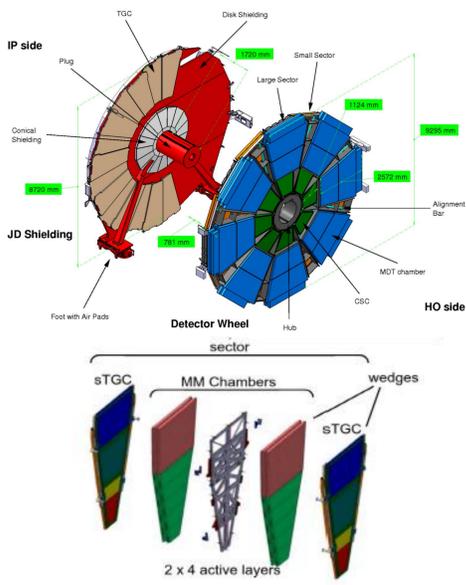


The industrial production and validation of Micromegas boards for the ATLAS upgrade

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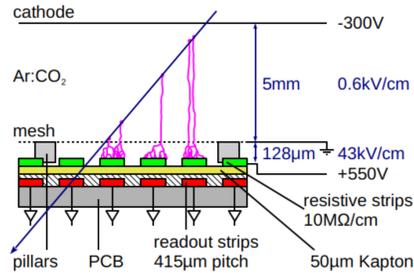
The muon system of the ATLAS Experiment is currently undergoing a major upgrade, with the replacement of the innermost detector wheel with new structures (New Small Wheel, NSW) based on resistive Micromegas and small-strip Thin Gap Chambers.

The Micromegas detectors for the New Small Wheel cover an active area of about 1280 m², being the largest system based on Micro Pattern Gaseous Detector (MPGD) ever built so far. The key element of the detectors are the anode boards which carry the readout strips, the resistive protection layer and the insulating pillars supporting the mesh. In total more about 3000 boards of 16 different types with size up to 40x220 cm² have been produced. The boards, of 16 different types with size up to 40x220 cm², are produced by two industries in Europe, which opened the road to MPGD mass production.

The industrial production of about 3000 boards is now completed. Each board undergoes a detailed quality control and quality assurance at CERN, prior to be mounted into the final detectors.

The poster will review the technological transfer effort made by CERN and ATLAS to make the Micromegas board production an industrial process. The main challenges encountered during the industrialisation and the adopted solutions will be presented in detail, together with the results of the QA/QC performed at CERN.

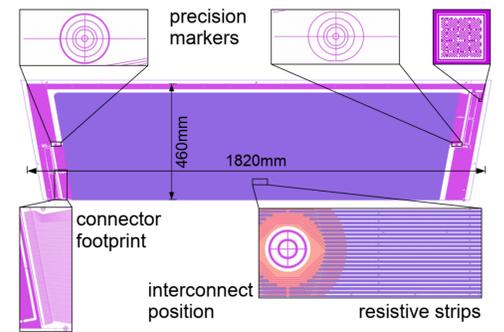
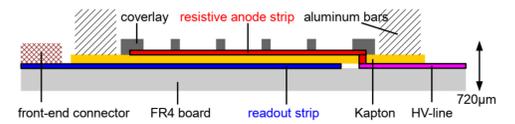
Micromegas is a micropattern gaseous detector consisting of a cathode, a mesh and an anode. The cathode-mesh gap forms a drift volume where drift field guides primary electrons and ions to the electrodes. Strong amplification field between the mesh and the anode drives the primary electrons to the thin amplification gap and accelerates them leading to ionizing collision with the gas molecules and formation of avalanches. When reaching the anode the avalanche is spread over the area of 1-2 mm diameter that leads to signal formation at several read-out strips.



In ATLAS Micromegas resistive anode is used. This technology consists in dividing the anode in high voltage and read-out parts and provides more stable operation and spark protection both the detector volume and the front-end electronics. High voltage (+500-600V) is applied to resistive strips disposed at insulative Kapton® film. The film is glued on the FR4 based PCB with the read-out copper strips.

- ❖ The resistive foils were produced in Kobe (Japan) using the screen-printing technique. The resistive strips were printed on Kapton foil according to the copper pattern.
- ❖ The read-out PCBs with the foils glued on top of the copper pattern were produced by Elvia (France) and Eltos (Italy) companies.
- ❖ Quality assurance/quality control of the anode boards was done at CERN.

HV is distributed over the resistive strips using conductive silver paste plated on top of the resistive strips and connected to the HV copper strip through the via in the foil. The silver line is covered with insulating strip made with Pyralux®. The same material is used to create pillars supporting the mesh and determining the width of amplification gap.



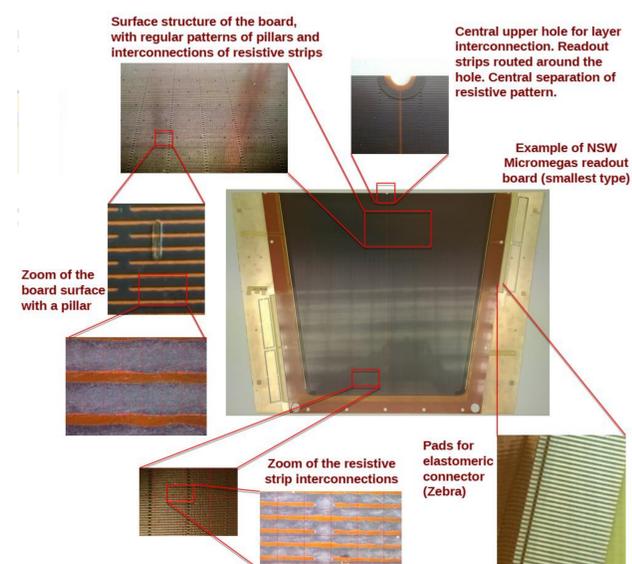
Main requirements applied to the anode boards:

- High planarity of the PCBs
- Precise copper pattern etching
- High quality read-out connector silver plating
- Precise positioning of the resistive foil
- Regularity of the resistive pattern
- Appropriate resistivity of the resistive pattern
- Correct positioning and performance of the silver-lines
- Pyralux® layer (pillars and silver-line cover) high planarity, appropriate attachment, appropriate insulation
- Amplification gap thickness consistency
- Appropriate size and shape of the ready-made anode boards

QA/QC procedure consists of:

- ❖ Visual inspection
 - look for any visual non-conformity at the active area
 - scratches, through-holes on the Kapton foil
 - bumps at the active area
 - missing pillars
- ❖ Silver line and read-out connectors inspection
 - look for defects of silver line using stereo microscope
 - look for bubbles of gas between silver line and Pyralux cover
 - measurement of r/o strips' width at the connector pads
- ❖ HV distribution and insulation tests
 - check uniformity of silver line conductivity
 - tests of insulative layers at 1kV applied voltage
- ❖ Cutting quality inspection
 - check the quality of the edges of the boards
 - check the cutting performed at correct position
 - Kapton foil covers the first readout strip with appropriate margin
- ❖ Dimensions inspection
 - check if the boards' size is within the tolerance several weeks after production using specially-made optical tool
- ❖ Pillars' height mapping
 - mapping of the amplification gap width using specially-made tool based on mechanical micrometers
- ❖ Resistivity mapping of the resistive layer
 - mapping of resistivity of the resistive strips using specially-made electrical tool
- ❖ Check of the read-out strips connection
 - check if there is no cut/broken read-out strips measuring capacitance between resistive and read-out strips

- ❖ ~ 3000 anode boards of 16 different types were produced in total
- ❖ A few hundred of the boards were reproduced due to major non-conformity that may lead to detector damage during operation
- ❖ 2000 boards meet the requirements and used to build the Micromegas modules
- ❖ A few hundred of the boards have issues that could be repaired and the boards could be potentially used



- Some of the listed defects can be repaired such as:
- ❖ bumps, scratches at the active area → insulated if possible
 - ❖ missing pillars → reglued
 - ❖ bubbles under Pyralux layer → filled with epoxy

For the other defects there is no way to repair and be ensured that problems won't appear during detector operation.

- ❖ those boards are rejected

