Construction and test of the Micromegas SM1 chambers for the upgrade of the forward muon spectrometer in the ATLAS experiment

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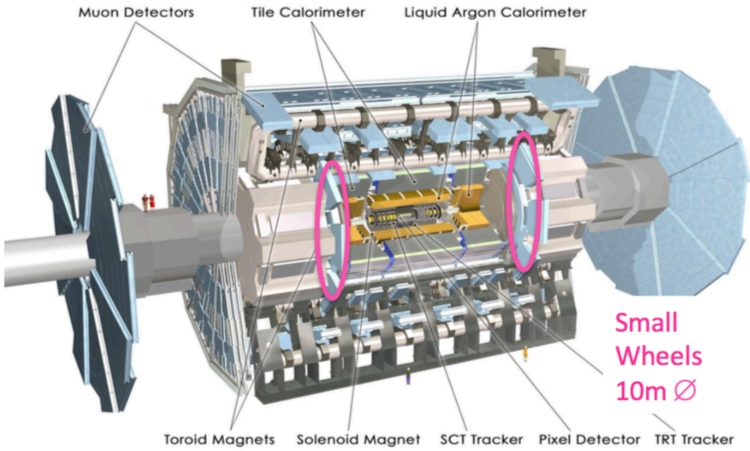
Outline

- The Small Wheel (SW) in ATLAS and the need for a new detector in view of the future LHC runs
- Brief overview of the working principles and structure of a MicroMeGaS (MM)
- MM in ATLAS: New Small Wheel (NSW)
- Production of the Small Module 1 (SM1) by INFN
- Test on the first prototypes at the Cosmic Ray Station (CRS – LNF) and at H4 (CERN)

MM performances

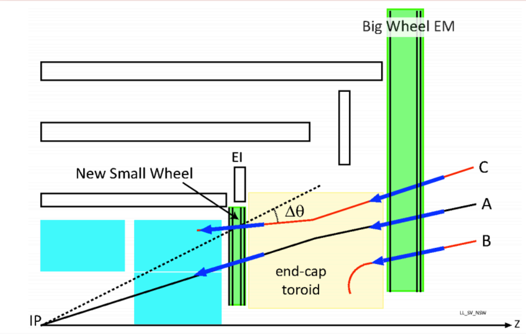
The actual SW (Small Wheels):

- the first muon spectrometer station in the forward region (End-Cap)
- angular coverage: $1.3<|\eta|<2.7$
- between the End-Cap calorimeter and the toroid ($z = \pm 7$ m)
- CSC e MDT (TGCs per la 2 coord.)

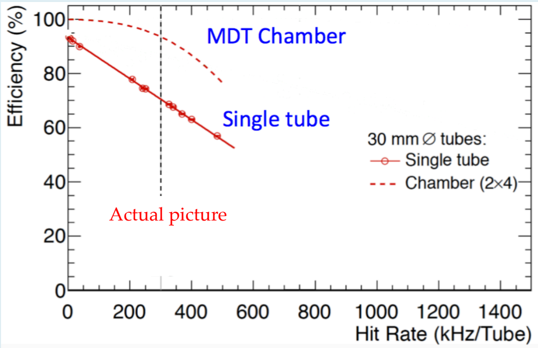


An improvement in the performances is required both for the trigger and tracking in view of the increasing luminosity for the future LHC runs (5-7 10^{34} cm^{-2} s^{-1})

Level 1 End-Cap trigger, only BW, dominated by fake trigger events (type B e C)



HL-LHC: (MDT) expected frequency > 5 MHz / tube -> efficiency decrease significantly



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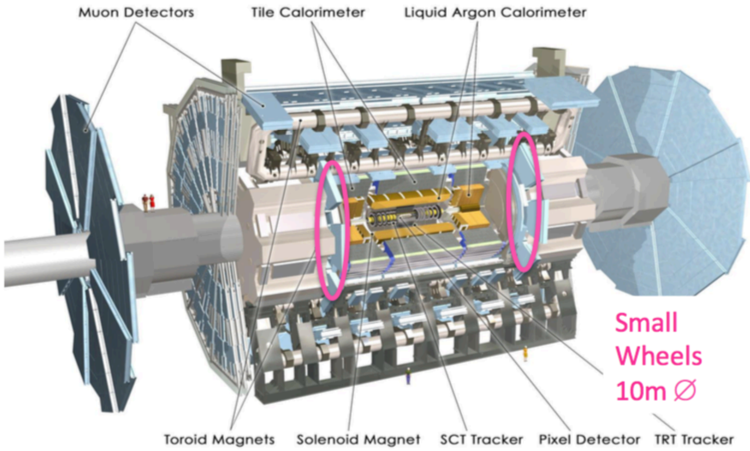

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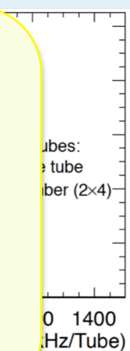
B e C)

HL-LHC:



Need a detector:

- fast and able to perform a precision tracking (~100 μm per plane)
- able to cope with the increasing background particle flux (pileup) as the luminosity increases
- reject fake triggers

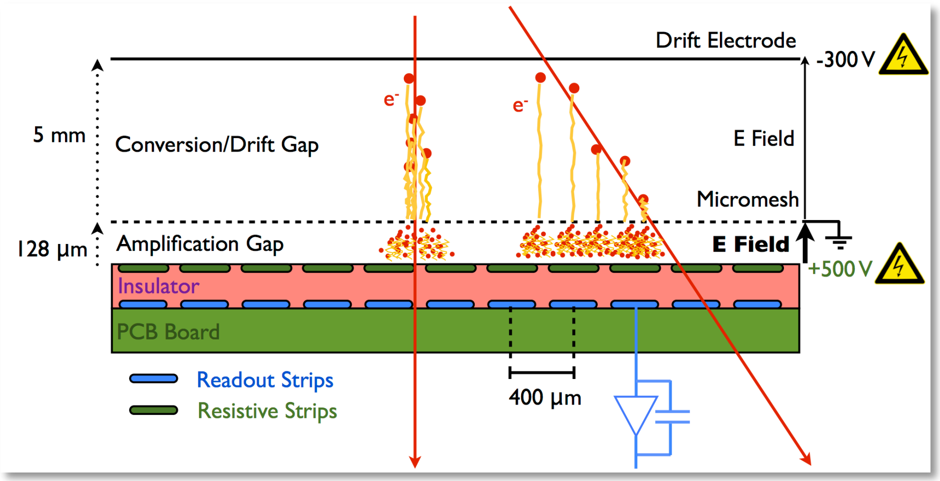
Y.Giomataris et al. NIM A 376 (1996) 29-35

MicroMeGaS (Micro Mesh Gaseous Structure) are micropattern gaseous detectors

- charged particles ionize the gas in the detector volume (100 pairs/cm in Ar:CO_2 93:7 for μ)
- e^- produced by ionization are transported to the drift field in the drift region, traverse the mesh and are amplified by avalanches (high electric field between micro-mesh and read out strips).
- signal collected on resistive strips and transferred by capacitive coupling to the read-out strips
- amplification factor ~10^4 and transparency of the mesh to electrons ~1 (E_A ~ 100 E_C)
- fast evacuation of positive ions: 100 ns allowing to work in high luminosity regimes

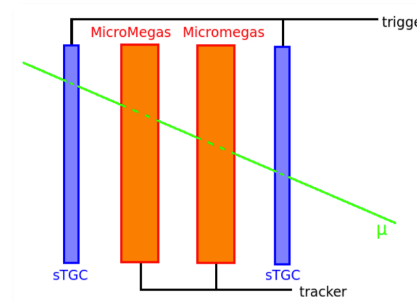
Working conditions:

- gas: 93% Ar - 7% CO_2
- conversion gap 5 mm, amplification gap 128 μm
- HV (mesh to ground):
  - Conversion: HV_{drift}= -300 V, h=5mm, E_C~500 V/cm
  - Amplification: HV_{RO}= 590 V, h=128μm, E_A~50 kV/cm
- resistivity strip≈10 MΩ/cm (introduced to reduce the probability of discharges)
- strip width 300 μm, strip pitch 425-450 μm



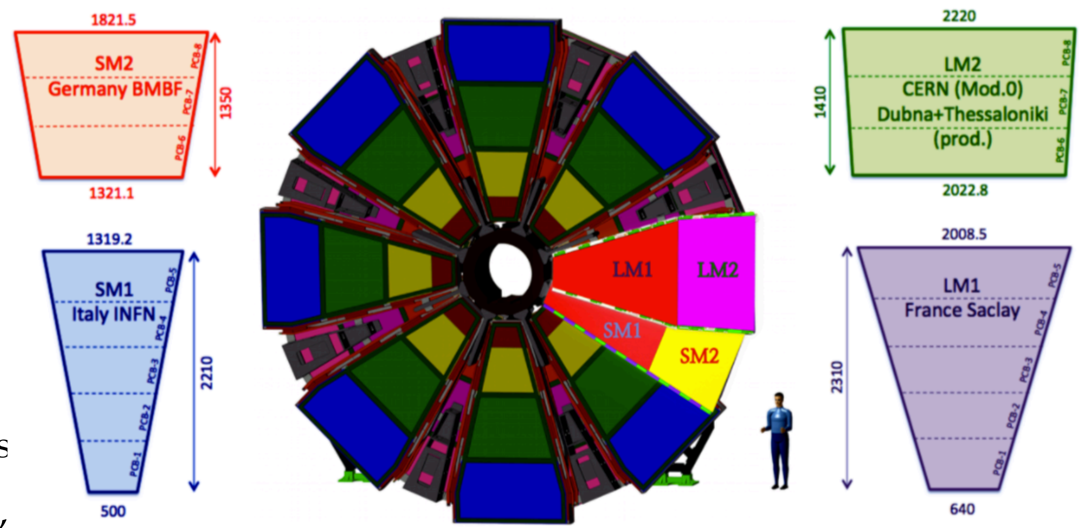
MicroMegas:

- good tracking capability (**~100 μm per layer**)
- able to work in **high luminosity regimes** (15 kHz/cm^2)
- **ε > 97% and σ < 100 μm !**
- **-> NSW of the ATLAS experiment!**



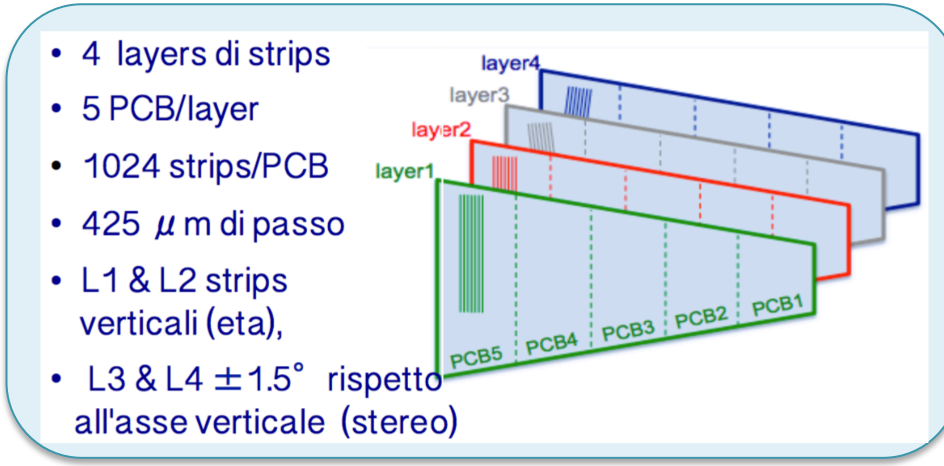
NSW, wheel structure:

- 8 large sectors (LM) and 8 small ones (SM) (2 MM modules per sector)
- MM aim: **precision tracking** (between 2 sTGC chambers for trigger)
- **p_T resolution ~15% at 1TeV**
- 4 type of chambers: LM 1-2, SM 1-2
- production shared between several institutes and industries: **Italy (SM1)**, Germany (SM2), France (LM1), Russia/Greece (LM2 – CERN for drawings and first prototypes)



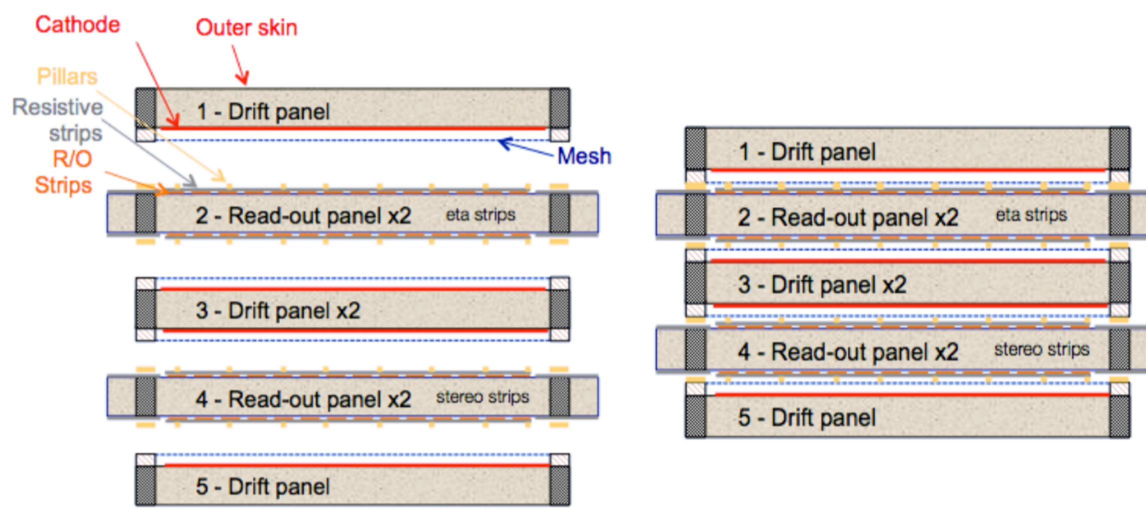
L' INFN is involved in the construction of 32 SM1 chambers (~2m^2) in order to reconstruct muon tracks trough the 4 layers of which they are composed (forming a quadruplet):

2 of the 4 layers have strips inclined by ±1.5° in order to reconstruct the 2nd coordinate

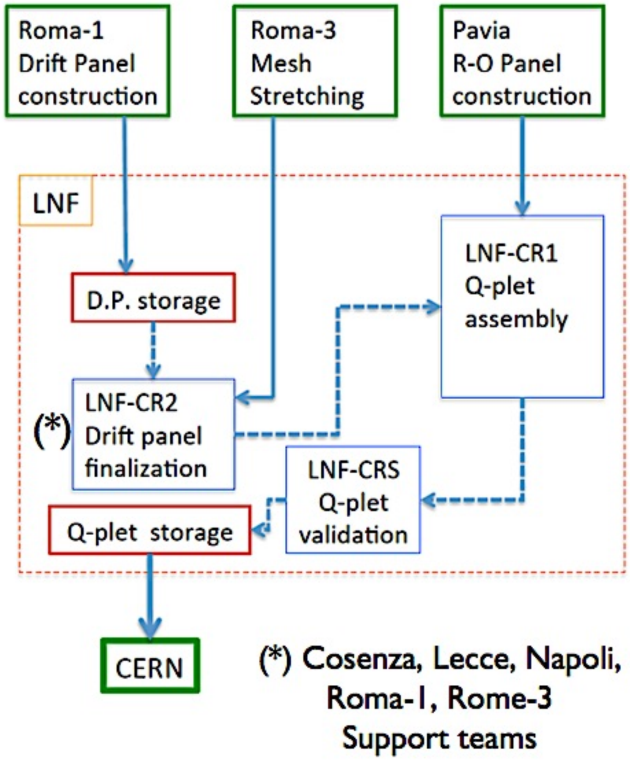


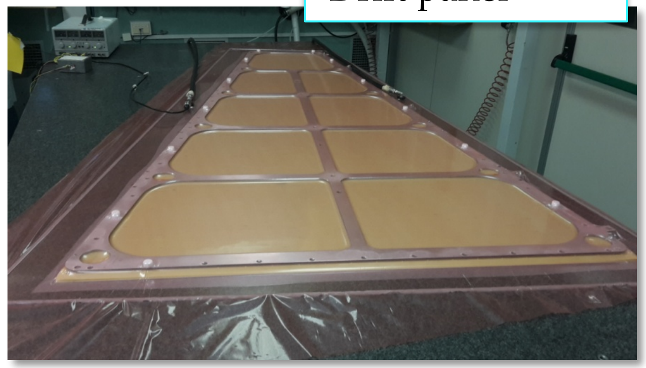
In order to compose a quadruplet, 5 panels are needed:

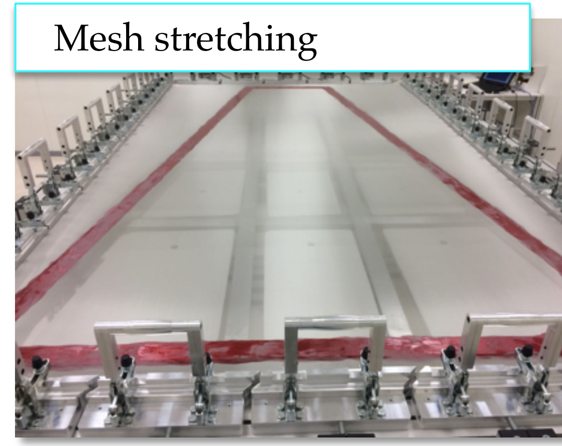
- 2 read out panels (1 eta and 1 stereo)
- 2 external drift panels
- 1 central drift panel

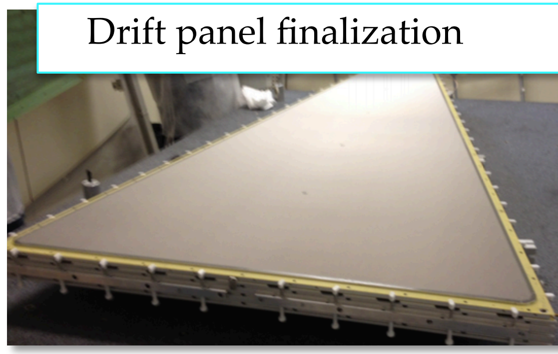


SM1 production scheme

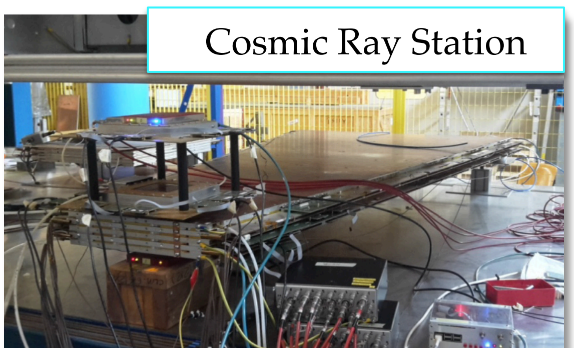


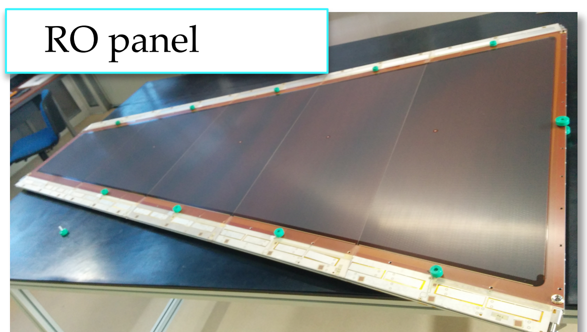

Drift panel


Mesh stretching

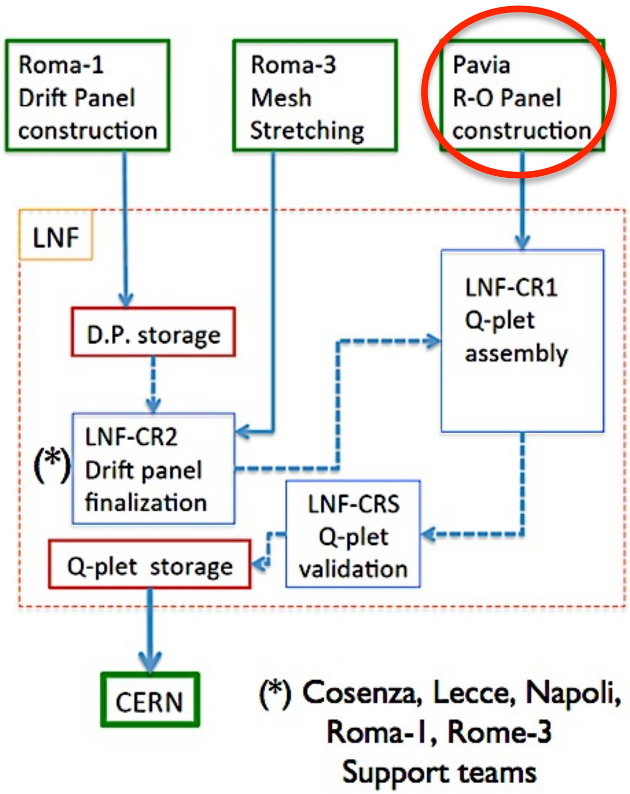

Drift panel finalization

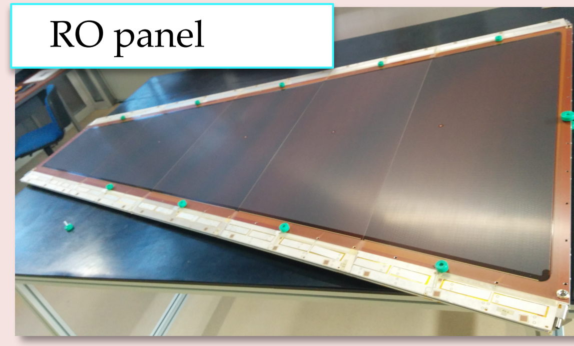

Assembly


Cosmic Ray Station


RO panel

RO panel construction

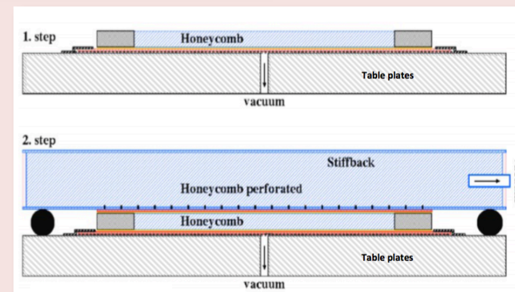


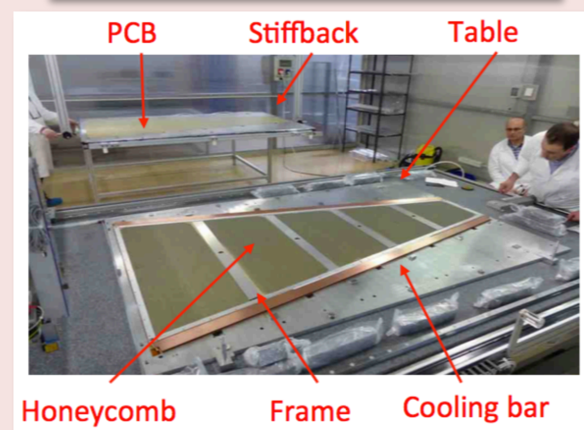


5x2 trapezoidal PCB sheets

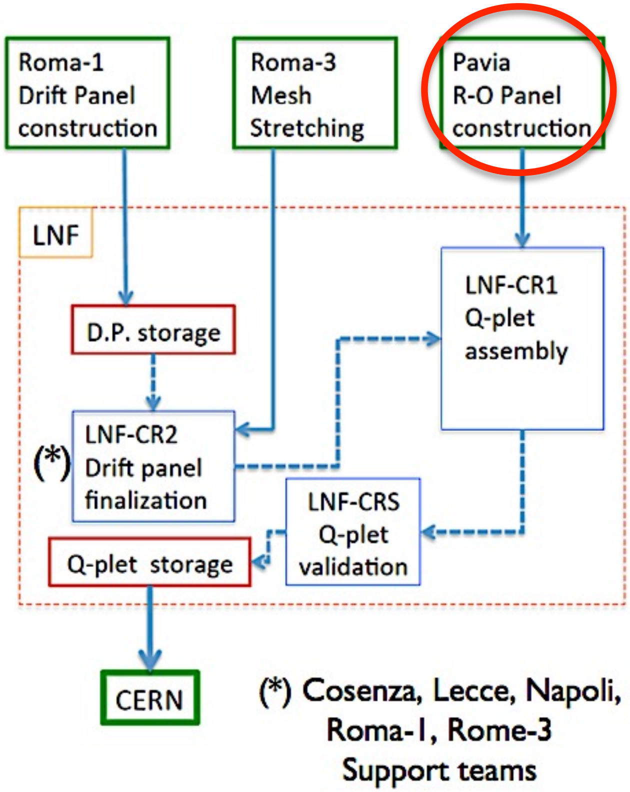
Gluing technique: **Stiffback**

- one PCB plane is sucked on the Al plane fixed on the granite table, the other one on the stiffback (P/Pext ~ 0.2)
- Glue distributed automatically, the internal components are positioned
- stiffback rotated and positioned on the assembled structure
- panel planarity < 37 μm





RO panel construction



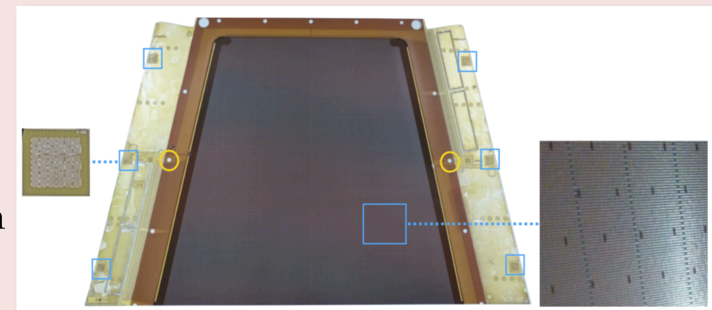
Strip alignment procedure

Mechanical alignment (pin, supports):

- alignment of the supports to the PCB, Stiffback and granite tables

Rasnick technique:

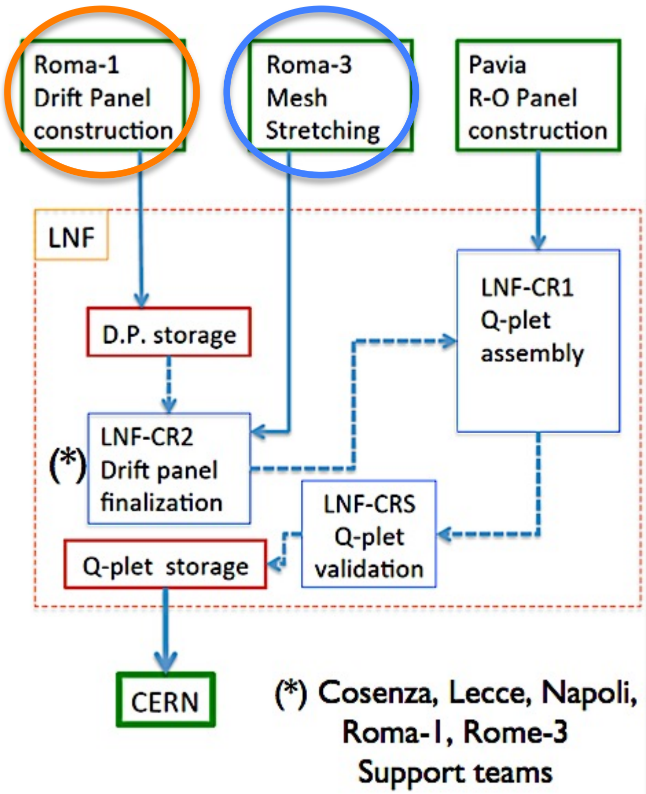
- coded masks read by contact-CCD on the external side of pcbs -> alignment and rotation of the strips



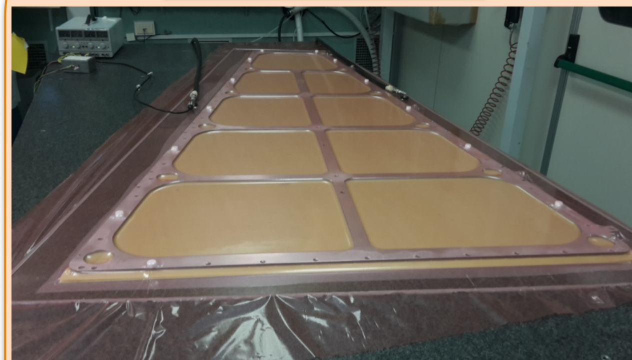
- layer alignment:
  dedicated technique (Jig) starting from the position read on the coded mask

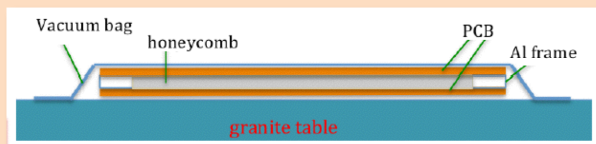
Requirements: 30 μm of RMS in η, 80 μm of RMS in the transverse direction (z)

SM1 production scheme



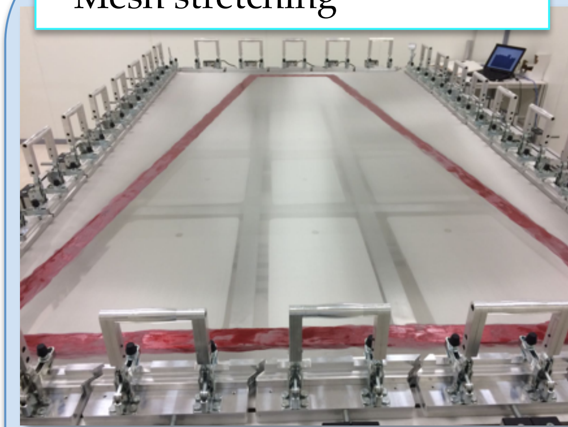
Drift panels





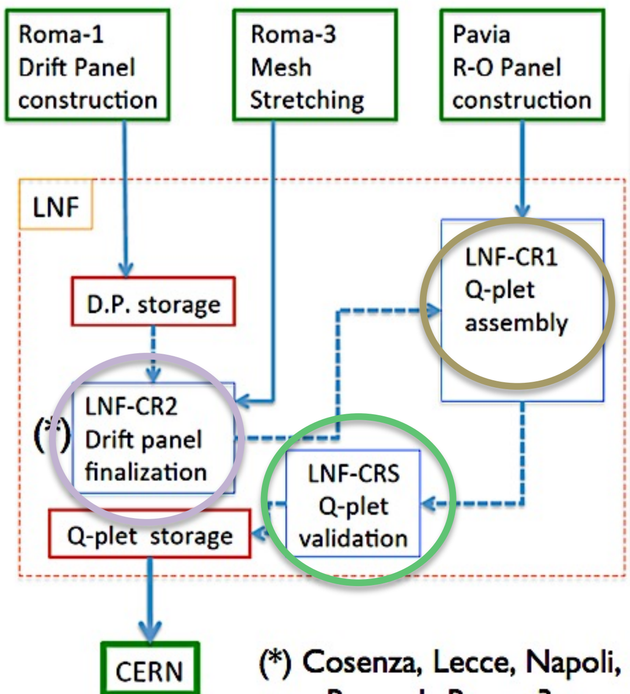
- panel gluing with the vacuum bag technique (P/Pext ~ 0.1)
- mask used to guarantee uniform pressure on the whole panel

Mesh stretching



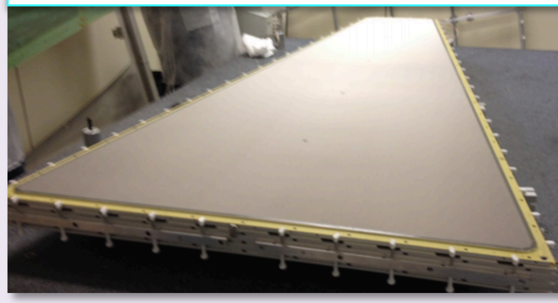
- clamp are closed and slowly rolled away from each other till the optimal tension on the mesh is reached: ~10 N/cm

Drift panel construction



(*) Cosenza, Lecce, Napoli, Roma-I, Rome-3 Support teams

Drift panel finalization

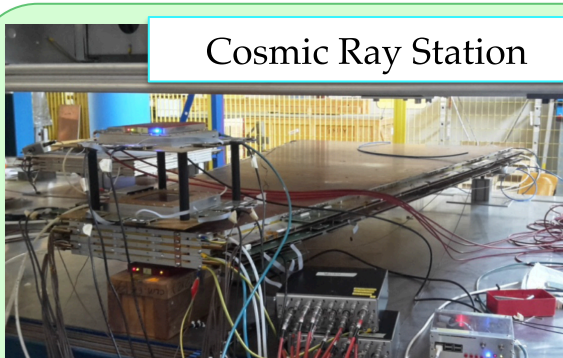


- gas leak test, washing, drift panel finalization

Assembly

- vertical assembly
- alignment using pins < 60 μm

Cosmic Ray Station

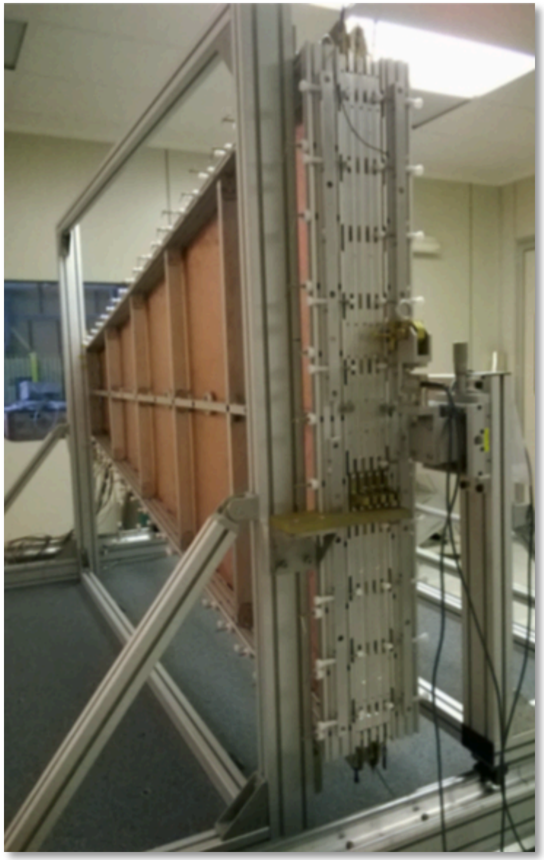


- validation of the quadruplet at the LNF -CRS

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

Mechanical precision measurements represent a challenge in the construction of the MM:

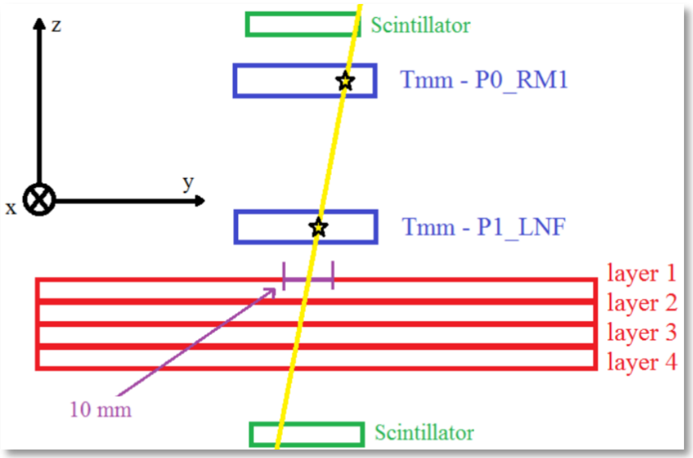
- strip alignment on each layer of 30 μm RMS in η
- planarity within 80 μm RMS

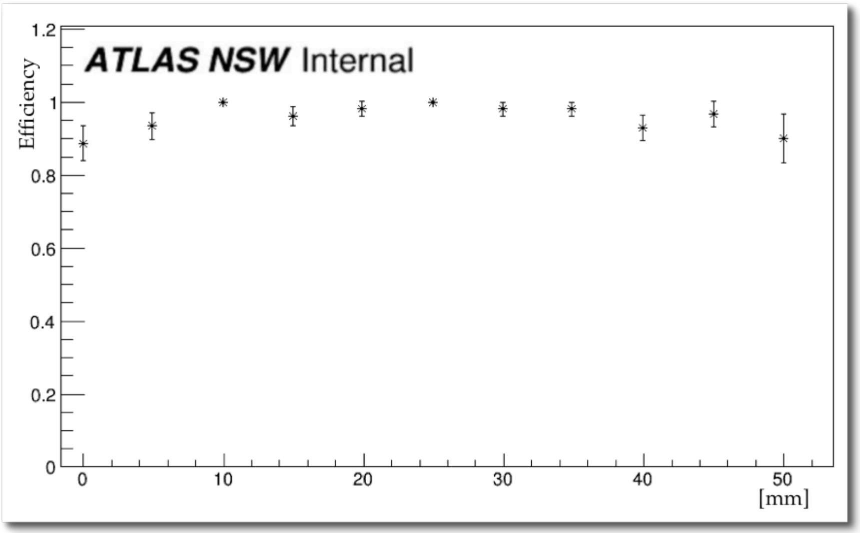


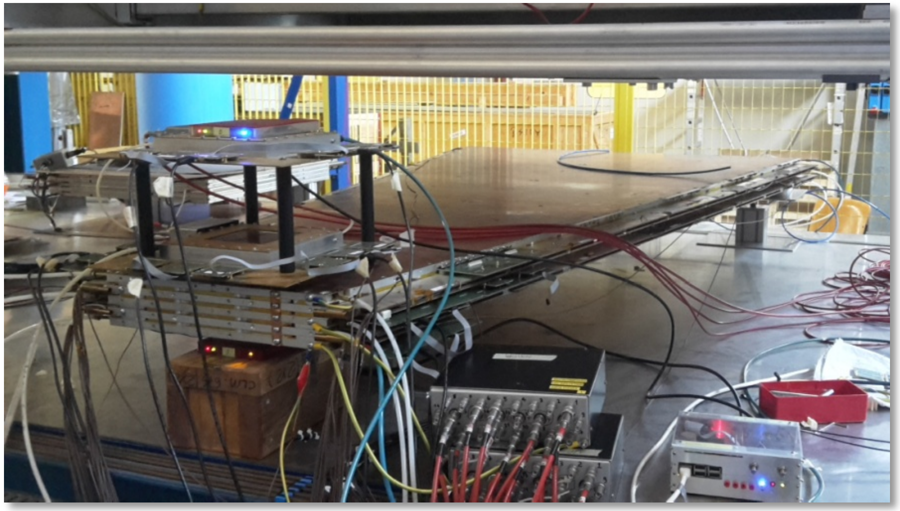
	Ritmo di produzione	Frazione del totale
Drift panels (RM1)	1 panel/week	40/96
Stretched mesh (RM3)	4 mesh/week	35/128
Finalized drift panels (LNF CR2)	3-4 panels/week	24/96
RO Panels – Eta (PV)	1 panel/2 weeks	3/32
RO Panels – Stereo (PV)	1 panel/2 weeks	4/32
Quadruplets (LNF CR1) and validation (CRS LNF)	1 quadruplet/2 weeks	2/32

Mod 0.5 tested at the LNF - CRS:

- cosmic muons
- 2 scintillators for the trigger
- 2 Tmm (prototype MM of smaller dimension 10x10 cm^2) used for external tracking
- efficiency > 98%

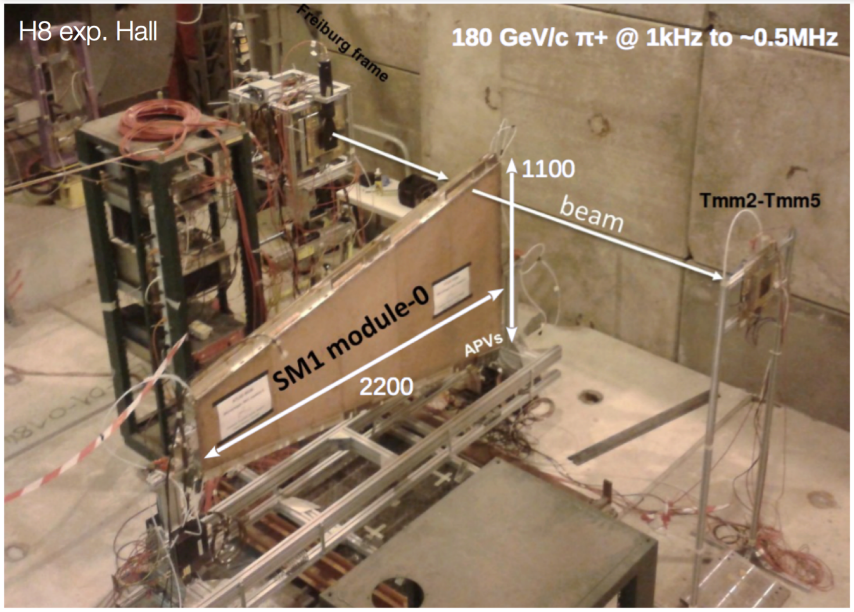


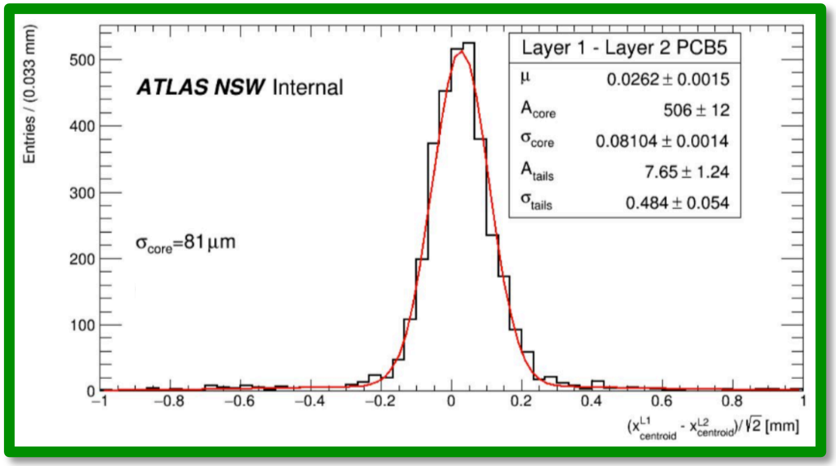


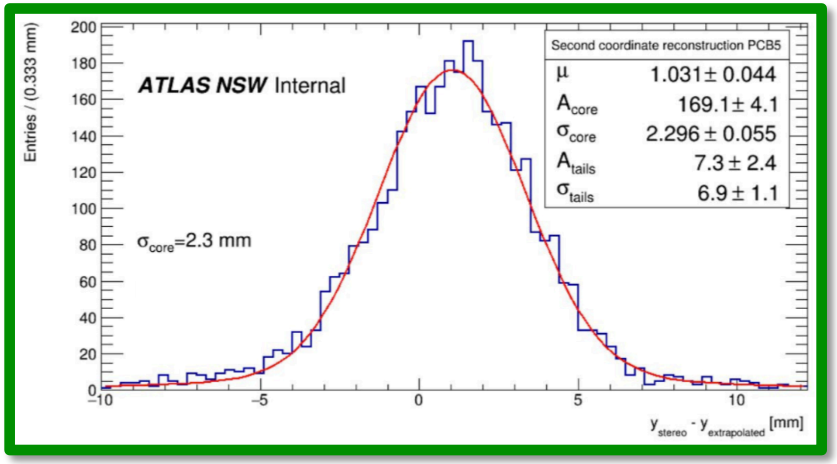


Mod 0 tested at CERN:

- H4 beam line of the SPS: π^+ beam of 180 GeV/c with a frequency between 1-500 kHz and beam dimension of 1x1 cm^2
- 5 Tmm used as reference
- performance are within expectations: σ< 100 μm precision coordinate (η)







Conclusions

- MM chambers will be used after LS2 for the precision tracking in the NSW of the ATLAS experiment
- technology chosen to be used in demanding enviroments as the high pseudorapidity regions in the LHC experiments
- the SM1 INFN group has been the first one to construct two full scale prototypes
- performances of the prototypes are within expectations
- test and assembly procedure validated
- currently 2 SM1 chambers assembled -> to be tested for validation

Thanks for your attention