

Magnetic Modelling

12/03/2013

Before looking at the quad model it is probably worth reporting that I've spending some time (probably a bit too much) upgrading/debugging the plot generator to create vector plots alongside the Bmod plots.

Debugging has been done using Hall model 51, so vector plots of this model can sometimes be seen online – this is when I haven't deleted the plots to rerun the plot generation script. Bear in mind that we now know that model 51 is antiquated so these plots shouldn't really be used.

The script also generates 'master' plots for the Hall& SSB that encompass the entire area Hall & SSB at the same time.

The code should work with other models, other than just the large Hall and SSB models (i.e. models 51-56) but this hasn't been tested yet. Hopefully I will get the chance to try this on the Quad model later this week.

I have this week fixed the code in the hall model so that the boundary conditions are correctly applied but I need the modeller free for an extended period to rerun models 51-56. I will try and run these over the Easter break as I will be taking some A/L anyway.

Other News...

We have a preliminary meeting with VF tomorrow afternoon to discuss the consultancy.

Last week I justified why I wanted to work on the Quad sub-model (or reduced model) but to reiterate:

To do an initial investigation of the field in the area around Q9.

Now some of this could be done with the Hall model but this seemed like a good opportunity to test a number of processes that could be useful for benchmarking the Hall model and other sub-models.

So I built a reduced sub-model of the area around Q9. Basically I reused a few of the Hall components and built a small model that enclosed the Step IV coils. This includes Solenoids, NSW, SSW, Q9-Q7 with bases and baseplates, Virostek plates and TOF shield.

Last week I had the first of the Quad models solved and I had just showed a pretty vector plot illustrating how changing the boundary conditions (or just the effect of a simpler model) had given a pleasing dipole field around the coils as one would expect. – (Sadly this field shape is lacking in the Hall model at low field.)

What Benchmarking do I hope to be able to do?

I'd like to do some comparisons between the Quad model and the Hall model. Do they agree in areas of interest?

I've done some initial comparisons along specific lines inside the quads which I'll show shortly. Might be good to do some more comparisons between the Hall/Quad model but these are time consuming to do.

To extend the boundary of the model on the simpler Quad model – Does this have an effect?

It appears to have a small effect which suggests that the boundary is not far enough away but we do pay a heavy price for extending the boundary...as before more comparisons would be useful but are time consuming to do.

To run some mesh convergence models. Tighten the mesh up and do we see a change in the solution. No change means that the mesh was sufficient.

This is in progress. I have added a variable (b) which changes the mesh of all objects by a multiplying factor of $1/b^{(1/3)}$. This means that if a model solves in time (t) then the solve time can in principle be extended linearly by a factor of (b).

So what models have I run?

Quad Sub Model 1 – First Attempt – Solve time 14 Hours – Same meshing resolution as Hall Model 51.

Quad Sub Model 2- Extended Boundaries – Solve time 23 Hours

Quad Sub Model 3- Set $b=2$ – Solve time 46 Hours

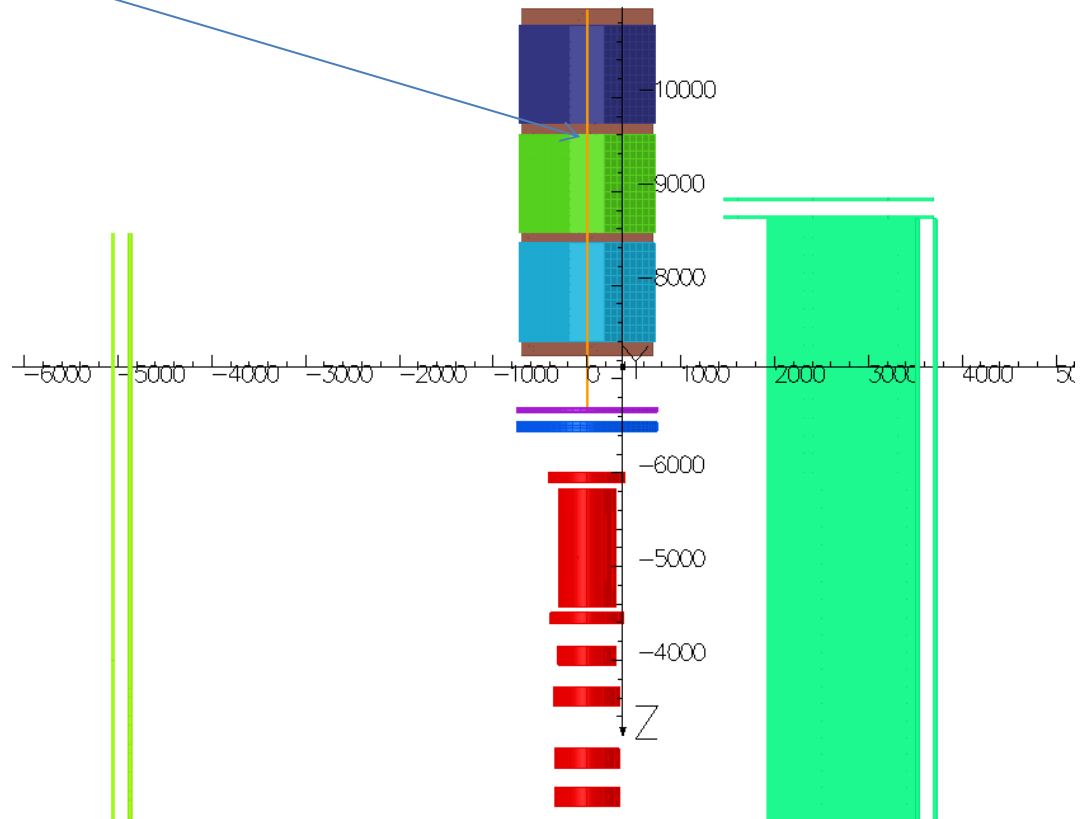
Quad Sub Model 4- Set $b=4$ – Solve time ...still Running.

Comparison between Quad Model 01 and Hall Model 51

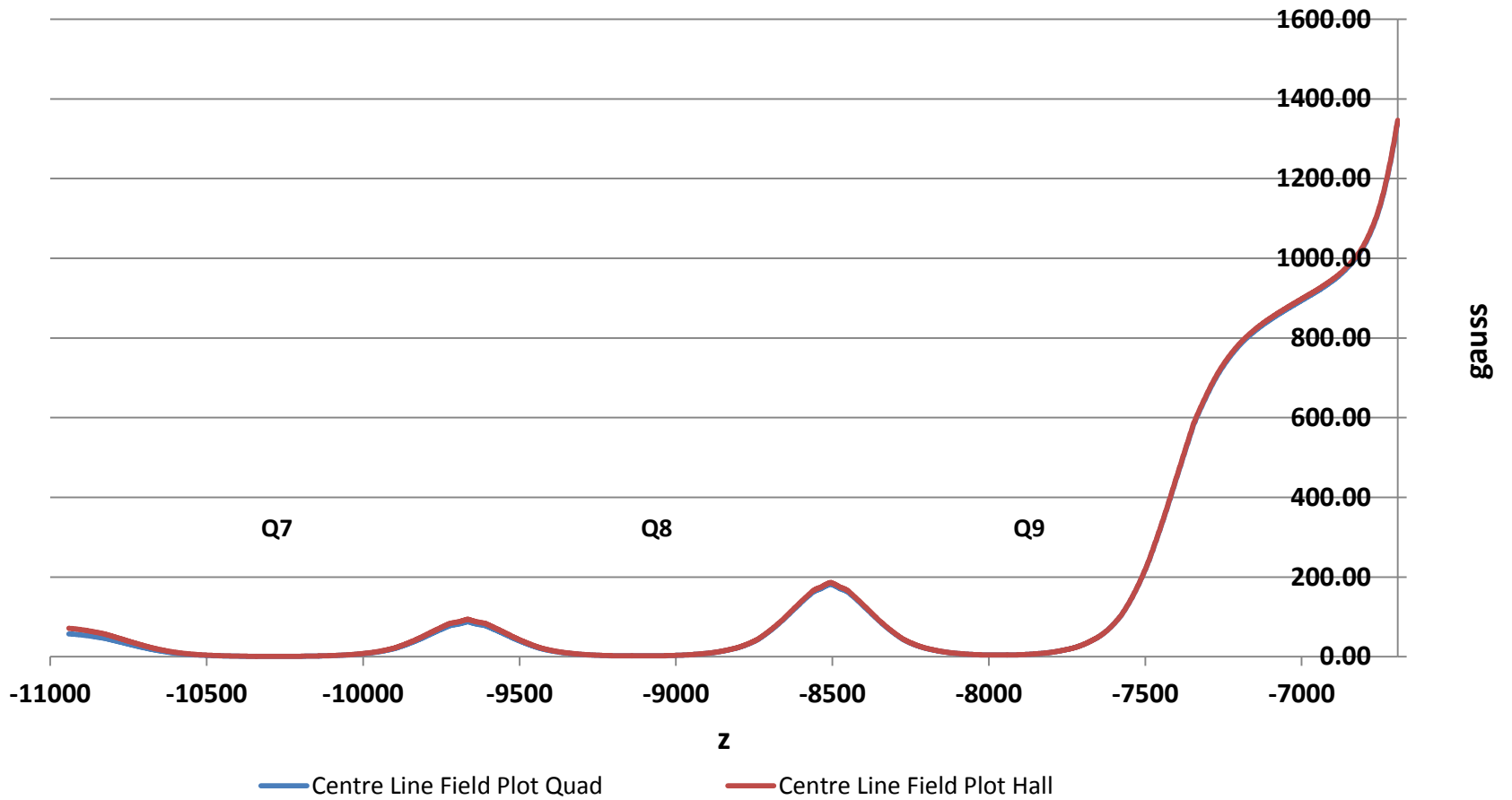
I've taken 5 lines from the TOF cover through Q9 to the end of Q7.

Coordinates are $z = -10941$ to -6693

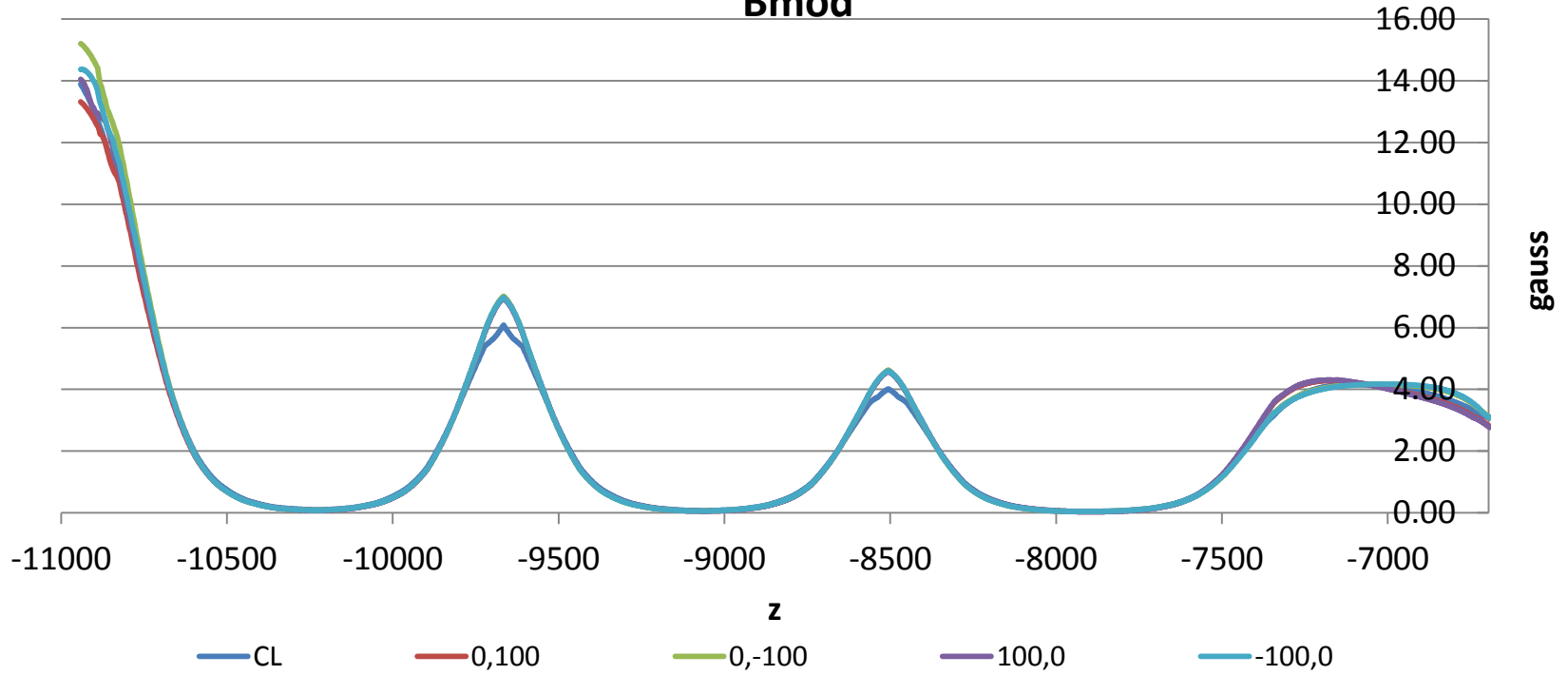
$(x,y) = (0,0)(0,100)(0,-100)(100,0)(-100,0)$



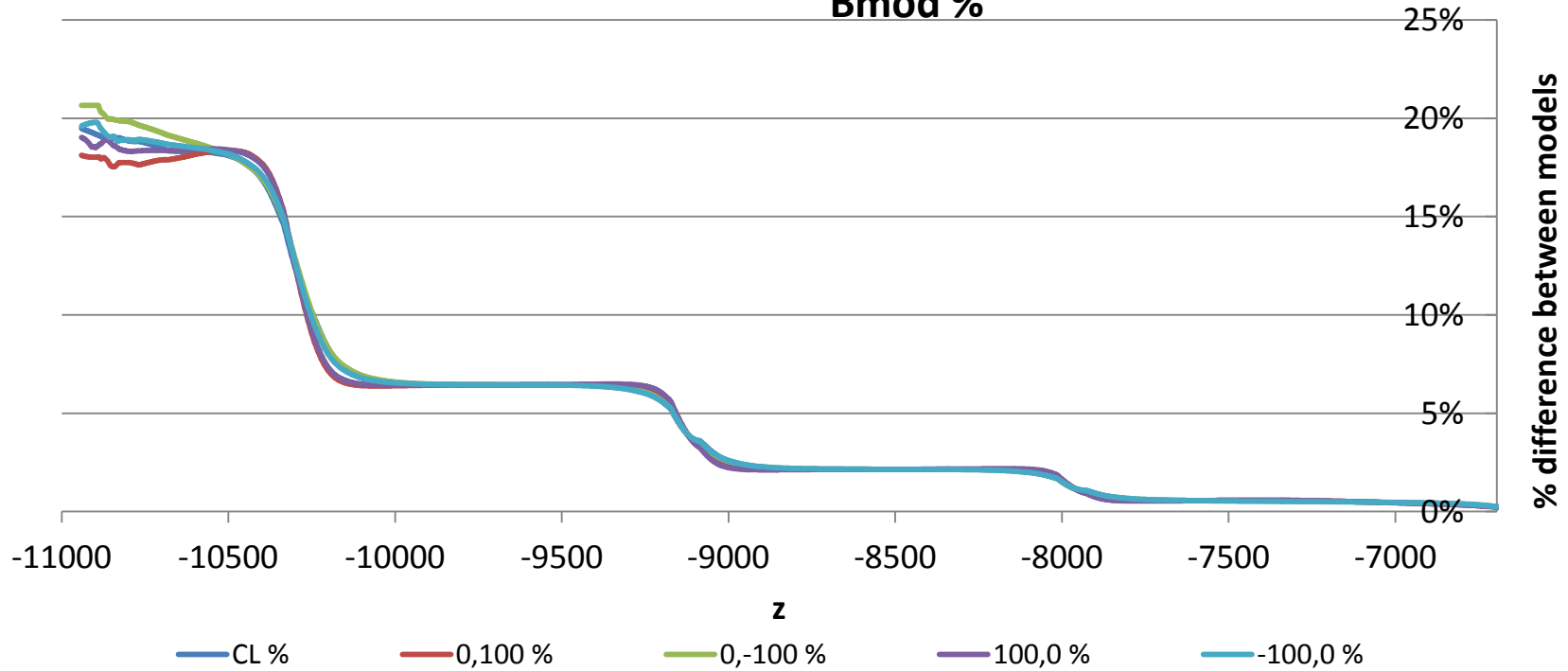
Centre Line Field Plot - TOF Plates through Q9 - Q7 QM01 vs Mod 51



Difference between Hall model 51 and Quad model 01 Values - Bmod



Difference between Hall model 51 and Quad model 01 Values - Bmod %



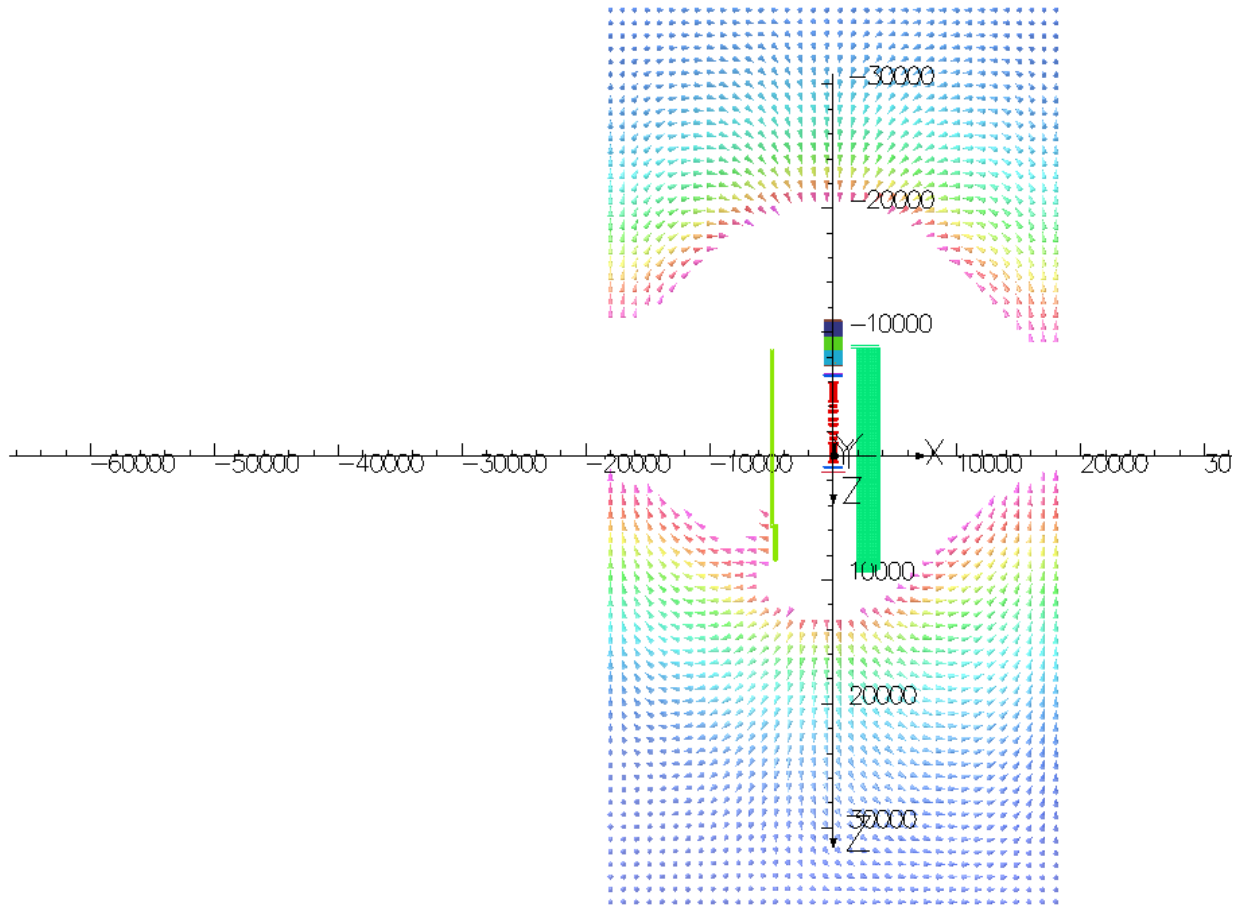
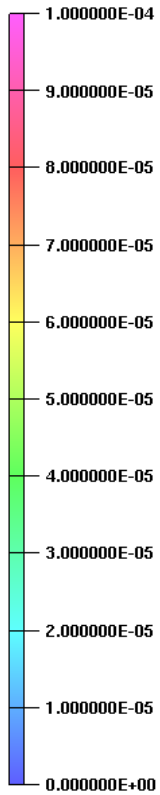
Conclusion from these plots

Good agreement between the hall model and the simpler quad model to within a few gauss in the region between the TOF plates and the face of Q9. – Not surprising as in this region the model iron is the same.

The agreement between the models gets worse as we go upstream. Once again qualitatively this makes sense as this is where the two models start to differ. The hall model contains the DSA, beamstop which is missing from the Quad Model. Further analysis may help determine whether this is the case but not sure that this is useful at this stage...

Of course its hard to know that it's quantitatively right but the agreement between this simple model and the hall model **in this small volume** is encouraging.

Map vectors: B



This is QM01 on the 1 gauss scale.

I was concerned that the boundary in the plots was too close, as a result I moved it out by about 5m in each x, y and z for quad model 02.

Boundary Conditions

There was some evidence that the boundary in the plots in quad model 01 was too close, as a result I moved it out by about ~5m in each x, y and z for quad model 02

My feeling is that if this statement is true then the field in the region between the coils and the boundary will drop slightly resulting in a slightly lower magnetisation in the steel objects.

There is some evidence that this is visible in model 02 but I've not had the chance to produce enough plots to understand this.

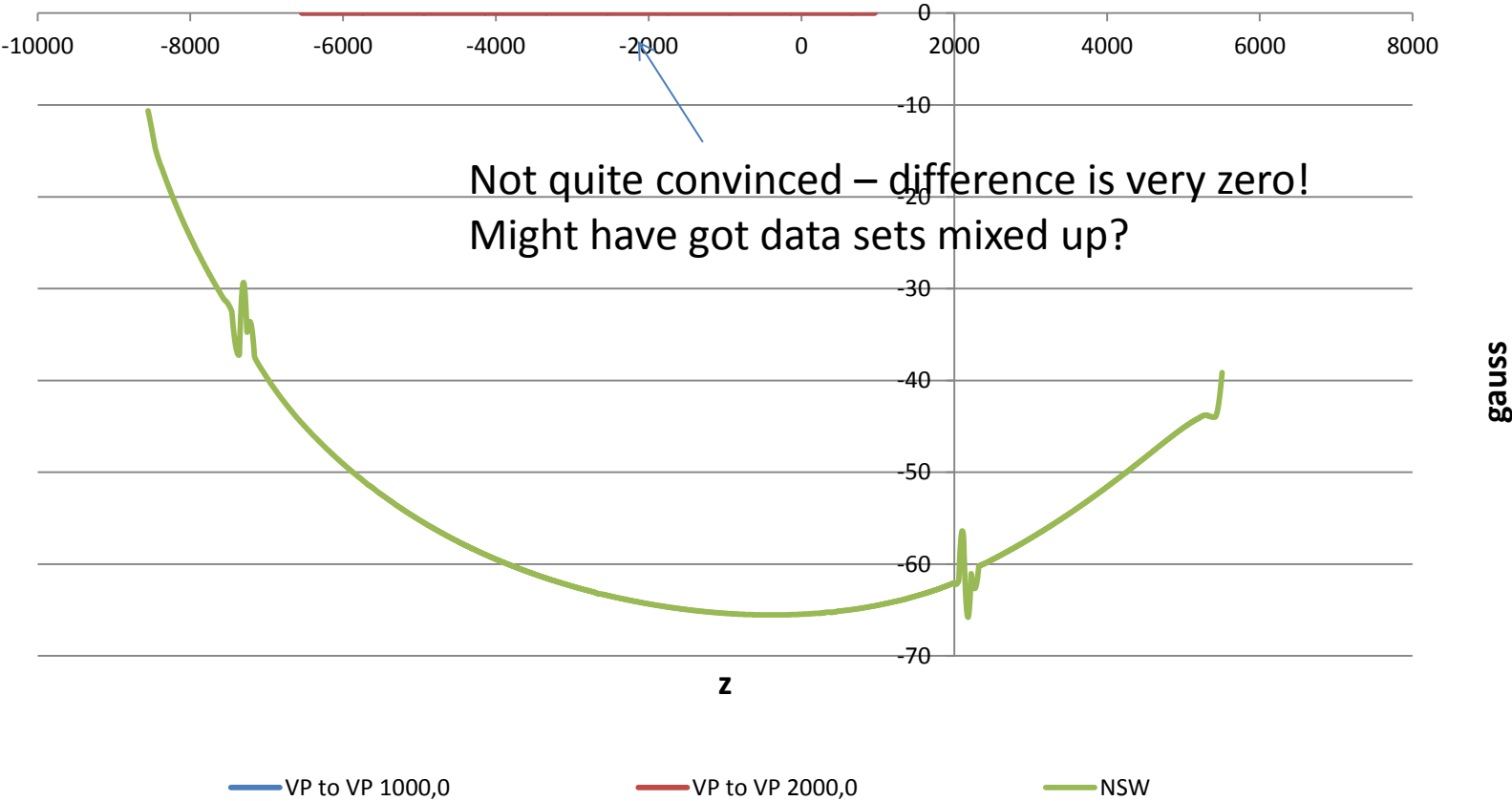
Produced the following plots this morning... I can't yet explain everything in the plot.

I REALLY NEED TO RECHECK THE FOLLOWING PLOTS!!!

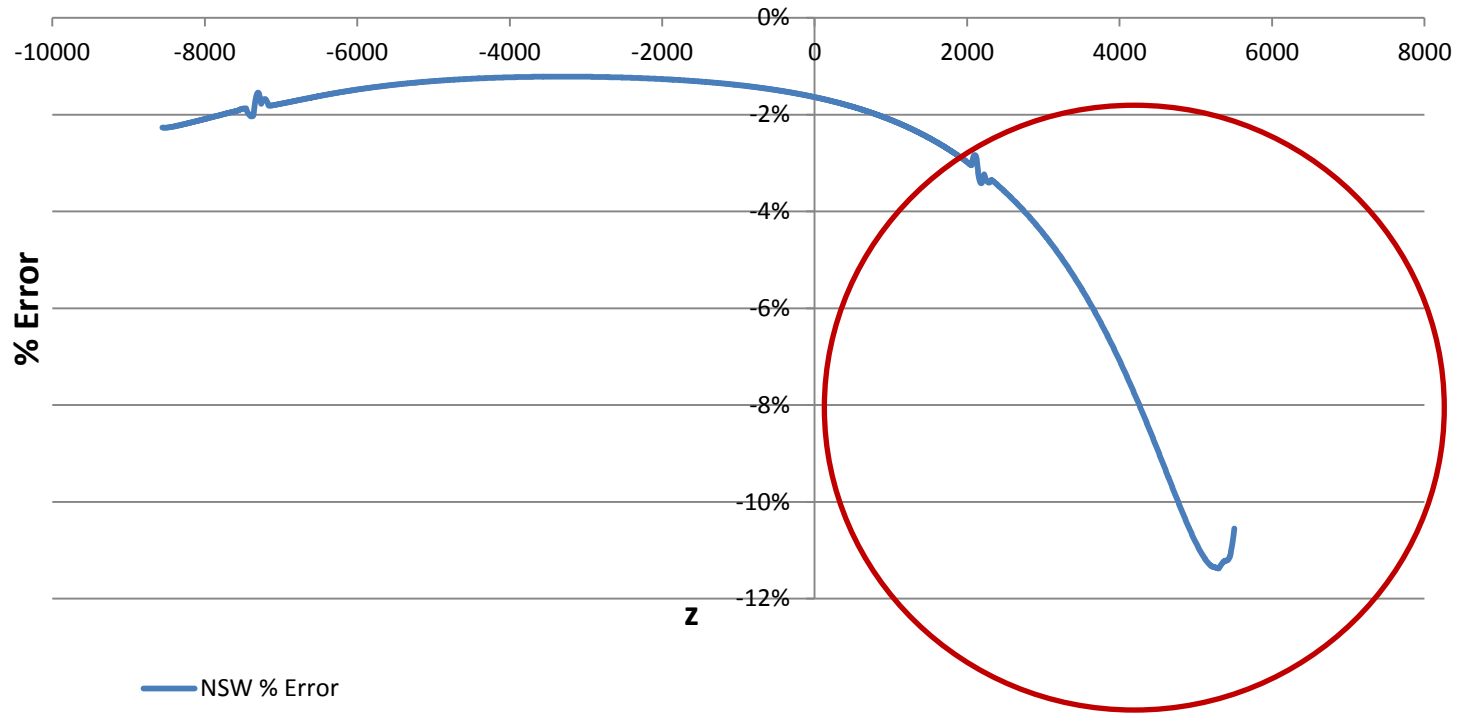
Plots run from

- 1) Virostek Plate to Virostek Plate towards the South Shield Wall
($y=0$, $x=1000$, $x=2000$ $z=-6541$ to 961)
- 2) Through Inner sheet of NSW ($y=0$, $x=-4869$, $z=-8555$ to 5505)

Difference in Field Quad Model 2 - Quad Model 1 (Extended Boundary in QM2)



NSW % Error between QM 01 and QM 02 (extended boundary)



Only found this morning! Clear need to investigate as this has implications for the hall model.

Convergence

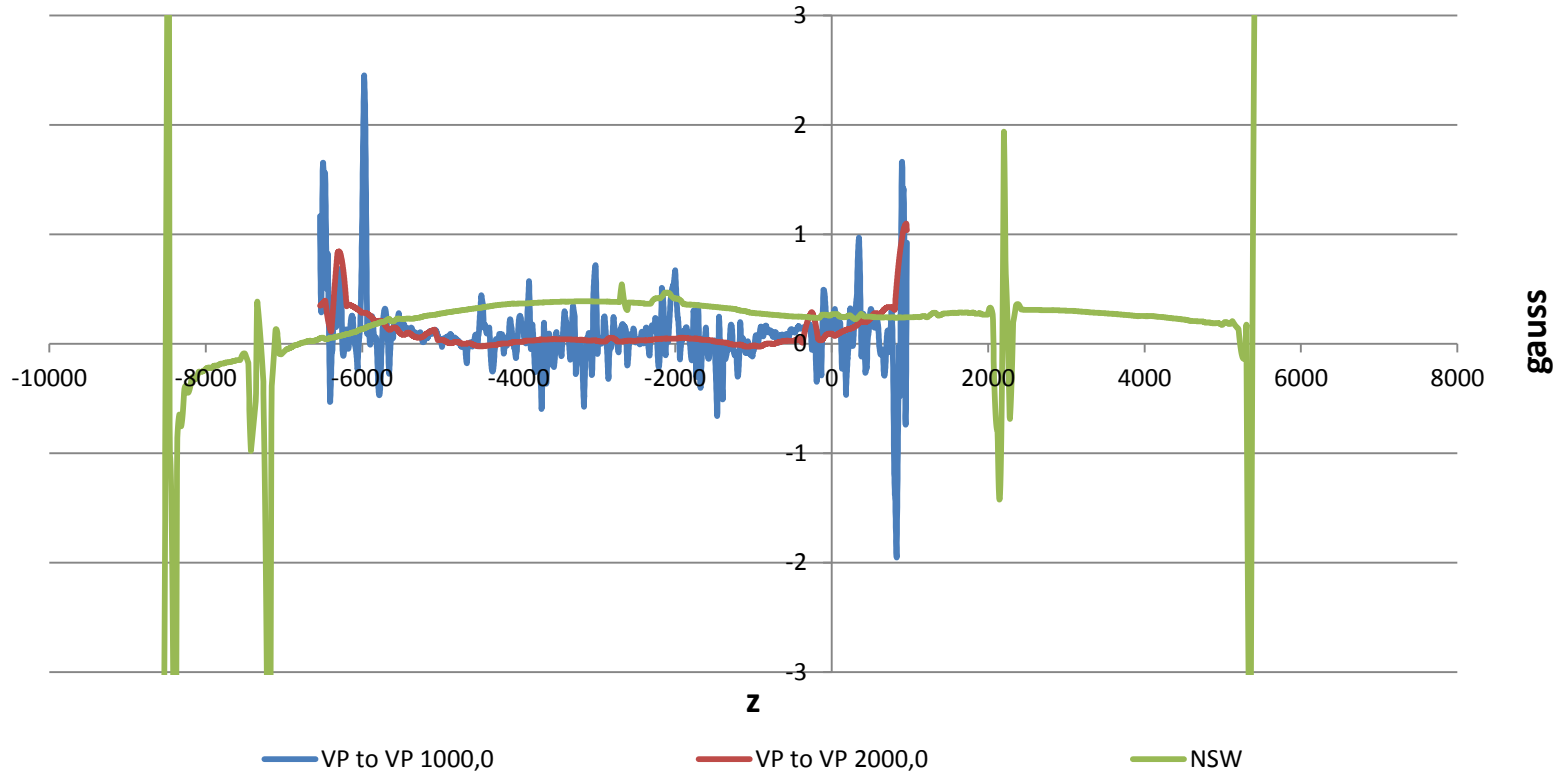
I've been able to do a preliminary comparison between QM2 and QM3 close to the beamline and through the NSW.

Preliminarily the mesh convergence looks ok in the FEW areas that I have looked— will be interesting to compare with QM3.

Might be worth checking more areas – but time consuming.

Any suggestions from experts?

Mesh Convergence Values QM3-QM2



Artefacts at the end of NSW plot line have been clipped so VP plots are visible (but these artefacts are not of too much concern). Those artefacts on the NSW plot at ~7000 and 2000 are odd though.

Conclusions

Generally happy with the agreement between the Quad Model (QM01) and the Hall Model (Mod 51) in the very small volume that I've looked at!

I'm waiting for the QM 03 to finish running so that I can do another set of tests for convergence. This will determine whether we run another Quad Model on a finer mesh or not - suspecting they'll be no need.

There is a clear need for me to recheck my data and investigate the location of the boundary of the Quad model. This has implications for the hall model as the boundary for the Hall model is in a similar location as QM01. (In addition to the known boundary errors in the hall model)

Once we are happy with the boundaries and convergence we can then take a look at the magnitude and gradient of the fields at Q9.

From this we can determine whether we want to take this quad model any further, including any improvements to the model of the quads themselves.