Field study of PMT mesh screen effectiveness: D. Shuman Aug. 29 2012

An investigation of electric field between a grounded plane (such as a PMT photocathode) and a grounded mesh plane, as a function of plane-to-mesh distance, given a nominal electric field above the grounded mesh plane, is presented here. The results indicate an power law (essentially inverse) decay of the field as the plane-to-mesh distance is increased well beyond the mesh wire-to-wire pitch distance. The field is uniform from the ground plane up to a distance of one pitch length from the mesh, as shown in the last plot.

The results were obtained using a series of finite element models (ANSYS 12.1), each of a unit mesh cell of one half the pitch width. Although the proper method is to use a 3D mesh model which captures the square mesh wire arrangement, a close 2D approximation can be made by running the 2D half cell in axisymmetric mode, simulating a ring shaped wire; resulting field is 85% of that of an equivalent square cell (from 3d model). The field values (y component) are obtained at the ground plane, on the axis. Two wire diameters, at same pitch, were run. The models all assumed relative permittivity = 1.0; actual field across a PMT quartz window will be reduced by a factor = the relative permittivity of quartz = 3.7.

Grounded mesh (wire) y (vert) location, in m:

$vw := .01455$

Electric field (vertical component only, or y) above grounded mesh, V/m

$ey_h := 1.000$

Mesh wire pitch spacing, in m:

$vx := .0005$

Electric field (col. 1) at ground plane (below grounded mesh), as function of ground plane location (col. 0)

for wire r =15 µm (actual, 88% transparent)

eyd :=

efy0.txt

eyd =

	0	1
0	0	$3.648\cdot10^{-3}$
1	$1\cdot10^{-3}$	$3.916\cdot10^{-3}$
2	$2\cdot10^{-3}$	$4.227\cdot10^{-3}$
3	$3\cdot10^{-3}$	$4.591\cdot10^{-3}$
4	$4\cdot10^{-3}$	$5.025\cdot10^{-3}$
5	$5\cdot10^{-3}$	$5.548\cdot10^{-3}$
6	$6\cdot10^{-3}$	$6.193\cdot10^{-3}$
7	$7\cdot10^{-3}$	$7.008\cdot10^{-3}$
8	$8\cdot10^{-3}$	$8.07\cdot10^{-3}$
9	$9\cdot10^{-3}$	$9.511\cdot10^{-3}$
10	0.01	0.012
11	0.011	0.015
12	0.012	0.02
13	0.013	0.033

For wire r =30 µm

eyd2r :=

efy0b.txt

eyd2r =

	0	1
0	0	$1.908\cdot10^{-3}$
1	$1\cdot10^{-3}$	$2.049\cdot10^{-3}$
2	$2\cdot10^{-3}$	$2.212\cdot10^{-3}$
3	$3\cdot10^{-3}$	$2.403\cdot10^{-3}$
4	$4\cdot10^{-3}$	$2.63\cdot10^{-3}$
5	$5\cdot10^{-3}$	$2.905\cdot10^{-3}$
6	$6\cdot10^{-3}$	$3.244\cdot10^{-3}$
7	$7\cdot10^{-3}$	$3.673\cdot10^{-3}$
8	$8\cdot10^{-3}$	$4.232\cdot10^{-3}$
9	$9\cdot10^{-3}$	$4.992\cdot10^{-3}$
10	0.01	$6.085\cdot10^{-3}$
11	0.011	$7.791\cdot10^{-3}$
12	0.012	0.011
13	0.013	0.018

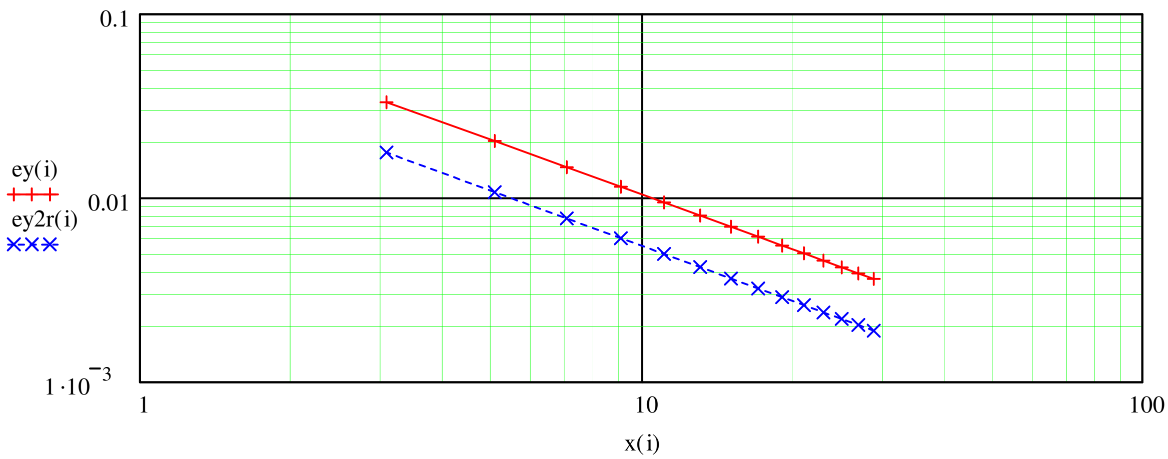
$i := 0, 1 .. 13$

Normalize ground plane to ground mesh distance x(i), in units of wire mesh pitch

$$x(i) := \frac{vw - eyd_{i,0}}{vx}$$

Normalized electric field, Ey

$$ey(i) := eyd_{i,1} \qquad ey2r(i) := eyd2r_{i,1}$$



since the curves appear linear:

$$m_r := \frac{\ln(ey(13)) - \ln(ey(0))}{\ln(x(13)) - \ln(x(0))} \quad m_r = -0.987 \qquad m_{2r} := \frac{\ln(ey2r(13)) - \ln(ey2r(0))}{\ln(x(13)) - \ln(x(0))} \quad m_{2r} = -0.995$$

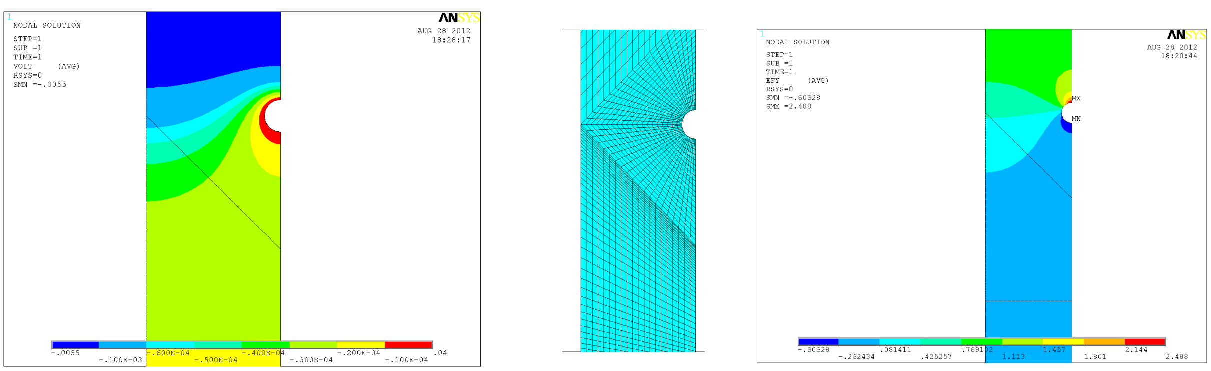
$$b_r := ey(13)\cdot x(13)^{-m_r} \quad b_r = 0.102 \qquad b_{2r} := ey2r(13)\cdot x(13)^{-m_{2r}} \quad b_{2r} = 0.055$$

or, (x in units of mesh pitch), normalized field:

$E_y(x) := b_r\cdot x^{m_r}$ e.g. $E_y(1000) = 1.11\times 10^{-4}$ for our typical 88% transparent mesh

$E_{y2r}(x) := b_{2r}\cdot x^{m_{2r}}$ $E_{y2r}(1000) = 5.641\times 10^{-5}$ for a 77% transparent mesh

Equipotentials, elements, and field (vert component) in vicinity of wire (30 μm radius)



representative field plot along axis for ground plane at y = 1 cm, mesh at y= 1.455 cm, r wire= 30 μm