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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the US National Science Foundation (LEPP cooperative agreement)
and by the US Department of Energy (Purdue HEP group base grant)
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Topics

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

- Measurements of the Bulk Micromegas , B=0, Ar-isoC_4H_{10}(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

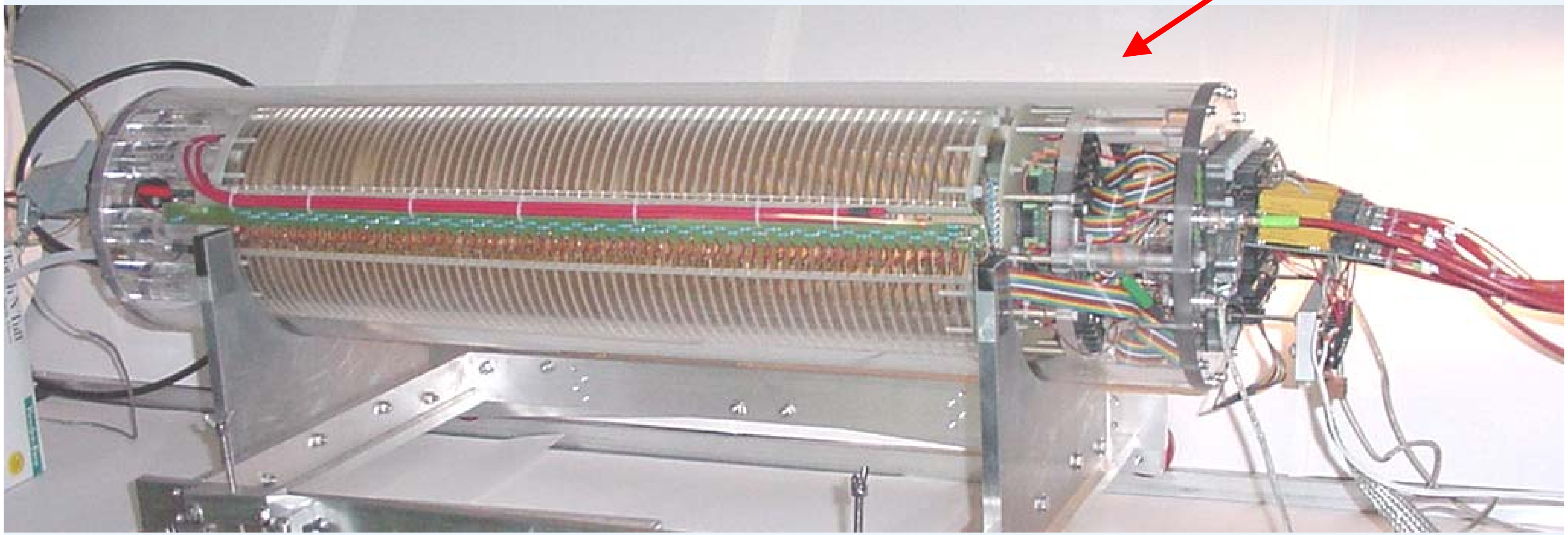
* presentation at	ECFA Valencia	07-November-2006	electron and ion transmission
* presentation at	ALCPG Vancouver	18-July-2006	demonstration of ion signal
* presentation at	Berkeley TPC Workshop	08-April-2006	Purdue-3M Micromegas
* presentation at	ECFA 2005 Vienna	24-November-2005	
* presentation at	ALCPG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

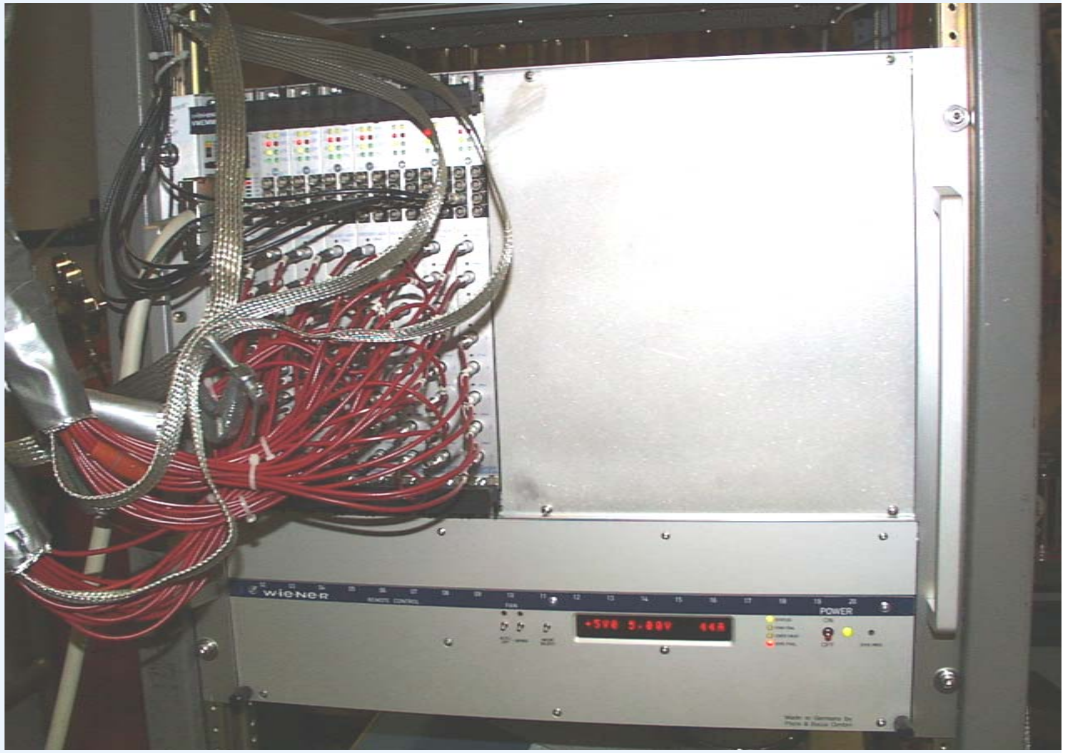


Electronics

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



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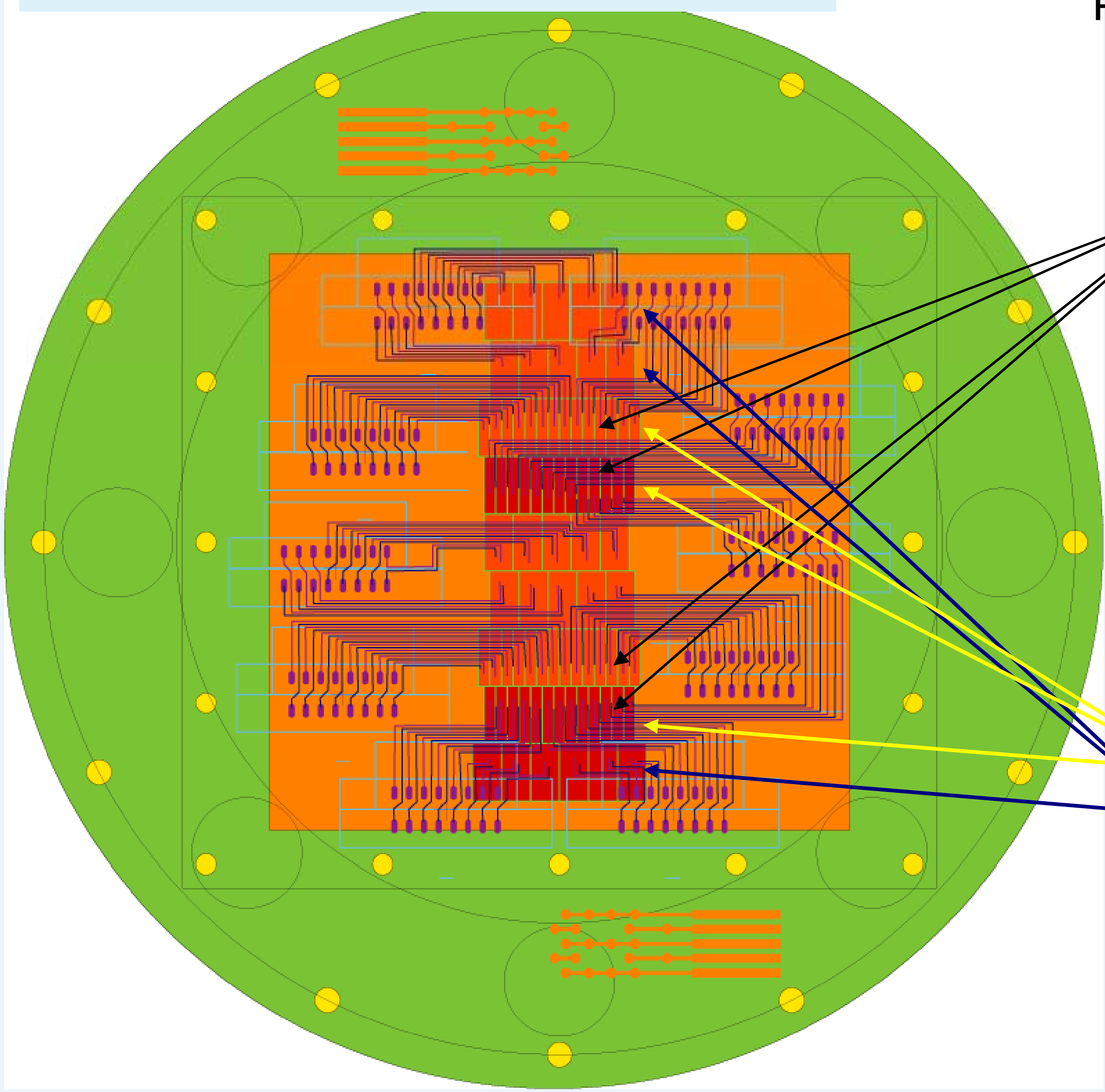
TPC pad board



Pad board with 2 mm pads.

80 pads on the board

4 layers of 2mm pads

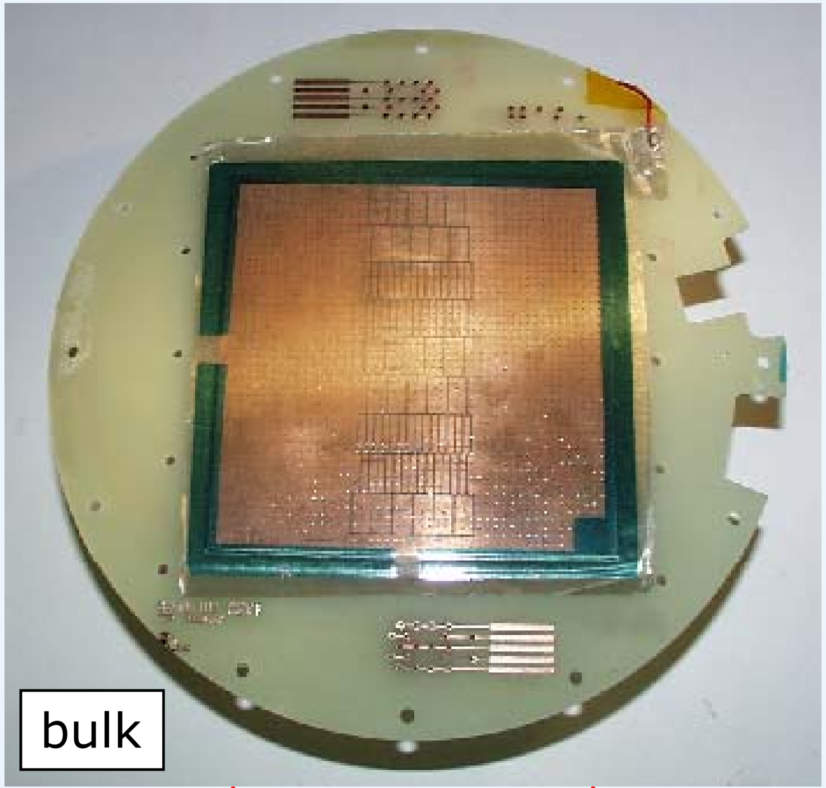
5 layer of 5mm pads
for track definition

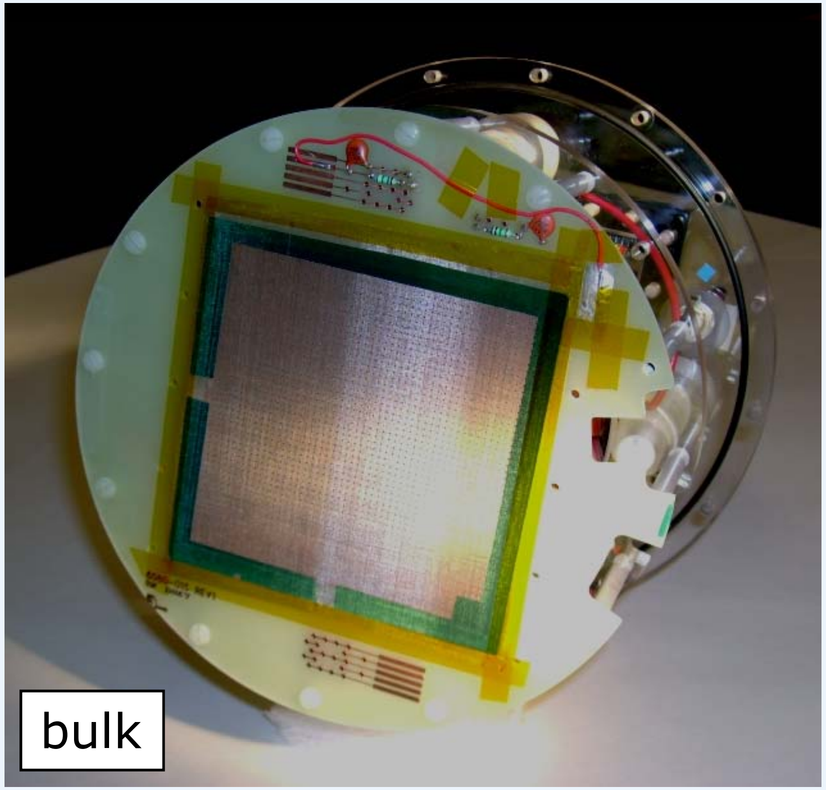
For this data set,
limited to 56 channels

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



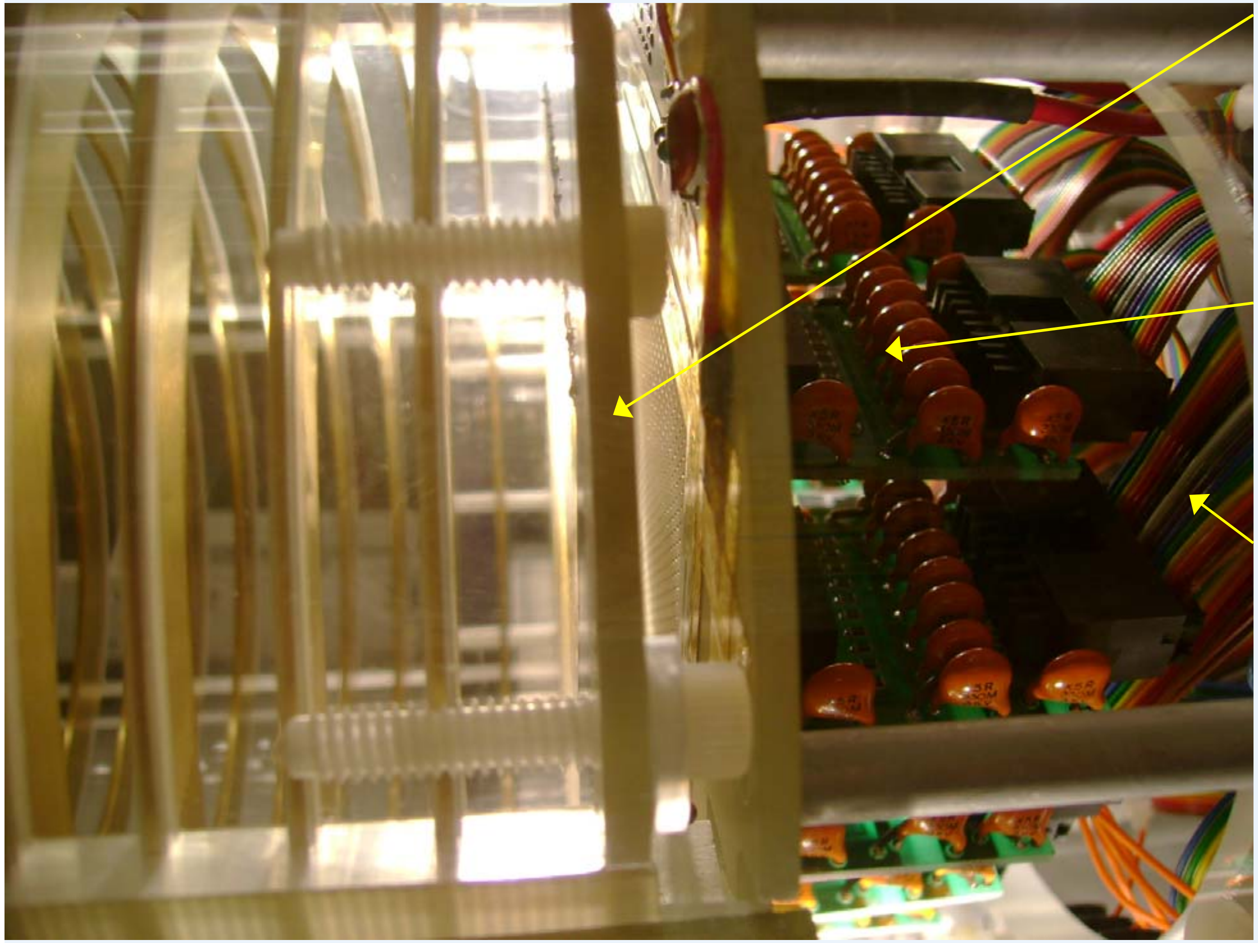


10 cm

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



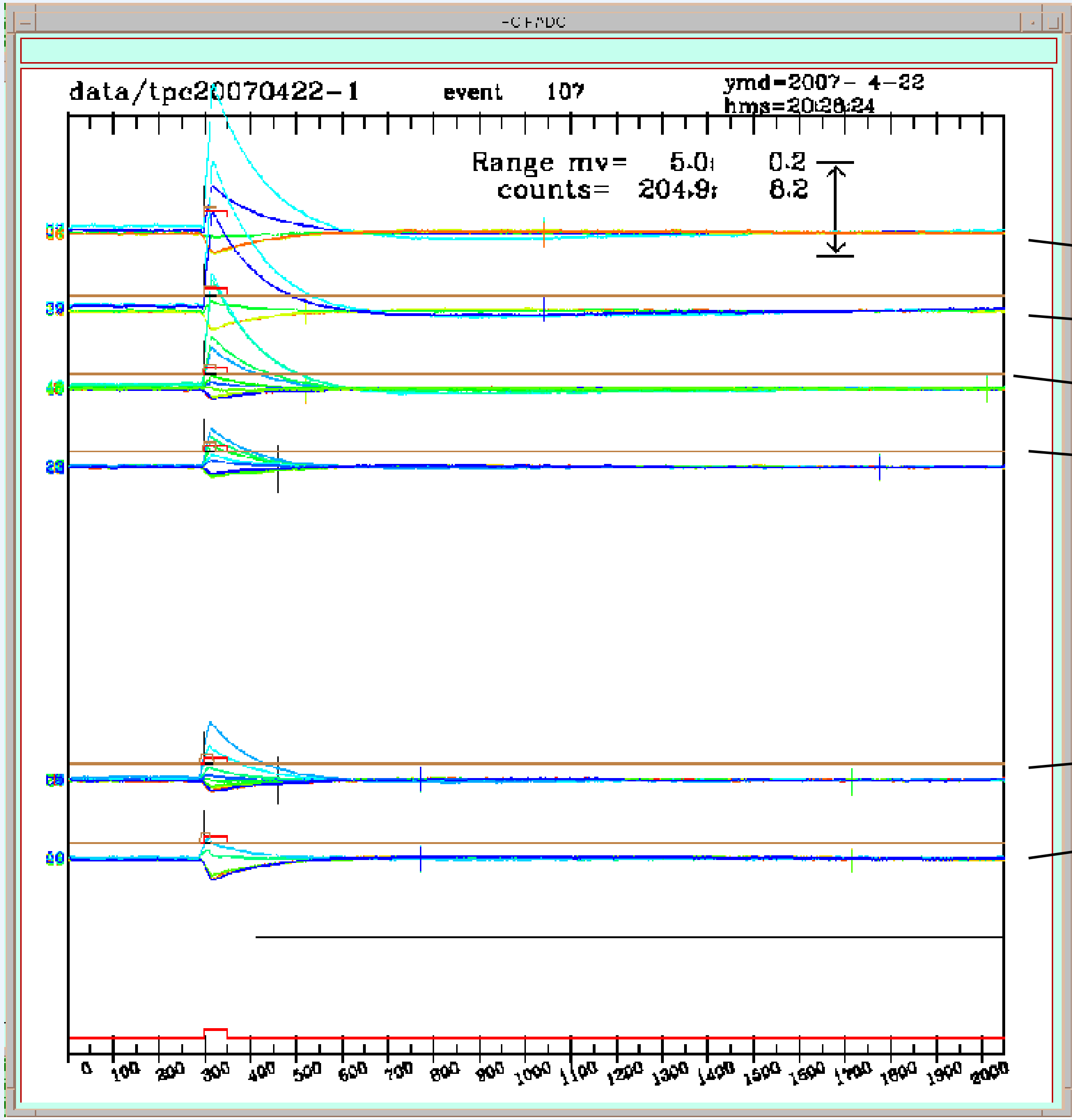
The Micromegas is located
0.78 cm from the
field cage termination.

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

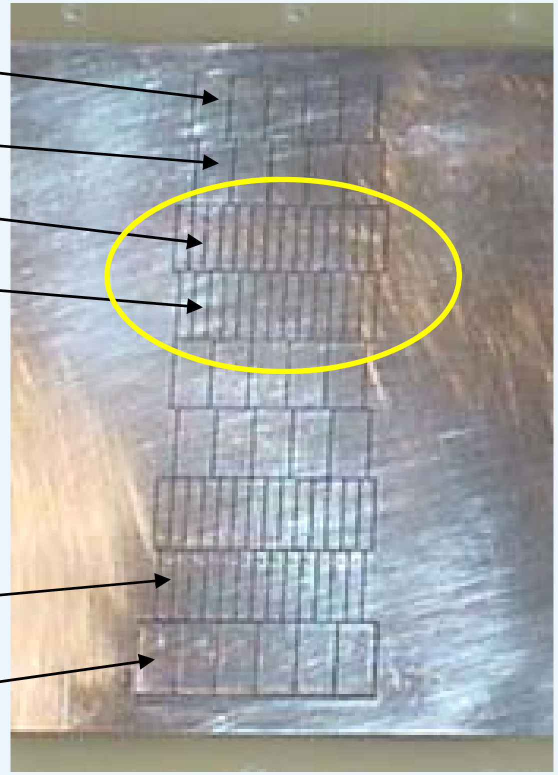
Low voltage signals
routed to preamps outside
(on ribbon cable).

**Micromegas is at ground;
pads at +410V
for Ar-isoC_4H_{10} (7%).**

bulk Micromegas event

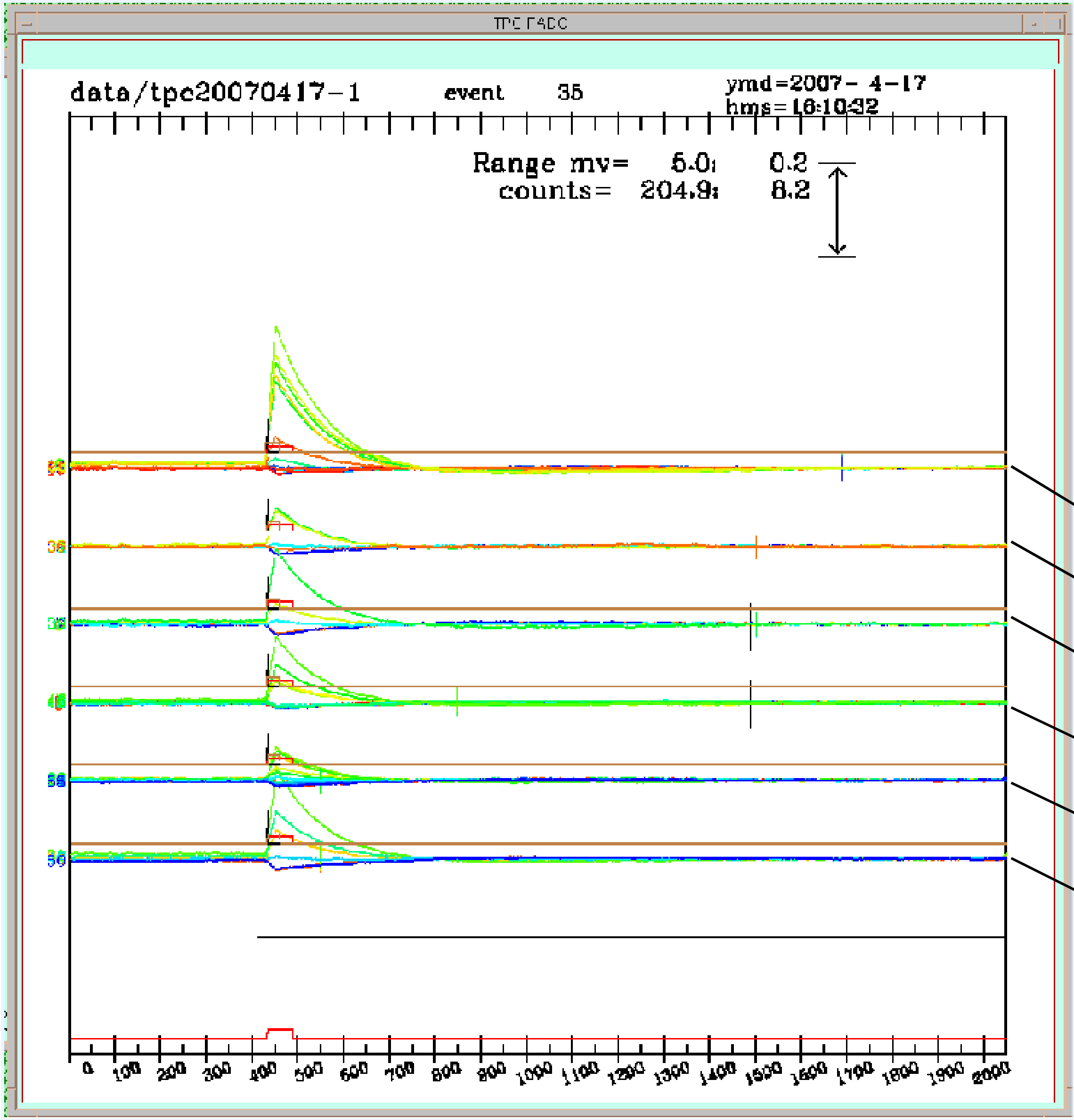


Ar-isoC_4H_{10} (7%) , 200V/cm
Micromegas: 410V / 50 μm



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

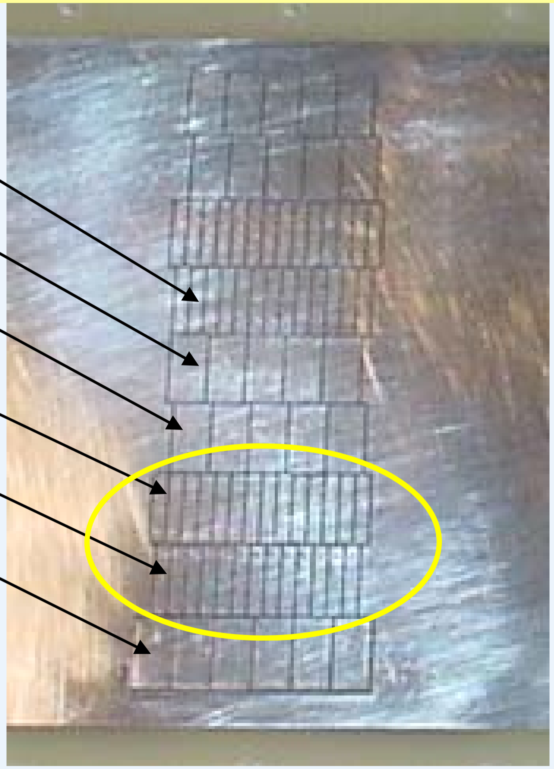
bulk Micromegas event



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.



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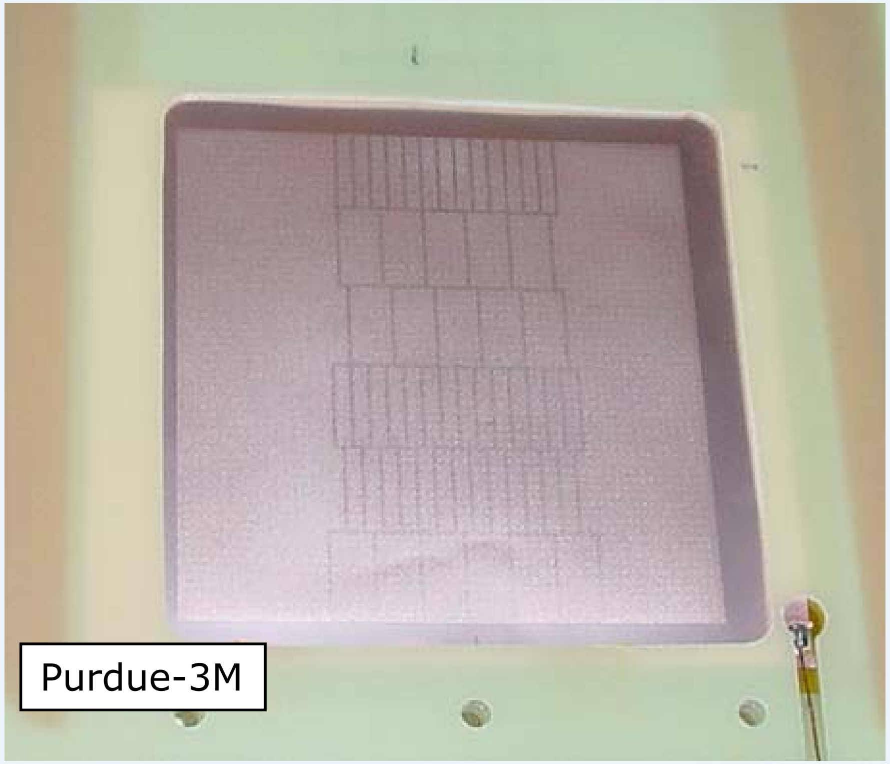
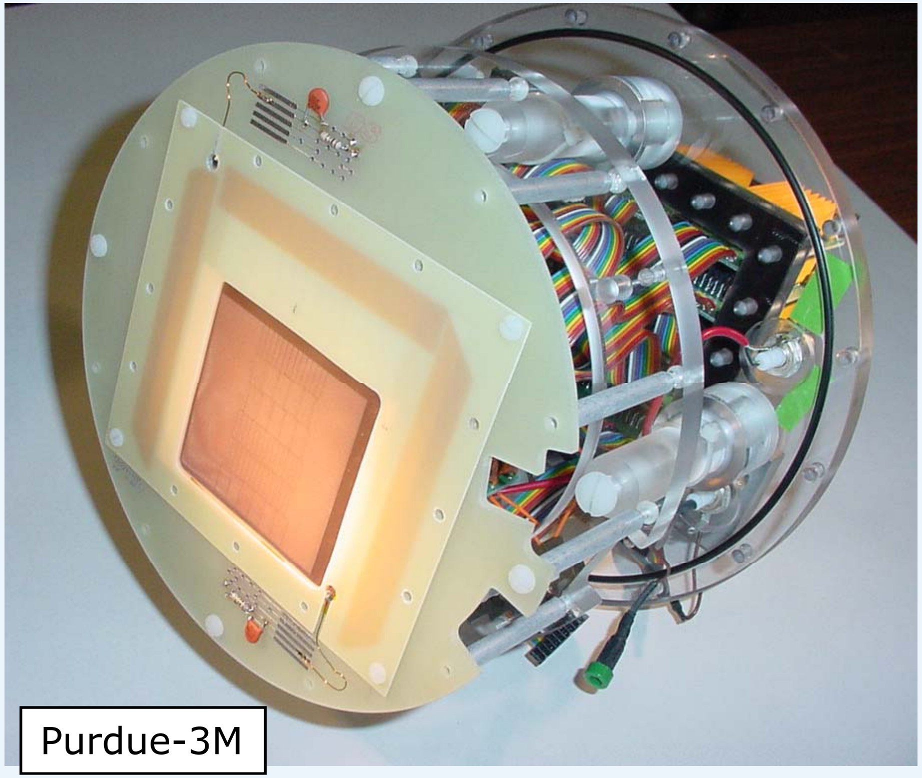
Purdue-3M Micromegas





10 cm

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

A similar “opposite signal” was observed with this device (below).

Purdue-3M Micromegas

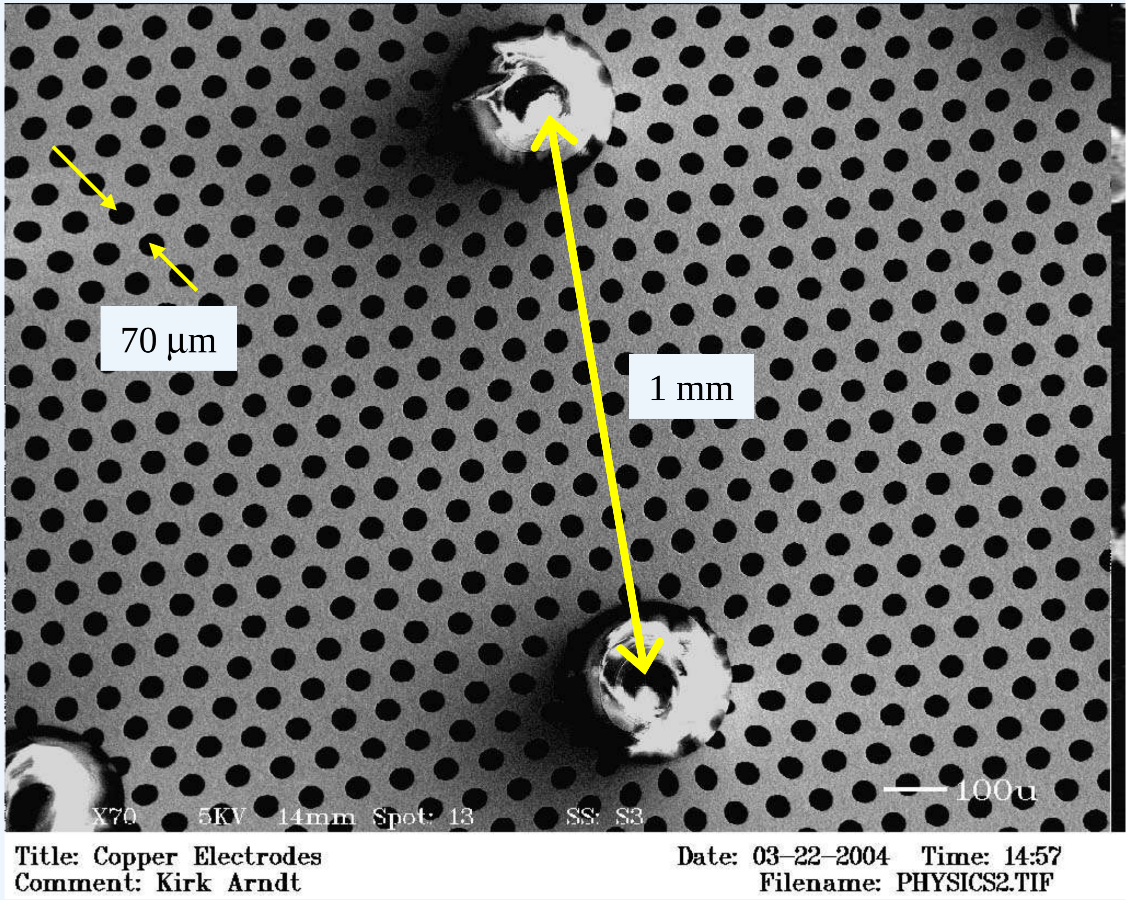
Micromegas is commercially made by the 3M corporation
in a proprietary subtractive process
starting with
copper clad Kapton.

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

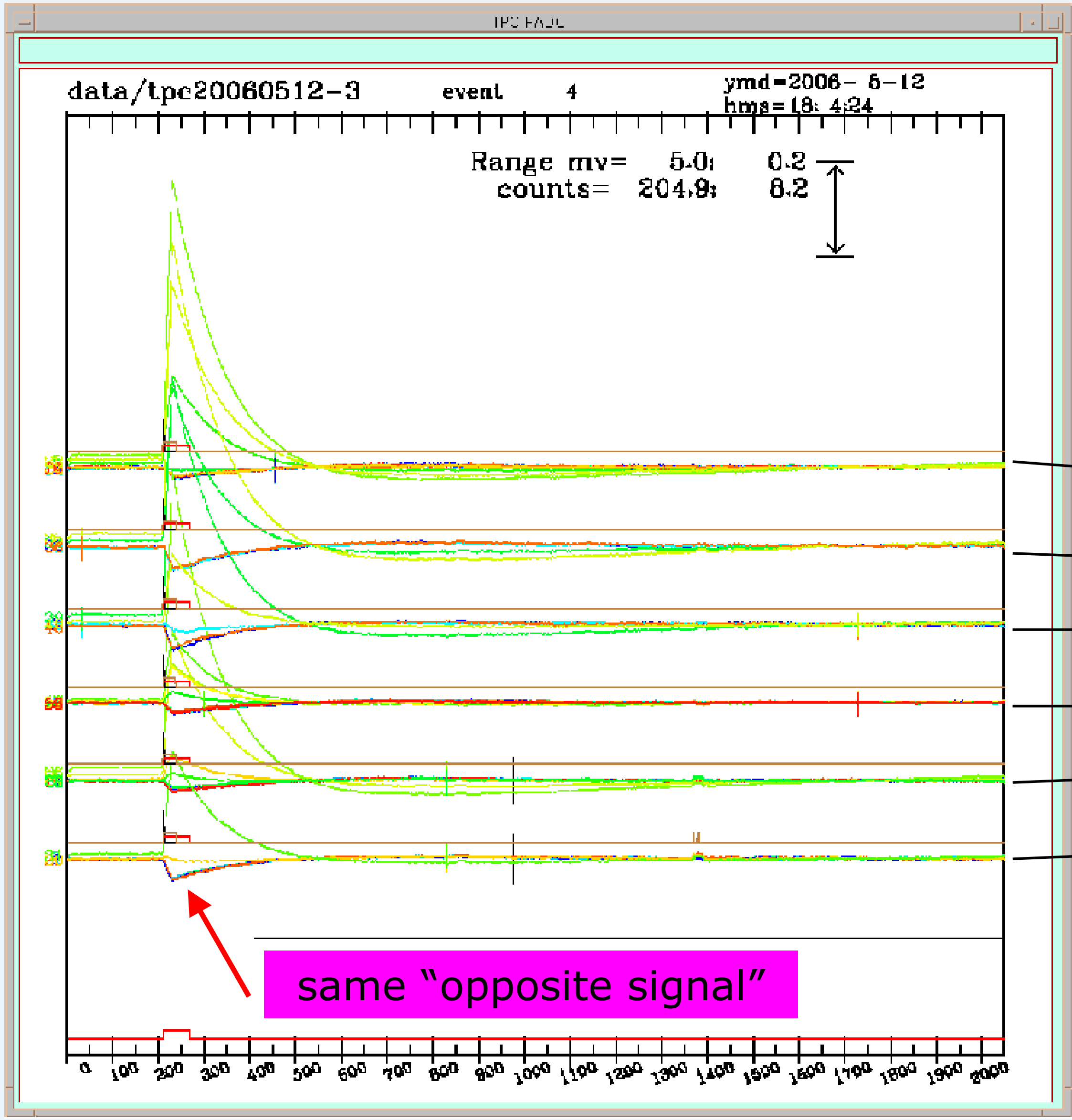
Copper thickness: 9 µm

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

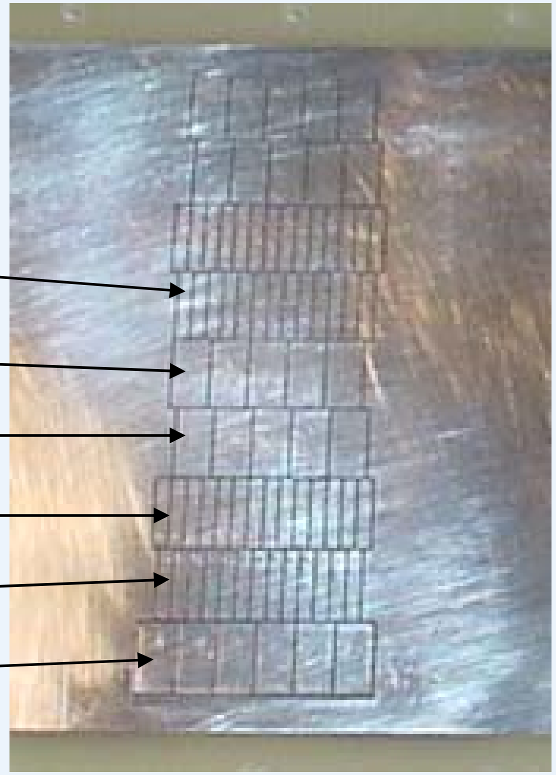
The shiny surface of the pillars is due to charge build-up from the electron microscope.



Purdue-3M Micromegas event

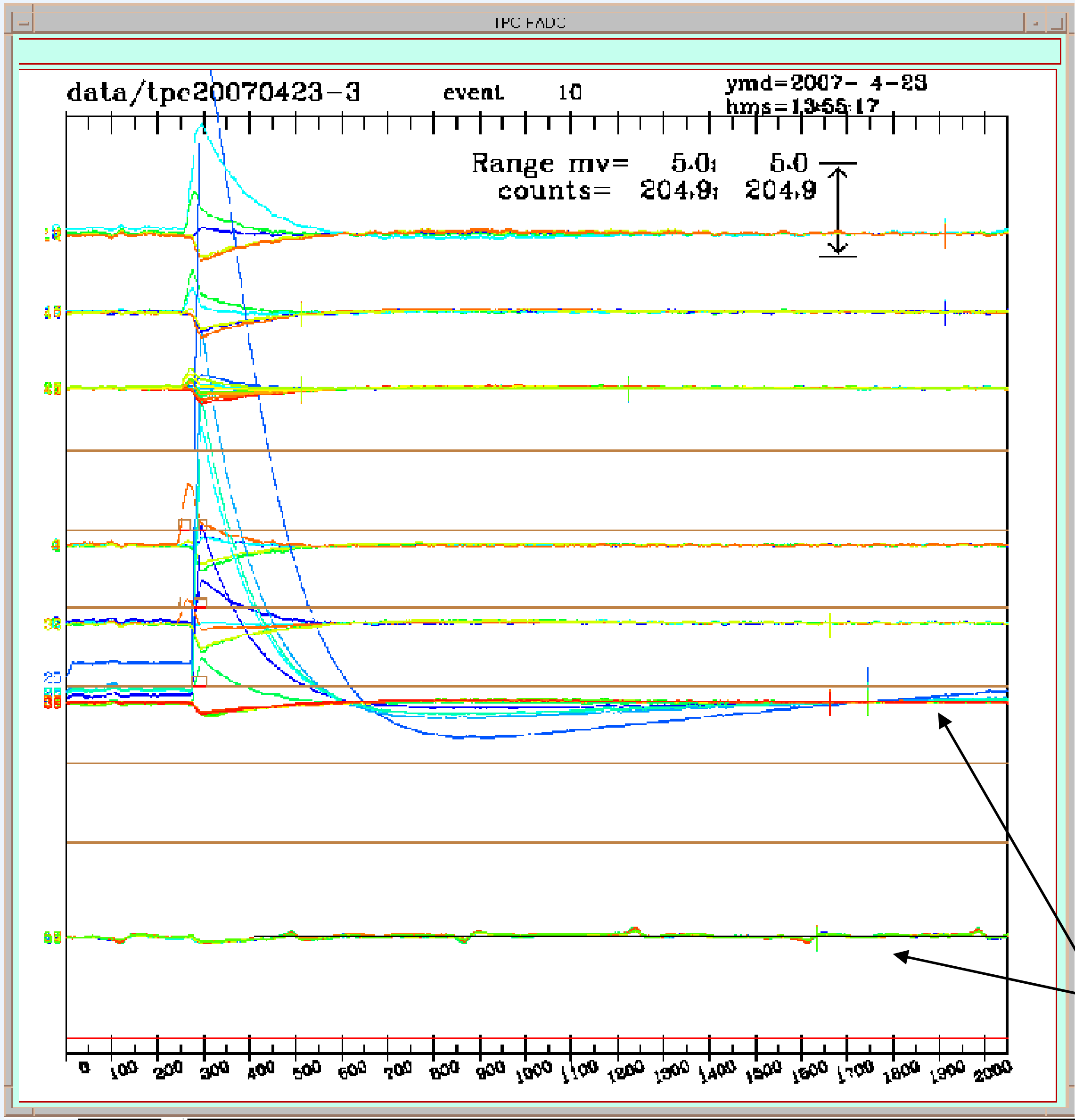


Ar-isoC_4H_{10} (10%) , 200V/cm
Micromegas: 410V / 50 mm



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

“opposite signal” not in FCT



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

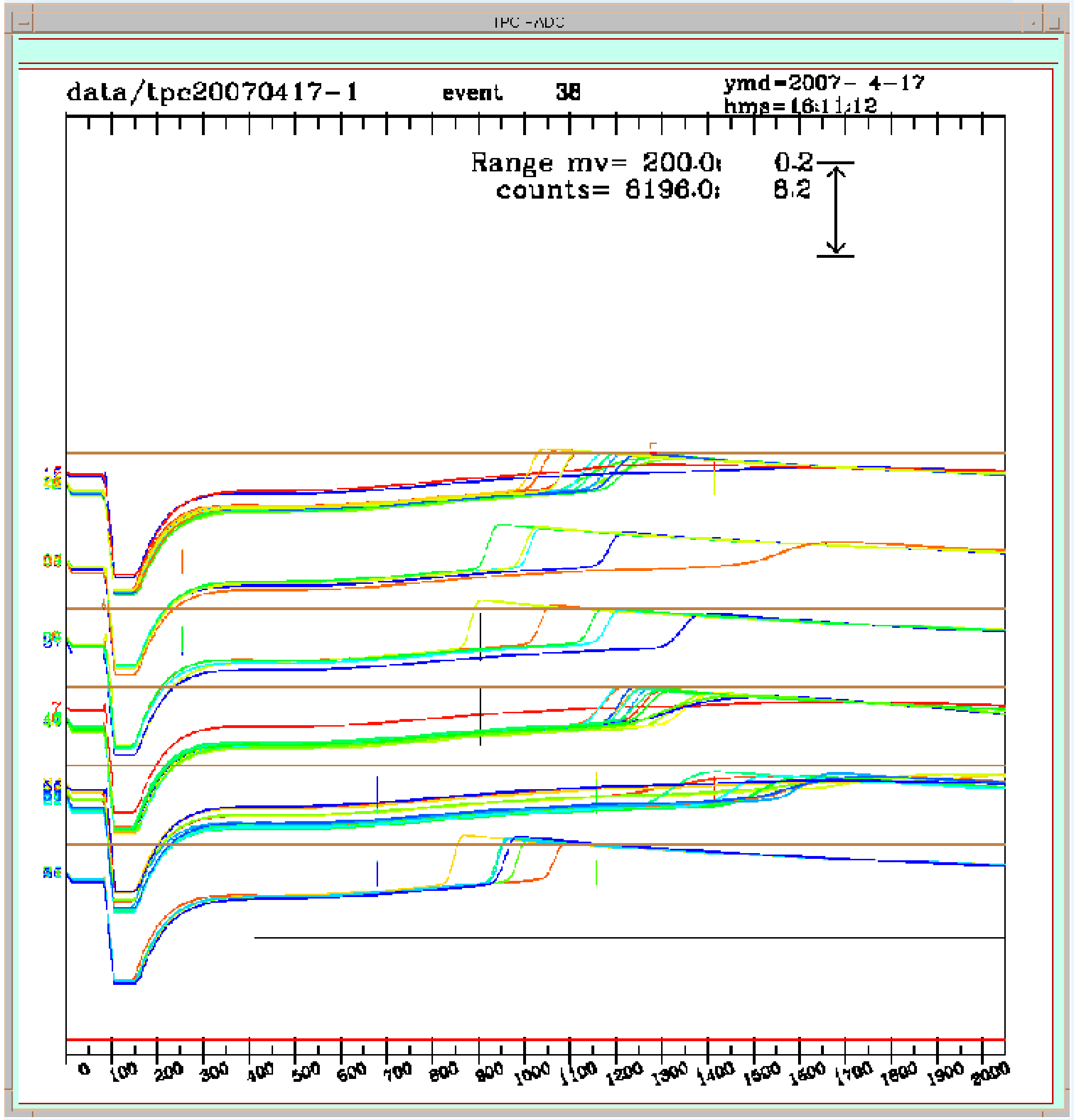
It is not clear if this signal is coming from the pad board or from the pickup in the electronics.

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 CO_2 410V 1 hour
420V 18 hours
430V 4 days

Ar-isoC_4H_{10} (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 CO_2 running

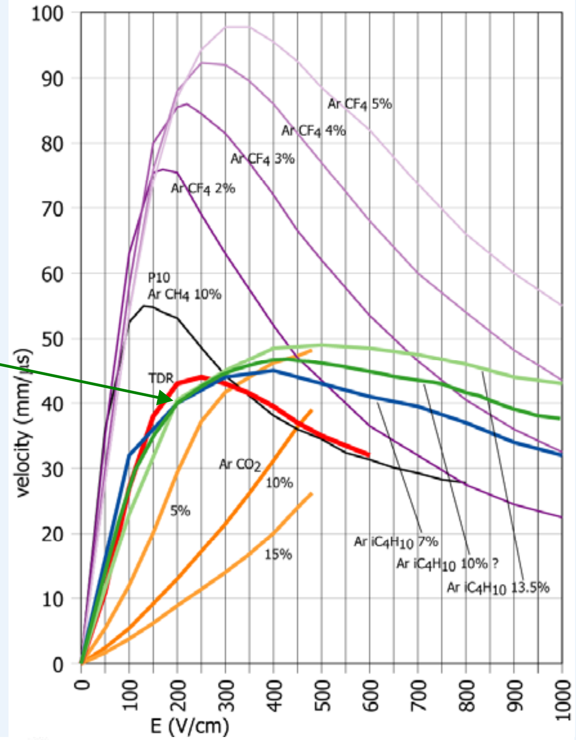
5.9 / hour at beginning and end of Ar-isoC_4H_{10} .

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_4H_{10} (7%), expect ~39 mm/μs .

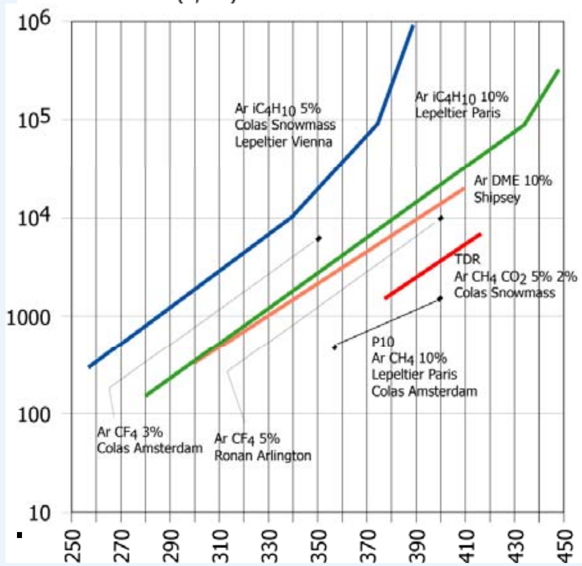
Observed time for a maximum drift 64.7 cm is (410 FADC time buckets)x(40ns/bucket), or 39.5 mm/μs .



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

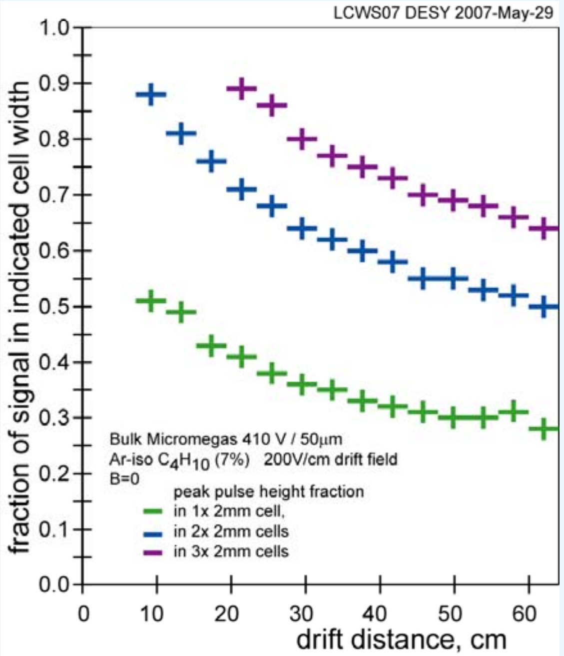
Although it is difficult to extrapolate for Ar-isoC_4H_{10} (7%) , at 410V, the gain is about estimated to be ~10^5 .

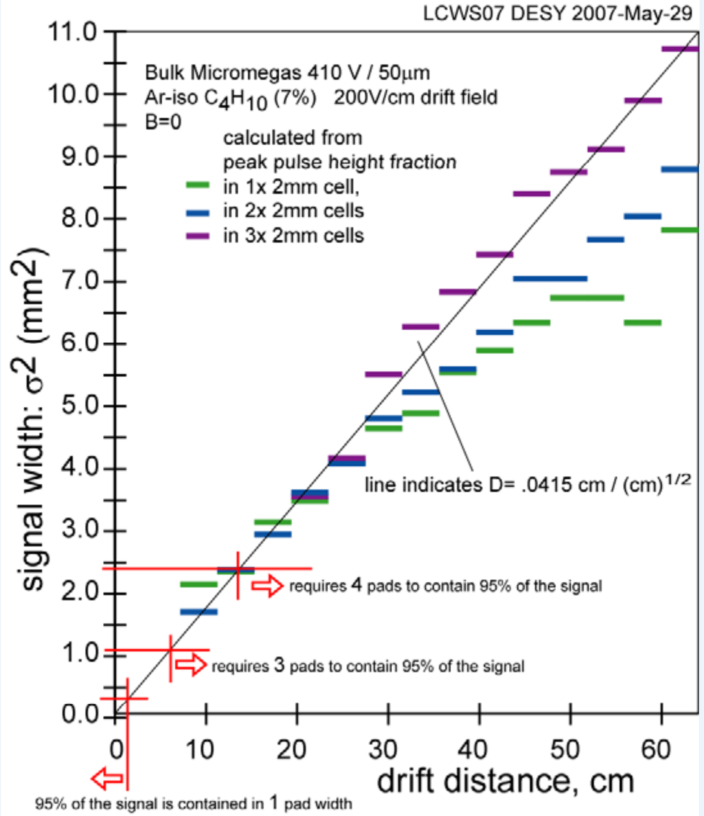
While Gain estimates were stated for the Purdue-3M Micromegas at Berkeley, April 2006, the absolute gain requires more study.



However, the gain ratio, Bulk/Purdue, is ~20% .

Charge width / diffusion



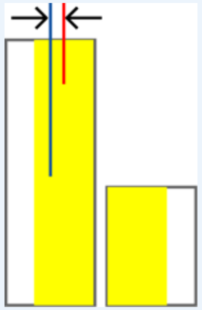


The charge width is determined from the fraction of the total charge in 1,2 or 3 pads, shown above, assuming a gaussian charge distribution.

(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=.0415 cm / (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

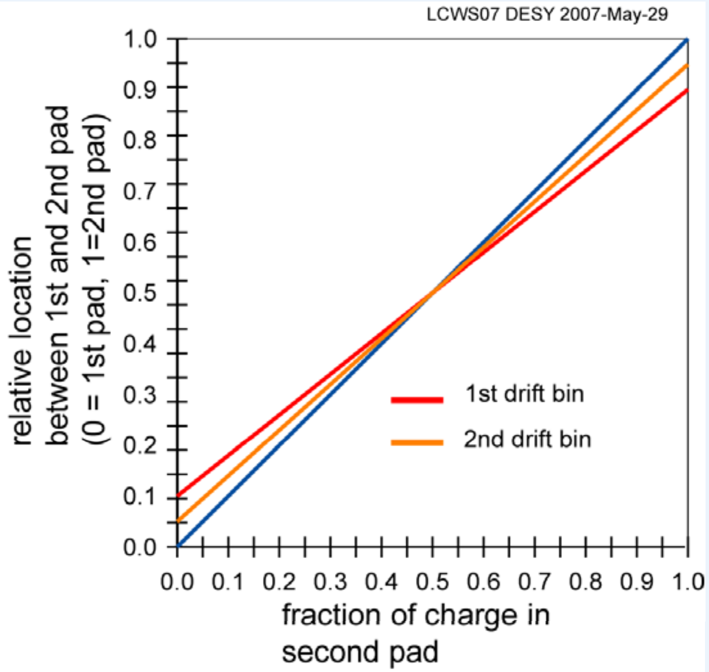
find PH center using maximum PH pad
plus nearest neighbors
(total 2 to 4 pads)

fit, deweighting the 5mm pad measurements

Here, the containment width of the pad distribution function is small; any sharing indicates that the charge center of each pad is not the geometric center. Thus, there is a shift of the effective pad center.

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.)

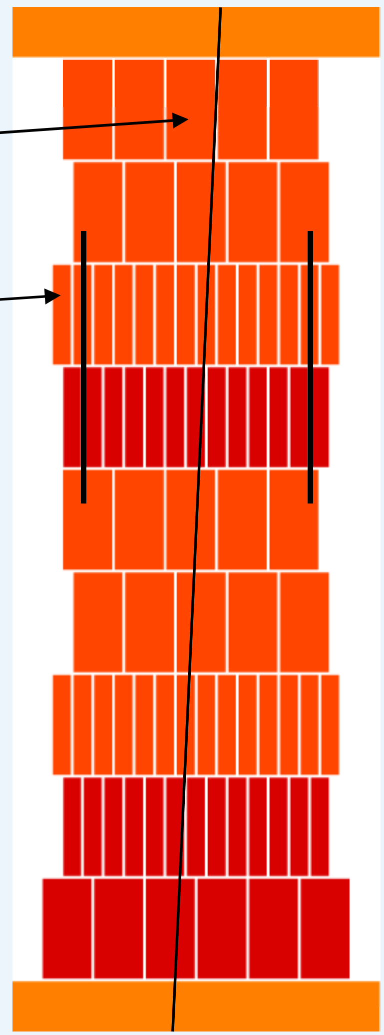


resolution difference

RMS of difference in residual
for the adjacent 2mm layers

correct with : $\sigma = \text{RMS} / \sqrt{2}$

cuts, calibration



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 $\sigma=(\sigma_0^2 + D^2/n\ x)^{1/2}$

use $D=.0415\ cm/(cm)^{1/2}$.

result: $n=17.4 \pm .5$

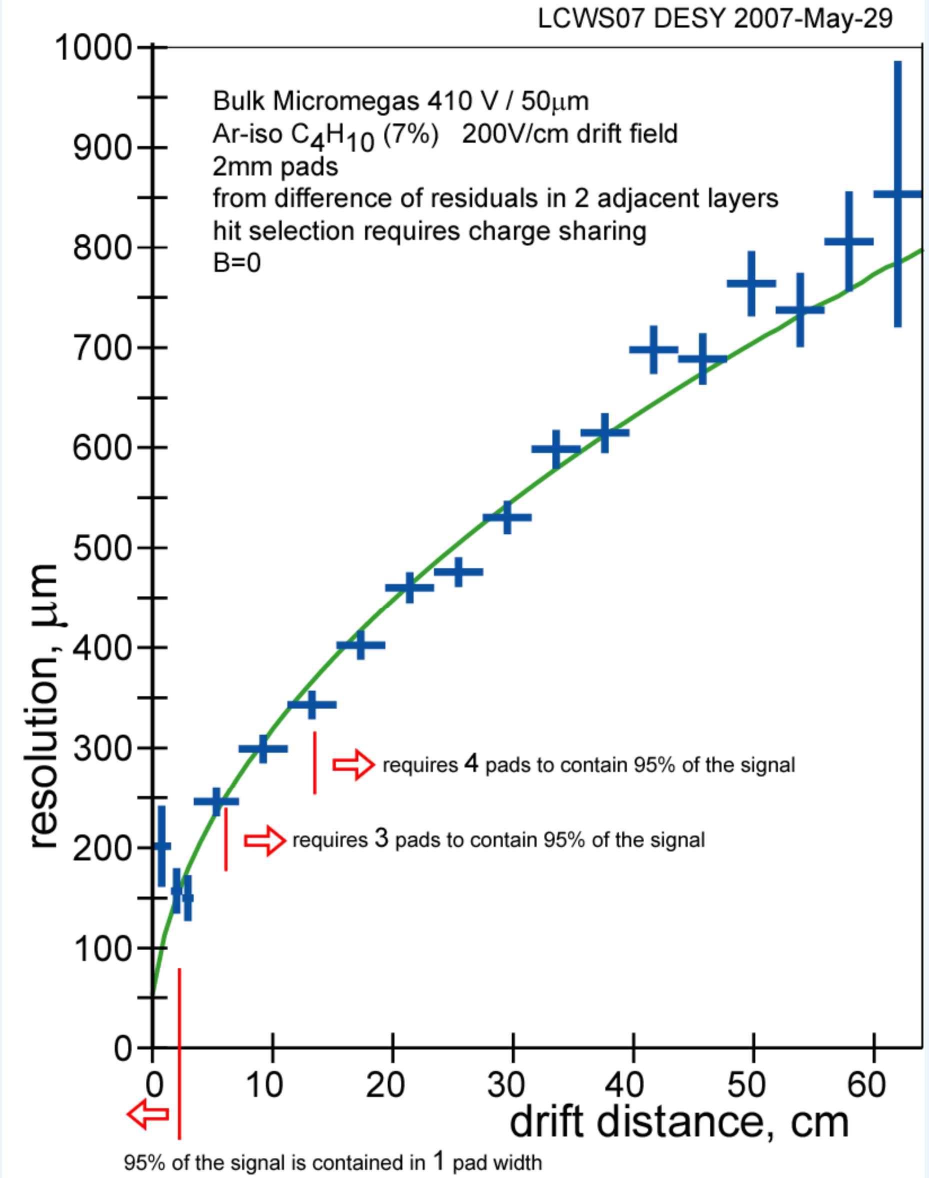
$\sigma_0 = 53 \pm 36\ \mu m$

$\chi^2/dof = 1.7$

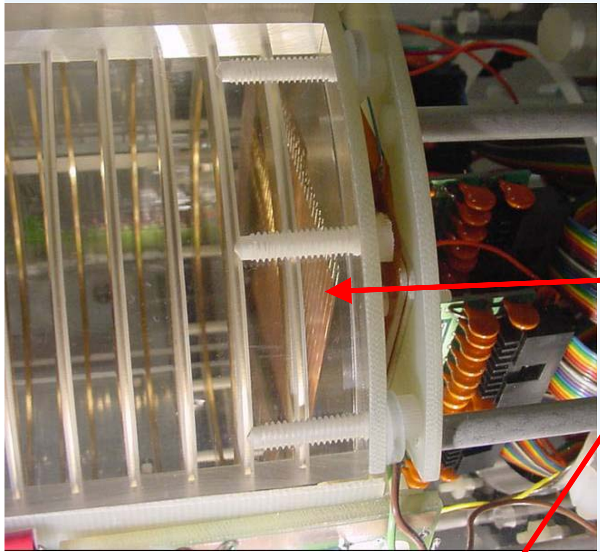
All points are in the fit.

A systematic uncertainty in σ_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

σ_0 (modified T_0) = 103 μm.



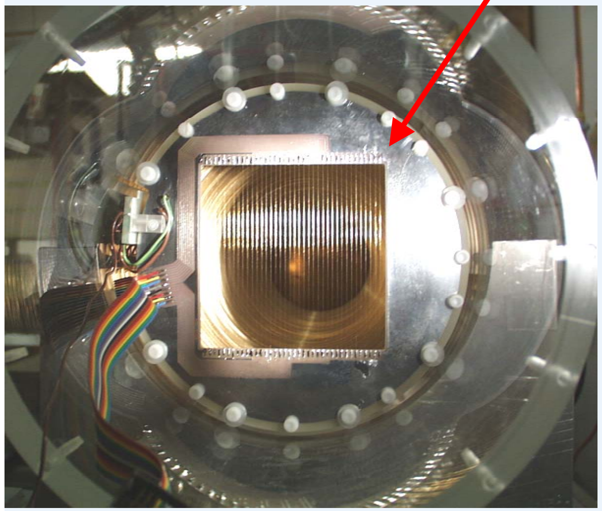
Ion Feedback Detection



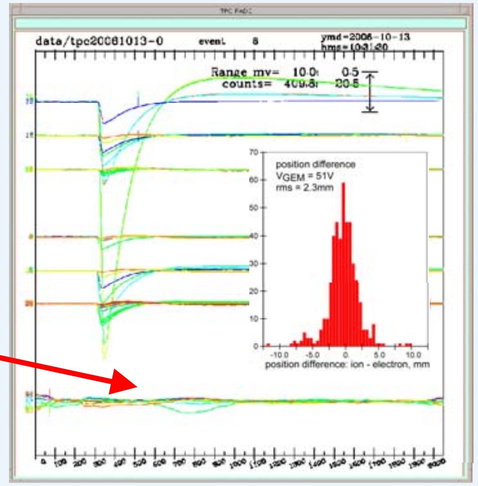
We continue plans to measure positive ion feed-back into the field cage

using a technique of ion collection,
for individual tracks,
on the (double) field cage termination.

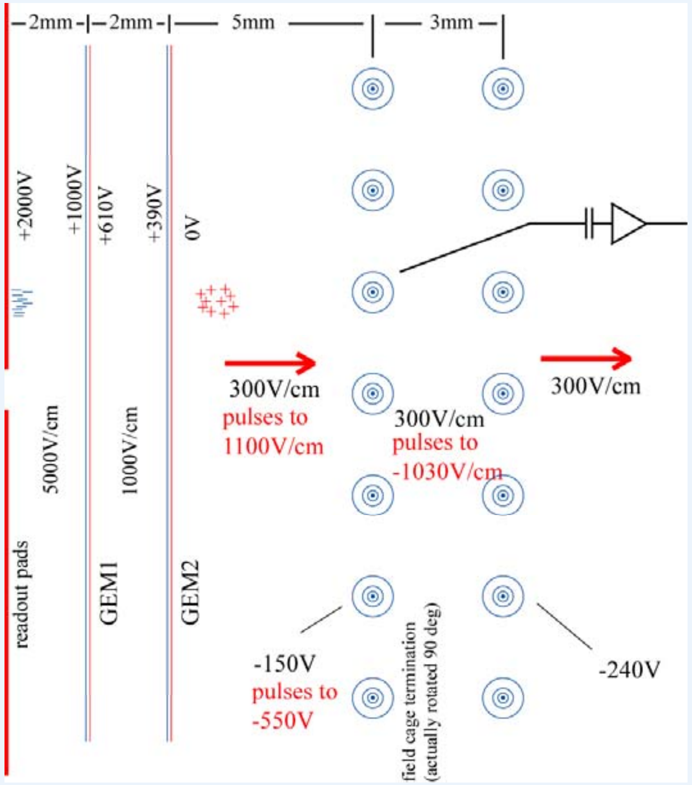
The method differs from that used by Saclay/Orsay on MicroMegas and by Aachen on GEM. For those measurements, a source was used to create ionization. Current was measured on the cathode.

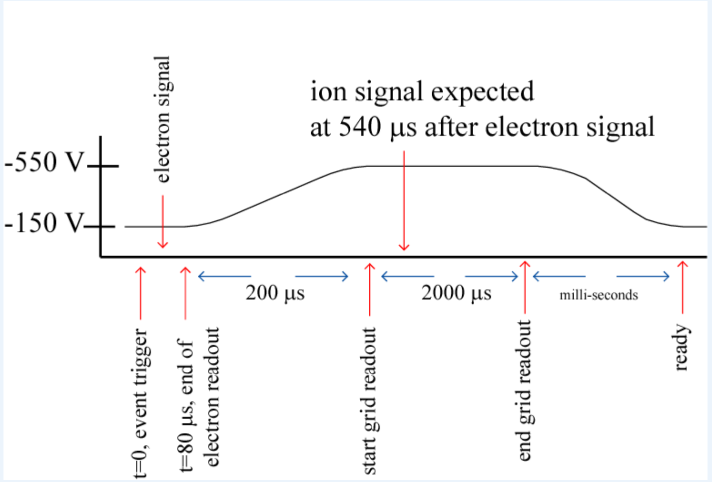


The ion collection
was demonstrated in earlier talks,
using a constant bias on the
field cage termination plane.



Ion Feedback measurement, with pulsed field cage termination

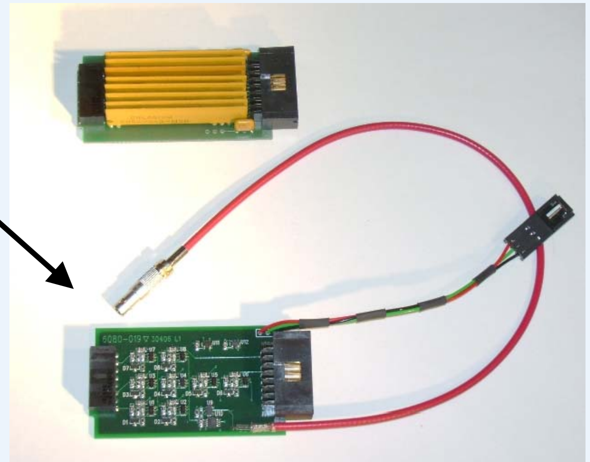




More sensitive measurements will require a pulsed bias on the field cage termination to provide full electron transmission and full ion collection.

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.

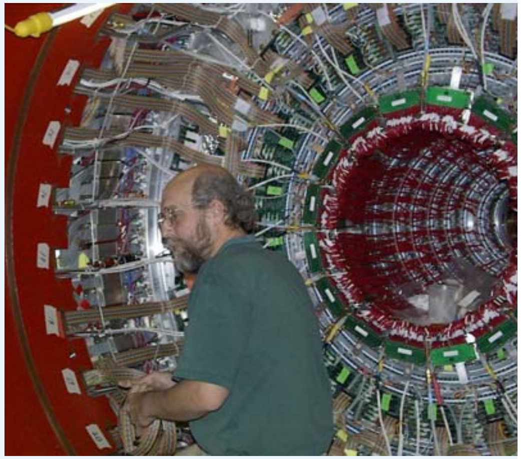
Plan to repeat measurements of the Purdue-3M Micromegas with consistent conditions.

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)