Report from the MDI Common Task Group

Karsten Buesser

international linear collider

TILC'09

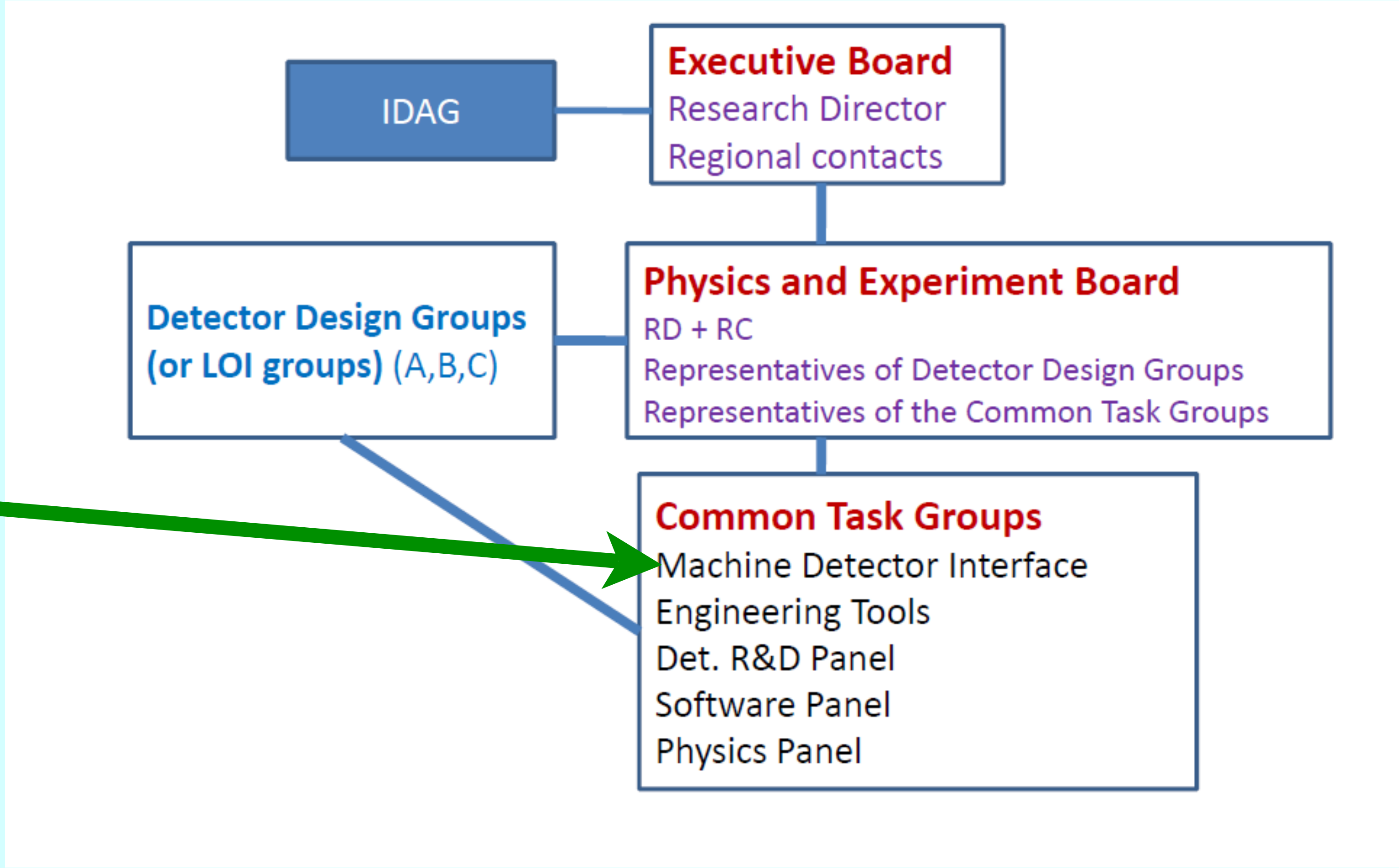
Tsukuba

19. April 2009

The MDI Common Task Group

- Common task group of the Research Director's organisation:

- Members:
  - J. Hauptman
  - A. Mikhailichenko
  - P. Burrows (deputy convener)
  - M. Oriunno
  - K. Buesser (convener)
  - T. Tauchi



- Usually meets in phone meetings
- Close contact to the GDE BDS group

IR Interface Document

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.

IR Interface Document

- Common document of the MDI-D common task group together with the GDE-BDS group
- Definition of the functional requirements to allow a friendly co-existence of two detectors and the ILC machine in a push-pull scenario
- Provide a set of ground rules, not technical solutions to the problems!

- Document has been discussed in the workshops in Warsaw and Chicago
- Several phone meetings of the MDI-D group together with GDE-BDS
- Sent to the detector concept groups and the RD for comments
- Approved by concept groups, BDS technical area leaders and PM for accelerator systems
- Published as ILC-Note-2009-050

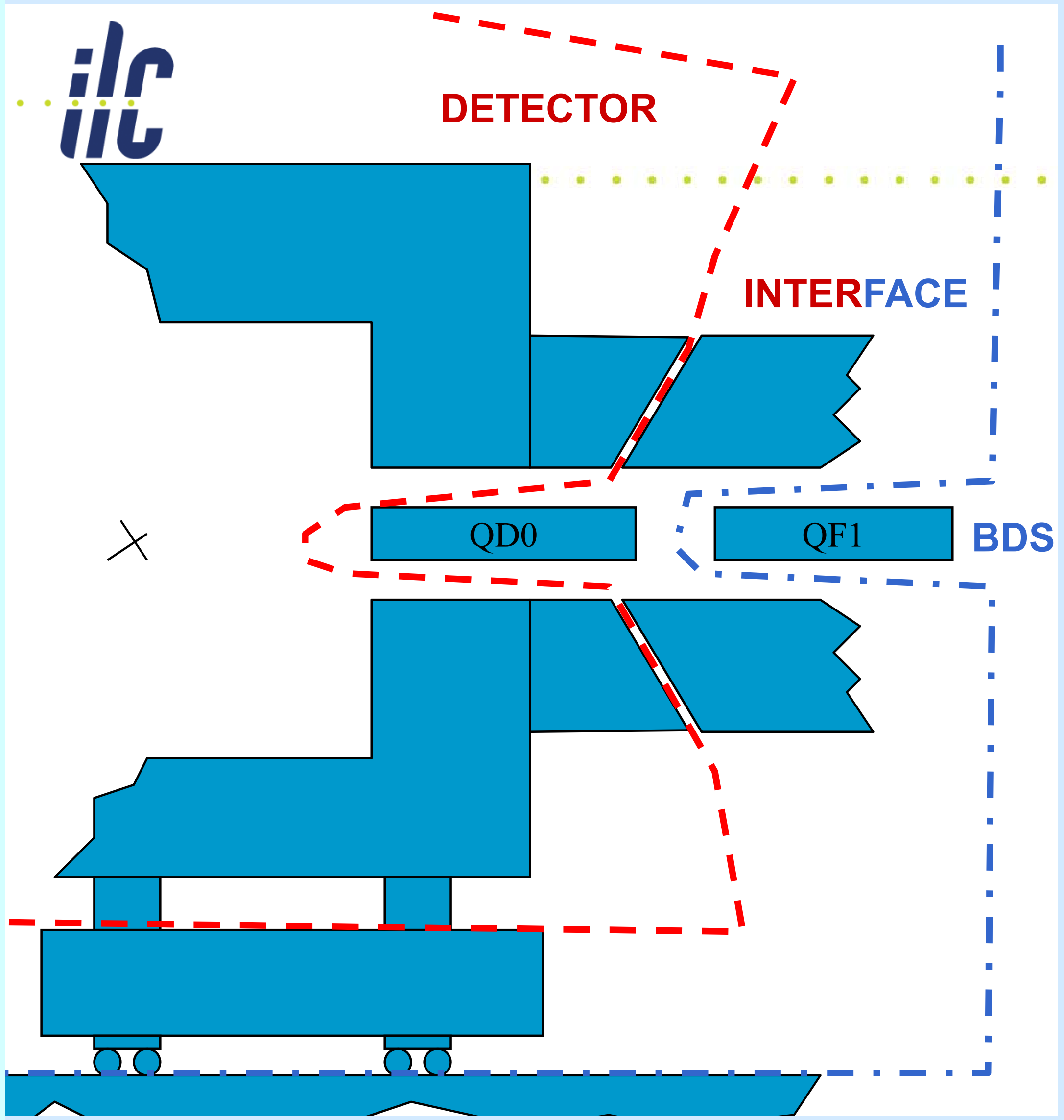
IR Interface Document

The following functional requirements have been identified:

- Final Doublet
- Elapsed time for an exchange of detectors
  - Roll-in and roll-out times
  - Cryogenic safety assumptions
- Vacuum
- Beam Feedback Systems
- Beam-beam parameter space
- QD0 support and alignment
- IR Hall geometry
  - Length
  - Beam height
- Radiation and magnetiv environment

Final Doublet

- QD0 moves with the detector
- QF1 remains stationary and is shared by both push-pull detectors
- Vaccum valve interface between QF1 and QD0
- QD0 L* between 3.5 and 4.5m, to be chosen by each detector
- QF1 L*=9.5m (magnet, cryostat and valves will extend to 9.0m), i.e. available space for detector is 18m along the beamline
- Helium supply (2K) for QD0 must be provided by service cryostat which moves with the detector
- QD0/QF1 magnets will be built and maintained by ILC-BDS
- QD0 alignment discussed later



4th Concept Suggestion

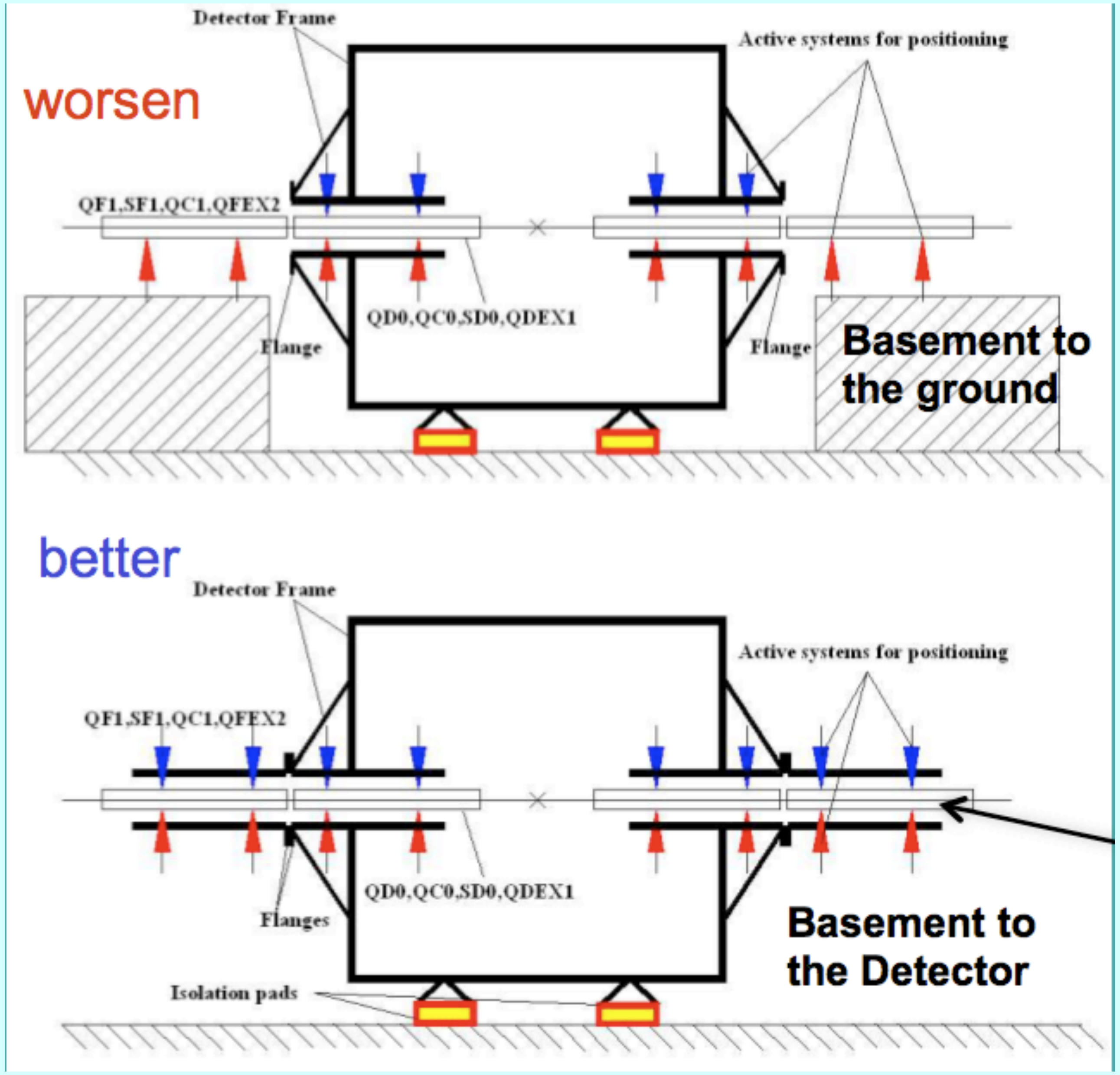
Stability concerns on final lens

Proposal:

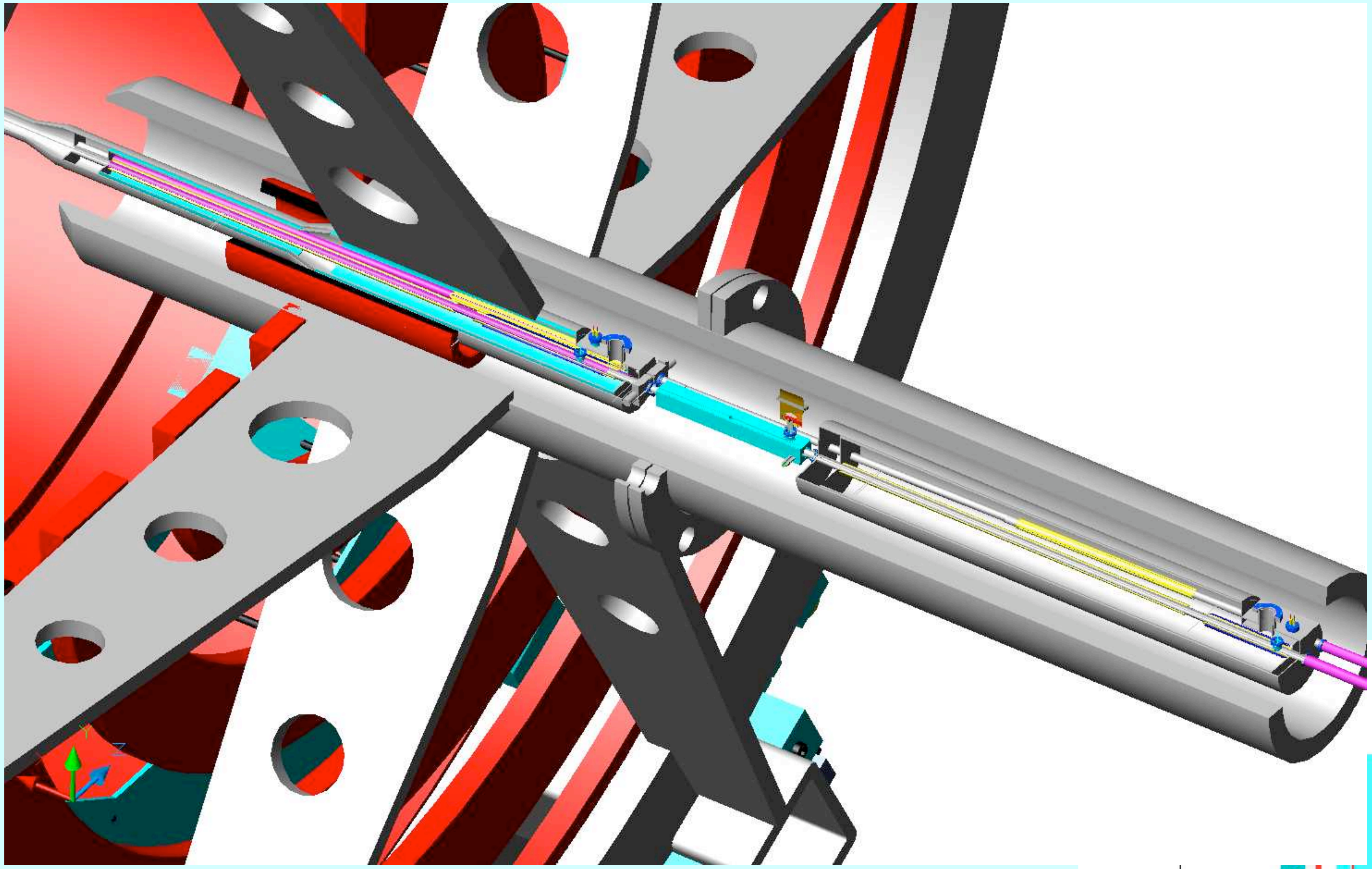
- Move QD0 with the detector
- Attach QF1 to detector frame in beam position

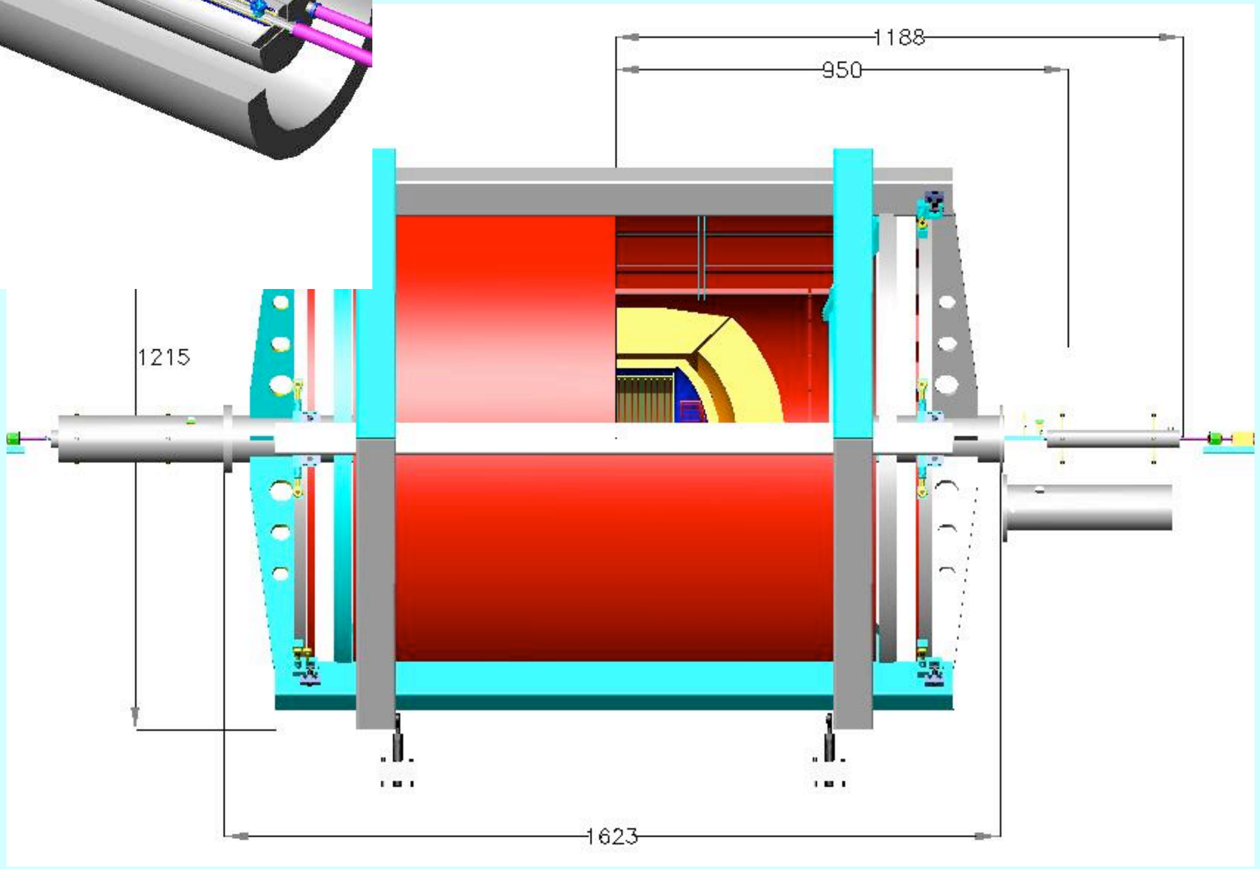
Problems:

- QF1 is the reference for the alignment of the detector and the QD0 magnets
- Needs further studies

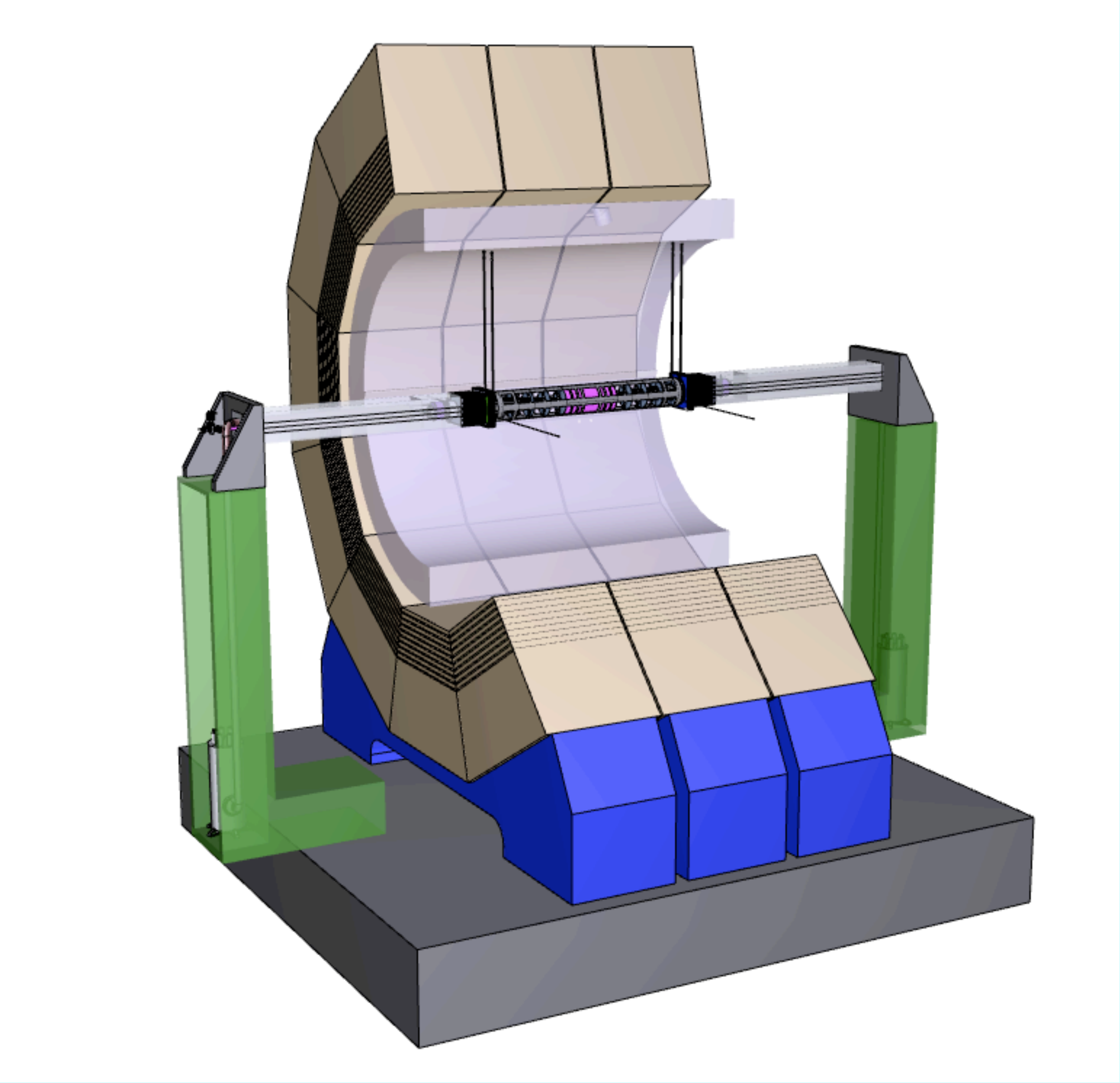


QD0/QF1 Support in the 4th Concept

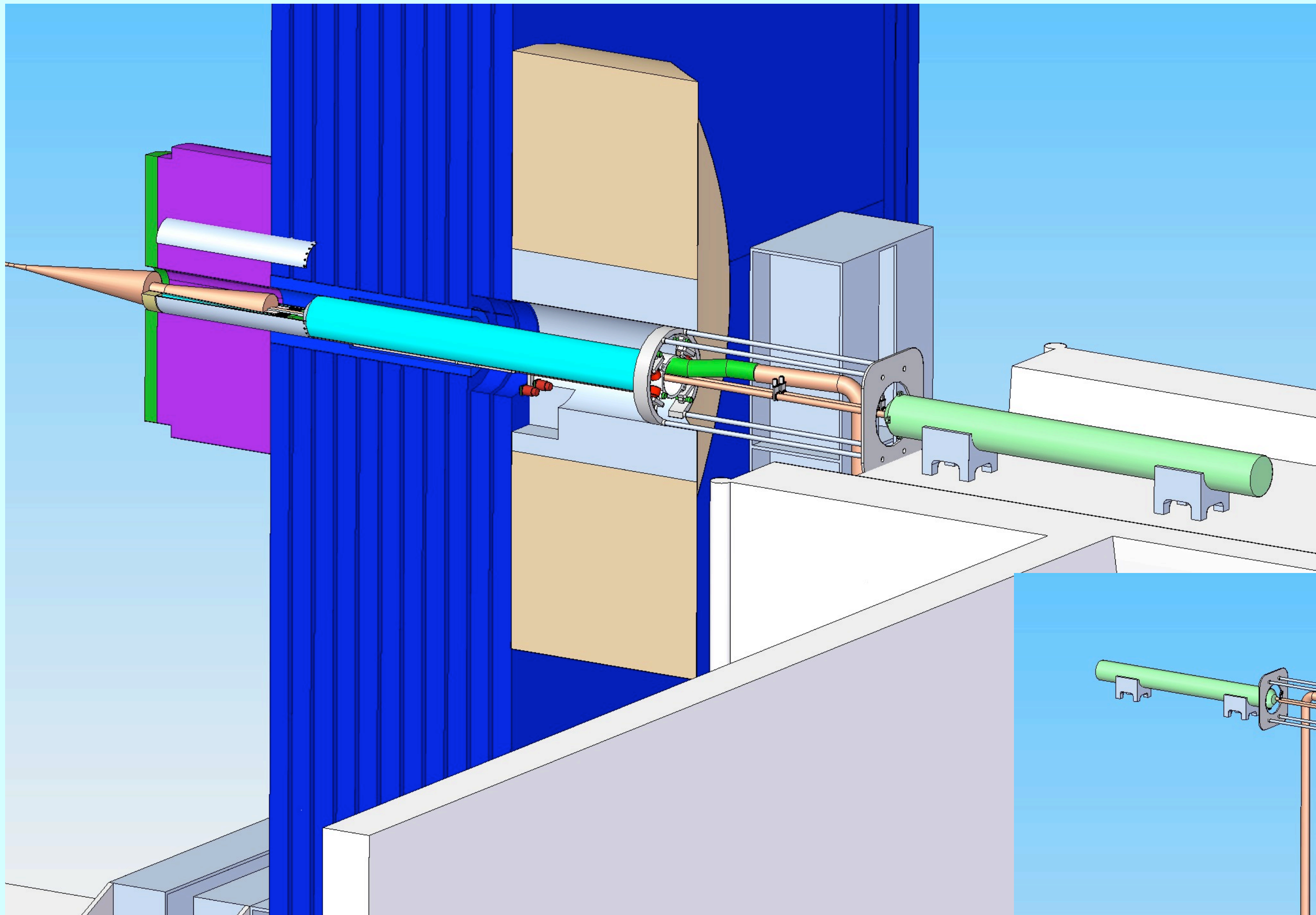


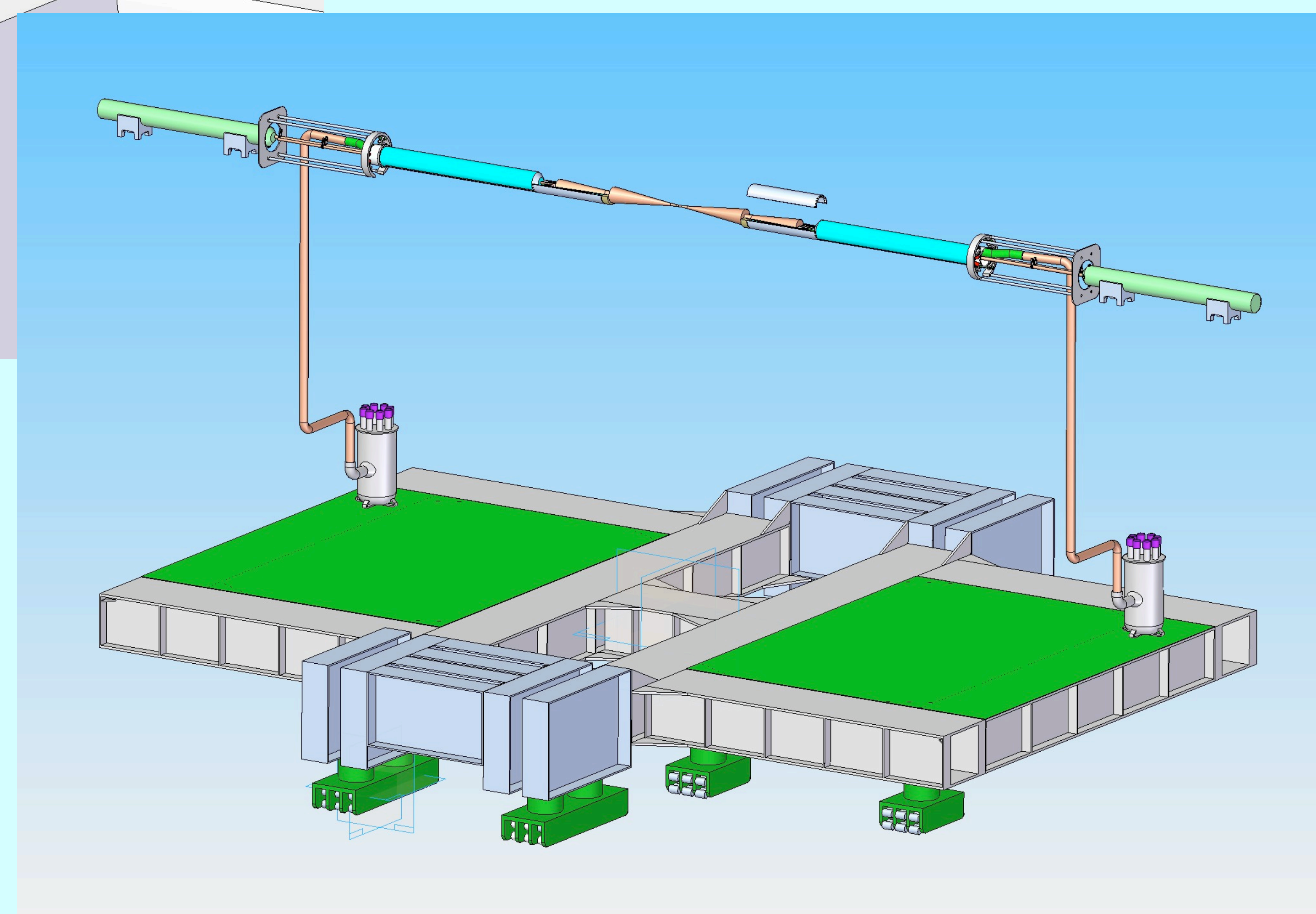


QD0 Support in ILD



QD0 Support in SiD





Time for the Exchange of the Detectors

IR Interface document does not define times for roll-in/out or frequency of push-pulls!

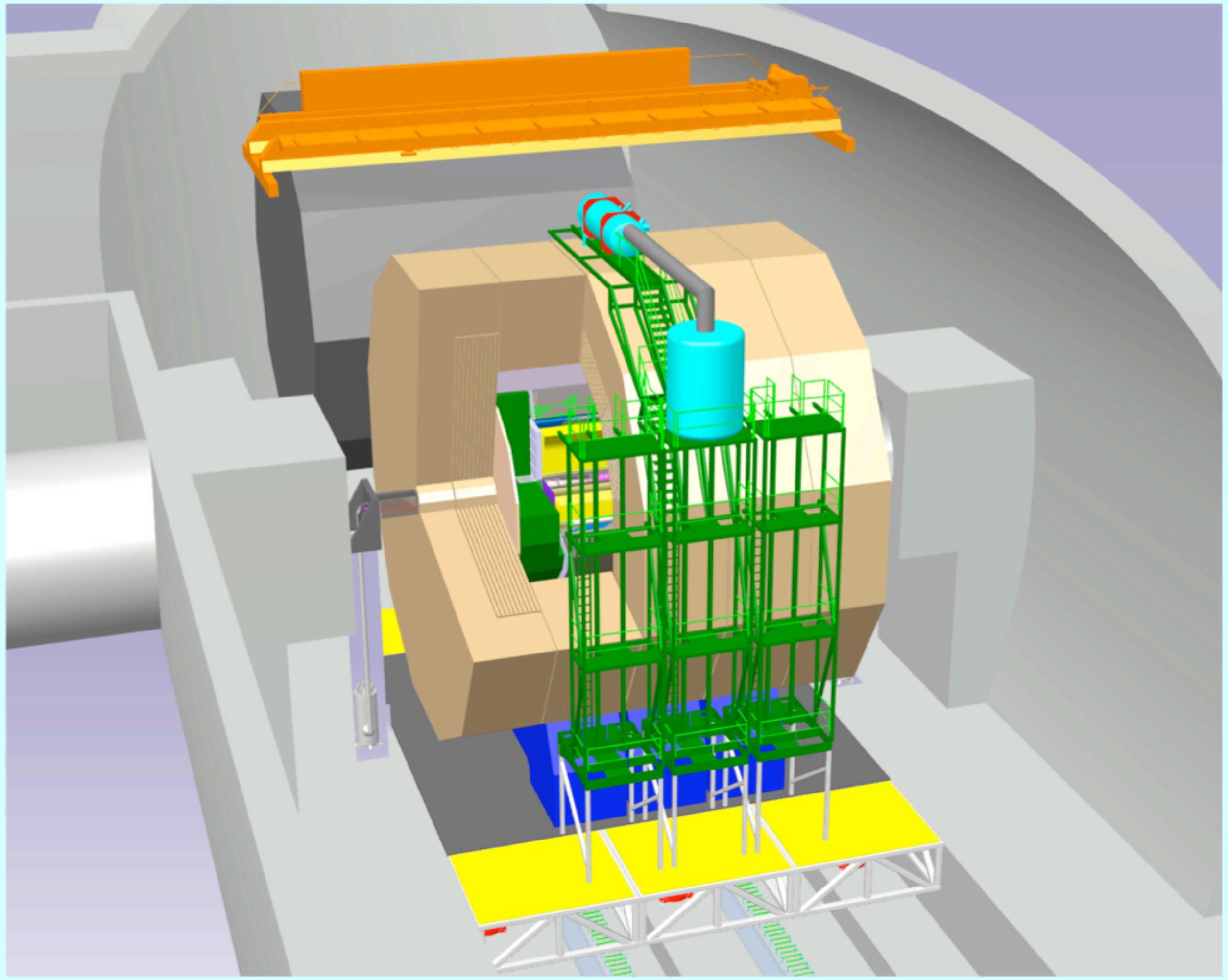
- Try to define how times for roll-in/out are measured
- Roll-out:
  - Start with end of ILC operations.
  - End when detector leaving the beamline could grant safe beneficial occupancy of the agreed upon floor space and shared resources (cranes, etc.) to the entering detector.
  - Would include time for the removal of shieldings (if any).
- Roll-in:
  - Would start with the granted beneficial occupancy as defined above.
  - Would end when safety authorities allow access to the garaged detector whatever the programme of the detector on the beamline is.

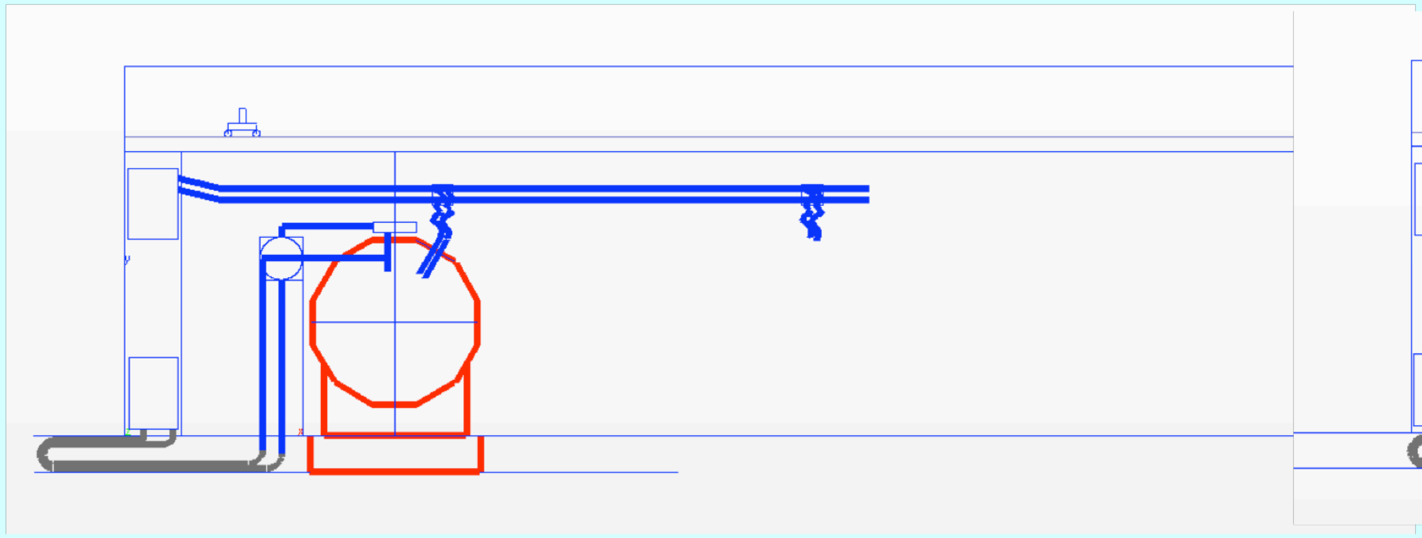
- Frequency of push-pull depends on the yet to be defined physics programme
  - Just state that time for push-pull should be less than 10% of the total operations time

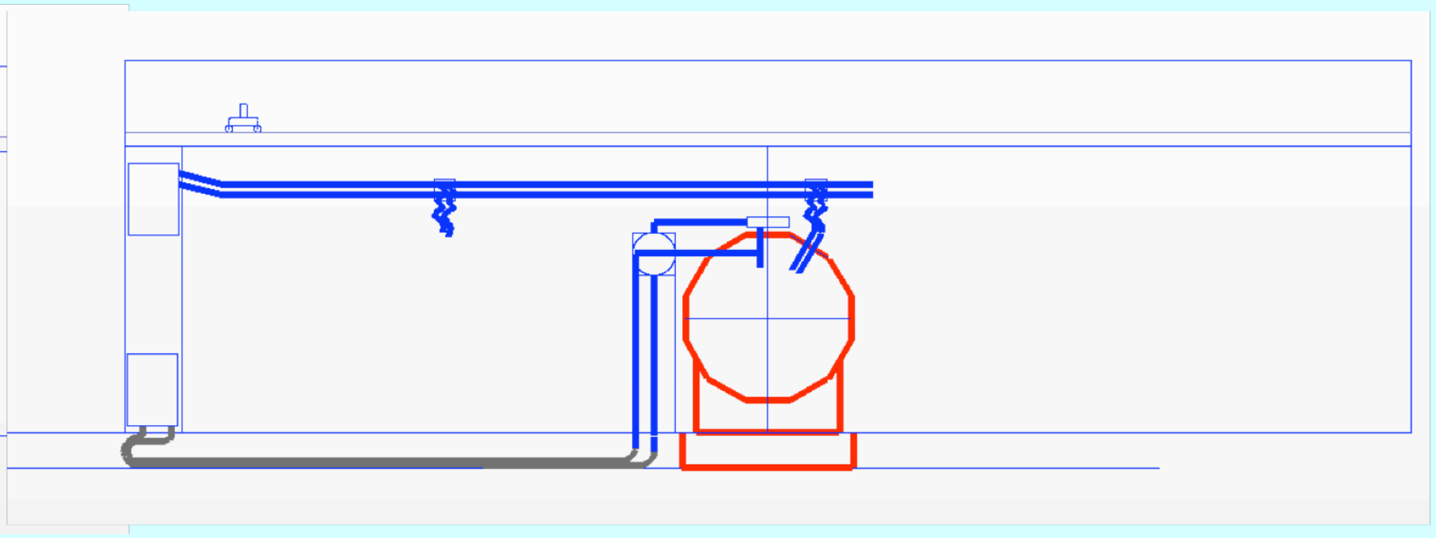
Pushing and Pulling ILD

ILD would move on a platform

- Minimise vibrations during movement
- All services would be run through cable-chains (including cryogenics)
- Main bus-bar for voltage supply to the detector solenoid
- Aim: two days for the push- or pull-operation
  - one day for the mechanical movement
  - one day for calibration

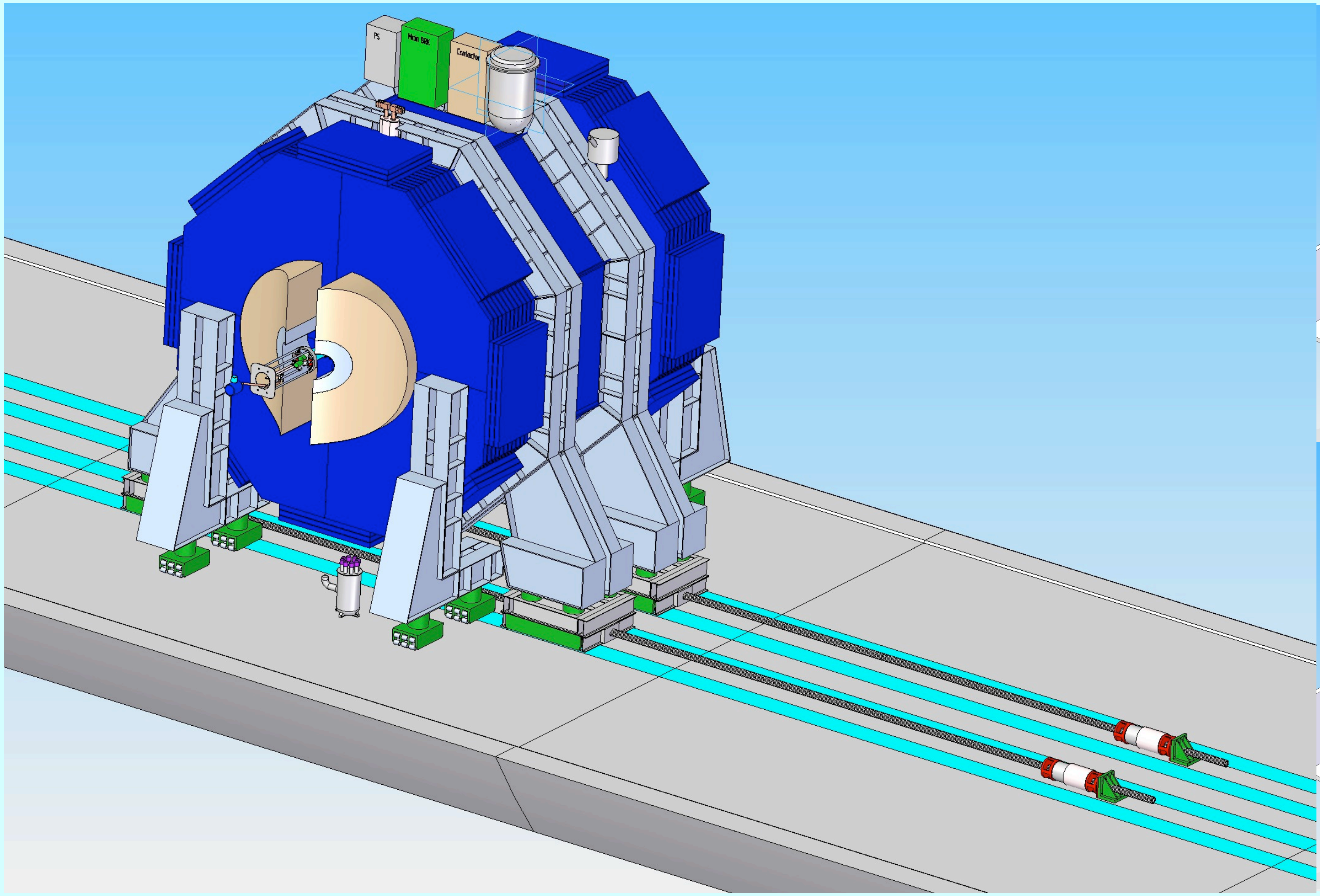


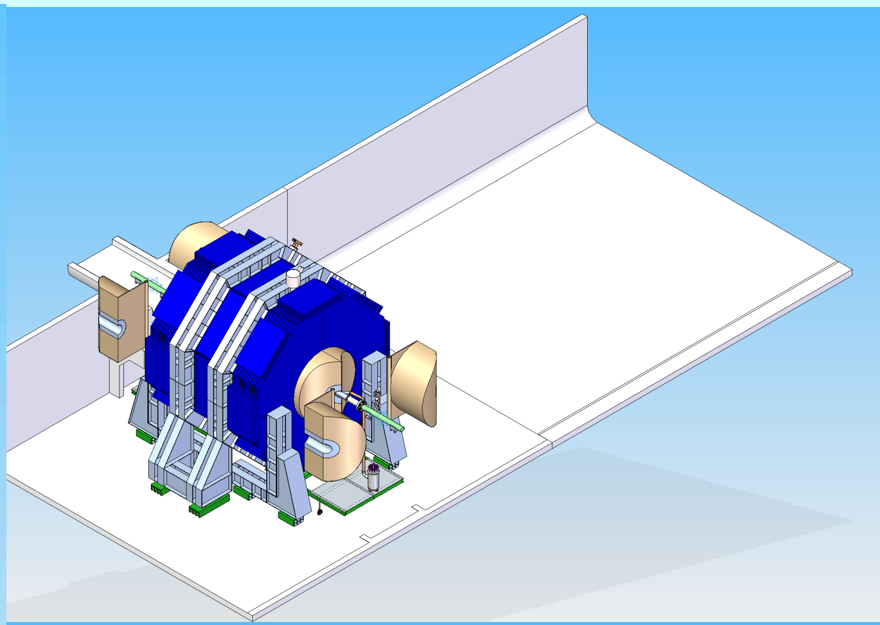


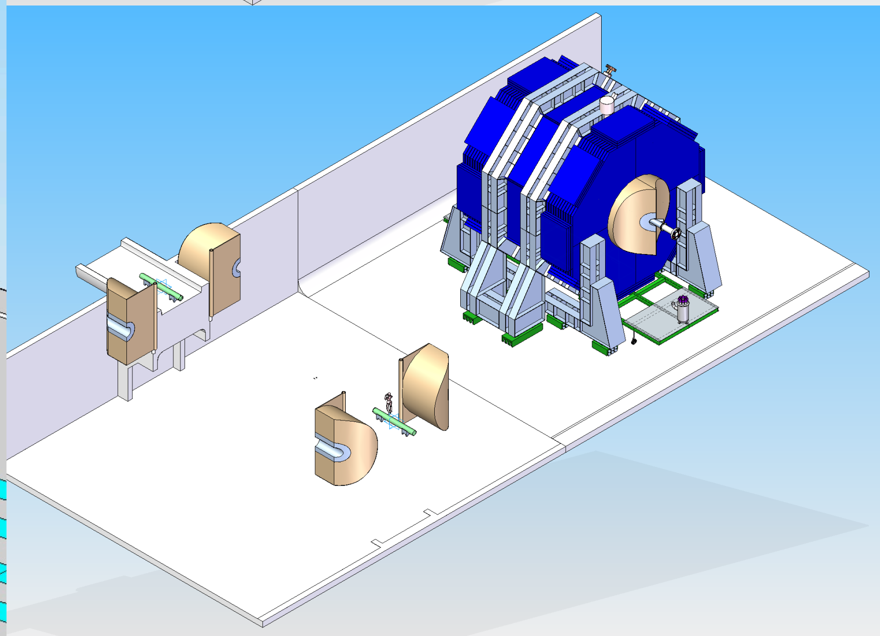


SiD Push-Pull Concept

- SiD will run on hardened steel rails using Hilman rollers
- Time needed ~1 day for luminosity-luminosity transition

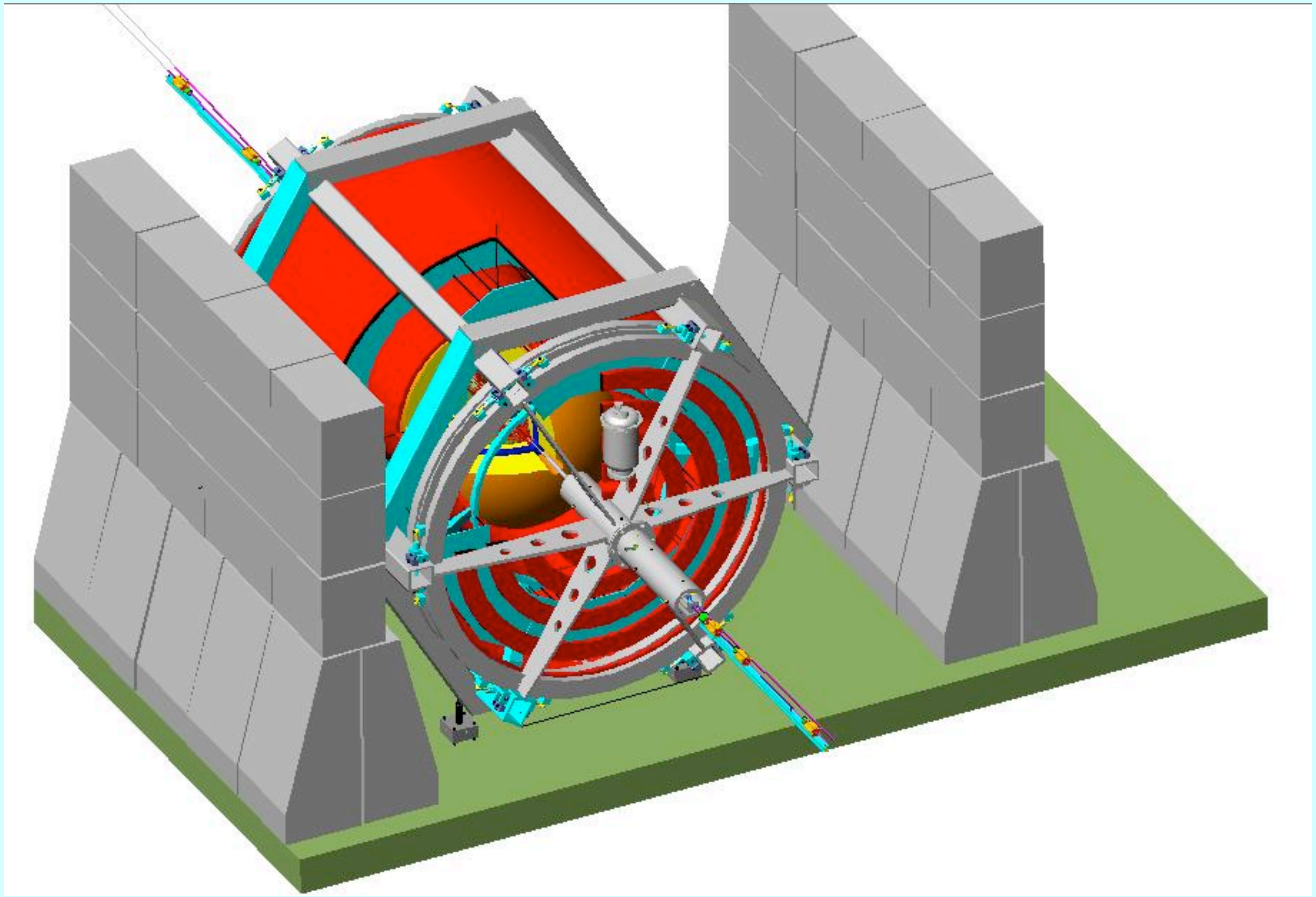






4th Push-Pull Concept

- 4th is a very lightweight detector
- could also move on a platform to ease intereface with other detector

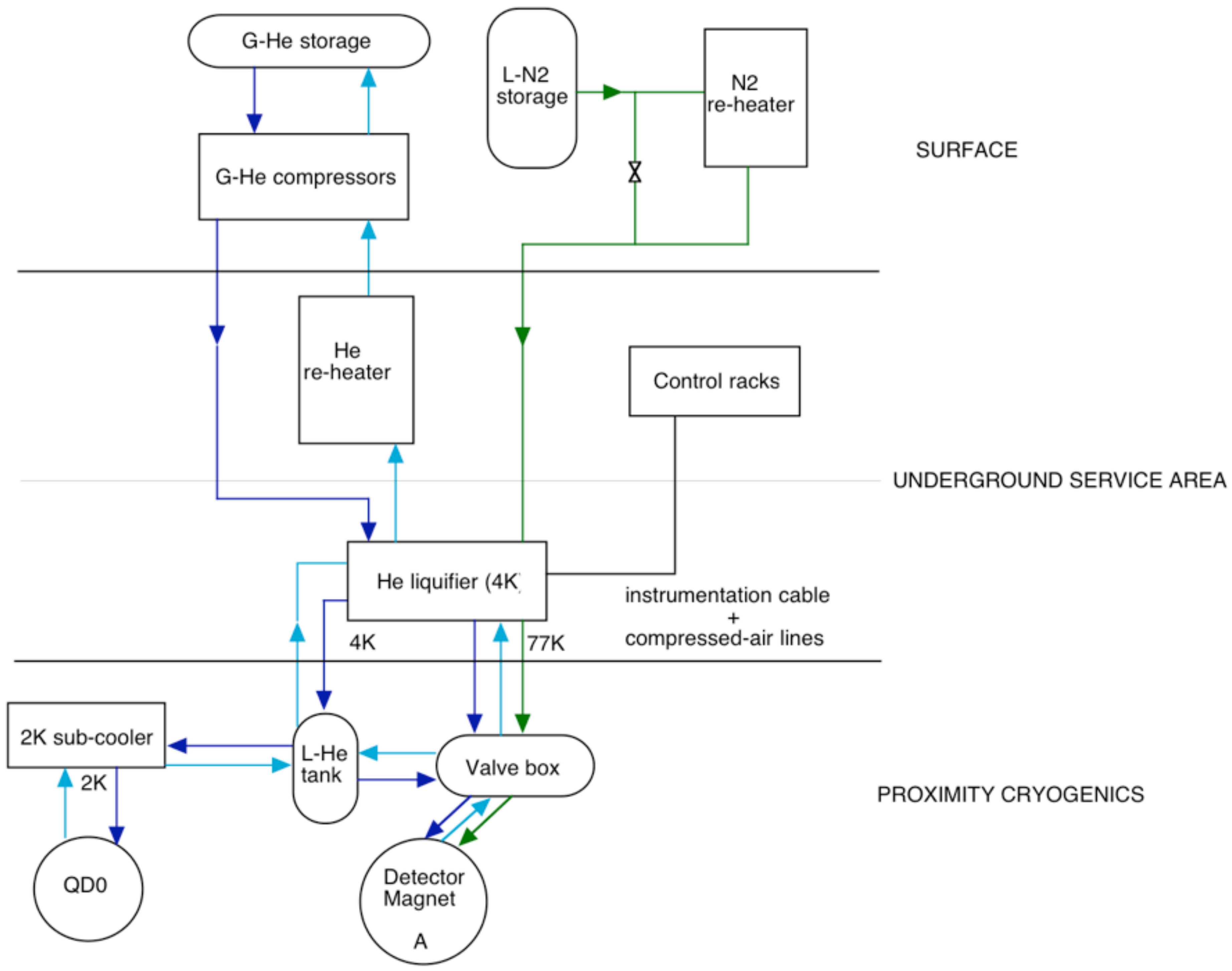


Cryogenics Safety Assumptions

Detector magnets need to be kept cold but de-energised during the movement

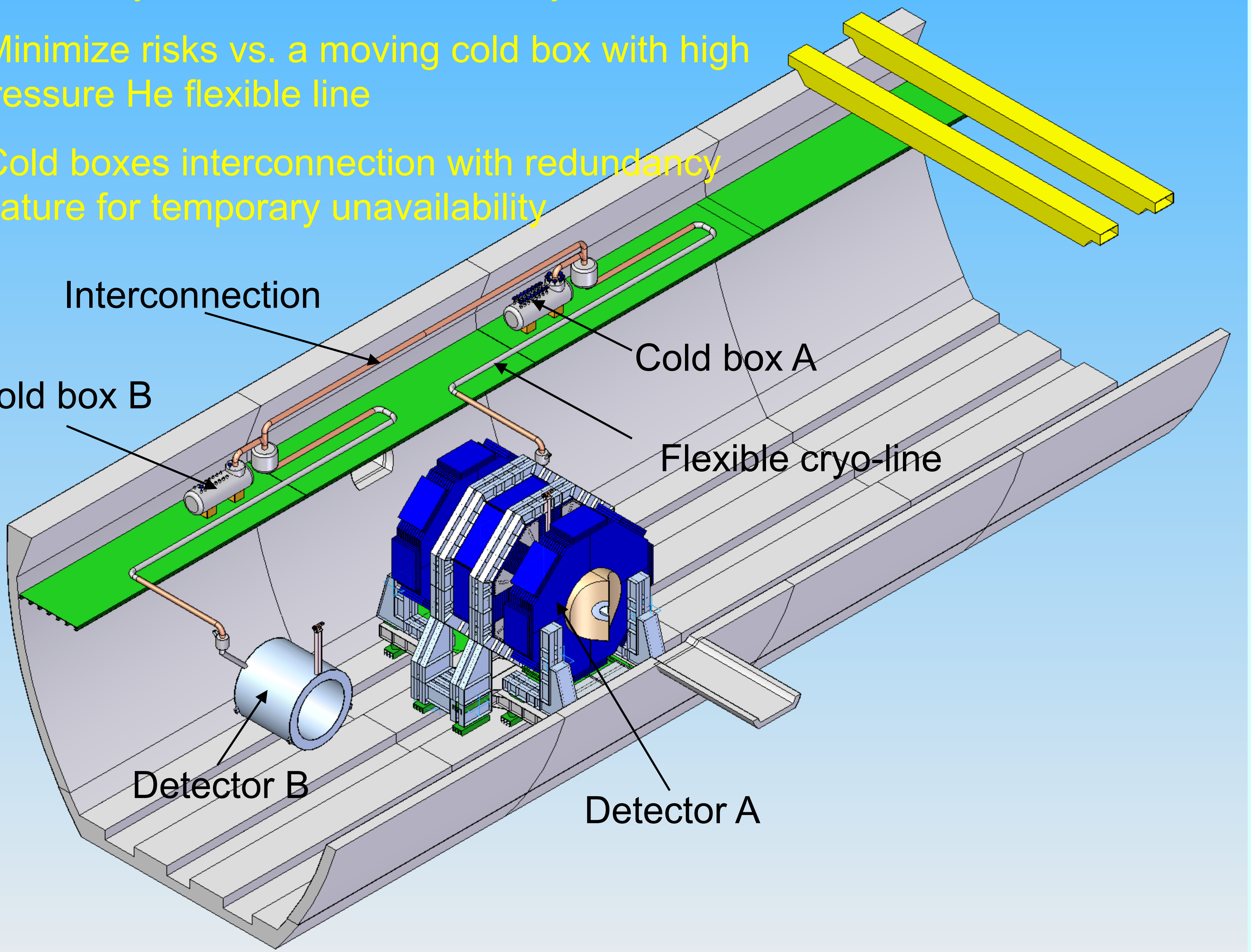
- Helium supply during the movement is needed
  - Either have the cryo cold-box on the platform and supply warm helium
  - Or have the cryo plant somewhere else (service cavern) and provide cold helium via flexible cryo lines
- Both solutions could work but need major R&D efforts

Helium Supply Example (ILD)



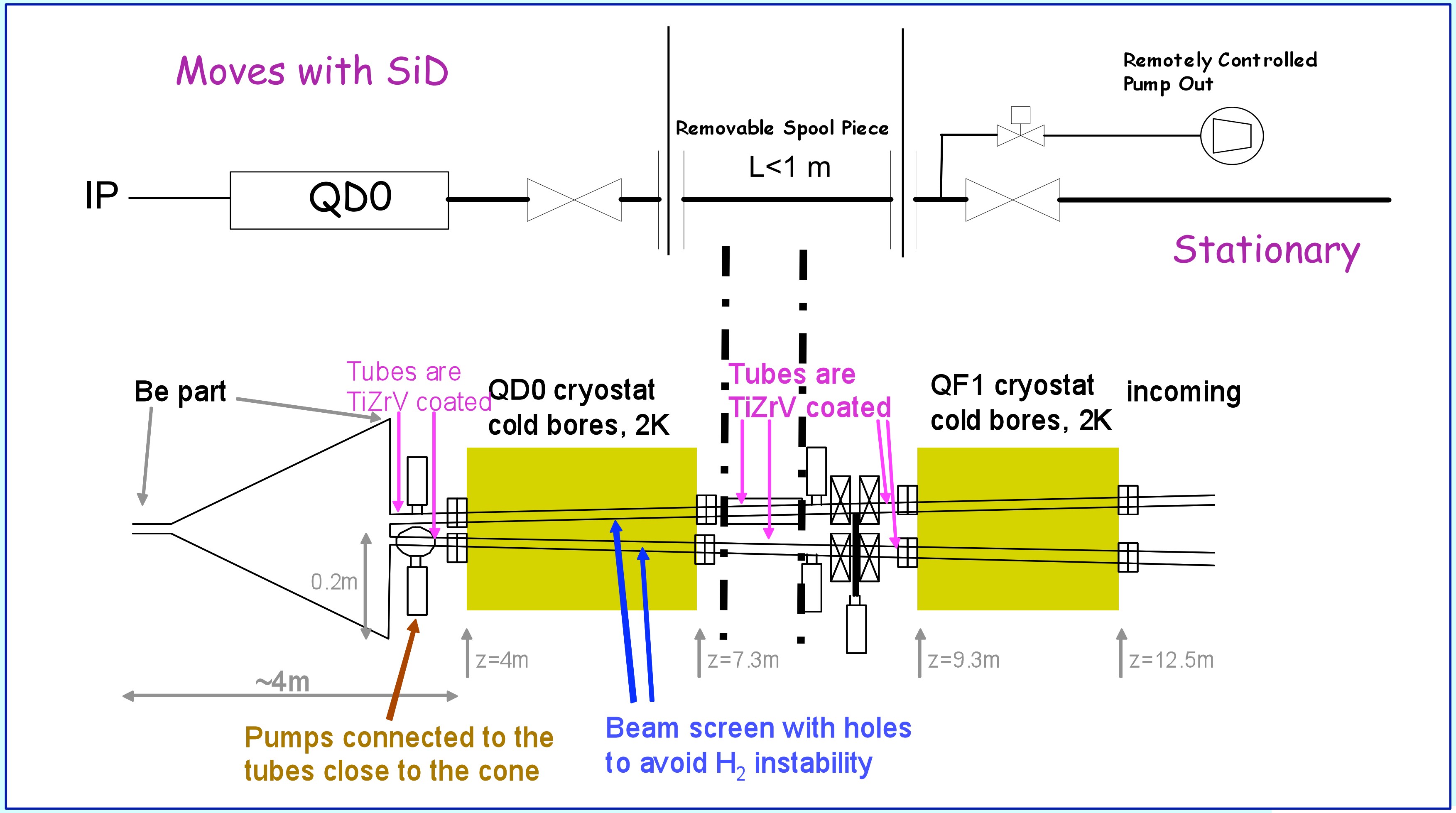
Cryogenics Study (SiD)

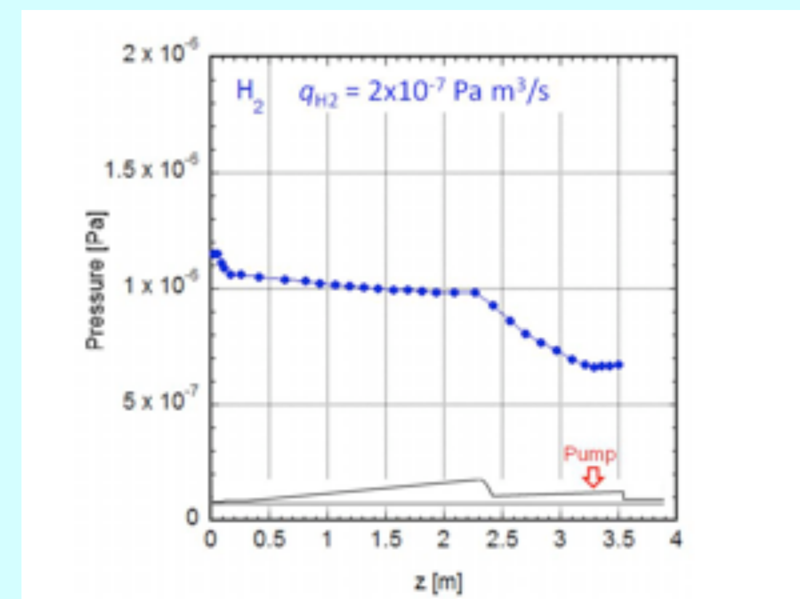
- Stationary cold box with flexible cryo-transfer line
- Minimize risks vs. a moving cold box with high pressure He flexible line
- Cold boxes interconnection with redundancy feature for temporary unavailability



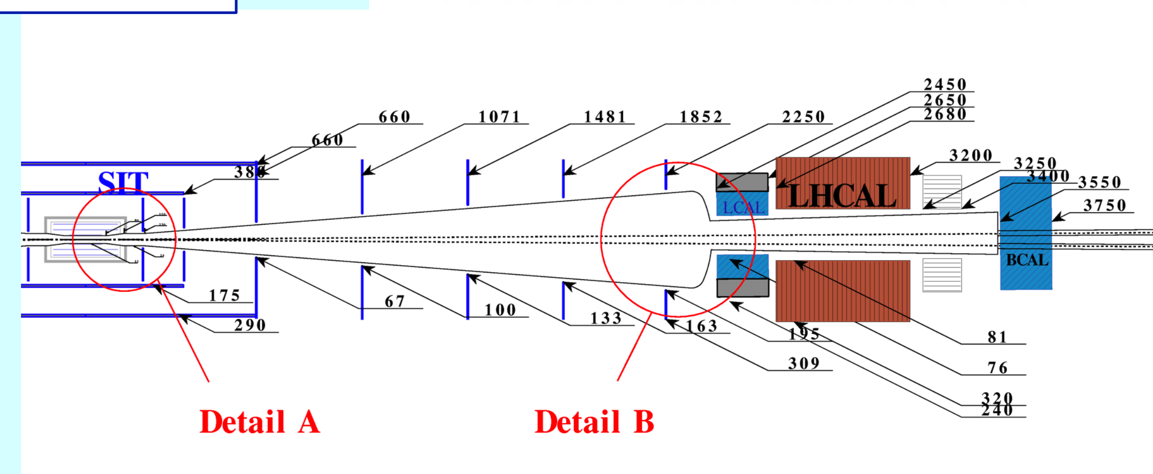
Vacuum

- Vacuum up to the valves between QD0 and QF1 will be provided by the BDS ($<10^{-9}$ mbar)
- Vacuum downstream of these valves is the choice and responsibility of the detectors



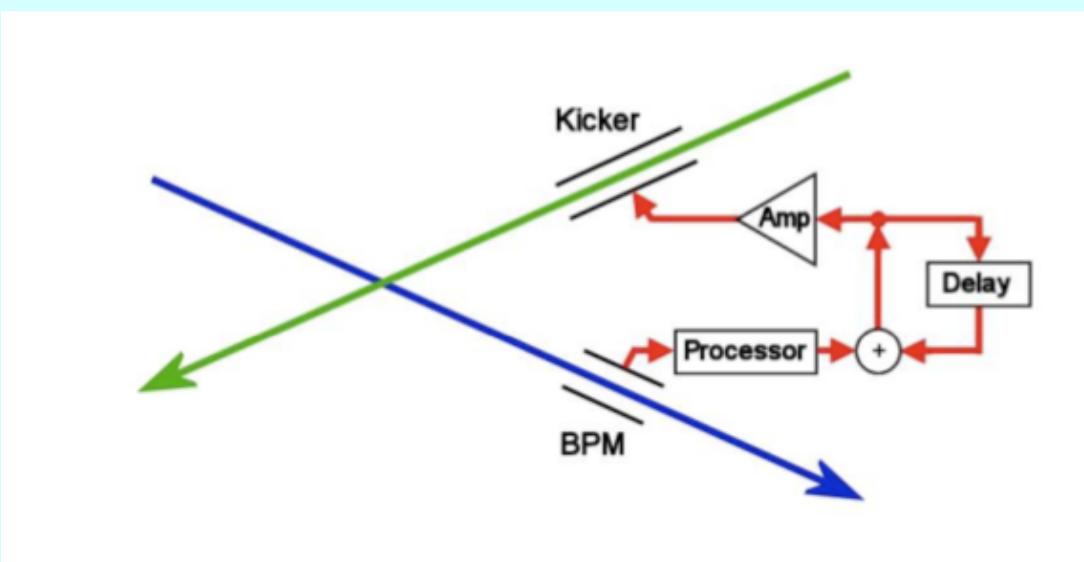


- ILD beam pipe conceptual design:
  - Made from beryllium (8kg mass in total)
  - Vacuum simulation study done, 10^{-9}mbar will be difficult to reach

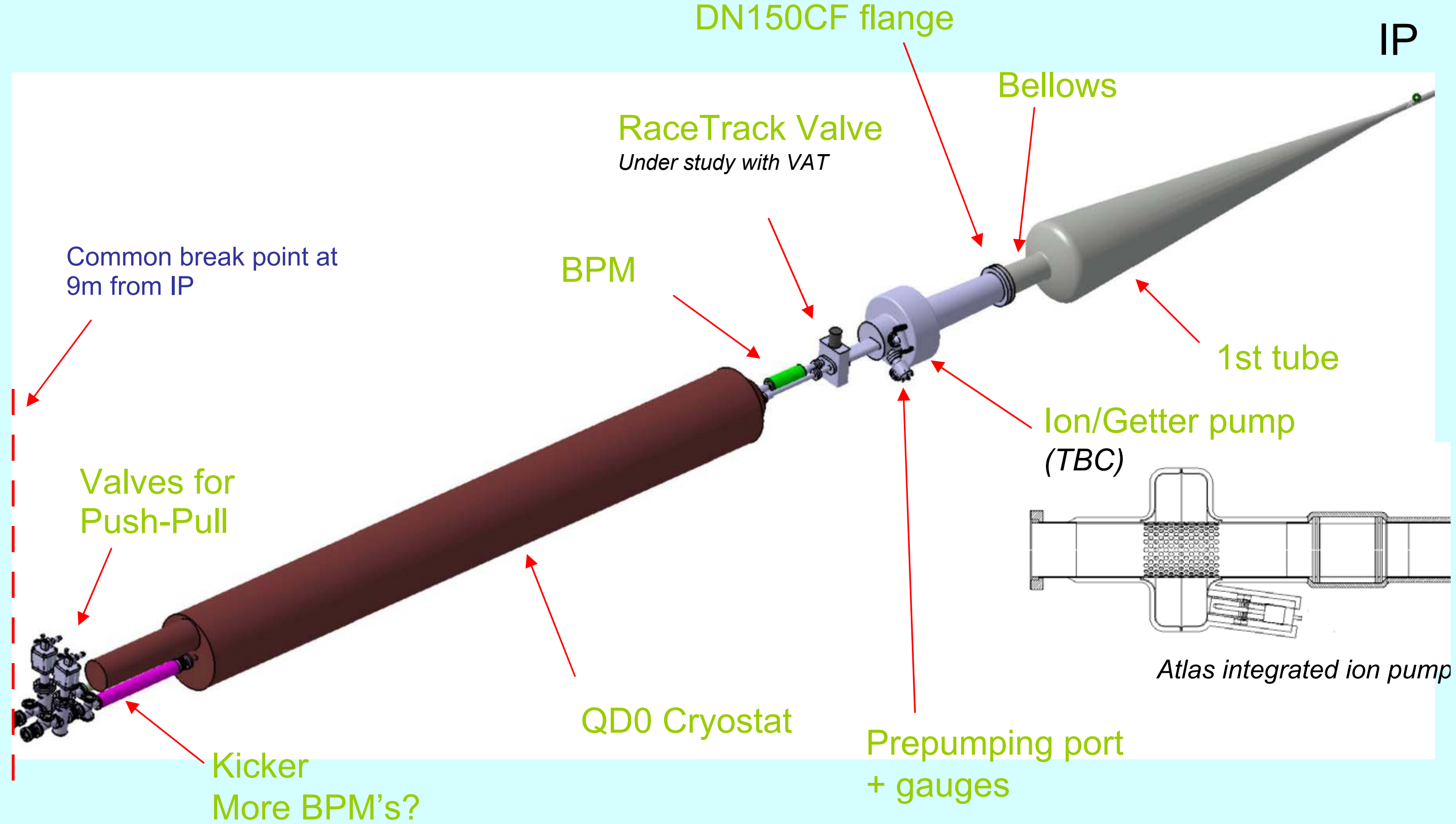


Beam Feedback System

- Luminosity feed-back system is required at the ILC
- BPM and stripline kicker need to be implemented in the detector environment
  - kicker at the back of QD0
  - BPM behind the BeamCal in a region with low backgrounds



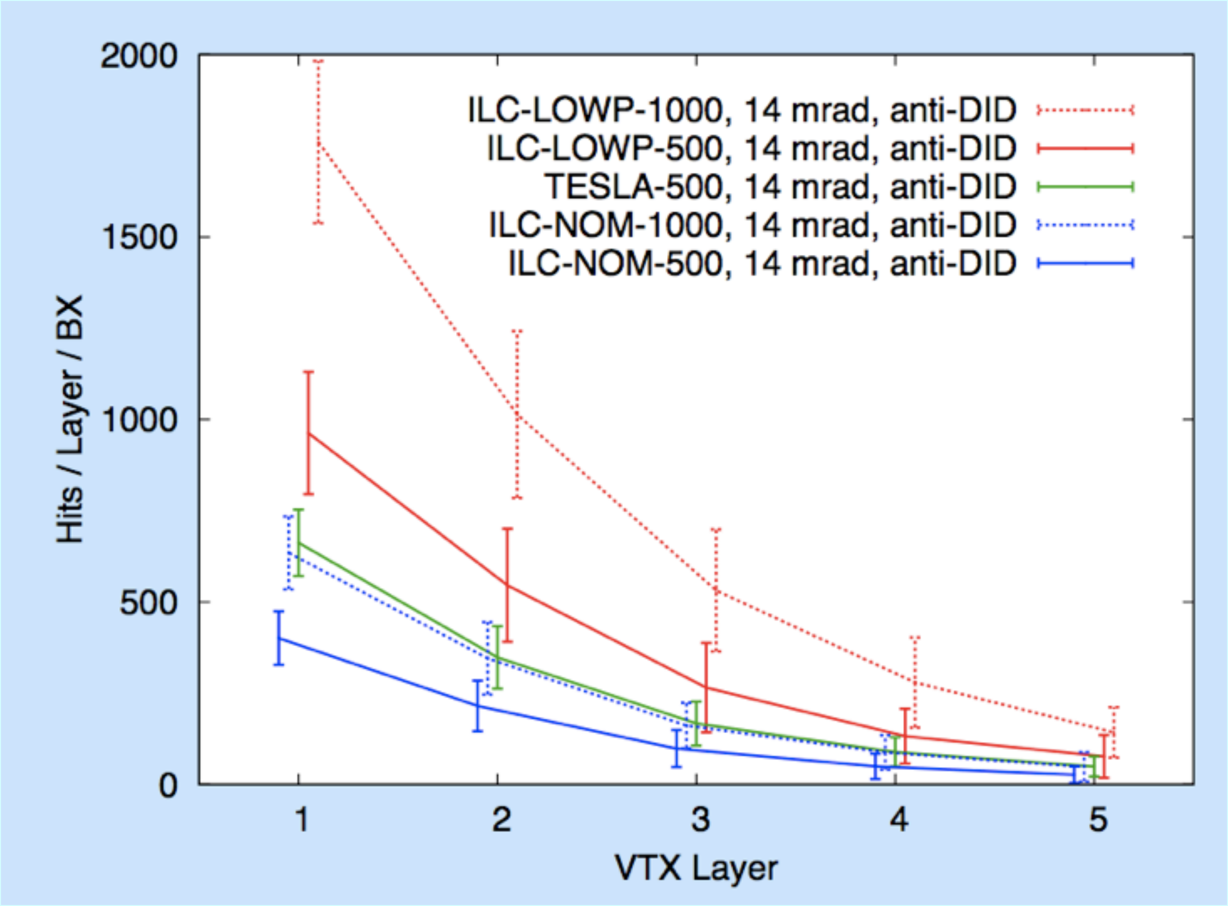
- Beam line design for 14mrad and L* 4,5m



Beam Parameter Space

The beam parameters for ILC are defined in a parameter space in the RDR. Examples parameter sets are defined, e.g. Nominal, Low-P, etc.)

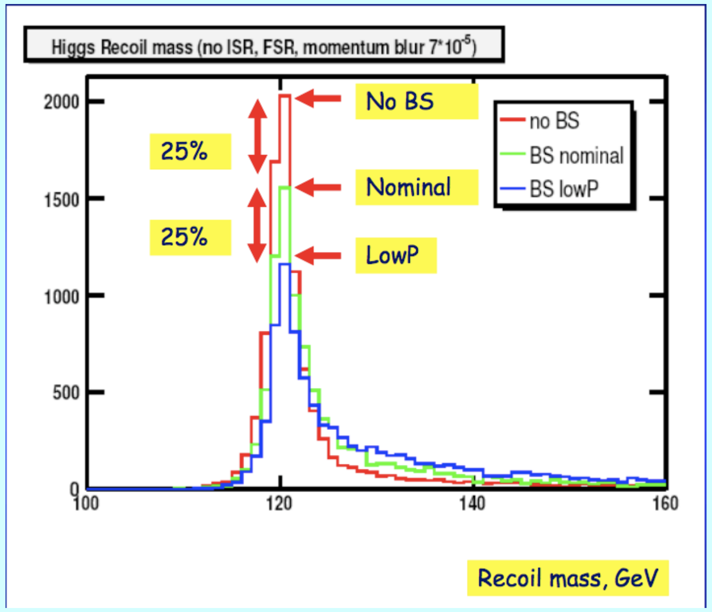
- Each detector must be able to function with nominal parameters
- Discussions for other parameter sets (Low-P, Low-N, Large-Y) is ongoing
- Concept groups comment on impact of parameter sets in their LoIs

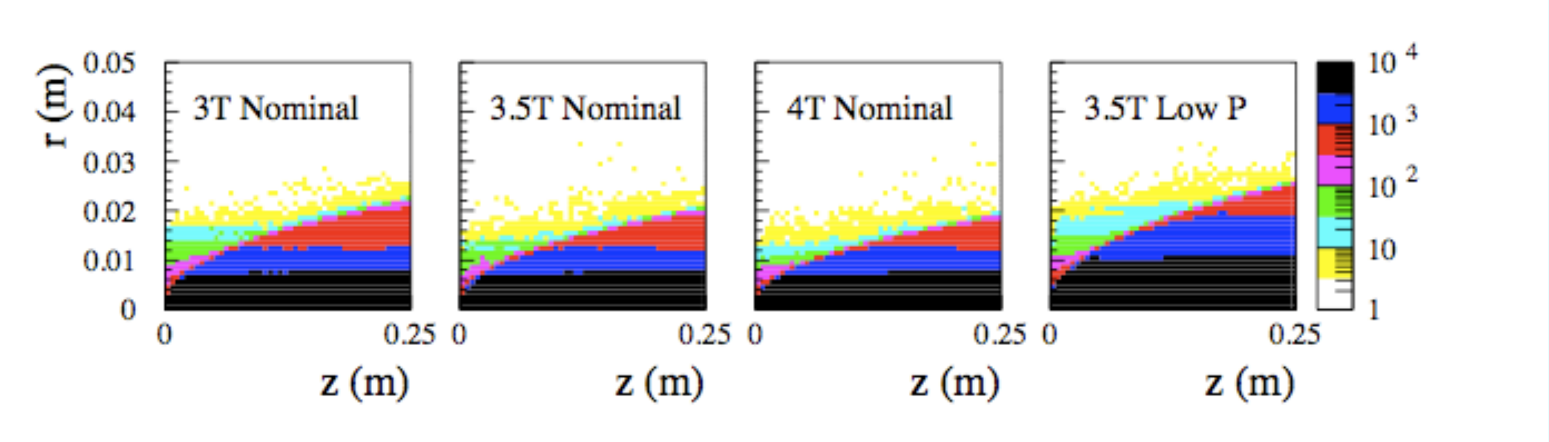


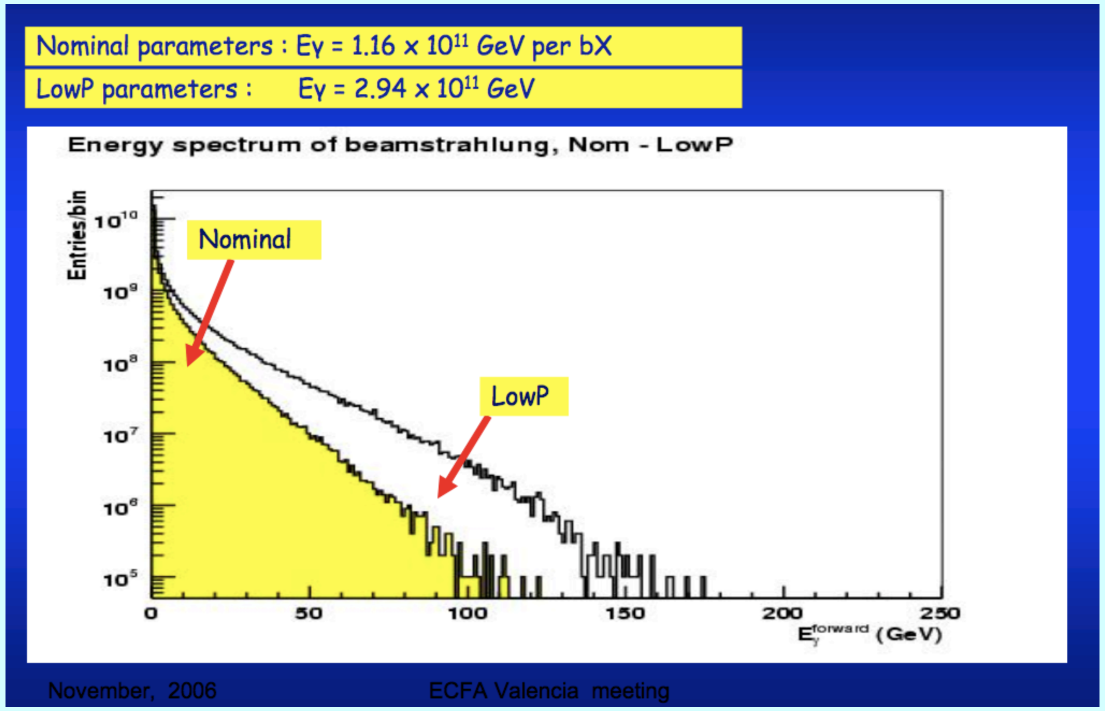
Beam Parameters Impact on Physics

ILC Beam Parameter Plane

- Low-P parameter set is most critical for backgrounds
  - Might have impact on VTX design (e.g. radius of inner layers)
- Larger beamstrahlung losses have also impact on physics via dilution of luminosity spectrum
  - Is the same for all detectors, so has no discriminative power, but is very important consideration in the minumum machine discussions







Alignment Requirements

Detector axis:

- ±1mm and 100µrad w.r.t. line defined by QF1
- detector height adjustment range: ± several cm, depending on geological requirements

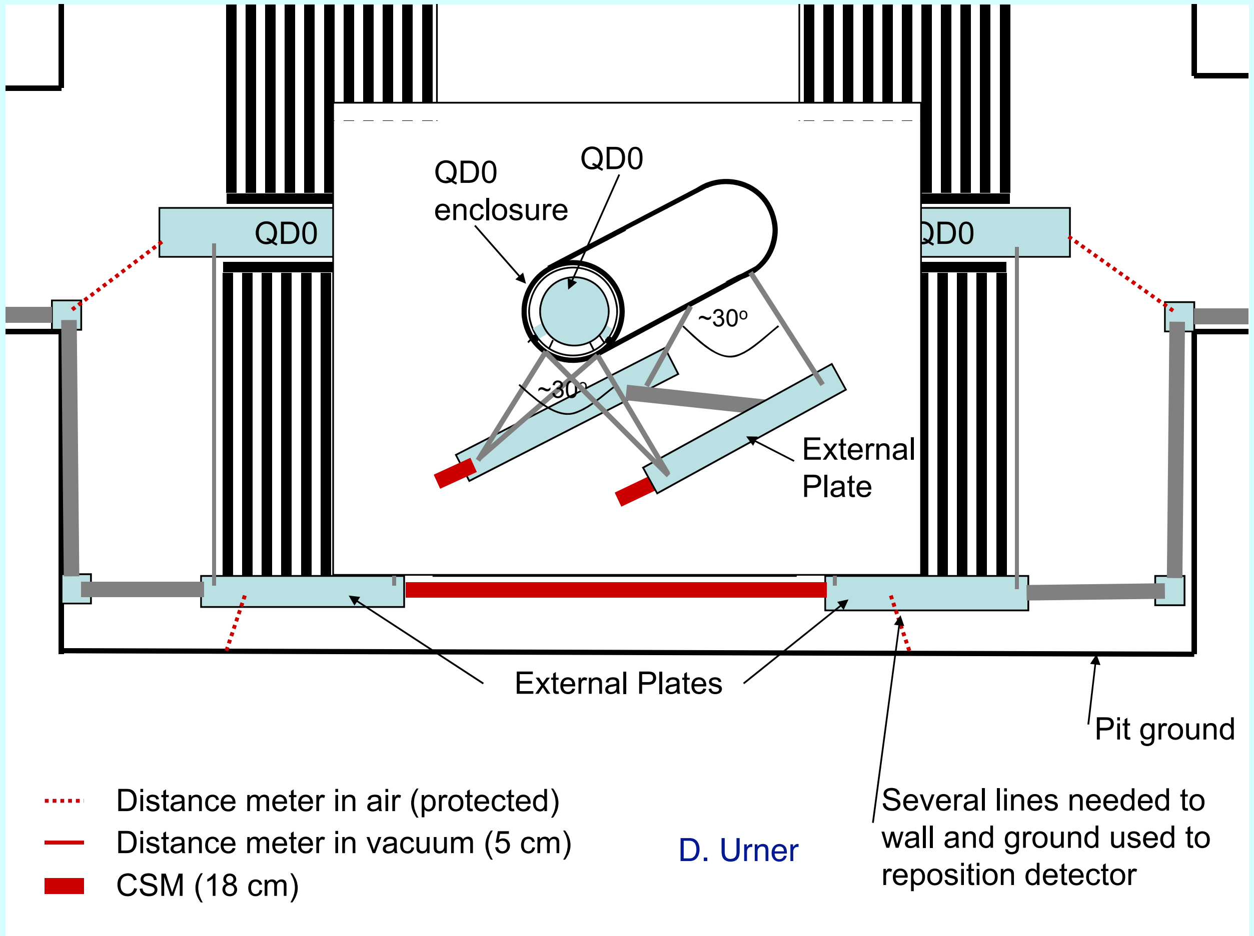
QD0 alignment:

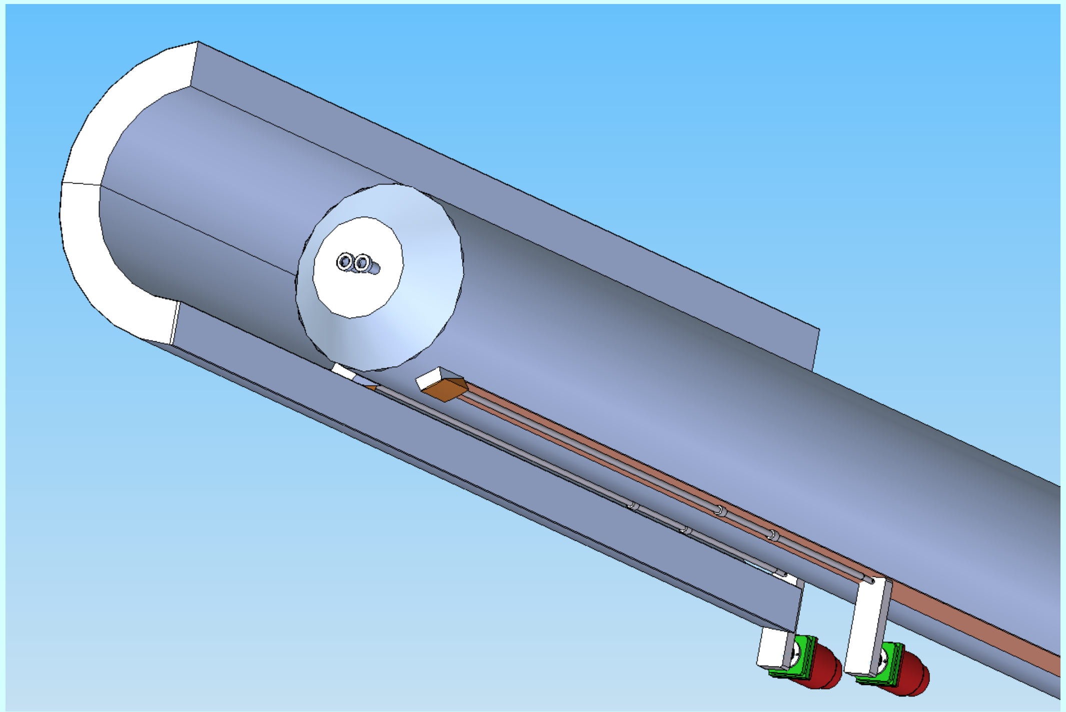
- Alignment system:
  - Degrees of freedom: 5 (x,y,pitch,yaw,roll)
  - Range per d.o.f.: ±2mm, ±30mrad (roll), ±1 mrad (pitch, yaw)
  - Step size per d.o.f.: 0.05 µm
- Accuracy before low-intensity beams are allowed to pass:
  - ±50µm (x,y), ±20mrad(roll), ±20µrad (pitch, yaw)
- Accuracy and stability after beam-based alignment:
  - ±200nm and 0.1 µrad w.r.t. line defined by QF1 stable over 200ms between bunch trains
  - QD0 vibration stability: less than 50 nm within 1ms bunch train

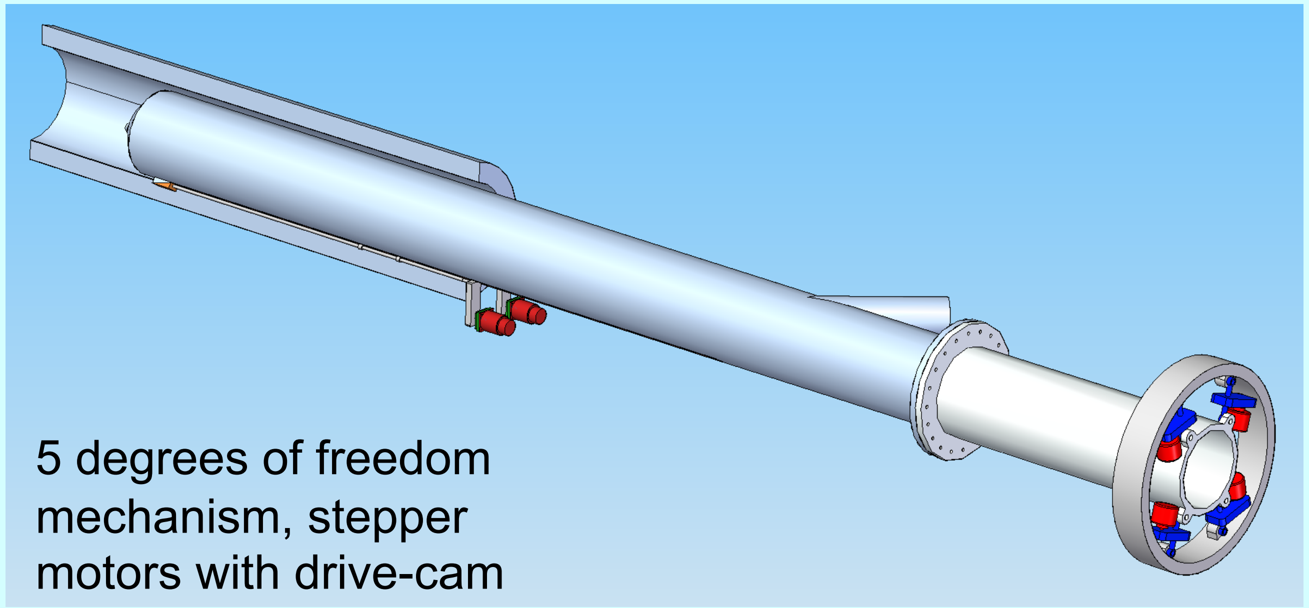
  - Control of the mover system will remain under control of BDS system and might be adjusted during the run

Alignment

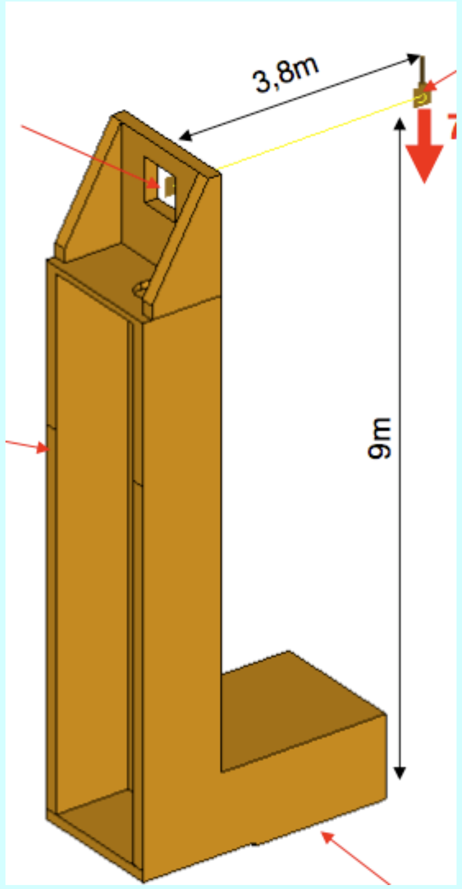
- Interferometric laser system could be used to align both QD0 magnets with respect to each other and to the beam axis
- Could also be used to align the detector itself
- Conceptual studies have started

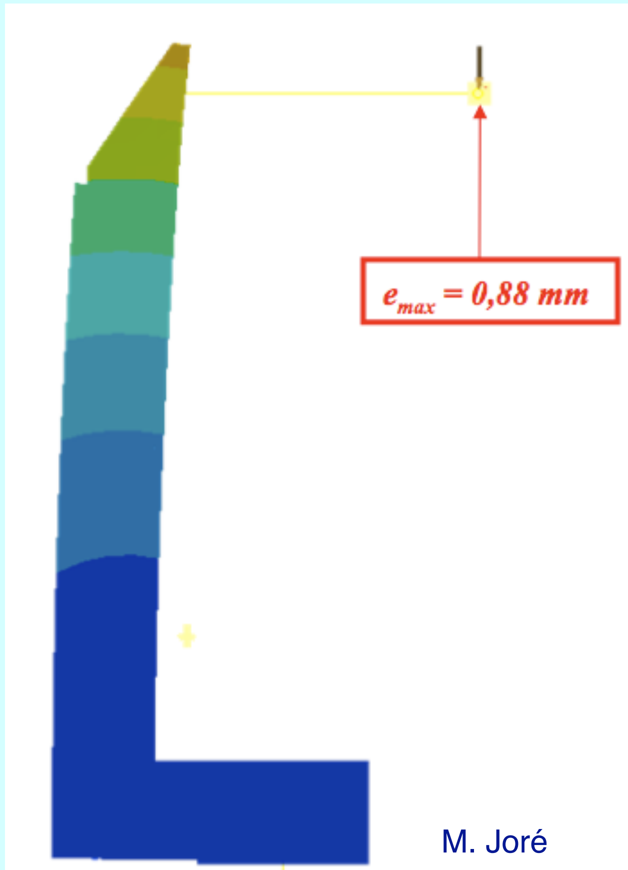




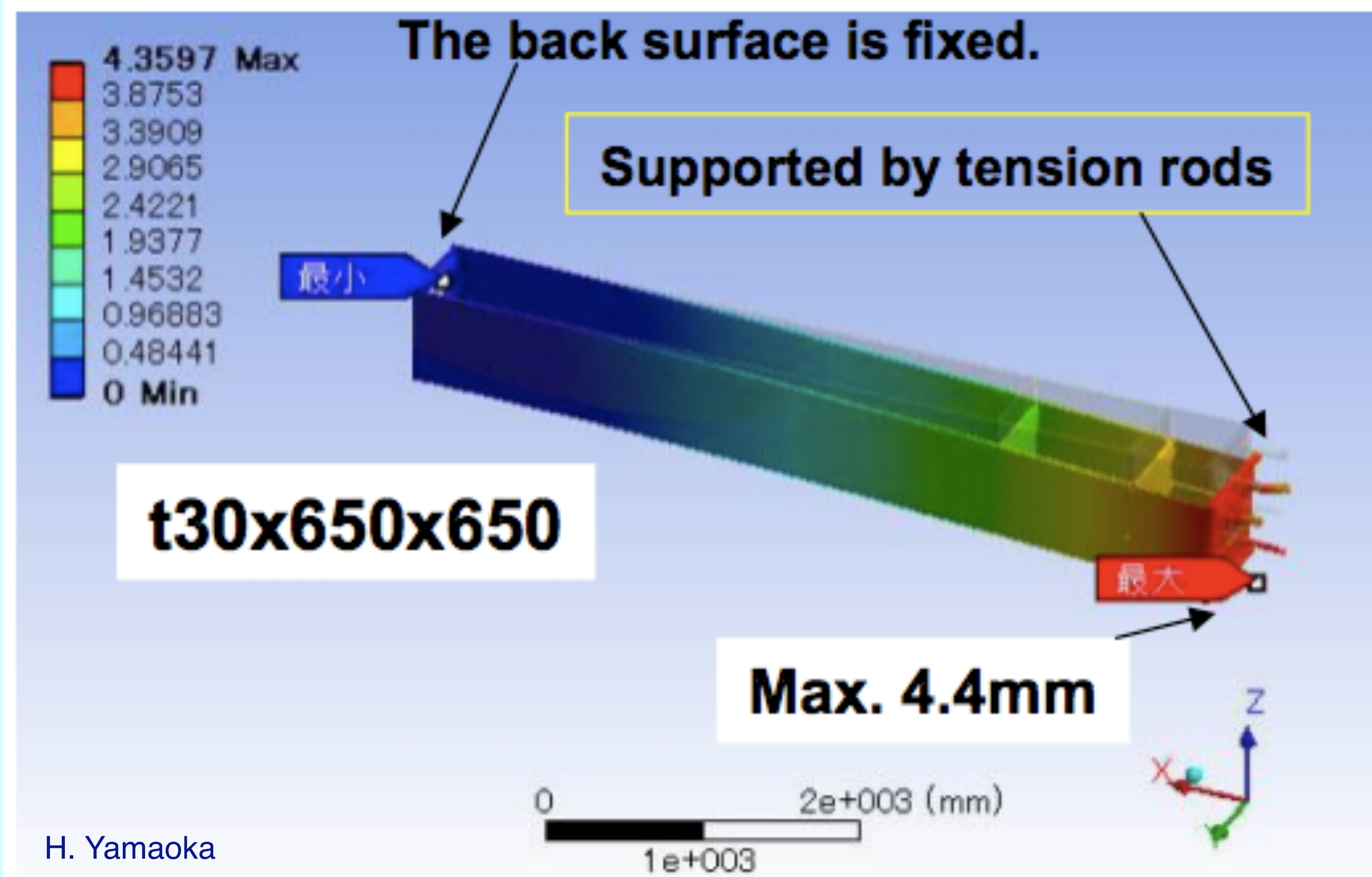


QD0 Support (ILD)



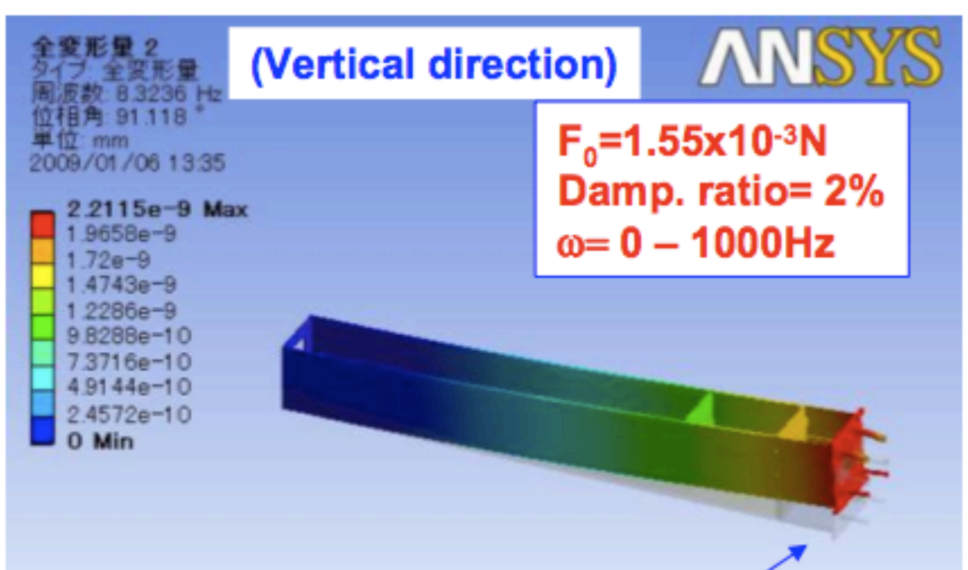


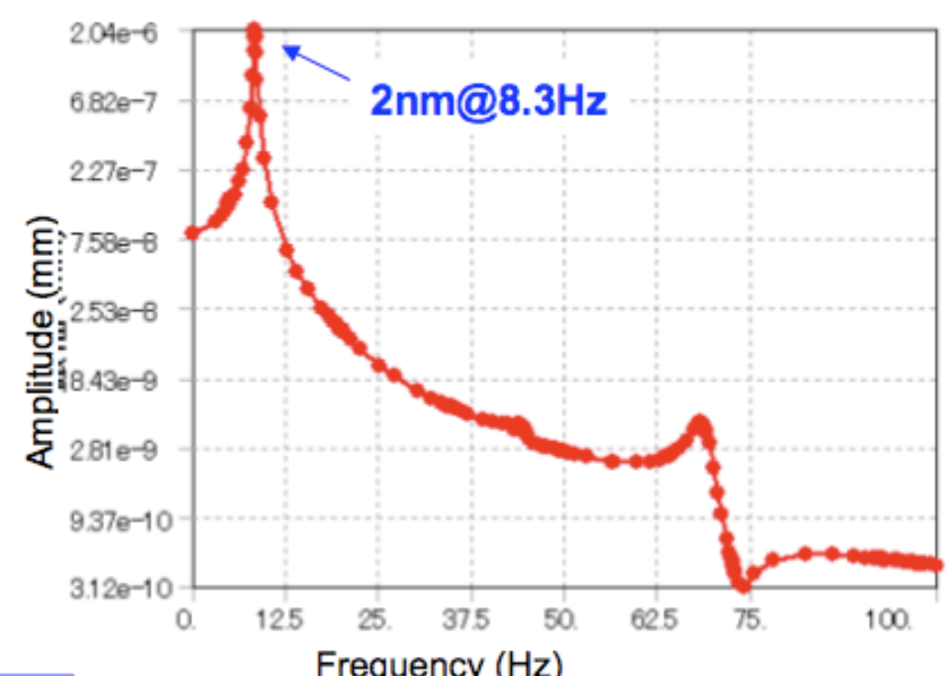
M. Joré



H. Yamaoka

Amplitude due to ground motion





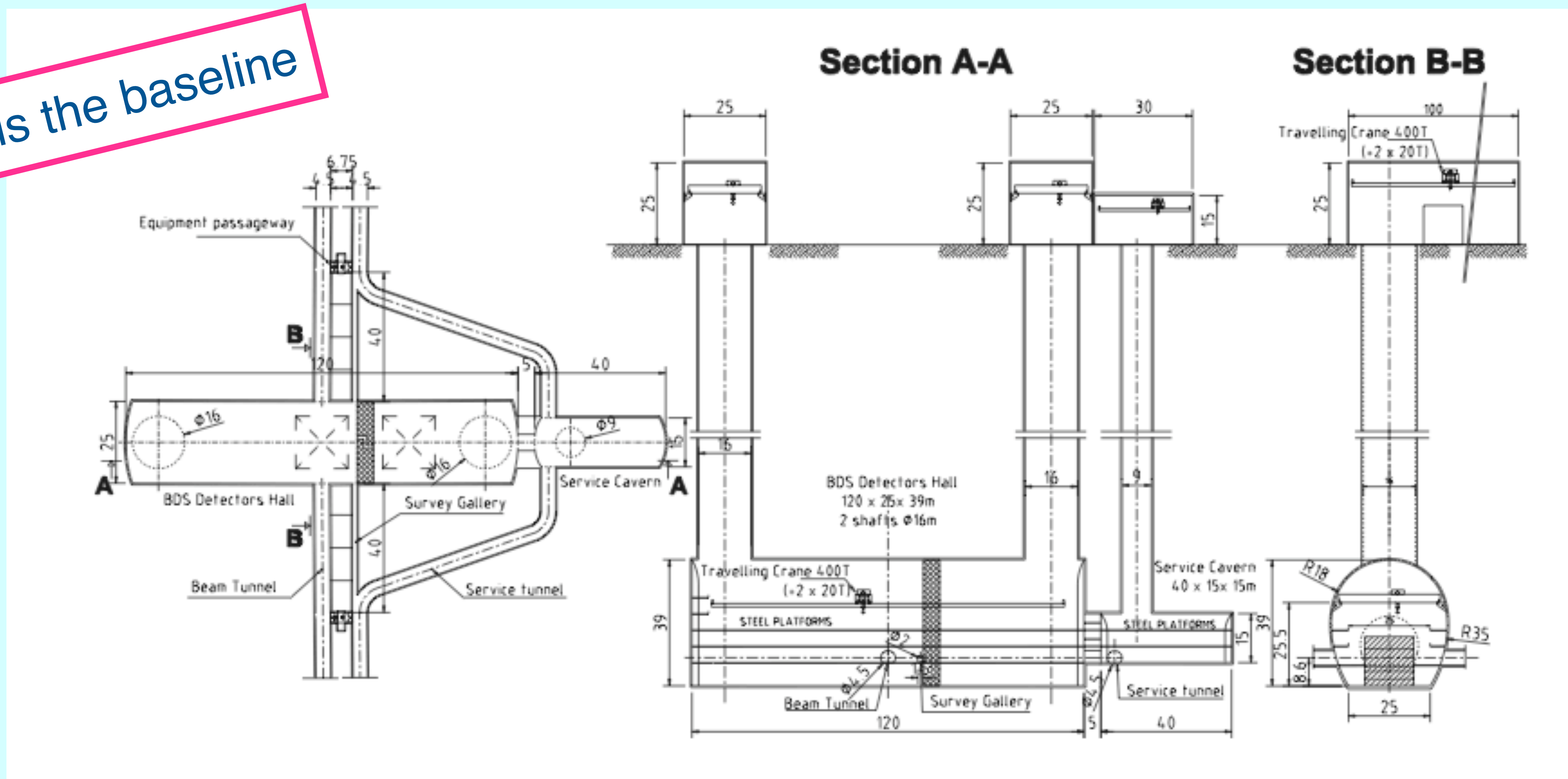
→ Amplitude: 2nm< 50nm @8.3Hz (Vetical direction)

H. Yamaoka

Underground Cavern Issues

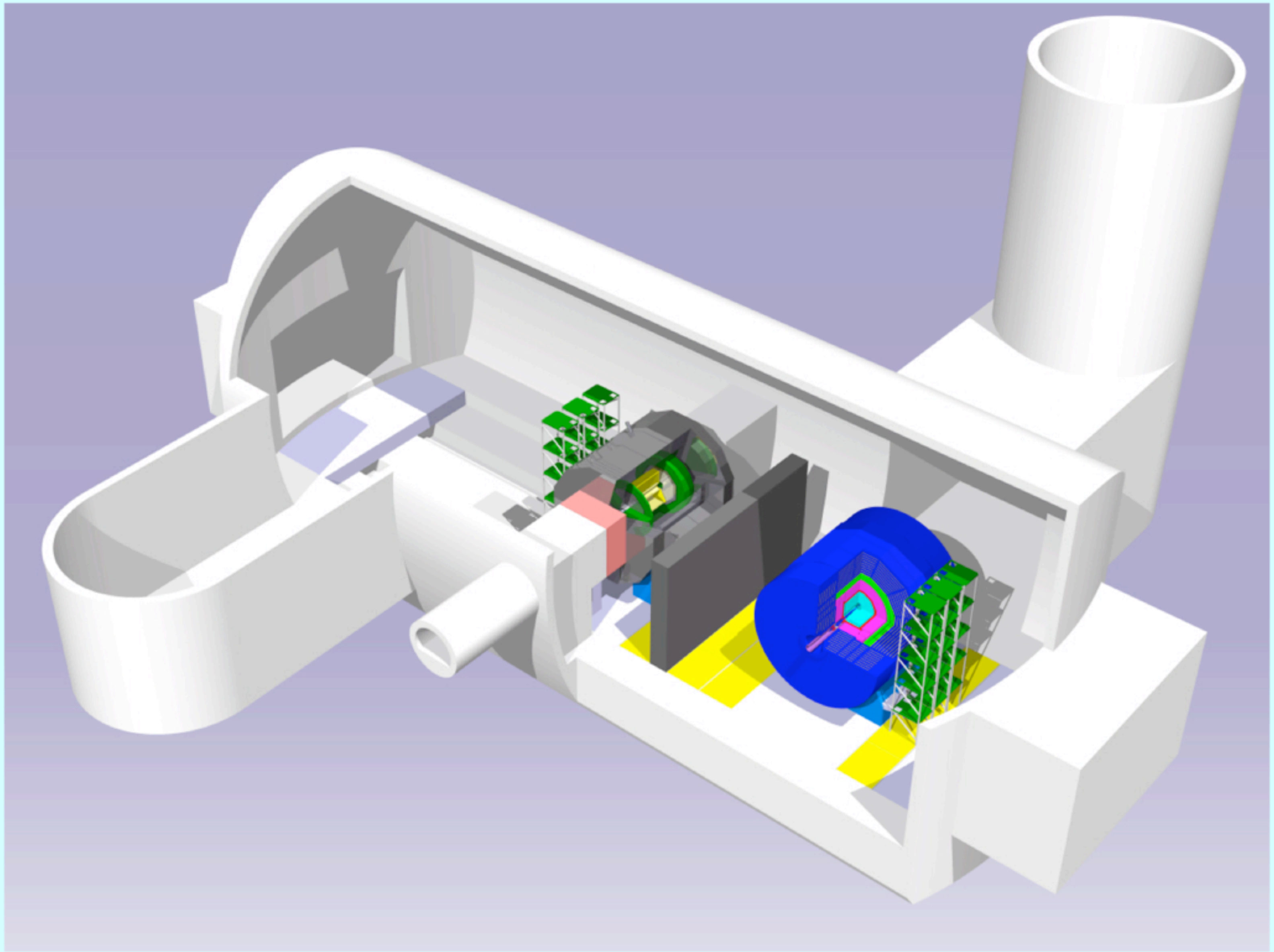
- Detectors can occupy up to 18m along the beamline (discussed before)
- Beam height is 10-12m above floor (sufficient for ILD on platform)
- Garage position of the off-beamline detector starts 15m perpendicular from the beam pipe
  - This has consequences for radiation and magnetic environment
  - The garaged detector should not be disturbed by the operation of the beamline detector and vice-versa

RDR is the baseline



Underground Cavern Study

- ILD presents study for underground cavern in the LoI
- More transverse space in the garage position for detector assembly
- Shafts relocated to the side alcoves
  - safety issue!
- Service cavern for both detectors



Radiation Environment

- Radiation shielding is crucial if two detectors occupy the same hall
- Detectors need to be either self-shielding or take responsibility for additional shields
  - choice of shielding will have impact on hall design
- Radiation requirements depend on the site. For the time being assume:
  - normal operation: less than 0.5μSv/h everywhere beyond the 15m-line
  - accidental beam loss: simultaneous loss of both beams with maximum power anywhere in the BDS or detector: dose less than 250 mSv/h and 1mSv per accident. Beam shut-off assumed after one beam train.
  - these numbers are compatible with regulations at KEK, CERN, FNAL for supervised access or similar
- Radiation levels on the beamline could be different, but depend on the access procedures of the on-beamline detector

Simulations done by T. Sanami et al.:

SLAC RADIATION PHYSICS NOTE **RP-09-08**

March 30, 2009

IR hall dose rate estimates with detector concepts

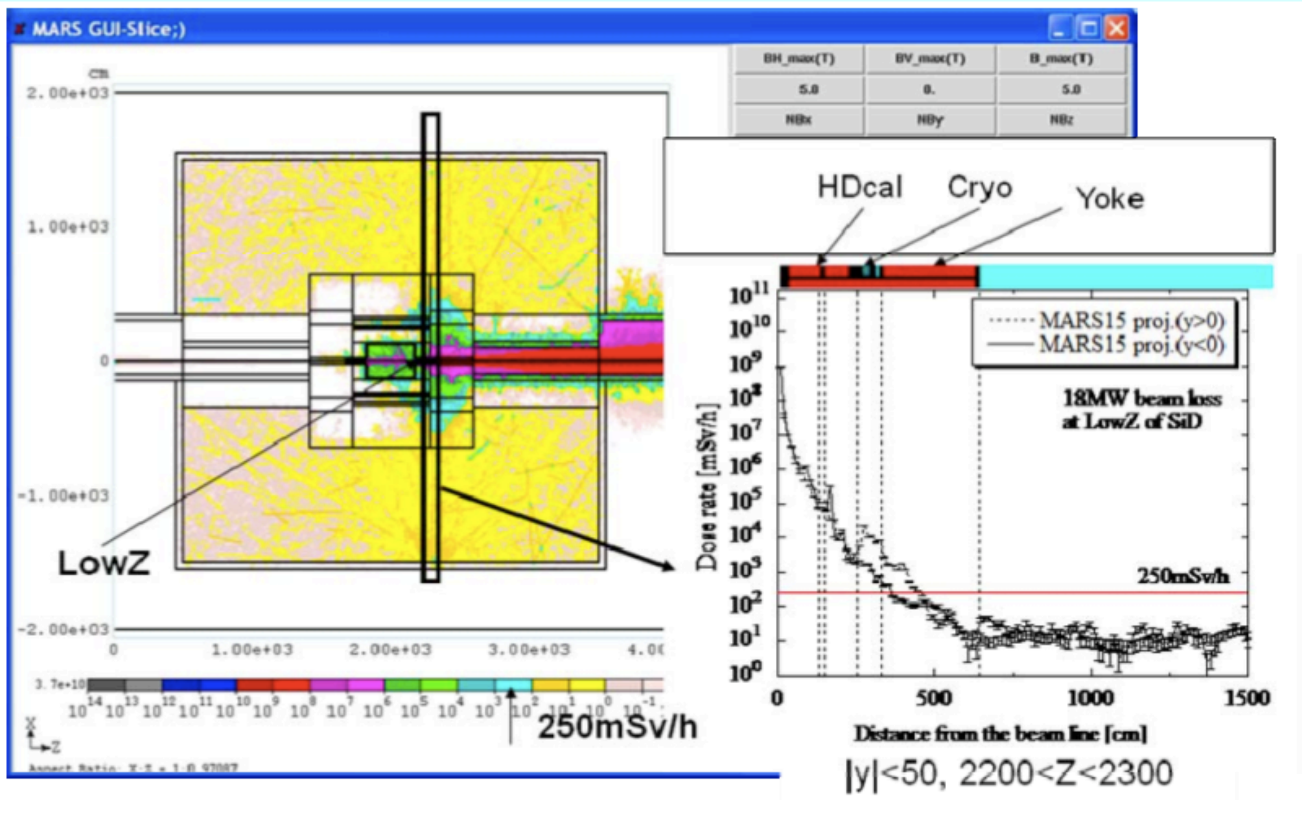
T.Sanami[1,2], A.Fasso[2], M.Santana[2], L.Keller[2], A.Seryi[2], S.Rokni[2], S.Ban[1]

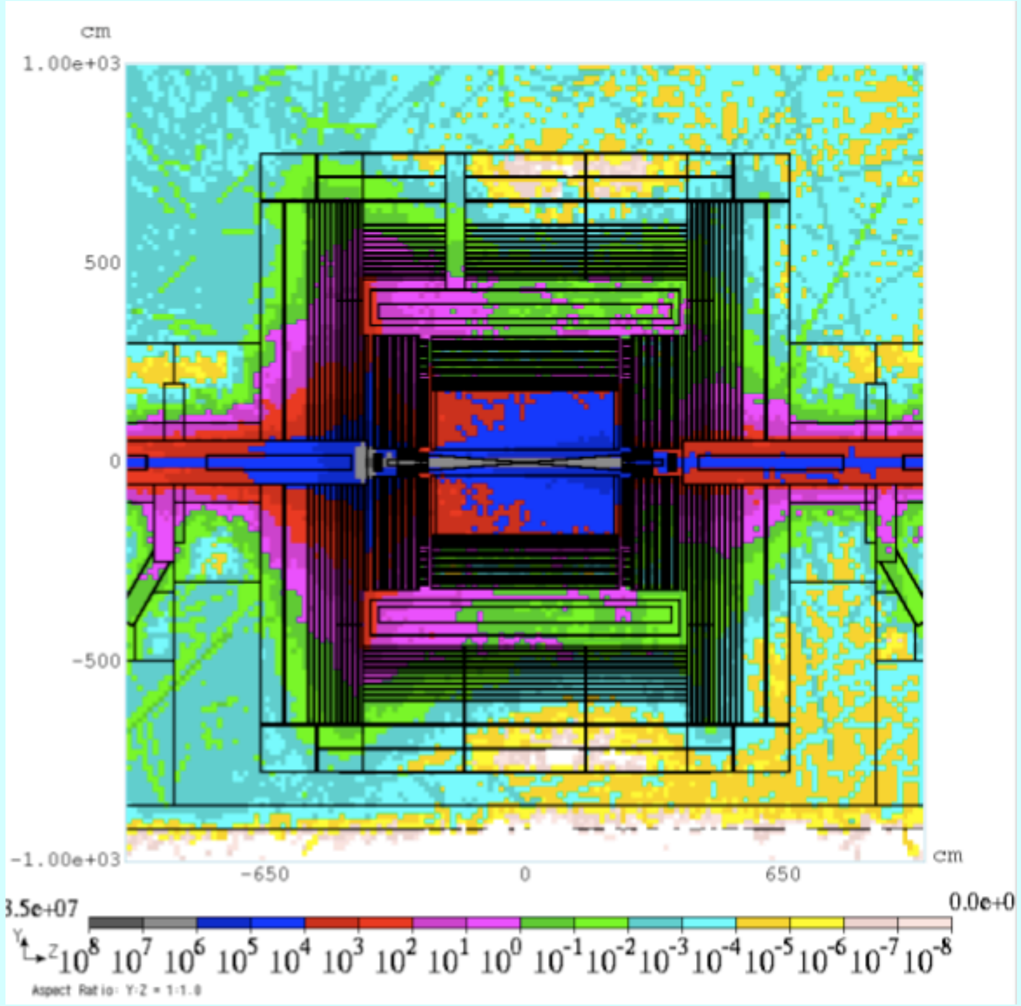
[1]Radiation Science Center, KEK,
Oho 1-1, Tsukuba, Ibaraki 305-0801
[2]Radiation Protection Department, SLAC, MS48
2575 Sand Hill Road, Menlo Park, CA 94025

- Studying dose rate distributions for maximum credible beam loss scenarios: 18 MW beam at 500 GeV
- Dose rate limit: 0.014 mSv/h/kW

SiD and ILD

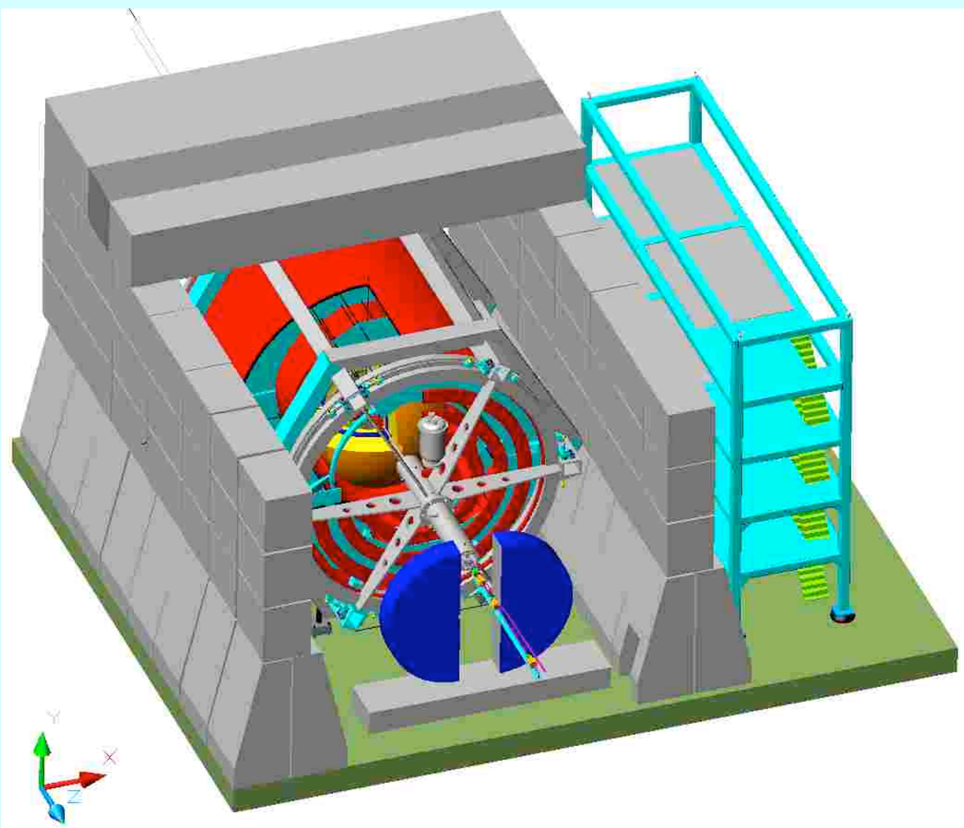
- SiD and ILD will be self-shielding if properly designed
- Careful study of the yoke geometries is needed
- Dose rate limits will be reached

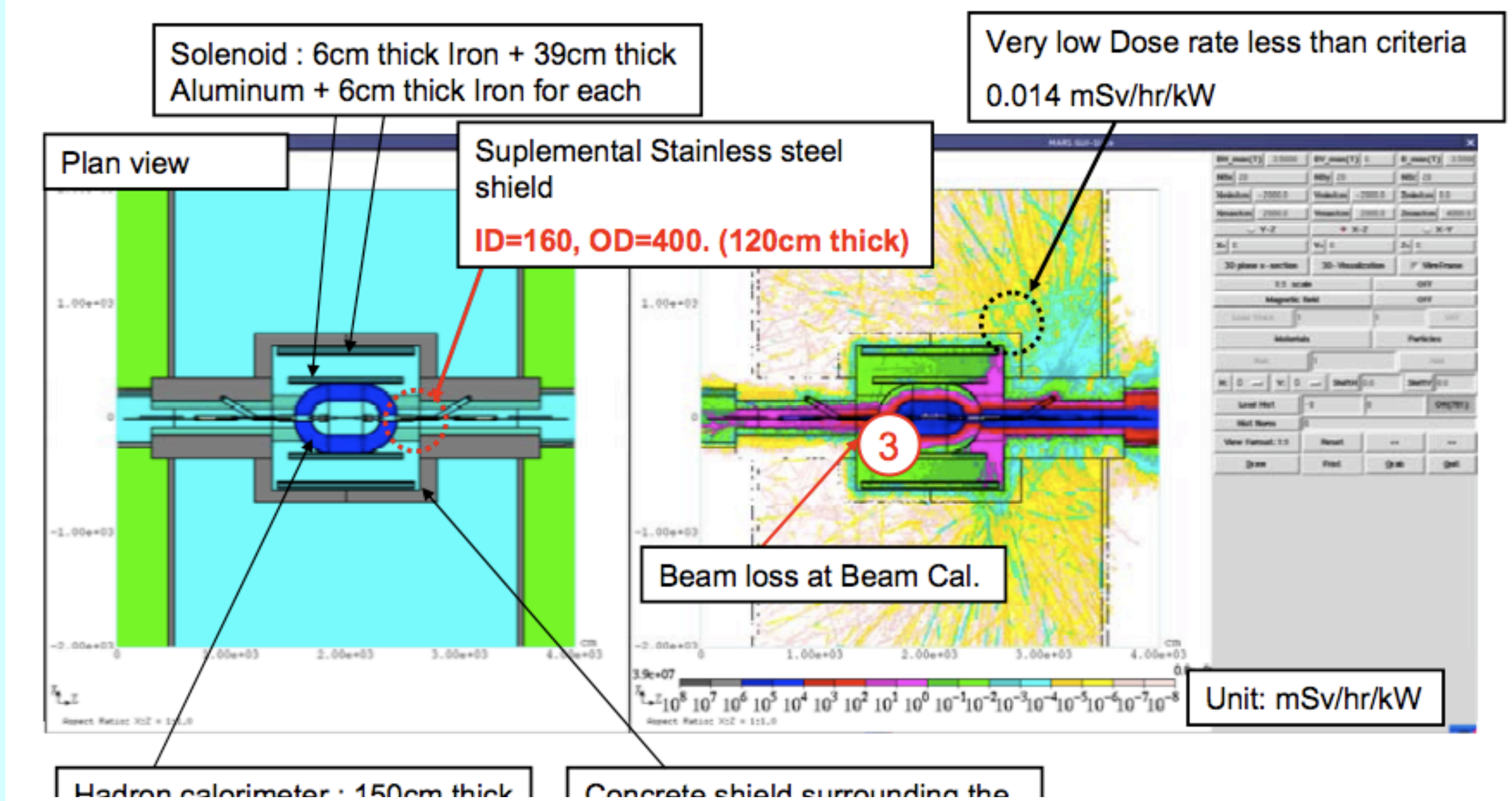


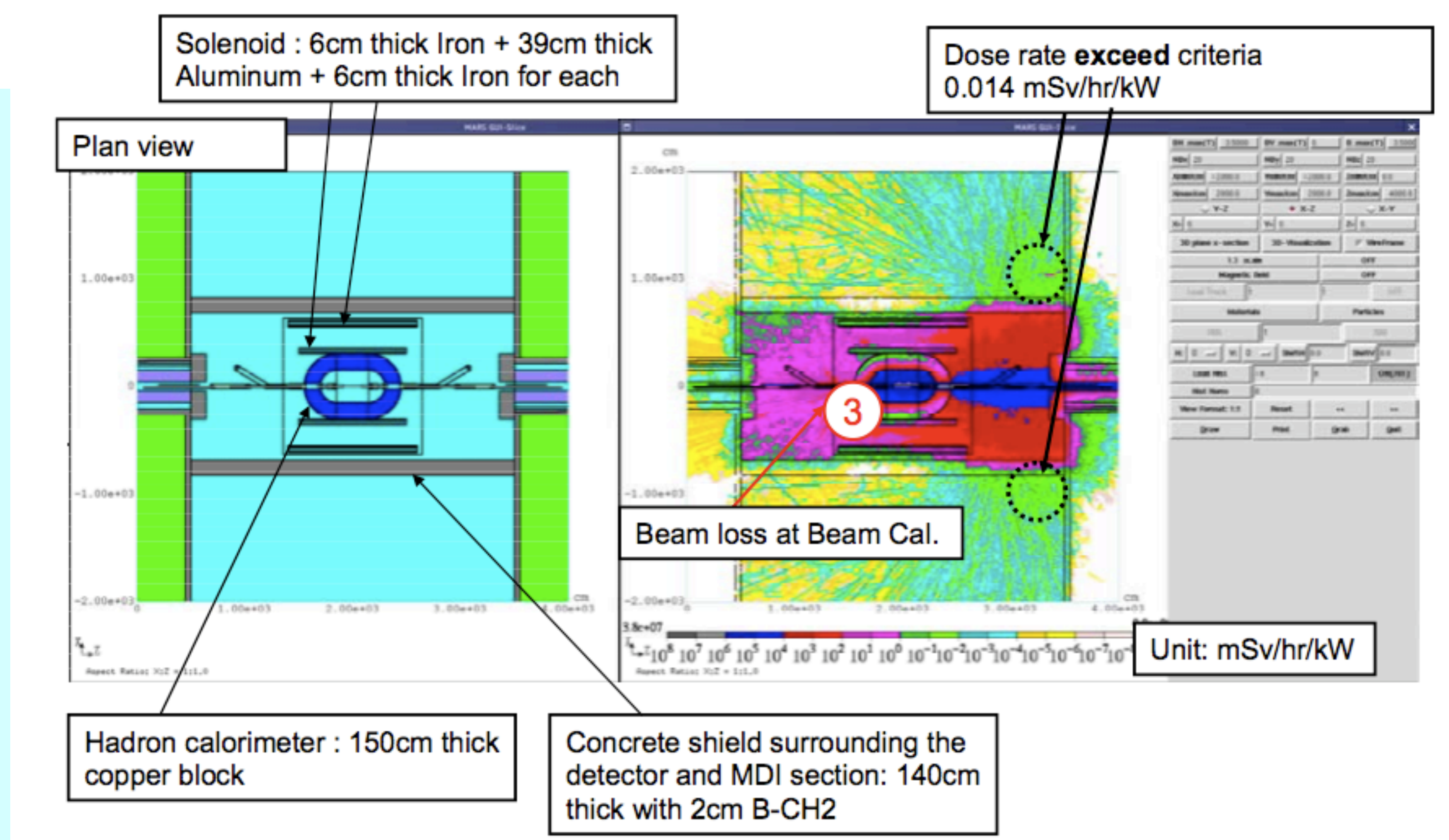


4th Concept Shielding

- 4th concept is not self-shielding
- Additional concrete and iron shieldings under study
- Dose rate limits can be reached with the proper shielding configuration

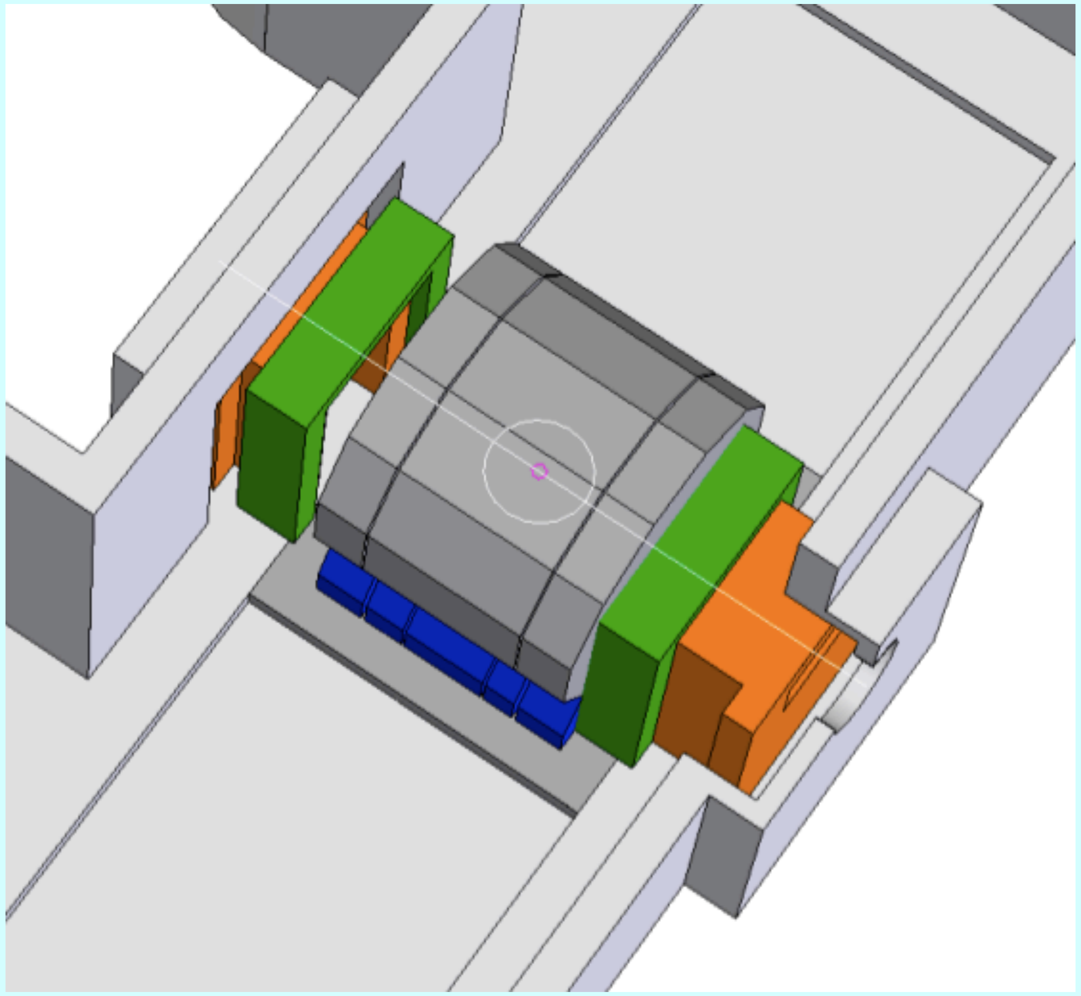


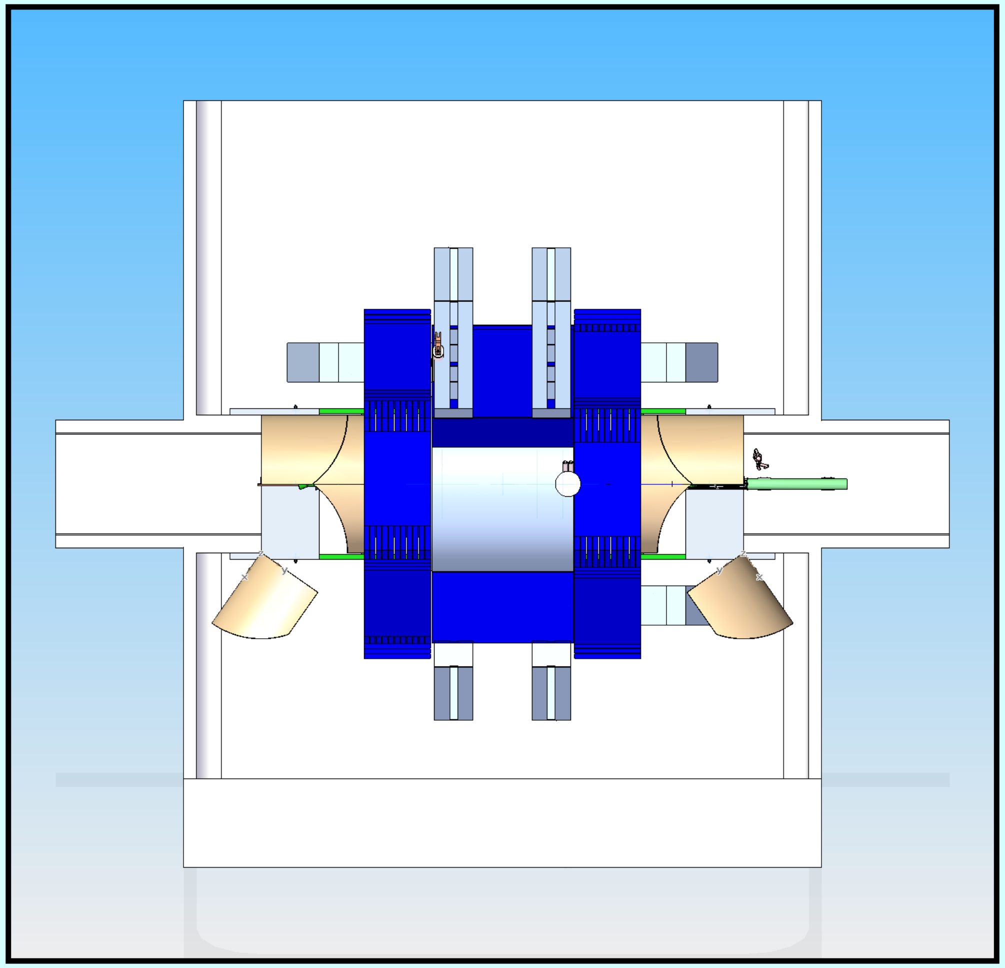




„Pacman“ Shielding

- „Pacman“ Shielding of ~2.5m concrete/iron is needed for radiation protection
- Solution needs to fit to both detectors
- Should be part of the bilateral discussions of the two final detectors





Magnetic Environment

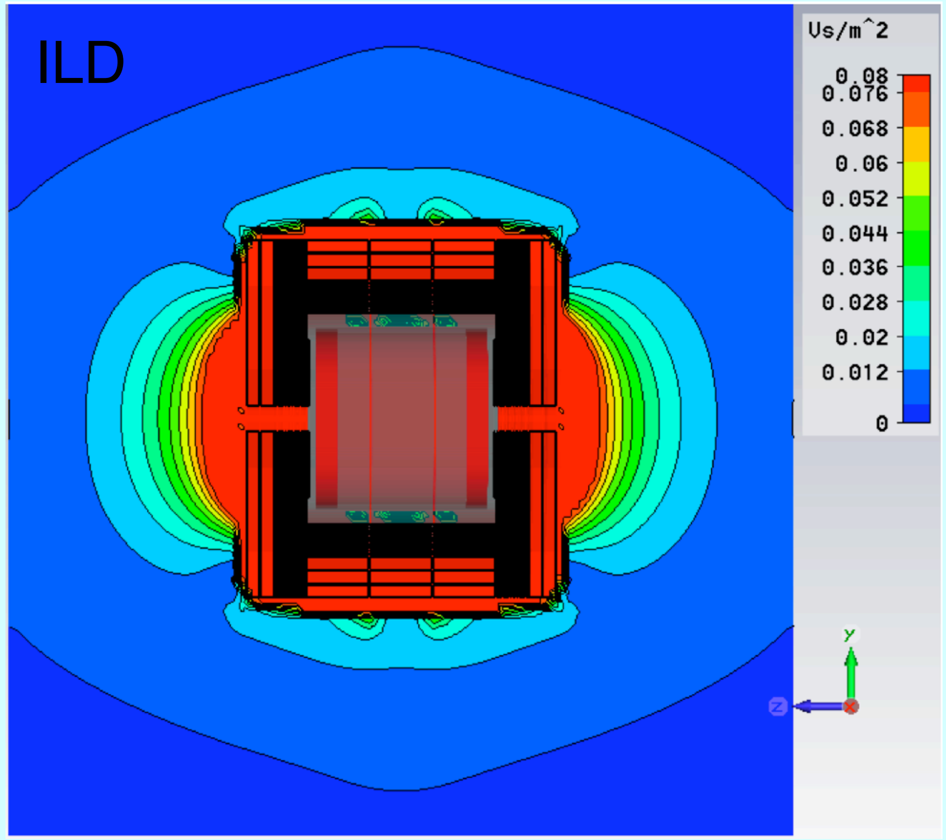
- Requirements on the magnetic fields outside of the detectors define the amount of iron (or compensating coils) on the detectors
- Agree on the following numbers (CERN):
  - 5 Gauss for people wearing pacemakers
  - 50 Gauss for the use of iron-based tools
  - 100 Gauss for the general public
  - 2000 Gaus for occupational exposure
- Less than 50 Gauss at the start of the garage position (15m) to allow the parked detector to be maintained with whatever the respective collaboration needs.
- No restrictions for the fields along the beamline. Assumes that any static field can be corrected.

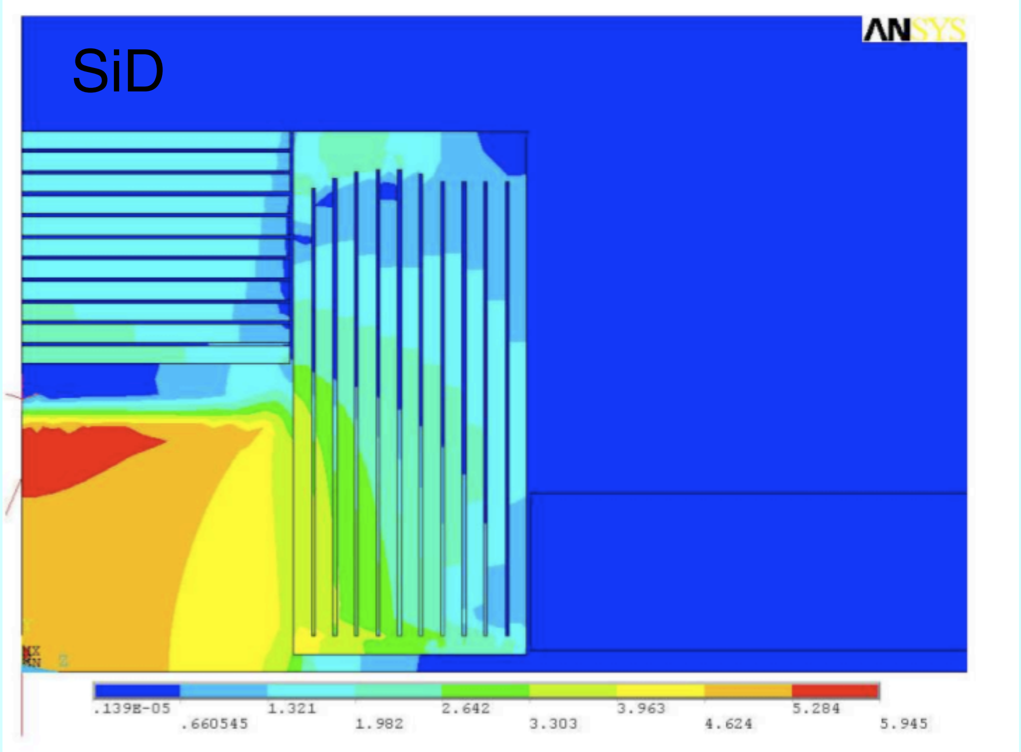
- Field of the parked detector must have less than 0.01% effect on the field in the tracking region of the beamline detector.

- All requirements for static fields as well as rampings, quenches, etc.

SiD and ILD Stray Fields

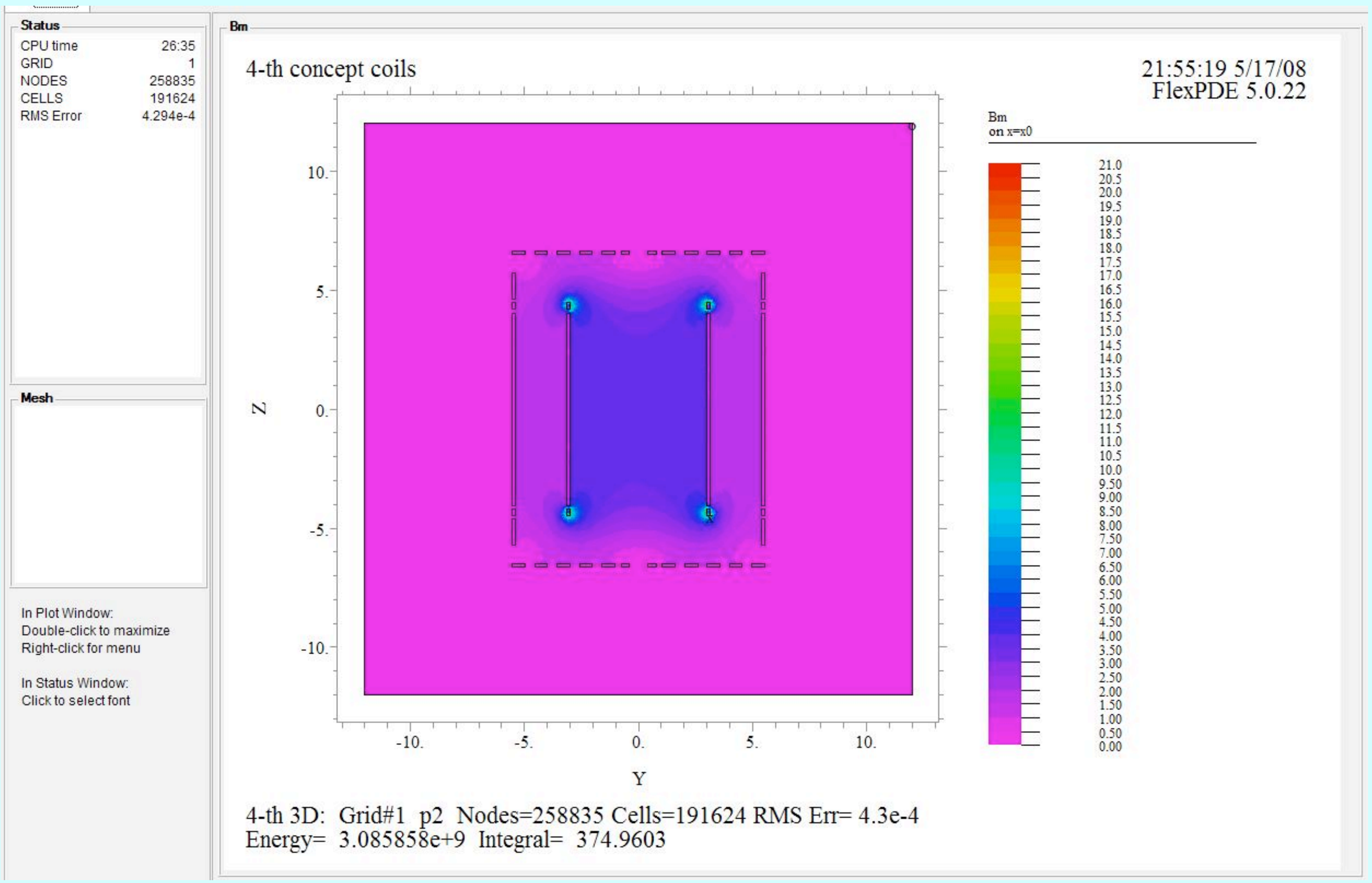
- ILD: less than 40 Gauss outside the 15m line
- SiD: 100 Gauss at 1m from the iron surface
- Major cost item: lots of iron needed!
- e.g. CMS has much less iron and much larger stray fields - but is alone in the hall!





4th Concept Stray Fields

- 4th compensates the magnetic field actively
- fringe fields are very low



Polarisation and Energy Measurement

- Expert group produced a document (ILC-Note-2009-049) which describes the common design for the polarimeters and the energy spectrometers:

DESY 09-028
SLAC-PUB-13551
February, 2009

Polarimeters and Energy Spectrometers for the ILC Beam Delivery System

S. Boogert[1], M. Hildreth[2], D. Käfer[3], J. List[3], K. Mönig[3], K.C. Moffeit[4], G. Moortgat-Pick[5], S. Riemann[3], H.J. Schreiber[3], P. Schüler[3], E. Torrence[6], M. Woods[4]

[1]Royal Holloway, University of London, UK
[2]University of Notre Dame, USA
[3]DESY, Hamburg and Zeuthen, Germany
[4]SLAC National Accelerator Laboratory, Stanford, USA
[5]IPPP, University of Durham, UK
[6]University of Oregon, USA

Abstract

This article gives an overview of current plans and issues for polarimeters and energy spectrometers in the Beam Delivery System of the ILC. It is meant to serve as a useful reference for the Detector Letter of Intent documents currently being prepared.

- Dedicated talk by Jenny List on Sunday

How to proceed

Many technical details need to be specified in bi-lateral agreements between the two final detectors: