FORWARD DRIFT CHAMBER DETECTOR REVIEW

Outline:

- *Subsystem Design*
- *R&D Issues*
- *Manpower*
- *Schedules (short + long term)*
- *R&D Work*
- *Failure Modes*
- *Budget*

Simon Taylor
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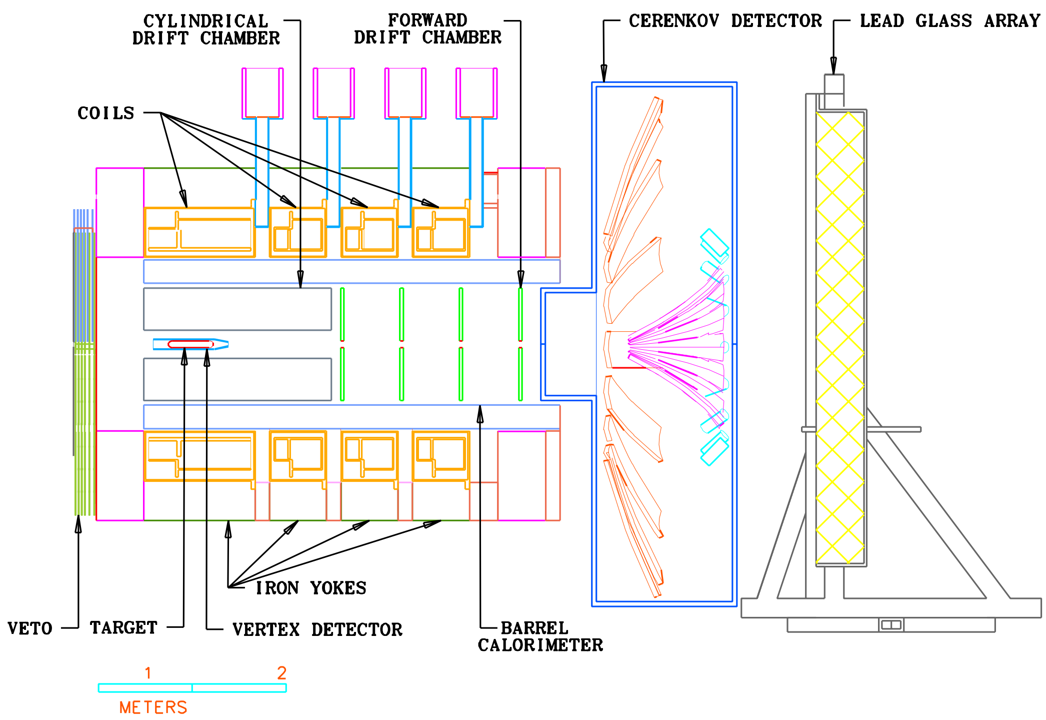
GLUE X CITATIONS PERIMENT

Forward Drift Chambers

- **Measure momenta of charged particle tracks emerging from the target up to 30° relative to the photon beam line.**



Preliminary Design

> Four separate packages

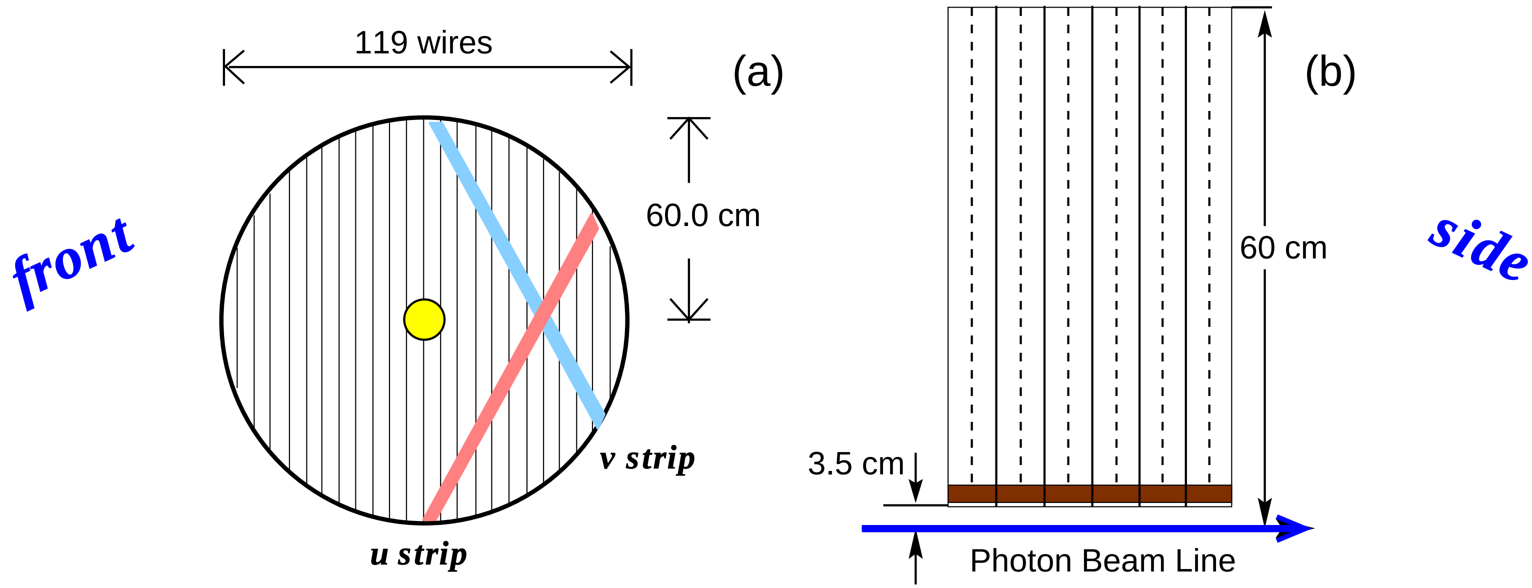
(equidistant along z)

> Package design:

- *6 planes of anode wires*
- *12 planes of cathode strips*

Goal: **Space points in each coordinate measured with ~150 micron resolution.**

Forward Drift Chambers



- **Neighboring chambers within package rotated by 60°.**
- **Total number of channels/package = 2142:**

  119 anode wires/plane x 6 planes = 714 channels

  238 cathode strips/ anode plane x 6 anode planes/package = 1428 channels

- **Total number of channels = 8568**
- **Readout: Anodes − 40 MHz F1 TDCs, Cathodes − 250 MHz 8−bit FADCs**

Cathode Strip Chambers

- The FDCs represent a set of MWDCs with cathode plane readout, referred to as cathode strip chambers or CSCs.

- CSCs are the most sensible choice for the FDC tracking system for the following reasons:

  - Large number of tracks with each track undergoing multiple spirals in solenoid ⇒ crucial that chambers provide good spatial resolution AND reasonable direction information to facilitate track linking.

  - Cathode chambers allow for 3-D space point reconstruction from EACH anode wire hit. This cannot be done with a single MWDC hit (provides only info in 2-D).

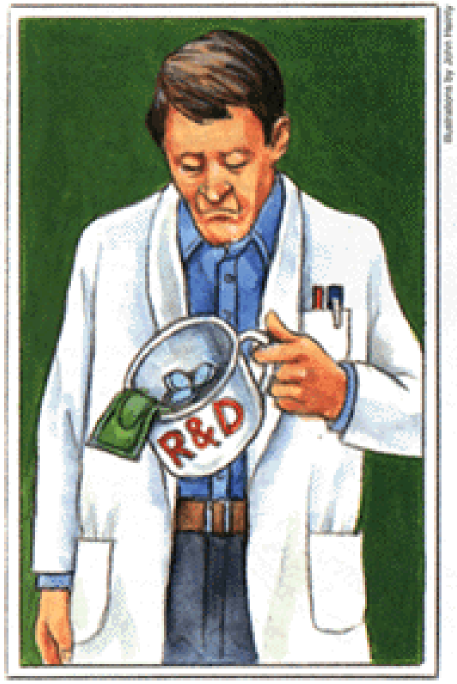
  - An MWDC stack (with x and y chambers) is better suited for straight tracks or curved tracks through a dipole field. Cathode chambers better suited for this purpose.

  - Cathode chambers typically allow for a higher resolution coordinate measure than an MWDC chamber. ($\sim 100 - 150$ μm vs. $\sim 150 - 250$ μm)

- Established technology used by several groups in HEP that generally have tighter resolution requirements and higher radiation doses than GlueX.
  - LHC groups: LHC-B, CMS, ATLAS
  - PHENIX, LASS, KVI, SSC

FDC R&D Issues

- Optimization of electrode configuration.
  Circuit board design.
  Mechanical support design.
  Optimization of gas choice.
  Performance in magnetic field.
  Performance in RF environment.
  Noise immunity.
  Manufacturing techniques.
  Strip−to−strip intercalibration.
  Pulse shaping and amplification.
  Radiation tolerance assurance.
  Gain monitoring.
  Mounting and alignment.
  Serviceability.
  Cable routing.
  Aging.



Manpower

- OHIO UNIVERSITY
  - *Daniel Carman*
  - *Simon Taylor*
  - *Rafail Yarulin (graduate student)*

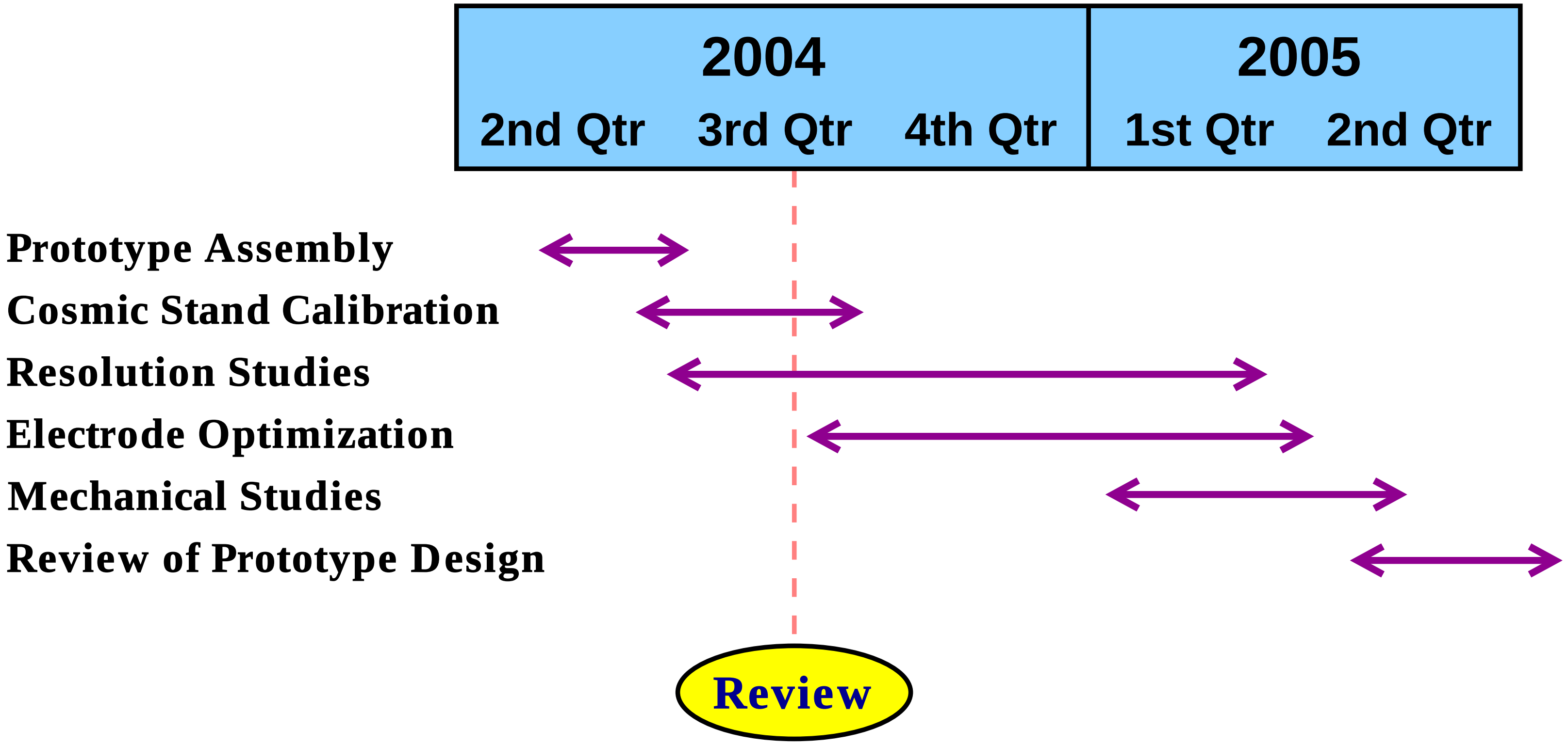
- TJNAF

** Key contributors **

- *Elton Smith, Elliott Wolin, Fernando Barbosa*
- *Detector−Meister Group: Stan Majewski, Brian Kross, Vladimir Popov, Benjamin Welch, Randy Wojcik*

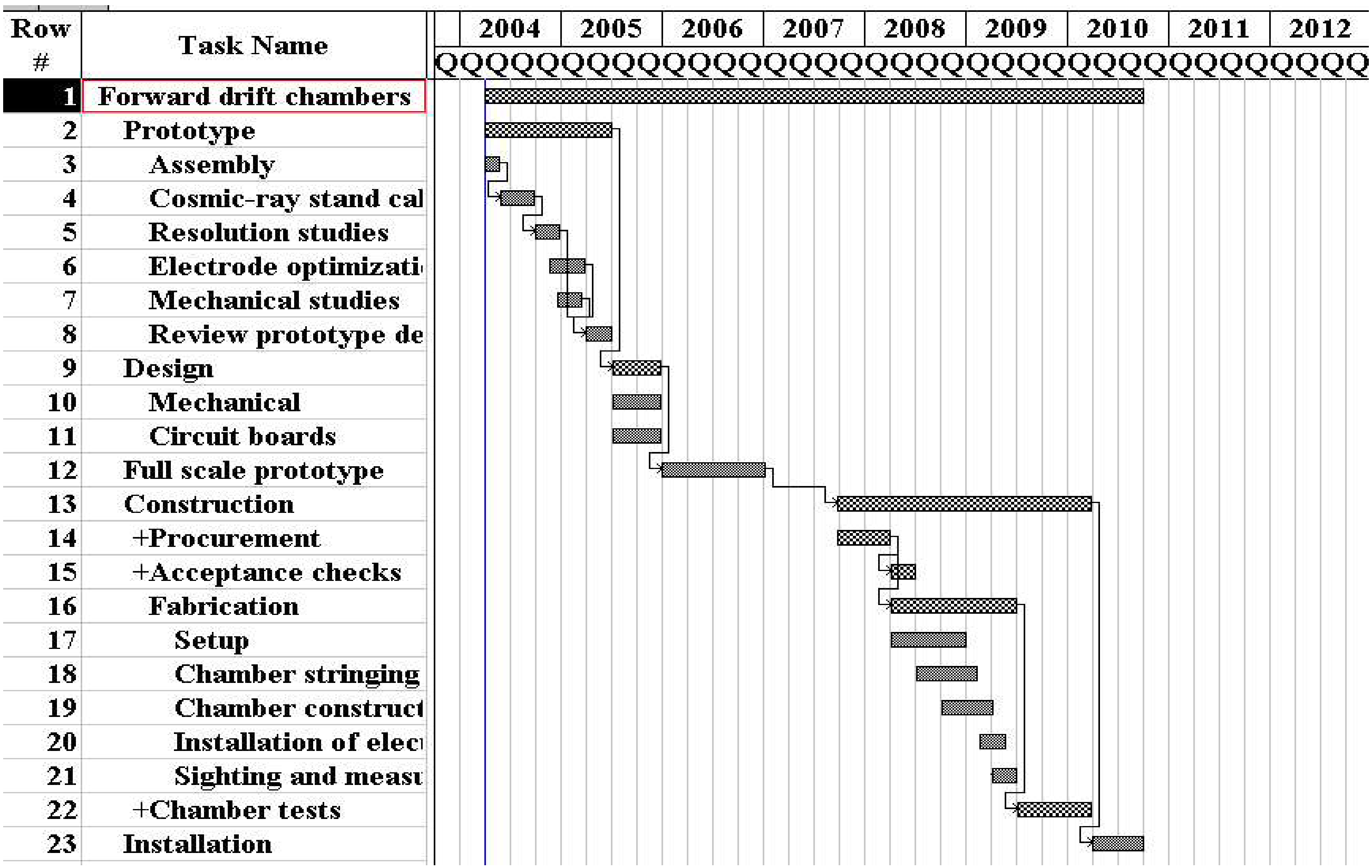
Detector−Meisters will help out with gas system, give advice on electronics, help design circuit boards, generate CAD drawings ...

Short Term Schedule

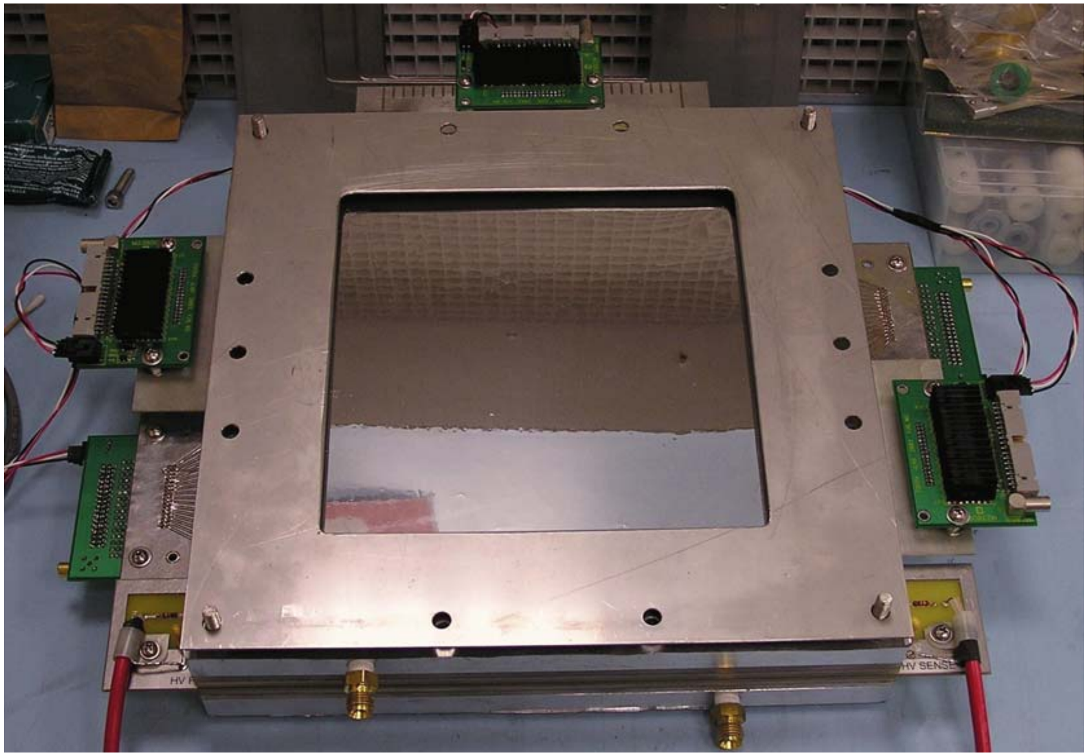


By the time of the review we should have a first−order number for the operational characteristics of our first prototype configuration.

Forward drift chambers timeline



FDC Prototype #1



Test bed for optimizing the wire plane and cathode plane electrode configurations.

- **1 anode plane consisting of 16 sense wires (10 mm separation) Second configuration with alternating anode and field wires.**

  → **Understand trade−offs between position resolution at cathode plane and timing resolution in the wire plane.**

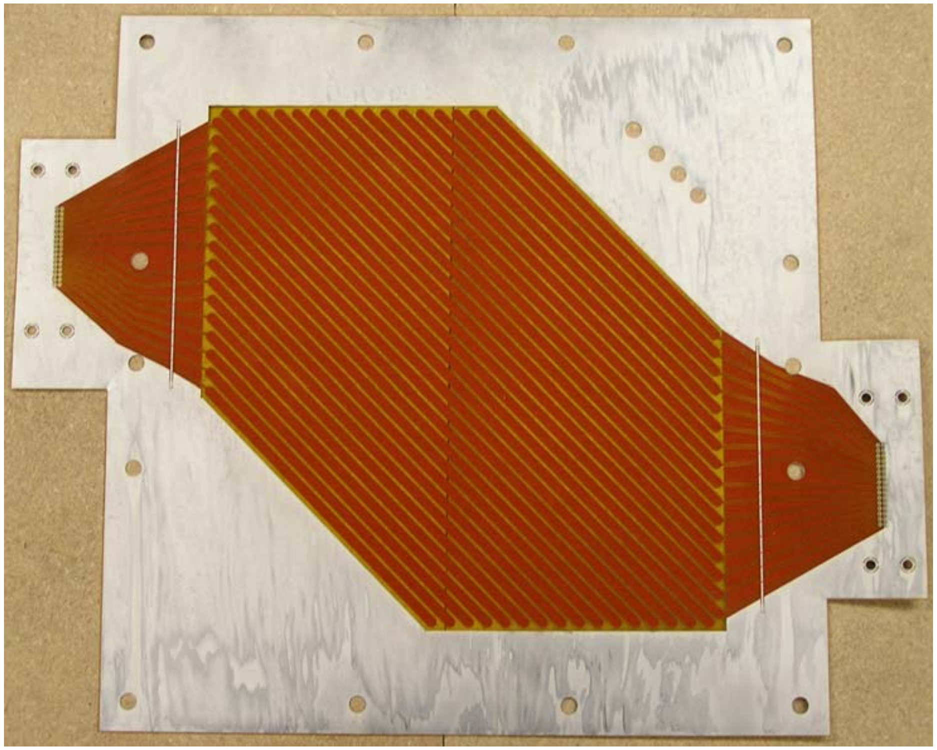
- **2 cathode planes oriented at 45° with respect to wires and 90° with respect to each other.**

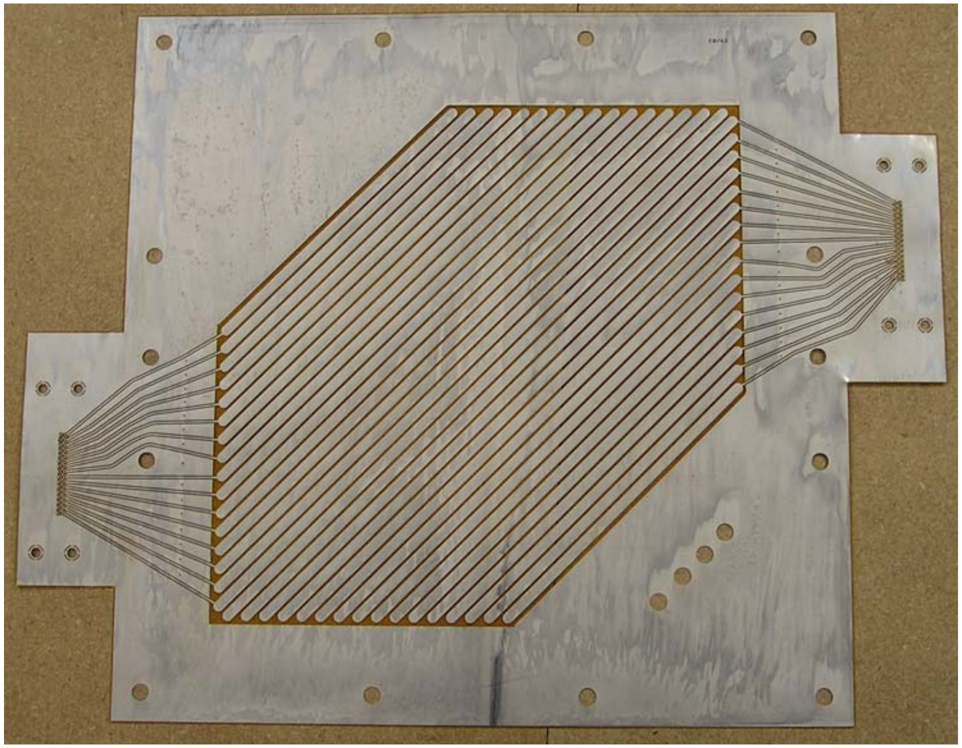
- **Signal routing circuit boards with SIP preamps (CLAS DC design).**

FDC Prototype #1

Cathode Planes

Aluminized kapton, 32 strips, 5mm pitch, dielectric thickness = 50 μm





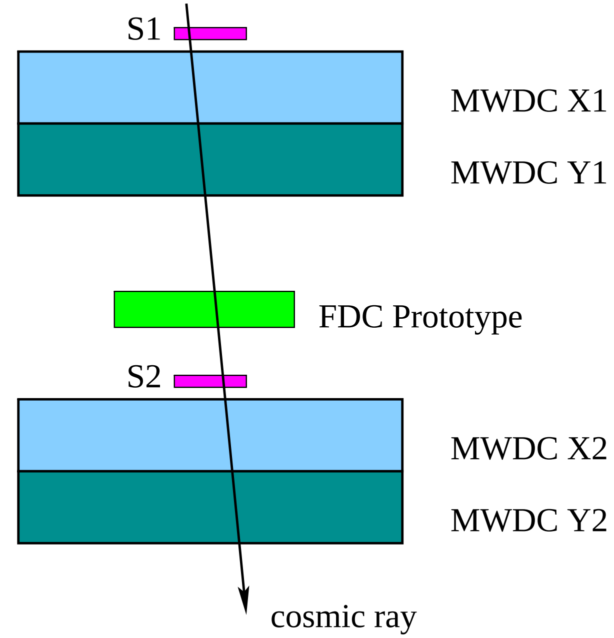
Several cathode planes designed: strip separations = 0.25, 0.50, 1.0 mm

FDC Test Plan

- **A full and complete test plan for the FDC prototype has been posted as GlueX Note #68.**

  - **Prototype Assembly**
    - *chamber cleaning*
    - *wire plane stringing*
    - *electronics mounting*
    - *stack assembly*
  - **Bench Testing**
    - *short checking*
    - *gas flow*
    - *HV plateau*
    - *gas gain measurements*
    - *noise measurements*
  - **Resolution Studies**
    - *cosmic−ray telescope*
    - *single track resolution*
    - *two−track resolution*
    - *electrode configurations*
    - *cross talk measurements*
    - *efficiency*
  - **Miscellaneous**
    - *magnetic field studies*
    - *wire deadening*
    - *RF noise pickup*
    - *alignment & positioning*
    - *internal chamber supports*

Cosmic Ray Telescope



Purpose: Define tracks with ~200 μm resolution at FDC position.

- **Trigger: coincidence between top and bottom scintillator paddles.**

  Coincidence logic in NIM electronics.

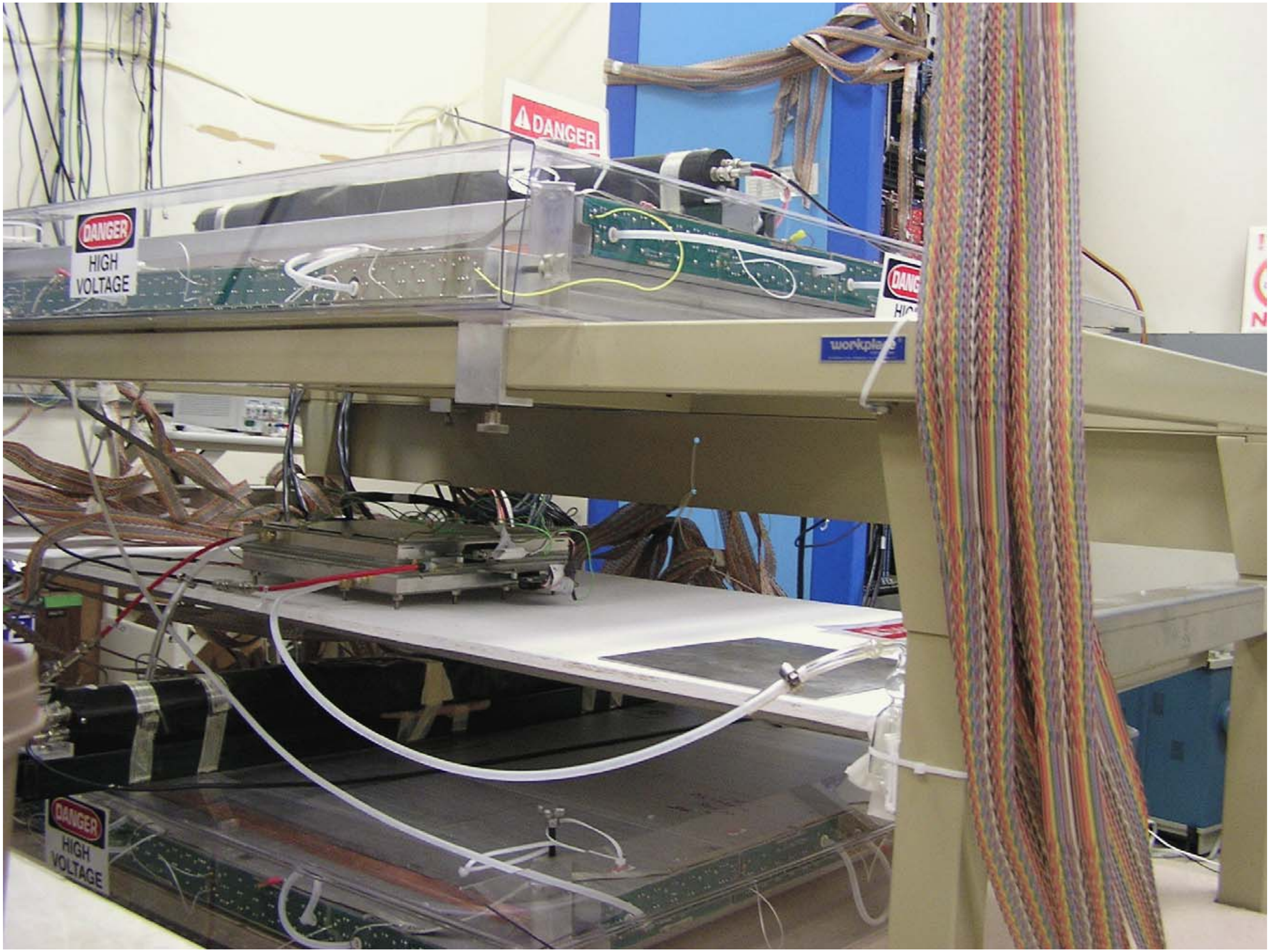
- **Cosmic ray test chamber anode signals amplified and discriminated by chamber−mounted LeCroy 2735DC boards with adjustable thresholds.**

  Timing signals read out with LeCroy 1877S multi−hit FASTBUS TDCs.

- **FDC prototype signals amplified by VPI postamplifier set to minimum gain.**

  Anode signals discriminated by LeCroy 3412E and digitized by 1877S TDC.

  Cathode signals to be read out with LeCroy 1881M FASTBUS ADC.

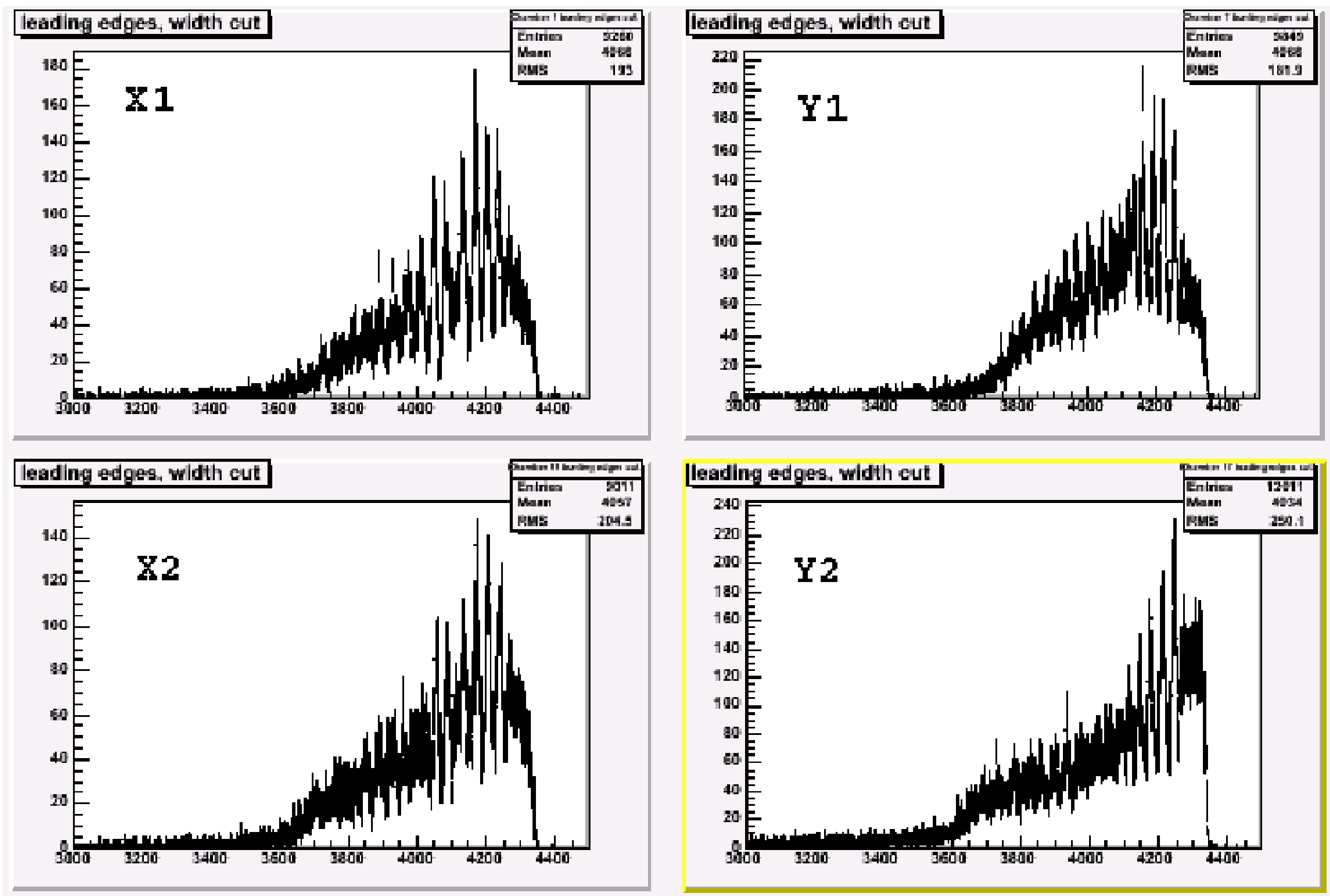


DANGER
DANGER
HIGH
VOLTAGE
workplace
DANGER
HIGH
VOLTAGE

Cosmic Ray Test Stand Data

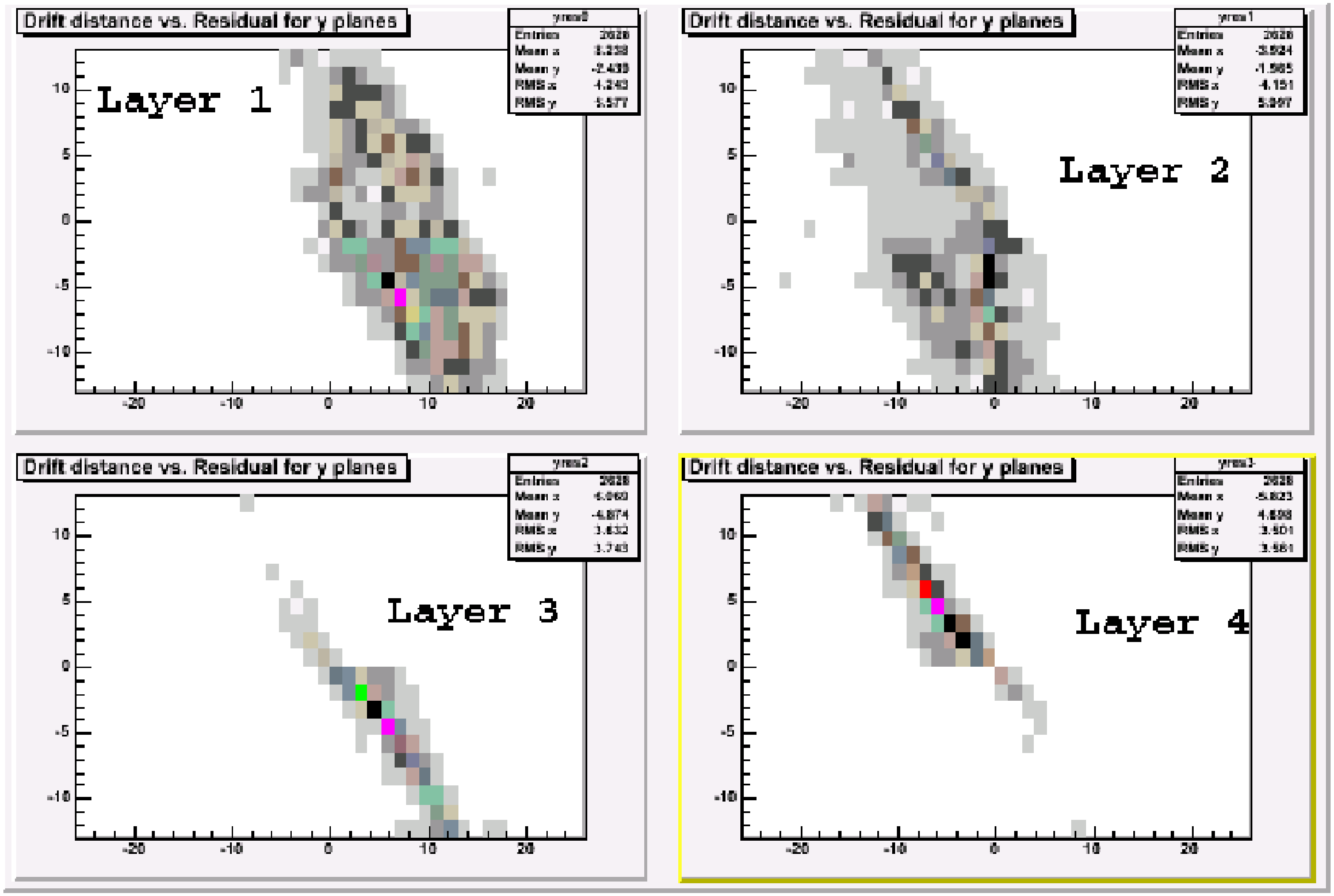
Timing data

X1, Y1, X2 chambers at +2140 V, Y2 chamber at +2240 V.



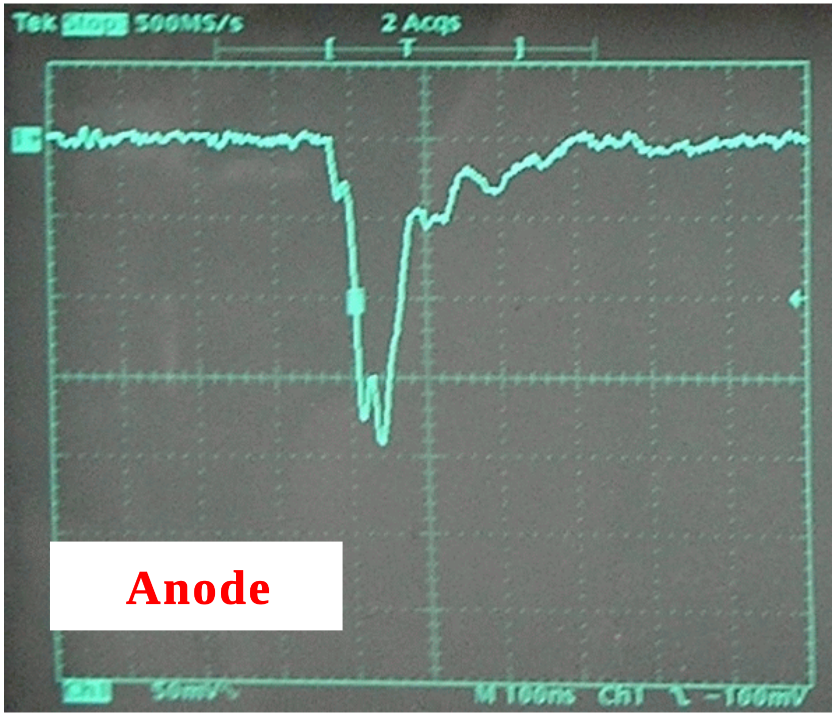
Cosmic Ray Test Stand Data

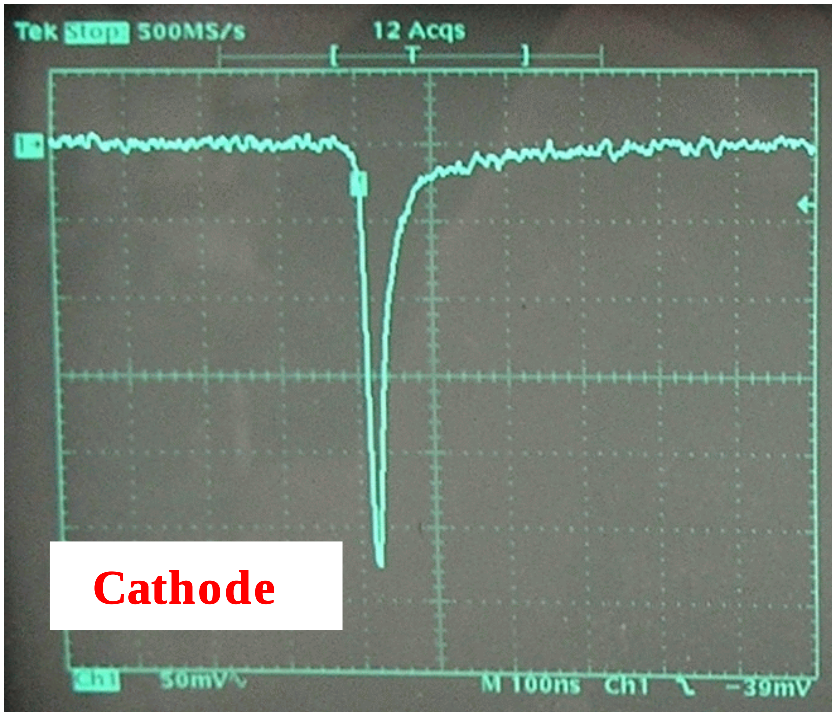
Tracking residuals



FDC Prototype Signals

Anode wires at +1.8 kV, field wires at ground.





100 ns/div **50 mV/div**

Preliminary Results and Status

- **Pulses seen on both the FDC anode wires and the cathode strips.**
- **Tracks defined through the cosmic ray telescope.**

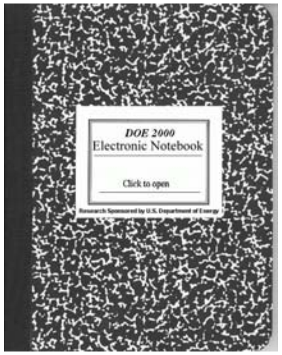
  TDC spectra suffer from periodic noise (~60 MHz).

  Cut very narrow timing pulses (< 20 ns)

  Crude time−to−distance calibrations are in place.

- **Following steps in our test plan.**
- **Latest developments can be found online in the FDC electronic logbook:**

http://www.jlab.org/htbin/PHYSICS/halld/enote112.pl?nb=notebook



FDC Prototype #2

- **In terms of detector prototyping, we foresee that at least two working chamber prototypes will be required to complete the FDC R&D.**

Prototype #2: **Main design issues include:**

(field uniformity)

> Mechanical design issues.

> On−chamber electronics design/layout.

Design work to commence in the late winter/early spring.

Other R&D: **− Full scale mock−ups for testing chamber mounting & alignment schemes + cable routing + installation.**

− Gas system design (detector group).

Monte Carlo Studies

Purpose: To find optimum configuration for FDC packages.

- Decide upon number of chamber packages (3 or 4).
- Find optimum z-positioning of packages.
- Find number of wire/cathode planes needed to meet design specifications for momentum and position resolution.

Recent studies (Mehmet Bektasoglu)

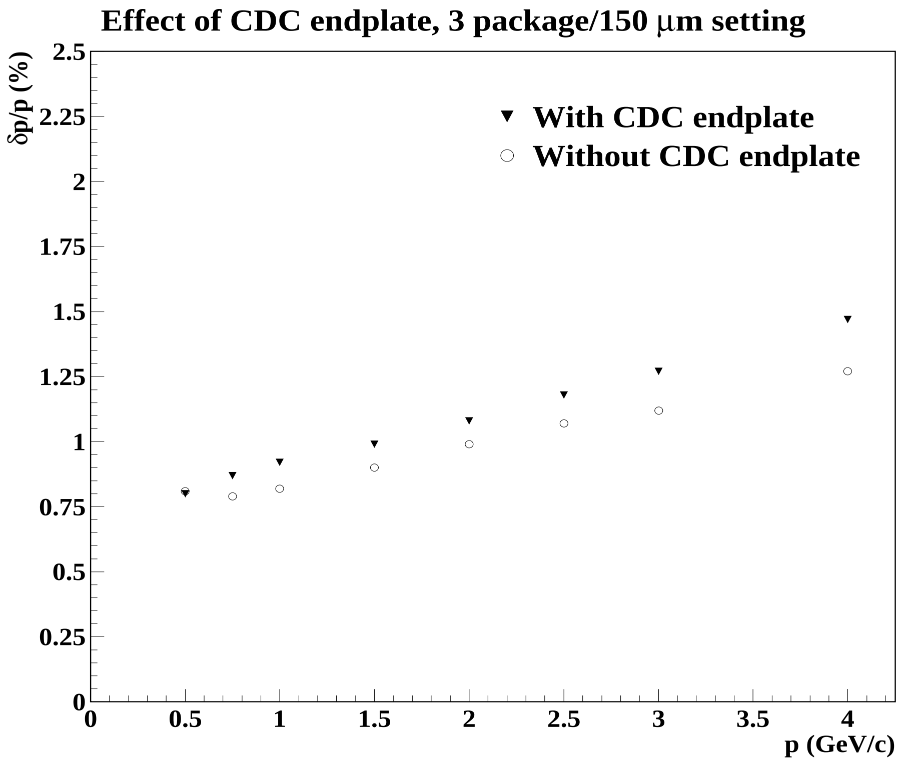
- Simulated tracking elements in the solenoid field (B = 2.24 T) using HDFast.
- Generated 1000 π^+ tracks for 9 different momenta (0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0 GeV/c)

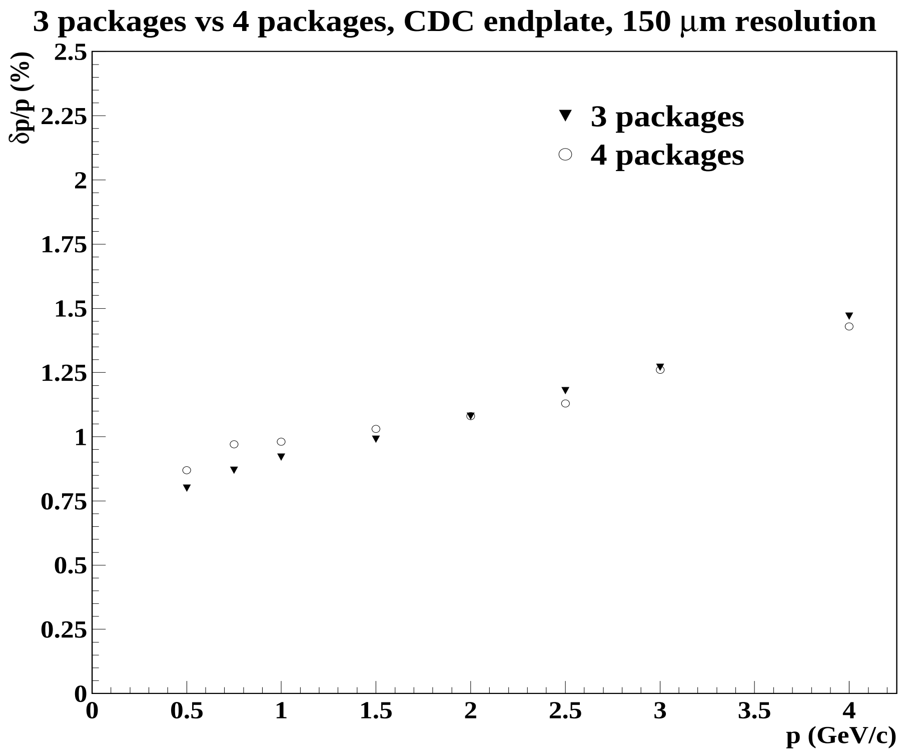
$$5^\circ < \theta < 10^\circ$$

- Measured $(P_{generated} - P_{simulated})/P_{generated} = \delta P/P$ for each momentum bin.
  - Studied different FDC resolutions (10, 150, 200, 500, 1000 μm).
  - Studied different number of FDC packages (3 or 4).
  - Studied effect of 1-cm thick Al CDC end-plate.

Monte Carlo Studies

PRELIMINARY





- For 150 μm resolution setting, no significant difference seen between 3 packages and 4 packages (3 packages marginally better near 1 GeV/c).
- For 150 μm resolution/3 package setting, presence of CDC endplate worsens momentum resolution by $\sim 10 - 15\%$.
- Need to revisit simulation

  Understand HDFast settings (multiple scattering, etc.).

  Study z-positions of packages.

Chamber Failure Modes

- **An important design aspect is to understand potential chamber failure modes.**
  - **Understand impact on system operation.**
  - **Affect design to minimize impact.**
  - **Minimize access time to system within solenoid.**
  - **Design must allow for access to critical detector components.**

Failure Modes

- ***Broken wires***
- ***LV transformer failure***
- ***Circuit board short***
- ***Preamp corrosion***
- ***High current draw***
- ***Cable disconnect***
- ***Increased noise***
- ***Swapped cables***
- ***HV disconnect***
- ***LV disconnect***
- ***Pinched gas line***
- ***Gas leak***
- ***Window tear/rupture***
- ***Internal chamber short***

FY05 R&D Budget

- **Crucial needs for R&D for the FDC system are coming up for FY05.**

Items for discussion:

> High voltage mainframe system or Bertans (\$15k−25k).

> Electronics − amplifiers, discriminators (\$5k−10k);
readout electronics (ADCs,TDCs) (\$15−30k).

> Low voltage power supply (\$2−3k).

> 1.2m diameter circuit boards (multilayer?) (\$5−8k).

> Scintillators, light guides, PMTs (\$5k).

> Construction, machining, materials, tools, jigs, misc. supplies, chamber wire (\$10k).

> Cathode planes (small,large) (\$10k).

Request: **Roughly \$60k for upcoming year.**

(with some obvious uncertainties)