Large - scale performance studies of the Resistive Plate Chamber fast tracker for the ATLAS first - level muon trigger

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Abstract

The Resistive Plate Chambers (RPCs) provide the first - level muon trigger and the measurement of the coordinate in the non - bending direction in the barrel region of the muon spectrometer of the ATLAS experiment. Calibrating such a system means fine - tuning thousands of parameters (involving both front - end electronics and gap voltages) as well as constantly monitoring performance and environmental quantities such as gap efficiency, average cluster size, temperature, gas flow, gap currents, counting rates. In this paper the RPC calibration effort will be presented. An overview of the performance measurements done using cosmic rays will be also given.

Key words:

ATLAS, RPC, calibration, performance

1. Introduction

In the ATLAS experiment, Resistive Plate Chambers provide the first - level muon trigger and bunch crossing identification over the large area of the barrel region, as well as being used as a very fast 3D tracker. To achieve these goals a system of about ~ 4000 gas gaps operating in avalanche mode was built (resulting in a total readout surface of about 16000 m^2 segmented into 350000 strips) and is now fully operational in the ATLAS cavern, where its functionality has been widely tested up to now using cosmic rays. Such a large scale system allows the study of the performance of RPCs (both from the point of view of gas gaps and readout electronics) with unprecedented sensitivity to rare effects, as well as providing the means to correlate (in a statistically significant way) characteristics at production sites with performance during operation.

2. Input Data

ATLAS data is organized in *streams*. One of these is called *Muon Calibration stream* and it permits a detailed and reliable measurement of the detector response up to the level of the individual strips, thanks to the high statistics available.

It contains the output of the Level 1 muon trigger, which occurs at a higher rate than the events selected by the full trigger chain. Each event contains only hits from the muon spectrometer, in the region where a muon trigger occurred.

Results shown here were obtained with the full stream, with granularity up to the panel level.

3. Results with cosmic rays

This results are to be intended as very preliminary, and not representative of the general status of the detector, referring actually to one particular run.

RPC efficiency, in figure 1, is estimated extrapolating muon tracks reconstructed from MDT ² hits and requiring the presence of an RPC hit within $\pm 70 \text{ mm}$. Figure 2 shows the differ-

Figure 1: Distribution of average efficiency for RPC BM panels (middle layer of RPCs) at working point (HV 9.6 kV, $V_{th} = 1.0 \text{ V}$).

ence of RPCs efficiency between different high voltage values. The efficiency plateau is already reached for 9.6 kV.

Finally, figure 3 shows the spatial resolutions as measured on η panels, for clusters of size 1 and 2. The residual distributions

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²MDT, Monitored Drift Tube chambers which are part of the ATLAS muon spectrometer which provide the precision measurement in bending plane of the magnetic field.

Figure 2: Distribution of efficiency gradients between different HV values. Each panel gives an entry in each one of the distributions. The red plot for example shows that panels do not change significantly their efficiency between 9.8 kV and 9.6 kV. Brown and green curves show instead the effect of the rise of the efficiency plateaus.

are fitted with a gaussian, and the resulting standard deviation is divided by the strip pitch, to allow comparison between different panels. As expected, clusters of size 2 give an improved spatial resolution.

Figure 3: Distribution of spatial resolution divided by the strip pitch (typically 30 mm) for clusters of size 1 (blue line) and size 2 (red line). Only η RPC panels of BM chambers are shown. As expected clusters of size 2 show a better resolution due to the fact that the particle has crossed a very narrow region near the border of two adjacent strips.

4. Panel classification

Given the large number (~ 8000) of RPC readout panels some automatic procedure is needed to spot potential problems. For example one can look at the efficiency vs. HV relation.

Figure 4 shows an example of a category of panels whose performance does not vary with HV. This kind of behavior has no possible explanation in terms of the physics of the detector, and was actually found to be due to a channel - mapping error, i.e. the HV value was not being changed at all on those gaps. These findings were fed back to electronics experts who have fixed the problems.

Other panels (figure 5) show a rising to plateau shifted towards higher HV values. This effect is under investigation.

Finally, most of the total tested panels behave as expected, like in figure 6.

5. Correlation with production database

The idea is to correlate the performances and status of RPCs as installed in the ATLAS cavern with the information recorded during the different production phases.

Figure 4: Panels not varying their performance when changing HV, mostly due to channel - mapping errors. 1.9% of total tested panels falls in this category.

Figure 5: Panels with the rising shifted towards higher HV values and/or low plateau values. This effect is under investigation. 2.3% of the total tested panels falls in this category.

Figure 6: Panels with normal behaviour. Most of the total tested panels falls in this category.

The high number of available panels and gas gaps gives a unique opportunity to perform detailed and statistically significant studies.

A variety of information was stored during production at different sites (Lecce, Naples and Roma “Tor Vergata”) so the merging of databases with different technologies is needed.

The work has already begun to gain access to all relevant databases and the next step will be to merge them into a unique data source for easy correlation with measurements done in the ATLAS cavern.

References

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