A Framework for TPC Simulation

Santa Cruz Linear Collider Retreat
June 27-29, 2002

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Motivation for this work

 Explore the parameter space for TPC design:
  – dimensions, gas, B field, gas amplification technology, pad designs

 Simulation must be anchored on reality:
  – compare with several prototype TPCs
  – understand signals
  – test out tracking ideas

 Not intended for use inside a LC detector simulation package for physics studies
Requirements/Design

✦ Requirements
   – Easy to use (graphical interface)
   – Flexible enough to allow any TPC design
   – Easy to maintain / add additional features
   – Portable

✦ Design choices
   – Object oriented (Java)
   – Use JAS tools:
     • JAS Histogrammer
     • JAIDA
Building a TPC

✦ The TPC is built from a set of TPC parts
  – gas volumes
  – GEM foil amplification stages
  – readout pad structures

✦ TPC parts have methods to transport electron clouds through them

✦ The parameters for each TPC part are accessible through a single design window
TPC design window

- Drift Volume
- GEM foil 2
- Transfer gap
- GEM foil 1
- Induct. gap
- Readout
Designing readout pads
Adding an ionization track
Signals on pads
Signals on pads

Data can be written to disk for “offline” analysis…
Comparison with prototype TPC data

Run -200 Event 6
ymax 20, ymin -20.
Comparison with prototype TPC data

Row charge

Track residuals
Track fitting

uses the Nonlinear Optimization Java Package (uncmin) translated to java by Steve Verrill
Comparison of pad geometries for GEM

From TESLA TDR: advocates chevrons
Comparison of pad geometries for GEM

- Current favourite gas mix: Ar CF₄
  - fast at low fields
    - low transverse diffusion in magnetic fields
  - larger diffusion at higher fields
  - Example: Ar CF₄ (98:2)

![Graphs showing drift field and GEM transfer field](image)
Comparison of pad geometries for GEM

- Single tracks with \(-0.1 < \phi, \psi < 0.1\)
- Seven pad geometries sample same ionization
Comparison of pad geometries for GEM

- Single tracks with $-0.1 < \phi, \psi < 0.1$
- Seven pad geometries sample same ionization
Comparison of pad geometries for GEM

Ar CF4 (98:2): 5 rows of 2.5 mm x 5 mm pads

Drift length (cm)

- standard rectangle pattern
- narrow rectangles
- mixed narrow and wide rectangles
- chevron pattern 1
- chevron pattern 2
- chevron pattern 3
- chevron pattern 4
- ultimate (naive calculation)

Defocussing in 1 cm GEM gap
Chevrons unnecessary in Ar CF4 GEM TPC
Comparison of pads for Micromegas

Ar CF4 (98:2): 5 rows of 2.5 mm x 5 mm pads

Defocussing required for micromegas
Future possible development

✦ Include cluster size distributions calculated by HEED
✦ Add noise: electronic & random SR conversions
✦ Include “offline analysis”

✦ Question: If other groups interested in the program, how best to allow for group development?

✦ To download program, go to:
  http://www.physics.carleton.ca/~karlen/gem/simulation