Final test of the MRPC production for the ALICE TOF detector

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Abstract

During the autumn of 2006 a final test of a sample of double-stack MRPC (Multigap Resistive Plate Chamber) strips, randomly chosen from two years of mass production (the ALICE Time-Of-Flight detector is made of 1638 strips), was carried out at the CERN Proton Synchrotron facility. The results on the performances of the MRPCs and of the front-end and readout electronics will be presented. It is confirmed that these devices have a very good uniformity of response, a long streamer-free plateau, an efficiency higher than 99% and an '"intrinsic" time resolution better than about 40 ps.

Key words: TOF; MRPC; mass production; efficiency; time resolution; uniformity.
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1. Introduction

The ALICE experiment [1] at LHC is optimized for the study of the heavy-ion collisions at a centre-of-mass energy of 5.5 TeV/nucleon pair. The prime aim of the experiment is to investigate the behaviour of nuclear matter at extreme densities and temperatures, focusing the attention on the QCD phase transition of nuclear matter into a deconfined state of quarks and gluons: the Quark Gluon Plasma (QGP).

In this scenario particle identification (PID) is a key element to study the QGP. The PID power of a very large Time-Of-Flight (TOF) system covering the central rapidity region ($|\eta| < 0.9$) is of crucial importance in the ALICE experiment. The TOF system provides charged particle identification with momentum up to 2.5 GeV/c for π/K and up to 4 GeV/c for K/p. The event-by-event hadron identification allows to measure with high statistics the shape of p_t distributions and the π/K/p ratios which can be used to probe the nature and dynamical evolution of the system produced in ultra relativistic heavy-ion collisions at LHC.

The TOF system [2] covers a cylindrical surface of polar acceptance $|\theta - 90°| < 45°$ and full coverage in the azimuthal angle ϕ. The inner radius of the TOF from the interaction point is 3.70 m.

The whole system is divided into 18 SuperModules (SM) (see fig.1) along ϕ and each SM is composed of 5 Modules along θ of three different types (2 outer, 2 intermediate and 1 central). At both ends special crates contain the readout electronics (HPTDCs and controllers) as well as the slow control modules.

In order to keep the detector occupancy below the 15% level with a few 10^3 primary charged particles produced per unit of rapidity the ALICE TOF surface (about 150 m^2) is segmented into 1638 double-stack Multigap Resistive Plate Chamber (MRPC) strips [3] (each of 120×7.4 cm^2 ac-

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Fig. 1. Photo of one SuperModule.

tive area) for a total of 157248 readout channels of $3.7 \times 2.5\ cm^2$.

The MRPCs (see fig.2) are placed orthogonally with respect to the beam direction and tilted in such a way as to be perpendicular to the particle trajectory from the interaction point. To minimize the dead area, adjacent MRPCs inside the modules are overlapped by about 2 mm.

2. MRPC mass production

During the last two years the MRPC mass production was carried on at the INFN TOF laboratory in Bologna (fig.3).

To simplify, automate and speed up the MRPC assembly, a series of tools and procedures were developed, as for example:

– a washing/drying system (fig.4) consisting of an ultrasound tank (A), two rinsing water tanks (B and C), a oven (D) and a water filtering system (E) to clean at the same time about 100 internal glass plates (E in fig. 2),
– two fishing-line machines (see fig. 3) used to run the spacer across the surface of the glass plates around the nylon pins (C in the fig.2); in this way it takes only a few minutes to place each fishing-line layer;

Moreover all the components of each MRPC were checked and selected before the assembly of the single de-

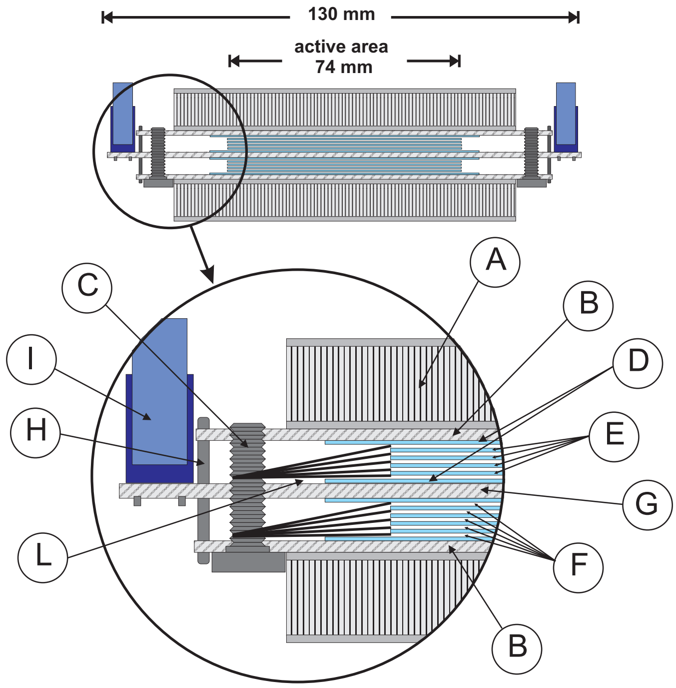

Fig. 2. Cross-section of the double-stack MRPC of the ALICE TOF system: A: 10 mm thick honeycomb panel used to guarantee a good mechanical rigidity; B: Printed Circuit Board - PCB (0.8 mm thick) with the cathode pickup pads; C: nylon pin to hold the fishing-line spacer; D: 0.55 μm thick external glass plates (with an acrylic paint loaded whit metal oxide) used to apply the voltage; E: four 400 μm thick internal glass plates; F: five gas gaps of 250 μm; G: central PCB (1.6 mm thick) with the anode pickup pads; H: 384 metallic pins used to bring cathode signals to central PCB and also to hold the stacks together; I: 32 connectors for differential signals sent from the MRPC to the front-end electronics; L: fishing-line spacers.

Fig. 3. Photo of the INFN TOF laboratory in Bologna.

tector to guarantee the uniformity of the production. In fact a set of quality assurance tests was developed for this purpose (for more detailes see [4]). In particular, before the MRPC assembly the following tests were done:

– the measurement of the red-glass resistivity in 5 different points;

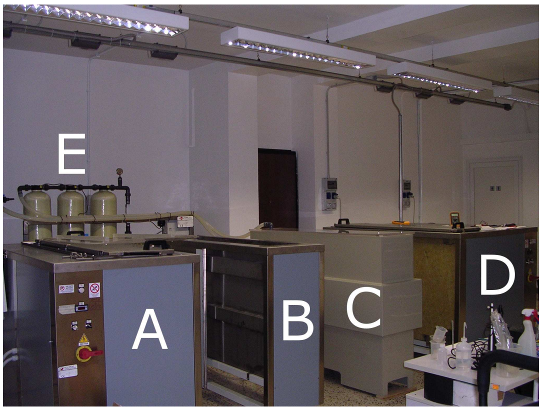

Fig. 4. Photo of the washing/drying system. A: ultrasound tank; B and C: two cold water tanks; D: owen and E: water filtering system.

– the check of the honeycomb plates (A in fig.2) and PCB (B and G in fig.2) planarity.
After the MRPC assembly:
– the measurement of the global resistance of the resistive glass plates;
– the measurement of the gas-gap size (F in fig.2) in 5 different positions by using a microscope and a high-resolution analog CCD device;
– the high voltage test in air up to $\pm 3\ kV$;
– the signal-connector (I in fig.2) soldering test (there are 1664 solderings/MRPC) and the anode-cathode connections (the soldering of the pins, H in fig.2).
– the high voltage test in gas;
– the measurement of the efficiency and time resolution with a cosmic ray telescope on a sample of about 3%.

Thanks to these procedures and tests the total rejection of the MRPC production was less than 2%.

3. Experimental Results

A test of a representative sample of the two-year mass production was carried out during November 2006: 10 MRPCs were randomly chosen from the 1638 produced ones and tested at CERN.

This test was performed using the complete and final electronics: the Front-End Electronic (FEE) cards with the NINO-ASIC chips [5] and the readout boards which host the HPTDC ASIC chips [6].

The measurements were collected at the PS-T10 beam line of the CERN Proton Synchrotron. The experimental setup consisted of:
– two fast scintillator bars ($2 \times 2 \times 10\ cm^3$), each equipped with two photomultipliers to provide an accurate time resolution,
– two pairs of crossed scintillators, whose coincidence defines a 1 cm^2 area to provide the trigger,
– the device under test, an aluminium box containing 5 MRPCs.

To allow the positioning of the beam on different readout pads, a mechanical frame was used to move (by remote

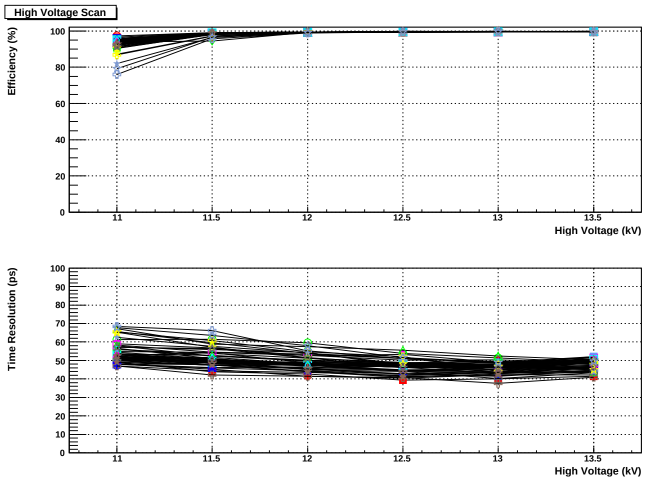

Fig. 5. Efficiency (top) and time resolution (bottom) as a function of the applied voltage for 55 readout pads randomly distributed on 10 MRPCs.

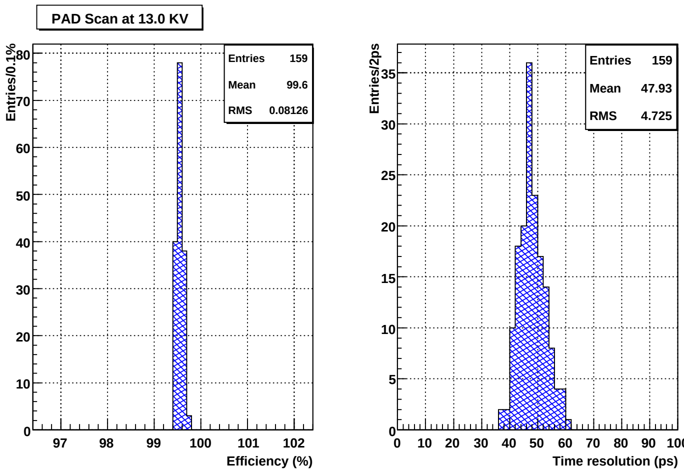

Fig. 6. Efficiency (left) and time resolution (right) distributions for 159 readout pads at a fixed applied voltage of 13.0 kV.

control) the aluminium box with relative millimetric accuracy.

Moreover the MRPC standard gas mixture (90% $C_2F_4H_2$, 5% SF_6, 5% C_4H_{10}) was used.

The uniformity of response of the chambers was studied first by centering the beam on many different readout pads, randomly distributed along each MRPC. The efficiency and time resolution as a function of the applied voltage for 55 channels belonging to the 10 MRPCs are shown in Fig. 5.

In the HV range between 12.0 and 13.5 kV, the mean efficiency is higher than 99% and the mean time resolution is 50 ps. This means a very good uniformity and a long streamer–free plateau.

The contribution of the full electronic chain to the overall time resolution was measured to be about 38 ps.

Then a scan over 159 readout pads was performed by fixing the high voltage value to 13.0 kV. The results are plotted in Fig. 6 where the efficiency (left) and the time reso-

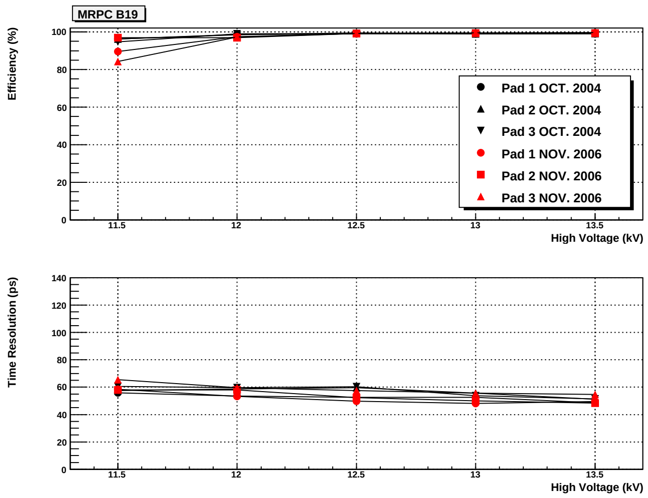

Fig. 7. Efficiency (top) and time resolution (bottom) vs applied voltage of the MRPC B19 which was used as reference in the cosmic-ray test facility in Bologna.

lution (right) are presented. It should be noticed that the mean efficiency is 99.6% and the time resolution is about 48 ps. The RMS of the time resolution distribution (4.7 ps) gives an estimate of the uniformity of the devices.

This final result on the TOF time resolution will allow to extend (see [1] Volume II) the momentum range for particle identification, for example the π/K separation will be possible up to about 3 GeV/c with a contamination smaller than 20%.

To conclude, the strip B19, produced and tested at PS in 2004 [3], was tested again in 2006. This MRPC was used as reference in the cosmic ray telescope in Bologna continuously running since 2 years. As it can be seen in fig. 7 the detector's response was not affected by a so long "ageing" process.

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