Performace Studies of Micromegas Detector for the ATLAS Experiment

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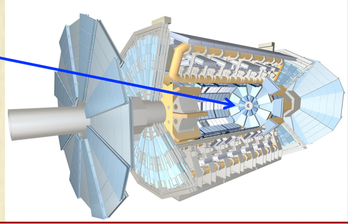
On behalf of the Muon ATLAS MicroMegas Collaboration

Introduction

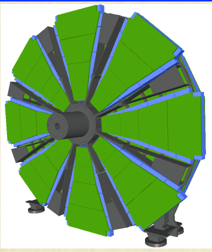
The Large Hadron Collider (LHC) will be upgraded in several phases which will allow a significant extension of the physics program. After the second long shutdown in 2018, the accelerator luminosity will be increased to 2–3×10^{34} $cm^{-2}s^{-1}$, allowing the ATLAS experiment to collect approximately 100 fb^{-1}/year. A subsequent upgrade step is planned which will result in the luminosity increasing to 5×1034 $cm^{-2}s^{-1}$. The integrated luminosity with this ultimate upgrade will be 3000 fb^{-1} after about 10 years of operation.

The energy and luminosity increase of the LHC will require an upgrade of the ATLAS detector in order to keep the excellent performance in the new running conditions.
In particular the forward part of the muon spectrometer of ATLAS (the Small Wheels) need to be replaced witht wo new detector wheels (NSW for New Small Wheel) assuring higher rate capabilities and a better performance for the level1 muon trigger

The Small Wheel

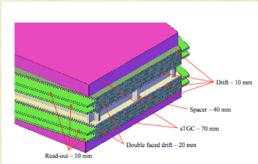


The ATLAS New Small Wheel



The New Small Wheel

The NSW has been designed as a detector assembly of two different technologies: sTGC and Micromegas, both able to provide precision position measurement and the identification of the buncg crossing for trigger decisio. Two quadruplets of each technology will be used to build each sector of the two wheels, leading to an active area of about 1200 m^2 for both sTGC and Micromegas.
The NSW is the most ambitious project involving Micromegas detector ever proposed.



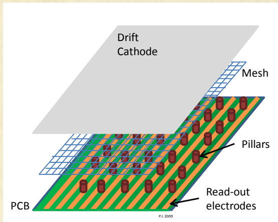
Schematic of a sector of the New Small Wheel

Micromegas for the NSW

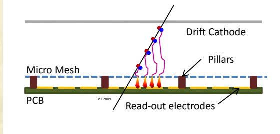
The layout of the detector have been optimized for the use of the Micromegas in ATLAS.
Micromegas for ATLAS have 128 um amplification gap; 5 mm drift gap; 400 um strip pitch (with resistive strips for spark reduction); gas mizture Ar:CO2 93:7.
After a long R&D effort, the Micromegas technology is now mature to equip large detector systems, satisfying the stringent requirements for the NSW:

- Single plane spatial resolution <1oo um
- Time resolution ~ 10 ns
- Efficiency >98%
- Rate capability >14 kHz/cm2
- Good againg properties
- Capability to work in a magnetic field
- Good double-track separation

An intense test beam activity has been carried out to verify the required performance.
Test were performed on 120 GeV pion beam at CERN

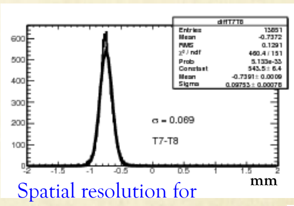


Micromegas schematic

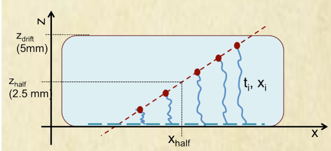


Micromegas performance

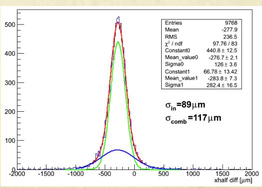
Spatial resolution of about 70 μm has been obtained for all chambers under test for perpendicular tracks.
A global detector inefficiencies have been measured to be in the range of 1–2%, consistent with the partially dead area expected from the presence of the 300 μm diameter pillars separated by 2.5 mm.
For impact angles greater than 10° the μTPC method is used for a local track segment reconstruction in the few-millimeter wide drift gap. It exploits the measurement of the hits time and the highly segmented readout electrodes: the position of each strip gives an x coordinate, while the z coordinate (perpendicular to the strip plane) can be reconstructed from the time measurement of the hit after calibrating the z–t relation.
By combining the μTPC method and the charge centroid a spatial resolution below 100 μm is obtained in the full angular range on the NSW.



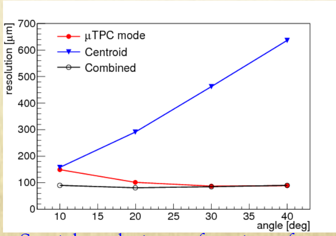
Spatial resolution for perpendicular tracks



Principle of the μTPC method



Spatial resolution for tracks inclined at 30°



Spatial resolution as function of the track impact angle

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