Recent work on Hall A magnets
Present and future

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Sources

All of the information contained herein can be found in much more detail in the following Tech Notes: 16-043 (SoLID), 17-003 (SoLID), 17-032 (HRS), 17-035 (SoLID), 17-044 (SoLID), 17-050 (HRS), 17-051 (He3), 18-005 (ferrite fast raster). 18-004 outlines a hypothesis re parity beam.

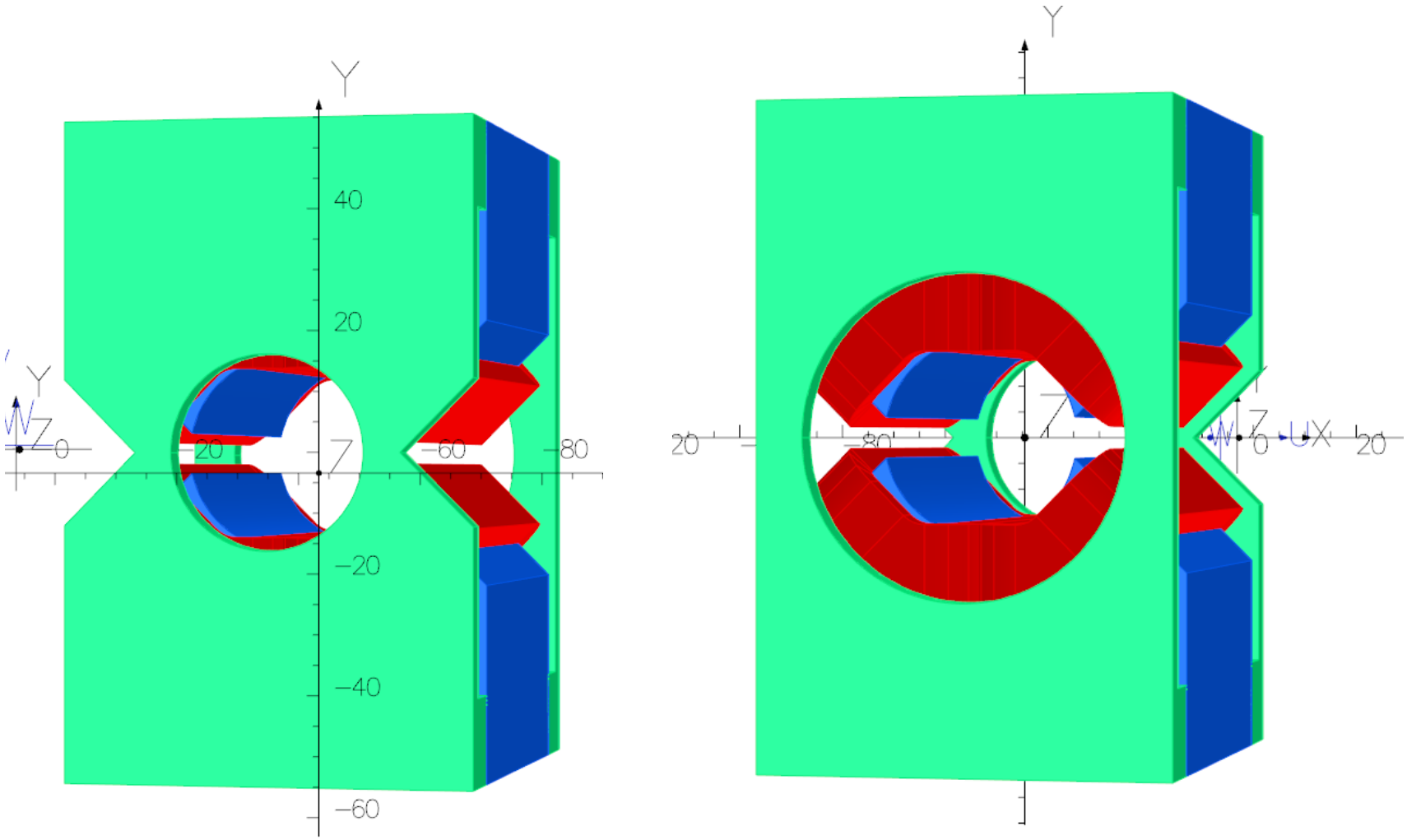
Outline

- HRS quad fields, within and between
- Ferrite fast raster (MOLLER)
- He3 coils
- SoLID

HRS quads

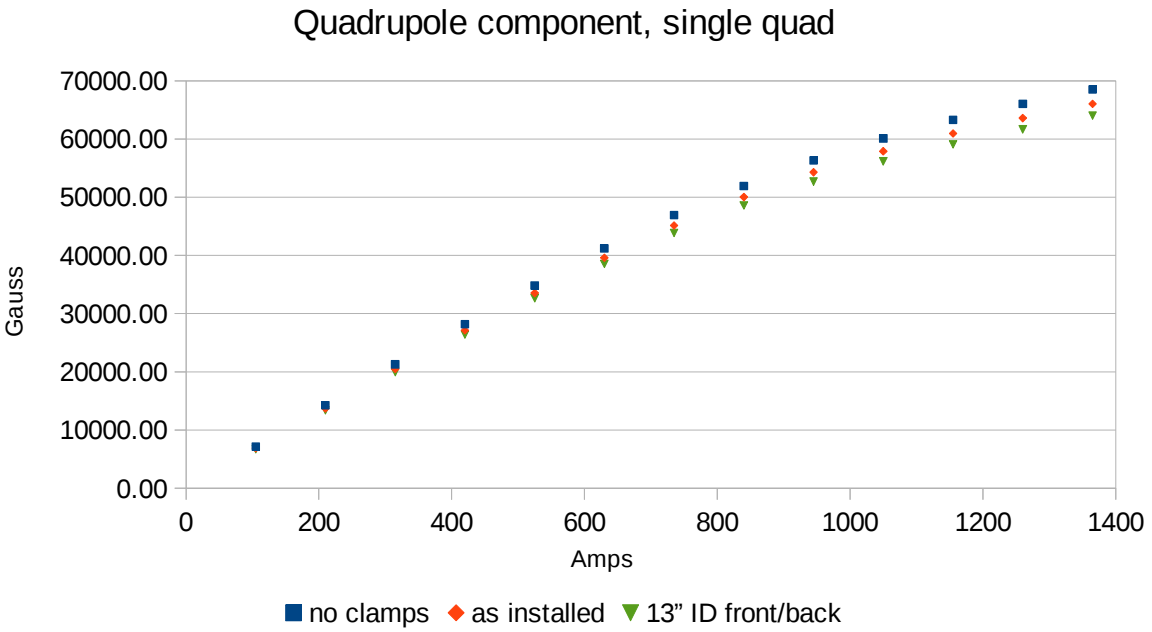
- Quad model originated with Bogdan Wojtsekhowski
- PREX/CREX septum and HRS pair at 12.5° modeled by Juliette Mammei and Iris Halilovic (U Manitoba)
- I was asked to extend Manitoba model to evaluate fields on beam to dump with two or one HRS operating during CREX
- Magnetic shield concepts replacing the existing stepped-cylinder beam pipe were created.
- Worst case scenario: HRS set to opposite signs, e.g. Tritium hypernuclear run next fall.
- 5 mm thick conical shield suffices for worst case

As installed quad model



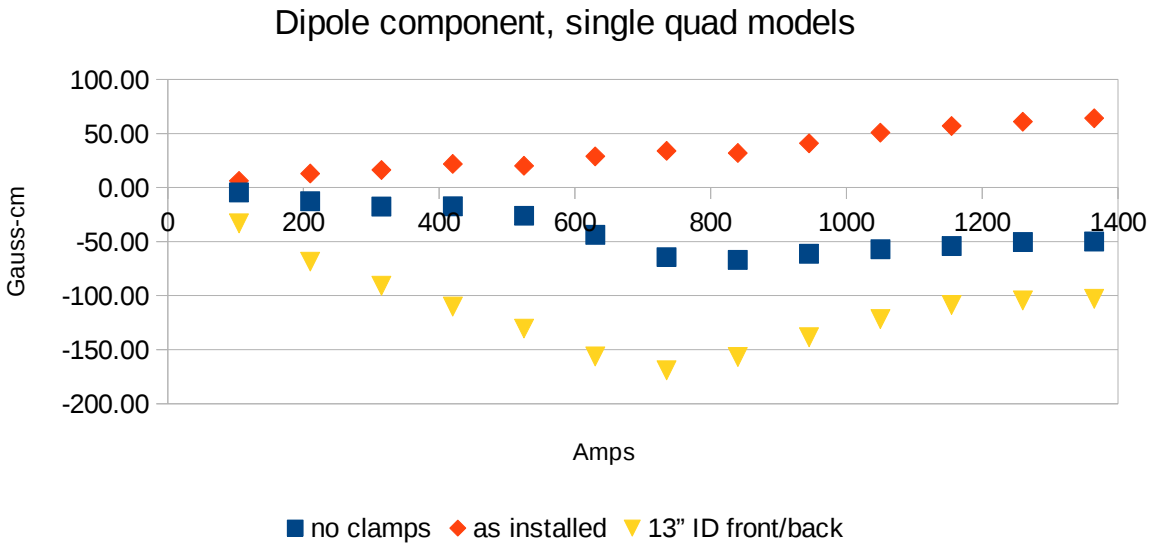
Hole in front field clamp diameter is ~60% of that in back plate so dipole kicks cancel only on centerline. I recommend removing them.

Multipoles induced by field clamps

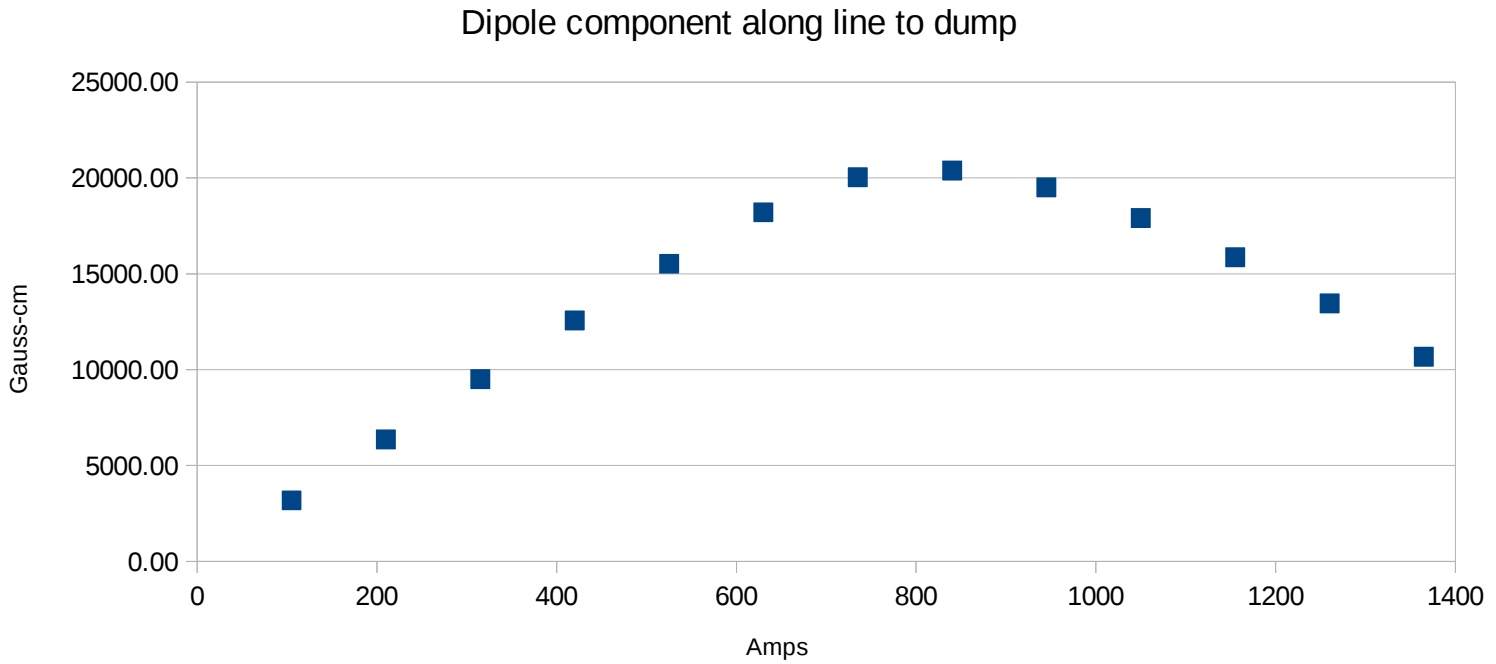


Multipoles evaluated on 10 cm radius circle and reported on 1 cm radius, CEBAF standard

Origin of centerline of model was determined by feed-down of quadrupole to dipole with steel unsaturated (<500A). Two micron change in line origin affects result.

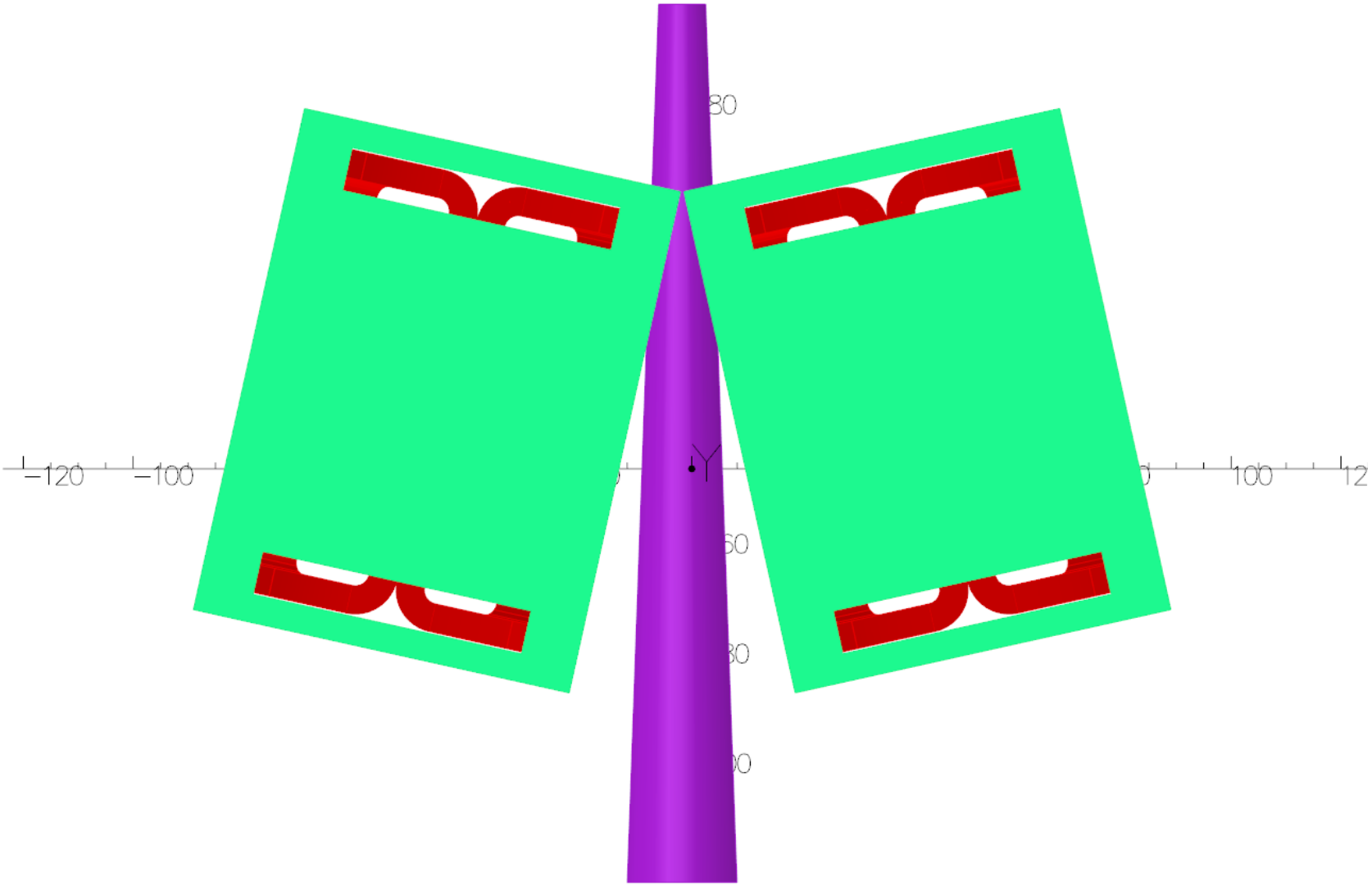


Dipole on line to dump, one HRS off



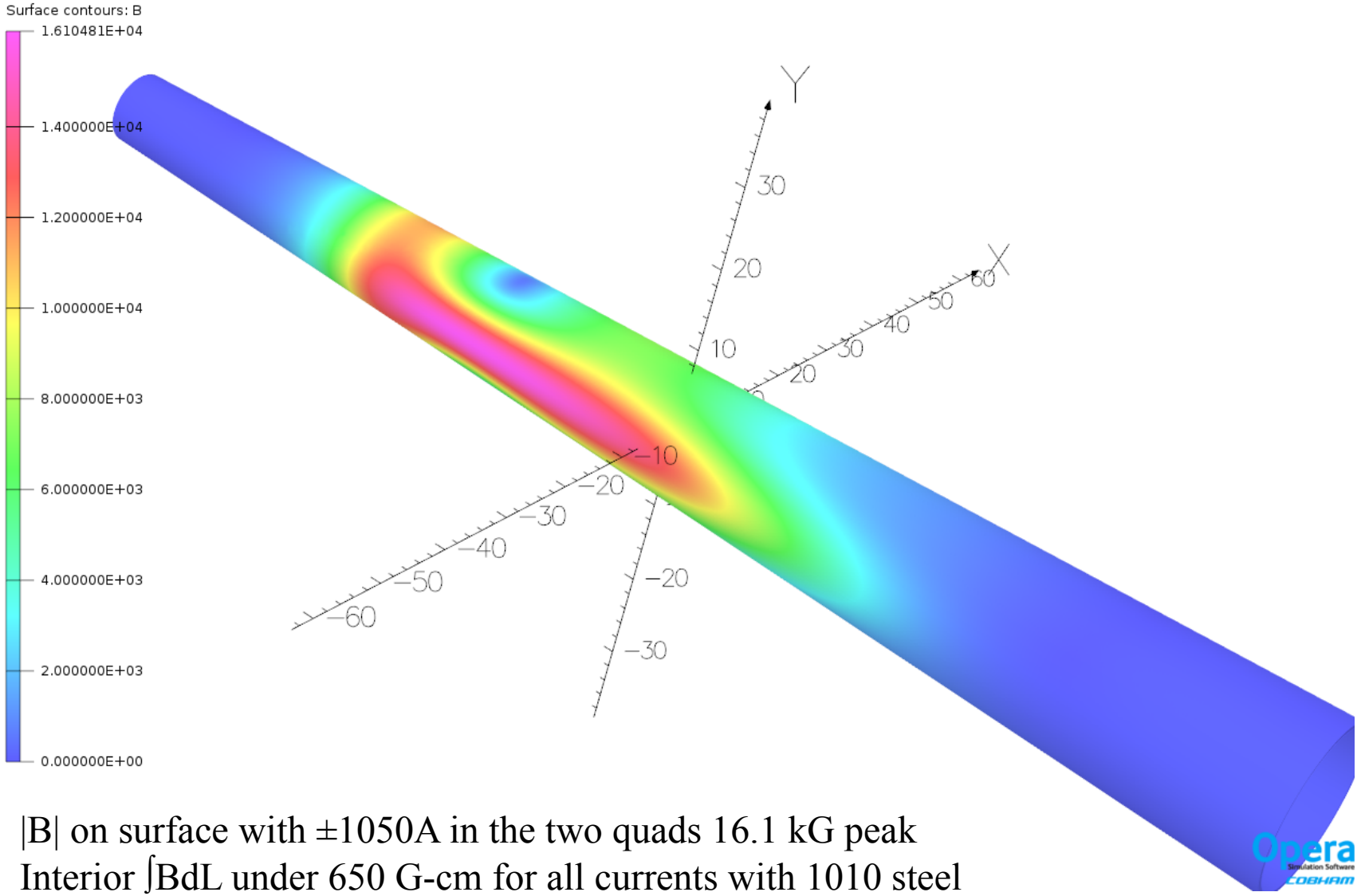
With two HRS systems of opposite sign, fields are higher

My preferred solution; Robin's will vary



Conical steel beam pipe, 5 mm wall, same entrance and exit diameters as existing aluminum beam pipe. Differential thermal expansion between steel and aluminum fore/aft requires care with vacuum seals.

Field on 5 mm steel beam pipe

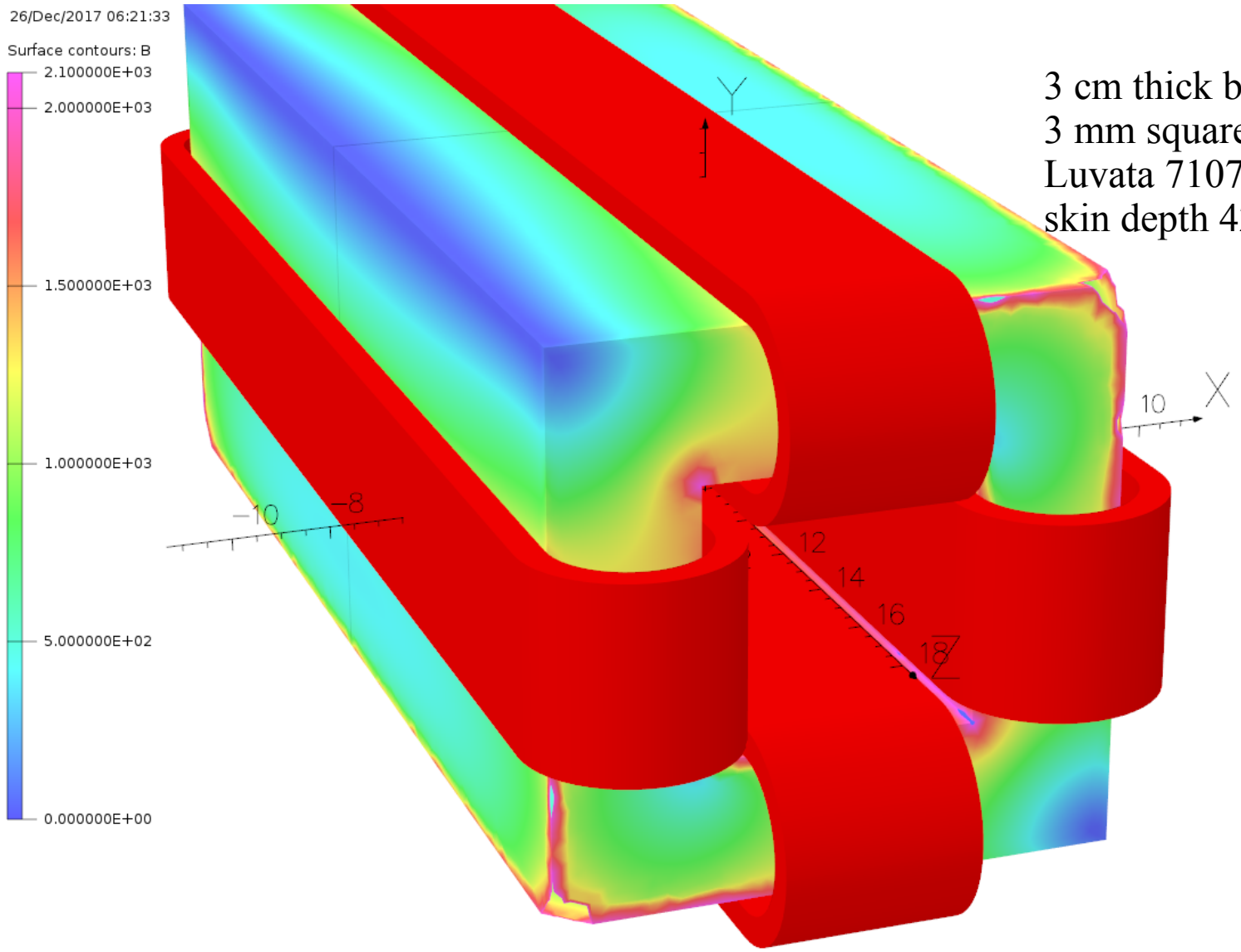


|B| on surface with ±1050A in the two quads 16.1 kG peak
Interior ∫BdL under 650 G-cm for all currents with 1010 steel
Without steel ∫BdL 27250 G-cm

Ferrite fast raster

- Specification (10,000 G-cm) driven by MOLLER requirement of 5 mm square raster at center of target, 6 m upstream of pivot. See my TNs 09-055 and 13-027 for details of the beam line.
- Javier realized that the Moller polarimeter dipole reduced Y offset meant the existing rasters couldn't be located over it due to image currents so the short ferrite raster became mandatory - it fits after the polarimeter dipole.
- If designer time is made available, ferrite and conductor will be purchased this year and a prototype fabricated. Hall A funds.
- There were two raster power supply failures January 12-15 so a design with fewer points of failure is desirable - but the power supply is a lot more challenging.

Ferrite fast raster

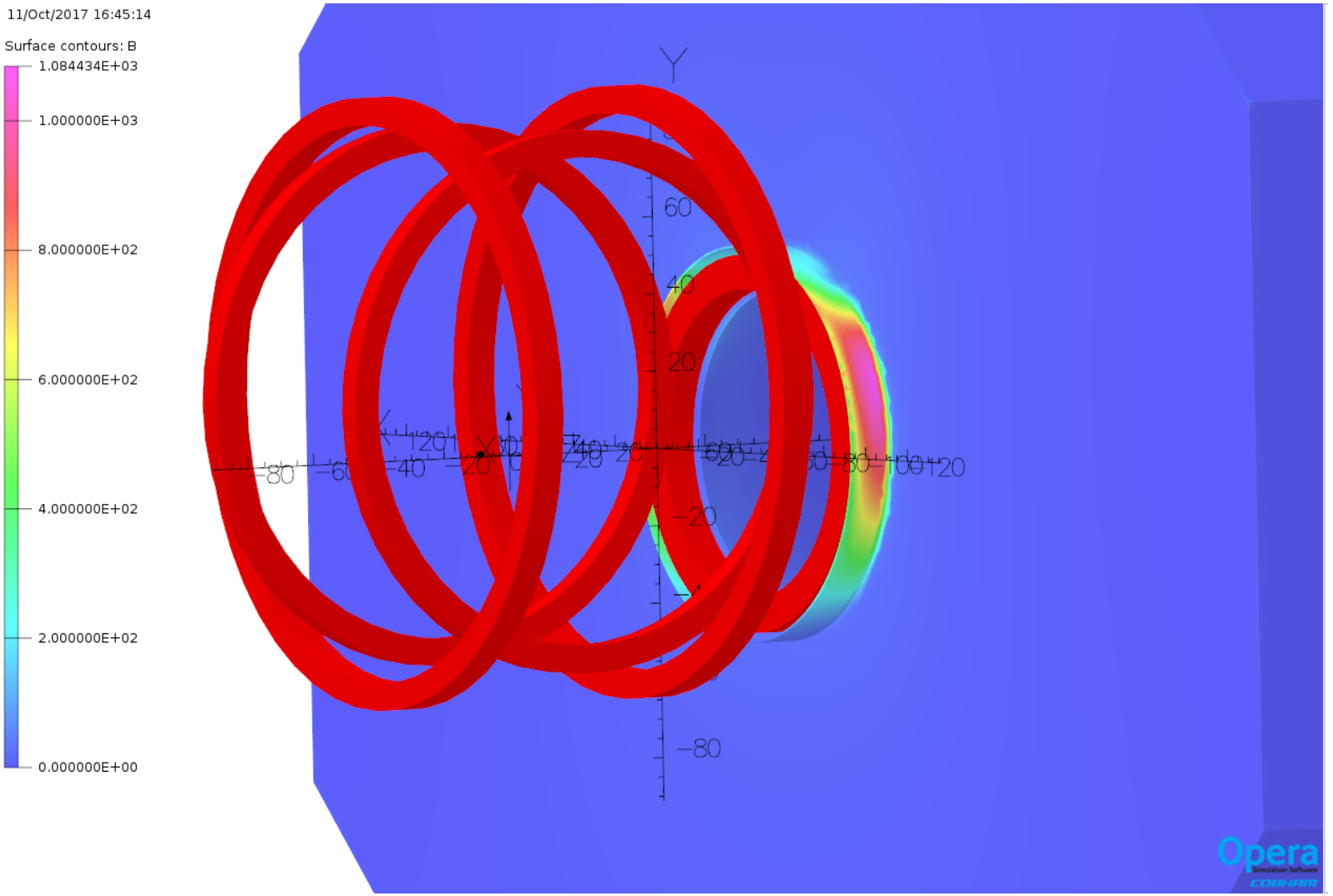


3 cm thick by 30 cm long ferrite
3 mm square with 2 mm hole
Luvata 7107 conductor
skin depth 420 microns @ 24 kHz

26 turns/coil
132 mΩ/pair
0.9 mH/pair
sq bore 4.34 cm

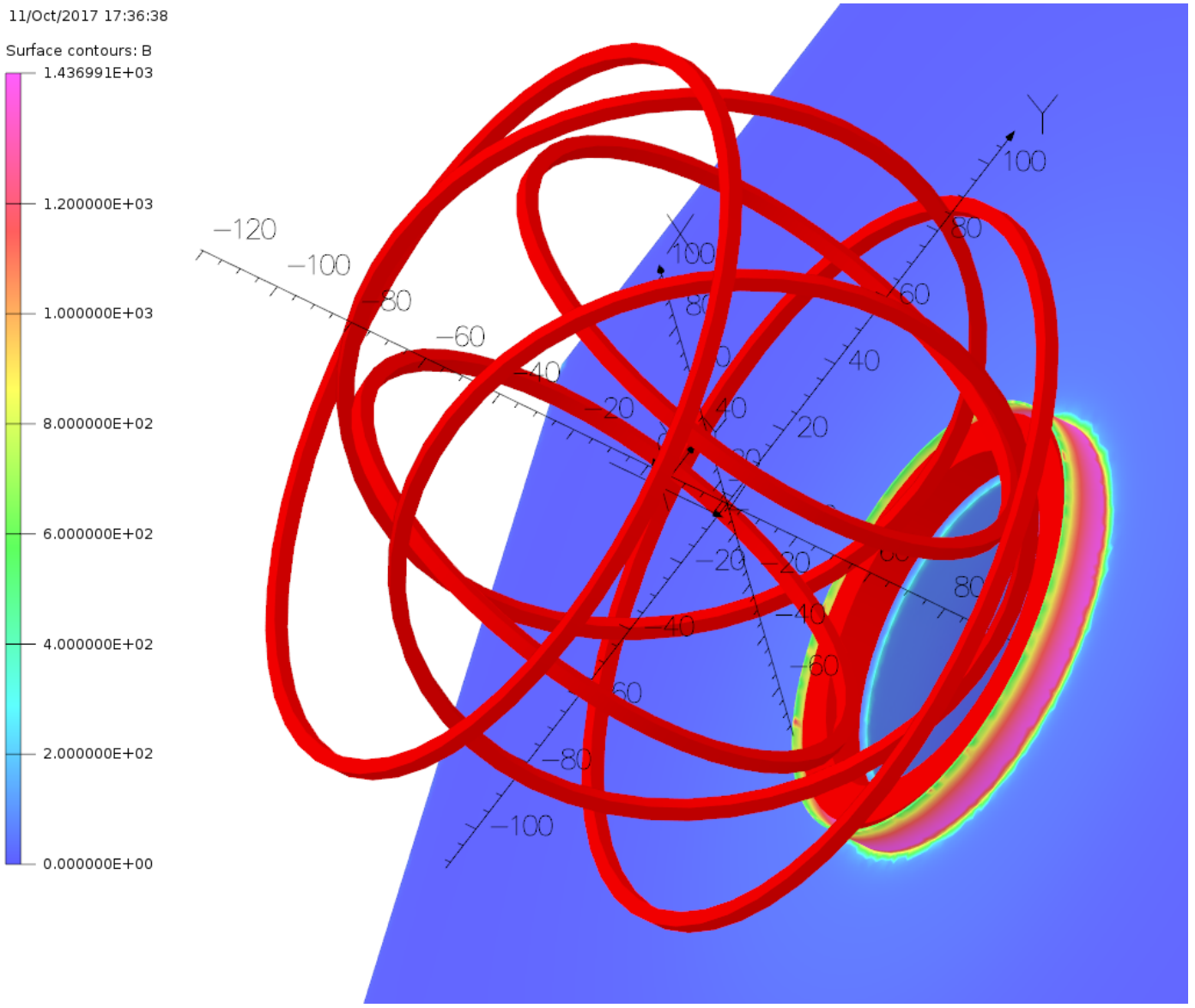
44 A for 10 kG-cm
50 A , 4500 V
power supply,
99.8% inductive

He3 target coils



Existing coil set shown in front of SoLID. Only Bx and Bz coils are generally used. Bz coils must be independently powered given effect of steel. Steel of HB on SHMS will affect the field from these coils as well, varying with SHMS angle

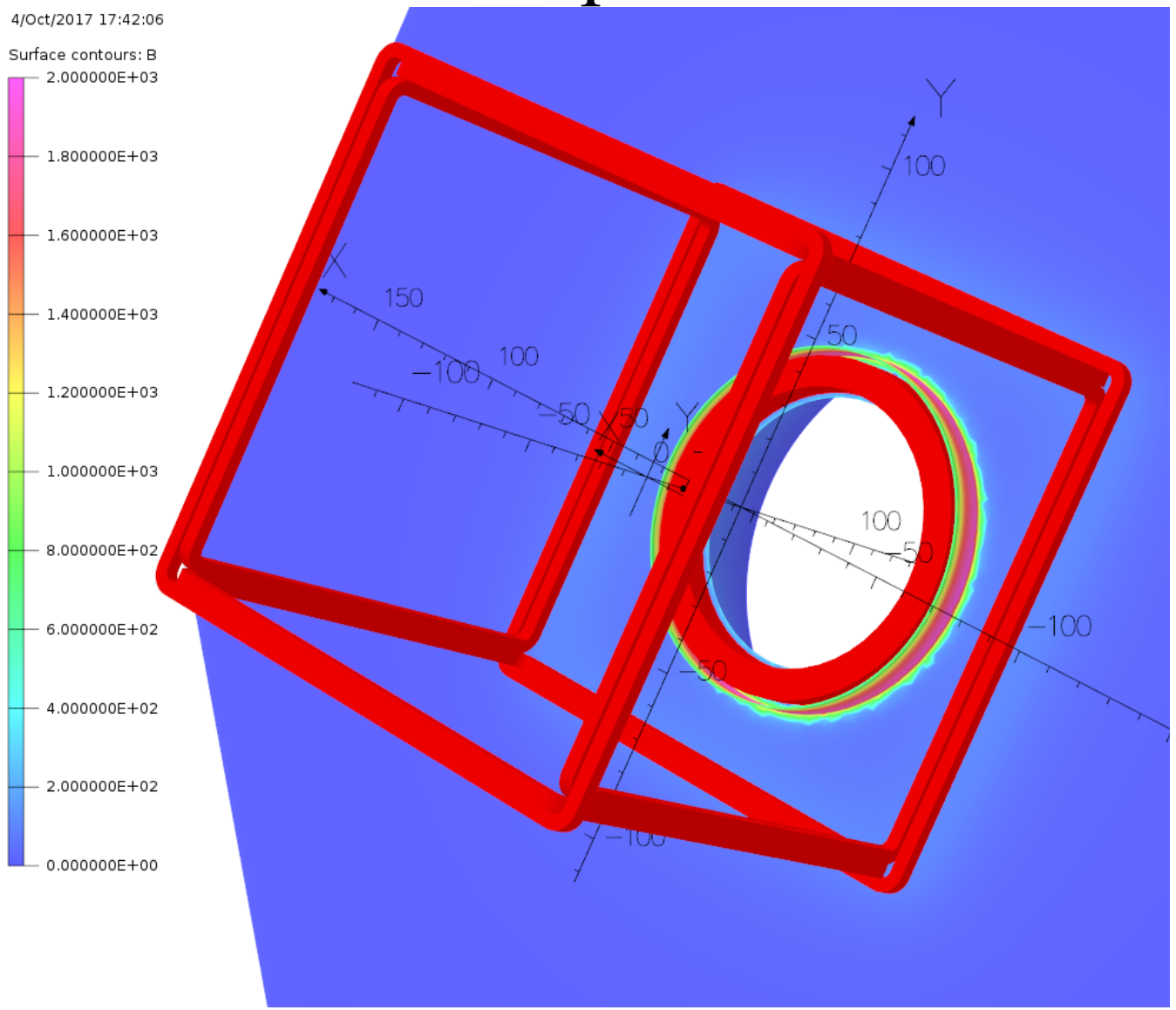
Full round Helmholtz set



Conductor and turns counts matched to 20 A, 75V trim supply

X and Y coils offset 10 cm vertically to put reservoir and target tube in good field

Cube quasi-Helmholtz set

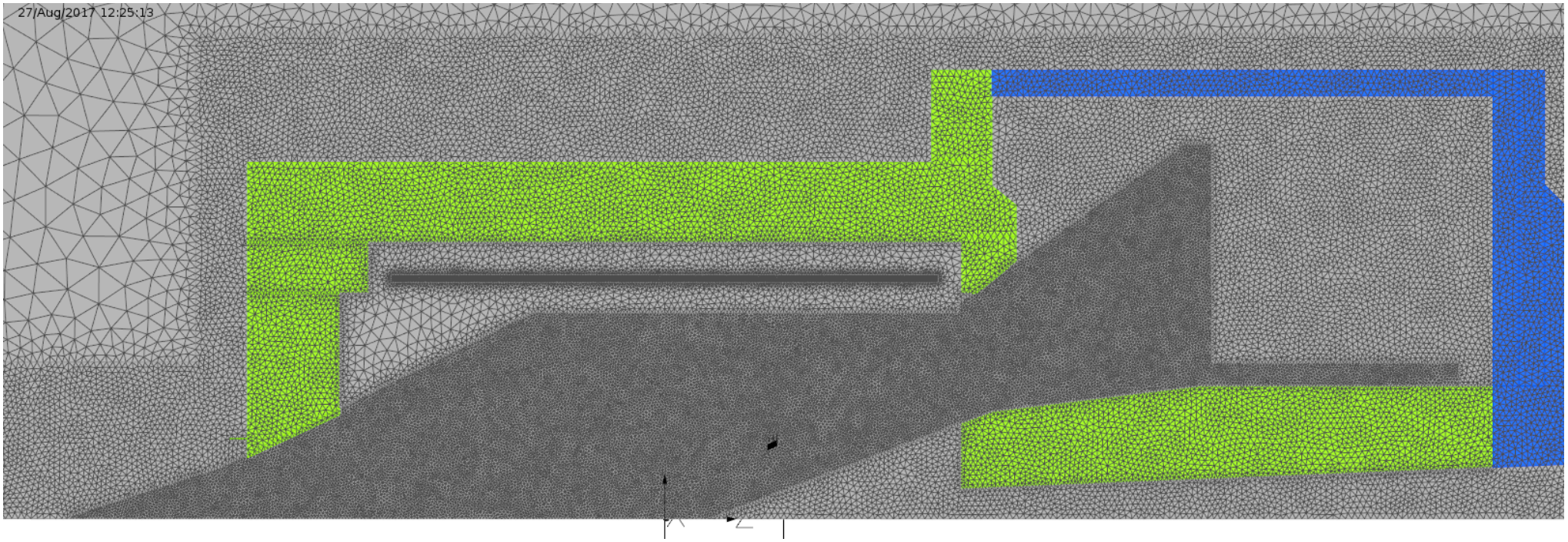


Coils on a 1.5 meter cube do almost as well as true Helmholtz set and provide a lot more access. See TN-17-051 for numbers.

SoLID

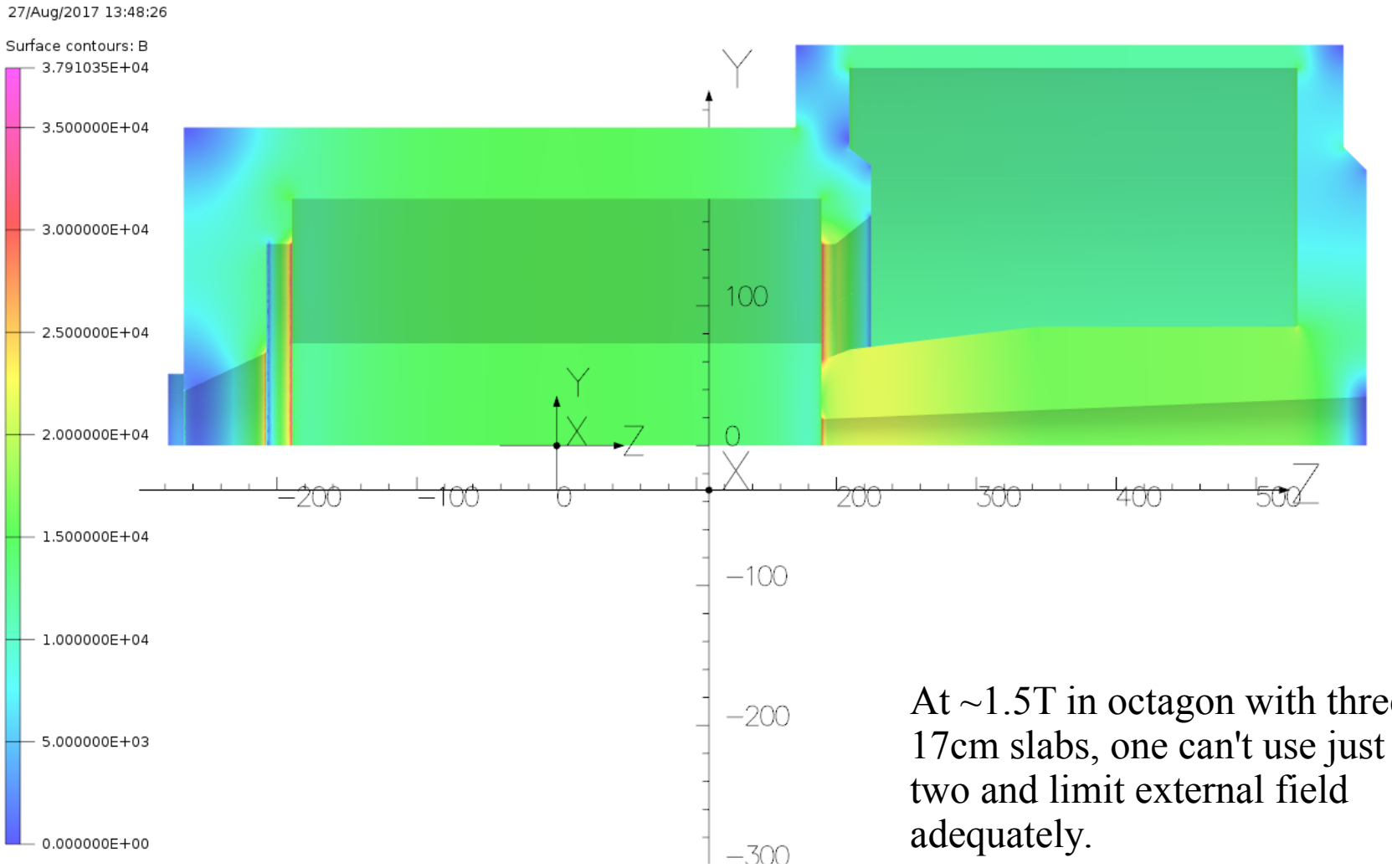
- See the four TNs listed on slide 2 for full evolution of magnet model
- Key changes from proposal:
- Detector cylinder length increased from 260 cm to 304.8 cm (10'). 90% of increase has already been allocated to subsystems.
- All steel except coil collars to be procured by collaboration in the form of 17 cm slabs. Octagon will be 51 cm thick. No gaps for muon detectors as in CLEO. "Nose" will be cast, as before.
- Detector cylinder will be ~16.7 cm thick after rolling. Model has 16.5 cm.
- Detector cylinder steel BH curve has B multiplied by 0.98 to model effects of longitudinal slots needed to extract detector cables.

Mesh



Mesh viewed at 45° angle so Y coordinate ≠ Z coordinate
1 cm mesh around solenoid, 2 cm mesh from external target center through accessible volume with high field, 4 cm mesh otherwise within volume of interest
Number of non-zeroes in matrices ~72% of Opera capacity
See TNs for mesh evolution.

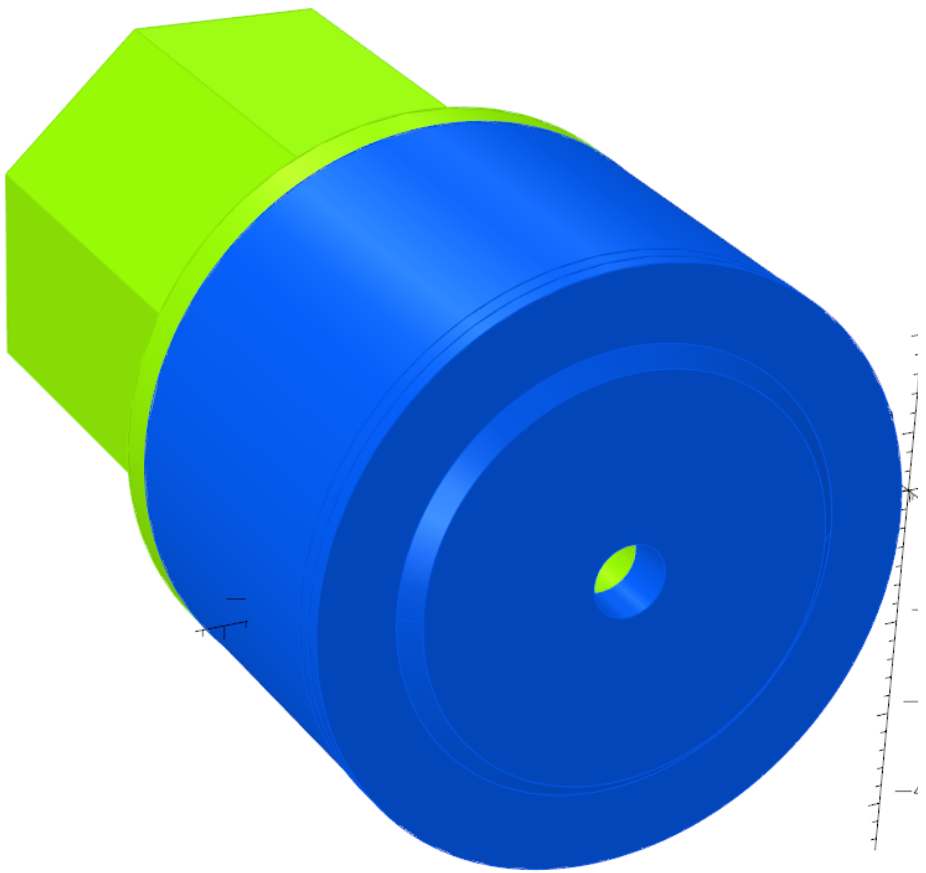
Field |B| on surface of steel

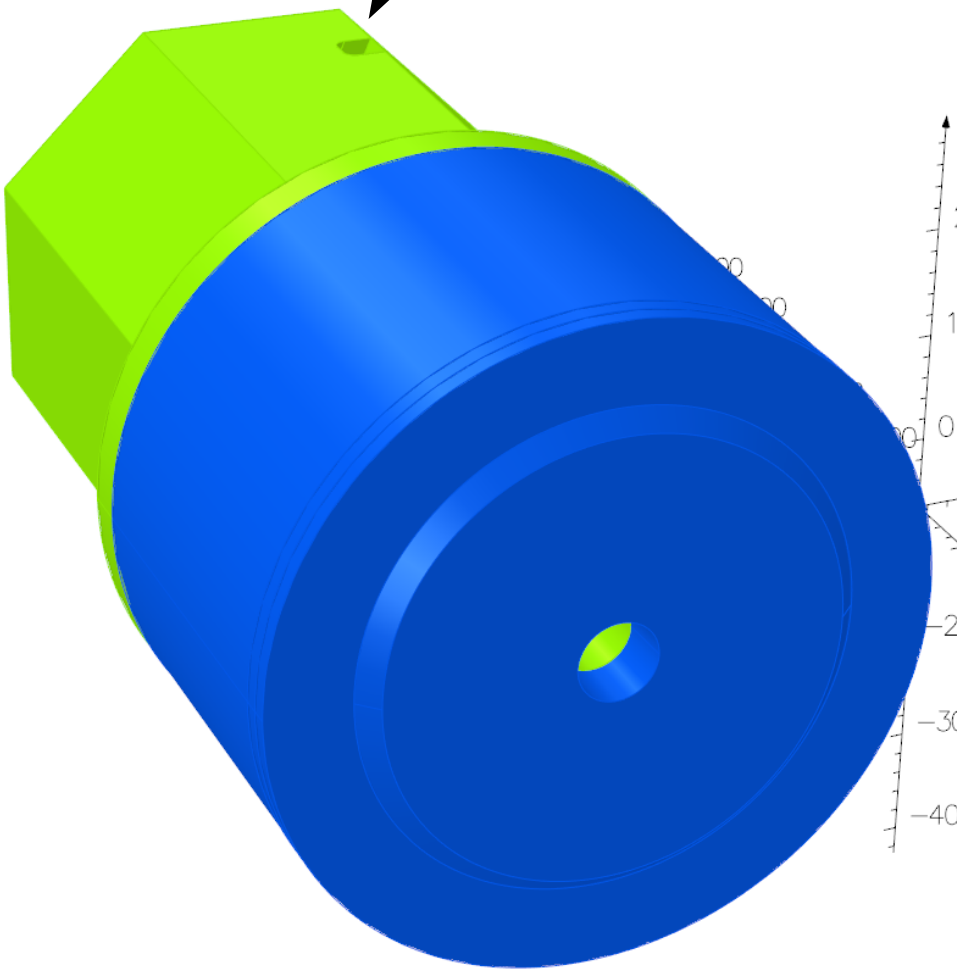


At ~1.5T in octagon with three 17cm slabs, one can't use just two and limit external field adequately.

Full models

Difference between models is hole for turret



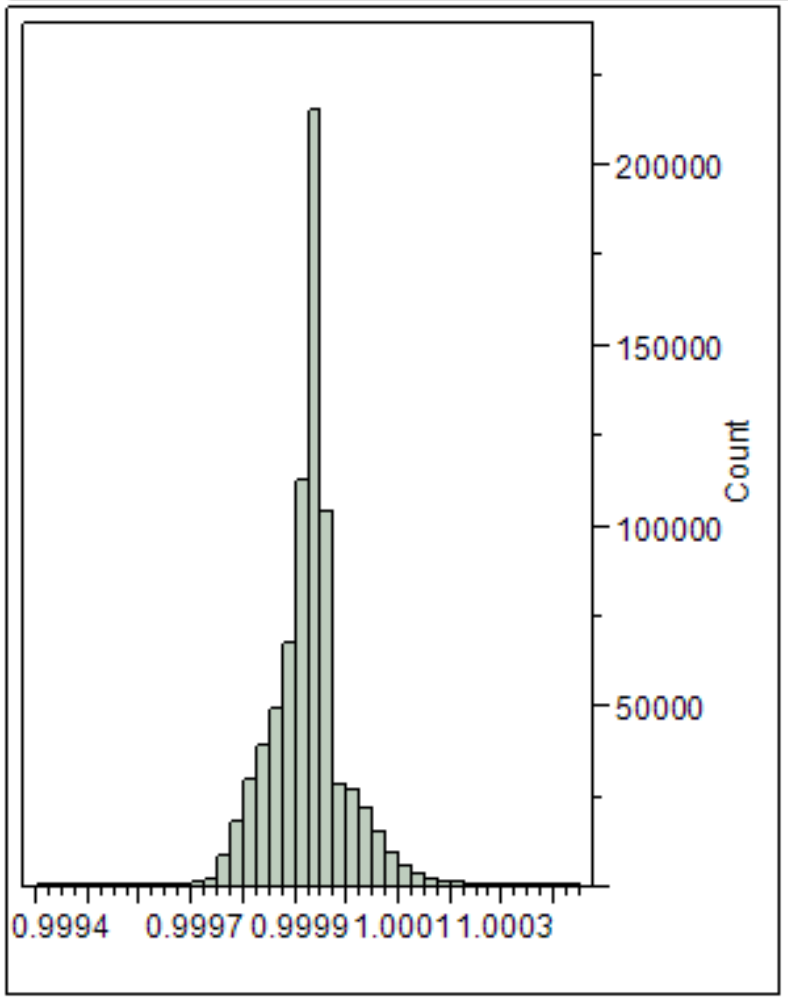


Field maps

- Mesh was iterated in symmetric model until forces and torques on solenoid, which should be zero, were well under 1% of un-summed forces and changed in a non-monotonic fashion as mesh element maxima were reduced.
- This mesh was then applied to model with turret hole.
- Field maps were generated in particle-accessible volumes which might be affected by hole and compared in gross manner.
- Field maps were provided to collaboration for simulation studies to determine if the full model is necessary or a 45° segment suffices. AFAIK these haven't been done.

B ratios, Turret/Symmetric

BratioT/S



Quantiles

100.0%	maximum	1.00045
99.5%		1.00015
97.5%		1.00008
90.0%		1.00001
75.0%	quartile	0.99995
50.0%	median	0.99993
25.0%	quartile	0.99989
10.0%		0.99984
2.5%		0.99979
0.5%		0.99975
0.0%	minimum	0.99942

Moments

Mean	0.9999261
Std Dev	6.7643e-5
Std Err Mean	7.8133e-8
Upper 95% Mean	0.9999262
Lower 95% Mean	0.9999259
N	749521

For volume r=[100,140] z=[-100,0] All of this is within acceptance. Symmetric model may suffice.

For r=[100,120] z=[-135,-100] (not shown) about half volume is within acceptance. The 137K ratios calculated are within 0.18% of unity.

Conclusions

- My FY17 objectives included 40% allocated to magnet modeling.
- Hall A got most of the benefit.
- How this will change given new Physics Division magnet group I can't say.
- Robin Wines has a 2 TB disk with all of my work for Halls A and C through FY17. The He3 target and fast ferrite work shown here was done after I handed it to her.