JGG Field Uniformity with Extended Coils

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Abstract

The need to replace failed JGG coils opens up an opportunity to improve the magnetic field uniformity in the TPC in MIPP. The field used in the last MIPP run is compared to the field resulting from larger coils. The larger coil models have same coil size in x and y as before, but are extended in z (along the beam axis) by 9" and 18". We find that extending the coils by 9 inches results in a significantly more uniform magnetic field. Further extension to 18 inches does not yield much further improvement.

I. MOTIVATION

The non-uniform magnetic field in the TPC results in $E \times B$ distortions of the tracks. Transverse components of the magnetic field cause the drifting electrons to shift in x and z by as much as 2.5 centimeters with the existing JGG coils. These distortions can be corrected. The resulting residuals with the present state of analysis are of the order of 10% of the distortion, i.e. up to several millimeters. It is desirable to reduce the distortions in a future run.

The magnetic field of the Jolly Green Giant has been modeled by Bob Wands based on the geometry of yoke and coils and electric current in the coils. The resulting fieldmaps have been compared and the drift distortions and residuals at a few points in the active TPC volume have been determined for each map.

II. MAGNETIC FIELD MAPS

The field maps from Bob Wands have been converted to the format used by MIPP and are available in the MIPP CVS repository. MIPP cares about the magnetic field in the active volume of the TPC. This volume is centered in the JGG in x and z. Its center is slightly higher than the JGG center due to the size of the amplification region, readout electronics and cart below the active TPC volume.

The active volume of the TPC is as follows w.r.t. the JGG:
104 cm wide in x, from -52 to +52 cm, +/- 10 Grid points
90 cm high in y, from -43 to +46 cm, +/- 9 Grid points
164 cm long in z, from -82 to +82 cm. +/- 16 Grid points

The plots show the magnetic field components for the original coils (black), 9" extended coils (blue), and 18" extended coils (green) along four lines through the magnet. The x and z component are small for the extended maps in the active region of the TPC.

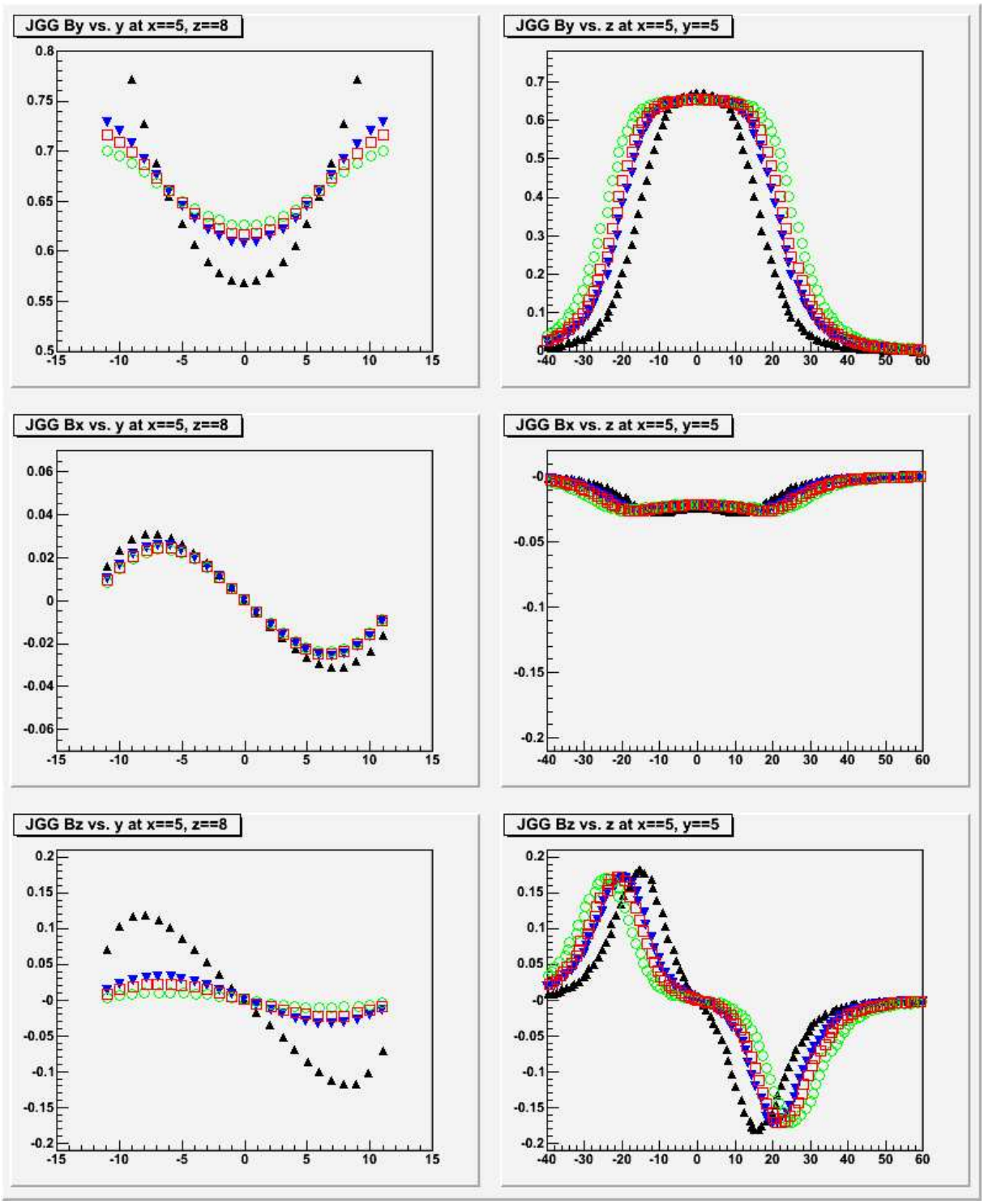

FIG. 1: Black: Original design, Blue: 9", Red: 12", Green: 18". Y-axis: Components of magnetic field in Tesla. X-axis: grid-points, 2" per grid p3int. 0 is at the center of the JGG.

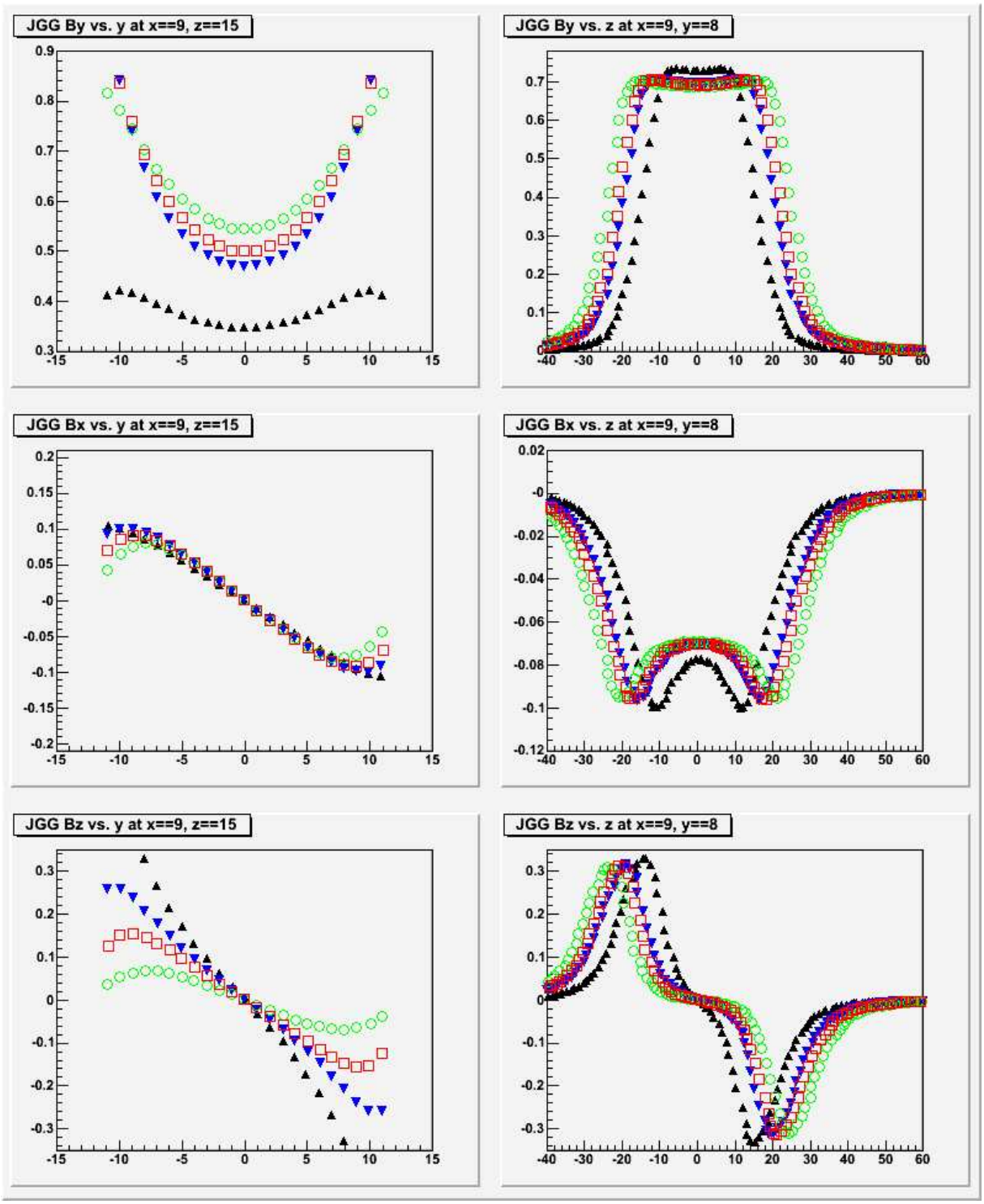

FIG. 2: Black: Original design, Blue: 9", Red: 12", Green: 18". Y-axis: Components of magnetic field in Tesla. X-axis: grid-points, 2" per grid point. 0 is at the center of the JGG.

III. DISTORTIONS

The swDrift program from the Swimmer package of the MIPP offline software has been used to determine the distortions and residuals for a few points inside the TPC volume. In the MIPP geometry the center of the active TPC volume and the JGG are at z=-740 cm. The upstream end of the field cage is at z=-822cm.

```
(0,0,-812) -- near upstream center
Model | Distortion (x,z)   | back to
Zip   | -3.1714,   4.634   |  0.0866,   -0.0658,   -812.152
Ext0  | -2.8493,   4.705   |  0.0865,   -0.0648,   -812.152
Ext9  | -1.1302,   2.514   |  0.0318,   -0.0142,   -812.076
Ext12 | -0.8136,   1.904   |  0.0224,   -0.0076,   -812.056
Ext18 | -0.4071,   1.019   |  0.0109,   -0.0020,   -812.028

(0,0,-822) -- at upstream center
Model | Distortion (x,z)   | back to
Zip   | -4.1826,   5.15    |  0.1184,   -0.0949,   -822.171
Ext0  | -3.8307,   5.268   |  0.1200,   -0.0944,   -822.171
Ext9  | -1.6732,   3.433   |  0.0485,   -0.0290,   -822.107
Ext12 | -1.2361,   2.719   |  0.0351,   -0.0170,   -822.083
Ext18 | -0.6419,   1.55    |  0.0175,   -0.0049,   -822.045

(52,46,-822) -- at upstream top left corner (worst case)
Model | Distortion (x,z)   | back to
Zip   | 10.2124,  -3.447   | 52.4539,   46.0904,   -822.309
Ext0  |  9.9842,  -4.569   | 52.4055,   46.0777,   -822.35
Ext9  |  5.6238,  -4.02    | 52.2383,   45.9626,   -822.238
Ext12 |  4.4953,  -2.841   | 52.1996,   45.965,    -822.164
Ext18 |  3.1615,  -0.999   | 52.1508,   45.9815,   -822.064
```

```
(10,10,-812) -- near upstream offset 10cm
Model | Distortion (x,z)   | back to
Zip   | -3.2974,   3.961   | 10.1432,    9.9394,   -812.204
Ext0  | -2.8193,   4.114   | 10.1377,    9.9409,   -812.206
Ext9  | -1.2170,   2.168   | 10.0567,    9.9873,   -812.104
Ext12 | -0.9232,   1.622   | 10.0425,    9.9932,   -812.077
Ext18 | -0.5421,   0.835   | 10.0247,    9.9983,   -812.039

(30,30,-812) -- near upstream offset 30cm
Model | Distortion (x,z)   | back to
Zip   | -0.4988,  -0.067   | 30.2625,   29.9806,   -812.287
Ext0  | -0.0219,   0.012   | 30.2414,   29.9828,   -812.293
Ext9  | -0.0067,   0.006   | 30.1165,   29.9948,   -812.143
Ext12 | -0.0044,   0.003   | 30.0944,   29.9975,   -812.102
Ext18 | -0.0020,   0.001   | 30.3666,   29.9995,   -812.045

(-30,30,-812) -- near upstream offset 30cm opposite direction
Model | Distortion (x,z)   | back to
Zip   | -0.4178   -0.003   | -29.8918,  29.9824,   -812.376
Ext0  | -0.0190    0.019   | -29.8706,  29.9815,   -812.355
Ext9  | -0.0041    0.009   | -29.9821,  29.9943,   -812.182
Ext12 | -0.0020    0.006   | -29.9989,  29.9972,   -812.138
Ext18 | -0.0002    0.002   | -30.019,   29.9994,   -812.078
```

The distortions obtained from the Ziptrack map and the model of the original field (Ext0) agree roughly. The 9 inch extension (Ext9) results in much smaller distortions. Distortions exceed 1 cm only very close to the edge of the active TPC volume and residuals (difference of initial electron position and electron position after drifting down and up again) are below 1 mm. The 12" and 18" extensions (Ext12 and Ext18, respectively) further reduce distortions

and residuals. However, the gain in the first 9 inches is much larger than the gain in the second 9 inches and the additional gain seems inconsequential given that the residuals are only tenth of millimeters in the 9 inch extension model over most of the active volume of the TPC including the region near the primary interaction vertex.

IV. CONCLUSION

Different models for new JGG coils were compared. The model with a 9 inch coil extension is favored.