COMSOL simulation of the Micromegas Detector

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Outline

- Why Micromegas?
- Micromegas constituents and principle
- Performance studies in presence of the gas mixture contamination
- Simulation of the electric field
- Simulation of the behaviour of an electron
- Summary and Future work

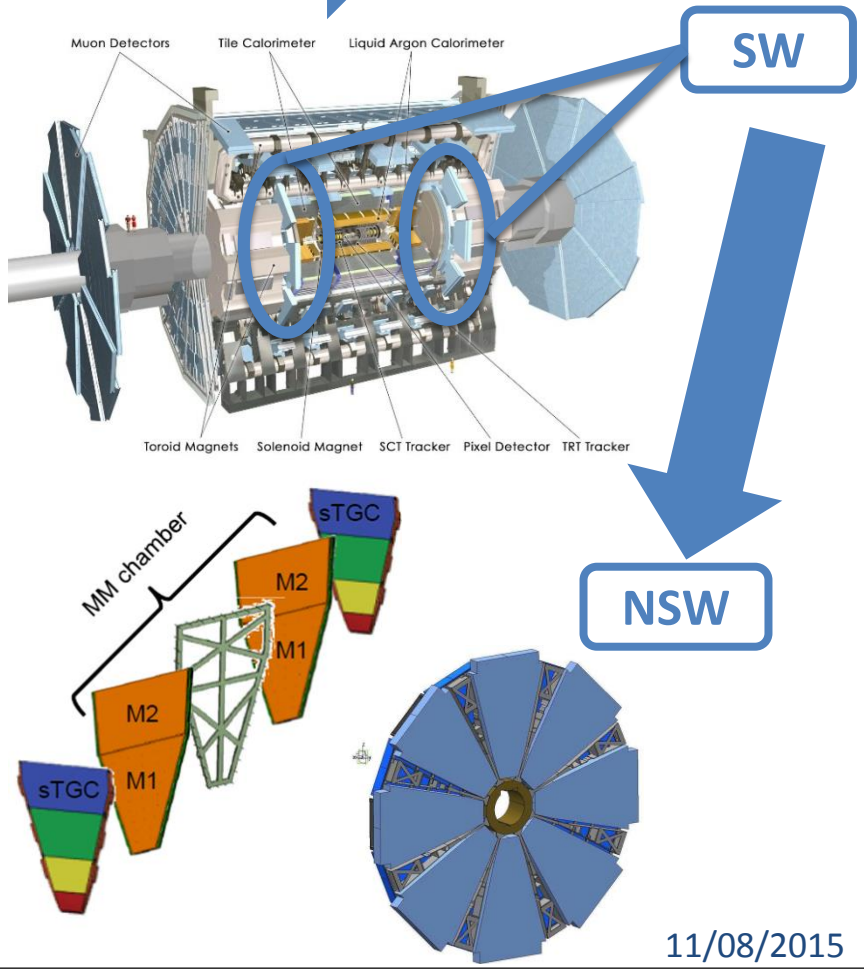
Why Micromegas?

Higgs, Physics Beyond the Standard Model (SUSY), … → **LHC upgrade** → **ATLAS Upgrade**

To cope with the increased rate expected at higher luminosity, the innermost end-cap muon stations Small Wheels (SW) at the ATLAS muon spectrometer will be replaced by the New Small Wheels (NSW) constituted by:

- Small-strip Thin Gap Chambers (sTGC)
- Micromegas (MM)

Both will be used as triggering and tracking devices, with MM being the main precision tracking system.

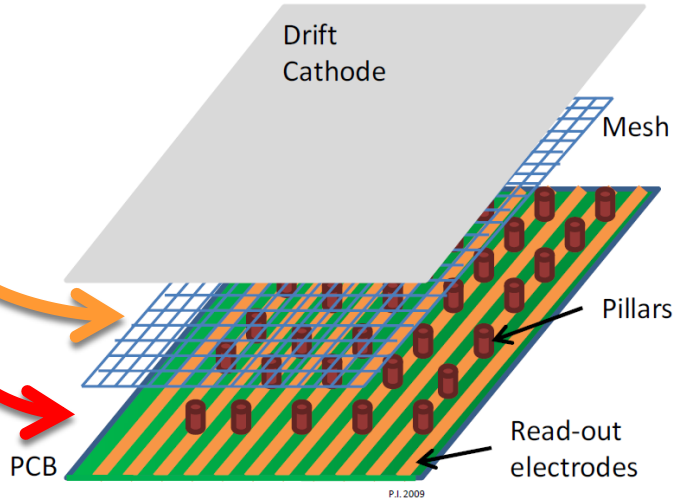


Micromegas constituents and principle

Micromegas are parallel plate avalanche chambers consisting of:

- several millimeter wide **Drift Region**
- approximately 0.1 mm wide **Amplification Region**

separated by a thin conductive micromesh.



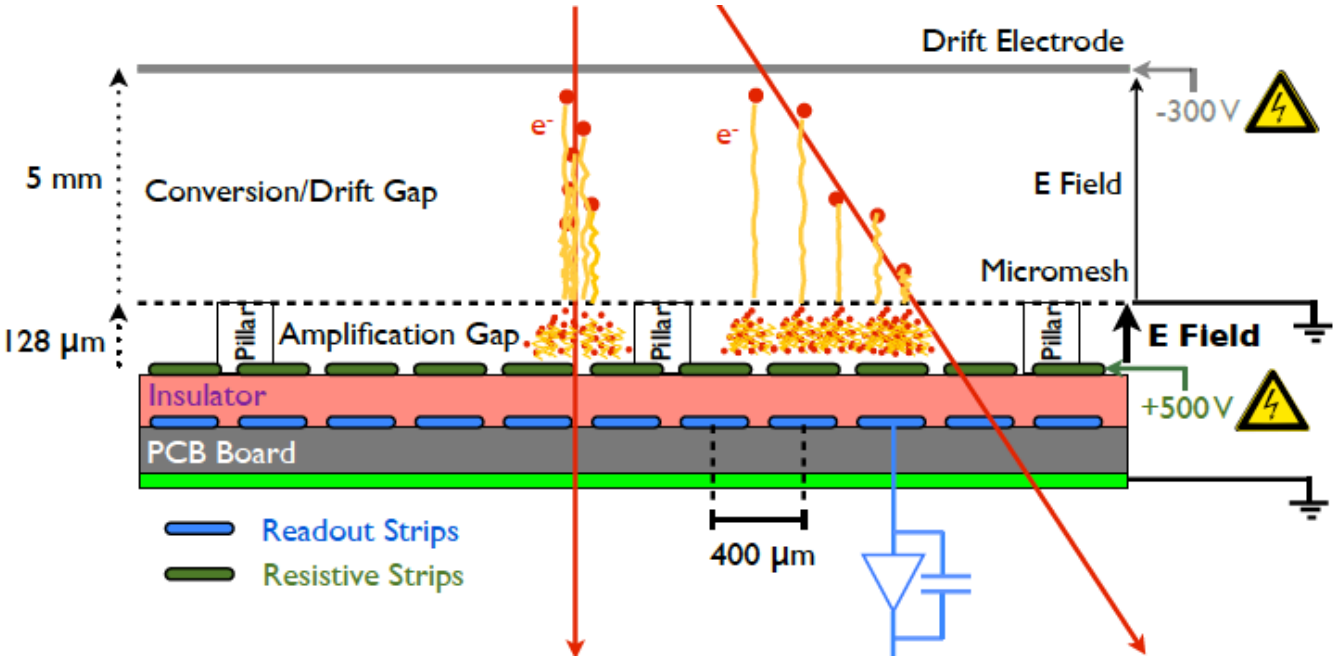
Drift Cathode	Copper
Gas Mixture	Ar/ CO_2: 93/7 %
Mesh	Stainless Steel
Read-out Strips	Copper on PCB substrate

Having a very thin amplification region, the MM detectors are vulnerable to sparking. For this reason, the MM in ATLAS will have the read-out panels covered by 25 µm insulator layer (kapton foil) carrying high-resistivity carbon strips.

Micromegas constituents and principle

Operating Principle:

1) Charged particles traversing the drift space ionize the gas releasing electron-ion pairs
2) Ionization electrons drift within 100 ns towards the high field amplification region while ions drift towards the cathode
2) The electrons are multiplied in an avalanche process and released on the anode strips where they are detected
3) The ions produced in the amplification region are quickly evacuated by the mesh



Performance studies of the gas mixture contamination

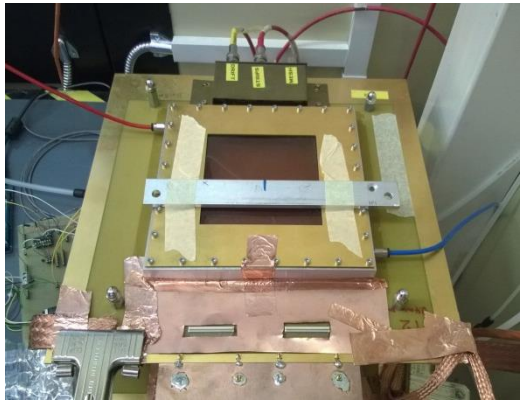
Why?

→ To know and understand the behaviour of the detector in case of gas leak and gas mixture contamination by air

How?

→ Laboratory tests with small prototypes (10 x 10 cm^2)

→ Simulations using the COMSOL Multiphysics software. It uses Finite Element methods to solve the differential equations of the physics model that describes the real situation



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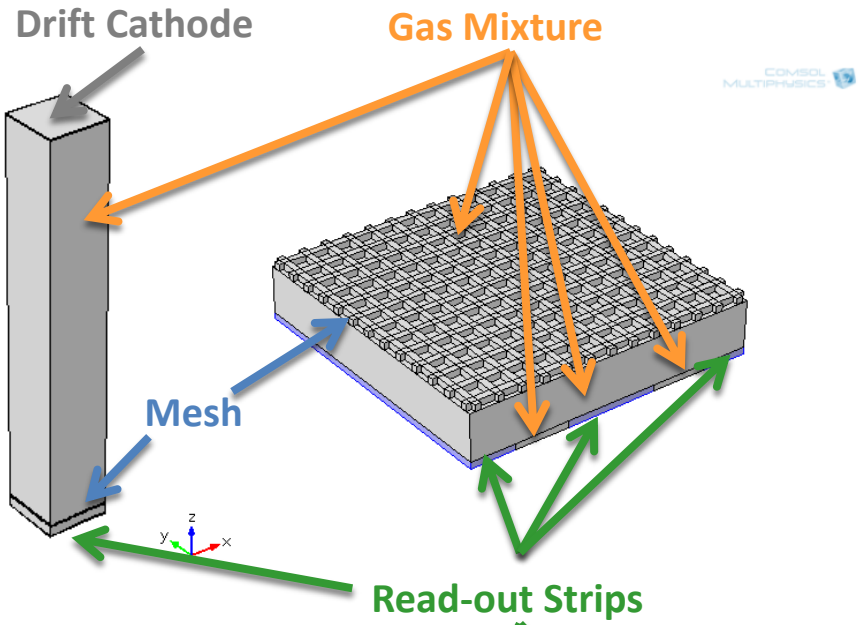
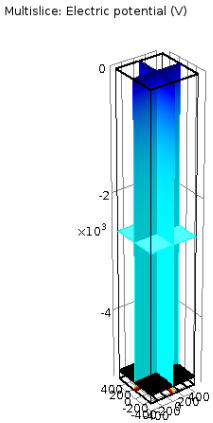
Simulation of the electric field

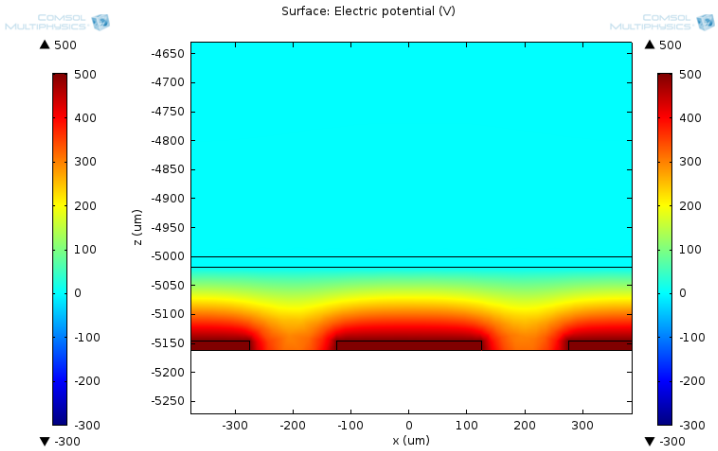
A simplified version of the Micromegas detector was simulated, containing the drift cathode, the mesh and read-out strips.

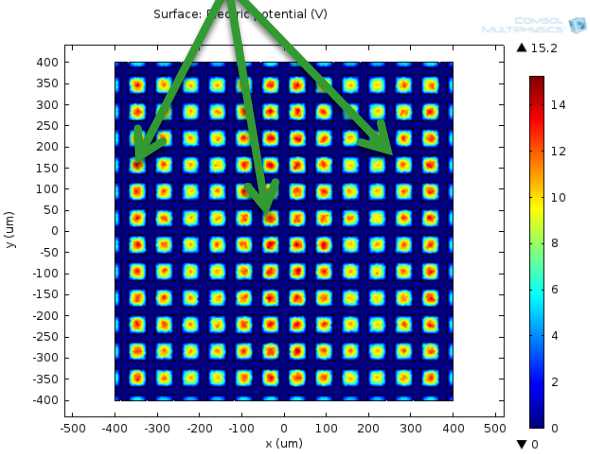
With the Electric Currents model, the electric field and potential were obtained:

→ The potential obeys the boundary conditions imposed



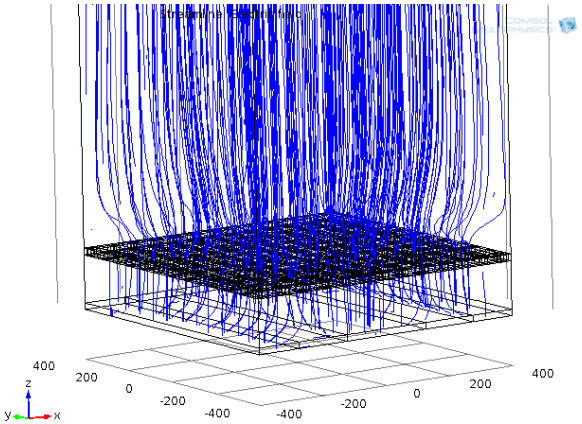


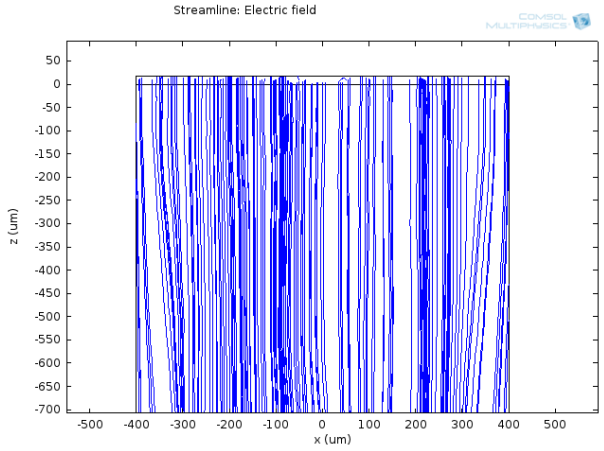


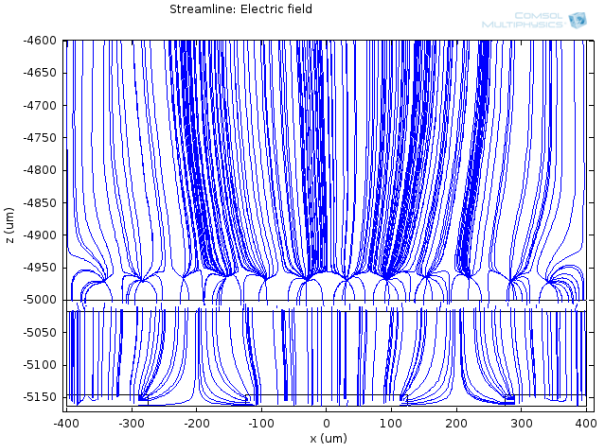


Simulation of the electric field

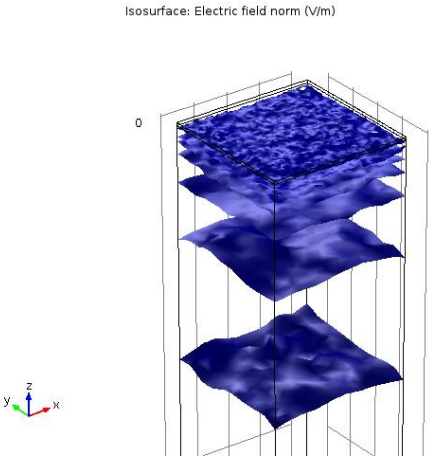
- The electric field in the drift region is approximately uniform
- The electric field lines converge to the holes of the mesh
- In the amplification region, the field lines converge to the read-out strips

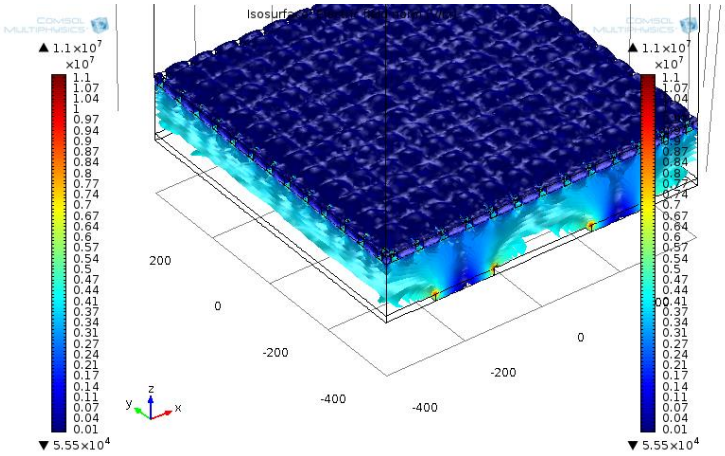


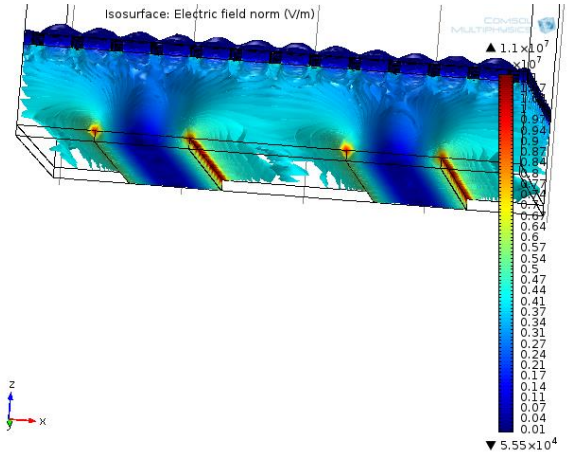




- The electric field is of the order of 10^4 V/cm in the amplification region





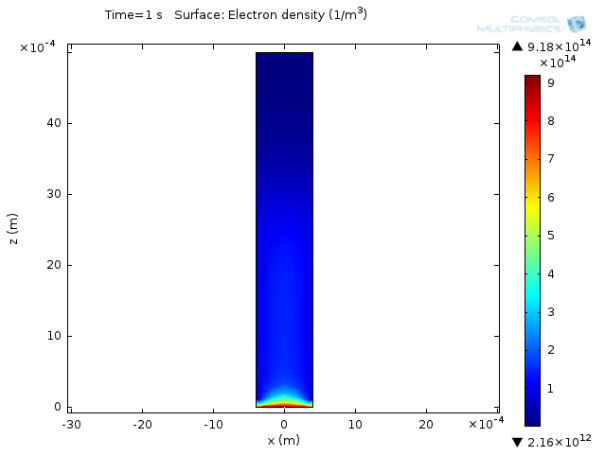


Simulation of the behaviour of an electron

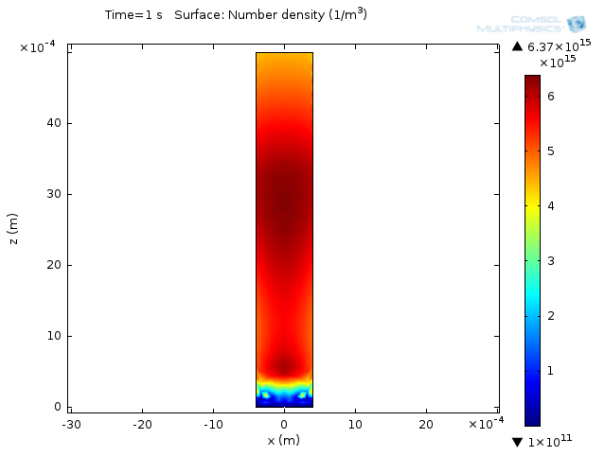
2 models: Particle Tracing and Drift Diffusion models

→ **Problem:** the electron did not interacted with the gas mixture and did not follow the field lines

→ **Solution**: DC discharge model (interaction with gas mixture).



Work in progress



Summary and Future Work

- ✓ The Micromegas was one of the technologies chosen for the upgrade of the Small Wheel of the ATLAS muons spectrometer due to its tracking capabilities
- ✓ The micromegas principle of operation is based on the ionization of the gas of the chamber and on the avalanche of electrons produced
- ✓ The electric field of the micromegas was simulated and has the expected behaviour and values

Future Work

- Simulate a more realistic Micromegas
- Calculate the gain at the readout strips that the Micromegas detector produces
- Obtain the dependence of the gain on the composition of the gas mixture
- Compare the simulations results with experimental results from laboratory test

Thank you for listening!