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Status of the Art of the Resistive Micromegas for the Upgrade of the ATLAS Detector

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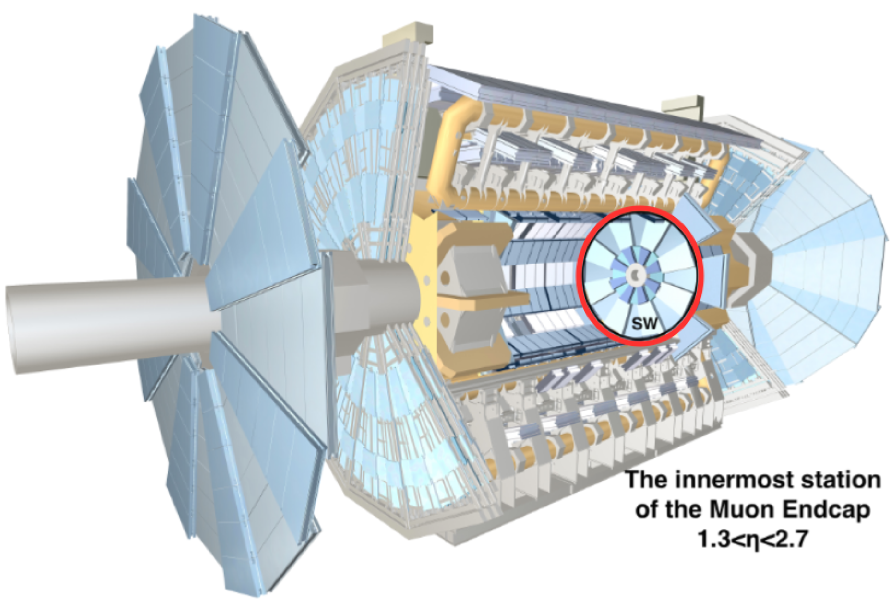
ATLAS New Small Wheels

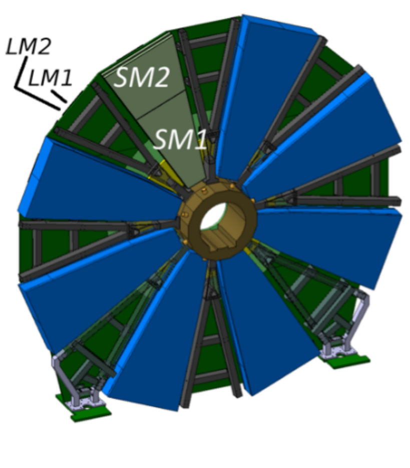
Large area MicroMegas (MM) detectors will be part of the upgraded innermost station of the muon end caps (New Small Wheels) of the ATLAS experiment during the long shutdown in 2019/20. These detectors will provide primarily tracking and secondly triggering information, while being able to withstand the high pile up expected from Run III onward, resulting in rates up to 15 kHz/cm^2.



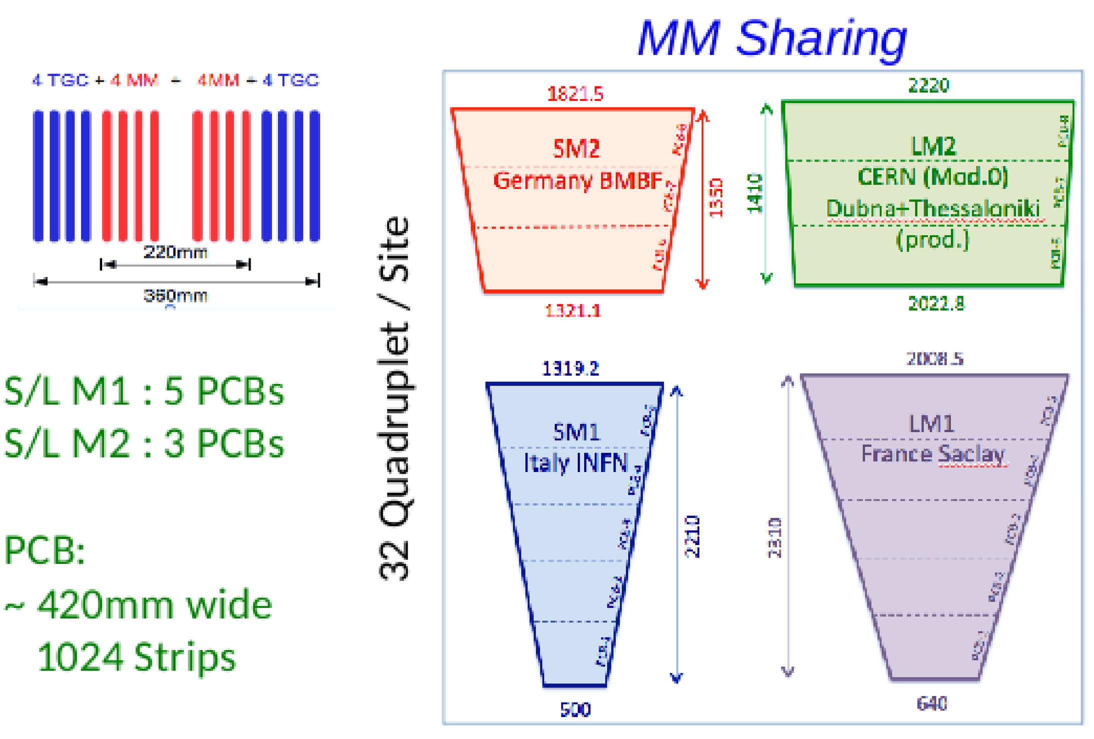
NSW specifications:

- Good spatial resolution (less than 100 μm)
- Good track separation (0.4 mm track granularity)
- Good angular resolution (1 mrad)
- 15% momentum resolution at 1 TeV

In each of the two New Small Wheels, four detector quadruplets will be sandwiched together along the beam direction: two small-strip Thin Gas Chambers (sTGC) and two MM detectors, for a total of 16 active planes. Each MM quadruplet will contain two eta (read-out strips parallel to the basis) and two stereo (strips slanted by 1.5°) layers.



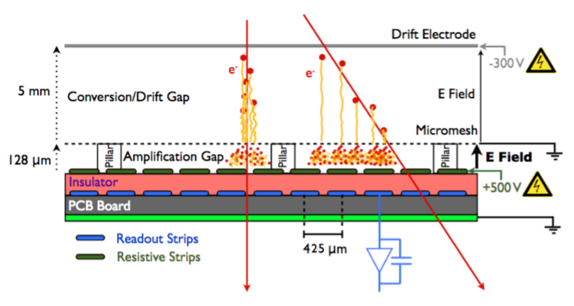
Four types of MM quadruplets will be integrated in the New Small Wheels, divided into 128 quadruplets covering an active area of 1280 m^2: SM1, SM2 (small wedges) and LM1, LM2 (large wedges), constructed in Italy, Germany, France and Russia/Greece respectively.

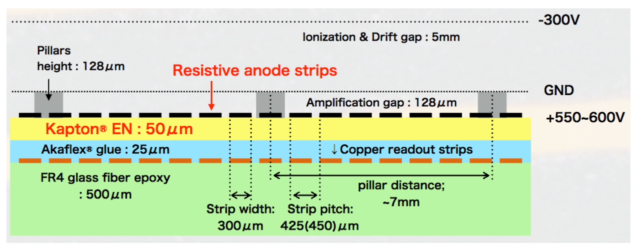


Micromegas detectors for the New Small Wheel

MicroMegas detector characteristics:

- 93% Ar and 7% CO_2 gas mixture
- Strip resistivity ≈10 MΩ/cm
- Drift voltage -300 V, readout strip voltage 600 V
- Drift gap 5 mm, amplification gap 128 μm



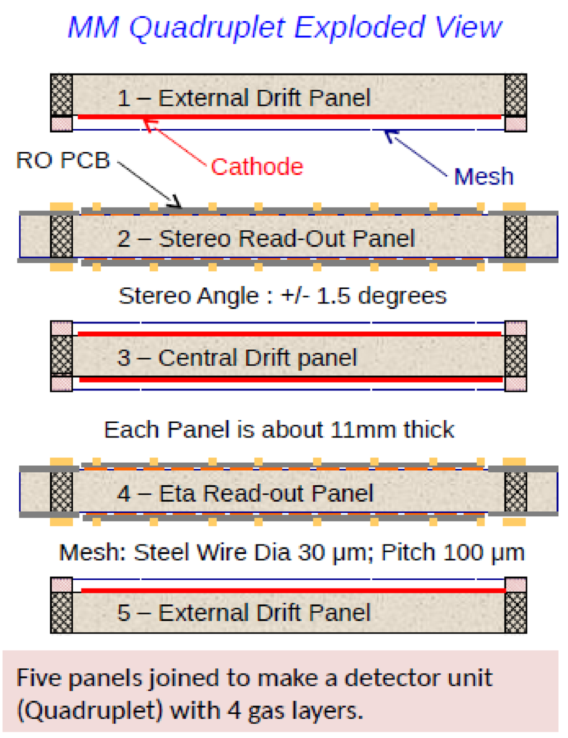


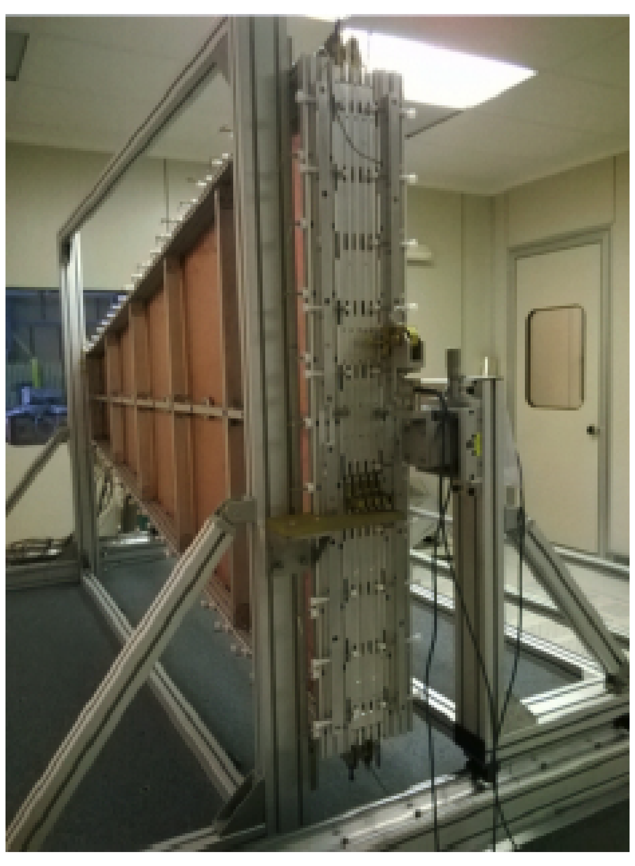
SM1 quadruplets

The INFN groups responsible for the construction of the SM1 quadruplets are: Pavia for the readout panels, Roma 1 for the drift panels, Roma Tre for the mesh stretching, Frascati for the quadruplet assembly while Cosenza, Lecce and Napoli provide support. The mechanical precision represents a challenge in MM construction: alignments of the readout strips on each detection layer within 30 μm RMS in η and 80 μm RMS in Z are required.

In May 2016 the first full size SM1 prototype (Module 0) was constructed by the INFN consortium, and studied on a dedicated test beam at CERN in June. Further tests included mechanical studies for the detector assembly in the wheel and performance under deformation, as well as tests on high-voltage stability and ongoing checks using cosmic rays.

To address issues that arised during Module 0 construction as well as to test new tooling, a second SM1 prototype (Module 0.5) will be completed by the end of April 2017. Tests and studies of the performance of the new quadruplet will take place during Spring and Summer 2017.

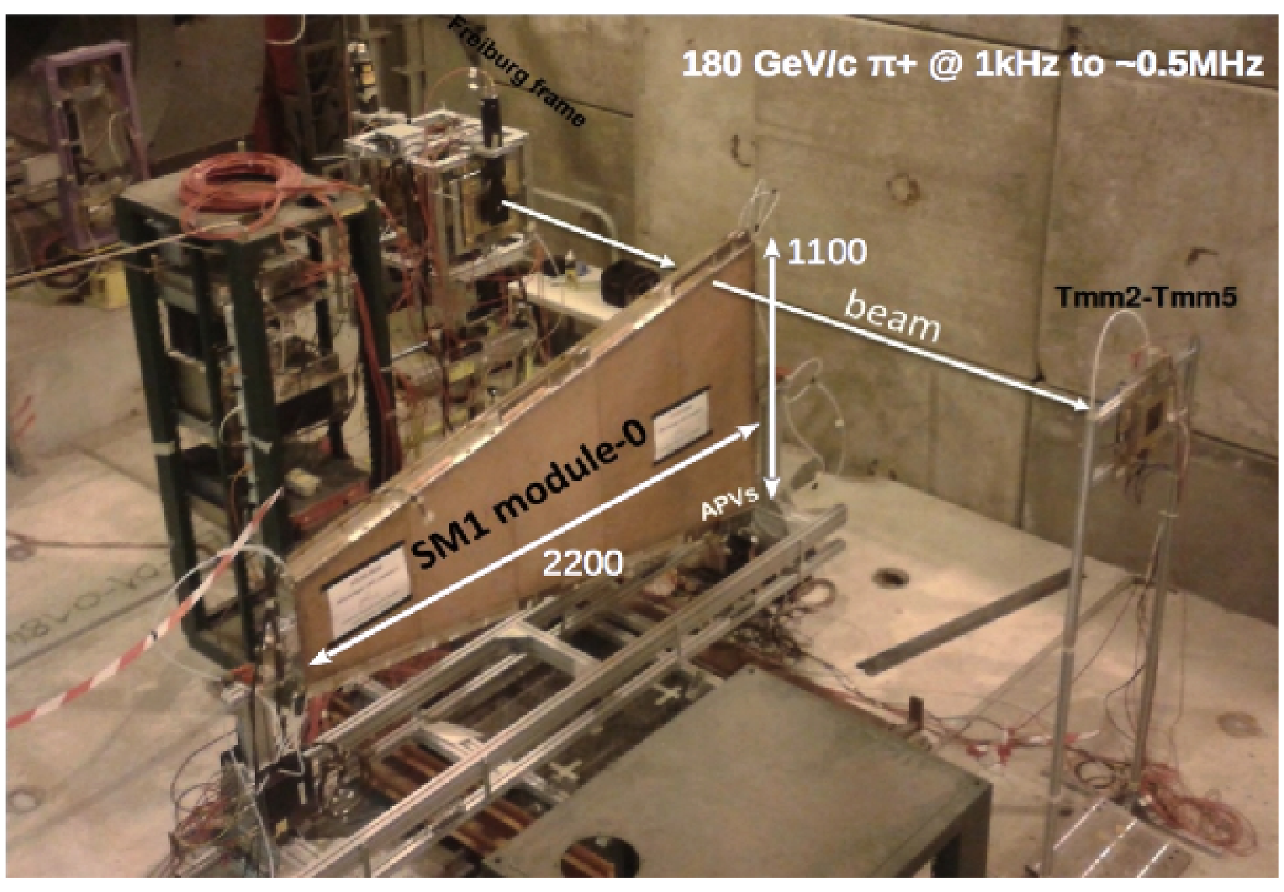




SM1 Module 0 test beam

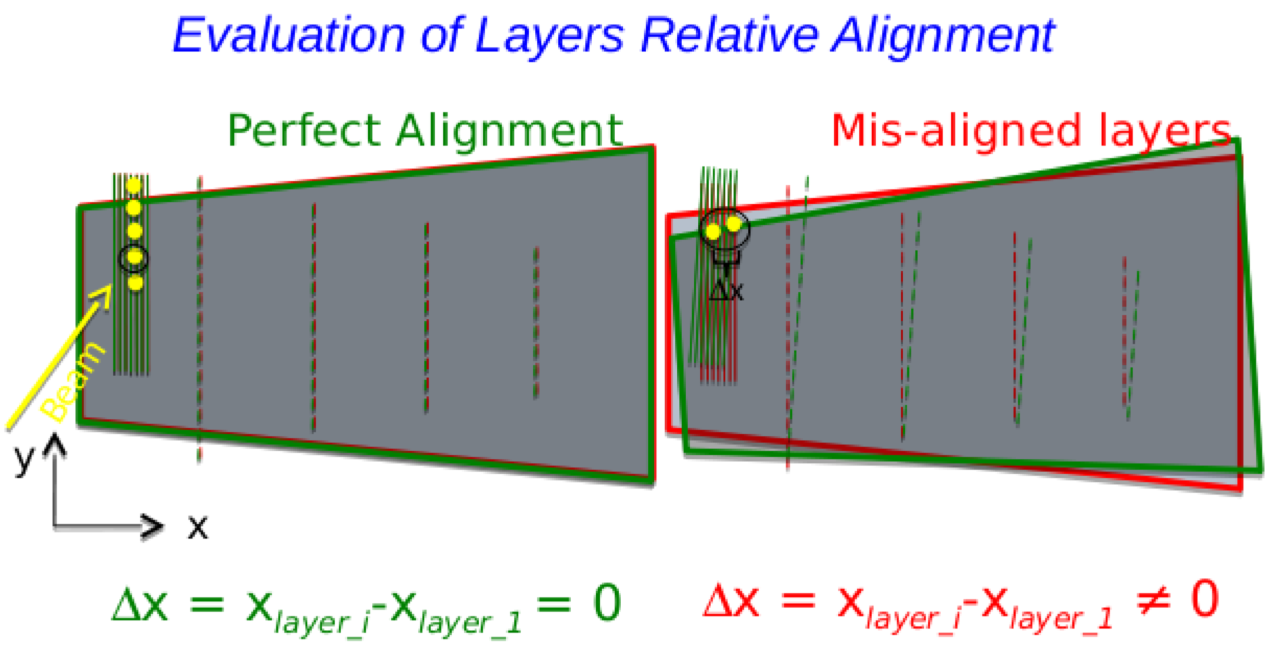
Test beam measurements were performed at CERN in June 2016 at SPS H8 experimental hall. A 180 GeV/c π^+ beam with a rate between 1 kHz and ∼ 0.5 MHz (beam spot of about 1 cm^2) was used. The experimental setup was a detector array composed by the SM1 Module 0 and five small dimension MM chambers, with X and Y coordinate readout, used as reference.

The purpose of the test beam was to certify the Module 0 prototype with respect to the project requirements. Both the quality of the single layer and the quality of layer assembly have been tested. The beam was centered on PCB3 (the middle one) and PCB5 (the largest) of Module 0, performing X and Y scanning on both PCBs. Data have been collected at different HV amplification values (from 550 to 590 V). The HV drift baseline was set at 300 V but data have been collected also at 200 V and 400 V.



The **spatial resolution** of two SM1 RO layers has been evaluated – using data collected on PCB5 in both cases – for the precision coordinate η and for the second coordinate ϕ. The residuals between the two precision layers of the SM1 Module 0 have been used to estimate the spatial resolution of the η coordinate. The position is reconstructed in each layer by exploiting the charge-centroid method. A fit with a bi-gaussian function estimates a width of the core gaussian of **81 μm (required resolution: less than 100 μm)**, while the weighted average of the widths of the two gaussians is 160 μm, well within requirements.

Similary, to evaluate the spatial resolution of the ϕ coordinate, the difference between the second coordinate position reconstructed in the stereo layers of SM1 Module 0 and that extrapolated from reference chambers has been calculated. The positions are reconstructed with the centroid method. A fit with a bi-gaussian function estimates a width of the core gaussian of 2.3 mm whereas the weighted average of the widths of the two gaussians results to be 3.2 mm, both in good agreement with expectations.



A measurement of the **displacement of strips** in the precision coordinate as a function of the second coordinate for the different layers of PCB3 and PCB5 has been performed. This kind of measurement is an indication of layer-to-layer rotation or strip pattern global deformation.

Measurements are taken at different vertical positions along the strips (yellow spots). For each y-position, Δx are measured between layer i and layer (i - 1) using reference tracks. The displacements are **less than ± 80 μm**, indicating the presence of both shift and rotation **within tolerance (± 90 μm)**.

These effects are under investigation at the construction site in Pavia using compact Charge-Coupled Devices (cCCDs). Twenty cCCDs are used to read twenty Rasnik masks located on the ten RO PCBs used for a RO panel, to establish the precise PCB coordinates and to control strip alignment and rotation.

MM production & NSWs installation

Due to the technological and managerial complexity of the NSW project, a year long delay has been accumulated during the R&D phase (2013/16). As consequence, the present schedule is extremely tight.

The mass production of 32 SM1 quadruplets is expected to start in May 2017 and last for two years. The installation of the first NSW in the ATLAS detector is scheduled for late Fall 2019; the one of the second NSW for Spring 2020.

Acknowledgements

Many thanks to the Italian MM groups, and in particular to the Pavia INFN team (Edoardo Farina, Roberto Ferrari, Gabriella Gaudio, Athina Kourkoumeli-Charalampidi, Agostino Lanza, Simone Sottocornola) as well as to the mechanical and electrical workshops for the success of the SM1 construction.

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