LDRD GTS Magnetic Model
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Abstract

A magnetic model of the LDRD GTS (lab directed research and development gun test stand) was developed at the request of Riad Suleiman. Locations were taken from drawing JL0038343 "magnetized beam LDRD assy" except for the first corrector, nominally at z=41.38 cm, because it would have interferred with the adjacent solenoid. Its centerline was changed to z=40 cm. The magnetic elements of the model are discussed individually in the next section. The following section shows fields in simulations with single elements energized.

Magnetic elements

The large LDRD coil was procured to a specification I wrote:

One water cooled magnet coil

Inside diameter 30 cm, round to 0.2 cm
Outside diameter roundness: 0.5 cm
Flatness, each side, 0.3 cm

Eight double pancakes of 20 turns per pancake using Luvata 6092 or equivalent copper conductor, 9 mm square with 6 mm round hole for water cooling. 320 turns total. These may be soldered or bolted together as vendor prefers, see also potting options below. Vendor should propose input/output flags suitable for 500A.

Eight parallel water cooling circuits, one per double pancake, with 37° flare JIC tube fittings. All eight water connections shall be located on the coil outer diameter within a 15 degree region of the assembly. Vendor shall provide a cooling water specification (flow rate and pressure) for each water circuit assuming 400A current and water inlet temperature of 35C.

Coil cross-section shall be less than 16 cm Z by 20 cm R.

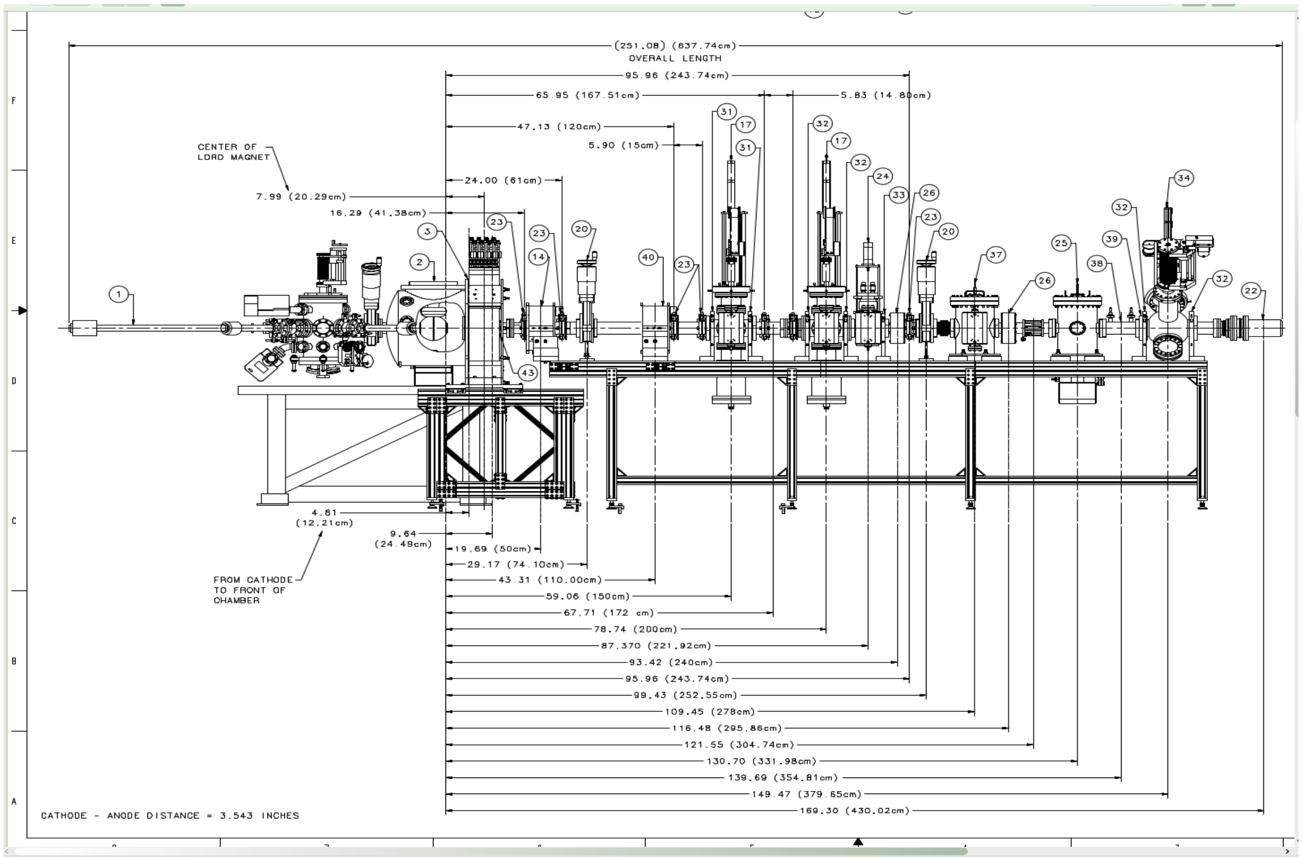
Vendor shall propose insulation system. Glass-epoxy with at least 110C capability preferred. Potting may be done as a "bag job". Tooling could also be built to pot four double pancakes as a coil half with four water circuits and two leads. Bolted jumper plate to electrically join the two halves shall be provided in this case. Or full depth tooling can be built.

The two FEL-style focusing solenoids are documented only in JLab mechanical drawings and my Opera models. The work was done over two decades ago and I didn't write a TN.

The seven correctors were purchased from Radiabeam. https://logbooks/entry/3485463 was written by Riad to retain relevant links.

Mechanical drawing

Figure 1. The portion of JL0038343 which has Z locations is below. The centerline values were used except for corrector 1, the leftmost in figure 2, which would have intefered with the adjacent solenoid.



Opera model

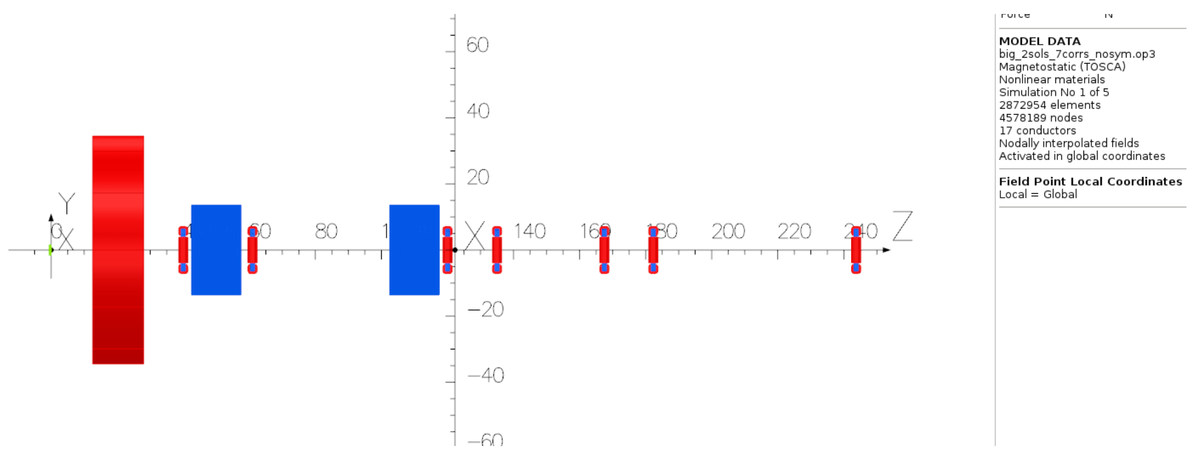


Figure 2. Opera model. Cathode is at left, 0. Big red object is the LDRD coil defined above. The two blue boxes are the FEL-style focusing solenoids. The other seven red/blue items are the correctors. I numbered them left to right.

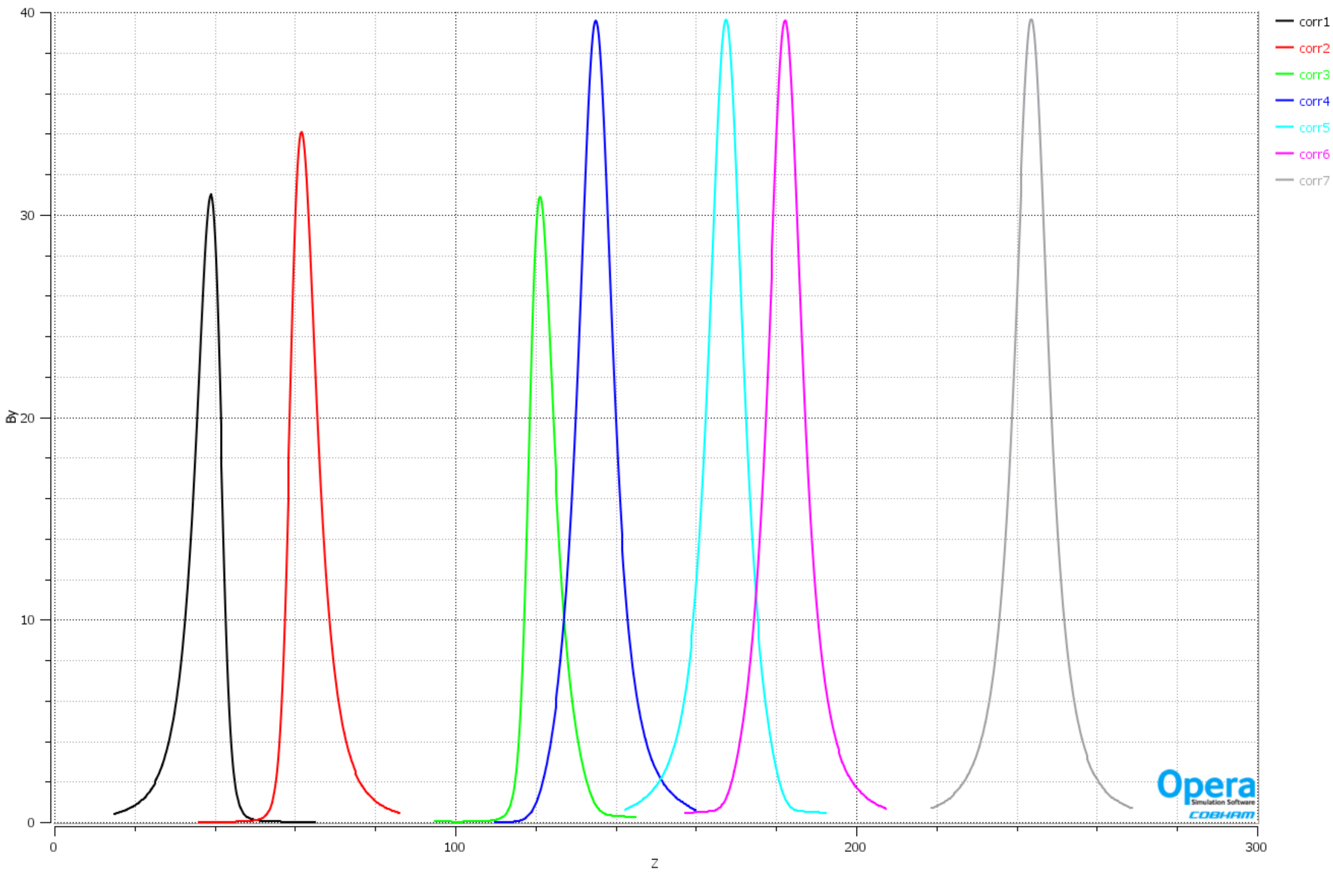


Figure 3. BY due to the seven correctors, all driven by the same current. The effect of the steel solenoid casings is obvious in the first three and even affects the others slightly.

simulation	**By BdL at 477.75 AT per coil (G-cm)**
separate model, corrector only	500.4
sim 2, corrector 1 energized	280.8
sim 3, corrector 2 energized	320.4
sim 4, corrector 3 energized	268.3
sim 5, corrector 4 energized	480.9
sim 6, corrector 5 energized	487.2
sim 7, corrector 6 energized	487.0
sim 1, corrector 7 energized	505.6

Table 1. BdL integrated over ± 25 cm from corrector center. Corrector 7 is first simulation because I wanted to see if a mesh change brought it closer to value for isolated corrector in separate model. In previous model corr7 BdL was 489 G-cm, so it swung from -2.3% to +1%. Corrector steel is meshed at 0.25 cm in the separate model and 0.5 cm in the large model, likely accounting for the 1% discrepancy. If requested I will change all the steel to 0.25 cm and re-solve.

Measurements with beam suggested that the correctors adjacent to the solenoid steel have about half the strength of those far away from it per Riad. The model supports these conclusions. By(z) shapes are distorted too. Small differences in proximity have large BdL effect.

Field from main coil

I was asked to run the model with 100A, 200A and 400A in the big coil; zero in others, to check for nonlinearity. There is a slight non-linearity in the steel of the first solenoid apparent in figure 5 below.

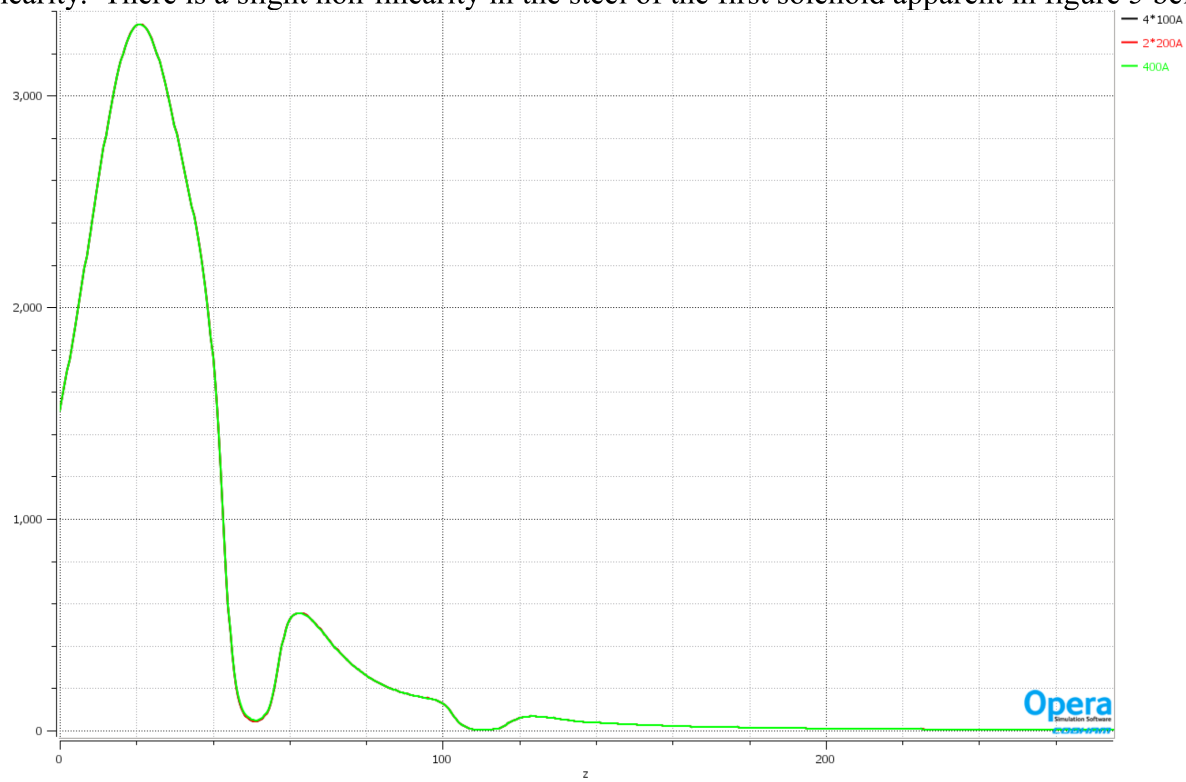


Figure 4. Bz is plotted as 4*100A response, 2*200A response and 400A response.

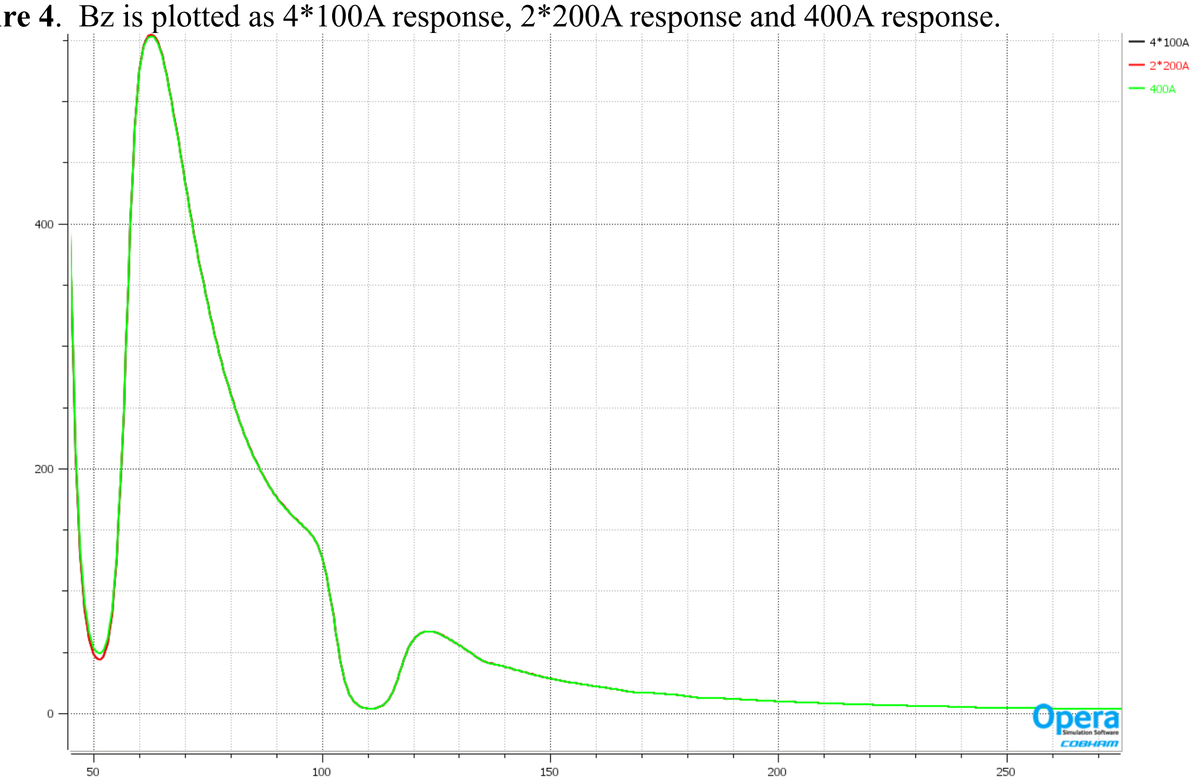


Figure 5. Same three curves on 555G maximum vertical axis and z=[45,275]. One sees a little red around z=50, inside the first solenoid, indicating a difference between 200A and 400A response.

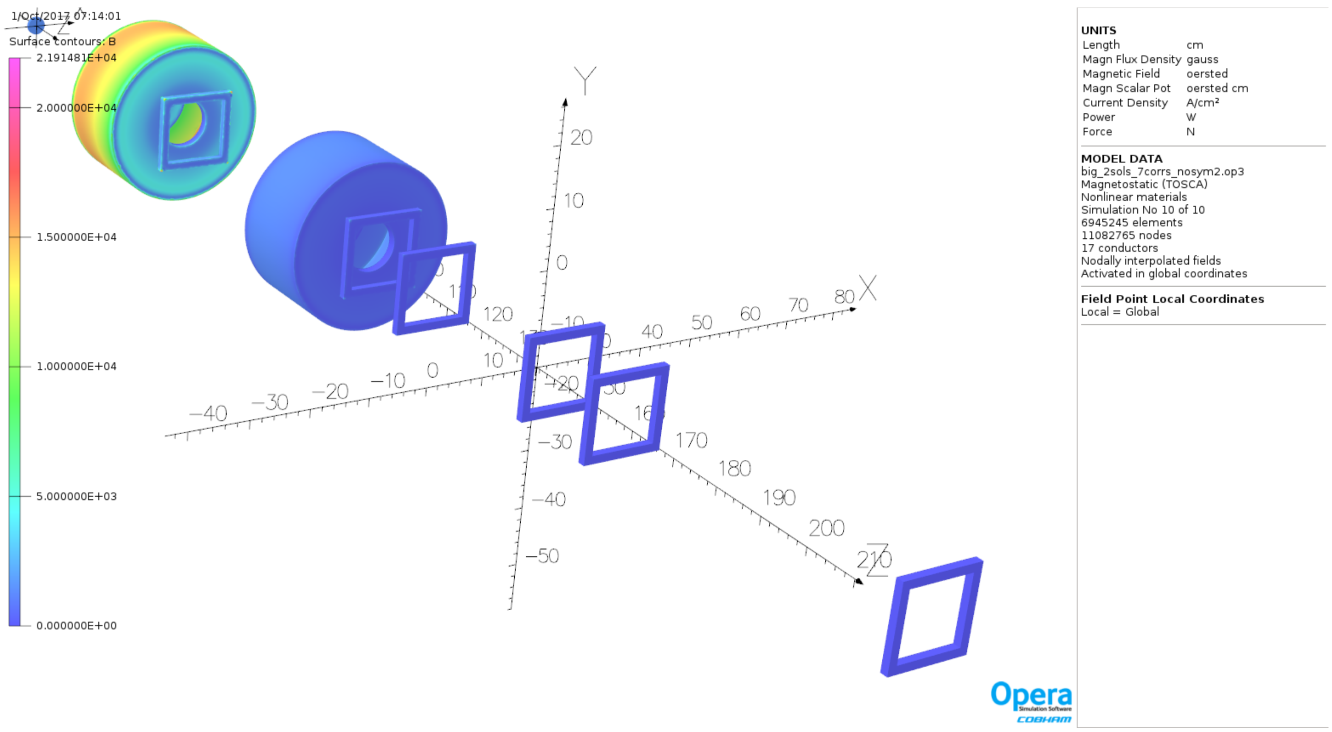


Figure 6. Field |B| on the surface of the steel, cathode puck at top left. Coils suppressed. 400A in big coil.

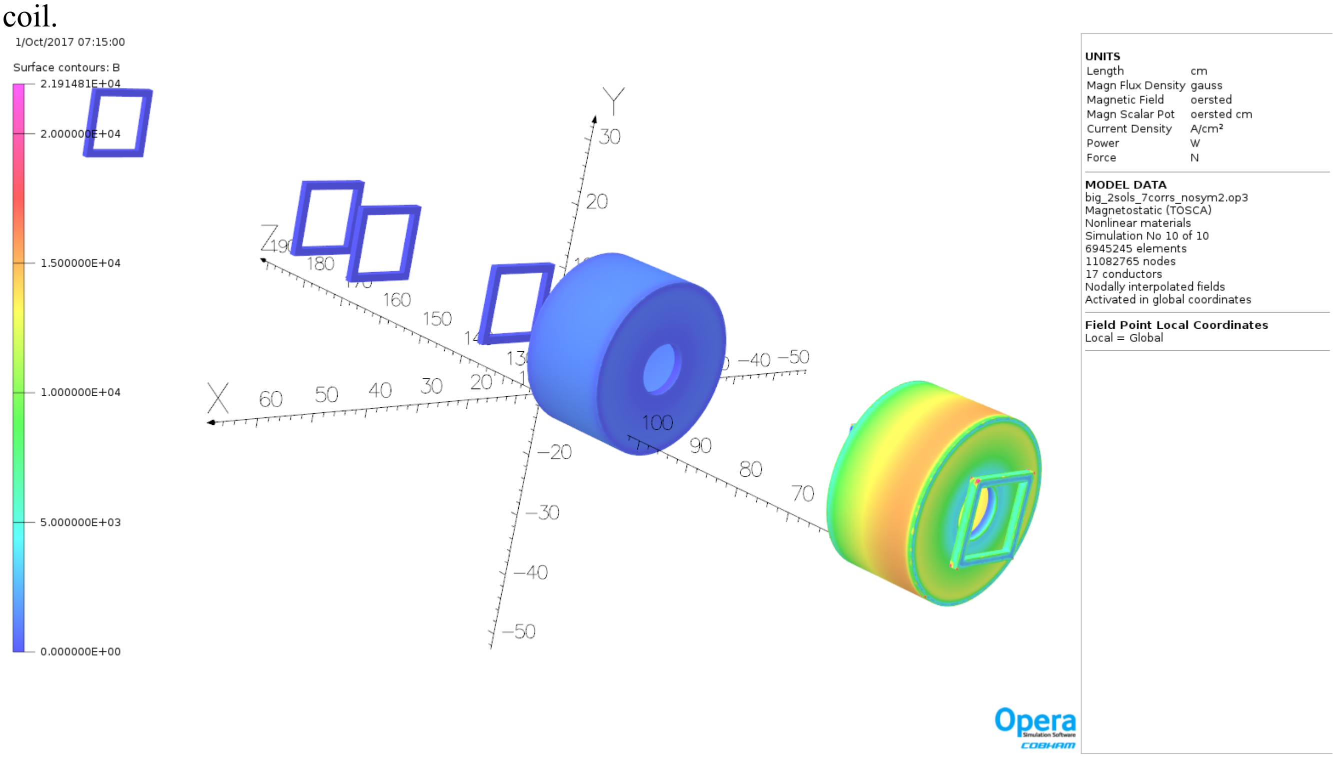


Figure 7. |B| on steel surface, image rotated about 180º so first corrector may be seen.

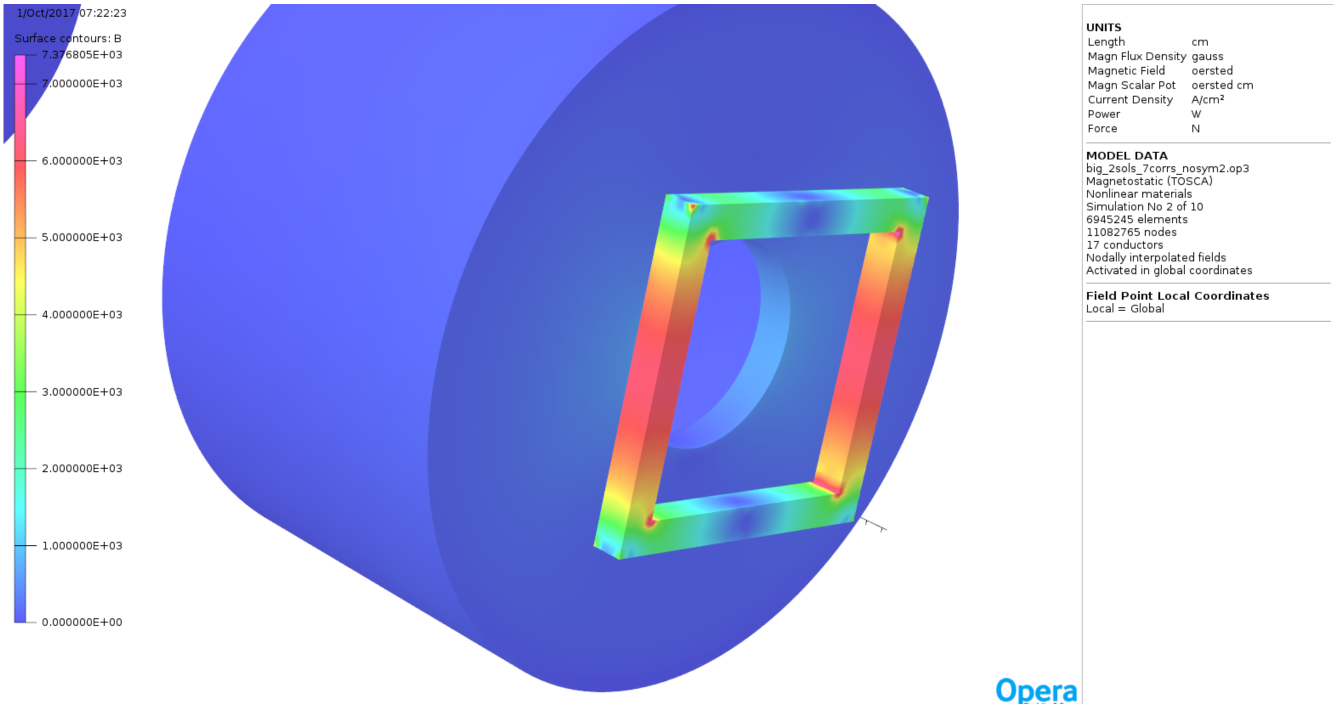


Figure 8. Field |B| on surface of steel with 477.75 AT in corrector 1. There's a haze of lighter blue on the face of the solenoid. I deduce that each coil has 160 turns so this field corresponds to 3A with a BH curve that's not quite right. The field in the steel is below 10 kG at 4A

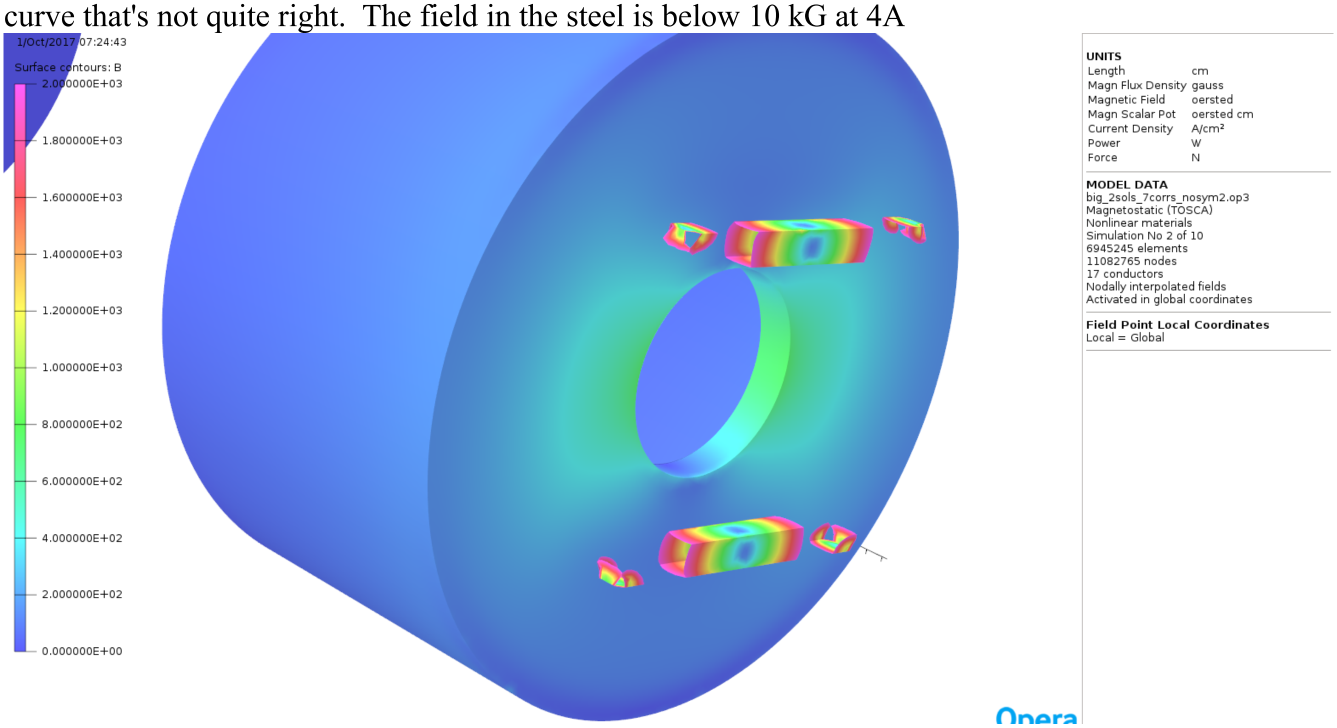


Figure 9. |B| axis truncated at 2000 G so most of corrector steel vanishes but 1 kG field on solenoid steel is more obvious.

Conclusions

A useful magnetic model of the GTS system has been prepared. Effects seen in experiments have at least qualitatively been explained. Refining steel mesh and checking effects of focusing solenoids on correctors when the former are energized will be implemented upon request. Focusing solenoid currents must be supplied with such a request.