Composite Structures 207 (2019) 53–61

Contents lists available at ScienceDirect

Composite Structures

journal homepage: www.elsevier.com/locate/compstruct

Mechanical modelling of the micromegas detectors for the atlas new small wheel

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ARTICLE INFO

Keywords:
CERN
ATLAS
NSW
MicroMegas
Detector
Composite
Honeycomb panel
Finite element model
Experimental test
Validation

ABSTRACT

In order to benefit from the expected high luminosity performance provided by the Phase-I upgraded LHC at CERN, the New Small Wheel (NSW) will be installed in the ATLAS detector during the Long Shutdown 2. The ATLAS NSW will be equipped with a new technology for the detection of muons: the MicroMegas (MM) detectors. They consist of different panels made of composite materials and when charged particles traverse the drift space, the gas is ionized and electrons are liberated; the avalanche of electrons takes place in the amplification region after the mesh and they are detected by read-out strips to reconstruct the trajectory of muons produced after the collision. Very tight mechanical tolerances are given in the design phase and they must be preserved from the panel construction to the final operation in the ATLAS cavern.

In this paper the construction procedure of these very precise particle detectors is described and the mechanical modelling to predict their mechanical behaviour is presented. Finally, the experimental tests done to validate the numerical models are discussed.

1. Introduction

The Large Hadron Collider (LHC) is the largest and most powerful particle accelerator in the world. It consists of a 27-kilometre ring of superconducting magnets and accelerating structures to boost the energy of the particles along the way. Two high-energy particle beams travel at close to the speed of light and they are made to collide at four locations around the accelerator ring, corresponding to the positions of four huge particle detectors: ATLAS, CMS, ALICE and LHCb.

Since its official inauguration in 2009, the LHC has been producing a lot of results which have led to the announcement of the Higgs Boson three years later. After the first Long Shutdown (LS1) in 2013–2015 the particle beams are travelling at higher energy (13 TeV), while the LS2 foreseen in 2018–2019 is aimed at increasing the luminosity of the machine to achieve more than one billion of collisions per second.

In order to benefit from the expected higher luminosity performance provided by the upgraded LHC, the smallest wheel of ATLAS for the muon detection has to be replaced [1]. The New Small Wheel (NSW) will be installed in the ATLAS cavern during the LS2 and it will be equipped with a new technology to reconstruct the trajectory of muons produced after the collision: the MicroMegas (MM) detectors [2]. They consist of drift (cathode) and read-out (anode) honeycomb panels, which are assembled together and separated by a gas volume (Fig. 1). When charged particles traverse the drift space, they ionize the gas and liberate electrons; the avalanche of electron takes place in the amplification region after the mesh and they are detected by the strips of the read-out (r/o) panels. The MM detectors are then assembled on a central spacer frame, together with the sTGC trigger detectors, to form a *sector* that is mounted on the 10-meter diameter wheel (Fig. 2). Two new small wheels will be installed at the two extremities of the ATLAS calorimeter and each side of the wheel is equipped with 8 Large Sectors (LS) and 8 Small Sectors (SS) respectively.

Several European institutes (INFN, LMU, JINR and the University of Thessaloniki) are contributing to this project and the IRFU at CEA Paris-Saclay is in charge of the construction of the MM detectors for the lower part of the large sector, which are called Large Modules 1 (LM1).

The design of the MM detectors is strongly driven by very tight physics requirements, for this reason the geometrical tolerances are restricted to a few micrometres and they must be preserved from the panel construction to the final operation of the detector. For instance, given a typical detecting surface of a couple of square meters, the flatness variation of each panel must not exceed 200 μm [3].

2. Construction, assembly and integration of the micromegas detectors

The honeycomb panels are constructed in two steps in an ISO 7 clean room designed in Saclay since the detector performances are

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https://doi.org/10.1016/j.compstruct.2018.09.015
Received 25 July 2018; Received in revised form 12 September 2018; Accepted 17 September 2018
Available online 18 September 2018

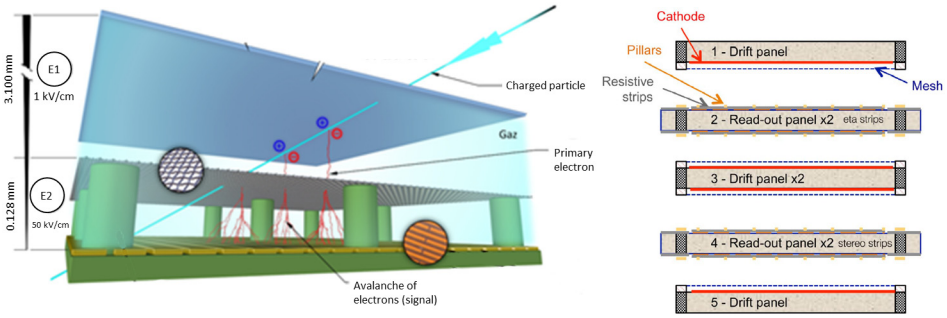

Fig. 1. Operating principle of the MM detectors.

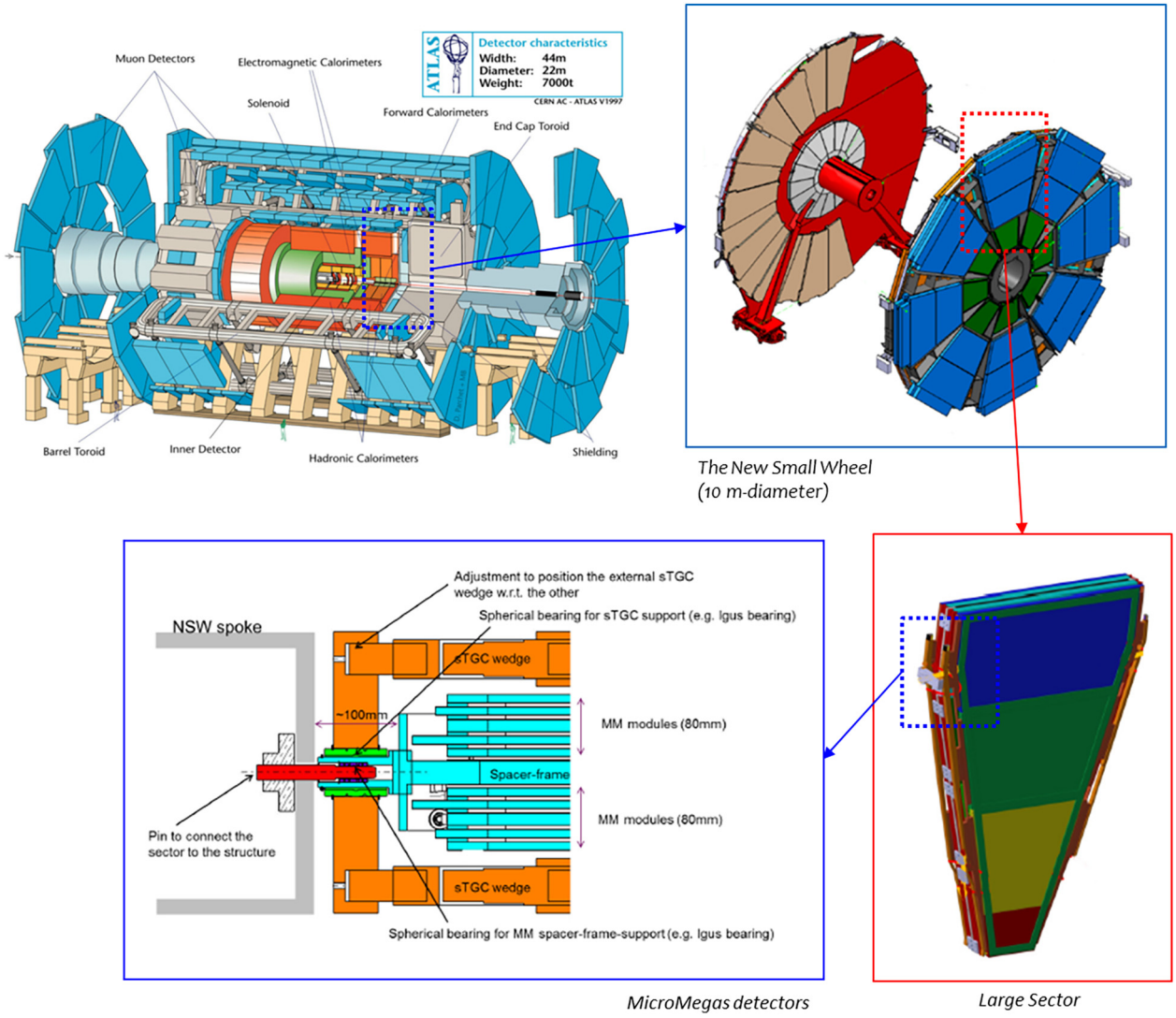

Fig. 2. The New Small Wheel to be installed in the ATLAS cavern.