Fermi National Accelerator Laboratory
PPD / Mechanical Support / Engineering Analysis

Edge Effect of Electrical Field

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In FLARE experiment, in the liquid argon tank, there will be parallel cathode plates and wire meshes. The electrons from the ionization by energetic particles will be collected by the wire meshes. The ideal electric field will be perpendicular to them. Near the edges, however, there will be some distortion of the electric field. There the detectors may not be as effective as in the interior. The voltage cage is used to shape the field near the edges. In this study, we will discuss some ways to measure how bad the edge effect will be, i.e. how different is the edge field compared with the interior field.

An example problem is described in Fig.1. There are three voltage cage tubes. One is directly connected to the cathode plate, and is at 150 kV. The other two are set at 100 kV and 50 kV, respectively.

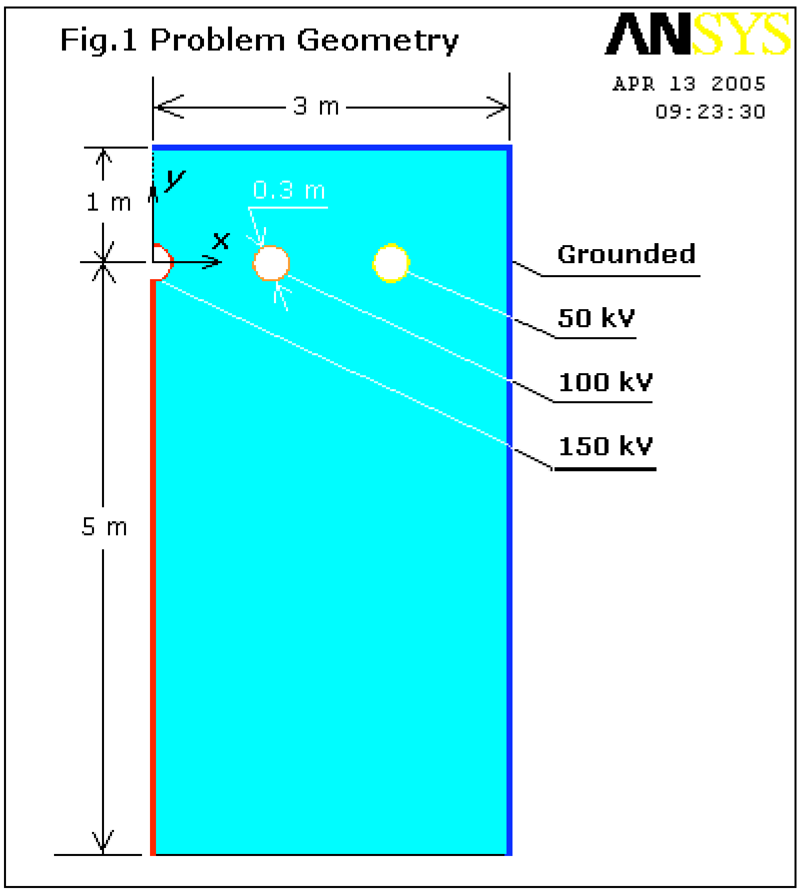
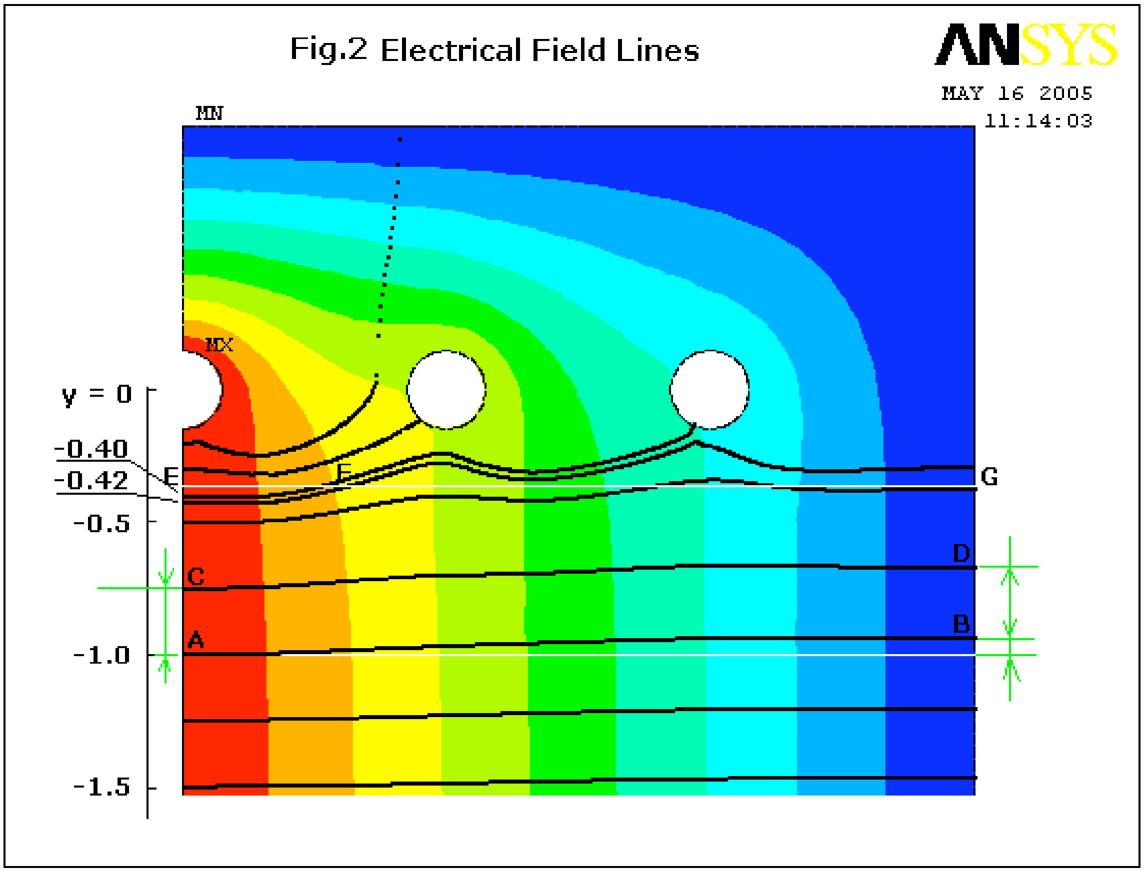


Fig.1 Problem Geometry

The electric field solution is presented in Fig.2. Only top part is shown. The contour plot is the voltage. The black lines are the field line, which is perpendicular to the voltage contours. We see that there are some distortions of the electric field near the edge. The electric field line is not straight and not perpendicular to the voltage plates.

In order to measure just how much is this field different from the interior field, we need to look at these field line carefully. Notice the field line from $y = -0.42$. Bellow that all the field lines reach the right (the wire mesh). For a perfect field, the y coordinates of the left end and right end are the same. This is not the case near the edge (point **A** and **B**). We call their difference of *y* coordinates drifting.



Second, consider two field lines **AB** and **CD**, and measure the distance **AC** and **BD**. For a perfect filed, they are the same. That is, their ratio is 1. Near the edge, the ratio is different from 1. We call this phenomenon spreading.

These two quantities can be expressed as continuous functions. For each field line, the *y* coordinate of right end is the function of left end *y* coordinate. We denote it as $\eta = \eta(y)$. Then the drifting is just $(\eta - y)$, and the spread is $(1 + d\eta/dy)$.

Third, we draw a horizontal line, and assume the ionization occurs uniformly along this line. In the interior, all the electrons will be collected by the wire mesh. Near the edge, however, not all the electrons will reach the wire mesh. For example, along line **EG**, only the **FG** part will be collected, and the **EF** part will be lost. We call **FG**/**EG** the collect ratio.

For the field in Fig.2, these three measures of the edge effects are plotted in Figs. 3~5. The distance from edge is the distance from the center of the voltage cage. Note that the points in Fig.4 are not that nice. That is because we don't have smooth algorithm for the numerical differentiation. The red dots are added to show what I think the smoothed curve should be.

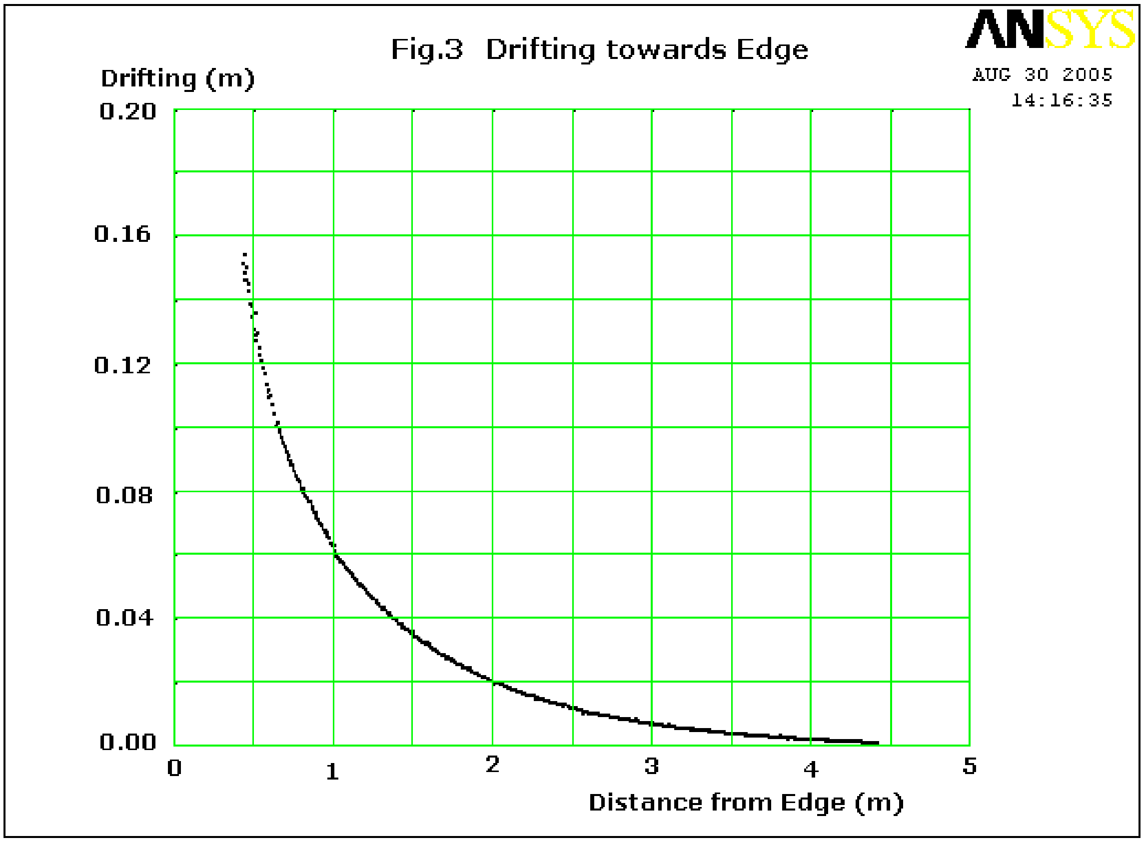


Fig.3 Drifting towards Edge
ANSYS
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14:16:35
Drifting (m)
0.20
0.16
0.12
0.08
0.04
0.00
0
1
2
3
4
5
Distance from Edge (m)

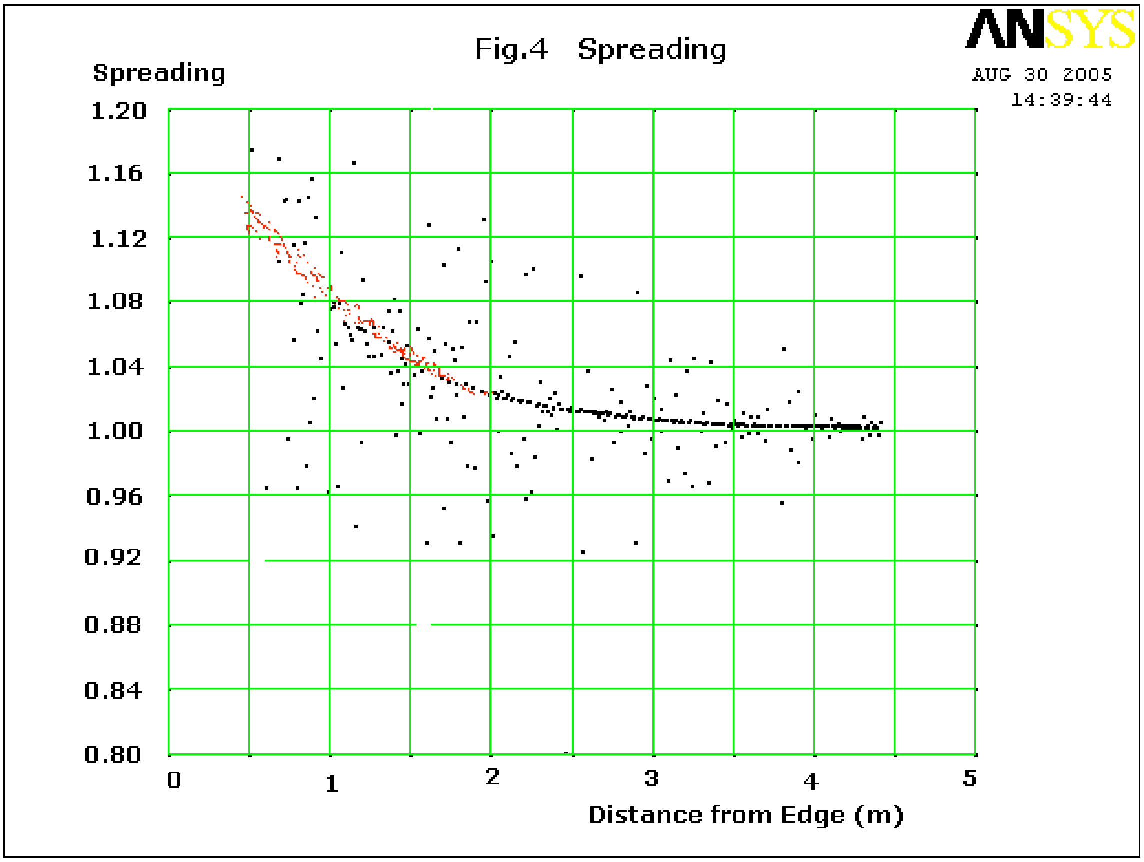

Fig.4 Spreading

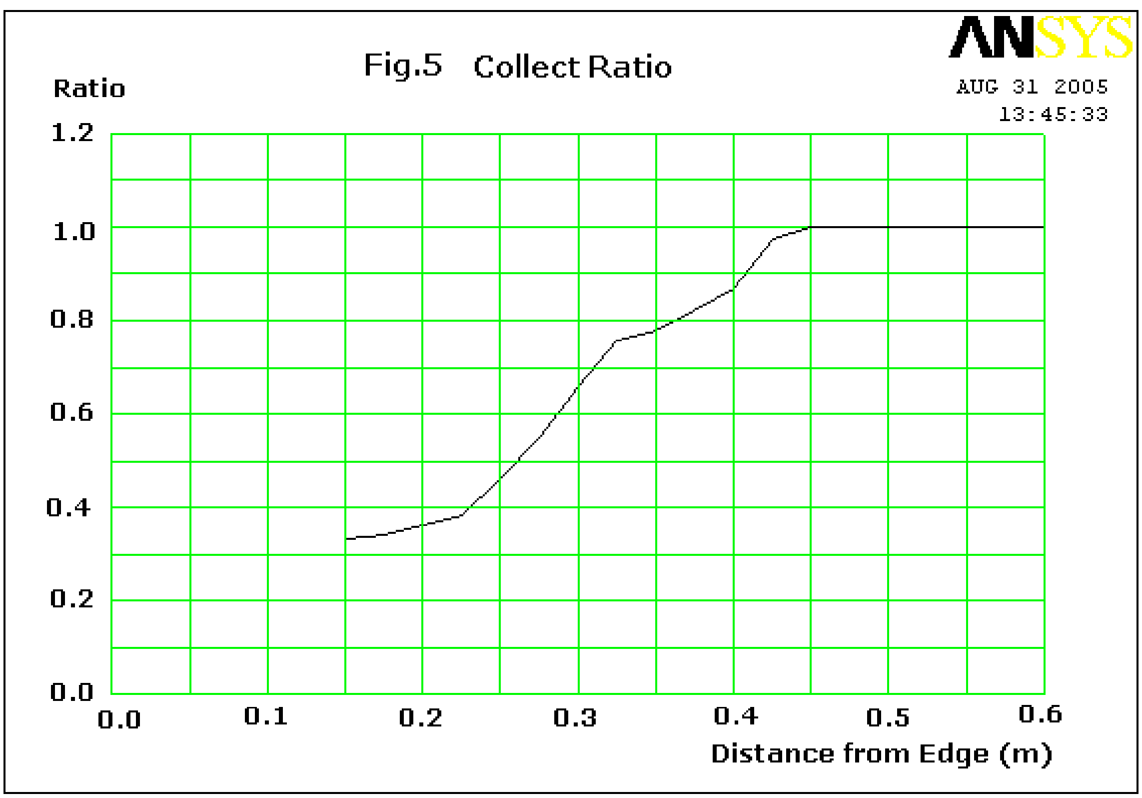

Fig.5 Collect Ratio