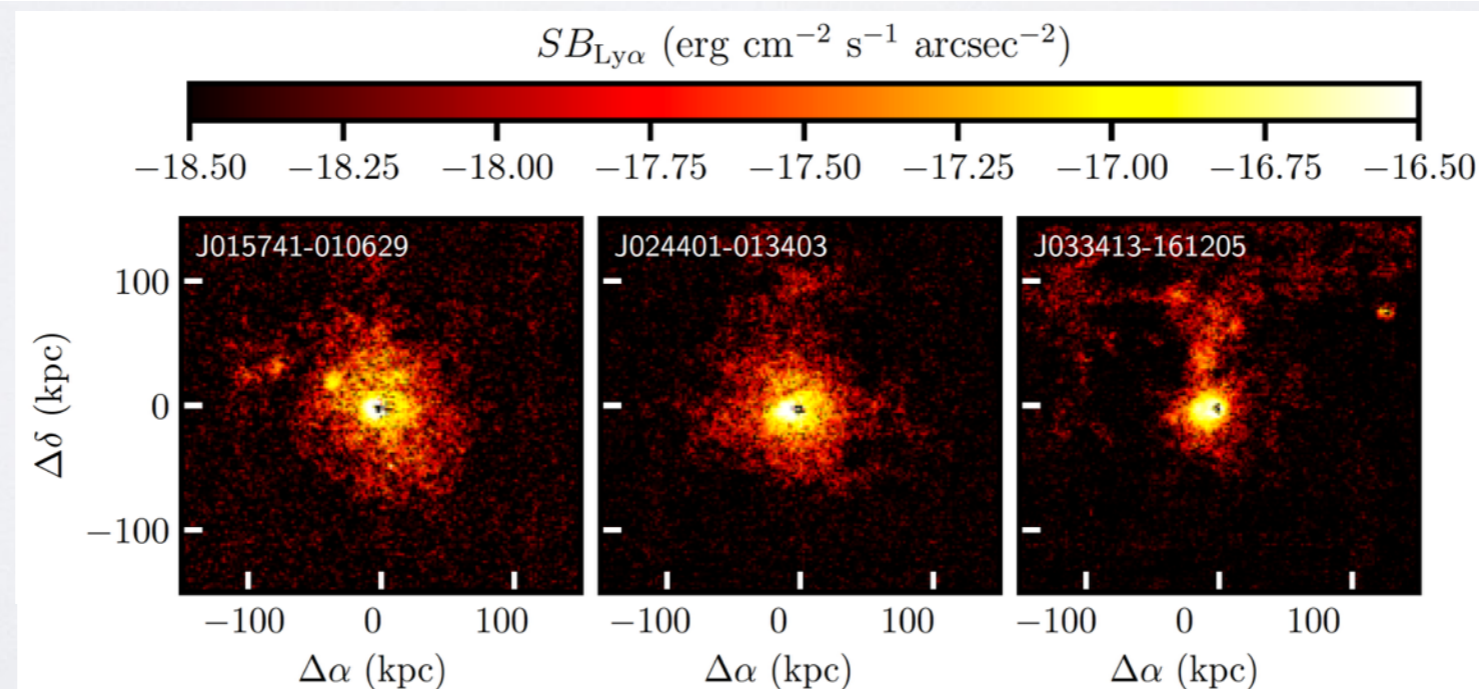
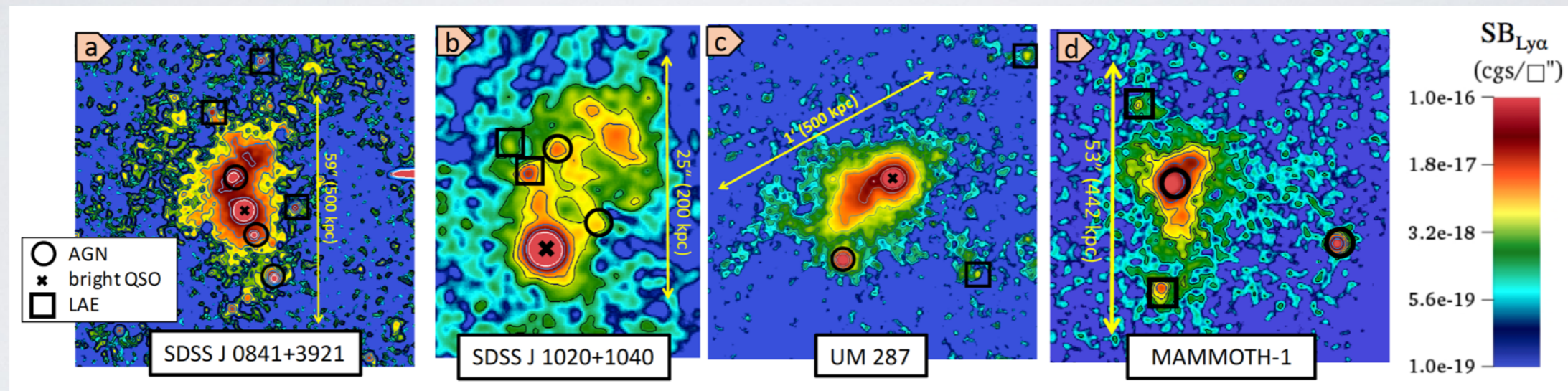


Madau & Dickinson 2014

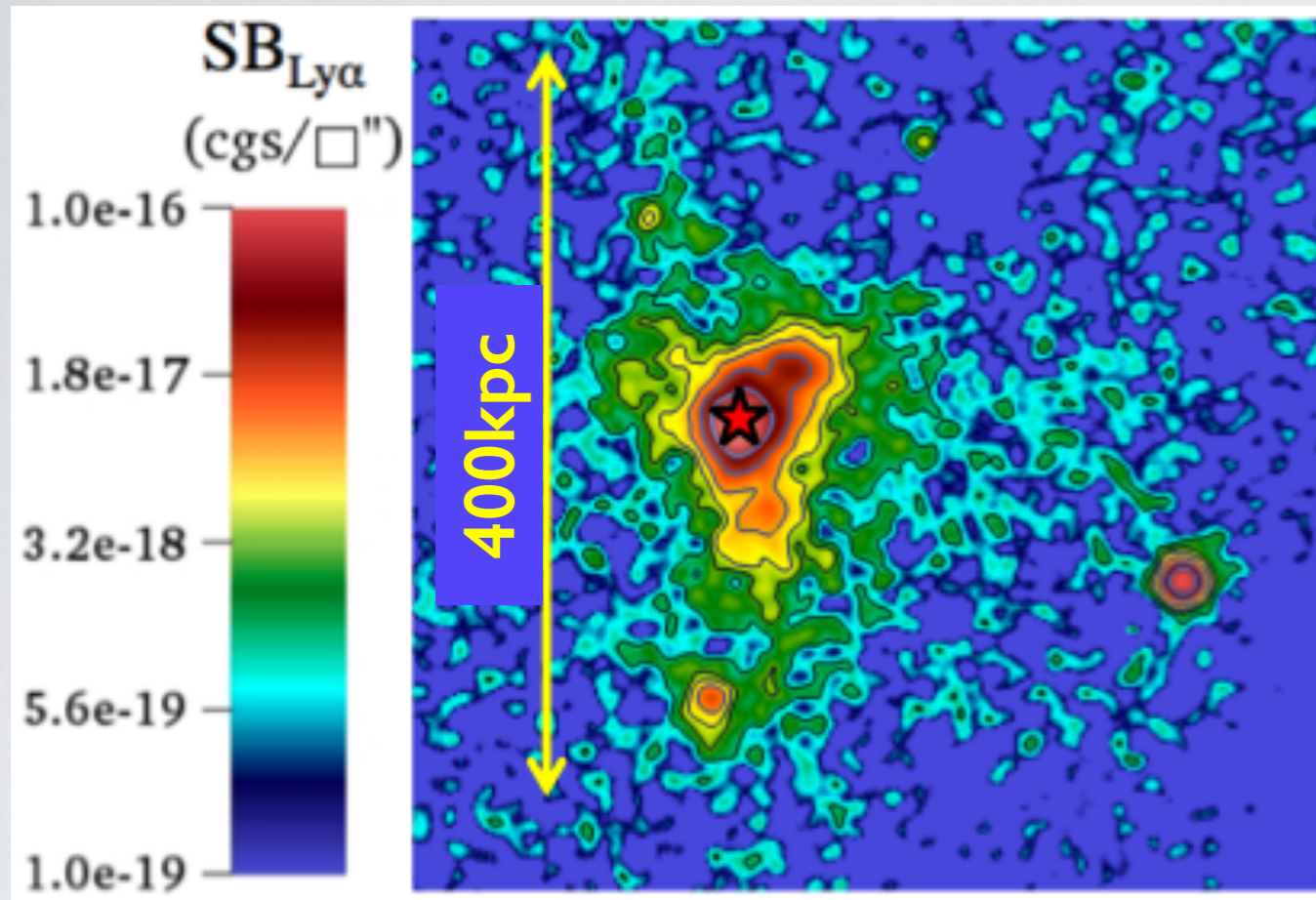
Dusty star formation around quasars is expected

A SCUBA-2 survey on QSO and ELAN

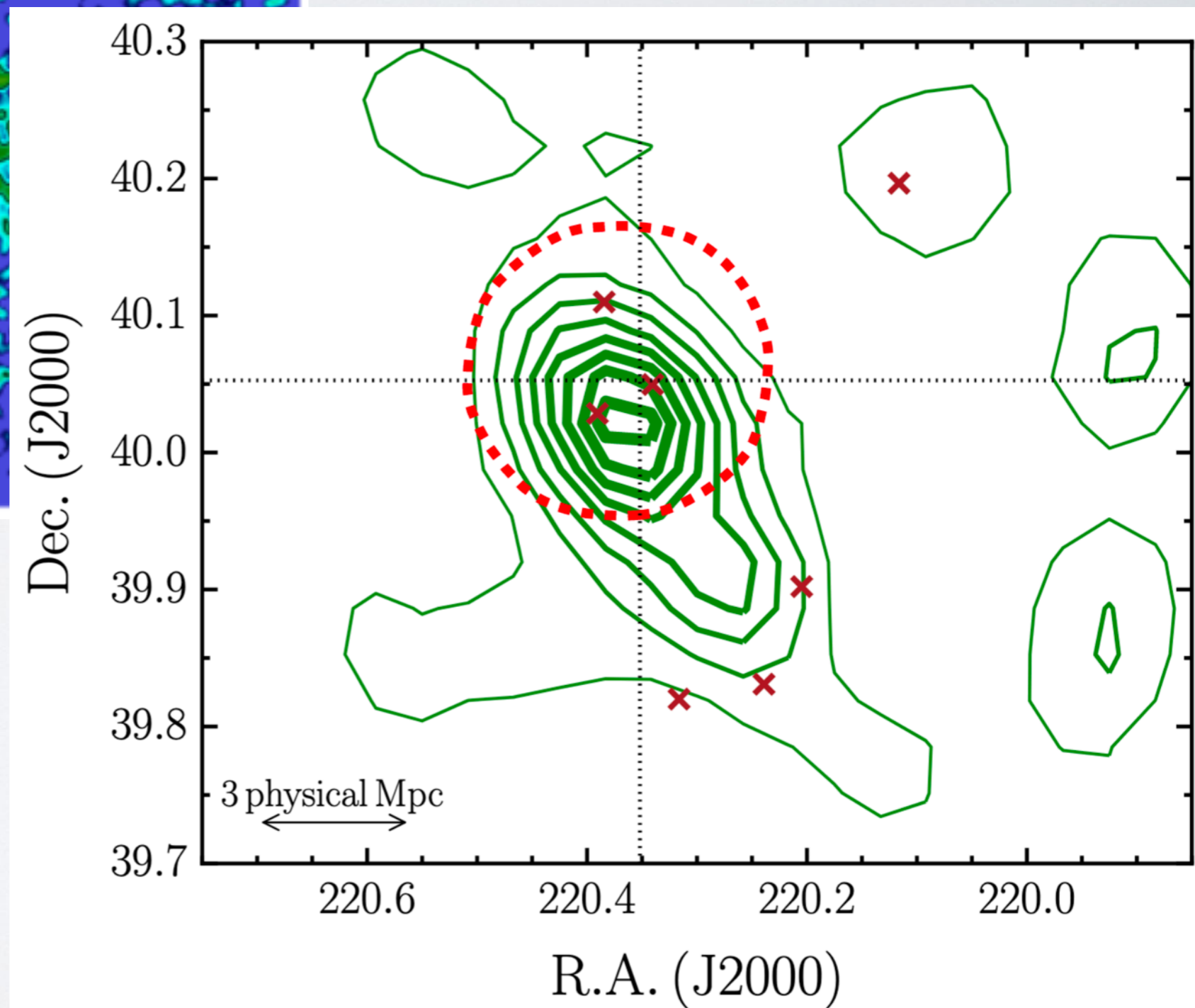
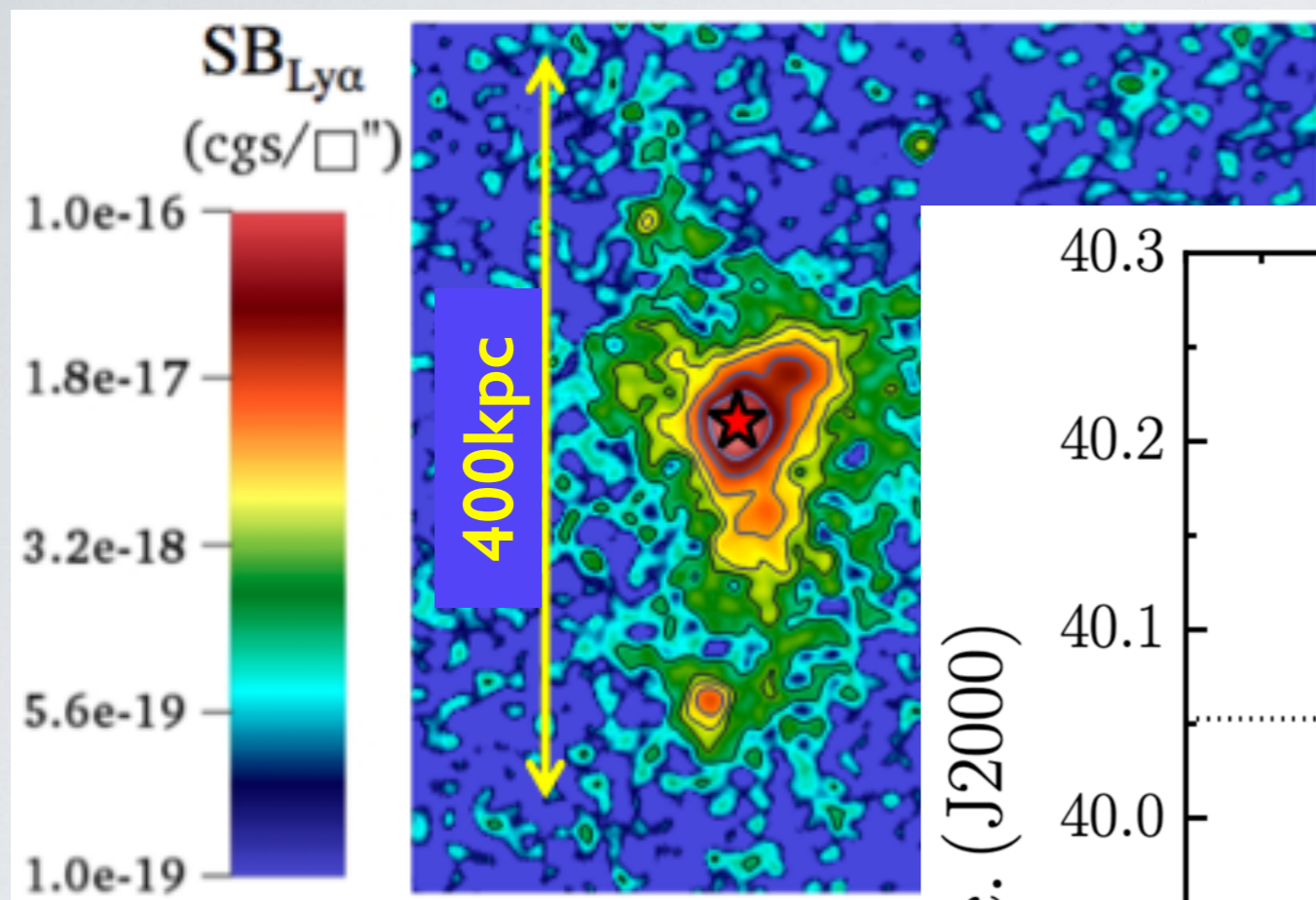
- 3hrs band 1/2 each, reaching ~ 1 mJy/beam at 850 micron
- 4 ELAN, 13 QSOs - all observed by MUSE
- Awarded over 90 hrs so far in the past ~ 3 years



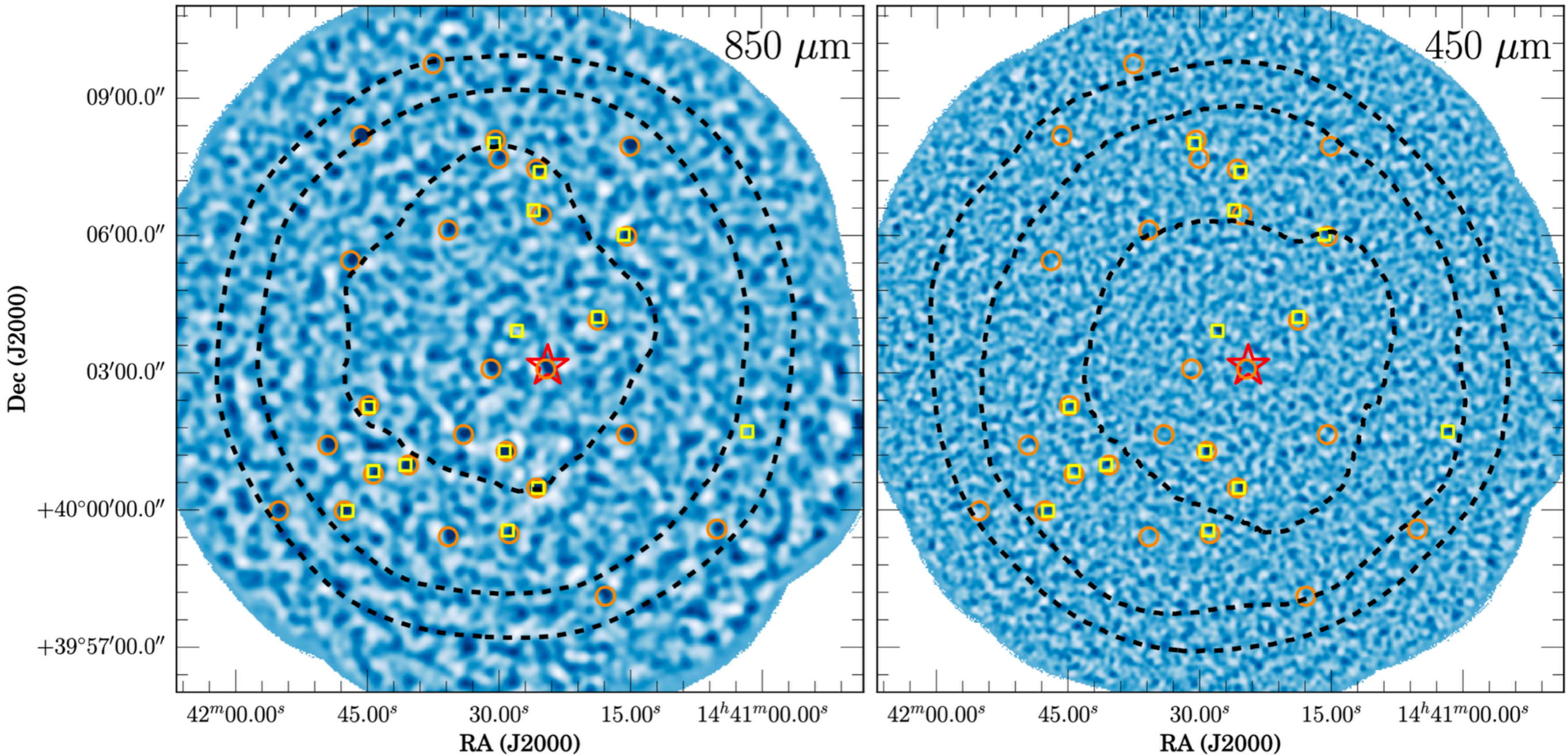
First results on MAMMOTH-1



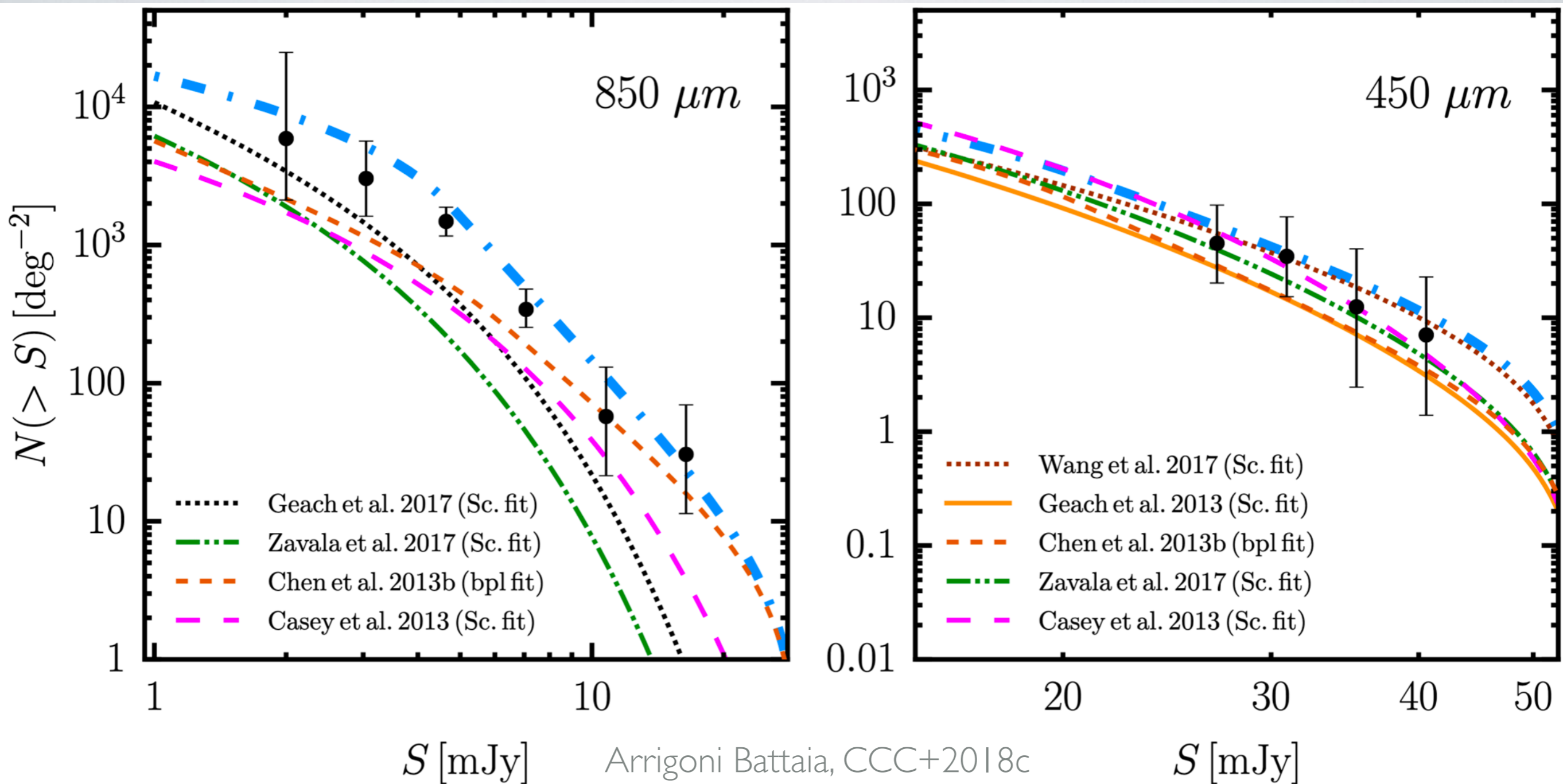
First results on MAMMOTH-I



First results on MAMMOTH-I

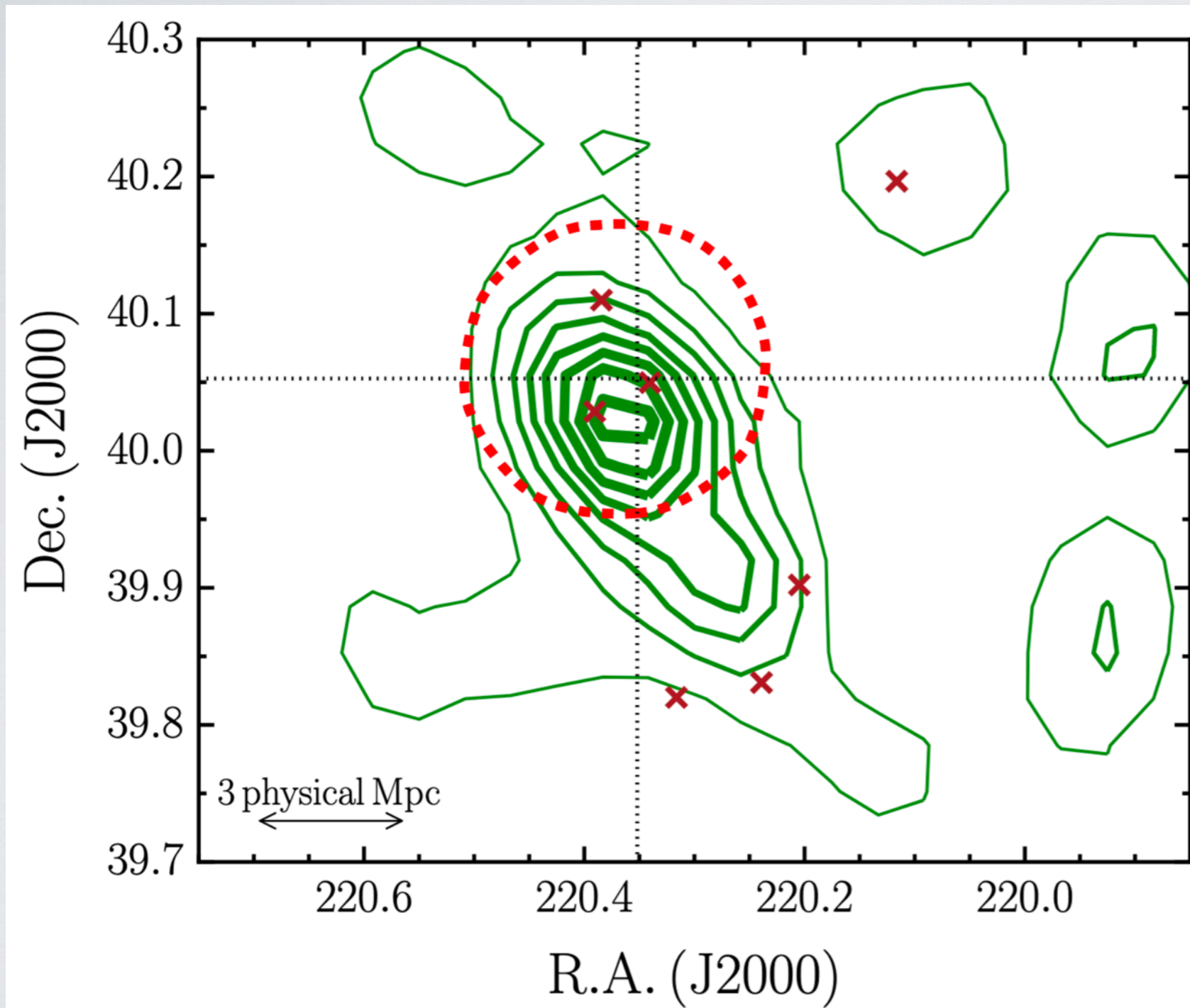


First results on MAMMOTH-1

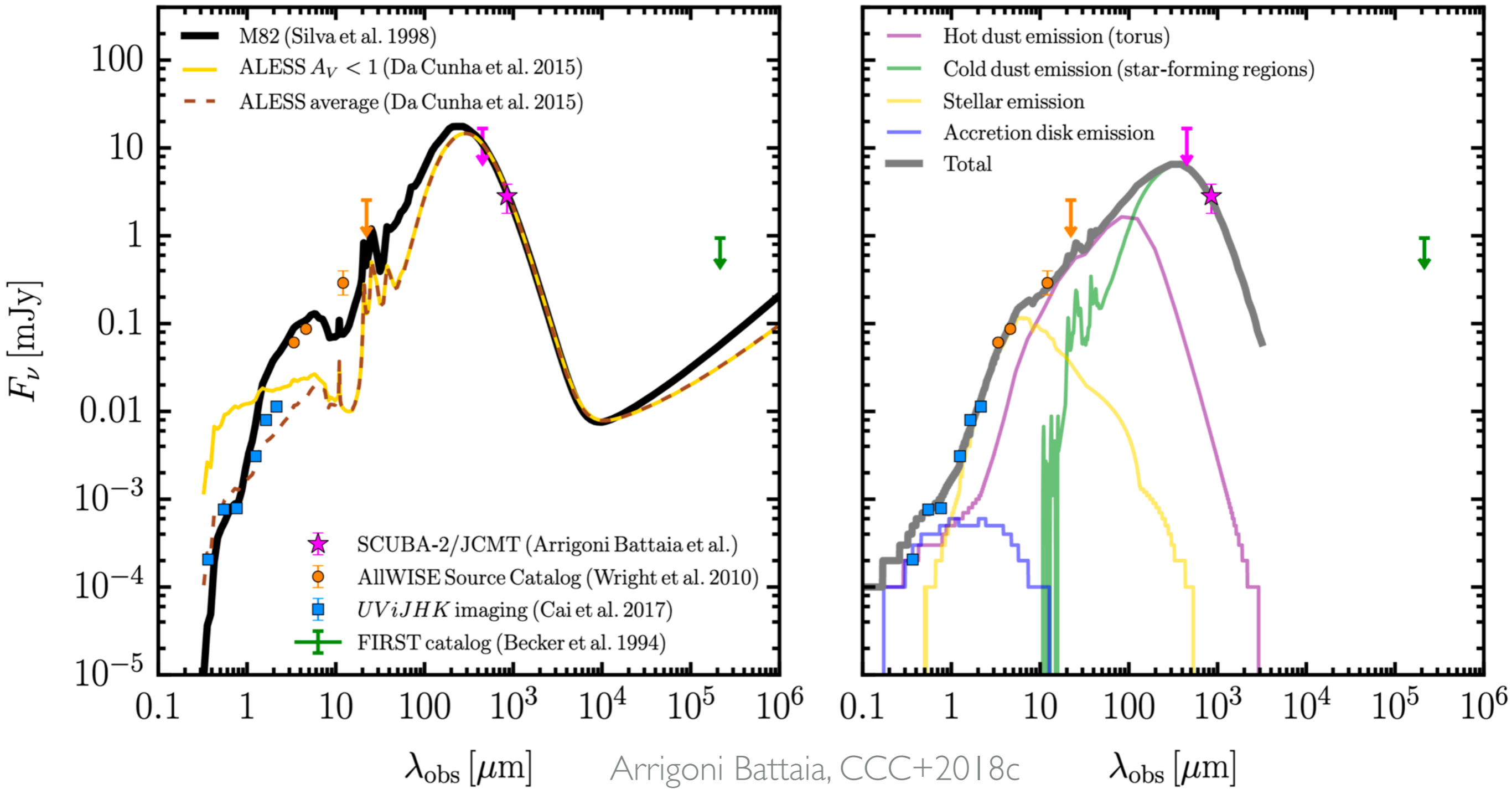


**A factor of ~ 4 more numerous than the field -
evidence of dusty star formation**

First results on MAMMOTH-1



First results on MAMMOTH-1



ELAN powered by both black hole accretion and star formation

Take aways...

- A SCUBA-2 program to map the dusty star formation around a sample of ELAN and quasars.
- We found a factor of ~ 4 over-density of dusty sources around MAMMOTH-1, suggesting significant amount of dusty star formation around this ELAN.
- The MAMMOTH-1 ELAN is likely powered by both the AGN and extensive star formation
- Preliminary analyses on other fields also show over-densities, and ALMA follow-up studies are under way.