Temperature and relativity humidity test on small MicroMegas bulk prototype

E. Gorini[1 2] , L. Longo[1 2], M.Primavera[2], A. Ventura[12]

[1]Dipartimento di Matematica e Fisica ”Ennio De Giorgi”, Università del Salento, Italy

[2]Istituto Nazionale di Fisica Nucleare, sezione di Lecce, Italy

1. Introduction

The Large Hadron Collider (LHC) will be upgraded in several phases. After the second long shutdown (LS2) in 2018, the accelerator luminosity will be increased to $\sim 2 \times 10^{34} cm^{-2}s^{-1}$, allowing ATLAS to collect approximately $100 fb^{-1}/year$. A subsequent upgrade step is planned and will result in the luminosity increasing to $5 \times 10^{34} cm^{-2}s^{-1}$. The integrated luminosity with this ultimate upgrade will be $3000 fb^{-1}$ after about 10 years of operation.

In order to take advantage of the improved LHC operation the ATLAS detector must be upgraded to have better performance at higher luminosity. The Phase-I upgrade of the ATLAS muon spectrometer focuses on the end-cap region to let the trigger work to the desired efficiency. ATLAS proposes to replace the present muon Endcap Small Wheels with the New Small Wheels (NSW). The NSW is a set of precision tracking and trigger detectors able to work at high rates with excellent real-time spatial and time resolution. These detectors can provide the muon Level-1 trigger system with online track segments of good angular resolution to confirm that muon tracks originate from the IP. The NSW consists of 16 detector planes in two multilayers. Each multilayer comprises four small-strip Thin Gap Chambers (sTGC) and four MicroMegas (MM) detector planes.

In order to achieve good performances for the MM detectors, the MicroMegas community has decided to carry out different tests about the detector ageing and the performance under stress-conditions. In the next sections the results obtained on 2 small MicroMegas prototype increasing the gas relative humidity (RH) and the temperature will be discussed.

2. MicroMegas technology

The MicroMegas technology, abbreviation of *Micro Mesh gaseous detector*, was developed in the middle of 1990s[1]. It consist of a planar (drift) electrode, a gas gap of a few millimetres thickness acting as conversion and a micro mesh region, where a thin metallic mesh, called *micro mesh*, at typically 100-150 μm distance from the readout electrode creates the amplification and separate the two regions. A sketch of the MM layout and the operating principle are shown respectively in Fig. 1 and in Fig. 2. The weak

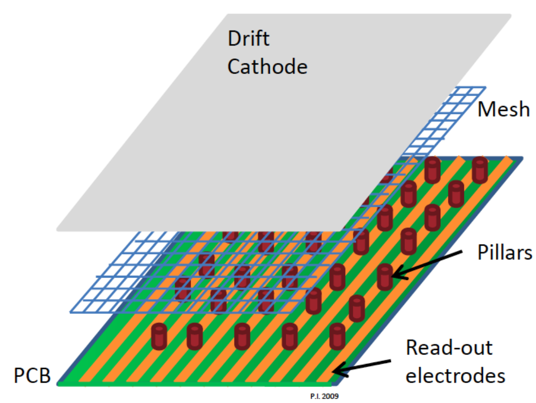

Figure 1. MicroMegas chamber layout.

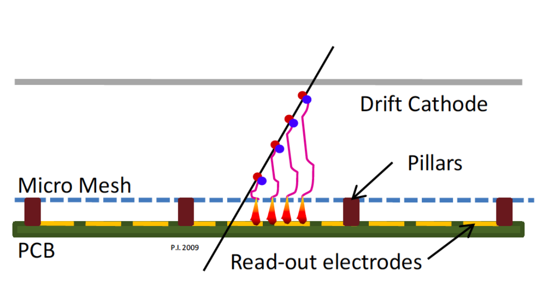

Figure 2. Schema of MM operating principle. The electrons produced into the drift area drift to the amplification region where the avalanche will be produced.

point of this kind of detectors is their vulnerability to sparking[1]. In order to avoid this effect, for the MM to be installed on the New Small Wheel a spark protection system has developed. By adding a layer of resistive strips on top of a thin insulator directly above the readout electrode the chambers become spark-insensitive. The readout electrode is no longer directly exposed to the charge created in the amplification region, instead the signals are capacitively coupled to it; some fraction of the signal height is lost but the detector can operated at higher gas gain and thus have spark intensities reduced by about three orders of magnitude.

For the temperature and relative humidity test that will be shown in the next session, the so called *bulk MicroMegas* have been considered. For these chambers the micro mesh is fixed to the pillars and the amplification region gap is equal to 128 μm (Fig.3). As suggested by the ATLAS MicroMegas community the Ar:CO_2 (93:7) has been used. Furthermore for all the analyses the *TChambers*[2] T1,T2 and T5 have been used. The resistivity of these chambers varies from 20 to 30 $M\Omega$/cm for T5 and between 5 and 10 $M\Omega$/ cm for T1 and T2. Moreover T5 has been aged at GIF++ collecting a total charge of 30 mC/cm.

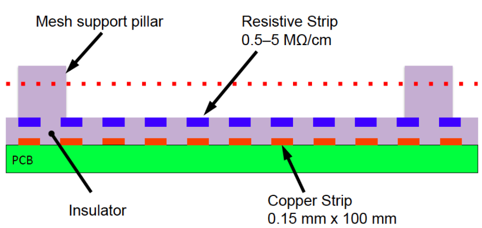

Figure 3. Sketch of the layout of a bulk MM detector.

[1]In the MicroMegas detector sparks occur when the total number of electrons in the avalanche reaches a few 10^7 (Raether limit [2]).

[2]The T type bulk resistive MM have 10 cm x 10 cm active area, readout strips 300 μm wide with 400 μm pitch. The resistive strips follow the readout strips geometry with a resistivity up to 30 MΩ/cm. The woven stainless steel mesh structure has a wire diameter of 18 μm and is segmented in 400 lines/inch corresponding to a mesh pitch of 63.5μm. The drift electrode had also a mesh structure with a density of 325 lines/inch (wires of 30 μm diameter with a pitch of 80 μm) [3].

3. Temperature and Relative humidity test

For the RH test the chambers T1 and T2 have been utilised while T1 and T5 have been used for the temperature one. For the first case, to be sure that all the effect could be related to relative humidity variation, T2 has been flushed with a dry gas while T1 has gotten a wet gas in input. Instead, for the temperature test, T1 and T5 have

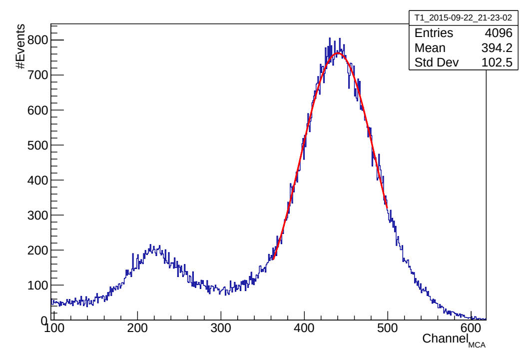

Figure 4. ^{55}Fe spectrum in MultiChannel Analyser unit obtained from a gas mixture of Ar:CO_2 (93:7). For each measure the main peak has been fitted by a gaussian and the gaussian mean has been assumed as peak position.

been warmed to understand if the different resistivity and the aging could affect their behaviour. For both the measurements an ^{55}Fe source has been used and its spectrum has been measured while the T and RH have been varied; since the peak position is proportional to the gain, it is possible to have a measure of the amplification as function of the two ambient variables considered (Fig. 4).

A dependence of the gain has function of T and RH has been seen. For example it has been possible to observe for T1 chamber (Fig. 5) how the gain increases coherently with the humidity and how the effect is more evident when the readout voltage is raised; in contrast no change has been observed for T2 (Fig. 6).

Instead Fig. 7 shows how T5 gain increases also with temperature while the resolution continues to be stable for all the temperature range investigated (Fig. 8). The same effect has been also observed for T1 chamber.

An other interesting aspect has been observed during the temperature test; at high temperature both T1 and T5 have started to spark (Fig. 9); the effect is not yet understood but the idea is that it

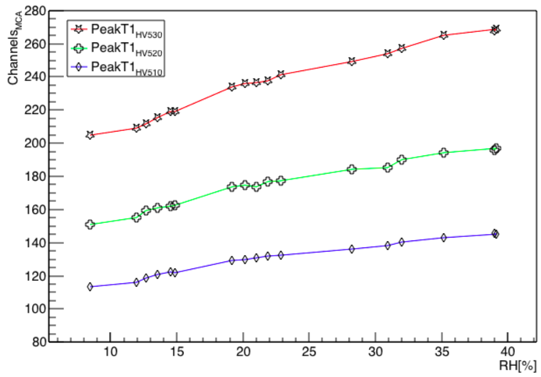

Figure 5. Behaviour of the peak position as function of the T1 gas relative humidity for different read-out voltages applied to T1.

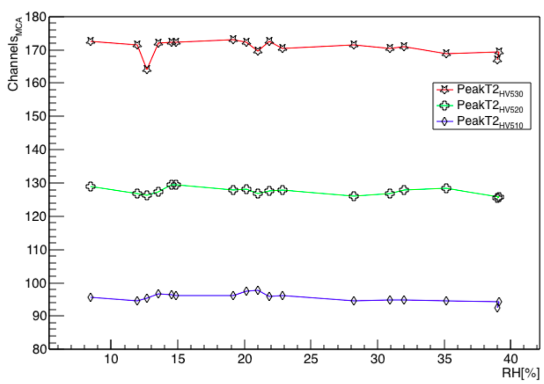

Figure 6. Behaviour of the peak position as function of the T1 gas relative humidity for different read-out voltages applied to T2.

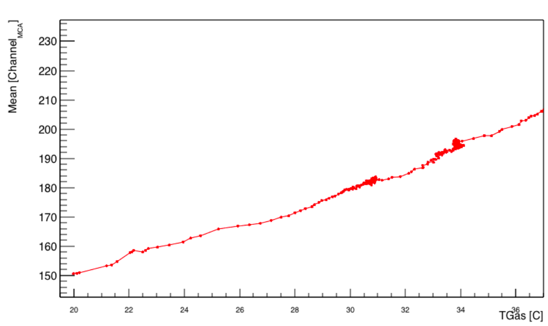

Figure 7. Behaviour of the peak position as function of the T5 gas temperature.

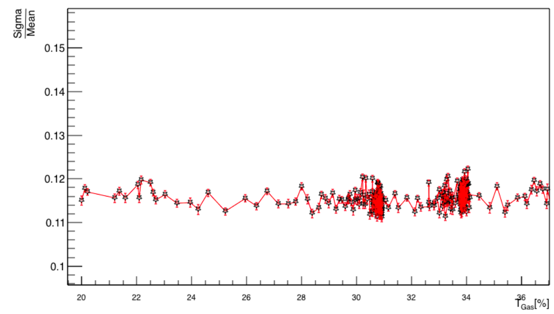

Figure 8. Behaviour of the resolution as function of the T5 gas temperature.

could be related to the thermal characteristics of the *DuPoint Pyralux coverlay* used to make the pillars. Further tests are on going.

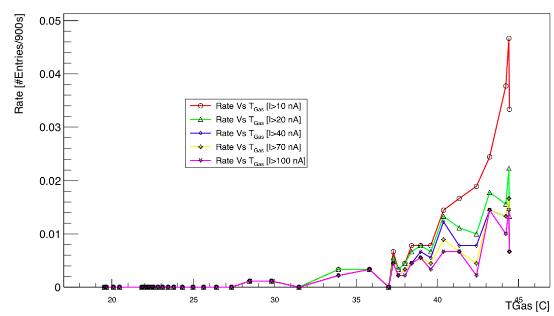

Figure 9. Sparks rate as function of the T1 gas temperature for different current threshold.

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