ATLAS RPC QA results at INFN Lecce

M. Bianco*,†, I. Borjanovic*, G. Cataldi†, A. Cazzato*,†, G. Chiodini†, M.R. Coluccia*,†, P. Creti†, E. Gorini*,†, F. Grancagnolo†, R. Perrino†, M. Primavera†, S. Spagnolo*,†, G. Tassielli,*,† and A. Ventura†

*Dipartimento di Fisica - via Arnesano 73100, Lecce - Italy
†*INFN - via Arnesano 73100, Lecce - Italy*

Abstract. The main results of the quality assurance tests performed on the Resistive Plate Chamber used by the ATLAS experiment at LHC as muon trigger chambers are reported and discussed. These are dark current, gas volume tomography, gas tightness, efficiency, and noise rate.

Keywords: ATLAS, RPC, Quality Assurance, Cosmic ray test.
PACS: PACS numbers: 29.40.Cs.

INTRODUCTION

Resistive Plate Chamber RPC [1] will be used as the muon trigger detector, in the barrel region of the ATLAS experiment at LHC [2]. A total number of 1116 RPC modules will be installed, for a total surface area of about 3800 m^2. The extreme difficulty in accessing the ATLAS detectors, after installation is complete, imposes a high standard quality assurance for these modules. For this purpose three cosmic ray teststands have been built at INFN Napoli[3], Lecce [4], and Roma 2. Here, we report on the results from the Lecce site.

ATLAS RPC MODULES

In the ATLAS muon spectrometer a large variety of sizes and shapes of stations and, hence, RPC counters is foreseen. All counters, however, share the standard internal structure, described here in the following.

A unit consists of a doublet of RPC detector layers enclosed in rigid lateral profiles and two support panels. A thin honeycomb-paper panel with aluminum skin separates the two layers realizing two independent Faraday cages. In figure [1] a cartoon of a RPC layer and a read-out panel are shown. A RPC layer contains a 2 mm thick active gas layer inside a planar bakelite gas volume ($\approx 10^{10}\Omega cm$) externally painted with graphite. The gas volume is surrounded by two pick-up strip panels segmented in two orthogonal views and separated by insulating plastic foils. The gas volume high voltage electrode is connected directly to the power supply, but the other one is connected to ground by a shunt resistor, in such a way that the dark current can be monitored.

The RPC dimension can be as large as 4.8 m in one direction and 1.1 m in the other. Depending on the module size, a bakelite gas layer can consist of a single gas volume or of two adjacent gas volumes, and, most of the times, a read-out strip plane consists of

CP815, *XXV Physics in Collision*,
edited by V. Šimák, R. Leitner, J. Valenta, and A. Valkárová

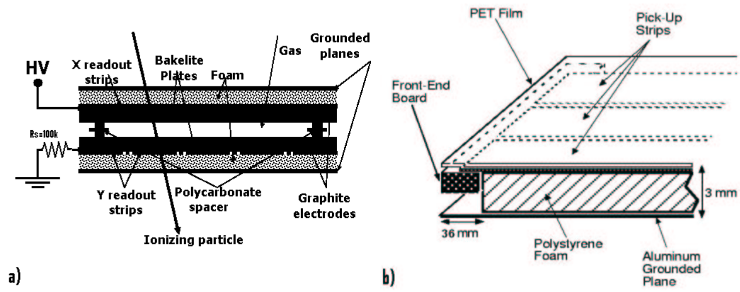

FIGURE 1. Drawing of ATLAS RPC layer (a) and read-out strip panel (b).

two adjacent strip panels, instead of one. This results in modules which have 2 or 4 gas volumes and 4 or 8 read-out strip panels.

QUALITY ASSURANCE PROCEDURE

The quality control of the RPC chamber is accomplished with a series of accurate measurements and tests intended to verify the correctness of the assembly and detector performance. They represent the very first full chamber characterization and allow to extract statistical information useful to monitor the assembly line and give useful feedback for improvements.

The quality control procedure consists of main certification tests and subsidiary control tests. The main tests regard leakage current versus high voltage curves, chamber efficiency and noise versus high voltage and front-end voltage threshold, and, finally, chamber 2D tomography. Instead, subsidiary control tests regard pulse test, gas volume leak test, front-end current absorption, and gas volume leakage current temporal drift.

QUALITY ASSURANCE RESULTS

Gas volume tests

The radiation reliance and aging properties of the ATLAS RPC has been proven and carefully investigated at X5 gamma irradiation facility at CERN [5]. Nevertheless, the quality control of the gas volumes is crucial. The dark current versus high voltage curve is measured during the chamber conditioning and at the end of the tests. Gas volumes showing a dark current with a large ohmic or exponential part are rejected. In addition the dark current of each gas volume is monitored continuously to look for anomalous drift or current glitches (maybe due to local discharge or defective high voltage connectors). In figure [2] on the left the gas volume dark current distribution of ATLAS RPC tested in Lecce is shown at nominal conditions. On the same figure, on the right, is plotted the distribution of the difference between the high voltage power supply current and the gas volume current. From this plot is possible to infer a high level of electrical insulation

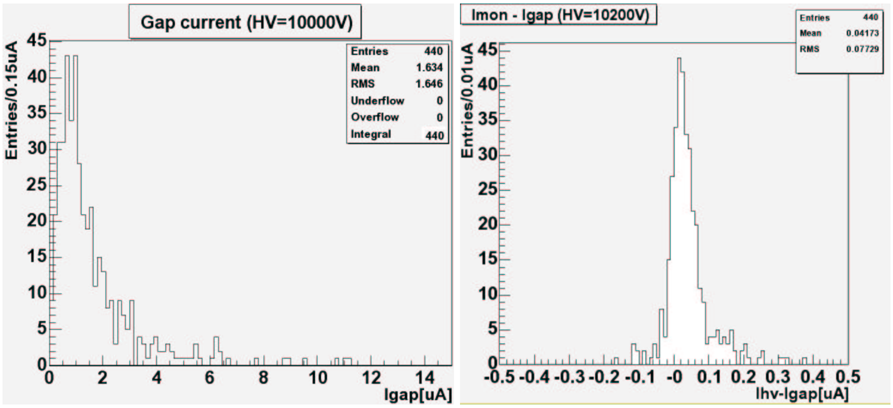

FIGURE 2. Gas volume dark current distribution (on the left) and power supply current and dark current difference distribution (on the right). The data are taken from the ATLAS RPC tested in Lecce with a high voltage of 10kV.

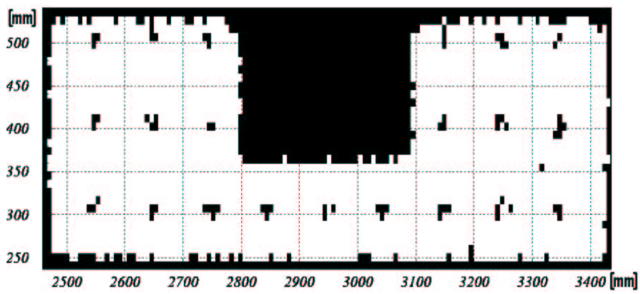

FIGURE 3. Example of tomography plot of a small size gas volume with cut-out. The dark regular spot array are due to the spacers dead area.

between gas volumes and other parts, such as mechanical supports and read-out strip panels ($> 100G\Omega$) .

The 2D efficiency of each gas volume is measured with high accuracy and this is the most time consuming test which takes about 24 hours of running. The muon cosmic ray tomography is a very powerful tool to discover gas volume assembly defects (due for example to glue spots, badly glued spacers, and inner surface contaminations) which can compromise the aging performance of the unit. A noise rate 2D map is also taken, in order to exclude the presence of hot spots, which can become degenerative in the long term period. A gas volume tomography of a special unit is reported in figure [3]. This particular gas volume has a cut-out in order to leave room for the barrel toroid feet. Other special counters have gas volumes with cut-out for the alignment laser rays of the MDT precision muon chambers. Figure [3] shows that the high quality of the gas volumes is also achieved when shapes more complicated than the rectangular one are realized.

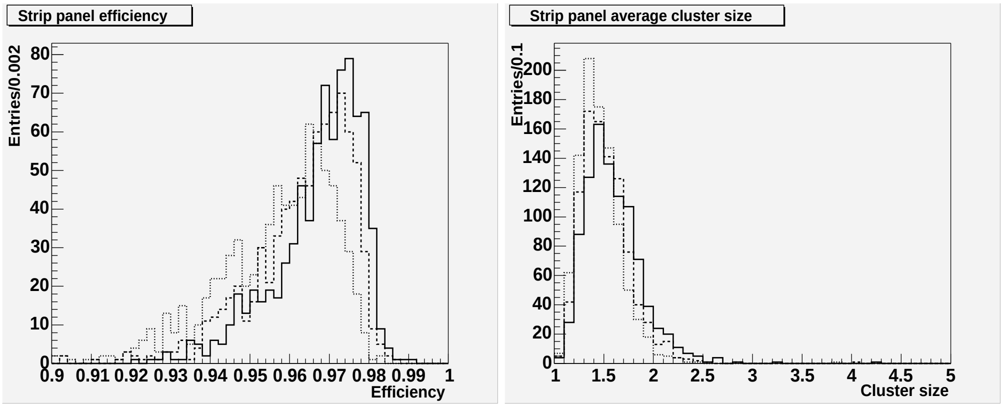

FIGURE 4. Total efficiency distribution (on the left) and average cluster size distribution (on the right) for different high voltage values of 10kV (...), 10.1kV (.-.), and (-) 10.2 kV. The data are taken from the ATLAS RPC tested in Lecce with an equivalent input voltage threshold of about 0.5 mV.

Gas tightness test, which is performed independently for each layer, consists in monitoring the differential pressure for about 2 hours, after imposing about 3 mbar of overpressure and closing the gas inlet and outlet. With our instrumental sensitivity of about 10^{-1} mbar we can reject modules with a gas leak larger than about $10^{-4} mbar \frac{l}{s}$.

Read-out strip panel tests

The read-out strip panel efficiency (given by the convolution of gas volume efficiency and strip panel electronic efficiency) is measured as a function of the applied high voltage and front-end voltage threshold. This allows to establish the detector working point and the parameter range where the chamber performs well. In figure [4] the distribution of the read-out strip panel efficiency (dead channels included) and the average cluster sizes (number of adjacent firing strips) are shown. The RPC counters have in average an efficiency greater than 97%, as expected by the detector active area coverage and required by the trigger design.

The read-out strip panel noise rate is also measured at different high voltage and voltage threshold. In figure [5] the corresponding distribution is shown on the left. The average noise rate is less than 1 $\frac{Hz}{cm^2}$, which is an order of magnitude smaller than the expected counting rate due to the photon and neutron background in the ATLAS experiment at the designed LHC luminosity. In the same figure on the right, we reported the distribution of the ratio between the gas volume dark current (with the ohmic component subtracted) and the total strip panel noise rate. By assuming that the exponential part of the dark current is due to noise counts, we can estimate an average saturated avalanche charge of about 15 pC.

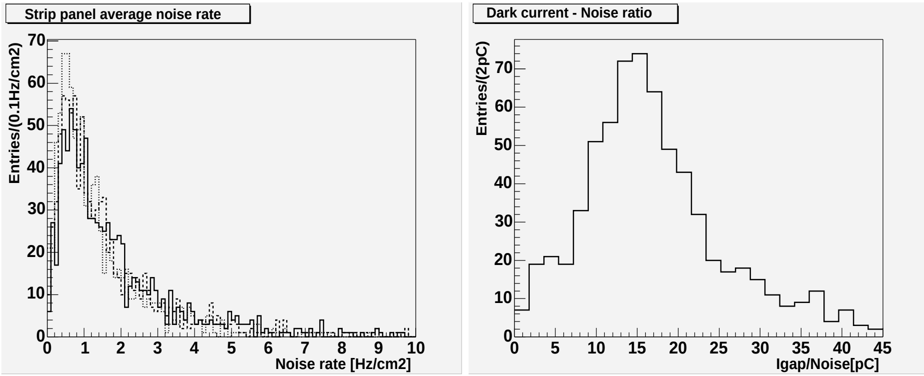

FIGURE 5. Noise rate distribution (on the left) for different high voltage values of 10kV (...), 10.1kV (.-.), and (-) 10.2 kV. Current-to-Noise ratio distribution at a high voltage value of 10kV (on the right). The data are taken from the ATLAS RPC tested in Lecce with an equivalent input voltage threshold of about 0.5 mV.

TABLE 1. RPC modules failure rate observed during QA tests in Lecce.

Component failure	Number of modules out of 272	Fraction of modules
Readout strip panel	37	14%
Gas volume spot	9	3.5%
Gas volume high dark current	7	2.6%
Gas leak	9	3.5%
HV connector	2	0.9%
Gas volume shunt resistor	3	1.3%

Production components yield

Table [1] reports the number of counters which failed the quality assurance test and the defective component responsible for the rejection. A rejection rate of about 6% is due to the gas volumes, which are discarded, 14% to the read-out panels, which are repaired, and, finally, 6% to assembly errors. Taking into account the number of components inside a module (we tested about 2000 strip panels and 1000 gas volumes), we have a yield of 98.5% for gas volume and 98.3% for the strip panel (without considering the factory single component pre-selection).

CONCLUSIONS

The cosmic rays teststand for the ATLAS RPCs in Lecce is routinely in operation since July 2004, and up to now, july 2005, it has certified about 270 RPC modules, corresponding to about 25% of the ATLAS Muon Spectrometer. The test results and their statistical distributions show that the RPC properties are stable and uniform, satisfying the ATLAS experiment requirements. The end of the Quality Assurance Tests is foreseen for the end of October 2005.

ACKNOWLEDGMENTS

We thank R. Assiro, E.M. Fasanelli, G. Fiore, R. Gerardi, A. Miccoli, S. Podladkin and F. Ricciardi for the generous technical assistance they provide us in the construction and operational phase of the cosmic ray test-stand.

REFERENCES

1. R. Santonico and R. Cardarelli, Nucl. Instrum. and Meth. **187**, 377 (1981).
2. ATLAS detector and physics performance. Technical Design Report (May 1999).
3. M. Alviggi *et al*, Nucl. Instrum. and Meth. **A518**, 79 (2004).
4. G. Cataldi *et al.*, *ATLAS RPC Cosmic ray Teststand at INFN Lecce* - proceedings of XXIV Physics in Collision - Boston, June 27-29, 2004. arXiv:physics/0409075.
5. G. Aielli *et al.*, Nucl. Instrum. and Meth. A **533**, 98 (2004).