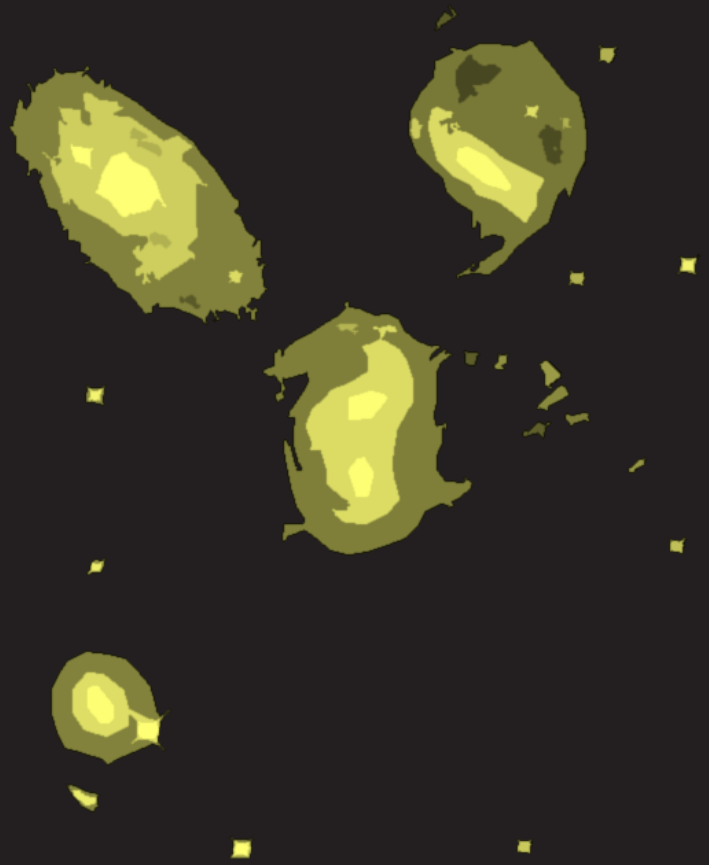
Compact Group

The densest system known in our universe



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1 CRITERIA OF COMPACT GROUP
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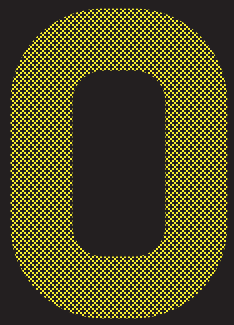


What is Compact Group

Compact Group

- Similar environment to the early universe
- High Number Density
- Low Velocity difference
- Dynamically bound system
- Short time scales due to merging

Inevitable Problem

How to identify compact groups based on the data we have?

1

Criteria of Compact Group

Hickson criteria

Paul Hickson (1982)

① $N(\Delta m = 3) \geq 4$

② $\theta_N \geq 3\theta_G$

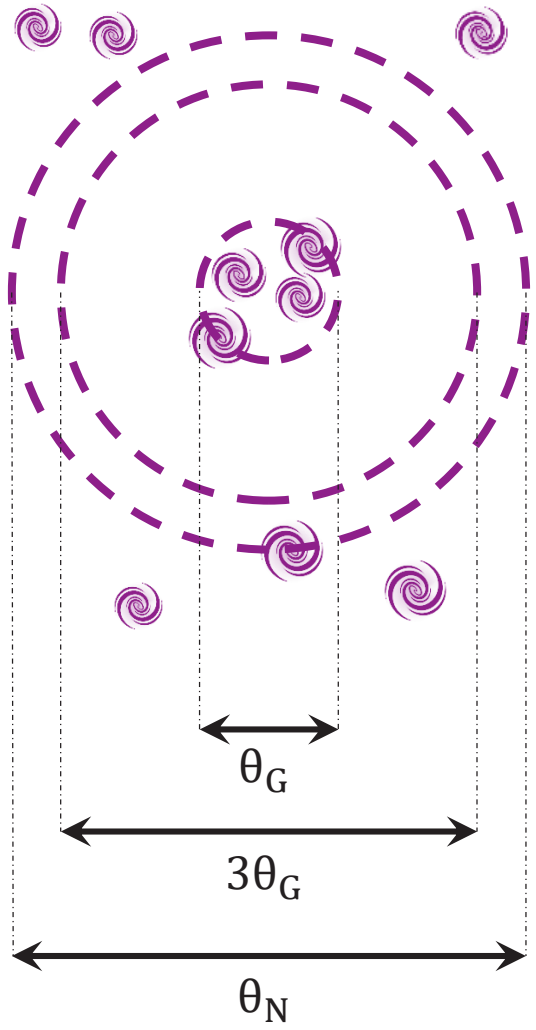
③ $\mu_e \leq 26.0 \text{ mags arcsec}^{-2}$

$N(\Delta m = 3)$: the number of galaxies within 3 mag of the brightest galaxy

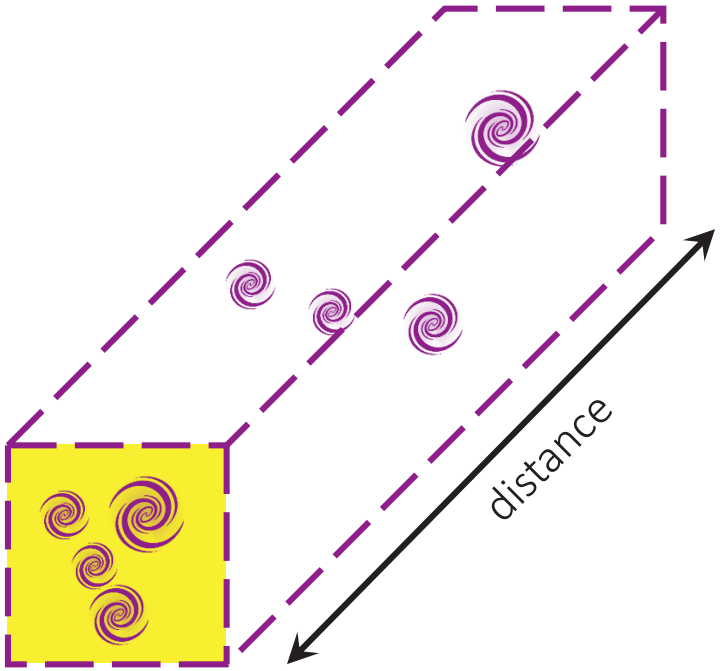
θ_G: the smallest circle contains these galaxies

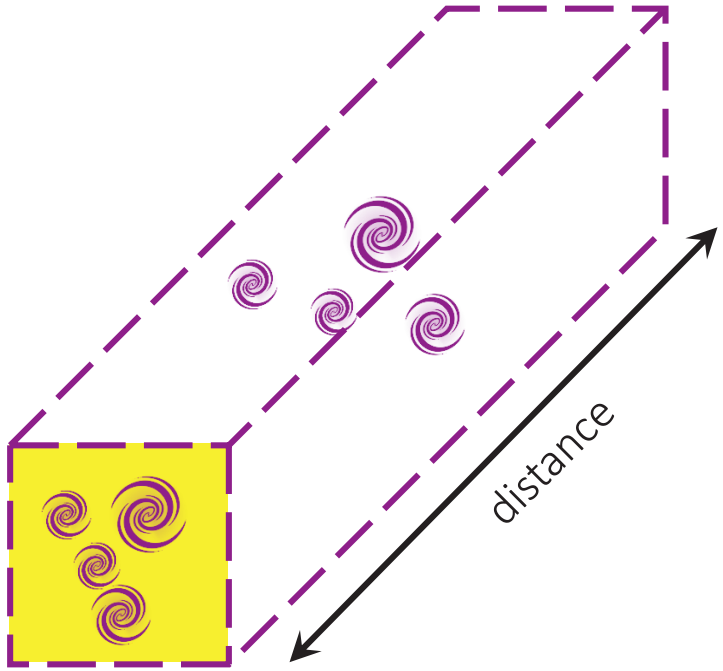
θ_N: the largest concentric circle contains no additional galaxies in this mag range or brighter

μ_e: the effective surface brightness of these galaxies and the total flux of these galaxies over the smallest circle with angular diameter θ_G



The Interlopers





Friends-of-Friends Algorithm

Elizabeth Barton et al. (1996)

① $\Delta D_{proj} = 2\left(\frac{cz}{H_0}\right)\sin\left(\frac{\Delta\theta}{2}\right) \leq D_0$

② $\Delta V_{LOS} = c\,\Delta z \leq V_0$

③ $\mu_{G,Zw} \leq 27.7 \text{mags arcsec}^{-2}$

ΔD_{proj}: the projected separation of two galaxies

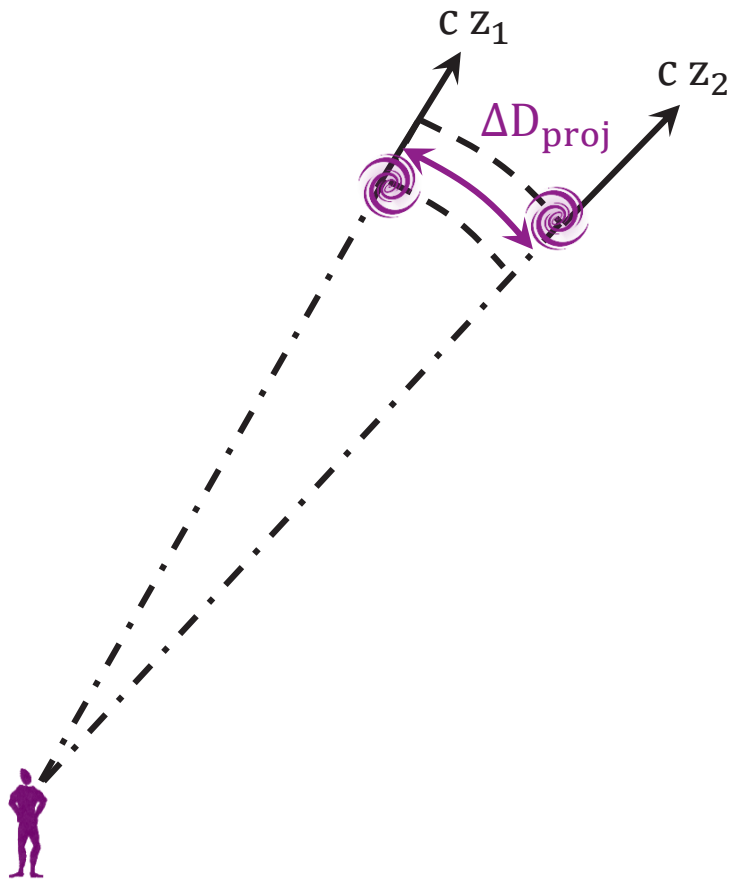
Z: the average redshift

$\Delta\theta$: the angular separation on the sky

ΔV_{LOS}: their line-of-sight velocity difference

$D_0 = 50h^{-1}$ kpc

$V_0 = 1000$ km/s



Hickson VS FoF

Hickson Criteria

- Mag limit: $\Delta m = 3$
  CGs have small ang extent, not all of them have redshift data because of fiber collision.
  Similar mag are more likely to be at the same redshift.
- $\theta_N \geq 3\theta_G$
  Only have projected information
- $\mu_G \leq 26.0\ \mathrm{mags\,arcsec^{-2}}$
  Exclude groups containing only low luminosity, low surface brightness galaxies

FoF Algorithm

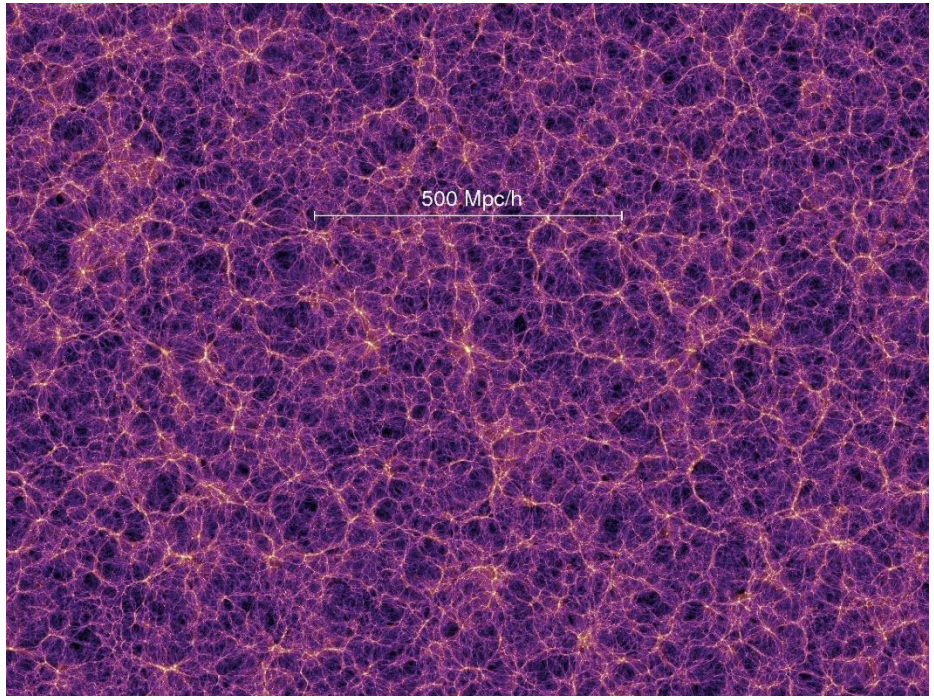
- Apply to the Redshift surveys
  It's not a problem for redshift survey
- A complete catalog in redshift
  Prefer a cleaner isolation criterion in 3-dim
- $\mu_{G,Zw} \leq 27.7\ \mathrm{mags\,arcsec^{-2}}$
  Translate the left criterion to Zwicky mag scale

2

Compact groups in theory

Effect of Interlopers

- Mamon (1986) :
  ~50% loose groups or unassociated galaxies.
- Hickson (1990) :
  17% HCGs are line-of-sight galaxies.
  13% projections of loose groups.
- McConnachie et al.(2009):
  analysis the mock catalogue.
  De Lucia & Blaizot (2007) all-sky mock catalogues based on Millennium Simulation.
  ~5.7 millionn galaxies brighter than r = 18.

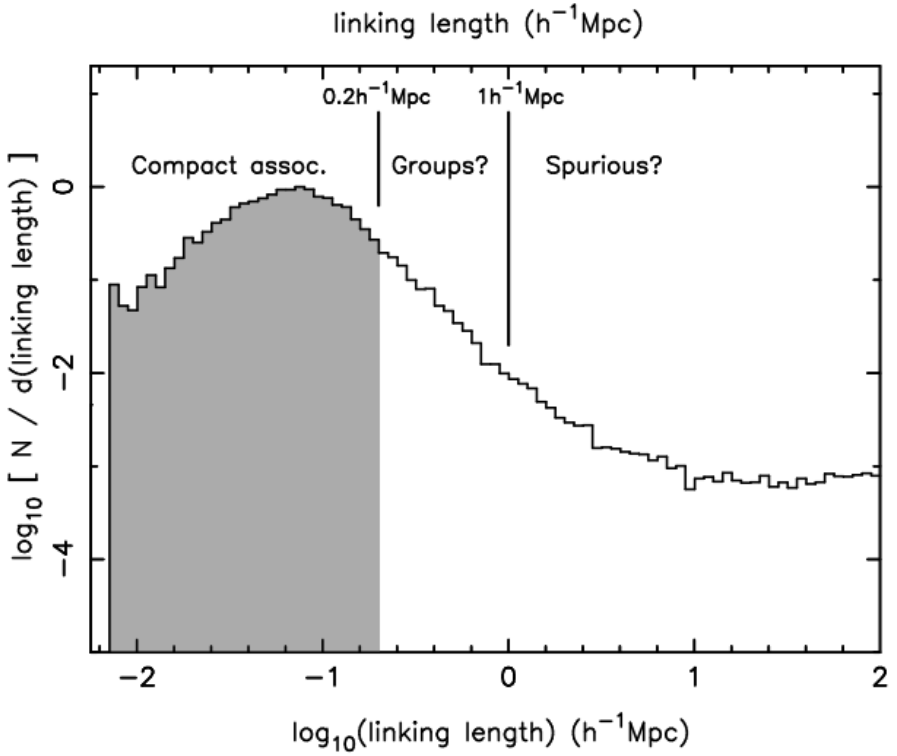


Compactness distribution

McConnachie et al.(2008)

- Hickson Association(HA)
  All galaxies association identified by Hickson criteria
- Compact Association(CA)
  truly compact in 3-dim

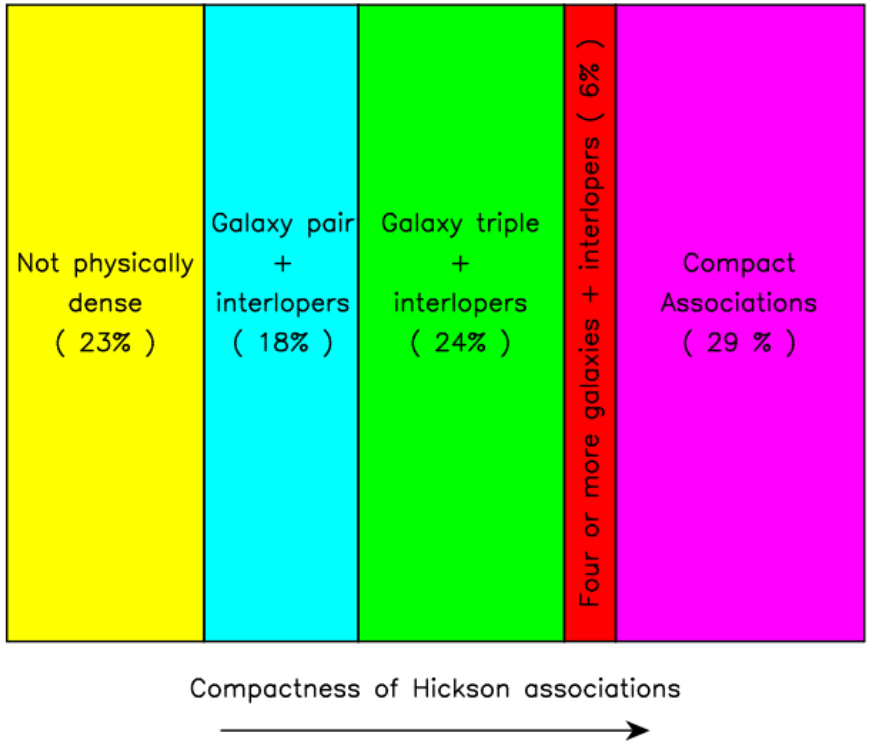
- 15122 HAs (64525 galaxies) identified from the mock catalogue.
- If linking length $l < 200\ kpc\ h^{-1}$, CA
- ~29%(4446) HAs is CAs



Interloping Groups

McConnachie et al.(2008)

- Though Interlopers are significant, but:
  29% no interlopers
  77% consist in part of a compact arrangement of at least 2 galaxies
  35% have true groups
  24% Trip + intelopers
  18% Pair + intelopers
- What affect the contamination?
  Number of galaxies?
  Apparent magnitude range?
  Projected distance to nearest non-member galaxy?
  Surface brightness?

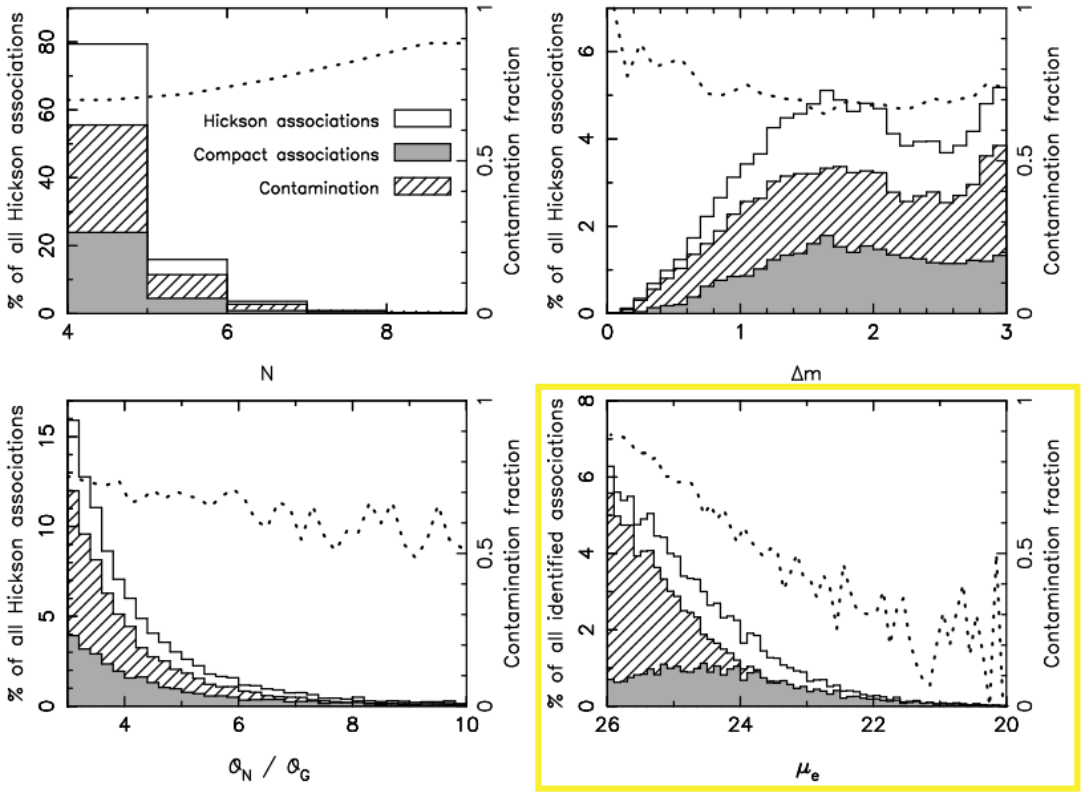


Contamination

McConnachie et al.(2008)

N	% CAs	% HAs	Δm	% CAs	% HAs
4	100	29	3.0	100	29
5	19	27	2.5	79	30
6	4	22	2.0	57	29
7	1	17	1.5	31	27
θ_N/θ_G	% CAs	% HAs	μ_e	% CAs	% HAs
3	100	29	26	100	29
4	51	34	25	72	43
5	29	37	24	39	56
6	19	41	23	16	67

- Only select by surface brightness can reduce contamination rates dramatically.



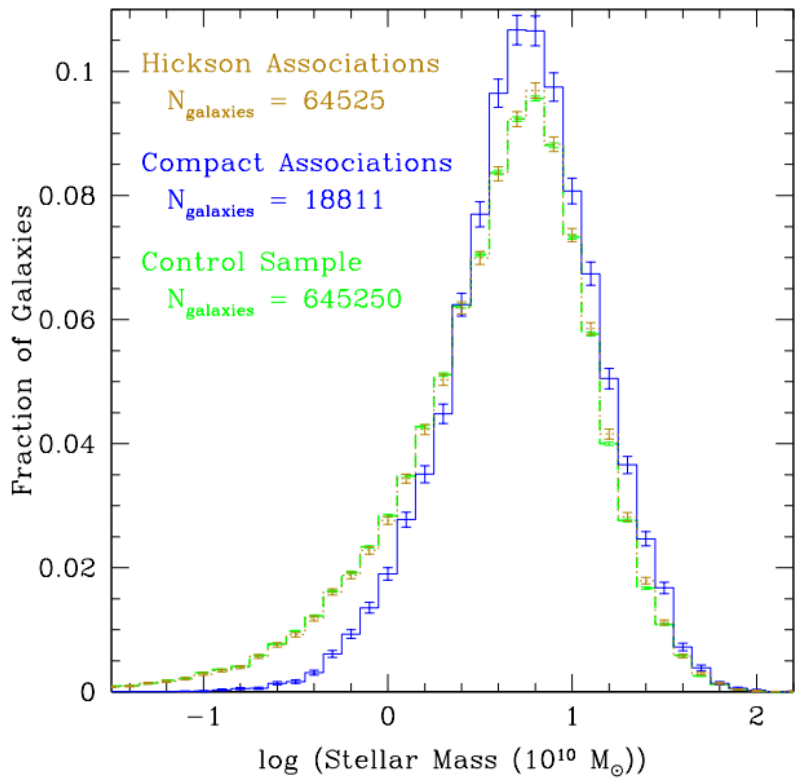
The nature of galaxies in CGs

- Stellar Mass
- Redshift
- Colour
- Morphology

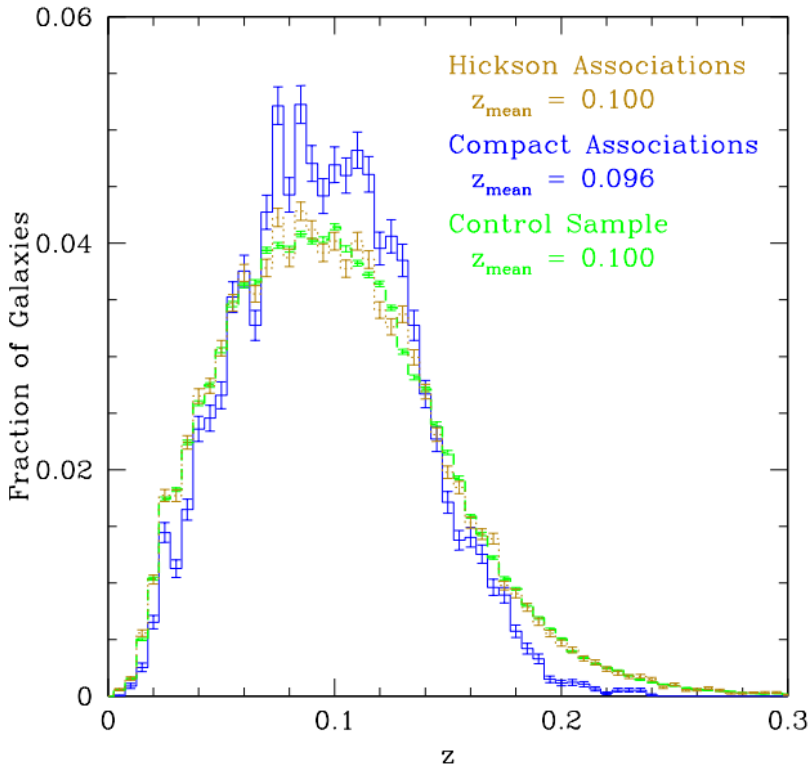
Stellar Mass & Redshift

Brasseur et al.(2008)

$M_*(CA) \simeq 7.9 \times 10^{10} M_\odot > M_*(HA)$



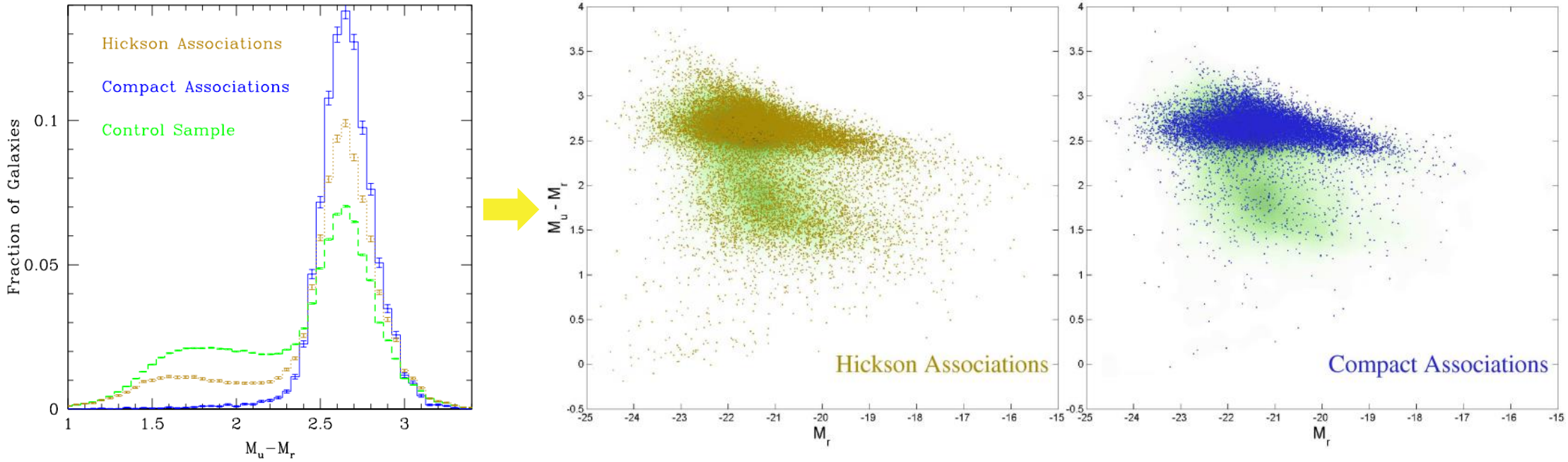
$z_{CA} \simeq 0.096 < z_{control} \simeq 0.100$



Colour

Brasseur et al.(2008)

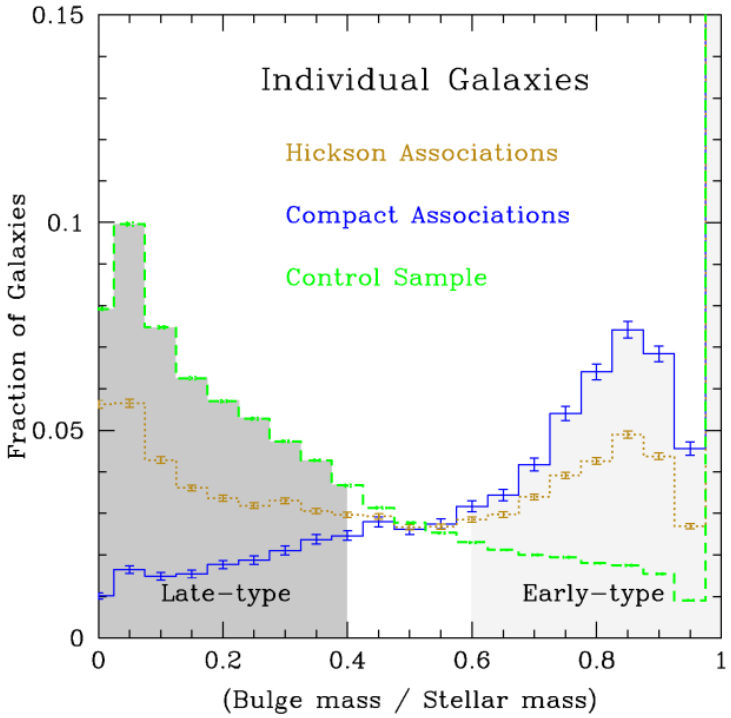
CAs are nearly all red, $(M_u - M_r) > 2.25$, only a very low level tail to bluer colours.
CAs effectively lack a blue population and nearly all galaxies are found in a very strong red sequence.

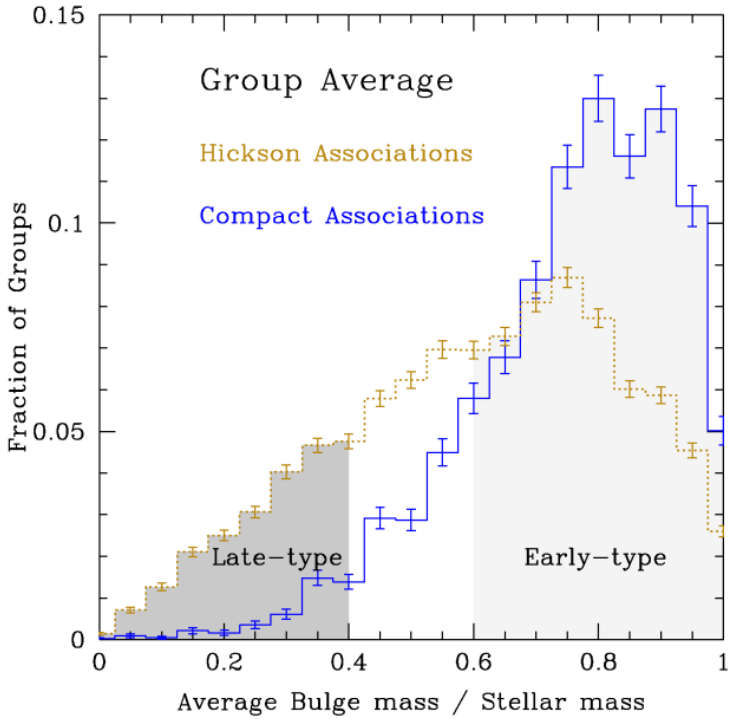


Morphology

Brasseur et al.(2008)

Galaxies in the HA sample possess a much higher fraction of bulge-dominated galaxies than the control sample.





3

Compact groups in SDSS

Compact Groups in SDSS DR6

McConnachie et al.(2009)

Catalogue A:

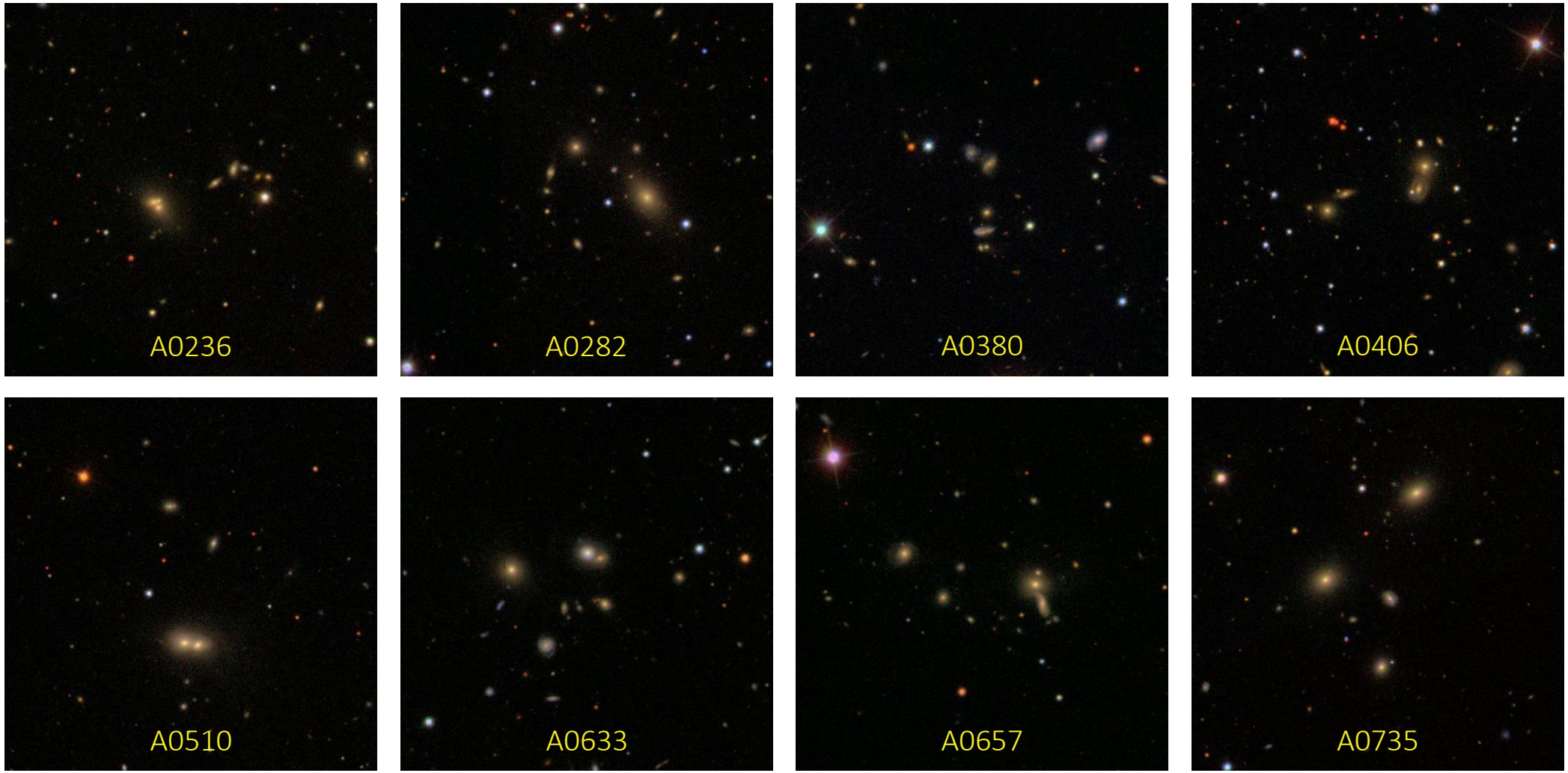
~1.1 M galaxies $14.5 \leq r \leq 18.0$

ID	α (J2000)			δ (J2000)			n_{mem}	μ	θ_G
SDSSCGA00001	14	49	34.3	+11	14	53.4	4	20.991	0.22
SDSSCGA00002	2	14	4.5	+13	18	54.3	4	21.238	0.28
SDSSCGA00003	23	54	13.5	-10	23	17.2	4	21.279	0.16
SDSSCGA00004	15	25	53.7	+5	44	17.8	4	21.501	0.16
SDSSCGA00005	23	33	23.6	-1	8	43.8	4	21.519	0.29
SDSSCGA00006	21	40	17.4	-8	4	11.7	4	21.566	0.14
SDSSCGA00007	8	24	31.6	+20	27	28.5	4	21.585	0.19
SDSSCGA00008	16	10	2.6	+5	54	53.5	4	21.747	0.31
SDSSCGA00009	12	3	12.9	+57	53	39.2	4	21.755	0.32
SDSSCGA00010	16	26	50.4	+25	53	34.7	4	21.913	0.20
SDSSCGA00011	16	21	56.5	+25	41	20.1	4	22.054	0.21
SDSSCGA00012	7	44	42.7	+16	55	21.6	4	22.130	0.29

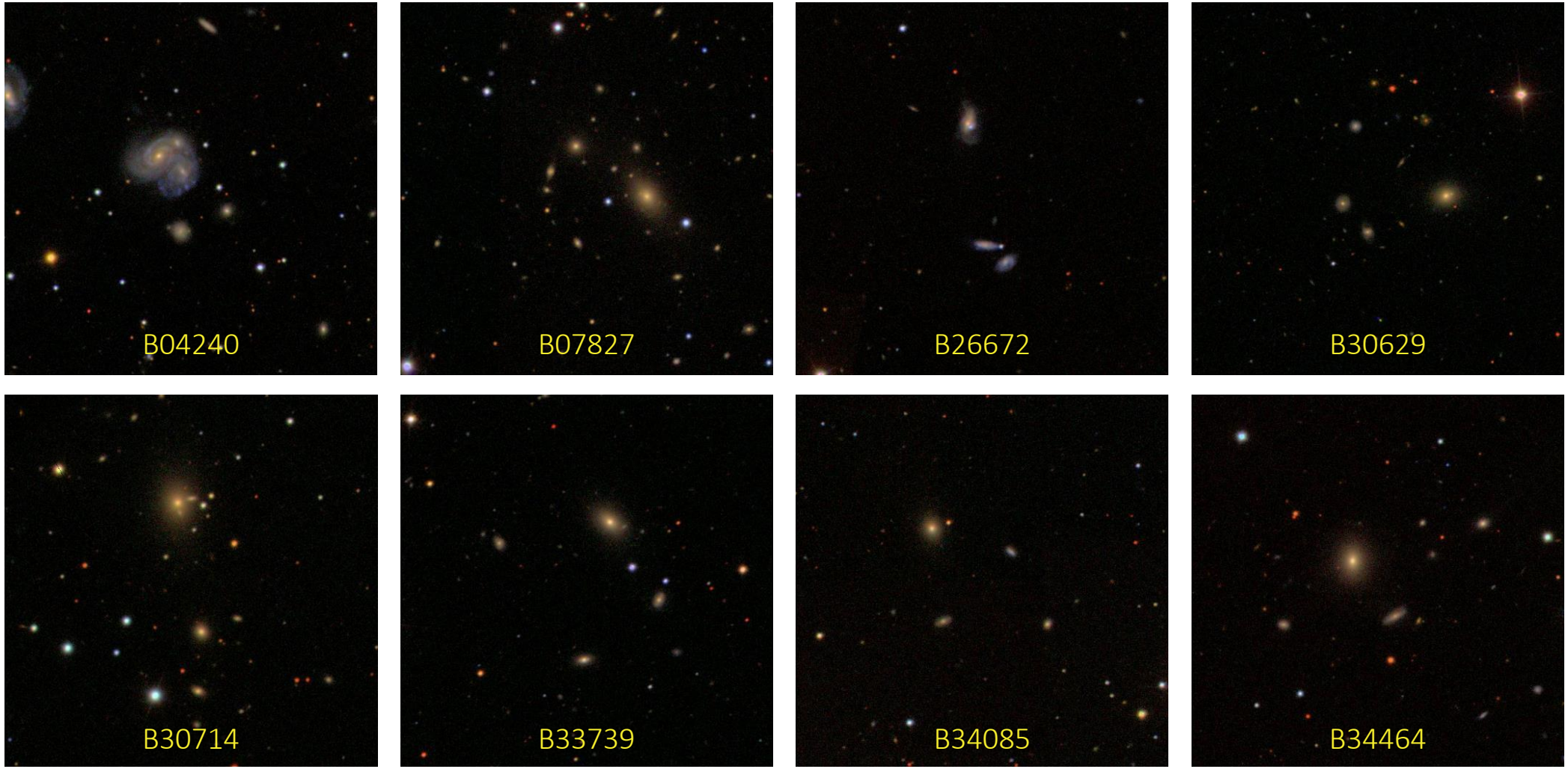
Catalogue B:

~29 M galaxies $14.5 \leq r \leq 21.0$

ID	α (J2000)			δ (J2000)			n_{mem}	μ	θ_G
SDSSCGB00001	14	12	15.8	+35	50	59.0	4	19.730	0.08
SDSSCGB00002	16	15	45.9	+54	40	19.6	4	19.791	0.10
SDSSCGB00003	13	25	10.4	+17	3	8.0	4	20.333	0.13
SDSSCGB00004	11	44	12.1	+27	0	12.0	4	20.347	0.09
SDSSCGB00005	7	55	30.4	+10	25	51.8	4	20.366	0.14
SDSSCGB00006	9	4	34.9	+14	35	42.4	5	20.547	0.19
SDSSCGB00007	13	54	19.5	+7	23	8.3	4	20.577	0.12
SDSSCGB00008	11	4	36.7	+6	23	46.1	4	20.725	0.13
SDSSCGB00009	16	28	28.3	+41	13	6.2	4	20.749	0.21
SDSSCGB00010	16	13	18.9	+50	2	12.7	4	20.805	0.04
SDSSCGB00011	14	29	17.4	-3	9	13.3	4	20.889	0.16
SDSSCGB00012	13	39	44.9	+45	39	58.9	4	20.966	0.05



Compact Association in Catalogue A



Compact Association in Catalogue B

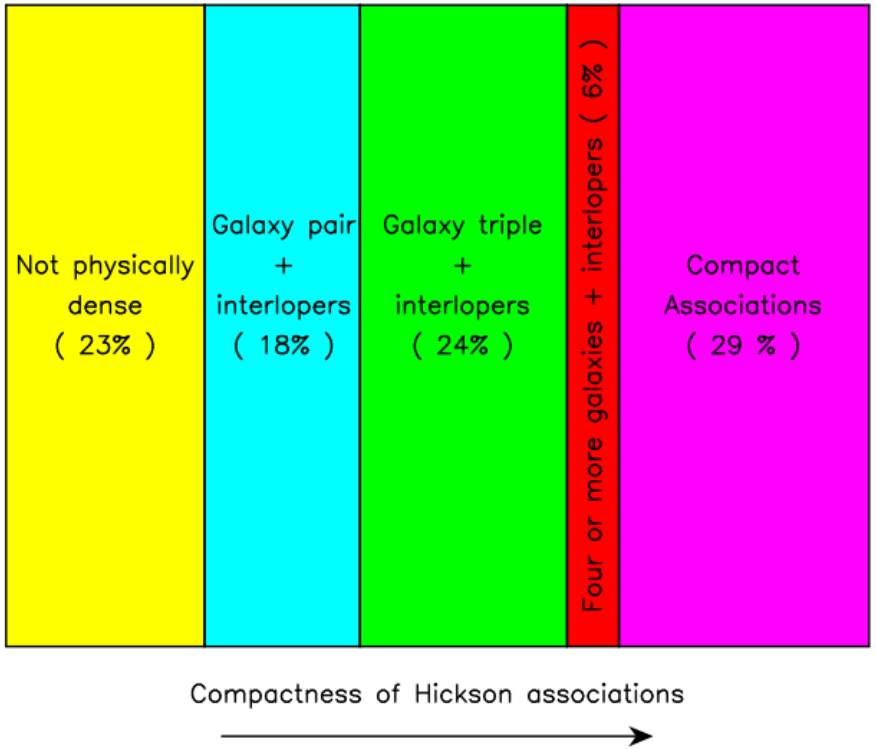
Compact Groups in SDSS DR7

- SDSS DR7 main galaxy catalogue
- ~0.7 M galaxies $14.5 \leq r \leq 17.77$

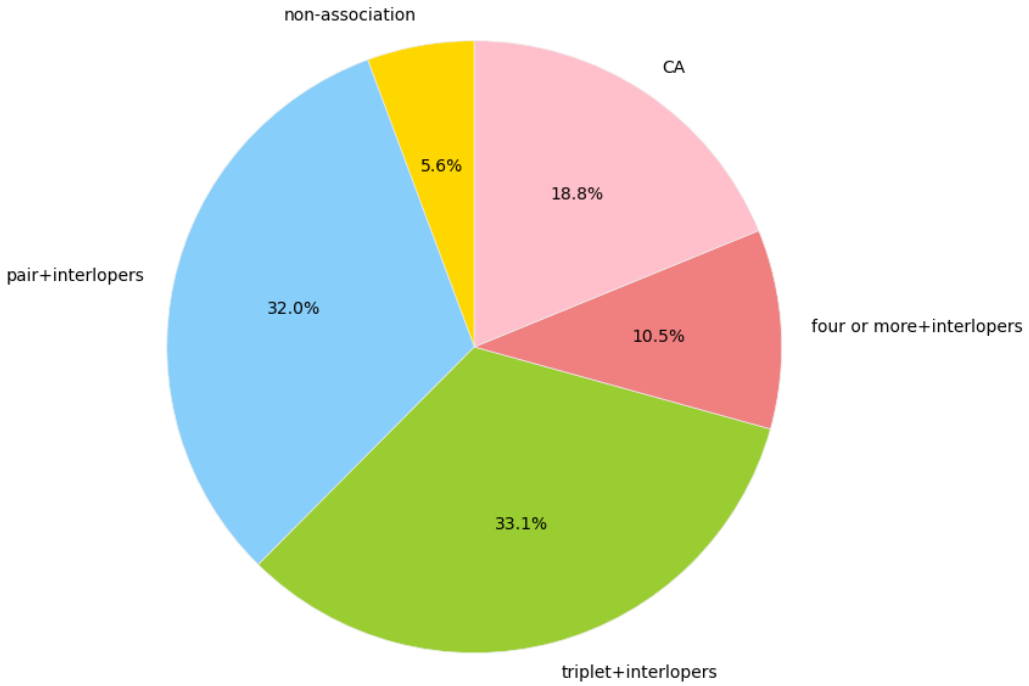
GroupID	RA	DEC	Radius	N	intelopers	SurBri
1	176.964	66.0856	0.0134613	4	1	24.6455
2	181.78	64.9676	0.0237859	5	1	25.873
3	184.947	65.0958	0.015706	4	2	25.8945
4	175.163	64.1841	0.0179041	4	2	25.393
6	170.67	63.5264	0.0190296	4	1	25.7776
9	185.403	62.9438	0.0187959	4	1	25.173
10	171.571	62.7384	0.032246	4	1	25.8059
11	166.227	61.6324	0.0291424	4	2	25.9475

Interlopers in HAs

Mock Catalogue

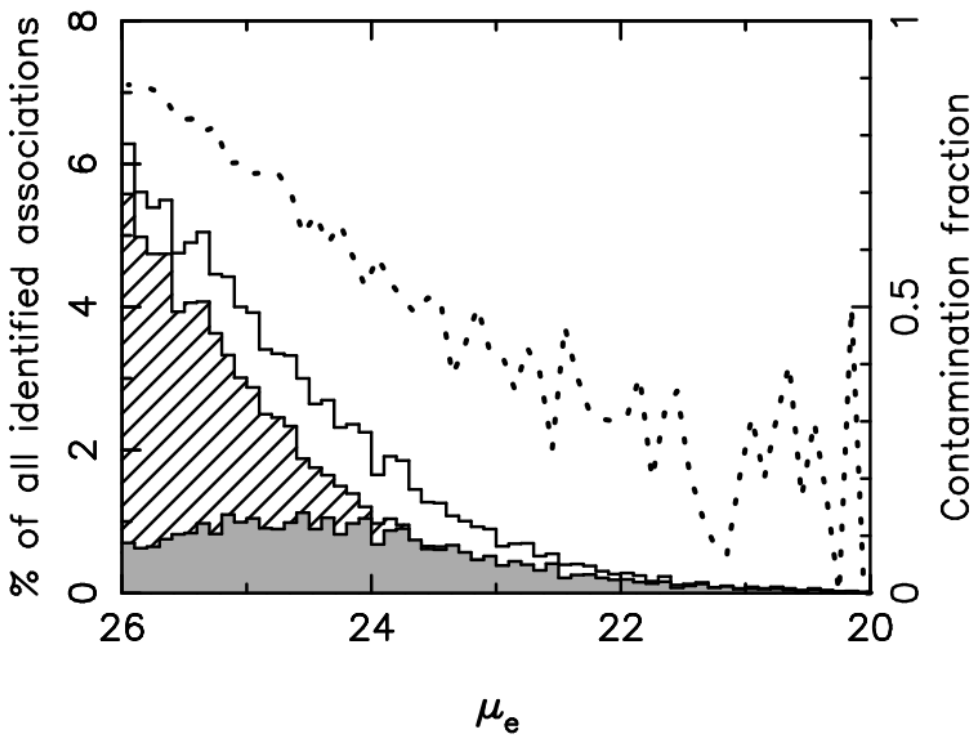


SSDS DR7 main galaxy catalogue:(~260)

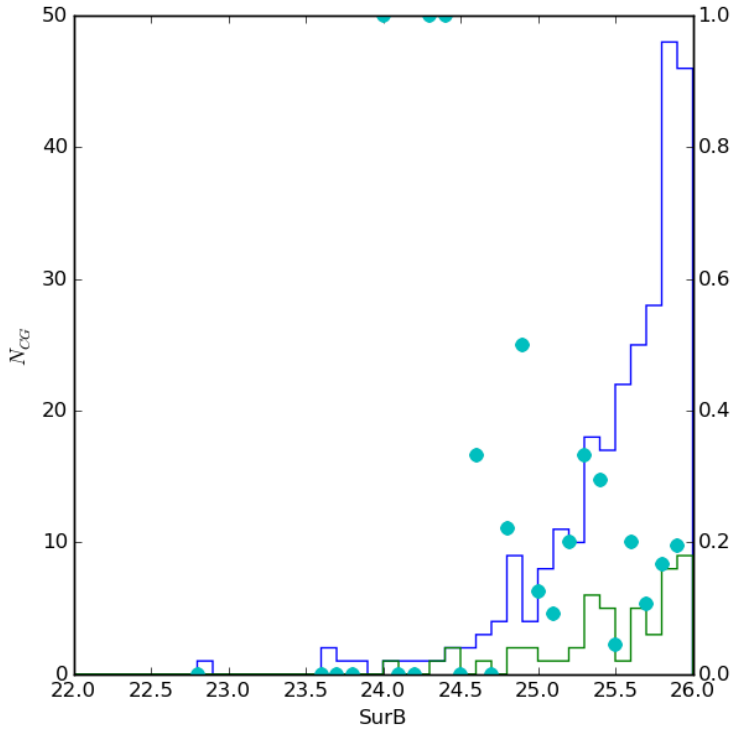


Contamination

Mock Catalogue



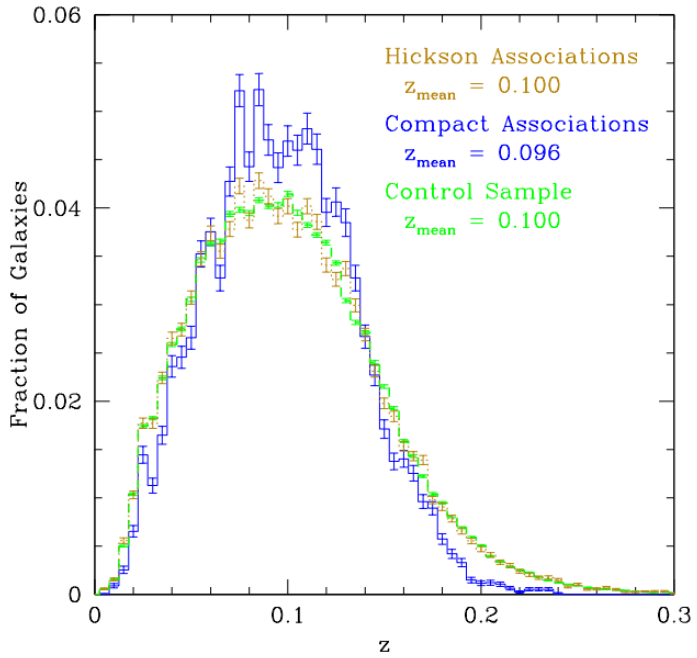
SSDS DR7 main galaxy catalogue:



Redshift of galaxies in CGs

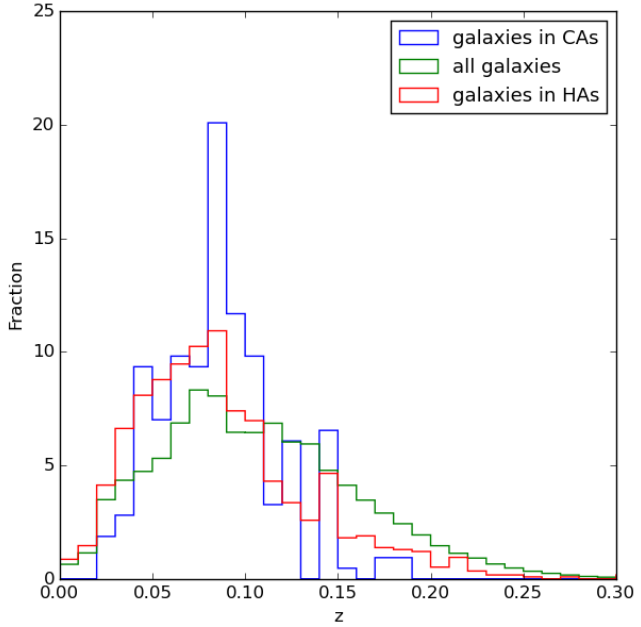
Brasseur et al.(2008):

$z_{CA} \simeq 0.096$, $z_{HA} \simeq 0.100$, $z_{control} \simeq 0.100$



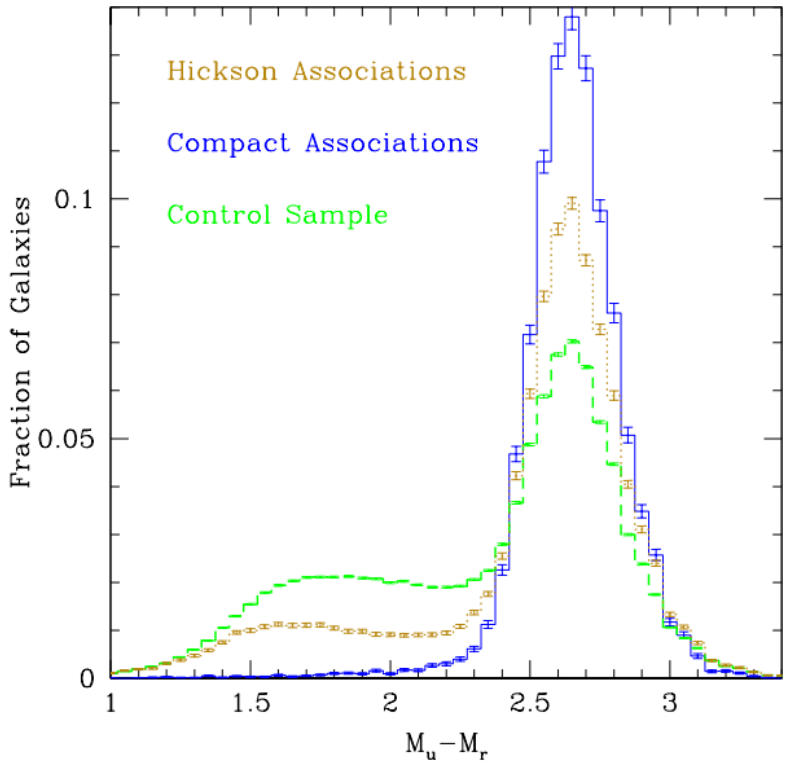
SSDS DR7 main galaxy catalogue:

$z_{CA} \simeq 0.085$, $z_{HA} \simeq 0.088$, $z_{all} \simeq 0.107$

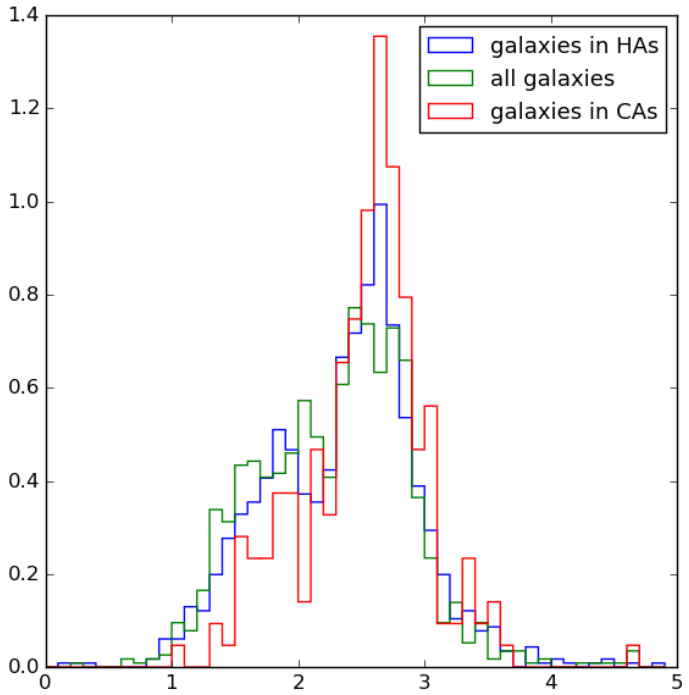


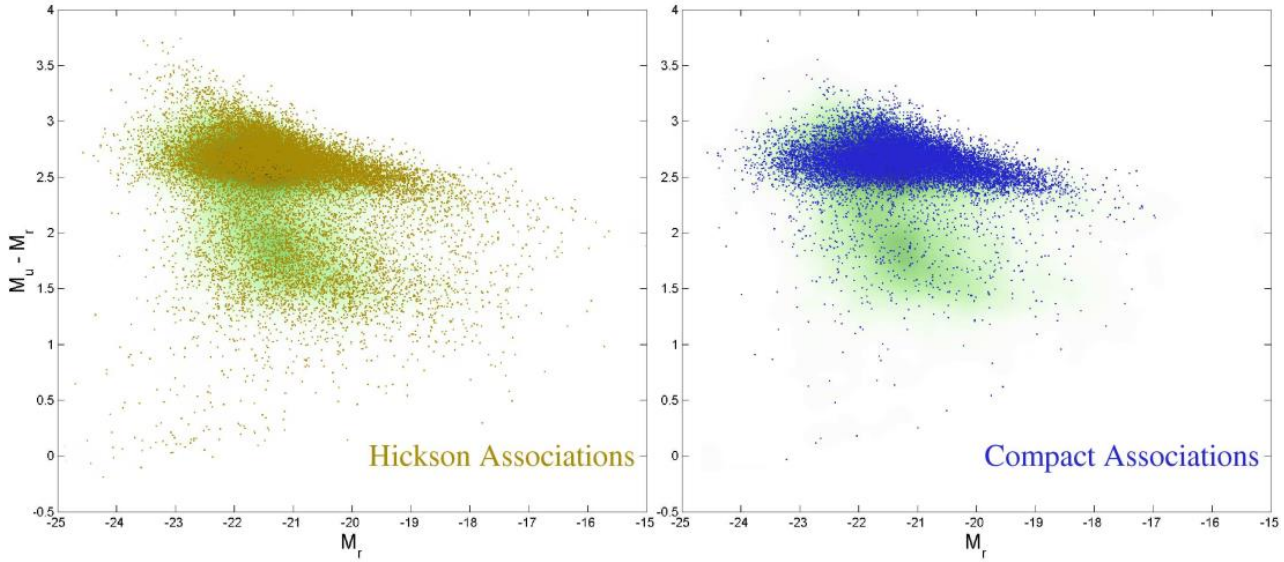
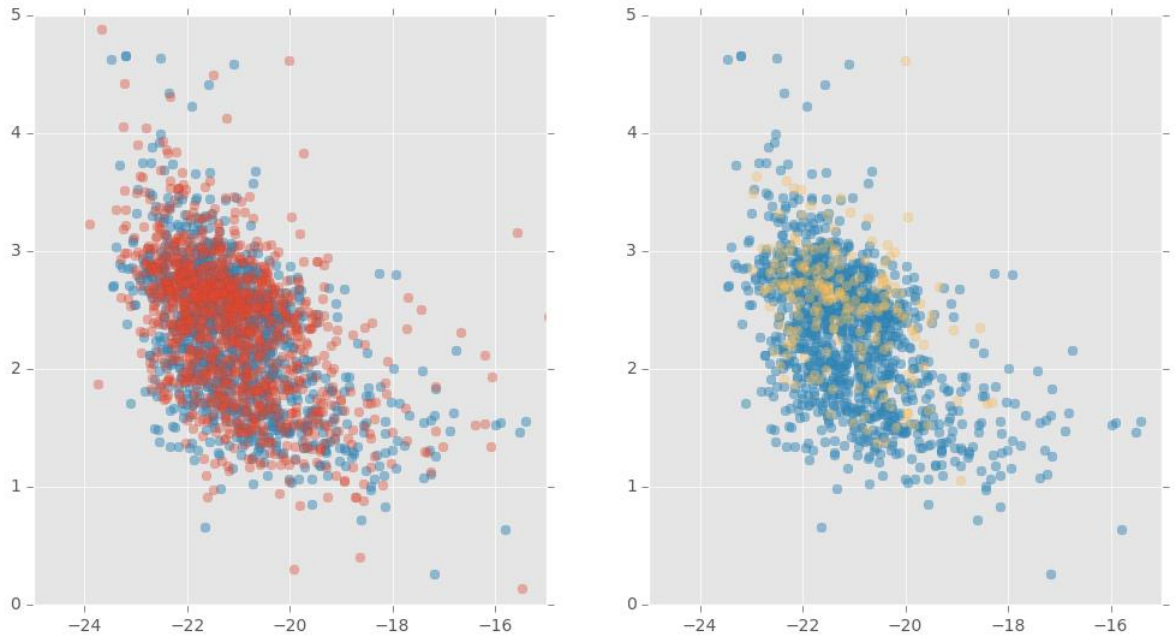
Colour of galaxies in CGs

Mock Catalogue



SSDS DR7 main galaxy catalogue




Hickson Associations
Compact Associations
M_u - M_r
M_r