SSG workshop 2023.01.16

Spatial Distribution Study of Intracluster Light vs. Dark Matter using HR5

KIAS KOREA INSTITUTE FOR ADVANCED STUDY

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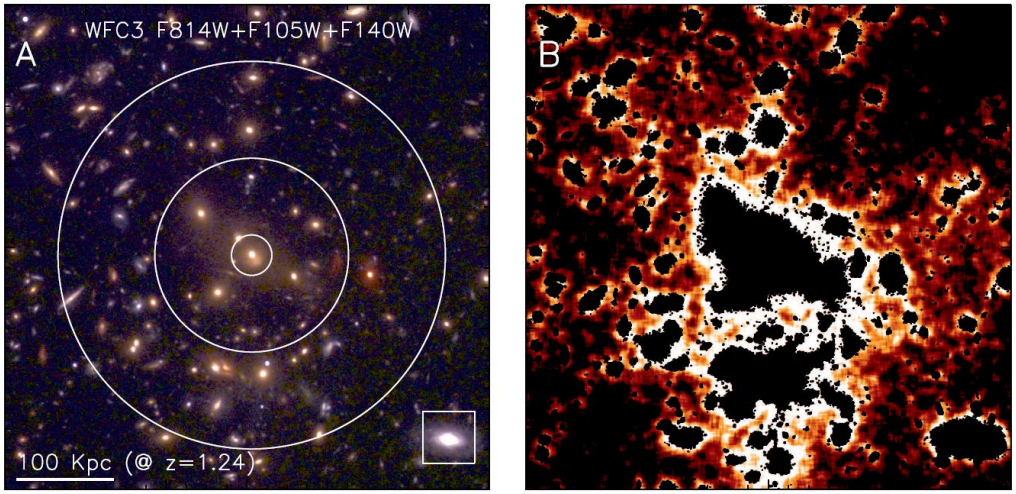
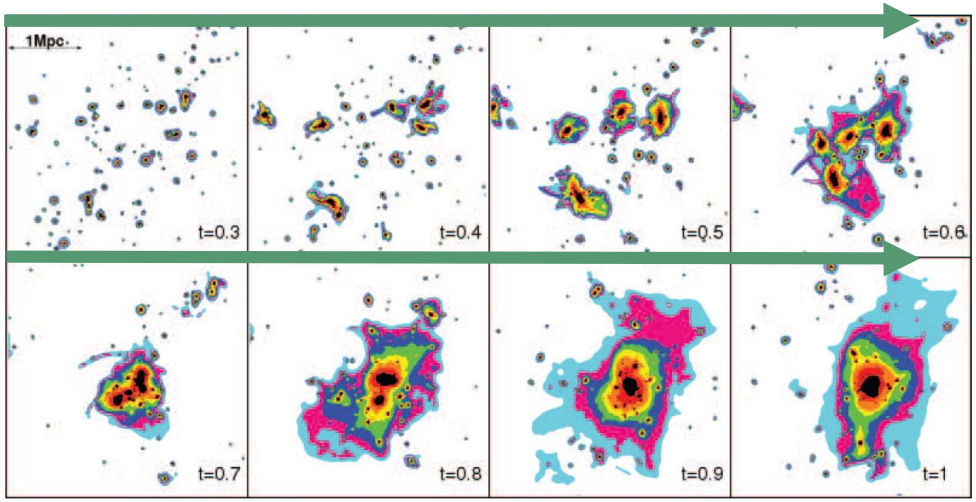
Intracluster Light

Definition of Intracluster Light

The light from stars which are bound to the cluster but not to galaxies within them.



MOO J1014+0038 Ko & Jee 2018



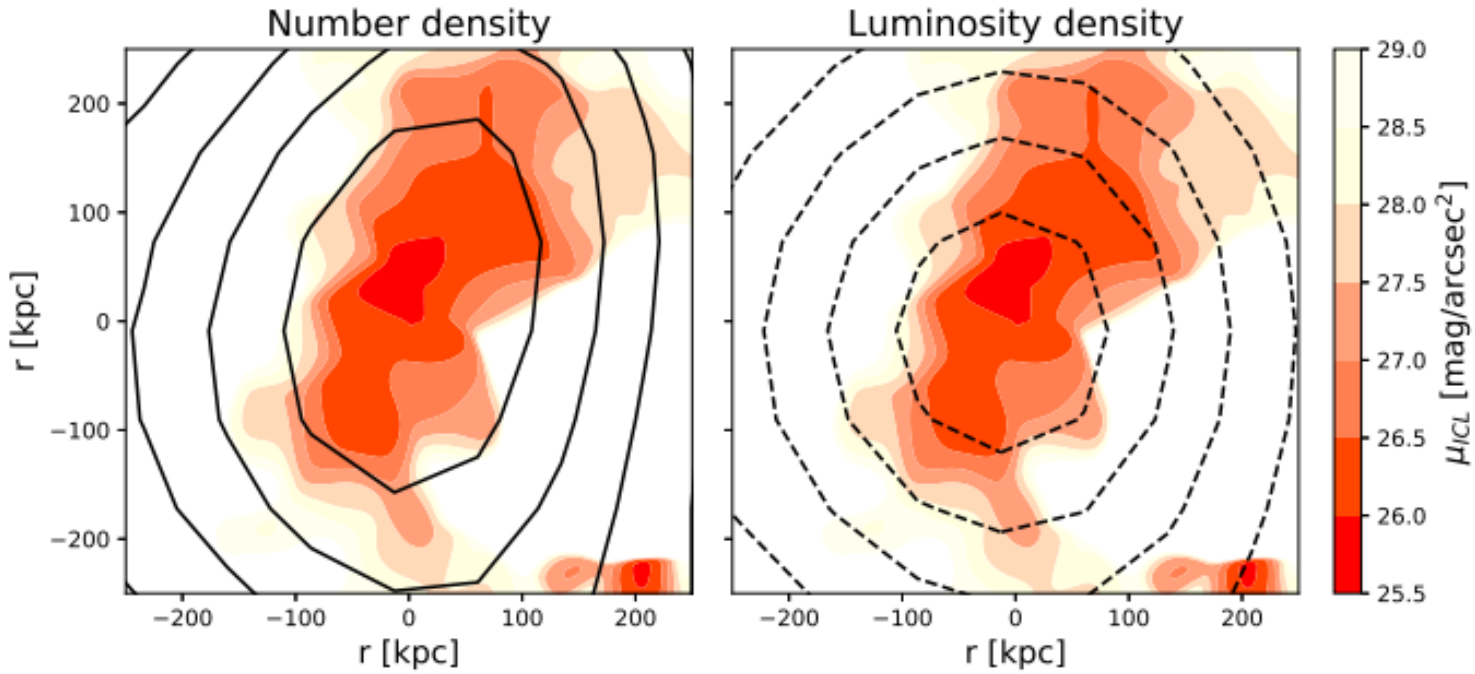
z=2 (upper left) z=0 (lower right) Rudick et al. 2006, 2011

Meaning of ICL research

1. **Measure the evolutionary stage of the galaxy cluster**
2. **Understand galaxy evolution process in dense environment**
3. **Effective tracer of dark matter**

ICL 2D map

Yoo et al. 2021, MNRAS, 508, 2

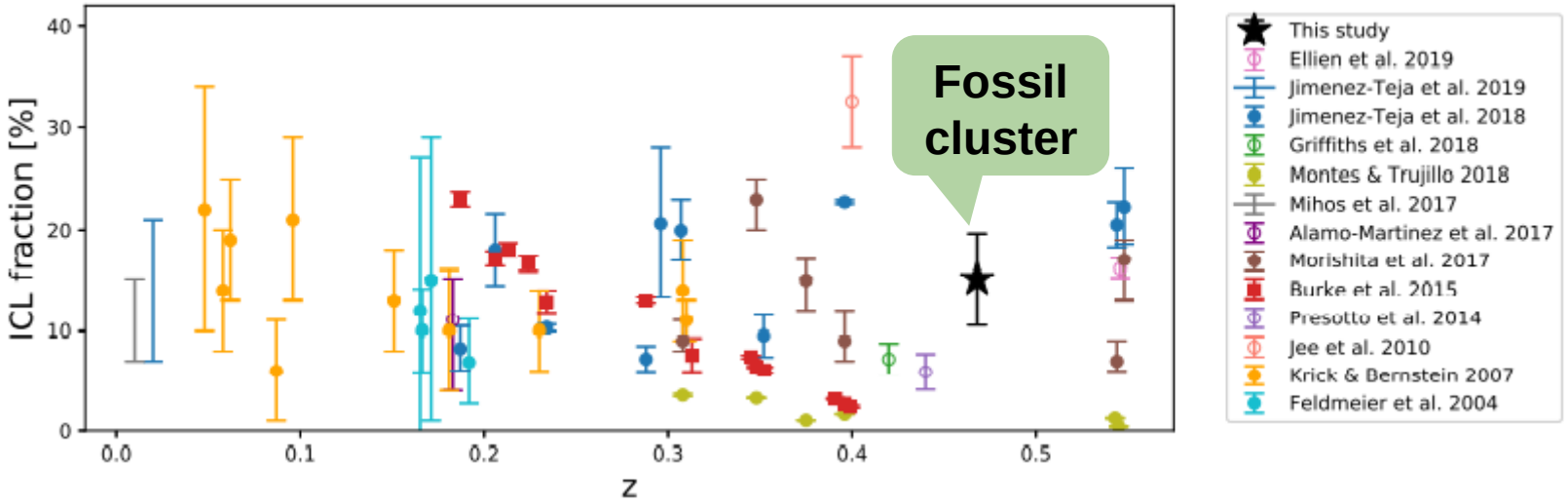


- ICL increases through **interactions between galaxies** in galaxy cluster.
- **Spatial distribution** of ICL gives us hint for the **assembly history**.

ICL and Cluster Dynamics

Yoo et al. 2021, MNRAS, 508, 2

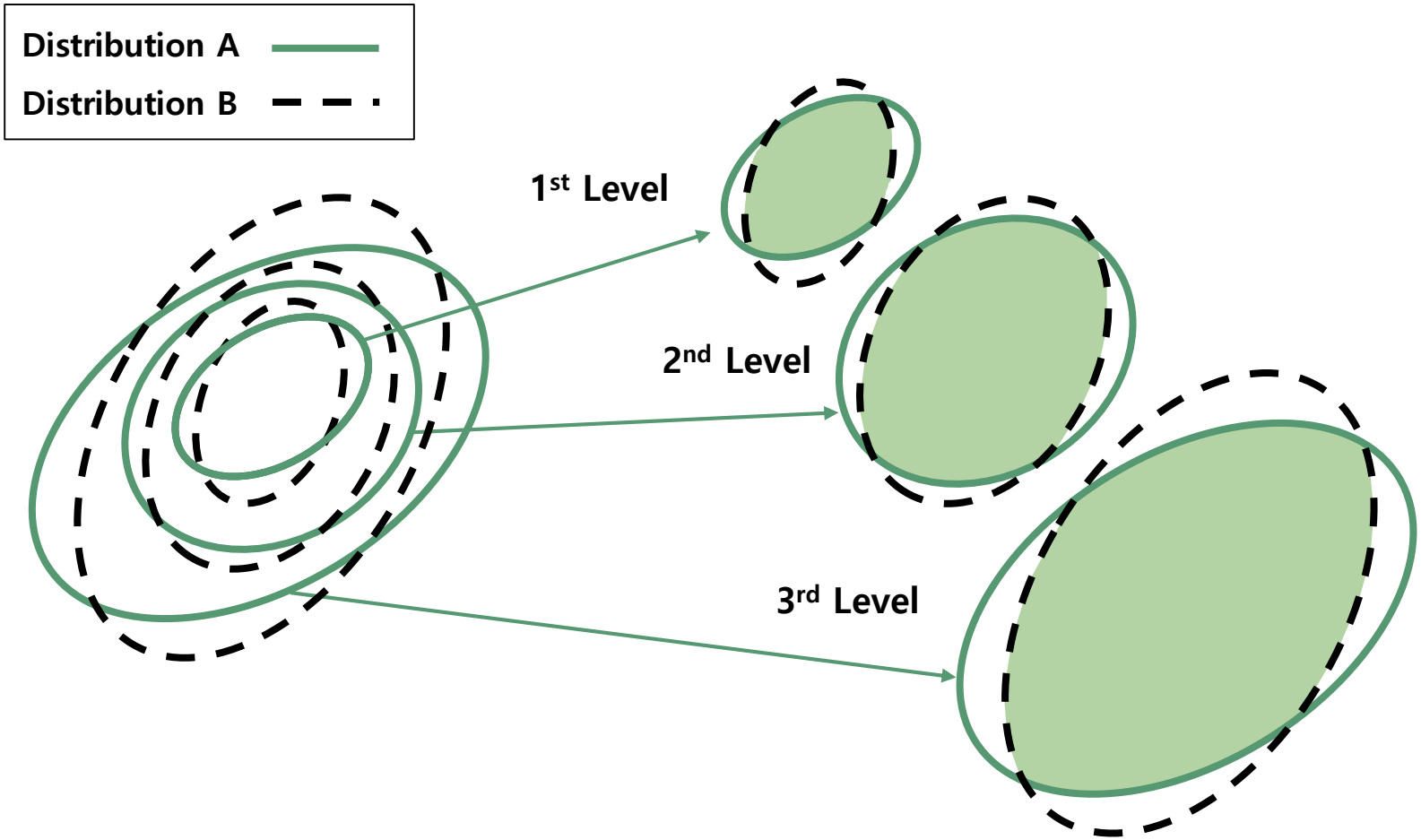
Different detection Methods/ Dynamic states!



- ICL fraction varies for different **dynamical status of galaxy clusters**

Spatial Distribution Comparison

Yoo et al. 2022, ApJS, 261, 28



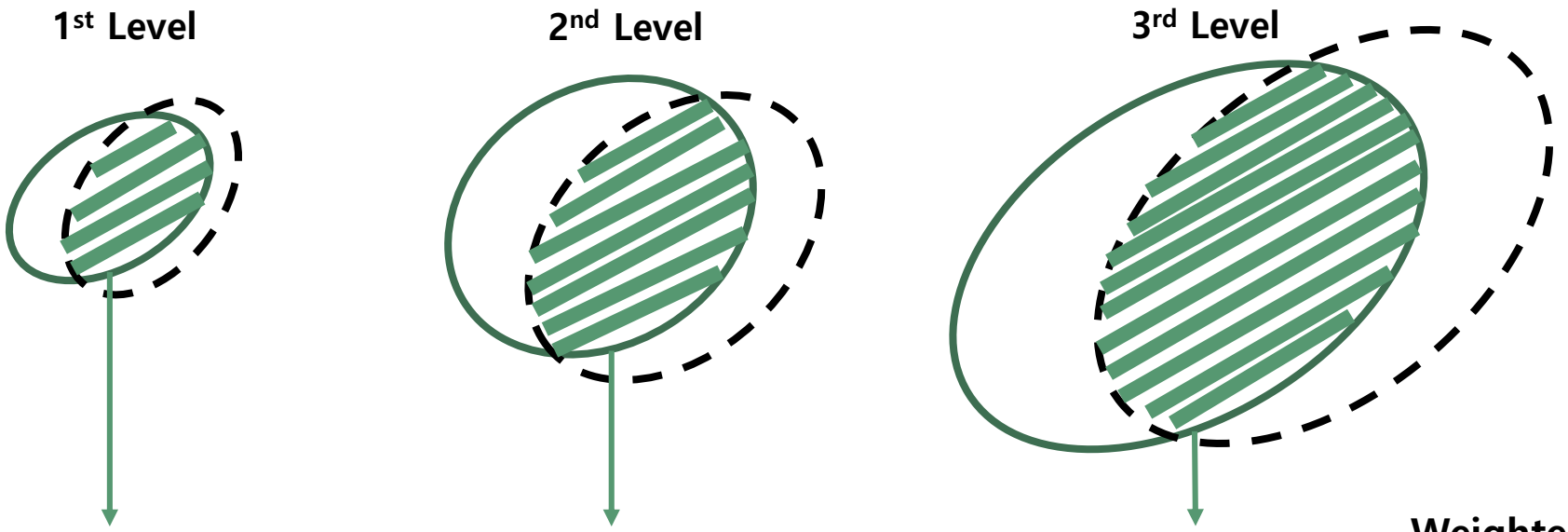
WOC method

$$WOC(I_1, I_2) = \frac{\sum_{i=1}^{n} x_i \left(w_{A,i} + w_{\rho_1,i} + w_{\rho_2,i}\right)}{\sum_{i=1}^{n} \left(w_{A,i} + w_{\rho_1,i} + w_{\rho_2,i}\right)}$$

with

$$\sum_{i=1}^{n} w_{A,i} = \sum_{i=1}^{n} w_{\rho_1,i} = \sum_{i=1}^{n} w_{\rho_2,i} = 1$$

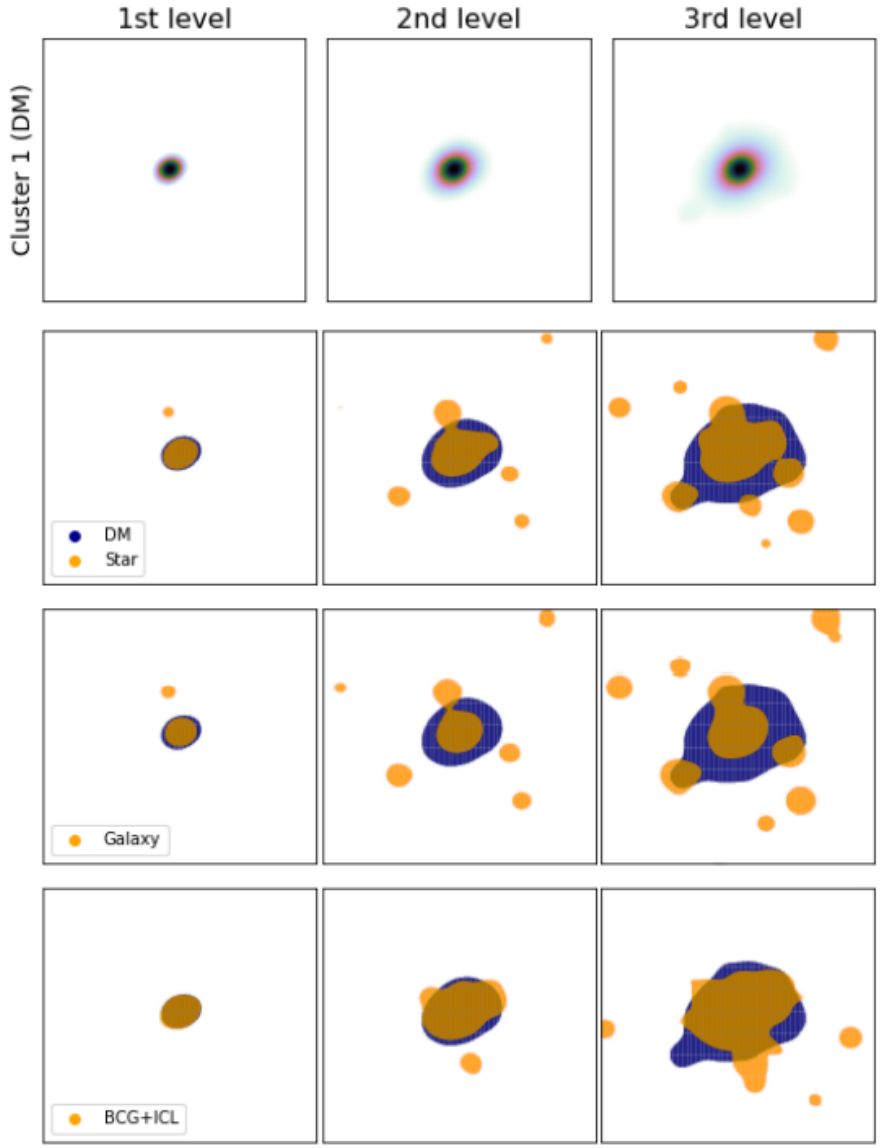
- Give Weight to the overlapping area



$$\frac{1^{st}\ \text{Area(\%)} \times 1^{st}\ \text{Weight} + 2^{nd}\ \text{Area(\%)} \times 2^{nd}\ \text{Weight} + 3^{rd}\ \text{Area(\%)} \times 3^{rd}\ \text{Weight}}{1^{st}\ \text{Weight} + 2^{nd}\ \text{Weight} + 3^{rd}\ \text{Weight}} = \text{Weighted Overlap Coefficient}$$

- Give number between 0 and 1

WOC for different component



Yoo et al. 2022, ApJS, 261, 28

Dark Matter

DM vs Star

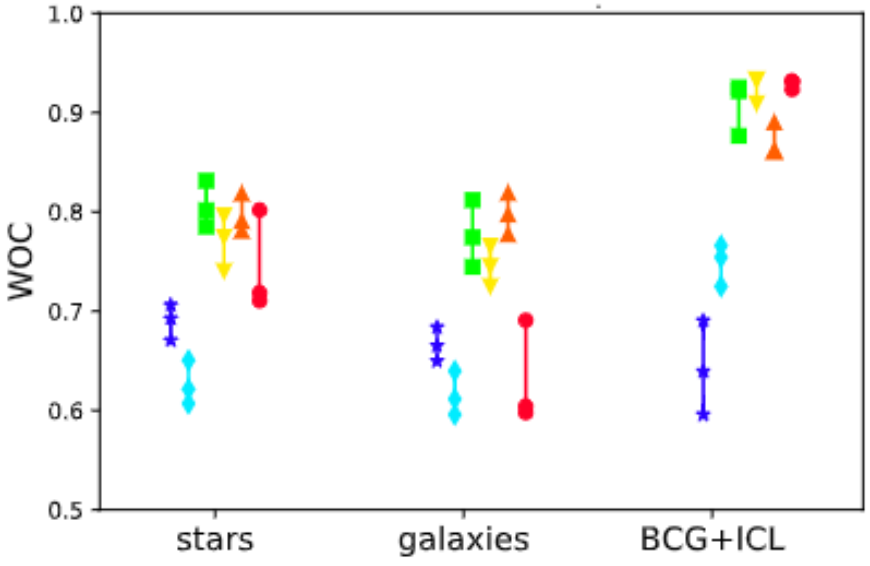
DM vs Galaxy

DM vs BCG+ICL

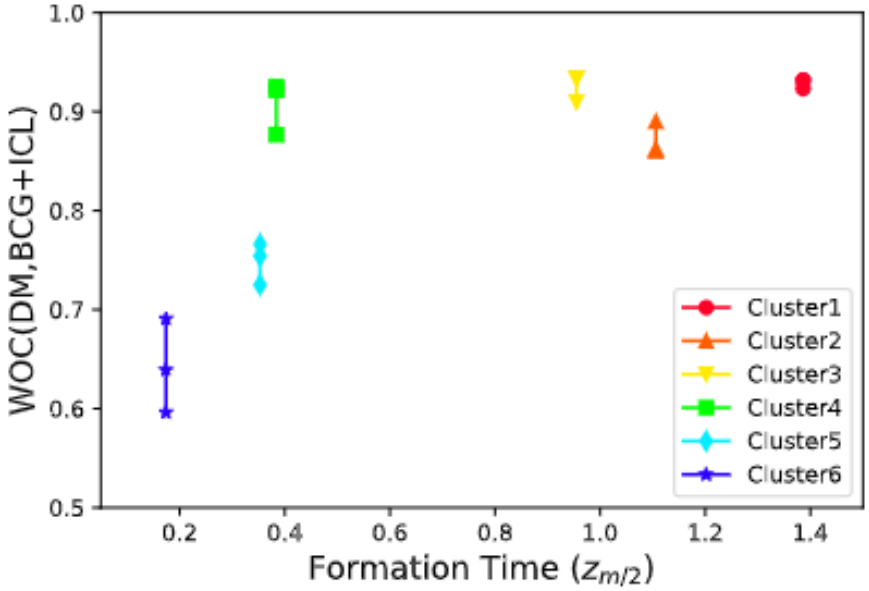
WOC using GRT simulation

Yoo et al. 2022, ApJS, 261, 28

➢ **BCG+ICL trace DM best**



➢ **Relaxed system have bigger WOC**

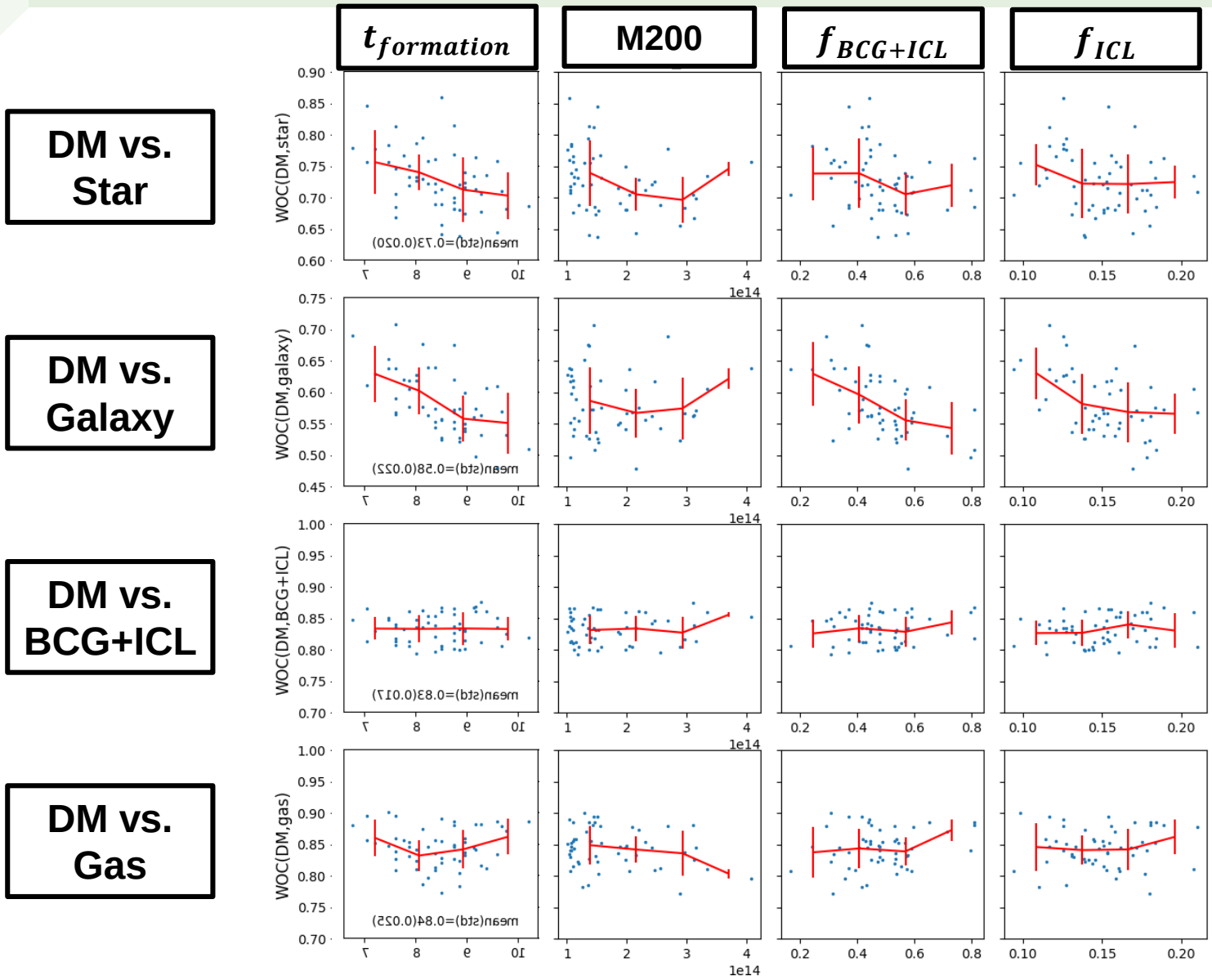


✓ **The WOC method code is available for public use!** https://github.com/csabiu/WOC

```
pip install pywoc
```

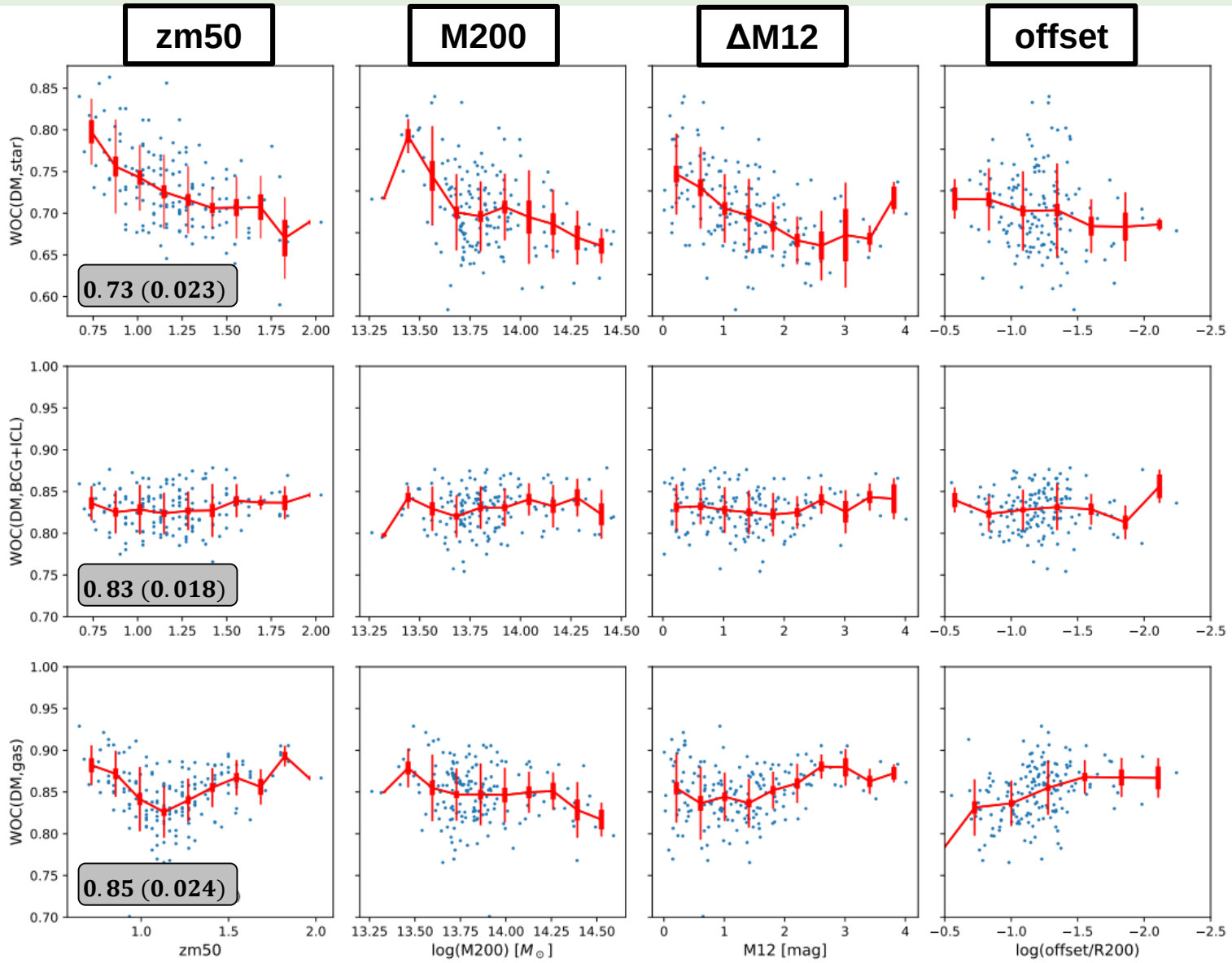
WOC using HR5

$> 10^{14} M_{\odot}$ @ z=0.625
55 clusters



WOC using HR5

$> 5 \times 10^{13} M_{\odot}$ @ z=0.625
174 clusters



Summary

- **Gas/ BCG+ICL trace better DM than stars** (BCG+ICL+satellite galaxies).
- WOC(DM,gas) has **larger std for different projection angle** than WOC(DM,BCG+ICL).
- Dynamical status of cluster: Only WOC(DM,star) shows trend with formation time.
- **BCG+ICL trace DM well regardless formation time**.
- Virial ratio calculation ongoing..

Thank You!

Jaewon Yoo ▪ ICL ▪ Galaxy Cluster