Simulation and design of large area Micromegas Prototypes for the New Small Wheel ATLAS upgrade

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1. Introduction

The Large Hadron Collider (LHC) will be upgraded in several phases which will allow the reach of the physics program to be significantly extended. After the second long shutdown (LS2) in 2018, the accelerator luminosity will be increased to $2-3\times10^{34}cm^{-2}s^{-1}$, allowing ATLAS to collect approximately $100fb^{-1}/year$. A subsequent upgrade step is planned and will result in the luminosity increasing to $4\times10^{34}cm^{-2}s^{-1}$. The integrated luminosity with this ultimate upgrade will be $3000fb^{-1}$ 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.

2. The Micromegas Detector

The micromegas (an abbreviation for micro mesh gaseous structure (MM)) technology was developed in the middle of the 1990s [21]. It permits the construction of thin wireless gaseous particle detectors. MM detectors consist of a planar (drift) electrode, a gas gap of a few millimeters thickness acting as conversion and drift region, and a thin metallic mesh at typically $100-150\mu m$ distance from the readout electrode, creating the amplification region. A sketch of the MM operating principle is shown in Fig. 1

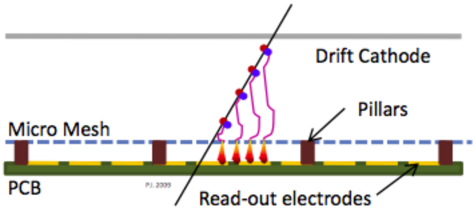

Figure 1. Sketch of the operating principle of a Micromegas detector.

3. Micromegas Mechanics Component Design

The activities carried out in the Lecce ATLAS Group covered some aspects and details of the mechanics design of the chambers. In particular the design and realization of some precision components of the structure of a dummy mechanical prototype to be build at CERN together with CERN ATLAS Micromegas Group shown in Fig. 2. A study was performed on a new machining solution which involves the design of the extruded aluminum profiles to be used in place of standard ones. This allows for a more efficient assembly of Micromegas in terms of accuracy and removal of the heat generated by electronic components. The section of the extruded profile is shown in Fig. 4.

4. Micromegas Full Wedge Simulation

A structural analysis of stresses and deformations induced on the detector from thermal gra-

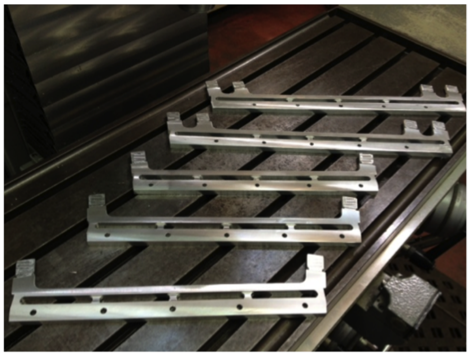

Figure 2. some MM components built for a dummy mechanical prototype

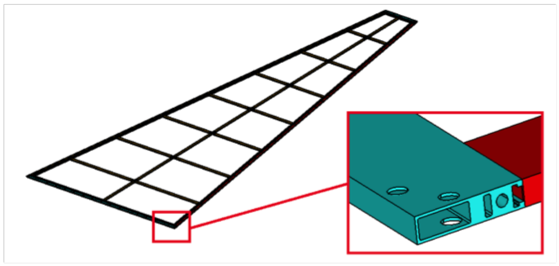

Figure 3. Extruded profiles

dients which are present within in the ATLAS cavern has also been performed. The structural analysis was performed with the finite element method, a numerical technique aimed at obtaining approximate solutions to a variety of problems of Physics and Engineering. The present thermal gradients induce the deformation of the composite and each material has its own thermal expansion coefficient. Therefore, the aluminum that make up the structure has a different behavior with respect to the epoxy glass and PCB of which the support panel of the chamber are done. It is important , therefore, to evaluate the behavior and interaction of the different parts of the structure under the effect of thermal gradients for the assessment of performance in terms of rigidity of the structure itself. The presence of deformations induced by the external temperature outside the range of permissible tolerance would result in a malfunction of the detector. For the reasons mentioned above it has been assumed a reasonable temperature distribution that provided for a thermal gradient between the top and the bottom of the detector of $2C$. Fig. **??** shows the distribution of the displacements induced on the structure by the thermal gradient. The maximum displacement is found to be equal to $6.2\mu m$. The range of tolerance provided a threshold value equal to $50\mu m$, therefore, the thermal gradient is not considered to affect the operation of the detector. The numerical analysis has also made it possible to highlight the fundamental importance of the fixing of the honeycomb structure to the panel structure itself to ensure the proper functioning of the panel itself.

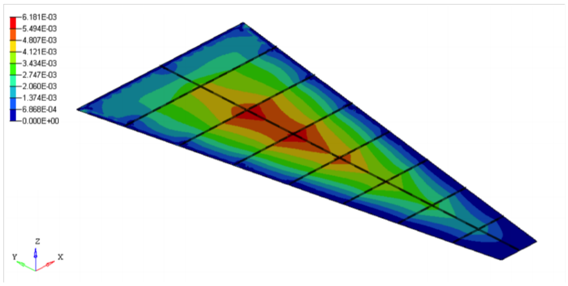

Figure 4. Simulation of displacement induced by the thermal gradient

REFERENCES

1. ATLAS Collaboration is made of about 3000 Physicists coming from 173 Institutions of the following countries: Argentina, Armenia, Australia, Austria, Azerbaijan, Belarus, Brazil, Canada, Chile, China, Colombia, Czech Republic, Denmark, France, Georgia, Germany, Greece, Israel, Italy, Japan, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan, Turkey, UK, USA, CERN, JINR.
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3. ATLAS Collaboration, CERN-LHCC-2013-006, ATLAS-TDR-20-2013, June 2013.