The Air Microwave Yield (AMY) experiment to measure the microwave emission from air shower plasmas.

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The University of Salento and the Lecce unit of INFN (Istituto Nazionale Fisica Nucleare) participate in an international astroparticle physics experiment called AUGER[1]. AUGER is the largest experimental facility studying Ultra-High Energy Cosmic Rays. It is well known to the community not only for the remarkable dimensions, but also since a hybrid technology has been applied. The Hybrid technology provides for two independent ways to see cosmic rays, using two type of detector complementary to each other: an array of Surface Detectors (SD) measuring the atmospheric shower size at ground and a collection of air fluorescence telescopes (FD) measuring the fuorescence light emitted by the de-excitation of atmospheric nitrogen. The small FD duty cycle (around 10% limited to clear, moonless nights) is compensated by the high statistics of the SD data (100% duty cycle).

Recently, the observation of a microwave continuum emission from air shower plasmas[2] has raised the interest in a possible new technique for detection of cosmic-ray extensive air showers that may be able to provide a full longitudinal profile measurement (like an FD) with a 100% duty cycle (like an SD). Following this observation, the plasma is created after the release of the energy of the shower into the atmosphere and it is made by electrons of temperature of about 105°K. The cooling process of the plasma holds over a time scale of 1-10 ns and it comes mainly via the excitation of the medium. However, a small part of the plasma energy can be released through bremsstrahlung emission in the collisions of the electrons with the neutral molecules[2] of the atmosphere. The emitted radiation is in the microwave band and it is expected to be isotropic and proportional to the shower energy deposit. This properties of the microwave molecular bremsstrahlung radiation (MBR) open the possibility to develop a radio telescope which is able to reconstruct the full shower longitudinal development and to provide a calorimetric measurement of the shower energy. In comparison to the fluorescence telescopes, the technique of detection of the microwaves has two fundamental advantages : the duty cycle of 100% and the foreseen independence from the atmospheric condition. There are various groups inside or related to the AUGER experiment (AMBER[2], MIDAS [3] , EASIER[4], CROMe[5]) exploring this technique by means of prototype telescopes.

Our group has started at the end of 2010 a series of activities in order to study in detail the process of emission of microwaves within the AMY (Air Microwave Yield) experiment. The aim of AMY is to confirm and measure the absolute rate emission of microwaves and the spectrum in frequency in the range between 1 and 25 GHz. The idea is to study the process in a well controlled situation using an electron beam impinging on a showering media, and observing the emission at different stage of shower development. The experiment uses the Beam-Test Facility (BTF) of the National Laboratories of INFN in Frascati. The electron beam impinges on a showering target and subsequently enter an anechoic Faraday chamber (4 x 2 x 2 m^3). In order to prevent the detection of the electromagnetic radiation present in the area and to avoid the reflections, the inner wall of the chamber is covered with an RF absorber, providing a good shielding from 2 until 20 GHz. The chamber is equipped with 5 antennas: 3 of them are placed in the central part, and 2 are placed at the angles of the entrance wall of the chamber and oriented in such a way that the centre of the chamber falls in their field of view. The antennas tested as receivers are 2 log-periodic antennas, 1 horn antenna and various LNBFs (Low Noise Block Feed) in the satellite bands S, C and Ku.

In November 2011 we have participated to the first test beam of the AMY experiment. The duties of our group for the tests were of set-up and calibrate all the electronic parts for conversion and acquisition chain. In order to do so we have tested and calibrated different kind of power detectors, several amplifiers covering various ranges of frequency, as well as LNB in S band(2.5-2.7 GHz), C band (3.4-4.2 GHz) and Ku band (10.7-

12.7 GHz). Moreover we have set up all the software for acquiring a 4 channels Flash ADC of Struck SIS3350 (12 bits and 500 MS/sec sampling) under VME DAQ system. A particular care has been taken in analyzing the time rapidity of the power detector. In fact, in order to characterize the microwave signal is crucial to detect also the time evolution of the signal. With the tests performed locally in the Lecce Astroparticle Laboratory has been possible to demonstrate that the rapidity of time response of the power detector comes meaningfully improved removing a capacitor installed on the board (see Fig.1). Moreover the dynamic range has been verified and it is seen to be extended until an intensity of -70 dBm. For the FADC a graphical interface of monitoring and analysis of the acquisition data has been developed. A large amount of work has been also devoted to the simulation of the response.

The analysis of the data collected at the first test beam at Frascati BTF is still ongoing. In Fig. 2 and 3 some of these preliminary results. The data show the presence of a strong radiation directly produced from the relativistic electron beam. From the measures performed orienting the various plane of polarization of the antennas one can infer that the radiation is strongly polarized with the plane defined from the axis of the shower and from the Poynting vector. A quadratic dependence of the signal power as a function of intensity of the beam is seen independently from the antenna orientation. The study for time evolution shows the presence of tails, probably related to residual reflections inside the chamber.

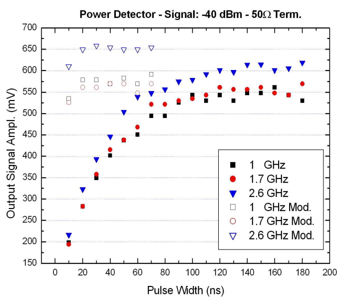

Figure 1. Measure of Time response for a power detector ZX 47-60-S+ Mini-Circuit (Mod. Refers to modified board)

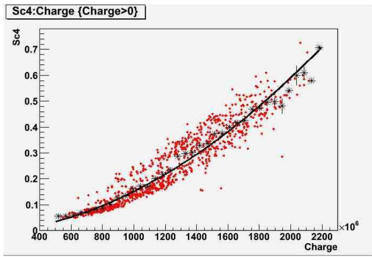

Figure 2. Power of the signal (a.u.) as a function of the charge of the beam for a cross polarized horn antenna. A quadratic dependence is observed. This is independent from the polarization plane.

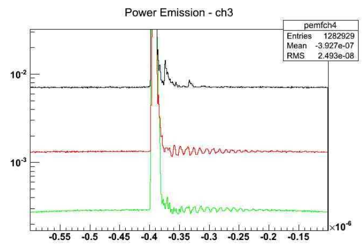

Figure 3. Power emission as a function of time, showing the time evolution of the signal acquired from horn and log periodic antennas.

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