Color Properties of Group Galaxies in Pan-STARRs MD Survey Fields

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Outline

- Introduction: Are Brightest Cluster Galaxies Different from Ellipticals?
- BCGs in X-ray group galaxy catalog in COSMOS field
- PFOF+COSMOS photoz
- PFOF+PS1 photoz
- Conclusion

Introduction

- Brightest Cluster Galaxies (BCGs): The most luminous/ massive galaxies in the minimum of the gravitational potential well of clusters and groups.
- Observationally dry mergers may contribute to the growth of BCGs (McIntosh et al. 2008; Tran et al. 2008; Lotz et al. 2011) due to the dense environments that the BCGs locate (Lin et al. 2010).
- Controversially, recent studies of a small number of $z \sim 1$ BCGs based on color and stellar mass analysis indicated that ~90% of the stellar masses in BCGs have been assembled by at least $z \sim 1$ (e.g. Collins et al. 2009), in contradiction with the predictions of hierarchical assembling models (De Lucia & Blaizot 2007).

Introduction:
Not all BCGs are red and dead

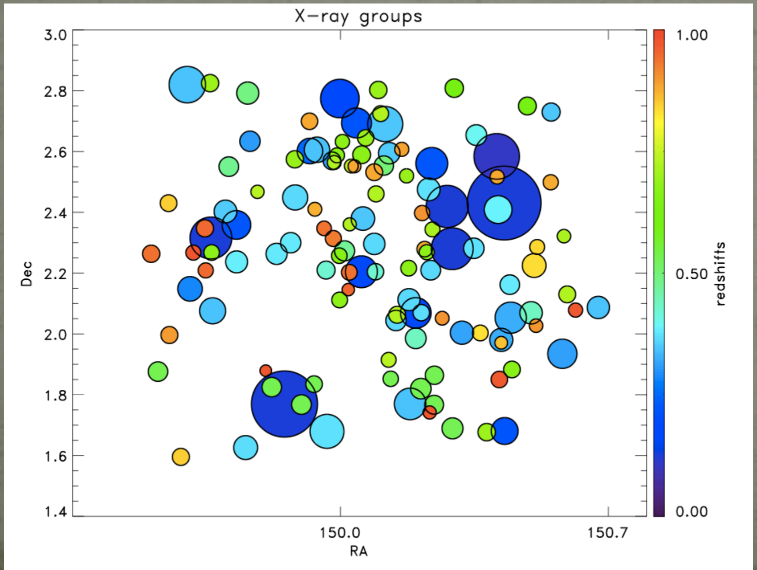
- Optically selected BCGs are as old as their field counter parts (Crawford et al. 1999, Edwards et al. 2007 and von der Lindon et al. 2007)
- In cluster scale, significant fraction of X-ray selected BCGs show excess of NUV-r or Mid-IR emissions (Egami 2006; Edwards et al. 2007; Wang et al. 2010)
- Much effort has been made to study environmental effects on BCGs/group galaxies in cluster scale but not so much for galaxies in group scale at higher redshift.

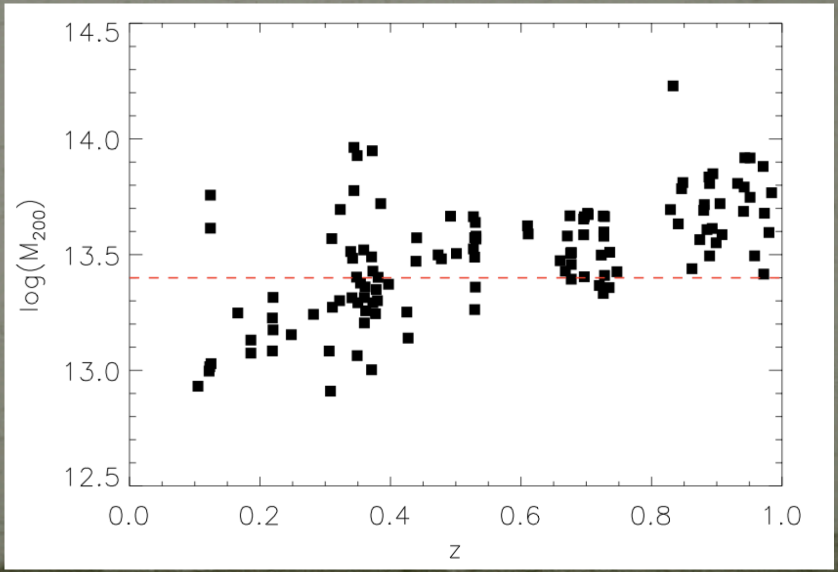
Questions we would like to address?

- Scientifically
  How environment shapes the galaxies to the group scales and early universe?
  In group scales, whether BCGs are indeed forming stars more actively than other massive elliptical galaxies? What is the difference between optically selected BCGs and X-ray selected BCGs?
- Practically,
  To what extent we can study color properties of BCGs based on PFOF+PS1 photoz?
  1. X-ray group galaxy catalog
  2. PFOF+COSMOS photoz
  3. PFOF+PS1

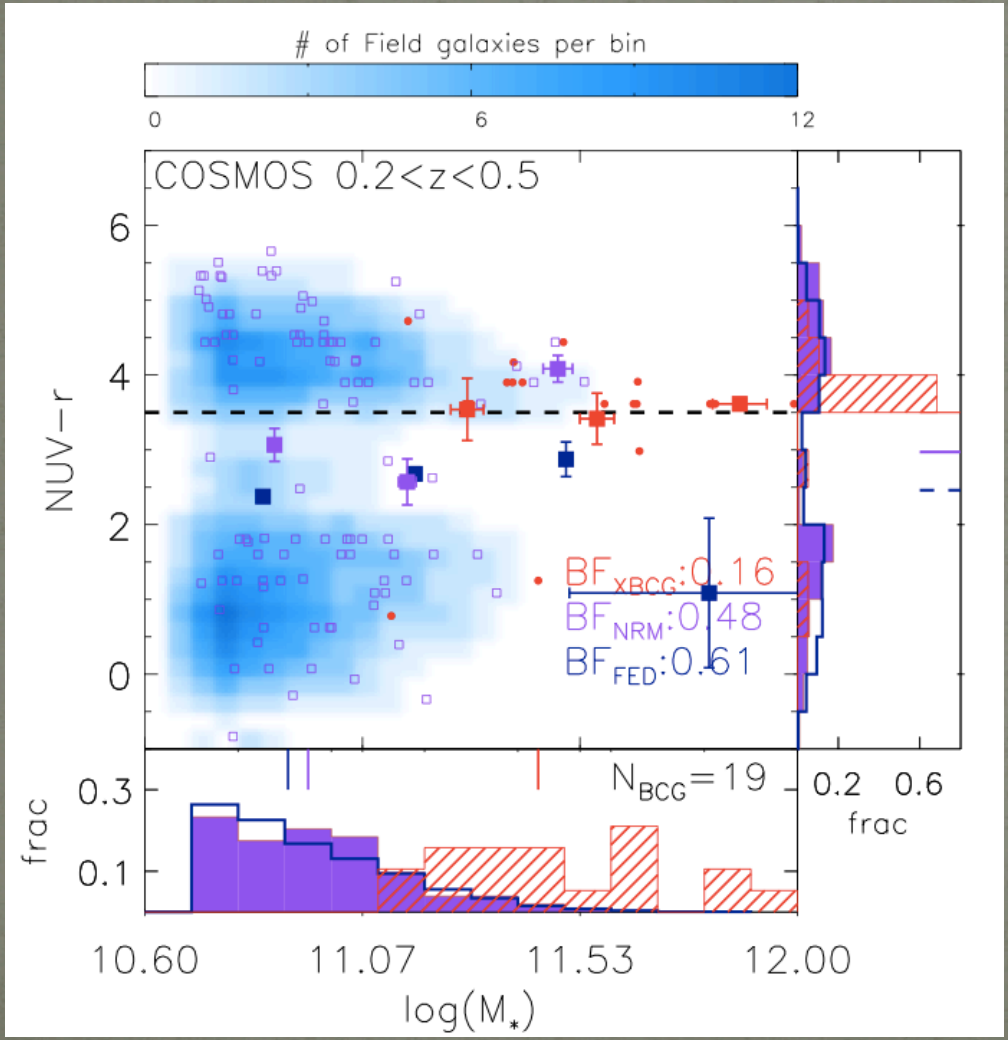
COSMOS X-ray group catalog

- X-ray group and member catalog
(Finoguenov et al. 2007; George et al. 2011)
Deep imaging by XMM-NEWTON and Chandra. BCGs are determined by Weak-Lensing (George et al. 2012).
122 groups with confident determination with 0<z<1
(BCGs with log(M*)> 10.7)



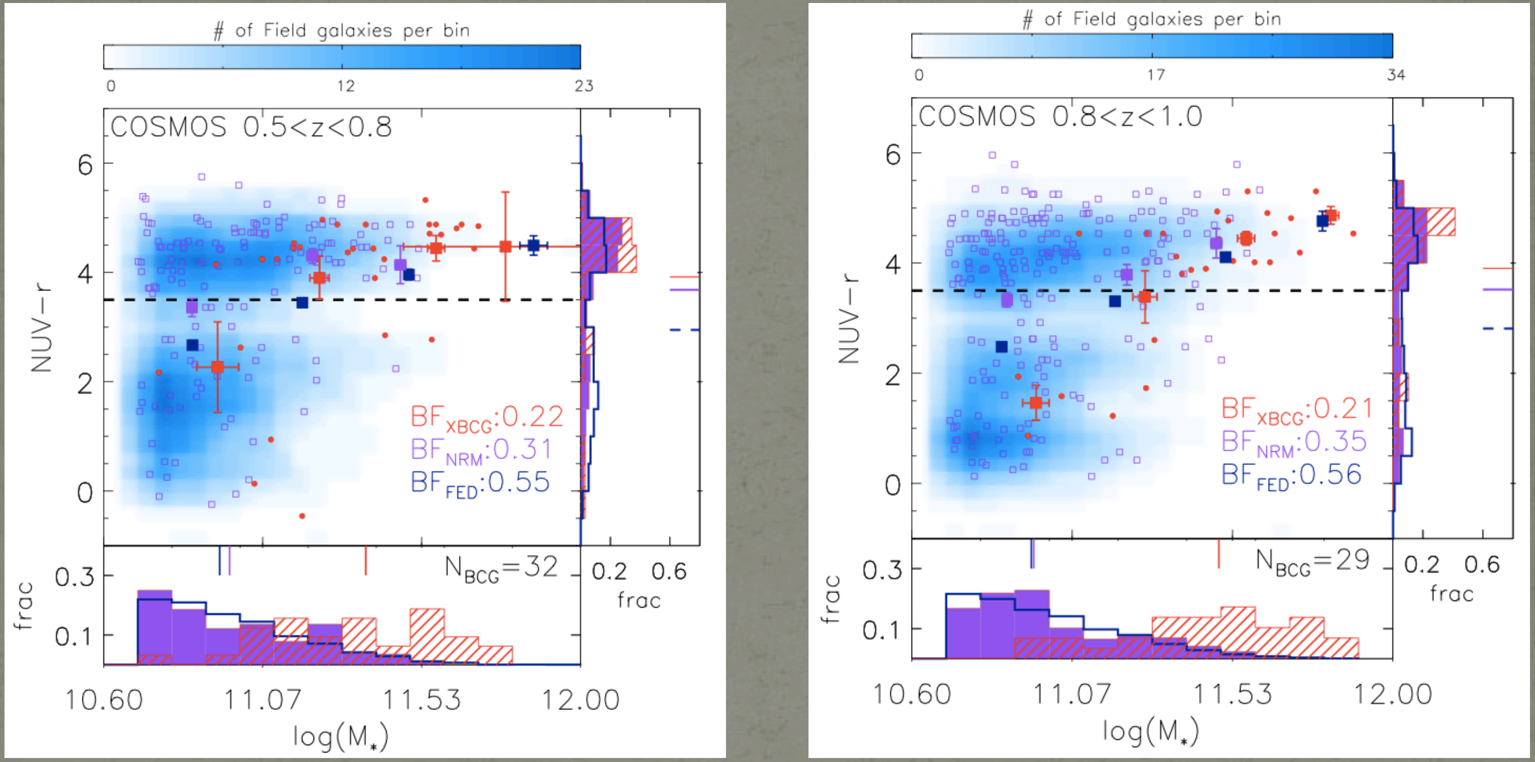


Color Properties of BCGs in X-ray Selected Groups



- There are 19 BCGs and they dominate the massive end of mass function (median log(M*)~11.5
- BCGs are basically red and passively evolved with BF~16%.
- For a given mass range, group galaxies are in general redder than field galaxies and not distinguishable with BCGs. However, BCGs have much smaller color scattering than non-BCG members.

Color Properties of BCGs in X-ray Selected Groups



- 32 BCGs at 0.5<z<0.8 and 29 BCGs at 0.8<z<0.1, extending to low mass end.
- BCG BFs are higher (21-22%) than the low z sample. For a given mass , group galaxies are redder than fields. The BCGs are not different with group non-BCG members at massive end. At low mass end, i.e., Log(M*)< 11.3, the BCGs are bluer because of a prompt fraction of SF BCGs.

Conclusion:

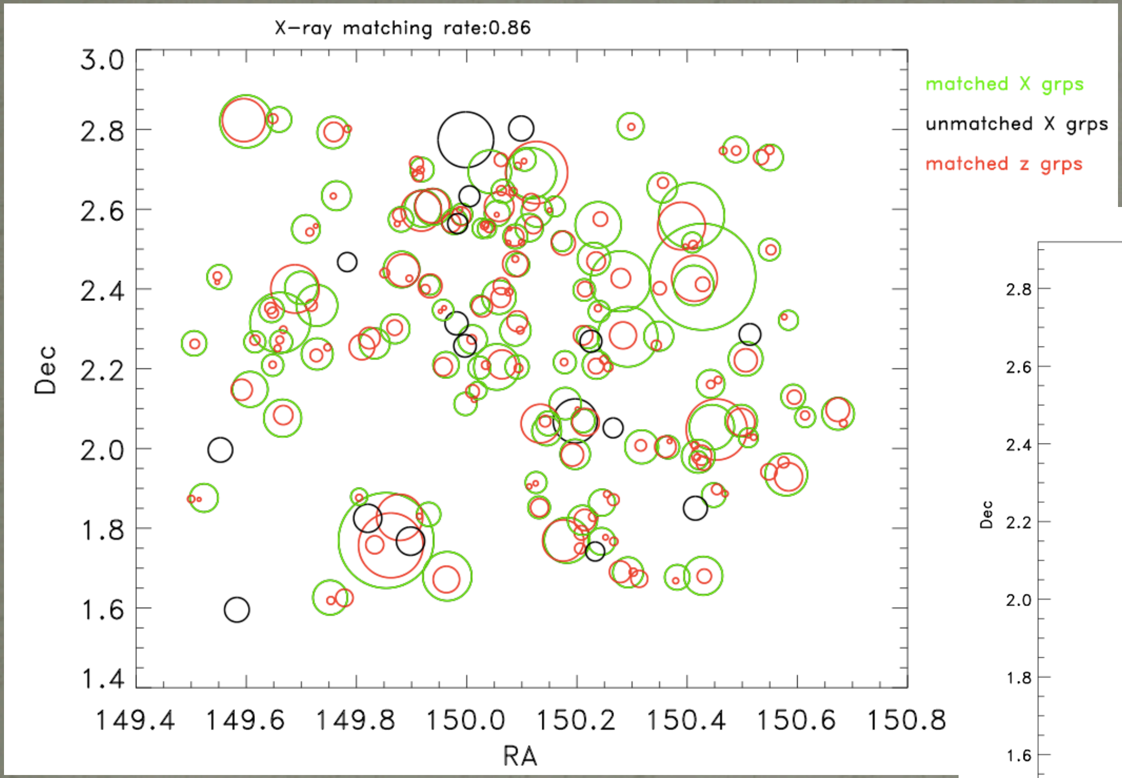
- COSMOS X-ray group galaxy catalog allowed us to study NUV-r properties of 80 X-ray selected BCGs with log(M*)> 10.7 in group scales (log(M200)> 13.4) to z=1.
- Group galaxies at all redshift are found to be redder than field galaxies at fixed mass range➔ environmental effects on galaxy evolutions, i.e. group galaxies may experience more dry mergers than their field counterparts.
- BCG BF decreased at lower redshift: 1. Cooling flows were deactivated recently. 2. SF BCGs may merge into more massive but passively evolved galaxies.
- Only 80 X-ray selected BCGs ➔ Need to enlarge the samples (MD04+MD10)!

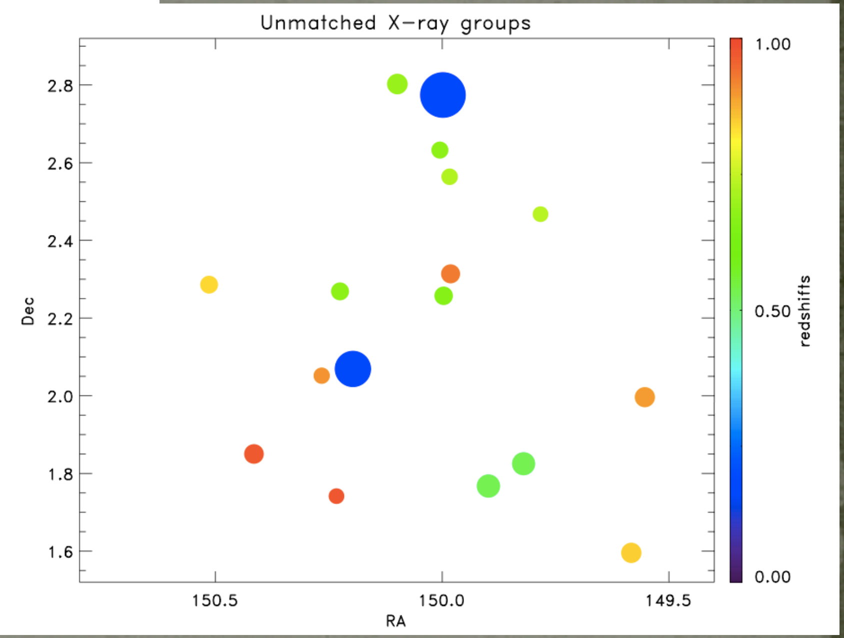
PFOF+COSMOS Photoz

PFOF Group Finder

- PFOF is developed by Liu et al. 2008, for which a neighbor galaxy is identified as a "Friend" if (1) angular separation $< XY_{link}$ and (2) probability of line-of-sight separation less than z_{link} is greater than a threshold P_{th}.
- Unlike the red-sequence cluster finder, PFOF has less bias toward blue galaxies. But optimization of the linking parameters need to be carried out with X-ray groups or Spec-z groups in advance.
- PFOF groups are matched with X-ray groups. The BCGs are defined as the most massive galaxies in the matched PFOF groups.

Matching PFOF groups with X-ray groups: Group Scale

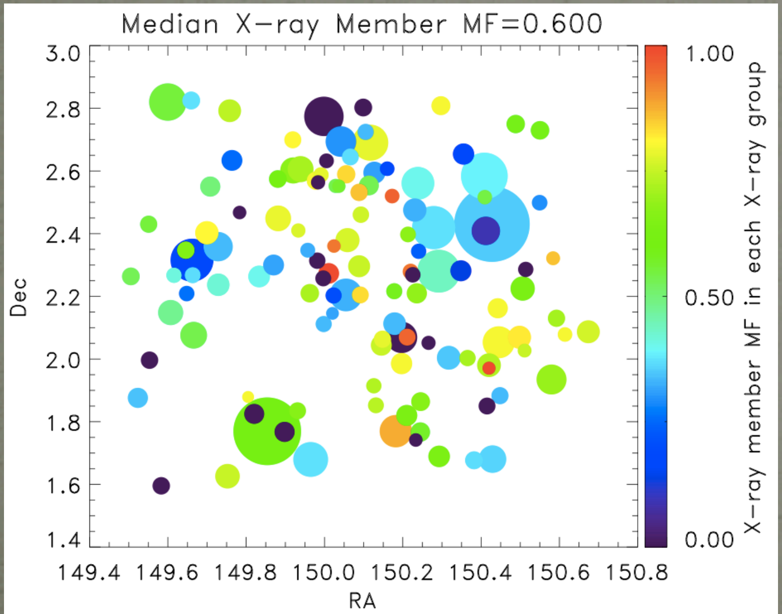


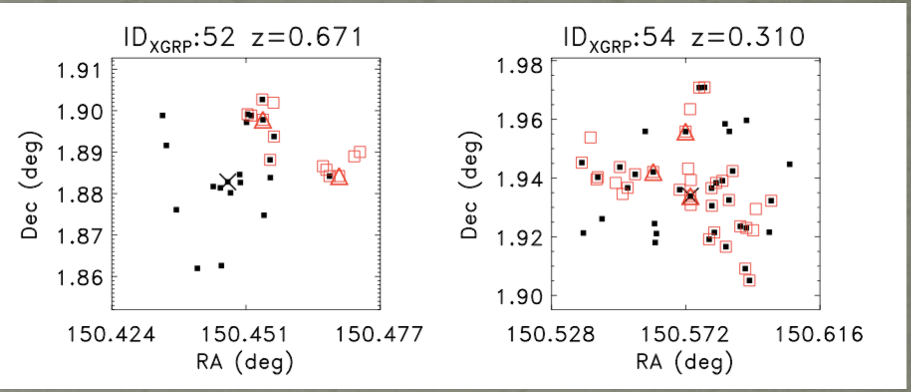


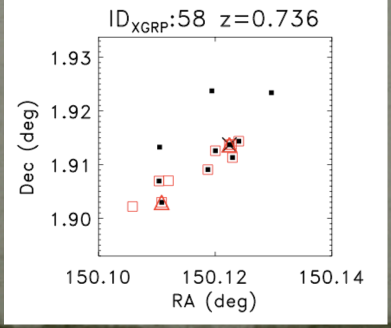
- N_{match}/N_{xray}=104/121~0.86
- The unmatched cases are by groups with z >0.5.
- Fragmentation

Matching PFOF groups with X-ray groups: Galaxy Scale

- Group members averaged MF: $N_{match}/N_{T,pfof}$=78.6%
- BCG Matching Fraction: $N_{BCGmatch}/N_{XGRPmatch}$
  Case I (Matching): 76.2%
  Case II (xBCGs ≠ PFOF members): 16.2%
  Case III (xBCGs = PFOF membersxBCG in): 7.6%

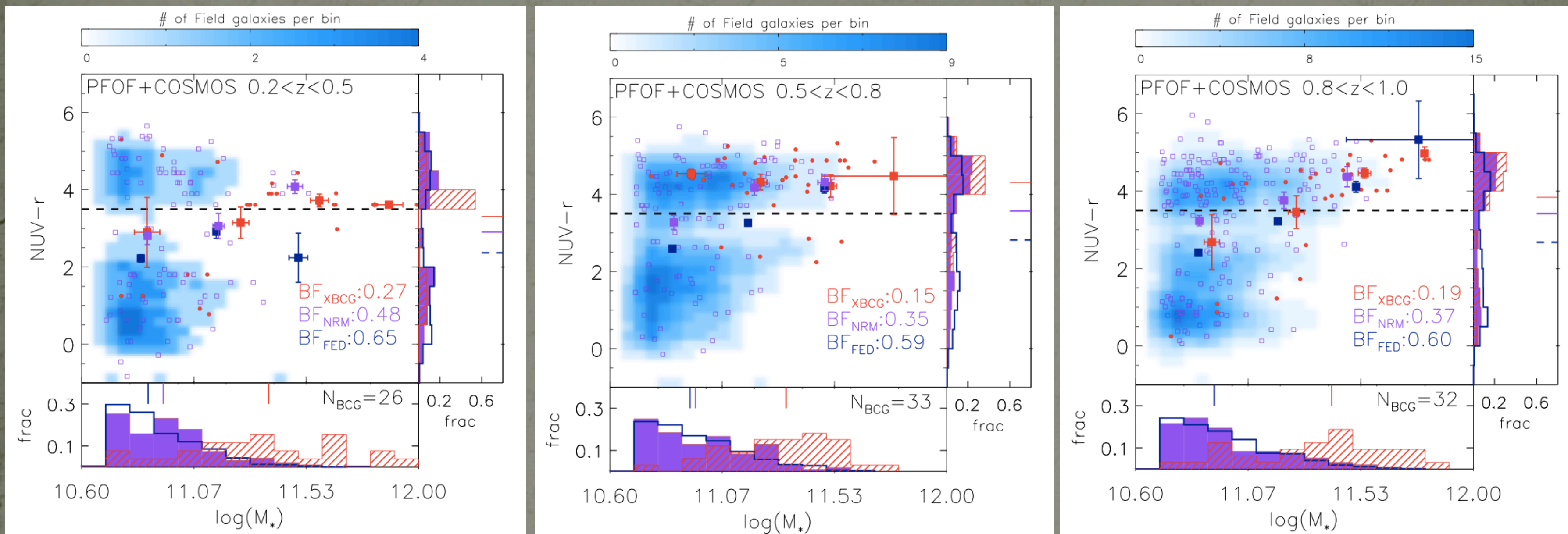






X---xBCGs
Δ----PFOF BCGs
•----x Group mems
□---PFOF mems

Color Properties of BCGs



- Color per given mass range follow similar tendency as COSMOS x-ray galaxies result.
- Subgroup BCGs should be corrected.

PFOF+PS1 Photoz

Data

- Taiwan Stacks

From PS1 and archival CFHT pre-reduced data, we recomputed the global astrometric calibration relative to the SDSS DR7 (Abazajian et al. 2009) using the software SCAMP. We then process the final stacked images using SWARP . The global photometric calibration is made at the final stage on the stacks by referring to SDSS DR7.

	g	*r*	*i*	*z*	*y*	*u*
Seeing (“)	1.20±0.04	1.08±0.04	1.02±0.06	1.01±0.03	1.08±0.06	0.85±0.04
Depth (mag)	24.875±0.067	24.743±0.080	24.611±0.068	24.045±0.086	22.205±0.110	26.091±0.544

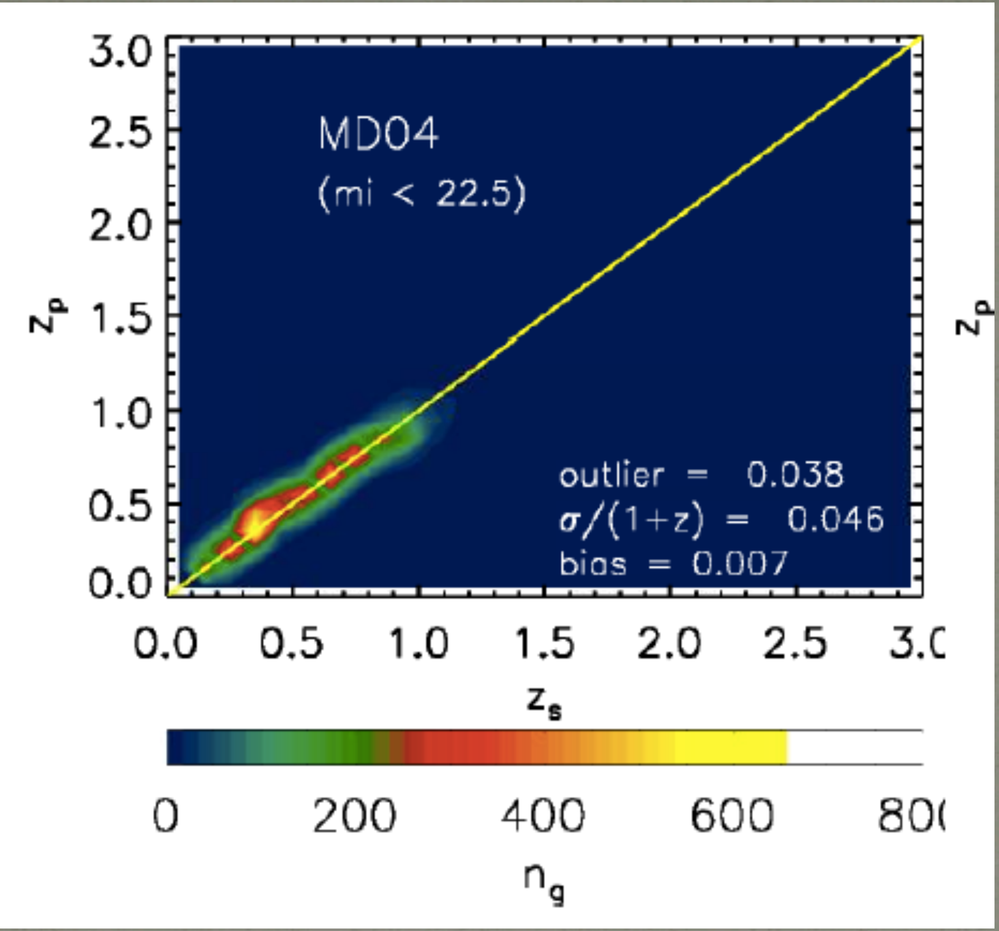
Data

- The average seeing and the depth (measured from 5 sigma sky brightness within a 2” aperture) of the stacks are summarized as below.

	g	*r*	*i*	*z*	*y*	*u*
Seeing (“)	1.20±0.04	1.08±0.04	1.02±0.06	1.01±0.03	1.08±0.06	0.85±0.04
Depth (mag)	24.875±0.067	24.743±0.080	24.611±0.068	24.045±0.086	22.205±0.110	26.091±0.544

Photoz

- PS1 Medium Deep survey field 04 (MD04) covers the whole field of COSMOS, one of the most comprehensive studied deep field to date. The extensive amount of COSMOS measurement, such as photo-z (e.g. Ilbert et al. 2009), spectral-*z* (e.g. Knobel et al. 2012) and X-ray observations (e.g. Finoguenov et al. 2007 and George et al. 2011) make it an ideal calibration field for us to start the photo-z measurement and group finder.
- Photo-z of ~ 0.75M sources in MD04 were derived based on *ugrizy* photometry with EAZY. 0.35M sources with cs<0.4 were selected.



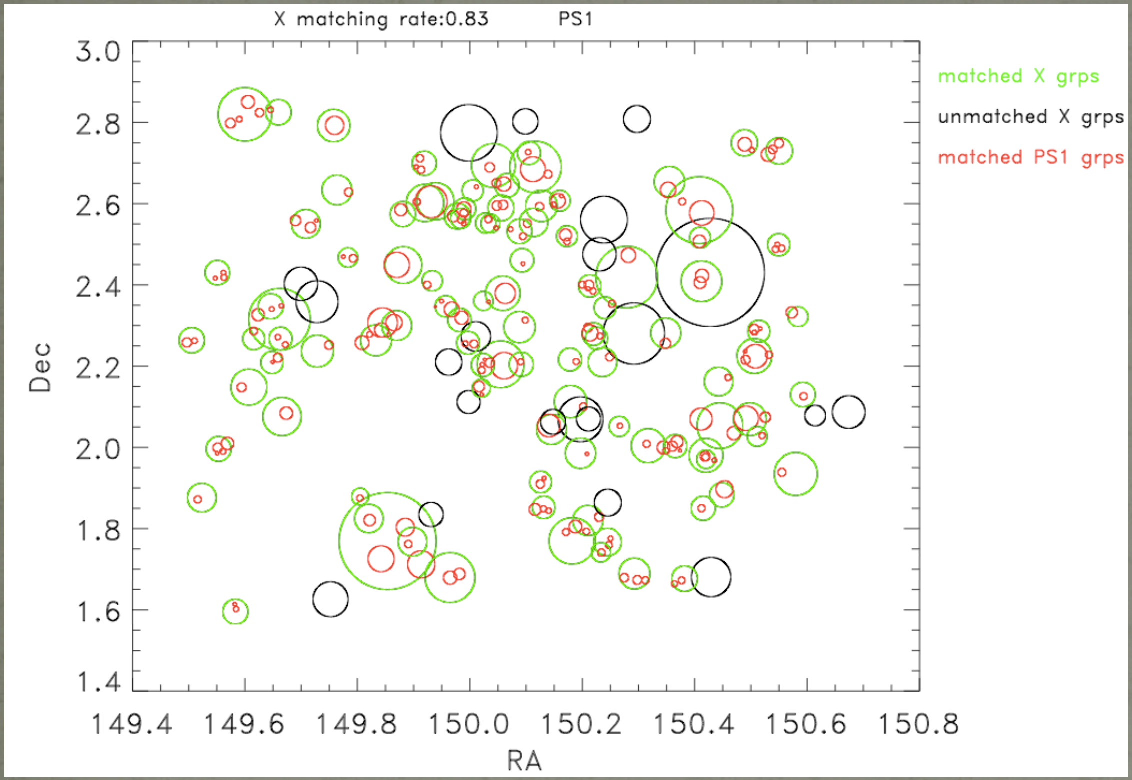
The overall $\Delta z/(1+z) \sim 0.046$.

Sample selection

- Class_star < 0.4
- $16<m_i<24$
- $0 < z < 1$
- $Log(M_*)> 10.7$

11076 galaxies
$0.2<z<0.5$
$0.5<z<0.8$
$0.8<z<1$

Group-Group matching:

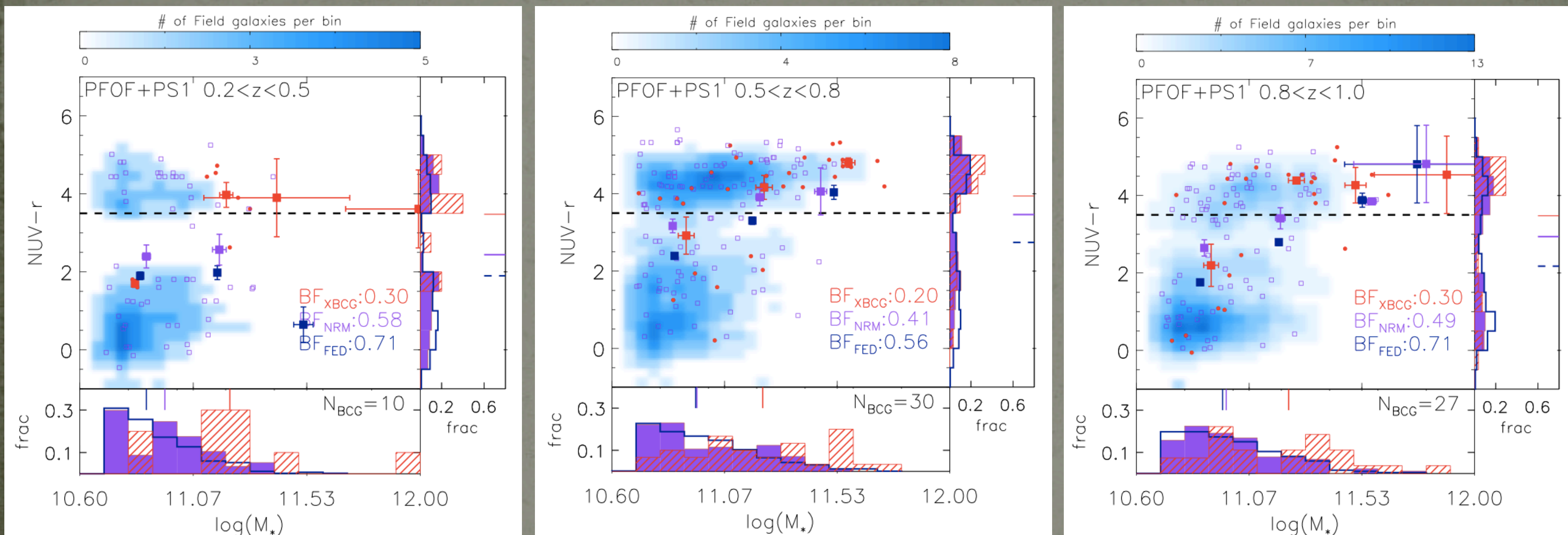


- N_{match}/N_{xray}=101/121~0.83
- More significant fraction of Fragmentations than PFOF +COSMOS~

Galaxy-Galaxy matching

- Group members averaged MF: 46%
- BCG MF:
  Case I (Matching): 29.7%
  Case II (xBCGs ≠ PFOF members): 52.4%
  Case III(xBCGs = PFOF members): 17.8%

Color Properties of BCGs



- At given mass range, group galaxies are redder than the field galaxies.
- Out of 67 PFOF BCGs, 36 X-ray BCGs are recovered➔ fragmentation.

Conclusion

- With good photoz (e.g. $\sigma_z(1+z) \sim 0.01$), PFOF is robust to determine groups/ fields in a non-color biased manner. Besides, under-dense regions can also be located. Therefore, by matching with X-ray groups, it allows us to assert the environmental effect on galaxy color or sizes (group galaxies, fields and BCGs).
- PFOF+PS1 photoz ($\sigma_z(1+z) \sim 0.05$-0.06), PFOF is ok to study the group and fields but suffering significant fragmentation issues. ➔ Improve Photoz / regroup BCGs / better optimization of PFOF.