Large - scale performance studies of the Resistive Plate Chamber fast tracker for the ATLAS 1st - level muon trigger

Frontier Detectors for Frontier Physics

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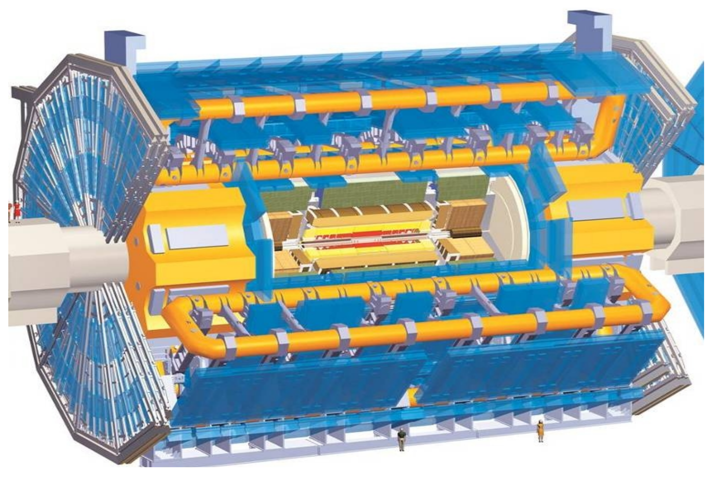
ATLAS Muon Spectrometer



Precision Track Reconstruction:

- 1150 Monitored Drift Tube Chambers (MDTs)
- 32 Cathode Strip Chambers (CSCs) in the region closest to the beam pipe

Trigger and 2nd coordinate measurement of trajectories:

- 605 Resistive Plate Chambers (RPC, Barrel region)
- 3588 Thin Gap Chambers (TGC, End Cap region)

Magnet System:

- Toroidal field geometry, 8 (Barrel), 2x8 (End Cap) superconducting coils, bending power up to 7.5 Tm

Input data / analysis strategy

• ATLAS data is divided into different *streams*. They can correspond, for example, to different trigger menus (calorimeter trigger, muon trigger, minimum bias trigger, etc). An *express stream* is also foreseen, including the most promising topologies for discovery channels, which will have the highest priority in the data processing. All these streams contain full events, and can be used, to some extent, to estimate the detector behavior by means of Data Quality applications.

• However, in order to achieve a detailed and reliable measurement of the detector response up to the level of the individual strips, a significant number of muon tracks must be analyzed, which is not achievable in a reasonable time with the normal data streams. A dedicated stream has been foreseen to answer to this necessities, called *muon calibration stream.* It contains the output of the Level 1 muon trigger (before any Level 2 selection), hence it comes at a much higher rate than the events selected by the full trigger chain. Each event contains *only hits from the muon spectrometer*, in a region where a muon trigger occurred

• The main advantage of the calibration stream is its high statistics. Its simplified event format, which contains only muon hits in only one part of the spectrometer, allows a relatively easy and fast reconstruction of the muon tracks. This is very useful, given the high number of events to be processed. On the other hand, the fact that it does not contain full events, means that it cannot be used in a straightforward way for a reliable measurement of the noise rate.

• From the point of view of the analysis algorithms, there are two main issues in our case: first, RPCs are actually providing the muon trigger and, second, RPCs are also used in reconstruction; in particular, in the barrel region, they are the only source of space measurements, in the non-bending direction. Both these effects tend to introduce a bias on efficiency measurements if not adequately treated

• As far as the reconstruction bias is concerned, one simply has to exclude from pattern recognition and track fitting one given layer, whose efficiency can thus be measured with no bias at all. On the other hand, removing the trigger bias is less trivial. Knowing the trigger configuration (in particular its majority) one can extract from the data an unbiased sample for a given layer. For example if the trigger is requiring a coincidence of at least 3 RPC layers out of the 4 in the inner station one can have an unbiased efficiency measurement for layer 1, by using only events where layers 2, 3 and 4 had a hit. This approach is particularly useful for monitoring during normal data taking, and has been already implemented in the analysis. One could also run with dedicated trigger configurations where a given layer is excluded from the trigger decision. This second possibility is a better choice in dedicated calibration runs, since higher statistics can be achieved

In order to ensure redundancy and robustness, a twofold strategy is used for RPC detector studies:

1) Exploiting the precision of the muon tracking detector:

- ☺Tracking and extrapolation to RPC layers takes into account materials and magnetic field
- ☺precise extrapolation allows to determine spatial resolution and to study small local effects
- ☹presently all RPC hits are used in reconstruction, hence a bias is introduced in efficiency measurement. This will be fixed in a more refined version of the analysis which is in preparation.

2) Using stand alone, RPC-only tracking:

- ☺Does not depend on precision detector at all
- ☺Dedicated tracking algorithm avoids reconstruction bias on efficiency (by not using hits of a given layer)
- ☹Interoperability with other reconstruction tools is missing
- ☹Magnetic field and material effects not implemented yet
- ☹Extrapolation precision limited by RPC granularity

• The baseline strategy is to exploit the possibilities given by both our analysis techniques and both the data sources:

- Data Quality applications, running on the full streams, measure all relevant quantities using standalone RPC tracking. This is done mainly at CERN's computing facilities.
- Different analysis jobs perform high statistics analysis on the calibration stream, using the full tracking capabilities of the muon spectrometer. A computing farm has been foreseen at Naples for this kind of studies, where calibration stream data is replicated

• Other possibilities are of course available (running DQ-like analysis at Naples on the calibration stream or running precise tracking on the full streams) and, even though they would not add any new information to what already obtained by the previous ones, they play an important role as fall-back solution in case any of the baseline measurement fail.

References

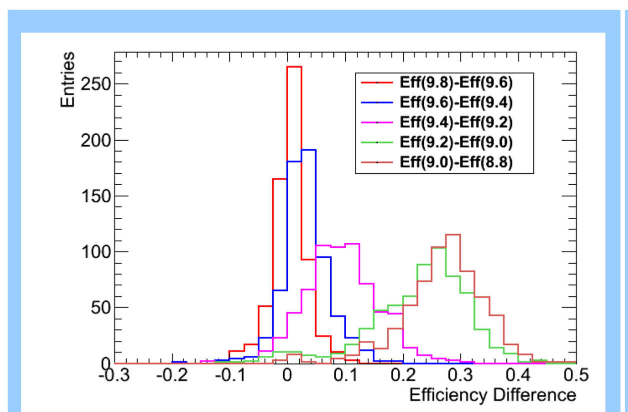
[1] *The ATLAS Experiment at the CERN Large Hadron Collider*, ATLAS collaboration, 2008 JINST 3 S08003

Results with Cosmics

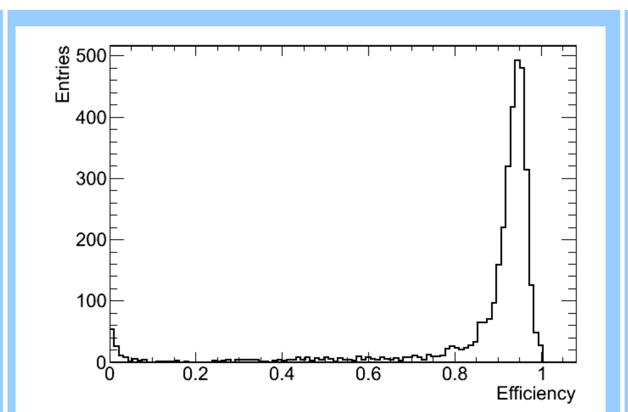
• Several dedicated calibration runs were taken in the last months in order to test the apparatus and to exercise the software tools for Data Quality/Calibration

• Results shown here were obtained with the full stream, with granularity up to the panel level. Tracks reconstructed from MDT hits are used in the analysis.

• Tests with muon calibration stream were performed on different runs (less relevant for the detector calibration), and the software chain was proved to be functional



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.

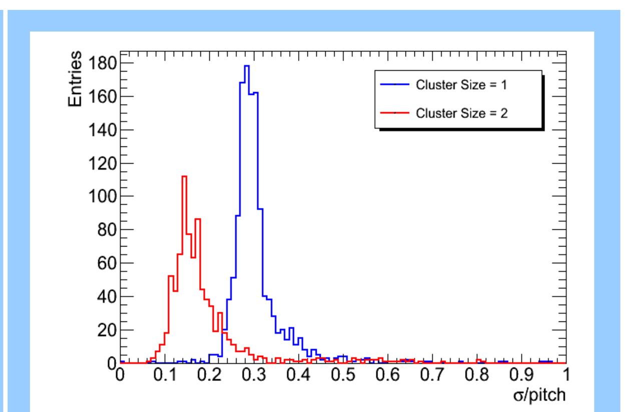


Panel efficiency for BM chambers at working point (HV 9.6 kV, V_{th} = 1.0 V). Low efficiency tail due to few panels temporary disconnected from HV/Gas

• 2547 panels have efficiency above 90%

• 583 panels have efficiency between 70% and 90%

• 478 panels have efficiency under 70%



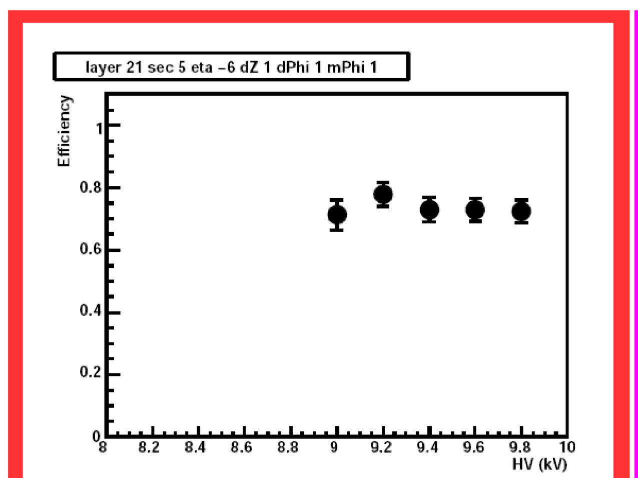
Spatial resolution for BM chambers obtained from a gaussian fit of the residual distribution normalized to strip pitch (pitch typically 30 mm), in the case of clusters of size 1 (blue line) and size 2 (red line). As expected cluster of size 2 show a better resolution due to the small region in which the particle crosses the detector.

Panel Classification

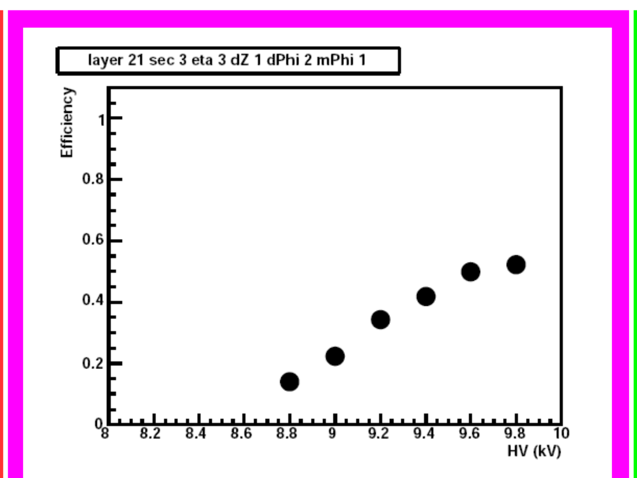
• Given the large number (~8000) of RPC readout panels some automatic procedure is needed to spot potential problems;

• For example one can look at the efficiency vs. HV relation;

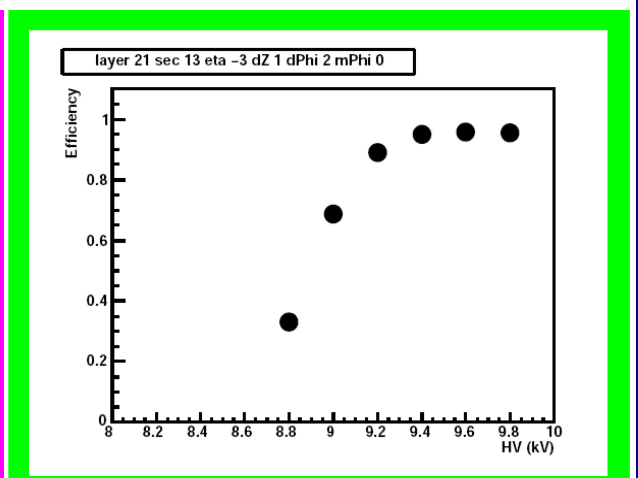
• The results of the analysis are summarized in the plots below, showing three example categories:



Panels not varying their performance when changing HV, mostly due to DCS mapping errors. ***1.9%*** of total tested panels falls in this category



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



Panels behaving as expected. Most of the total tested panels fall in this category

Correlation with Production DB

• 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

• High number of available panels and gas gaps, gives us a unique opportunity to perform detailed and statistically significant studies

• Several informations were stored during production at different sites (Lecce, Naples, Roma2)

- Needs the merging of databases with different technologies

• Work has already begun to gain access to all relevant databases

- Next step will be to merge them into a unique data source for easy correlation with calibration DB