Magnetic Modelling 16/07/2013

Today I shall focus on the results from running a set of models of the shield walls, this continues on from what I started 2 weeks ago.

I’ve been able to run and solve 3 models:

Shield_Wall_Model_04	Plates and I beams. Plates contact I beams	(Best Case)
Shield_Wall_Model_05	Plates only. Plates are continuous like Hall model	(Reference)
Shield_Wall_Model_06	Plates and I beams. Plates stand off I beams by 1.5mm	(Worst Case)

It’s worth making a few comments.

This was for a plate array of 2 x 3 plates (v x h), so it’s much, much smaller than a real shield wall. I would have liked to run a larger model but both a lack of computer memory and time has prevented me from doing so.

I’ve had few crashes, and another power cut(!) so I’ve not been able to complete as many models as I would have liked. The 1.5mm gap was a bit more larger than I would have liked. I think the model will run with a narrower plate gap but I’ve not had the chance to prove it.

These models are very large (they take about 34G of memory to solve and the solution file is about 17G). The models are solved as ¼ symmetry!

I haven’t done any sanity tests on the model but a lot of the model is based upon Hall model code. Boundaries at +/20m, +/15m, +/10m.

MICE shield wall – basic details. CM 4/7/13

Universal column dimensions. Used for horizontal and vertical framework

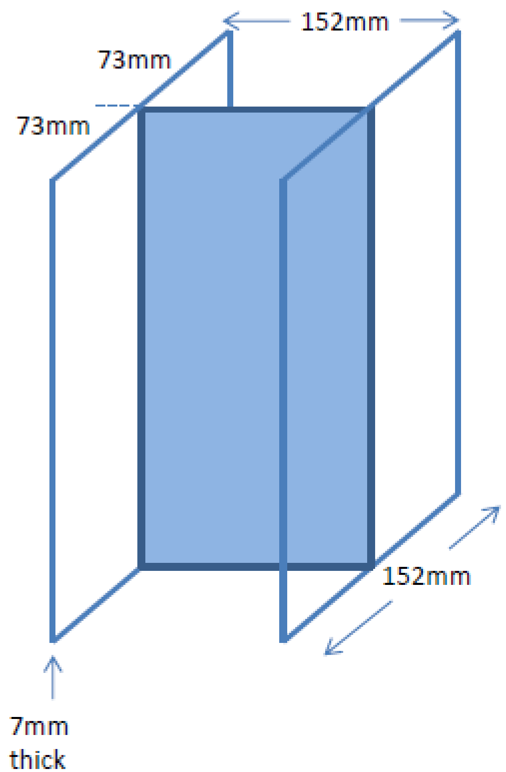
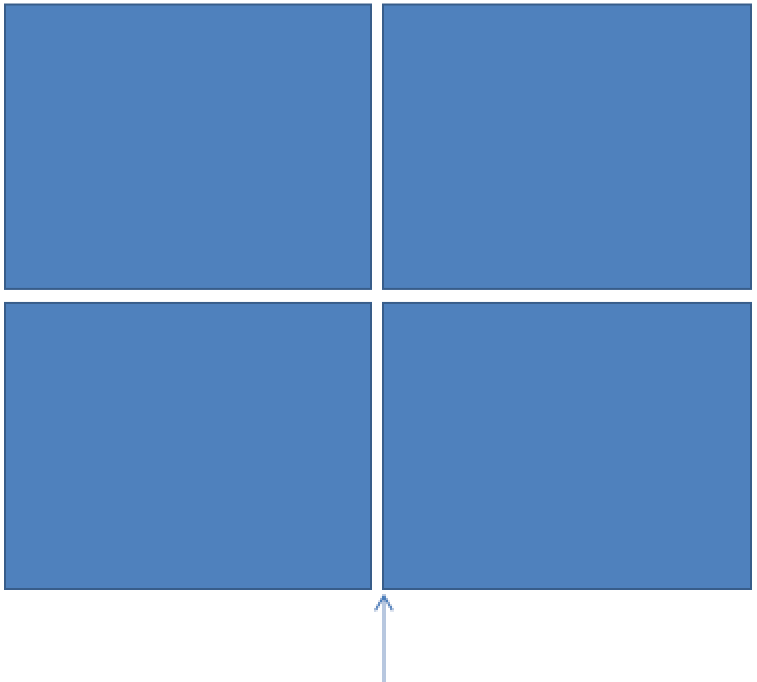


Plate dimensions average 140cm wide x 125cm high x 35mm thick



Gaps vary from 5 to 21mm. 8mm average

I've assumed 7mm in my model to match the web thickness.

Comparing model 5 to the hall model:

1) The shield wall model (SWM) is quite different to the hall model, this was necessary to obtain a simple(r) model and to obtain the resolution and the model symmetry that was necessary to give us a tractable model.

2) The shield wall is much smaller in the SWM that it is in the hall model. (In principle we could run a bigger shield wall in the SWM though)

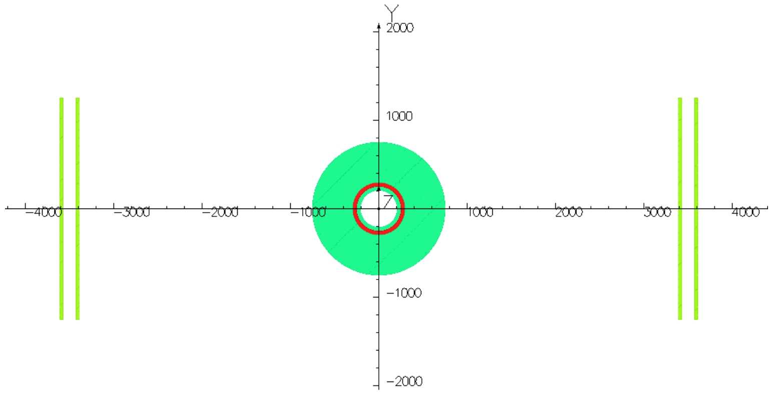
3) A symmetry is assumed in the SWM that does not exist in the hall model.

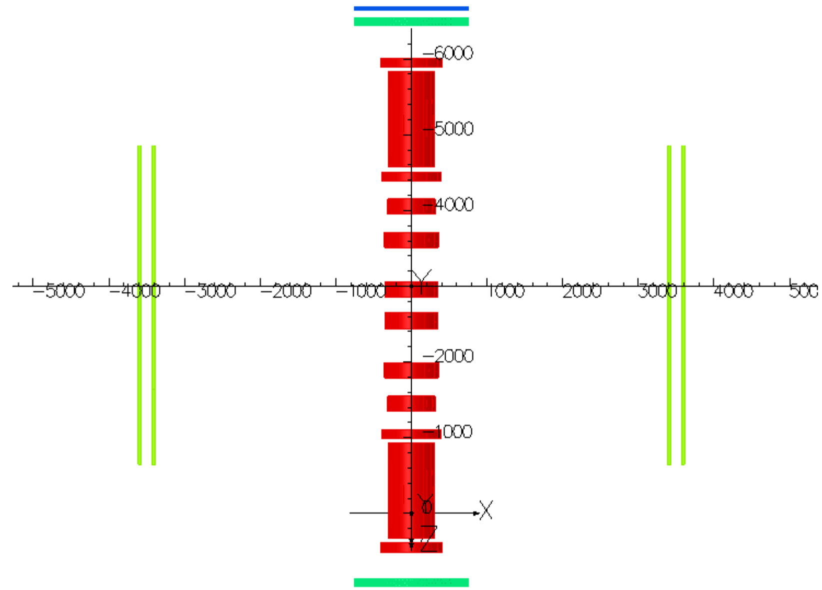
4) The SWM is run with Step IV magnets solenoid 240Mev/C with Virostek plates and uTOF plate.

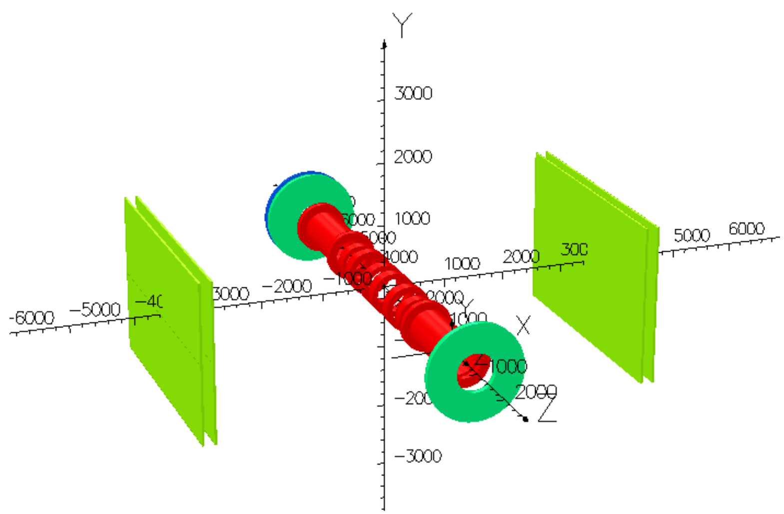
5) The distance between beamline centre and shield wall in the SWM is a similar distance as from the beamline centre to the SSW in the hall model. - 3500mm to centre of double wall in SWM – cp with 3505mm to outside of wall in Hall Model. This means that the wall is ~111mm closer in SWM – 3% difference. Note that NSW in Hall model is -4851mm from BL centre.

These differences may make direct comparison with the hall model difficult…

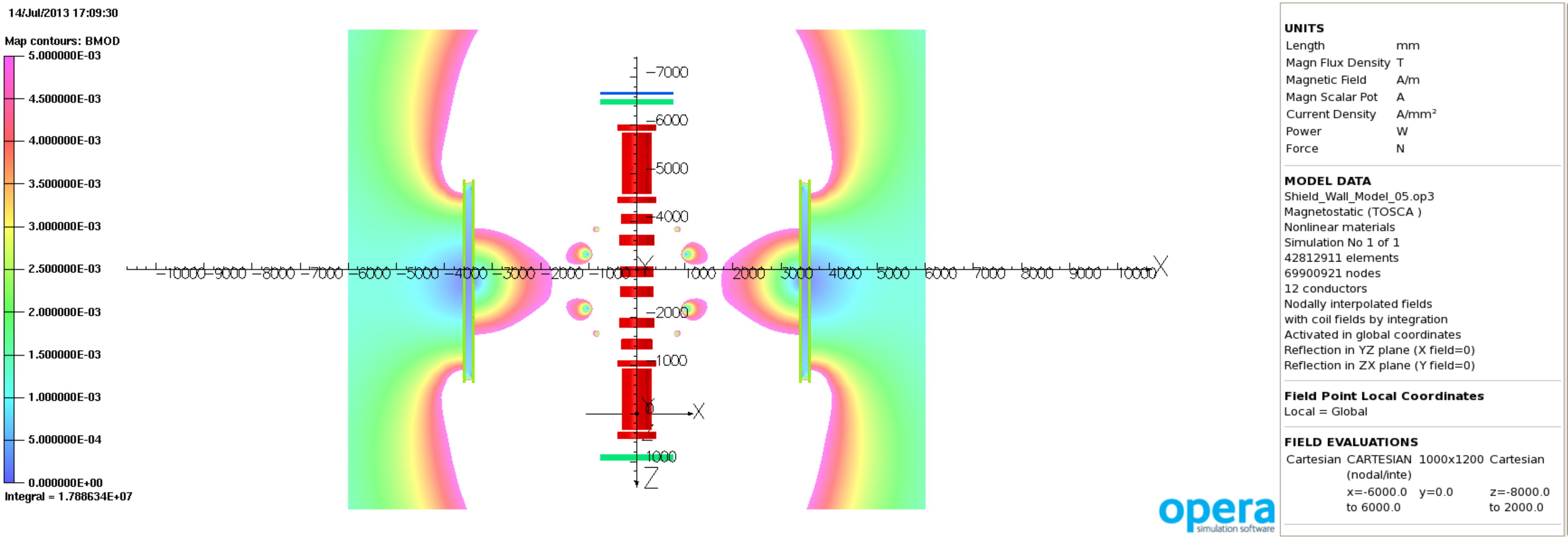
Overview of Model shots – Model 5 which has continuous walls without I beams but this model was solved at the same resolution as the other models.

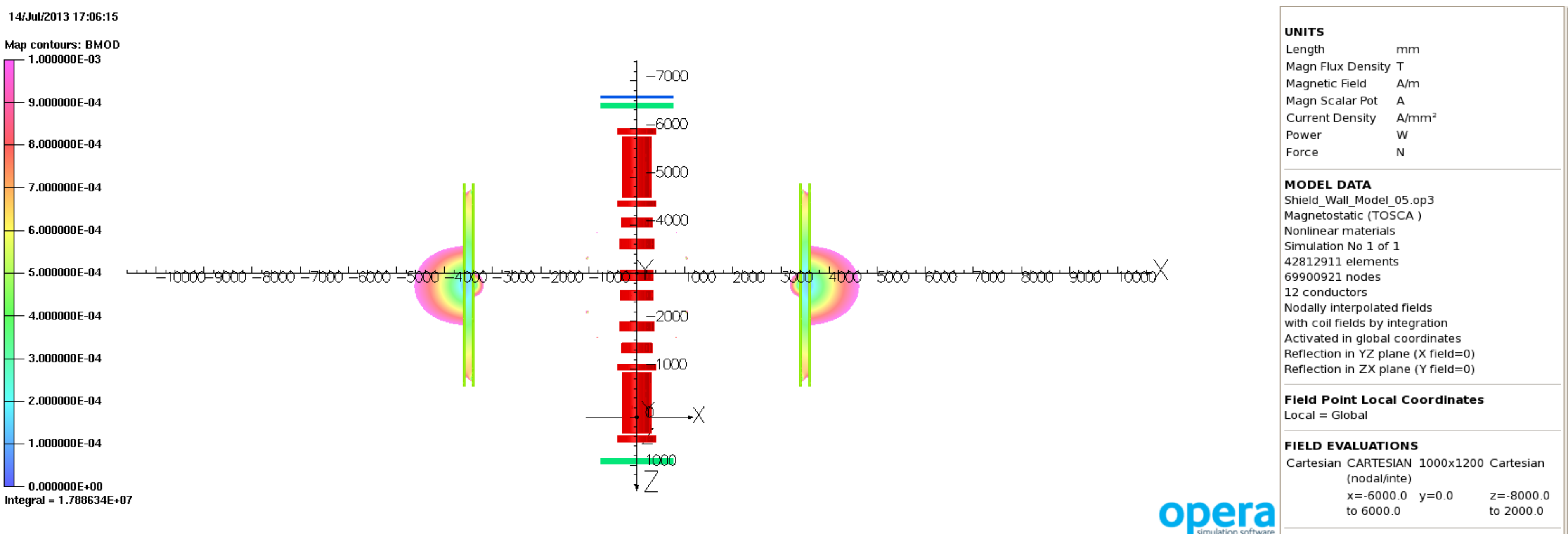




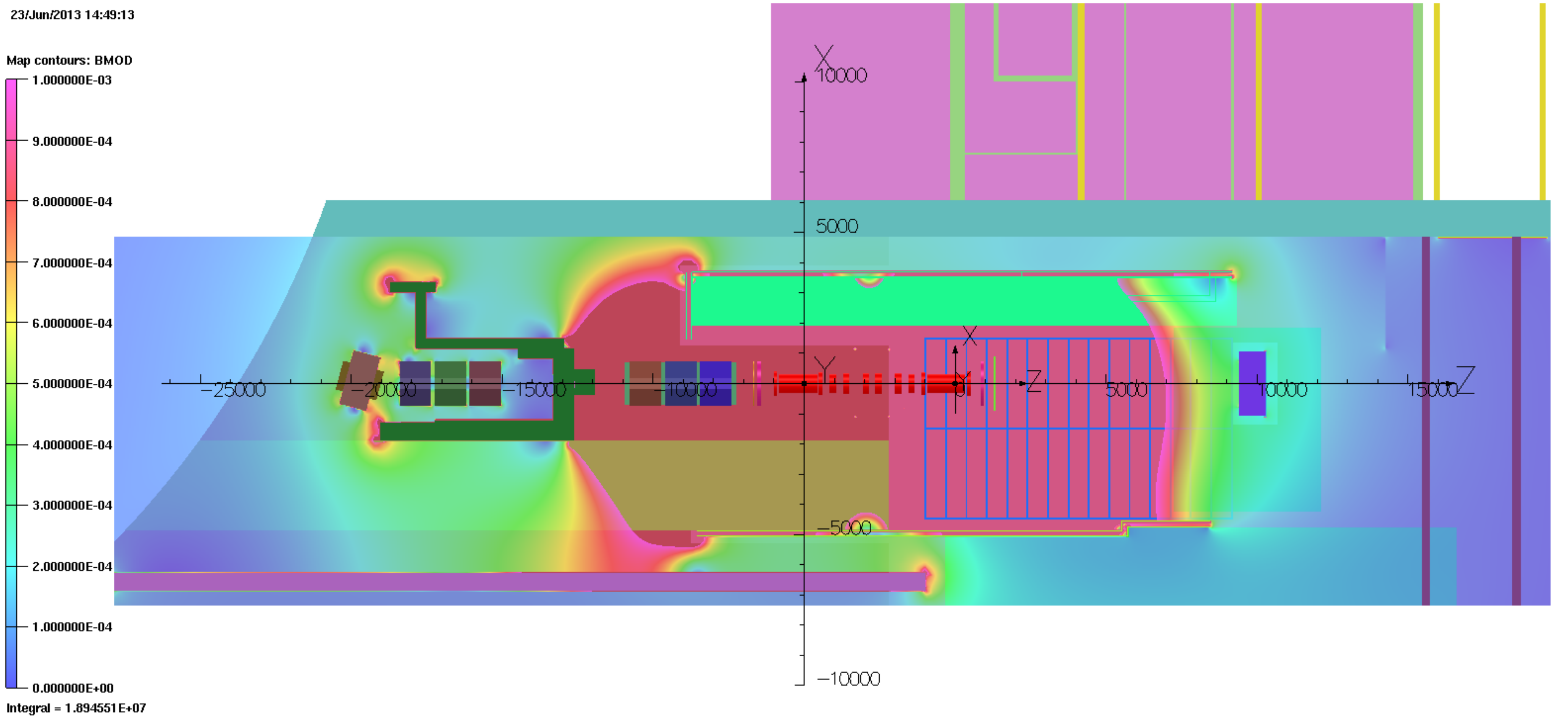


50 gauss and 10 gauss plots of Bmod at y=0. SWM 5 – continuous shield. Shielding effect is still readily apparent even in the shorter shield…





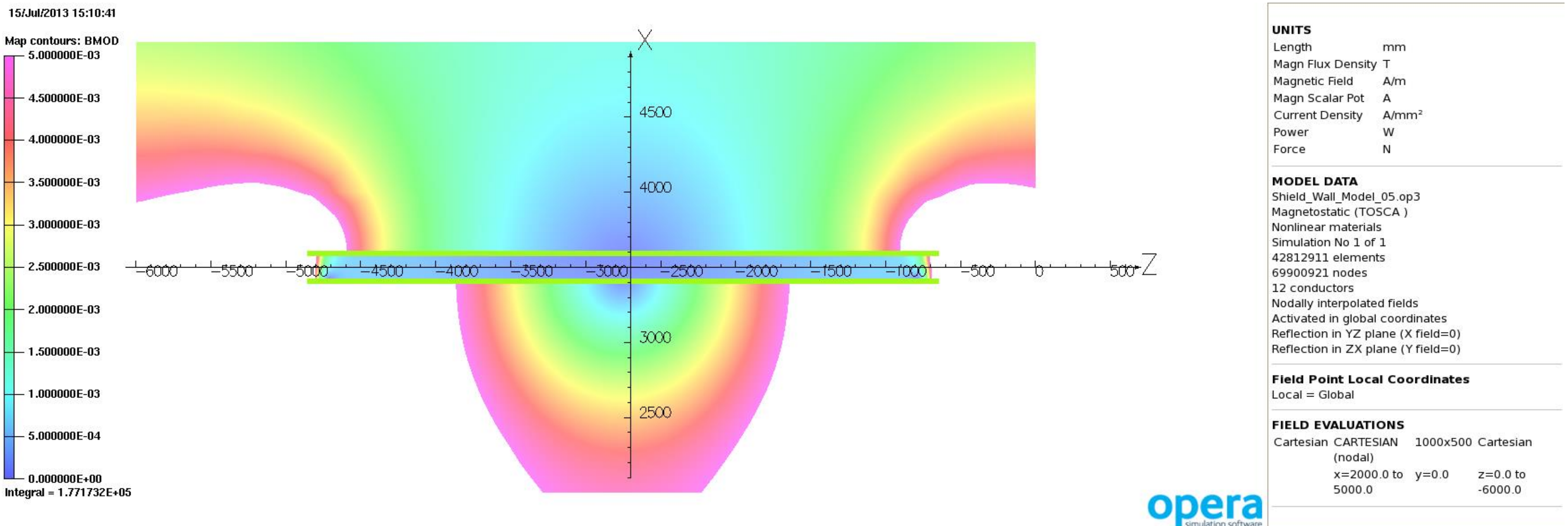
But not surprisingly they're quite different to the 10 gauss Bmod plot of the Field in the Hall Model @ y=0…

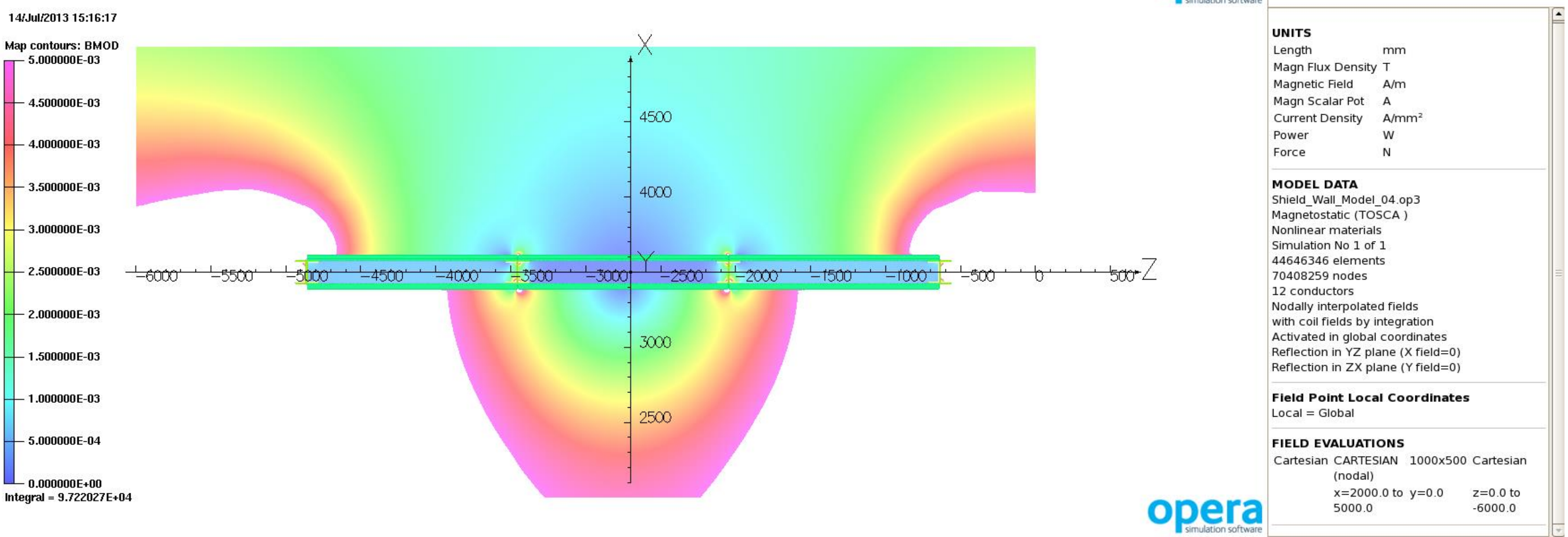


The NSW is further away from the beamline (-4851mm) than the SSW (3390mm) but one can see more 'leakage' behind the NSW. How much of this is due to the linac wall and how much is due to the lack of floor plates on the NSW I do not know.

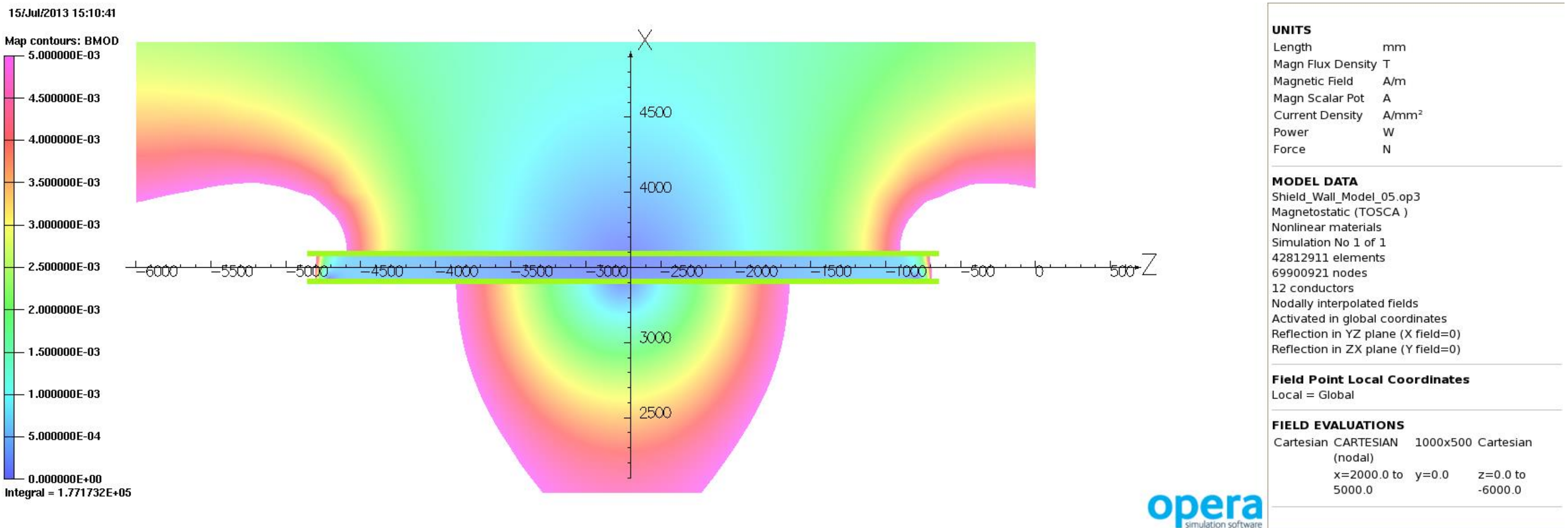
It's obvious that the models are not directly comparable…

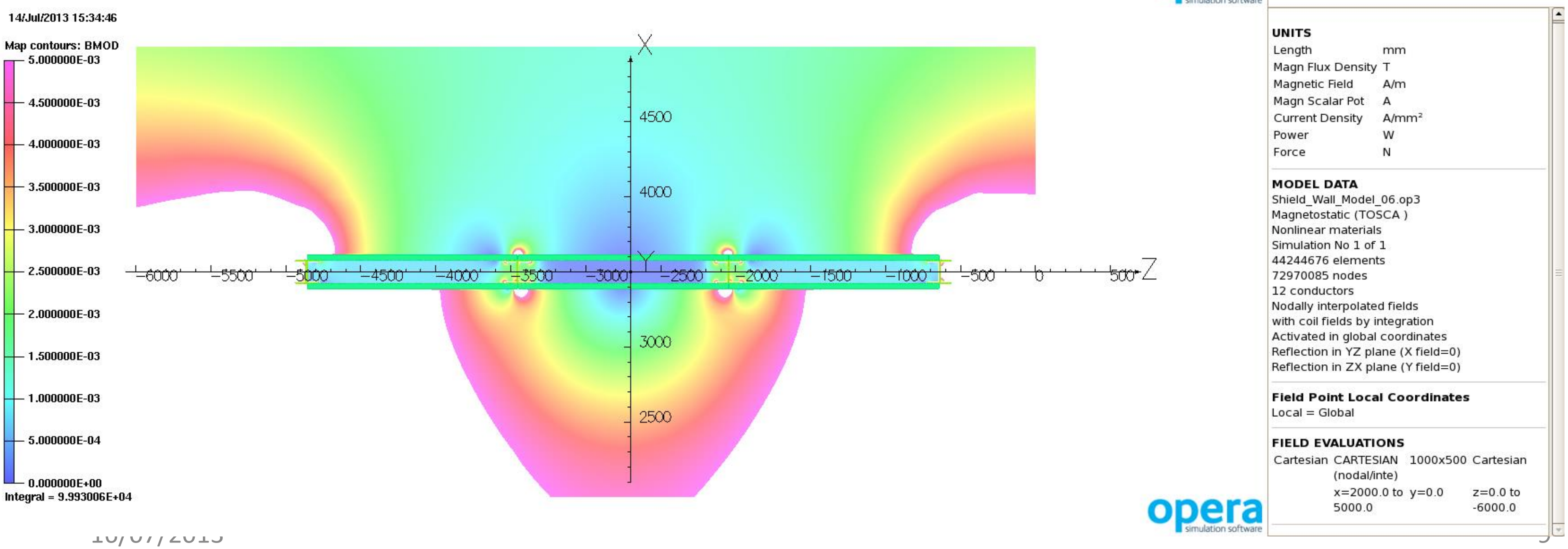
Field Plots SWM 5 vs SWM 4 @ y=0



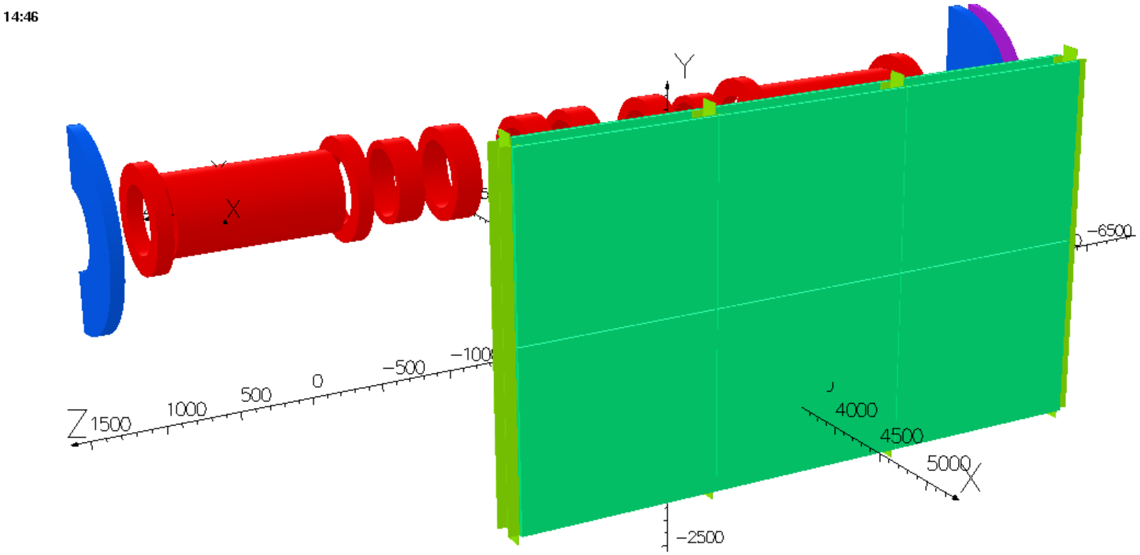


Field Plots SWM 5 vs SWM 6 @ y=0



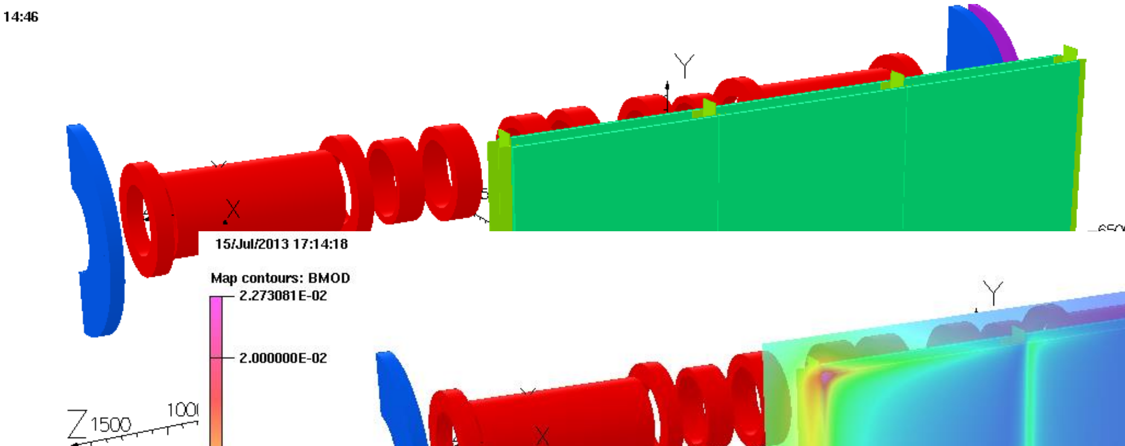


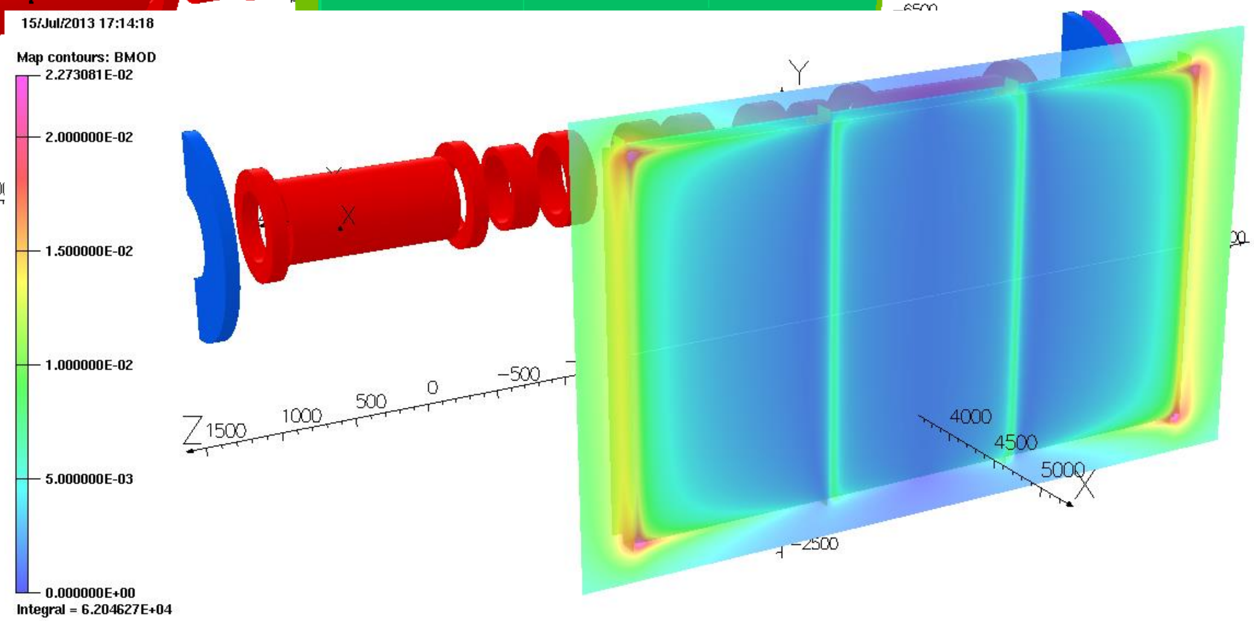
Field Plots Model 5 vs Model 6



Field Plots Model 5 vs Model 6

Vertical gap features readily apparent but no noticeable horizontal gap features (The very thin line is an artefact of the physical plate gap showing through the translucent plot)

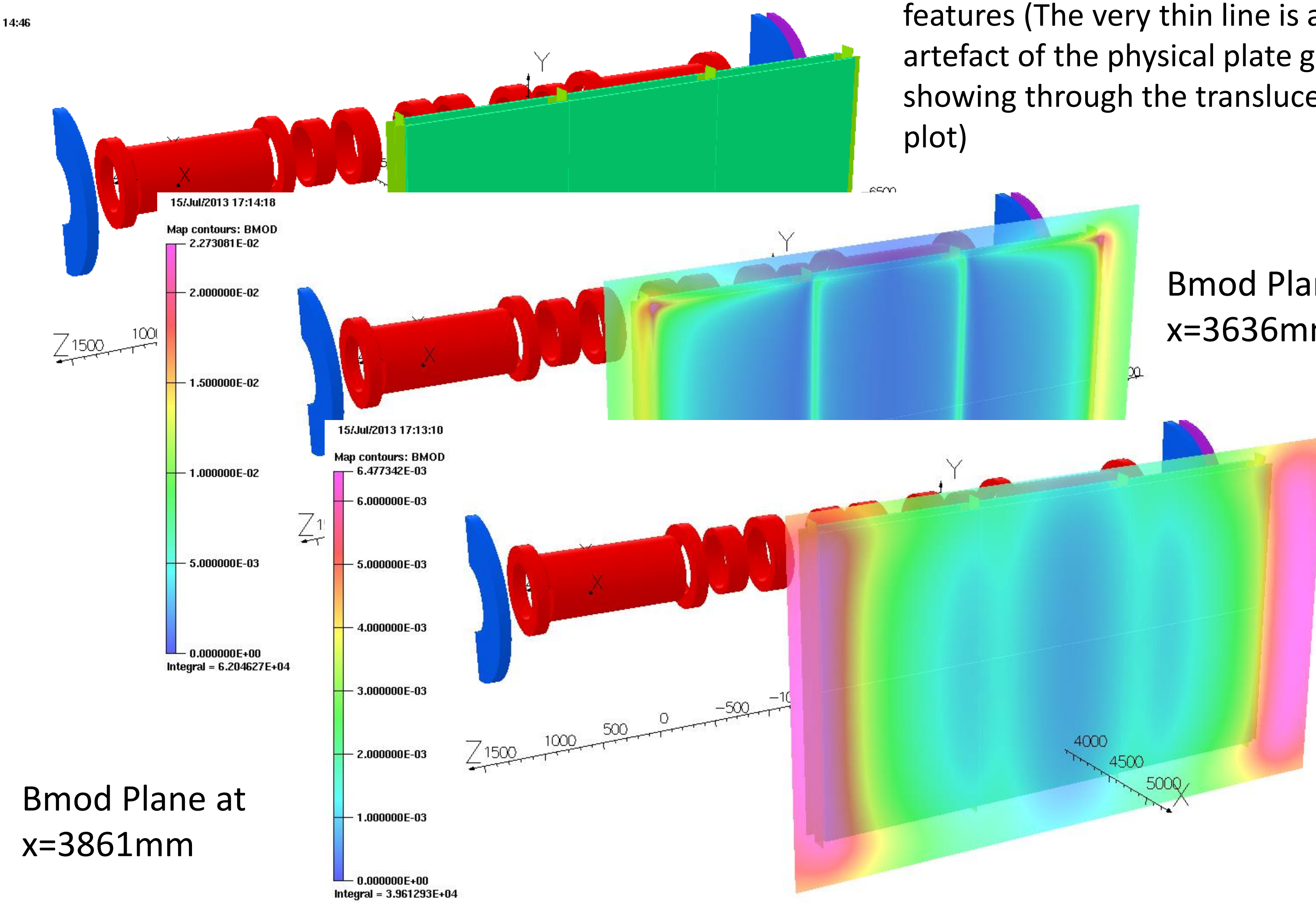




Bmod Plane at x=3636mm

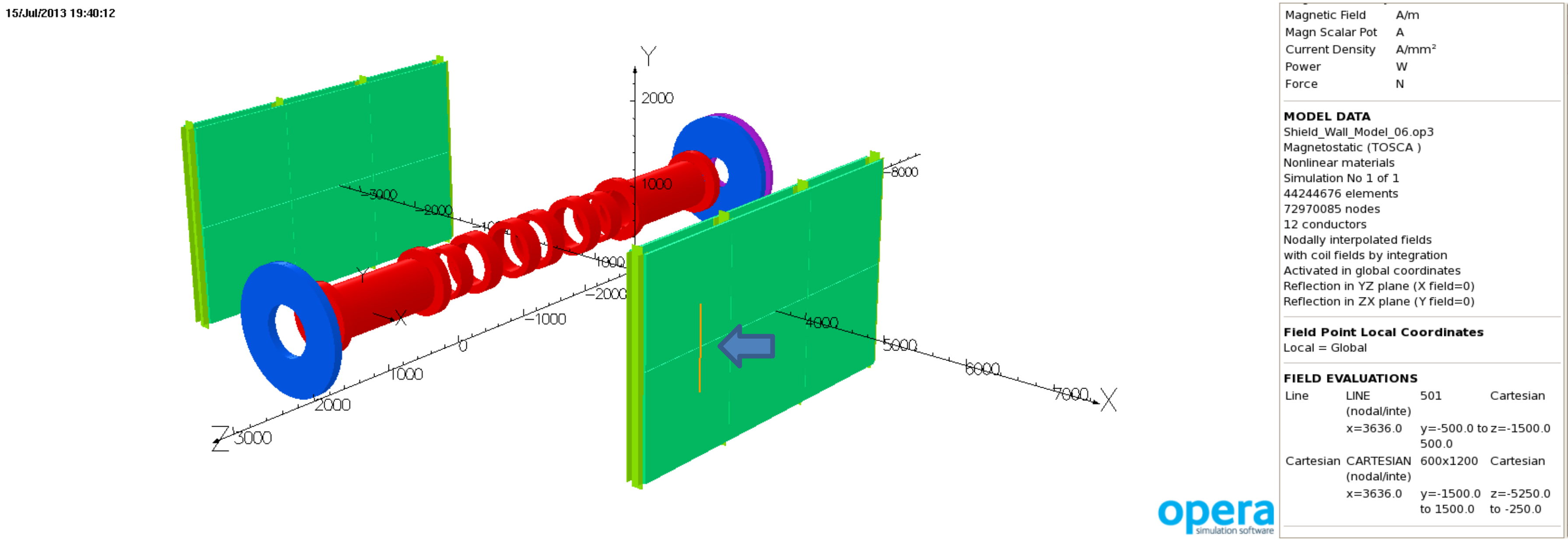
Field Plots Model 5 vs Model 6

Vertical gap features readily apparent but no noticeable horizontal gap features (The very thin line is an artefact of the physical plate gap showing through the translucent plot)

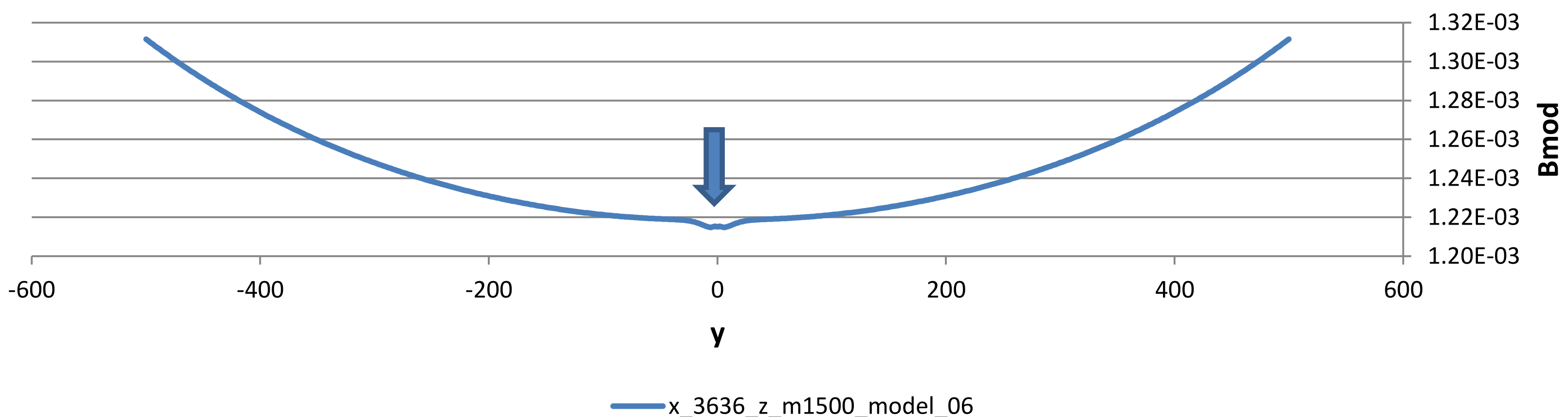


Bmod Plane at x=3636mm

Bmod Plane at x=3861mm



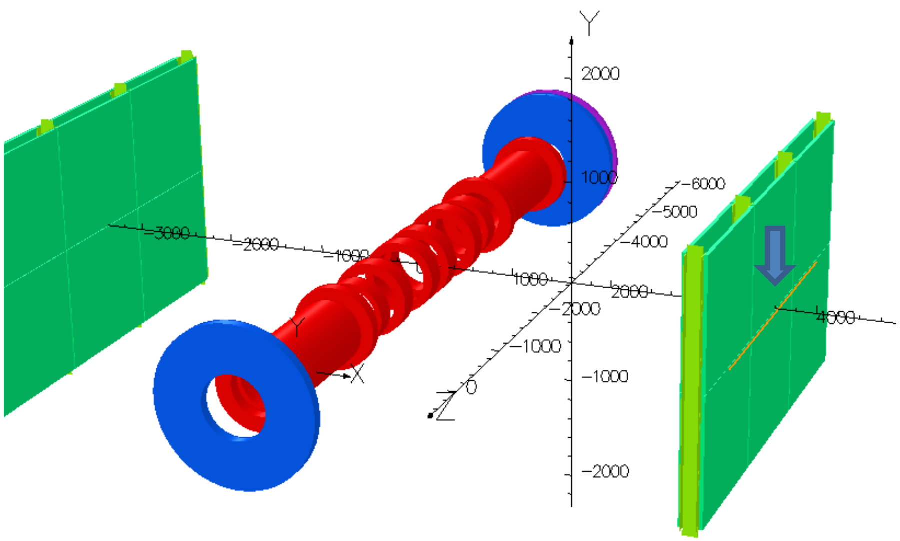
Comparison Plots of Field Behind Modelled Shield Wall at x=3636mm z=-1500mm



There is a small effect as you cross the horizontal gap – note scale on the right

Now trying to be a bit more quantitative… Comparing model 5 (baseline) with model 4 (best case) and model 6 (worst case)

I've produced line plots of Bmod along 4 lines. I've fixed the x distance at 3636mm and 3861mm from the beamline centre at y=0mm and y=1000mm running in the z direction +/-1500mm from the centre of the beamline.



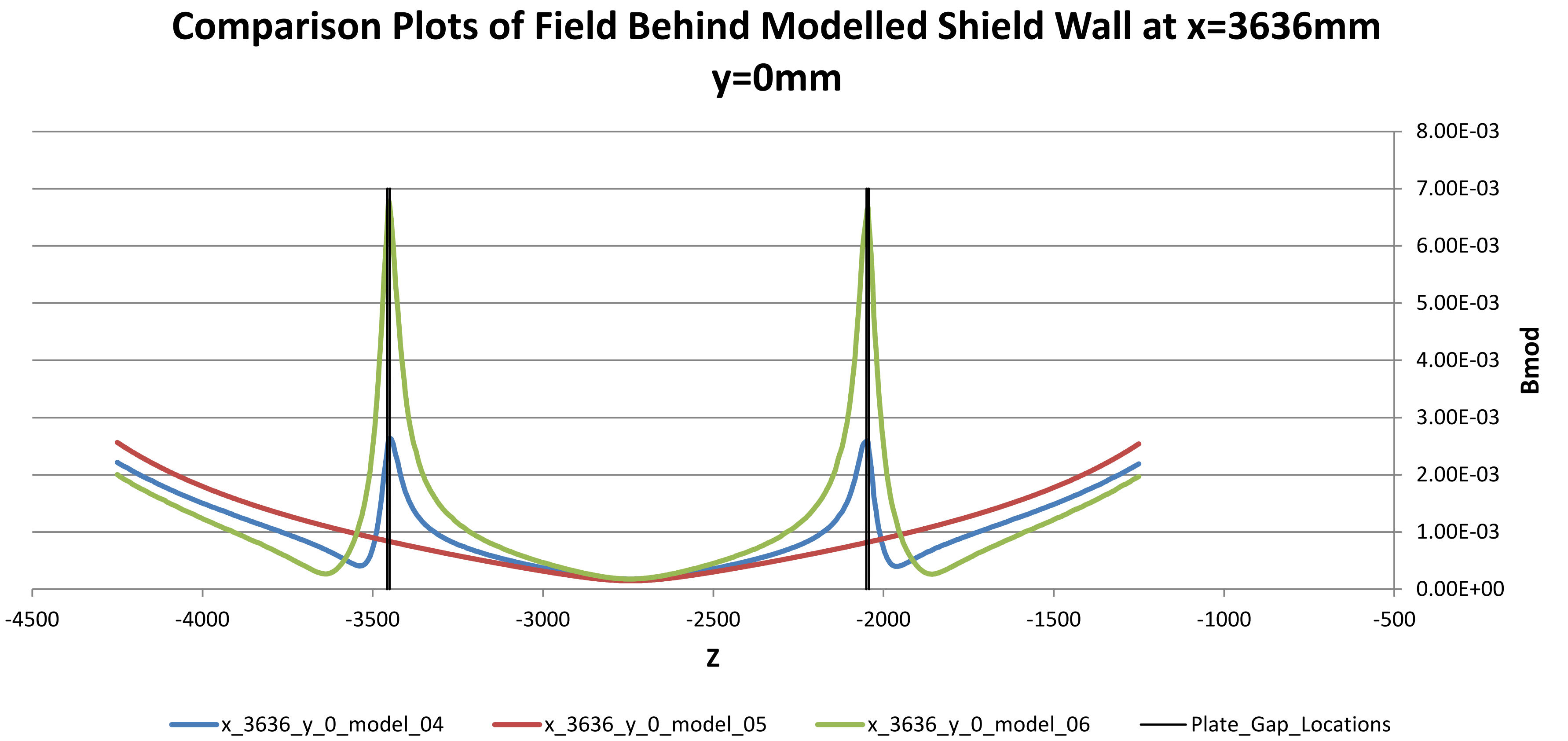
Line at x= 3636mm, y=0mm, z=-1250 to -4250mm

Also lines sampled at:
x= 3636mm, y=1000mm,
x =3861mm y =0mm, y=1000mm

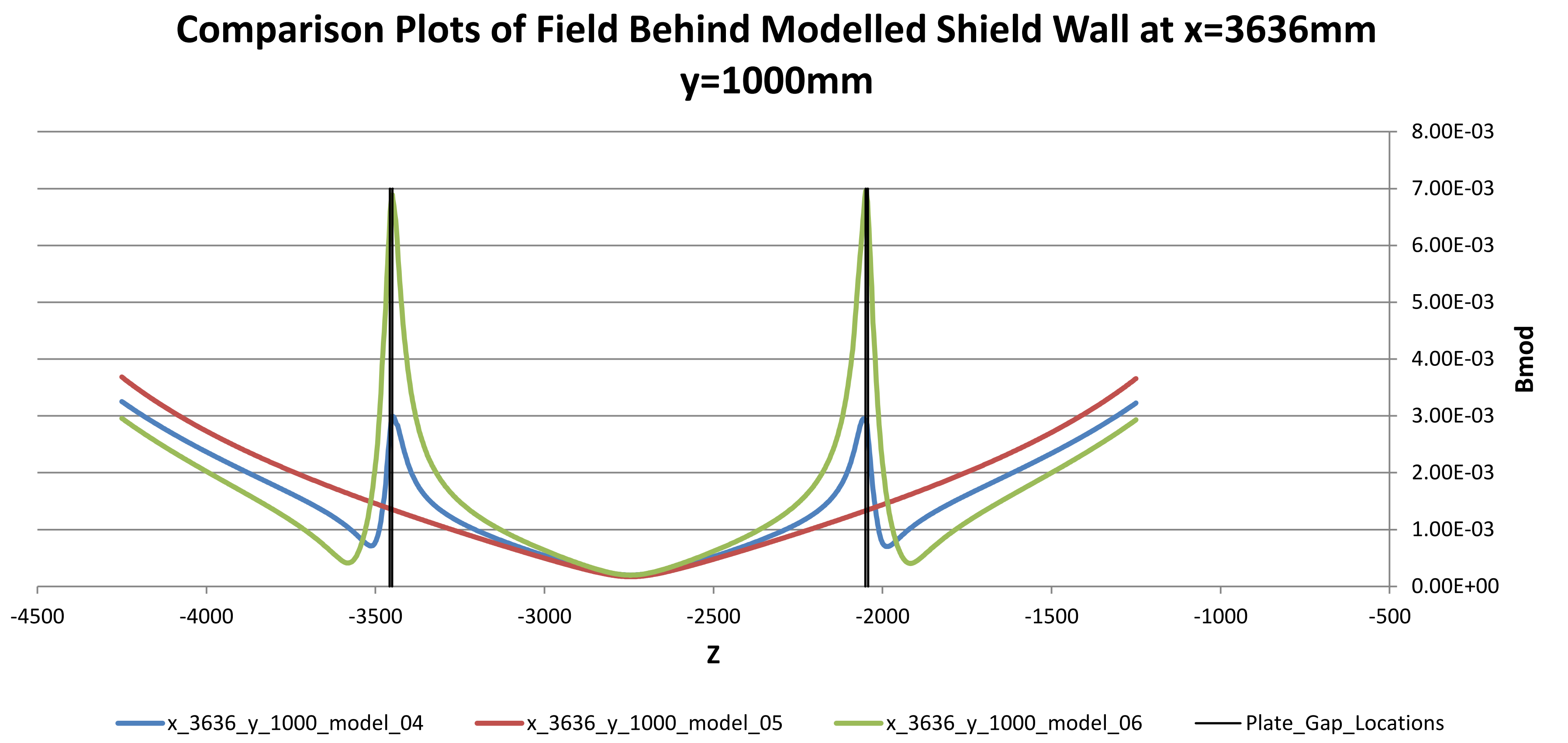
Nominally the fixed x distance puts these lines 25mm or 250mm behind the plates when the plates are attached to the I beams and 23.5mm/248.5mm behind the plates when there is a plate gap of 1.5mm.

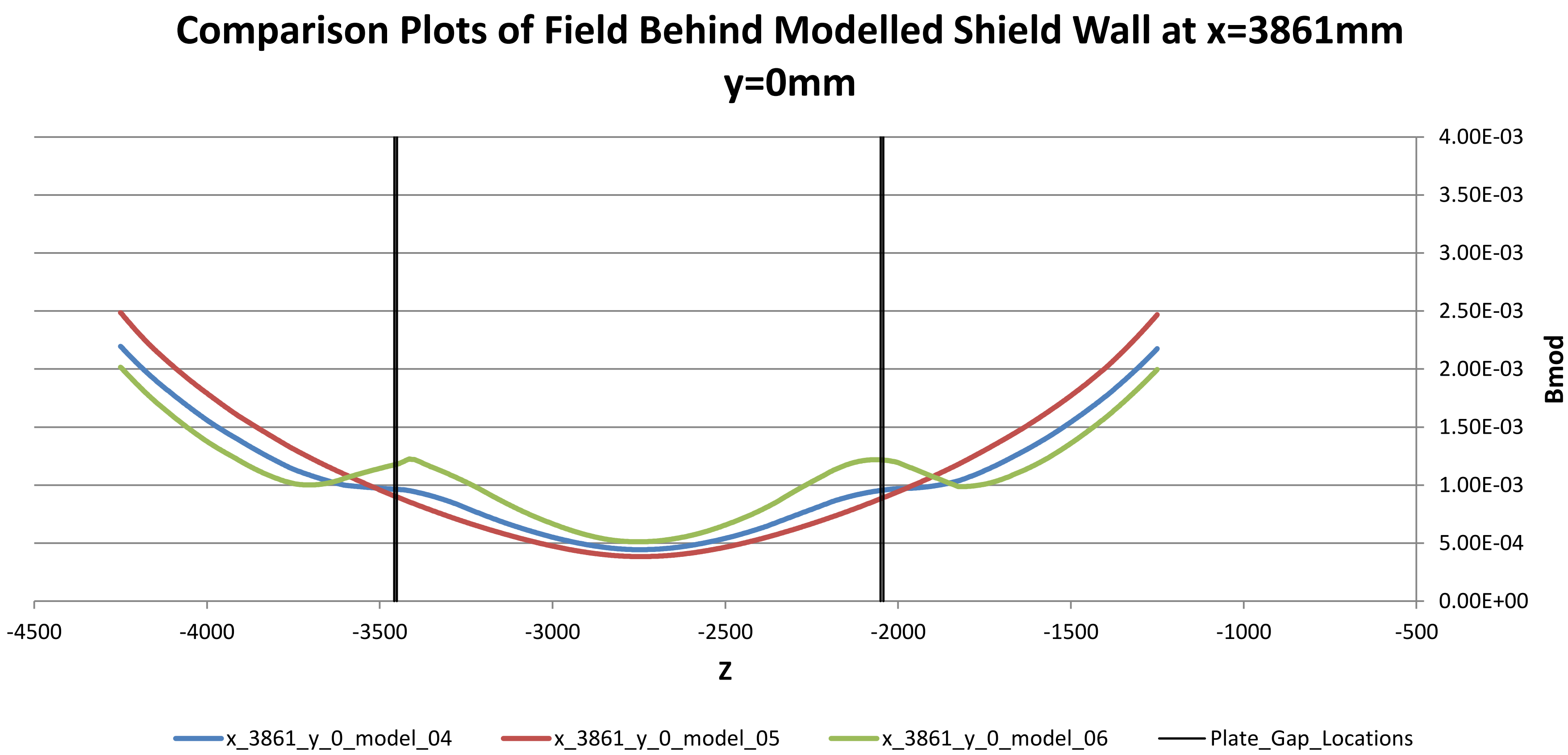
Normally you would want to integrate along these lines, but the sheer number of elements in this model means that even along a simple line this method would have taken too long to get answers out for today - so I've done nodal + field integration.

Note that the y = 0 line corresponds to the location of a horizontal gap in the plates in models 4 and 6



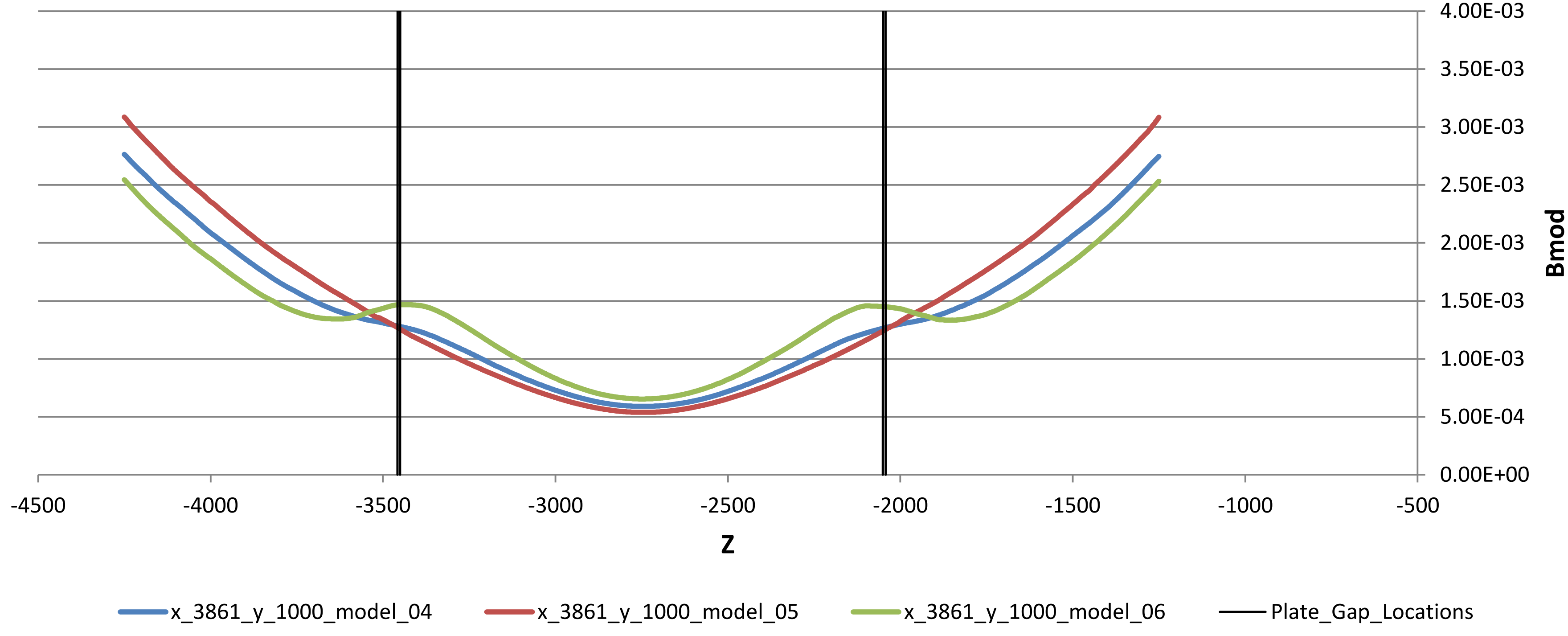
Brown line is baseline (continuous shield)
One would like to hope that reality lies between the blue (best case) and the green line (worst case?)

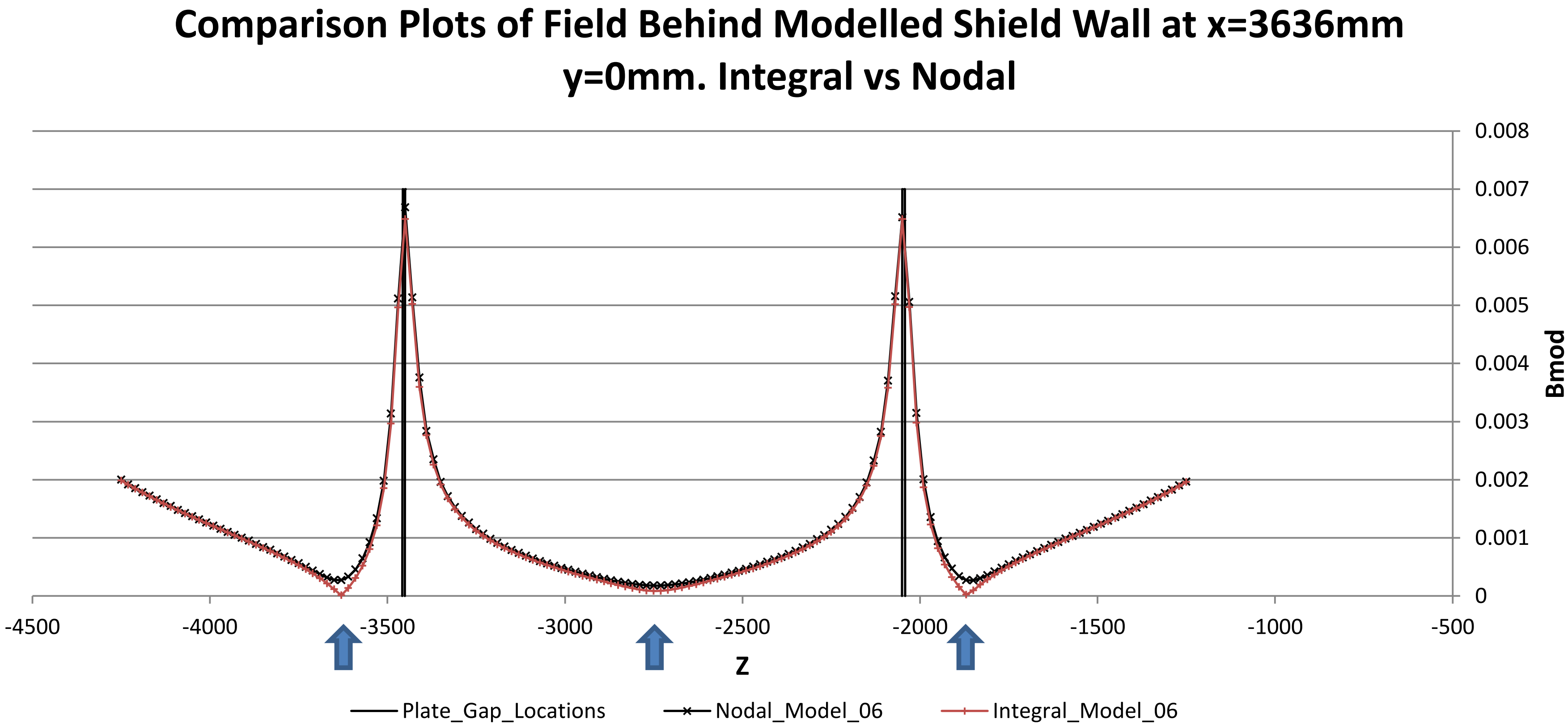

Comparison Plots of Field Behind Modelled Shield Wall at x=3636mm y=1000mm
8.00E-03
7.00E-03
6.00E-03
5.00E-03
4.00E-03
3.00E-03
2.00E-03
1.00E-03
0.00E+00
Bmod
-4500
-4000
-3500
-3000
-2500
-2000
-1500
-1000
-500
Z
x_3636_y_1000_model_04
x_3636_y_1000_model_05
x_3636_y_1000_model_06
Plate_Gap_Locations



Comparison Plots of Field Behind Modelled Shield Wall at x=3861mm y=0mm
4.00E-03
3.50E-03
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
Bmod
-4500
-4000
-3500
-3000
-2500
-2000
-1500
-1000
-500
Z
x_3861_y_0_model_04
x_3861_y_0_model_05
x_3861_y_0_model_06
Plate_Gap_Locations

Comparison Plots of Field Behind Modelled Shield Wall at x=3861mm y=1000mm





Comparison of nodal vs integral method on a single line plot – model 06, y=0, x=3636. 150 points.

There is some difference between the plots in places.

Conclusions

The field behind the central plates increases when the I beams and gaps are introduced into the model. The field behind the plates on the outside of the shield wall reduces. How this effect extends for longer shield walls is unknown.

It is hard to know how this result translates to the Hall model because of the relatively small size of the shield wall in the SWM. The SWM results are not directly comparable with the Hall models but it COULD be indicative that the hall model MAY be underestimating & overestimating the field behind the shield walls.

In the SWM there is measurable leakage of flux behind the shield wall at the location of the vertical gaps in the plates. This increases the flux density in those areas, particularly close to the shield wall.

Comments

Ideally I would like to run a set of models with an extended shield, one that is closer in size to the real shield wall (5 x 2 panels minimum) but if I have enough RAM (doubtful) it would tie my computer up for a significant period of time. I would be unable to do any other analysis using OPERA during these runs. On this basis probably not a great idea unless there is good reason to take this further?

Is there anything else that anyone would like looking at in these solution files?

Critical question: What is going behind the shield walls and where?

Addendum

VF released their reports last night and in one of their reports they too had run a sub-model of the shield wall. There are some significant differences between the structure of our models due to variations in geometry. Their geometry is incorrect as they took an educated guess at what the geomety is. Additionally their shield wall was only single skinned. They were more rigorous in checking the sub-model than I have been and the process for this is interesting.

I would recommend reading the full report but here are a couple of snippets from the conclusions:

Recommendation 5 for MICE Hall model: If substructure modelling of shielding walls is undertaken, the discretization of the wall and supports only needs to be at a reasonable level to capture the geometry. A fine mesh is not needed to capture variations in flux density as these will be small.

I take some issue with this as their approximations in the geometry were way off. For a realistic representation of the geometry a fine mesh was needed so as not to get any meshing errors. I could simplify the model geometry but unless you are VERY confident that this will not change the results does that not defeat the purpose? I want to query this.

However…

Recommendation 7 for MICE Hall model: Simplified models of the shielding walls in the model should be adequate to determine if the flux density is low enough for equipment to be mounted behind them, unless the sensitive equipment is very close to discontinuities in the wall occurring because it is constructed from a finite number of plates. Substructure modelling will not be beneficial.…

It seems that we have similar indications in our models which is encouraging.