

Discovery of the first radio halo in a new Planck cluster confirmed by XMM Newton

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Galaxy cluster studies

Dark matter, Galaxies, Diffuse matter

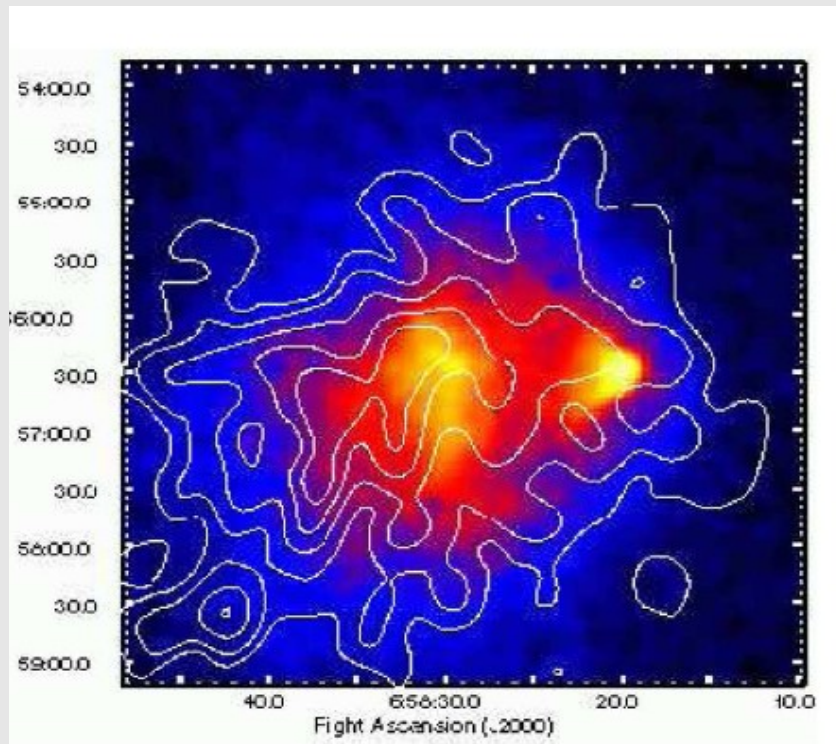


Intra-cluster
medium (ICM):
T~1-10 keV plasma
Relativistic
electrons (E ~ GeV)
Magnetic fields
(micro Gauss)
Radio halos and
relics

Radio halos :

central, Mpc sized,
diffuse radio sources

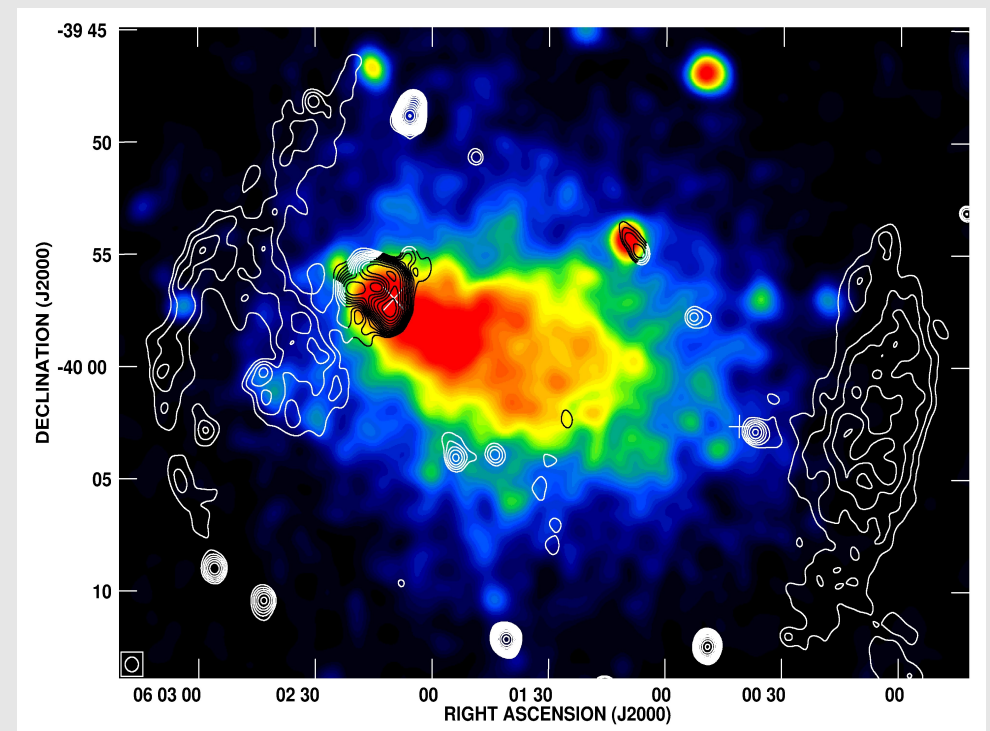
(e.g. Ferrari et al 2008)



Bullet cluster
Markevitch et al. 2001

Radio relics:

peripheral, elongated,
Mpc sized,
polarized radio sources



Abell 3376 Bagchi et al. 2006, Kale et al. 2012
(submitted)

Probes of cosmic rays in the ICM

Rare sources

~5% of all and ~ 30% of very X-ray luminous clusters

(e.g. Venturi et al. 2007, 2008)

Studies limited by the small number of radio halos and relics known.

Motivation for searching radio halos and relics in galaxy clusters using radio observations.

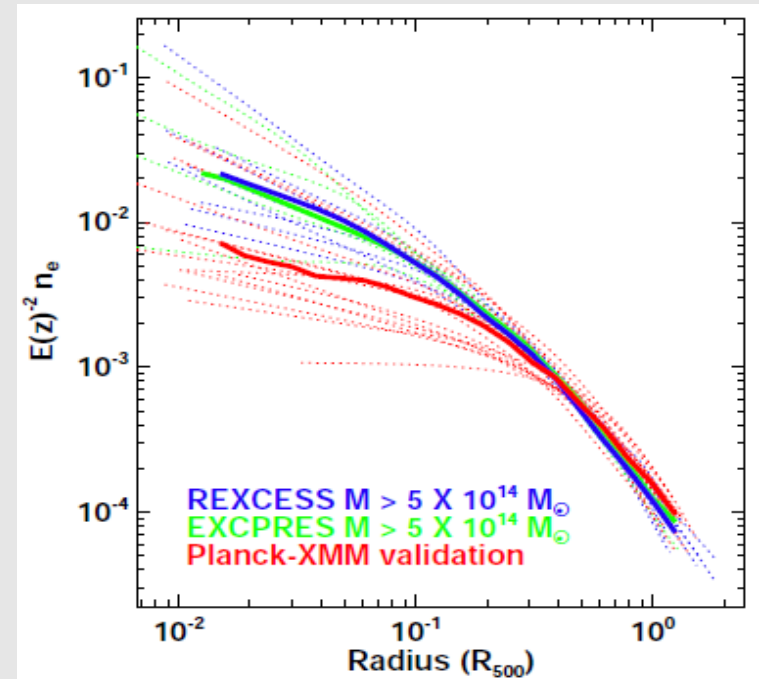
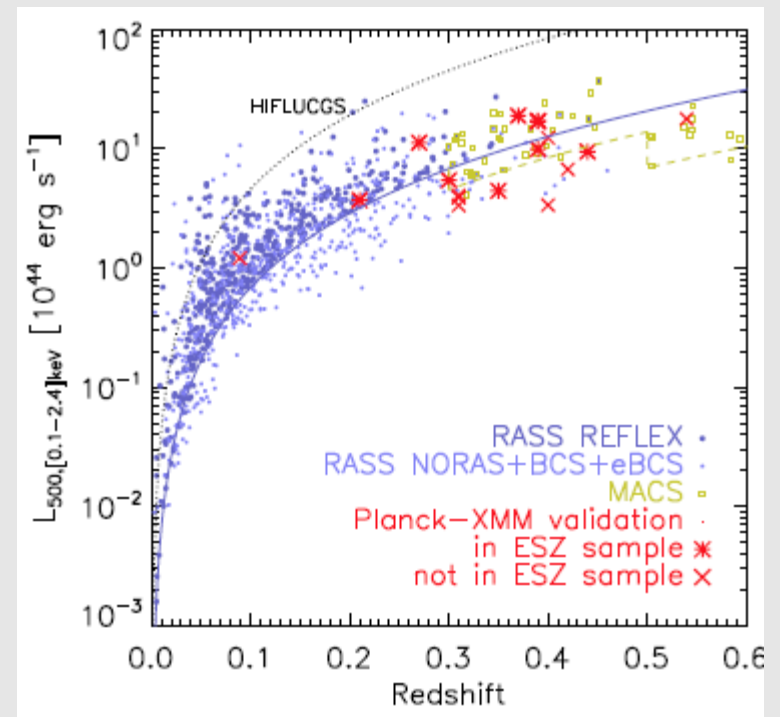
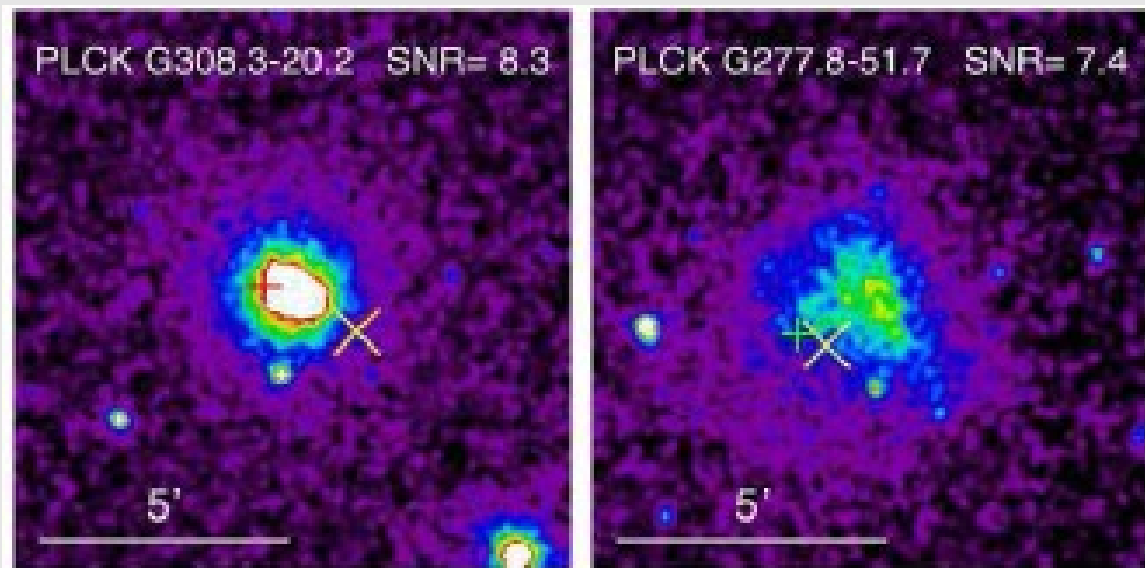
Evidence for association with massive and merging clusters

(Cassano et al. 2006, Feretti 2006, Cassano et al. 2010)

Planck ESZ clusters

- Massive
- Disturbed/merging

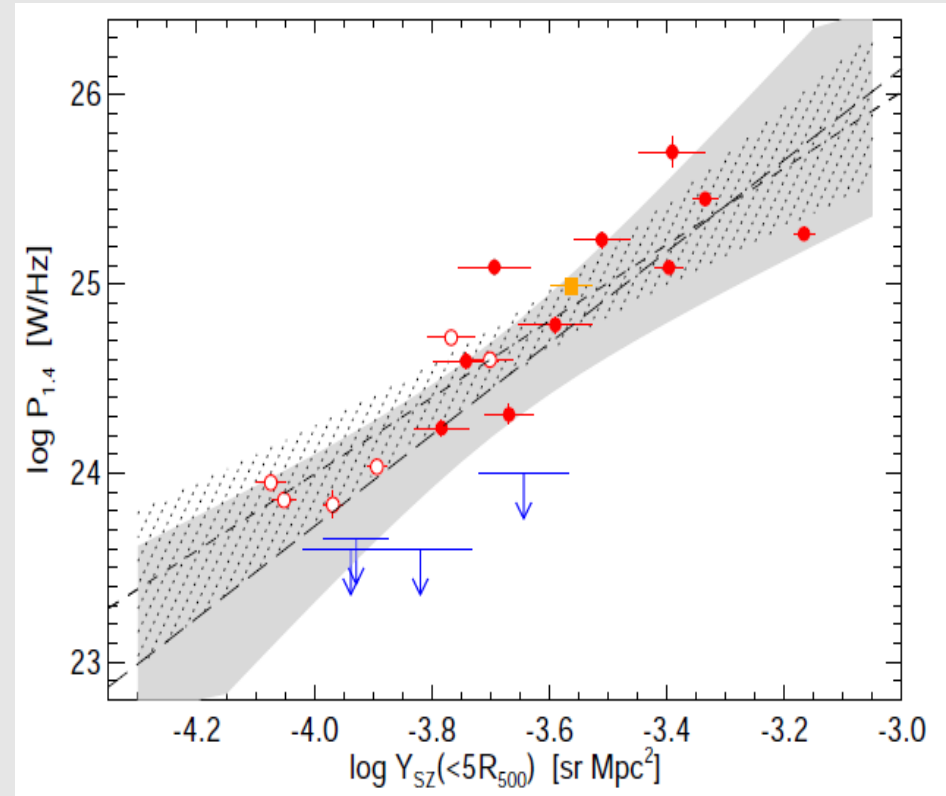
Further evidence for disturbed dynamical states from XMM Newton images



Planck collaboration early results: IX

Planck ESZ sample and radio halos

It is striking that several of the radio halo clusters are among the strongest SZ detected clusters.

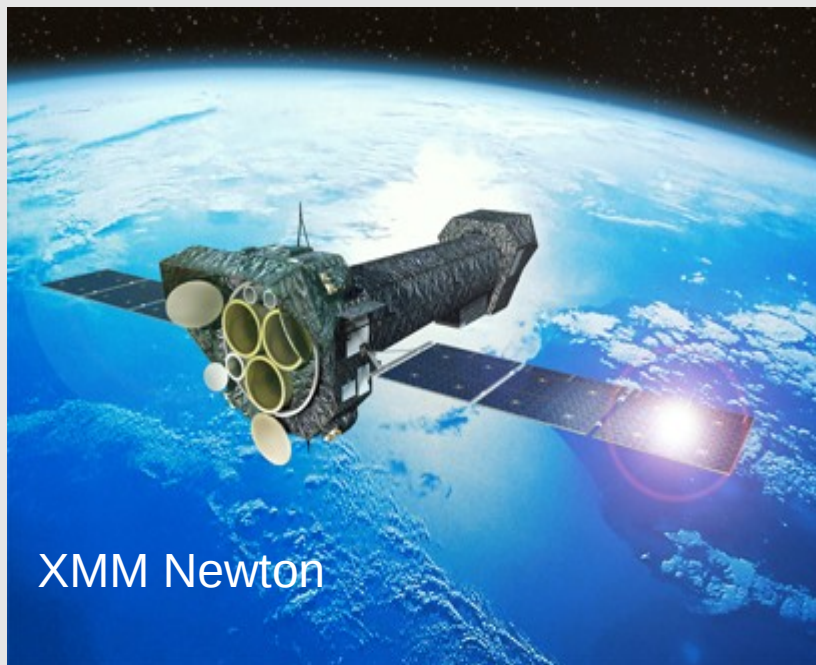


Basu 2011

- GMRT survey of 8 clusters that show evidence for diffuse emission in the NRAO VLA Sky Survey(1.4 GHz)
- 610, 235 MHz observations in Oct-Nov. 2011.

Story in a nutshell..

Galaxy cluster PLCK G171.9-40.7 (Plck171, hereafter)



Discovered by Planck

S/N 10.6

Confirmed by XMM Newton

10 ks snapshot

Radio Observations:

Suspected diffuse emission in
1.4 GHz NRAO VLA Sky
Survey

Confirmed with GMRT

*Giacintucci et al. 2012,
in prep.*

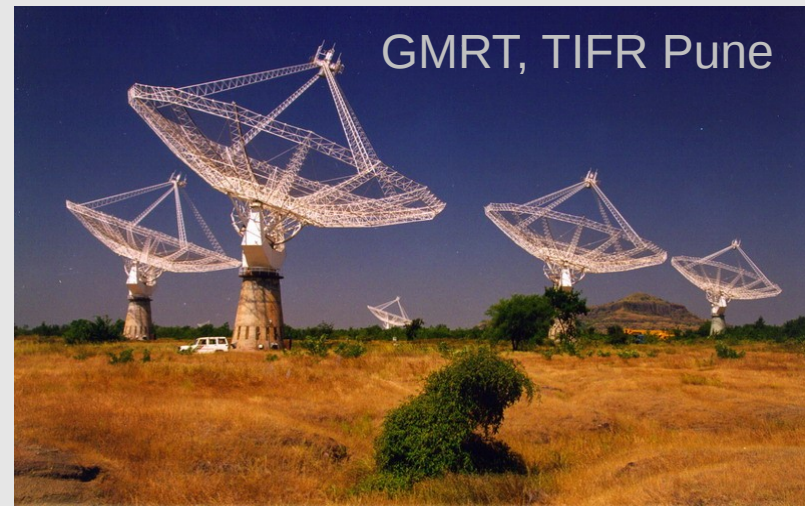


Image credits:
ESA-Planck,
XMM Newton,
NRAO & TIFR

Properties of the cluster Plck171

RA 03h12m 57.4s

DEC 08d22m10s

$z = 0.27$ (Fe line)

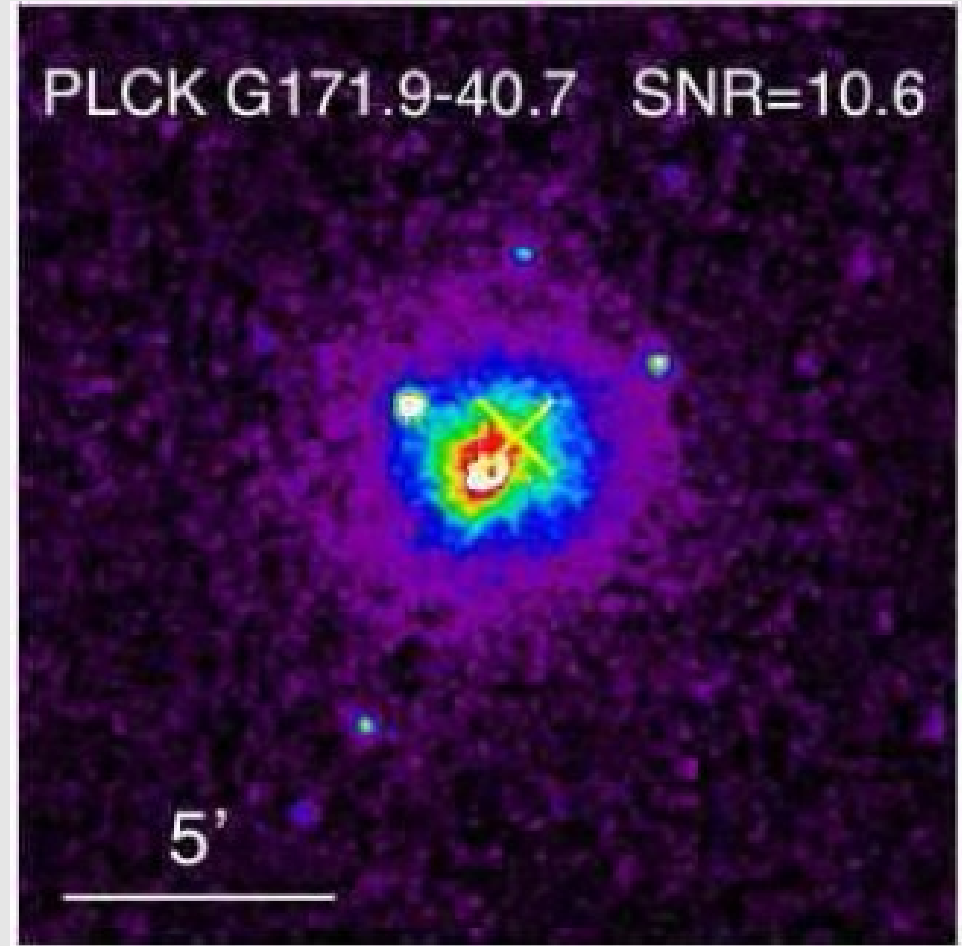
$L_{x[0.1 - 2.4 \text{ keV}]} \sim 1.14 \times 10^{45} \text{ erg/s}$

Lum. distance = 1364.5 kpc

Scale: 4.1 kpc/''

$T_x \sim 10.65 \text{ keV}$

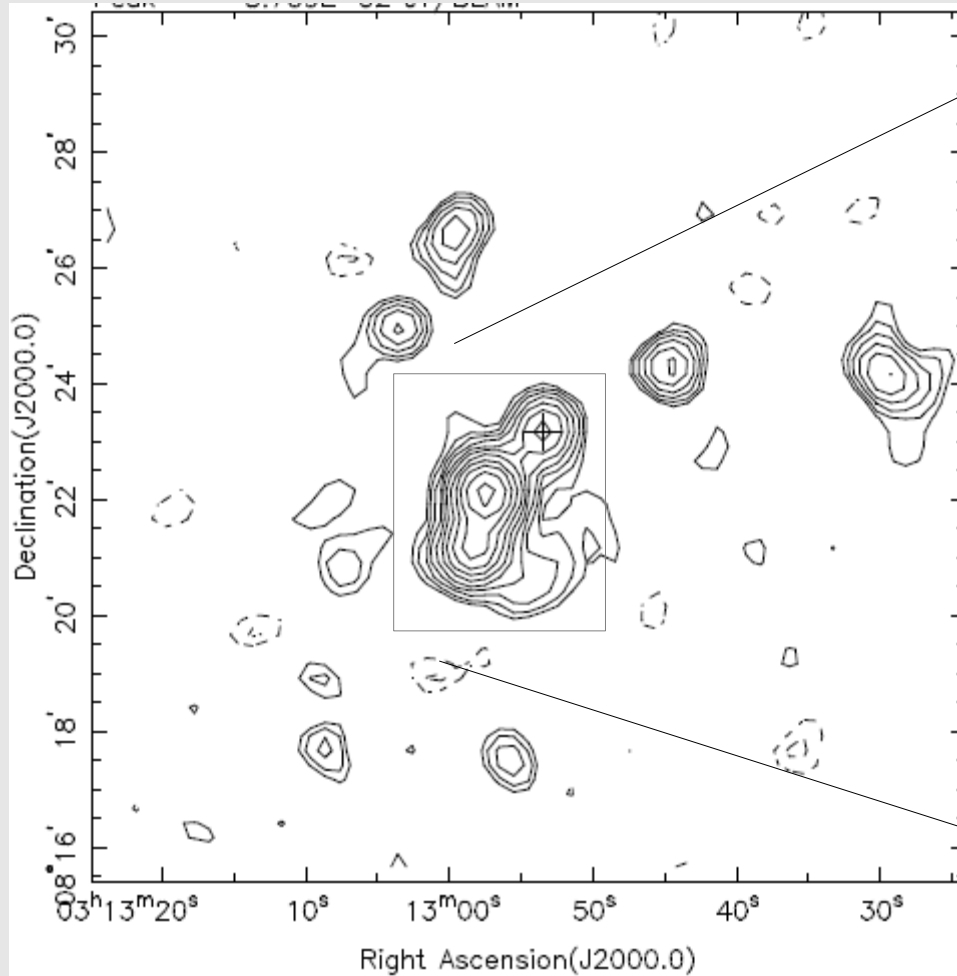
$M_{500} \sim 10.92 \times 10^{14} M_{\odot}$



Planck collaboration early results:IX

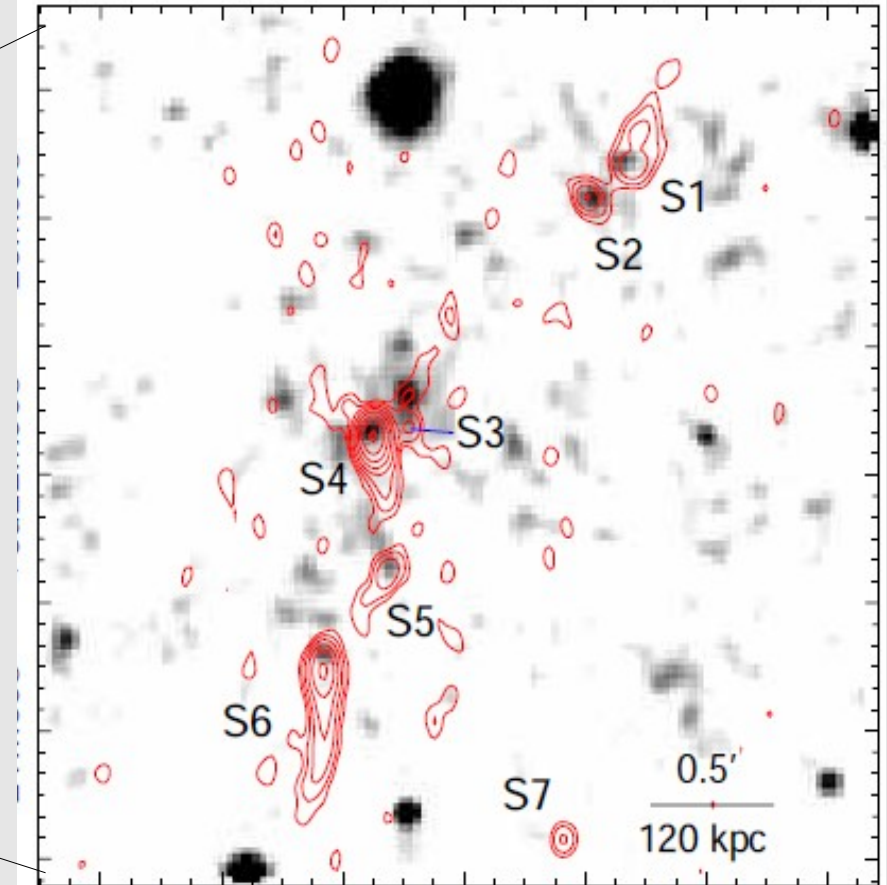
Results:

NRAO VLA Sky Survey image



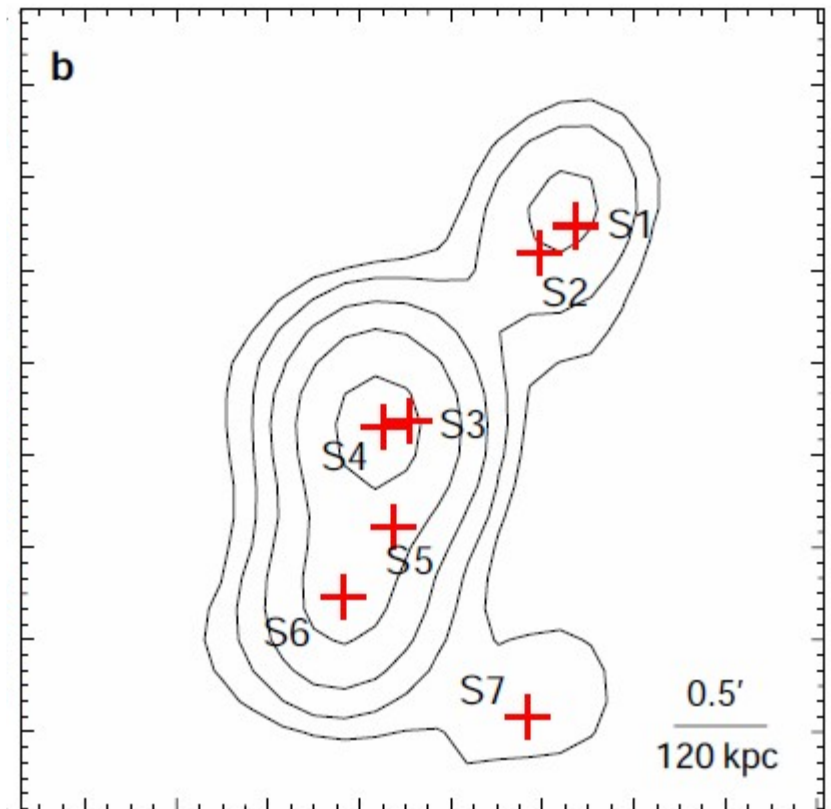
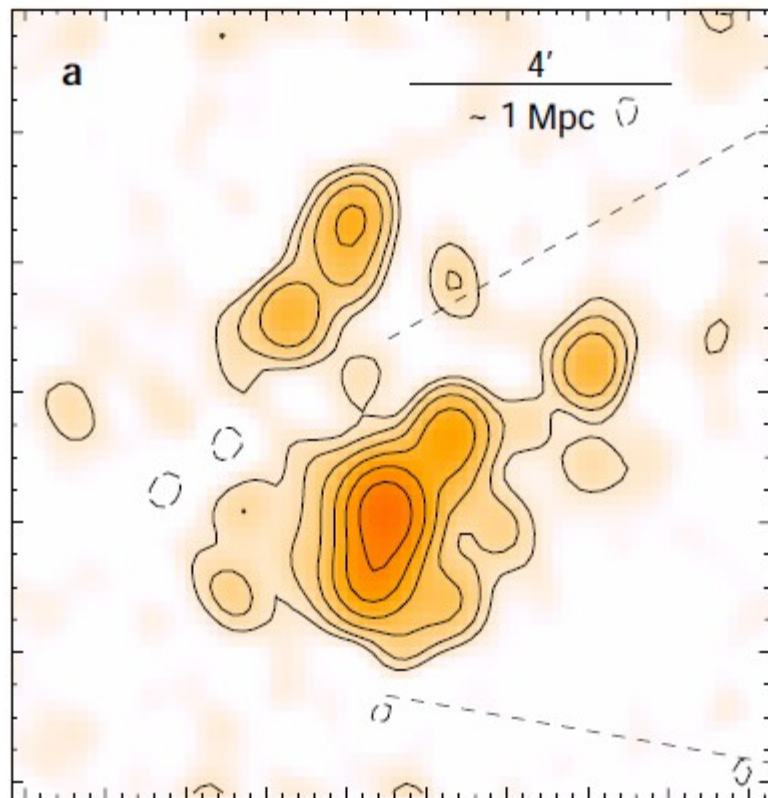
1400 MHz, 45"x45"
Rms = 0.5 mJy/beam

High resolution image at
610 MHz (red contours)
on optical DSS image



5.5"x4.5", PA 0 deg.
Rms = 0.12 mJy/beam

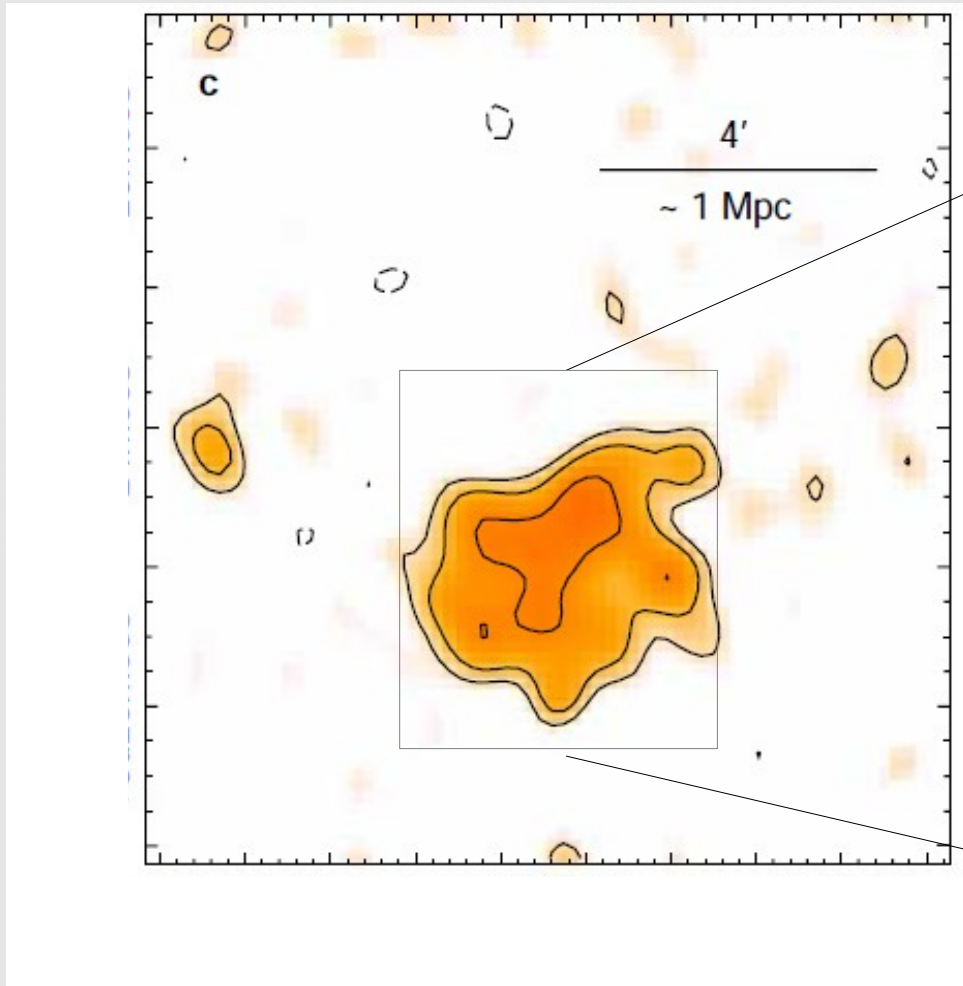
Re-processed NRAO VLA Sky Survey data



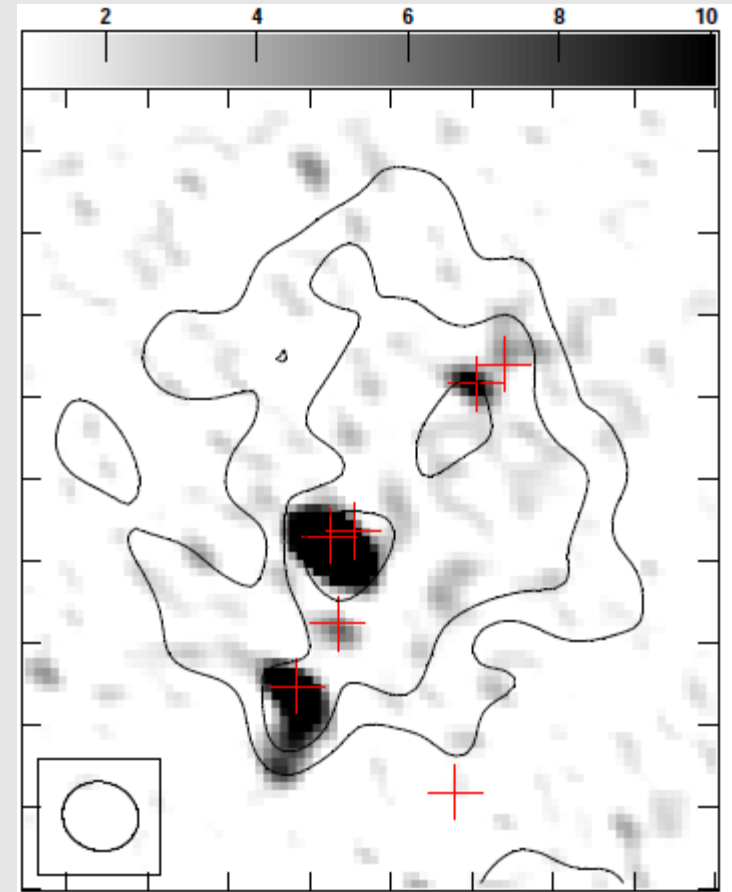
1.4 GHz, 58"x48" (PA -5 deg)
3 σ rms = 0.6 mJy/beam

1.4 GHz, 50"x42" (PA -7 deg)

Radio halo at 1400 and 235 MHz



50"x50"
Rms ~ 0.4 mJy/beam

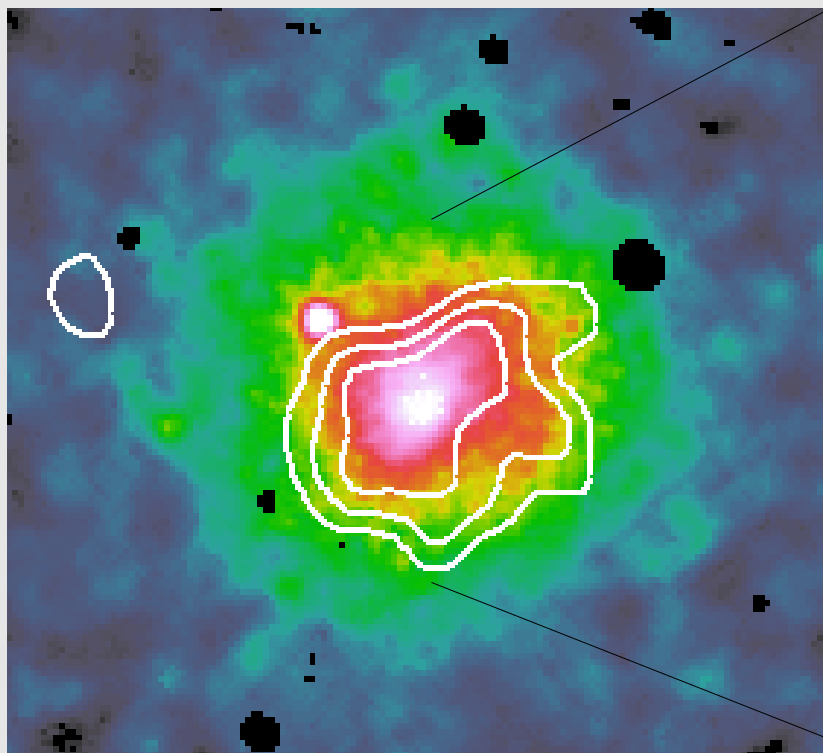


15"x9", PA 63.5 degrees, rms ~0.8
mJy/beam
23"x23", rms ~ 1.5 mJy/beam

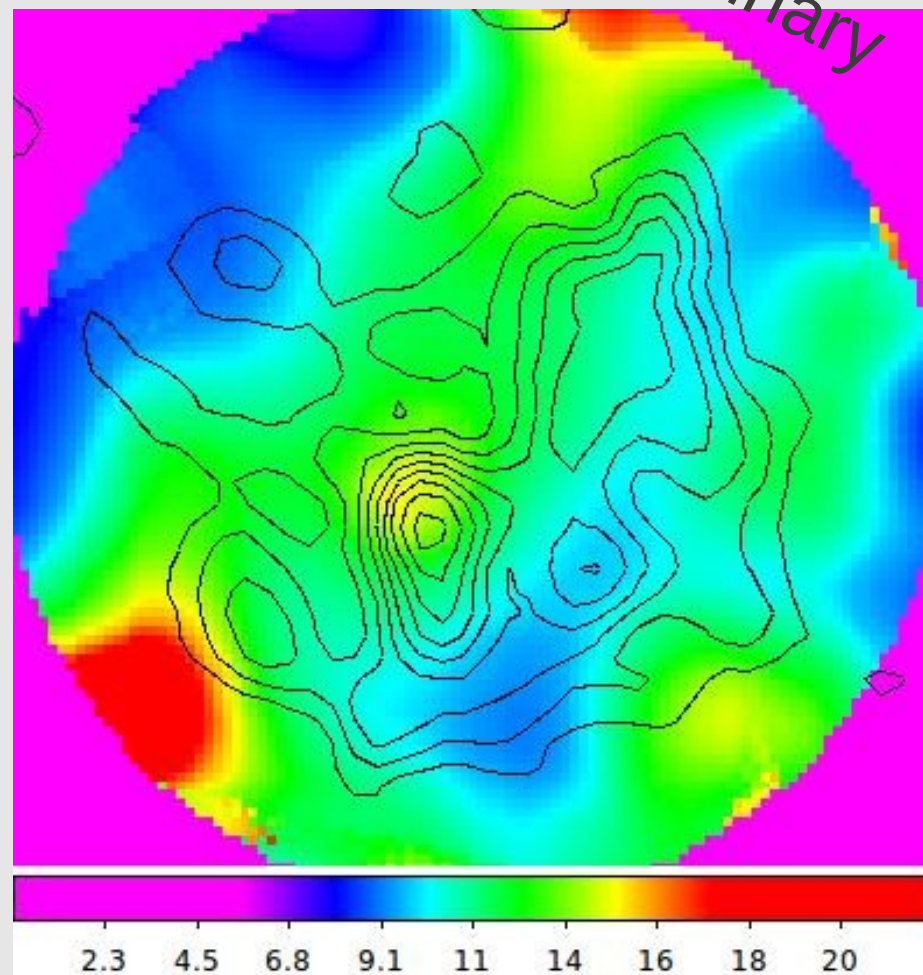
Comparison of X-ray and radio maps

Temperature in the range 6 – 16 keV

Preliminary

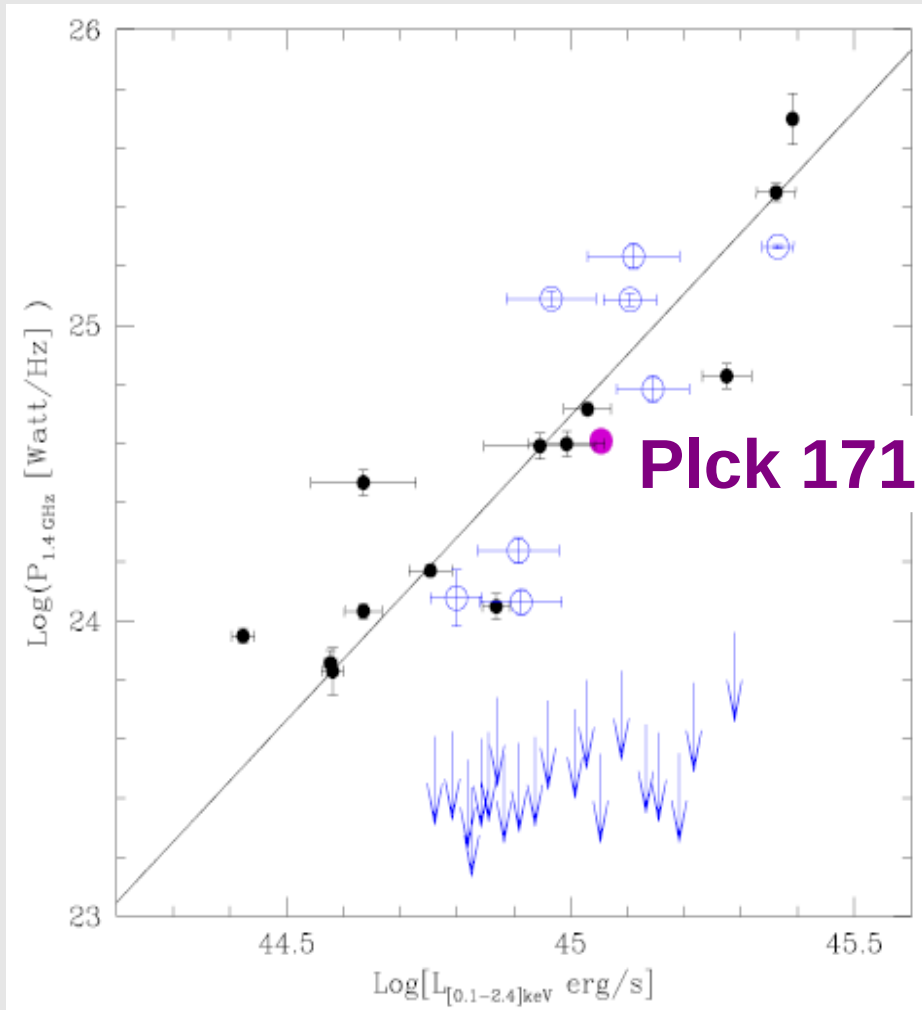


X-ray surface brightness in colour and 1400 MHz contours

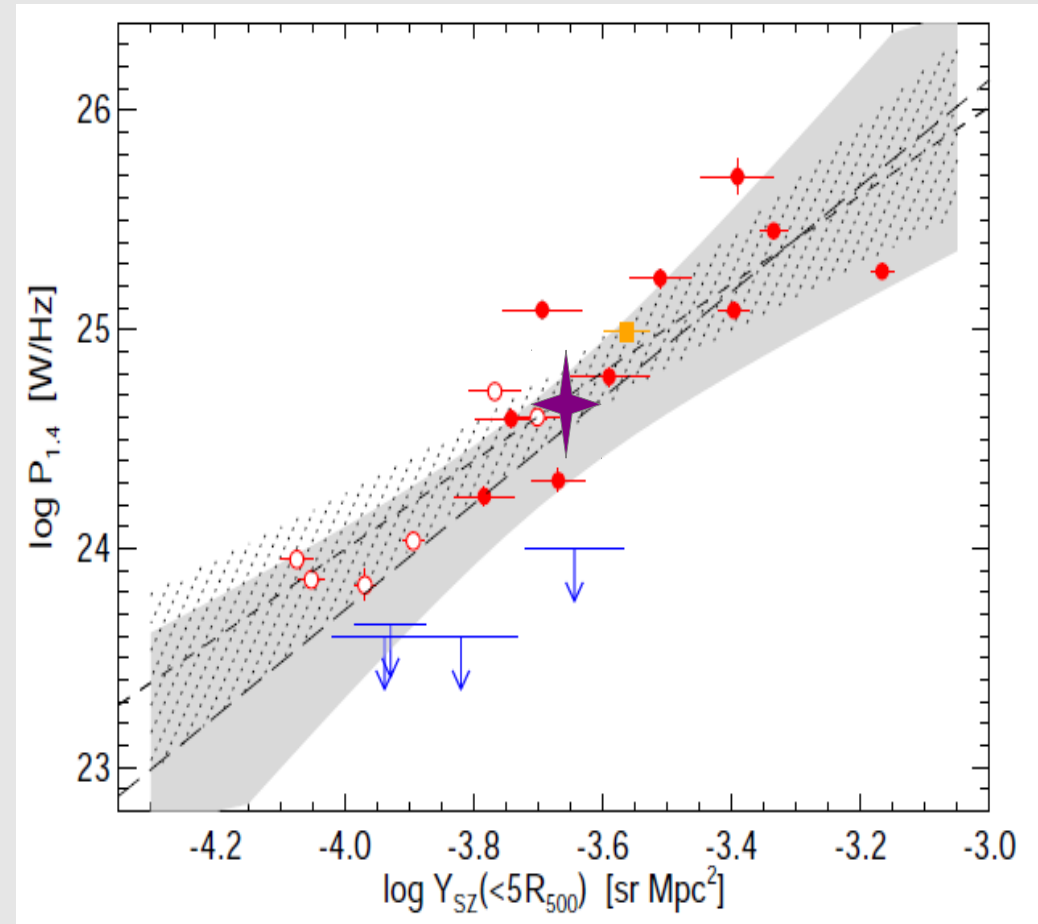


Temperature map in colour and 235 MHz contours

Radio power - X-ray luminosity, Y



Data for other clusters from Brunetti et al. 2009



Plck171 plotted on the plot in Basu 2011

Conclusions and future work

A radio halo is discovered in the cluster Plck171.

The size of the halo is ~ 1 Mpc and is cospatial with the X-ray emission from the cluster.

The cluster is hot with temperature ~ 10 keV, showing signatures of merger.

The radio power and X-ray luminosity of Plck171 follow the correlation followed by other radio halos.

Deeper radio observations at 150, 235, 610 and 1400 MHz will be undertaken to better characterize the radio halo.

Long exposure observations in X-rays (XMM Newton, Chandra) are required to study the dynamical state of the cluster in detail.

Conclusions and future work..

Planck detected clusters are promising candidates for the search of radio halos and relics. The analysis of GMRT data on 7 other clusters is in progress and there will be **more results soon**.

Three clusters with extreme properties discovered by the South Pole Telescope have been observed with the ATCA at 1400 MHz and the analysis is in progress.

Larger, “well defined” samples of SZ selected clusters are required to be surveyed in radio to improve the understanding of the connection of radio halos with cluster dynamical properties.