Pisa Meeting on Advanced Detectors – La Biodola, 27 May - 2 June 2018

# Construction and test of the SM1 MicroMegas chambers for the upgrade of the forward muon spectrometer of the ATLAS experiment

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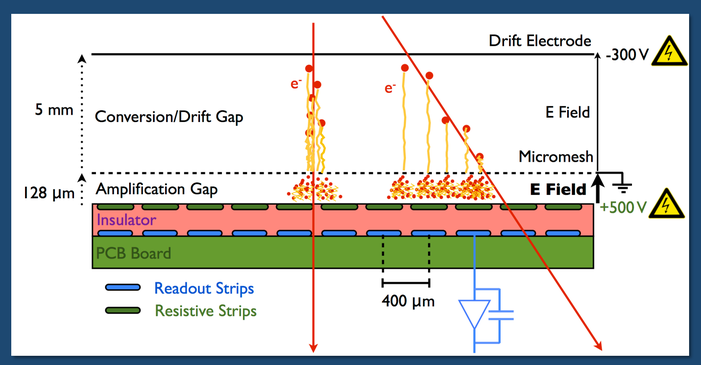
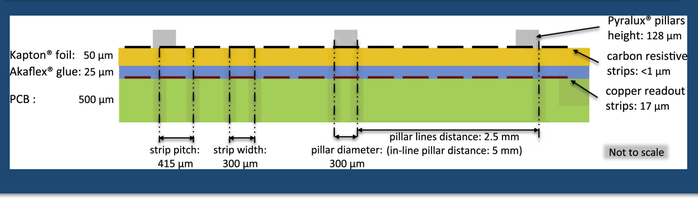
- MicroMegas (Micro Mesh Gaseous System, MM) are Micro Pattern Gaseous Detectors (MPGD)
- together with the sTGCs they will compose the New Small Wheel (NSW) of the ATLAS experiment to be installed during the second long shut down of LHC (LS2, 2019-2020) before the forseen increasing luminosity
- good tracking capability ($p_T$ resolution ~15% for 1TeV) and suitable to work in high luminosity regimes (up to 15 kHz/cm$^2$)
- MM and sTGCs will deal with the increasing luminosity for the future LHC Runs maintaining the excellent performances both in terms of trigger and tracking
- the NSW (sTGCs+MM) provide 16 measurements for each track and a mrad resolution trigger
- the INFN Consortium is responsible for the construction of 32 SM1 chambers (~2m$^2$) in order to reconstruct the muon tracks trough the 4 layers of which they are composed (2 eta and 2 stereo with strips inclined by ±1.5°)

## 1) Operating principles [2,3]

- charged particles ionize the detector gas producing ~100 pairs/cm in Ar:$CO_2$ 93:7 for μ (primary and secondary ionization)
- electrons produced by the ionization process are amplified by an avalanche effect between micro-mesh and the read-out strips (RO, anode)
- fast evacuation of positive ions to the cathode (drift plane): ~100 ns, allowing to work in high luminosity regimes (tested with flux density up to 7MHz/cm$^2$)
- high resolution: strip width 300 μm, strip pitch 425-450 μm
- 2 out of 4 layers have strips inclined by ±1.5° in order to reconstruct the 2nd coordinate (stereo, being η the precision coordinate)

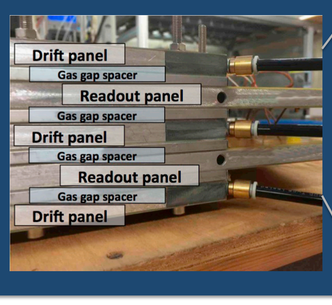


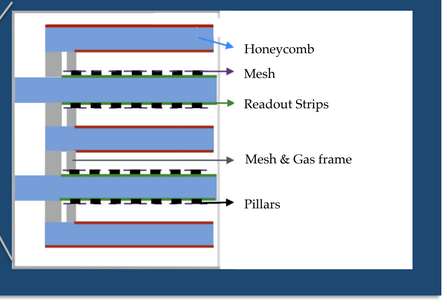




### Caracteristics:

- Gas: 93% Ar - 7% $CO_2$
- Strip resistivity≈10 MΩ/cm
- $HV_{drift}$= -300 V, $HV_{RO}$= 590 V
- 5 mm drift gap, 128 μm amplification gap

### Schematic view of a MM quadruplet:

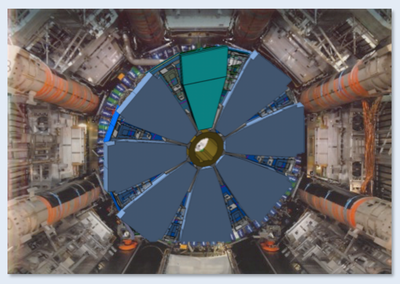


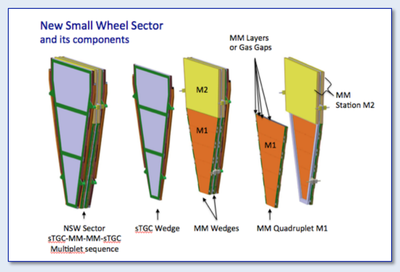



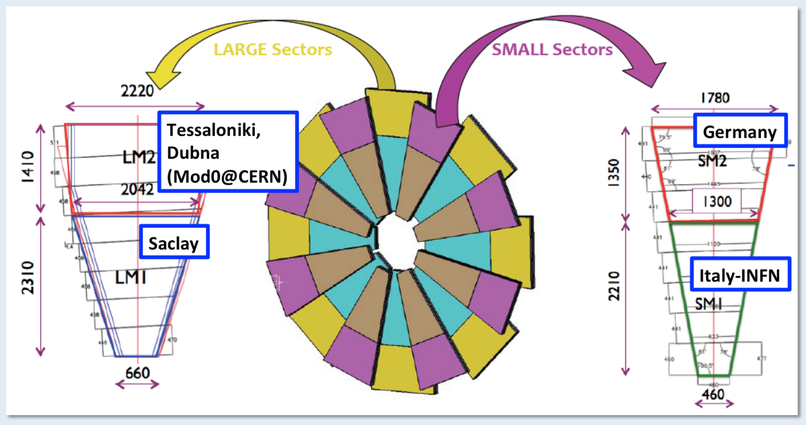

## 2) The NSW: MM for the ATLAS upgrade [1,4]

### Wheel-like structure:

- 8 large sectors (LM) and 8 small ones (SM) (2 modules per sector, 4 MM quadruplets)
- Aim: precision tracking (between sTGCs chambers for the trigger)
- 4 types of chambers: LM 1-2, SM 1-2
- Production distributed between several industries and institutes: Italy(SM1), Germany(SM2), France(LM1), Russia/Greece/CERN (LM2)






## 3) SM1 production scheme

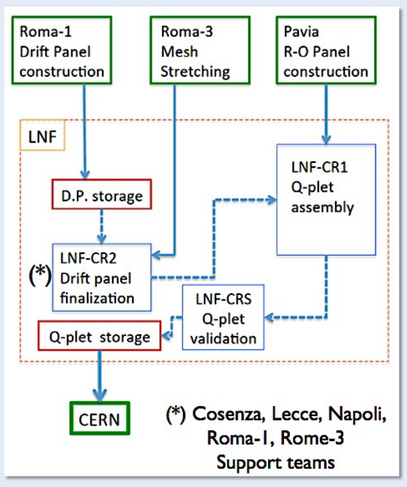
**The INFN group is responsible of the SM1 quadruplets construction.**

Mechanical precision measurements represent a challenge in the MM construction:

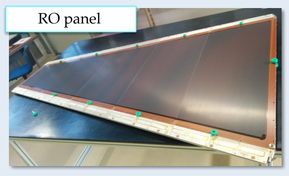
- strip alignment on each RO layer within 30 μm RMS in η and 80 μm RMS in Z
- planarity within 80 μm RMS

| | Fraction of the total |
|---|---|
| Drift panels (RM1) | 43/96 |
| Mesh Stretched (RM3) | 39/128 |
| Finalized Drift panels (LNF CR2) | 25/96 |
| RO panels – Eta (PV) | 4/32 |
| RO panels– Stereo (PV) | 3/32 |
| Quadruplets (LNF CR1) | 2/32 |

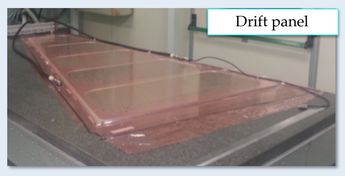
### SM1 production scheme:




RO panel



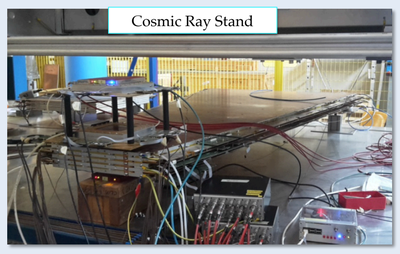
Drift panel



Assembly

Drift panel completion

Cosmic Ray Stand

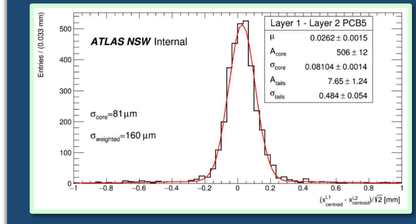


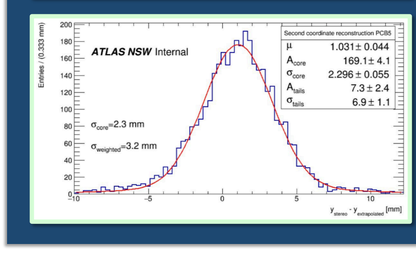
## 4) Preliminary results on first prototypes

Read-out electronics used for prototypes based on APV25+SRS (final version forsee VMM ASICs): APV25 are 128 channels chips whose signal corresponds to the values of the collected charge for different time samplings.

**Reconstruction:**

- 18 time samplings (every 25 ns) each event
- time samplings fitted with a Fermi-Dirac ($t_0$=signal start)
- pedestal subtraction, correction of the cross-talk effect between strips
- track hit reconstruction and definition of the cluster
- hardware efficiency defined using external tracking chambers as reference
- residues computed as $\Delta x = x_{meas} - x_{estr}$



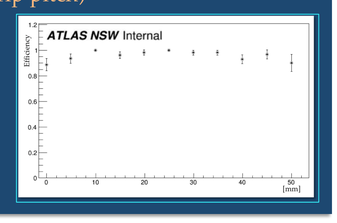

### Mod 0 tested at CERN:

- H8 beam line of the SPS: $\pi^+$ beam at 180 GeV/c with a frequency between 1-500 kHz and beam dimension of 1x1 cm$^2$
- 5 Tmm chambers used as external tracking chambers

  Bulk-type MM with resistive strips (10x10 cm$^2$ dof active area, 150 μm strip width and 250 μm strip pitch)

### Mod 0.5 tested at the CRS at LNF:

- cosmic muons
- 2 Tmm as reference




## 5) Conclusions

- MM will be used after LS2 for the precision tracking in the NSW of the ATLAS experiment
- the SM1 INFN group has been the first to construct 2 full size prototypes: Mod0 and Mod0.5
- HV instability effects energed on the first built chambers (see poster by P. Massarotti)
- performance measurements on first prototypes are well within expectations
- assembly and test procedures validated, ready for the production

## Bibliography

[1] ATLAS collaboration, New Small Wheel, Technical Design Report, CERN-LHCC-2013-006 (2013)
[2] Y. Giomataris, P. Rebourgeard, J. Robert and G. Charpak, A High granularity position sensitive gaseous detector for high particle flux environments, Nucl. Instrum. Meth. A 376 (1996) 29
[3] T. Alexopoulos et al., A spark-resistant bulk-Micromegas chamber for high-rate applications, Nucl. Instrum. Meth. A 640 (2011) 110
[4] T. Alexopoulos et al., Development of large size Micromegas detector for the upgrade of the ATLAS muon system, Nucl. Instrum. Meth. A 617 (2010) 161

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