ATLAS RPC commissioning and cosmic ray tests

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The Lecce ATLAS group was involved in hardware and software commissioning of the Resistive Plate Chambers (RPC [2]) used as trigger detector in the barrel region of the ATLAS muon spectrometer [3].

RPC detector and its trigger electronics are designed to detect and select high momentum muon with high time resolution and tracking capability covering a total surface of 3650 m^2. Both systems were tested and certified before large Hadron Collider (LHC) operation by stand-alone cosmics runs and dedicated ATLAS combined operations.

The functionality of the muon trigger components - such as: detector chambers, trigger electronics, detector slow control system (DCS), data acquisition chain, software, and computing - were exercised and verified carefully during those commissioning phases. This was assured by several hardware and software tests. Due to the high level of inter-dependence between different components, a well defined commissioning schedule was followed and specific diagnostic tools used.

Since 2007 cosmic muons were acquired with the ATLAS muon spectrometer [4]. Each geometrical sector, realizing the ATLAS muon spectrometer layout, was studied in detail, fixing all hardware problem identified by cosmic ray analysis. This intense activity allowed to debug and characterize the RPC detector completely. By then onwards, we participate at several ATLAS combined data taking periods and to the first circulating proton beams of september 10^{th} 2008 in LHC.

The hardware commissioning was divided in four main parts: gas system, electrical service, power system, and cosmic ray runs.

Gas system commissioning:

The gas system works in re-circulating mode, with a constant fraction of fresh gas mixture at the input. The total amount of gas volume, including also the volume pipes, is about 18 m^3. Our group, with a strong support of our technicians, provided the sealing of the 128 gas lines of the system. In addition, several gas inlet, glued on the gas volume inside the chambers, were found broken and were repaired *insitu*, without removing the detectors from the apparatus. Since May 2008, the gas system is complete and working in steadily in recirculating mode.

Electrical service commissioning :

A huge amount of work were done in the experimental cavern to connect each RPC chamber and trigger tower to the electrical service cables in order to power the detector. All electrical cables were tested on both sides, before the connection to the chambers and racks, using specific tools made available by the DCS software. This procedure reduced significantly the amount of mapping errors of such a complicated system. Before the cavern closure for LHC start-up, almost all RPC chambers were cabled and tested with cosmics.

Power system:

In order to power all the RPC chambers and trigger towers, a complex power system were setup in the service and experimental caverns. In the experimental cavern 29 racks were arranged, each one containing several crates were the electronic boards are located. A big effort were done to implement and verify the rack cabling. To assure the correct operations and control of every electronic board, each crate were powered and the DCS mapping verified.

Cosmic ray runs:

Lecce group is responsible of the RPC commissioning with cosmic rays. To this purpose, we developed a stand-alone commissioning software and several debugging techniques to prove the system functionality in details, and to monitor and characterize the detector response in all aspects. We verified and debugged the detector mapping in the ATLAS standard software framework, named ATHENA [5], and its hardware realization in the cavern. The RPC mapping is highly not trivial because it realizes the projective trigger logic without introducing inefficiency. This requires a channel overlap schema in both views which changes accordingly to the position along the beam. Moreover, the correlation between precision tracking chambers and trigger chambers were extensively studied in order to exclude data corruptions and synchronization problems.

In Figure 1 the RPC average readout strip detection efficiency distribution is shown as measured by cosmic rays during commissioning. It turns out that the resulting fraction of dead strips is about 1.7%.

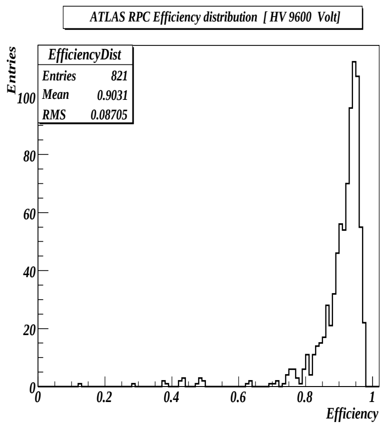

Figure 1. Distribution of the RPC average readout strip panel average detection efficiency for a high voltage of 9600 V and nominal voltage front-end threshold (T=20 ^{0}C and P= 980 mbar).

In addition, we carried out extensive studies to characterize the detector in terms of noise and to map noisy channels (see Figure 2).

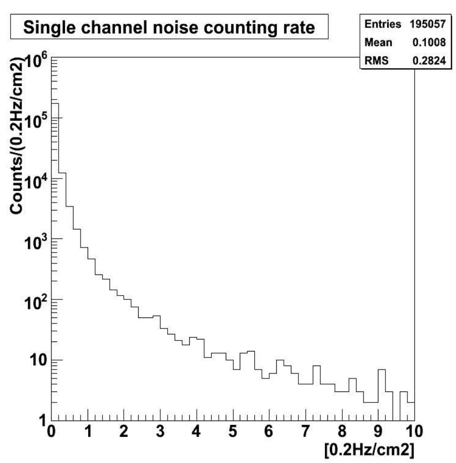

Figure 2. Distribution of RPC single channel counting rate for a high voltage of 9600 V and nominal voltage front-end threshold (T=20 ^{0}C and P= 980 mbar).

Dedicated run were taken with random trigger as a function of the applied gas volume high voltage and front-end voltage threshold. We found an average noise value of about 0.1 Hz/cm^2 in nominal conditions and less than 200 strips (out of 355000) with a noise counting rate above 10 Hz/cm^2. Also the gap current was monitored along all data taking period to prevent aging problem, while correlation studies between gap currents and noisy panels are undergoing.

In Figure 3 the RPC gap current distribution, for the the detector operated during 2008 runs, is shown.

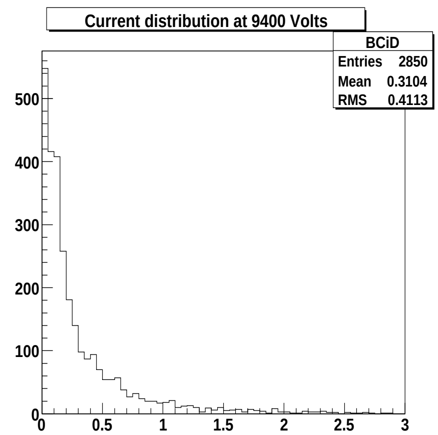

Figure 3. Gap current distribution for RPC ATLAS chamber for a high voltage of 9400 V

Over a year's work in the ATLAS cavern and with cosmic rays enabled us to commission ATLAS RPC detector before LHC start-up operation. Moreover, the huge amount of cosmic ray triggered by ATLAS RPC were made available to the other sub-detectors for their own commissioning studies.

REFERENCES

1. ATLAS Collaboration is made of about 2500 Physicists coming from 167 Institutions of the following countries: Argentina, Armenia, Australia, Austria, Azerbaijan, Belarus, Brazil, Canada, Chile, China, Colombia, Czech Republic, Denmark, France, Georgia, Germany, Greece, Israel, Italy, Japan, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan, Turkey, UK, USA, CERN, JINR.
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