Galaxy Evolution in X-ray Seleced Galaxy Clusters and Groups in Dark Energy Survey Data

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XCS
XMM Cluster Survey

DES

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- In the progress of imaging 5,000 deg^2 of the sky (2013 to 2018).
- Uses the Blanco Telescope (4m) in Chile.
- Dedicated to cosmology studies.
- Also great for non-cosmological studies.
- Fermilab plays a major role.

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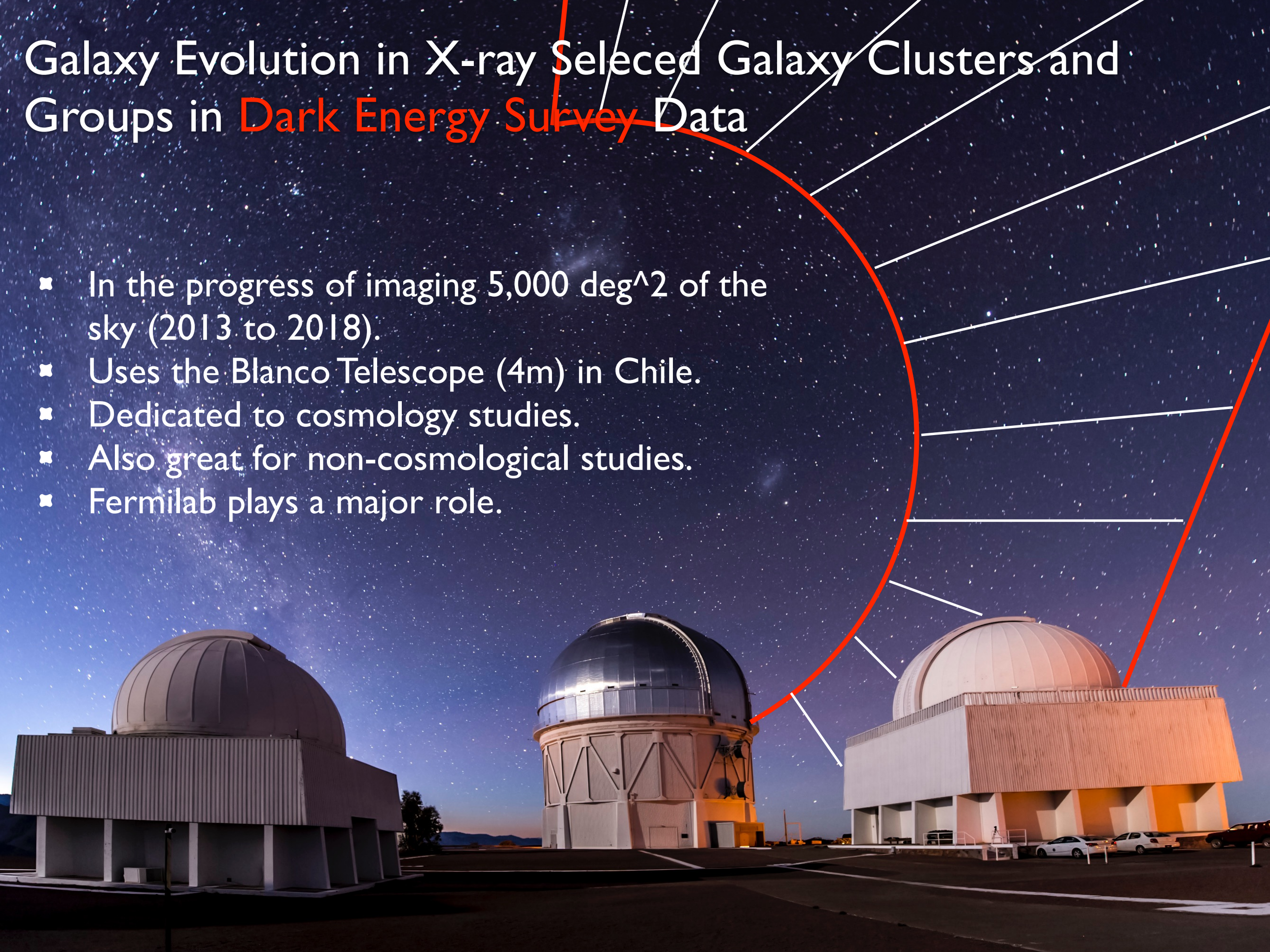

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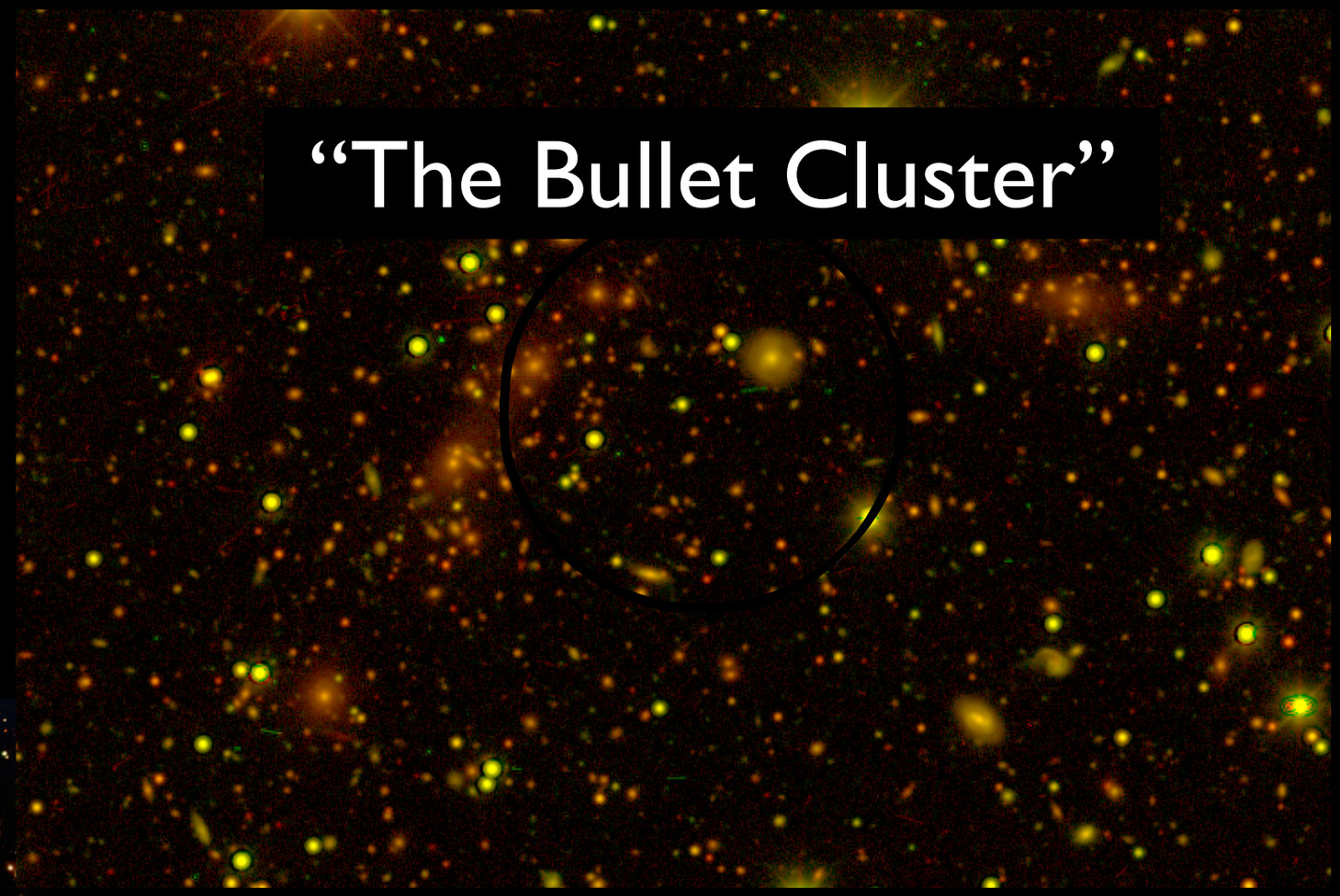
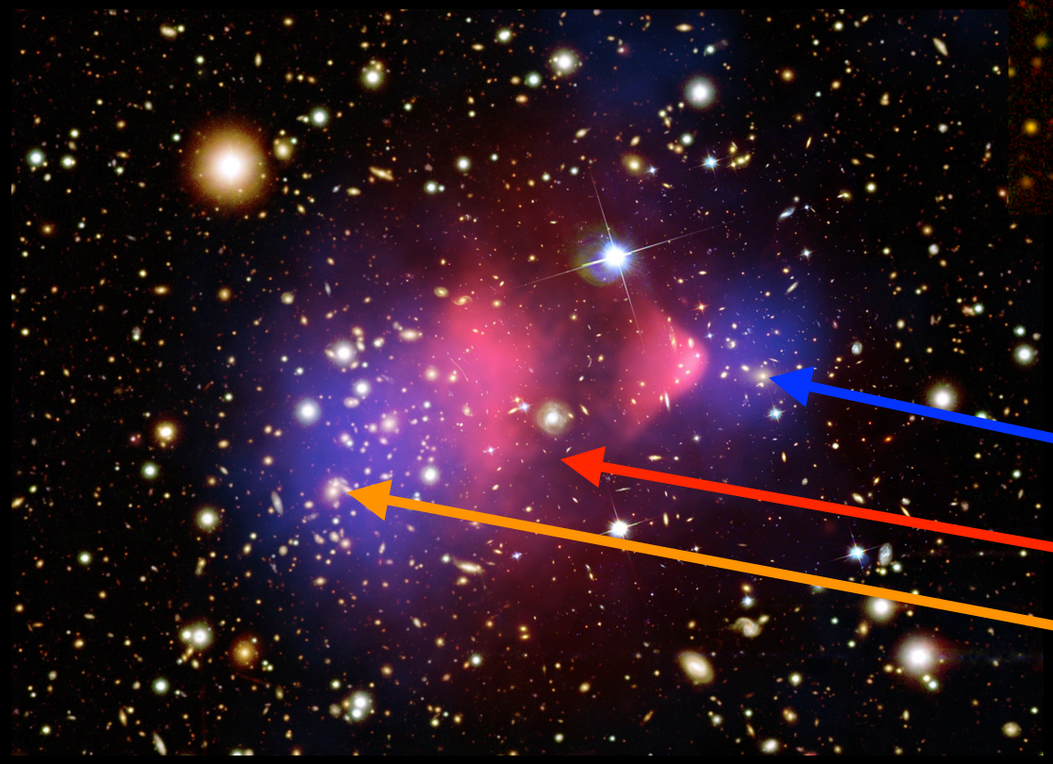
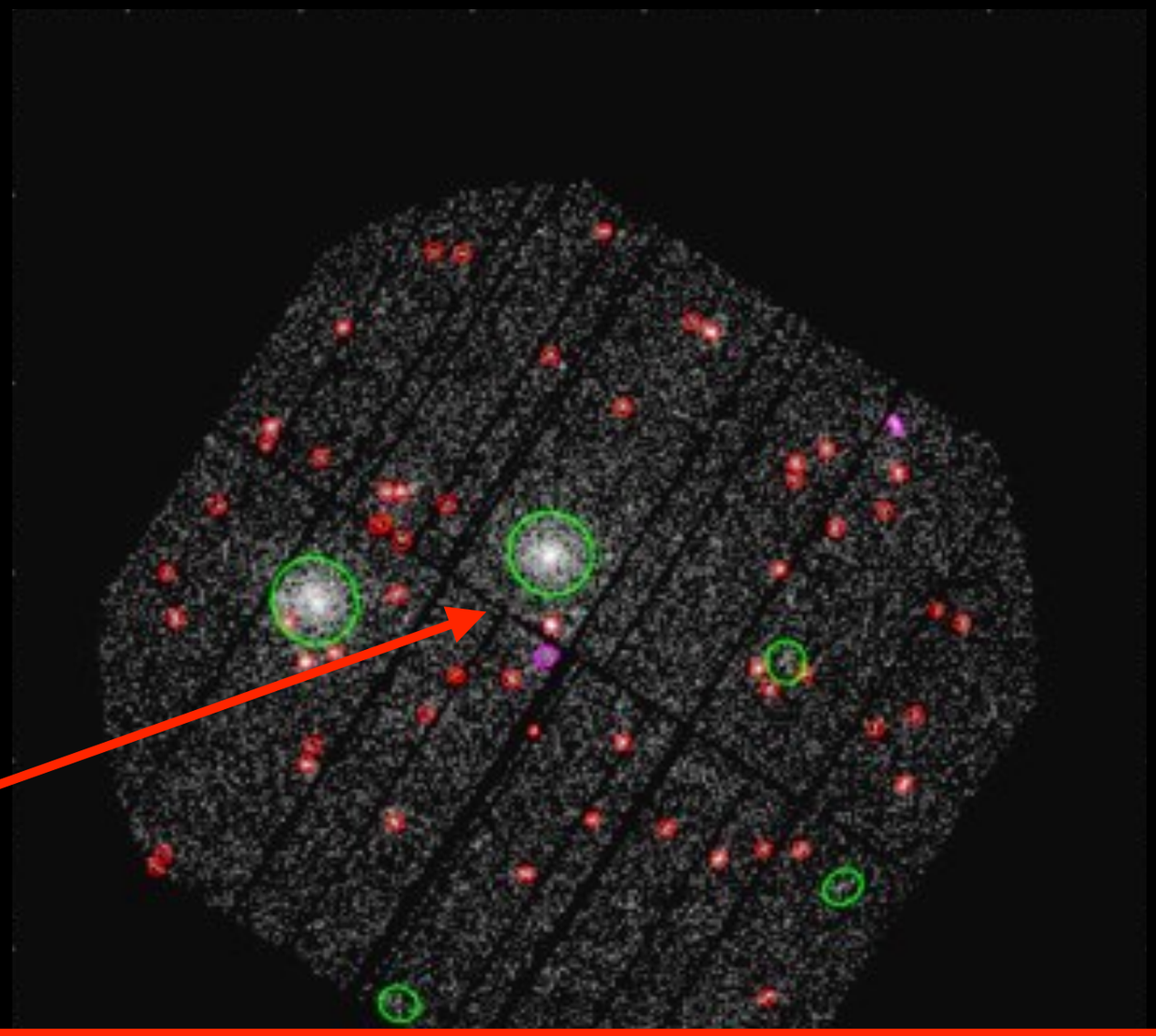
The largest gravitationally bound structures in the universe.

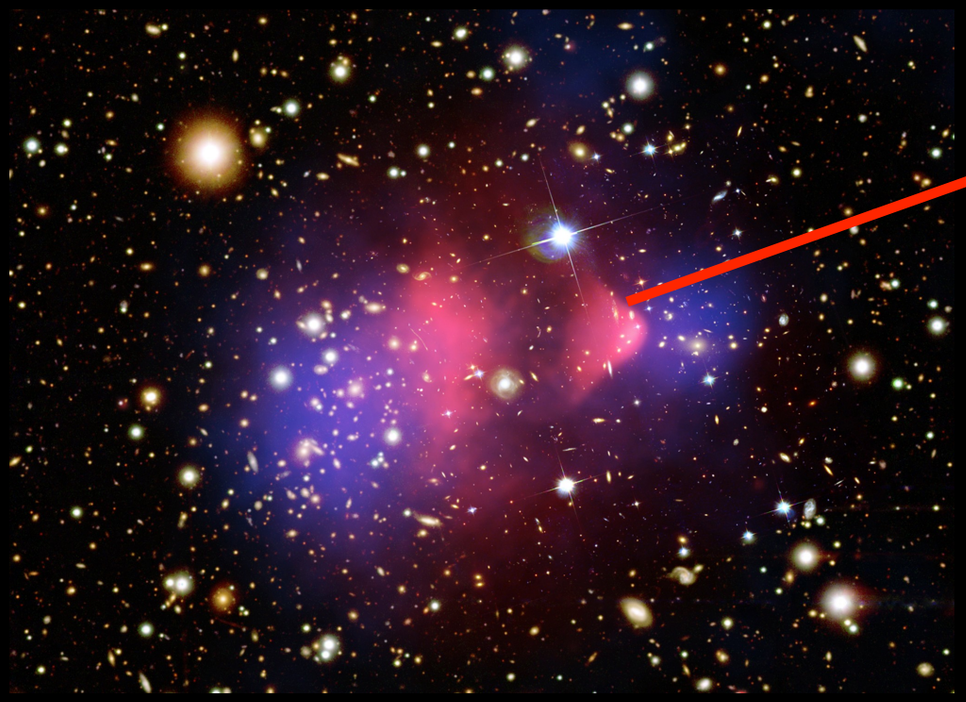




Contain enormous amount of
dark matter,
hot gas, and
galaxies (stellar content).

Galaxy Evolution in X-ray Seleced Galaxy Clusters and Groups in Dark Energy Survey Data — The XMM Cluster Survey (XCS)





Galaxy clusters can be selected through the X-ray emissions from their hot gas content

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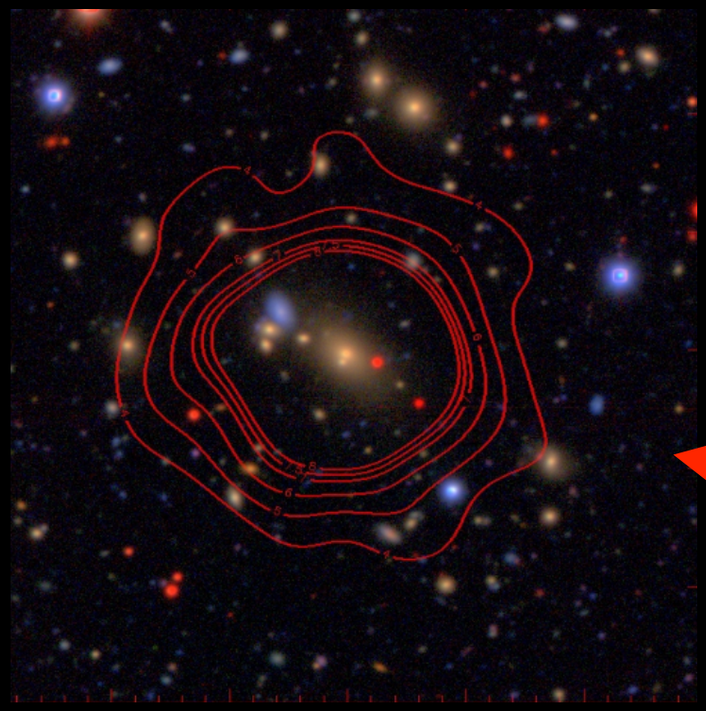
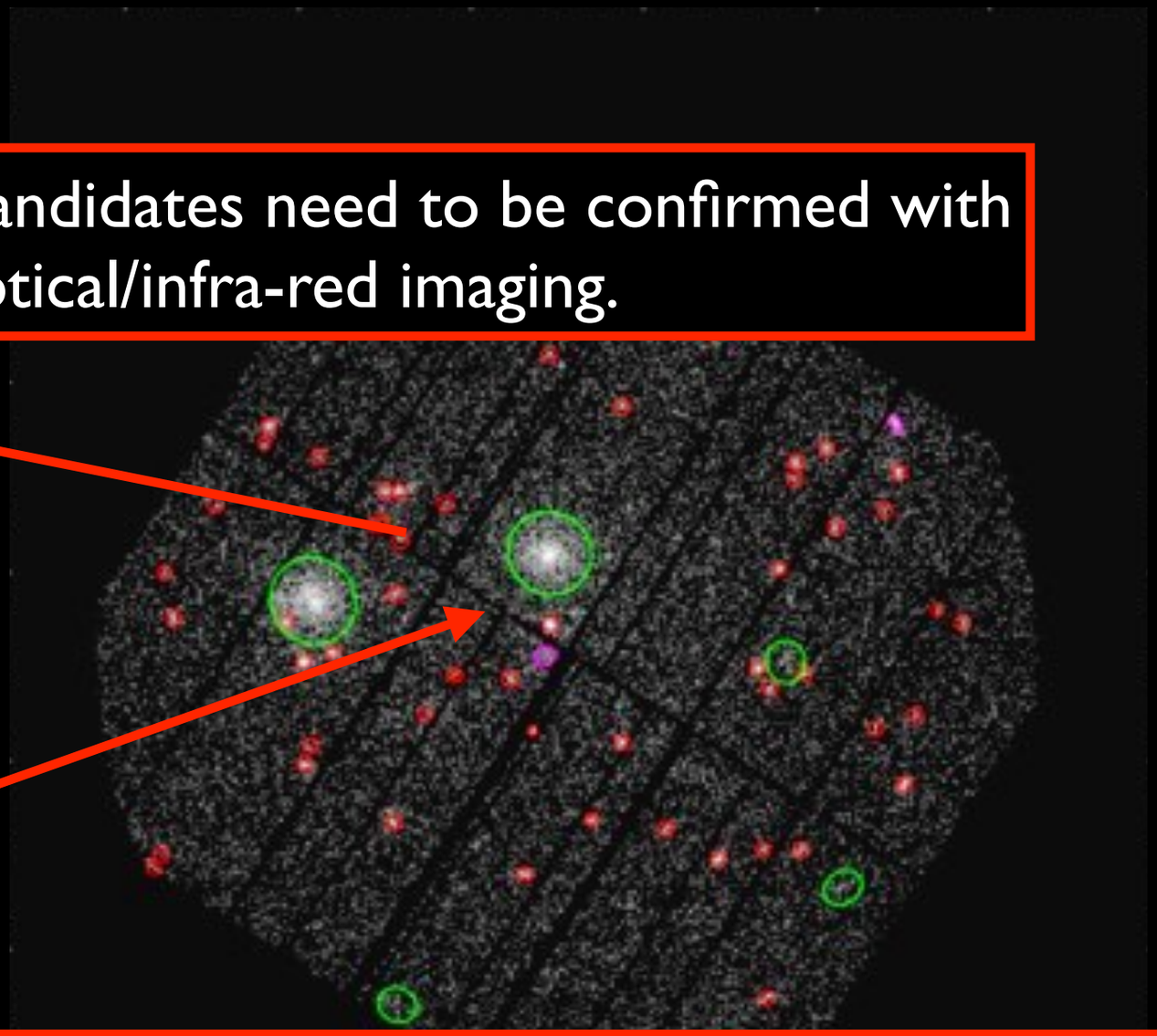
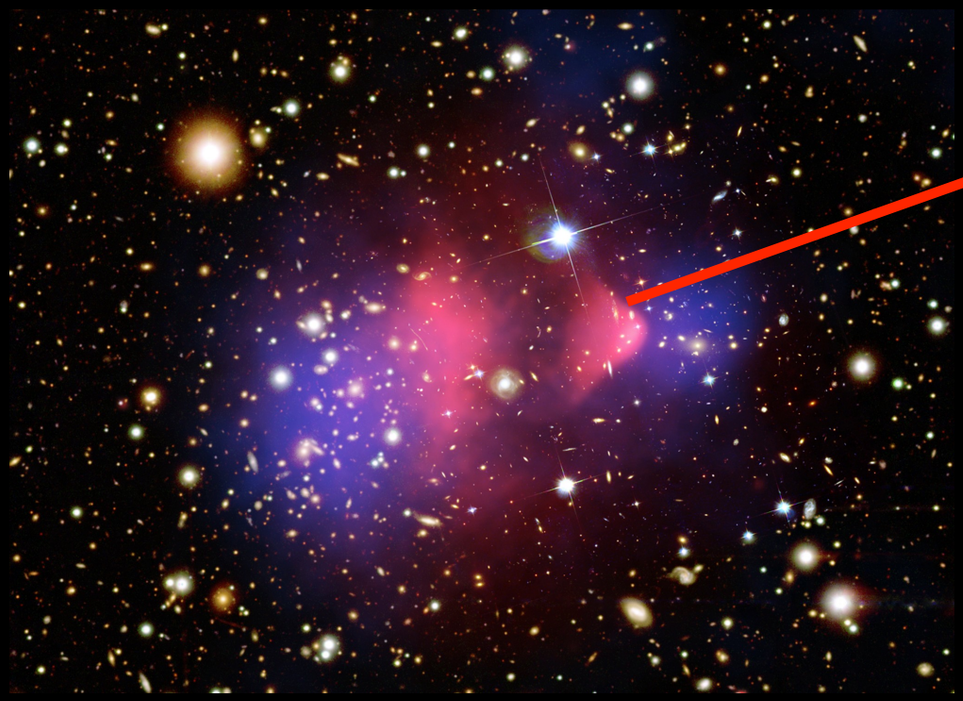


Candidates need to be confirmed with optical/infra-red imaging.





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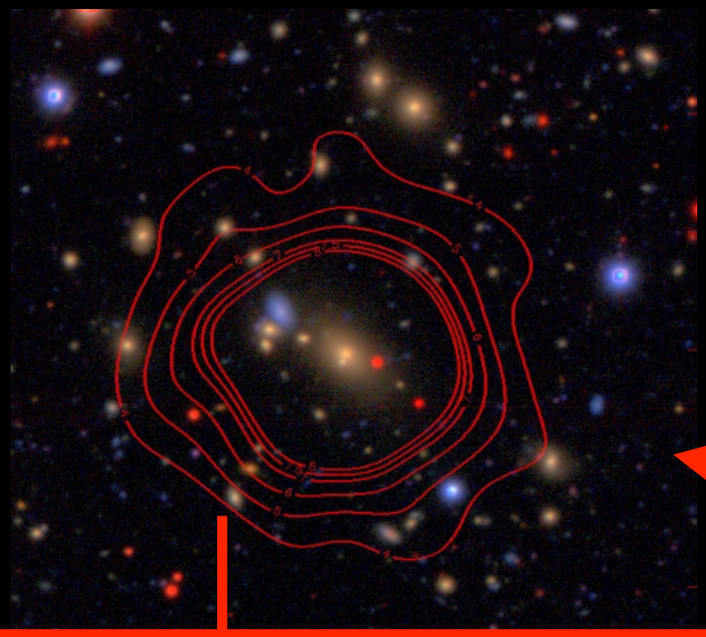
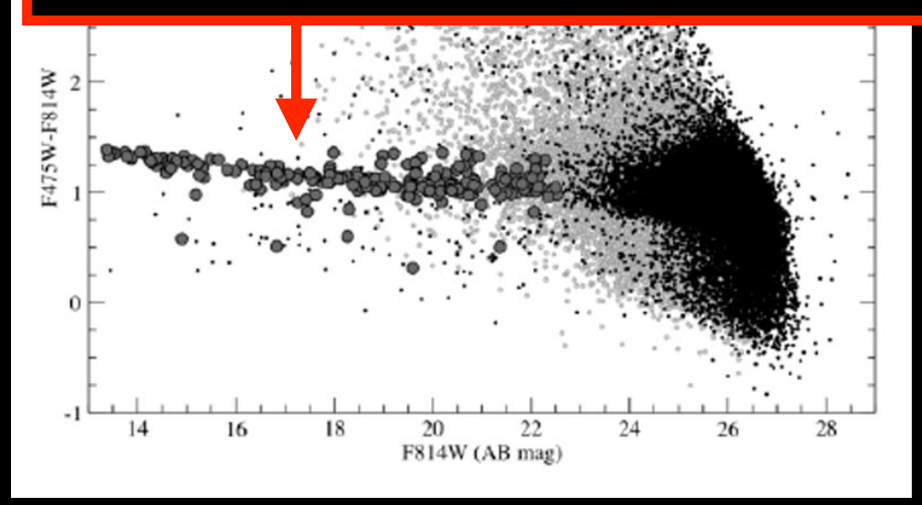
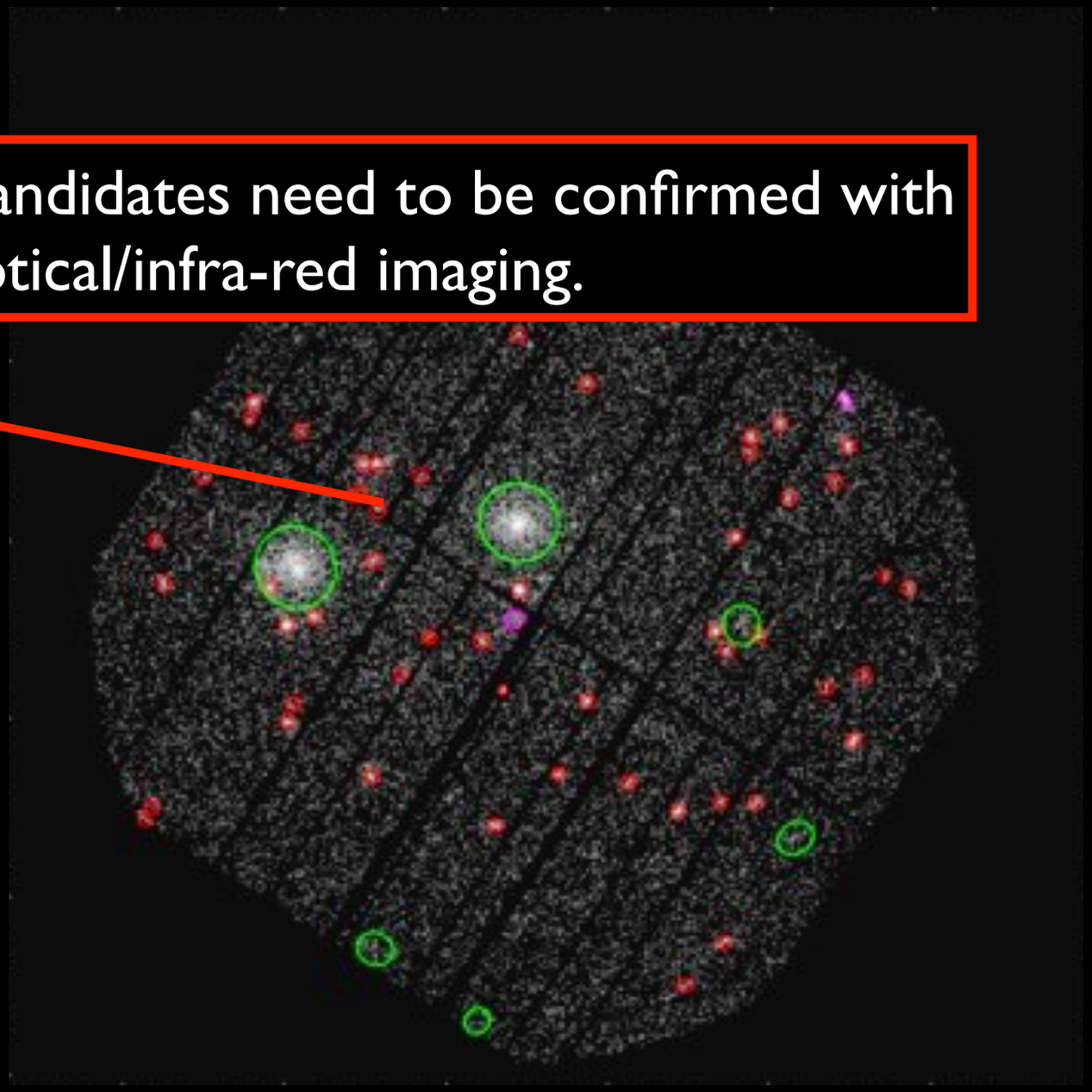


Candidates need to be confirmed with optical/infra-red imaging.

Imaging data confirm the existence of cluster galaxies, which also contain redshift information.





Miller, Rooney et al. in prep.

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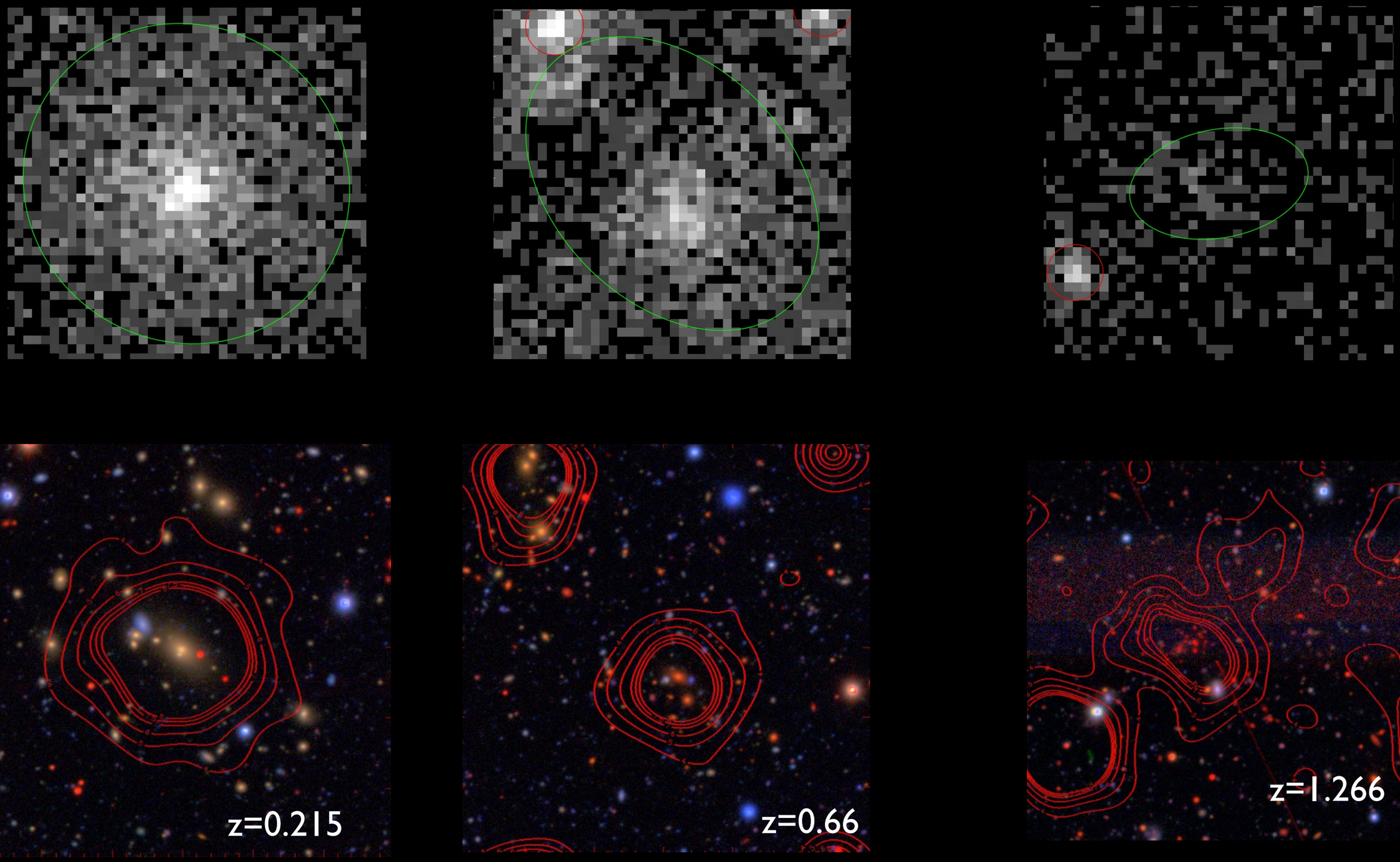

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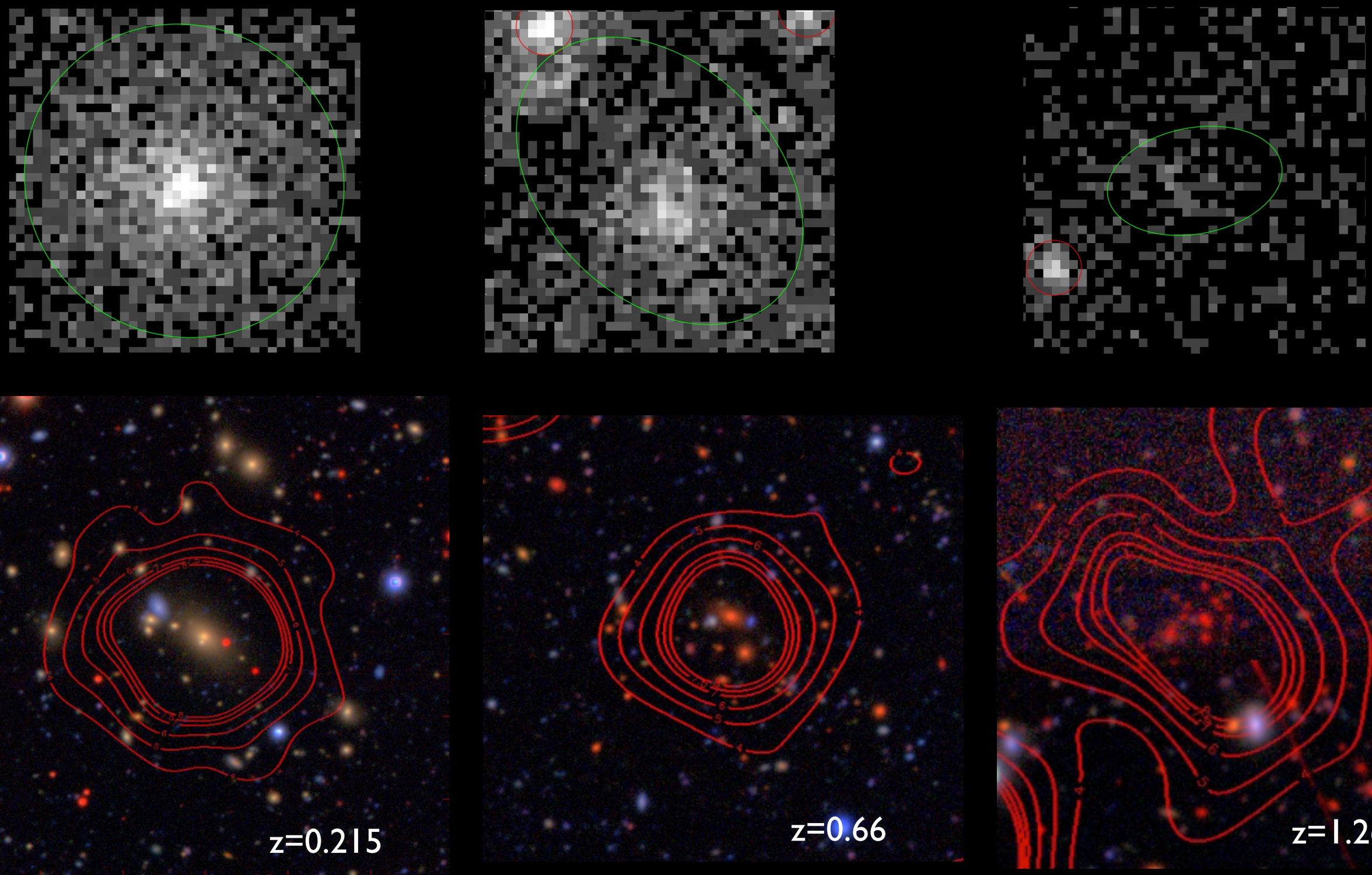
Galaxy Evolution in X-ray Seleced Galaxy Clusters and Groups in Dark Energy Survey Data — Bright Central Galaxies (BCGs)



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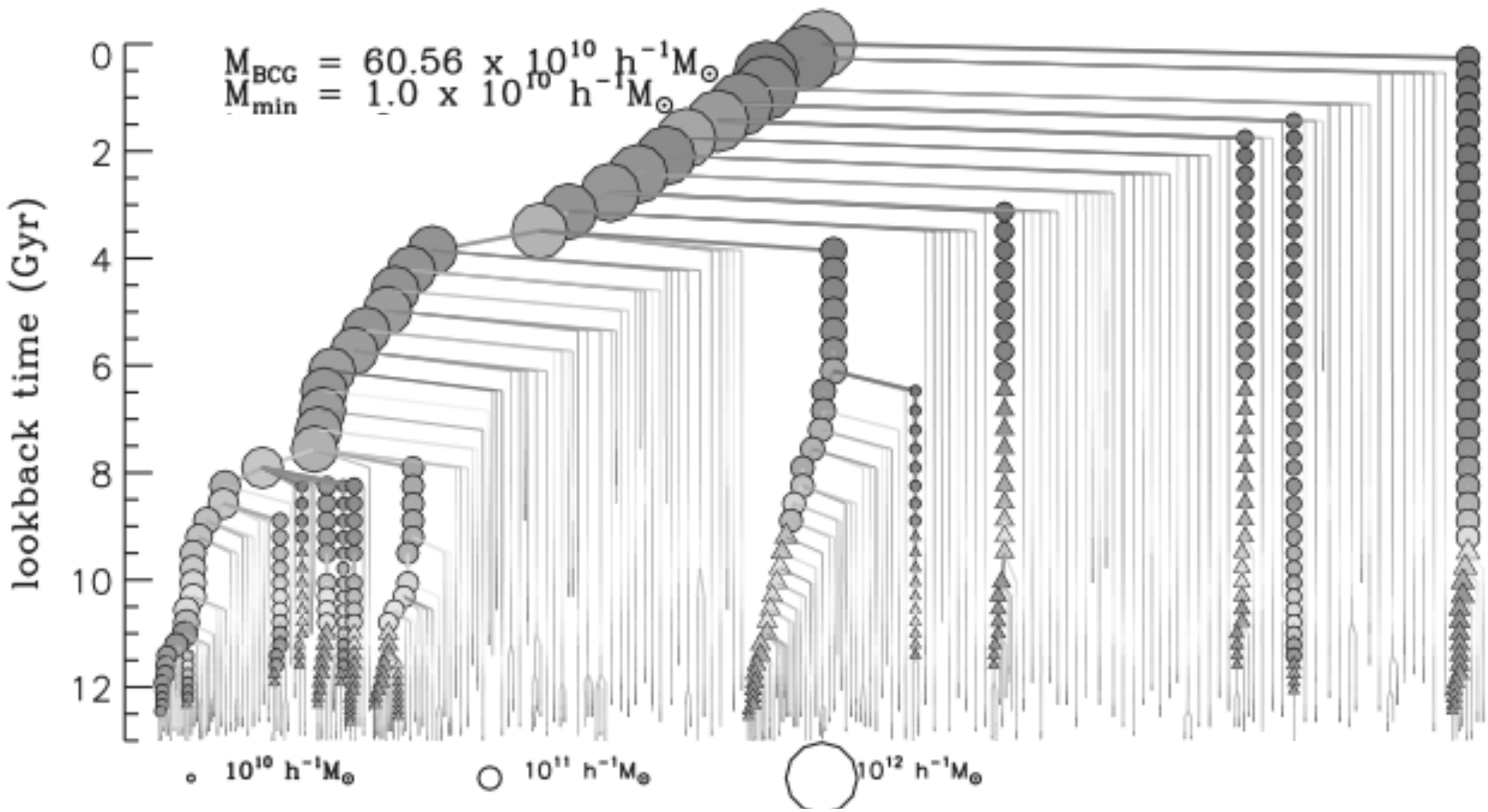
Bright Central Galaxies: BCGs grow through merging with red and old galaxies, which are good tracers of dark matter halos.



The growth of BCGs shall be simple to predict.

De Lucia 2007

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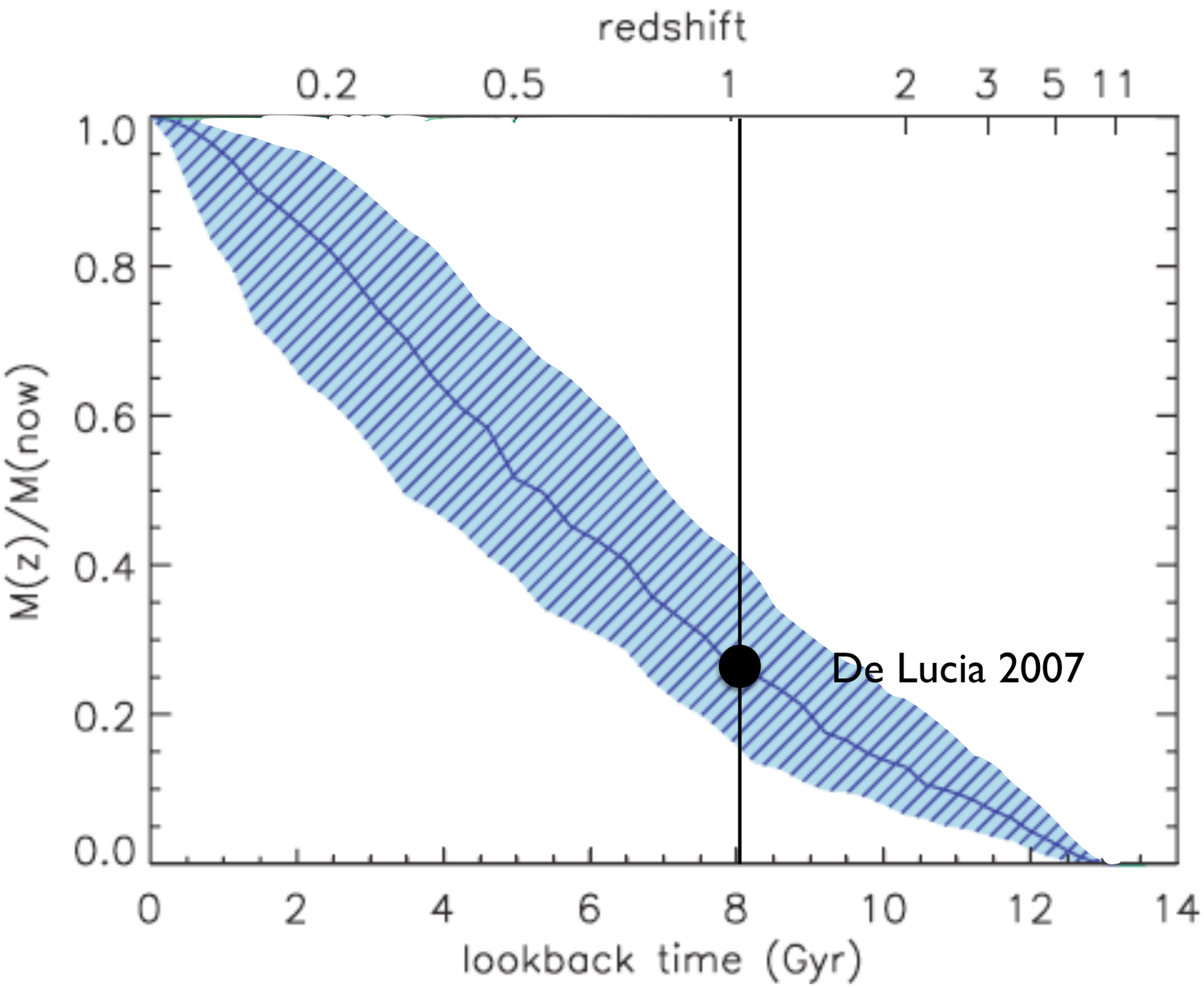
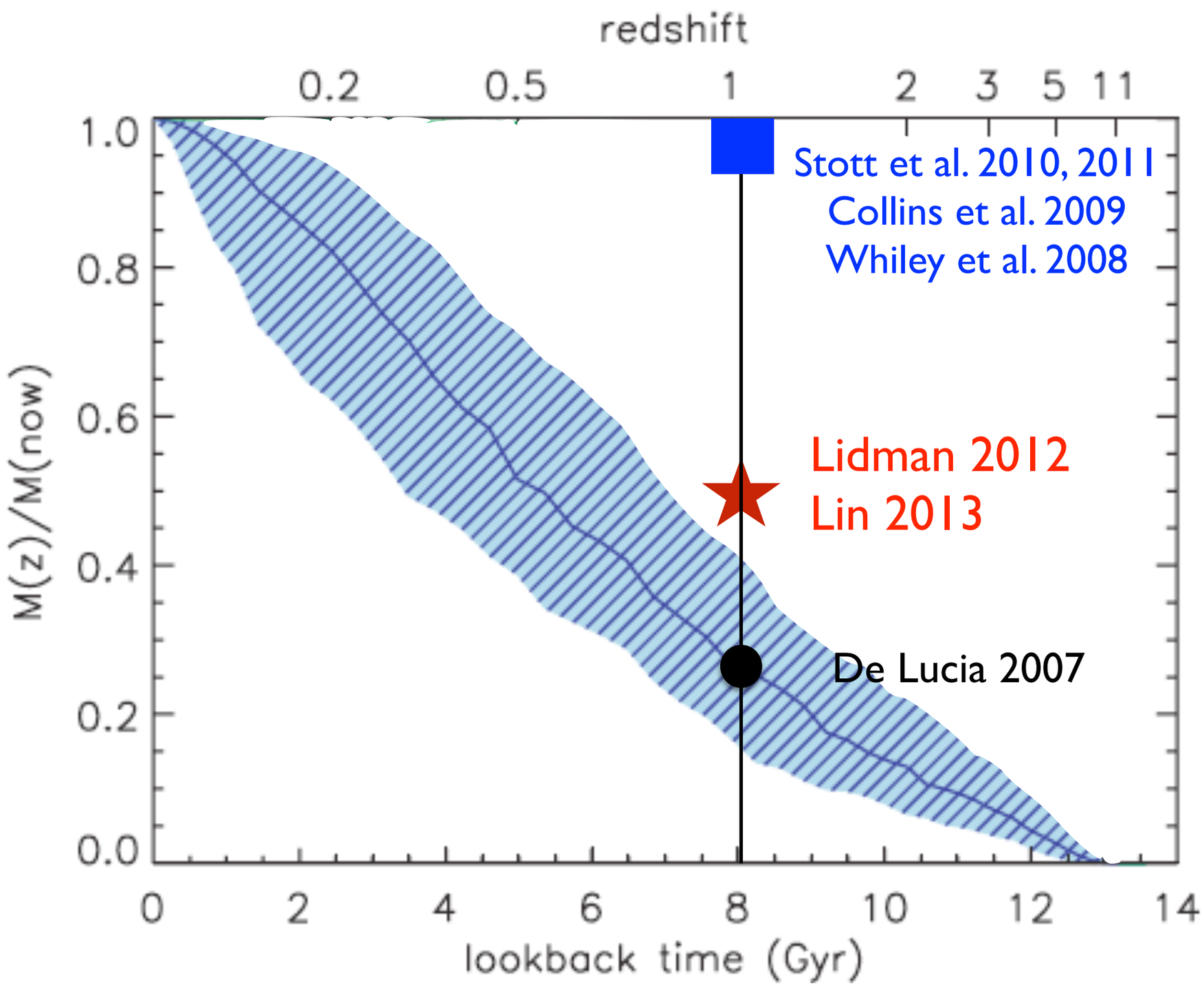


The growth of BCGs shall be simple to predict, but observations do not agree with a simple prediction on BCG growth. Observations also do not agree with each other.



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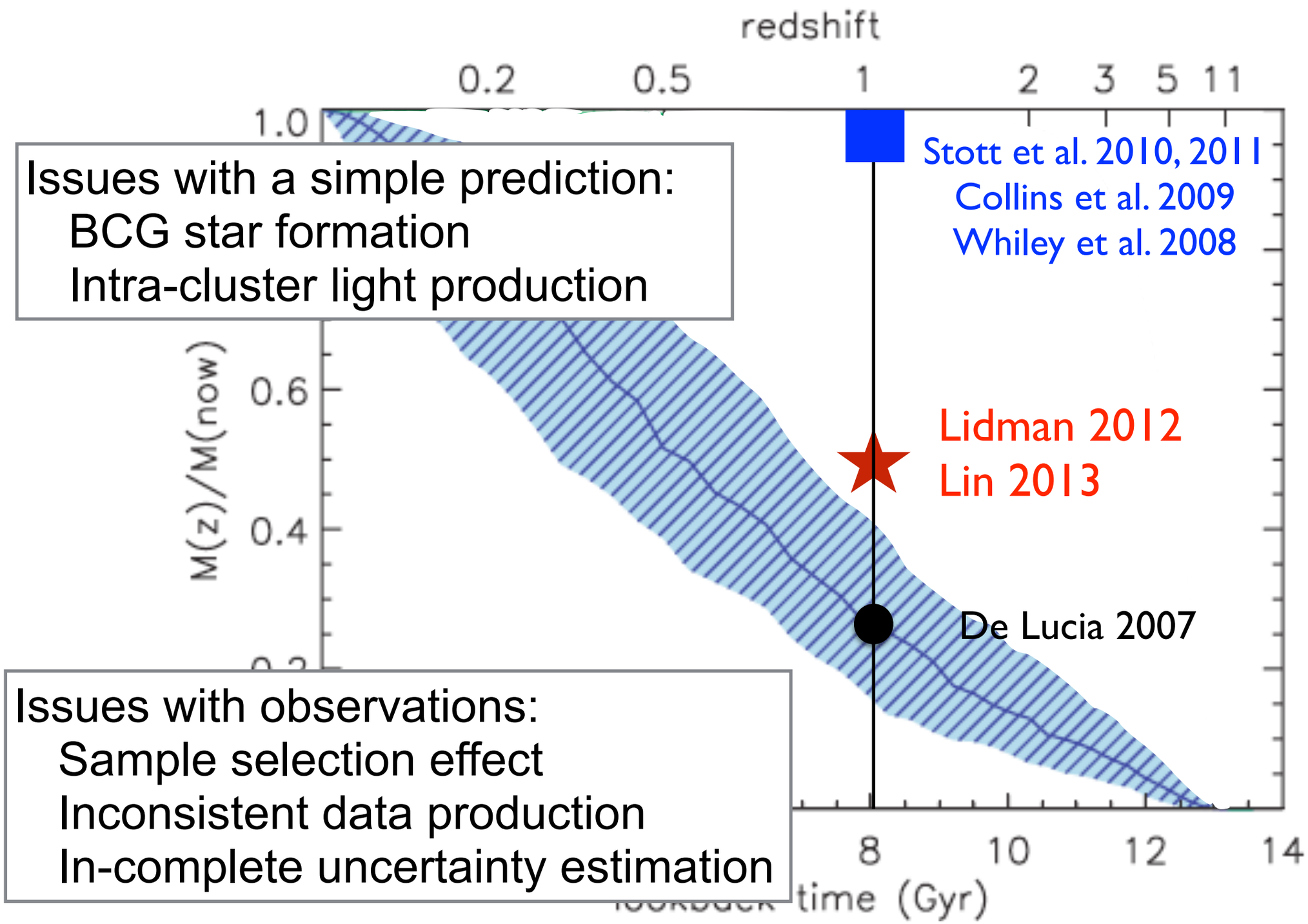
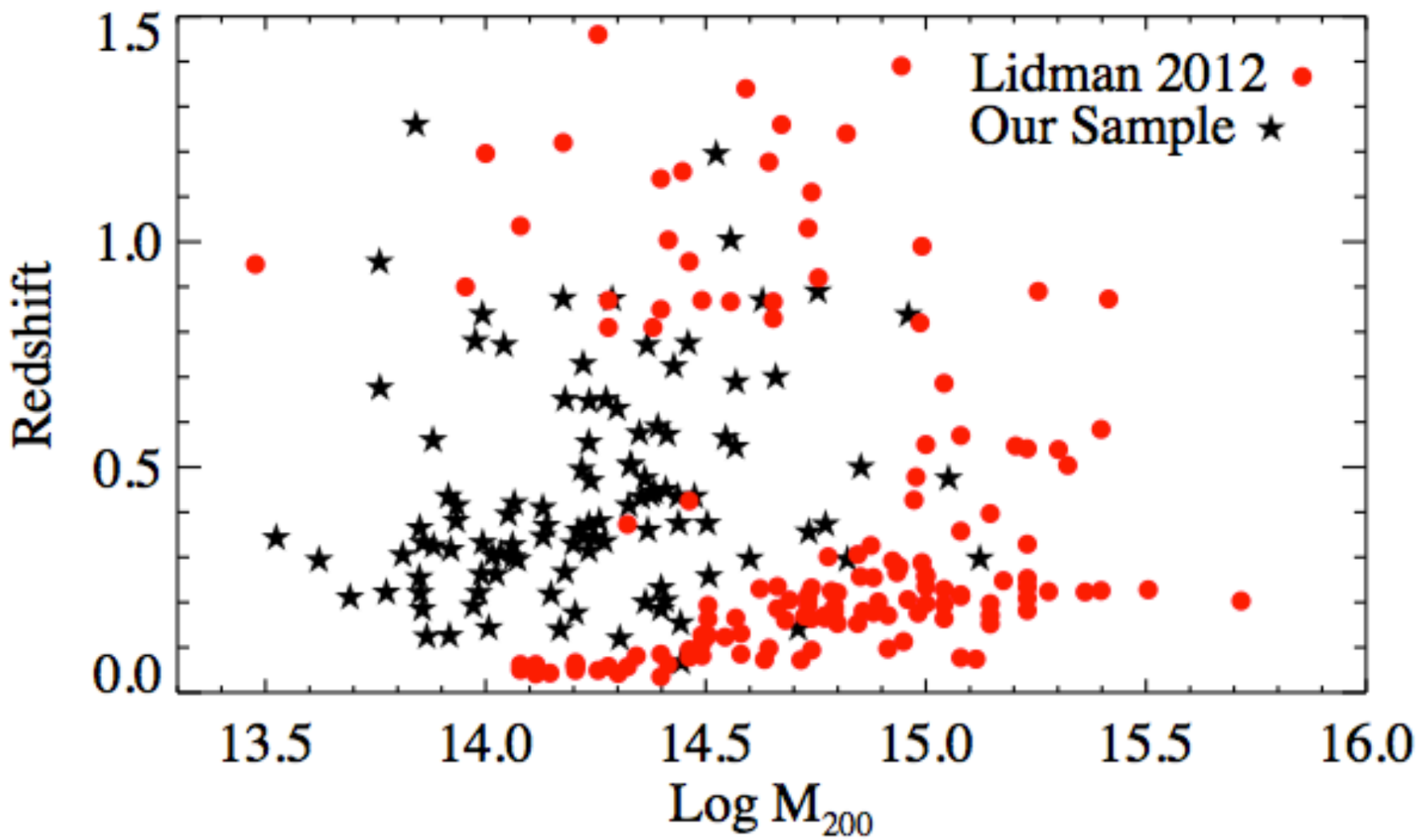


Issues with a simple prediction:
- BCG star formation
- Intra-cluster light production

Issues with observations:
- Sample selection effect
- Inconsistent data production
- In-complete uncertainty estimation

We approach the BCG stellar mass growth problem with the DES X-ray selected cluster and group sample.



Zhang et al. 2015.

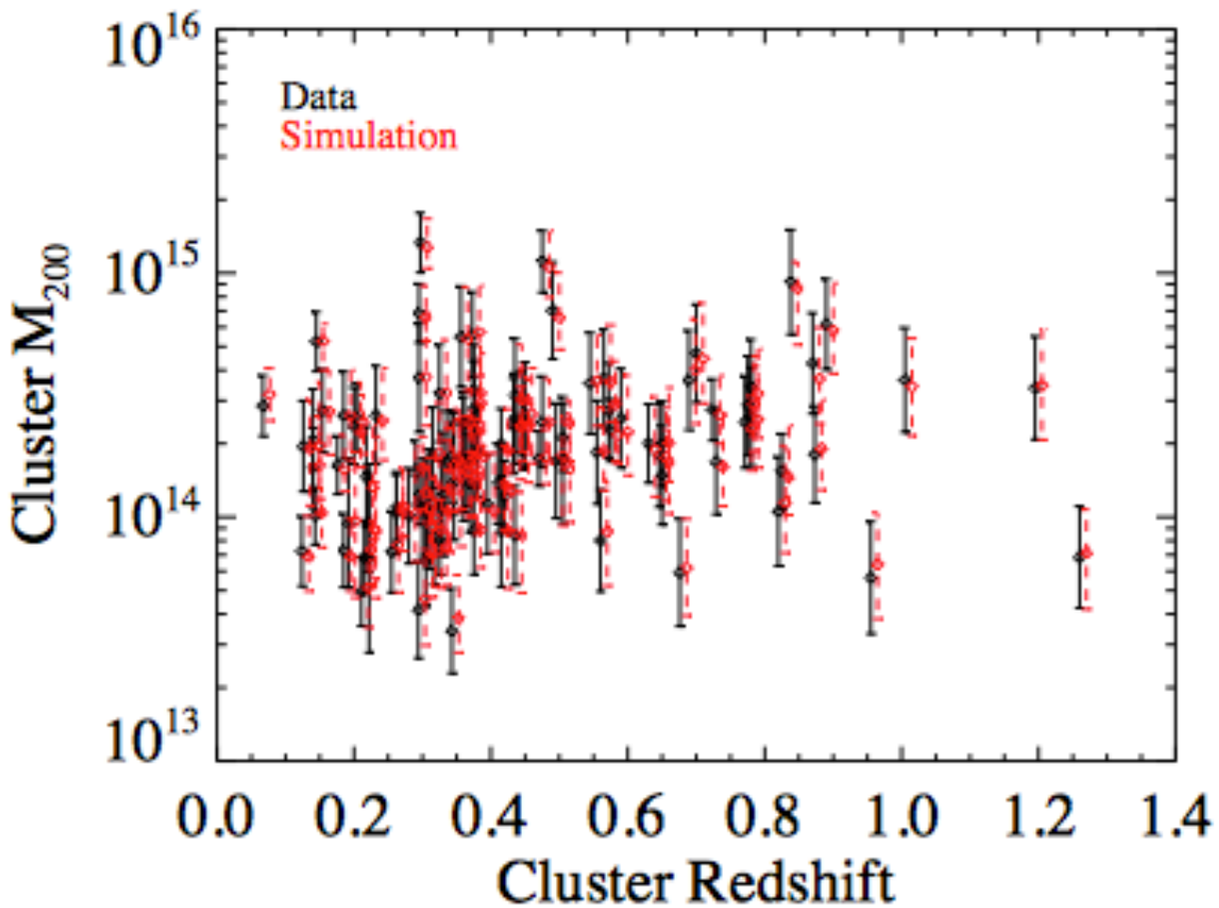
Issues with previous studies:

Sample selection effect — Little.

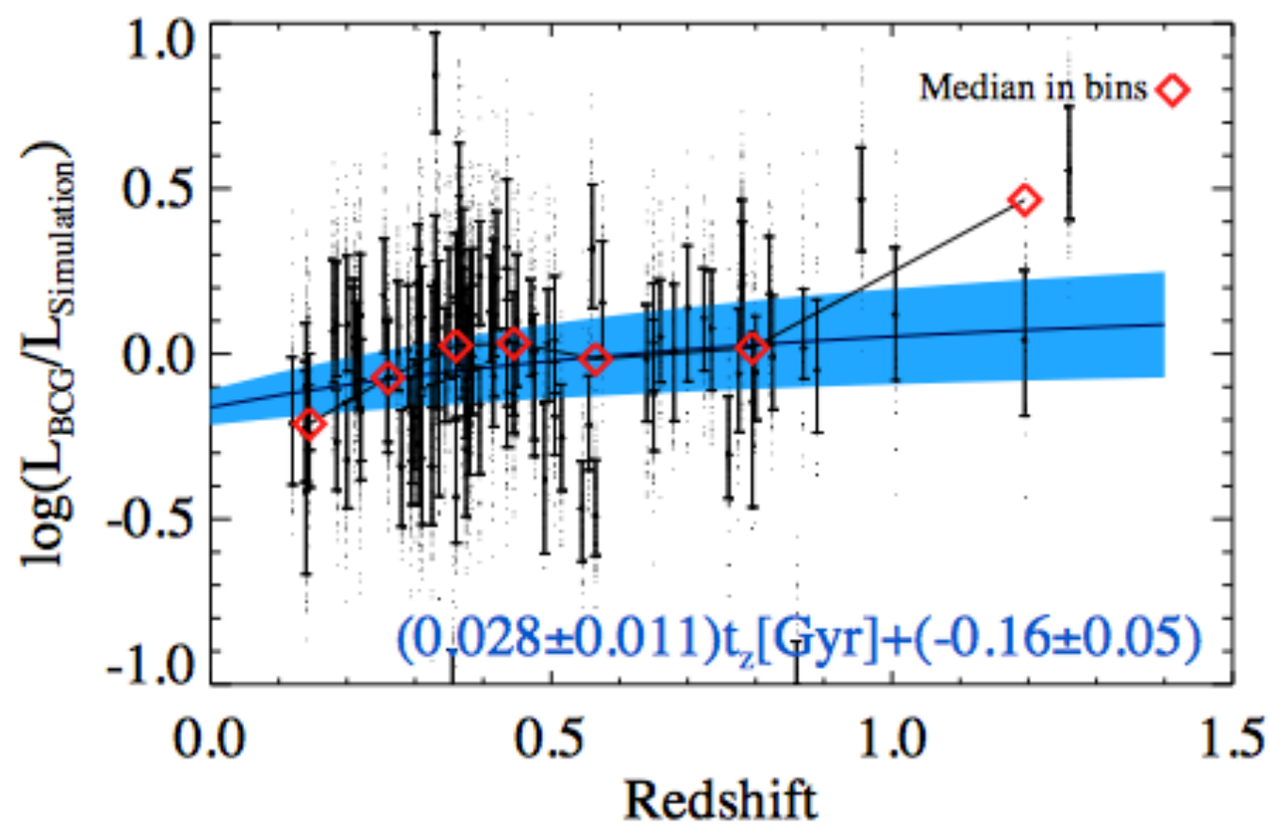
Inconsistent data production — DES data are processed consistently.

In-complete uncertainty estimation — We try our best.

Method 1: A simulation matching exercise



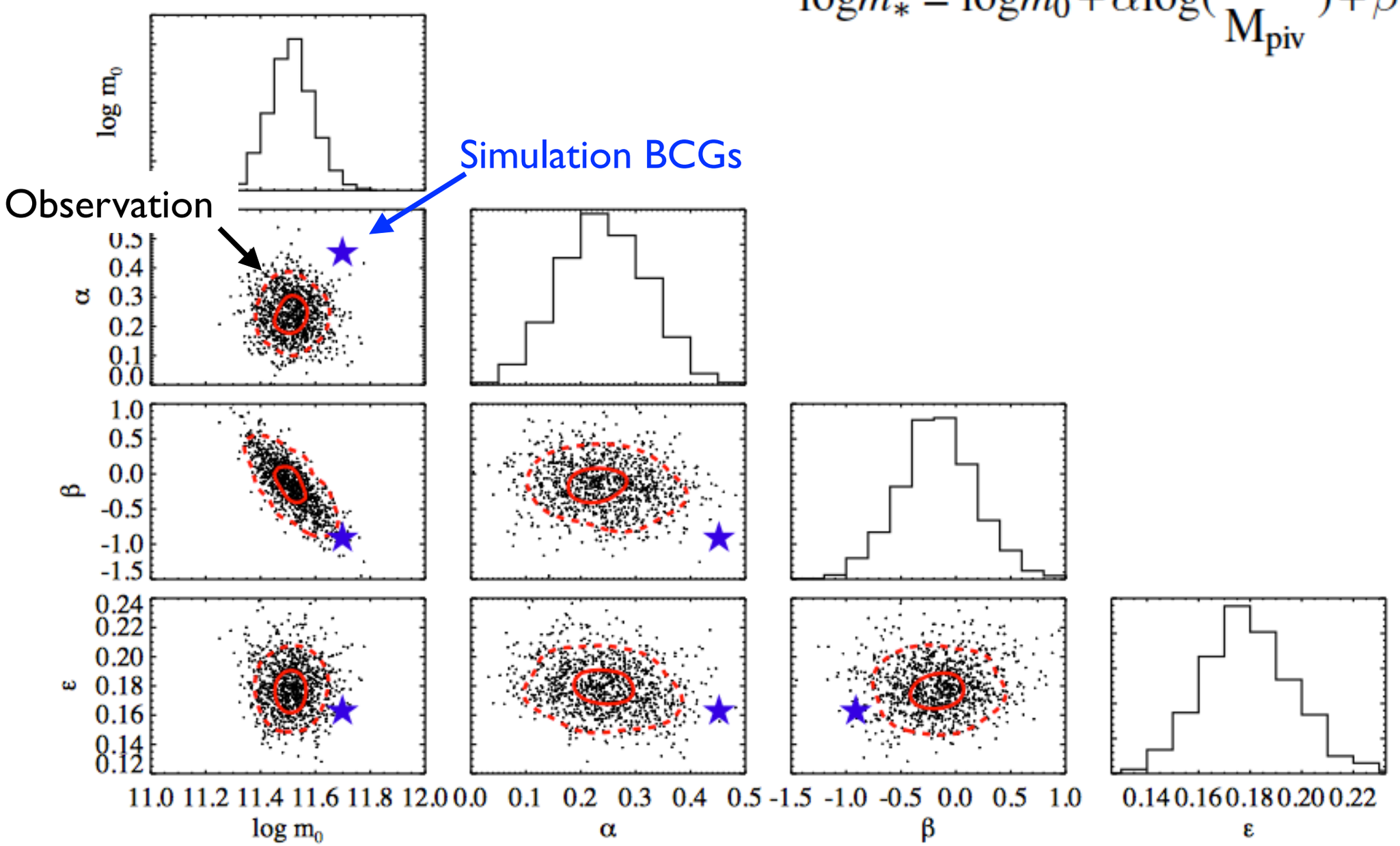
Method 1 Result: Compared to simulation BCGs, the observed BCGs do not gain as much mass toward low redshift.



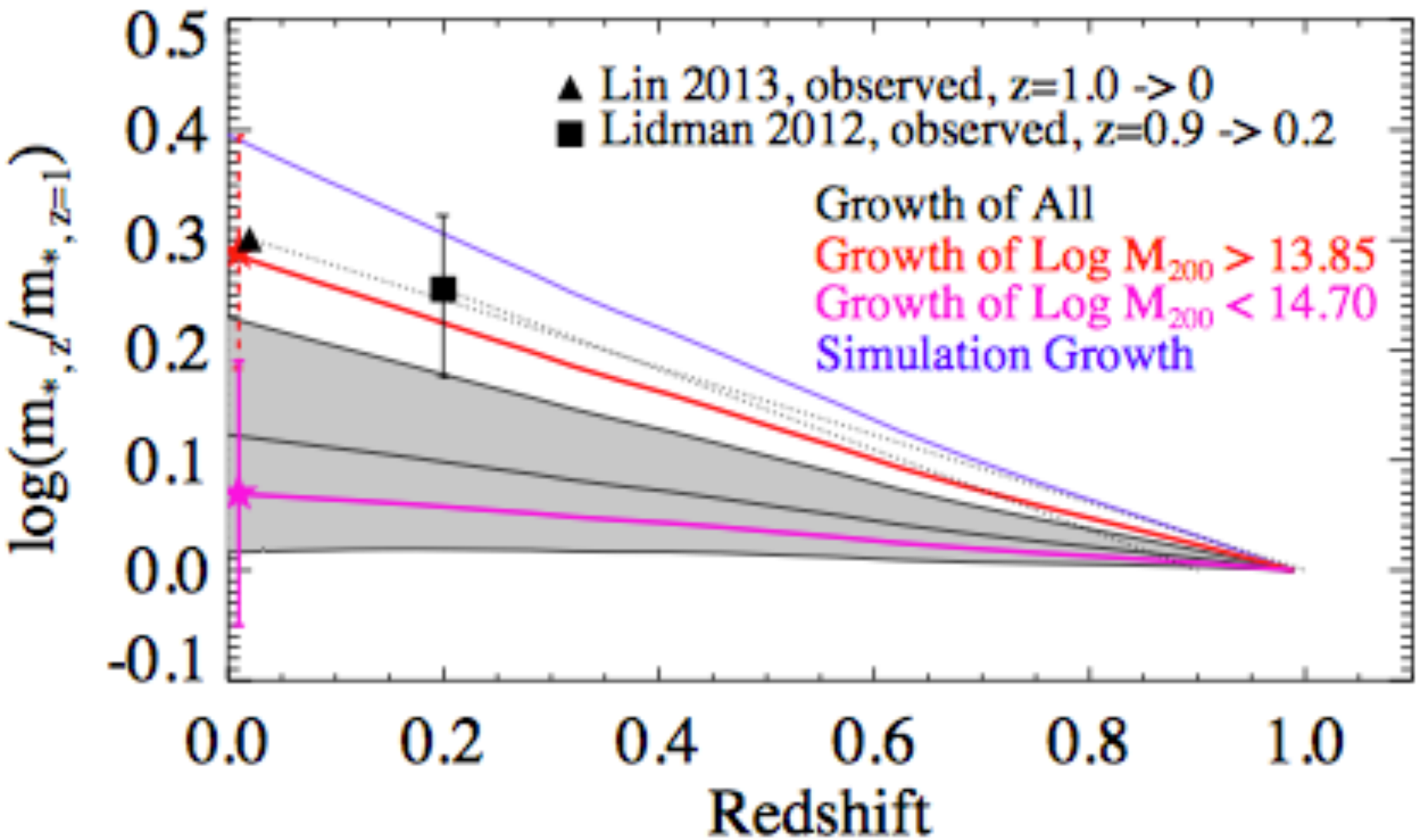
Zhang et al. 2015.

Method 2: Model stellar mass growth for both simulation and observation growth — convenient to incorporate all measurement uncertainties.

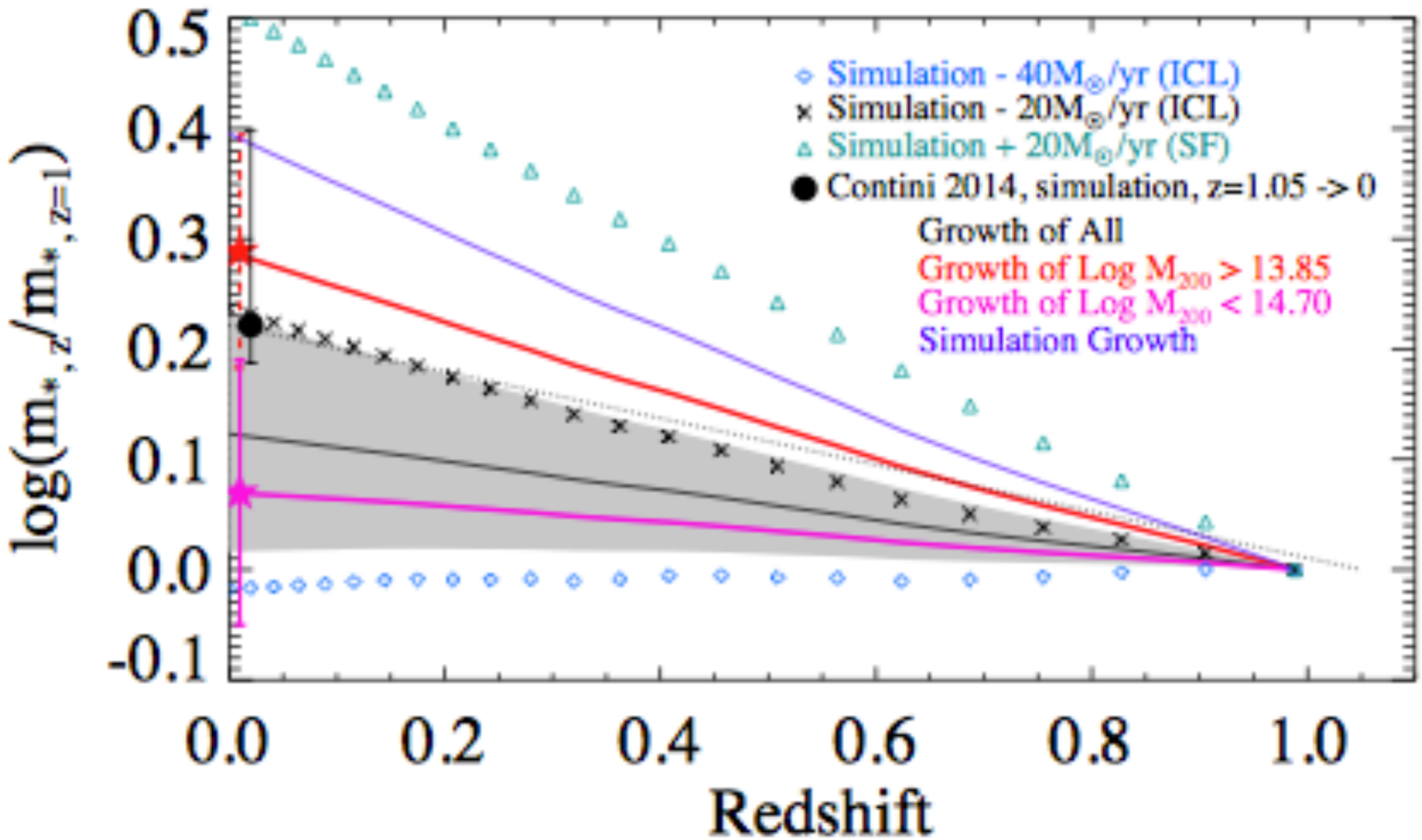
$$\log m_* = \log m_0 + \alpha \log\left(\frac{M_{200}}{M_{piv}}\right) + \beta \log(1+z).$$



Method 2: Observed BCGs grow slower than simulation BCGs. Result is consistent with previous studies considering all known uncertainties.



Method 2: The slow growth can be justified with the late formation of Intra-cluster light.



~ 10 to 50 $M_\odot/\mathrm{yr}$ after z = 1.0.

~ 10% to 40% the total of BCG+ICL stellar masses.

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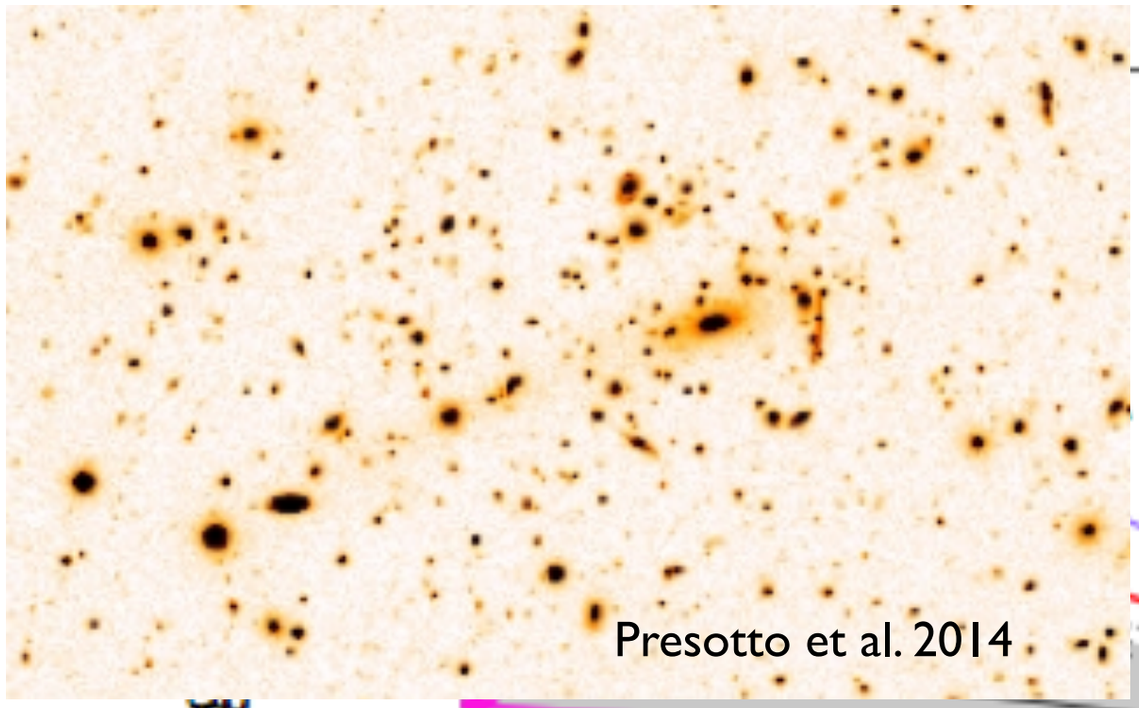
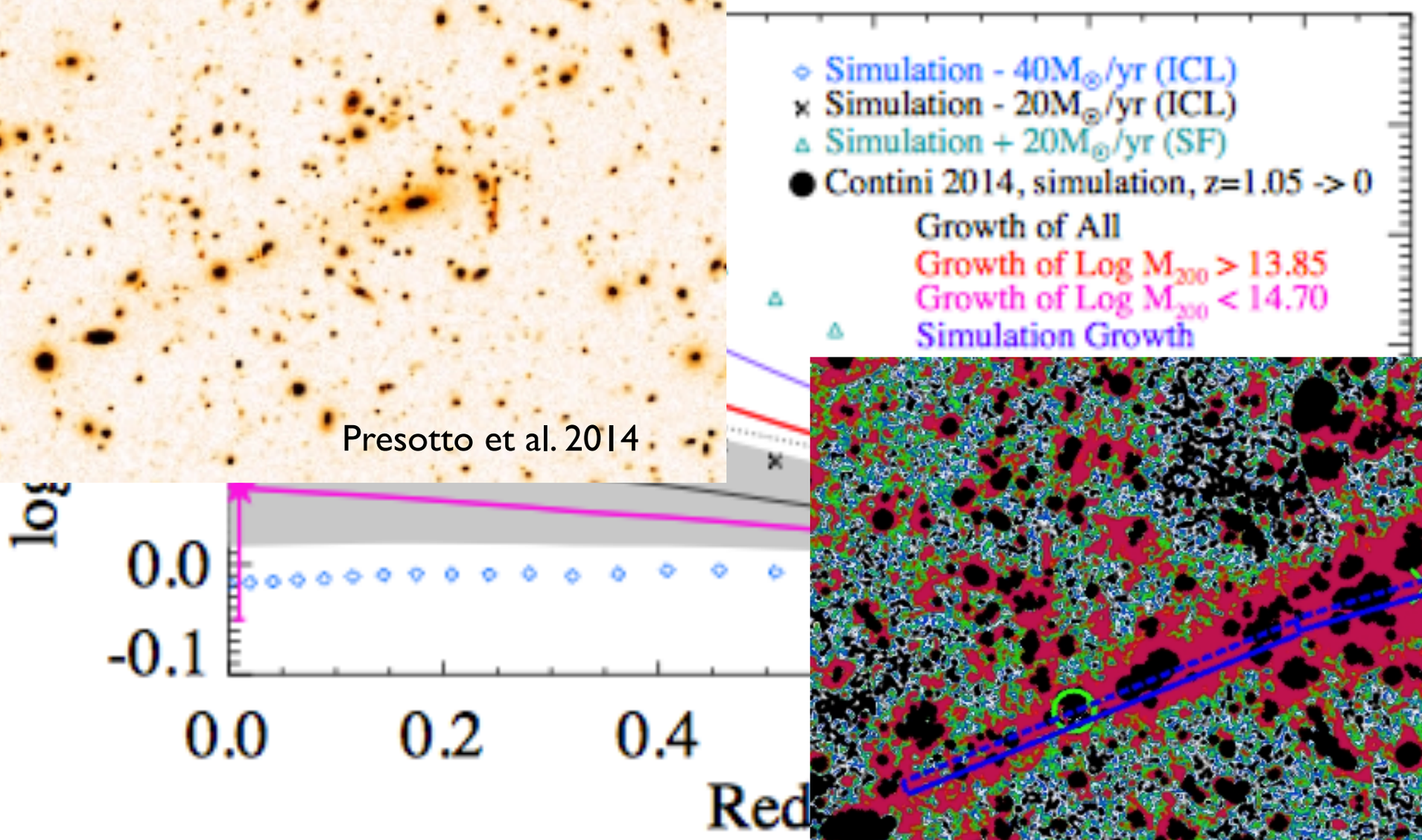
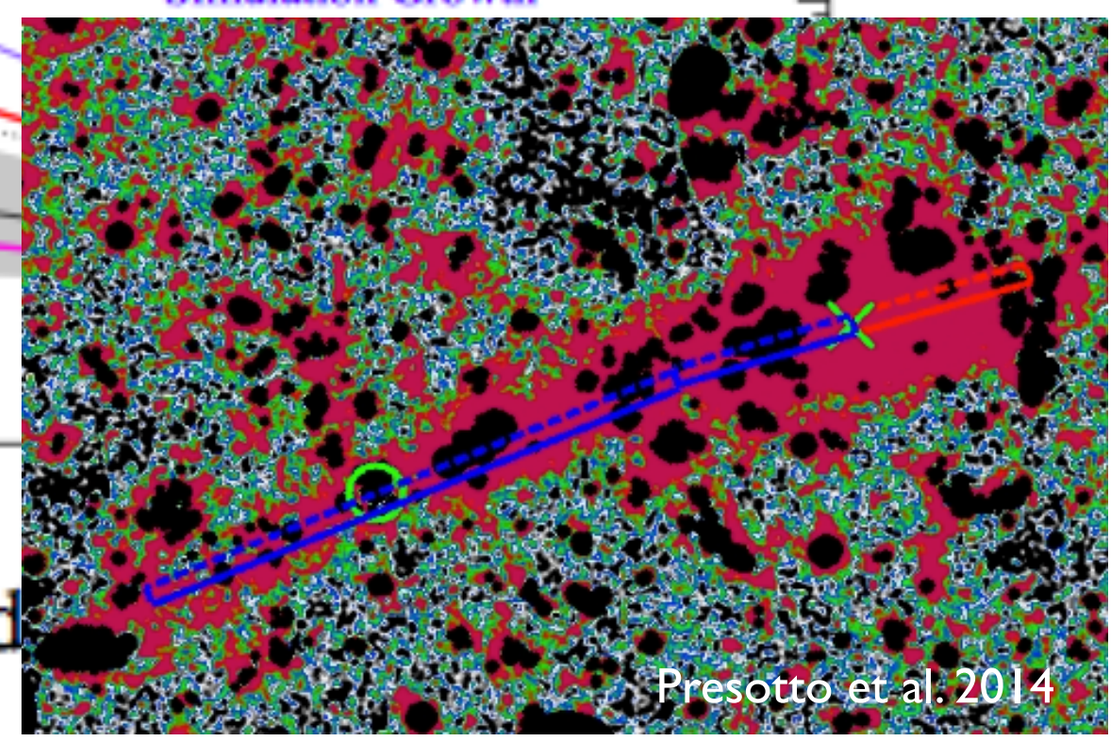




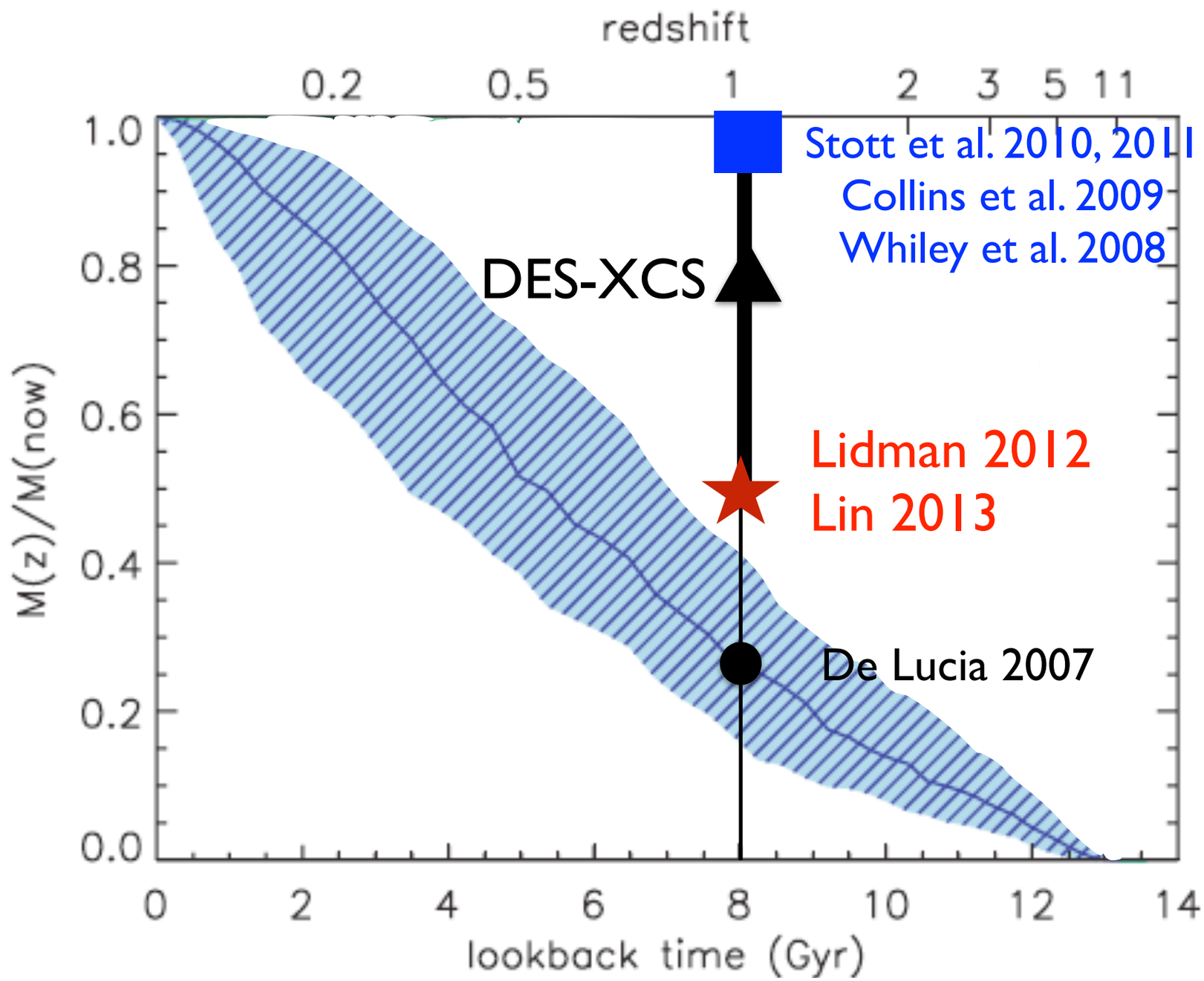


$\sim$ 10 to 50 $M_\odot/\mathrm{yr}$ after z = 1.0.

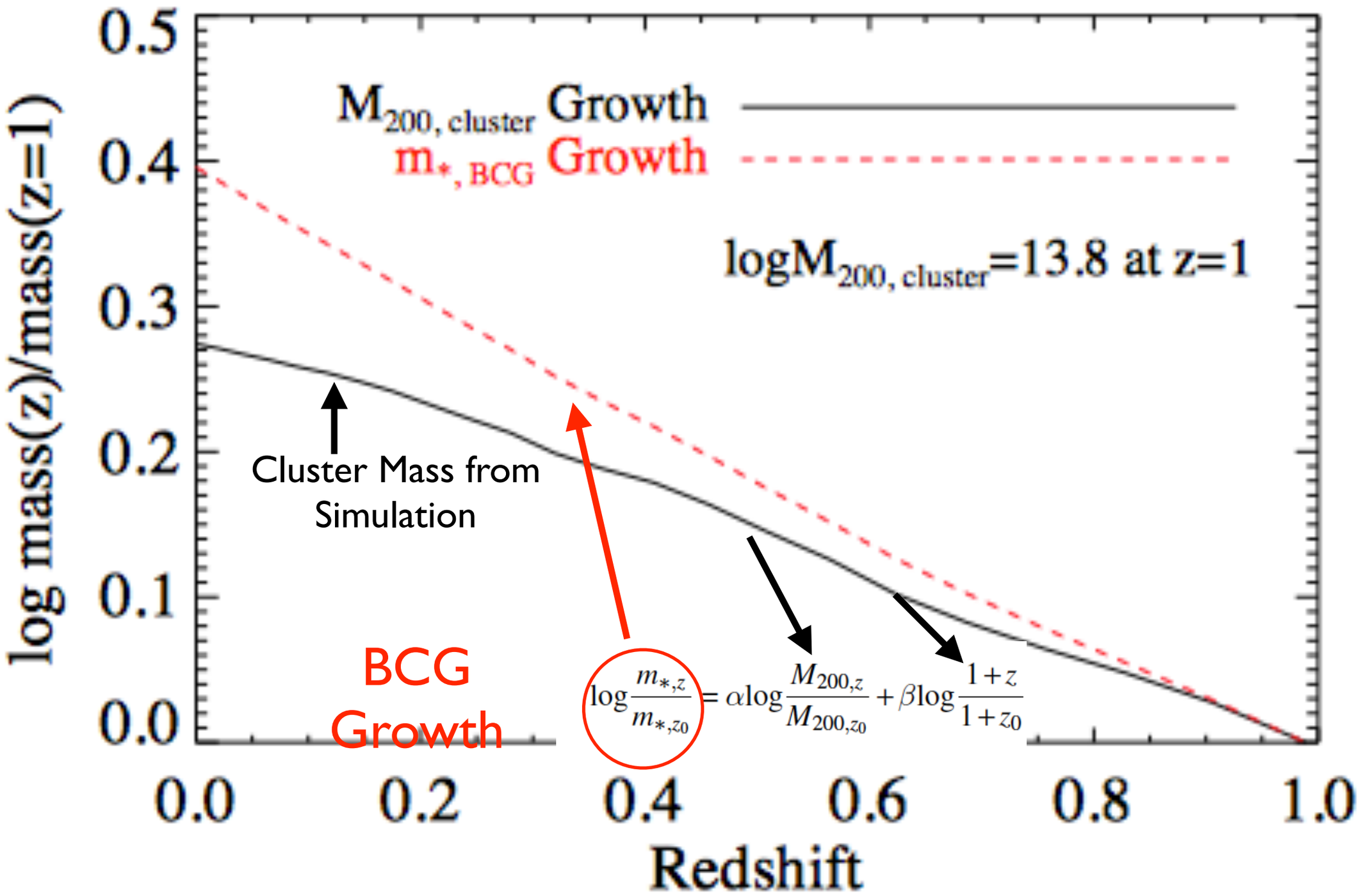
$\sim$ 10% to 40% the total of BCG+ICL stellar masses.

Summary: We use X-ray selected clusters and groups to study the evolution of bright central galaxies.

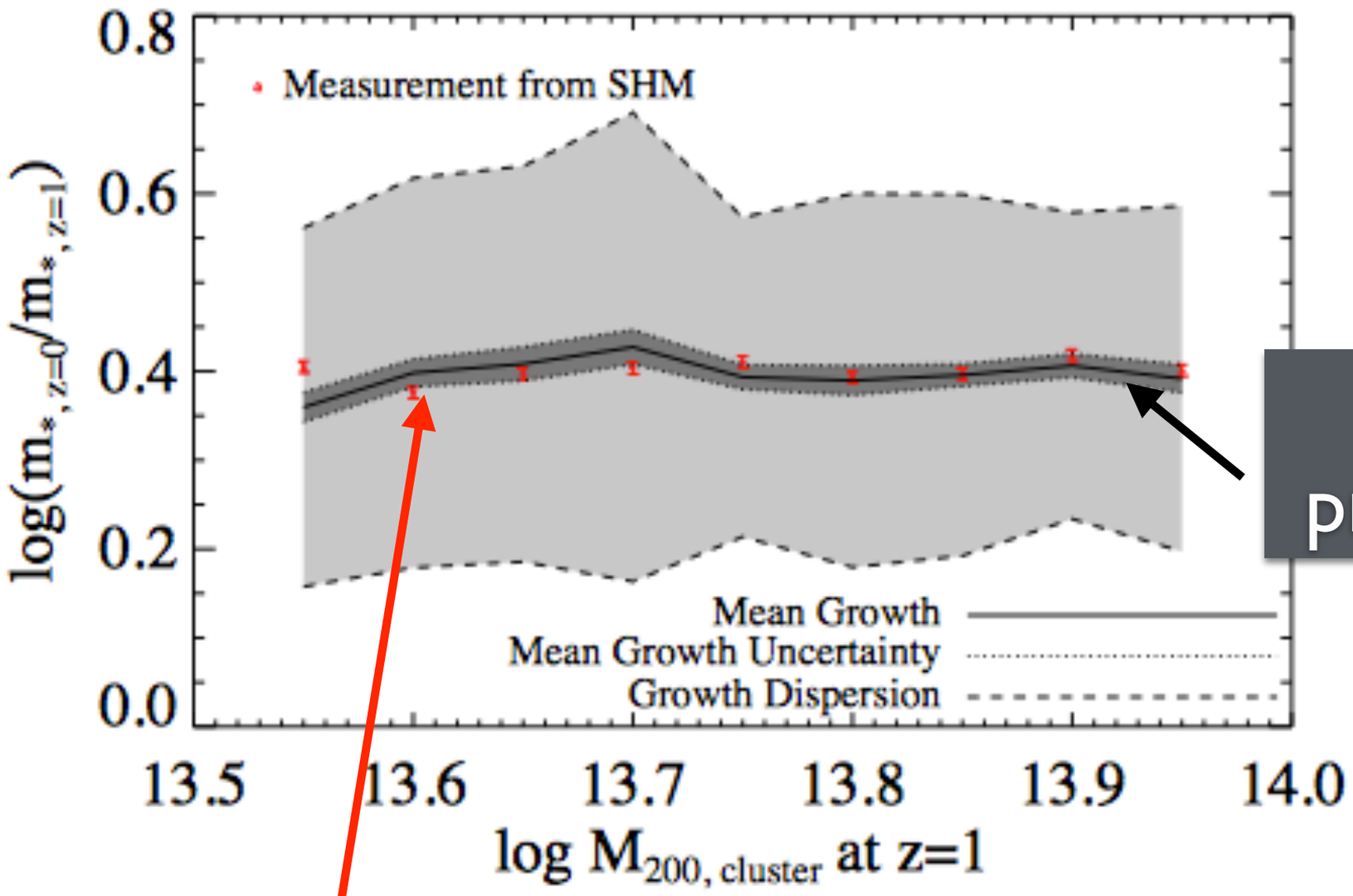
We suggest that the physical processes that control intra-cluster light production to be strengthened in BCGs modeling.



Backup slide: Method for computing BCG stellar mass growth rate.



Backup slide: Method test with simulation.



Tracking progenitors

BCG Growth $\log\frac{m_{*,z}}{m_{*,z_0}} = \alpha\log\frac{M_{200,z}}{M_{200,z_0}} + \beta\log\frac{1+z}{1+z_0}$