Micromegas for the ATLAS upgrade (MAMMA)

Status report

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for the
MAMMA Collaboration

Work in close collaboration with CERN PCB workshop (R. de Oliveira)

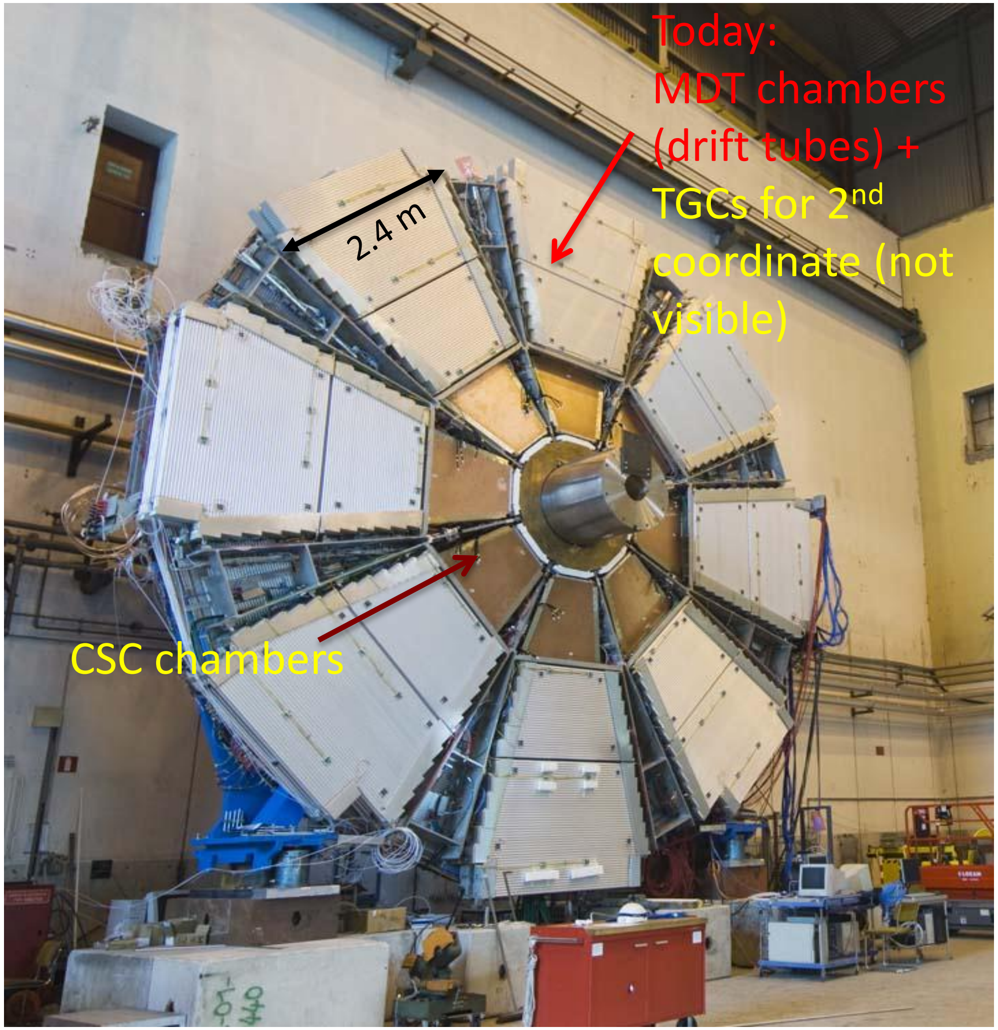
Topics covered

- Status of NSW project in ATLAS
- 1 x 1 m^2 prototype MM chamber, first experience
- 1 x 2 m^2 chamber construction issues & plans
- Construction simplifications in view of production
- Test of mechanical precision of large micromegas (MM) boards
- Next steps

Status of the New Small Wheel project

- The ATLAS upgrade programme foresees to replace in the LHC shutdown 2018 the first station of forward muon chambers (Small Wheel) to cope with the anticipated higher rates
- Early May 2012 the ATLAS Muon Collaboration chose to equip the New Small Wheels with two detector technologies, each covering the full detector area: thin-gap MWPCs (TGCs) and micromegas
- The decision was subject to a number of milestones to be fulfilled by end of 2012
- Initial Design Review took place 29/30 August 2012
- Kick-off meeting on 31 August(for institutes to express their interest to participate in the NSW)
- ATLAS Executive Board (EB) endorsed the project
- ATLAS Collaboration Board (CB) approval is expected this week

ATLAS Small Wheel upgrade project



Equip the New Small Wheels with sTGCs and micromegas detectors

- Detector dimensions: 0.5–2.5 m^2
- Combine precision and 2nd coord. measurement as well as trigger functionality in a single device
- Each detector technology comprises eight active layers, arranged in two multilayers
- Each MM layer comprises two coordinates with 0.5 and 1.5 mm strip pitch

  ⇒ 2M readout channels

  ⇒ a total of about 1200 m^2 of detection layers

Milestones for MMs

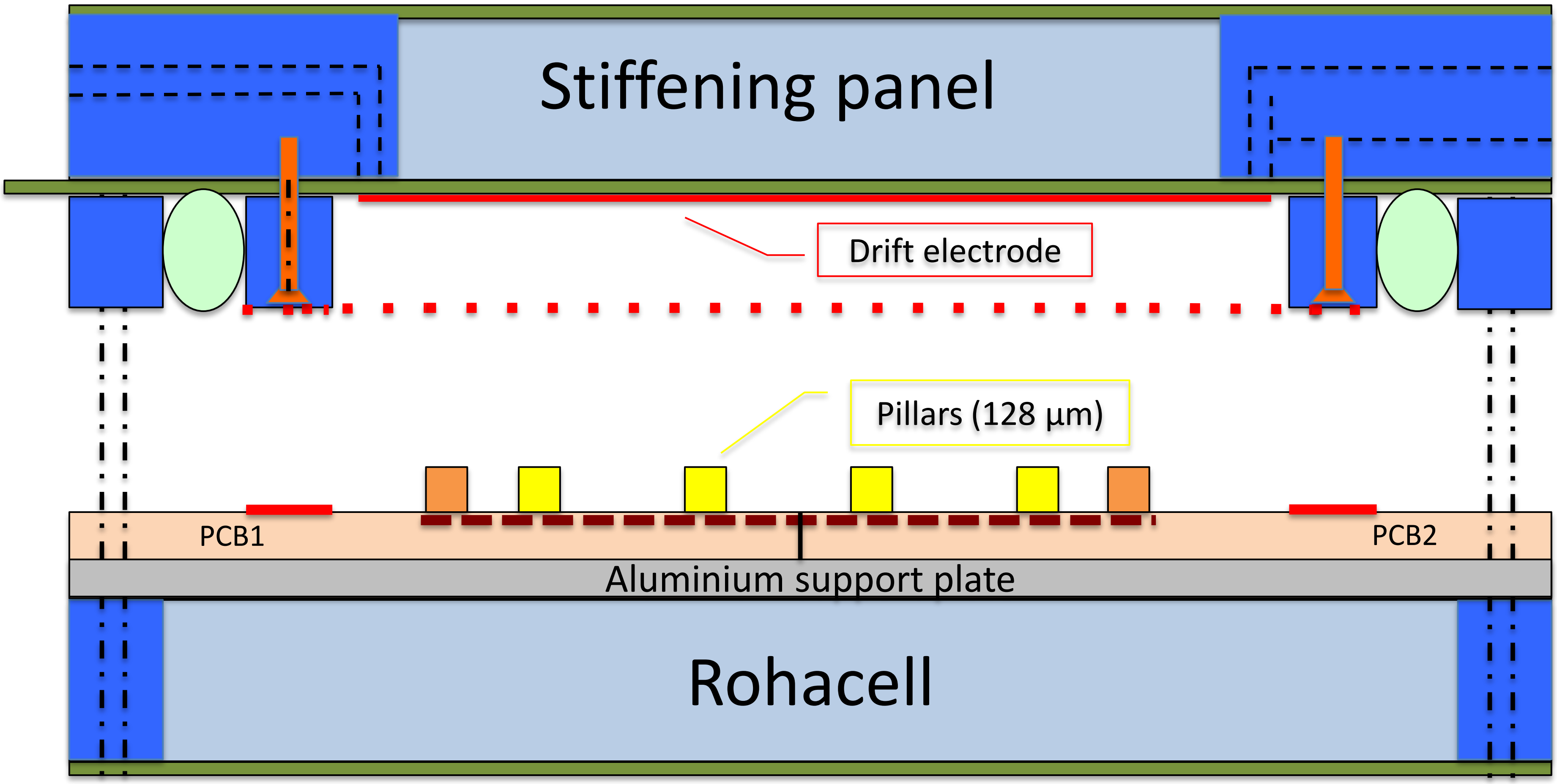
- Demonstration that MMs of 2 x 1 m^2 can be built with the required precision
- Demonstration of resolution for inclined tracks (µTPC scheme) – has been addressed and shown in H6 test beam during summer (see talk by T. Alexopoulos in WG2 on Thursday)
- Demonstration that sparks do not create long-term damage to the chambers – has been addressed at CEA Saclay by studying alpha decays in MMs (see talk by F. Jeanneau in WG2 on Thursday)
- Demonstration that MMs can operate in magnetic field and the required spatial resolution can be achieved (H2 test in June)

- In addition reporting items include:
  - Demonstration of MM trigger concept (H6 test in Aug.–Oct. using new VMM1 chip from BNL)
  - MM industrialization (see talks by F. Jeanneau and M. Hoffmann in WG7)

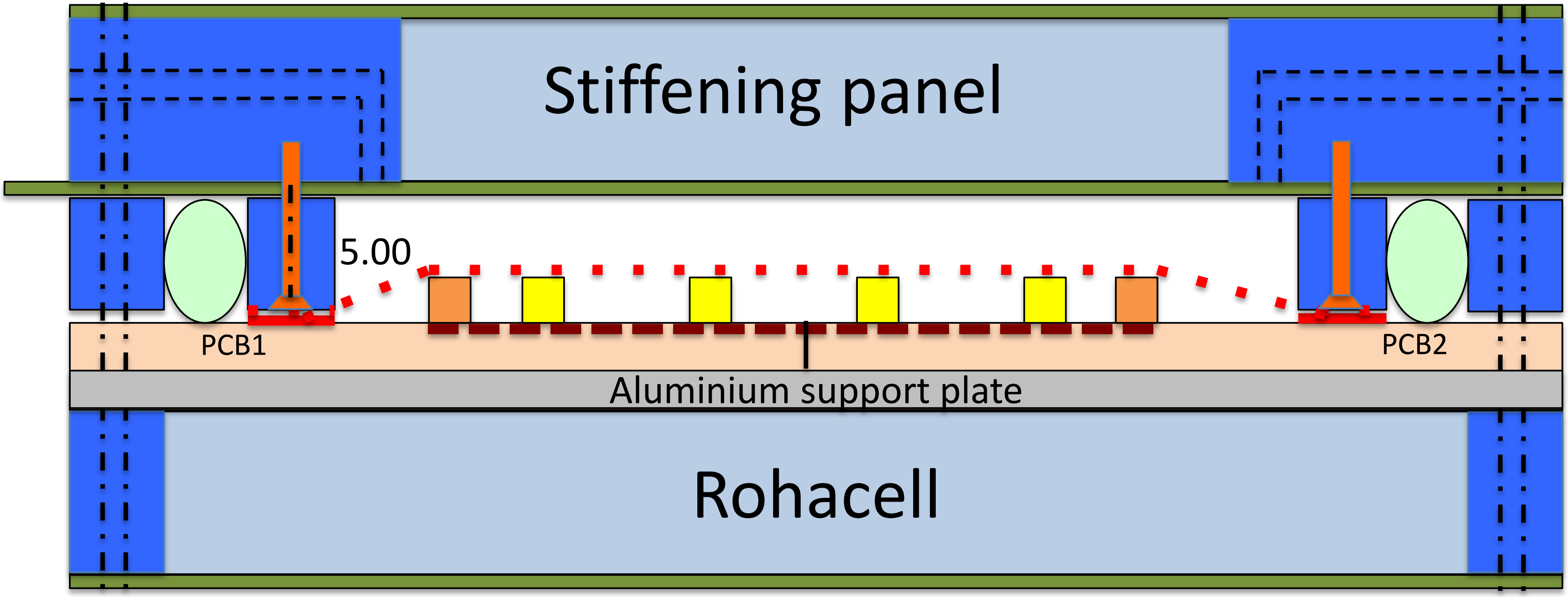
Towards large-area MMs

- First step was to build a 1 x 1 m^2 chamber and to test it during summer in the H6 beam
  - The goal was to establish a construction concept that could be used for the larger chambers
- Given that the machines to go to larger dimensions were not yet installed in the CERN PCB workshop we were obliged to go with standard-size PCBs.
- The next question was the mesh, bulk or no bulk?
  - We had experienced problems in large chambers with currents; any dust caught under the mesh is hard to remove
  - We opted for a non-bulk technique that uses also pillars to keep the mesh at a defined distance from the board, however, the mesh is not fixed but integrated with the drift-electrode panel and placed on the pillars when the chamber is closed.

1 x 1 m^2 sketch (not to scale)



1 x 1 m² sketch (closed)



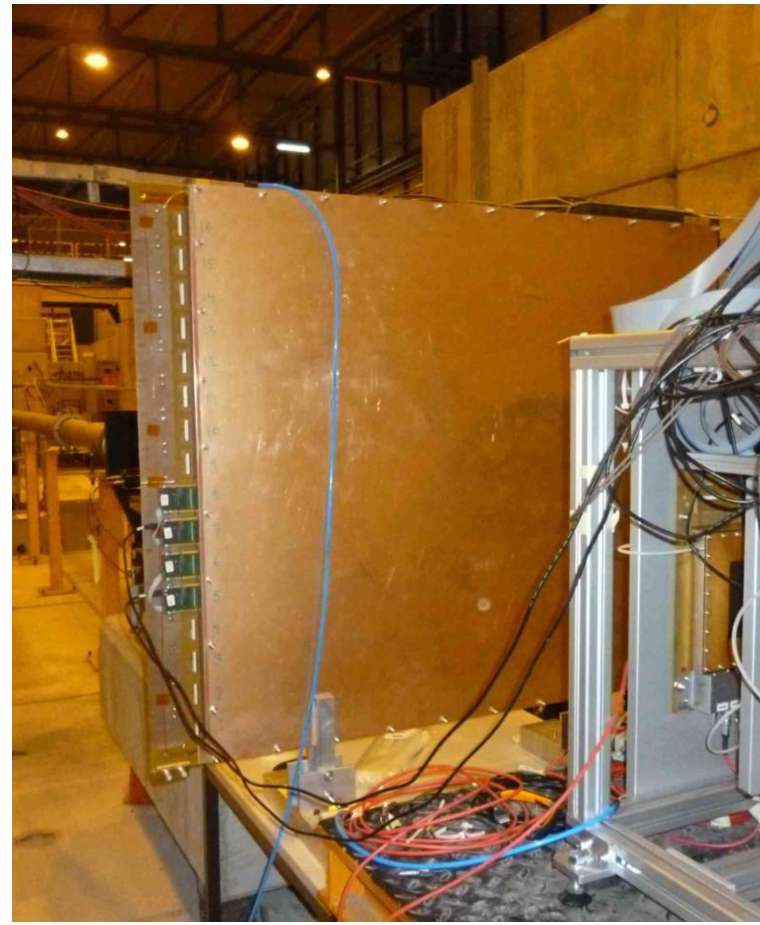
1 x 1 m^2 micromegas

1 x 1 m^2 readout board composed of 2 boards of 0.5 x 1 m^2
2048 strips of 1.06 m length with a pitch of 0.45 mm

Drift electrode and mesh panel (top) and detail showing the O-ring as gas seal

1 x 1 m^2 micromegas

1 x 1 m^2 MM being closed in Rui's 'clean room



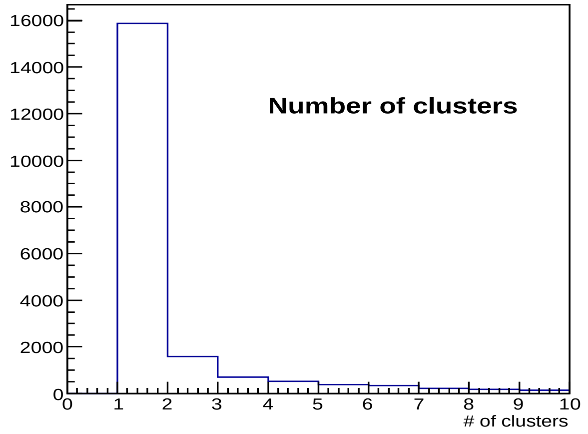
1 x 1 m^2 MM in H6 test beam

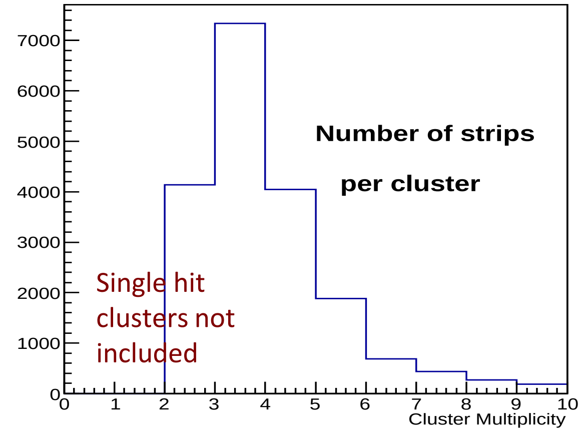
First experience with 1 x 1 m^2 chamber

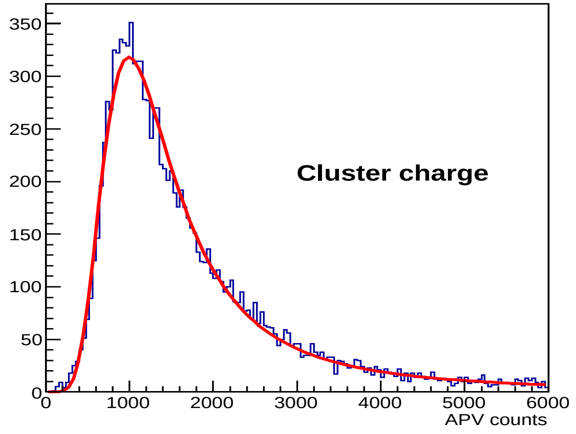
- Chamber construction and assembly was straight-forward
  - Separation of readout panel and drift/mesh panel is attractive
  - Chamber can be opened and cleaned, if required; easy assembly
- The chamber works as expected
  - Initial currents (few 100 nA to µA) traced back to gas pipe material (Rilsan) leading to high water content in the gas, cured by using Cu pipes (after that very low currents)
  - Cosmics showed nice signals and good homogeneity over full chamber area; low noise despite 1.06 m long strips
  - Good performance confirmed by test beam results

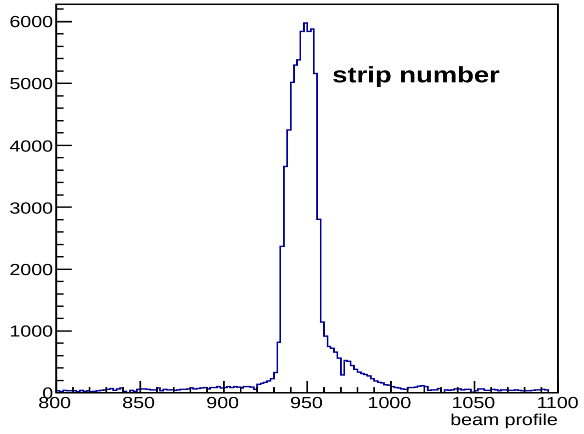
Performance of 1 x 1m^2 MM

Test beam results (120 GeV pions)





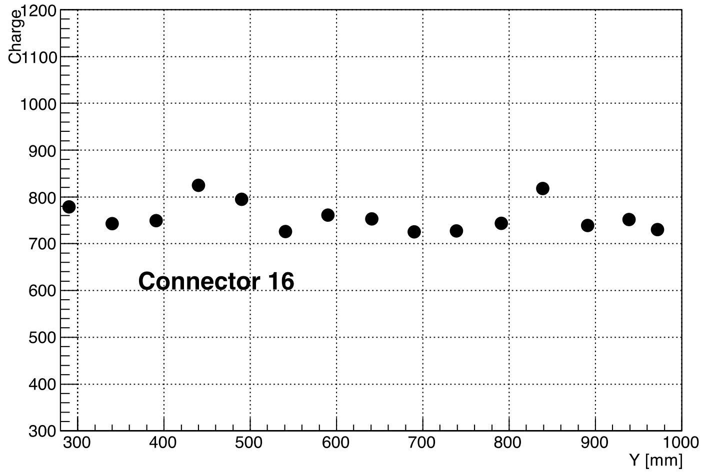


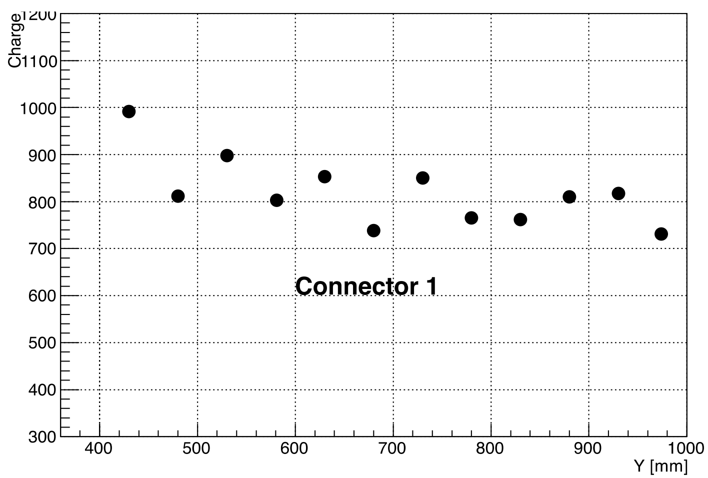


Typical distributions for H6 run

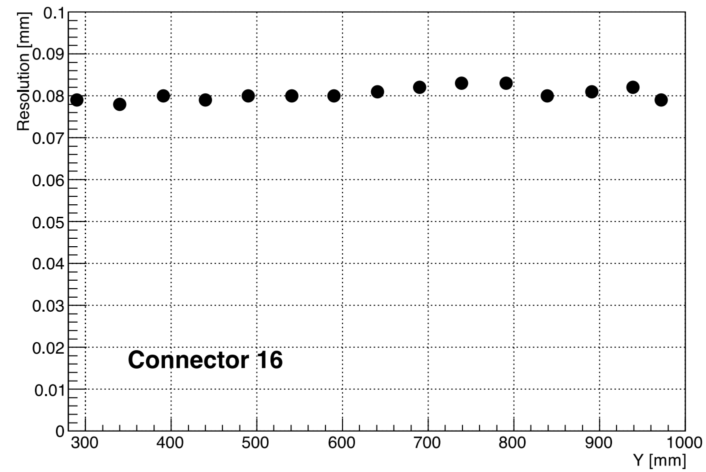
Performance of 1 x 1m^2 MM

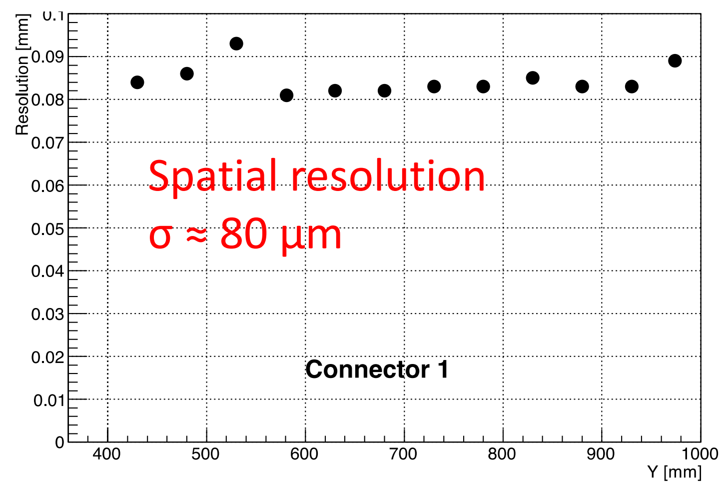
Test beam results (120 GeV pions)





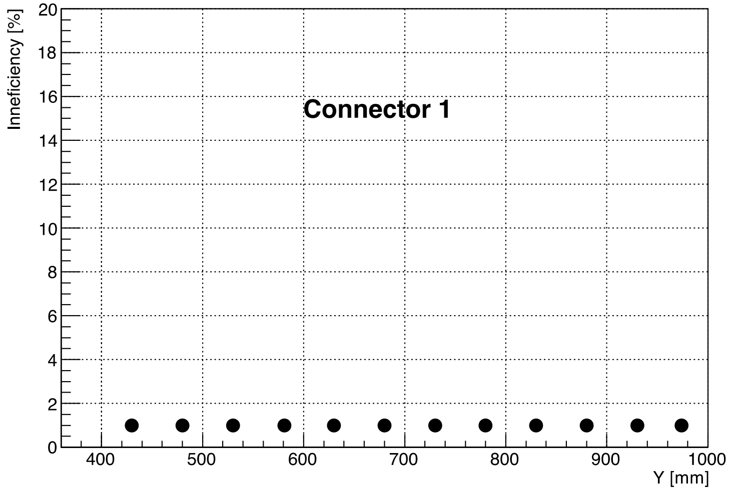
Charge response along strip

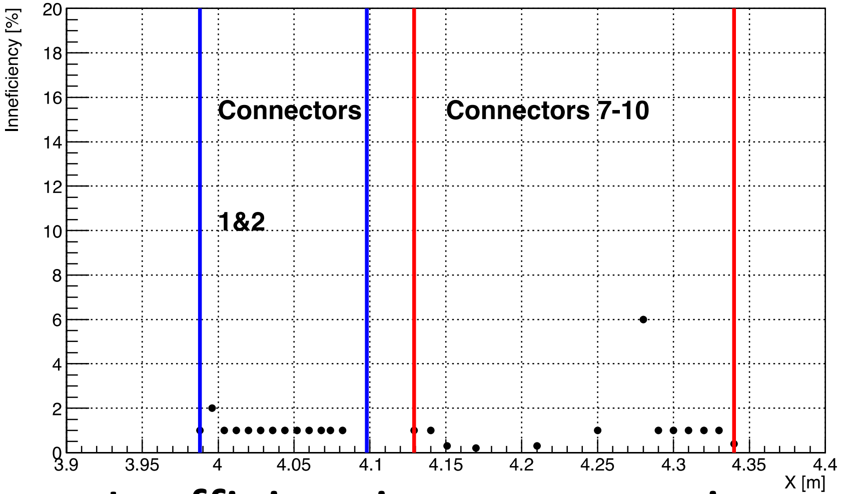




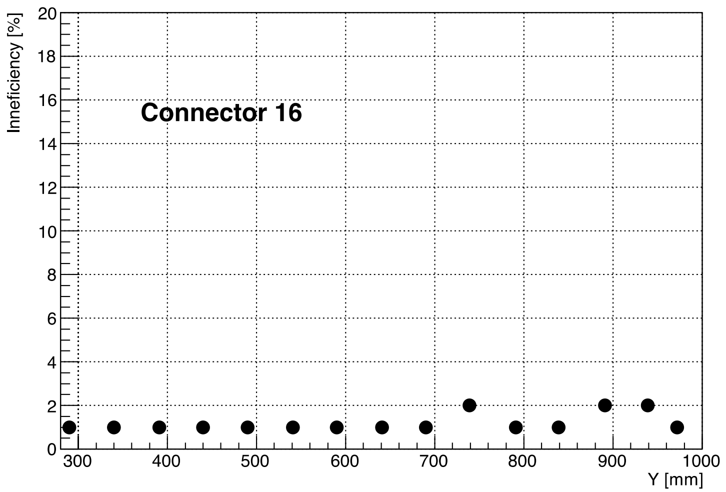
Resolution along strips

Inefficiencies for 1 x 1m^2 MM





Inefficiencies across strips



Inefficiency ≈ 1%

(compatible with the area covered by the pillars (d= 4 mm))

Inefficiencies along strips

Preliminary conclusions on 1 x 1 m^2 MMs

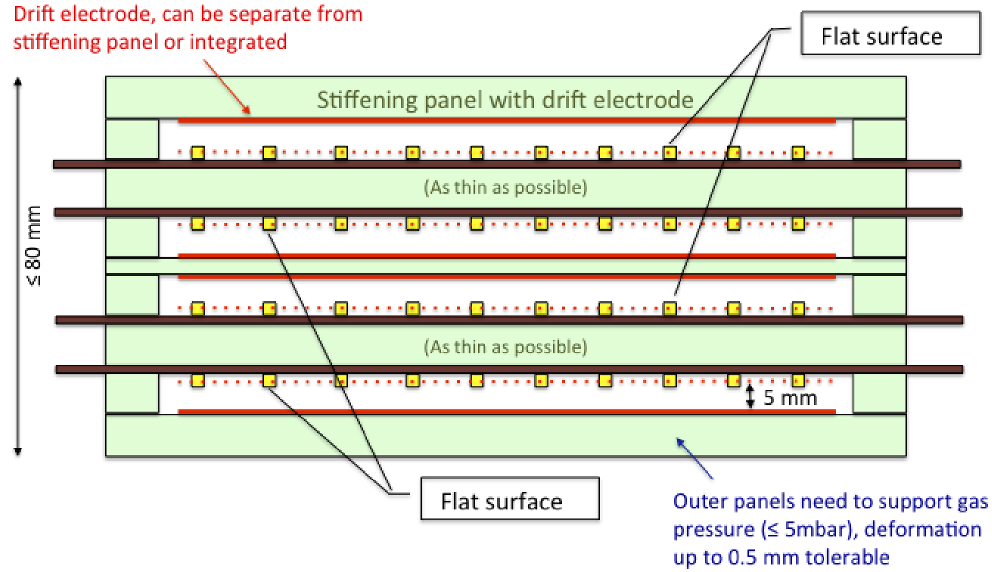
- The chambers work nicely
  - Response is as expected and homogeneous (at least to our requirements)over the full area
  - With strips of 1.06 m length and 0.45 mm the pedestal fluctations are about a factor 2 larger than for the 10 x 10 cm^2 MMs
  - Beware of plastic (Rilsan) pipes
- The floating mesh concept works
  - The chamber needs an about 10% higher HV compared to a bulk chamber, suggesting that the amplification gap is about 10–15 µm larger

Towards 2 x 1 m^2 MMs

- Requirements:
  - Chamber dimensions 1 x 2.4 m^2 (overall)
  - 2 x 2048 readout + resistive strips (0.45 mm pitch), separated in the middle
  - Flatness of readout plane to better than 60 µm over full area
  - Alignment of layers with respect to each other to 40 µm
- Construction ideas
  - Follow the scheme used for 1 x 1 m^2 chamber
  - Four 0.5 x 1.2 m2 PCBs glued to stiffening panel
  - Floating mesh, integrated into drift-electrode panel

Multilayers

- The basic detector unit is an assembly of four layers that form a stiff multilayer.
- The individual (flat) layers should be arranged in two doublets in which the micromegas are mounted back-to-back
- The flat surfaces of all layers should be parallel to within 40–60 µm and the strips in all layers must be parallel with the same precision.
- The overall size of the ML (3 or 4 units or full sector) is still subject to discussion and depends on the overall NSW layout
- Strip position references should be visible for the alignment system



Sketch of a multilayer arrangement (not to scale). The overall thickness should not exceed 80 mm.

Several assembly schemes are under study

Board construction improvements under study

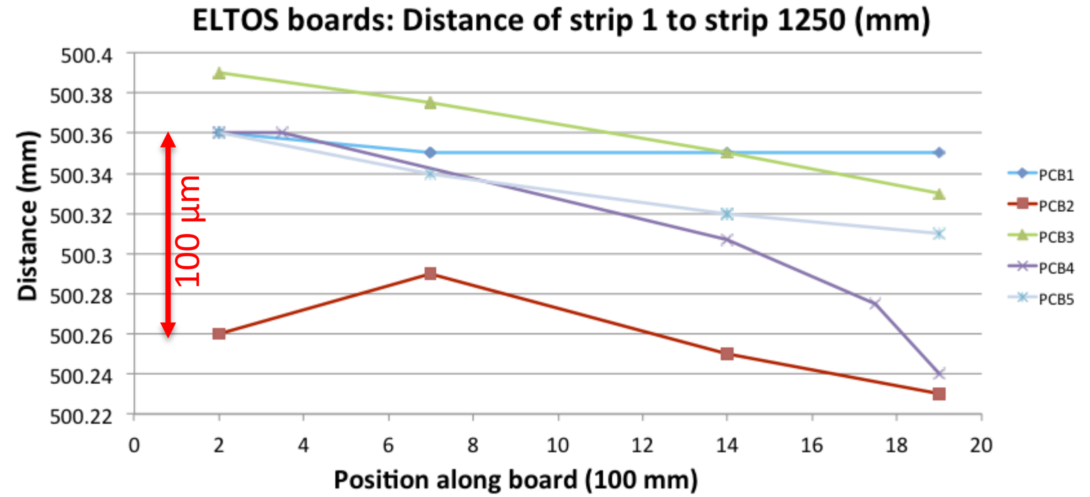
- Board weight
  - PCB thickness of 0.5 mm or less seems feasible
- Printing of resistive strips and 2nd coordinate strips instead of etching
  - First tests with printing the resistive strips were done in Kobe (Japan) and at CERN with promising results (see Rui’s talk)
  - Expect considerable reduction of production time and cost
- Connectivity
  - For 2 M channels, connectors are an important cost factor. We are studying a connector-less system using elastomer Zebra interconnects that does not require any soldering.
- All three features are incorporated in the design of the next (small) prototype (under construction)

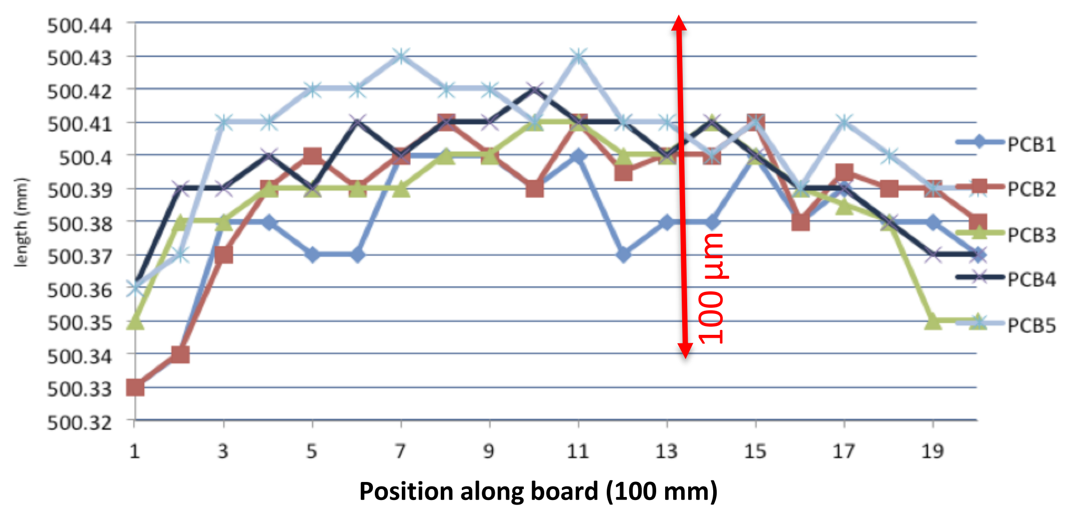
PCB strip precision measurements

- Largest boards to be produced are 1 x 2.4 m^2
- In order to understand which strip precision can be obtained in a standard PCB, we ordered 6 boards with dimensions of 1 x 0.6 m^2 and five boards of 2 x 0.6 m^2 from Eltos, Arezzo, Italy, and Triangle Lab, Carson City, Nevada, USA
- The art work (1250 strips of 300 µm width and 400 µm pitch) was done at CERN, no special precision was asked to the companies
- Board quality was in general good, but not perfect
- Strip pitch of 400±1 µm was achieved, however, a max. deviation of distance between 1^{st} and last strip (0.5 m) of up to 100 µm was observed in boards of both producers
- Reason for this needs to be understood, probably the film masks are the culprits

Measurements of 2m boards

- Measurements with laser interferometer and traveling microscope
- Different boards from same producer follow same trends, but different for Triangle and Eltos
- Similar results for 1 m boards
- Results are almost OK; can probably be improved without adding (too much) cost





Next steps

- Construction and test of a few small chambers to test the ideas outline above
  - Test beam in 2nd half of October
- Construction of 2 x 1 m^2 MM chambers for end of 2012 (milestone)
  - Construction follows the scheme used for the 1 x 1 m^2; 4 boards and floating mesh
  - In parallel, follow bulk scheme

Time line for MM production

- Demonstration of 2 x 1 m^2 MM construction by end of 2012 (milestone)
- NSW Technical Design Report (TDR) by 31 May 2013
- By mid 2013 a baseline detector design should be available, followed by a full-size prototype in fall 2013, involving industry
- Module_0 in 2014, in parallel with setup of production and assembly sites and procedures
- Production in 2015/16
- Installation as of 2016 possible, if NSW structure available
- Installation in ATLAS during LHC shutdown 2018