Yet another 15 degree bend
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Abstract

JLab Center for Injector and Sources (CIS) asked that the power draw for the previous design be reduced by increasing the wire size. Accordingly, the wire size was increased from AWG 18 to AWG 17, lowering resistance ~20%. Turns count is still 72. Coils are a bit thicker and wider. Hexagonal close pack of maximum material condition single film wire assumed in sizing coil. An Opera model with steel cylinder was created and six cases each were run with the BH properties of the steel set to 1010 and to air. The exact same mesh was thus used for both sets of simulations. For a 200 keV KE beam, 2.21 A and 6 W for air return case and 1.37 A and 2.3 W for steel return case. The modified coil form drawing is JL0087295.

Coil models

HELICALEND WIDTH=0.9 THICKNESS=1.13 H1=5 H2=5 R1=4.1 R2=1.13 ALPHA=23.1 BETA=90

HELICALEND WIDTH=0.9 THICKNESS=1.13 H1=5 H2=5 R1=5 R2=1.13 ALPHA=44 BETA=90

Steel (air) tube 6.35 cm OR, 0.15 cm wall aka 5” OD, 0.06” wall

Discussion

Much of the discussion in https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-202064/19-034.pdf carries over. I repeat here figure 2 showing psi rotation.

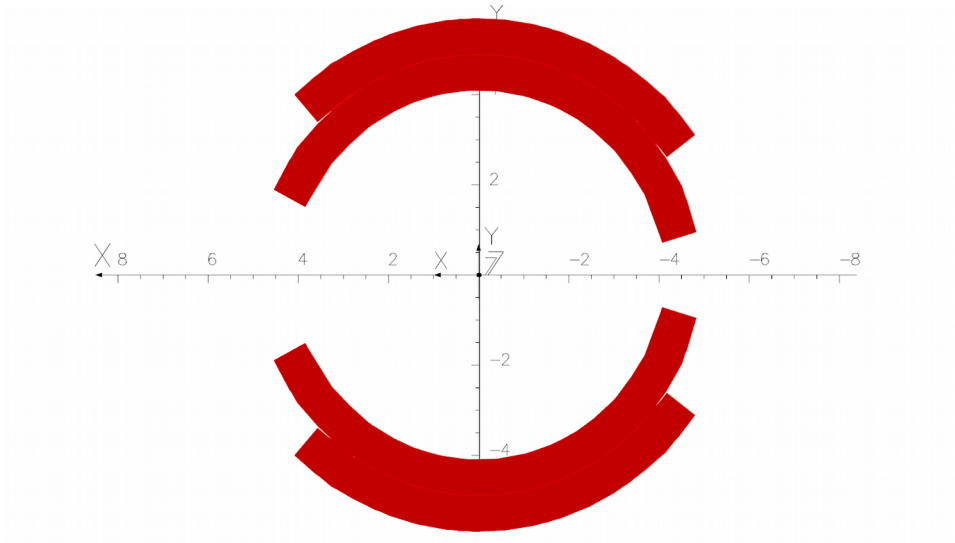

Figure 1. View from -Z, aka looking downstream, with +0.1 radian psi rotation applied to the coils. This is much larger than optimum. It is included to orient the author and reader.

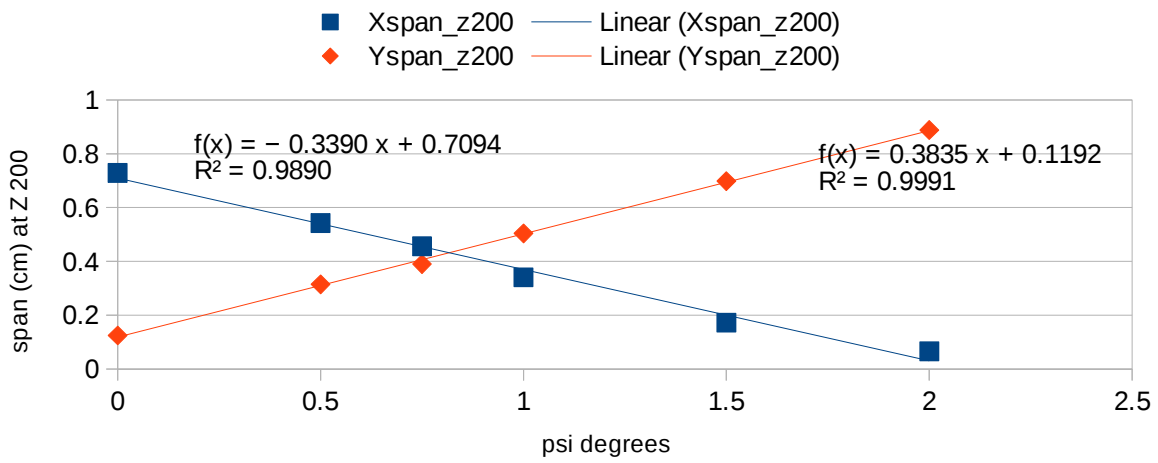

Figure 2. X and Y spans at Z=200 cm of an array initially (z=-40) 1 cm square. Air return. X span corrected for 7.5° angle. The lines intersect at 0.82° rotation of coils in same manner as figure 1.

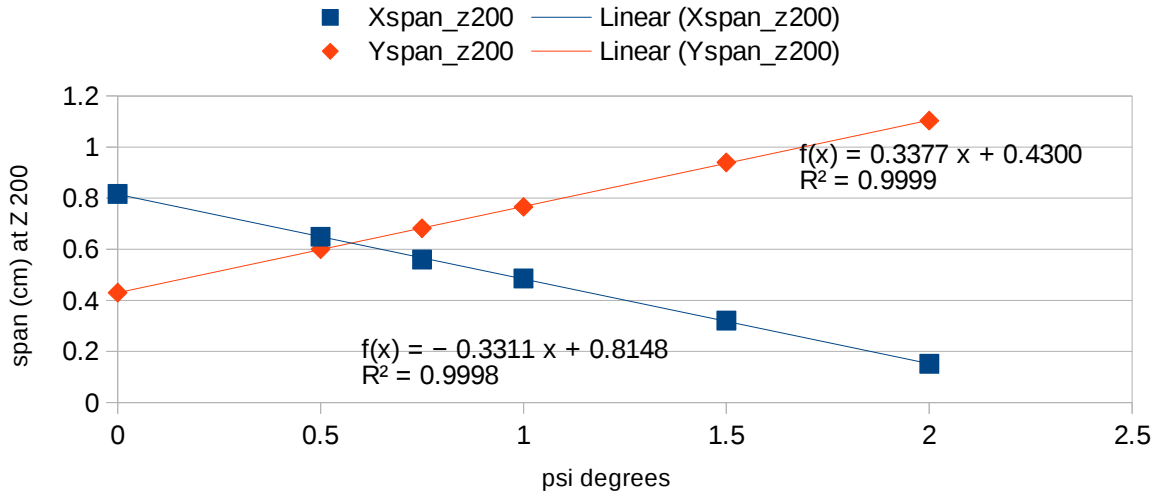

Figure 3. X and Y spans at Z=200 cm of an array initially (z=-40) 1 cm square. Steel return. X span corrected for 7.5° angle. The lines intersect at 0.575° rotation of coils in same manner as figure 1.

The models were evaluated with 3A aka 216 AT. For the air return case, electron energy of 332 keV KE resulted in split sagitta with 7.5° entry and exit angles. Displacing the orbit so entry and exit are on axis instead of 1.8 mm offset did not affect the results given the size of the coils. For the steel return case, 685 keV KE produced Figure 3. Again sagitta was split but a couple of offset checks showed that central entry woul give the same focusing results. Calculated resistance of the full coil set assuming nominal wire resistance at 20 C, 5.054 Ω/1000', is 1.23 Ω. This resistance was used to calculate the power values in the Abstract. The coil will equilibrate at higher temperature in the tunnel but the power will still be lower than that for AWG 18.

Perhaps more changes

Sarin Philip asked me October 21 about designing a replacement for the DB magnet as they have been thermally damaged by running up to 6A in CEBAF, roughly twice the maximum used in the FEL. Traces have bubbled the circuit boards, indicating heat not radiation. The DB is ~4.5" long. The coil former for this dipole is 4.42" long. The steel tube is 5.5" long but could be shortened to 5" without too much loss of central B field. The DB field map shows 927 G-cm at 10A. The fields for this dipole are shown below. Air return integral 590 G-cm, iron return integral 942 G-cm, both at 3A.

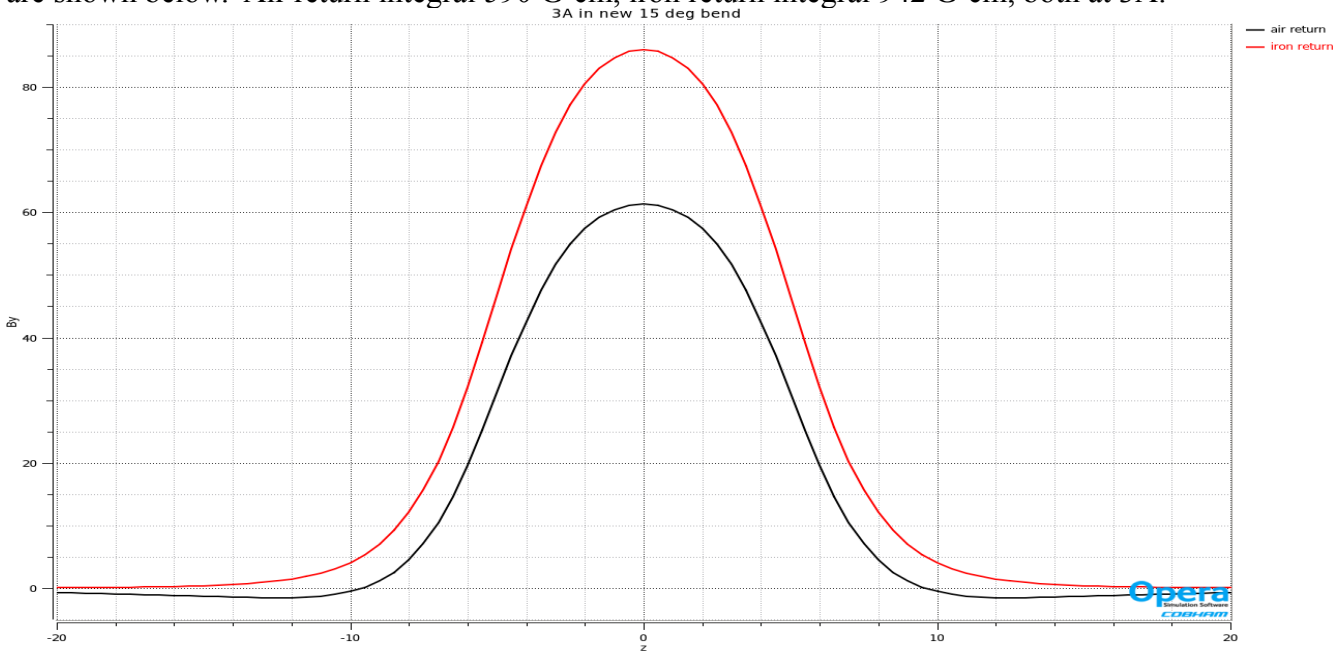

Figure 4. By along Z axis for air return (black) and iron return (red) versions, 3A.

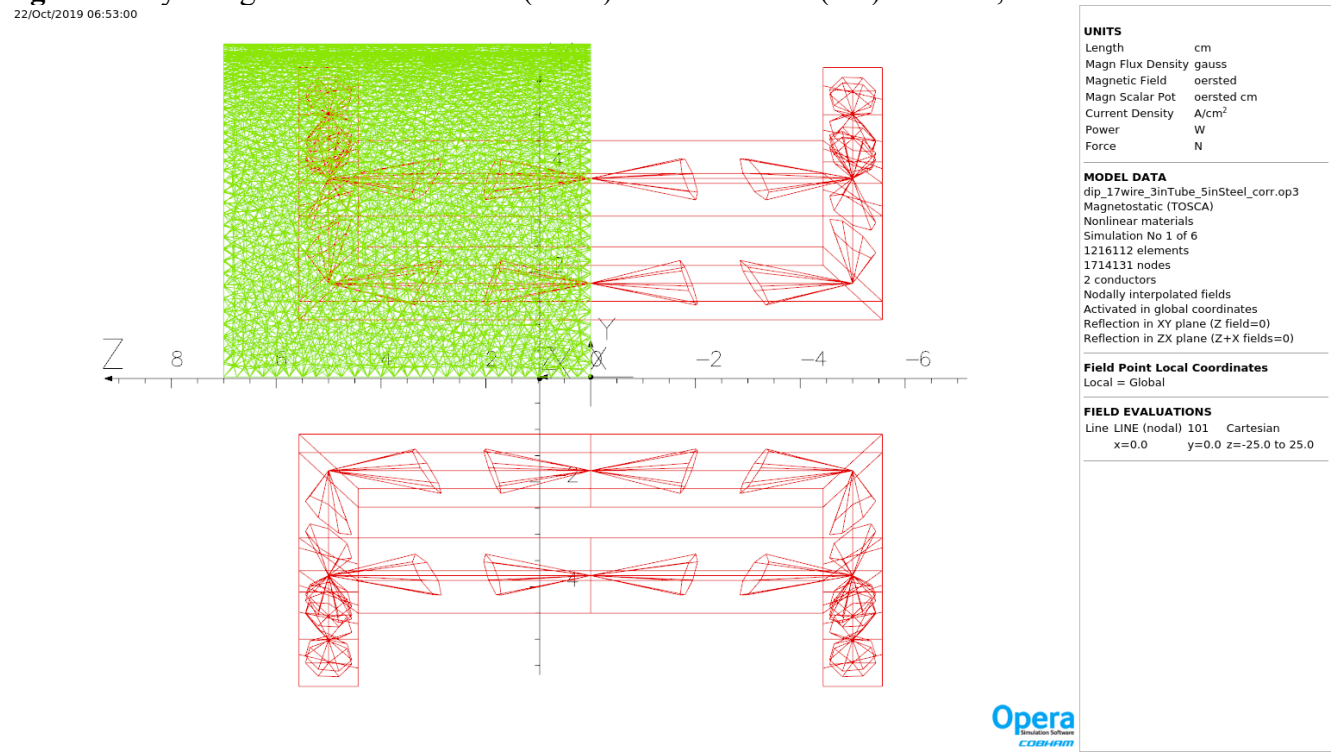

Figure 5. Section, viewing from +X, of model less air. This shows extension of (green) steel beyond end of the coils. 5.5" is available in the injector so I used it.

I designed the coils using single film 17 AWG copper because that is ample for 30 V power supply and there's no radiation at 200 keV KE. Diameter at maximum material condition 0.0475". If these are to replace the DB and DJ units in high radiation areas by the C100s, heavy film is more appropriate. Diameter 0.0482" nominal, 0.0488" max material. I should increase the coil transverse sizes by 2.7% (0.0488") to 0.925 cm by 1.16 cm and solve the models again, alas. Integral BdL will drop slightly and resistance will increase but remain under 1.3 Ω at 20C. Higher in the tunnel but still not an issue for the trim cards.