Micromegas TPC beam tests at KEK


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• MPI TPC, Micromegas option
• Beam test data taking
• Preliminary results
• Future

Saclay, Orsay, Carleton, MPI, DESY, MSU, KEK, Tsukuba U, TUAT, Kogakuin U, Kinki U, Saga U (Canada, France, Germany, Japan, Philippines)
Motivation

• Initiated by Ron Settles. Comparison of several gas amplifiers using same Field Cage, Electronics, analysis
  - MWPC: Beam test in Jun, 2004
  - GEM: Beam test in Apr, 2005
  - Micromegas
  
  Beam test in Jun. 22 Jul. 1, 2005
**Micromegas**

- Micromesh supported by 50-100µm - high insulating pillars
- Multiplication takes place between the anode and the mesh
- One stage
- Direct detection of avalanche electrons
  - Small $E \times B$ effect
  - Fast signals
  - Self-suppression of positive ion feedback
    - the ions return to the grid
  - Better potential spatial resolution
  - No wire angular effect
The MPI TPC at KEK

- Drift length: 26 cm
- Pads
  - 2.3×6.3 mm pitches
  - 32 pads×12 pad rows
    - 384 readout channels
  - pad plane: 10×10 cm
- Readout
  - ALEPH TPC electronics
    - 24 amplifiers, 16 channels each
      - 500 ns shaping time, charge sensitive
    - sampled every 80 ns
    - digitized by 6 TPDs
Experimental Setup

- KEK-PS π2 beam line
  - mainly 4 GeV π⁻
- Superconducting magnet (JACEE)
  - B = 0, 0.5 and 1T
- Gas
  - Ar + isobutane (95:5)
- Drift field:
  - mainly 220 V/cm
Mesh readout

Calibration with a $^{55}$Fe source installed inside the chamber.

Mesh readout by a Multichannel Analyser. Used for monitoring the gain.
Snowmass, August 2005

P. Colas - Micromegas TPC beam tests

55Fe
6keV
Escape
3keV

Cosmics
December to May: design and build the Micromegas endplate, all from drawings and photographs of the GEM endplate.

June 4th, 5th: assemble, test, install in Cryo-hall. Detect a leak. Re-glue the pad plane.

June 6th: Re-assemble, test with $^{55}$Fe in Ar+5%isobutane, OK, connect pad electronics. See tracks! Take data overnight.

June 7th-10th: Take cosmic data.

June 21st: Set last resistor value for E field continuity. Move to beam hall.

June 22nd to 25th: setup DAQ (with 380 channels) during machine studies.

June 26th, 0:00: start beam DAQ.

July 1st: end of beam, end-of-run party and analysis meeting…
B=0T
B = 0.5 T
Charge Distribution

B = 1T, row by row

Aver. charge distribution, Row6, as a function of z

no significant attenuation
Drift velocity measurement

Method

Using a beam at 45 deg. Look at time distribution on one pad. Max time gives drift time over 26.08\pm0.02 \text{ cm}
Time distributions

![Histograms showing time distributions with data points and mean, RMS values for time intervals.](image)

- **time06**
  - Entries: 86
  - Mean: 5.234
  - RMS: 1.276

- **time07**
  - Entries: 134
  - Mean: 5.418
  - RMS: 0.9847

- **time08**
  - Entries: 219
  - Mean: 5.441
  - RMS: 0.3012

- **time09**
  - Entries: 279
  - Mean: 5.38
  - RMS: 0.8739
Result

Avoid side pads where the field might not be nominal.

Padrow 6: 5.907 µs
Padrow 7: 5.911 µs
Padrow 8: 5.911 µs
Padrow 9: 5.901 µs

Average 5.907 ± 30 ns
Trigger cable delay (measured): 310±5 ns
Trig. Logic and start TPD (guess): 20±20 ns

Total time 6.237± 0.050 µs

Velocity = 4.181±0.034 (t meas)+-0.003 (length) cm/µs

V_{drift} (Ar+5%iso) = 4.181 ± 0.034 cm/µs

In agreement with Magboltz: 4.173 ± 0.016

Gas composition
Pad Response Function

evaluated by the charge fraction \( NQ_i = \frac{Q_i}{\sum Q} \) on pad i, as a function of \( (X_{\text{pad}} - X_{\text{track}}) \).

Charge width for different z drift regions \((B = 0T)\)

- Anode \( \rightarrow \) cathode

Width increases with drift distance (diffusion)
Width of Pad Response Function as a function of $z$

**B = 0T**

$C_D = 480. \pm 4.\,[\mu m]$  
$\quad = 469 \,(\text{Magboltz})$

**B = 0.5T**

$C_D = 293. \pm 4.\,[\mu m]$  
$\quad = 285 \,(\text{Magboltz})$

**B = 1T**

$C_D = 188. \pm 17.\,[\mu m]$  
$\quad = 193 \,(\text{Magboltz})$

Measured $C_D$ in good agreement with Magboltz Simulation
X Resolution vs Z

Use 8 rows, fix $C_d$, and fit:

$$\sigma_x^2 = \sigma_0^2 + \frac{C d^2 \cdot z}{N_{\text{eff}}}$$

$N_{\text{eff}} \sim 35$, much smaller than the average number of electrons (63 for 6.3 mm)

$$\frac{2.3\text{mm}}{\sqrt{12}}$$

Preliminary results

Neff = 37+-1

Neff = 28+-9

Neff = 24+-6
**z Resolution as a function of z**

- **B = 0T**
  \[ \sigma_0 = 437. \pm 45. [\mu m] \]

**Preliminary results**

- **B = 0.5T**
  \[ \sigma_0 = 441. \pm 39. [\mu m] \]

- **B = 1T**
  \[ \sigma_0 = 684. \pm 191. [\mu m] \]

As expected, Unlike \( \sigma_X \), \( \sigma_Z \) has no significant B-dependence.
Distortions

X Residual Mean and r.m.s. vs PadRows

Mean

B = 0T

B = 0.5T

B = 1T

r.m.s.

B = 0T

B = 0.5T

B = 1T
Conclusions

• Micromegas tests went very smoothly (first ‘pad partout’ Micromegas TPC)
• Provided a lot of accurate and clean data on diffusion, resolution, etc...
• Much work remains for understanding $\sigma_0$, $N_{\text{eff}}$, etc
• Next step (October) : study the effect of a resistive foil on resolution, with 2 setups
  – The same, with a resistive foil added
  – The Carleton TPC, with a new 128 pad endplate and special electronics.
• Very nice beginning of a world-wide collaboration