PROJECT: Studi di Cosmologia		WP REF.:
WP TITLE: Sunyaev Zel'dovich signal from future CMB data **REPORT**: A1 **WP MANAGER: Pasquale Mazzotta**		**Sheet**: 1 **of** 1 **Issue Ref**: 1 **Issue Date**:01/09/2016

1. TASKS

- *Main collaborations: Astronomical Observatory of Trieste and University of Padua*

Through this project, we will develop and test a new imaging algorithm aiming at restoring the SZ signal to the highest resolution allowed by the local signal-to-noise ratio. This goal will be achieved following a multiscale approach combining datasets at different frequencies, each of them being characterized by its own spatial resolution. Beyond the data analysis of space observatories (e.g. Planck or Core+), this approach will be relevant for combining the observations of space observatories with balloon-born and ground instruments working in several bands with different angular resolutions, such as ACT, SPT and the future CCAT. Moreover, the restoration of the bi-dimensional distribution of a local parameter estimated via spectroscopy is a general problem with applications at other wavelenghts: among them are the restoration of temperature maps in X-ray astronomy or spectral index maps in radio-astronomy. Inspired from recent development in radar imaging, we propose to solve this problem from a coupling between bayesian inference and multi-scale analyses. Multi-scale algorithms being routinely used for many applications in image denoising and compression, this approach might also apply outside astronomy.

This project will make use of advanced cosmological hydrodynamical simulations of galaxy clusters, which will include astrophysical processes, such as radiative cooling, star formation and the effect of feedback from supernovae and AGN. These simulations, which will reproduce basic X-ray observational properties of the intra-cluster medium (ICM), represents the starting point to produce detailed maps of pressure and of the Compton-y parameter, by including both the thermal and the kinematic components. These maps will be "observed" in realistic conditions, by producing SZ mock observations at different frequencies, beam smearing, realistic level of signal-to-noise, contaminating backgrounds and point sources. Producing the same maps in the X-ray band will further allow exploring the synergies between the next generation of mm and X-ray telescopes in tuning galaxy clusters as precision tools for cosmology.

2. CURRENT STATUS

By the end of the 1st Semester of the first year we were aiming at obtaining a full set of:
a) Hydrodynamical simulations;
b) Development of the fully parametric component separation algorithm.

We managed to fully complete both tasks and, actually, we are a bit ahead of schedule as we also started the implementation of an instrument-optimized denoising algorithm which was planned for the second semester.

At this stage we applied the fully parametric component separation algorithm to the observed frequency maps of Planck HFI. Just as an example, in Fig. 1 and 2 we provide a visual illustration of the performance of our fully parametric component separation algorithm. Fig. 1 shows the 6 observed frequency maps of Planck –HFI extracted in a sky region centered in the massive galaxy cluster Abell 2163. This is a good test case as the SZ signal in this area is highly contaminated by the presence of a strong filamentary thermal dust component clearly visible in the high frequency range [353–857] GHz but that extends also in the low frequency maps where the CMB anisotropies and the thermal SZ distortions should be dominant. Fig. 2 shows the recovered SZ contribution at each frequency. The panels clearly demonstrate the quality of the SZ component separation.

Beside the proposed task, we also started new projects that we intend to carry on as part of this program. A short description of the new projects is scratched in the next section.

3. NEW PROJECTS

Within this WP we started two new scientific activities.

Testing Modified Gravity with the Compton-y map *(Lead by M. Liguori)*

We will study the y-Compton parameter map and its dependence on modifications of standard GR on cosmological scales. In a Modified Gravity (MG) scenario, the y map can change due to modifications of the cluster mass function, of the bias of halos and of the gas profile in clusters. We intend to model y in different MG settings, starting from a simple halo-model based analysis and moving to more sophisticated studies, making use of accurate N-body simulations.

We will then study several potential observational signatures, such as changes in the power spectrum of the y-map and various cross-correlation signals (e.g. lensing-SZ cross-spectra), as well as higher-order cumulants (e.g. SZ bispectrum). A preliminary phase of the work is completed, in which we used halo model to numerically extract various power spectrum signals in a standard GR framework. We are now starting to include some simple modifications of the mass function and bias in f(R) scenarios, based on N-body simulations, to produce a first assessment of our potential ability to discriminate between f(R) and the standard cosmological scenario, with this approach.

Simulations of the kinematic SZ observations from future CMB survey *(Lead by S. Borgani)*

Within this activity we propose to use the above mentioned cosmological hydrodynamical simulations of of clusters to generate the kinetic-SZ (kSZ) maps of sky regions surrounding such clusters. We will

convolve these maps with the "response function" of a CMB telescope to define the redshift-dependent mass-limit down to which peculiar velocities of clusters through the kSZ effect can be measured with a given error.

Finally, we will use this calibration of the kSZ selection function to make forecasts on the capability of cosmic velocity fields traced by kSZ to measure the large-scale growth of density perturbations and, from this, to constrain possible deviations from the LCDM paradigm (e.g., modification of gravity on very large scales). Both on the Fisher Matrix formalism and MonteCarlo Markov Chain methods will be used to produce such forecasts.

4. PEOPLE

The people involved, so far, with the activities of this WG are:

Senior Researchers

1. Bartolo N. (Padova)
2. Biffi V. (Tieste)
3. Borgani S. (Trieste)
4. Bourdin H. (Cambridge)
5. De Gasperis G (RomaTV)
6. Liguori M. (Padova)
7. Mazzotta P. (RomaTV)
8. Rasia E. (Trieste)

PhD Strudents

1. Baldi. A. S. (RomaTV)
2. Kozmanyan. A. (RomaTV)
3. Ravenni Andrea (Padova)

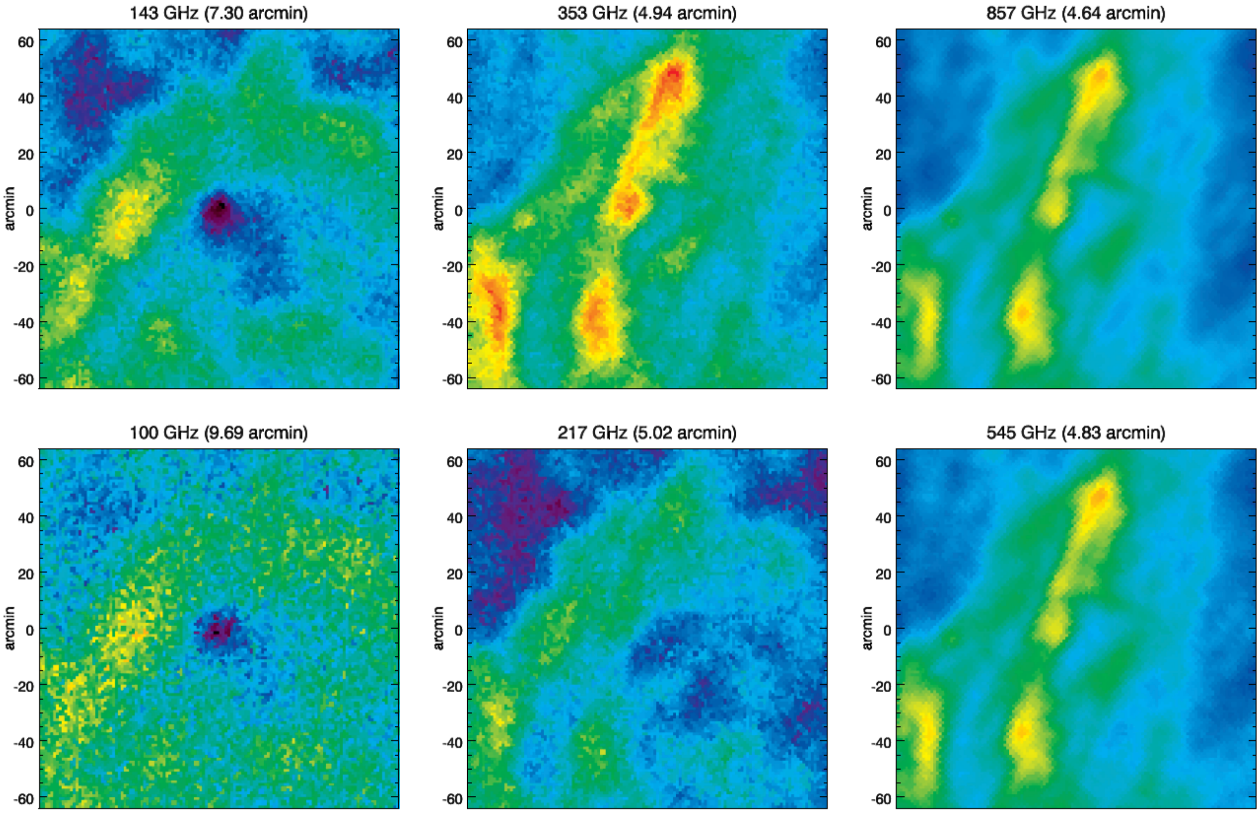

Figure 1. Planck-HFI frequency maps in the neighbourhood of the galaxy cluster Abell 2163. Numbers in brackets stand for the angular resolution. The cluster signal is primarily superposed onto temperature anisotropies of the Cosmic Microwave Background, and spatial variations of the Galactic Thermal Dust emissivity.

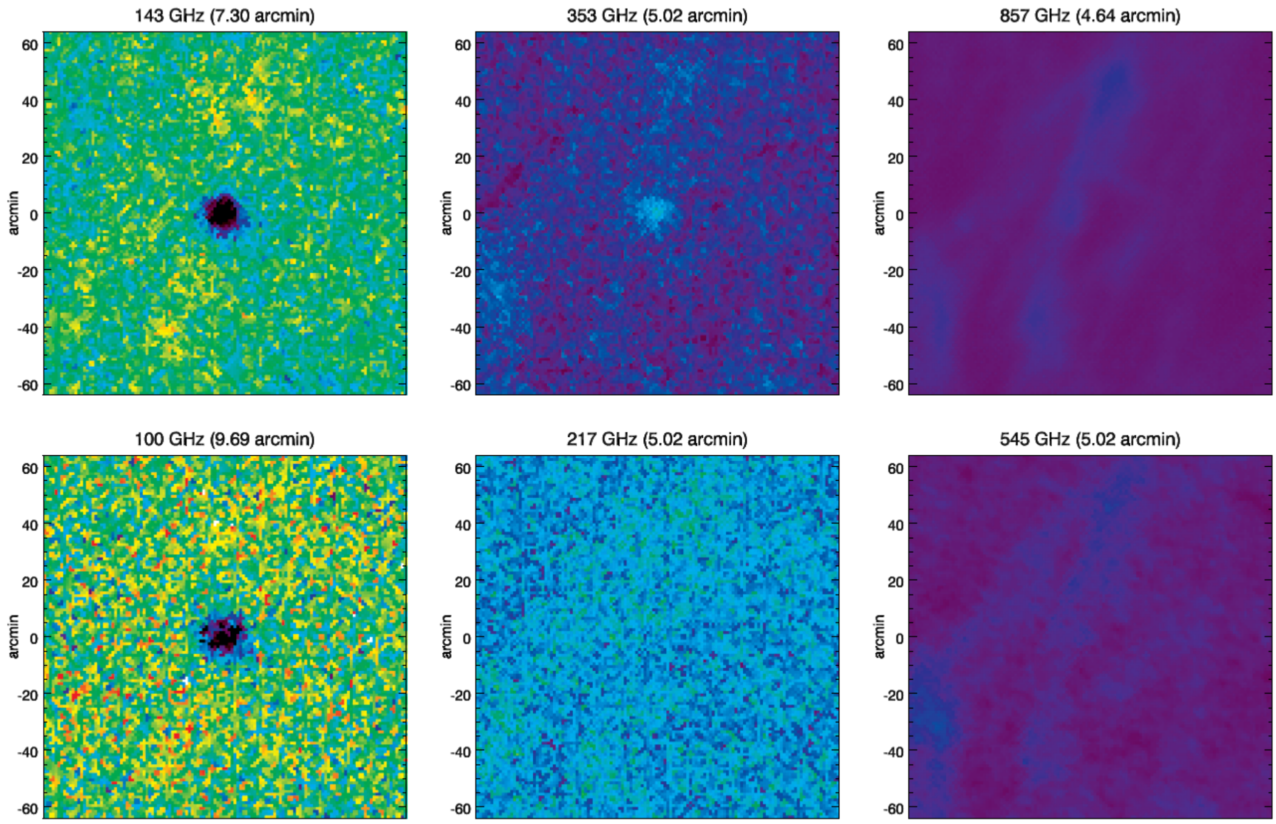

Figure 2. Millimetric signal detected toward the galaxy cluster Abell 2163. Maps result from the Planck-HFI frequency maps (see Fig. 1) and a subtraction of CMB and Galactic thermal dust anisotropies. They show a combination of the thermal SZ signal with residual anisotropies related to the cluster thermal dust emissivity.