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 $\mu$m spatial resolution (2 meter, 3 Tesla)
- 10 $\mu$m intermediate detector at R=0.4 meter
- 10 $\mu$m vertex detector

Track density: 100 tracks/steradian …

- readout segmentation: better than 1/2000 ster.
  - example: 1.25cm(r-$\phi$) 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, consistent with 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

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Currently Active R&D

TPC with GEM/MicroMEGAS

<table>
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<tr>
<th>Location</th>
<th>Description</th>
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</table>
| 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.
Experience with …

Large drift chambers for CLEO

Test chambers

Manufacturing

Small drift chambers

Innovative construction

calibration

what Cornell can offer

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Micro Pattern Detector Aging
(Radiation Hardness)

Example: triple GEM with PCB readout
Gas Ar/CO₂ 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 10⁴ Hz/mm² 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
Optimize the pad size/shape for track-track separation and position resolution

We must understand the signal response function and its 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 $\phi$ 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 $\gamma$ 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

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