Cornell Linear Collider Detector Research

Cornell Interests:

The Cornell group proposes to contribute
to development of charged particle tracking
for the the N. American “Large Detector” design.

Detector Development (in collaboration with Purdue University)
(funding requested through UCLC)

Personnel: R. S. Galik
J. Miyamoto (Purdue)
D. Peterson
I. P. J. Shipsey (Purdue)
& students

Event Reconstruction, Pattern Recognition
(funding through the LEPP base grant)

Charged Particle Tracking at the Linear Collider

The challenges:

Momentum resolution

$\delta p_t/p_t = 4 \times 10^{-5}$/Gev …

(can be achieved with)

2 meter outer radius detector, 3 Tesla

120 µm spatial resolution

10 µm intermediate detector at R=0.4 m

10 µm vertex detector

Track density, Reconstruction efficiency

100 tracks/steradian …

"full" efficiency for "energy flow"

5% occupancy goal requires

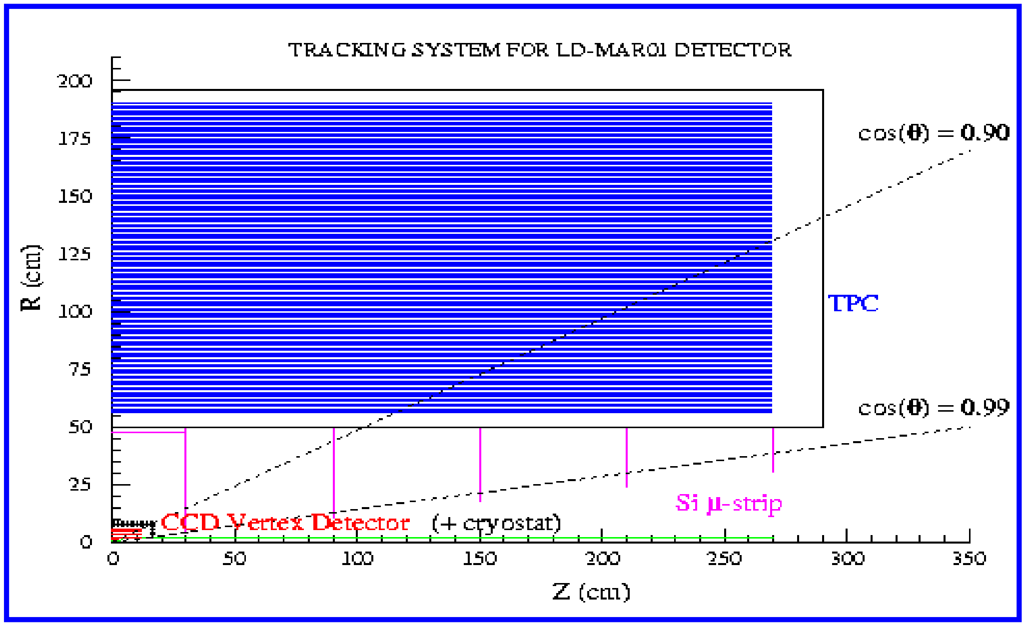
1/2000 ster. segmentation

example: 1.25cm(r-ϕ) x 1cm(z) at 50cm(R)

Noise density

" 1% by volume "

requires more segmentation



Schematic quarter-section of the
N. American "Large Detector"
including a 2 m radius Time Projection Chamber.

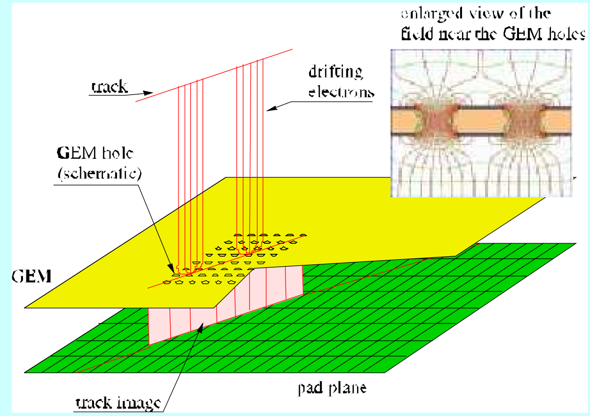
Detector Development, issues

GEM/MicroMegas amplification read-outs are expected to have advantages over traditional anode-amplification read-outs.

Signals are due to electron transport, rather than induction.
The signal width is narrow, typically 1 mm, or less,
providing improved **segmentation** and **resolution.**

ExB effects, present with anode-wire-amplification, are minimized;
an improvement in resolution is expected.

But, there are many outstanding issues.



GEM readout: amplification is localized in the GEM holes. Signal is due to electron transport.

Resolution: How do we balance resolution with the size of the readout ?

GEM/MicroMegas signals may be small compared to the pad width. ⇨ minimal charge sharing

e.g. 5mm (ϕ) x 1cm (r) pads (500 thousand pads)
The resolution, without charge sharing, is 1.4mm (require < 120 μm).

e.g. 1mm (ϕ) x 1cm (r) pads (2.4 million pads !) ⇨ provides charge sharing
The resolution ***may*** be sufficient but number of channels is prohibitive.

While the electron transport signal is fundamentally narrower than the induction signal, sufficient (anticipated) resolution, in a TPC, has not been demonstrated.

Detector Development, Cornell/Purdue Program

Systematic study **spatial resolution** and **signal width** using
GEM/MicroMegas TPC readout devices

amplification device,
details of spacings and gain,
pad size and shape
gas
applied signal isolation/spreading (Signal may require spreading in ϕ and isolation in R.)

Signal spreading must be optimized for segmentation and resolution.

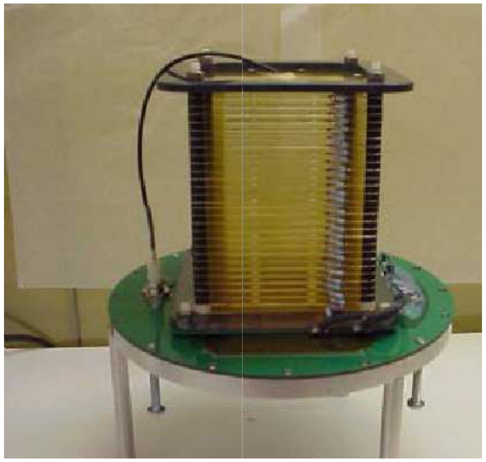
Spatial resolution and signal width studies using
traditional anode-wire-amplification read-out devices
Investigate a readout using smaller wire spacing to reduce the **ExB** effects.

Ion Feedback measurements
Instrument the high voltage plane, or an intermediate grid.

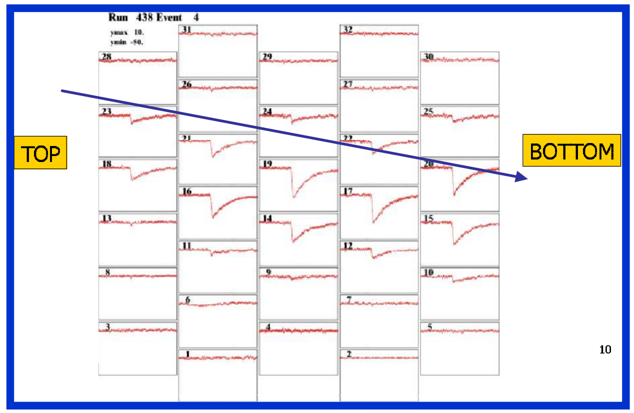
Tracking studies in a **high radiation environment**
Studies of signal distortion and electric-field break-down.

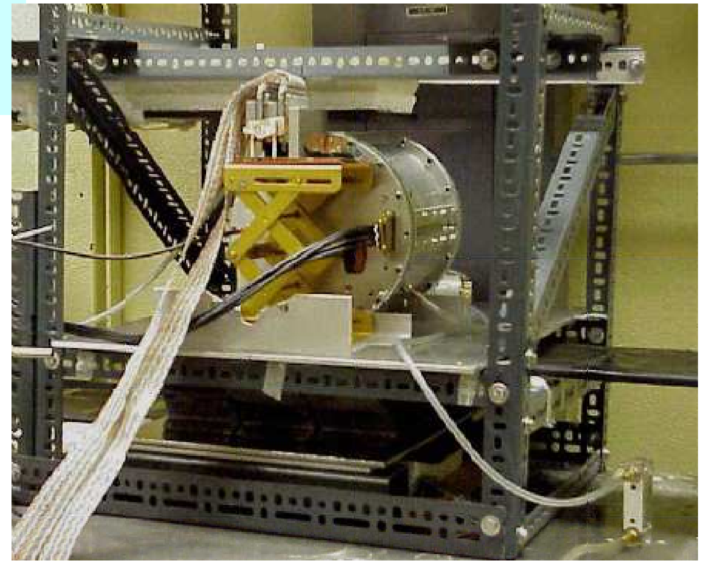
Tracking studies in a **magnetic field**
Cornell has the expertise and utilities to build and operate a superconducting test magnet.

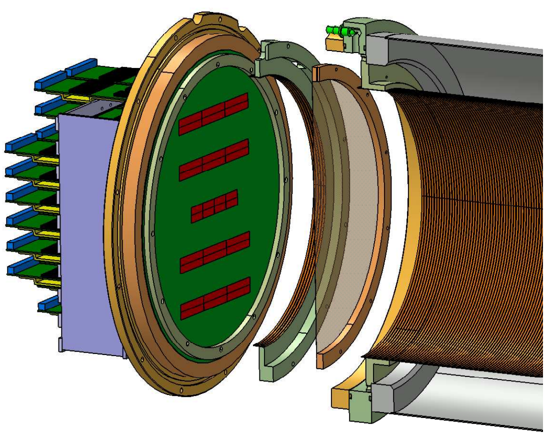
Currently Active/Funded R&D TPC with GEM/MicroMEGAS



Carleton
(GEM)

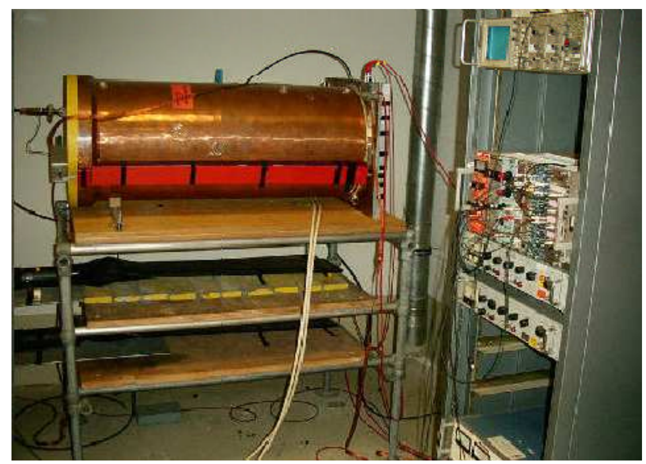






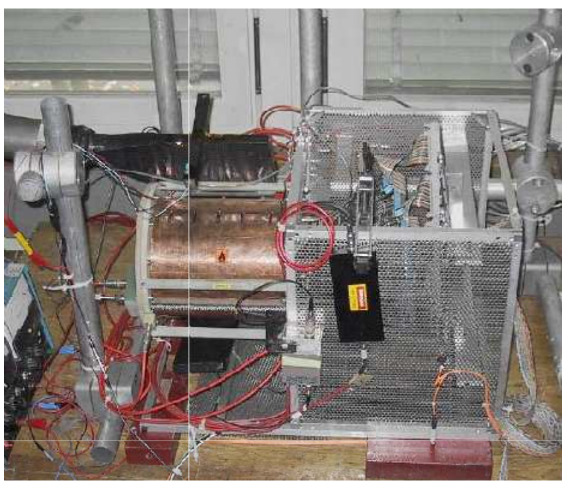
Saclay/Orsay
(MicroMegas)

DESY (GEM)
(printed cage)

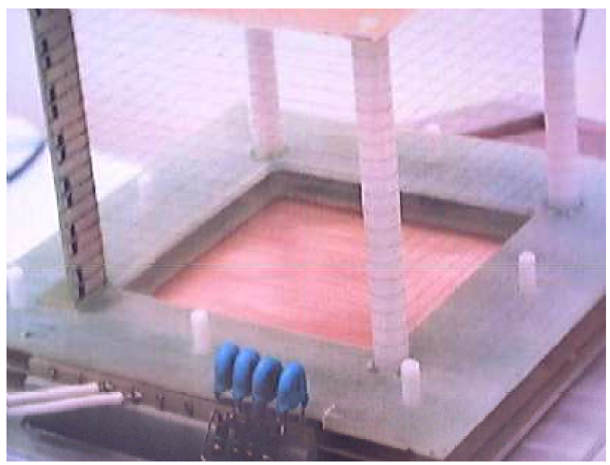


Currently Active/ Funded R&D TPC with GEM or MicroMEGAS

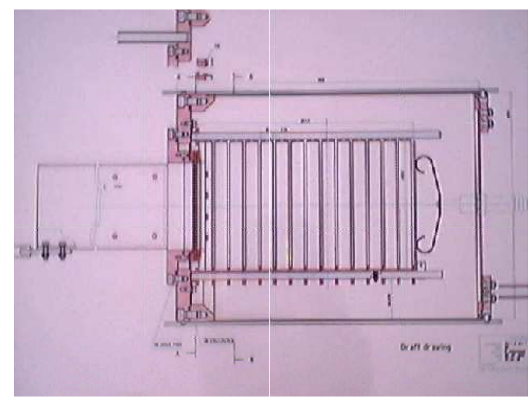
Victoria (GEM)



Karlsruhe (fits in DESY magnet)

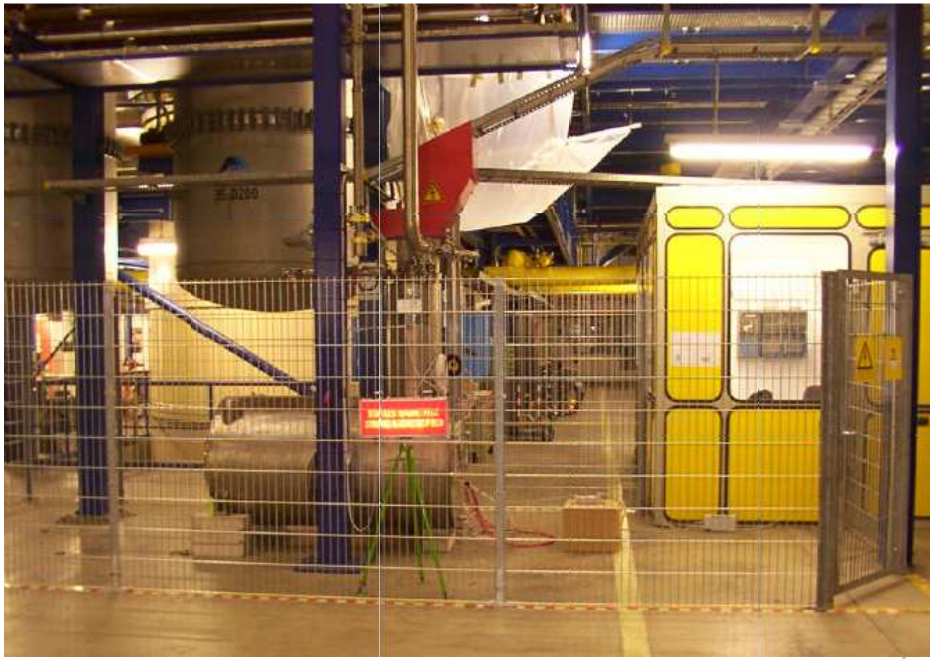


NIKHEF (GEM)



MPI Munich (wire ampl.)

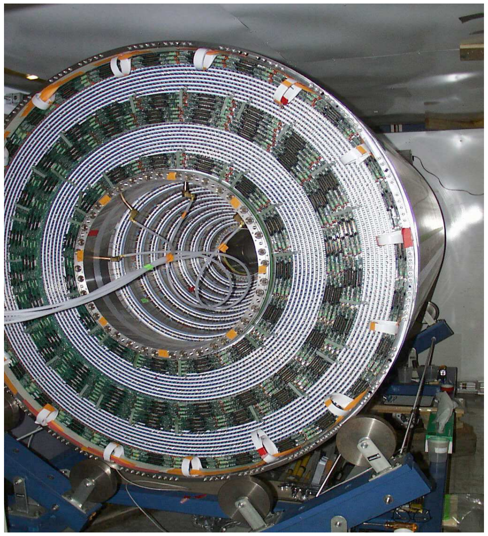
Currently Active/Funded R&D TPC with GEM/MicroMEGAS

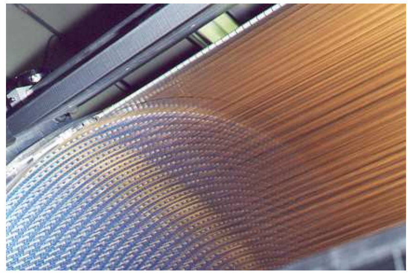


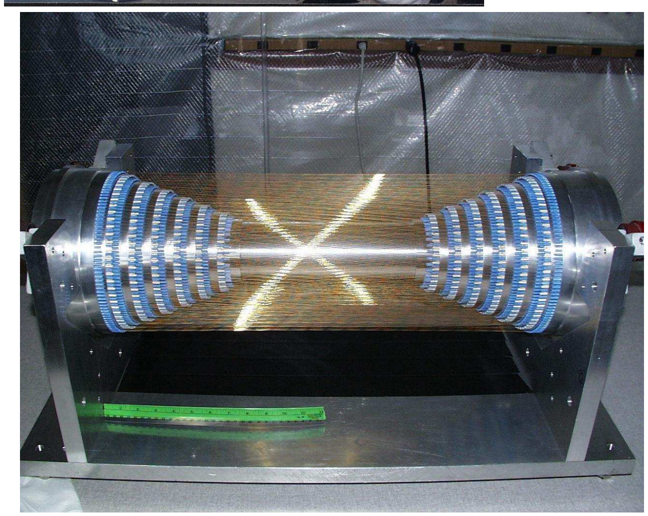
DESY

Saclay

what Cornell can offer







Experience with …

Large drift chambers for CLEO

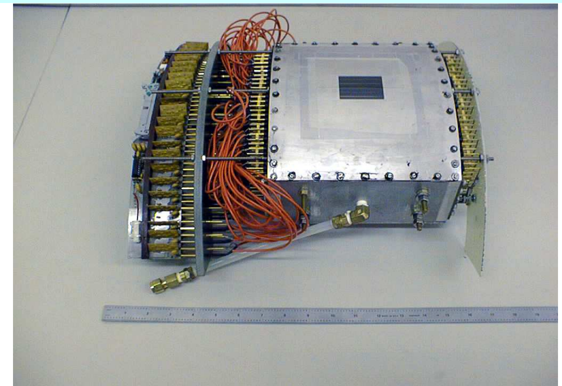
Test chambers

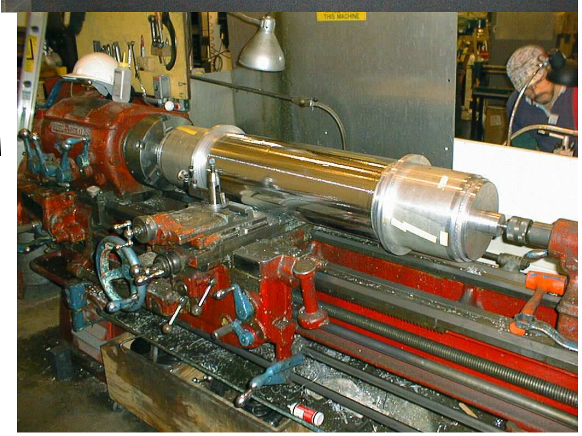
Manufacturing

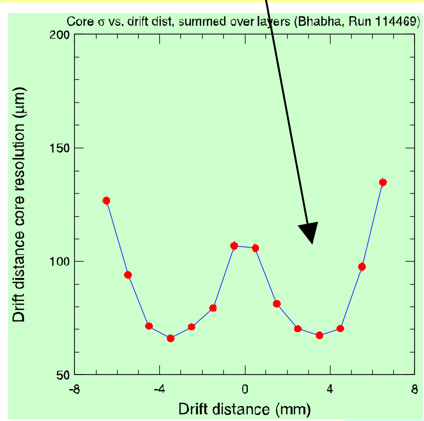
Small drift chambers

Innovative construction

calibration







what Purdue can offer

Years of experience with MPGDs,
preparation and radiation hardness measurements

Micro Pattern Detector Aging
(Radiation Hardness)

Example: triple GEM with PCB readout

Gas Ar/CO_2 70/30 (99.99%)

GEM1= 400 V
GEM2= 390 V
GEM3 =380 V
PCB as e^- collector

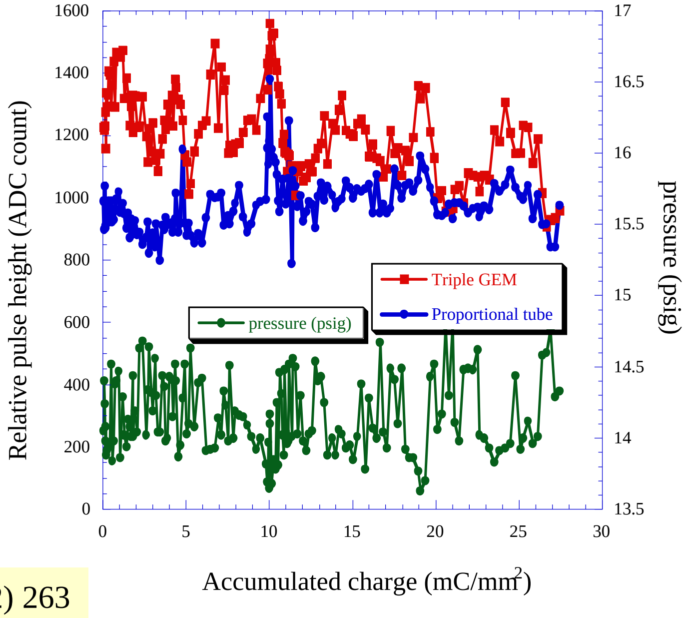
Cr X-rays (5.4 KeV)
@ 6 x 10^4 Hz/mm^2 for 750hrs

Gas gain 6,000

Detector performance
small (~15% gain loss) after
~ 8 years @LHC 10 cm from IP.
Minimal signs of aging.

Best result obtained with a GEM.

Similar result obtained with
a MicroMEGAS + GEM



Stolen from I. Shipsey, NIM A 478 (2002) 263

TPC Test Chamber R&D at Cornell University and Purdue University Three Year Plan

		Plan	Purchases	
(at Cornell)	1st Year	track definition	VME crate	
		scintillator trigger	Computer and LabView controller	
		small drift chambers	discriminators for drift chambers	
		test device, TPC	TDCs for drift chambers	
		power supplies	FADCs for TPC (limited)	
		data acquisition	power supply frame	
			power supplies	
			electronics boards	$ 52,000 equipment
	2nd Year	expanded TPC	expanded DAQ	
		superconducting magnet		$ 121,000 equipment
	3rd Year	expanded TPC	expanded DAQ	
		superconducting magnet		$ 74,000 equipment
(at Purdue)	1st Year	MPGD readout modules	printed circuit pad readout planes	
			GEMs, MicroMegas	$ 10,000 equipment
				$ 16,000 student support
	2nd Year	advances in MPGD readout modules		$ 10,000 equipment
				$ 16,000 student support
	3rd Year	advances in MPGD readout modules		$ 10,000 equipment
				$ 16,000 student support

Short Term Activities

Cornell:

Purchases of electronics,
set-up and testing of electronics,

are delayed until we receive UCLC funding from NFS.

(That will be late spring 2003 under the absolute best conditions.)

construction of a first TPC device
construction of telescope drift chambers and trigger scintillators

We can start when technical staff and machine shop staff are available,
at the completion of the CESR-Wiggler/CLEO-inner-chamber installation,
~ June 2003 .

Purdue:

may be ready to construct a readout module