

Electrons and magnetic field from galaxies in clusters

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Based on a study of the Shapley Concentration

In collaboration with

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More specifically on

Cosmic dance in the Shapley Concentration Core – I. A study of the radio emission of the BCGs and tailed radio galaxies

By Di Gennaro et al, arXiv:1807.06904

Electrons and magnetic field from galaxies in clusters

What we (think to) know:

- Active radio galaxies deposit magnetized relativistic plasma in the IGM
- Star formation does a similar job on [likely] different scales (duration, luminosity, size,...)
- Both phenomena are "transient", sometimes "recurrent" (duty-cycle)
- Related to other astrophysical problems/studies

(CR in the IGM, energy budget...)

Interaction with the thermal plasma (environment), energy exchange, etc.; history of SF and RA of cluster galaxies

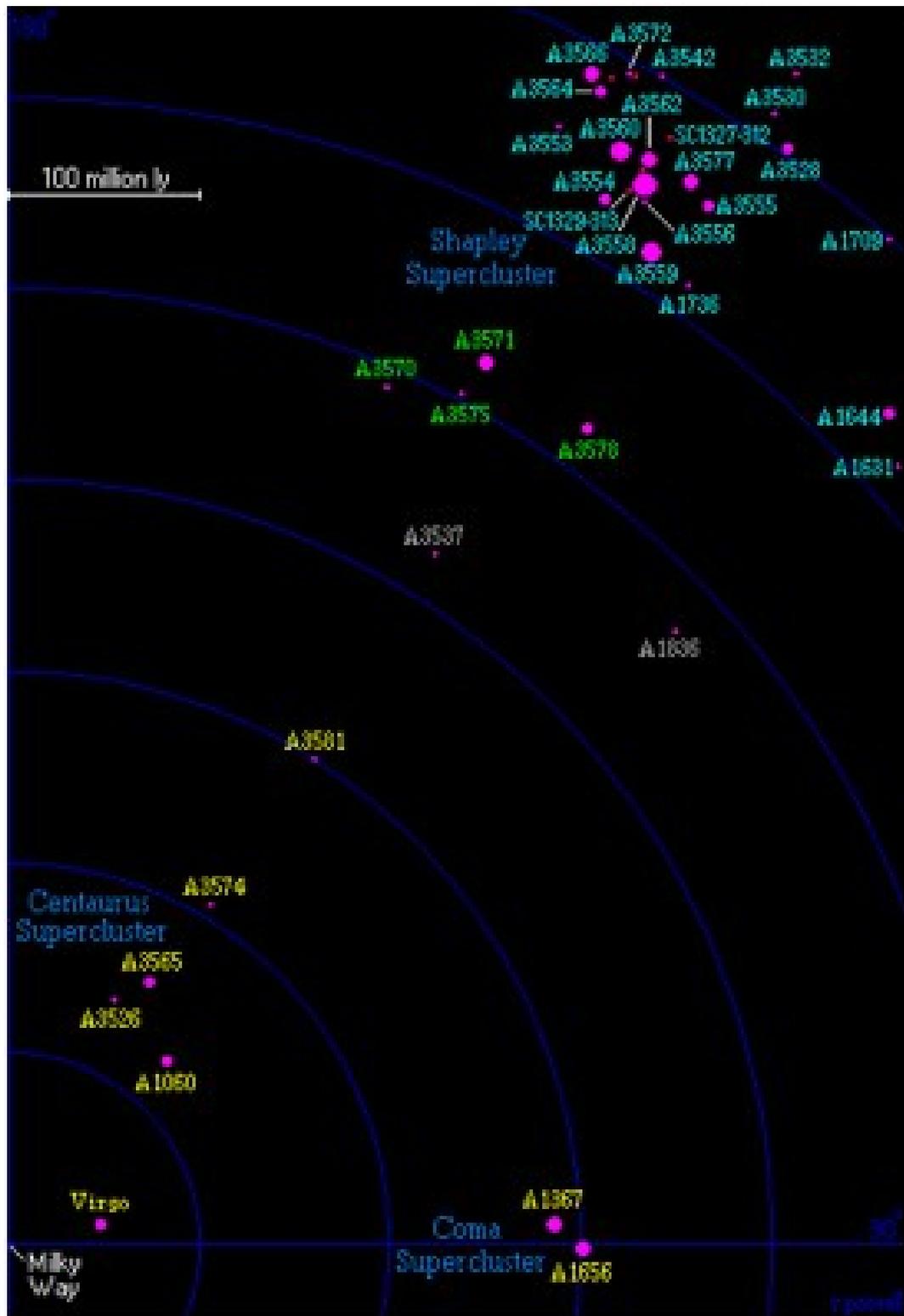
Shapley Concentration aka Shapley SuperCluster:

Nearest example of cluster chain several tens of Abell clusters + many other minor systems

Filaments (following anyone's preferred definition!)

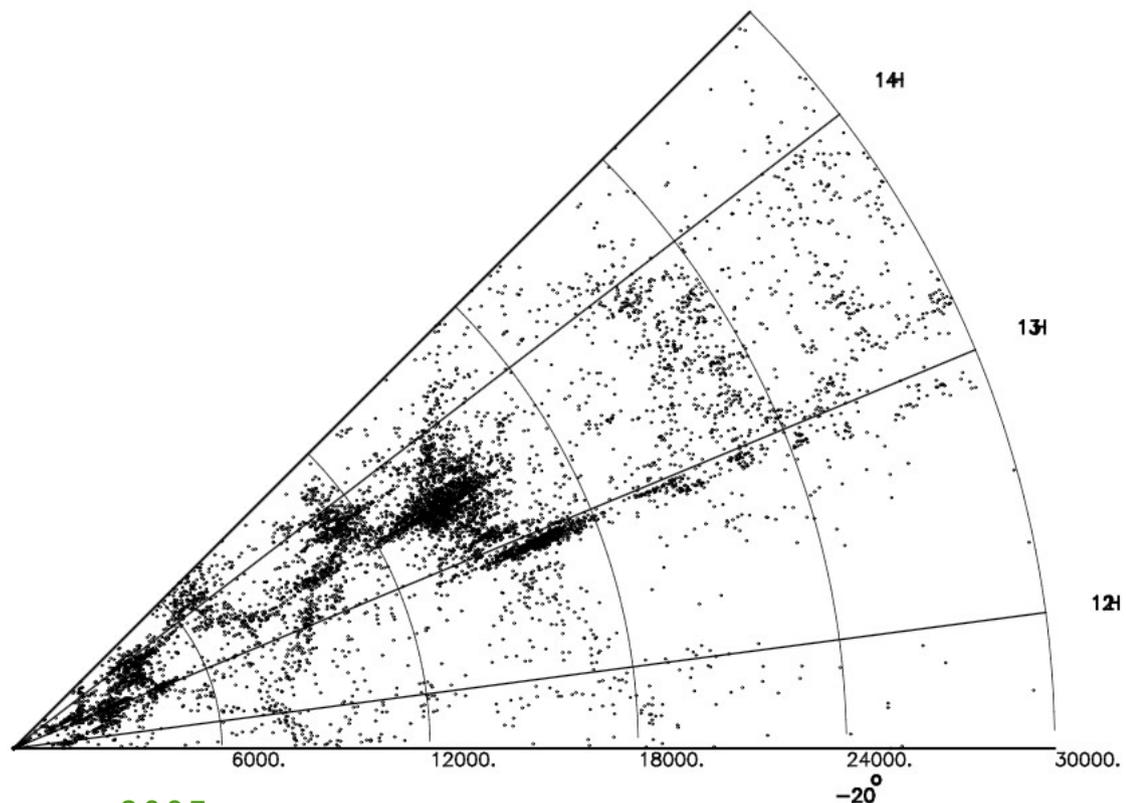
Both ~relaxed and many interacting systems

Target of many programs at various wavelengths

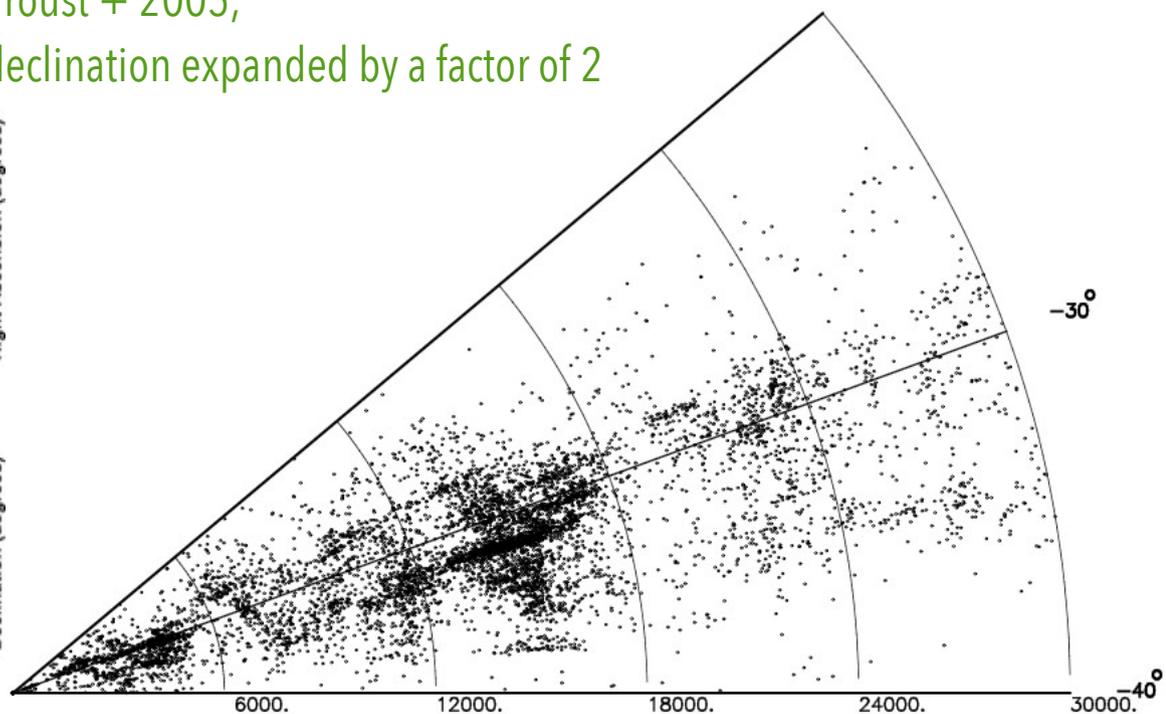
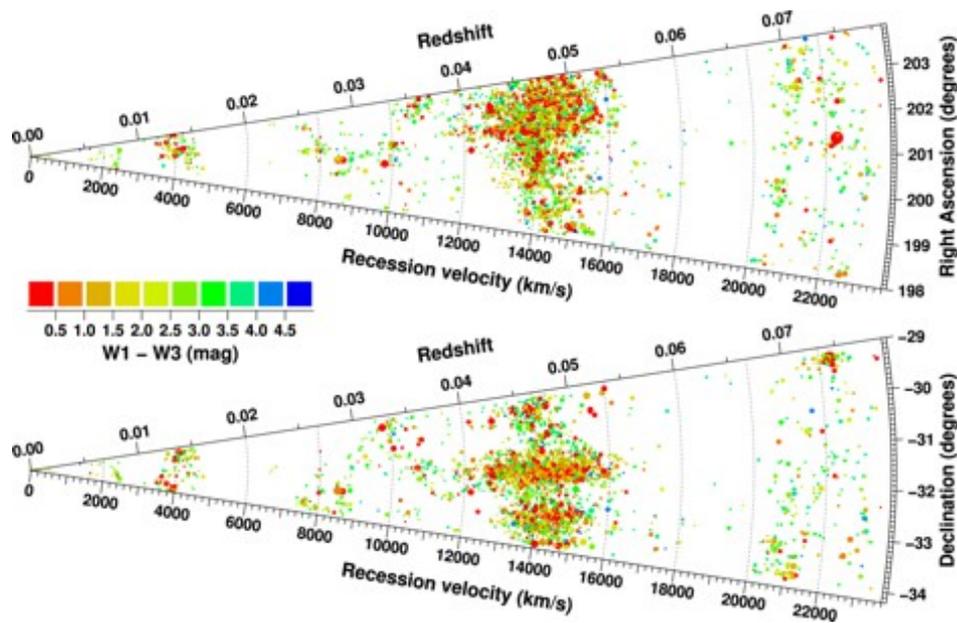


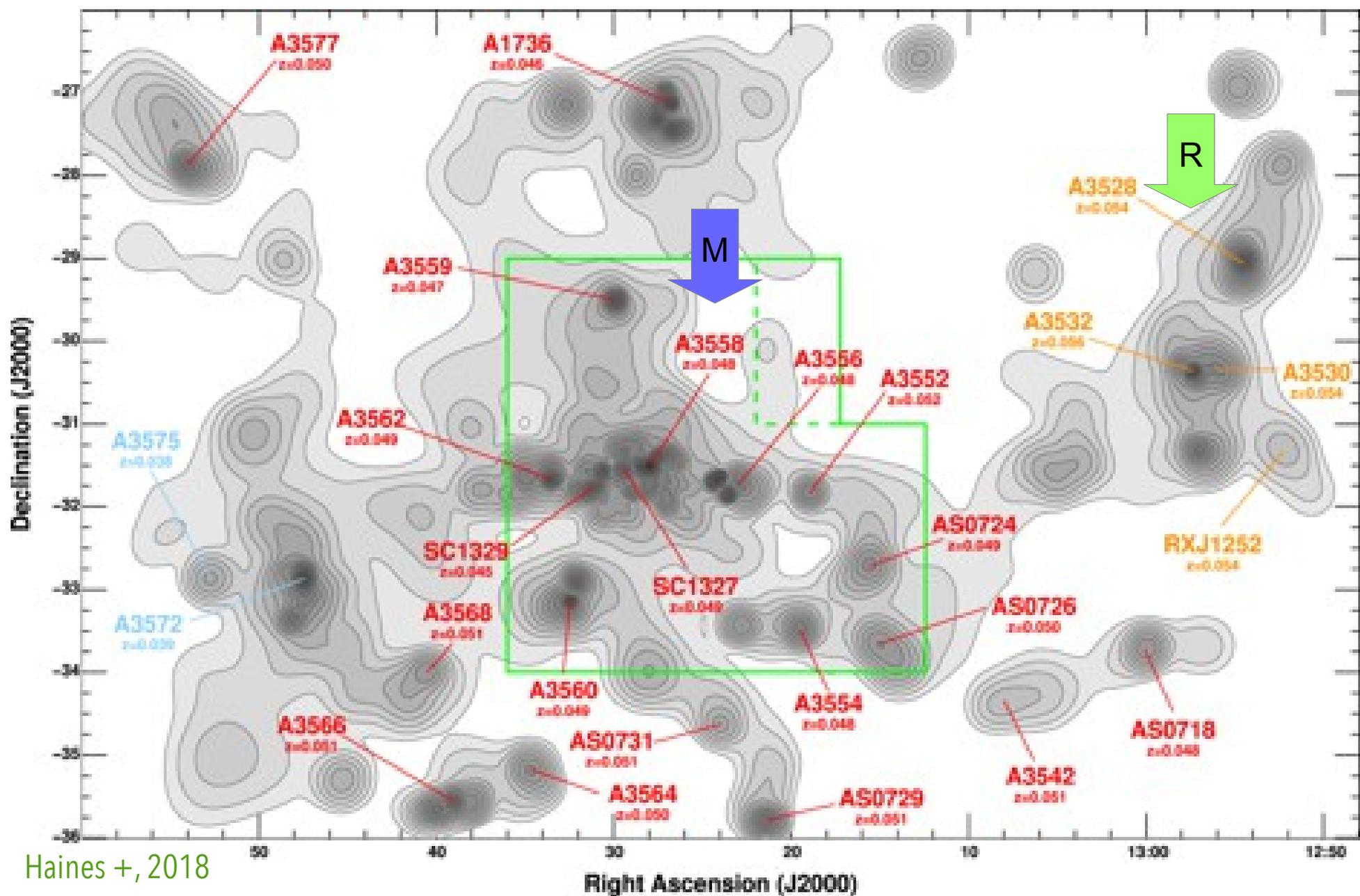
Shapley Concentration aka Shapley SuperCluster:

Galaxies in the redshift/velocity space



Proust + 2005;
declination expanded by a factor of 2





K-band luminosity-weighted density map of $0.035 \leq z < 0.060$ galaxies across the full extent of the Shapley Supercluster. Abell clusters within the same redshift range are labelled, colour coded as: (red) recession velocities within 1500 km s^{-1} of the central cluster Abell 3558; (cyan) low-velocity extension $0.035 \leq z < 0.040$; (orange) high-velocity wing, $0.053 \leq z < 0.060$.

Shapley Concentration aka Shapley Supercluster:

Both ~relaxed and many interacting systems

A3558 / A3528 comparison: search for differences in radio (but not only!) properties?

"Small" scale perturbations in the IGM (see optical edges)

e.g. 3C84 in Perseus, structures in the X-ray brightness from the BCGs

Effects on cluster members (e.g. cluster weather on extended radio sources)

Radio source population studies

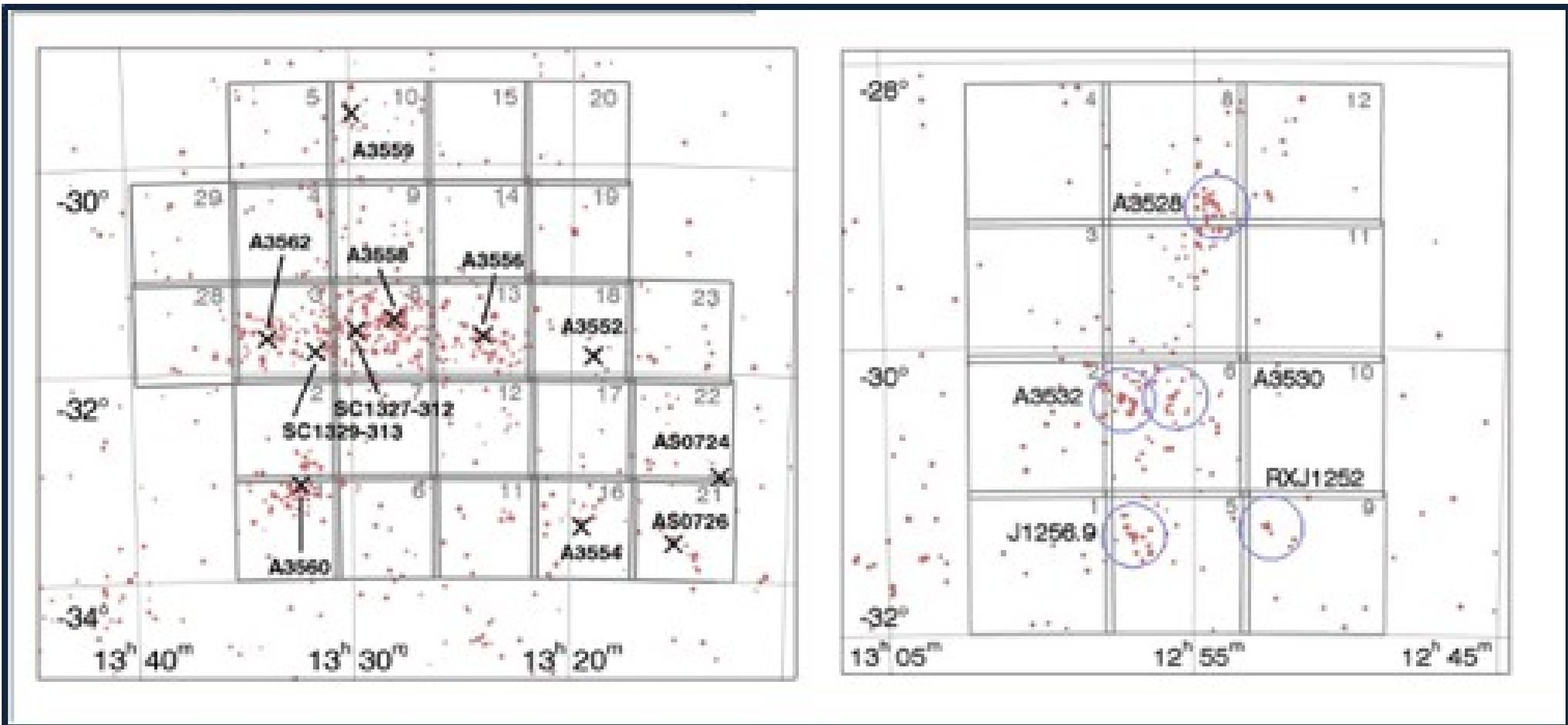
... in general ... Relevance of radio emission in galaxy clusters

- AGN activity, radio emission of the BCG, tailed radio galaxies, diffuse emission on the cluster scale \Rightarrow tool to understand the details/consequences of merging and "accretion"
- Provide magnetized relativistic plasma \Rightarrow as it ages it becomes "fossil plasma" and CR

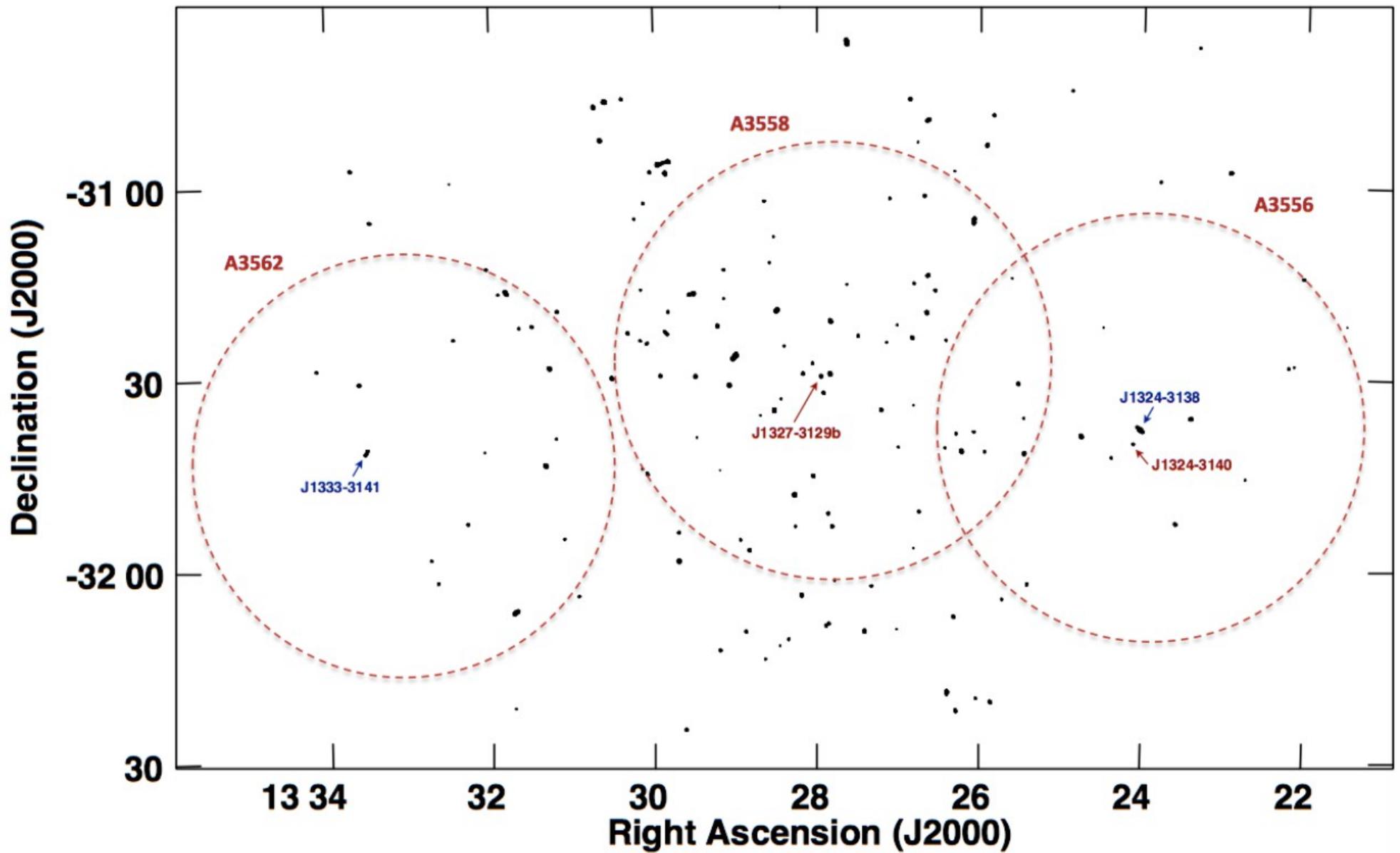
Report on radio data

mostly from a number of GMRT observing programs at 610, 330 and 240 MHz.

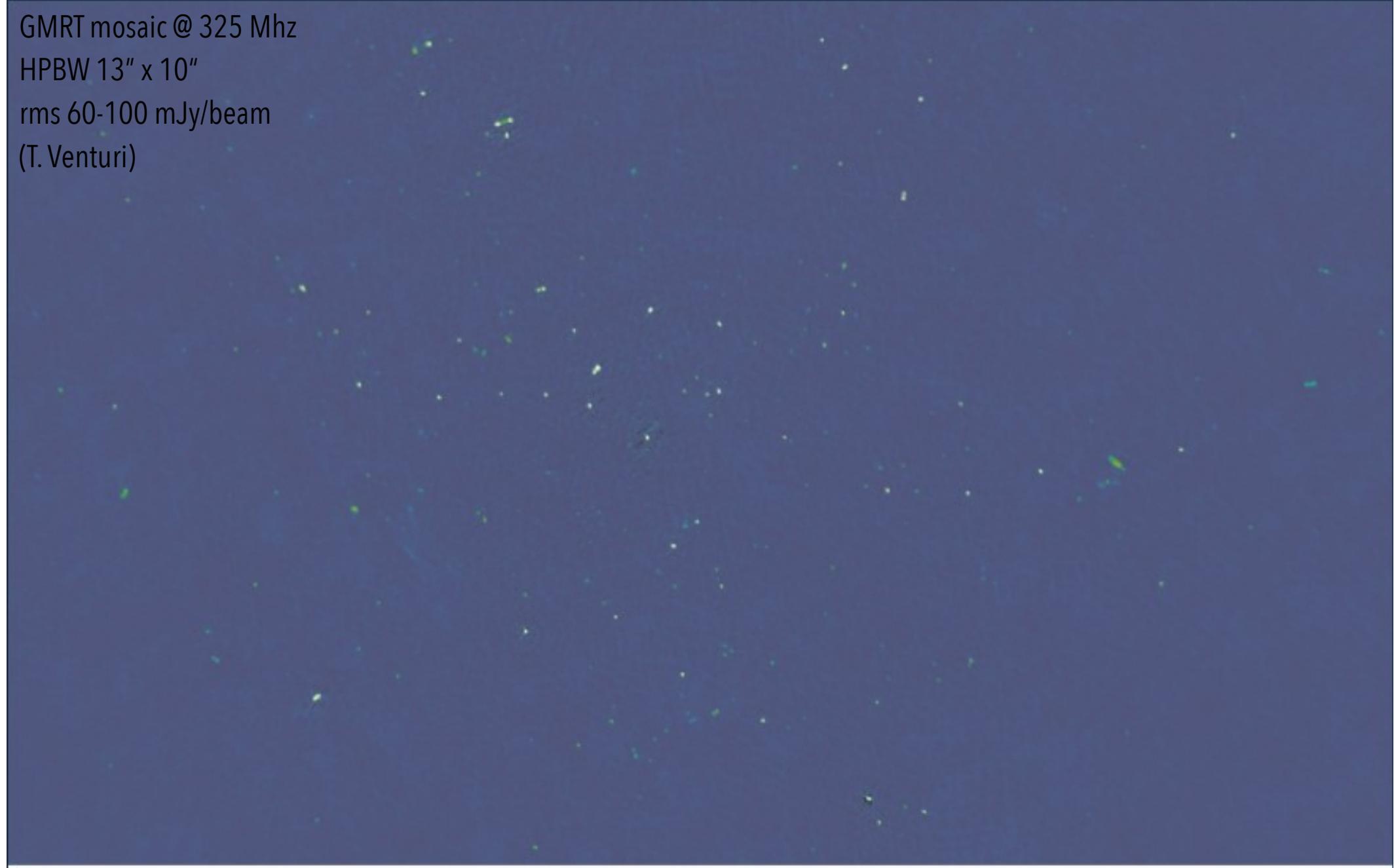
Cosmic dance in the Shapley Concentration Core – I. A study of the radio emission of the BCGs and tailed radio galaxies by *Di Gennaro et al*, *arXiv:1807.06904*



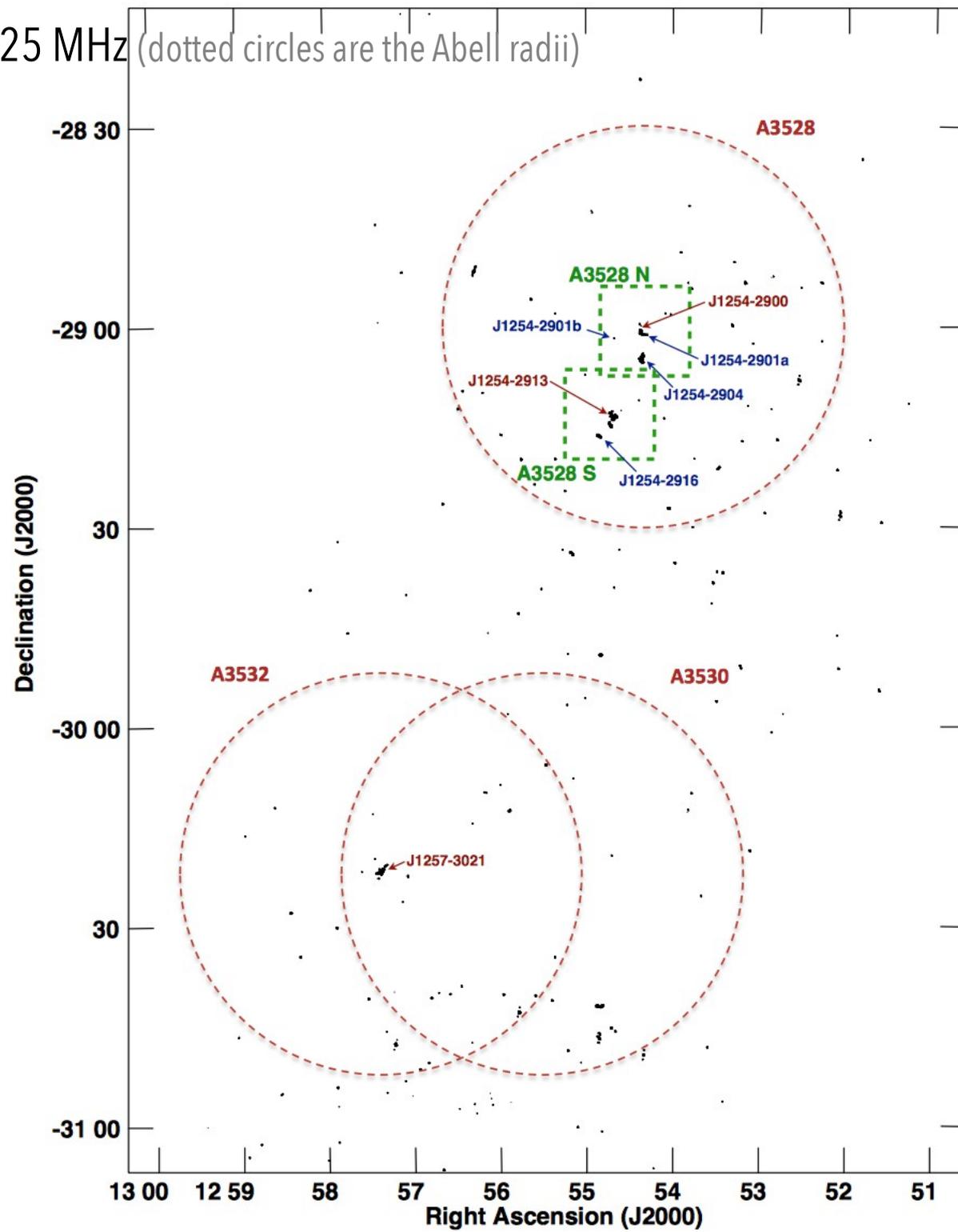
A3558 and his fellows @ 325 MHz (dotted circles are the Abell radii)

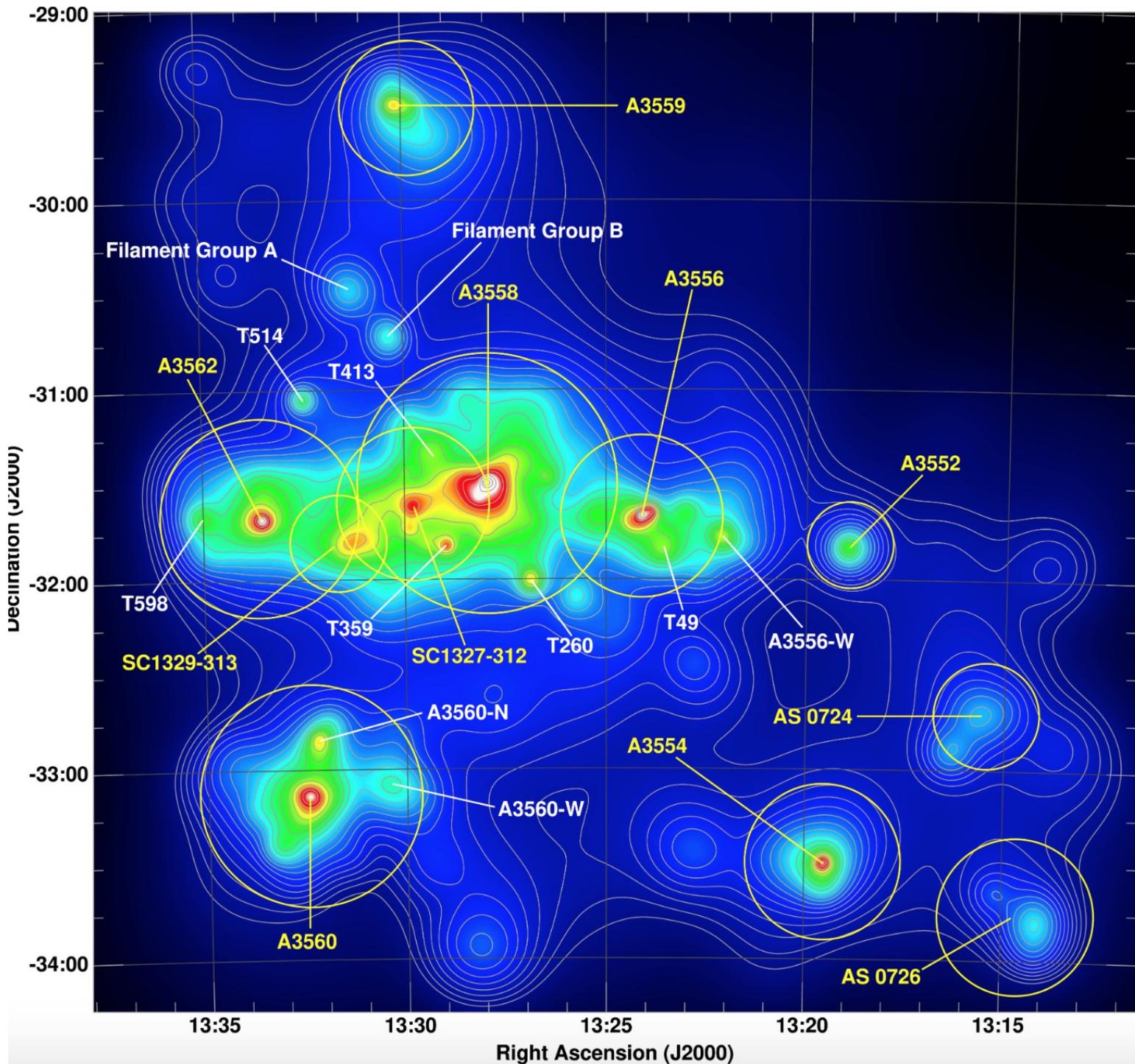


GMRT mosaic @ 325 Mhz
HPBW 13" x 10"
rms 60-100 mJy/beam
(T. Venturi)



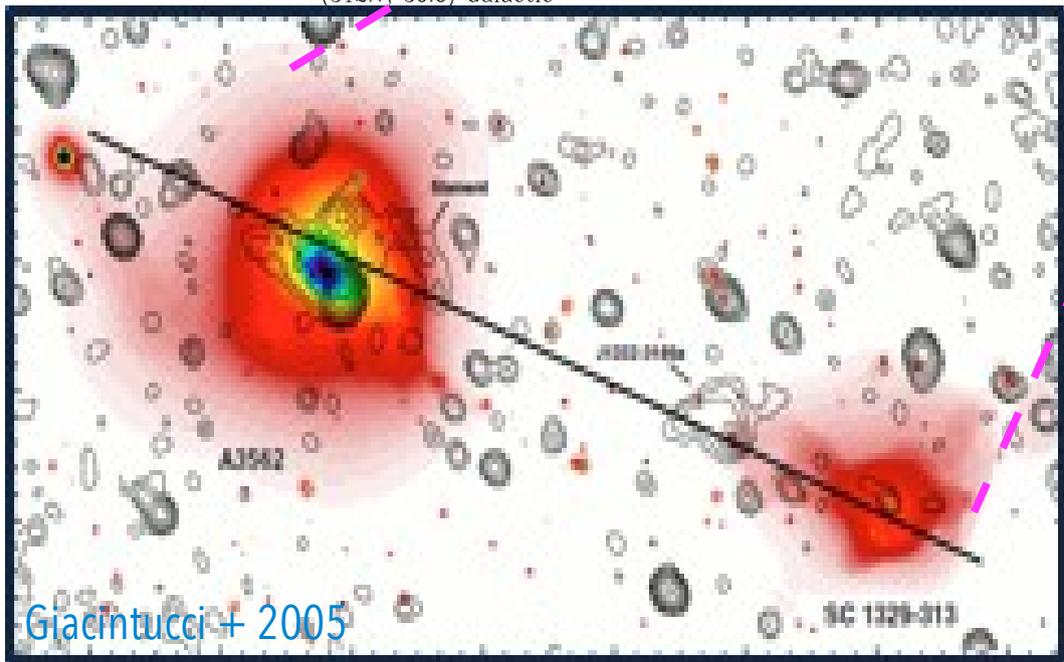
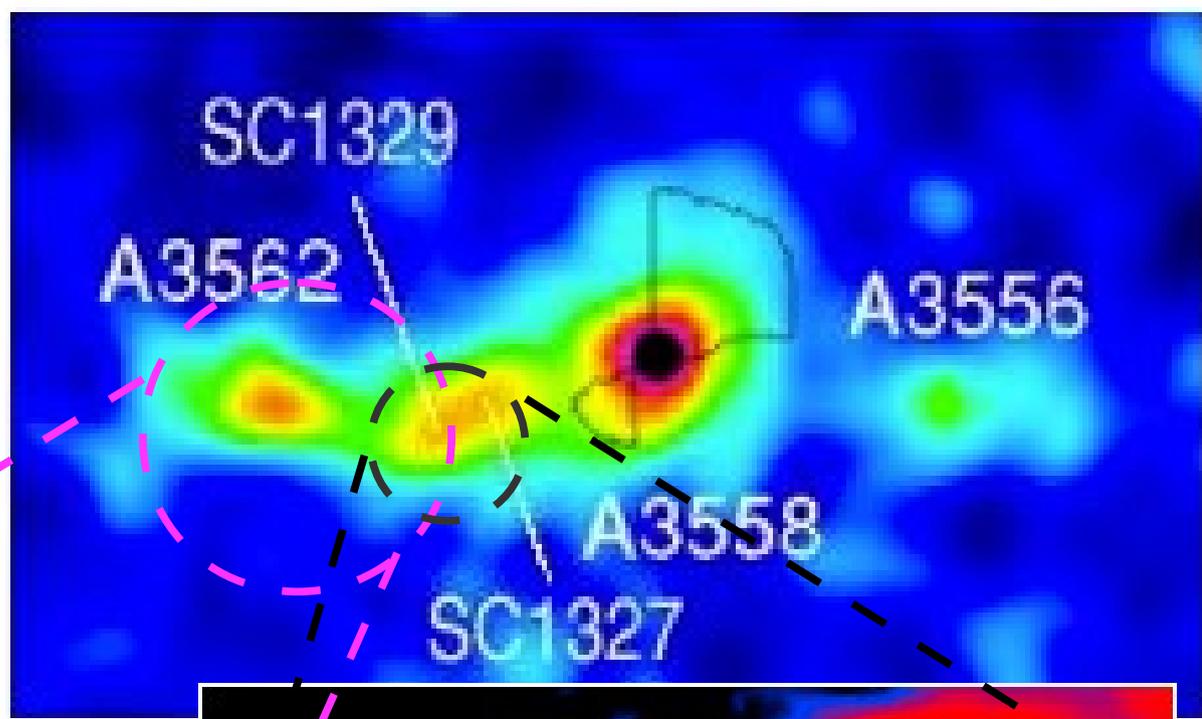
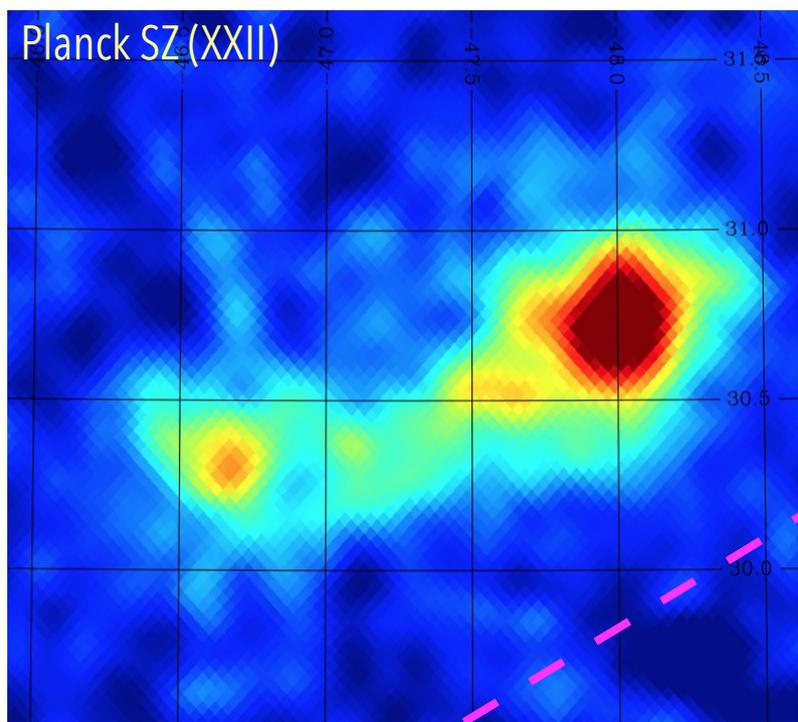
A3528 and his fellows @ 325 MHz (dotted circles are the Abell radii)



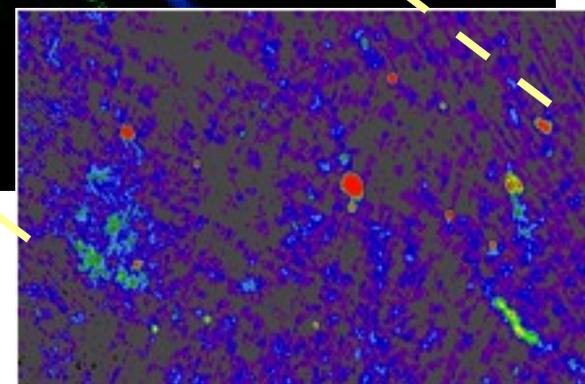
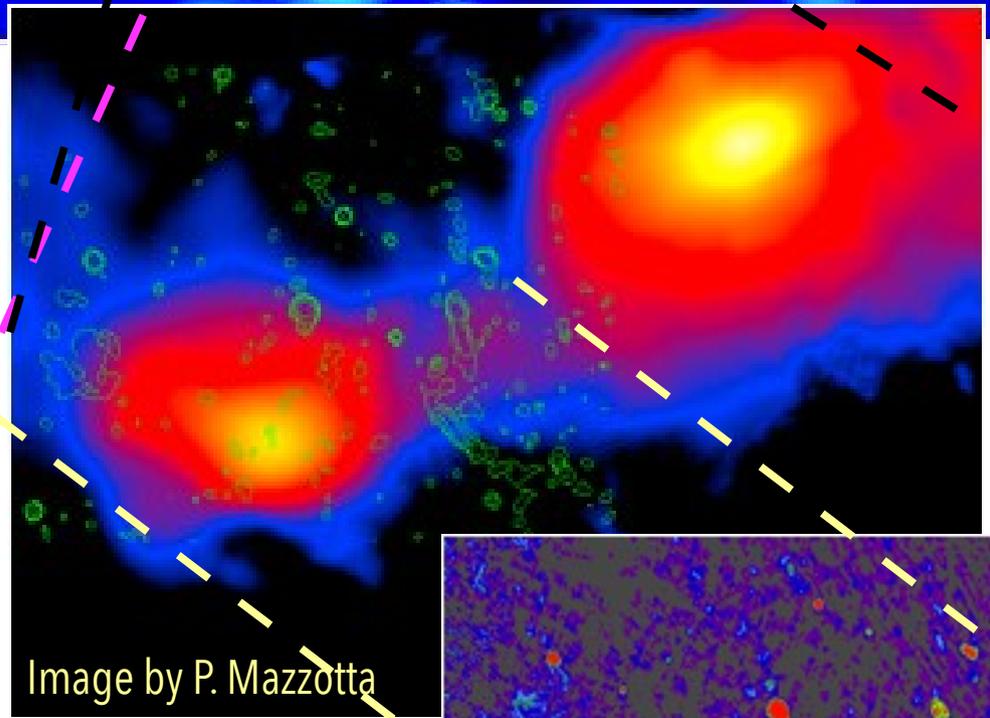


Bidimensional distribution of Shapley supercluster galaxies for A3558 and the system close to it. The grey isodensity contours are spaced with 0.1 dex (log) separation. The 11 known clusters are labelled and their r_{200} radii shown by yellow circles (from Haines +, 2018)

Planck SZ (XXII)



Giacintucci + 2005

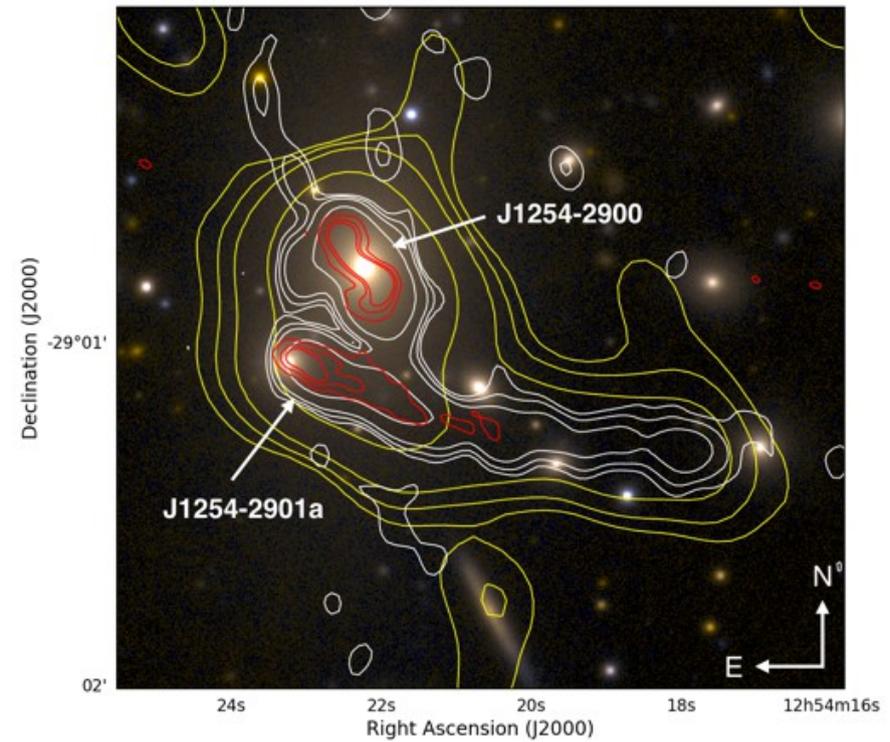


- The radio halo in A3562 was interpreted as due to a minor merger, most likely the infalling SC1329 group
- The steep spectrum radio source and the candidate relic are further signatures of such minor merger
- The area of the Shapley Concentration Core surveyed so far in the radio band supports a scenario of "gentle" accretion rather than major merging events (e.g. Gastaldello + 2003)
- Relatively weak and generally pointlike radio sources in A3558

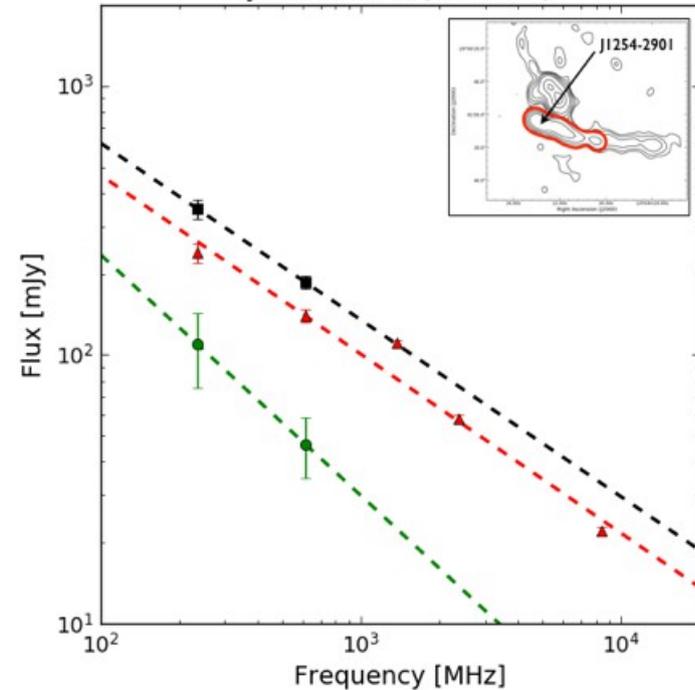
Active radio galaxies provide "current"
supply of relativistic plasma

Radio emission is "transient" /recurrent
(duty cycle, generally poorly known)

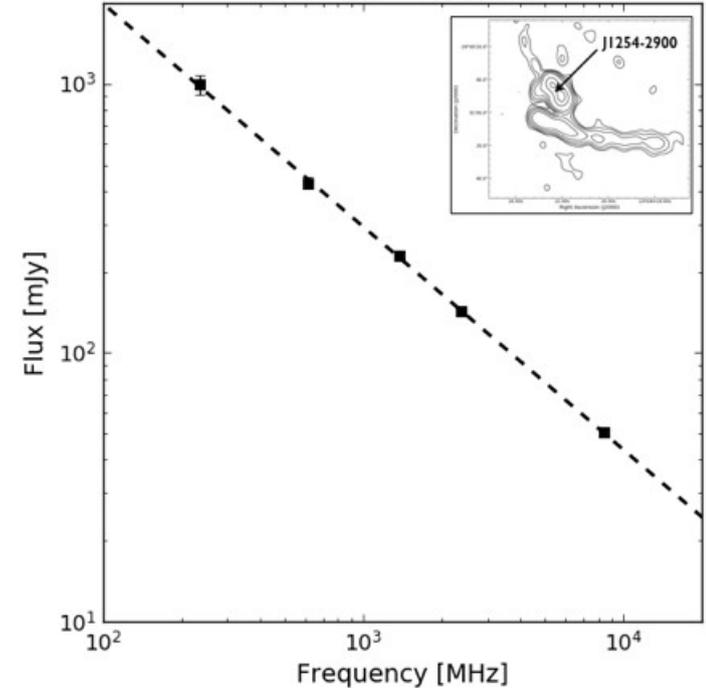
J1254-2900 and J1254-2901a (A3528 N)



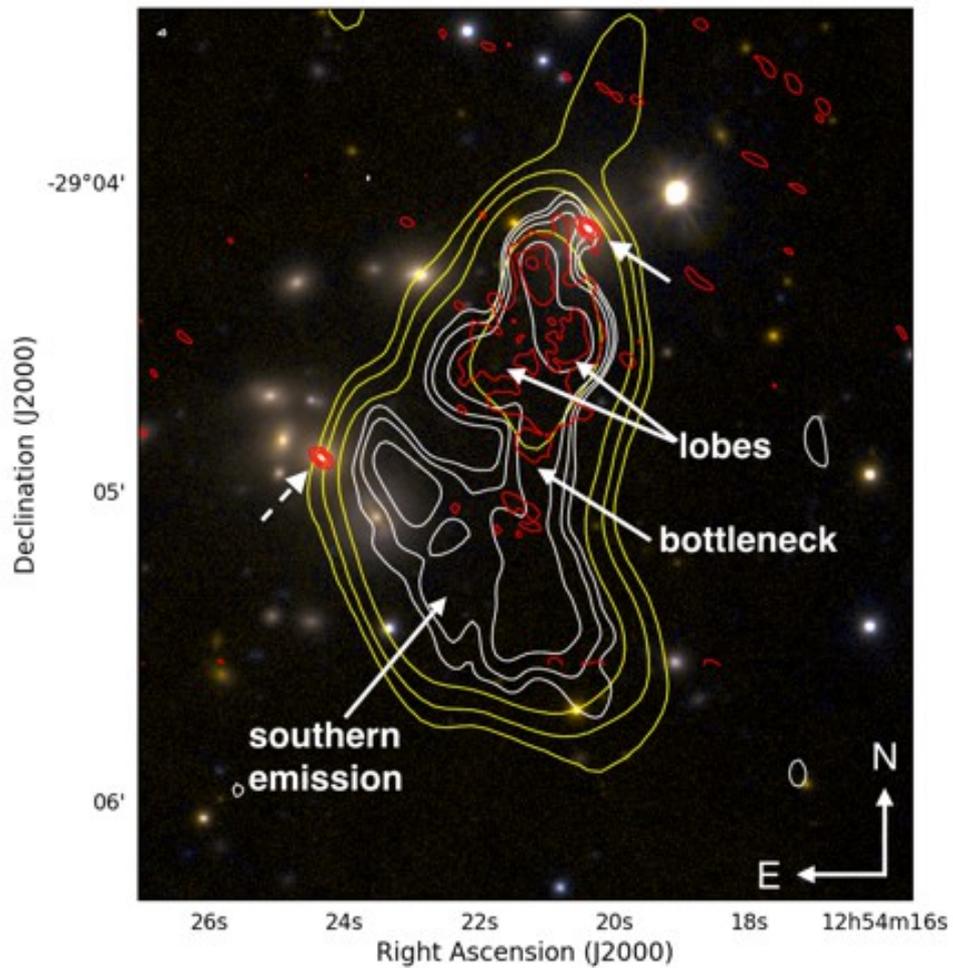
J1254-2901a (A3528 N)



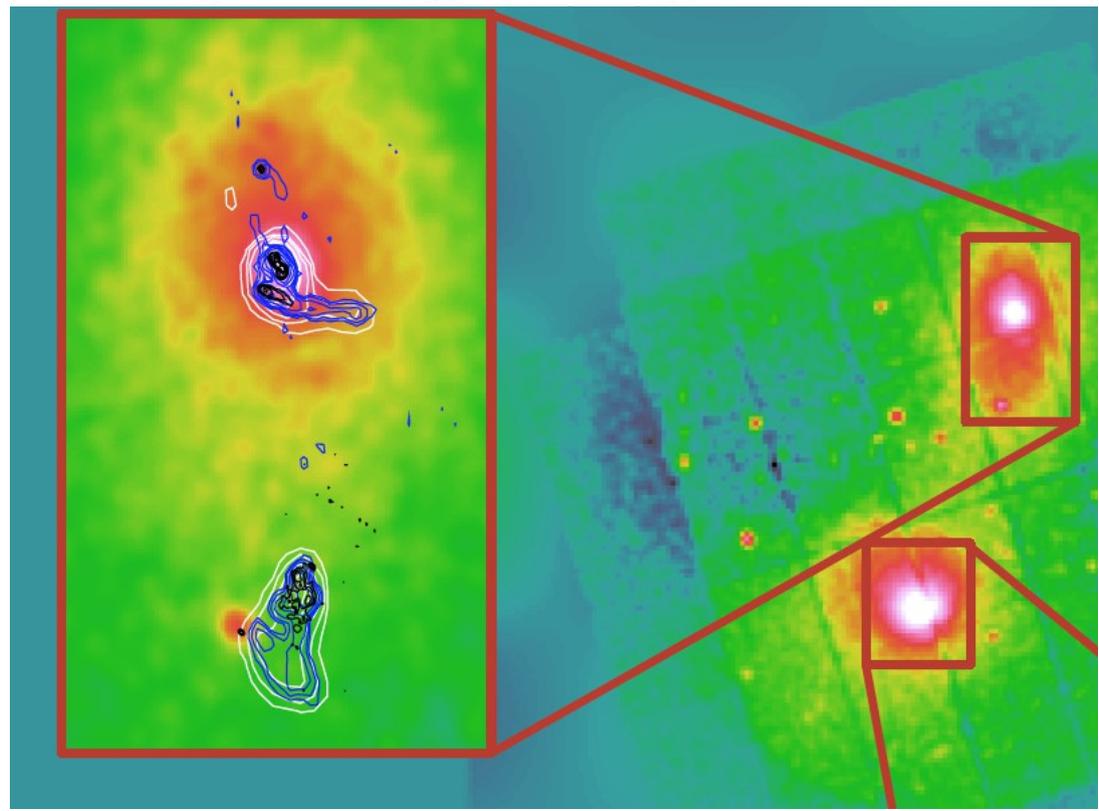
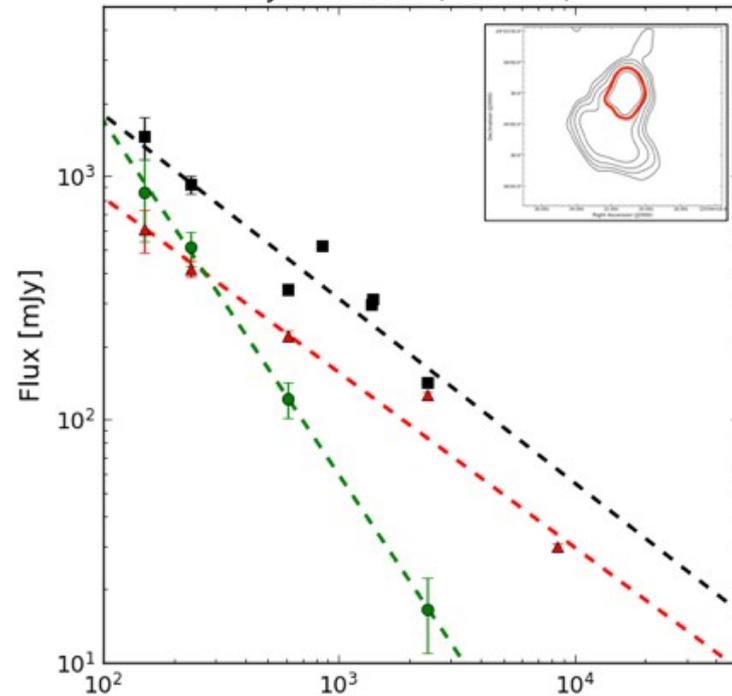
J1254-2900 (A3528 N)

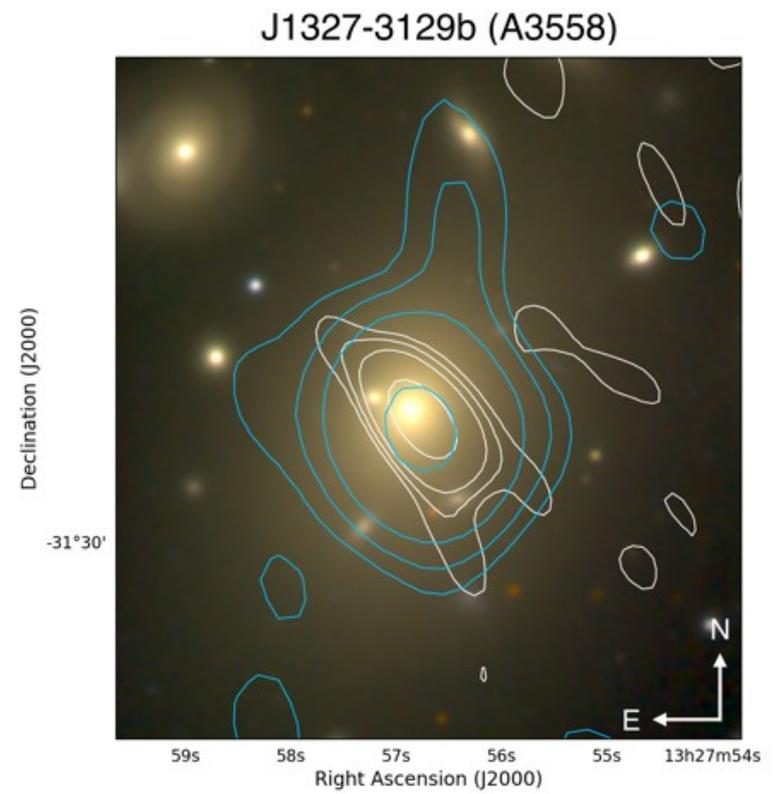
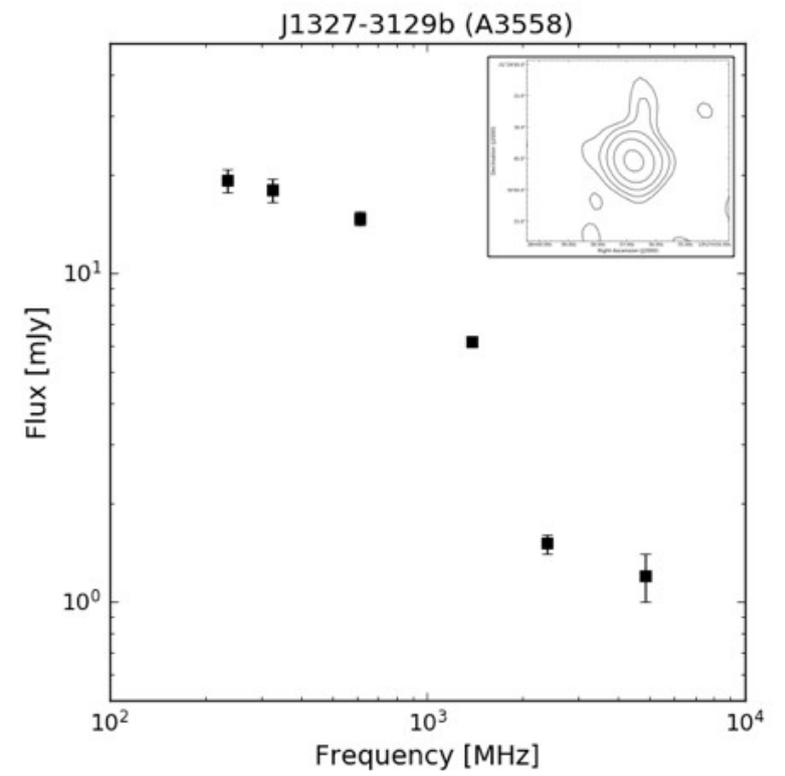
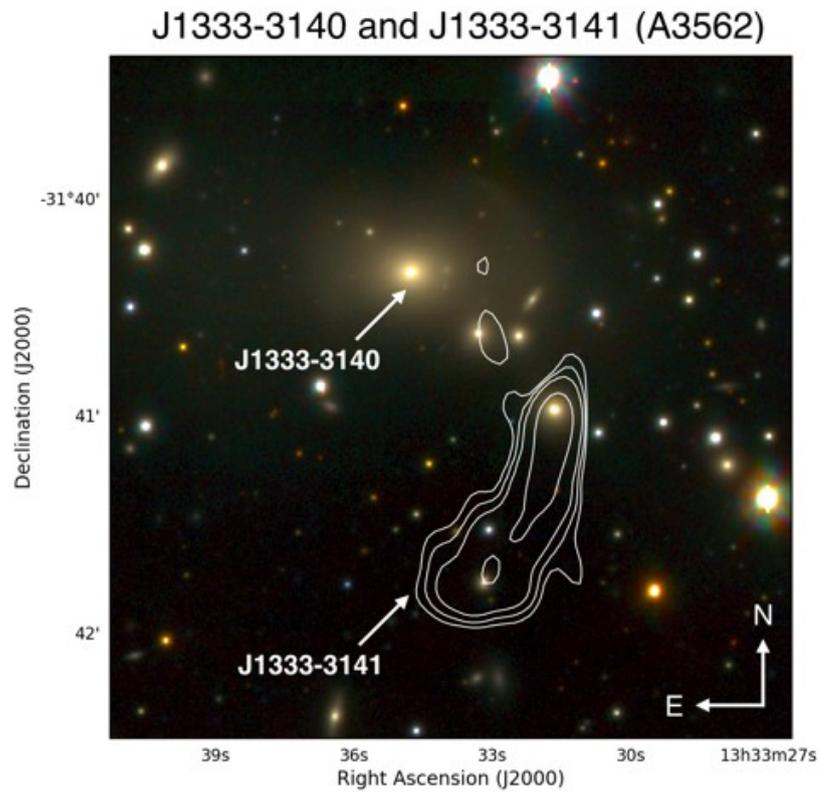


J1254-2904 (A3528 N)

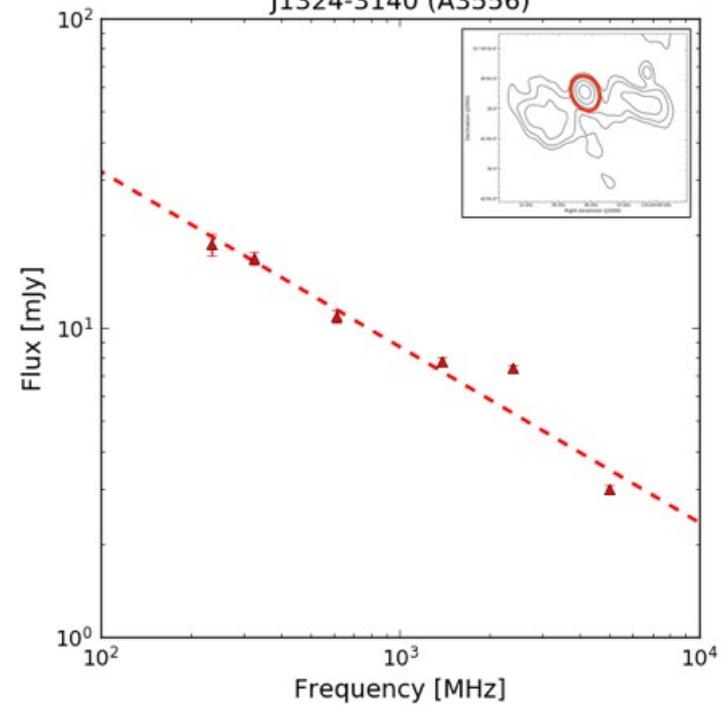


J1254-2904 (A3528 N)

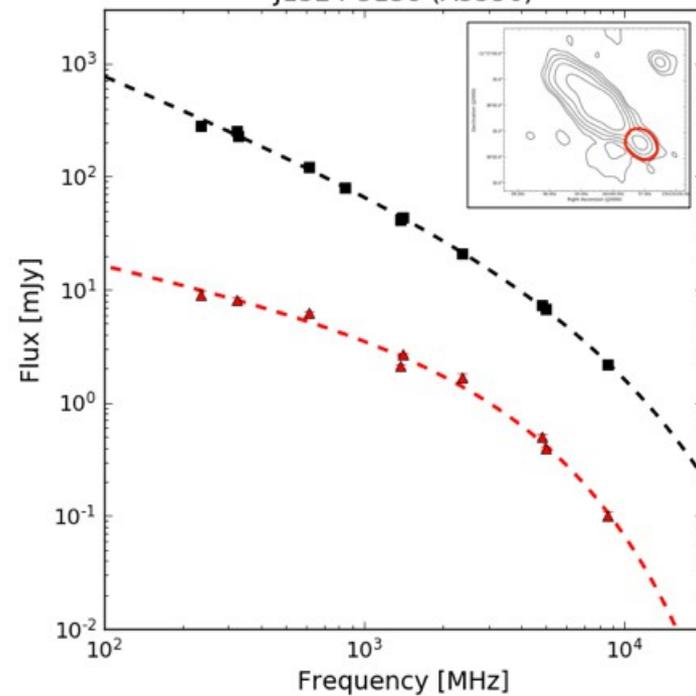




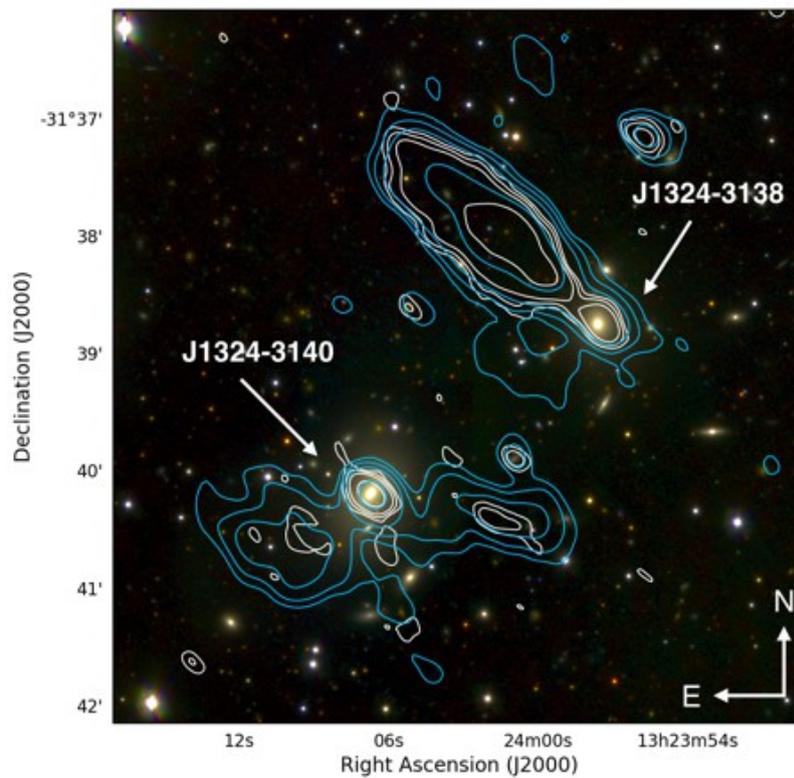
J1324-3140 (A3556)



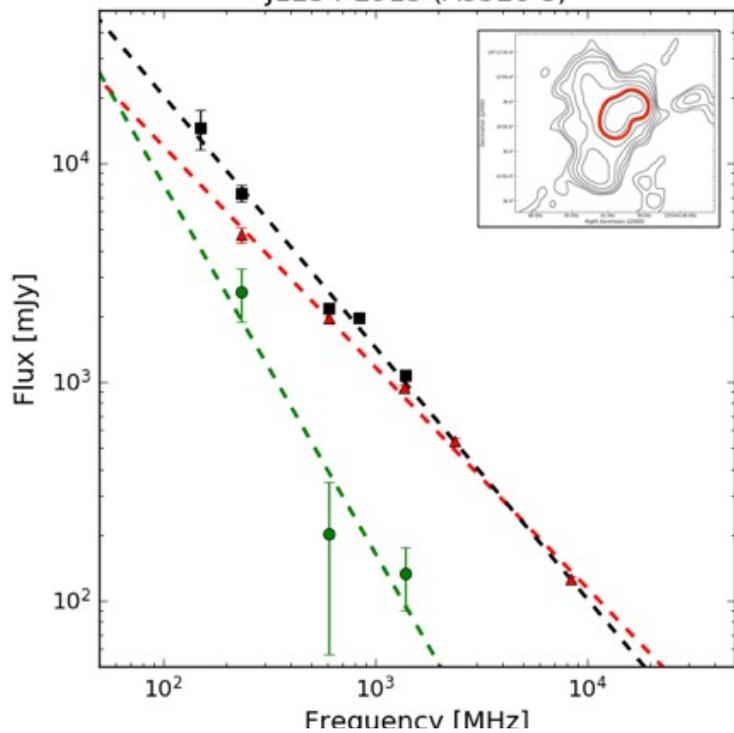
J1324-3138 (A3556)



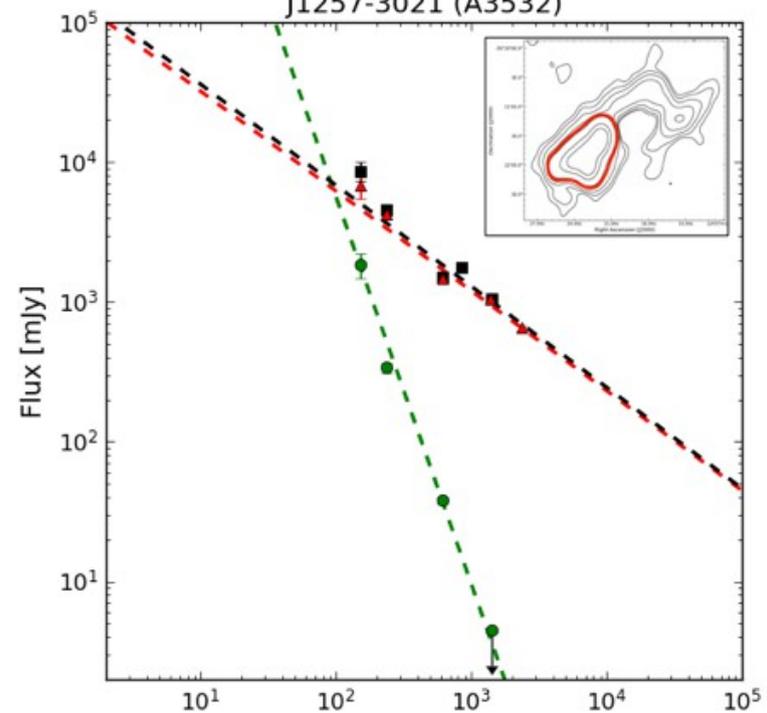
J1324-3138 and J1324-3140 (A3556)



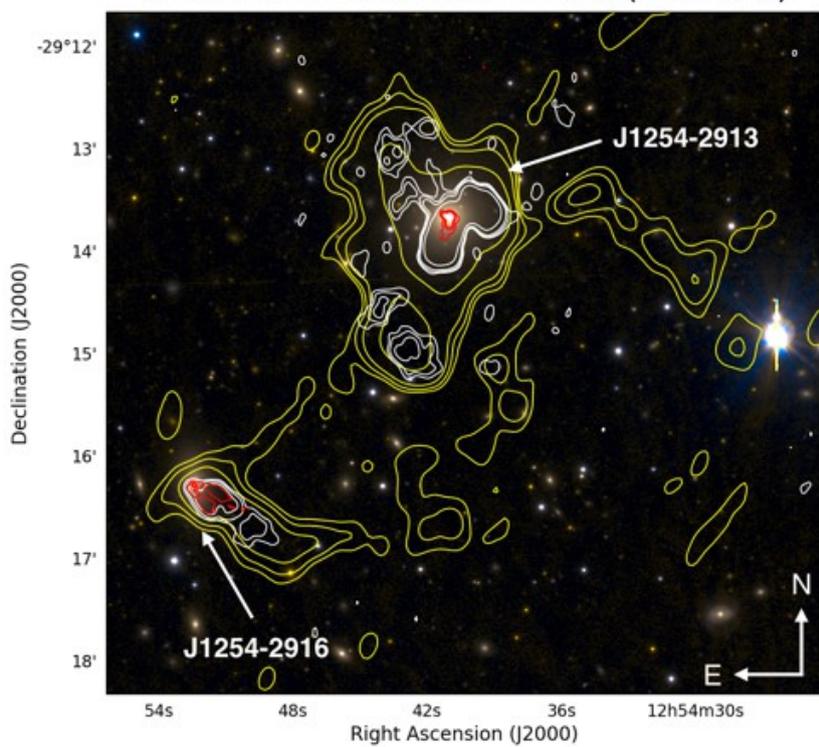
J1254-2913 (A3528 S)



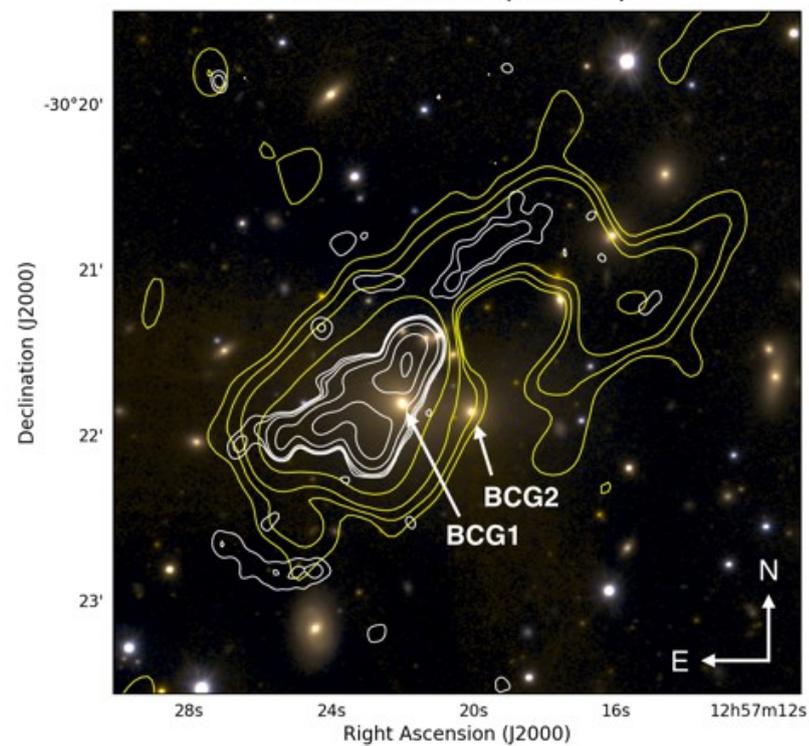
J1257-3021 (A3532)



J1254-2913 and J1254-2916 (A3528 S)



J1257-3021 (A3532)



Cluster name	Galaxy name	RA _{J2000} (^h ^m ^s)	DEC _{J2000} ([°] ['] ^{''})	z	optical morphology	radio morphology	logP _{610 MHz} W Hz ⁻¹
A 3528 N	J 1254-2900	12 54 22.1	-29 00 48	0.0541	cD (BCG)	D	24.47
A 3528 N	J 1254-2901a	12 54 22.9	-29 01 02	0.0544	ellipt.	HT	24.12
A 3528 N	J 1254-2904	12 54 20.4	-29 04 09	0.0545	ellipt.	NAT	24.41
A 3528 N	J 1254-2901b	12 54 40.7	-29 01 49	0.0529	ellipt.	NAT	22.94
A 3528 S	J 1254-2913	12 54 41.0	-29 13 39	0.0573	cD (BCG)	WAT	25.23
A 3528 S	J 1254-2916	12 54 52.4	-29 16 18	0.0481	ellipt.	HT	23.68
A 3530	J 1255-3019	12 55 34.5	-30 19 50	0.0537	ellipt.	undet.	–
A 3532	J 1257-3021	12 57 22.5	-30 21 45	0.0541	dumb-bell (BCG)	WAT	25.03
A 3556	J 1324-3138	13 23 57.5	-31 38 45	0.0502	ellipt.	HT	23.89
A 3556	J 1324-3140	13 24 06.7	-31 40 12	0.0480	cD (BCG)	D	23.01
A 3558	J 1327-3129b	13 27 56.8	-31 29 43	0.0469	cD (BCG)	unres.	22.88
A 3562	J 1333-3140	13 33 34.8	-31 40 21	0.0488	cD (BCG)	undet.	–
A 3562	J 1333-3141	13 33 31.6	-31 41 01	0.0501	ellipt.	HT	23.58*

- Different radio galaxy morphology contents for the two cluster complexes:
- A 3558 complex (dynamically active) dominated by compact radio sources
- A 3528 complex (~ relaxed) has of several radio tails and diffuse radio emission surrounding the BCGs(i.e. J 1254-2913 in A 3528 S and J 1257-3021 in A 3532: both have an active nucleus and radio emission with very steep spectrum extending out in the ICM well beyond the boundaries of the optical counterpart and possibly tracing a previous cycle of activity).
- The BCGs in A3558 and in A3562 show remarkable differences from the ones in the A 3528 complex. The former is a faint compact source with concave spectrum, typical of compact steep spectrum sources.
- Host galaxies in both complexes. Not surprisingly, they are associated with high- stellar mass passive galaxies. We do not observe any difference between the A3528 and A3558 complexes. We speculate that the **cluster dynamical state does not affect the optical counterparts** of the radio galaxies, at least on the life-time of the radio emission, i.e., $10^7 - 10^8$ yr.

Take home message(s)

- The Shapley SuperCluster has a lot of valuable information that can be exploited
- Instantaneous picture of thermal & relativistic plasma (and their interplay), galaxy distribution, etc.
- Indications on radio source duty cycle and total RC content (to be fully constrained and understood)