Beam Testing of Fast Timing Micromegas

A Contribution to the Picosec Detector Development

By Lukas Sohl

Supervisors: Eraldo Oliveri Leszek Ropelewski

08.08.2017
Outline

- Micromegas
- Picosec
- Beam Setup
- Tracker
- Measurements
- Time Resolution
- Summary & Outlook
Time jitter due to multiple ionization clusters\(^1\):

\[
\sigma_t = \frac{\sigma_I}{v_e} \sim \frac{300 \ \mu m}{50 \ \frac{mm}{\mu s}} = 6 \ ns
\]

\(^1\) (Ultra-) Fast tracking of Minimum Ionizing Particle with a Micromegas detector; Thomas Papaevangelou; IPRD16
Particle produce Cherenkov radiation
Photons producing electrons in the photocathode
All primary ionized electrons are localized on the photocathode
Time resolution below 40 ps at 99% efficiency reached in 2016
2017 Prototypes

• Reach the optimal time resolution and understand the behavior of the detectors
  • Electric field scan
  • Different photocathode material and thickness

• Detector designed for future applications
  • Resistive detector for higher particle flux
  • Multipad detector
2017 Prototypes

- Reach the optimal time resolution and understand the behavior of the detectors
  - Electric field scan
  - Different photocathode material and thickness

- Detector designed for future applications
  - Resistive detector for higher particle flux
  - Multipad detector
2017 Prototypes

• Reach the optimal time resolution and understand the behavior of the detectors
  • Electric field scan
  • Different photocathode material and thickness

• Detector designed for future applications
  • Resistive detector for higher particle flux
  • Multipad detector
Two Possibilities:

- Large 2 x 2 cm Trigger
- Small 5 mm circle Trigger
Measurements

- MCP-PMT signal is used as a time reference ($\sigma \approx 5.5$ ps$^1$)
- Tracking software provides a digital timestamp to match the signals with the event counter
- MCP-PMT, Picosec and event counter are sampled and saved by the same Oscilloscope

1) I. Time Resolution of a MCP-PMT and II. Test Infrastructure in the Solid State Detector Lab; M. Centis Vignali; RD51 Precise Timing Workshop, CERN; 22.02.2017
Time Resolution

- Time difference between reference MCP-PMT and Picosec is calculated
- Standard deviation of the time difference provides time resolution of the Picosec
- Resolution up to some ten picoseconds possible
During my Summer Student Project I learn all aspects of generic detector R&D:

- Assemble and operate gaseous detectors
- Set up and operate tracker and trigger systems
- Work at and control a beam line.
- Process and analyze sampled waveforms
- Discuss results and draw conclusions
Lukas Sohl

EP-DT-DD
GDD-RD51

Office: 15/R-002
Mail: lukas.sohl@cern.ch

Ruhr-Universität Bochum
Institut für Experimentalphysik I
Universitätsstr. 150
44780 Bochum
GERMANY

Office: NB 2/174
Phone: +49 234-32-23539
Web: www.ep1.rub.de
Mail: lukas.sohl@rub.de
Backup
Micromegas

- Particle ionize gas in an electric field
- Electrons move to the anode and ionizing more atoms
- In a strong electric field the signal gets amplified
Some words about the analysis

**Naive 20%-CFD timing**

MM2_naive_time-MCP1_twentypercent_time

<table>
<thead>
<tr>
<th>Entry</th>
<th>6000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.7876</td>
</tr>
<tr>
<td>Std Dev</td>
<td>0.0675</td>
</tr>
<tr>
<td>$\chi^2 / \text{ndf}$</td>
<td>224.6 / 127</td>
</tr>
<tr>
<td>Constant</td>
<td>182.3 ± 3.5</td>
</tr>
<tr>
<td>Mean</td>
<td>0.7889 ± 0.0008</td>
</tr>
<tr>
<td>Sigma</td>
<td>0.05388 ± 0.00067</td>
</tr>
</tbody>
</table>

**Sigmoid Fit**

$$t = p_1 - \frac{\ln\left(\frac{p_0}{y - p_3} - 1\right)}{p_2}$$

$$FD(x; p_0, p_1, p_2, p_3) = \frac{p_0}{1 + \exp\left(-\frac{x - p_1}{p_2}\right) + p_3}$$
Slewing Correction

\[ t = t_{\text{sigmoid}} - \frac{P_0}{y^P_1 - P_2} \]
Compass Gas: Ne-10%C2H6-10%CF4

3 mm MgF2 windows

- Saclay 5.7nmCr+20nmCsI
- Saclay 20 nm Cr (thin Mesh)
- USTC 5.5nmCr+18nmCsI
- Resistive a la Mamma (82 MΩ) 5.5 nm Cr + 18 nm CsI
- Resistive a la Mamma (292 kΩ) 5.5 nm Cr + 18 nm CsI
- Discret Resistive Detector
- Multipad Readout

- Difference Cromium, CsI Photocathode
- Voltage Scan to find optimal setting
- Functional Test of USTS Detector
- Functional Test of Resistive Detectors in Pion Beam
- First test of a multipad detector
- Charge sharing on a multipad anode