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CONSTRUCTION AND TEST OF A PROTOTYPE STRAW CHAMBER DETECTOR OF LENGTH 2.7 METERS

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Construction and Test of a Prototype Straw Chamber Detector of Length 2.7 meters.

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Abstract

In this paper, we report the construction and test of a 2.7 meter long straw tube drift chamber consisting of 60 channels. The tubes are stacked in a pyramid shape with 8 tube layers. There are 11 tubes at the bottom layer and 4 tubes at the top layer. The tube radius is 2 mm. 28 channels out of 60 are instrumented for measurement of resolution, gain, and attenuation length.

I. Introduction.

The design of the central tracking chamber in a solenoidal detector for the SSC calls for a long cylindrical tracking chamber with a length of about 6 meters. Using straw tubes with small radii is one of the options for the tracking chamber. Due to the bunch spacing and the occupancy rate, the drift space has to be less than 2 mm. For a feasibility study, we have constructed a 2.7 meter long, 60 channel prototype chamber with 2 mm radius straw tubes. By successfully constructing and operating the prototype, we have demonstrated that the basic design concept of the cylindrical chamber is sound and can be extended to a full size cylindrical chamber. Specifically we have shown the following. First, we showed that layers of tubes can be placed straight with an accuracy better than 100 microns over several meters once a flat base surface is provided. Second, an end plate designed by our group using two plates does work. The design provides a simple way to supply gas, tension the sense wire and mount electronics. Third, the wires can be supported every meter inside tubes with proper wire supports. (A contributed paper in this preceeding with the title "Study of sense wire stability and support in straw tube detector elements" describes this in detail). Fourth, a large number of channels can be made operational simultaneously without difficulty. This is important since the expected number of channels for the final tracking chamber is about 200000.

In the next section we describe the construction of the prototype in detail. In the third section we describe the tests performed with the prototype.

II. The construction of the prototype.

We have successfully constructed a 2.7m l[illegible] prototype chamber with 8 layers of tubes. In this section, we present the construction of the prototype. The geometry of the tubes in the prototype is shown in Figure 1. The 60 tubes are arranged in a pyramid shape with 11 tubes at the bottom and 4 tubes at the top. The radius of each tube is 2 mm.

The construction of the prototype starts with a sturdy base. The base could be an optical table or a rail. It is important that the base has a flat surface that tubes can be placed on. Our base looks like the bottom third of a disk. It is 3.3 meter long with a 7 cm wide machined face. The surface was scanned with a survey telescope and found to be flat to better than 25 microns over the entire surface.

On the top of the base, four aluminum plates with machined grooves are placed. The grooves on the plates are to guide the tubes. The plates are aligned among themselves using the su[illegible]y instrument. The plate simulates the cylindric[illegible]

The attenuation length is measured using a Fe^{55} source. Because of the variation of gain near the straw tube joints, the peak of the signal is measured from both ends of the chamber. From the ratio of the two peaks as a function of distance from one end, the attenuation length is calculated. Figure 7 shows the plotted ratio for several channels. The overlapped curves are fits using an exponential function. Although there is some variation between tubes, an average attenuation length of 500 cm is obtained. (The attenuation length calculated this way is one-half of the true attenuation length. The 500 cm and the numbers in Figure 7 are already multiplied by a factor of 2.)

Figure 8 shows the gain measurement for several different gases using the Fe^{55} source. The output from a cell is connected to a charge amplifier and then to a multichannel analyzer. The absolute calibration is accomplished by inserting a known amount of charges into the amplifier. Due to the uncertainty in the calibration, we expect a 10-20 percent systematic error in the absolute gain values.

28 straw tube channels were instrumented for the resolution study using a cosmic ray trigger. The output from the chamber was connected to the Lecroy 2735DC amplifier-discriminator. The discriminated outputs were connected to Lecroy TDC's. Figure 9 shows a track traversing the superlayer. Using the fitted tracks, the residuals are calculated and plotted in Figure 10 (Ar-Ethane 50-50 mixture, operating voltage=1700 volts). The residuals are calculated using tracks with 6 or more hits. A sigma of 110 microns is obtained by fitting the distribution of the residuals. We also have tried different gases. For CF_4-Ethane (50-50 mixture, operating voltage=2100 volts), a sigma of 120 microns is obtained. For CF_4-Isobutane (80-20 mixture, operating voltage=2200 volts), a sigma of 125 microns is obtained.

In conclusion, a 2.7 meter long prototype straw tube drift chamber has been successfully constructed and tested. The prototype consists of 8 layers of tubes with a total of 60 channels. 28 channels were instrumented with readout electronics. Using the prototype, we obtain about 500 cm for the attenuation length and about 120 microns for the resolution of the 2 mm radius straw tubes. The basic design concepts studied using the prototype can be extended to a full size cylindrical straw tube superlayer.

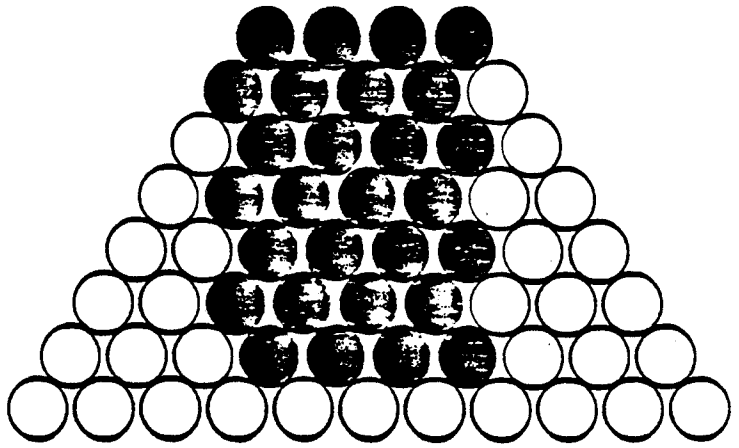

Figure 1. Cross section of the straw tube superlayer. The shaded tubes were instrumented.

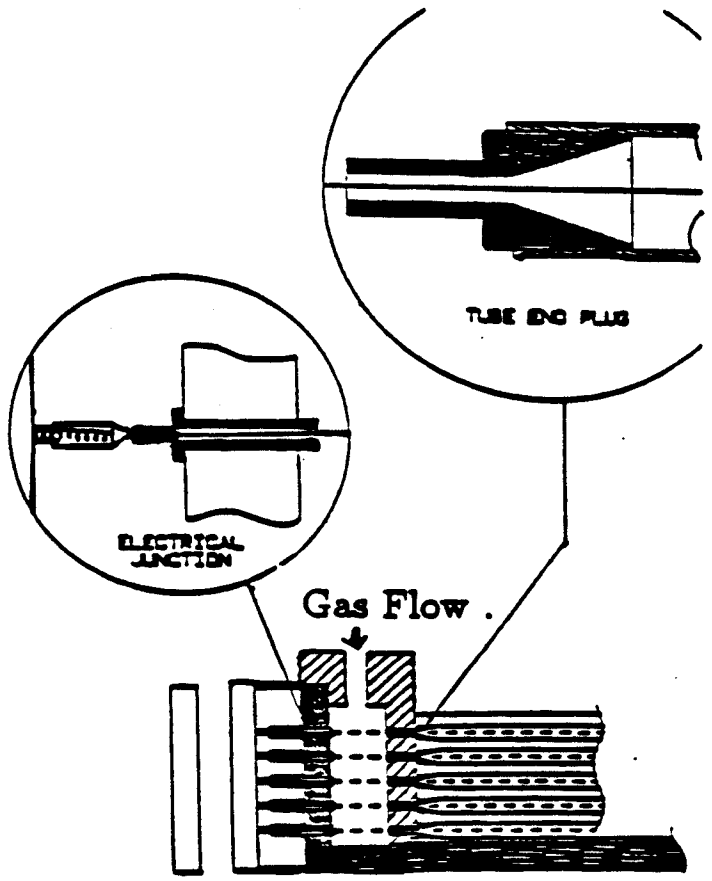

Figure 2. The end plate used in the prototype.

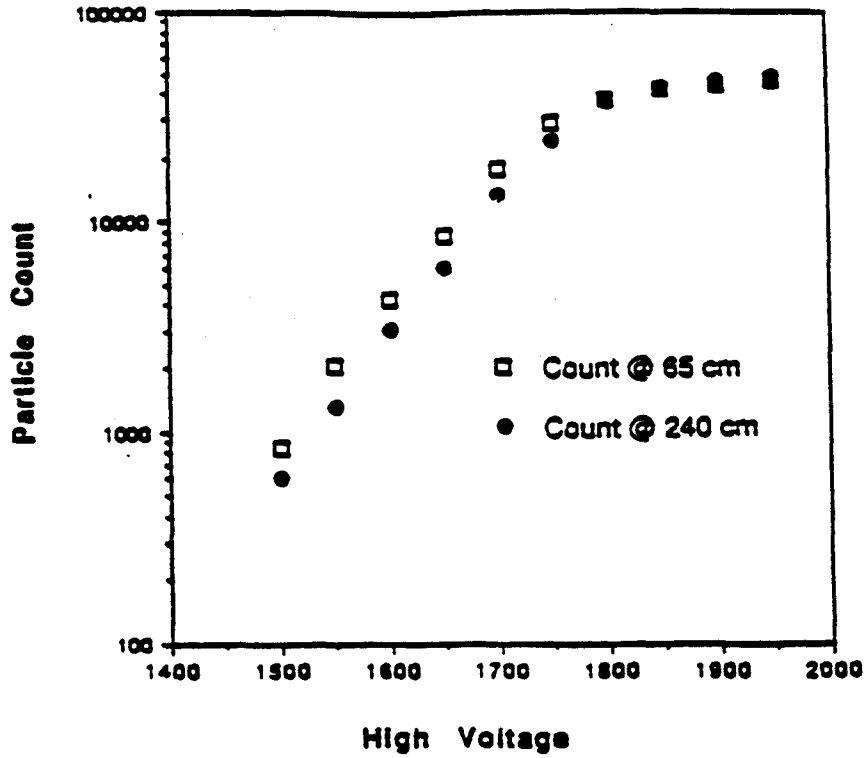

Figure 6. Plateau curves obtained using Sr^{90} source at two different positions from the end of tubes. The gas mixture is Ar-CF_4-Ethane (33-33-33).

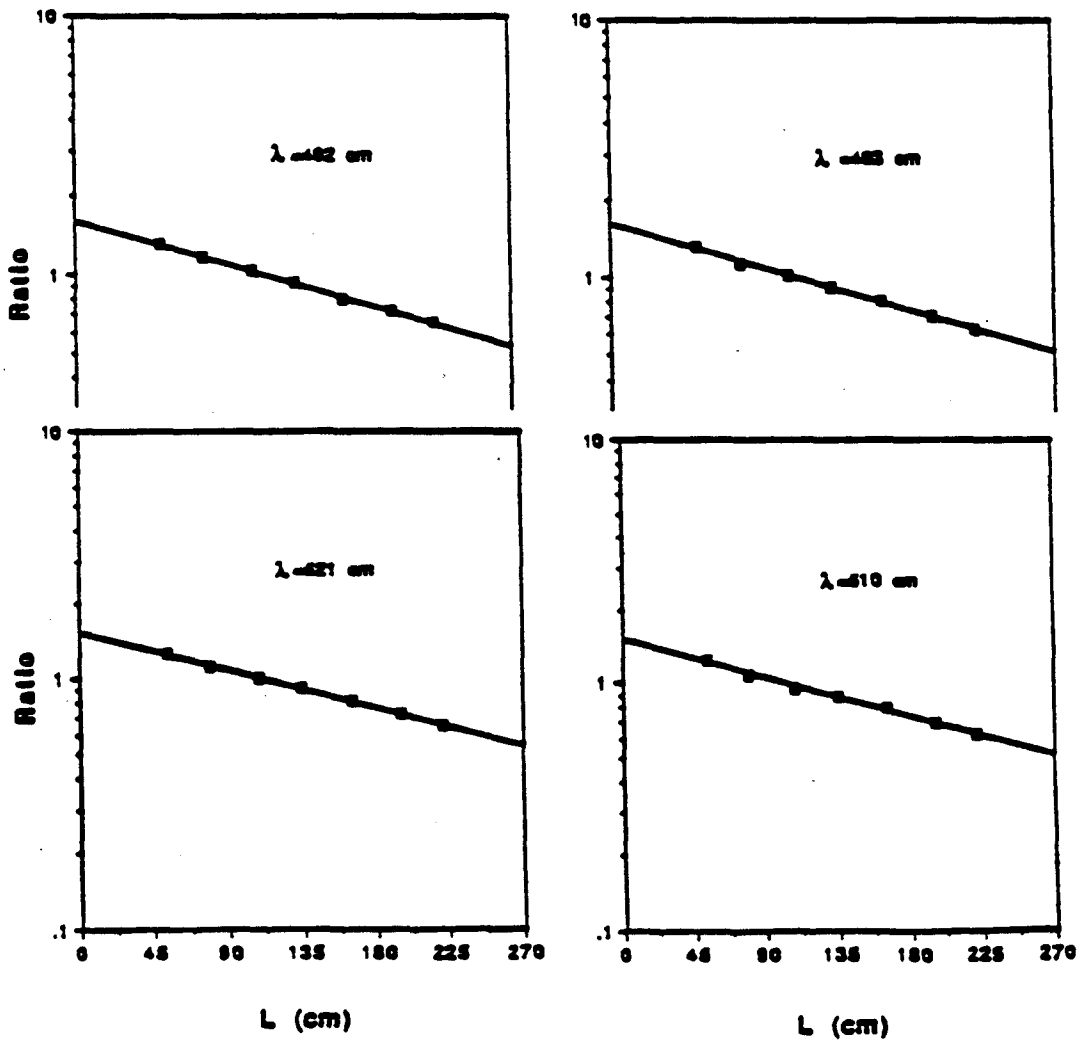

Figure 7. The ratio of amplitude from one end to the other end using Fe^{55} source. The attenuation length is obtained from the slope.