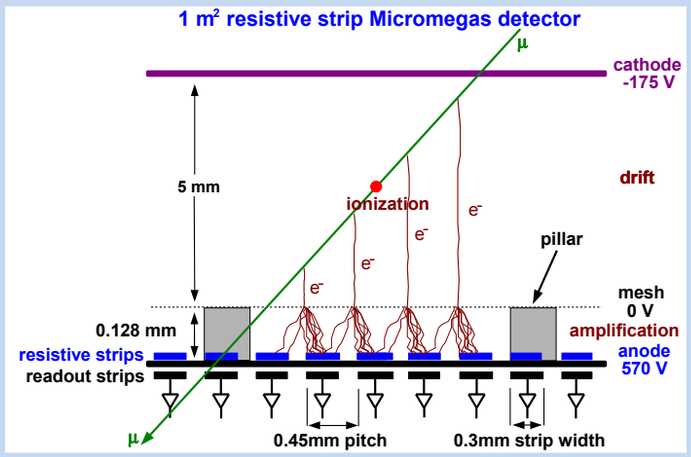
Characterization and Calibration of Large Area Resistive Strip Micromegas Detectors

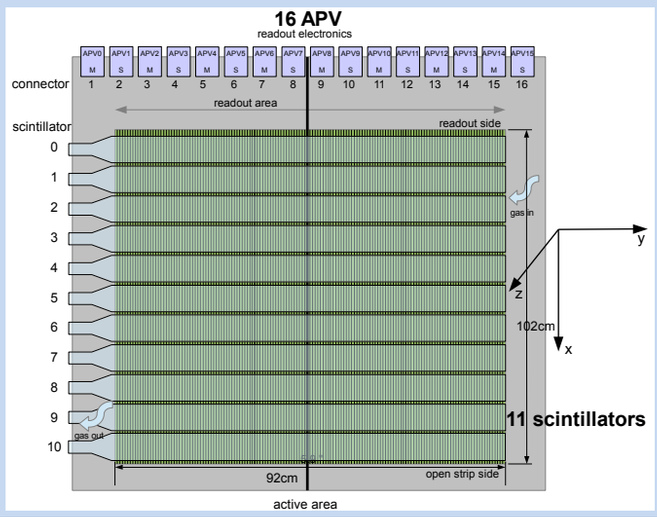
Resistive strip Micromegas detectors are discharge tolerant. They have been tested extensively as small detectors of about 10 x 10 cm^2 in size and they work reliably at high rates of 100 kHz/cm^2 and above. Tracking resolutions well below 100 µm have been observed for 100 GeV muons and pions. Micromegas detectors are meanwhile proposed as large area muon precision trackers of 2-3 m^2 in size. To investigate possible differences between small and large detectors, a 1 m^2 detector with 2048 resistive strips at a pitch of 450 µm was studied in the LMU Cosmic Ray Facility (CRF) using two 4 × 2.2 m^2 large Monitored Drift Tube (MDT) chambers for cosmic muon reference tracking. A subdivision of the resistive strip anode plane in 57.6 mm x 93 mm large areas has been realized by the readout of 128 strips with one APV25 chip each and by eleven 93 mm wide trigger scintillators placed along the readout strips. This allows for mapping of homogenity in pulse height and efficiency, determination of signal propagation along the 1 m long anode strips and calibration of the position of the anode strips.

Principle of Resistive Strip Micromegas Detectors

- 100 e^-/cm ionization by minimum ionizing particles in Ar:CO_2 93:7
- Electron drift velocity ≈ 40 µm/ns (for an electric field of 350 V/cm)
- Gas amplification between mesh and cathode
- Charge collection on resistive strips
- Capacitive coupling between resistive and copper readout strips (Kapton insulator)
- Strip width: 300 µm
- Strip pitch: 450 µm
- Resistivity of strips R_s ≈ 10 MΩ/cm

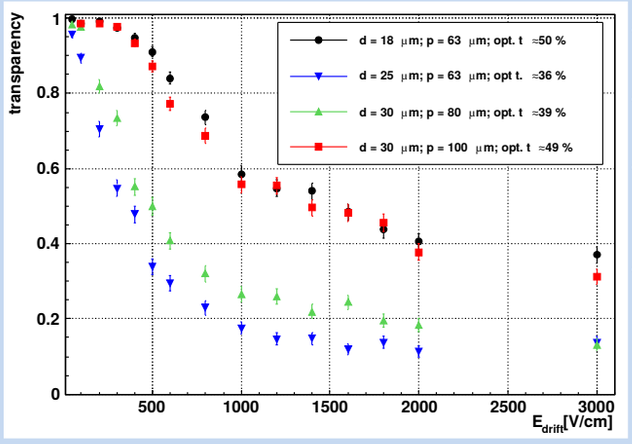


Micromegas Chamber under Investigation

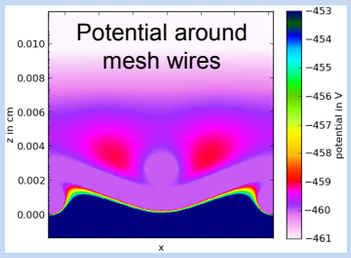


- Active area: 92 × 102 cm^2
- Gas: Ar:CO_2 93:7 @ atmospheric pressure
- 16 APV25 frontend-boards with 128 readout channels each → 2048 readout channels
- 11 scintillators perpendicular to readout strips → second coordinate Δx ≈ 9.3 cm
- Subdivision of detector in 16 APV × 11 scintillators = 176 partitions
- Readout plane composed of two 46 cm wide PCB sheets

Simulation of Mesh Electron Transparency

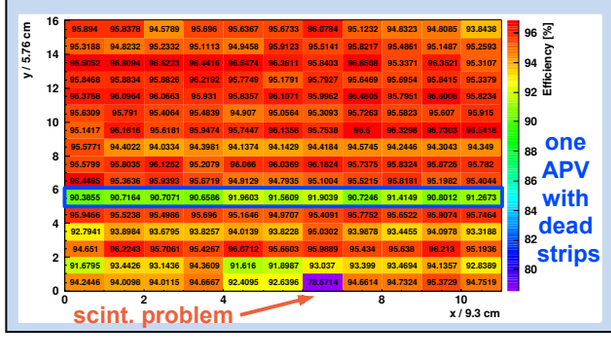


- Simulation of transparency *trsp* using Garfield++, ELMER and Gmsh
- Electron *trsp* ≠ optical *trsp* due to ratio between drift and amplification field
- Depending on wire diameter *d*, pitch *p* and diffusion coefficient
- *trsp* > 95% at small E_{drift} for meshes with optical *trsp* ≈ 50 %

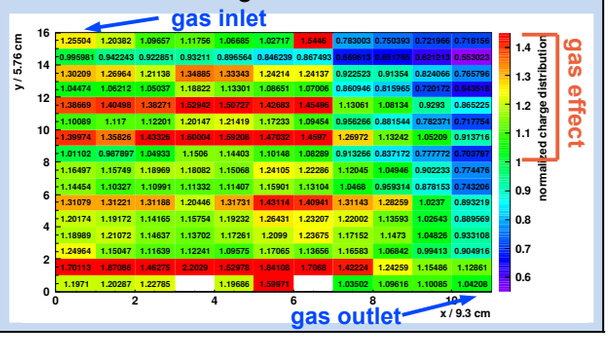


Efficiency and Pulse Height Distribution

- High efficiency over whole active area of (94.9 ± 0.9) %
- Despite many dead channels in one APV homogeneous efficiency distribution

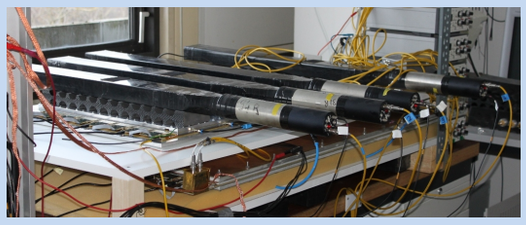


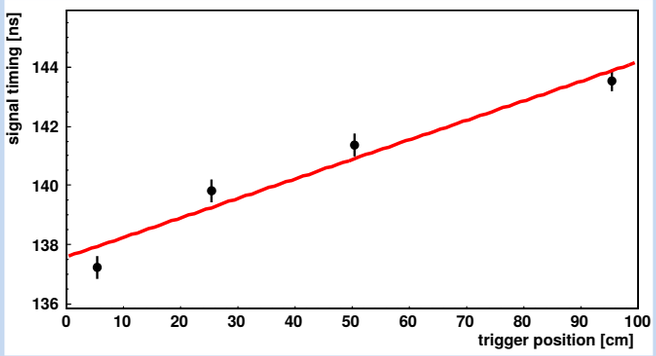
- Pulse height for each partition normalized to total pulse height
- Homogeneous with RMS of 10 %
- In upper right part lower pulse height due to reduced gas circulation



Signal Propagation Time

- Four trigger scintillators on top and below the Micromegas detector triggering on cosmic muons
- Signal arrival time plotted versus trigger position along strips
- $t_{propagation}$ = (6 ± 1) ns/m

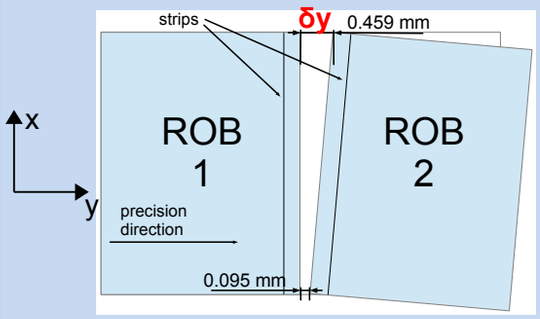


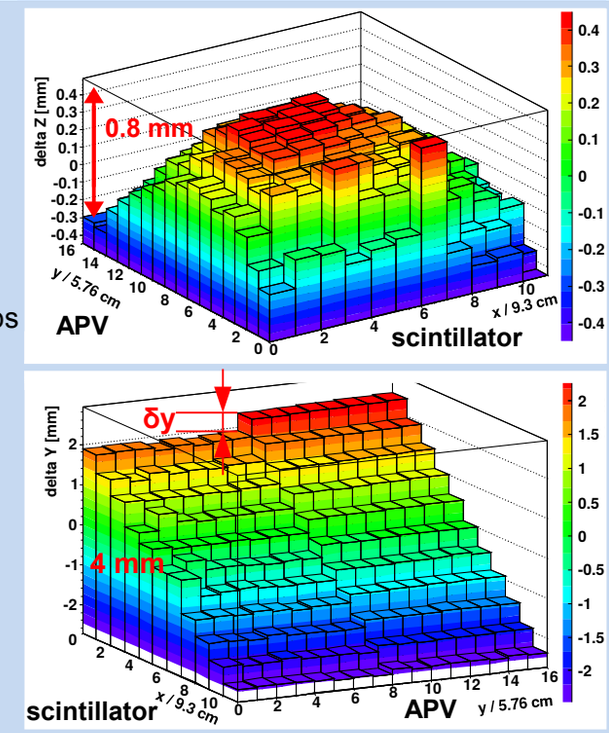


expectation:
$t_{propagation}$ = 3.34 (0.48×ε+0.7) [ns/m] = 5.64 ns/m
(D. Nührmann; 'Electronic Handbook')

Mechanical Deformations

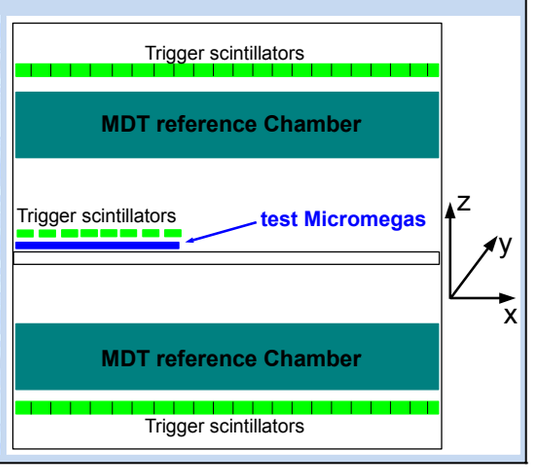
- Inclined muon tracks:
  - Determination of z-position of middle plane of drift gap
  - Bulging due to small overpressure
  - Deviation 0.8 mm from plane → 1.6 mm at drift cathode (stiff base plate support)
- Perpendicular muon track:
  - Determination of y-position of readout strips
  - Visible shift between two PCB sheets due to inaccurate glueing process





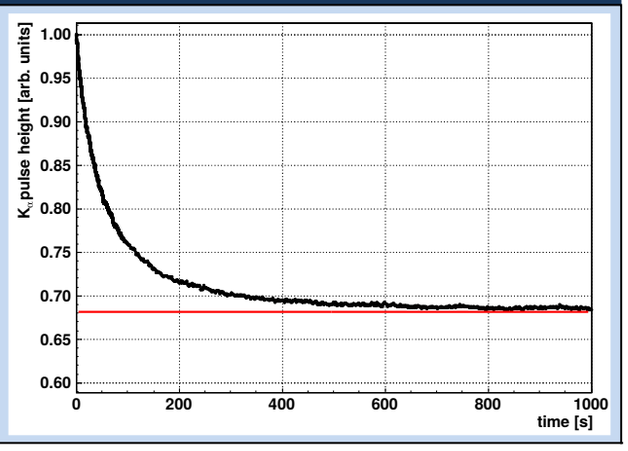
LMU Cosmic Ray Facility (CRF)

- Two Monitored Drift Tube (MDT) reference chambers with an active area of 9 m^2 → two reference track segments
- Two trigger hodoscopes
- Angular acceptance between -30° and +30°
- 34 cm iron absorber → E_μ > 600 MeV
- Trigger rate ≈ 35 Hz (CRF + test chamber)
- 12 h run for analysis used → 1.5 M triggers → 600 k events after cuts on slope of reference tracks
- merging of three data streams for analysis:
  - MM: Scalable Readout System
  - MDT: ATLAS Gola/Filar Readout
  - Hodoscope: VME electronics



Effect of the Polarization of Dieletric Materials in the Readout Plane

- Measurement: ^{55}Fe source → 5.9 keV x-rays Small Micromegas (10 × 10 cm^2) with R_s ≈ 10 MΩ/cm
- Rate r ≈ 2.6 kHz at about 0.2 cm^2
- Dielectric absorbtion like in HV-capacitors due to polarization of dielectric materials
- Additional polarization effect due to localized charges on resistive strips → pulse height drop, rate dependent
- Saturation at 68 % of initial pulse height



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