Verifying the RFOFO Ring Field At Randomly Distributed Points
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RFOFO Field Map 27.doc

As part of our ongoing effort to assess the quality of our RFOFO field map, I have generated an ensemble of 10000 points pseudo-randomly distributed within the active (accessible to muons) volume of the RFOFO ring. For these purposes, the active volume consists of the Nominal Beam Trajectory (a circle 33 meters in circumference) and all points in space within 25 cm of the NBT.

The 10000 points are uniformly distributed in S (or equivalently, position angle b) and in X' and Y'; see the drawing below. Hence the points are almost (but not quite) uniformly distributed within the active volume. Plots showing the point distributions are below. I've made a file listing the test point positions, one line of text per point. The listed quantities are:

- X, Y, Z -- position of the point in cartesian ring coordinates
- S, b, X', Y' -- position of the point in accelerator coordinates (S and b redundant)

Our various field generating programs can read this file, generate the field at each test point, and output a line for each point specifying the position (from the input file) and the field components. Our field components are in cartesian ring coordinates, but these are easily converted back and forth to accelerator coordinates.

To date we have run three field generators against the first 5000 points of the 10000-point file of standard test points:

A -- The Biot-Savart field (24 coils, 50 x 11 turns per coil, 300 segments per turn) that remains our reference field. It exhibits very low divergences and curls, and the program that generates it is very simple and easily understood. It is very slow.

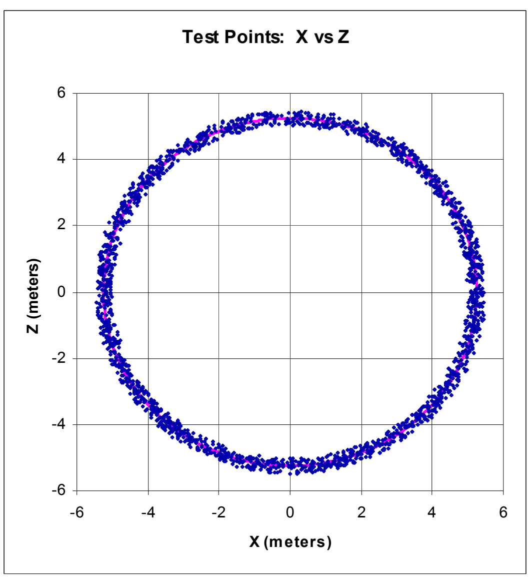
B -- Our standard BSHEET-based field (24 coils, 11 sheets per coil). This field is rapidly approaching the quality of Field A as we refine the algorithm and our use of it. It is very much faster than the Biot-Savart generator. For example, it can generate a full field map for 1 cell of the RFOFO ring on a 1 cm lattice in about ten hours of running on a single PC.

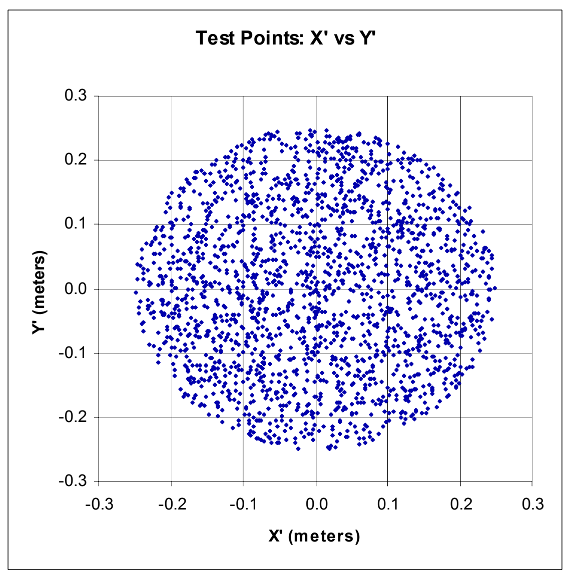
C -- A field generated by interpolating from a field map grid, which in turn was generated by a procedure that is a slight variant of the present Field B generator. As one would expect, this generator runs much faster than the Field B generator, but since the lattice spacing is fairly wide (1 cm in all three directions) there is naturally concern that it might be too coarse-grained to yield accurate field values.

When we compare field maps, it is consistent field shape that we are after. There are various reasons that a field generator may deliver a field that has the right shape but not quite the correct scale. This is of no consequence in an operating ring, since errors of scale can be mitigated by adjusting the coil currents. It turns out that the scale factors that must be applied to maximize consilience between the various fields is extremely low; the largest scale factor being used is 1.00011. I am not quite ready to report final results yet, but the preliminary analysis is extremely encouraging. The field discrepencies seem to be at the part per ten-thousand level everywhere within the active volume of the ring.

I have a set of programs and Excel templates for making the field comparisons and presenting the results. They will be ready for routine use within 2-3 days. I am hoping that all fields being used for RFOFO simulations -- both the original field generators that go into making grids or computing coefficients for parameterized fields, and the field finders that couple directly to the simulation packages -- will be run on the file of standard test points. I am willing to do the comparisons that will assure us that the various simulation efforts are seeing the same field throughout the ring's active volume.

I am about to generate a second file of standard test points. This file presents 1000 randomly distributed primary test points and for each primary, 6 secondary test points located half a millimeter from the primary. The secondaries are used for computing curls and divergences at the primary points. It will be very reassuring to know that fields we use have nearly-zero curls and divergences for randomly chosen points throughout the entire active area of the ring. Again I have a set of programs that input the field files, calculate the curls and divergences, and present the results. Again these are almost but not quite ready for routine use.





Distributions of test points around the RFOFO Ring; the first 1000 points are plotted. The (barely visible) magenta line in the left plot is the Nominal Beam Trajectory.

$s = R_{nbt}\ b$
$H = R_{nbt} + x' = \mathrm{sqrt}(X^2 + Z^2)$

$X = (R_{nbt} + x') \cos b$
$Y = y'$
$Z = (R_{nbt} + x') \sin b$

$b = \mathrm{atan2}\ (Z, X)$
$y' = Y$
$x' = H - R_{nbt} = \mathrm{sqrt}(X^2 + Z^2) - R_{nbt}$

Unit Vectors:
e_b -- parallel to tangent to NBT
$e_{y'}$ -- vertically downward
$e_{x'}$ -- radially outward