Production and test of the LHCb Muon Wire Chambers

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**Abstract.** The LHCb Muon Detector is composed of five tracking stations. The performance demanded for the Level-0 trigger of LHCb imposes very stringent requirements on the quality of the muon chambers. This paper describes the tests that chambers must overcome before being mounted in the experimental setup. Up to June 2005, about 500 chambers have been built and the end of the whole production phase is foreseen in April 2007.

1 Introduction

The LHCb experiment is dedicated to study the decays of beauty hadrons. The Level-0 trigger of the experiment calls for fast measurement of the muon transverse momentum and a high capability of bunch-crossing identification. The muon detector must therefore have a high detection efficiency and a good spatial and time resolution. The LHCb muon detector \cite{1} \cite{2} is composed of five tracking stations (M1–M5) which comprise 1388 MultiWire Proportional Chambers (MWPC) now under construction in different sites: CERN (CH), INFN-LNF-Frascati (ITA), Ferrara (ITA), Firenze (ITA) and PNPI-San Petersburg (RU).

The gas gap is filled with an Ar/CO\textsubscript{2}/CF\textsubscript{4} (40/55/5) gas mixture. The anode plane is composed of 30-μm diameter gold-plated tungsten wires with a pitch of 2 mm. While chambers in station M1 will be composed of two single gaps the ones of stations M2–M5 are composed of two double gaps in which the corresponding pads are ganged in pairs. The front-end electronics performs a further logical OR between the two signals of the single (double) gaps.

In order to meet the performance required for triggering and for physics analysis, each single (double) gap must satisfy the following conditions:

1. double-gap efficiency ≥ 95%, within a 20 ns time window;
2. low cross-talk between pads giving an average pad-cluster size ≤ 1.1;
3. good ageing properties, allowing 10 years of operation at an average luminosity of 2 × 10\textsuperscript{32} cm\textsuperscript{-2} s\textsuperscript{-1} with a chamber gain of about 10\textsuperscript{5}.

Several prototypes were tested at CERN on a minimum ionizing particle beam \cite{3}. The results obtained (see Fig. 1) allowed to define a 170 V wide HV working region (WR) of the chambers. Since the gas gain (G) doubles for a HV increase of about 110 V, the HV working region corresponds to a gain interval:

\[ \frac{1}{1.7} \leq G/G_0 \leq 1.7 \]

where \( G_0 \) is the nominal gas gain at the centre of the WR.

This requirement on the chamber gain fixes the mechanical precision to be achieved during production, particularly regarding the position and the tension of the wire and the size of the gap. These constraints were evaluated by a numerical simulation \cite{4} of the operation of a chamber. In order to check that the produced chambers fulfill these constraints a series of quality tests was organized.

2 Quality tests

Five tests have been developed to monitor the chambers quality during their production. The following subsections describe these tests and their results.
2.5 Cosmic ray test

The last test on the chambers is performed using cosmic rays. Up to six chambers, fully equipped with the CARIOCA read-out electronics [7] can be tested simultaneously. In Fig. 4 the time resolution of 3 different types of chambers as a function of the high voltage applied is shown. No significant differences have been found and all type of chambers reach time resolution of about 4 ns at a high voltage value of about 2600 V.

3 Production status

Up to June 2005 production sites have produced about 500 chambers. In Fig. 5 the number of chambers produced in each site and the total are shown and compared with the scheduled values. The current production rate is equal to the expected one. The end of the production phase is foreseen in April 2007.

4 Conclusion

A series of tests was organised to permit online control of the muon chambers produced. The measurements of the pitch and mechanical tension of the wires enabled us to check the quality of the wire winding with the necessary accuracy, before assembling the chamber. Possible gas leakage can be measured with the required sensitivity. The study of the gas gain uniformity inside each gap gives a rapid indication of the quality of the chamber, enabling improvements to be made to the assembly procedure, where necessary. The test with cosmic rays makes it possible to study the time performance of the chambers. About 500 MWPC have already been produced and all of them satisfy the requirements on detection performance.

References

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References