Tracking Working Group Report

Mike Ronan

LBNL

ALCPG 2004 Winter Workshop

SLAC, January 7-10, 2004

Detector Working Group: Tracking

Tracking Session I **Wednesday, Jan. 7, 1:00-3:00**

Time	Title	Speaker
1:00-1:15	General Introduction	Bruce Schumm
1:15-1:30	General Thoughts About Tracker Designs	Richard Partridge
1:30-1:45	TPC Studies at UVIC	Dean Karlen
1:45-2:00	TPC Studies at Carleton	Kirsten Sachs
2:00-2:20	Beam Tests of a GEM-Based TPC	Mike Ronan
2:20-2:40	Some Comments on TPC Tracking	Hans Bichsel
2:40-3:00	GEM Manufacture	Ian Shipsey (Dan Peterson)

Tracking Session II **Wednesday, Jan. 7, 4:00-6:00**

Time	Title	Speaker
4:00-4:20	Magnetic Field Tests of a Micromegas TPC	Mike Ronan
4:20-4:30	Tracking R&D at Cornell and Purdue	Dan Peterson
4:30-4:50	Forward Tracking and the Use of GEM's	Lee Sawyer
4:50-5:20	TPC Response Simulation and Pattern Recognition	Dan Peterson
5:20-5:40	Progress & Plans for Bunch Timing w/ Scintillating Fibers	Rick Van Kooten
	Thin Silicon Detectors	Daniela Bortoletto

Tracking Session III **Friday, Jan. 9, 8:30-10:30**

Time	Title	Speaker
8:30-8:20	Gamma-Gamma -> Hadrons Backgrounds	Tim Barklow
8:50-9:05	Pattern Recognition Studies at South Carolina	Achim Weidemann
9:05-9:25	SD Outer Tracker Studies at SLAC	Steve Wagner
9:25-9:45	Frequency Scanned Interferometer Demonstration System	Haijun Yang
9:45-10:05	Progress Towards a Short-Shaping Time Solid State Tracker	Bruce Schumm
10:05-10:30	Closing Discussion	All

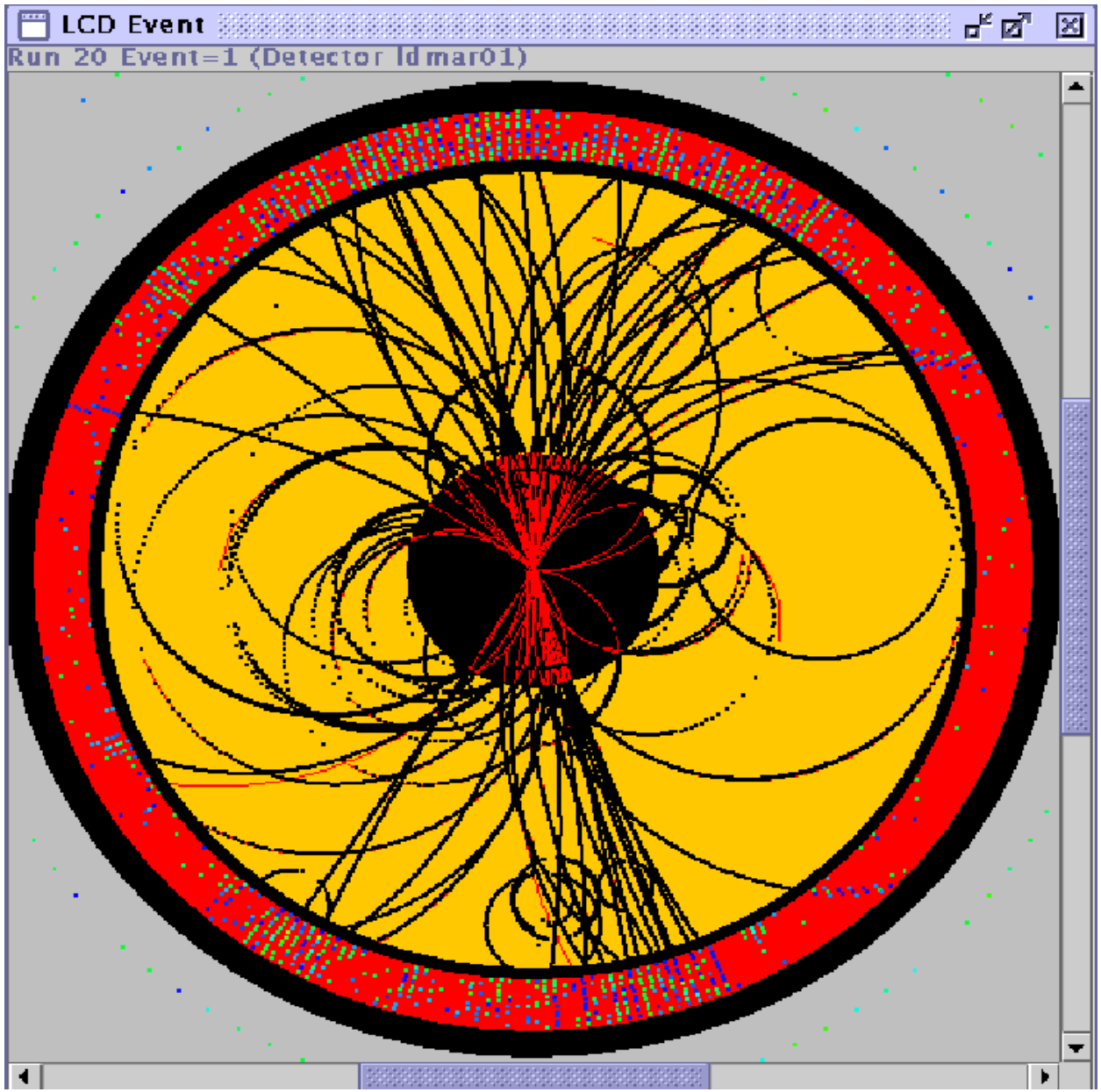
Session convenors: Bruce Schumm, Dean Karlen & Keith Riles

North American Large TPC detector simulations

LCD Modules:

Pattern recognition

Event display

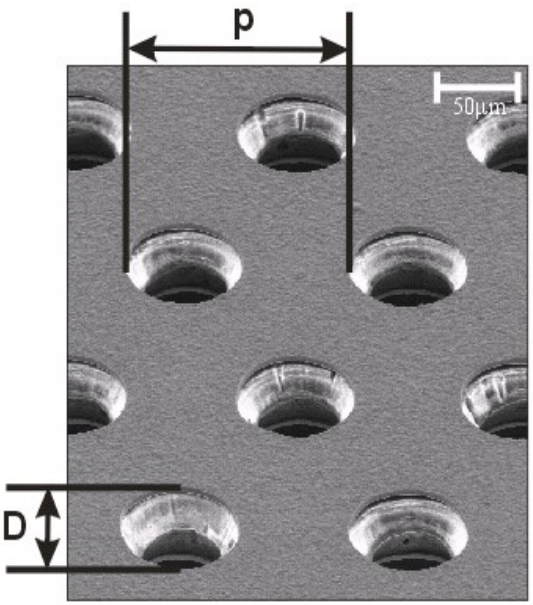


Reminder: GEM and Micromegas

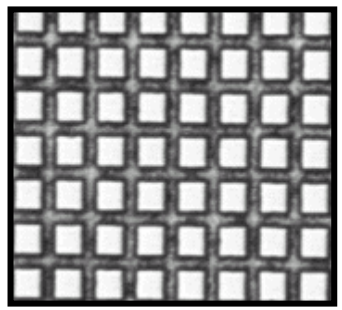
GEM: Two copper perforated foils separated by an insulator

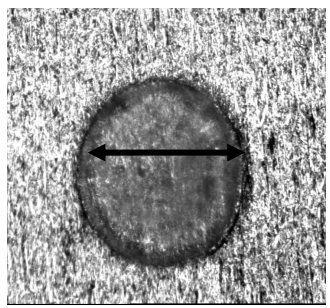
The multiplication takes place in the holes.

Usually used in 3 stages, even 4



Micromegas : a micromesh sustained by 50-100 µm - high insulating pillars.
The multiplication takes place between the anode and the mesh
One stage





200 µm

Slide stolen from P. Colas Amsterdam Tracking meeting March 31 2003

GEM Manufacture, I.Shipsey (D.Peterson)

Single roll of ~1,000 GEMS

3M GEM's

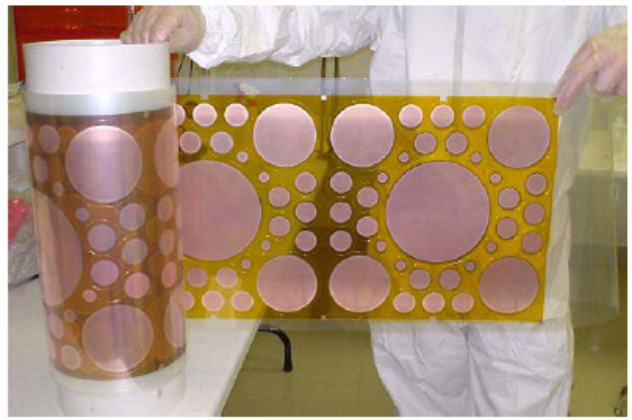
Chicago, Purdue

Aging

NITPC Gas

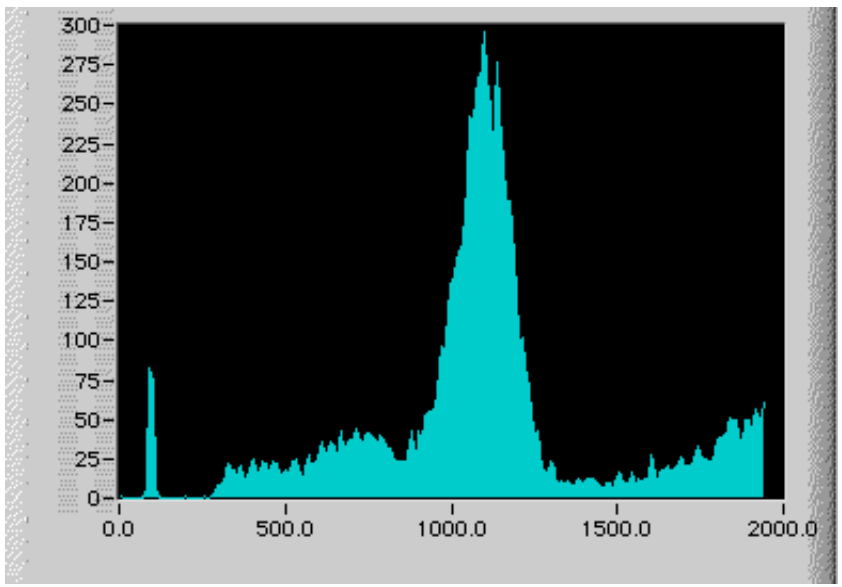
3M Micromegas

Preliminary studies➔
performance is equivalent to CERN GEMs, cost potentially lower

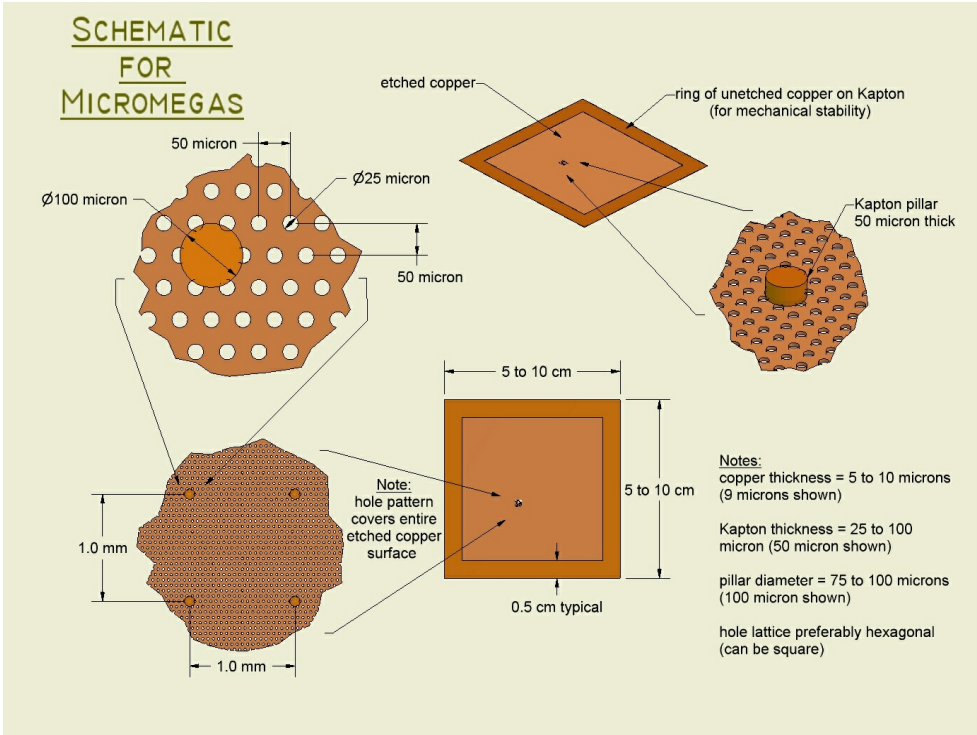


Purdue

After 400 hours of irradiation



5.4 keV X-ray peak



TPC Studies at U.Victoria, D.Karlen

GEM-based TPC
Triple GEM
8 pad rows
2mm X 6 mm

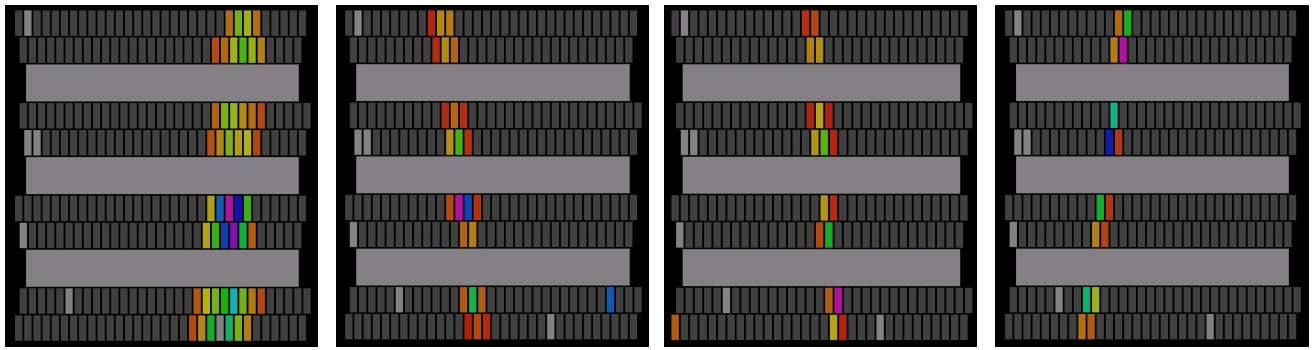
Cosmic ray tests
TRIUMF 0.9T magnet
DESY 5.3T magnet

Charge spreading
Suppressed by magnetic field in low field drift region ($\omega\tau$)

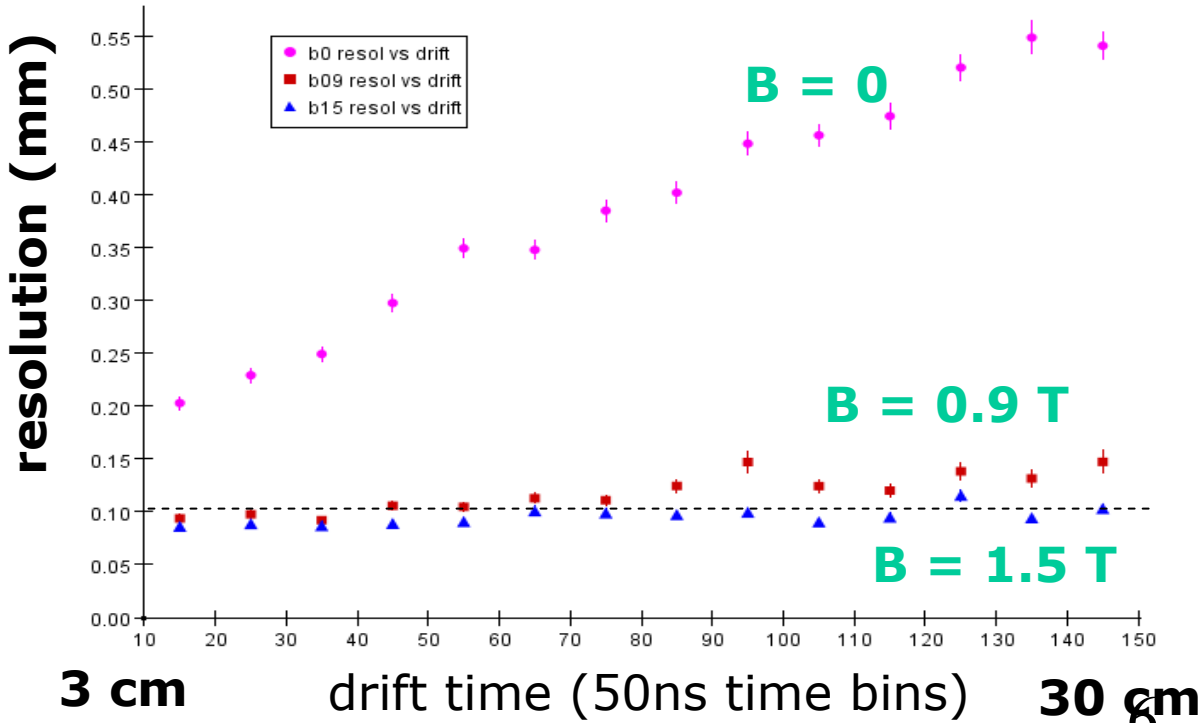
After pre-amplification in first GEM, make use of large diffusion in higher field transfer and induction gaps.

Point resolution
Down to 90 μm compared to 60 μm expected.

First MPGD TPC tracking in magnetic fields.



B=0T **B=0.9T** **B=2.5T** **B=4.5T**



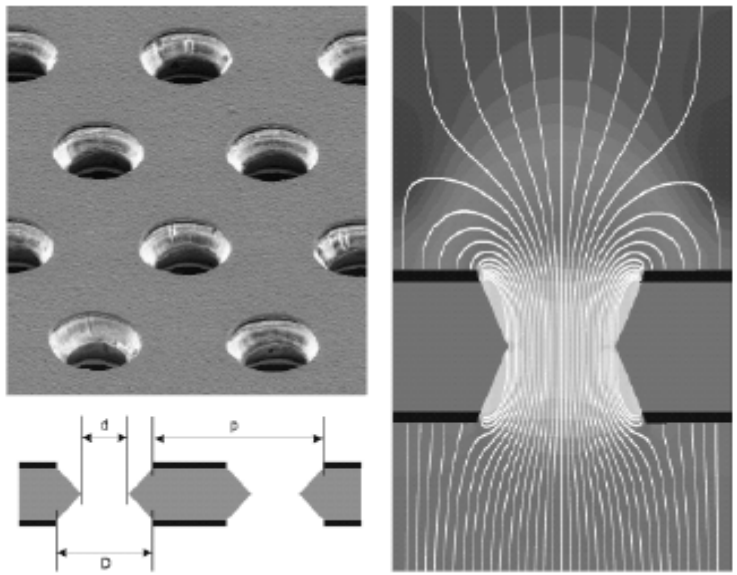
Beam Tests of a GEM-TPC, M. Ronan

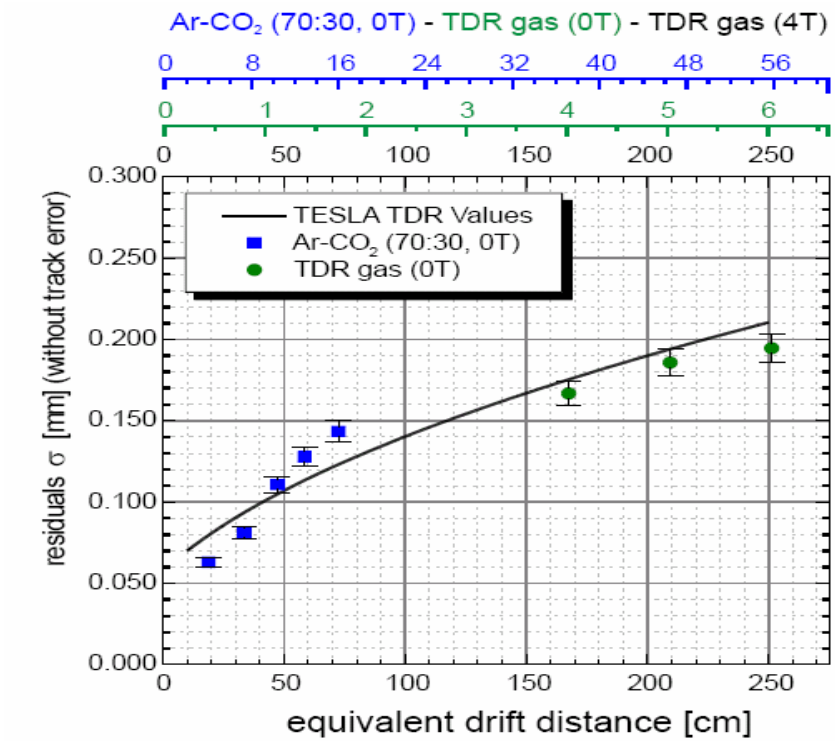
Karlsruhe, CERN, LBNL

GEM-TPC:

gases Ar-CH4
Ar-CO2
Ar-CO2-CH4 - TESLA TDR gas

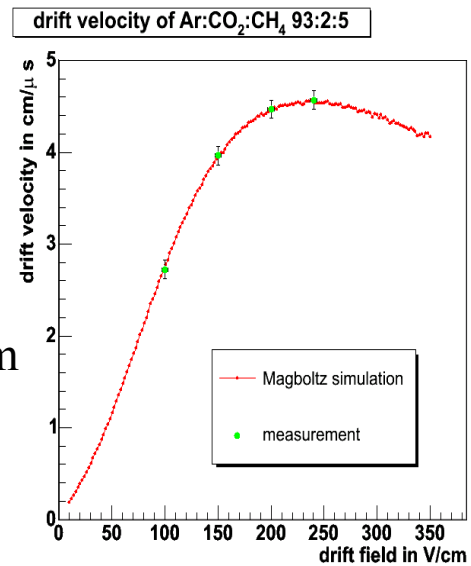
Achieve resolutions of < 100 μm with high efficiency, meeting TESLA TPC design requirements.





Drift velocity measurement

~4.5 cm/μsec
at E = 250 V/cm



Magnetic Field Tests of a Micromegas TPC, M.Ronan

Berkeley, Orsay & Saclay

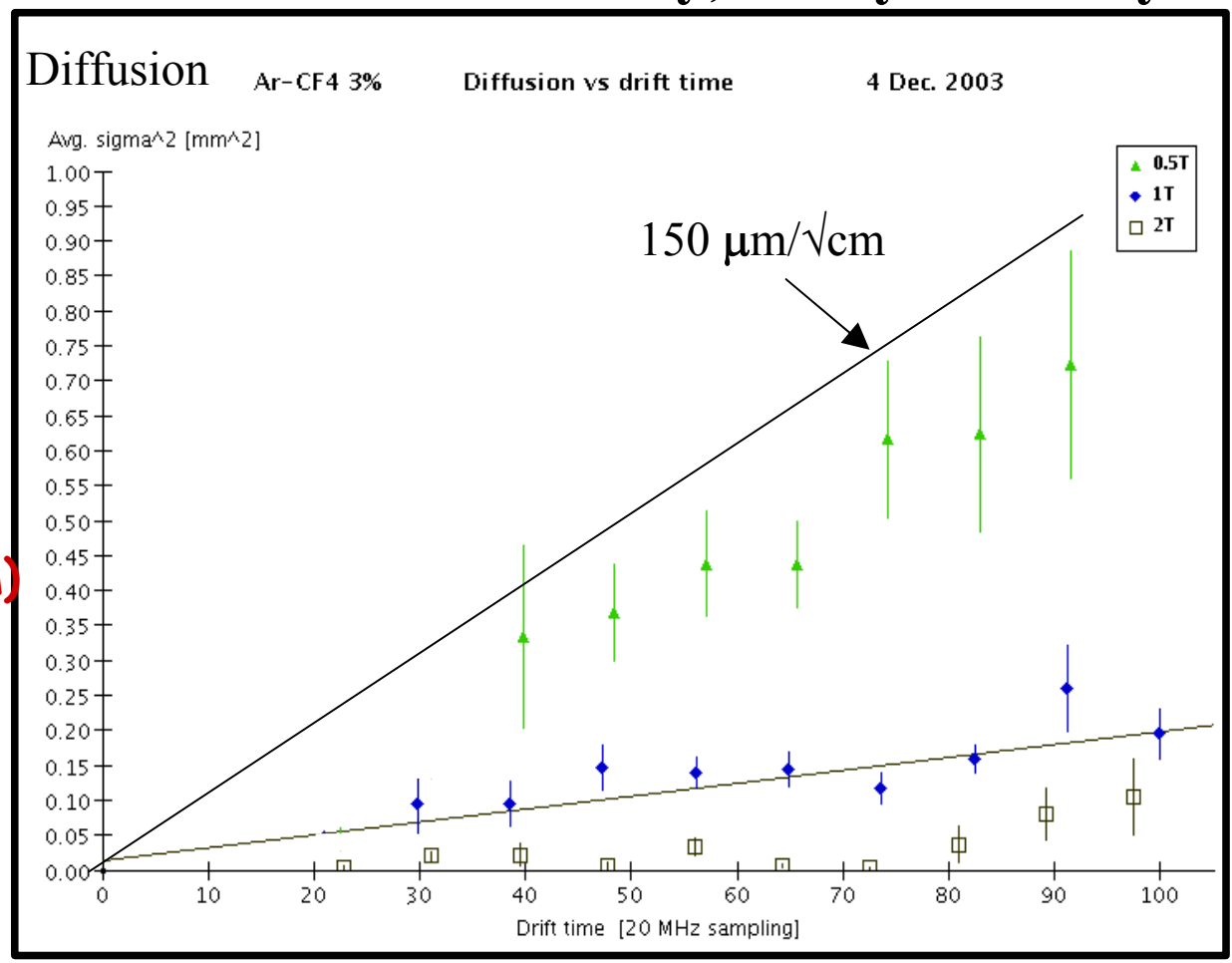
Gas	**Argon CF4 3%**
E field	200 V/cm
v drift	10 cm/μsec
diffusion	~400-500 μm @ 1 cm
Micromegas	
Vmesh	340 V

Expected transverse diffusion

B field	ωτ	Diff.(μm/√cm)
0 T	0	400
0.5 T	2.5	150
1 T	5	80
2 T	10	40
3 T	15	27
4 T	20	20

For B = 3 T and

d = 50 cm	1 m	2.5 m
188	266	421 μm



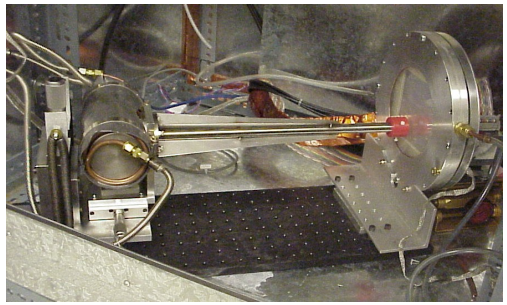
0 cm

50 cm

==> *Can't measure track width at B = 2T in using Ar-CF4 with present readout system.*

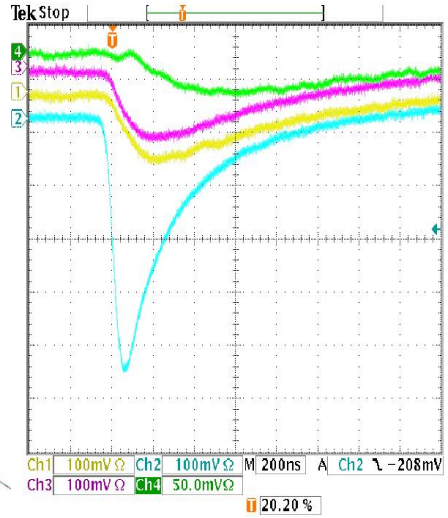
TPC Studies at Carleton, K.Sachs

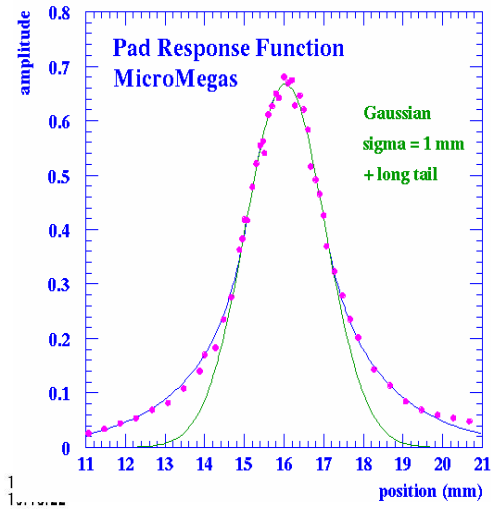
- X-ray source, colliminated photon conversion creates electron cloud, size ~50μm
- TPC test cell, 5mm drift distance, gas: Ar:CO_2 (90:10)
- Study both double GEM and Micromegas
- Use resistive anode to spread charge

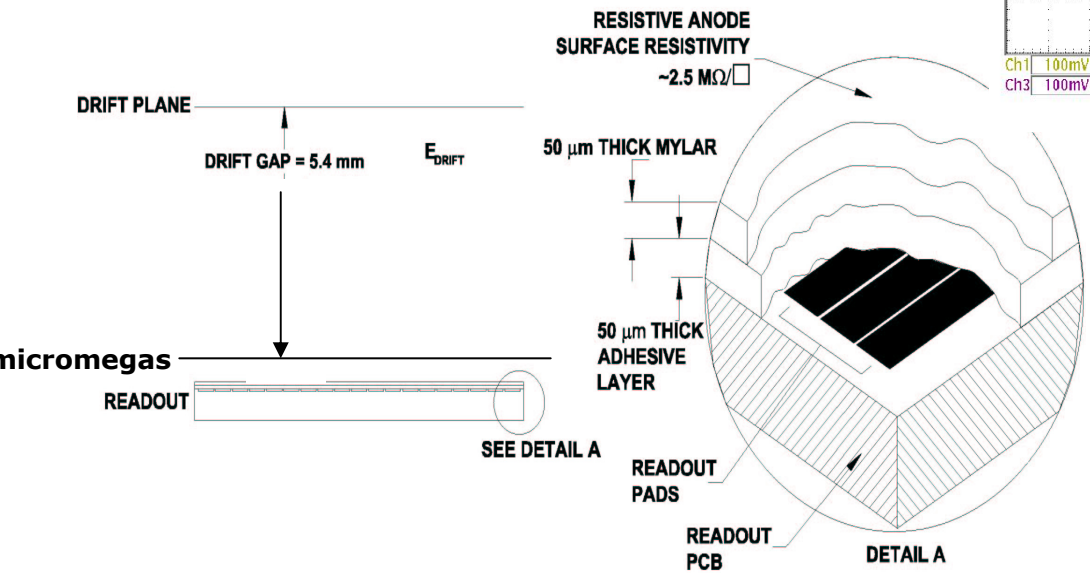


X-ray source

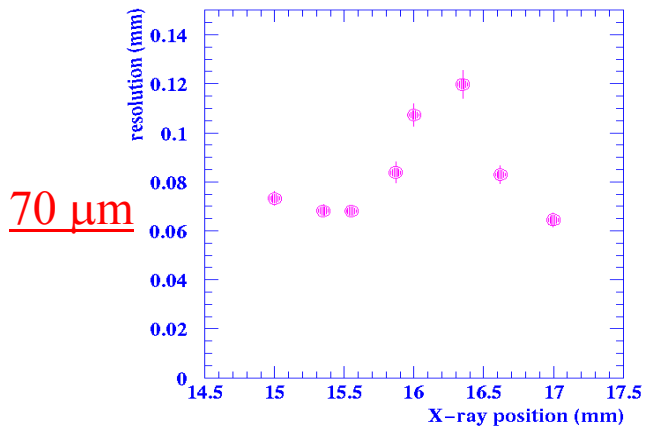
Micromegas signals







Point resolution



70 μm

Tracking R&D at Cornell and Purdue, D.Peterson

Cornell:

Electronics Purchase: **VME Crate and Interface**

Lab funds **FADC, 100 Mhz, 32 channels**

HV crate and computer interface

HV supplies: GEMS

20 KV supply module

TPC Construction *(Design influenced by Victoria TPC)*

60 cm drift

8.75" OD (Min. for mounting a 10cm GEM)

acrylic construction

==> Parts are being machined in LEPP shop.

Brass field cage hoops and acrylic hoop support bars are completed.

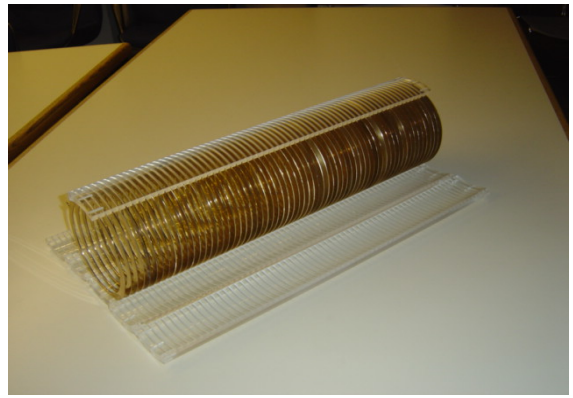
Purdue:

Readout module construction waiting for pad design and drawing of mounting scheme.

Meanwhile, aging tests of 3M GEM's are continuing.

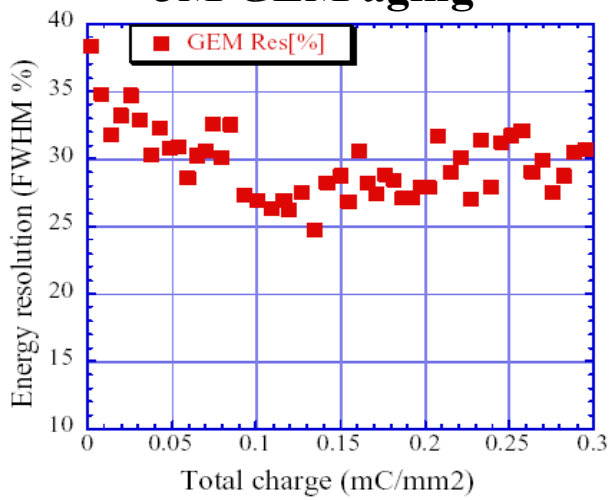
Cornell

TPC Field cage



Purdue

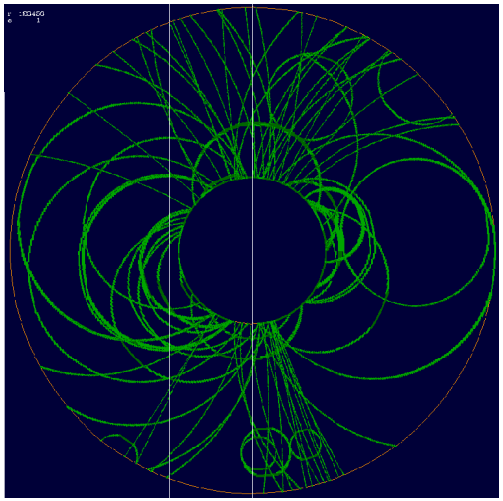
3M GEM aging



Now up to 3 mC/mm2

TPC Response Simulation and Pattern Recognition, D.Peterson

Cornell

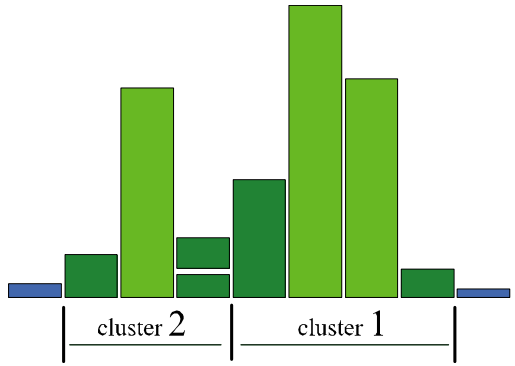


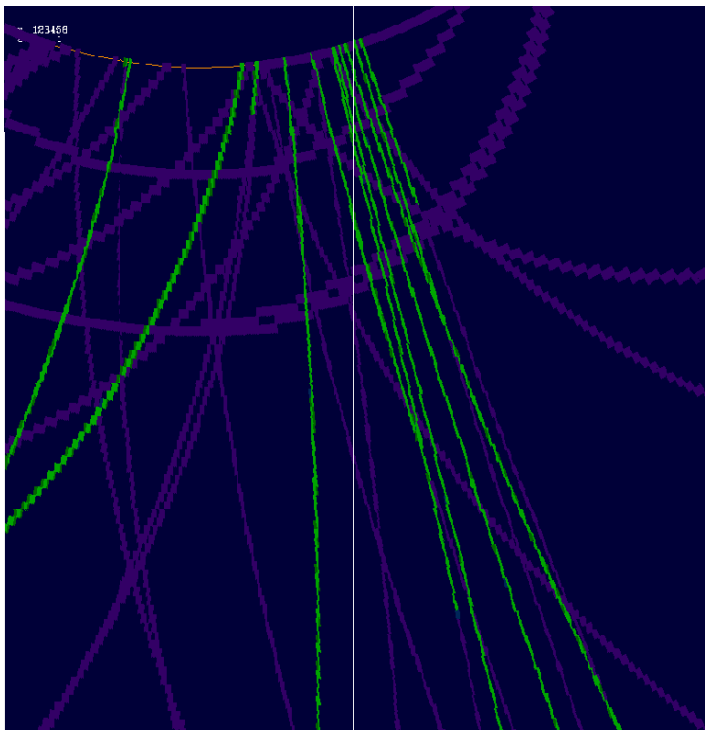
Response simulation

e.g.

Clustering in r-ϕ

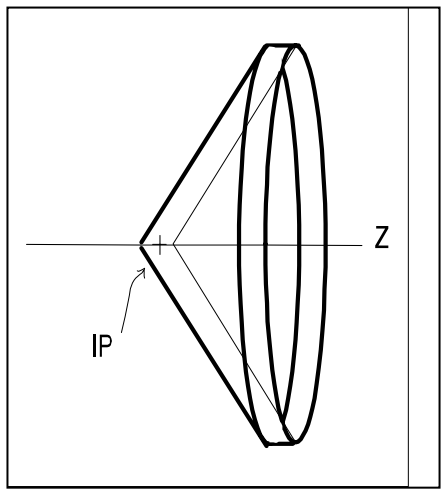
criteria for minimum **central pad** , added **adjacent** pads **splitting** at a local minimum, can lead to pulse height merging and incorrect clustering.

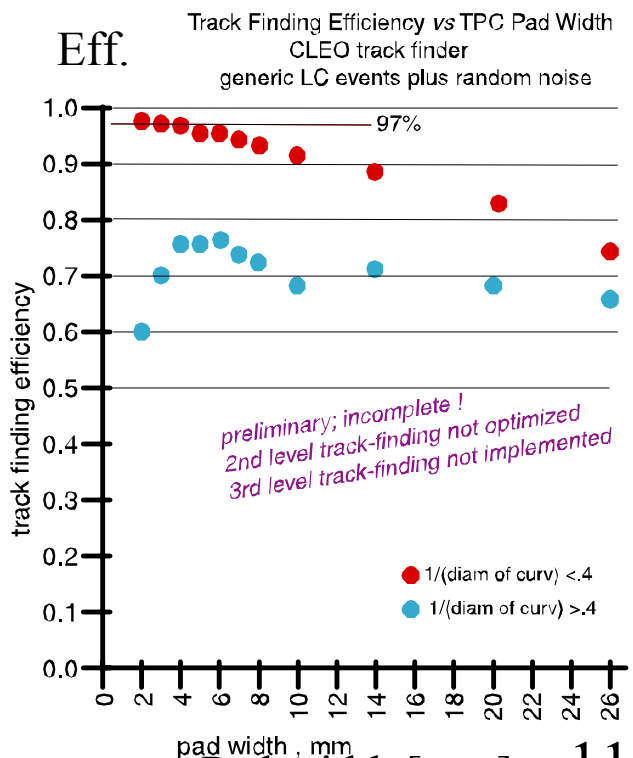




Pattern recognition

Segments found in pre-selected, I.P. pointing, cones are used as seeds for finding tracks.





Gamma-Gamma -> Hadrons Background, T.Barklow

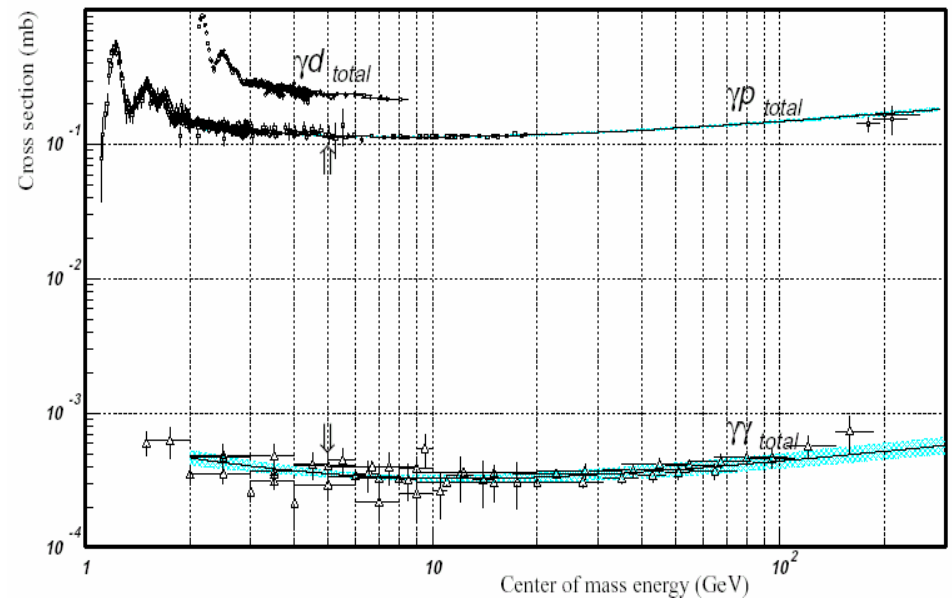
SLAC

Physics backgrounds

$\gamma\gamma \rightarrow \pi^+\pi^-$

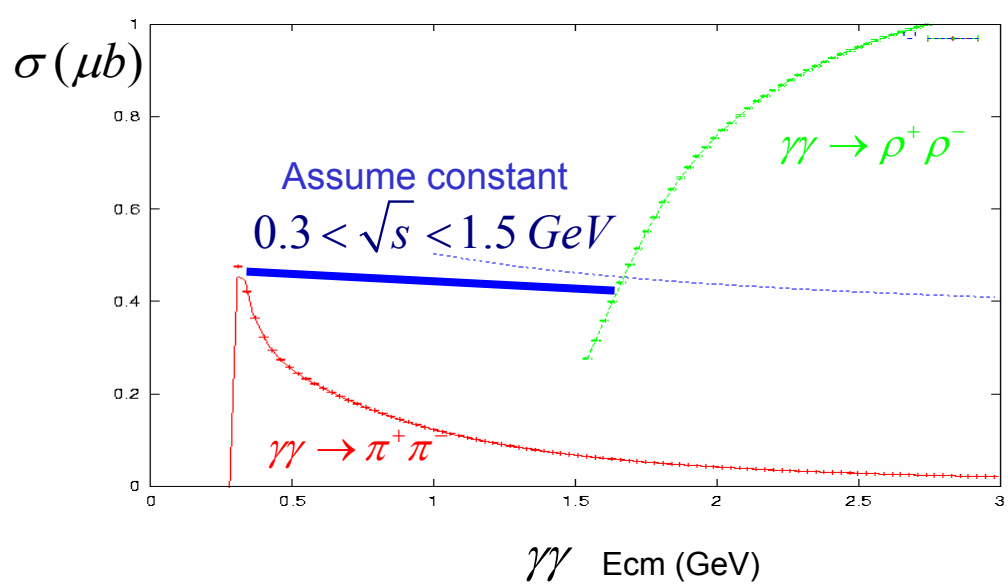
$\gamma\gamma \rightarrow \rho^+\rho^-$

…



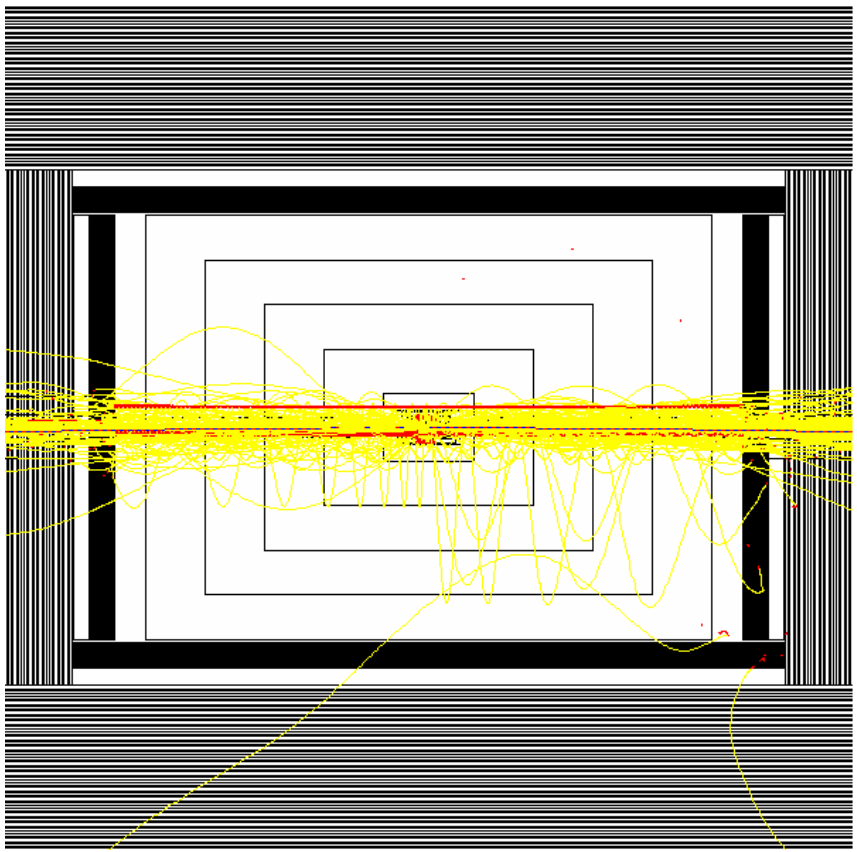
Summary

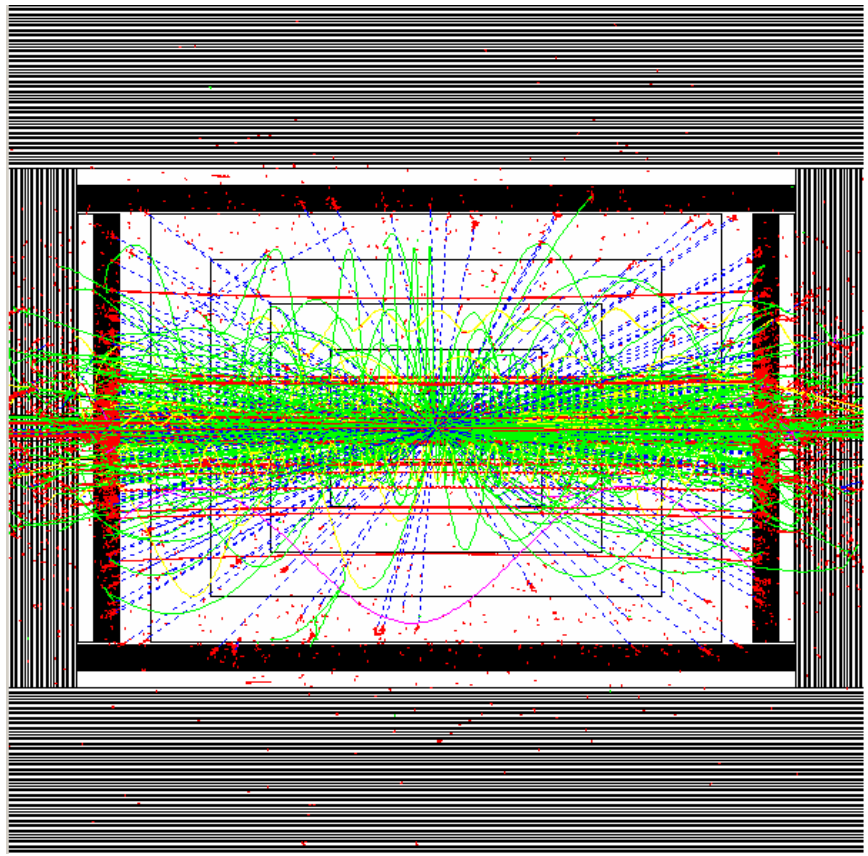
- Muon pairs and low-pt hadrons produced in the beam-beam interaction need to be considered along with e+e- pairs and high-pt hadrons.
- Muon pairs and hadrons create 124 detected charged tracks and 510 GeV detected energy per train. Tracker occupancies comparable to or greater than the occupancies from e+e- pairs.
- Further studies required to determine how well this background can be tagged and how much it will interfere with signal track finding/fitting and physics analyses.



Yellow = muons Red = electrons Green = charged pions

Dashed Blue = photons with E > 100 MeV





154 $\mu^+\mu^-$ pairs / train

56 GeV / train detected energy

24 detected charged tracks / train

56 hadronic events / train

no pt cut; Ecm down to $\pi^+\pi^-$ threshold

454 GeV / train detected energy

100 detected charged tracks / train

Bunch Timing with Scintillating Fibers, R. van Kooten

Indiana & Notre Dame

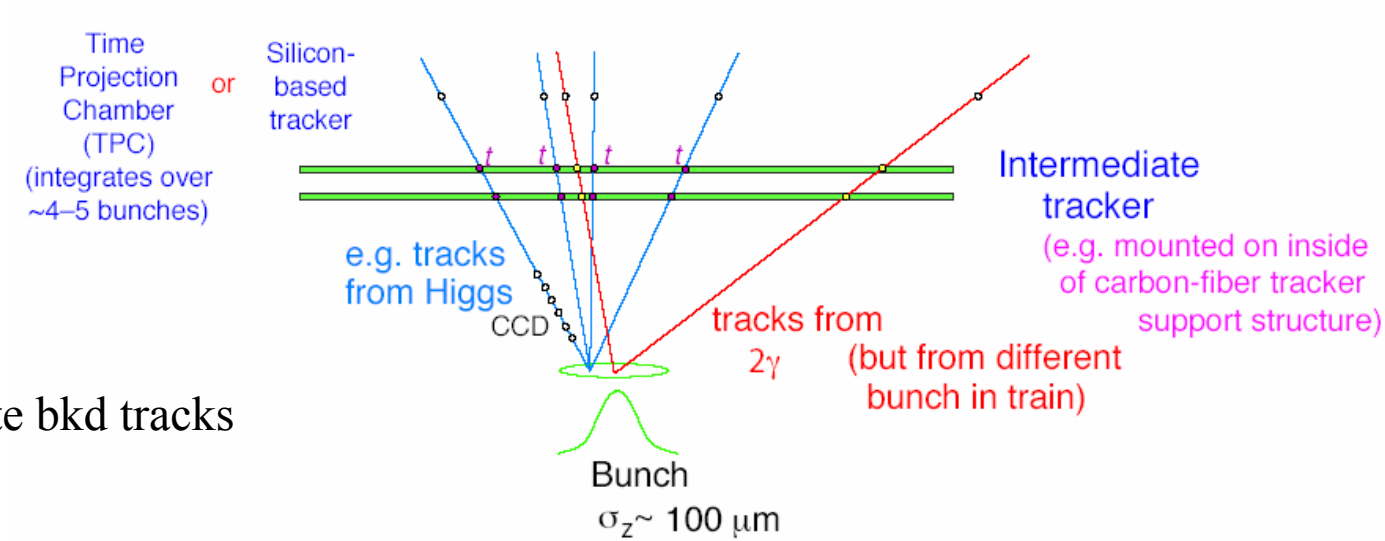
Warm machine
bunch structure
192 1.4 nsec
pulse rate 120 Hz

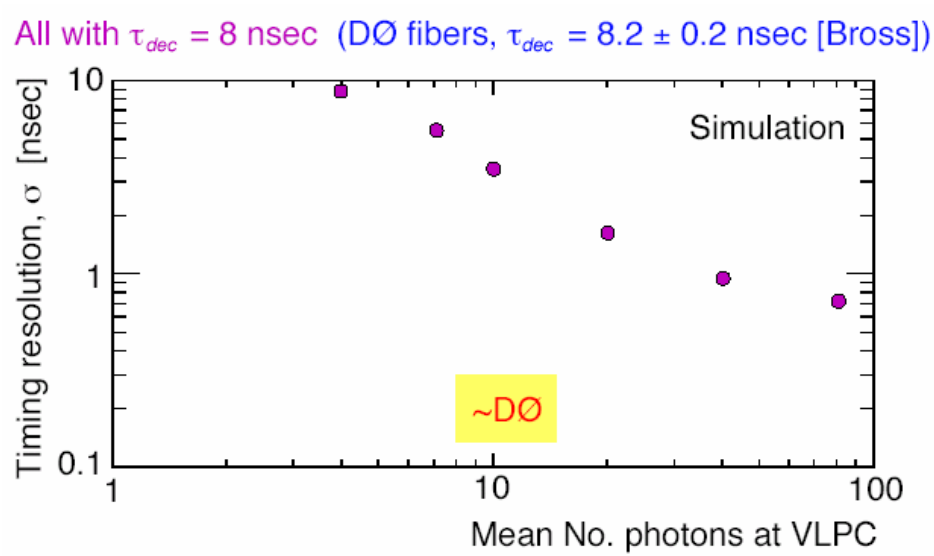
γγ background tracks
54 tracks / train
need timing to eliminate bkd tracks

TPC 2.4 nsec
SiD 150 nsec (3 μsec, S/N ~ 10)

Track bunch timing
Use scintillating fiber int. tracker

Readout with
VLPC - Visible Light Photon Counter
APD - Avalanche Photodiode (Geiger mode)
SiPM - Silicon Photon Multiplier



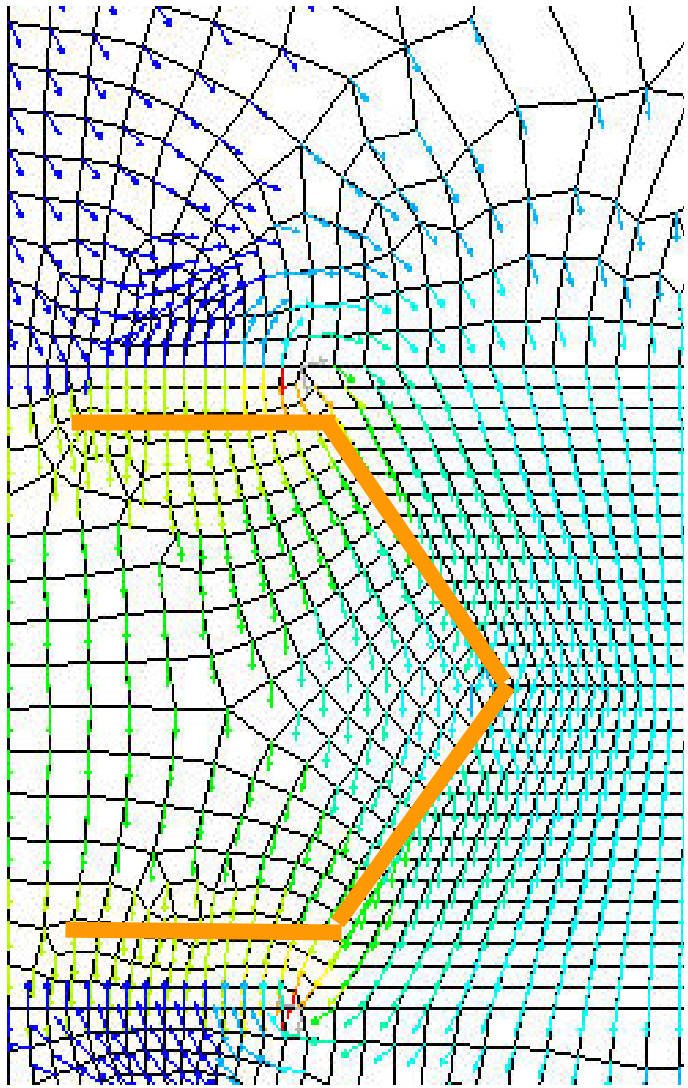


Forward Tracking and the Use of GEM's, L.Sawyer

LA Tech

- GEM detector development for QWEAK tracker.
- Interest in Linear Collider, forward tracking identified as area needing work
  - Physics needs include luminosity, precision electroweak measurements (WW, WZ),
    SUSY searches & measurements (e.g. selectron production)
- Can a GEM-based detector work in the Intermediate to Forward region of proposed LC detector?
  - Concentrating on LD, region from lower TPC to mask (FCH in the TESLA detector design)
  - Competing technologies are straw tubes, scintillating fibers (intermediate tracker)

Computation mesh

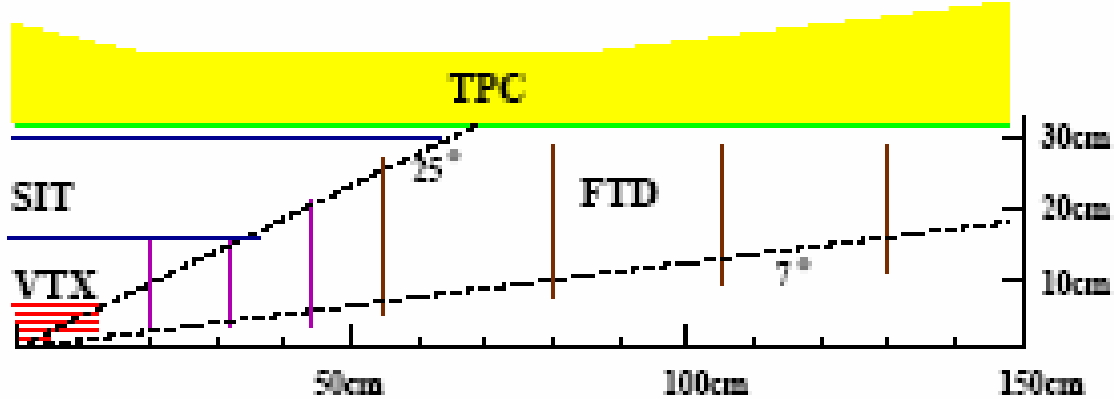


Thin Silicon Forward Detectors, D.Bortoletto

Purdue

Forward Tracking Detectors

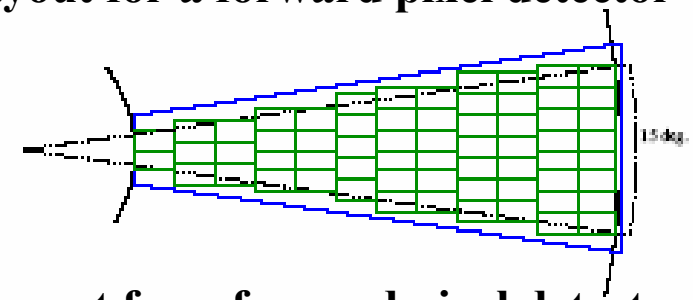
Silicon Outer Tracker



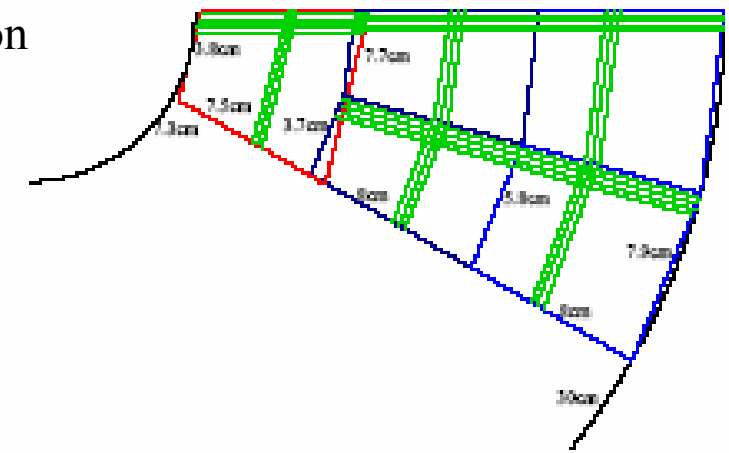
Issues

- Technical problems:
  - Manufacturing of thin devices is difficult
  - Thinning after processing is difficult
  - Industry has expressed interest in thin silicon devices
  - Collaboration with vendors is critical
- How thin:
  - The m.i.p. signal from such a thin, 50µm, silicon sensor layer is only ~3500 e-h pairs.
- R&D at Purdue has started last year. We got quotes from two vendors: Sintef and Micron
- Sintef: min. thickness 140 µm on 4 inch wafers
- Micron: 4" Thickness range from 20µm - 2mm, 6" Thickness range from 100µm - 1mm

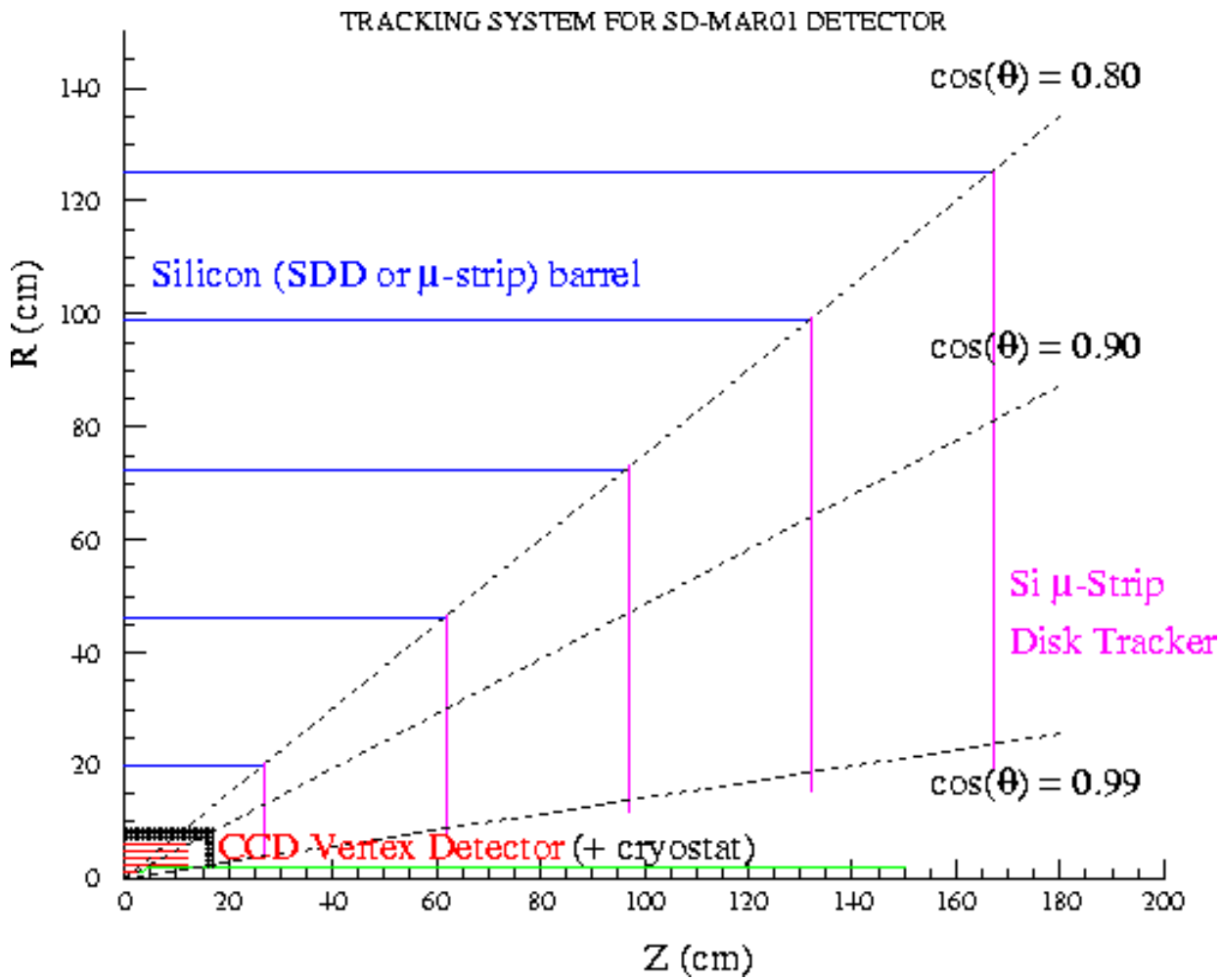
Layout for a forward pixel detector



Layout for a forward pixel detector



The SD Tracker



SD Outer Tracker Studies, S. Wagner

SLAC

SiD Tracker

5 single-sided axial Si layers

7 μm, 3 μsec shaping

Project VXD tracks out to SOD.

Simple Helix fit. Assign hits.

Get better as radius increases.

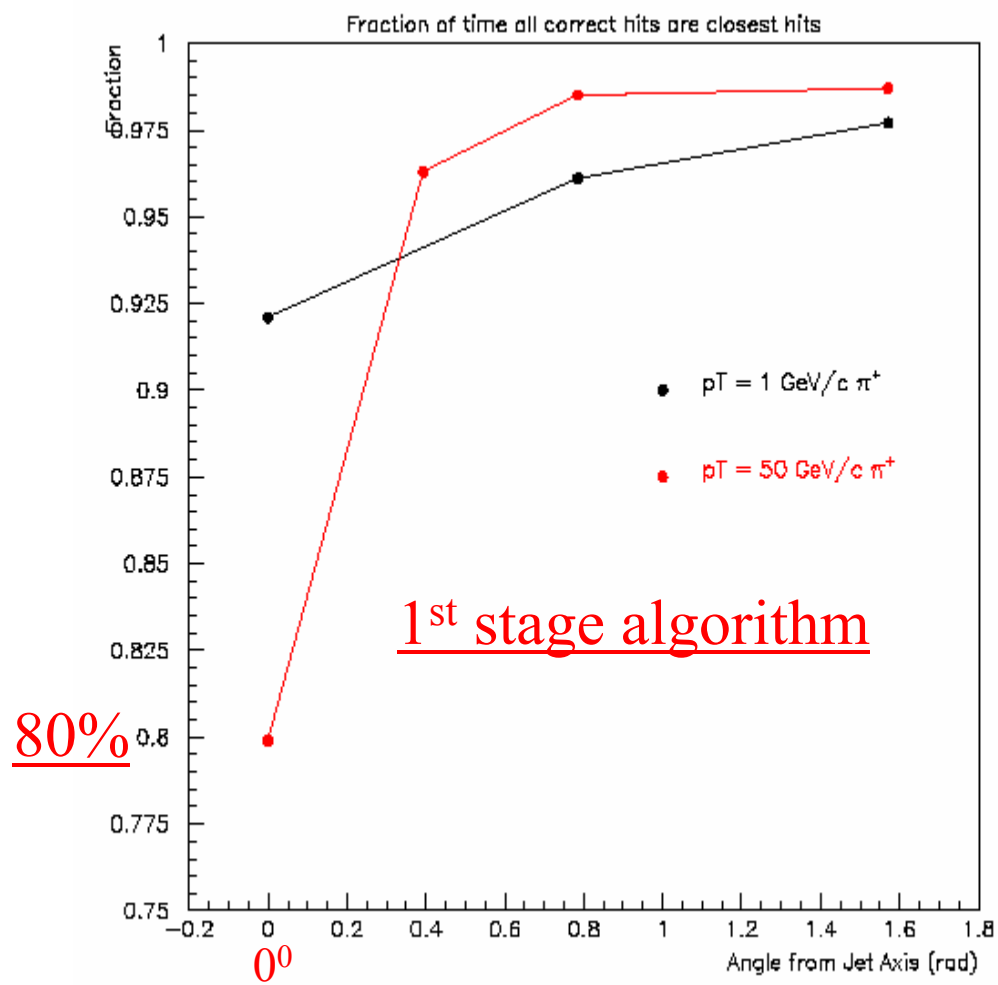
proj. error = 500 μm to 75 μm.

Start with qqbar events with no background at this time.

Need to show that it'll work.

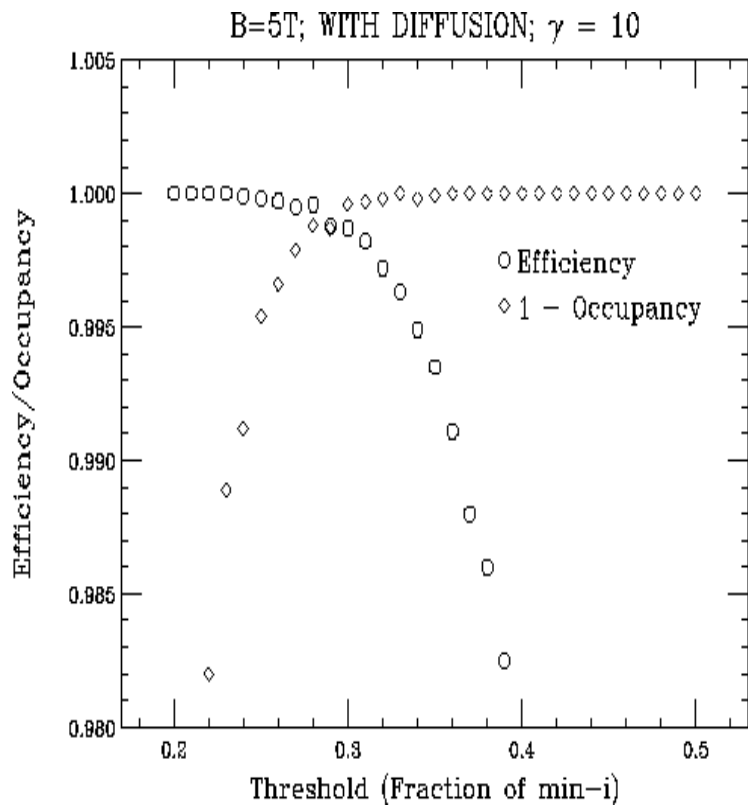
➔ **Remaining 20% will be the test!**

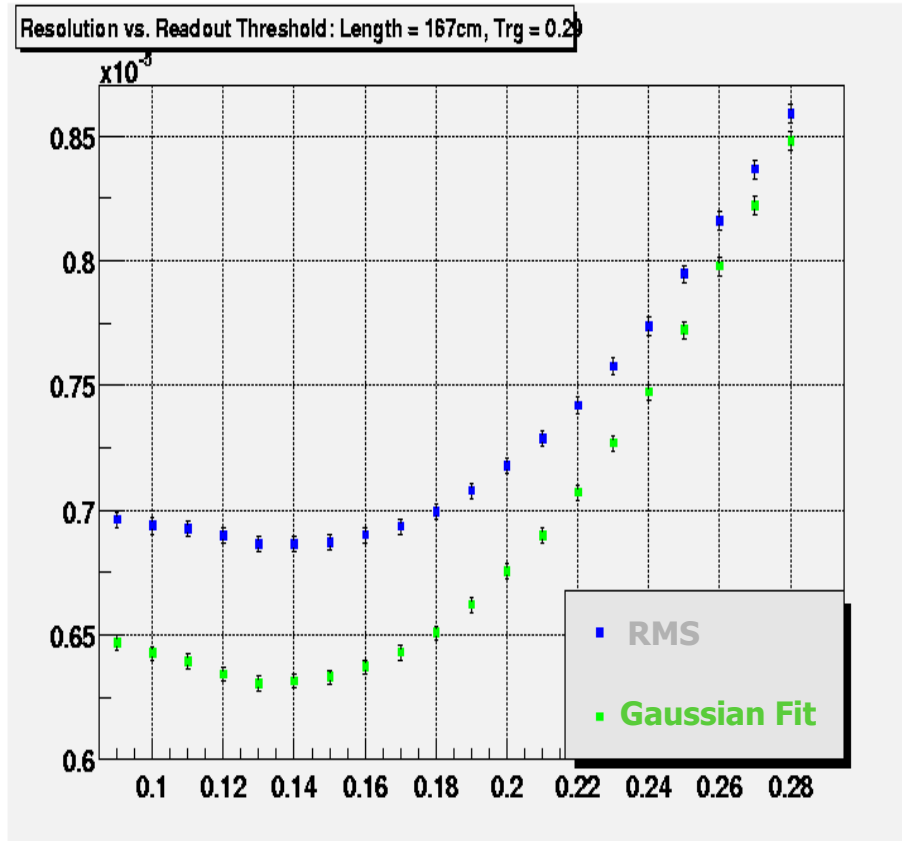
Fraction of tracks w/ all correct hits

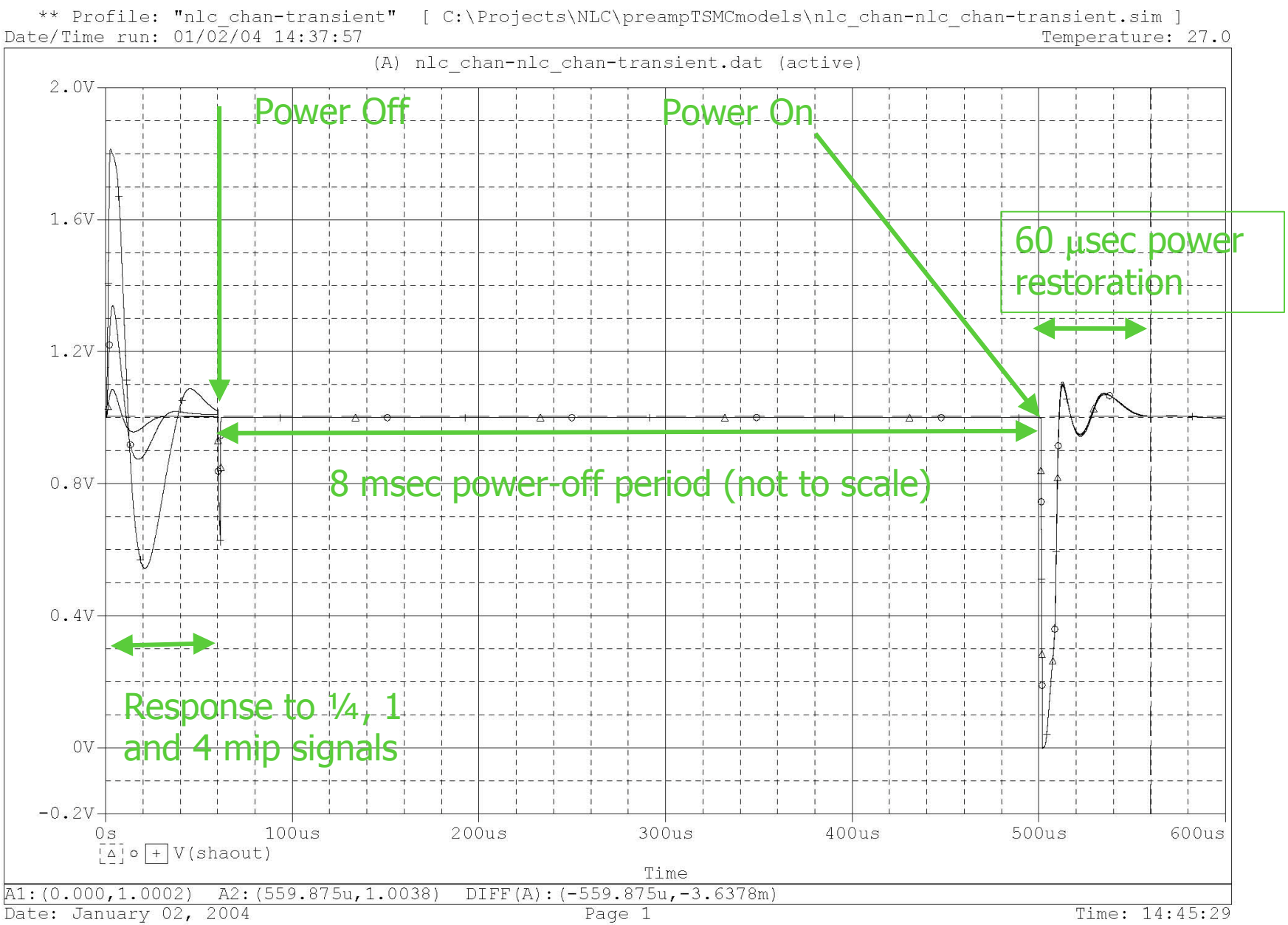


Angle w.r.t. jet axis

Short-Shaping Time Solid State Tracker, B.Schumm





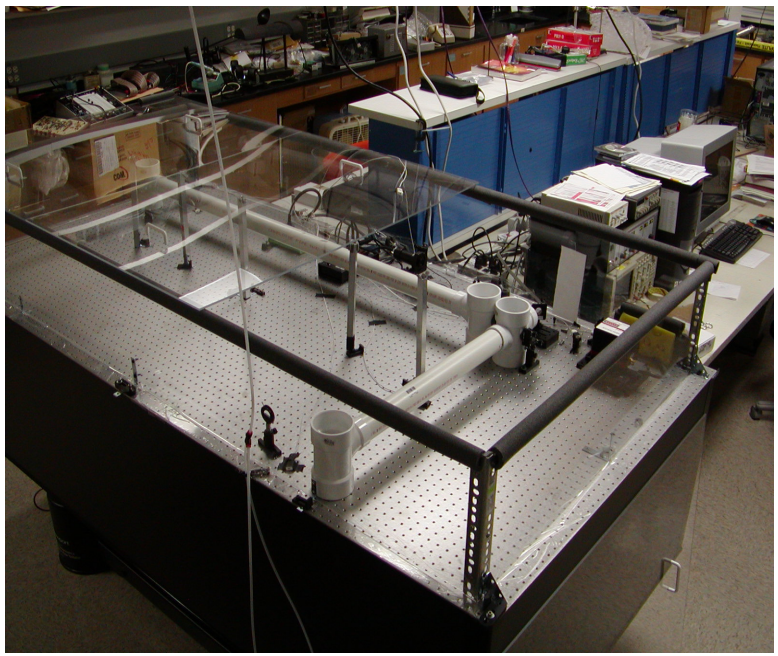

** Profile: "nlc_chan-transient" [C:\Projects\NLC\preampTSMCmodels\nlc_chan-nlc_chan-transient.sim]
Date/Time run: 01/02/04 14:37:57
Temperature: 27.0
(A) nlc_chan-nlc_chan-transient.dat (active)
Power Off
Power On
60 µsec power restoration
8 msec power-off period (not to scale)
Response to ¼, 1 and 4 mip signals
2.0V
1.6V
1.2V
0.8V
0.4V
0V
-0.2V
0s
100us
200us
300us
400us
500us
600us
V(shaout)
Time
A1:(0.000,1.0002) A2:(559.875u,1.0038) DIFF(A):(-559.875u,-3.6378m)
Date: January 02, 2004
Page 1
Time: 14:45:29

Freq.-Scanned Interferometer Tracker Alignment System, H.Yang

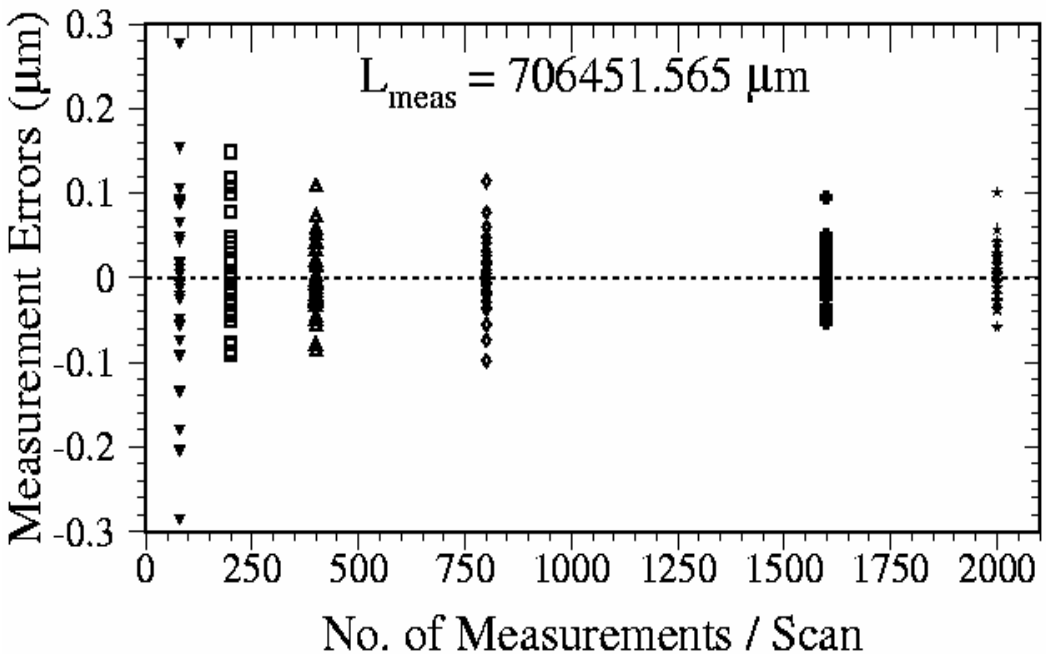
U. Michigan

Basic idea: To measure hundreds of absolute point-to-point distances of tracker elements in 3 dimensions by using an array of optical beams split from a central laser. Absolute distances are determined by scanning the laser frequency and counting interference fringes. Absolute 1D distance accuracy is of order 1 micron.

Demo System



Absolute Distance Measurements



An accuracy of 35 nm, or 50 ppb, was obtained.

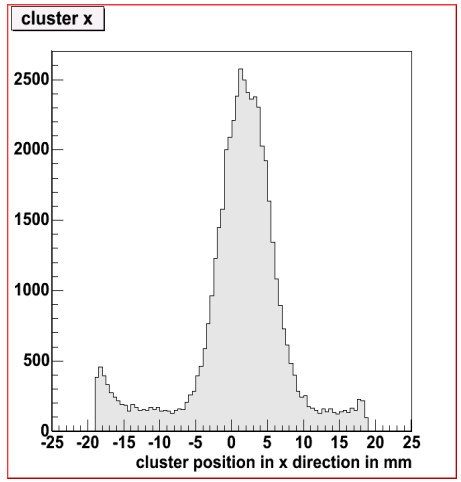
GEM-TPC Distortion measurements

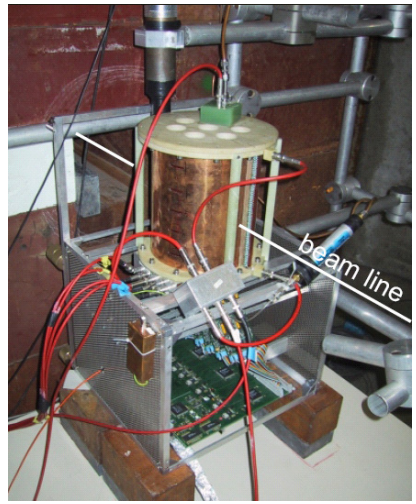
CERN test beam:

9 GeV hadrons

No problem with GEM operation.

Observe track positive ion distortions at high intensity.





<u>GEM feedback and TPC positive ion distortion models are under study.</u>