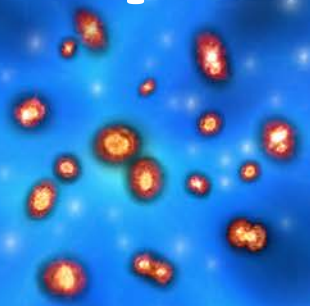
Gas filaments connecting galaxies and supermassive black holes in a proto-cluster



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Overarching motivation

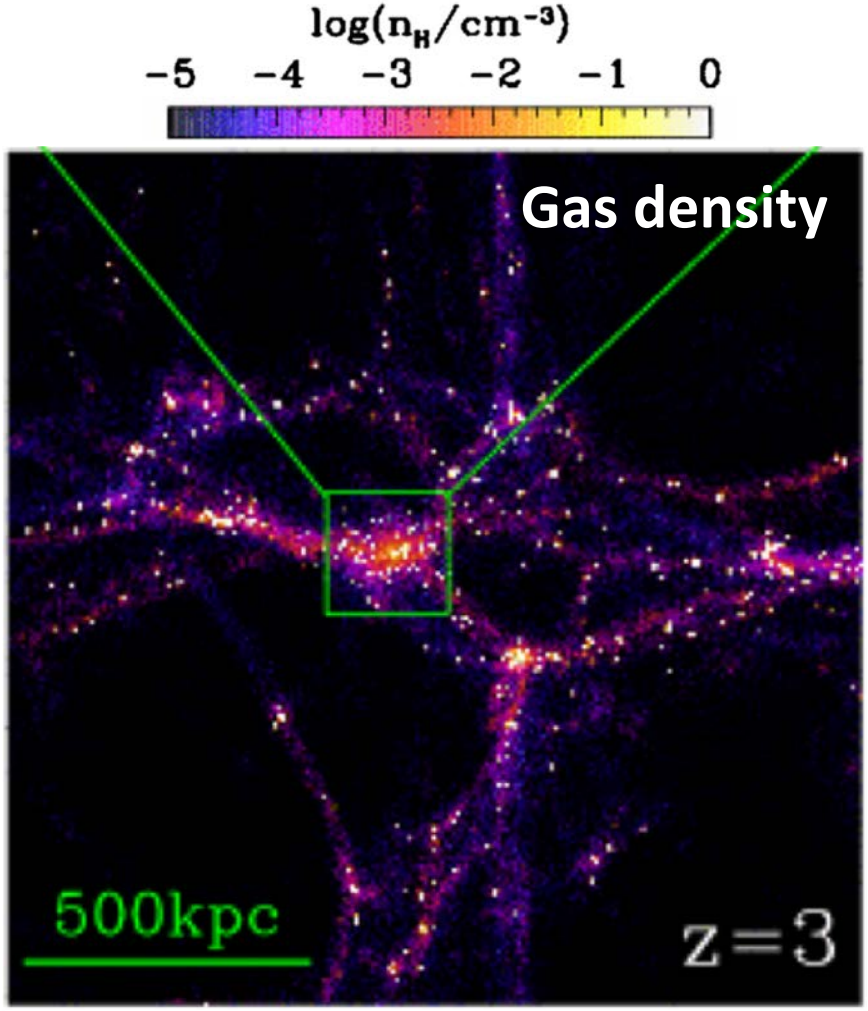
How do galaxies and SMBHs grow within cosmic structure?
How do they obtain their fuels?

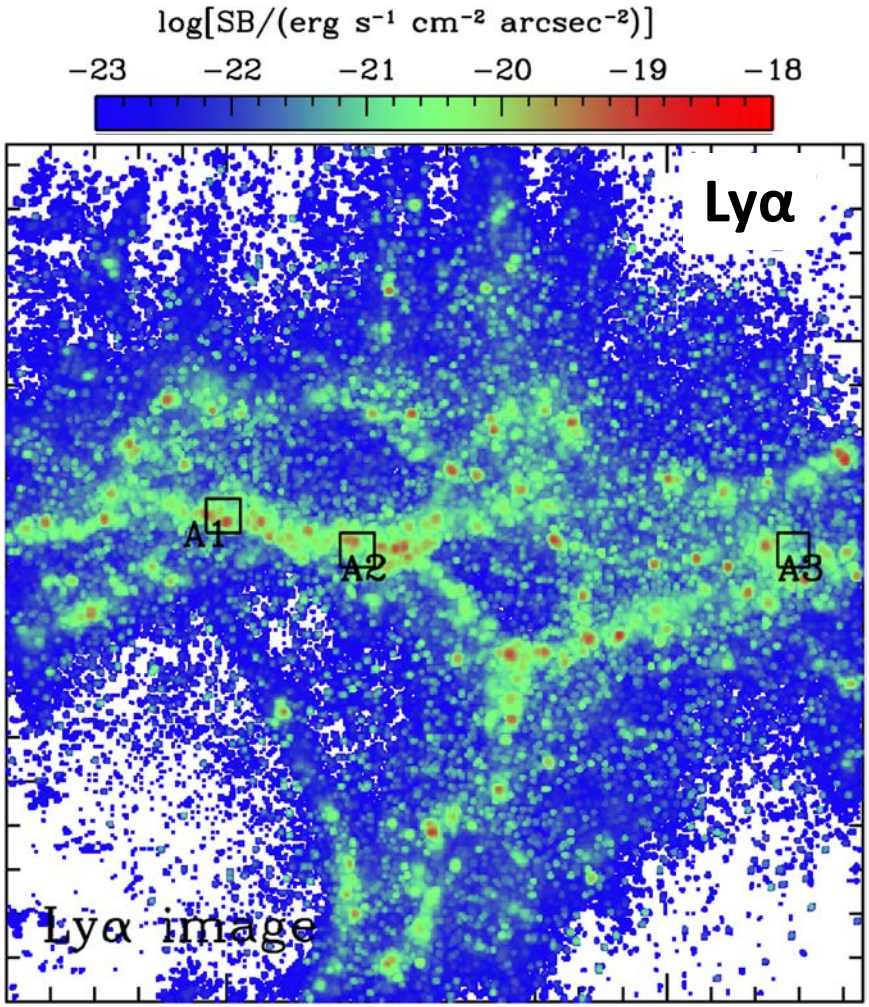
=> We need to trace galaxies, AGNs, and IGMs/CGMs.
=> Proto-clusters would be a nice target.

Schaye et al. 2015, MN, 446, 521 THE EAGLE PROJECT

Lyα emission from cosmic structure

Kollmeier et al. 2010, ApJ, 708, 1048



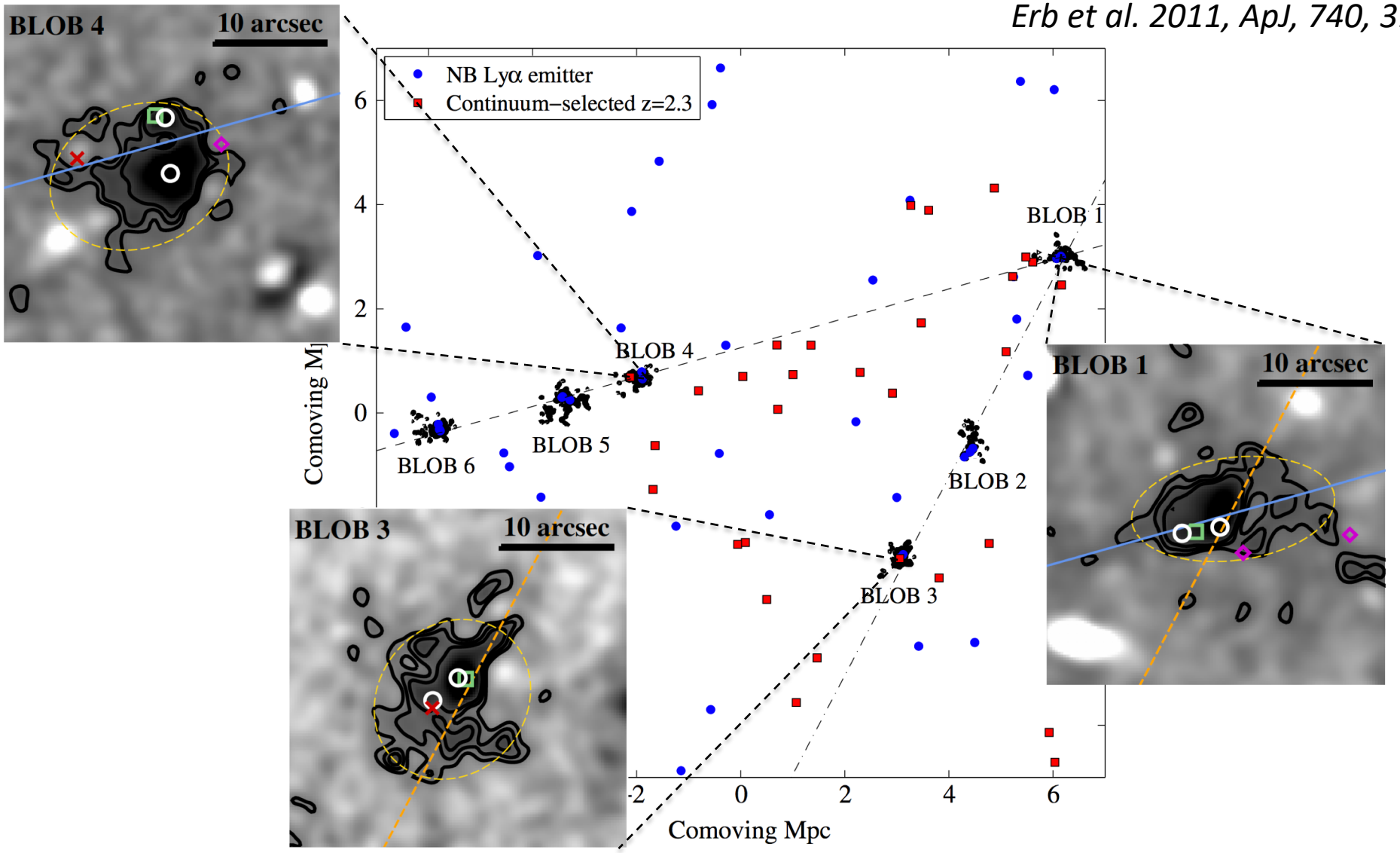


Lyα emission can be a tracer of cosmic web.

Some origins are expected: fluorescence, cooling radiation, scattering...

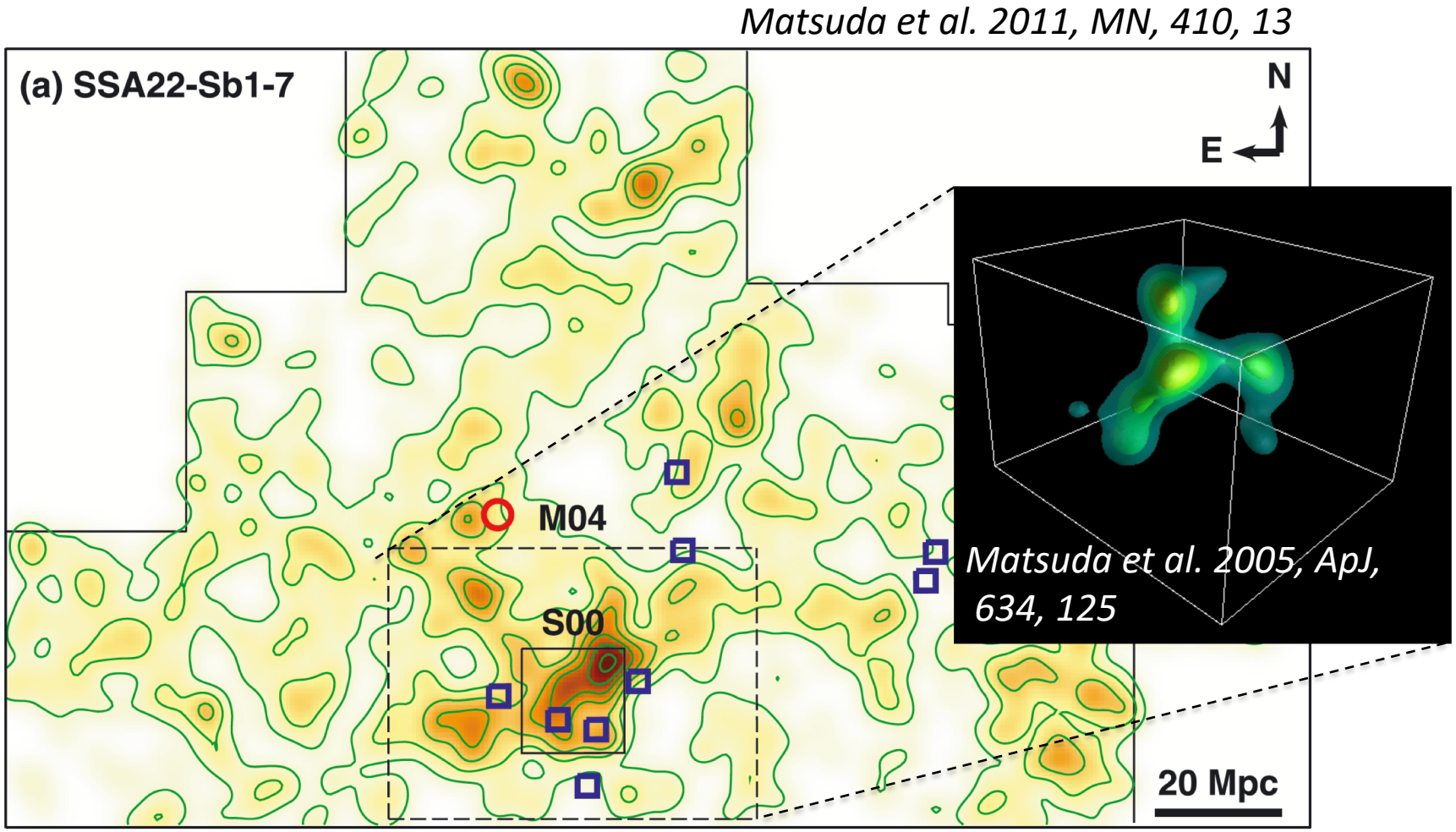
Lyα blobs in a proto-cluster

Erb et al. 2011, ApJ, 740, 31



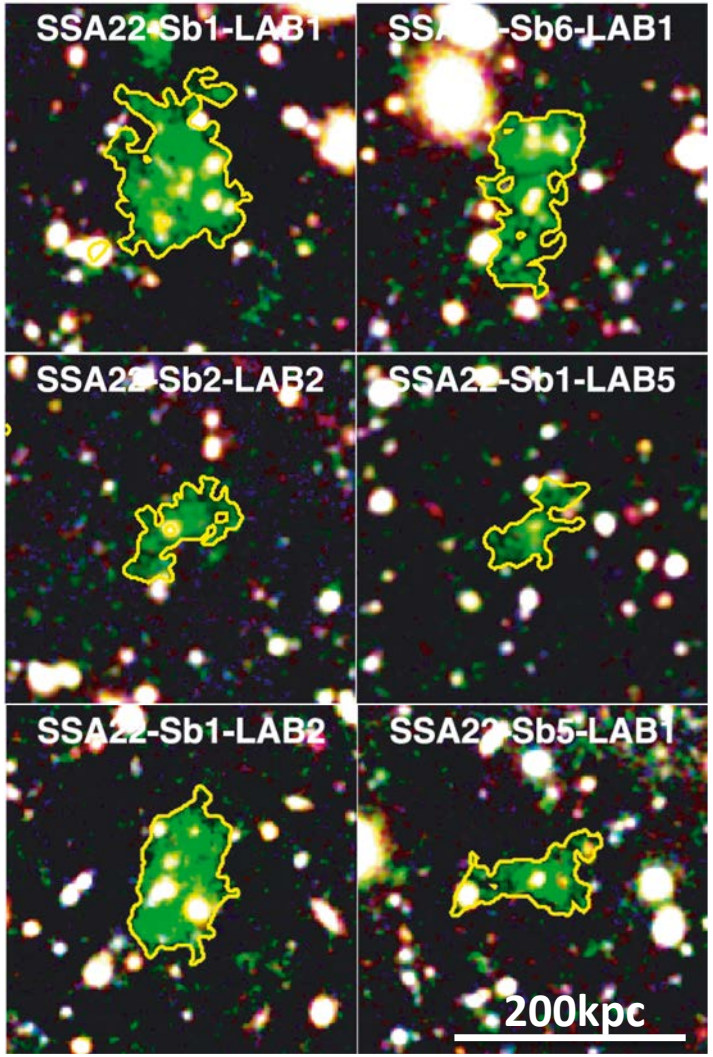
Possible connection between Lyα emission and underlying structure.

Panoramic Lyα survey in SSA22

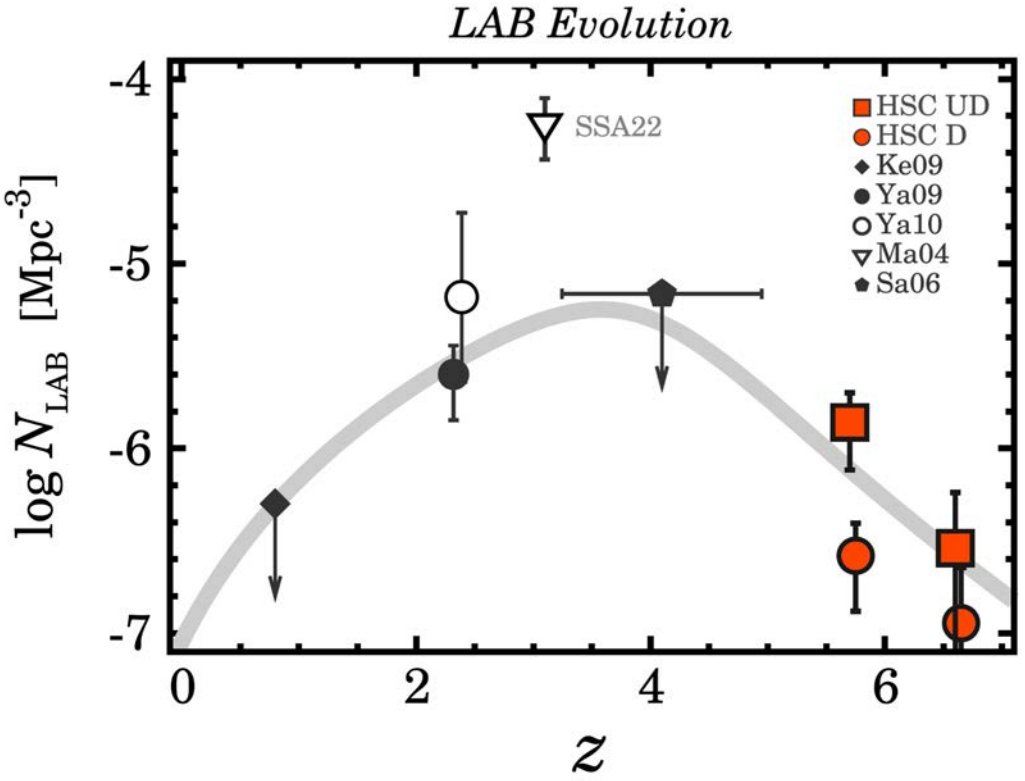


The LAE distribution delineates a z=3 cosmic structure on a large scale.

Panoramic Lyα survey in SSA22



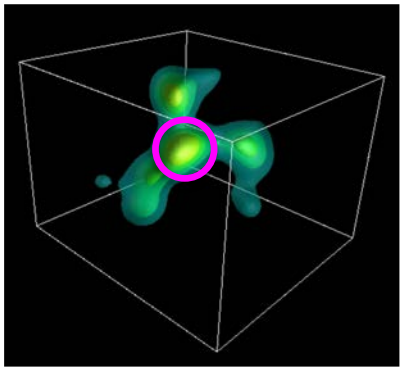
Shibuya et al. 2018, PASJ, 70, 14



Matsuda et al. 2011, MN, 410, 13

The prevalence of Lyα blobs depends on environment.

ADF22: ALMA Deep Field in SSA22



Primal strategy of this project:

1. Contiguous mapping of the proto-cluster core.
2. Tracing various aspects of galaxy formation

Obscured SF

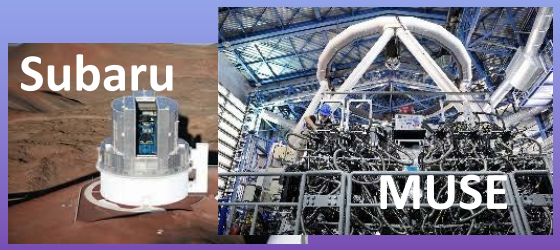
ALMA Band3, Band6
JVLA C-band

Mol. Gas

CO(1-0), CO(3-2),
CO(9-8).

IGMs/CGMs

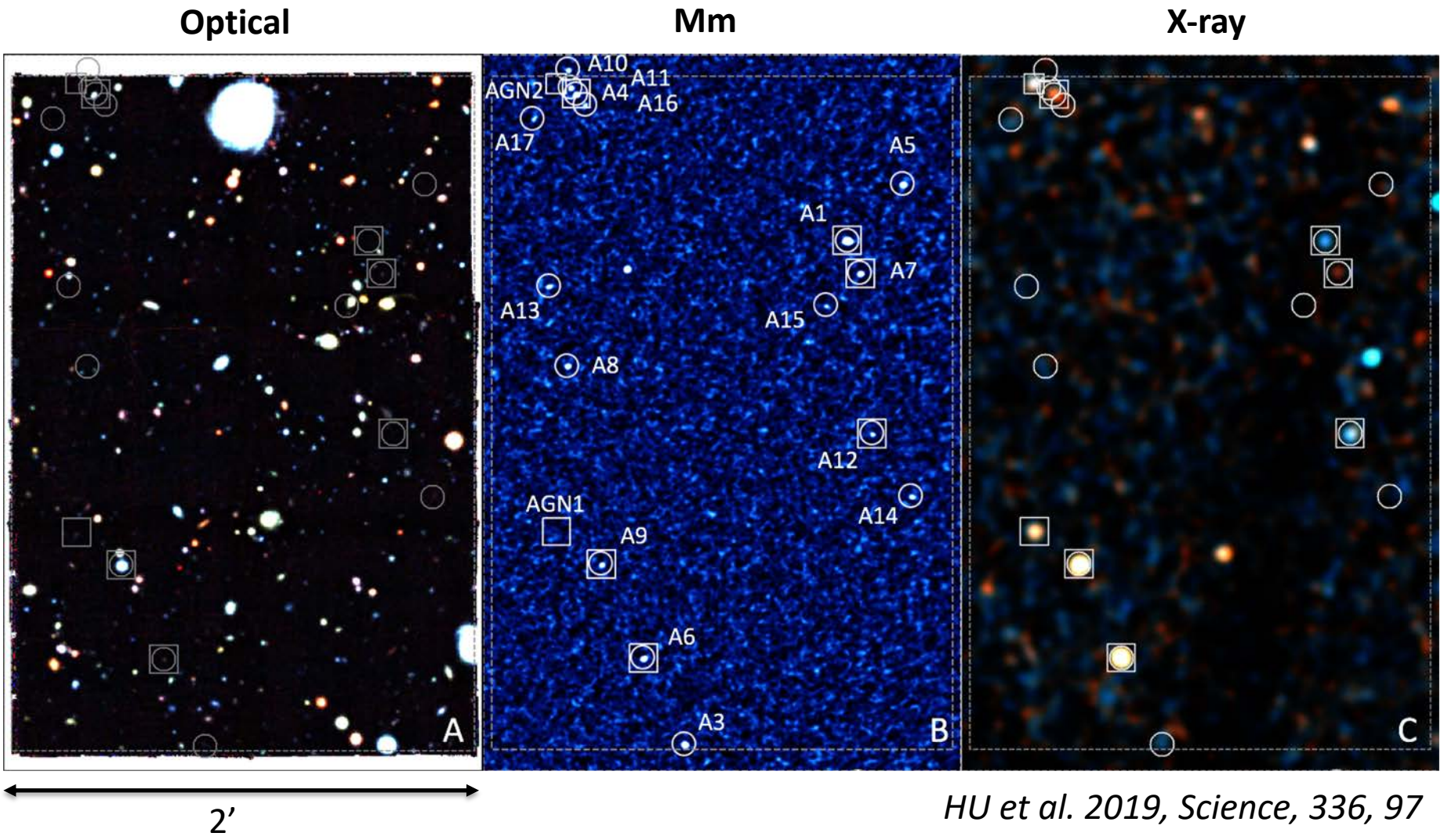
Lyα



e.g., HU et al. 2015, ApJ, 815, 8

And more multi-wavelength data is available/assembled.

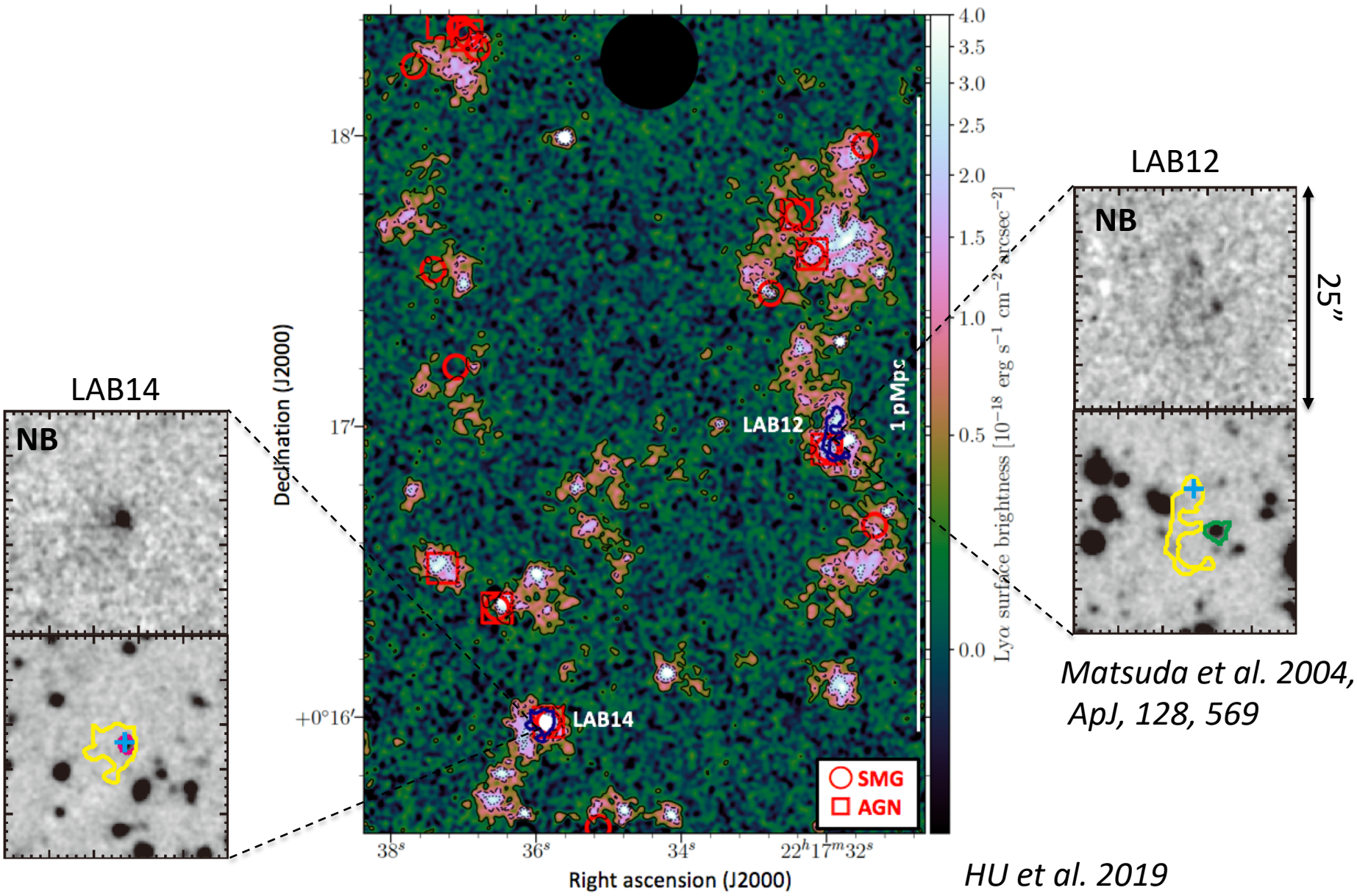
Enhanced activity at the PC Core



HU et al. 2019, Science, 336, 97

Both star-formation and SMBH growth are accelerated in the core.

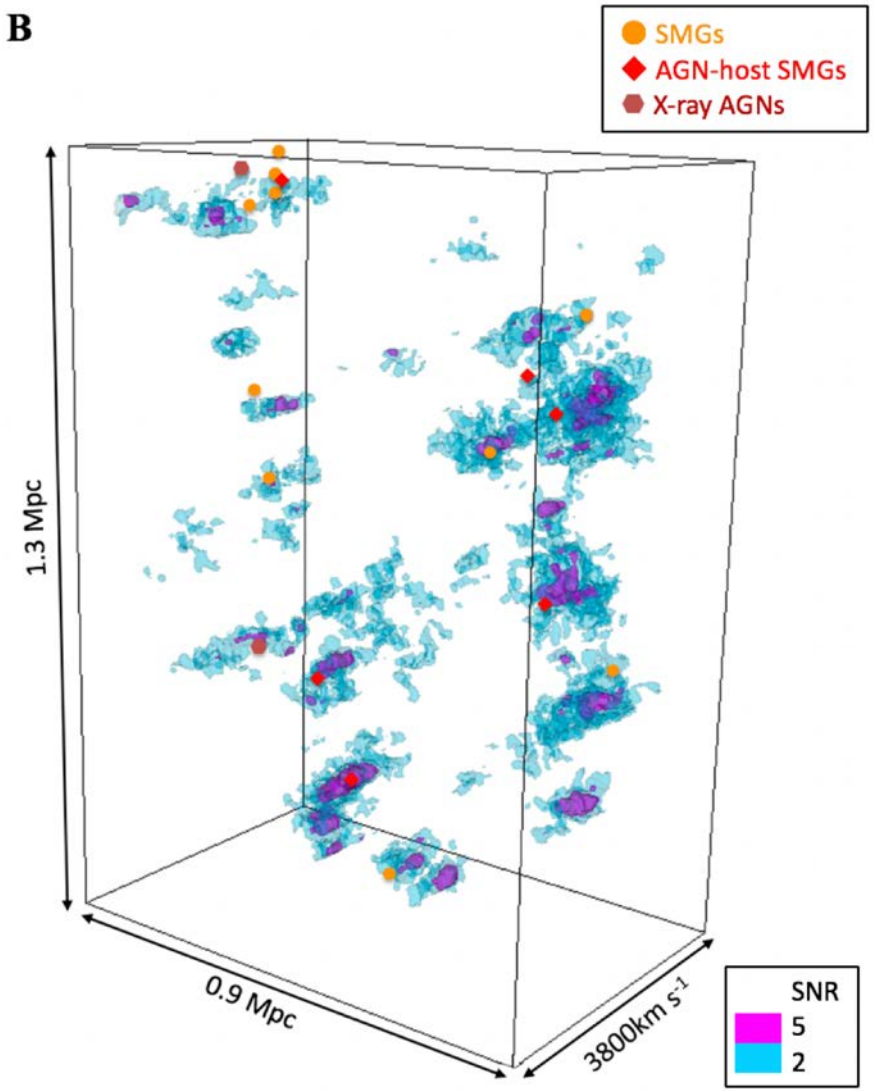
Extended Lyα Emission in ADF22

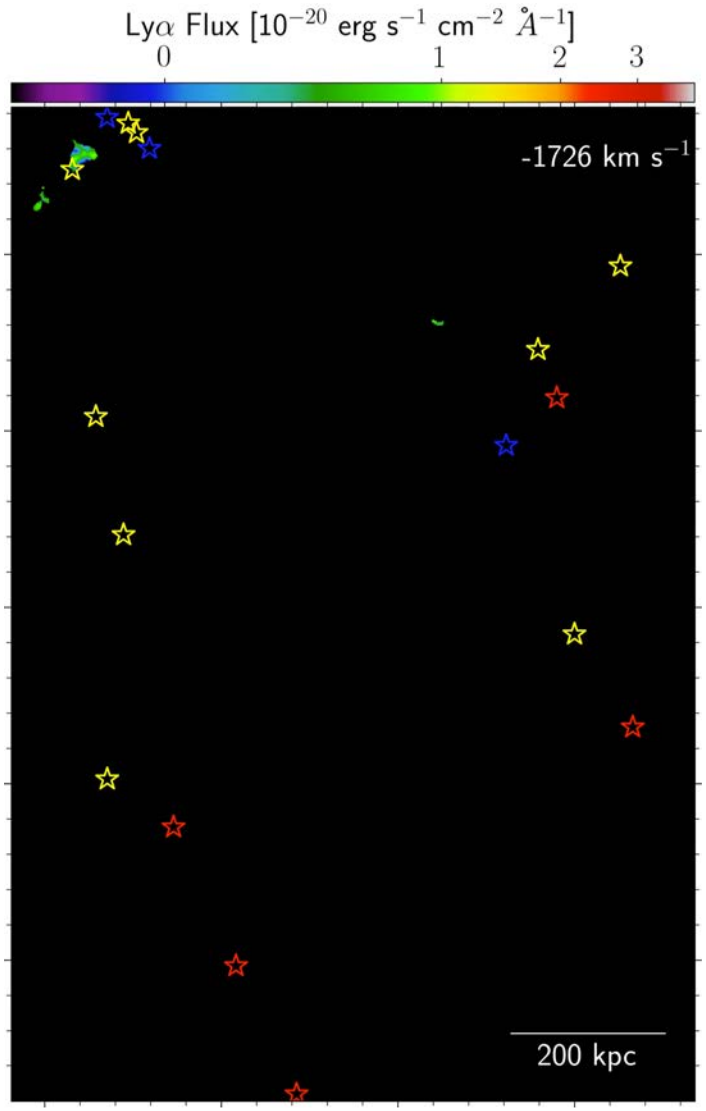


Matsuda et al. 2004, ApJ, 128, 569

HU et al. 2019

“3D” view of galaxies/nuclei/filaments

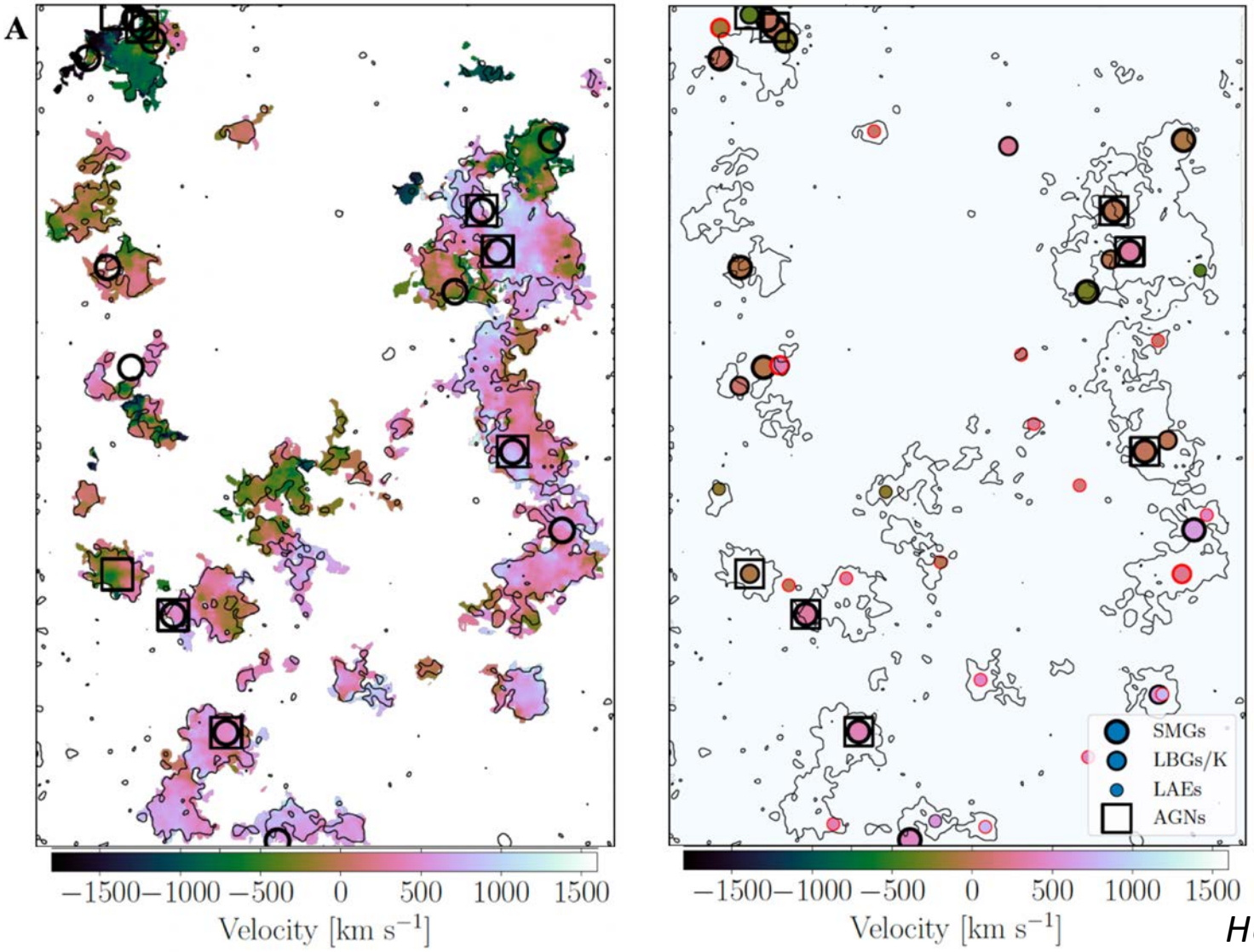




HU et al. 2019

All of SMGs/AGNs are embedded in Lyα filaments.

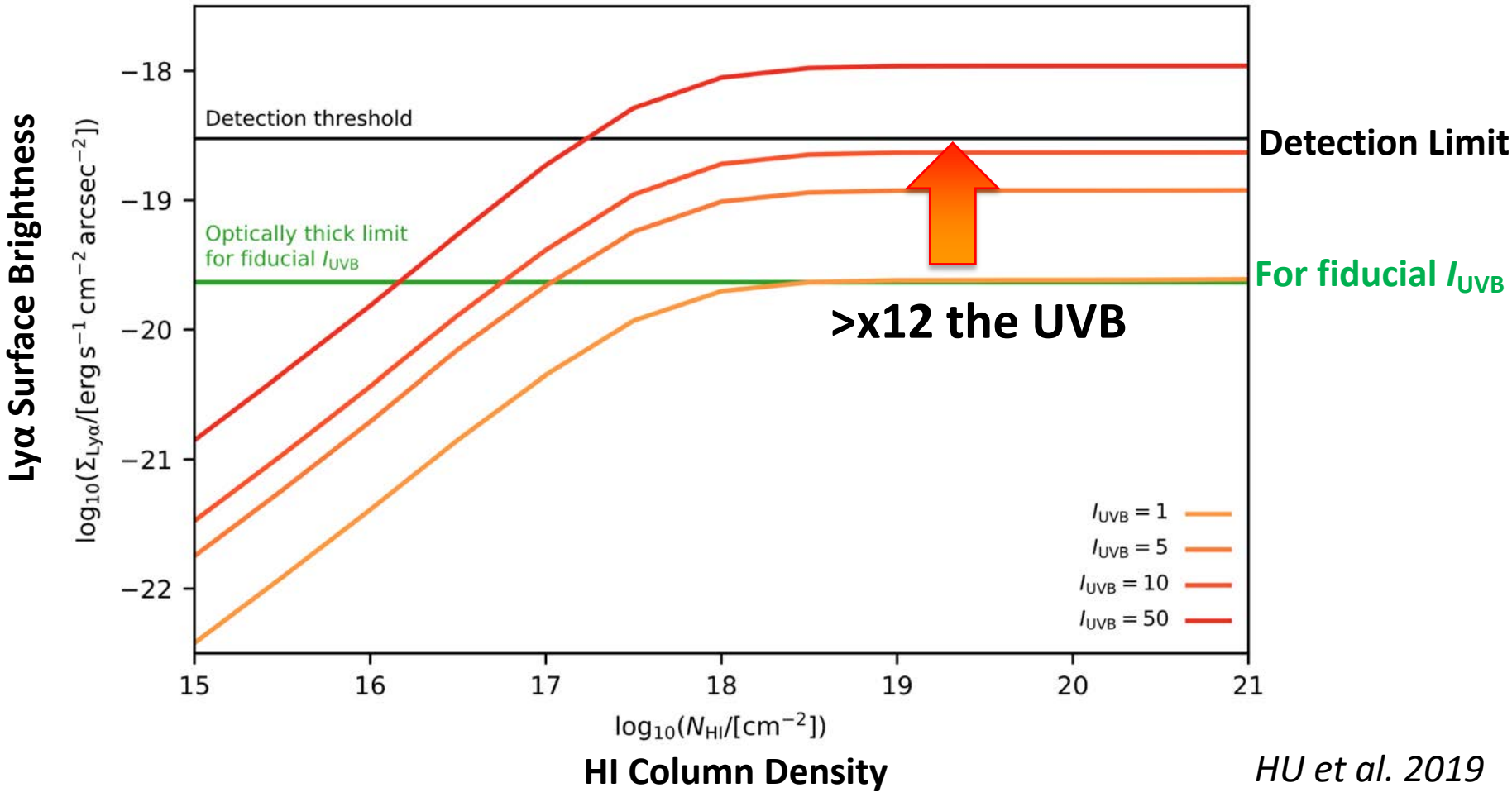
Galaxies and Filaments



HU et al. 2019

Filaments expand to intergalactic space.

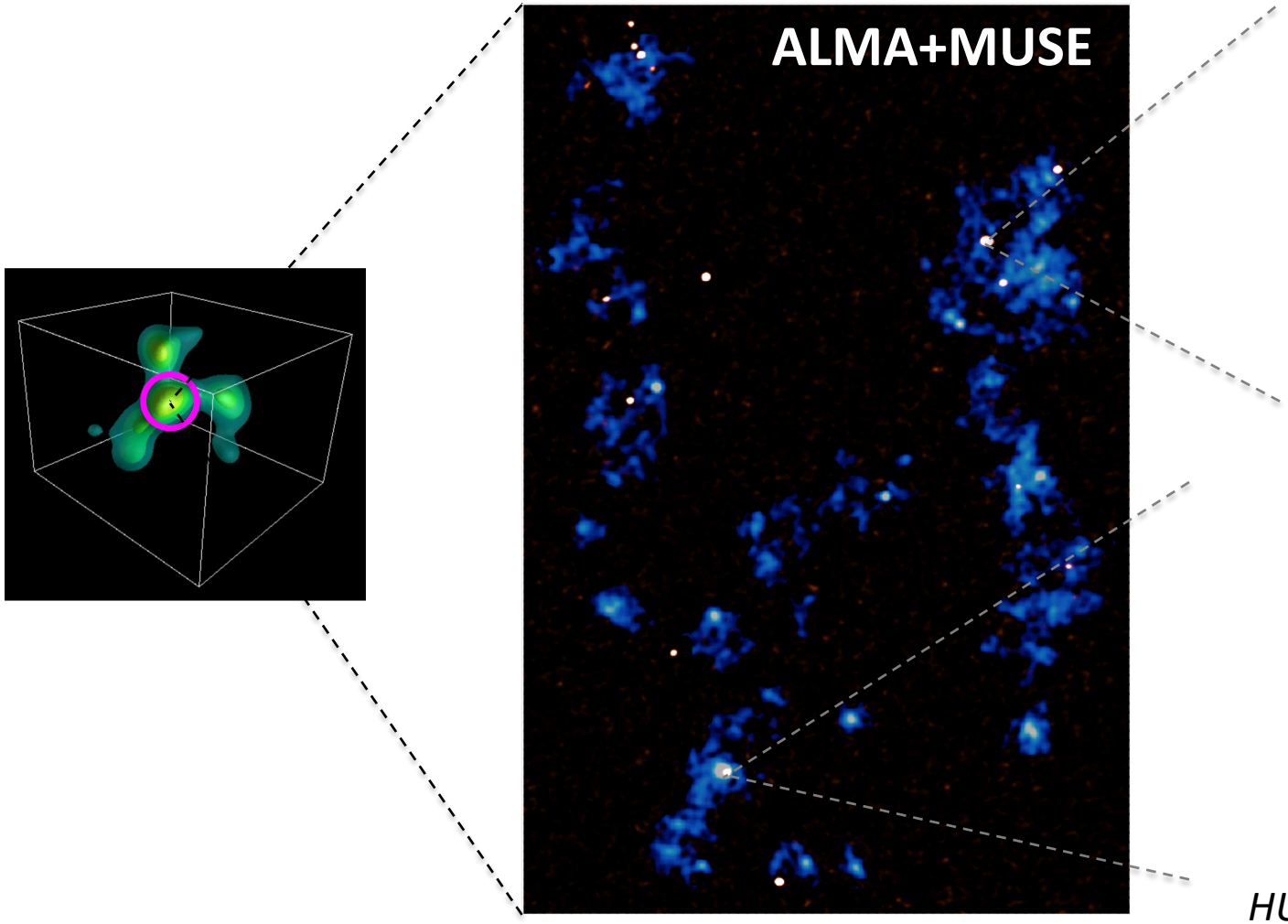
Powering source(s)



HU et al. 2019

Enhanced local radiation field would cause bright fluorescent emission.
Other mechanisms may also contribute it, though.

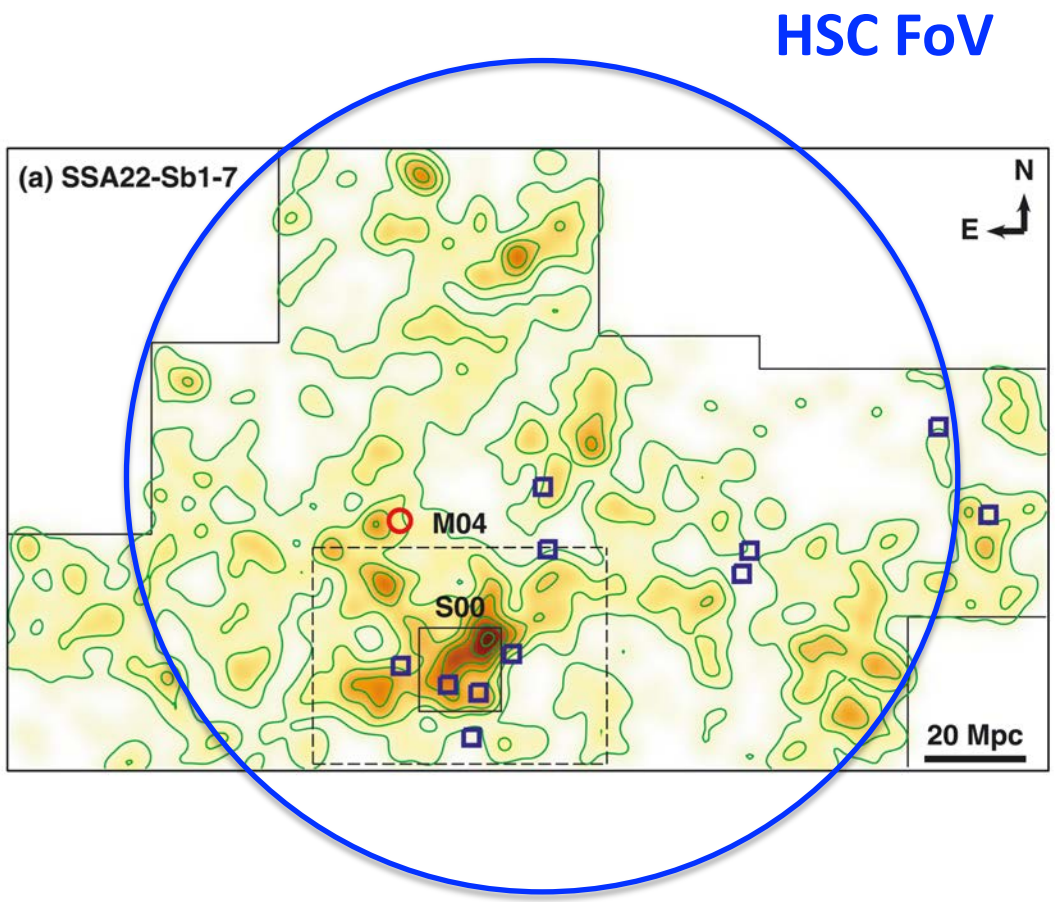
The role of gas filaments



HU et al. 2020, in prep

Filaments, which contain >10^{12} Msun gas, would fuel the galaxy growth.

Expectation for Subaru



Matsuda et al. 2011

HSC NB497 Imaging will uncover Lyα filaments on cosmological scales.
PFS will give us a complementary view, tracing HI absorption.

Summary

Proto-clusters in the early Universe are a nice laboratory to comprehend galaxy formation and evolution within cosmic structures.

In a z=3 proto-cluster core, we identify Lyα filaments on a Mpc-scale, which would provide original fuel for the growth of galaxies and SMBHs.

HSC/PFS on Subaru can play a unique role in uncovering the interplay between galaxies and filaments, utilizing their capability.