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Exploring the Evolution of Brightest Cluster Galaxies since z~2

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Brightest Cluster Galaxies (BCGs)

- The most massive and luminous galaxies in the nearby universe
- Reside in the centre of galaxy clusters/groups
- Unique properties and special environment make BCG evolution important to better understand the evolution of massive galaxies and galaxy clusters

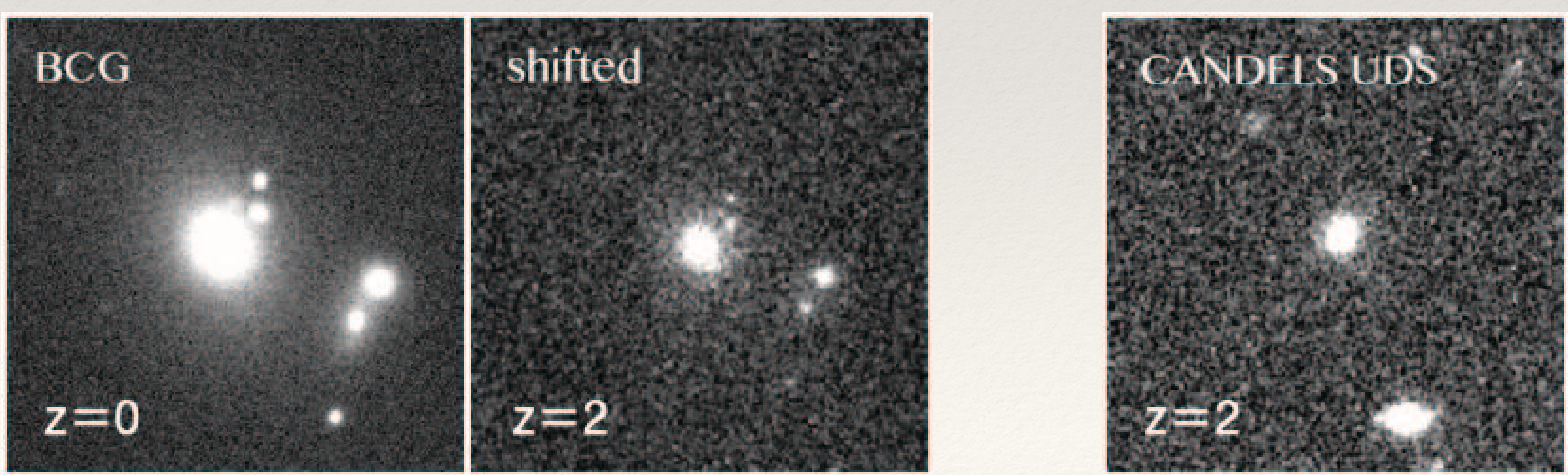
BCG in Abell 370 (*HST* ACS)

Motivation

- Selecting a statistically large sample of BCG progenitors at z~2 in observations
- Studying the structure (size and shape), morphology, stellar mass and SFR/sSFR of our selected BCG progenitors
- Comparing with local BCGs, and discussing the BCG evolution since z~2

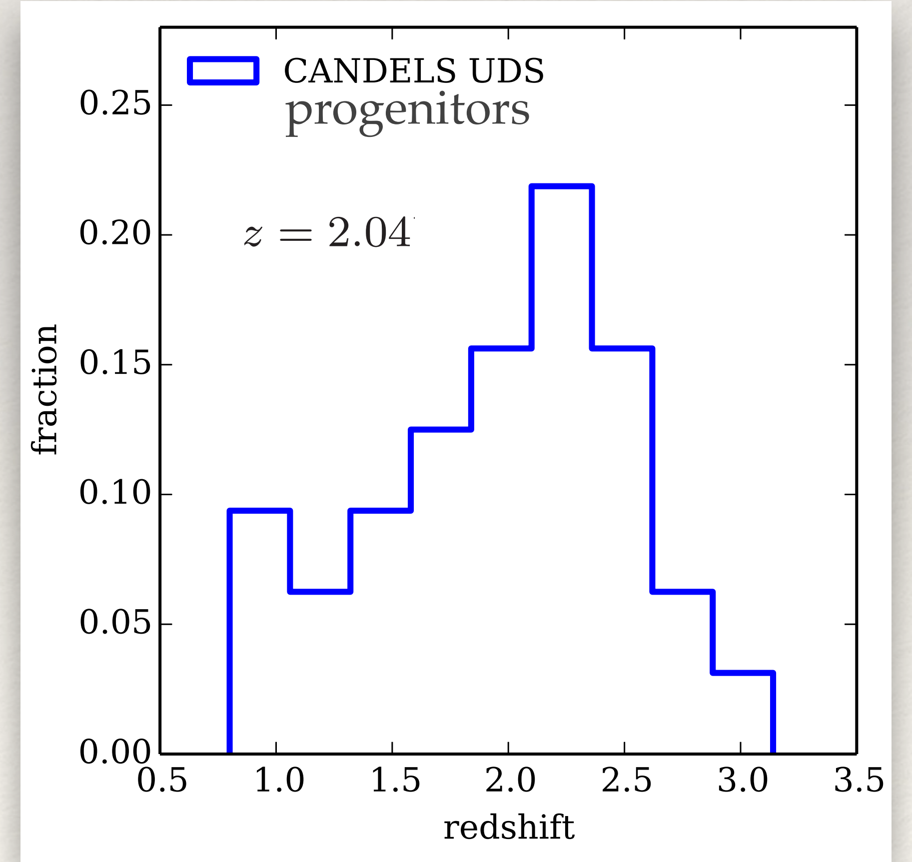
Observational Data

- High redshifts
  - CANDELS UDS galaxies over z=1~3
  - CANDELS UDS images
- Local universe
  - Descendants are selected from BCG catalogue of von der Linden+07 and SDSS DR7 galaxy catalogue over $0.02 \leq z \leq 0.10$
  - SDSS DR7 images, which are moved to z=2 and observed by CANDELS UDS. This is done by using FERENGI code (Barden+08)



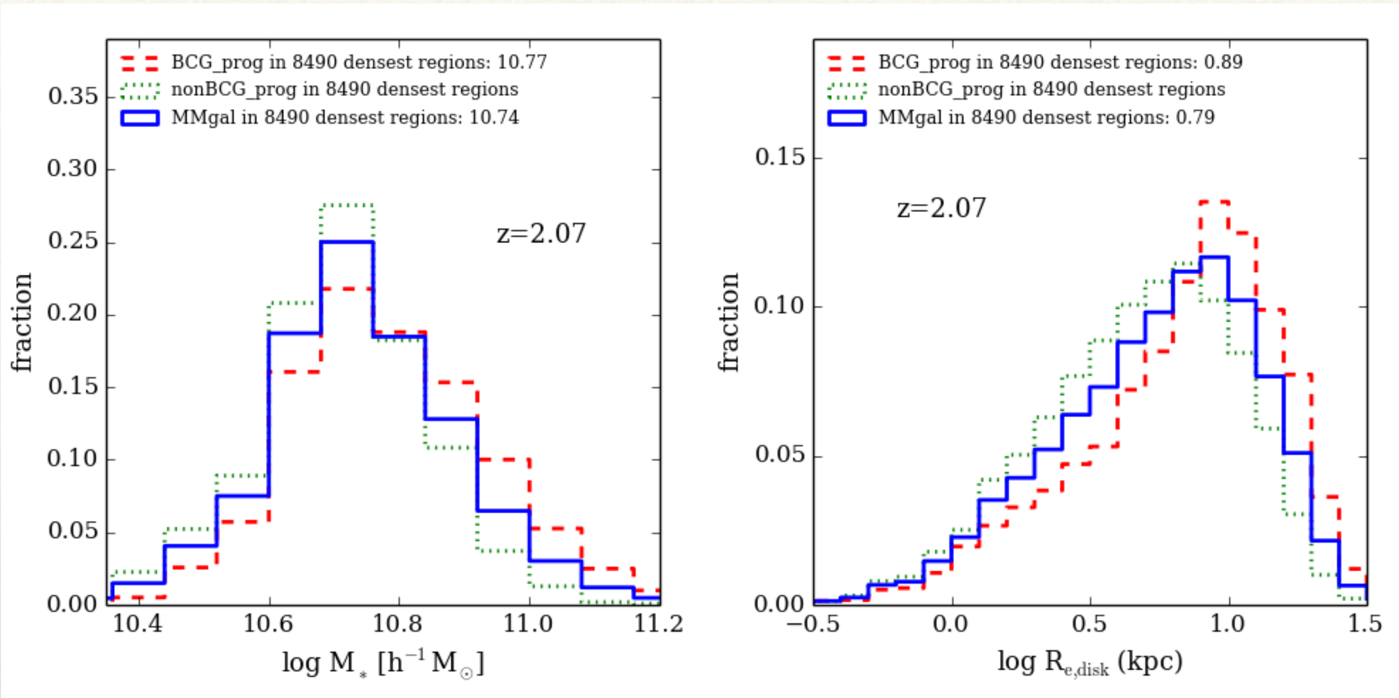
Selecting BCG Progenitors

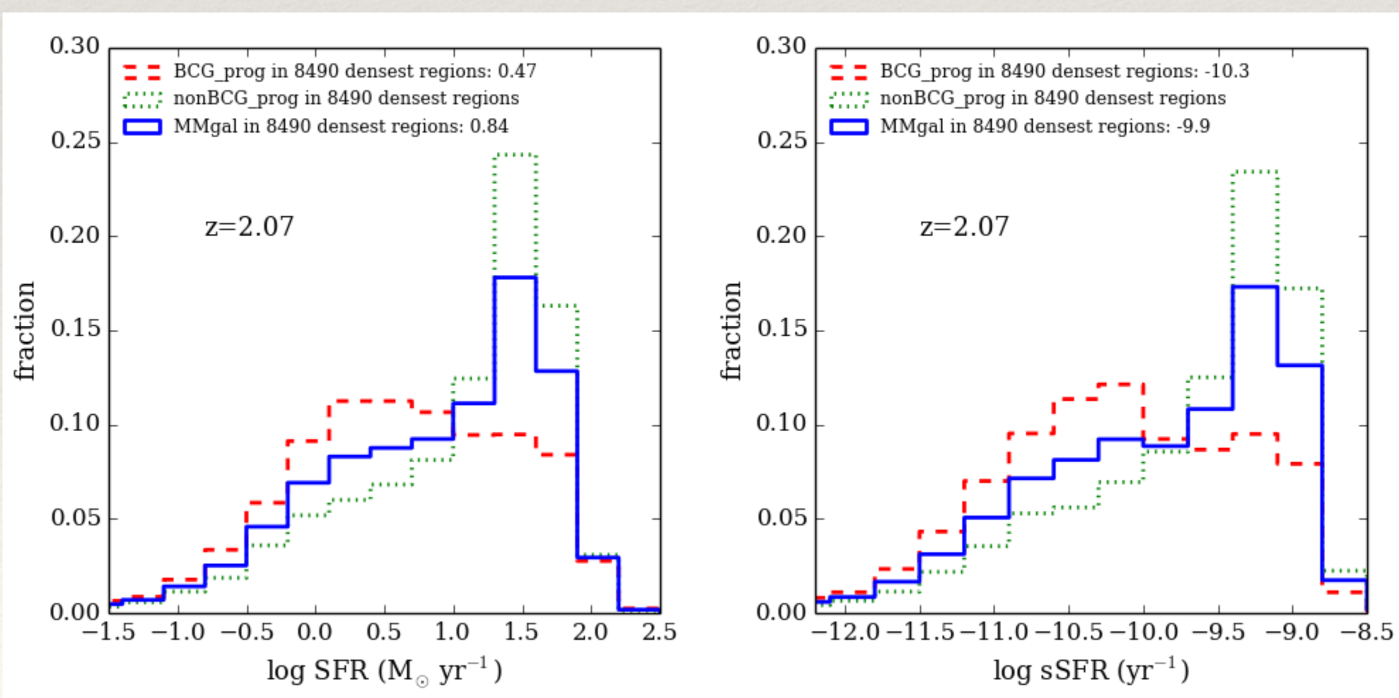
- Assumption1: **Progenitors of local BCGs are the most massive galaxies in the densest regions**
- Assumption2: **Constant number density of 10^{-4} h^3Mpc^{-3}**
- 38 progenitors can be selected as the most massive galaxy in the top 38 densest regions from CANDELS UDS survey



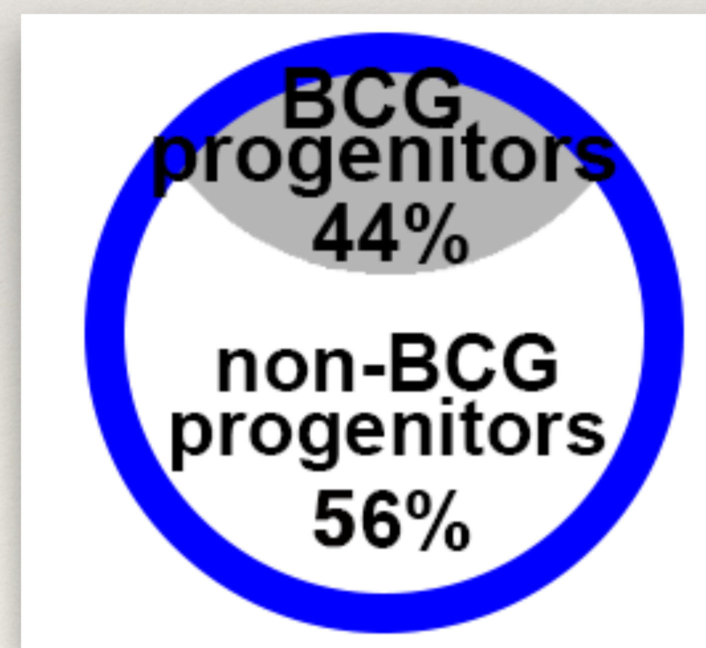
- Q: What fraction of the true BCG progenitors can likely be selected?
- A: **44%** of the selected progenitors by our method are true BCG progenitors, and 56% are non-BCG progenitors (contaminants)

Effect of Contaminants at High-z

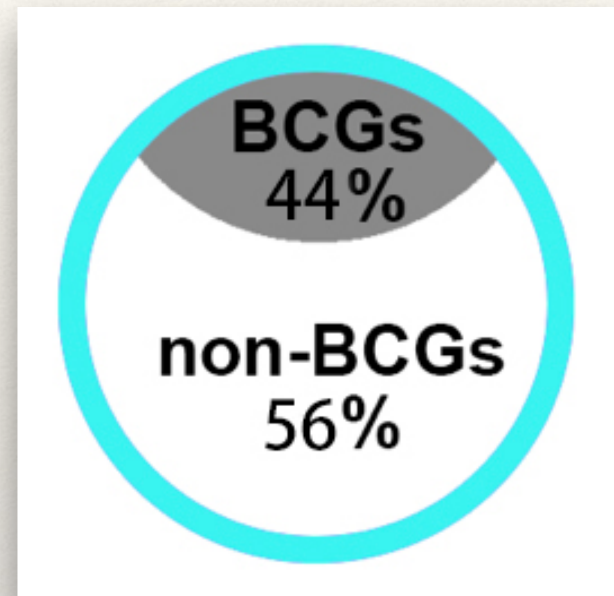




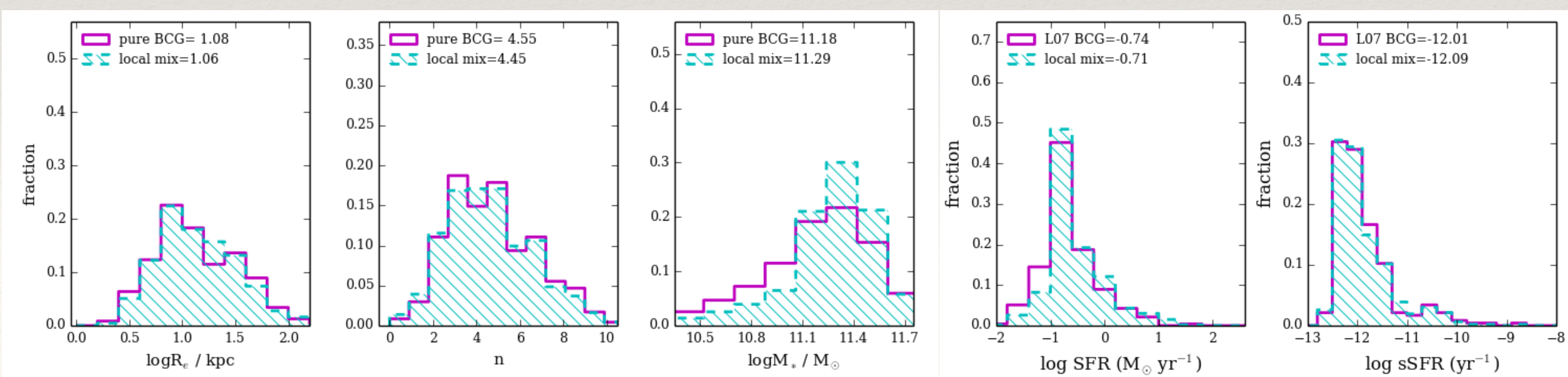
- The differences are ≤ 0.1 dex from contaminants for stellar mass and size.
- Contaminants make SFR / sSFR larger by a factor of ~0.4 dex.



Descendants at z=0



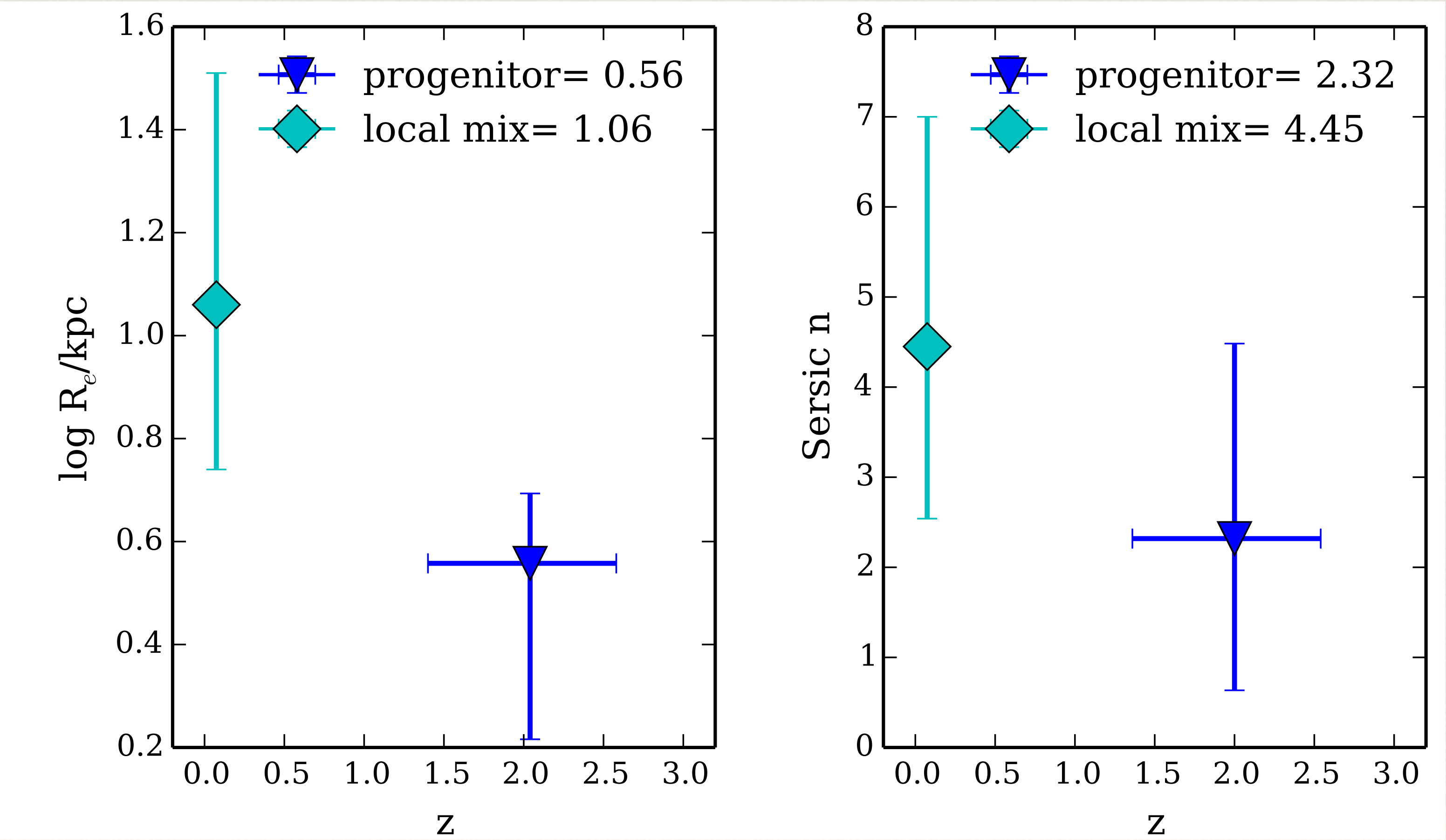
- 470 descendants with number density of 10^{-4} h^3Mpc^{-3}
- Within 470 local descendants, 44% (207) are BCGs and 56% (263) are non-BCGs
  - 207 BCGs are selected from BCG catalogue of von der Linden+07
  - 263 non-BCGs are selected from SDSS DR7 galaxy catalogue according to the mass distribution
- The contaminations are no more than 0.1 dex from non-BCGs for structure, stellar mass and SFR/sSFR



BCG Evolution since z~2

1. size and shape evolution

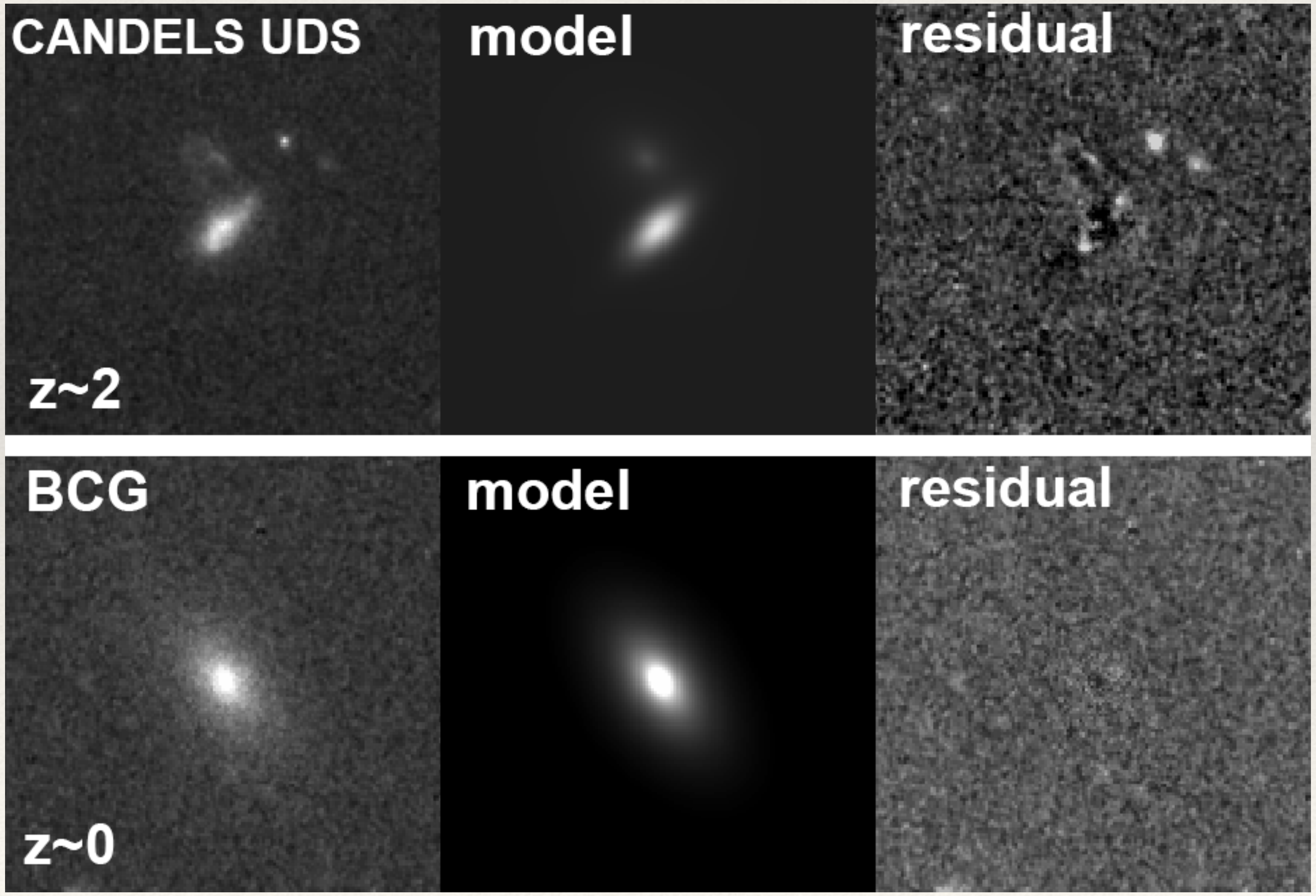
- Size of BCGs has grown by a factor of ~3.2 since z~2.
- BCG progenitors are late-type galaxies with Sersic index n~2.3, while their local descendants are early-type galaxies with Sersic index n~4.5.



BCG Evolution since z~2

2. morphology evolution

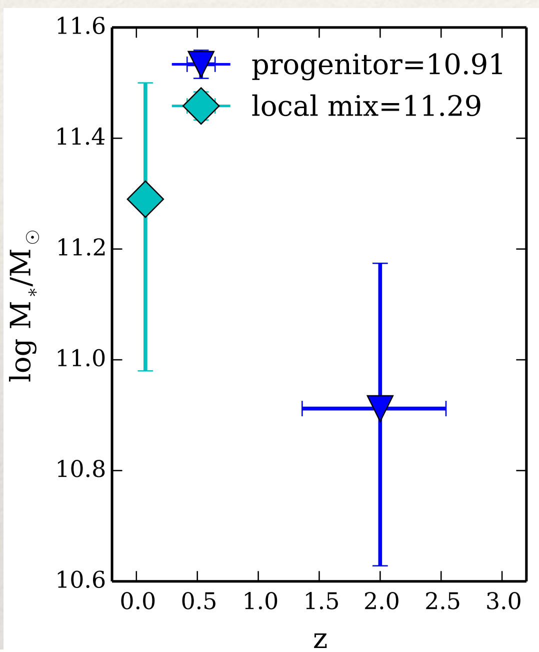
- 30% BCG progenitors at z~2 are disturbed, while all local BCGs have smoother profile.

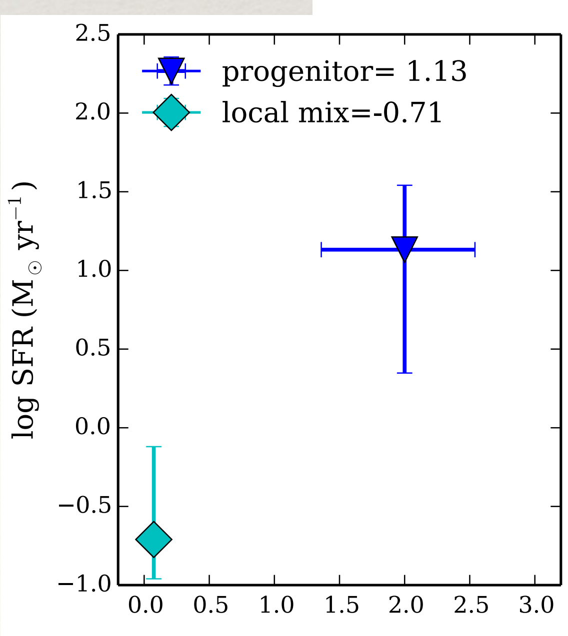


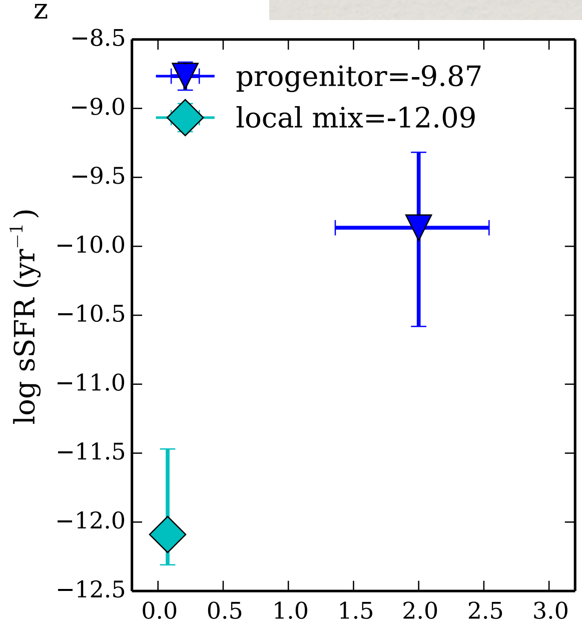
BCG Evolution since z~2

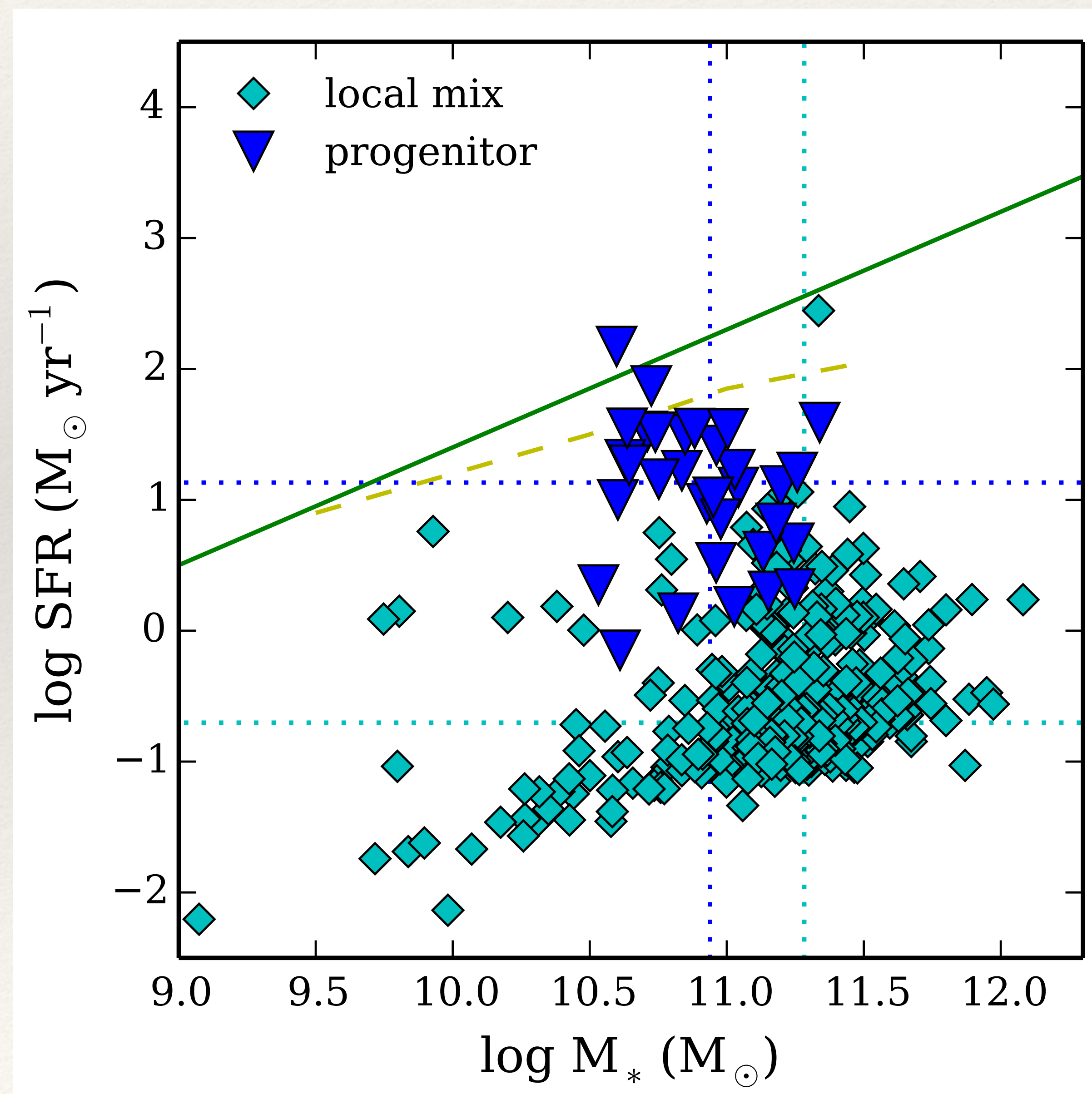
3. stellar mass evolution

- Stellar mass of BCGs has grown by a factor of ~2.5 since z~2
- SFR is ~70 times (sSFR is ~166 times) larger at z~2 than z~0









Mechanisms driving BCG Mass Growth

- At high redshifts (z=1~2):
  - Star formation contributes ~18% of the stellar mass of local BCGs
  - Merging contributes ~ 12% of the stellar mass of local BCGs by using merger rate of Hopkins+10
- At low redshifts (z<1):
  - Our results show that by z ~ 1 the BCG stellar mass will be no more than 70% of the total local mass, suggesting that there has to be an additional mass build-up in BCGs after z ~ 1. The BCG mass will increase by a factor of no less than 1.4 at z=1-0.
  - Little contribution from star formation.
  - Merger is the dominant process.

Take Home Messages

- At z~2, less than 50% of the most massive galaxies in the densest environments are the true BCG progenitors.
- Our selected observational sample can be employed to study BCG evolution since the uncertainties introduced by contaminants are relatively small.
- Since z~2, the size of BCG has grown by a factor of ~3.2 and stellar mass by a factor of ~2.5. The BCG progenitors are less concentrated and more disturbed while the local BCGs are smoother early-type galaxies.
- Merger and star formation contribute equally for BCG mass growth at high redshift (z=1~2). At lower redshift (z<1), merger is the dominant process.
- Dongyao Zhao, et al. 2017, MNRAS, 464, 1393

Thank you