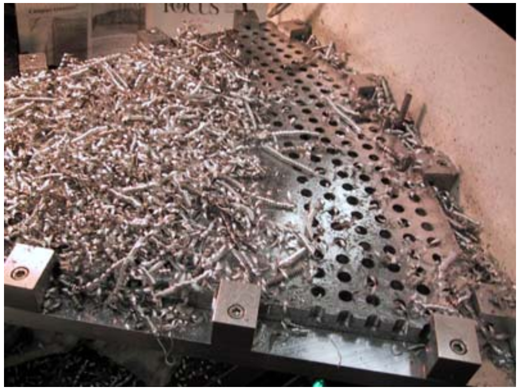
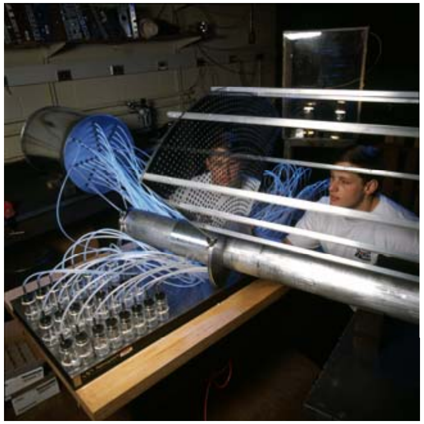
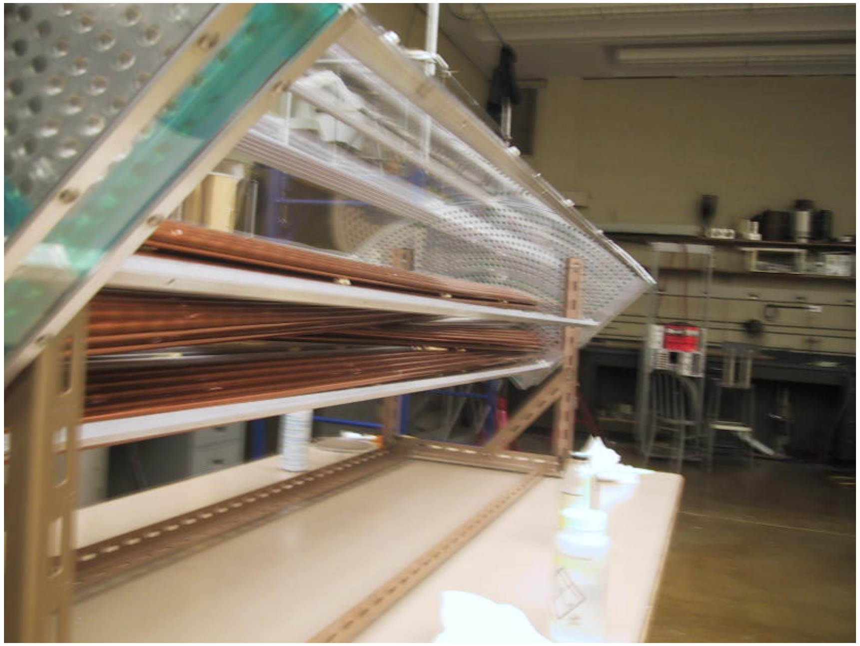
The GlueX Central Drift Chamber

Curtis A. Meyer, Carnegie Mellon University







Outline

Physics requirements for the CDC

The geometry and layout of the CDC

Resolutions & Backgrounds

Installation/Alignment

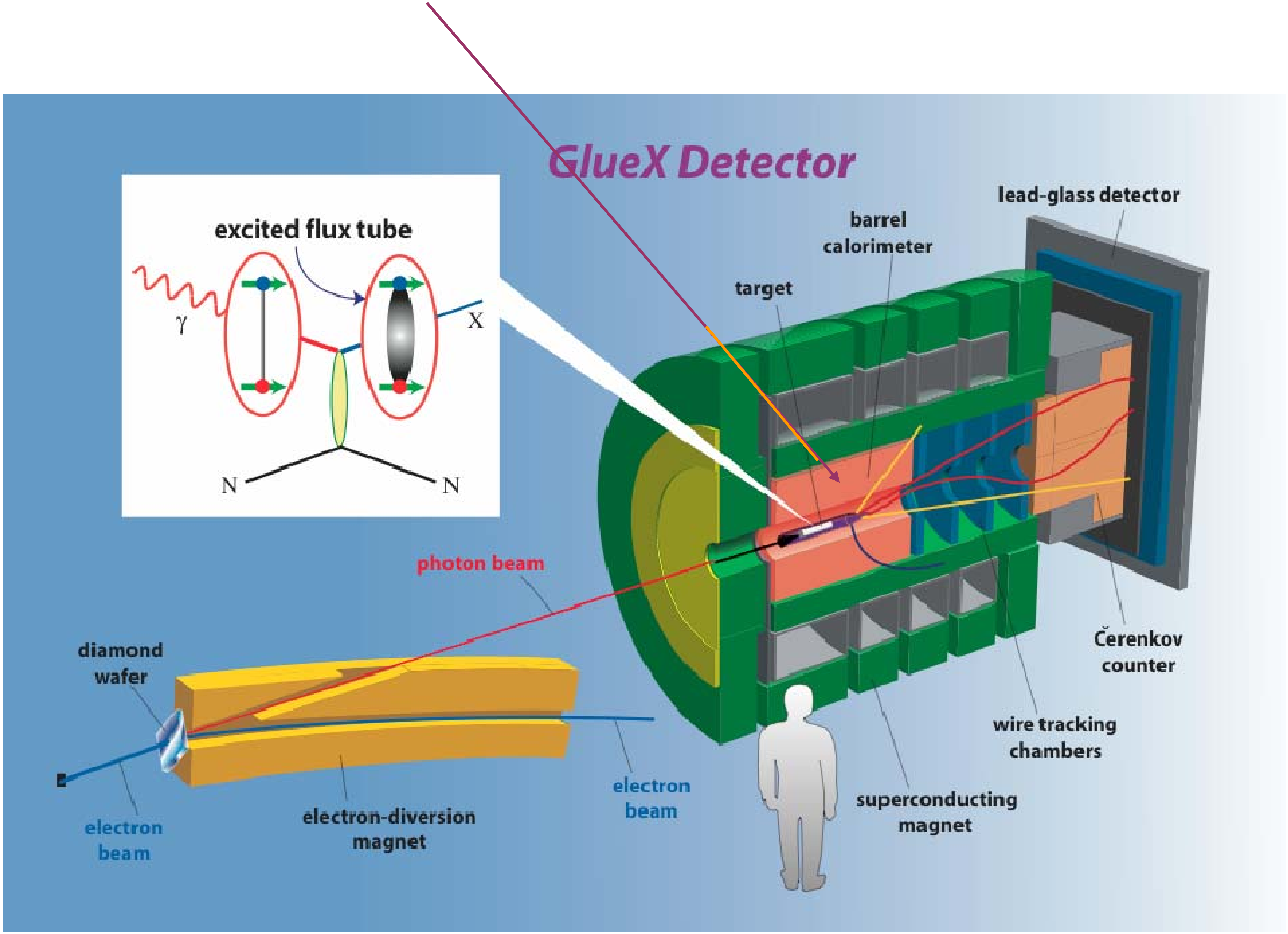
Construction of the CDC

The CDC prototype

R&D work to be completed

Summary

The GlueX Central Drift Chamber



Physics Requirements

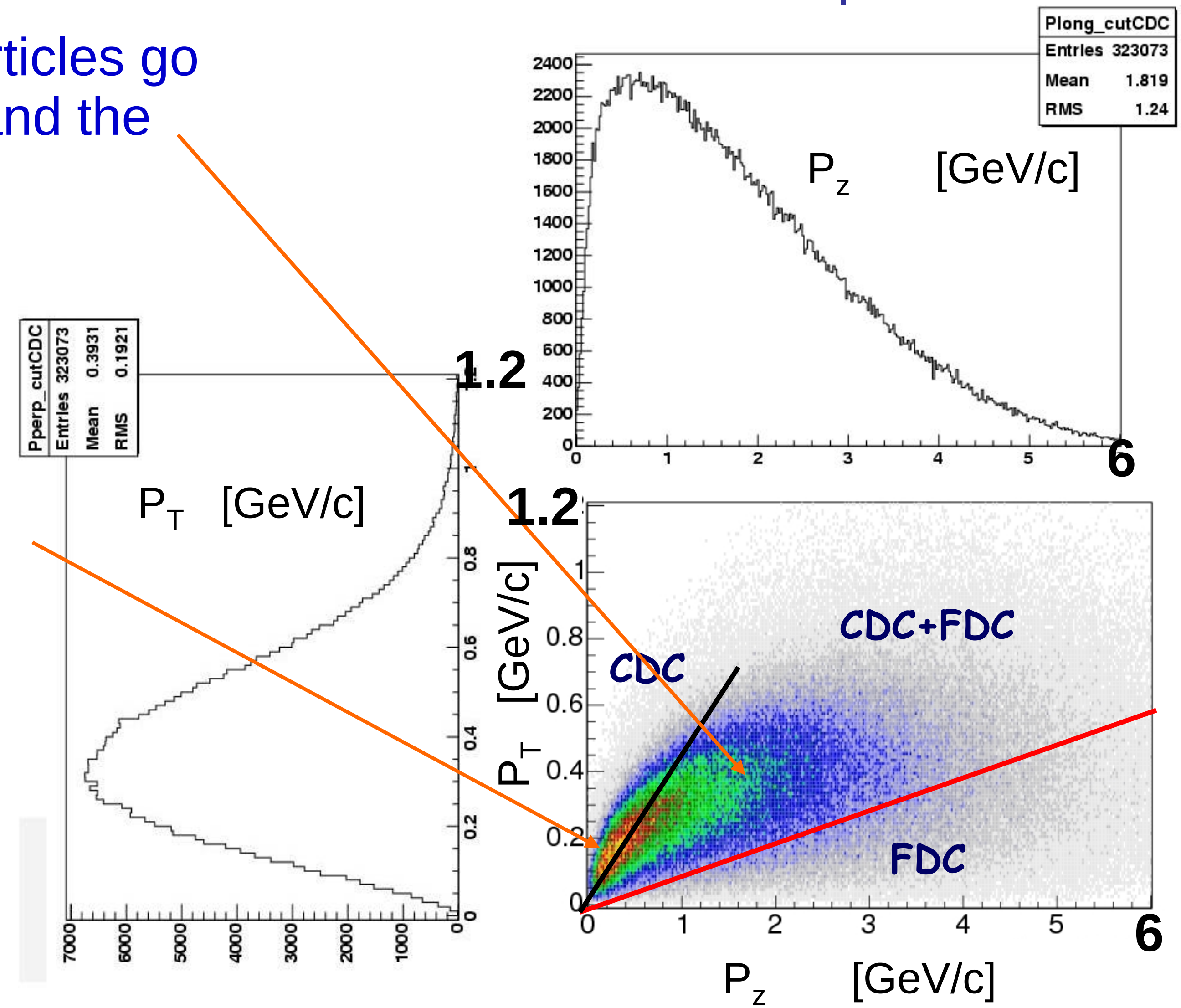
A typical exotic hybrid channel

$\gamma\ p \to \eta_1(1800)p \to 2\pi^+2\pi^-\pi^o p$

Most of the charged particles go through both the CDC and the FDC.

Pions in the CDC alone are typically slower. For slowest ones, dE/dx in the CDC is the only PID.

Momentum of pions



Chamber Requirements

To achieve the overall momentum and vertex goals of the experiment, the CDC needs to achieve:

$\sigma_{r\phi} \sim 150\ \mu m$ $\sigma_z \sim 2\ mm$

Stereo Layers $\sigma_z = \sigma_{r\phi} / \tan(\theta_{st}) \sim 1.4\ mm$

Down stream support wall needs to be as thin as possible. Most tracks go through the wall into the FDCs.

6 mm Al with Delrin feed through

Sweep time should be as short as possible ~600-700ns

Particle ID using dE/dx for $p \leq 450$ MeV/c (proton/ pion)

Electrostatics need to be very well understood and regular due to the large Lorentz Angle. (Straw Tubes nominally have excellent electrostatics).

Chamber Mechanics

In order to fully combine both the FDC and CDC for tracking, the material in the downstream end-plate of the chamber needs to be minimal.

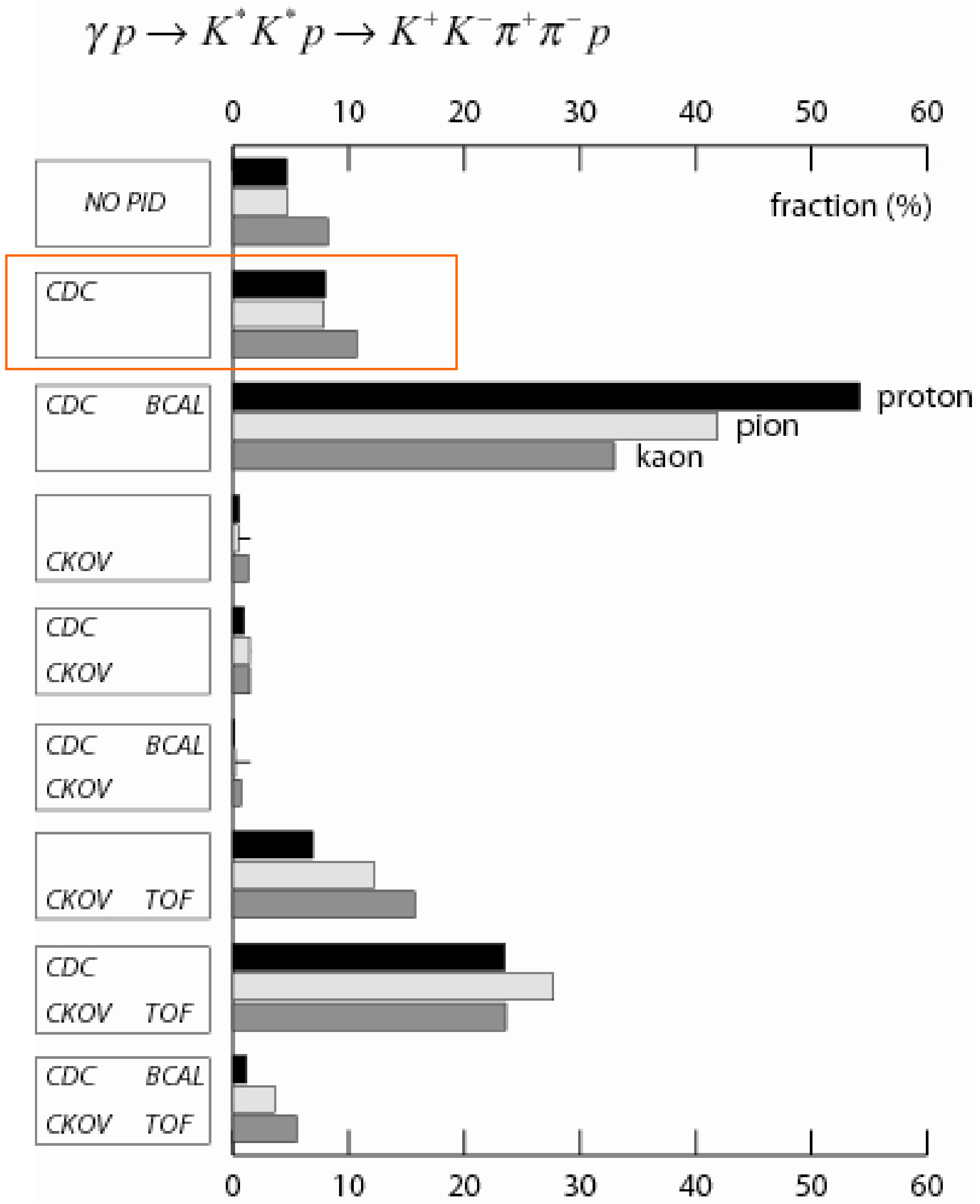
Sense wires: ~3300 ~50 gm tension 165 Kg

Straw tubes are sufficiently rigid to fully support this load.
Straw tubes provide very uniform electric fields
Garfield studies show that we can achieve the drift time limits.

Guard wire option: ~13000 ~200 gm tension 2650 Kg
Endplates and shells would need to be much thicker to support this! Probably more than 4 per sense wire to get a uniform field. Corners in the cells will produce large drift times.

Particle ID Systems

PID in the CDC is dE/dx.
This is the only PID for a small fraction of the tracks, all of which are low (under 450 MeV/c).

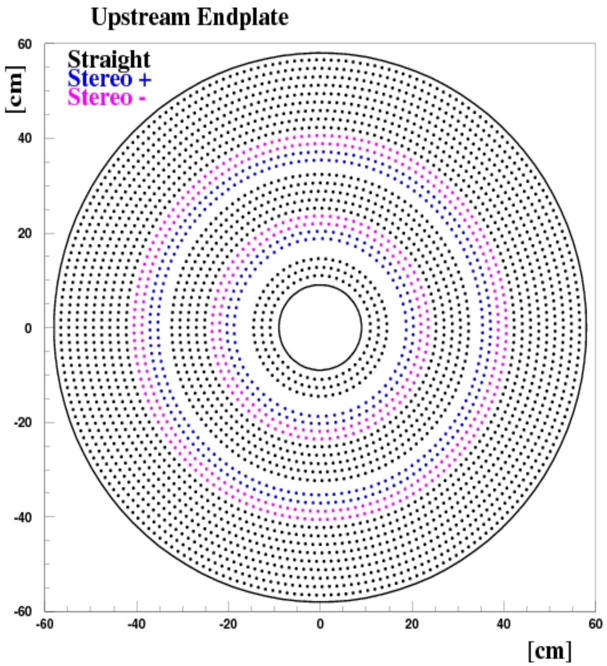


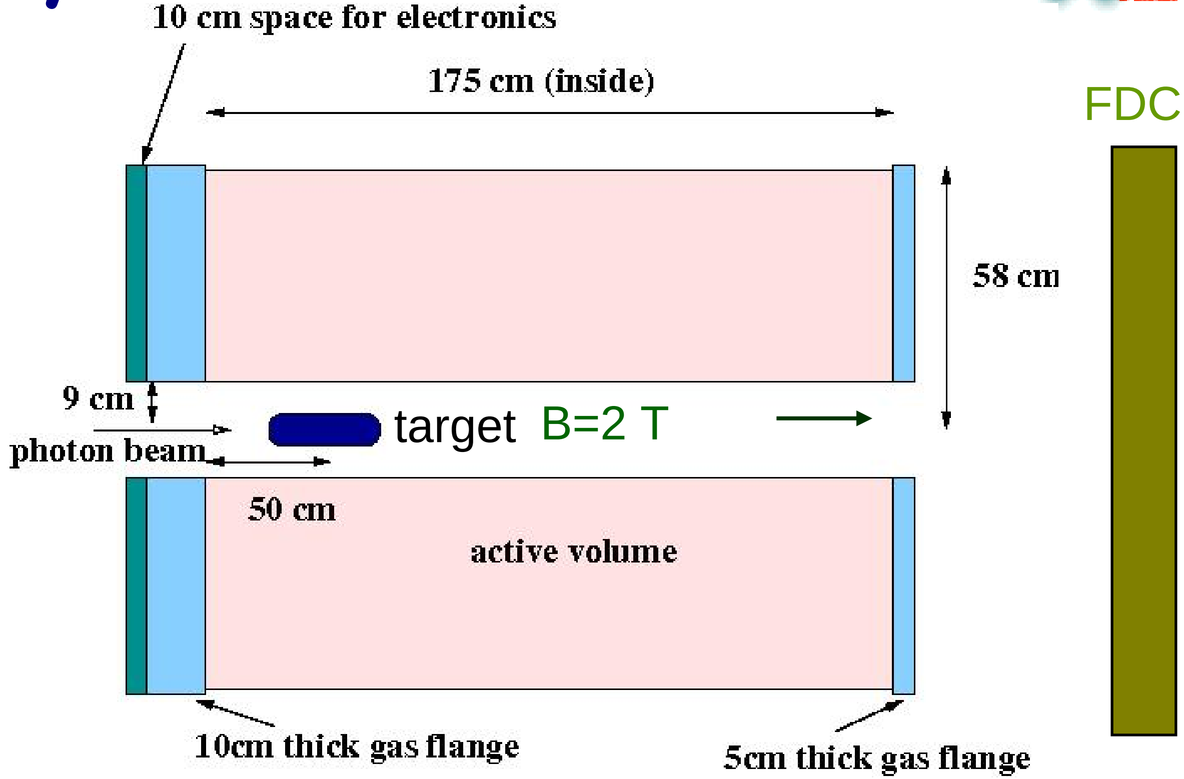
Path length (in straw tube) is the important correction.

<u>**dE/dx in Straw Tubes**</u>
JETSET: NIM **A367**, 248 (1995)
dE/dx at 10% resolution in straw tubes.

The CDC Geometry

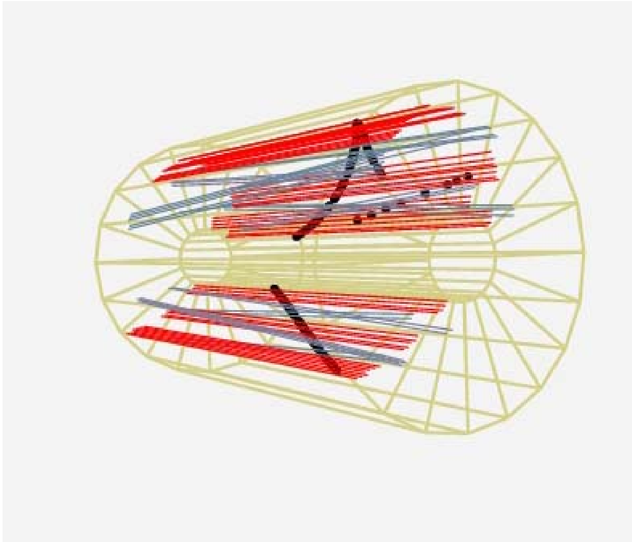
(not to scale)





25 radial layers of tubes
17 straight layers
4 +6º stereo layers
4 -6º stereo layers
~3200 channels

A straw-tube chamber



3 track in the chamber. Red tubes are straight, blue are stereo.

Chamber Geometry

Active Length: 175 cm
Radius of inner layer ~10 cm
Radius of outer layer ~58 cm

Straight Layers

Layer	Wires	Radius
1	43	11.0 cm
2	50	12.7 cm
3	57	14.5 cm
8	99	25.2 cm
9	106	27.0 cm
10	113	28.8 cm
11	120	30.6 cm
12	127	32.3 cm
17	166	42.3 cm
18	173	44.1 cm
19	180	45.8 cm
20	187	47.6 cm
21	194	49.4 cm
22	201	51.2 cm
23	208	53.0 cm
24	215	54.8 cm
25	222	56.5 cm

Stereo Layers

Layer	Wires	Radius	Angle
4	64	16.3 cm	+6
5	71	18.1 cm	+6
6	78	19.9 cm	-6
7	85	21.7 cm	-6
13	134	34.1 cm	+6
14	141	35.9 cm	+6
15	148	37.7 cm	-6
16	155	39.5 cm	-6

Straw-tube radius 0.8 cm
Straw-tube material 100 micron Kapton
5 micron Aluminum

Wires: 20 micron gold-plated tungsten
50 grams of tension
Tension load is carried by the straws.

Resolution

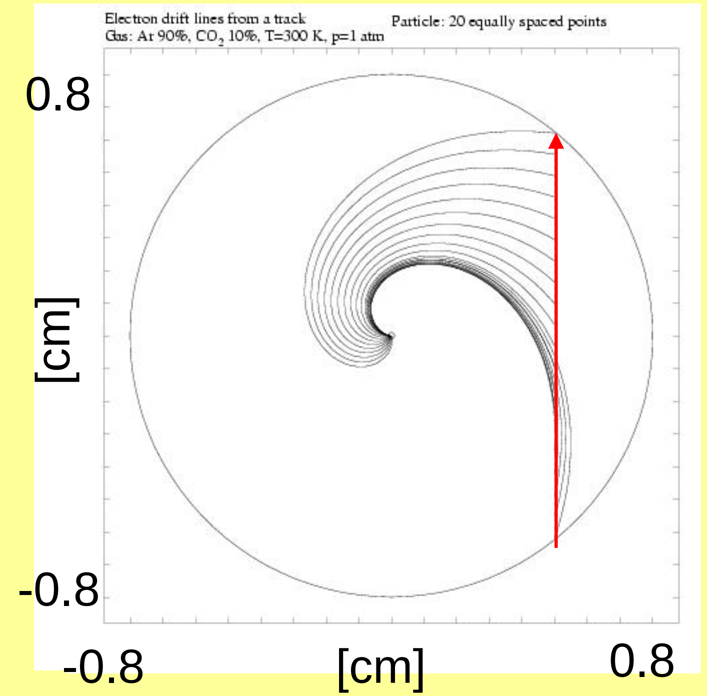
Contributions to Resolution

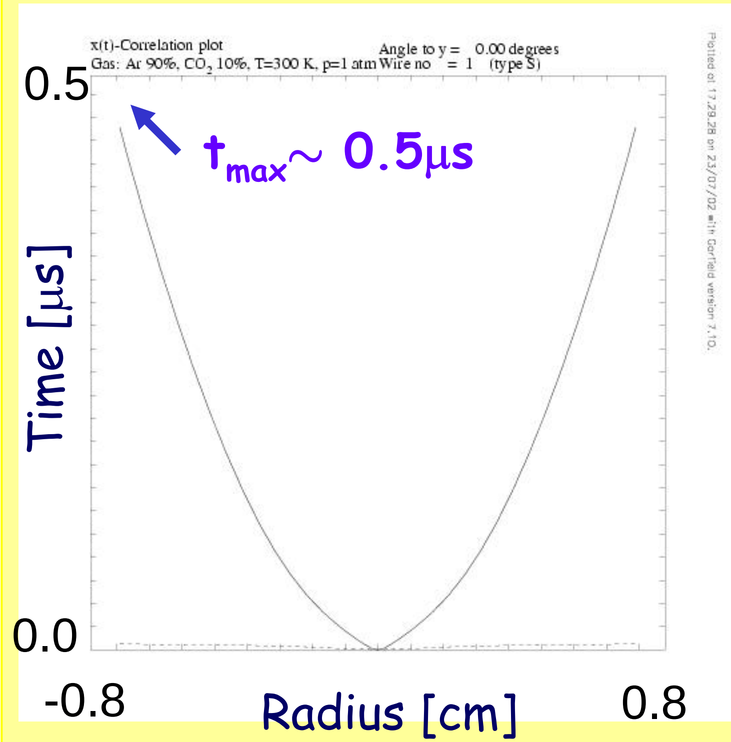
Geometrical Precision	40μm	
Gravitational Sag	56μm	
Timing Resolution	45μm	(2-3 ns)
Electrostatic Deflection	10μm	
Gas Diffusion	120μm	
Total	∼ 145μm	

We have a gas mixture that should work, but we would like to optimize this .

90-10 Ar-CO_2

If possible, we would like to use the same gas in both the FDC and the CDC. This is not required.

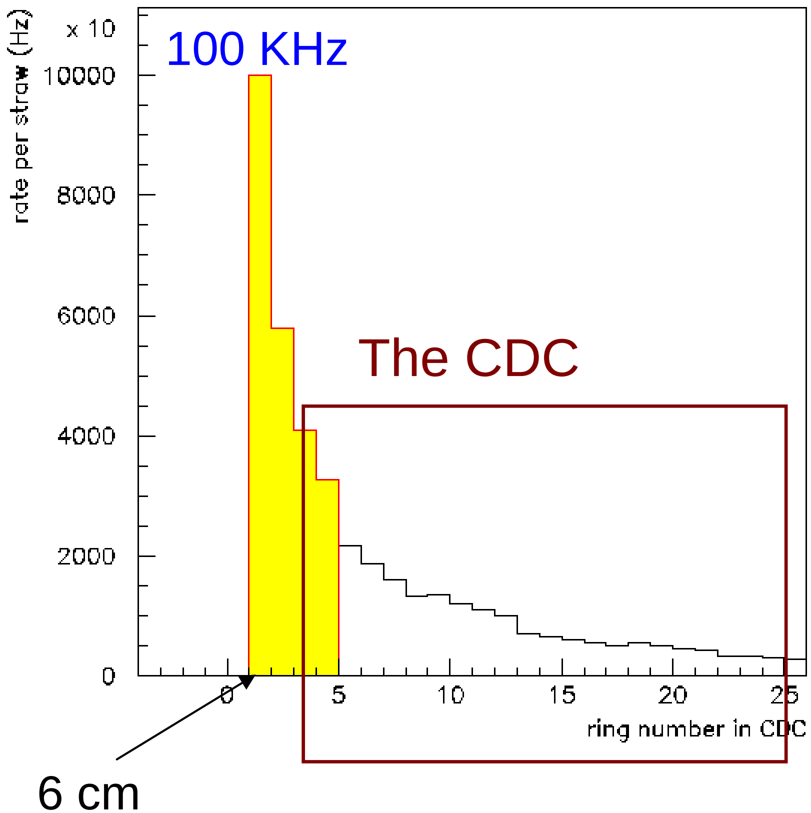




Background Rates

Electromagnetic background rates using the GEANT Monte Carlo and the highest beam rate. What is the average rate in a tube at a given radius (from the beam line)?

10^8 γ/s on target
600 ns time window



The radius of the innermost layer of tubes is limited by background rates.

~40 KHz per straw at 10.5 cm radius

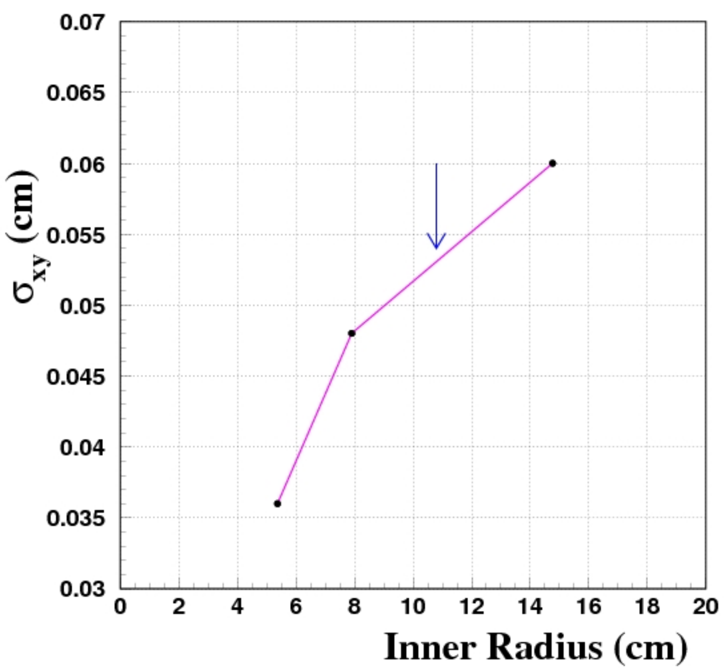
Background rates are not an issue for the innermost layers of the CDC.

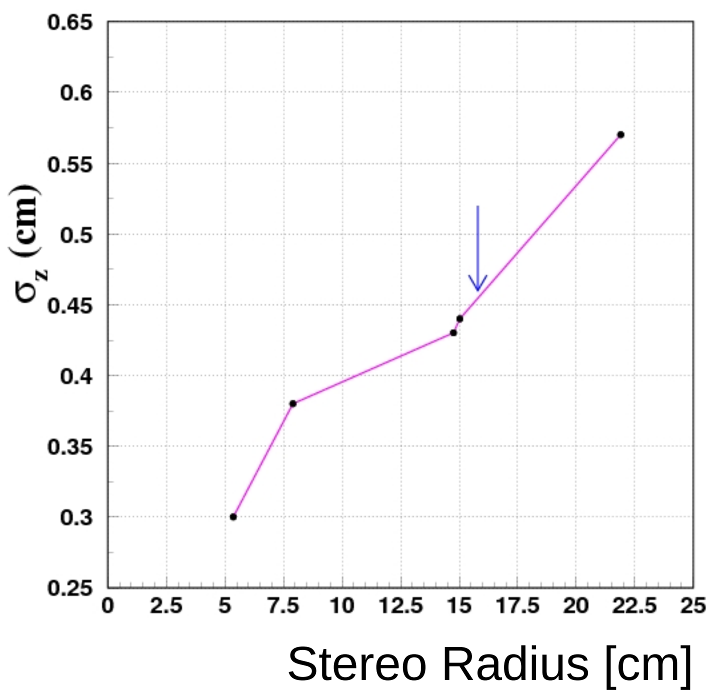
Vertex Resolution

Because of the z resolution is about ten times the x-y resolution, the z vertex will be less well defined. Nominally, z is driven by the radius of the stereo layers in the chamber.

Current Design Values: r_{min} = ~11 cm r_{stereo} = ~16 cm

$\sigma_{xy} \approx 0.53$ mm $\sigma_z \approx 4.7$ mm





Building the Final Chamber

Machine Endplates in industry
Acquire Shells
Machine Al and Delrin Donuts
Acquire Crimp pins
Acquire Straw tubes
Acquire Wire

Parts need to be spec'd, ordered and checked.

Tube building takes about 15 minutes per tube (1 person)

Tube installation takes about 15 minutes per tube (2 people)

Tube stringing takes about 15 minutes per tube (2 people)

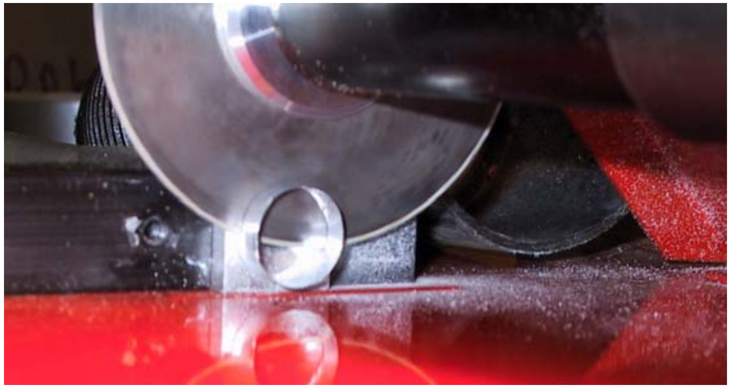
Electrical and gas hookup times are still not definitive.

3 to 3.5 year to build the final chamber

Building The Final Chamber

Select tube

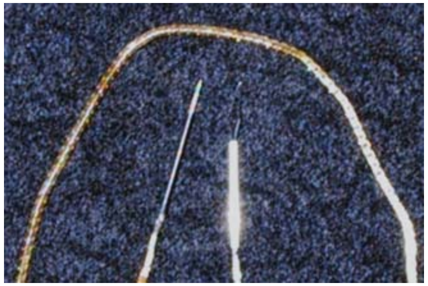
Cut to length



Glue donut

Glue in chamber

Magnetic Feeds



Pneumatic crimper

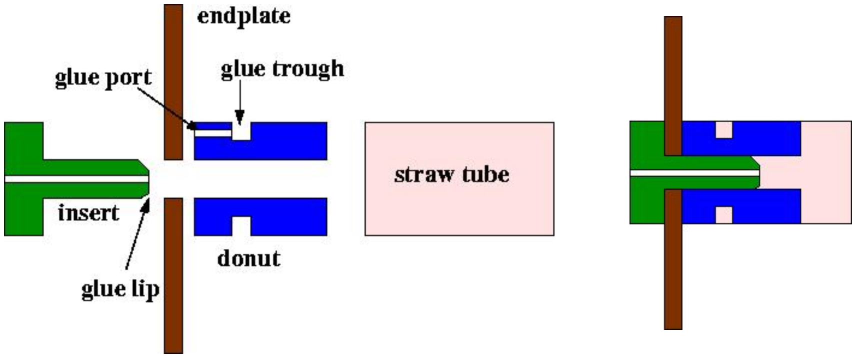
Vertical stringing

This slide shows Mylar tubes. The chamber will be built using Kapton.

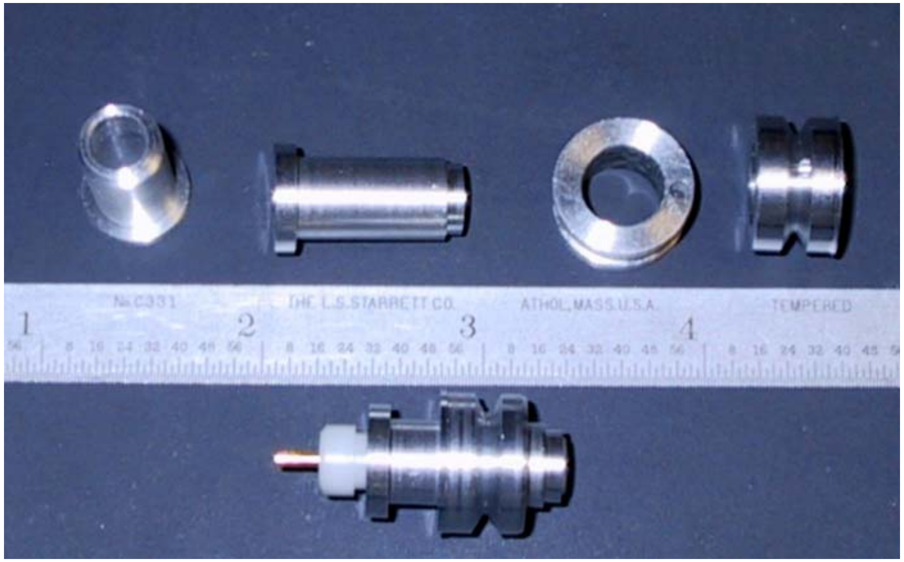
Gas Leaks

A problem with straw tube chambers is that the glue joints leak.

Designed, built and tested a feed through system that forms a solid glue seal.

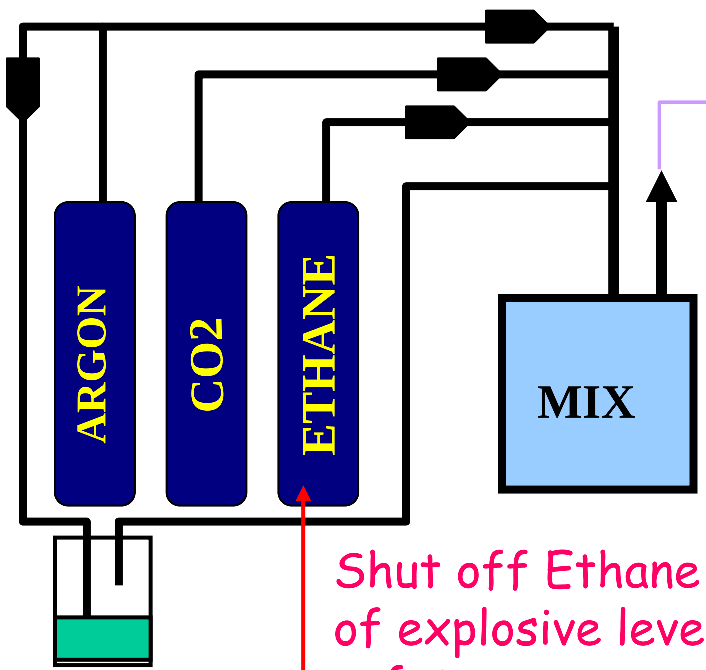


System has held several psi overpressure for nearly a year.



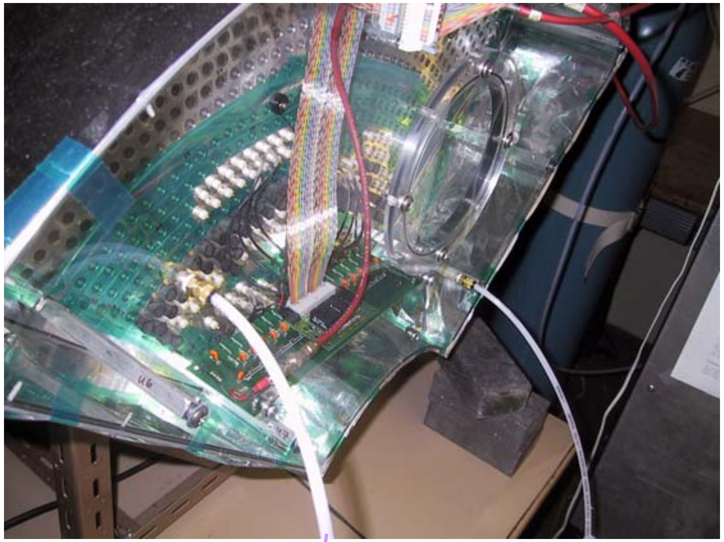
Gas System

Electronic Mass Flow



Shut off Ethane at 10% of explosive level for safety concerns.

Ethane Alarmed



Current Gas Mixture
90% Argon 10% CO_2

Flexibility in mixing up to three gases

Ability to bubble one gas through temperature controlled liquid

Filter all gasses.

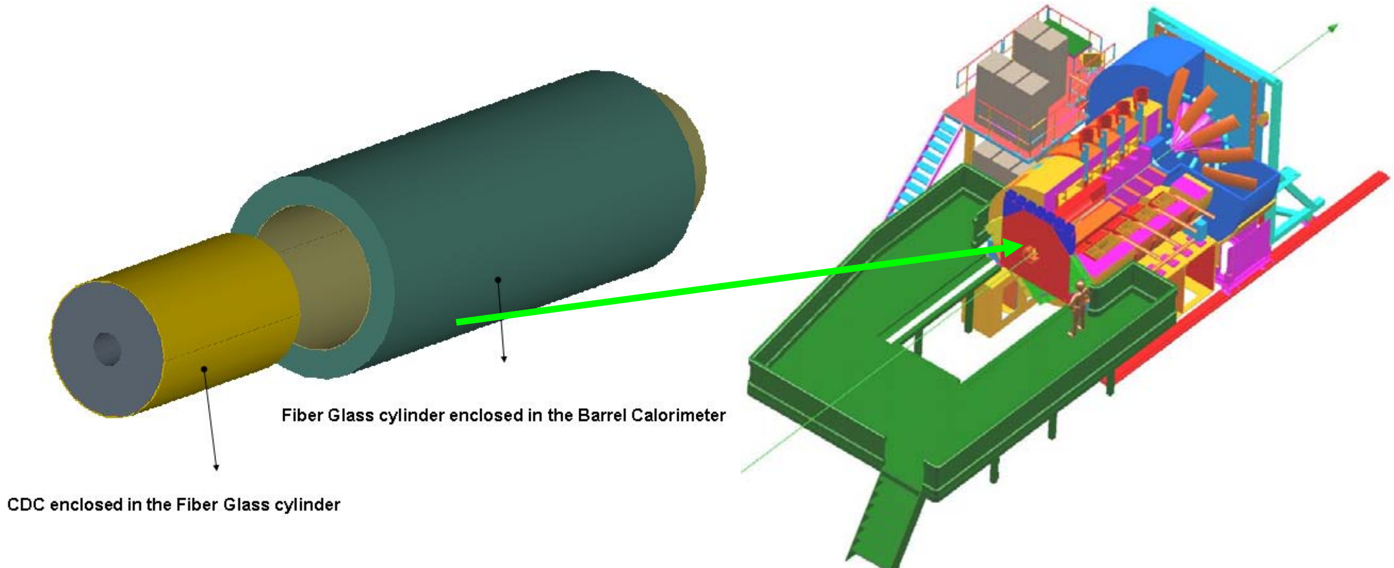
The exhaust gas will be discarded.

Temperature and pressure monitoring is needed to correct for gas density variations (velocity).

The gas system will have tanks of pure gas as input. It will then allow for three-component mixing.

Installation/Alignment

Chamber will ride on a pair of rails mounted inside the Barrel Calorimeter. Insertion and Extraction from the up-stream end of the detector.

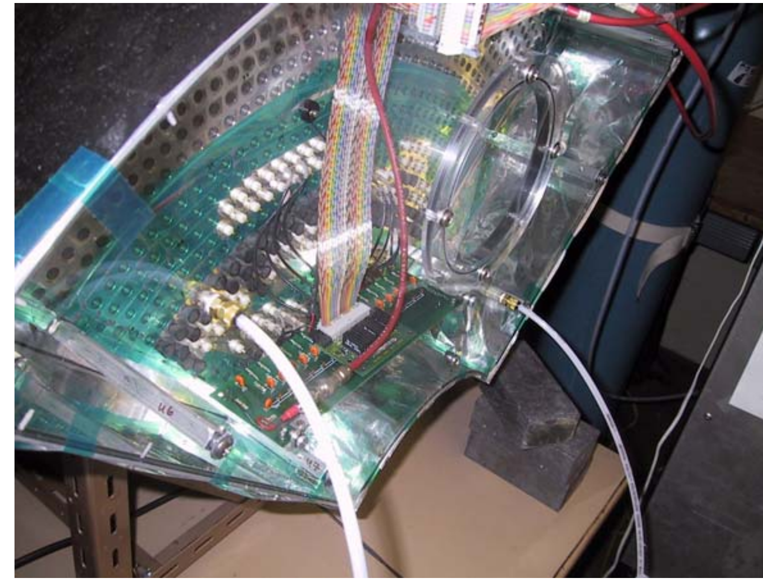


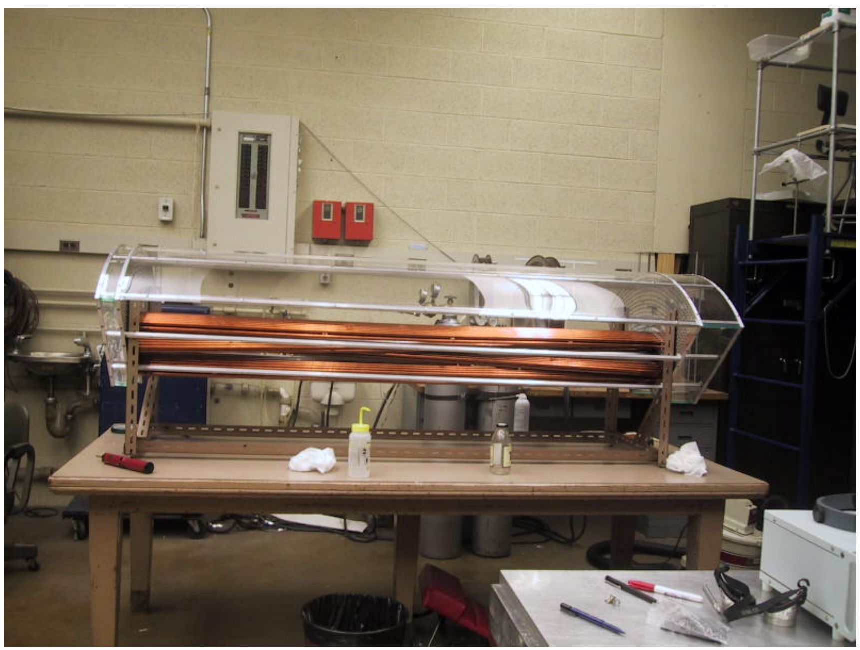
Alignment: We are still investigating alignment procedures. This will be a combination of pins, fiducial marks and external survey. It is crucial the FDC and CDC are well aligned.

Zero B-field: This will used to adjust the alignment between the CDC and FDC. The starting point is a good survey

Physics: Certain physics reactions may be used to fine tune combinations of calibrations and alignments.

The Prototype CDC





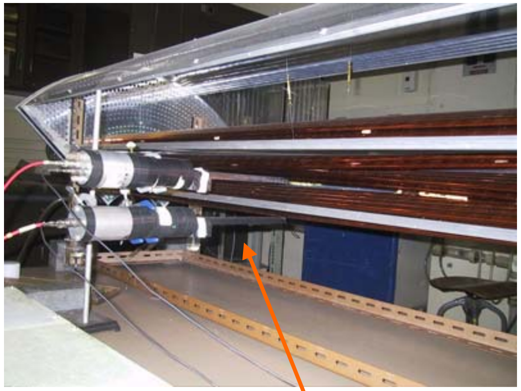
2m long built with both Mylar & Kapton Tubes. Kapton is more robust and will be used in the final chamber.

Full radius, but $\frac{1}{4}$ circle endplates.

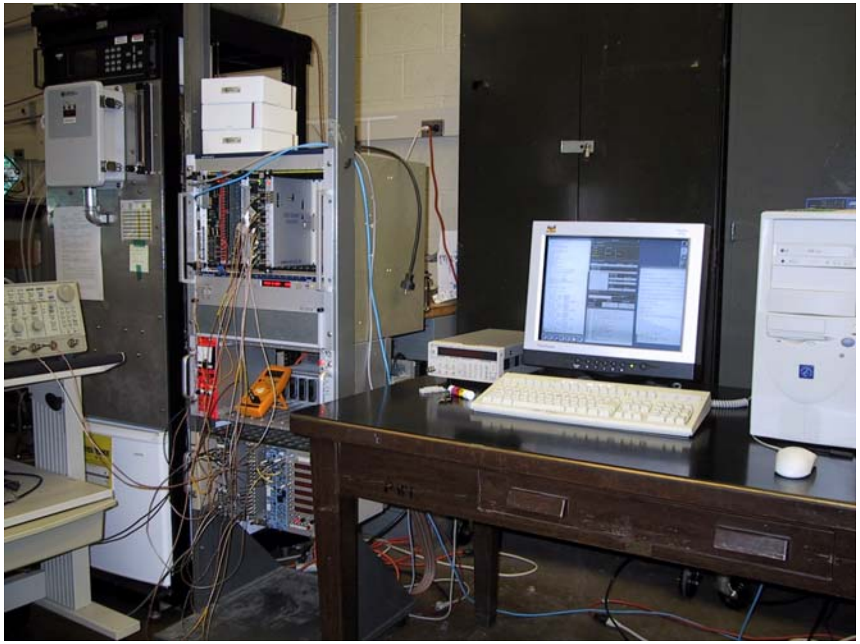
About 70 tubes in the chamber.

16 can be fully instrumented (electronics).

Cosmic Ray Studies



Trigger Scintillators



Small (~1 cm square scintillator telescope) is aligned over a block of 16 fully instrumented straw tubes (limited by FADC system).

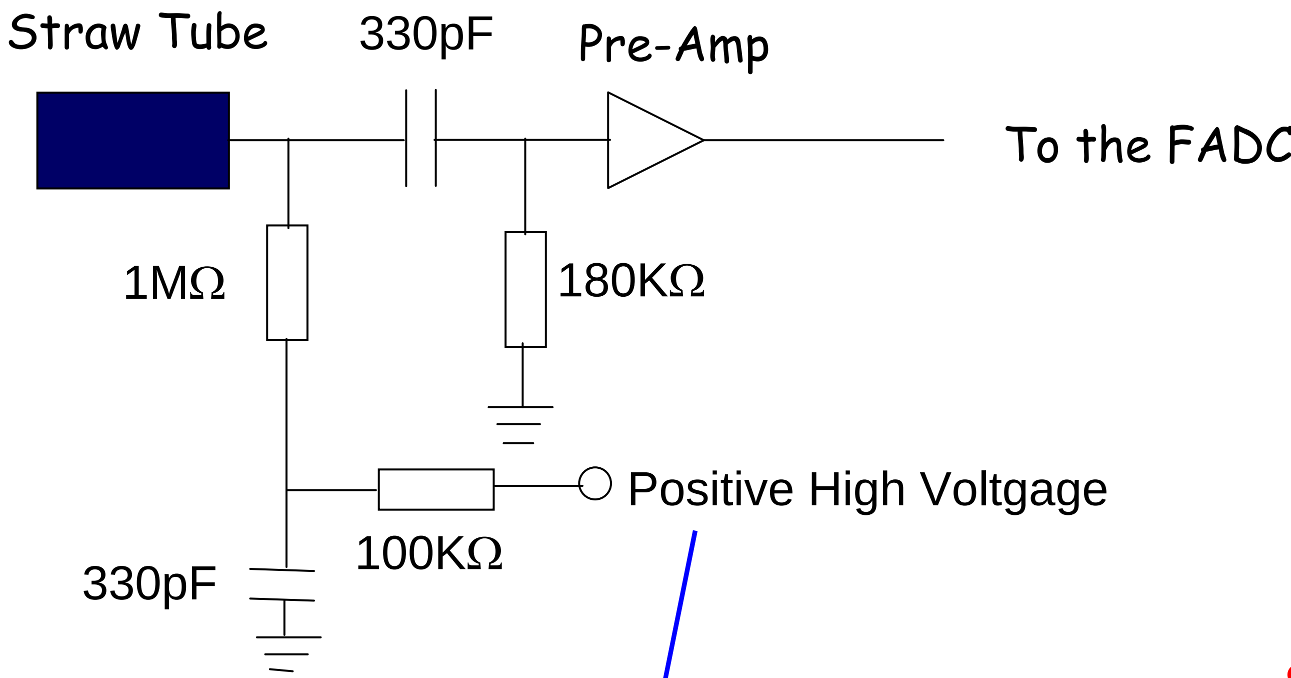
Using a 200 MHz FADC, but can simulate a 100 MHz system.

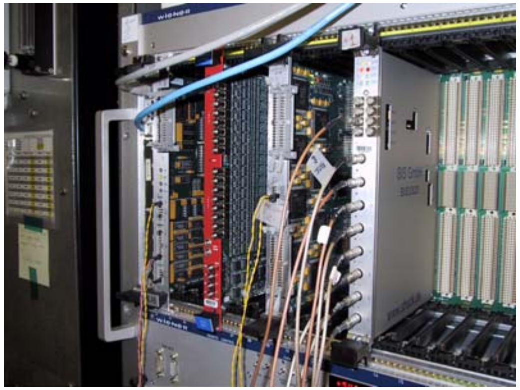
Currently collecting data at about 0.1 Hz, of which about 20% have sufficient tubes for use in studies.

Electronics

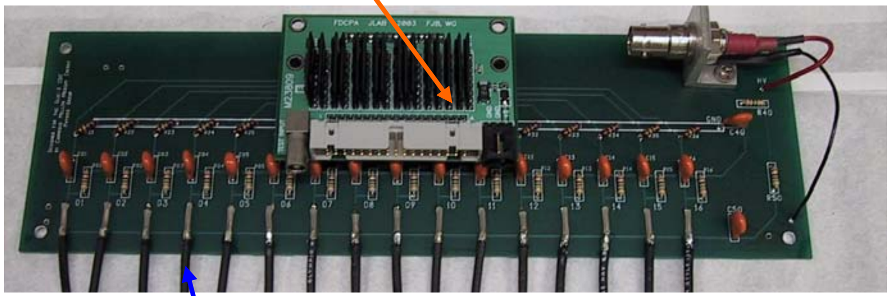
Final Chamber:
FADC: JLab/IUCF
Preamp: Alberta/UPenn/JLab

Prototype:
200 MHz Struck
CLAS

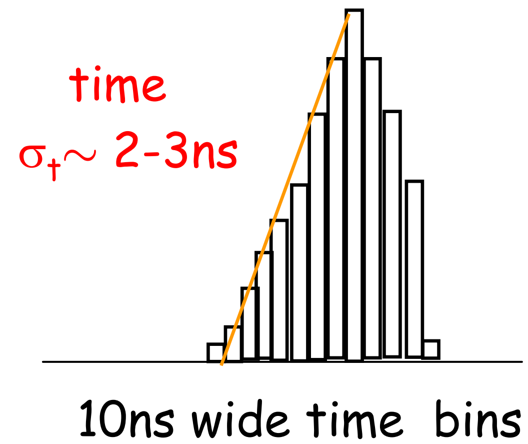




CLAS Preamp

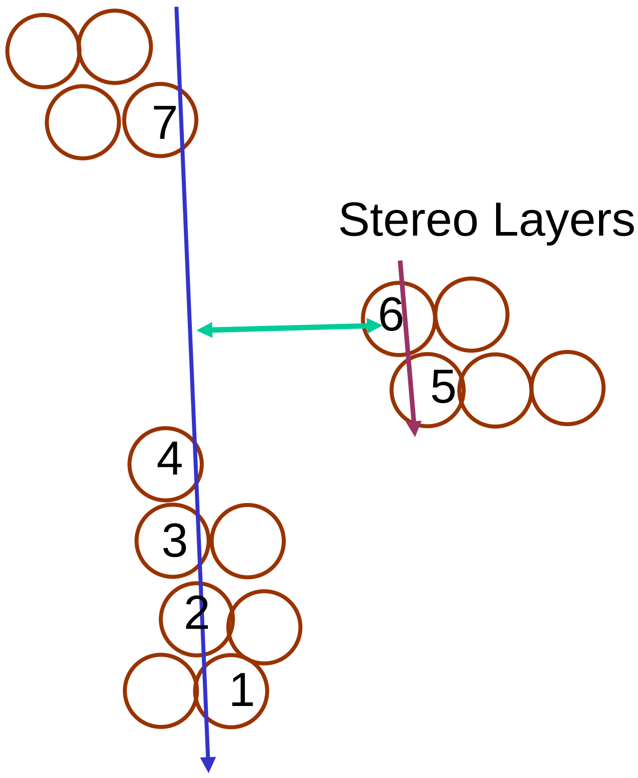


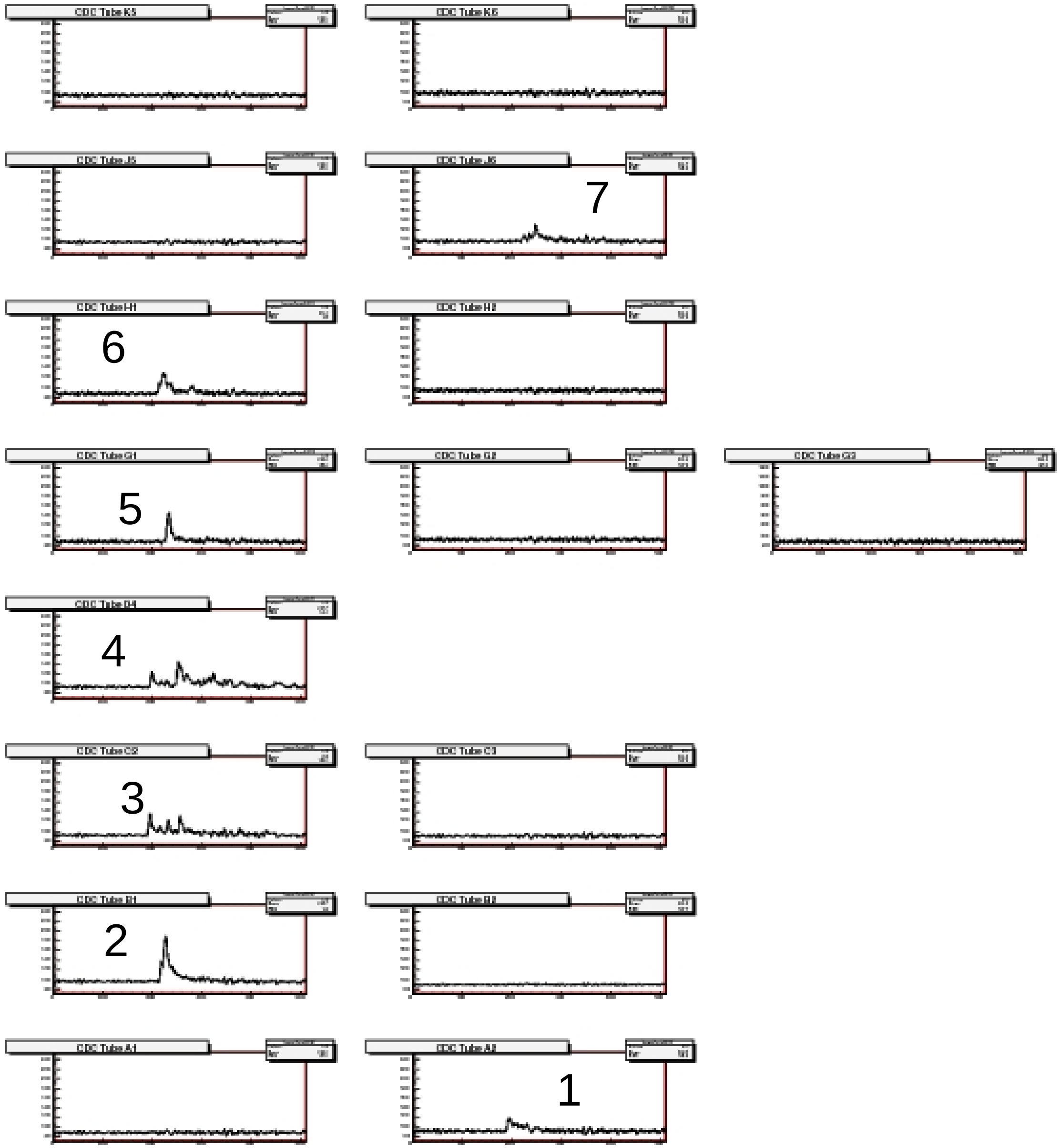
To Straw Tubes



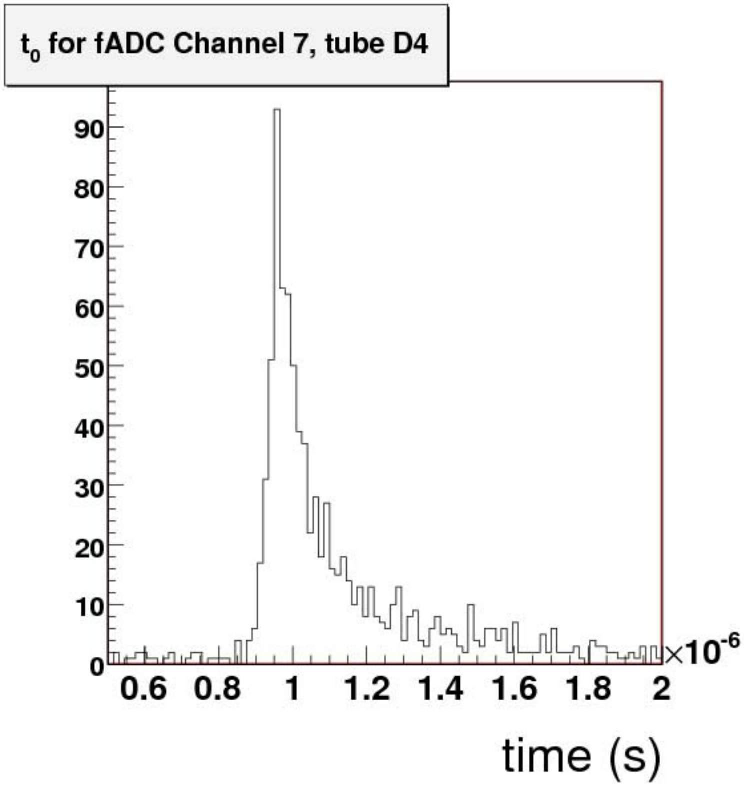
Final Preamp will allow channel-wise pulsing for inter-channel calibrations

Cosmic Ray Event





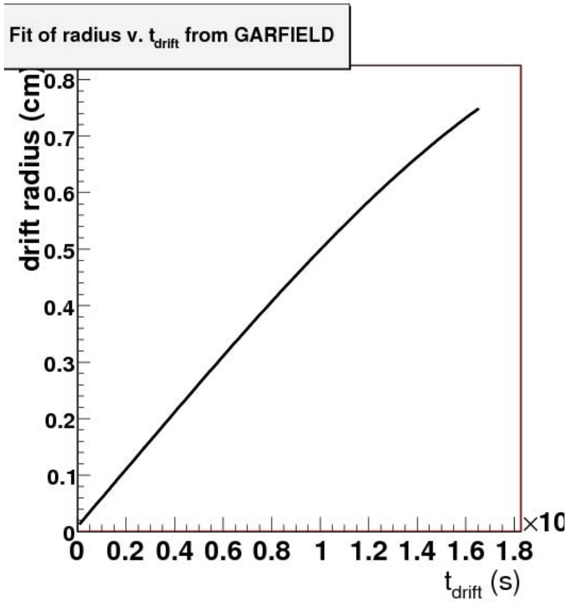
Time to Distance



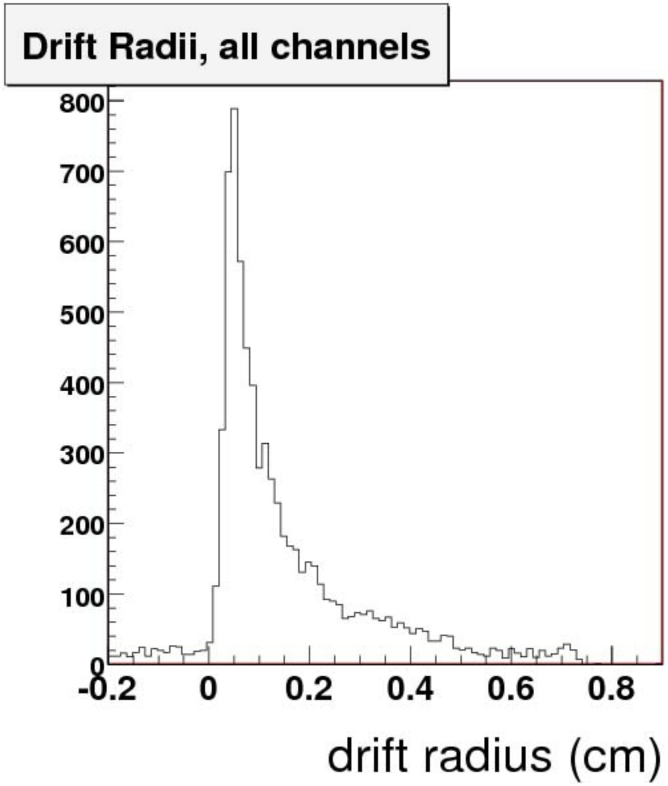
Statistics from cosmic tracks collected in the prototype chamber.

Time from the FADC. In order to get drift time, a time-zero needs to be subtracted.

A drift-time to radius conversion as computed by GARFIELD



The radius of the hits (distance from the wire).



Work In Progress

Developing straight-line track fitter to get resolution. This will allow us to measure resolution as a function of position and angle.

Plan to investigate “loose” charge division for use in pattern recognition.

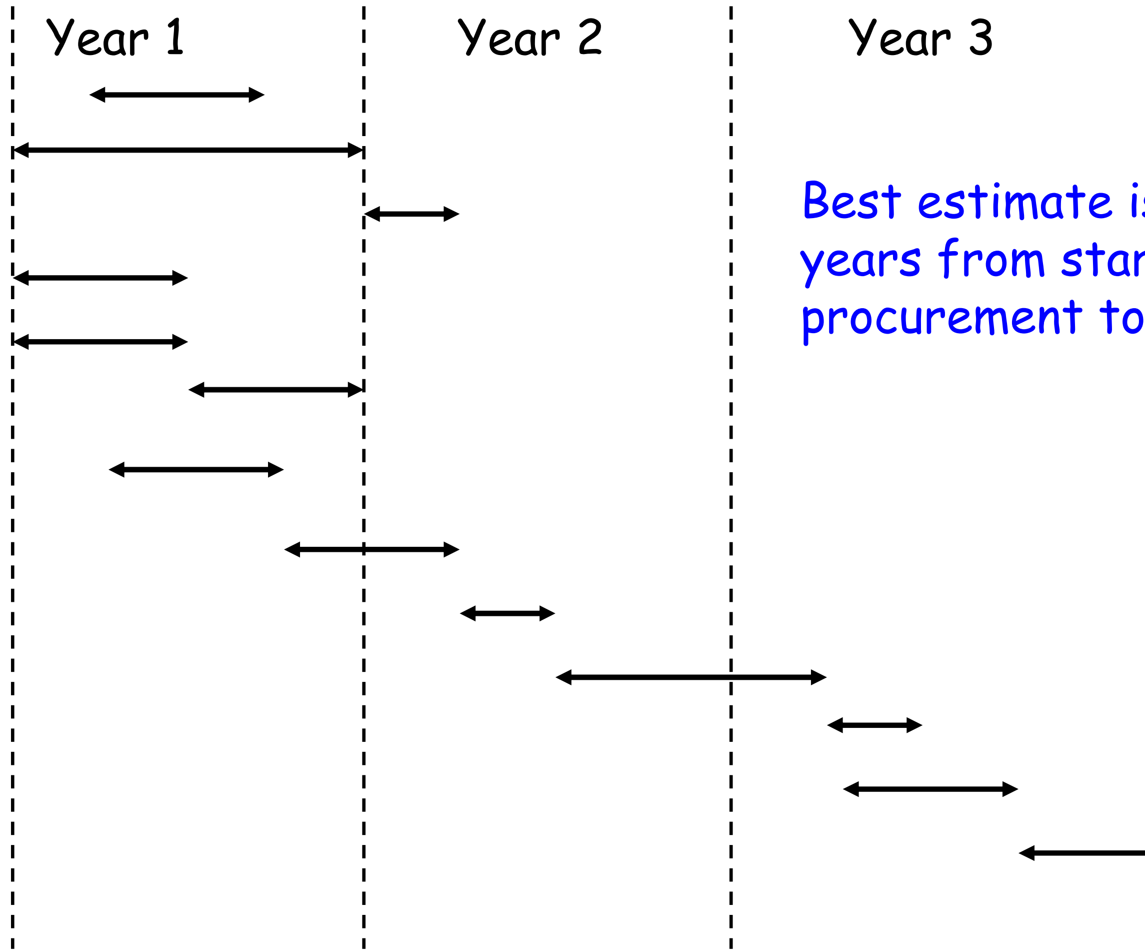
Plan to investigate dE/dx and what the path length corrections are that we will need.

We are in the middle of a Post-Doc search for someone to play a lead role in the remainder of the R&D work.

Final Chamber

Extra Manpower

Task
Tool Construction
Design and Procure Endplates
Acceptance Checks on plates
Procurement of feed throughs
Procurement of wires and pins
Acceptance of parts
Procurement of on-chamber electronics
Tests of electronics
Construction Setup
Chamber Stringing
Gas System Installation
Electronics Installation
Chamber Tests
Delivery of Chamber



Best estimate is 3.5 years from start of procurement to delivery

End Plates:	274K$	Pre Amps:	33K$
Support Frame:	75K$	Gas System:	65K$
Feed Throughs:	65K$	Cables:	52K$
Straw Tubes:	60K$		
Misc. Parts:	50K$		
Wire:	20K$	Total:	694K$

Very old quote

Summary

The CDC as designed meets the physics requirements of GlueX.

The choice of straw tubes over wire cages is driven by:
1) Minimizing the material in the down stream endplate.
2) Uniform electrostatics in the straw tube.

We have a reasonable time line (from start of procurement to delivery) based on building the prototype chamber.

A “full scale” prototype has been built and is being studied at Carnegie Mellon. We anticipate additional manpower in the next six months.