Field Mapping

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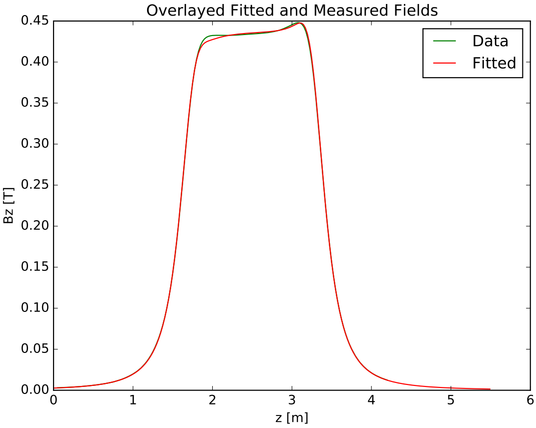
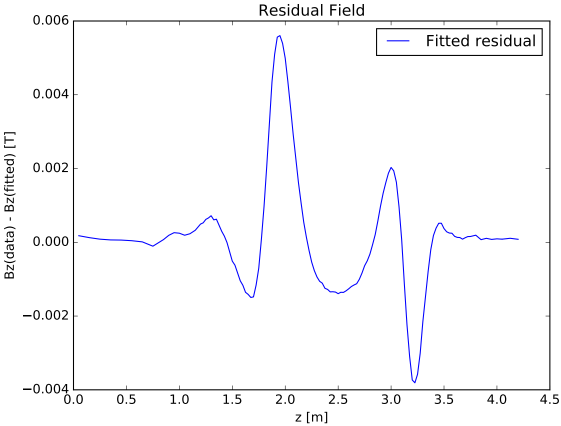
28th July
CM45

Previously

- Fitting bracketing fields to individual coils on SSU data.
- No data where Centre Coil is powered individually.
- Have to instead fit to ECE data.
- This caused some problems...



Easy to see by eye that the fit doesn't agree well in the E1 region.

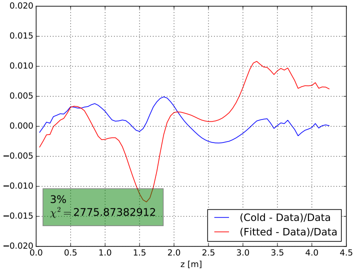


And the residual field also shows disagreement in E2 region. ($\sim 1\,\%$)

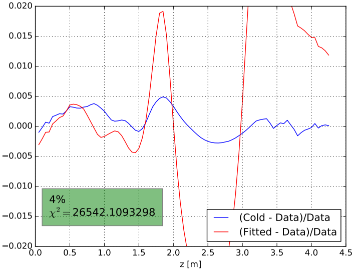
These ECE fields were fitted by making thinner/fatter Centre Coil fields only and then adding the fitted fields of E1 and E2.

- The quality of the fit changes depending on what aspect ratio is chosen for the bracketing fields.
- The previous plot used the ‘standard’ 10% thinner/fatter.
- For the ECE fit, the fitting algorithm was done 10 times for 1-10%

Some examples:



(a) 3%

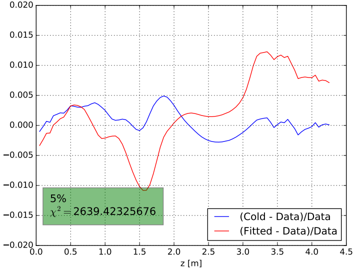


(b) 4%

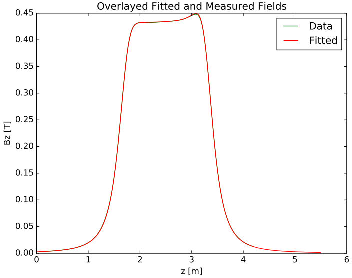
Percentage differences from data compared with the cold dimensions simulated field of SSU.

Interesting things happen at 4% . The same thing happens for 6% also, so something strange is happening! However 5% fits the best (it has the lowest χ^2):

Percent	χ^2
1	3631
2	2894
3	2775
4	26542
5	2639
6	56933
7	3080
8	3719
9	4755
10	6284



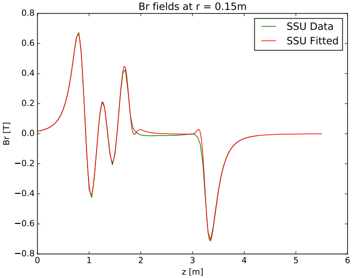
(a) 5% Residuals



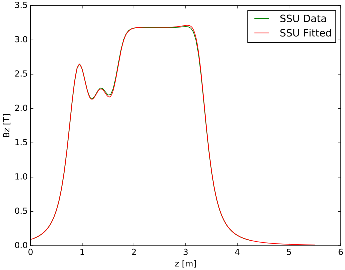
(b) Overlayed with data

5% seems to be the best fit for ECE.

All of the fitted fields for SSU were then scaled up to 80% of I_{max} to match the data. The fields were then added together to form a field map for SSU...

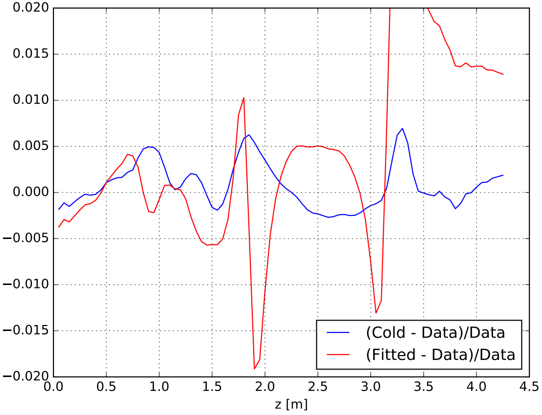


(a) B_r at $r = 0.15\,\text{m}$



(b) On Axis B_z

Needs work! $\sim 2\%$ difference with data and worse than simulation. Although I suspect this is mainly due to the ECE fit.



Fourier-Bessel Model

Victoria gave a talk at a previous CM (CM30!) about the then called "compromise model".

- The measured field obeys Maxwells equations
- The closed current loop model, given by B-S law, obeys Maxwells equations
- And so the difference should also obey Maxwells equations

So we can then use a Fourier-Bessel model to describe this difference and aid us in correcting it.

Quick F-B overview

In region with no currents, like *inside* our solenoids the magnetic field obeys:

$$\nabla \times \mathbf{B} = 0$$

Expressing $\mathbf{B}$ as a scalar potential Φ so that $\mathbf{B} = -\nabla\Phi$ gives Laplace's equation:

$$\nabla^2\Phi = 0$$

Which can be solved by separation of variables:

$$\Phi(r, \phi, z) = R(r)P(\phi)Z(z)$$

The solutions then involves (very) large series expansions involving Bessel functions with lots of arbitrary constants and phases.

However the advantage is that these can be found using the data lying on a closed cylinder, which we have. Then using the model the field anywhere inside this closed cylinder can be calculated!