ILD Magnetic Fringe Fields

Karsten Buesser

24.09.2013
ILD Workshop Cracow

Boundary Conditions

- IR Interface Document
  - Functional requirements for the co-existence of two experiments and the machine in a push-pull scenario
  - ILC-Note-2009-050
- Agreed on limit:
  - less than 50G (5 mT) at a distance of 15m from the beam axis

ILC-Note-2009-050
March 2009
Version 4, 2009-03-19

Functional Requirements on the Design of the Detectors and the Interaction Region of an e^+e^- Linear Collider with a Push-Pull Arrangement of Detectors

B.Parker (BNL), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY), J.Hauptman (Iowa State Univ.), T.Tauchi (KEK), P.Burrows (Oxford Univ.), T.Markiewicz, M.Oriunno, A.Seryi (SLAC)

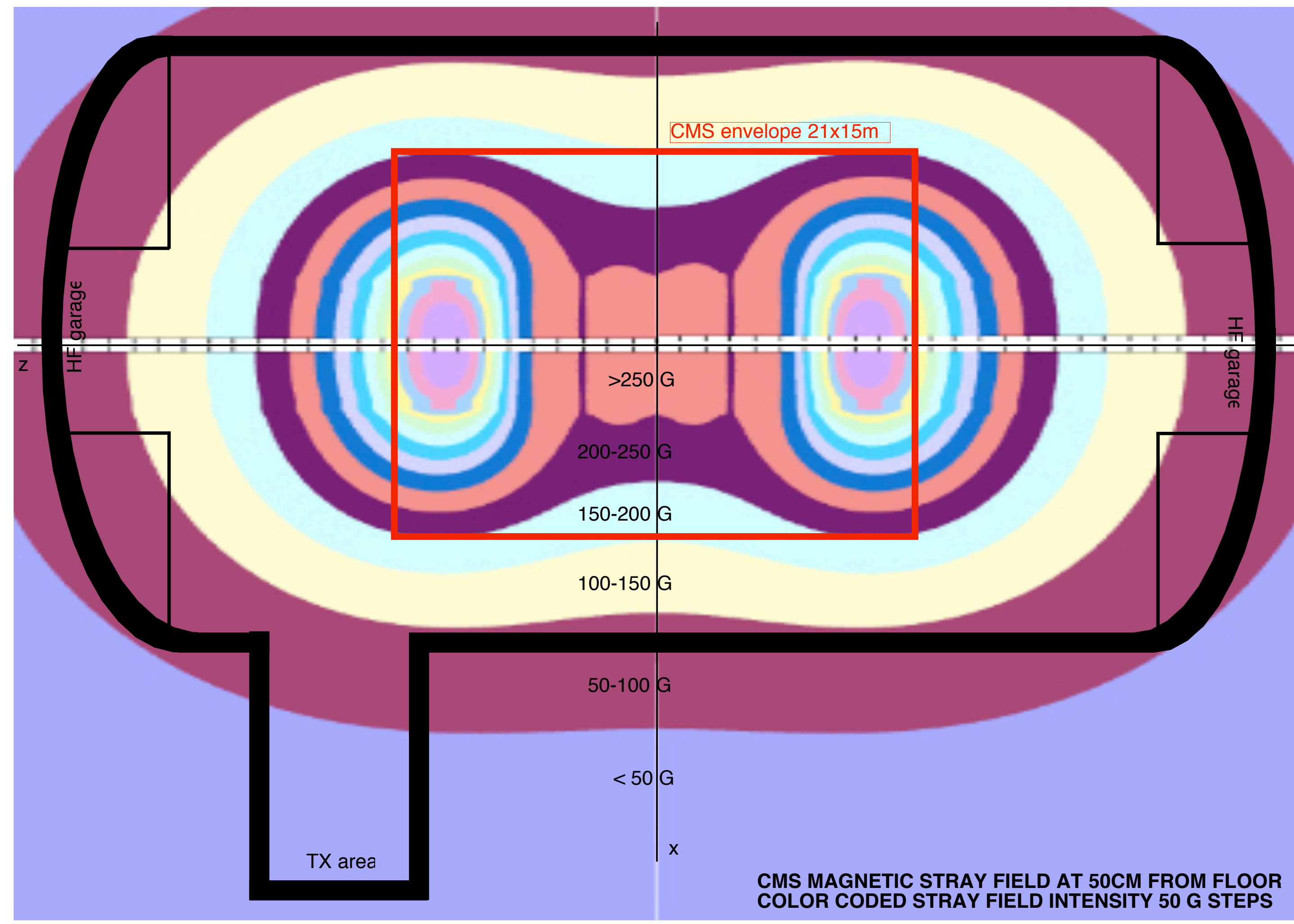
Abstract
The Interaction Region of the International Linear Collider [1] is based on two experimental detectors working in a push-pull mode. A time efficient implementation of this model sets specific requirements and challenges for many detector and machine systems, in particular the IR magnets, the cryogenics and the alignment system, the beamline shielding, the detector design and the overall integration. This paper attempts to separate the functional requirements of a push pull interaction region and machine detector interface from any particular conceptual or technical solution that might have been proposed to date by either the ILC Beam Delivery Group or any of the three detector concepts [2]. As such, we hope that it provides a set of ground rules for interpreting and evaluating the MDI parts of the proposed detector concept's Letters of Intent, due March 2009. The authors of the present paper are the leaders of the IR Integration Working Group within Global Design Effort Beam Delivery System and the representatives from each detector concept submitting the Letters Of Intent.

Requirements

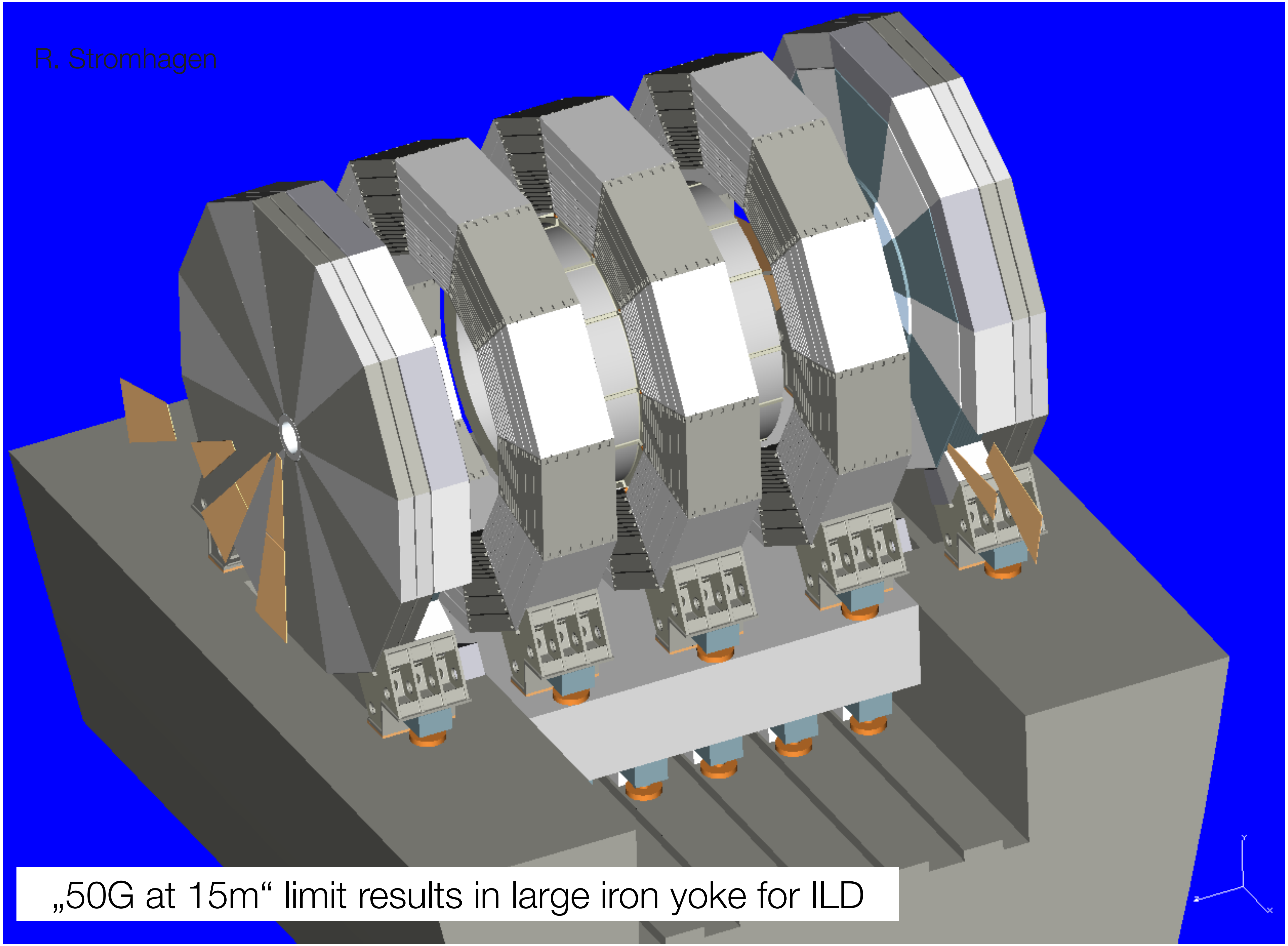
- Japanese safety regulations and site realities might change some of the pre-requisites we assumed in the 2009 document?
- Possible relaxations on requirements might make life in a mountain site hall easier for ILD
- Example: „<5 mT at 15 m from the beamline“ magnetic field limit
    - this drives the amount of iron in the ILD yoke
    - If we could relax that requirement:
        - ILD would become smaller
        - Less material to bring into the hall
        - Possible shorter construction time
- NB: I do NOT suggest to change this requirement now
- But we should have a closer look at the old requirements in view of the given conditions at a possible Japanese site
- Maybe we find even other requirements that make our life harder...

CMS Experience

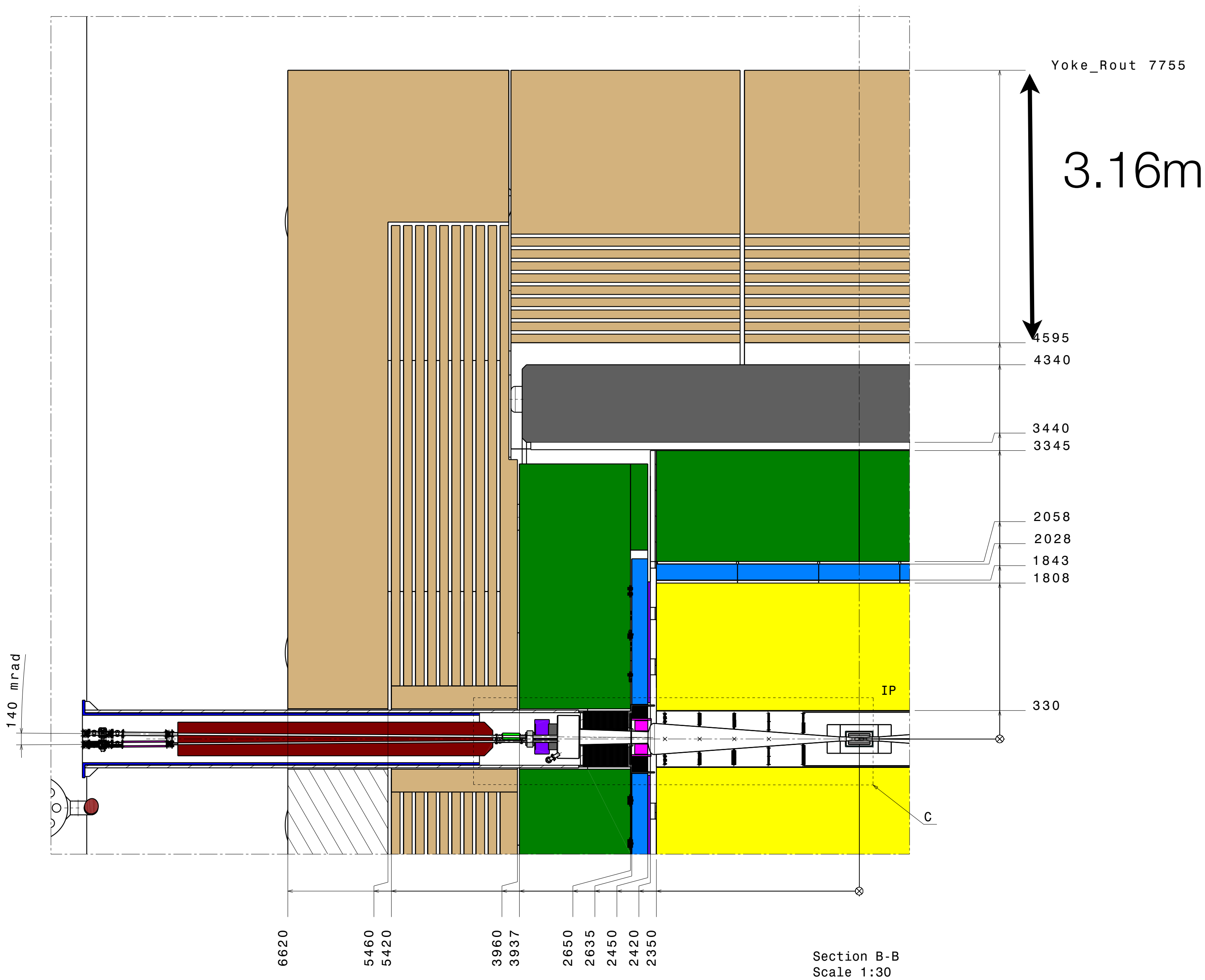
- From „Mechanical Works in Magnetic Stray Fields“ (A. Gaddi, CERN EDMS No 973739)
- Tests performed in CMS hall while magnet (4T) was on
- Below 50G:
  - no special precaution, standard workshop tools and procedures
- 50 to 150G:
  - more and more difficult, use of non-magnetic tools mandatory
- Over 150G:
  - real difficult work, dangerous above 200G, even difficult to handle non-magnetic tools



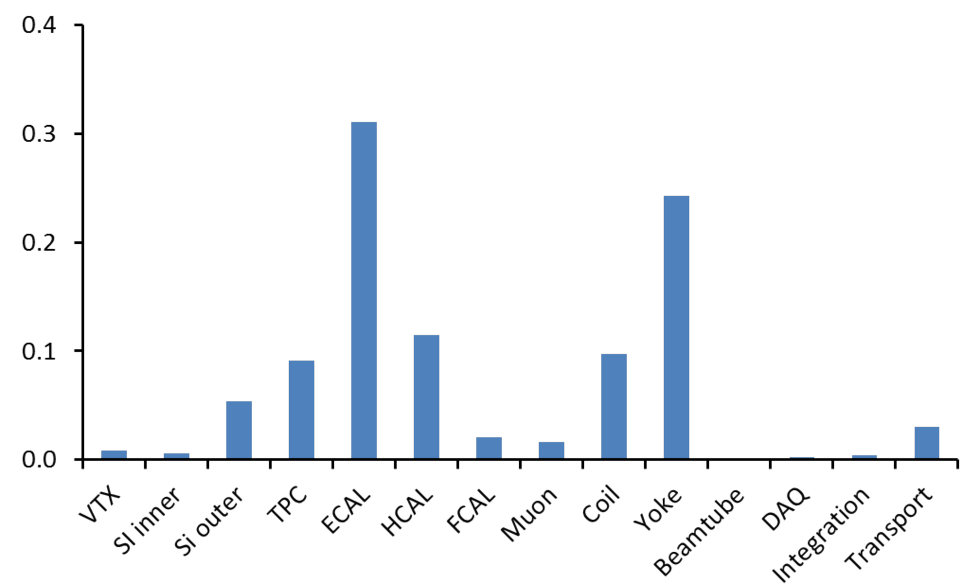
ILD Mechanical Design



ILD Iron Yoke



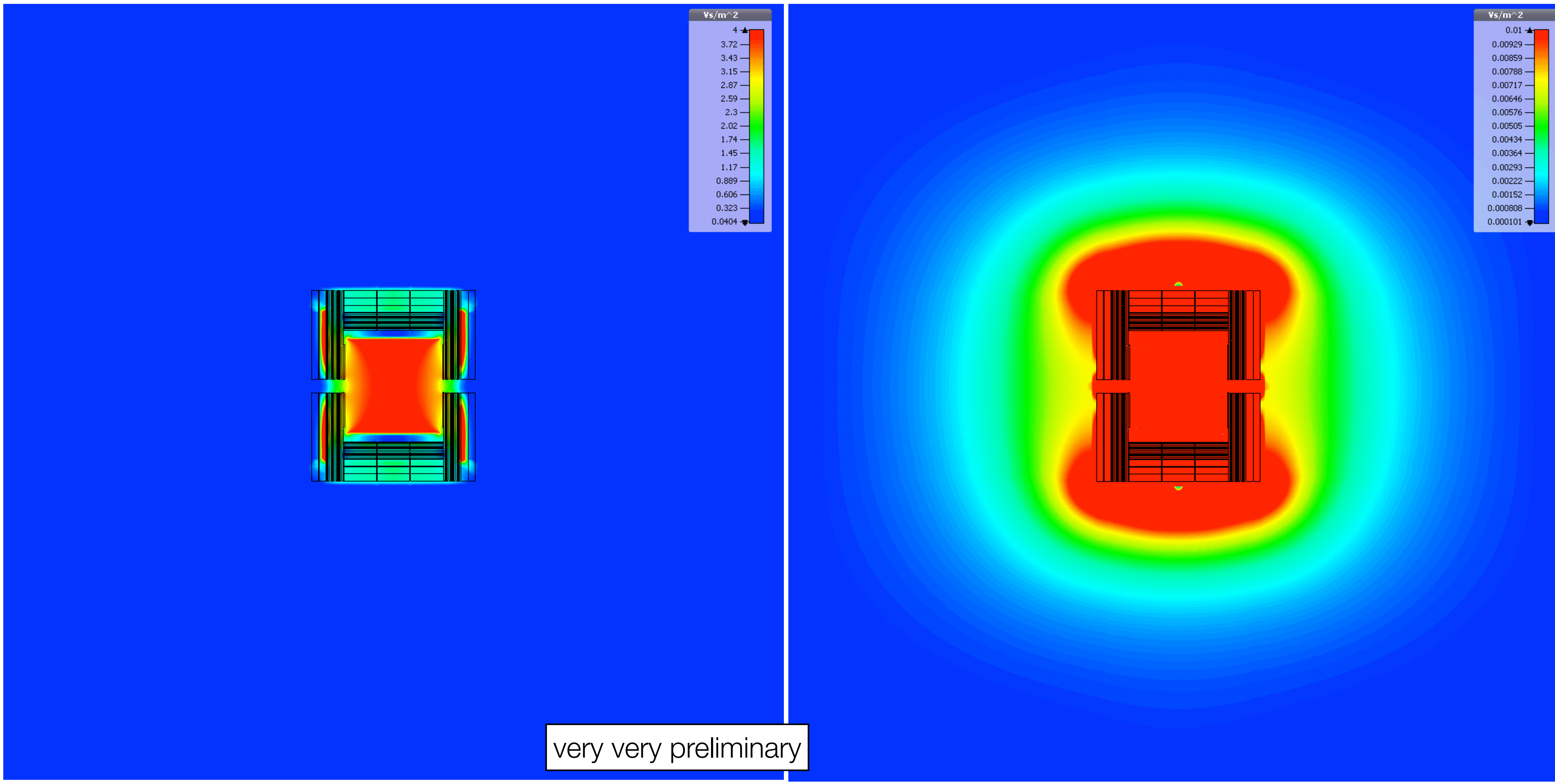
- Total cost of yoke:
  - 95 MILCU
  - 80 MILCU for steel and machining



- A reduction of the iron could save a lot

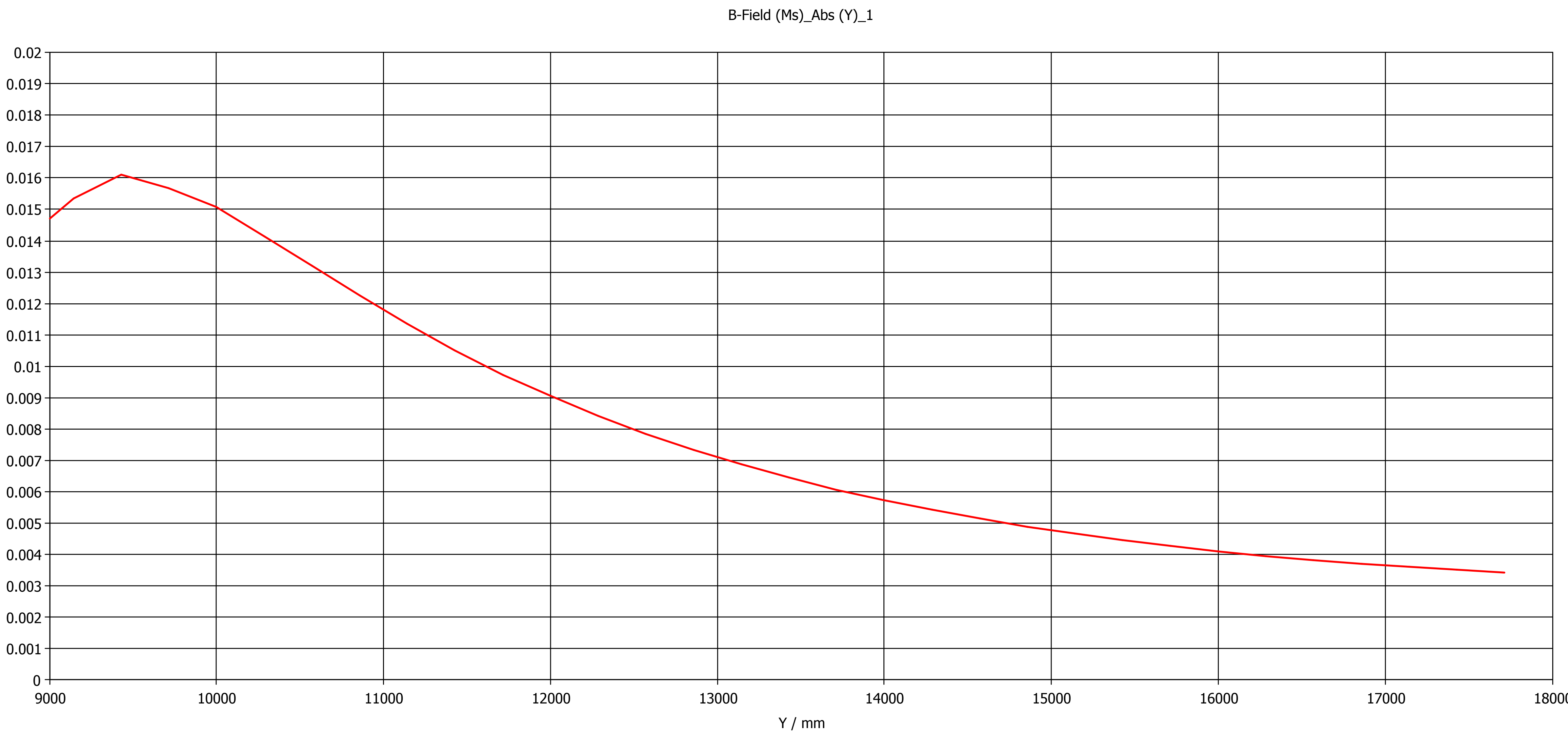
ILD Magnetic Field Simulations

- CST EM Studio



Magnetic Field Along Y-Axis

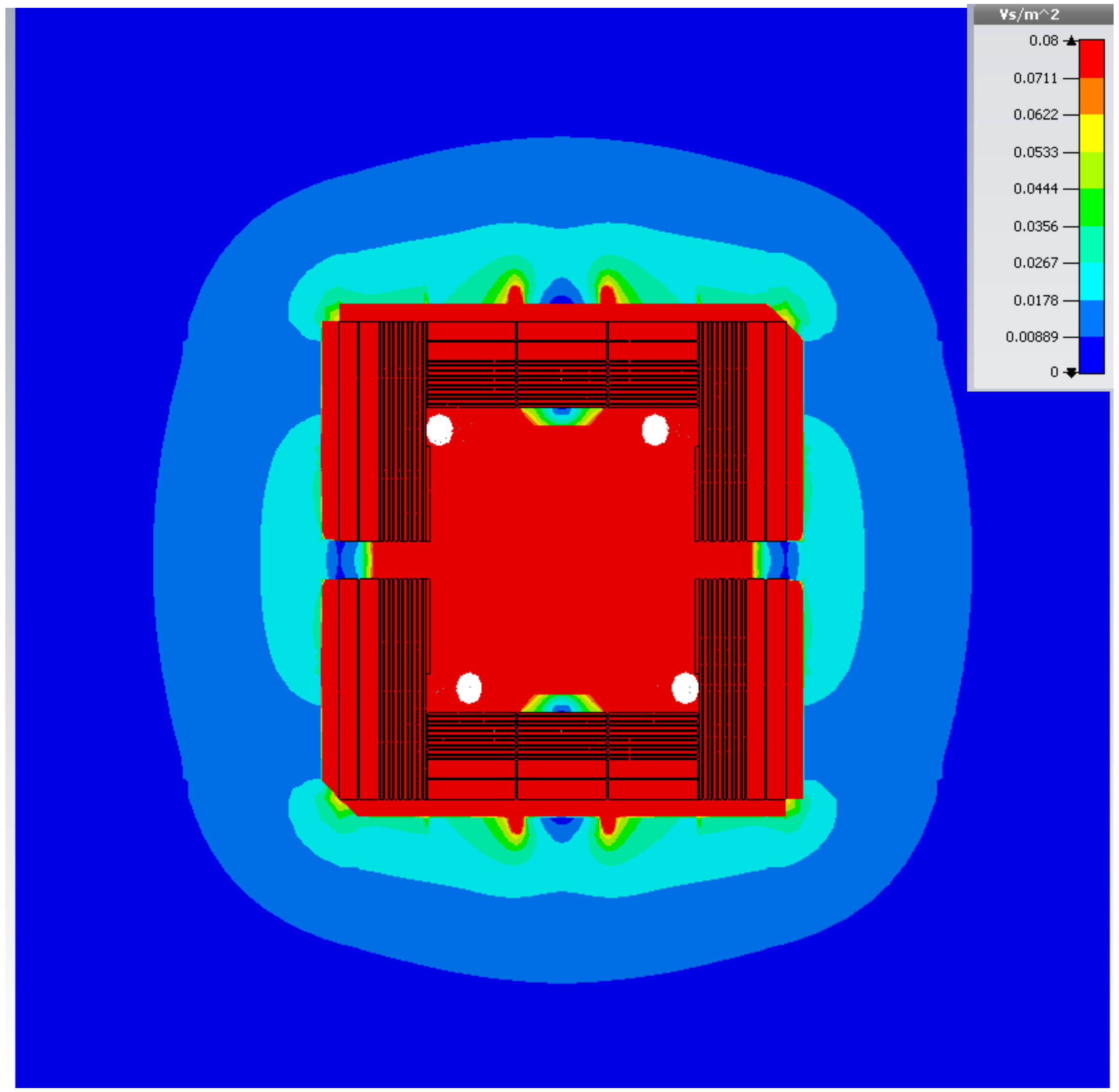
- Rather large fields directly outside of the yoke
  - drops rather sharply to less than 200G
  - slow drop to less than 50G at ~15m...

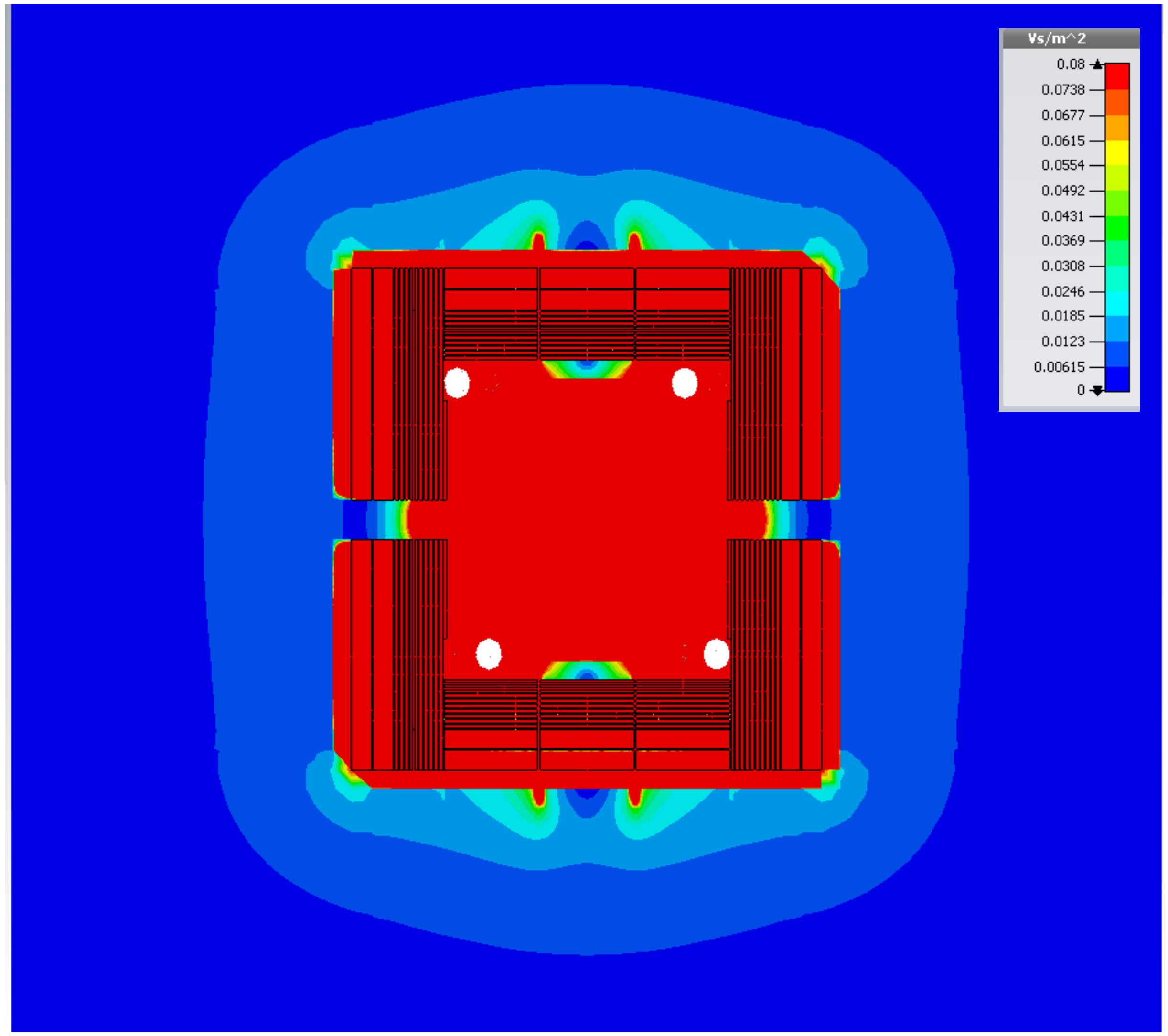


A. Petrov

ILD Magnetic Field Simulations

- Other options:
  - smaller yoke with 4T field (left) and 3.5T field (right)

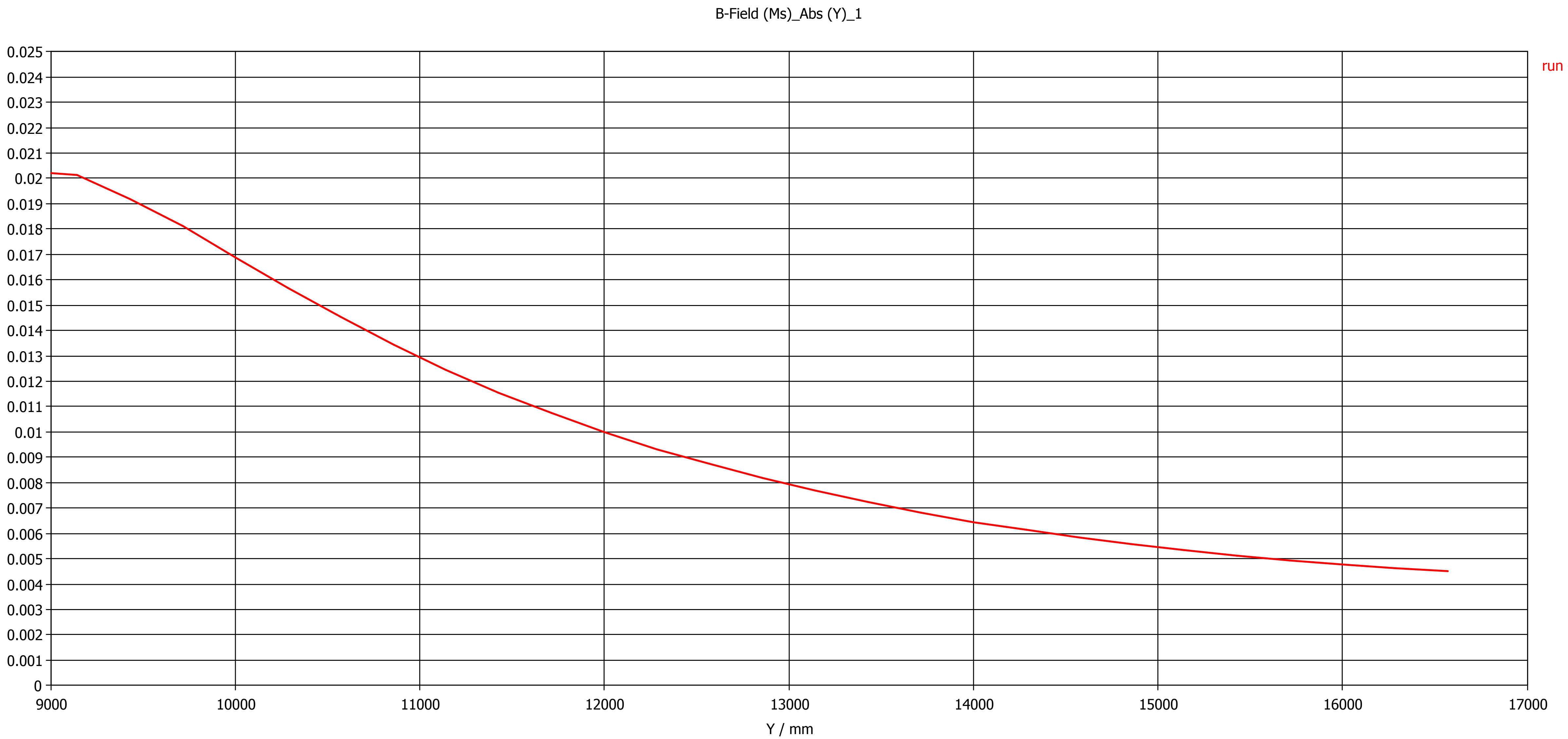




A. Petrov

ILD Magnetic Field Simulations

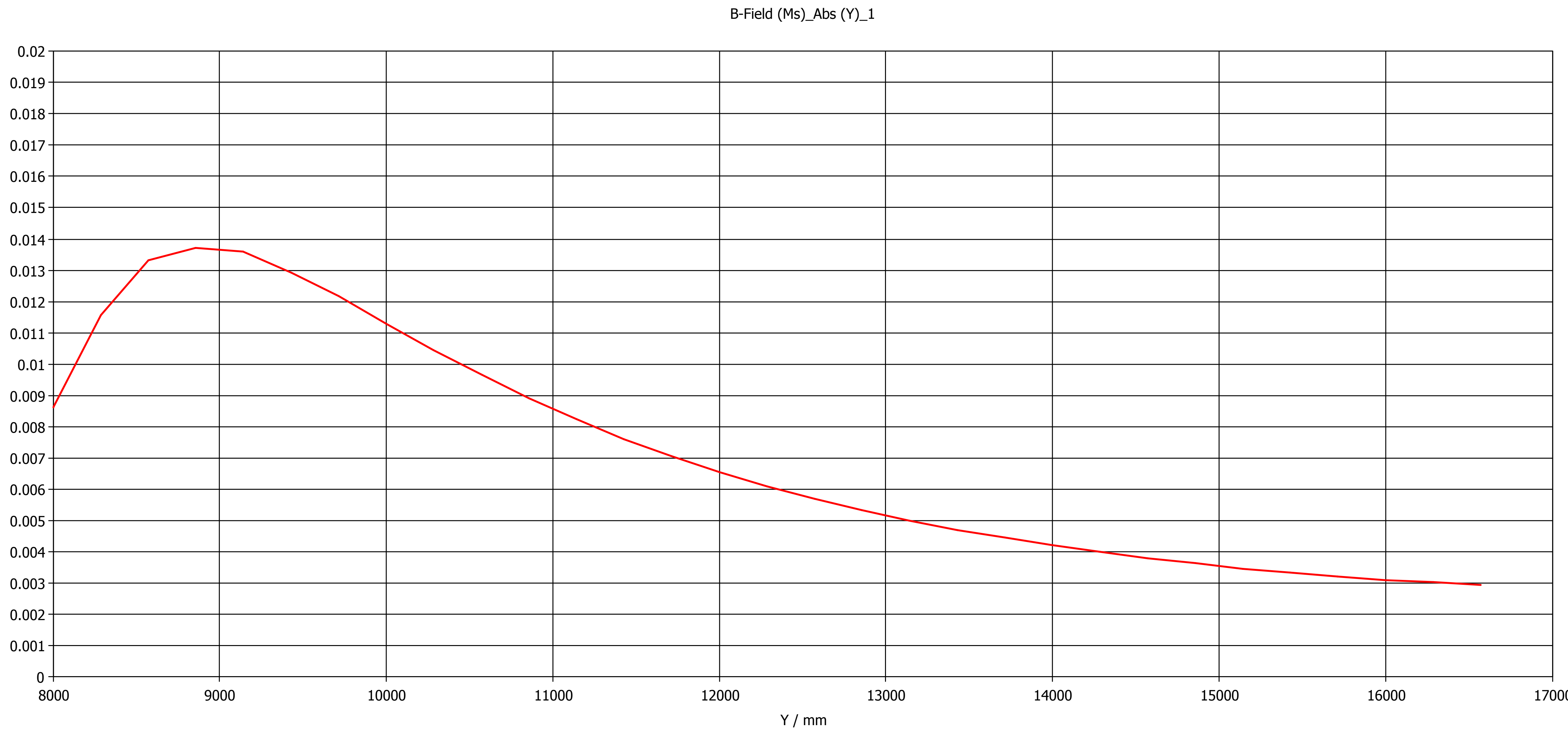
- Smaller Yoke, 4T:
  - ~55G at 15m



A. Petrov

ILD Magnetic Field Simulations

- Smaller Yoke, 3.5T:
  - >40G at 15m



A. Petrov

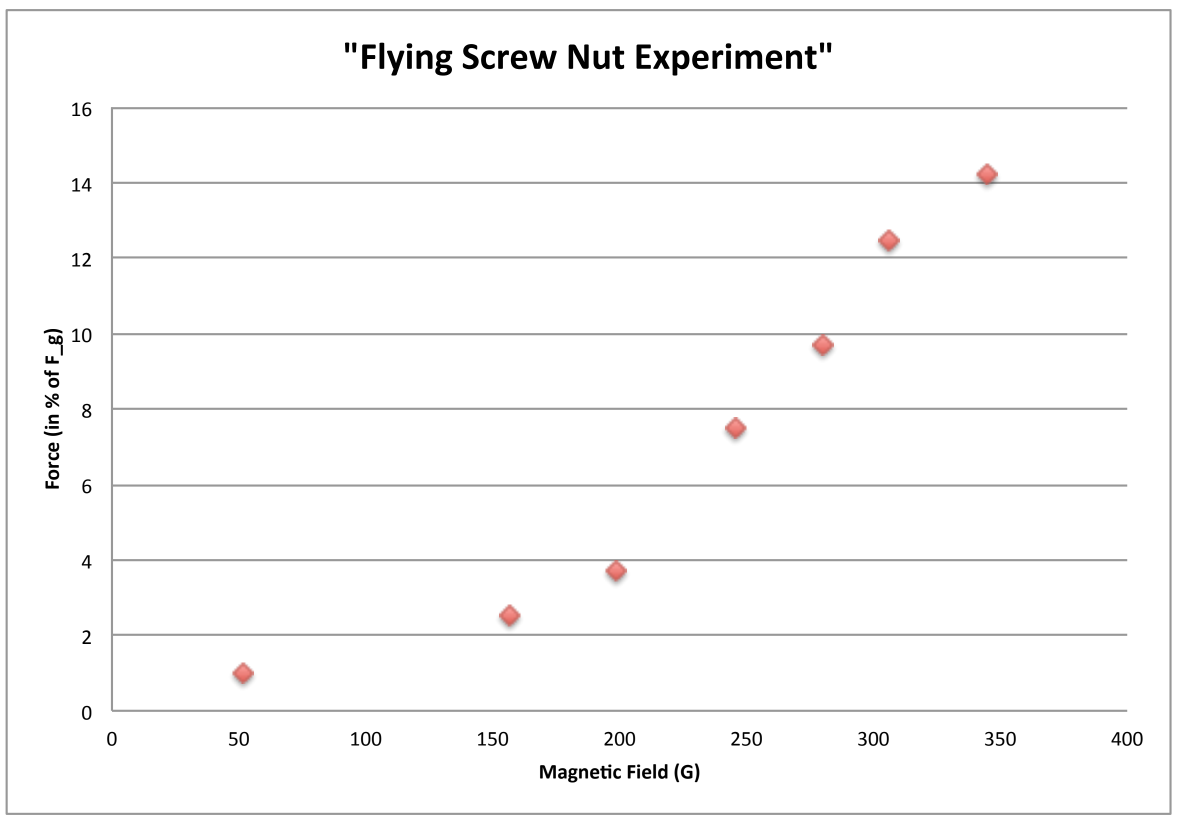
Caveat

- This is still preliminary
- Optimisation of simulation tool is rather difficult
  - many parameters for EM solver
  - long computing time
- Uncertainties of these numbers cannot be given at this time
  - can easily change results by ±20G (at 15m) by changing simulation mesh
- Need cross-checks with other tools
  - needed precision is at permill-level (compare 50G to 4T)...
  - can this be done with FEA based tools?

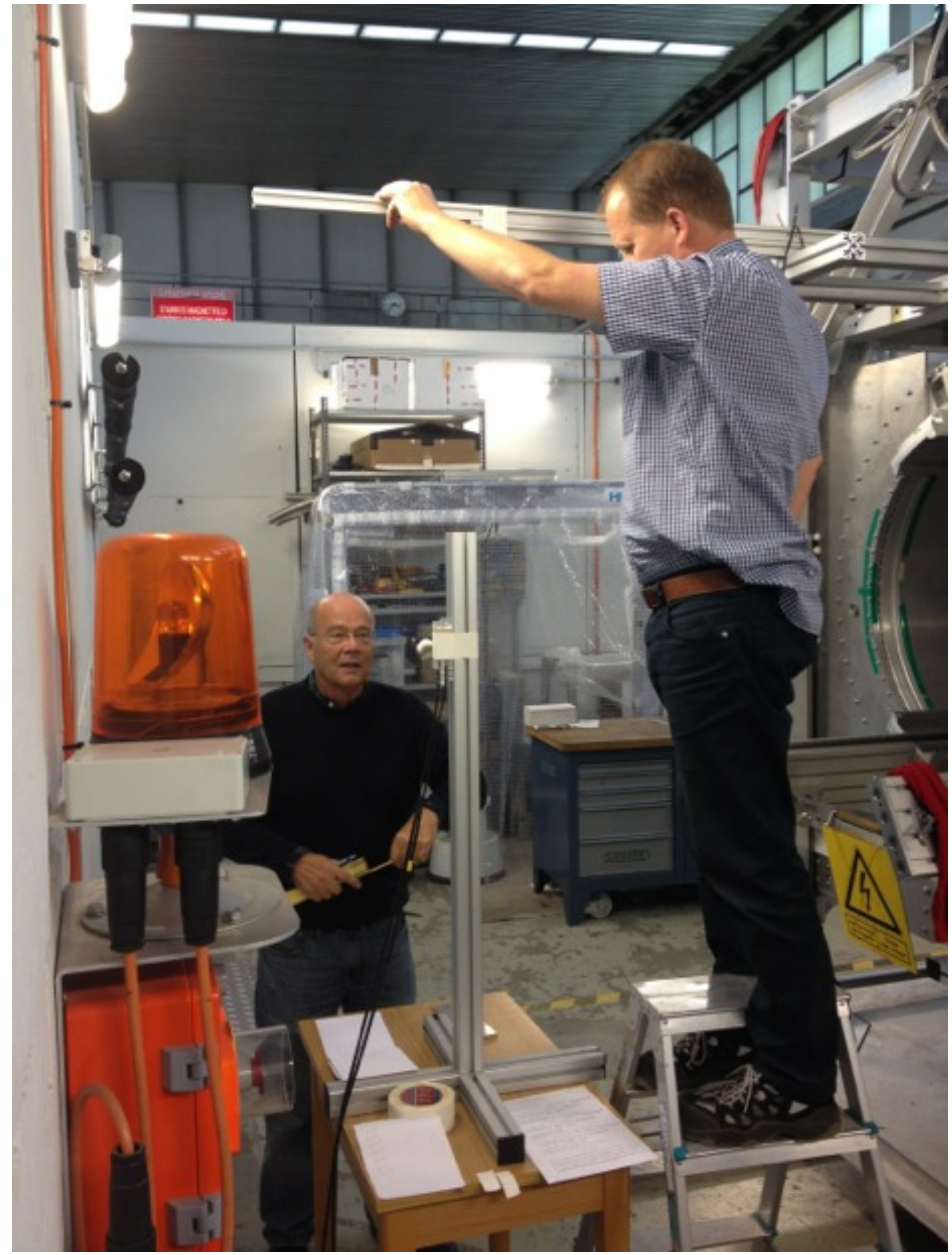
„The Flying Screw Nut Experiment“

The „Flying Screw Nut Experiment“

- Screw Nut: 108g
- PCMAG Solenoid: 1T central field
- Measured fringe fields in 50-300G range
- Determined magnetic fore on nut

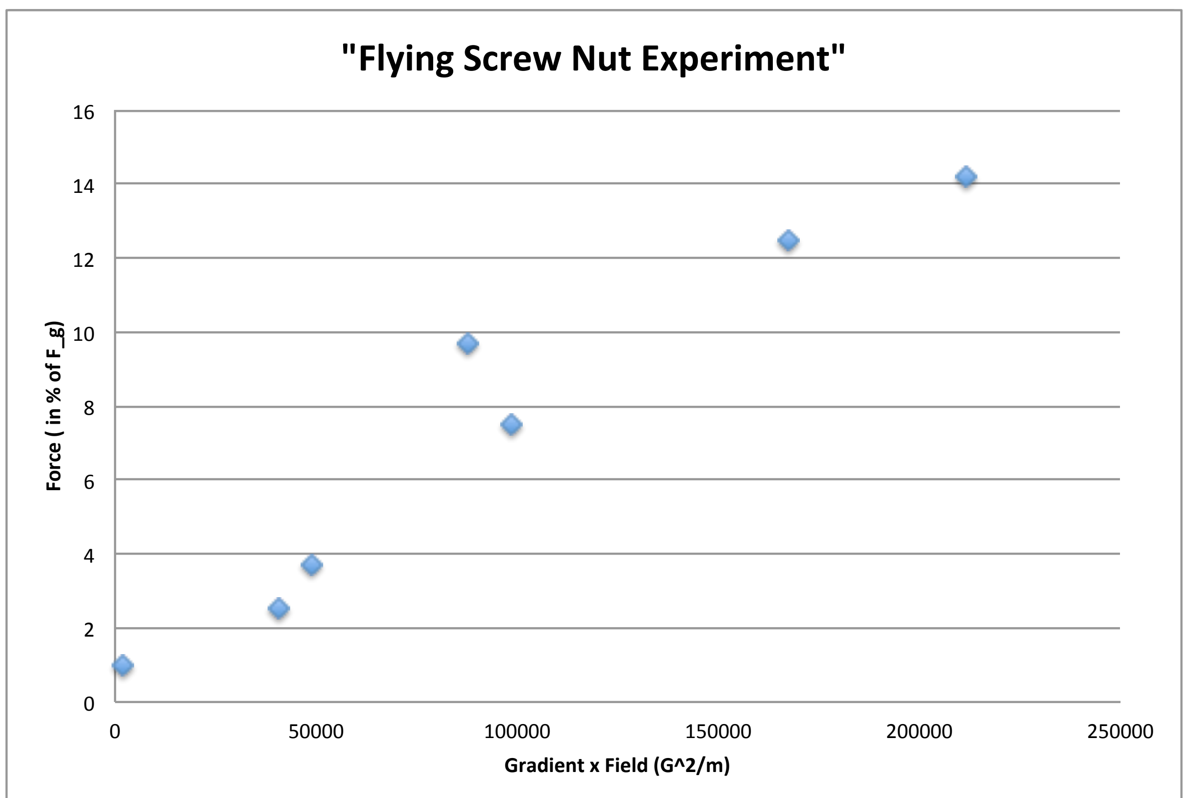


- Below 200G: magnetic force a few % of gravitational force
- Confirmation of CMS results: things get dangerous above 300G....

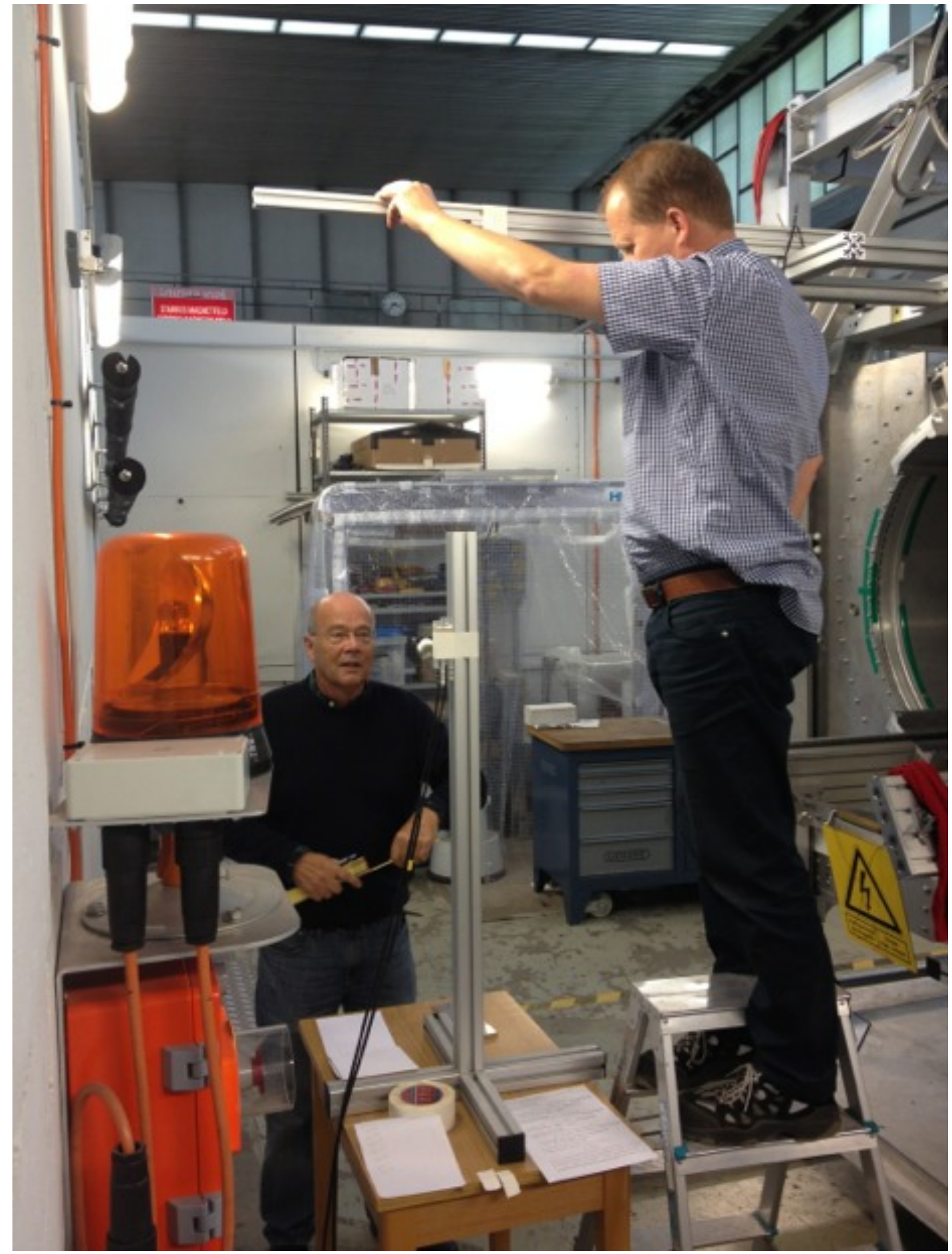


The „Flying Screw Nut Experiment“

- Screw Nut: 108g
- PCMAG Solenoid: 1T central field
- Measured fringe fields in 50-300G range
- Determined magnetic fore on nut



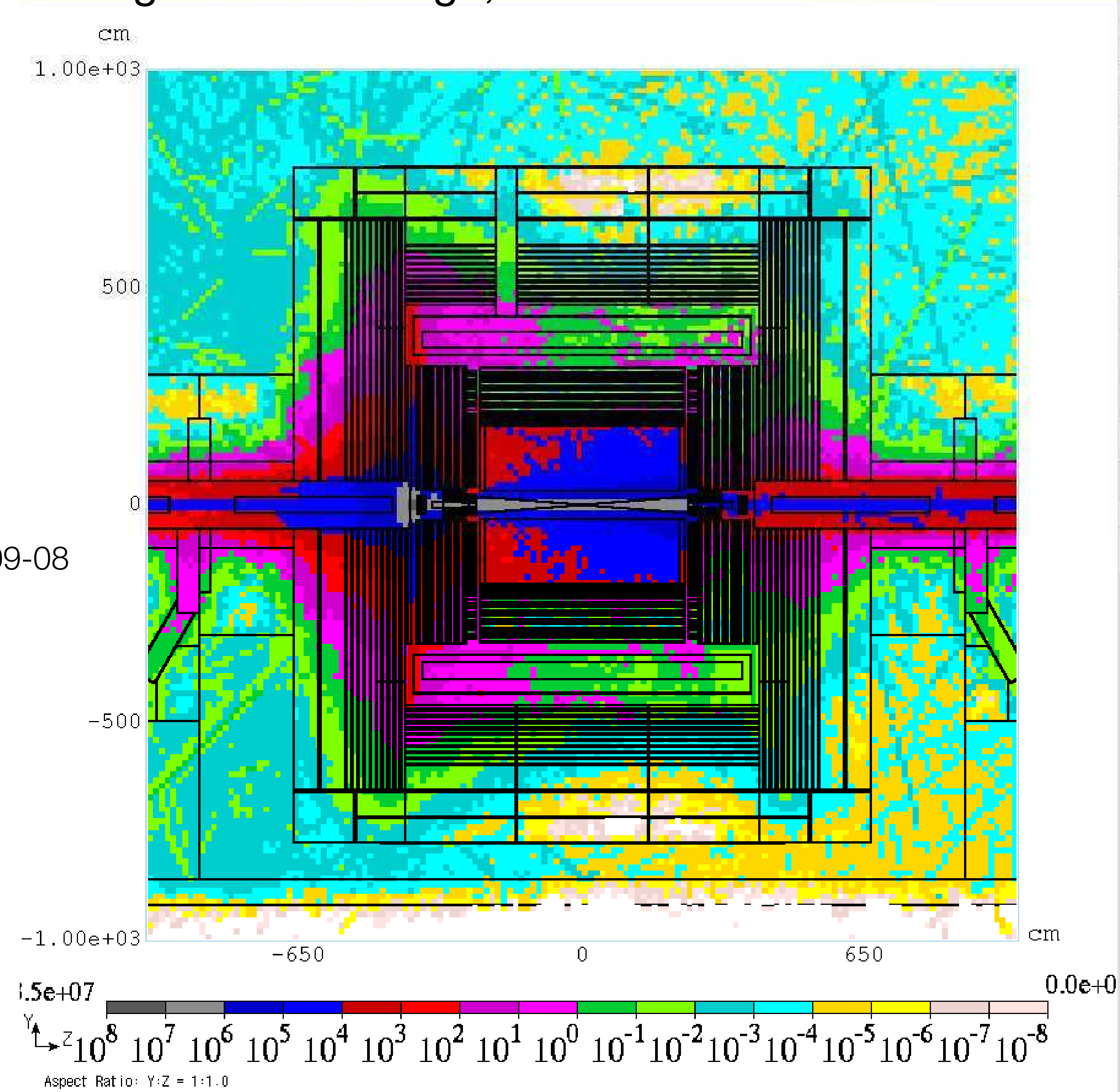
- Below 200G: magnetic force a few % of gravitational force
- Confirmation of CMS results: things get dangerous above 300G....



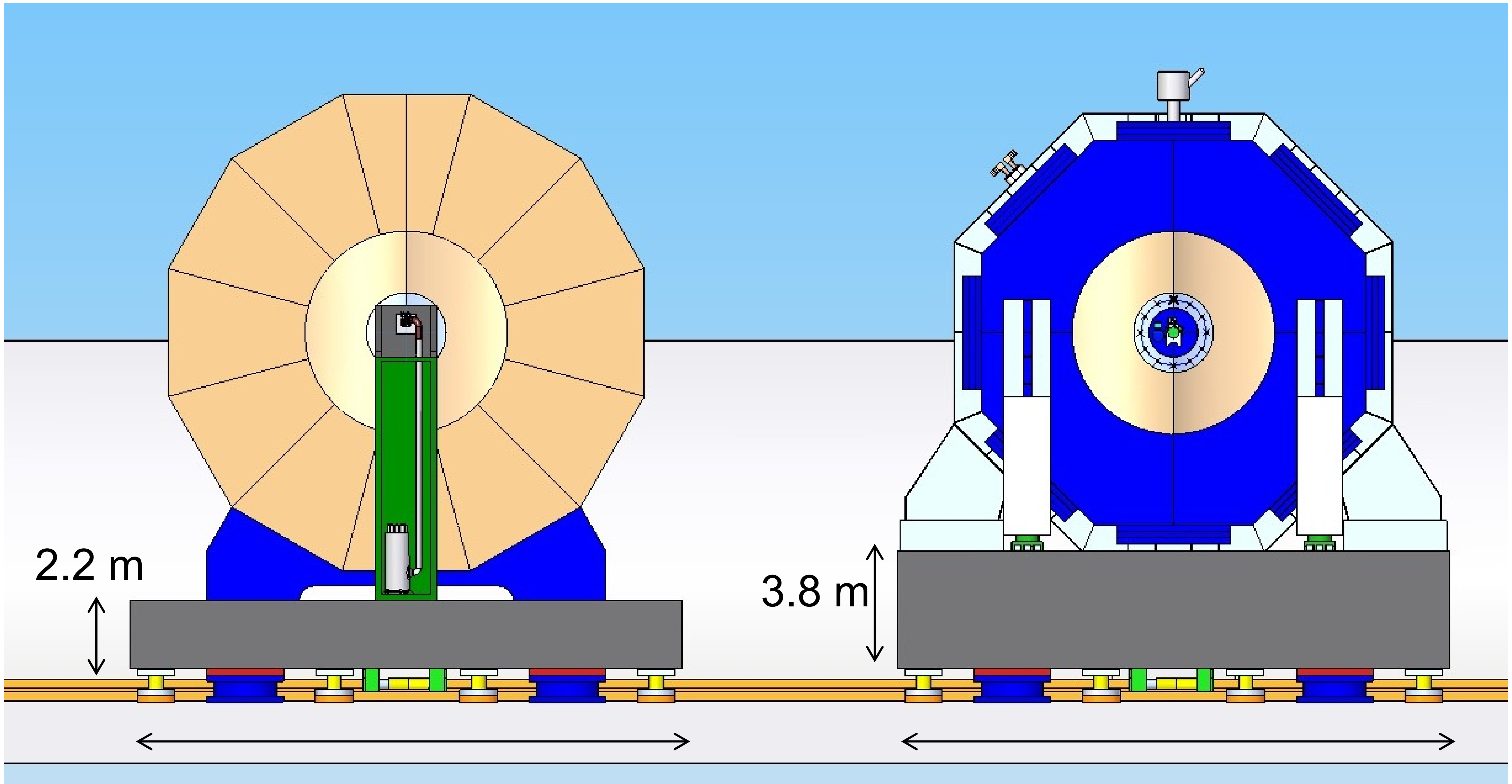
Interaction Region Radiation Shielding

- Detectors are self-shielding w.r.t. maximum credible beam loss scenarios
- If we really should change the ILD design, we need to re-check that!

Sanami et al., SLAC-RP-09-08

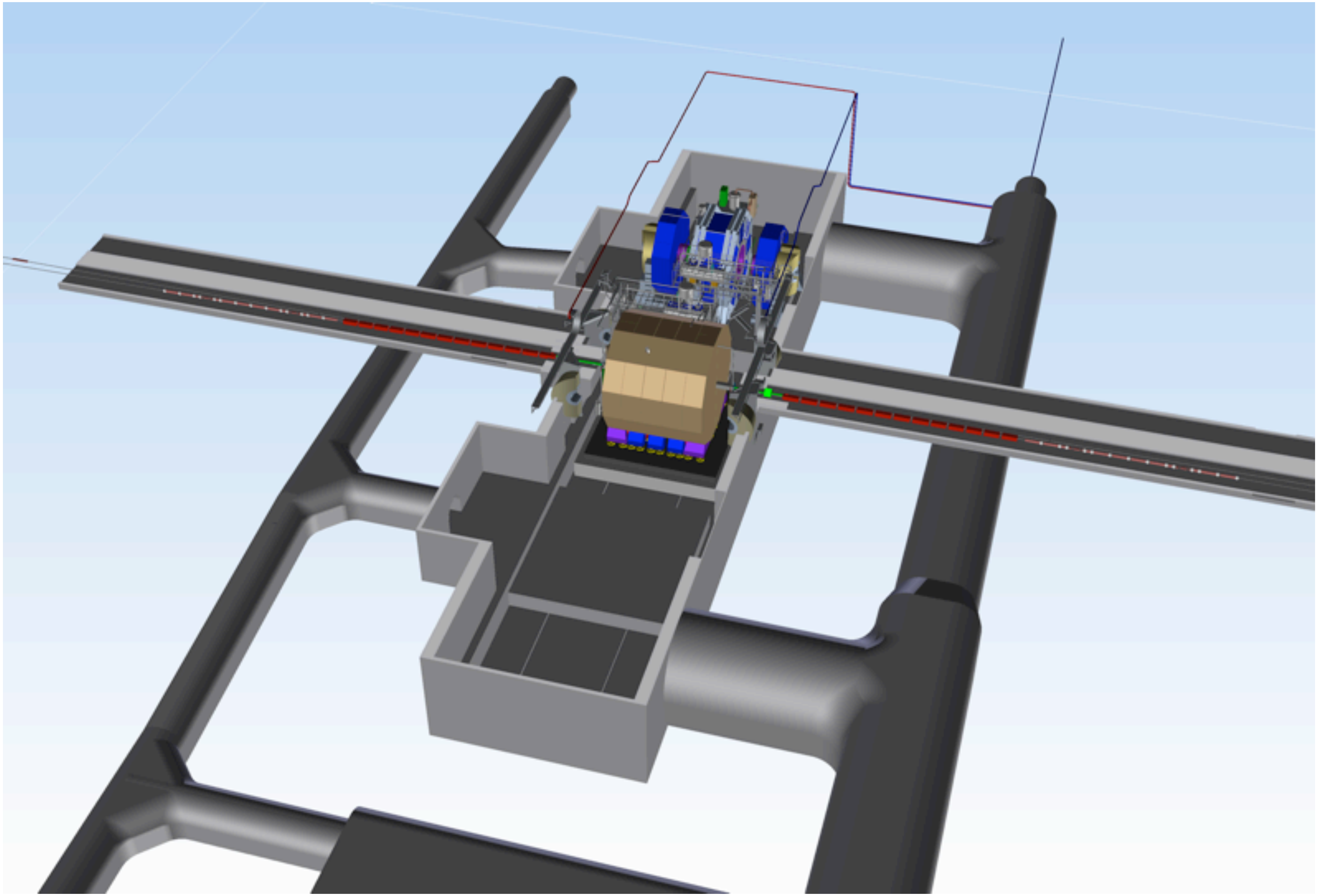


Platform Thickness



- Platform based detector motion system
- Large difference in platform thickness between ILD and SiD
- Did some work on reducing the feet height of ILD some time ago
  - reduction of iron in yoke would help...
  - need to re-visit this in context of earthquake protection

Underground Installation



Summary and Outlook

- ILD is undergoing another round of optimisations
- At the same time we now know the possible site
- We should take the time to re-visit some of the requirements for the IR design
  - needs negotiations with SiD and the machine!
- A possible relaxation of the 50G limit might save significant amount of steel in the yoke
  - less costly
  - better handling during installation phase in underground hall
- Do we need to stick with 4T as maximum field, or is 3.5T ok?
- This is only a very first look into this again, needs much more work
  - how precise are the simulations
  - are there other show-stoppers (e.g. radiation safety)?