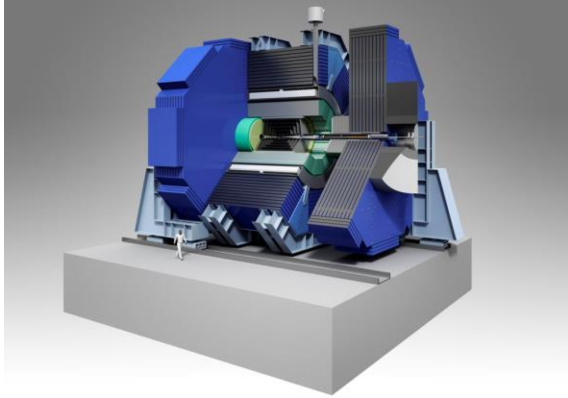


SID MDI & Engineering

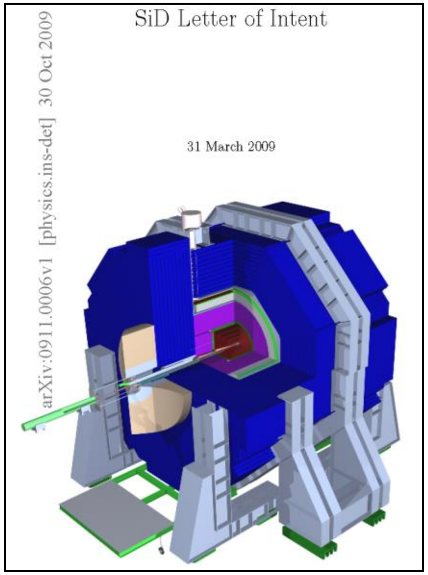
Marco Oriunno (SLAC), Nov. 12, 2013

LCWS13, TOKYO

U.S. DEPARTMENT OF ENERGY
Office of Science

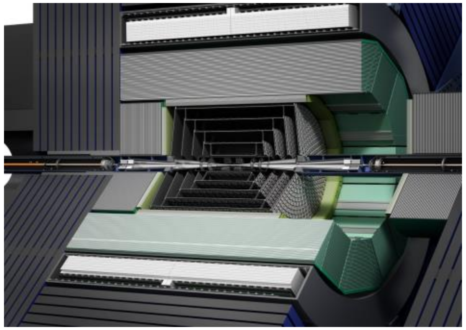
SLAC NATIONAL ACCELERATOR LABORATORY

Slowly but Steadily

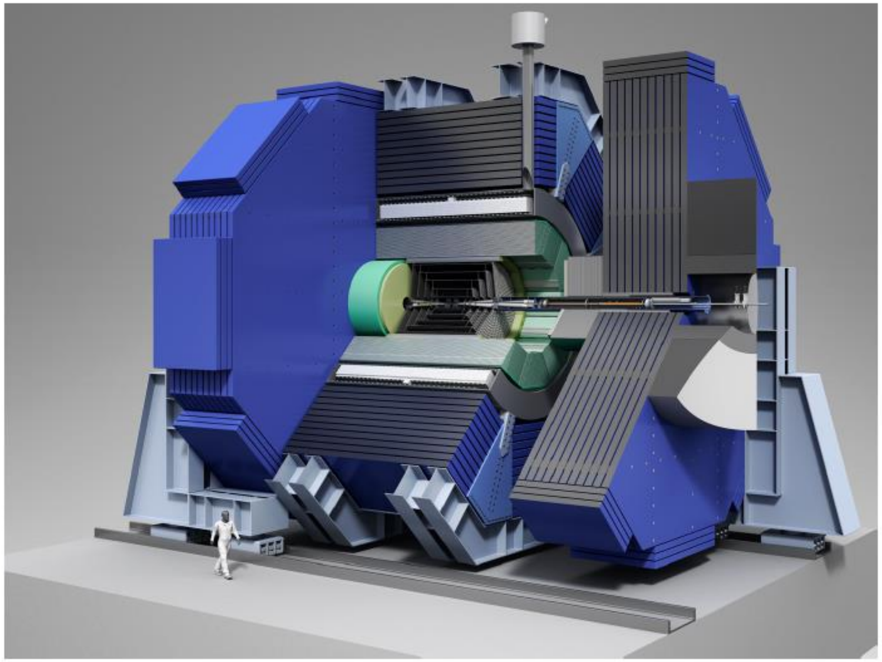


SiD

Technical Design Report
...2018 ?



Detailed Baseline Document - MDI



SiD

DETAILED BASELINE DESIGN

DRAFT SUBMITTED TO THE PAC (REVISED)

10 DECEMBER 2012

Steps toward a real SiD

Some national body (ies) (Japan and collaborators?) commits to linear collider 2014

Optimize SiD + Value engineering : lower costs and preserve performance

Prepare serious TDR with technical prototypes and serious cost estimate. 3 years: 2017

Requires a fully reviewed TDR. Assume the review process, with minor iterations, takes 1 year. 2018

Ready for Construction…Adding time for collaboration formation…

From here to Commitment

1. A Technical Design Report should include:
   - Clear baseline choices for all subsystems
   - Final subsystem dimensions & clearances
   - Reasonably complete mechanical designs including tooling
   - Prototypes and Testbeam
   - Serious cost estimate
2. We presently have < 0.5 Mechanical Engineers total in SiD. This would have to go to 2 FTE's to begin to make mechanical progress.
3. In the intensive TDR stage, this should be ~10 FTE's + similar number of designers.
4. The Electronic Engineering is in better shape.
5. System Engineering (Interfaces) needs serious effort, particularly cryogenics interfaces . Japanese codes (e.g. radiation, B fields, seismic, transport, etc) need to be studied. Need to encourage US-Japan collaboration proposal.

Critical Issues for Mechanical Engineering

Machine – Detector Interface

There is ~1.5 m radial difference between SiD and ILD. The SiD platform is 3.8 m thick. The platforms appear to add a year to the construction schedule. Revisit platforms??

SiD L* = 3.5 m; ILD L* = 4.5 m. BNL design dimensions for the SiD QD0 are needed.

Support and vibration issues need continued work.

Critical Issues for Mechanical Engineering

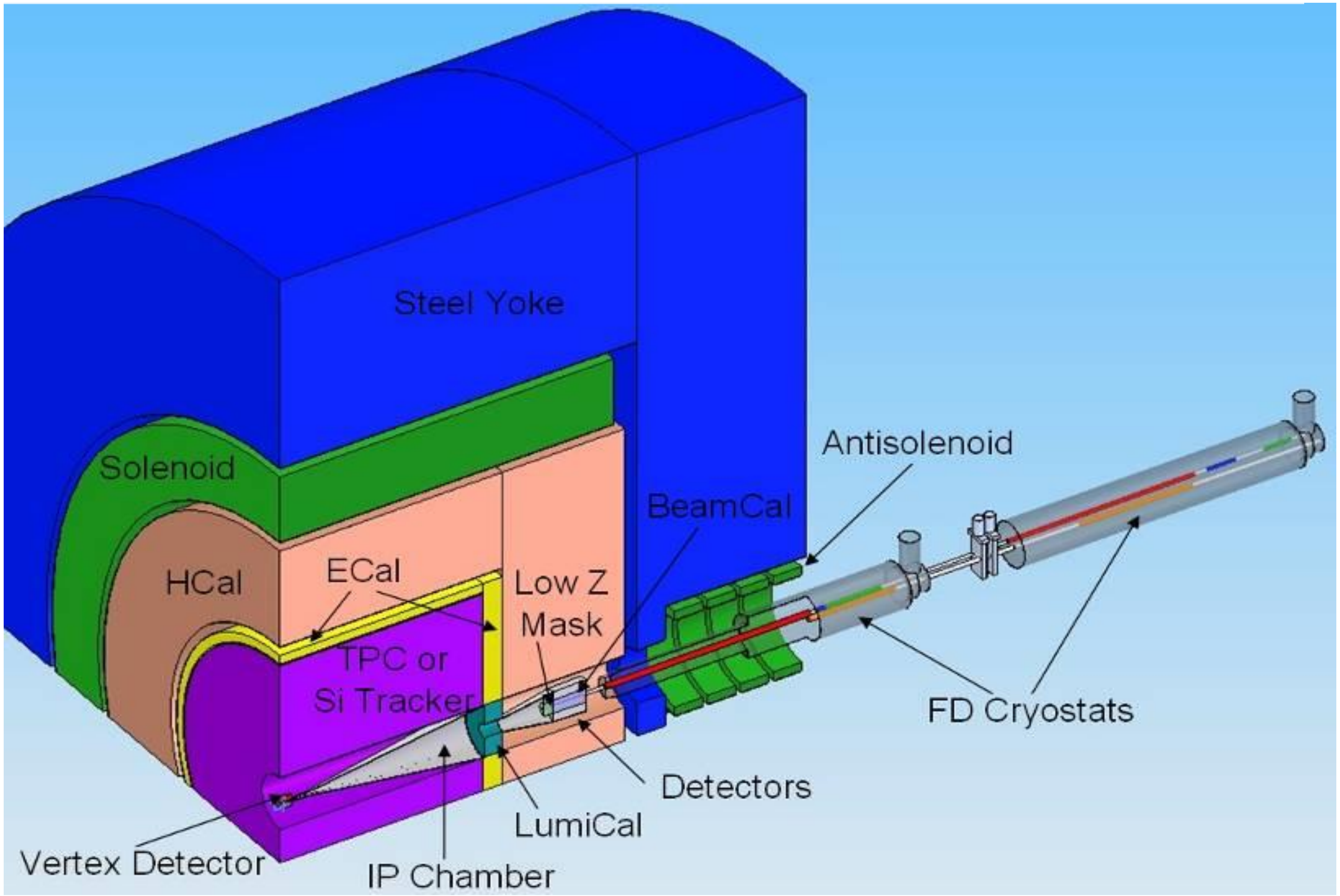
SLAC

It is believed – within the engineering group – that while there are *plenty* of other difficult problems to work on, they do not have the impact or logjam effect of optimization.

There is an enhanced effort on MDI issues at SLAC. We will try to focus them on Critical Issue 2 – Support of the detector, quads, and vibrations and costs.

Interaction Region deliverable

“Provide reliable collisions of ultra small beams (~few nanometers), with acceptable level of background”



Vacuum Spec from Beam Gas Scattering

SLAC

- Scattering inside the detector is negligible up to 1’000 nT

250 GeV e- → OD2.4 cm x 7 m long gas ($H_2/CO/CO_2$)

only Moller scattering off atomic electrons is significant.

Luminosity backgrounds (pairs, $\gamma\gamma\rightarrow$hadrons) are much higher

Within the IP region there are 0.02 - 0.04 hits/bunch (3-6 hits TPC) at an average energy of about 100 GeV/hit originating QD0–200 m from the IP.
Therefore 1 nT from QD0–200 m is conservative.

On the FD protection collimator there are 0.20 charged hits/bunch (33 hits TPC) at an average energy of about 240 GeV/hit and 0.06 photon hits/bunch (9 hits TPC) at an average energy of about 50 GeV/hit originating 0–800 m from the IP.
Therefore 10 nT from 200–800 m.

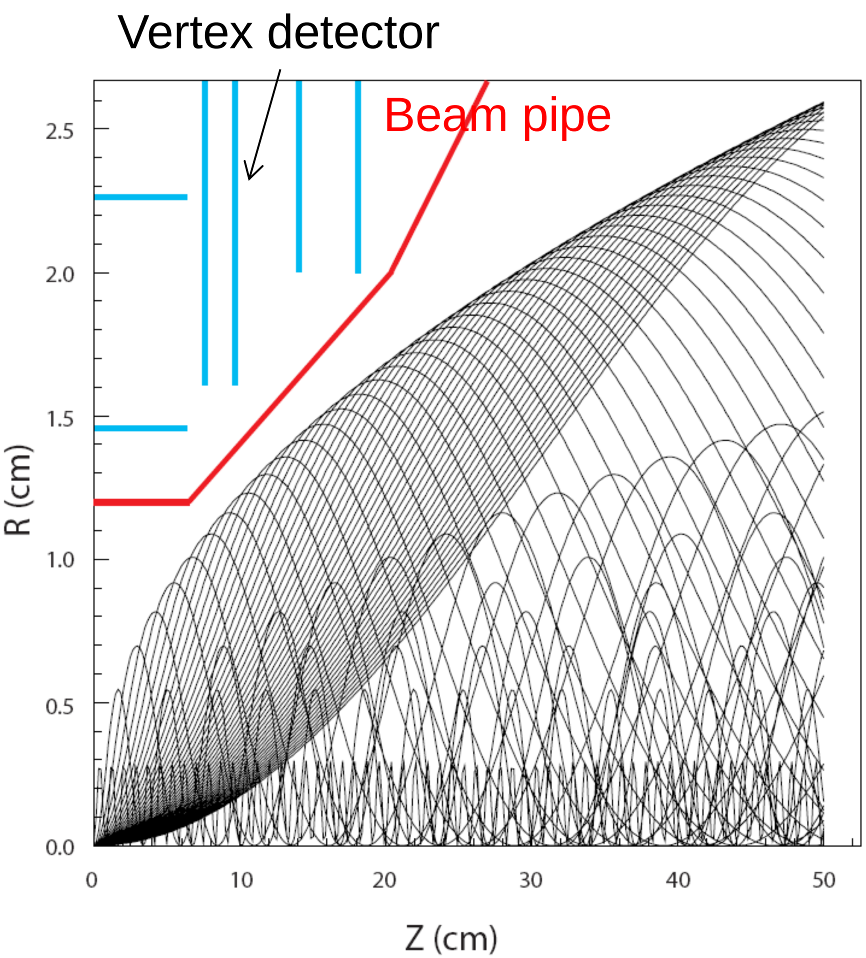
Beyond 800 m from the IP the pressure could conceivably be at least an order of magnitude higher than 10 nT, pending look at BGB background in the Compton polarimeter and energy spectrometer.

Pair edge and Beam pipe design

~200 k pairs/BX are produced.

Pairs develop a sharp edge and the beam pipe must be placed outside the edge.

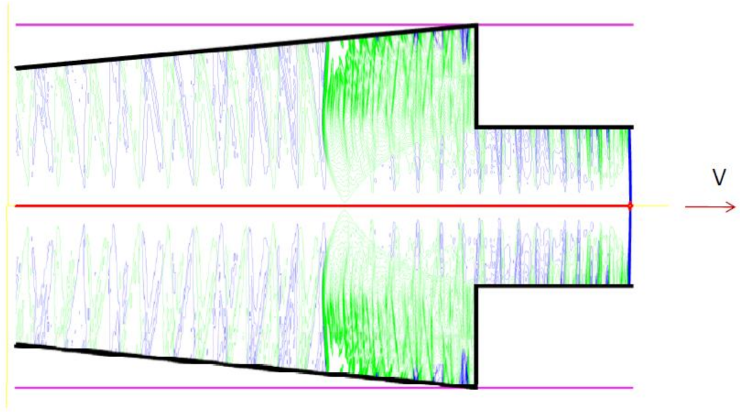
The pair edge is critically dependent on the IP beam parameters.



HOM heating at the IP and in QD0 *(S.Novokhatski, SLAC)*

- *Beam fields*
- *Wake potentials and loss power*
- *Trapped and propagating modes*
- *Frequency spectrum*
- *Resistive wake fields*
- *Total power loss*

Example of Wakefields



- The amount of beam energy loss in IR is very small.
- Spectrum of the wake fields is limited to 300 GHz
- Average power of the wake fields excited ~30 W nominal (6 kW pulsed)
- In the QD0 region the additional losses are of 4W (averaged) .
- BPMs and kickers must be added.

Limits of static magnetic field

Ministerial ordinance of Economic industrial ministry in Japan :
The technical standard regarding electric installation, 27th provision 2, 2011

less than 200μT (2G) in the place where the person enters easily

Guidelines on LIMITS OF EXPOSURE TO STATIC MAGNETIC FIELDS, ICNIRP, HEALTH PHYSICS 96(4):504-514; 2009

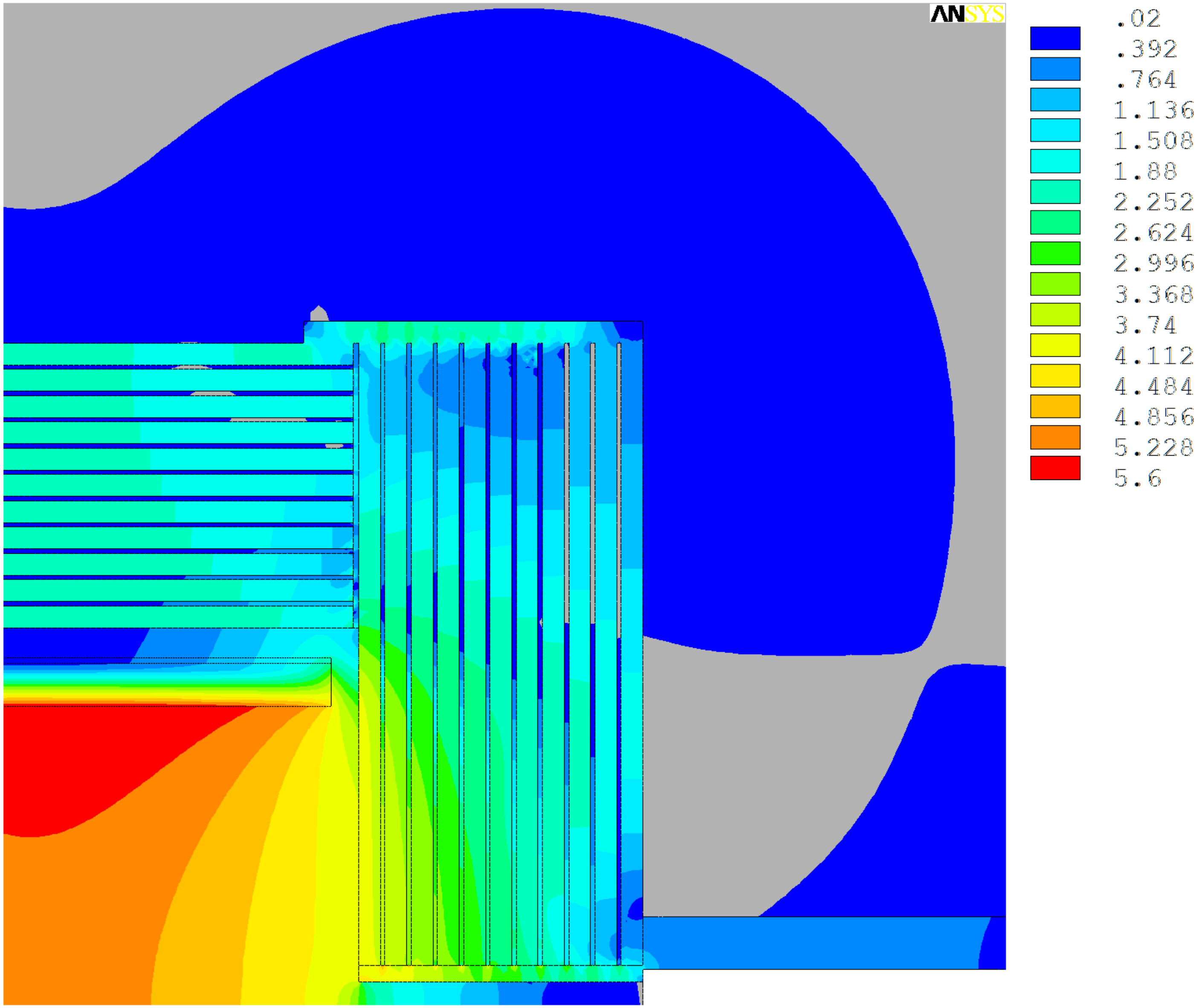
ICNIRP : International Commission on Non-Ionizing Radiation Protection

Table 2. Limits of exposure[a] to static magnetic fields.

Exposure characteristics	Magnetic flux density
Occupational[b]	
Exposure of head and of trunk	2 T
Exposure of limbs[c]	8 T
General public[d]	
Exposure of any part of the body	400 mT (4KG)

[a] ICNIRP recommends that these limits should be viewed operationally as spatial peak exposure limits.
[b] For specific work applications, exposure up to 8 T can be justified, if the environment is controlled and appropriate work practices are implemented to control movement-induced effects.
[c] Not enough information is available on which to base exposure limits beyond 8 T.
[d] Because of potential indirect adverse effects, ICNIRP recognizes that practical policies need to be implemented to prevent inadvertent harmful exposure of persons with implanted electronic medical devices and implants containing ferromagnetic material, and dangers from flying objects, which can lead to much lower restriction levels such as 0.5 mT. (5G)

Fringe Field for a quadrant view of SiD
Cut off @ 200 Gauss



Radiation Rules - Japan

Radiation Rules at KEK

- Normal operation
  - **0.2 μSv/h for Non-designated area (K1)**
  - **1.5 μSv/h for Supervised area (K2)** **experimental hall**
  - **20 μSv/h for Simple controlled area (K3)**
  - **100mSv/h for access restricted**
- Shielding 100 μ**Sv/event**
- Mis-steering beam loss
  - **1 hour integration of dose rate should not exceed 1.5 μSv/h using radiation monitor.**

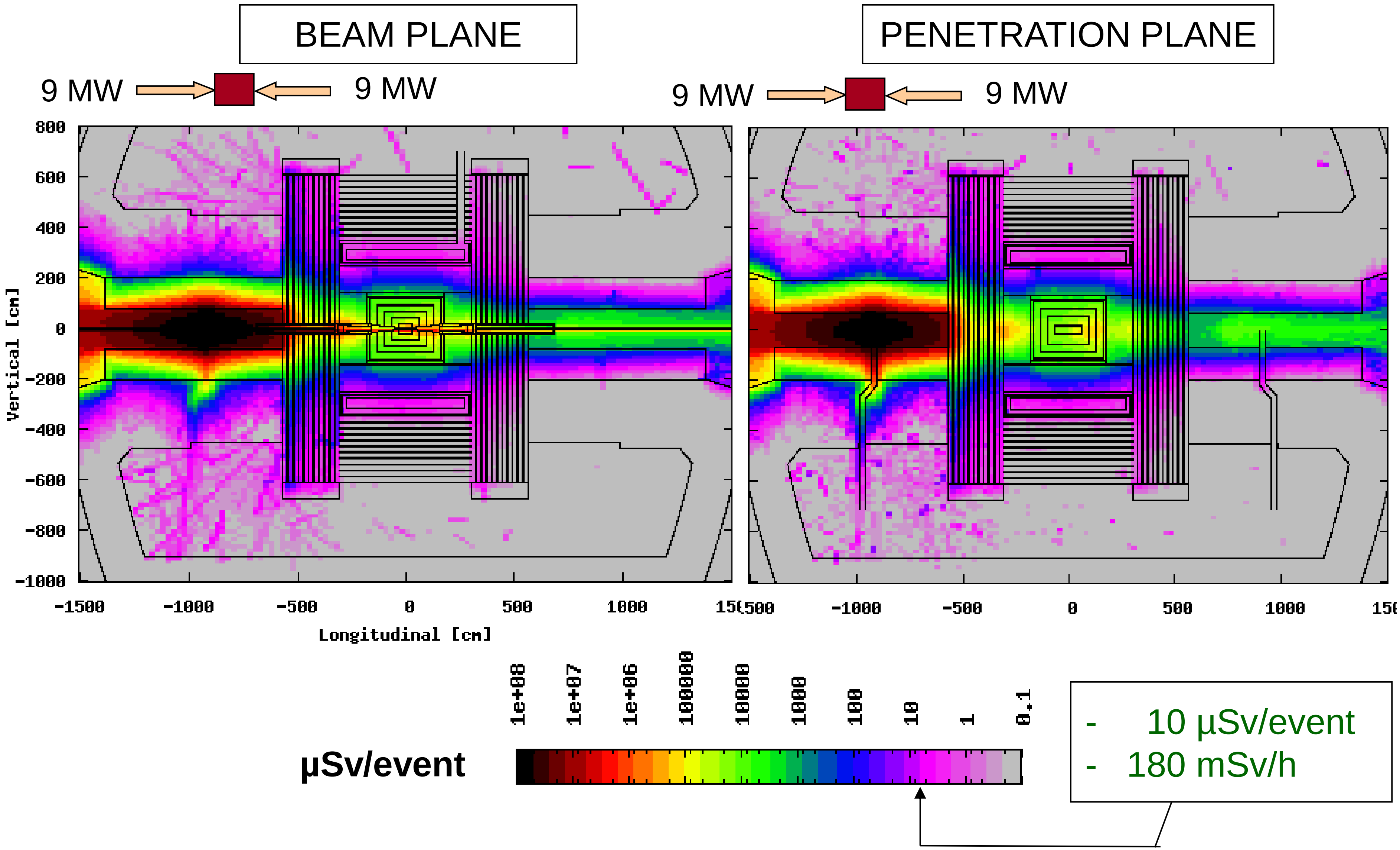
    (Terminate injection and wait 1 hour)

SiD and ILD : Shielding capability of 250 mSv/h / 18 MW = 0.014 mSv/h/kW is required everywhere to meet SLAC requirement

T.Sanami, IRENG 09/14/2007

20 R.L. Cu target in IP-9 m. Large pacman.

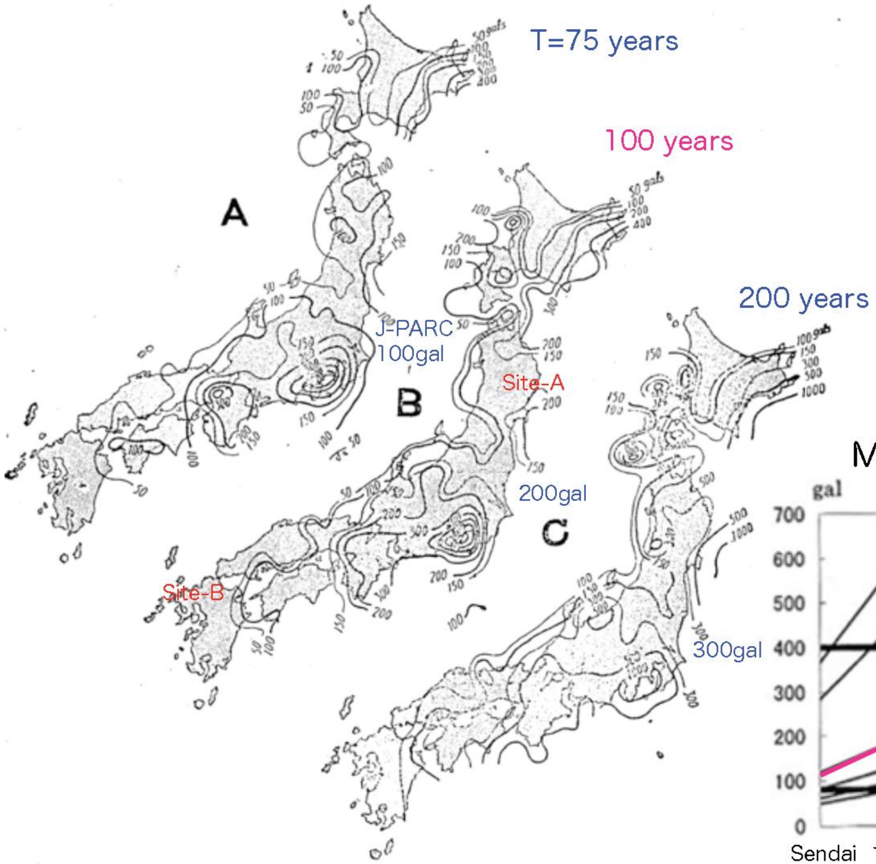
M.Santana, SLAC



Seismic Map Japan

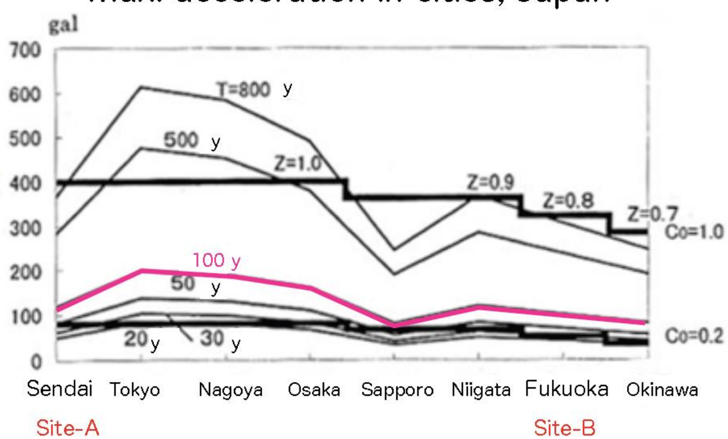
Seismic Hazard Map in Japan : Maximum acceleration (gal)
in recurrence intervals of earthquake

Kawasumi map : based on earthquakes from 679 to 1,948 in Japan



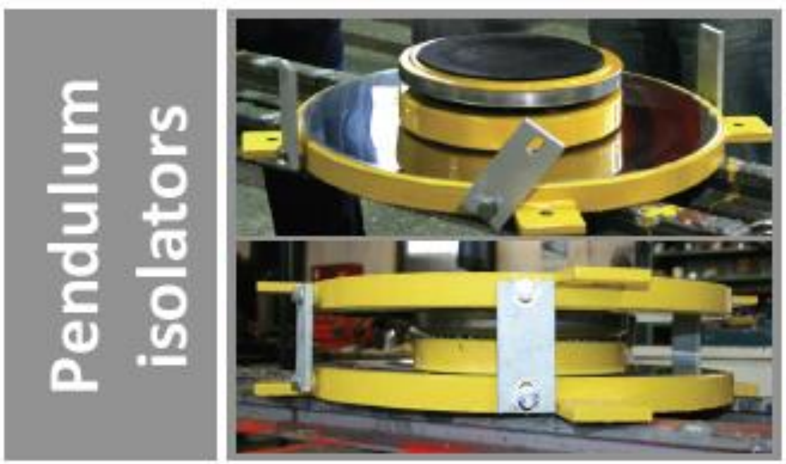
Kitakami Site :
- Ultimate Limit State 1g
- Service Limit state 0.15g

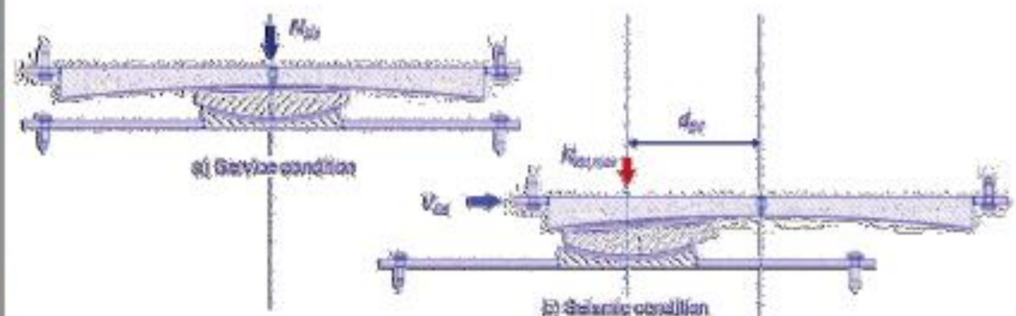
Max. acceleration in cities, Japan



Detector Seismic isolation

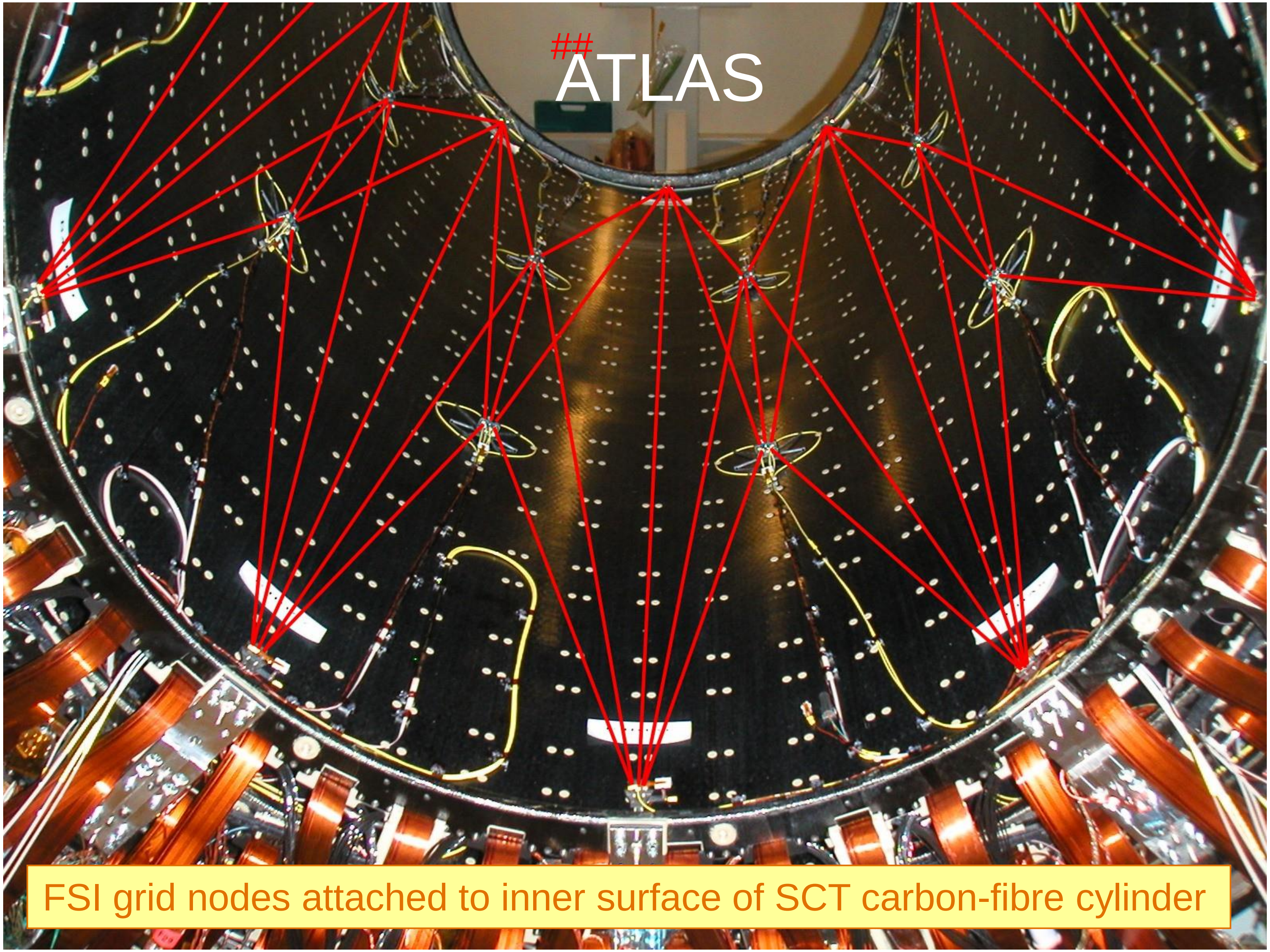
- Friction pendulum isolators beneath the detector feet;
- Energy dissipation due to dynamic friction;
- Reliable technology;
- No high compliance elements (e.g. rubber) improves the positioning of the detector;





F.Duarte Ramos, CERN

FSI alignment system, precision ~1um

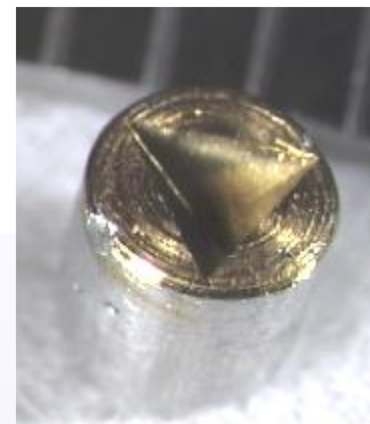


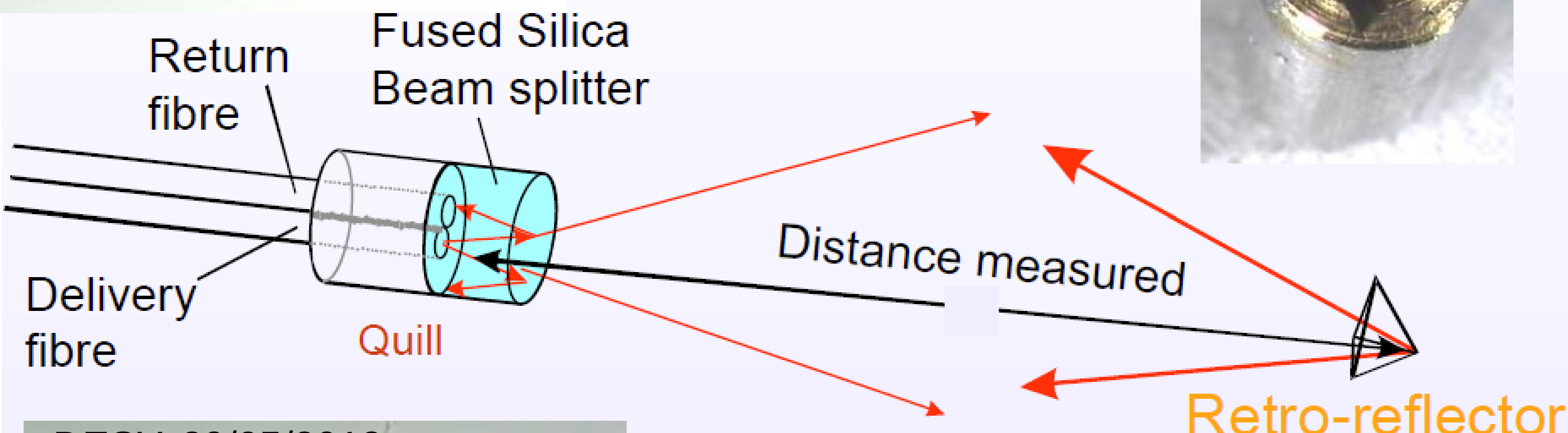
FSI grid nodes attached to inner surface of SCT carbon-fibre cylinder

Detector Alignement – Frequency Scan Interferometry

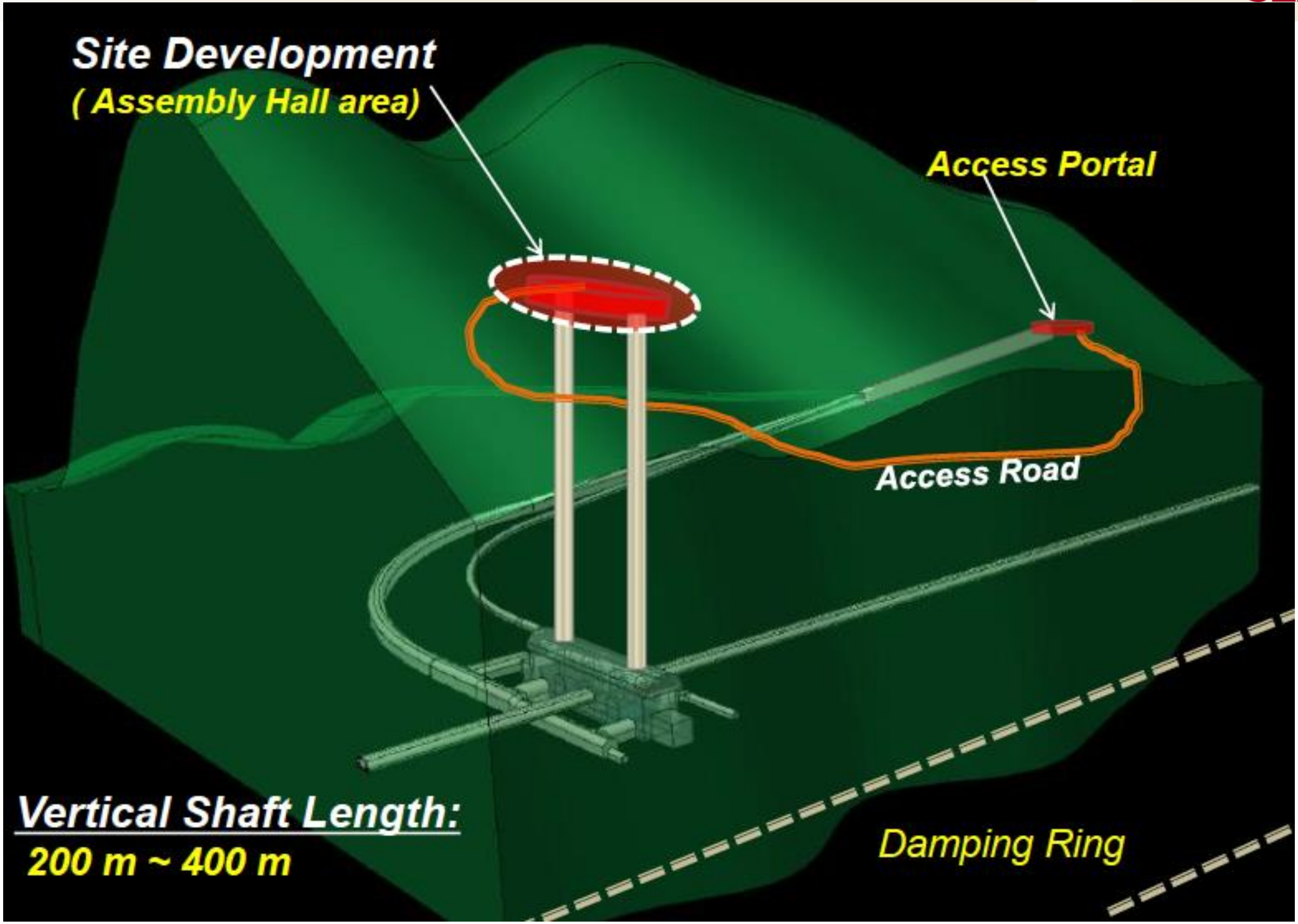
Front-end components of

- minimal mass
- high radiation tolerance





ILC Site


Site Development
(Assembly Hall area)
Access Portal
Access Road
Vertical Shaft Length:
200 m ~ 400 m
Damping Ring

Lean Detectors ?

Toyota Factories pioneered Lean Assembly :

"*preserving value with less work*"

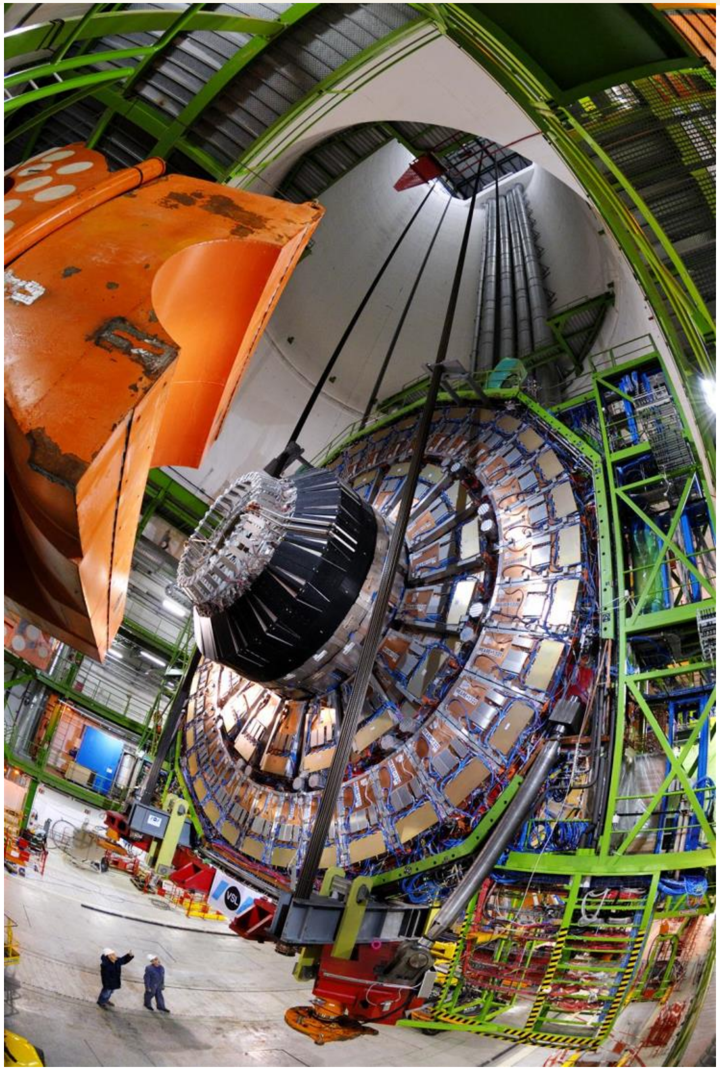
Fight The Seven Muda (futilities)

Transportation, Inventory, Motion, Waiting, Over-processing, Over-production, Defects.

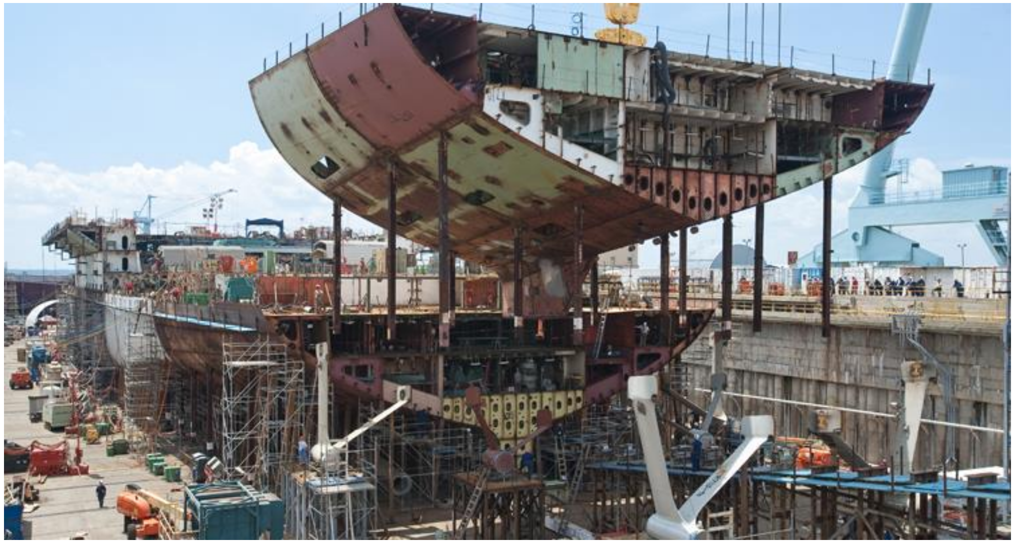
Big Detectors for Big Science must be Lean :

- Time vs labor (Costs)
- Time vs Technology drive (Increasing Performances)
- Low Maintenance (Costs)
- High Upgradability (Costs and Scientific reach)
- Shorter commissioning to get nominal performances
- International Competition

Lean assembly – Some Examples



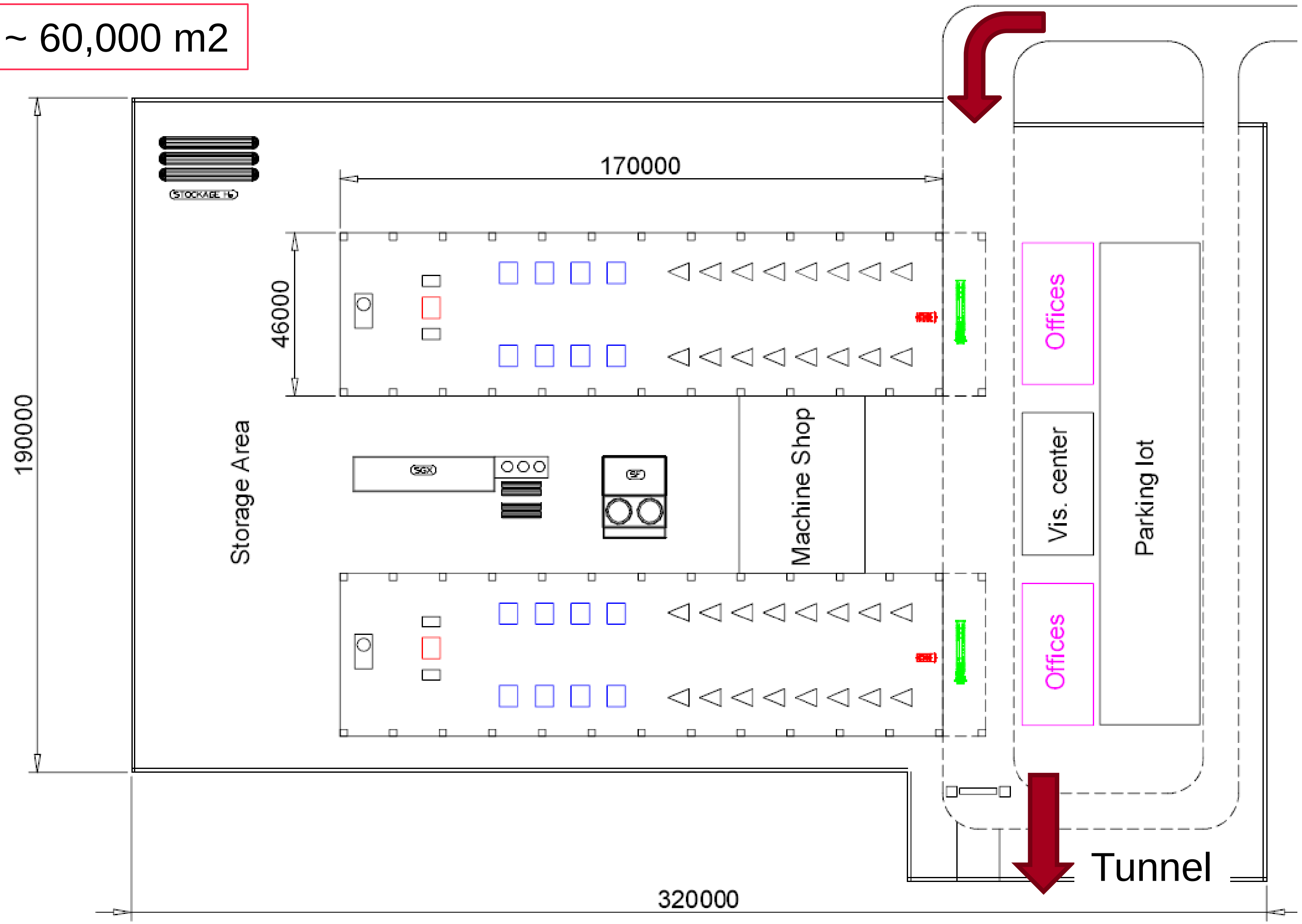
CMS Detector



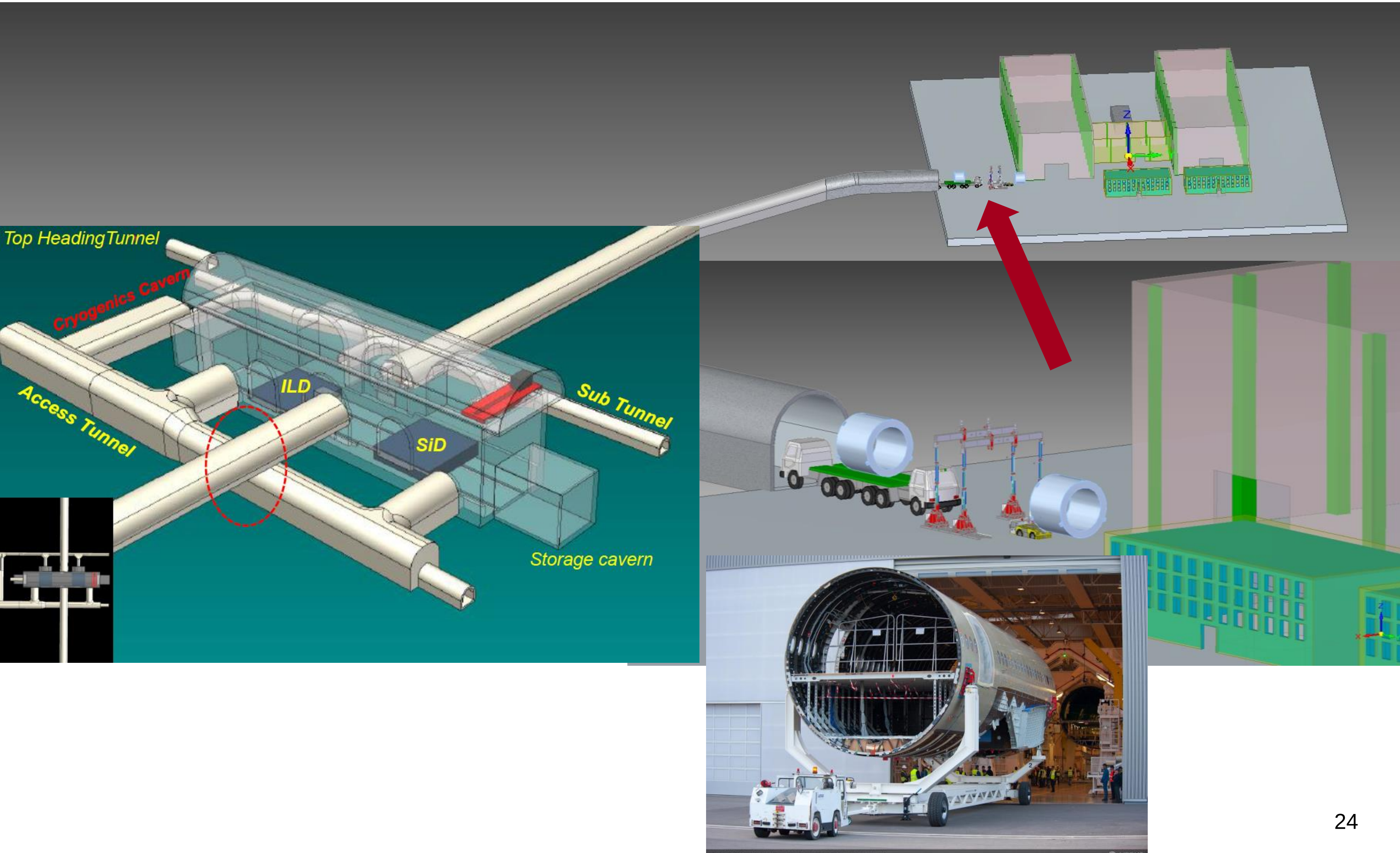
Shipbuilding

Kitakami Access Yard – Proposal

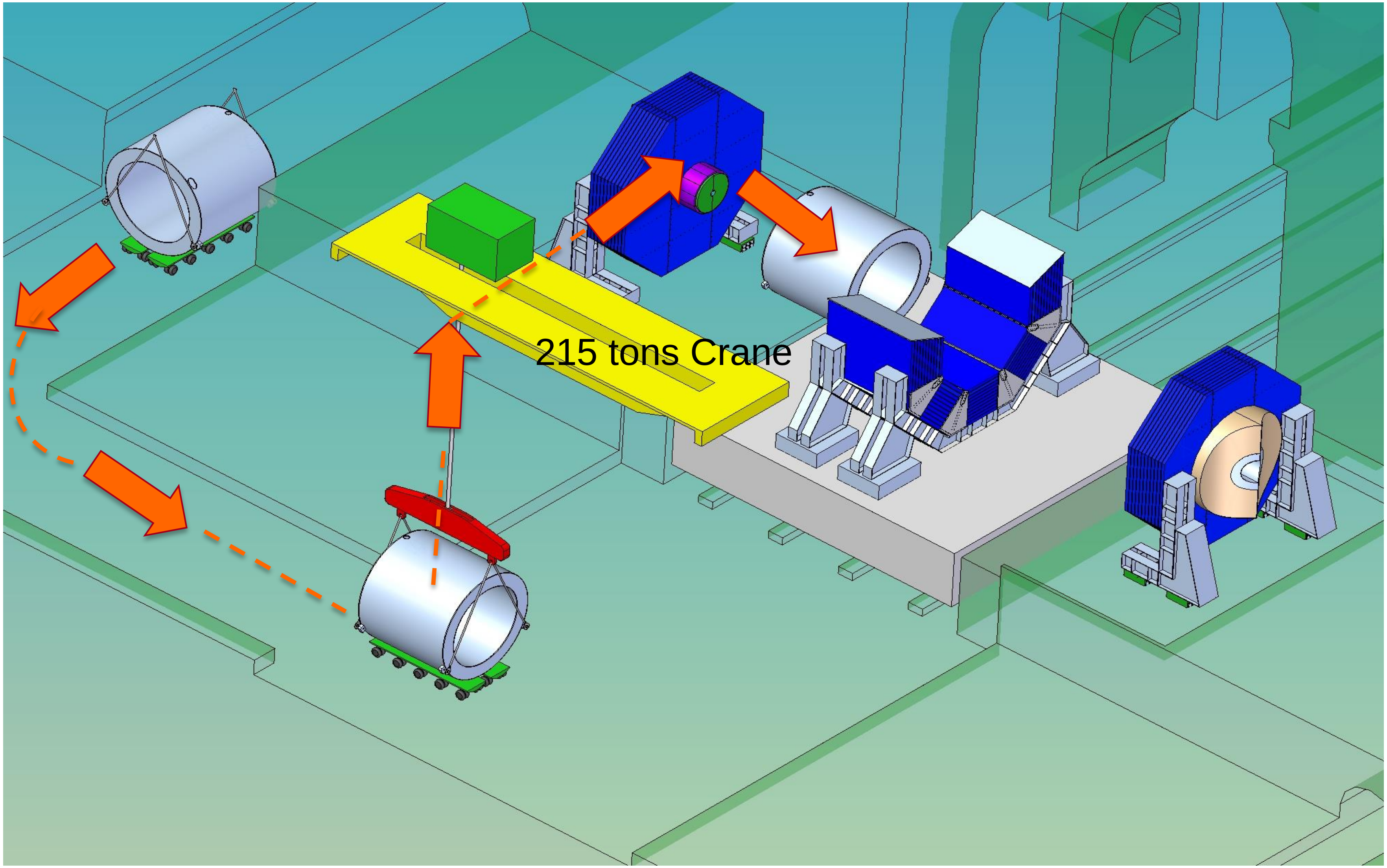
~ 60,000 m2



Kitakami Access Yard



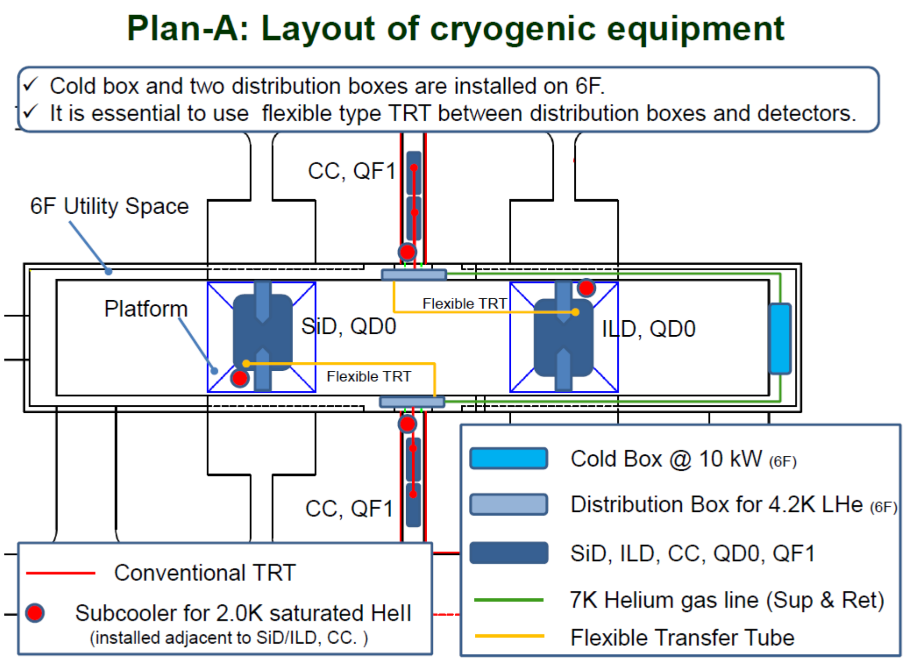
Magnet Installation – Japanese Site

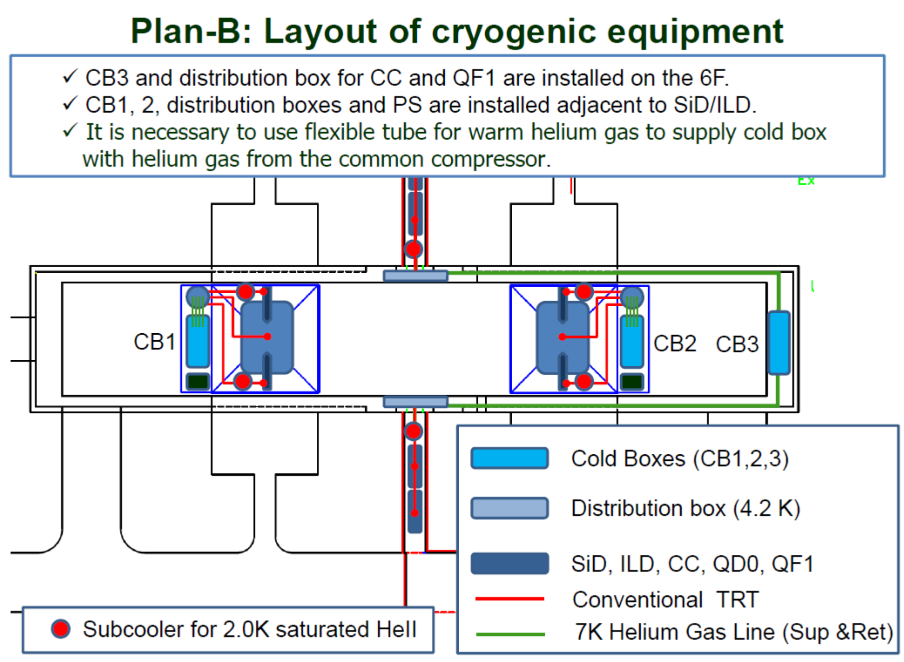


Cryogenic Layout : Two options

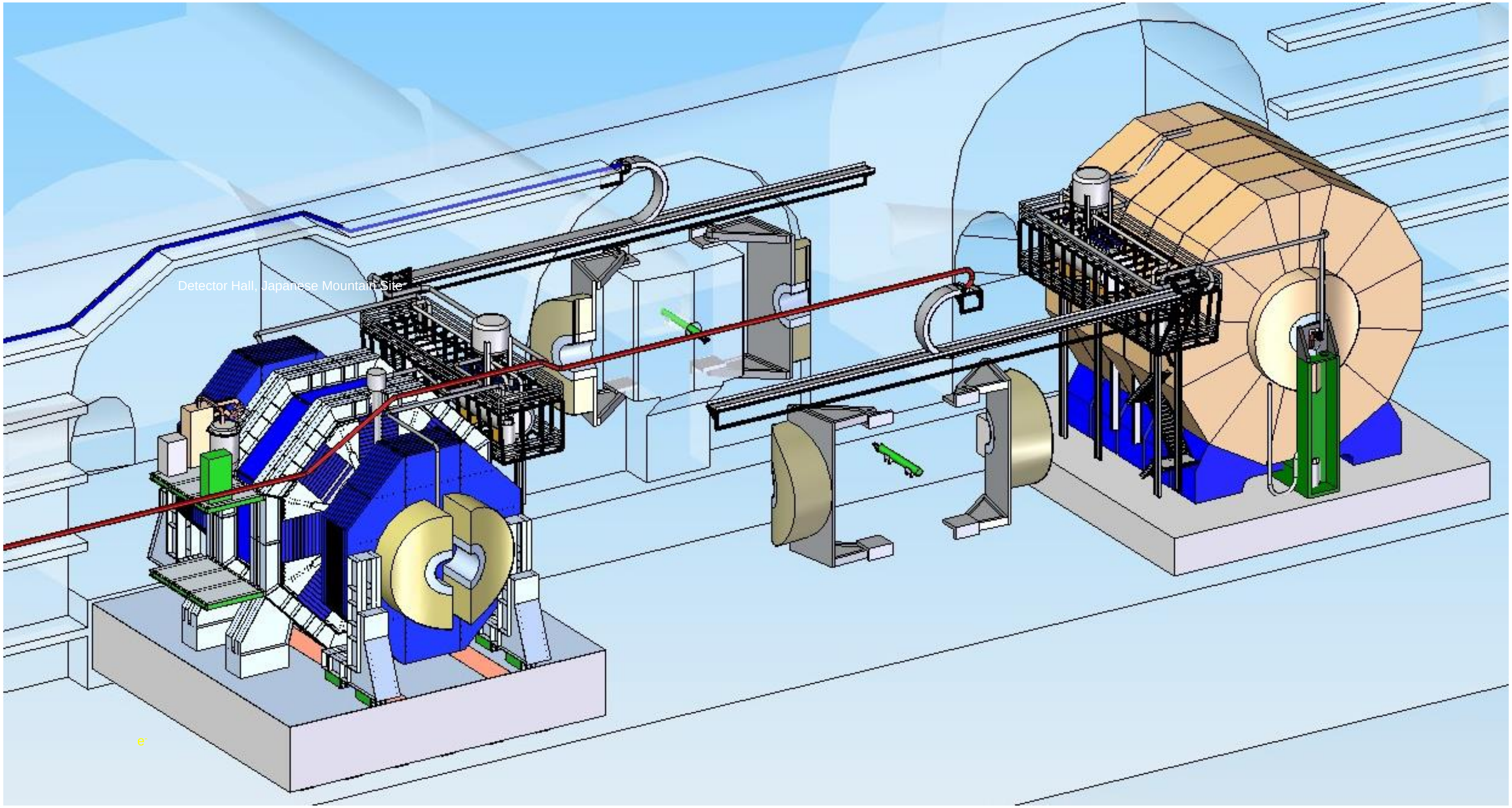
Plan A : Cold Boxes are stationary. Cold Transfer lines to each detector. Reliability for push-pull. Not off-the-shelf.

Plan B : Cold Boxes on the platform. Warm Transfer lines to each cold box. Vibrations, fringe field effects, space

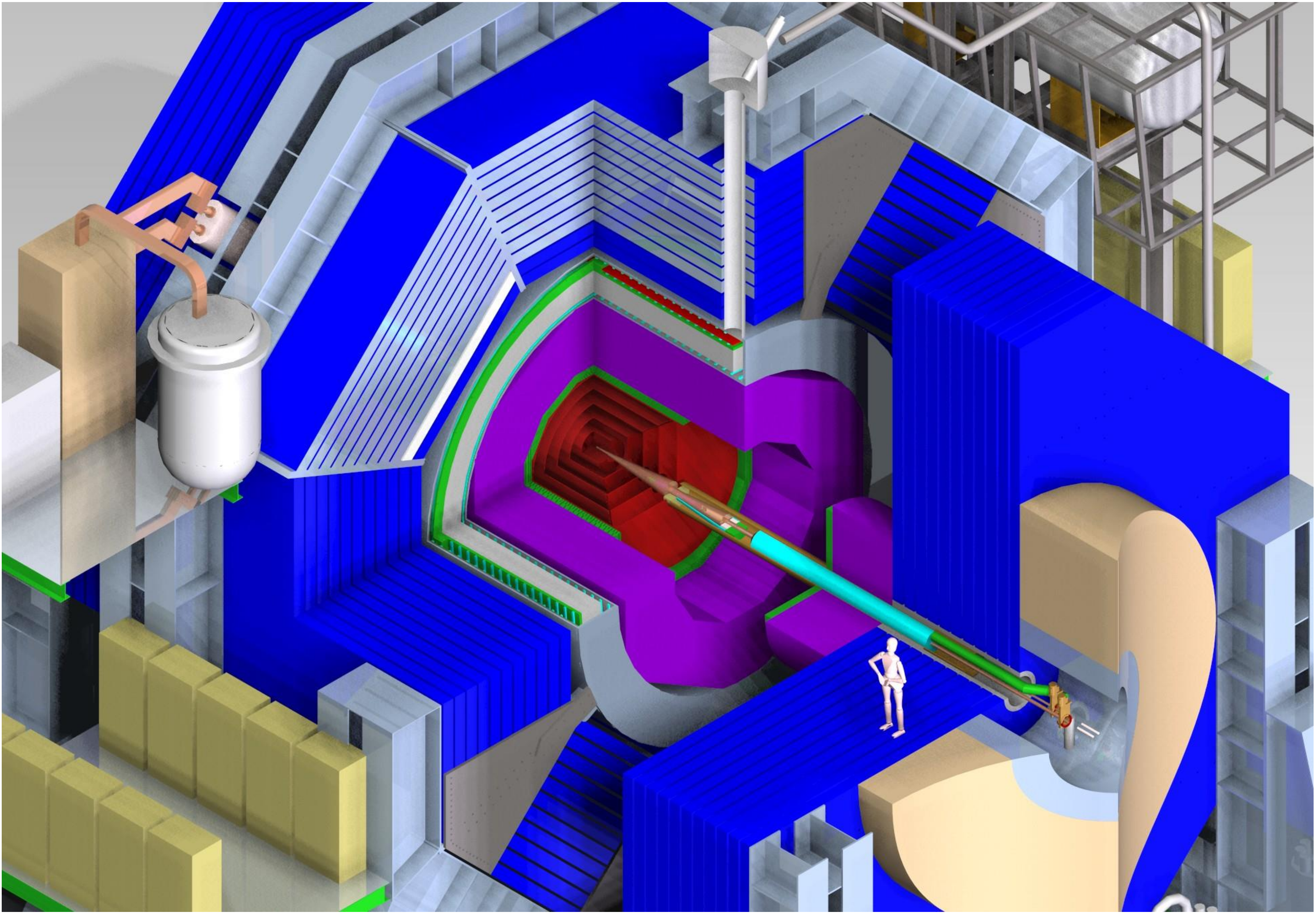




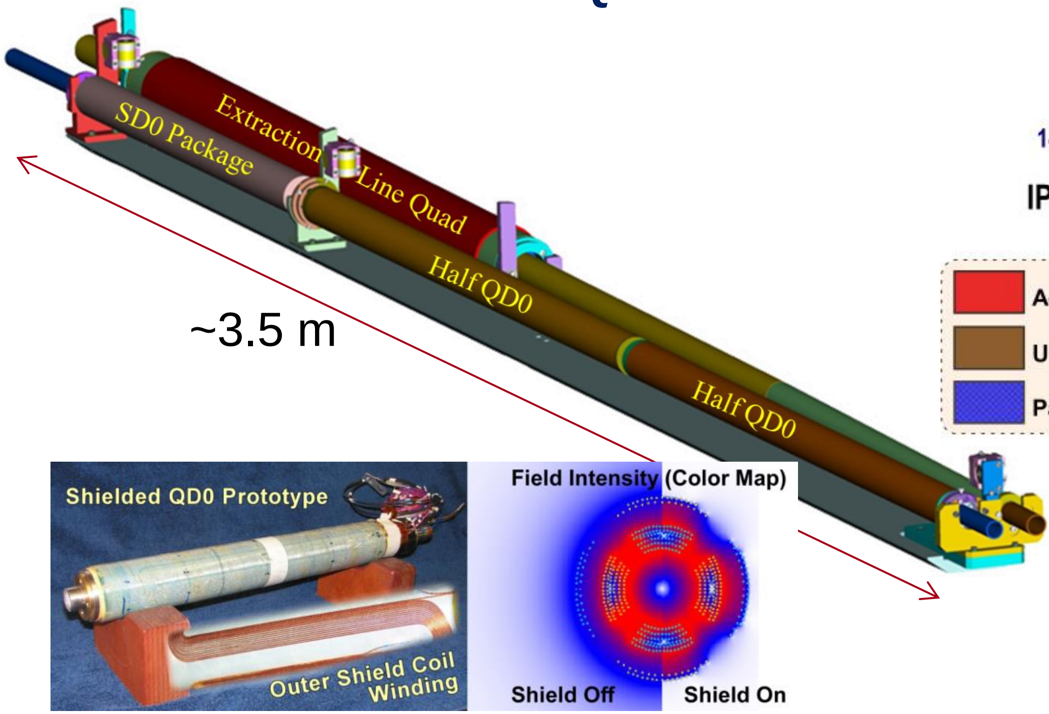
Push-Pull : Engineering Concept

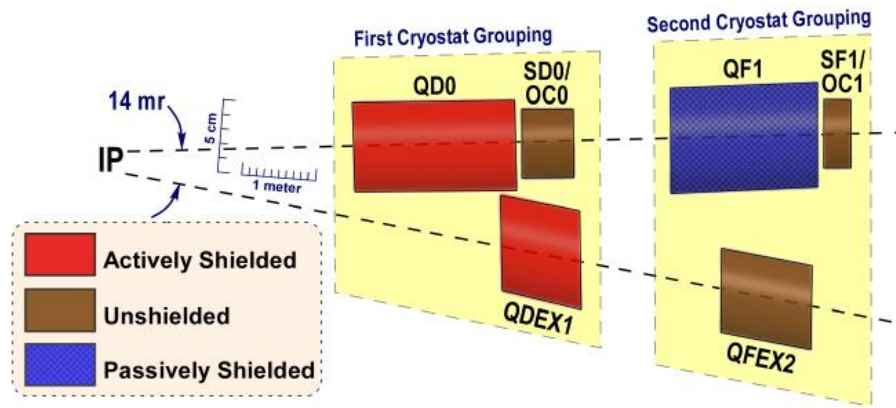


LHe refrigerator and LHe2 for the QD0's above level on metallic structure.



ILC QD0 : Cold Mass 2K Helium (BNL)



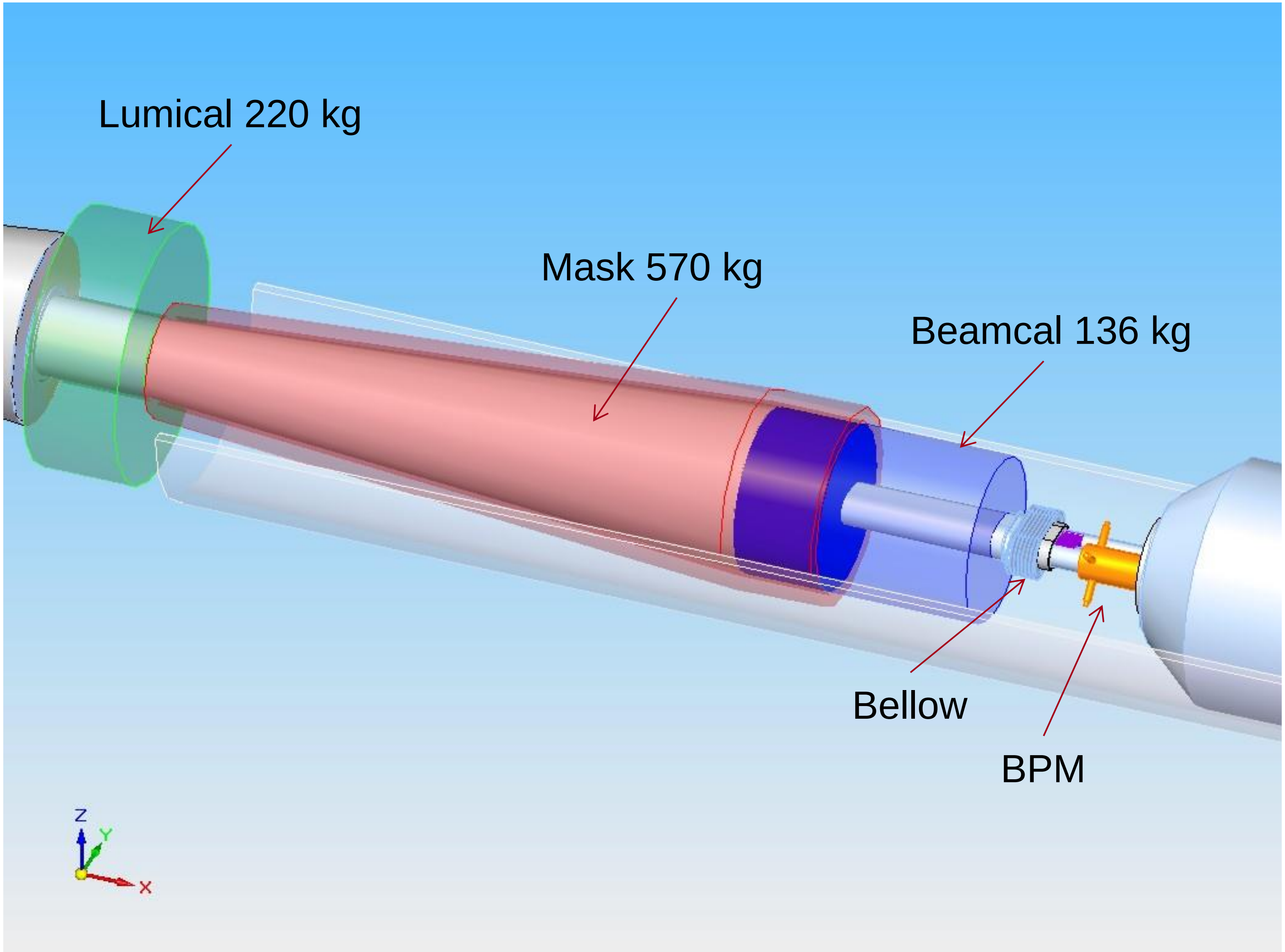


- Technology of the superconducting final focus magnets has been demonstrated by a series of short prototype multi-pole coils.
- QD0 magnet split into two coils to allow higher flexibility at lower energies.
- The quadrupoles closest to the IP are actually inside the detector solenoid.
- Actively shielded coil to control magnetic cross talk

•Additional large aperture anti-solenoid in the endcap region to avoid luminosity loss due to
beam optics effects.

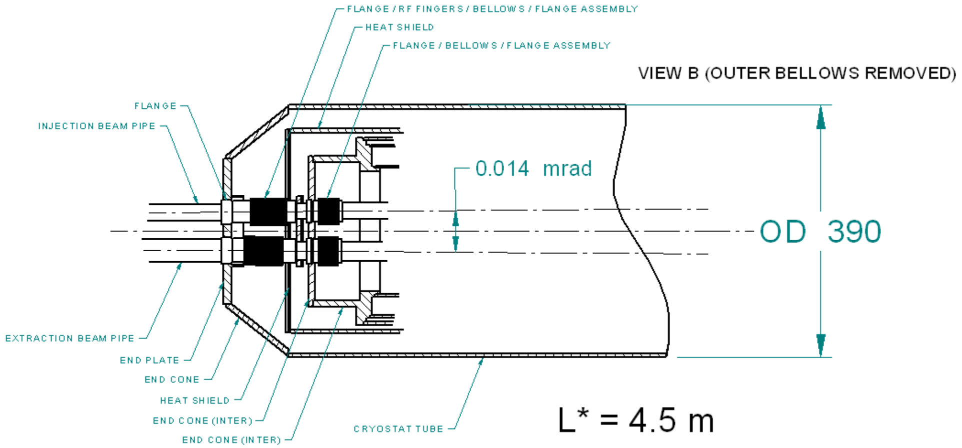
•Large aperture Detector Integrated Dipole (DID) used to reduce detector background at high beam energies or to minimize orbit deflections at low beam energies.

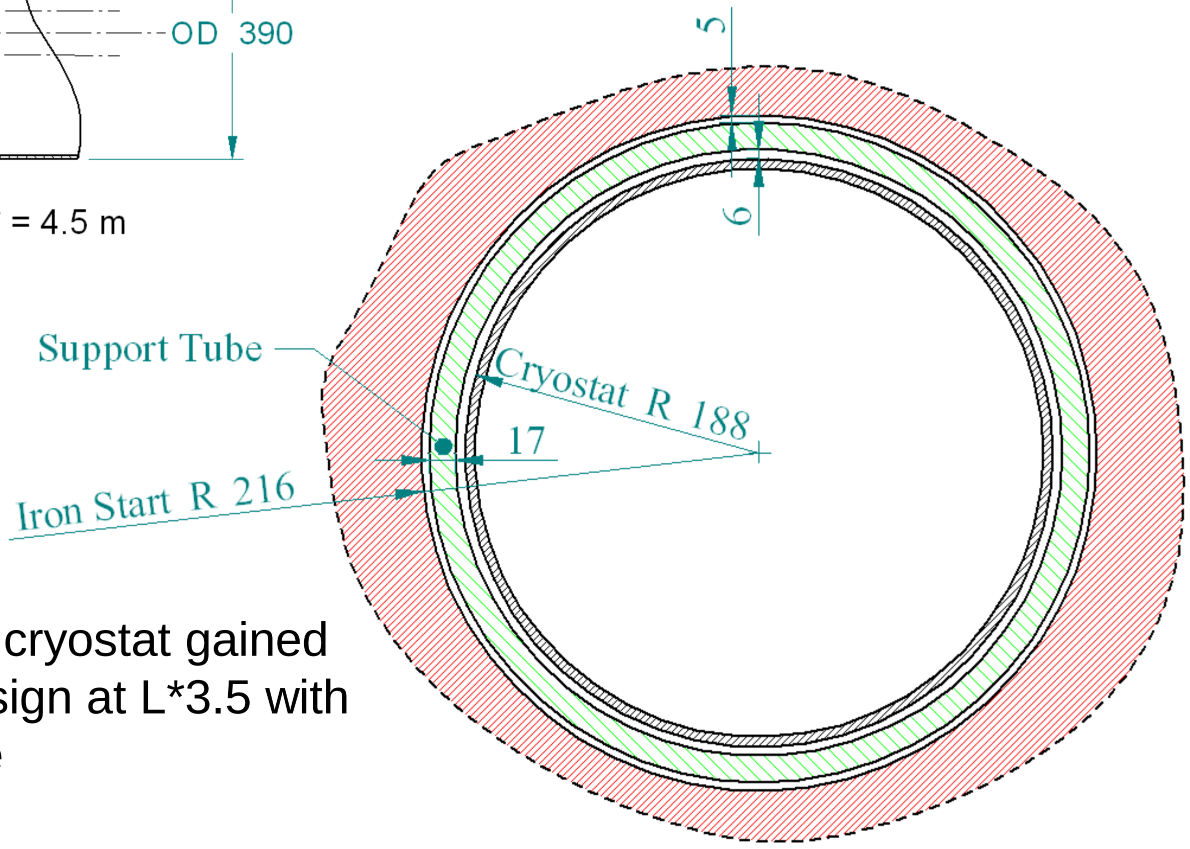
SID Forward Region



Space Requirements

Current QD0 Prototype is designed for L* 4.5 m



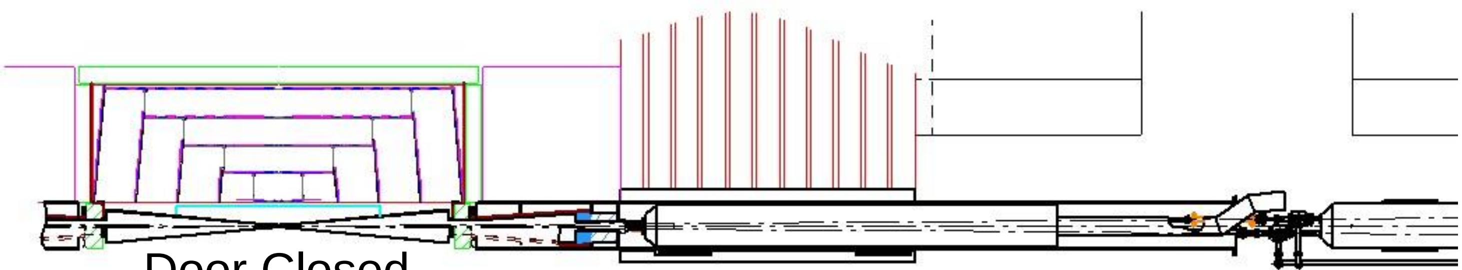


14 mm reduction of the QD0 cryostat gained moving the present QDO design at L*3.5 with the 14mrad crossing scheme
(1 m x 14 mrad = 14 mm)

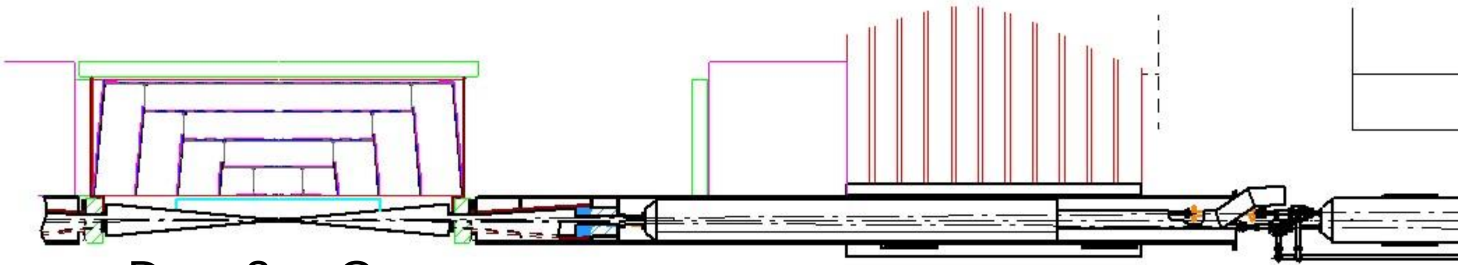
L* 3.5 m cross section

Forward Region Diameter – Tracker maintenance

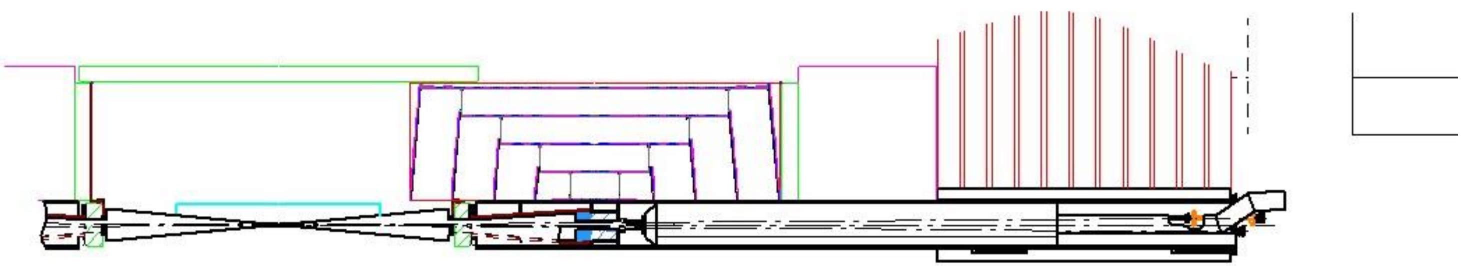
SLAC



Door Closed

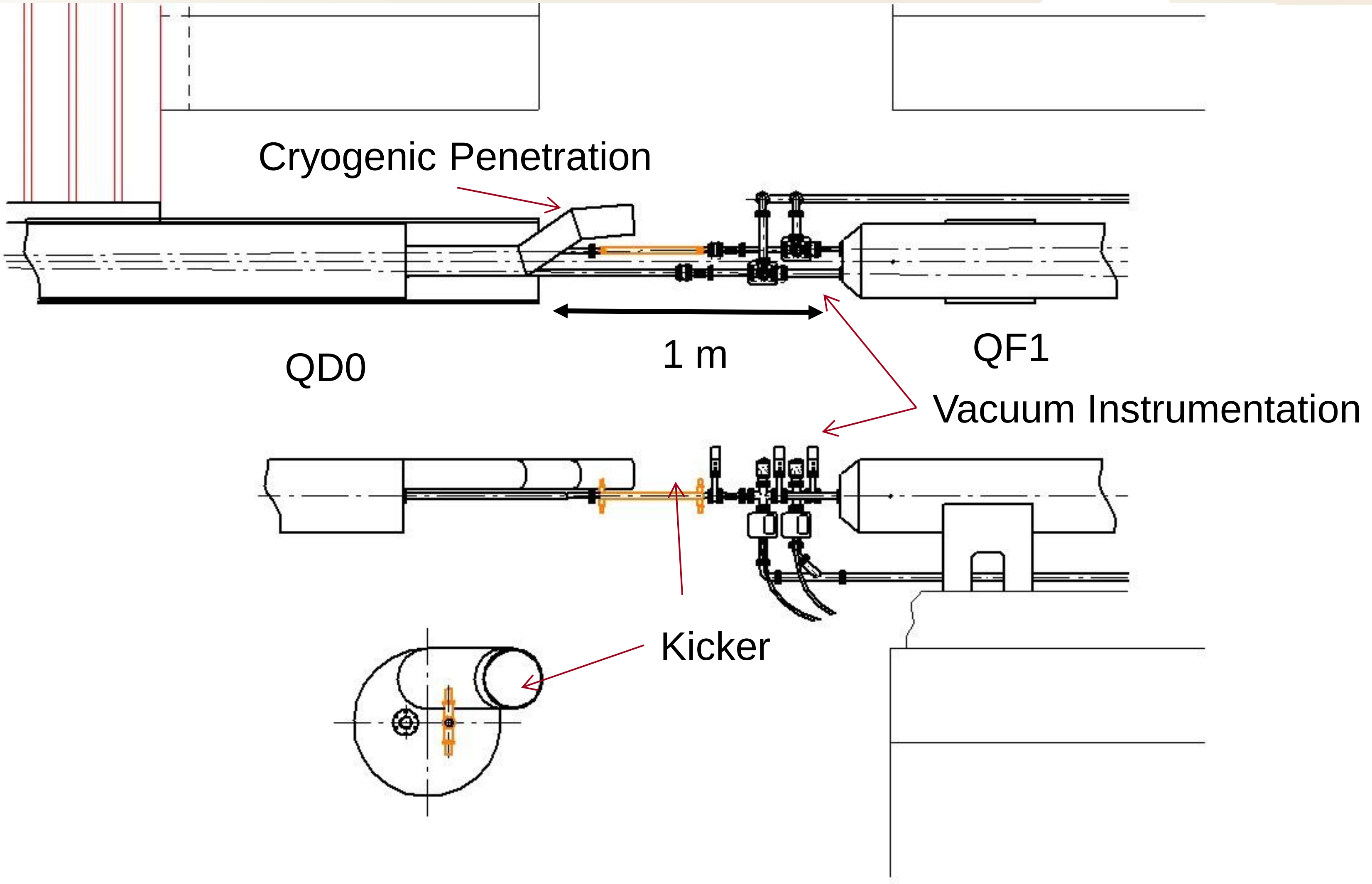


Door 2 m Open

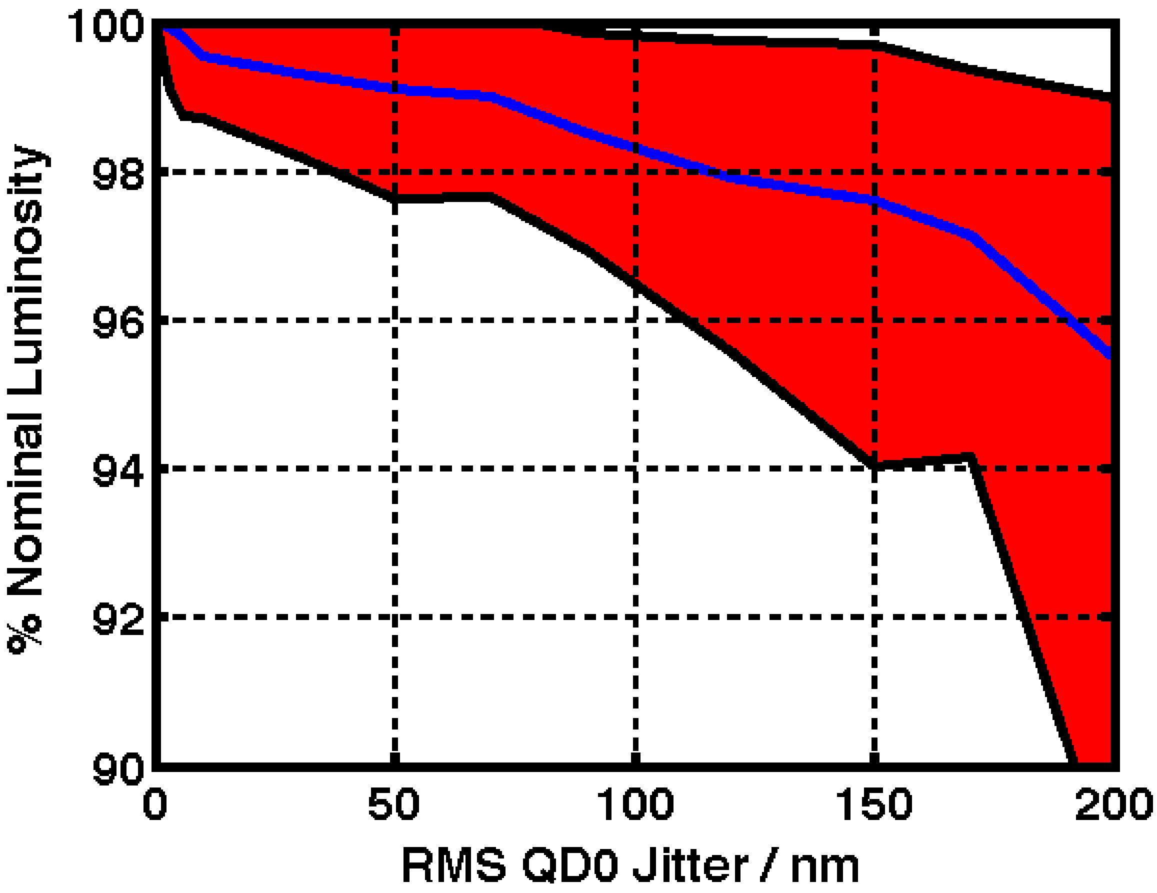


Door 3 m Open

Interface QD0-QF1: Critical for Fast&Reliable Push-Pulls



Luminosity Loss vs. QD0 Jitter

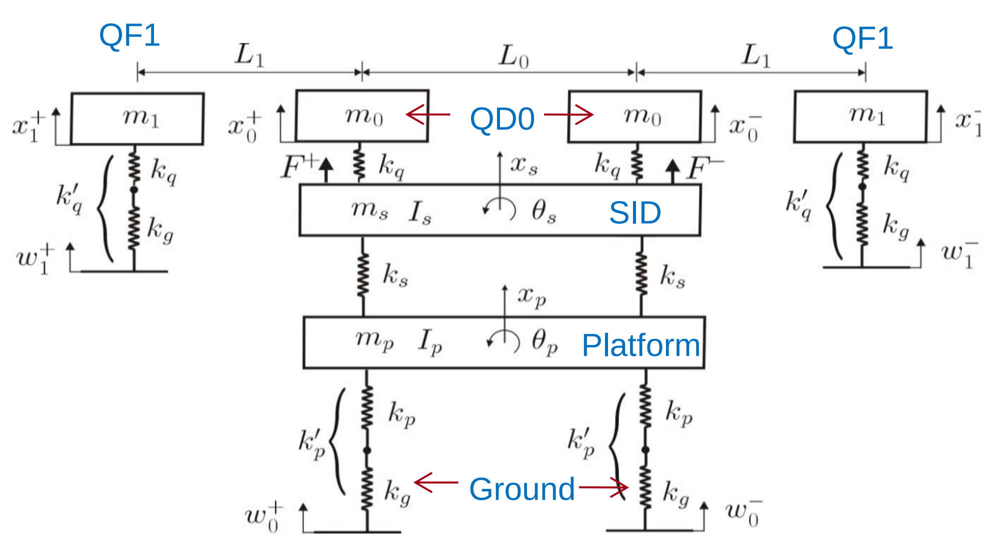


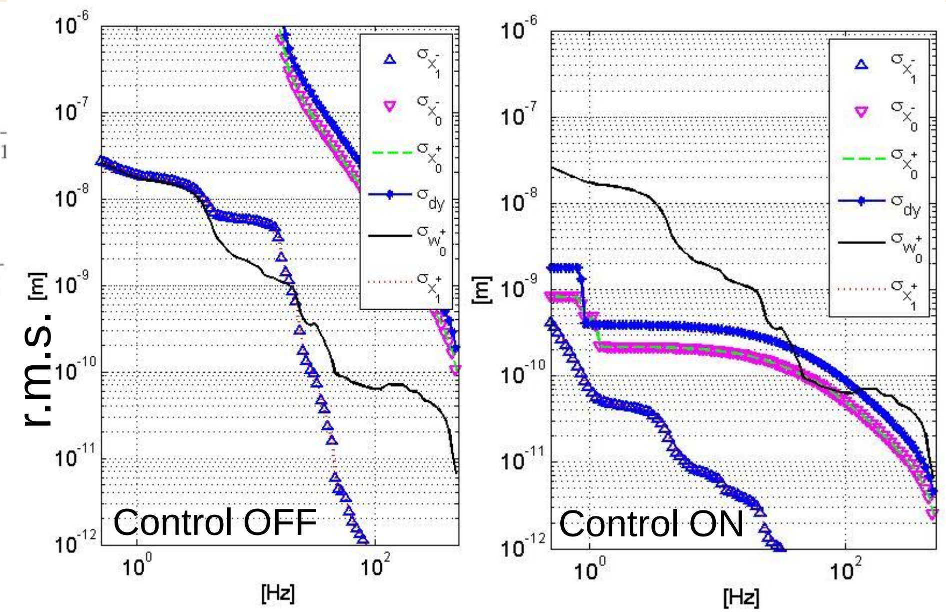
Data shown gives % nominal luminosity for different levels of uncorrelated QD0 jitter.

- 100 pulses simulated per jitter cases with FFB
- Mean, 10% & 90% CL results shown for each jitter point from 100 pulse simulations

Tolerance to keep luminosity loss <1% is <50nm RMS QD0 jitter.

Vibration Study (C.Collette, D.Thsilumba,ULB)





1. Ground Motions measured at the SLD detector hall
2. Conservative spectrum of the technical noise on the detector.
3. The model predicts that the maximum level of *r.m.s.* vibration seen by QDO is well below the capture range of the IP feedback system available in the ILC. With the addiction of an active stabilization system on QD0, it is also possible to achieve the stability requirements of CLIC.
4. Experimental measurements of the technical noise instrumenting CMS during LS1 with permanent vibration sensors

Summary

Many of the requirements of the MDI and the Detector Engineering are well established, but a vigorous Engineering effort needs to be deployed to spec them out.

Additional R&D is required on few cases.

The limiting factor at this stage is the Manpower (Engineers and Draftsmen) required to spec out the requirements in a consistent engineering design. It is not an SID specific problem.

The choice of a site (Kitakami) eliminates some options, although is not a game changer at this stage since the Engineering Design is still very conceptual.

EXTRA SLIDES

SID key design features

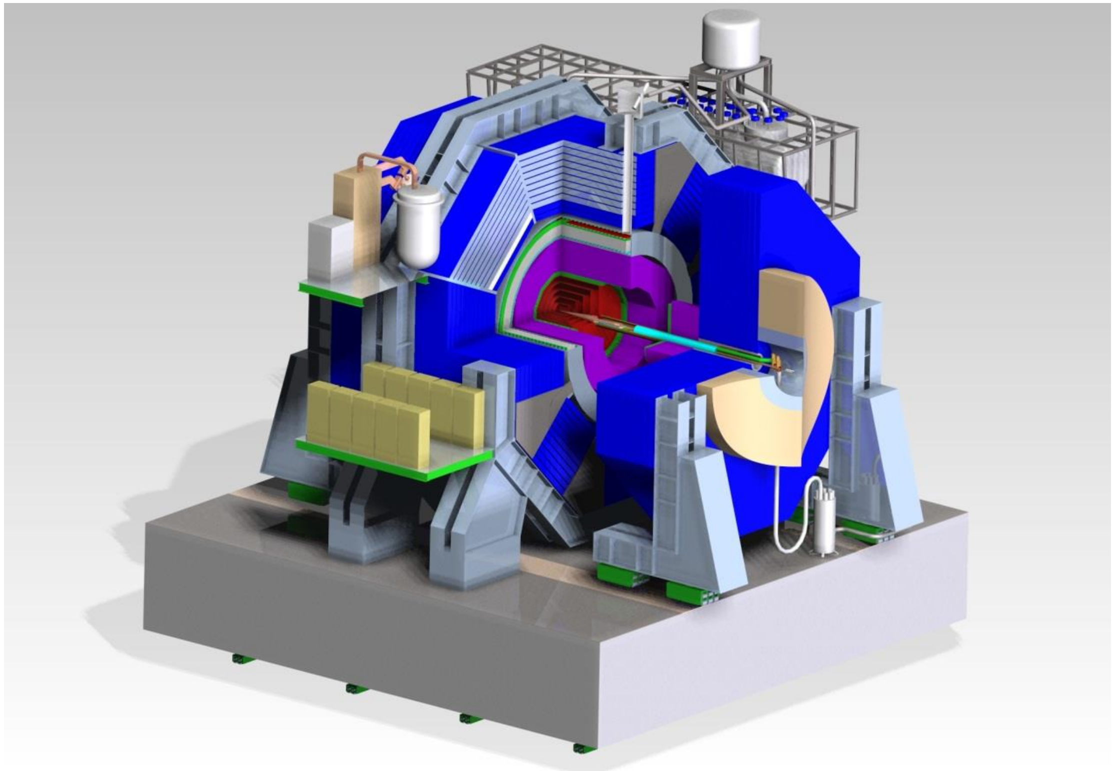
Compact design with 5 T Solenoid

Single Ring Barrel ~ 4'000 tons

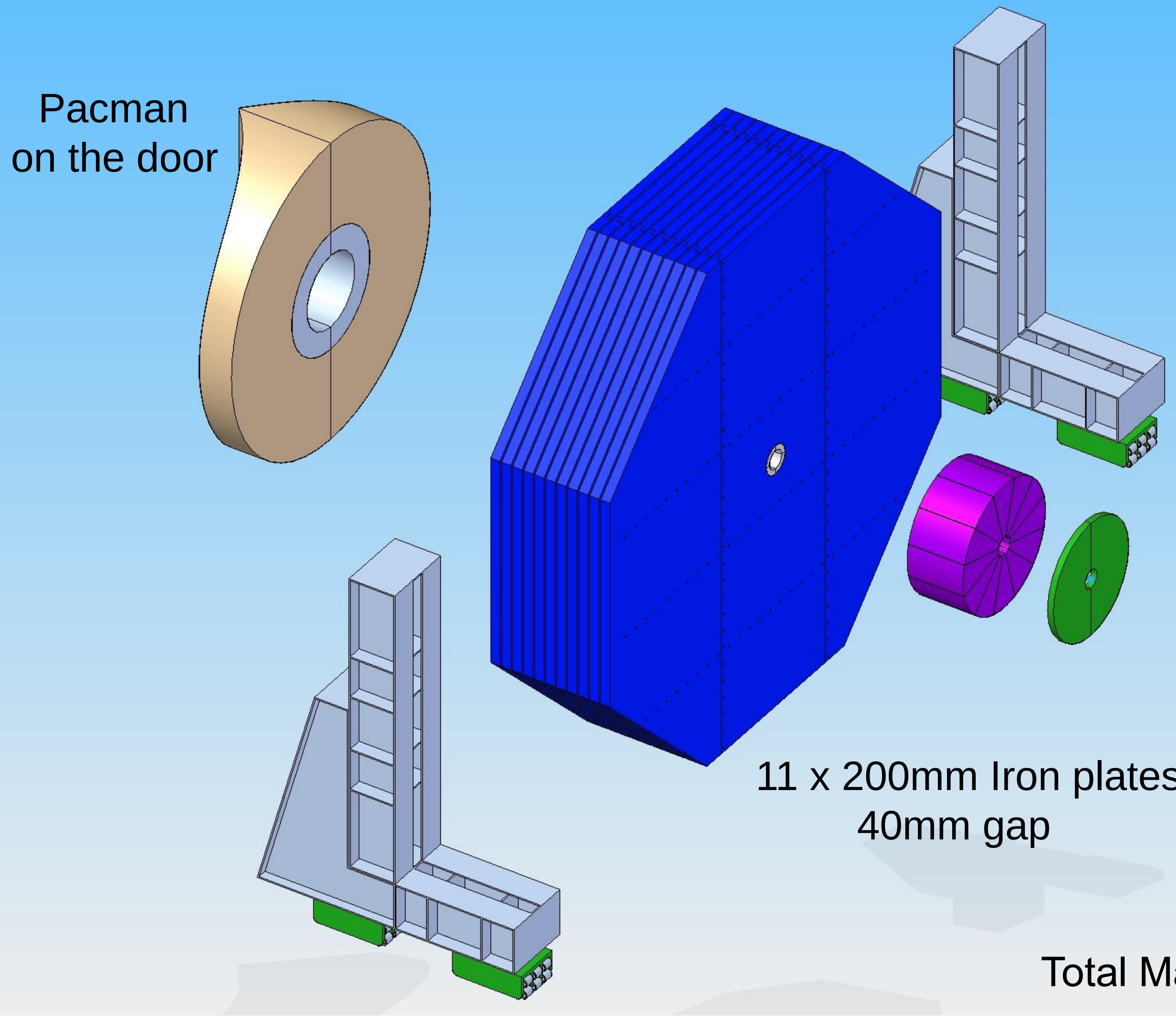
Self Shielded: Stray Fields & Radiation

Short L* with QD0's supported from the doors

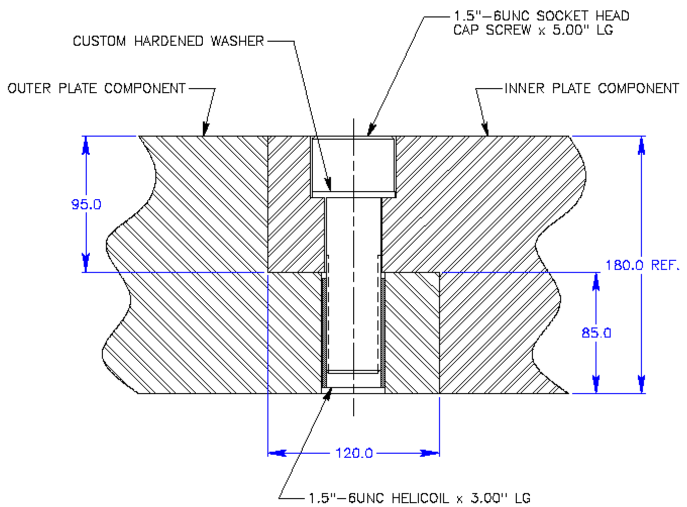
Barrel Ecal	60
Barrel Hcal	450
Coil	192
Barrel Iron	3287
Total Barrel	**3990**
Endcap Ecal	10
Endcap Hcal	38
Endcap Iron	2100
Pacman	100
Feet	60
BDS	5
Total Door (x1)	**2313**
Total SiD	**8615**



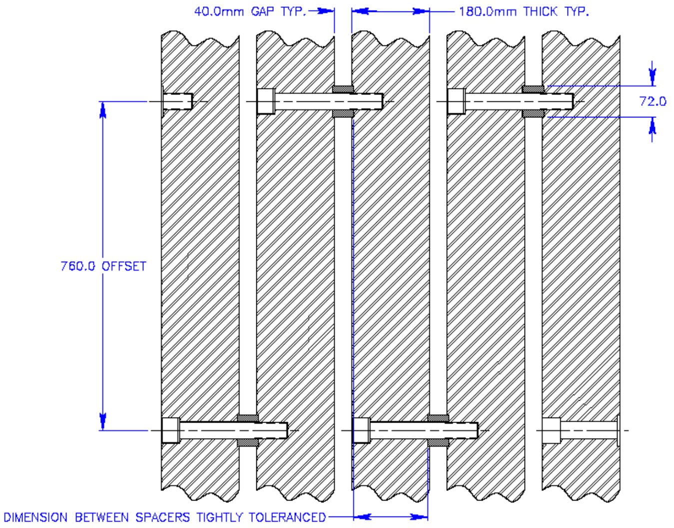
End Door



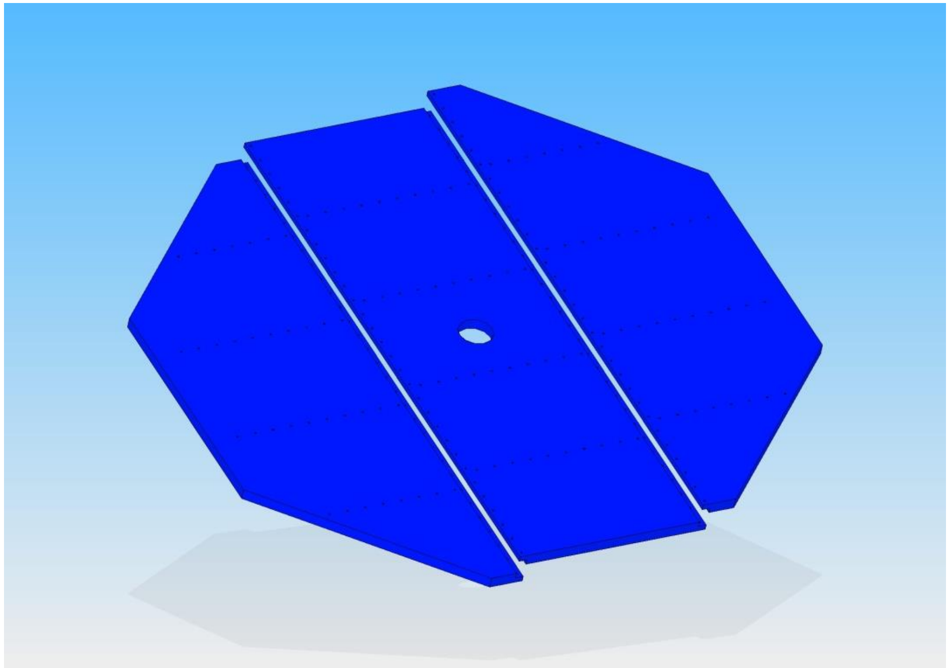
Total Mass ~ 2’300 Tons

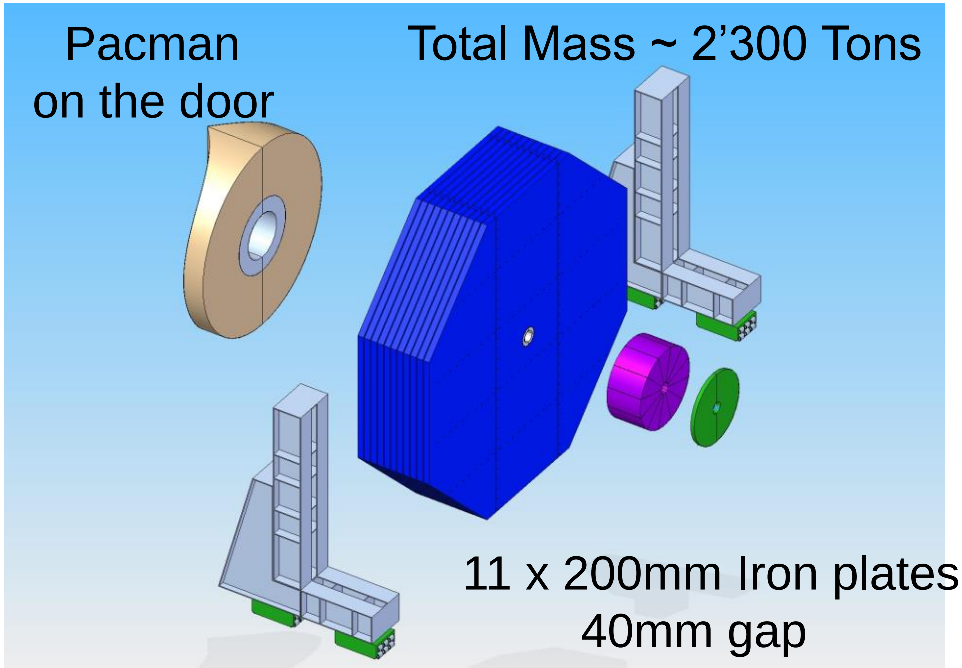


Intraplate connections

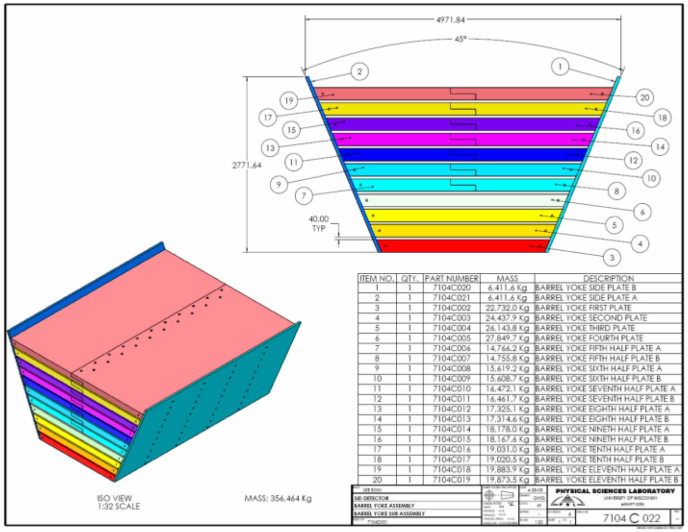


Spacer Offset





Iron Barrel Yoke layout



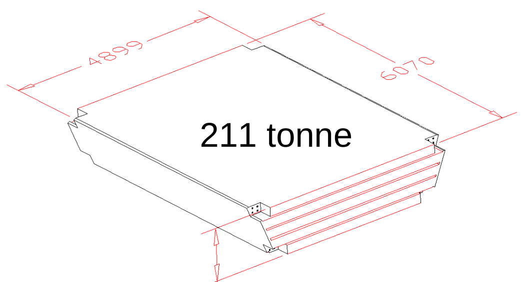
ITEM NO.	QTY.	PART NUMBER	MASS	DESCRIPTION
1	1	7104C020	6,411.6 Kg	BARREL YOKE SIDE PLATE B
2	1	7104C021	6,411.6 Kg	BARREL YOKE SIDE PLATE A
3	1	7104C002	22,732.0 Kg	BARREL YOKE FIRST PLATE
4	1	7104C003	24,437.9 Kg	BARREL YOKE SECOND PLATE
5	1	7104C004	26,143.8 Kg	BARREL YOKE THIRD PLATE
6	1	7104C005	27,849.7 Kg	BARREL YOKE FOURTH PLATE
7	1	7104C006	14,766.2 Kg	BARREL YOKE FIFTH HALF PLATE A
8	1	7104C007	14,755.8 Kg	BARREL YOKE FIFTH HALF PLATE B
9	1	7104C008	15,619.2 Kg	BARREL YOKE SIXTH HALF PLATE A
10	1	7104C009	15,608.7 Kg	BARREL YOKE SIXTH HALF PLATE B
11	1	7104C010	16,472.1 Kg	BARREL YOKE SEVENTH HALF PLATE A
12	1	7104C011	16,461.7 Kg	BARREL YOKE SEVENTH HALF PLATE B
13	1	7104C012	17,325.1 Kg	BARREL YOKE EIGHTH HALF PLATE A
14	1	7104C013	17,314.6 Kg	BARREL YOKE EIGHTH HALF PLATE B
15	1	7104C014	18,178.0 Kg	BARREL YOKE NINETH HALF PLATE A
16	1	7104C015	18,167.6 Kg	BARREL YOKE NINETH HALF PLATE B
17	1	7104C016	19,031.0 Kg	BARREL YOKE TENTH HALF PLATE A
18	1	7104C017	19,020.5 Kg	BARREL YOKE TENTH HALF PLATE B
19	1	7104C018	19,883.9 Kg	BARREL YOKE ELEVENTH HALF PLATE A
20	1	7104C019	19,873.5 Kg	BARREL YOKE ELEVENTH HALF PLATE B

Bolted assembly, 144 plates 200 mm thick, 40mm gap

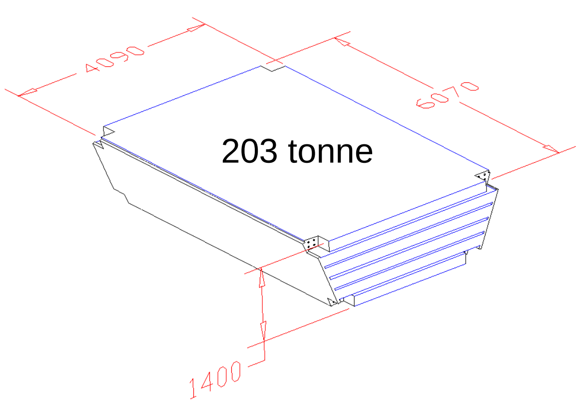
Opportunity to make blank assembly at the factory before shipping

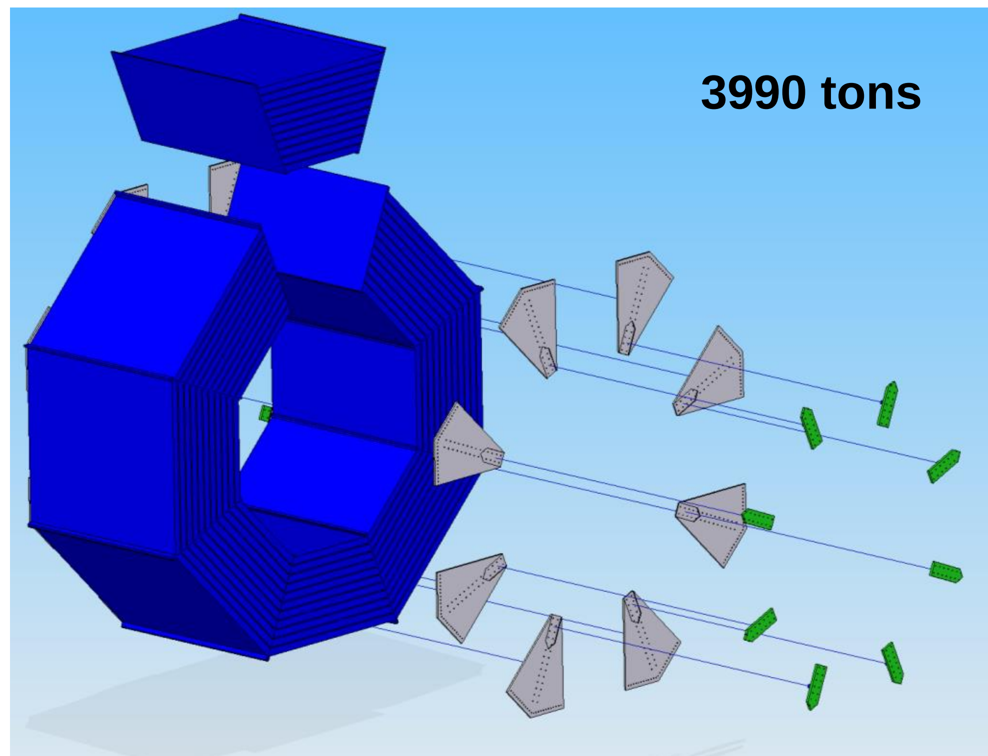
Preliminary Contacts with Kawasaki Heavy Industries

- Plate thickness tolerance for each: 0.1mm
- Plate flatness: 4mm (in a plate)
- Fabrication (assembling & welding) tolerance: 2mm
- Full trial assembly: capable (but need to study)

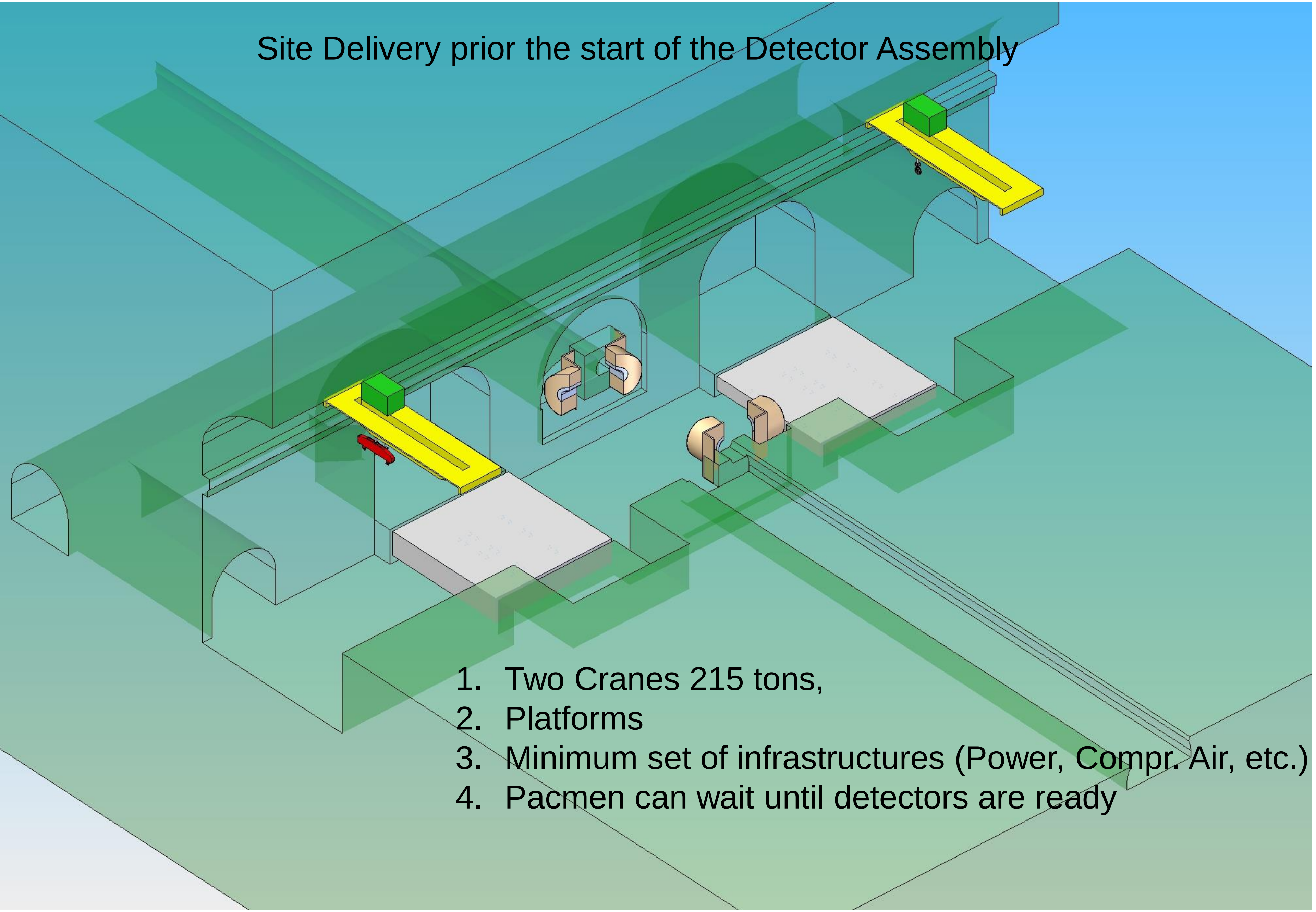


Max. Crane capacity 215 Tons



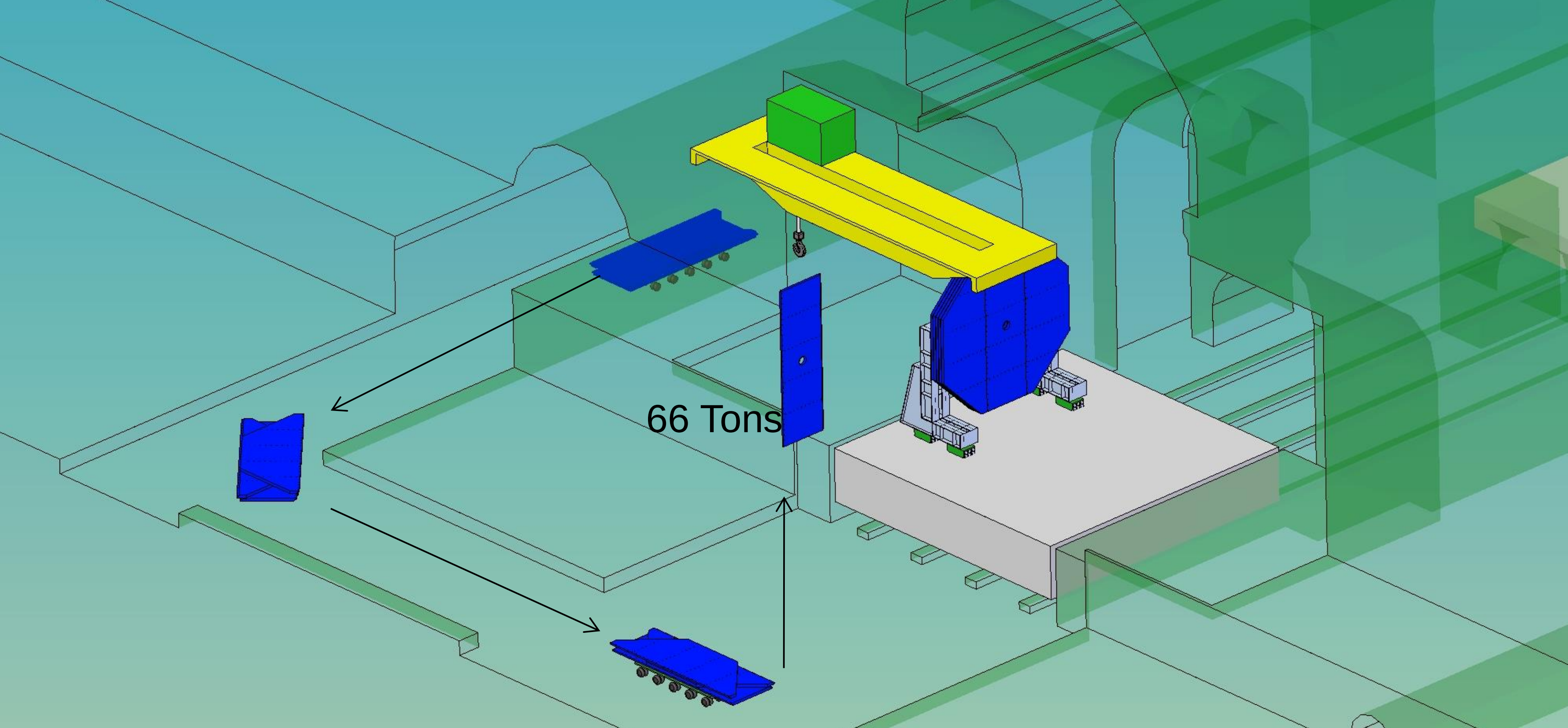


Site Delivery prior the start of the Detector Assembly

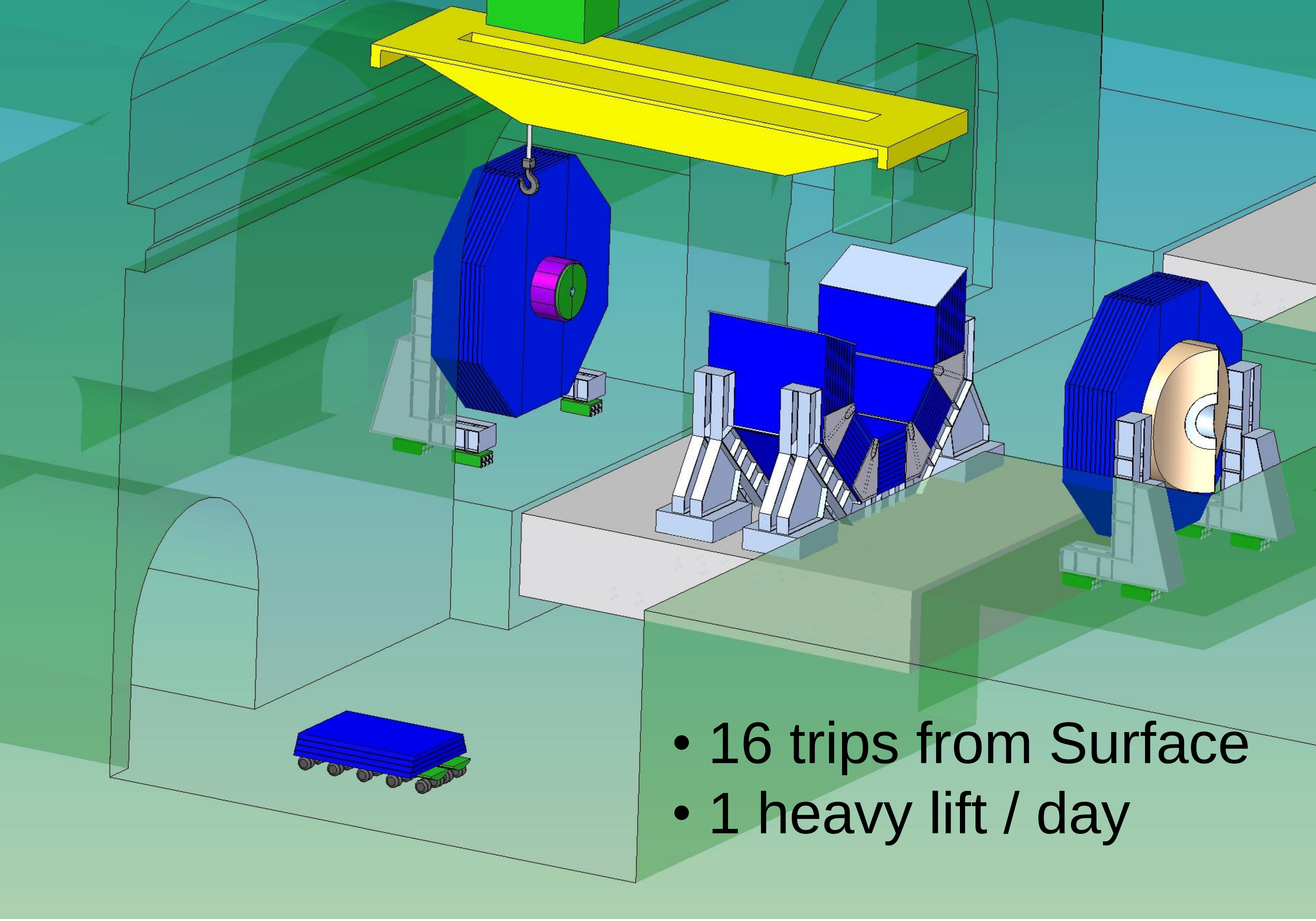


1. Two Cranes 215 tons,
2. Platforms
3. Minimum set of infrastructures (Power, Compr. Air, etc.)
4. Pacmen can wait until detectors are ready

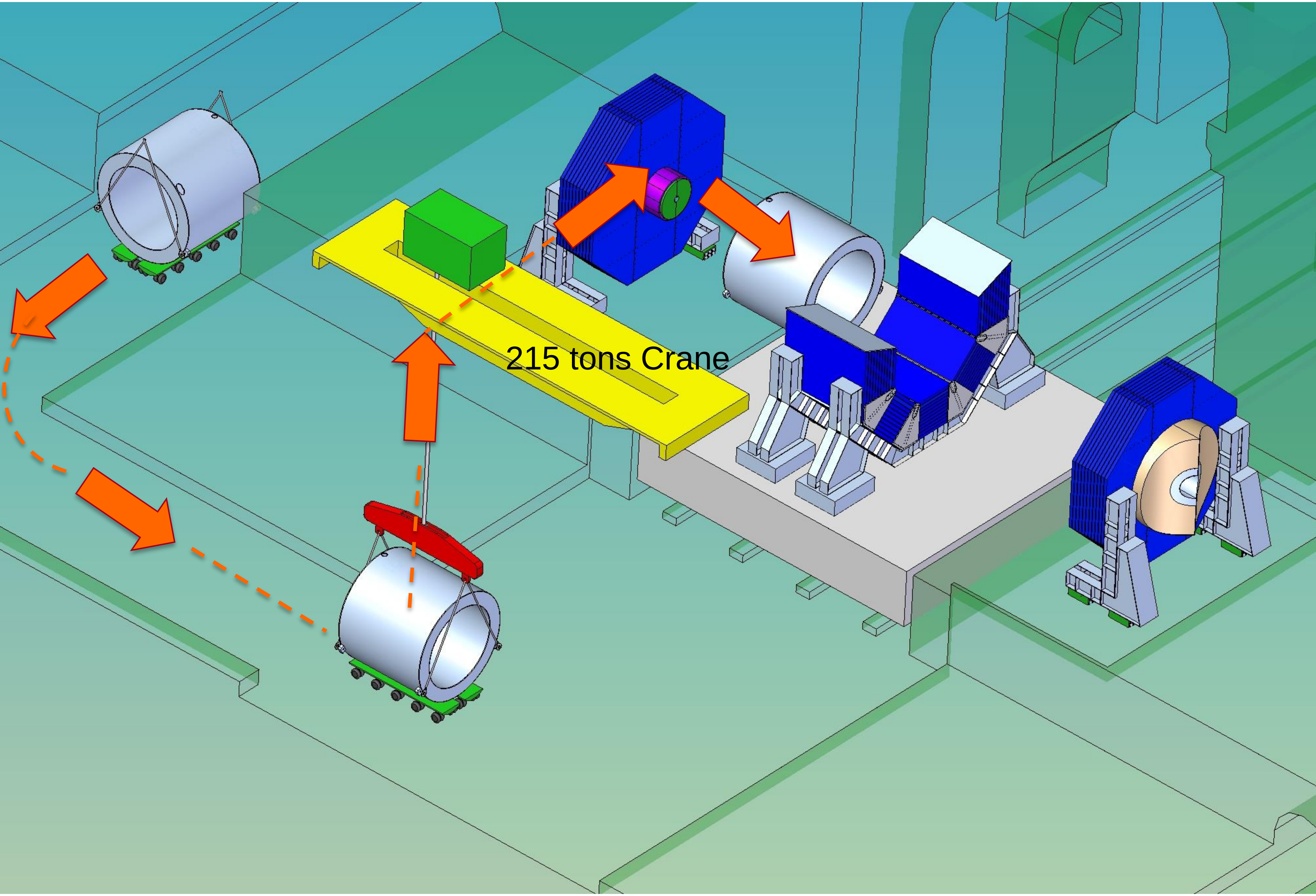
Door Assembly on the platform



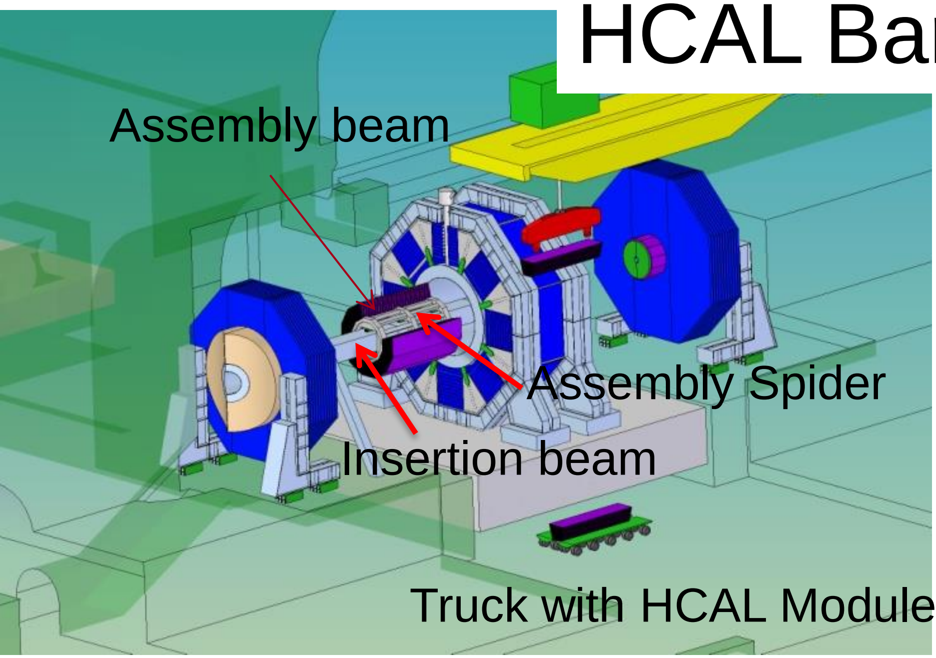
- 11 trips from Surface /Door
- 1 heavy lift / day

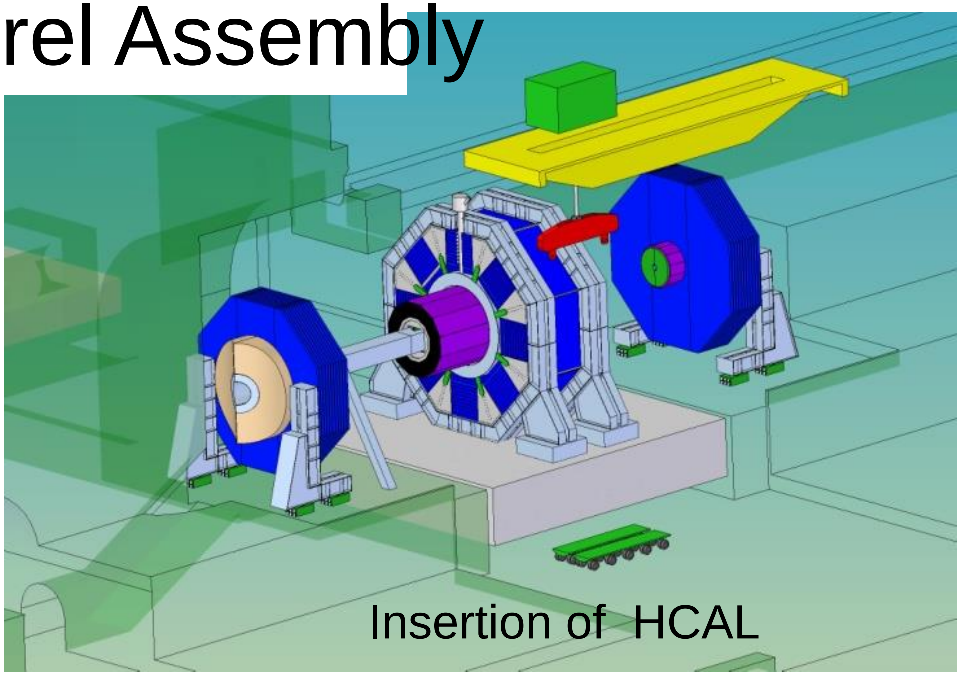

• 16 trips from Surface
• 1 heavy lift / day

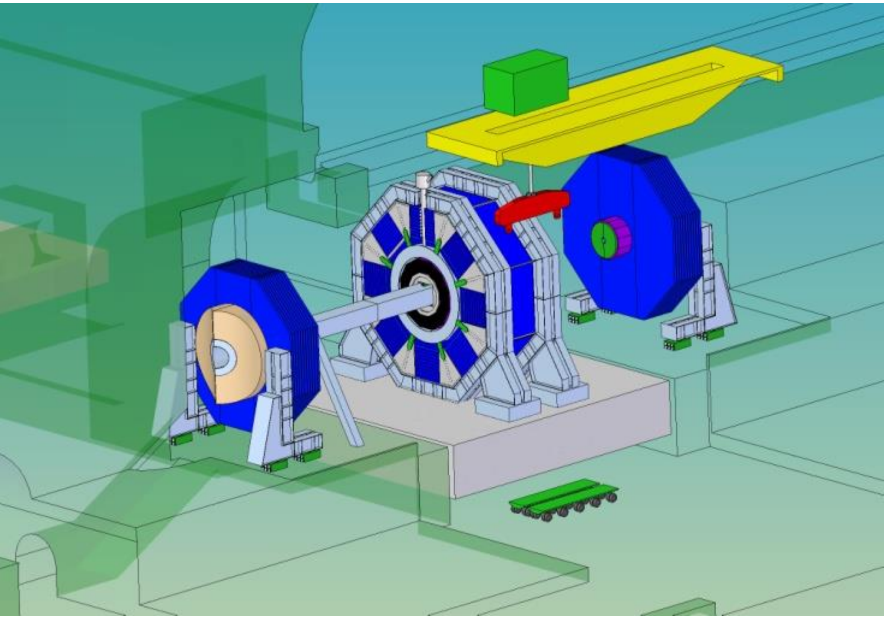
Solenoid Installation



HCAL Barrel Assembly



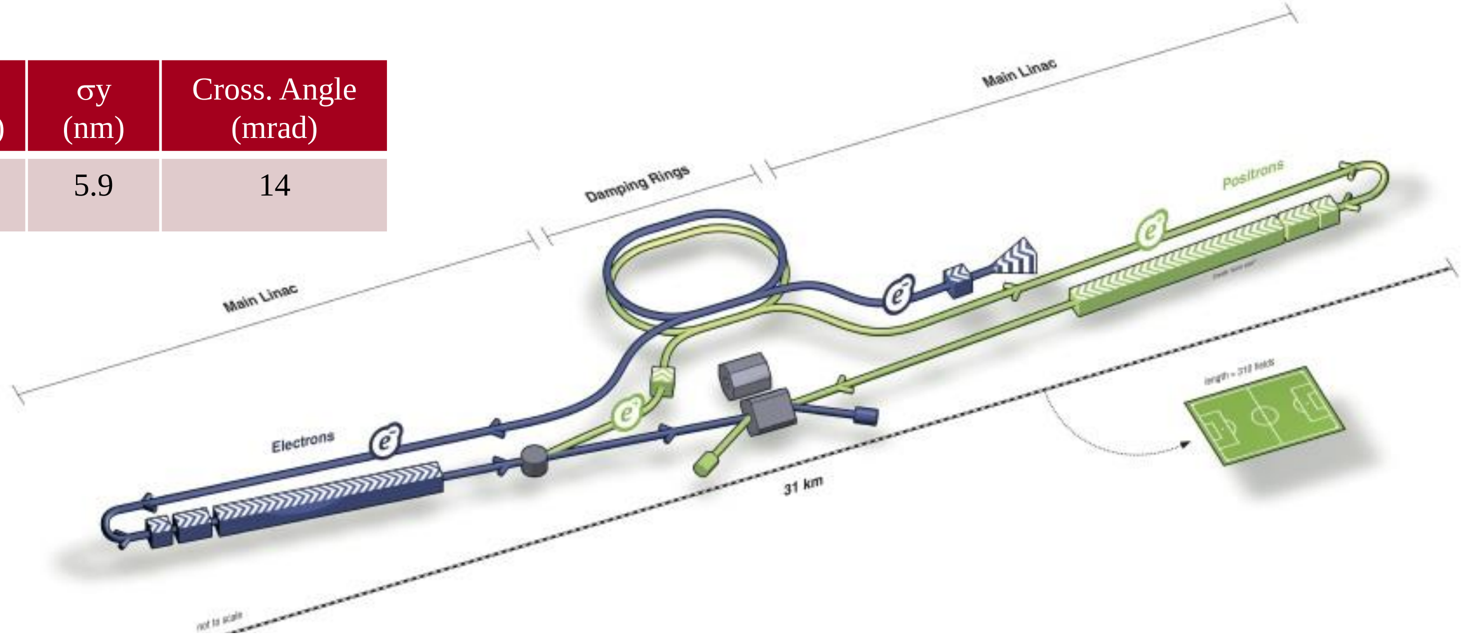


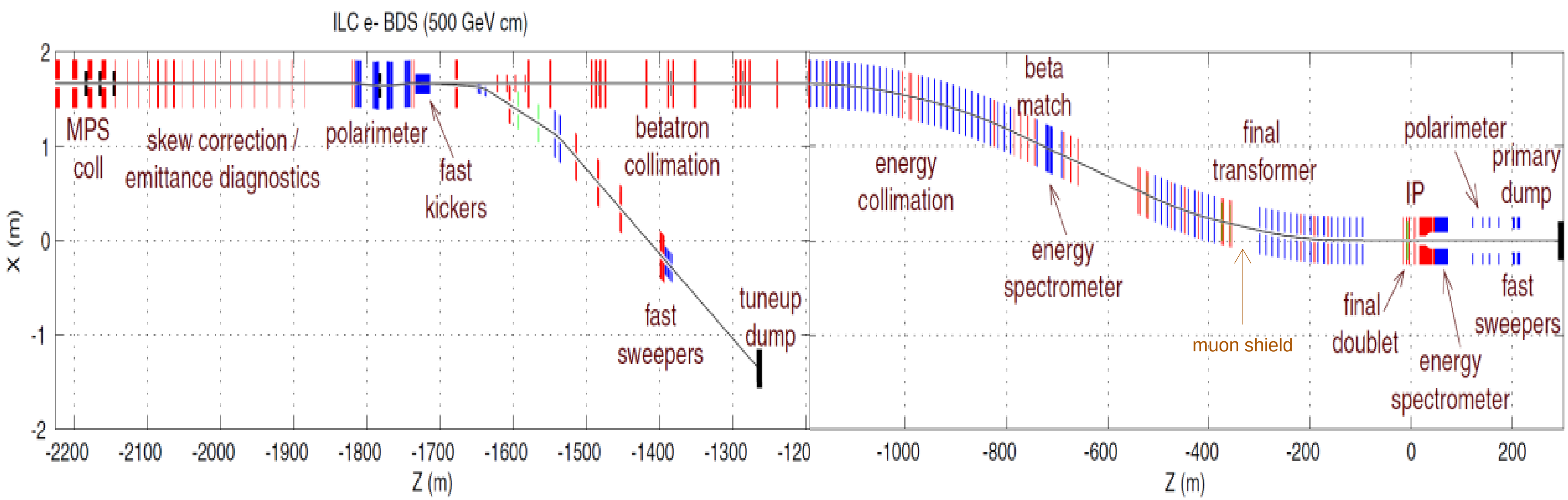


SLD, Liquid Argon Calorimeter
Assembly Beam

Beam Delivery System, ILC 500 GeV cm

IP Beam Parameter	σx (nm)	σy (nm)	Cross. Angle (mrad)
ILC 500 GeV_{cm}	474	5.9	14

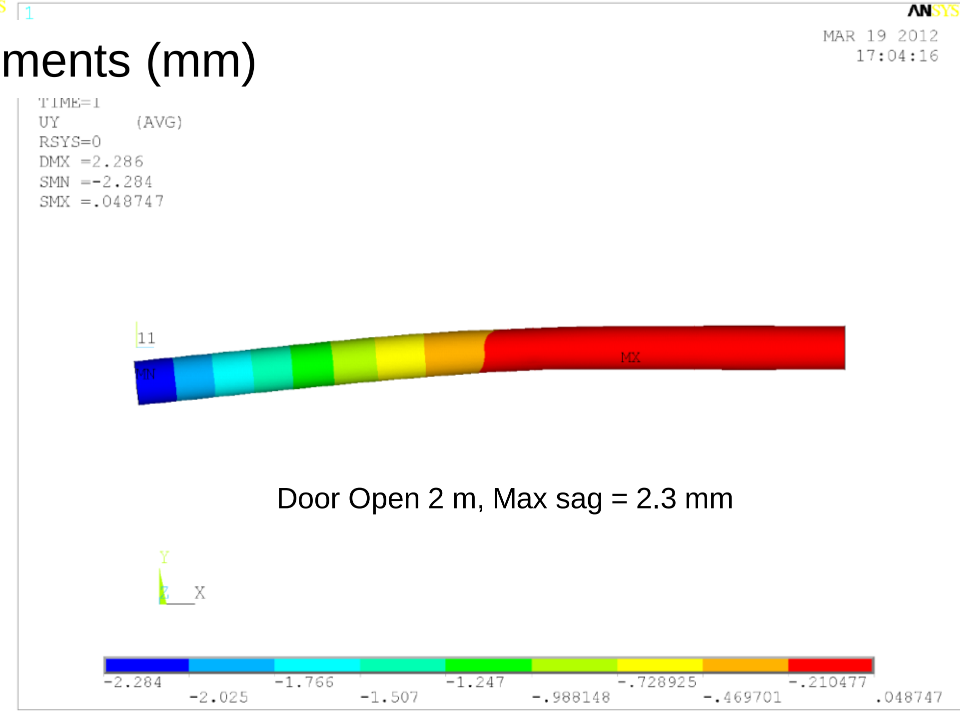




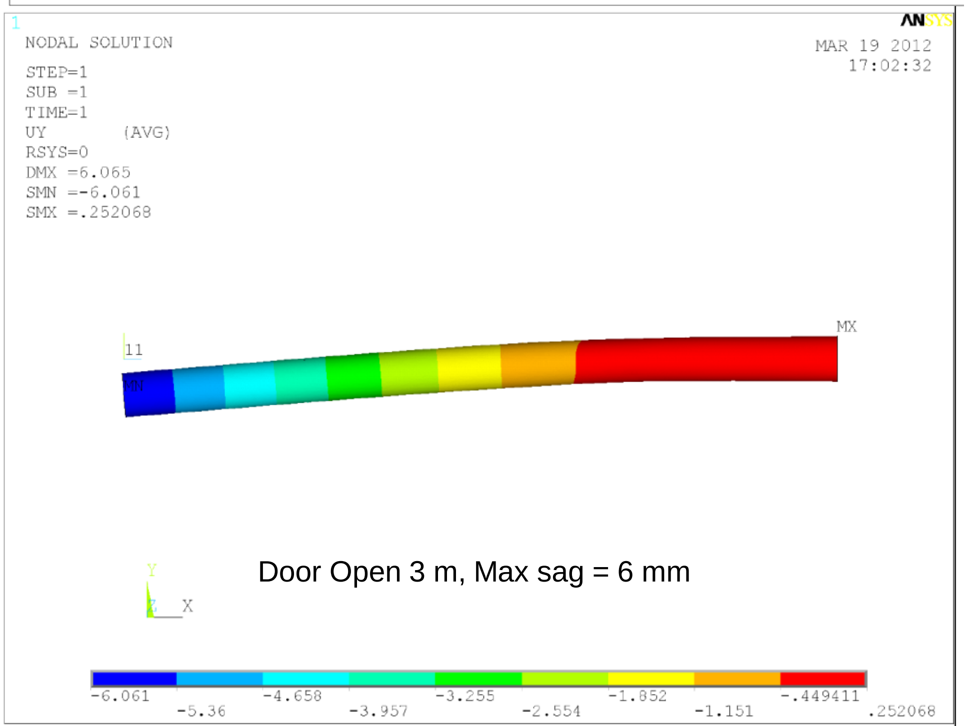
ILC BDS, ± 2.2 km

Displacements (mm)

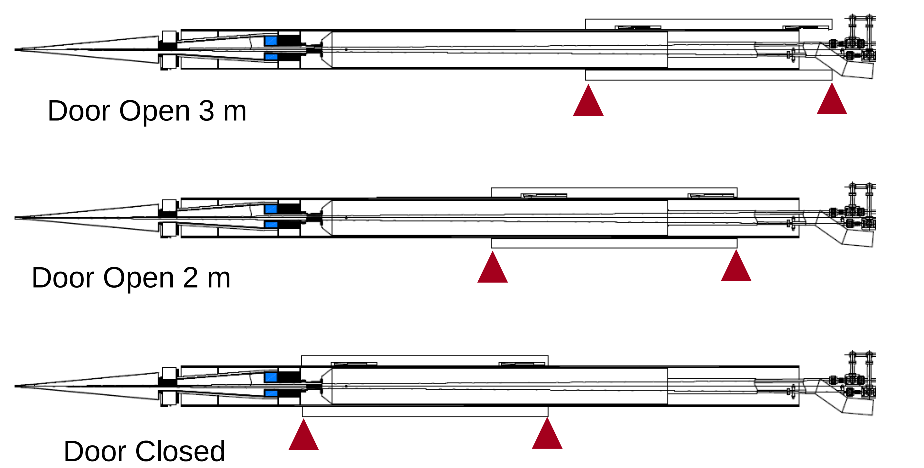
Door Closed, Max sag = 0.1 mm



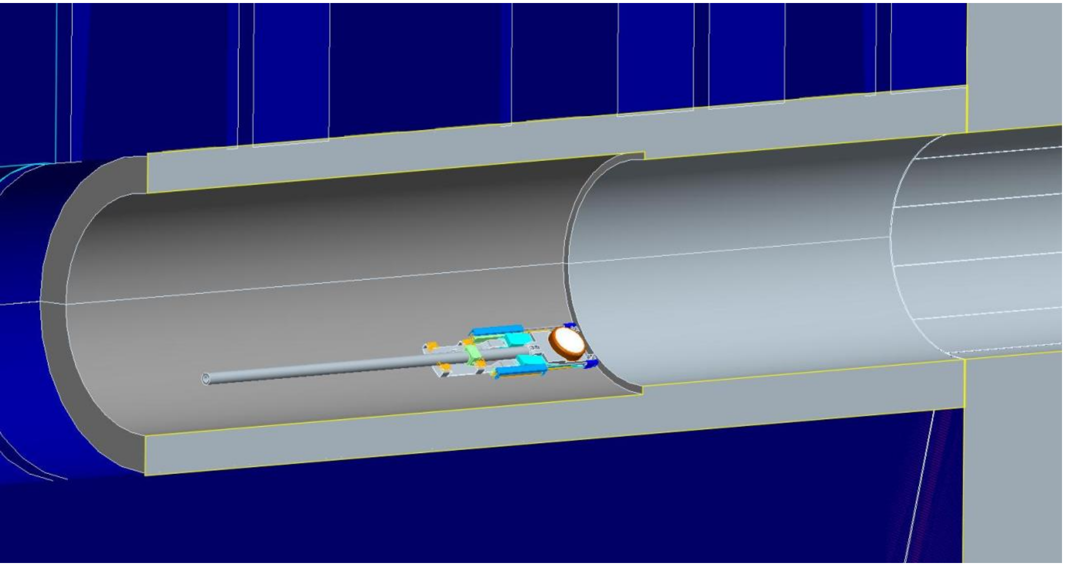
Door Open 2 m, Max sag = 2.3 mm

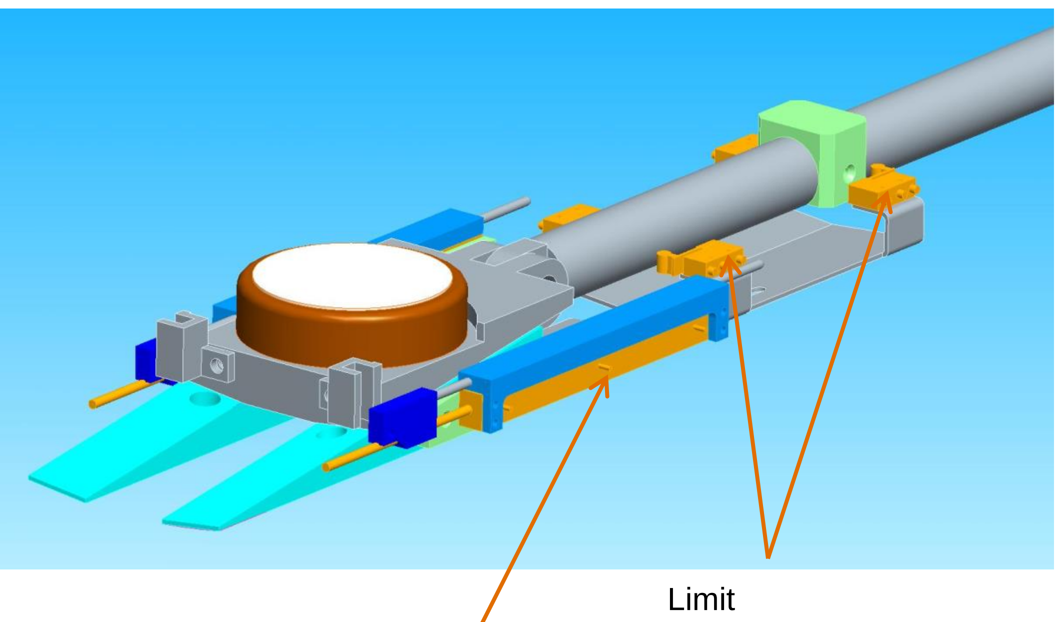


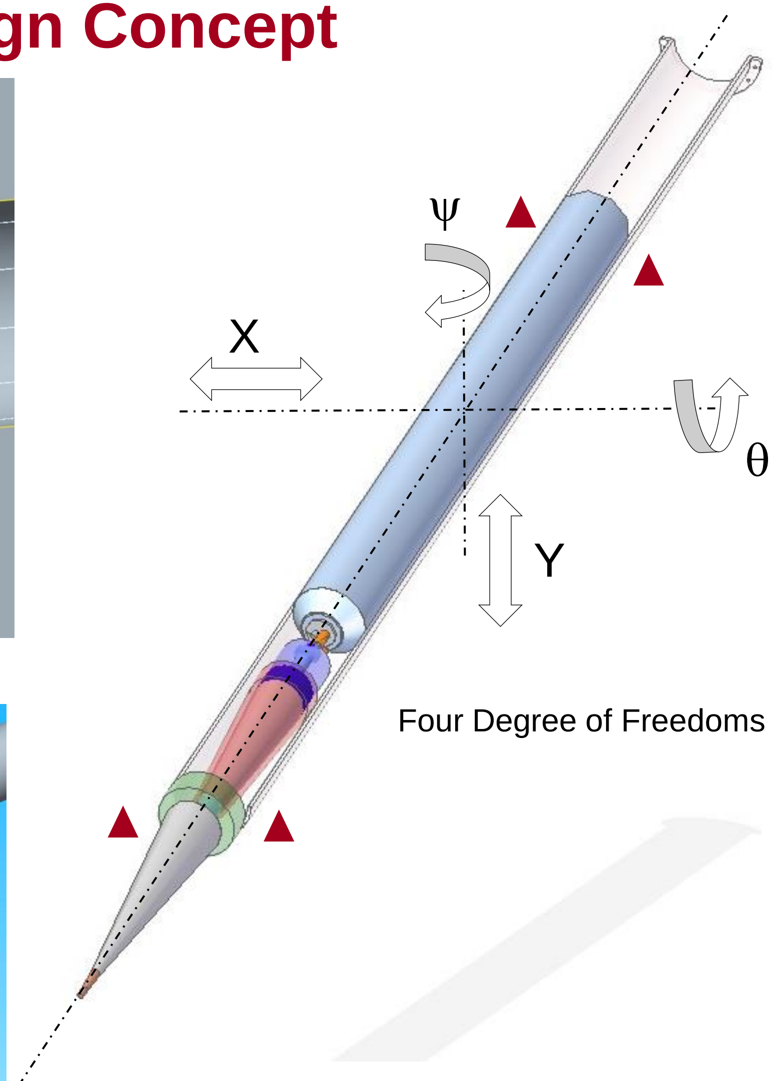
Door Open 3 m, Max sag = 6 mm



QD0 Wedge Design Concept







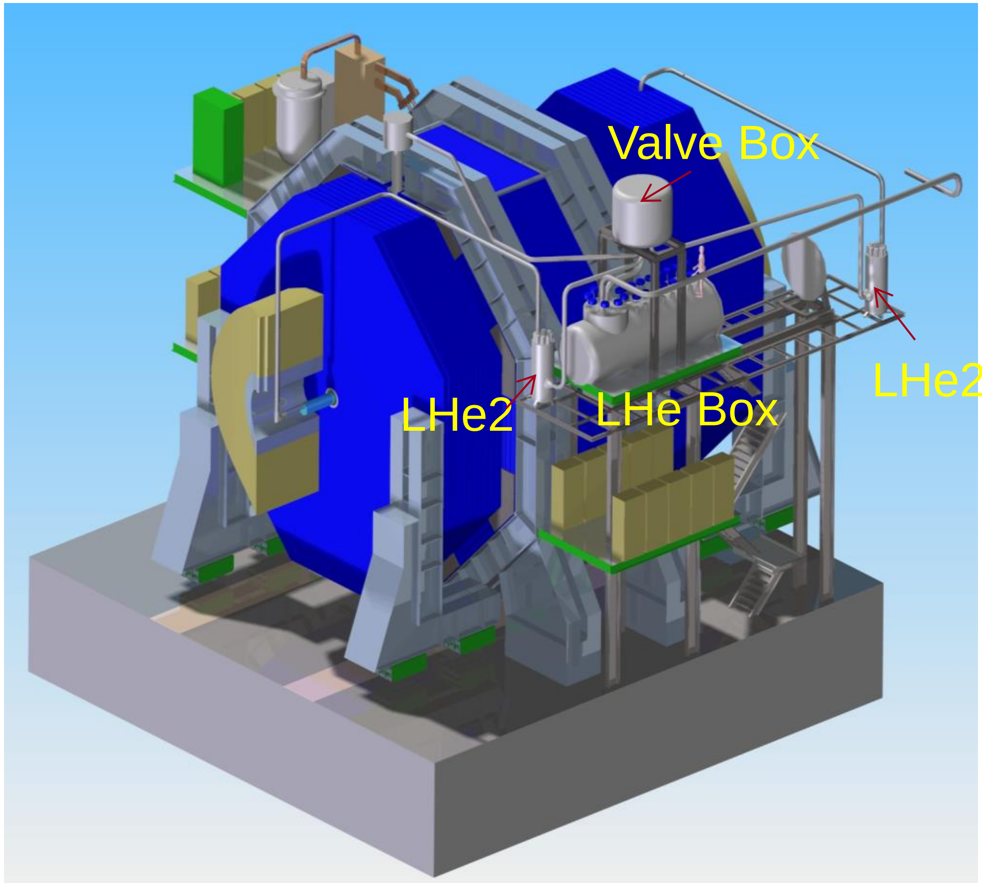
Total Pad Travel as is = .475in

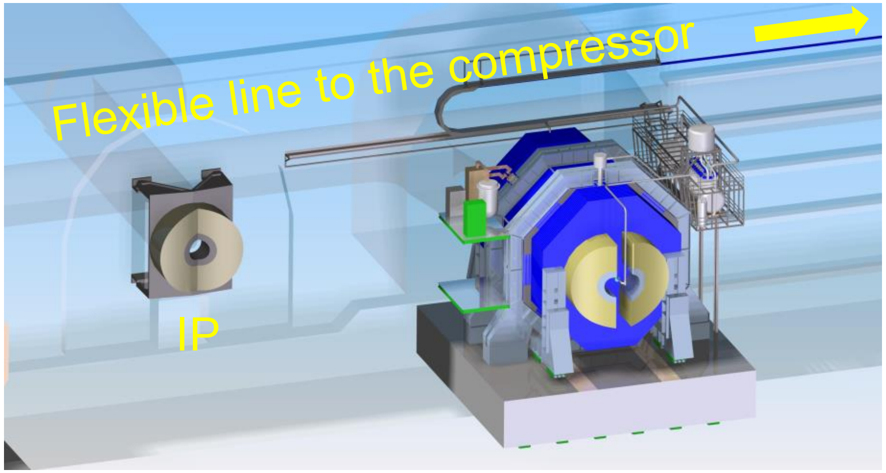
Height of pad and distance of displacement will be changed pending analysis on sagging of beam line.

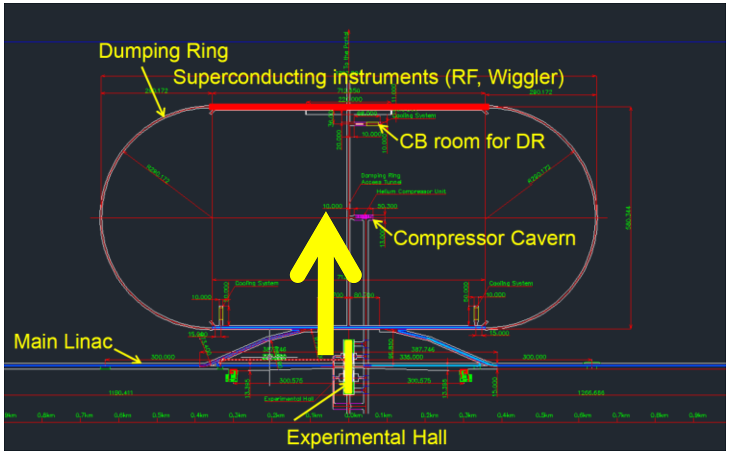
Conceptual design only at this point

Integration of the Cryogenic plant on the platform

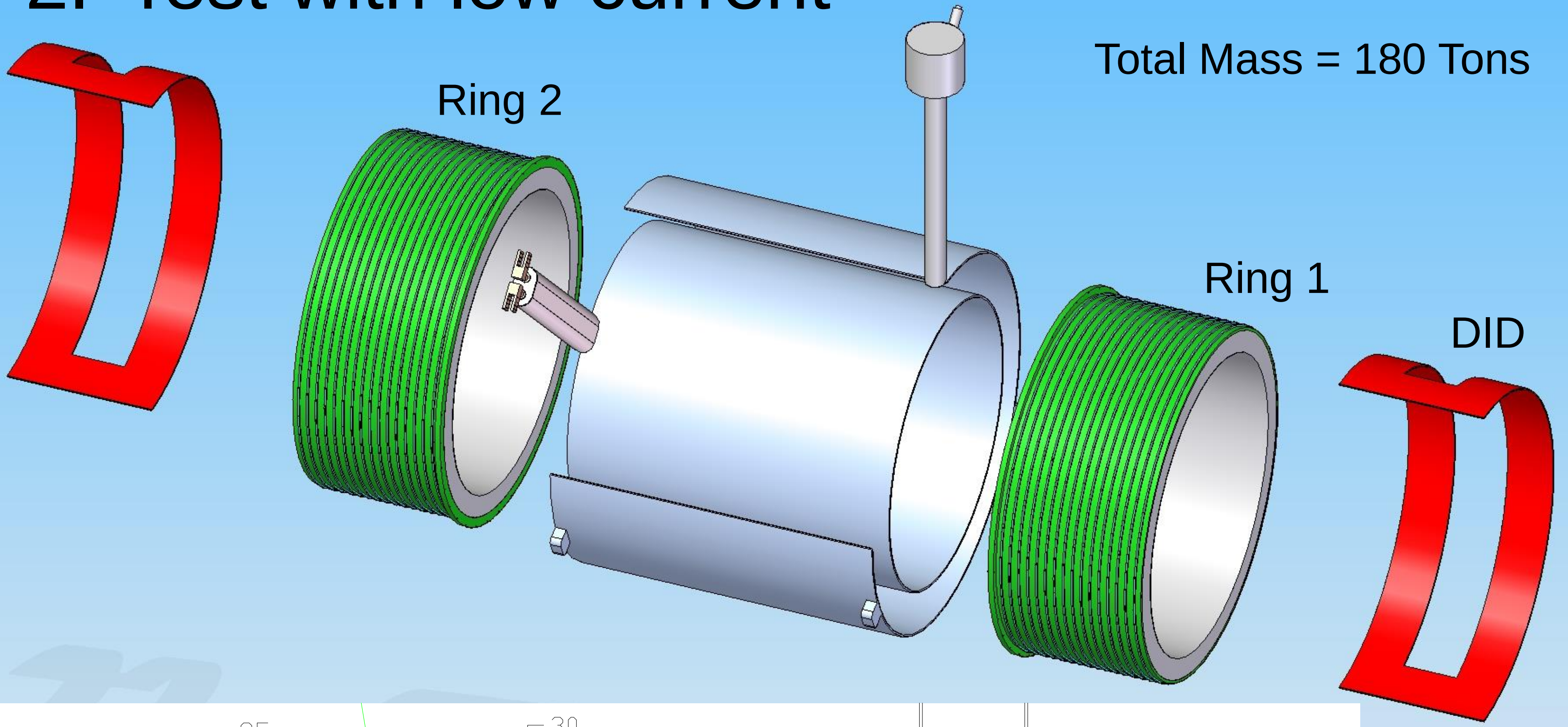
Main LHe refrigerator and LHe2 for the QD0's above level on metallic structure.

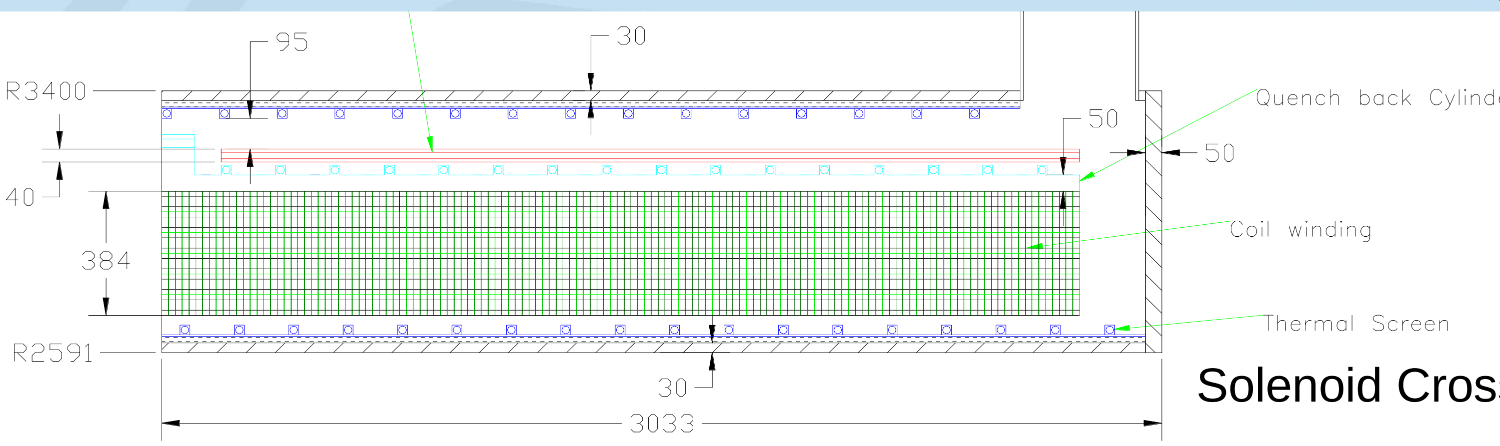






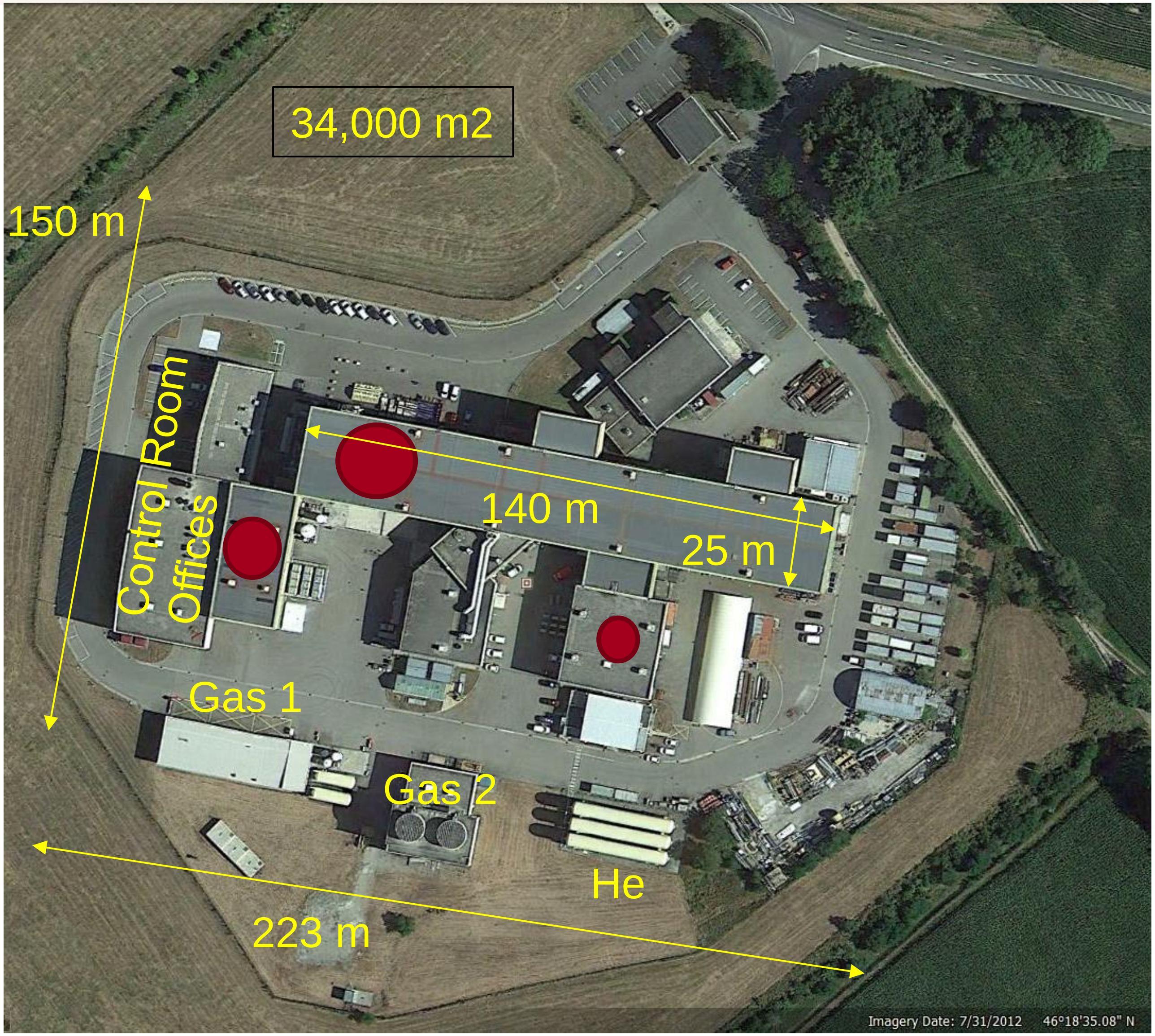
1. Assembly on Site (surface)
2. Test with low current





Solenoid Cross section

Assembly Yard - CMS



SPS beam extraction - North area (CERN)