Tracking Detector R&D at Cornell University and Purdue University

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The challenges

Momentum resolution: $\delta p/p = 4 \times 10^{-5}$/Gev …

120 μm spatial resolution (2 meter, 3 Tesla)
10 μm intermediate detector at R=0.4 meter
10 μm vertex detector

Track density: 100 tracks/steradian …

readout segmentation: better than 1/2000 ster.
example: 1.25cm(r-ϕ) x 1cm(z) at 50cm(R)

Noise density: 1% by volume

more segmentation
reduced ion feedback (in a TPC)

World Goals of TPC R&D (abridged)

A TPC read-out with GEM or MicroMegas amplification promises to provide the segmentation and spatial resolution required to meet the physics goals and the operating conditions. Significant development and operating experience is required before a design can be finalized.

X-Y resolution and segmentation: optimum pad size, pad structure, amplification

Z resolution and segmentation: optimum gas, amplification

Ion feedback: amplification, radiation background
Requires detailed measurements. Is a gating grid required?

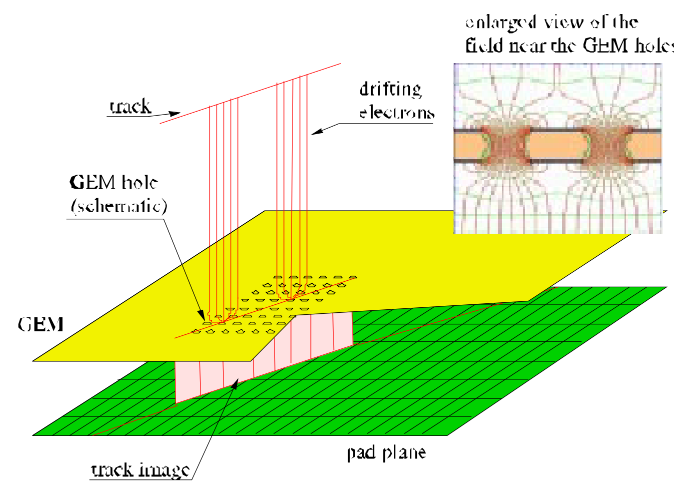
Aging: breakdown of the amplification device

Electronics: very large channel count to achieve segmentation

Mounting structure: The final device requires minimum dead regions due to mounting of the pads and the amplification device. Minimize signal distortion at edges.

Alignment methods: internal, external, consistant wit improved resolution (in an inhomogeneous magnetic field)

The electron transport signal is fundamentally narrower than an induction signal.



Gem TPC read-out
Stolen from TESLA TDR

D. Peterson, Cornell University, UCLC 30-June-2002

Currently Active R&D
TPC with GEM/MicroMEGAS

Carleton TPC with GEM readout
- X-ray point resolution, induction resolution, track resolution
- Pad shape, signal shaping

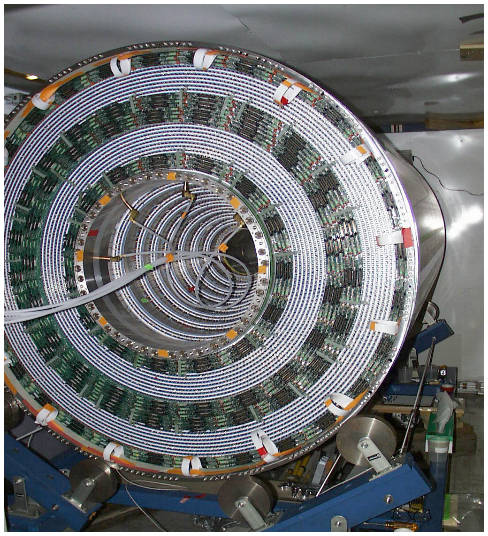
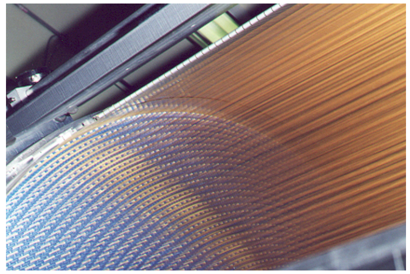
Saclay TPC with MicroMegas readout
- planned (January) 0.45 m diameter TPC in 2 Tesla field

Desy TPC with GEM readout
- 1 m drift TPC: amplification, track resolution
- small TPC: ion feedback
- planned (January) up to 5 Tesla field

(many apologies for omissions)

We propose to initiate a new program in gas chamber development.
Prototype TPC detectors would be constructed and tested at Cornell.
GEM and MicroMegas readout modules would be constructed at Purdue.

what Cornell can offer

Experience with …

Large drift chambers for CLEO

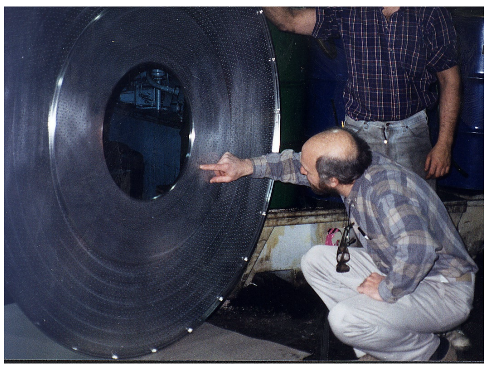
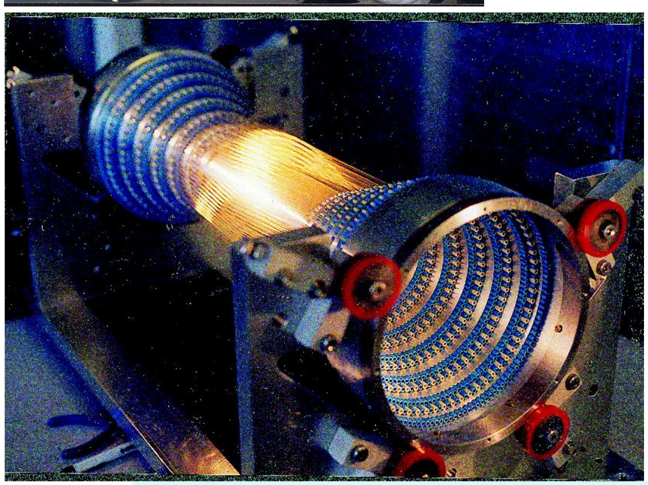
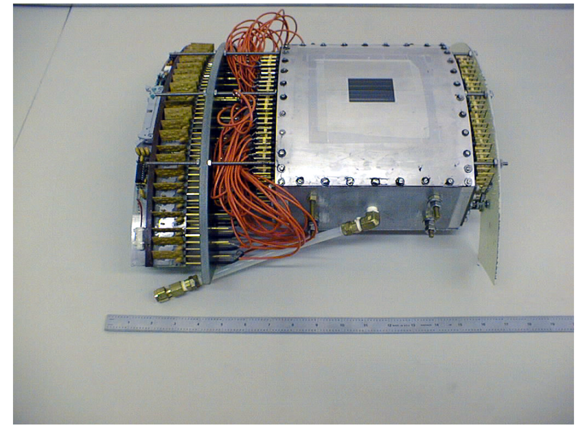
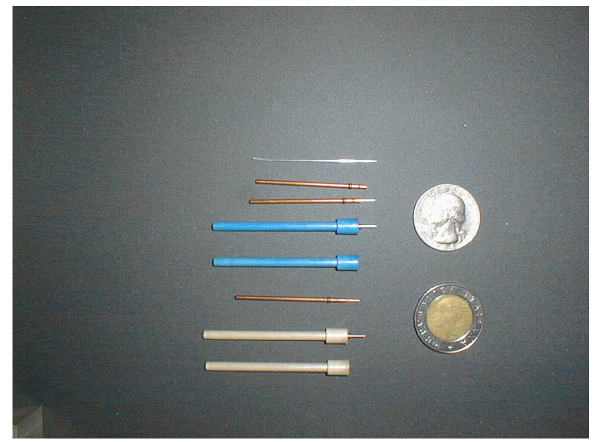
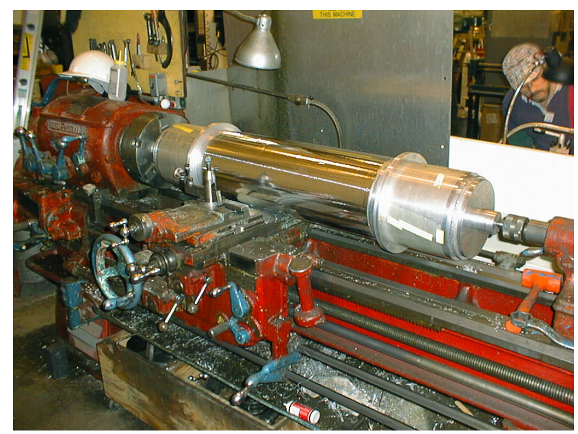
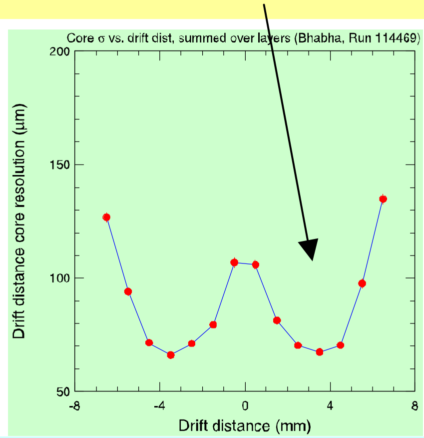
Test chambers

Manufacturing

Small drift chambers

Innovative construction

calibration

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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

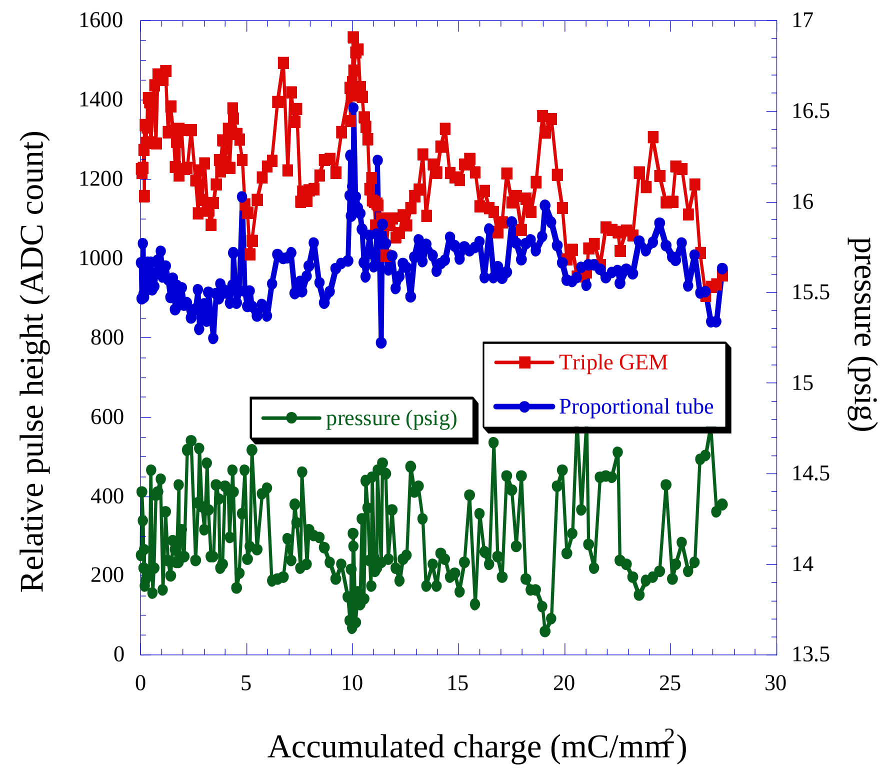
Cr X-rays (5.4 KeV)
@ 6 x 10^4 Hz/mm^2 for 750hrs

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

Interests/Directions, Cornell/Purdue

Optimize the pad size/shape for **track-track separation** and **position resolution**

We must understand the signal response function and it's dependence on

- amplification device, spacing and distribution of the amplification
- pad size and shape
- gas
- applied signal isolation/spreading

(While the electron transport signal is fundamentally narrower than an induction signal, the MPGD amplification device does not provide radial isolation of the signal.

The signal may require spreading in ϕ and isolation in R.)

Cornell brings to this effort an expertise in building and calibrating gas tracking devices and the hardware development program compliments the pattern recognition development program.

Consequences of the measured signal shape can be directly observed in the pattern recognition.

Code can be developed to optimize track separation for particular signal response functions.

Tracking studies in a **high radiation environment**

Cornell has access to controlled γ radiation at CHESS.

Tracking studies in a **magnetic field**

Cornell has access to the expertise and utilities to provide a superconducting test magnet.

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

		Plan	Purchases	Cost
(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
				$ 45,000 grad student support
	2nd Year	expanded TPC	expanded DAQ	
		superconducting magnet		
		radiation environment		
				$ 175,000 equipment
				$ 45,000 grad student support
(at Purdue)	1st Year	MPGD readout modules	GEMs, MicroMegas	
			printed circuit pad readout planes	
				$ 10,000 equipment
				$ 32,000 student support
	2nd Year	advances in MPGD readout modules		
				$ 10,000 equipment
				$ 32,000 student support