



Baby-Mind Magnetic Module Design

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Baby-MIND update meeting #1

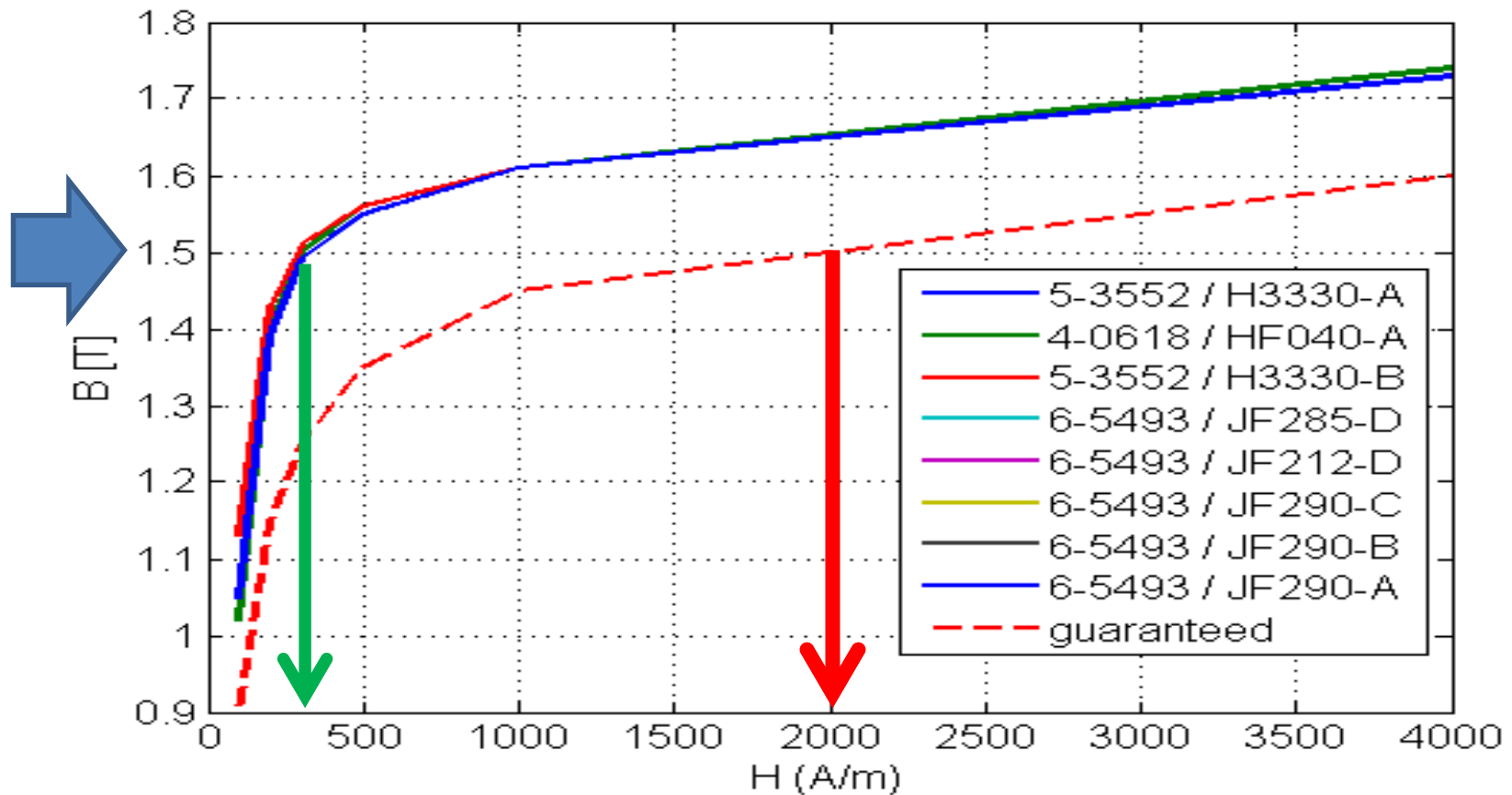
July 29, 2015

1. Constrains and goals

- Plate length is 3500 mm (size of the vertical pit)
- Plate thickness is 30 mm (optimized for physics)
- Plate height is 2000 mm
- Coil thickness is less than 10 mm
- Power dissipation to be minimised (stacking and no active cooling)

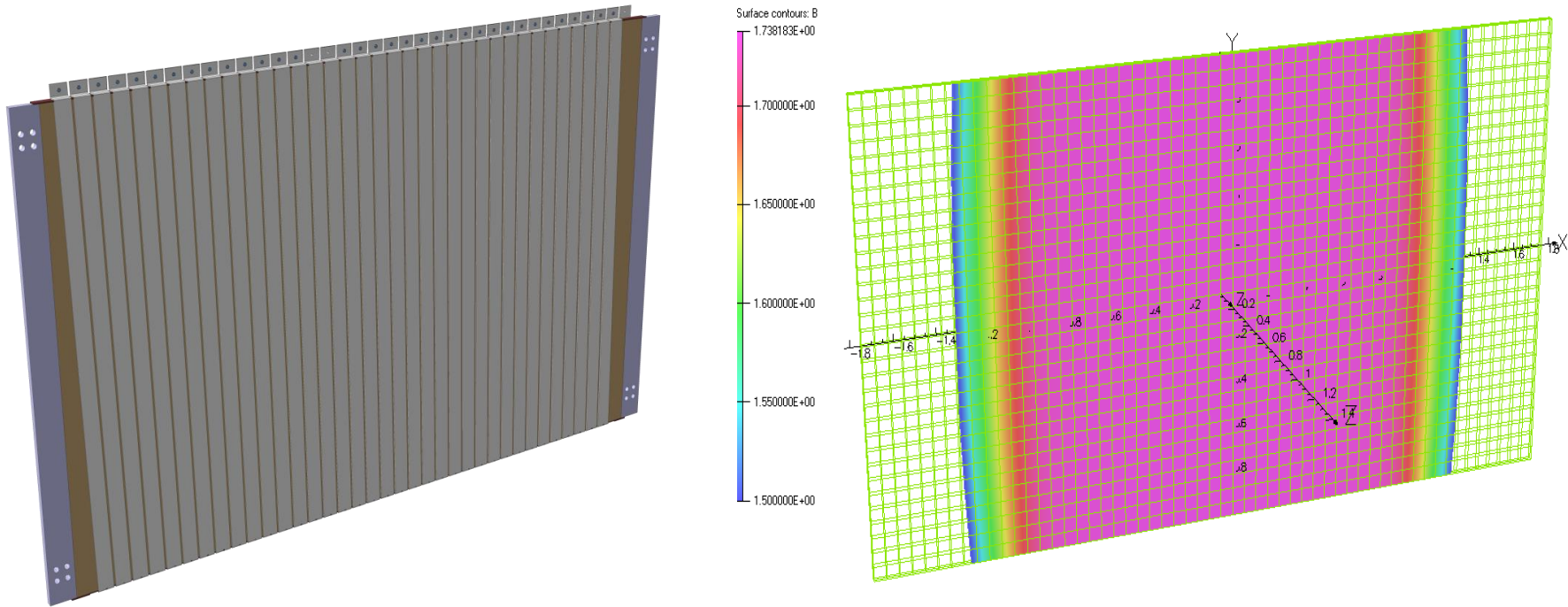
The module plate has to be magnetised by low current and a predictable and homogeneous magnetic of field distribution at 1.5 T has to be guaranteed.

2. Magnetisation of a steel plate (ARMCO)



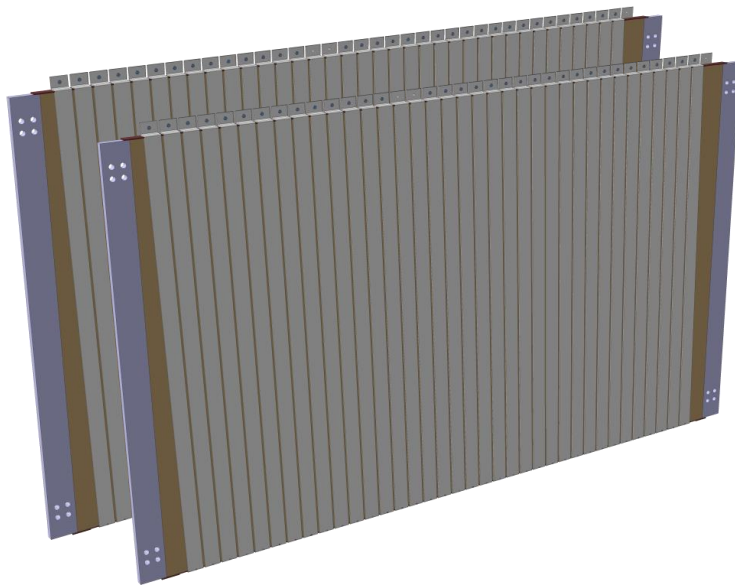
- For an infinitively long plate with good properties, a **< 300 A/m** coil will do the job, but when plate properties are only “as guaranteed”, the power dissipation will be **40 times higher!**

3. "Ideal" plate with no gap



- 300 A / 1 m of coil (4 mm thick Al) corresponds to a power dissipation of less than **3 W/m**
but with a total of 50 kA it will be more than 6 kW/m!

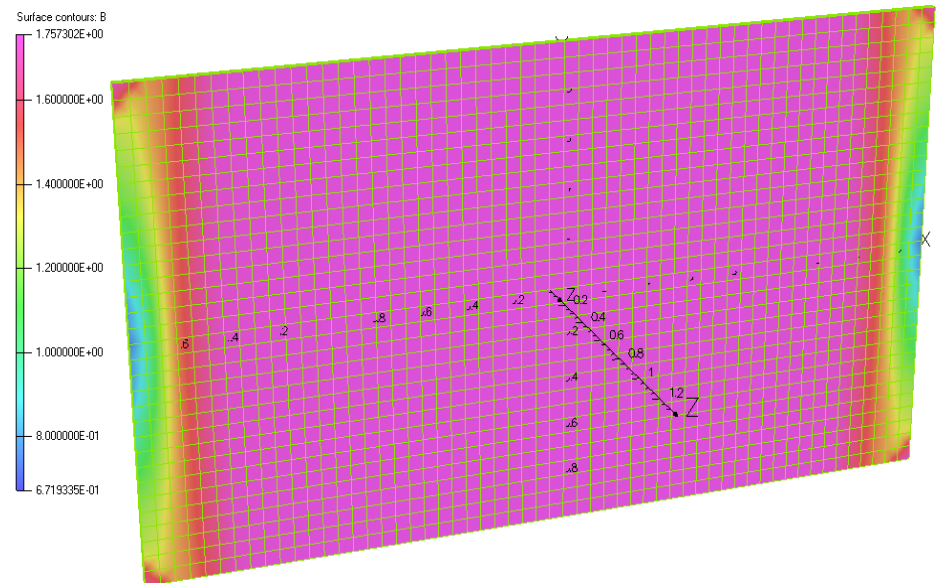
4. Repulsion force between neighbouring plates



- “Plus” and “Minus” current make “Zero” field outside the plate.
- The only interaction is due to effects at the plate edges where the field lines go outside.
- **But even in the case of no flux return it is small and affordable.**

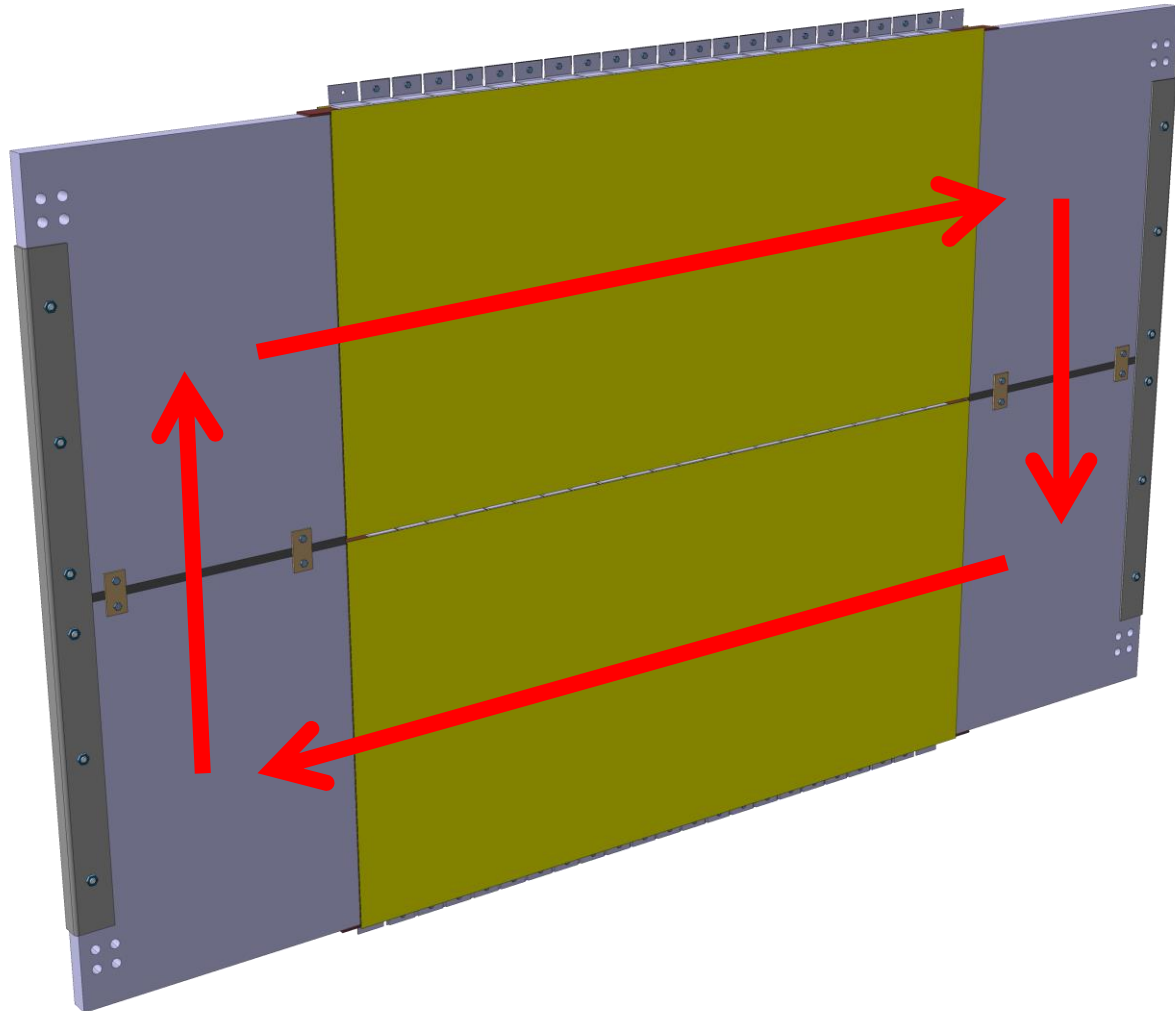
Example:

- Force between two plates with 100 kA total current and no gap between coils is only **6500 N (≈ 650 kg)**.

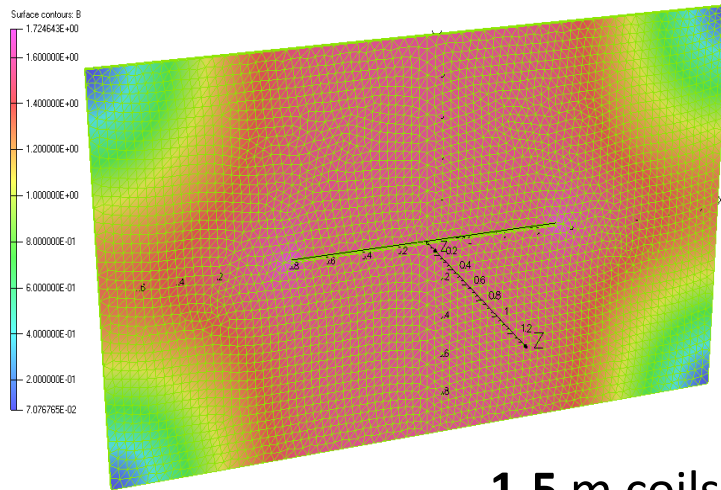


5. Flux return

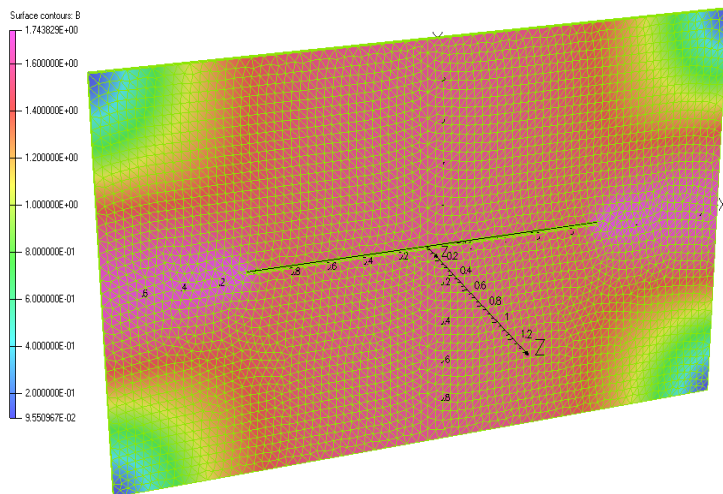
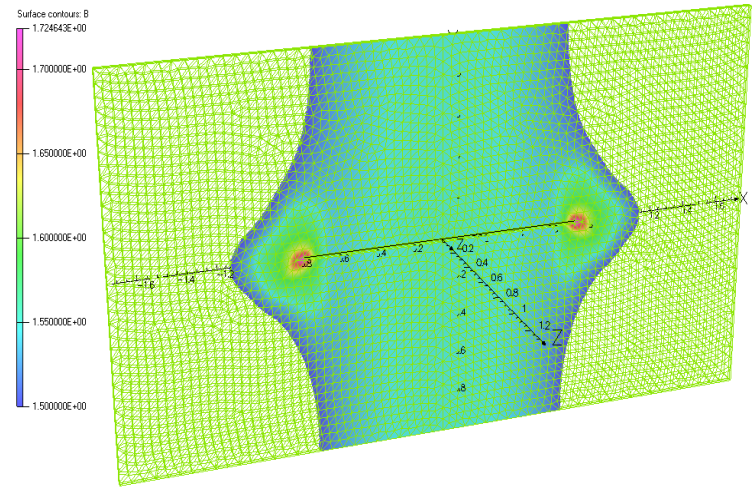
- Magnetic circuit is like in a “transformer”.



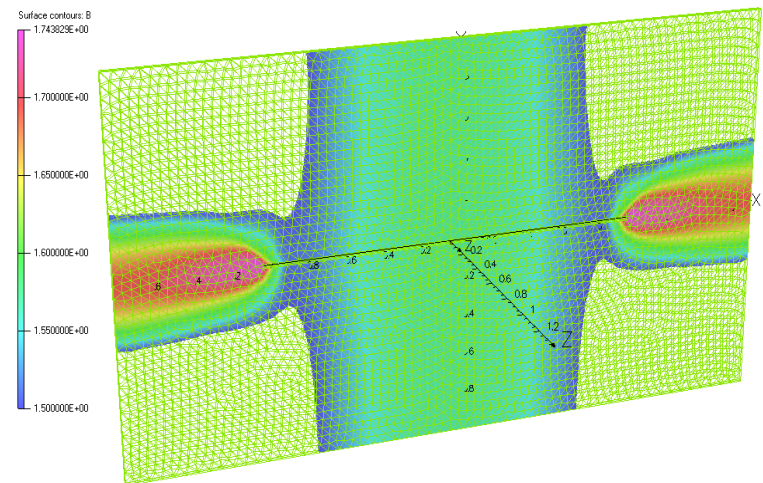
6. Single plate with 20 mm slot



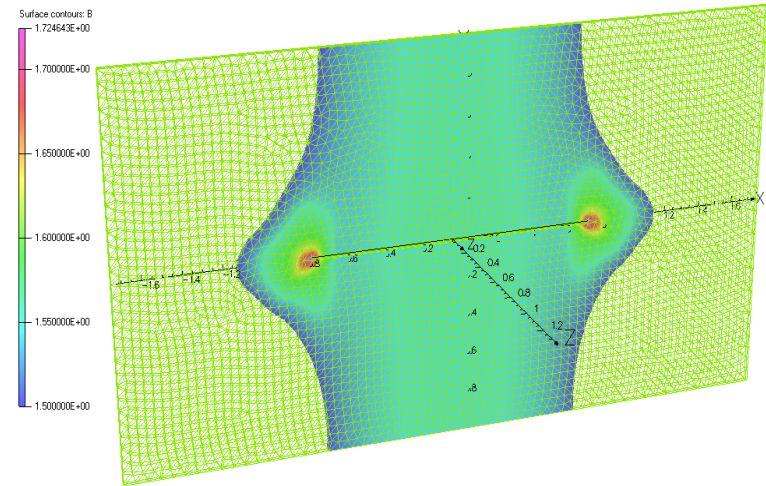
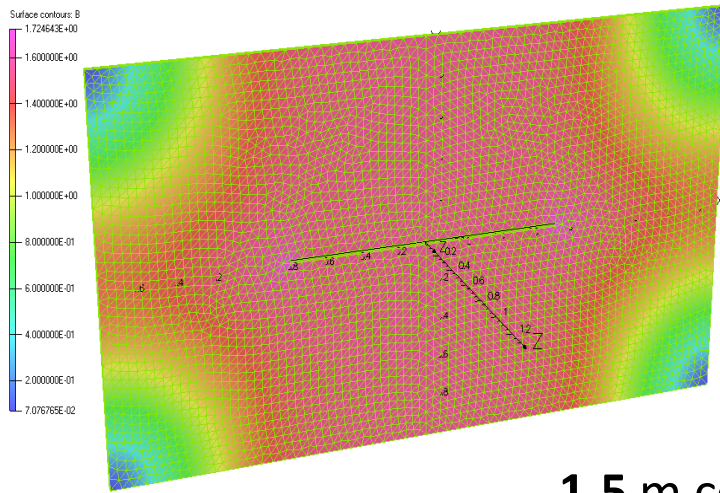
1.5 m coils with current of **2*800 A**



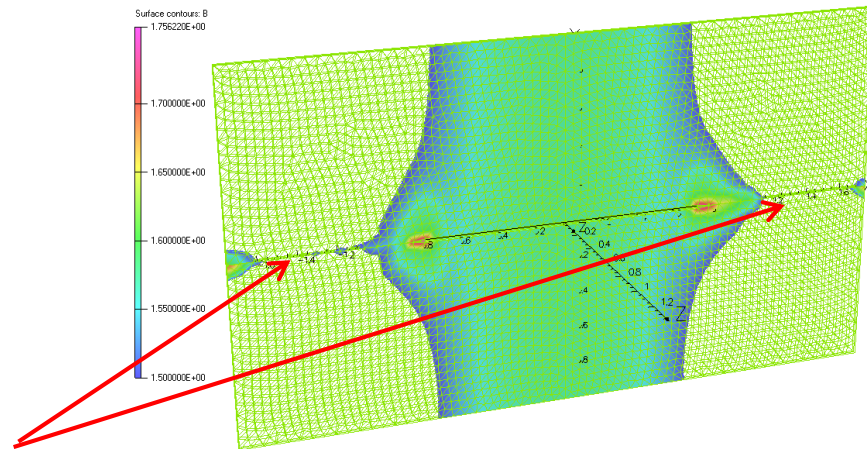
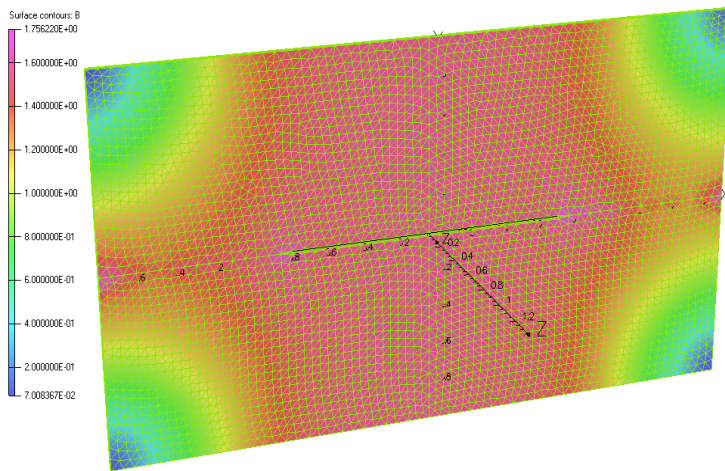
2.0 m coils with current of **2*1500 A**



7. Single plate (top) vs two plates with gap 1 mm (bottom)



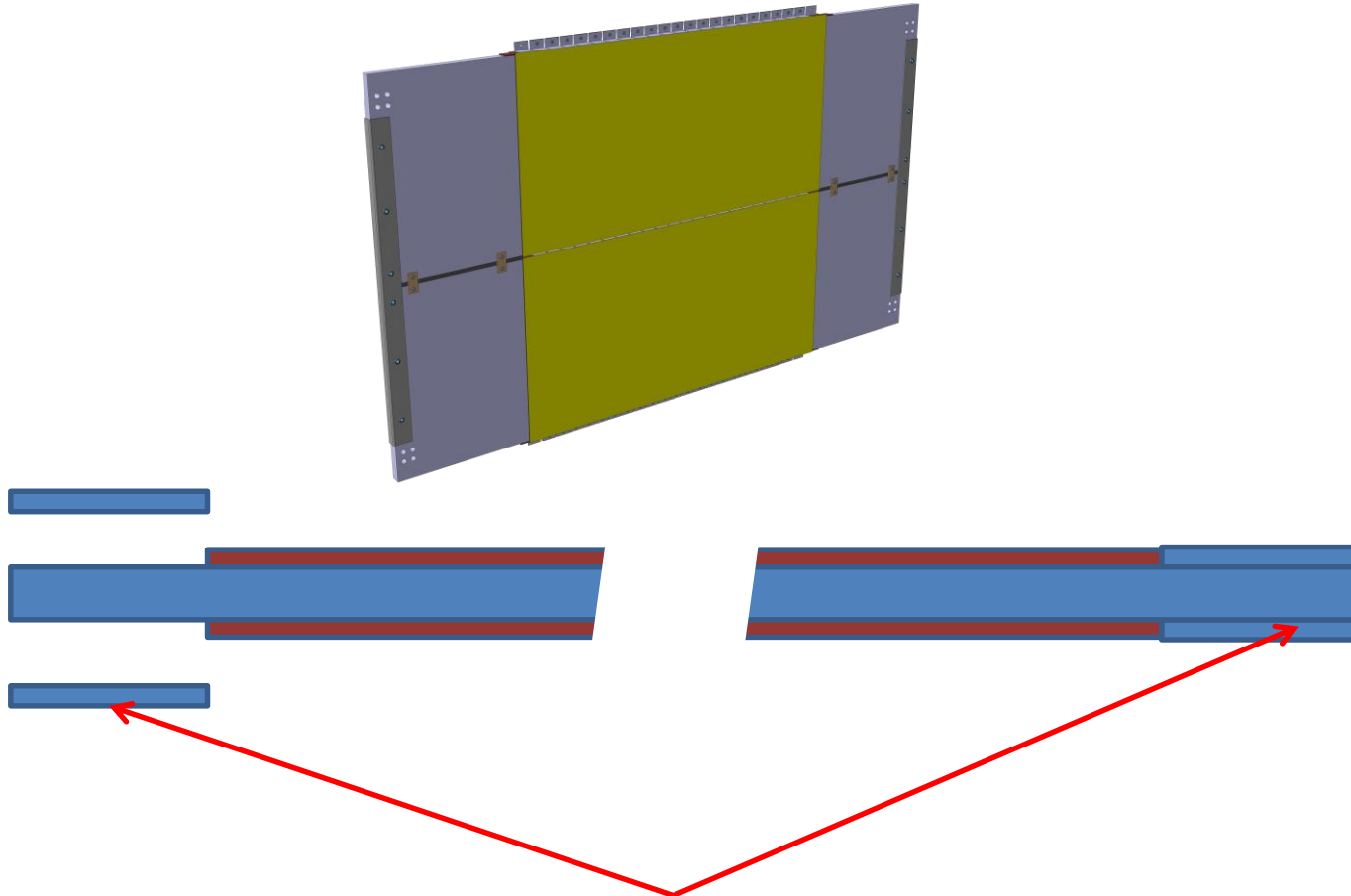
1.5 m coils with current of **2*800 A**



1 mm gap

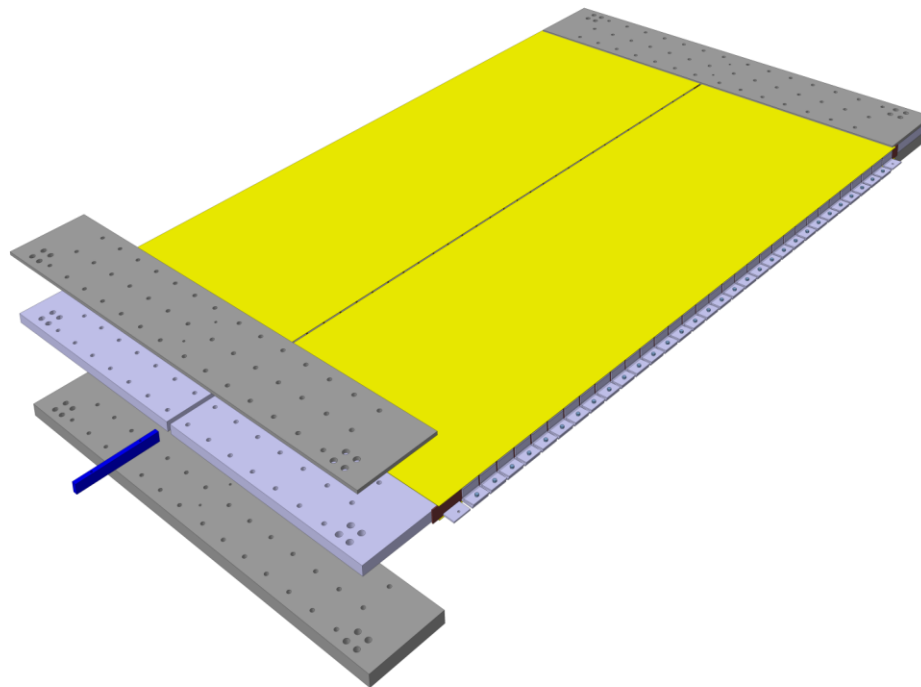
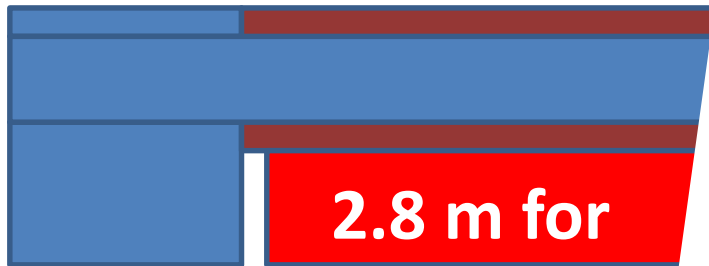
1.5 m coil with current of **2*1500 A**

8. To return flux properly extra material has to be added

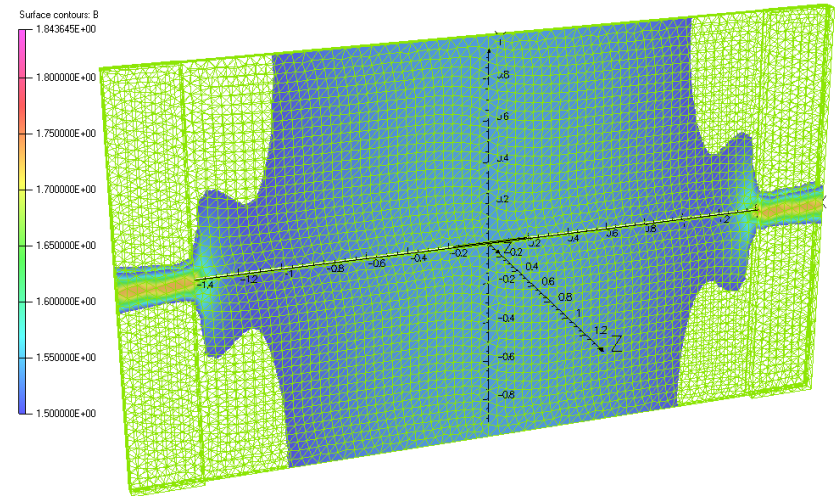
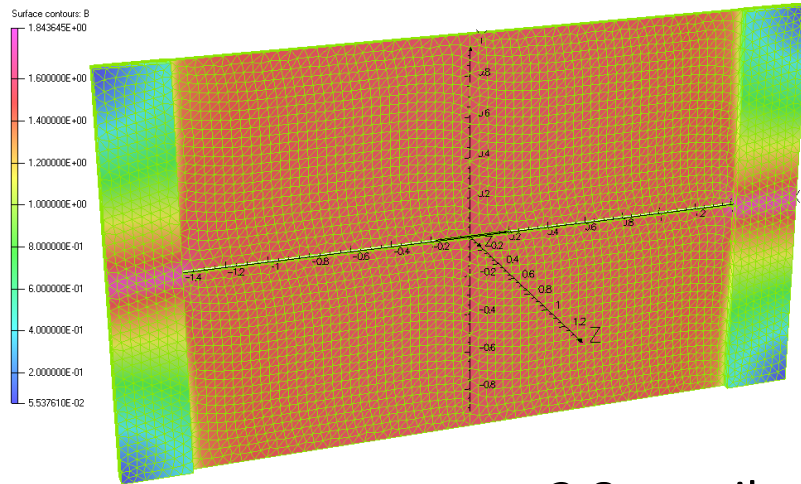


**10 mm plates to stay
within coil envelope**

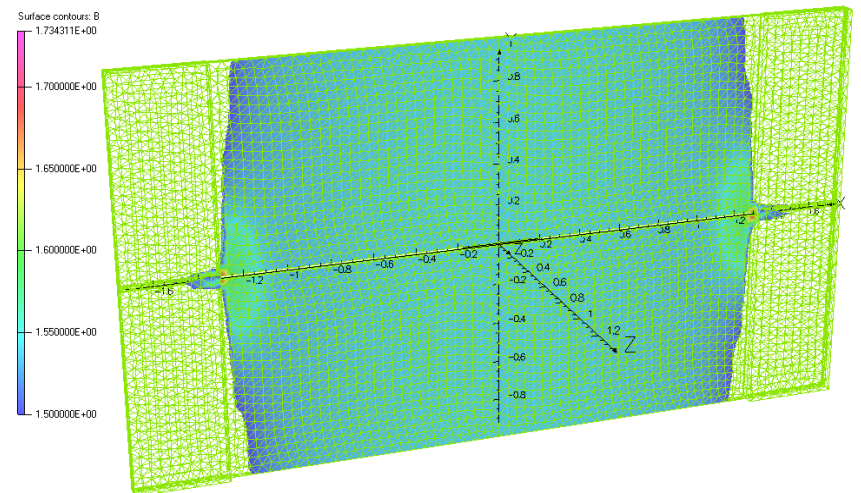
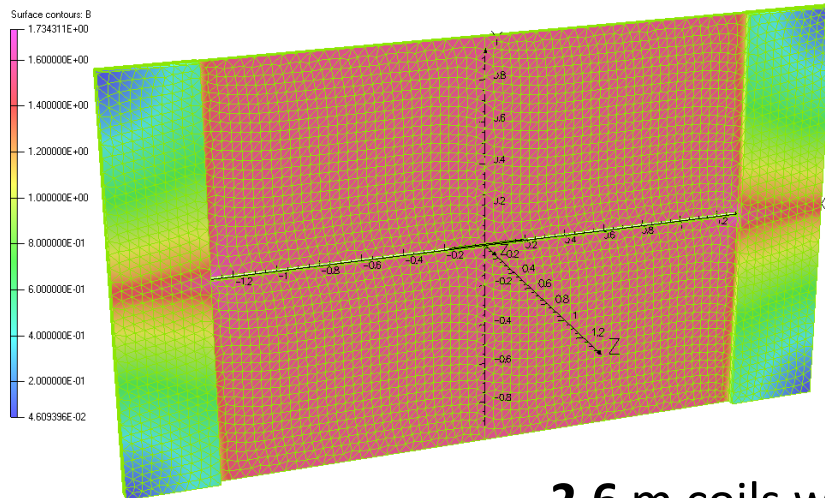
10. Baby MIND detector module (for 3.5 m)



11. Longer variants that can be selected as well

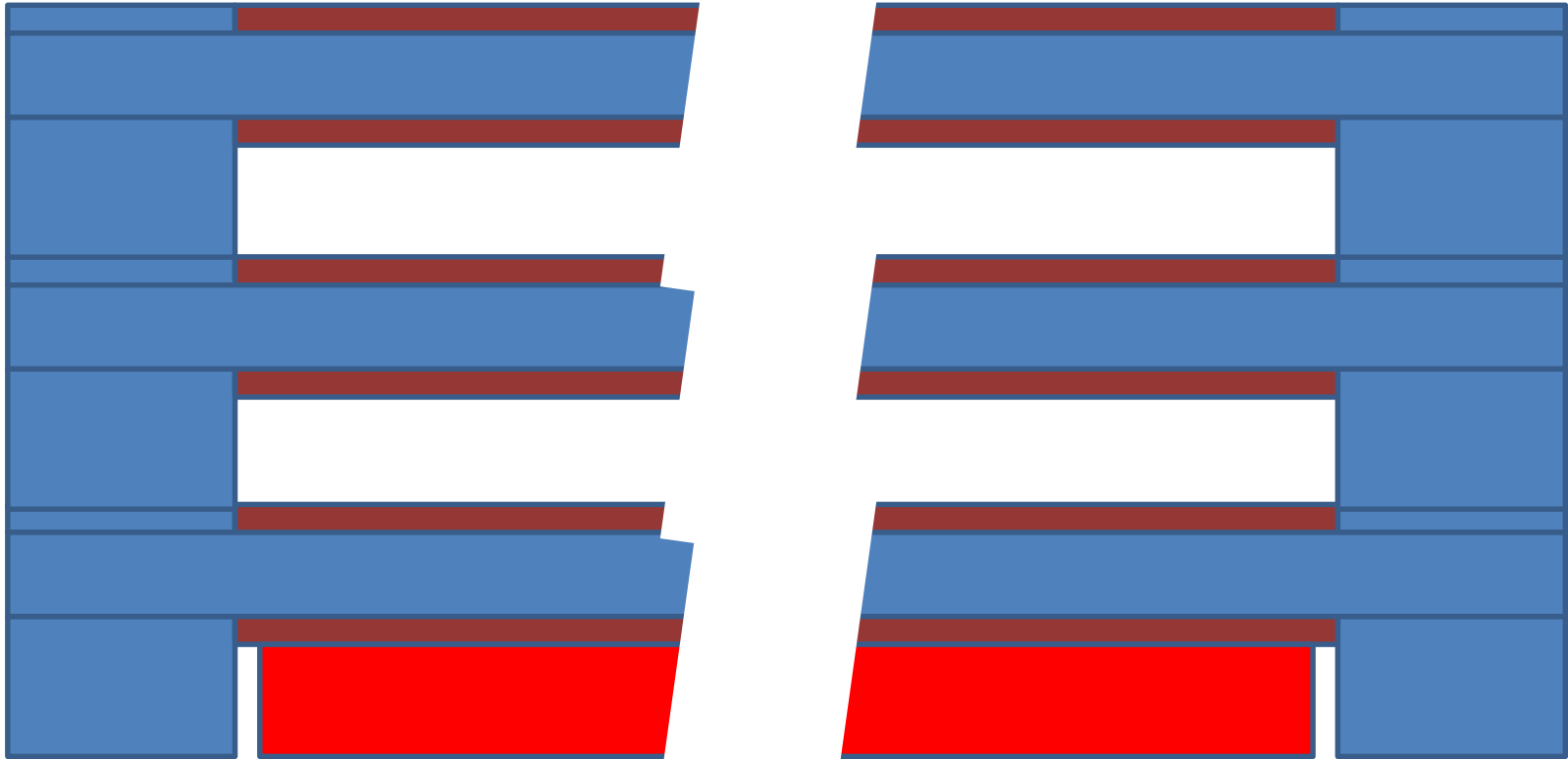


2.8 m coils with current of **2*1500 A**



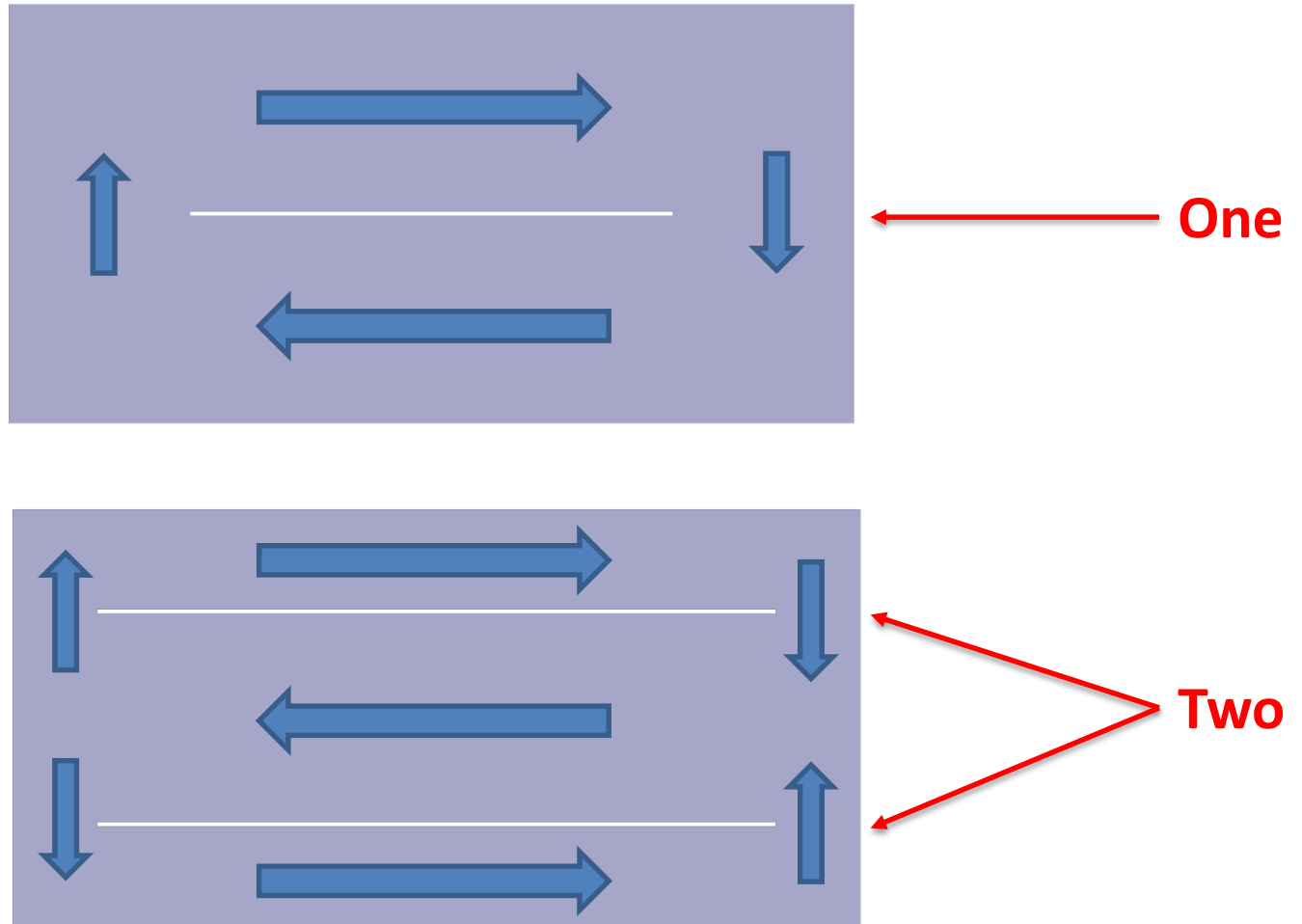
2.6 m coils with current of **2*1200 A**

12. Stacking of detector modules does not look nice

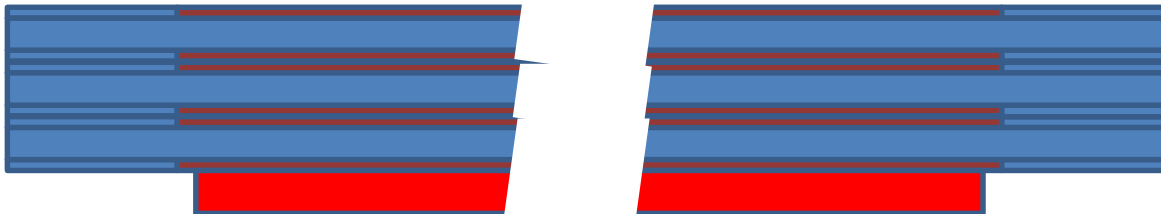
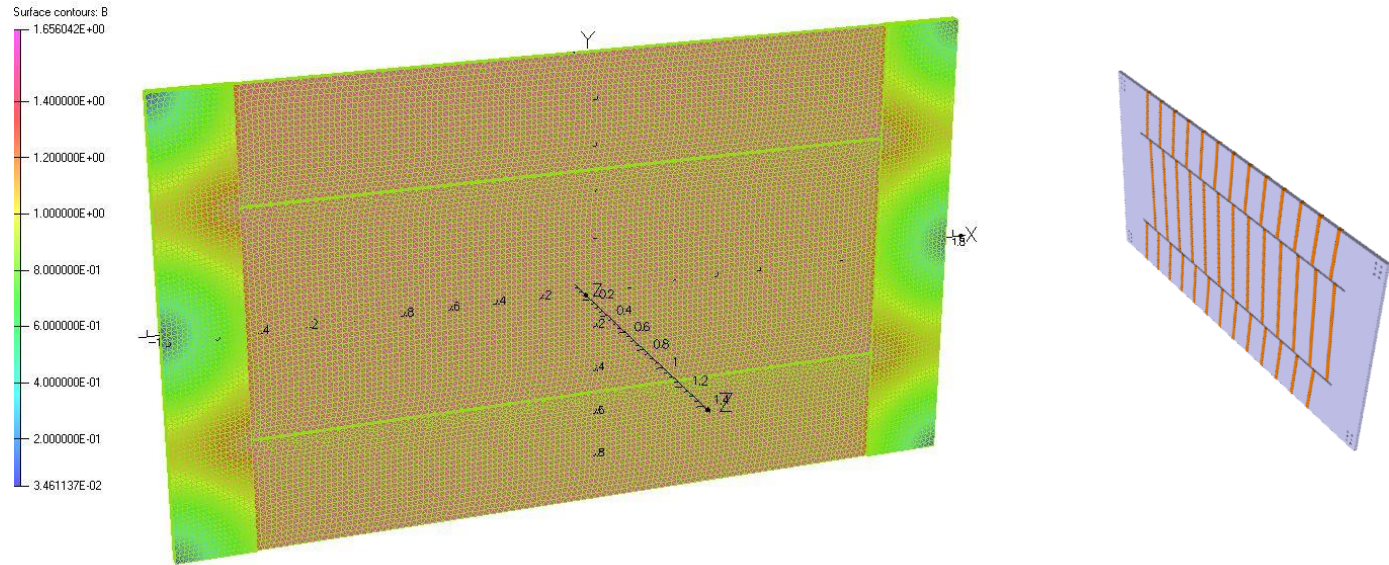


But there is a way to reduce extra thickness!

13. Two slits allow to reduce the thickness



14. Two-slit variant proposed



It is a bit more challenging for coil manufacturing
but certainly doable.

15. Current, voltage and power consumption

- For all cases the power dissipation is less than 100 W per module if the conductor thickness is >3 mm.
- Operating current depends on number of turns but it will be about 100 A.
- Voltage is also low and is within a few volt, a single standard power supply can charge all modules.

16. Conclusion and Outlook

- Magnetic design made is based on using raw magnetic steel plates with minimum machining.
- Effect of slit size and gaps between the plates in one module was analysed.
- Optimum flux return, and thus most uniform magnetic field across detector surface is achieved by adding extra side plates adjacent to the coils.
- A nearly perfect magnetic design was achieved and is proposed for approval.
- Final dimensions still to be agreed based on installation site study, where after the design can be frozen and production can start.
- Manufacturing of a full-size exercise module is foreseen for October-November 2015, where after production may start medio March-April 2016, however, provided single module design is frozen and steel plates ordered in September the latest.