The 21st Century COE Program of Tohoku University Symposium
"Exploring New Science by Bridging Particle-Matter Hierarchy"
4-5 Mar, 2005

Unveiling the Evolution of Galaxies using MOIRCS: the MOIRCS First Light

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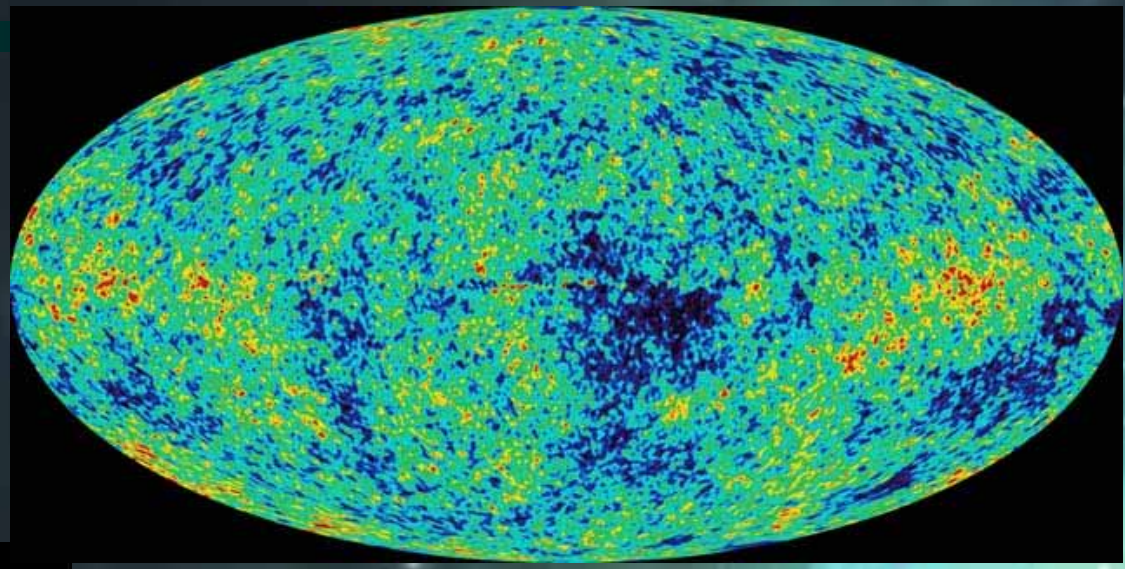
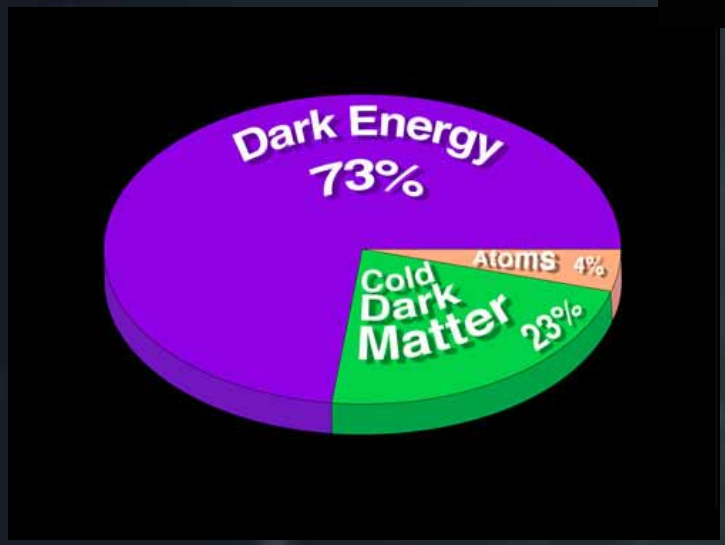
Introduction

2003 WMAP

We now know that...

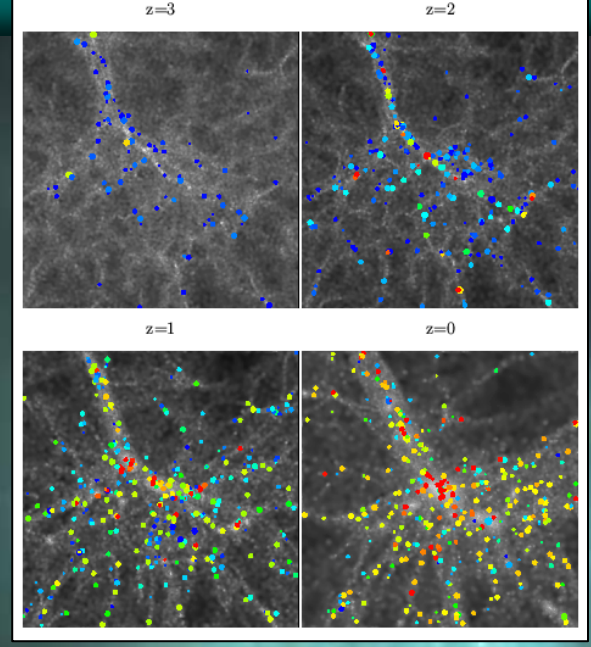




The Universe

- ‘‘‘ **Dominated by Dark Matter & Dark Energy.**
- **What is the nature of Dark Matter?**
- **How they affect to the evolution of galaxies?**

Viewpoint:



Large-scale structure formation by Cold Dark Matter: How galaxies are affected by it?

Known Fact:

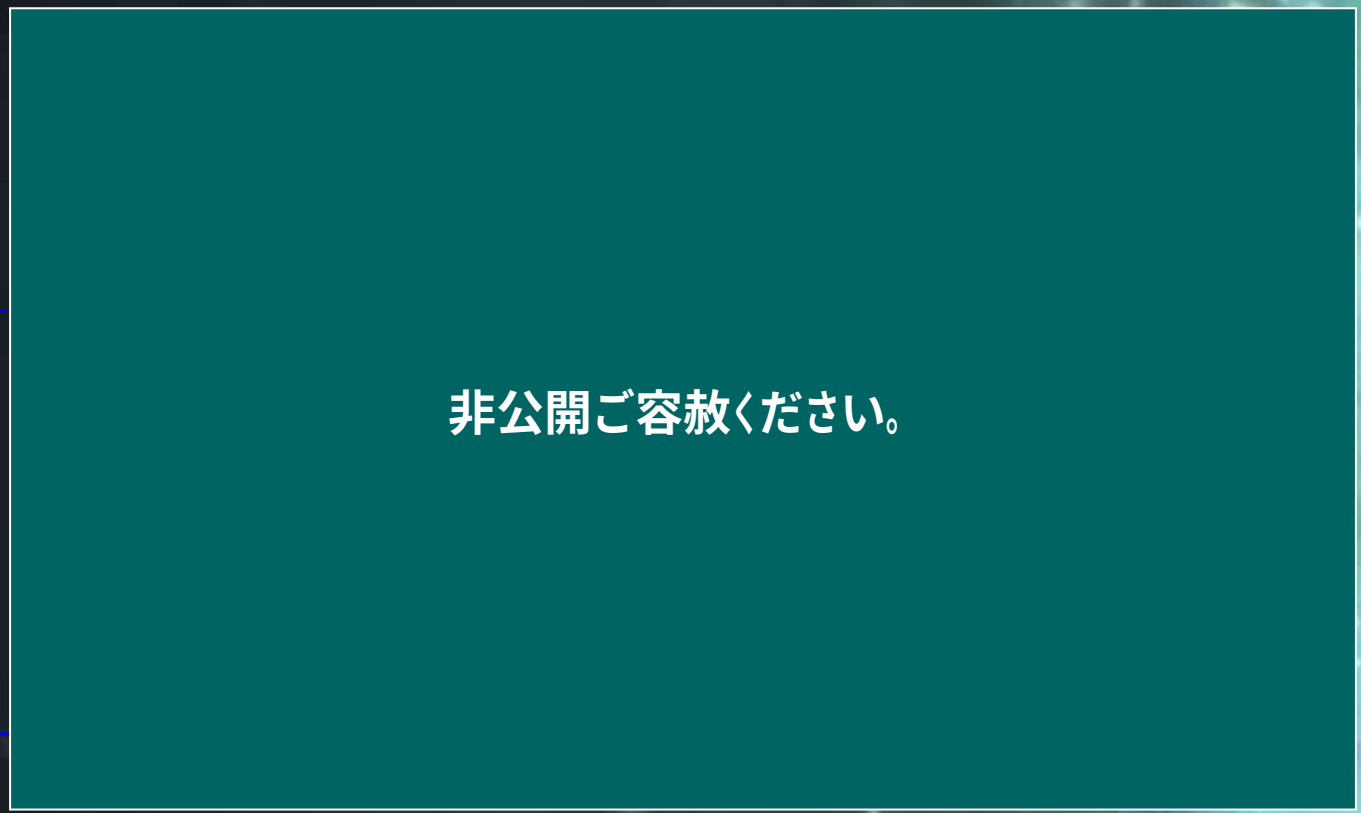
- **Galaxies in cluster environment are different from those in Field environment at z~0.***
- **Galaxies seems to form in *biased* manner in early Universe (strong clustering of galaxies at large redshifts of z=4-6). ***
- **Some recent detection of massive evolved galaxies at z~2 in Field Environment.**

MOIRCS will be the most powerful instrument for these studies..

Largest FOV / High Sensitivity / Good optics / MOS performance

MOIRCS First Light !

21-23 Sept. 2004



Orion Nebulae (Messier 42) in Near Infrared

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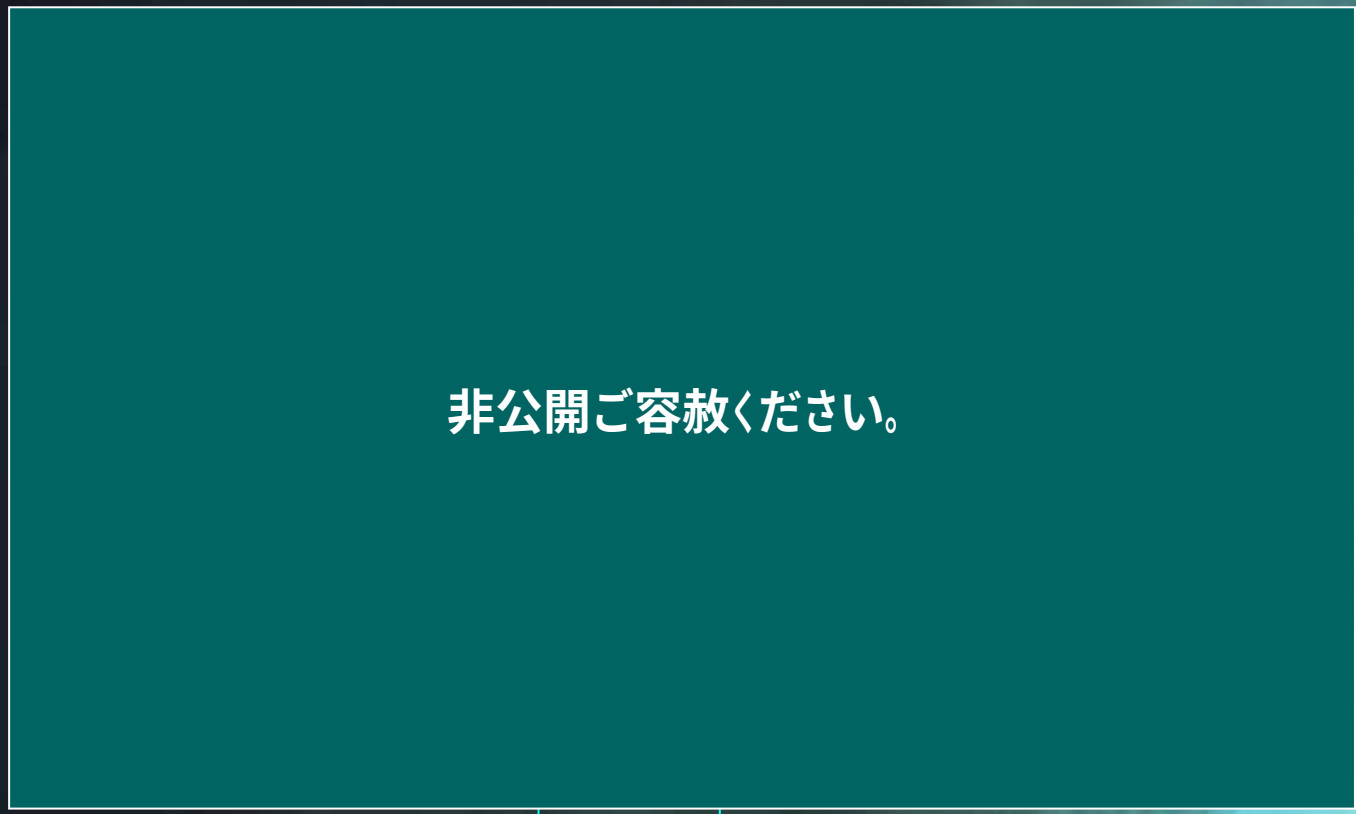


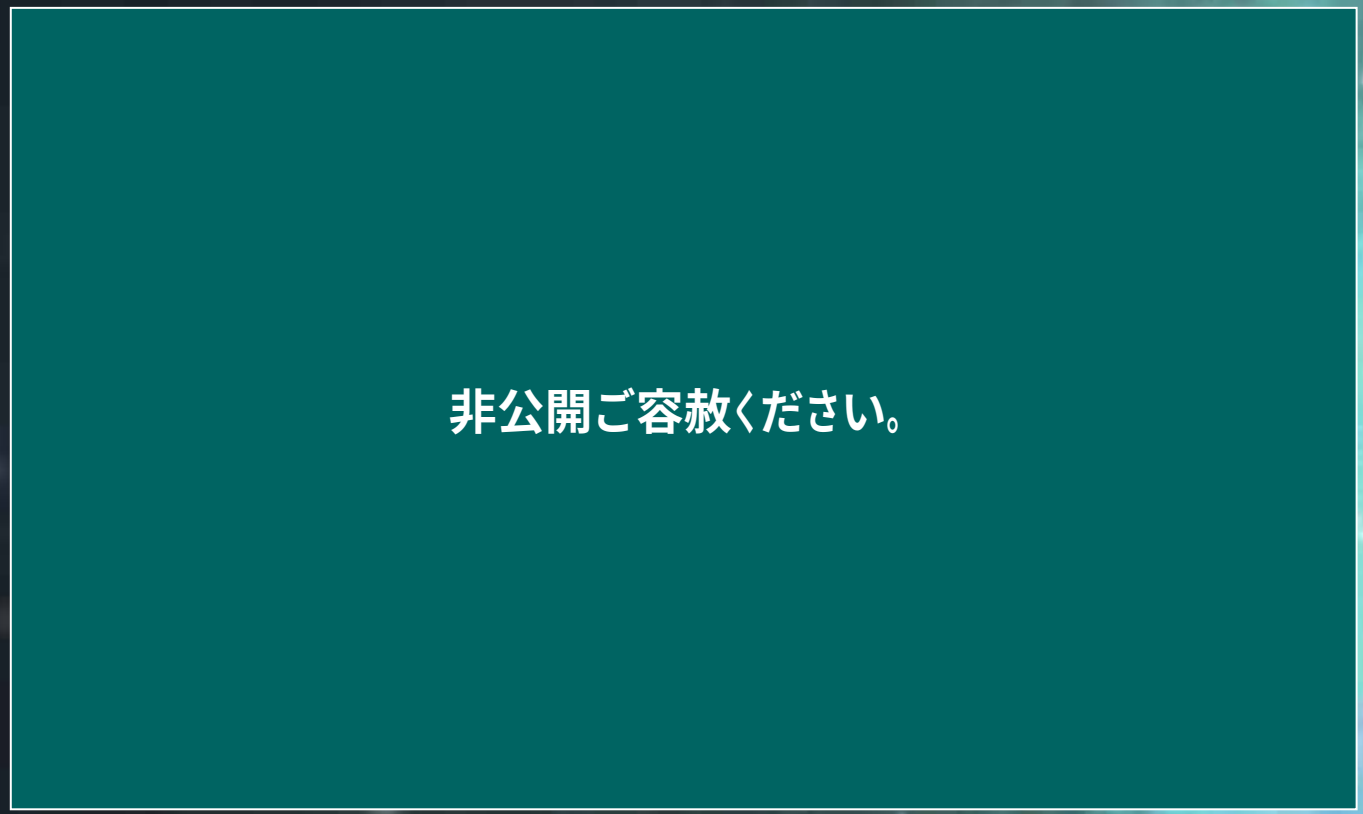
Hubble Space Telescope (NICMOS)　　MOIRCS Ks band

MOIRCS First Light

21-23 Sept. 2004

The Observation of the SSA22 proto-cluster region.

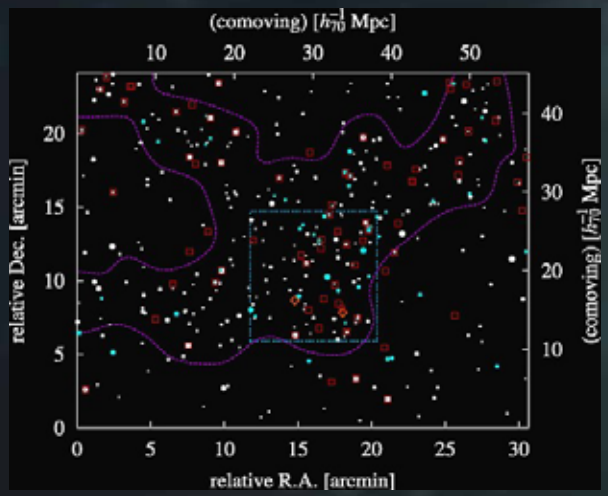
(Y. Katsuno, 2005 Tohoku Univ. Ph.D Thesis)



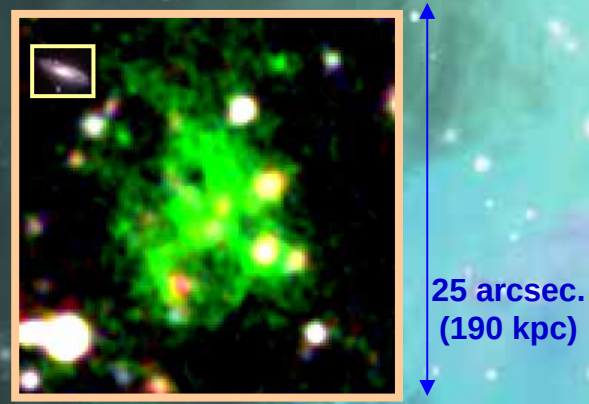
SSA22 proto-cluster region (4’ x 7’)

SSA22 Proto-Cluster Region

- One of the most distant proto clusters known (redshift~3.1).
- First Detected and Determined by Steidel's group in 1999.
- Detection of *a Number of* Huge "**Ly-α Blobs**" (Steidel et al. 2000; Matsuda et al. 2005, Tohoku Univ. Ph.D. Thesis).
  - Forming Site of Massive Cluster members?
  - Intensive Starbursts → Galactic Wind?
- Extremely Large (>50 Mpc) Structure Traced by Star-forming Galaxies (Hayashino et al. 2004)



Hayashino et al. 2004

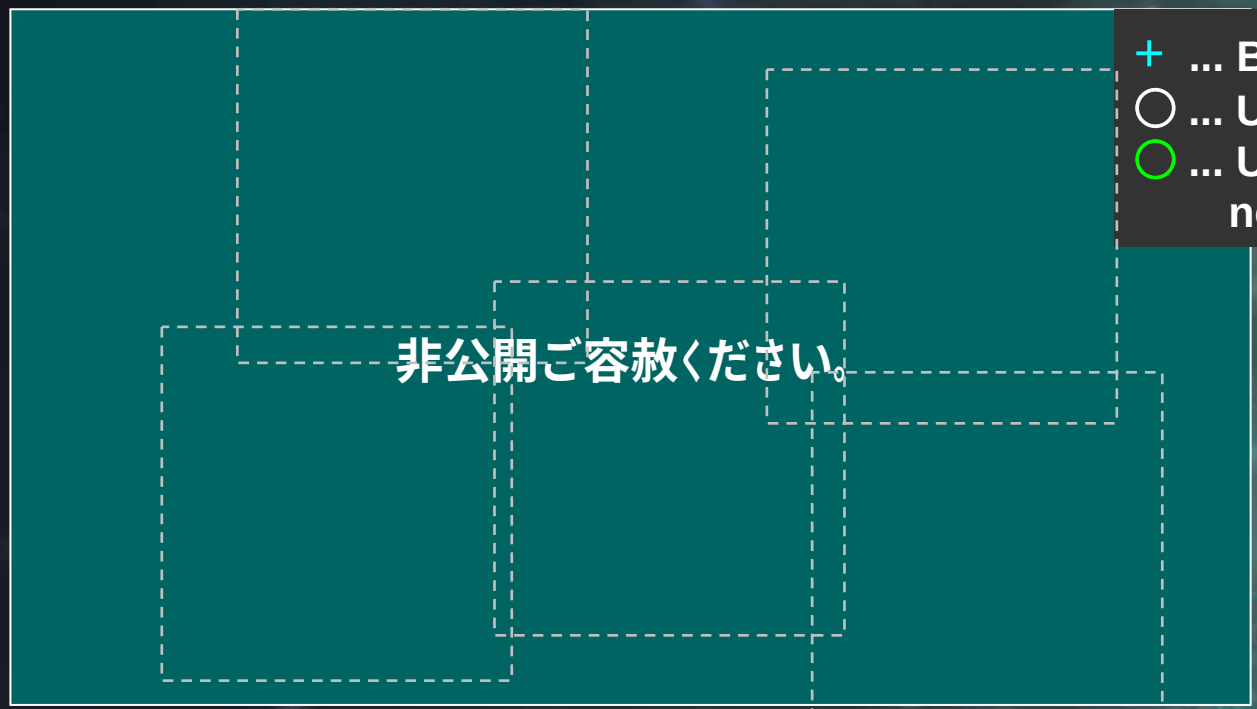


Matsuda et al. 2004

Near-IR properties of “Blobs” by MOIRCS

NIR light traces the STELLAR MASS of galaxies than Optical.

- **Are galaxies in the center of “Blobs” massive or not compared to other UV-luminous star-forming galaxies (LBGs) in the protocluster?**

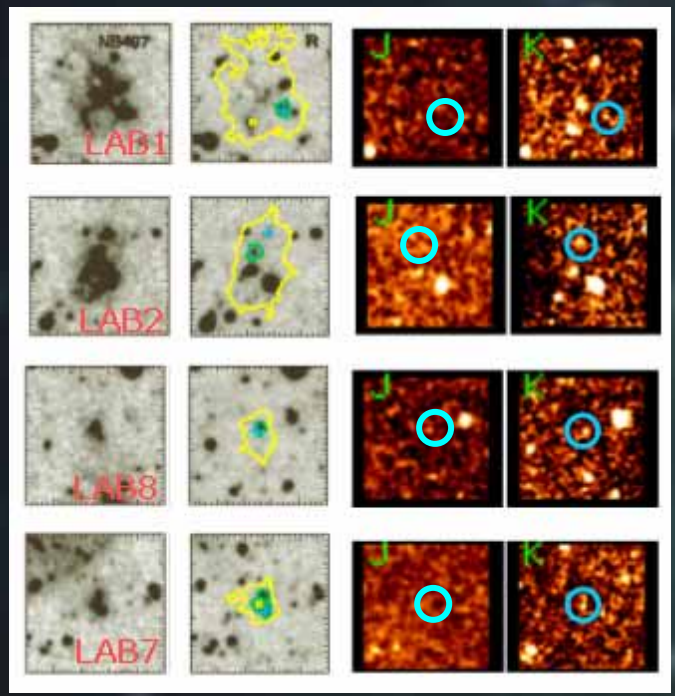


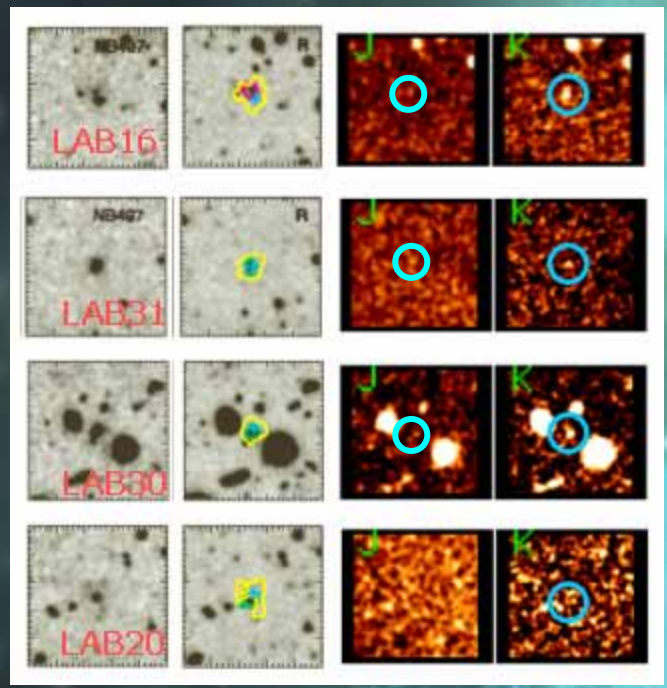
+ ... Blobs
○ ... UV-bright Galaxies
○ ... UV-bright Galaxies but not in the cluster redshift

NIR Detection of Blob Galaxies !

- We detect 7/8 NIR counterparts of UV-bright galaxies with Blobs.
- For Comparison, only 4/9 UV-bright galaxies without blobs are detected.

→ Blob galaxies are also massive in stellar mass.





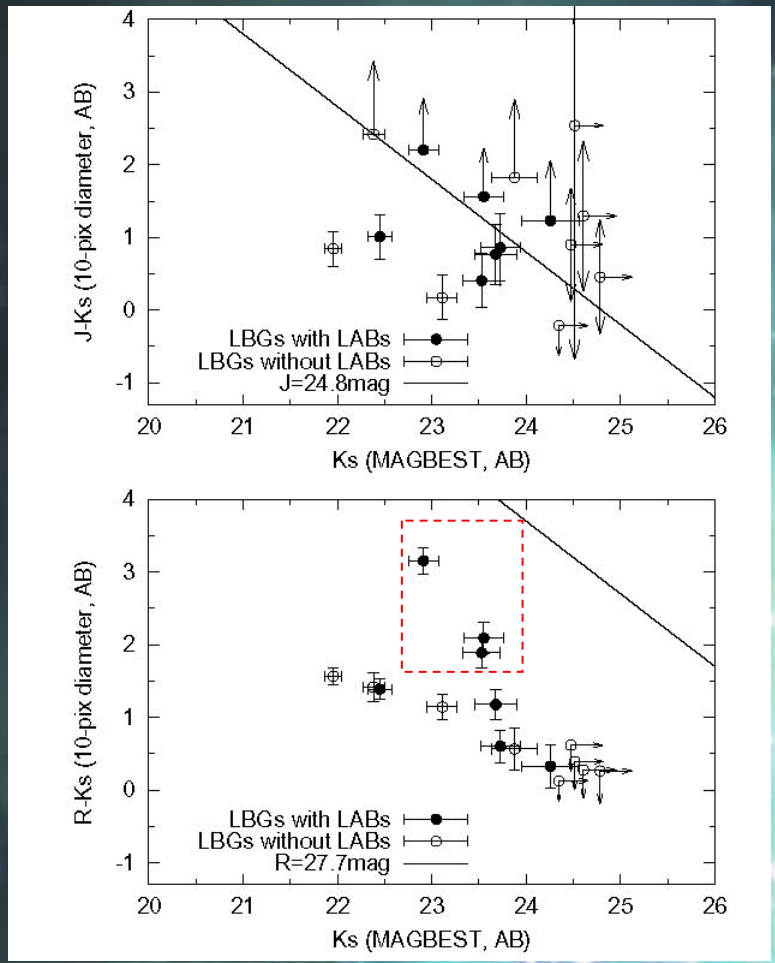
Katsuno et al. (2005)

Near-IR color properties of Blob Galaxies

- **Color Information ... difficult to get information due to the relative shallowness of our test data..**
- **Blob-associated UV-bright galaxies may show redder colors in R-K than UV-bright galaxies.**

Massive in stellar mass.
Dusy with (possible) gas outflow
Strong Clustering of of blobs.

・・・ consistent with the idea that blobs are the "forming massive cluster galaxies"

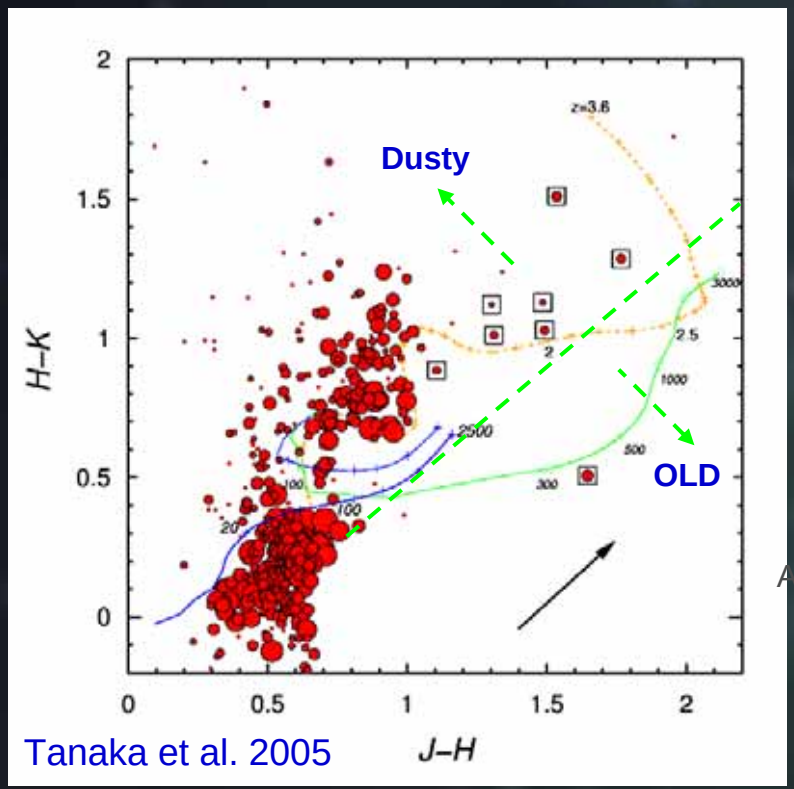


Katsuno et al. (2005)

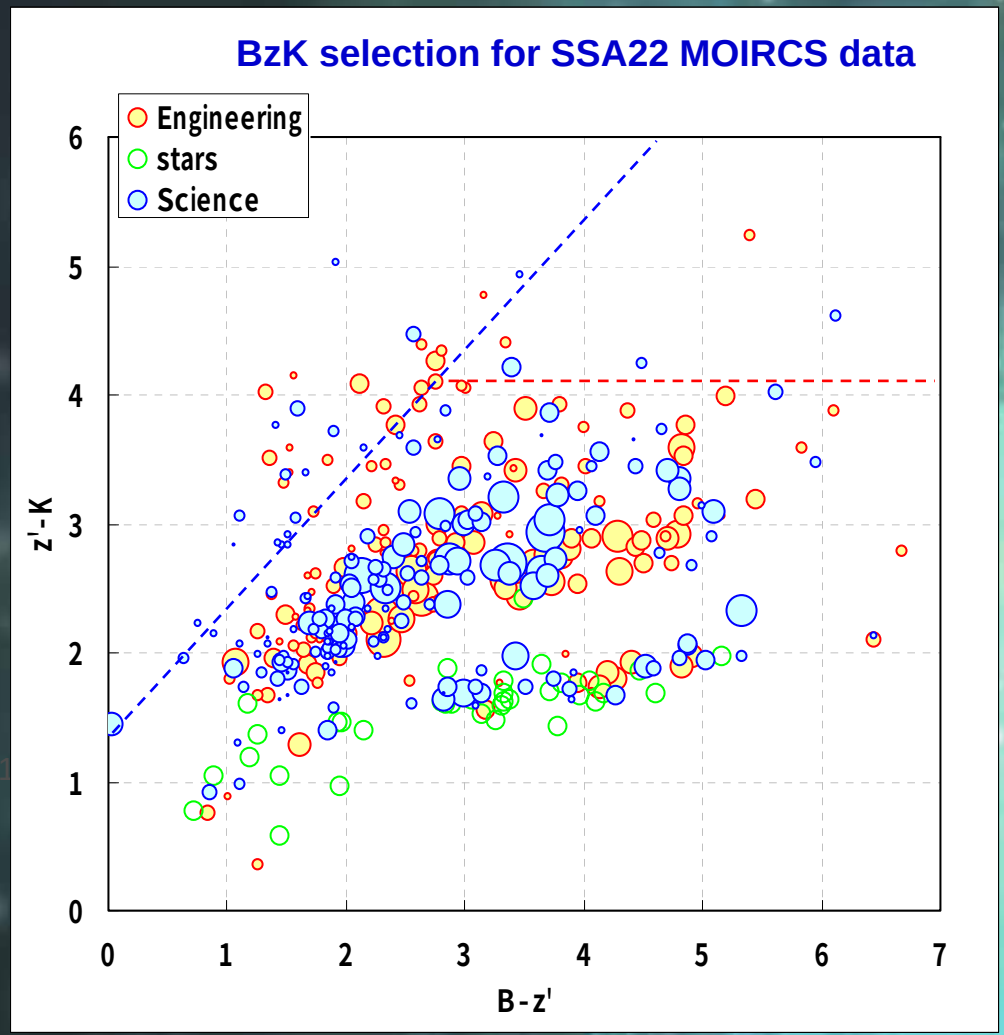
Strong indication for the "Baby Boom" cluster of galaxies.

Future Study for SSA22 region

- A further multi-color analysis → OLD / Dusty galaxy problem to z~3!
- Generality → more sample / comparison with Field.
- BzK galaxy selection → foreground objects at z>1.4.
- redshift evolution.

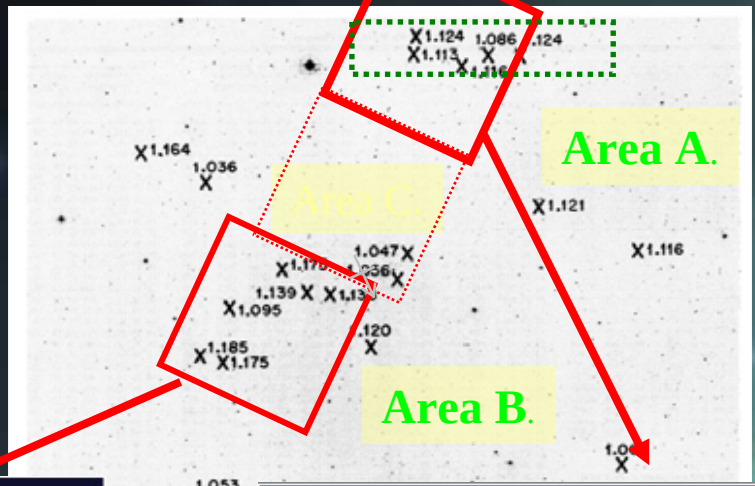


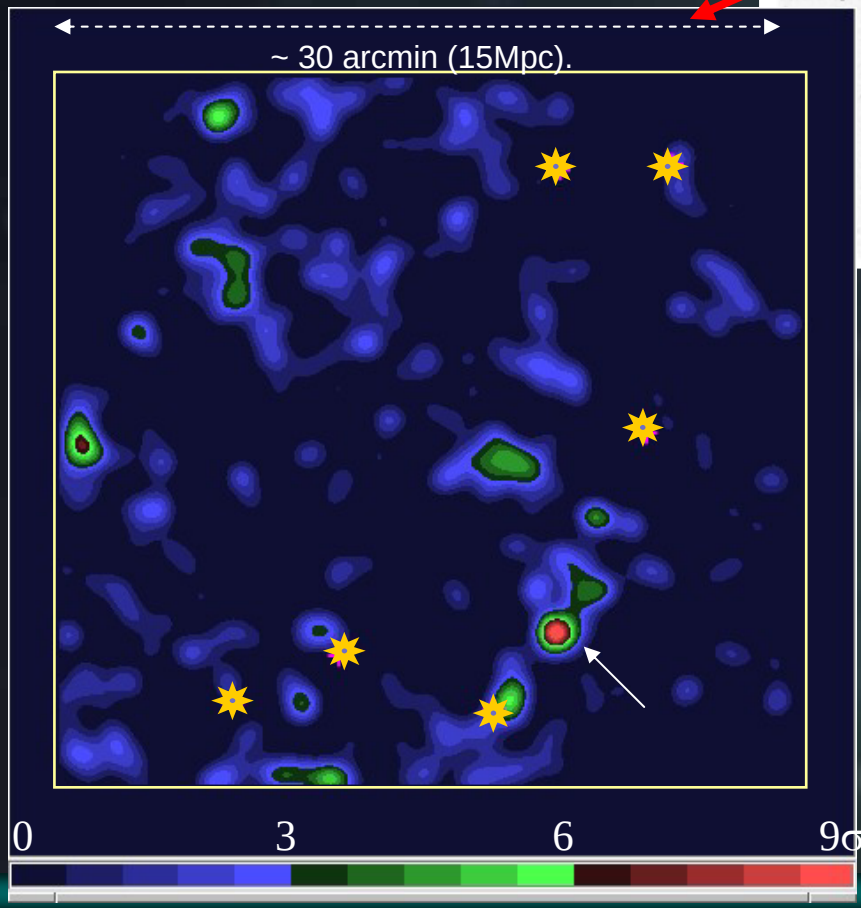
4C 23.56 Protocluster at z~2.5

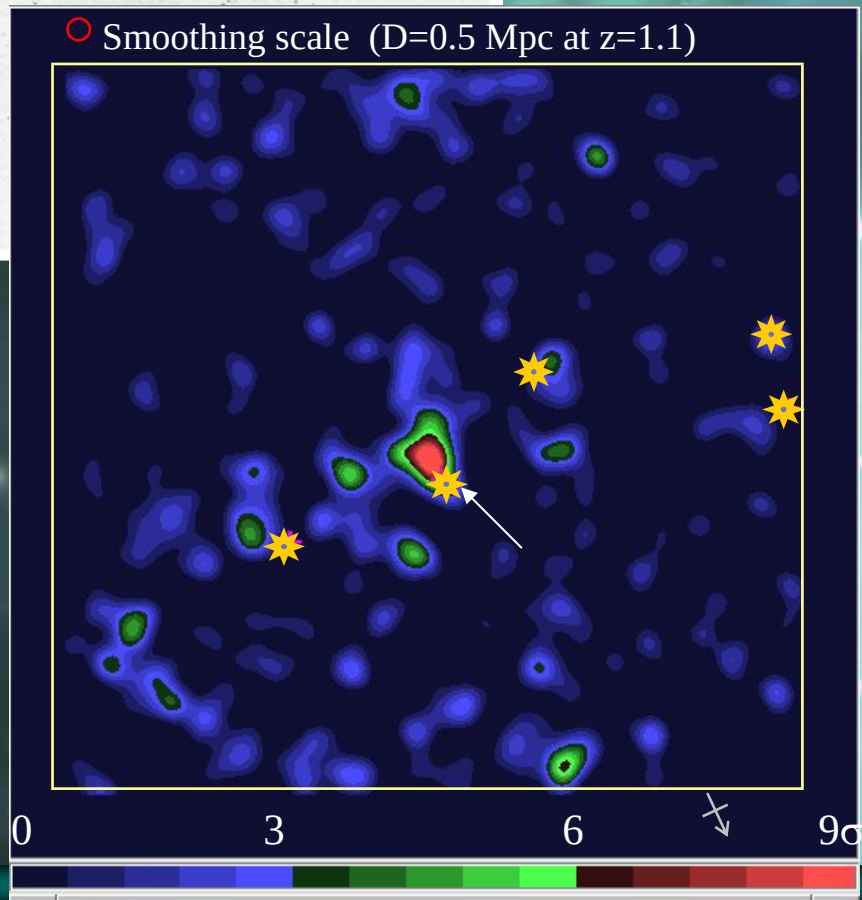


Approach to z evolution: z~1.1

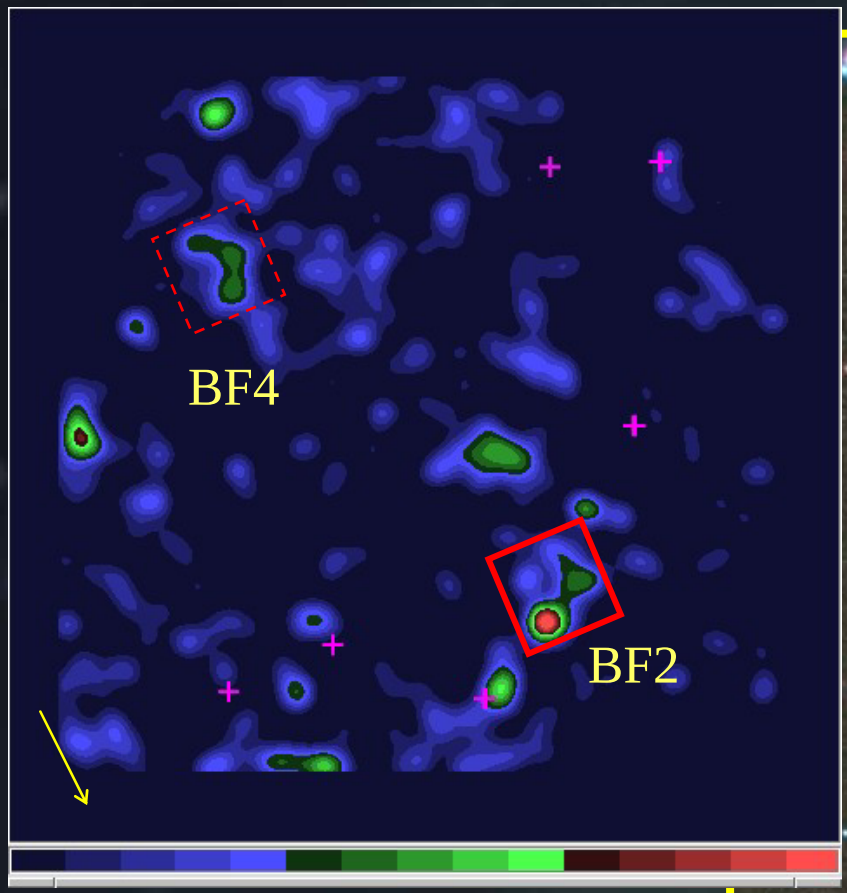
Detection of a Dozen of high-significance (>3σ) cluster signal by Subaru (optical observation).
(Tanaka et al. 2004 ASJ meet.)





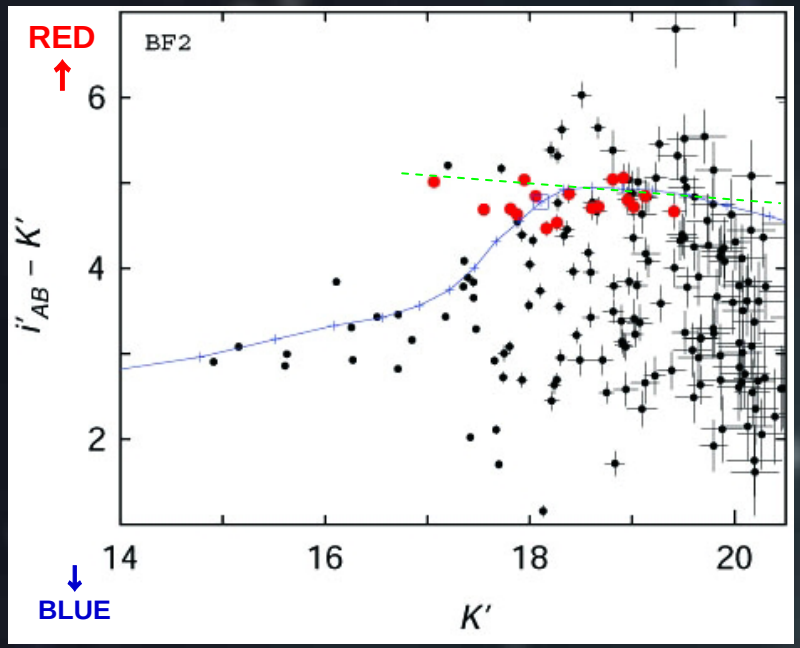


Example of a NIR Observation by WHT 4-m telescope



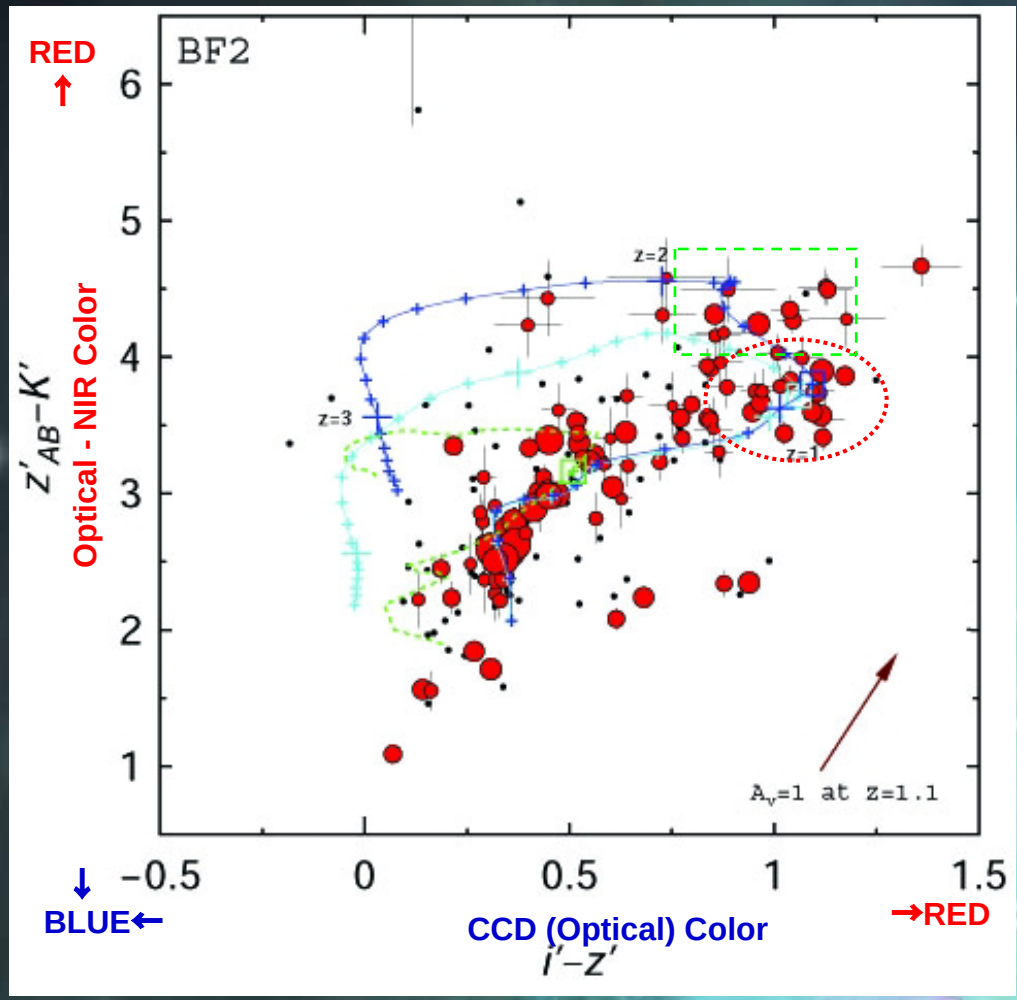
K-band Deep (~2hr)
FOV ~ 3.8x3.8 arcmin^2.
seeing ~ 0.9 arcsec.

Color Analysis of A New Cluster BF2



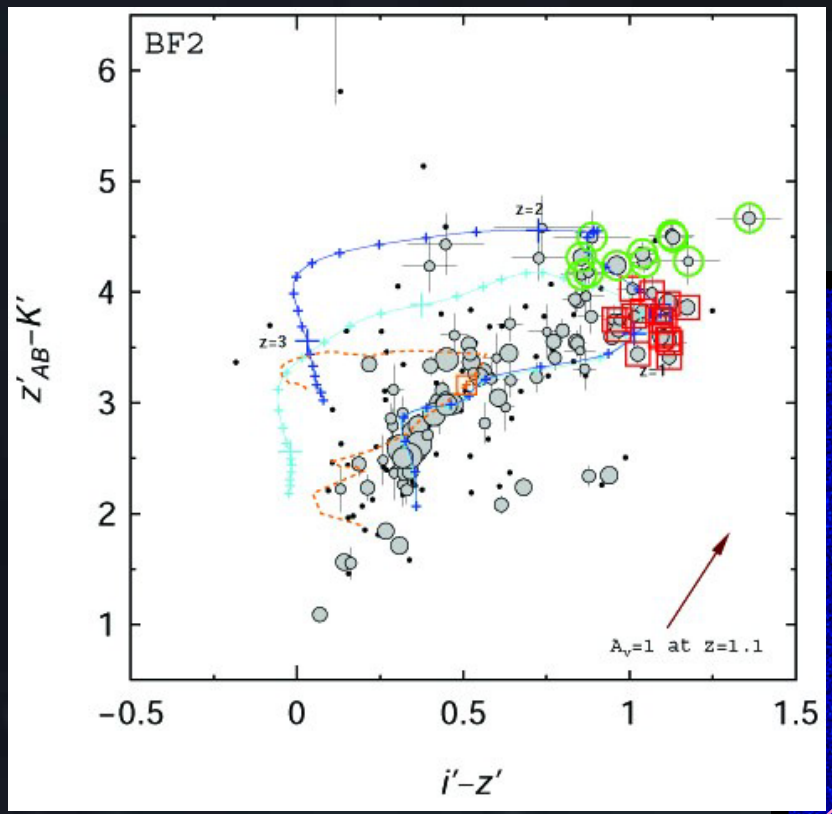
Color Track by PEGASE2.

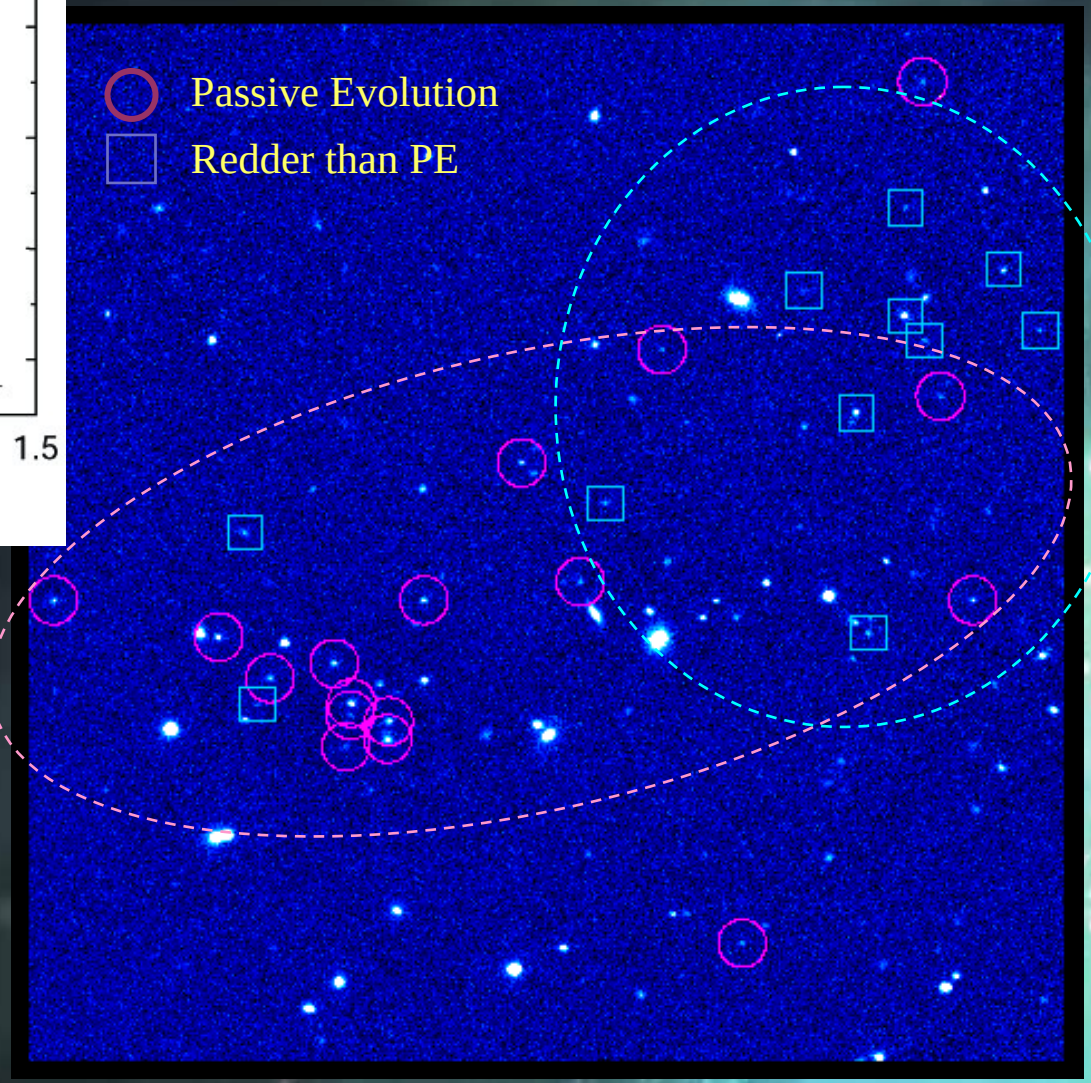
Passive Evolution: zf=4 (blue) & 7(cyan); No-Evolution Sb; Box marks on tracks show at z=1.1.



- **Strong clustering of galaxies on "Passive Galaxy" color at z~1.1.**
- **A "tight Color-Magnitude Relation" is seen, but a broader color distribution in NIR color...why?**

Another Background Cluster ?





Implication for BF2 region:

(1) Another cluster at z~1.4?

(2) A group of dust-rich members?

If (2), this may be related with the event of cluster-scale dark matter halo formation (major merger).

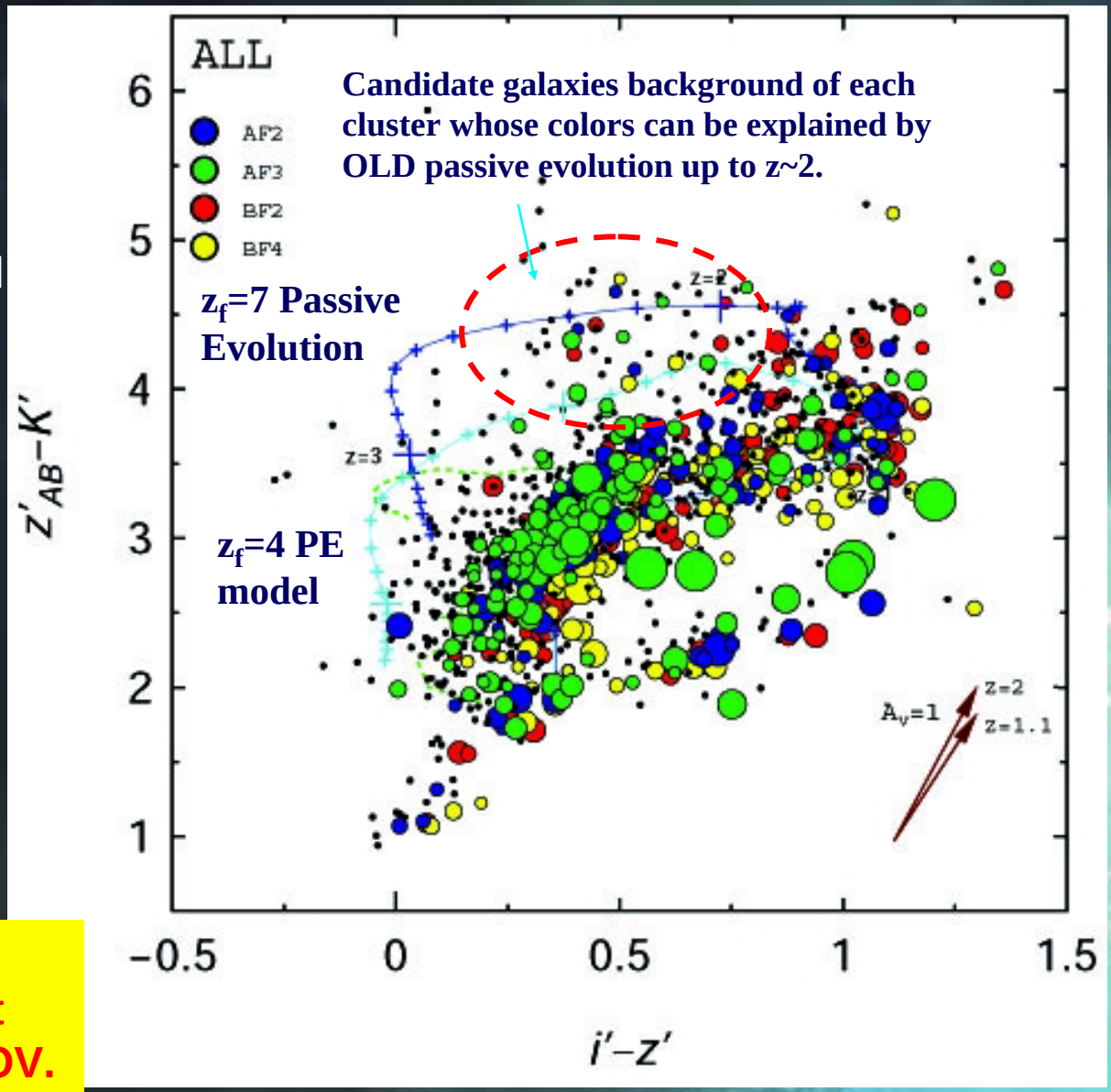
Combining 4 z~1 Cluster Fields

- A number of candidate background galaxies are clearly seen (Gravitational Lensing?). They are reddest in NIR color.

- Their color is consitent with Very Old galaxies with the formation redshift of z=5-7!

- They disappear suddenly at z~2.5..Why? MOIRCS deep data will address the issue.

ONLY ~30 min. MOIRCS exposure is enough to get the data with the same FOV.

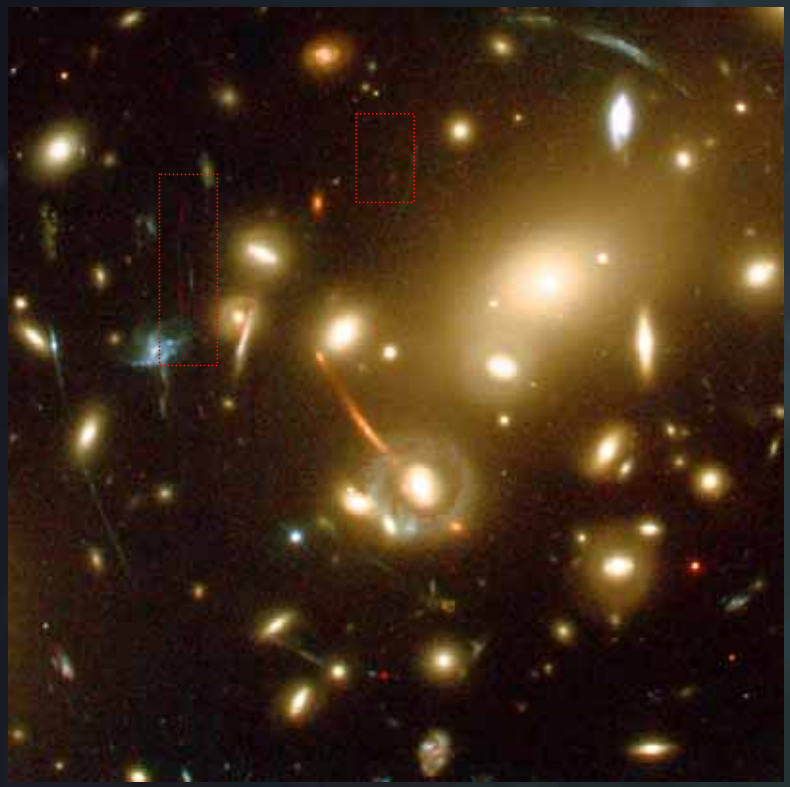


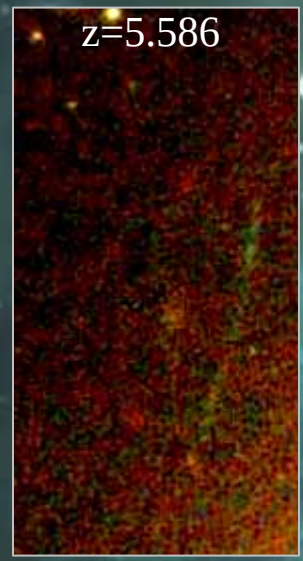
Clusters as the natural telescope

Clusters can be used as a natural photon-collector by their gravitational lensing effect.

→ **Gain the chance to detect super high-z galaxies.**

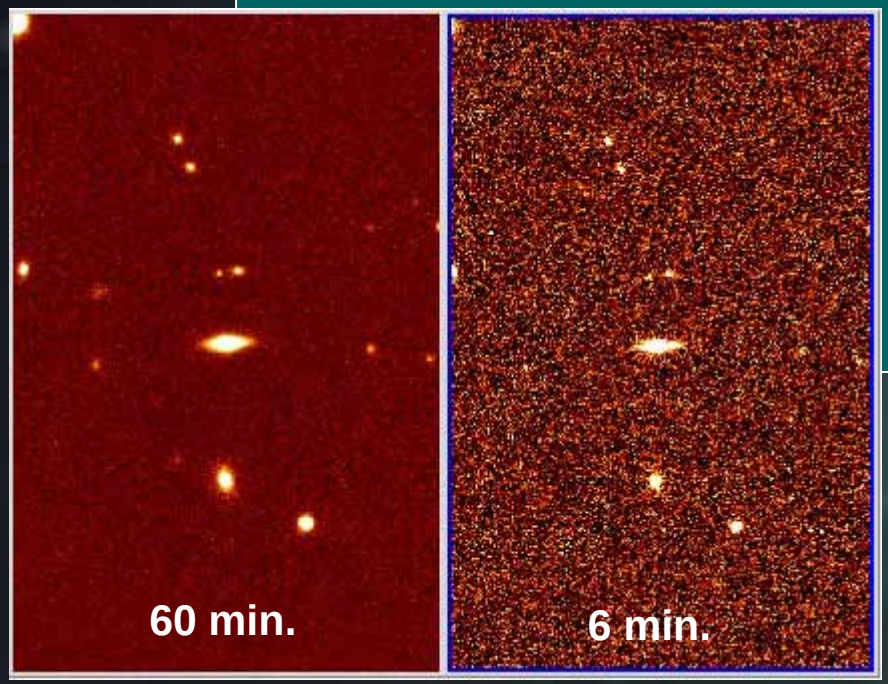
Only seen in NIR wavelengths





Test Imaging of A Nearby Lensing Cluster

非公開ご容赦ください。



- Just ~6 minutes exposure and a quck data reduction for test!
- Some Lensed arcs are already seen!

Summary: the impact of MOIRCS

- **MOIRCS is currently the most powerful NIR survey instrument thanks to the large FOV, good optical performance, MOS performance, and large photon-collecting power of Subaru.**
- **The study of galaxy evolution: the key is to evaluate the properties of various kind of objects as a function of their environments. We will try to observe both general field galaxies and high-z (proto-) clusters.**
- **Large FOV of MOIRCS: good for constructing large dataset, good for the detection of a rare objects, good for evaluation of the environment of the observing targets.**


End