Testing the Purdue-3M Micromegas in the Cornell/Purdue TPC

Cornell University
D. P. Peterson
L. Fields
R. S. Galik
P. Onyisi

Purdue University
K. Arndt
G. Bolla
I. P. J. Shipsey

* presentation at ECFA 2005 Vienna 24-November-2005
* presentation at ALCPG Snowmass 23-August-2005
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* presentation at TPC mini-workshop, Orsay 12-January-2005
* presentation by Gino Bolla, Berkeley March-2005

Information available at the web site: http://www.lepp.cornell.edu/~dpp/tpc_test_lab_info.html
www.physics.purdue.edu/msgc

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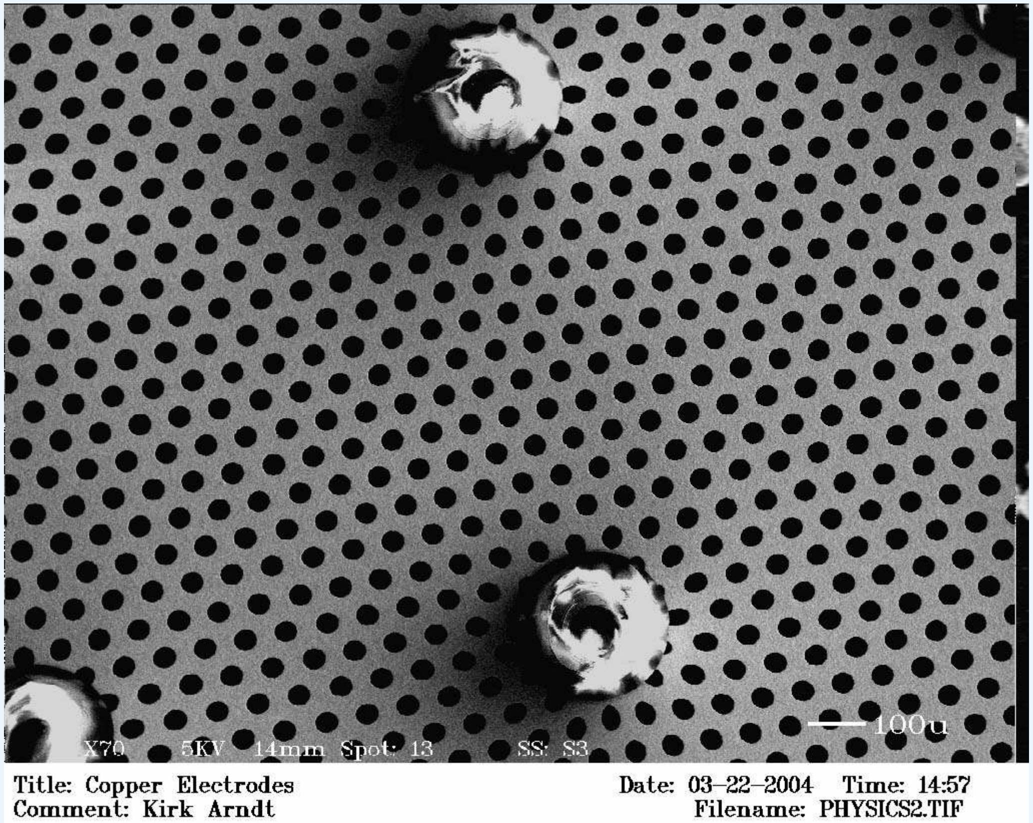
Purdue-3M Micromegas

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

Hole are etched in the copper
- 70 μm spacing (smallest distance)
- 35 μm diameter

Copper thickness: 9 μm ?

Pillars are the 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.

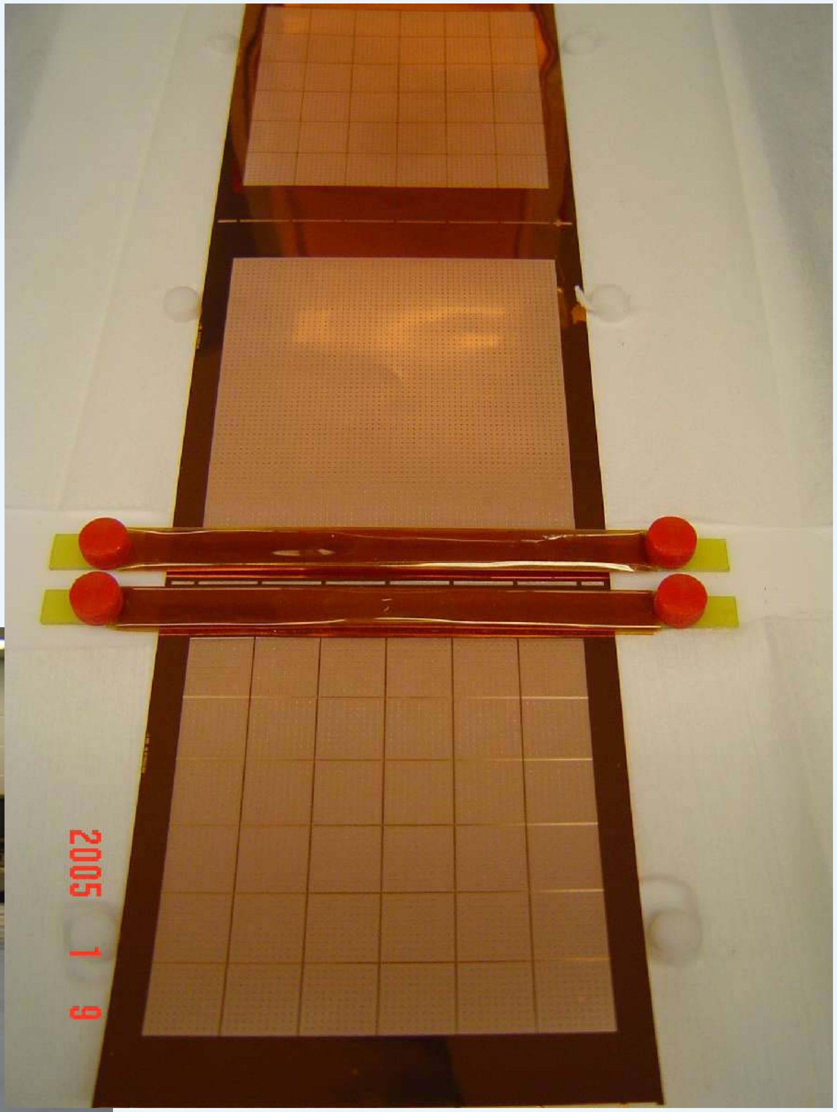
Purdue-3M Micromegas

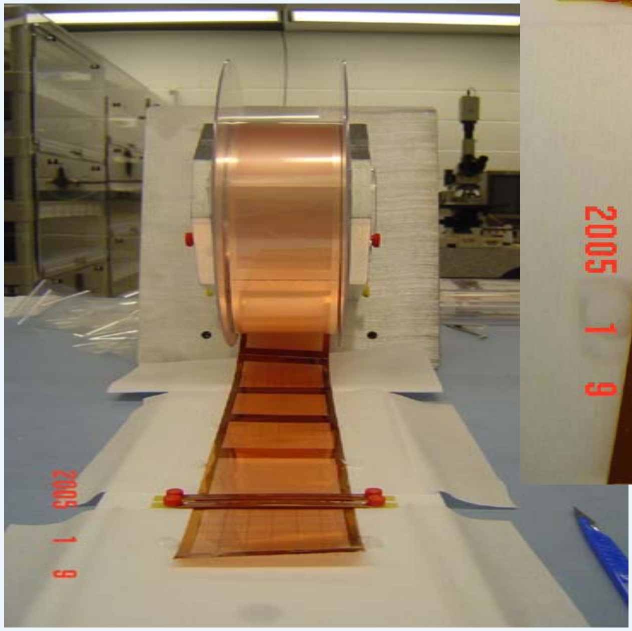
Devices are delivered on a roll.

There are 2 designs,
with and without the extra stand-off ribs.
(The designs alternate on the roll.)

Active area is 6 cm square.

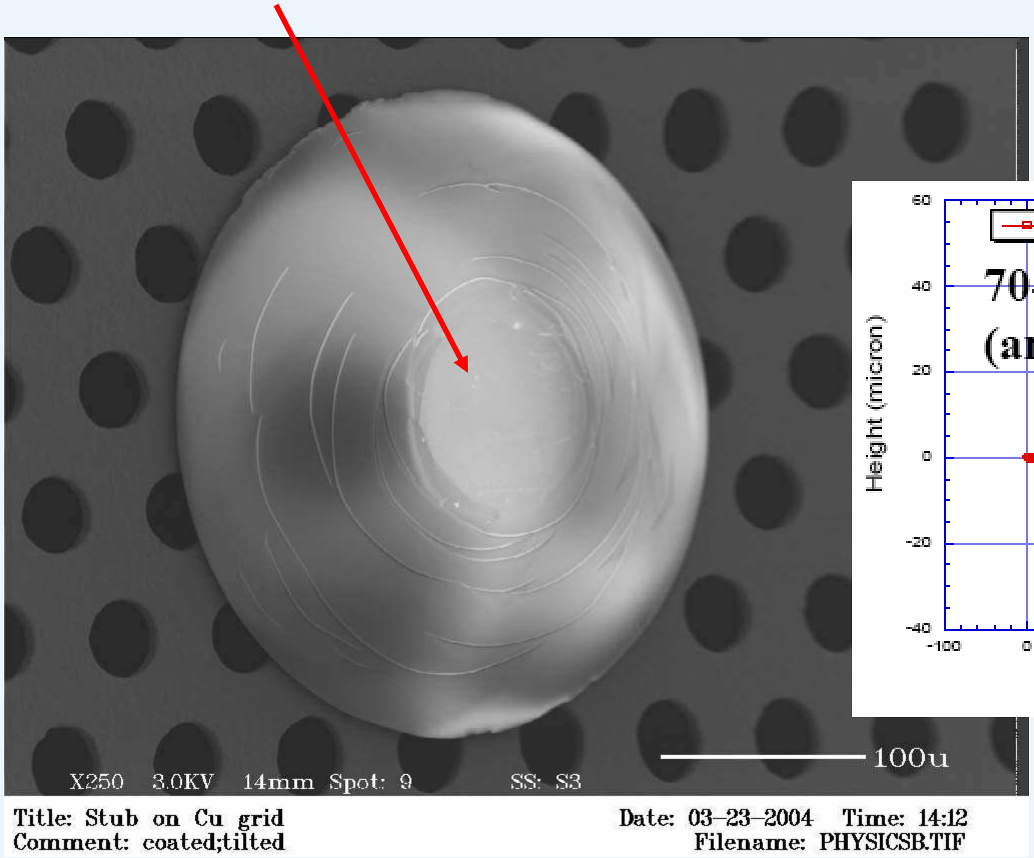
We are testing a
device without ribs.

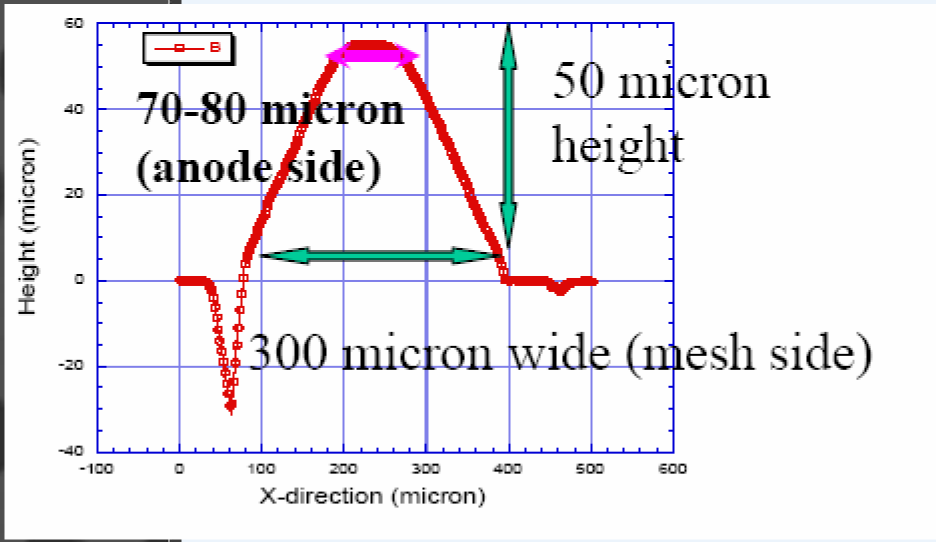




Purdue-3M Micromegas

High magnification photo shows the flat contact section of the pillar.





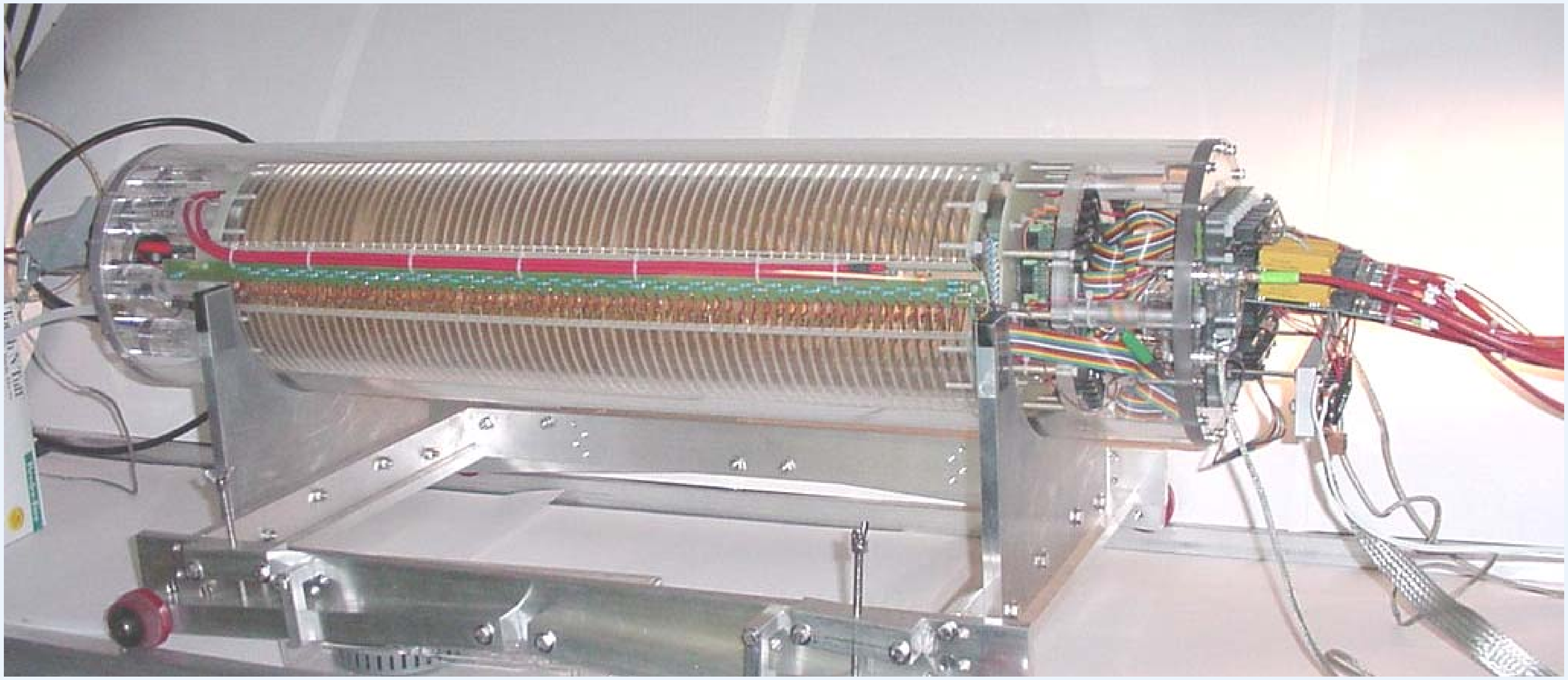
TPC

The construction is influenced by our research goal: to compare the various amplification technologies in a common environment.

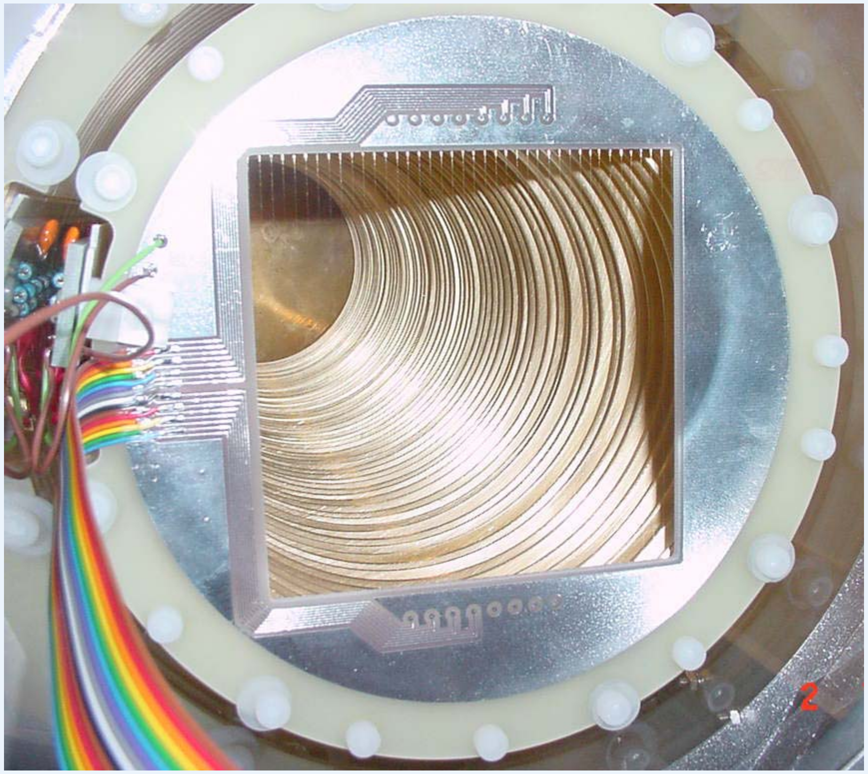
14.6 cm ID field cage - accommodates a 10 cm GEM
64 cm drift field length
22.2 cm OD outer structure (8.75 inch)

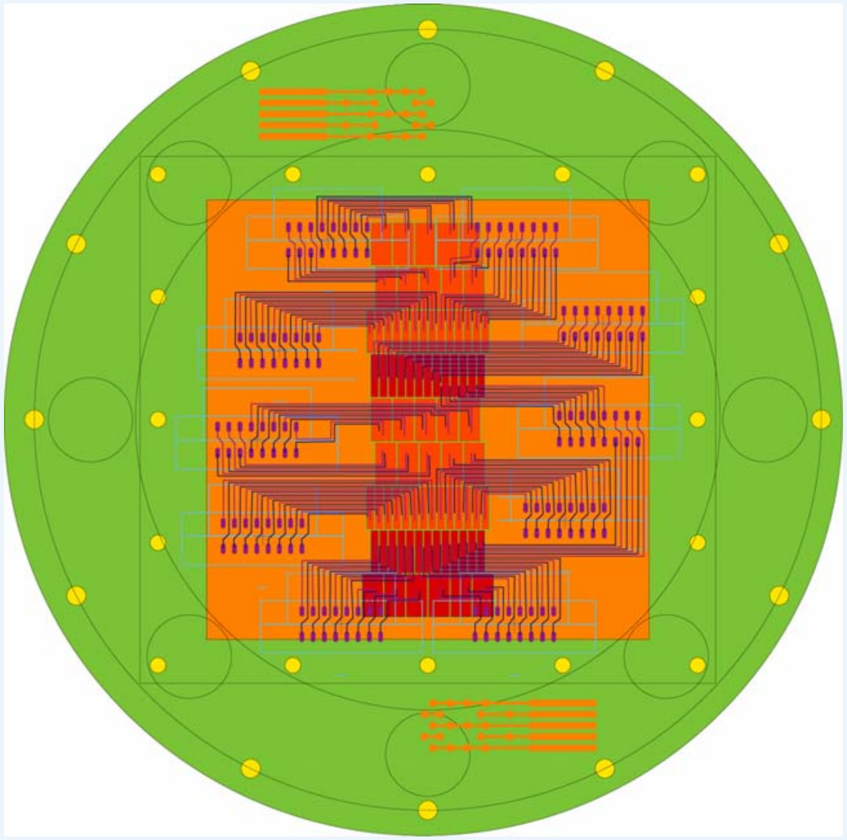
"field cage termination" and "final" return lines for the field cage HV distribution allow trimming the termination bias voltage.

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



Field cage termination





10 cm

Field cage termination area is 10cm square

The instrumented readout area is
~2.5 cm x 9 cm , 80 pads.
Instrument with only 56 channels

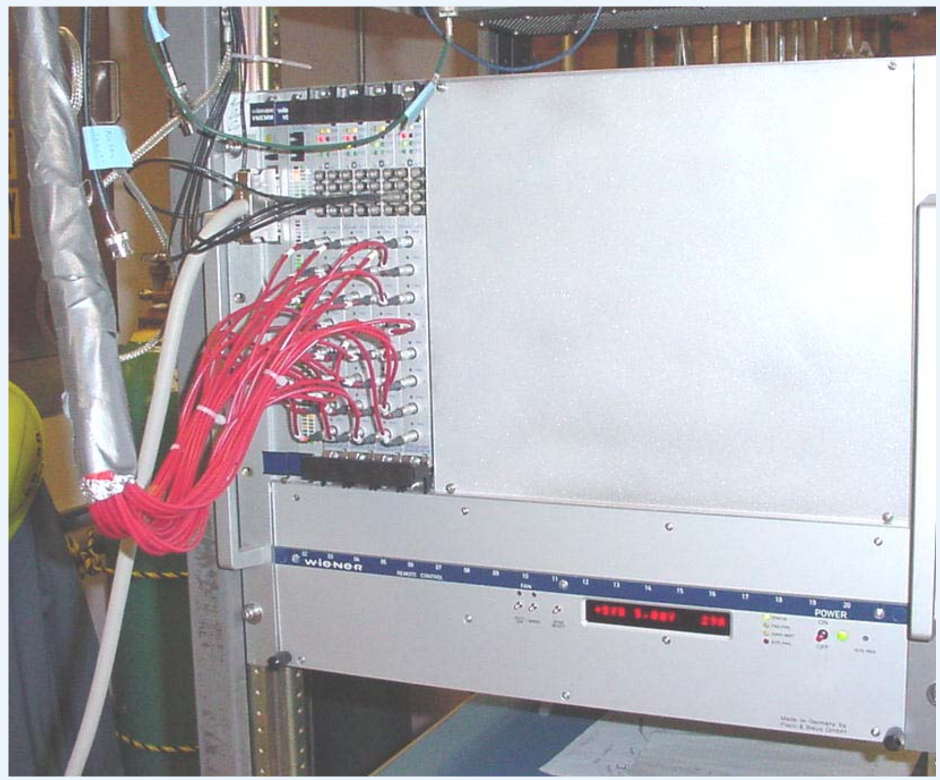
The biased area is 10cm square.

Electronics

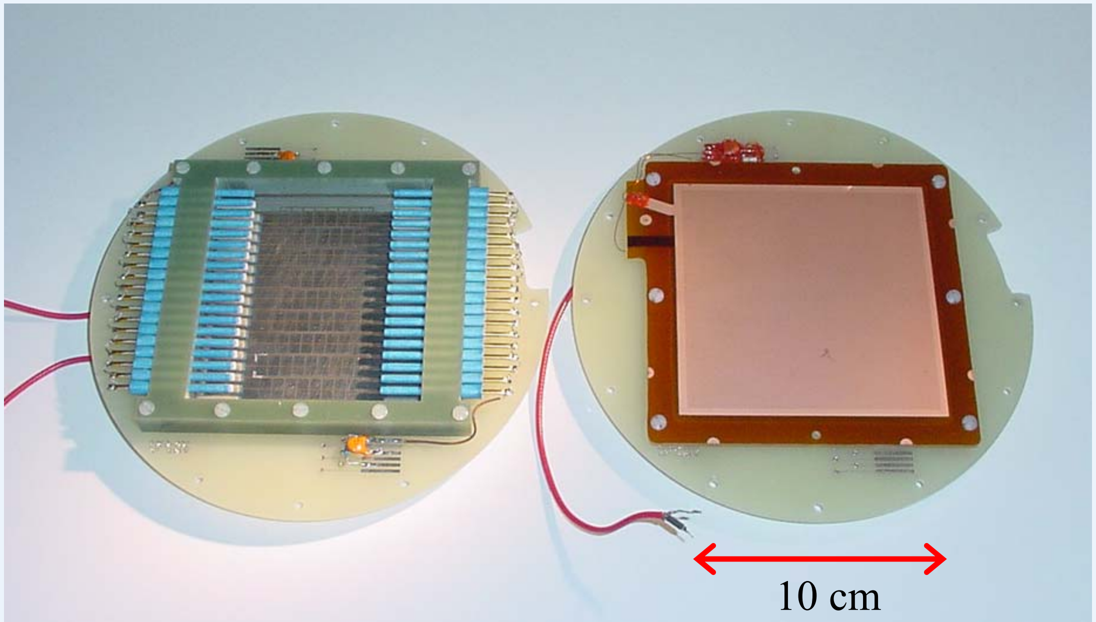
High voltage system:
- -20 kV module, 2 channels available
- -2 kV module, 4 channels available
- +2 kV module, 4 channels (new)

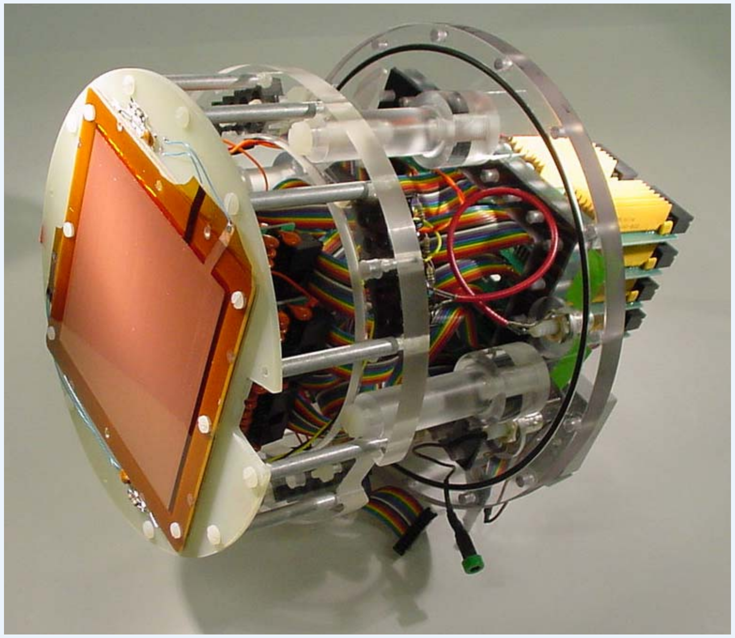
    previously used
    a NIM modules for +2kV

Readout:
- VME crate
  - PC interface card
    - LabView
- Struck FADC
  - 56 channels
  - 105 M Hz
  - 14 bit
  - +/- 200 mV input range
    (least count is 0.025mV)
  - NIM external trigger input
  - circular memory buffer



MPWC and GEM amplification





Demonstration data has been taken with the readout board with 5 mm width pads.

The instrumented readout area is ~2cm x7 cm , 32 pads.

The biased area is 10cm square.

(This pad board allows ~3 x 9 cm , 62 pads.)

The readout module including a double-GEM amplification device mounted on pad board

MWPC gas-amplification

MWPC
built at Cornell with
CLEO III drift chamber
spare parts.

mounted Dec-2004

biasing:
field cage, -20kV, 300 V/cm
termination: -900V

termination:grid **300V/cm**, 10mm

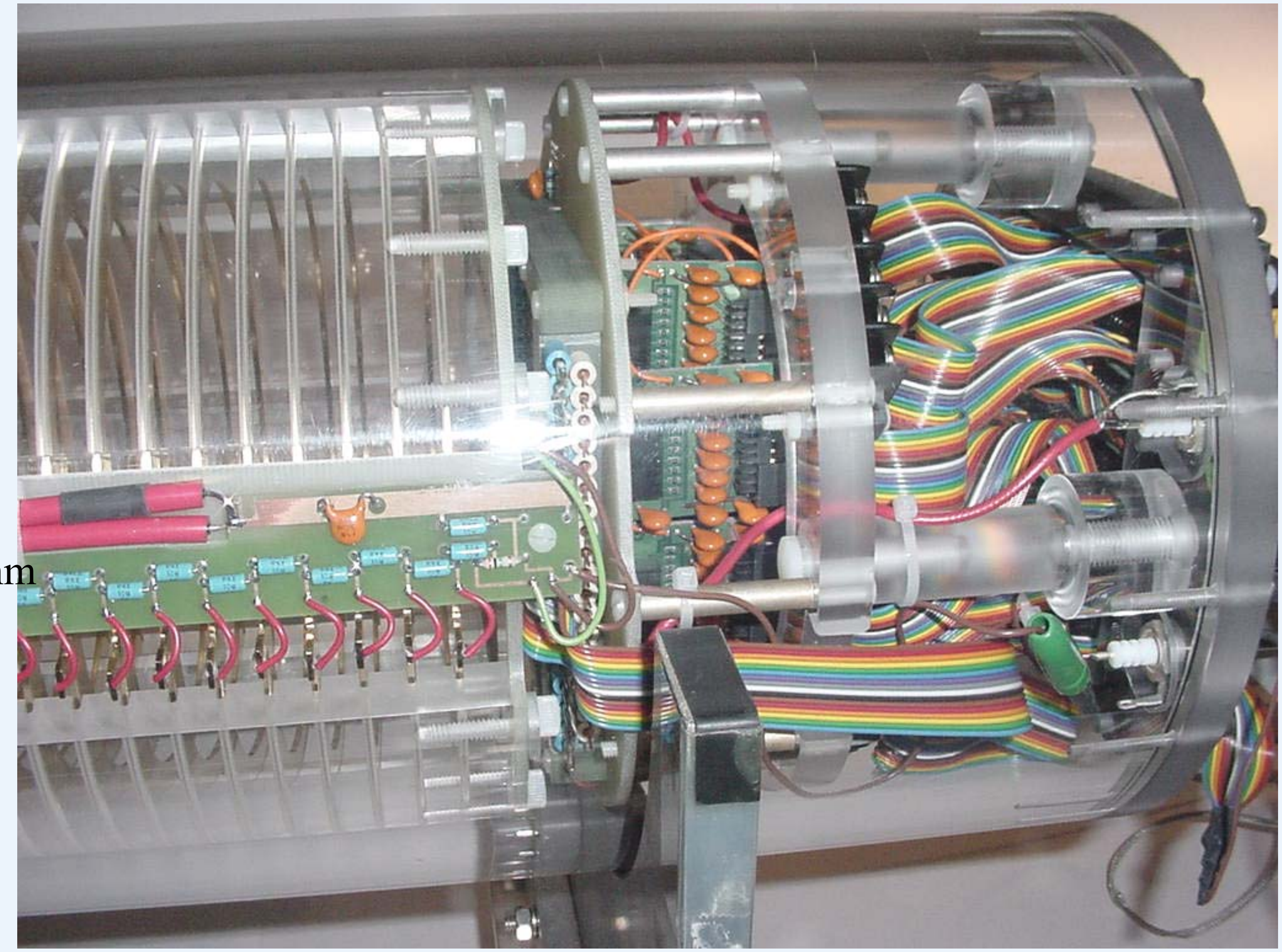
grid: -600V

grid:anode 5mm

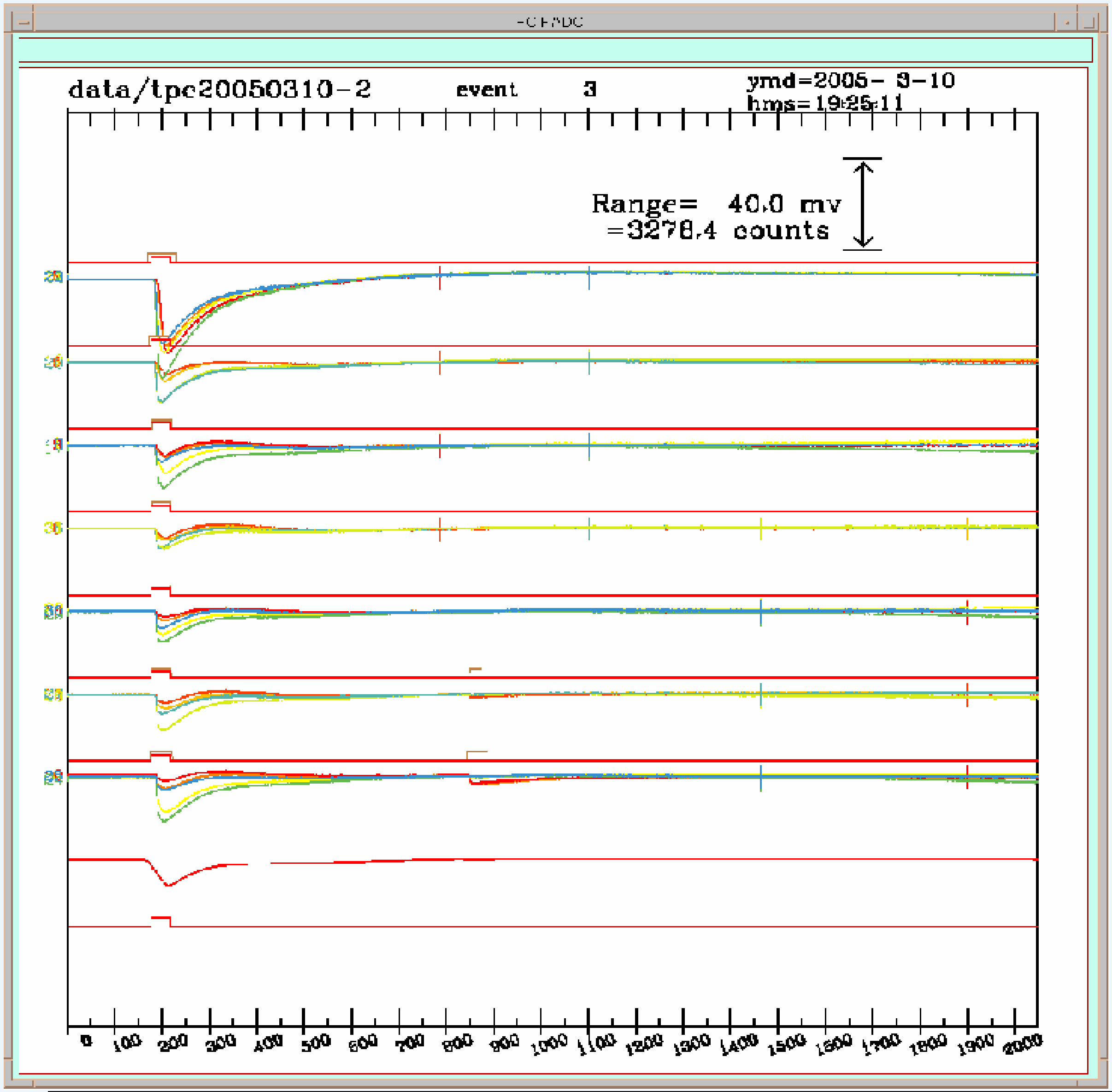
anode: +550V

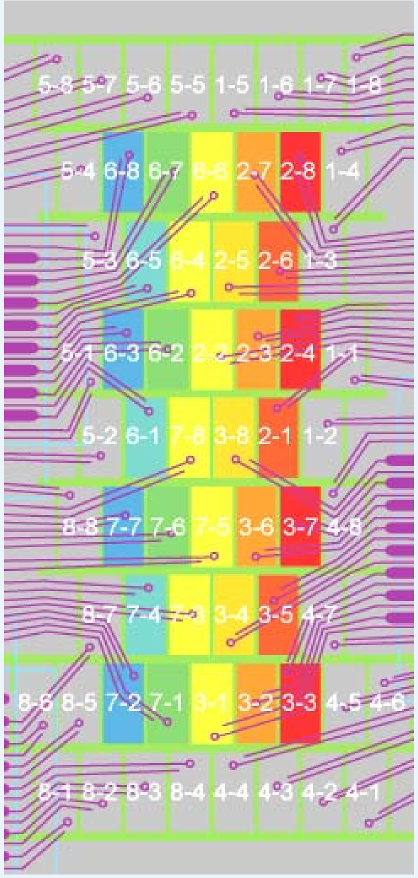
anode:pads 5mm

pads: -2000V



MWPC event (typical)





$ArCO_2$ (10%) , 300V/cm
25 MHz , 40 ns
2048 time buckets (81.92 μs)

single GEM

CERN GEM
mounted, tested by Purdue

installed 11-March-2005

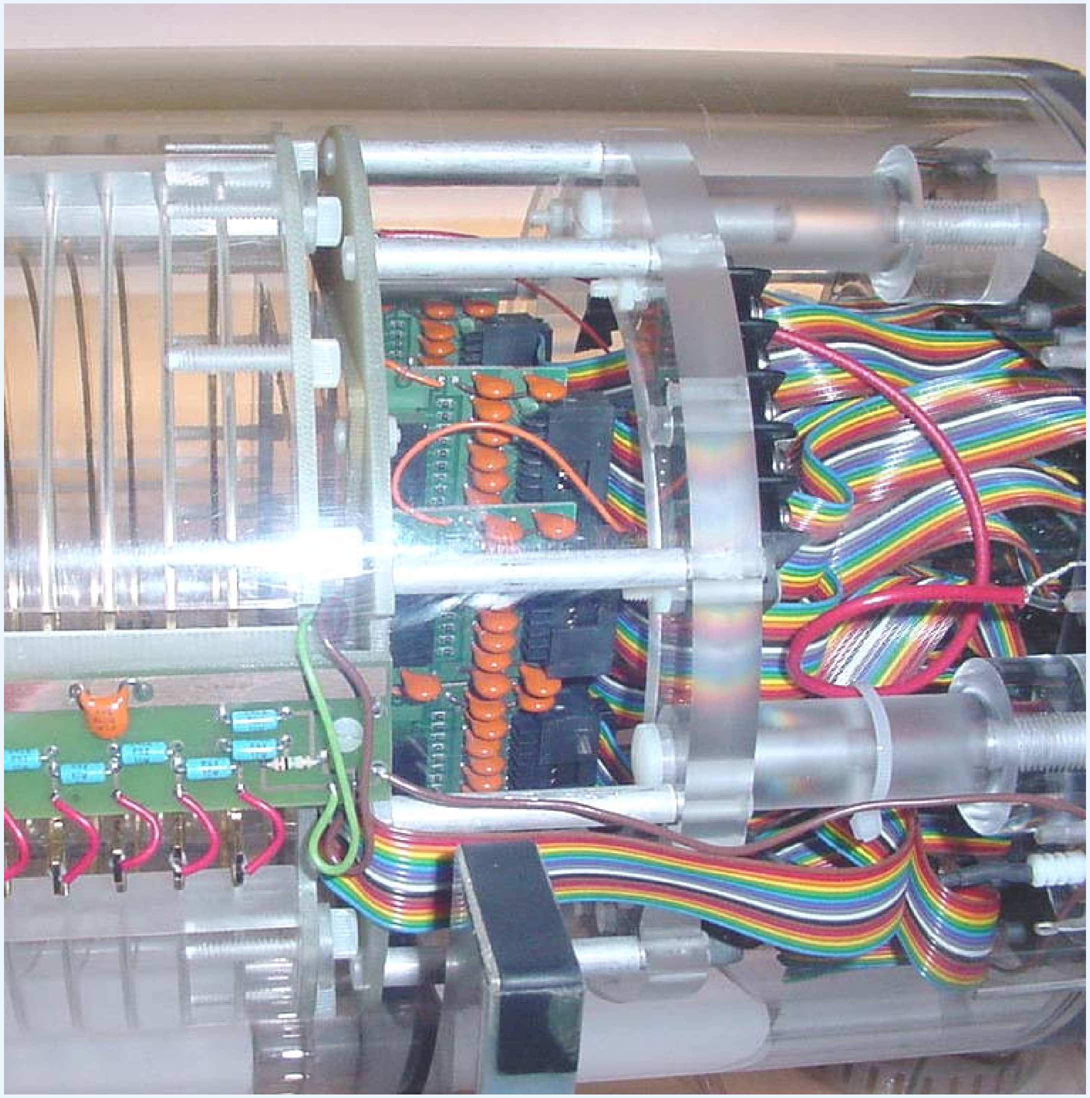
biasing:
field cage, -20kV, 300 V/cm
termination: -900V

termination : GEM **960V/cm** , 0.5 cm

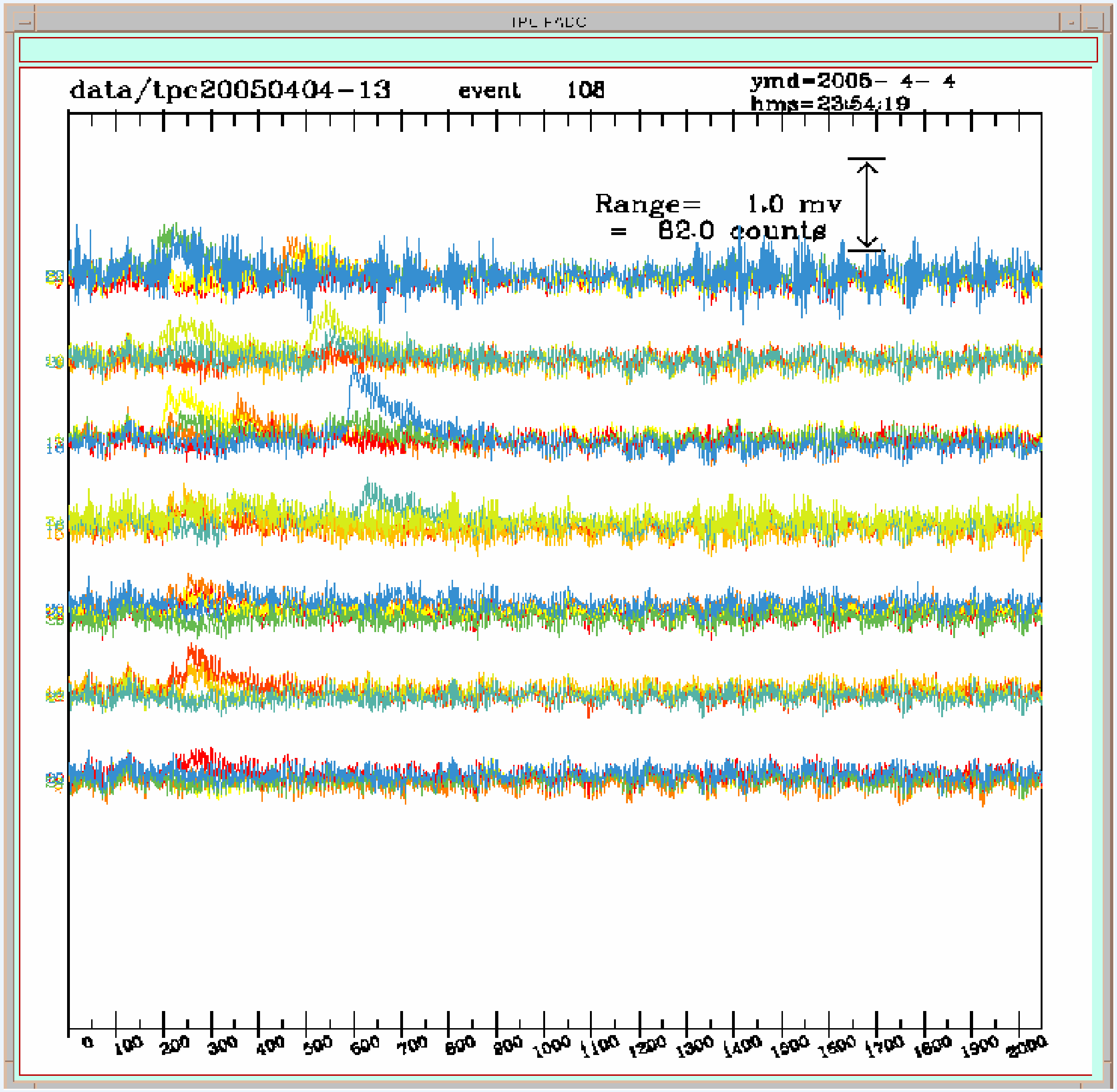
GEM voltage: -400V , -400V:0V
(Gas amplification ~100.)

GEM : pads: **5000V/cm** , 0.3 cm,

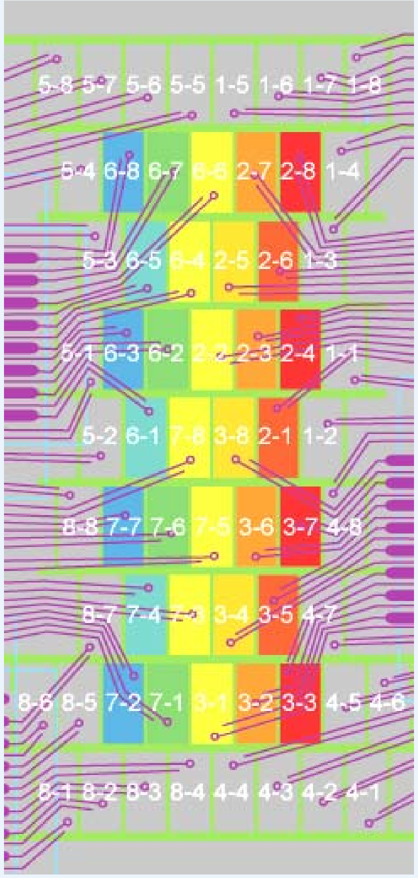
pads: +1500 V



single-GEM event

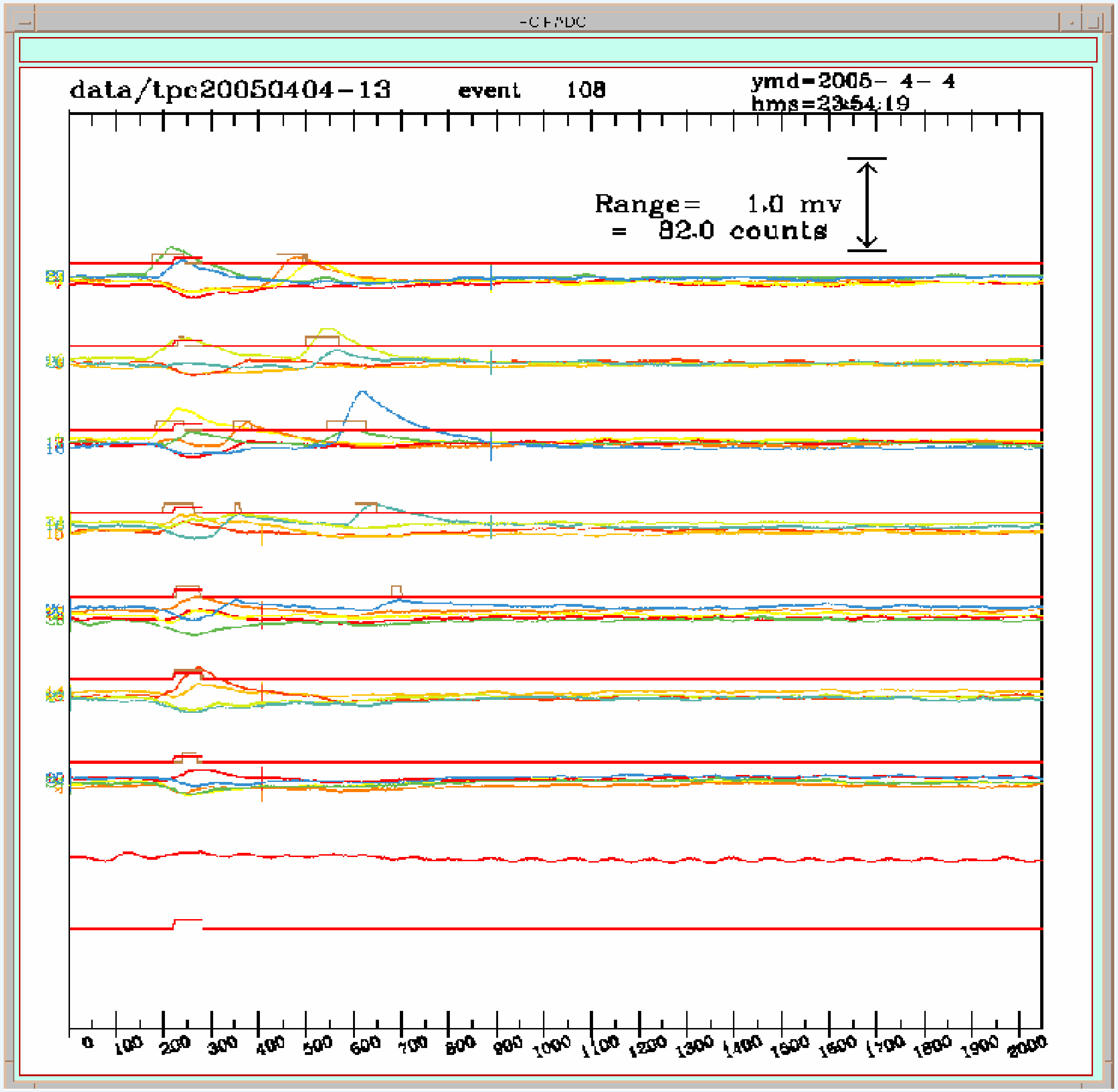


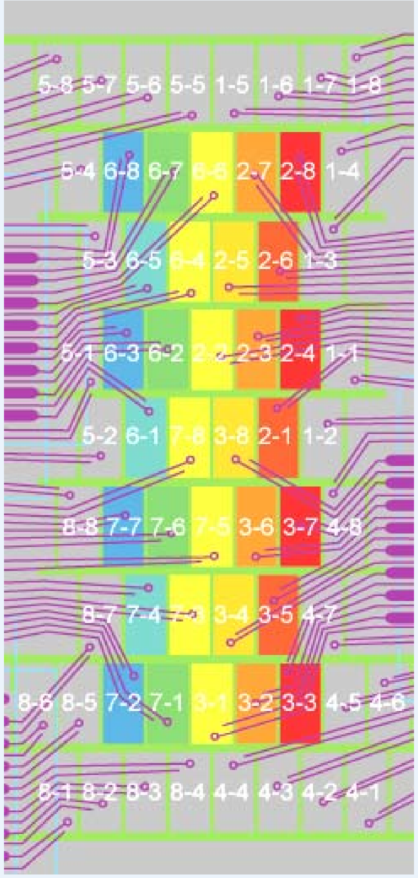
Note the 1 mv scale.
Gas amplification is about 100



$ArCO_2$ (10%) , 300V/cm
25 MHz , 40 ns
2048 time buckets (81.92 μs)

single-GEM after smoothing & common noise subtraction





$ArCO_2$ (10%) , 300V/cm
25 MHz , 40 ns
2048 time buckets (81.92 μs)

double-GEM

CERN GEM
mounted, tested by Purdue

installed 20-October-2005

biasing:
field cage, -20kV, 300 V/cm
termination: -919V

termination : GEM2 **300V/cm** , 0.432 cm

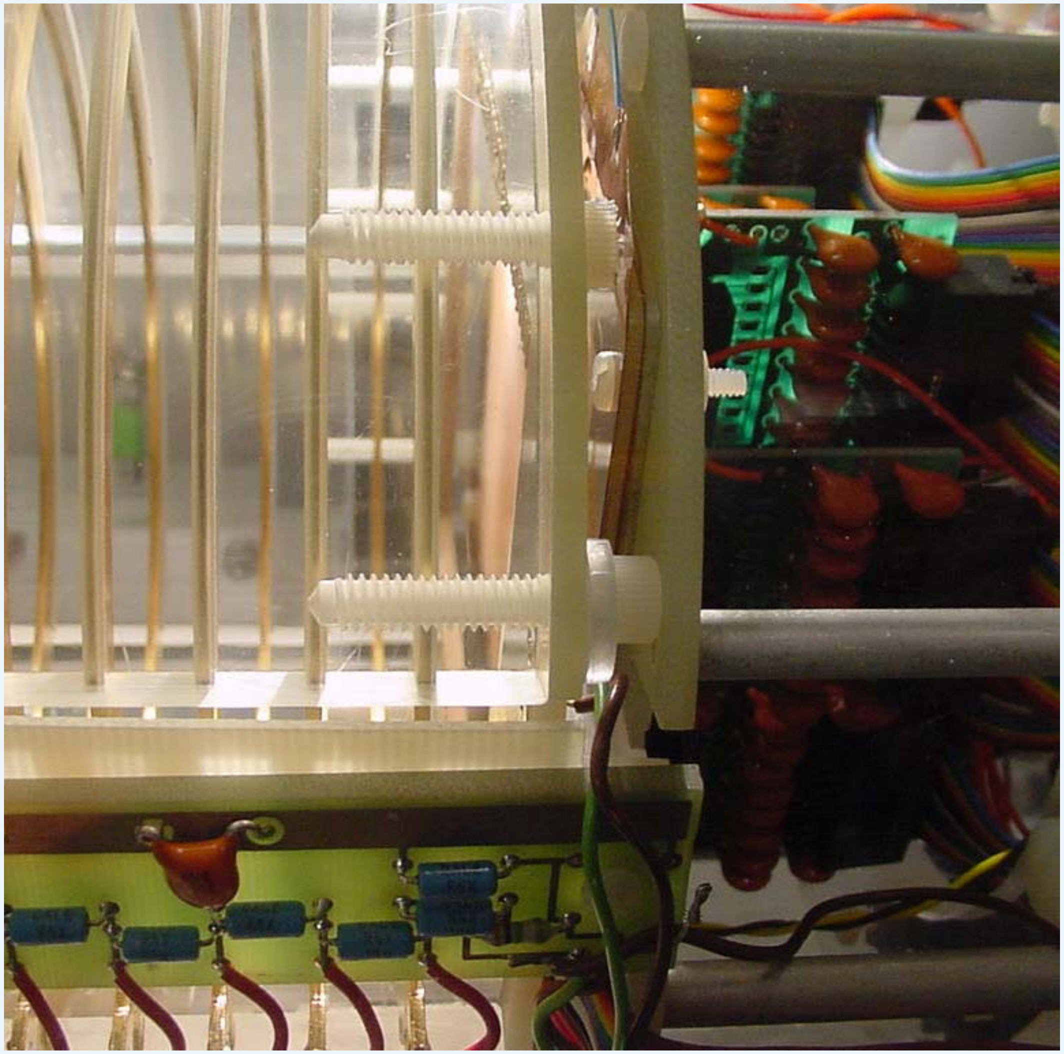
GEM2 voltage: -370V , -789V:-419V

GEM2:GEM1 300V/cm , .165cm

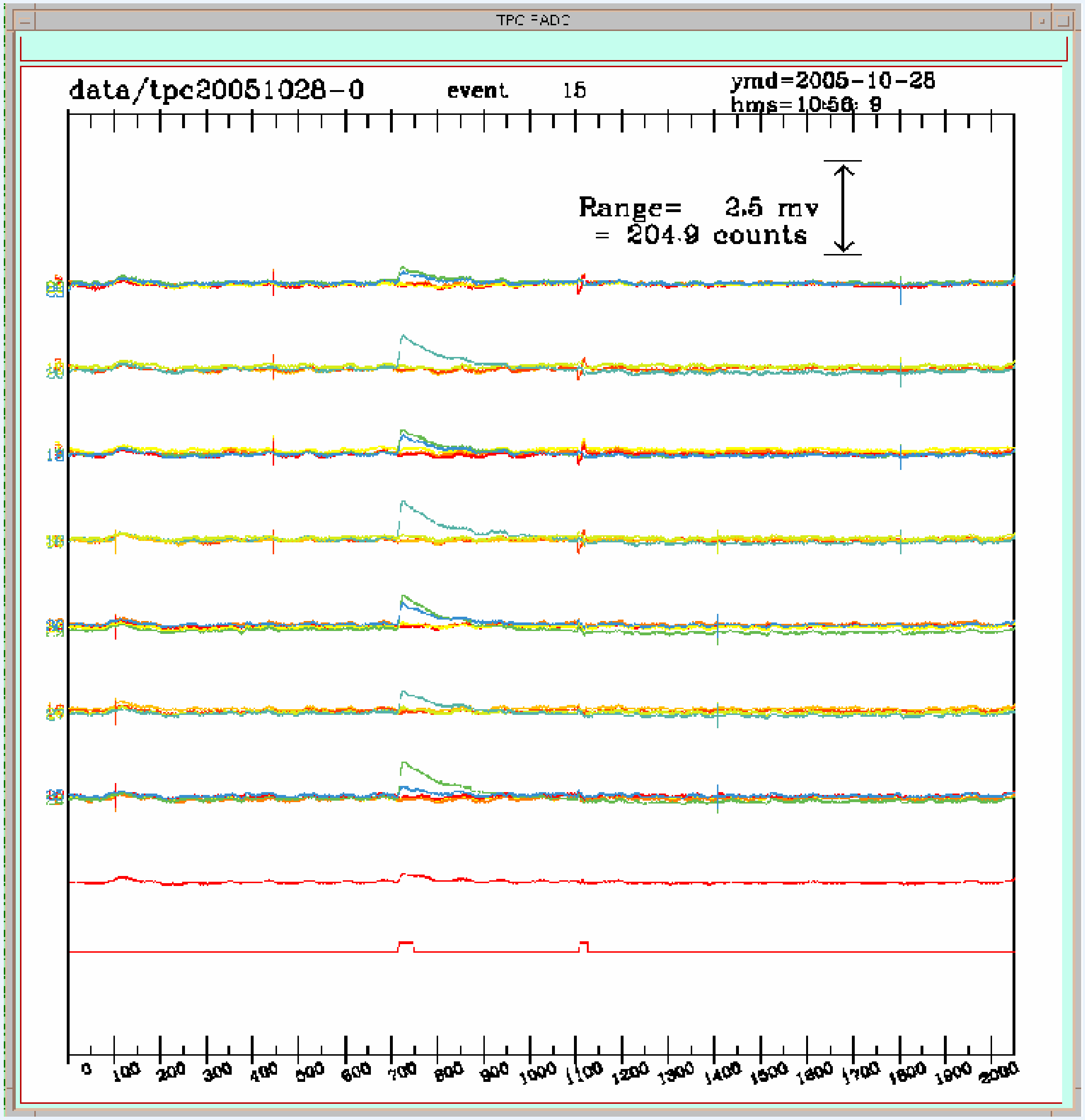
GEM1 voltage: -370V , -370V: 0

GEM1: pads **5000V/cm** , .165cm

pads: +825 V

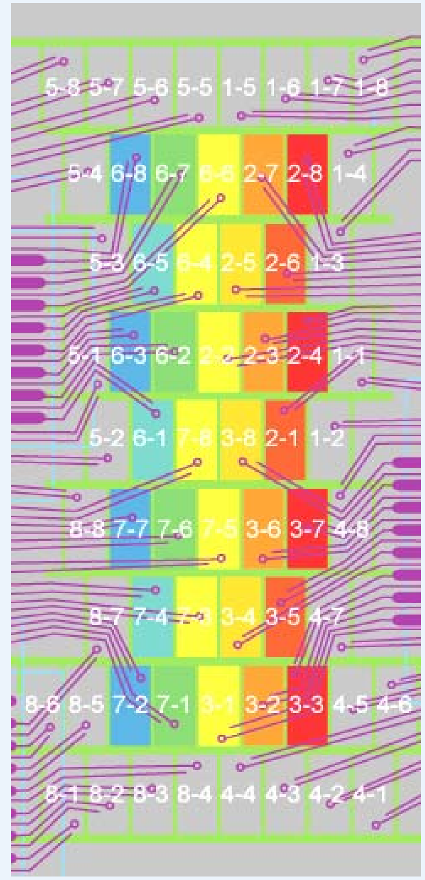


double-GEM event



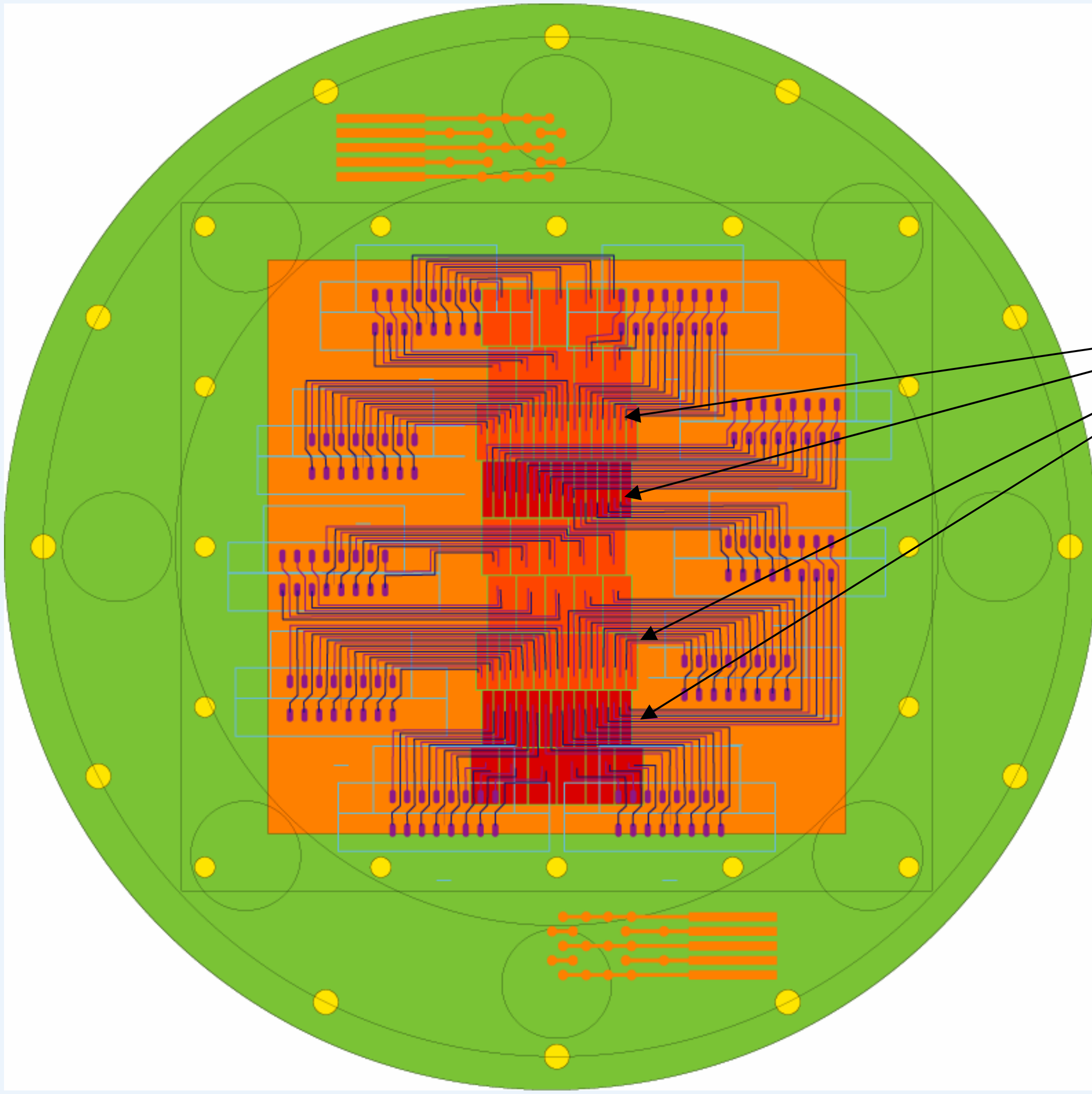
$ArCO_2$ (10%) , 300V/cm
drift velocity = 22 μm/ns

drift distance (this event) ~55cm



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

TPC Improvements:



+2 kV HV module
(part of CAEN system)

FADC channels increase from 32 to 56 channels

Pad board with 2 mm pads.

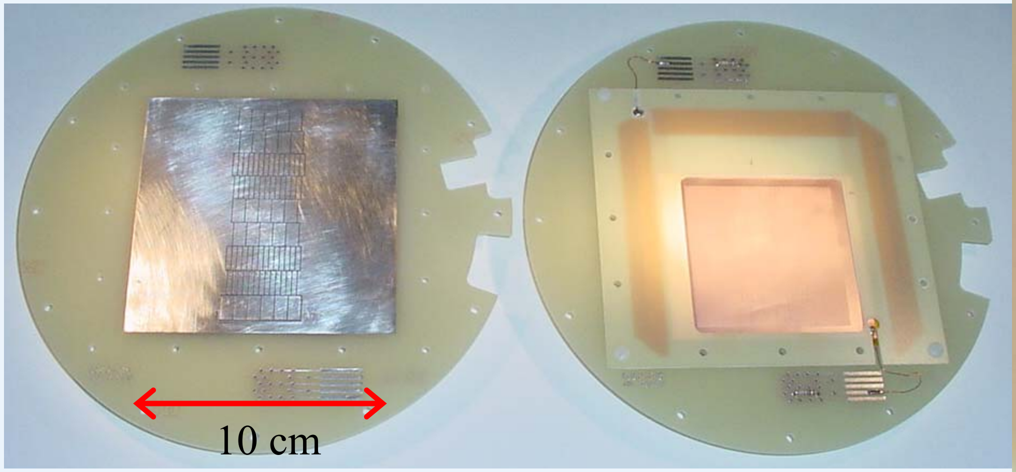
4 layers of 2mm pads
5 layer of 5mm pads
for track definition

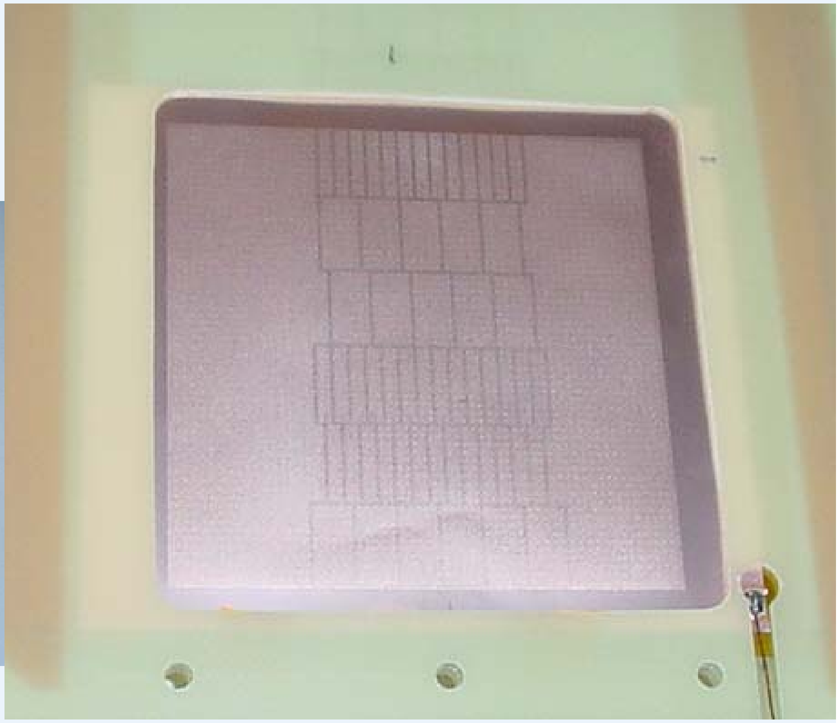
80 pads on the board

These tests are the first use of the new components.

We instrument the
lower 6 layers (56 pads);
the Micromegas is 6 cm square.

Micromegas amplification





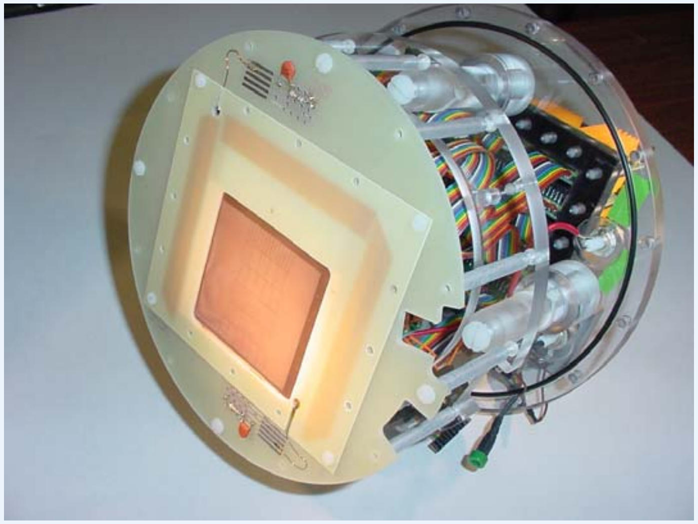
Plastic frame holds the Micromegas until electrostatic force pulls it in at about 250V.

The wrinkle flattens at about 400V.

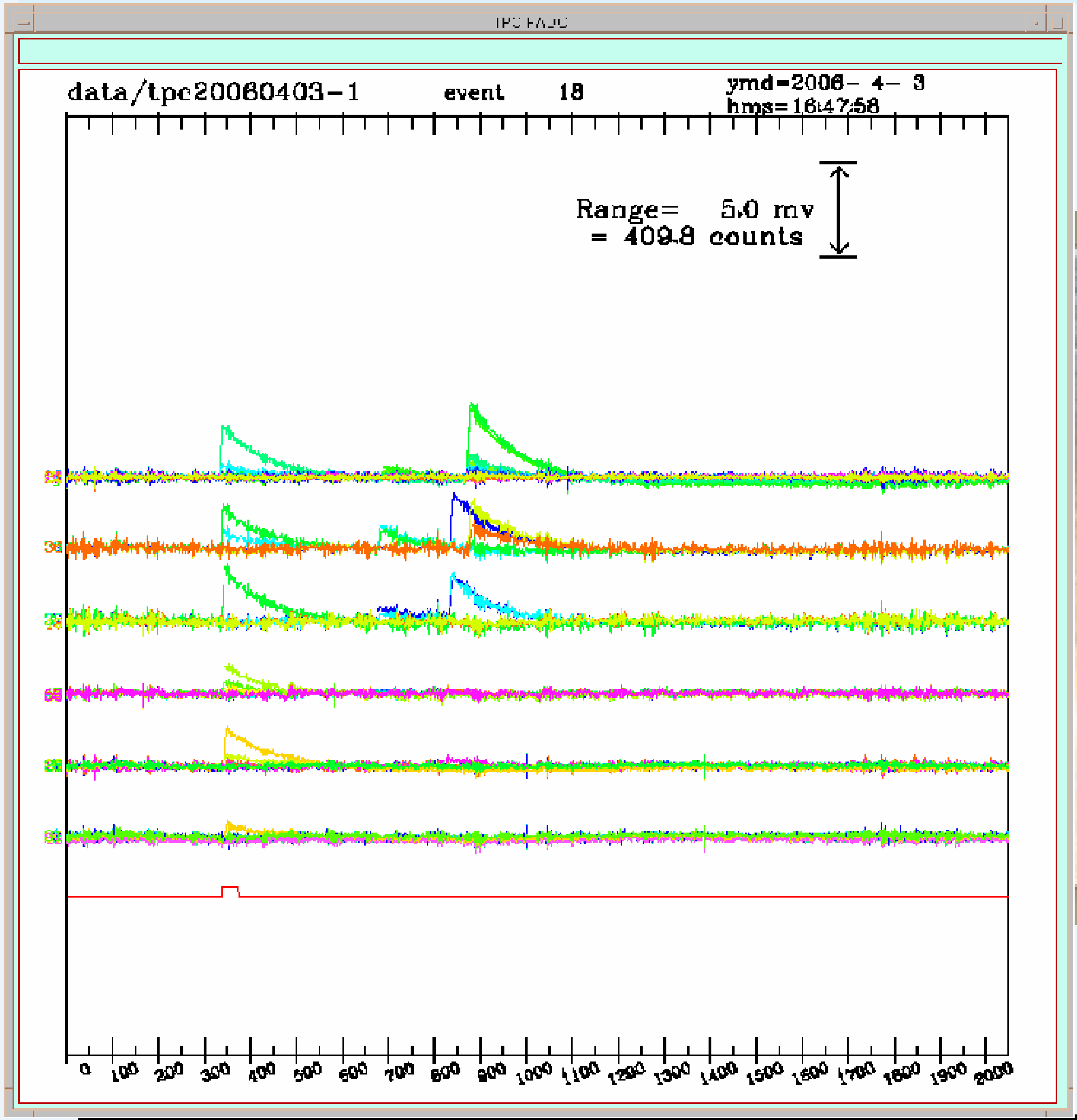
56 pad readout

Pillars are located in a 1mm square array.
All pads are located at integer x 1mm spacing.

The single 2mm pad layer (at top)
is used to define the track angle, and thus,
the residual difference of the pair of layers.

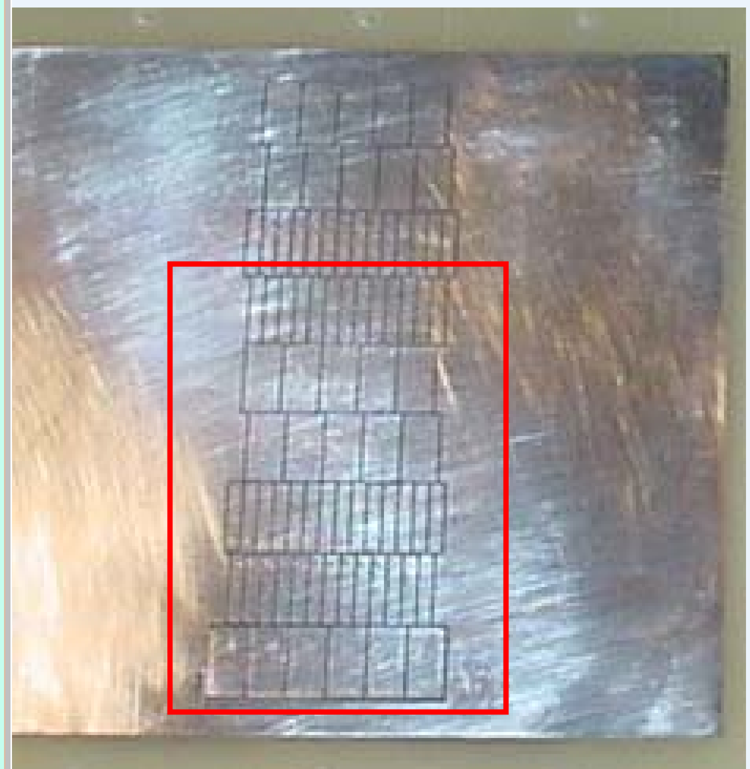


Micromegas event - raw



$ArCO_2$ (10%) , 300V/cm

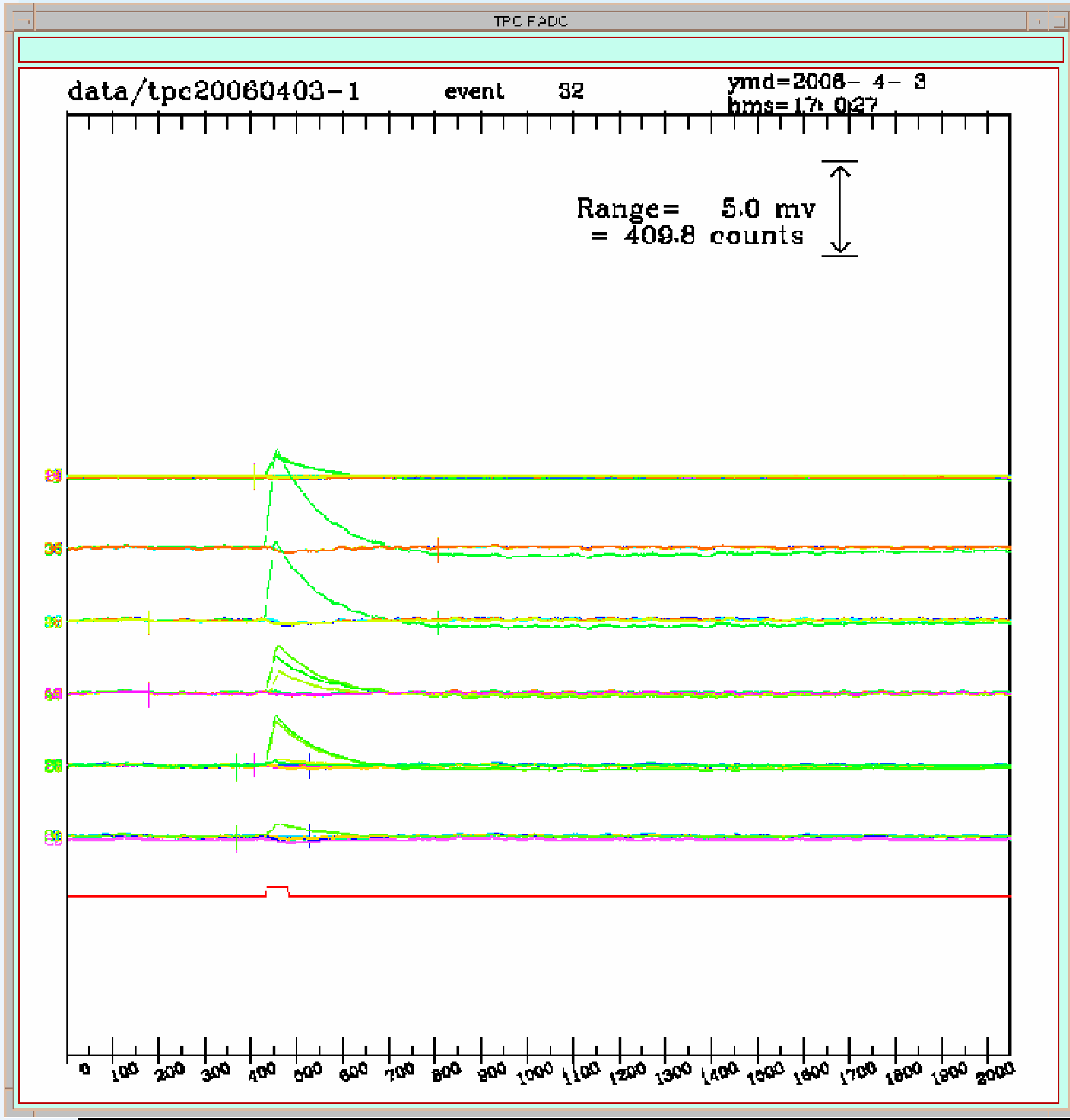
Micromegas: 430V / 50 µm



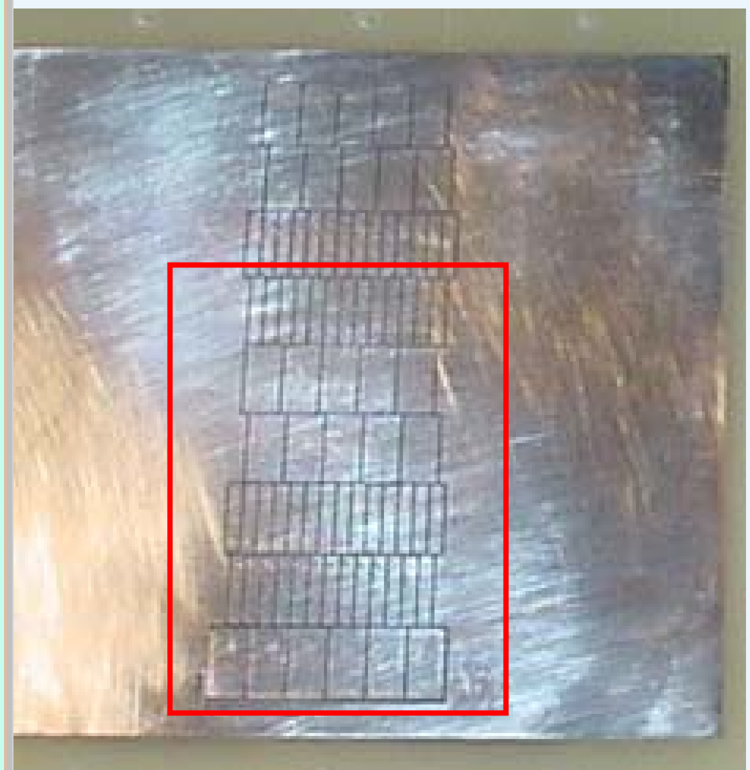
25 MHz , 40 ns

2048 time buckets (81.92 µs)

Micromegas event – smoothed (but no common mode subtraction)

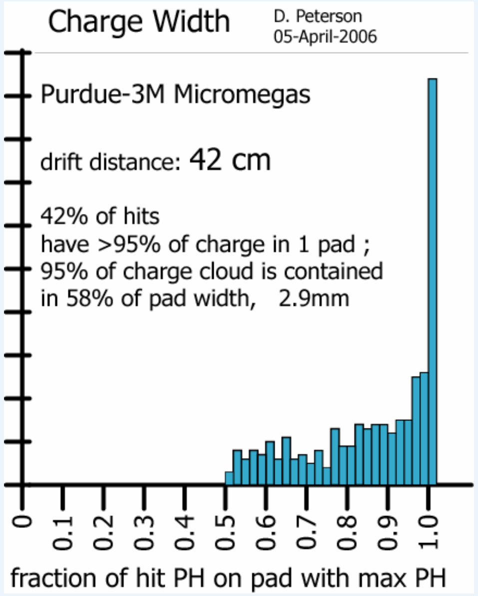


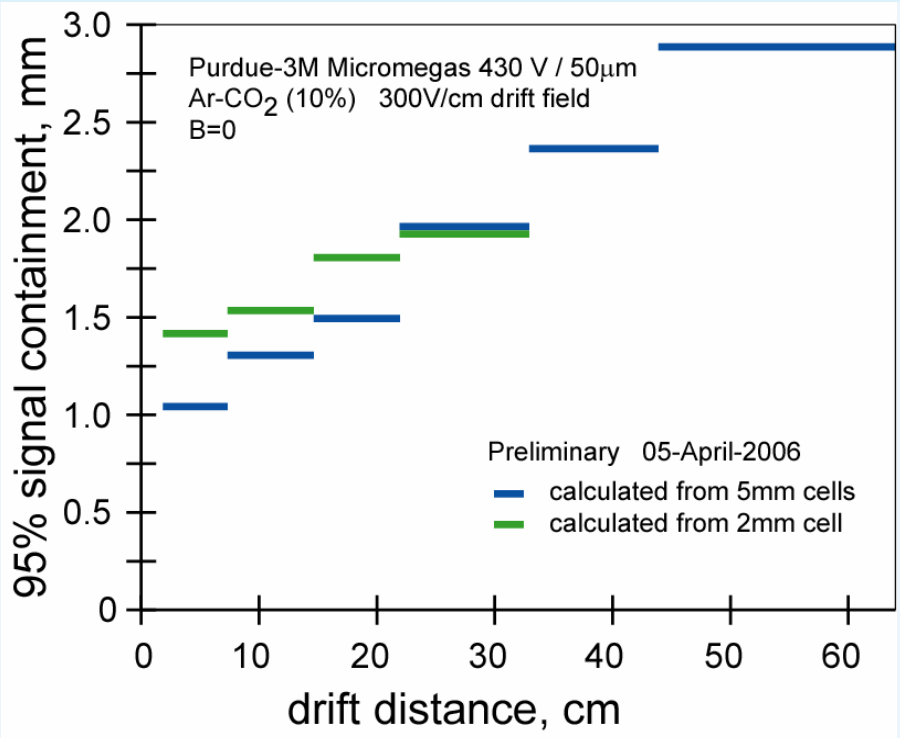
$ArCO_2$ (10%) , 300V/cm
Micromegas: 430V / 50 µm

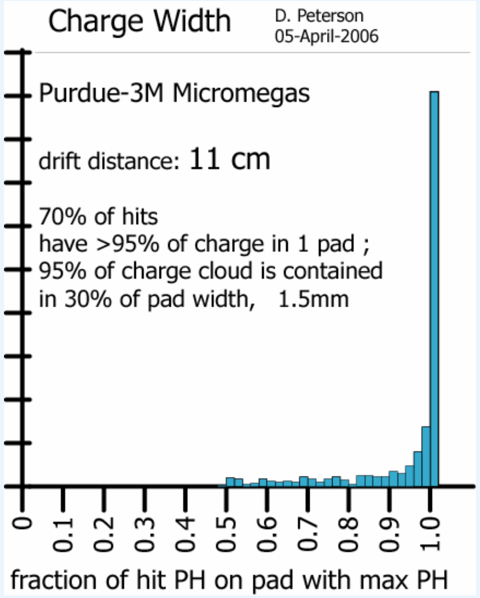


25 MHz , 40 ns
2048 time buckets (81.92 µs)

charge width – pad distribution

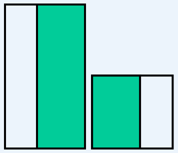






As the charge width is less than the pad width, particularly in the 2 bins for drift < 14 cm, when charge is observed on adjacent pads, that charge is not centered on each on the pads.

The charge center on the pads must be corrected for an “effective pad width”.



hit resolution (2mm pad)

find tracks

require time coincident signals in 5 layers

find PH center using maximum PH pad
plus nearest neighbors (total 2 or 3 pads)

fit, deweighting the 5mm pad measurements

track selection

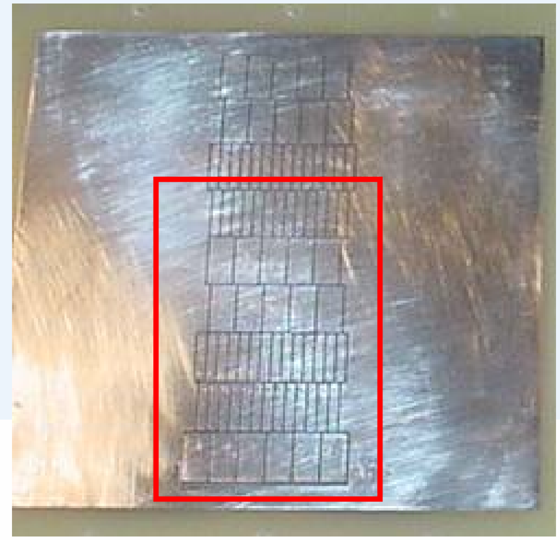
require
all (3) 2mm pad layers
"non-edge" hits in the adjacent 2mm layers
charge sharing in the adjacent 2mm layers
(< 95% of charge on one pad)

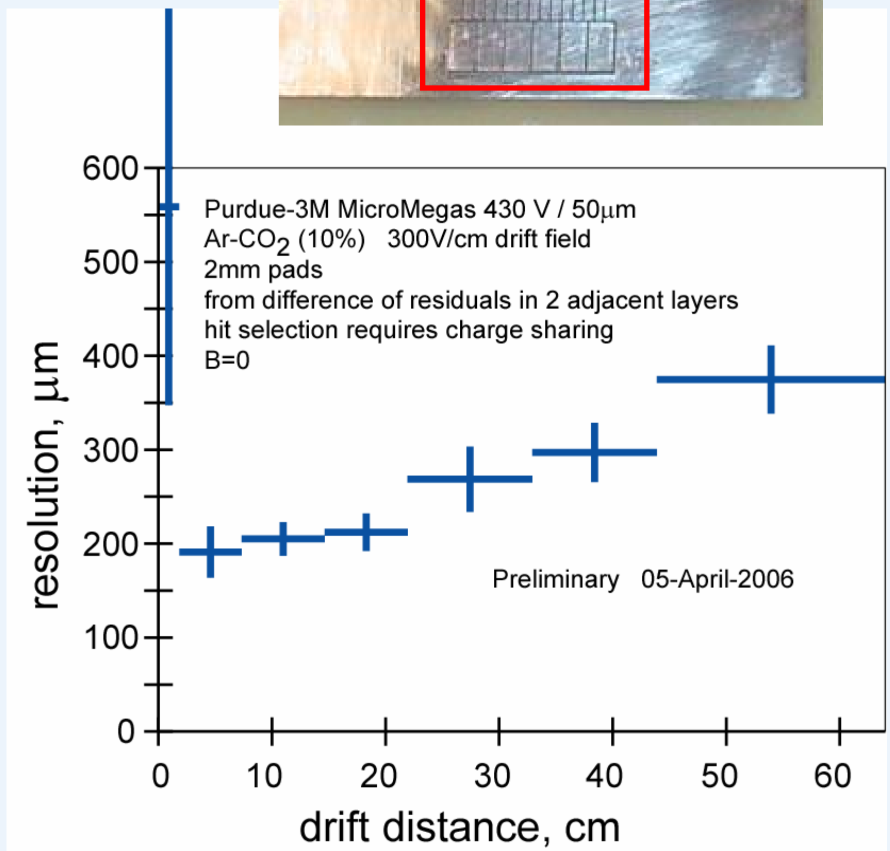
measure

RMS of difference in residual
for the adjacent 2mm layers

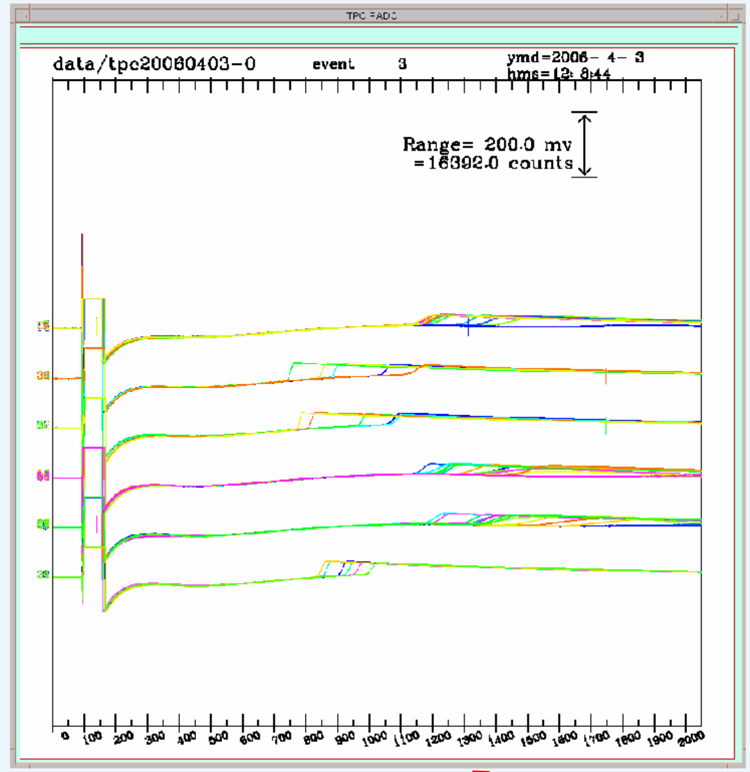
correct with : σ = RMS / $\sqrt{2}$

with C_d=.023/$\sqrt{\text{cm}}$, N = 24





Sparking / Discharging



Ran for 10 days at 430 V in $ArCO_2$ (10%)

There was an initial training period to get from 400 V to 430 V, ~ 2 hours.

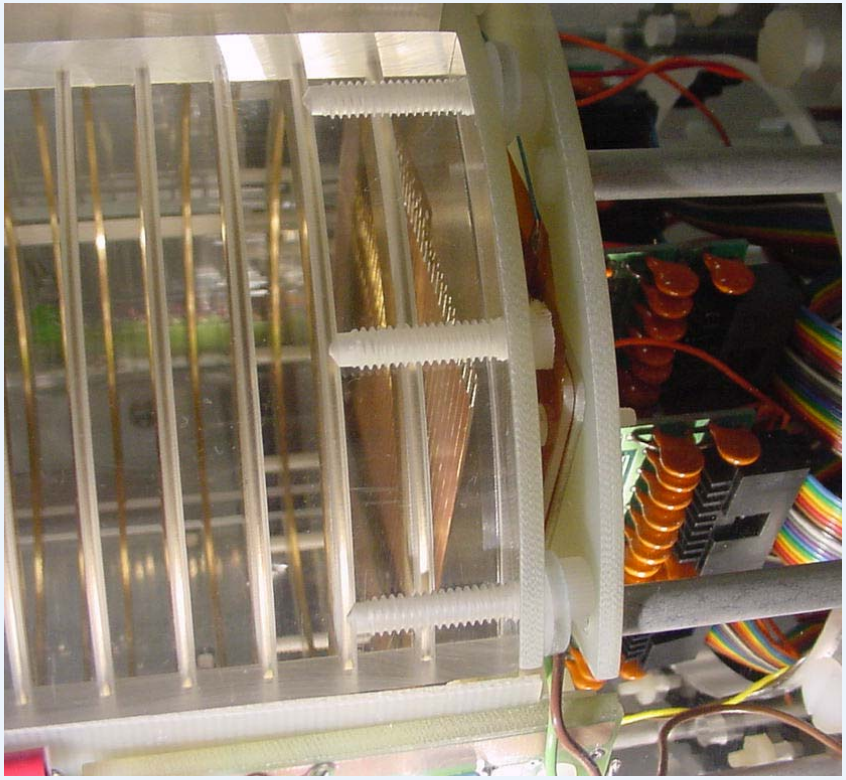
Sparks that tripped the HV occurred about 1 per 2 days after the first couple days.

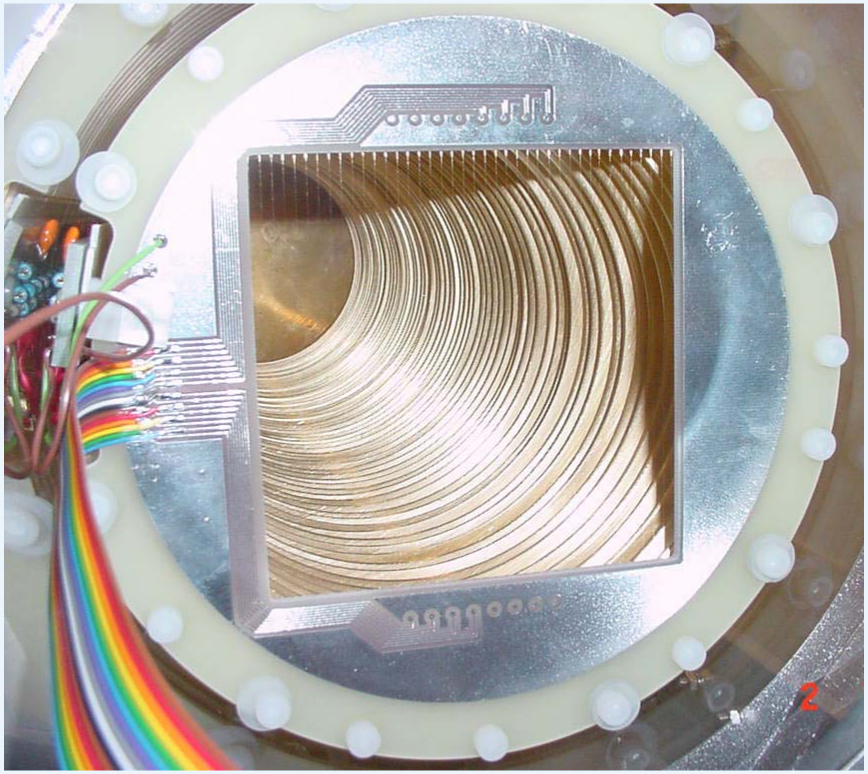
The trip circuit was set at 40 µA, for the minimum duration, less than 20 µs.

(The last day of running was with a trip setting of 10 µA for 0.2 sec – no trip.)

A new occurrence are the events as shown. (Note 200mv scale)
These could be due to the Micromegas.
These could be an external problem.
They fake a scintillator trigger or are in-time with a scintillator trigger.
More investigation…

Future: Ion Feedback Measurement



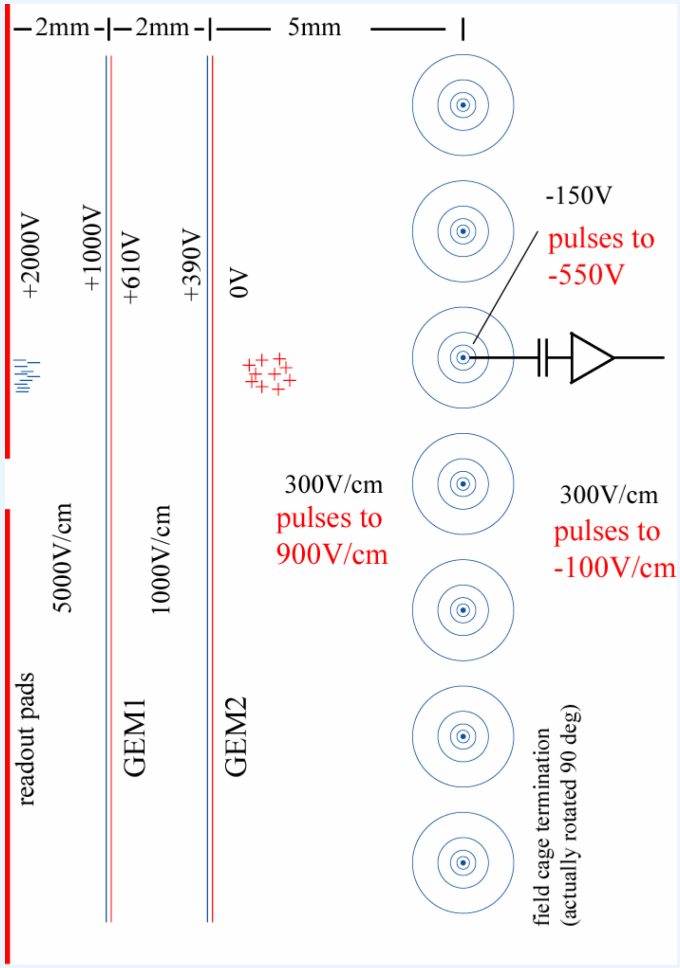


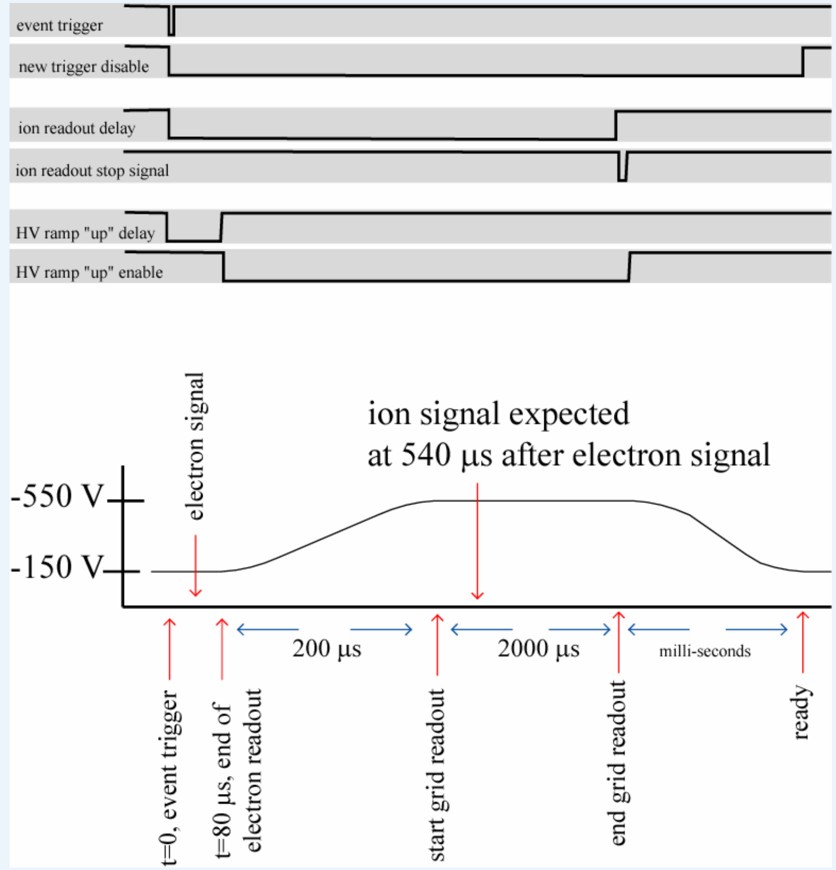
Positive ions are created in the amplification and drift back into the field cage.

We will attempt to measure the ion feedback on the field cage termination plane, for individual tracks.

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.

Ion Feedback Measurement





Require small ion drift time to reduce diffusion.
(Expect ~7 µs diffusion at 540 µs drift.)

Require large ion drift time because
the amplifiers saturate during the voltage ramp.
New amplifiers will have a recovery time
within this drift time.

Summary / Outlook

We have operated the Purdue-3M Micromegas in a TPC.

The charge width (95% containment) is 1 to 1.4 mm at drift=0.

Resolution extrapolates to about 170 μm with B=0.

Sparking/discharging is not a serious problem, but needs further investigation.

With the 2mm pad board, we are ready for comparative tests:

reinstall the double-GEM (CERN) (prepared by Purdue)

install a bulk Micromegas

install the resistive coating, for use with GEM or Micromegas

With a summer-program student for summer, 2006,
we will make preliminary measurements for the ion-feedback studies.