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Beam Tests of a GEM-TPC
at CERN

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**Chamber**

**Dimensions:**
- Length: 25 cm
- Inner diameter: 20 cm
- Flexible readout endcap

**Amplification:**
- GEMs pitch = 140 µm
- Outer diameter holes = 70 µm
- Inner diameter holes = 60 µm
- Transfer gap: 2 mm
- Induction gap: 2 mm
- Transfer field: 2.5 kV/cm
- Induction field: 3.5 kV/cm

**Pad size:**
- 1.27 * 12.5 mm²

**Number of pads:**
- 8 * 32

Experimental setup at CERN East Hall, T7
Trigger, DAQ and FEE

scintillator 1: 4.5*19cm² vertical
scintillator 2: 3*7.3cm² horizontal

trigger rate: one event per spill, but 500 time slices read out to see more beam particles

STAR front-end electronics:
Sampling rate: 19.66MHz
Peak time: 150ns
FWHM of pulse width: 180ns
Beam properties - width

standard orientation horizontal beam width

turning of chamber vertical beam width

Spill length: 550ms

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Presented by M. Ronan
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Software tools

Besides the existing VB-package (s. talk by S. Kappler at Berkeley) a JAVA based analysis tool is being developed.

functionality similar but code developed independently (=> cross check)

New feature: ‘parabolic linear regression’:

\[ y = A + B \times x + C \times x^2 \]

=> a measure of the curvature (C)
Monte Carlo

Simulation of cosmic muons passing through detector and trigger counter

Input parameter distributions

Difference: input – analysis results

8mm ≅ 150ns

=> shaping of FEE simulated, but not corrected in analysis

gas parameters of Ar-CH$_4$ 90:10 given by Magboltz

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Cluster properties

hadron beam of 9GeV-particles at CERN  
gas:Ar:CH₄ 95:5

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Track properties

hadronic beam of 9GeV-particles at CERN  
gas:Ar:CH$_4$ 95:5

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drift velocity in Ar:CO$_2$:CH$_4$ 93:2:5

![Diagram showing drift velocity](image)

**Drift Velocity Analysis**

- **Cluster z**
  - Cluster position in z direction in mm

- **Graph**
  - Drift velocity vs. drift field in V/cm
  - Magboltz simulation
  - Measurement

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Spatial resolution

- TESLA TDR Values
- Ar-CO₂ (70:30, 0T, 0.31kV/cm)
- TDR gas (0T, 0.24kV/cm)

Equivalent drift distance to get the same transv. diffusion

Ar-CO₂ (70:30, 0T) - TDR gas (0T) - TDR gas (4T)

Drift distance [cm]

Equivalent drift distance [cm]
Intrinsic single-pad-row efficiency

Improved algorithm
Isolation criterion ensures:
- no crossing tracks
- effect of delta electrons removed

\[ \varepsilon_{\text{max}} = (99.3 \pm 0.1)\% \]
Track distortions (I)

hadronic beam of 9GeV-particles at CERN  gas:Ar:CH₄ 95:5
Track distortions (II)

Curvature $C$ is plotted vs. $x$ position of track cluster in top row (= track position)

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Track distortions (III)

Slope dependence on drift distance

Slope dependence on GEM voltages

Theoretical interpretation is being developed

middle axis of ‘galaxy’ is fitted with linear fit => slope taken as measure of distortions
Current measurements

Observations:
1.) Current pulse reflects beam time structure.
2.) Nearly 10% feedback at low GEM voltages.
3.) Larger feedback at higher drift fields.
4.) Dependence on $E_D$ and $V_{GEM}$

$$f = rac{E_D}{E_i} \times 16.0 \times \exp(-U_{GEM}/258.4V)$$

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Conclusion

Detector was tested in a high rate hadronic beam => no problems were observed

Intrinsic single-pad-row efficiency plateau of (99.3 +/- 0.1)\% was reached for all gases.

Efficiency plateau starting at effective gains of 2500.

Spatial resolution were between
- 63\mu m in Ar:CO_2 (4cm drift) corresp. to 10cm drift in TDR gas (4T)
- 190\mu m in TDR gas (6cm drift,0T) corresp. to 250cm in 4T

Track distortions due to space charges inside the drift volume observed and under study.