The Cornell/Purdue TPC

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* presentation at ALCPG Snowmass 23-August-2005
* presentation at LCWS05, Stanford 21-March-2005
* presentation at TPC mini-workshop, Orsay 12-January-2005

Information available at the web site: http://w4.lns.cornell.edu/~dpp/tpc_test_lab_info.html

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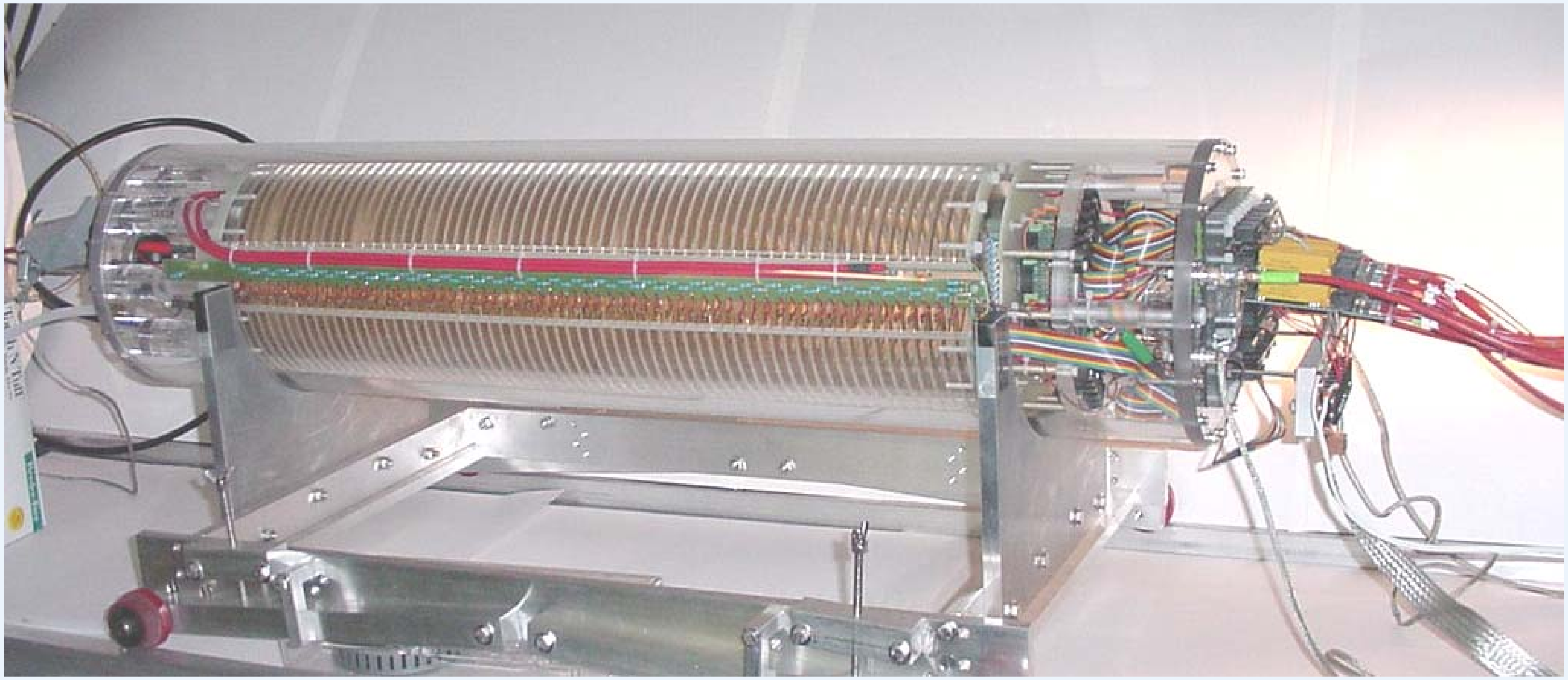
TPC

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

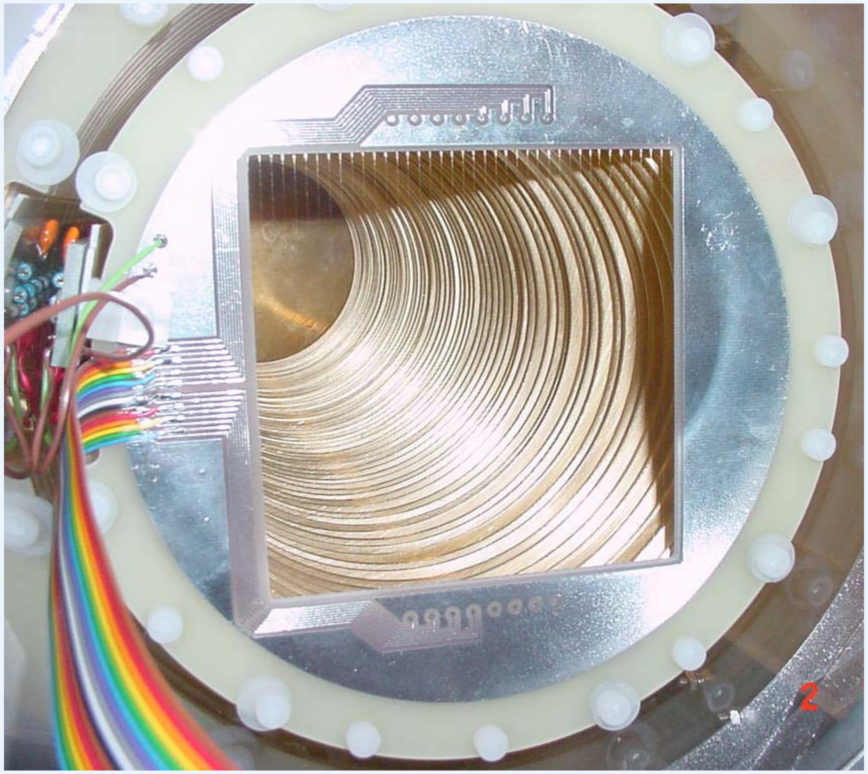
14.6 cm ID field cage - accommodates a 10 cm GEM
64 cm drift field length
22.2 cm OD outer structure (8.75 inch)

“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

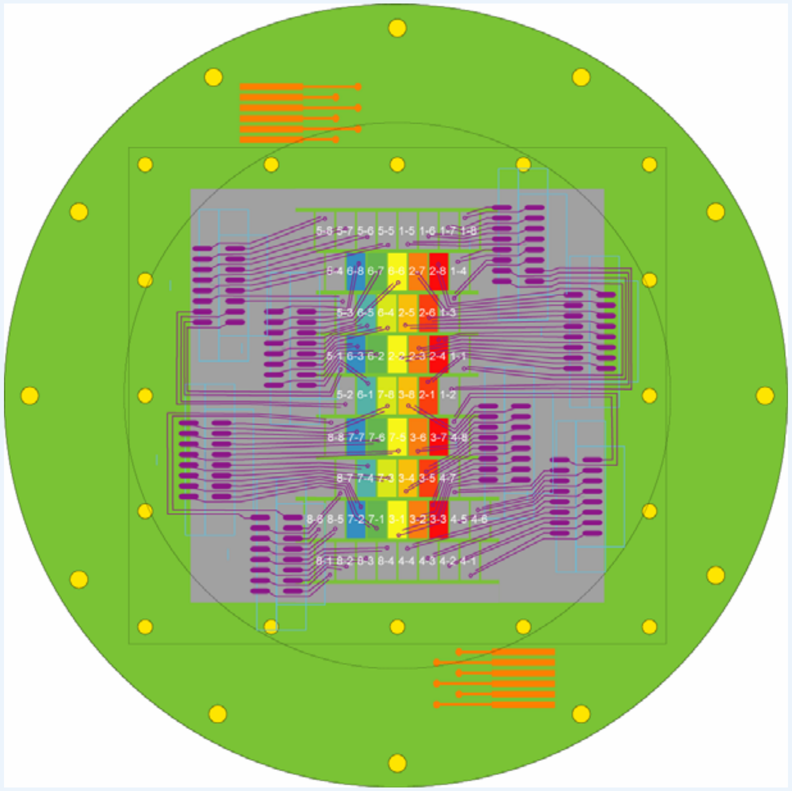


Field cage termination



10 cm

Field cage termination area is 10cm square

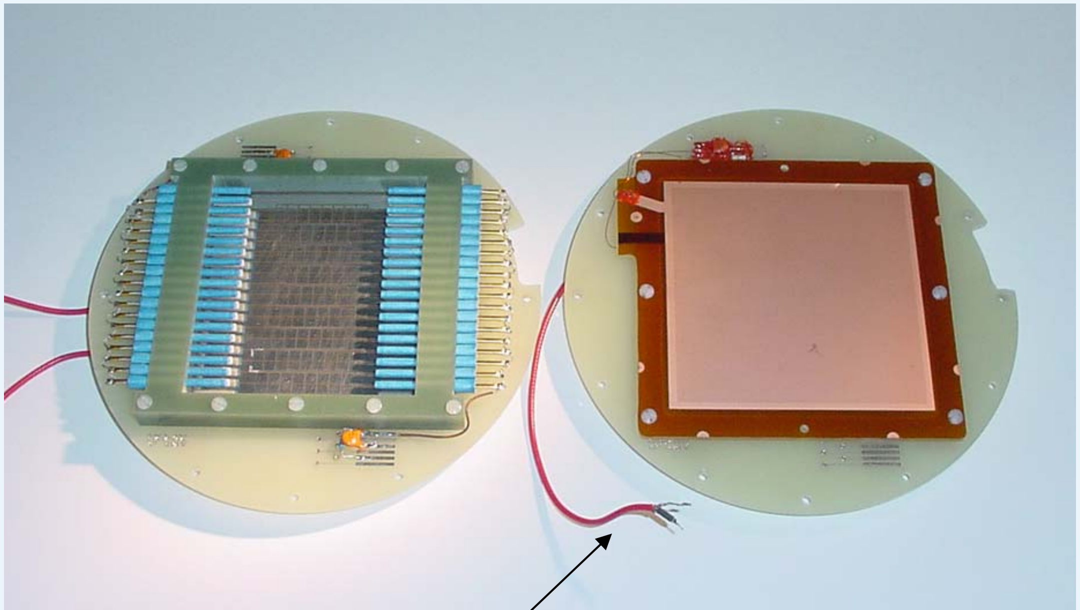


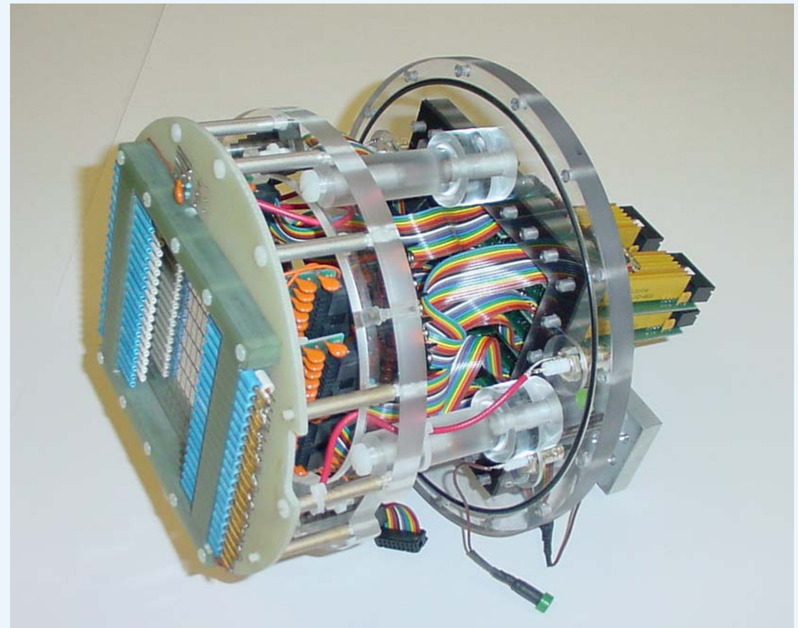
The instrumented readout area is
~2cm x7 cm , 32 pads.

The biased area is 10cm square.

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

MPWC and GEM amplification





10 cm

The readout module including the amplification device mounted on pad board

Shown: single-GEM
Will discuss Single-GEM and double-GEM.

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

The biased area is 10cm square.

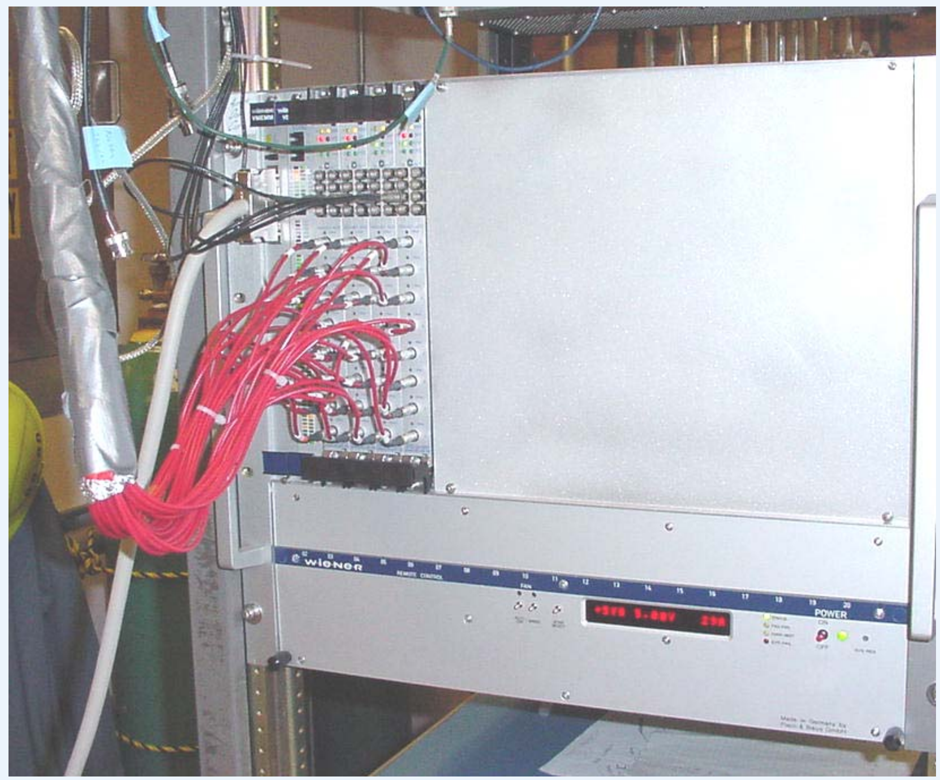
(This pad board allows ~3 x 9 cm , 62 pads.)

Electronics

High voltage system:
- -20 kV module, 2 channels available
- -2 kV module, 4 channels available

(not part of interfaced system) +2 kV

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



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

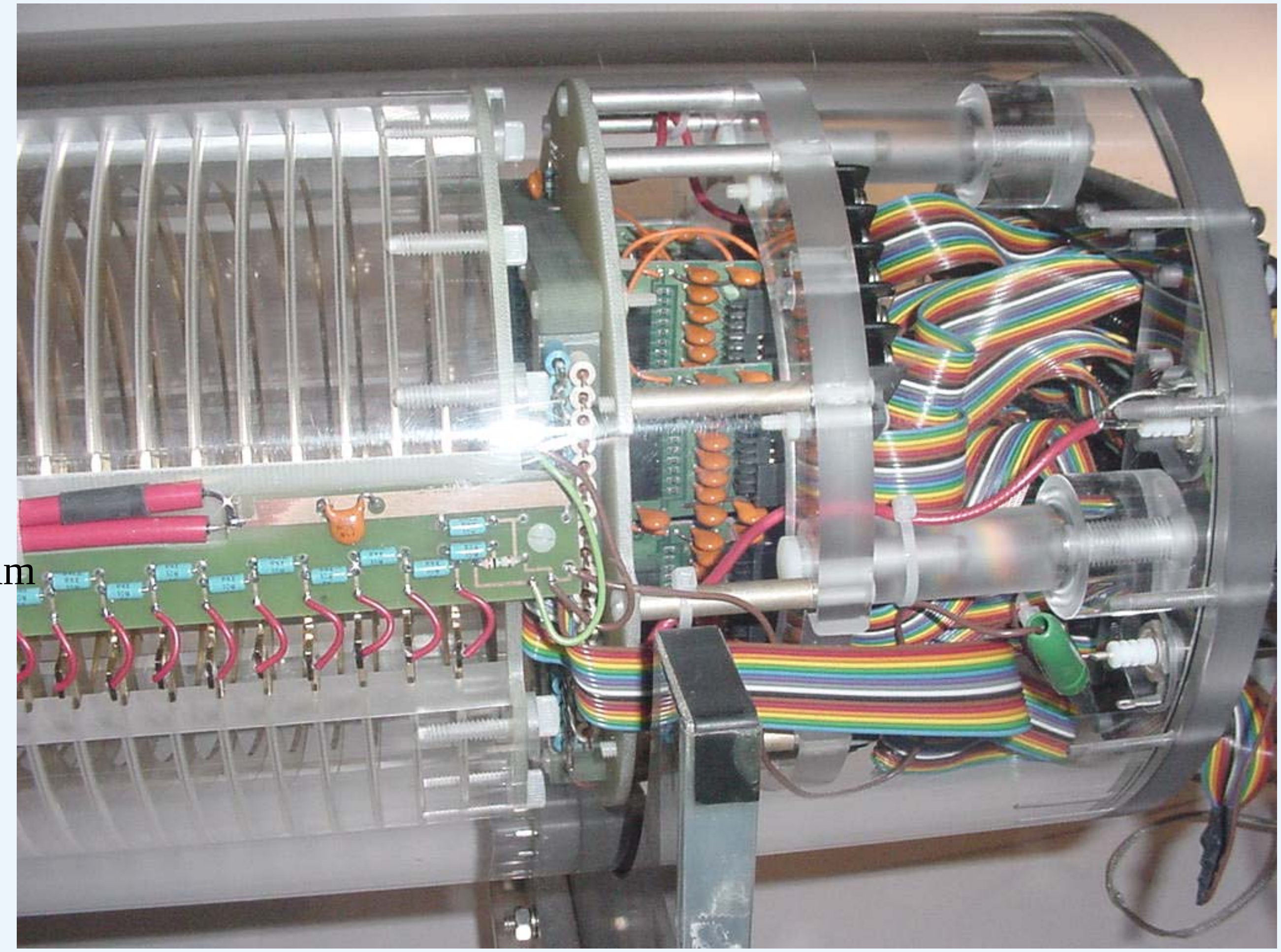
grid: -600V

grid:anode 5mm

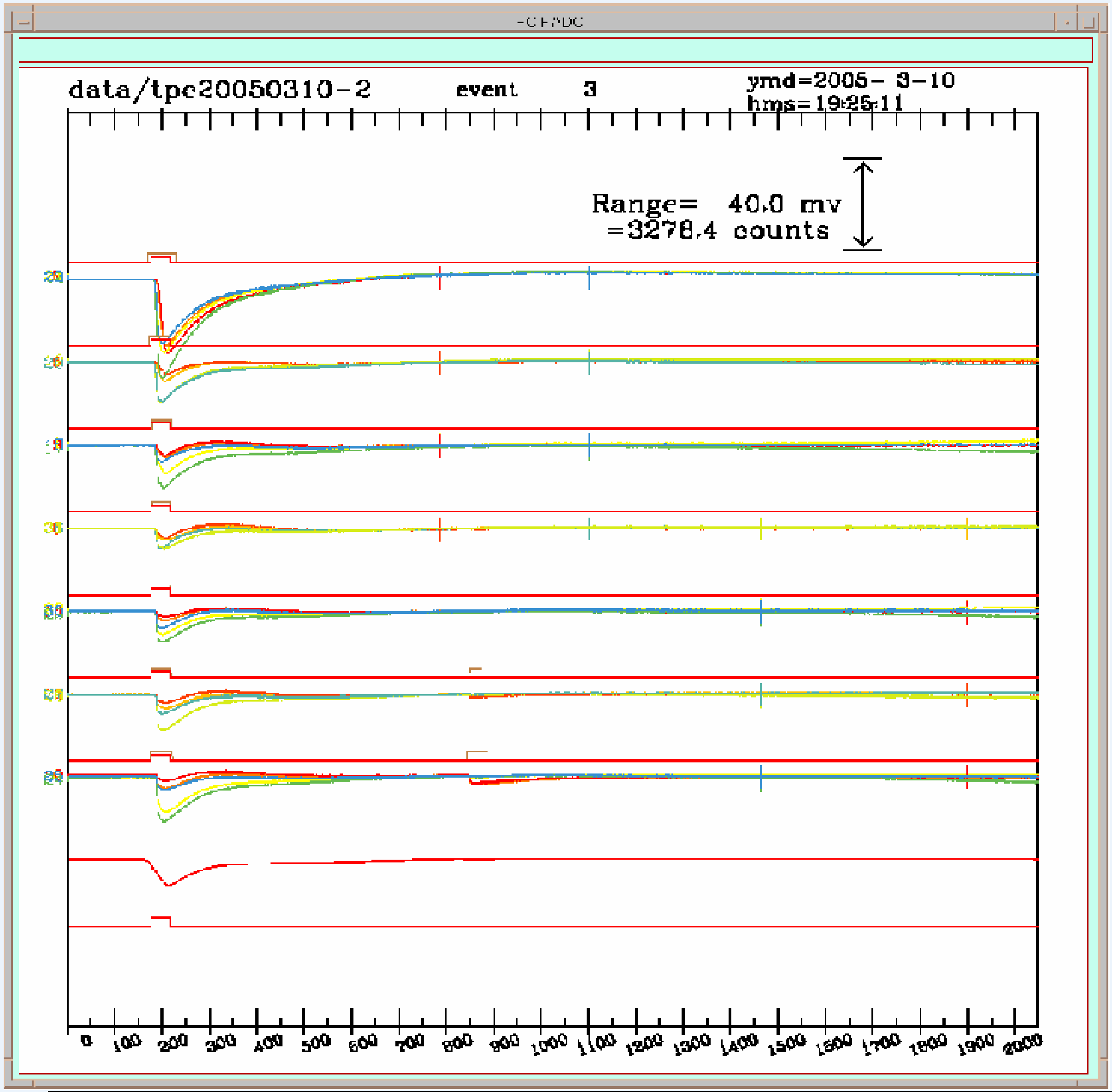
anode: +550V

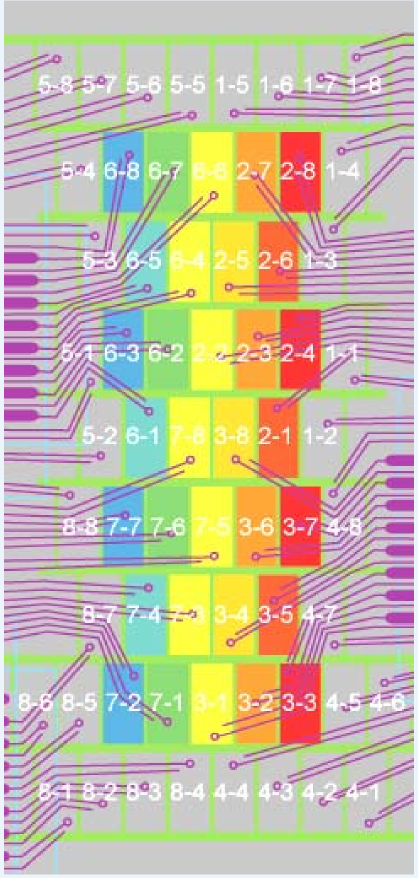
anode:pads 5mm

pads: -2000V



MWPC event (typical)





ArCO2 (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

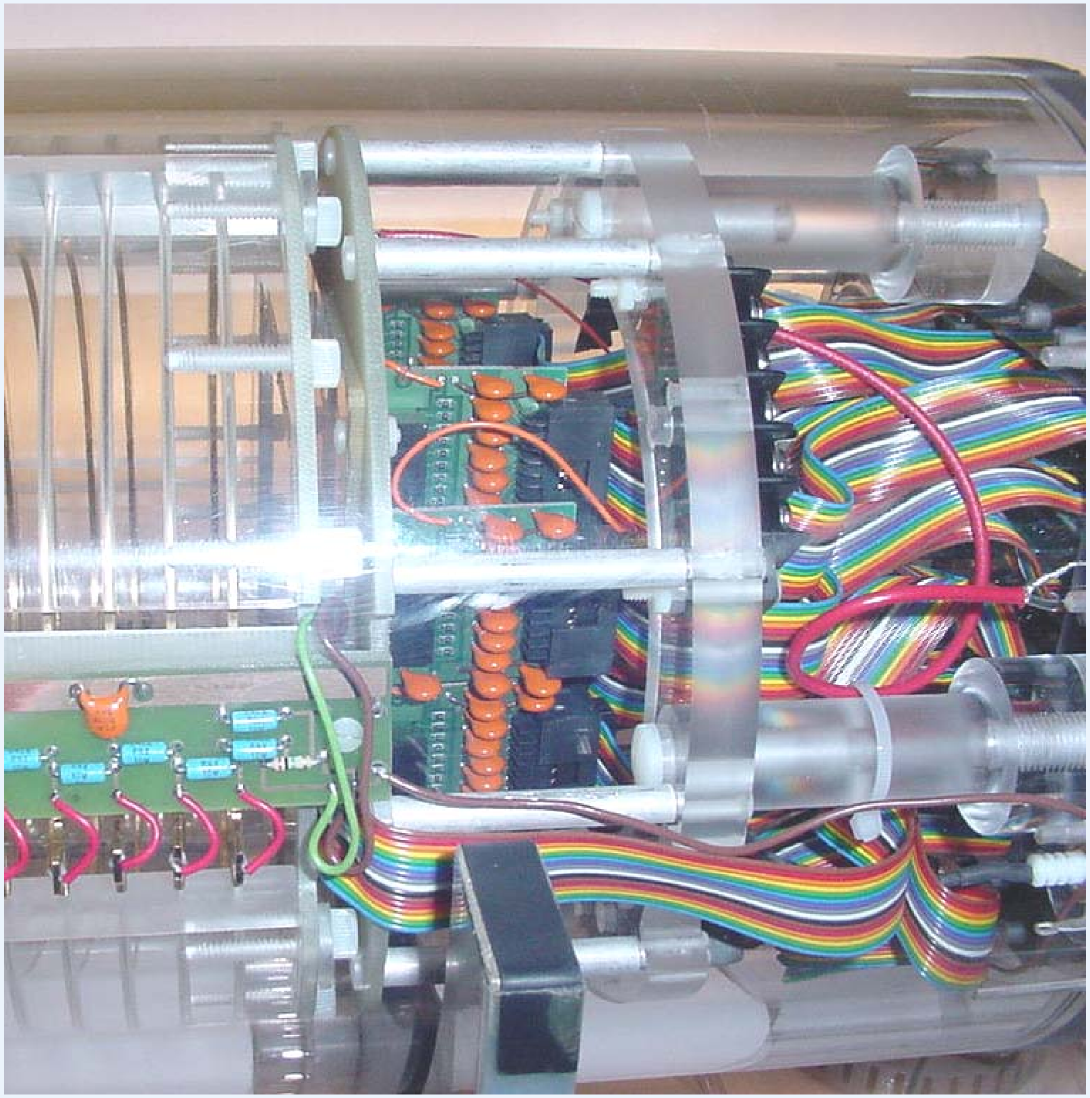
biasing:
field cage, -20kV, 300 V/cm
termination: -900V

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

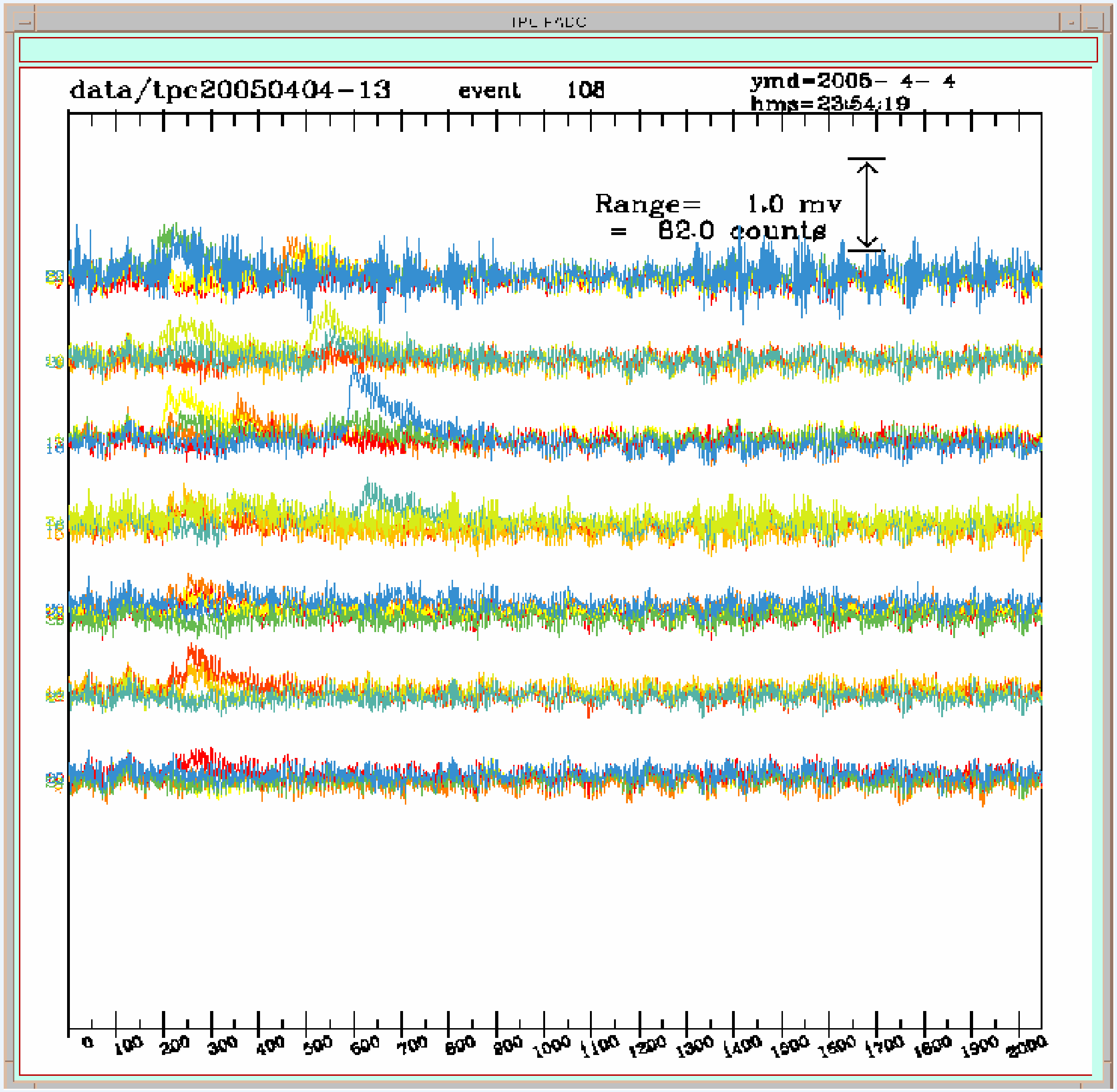
GEM voltage: -400V , -400V:0V
(Gas amplification ~100.)

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

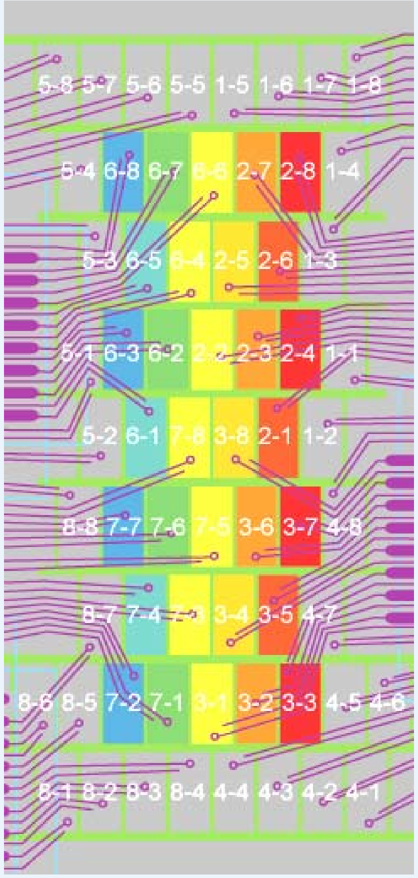
pads: +1500 V



single-GEM event

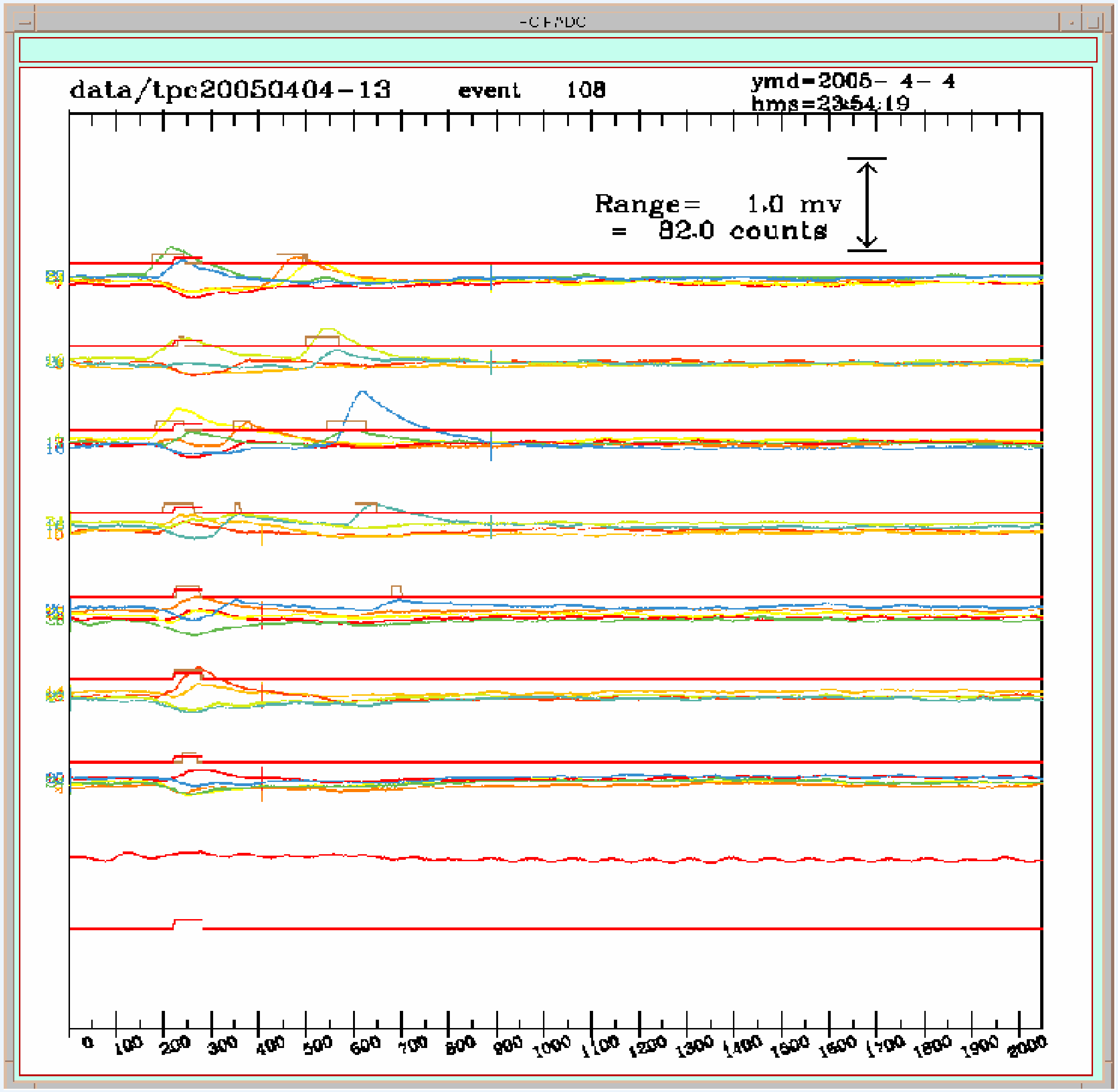


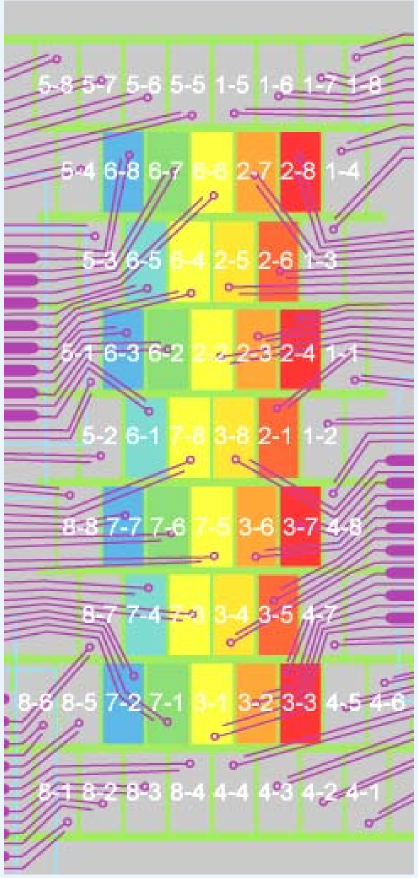
Note the 1 mv scale.
Gas amplification is about 100



ArCO2 (10%) , 300V/cm
25 MHz , 40 ns
2048 time buckets (81.92 μs)

single-GEM after smoothing & common noise subtraction





ArCO2 (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

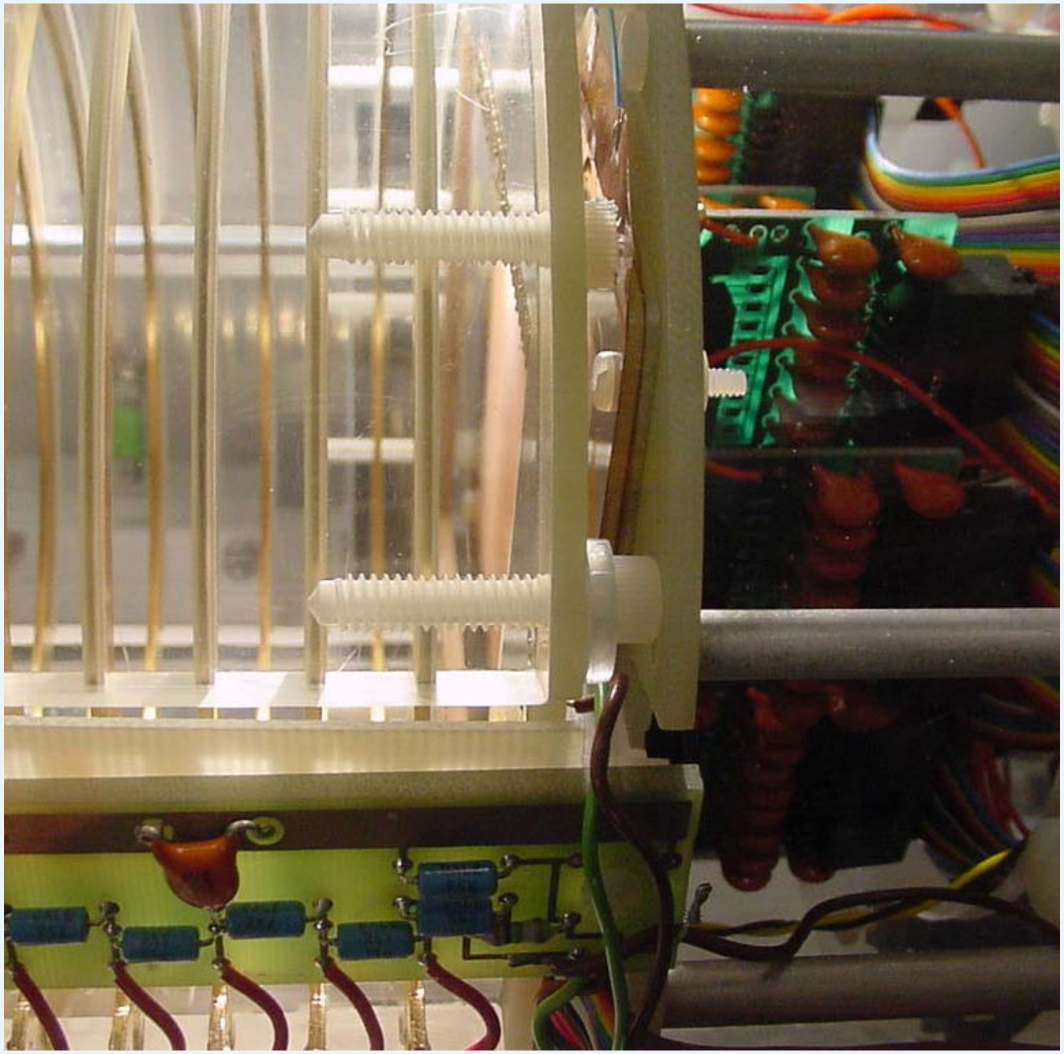
GEM2 voltage: -370V , -789V:-419V

GEM2:GEM1 300V/cm , .165cm

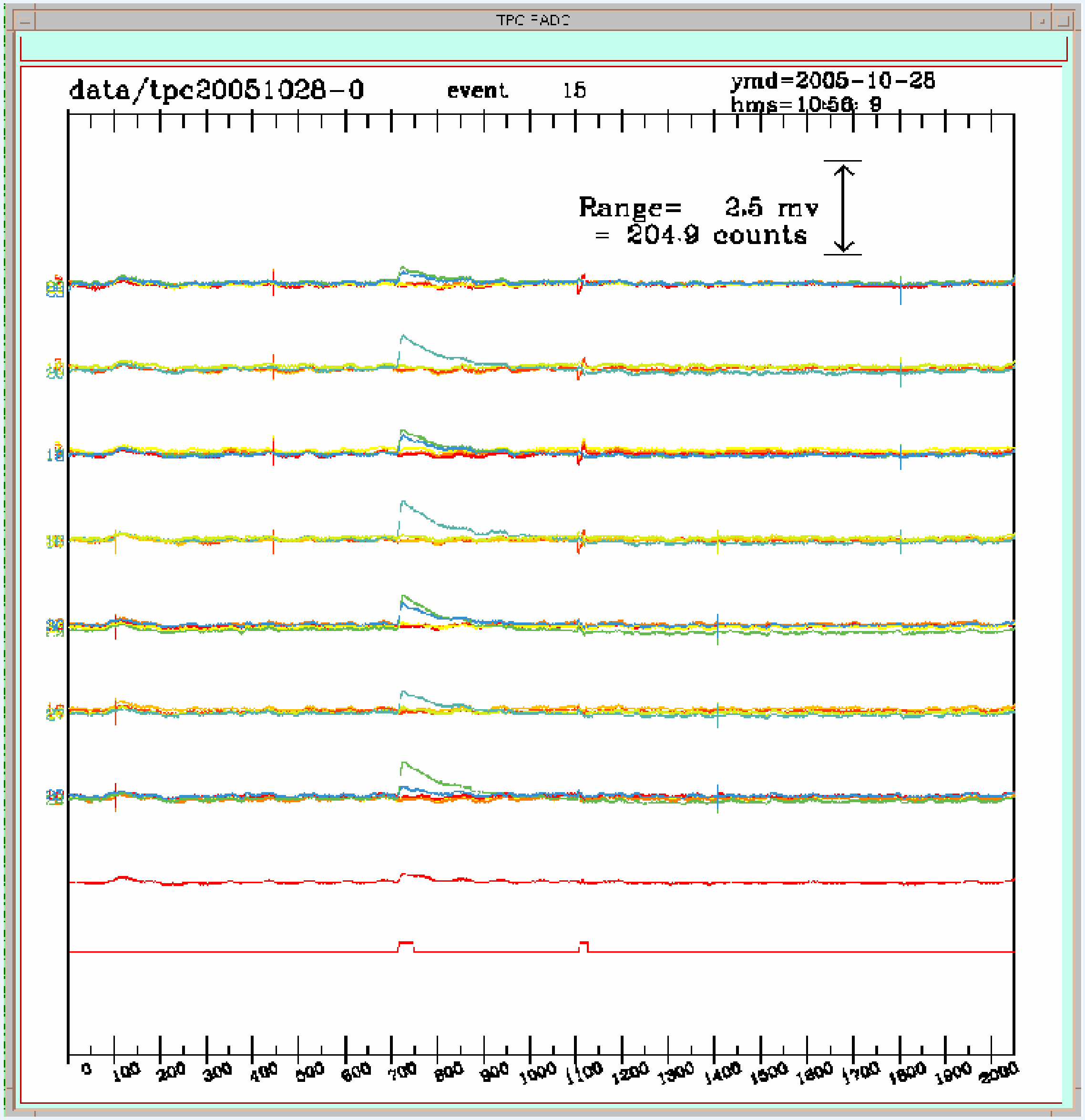
GEM1 voltage: -370V , -370V: 0

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

pads: +825 V

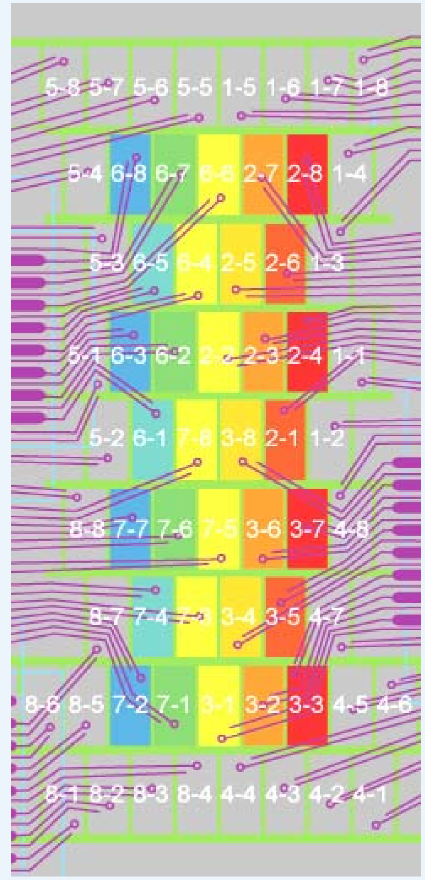


double-GEM event



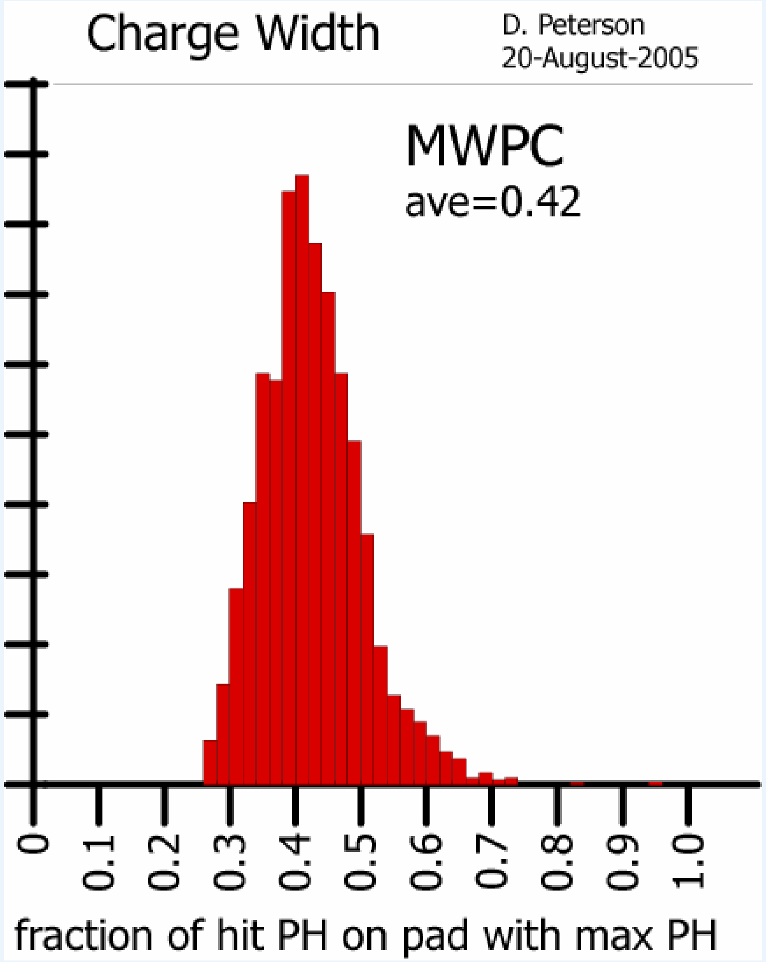
ArCO2 (10%) , 300V/cm
drift velocity = 22 μm/ns

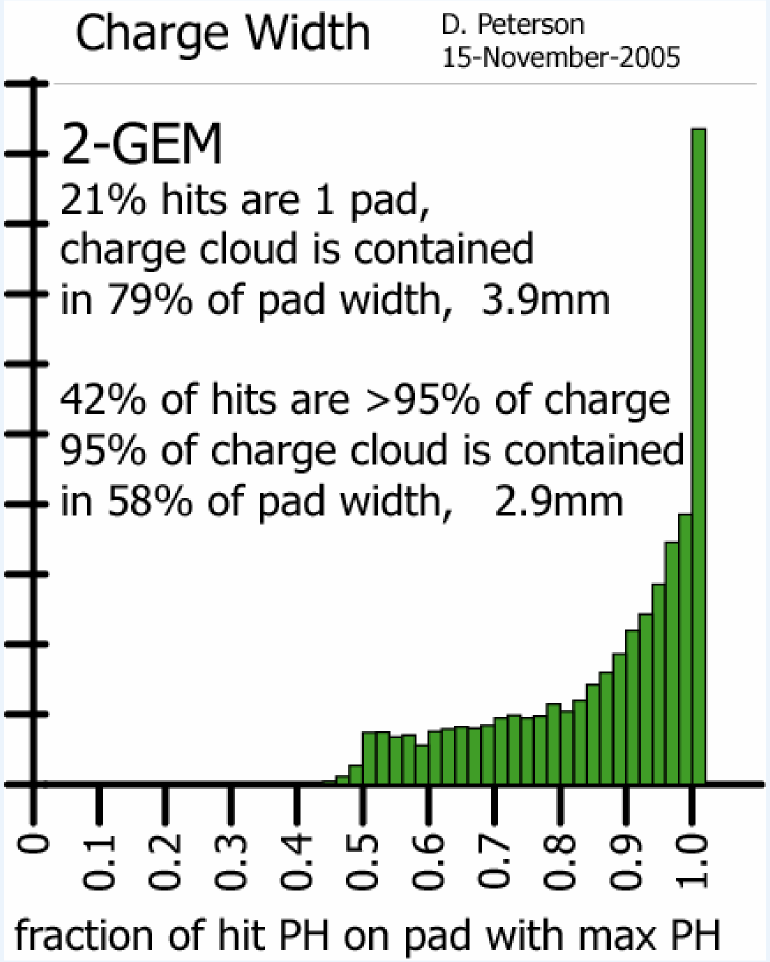
drift distance ~55cm



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

charge width





The charge width for the 1-GEM (shown at Snowmass) was influenced by the common “noise” subtraction.
The 2-GEM does not require common “noise” subtraction.

hit resolution (5mm pad)

find tracks - require time coincident signals
MWPC: 6 layers, GEM: 5 layers

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

MWPC: select clean, "contained" hits
require the hit PH sum to
contain 70% of layer PH sum

require 5 layers with interior hits
(Max. ph pad is NOT on the edge.)

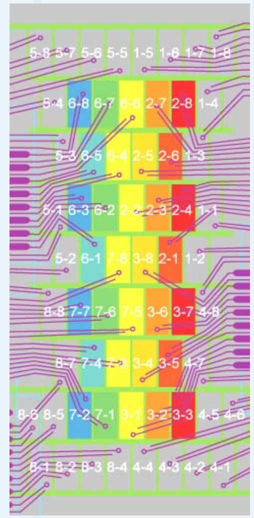
fit to a line
may eliminate 1 hit with residual > 2.5mm
(Still require 5 layers with interior hits.)

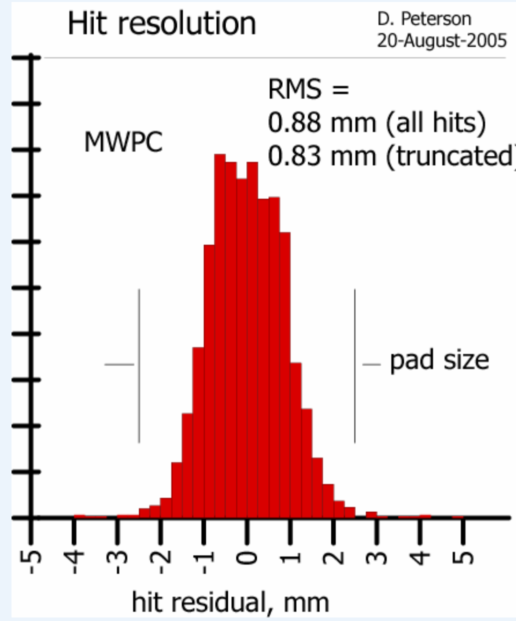
refit

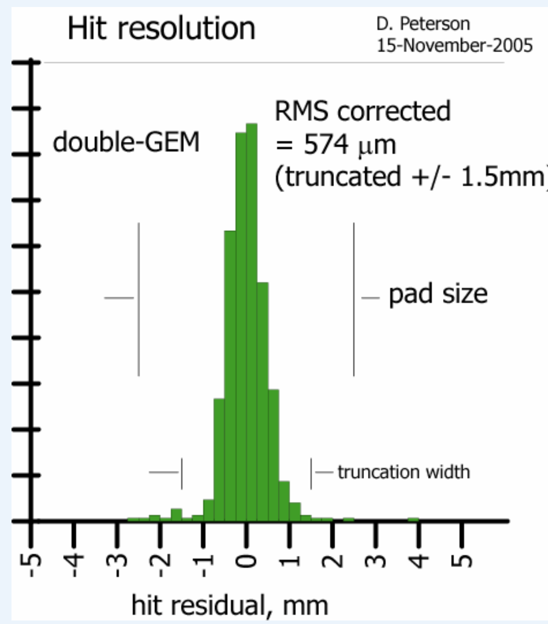
double-GEM: select 4 clean, charge-share hits
require sum of 2 pads > 96% of layer pulse height
require peak pad PH < 92% of layer
require 4 hits, 1 each in layers (1,2) (3,4,5) (6,7)

fit

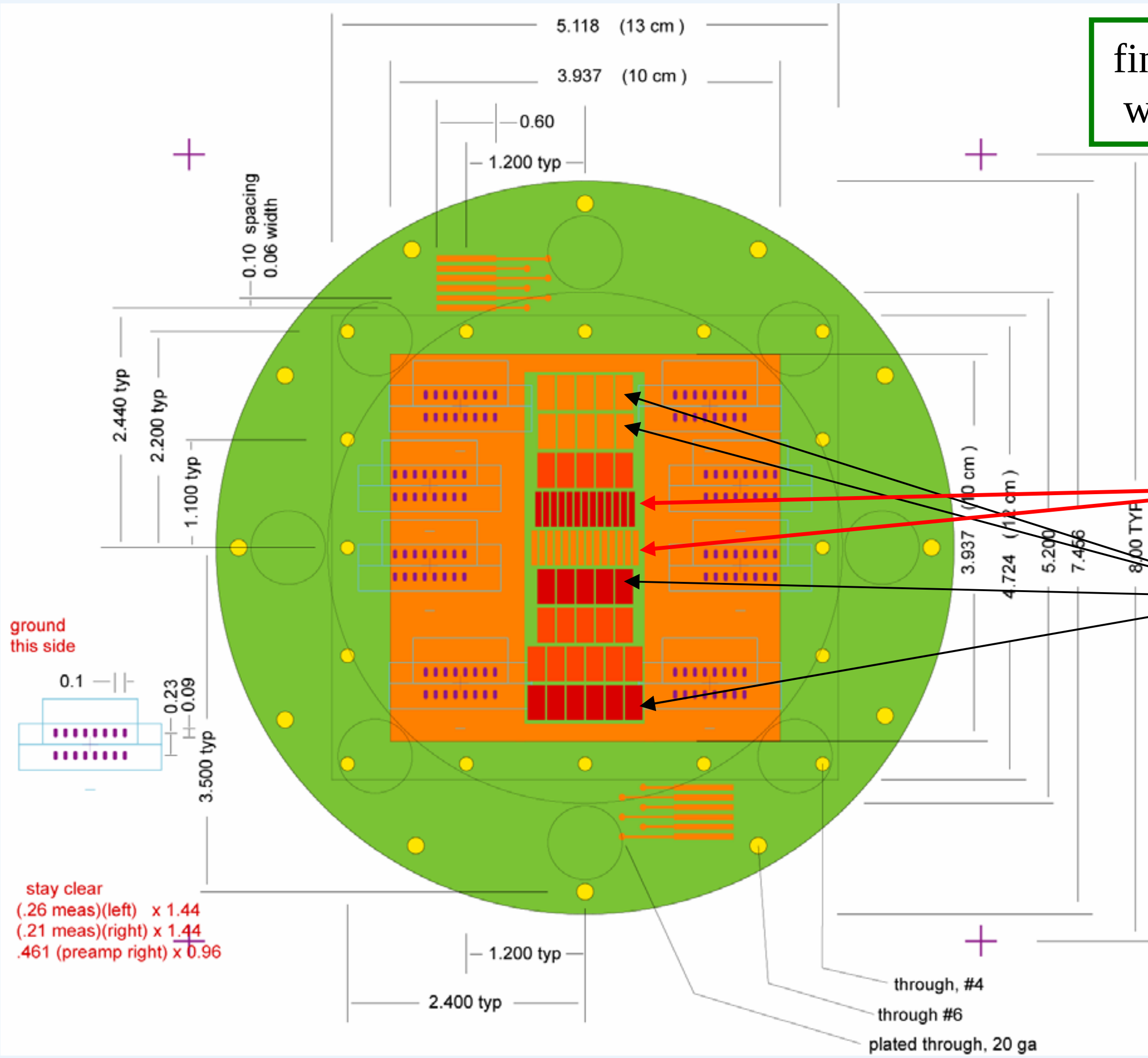
correct: $\sigma^2 = \Sigma r^2/DOF$; $\sigma =$ RMS * $(points/DOF)^{1/2}$







Future: Finer Segmentation Pad Board



finally make resolution measurements with 2mm pads

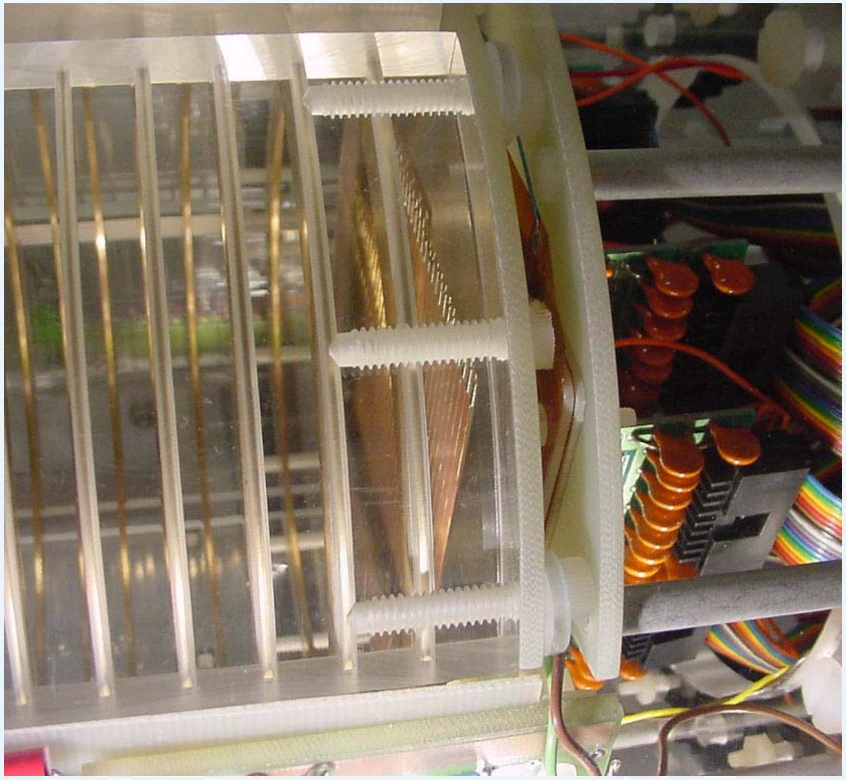
We can purchase a minor increase the DAQ , 16 channels.

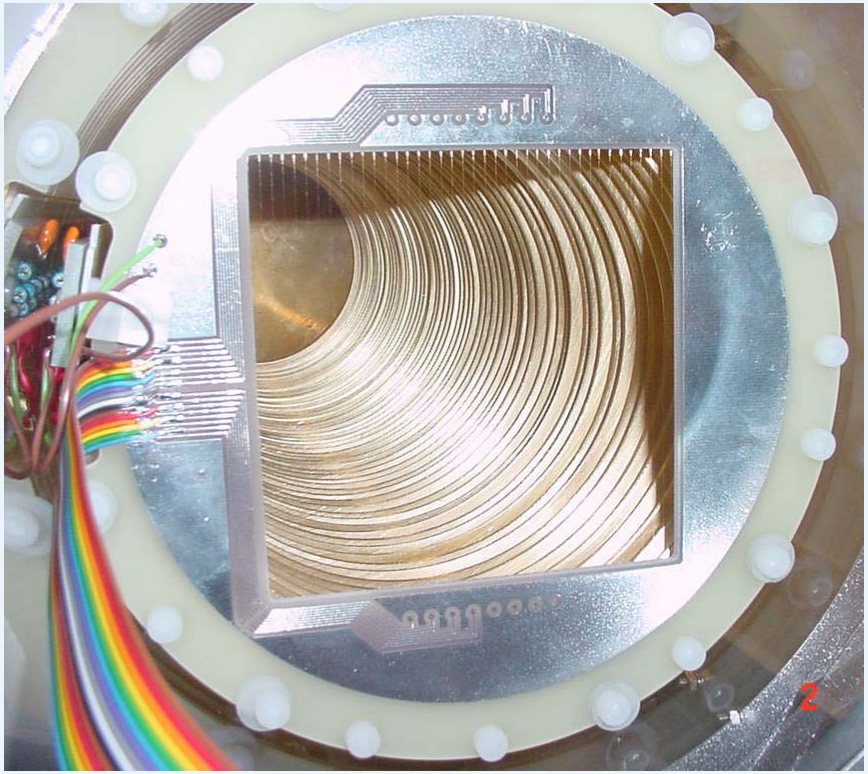
48 channels will allow …
2 rows of 2mm pads
plus
4 rows of 5mm pads
for track definition

Or..
1 row of 2mm pads
4 rows of 5mm pads

8 channels for
positive ion feedback
measurement

Future: Ion Feedback Measurement



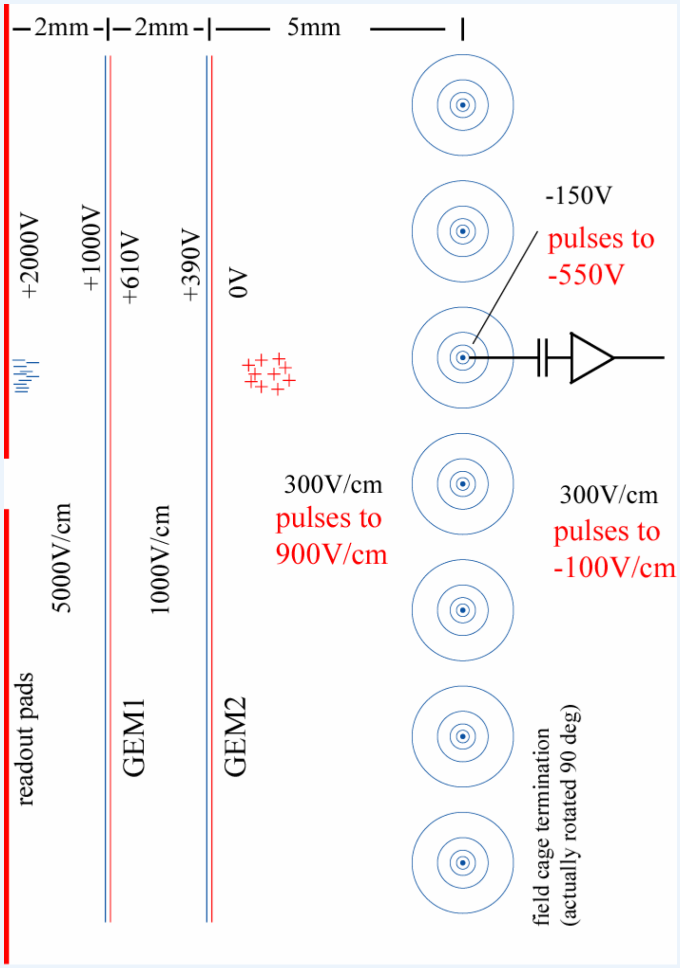


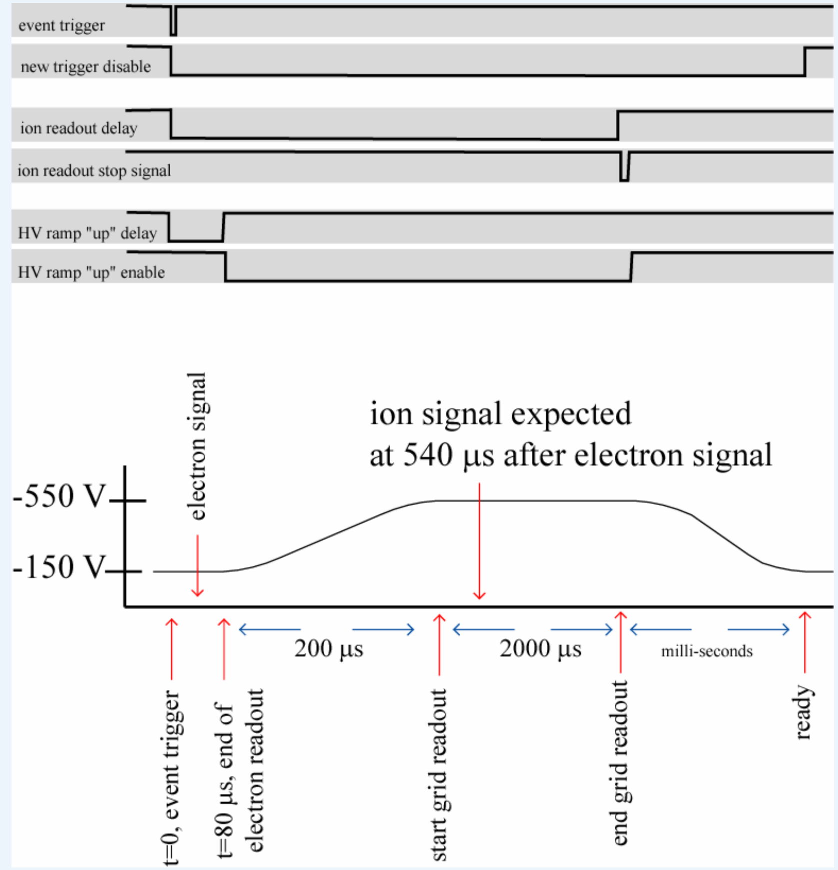
Positive ions are created in the amplification and drift back into the field cage.

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 time to recover
with this drift time.

Next 1 year

Cornell/Purdue: Minor equipment expansion -
Purchase low noise, positive HV supply for the anode
Implement rows of small pads.
(Large pads, similar to the present pads, will be used for track definition.)
Switch to TESLA TDR gas.

Compare 2-GEM, 3-GEM, MicroMegas, and Wires within the same TPC.

Compare multiple assemblies of "identical" gas-amplification devices.
Measure resolution vs. drift distance, details of biasing, gas, (location on pad).
Measure ion feedback with the various gas-amplification devices.

Purdue: next: mount a 3M MicroMegas on the old pad board

Carleton: The Carleton group (Alain Bellerive and Madhu Dixit) will prepare gas-amplification devices on the Cornell readout board for mounting in the Cornell/Purdue TPC.
This will include resistive charge dispersion read-out stages.
The groups will share in data-taking and developing a common analysis.