Studies of a Bulk Micromegas using the Cornell/Purdue TPC

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The “Bulk Micromegas”, was prepared on one of our pad boards by Paul Colas’ group.

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Topics

- Description of the chamber (mostly repeat, a few updates)

- Measurements of the Bulk Micromegas, B=0, Ar-isoC₄H₁₀(7%) running conditions (training, sparking)
anode signal width
spatial resolution

- Comments on continued preparations for ion feedback measurements

Further information available at the web site:
http://www.lepp.cornell.edu/~dpp/tpc_test_lab_info.html

* presentation at ECFA Valencia 07-November-2006 electron and ion transmission demonstration of ion signal
* presentation at ALCPG Vancouver 18-July-2006 Purdue-3M Micromegas
* presentation at Berkeley TPC Workshop 08-April-2006
* presentation at ECFA 2005 Vienna 24-November-2005
* presentation at ALCPG Snowmass 23-August-2005
* presentation at LCWS05, Stanford 21-March-2005
TPC

14.6 cm ID field cage - accommodates a 10 cm gas amplification device
64 cm drift field length
22.2 cm OD outer structure (8.75 inch)

“field cage termination” and “final” return lines for the field cage HV distribution allow adjustment of the termination bias voltage with an external resistor.

Read-out end:
field cage termination
readout pad and
gas amplification module
pad biasing boards
CLEO II cathode preamps
Electronics

High voltage system:
- -20 kV module
- -2 kV module, 4 channels
+ +2 kV module, 4 channels
+ +4 kV module, for 3-GEM

Readout:
VME crate
PC interface card
LabView

Struck FADC
56 channels (increasing to 88)
105 M Hz
14 bit
+/- 200 mV input range
( least count is 0.025mV )
NIM external trigger input
circular memory buffer
TPC pad board

Pad board with 2 mm pads.
- 80 pads on the board
- 4 layers of 2mm pads
- 5 layer of 5mm pads for track definition

For this data set, limited to 56 channels
- use 6 layers:
  - 3 @ 2 mm width
  - 3 @ 5 mm width.

Resolution measurements are derived from the difference in residuals on adjacent 2mm pad rows.
Micromegas amplification

The “bulk Micromegas”, was prepared on one of our pad boards by Paul Colas’ group.

Measurements with the Purdue-3M Micromegas were shown at Vancouver 2006.
Micromegas amplification

The Micromegas is located 0.78 cm from the field cage termination.

HV is distributed to the pads; note blocking capacitors, HV resistors.

Low voltage signals routed to preamps outside (on ribbon cable).

**Micromegas is at ground; pads at +410V for Ar-isoC₄H₁₀ (7%).**
bulk Micromegas event

Ar-isotopic $\text{C}_4\text{H}_{10}$ (7%), 200V/cm
Micromegas: 410V / 50 $\mu$m

25 MHz, 40 ns
2048 time buckets (81.92 $\mu$s)
bulk Micromegas event

Notice that in these events, there is an opposite signal on every channel.

This will affect the apparent charge width.

This “opposite signal” is not unique to this type of Micromegas.
Purdue-3M Micromegas

Measurements with the Purdue-3M Micromegas were shown at Vancouver 2006.

A similar “opposite signal” was observed with this device (below).
Purdue-3M Micromegas

Micromegas is commercially made by the 3M corporation in a proprietary subtractive process starting with copper clad Kapton.

Holes are etched in the copper
- 70 mm spacing
- 35 mm diameter

Copper thickness: 9 µm

Pillars: remains of etched Kapton.
- 50 µm height
- 300 µm diameter at base
- 1 mm spacing, square array

The shiny surface of the pillars is due to charge build-up from the electron microscope.
Purdue-3M Micromegas event

Ar-isoC$_4$H$_{10}$ (10%), 200V/cm
Micromegas: 410V / 50 mm

25 MHz, 40 ns
2048 time buckets (81.92 µs)

same “opposite signal”
The “opposite signal” is observed in both the Bulk Micromegas and the Purdue-3M Micromegas.

It is not clear if this signal is coming from the pad board or from the pickup in the electronics.

Shown at left is an event with 8 FADC channels connected to the field cage termination. The preamps are connected to power supplies in the same way.

By not seeing the “opposite signal” in the FCT, electronic pickup is ruled out; The “opposite signal” originates at the pads.

25 MHz, 40 ns, 2048 time buckets (81.92 µs)
Micromegas sparking

Training:
- air 500-520V  24 hours
- Ar CO₂ 410V  1 hour
  420V  18 hours
  430V  4 days
- Ar-isoC₄H₁₀ (7%)  
  400V / 50 µm  22 hours
  410V  6 days

Non-destructive sparking observed:
PH ~100x typical min. ionizing.
*Sparking is picked-up by the scintillator/trigger (pad signal in channel 90±1).*

Rate: 7.6 / hour at beginning of Ar CO₂ running
5.9 / hour at beginning and end of Ar-isoC₄H₁₀.

25 MHz, 40 ns
2048 time buckets (81.92 µs)
Drift velocity / Gain

Drift velocities for various gas mixtures are shown at right (from various sources). For Ar-isoC$_4$H$_{10}$ (7%), expect ~39 mm/µs.

Observed time for a maximum drift 64.7 cm is (410 FADC time buckets)x(40ns/bucket), or 39.5 mm/µs.

The gain for various gas mixtures are shown at right. Sources are indicated.

Although it is difficult to extrapolate for Ar-isoC$_4$H$_{10}$ (7%) at 410V, the gain is about estimated to be ~10$^5$.

While Gain estimates were stated for the Purdue-3M Micromegas at Berkeley, April 2006, the absolute gain requires more study.

**However, the gain ratio, Bulk/Purdue, is ~20%.**
The charge width is determined from the fraction of the total charge in 1, 2 or 3 pads, shown above, assuming a gaussian charge distribution.

(The measurement deviates for the 1 and 2 pad measurement at large drift distance. Possibly, the fraction of the signal in a “small” width is overestimated by selecting the maximum.)

**The line at left indicates a diffusion constant of \( D = 0.0415 \text{ cm}/(\text{cm})^{1/2} \).**

(Recall that this will be affected by the loss of small signals due to the “opposite signal”.)
hit resolution (2mm pad)

find tracks
require time coincident signals in 5 layers
there are 6 layers available:
  3x 5mm-pad layers,
a single 2mm-pad layer, a 2mm-pad pair

find PH center using maximum PH pad
plus nearest neighbors
(total 2 to 4 pads)

fit, deweighting the 5mm pad measurements

point measurement
  low drift (narrow pad distribution function)
  hits are corrected for an “effective pad center”
  (This is not ideal, but it is what we are currently using.)

resolution difference
  RMS of difference in residual
  for the adjacent 2mm layers

correct with: \( \sigma = \frac{\text{RMS}}{\sqrt{2}} \)
slope < 0.05
the trigger allows ~ 0.08

|x| < 11 mm
removes poorly measured edge tracks

residual in the single (2mm) layer < 0.4 mm
requires consistent hits in adjacent 5mm layers
although it is higher weighted in the fit

fraction of signal in 1 pad < 99%
much looser than previous analysis

(for low drift bins)
fraction of signal in 2 bins > 80%
removes a type of noise event with
equal pulse height in all pads.

Pad-to-pad pulse height calibration (as large as ± ~30%)
Hit resolution

Fit to \( \sigma = (\sigma_0^2 + D^2/n \chi)^{1/2} \)

use \( D = 0.0415 \text{ cm}/(\text{cm})^{1/2} \).

result: \( n = 17.4 \pm 0.5 \)

\( \sigma_0 = 53 \pm 36 \mu \text{m} \)

\( \chi^2/\text{dof} = 1.7 \)

All points are in the fit.

A systematic uncertainty in \( \sigma_0 \) arises from a possible error in determining the time for drift=0. If \( T_0 \) is actually in the center of the first drift bin, then

\( \sigma_0 (\text{modified } T_0) = 103 \mu \text{m} \).
Ion Feedback Detection

We continue plans to measure positive ion feed-back into the field cage using a technique of ion collection, for individual tracks, on the (double) field cage termination.

*The method differs from that used by Saclay/Orsay on MicroMegas and by Aachen on GEM. For those measurements, a source was used to create ionization. Current was measured on the cathode.*

The ion collection was demonstrated in earlier talks, using a constant bias on the field cage termination plane.
More sensitive measurements will require a pulsed bias on the field cage termination to provide full electron transmission and full ion collection.

The pulsed bias will require new gated preamplifiers.

These have been assembled and are awaiting testing.
Summary, outlook

We have made measurements of the Bulk Micromegas.

Plan to repeat measurements of the Purdue-3M Micromegas with consistent conditions.

We plan to study a triple-GEM.

We are continuing plans for comparative measurements of ion feed-back. (graduate student)

CLEO will end data taking April 2008 (after 28.5 years).
Cornell proposals to reconfigure CESR for studies of a wiggler-dominated damping ring.

If this proposal is funded, the CLEO drift chamber will be removed from solenoid as part of the CESR reconfiguration.

In that case, we will be able to run the small prototype in the 1.5 Tesla CLEO magnet, for resolution, and GEM ion/electron transmission studies. (4 weeks /year, maximum)