ATLAS RPC performance in run I

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The off-line ATLAS RPC monitor developed at INFN Lecce [1] is used to measure the basic performance reached by the Resistive Plate Chamber detector in the ATLAS experiment for data recorded during all run I in LHC p-p collisions. The off-line monitoring and data quality assessment of such a large sub-system are crucial to maximize the physics reach of the experiment. This can be accomplished by a detailed knowledge of the detector performance during runs and ensuring a uniform detector behavior between runs in order to reduce systematic errors.

The ATLAS Resistive Plate Chambers (RPC's) are planar large size gaseous detectors working in saturated avalanche regime with resistive electrodes and two orthogonal pick-up readout strip panels located outside a 2 mm-thick active gas volume. In the ATLAS experiment three layers of RPC detectors are used in the barrel of ATLAS Muon Spectrometer ($|\eta| < 1.05$) to generate a hardware muon trigger signal.

The muon candidates are identified by fast geometrical coincidence pattern (trigger roads) in the two measurement views (η-ϕ). This allows to provide a Region of Interest $\Delta\eta \times \Delta\phi$=0.1×0.1 for the muon canditates, the highest among one of the six programmable transverse momentum thresholds, and the coarse measurement of the bending (η) and non-bending (ϕ) coordinates, useful to seed the next on-line trigger level, in addition to the bunch crossing identification number.

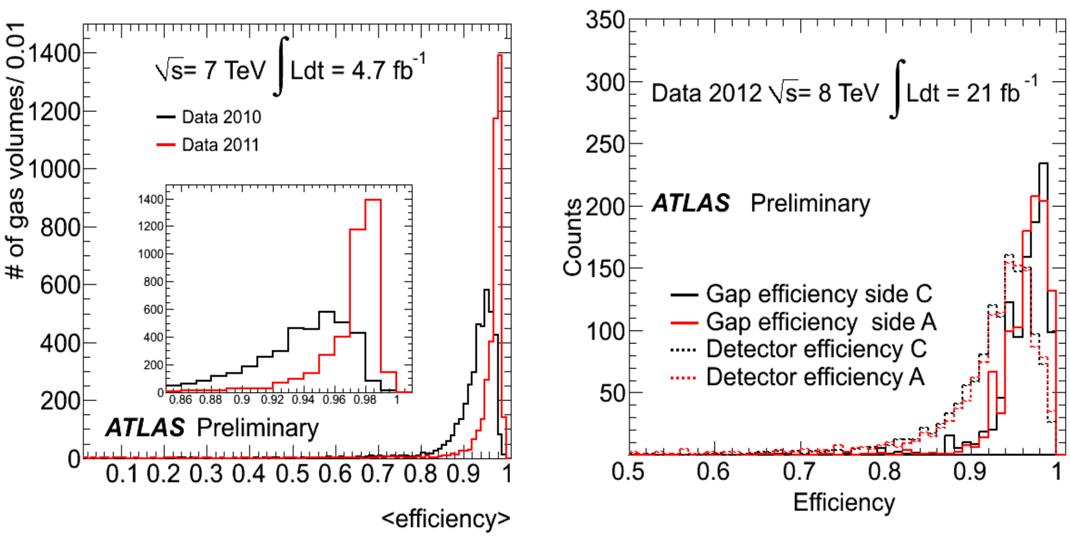

Figure 1. Distribution of the RPC gas volume efficiencies measured in 2010, 2011 (left) and 2012 (right) data taking periods. The gas volume efficiency are separated in side A and side C for the right plot.

Run 1 started in 2009 and ended in 2012. During data taking the ATLAS detector has operated in a wide spectrum of pile-up conditions with a maximum number of interactions per bunch crossing of about 40. The majors data taking periods were the 2011, with recorded luminosity of 5.2 fb^{-1} and an average number of interactions per bunch crossing of 9.1, and the 2012, with recorded luminosity of 21.7 fb^{-1} and an average number of interactions per bunch crossing of 20.7. The data taking conditions reached during the 2012 were close or beyond to the design pile-up conditions characterized by a mean number of interactions per bunch crossing of about 25. In this scenario the typically expected bunch crossing rate was of 40 MHz, which was reduced to 200 Hz by a trigger system made of three levels.

A RPC standalone tracking is implemented in off-line monitoring. The tracking is based on RPC space points, which are defined by orthogonal RPC cluster hits of the same gas volume. The pattern recognition is seeded by a straight line, which is defined by two RPC space points belonging, respectively, to low-pt and pivot planes of the same or nearby station. RPC space points not part of any previous tracks and inside a predefined distance from the straight line are associated to the pattern. Resulting patterns with points in at least 3 out of 4 layers in low-pt and pivot planes are retained and a linear interpolation is performed in two orthogonal views. Applying a quality cut of chi2/dof < 1 about 70 percent of events have at least a good tracks and 10 percent with more than one. In order to measure the detection efficiency the RPC tracking is repeated 6 times, each time removing the layer under test from the pattern recognition and track fitting. Figure 1 shows the average detector and gas volume efficiency at nominal high voltage and nominal front-end voltage threshold for three different years of data taking. The observed improvements of the average RPC efficiency from 2010 to 2011 is just due to some in situ repair and high voltage setting normalized to the local temperature and pressure.

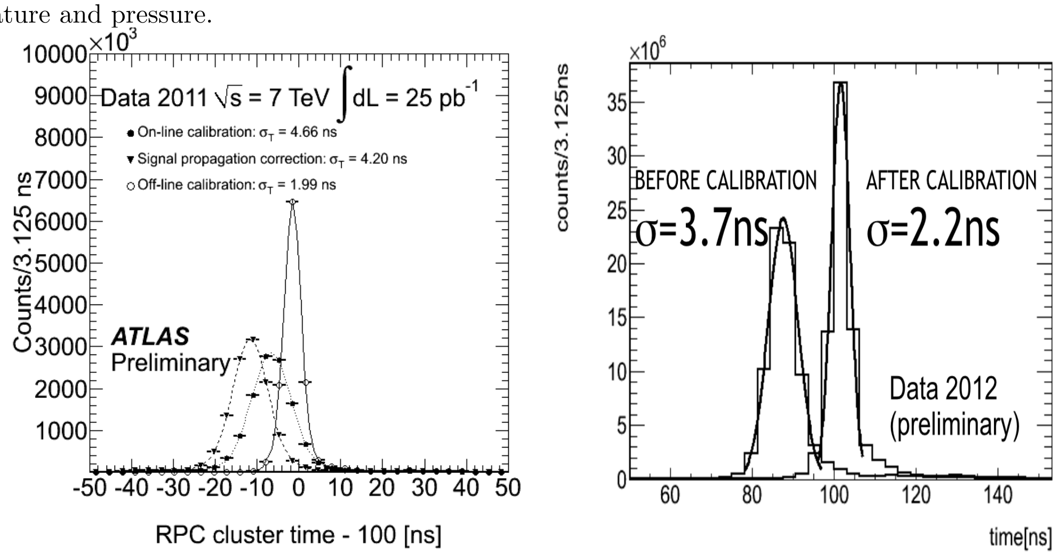

Figure 2. The plots show the distribution of RPC time in readout hits for both views before and after offline calibration in 2011 (left) and 2012 (right) data taking periods. The time of the hits is shifted of 100 ns in the left plot.

As off-line time calibration criteria we assumed that the arrival time of a relativistic track leaving the interaction point is on average equal to 100 ns. A simple calibration algorithm is employed strip by strip. The calibration constant per strip $\tau_{cal}$is defined as: $\tau_{cal} = t_c - MP[t_{raw} - t_{prop}]$, where MP is the most probable value of the distribution of the strip time t_{raw}, minus the signal delay t_{prop}; t_c is conventionally set to 100 ns , which corresponds to the readout window center. In order to have a clean sample of tracks for the calibrations only RPC hits matched with muon tracks are considered in the time distribution. The RPC time resolution achieved by simple off-line calibration algorithms is shown in Figure 2 for year 2011 and 2012 and turn out to be very near to the single unit resolution. This proves that RPC detector can easily operate in standalone mode thanks to its tracking and timing capability.

We can conclude that no significant change of RPC efficiency and time resolution is observed in the extreme design conditions.

REFERENCES

1. "Off-line time calibration of the ATLAS RPC system" Chiodini G, Spagnolo S, On behalf of the ATLAS Collaboration. JJINST 8 (2013) T02004.