Forward Tracking and GEM-based Tracker Development

Lee Sawyer

Louisiana Tech University

Tracking Working Session
SLAC ALCPG Workshop
07 Jan 2004

Overview

- Group Introduction: Who are these guys and why are they working with GEMs?
- What we have done so far
  - Tracker Prototype Development
  - Detector Simulation
  - Physics Simulation
- What we plan to do in the next year
  - Tracker construction and testing
  - Simulations and physics studies

2003 Proposed Work at Louisiana Tech

- Joint Proposal: "Evaluation of a GEM-Based Forward Tracker for the NLC" ($39k in Y1)
  - Hardware: Build a prototype GEM chamber suitable for forward tracking
  - Software: Study design parameters for a tracker in the far-forward region.
- Since the proposal
  - Additional funds requested from LA Board of Regents (3 proposals) for chamber manufacture, multiplexing circuitry, faculty & student support (~ $200k).
  - Foils + test chamber delivered from Sauli at CERN
  - Investigating alternate sources for foils (w/ UTA, et al.)
  - First meeting with OK on simulation studies
  - Standalone GEM simulation software installed -> simulate detector configurations

<= 33% of my talk at Arlington Workshop

(Jan 2003)

2004-2006 LCRD/UCLC proposal requests continuation at this level.

Louisiana Tech University

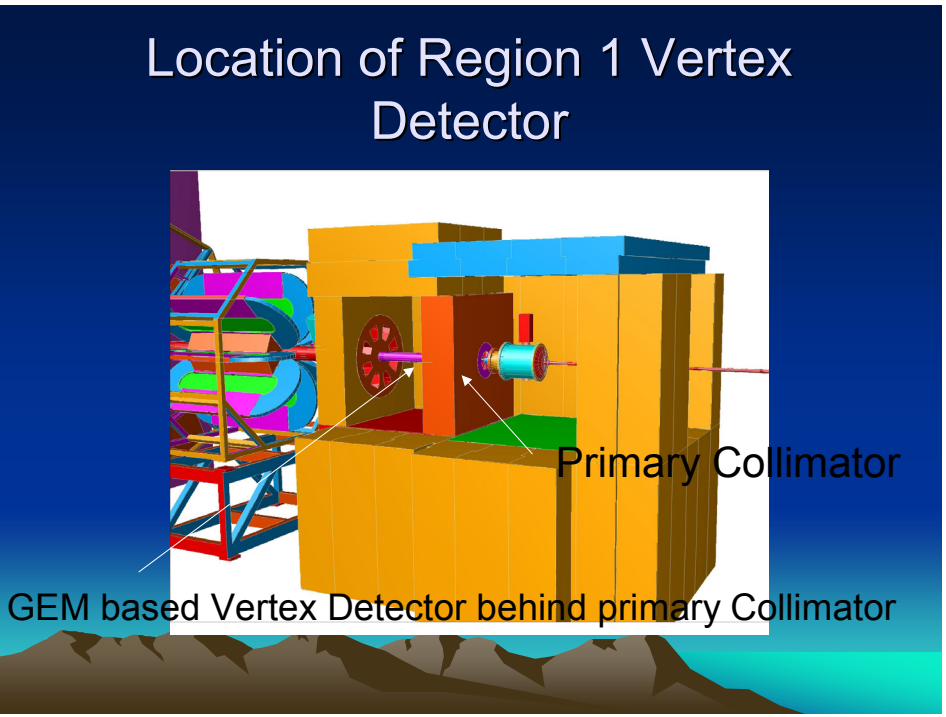
- Engineering school in north central LA
  - Near Shreveport
  - Graduate programs in engineering and science, MS Physics, PhD Engineering Physics and Computational Physics
- High Energy Physics Group
  - Three faculty: Sawyer, Greenwood, Parashar
  - DoE supported group; primary focus is D0 at Fermilab
  - Two postdocs, 4-6 graduate students
  - Previous detector construction
    - Intercryostat Detector: Built electronics, support structures, installed & commissioned.
    - Run IIb Silicon Upgrade: Cable design & testing
      - Smaller project with curtailed upgrade (Layer 0)
  - Groups members have previous experience at e+e- colliders (Sawyer ->ALEPH) and neutrino experiments (Greenwood).
- Medium Energy Nuclear Physics Group
  - Four faculty: Forest, Johnston, Simicevic, Wells
  - NSF supported group; several experiment collaborations at JLAB (G0, QWEAK, CLAS,…)
  - 4-6 graduate students
  - Previous detector construction
    - Cryostat Exit Detectors (CED), trigger electronics for G0.
    - Responsible for designing trackers for QWEAK.

Greenwood

Parashar

Forest

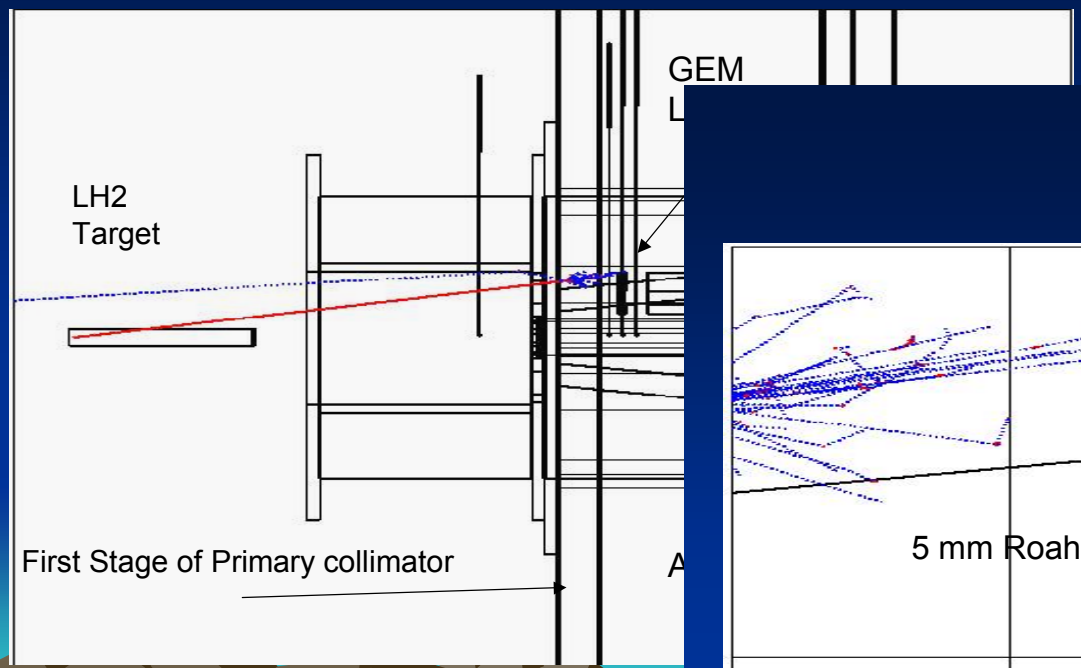
QWEAK Experiment



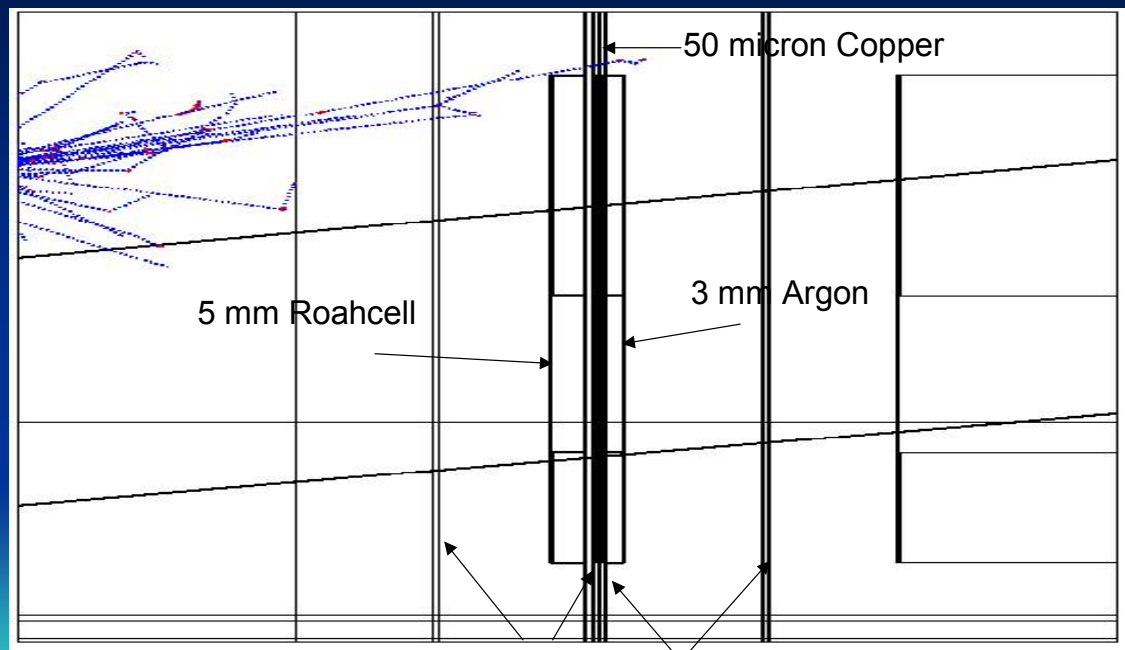
- Approved JLAB Hall C experiment
  - Study of proton weak charge
  - Search for new TeV-scale physics
- Magnet design and vertex detector are primary LA Tech responsibilities
- Proposed Vertex Detector is a 3-layer GEM within Roahcell chamber
  - First GEM foils delivered June, 2003
  - Work began in earnest Mid-summer, 2003
  - Prototype completed for testing by Fall, 2004
  - Chamber construction slated to begin Fall, 2005.

QWEAK GEM Chamber

2 stage primary collimator



Zoom In



GEM Studies at LA Tech

- GEM detector development for QWEAK tracker => Application to other experiments?
- 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)

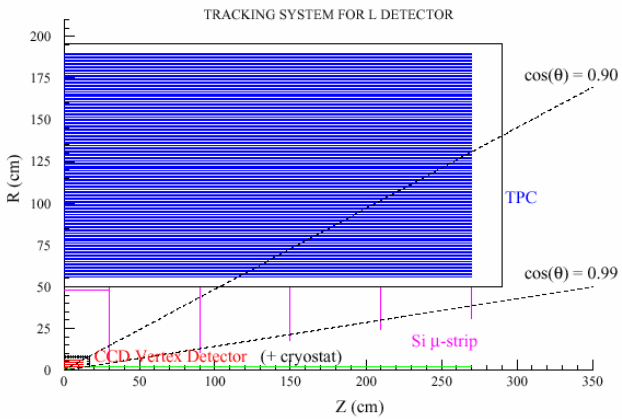


Figure 15.10: Sketch of L detector tracking system.

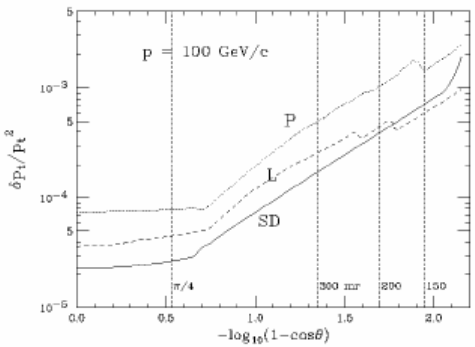


Figure 15.12: Expected fractional momentum resolution *vs.* $\cos\theta$ for the L, SD, and P central trackers for 100 GeV tracks.

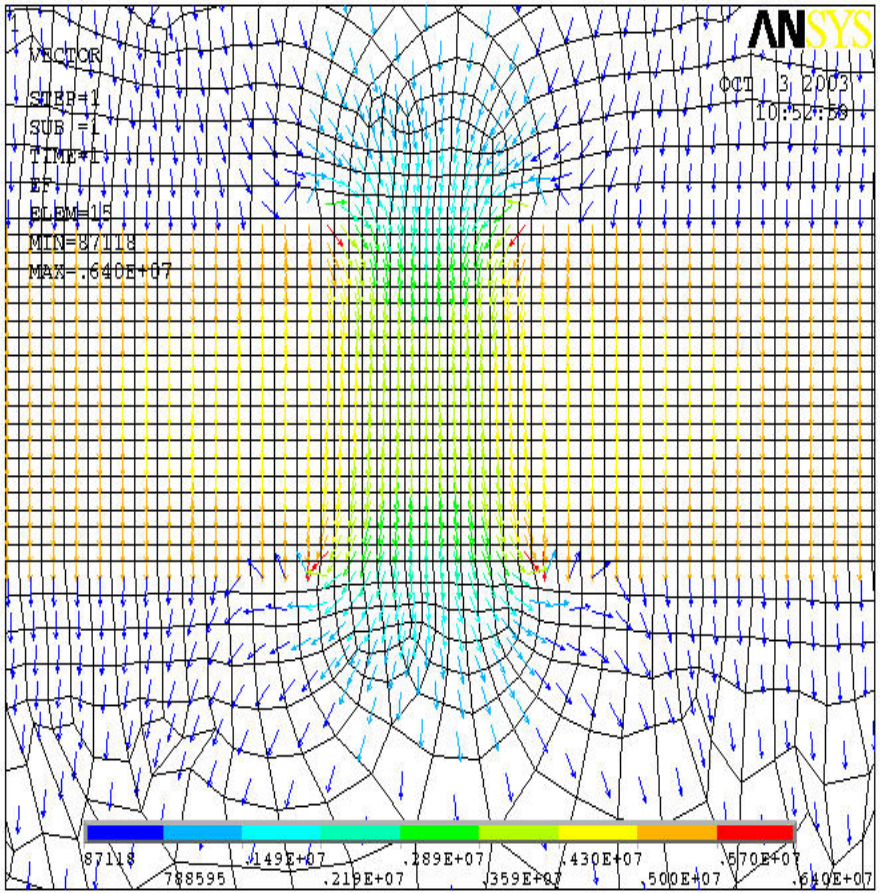
Figures from Linear Collider Resource Book

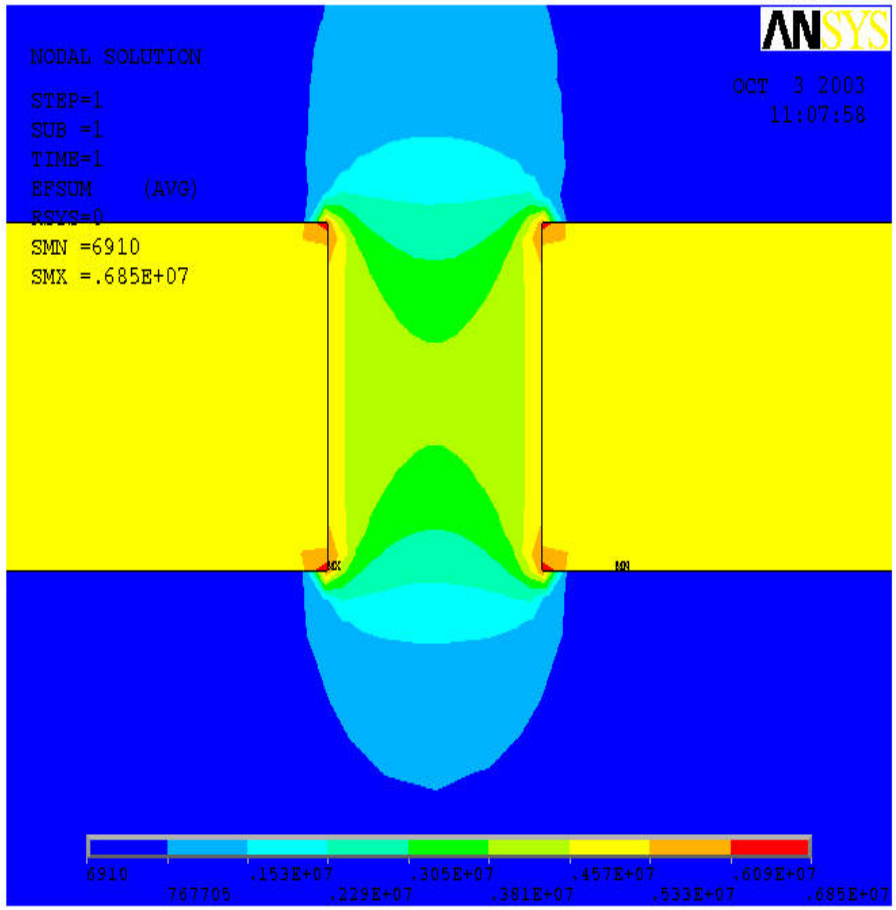
GEM Work on 2003

- Procured first GEM foils
- Design pf charge collector
  - LASER milled at local manufacturer
  - Expect delivery summer, '04
- Developing HELIX-128 chip for readout
  - Used in COMPASS experiment
- Studies of electric field using ANSYS simulations
  - Important for QWEAK resolution studies
  - Input to tracking algorithm
- All work represents a partnership between QWEAK/LC groups
  - Two grad. Students supported by DoE LC supplement
    - Bharat Madireddy (HELIX r/o, JAS2)
    - Subramanian Narayanan (Current monitor & trigger)
  - Two more students supported by Nuclear group (GEM field simulations, tracker construction)

GEM Simulations

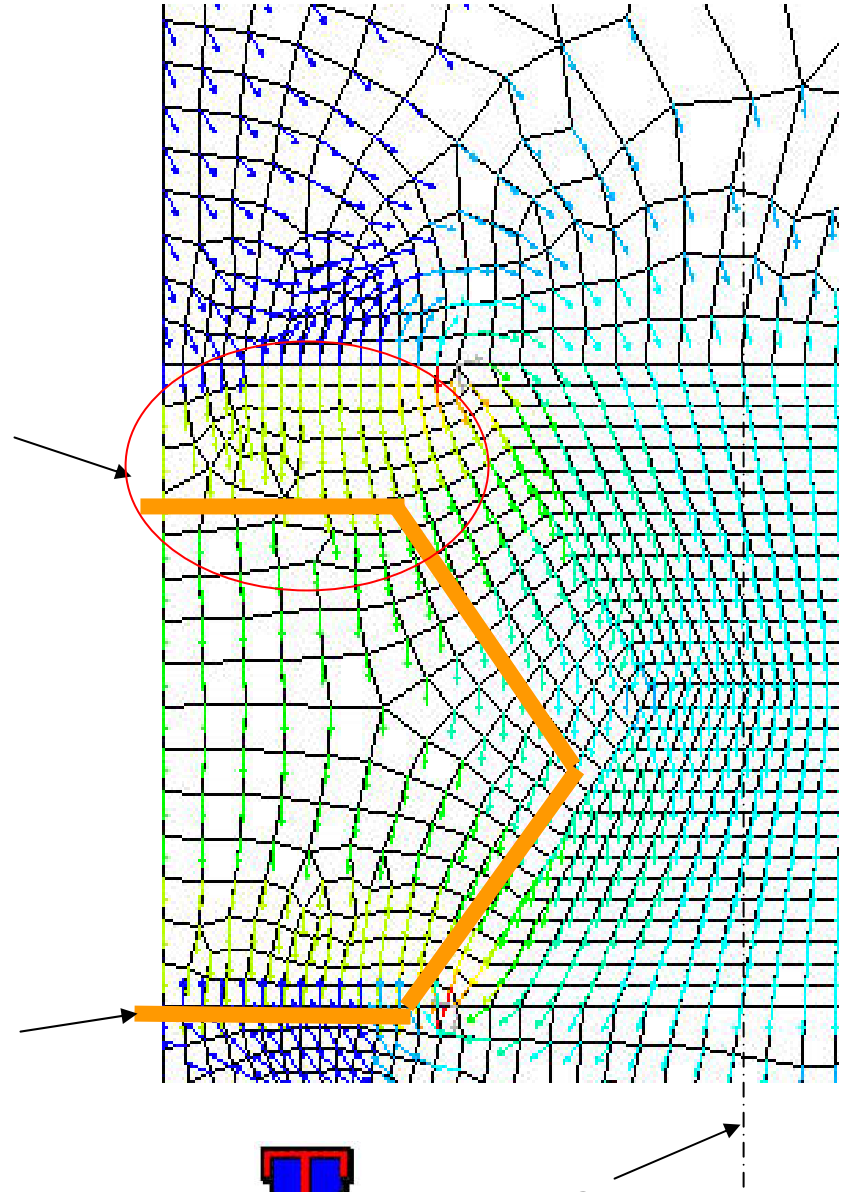
- 2-D ANSYS simulation



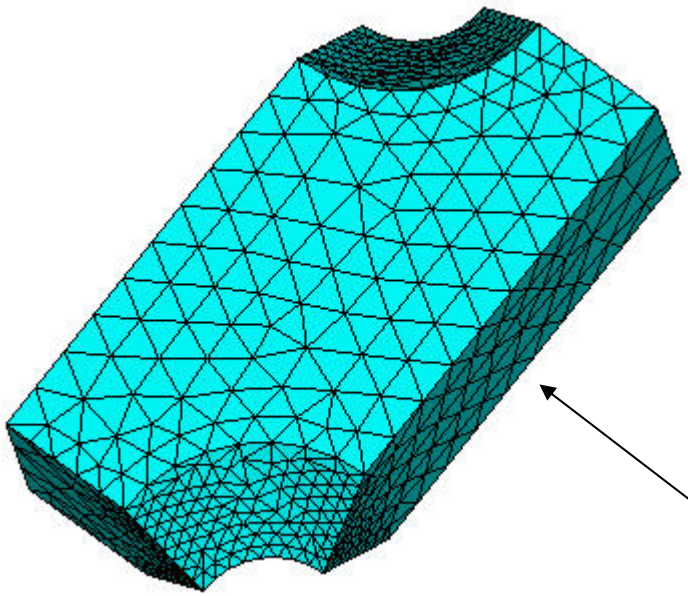


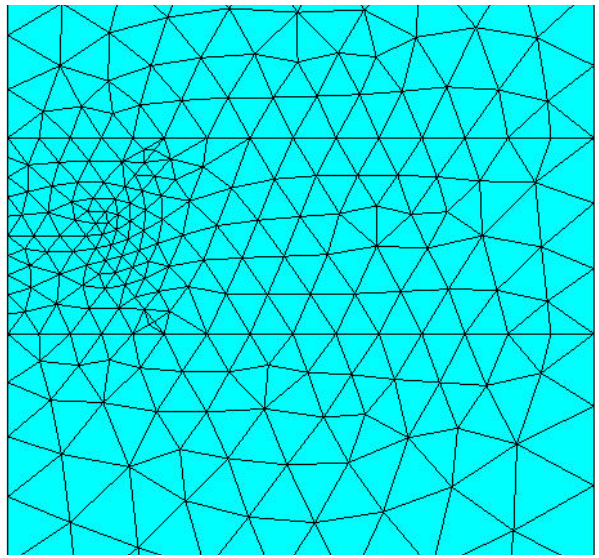
2D Model – Additional Notes

- Computational mesh
  - Requires high grid density in areas around the hole to sufficiently resolve the electric field
  - Becomes an issue when generating the 3D mesh



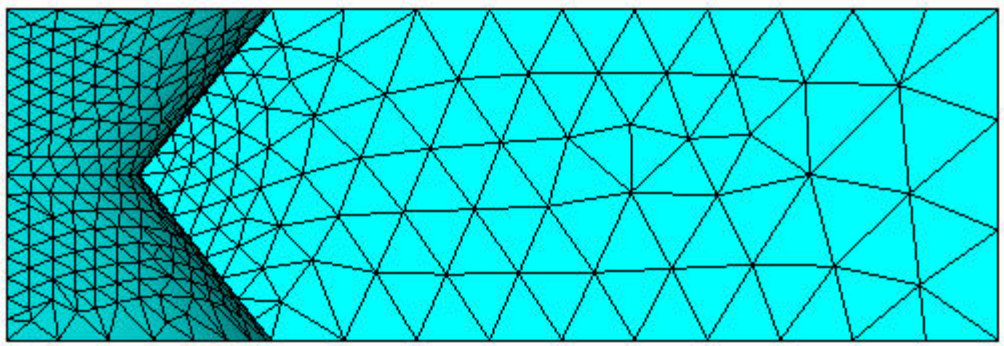
3D Model Mesh





Shown with Argon cells

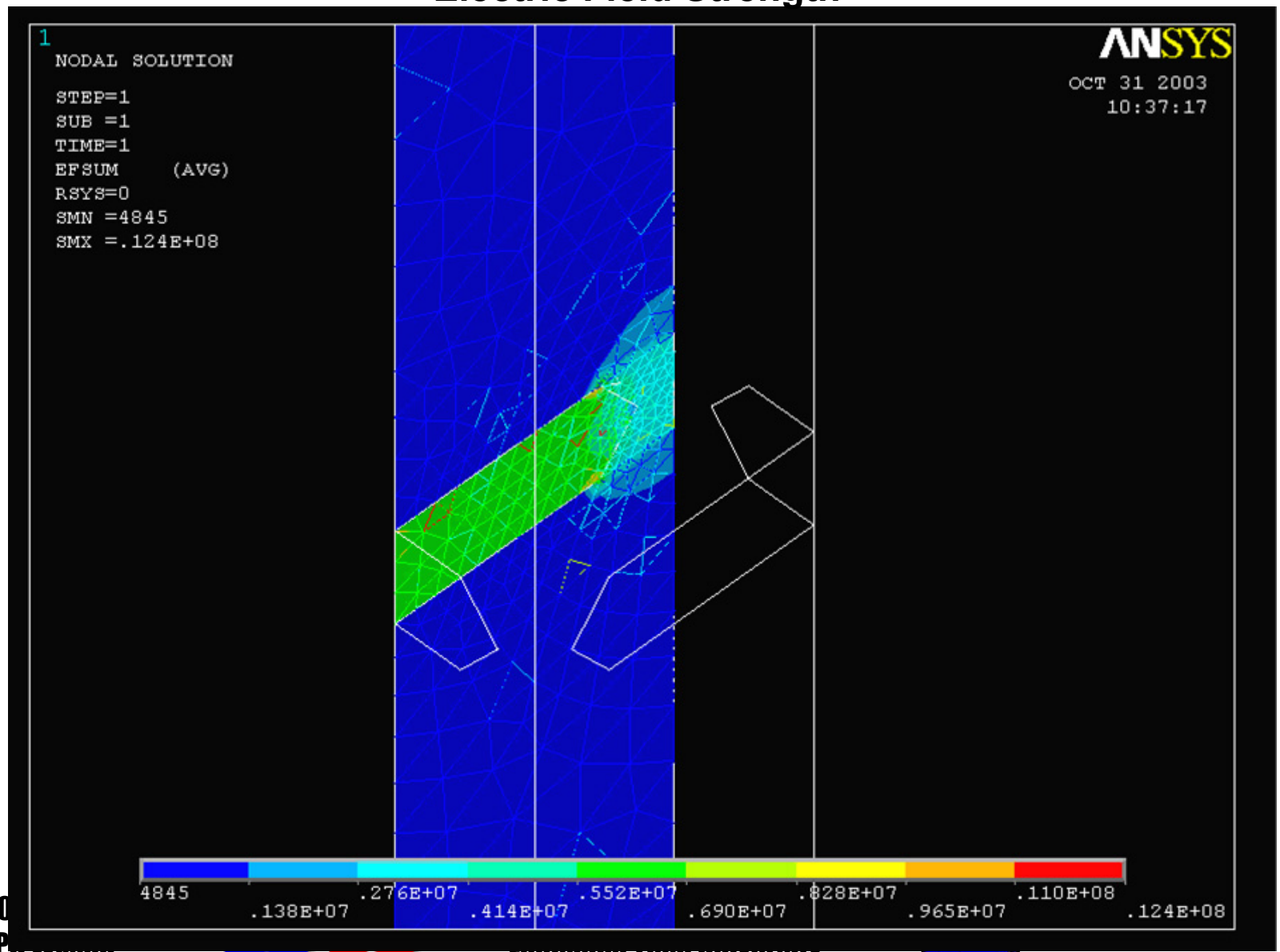
Without Argon Cells



Some views of the Kapton Foil

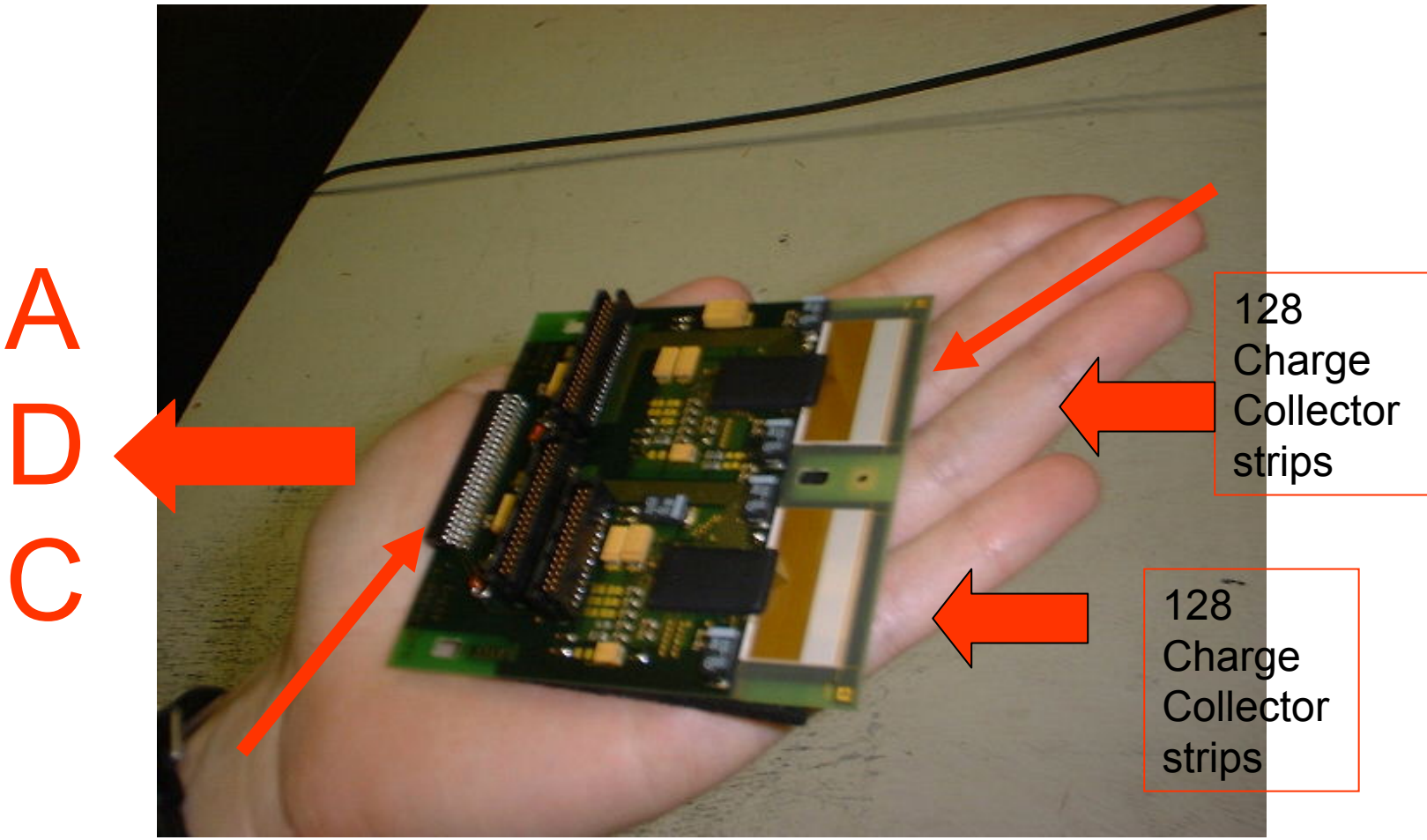
3D Model Results Animated

Electric Field Strength

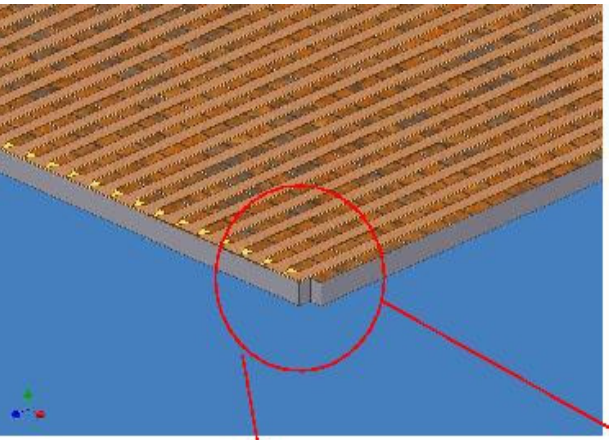


HELIX-128 CHIP

- Fast digitizing 128 Ch. ADC

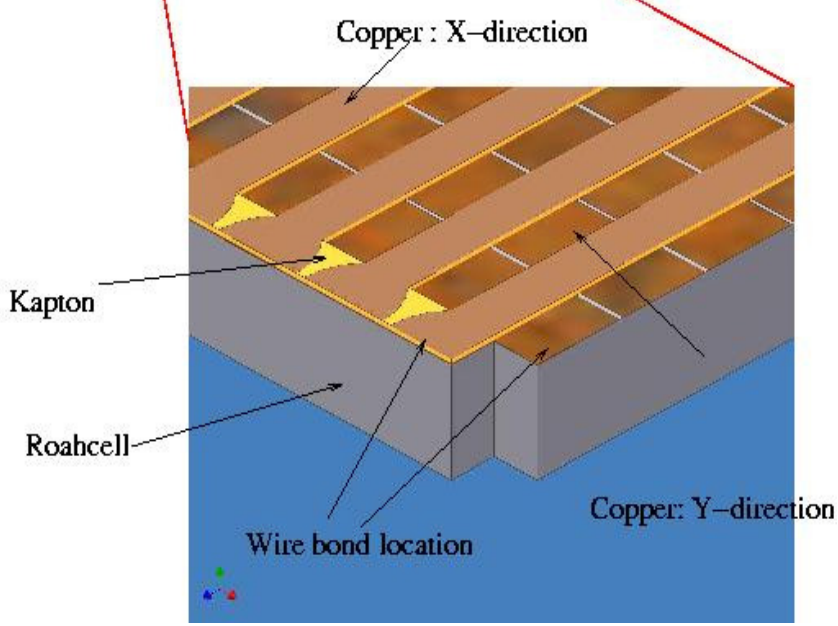


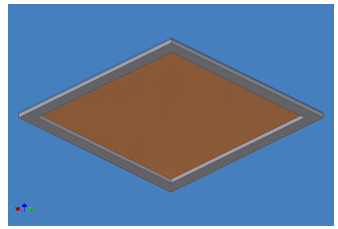
Design

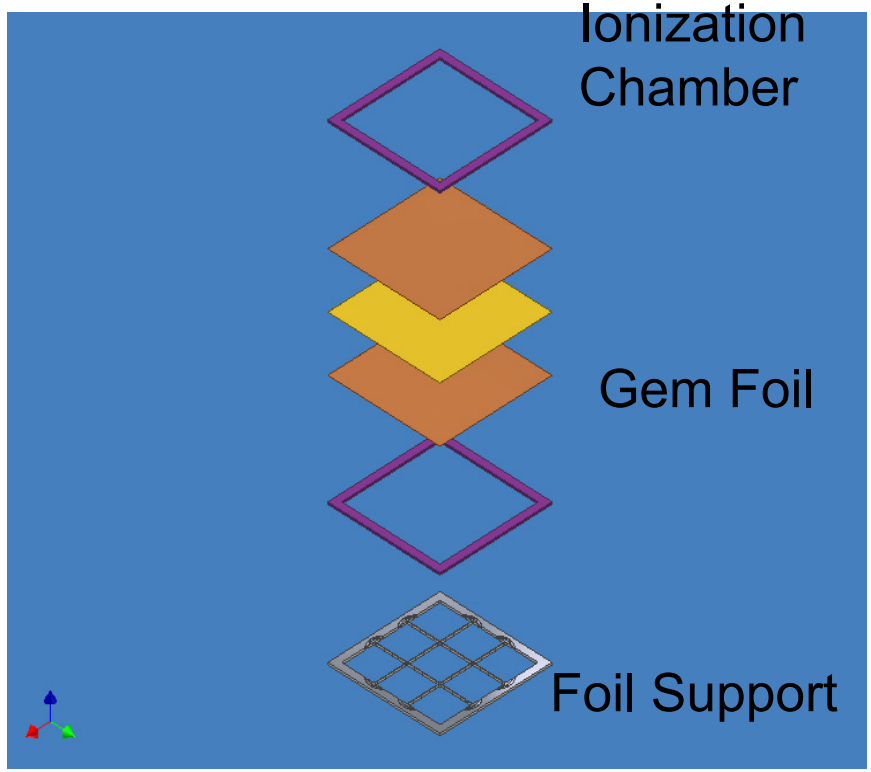


"Dynamic" CAD design template

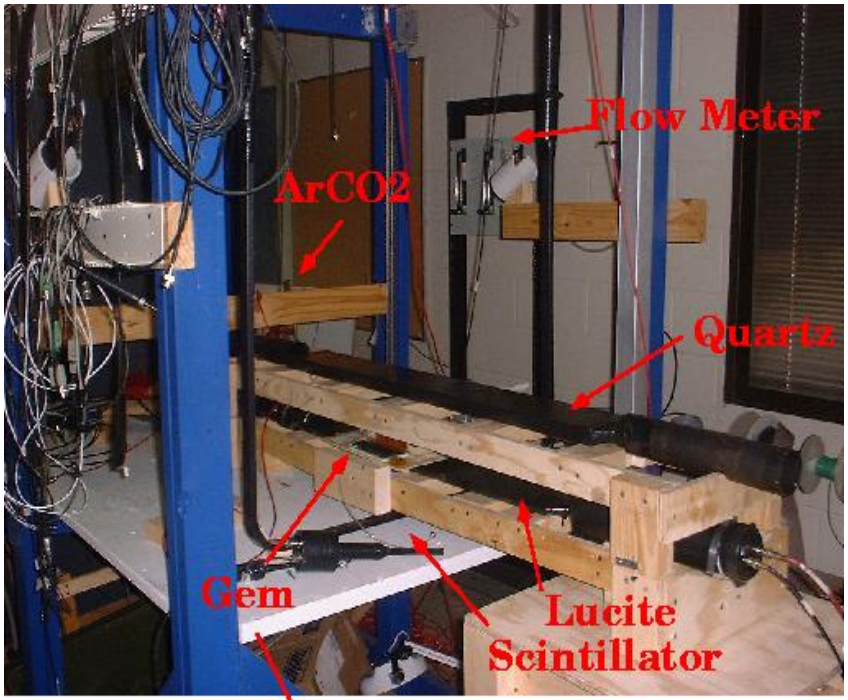
- Pitches and geometries are parameters
- Flexible design changes

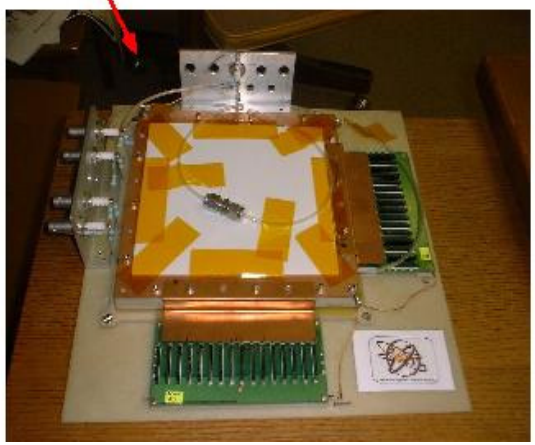


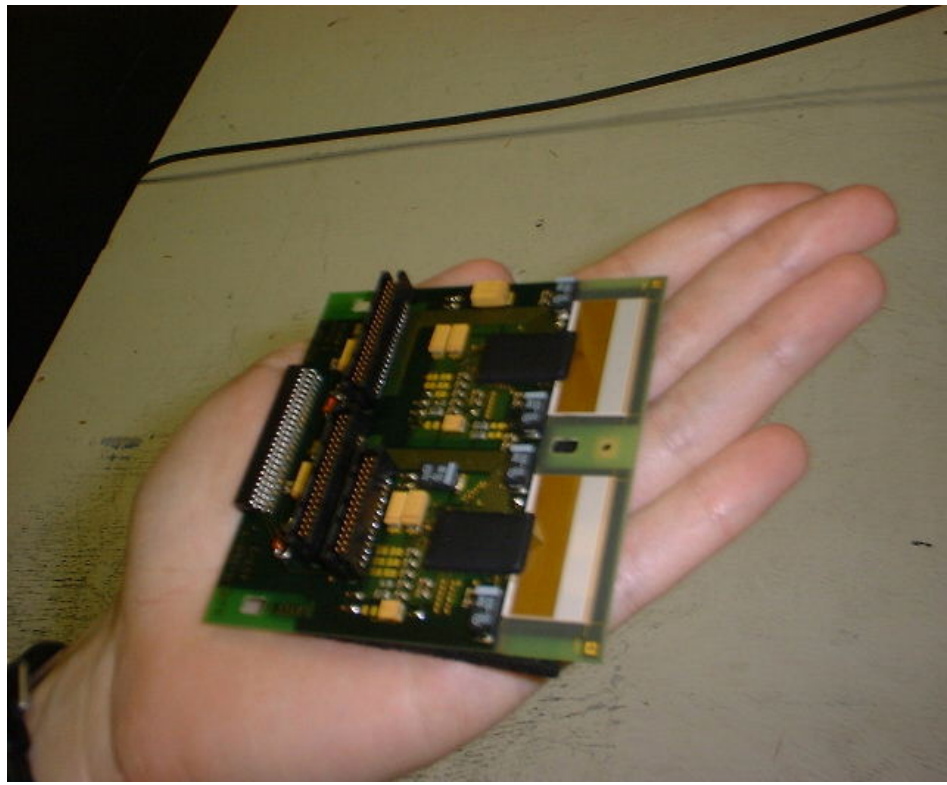




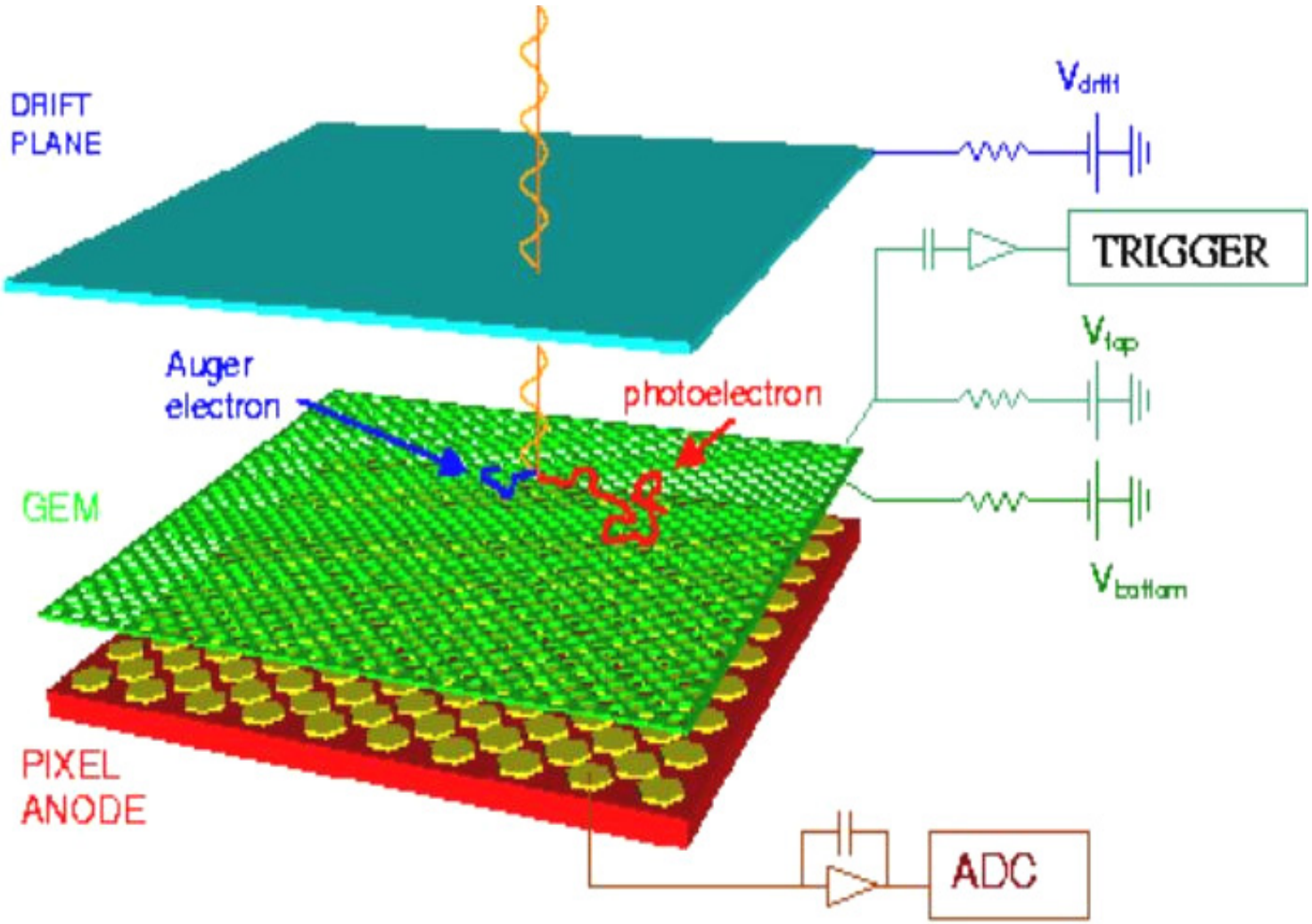
Prototype





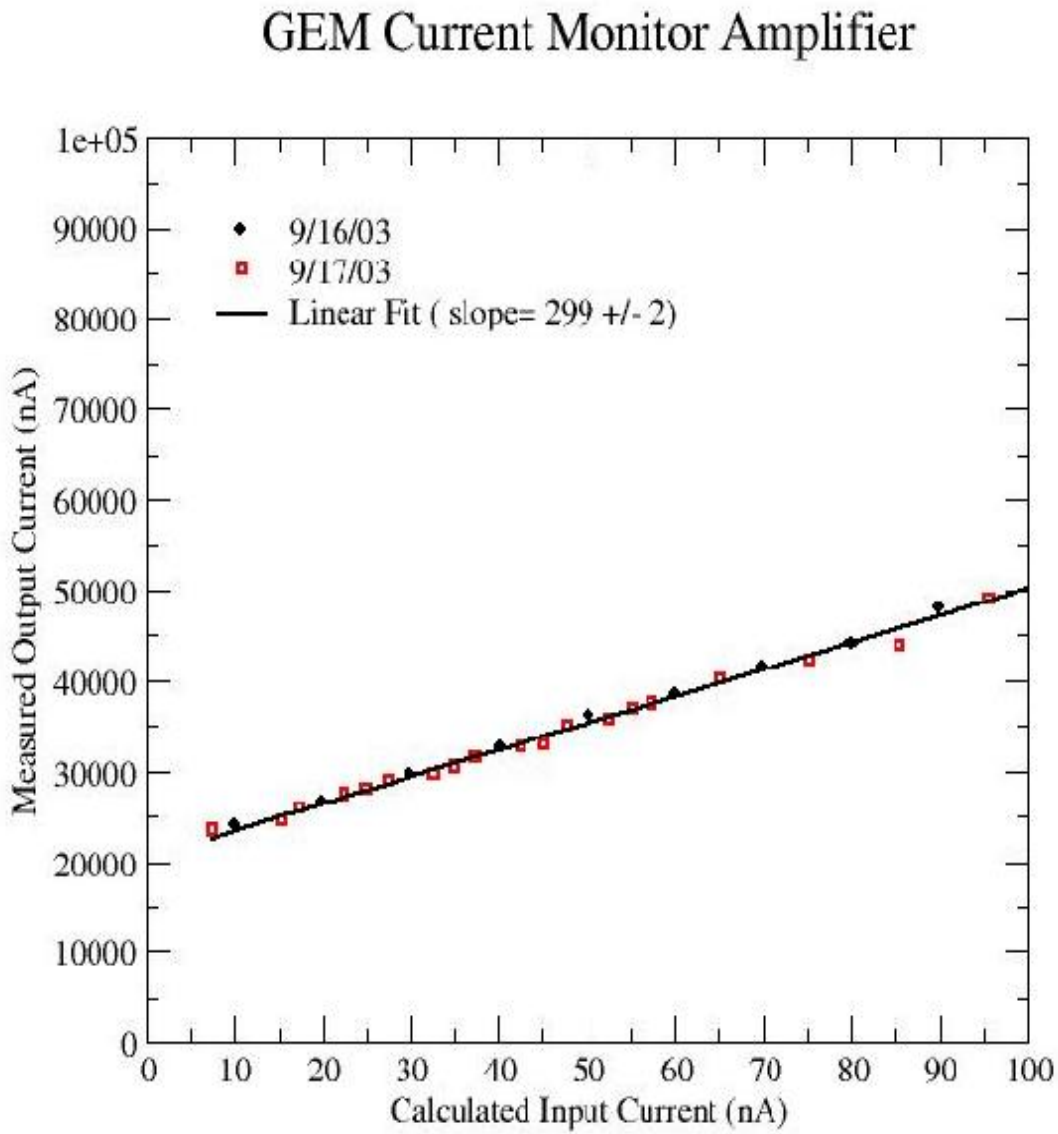


Trigger Electronics



R.Bellazzini , NIM A478, (2002)13-25

Power supply current Monitor

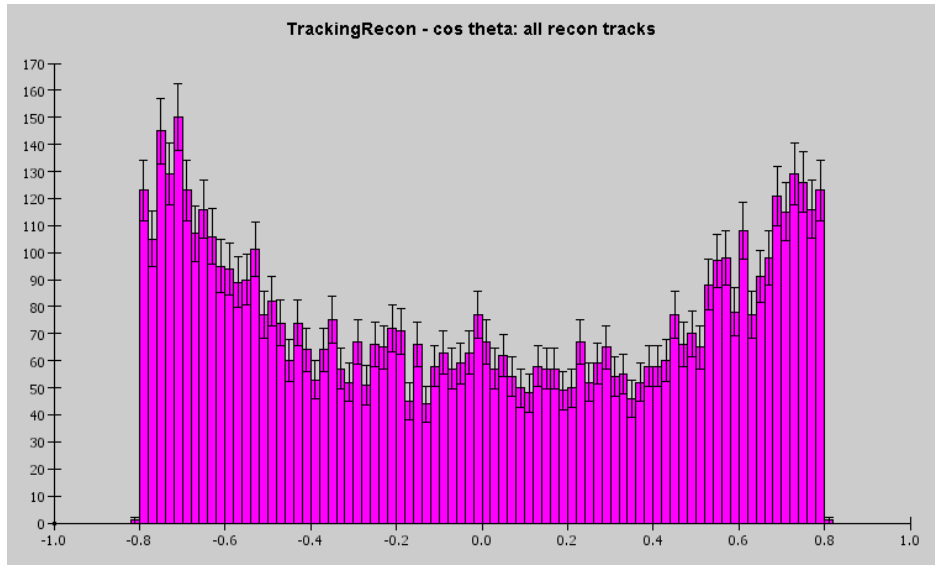


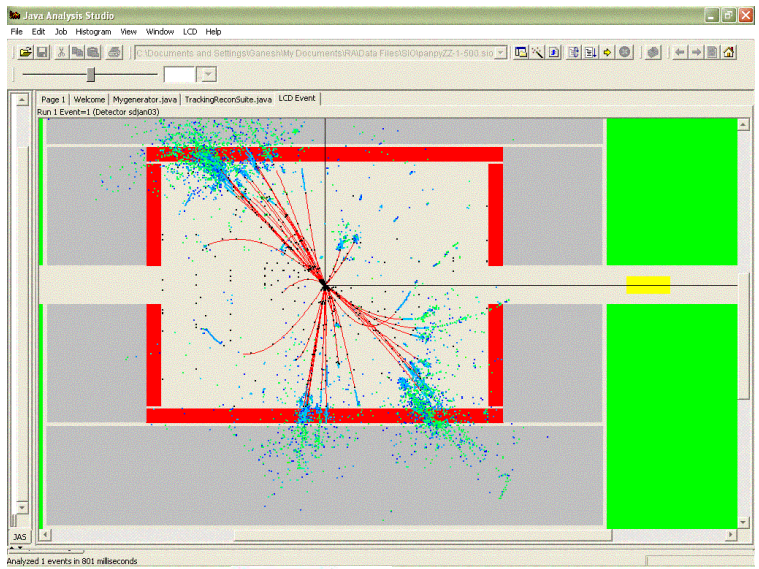
LC Simulations

- Less progress to report
- Have installed JAS2, copied SIO files from SLAC
  - Firewall issues prevented remote processing
- Attempts to install GEANT4 version of simulation failed
  - Current D0 simulation configuration is GEANT3+Linux
  - Tried to install GEANT4 in WinXP env.
    - Is documentation up to date?

JAS2 Results

- Mostly proof-of-principle at this point…
- Track reconstruction:
  - ZZ pair production
  - 500 events
- Event Display
  - Using hep.lcd plug-in
  - SD detector





Plans for the Coming Year

- Continue Work on GEM tracker design
  - LC prototype tracker in parallel development with QWEAK tracker
    - What are the unique design consideration for the FCH? (Timing for bunch separation? Rate?)
  - Cosmic tests of prototype tracker by 2005
  - Beam tests at JLAB in 2006?
- Ramp-up simulations work
  - Closer collaboration with other forward tracking groups (OK, Hampton, UCSC)