A MIGHTEE Study of the Group Environment

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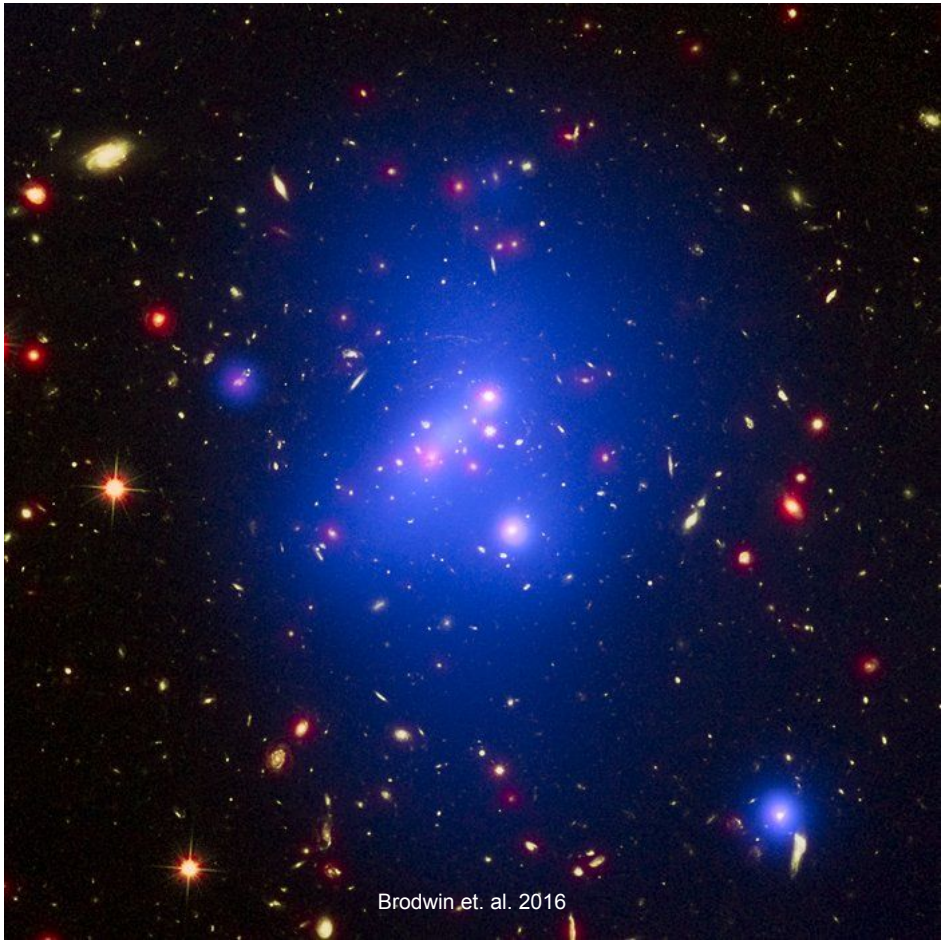
M.Sc. Thesis under the guidance of Prof. Dr. Joseph Mohr
at LMU, Munich

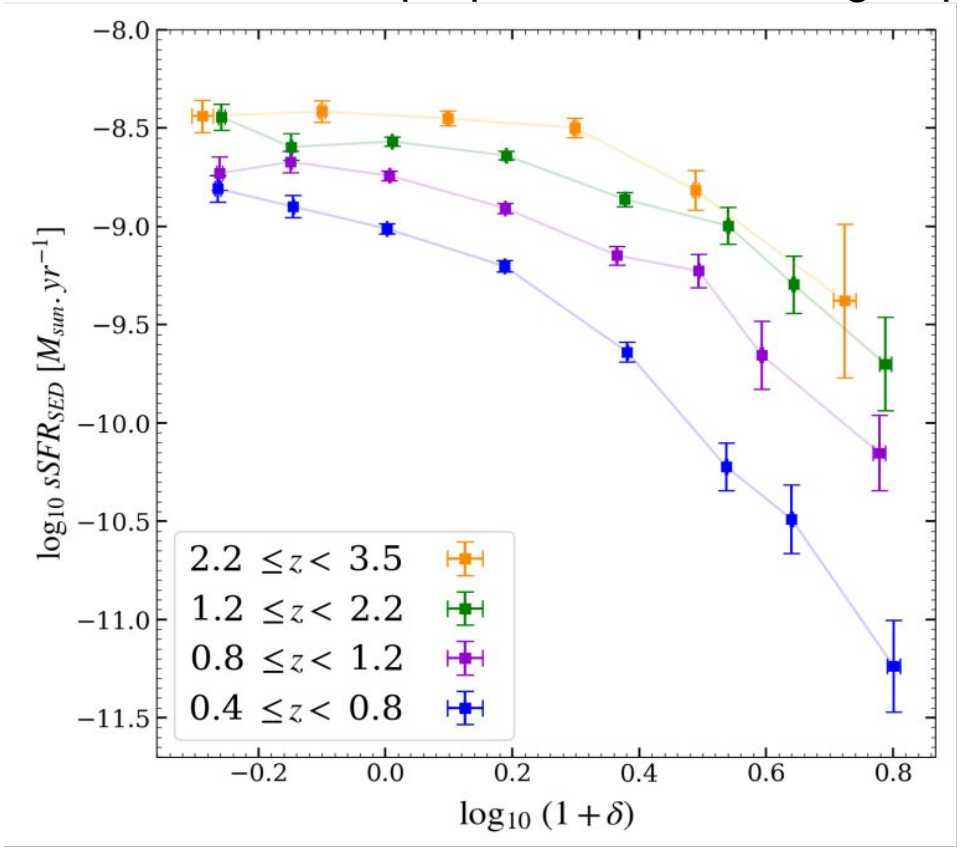
Outline:

- Environmental Effects on Evolution of Galaxies
- Data Sources
- Analysis
  - Radial Surface Density Profiles
  - Discrepancy b/w Radio and IR Profiles
  - Nearest Neighbours
- Results



Environmental Effects on Evolution of Galaxies

- Significant variation in observed properties of cluster, group & field galaxies



Chartab+19

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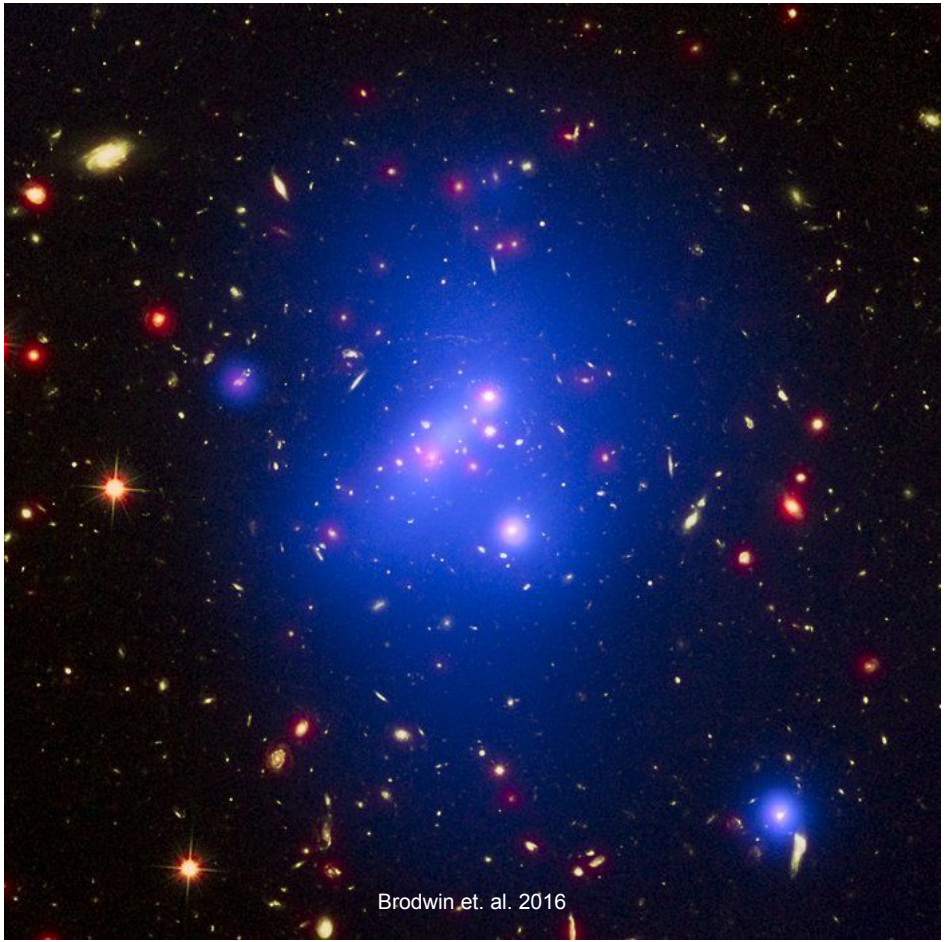
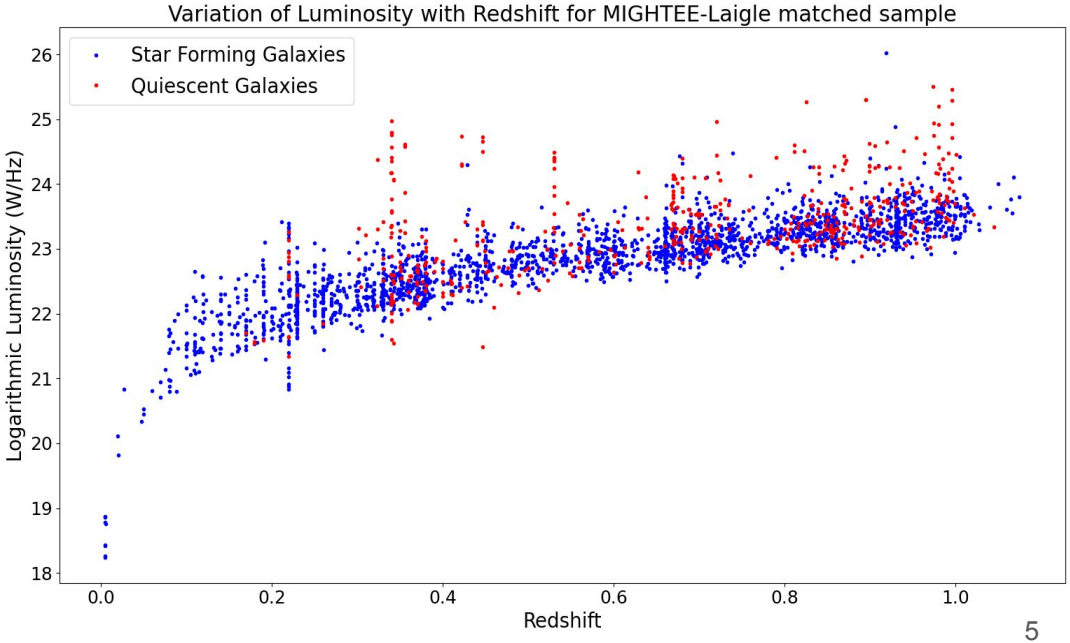


Data Sources

- MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE) Survey (Jarvis+17) Cross-matched Radio Catalog
  - COSMOS (0.85 deg^2)
  - 5 σ S1.4GHz ~ 20 μJy
  - Unprecedented sensitivity to radio AGN and star forming galaxies.
  - Cross-matched to MIGHTEE multiwavelength catalog
- MIGHTEE Multiwavelength Catalog
  - 216,268 K_s band selected sources
  - Galaxy coordinates, SED quantities
- COSMOS2015 Catalog (Laigle+16)
  - Star forming flag - Star forming (SF) /Non-star-forming (Non SF) Galaxies
- Cosmos Cluster Catalogs (George+11)
  - Group coordinates, z, mass, concentrations



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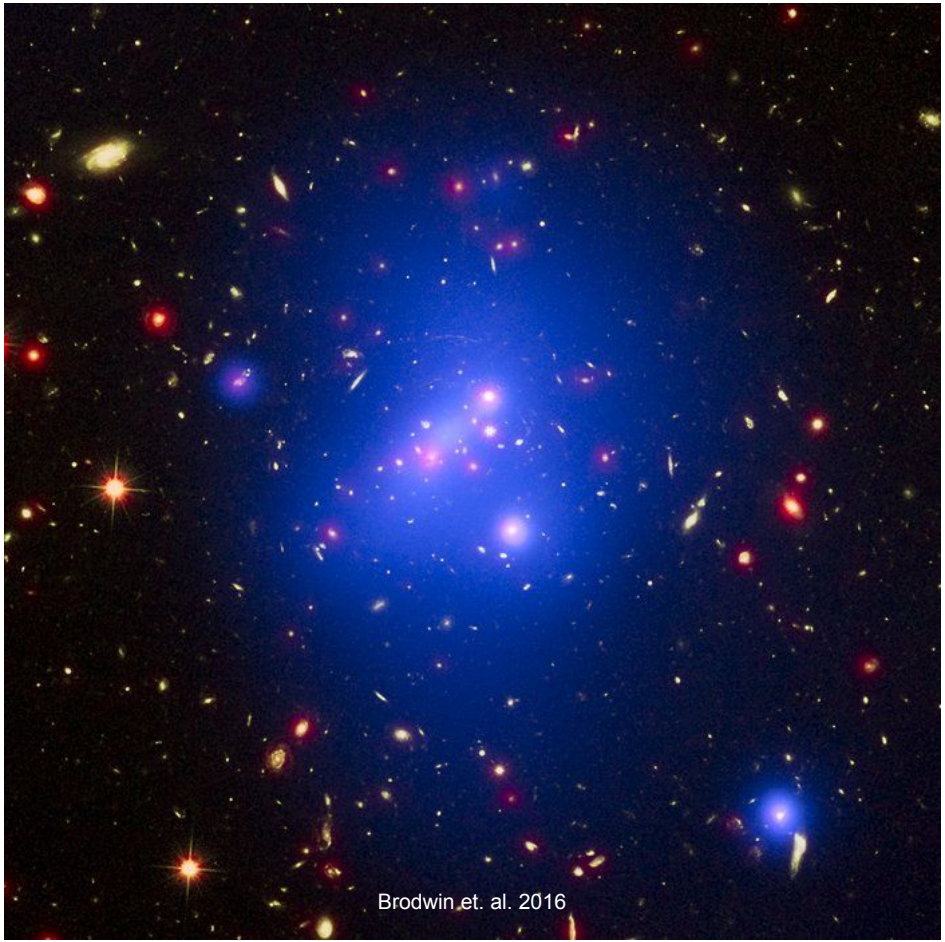
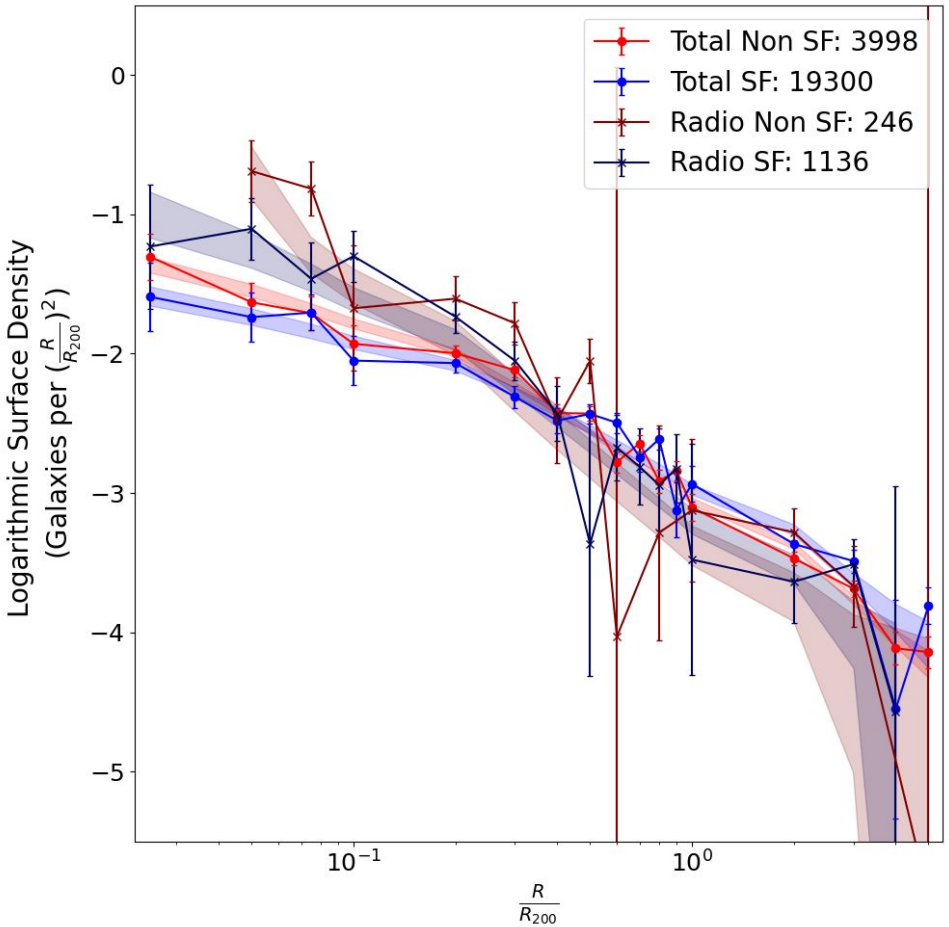


Radial Surface Density Profiles



Fit Model (Hennig+17):

$NGal_{annulus}$ = ($NGal_{outer\ radius}$ - $NGal_{inner\ radius}$) + background * area

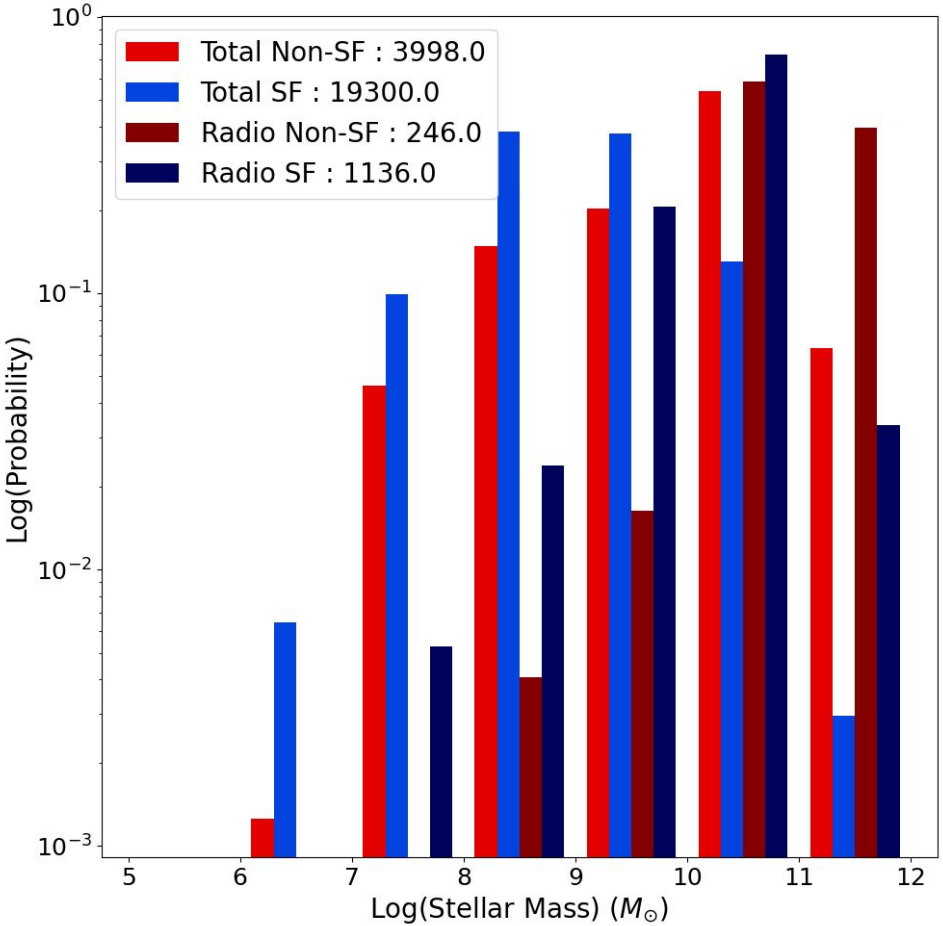
$$N(R) = \frac{N_{200} \cdot g(cR)}{g(c)}$$

$$g(x) = \begin{cases} \frac{2}{\sqrt{(x)^2-1}} arctan \frac{\sqrt{x-1}}{\sqrt{x+1}} + ln(\frac{x}{2}) & \text{if x} > 1 \\ \frac{2}{\sqrt{1-(x)^2}} arctan \frac{\sqrt{1-x}}{\sqrt{1+x}} + ln(\frac{x}{2}) & \text{if x} < 1 \\ 1 + ln(\frac{x}{2}) & \text{if x} = 1 \end{cases}$$

2D Projected NFW Fits:

Dataset	Concentration	Σ_{bg}	N_{200}
Total Non SF	$3.898^{+0.479}_{-0.490}$	$0.283^{+0.008}_{-0.008}$	$513.479^{+23.569}_{-24.417}$
Total SF	$2.235^{+0.439}_{-0.462}$	$1.820^{+0.020}_{-0.022}$	$505.850^{+34.296}_{-37.073}$
Radio Non SF	$32.480^{+19.147}_{-18.845}$	$0.019^{+0.002}_{-0.002}$	$26.006^{+5.614}_{-7.331}$
Radio SF	$12.712^{+4.755}_{-5.070}$	$0.103^{+0.004}_{-0.004}$	$62.720^{+9.496}_{-11.432}$

Discrepancy between Radio and IR radial profiles



Radio detected galaxies prefer higher masses!

2 Methods to try and explain the underlying reason for this discrepancy:

- Nearest Neighbours Analysis
- Forward Modelling (prone to Eddington bias)

Nearest Neighbours Analysis

- Normalise mass, sSFR and redshift by subtracting median from the sample and dividing by median absolute deviation.

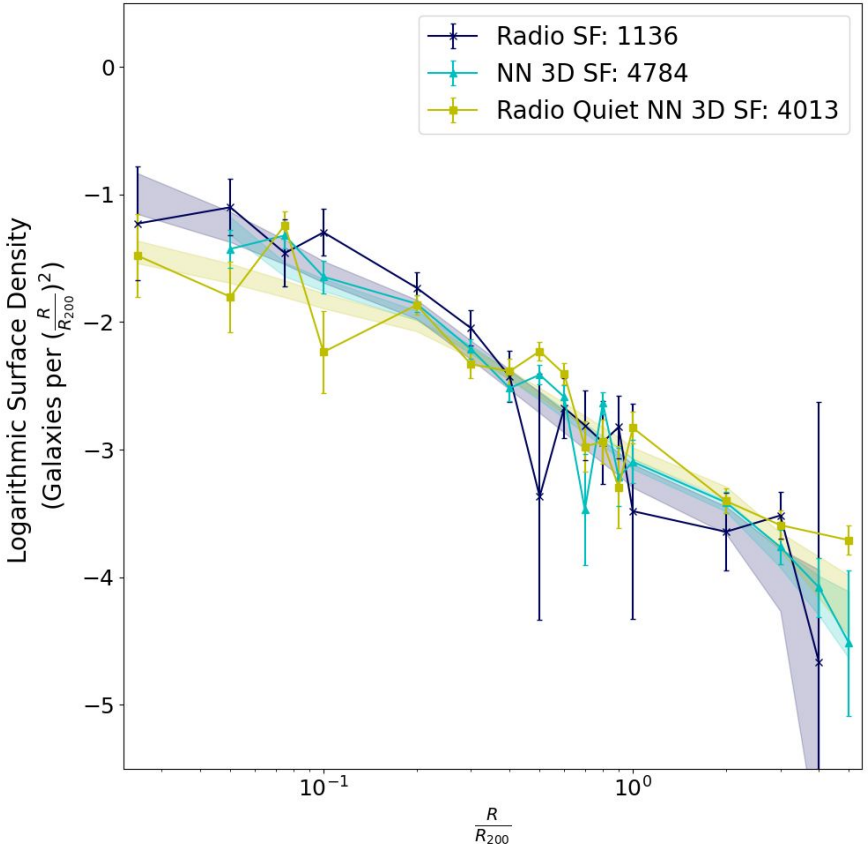
- Make initial catalog using 10 closest neighbours in normalised redshift, mass & sSFR space. Select only the nearest neighbours of radio loud galaxies.

- We are selecting for similar redshift, mass and sSFR - only the radial profile will provide an insight.

- Same process is carried out in normalised redshift-mass space and normalised redshift-sSFR space. Now the sSFR histogram and the mass histogram, respectively, will also provide information.

- Nearest neighbour radial surface density profiles normalised identically i.e. fitted background is subtracted from observed radial surface density and then the whole profile is normalised by the fitted n200 value.

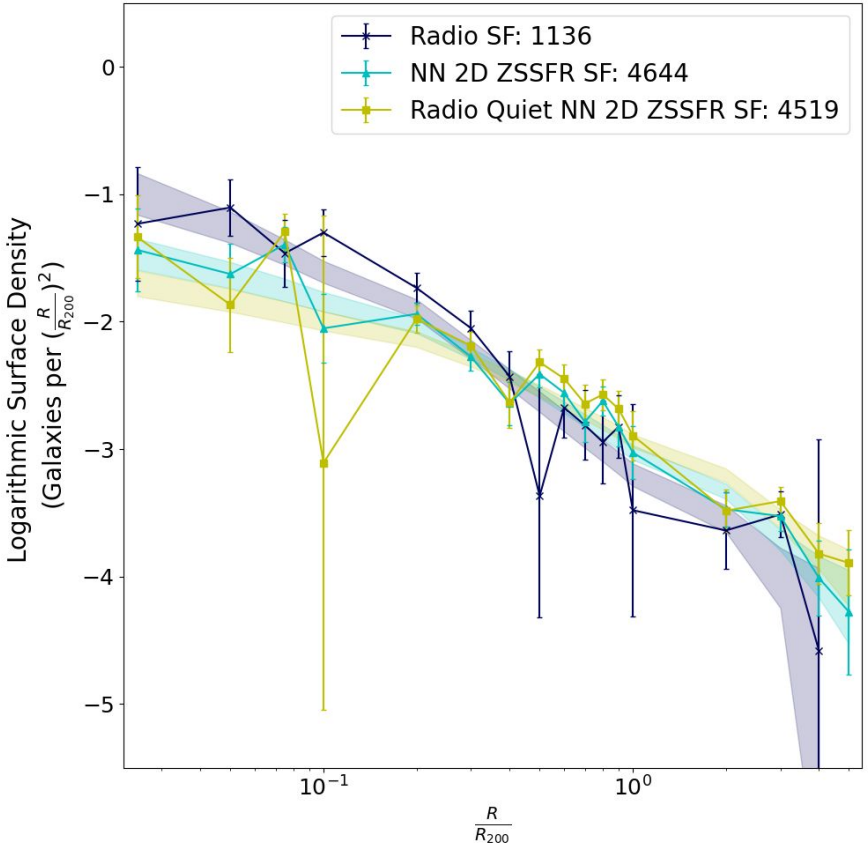
SF Nearest Neighbours (Redshift, Mass & sSFR)



Dataset	Concentration	Σ_{bg}	N_{200}
Radio SF	$10.131^{+3.498}_{-3.796}$	$0.103^{+0.004}_{-0.004}$	$60.878^{+9.534}_{-11.014}$
Nearest Neighbours 3D SF	$5.410^{+1.030}_{-1.075}$	$0.422^{+0.008}_{-0.009}$	$283.930^{+20.068}_{-21.436}$
Radio Quiet NN 3D SF	$3.187^{+0.711}_{-0.716}$	$0.350^{+0.008}_{-0.008}$	$211.661^{+18.024}_{-19.172}$

- Nearest neighbour profile consistent with radio SF profile
- Radio quiet nearest neighbour profile NOT consistent with radio SF profile

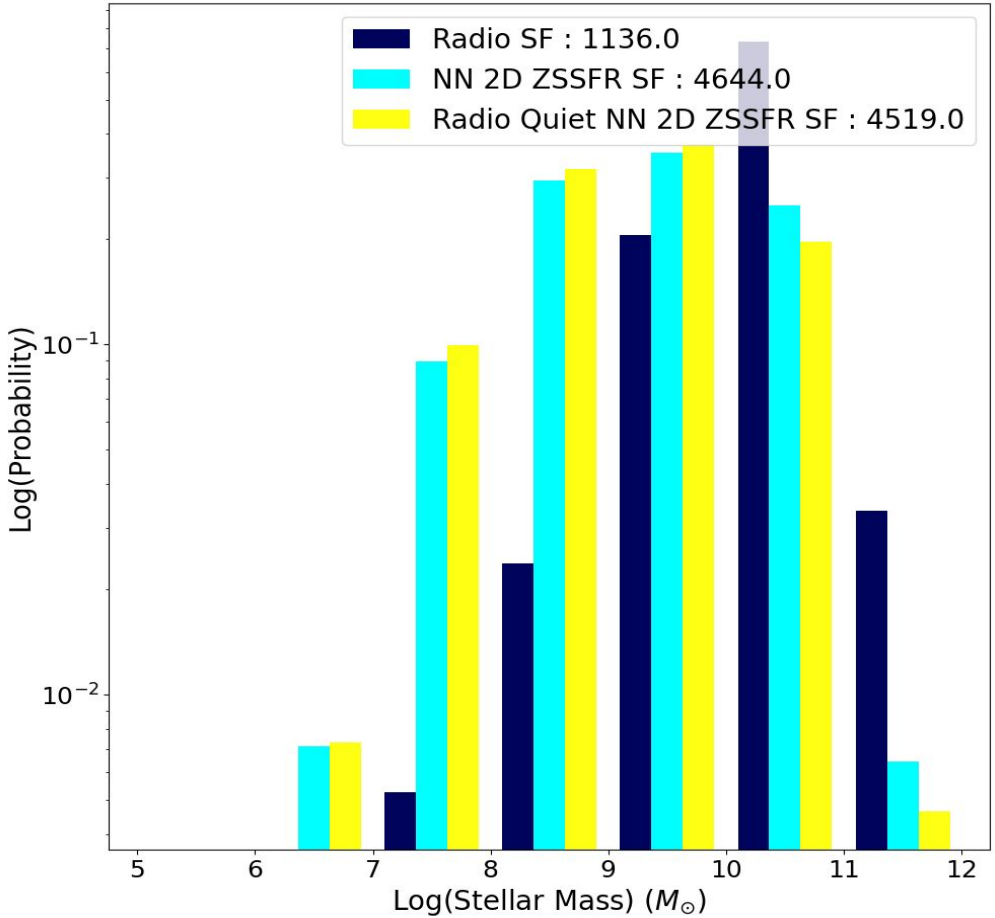
SF Nearest Neighbours (Redshift & sSFR)



Dataset	Concentration	Σ_{bg}	N_{200}
Radio SF	$9.818^{+3.243}_{-3.819}$	$0.103^{+0.004}_{-0.004}$	$61.268^{+9.435}_{-11.054}$
Nearest Neighbours 2D ZSSFR SF	$3.075^{+0.908}_{-0.938}$	$0.422^{+0.010}_{-0.010}$	$189.162^{+19.382}_{-19.807}$
Radio Quiet NN 2D ZSSFR SF	$1.675^{+0.506}_{-0.465}$	$0.410^{+0.010}_{-0.011}$	$148.892^{+17.167}_{-18.948}$

- Nearest neighbour profiles not Consistent with radio profile
- Mass selection is important for reproducing the radio profile

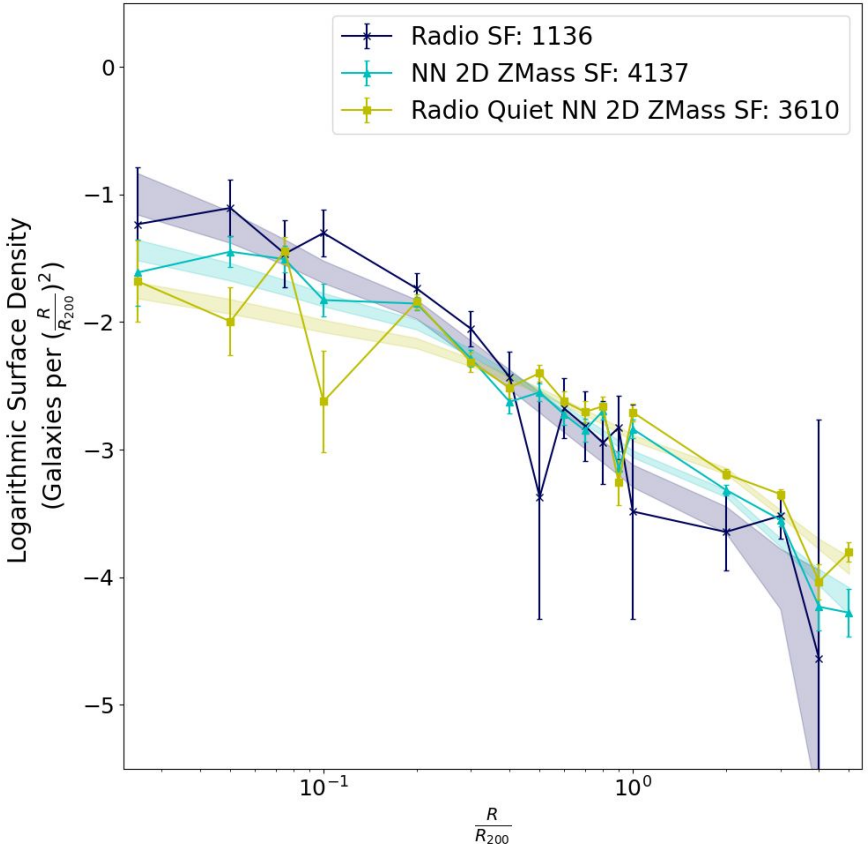
SF Nearest Neighbours (Redshift & sSFR)



Matching in z, sSFR space leads to selection of low mass star-forming galaxies. But, radio SF sample is dominated by high mass star-forming galaxies

Evidence of AGN Contamination in Radio Loud SF Sample

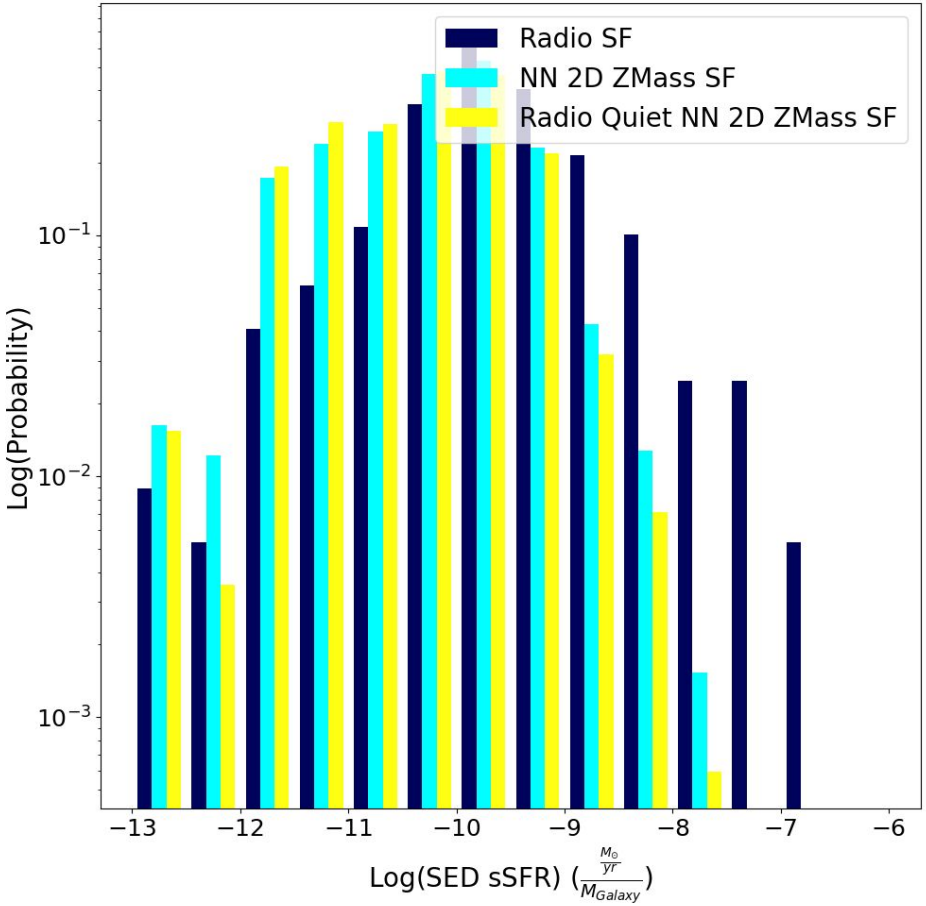
SF Nearest Neighbours (Redshift & Mass)



Dataset	Concentration	Σ_{bg}	N_{200}
Radio SF	$10.013^{+3.455}_{-3.816}$	$0.102^{+0.004}_{-0.004}$	$60.935^{+9.491}_{-11.441}$
Nearest Neighbours 2D ZMASS SF	$3.313^{+0.582}_{-0.622}$	$0.307^{+0.009}_{-0.010}$	$438.945^{+22.369}_{-22.906}$
Radio Quiet NN 2D ZMASS SF	$1.345^{+0.233}_{-0.226}$	$0.241^{+0.011}_{-0.011}$	$339.657^{+19.393}_{-20.553}$

- Nearest neighbour profiles not consistent with radio profile
- Simultaneous matching in BOTH mass and sSFR important to reproduce radio profile.

SF Nearest Neighbours (Redshift & Mass)



Matching in z, Mass space leads to selection of high mass quiescent galaxies. Radio SF Sample dominated by High Mass Star-Forming Galaxies

We may be witnessing the feedback responsible for the transition of preferentially massive galaxies from SF to passive in the cores of groups of galaxies

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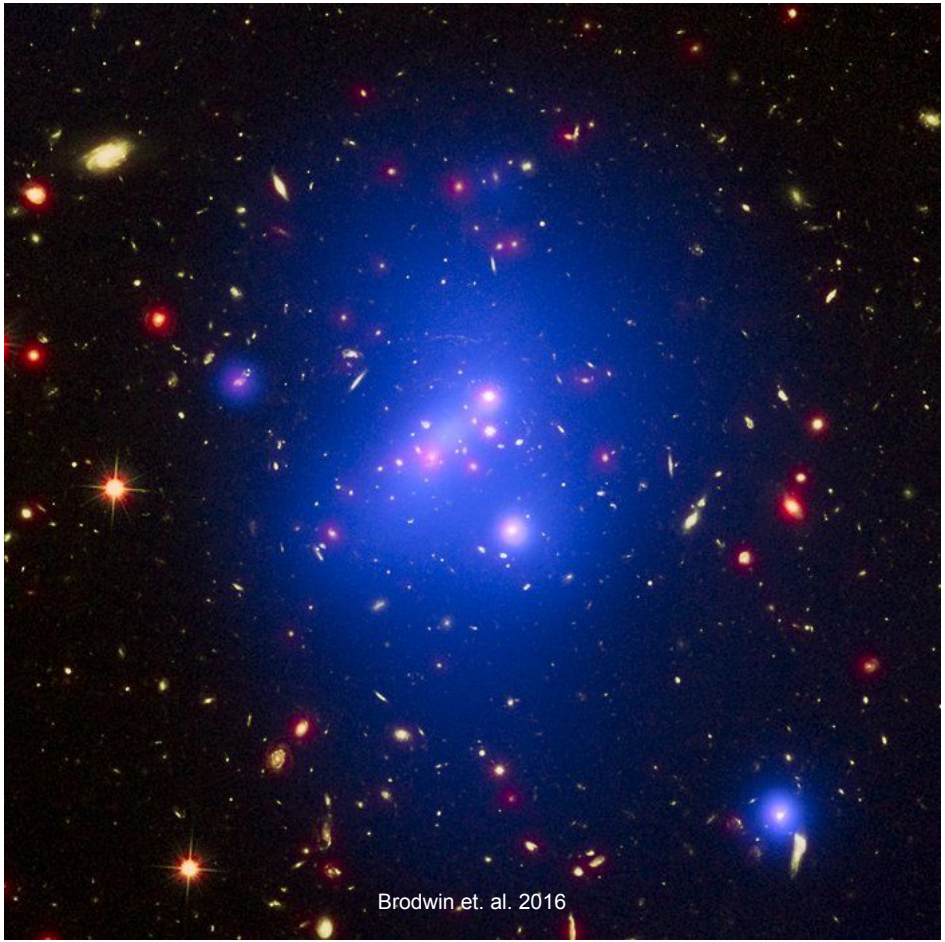

Results

- Radio SF sample has both high mass, and high sSFR.
- Significant markers of AGN Contamination in Radio SF Sample.
- Radio sample is more concentrated than IR selected sample. This is in keeping with previous studies of massive clusters (Eg. Gupta+19), and indicates that the environment in the cluster and group core is responsible for enhancing radio mode accretion.