RADIAL DRIFT CHAMBERS FOR CDF FORWARD TRACKING

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Summary

Radial wire drift chambers are built for the Collider Detector of Fermilab to cover forward and backward regions between 2° and 10° cones which will provide good azimuthal position information of tracks, good multi-track, and high rate capability. Results obtained from a prototype chamber show ϕ resolution of $\sigma_{rms} \simeq 130$ μm and a charge division accuracy of 0.7 percent along the wire (θ,r) running in the saturated avalanche mode.

Description of the Radial Drift Chambers

We describe here the radial drift chambers (RDC) (Ref. 1-4) designed to cover the forward-backward tracking regions between 2° and 10° as shown in Fig. 1. In this configuration radial wires provide good azimuthal position information, good multi-track and rate capability, and help determine sign of isolated electrons of $P \leqslant 20$ GeV/c (Ref. 5). The chambers optimize number of readout wires as they provide constant number of wires per unit rapidity.

Each end cap will contain 72 wedge shaped drift chamber cells, each having 21 sense wires and 26 field shaping wires. There is a field shaping wire between every pair of sense wires to focus the drifting primary electrons to help in gas gain adjustment and to reduce cross talk between adjacent channels. Fig. 2 shows an isometric view of the wires and the cathode planes. It also shows the wire positioning (Noryl) feed-throughs with crimp tubes which position the wires to better than 25 μm accuracy. Noryl (Polyphenylene oxide with polystyrene made by General Electric Co.) is found to be excellent in electrical and mechanical characteristics that can hold 50 percent more voltage without producing noise pulses and breakdowns relative to Delrin which is widely used. The sense wires are 10 mm apart in the axial direction. They are 50 μm thick Stablohm, and the field wires are 150 μm thick stainless steel altogether arranged in a plane that is slanted by 2° relative to the beam axis for removing left-right ambiguity. The field shaping cathode planes are made of 6 mm wide 25 μm thick aluminum strips on 100 μm thick G-10 sheets. The wires and the cathode sheets are stretched between two concentric cylinders, and the load is carried by two carbon fiber-hexcell boards on each side. The detailed structure of a single cell is shown in Fig. 3.

The inner cylinder will have an inside radius of 12.5 cm, and the outer cylinder will have an outside radius of 72.6 cm. The length of the cylinders are 35.6 cm. The inner cylinder consists of 0.25 mm thick aluminum - 12 mm thick Rohacell rigid foam sandwich structure in order to minimize the amount of material and to provide good strength to carry wire tensions. Each wire is applied to 40 gm tension. The outside cylinder is made of 6 mm thick aluminum since it is shadowed by the end cap calorimeters. The table given below summarizes the radiation lengths of materials in the way of tracks in three regions as given in the following table.

Average radiation length of materials for tracks originated from the center of the collision region:

Angular Region	Type of Material	Radiation Length
I (1.8°-2°)	Graphite-Hexcell	0.012
	Aluminum-Rohafoam	0.16
	Noryl Feed-Through	0.02
II (2°-10°)	Graphite-Hexcell	0.012
	Cathode Sheet	0.03

The azimuthal coordinate of each track will be measured 21 times with an expected resolution of 125 μm that will give us an angular accuracy of 0.5 mr. We are planning to use LeCroy 1879 FASTBUS multihit TDC's for the drift time measurements. Our wish is to add a pair of octogonal θ-planes to the RDC that would give us 125 μm accuracy for the θ-coordinate measurements.

Beam Test with Prototype

A prototype radial wire chamber was constructed for testing the concept. Two cells were sufficient to provide needed data on the characteristics. The details are given in Fig. 4. In this case anode wires are staggered by 0.5 mm to remove left-right ambiguity.

The gas mixture for the tests was 50 percent A - 50 percent ethane that is bubbled through ethyl alcohol at 0°C adding ~ 1.5 percent vapor. Field wires were kept at ground, the anode wires were applied positive high voltage of 2,150 V, and the cathode strips voltage was linearly increased from a minimum of -800 V to a maximum value of -5,000 V in increments of ~ 40 volts between the adjacent strips. These optimum voltages were determined by measuring the wire gains along some wires and achieving a gain uniformity by varying $-V_{min}$ and $-V_{max}$ on the cathode strips. For this 5.9 keV line of a collimated Fe^{55} source were moved in steps along the wires recording the pulse height at each step. A 2 percent gain uniformity was easily achieved as shown in Fig. 5.

Pulse height as a function of drift spacing (at a point in the direction perpendicular to the anode wires) was also measured. Fig. 6 shows that there may be a small left-right asymmetry and a few percent drop in the pulse height. The first effect is due to differences in electric field between the left and the right side of the anode wire because of 0.5 mm staggering. The second effect is due to attachment of electrons to impurity gases (most probably oxygen).

Some tests were carried out in the M4 beam line of Fermilab. Two proportional chambers and two drift chambers defined the beam as shown in Fig. 7. The PWC's and the drift chambers aided in selecting single track events and provided track positions for measured drift-time to drift-distance measurements for the RDC. The drift chambers were 1 cm drift spacing with thin aluminized mylar cathodes (aluminum facing outside) of electrodeless drift chamber type.

Thirteen wires of the RDC were for drift time measurements, and two wires were used for charge division. Fig. 8 shows this drift-time to drift-distance relation for the left side of the drift cell extending to part of the right section. The range was limited by the beam size.

Using drift times from six odd and seven even wires tracks were fitted for odd wires and even wires separately by using the wire offsets (x) and time (t) offsets and the slope using 1 mm windows. Fig. 9 shows the σ_{rms} resolution as a function of drift distance. It is a little worse close to the sense wire and further away as expected. A typical single wire resolution is given in Fig. 10.

Preamplifiers for charge division were a modified version of a hybrid circuit (designed by V. Radeka, BNL) produced by Centralab, Inc. It has a rise time of less than 2 nsec and decay time of 32 nsec and a charge gain of 160 with an input equivalent noise of ~ 3000 electrons. Two wires were instrumented for charge division. A resolution σ_{rms} = 6.4 mm was obtained along the wire with a gas gain of 5×10^4 running in the saturated avalanche mode. Fig. 11 shows a typical resolution obtained. The distribution shows no tail. This is obtained by connecting output of the preamplifier directly to commercial ADC's with no filtering. We hope to improve this to σ_{rms} of 4 mm with some filtering and shaping the output. 6.4 mm out of a total wire length of 900 mm is a reasonable accuracy for charge division.

References

1. M. Atac, D. Ayres et al., Design Report for the Fermilab Collider Detector (CDF), August 1981.

2. M. Atac and G. Chiarelli, Fermilab CDF Note 193.

3. M. Atac, Proceedings of the PSSC Tracking Workshop (SLAC, March 1984).

4. M. Atac, Proceedings of the PSSC Workshop, Fermilab (May 1984).

5. H. Frisch, Fermilab CDF Note 100, July 29, 1981.

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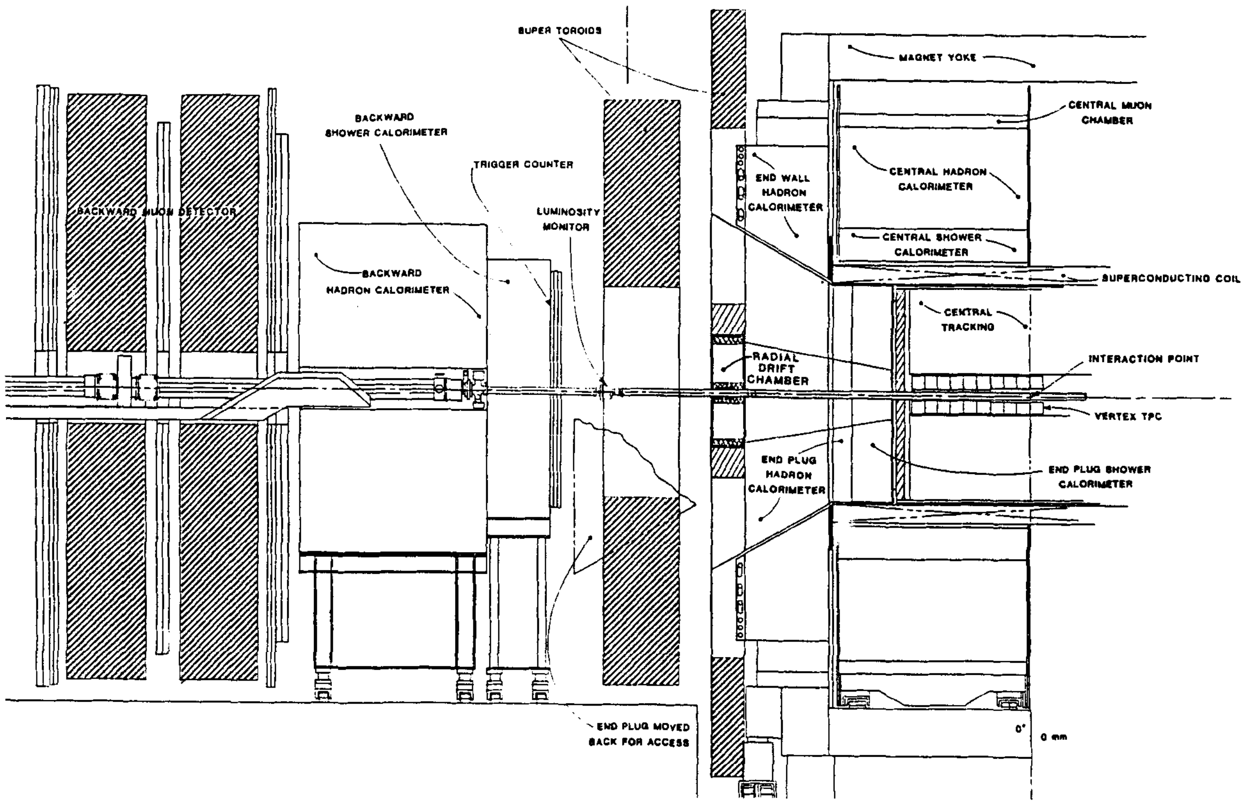
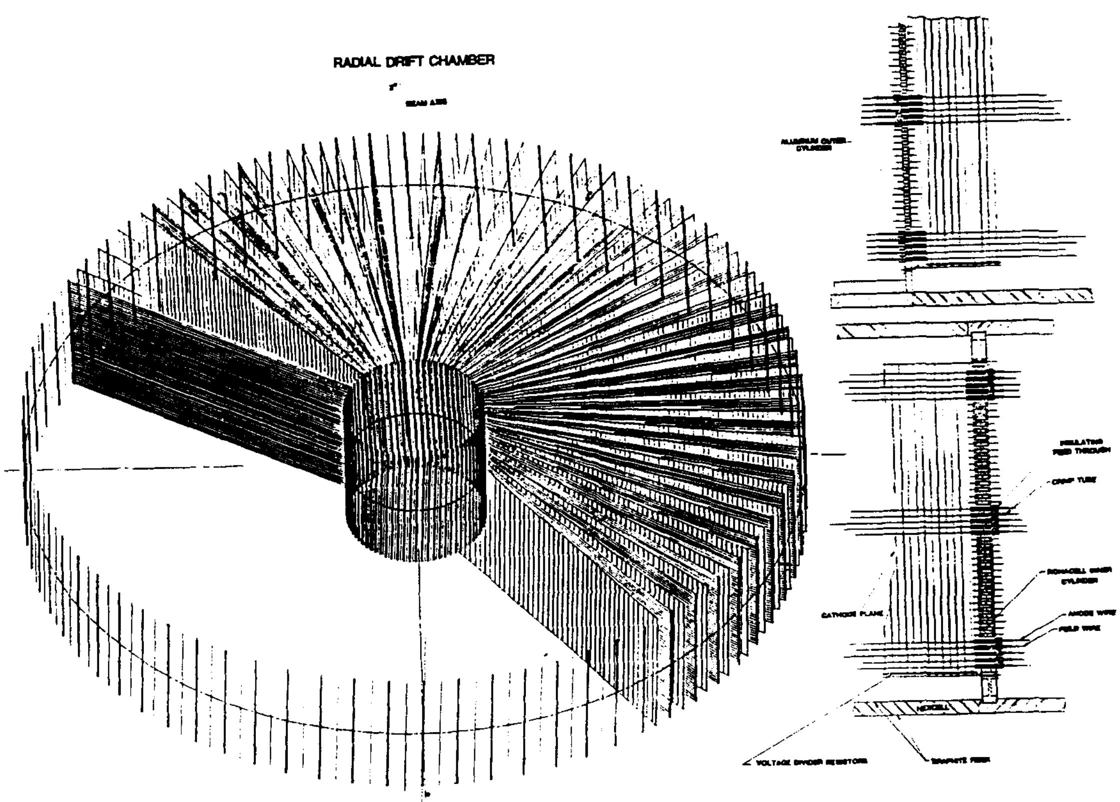
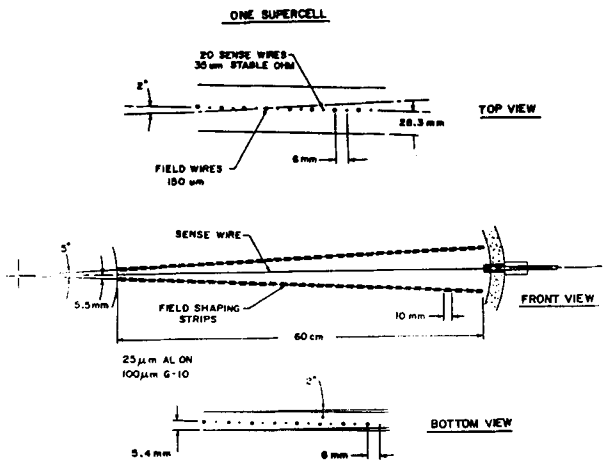


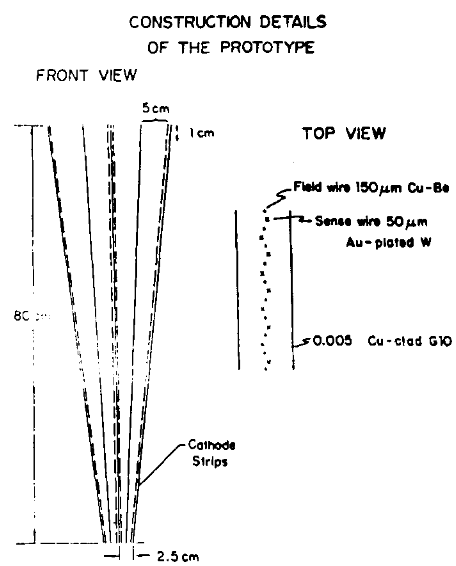
1. Half cross section view of the CDF.



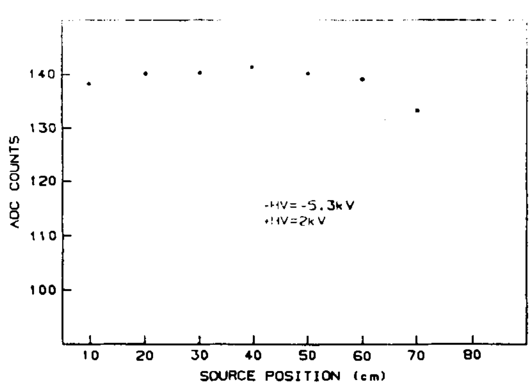
2. Isometric view of the wires and cathode planes. Detailed wire positioning structure is also shown.



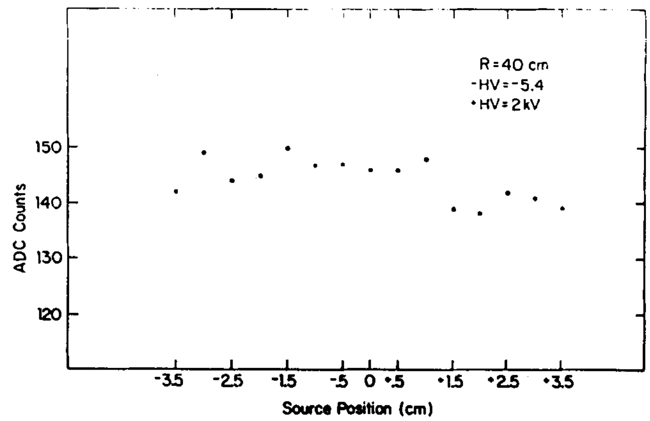
3. Detailed configuration of a single cell.



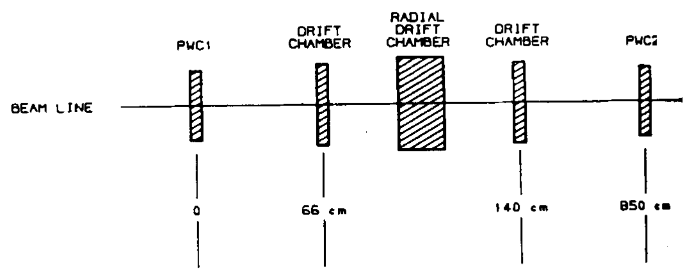
4. Detailed structure of a cell of the prototype chamber.



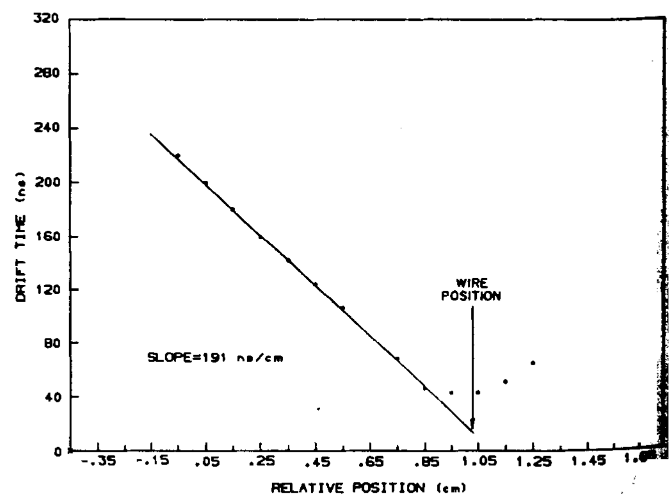
5. Gain uniformity along the wire. It is within 2 percent.



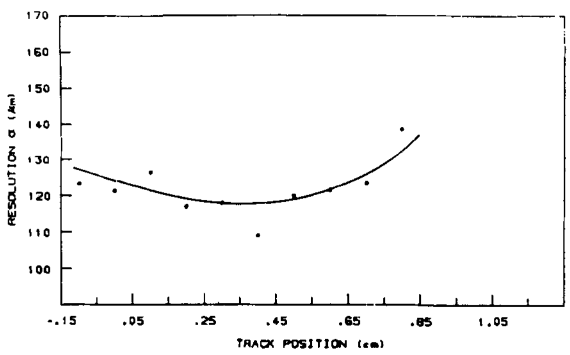
6. Gain variations perpendicular to the sense wire.



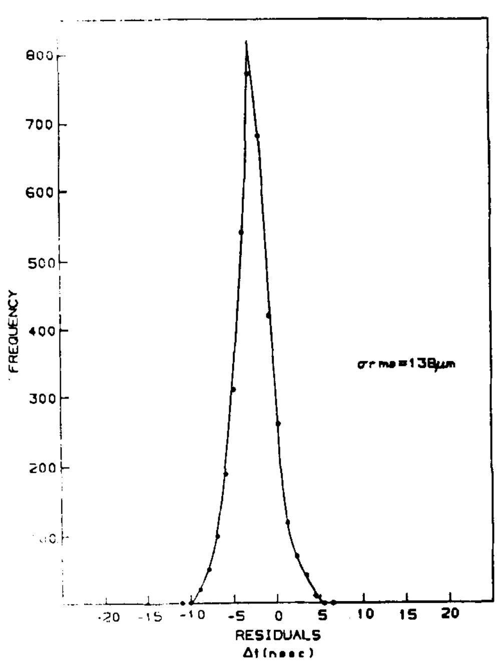
7. Beam layout of the test setup. The z-distances are not to scale.



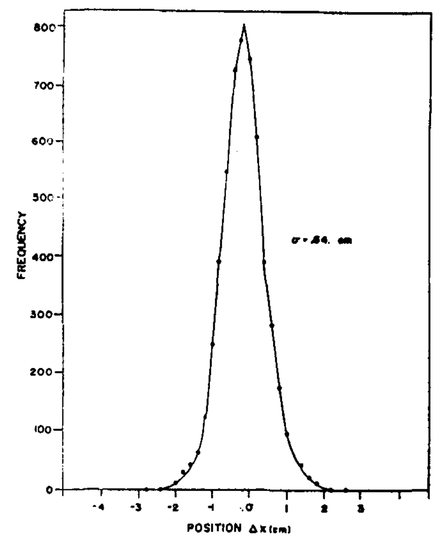
8. Drift-time to drift-distance relation.



9. σ_{rms} residuals from a wire as a function of drift distance.



10. Typical residuals from a wire.



11. Charge division resolution along a wire.