Intermediate positron capture solenoid

Jay Benesch

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Background

My first design, TN-24-021, has two half-coils, total length 54.4 cm, within the iron return. Sixteen double pancakes were in this model. Field maps with both coils and only the first coil were provided to Andriy Ushakov. In his presentation to the 18 December 2024 CE+BAF meeting, he showed that pushing the first coil alone to the boiling point of the cooling water provided about the same capture efficiency as the full magnet at lower excitation.
https://jeffersonlab.sharepoint.com/sites/PositronSource/SitePages/2024-12-18-Ce+BAF.aspx

As a result, a solenoid with ten double pancakes was modeled, TN-25-002. The peak field of 14.4 kG over the shorter length proved less than effective in capturing high polarization positrons. This TN describes a solenoid with twelve double pancakes, 40.8 cm coil length, with 15.8 kG peak field. Andriy Ushakov is evaluating its utility.

Discussion

With twelve double pancakes at 2023 A, peak field is 15.8 kG and ∫BdL 867 kG-cm. Compensation coil was not changed in the model but will be in a real device. Multiple simulations were run to get the current in the compensation coil adjusted to null the main field at the target, Z=-45 cm in this model. Temperature rise in 4C cooling water is 78 C with 20 bar water pressure. The end plate thickness was increased from 15 cm in the previous models to 16.5 cm here to reduce the field in the steel to 21 kG. Cylinder 20 cm thick with notch for leads.

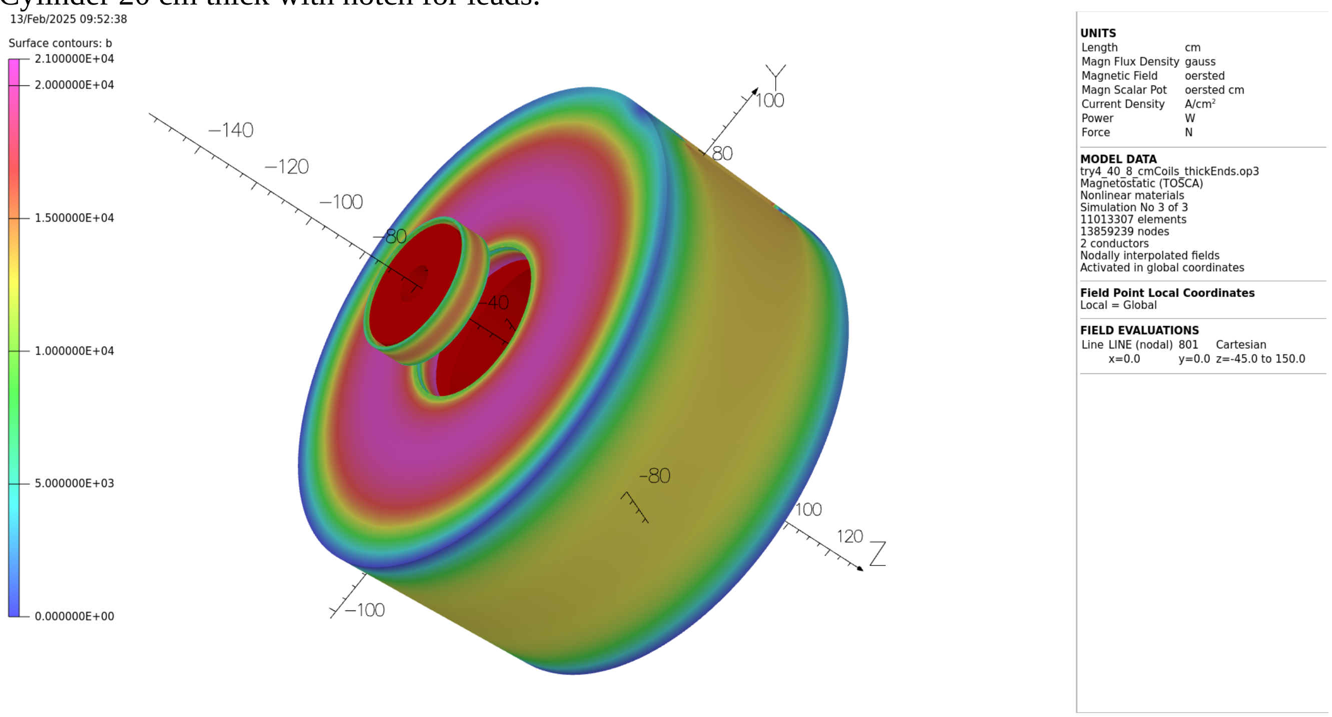

Figure 1. Model with 15.8kG peak field. The surface field scale is 0-21kG. The barely visible notch in the steel near Y=80 cm mark allows the leads of the double pancakes to be connected in series for current and parallel for cooling. The purple ring would vanish if the scale were 0-20 kG, aka the steel is between 20-21 kG at this excitation. Pushing it.

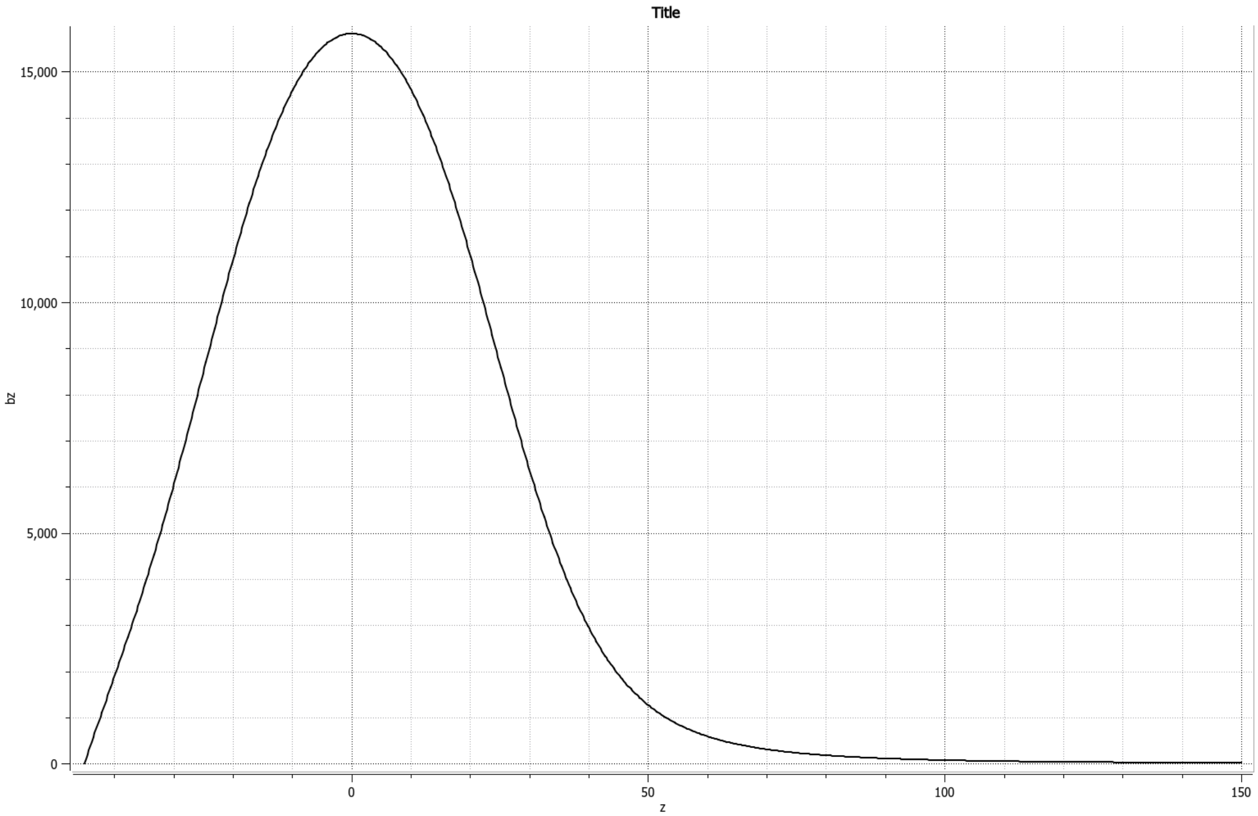

Figure 2. Field along the Z axis for the model of figure 1, starting at target Z = -45 cm

The current density in the compensation coil of this model is too high for the solid conductor specified in TN-24-021. I will not modify the coil in the model to increase turns count (solid) or change to hollow conductor until Andriy's simulations indicate what field is required for efficient capture.

Luvata 6826 was assumed. 16 mm square copper, assumed 17 mm square insulated. Double pancakes with 15 radial turns, 30 turns per double pancake. Twelve such double pancakes yield 40.8 cm coil length and 360 turns. 30 cm IR, 55.5 cm OR. End plates 16.5 cm thick. Steel cylinder 43 cm long, 60 cm IR, 80 cm OR with 10 cm wide notch for conductors. Cylinder thickness can be reduced, perhaps to 18 cm thick. It will have to be cast for cylindricity. There's no way one can roll 18-20 cm steel on a 60 cm radius and not have it spring open at the notch, affecting the field profile. One might compel the cylinder with tooling and then match drill holes in the end plates to restrain its conformation, but casting will be easier and likely cheaper. 6.5” (16.5 cm) plate is not available so cast the end plates too. If SoLID is approved and funded in a time coincident with the positron project, its endcap needs 17 cm thick plate. The endplates here could also be 17 cm, providing a 3% reduction in end plate field from Figure 1. Whit Seay found a vendor to cast the large SoLID nose piece, providing more synergy. Timing will be everything.

Conclusion

An intermediate length solenoid which may be effective for positron capture has been designed. Another iteration will be required once positron simulations are done to make the compensation solenoid manufacturable. Field map from the model shown in Figures 1 and 2 was supplied to Andriy Ushakov February 13, 2025. It can be scaled down linearly in field strength in his simulations.