Intergalactic stellar populations at z=0.3

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A brief history of the ICL

In 1937 Fritz Zwicky had a series of deep astronomical insights, among which…

“*We should expect a considerable number of stars, as well as matter in dispersed form from disrupted nebulae, to be scattered through the internebular spaces within clusters [of galaxies]*.”

The history of the ICL starts with Fritz Zwicky

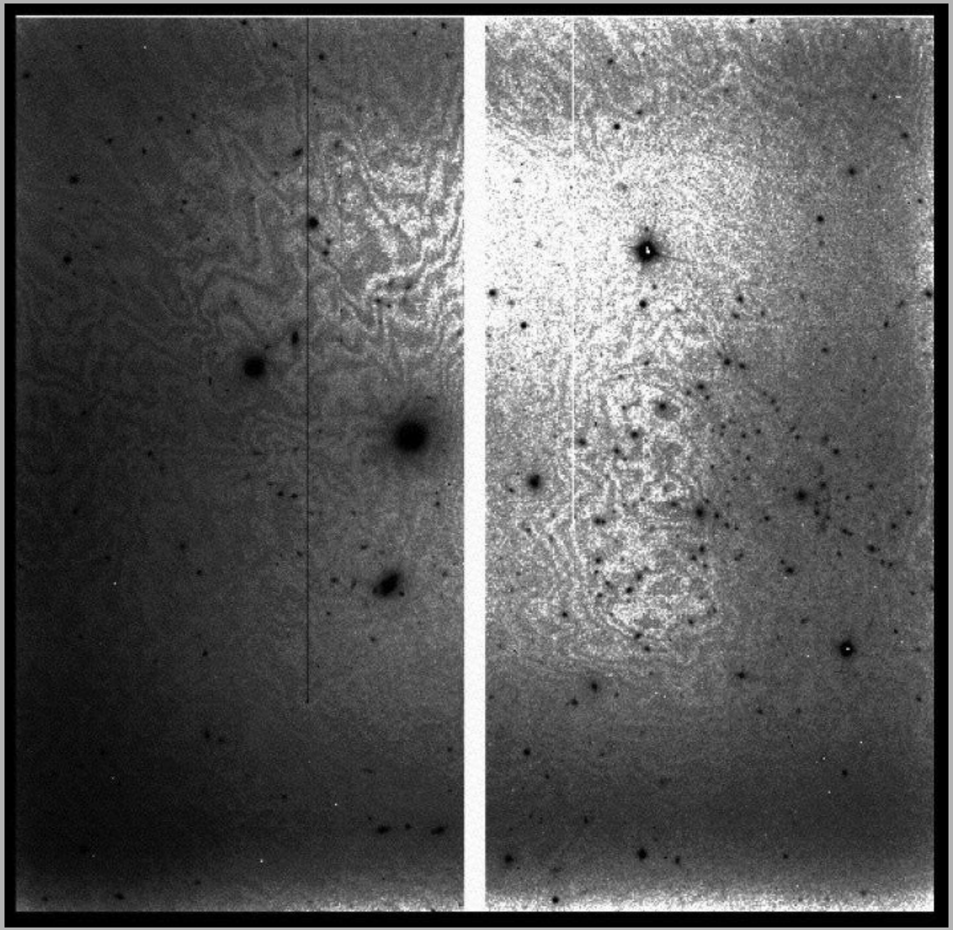
Zwicky used the Palomar 18-inch Schmidt telescope (and later the 48-inch) to search for intergalactic stars and in 1952 he found them in the Coma cluster and gave the right explanation for their origin.

The field was forgotten until the 1970’s when it was revived in the context of the missing mass problem*…

… and forgotten again for another 20 years until it was resurrected thanks to new observing and data analysis technologies

* which was also envisioned by Zwicky in the 1930’s

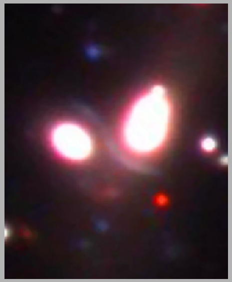
In the late 1990's we started a program with the NTT/SUSI2 to observe the ICL in X-ray clusters at z~0.3



Melnick, Selman, & Quintana, 1999

One of the clusters in our NTT sample showed a prominent ICL and a very intriguing central structure

RXJ0054.0-2823



Observations

It is extremely difficult, if not impossible, to separate the ICL from the halo of the BCG

MODEL

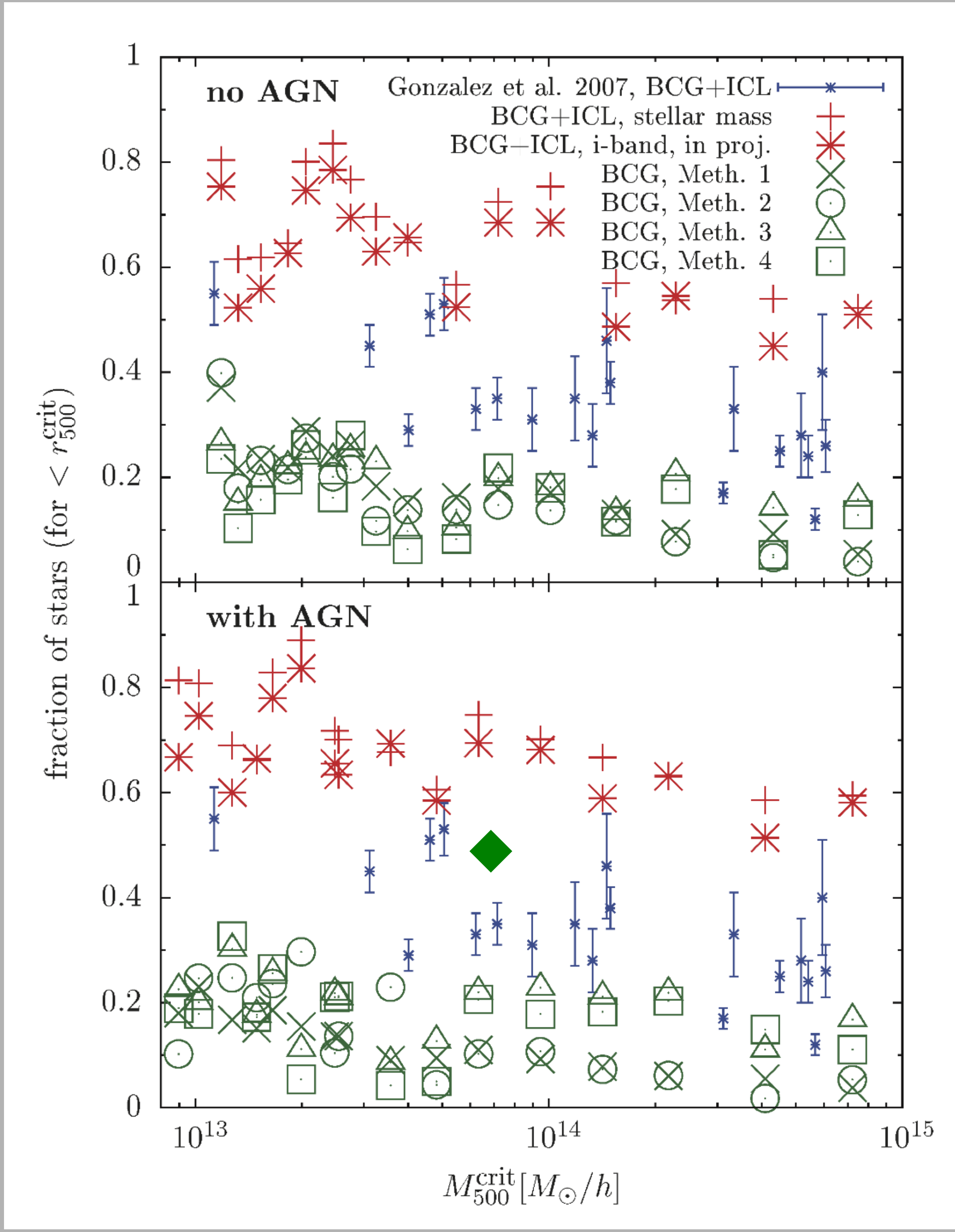
RX J0054.0-2823

ovwa
y

Murante et al., 2007

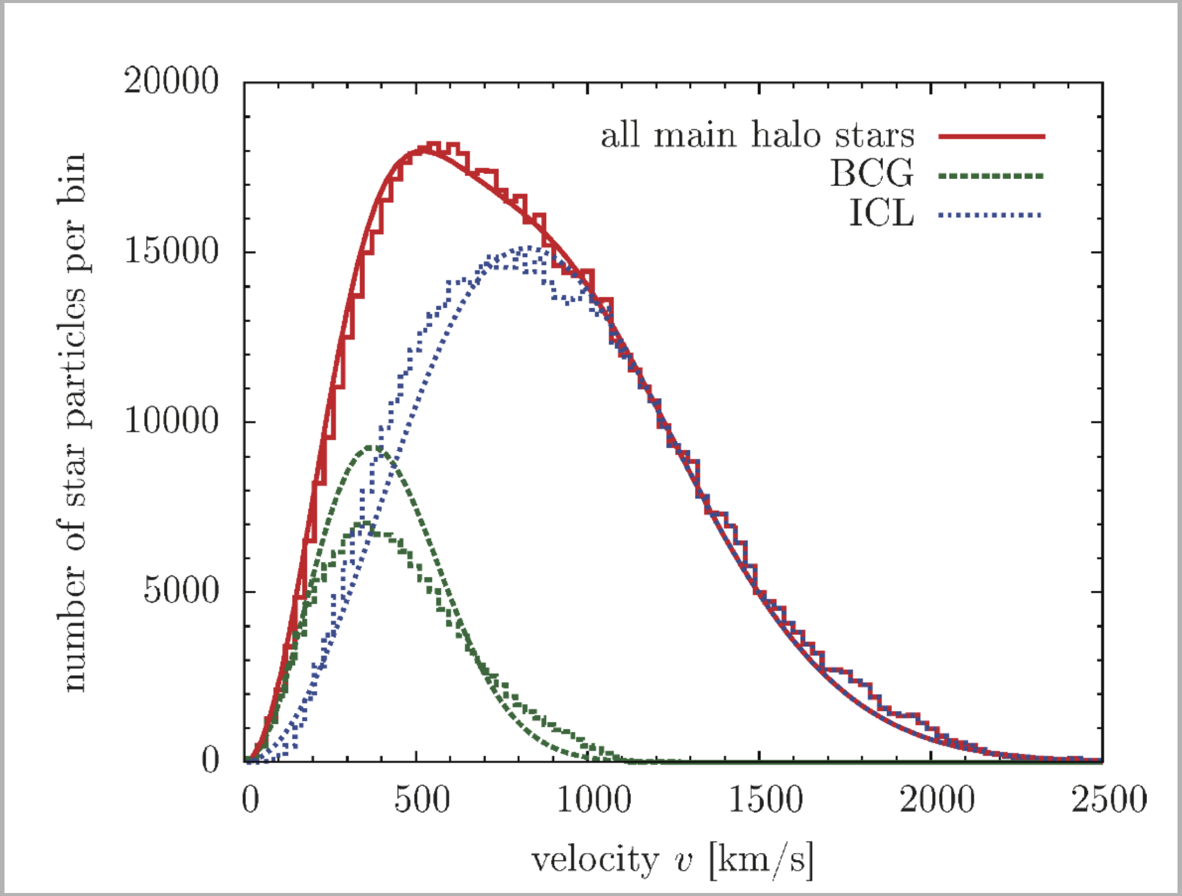
Toledo et al., 2011

We are forced to study the BCG and the ICL together



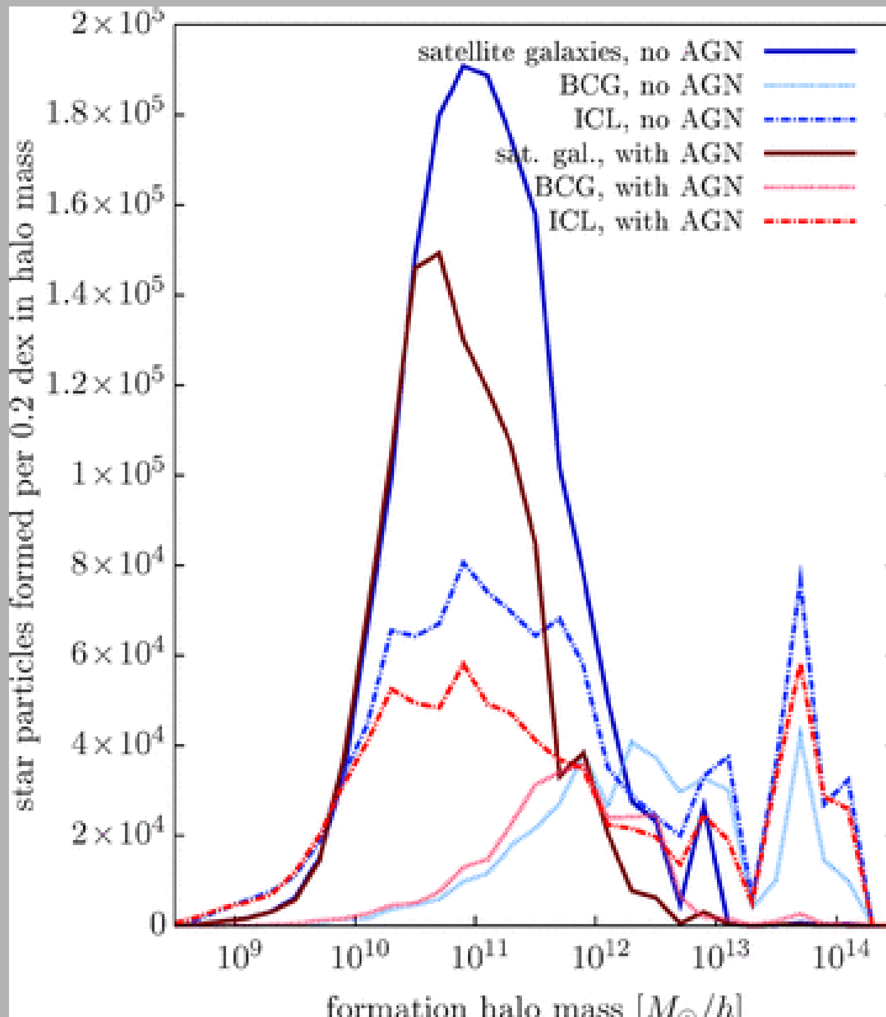
But the simulations also make predictions about the intergalactic stellar populations

1) The velocity dispersion of the ICL stars should be comparable to that of the parent clusters



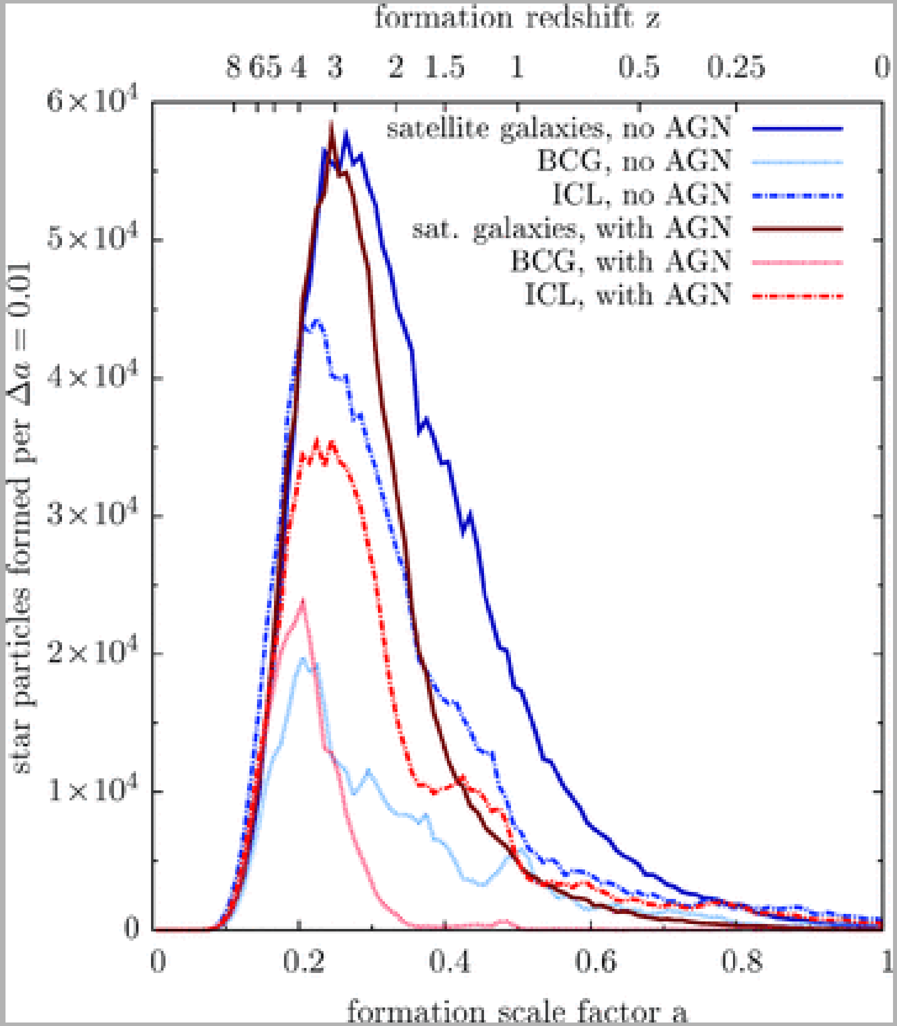
Puchwein et al. 2010

2) A significant fraction of the ICL stars are born in low-mass (M<1010.5M) halos



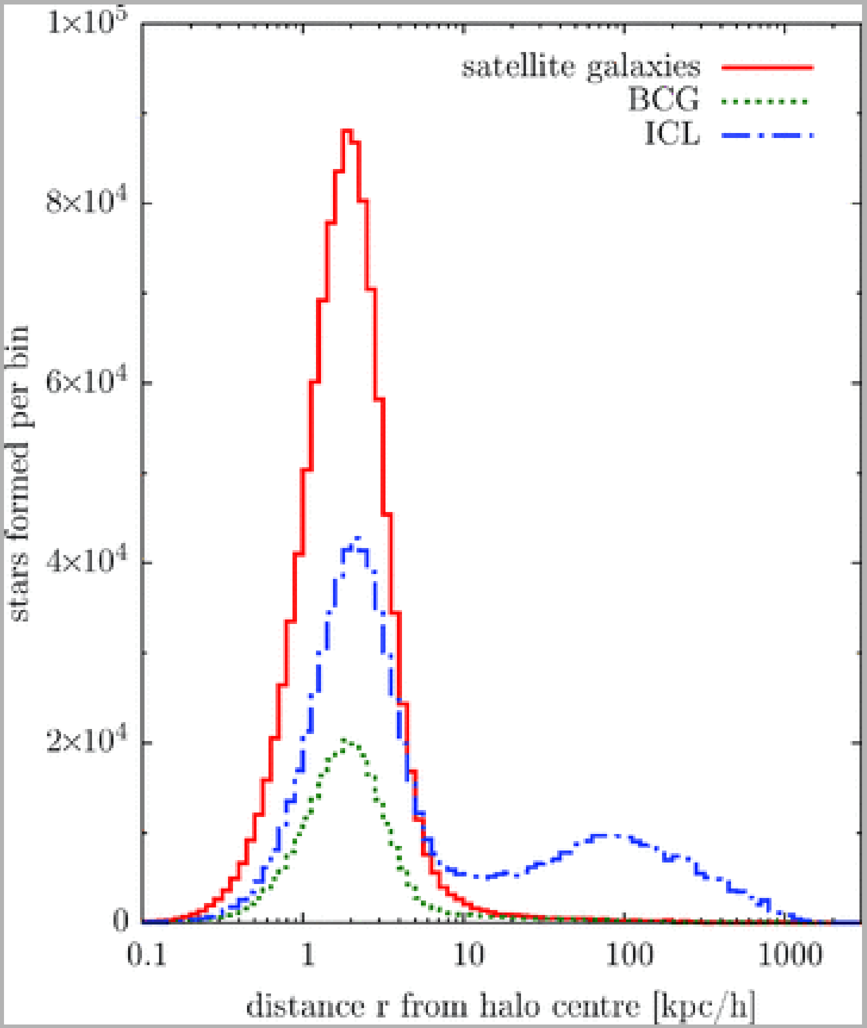
Puchwein et al. 2010;
1014Mcluster

3) A significant fraction of ICL stars formed at z<1.5



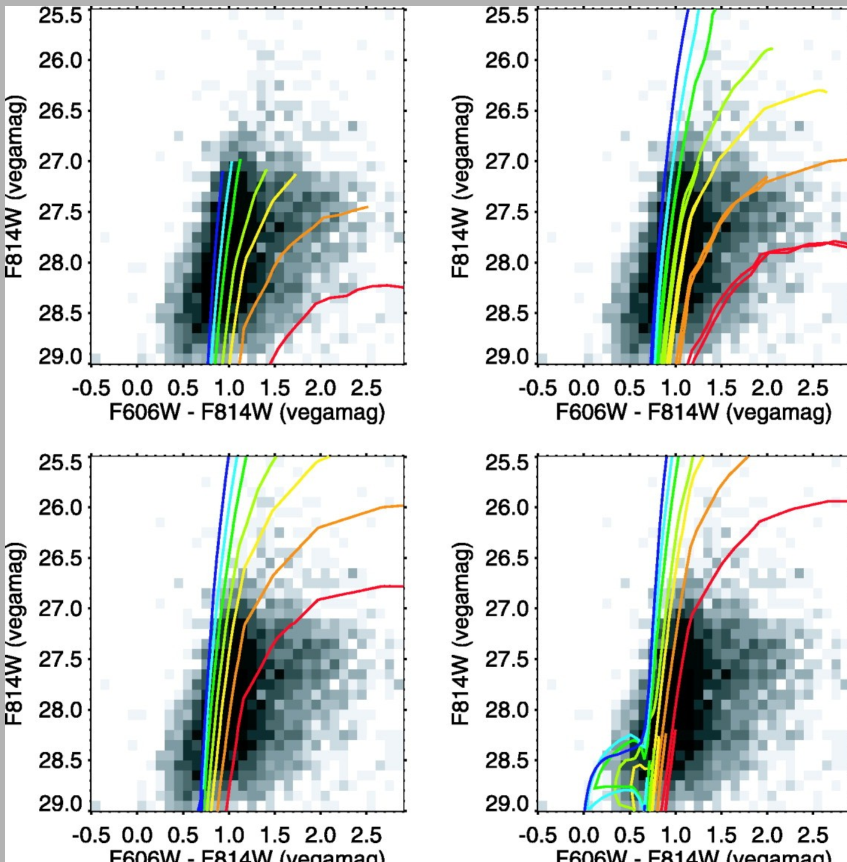
Puchwein et al. 2010

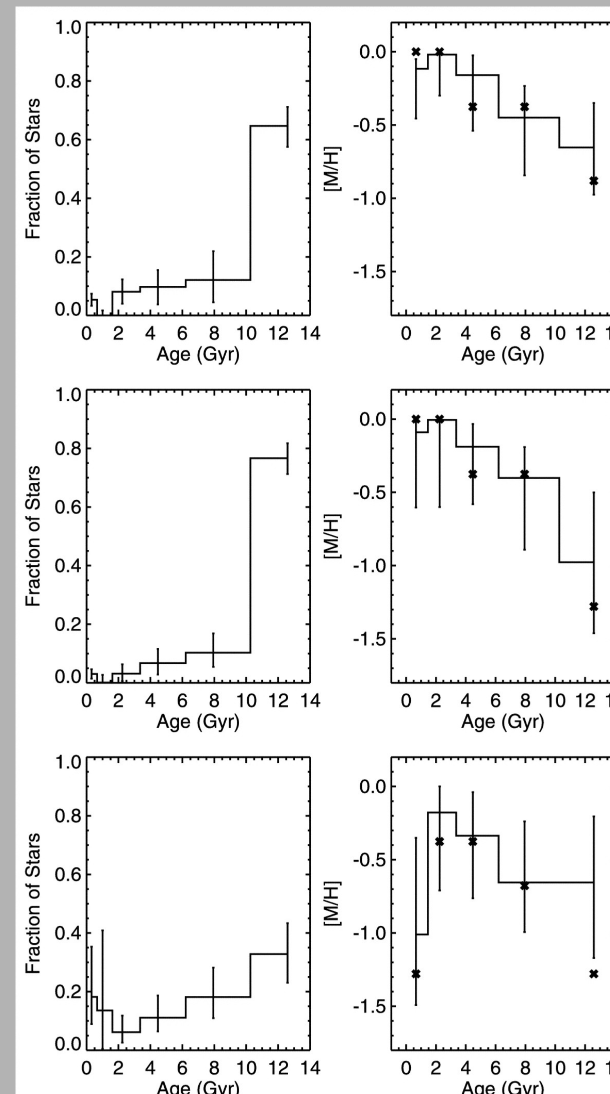
4) The young ICL stars form in the intergalactic medium from cold metal poor gas clouds that infalls late in the evolution of the clusters



Puchwein et al. 2010

These predictions can in principle be tested against observations in nearby clusters





Williams et al. 2007

Z = 0.001 – 0.019

log(age) = 8.5-10.1 yrs

Can we test the predictions of the models at z=0.29?

_Toledo et al., 2011

To observe the `pure' ICL we need to reach down to ~26 mag/□''

Toledo et al., 2011

Long exposures with VLT/FORS2 in MOS mode

Observing Log	
Slit width	1.6 arc-sec
Grisms	300V (+600RI arcs)
Total exp. times:	**(hours)**
N-S slit	9.8
E-W slit	7.2
Arcs	8.9+8.9

+ redshifts for ~650 galaxies in the field

Toledo et al., 2011

The radial velocity histogram has two peaks, but we find no evidence of two merging sub-structures

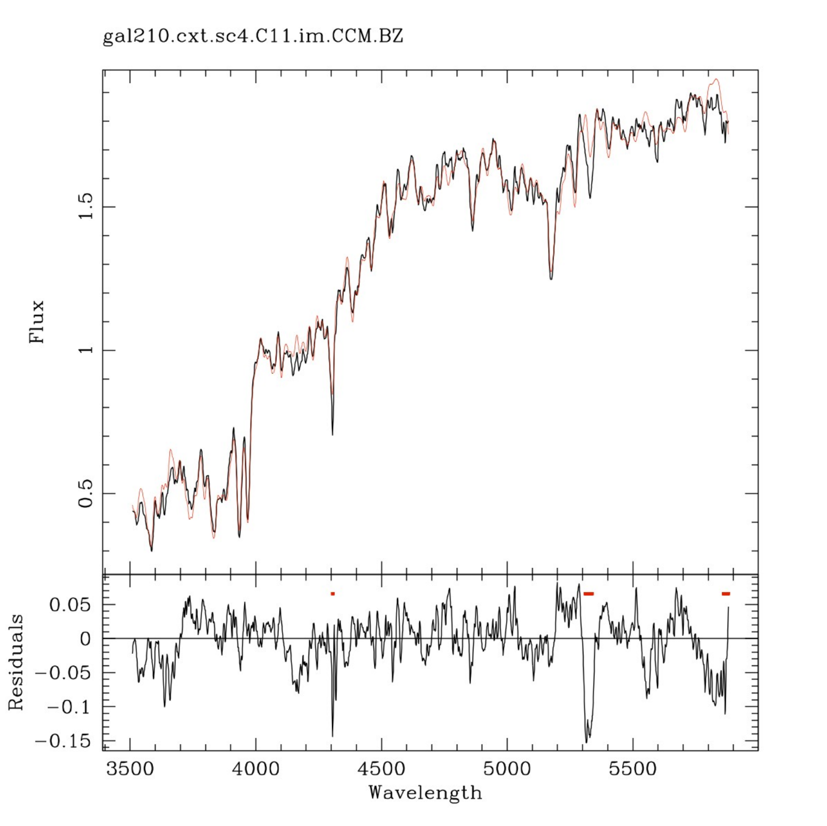
Toledo et al., 2011

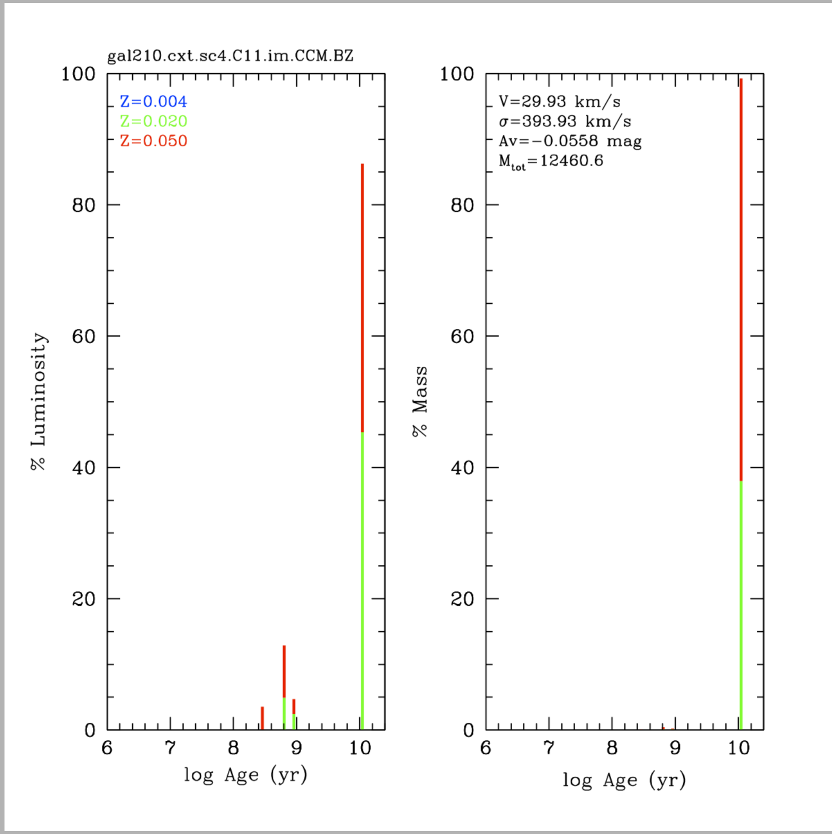
Giraud et al., 2011

We used ***starlight*** (Cid-Fernandes et al.) to fit a base of BC03 models to our spectra

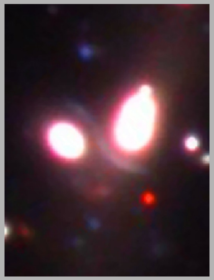
3 metallicities: Z = **0.004**; **0.02**; **0.05**

14 ages: **0.001 – 11** Gyr





Stellar populations of the inner BCG halo (just North of the arc feature)



Stellar populations of the S-shaped arc

The arc is a tidally distorted spiral galaxy. The interaction induced a galaxy-scale burst of star formation 500 Myr ago.

Stellar populations of the outer BCG halo (just South of the S-shaped arc)

The metal-rich HII region could be ionized by the young stars

Stellar populations of the ICL (sum of 4 positions)

Ionized gas seems to be pervasive within the ICL

About 15% of the ICL stars appear to be younger than 9.5 Gyr and metal-rich

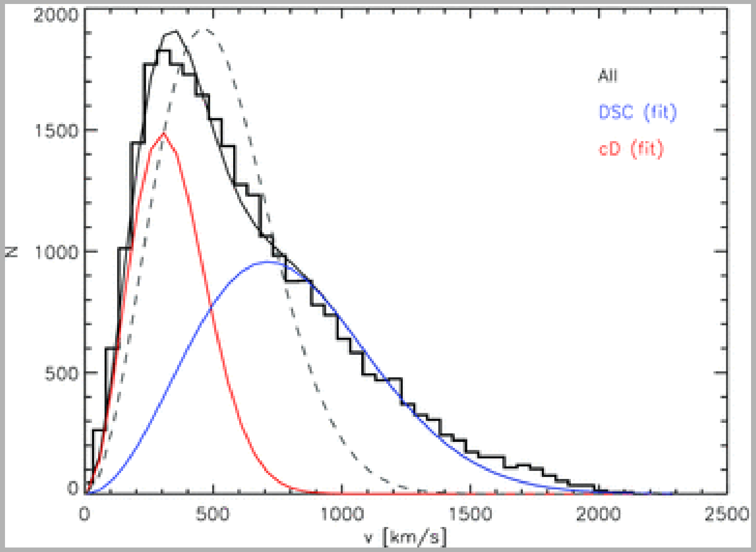
Nebular emission in the ICL is powered either by collisions with the hot (X-ray) gas or by evolved stars

Retired galaxies:
Cid-Fernandes, Stasinska, et al., 2010

The velocity dispersion of the ICL appears to be similar to that of the cluster

Component	Velocity Dispersion (km s-1)
Cluster	496/328
Galaxy #210	210
BCG Halo	320
S-shaped Arc	300
Outer halo	400*
ICL	400*

*with rather large errors…



Dolag, Murante, Borgani, 2010

Conclusions

About 15% of the ICL stars in our cluster at z~0.3 are young and metal rich. These were probably born in the intergalactic medium from gas ejected from spiral galaxies disrupted by the central triple system in the center of the cluster.

The S-shaped arc is a flagrant example of a spiral galaxy caught in the act of being destroyed by the `grinding machine' at the center of the cluster.

The population of young, metal-poor ICL stars predicted by models is not observed in our cluster.

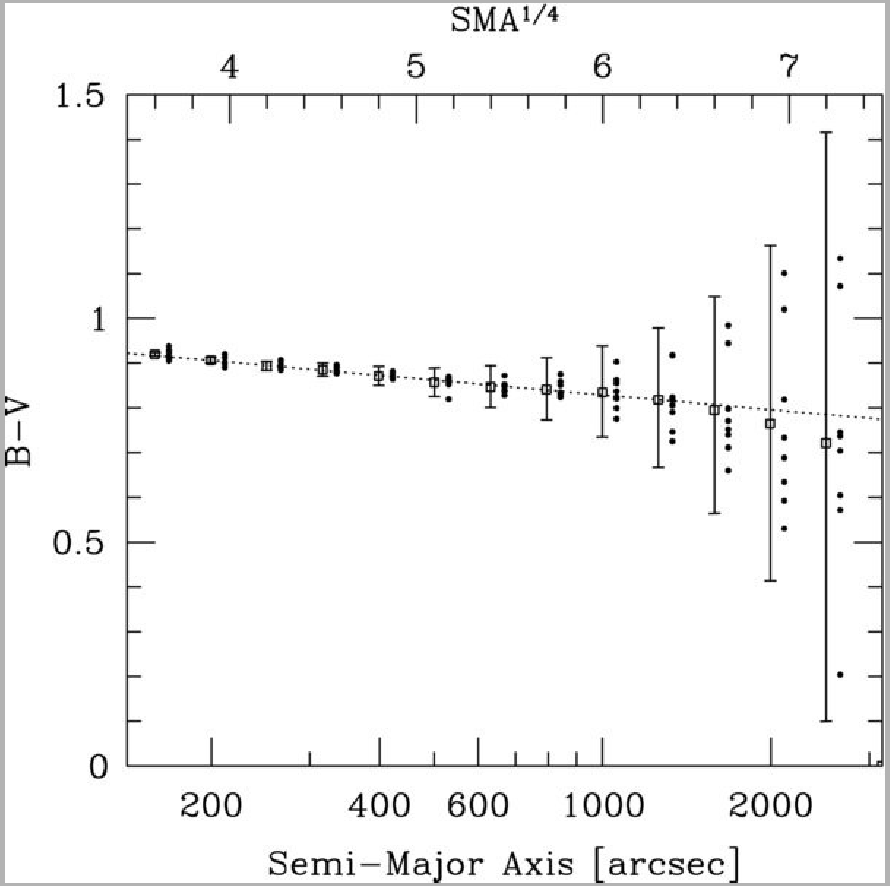
The ICL stars have a velocity dispersion consistent with that of the cluster

Faint emission lines are pervasive in the ICL probably arising from striped gas or from planetary nebulae.

Thank you!

Auxiliary Material

Observations: the halo of M87 gets bluer with radius



Rudick et al., 2010

Any velocity dispersion fits the Gonzales et al. relation

Toledo et al., 2011