Wire Stability Studies for an SSC Central Drift Tracker

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INTRODUCTION.
The 4π detectors envisioned for SSC physics contain central tracking chambers larger by factors 2-3 than existing cylindrical drift chambers. Wire supports in the middle of large chambers are difficult to engineer and so to determine at what chamber length these become necessary, we have studied the electrostatic stability of a number of possible cell designs. We have concentrated on two styles of electrode structure. The first is fairly conventional, following from the design of the CLEO II tracker, with a box cell structure consisting of staggered layers of square drift cells as in figure 1b. The second unconventional approach is that of long straw tubes, figure 1a.

We have made stability calculations analytically for the simple geometry of the straw chamber and with a 3-D computer simulation for the more complicated arrangements of the wire box cells.

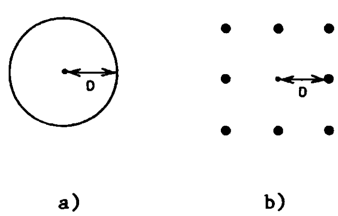

Figure 1. Electrode configurations for the straw chamber and wire box cell.

STABILITY OF STRAW CHAMBER
The force per unit length, F, on a wire radius, r_0, displaced a distance, δ, from the centre of a cylinder radius D, with applied voltage V is given by:

$$F = \frac{2\pi\varepsilon_0 V^2}{[\ln(\frac{D}{r_0})]^2}\left(\frac{\delta}{D^2}\right),$$

for small δ. Then for a stable solution to the displacement equation of the wire:

$$\tau\, d^2\delta/dx^2 = -F,$$

where τ is the tension and x is the coordinate along the wire, L is the length of wire, we require:

$$\tau > \frac{2\varepsilon_0 V^2 L^2}{\pi D^2[\ln(\frac{D}{r_0})]^2}.$$

Figure 2 shows a plot of the maximum stable length from this function for two straw radii with the cathode voltages arranged to give a surface field of 280 Kv/cm (a typical operating condition for a gas mixture of 50% argon, 50% ethane)

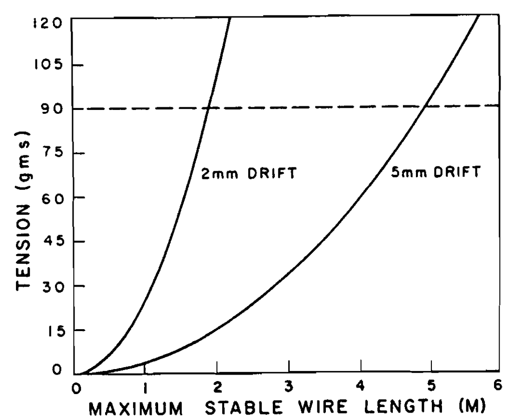

Figure 2. Analytic calculation of stability limit of straw chamber.

SIMULATIONS OF WIRE BOX CELL STABILITY
For the wire box cell, a realistic design must be stable if some wires in the layer are disconnected due to breakdown problems, and allow for edge effects at the outsides of superlayers. The section of three layers shown in figure 3 has been choosen to make a realistic study including these effects. A computer simulation has been used to calculate deflection and limits of stability for this arrangement.

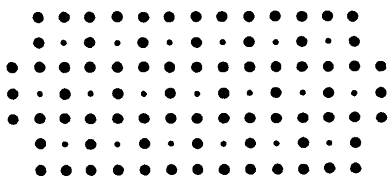

Figure 3. Sections of all layers used for computer simulation of "conventional wire chamber".

This computer code uses various routines from the drift chamber design program of J. Vavr'a[2]. The code used here extends the original electrostatic deflection calculations of Vavr'a to include the increase in forces when the wires deflect, by iterating to a stable wire position in 3-D.

Versions of this code have been used extensively to design both the SLD Endcap and Central Drift Chambers. The code has been tested for the well known MWPC stability limits[3] and also against the analytical calculation given above.

Figure 4 shows the equilibrium maximum displacements of a middle sense wire on an outer layer (as indicated in figure 3) for two drift cell sizes of 2mm and 5mm, as a function of unsupported wire length. The plot is made for 25μm, tungsten sense wires with tensions of 90 gm and 110μm aluminum field wires with a tension 220gms. As for the straw chambers the sense wire surface field was made 280 kv/cm by setting a voltage of 2 kv(2.33kv) on the field wire for the 2mm(5mm) cell size. The maximum stable length for a 2mm cell is 1.75m and for a 5mm cell is 4m. These stable lengths for the wire cells are 10-20% less than the corresponding stable lengths for straw tubes with the same surface fields and sense wire diameters.

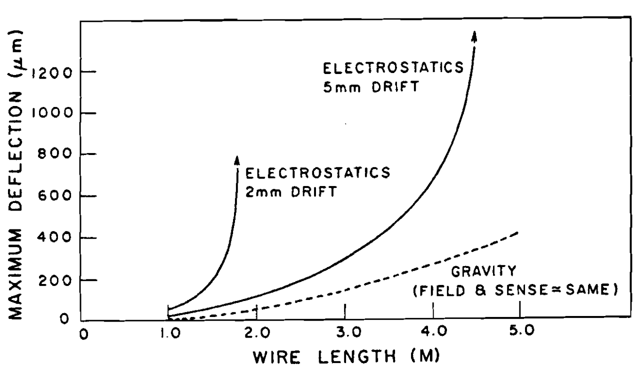

Figure 4. Wire displacements showing stability limits for the wire box cell structure.

REFERENCES

1) R. DeSalvo, "A Proposal for an SSC Central Tracker Detector; in These Proceedings.
2) J. Vavr'a and L. Roberts, DRIFT program, SLAC 1982
3) T. Trippe, CERN NP Internal Report 69-18 (1969)