Auger SSD Muon Scintillator Detector Prototype: LUNA

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In this note we describe the assembly and test of the first muon detector prototype for the Pierre Auger Surface Detector upgrade.
The approved Auger upgrade program foresees a complementary measurements of the shower particles through a plastic scintillator plane positioned above the existing Water-Cherenk+ov Detector (WCD). In this case we can sample the shower with two different detectors having different responses to muon and electromagnetic particles.
The design chosen consists of a detector based on a plane of plastic scintillator and read out in an integral way using only one photodetector (PMT). The dinamic range of the unit has to be adequate to garantee the physics gaols of the upgrade. The detecor will be assembled and tested in paralle in multiple assembly facilities in order to reduce the production time. Part of the production work will be done in Lecce.
The first scintillator detector prototype has been assembled in our laboratory. Up to know only the fibers of half module has been connected to the R9420 HAMAMATSU PMT. This first half module has been named LUNA.

1. Detector Design

The Surface Scintillator Detector (SSD) basic unit consists of two modules of 2 m^2 extruded plastic scintillator read out by wavelength-shifting (WLS) fibers coupled to a single photmultiplier. The active part of ech module is a scintillator plane made by 12 bars 1.6 m long of extruded polystyrene scintillator produced by Fermi National Accelerator Laboratory (FNAL). Each bar is 1 cm thick and 10 cm wide. The scintillator bars are co-extruded with a TiO_2 outer layer for reflectivity and have four holes in which the fibers can be inserted. At both ends of the scintillator plane there are routers, made by extruded polystyrene, with grooves having a "U" configuration for maximizing light yield and allowing the use of a single PMT. The routers have been designed with curvature radii of 5 cm and this, together with the "U" shape, means that each fiber passes from one hole of a scintillator bar to one hole of the neighbor bar. The fibers are cut all at the same lengh and in the internal part of the module they are forced to follow grooves with a "snake" shape from the bars to the PMT. In this configuration the fibers are read out from both ends. The fiber bundle terminations from the two modules are inserted in a PVD cylinder and glued using the optical cement POLYTEC 601. See Fig. 1 for details. This allow the coupling to the PMT via a SAINT-GOBAIN optical grease. The two modules are hosted inside a alluminum vessel to warranty isolation from light and water.The routers at the center and at the opposite ends of the SSD are wrapped into aluminized mylar foils to ensure good light reflectivity.
For the first SSD prototype assembled in the Lecce laboratory, we have half module realized with the 12 scintillator bars as described up to now and half module realized with 24 scintillator bars having same length but 2 cm thickness and 5 cm width (named TERRA). In this case only two holes are present on each bar. Fig. 2

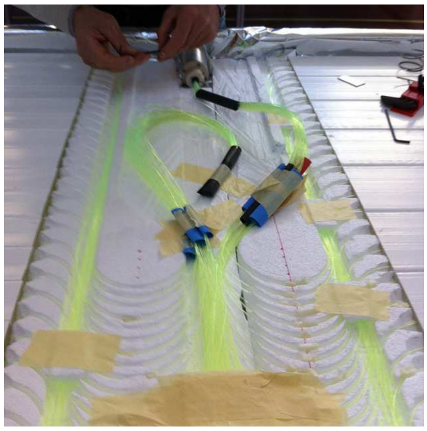

Figure 1. Routers with the snake shape in the central part of the detector. The fibers connected to the PMT are from LUNA module.

Figure 2. Complete view of the two module, LUNA and TERRA, before closing the detector.

shows the two modules before closing, in foreground the 10 cm wide bars are visible, while in background the 5 cm wide bars. Due to the different bars dimension, we decided to test one module per time. We perform the first test measurements on LUNA that has the technical design bars (160x1x10 cm^3).

The baseline SSD PMT is the HAMAMATSU R9420, head-on type, 8 stage with a 38 mm bialkali photochatode. This PMT shows good quantum efficiency at the wavelength of interest (in the green region) associated with an excellent linearity range (through a proper tapered ratio divider) of up 200 mA of anode peak current [1].

2. Test Measurements

In the first phase, we perform same tests in order to measure the MIP (Minimum Ionizing Particle). We use a small cosmic ray detector made by 4 scintillator tiles (14x14x1 cm^3), having a circular wavelength-shift fiber read out by APDs (Avalanche Photo-Diode), and put into coincidence. We position this small detector under the LUNA module and, using the NIM logic, we acquire the signal from the PMT in coincidence with the signal coming from this detector. In this way we select only Minimum Ionizing Particles coming through the detector.

The data acquisition system is written in labview; we acquire the signal from the PMT with an oscilloscope and the data are saved for later analysis. We performed measurements changing the applied voltage to the PMT and putting the small detector in different position under the LUNA module in order to cover all the detector area.

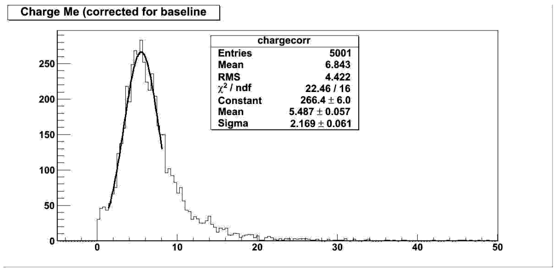

Figure 3. Distribution of the charge for the MIP measured at an applied voltage of 1100 V.

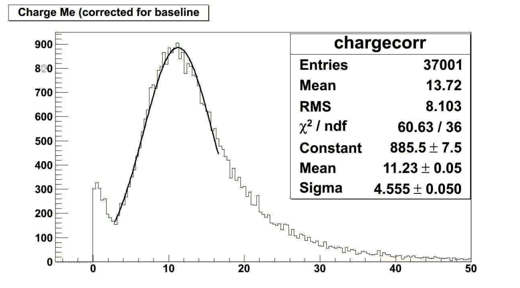

Figure 4. Distribution of the charge for the MIP measured at an applied voltage of 1300 V.

Fig. 3 shows the charge distribution in Me for the MIP measured at 1100 V applied voltage to the PMT. Considering the gain of the PMT at 1100 V we get 19 photoelectrons for MIP. Fig. 4 shows the same measurements performed at HV = 1300 V. In this case we get 18 photoelectrons for MIP. The measurements have been performed also at 900 V, 1000V, 1200 V, 1400 V and 1500 V obtaining results compatible in the range of 18-20 photoelectrons for MIP as expected.

REFERENCES

1. *PMT R9420 Test Results*, in this annual report contributions.