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ACORDE, The ALICE cosmic ray detector

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Abstract: ACORDE (ALICE cosmic ray detector) is one of the ALICE(A Large Ion Collider Experiment at CERN LHC) subdetectors, presently in construction. It will consist of an array of plastic scintillator counters placed on the three upper faces of the magnet. This array will act as the cosmic ray trigger for ALICE calibration, as well as the multiple muon trigger to study high energy cosmic rays. In this paper we briefly present the main goals of this cosmic ray detector reporting also on the ACORDE construction activities and integration to the ALICE experiment.

Introduction

ACORDE will play a two-fold role in ALICE: **a)** It will act as the cosmic ray trigger for ALICE and **b)** it will detect, in combination with some of the tracking detectors, single atmospheric muons and multi-muon events. The first task will provide a fast (level zero) trigger signal, for the commissioning, calibration and alignment procedures of some of the ALICE tracking sub-detectors. On the other hand, the ACORDE scintillator counter array will allow the study of cosmic rays in the energy region of the knee in the cosmic ray spectrum. Taking into account the fine granularity of the TPC (ALICE-Time Projection Chamber) and the fast response of the ACORDE array it will be possible to measure several properties of cosmic ray events with high density muon tracks, the so-called muon bundles [1, 3].

To obtain information of the lateral distribution and the core position of the induced shower, there is available a working surface array, previously used by the L3+C experiment [2].

The present construction state of the ACORDE scintillator module array, which includes 60 scintillator counter modules (see Figure 1) placed on top of the ALICE magnet, is shown in Figure 2. ACORDE will provide a fast level-zero trigger signal to the central trigger processor, when atmospheric muons impinge upon the ALICE detector. The signal will be useful for the calibration, alignment and performance of several ALICE tracking detectors, mainly the TPC, TOF, HMPID and ITS. The cosmic ray trigger signal will be operational before the first LHC beams are produced. Also it will be capable of delivering trigger signals with the beam on or off.

Although the typical rate for single atmospheric muons reaching the ALICE detector is relatively low (we have measured a rate of 6.3 Hz/m^2, on top of the magnet), the rate for multi-muon events is expected to be much lower (less than 10^{-3} Hz/m^2) but statistically sufficient for the study of these type of events, provided we can trigger and store tracking information from cosmic muons parallel to the ALICE normal data taking with colliding beams. Atmospheric muons need an energy of at least 17 GeV to reach the ALICE hall, while the upper energy limit for reconstructed muons in the TPC will be less than 2 TeV, at a magnetic field intensity of 0.5 T. It will allow us to measure the atmospheric muon momentum spectra in a wide GeV range.

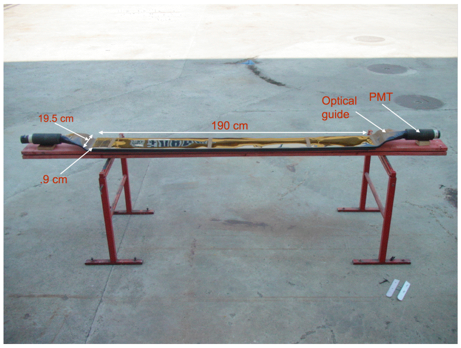

Figure 1: ACORDE module unit. This device includes two sctincillator counters overlapped, each with 190x20cm^2 effective area, and 10mm thickness, plus two PMts placed on the ending side of each scintillator, with optic guide and iron magnetic shielding. All components are attached to an aluminum structure, assembling a 40kg robust box.

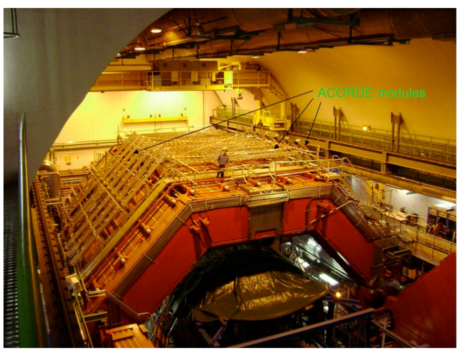

Figure 2: Photo of the ACORDE scintillator module array on the upper fases of the magnet yoke, in the ALICE pit, located in the P2 site, of the LHC ring, 60m underground. There are twenty modules on each one of the three upper fases.

Detector specifications

Besides the the construction of the scintillator counter array, we developed an electronics system for readout and trigger signal generation, as well as the related software to control and monitor the operation of the ACORDE detector, named ACORDE-DCS.

An ACORDE module consist of two scintillator counters, each with 1.90×0.195 m^2 effective area, arranged in a doublet configuration, see Figure 1. With this setup we achieved a uniform efficiency higher than 90% along the whole length of a test module.The current layout of the cosmic trigger on the top faces of the ALICE magnet consists of 60 scintillator modules located perpendicularly to the beam axis. See Figure 2. Details of the construction and performance of this counters are explained in Reference [3].

In the following lines we will describe the main features of the ACORDE electronics system and the DCS.

Electronics Requirements for the ACORDE scintillator array.

The ACORDE electronics have fulfiled the following requirements:

1. Produce the single muon trigger signal and a (rough) spatial position when atmspheric muons hit the ALICE magnet. This information will be used to calibrate the ALICE TPC detector and other tracking detectors.

2. To study multi-muon events, ACORDE must provide a multi-coincidence trigger signal and store kinematics information from cosmic muons. Given the low frequency rate of this trigger (less than 1Hz), we plan to run this trigger parallel to ALICE normal data taking.

3. Provide the wake-up signal to the ALICE Transision Radiation Detector (TRD).

4. Supervise the performance of the ACORDE scintillator counter array.

The ACORDE Electronics is made of several parts: i) 60 FEE cards, one per ACORDE module; ii) "ACORDE OR" card to generate the TRD wake up signal. This card receives the 60 coincidence LVDs signals coming from the FEE cards; iii) main card, which contains the electronics to receive the 120 LVDS signals coming from 120 scintillator. This card will produce the single and the multi-coincidence trigger signals and will provide the connectivity to the ALICE trigger and DAQ systems. This electronics has been designed and implemented at BUAP and UNAM. At CERN, a complete test procedure, in coordination with the Trigger and DAQ ALICE groups in underway.

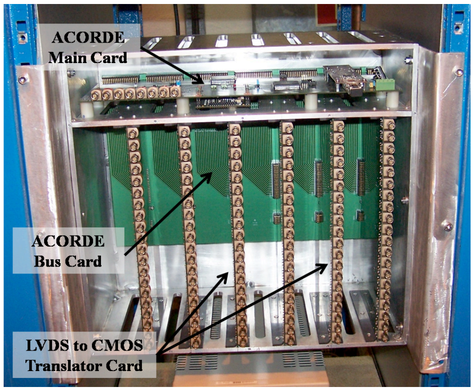

Figure 3: Photo of the ACORDE electronics system.

Detector Control System

The main tasks of the ALICE Detector Control System (DCS) of any subdetector are the monitoring and control of the necessary signals to operate the subdetector at all times of the experiment. This includes the HV and LV power supplies, the front-end electronics (FEE) configuration parameters, alarm handling, DB archiving and all other services (gas, cooling, etc.).

In the case of ACORDE we will need only the HV and LV supply to be monitored and controlled. The only parameter of the FEE to be programmed, namely the multi-coincidence number, will be accounted for in the DAQ system; that is, it will be programmed via the DDL and not through the DCS.

We will use the SY2527 and the EASY (E*mbedded* A*ssembly* SY*stem*) power supplies systems from CAEN as the HV and LV supplies respectively. The latter is a radiation- and high magnetic field-tolerant power supply system to be installed in the cavern racks to supply the LV for ACORDE.

Calibration of the ALICE TPC using cosmics

On May 2006, the ALICE TPC detector started its characterization procedure up in the assemble area in LHC-Point II [4], finishing by the end of that year. The ALICE-TPC is the main tracking detector in the ALICE central barrel situated between a silicon vertex detector (ITS) on the inside a Transition Radiation Detector and Time of flight array on the outside, designed for a maximum multiplicity DN_{ch}/dy =8000, resulting in 20 000 charged primary tracks in the acceptance region, which covers a pseudorapidity range $\mid \eta \mid < 0.9$. The position resolution of the TPC is expected to vary from 1100 to 800 μm in ϕ direction and 1250 to 1100 μm in z-direction. The efficiency of track reconstruction is near 97% with an excellent momentum resolution (For DN_{ch}/dy =6000 and magnetic field of 0.5T, the expected resolution is s below 4% at 100GeV/c). For cosmic ray measurements, the features of this tracking detector is well above our necessities because the must populated muon bundle events that we expect, should have few hundred particles, crossing the TPC.

We have successfully provided the cosmic ray trigger, using 20 ACORDE modules (10 modules on top, 10 underneath the TPC) and a specific electronics to generate trigger signals. See Figures 4. For this specific setup, we generated signal triggers when a defined number of upper modules were in coincidence with some specific modules placed below the TPC. Figure 5 present typical examples of reconstructed cosmic ray events,recorded by the TPC, triggered by ACORDE, showing clearly how precise will be our cosmic ray measurements.

Remarks

The ACORDE detector commissioning started this Spring 2007, planning to finish it by the end of this Summer. Then we will participate in the calibration and alignment of the ALICE tracking detectors, just before the start up of the LHC operation. Having the ACORDE detector in operation, together with the high quality of reconstructed events that the ALICE-TPC will provide, as well as the possibility to use the L3+C surfacer array, we will have the capability to contribute to the study of high energy cosmic rays physics.

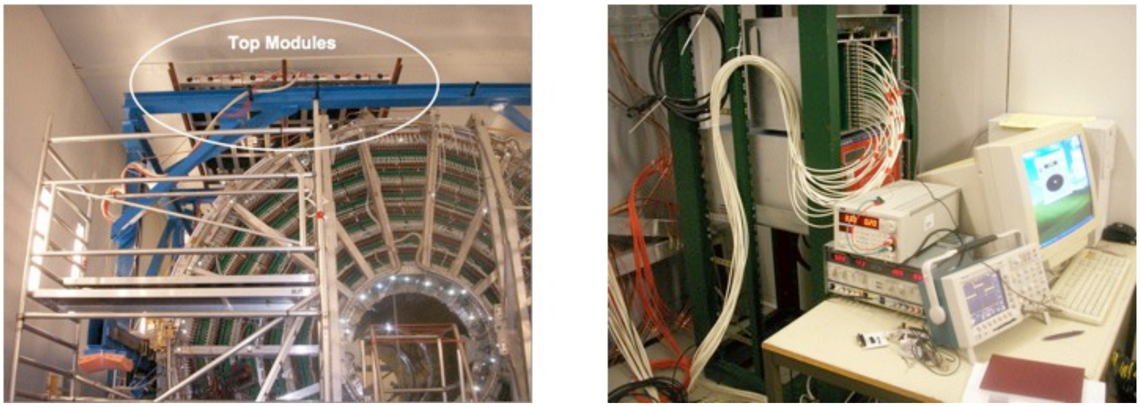

Figure 4: Left: ACORDE modules on top of the and ALICE-TPC. Rigth: ACORDE electronics and related DAQ system for the ALICE-TPC cosmic ray characterization.

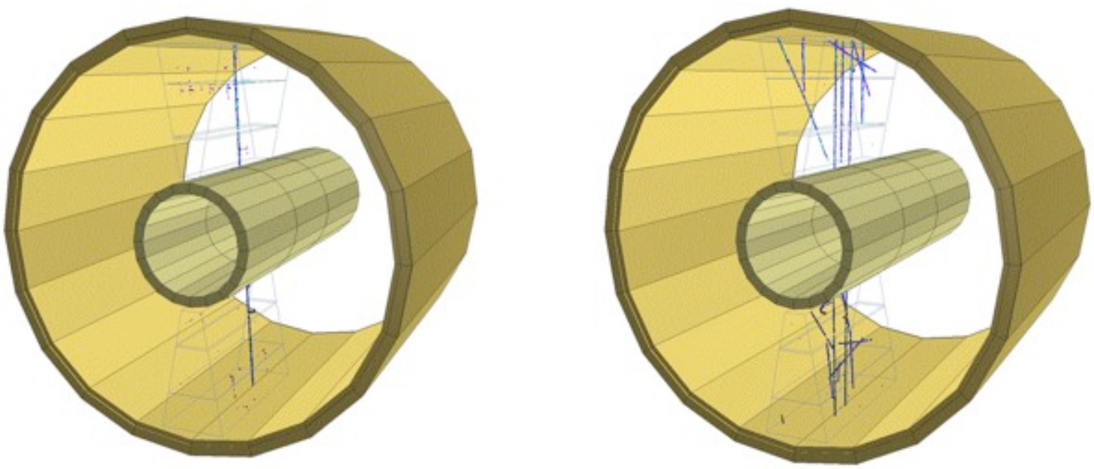

Figure 5: 3D-view of reconstructed cosmic ray events recorded by the TPC, triggered by ACORDE. Left: Single cosmic track crossing the TPC. Rigth: A shower induced by cosmic rays. We thank the TPC collaboration for providing this plots.

Acknowledgements

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