MICE Hall Model
Status and Plans

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Introduction

Since last July I have spent some considerable time and effort building a magnetic model of the MICE Hall.

The structure of the hall model is now well advanced, and we are at a point where others and myself are also starting to do some sub-modelling. Sub-modelling is where we take regions or components of interest and model these to a higher resolution, but as we haven't done any sub-models of any areas that you are specifically interested in I won't cover this detail today.

I'll spend a few slides detailing the work that has been done on this model.

Introduction

There is a big caveat that must be borne in mind throughout the presentation…

The Hall model has yet to be benchmarked. We are in the process of negotiating to have the model independently benchmarked by 'Vector Fields'. This benchmarking process should help us to understand the limitations of our model, find out if there are any major faults in the model and suggest ways in which it can be improved.

Until we have the results of this benchmarking all results shown in this presentation must be considered both provisional and unverified, consider them as a guide based upon the current status of our models.

The 5 Gauss Limit

At what point do we become concerned about the level of field observed?

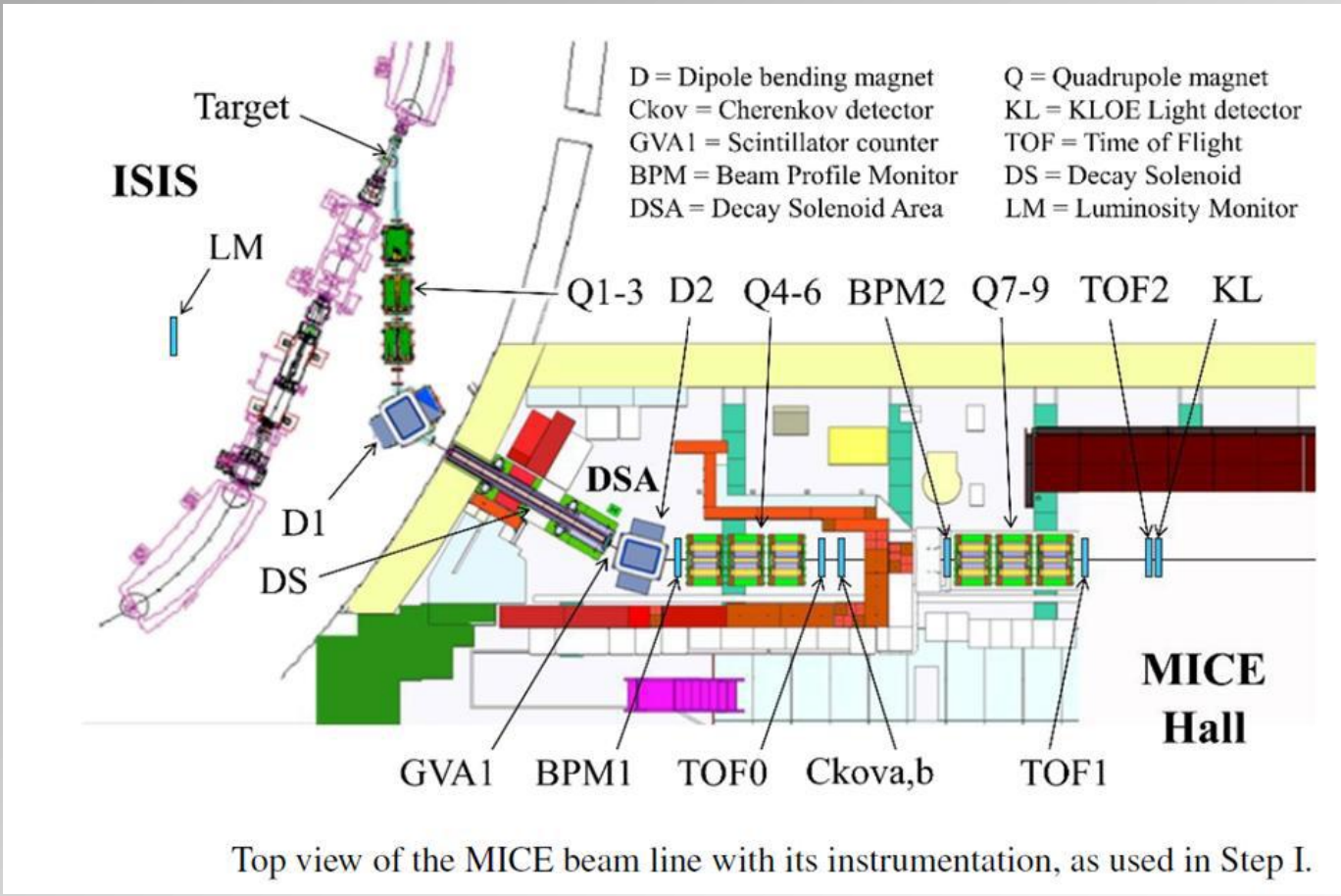
Of course the answer to this is location dependent but in general if the magnetic field strength Bmod is below 5 gauss (0.5 mT) in air, then unless we have specific reason to be concerned, we worry slightly less. This is a limit self-imposed by RAL & CERN by "Best Practise", due to the possibility that members of the public with Pace-Makers might be present in the ISIS & MICE Control Rooms.

One of the most common sensitive components are relays which start to become affected from ~>13 gauss* but of course there are other possibilities – hall probes, crts.

**Magnetic compatibility of standard components for electrical installations tests on programmable logical controllers and other electronic devices.- J. Hourtoule ⁎, D. van Houtte, P. Fejoz, P. Hertout - November 2005, Pages 179–183 - Proceedings of the 23rd Symposium of Fusion Technology — SOFT 23*

Clearly the level of field that will cause a problem is application/area specific and each location needs to considered individually.

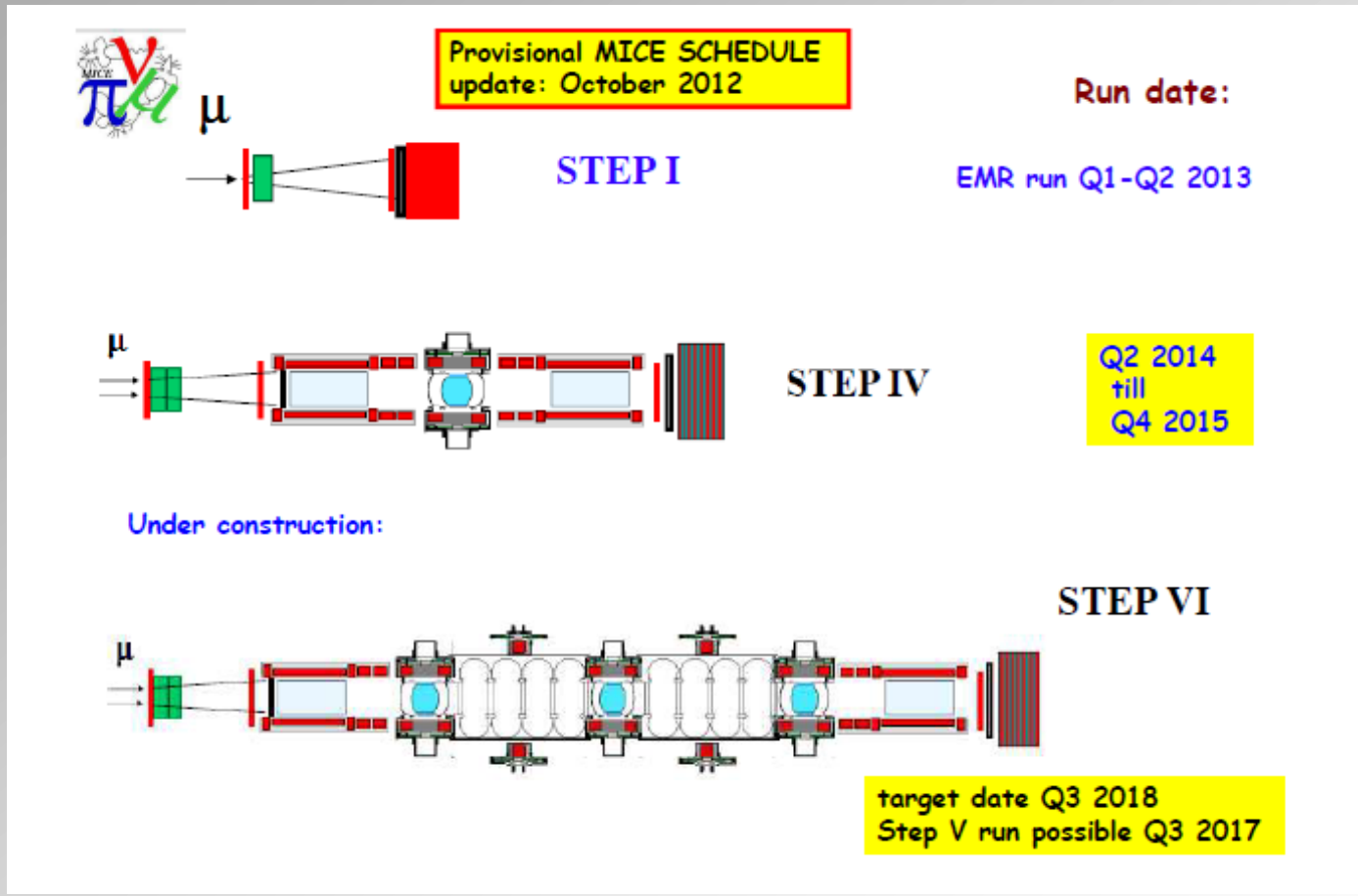
The MICE Hall Model - Beamline



Top view of the MICE beam line with its instrumentation, as used in Step I.

Clearly we have no concerns with any of the beam line that is currently installed. This includes the 4T decay solenoid (DS).

The MICE Hall Model – Cooling Channel



But the actual cooling channel itself is a potential source of stray field.

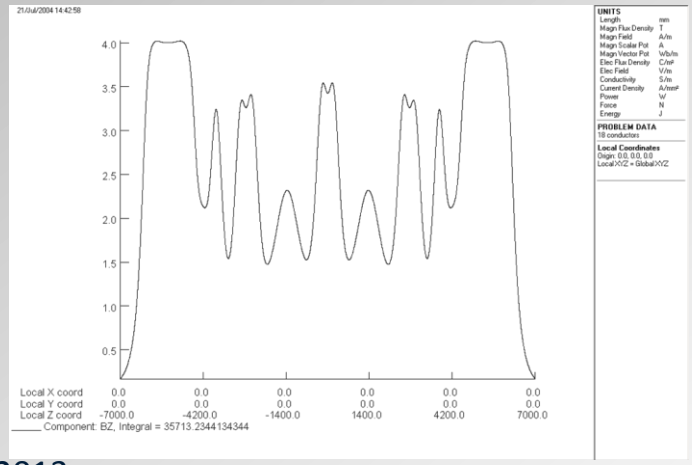
The MICE Hall Model – Cooling Channel

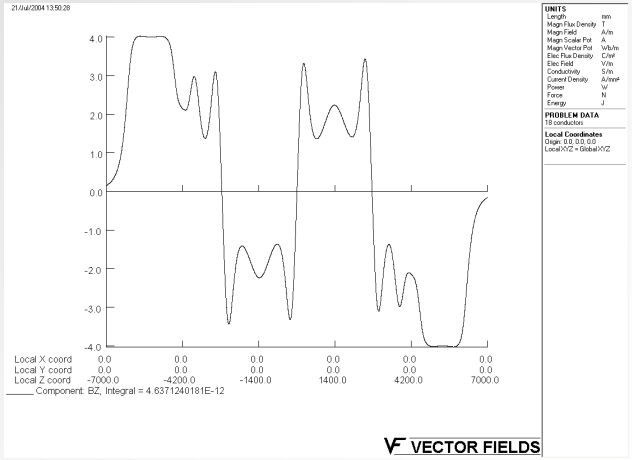
The MICE magnets will be run in two configurations, Solenoid and Flip Mode over a range of operating currents.

Solenoid mode permits stronger focusing which helps improve the accuracy of our measurements.

Flip mode is the mode that a real extended cooling channel would need to run in to in order to simultaneously reduce the rms divergence and size of the beam.

All the models are run with the magnets set for 240Mev/c muons; this represents the highest magnet operating currents.





Model Definitions

I am going to start talking about several different models. The geometry is the same in the models but the magnet setup is different. Our most current models are:

Model 51 - Step IV Solenoid - 240MeV/c - No return yoke.
Model 52 - Step IV Solenoid - 240MeV/c - With return yoke.
Model 53 - Step VI Solenoid - 240MeV/c - No return yoke.

Model 54 - Step IV Flip mode - 240MeV/c - No return yoke.
Model 55 - Step IV Flip mode - 240MeV/c - With return yoke.
Model 56 - Step VI Flip Mode - 240MeV/c - No return yoke.

The above models have a minor issue with the boundary conditions which means that there was a discrepancy between how the coil fields and magnetisation fields were treated at the boundary of the model. This was a small effect which left artefacts at the <1 gauss in the model. This has now been corrected and I'm currently in the process of re-running the models. The newer models seem to be predicting slightly lower fields (fraction of a gauss) than the older models.

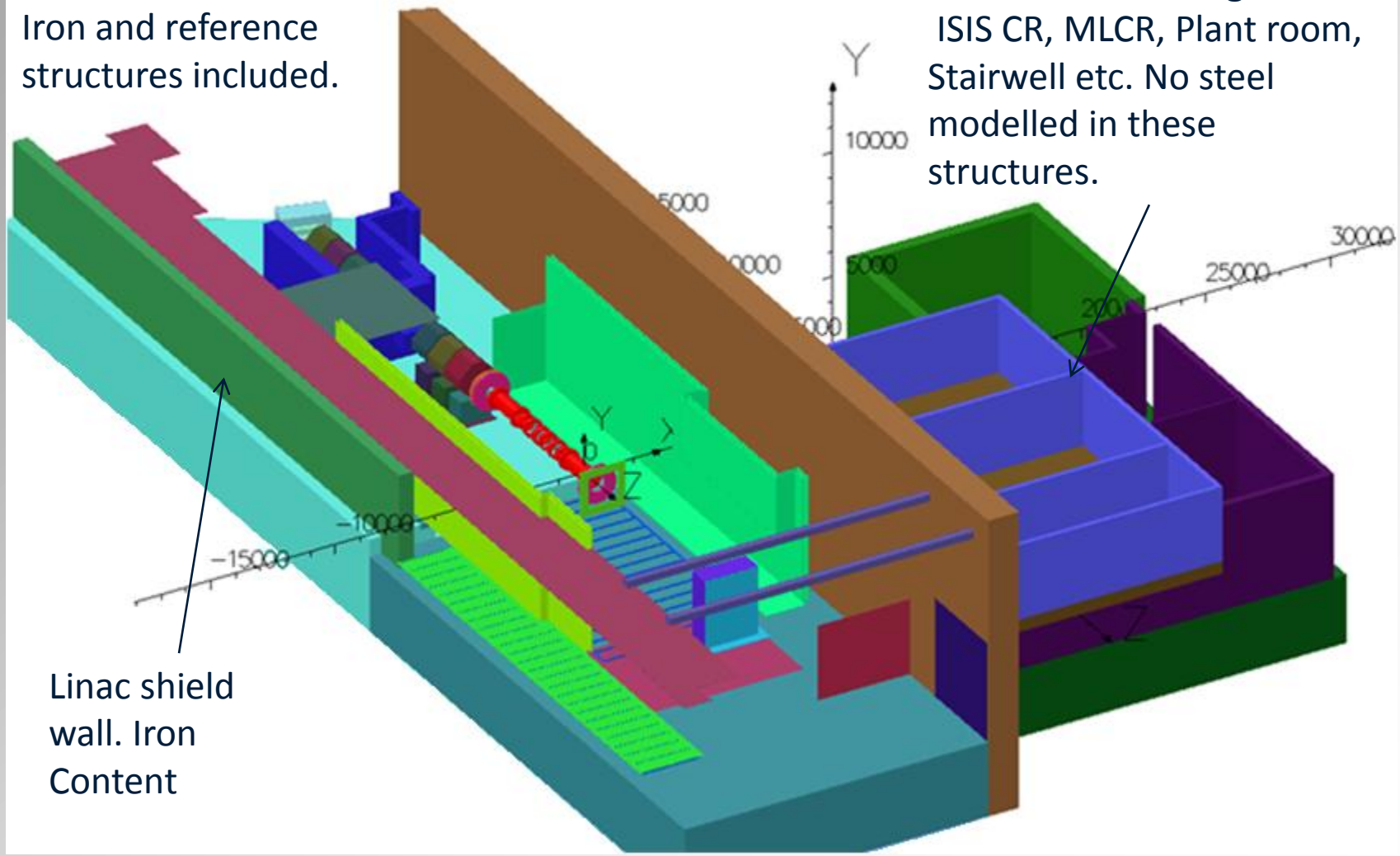
Model 61 - Step IV Solenoid - 240MeV/c - No return yoke
Model 63 - Step VI Solenoid - 240MeV/c - No return yoke

It is also now clear that the model boundary need to be moved out but this won't have a huge effect on the results, particularly in the CR areas.
I am only going to look at the step IV models that have no return yoke today.

So what is in the model? – Model 51

MICE Hall – Mixture of Iron and reference structures included.

South Side Buildings ISIS CR, MLCR, Plant room, Stairwell etc. No steel modelled in these structures.



Linac shield wall. Iron Content

List of ISIS concerns

David Findlay circulated a list yesterday of items that ISIS are concerned about.

Areas to consider for magnetic fields and people? MICE Local Control Room, ISIS Main Control Room (MCR), area outside MICE Hall main door, the new toilets beyond the MCR, offices and labs. near the MCR, the newly shielded EHT area, the linac, and anyone on the roofs of R5.2 and nearby roofs, ...

ISIS equipment possibly affected by magnetic fields? ISIS linac, equipment in the newly shielded EHT area, ISIS equipment in the MICE Hall (*e.g.* the DSA PPS interlocks, and the HEDS beam chopper driver), the linac air conditioning plant up on the roof of the MICE Hall, other ISIS equipment in the MICE Hall which we've forgotten about but which helps to keep ISIS going, ...

I'm not going to address all of these today, but I have taken this list on board. It's my suggestion that this list needs to considered in a report rather than in a presentation? – but we do need to benchmark the model first .

There is also the question of whether we need to add additional steel to the model so that r us to answer these questions?

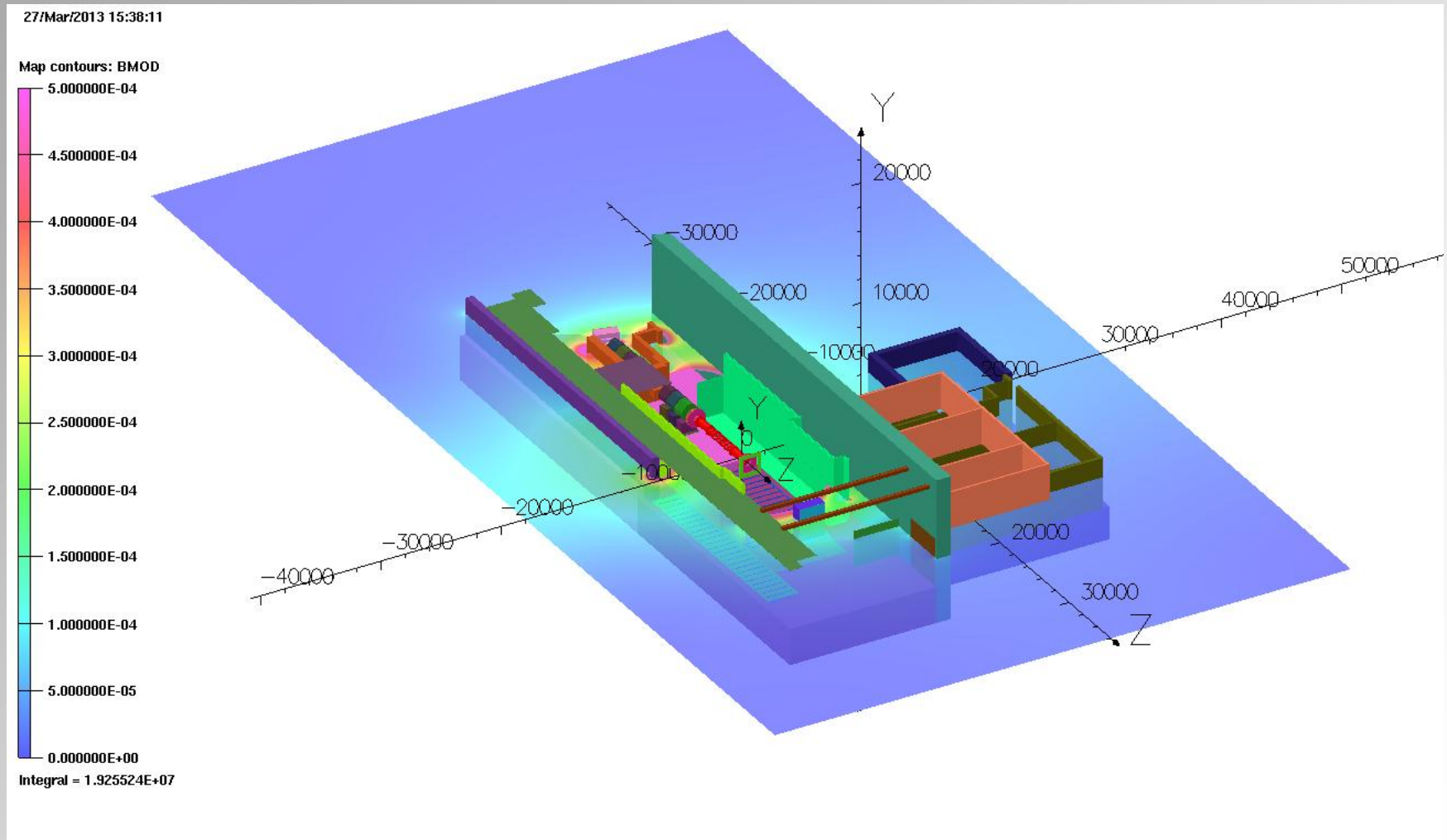
List of ISIS concerns

What I had planned to look at today are a few overview plots of the Hall and the surrounding area and the ISIS control rooms as these have been discussed previously.

We produce a lot of information that is available on line including a significant number of auto-generated images of each model, you can view these at your leisure but bear in mind the current model caveats.

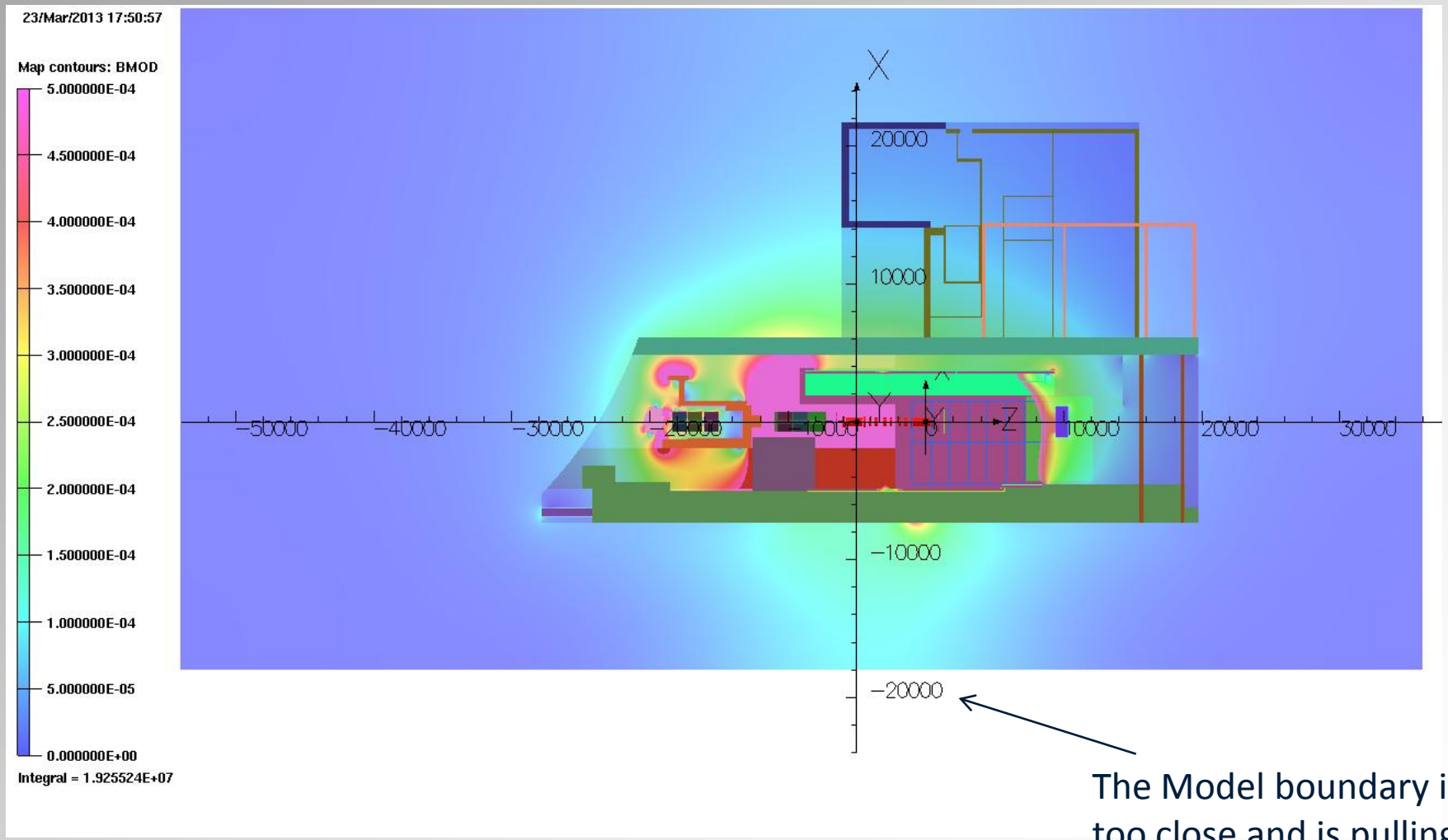
http://www.hep.shef.ac.uk/research/mice/opera_models/

Preliminary Results Hall Overview Step IV Solenoid 240 MeV/c



Model 61 - Step IV Solenoid 240MeV/c .
5 Gauss Scale. Beam Height (y=0)

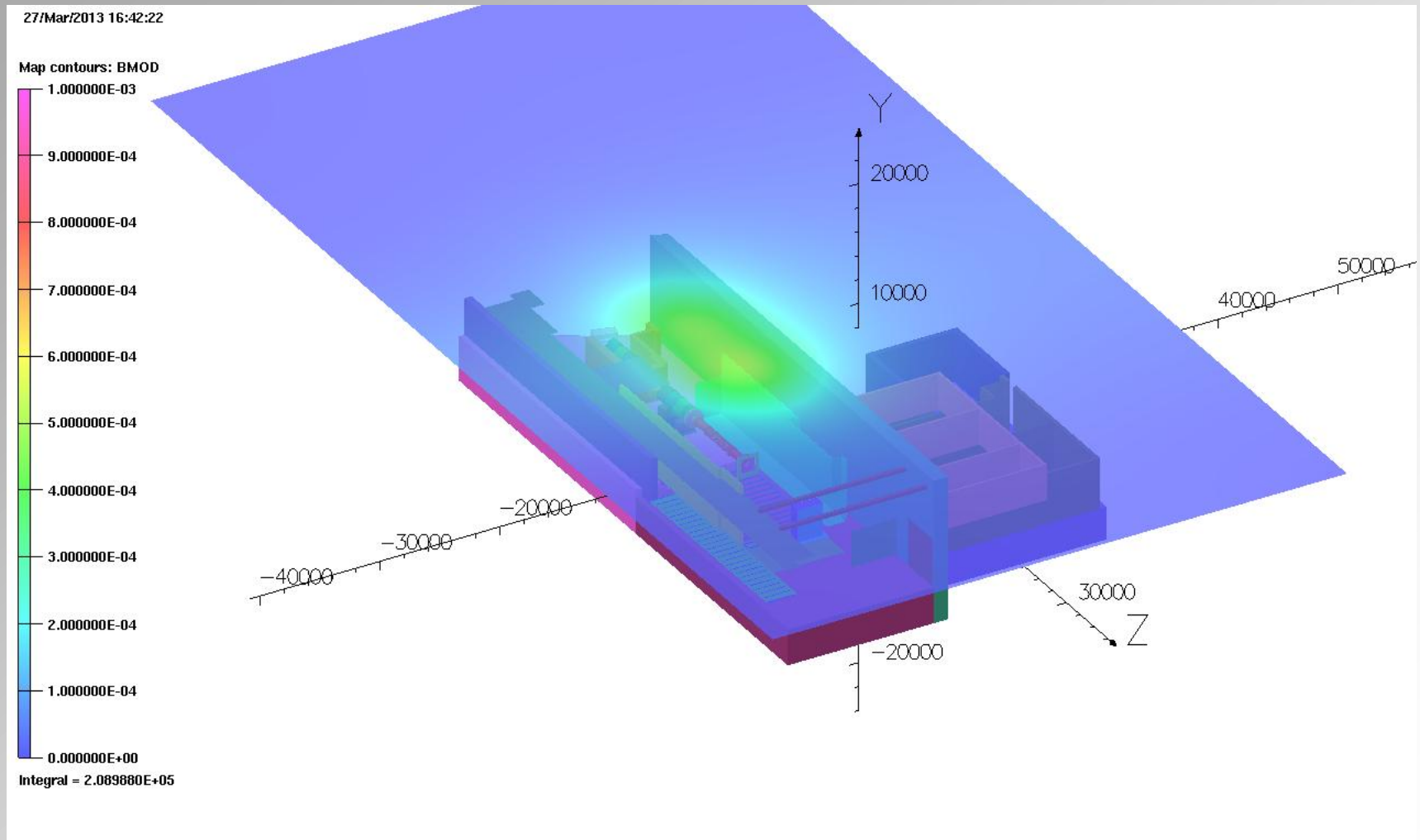
Preliminary Results Hall Overview Step IV Solenoid 240 MeV/c



The Model boundary is too close and is pulling the field slightly.

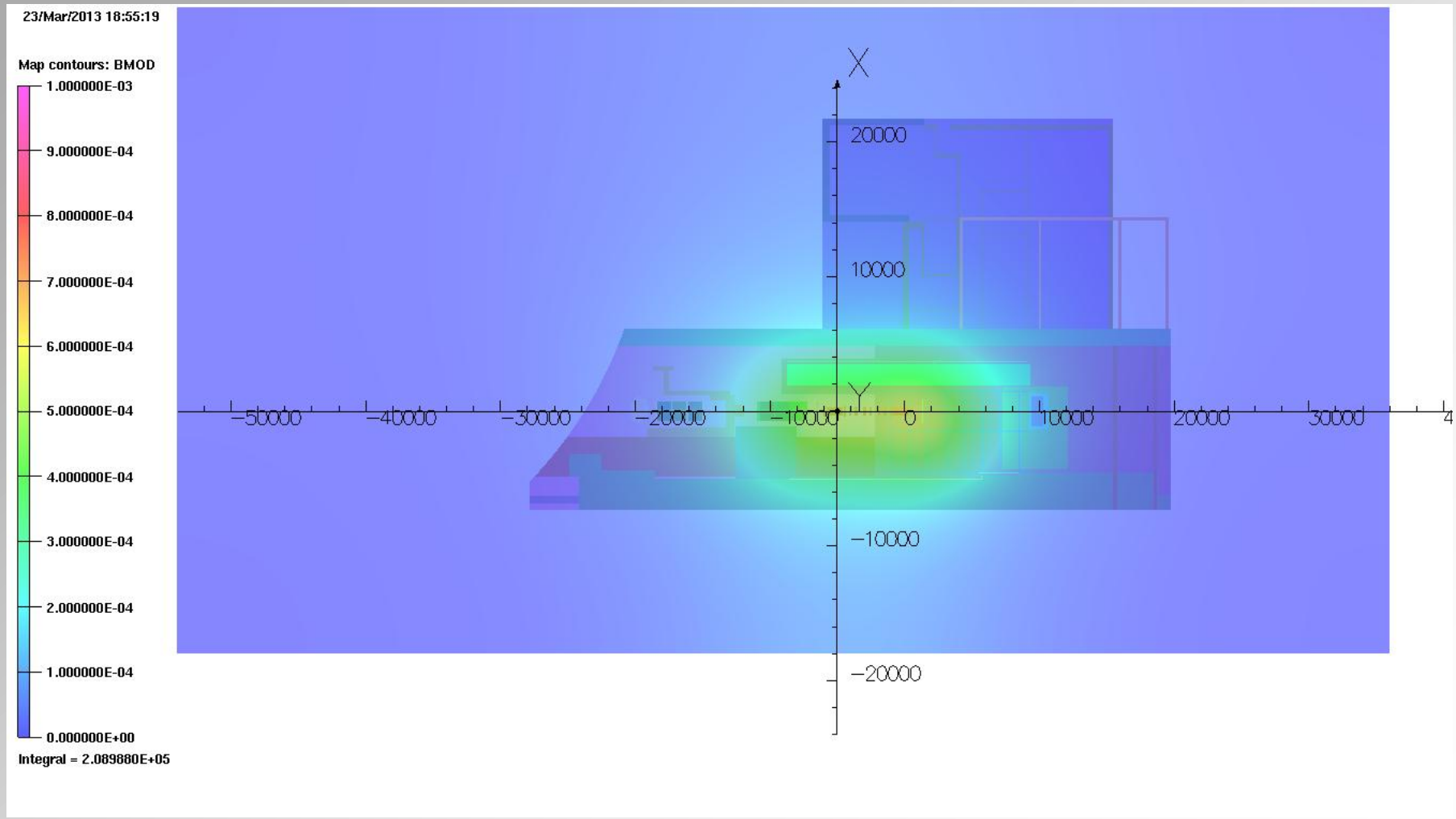
Model 61 - Step IV Solenoid 240MeV/c .
5 Gauss Scale. Beam Height (y=0)

Preliminary Results Hall Overview Step IV Solenoid 240 MeV/c

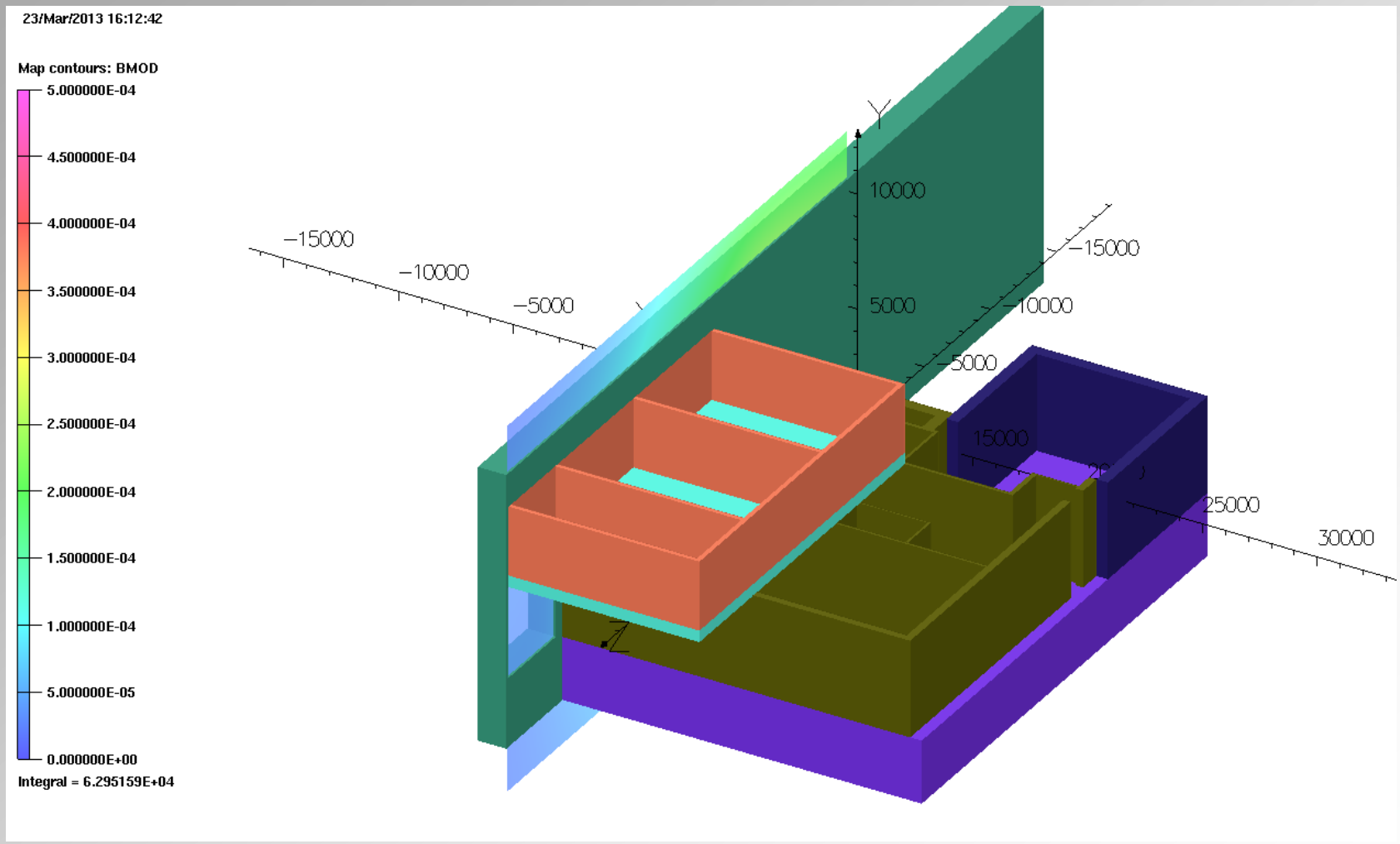


Model 61 - Step IV Solenoid 240MeV/c .
10 Gauss Scale. Roof Height (y=8000)

Preliminary Results Hall Overview Step IV Solenoid 240 MeV/c



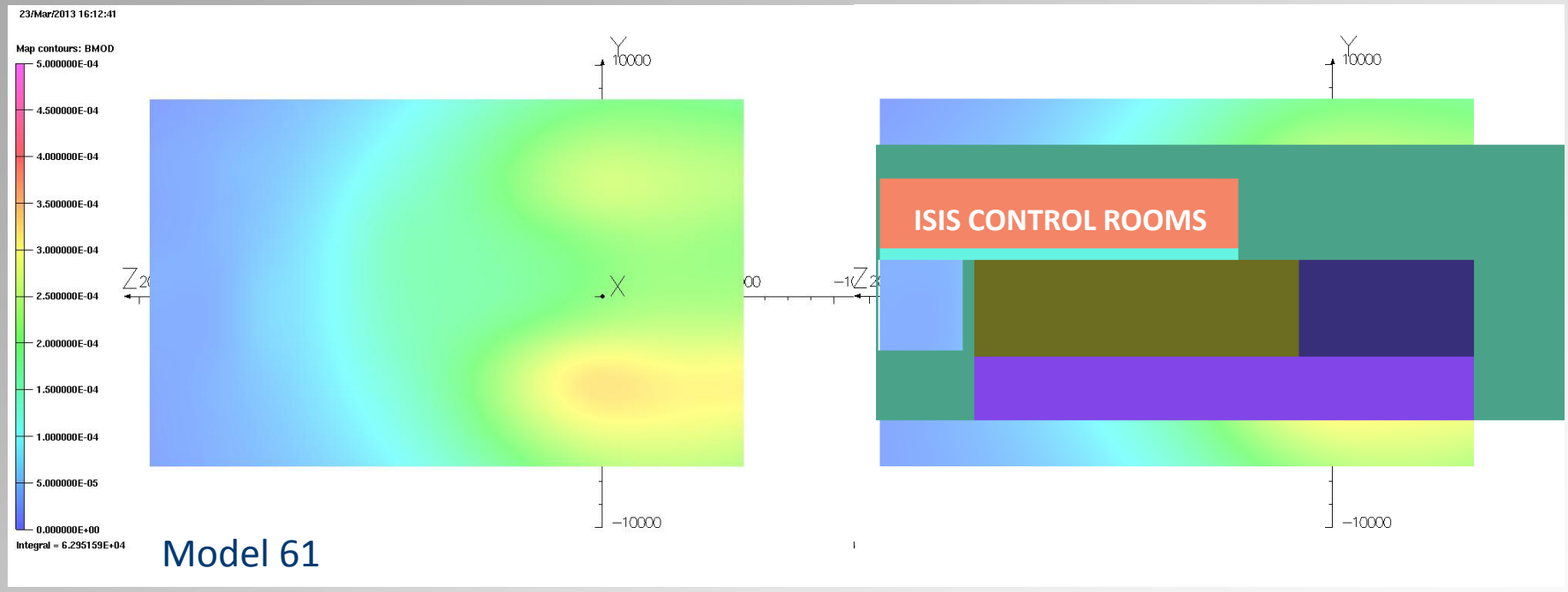
Model 61 - Step IV Solenoid 240MeV/c .
10 Gauss Scale. Roof Height (y=8000)



Model 61. x=6000 mm

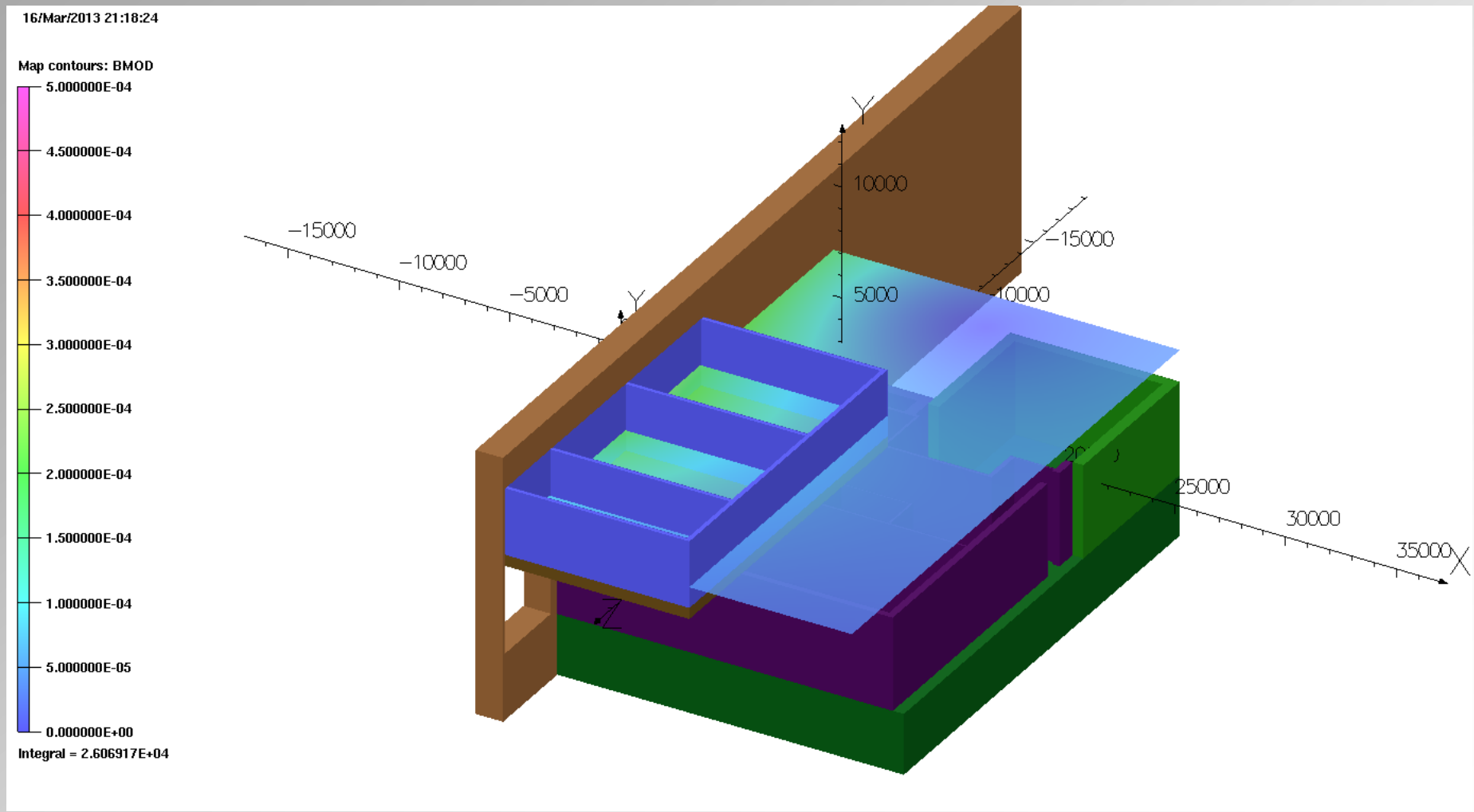
Step IV - Solenoid

LHS is the same plot as RHS but with structures superimposed

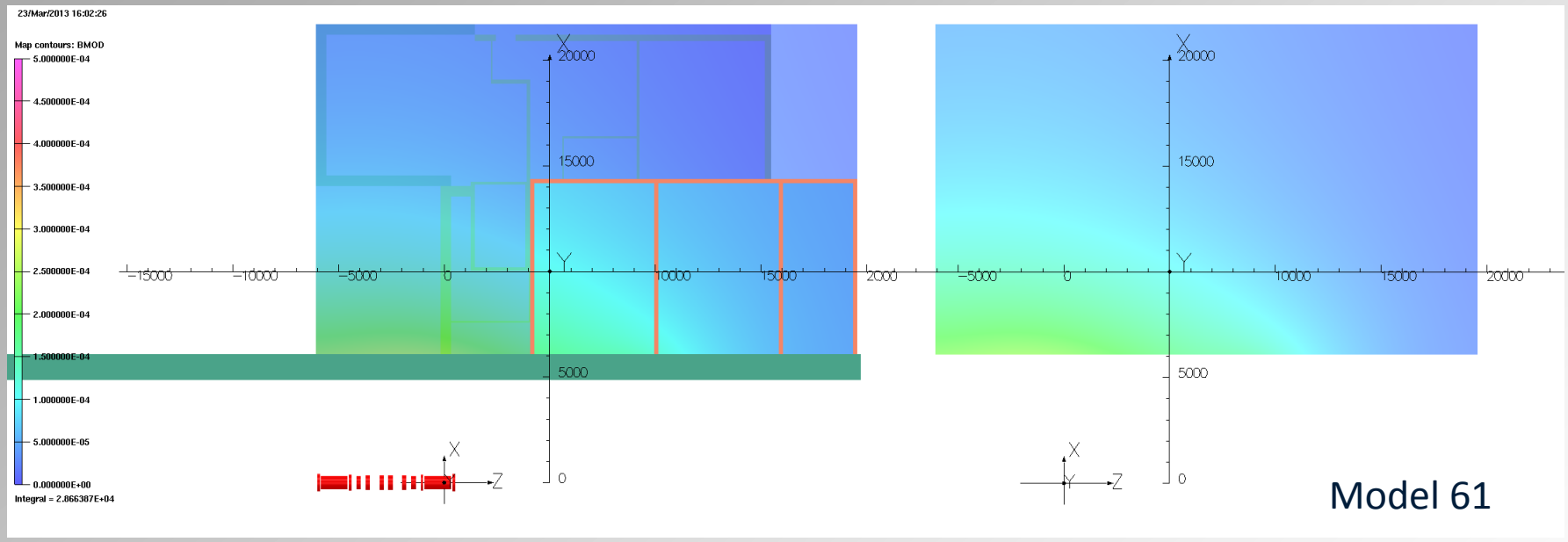


Model 61

(Apologies in the auto-generator a bug means the scale appears behind plot.)
5 gauss scale. Bmod. x=6000



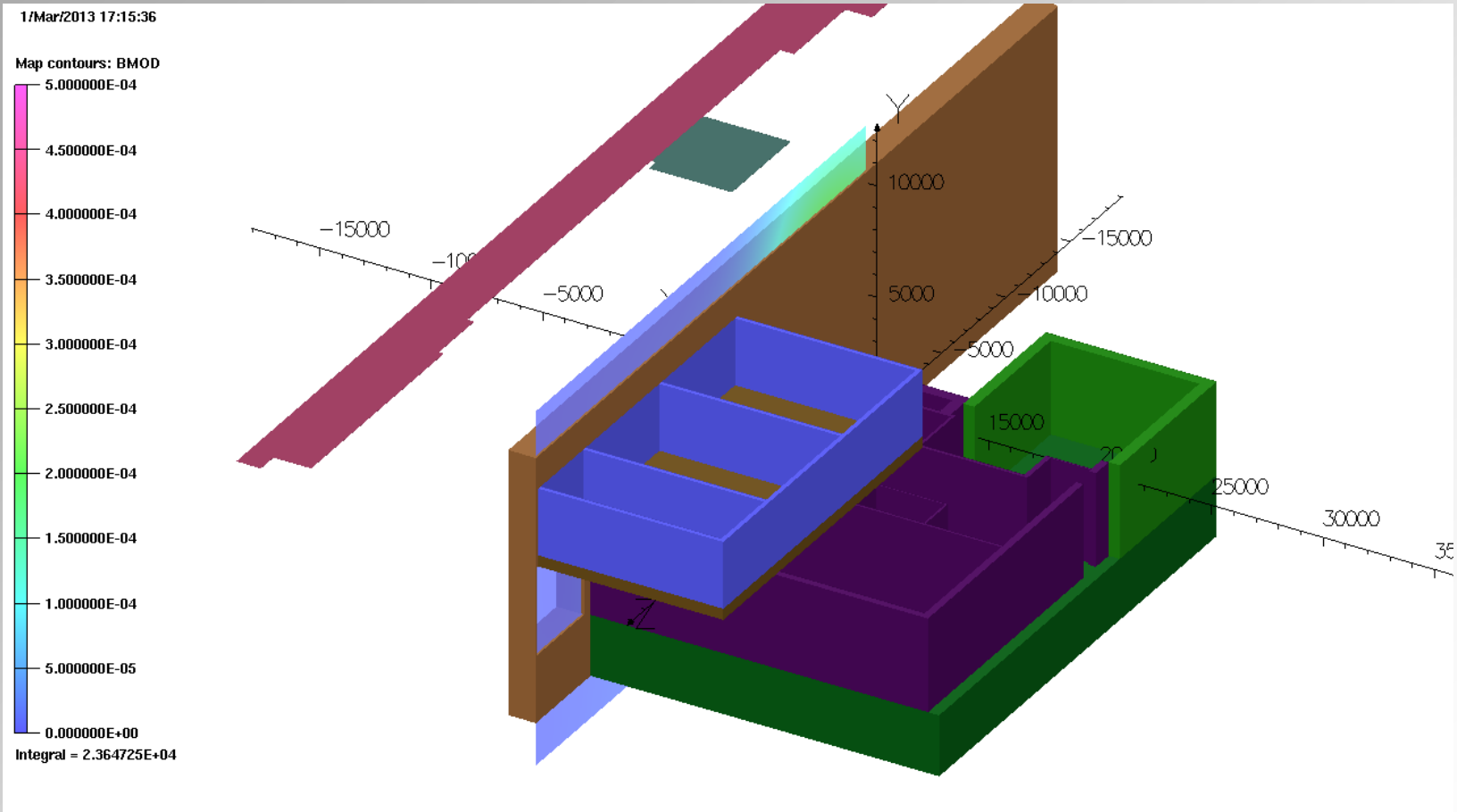
Model 61. y=3000 (3m above beam height)



I'm continuing to show plots with both structures turned 'on' and 'off' because when the structures are turned 'on' the transparency of the plot can affects the apparent colouration of it .

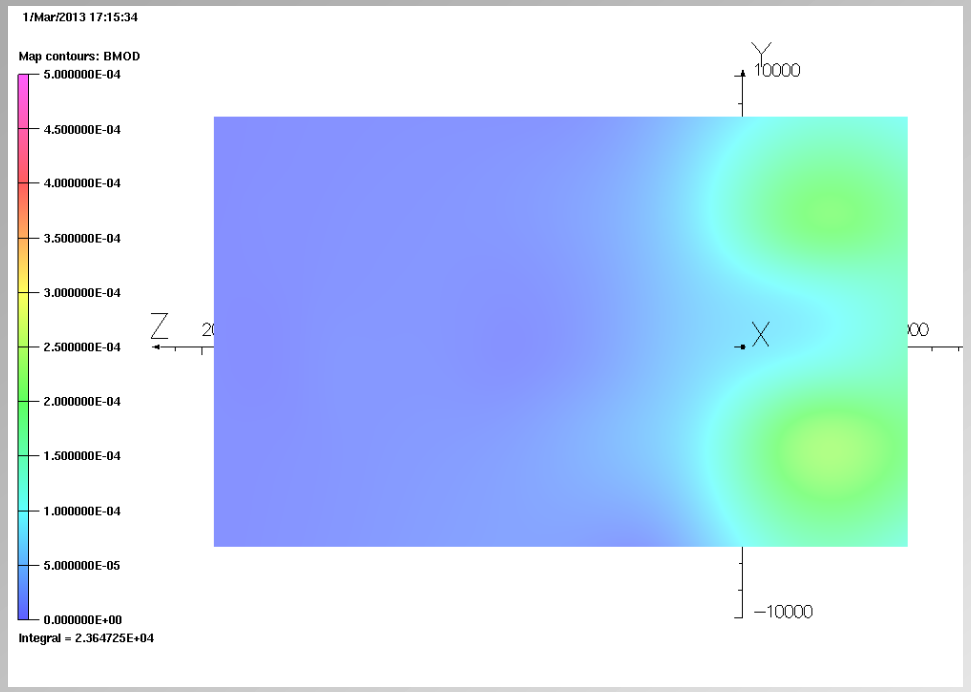
5 gauss scale Bmod. y=3000

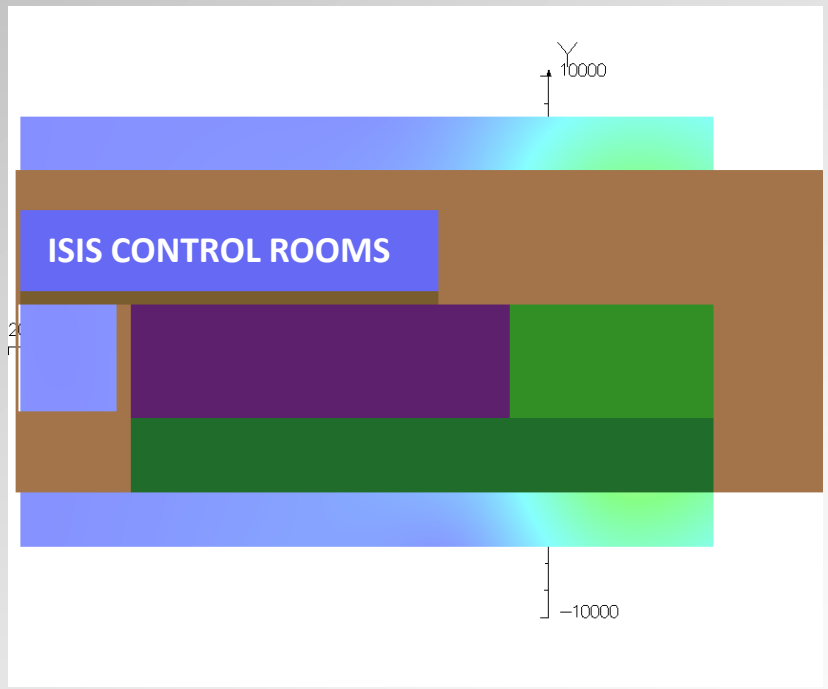
Preliminary Results
Step IV- Flip



Model 54. x=6000 mm (yes there's was another small bug in the plot auto-generator when this plot was generated!)

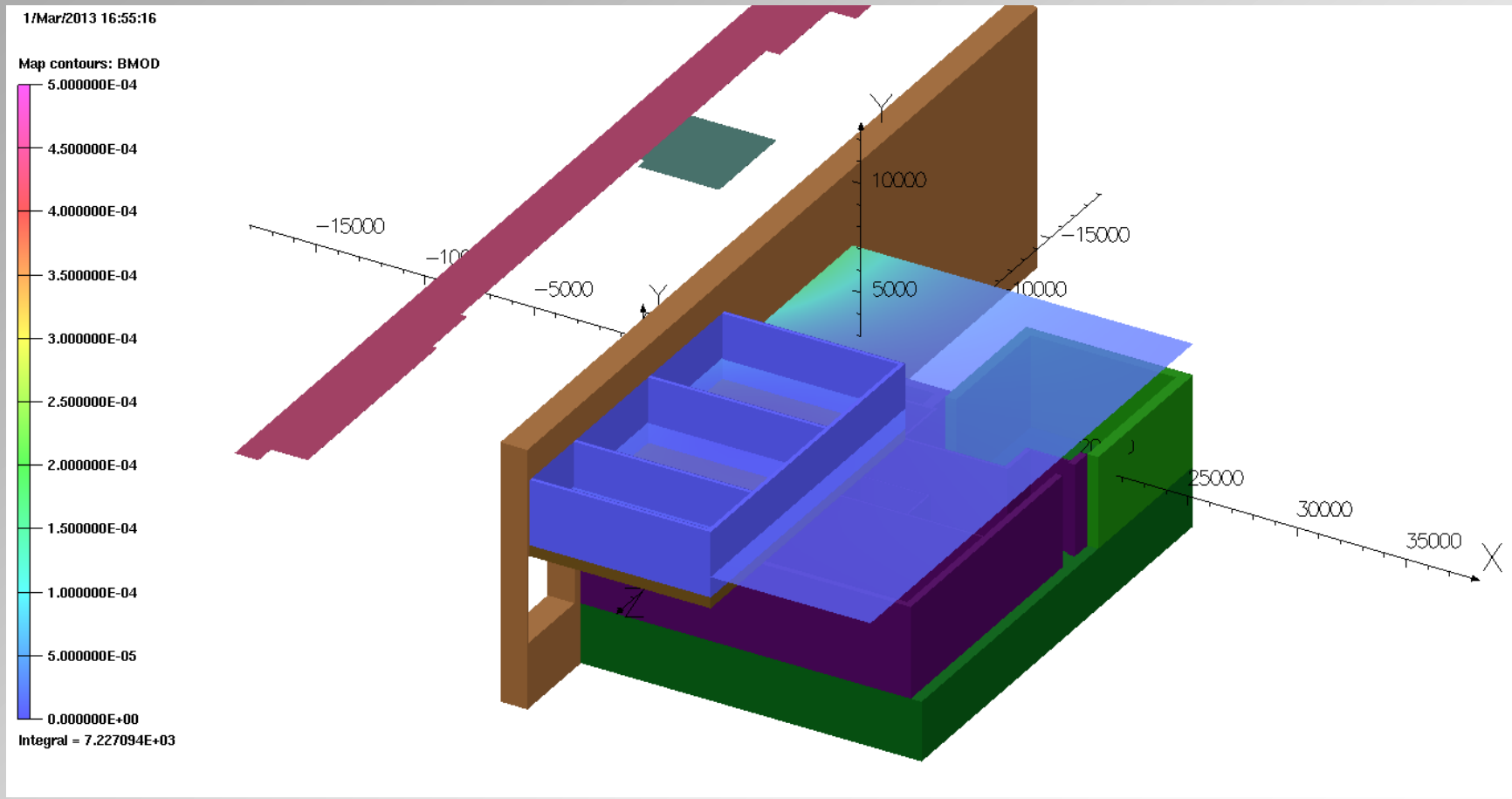
Preliminary Results
Step IV - Flip





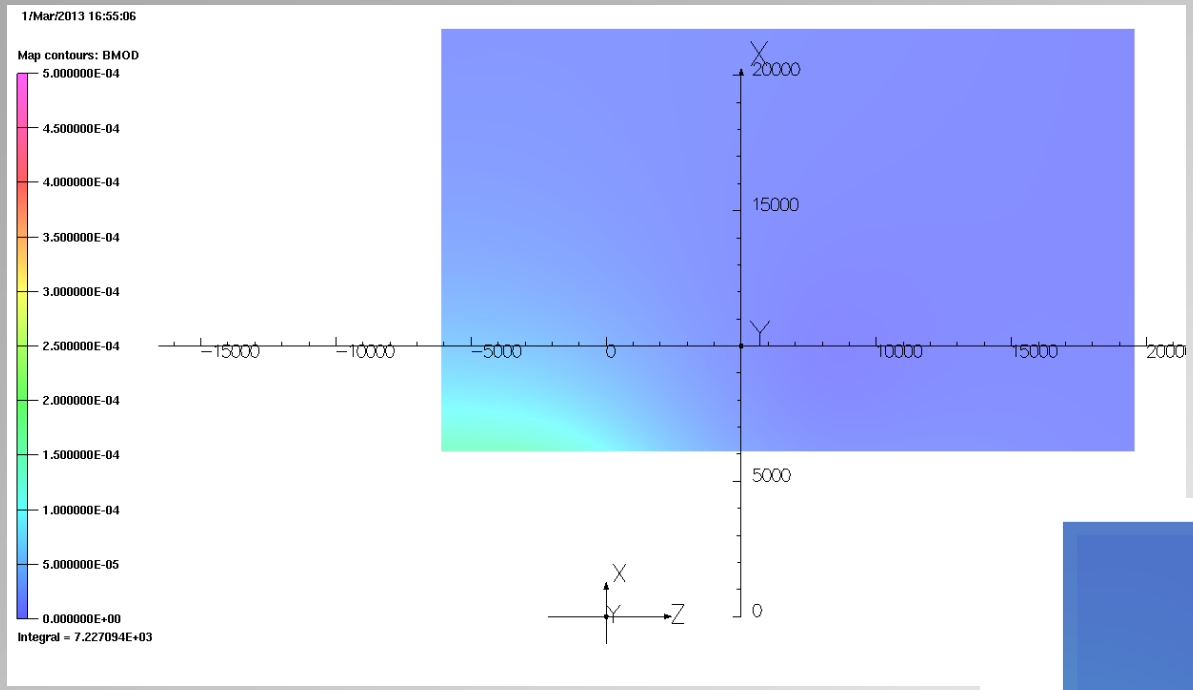
Model 54 – Step IV Flip 240 MeV/c.
Bmod. 5 gauss scale. x=6000

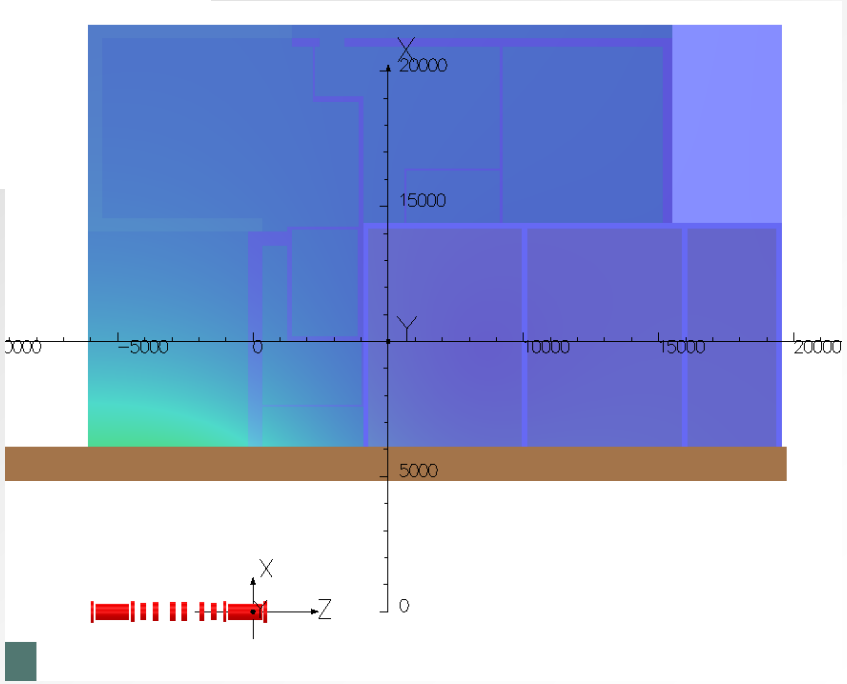
Preliminary Results
Step IV- Flip



Model 54. y=3000 mm

Preliminary Results
Step IV - Flip





Model 54 – Step IV Flip 240 MeV/c.
Bmod. 5 gauss scale. y=3000

27/03/2013

Step IV

I haven't done an extensive search through the control room volumes but from these plots it is indicative that the field levels within these volumes peak at a few gauss (~3 max) but are for the most part in the region of 0.5-2 gauss. These values compare favourably with values earlier models produced by Mike Courthold and reported in the document titled MICE Shielding Issues presented to the ISIS safety review on 20th July, 2011

The equivalent vector plots are also available online.

Clearly the field levels are worse for solenoid mode than flip mode.

They field levels may go a little higher if the planes were taken at the floor level in the CR as they would be slightly closer to our beam line – this needs checking at some point but I wouldn't expect a huge change.

Step VI

I've spent most of my time trying to understand the results for Step IV with much less attention paid to the Step VI results.

I had a look at the Step VI plots yesterday with the hope of including some of these in this presentation but there were some unusual features in some the plots (particularly flip mode) that would need explaining. As I have not had time to thoroughly examine these plots it didn't seem wise to show these plots.

However I can make the general comment that by looking on identical planes to what I've been showing here the field values for step VI generally looked quite low, with max fields well below 10 gauss. This is a bit lower than that predicted in earlier models- not understood.

Like all the plots shown so far these plots are available online, but I suggest caution with their interpretation.

Conclusions

We have a hall model that is producing field plots that we feel are believable but we also understand that the model needs benchmarking to give us the confidence to progress using these models. We are currently pursuing this with Vector Fields.

For Step IV:

It looks like there is very little intrusion of anything above 5 gauss outside the MICE Hall – occasional spots from what I can see but it needs a more thorough examination after the model boundary has been moved outwards & VF checks.

Solenoid Mode looks worse than Flip mode; that is reasonable as one would expect some field cancellation with Flip mode.

For the ISIS control rooms the model currently predicts a field of a few gauss at most, typically 1-2 gauss with peaks of ~3 gauss in very localised volumes.

We have taken your list of 'locations of concern' on-board and will give our consideration to the field strength in these areas in due course.