Micromegas for the upgrade of the ATLAS muon chambers for the SLHC

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on behalf of

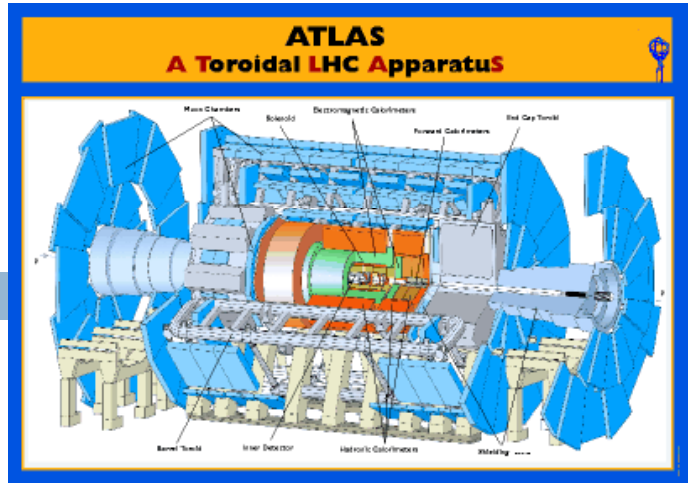
Arizona, Athens (U, NTU, Demokritos), Brookhaven, Bucharest, CERN, Harvard, Naples, Saclay , Seattle, U. of Science and Technology of China, South Carolina, St. Peterburg, Thessaloniki

https://twiki.cern.ch/twiki/bin/view/Atlas/MuonMicromegas

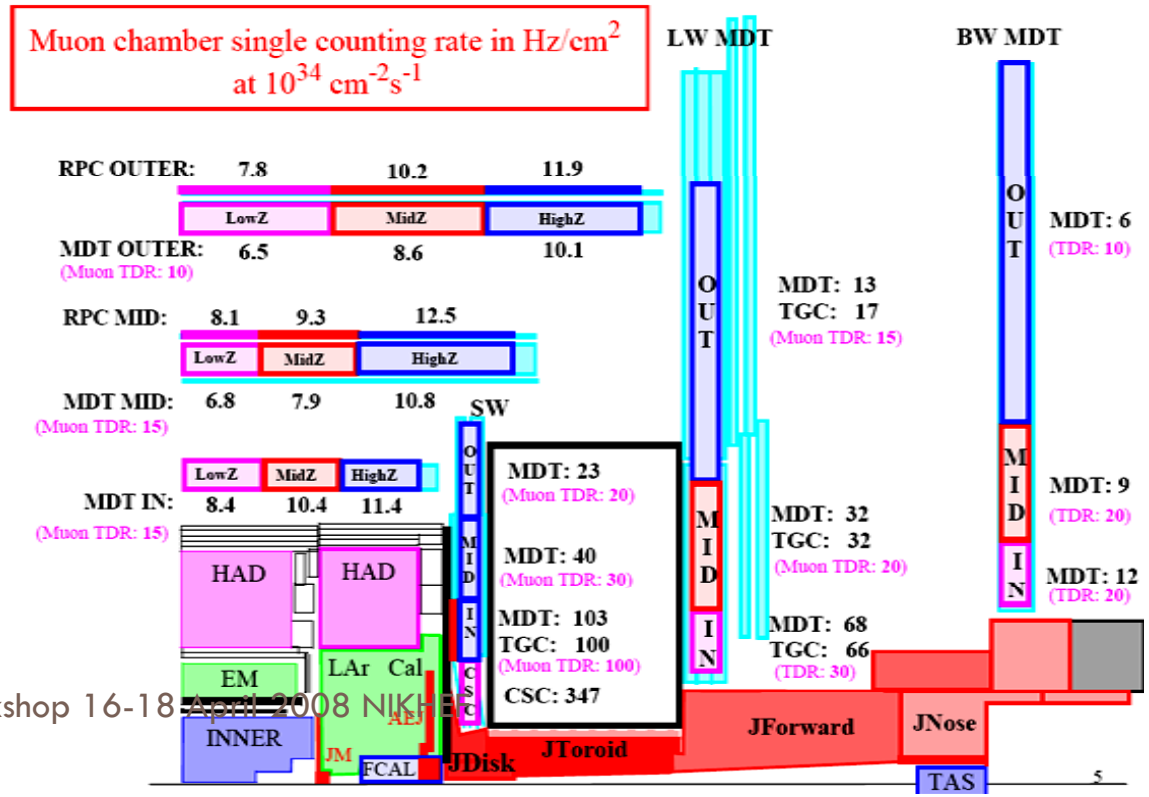
OUTLINE

- Introduction and motivation
- Goals of R&D activity
- Prototype construction
- Test beam 2007
- Status and plans
- Conclusions

The Upgrade of ATLAS

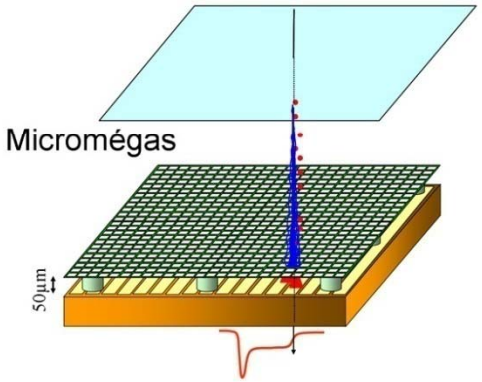


- LHC upgrade
  - $L_{SLHC} \sim 10 L_{LHC}$
  - bunch crossing time: 50ns (25 ns)
- Critical regions in Atlas Spectrometer:
  - EI layers:
    - CSC($27m^2$)
    - EIS/L1($54m^2$)
    - EIS/L2 ($68m^2$)
  - EM η>2: EMS/L1($85m^2$)



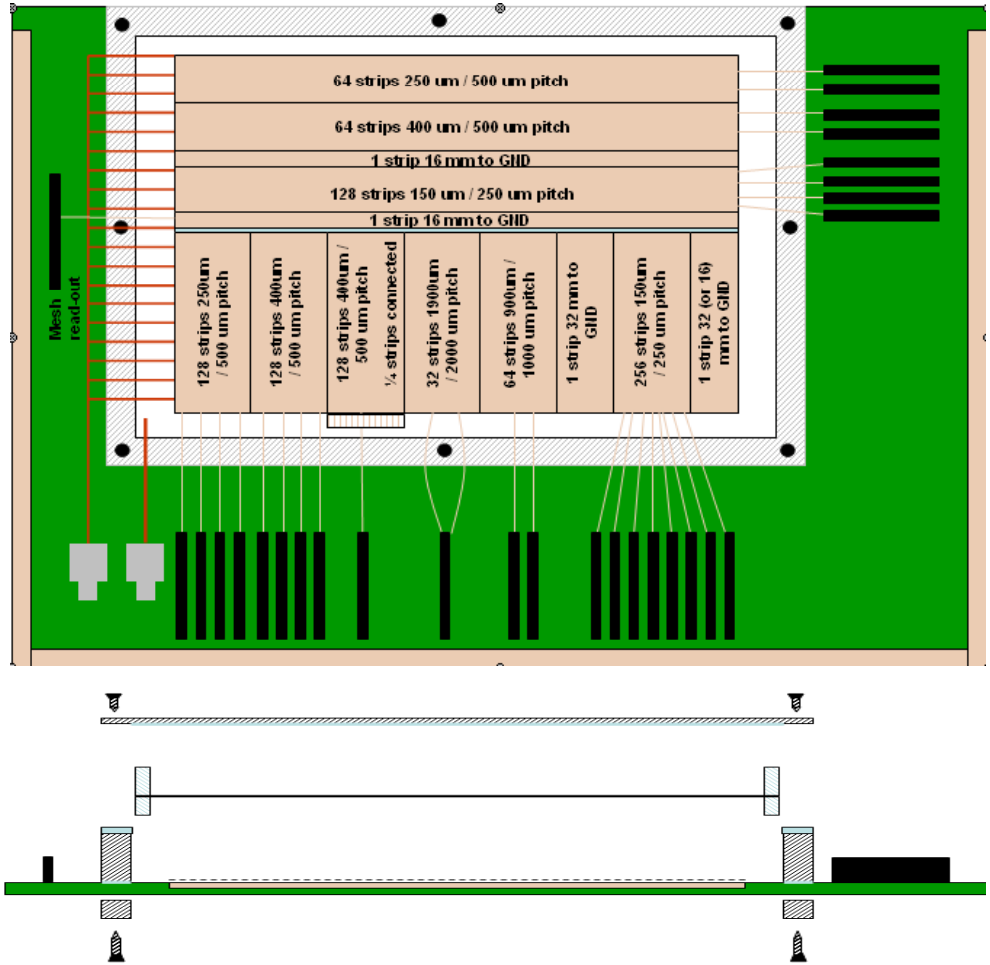
Micromegas as candidate technology

- Combine triggering and tracking functions
- Required performances:
  - Spatial resolution ~ 100 um μm (Θ_{track}<45 degr)
  - Good double track resolution
  - Time resolution ~ 5 ns
  - Efficiency > 98%
  - Rate capability > 5 kHz/cm^2
- Potential for going to large areas ~ 1mx2m

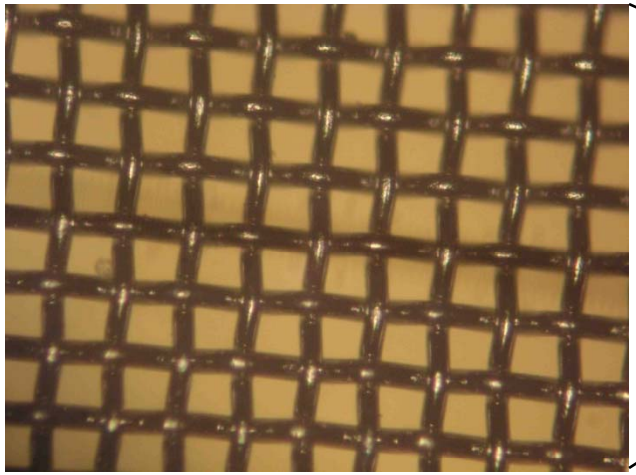


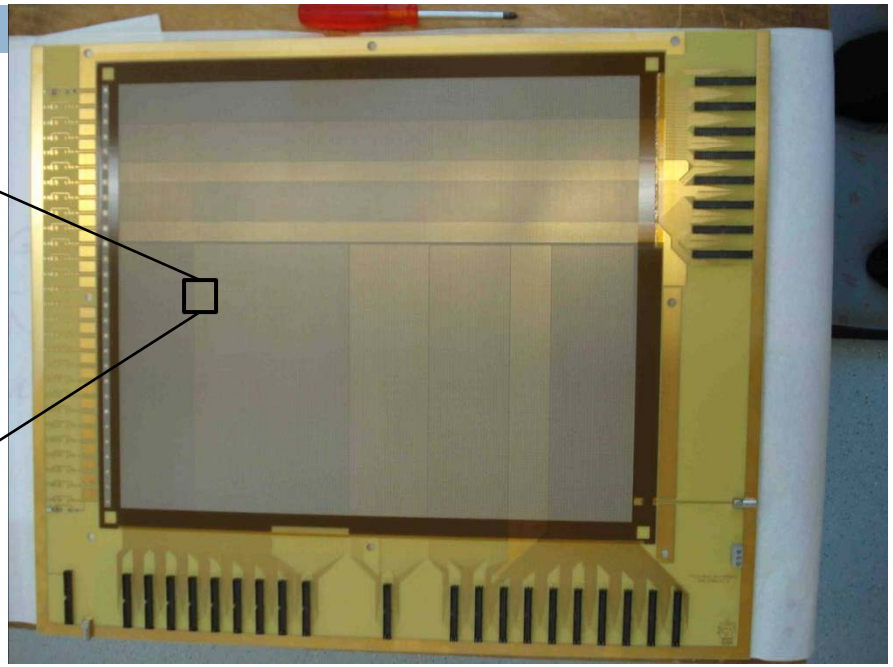
Prototype layout

- Board Layout (not to scale)
- 450mm x 350mm active area
- Different strip patterns (250, 500, 1000, 2000 µm pitch; 450mm and 225 mm long)
- Drift gap: 2-5 mm
- Two prototypes have been fabricated at CERN-TS/DEN on the same layout board



Prototype 1 (P1)

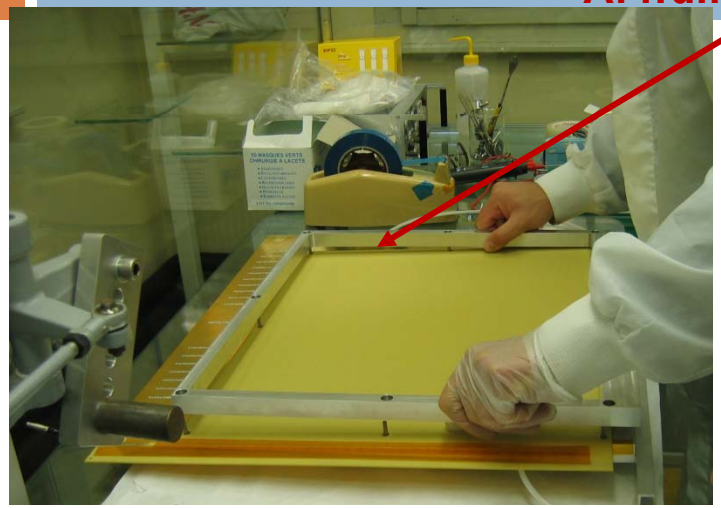


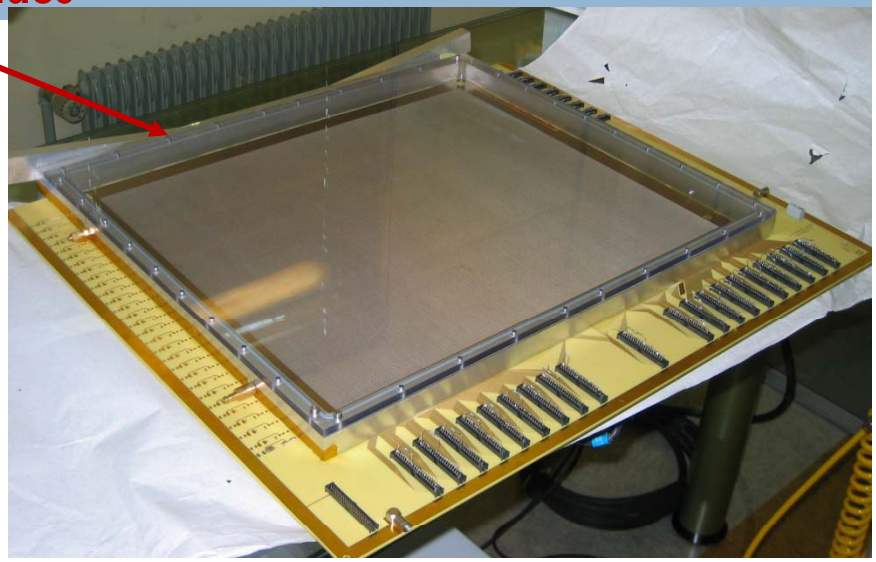


- Standard bulk Micromegas
- Homogeneous stainless steel mesh
- 325 line/inch = 78 μm pitch
- Wire diameter ~25 μm
- Amplification gap = 128 μm

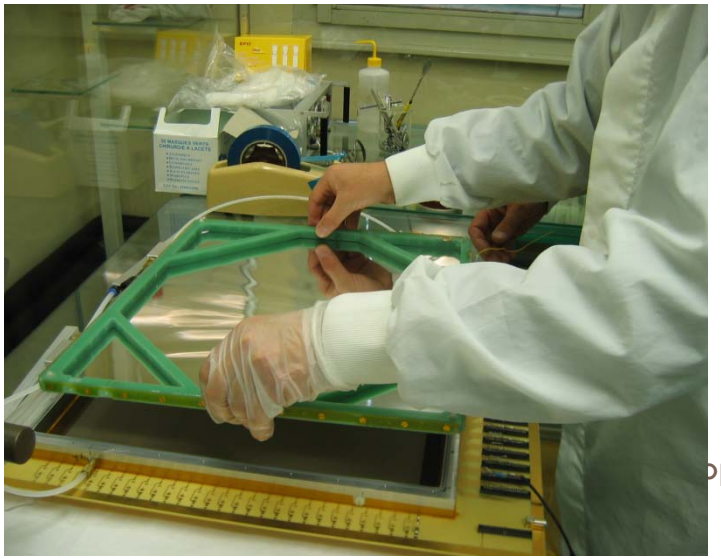
P1 assembling

Al frame on both sides

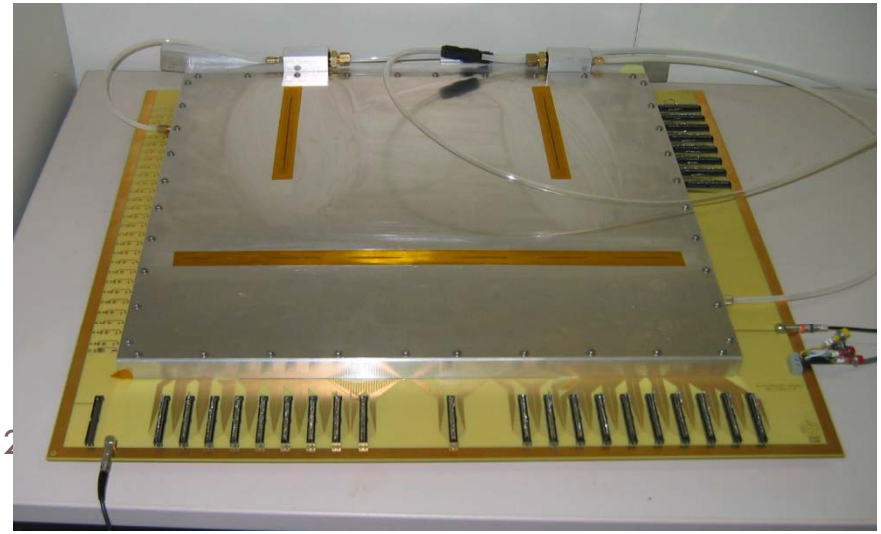




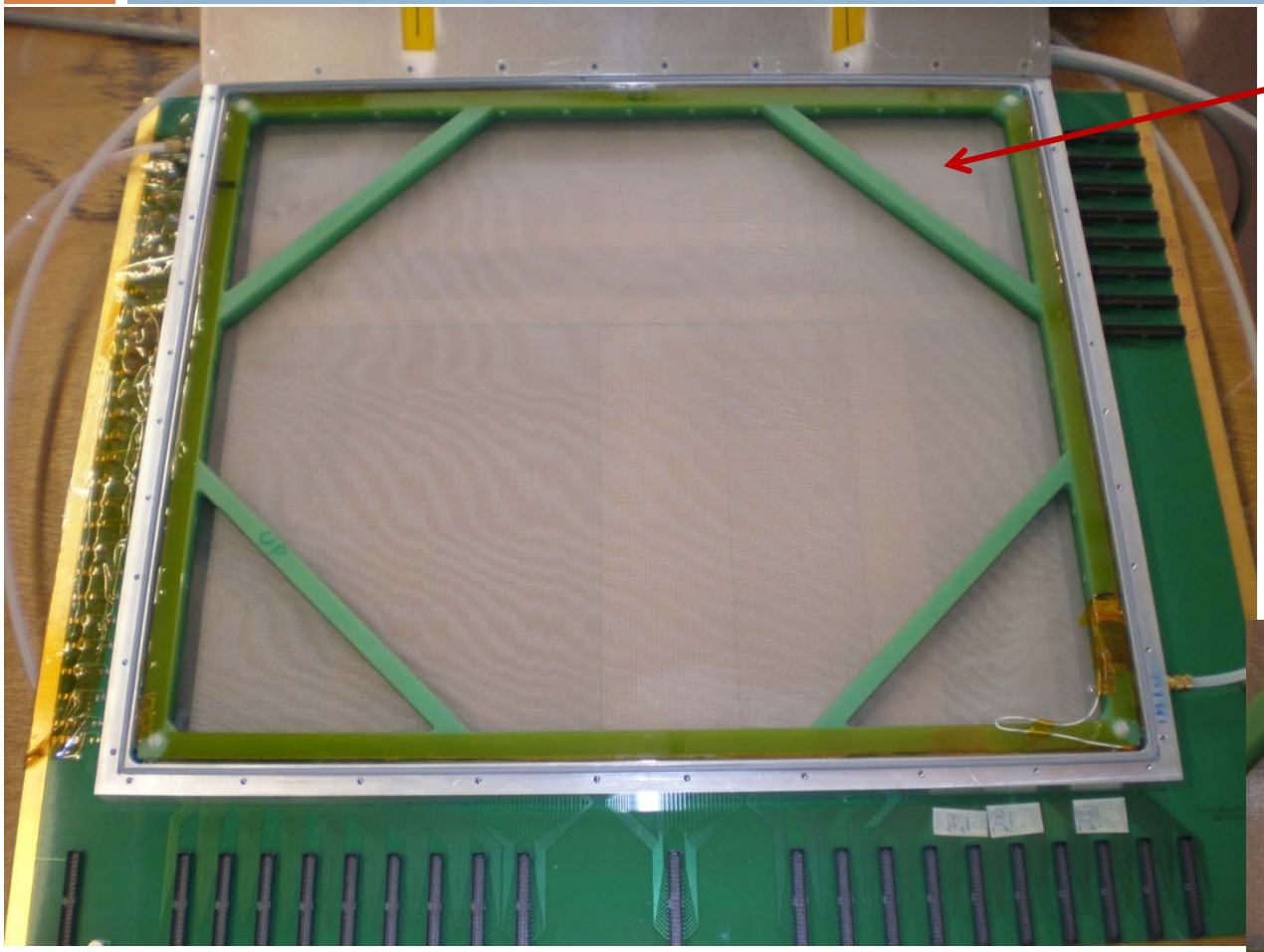
Cathode mounting



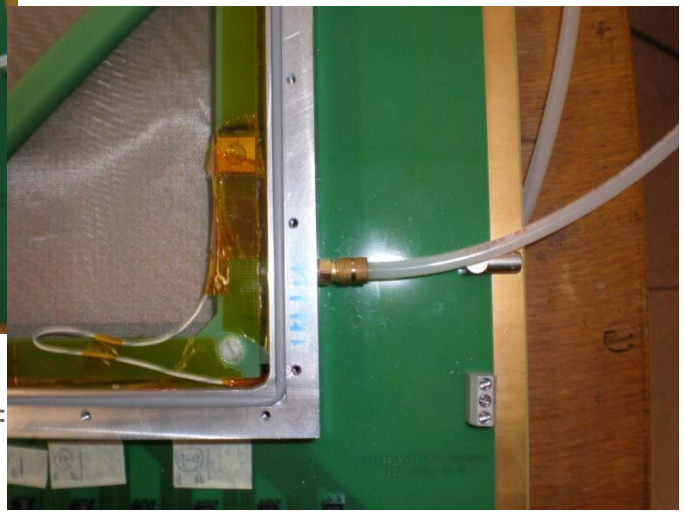
Assembled chamber



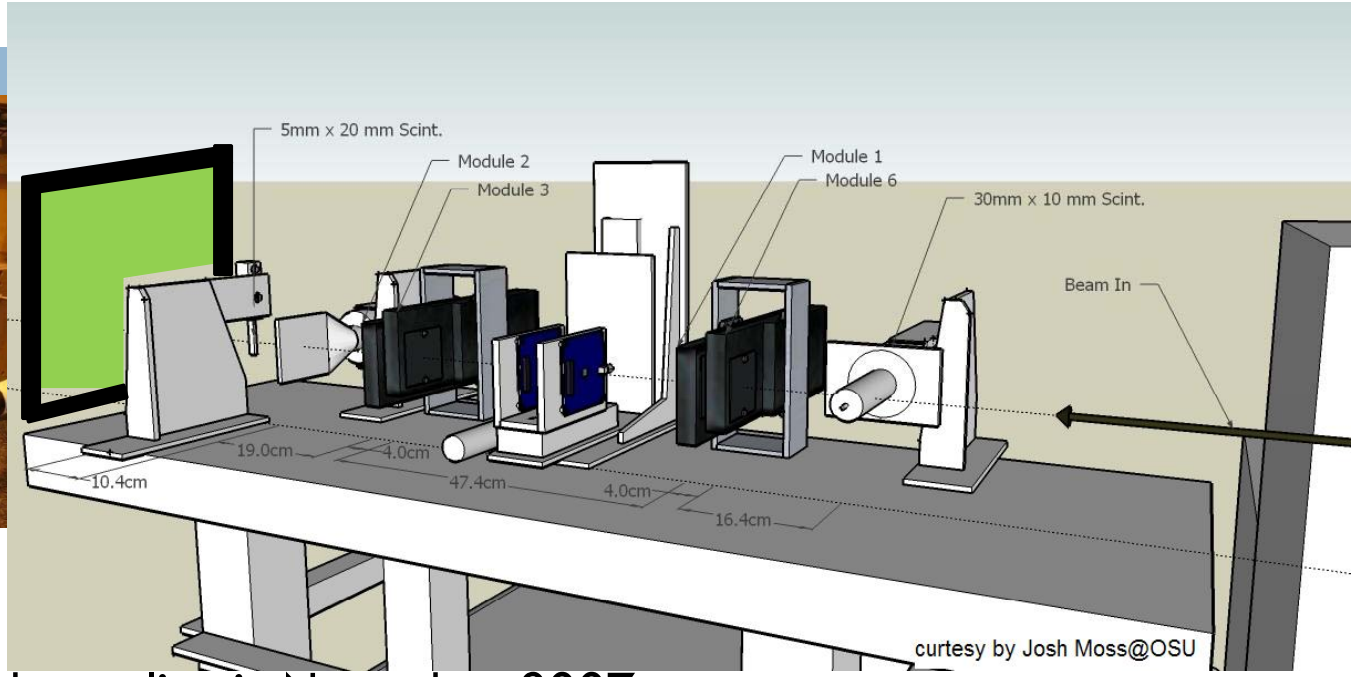
Mechanical issues



Cathode:
G10 frame with metallic mesh
Good gas circulation, mech. properties, electrical contact



2007 Test beam set up



- P1 tested @ CERN H6 beam line in November 2007
- 180 GeV pions beam
- Scintillator trigger
- External tracking with four Si detector modules (Bonn Atlas Telescope) Independent DAQ synchronization problem
- Two non flammable gas mixtures: Ar:CF4 (90:10) Ar:Ne:CF4(45:45:10)
- Data acquired for 6 different strip patterns

2007 Test beam set up

DAQ based on ALTRO CHIP

DAQ PC

ALICE DATE

trigger

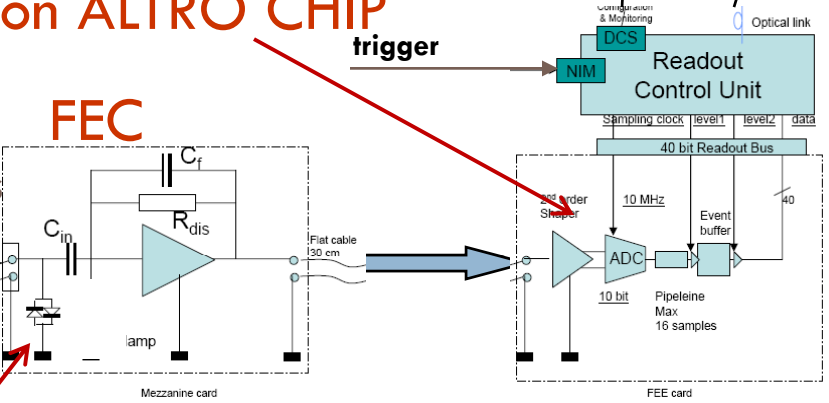
FEC

32 channels

Micro Megas

32 ored channels

Bipolar Preamplifier form BNL



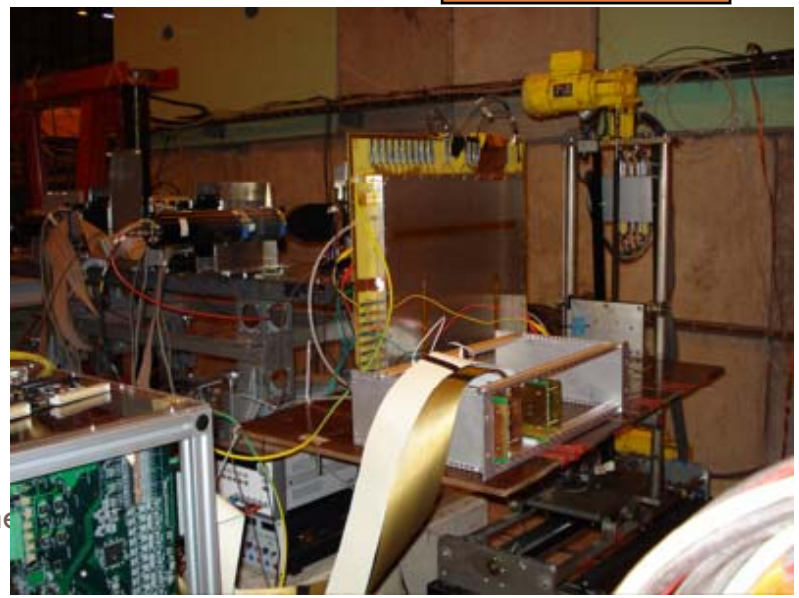
100 ns/sample

64 samples

15 pre-sample

1 ADC count ~ 1000e-

Signal analyzer + counter

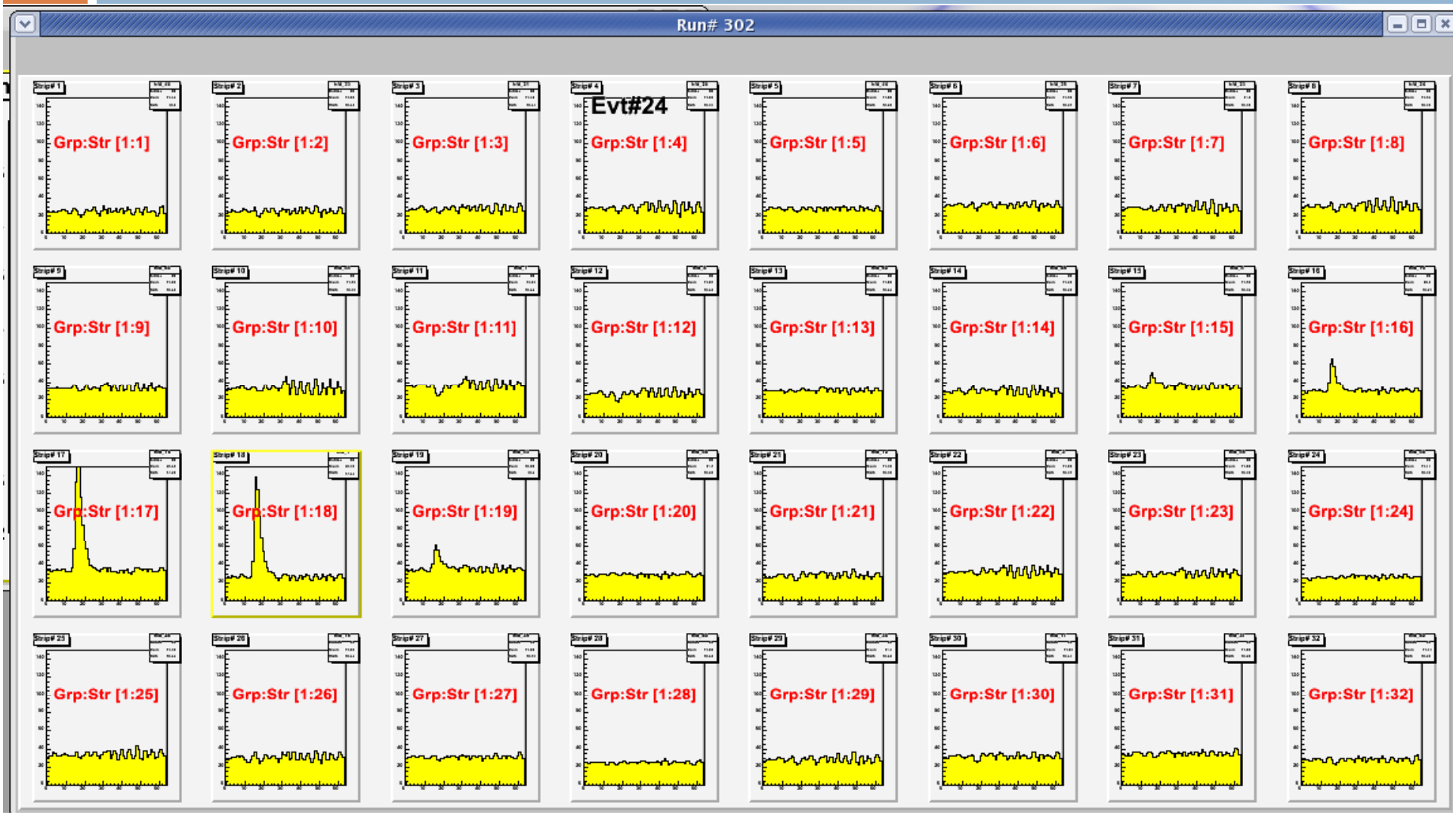


Two inverted diodes for spark protection

No channel died

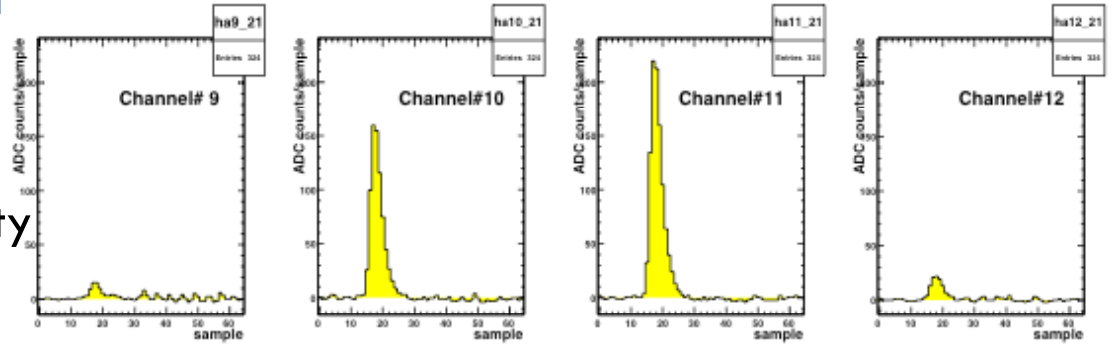
Sparks counting with mesh R/O via attenuator

A typical ADC spectra for 32 channels

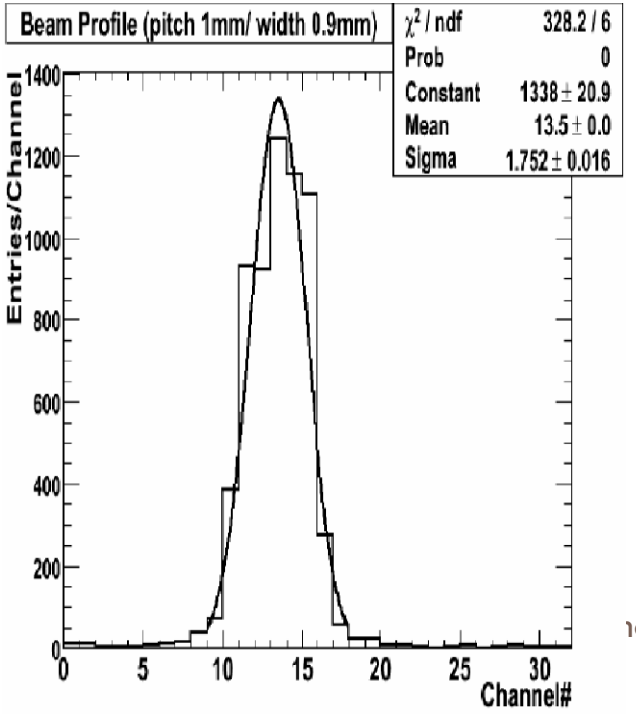


Beam profiles

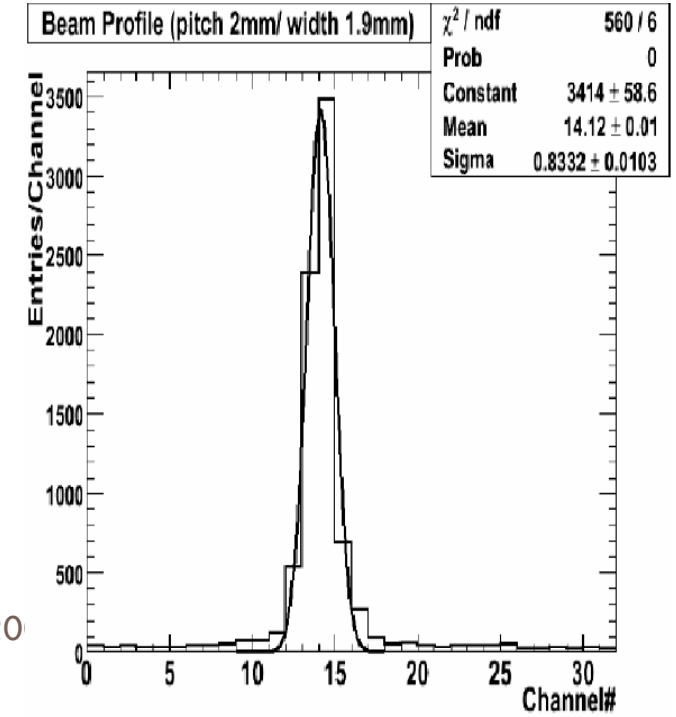
- Noise subtraction (from 12 pre-samples)
- Custer position with center of gravity



Beam profile with 1 mm pitch strips



Beam profile with 2 mm pitch strips



(Preliminary) Data Analysis

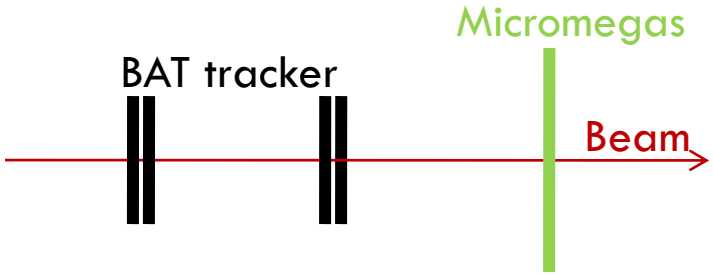
- Synchronization problem between Si tracker and Micromegas (DAQ of tracker lost some events per run) and among the different Si modules
- Hard to find a bunch of synchronized events for data analysis
- Some cross talk observed due to a long bundle of two not shielded cables from FEC to DAQ

Simple event display

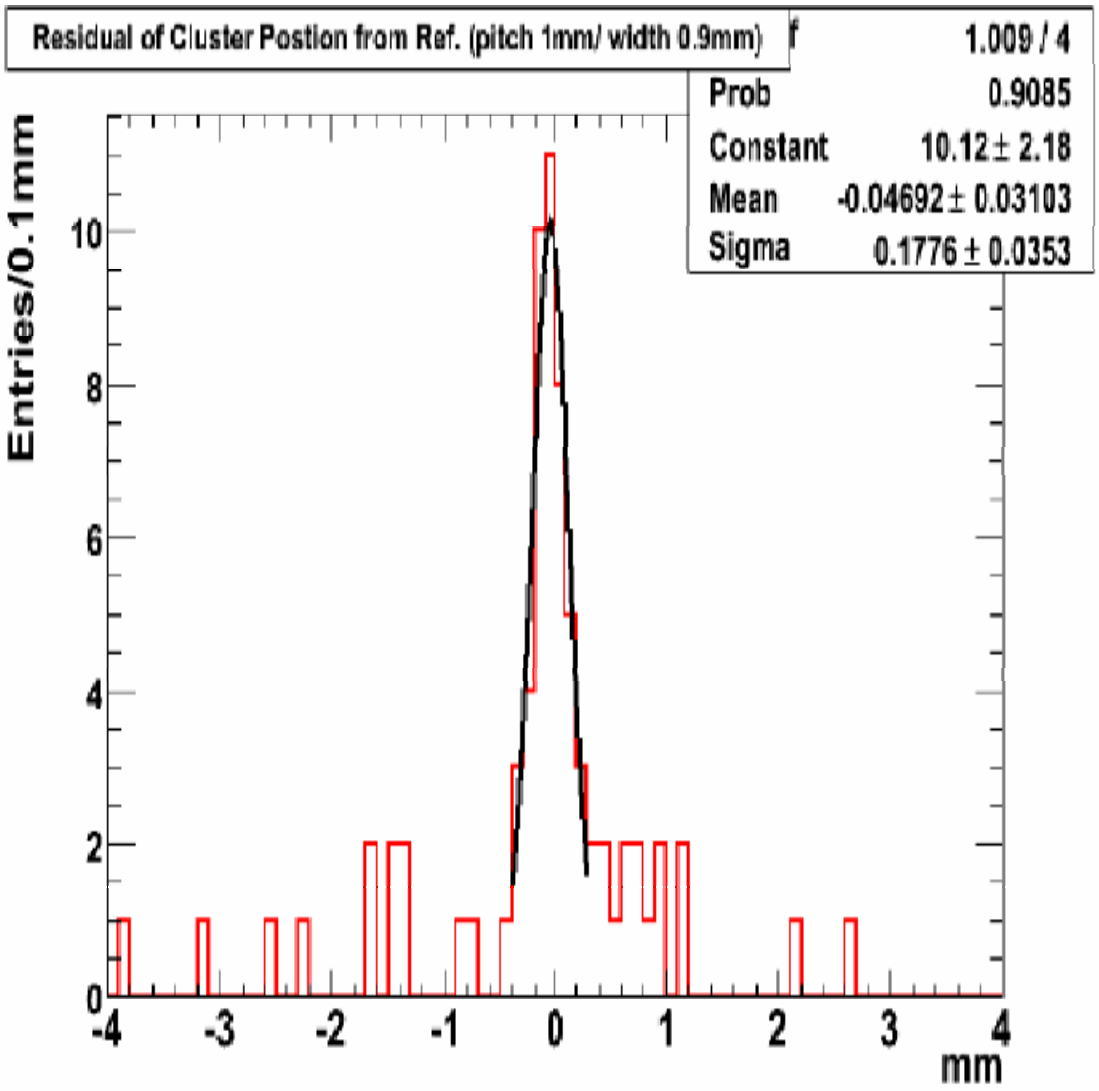
Simple event display

A double rack event

(Preliminary) track resolution

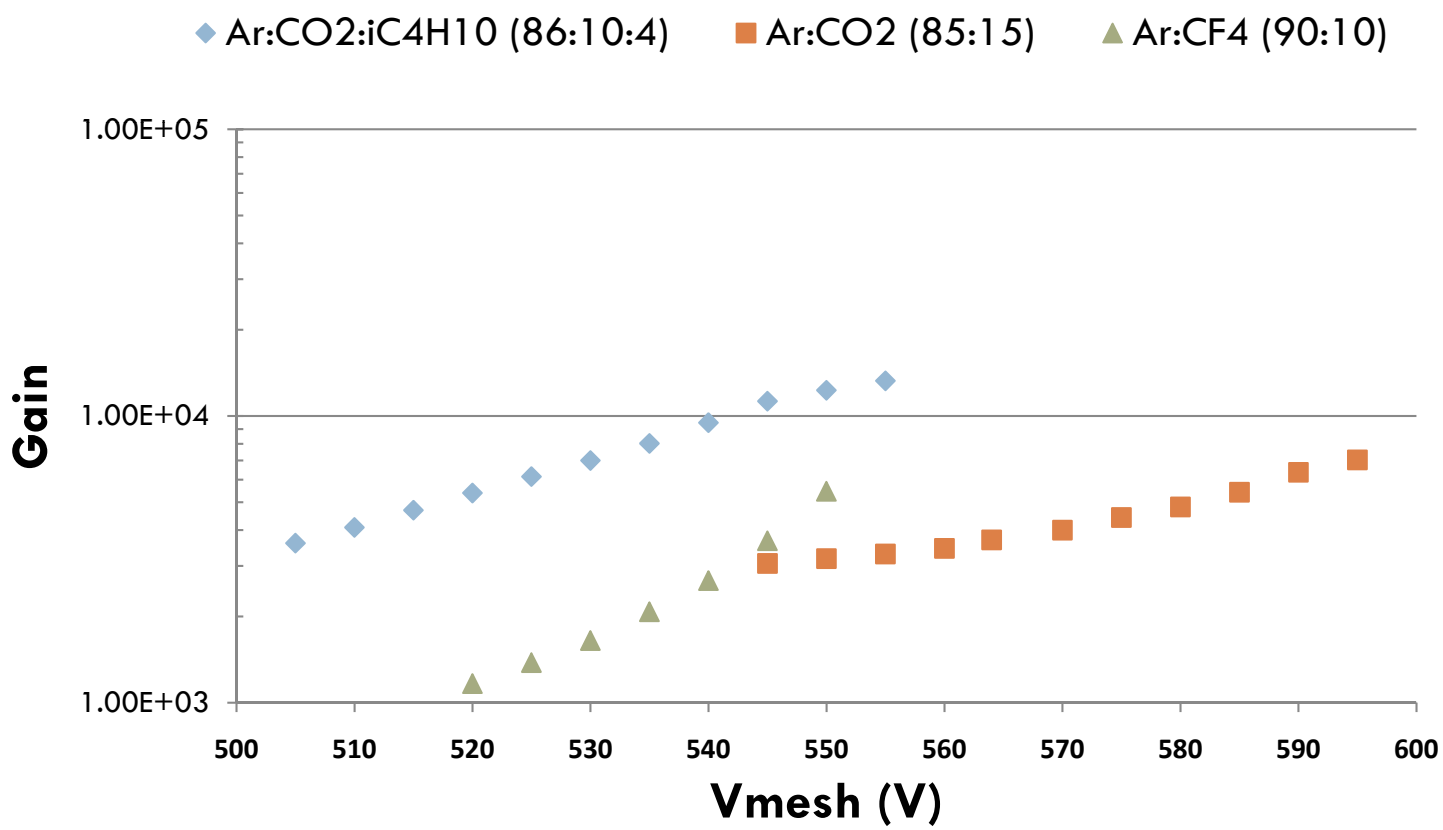


- Three contributions:
  - Intrinsic MM resolution
  - Tracker resolution
  - Extrapolation error
- 1mm strip pitch
- Ar:Ne:CF4 (45:45:10)
- σ global = 180 μm

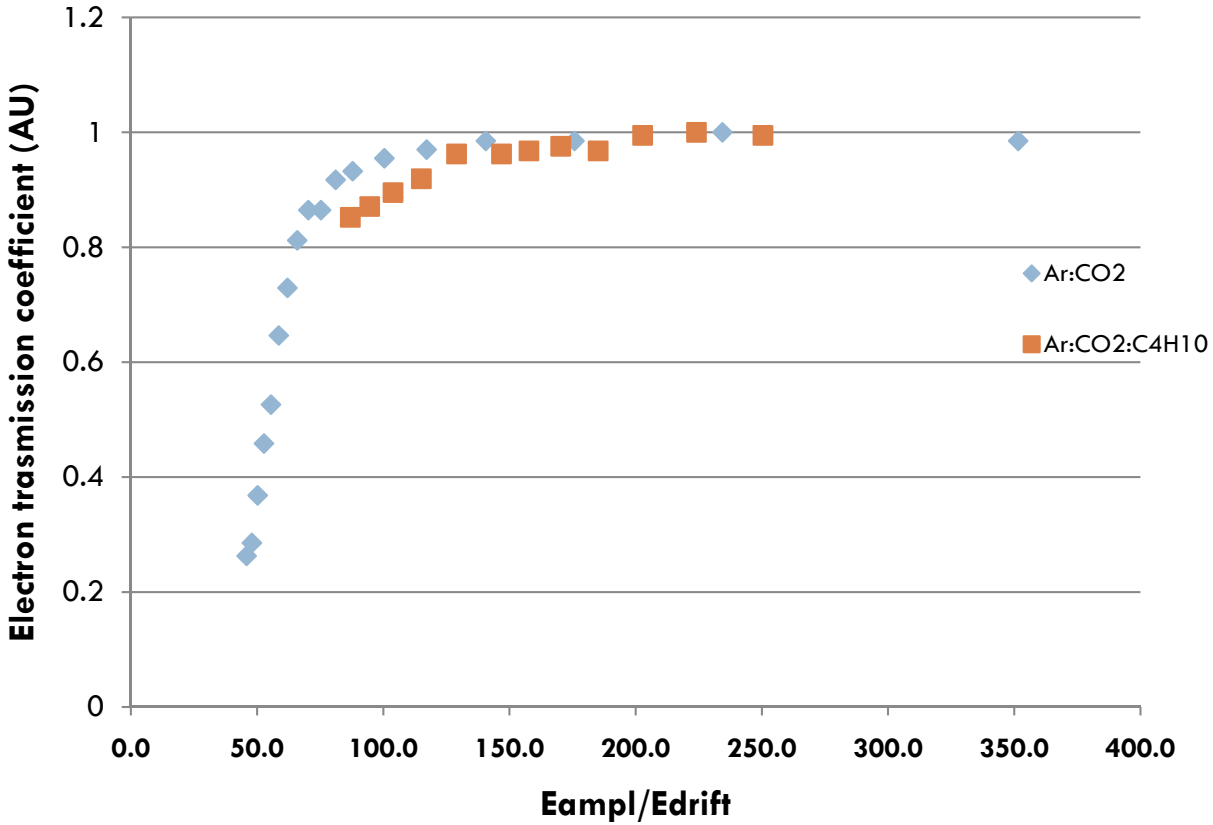


Some gain measurements

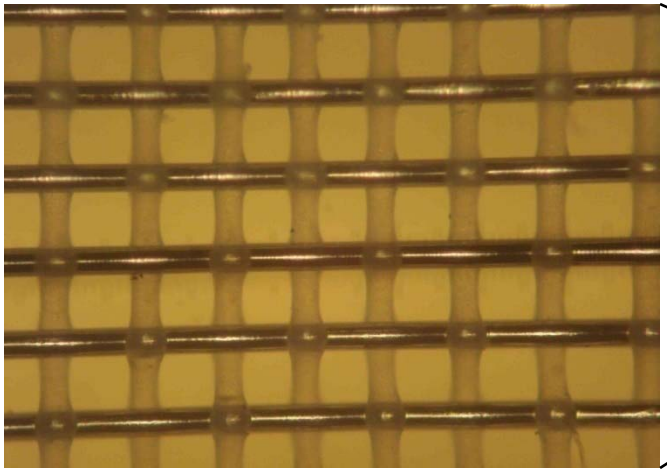
Gain measurement with Fe55 sorce
Test set-up at CERN

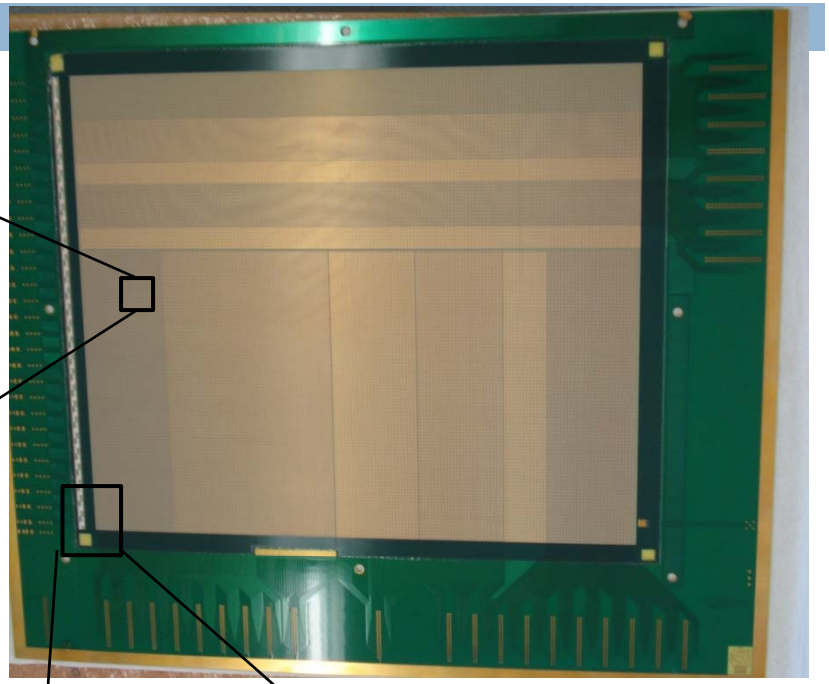


Electronic transparency

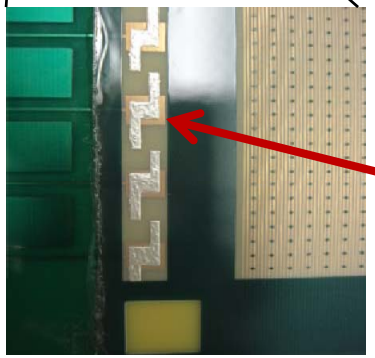


Prototype 2 (P2)





- Standard bulk Micromegas
- Unidirectional stainless steel/plastic mesh
- 200 line/inch = 127 µm pitch
- Wire diameter ~45 µm
- Amplification gap = 128 µm



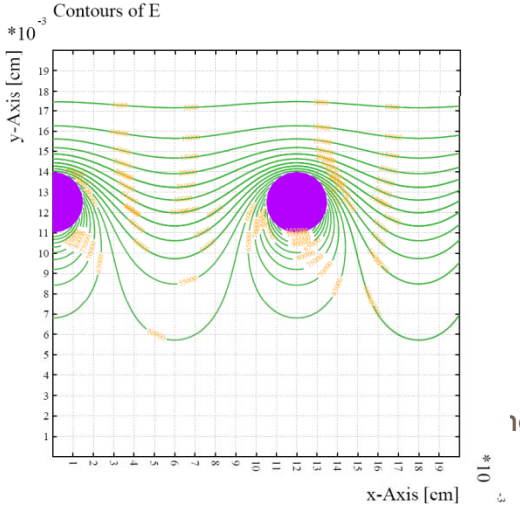
HV + signal connection for segmented mesh (groups of 100 wires)

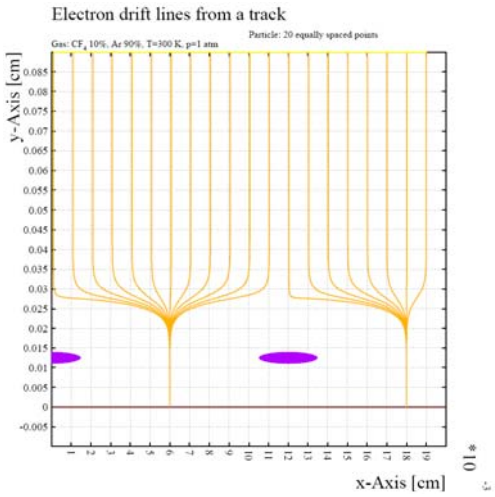
Attractive features and drawbacks

- Possibility to segment the mesh w/o introducing dead areas
- Capacitance reduction
- Second coordinate measurement
- Trigger on larger pitch
- …but plastic wires inside the detector:
  - Charging up
  - Aging

P2 first (discouraging) indications

- Systematic studies still to be performed
- Gain very low compared to P1 (factor ~10 less)
- Indication of charge up
- Unstable behavior
- Some hints:
  - Mesh quality not excellent (large wire diameter, presence of numerous impurities)
  - Geometry not optimal: wire pitch ~ amplification gap
- Idea not abandoned yet, but many improvement and test are needed





Status and plan

- R&D activity approved by the Atlas Upgrade Office
- Test bank set-up at CERN (L. Ropelewski's lab) and now under development (gas infrastructure, DAQ)
- Some small (10x10 cm2) prototypes have been built with a 'low profile' mesh to be used for gas characterization, gain and energy resolution studies
- Three more test beam period foreseen this year (June, July, October)
  - Exploring several option for new electronics (Altro/DATE; custom chip from BNL; Elx for T2K; development at CERN of chip designed for MPGD)
  - Precise spatial and time resolution studies
  - Define the preferred strip pattern for our purposes
- Micromegas with resistive layer
- Chamber construction
  - Going from medium size to large size (~1mx2m)
  - Mesh segmentation (possible also with fully metallic mesh, with a 2mm wide dead zone)

Summary & conclusions

- With SLHC an upgrade of some Atlas Muon chambers is needed
- Micromegas is a good candidate
- Activity started in 2007
- Two 'small' prototypes designed and built
- Test beam on P1 with encouraging results
- Problems with P2 under study
- New test beam campaign in 2008
- R&D approved by Atlas Upgrade Office