Non thermal properties of the *Planck* Sunyaev-Zeldovich cluster sample

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SUMMARY. *The Intra Cluster Medium is characterized by thermal emission, and by the presence of large scale magnetic fields. In about 80 clusters has been also detected a diffuse non-thermal emission. These extended sources are classified as Halos, Relics or Mini-halos, according to their properties and position with respect to the cluster center. The radio properties of these diffuse sources are linked to the cluster properties.*
In this preliminary work we present the correlation between non-thermal cluster radio power and Sunyaev-Zeldovich (SZ) effect measurements to better understand the origin and evolution of non-thermal emission in galaxy clusters.

INTRODUCTION. In recent years, there has been growing evidence for the existence of cluster large scale diffuse radio sources, which have no optical counterpart and no obvious connection to the cluster galaxies, and are therefore associated with the ICM. Diffuse sources are grouped in 3 classes according to their location in the cluster (center or periphery), and to the evolutionary stage of the host cluster (merging or relaxed). These classes are: **halos, relics and mini-halos**.

♦**Radio halos** are diffuse sources of low surface brightness permeating the central volume of a cluster. They are typically extended with sizes > 1 Mpc, and regular in morphology. However, thanks to new recent observations also radio halos with a smaller size and irregular morphology have been detected in rich galaxy clusters. All halo clusters are undergoing merger processes. The radio properties of halos are linked to the cluster properties The probability to detect radio halos is highest in the cluster with the highest X-ray luminosity. The monocrochromatic radio power of a halo at 1.4 GHz correlates with the cluster X-ray luminosity.

♦**Radio relics** are diffuse extended sources similar to radio halos in their low surface brightness, large size, and steep spectrum, but, unlike halos, relics are located in cluster peripheral regions and are strongly polarized. Relics are found in clusters with and without a cooling core, suggesting that they may be related to minor or off-axis merger, as well as to major mergers. This is consistent with their elongated structure, almost perpendicular to the merger axis and is confirmed by observational results.

♦ **Mini-halos** are extended on a moderate scale (about 500 kpc) diffuse sources at the center of relaxed, cool core clusters. The origin of mini-halos is still poorly known. Gitti et al. 2002, A&A 386, 456 proposed that they result from a relic population of relativistic electrons re-accelerated by MHD turbulence, the necessary energetics being supplied by the cooling flow. Additional energy might be provided by sub-cluster mergers that have not been able to destroy the central cluster cooling-core.

♦**Halos and relics correlates wit the cluster X-ray luminosity in according to their similarity and their link to cluster mergers.**

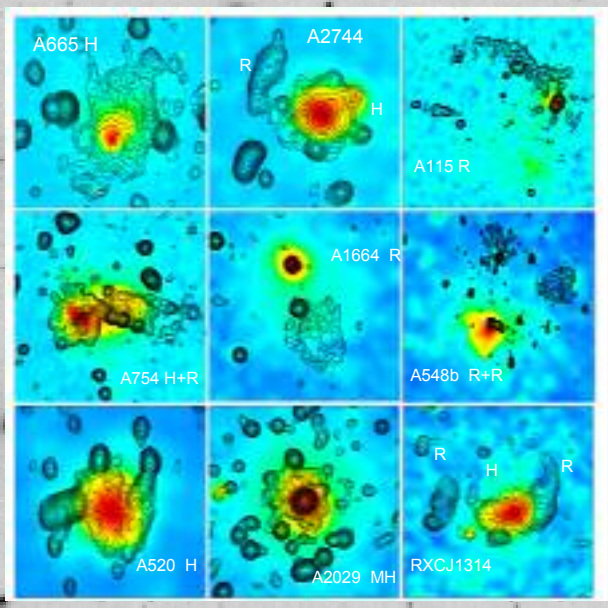

Fig. 1 – Cluster collection showing several types of radio emission (Halo, Relic Mini-Halo), shown in contours, overlaid onto the X-ray emission shown in colors.

To investigate the correlation between non-thermal and physical properties of galaxy clusters, and in particular to try to understand why non thermal emission is present only in a few galaxy clusters we have compared non thermal cluster properties with the integrated Compton parameter $D^2_A Y_{SZ}$. This quantity is expected to scale particularly close with the total mass

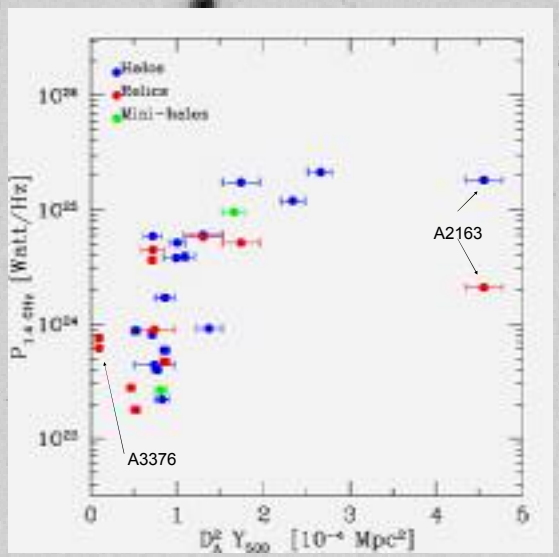

Fig. 2 – Monochromatic radio power at 1.4 GHz of extended diffuse radio emission in galaxy clusters versus $D^2_A Y_{500}$, the spherically integrated Compton Parameter proportional to the flux of the SZ signal within R500 in 10^{-4}Mpc^2 (Planck collaboration et al., paper XI).
The cluster with the highest valu $D^2_A Y_{500}$ e is A2163 where are present both a radio halo and a faint radio relic. The cluster with the lowest value of $D^2_A Y_{500}$ is A3376 where double symmetric relics are present. In this case Bagchi et al. 2006, Science 314, 791, suggested the possibility that the two relics could be tracking shocks induced by the accretion flows of the IGM during the large-scale structure formation (accretion shocks). This could explain the presence of diffuse non-thermal emission despite of the low value of the Compton parameter.

Discussion – Preliminary results shown in Fig. 2 suggest that the non-thermal radio power in galaxy clusters correlates with the Compton parameter $D^2_A Y_{500}$. Clusters with a higher value have a higher non thermal radio power. However a marginal evidence is present that for values of $D^2_A Y_{500}$ higher than 2 the non thermal radio power becomes almost constant with values of 1-2 x 10^{25} W/Hz.

Selected sample – the data set selected is the Planck Early Release Compact Source Catalogue SZ (ESZ)(Planck VIII), but we used the sub-sample of **62 clusters which represents the largest highest quality SZ-X-ray data set currently availble (Planck XI).** Among these clusters 20 show evidence of non thermal emission and in Fig. 2 we compare the cluster mochromatic radio power at 1.4 GHz with $D^2_A Y_{500}$, the spherically integrated Compton Parameter proprtional to the flux of the SZ signal within R500. Note that we do not consider clusters with no radio data since in most of them, images from the NVSS suggest the possible presence of non-thermal emission but more data are necessary to confirm and study this suggestion.