The Cornell/Purdue TPC

Cornell University   Purdue University

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* this presentation: ECFA 2005 Vienna   24-November-2005
* 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

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
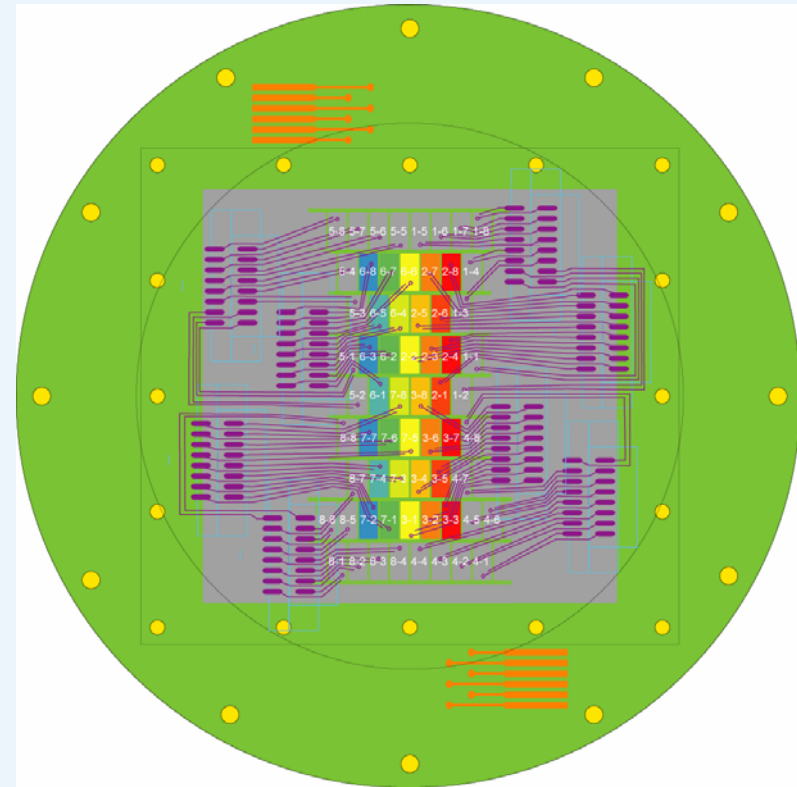termination bias voltage.

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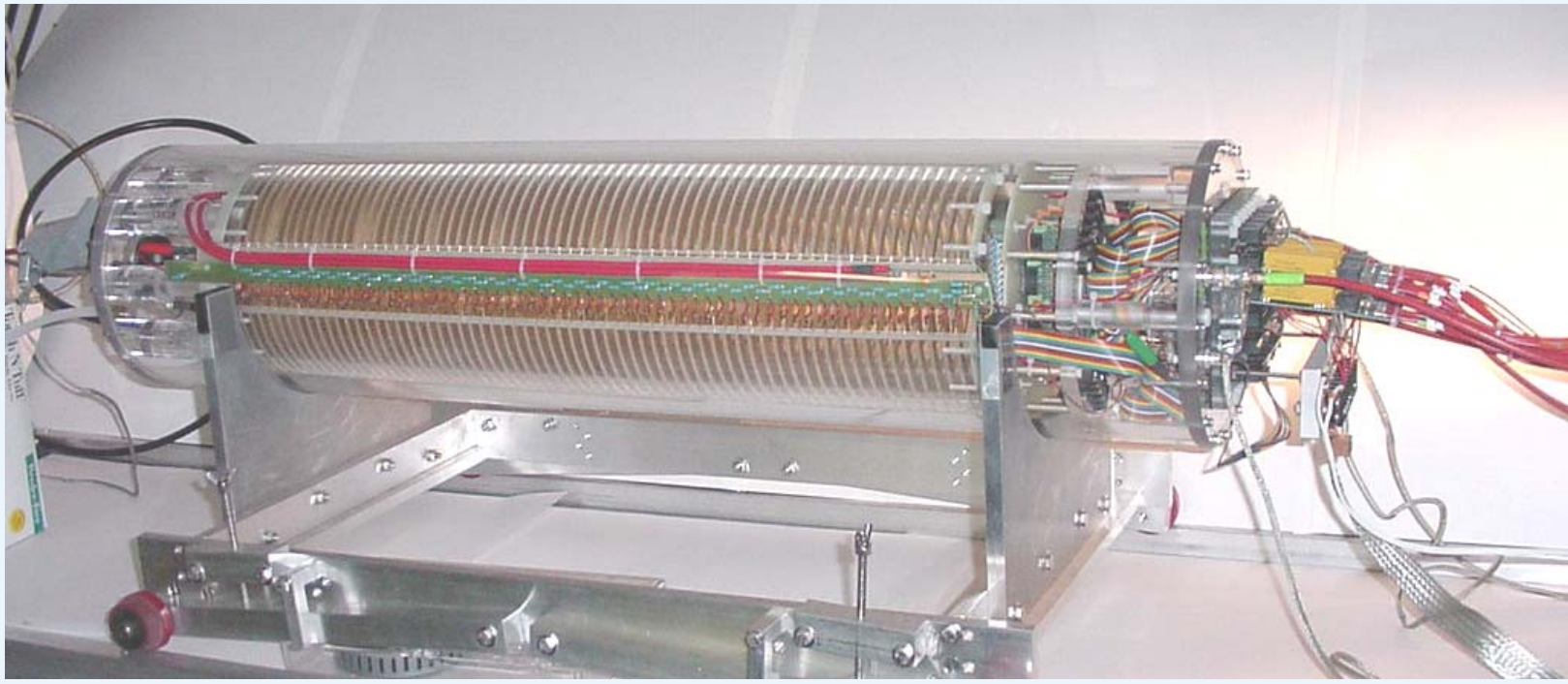
Field cage termination
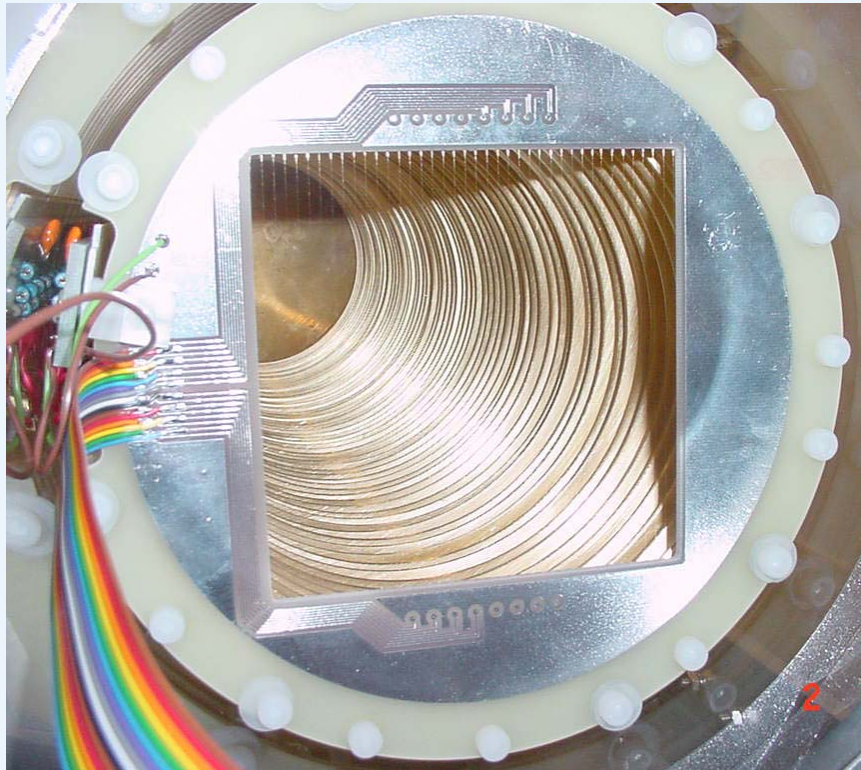
10 cm

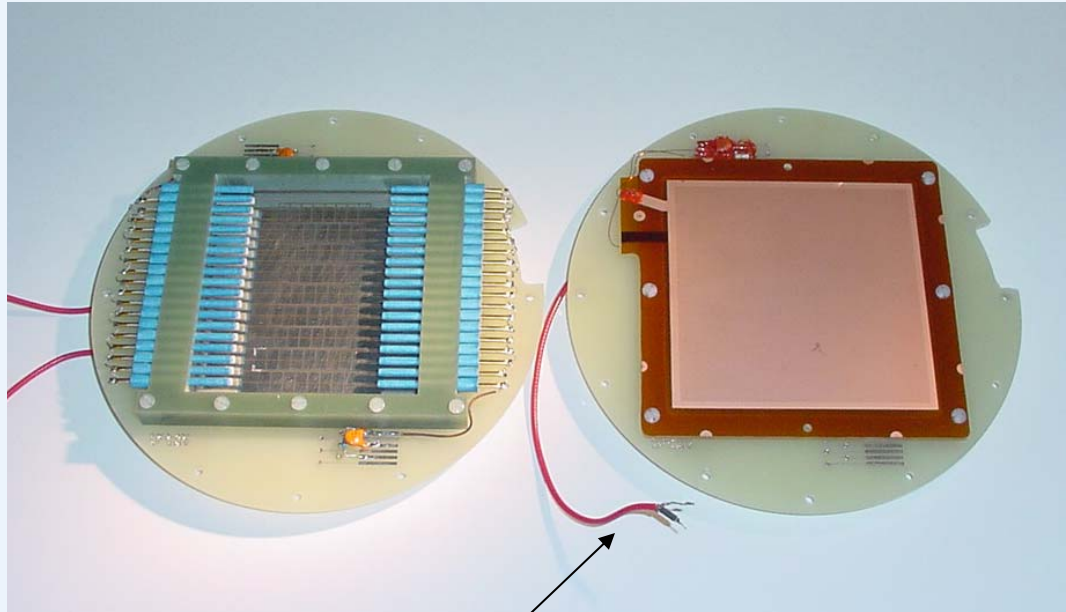Field cage termination area is 10cm square

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

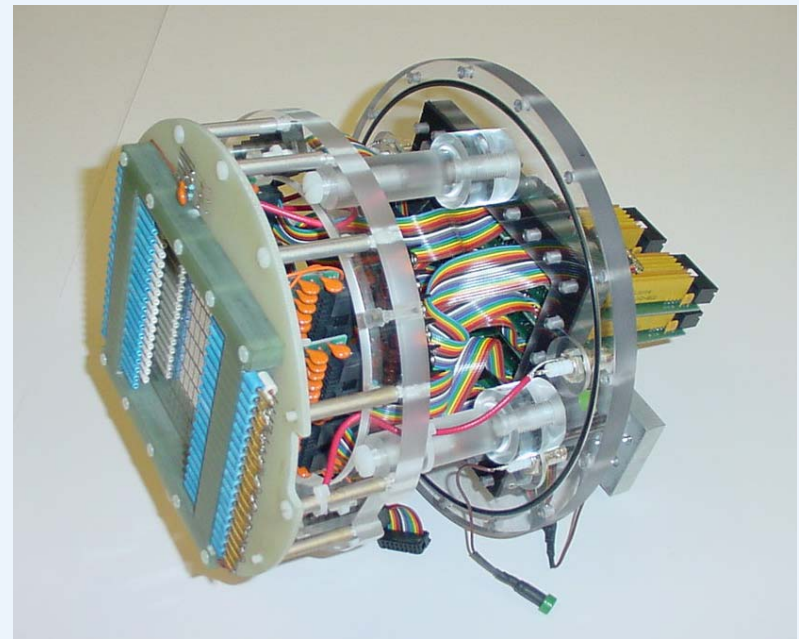The biased area is 10cm square.

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

MPWC and GEM amplification

10 cm

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

The readout module including the amplification device mounted on pad board

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
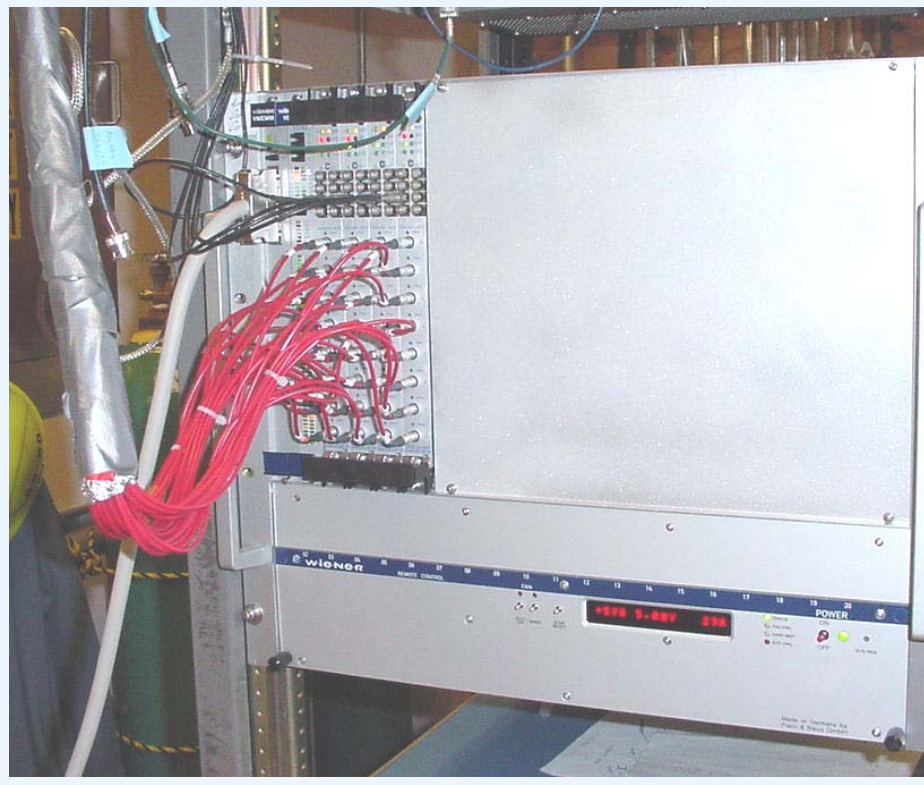   -2 kV module, 4 channels available

(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
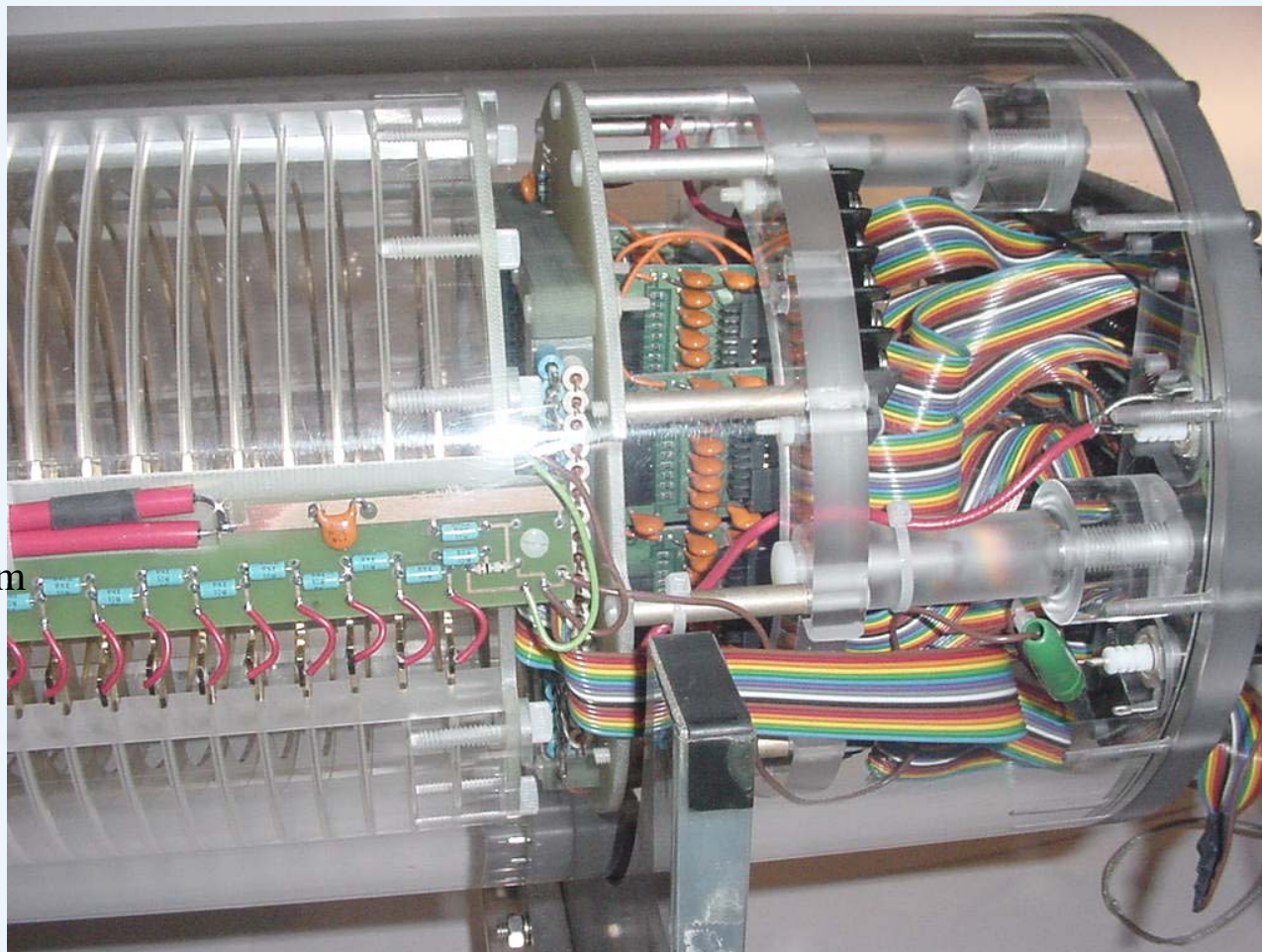
termination:grid **300V/cm**, 10mm
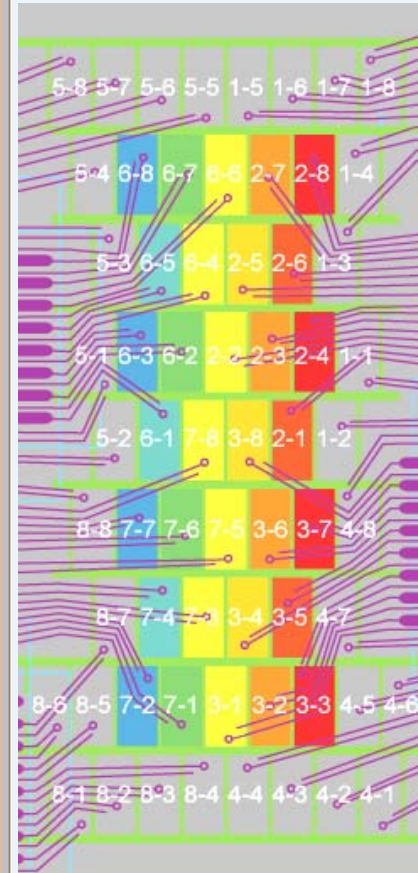
 grid: -600V

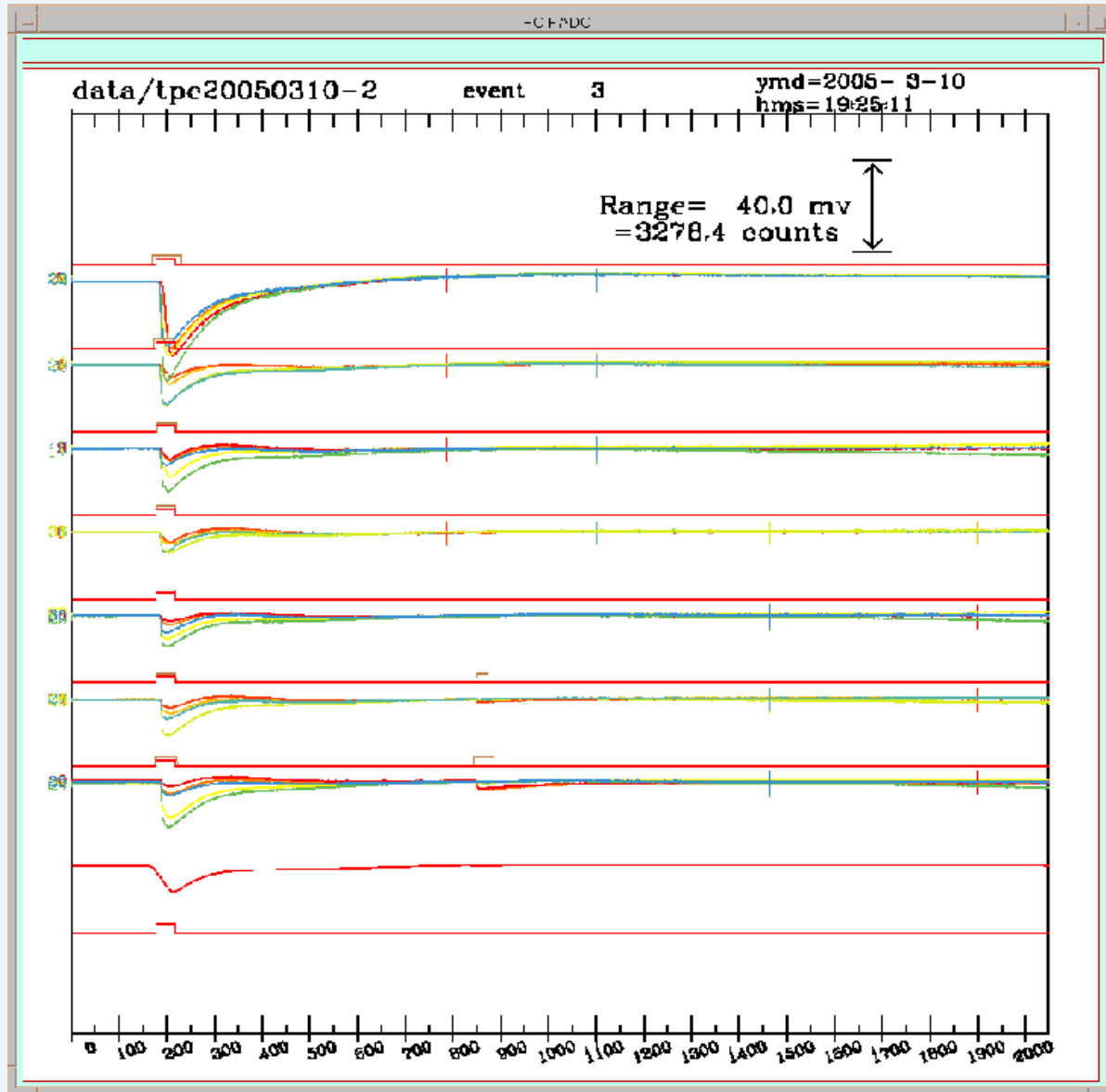grid:anode   5mm

 anode: +550V

anode:pads   5mm

 pads: -2000V

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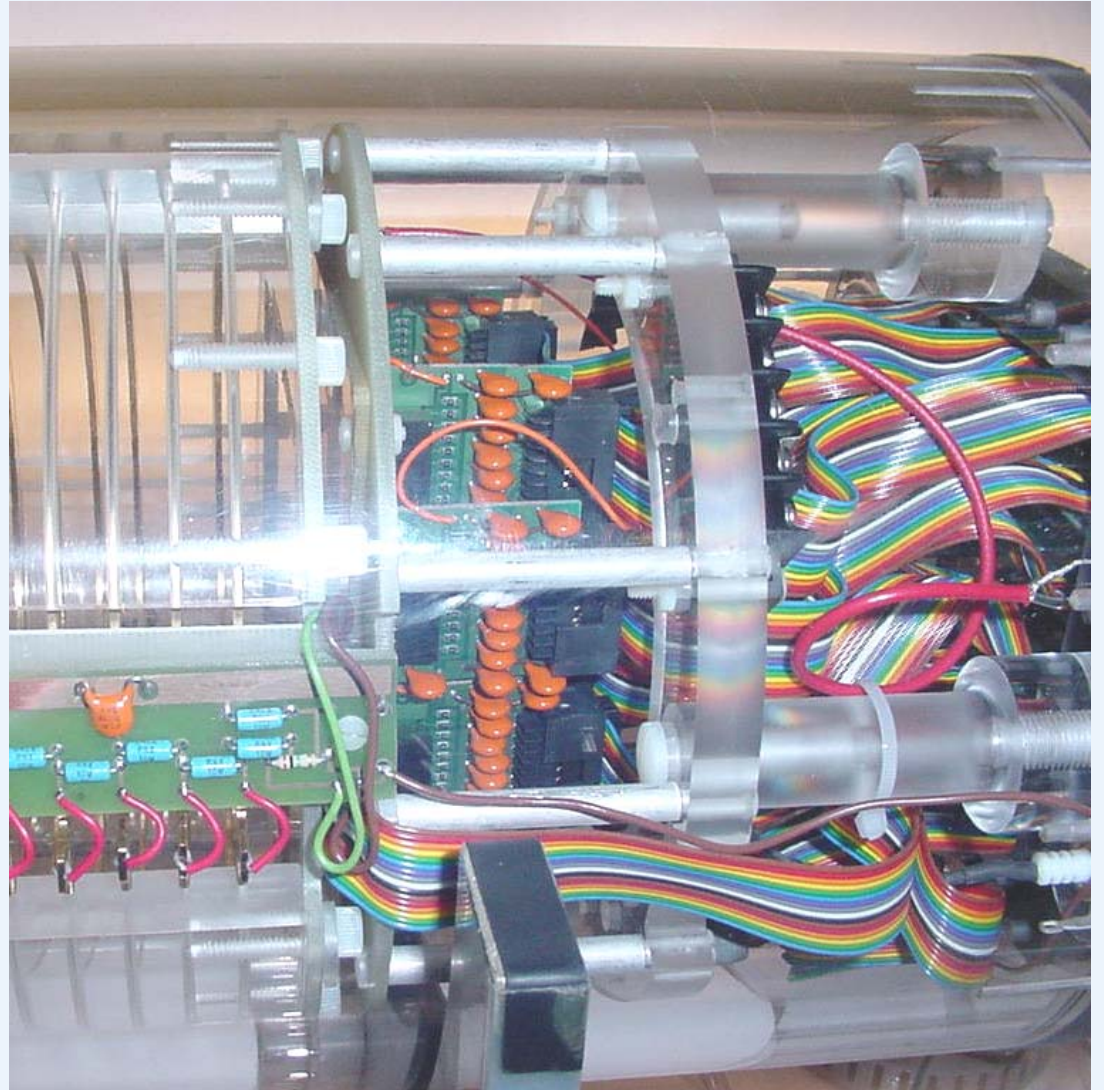 field cage, -20kV,   300 V/cm
   termination: -900V

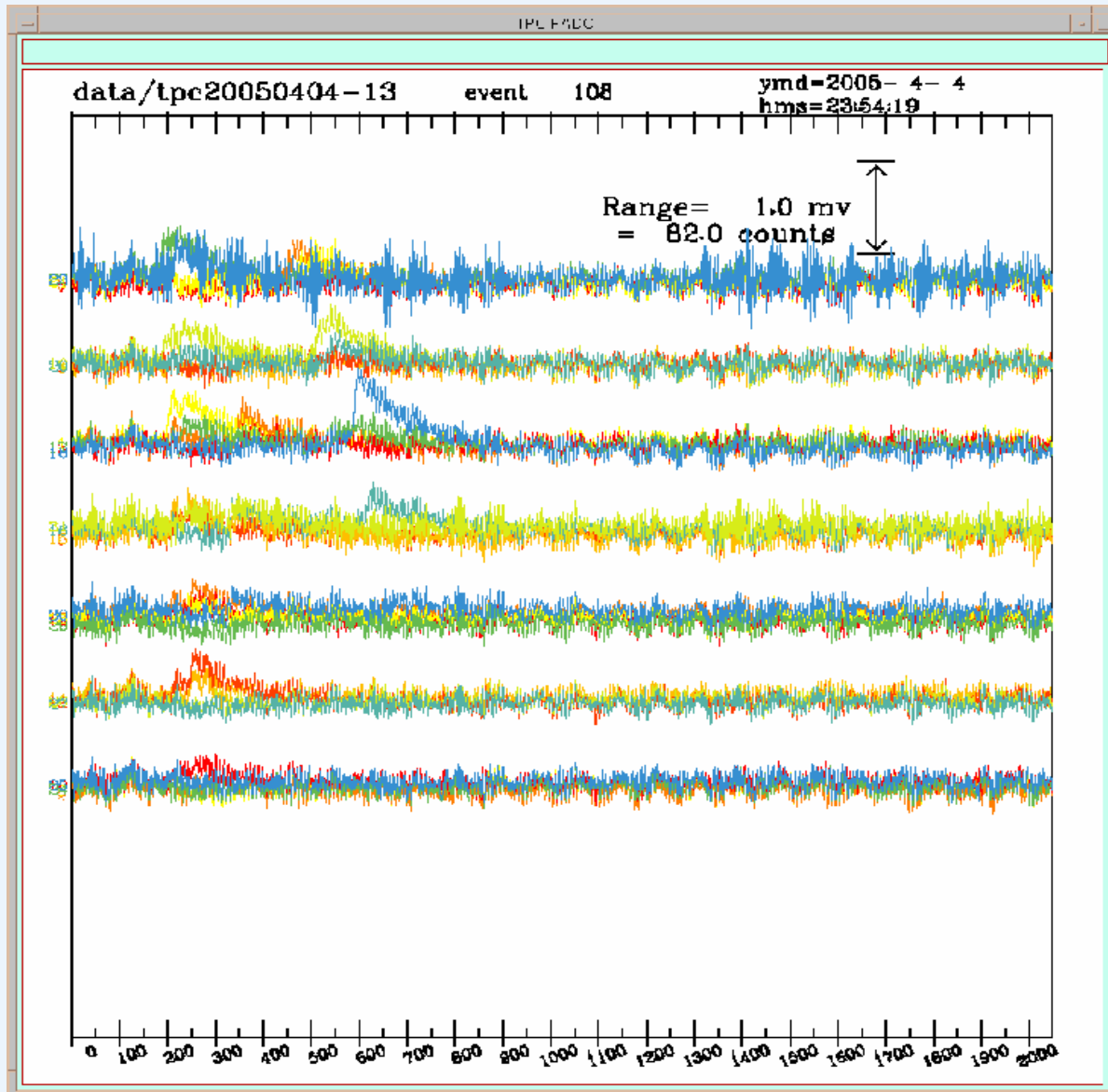termination : GEM **960V/cm** , 0.5 cm

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

GEM : pads: **5000V/cm** , 0.3 cm,
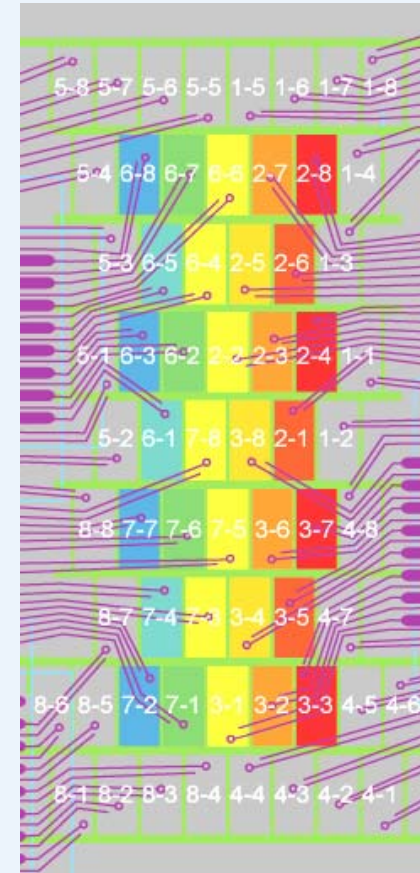
 pads: +1500 V

single-GEM event

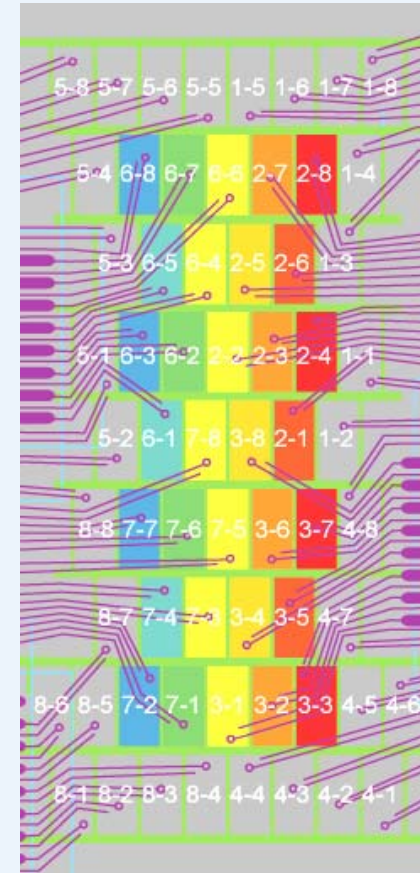ArCO2 (10%) , 300V/cm
25 MHz , 40 ns
2048 time buckets (81.92 μs)

single-GEM after smoothing & common noise subtraction
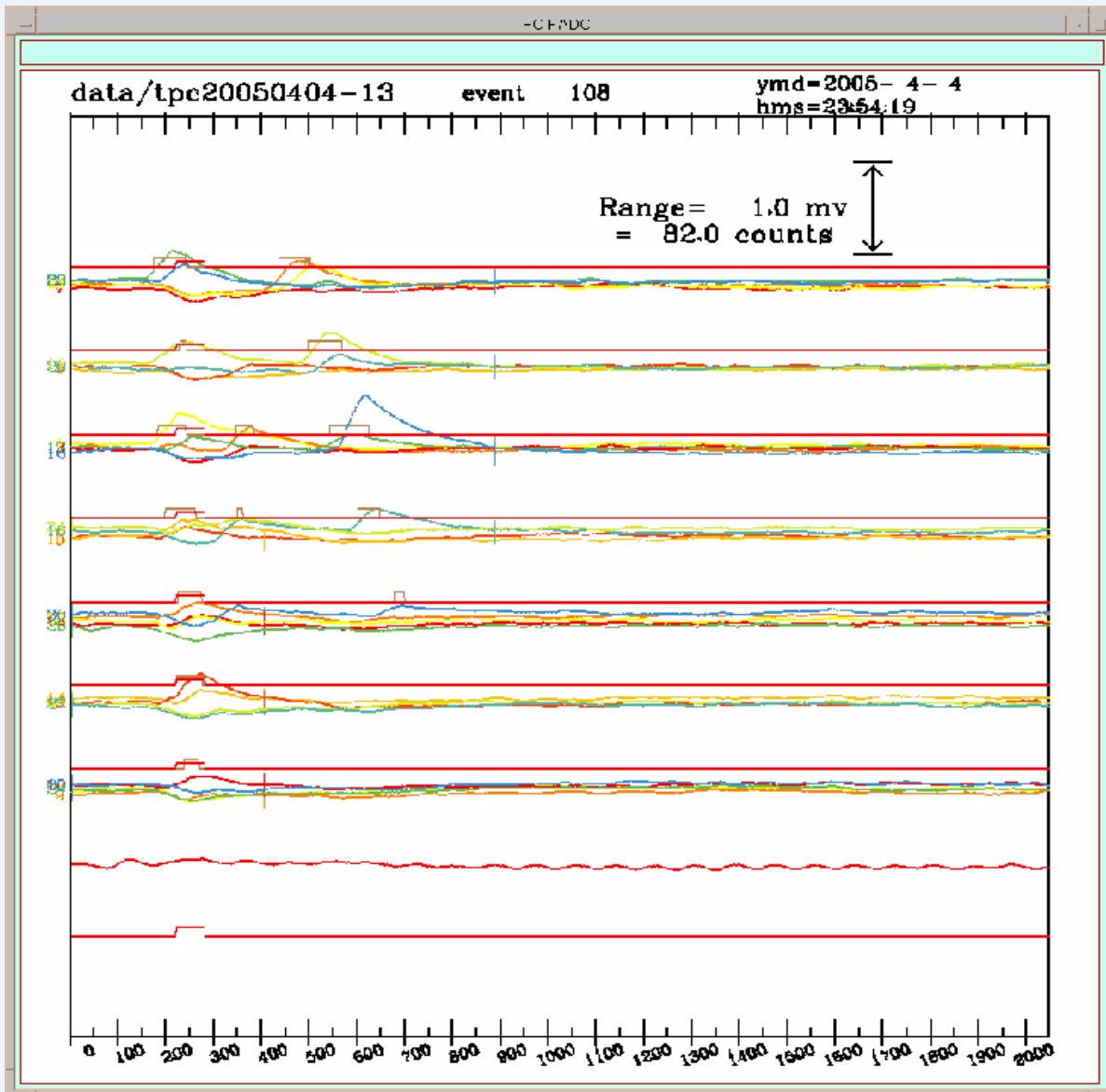
ArCO2 (10%) , 300V/cm
25 MHz , 40 ns
2048 time buckets (81.92 μs)

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

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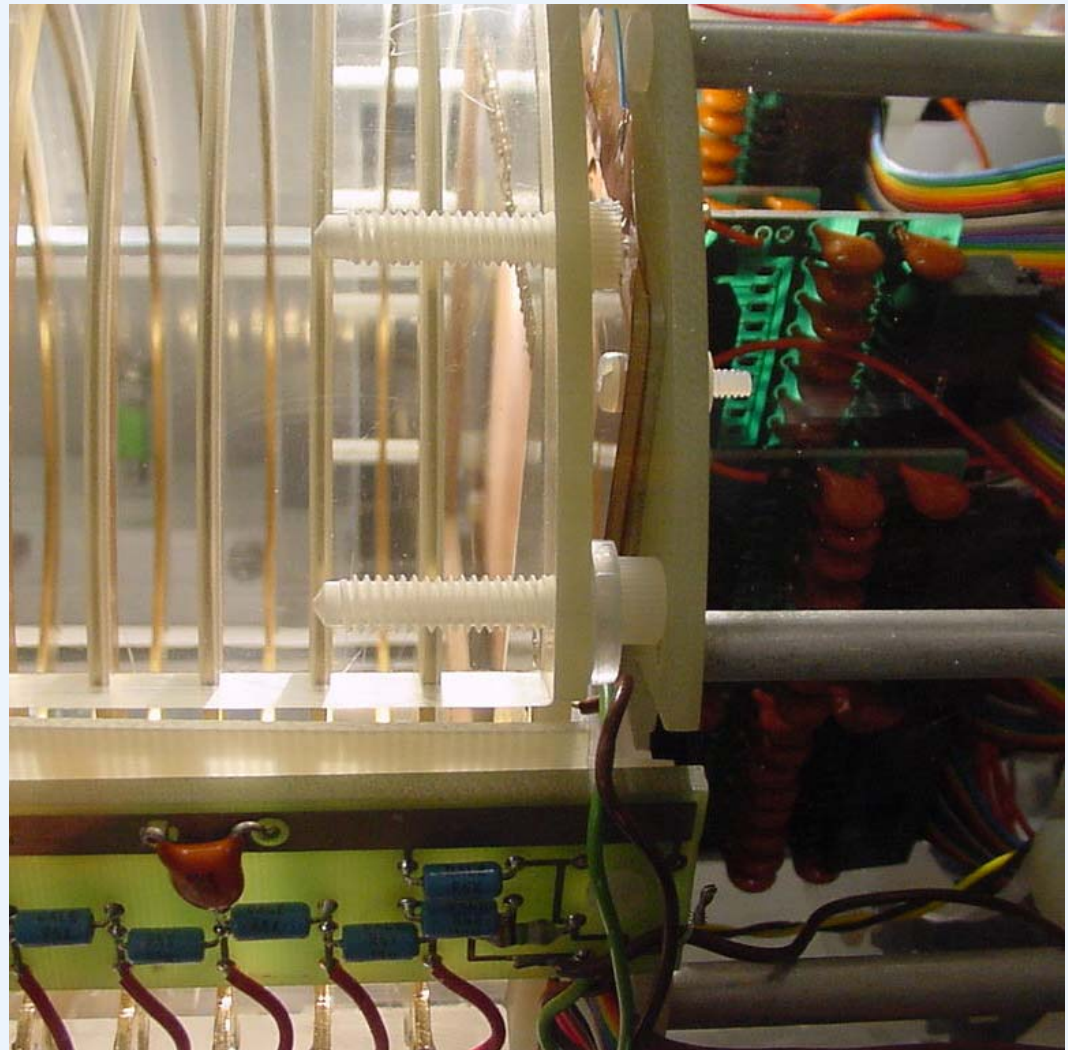
double-GEM event
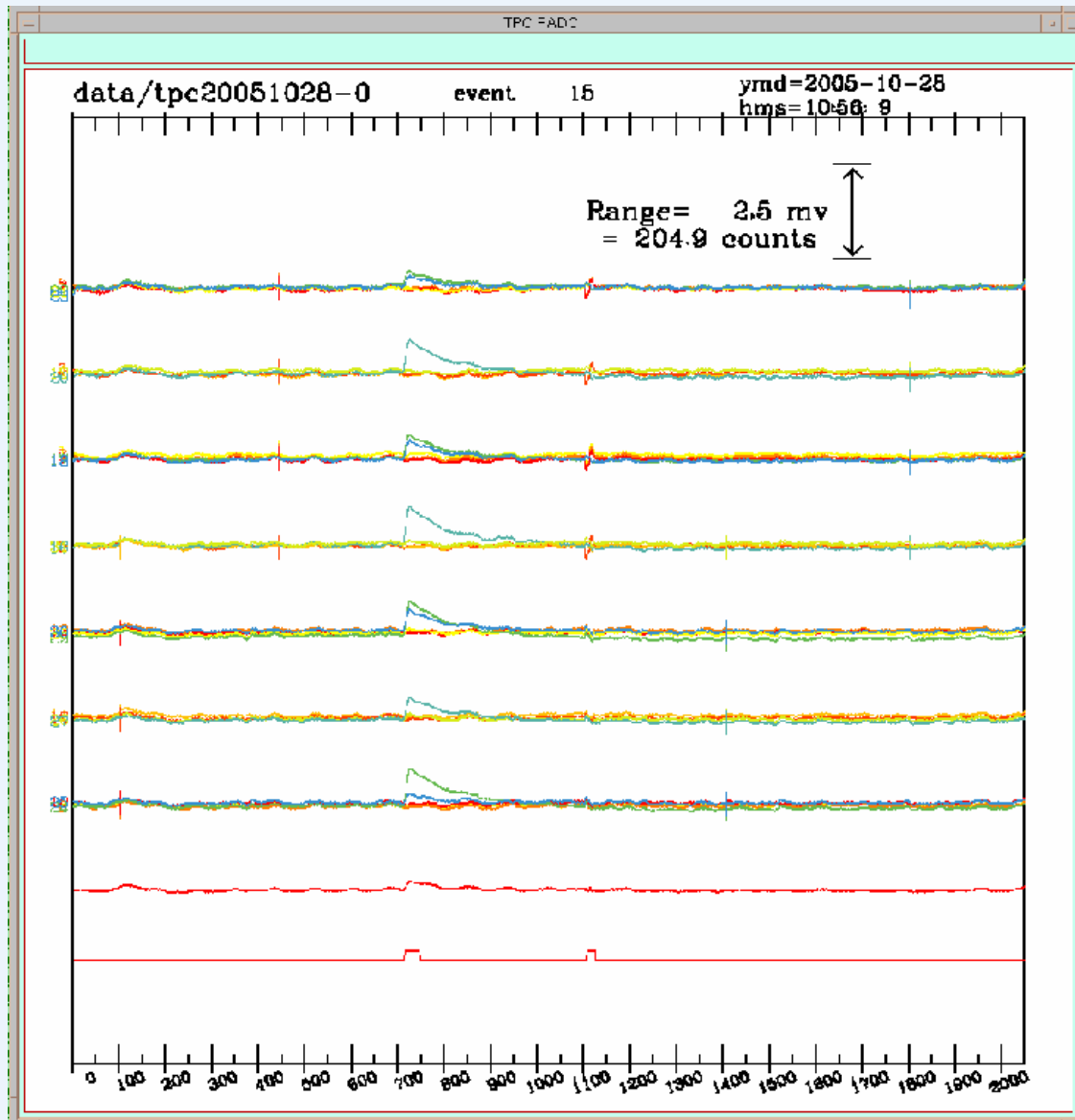
ArCO2 (10%) , 300V/cm
drift velocity = 22 μm/ns

drift distance ~55cm

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

charge width

Charge Width — D. Peterson 20-August-2005

MWPC
ave=0.42

fraction of hit PH on pad with max PH

Charge Width — D. Peterson 15-November-2005

2-GEM
21% hits are 1 pad,
charge cloud is contained
in 79% of pad width, 3.9mm

42% of hits are >95% of charge
95% of charge cloud is contained
in 58% of pad width, 2.9mm
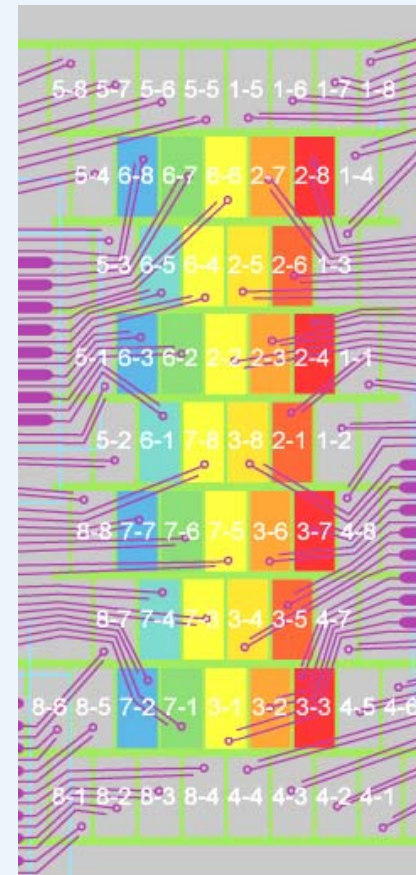
fraction of hit PH on pad with max PH
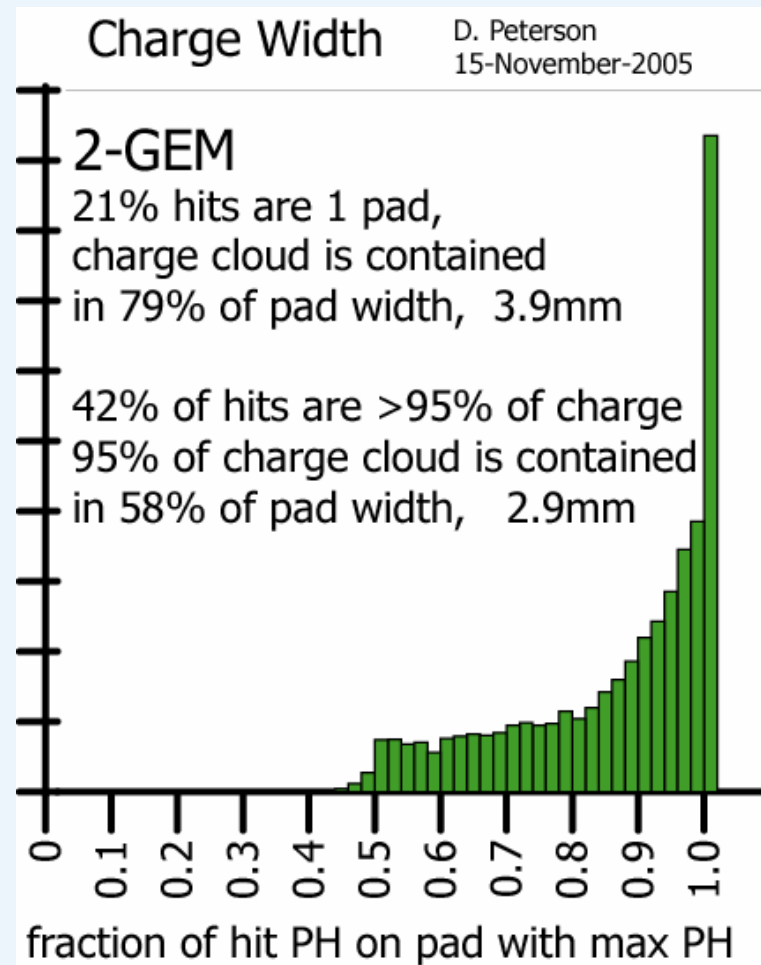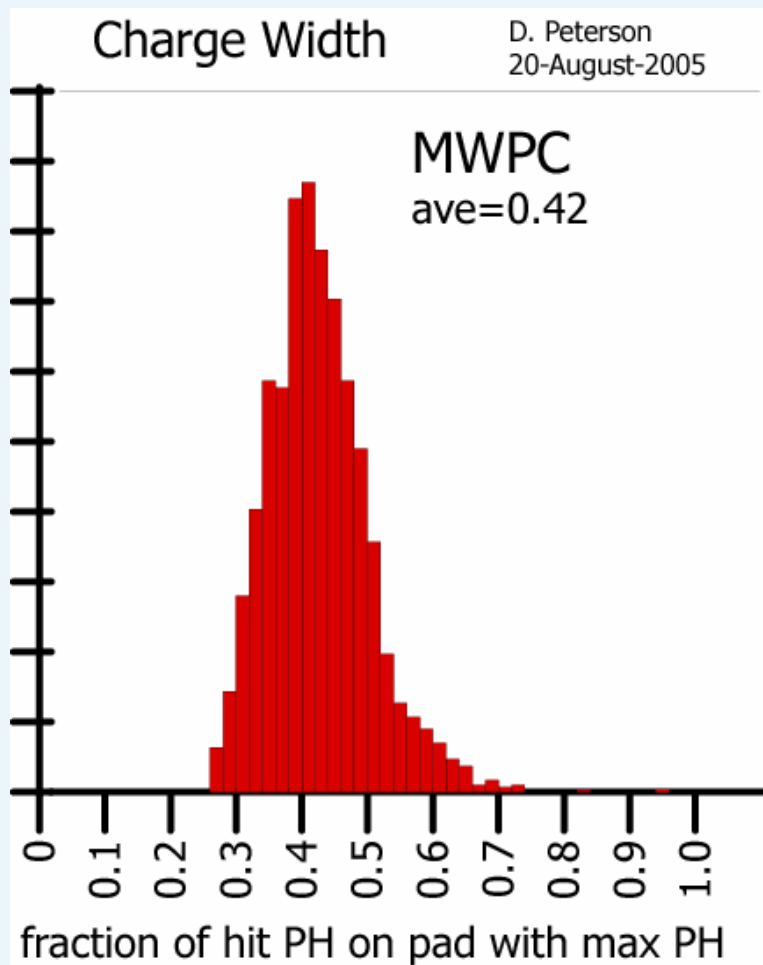
The charge width for the 1-GEM (shown at Snowmass) was
influenced by the common "noise" subtraction.
The 2-GEM does not require common "noise" subtraction.

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.)
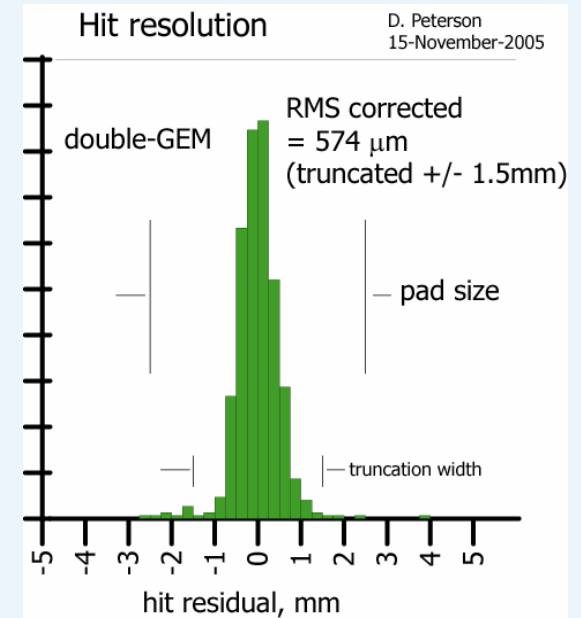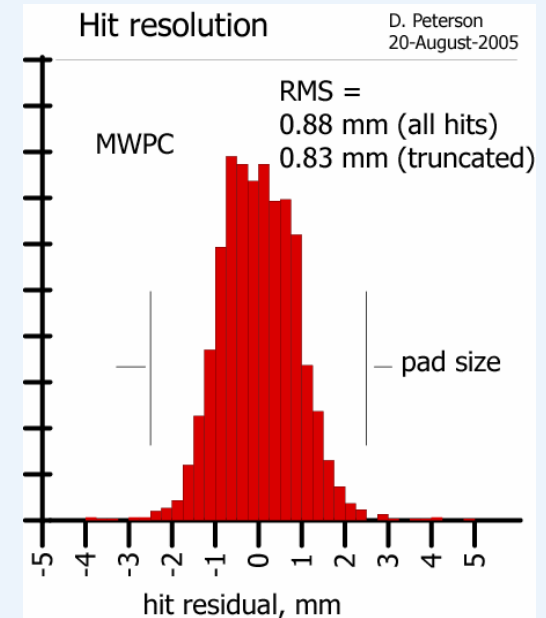**refit**

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

Hit resolution — D. Peterson 20-August-2005
RMS = 0.88 mm (all hits) / 0.83 mm (truncated) — MWPC — pad size — hit residual, mm

Hit resolution — D. Peterson 15-November-2005
RMS corrected = 574 μm (truncated +/- 1.5mm) — double-GEM — pad size — truncation width — hit residual, mm

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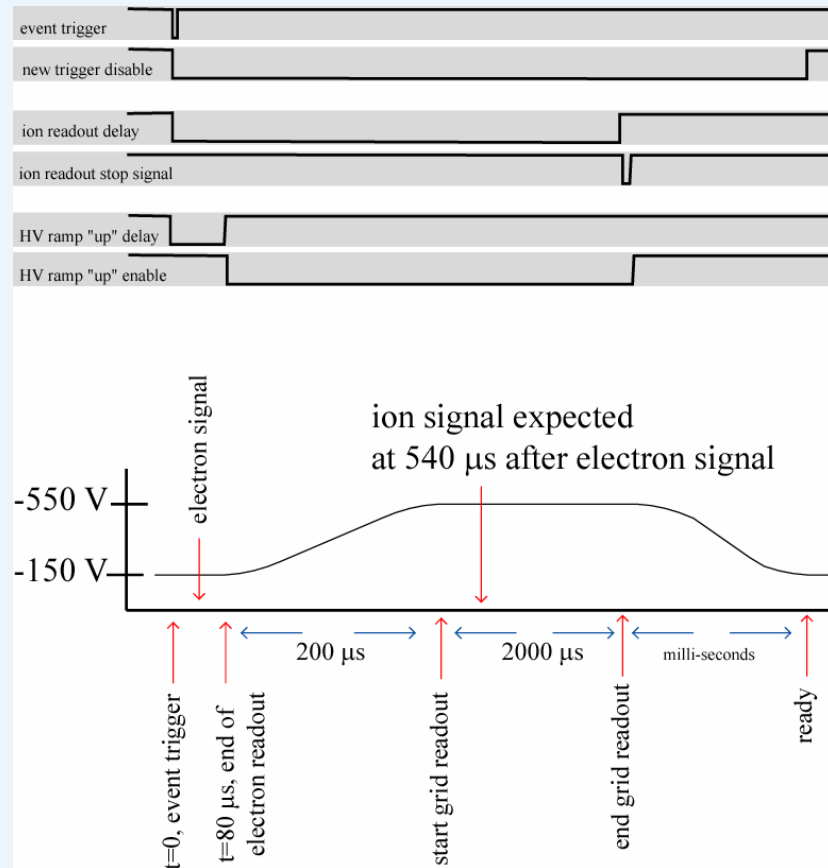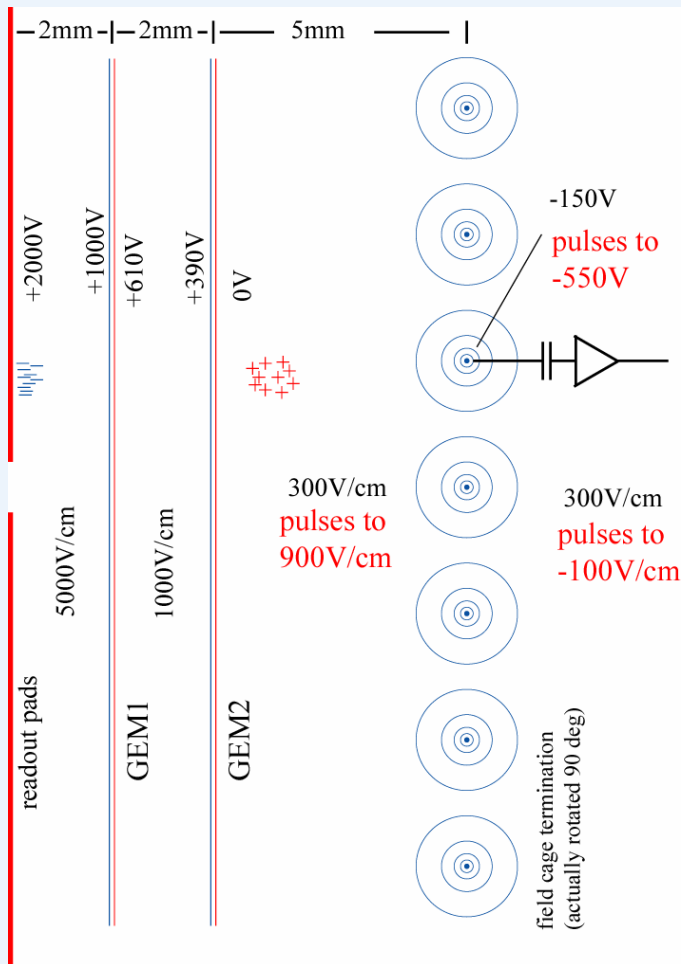
Require small ion drift time to reduce diffusion.
(Expect ~7 μs diffusion at 540 μs drift.)

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.