TPC Detector R&D at BNL

Craig Woody

Brookhaven National Lab

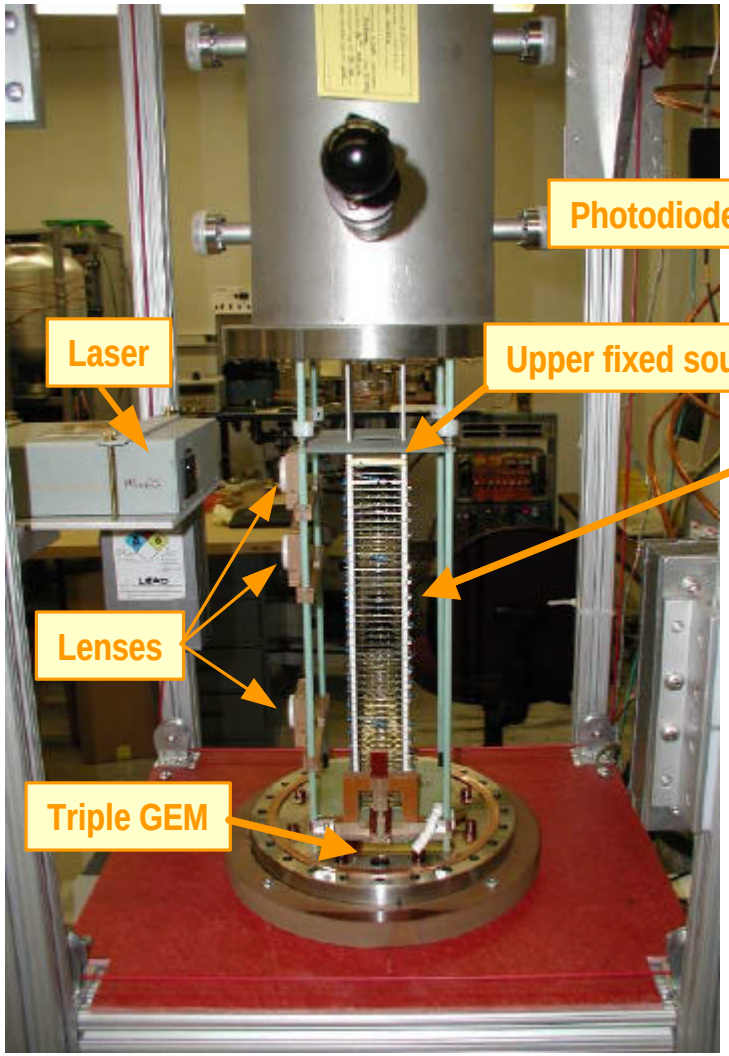
TPC/HBD Upgrade Working Group Meeting

November 19, 2003

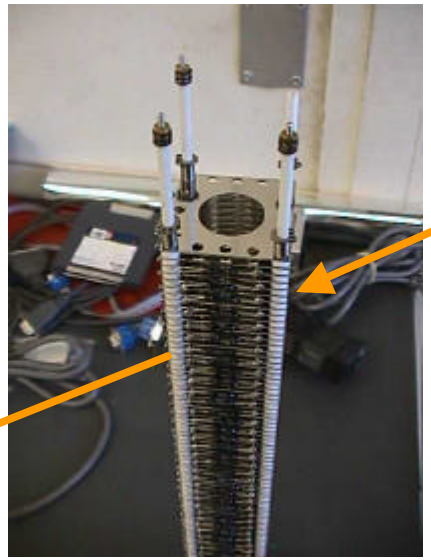
Overview of R&D Status

- Drift Cell is working
  - Measuring drift velocities of fast drift gases (CF_4 mixtures)
  - Studying GEM operation using drift cell with various gases
  - Studying charge distribution on readout plane
- Testing GEM foils (3M, CERN)
- Field cage design
- Other related R&D → Joint effort with STAR and LEGS
- FY04 R&D Plans

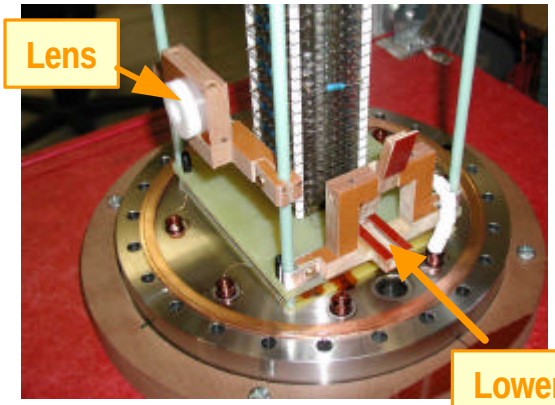
Test Drift Cell



Lab 2-86 in Physics



Drift Stack
(presently ~ 30 cm drift)



Used to study

- Drift velocities
- Drift lengths
- Diffusion parameters
- Energy loss (dE/dx)
- Study impurities
- Readout structures
- Field cage design

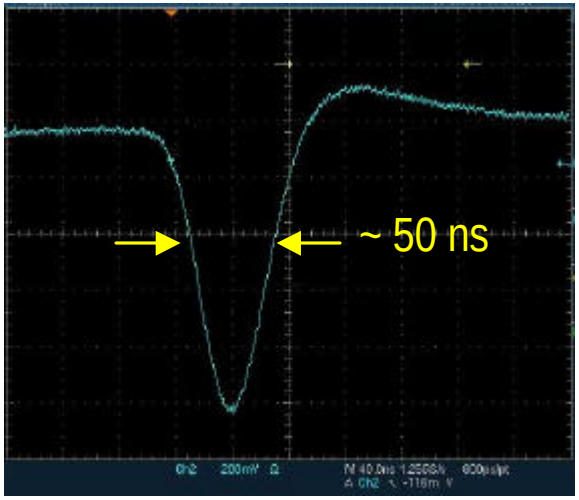
Detector Readout

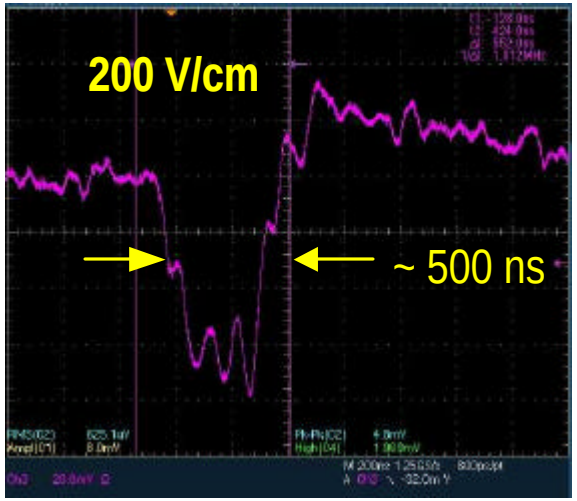
Present readout plane: 2x10 mm pads

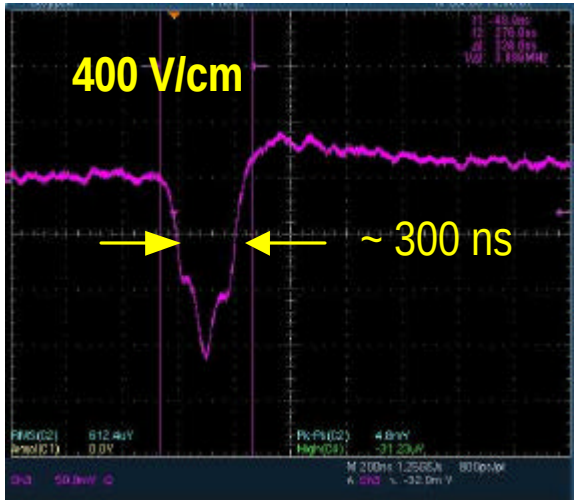
Electronics: Struck SIS3300 100 MHz FADC
(8 channel, 12 bit VME module)

Ar/CO_2 (80/20)
^{55}Fe source

Digital scope traces







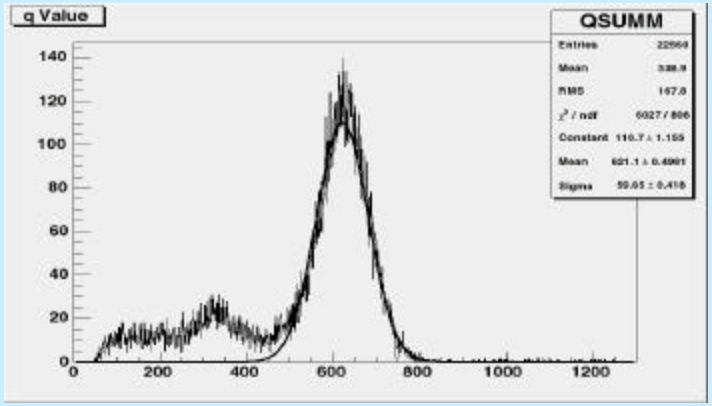
Lower source

Upper source

Clearly see effect of longitudinal diffusion and conversion depth of source

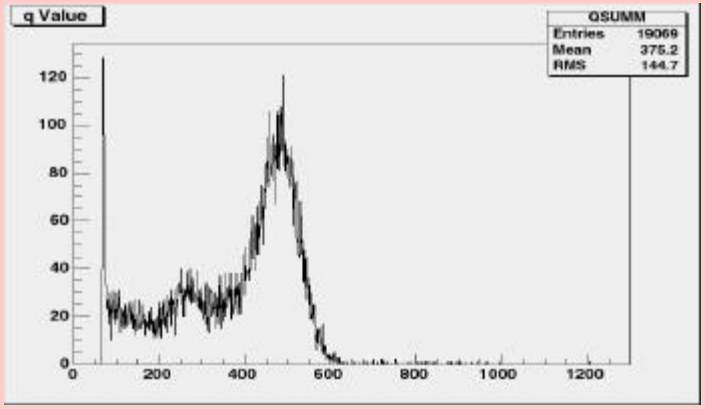
Drift Cell Measurements

Ar/CO_2 (80/20)



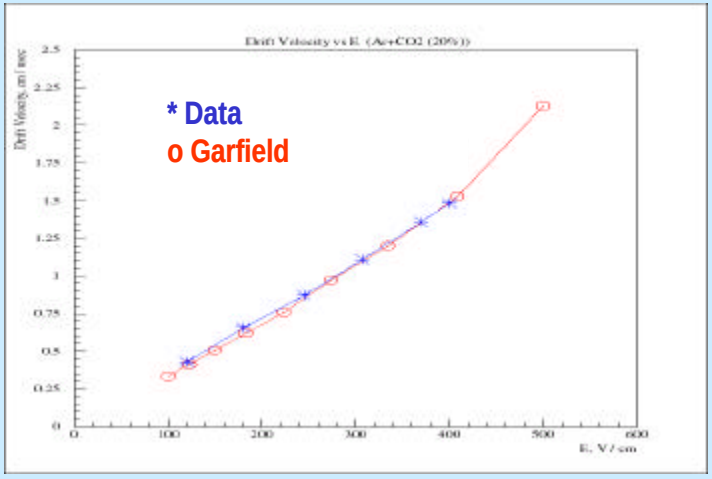
22% FWHM/mean

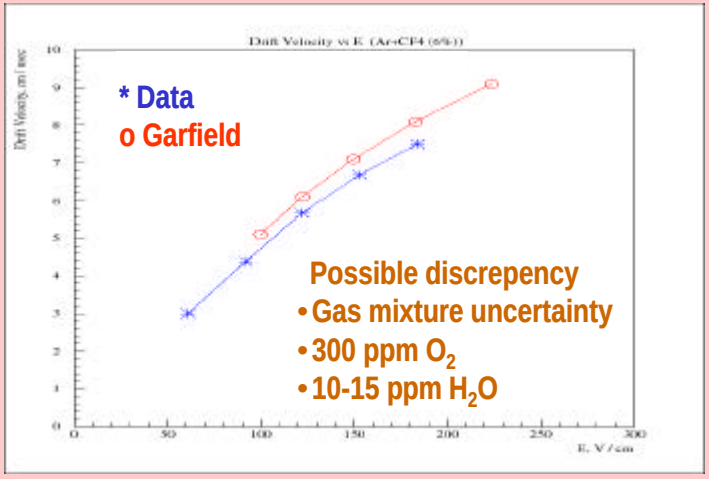
Ar/CF_4 (95/5)



28% FWHM/mean

Energy Resolution
(Top ^{55}Fe source)

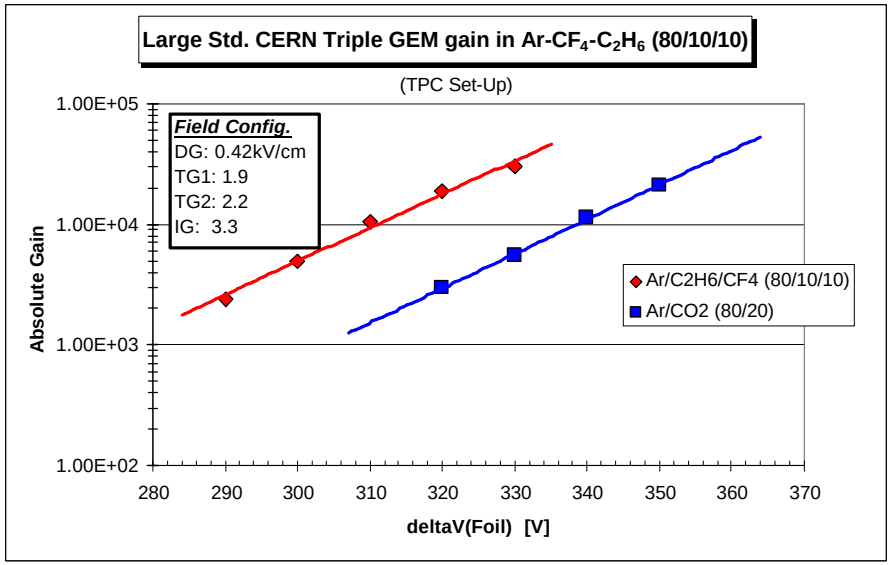


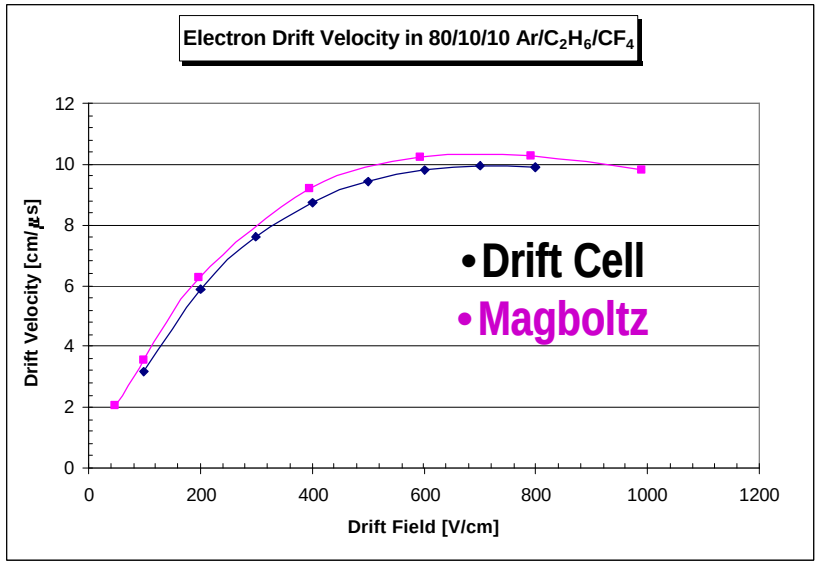


Drift Velocities (laser)

A Possible Fast Drift Gas

$Ar/C_2H_6/CF_4$ (80/10/10)





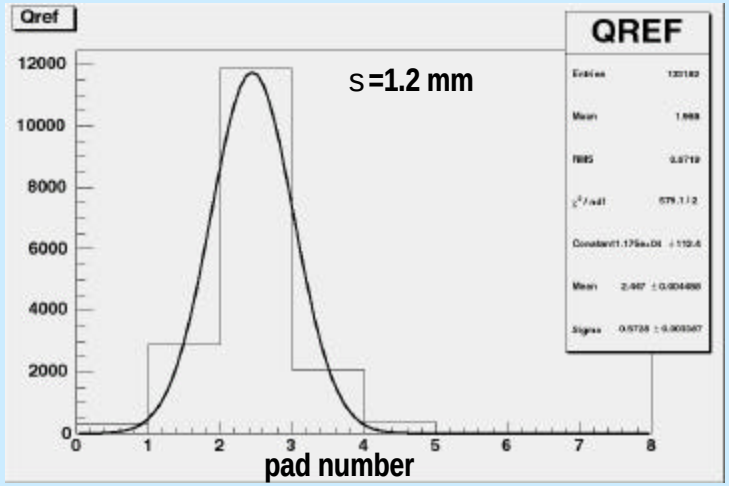
Very stable operation with GEMS

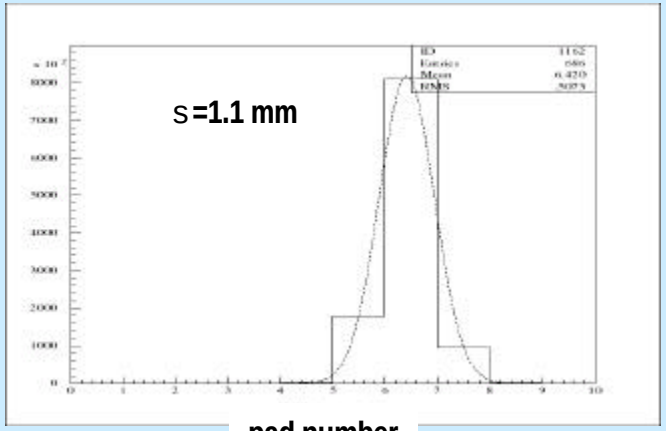
Proposed gas mixture for LEGS TPC

Charge Distribution from Drift Cell

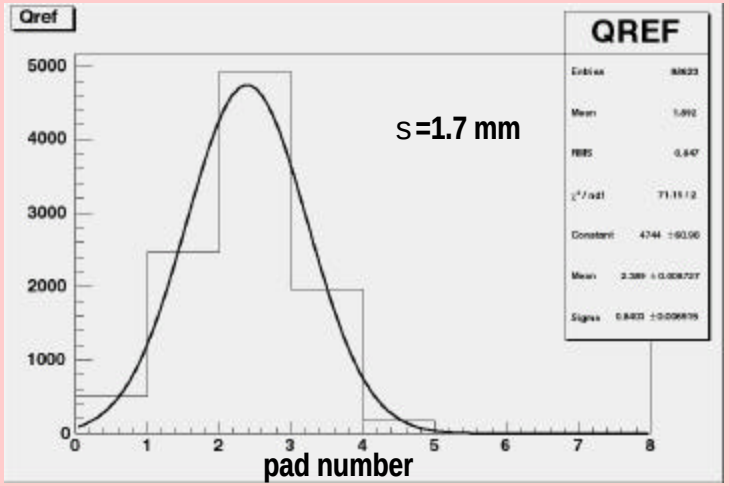
(top source, 2 mm pad readout)

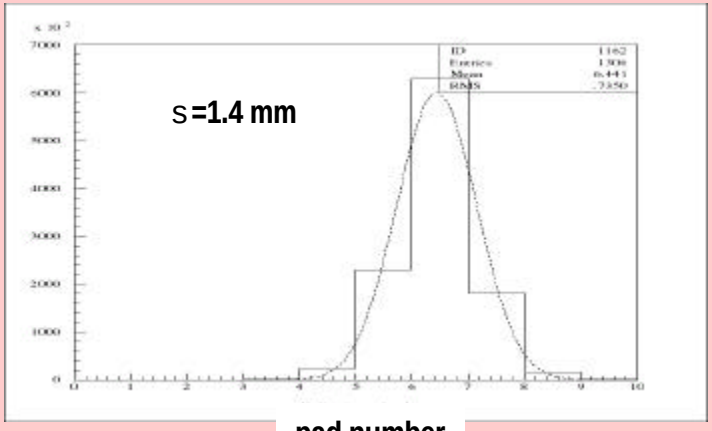
Ar/CO_2 (80/20)





Ar/CF_4 (95/5)





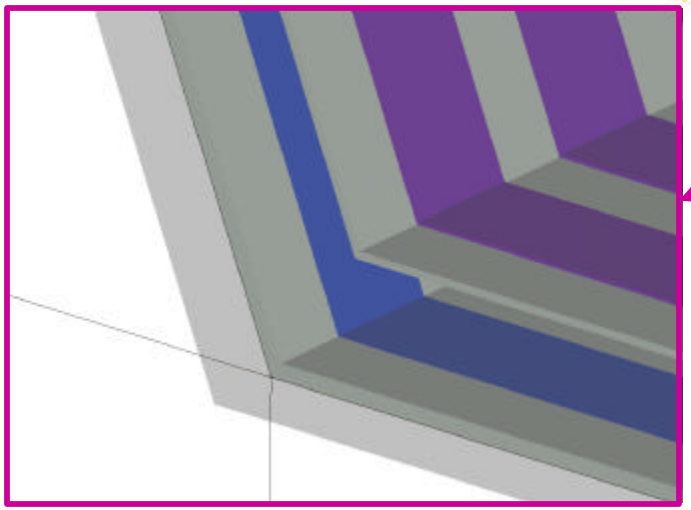
Measured

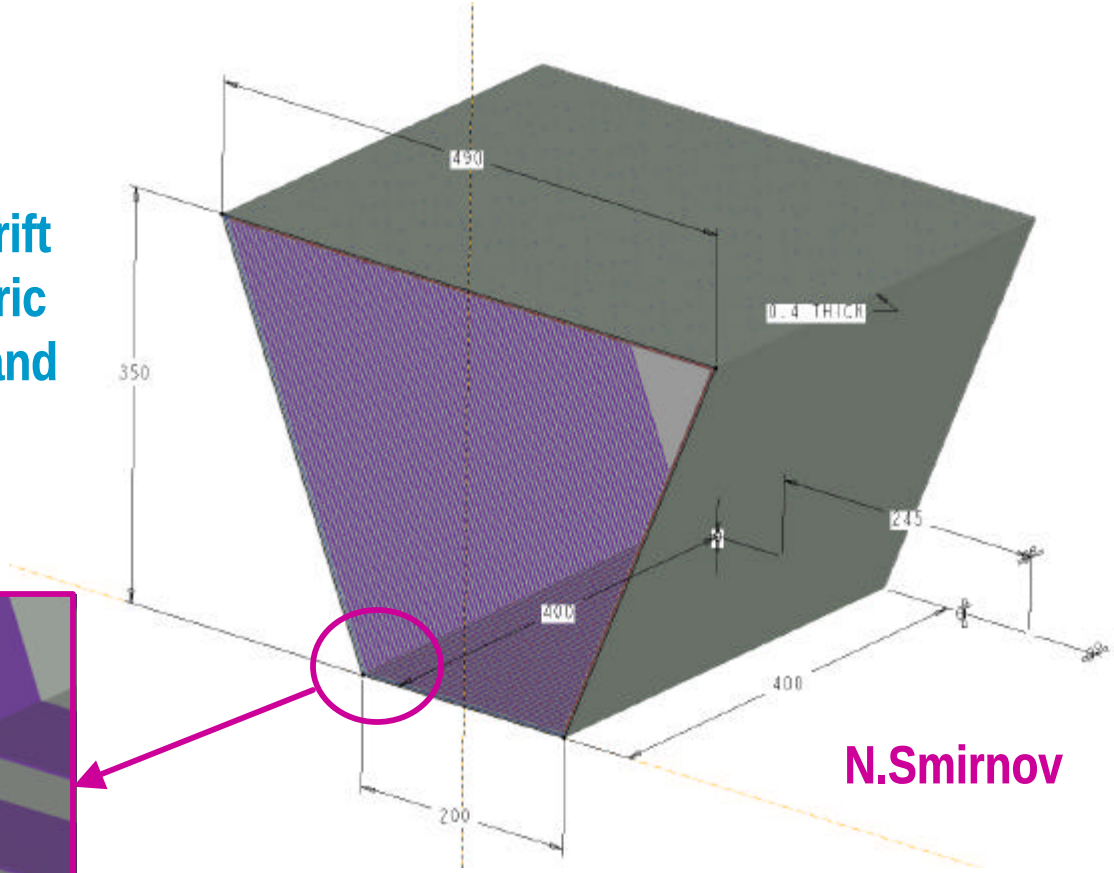
Simulation (N.Smirnov)

TPC Field Cage Design

Question:

How uniform can we make the drift field and how large are the electric field distortions near the edges and in the vicinity of the HBD ?





N.Smirnov

Two Methods:

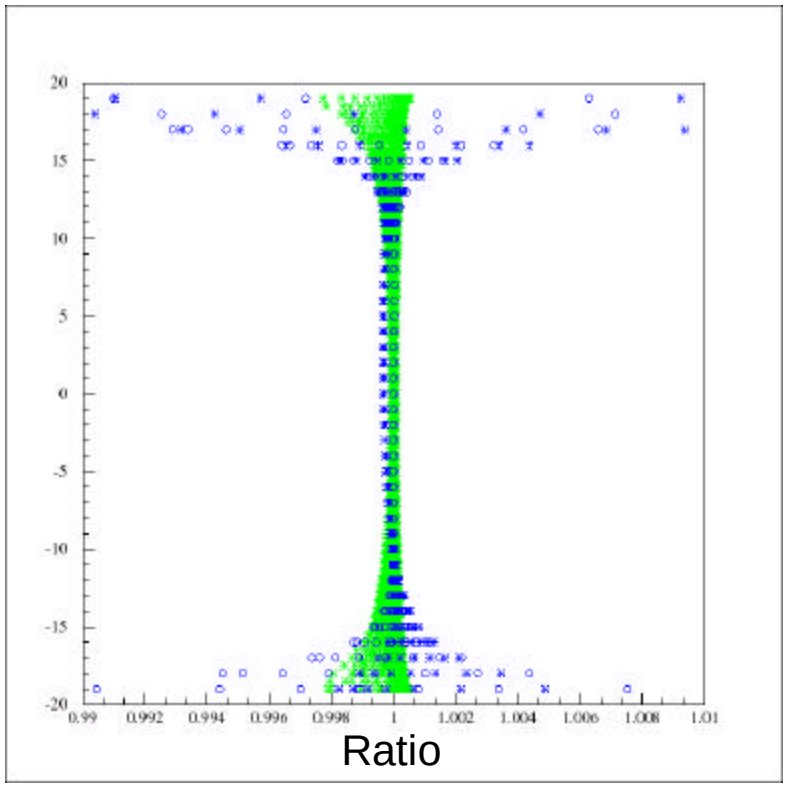
- **Autocad geometry ? MAXWELL**
- **2D calculation using GARFIELD**

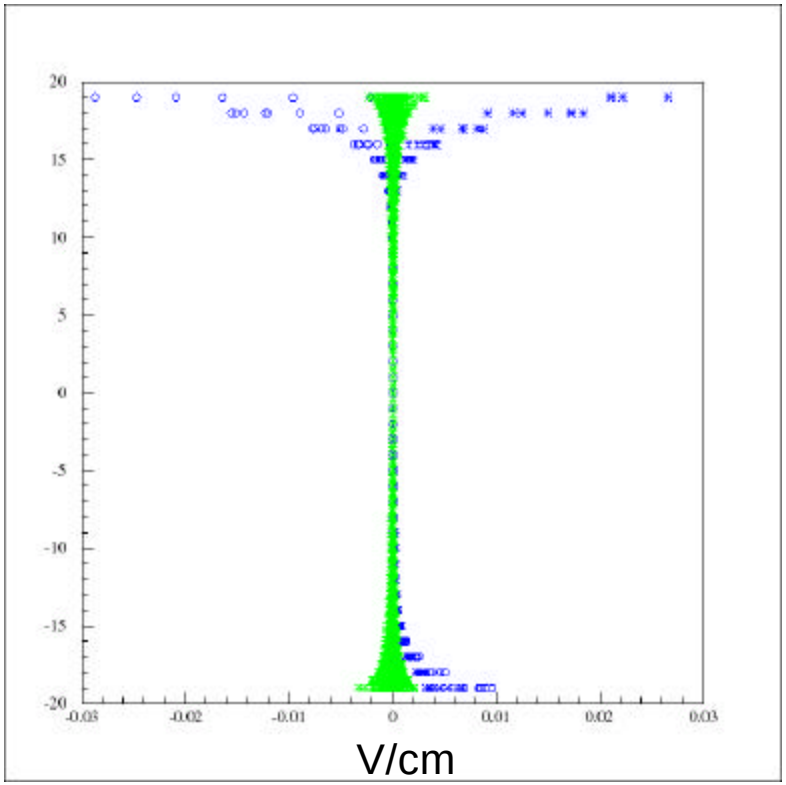
Drift Field Distortions

$E_Z / \langle E_Z \rangle$

E_R

R



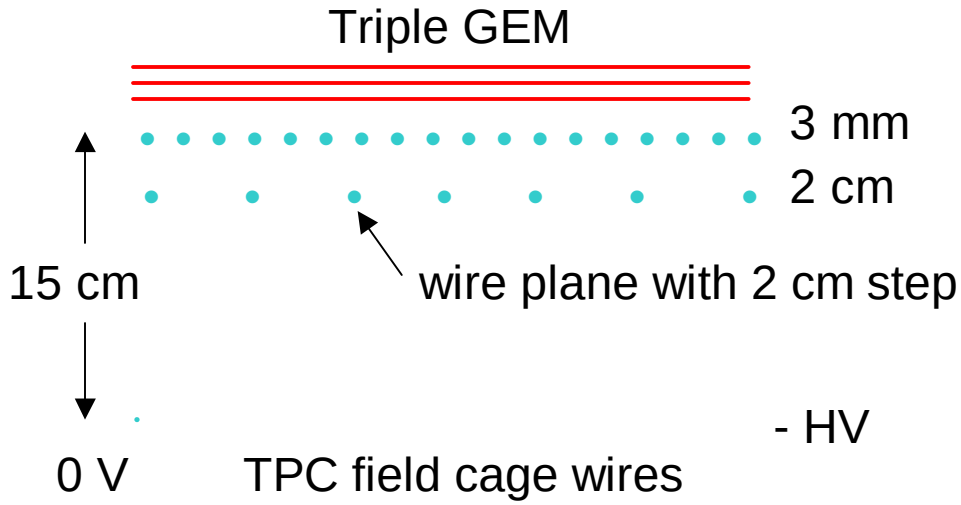


GARFIELD **MAXWELL** **N.Smirnov**

Drift field distortions are generally < 1%

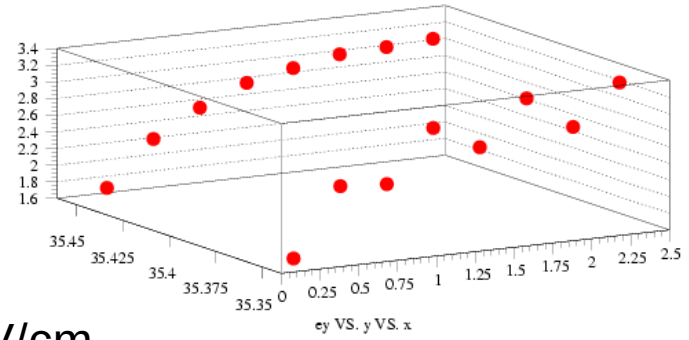
Electric Field Distortions Near the HBD

N.Smirnov

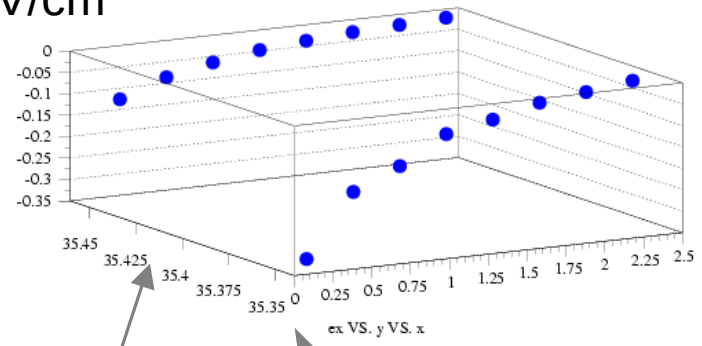


Initial calculations show that the electric field distortions from the TPC in the region of the HBD can be made small

E_R, V/cm



E_D, V/cm



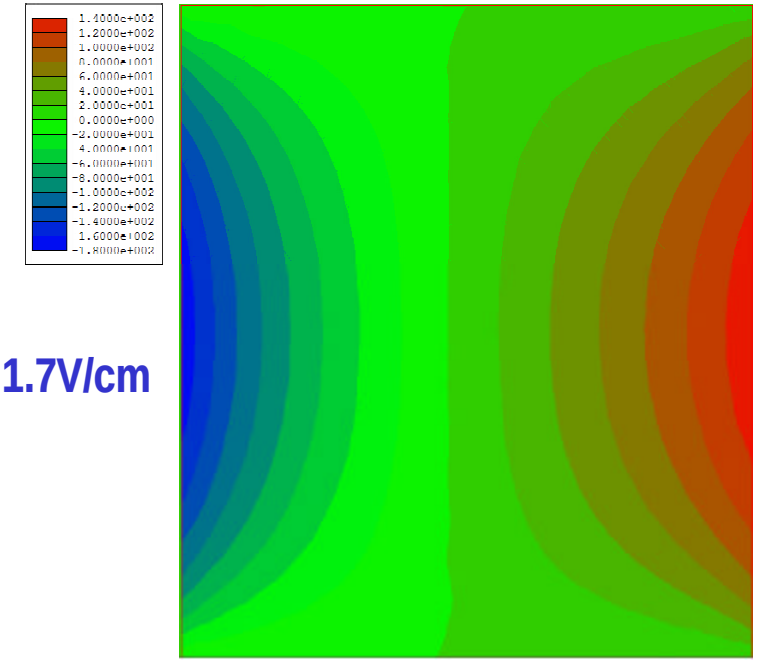
Zero Field region of HBD

Z position of TPC cathode

Space Charge

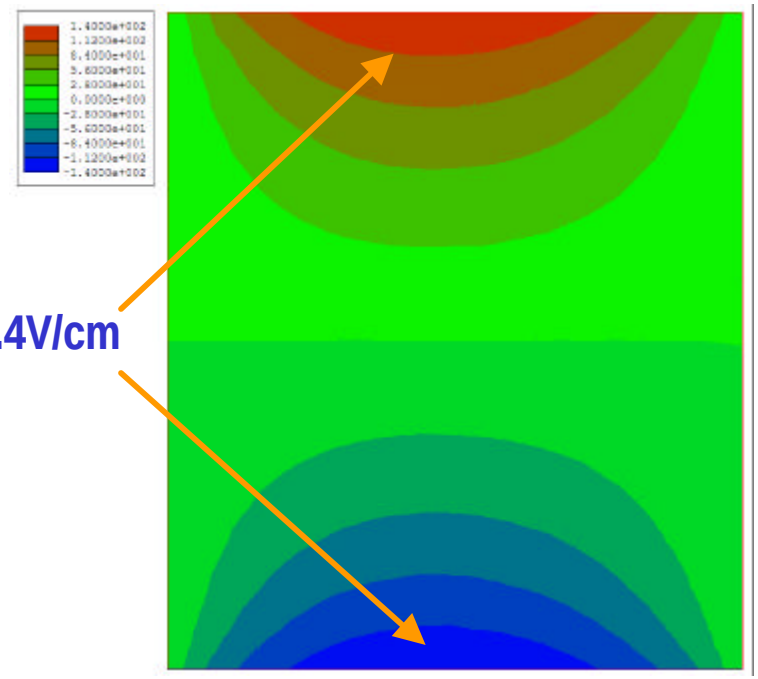
Distortion of field components in TPC volume

B. Yu



E_{max} ~ 1.7V/cm

Radial



E_{max} ~ 1.4V/cm

Axial

200 GeV Au+Au
Ion feedback 10%

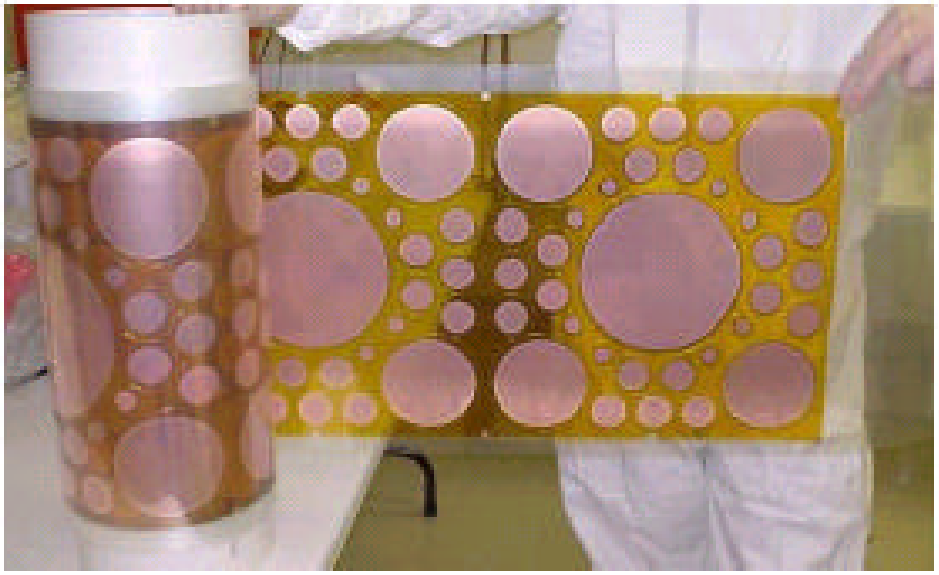
G ~ 10^3
r ~ 10^{-8} C/m^3

q ~ 2.5 x 10^{-3} rad
Dx ~ 0.5 mm for 40 cm drift

GEM foils from 3M

3M Microinterconnect Systems Division, Austin, TX

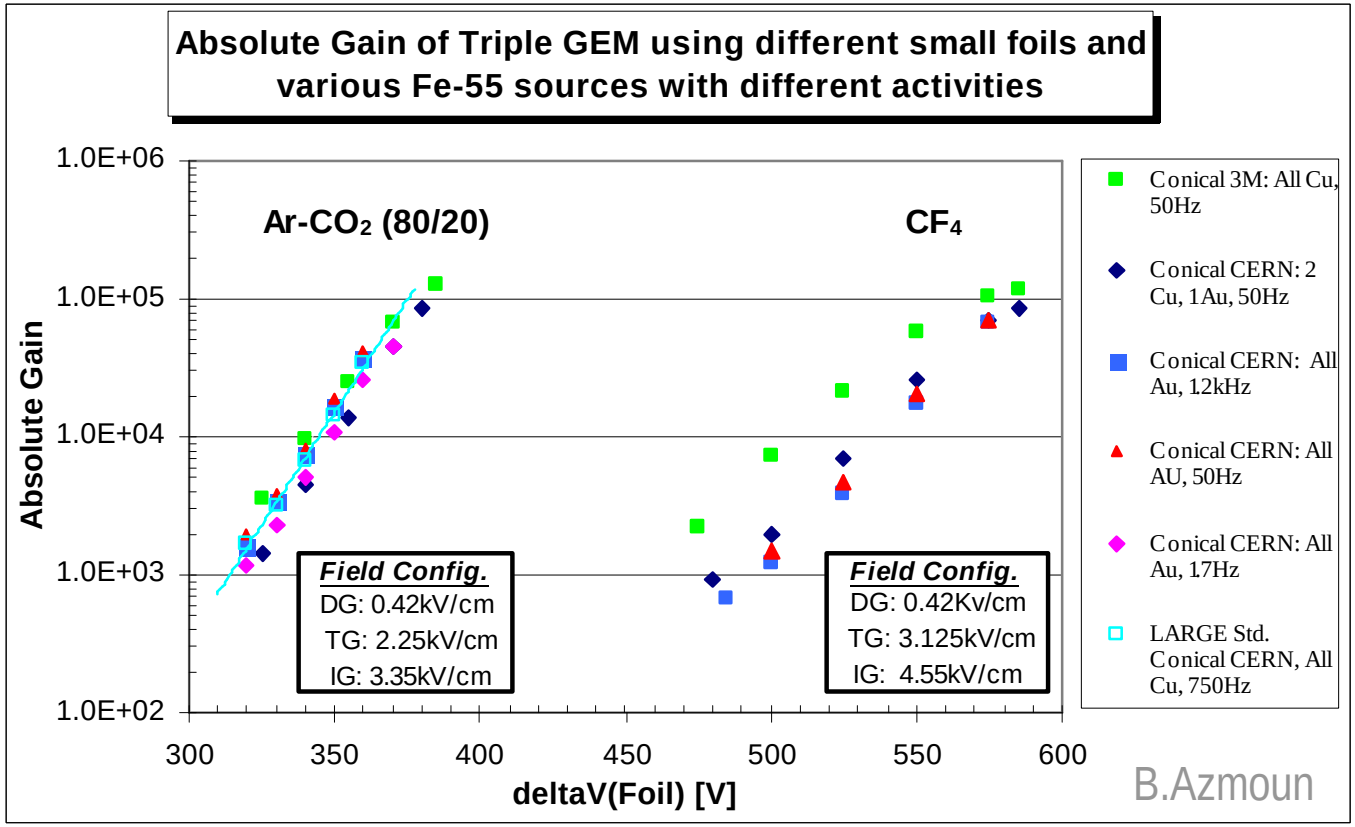
Roll-to-roll process



Limited to 12” width

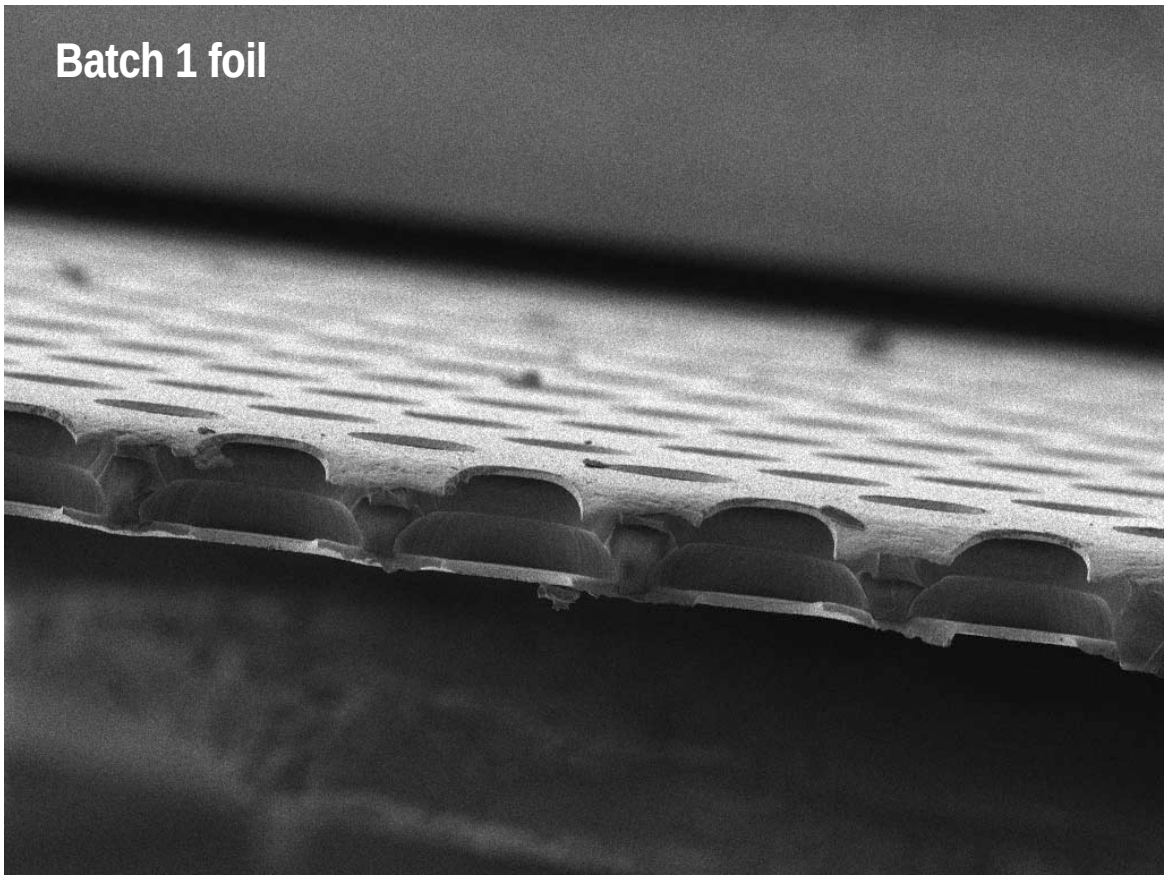
Received 2 shipments of 50 foils (10x10 cm^2 - identical to CERN layout)

Comparison of Small Triple GEMS



3M GEMs give similar gain to CERN foils in Ar/CO_2 but somewhat higher gain in CF_4

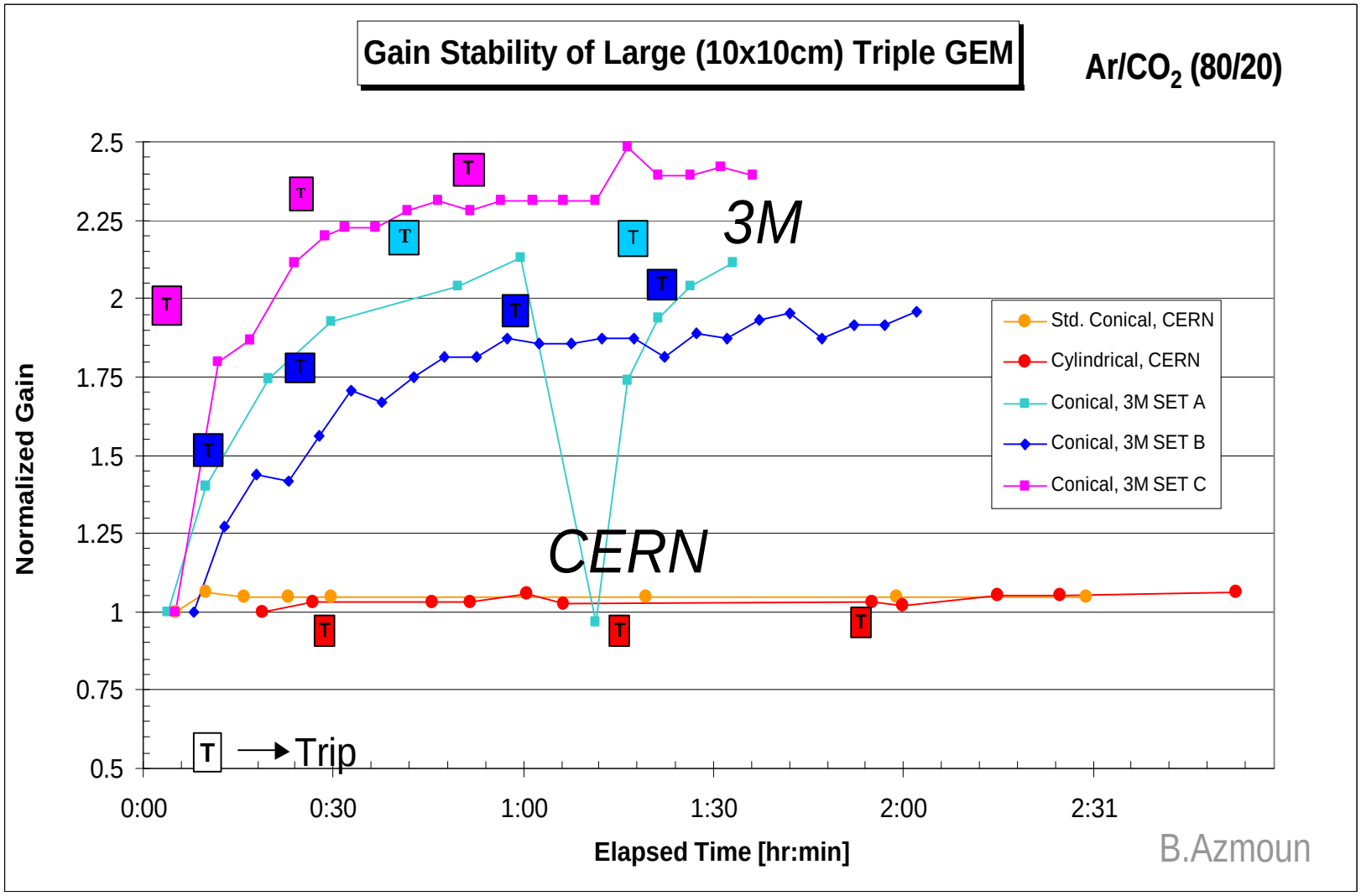
Large (10x10 cm^2) 3M GEM Foils



- **1st batch - "undercut" (faster etching kapton ? "over etched")**
- **2nd batch - "conical" (standard kapton but smaller holes)**

(70mm ? 40 mm vs 85 mm ? 55 mm)

Gain Stability - Large Foils



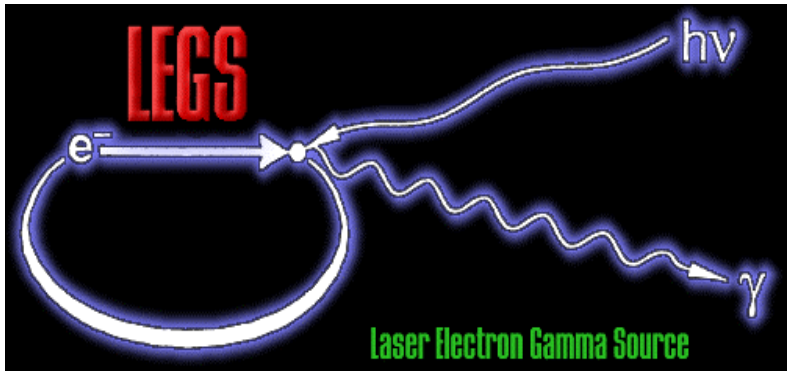
Other Related Work

Micropatten Detectors for TPCs

F.Sauli and C.Woody

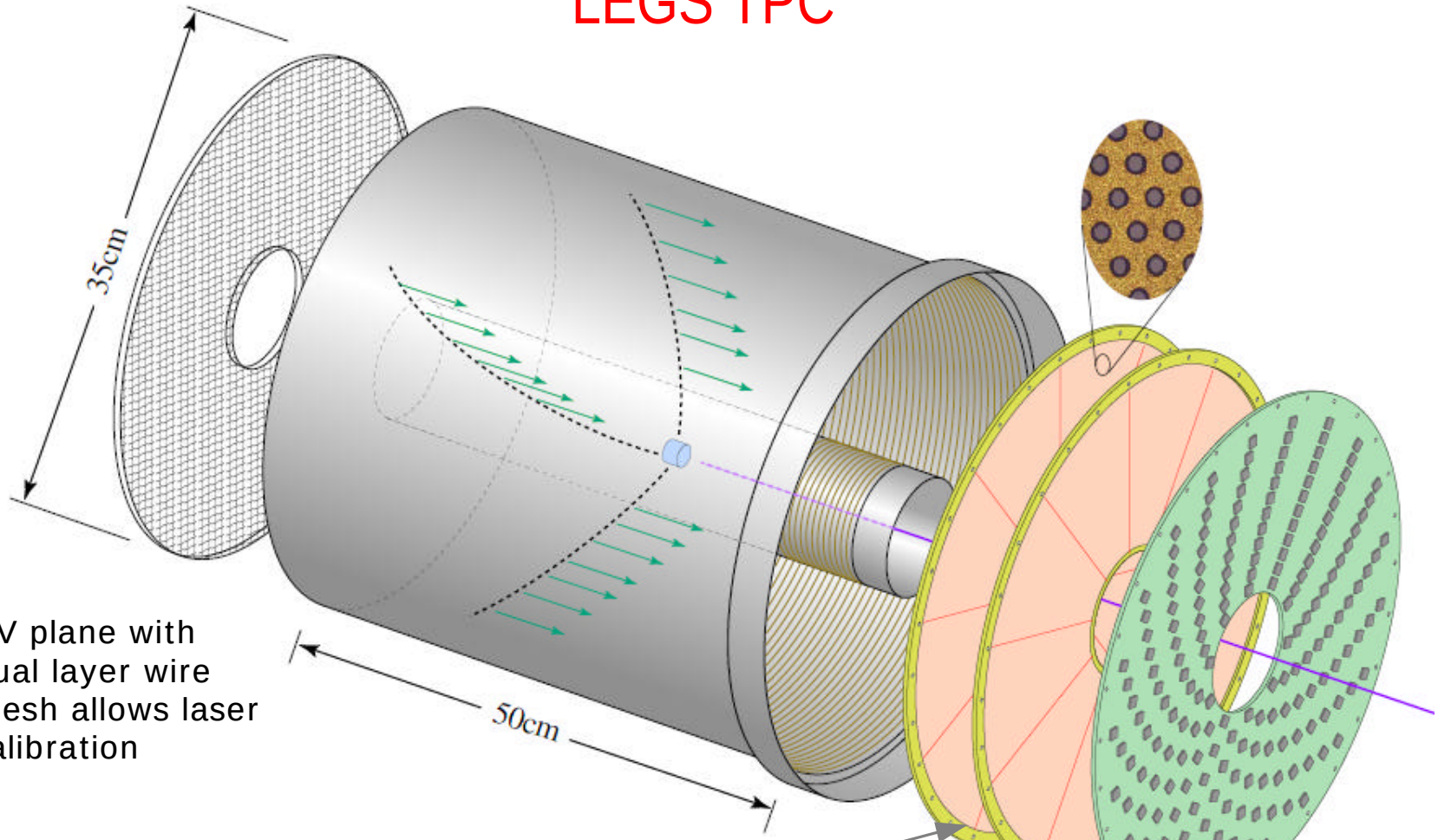
Workshop held at the IEEE NSS/MIC - Oct 20, 2003

- 40 registrants, ~ 100 attendees
- 4 Invited talks, 13 contributed talks
- Extensive R&D effort on TPC w/GEM readout for the Linear Collider
  (CERN,Karlsruhe,Achen,Munich,Carleton,Victoria)



LEGS TPC

LEGS TPC



HV plane with dual layer wire mesh allows laser calibration

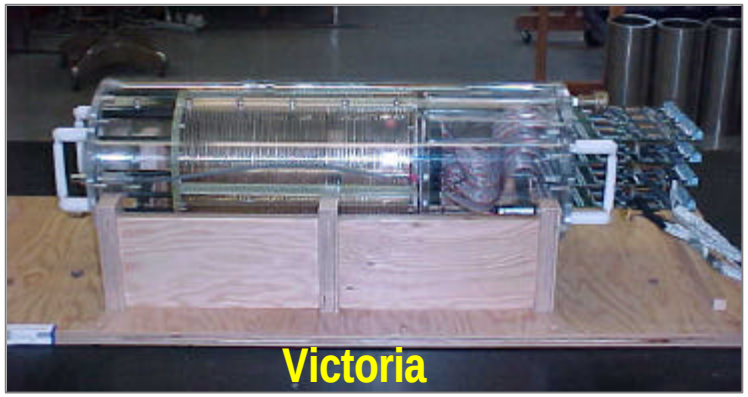
Two stage GEM

Operating with gain < 10^3

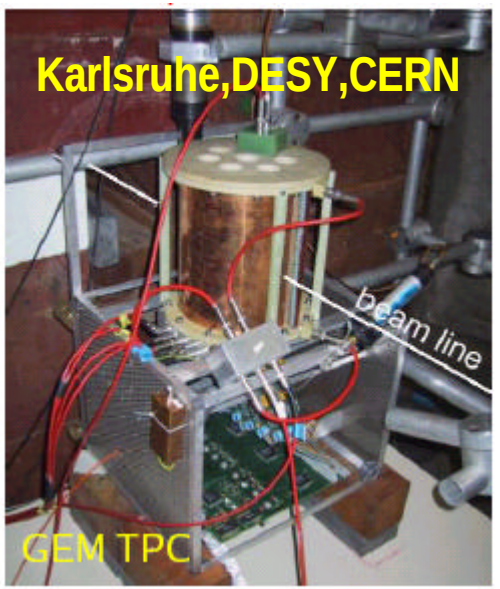
Interpolating anode pad plane with ASICs on the back

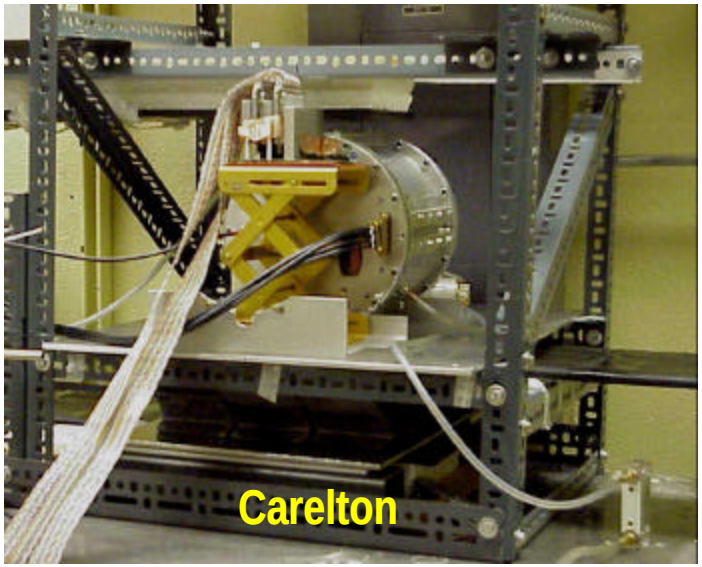
B.Yu

TPCs with GEM Readout for the Linear Collider



BNL,JLAB are the only US groups working on GEM/TPCs

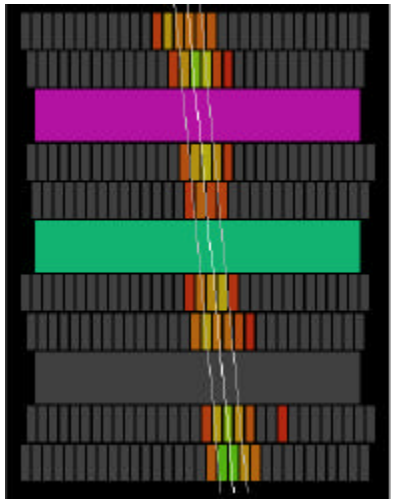




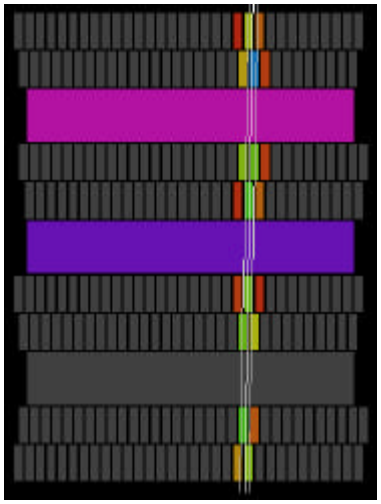
Results from TPCs with GEM Readout

Cosmic ray data

B=0

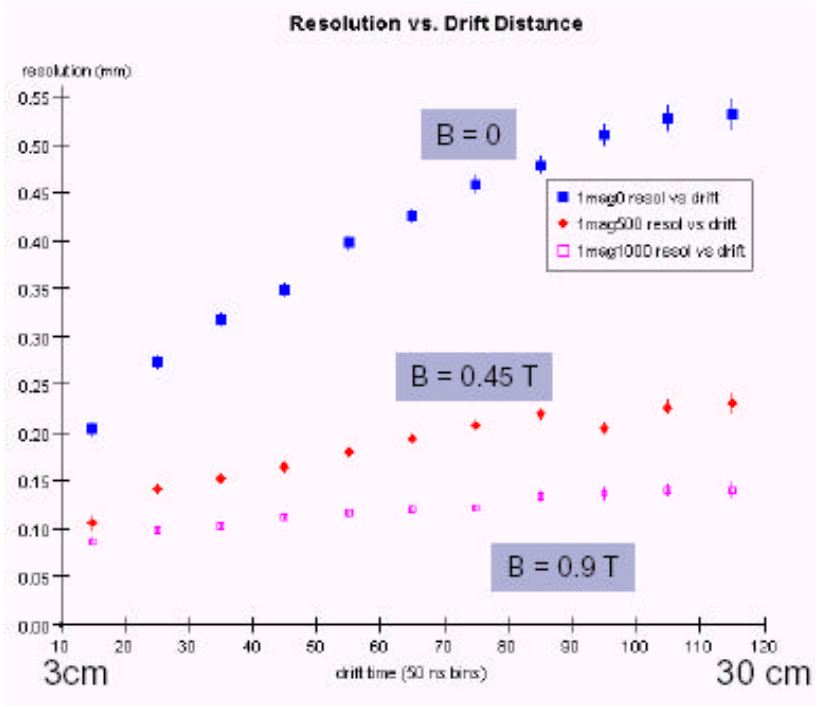


B=0.9 T



? = 2.3 mm ? = 0.8 mm

single point charge spread



Track fit to all but one row

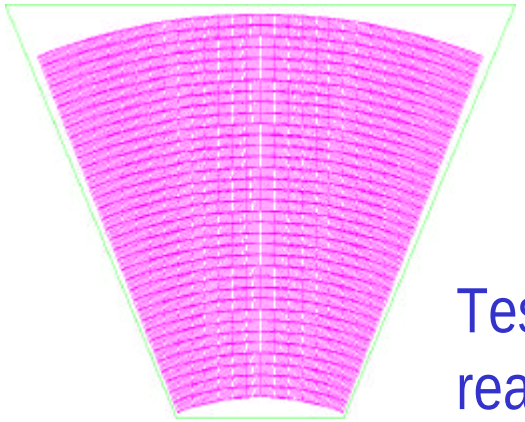
s < 100 **m**m for B = 0.9 T

D.Karlen, Univ. of Victoria

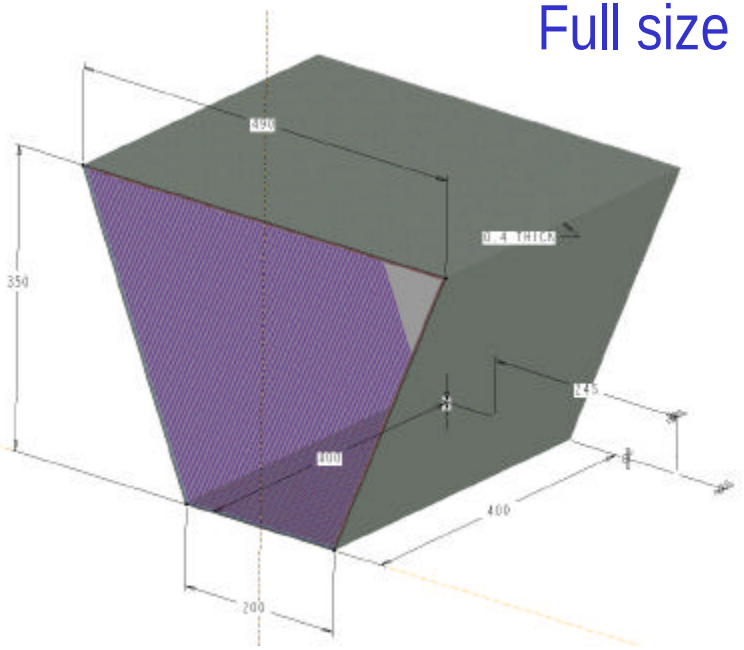
TPC Prototype - To be built in FY04

Test field cage design

Provides structure on which to design and study readout plane



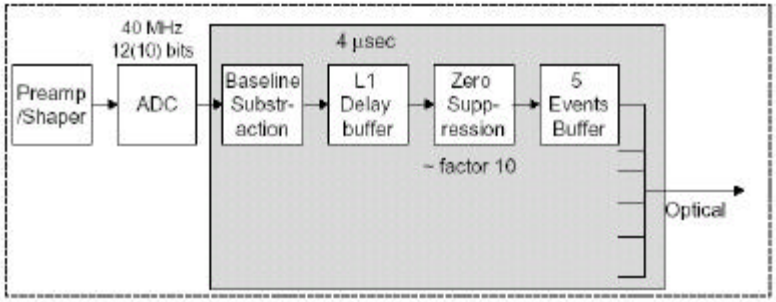
Full size module



Tests materials to be used in actual construction

Allows testing with cosmic rays

Test bench for new readout electronics



R&D Budget - FY04

GEMs	10
Readout board	5
Field cage & support	15
PA/shaper ASIC fab run	45
ADC design,fab	75
Labor	100
Total	**250**

Absolutely essential to continue R&D

R&D Plan for FY2004

- Study fast drift gases using drift cell
- Complete design of readout plane and field cage
- Build and test TPC prototype detector
- Build first prototype of readout electronics (also used for HBD)
- Start engineering design of TPC/HBD detector system