

PROCEEDINGS OF SCIENCE

Hybrid cosmic rays detector

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It has been developed at the Laboratorio de Partículas Elementales of the DCI, http://laboratoriodeparticulaselementales.blogspot.mx/, a four channel hybrid cosmic ray detector, that combines two detection techniques: ionization and Cherenkov light detection in a gaseous medium of 90%Ar+10%CH4. The basic detection cell consists of a quadrangular Aluminium tube of 1.01 m length, 2.54 cm x 2.54 cm cross section, and 0.1 cm thickness. Furthermore, inside it has been polished to mirror. For ionization detection channels, there is a metallic Tungsten fibre coated in Gold, with diameter of one thousandth inch. The fibre is coaxially to the Aluminium tube and welded to Gold connectors which are over caps, the ones are fixed at both tube's ends. A high voltage, around 2200V, is supplied to the metallic fibre which has been instrumented to read out the output signals. Besides, for Cherenkov detection channels, a Hamamatsu S10362-11-100U photodiode is placed and instrumented in each cap. Moreover the main cell, the hybrid cosmic ray detector comprises a gas system, the read out, amplification and discrimination electronic boards, as well as a data acquisition system. The DAQ system performs at 40MHz, and writes data into a file every 1ms for off line analysis. Technical information about this hybrid cosmic ray detector as the design, the construction, the characterization and the tests are treated here. The results on cosmic ray flux measurements obtained so far are discussed too.

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1. Introduction

Since the discovery of the cosmic rays by the Austrian physicist Victor F. Hess in 1912[1], who demonstrated by means of a series of balloon ascents the existence of a radiation of exceptionally high penetrating capacity, several kinds of detectors have been developed. Such as the spark, cloud, or bubble chamber mainly used for particle tracking imaging; another subsequent by means of plastic scintillator or Cherenkov light detection, both complemented with photo-multipliers tubes and multiwire chambers based on ionization detection. For teaching and research purposes, it has been developed a hybrid cosmic ray detector that combines both Cherenkov light and ionization detection. This is the basic cell to build a larger hybrid cosmic ray detector.

2. Design and construction

The detection cell is an Aluminum tube whose dimensions are, 1.01 m length, 54 cm x 2.54 cm cross section, and 0.1 cm thickness. Inside, it was polished to mirror in order to improve light reflection into the cell. There are a couple of caps for both tube's ends. Each cap is made of acrylic and painted in black to prevent the visible light pass into the cell. Figure 1 to Figure 3 illustrate the hybrid cosmic ray detector and cap designs.





Figure 3:Cap design detail with components.

A metallic fibre made of Tungsten and coated in Gold with one thousandth inch diameter was placed coaxially to the Aluminum tube. It was welded to Gold connectors over the caps, as well as a Hamamatsu photodiode, an optical fiber, a gas connector and Aluminum foils were placed over caps. In Figure 4 are shown the assemble stages, in adittion, a detail of the cap into the cell is shown in Figure 5 and Figure 6.

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Figure 4: Hybrid detector assembling.



Figure 5: Detail of inserted cap into the Aluminum tube, rear perspective.



Figure 6: Detail of inserted cap into the Aluminum tube, front perspective.

Aluminium is a suitable material because of its high reflectance greater than ninety percent for the visible electromagnetic spectrum, as it is shown in Figure 7. Cherenkov light is produced close to UV region, so the photodiode S10362-11-100U used in the detector has an efficiency peak around 400 nm wavelength. Its detection efficiency reaches up to 65 %.



Figure 7: Reflectance for some materials[2].



Figure 8: Photon detection efficiency vs wavelength for the photodiode Hamamatsu S10362-11100U model, green line[3].

3. Characterization tests

Two characterization test have been done in order to determine the suitable operation voltage and gas pressure values. Previously, the experimental system was set up as Figure 9 illustrates.



Figure 9: Experimental system connection diagram.



Figure 10: Experimental system: on the table, the hybrid cosmic rays detection cell; behind the cell, the electronic boards for power supply and read out (P&R), amplification (A) and discrimination; beside the table, gas container and gas flow sensor attached; and on the shelf, the CompactRIO (DAQ)[4].

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Figure 11: Typical output signals for ionization channels, on left channel 1 with 300 mV amplitude and right channel 2 with 250 mV amplitude. For both channels, in blue a

discriminator output pulse of 5 volts amplitude and duration of 100 ns,

setting a trigger of 100 mV.

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Figure 12: Typical output signals for Cherenkov channels, on left channel 1 and right channel 2 both with 60mV amplitude and in blue a discriminator output pulse of 5 volts amplitude and duration of 50 ns, setting a trigger of 50 mV.

By mean of the set of codes Poisson-Superfish[5] the electric potencial inside the cell was determined as well as the electric field, by solving numerically the Laplace equation. They are shown in Figure 13 and Figure 14 respectively.





Figure 14: Graph $|\vec{E}|$ vs *x* position.

3.1. Counts as function of HV power supply

For the ionization characterization tests, high voltage was increased in 500 V every five minutes starting from 500V using an Ultravolt power supply which supplies up to 3000V. The output signals were recorded by the DAQ every 1 ms. In similar way for Cherenkov channels, these were supplied by a BK presicion power supply from 50 V to 100 V increasing 10 V every 10 minutes. The suitable voltage operation found was about 2200V. Graphs for both characterization test are shown in Figures 15 and Figure 16 respectively.

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Figure 15: Characterization test, counts as function of voltage supplied. Ionization channels one (blue) and two (cyan). Vertical axis, correspond to the counts as function of the high voltage supplied in the horizontal axis.

Figure 16: Right Cherenkov channels 1 (red) and two (green). Vertical axis, correspond to the counts as function of the voltage supplied, which was increased every ten minutes (horizontal axis).

3.2. Counts as function of differential gas pressure

Regarding to characterization tests of counts as function of differencial gas pressure, this one was varied in order to determine a value that favor the detection rate. Ionization channels presented a dependence in the gas pressure. The desired value on differential pressure to operate the hybrid detector was about 0.35 mB.



Figure 17: Characterization test, counts as function of the differential pressure for ionization channel one. Vertical axis range 0 to 12, corresponds to the counts as function of the differential pressure, range in the horizontal axis from 0 to 0.45 mB.

Figure 18: Characterization test, counts as function of the differential pressure for Cherenkov channel one. Vertical axis range 0 to 7, corresponds to the counts as function of the differential pressure, range in the horizontal axis from 0 to 0.45 mB.

4. Cosmic ray flux measurements

In order to validate the cosmic rays counts, it has been analyzed the output signals for the ionization channel one, by means the intersection to the Cherenkov channels, that is, Ionization CH1 \cap Cherenkov CH2. The cosmic ray flux may be measured fitting the data. Fitting the first flat region in the Figure 19, the value measured for the cosmic ray flux obteined was



Figure 19: Cosmic rays flux measured in $\frac{N}{m^2 \min}$ during 60 minutes

Graphs and fit parameters were calculated using Root[6].

5.Conclusions

We have developed a Hybrid Cosmic Ray Detector. A Hybrid Cosmic Ray Detector of two Cherenkov light and two ionization detection channels works properly. According to cosmic ray flux measurements as function of time by means the Hybrid Cosmic Ray Detector, the cosmic ray flux varies sharply and then tends to stabilize. It is not constant.

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