SolidXL with a big LGC notch

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Abstract

After the teleconference Monday 20 February I built two more models with successively larger notches for the Light Gas Cherenkov system. The one shown below has a notch which runs Z=[209.55,224.79] R=[222,270] and a 5 cm chamfer on the corner just below it. This document consists mostly of figures but at the end I muse about fabrication and ugly but lower cost options.

Fields and Forces

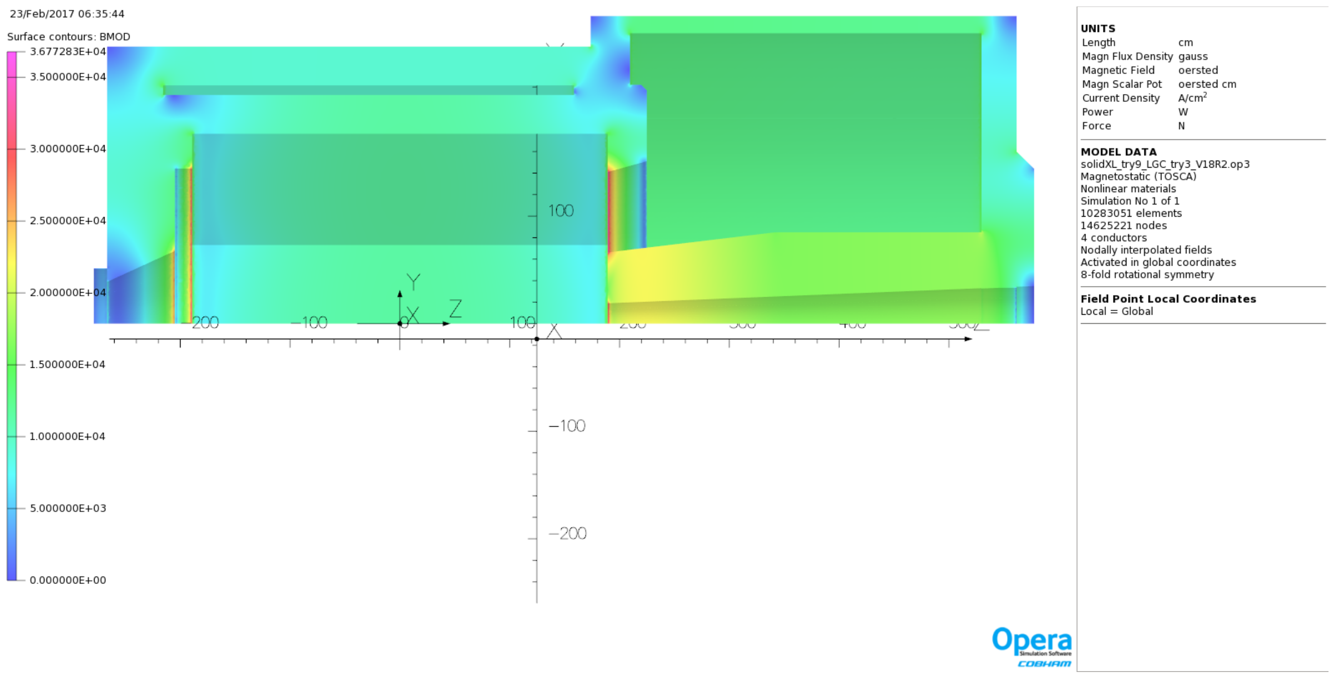

Figure 1. B(modulus) on surface of steel.

X Y Z forces

Total force on coil 1 = 3.7835E-10 0.0 2882404.689 N
Total force on coil 2 = -4.6566E-10 0.0 64464.72367 N
Total force on coil 3 = 1.45519E-10 0.0 -2940404.47 N
Total force on coil 4 = 5.32907E-14 -1.4211E-14 67.60073577 N
Total force on all coils = 5.8261E-11 -1.4211E-14 6532.548427 N

Coil 4 is the correction solenoid outside the upstream plug, 67N is irrelevant. Since the total force on all coils has increased from 2kN without the notch to 6.5 kN with it and associated changes, I should increase the thickness of the upstream plug by ~0.14 cm to null the longitudinal force again. It runs from -266.7 to -205 cm Z in this model. If the notch remains at roughly this size, it should run from -266.7 to -204.86 cm. 24.35” thickness puts the inside at -204.85 cm, close enough.

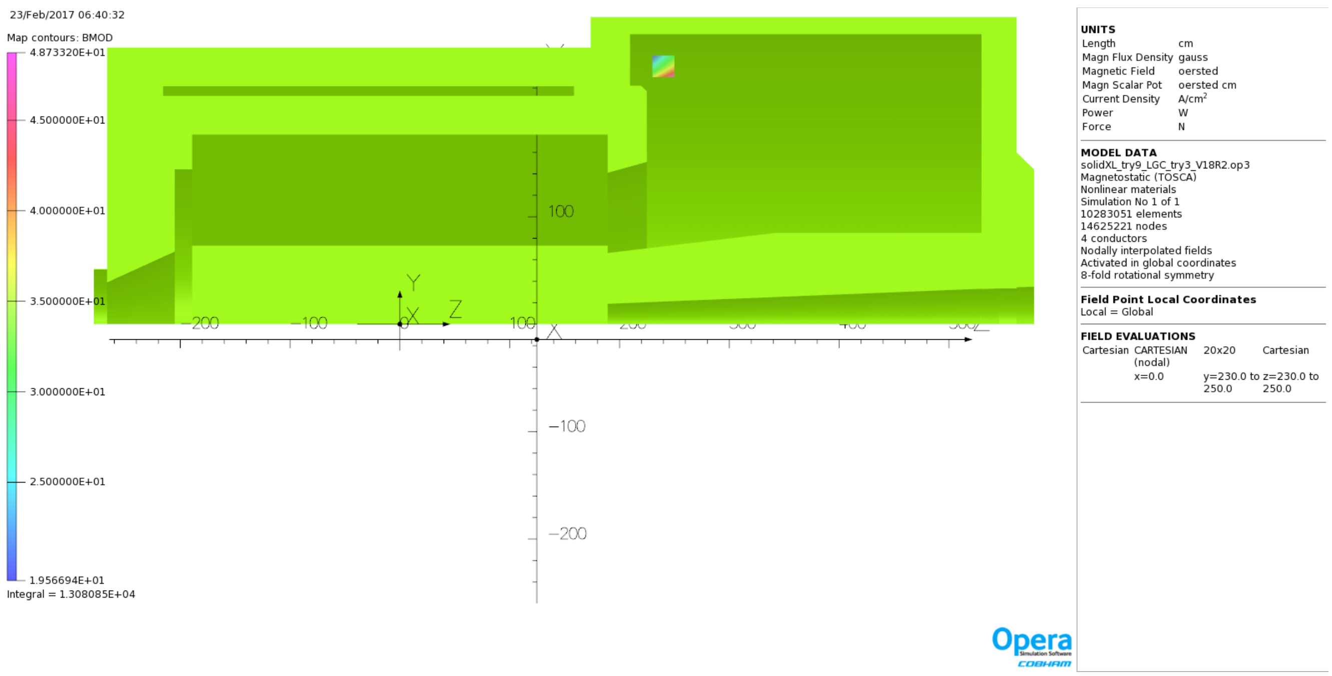

Figure 2. Stray field in 20 cm square on YZ plane around central location of LGC PMTs per M.Paolone. Under 50G throughout

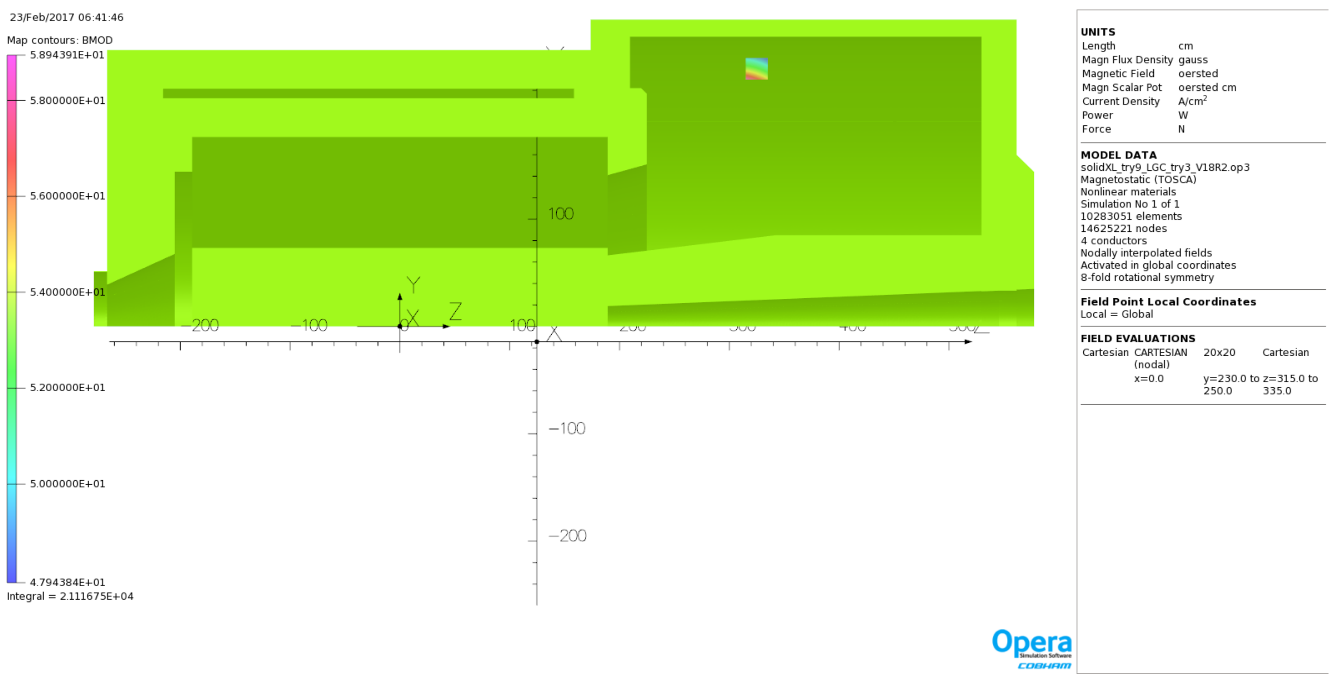

Figure 3 Stray field in 20 cm square on YZ plane around central location of HGC PMTs per Z. Zhao. Under 60G throughout

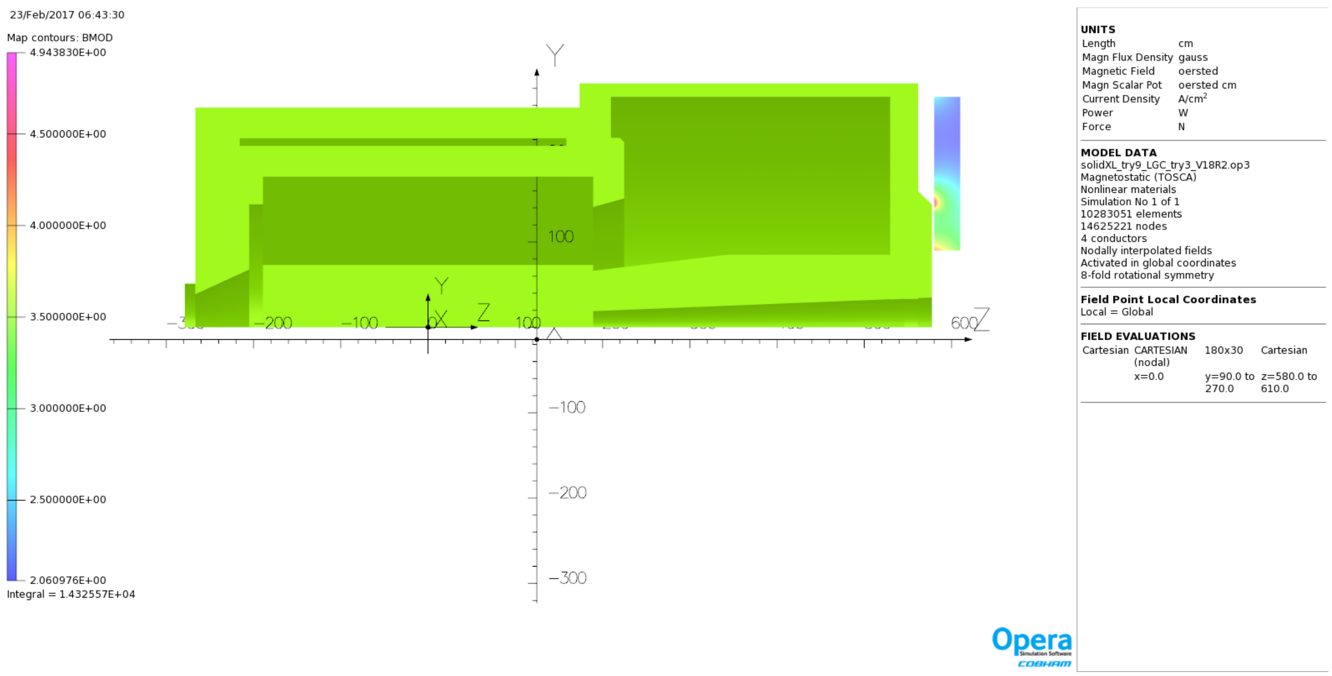

Figure 4. Stray field in 30 cm by 180 cm patch in YZ plane where ECAL PMTs may be located. I had to add another 16 cm of steel to the back plate at lower radii to get the field under 5 G in this region.

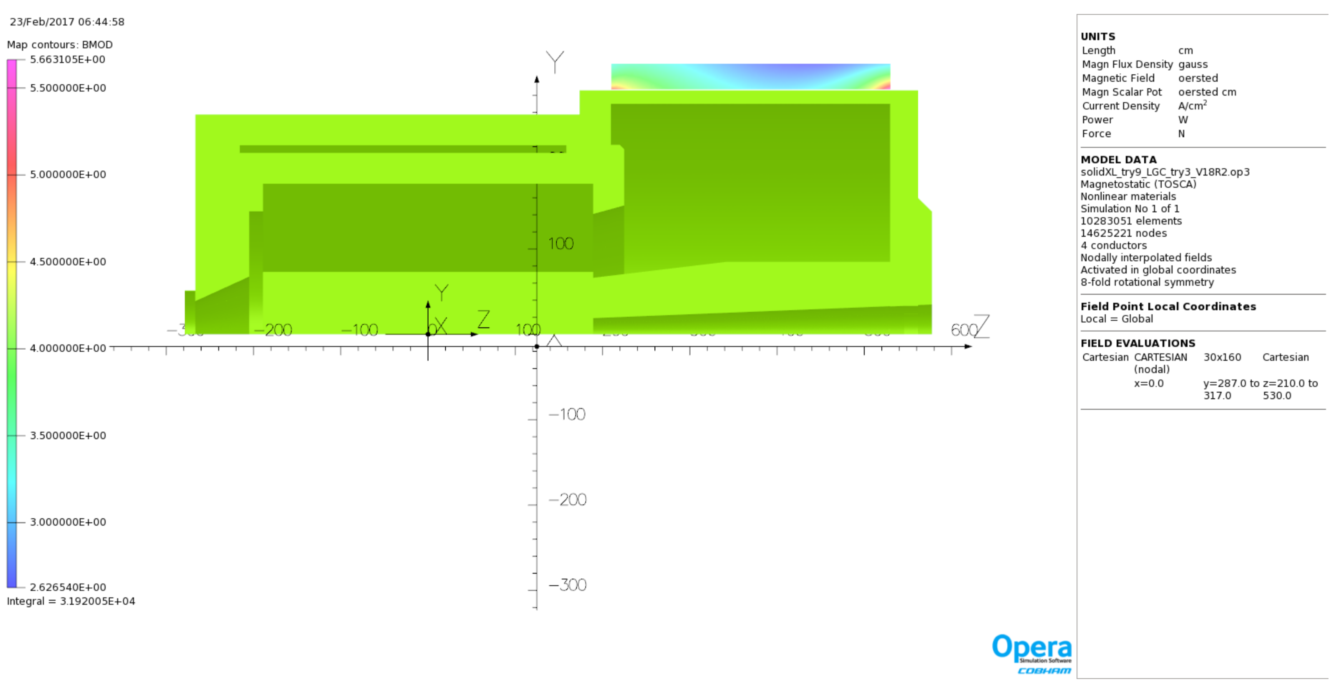

Figure 5. Stray field in 30 cm by 320 cm patch in YZ plane where GEM electronics may be located. Under 6 G throughout, so unlikely to be an issue.

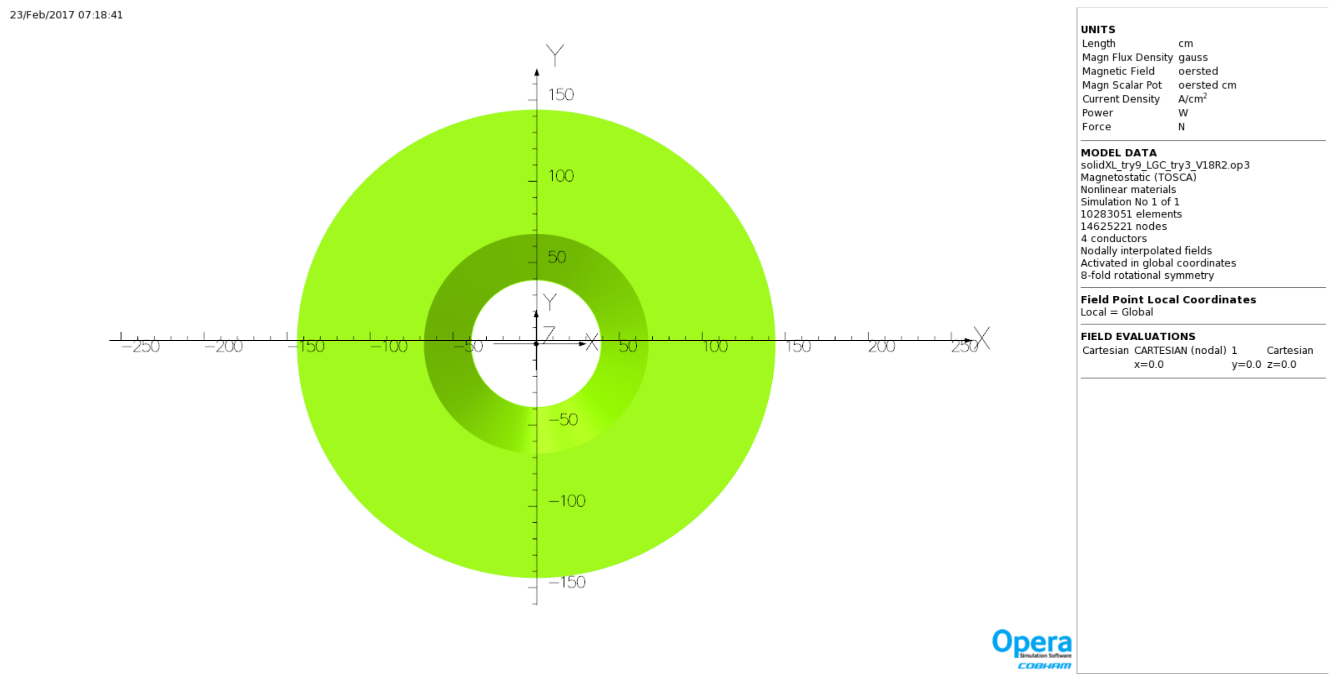

Figure 6. Upstream plug

Forces in N:

z-direction: 1.811246294181E+06 , cancellation: 0.147301%

Torques around (0.0,0.0,0.0) in N cm:

around z: -355.138693434284 , cancellation: 99.86626%

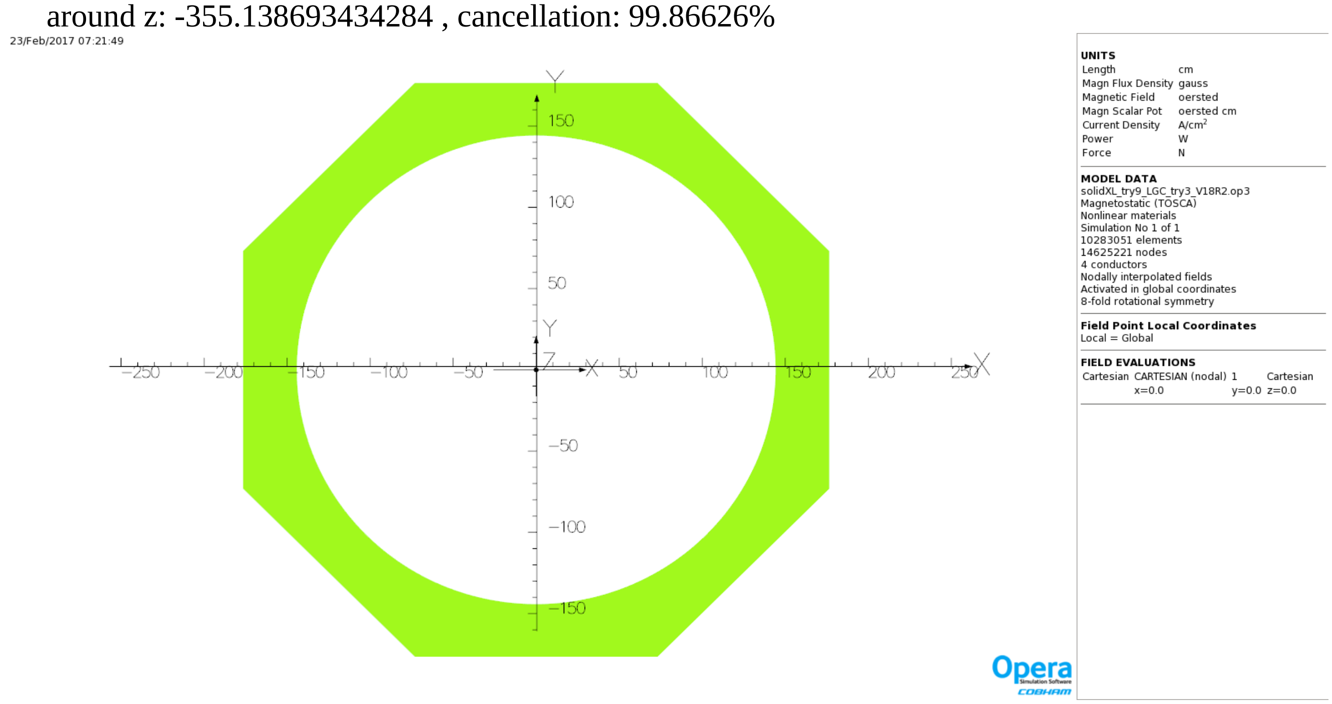

Figure 7. Upstream coil collar

Forces in N:

z-direction: 711564.336877175 , cancellation: 0.0344365%

Torques around (0.0,0.0,0.0) in N cm:

around z: -62659.6453005658 , cancellation: 99.93568%

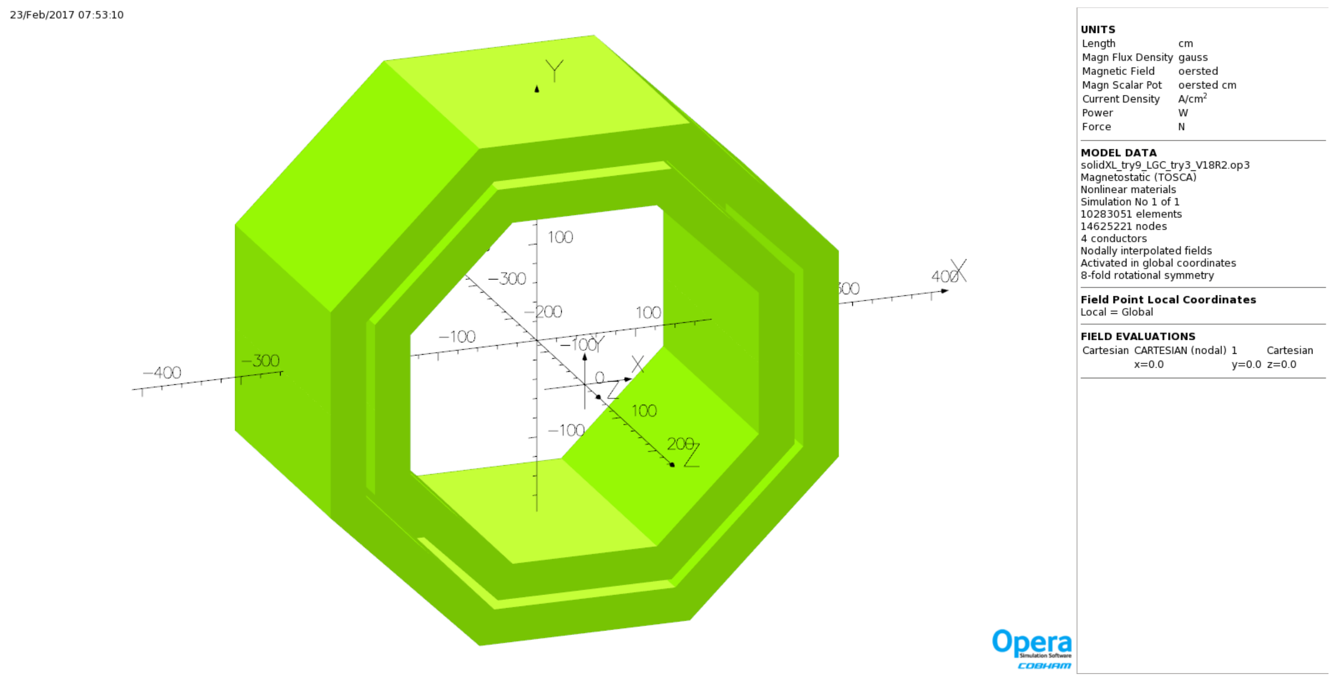

Figure 8 Upstream octagon

Forces in N:

z-direction: 4.27311947820841E+06, cancellation: 0.0248145%

Torques around (0.0,0.0,0.0) in N cm:

around z: 132.790068849707 , cancellation: 99.99987%

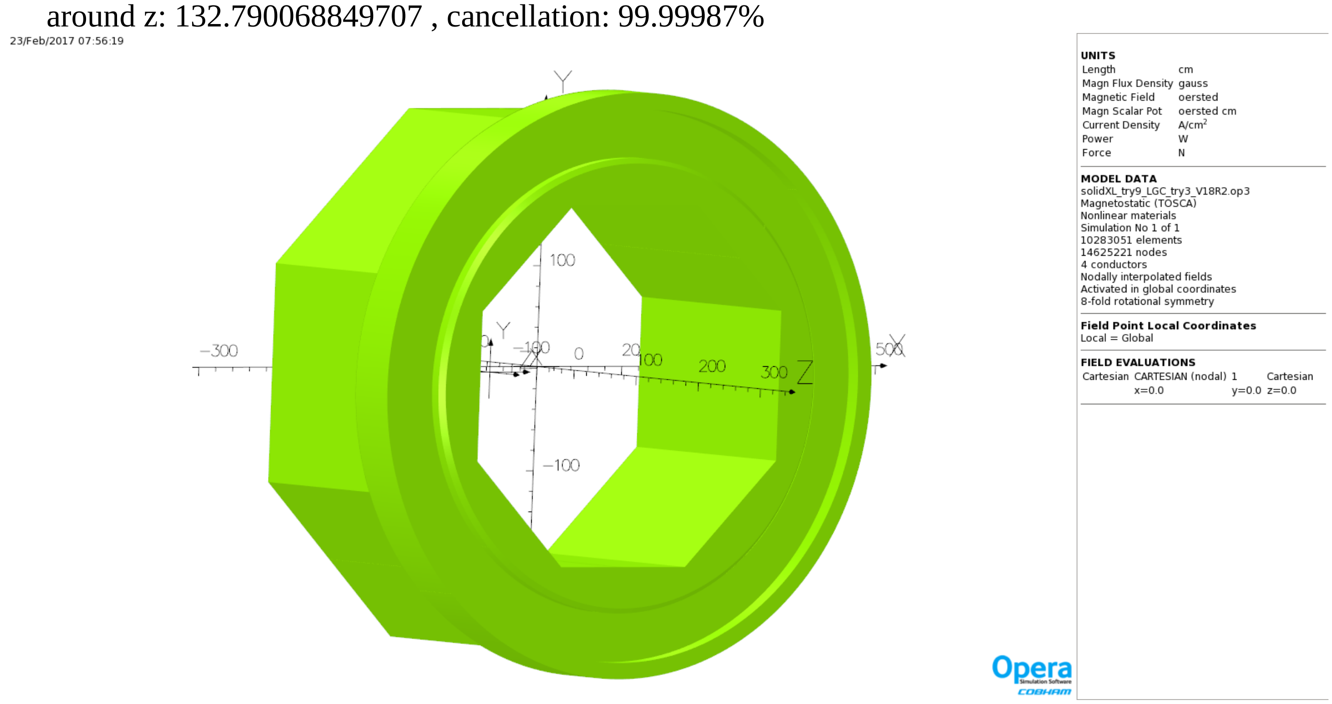

Figure 9 Downstream octagon and interface to endcap cylinder, including notch

Forces in N:

z-direction: -2.5080315829638E+06, cancellation: 58.47116%

Torques around (0.0,0.0,0.0) in N cm:

around z: 53877.1533949635 , cancellation: 99.92021%

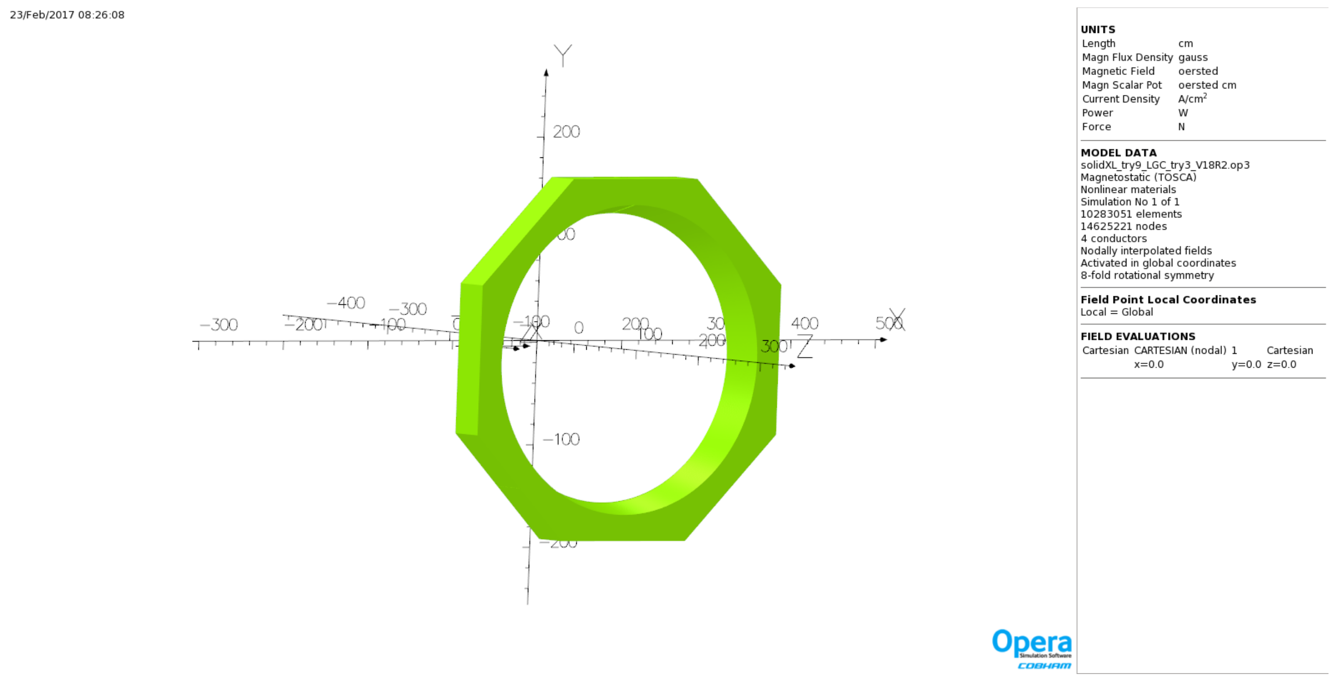

Figure 10. Downstream coil collar

Forces in N:

z-direction: -961537.813553235 , cancellation: 9.646303%

Torques around (0.0,0.0,0.0) in N cm:

around z: 6613.9295656022 , cancellation: 99.9895%

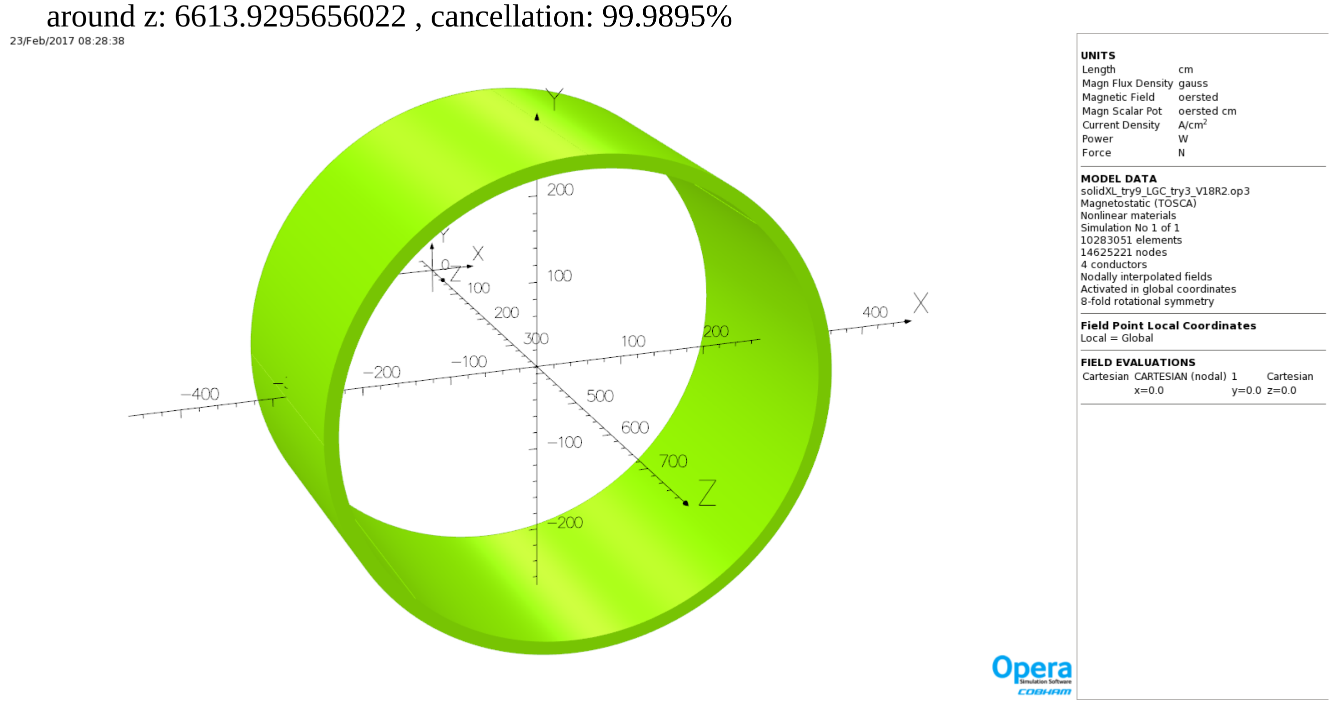

Figure 11 Endcap cylinder

Forces in N:

z-direction: -219208.634484158 , cancellation: 93.37758%

Torques around (0.0,0.0,0.0) in N cm:

around z: 2.93521286699889 , cancellation: 99.89404%

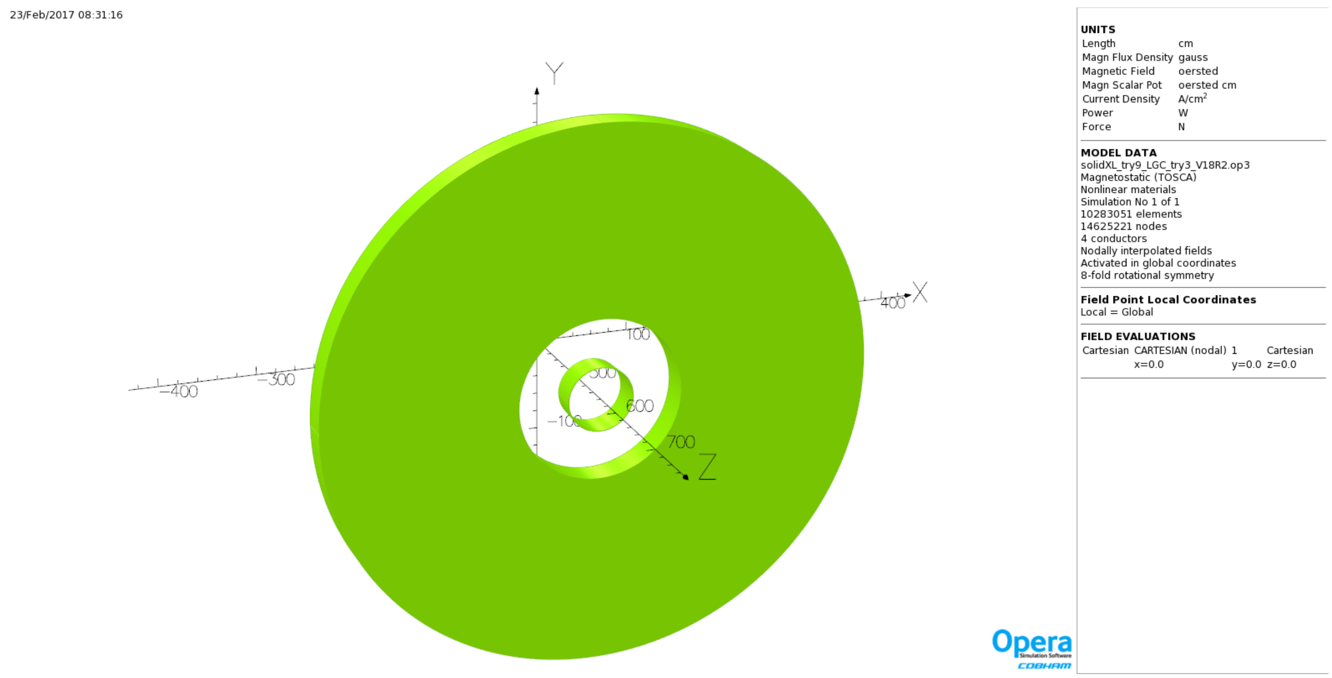

Figure 12. Endcap plate and a little steel inside that shouldn't be there. It should have been cut out when I created an air volume representing the beam line and "trimmed overlap" but it wasn't. Tsk, tsk.

Forces in N:

z-direction: -1.364326637509E+06 , cancellation: 21.15401%

Torques around (0.0,0.0,0.0) in N cm:

around z: -129.395822528546 , cancellation: 97.80598%

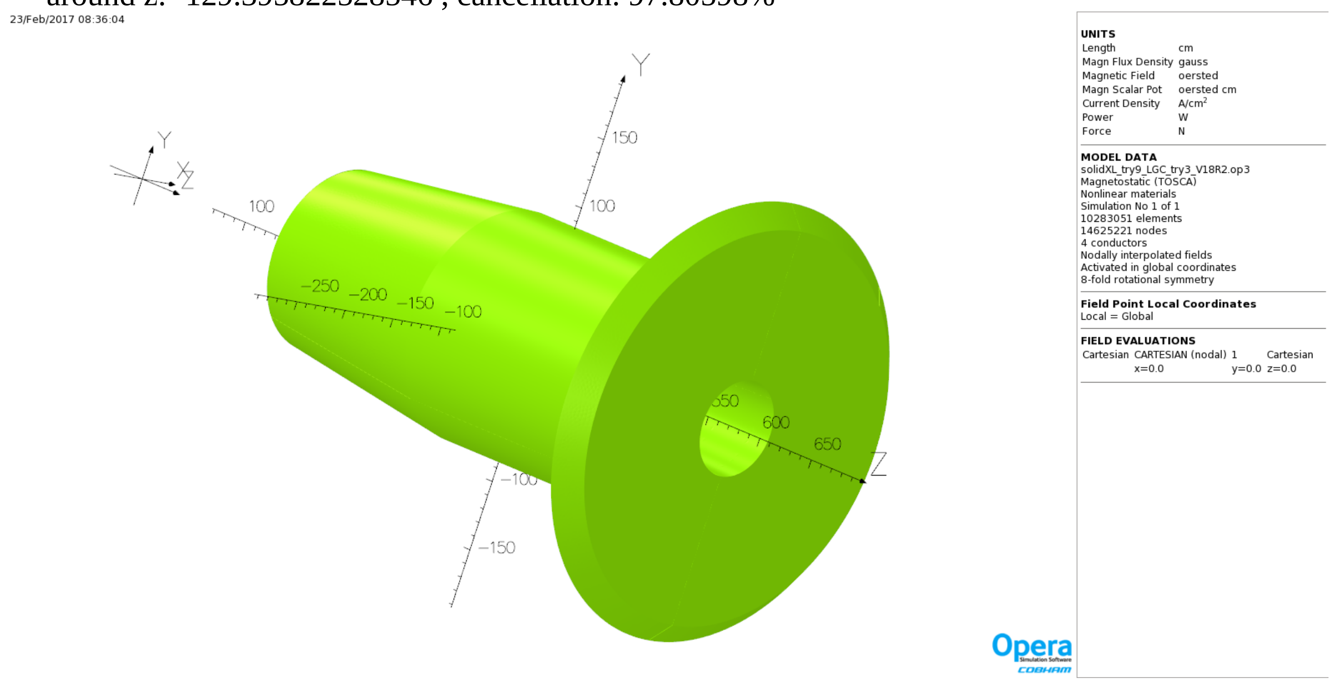

Figure 13 Downstream cone and 160 cm OR plate with 16 cm chamfer (to R144)

Forces in N:

z-direction: -1.7212793250632E+06, cancellation: 0.261079%

Torques around (0.0,0.0,0.0) in N cm:

around z: -28937.1096805861 , cancellation: 96.82405%

Musings on fabrication

The big plates that make up the octagons are 210” = 2*266.7 cm long. The downstream part of the inner octagon ends at 224.79 cm in this model, 41.91 cm short. The outer octagon ends at 209.55 in the notch, 57.15 cm short. Instead of cutting them short, perhaps they should be kept original length and the extra simply pushed to -Z. This won't affect the fields inside or at the He3 target significantly. It won't affect the Helmholtz set around the He3 target much either. New attachment holes for the coil collar would have to be created in the inner octagon plates, but new ones were already going to be needed for the downstream collar and those might no longer be required. New attachment holes for the 4” spacer plates would be needed at both ends instead of just the downstream end. Since this concept has two sets of 4” spacer plates at each end instead of one, lots of additional holes were going to be needed anyway. Drilling holes is cheap. Good magnet steel in 14” thickness isn't.

And as long as I'm making it look funky, why not use three of the outer muon steel plates as the back plate? They are also 266.7 cm half-length compared to 286 cm radius of the back plate. They taper from 204.4 cm wide to 231.6 cm wide. One of the plates could have the 170 cm hole needed for the cone cut out of the middle and the steel removed then machined and welded on each end to make up for the 286-266.7 =19.3 cm half-length vs radius difference. The other two plates could be used pretty much as is. They'd stick out some on the sides, since total width would be 613.2 cm vs 572 cm needed, but using existing material would save a lot of money. Back plate is now 32 cm thick. Increasing it to 14”, 35.56 cm, would drop the field at the ECAL PMTs to lower values than Figure 4 at a modest cost in signal attenuation.

Finally, the OD of the interface ring which is a part of figure 9 doesn't have to be circular. It can be eight flat pieces bolted to the outer octagon versus eight lunes. More cost reduction.

Modeling this lower cost variation will take several hours for first iteration and most of a calendar week to get the upstream plug thickness just right to null the Z force on the main coil. It won't take place before the March 5-6 collaboration meeting and probably not until after the accelerator run ends March 22.

Conclusions

By using more of the CLEO magnet steel one can lower the field to acceptable values in the vicinity of PMTs and lower the cost. It may be that only the cast cone and endcap cylinder halves would have to be made of new material.