Relationship between Morphology and Structure of Brightest Cluster Galaxies and their Environment

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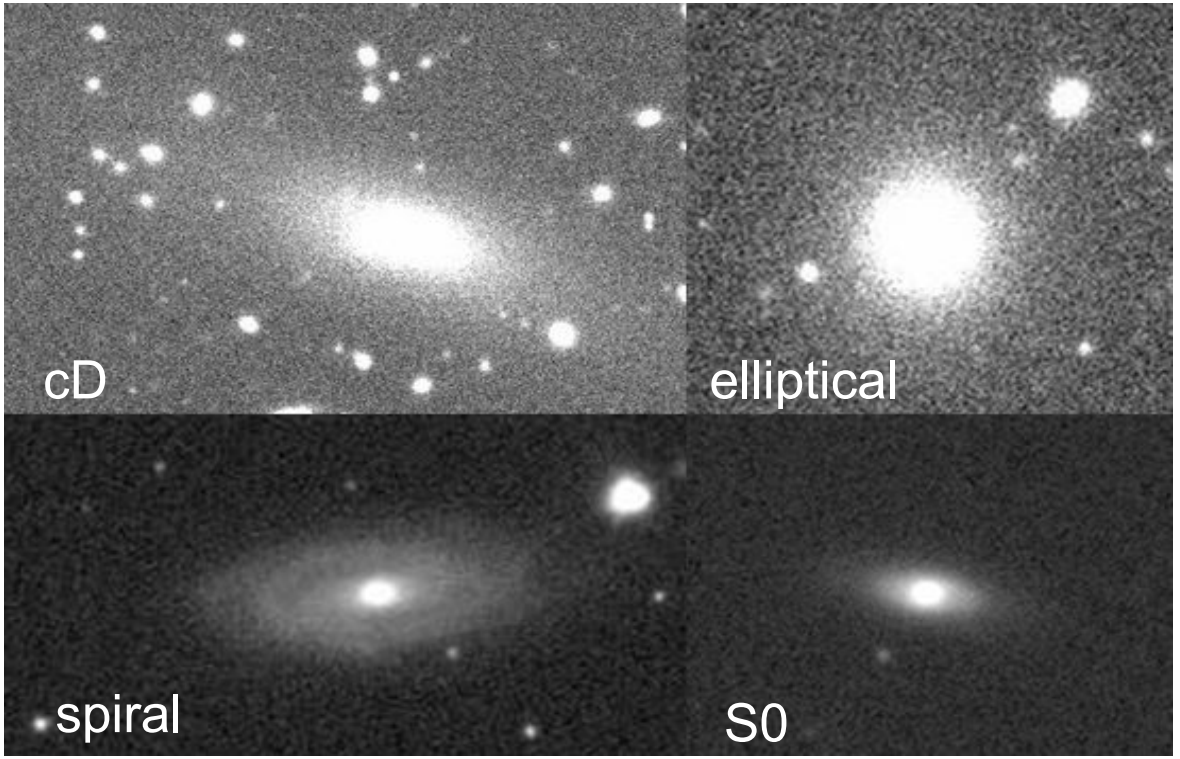
Motivation

- Brightest cluster galaixes (BCGs): the most massive and luminous galaxies in the universe
- Most BCGs are either giant ellipticals or cD galaixes
  - Do structural properties link with morphologies of BCGs?
  - Automatic selection of cD galaxies
  - Do structural properties of BCGs link with intrinsic properties or environments?
  - Do cDs have a distinct evolutionary history?

Abell 370 (HST ACS)

NGC 3551 (SDSS)

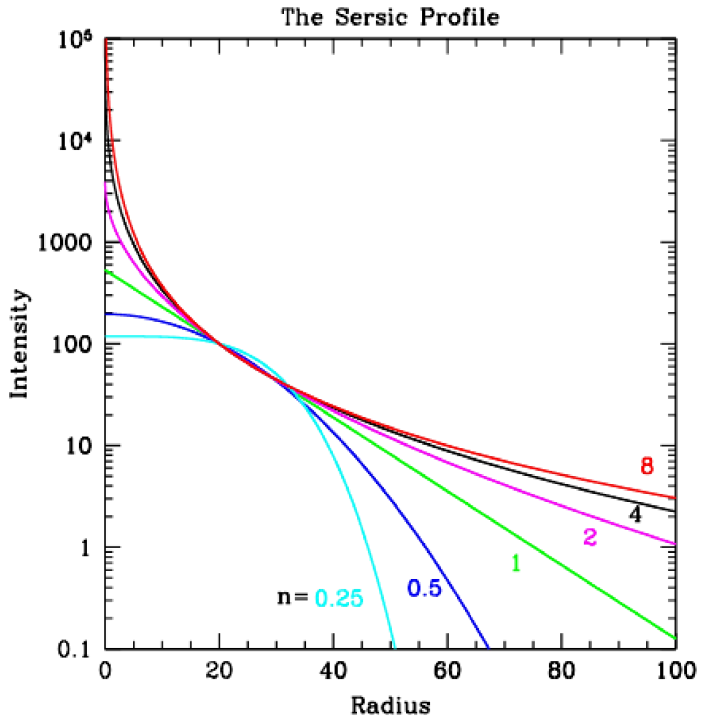
Visual Classification



Sloan Digital Sky Survey (SDSS) DR7 r-band

- 625 BCGs at $0.02 \leq z \leq 0.1$ from von der Linden et al. (2007)
- Three main types: cD (414), elliptical (155), disk (S0 22; spiral 24)

Measurements of Structure



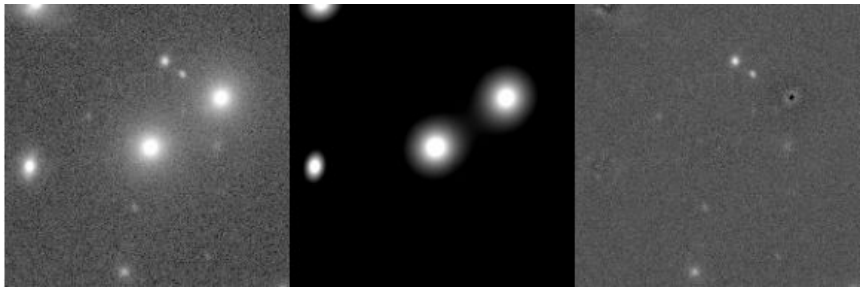
Peng et al. (2010)

- GALAPAGOS (Barden et al. 2012) and GALFIT (Peng et al. 2002)
- Sky value from GALAPAGOS
  - $\mu_{limit} \sim 27$ mag/arcsec^2
- Fitting model
  - single Sérsic profile

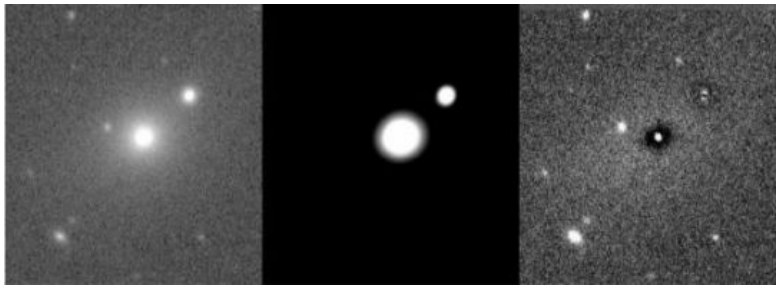
$$\Sigma(r) = \Sigma_e \exp\left[-\kappa\left(\left(\frac{r}{r_e}\right)^{1/n} - 1\right)\right]$$

Sérsic index: concentration

effective radius: size



origin model residual



origin model residual

Evaluate the Fittings

- Quantify the residual images
  - residual flux fraction (RFF)

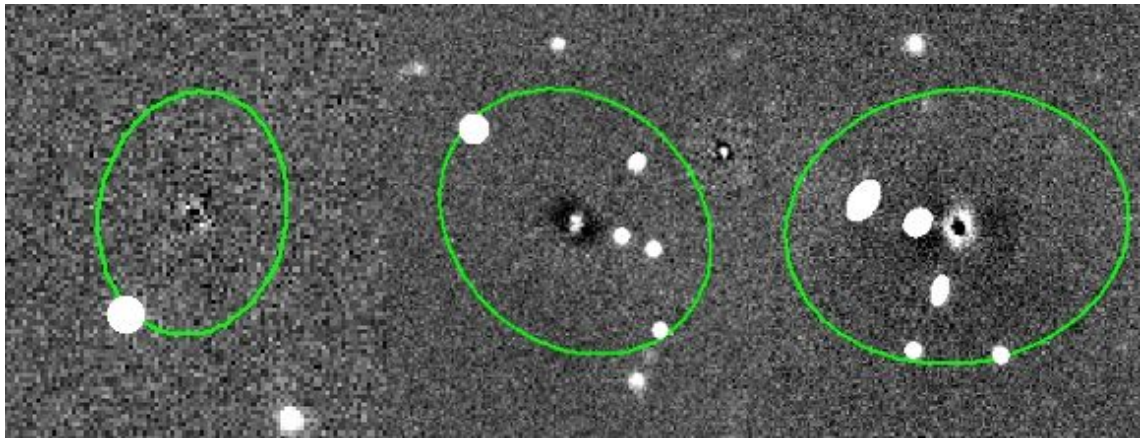
$$RFF = \frac{\sum_{i,j\in A} |I_{i,j} - I^{\rm model}_{i,j}| - 0.8 \times \Sigma_{i,j\in A}\sigma^{\rm bkg}_{i,j}}{\Sigma_{i,j\in A} I_{i,j}}$$

residual flux

  - reduced χ^2

$$\chi^2_\nu = \frac{1}{N_{\rm dof}} \sum_{i,j\in A} \frac{(I_{i,j} - I^{\rm model}_{i,j})^2}{\sigma^2_{i,j}}$$

Good fit:
RFF ~ 0.02
χ^2 ~ 1.1

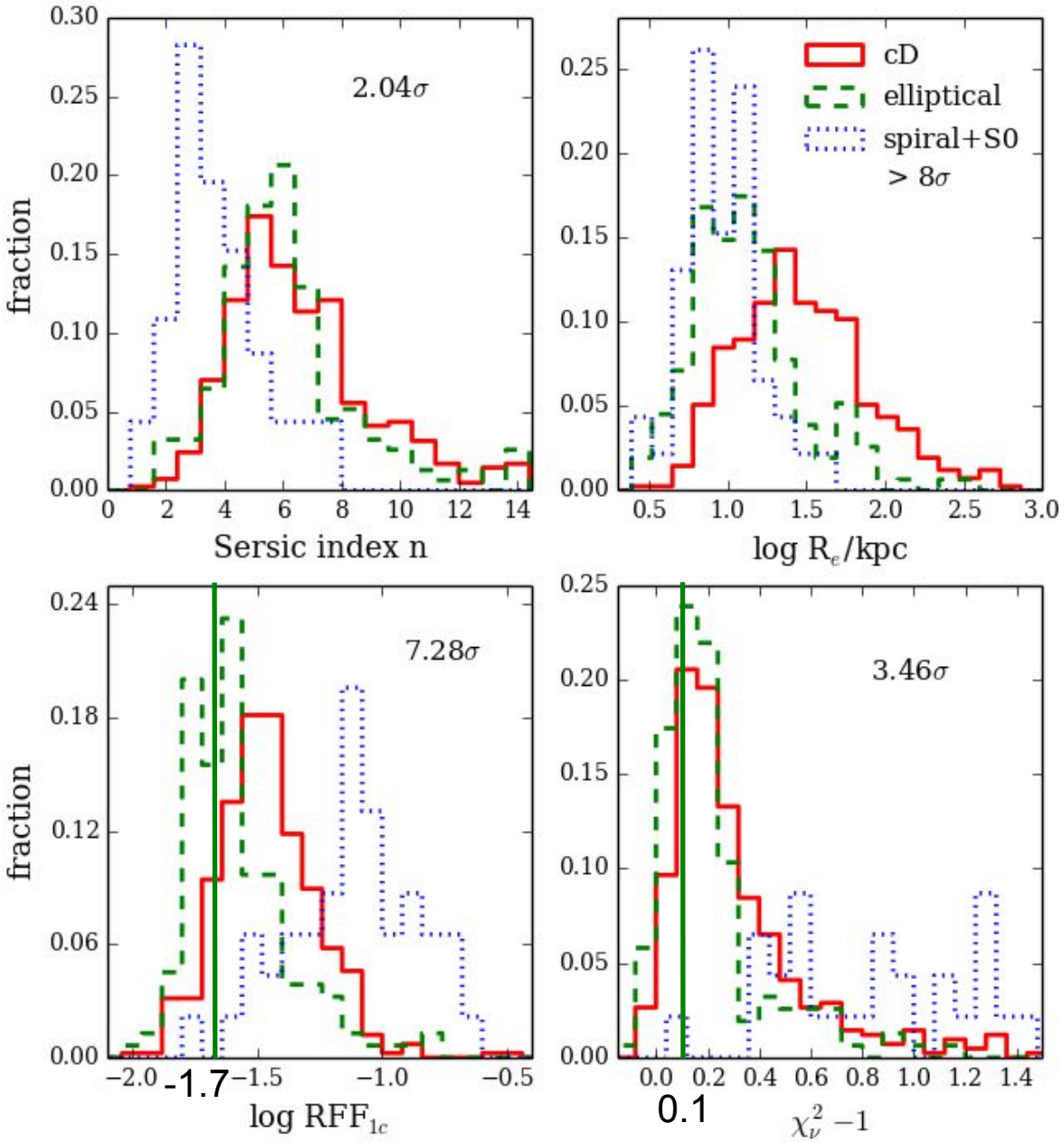


RFF=0.015
χ^2=1.052

RFF=0.045
χ^2=1.348

RFF=0.047
χ^2=1.455

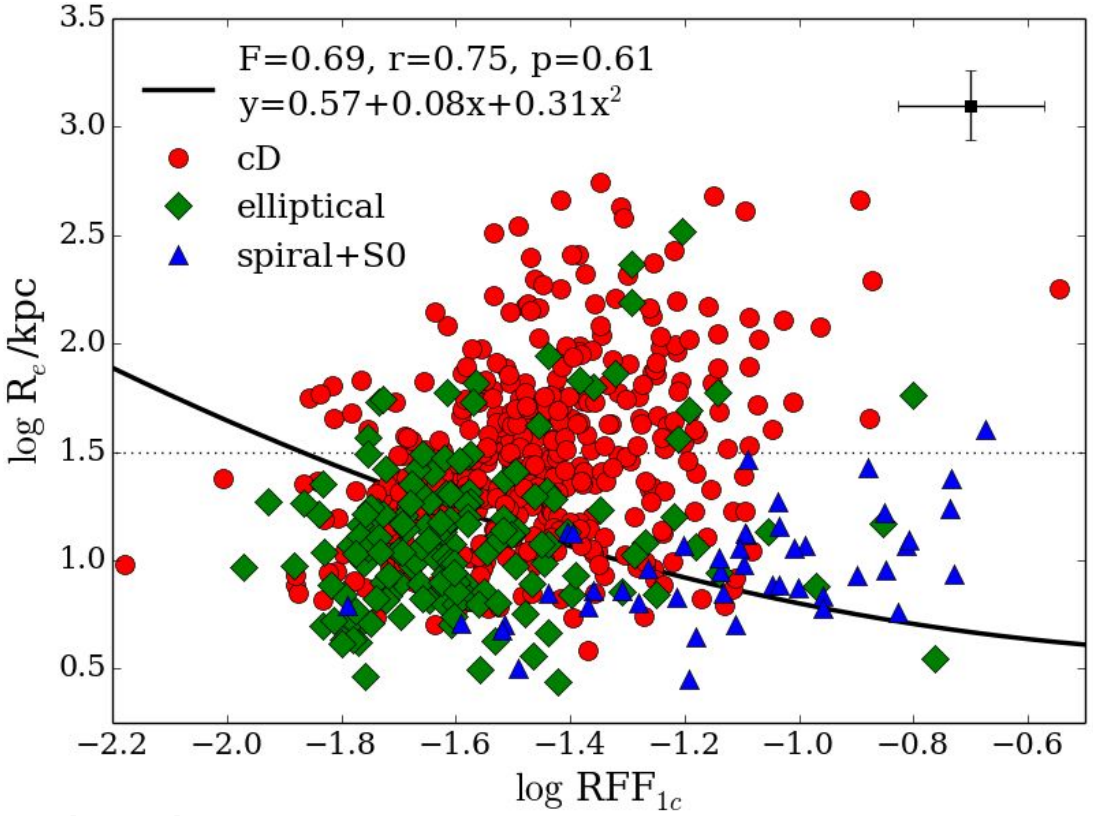
Link between Morphology and Structure of BCGs



Fitting with Single Sérsic Profile

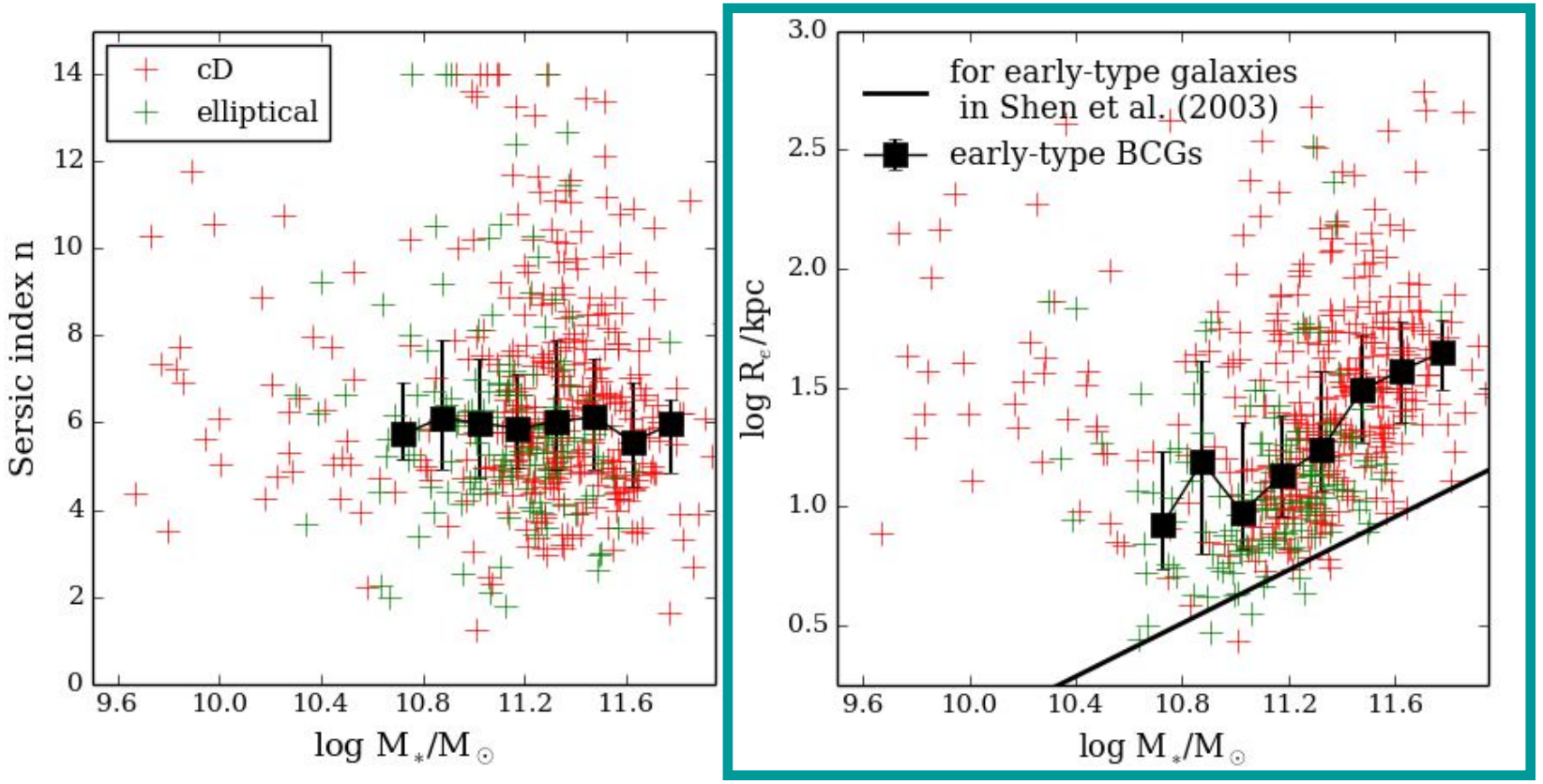
- cD and elliptical BCGs have similar n
- cD galaxies have larger effective radii
- It is harder to fit cD galaxies very well just by single Sérsic profile (larger RFF and χ^2)
- Clear link between morphology and structure

Automatic Selection of cD Galaxies



- Best border
  - Method from Hoyos et al. (2011)
  - Selected cDs have high completeness (75%) and low contamination (20%)
  - This method can be applied to future BCG samples

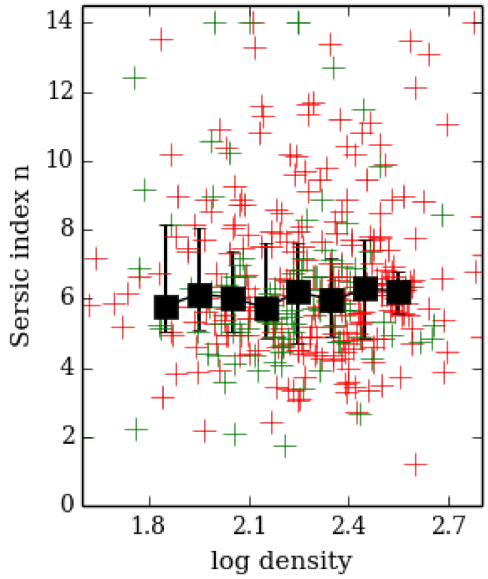
Stellar Mass

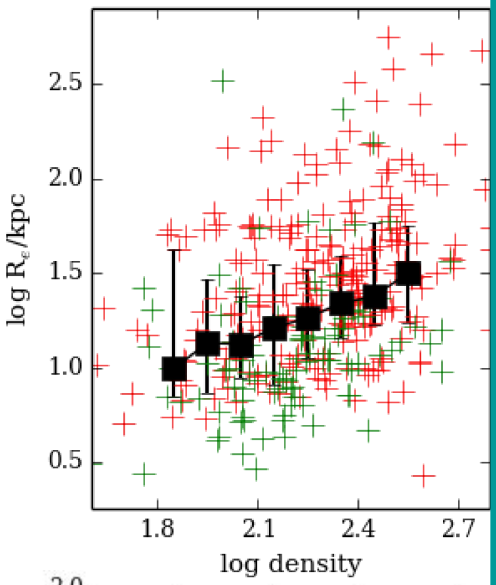


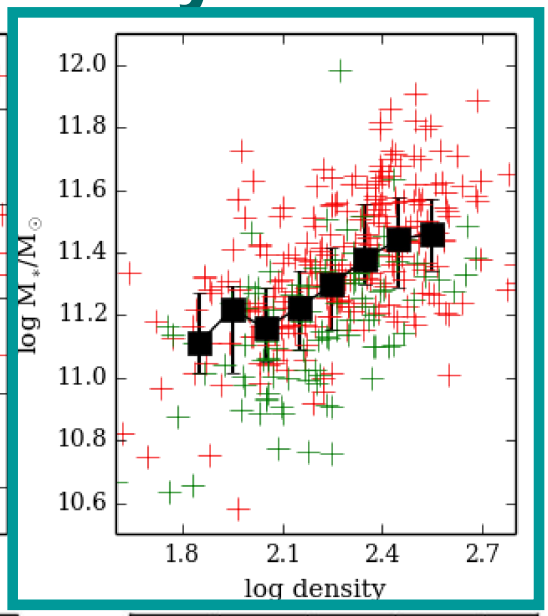
- M_* does not correlate with Sérsic index n
- M_* correlates with effective radius R_e

Stellar masses are from 'The MPA-JHU DR7 release of spectrum measurements'

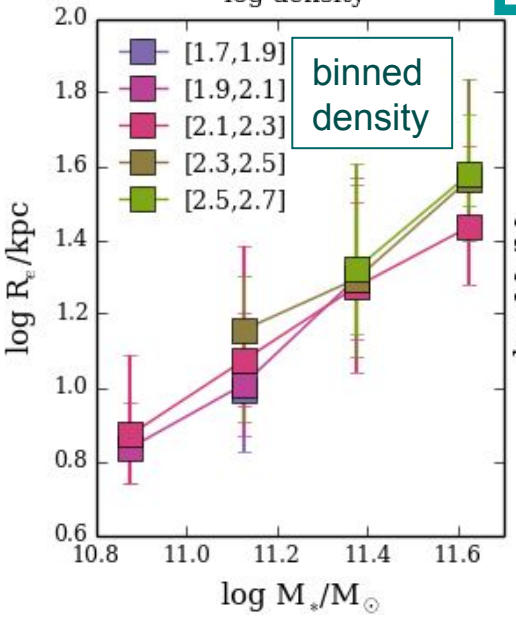
Environmental Density

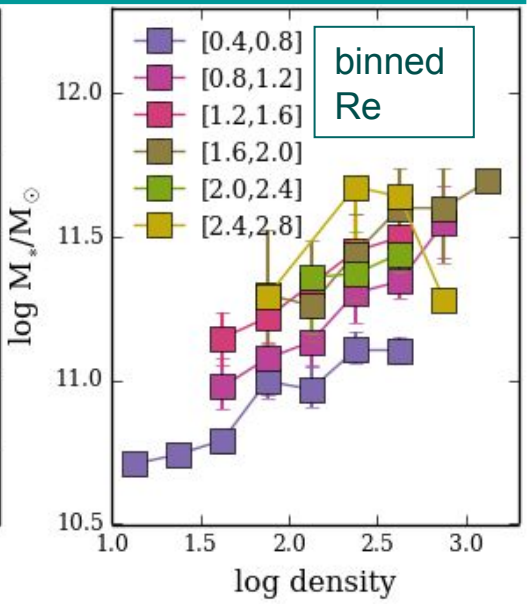




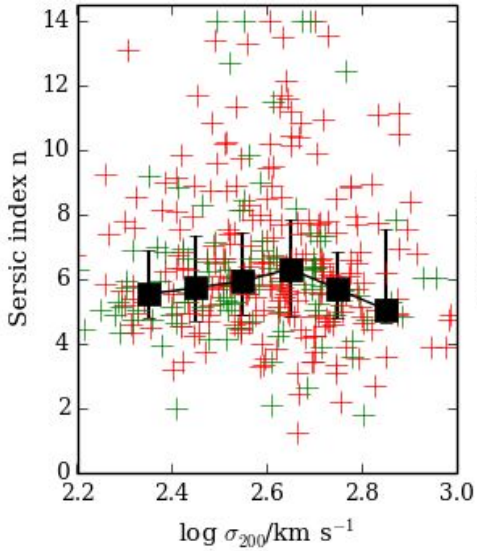


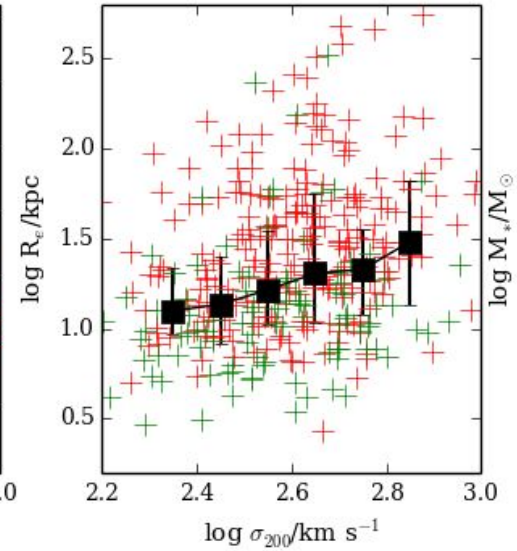
- Density does not correlate with n and R_e
- Density correlates with M_*

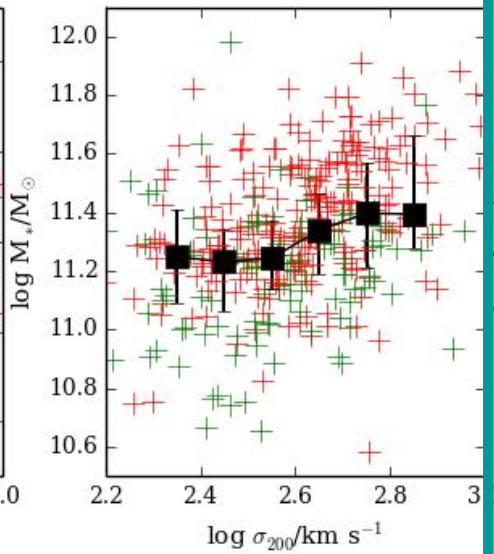


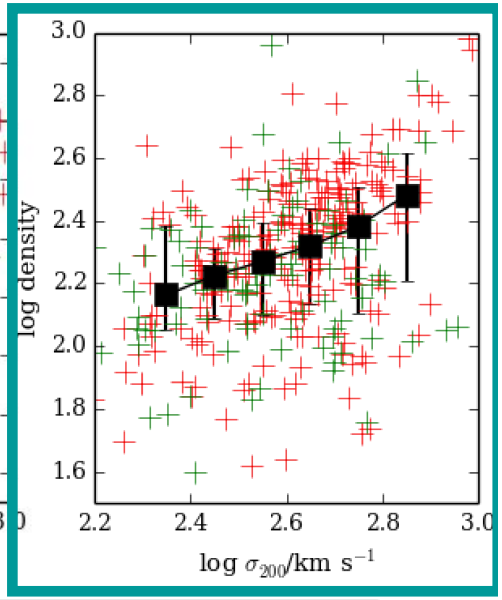


Dark Matter Halo Virial Mass

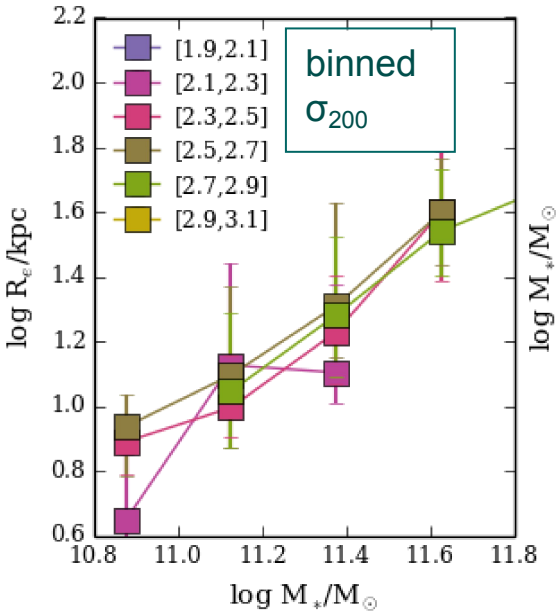


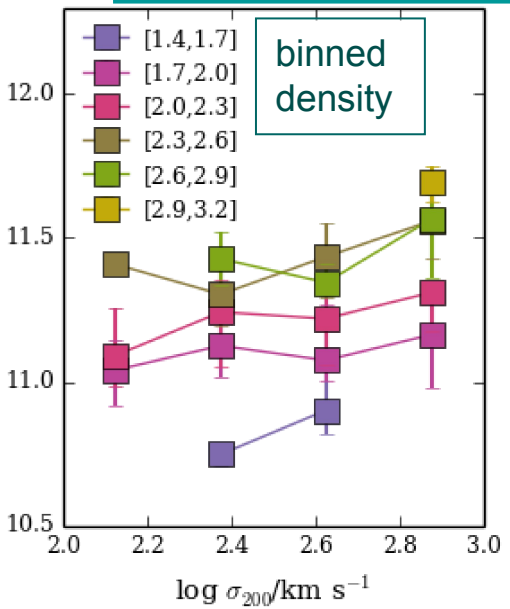






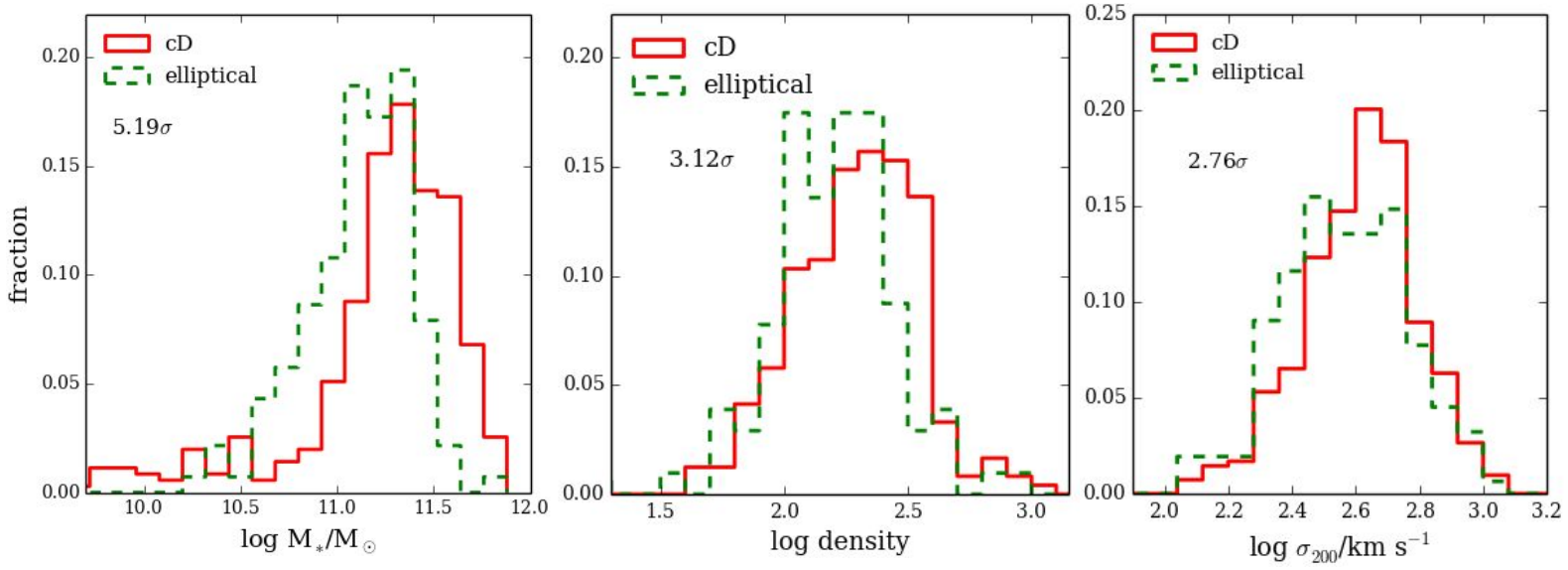
- DM halo virial mass does not correlate with n, Re and M* of BCGs
- DM halo virial mass correlates with density



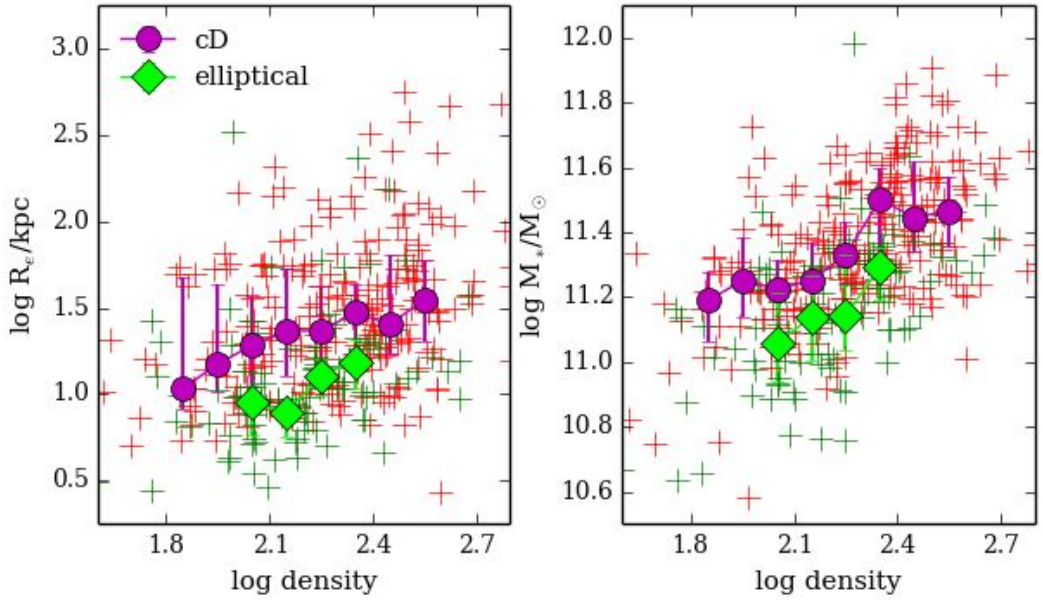


Cluster velocity dispersion is from von der Linden et al (2007)

cDs Properties Relate with M_* and environment



- cDs tend to be more massive and reside in denser clusters
- cDs are larger in factor of 2 and 60% more massive than ellipticals in same density
- cDs may grow through minor mergers



Conclusions

- Visual morphology strongly correlates with the structural parameters of BCGs
  - cDs are larger in size compared to elliptical BCGs
  - cDs are harder to fit with single Sérsic profile than elliptical BCGs--larger residuals
- » Automatic selection of cDs
- For BCGs
  - Size correlates with stellar mass
  - Stellar mass correlates with environmental density
  - cDs tend to live in denser environments than elliptical BCGs
  - At a fixed density, cDs are larger and more massive than elliptical BCGs implying that cDs may envolve from elliptical BCGs by forming the outer part through minor mergers