Fermilab

TS-SSC 91-144
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To: Magnet Control Board

From: Jim Strait

Subject: Outer coil wedge: symmetric or asymmetric

Figure 1 is a representation of the collider dipole cross section. Corners of the insulated cables are plotted in rectangular coordinates with the angle from the mid-plane along the x-axis and the radius along the y-axis. The r-axis (y-axis) is broken at two places to enhance the visibility of the cable corners. Straight lines are drawn between the corners on this highly non-linear scale which results in the apparent overlap between some pairs of adjacent cables. Two sets of coordinates were available to me in making this plot, one generated by Ramesh Gupta, which represents the "official" magnetic design and one generated by Howard Fulton, which was used for most of the mechanical design work at Fermilab. The rms deviation between the two sets of points is 0.6 mils and the maximum deviation is 2.2 mils. The dimensions quoted below are from the average of the two sets, rounded to the nearest 0.5 mil. Shown also are the inner and outer radii of the coil molds. Note that many cable corners extend outside the mold boundaries, particularly at the outer radius. This probably does not actually occur because of the non-zero radii of the cable corners which are ignored in this plot.

The asymmetric version of the outer wedge, which fills the full cavity at the outer radius, is shaded with diagonal lines and the symmetric version is cross-hatched. The symmetric wedge fails to fill the entire coil radius on the face towards the coil mid-plane leaving a 7 mil gap measured with respect to the outer mold surface. In computing this width of "unsupported" cable I have ignored the non-zero radius of the cable and wedge corners but take into account that no part of the coil can actually extend beyond the mold boundary. The point here is not to compute the exact amount of unsupported cable but to make comparisons between this point in the cross section and several others where, because the cables are far from radial, similar unsupported cable corners exist. The pole turn of the outer coil is quite far from radial (vertical on this plot) and therefore it and the adjacent cables do not fully support their neighbors. The "overhang" is approximately 8 mils at the inner radius and 5.5 mils at the outer radius. The maximum "overhang" anywhere in the cross section is 9.5 mils at the inner radius between turns 5 and 6 (counting from the mid-plane) of the inner coil. Thus corners of several cables are "unsupported" in this cross-section by amounts comparable to that which would occur if the outer coil wedge were made symmetric.

Figure 2 shows the Lorentz forces on each of the conductors at 7 radial locations. (This Figure was supplied by Bulent Aksel in a fax to Fred Nobrega dated 7/10/91.) Note that the force at the point where the cable just below the wedge would be "unsupported," the Lorentz force is almost zero and is pointed towards the mid-plane and away from the wedge. Thus the presence or absence of the 7 mils of wedge material can have little or no effect on the behavior of this cable under excitation. In contrast, the force at the inner edge of the pole turn of the outer coil is more than 5 times larger. It is directed in the azimuthal direction, that is in the direction in which this cable corner is "unsupported" by its neighbor. Furthermore, this is at the high field point of the outer coil (where the field margin is only a few percent greater than at the pole turn of the inner coil), while the turn just below the wedge is in a much lower field region. (See Figure 3, taken from R.C. Gupta, S.A. Kahn and G.H. Morgan, SSC 50 mm Dipole Cross Section, presented at the 3rd IISSC, march 13-15, 1991, Atlanta, GA.) At the point of maximum "overhang" between inner turns 5 and 6, the Lorentz force are both considerable, but the force is essentially in the plane of the cable, so the apparent lack of support is apparently irrelevant.

In summary:

1) The lack of cable support that would occur if the outer coil wedge were made symmetric is no larger than that which is present at the inner radius of the outer coil pole turn.

2) The force on the cable "unsupported" by the symmetric wedge is pointed away from the "support" and is very small. The force on the "unsupported" corner of the outer pole turn is towards the "support" and is >5 times larger.

3) The cable "unsupported" by a symmetric outer coil wedge is in a much lower field than the outer pole turn and therefore has a much larger temperature margin.

4) There have been no problems associated with the "unsupported" outer coil pole turn inner corner.

Therefore, there is no reason, from a magnet performance standpoint, that the outer coil wedge need be asymmetric.

cc: B.Aksel, R.Bossert, S.Delchamps, A.Devred, J.Jayakumar, W.Koska, M.Lamm, F.Nobrega, M.Wake

BNL: Mike Anerella, Gene Kelly, Erich Willen

W6733E cross section

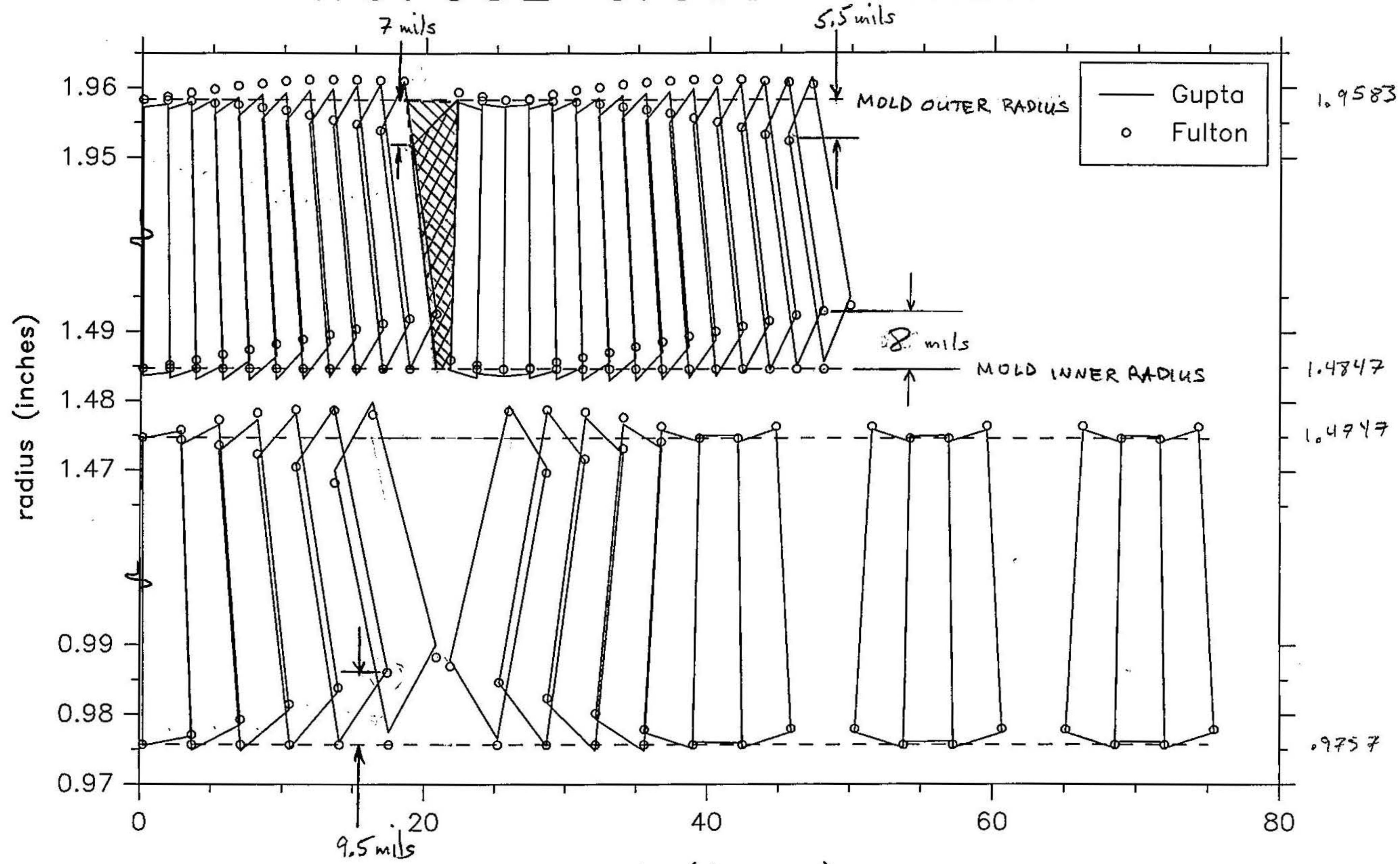

Figure 1

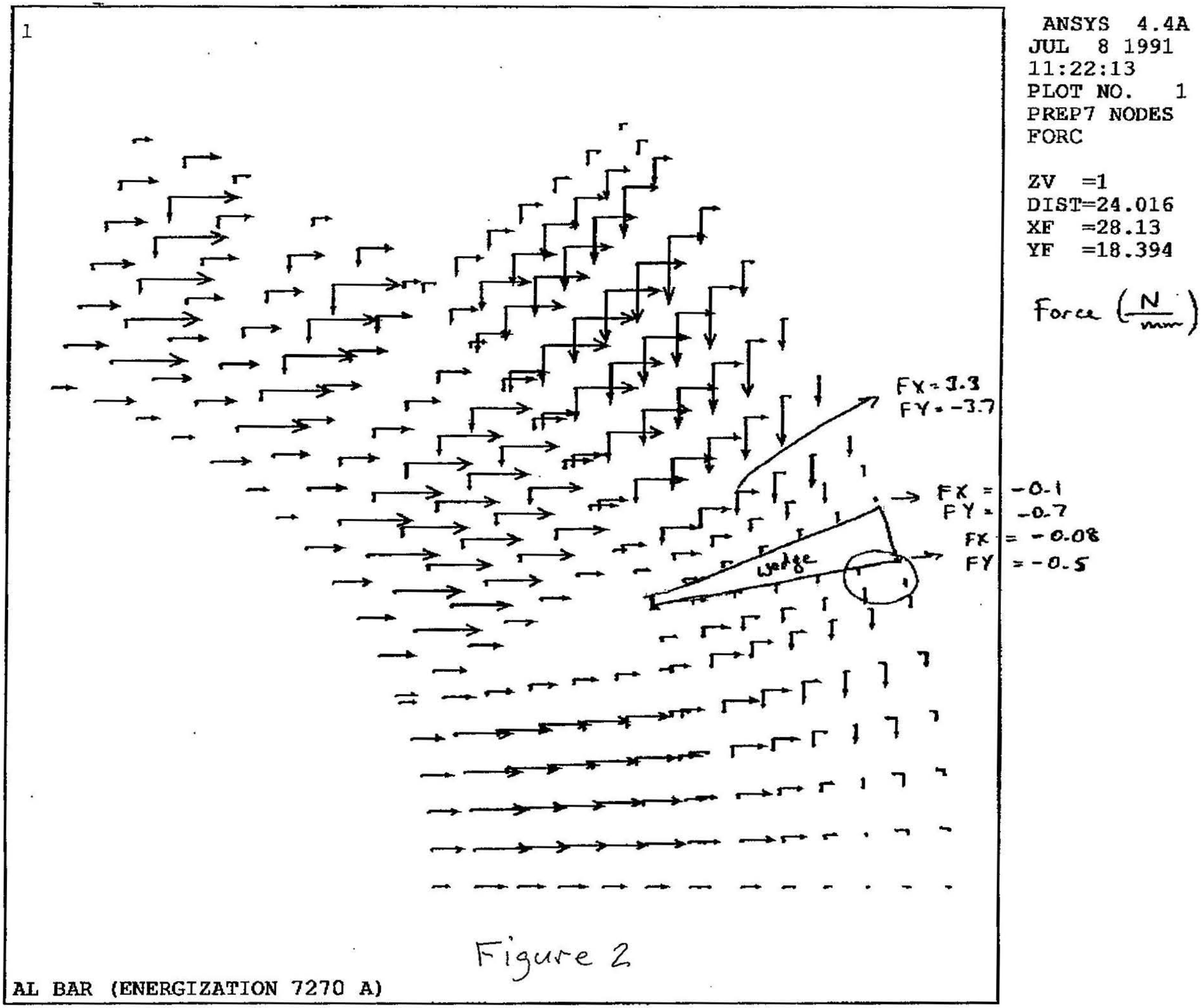
1
ANSYS 4.4A
JUL 8 1991
11:22:13
PLOT NO. 1
PREP7 NODES
FORC
ZV =1
DIST=24.016
XF =28.13
YF =18.394
Force (N/mm)
FX = 3.3
FY = -3.7
FX = -0.1
FY = -0.7
FX = -0.08
FY = -0.5
wedge
AL BAR (ENERGIZATION 7270 A)

Figure 2

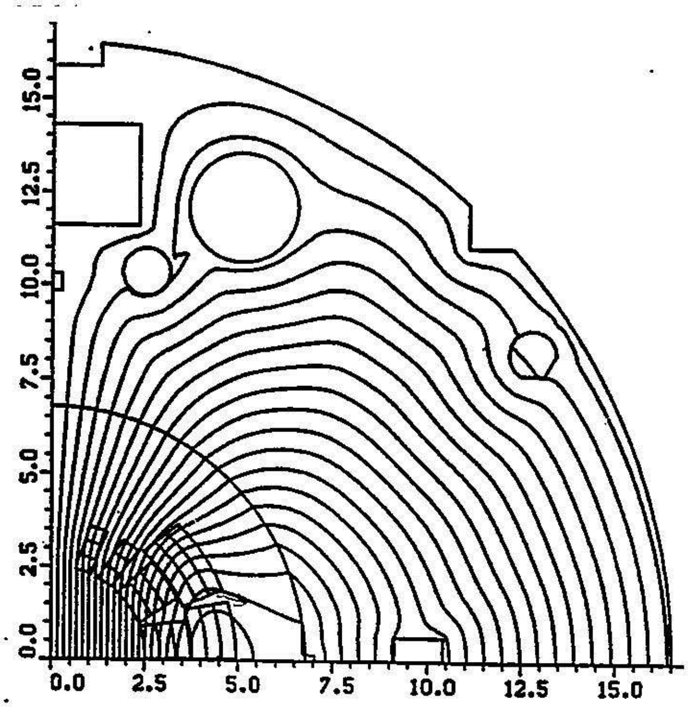

Figure 3: POISSON model and field lines at 6500 ampere for SSC 50 mm Dipole with the vertically split iron lamination.