Deep nearIR spectroscopy of high-z groups of galaxies

Masayuki Tanaka

IPMU
INSTITUTE FOR THE PHYSICS AND
MATHEMATICS OF THE UNIVERSE

Summary

▶ We have identified a group at z=1.61. Using the exquisite, deep multi-wavelength data, we find that this group is completely dominated by quiescent early-type galaxies. It looks like that almost nothing changed in groups in the last 10billiong years.

▶ Based on very deep near-IR spectroscopy with MOIRCS, we spectroscopically confirm that quiescent galaxies already populate in the proto-cluster environment at z=2.2.

1 – Motivation

The cosmic large-scale structure
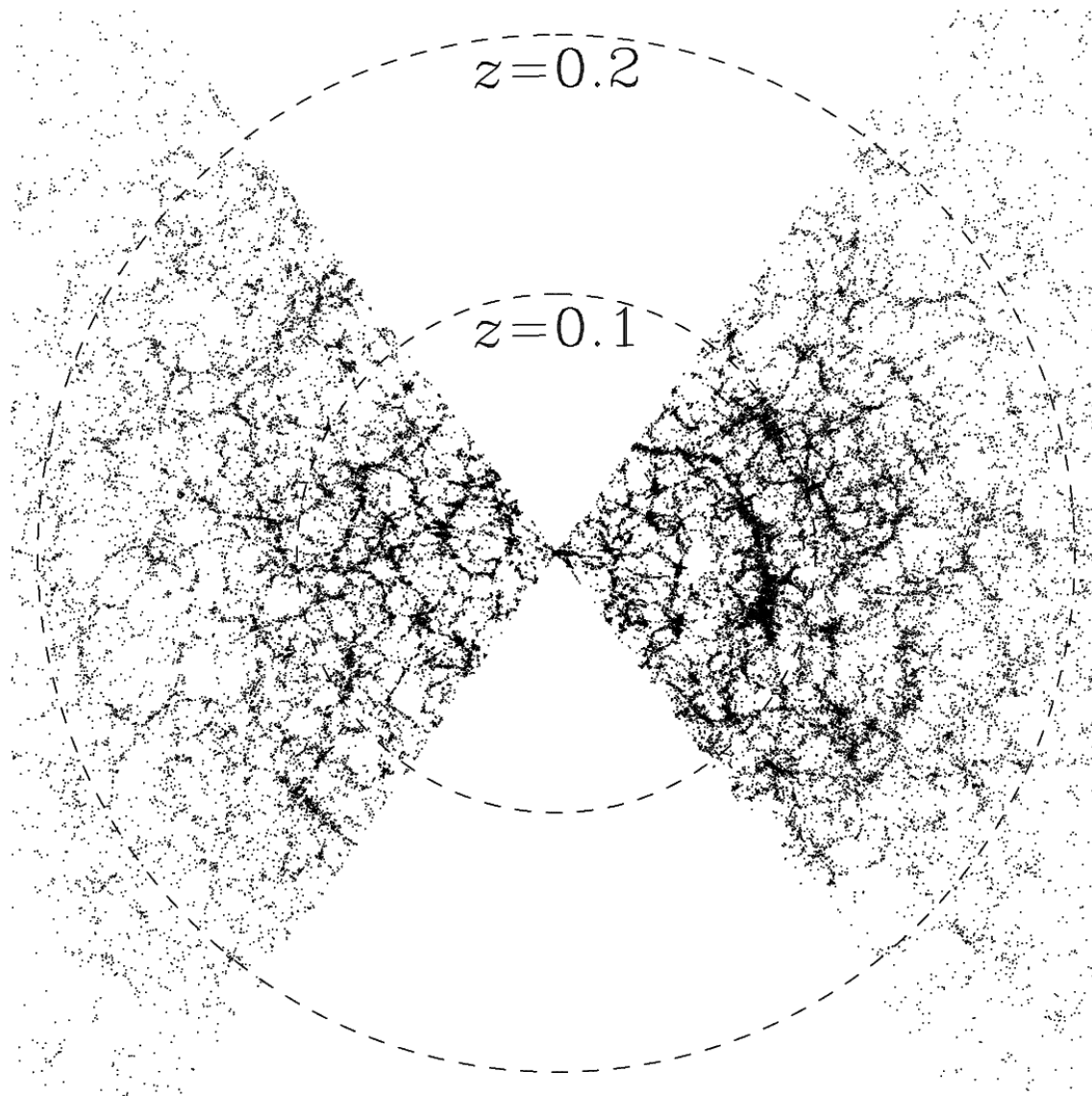
Low-density field
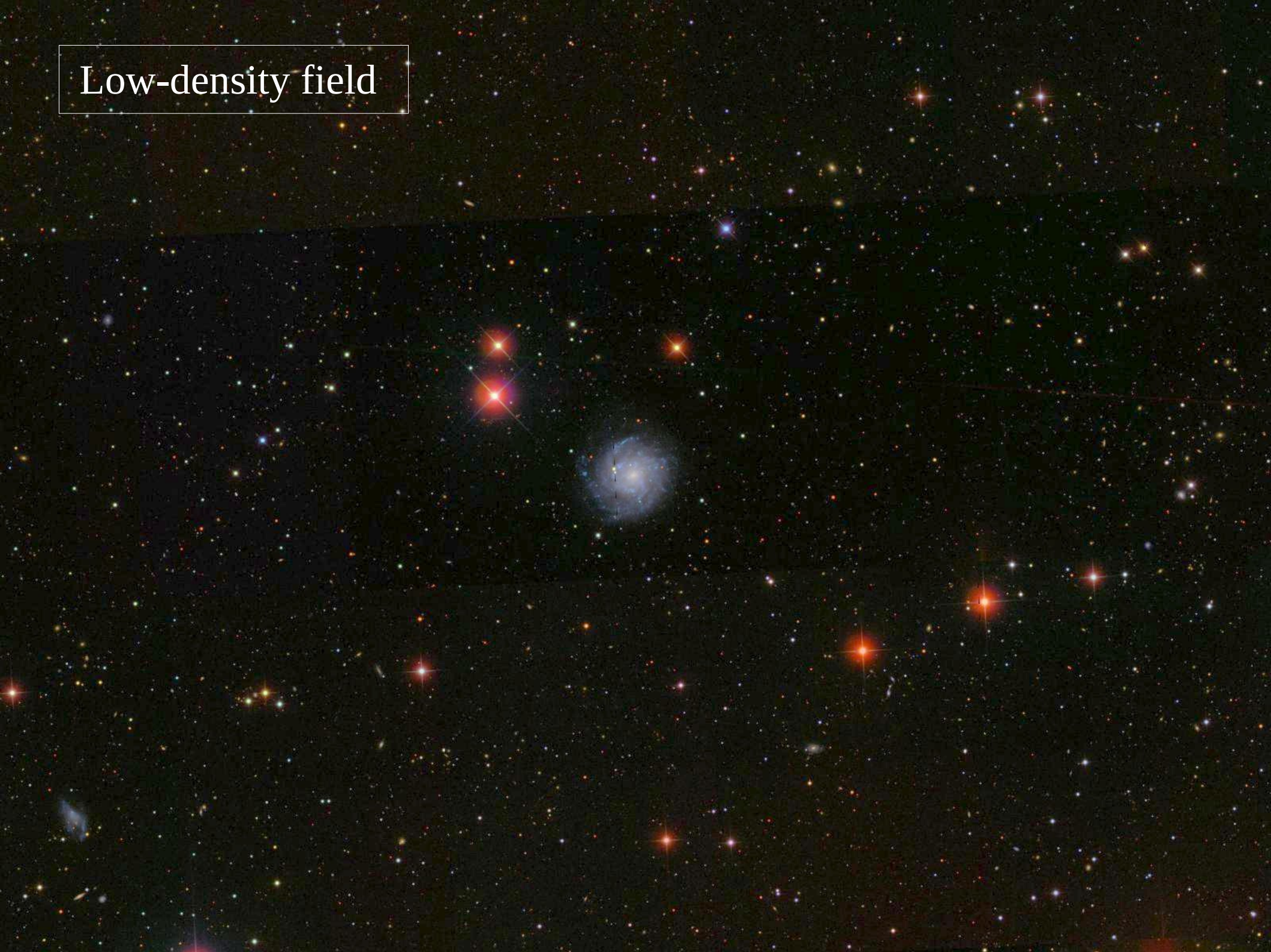
High-density cluster

Galaxy properties depend on the surrounding environment:
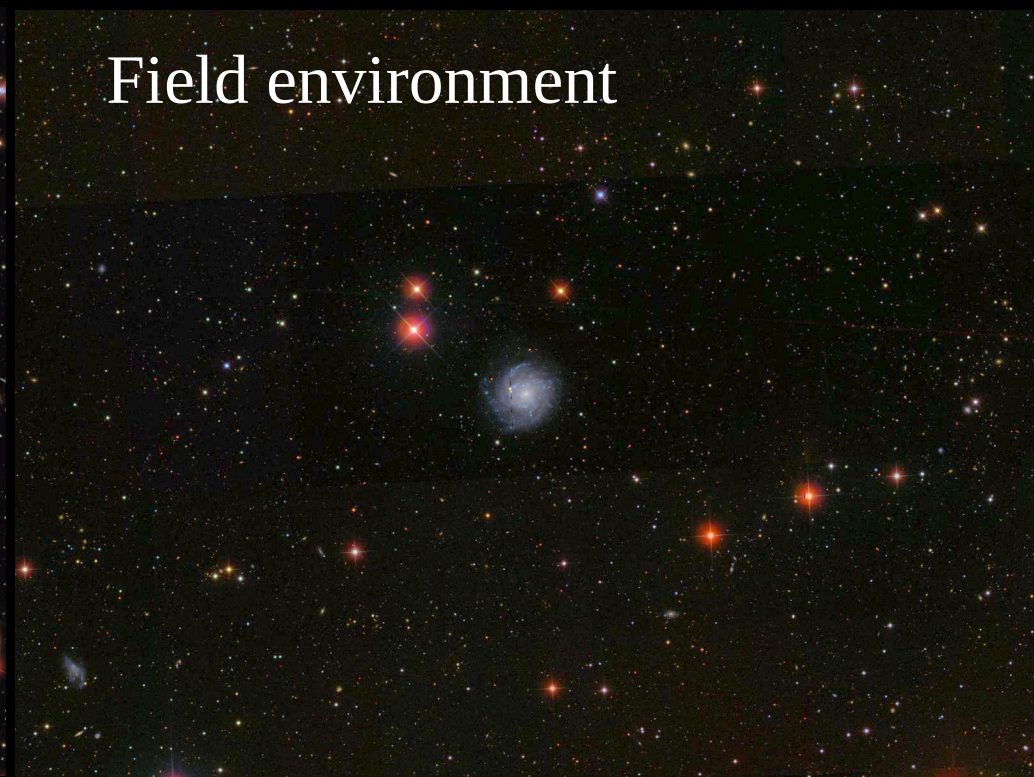
Cluster : red early-type galaxies
Field   : blue late-type galaxies

Cluster environment

Field environment

Origin of the Hubble Sequence?

The structure evolution played an essential role in shaping the "Hubble Sequence".

– When/How did the Hubble Sequence form?

– How does the environment affect the galaxy evolution?

One of the observational ways to address these issues is to observe galaxies over a wide range of redshift and environments. Field galaxies are everywhere, but groups and clusters are rare objects. So, we need to search for them.

When did quiescent early-type galaxies appear in clusters?

Origin of the Hubble Sequence?

The structure evolution played an essential role in shaping the "Hubble Sequence".

– When/How did the Hubble Sequence form?

– How does the structure evolution affect the galaxy evolution?

One of the observational ways to address these issues is to observe galaxies over a wide range of redshift and environments. Field galaxies are everywhere, but groups and clusters are rare objects. So, we need to search for them.
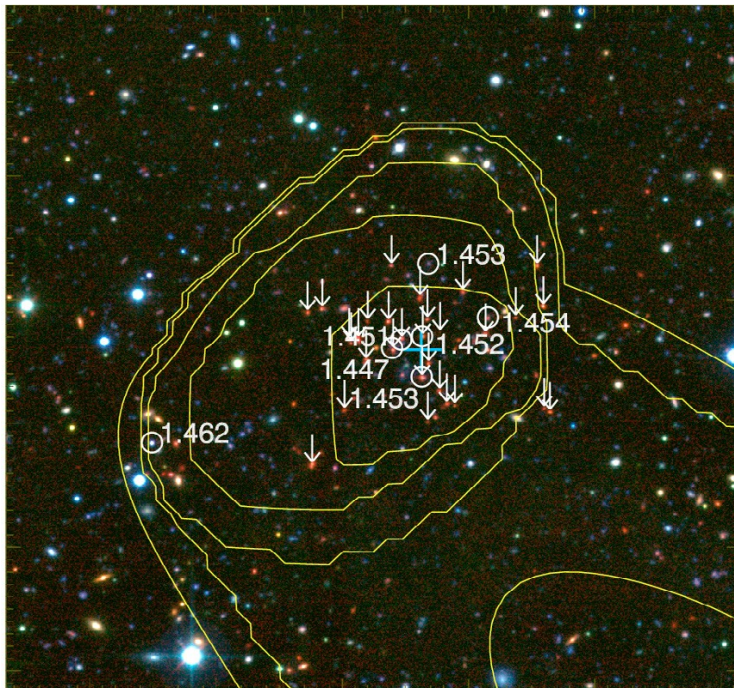
Discovery paper by Stanford et al. 2006.
Picture from Bielby et al. 2010

COSMOS :
Finoguenov et al. 2007 ApJ, Finoguenov et al 2012 in prep, Tanaka et al 2012 in prep

CFHT Deep Fields :
Bielby et al 2010 A&A (D1 and D4), Erfanianfar et al. 2012 A&A to be submitted soon (D3)

Subaru/XMM-Newton Deep Field :
Finoguenov et al. 2010 MNRAS, Tanaka et al. 2010 ApJL

Chandra Deep Field South :
Finoguenov et al. 2012 in prep. Tanaka et al. 2012 to be submitted soon

Lockman Hole
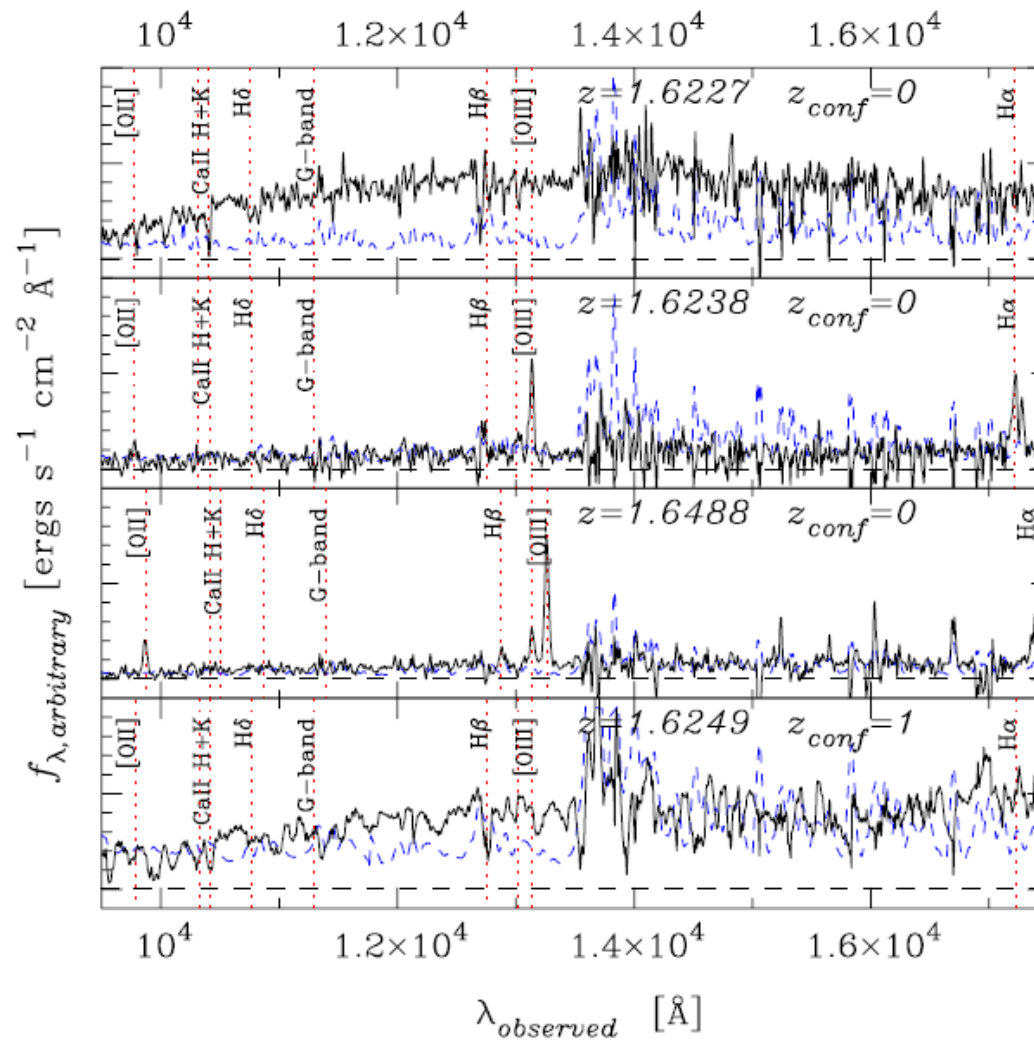Somebody et al. 201X?

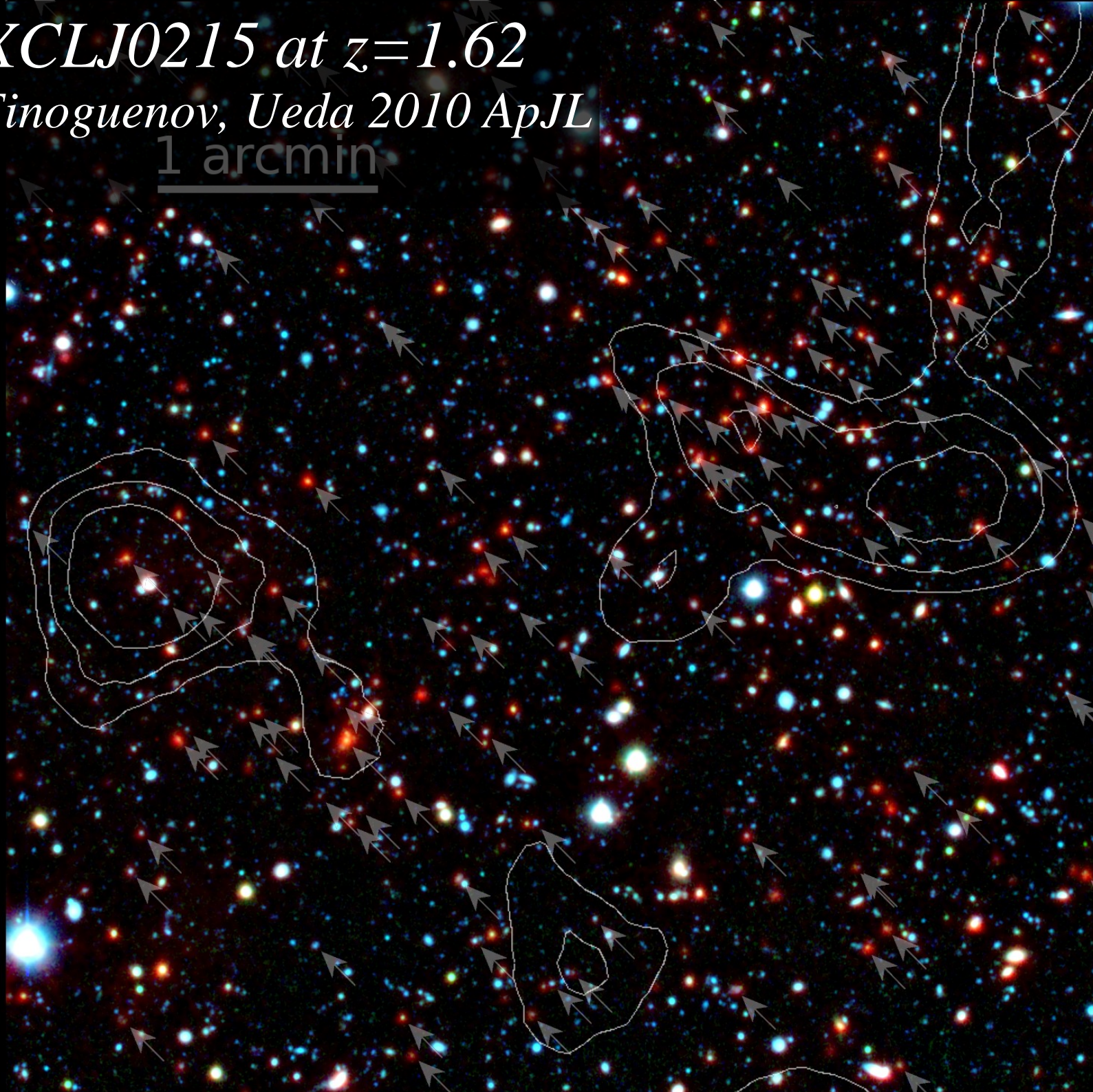*2 – X-ray survey in deep fields*

1 arcmin

Deep nearIR spectra taken with MOIRCS

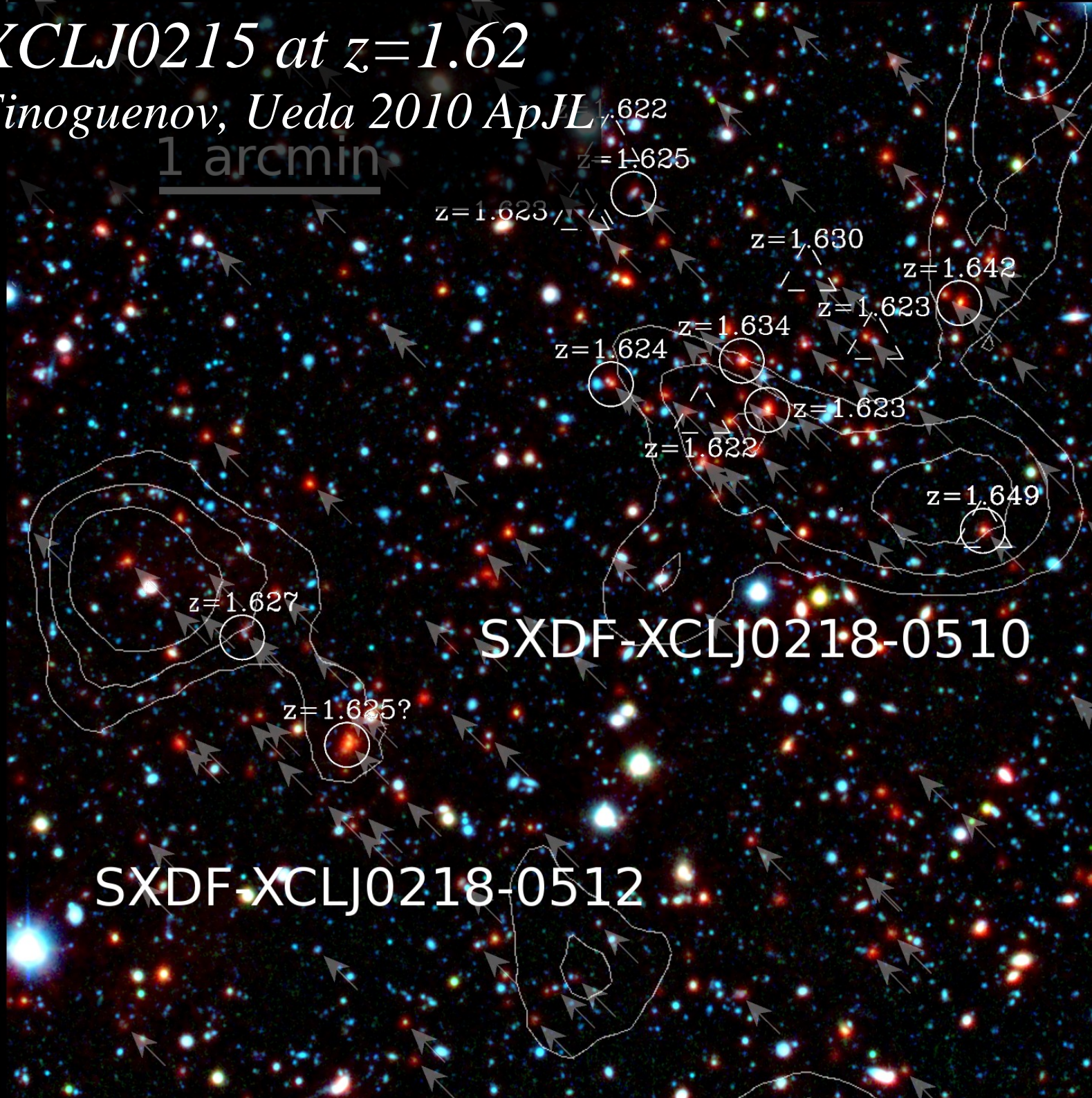*SXDF-XCLJ0215 at z=1.62*
Tanaka, Finoguenov, Ueda 2010 ApJL

1 arcmin

SXDF-XCLJ0215 at z=1.62
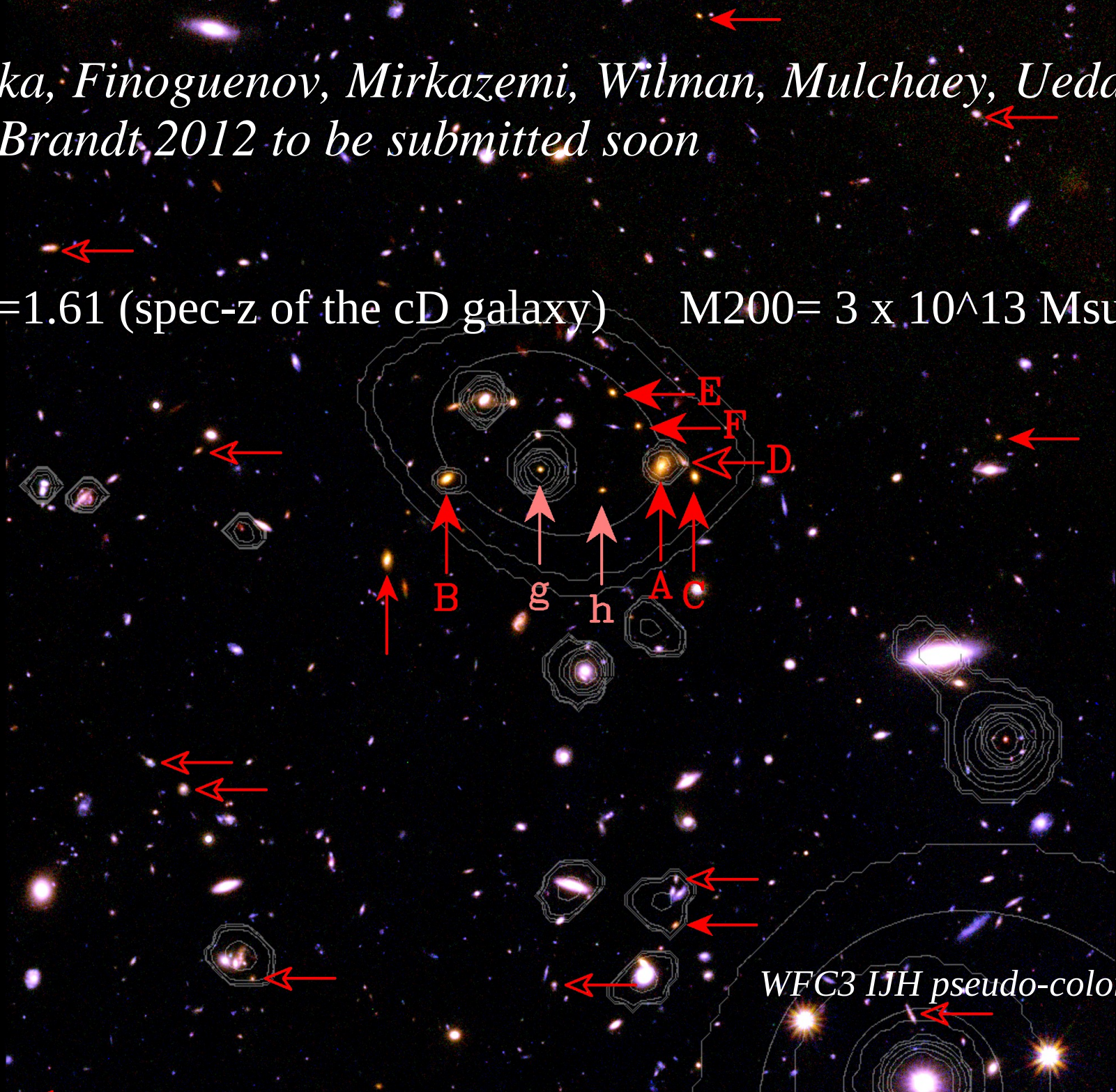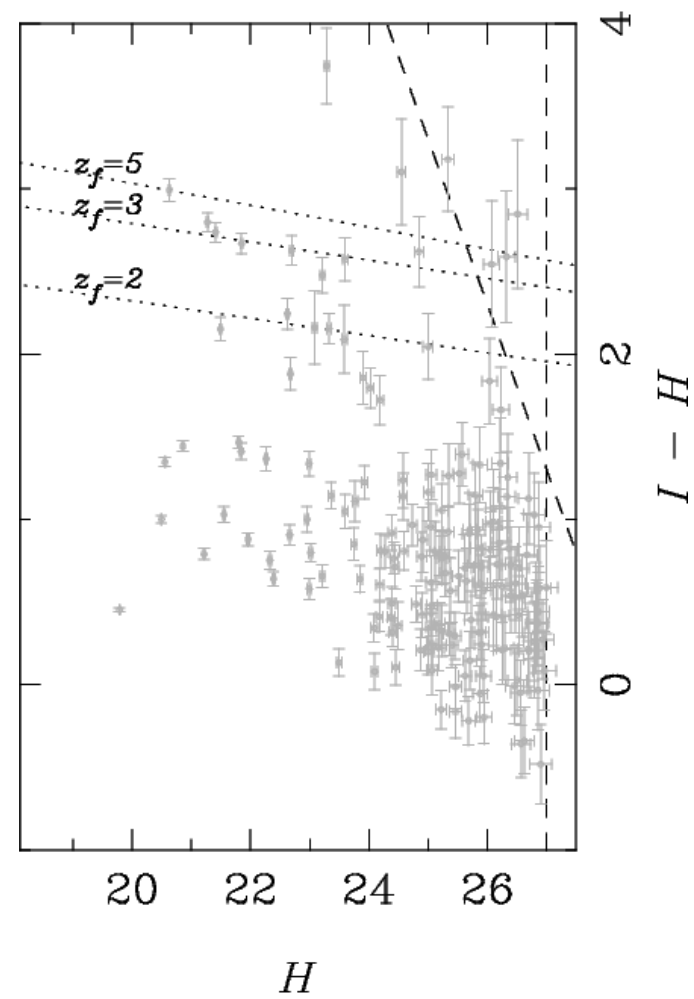*Tanaka, Finoguenov, Ueda 2010 ApJL*

Tanaka, Finoguenov, Mirkazemi, Wilman, Mulchaey, Ueda, Xue, Brandt 2012 to be submitted soon

z=1.61 (spec-z of the cD galaxy)   M200= 3 x 10^13 Msun
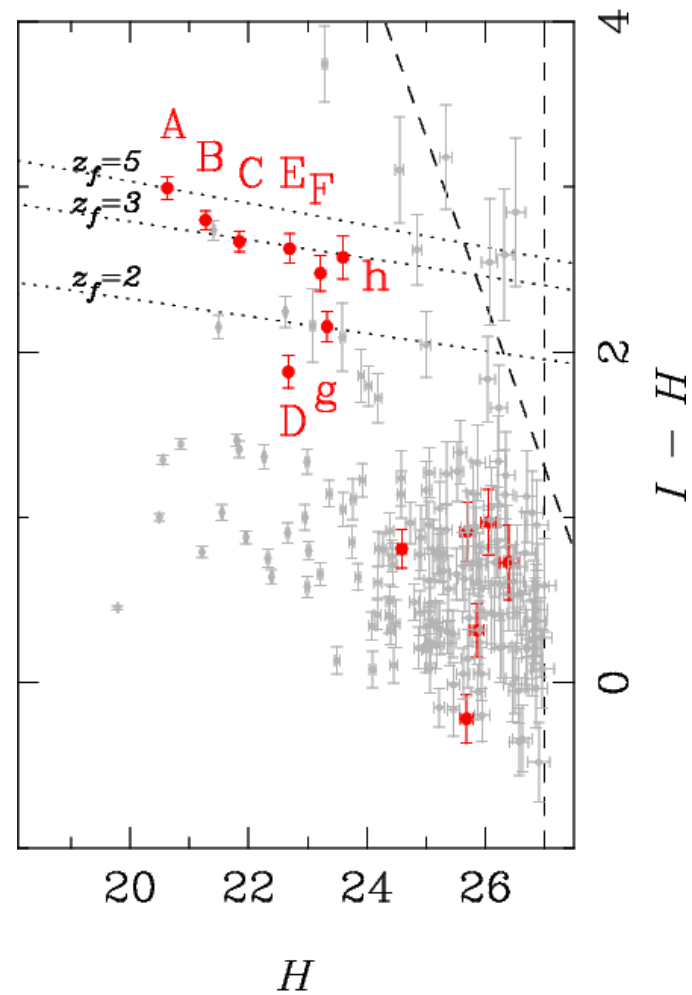
E
F
D
B   g   h   A C

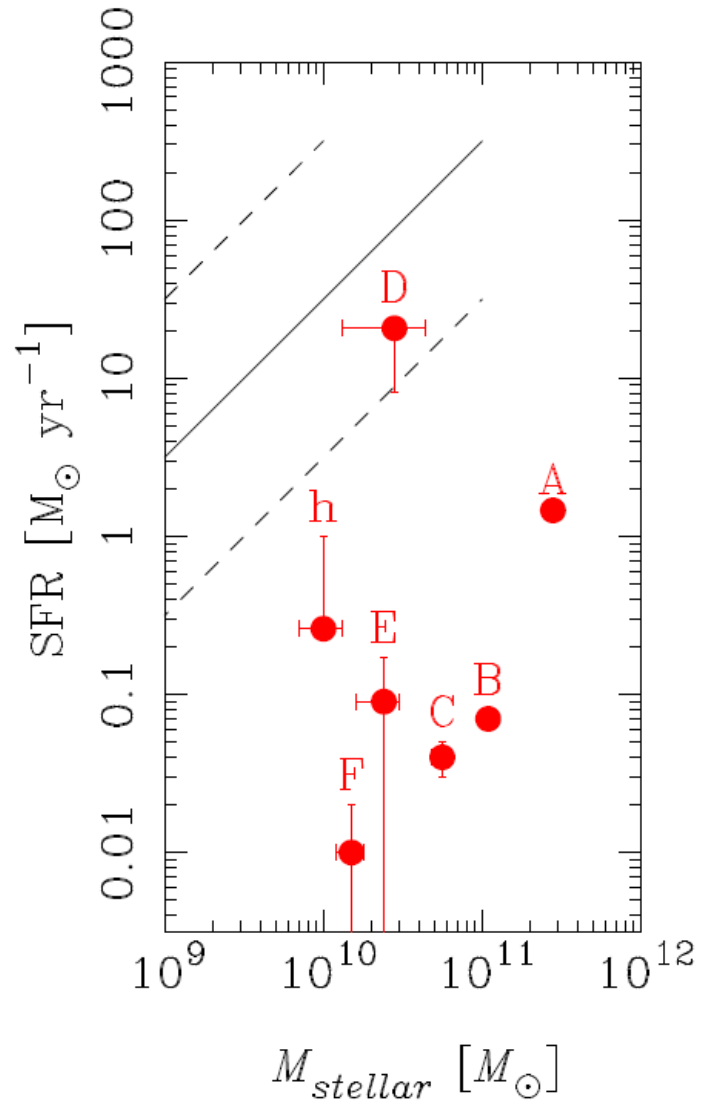*WFC3 IJH pseudo-color image*

A surprisingly prominent red sequence
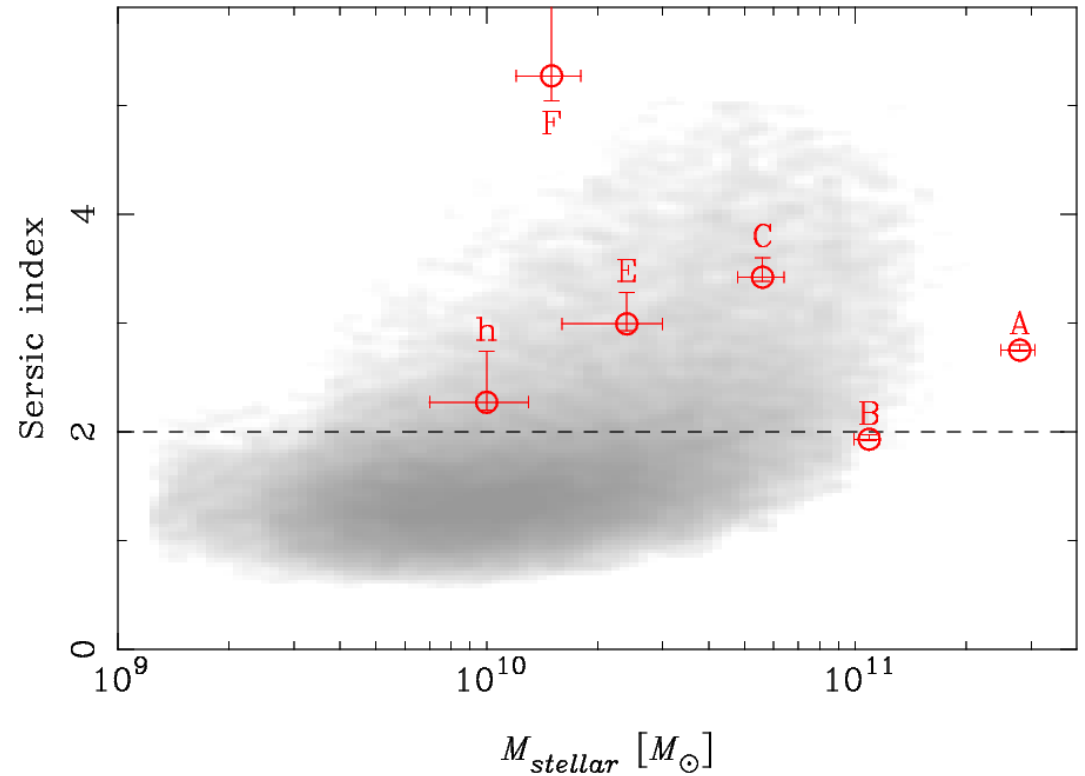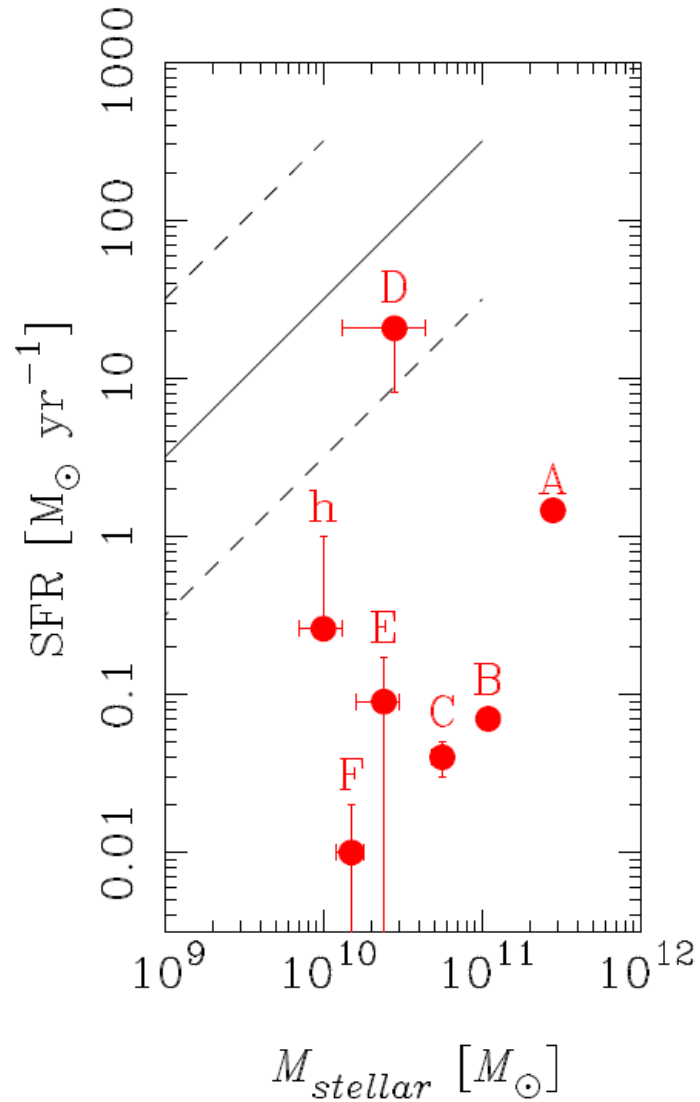
A surprisingly prominent red sequence
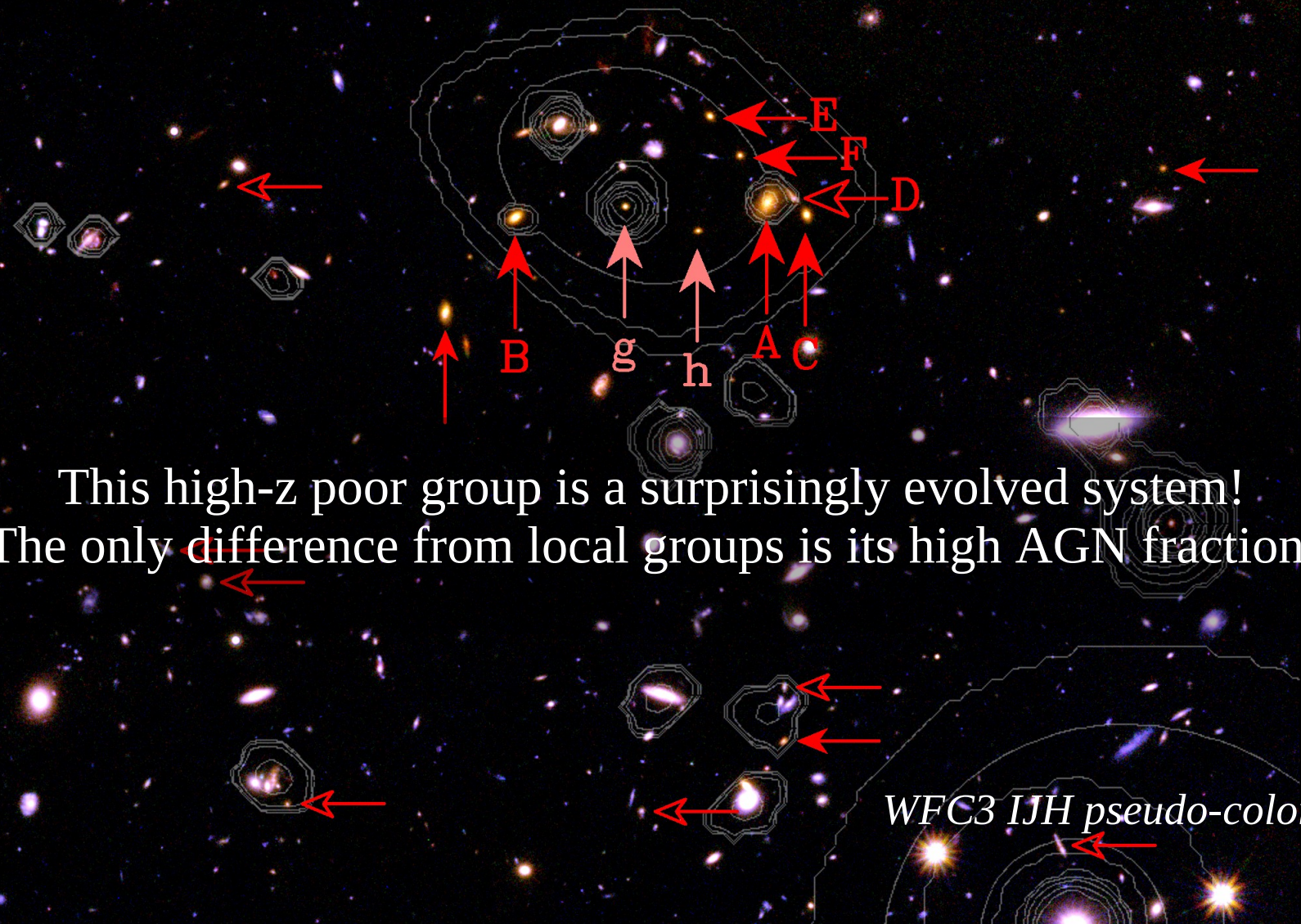

photo-z selected galaxies at z=1.6.

The group galaxies are quiescent

The group galaxies are quiescent and early-types

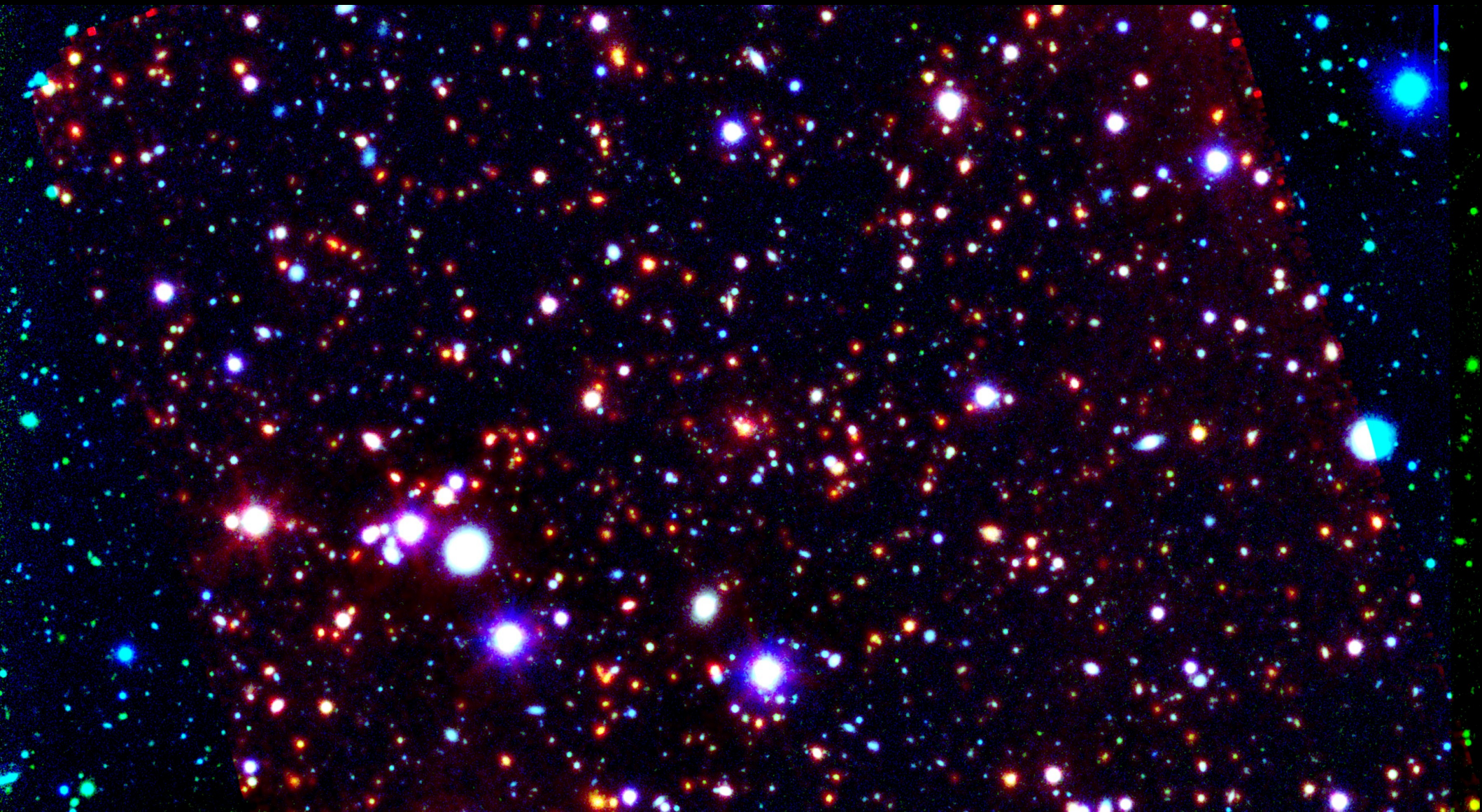*Tanaka, Finoguenov, Mirkazemi, Wilman, Mulchaey, Ueda, Xue, Brandt 2012 to be submitted soon*

This high-z poor group is a surprisingly evolved system!
The only difference from local groups is its high AGN fraction.
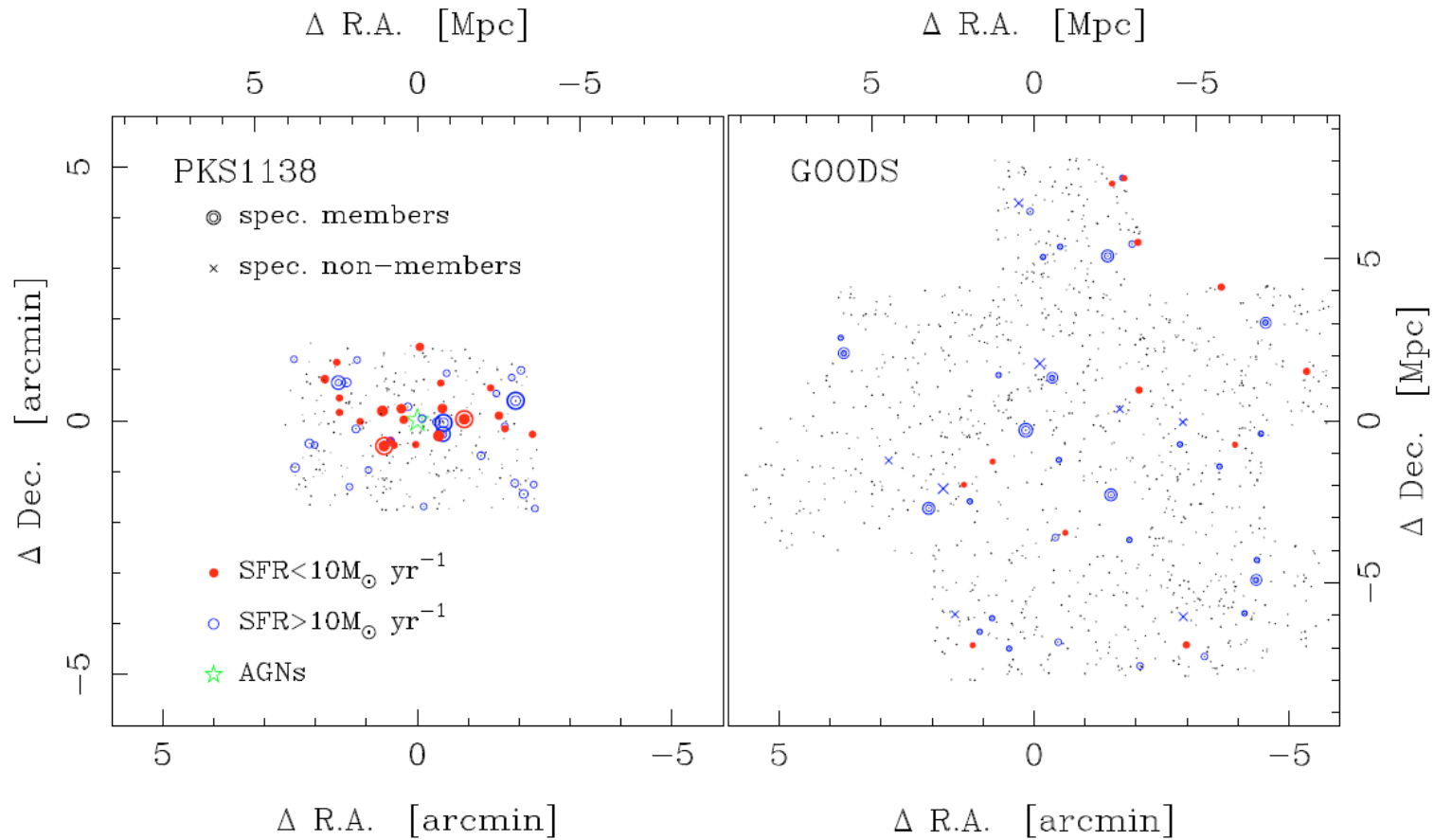
WFC3 IJH pseudo-color image

3 – Towards forming clusters

PKS1138 at z=2.15

Suppressed SFR in forming clusters???
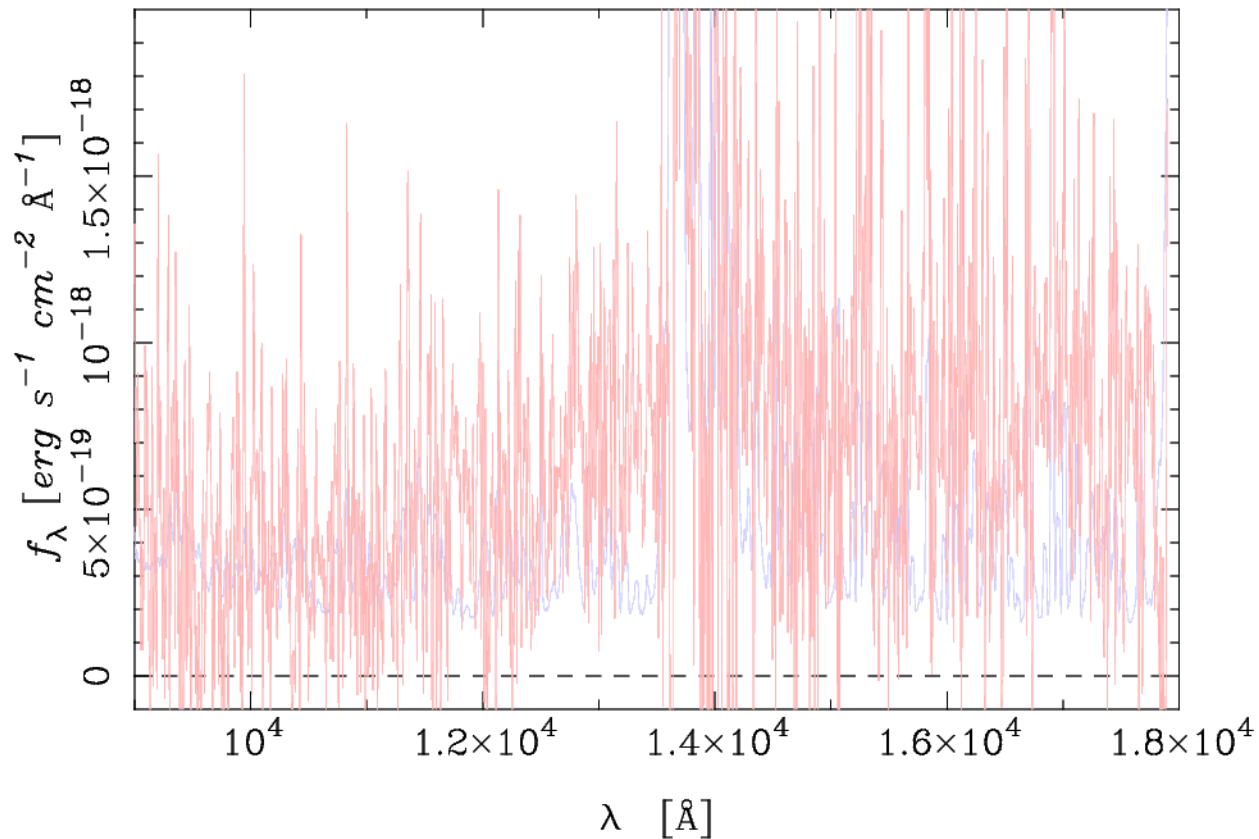
Tanaka et al. 2010 A&A

Deep nearIR spectroscopy with MOIRCS

6 hours integration on one of the brightest members...
Deep near-IR spectroscopy is hard!

Tanaka, Toft, Marchesini, Kodama, et al. 2012 in prep

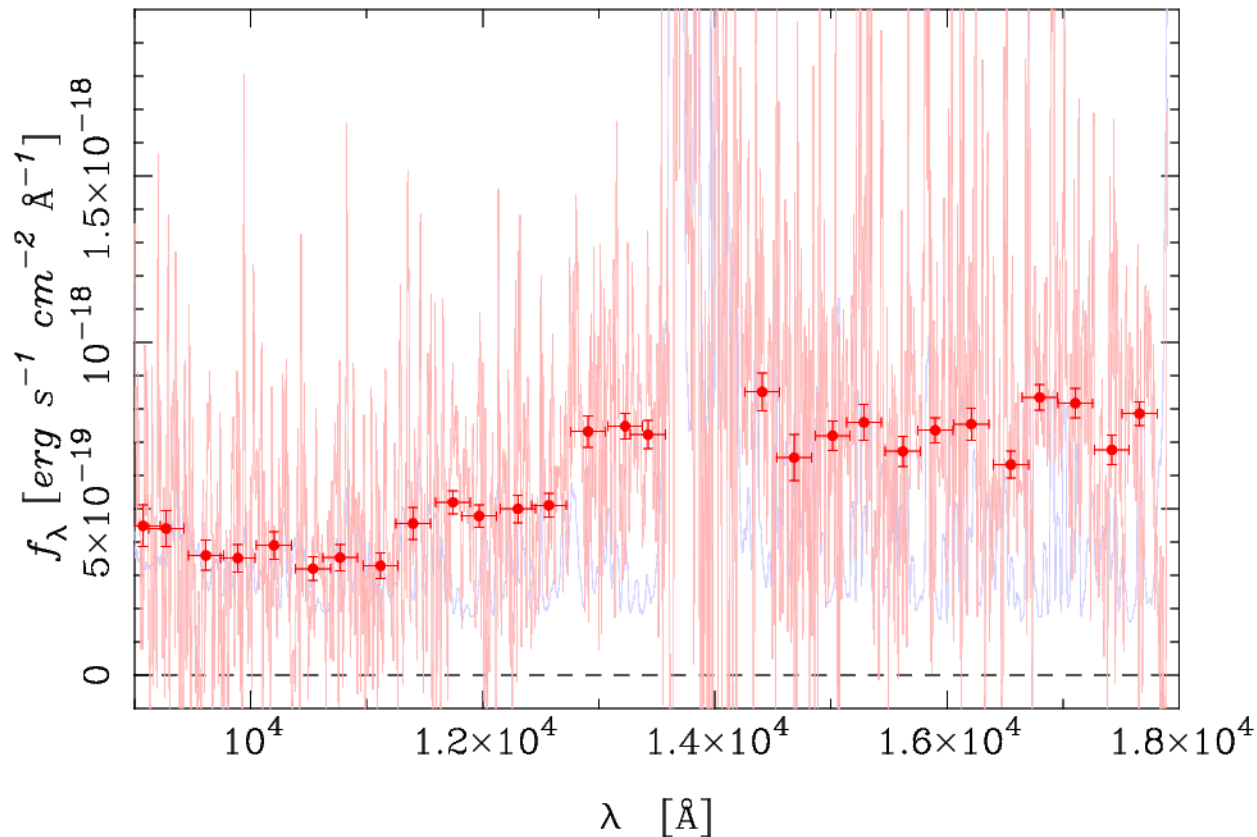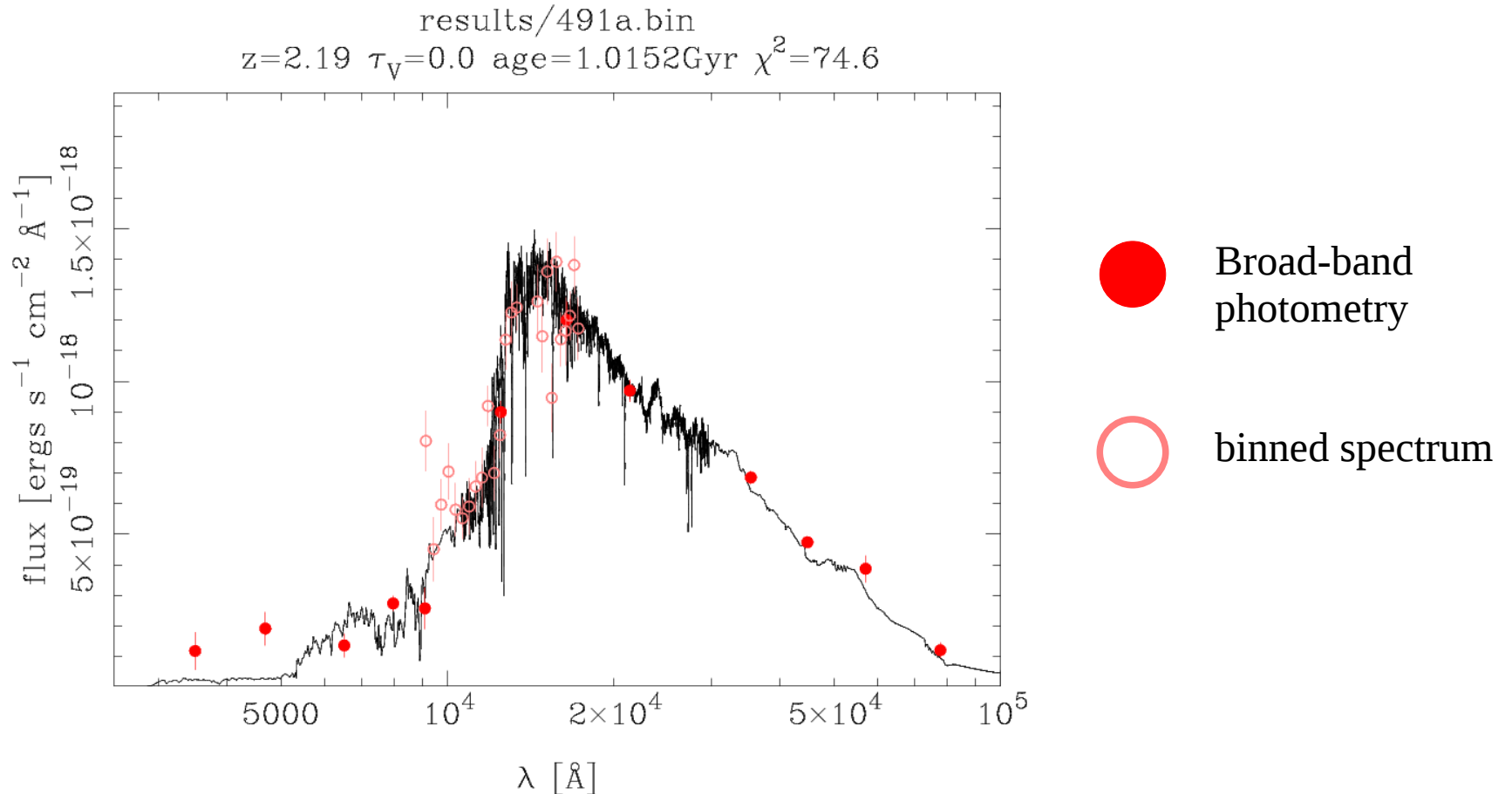# Deep nearIR spectroscopy with MOIRCS

6 hours integration on one of the brightest members...
Deep near-IR spectroscopy is hard!

Tanaka, Toft, Marchesini, Kodama, et al. 2012 in prep

Spectrophotometric fit

results/491a.bin
z=2.19 τ_V=0.0 age=1.0152Gyr χ^2=74.6

Broad-band photometry

binned spectrum

Combined spec + photometry places strong constraints on the stellar population.
Mstellar = 2 x 10^11 Msun,   SFR = 0.1 Msun / yr

Tanaka, Toft, Marchesini, Kodama, et al. 2012 in prep

Quiescent galaxies in forming system
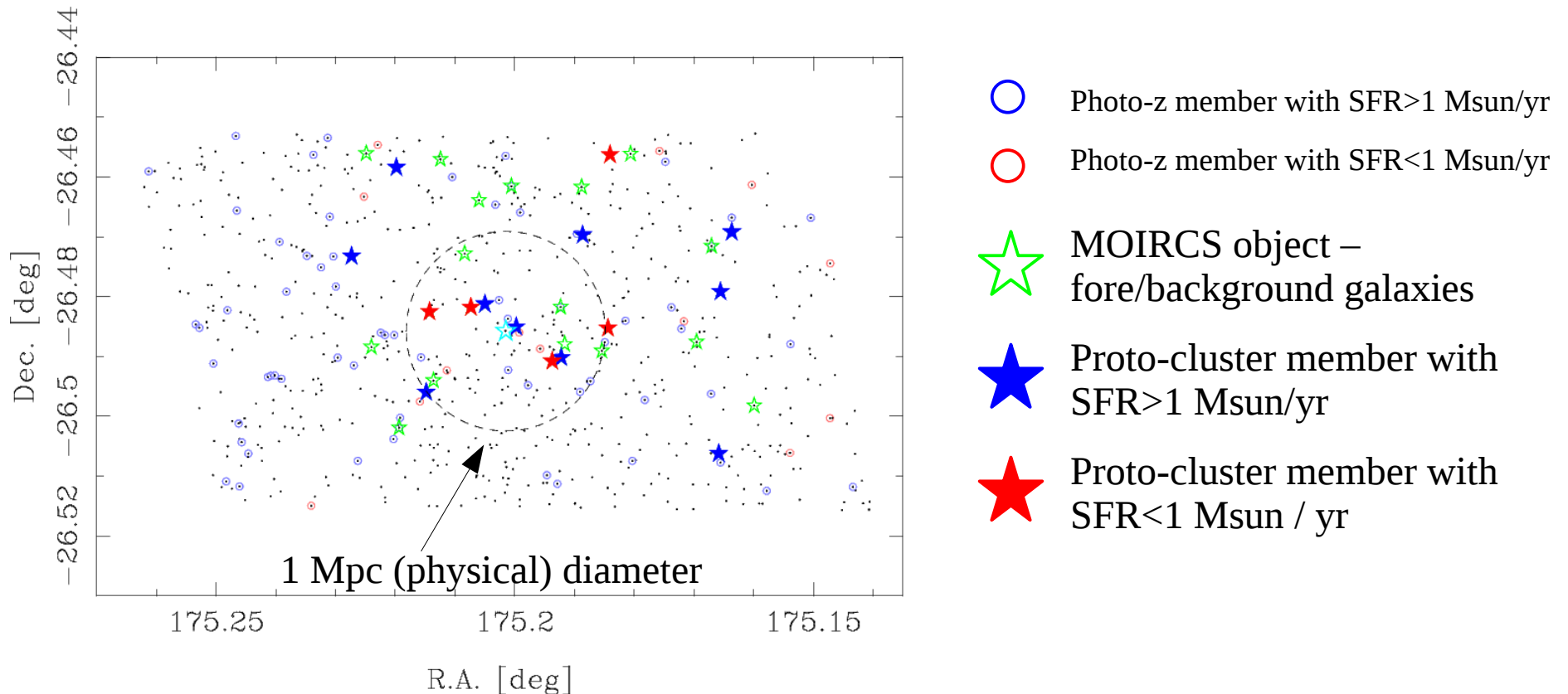
The spatial sampling is far from uniform, but this forming cluster seems to host quiescent galaxies. This is a first spectroscopic confirmation of quiescent galaxies in forming clusters.

Tanaka, Toft, Marchesini, Kodama, et al. 2012 in prep

When did quiescent early-type galaxies come in place in clusters/groups?

It's at least at z>2.

We need a much larger sample of high-z systems,
which we can hopefully make with HSC.

4 – Summary

Summary

▶ We are carrying out an X-ray survey of distant groups and clusters.

▶ We have confirmed a z=1.62 system in SXDS with MOIRCS.

▶ For the other group at z=1.61, we have the deep HST/WFC3 data. We find that this group looks surprisingly similar to local groups.

▶ Based on the deep MOIRCS data, we spectroscopically confirm that quiescent galaxies populate in the proto-cluster environment at z=2.2.

▶ Need a much larger sample. Hopefully, HSC will help us with that.