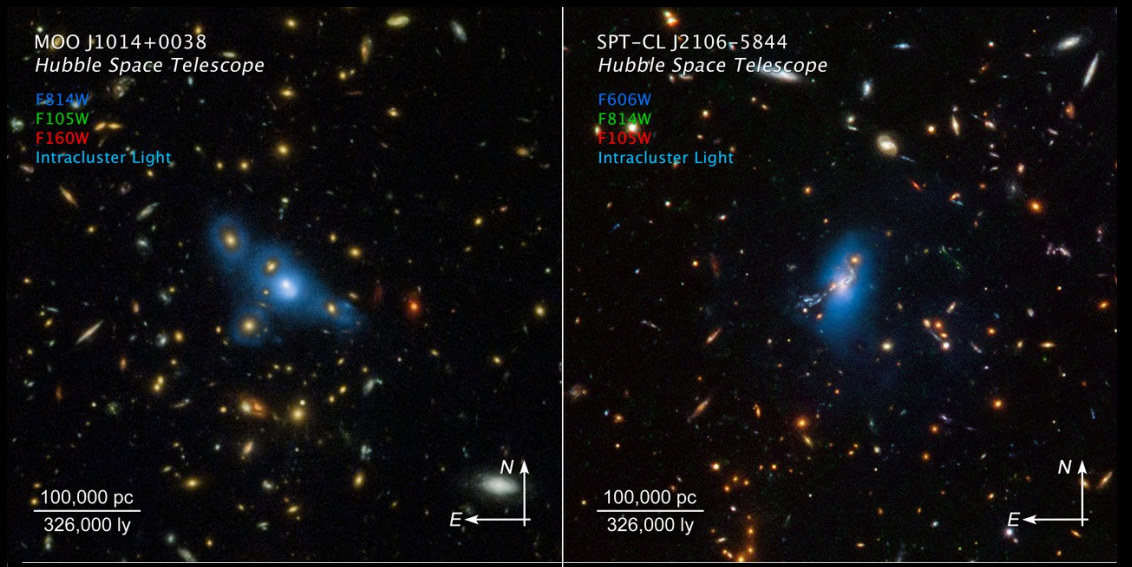
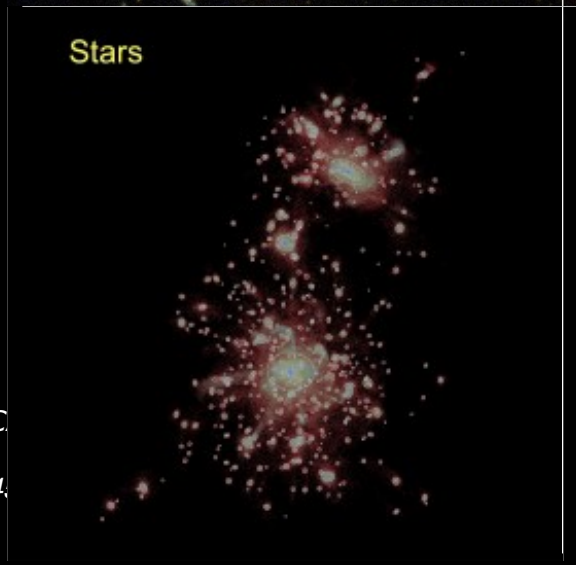
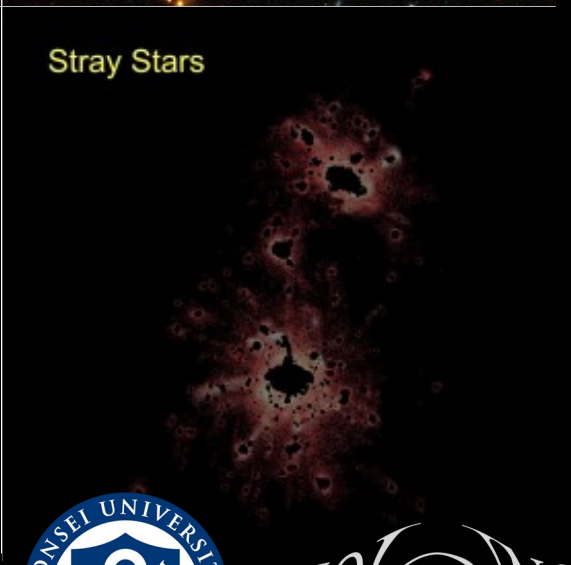
Unveiling the formation mechanism of intracluster light with HST data and Horizon Run 5





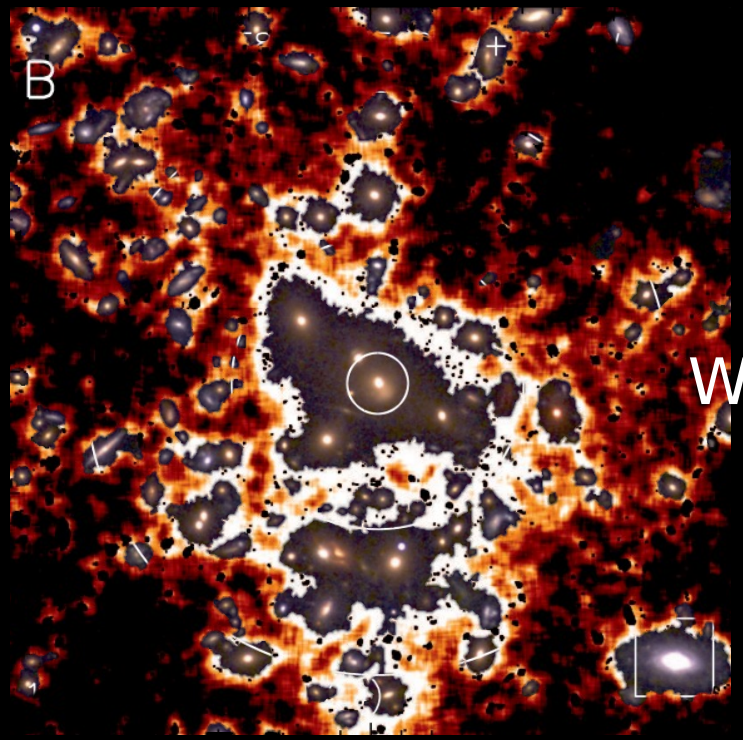


Hyungjin Joo[1], Myungkook James Jee[1,2], Jaehyun Lee[3], Juhan Kim[4], Jongwan Ko[5,6], Jihye Shin[5], Changbom Park[3]

[1] Department of Astronomy & Space Science, Yonsei University, Seoul 03722, Korea
[2] Department of Physics & Astronomy, University of California, Davis, One Shields Avenue, Davis, C
[3] Korea Institute of Advanced Study, 85 Hoegi-ro, Dongdaemun-gu, Seoul 02455, Korea,
[4] Center of Advanced Computation, Korea Institute for Advanced Study, 85 Hoegi-ro, Dongdaemun-gu, Seoul 024
[5] Korea Astronomy and Space Science Institute, 776 Daedeokdae-ro, Yuseong-gu, Daejeon 34055, Korea,
[6] University of Science and Technology, Daejeon 34113, Korea.

Intracluster Light

Ko & Jee (2018)



We can observe diffuse lights between cluster galaxies.

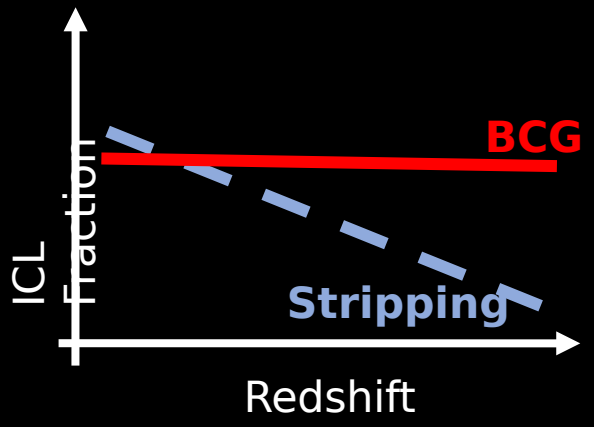
Intracluster Light (ICL)

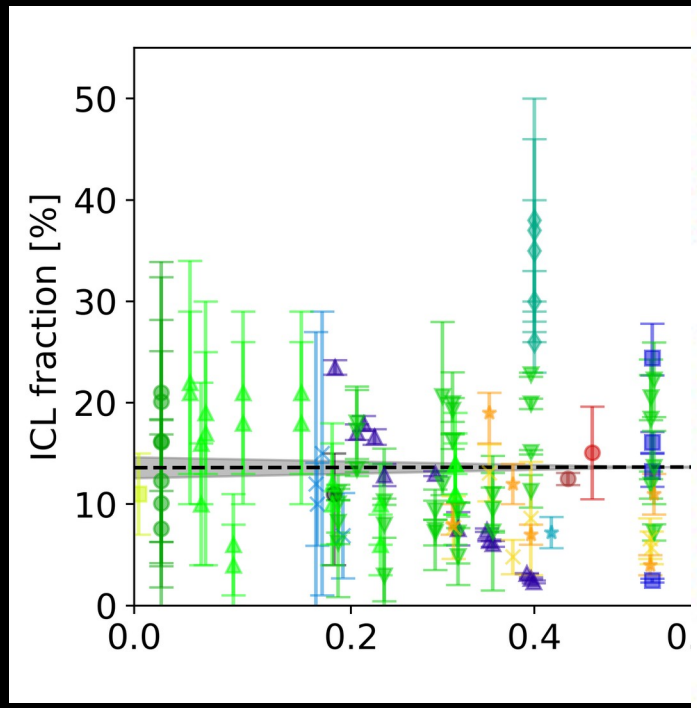
What is the dominant mechanism of ICL formation?

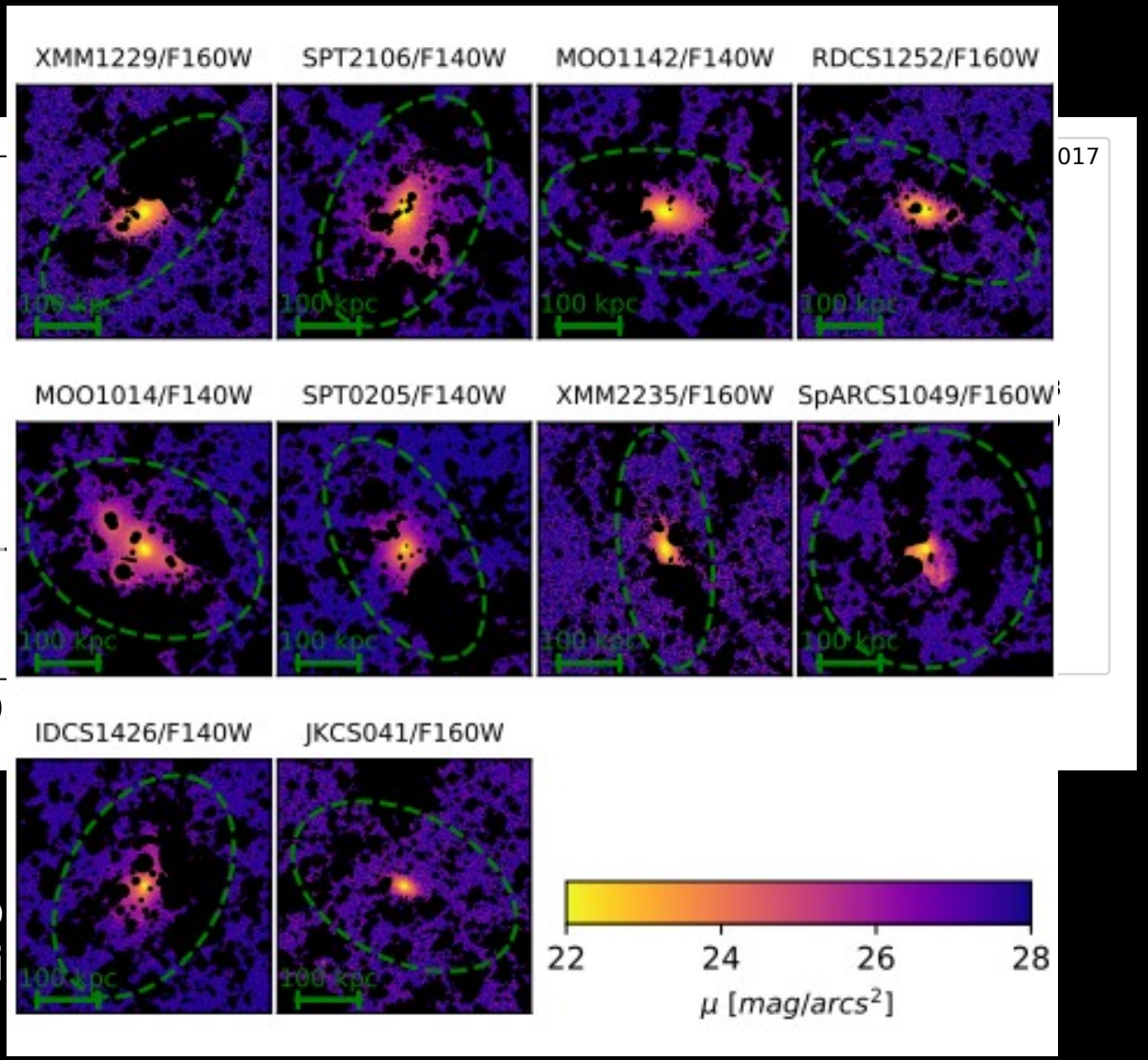
- Merger with / Formation of BCG
- Stripping of satellite galaxies

Still under debate!

ICL fraction evolution

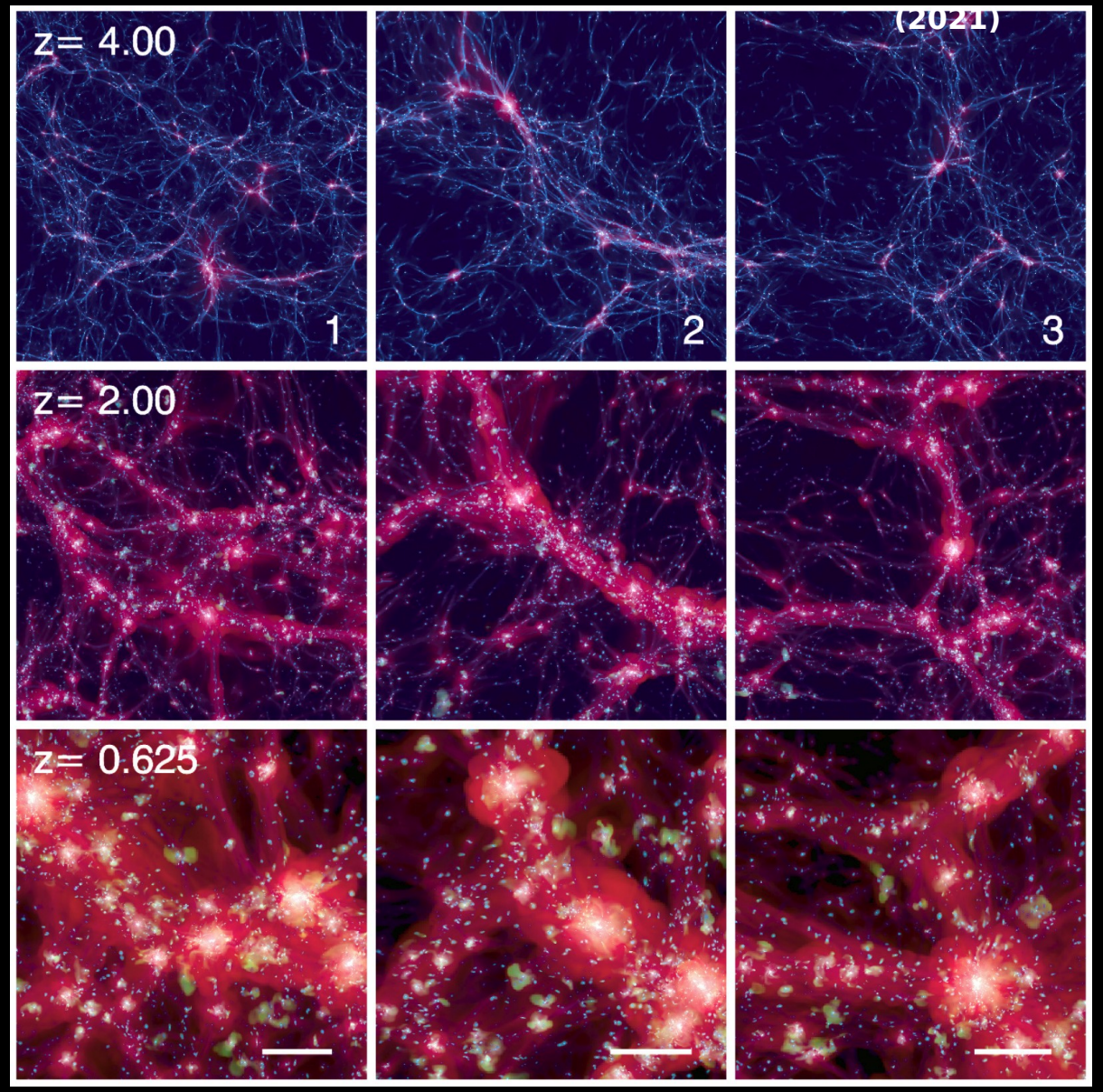






This study shifted the paradigm of ICL fo
from the stri

Horizon Run 5



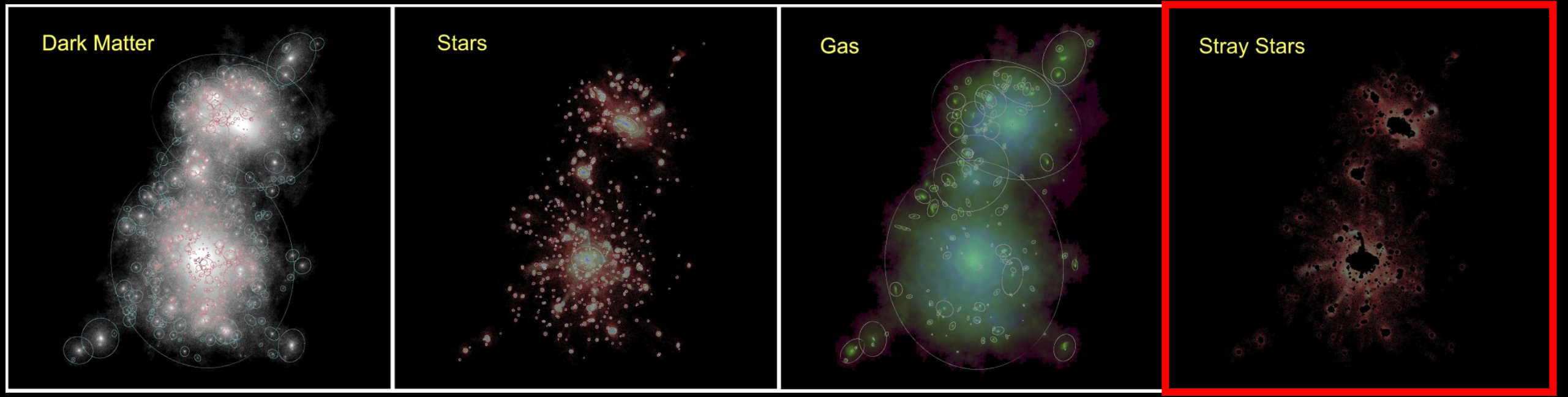
Box Size (Zoom-in region)	1049×1049×1049 cMpc^3 (1049×114×127 cMpc^3)
Finest spatial resolution	~1 kpc
Number of CDM particles	~2000^3
Finest DM particle mass	6.9 × 10^7
Final redshift	0.625
Number of FoF halo (at z=0.625)	1,202

- High mass/spatial resolution
  HR5 can reproduce realistic clusters.
- Large number of halo

  Statistical analysis of ICL is possible.

Definition of ICL

Lee et al. (202

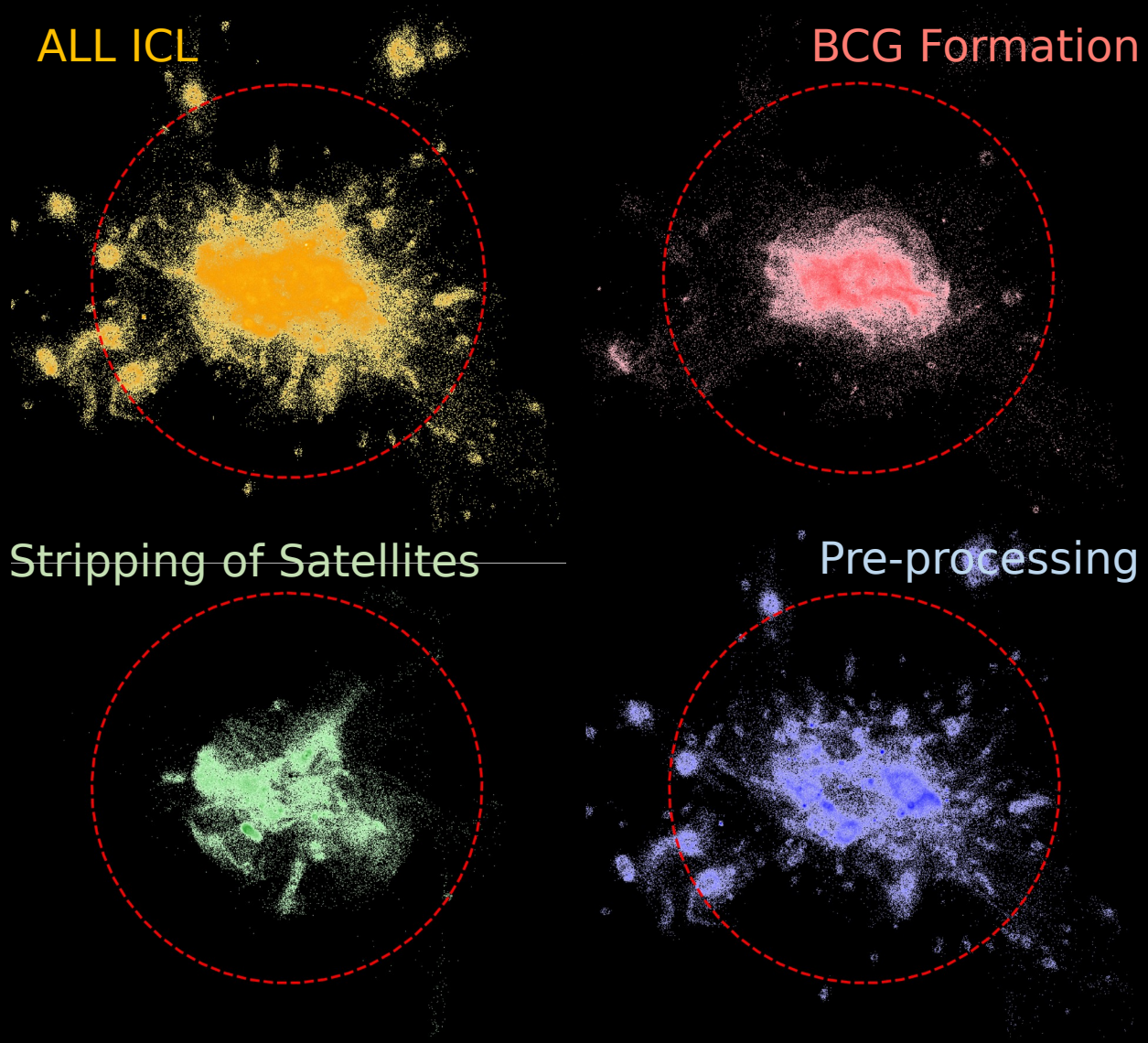


PGalF: Physically-Self-Bound(PSB) based Galaxy Finder (Kim et al. 2023. Appendix A.)

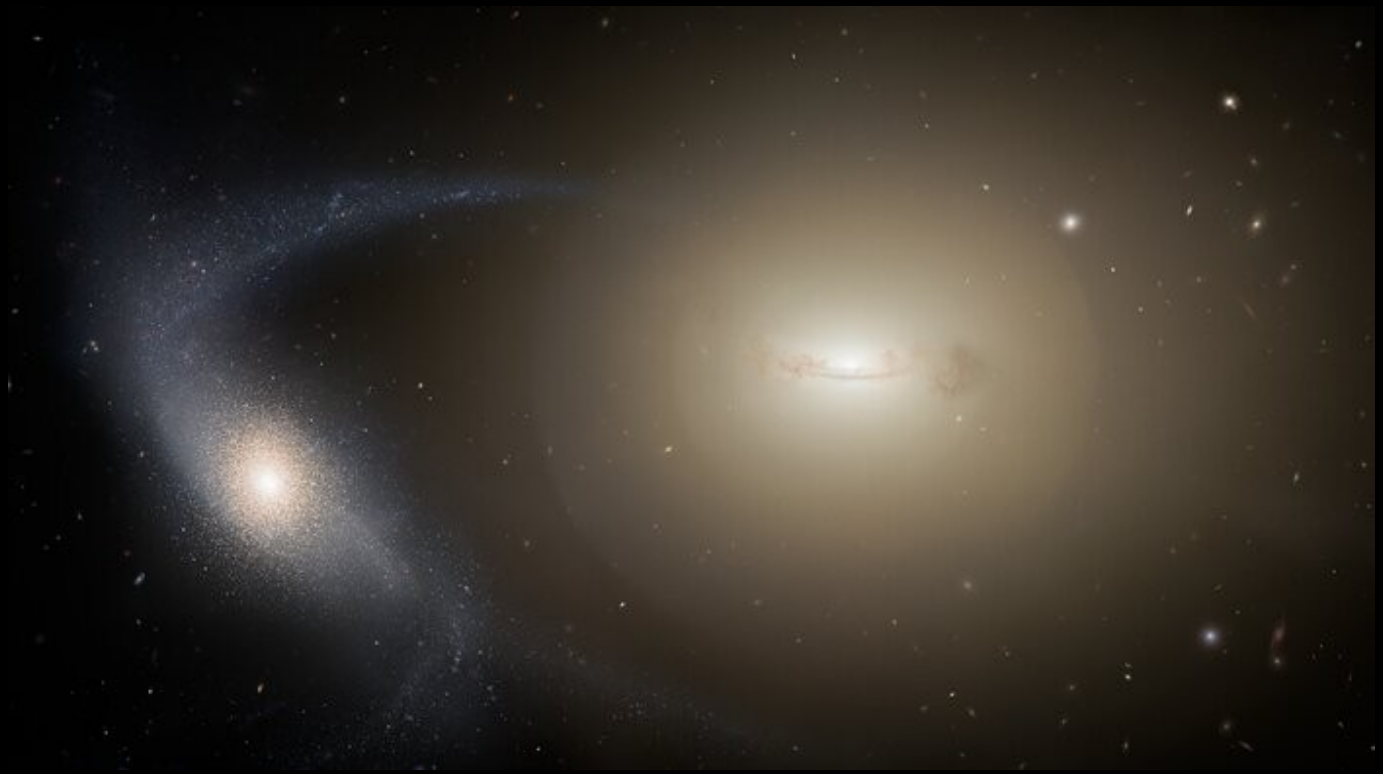
ICL!

- Uses stellar mass density map with tidal radius & total energy criteria
- Tidal radius: boundary of each galaxy
- Total energy: determination of member particles
- Extracting all components of galaxy (DM/star/BH/gas) at the same time
- Optimized for parallel computing

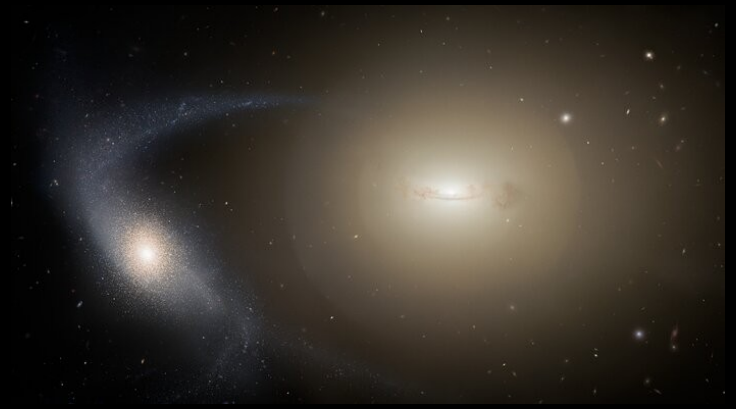
Classification of galaxy and ICL

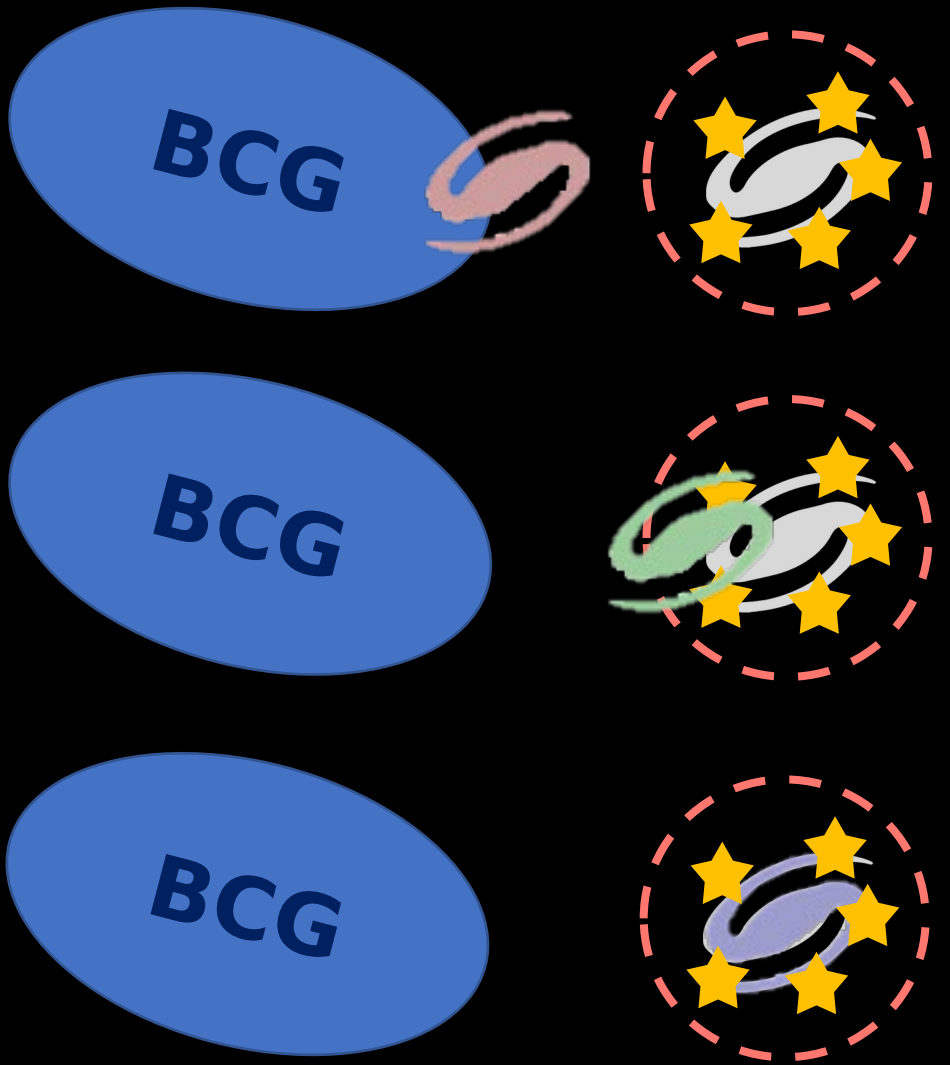


Classification of galaxy and ICL



Classification of galaxy and ICL



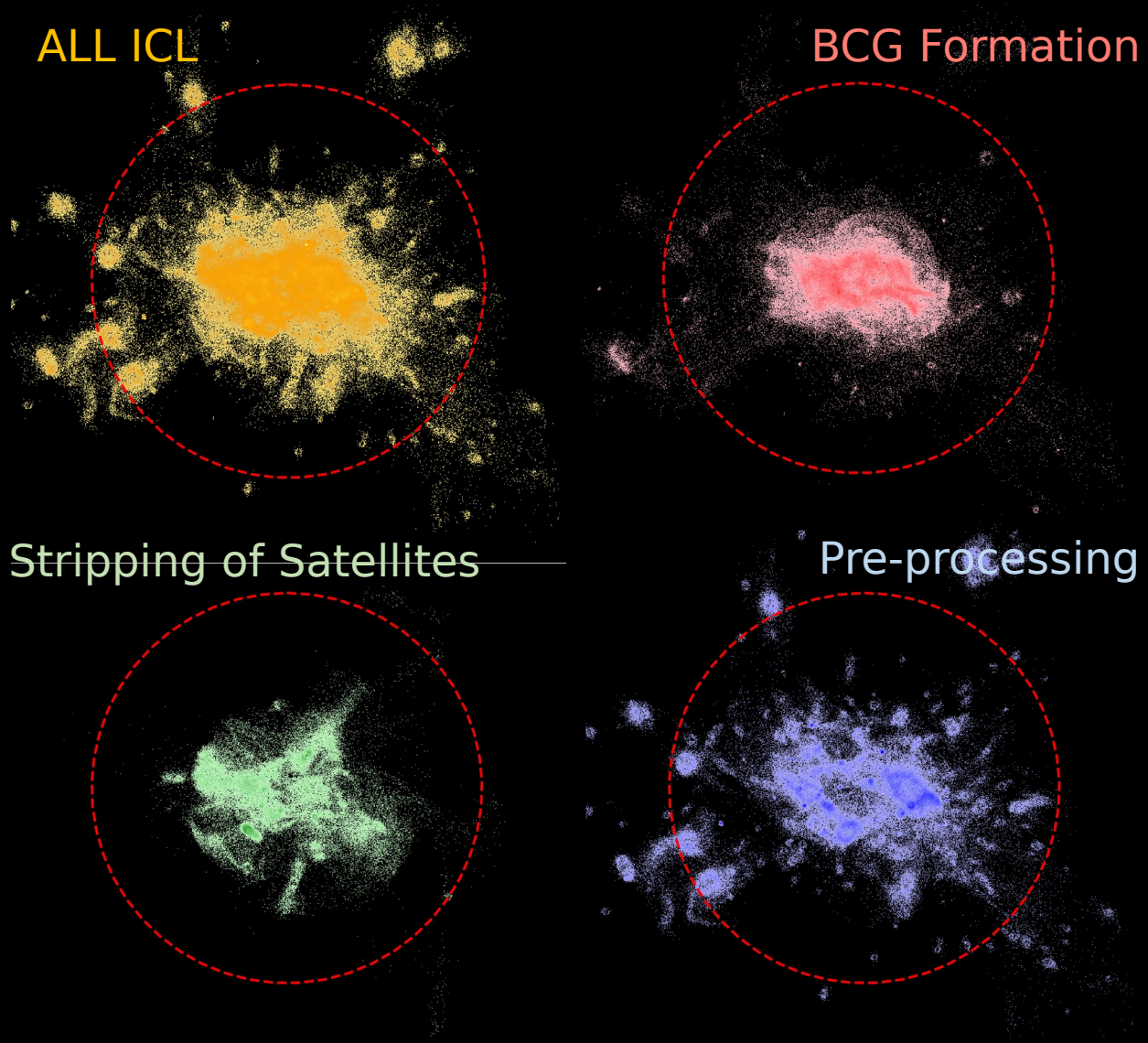


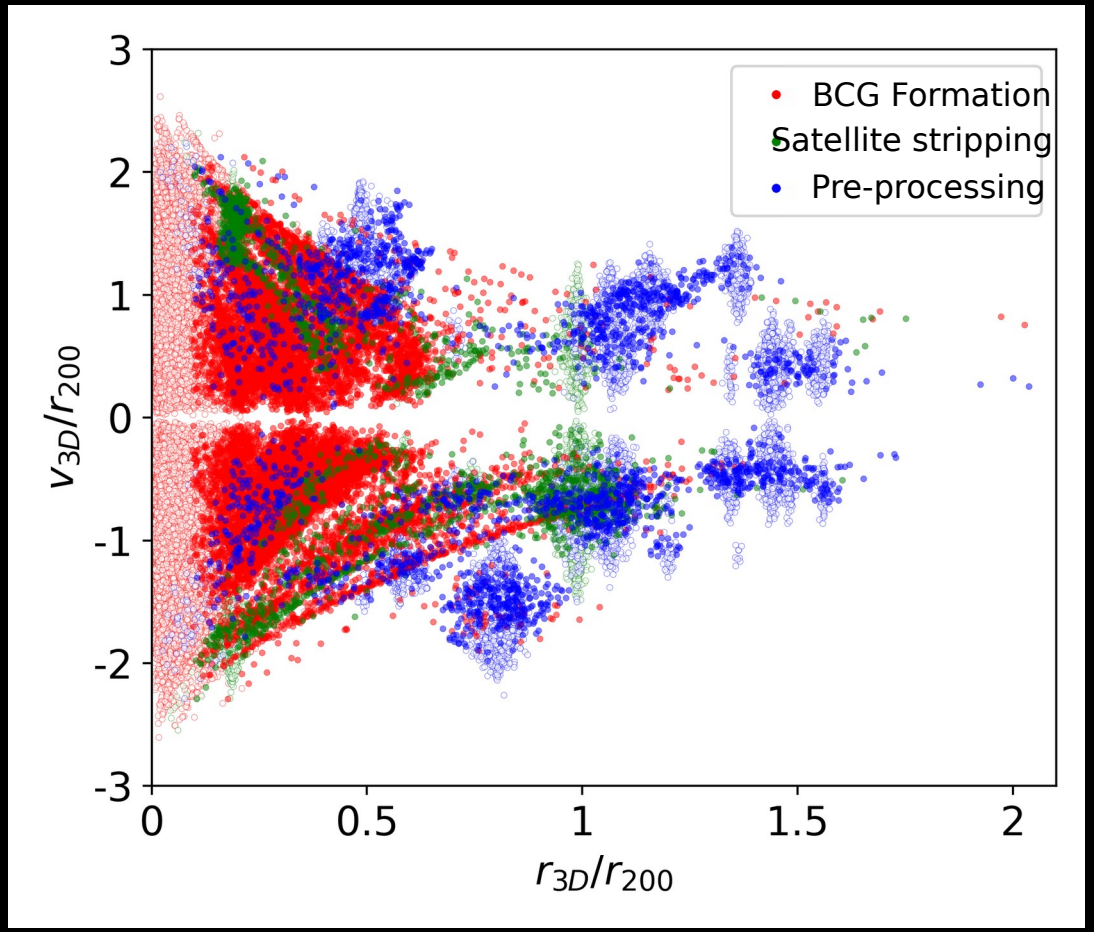
: stellar mass from i^{th} subhalo at z

: stellar mass from i^{th} subhalo to j^{th} subhalo at z

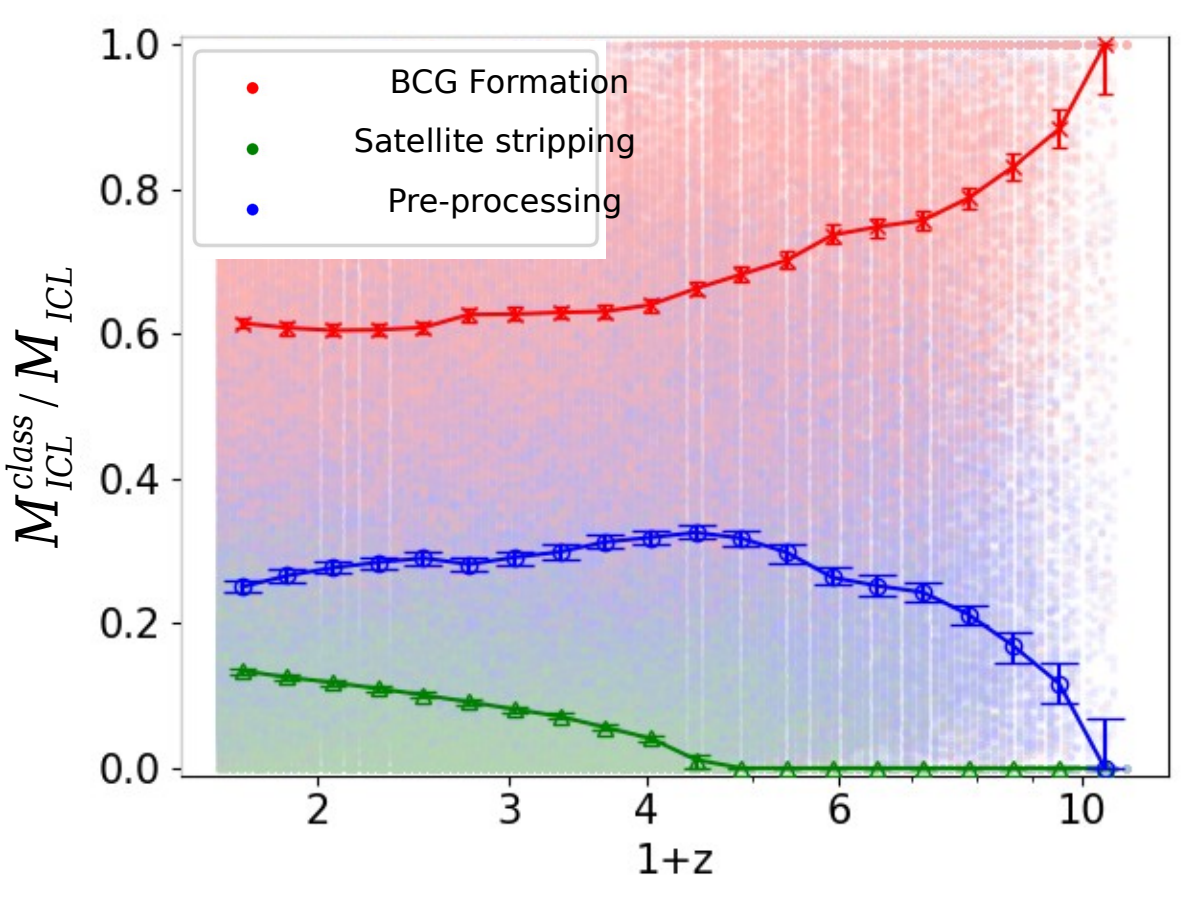
$\Rightarrow$ ICL particles can be classified too.

Result of Classification

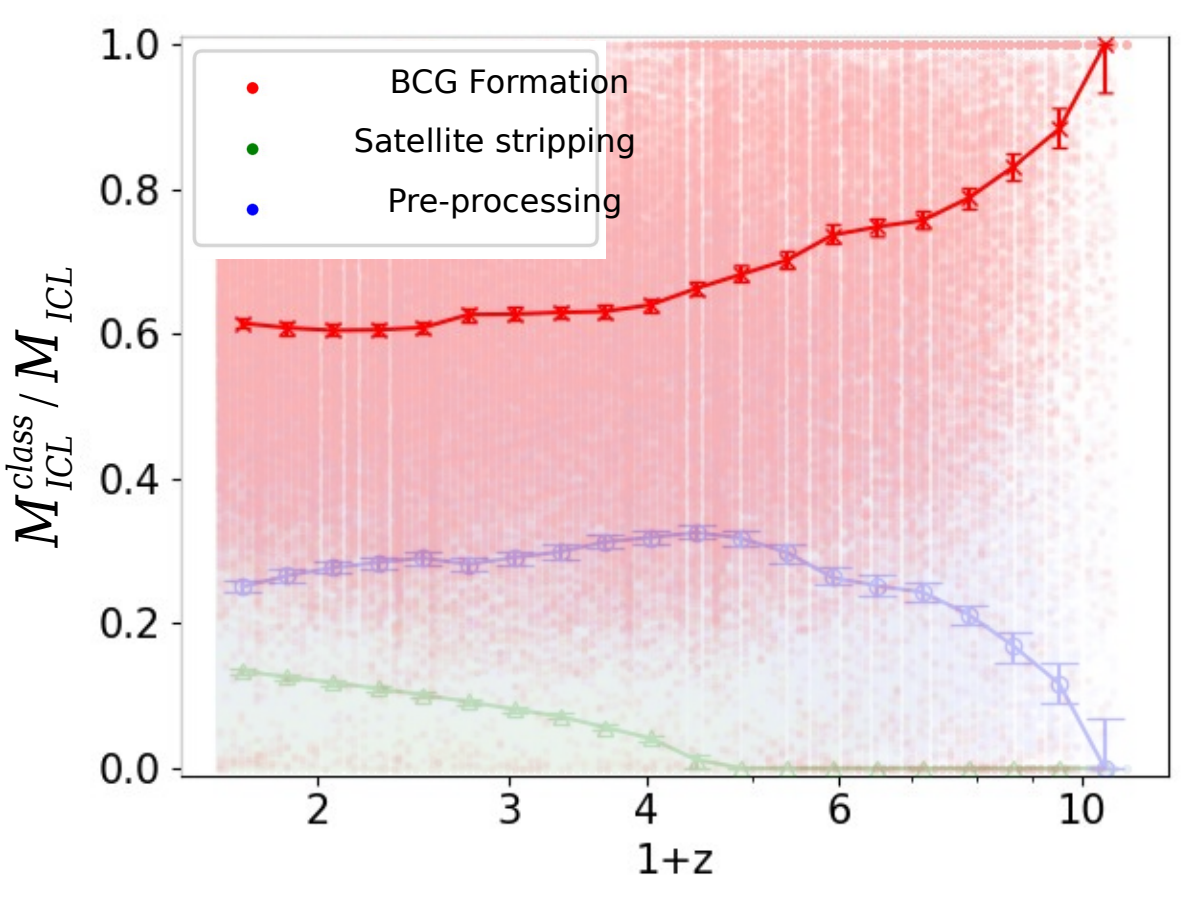




Class fraction evolution

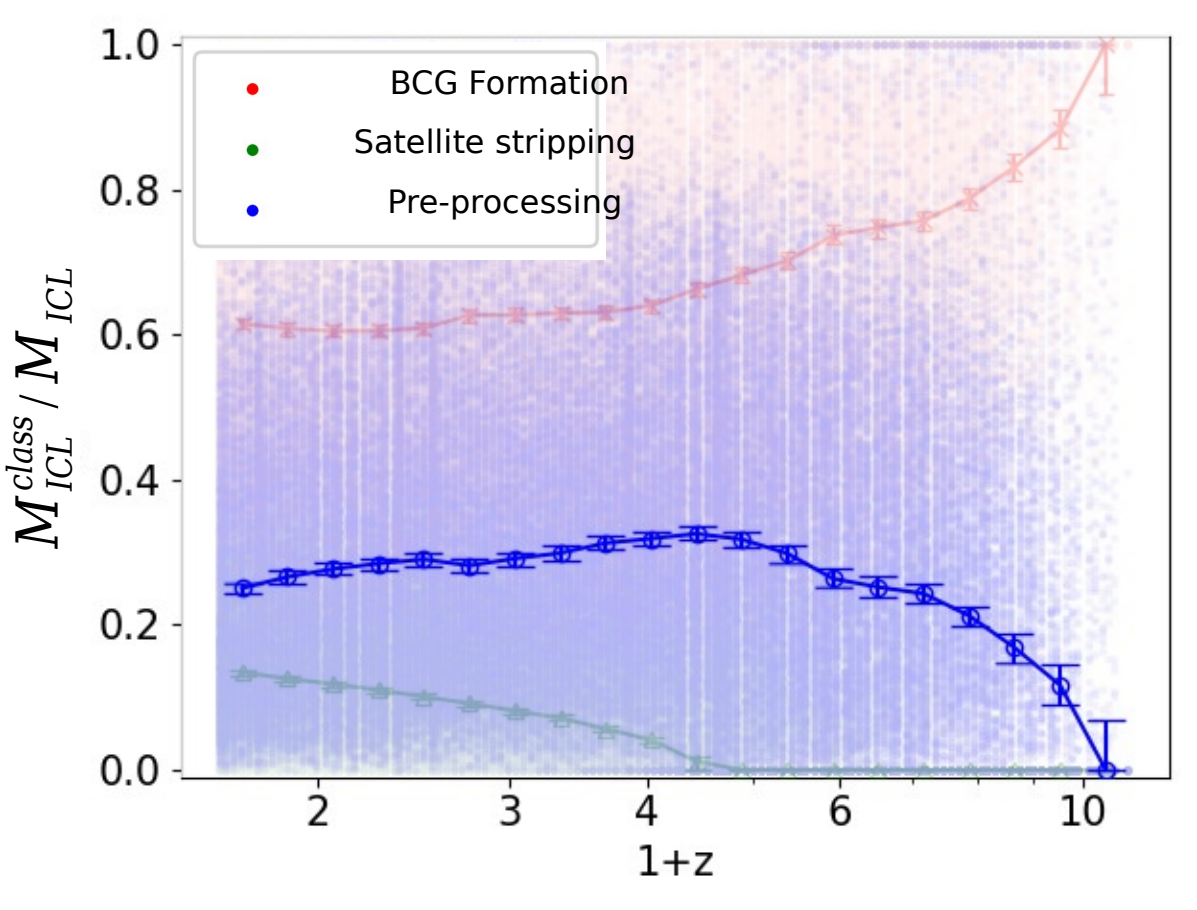


Class fraction evolution



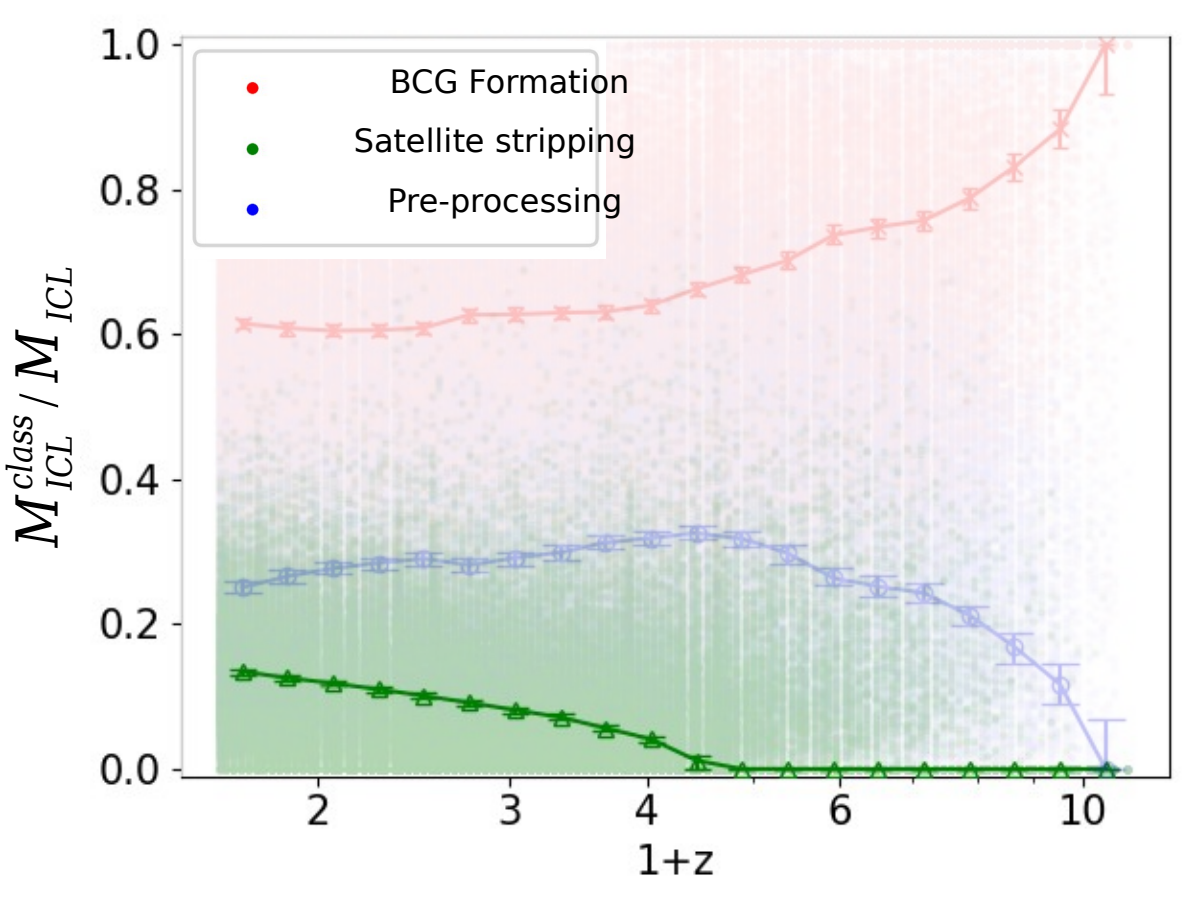
1. is always the **most dominant** origin of ICL.
+ Almost converged ~60%.

Class fraction evolution



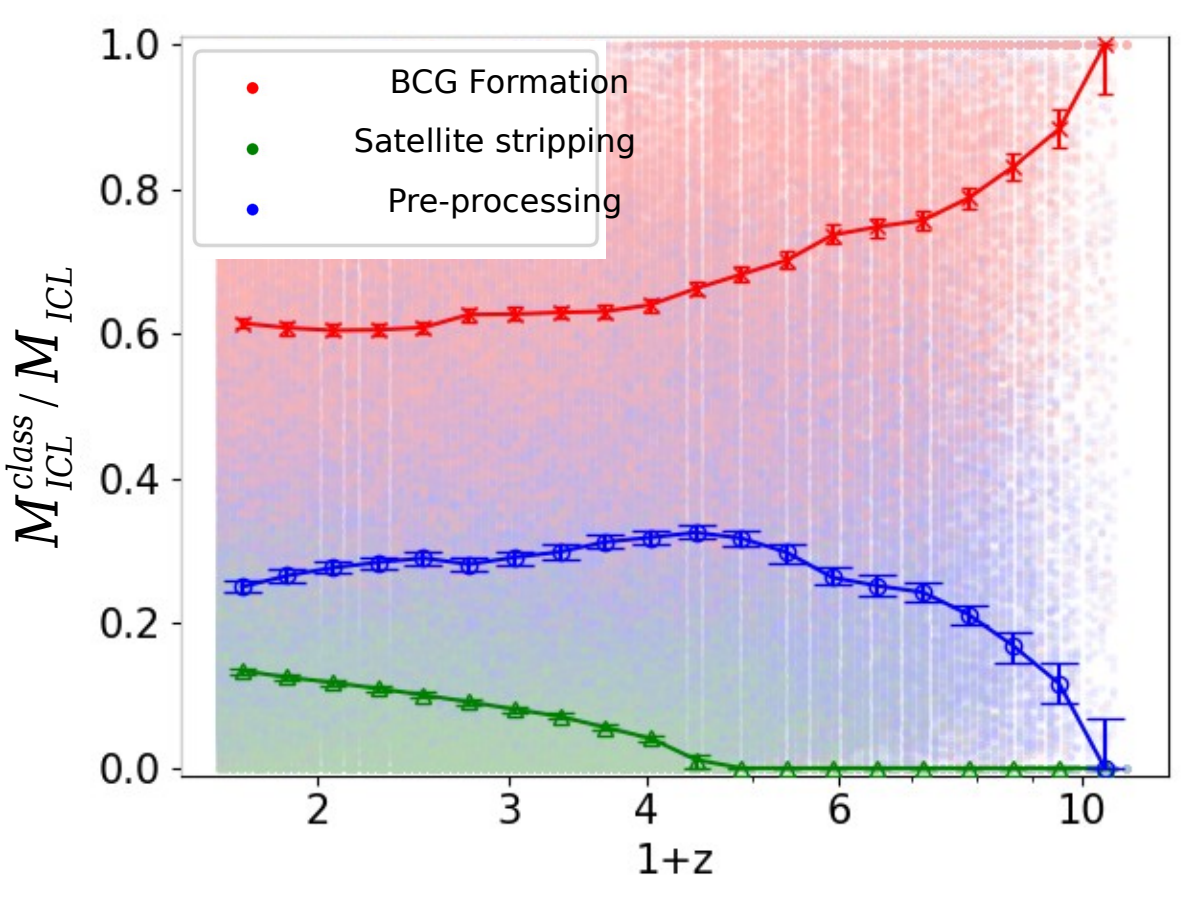
2. is the **secondary** origin
but slightly decrease as halo evolves.

Class fraction evolution



3. ICL from is the **third** key,
but constantly increases at z<3.

Class fraction evolution



1. is always the **most dominant** origin of ICL.
+ Almost converged ~60%.

2. is the **secondary** origin,
but slightly decrease as halo evolves.

3. ICL from is the **third** key,
but constantly increases at z<3.

Summary

th HST observations, we found a sufficient fraction of ICL at 1 < z < 2.

e observations support the ICL was mainly formed though the BCG formation.

r analysis with HR5 also support
the BCG formation is the **most dominant way of ICL producti**

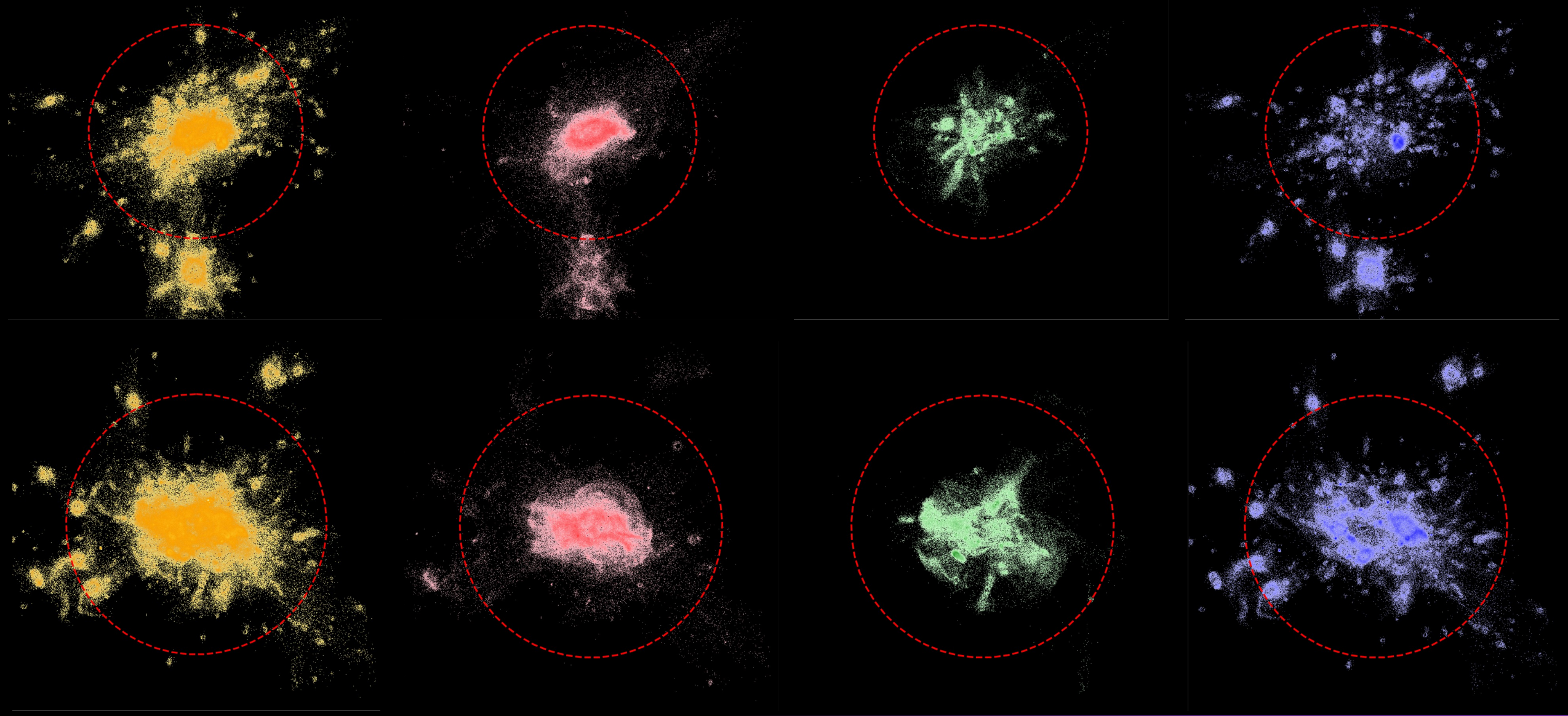
Target (Short Name)	Redshift (z)	SB limit [mag / arcs^2] (Exposure Time [s])		
		F105W	F140W	F160W
XDCP J1229+0151 (XMM1229)	0.98	29.62 (1,311.7)	-	29.12 (1,111.7)
SPT-CL J2106-5844 (SPT2106)	1.132	28.26 (12,567.7)	28.59 (12,771.6)	-
MOO J1142+1527 (MOO1142)	1.19	27.96 (6,283.8)	28.26 (6,983.8)	-
RDCS J1252+2927 (RDCS1252)	1.237	28.26 (1,211.7)	-	29.00 (1,211.7)
MOO J1014+0038 (MOO1014)	1.24	28.47 (18,255.5)	28.63 (17,810.1)	-
SPT-CL J0205-5829 (SPT0205)	1.322	28.66 (23,007.2)	28.84 (25,052.9)	-
XDCP J2235-2557 (XMM2235)	1.39	28.18 (1,211.7)	-	27.85 (1,211.7)
SpARCS J1049+5640 (SpARCS1049)	1.71	28.52 (8,543.3)	-	28.28 (9,237.4)
IDCS J1426.5+3508 (IDCS1426)	1.75	30.56 (10,972.4)	30.79 (11,225.4)	-
JKCS041	1.803	27.74 (2,670.6)	-	27.99 (4,509.4)

All ICL

BCG Merger

Stripping Galaxies

Pre-processed

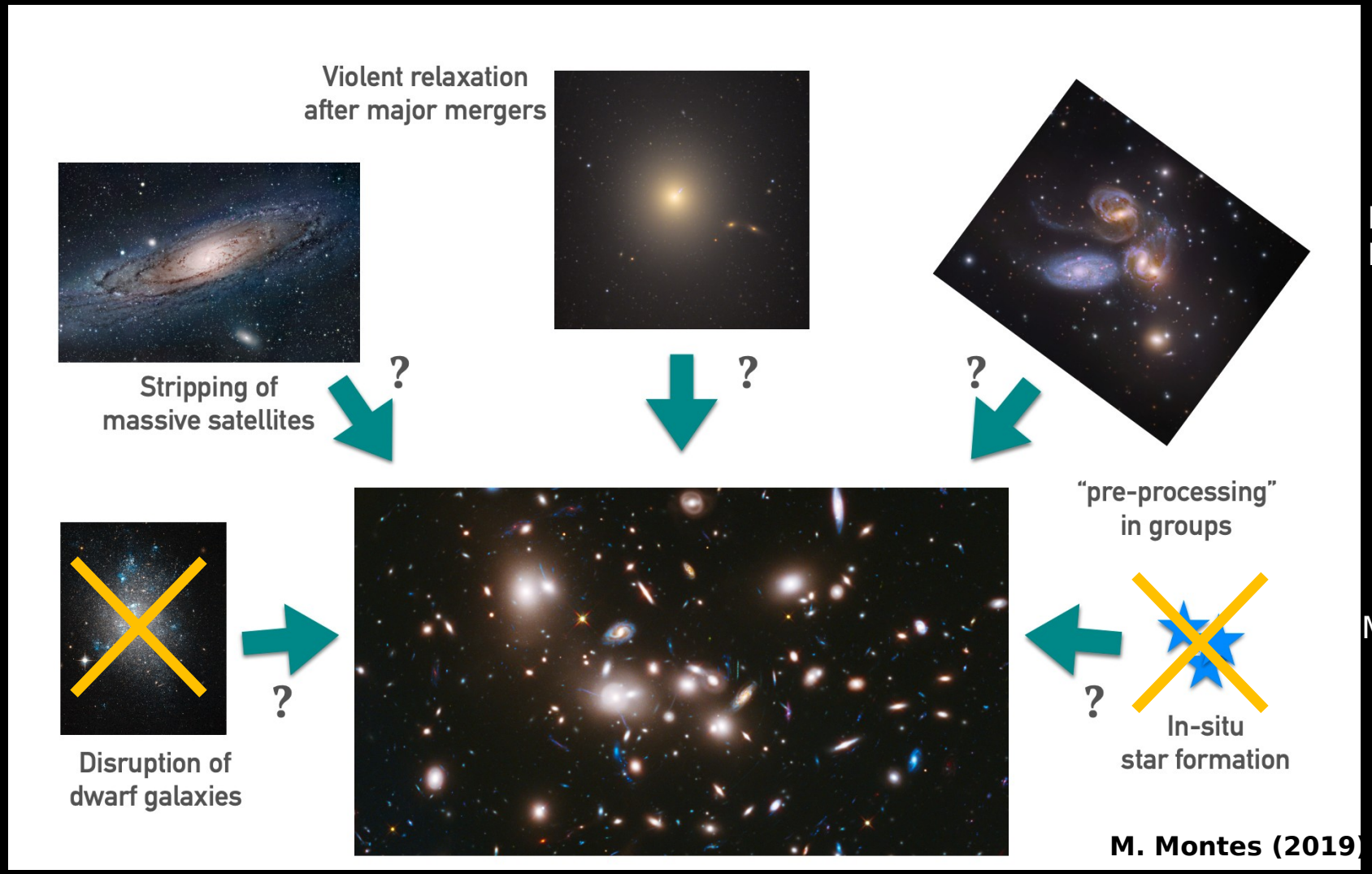


Formation of ICL

Murante et al. (2007)
Conroy et al. (2007)

Rudick et al. (2009)

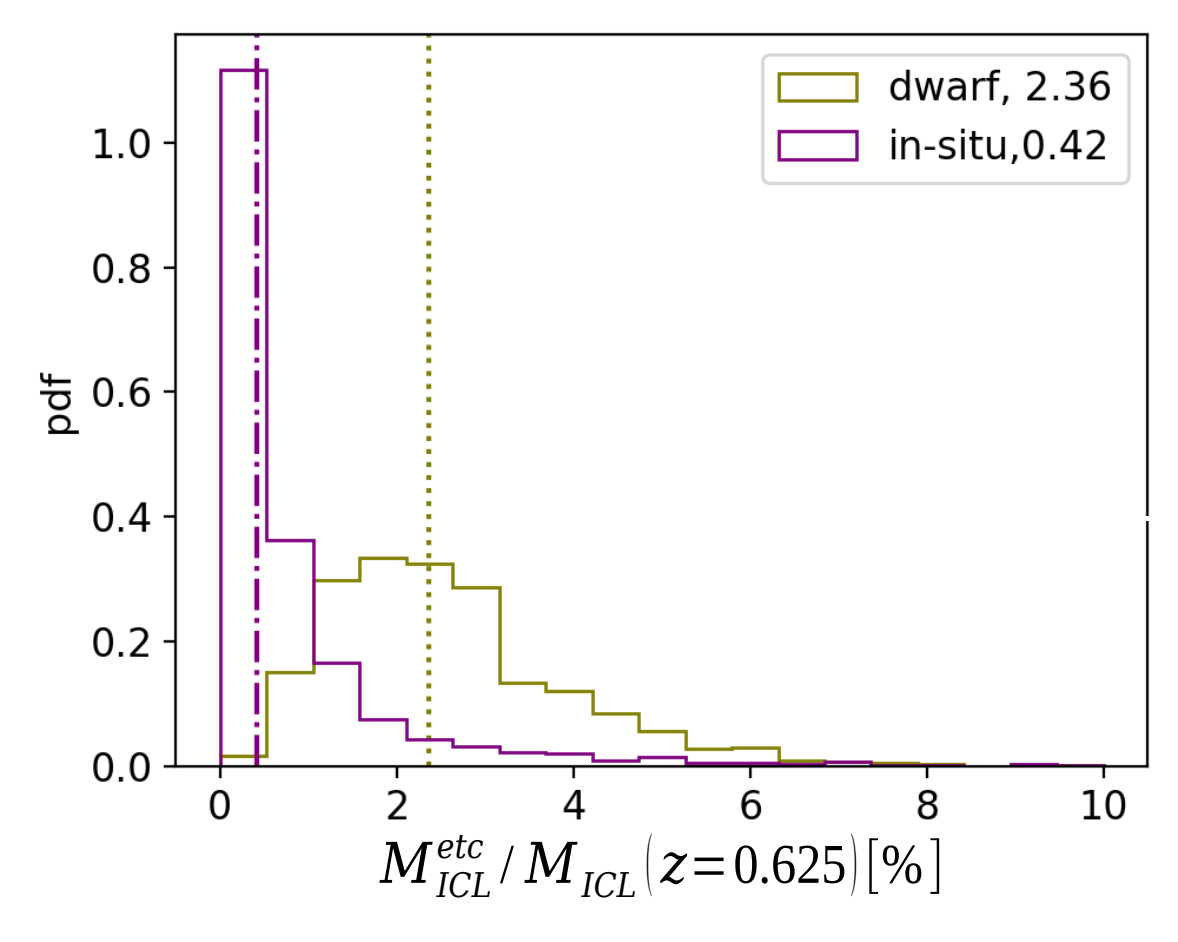
Mihos (2004)
Rudick et al. (2006)



DeMaio et al. (2015)
DeMaio et al. (2018)

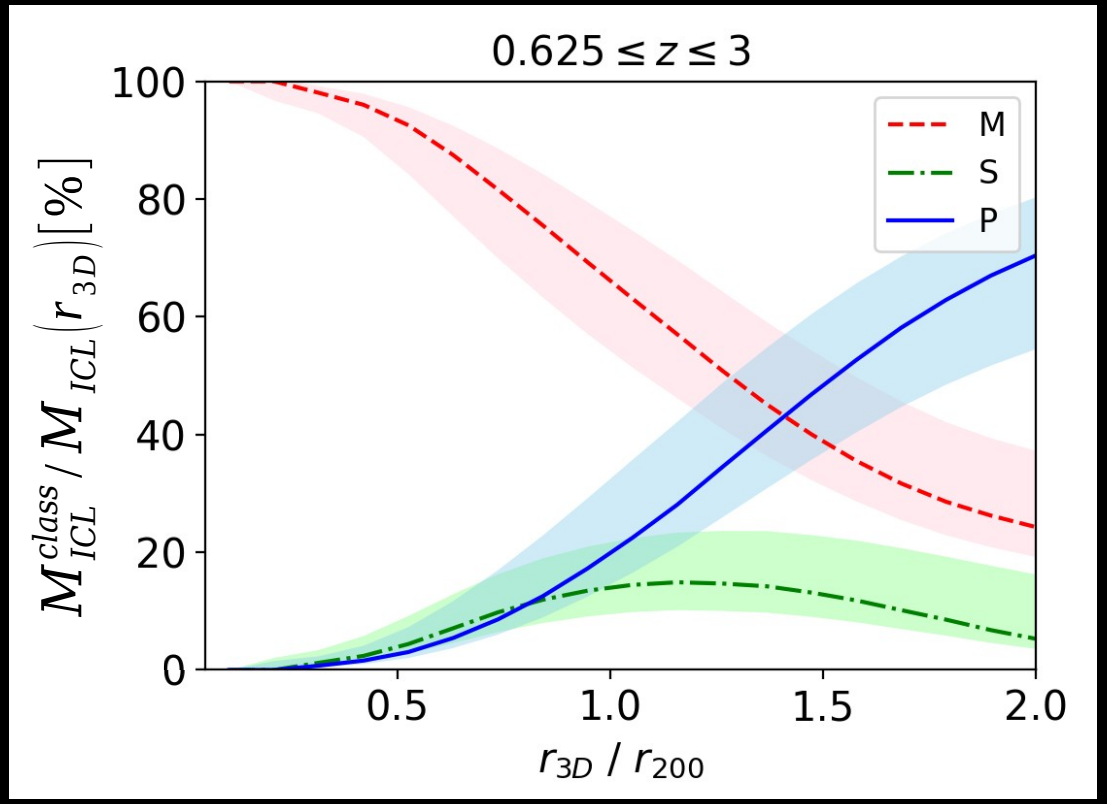
Melnick et al. (2012)

Dwarf & in-situ

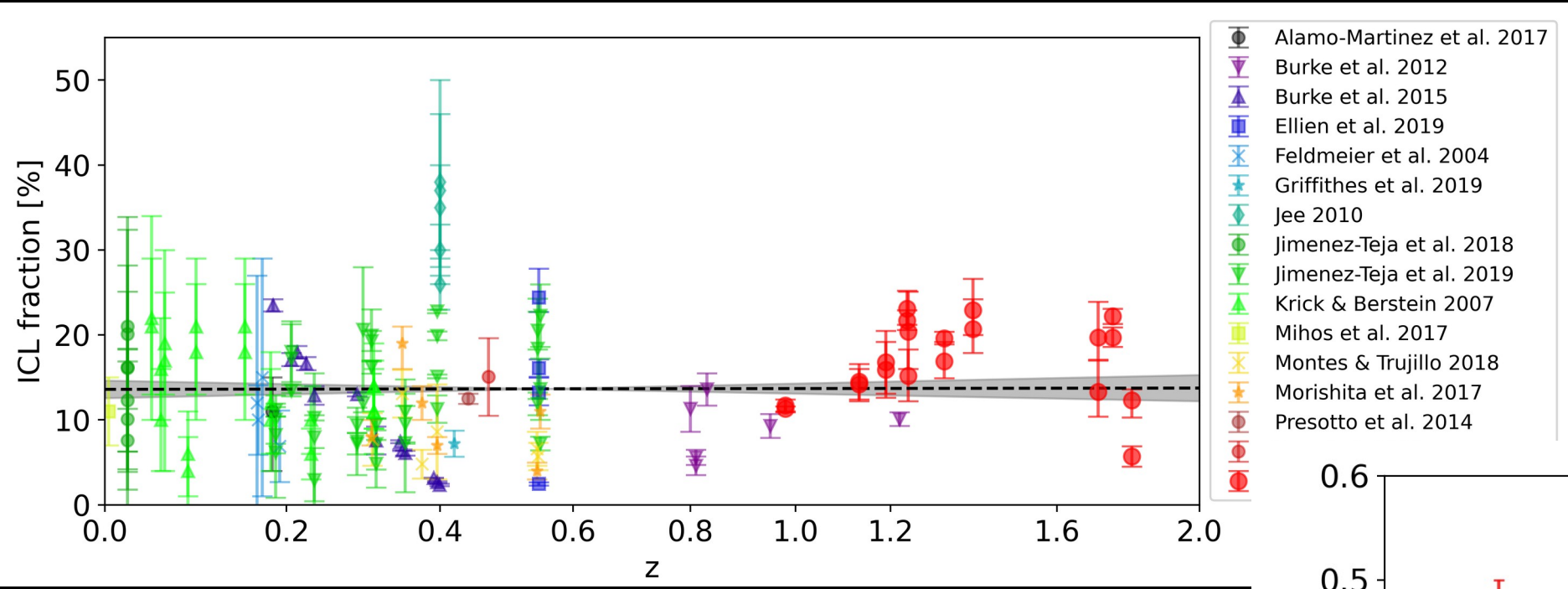


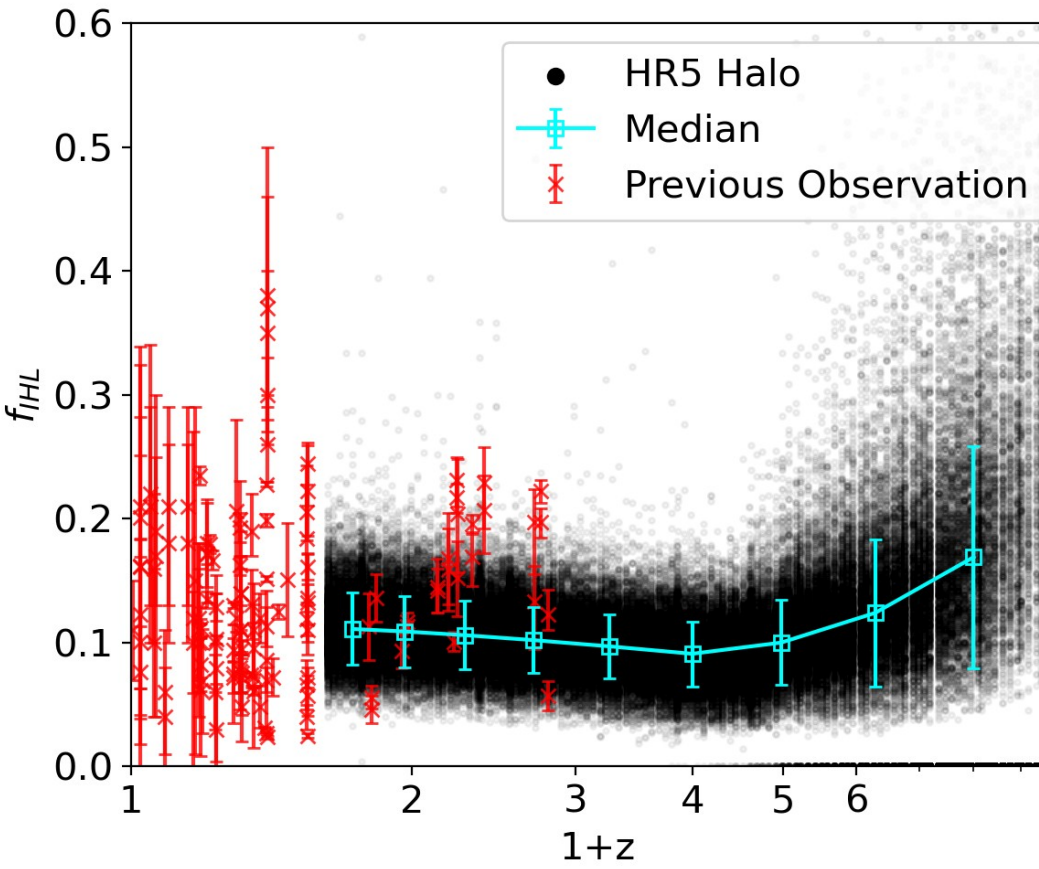
Dwarf disruption: ICL particle from galaxies

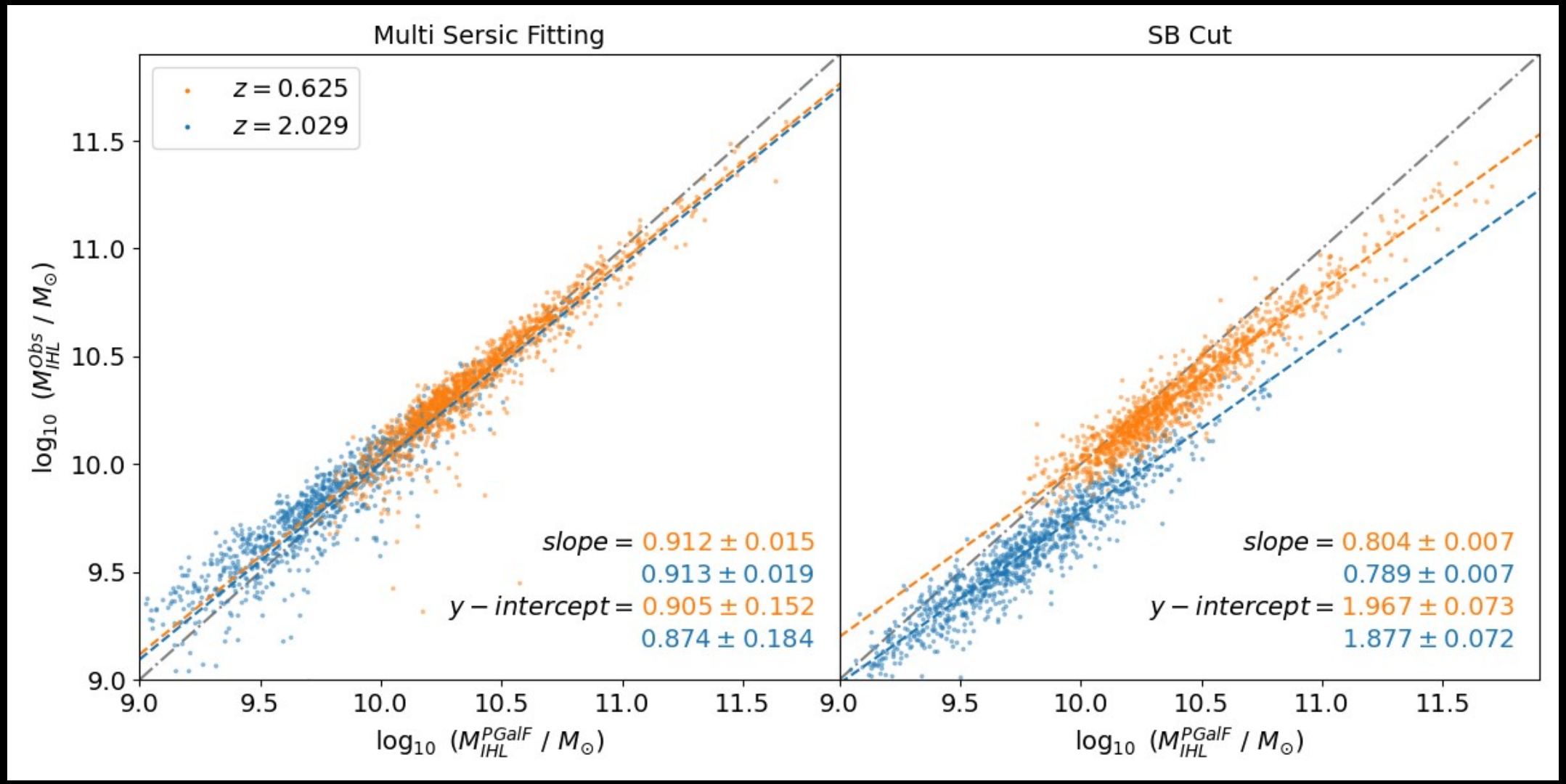
situ star formation: ICL particle with no parent gala

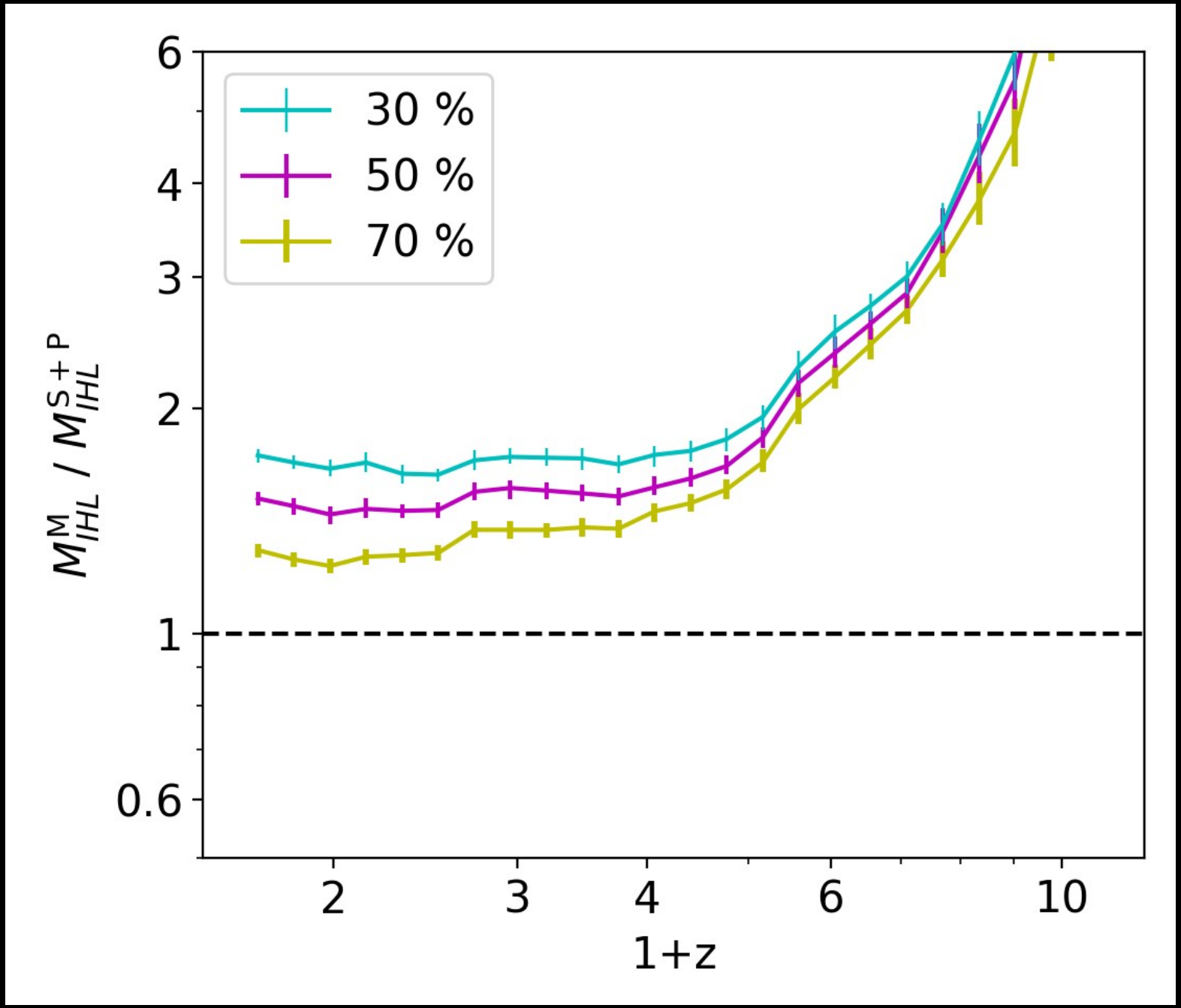


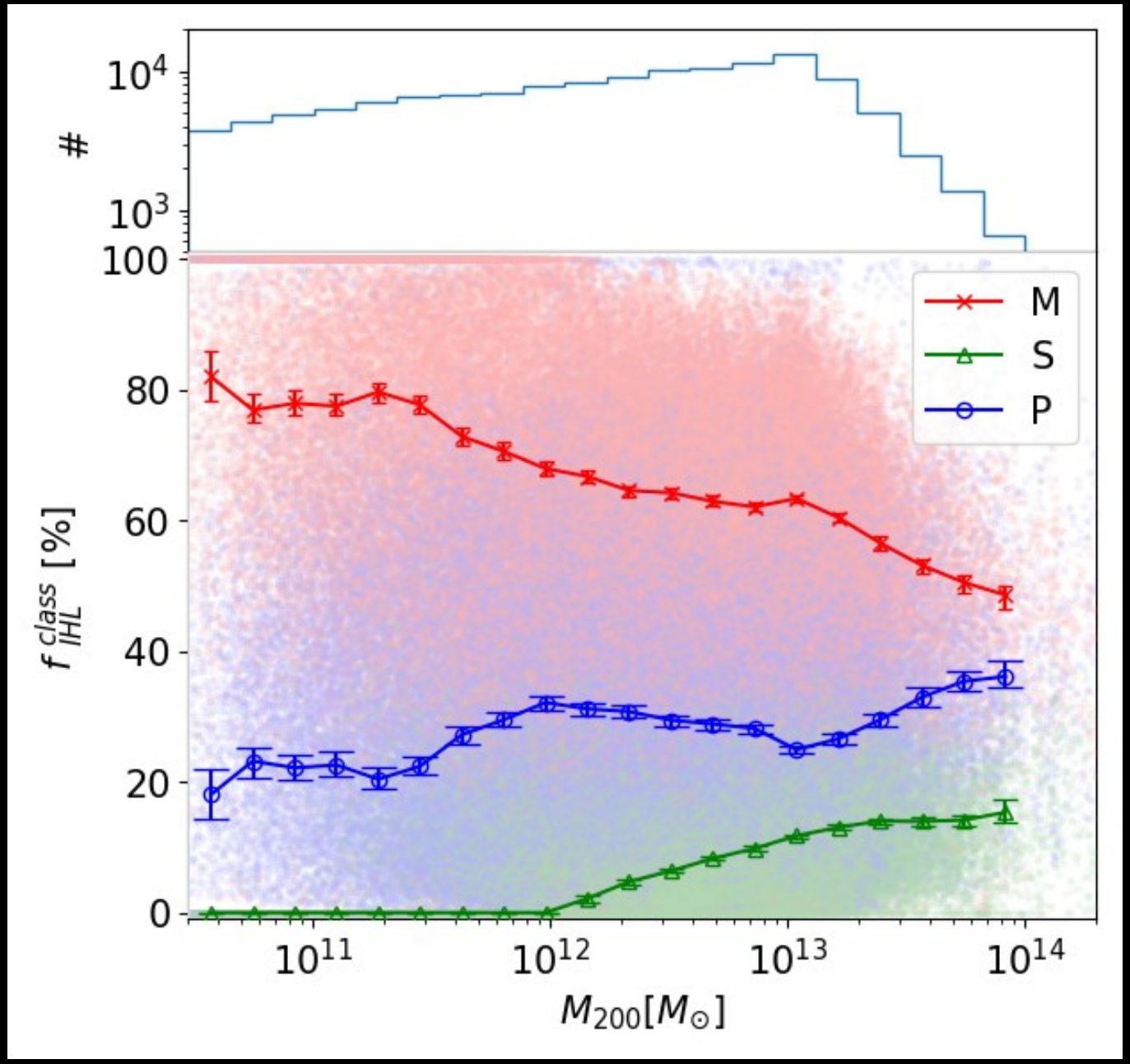
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ICL fraction [%]
z
Alamo-Martinez et al. 2017
Burke et al. 2012
Burke et al. 2015
Ellien et al. 2019
Feldmeier et al. 2004
Griffithes et al. 2019
Jee 2010
Jimenez-Teja et al. 2018
Jimenez-Teja et al. 2019
Krick & Berstein 2007
Mihos et al. 2017
Montes & Trujillo 2018
Morishita et al. 2017
Presotto et al. 2014


HR5 Halo
Median
Previous Observation
f_{IHL}
1+z


Multi Sersic Fitting
SB Cut
$z = 0.625$
$z = 2.029$
$slope = 0.912 \pm 0.015$
0.913 ± 0.019
$y - intercept = 0.905 \pm 0.152$
0.874 ± 0.184
$slope = 0.804 \pm 0.007$
0.789 ± 0.007
$y - intercept = 1.967 \pm 0.073$
1.877 ± 0.072
$\log_{10}\ (M_{IHL}^{Obs}\ /\ M_\odot)$
$\log_{10}\ (M_{IHL}^{PGalF}\ /\ M_\odot)$
9.0
9.5
10.0
10.5
11.0
11.5


30 %
50 %
70 %
6
4
3
2
1
0.6
2
3
4
6
10
1+z
M^{M}_{IHL} / M^{S+P}_{IHL}


#
10^4
10^3
100
80
60
40
20
0
f_{IHL}^{class} [%]
M
S
P
10^{11}
10^{12}
10^{13}
10^{14}
$M_{200}[M_\odot]$