

Novel Cavity Feature On Dipole Magnet Pole Face Improves Field Homogeneity While Reducing Coil Complexity

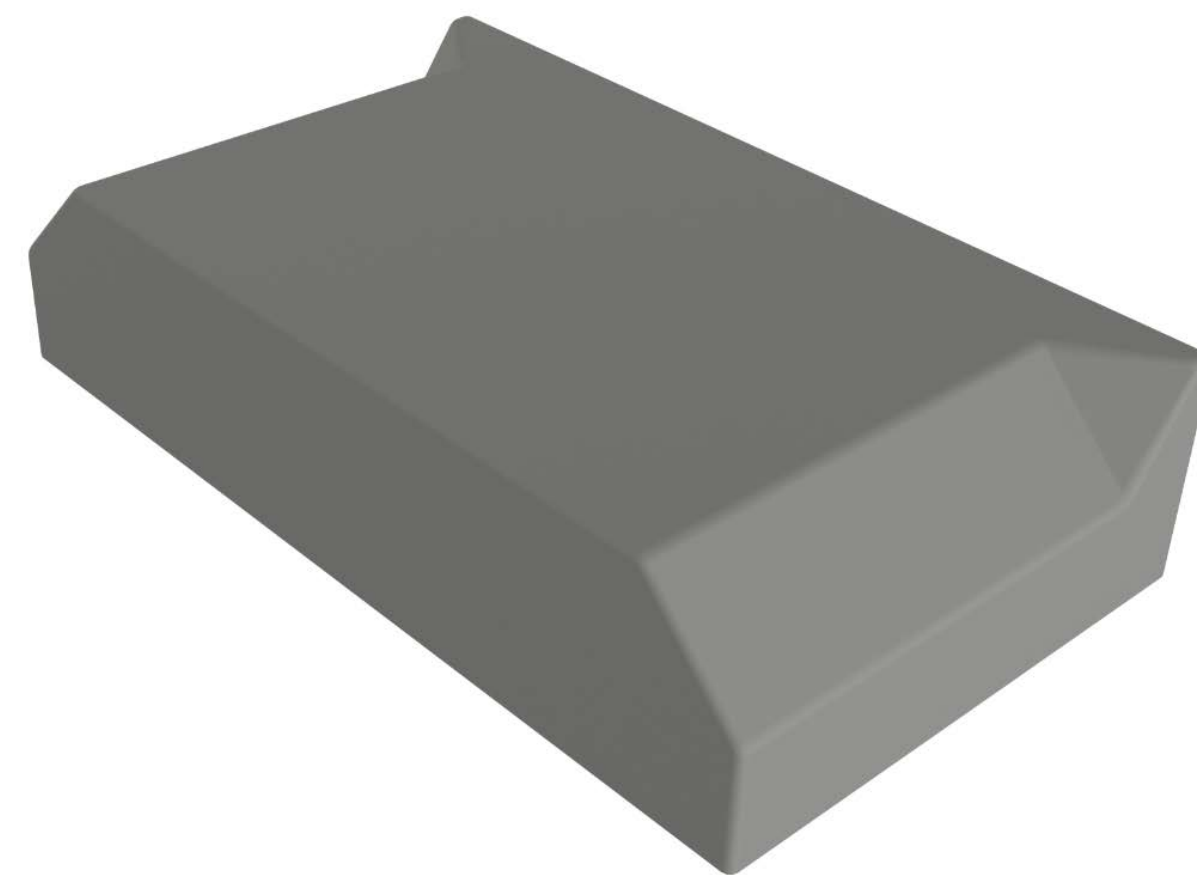
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C. YECKEL and P. HOLEN

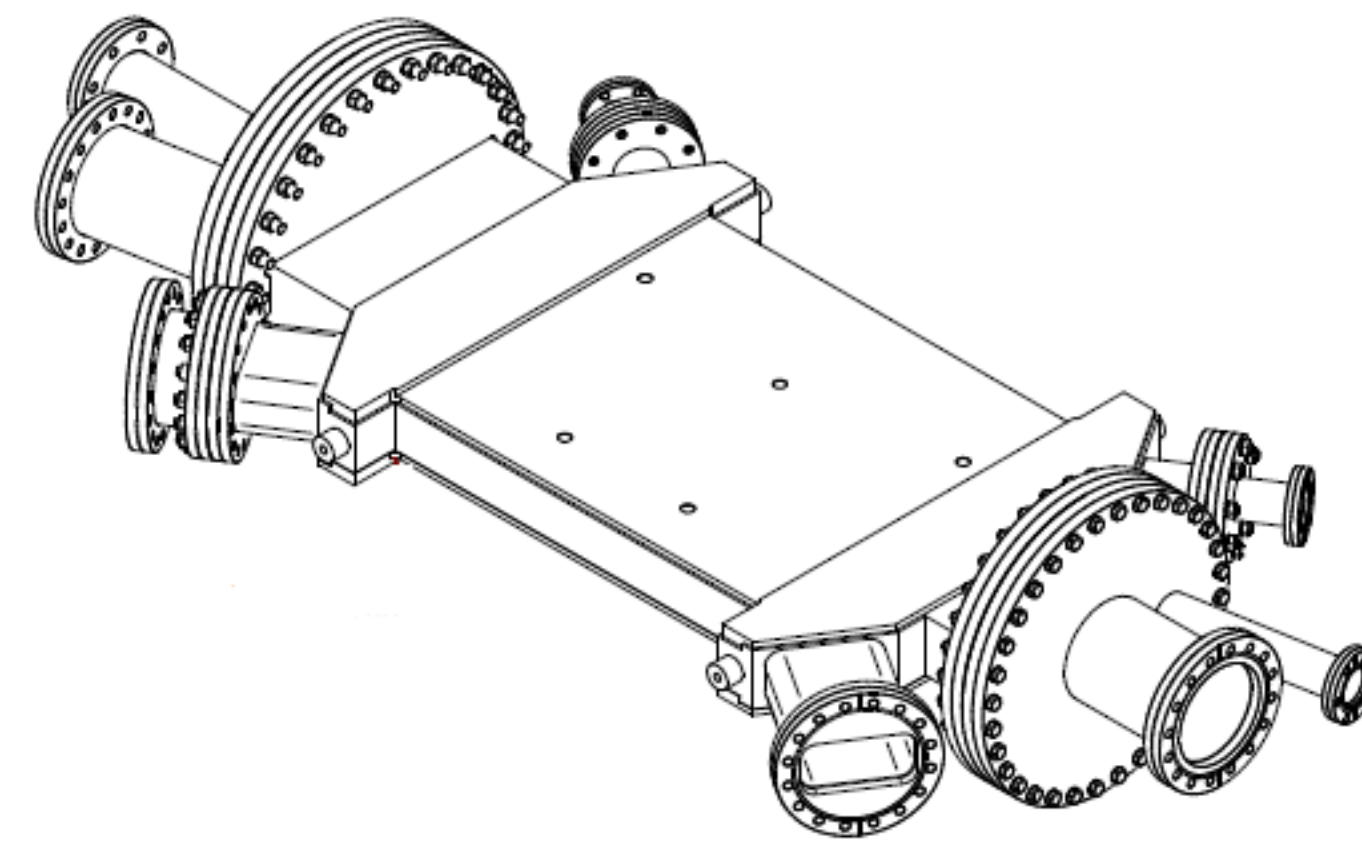
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Abstract

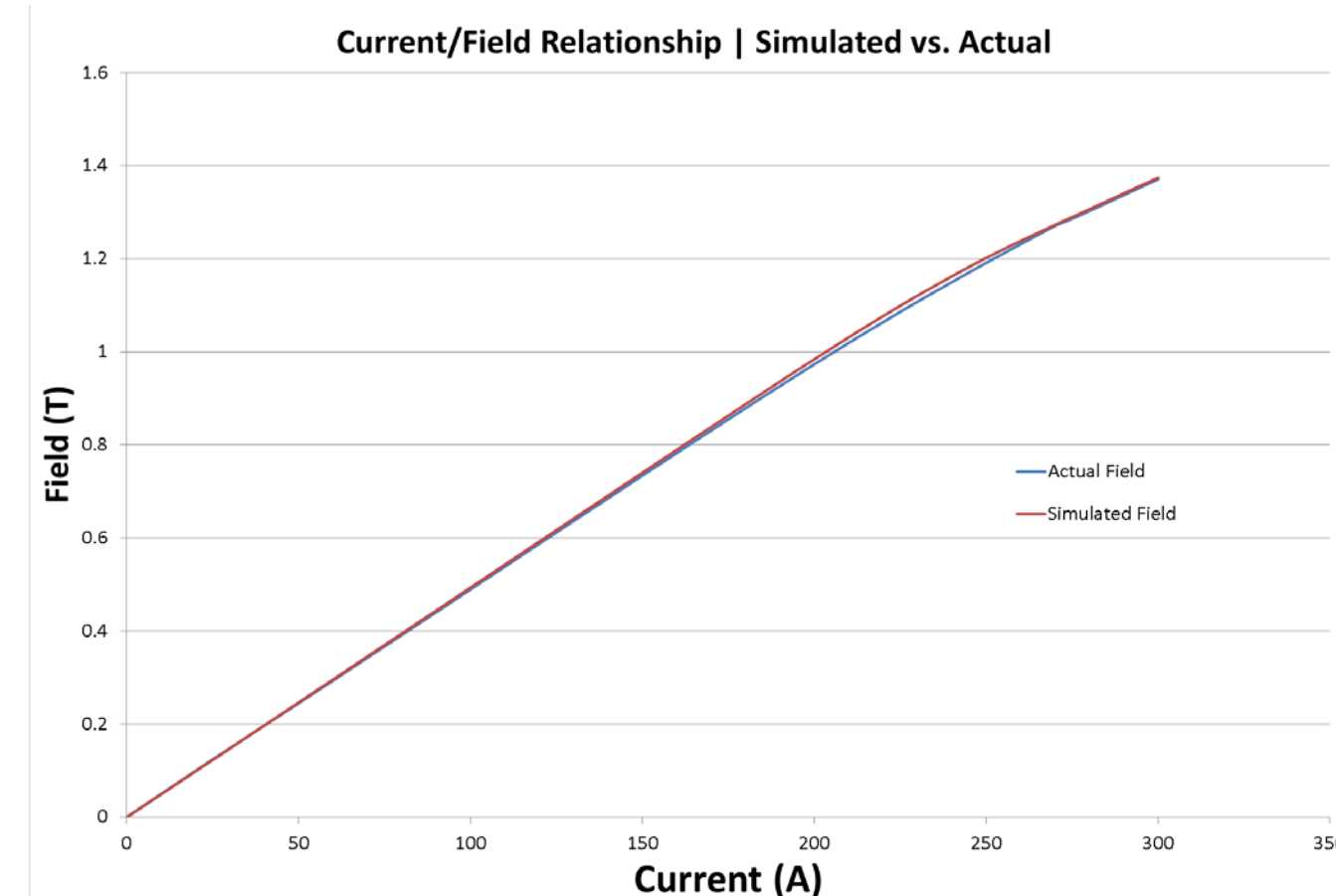
FEA simulation software OPERA 3D is used to develop a geometric cavity feature on the pole face at the beam entry and exit points of a dipole magnet. This cavity is incorporated into a prototype magnet designed at Stangenes Industries to improve field homogeneity along the beam arc to 0.1%. The magnet design handles beams entering at different angles, positions and beam energies. The optimized cavity lowers the cost and footprint of the magnet by allowing the coil to remain rectangular in shape. The magnet has been tested and is awaiting installation into a beam line at LLNL as part of a compact accelerator creating radiographic images using quasi-mono-energetic fast neutrons. The dipole bends both 4 and 7.07 MeV D+ ion beam 66 degrees on a 457.2 mm radius. The magnet is also capable of bending the same beams in multiple trajectories depending on applied field strength. The field strength is adjustable up to 1.4 T center field with minimal pole saturation, but operates at 1.27T nominal.



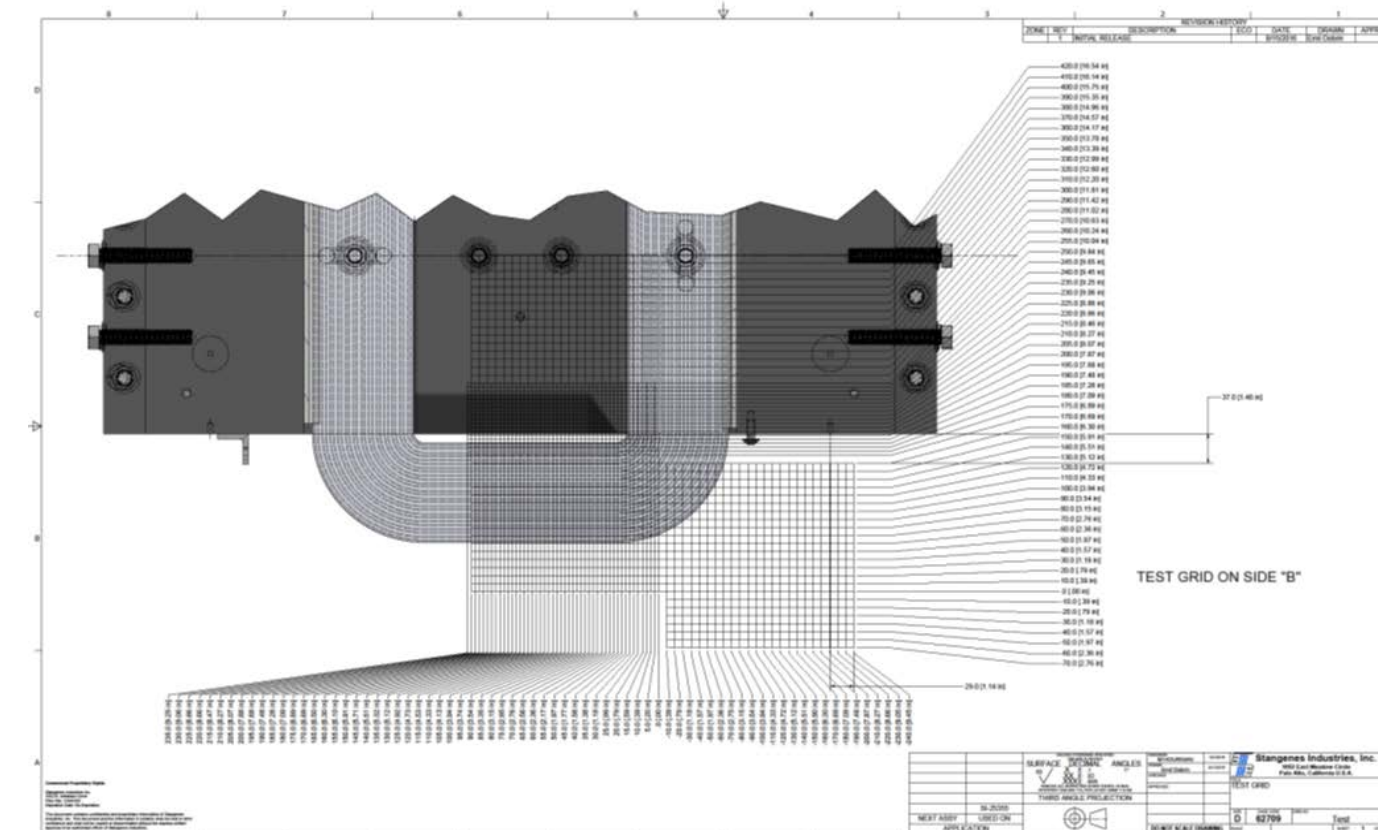
Dipole cavity feature allows for use of a standard rectangular coil.



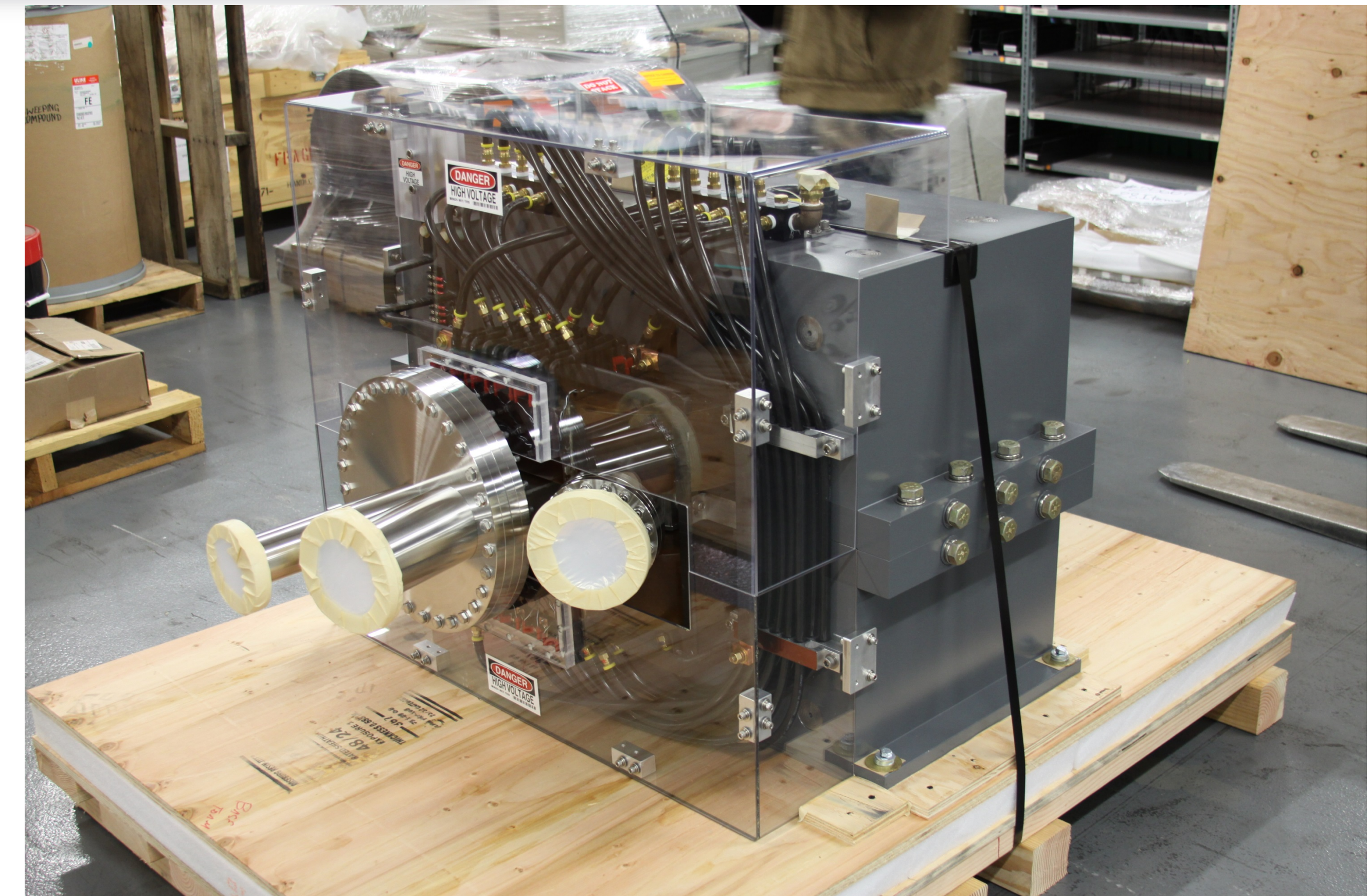
Vacuum chamber features 8 distinct ports for beam and diagnostic usage.



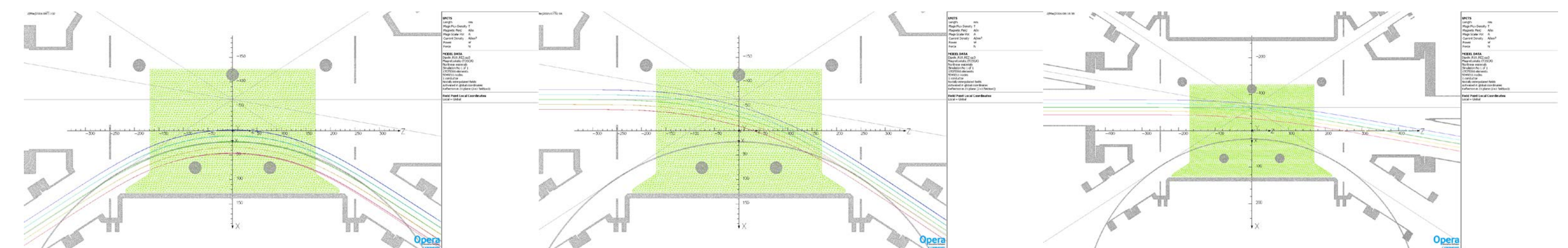
Actual Current vs. Field relationship values show low saturation over the operational area and good match to simulated values.



Test grid to ensure 0.1% homogeneity. Automated test stand reads over 10000 points with triple-axis gauss probe.



Ready to ship. The complete electromagnet with vacuum chamber installed and secured. The vacuum chamber is mechanically aligned to the dipole magnet to within $\pm 1\text{mm}$ of tolerance.



D+ 7.07MEV trajectory 66 °with 50mm beam height/width Port 1 to Port 5.
Center field 1.27T @ 269.8A/44V.

D+ 7.07MEV trajectory 33 °with 50mm beam height/width Port 1 to Port 6.

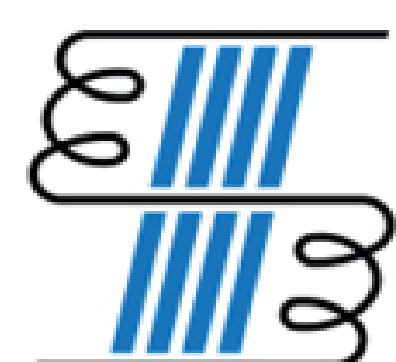
D+ 4Mev trajectory 10 °with 50mm beam height/width. Port 2 to Port 6.

Dipole Notes

The dipole magnet has been delivered to Lawrence Livermore National Lab to be integrated into a intense, high-brightness fast neutron source to create high resolution neutron radiographs and images. The magnet is integrated with a S.S. vacuum chamber developed in coordination with Kurt J. Lesker Company. To reduce cost and complexity of the coils, a series of manual optimization operations were performed at Stangenes Industries with Opera 3D FEA to maximize the field homogeneity for each of the 3 trajectories without resorting to exotic coil geometries.

It follows that future dipole designs thought to require curved coils to maintain homogeneity may meet the specifications with an optimized dipole cavity feature and rectangular coils. It is less costly to develop as the poles are easier to manipulate than the coils. Multi-trajectory and multi-beam-energy dipoles can benefit from this cavity technology.

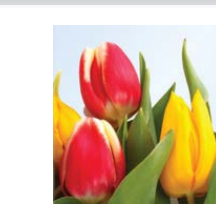
Stangenes would like to thank Lawrence Livermore National Lab and Kurt J. Lesker Corporation for their support.



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