CLAS-Note 90-010

Drift Chamber Design: the Implications of "Mini-Stagger"

Mac D. Mestayer
August 10, 1990

In early July we had a visit by the noted chamber-builder, Fabio Sauli. Among the questions he raised were some about our plans to have a small layer-by-layer displacement of the sense wires, referred to as "mini-stagger". I have thought about some of the implications of this scheme, and report my thoughts and conclusions here.

The sense wires in an hexagonal design are displaced by one half a cell width from one layer to the next; for example by $0.866cm$ in the case of the Region 2 chambers. The term "mini-stagger" refers to an additional small ($300\mu m$) displacement of the sense wires, alternating left then right as one goes from layer to layer. Figure 1 is a sketch which illustrates the method. The additional displacement is indicated (and greatly exaggerated) by the small arrows.

This scheme has been proposed as a means of resolving left-right ambiguities locally (using information from one super-layer alone). This note will not review this basic motivation further but will concentrate on the following issues:

1) how does the drift velocity vary from one side of the wire to the other?

2) how does the gain vary from one side to the other?, and

3) what are the sizes of the electrostatic forces generated, and what will be the equilibrium position of the wires under our assumed wire tensions and operating voltage conditions?

Left-Right Drift Velocity Variation

For tracks passing close to the wire, the drift time will only depend on the distance of closest approach of the track to the wire. For tracks far from the wire, however, the drift time will also depend on which side of the wire the track passes. The time will be shorter for tracks which pass to the side corresponding to the shorter distance between sense and field wires. This can be a significant effect for longer drift distances. These results are illustrated in Fig. 2, which shows the drift time versus distance of closest approach for tracks on the "long" side, "short" side, and for an undistorted cell. Looking at the figure, one can see that the drift times for two tracks which pass 0.8 cm from the wire, but on opposite sides, will differ by about 8 nsec. Equivalently, the distances of closest approach which result in equal drift times differ by about $300\mu m$, at a distance of 0.8 cm. This is a sizeable effect since the chambers are expected to have resolutions of order $200\mu m$.

Side-to-side Gain Variations due to Mini-Stagger

There should be no measurable gain variation from one side of the wire compared to the other. The reason is that the gain depends only on the local electric field close to the sense wire, and this is very little affected by a $300\mu m$ shift of the sense wire with respect to the field wire cage. I calculated the azimuthal dependence of the surface charge distributions on the sense wire using the drift chamber simulation program, GARFIELD.[1] The following table summarizes the GARFIELD results. The angle referred to is the azimuthal angle, ϕ, which is defined in Fig. 1. Note that the surface electric field varies by about 1 part in 5,000; therefore, the dependence of the gain on azimuth should be negligible.

Charge Distributions on Wire (Mini-Stagger Cell)	
Angle	Surface E Field (kV/cm)
0.	280.73
60.	280.77
120.	280.76
180.	280.71
240.	280.76
300.	280.77

Electrostatic Forces due to Mini-Stagger

Earlier notes by O'Meara and Chew[2] and by this author[3], have shown that the sense wires within an hexagonal grid of field wires are at points of unstable equilibrium. To be more precise, if the sense wire is displaced from the nominal center of the hexagon it will experience a force per unit wire length which is proportional to the displacement. The functional dependence of the force is given in Ref. 2; in particular, the force is proportional to the voltage squared, to the inverse square of the cell dimension, and only logarithmically depends on the sense wire radius. For a typical cell of Region 2 (that is, 1 cm wire spacing, $20\mu m$ sense wire diameter, $140\mu m$ field wire diameter and 2400 V operating point) I have calculated the electrostatic force due to a $300\mu m$ mini-stagger using the GARFIELD drift chamber simulation program. Figure 2 shows the quadratic dependence of the change in the charge on the sense wire as a function of displacement. At constant voltage, a change in charge corresponds to a change in electrostatic potential energy. A quadratic energy dependence corresponds to a linear dependence of the force on displacement. For Region 2, the calculated force is well described by the following equation::

$$Force/length(N/m) = 0.085 \cdot X(m)$$

For a $300\mu m$ displacement, this gives a force of $2.56 \cdot 10^{-5} N/m$, which is about 40% of the linear weight density of $20\mu m$ tungsten wire.

Conclusions

Although I have not presented arguments for the value of "mini-stagger" to a general track finding algorithm, I feel that they are considerable. Local resolution of left-right ambiguities is a great benefit. Weighed against this are two drawbacks: first, that the drift-time relation depends on which side of the wire the track passed, and second, the displacement will cause electrostatic forces on the wires which will move them from their zero-voltage positions.

As shown above, the drift velocity variation will require a correction as large as $150\mu m$. Even if we make this correction with an accuracy of only 20%, we will be left with a residual systematic error of $30\mu m$, or less. The extra displacement caused by electrostatic forces will be about 50% of that due to gravity, so, in principle, it should cause no problem either. The resulting software corrections will be straightforward but they are essential if we are to achieve good spatial resolution. Because of the large number of wires and the numerous corrections involved, I would like to emphasize that we can achieve good performance **only if** we have an adequately robust data base system.

REFERENCES

1) GARFIELD has been developed at the University of Mainz by R. Veenhof and revised by M. Guckes and K. Peters. It is described in HELIOS note 154.

2) Investigations into Wire Sag in the CLAS Drift Chamber, Part IV: Wire Sag due to Electrostatics; Mason Chew, John O'Meara.

3) Wire Tension Notes: LAS Drift Chamber; Mac Mestayer, Aug. 1, 1989. See references therein also.

FIGURE 1
"MINI STAGGER" Wire LAYOUT

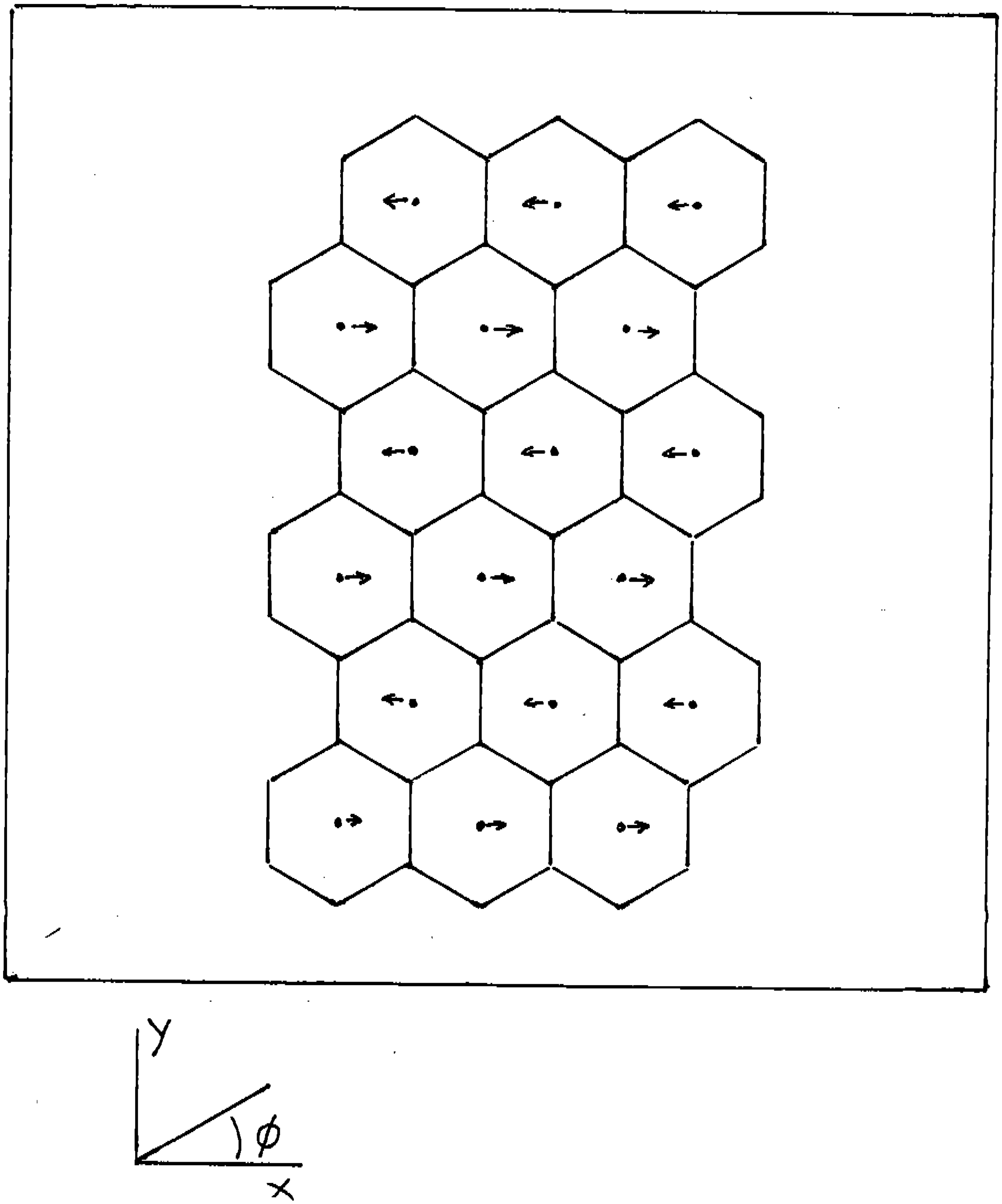


FIGURE 2 DRIFT TIME VS. DISTANCE

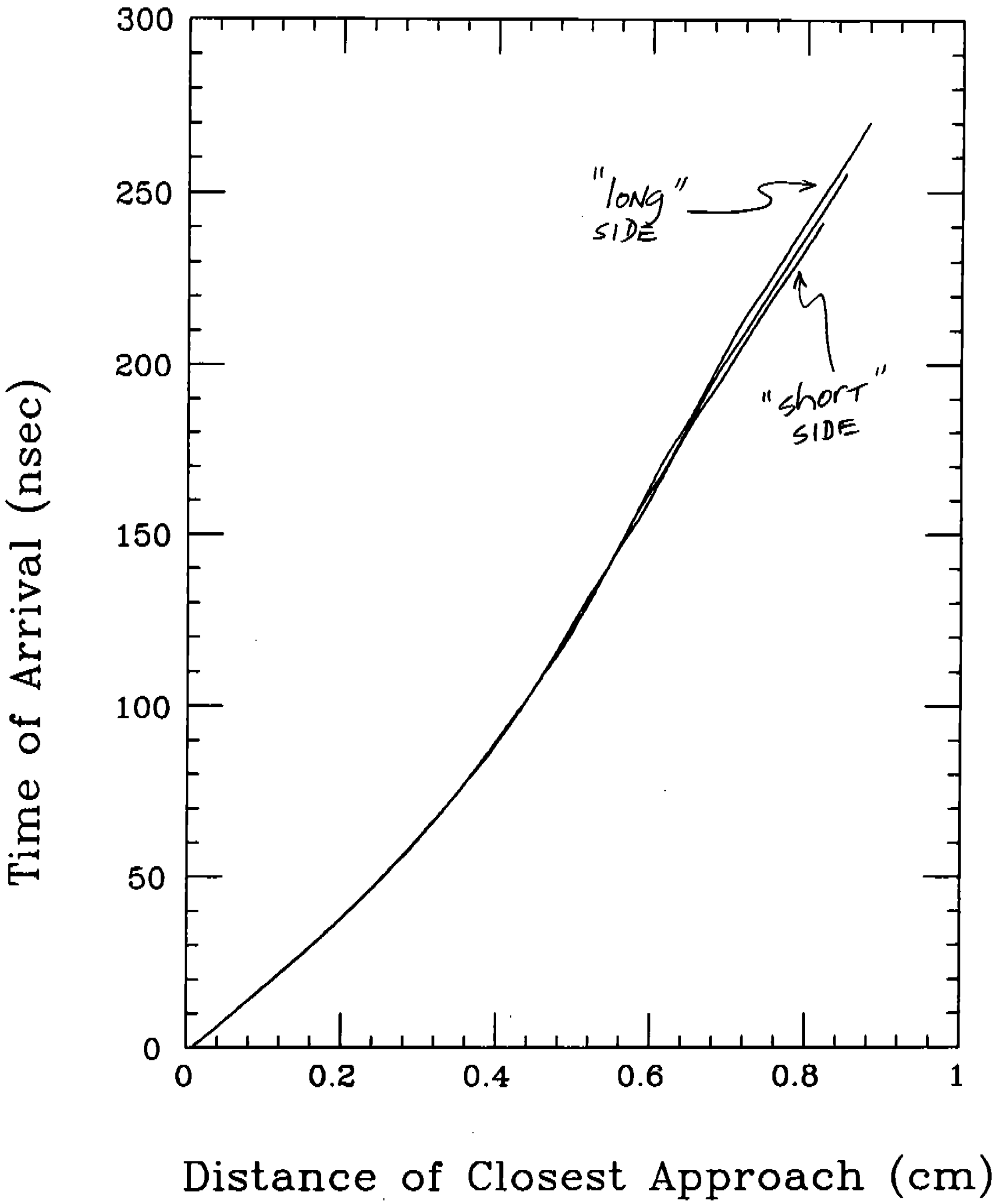
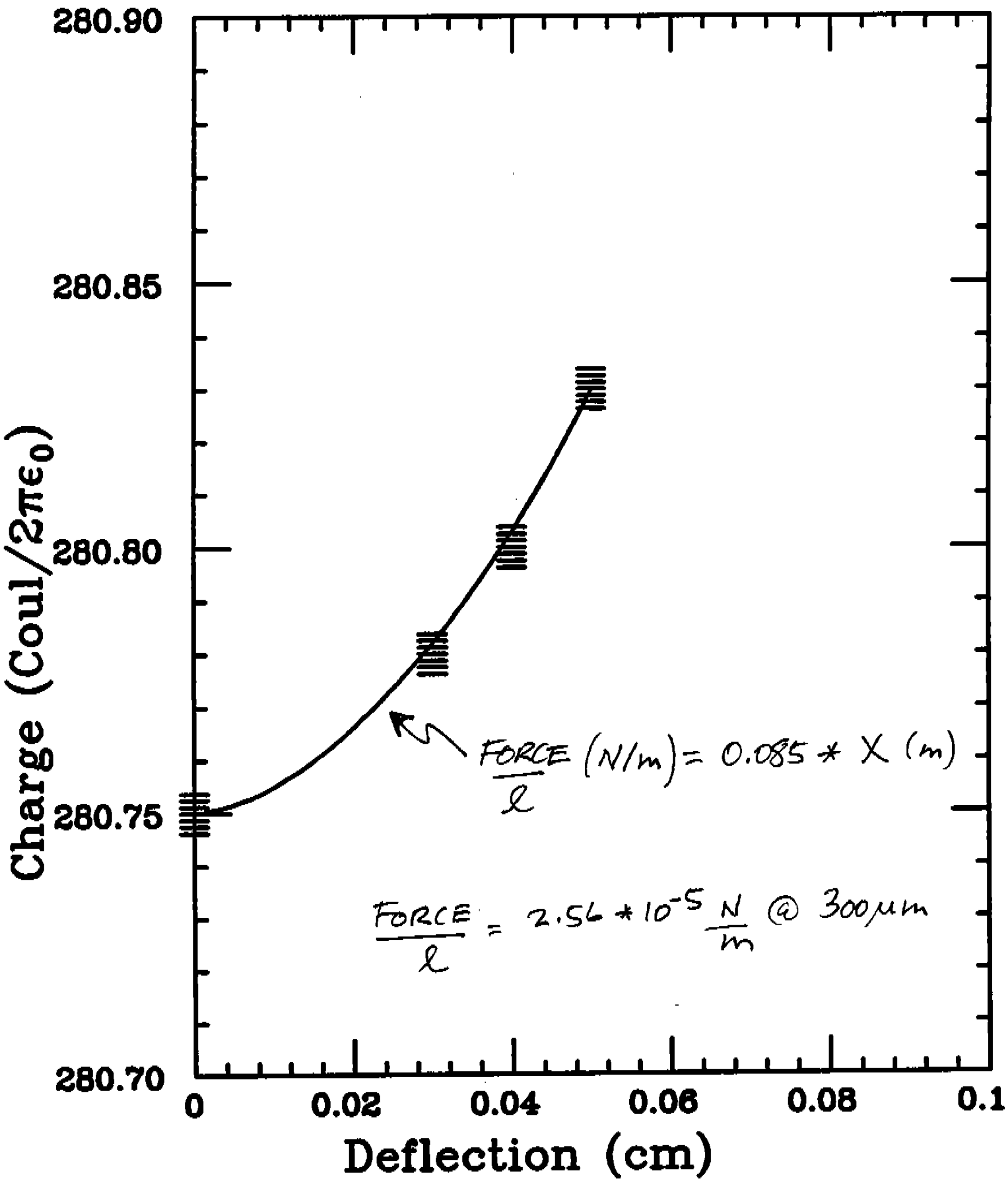


FIGURE 3 CHARGE (ON SENSE WIRE) VS. DEFLECTION



6-layer super-layer w/guard wires

V(sense) = 2400 V.

V(guard) = 600 V.

1 cm. cells

20μ sense wire

140μ field wire