Field Mapping

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1st March 2016

Aim:

- To make a computer model of the spectrometer solenoids such that the simulated field is sufficiently close to the measured field as measured by the field mapper.

This model can then be fed into opera to generate an in situ field map with the PRY taken into account.

The first task was make field maps from two sets of dimensions for the coils of SSU. Note: all work presented here is on SSU.

One set of dimensions is from MICE note 464. These dimensions are surveyed when the magnet is at room temperature. Of course this will change when cooled down to operating temperature!

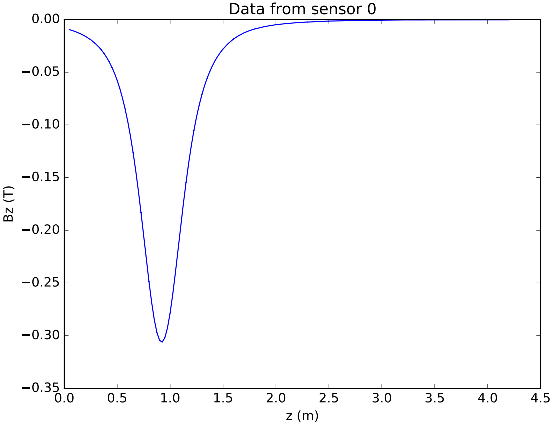
The next set of dimensions is from a talk given by Holger last year. In this talk he presents calculations of how much the dimensions of the coils will change when they are cooled.

First Problem:

- Both sets of dimensions use their own coordinate systems!
- They are both at different z offsets compared to the field mapper.
- Want to line up the coils in the model with the actual coils from the field mapper data so the difference can be taken.

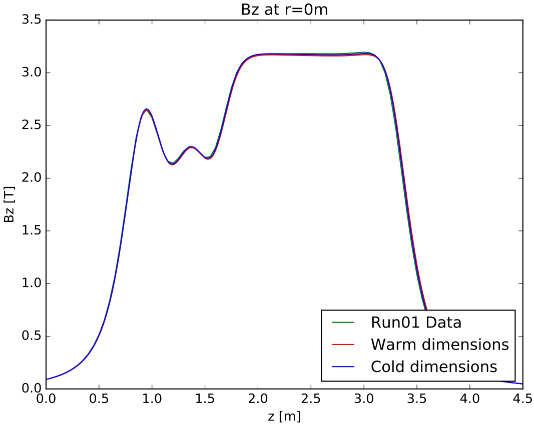
Solution:

- Assume the the distance between coils given by both sets of dimensions are good.
- Find the centre position of M1 in field mapper coordinates using data where only M1 is powered.
- Use this as the centre position of M1 in the computer models.

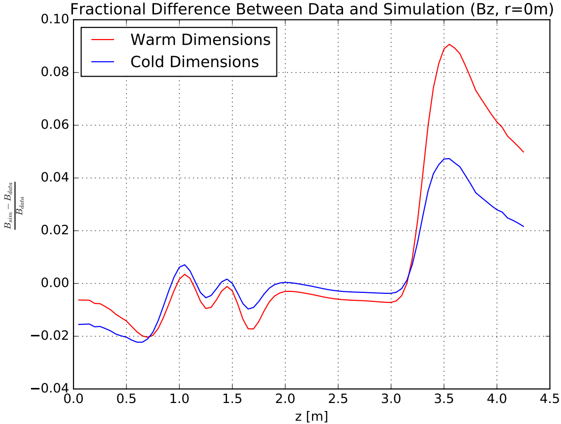


By roughly finding the where Bz is maximum (the absolute value of Bz was used) the centre position of M1 was found to be **z=0.925m**

The field maps for the cold and warm dimensions were then compared.



Sanity check



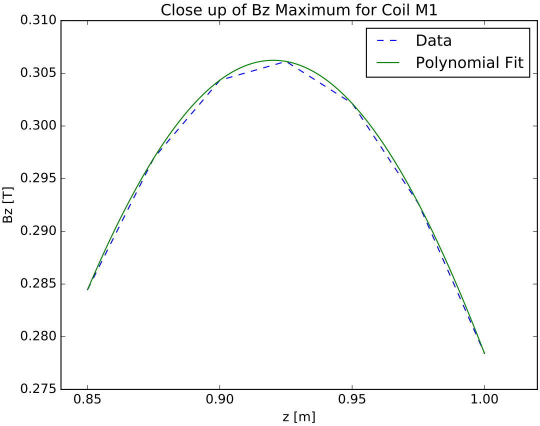
Fractional difference between warm/cold dimensions and data. Clearly shows the cold dimensions represent the magnet better as expected.

The warm dimensions are clearly worse, so these are no longer used.

However with both sets of dimensions, the difference with data showed the same shape. It was thought that this is caused by a mismatch between the coil centres of the dimensions and the coil itself.

A simple method of finding the centre of the coils was devised using polynomial fits. Then these centre positions were fed back into the computer model. The process is as follows:

- Get data where only the coil in question is powered.
- In this data, find the data point where the Bz field is maximum and take ± 3 data points around this.
- Fit a fourth order polynomial to these data points
- Differentiate polynomial and use a root finding algorithm to find where it is zero
- This should be the centre of the coil!



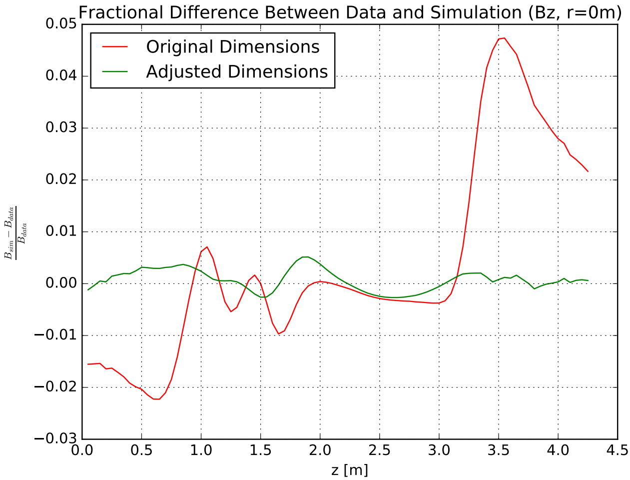
Plot showing the polynomial fit and the data points joined with straight lines.

However no data where only Centre Coil is powered. More on this later...

This method makes a difference on the order of a few millimetres.

Coil	Original Centre [m]	Centre position from fit [m]
M1	0.925	0.920
M2	1.363	1.357
E1	1.761	1.757
CC	2.509	2.502
E2	3.257	3.247

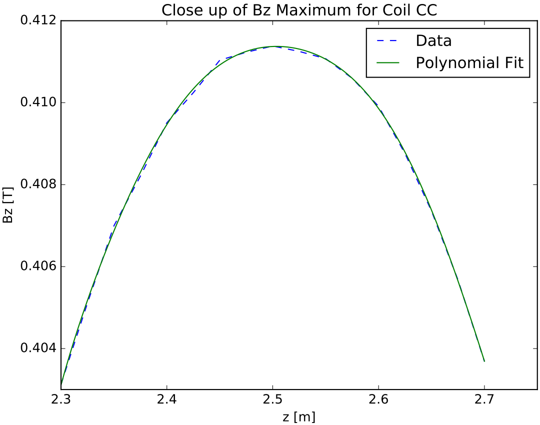
This difference makes a noticeable difference on the field.



It was noted that no data exists where only CC is powered. So the centre was crudely worked out as being exactly halfway between the centres of E1 and E2.

However data is present with E1, CC and E2 powered in series at the same current as the runs where E1 and E2 are powered individually.

Therefore it should be possible to subtract the E1 and E2 fields from the E1-CC-E2 data to obtain the Centre Coil's field.

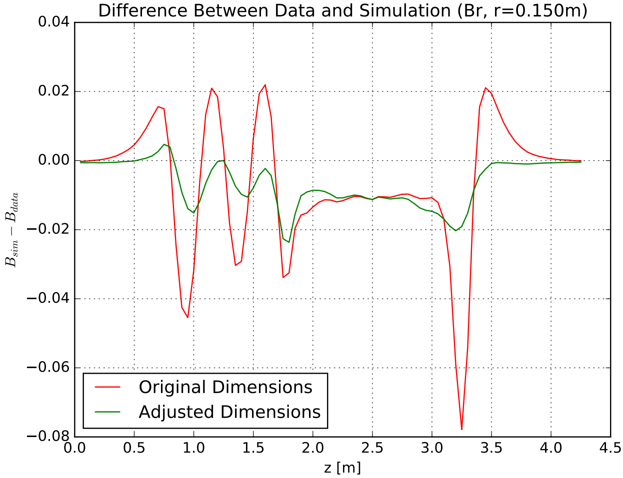


The application to the Centre coil is still being refined though since fourth order polynomials don't fit well and using higher orders give the centre of the coil between 2.500m and 2.505m.

There is always room for improvement as more factors are taken into account.

The next steps are:

- Refine the method for finding the centre position of the Centre Coil
- Take into account the axial tilt of the coils with respect to the mapping axis.
- Optimize individual coil dimensions (width, length etc) to improve on field map.
- Apply same methods to the other magnets!


Difference Between Data and Simulation (Br, r=0.150m)
$B_{sim} - B_{data}$
z [m]
Original Dimensions
Adjusted Dimensions
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.08
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5