New Sensors Activity

R.Assiro[1] , C.Bleve[1 2] , G.Cataldi[1], M.R.Coluccia[2], A.Corvaglia[1], P.Creti[1], S.D'Amico[1 3] , I.De Mitri[1 2], G.Fiore[1], G.Marsella[1 2], D.Martello[1 2], L.Perrone[1 2], C.Pinto[1 2], V.Scherini[1 2]

[1]Sezione INFN, Lecce, Italy

[2]Dipartimento di Matematica e Fisica "Ennio De Giorgi", Università del Salento, Lecce, Italy

[3]Dipartimento di Ingegneria dell'Innovazione, Università del Salento, Lecce, Italy

Pierre Auger Observatory is an experiment that allows to study the cosmic rays at these energies with high statistics [1][2][3]. The observatory is located in Argentina at about 1300 m above sea level. Main features are the large size of the apparatus and the fact that it uses a hybrid technology that is a combination of two types of detector : a detector surface (SD) and a fluorescence detector (FD) . The Auger SD consists of 1600 detectors spaced 1.5 km and spread over an area of $\sim$ 3000 km^2. These detectors allow to study the particle shawers produced by primary cosmic rays interact in the upper layers of Earth's atmosphere and are each consisting of a tank with a 3.6 m diameter containing pure water. The charged particles, going through the water, produce Cherenkov light detected by three photomultipliers.
The detector FD consists, instead, of 24 telescopes distributed in four stations located at the edges of the SD array in order to cover the whole experimental area. These telescopes observe the fluorescence light produced by the shower in the atmosphere.
The combination of these two techniques (SD and FD) allows to get informations on energy, type and direction of origin of the primary cosmic rays. This information is necessary to identify both the source and to understand the mechanisms of acceleration. The observatory is taking data continuously since 2005 and has produced significant results in the areas of physics related to the study of cosmic radiation. The Auger experiment is able to identify with great precision both the direction of origin of the primary cosmic radiation and its energy. Its current configuration does not allow , however, to identify the nature of the primary cosmic rays. In particular as regards the composition of primary cosmic rays the results obtained, published in [4][5], seem to indicate a mixed composition with average mass increasing to higher energies.

1. R&D Program and Activities

The future of the experiment is related to the ability to improve the results obtained both the statistical point of view and in terms of quality of the collected data. For the primary cosmic rays composition various solutions are under investigation. These solutions are related to both the longitudinal development of the showers and their muon component in order to significantly increase the discrimination capacity.
The Auger collaboration started an R&D activity in view of the experiment upgrade phase. New solution are under investigation concerning the detctors hardware and electronics, trigger, software and data acquisition systems. In particular, with regard to the SD, there is an effort to modify the inner lining of the Cherenkov stations, increase the sampling frequency of the signal (100 MHz) and integrating each station with a a muon detector in order to increase the sensitivity to this component of the cosmic radiation. The presence and the number of muons in a shower, in fact, is related to the mass (and the type) of the primary cosmic ray.
In our laboratory, we focused in particular on the latter possibility being the group of Lecce engaged in the proposal of a detector based on scintillating tiles material, optics fiber and light sensors (SiPM). The proposed detector would be placed under each of the 1660 SD stations. The tank filled with water acting as a natural absorber of electromagnetic particles (electrons, positrons, photons) would leave the muons pass through. It could be possible in this way to count the number of muons present in a shower.
Regarding the tanks inner lining, different solutions are under study in order to avoid multiple reflections of the Cherenkov photons and significantly increase the efficiency of light collection by the photomultipliers. One of these solutions regards the possibility to "black"the top of the tank, the so-called black-top. In this sense, we

Figure 1. The HAMAMATSU S12571-100C sensor.

investigated the best materials to be used in order to not alterate the water purity and that can withstand the climatic conditions in the Argentina pampas.

2. Scintillators

We started to assemby new scintillating detectors and to perform the first test measurements. Scintillator tiles coming from two industries are under investigation: six tiles fron FNAL (Chicago) with dimensions $4\times40\times1$ cm^3 and one tile from Epic-Crystal (China) with dimensions $20\times20\times1$ cm^3.
The light detector we decided to investigate are from HAMAMATSU (Japan) and from sensL (Ireland). We have six MPPC (Multi Pixel Photon Counter) from HAMAMATSU: two S12571-100C, two S12571-050C, one S10362-11-025C and one one S10362-11-100C; they have all a photosensive area of 1mm$\times$1mm but a different pixel pitch (25, 50, 100 μm). These sensors have an excellent photon counting capability, are compact, operate at room temperature, have low voltage (100 V or less) operation and high gain (10^5 to 10^6). The sensors from sensL are two MicroFM-10035-X18 that have 1mm$\times$1mm sensitive area but a pitch of 35μm. In Fig.1 a HAMAMATSU sensor is shown.
One detector has been assembled up to now. The FNAL scintillator has been equipped with the S10362-11-100C MPPC. The measurements program foresee a first test using radioactive source that can be located on the plastic scintillator at diffrent position respect to the mppc. After this, efficiency measurements using a cosmic telescope made by 4 plastic scintillator tile of $14\times14\times1$ cm^3 dimensions, already tested and equipped with electronics.
Fig.2 shows a new metallic structure that can host up to four scintillator bars equipped with eight MPPC.

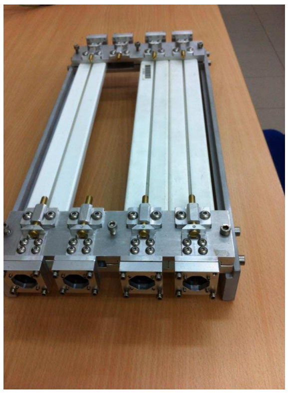

Figure 2. Metallic structure that can host four scintillator bars with MPPC.

REFERENCES

1. The Pierre Auger Collaboration, NIM A 523 (2004) 50.
2. The Pierre Auger Collaboration, NIM A 613 (2012) 29.
3. The Pierre Auger Collaboration, NIM A 620 (2010) 227.
4. The Pierre Auger Collaboration, Phys. Rev. Lett., 104 (2010) 091101.
5. P. Facal and D. Garcia-Pinto for the Pierre Auger Collaboration, 32nd ICRC, Beijing, China (11-18 Aug 2011). arXiv:1107.4804[astro-ph.HE].