Stray Fields in CLEO from the Phase III Superconducting Quadrupoles

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New superconducting quadrupoles magnets to be installed in CLEO III will improve the focussing performance and may raise current limits. Unlike the phase II REC magnets, the superconducting magnets generate relatively large stray fields which extend well into the fiducial volume of the CLEO detector. The size of the perturbations to the CLEO solenoid field is an order of magnitude larger than the field non-uniformities due to the hole in the end pole piece.

We have calculated the stray fields from a fairly realistic model of the quadrupole coils, including 3D end effects. The calculations do not take into account the CLEO iron, though it is likely to have only a very small effect on the Q1 magnet. Only the quadrupole fields have been calculated; other 'trim' coils (dipole and skew quadrupole) have not been included. The current in the coil is at 110% of the design operating current.

The calculated fields from the quadrupole were added to a uniform axial magnetic field of 1.5 T. The magnitude of the resulting field is plotted in the attached figures. In the plots, $z = 0$ is the interaction point. Figure 1 shows the field distortion in an $r - z$ plane where the maximum distortions appear. The other figures show slices of the field distortion perpendicular to the first figure.

Near the coil, the fields are over 5 T but the fall off rapidly with radius. The field near the ends of the quadrupole coils is more perturbed than the field near the generated by the main body of the quadrupole. This is because in the coil ends the current turns around and the coils generate fields in the axial direction. The symmetry of the quadrupole fields is such that they may be reflected through 45° lines, with the peak distortions occurring at $45°, 135°, 215°$, etc.

The worst area of distortion is around 800 mm from the interaction point: near the front end of Q1. The fiducial volume of the detector is down to fairly small radius here and the end effects are the strongest. Some points in this area of the fiducial volume may have as much as a 5% change in field strength. Substantial distortion, at the level of 1% occurs at radii of 500 mm and over most of the longitudinal space. Full 3D data for all field components can be made available for exploration of these fields in more detail.

The stray field from the quadrupole would not likely vary much from run to run, but would be subject to tuning changes of a few percent, and scale with energy, more or less. Because of the precise nature of the coil manufacture, in principle the fields can be calculated with great accuracy, once the geometry is finalized. The stray field from the skew quadrupole coils is likely to be smaller than from the main coils, but subject to more tuning range. The dipole coils will be weaker yet, but because they are used to compensate mechanical misalignments, their strength will be completely unpredictable up to a maximum value. Furthermore the dipole stray field will not drop off as quickly as the quadrupole fields. Further study of these coils is possible.

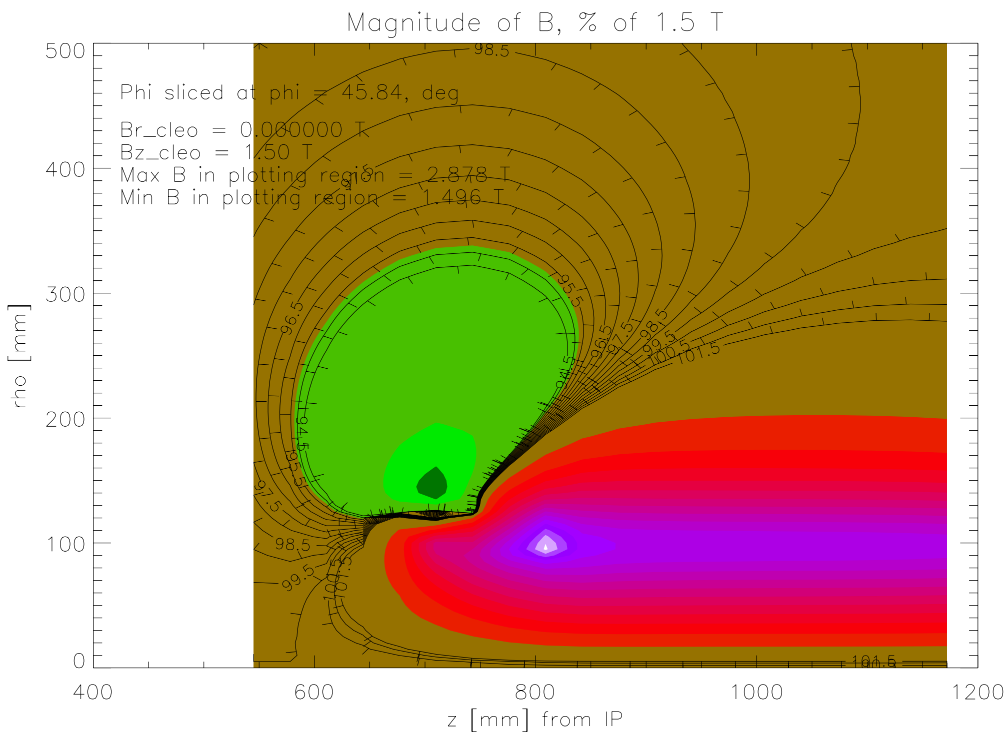

Figure 1: Distortions of the CLEO solenoid field caused by the superconducting quadrupole currents are displayed in the $\rho - z$ plane at cylindrical angle of 45 degrees where they are the strongest.

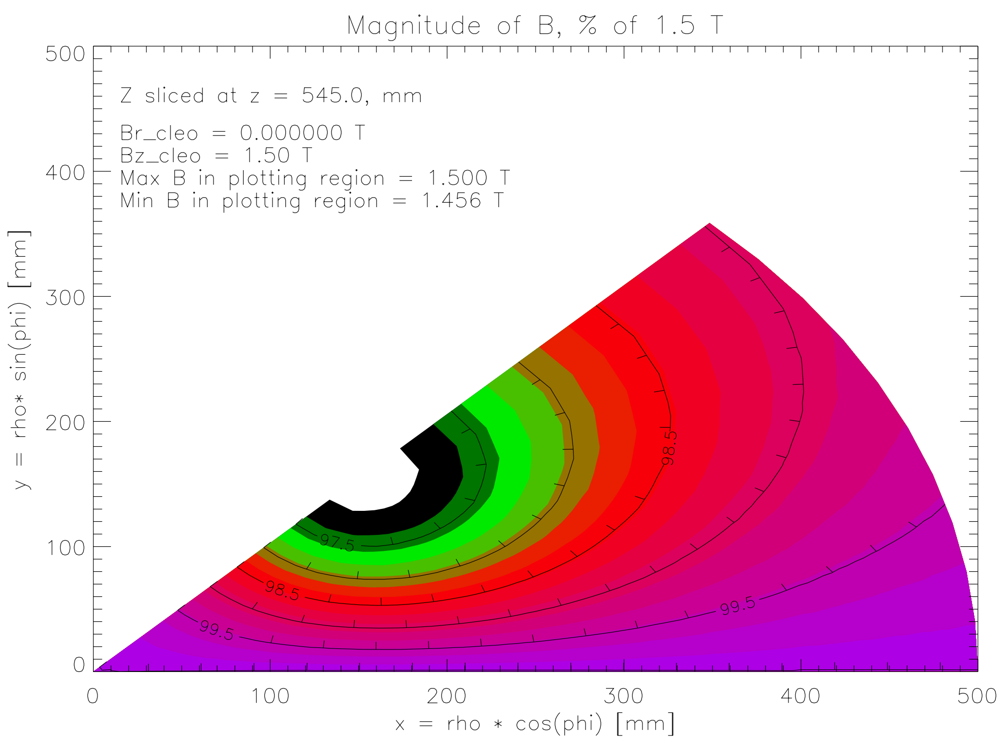

Figure 2: Distortions of the CLEO solenoid field in the transverse plane at $z = 545$ mm are shown.

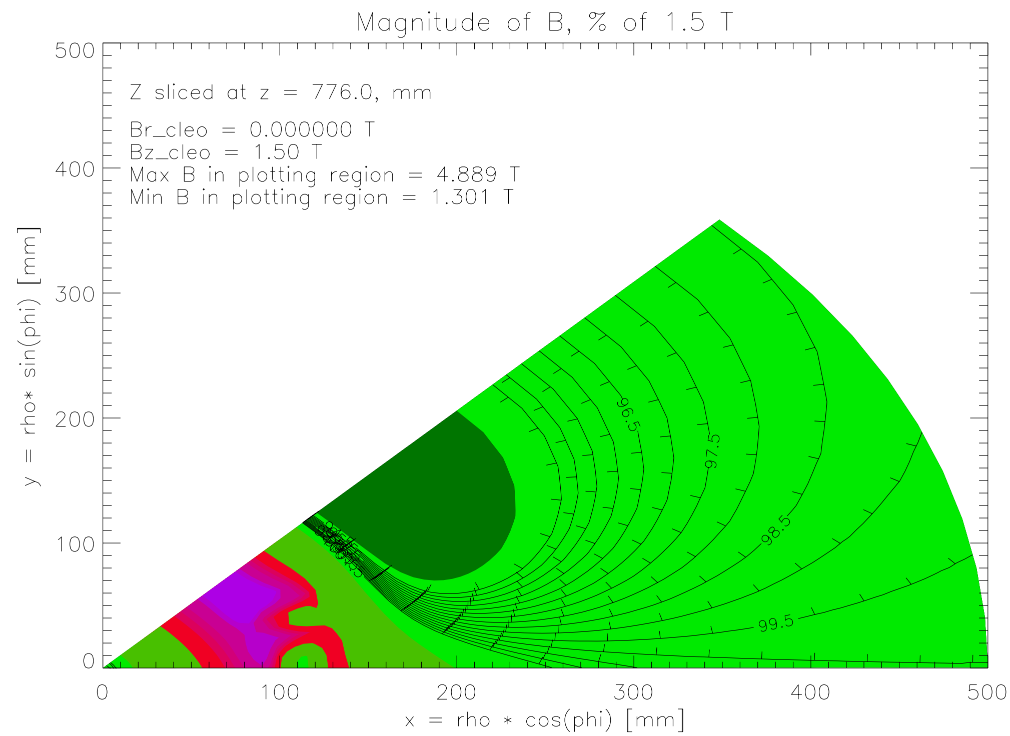

Figure 3: Distortions of the CLEO solenoid field in the transverse plane at $z = 776\ mm$ are shown. This z location is near the front of the Q1 coils.

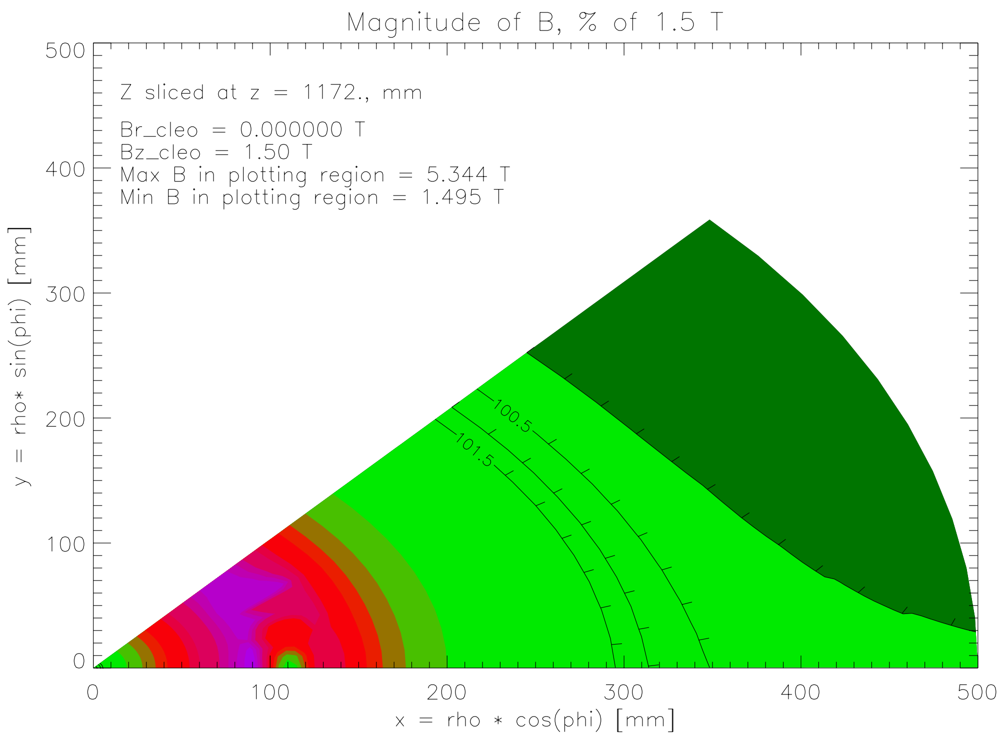

Figure 4: Distortions of the CLEO solenoid field in the transverse plane at $z = 1172$ mm are shown. This z location is near the middle of the Q1 coils.