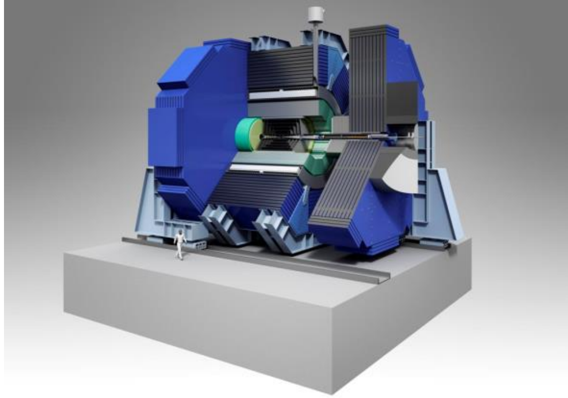


SID MDI & Engineering
Toward the TDR

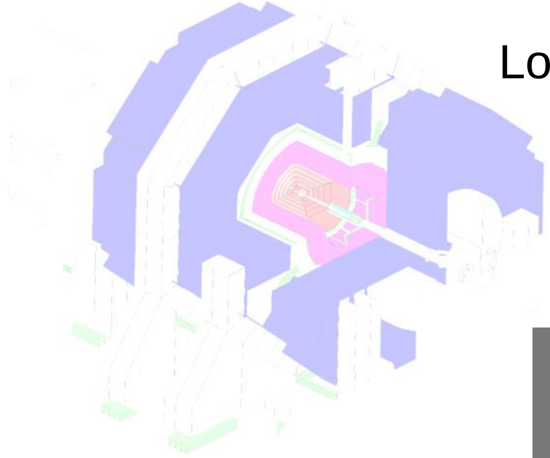
Marco Oriunno (SLAC), May 28, 2013

ECFA Linear Collider Workshop 2013, DESY

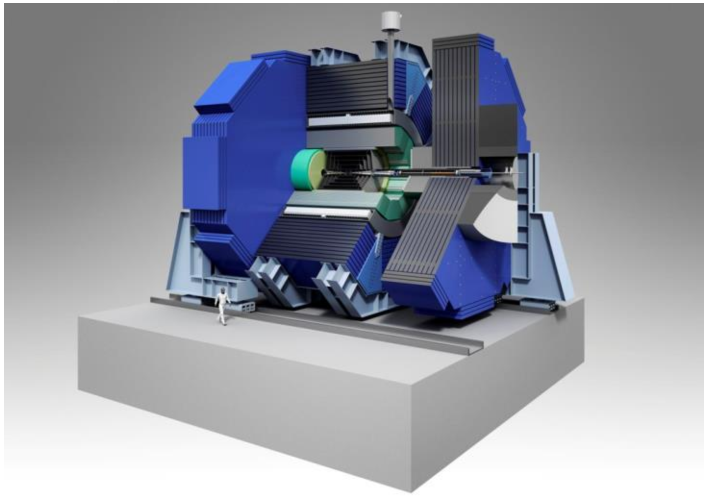
U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

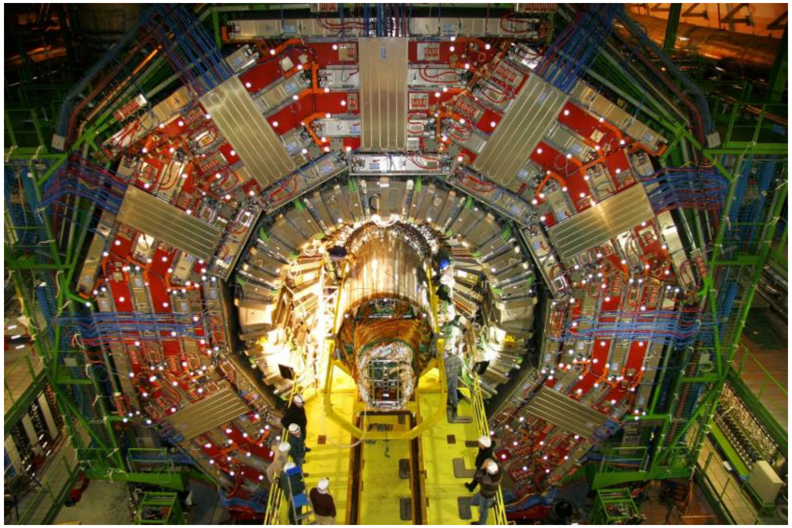
LoI-2009



DBD-2013



TDR-…..2016 ?



Steps toward a real SiD

Some national body (ies) (Japan and collaborators?) commits to linear collider 2013

Optimize SiD + Value engineering : lower costs and preserve performance

Prepare serious TDR with technical prototypes and serious cost estimate. 3 years: 2016

Requires a fully reviewed TDR. Assume the review process, with minor iterations, takes 1 year. 2017

Ready for Construction…Adding time for collaboration formation…

From here to Commitment

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

SID presently has < 0.5 Mechanical Engineers total. This would have to go to 2 FTE's to begin to make mechanical progress.

In the intensive TDR stage, this should be ~10 FTE's + similar number of designers.

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 : MDI

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.

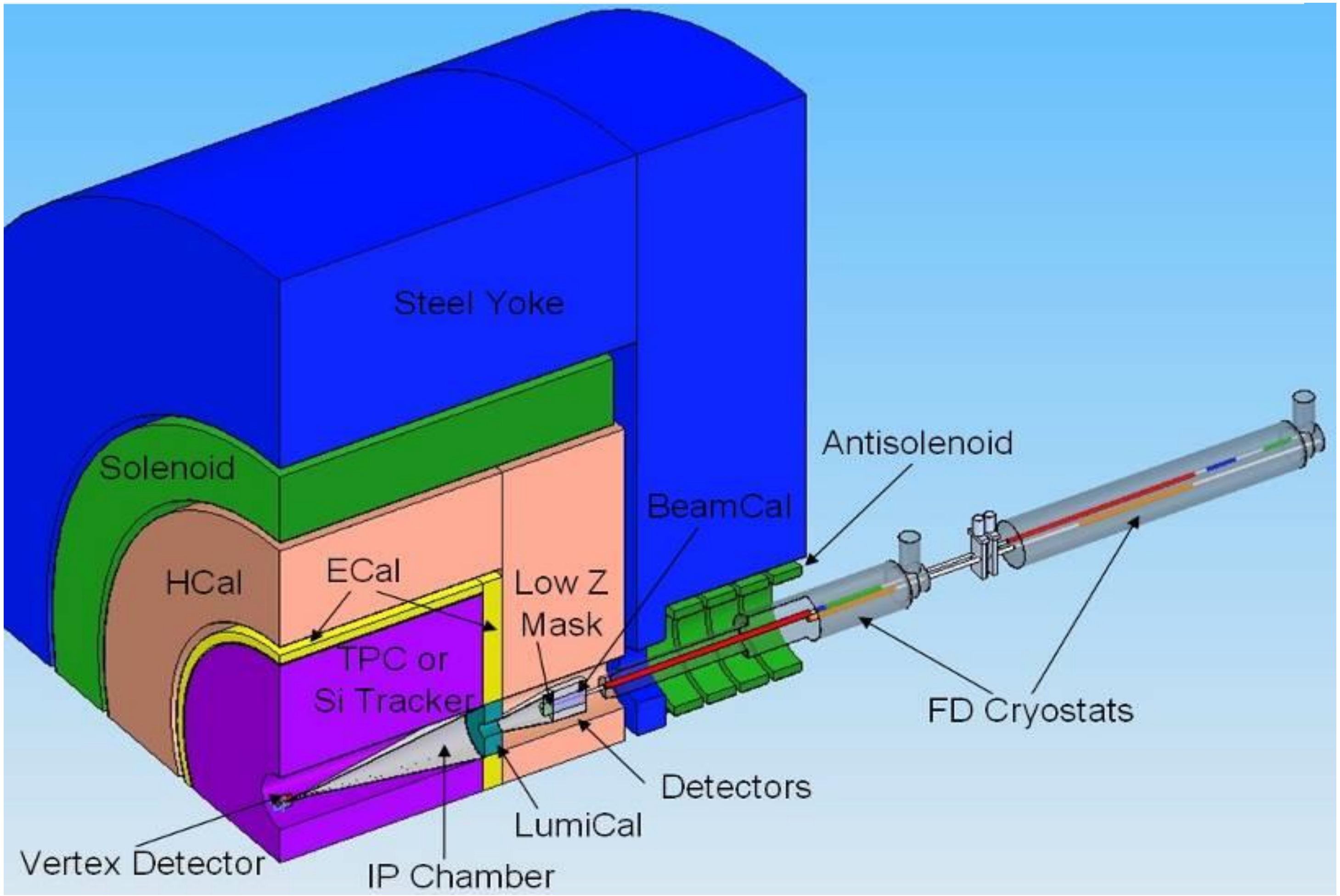
Support and vibration issues need continued work

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 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

- 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.

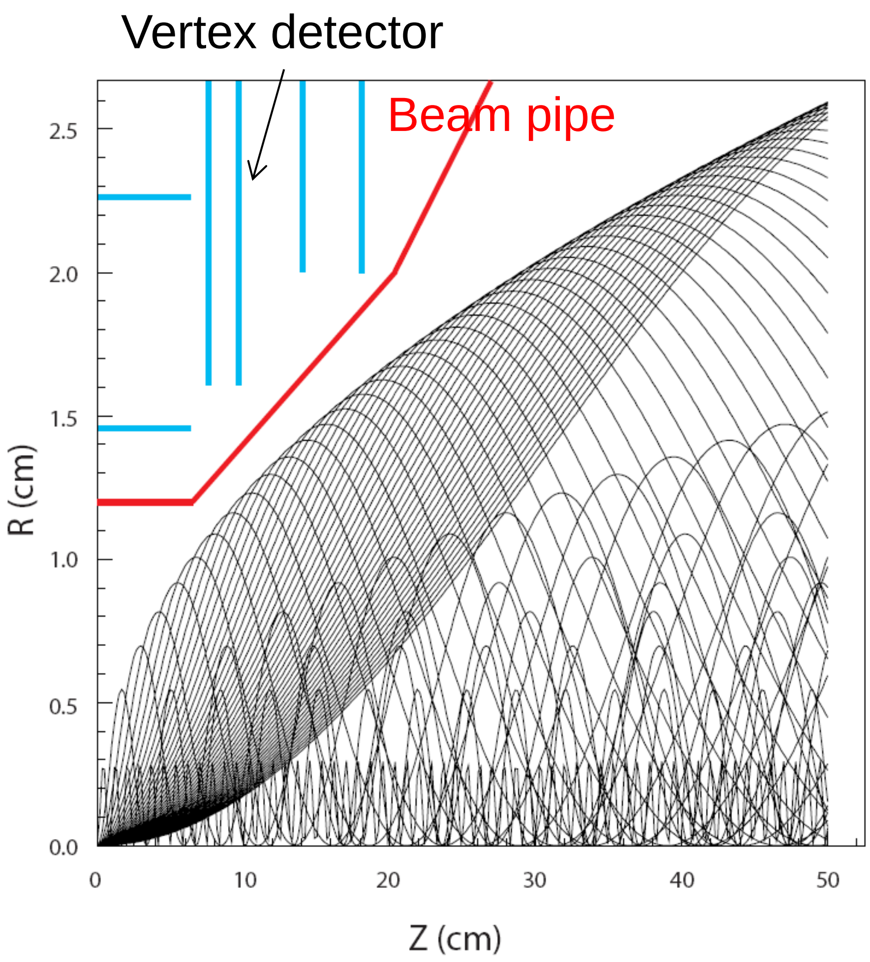
Beyond 800 m from the IP the pressure could conceivably be at least an order of magnitude higher than 10 nT, pending look at BGB background in the Compton polarimeter and energy spectrometer.

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.

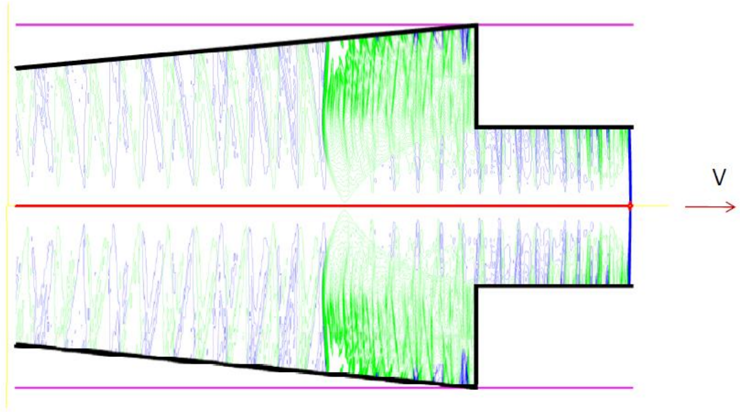
The pair edge is critically dependent on the IP beam parameters.



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.

Critical Issues for Mechanical Engineering : Solenoid

The SiD Solenoid:

Iron structure and supercoil – have a pre-conceptual design. R&D is ~stalled on interesting aspects such as better superconductors and stabilizers.

Japanese mountain sites require iron engineering & optimization study of segmentation for:

- Transport
- Assembly including handling fixtures
- Integration of muon system on surface

The integrated dipole seems difficult. ILC should confirm there is no beamline optics solution.

The design can not progress beyond this until the inner radius and length of the solenoid is settled.

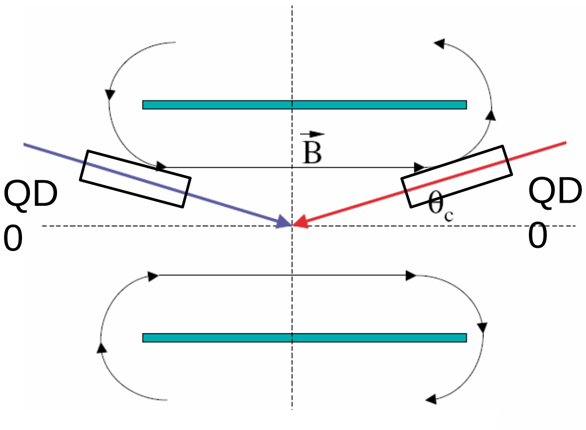
- This requires optimization of the solenoid.
- This is not an engineering choice, but a physics and cost issue.

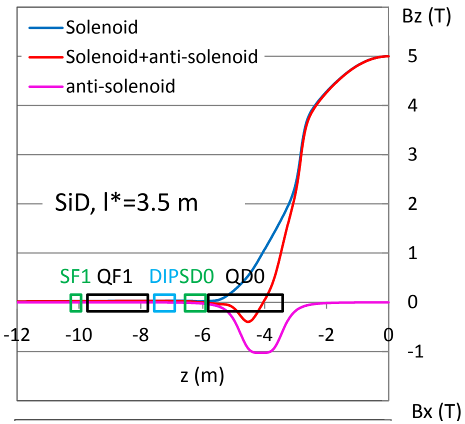
The Exoskeleton should be revisited. Is it needed?

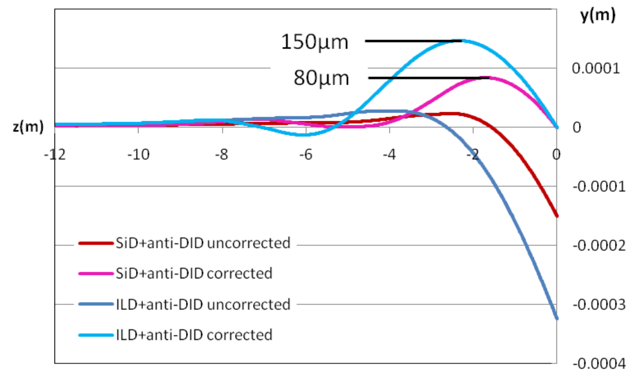
Magnetic Field compensations at IP, DID, antiDID

- Longitudinal field of the solenoid + Fringe field extending over QD0 -> **coupling** (x, y) (E,y) => beam size growth
- Radial field due to crossing angle -> **orbit deviation**, implying **synchrotron radiation**,
- Fringe field extending over QD0 -> no **compensation** of radial and longitudinal components, => non zero orbit at the IP

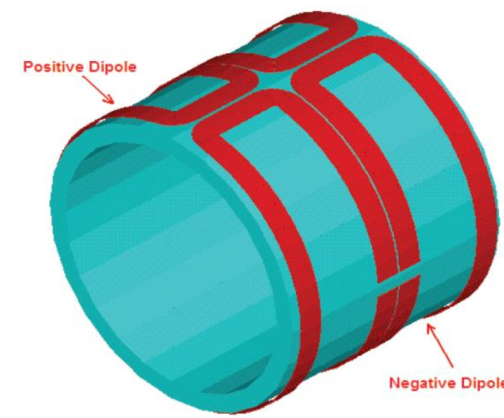
- **Anti-DID** field -> **additional radial field** deviating incoming particles.

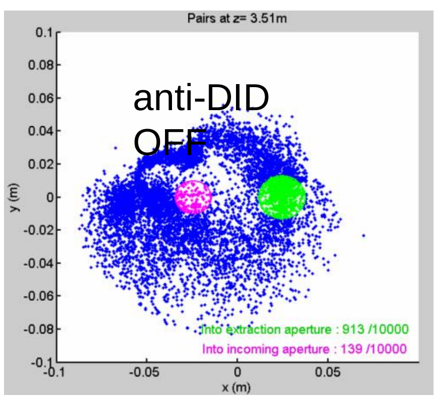


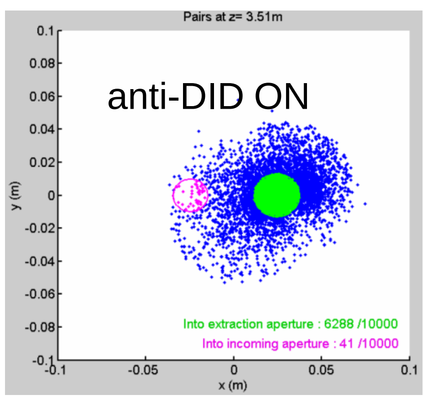


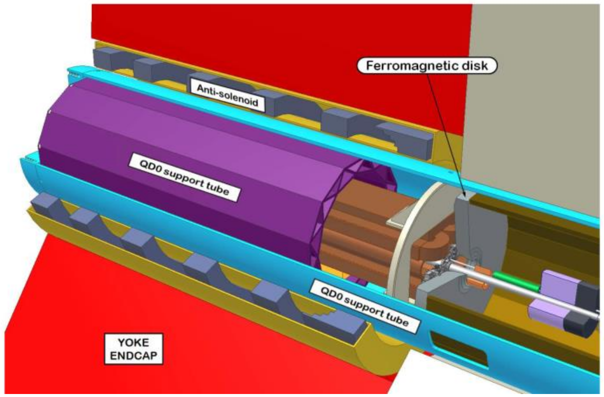


R. Versteegen



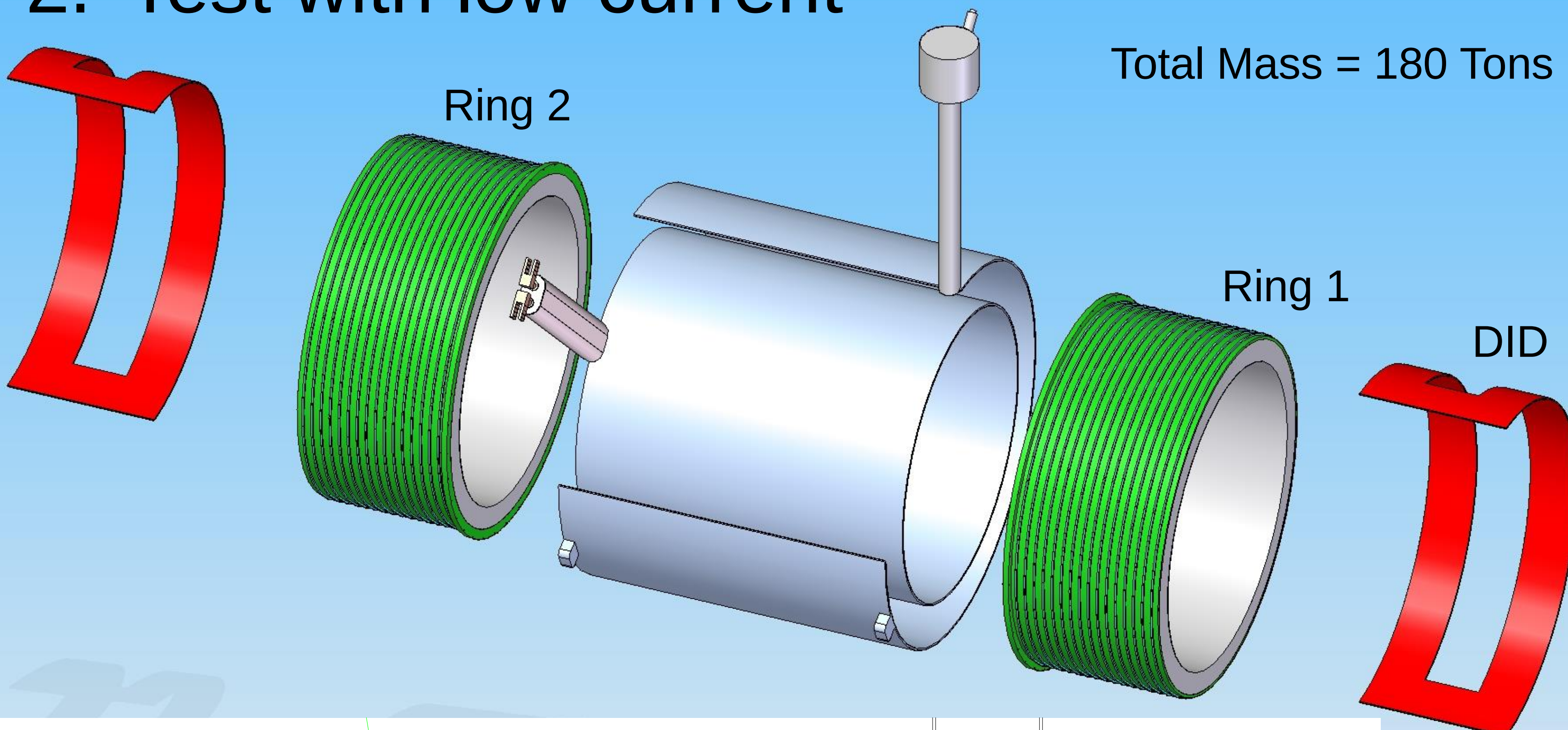


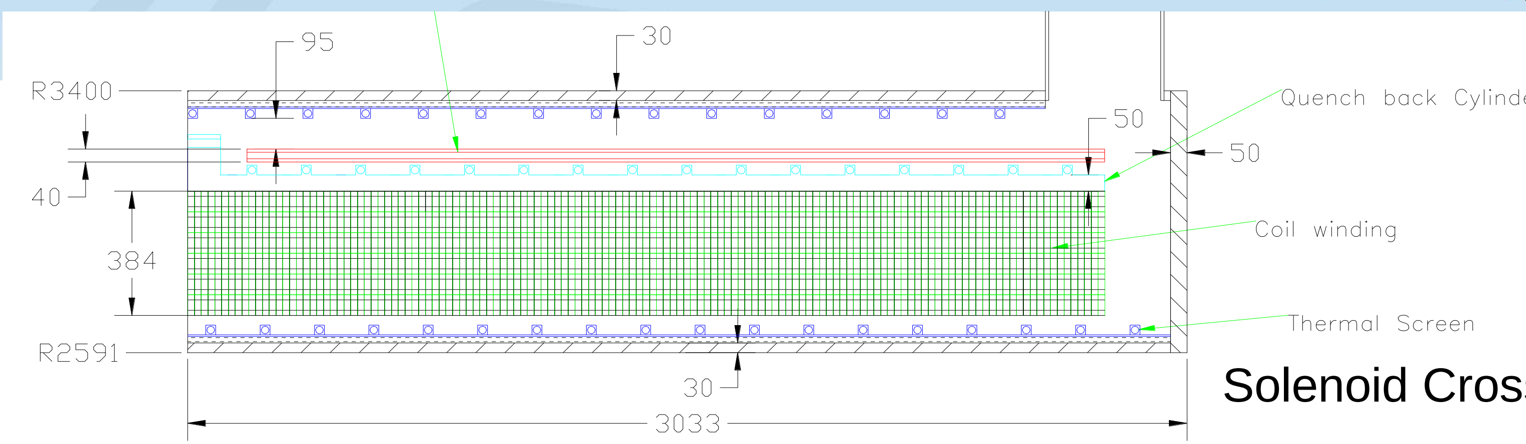




Pairs distributions at 3.5m from IP

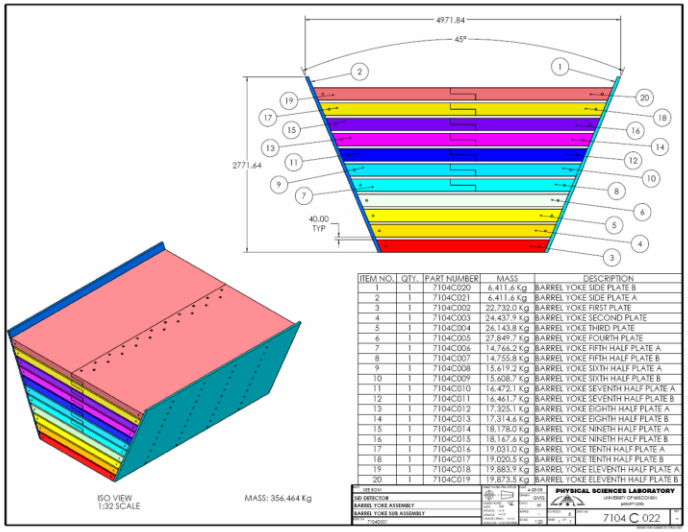
1. Assembly on Site (surface)
2. Test with low current





Solenoid Cross section

Iron Barrel Yoke layout



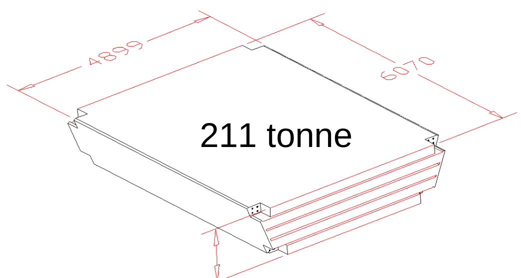
ITEM NO.	QTY.	PART NUMBER	MASS	DESCRIPTION
1	1	7104C020	6,411.6 Kg	BARREL YOKE SIDE PLATE B
2	1	7104C021	6,411.6 Kg	BARREL YOKE SIDE PLATE A
3	1	7104C002	22,732.0 Kg	BARREL YOKE FIRST PLATE
4	1	7104C003	24,437.9 Kg	BARREL YOKE SECOND PLATE
5	1	7104C004	26,143.8 Kg	BARREL YOKE THIRD PLATE
6	1	7104C005	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

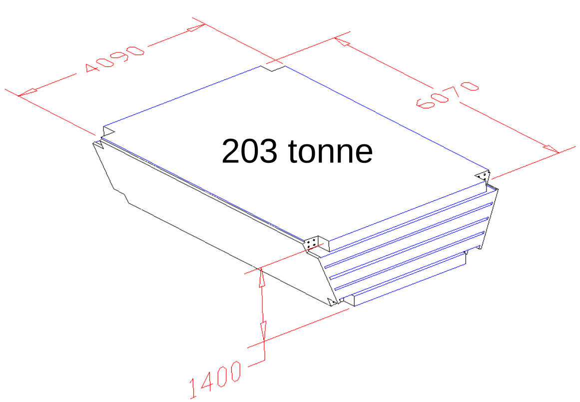
Opportunity to make blank assembly at the factory before shipping

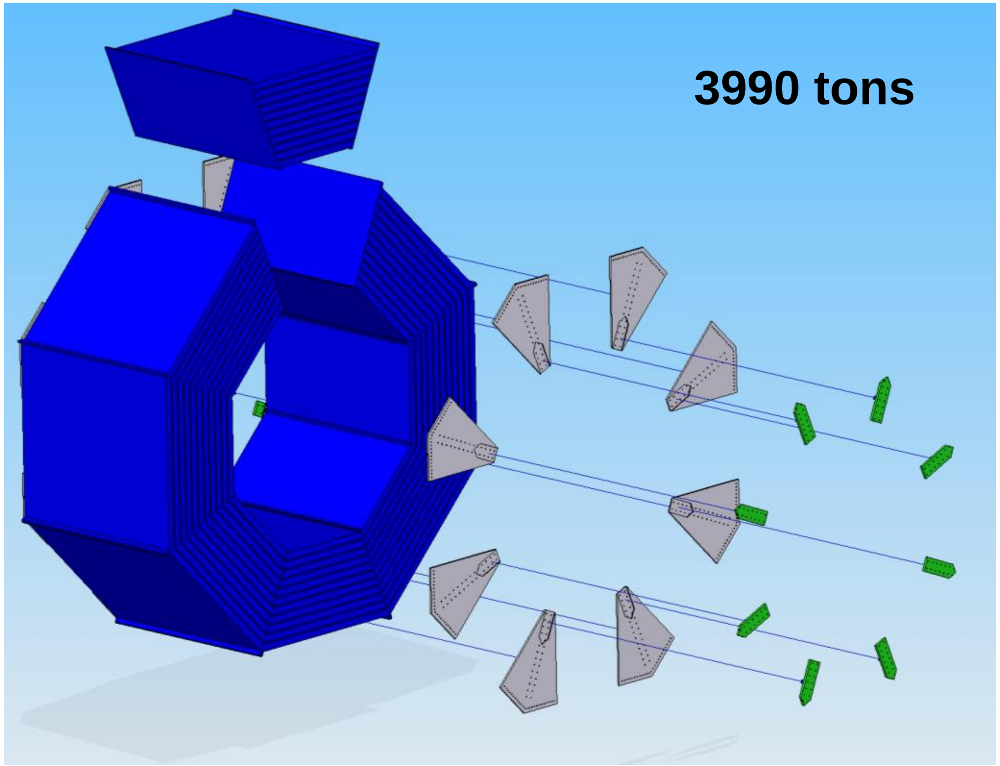
Preliminary Contacts with Kawasaki Heavy Industries

- 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





Critical Issues for Metrology

The SiD push-pull concept relies on a metrology system able to measure any motion to the required precision needed to avoid beam based re-calibration.

The key technology is a Frequency Scanning Interferometer (FSI) able to make absolute measurements of about a meter to an accuracy of ~ 1 micrometer in air between a fiber optic launcher and a corner reflector.

In addition there are higher precision systems contemplated for locating the QD0's (Mona Lisa, etc). Since the FSI's should be able to locate the quads well enough for Beam Based Alignment to work, the case is not as strong as for the FSI's.

Cooling and Power Consumption

SiD has been developing KPiX, a 1024 channel "System on Chip" to optimize low multiple scattering for the Si strip tracker and for highly pixellated, dense readout for the electromagnetic calorimeter.

A key feature is its low average power…

ILC: 1 ms spill @ 5 Hz

SiD currently uses power up 1 ms before train; 1 ms train; 10 μs fall, or 1% effective duty factor.

SLC power cycling worked ~ok at 120 Hz.

Estimated Tracker power consumption is <600 watts : gas cooling of the VXD and Si Tracker.

Estimated EMCal power is 2 kW. This is coupled to W plates and water cooled at the ends. ΔT ~4C. 100 x power will require direct cooling, SiD concept will not work.

Integration Issues

1. MDI issues are real, but are believed workable.

2. The Self Shielding concept has had another round of Fluka testing, and appears to be conservative. There are schemes for hinged Pacmen to work with both detectors.

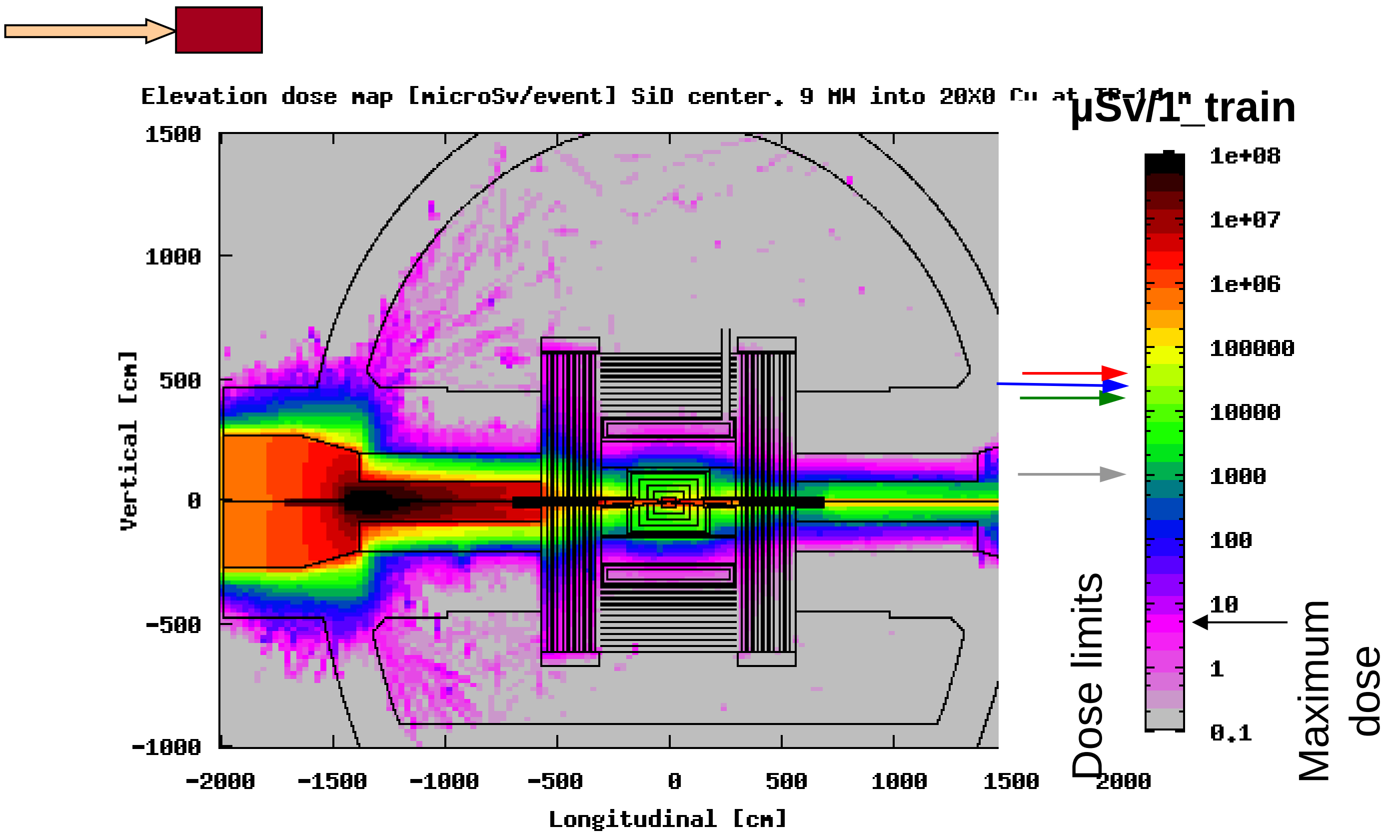
3. The vertex detector is being treated as a moderate integration issue.

4. The beampipe conceptual design accommodates the SiD vertex detector design, and appropriate space within the tracker volume is allocated. Details can be worked out once a sensor strategy is selected. This could be quite late.

5. The service penetration requirements for SiD have had a first look, and seem quite modest. Another study will be needed when the magnet end door concept settles down.

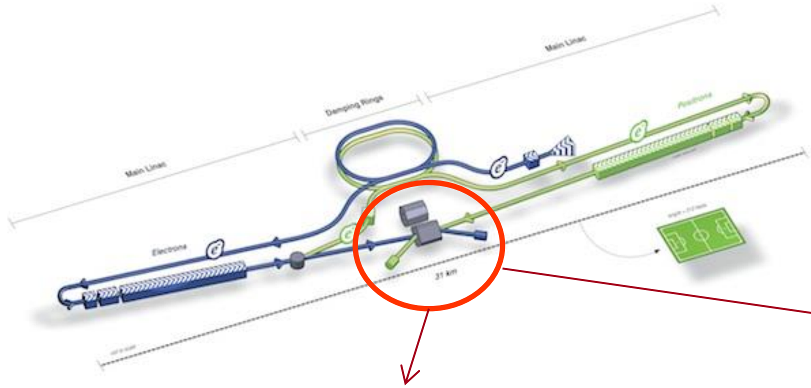
20 R.L. Cu target in IP-14 m. Large pacman.

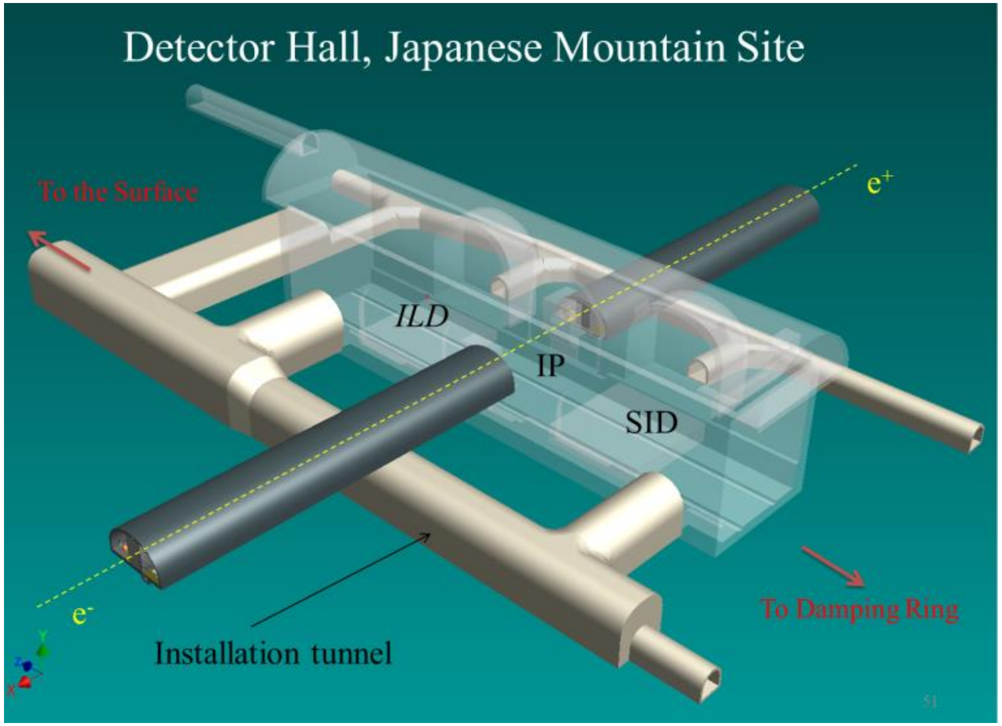
9 MW



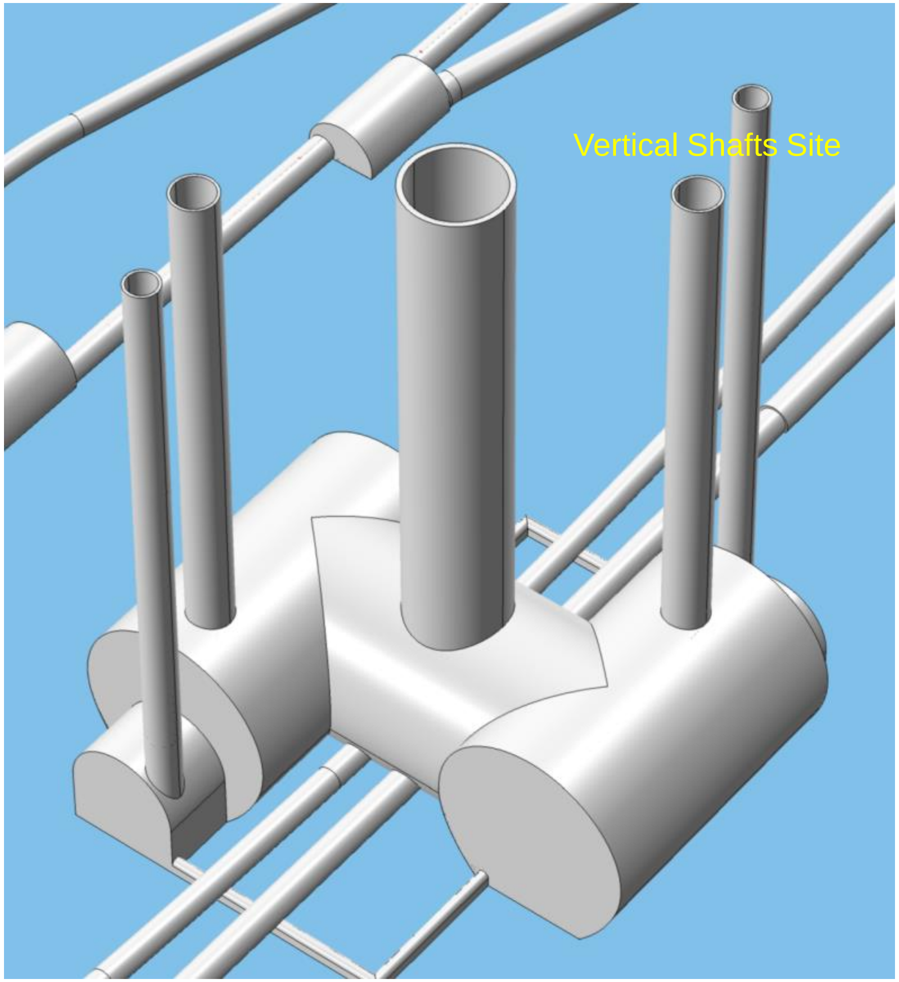
- The maximum **integrated dose** per event is ~8 µSv << 30 mSv
- The corresponding peak **dose rate** is ~140 mSv/h < 250 mSv/h

ILC Siting



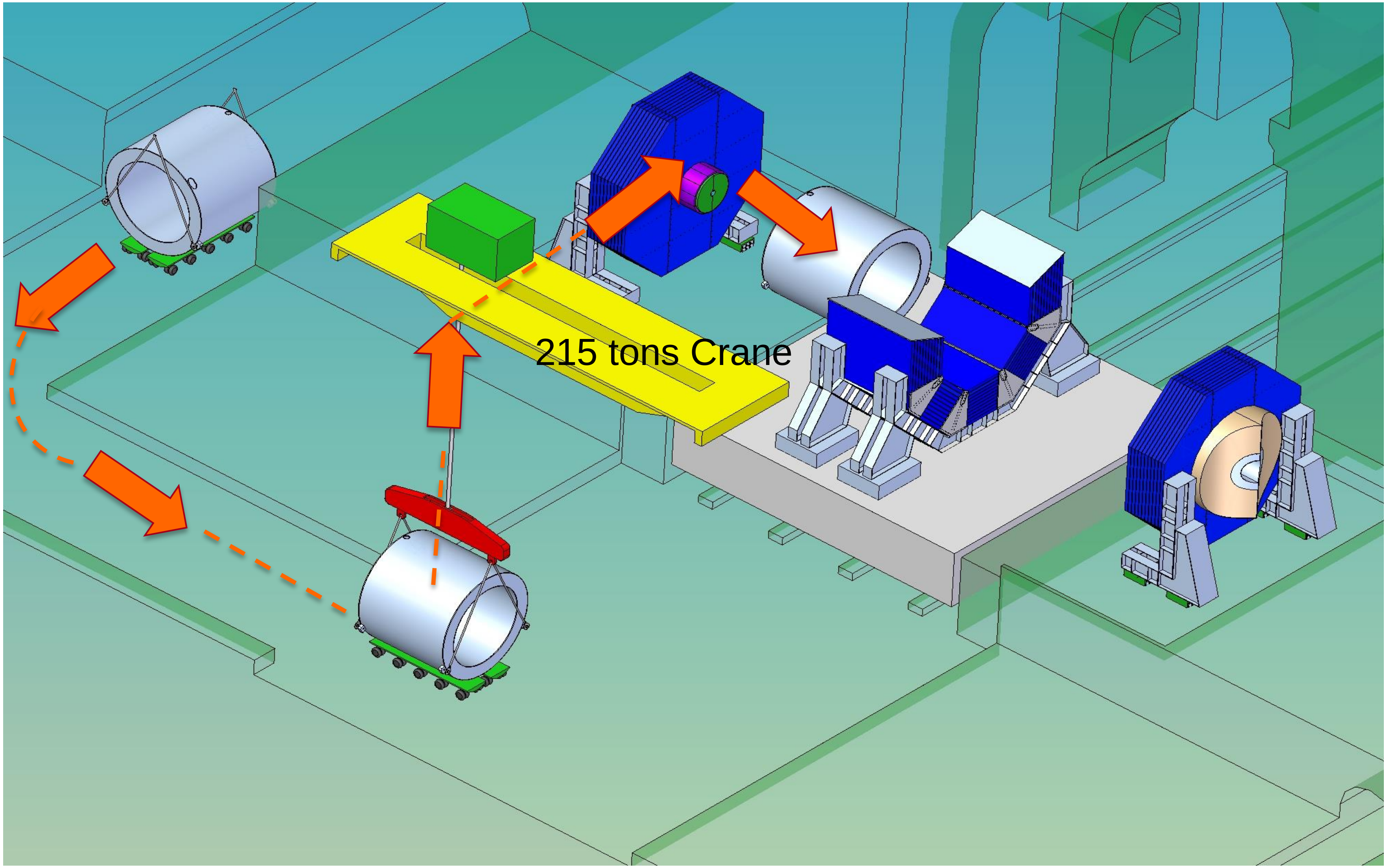


Detector Hall, Japanese Mountain Site
To the Surface
e^+
ILD
IP
SID
e^-
Installation tunnel
To Damping Ring

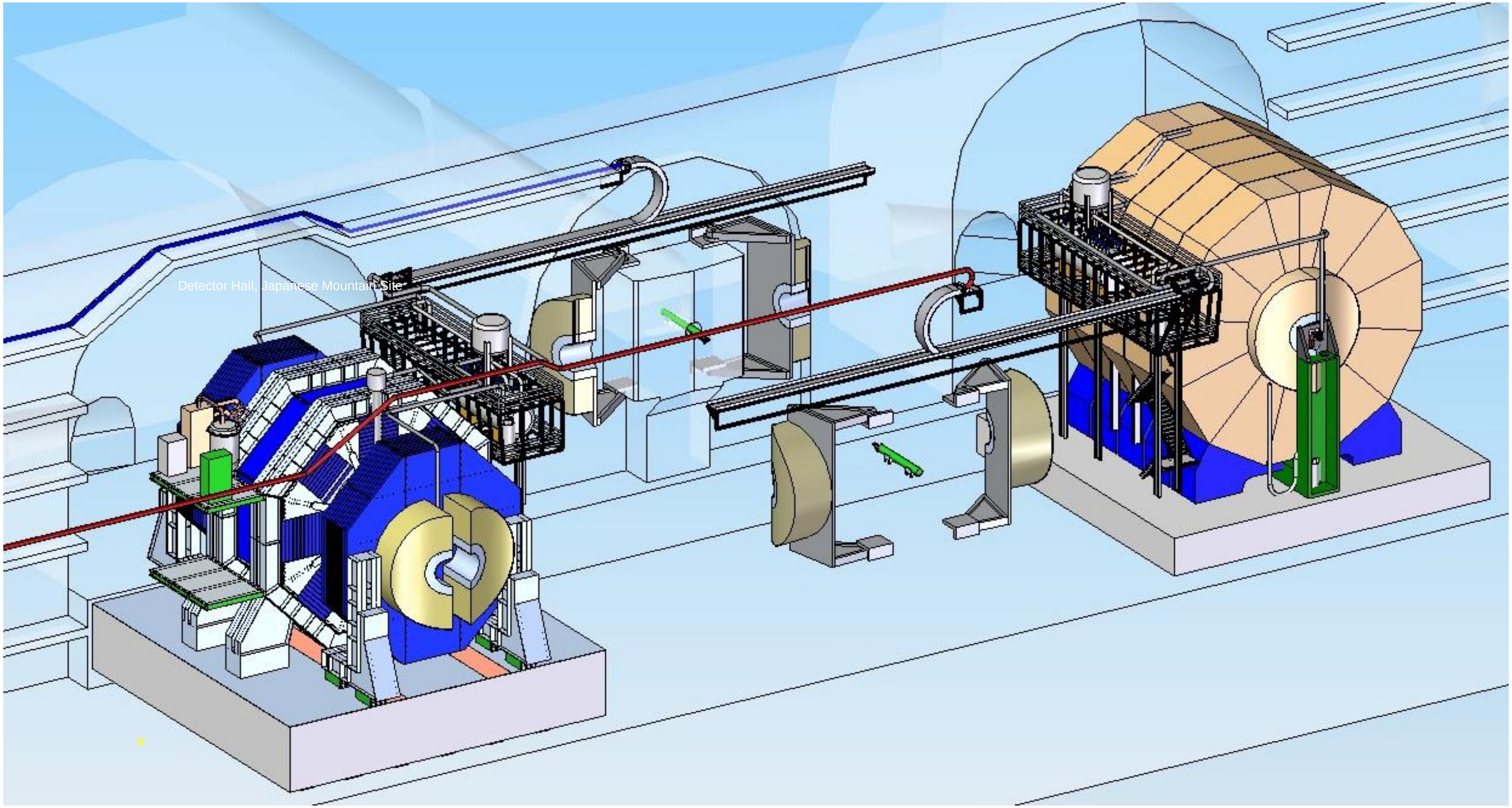


Vertical Shafts Site

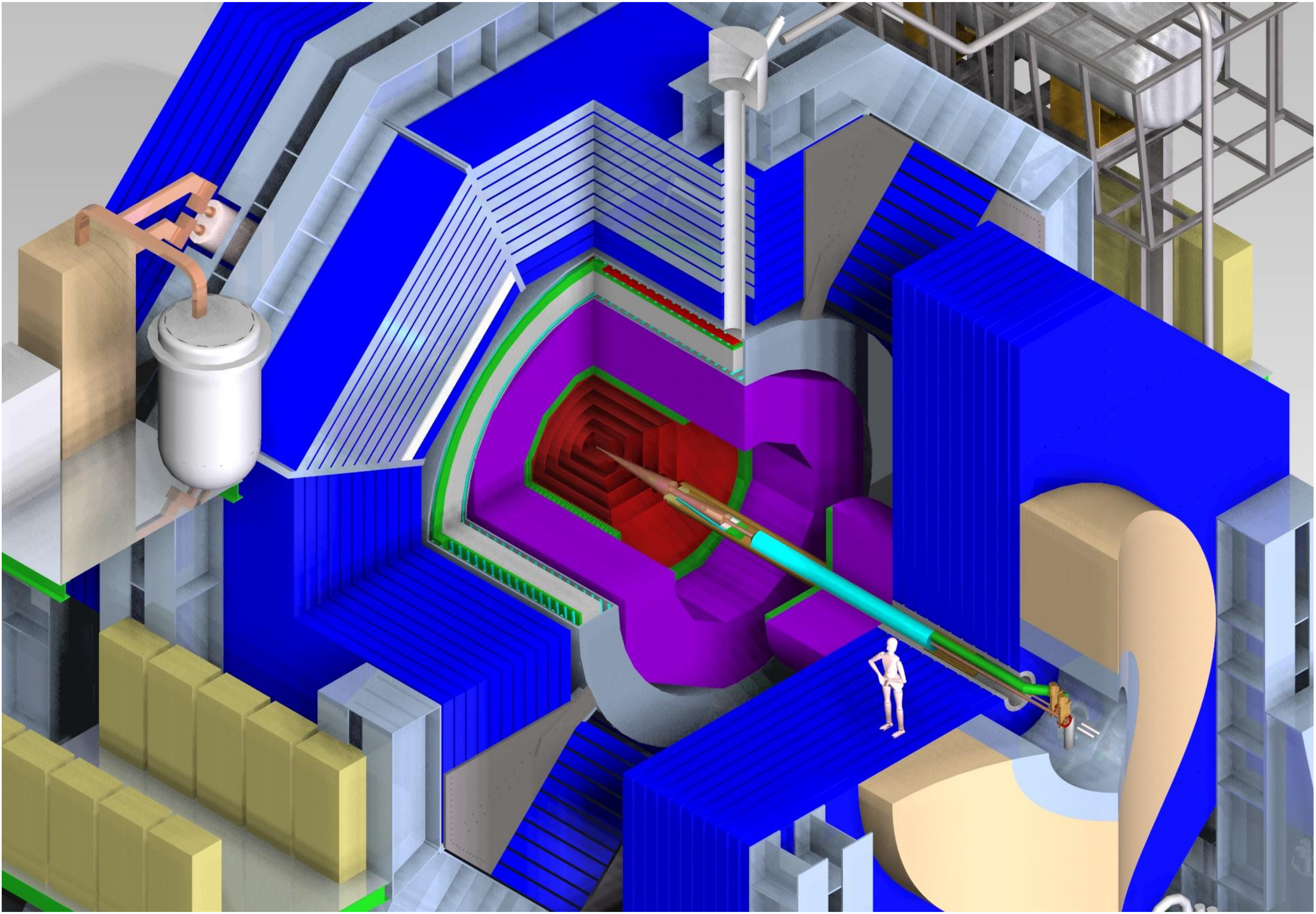
Magnet Installation – Japanese Site



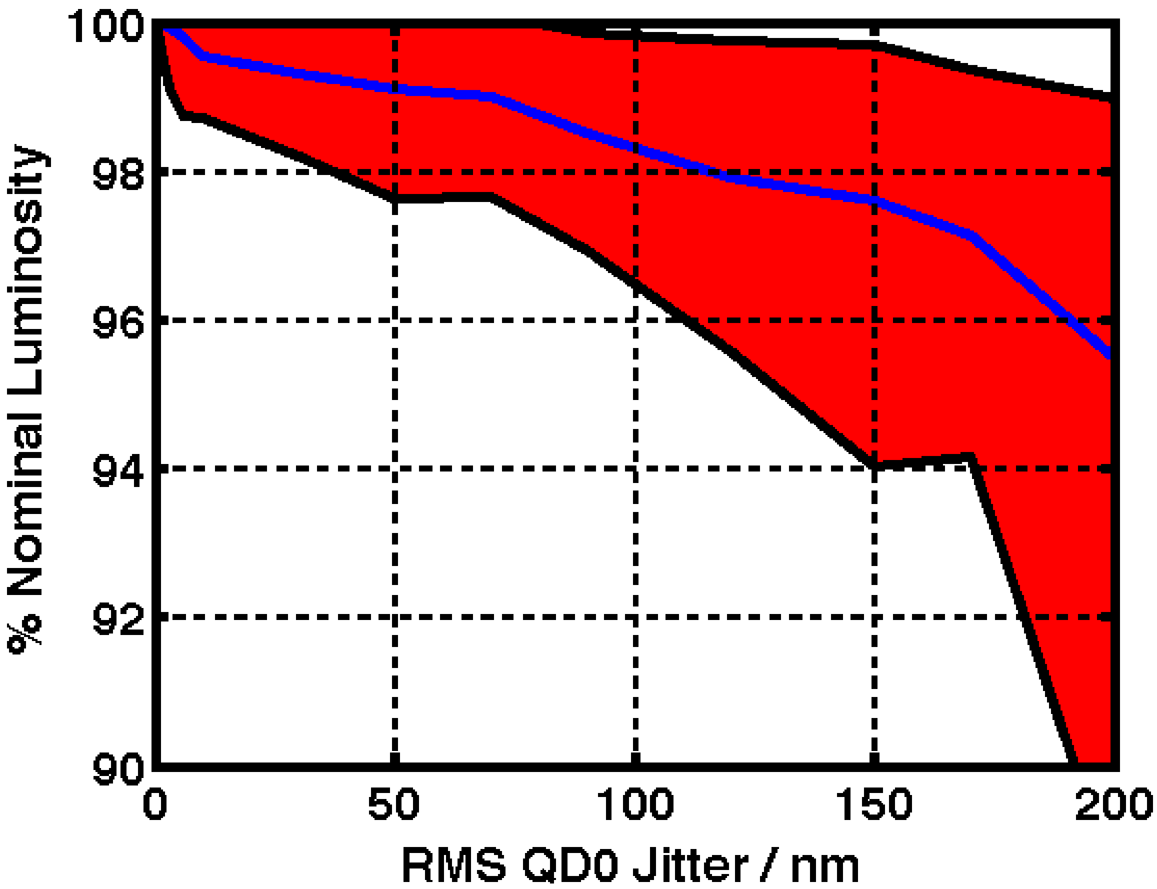
Push-Pull : Engineering Concept



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



Luminosity Loss vs. QD0 Jitter

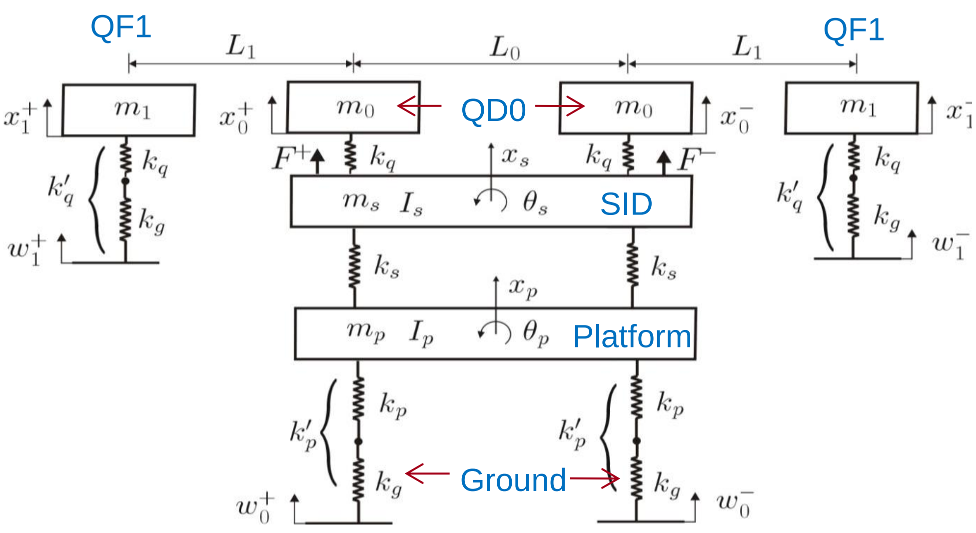


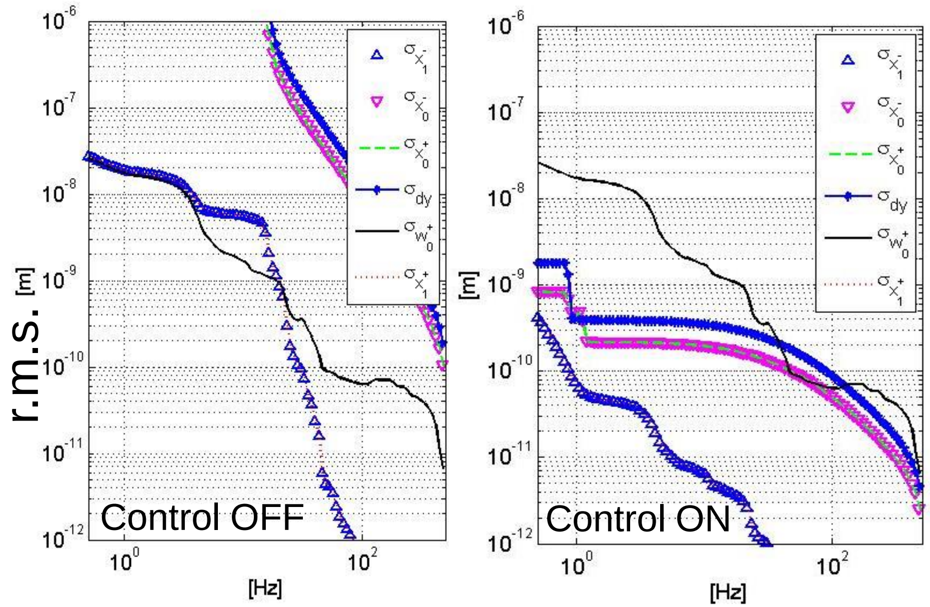
Data shown gives % nominal luminosity for different levels of uncorrelated QD0 jitter.

- 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

Questions ?

SID key design features

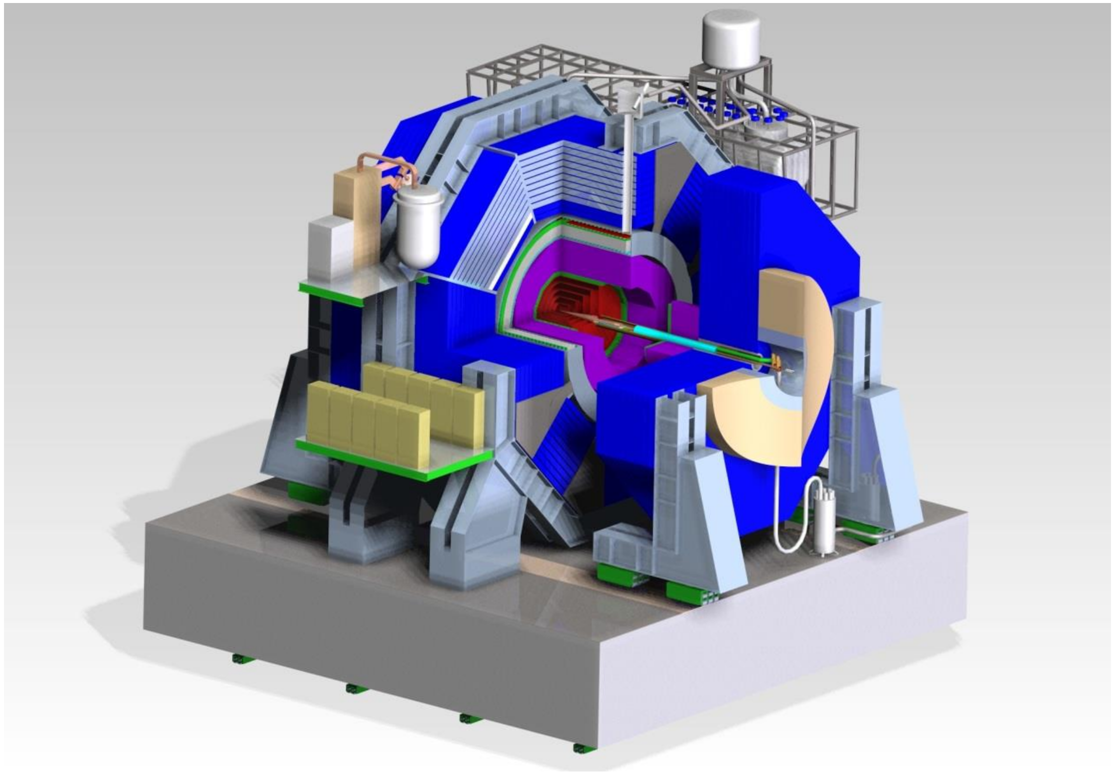
Compact design with 5 T Solenoid

Single Ring Barrel ~ 4'000 tons

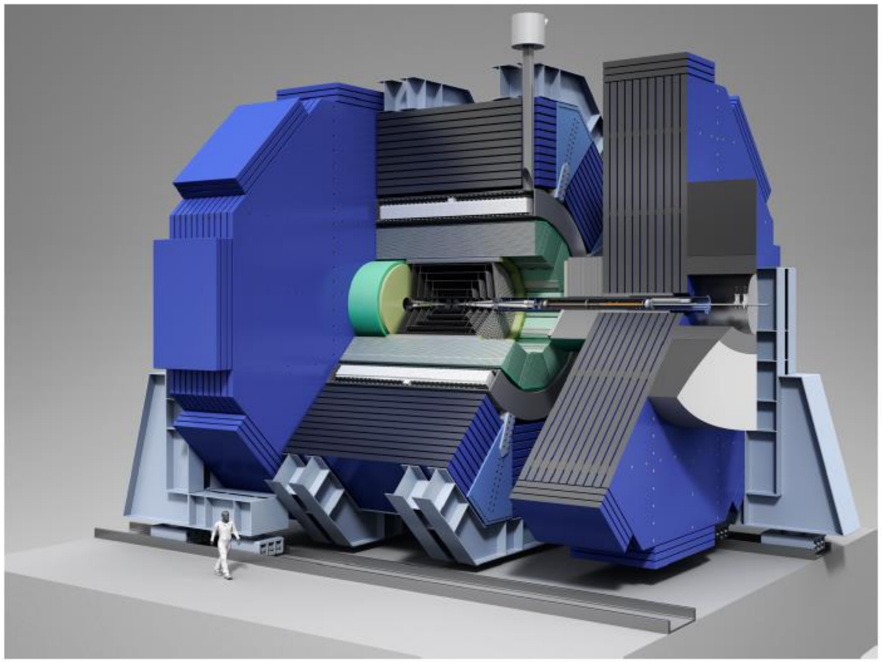
Self Shielded: Stray Fields & Radiation

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**



Detailed Baseline Document



SiD

DETAILED BASELINE DESIGN

DRAFT SUBMITTED TO THE PAC (REVISED)

10 DECEMBER 2012

Critical Issues for Electronic Engineering

Issues for Electrical Engineering (excluding sensors):

- Continue evolution of KPiX, including consideration of time structure of warm machines.
- Continue evolution of Beam Calorimeter readout chip.
- Support prototype work, including readout planes for gas detectors.
- Evaluate concepts for front end powering, e.g. DC-DC conversion.

Defer:

- Continued design of DAQ. Existing ATCA – RCE conceptual design is adequate, will profit by delay. This assumes uniform architectures of the front end systems (except for the vertex detector).
- Note that SiD will not have a hardware trigger. (A warm machine may need consideration of a trigger)

Engineering – Detector Subsystems

Beamline:

- Adequate conceptual design.
- Impedance issues that can generate wakefields and heating have been checked.
- Synchrotron radiation issues seem ok.
- Vacuum design seems ok.

Vertex Detector:

- Minimal conceptual design for modeling.
- Little ongoing work on support structures, power and cooling, which may make the modeling of multiple scattering and dead regions somewhat optimistic.

Tracker:

- Adequate conceptual design for modeling.
- Conceptual design for support mechanics.
- Need to understand Lorentz force issues from pulsed power and cable design.

EMCal:

- Adequate conceptual design for modeling. (But may not be optimized; CLIC work suggests 20 layers adequate for PFA)
- Mechanical prototyping of structure using relatively small tungsten sheets has stalled.
- First trials indicate some problems bump bonding KPiX. (Work active for beamtest)
- Need work on assembly strategy. Current estimate is extremely labor intensive. Robotics?

Engineering – Detector Subsystems

HCal:

- No settled conceptual design.
- Active efforts in PFA work.
- Critically need outer dimensions of barrel and endcap for solenoid and iron engineering.
- Radial cracks between modules are apparently accepted, documentation may be weak.
- The actual detector choice is secondary to the mechanical engineering issues as long as it fits in the allocated space.
- Cost may well be an issue.

Solenoid:

- In principle CMS approach is ok.
- Might be significant cost improvements with advanced conductor R&D.

Muon System:

- SiD has changed baseline to scintillator.
- Conceptual design probably stalled waiting iron segmentation design.
- Need conceptual design for SiPM readout.

BeamCal:

- Minor mechanical engineering issues.
- Needs sensor development!

Detector Strategic Work

Review and document:

- Radiation shielding properties of SiD.
- Magnetic field leakage
  - Identify any orientation issues for power transformers, motors, etc.

Seismic – Japan has very significant seismic activity. Understand interplay of platform, detector, and beamline. Japanese codes?

Detector Alignment procedures:

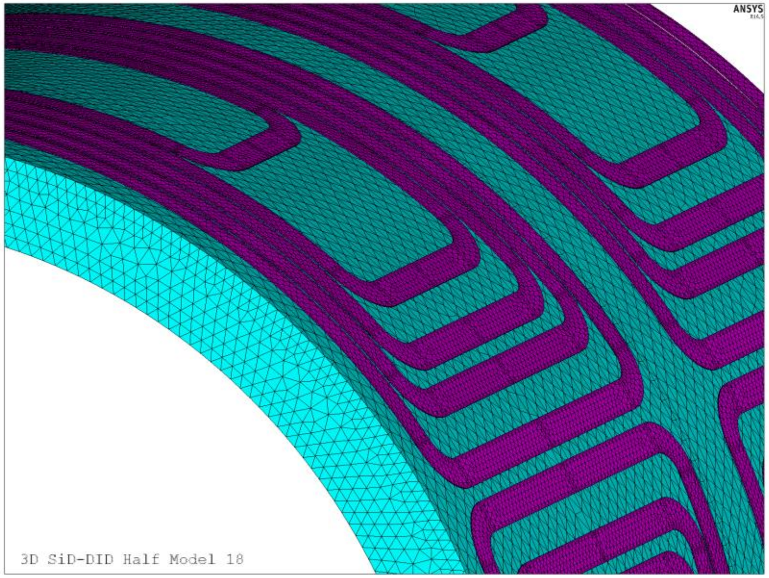
- How will initial assembly alignment be done?
- Conceptual design of FSI networks.

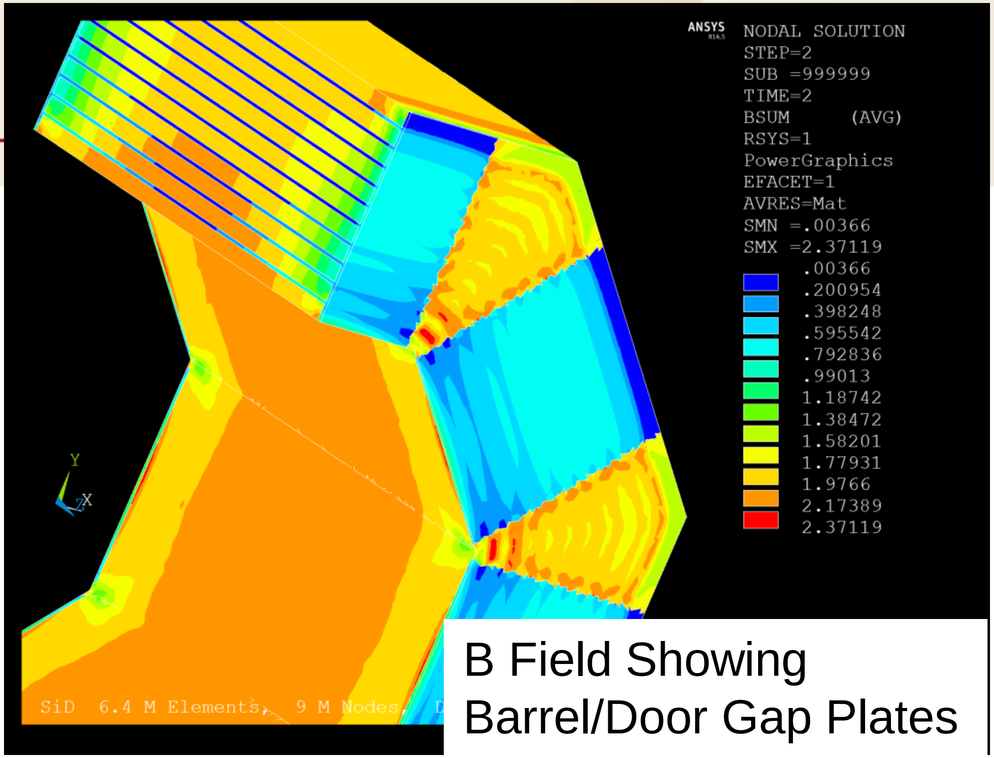
Internal detector services

- Space assignments for electronics, power conversion
- Preliminary cable routing

Develop better understanding of interfaces and Treaty points with ILC.

Solenoid (W. Craddock)





B Field Showing Barrel/Door Gap Plates

- **A PARAMETERIZED 3D MAGNETIC FIELD MODEL WAS CREATED THAT SHOULD BE SUFFICIENT FOR ENGINEERING DESIGN.**

- **FUTURE ANALYSIS :**

  A full 3D model for horizontal decentering forces.

  Transient analysis to predict DID quenching of solenoid.