CLAS Note 93-21

Criteria for Tensioning Guard Wires

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Abstract:

This note will briefly review wire tension requirements for the CLAS drift chamber system. The interested reader is referred to the more extensive document, "Wire Tension Notes: LAS Drift Chamber", Mestayer, Aug. 1, 1988. In addition to the brief review, this present note will redress an omission of the original paper; that is, the forces on the guard wires (at the superlayer boundaries) were never calculated.

Wire Tensioning Principles:

To keep tensions low and gains high we chose $20\mu m$ sense wire. To minimize cathode emission and multiple scattering we chose $140\mu m$ aluminum field wire. To minimize creep and wire breakage, we chose a wire tension of 140 g for the aluminum wire (this is about 50% of yield).

Principles:

1) all wires sag the same amount to maintain constant cell geometry. As an aside, this means that the vibrational frequencies of the all wires (of the same length) are equal.
2) guard wires must not move (much). The electrostatic forces are zero on the field and sense wires if the geometry is perfect. The forces on the guard wires are unbalanced, however, since they're at the superlayer boundary. Therefore, they must be tensioned sufficiently strongly to resist significant motion even under the influence of these unabalanced electrostatic forces.
3) the gravitational sag of the Region 3 wires under nominal tension is $38\mu m * L^2$.
4) we wish to keep the additional electrostatic deflection of the guard wires to $50\mu m$ or less.

I calculated the electrostatic force on the guard wire using the GARFIELD program. For a setup similar to Region 3, (that is, a 2 cm sense to field wire distance and voltages on sense, field and guard wires of 2800, 0 and 1600 V, respectively and $140\mu m$ diameter guard wire) I calculated the electrostatic energy of the system. It is the sum of charge times potential for all wires in the superlayer. GARFIELD does the charge calculation. I then changed the cell geometry, moving the guard wires outward by $100\mu m$ and recalculated the electrostatic energy. Setting the change in energy equal to the force on the guard wires times their total displacement, I calculated the force on each guard wire to be about $2 * 10^{-4}$ Newtons per meter length of wire.

This force is about 5% of the weight per unit length of $140\mu m$ diameter tungsten wire. This means that even for 3 m long wires, the additional deflection caused by the unbalance electrostatic forces is only about $17\mu m$. If we used aluminum as the guard wire, this additional deflection would be about $120\mu m$. Steel wire tensioned to give equal gravitational sag would have suffered an additional $40\mu m$ sag due to electrostatics.

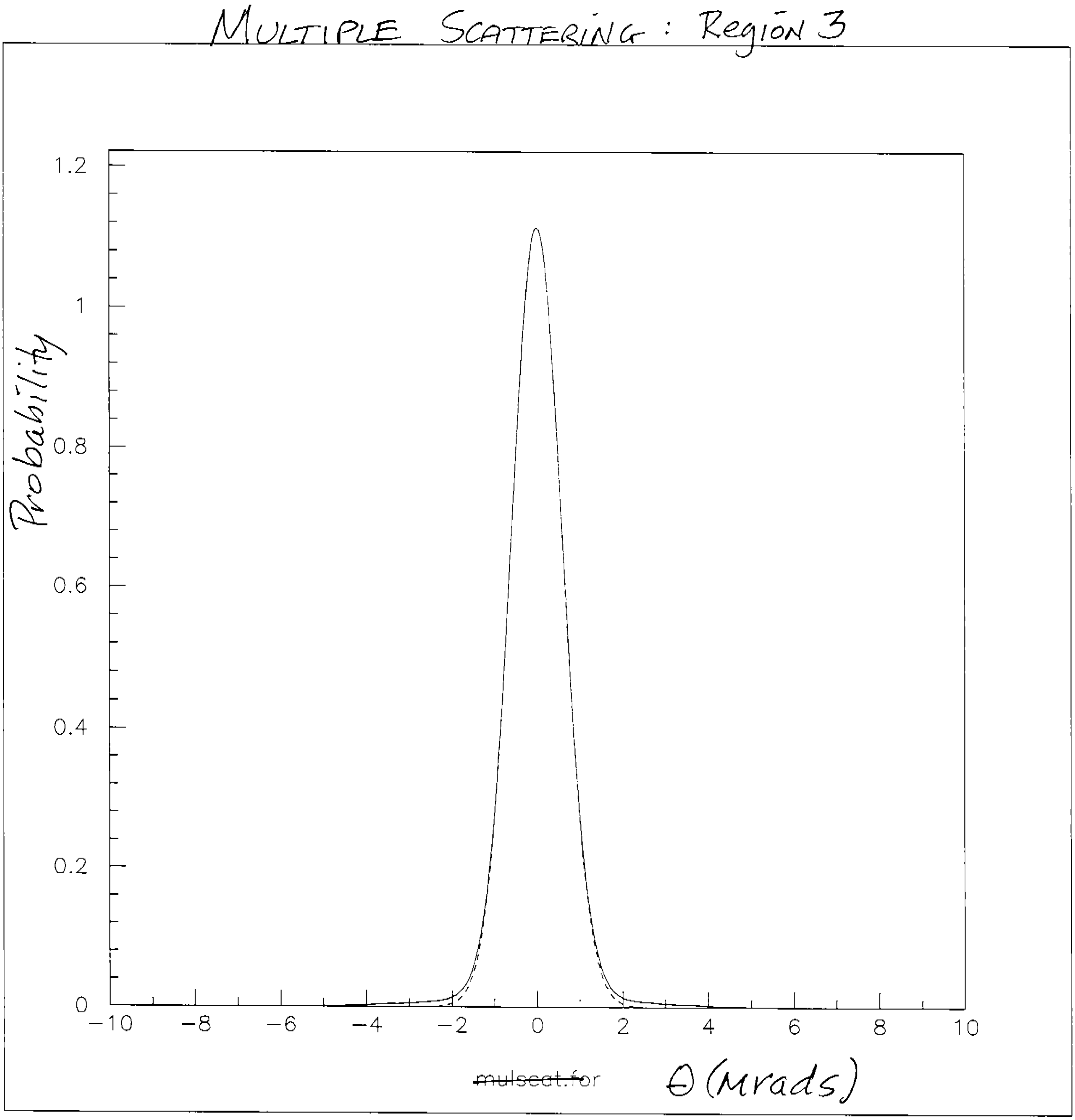
In summary, tungsten guard wires will move negligibly under electrostatic forces.

Appendix 1: Multiple Scattering

In Region 3 the sense wire to field wire spacing is 2 cm and there are 4 layers of guard wires, 28 layers of field wires and 12 layers of sense wires. If the guard and field wires are $140\mu m$ thick, then a particle has a 10.1% probability of hitting field wire, and a 1.4% chance of hitting a guard wire. The formula for multiple scattering, $\Theta_{ms} = 15GeV/p * \sqrt{L/Lrad}$, means that a 1 GeV particle will scatter an average of 0.6 mrad when traversing $140\mu m$ of aluminum; the equivalent scatter is 3.0 mrad for a tungsten guard wire. Traversing 50 cm of argon-ethane gas results in an average scatterr of 0.8 mrad.

Figure 1 shows the multiple scattering distributions for two scenarios: one in which the guard wires are aluminum and the other for tungsten guard wires. The distribution was assumed to be the sum of three gaussian distributions; one for gas-only scattering, one for the convolution of gas and field wire scattering and one for the convolution of gas and guard wire scattering. The tungsten guard wire scenario shows larger tails in the multiple scattering distribution with about 0.5% of the particles undergoing a scatter larger than 3 mrad.

Figure 1a


MULTIPLE SCATTERING : Region 3
Probability
1.2
1
0.8
0.6
0.4
0.2
0
−10
−8
−6
−4
−2
0
2
4
6
8
10
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Θ (Mrads)

Figure 1b

MULTIPLE SCATTERING : Region 3