ILC MDI Requirements

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LCWS13

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

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

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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.

- Now we have a site:
  - local regulations and realities might change the requirements!

2009 Requirements

- Final doublet issues
  - Moving QD0s
  - L* for QD0/QF1
  - Cryogenic requirements
  - Alignment and support
  - Vibration limits
- Definitions of push-pull times
  - roll-out, roll-in
- Vacuum
- Beam feedback systems
- Beam-beam parameters
- Underground hall geometries
  - position of garage location
  - distance between QF1s
  - beam height
- Radiation environment
  - depend on local regulations
- Magnetic field requirements
  - limits on fringe fields

- Need to re-check and identify missing items!

IR Engineering Specifications

Engineering Specifications (2) : Experimetnal Hall	RDR	SiD	SiD in Mtn. site	ILD	ILD in Mtn. site	Comments or notes
Parameters that define the underground hall volume						
IR Hall Area(m) ; (W x L)	25x120		25x142		25x142	Z-shape in EU and American sites, I-shape in Mtn. site
Beam height above IR hall floor (m)	8,6	9(7.5)	9(7.5)	9(8)	9	from top of the platform
IR Hall Crane Maximum Hook Height Needed(m)	20,5	5m above top of detector	5m above top of detector	20,5	20,5	
Largest Item to Lift in IR Hall (weight and dimensions)	400t	380t(HCAL)	380t(HCAL)	55t, 3x3x1.5m	400t	
IR Hall Crane	400t+2*20t	400t(200tx2)/10t	(215t+30t)x2	80t(40tx2)	(250t+30t)x2	
IR Hall Crane Clearance Above Hook to the roof (m)	14.5(includes arch)		15,8	6	15,8	
Utility caverns(m) ; (W x L xH)	40x15		77.5x15x13.5		77.5x15x13.5	
Resulted total size of the collider hall (W x L x H)	25x120x39	20.2x90x30	25x142x42	29x100x30	25x142x42	
Area at garage position		19x 55.5	25x50	with side cavern	25x50	
Parameters that define dimensions of the IR hall shaft and the shaft crane						
Largest Item; Heaviest item to Lower Through IR Shaft (weight and dimensions)	9x16m, 2000t	3287t (Barrel Iron)	-	3500t, 15.7x7.81m	-	
IR Shaft Size : diameter(m)	16	18, 8	-	18, 10	-	
IR shaft fixed surface gantry crane. If rented, duration	1.5 years	1.5 years	-	1.5 years	-	
Surface hall crane should serve IR shaft	Yes	Yes	-	Yes	-	
Other shafts near IR hall for access	No	Yes	-	No	-	
Elevator and stares in collider hall shaft	Yes	?	-	Yes	-	
Size of access tunnel at Mtn. site (W x H, m)	-	-	11x9	-	11x11	cable racks in the access tunnel, e.g. Air duct,
Inclination of access tunnel at Mtn. site (%)	-	-	< 7	-	< 7	
Length of access tunnel at Mtn. site (km)	-	-	1,5	-	1,5	
Parameters that define dimensions of the surface assembly building and its crane						
Surface Assembly Building Area ((W x L , m)	25 x 100 / detector	200x200		30x60	27x100 / detector	
Largest Item to Lift in SurfAsm. Bldg. (weight and dimensions)	400t	380t(HCAL)	$(125+\alpha)$t, 6.79 ϕ x6.066	180t	400t, 8.6 ϕ x8 (solenoid)	
Surface Assembly Crane	400t+2*20t	400t(200tx2)/10t	400t(200tx2)/10t	2x80t	(200t+20t)x2	same as in the hall
SurfAsm. Crane Maximum Hook Height Needed(m)	18	20	20	19	20,5	
SurfAsm. Crane Clearance Above Hook to the roof (m)	7			5m to ceiling	6,5	
Resulted volume of surface assembly building (W x L x H, m)	25 x 100 x 25			30x60x24	27x200x27	area is the main parameter
Parameters that define crane access area and clearance around detector						
SurfAsm. crane accessible area (needed) / available (W x L, m)	20 x 102	200 x 200	200 x 200	28x56		SID's very preliminary
IR hall crane accessible area (needed) / available (W x L, m)	22 x 98		18x98	28x41	18x98	
Maximum Detector Height(m)		16,15	16,15	15,74	15,74	
Detector Width (m)		18.53(14.334)	18.53(14.334)	15,665	15,665	
Minimum Detector Clearance (W x L x H, m)		12.4x11.2x12.4	12.4x11.2x12.4	15.67x13.26x15.74	15.67x13.26x15.74	from LoI
FILL IN OTHER IMPORTANT PARAMETERS WHICH ARE MISSING						
Maximum AC power (MW)	-					540KW/exp
Temerature control (^{o}C)	-					
Humidity control (%)	-					
Sump Pump Control System (ground water)	-					
Cryogenics system : 4K He liquefier and large dewar	-	same level as the coil	same level as the coil	service cavern	service cavern	the liqufier will be mounted at the same level as the top of the solenoid.
Dump registor	-	on the detector	on the detector	service cavern	service cavern	damp resister can be als0 at the side wall

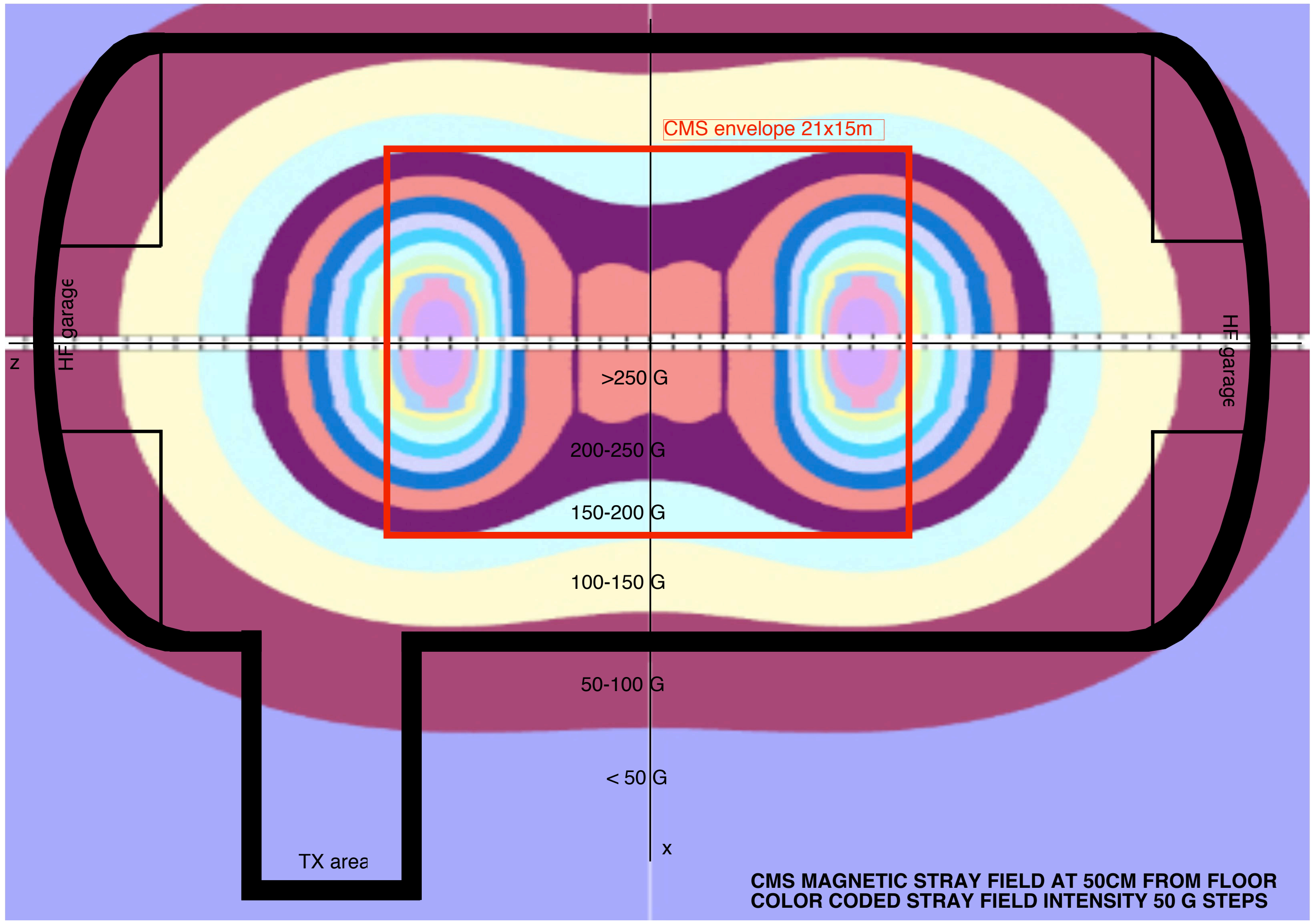
Example: Magnetic Field Requirements

- 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
    - Reduce difference in platform heights (ILD/SiD)

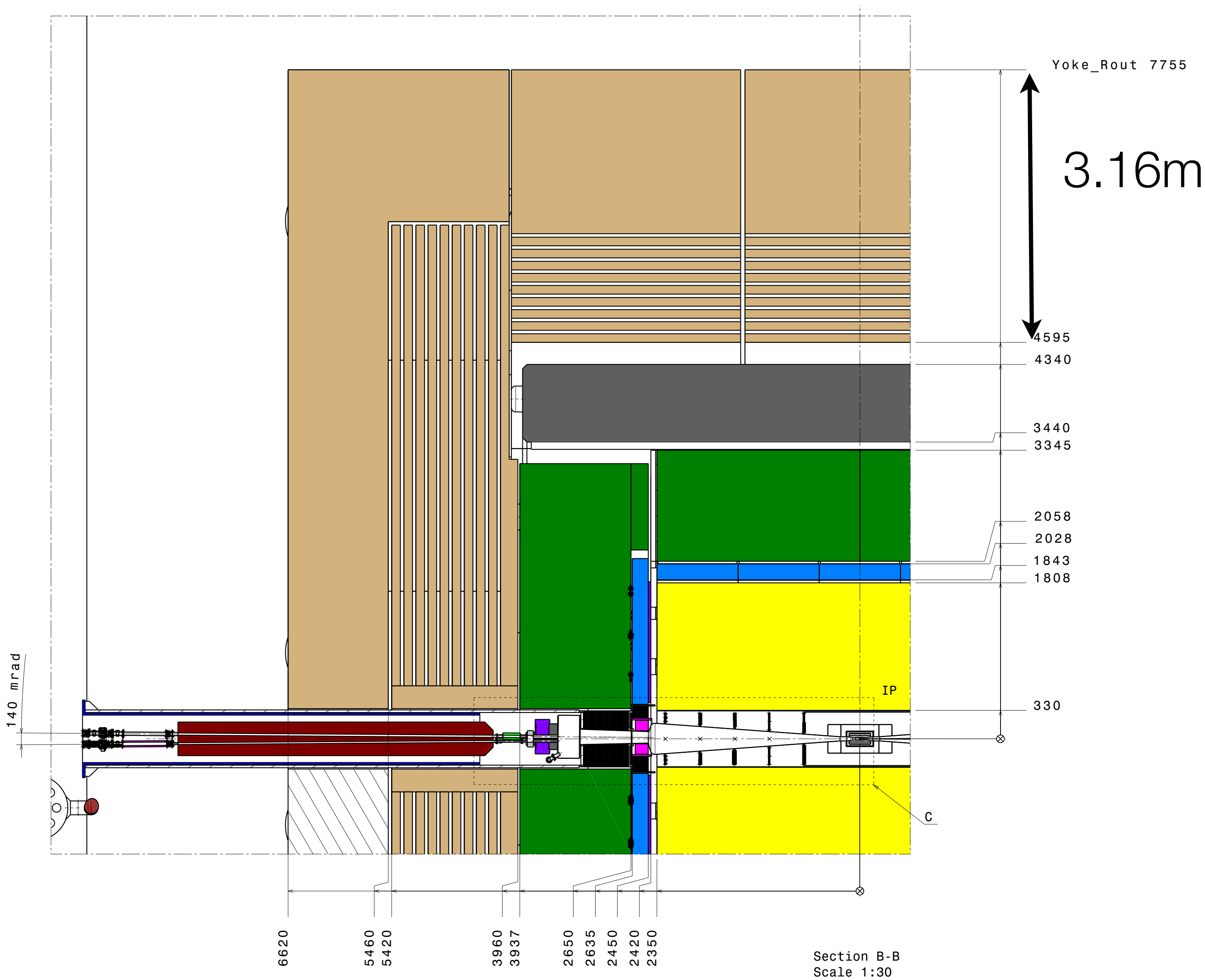
- NB: I do NOT suggest to change this requirement now
- But we should have a closer look at the old requirements in view of the given conditions at a possible Japanese site
- NB: Maybe we find even other requirements that make our life harder...

CMS Experience on Magnetic Fields

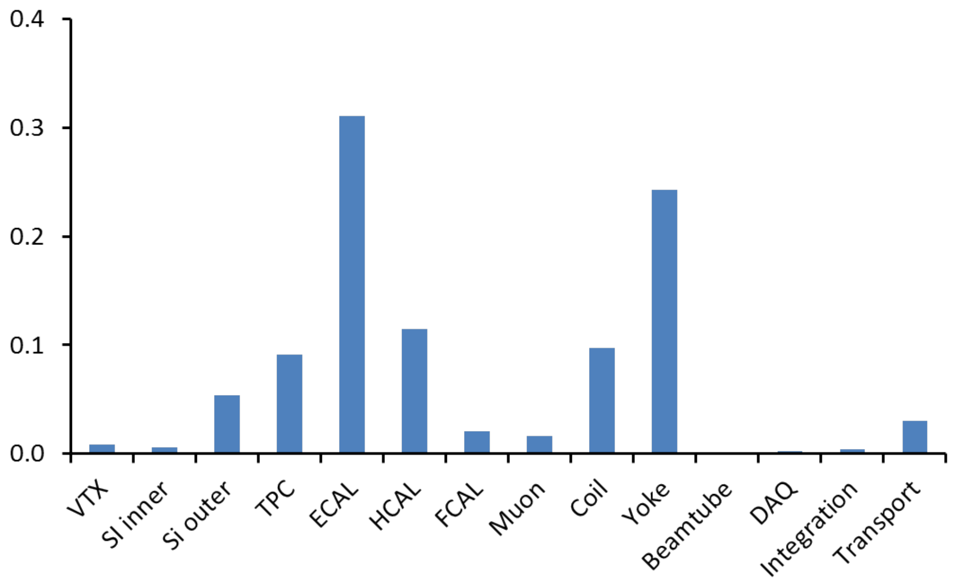
- From „Mechanical Works in Magnetic Stray Fields“ (A. Gaddi, CERN EDMS No 973739)
- Tests performed in CMS hall while magnet (4T) was on
- Below 50G:
  - no special precaution, standard workshop tools and procedures
- 50 to 150G:
  - more and more difficult, use of non-magnetic tools mandatory
- Over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



ILD Iron Yoke



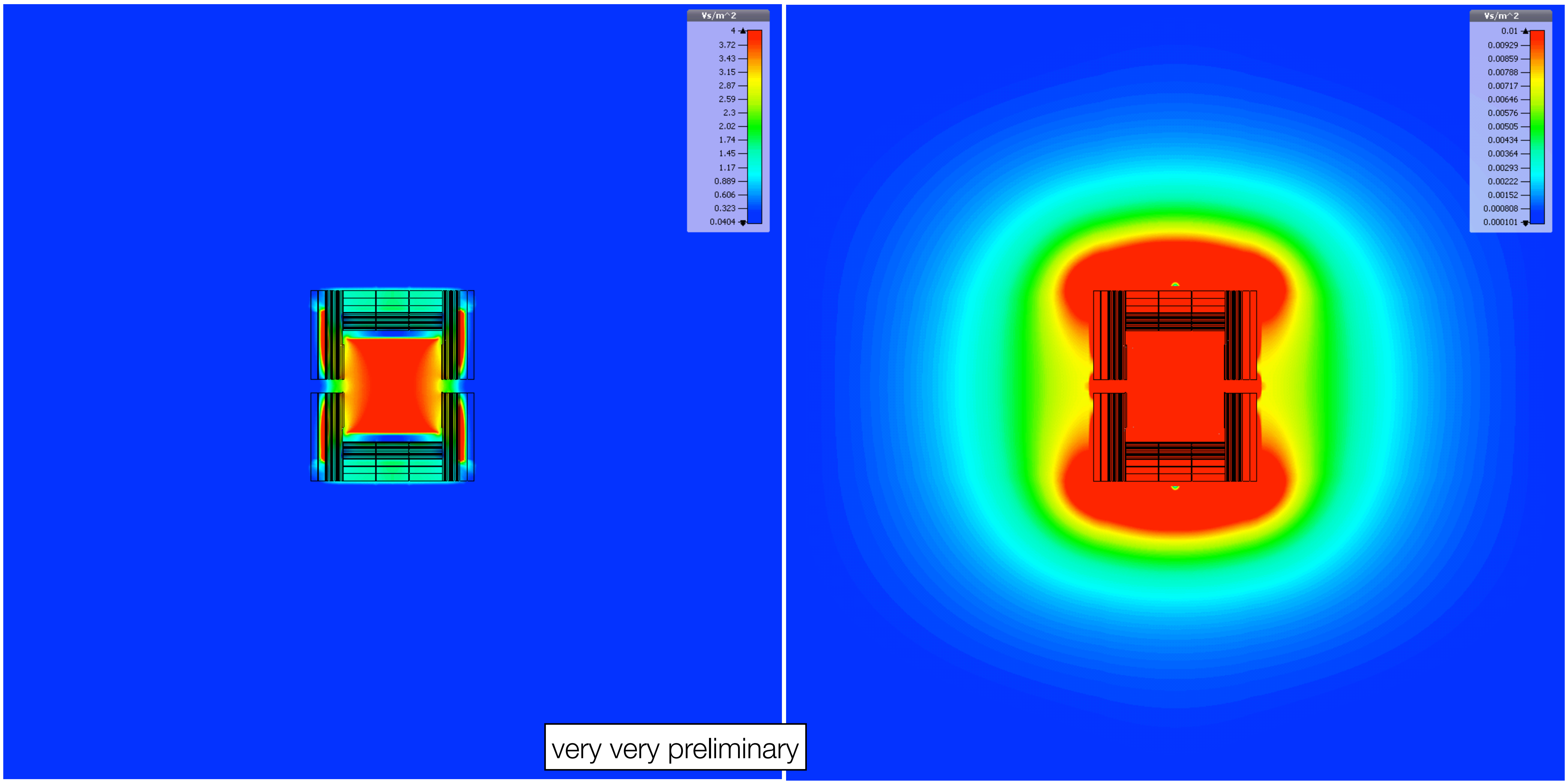
- Total cost of yoke:
  - 95 MILCU
  - 80 MILCU for steel and machining



- A reduction of the iron could save a lot

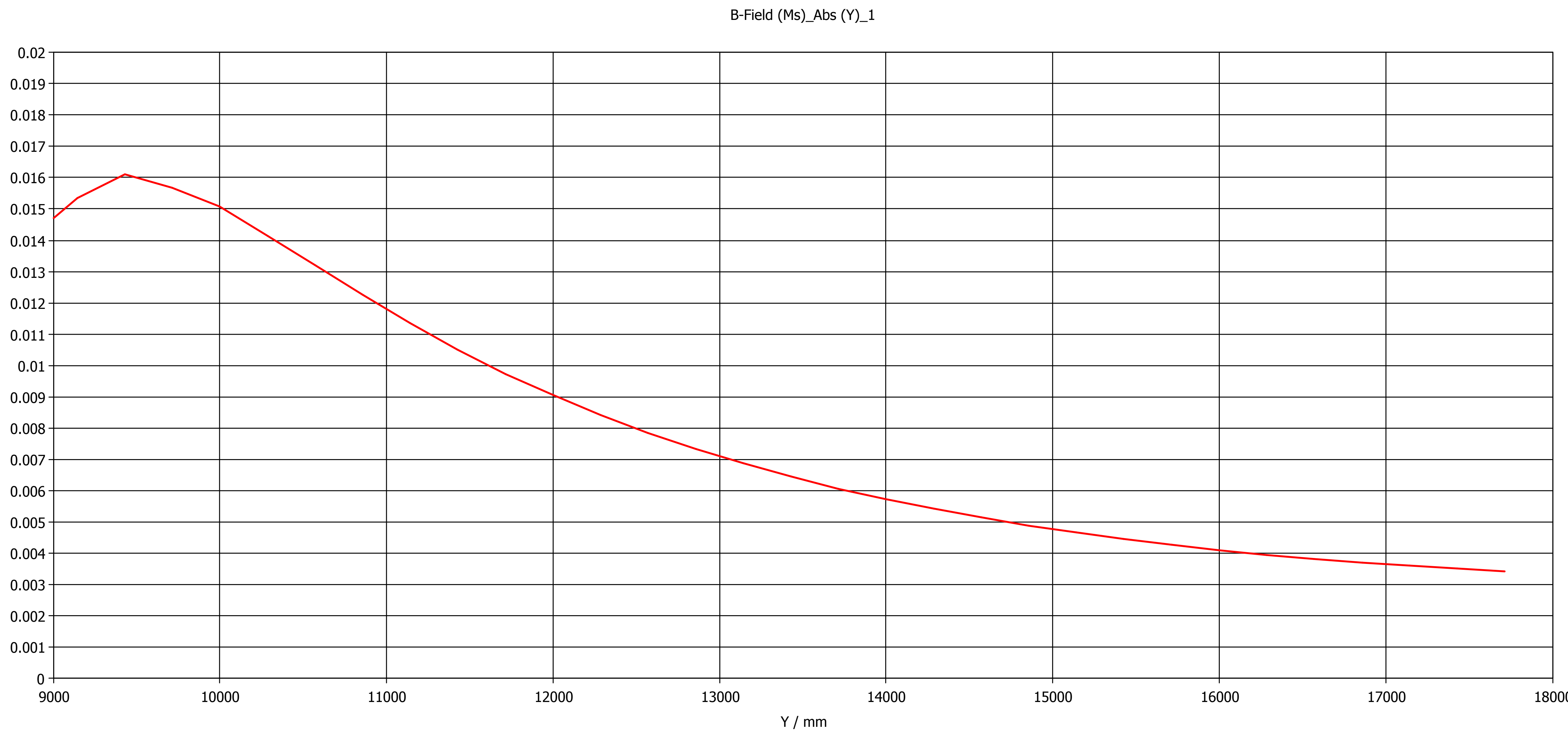
ILD Magnetic Field Simulations

- CST EM Studio



Magnetic Field Along Y-Axis

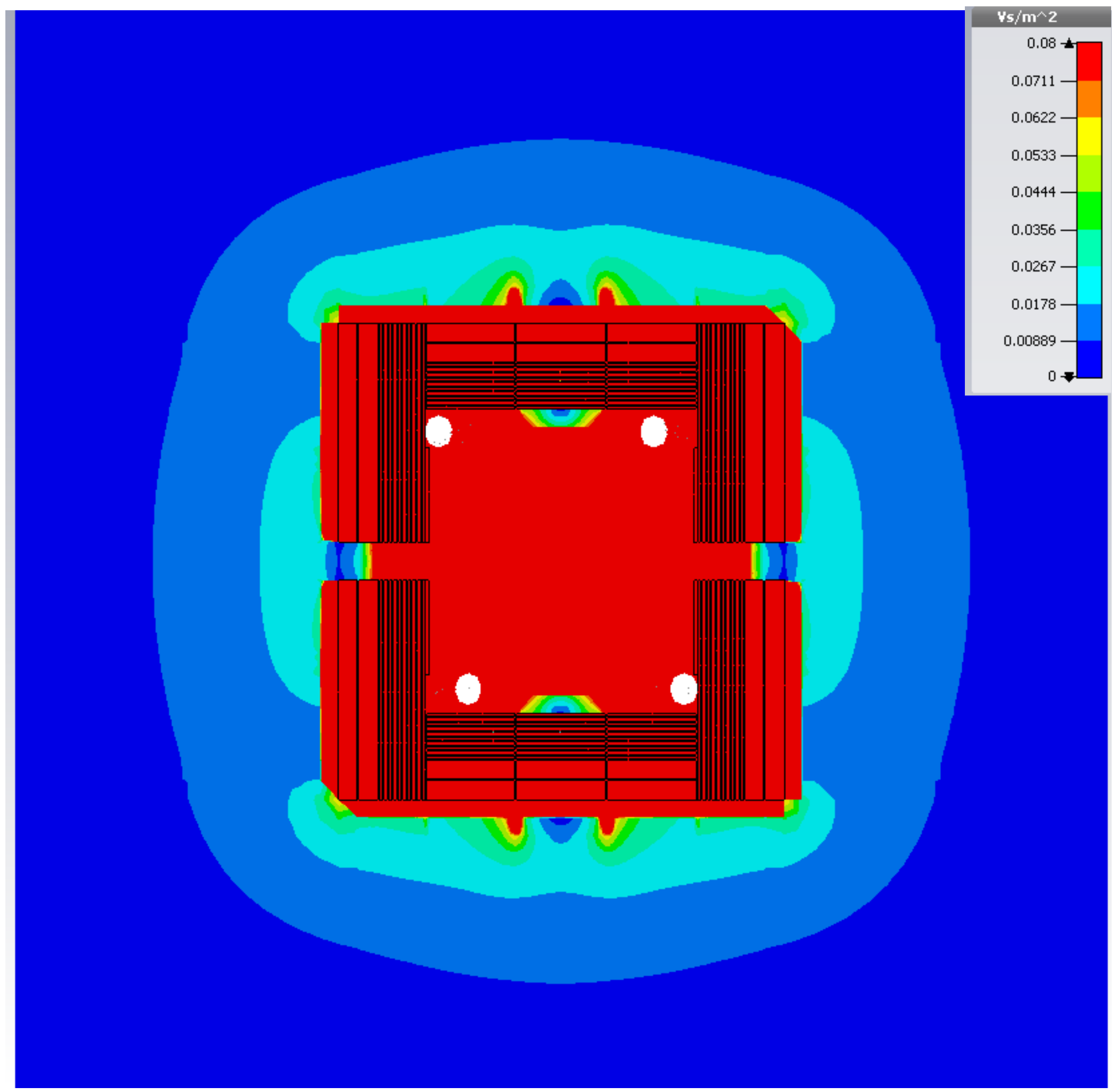
- Rather large fields directly outside of the yoke
  - drops rather sharply to less than 200G
  - slow drop to less than 50G at ~15m...

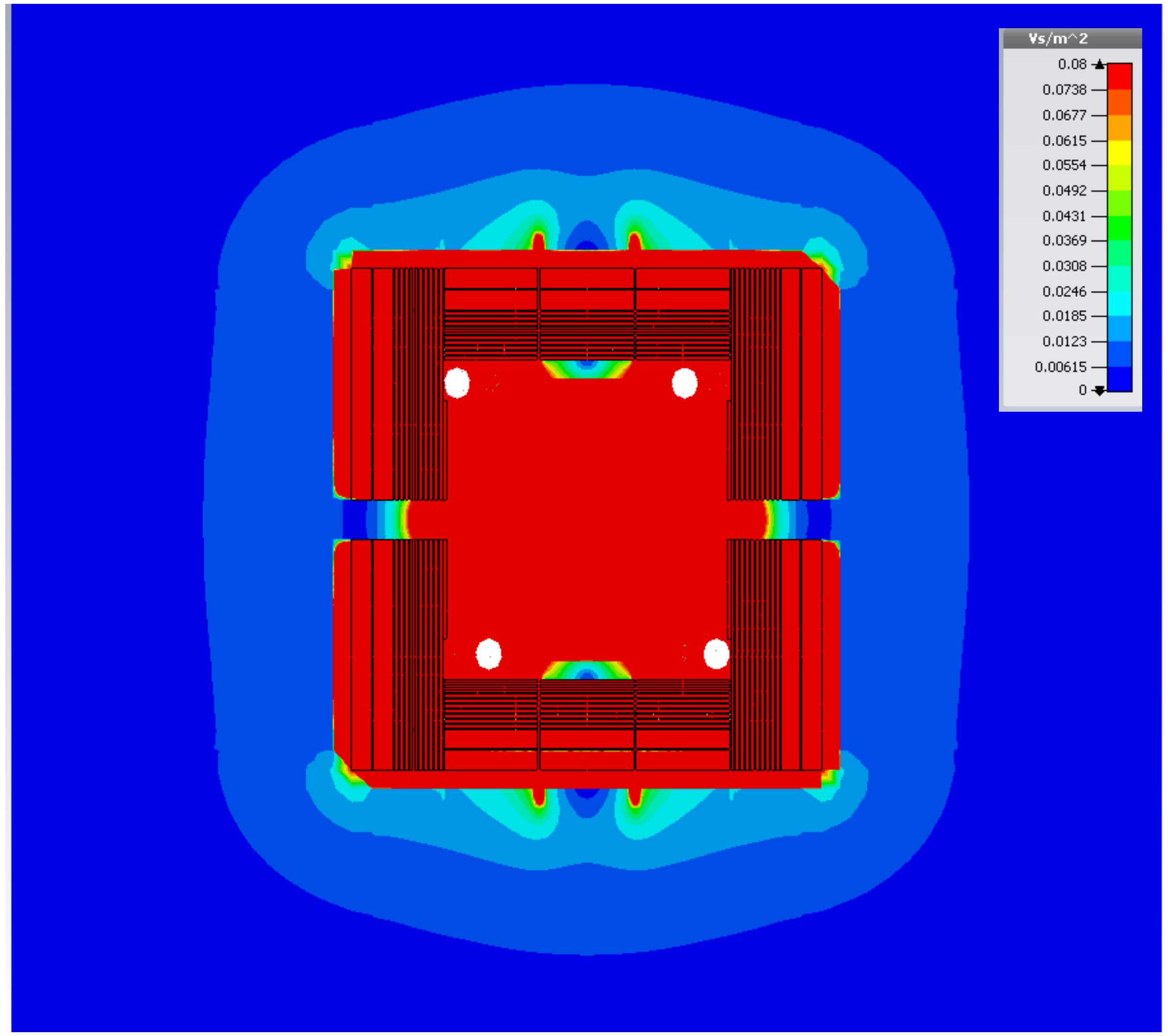


A. Petrov

ILD Magnetic Field Simulations

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





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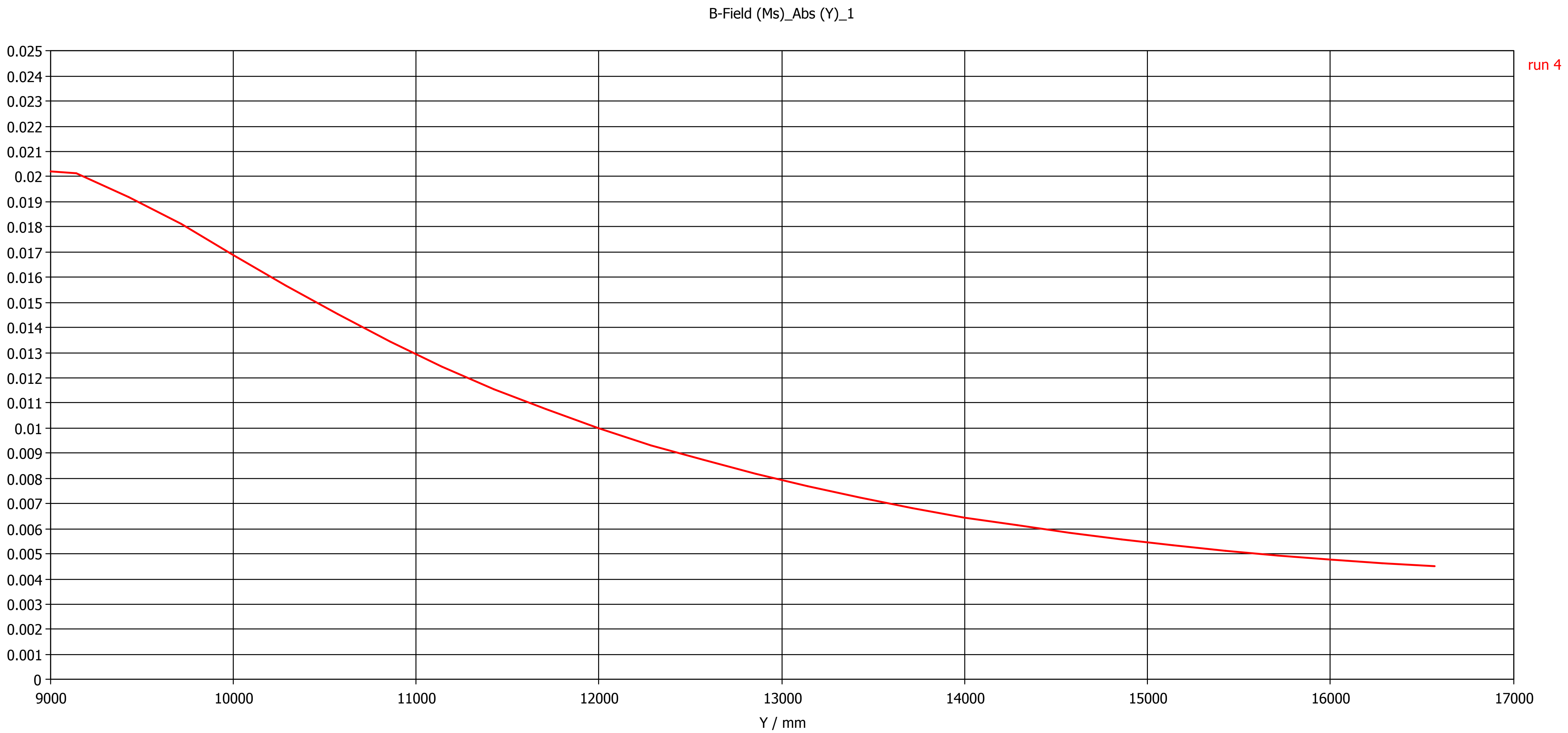
ILD Magnetic Field Simulations

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



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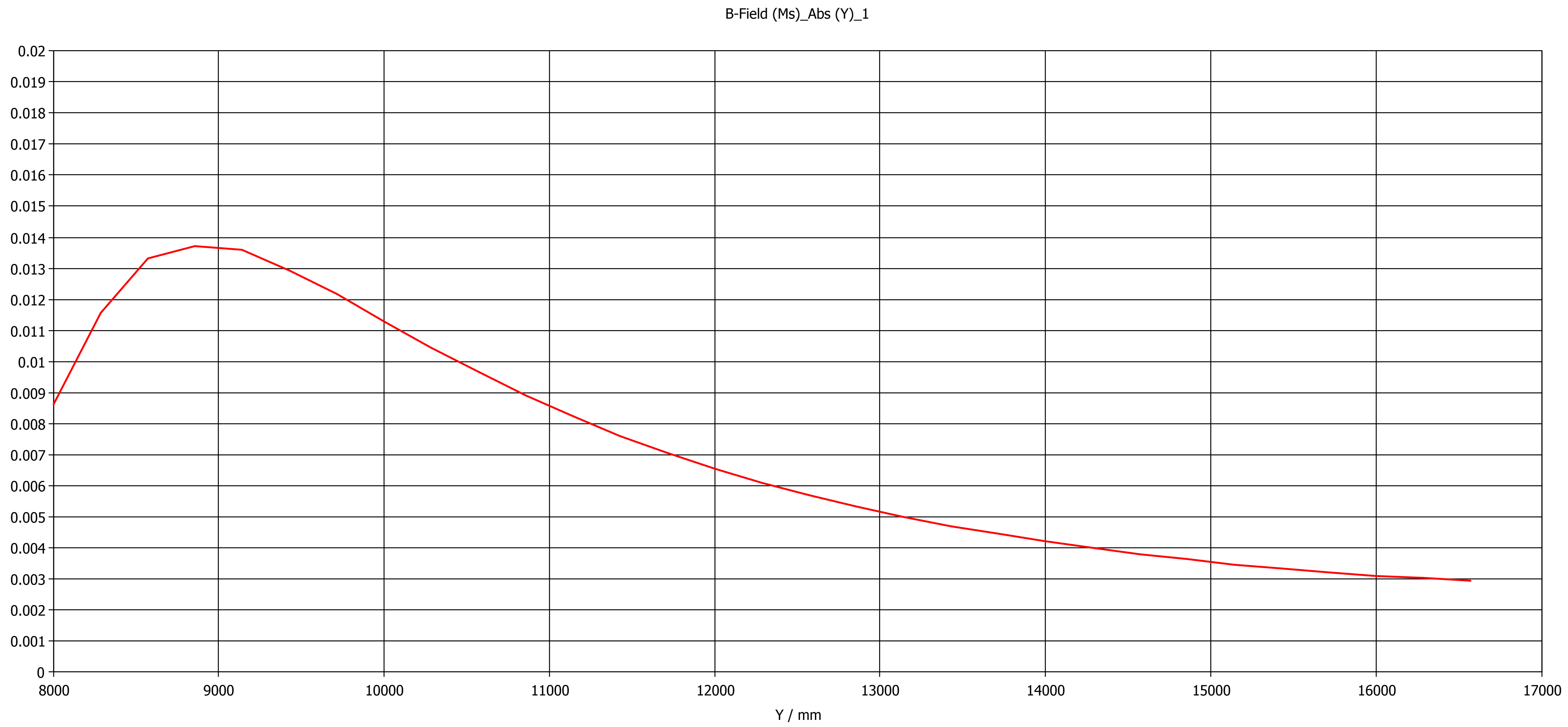
ILD Magnetic Field Simulations

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



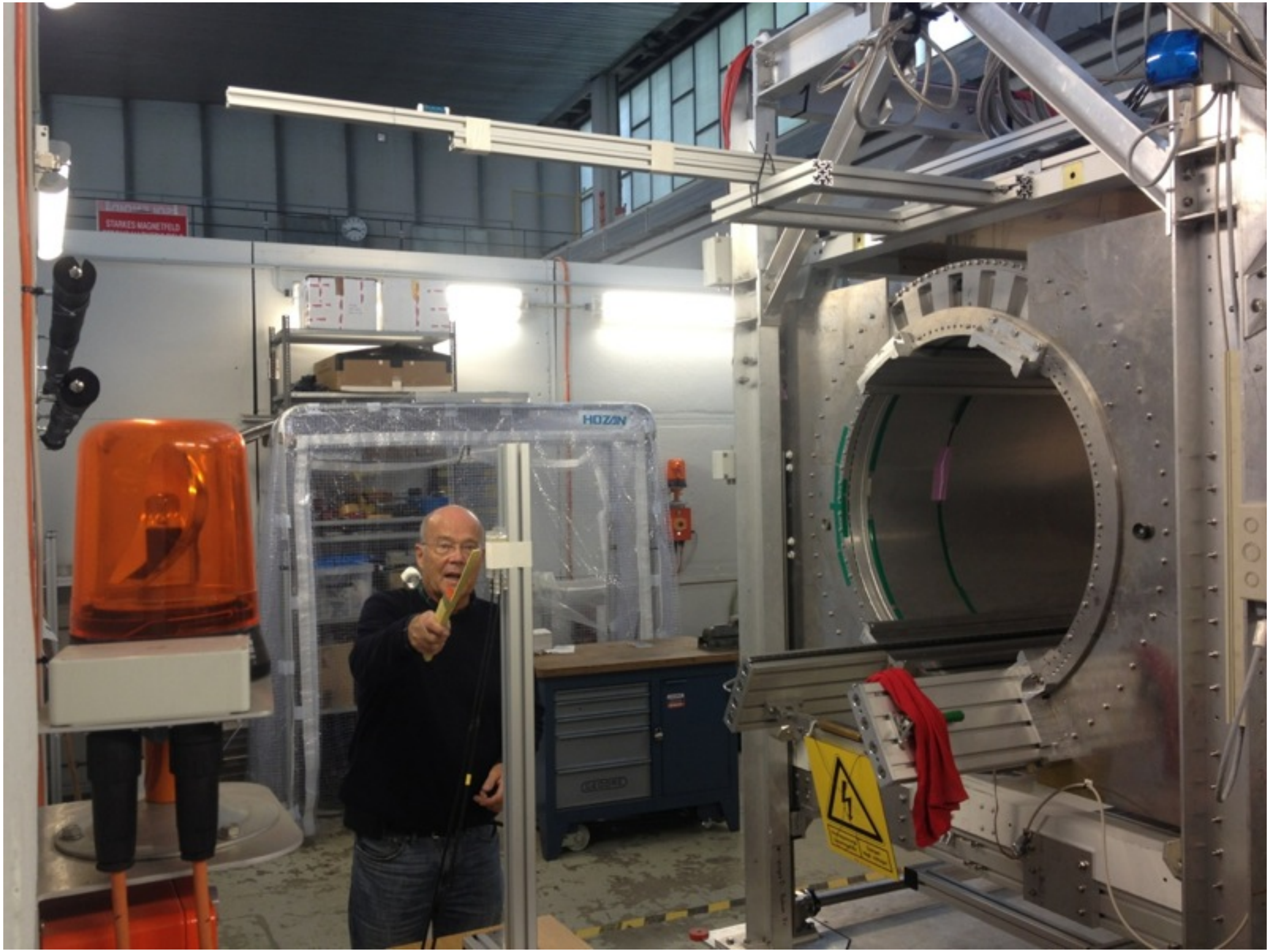
A. Petrov

Caveat

- This is still preliminary

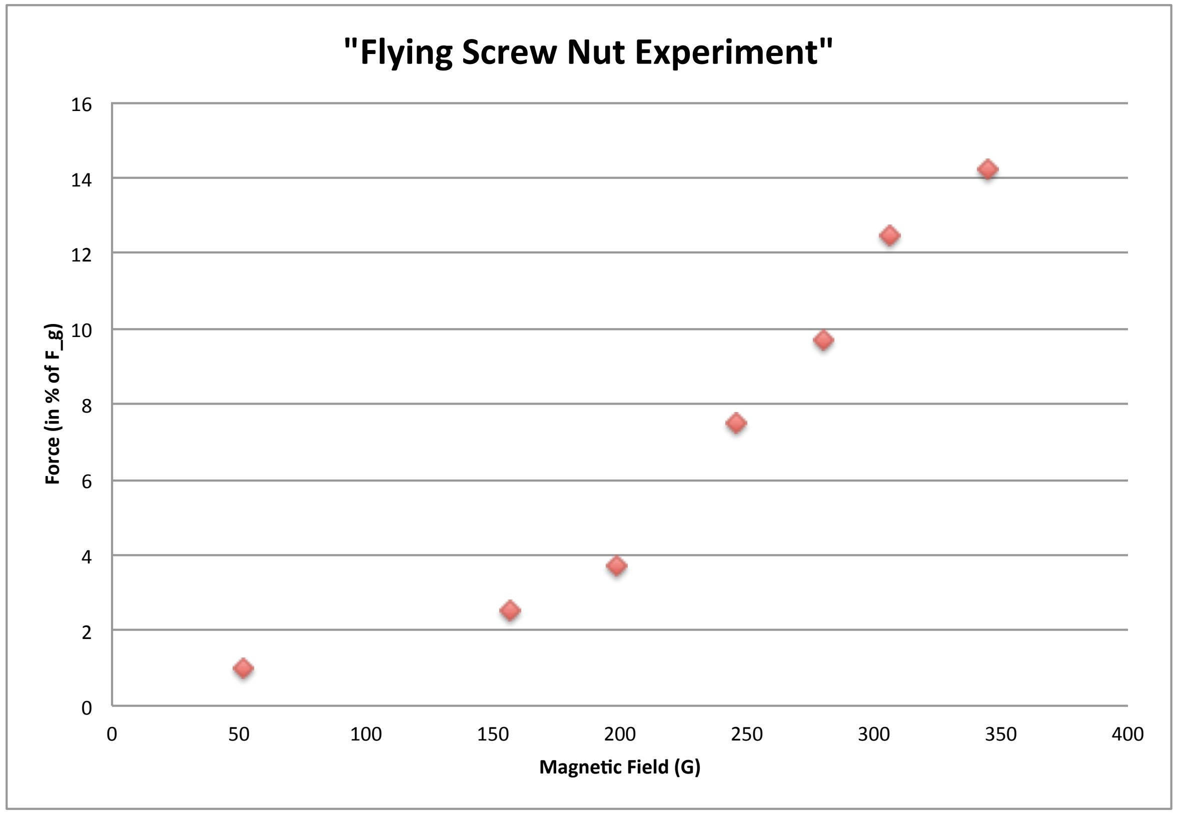
- Optimisation of simulation tool is rather difficult
  - many parameters for EM solver
  - long computing time
- Uncertainties of these numbers cannot be given at this time
  - can easily change results by ± tens of G (at 15m) by changing simulation mesh
- Need cross-checks with other tools
  - needed 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....

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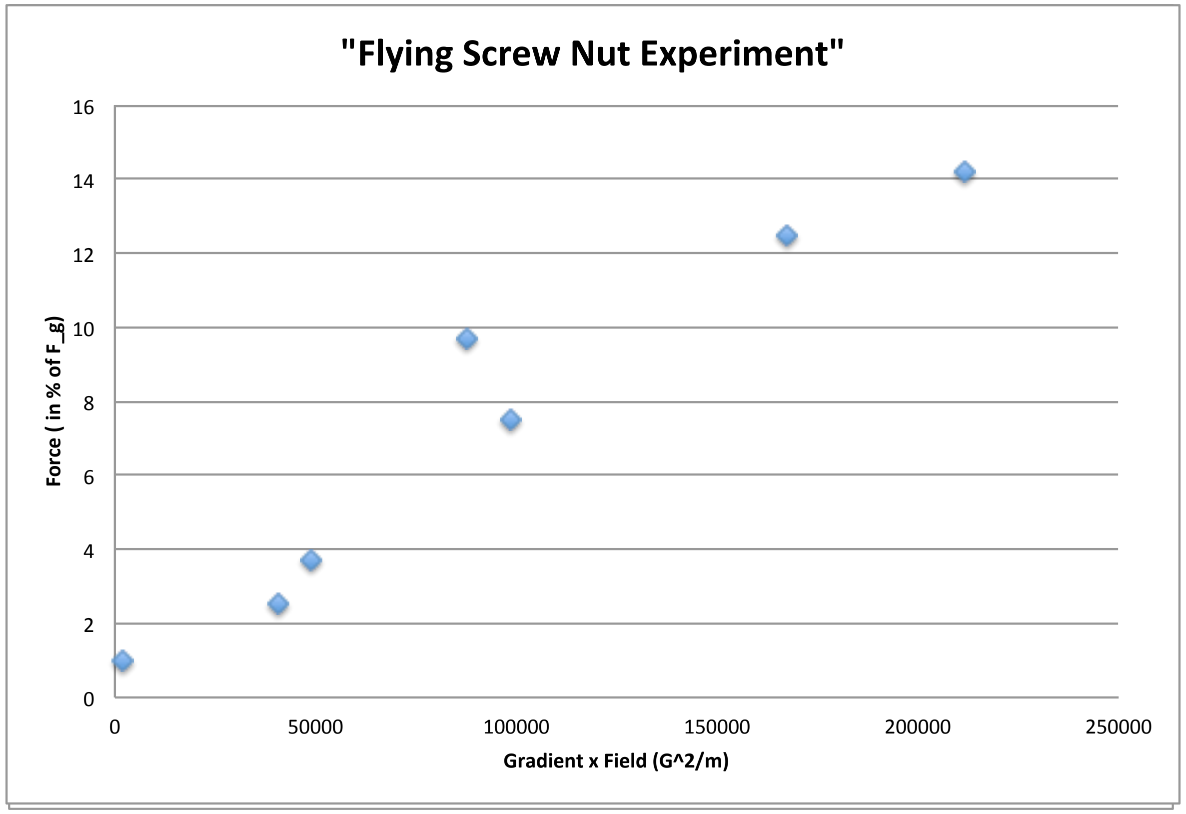

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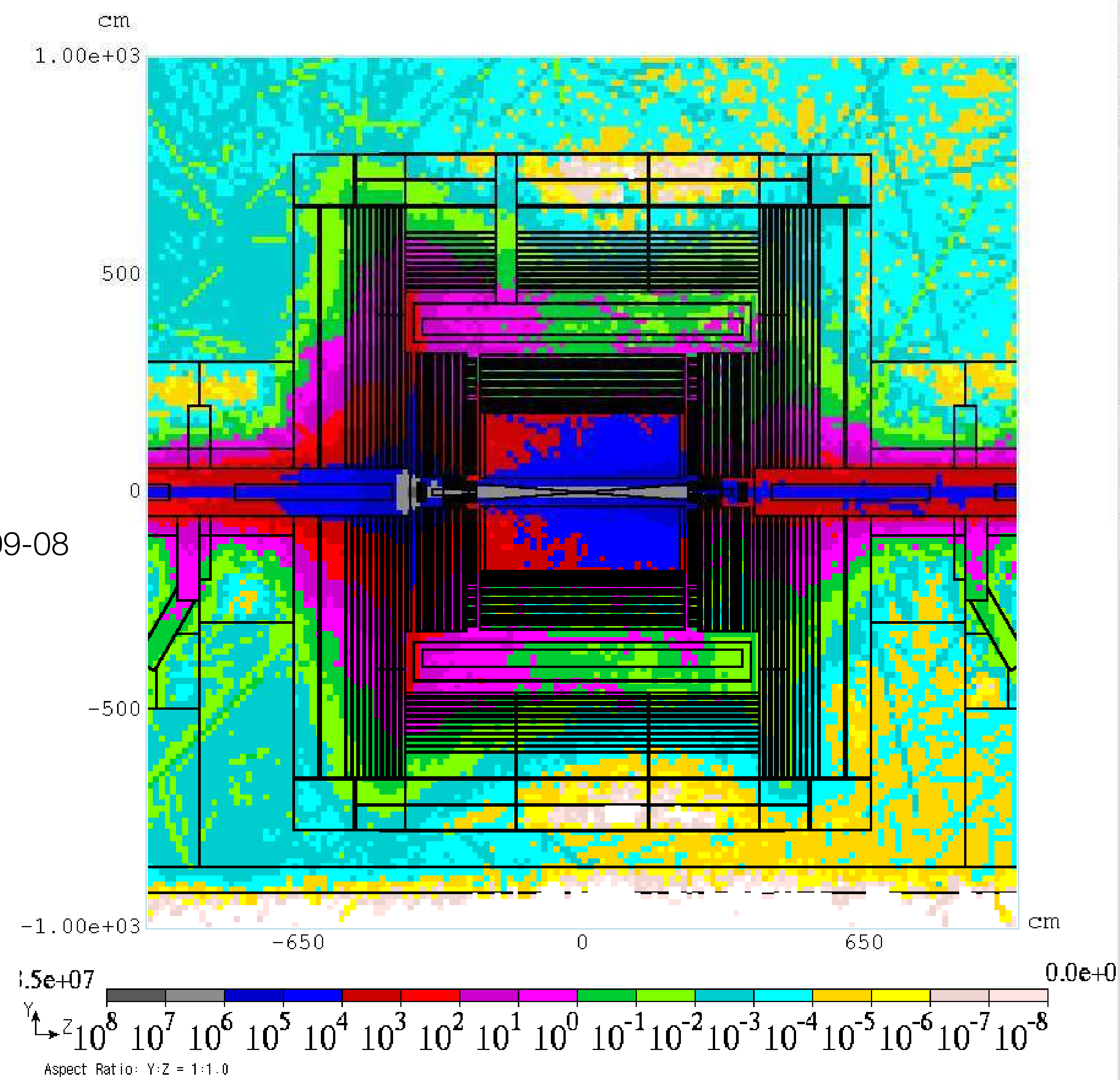
- Confirmation of CMS results: things get dangerous above 300G....

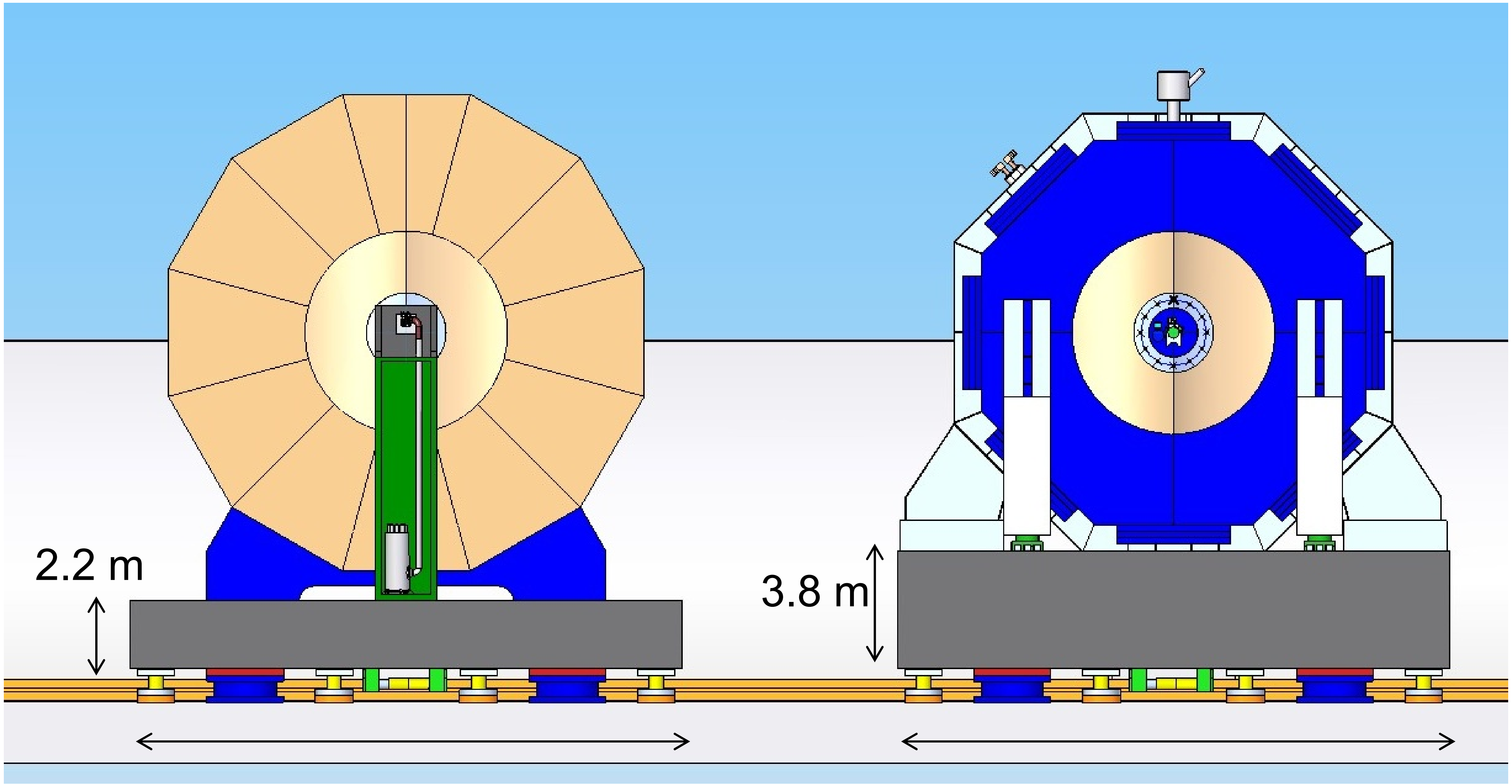
Interaction Region Radiation Shielding

- 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

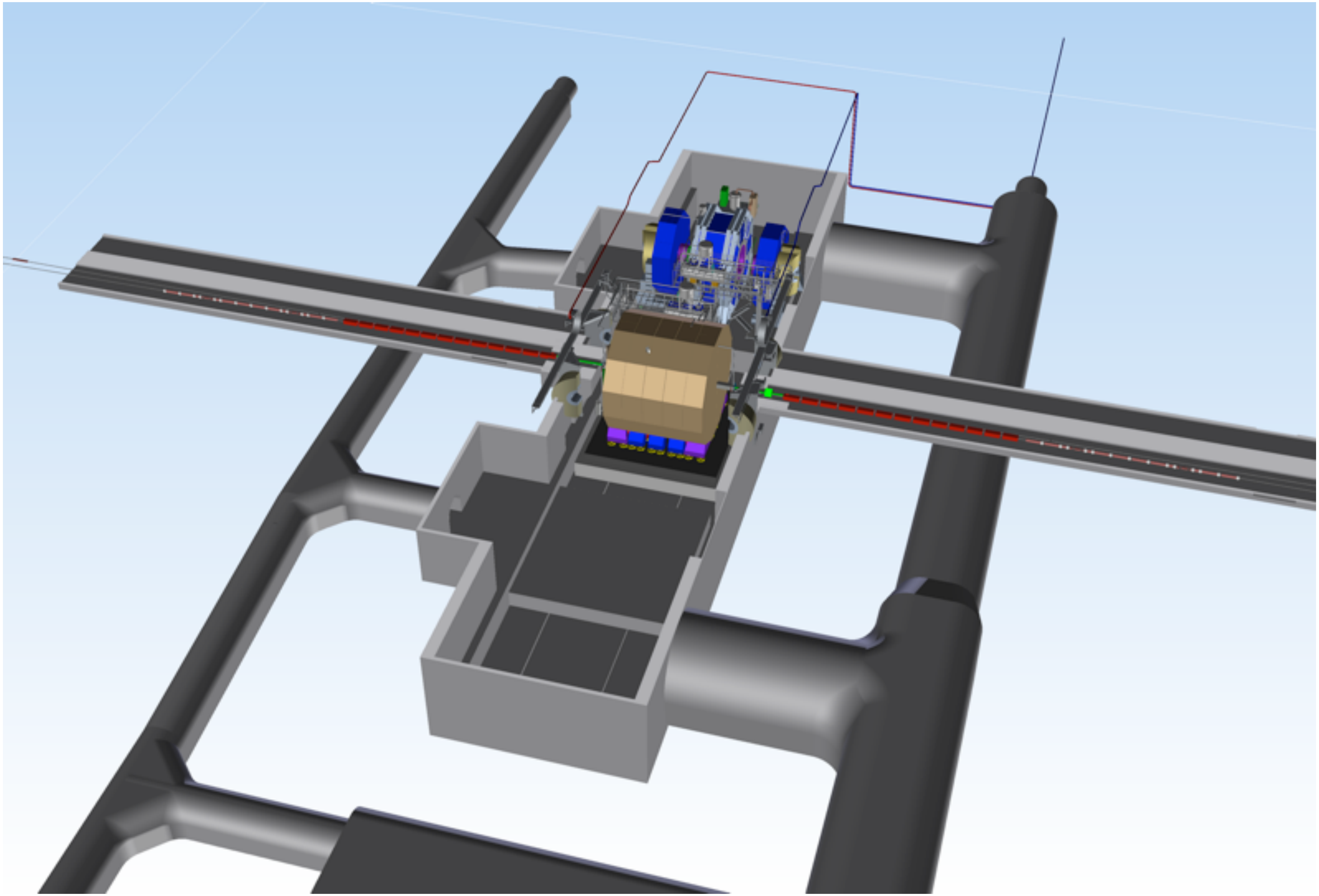


Platform Thickness



- 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

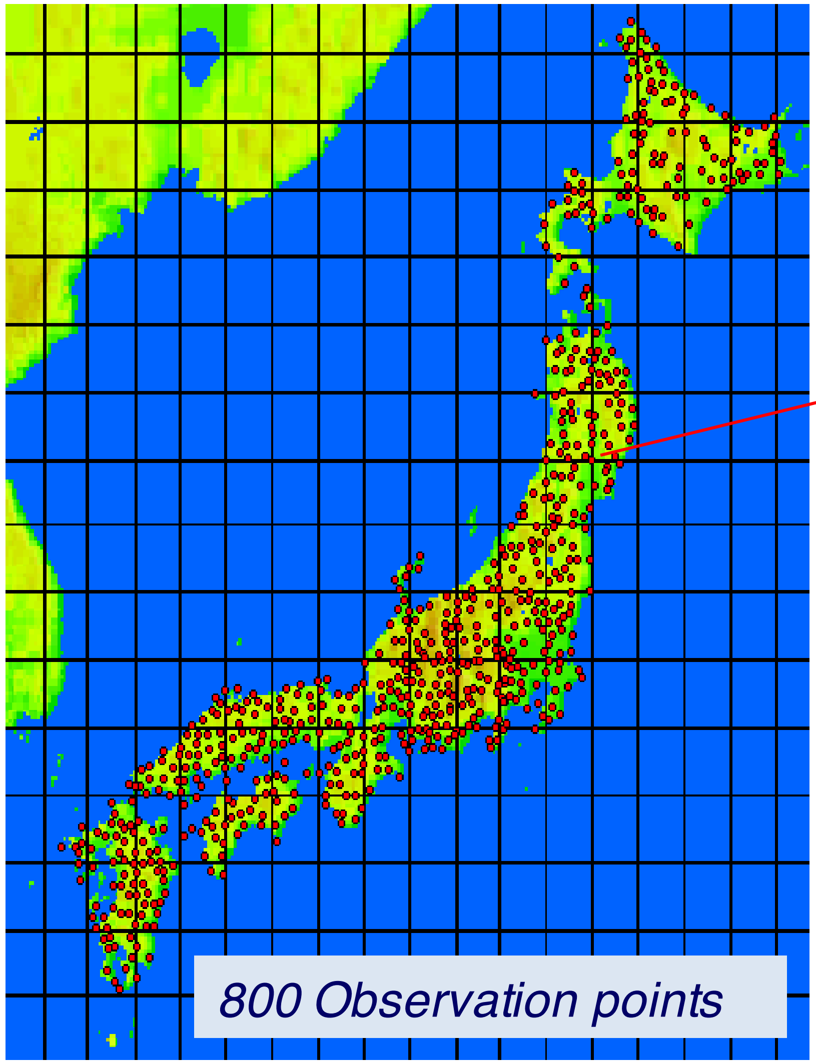
Underground Installation



Seismic Conditions

Global Design Effort - CFS

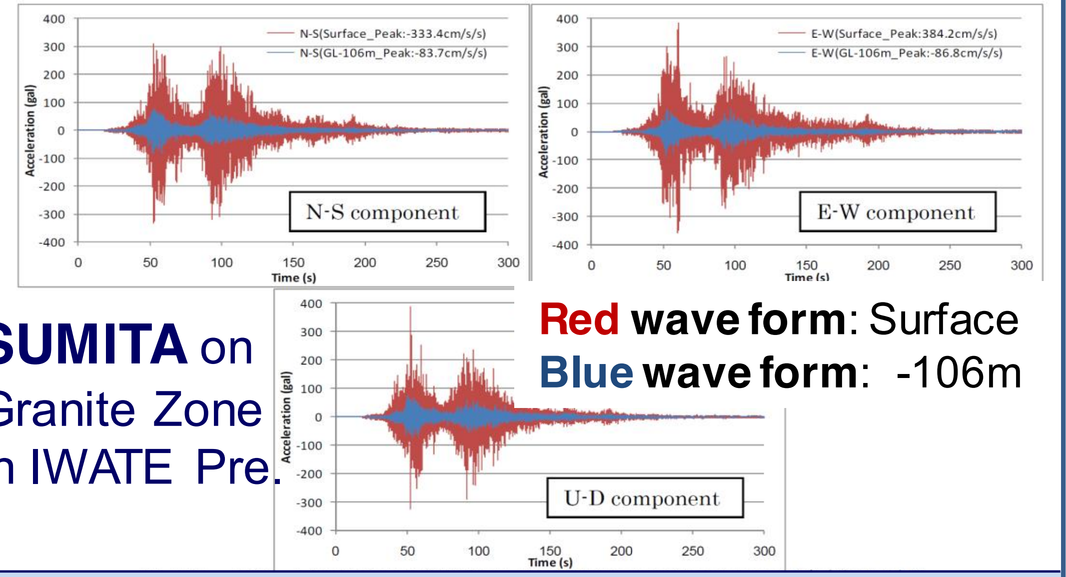
3.11 Seismic Observation



KiK-net *Observation Network*

(Kiban:Bedrock, Kyoshin:Strong-Motion)

Data by "National Research Institute for Earth Science and Disaster Prevention"



SUMITA on Granite Zone in IWATE Pre.

Red wave form: Surface
Blue wave form: -106m

Acceleration comparison of the Surface & underground at SUMITA in IWATE

Observation Data

Direction	Acceleration (gal)		Rate
	Surface	Underground	Undergrund /Surface
N-S	333.4	83.7	0.25
E-W	384.2	86.8	0.23
U-D	388.9	73.5	0.19

M. Miyahara

Seismic Conditions

- From Tauchi-san at ECFA-WS
- ISO3010:

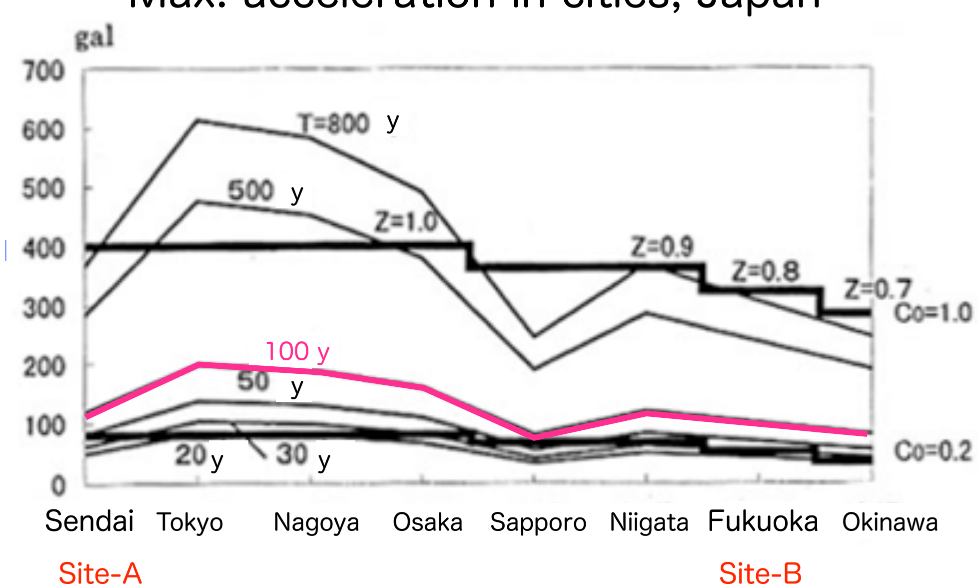
  a) (ultimate limit state: ULS) The structure should not collapse nor experience other similar forms of structural failure due to severe earthquake ground motions that could occur at the site .

  b) (serviceability limit state: SLS) The structure should withstand moderate earthquake ground motions which may be expected to occur at the site during the service life of the structure with damage within accepted limits.

In both cases, the seismic force can be the maximum acceleration of earthquakes in the recurrence intervals of 100 years.

- T. Tauchi at ILD-WS (09/2013):
  - ULS: assume ~1000 gal
  - SLS: assume ~150 gal
- 1 gal ~ 0.001g

Max. acceleration in cities, Japan



T. Tauchi

Summary and Outlook

- ILC realisation time scale is not yet clear
  - we will certainly have some ~2-3y for optimisation studies
- But we now know the possible site
- We should take the time to re-visit some of the requirements for the IR design
  - needs negotiations between both experiments and the machine!
- Possible adaptations:
  - magnetic field limits (cost driver for ILD)
  - seismic conditions (very much site dependend)
  - others
- (...)