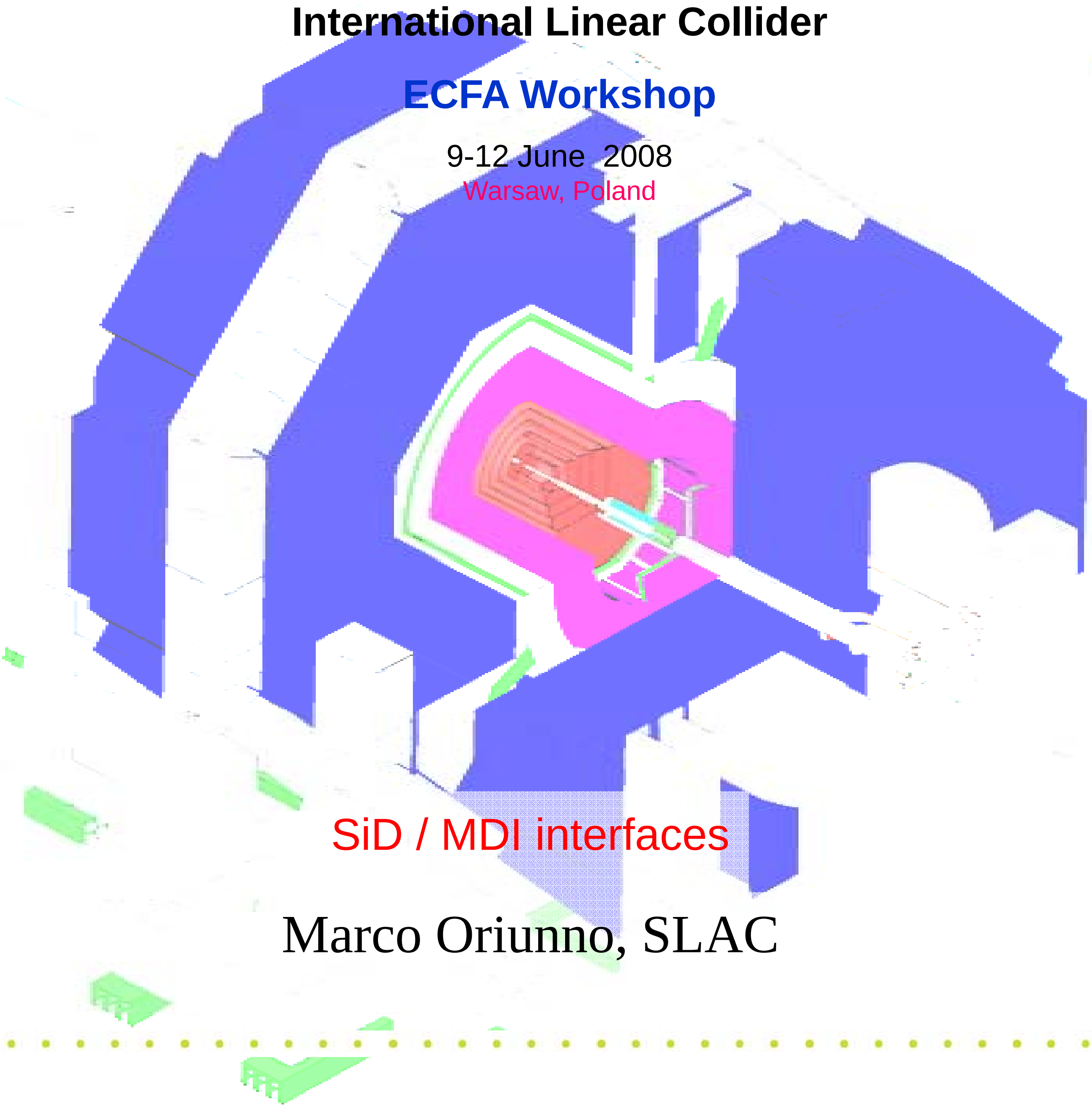
ECFA Study
Physics and Detectors for a Linear Collider

International Linear Collider

ECFA Workshop

9-12 June 2008
Warsaw, Poland



SiD / MDI interfaces

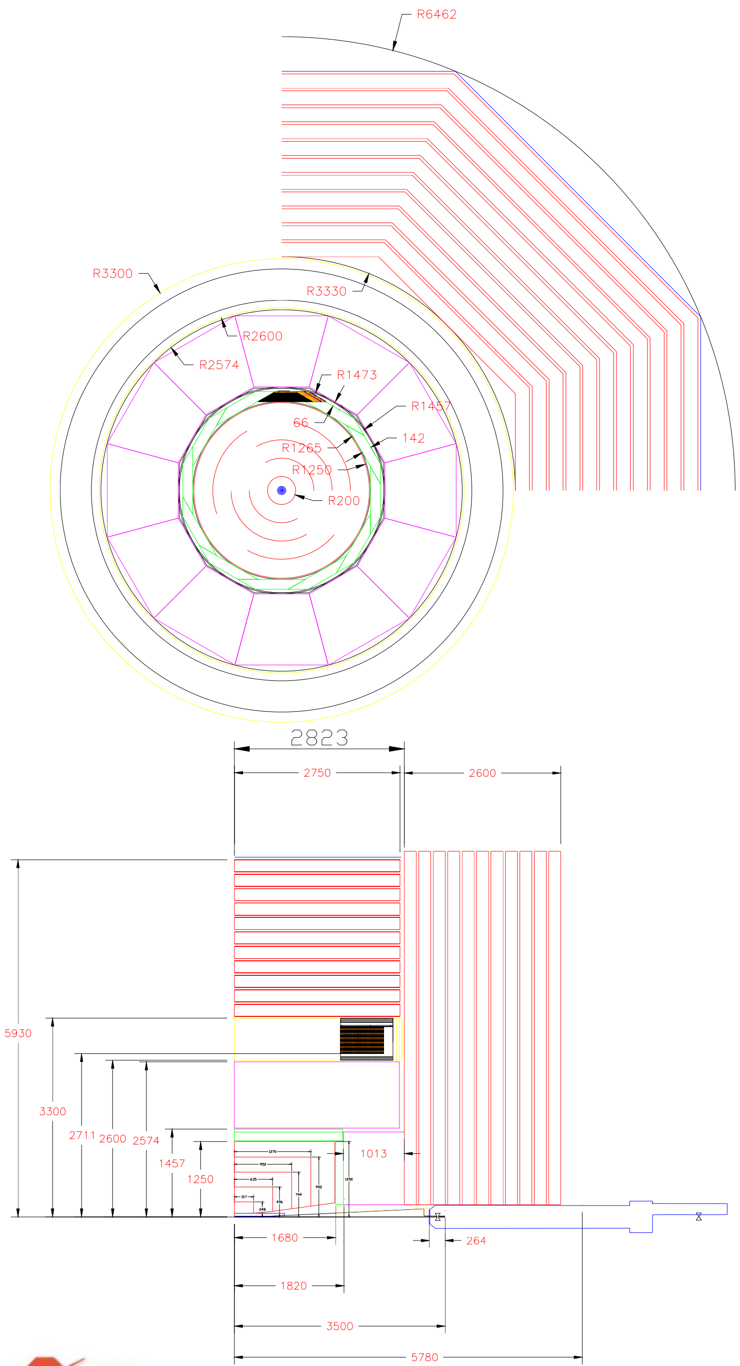
Marco Oriunno, SLAC

Acknowledgements

This work is the results of the meetings and discussions held in the context of the SiD engineering and MDI group over the last months :

K.Kremptz, B.Wands, B.Cooper	Fermilab
P.Burrows	Oxford University
N.Geffroy, Y.Kariotakis	LAPP Annecy
F.Feyzi	PSL Wisconsin
M.Breidenbach,T.Markiewicz, A.Seryi, T.Maruyama, J.Krebs, W.Craddock	SLAC

Parameters



R6462
R3300
R3330
R2600
R2574
R1473
R1457
66
142
R1265
R1250
R200
2823
2750
2600
5930
3300
2711
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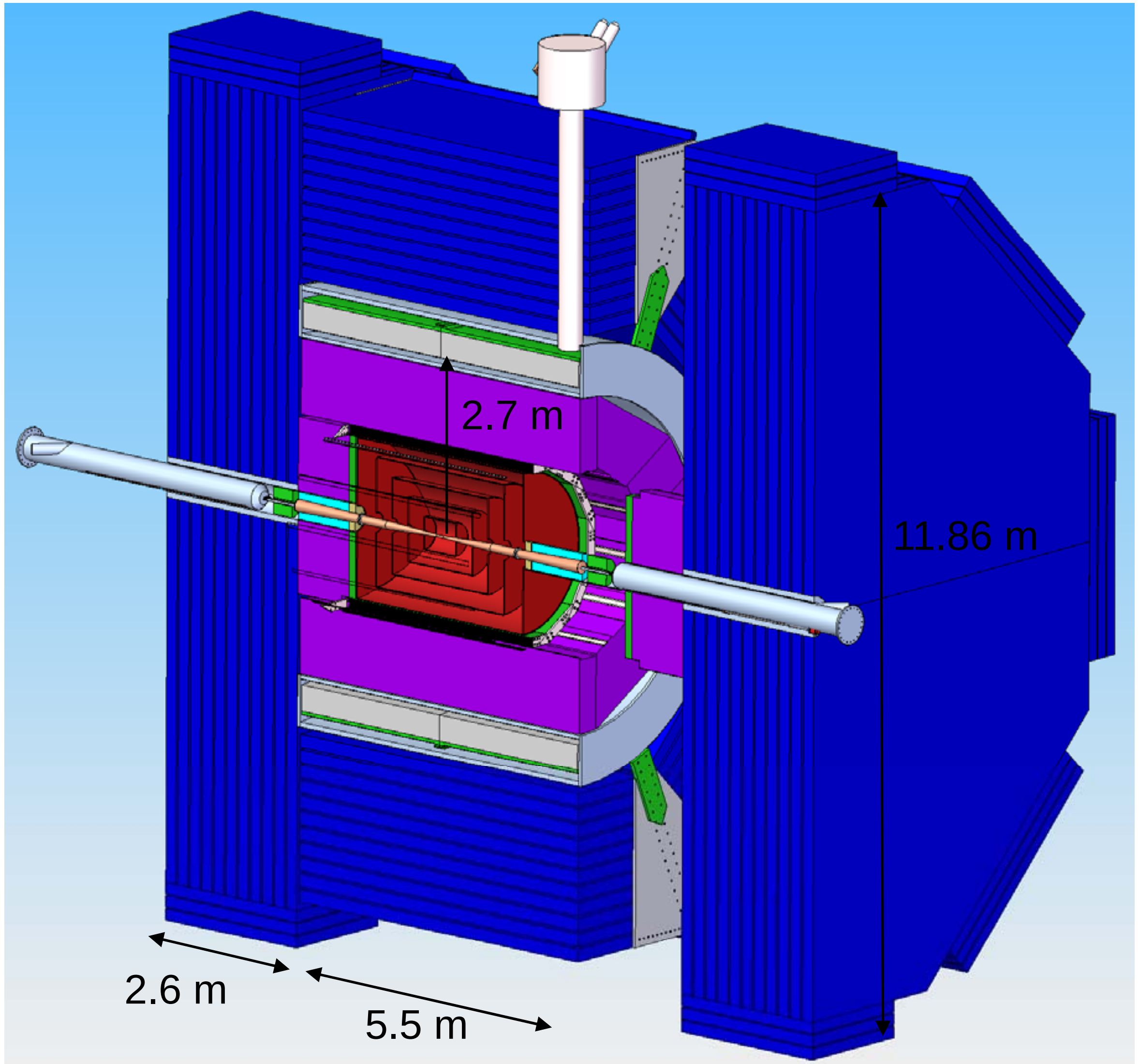
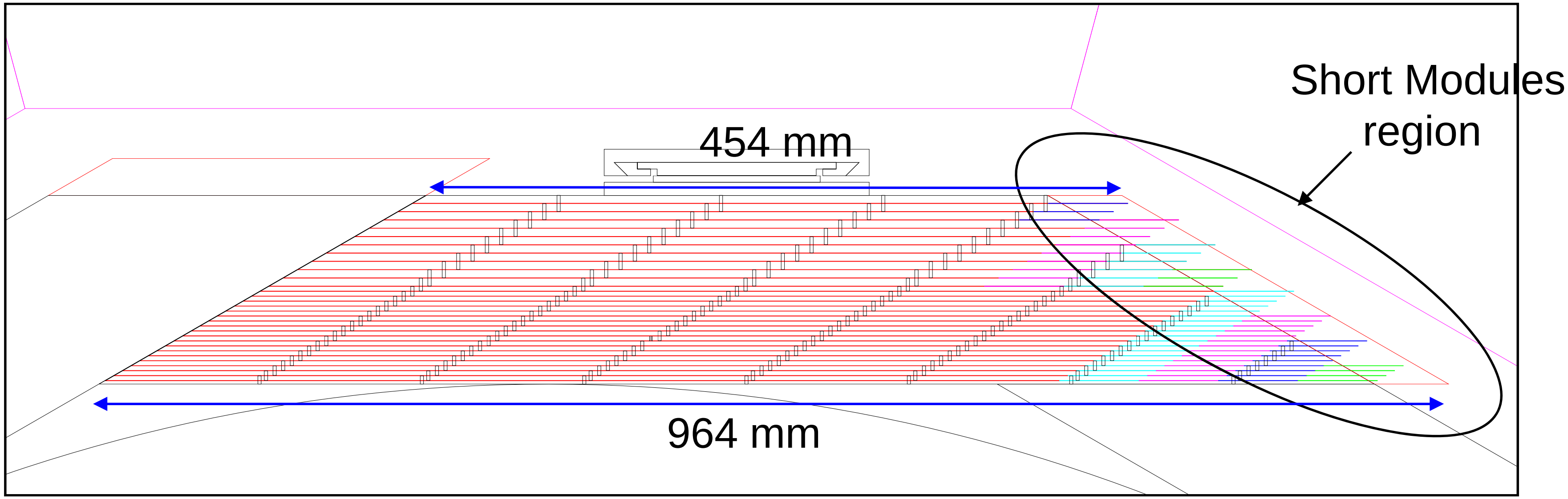
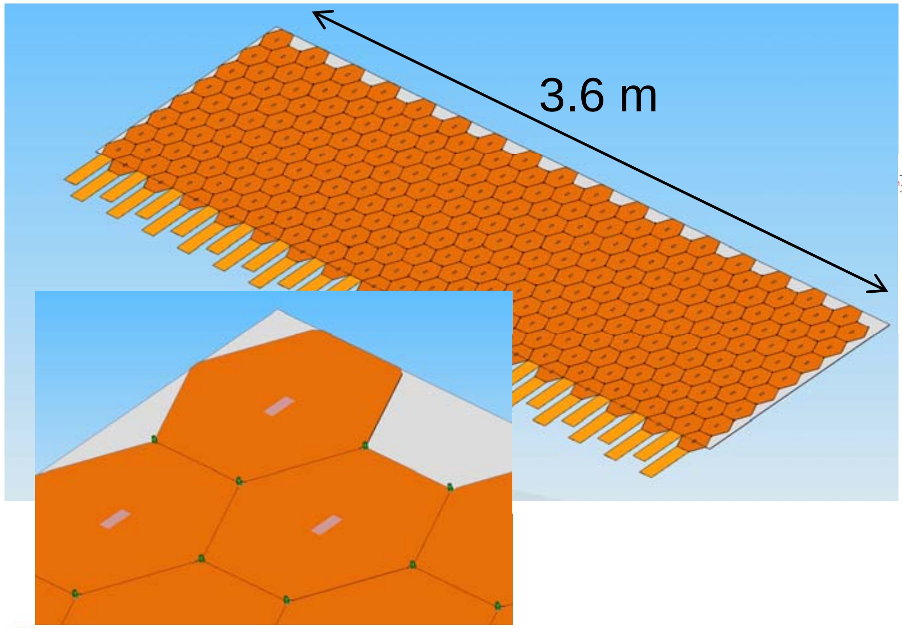
1013
1680
1820
3500
5780
264



2.7 m
11.86 m
2.6 m
5.5 m

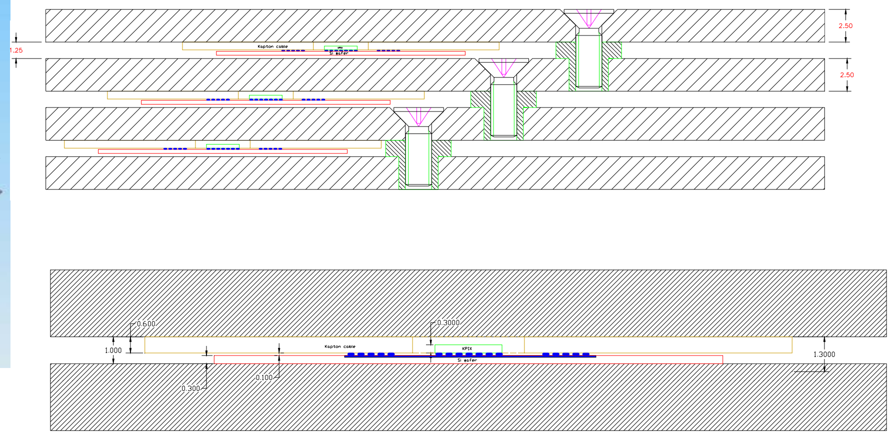
EMcal

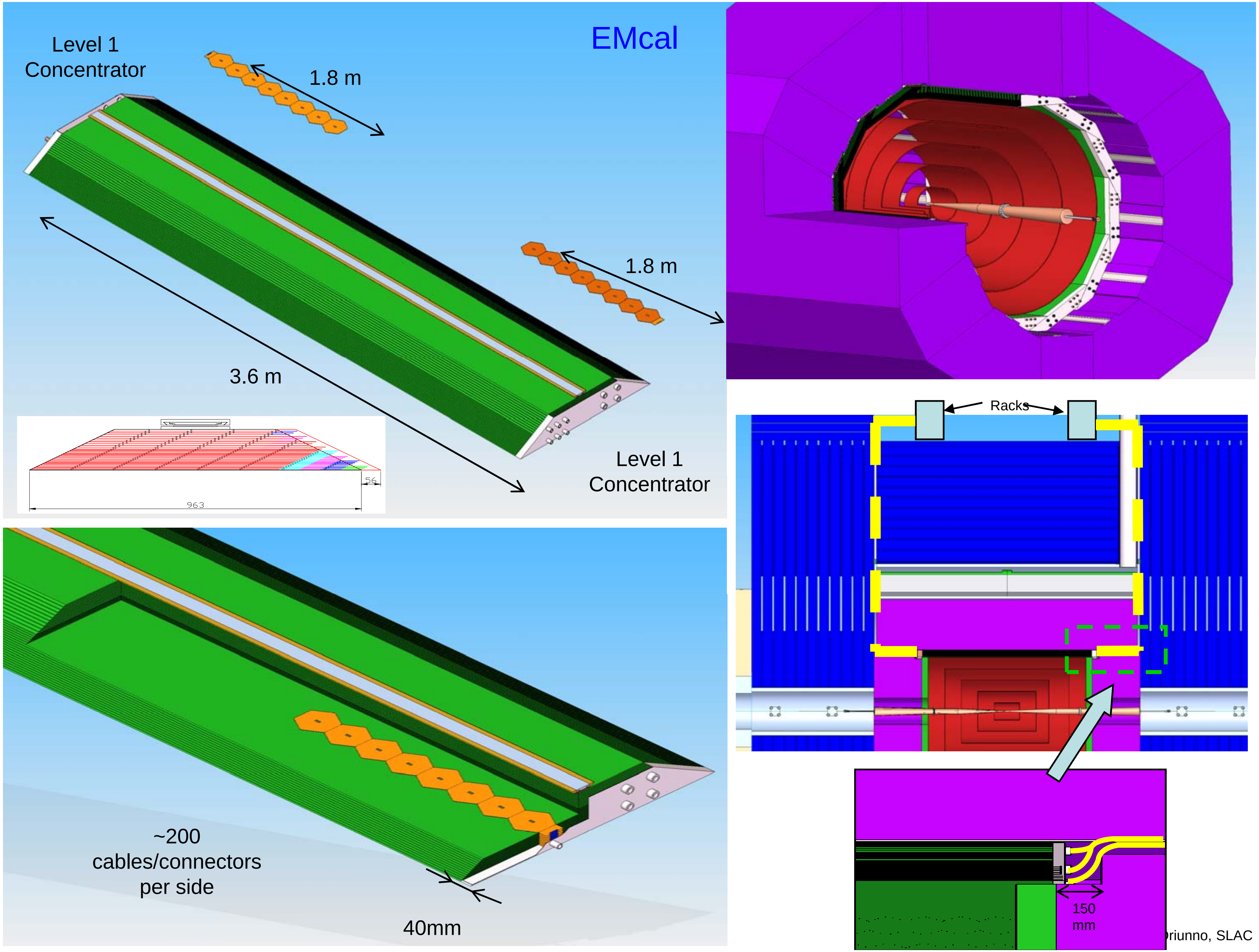




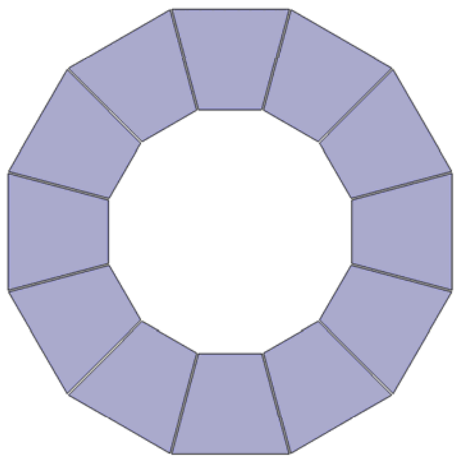
Staggered layout

Only 2 masks for the wafer and 8 for the kapton

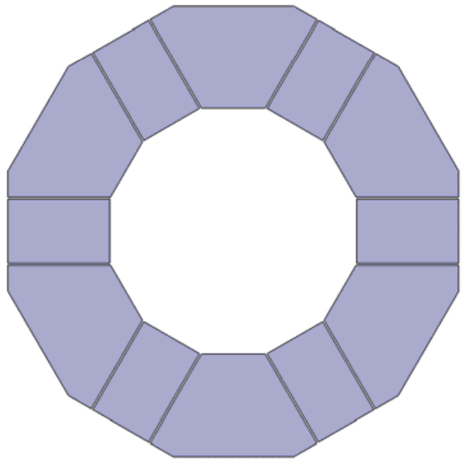



EMcal
Level 1
Concentrator
1.8 m
1.8 m
3.6 m
963
56
Level 1
Concentrator
~200
cables/connectors
per side
40mm
Racks
150
mm
riunno, SLAC

Hcal

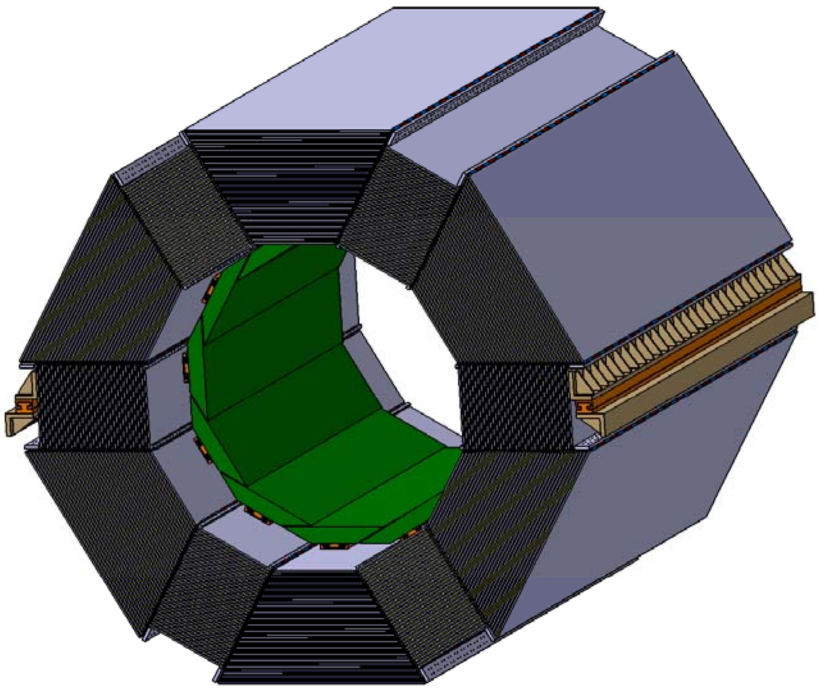


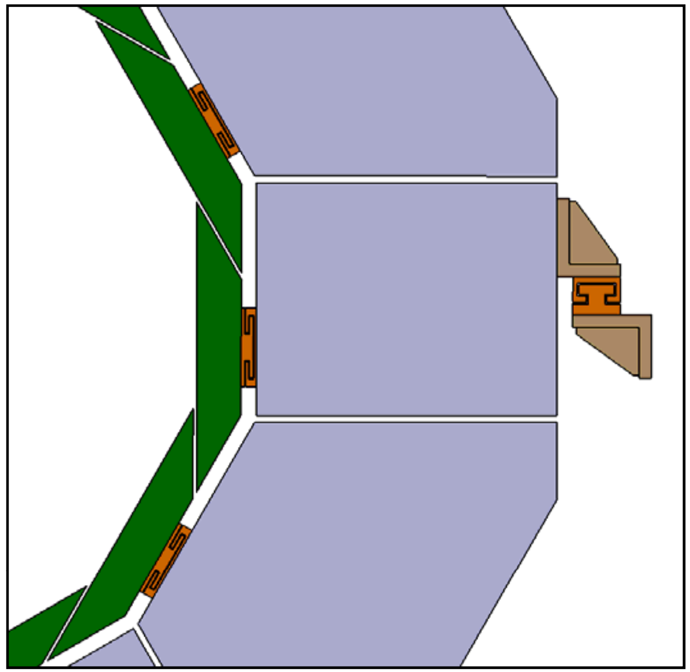
Projective



Tilted

- Plate thickness-20mm
- Gap thickness-8mm
- No point cracks to IP
- Detector are removable from gap
- Absorber Material Brass (Cu-90%,Zn-10%)



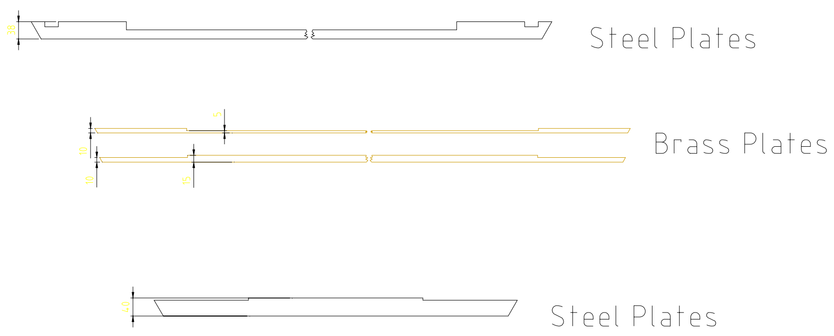


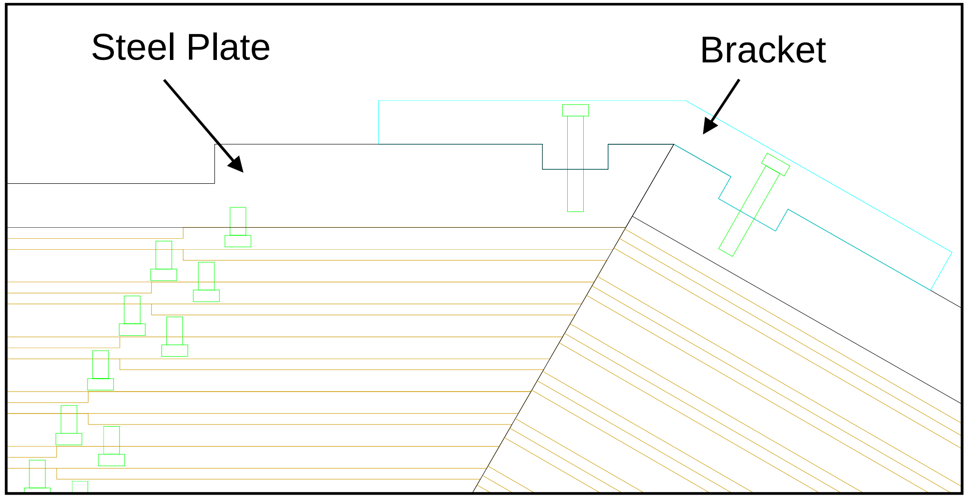
The whole system (Hcal & Ecal) slides inside the vacuum thanks to rails

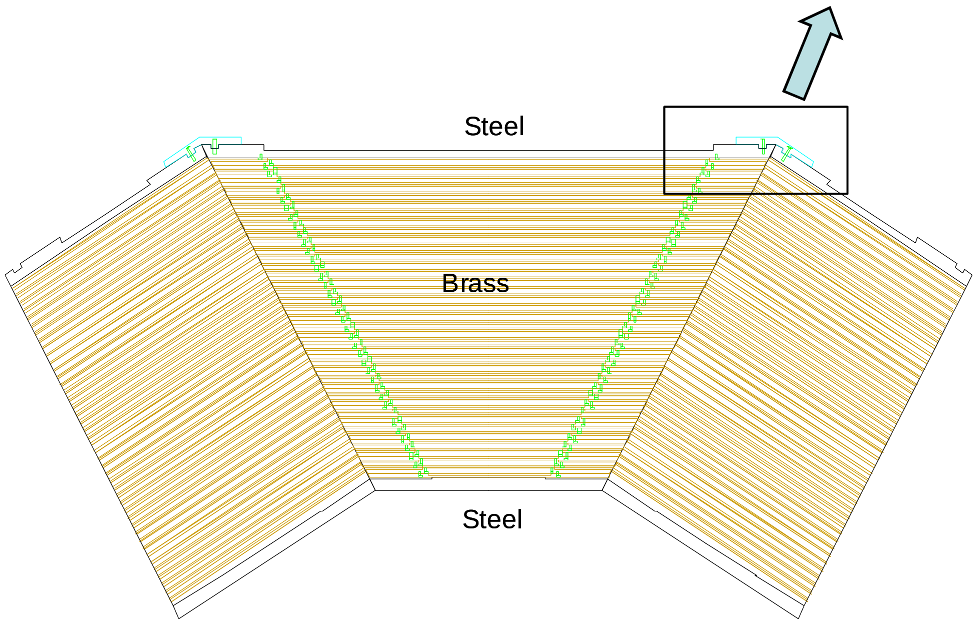
Hcal

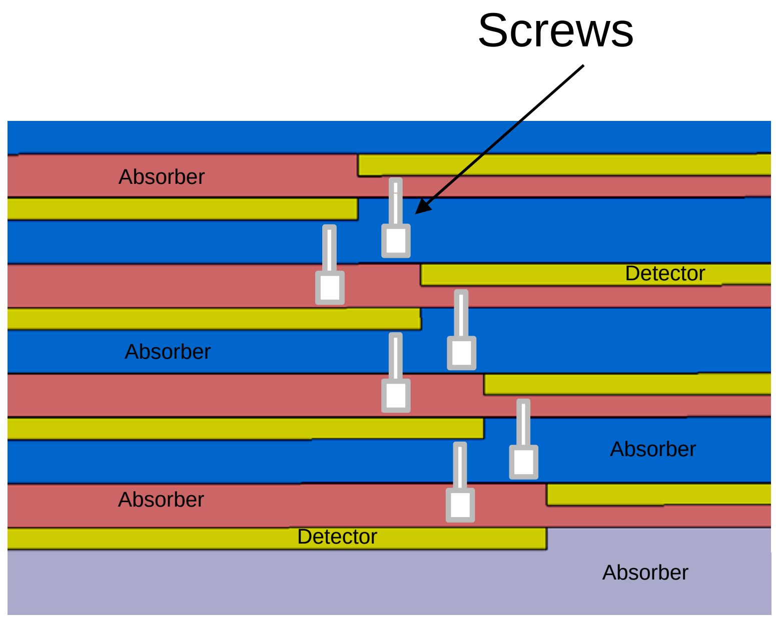
Sandwich assembly :

Brass plates with steel plates at the inner and outer radii

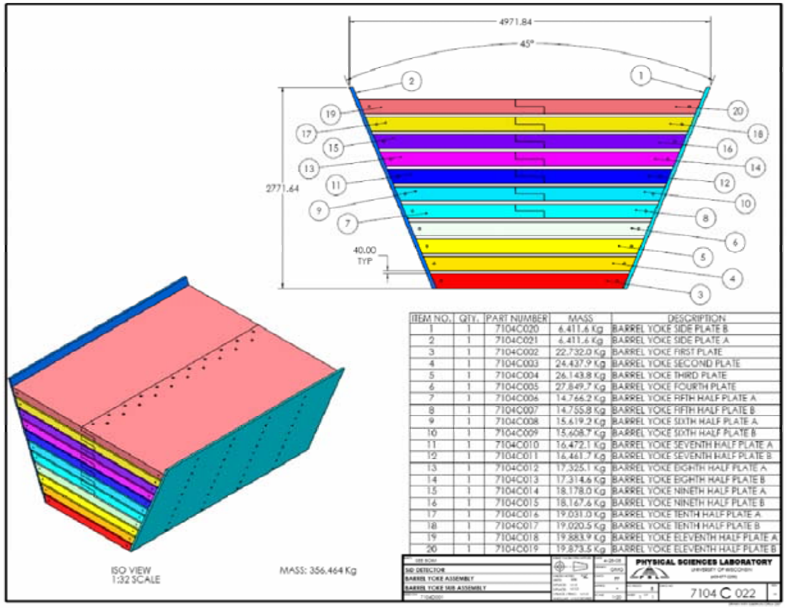








Iron Barrel Yoke layout



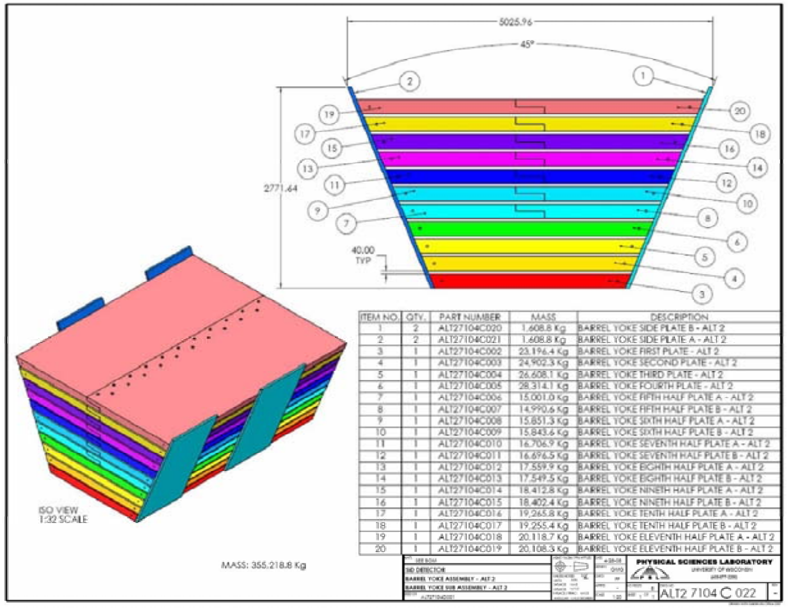
ITEM NO.	QTY.	PART NUMBER	MASS	DESCRIPTION
1	1	7104C020	6,411.6 Kg	BARREL YOKE SIDE PLATE B
2	1	7104C021	6,411.6 Kg	BARREL YOKE SIDE PLATE A
3	1	7104C002	22,732.0 Kg	BARREL YOKE FIRST PLATE
4	1	7104C003	24,437.9 Kg	BARREL YOKE SECOND PLATE
5	1	7104C004	26,143.8 Kg	BARREL YOKE THIRD PLATE
6	1	7104C005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

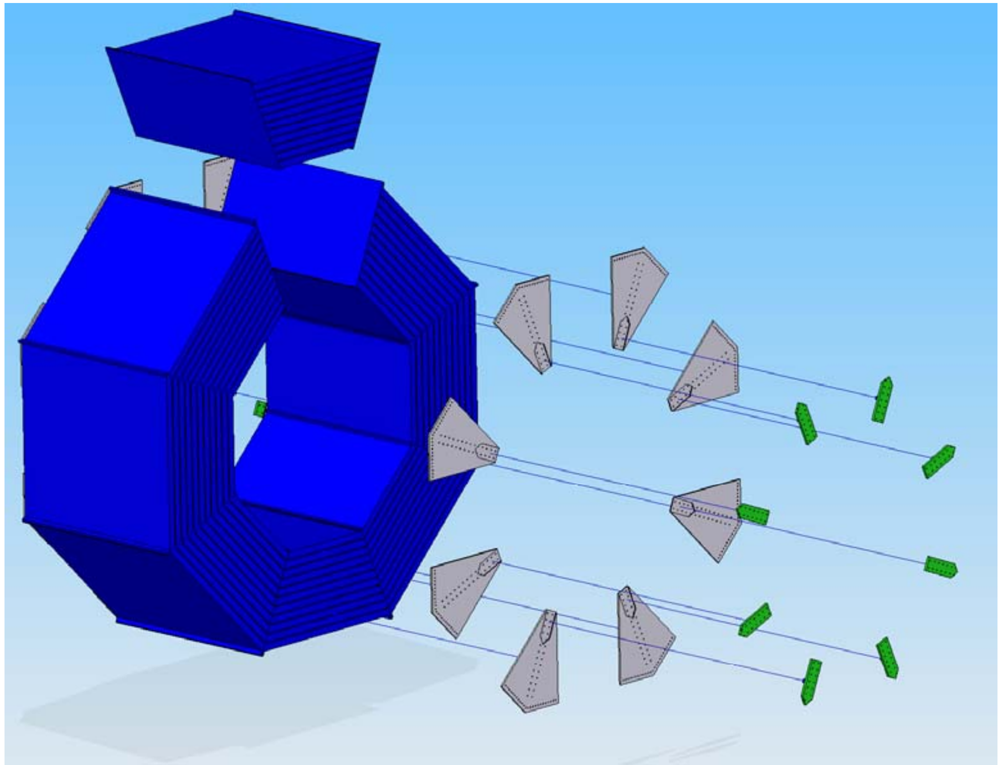
Opportunity to make blank assembly at the factory before shipping

Preliminary Contacts with Kawasaki Heavy Industries

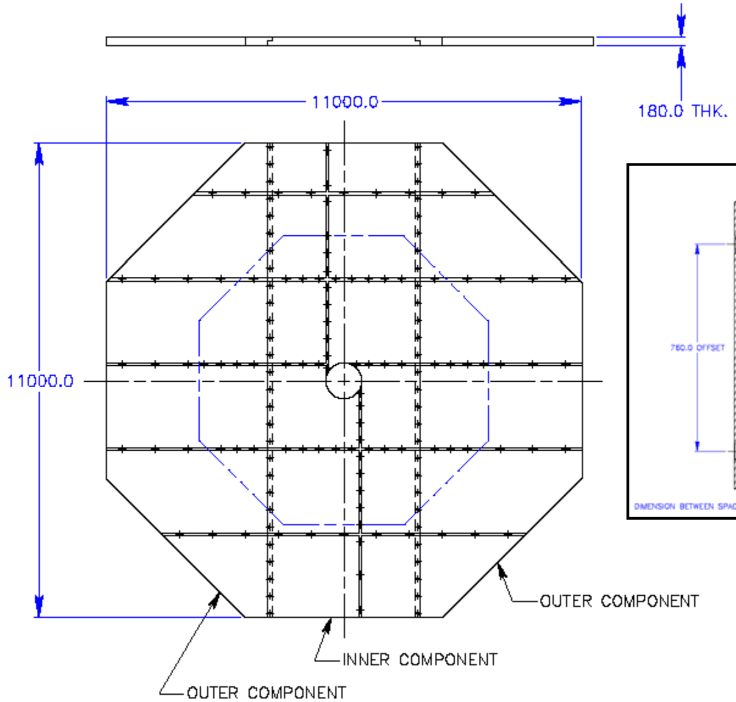
- Plate thickness tolerance for each: 0.1mm
- Plate flatness: 4mm (in a plate)
- Fabrication (assembling & welding) tolerance: 2mm
- Full trial assembly: capable (but need to study)

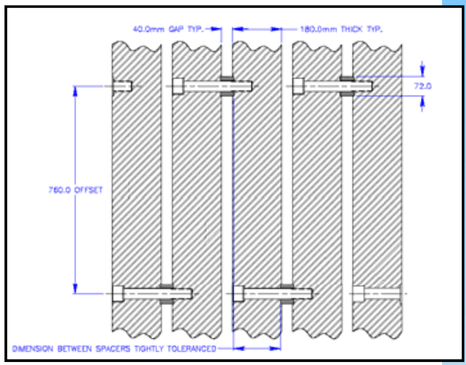


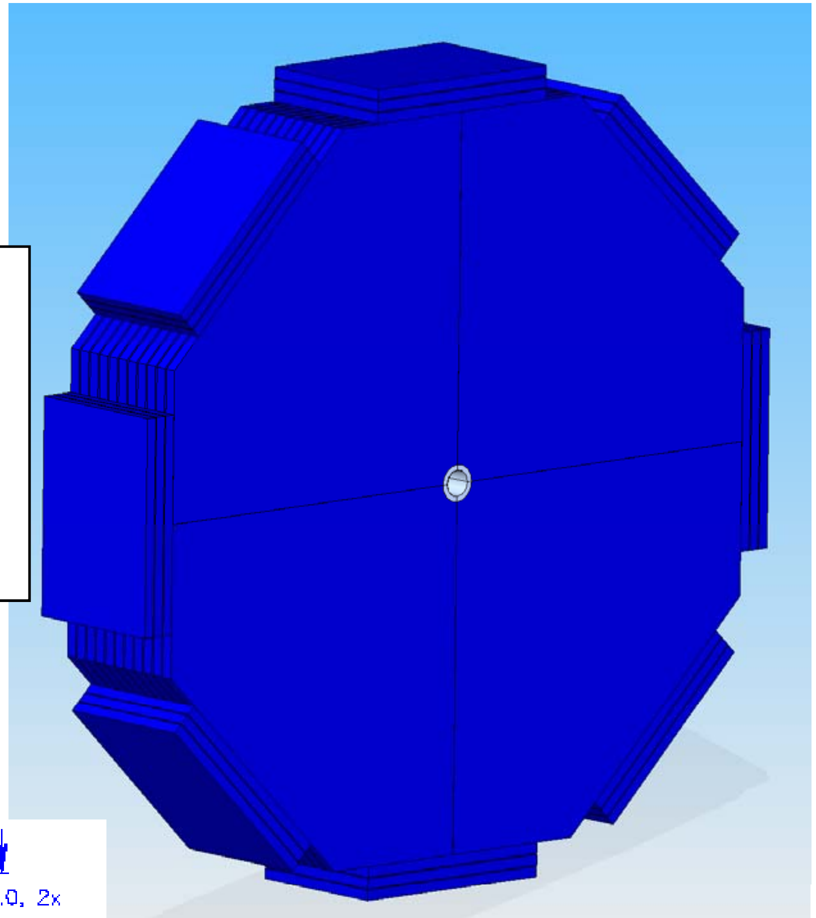
ITEM NO.	QTY.	PART NUMBER	MASS	DESCRIPTION
1	2	ALT27104C020	1,608.8 Kg	BARREL YOKE SIDE PLATE B - ALT 2
2	2	ALT27104C021	1,608.8 Kg	BARREL YOKE SIDE PLATE A - ALT 2
3	1	ALT27104C002	23,196.4 Kg	BARREL YOKE FIRST PLATE - ALT 2
4	1	ALT27104C003	24,902.3 Kg	BARREL YOKE SECOND PLATE - ALT 2
5	1	ALT27104C004	26,608.1 Kg	BARREL YOKE THIRD PLATE - ALT 2
6	1	ALT27104C005	28,314.1 Kg	BARREL YOKE FOURTH PLATE - ALT 2
7	1	ALT27104C006	15,001.0 Kg	BARREL YOKE FIFTH HALF PLATE A - ALT 2
8	1	ALT27104C007	14,990.6 Kg	BARREL YOKE FIFTH HALF PLATE B - ALT 2
9	1	ALT27104C008	15,851.3 Kg	BARREL YOKE SIXTH HALF PLATE A - ALT 2
10	1	ALT27104C009	15,843.6 Kg	BARREL YOKE SIXTH HALF PLATE B - ALT 2
11	1	ALT27104C010	16,706.9 Kg	BARREL YOKE SEVENTH HALF PLATE A - ALT 2
12	1	ALT27104C011	16,696.5 Kg	BARREL YOKE SEVENTH HALF PLATE B - ALT 2
13	1	ALT27104C012	17,559.9 Kg	BARREL YOKE EIGHTH HALF PLATE A - ALT 2
14	1	ALT27104C013	17,549.5 Kg	BARREL YOKE EIGHTH HALF PLATE B - ALT 2
15	1	ALT27104C014	18,412.8 Kg	BARREL YOKE NINETH HALF PLATE A - ALT 2
16	1	ALT27104C015	18,402.4 Kg	BARREL YOKE NINETH HALF PLATE B - ALT 2
17	1	ALT27104C016	19,265.8 Kg	BARREL YOKE TENTH HALF PLATE A - ALT 2
18	1	ALT27104C017	19,255.4 Kg	BARREL YOKE TENTH HALF PLATE B - ALT 2
19	1	ALT27104C018	20,118.7 Kg	BARREL YOKE ELEVENTH HALF PLATE A - ALT 2
20	1	ALT27104C019	20,108.3 Kg	BARREL YOKE ELEVENTH HALF PLATE B - ALT 2

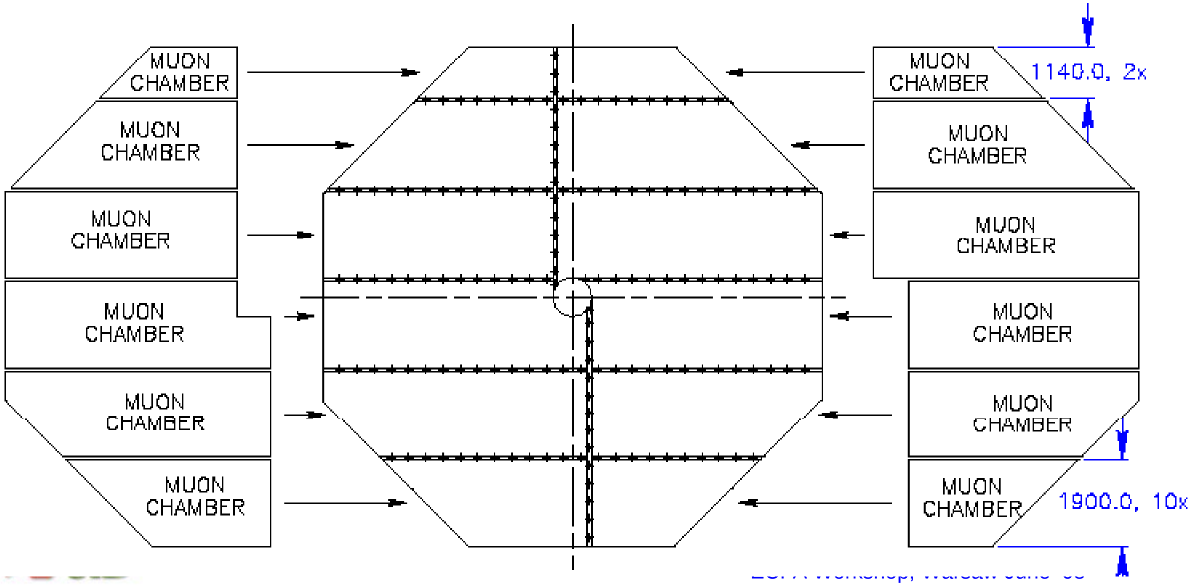


Iron Door Yoke, Bolted assembly, no vertical split

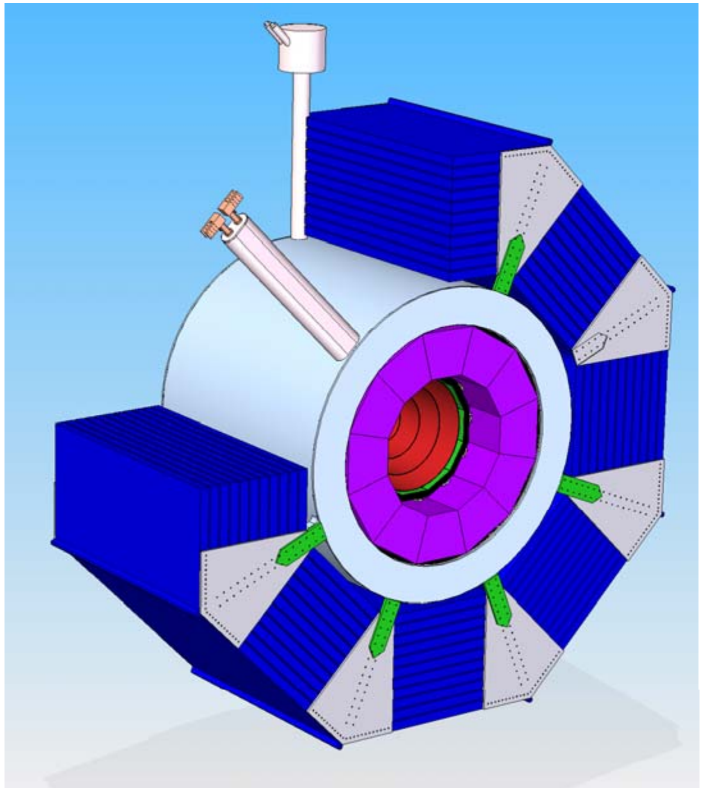








- Uses continuous cast steel plates rolled to 200 mm thickness
- 40mm gaps for muon identification chambers
- Plate-to-plate spacers are staggered for better muon identification coverage
- Bolted construction
- 100mm thick inner support cylinder



5T Solenoid

The solenoid is done by two coil modules of 6 layers each. The winding if self supporting with an outer quench-back cylinder

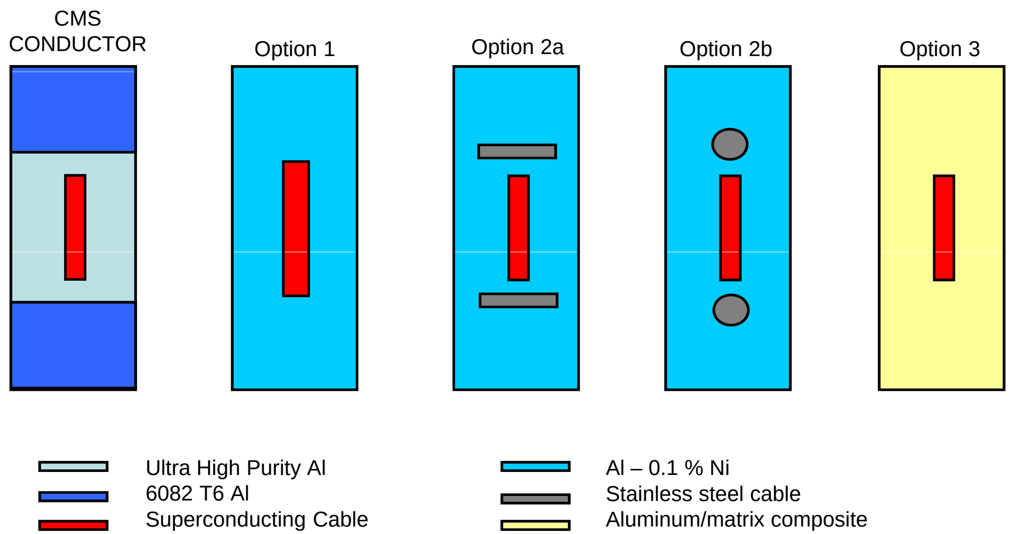
Two separate chimneys are required

1. OD360mm for Cryogenic piping
2. 700 mm x 400mm for current leads

Results based on preliminary calculations and extrapolation from the CMS solenoid

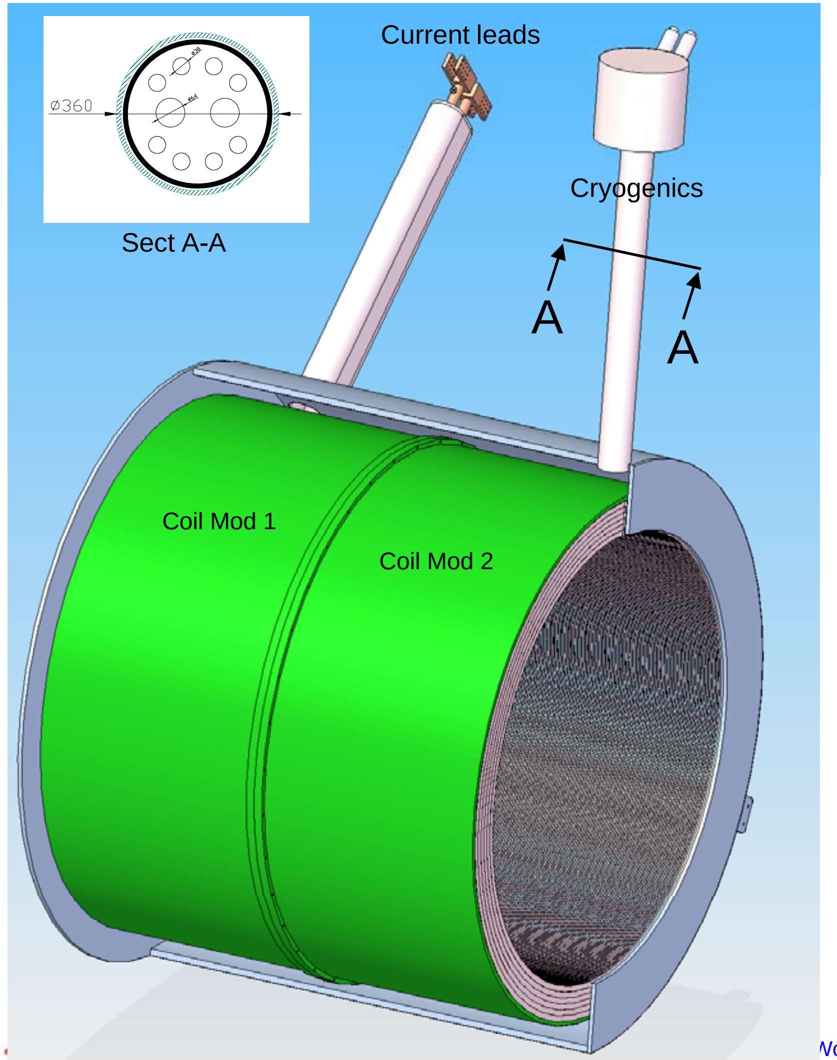
	SiD	CMS	Units
B^2R Coil	73.68	53.28	T^2m
B Field	5.00	4.00	T
R Min Sol	2.60	2.97	m
R Min Coil	2.75	3.18	m
Z max Coil	± 2.89	± 6.2	m
Z max Sol	± 3.19	± 6.5	m
DR Coil	0.40	0.308	m
R Max Coil	3.15	3.49	m
R Max Sol	3.44	3.78	m
R_{avg} Coil Package	2.95	3.33	m
Stored Energy	1'570	2'690	MJ
Number of layers	6	4	
Current	19	19	kA
Current Density		12.68	A/mm^2
Total turns	1464	2168	
Inductance	12.9	14.15	H
Total Mass	125	220	t

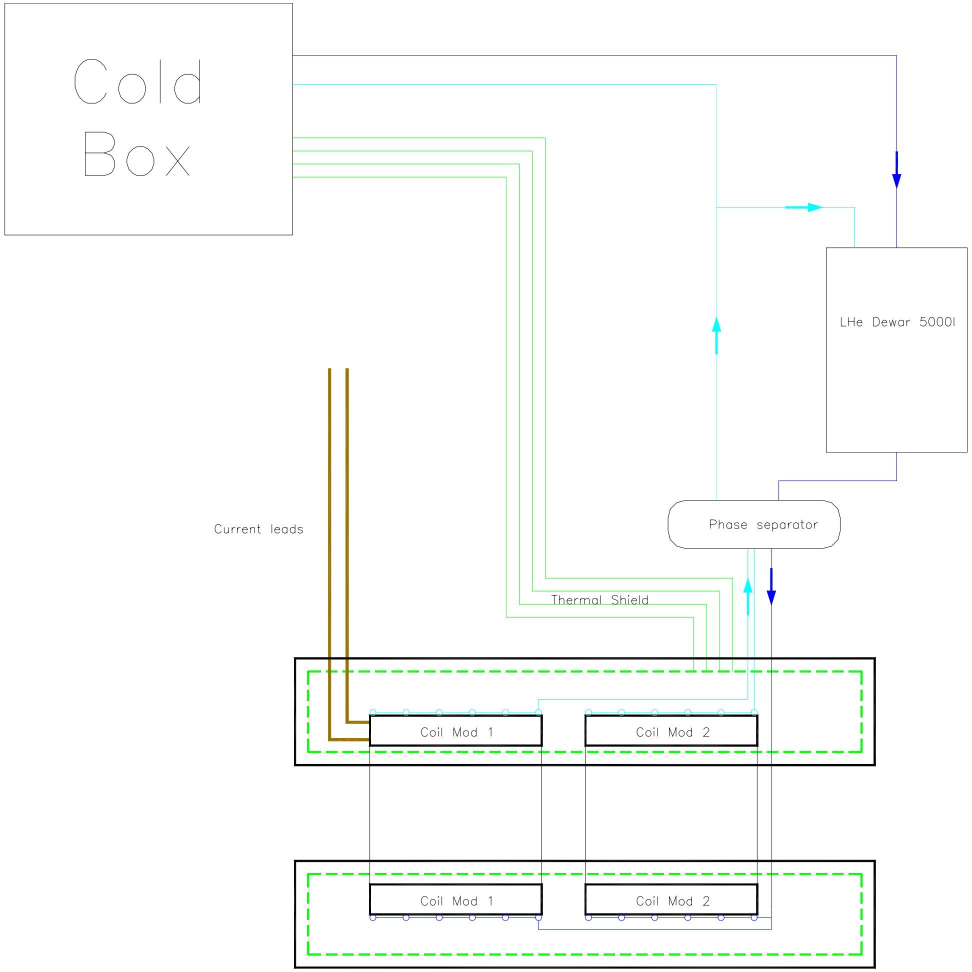
Possible SiD Conductor Options



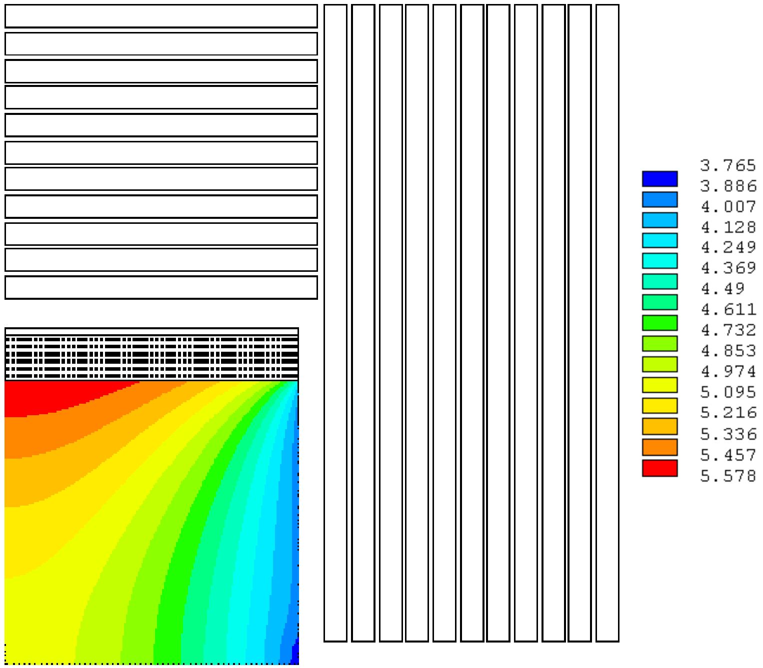
Solenoid Cryogenic

Cold mass kept cold by indirect method with a Thermosyphon circuit integrated in the quench-back cylinder

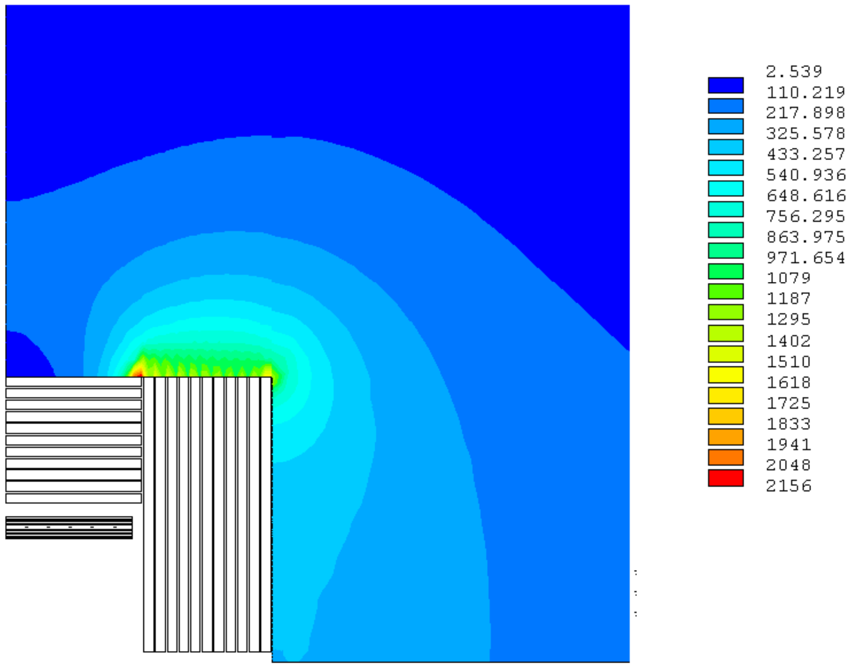


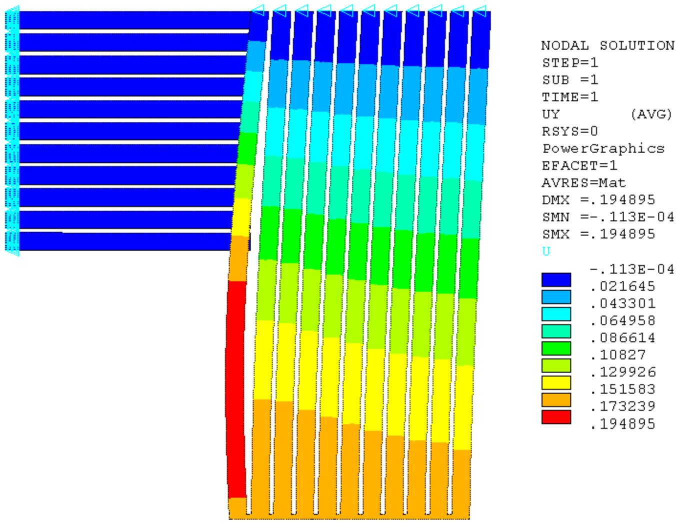


B Modulus Field

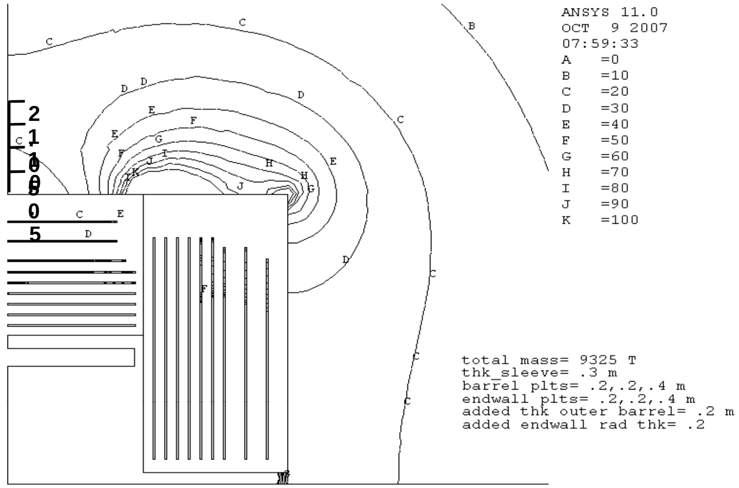


Fringe Field (Baseline)





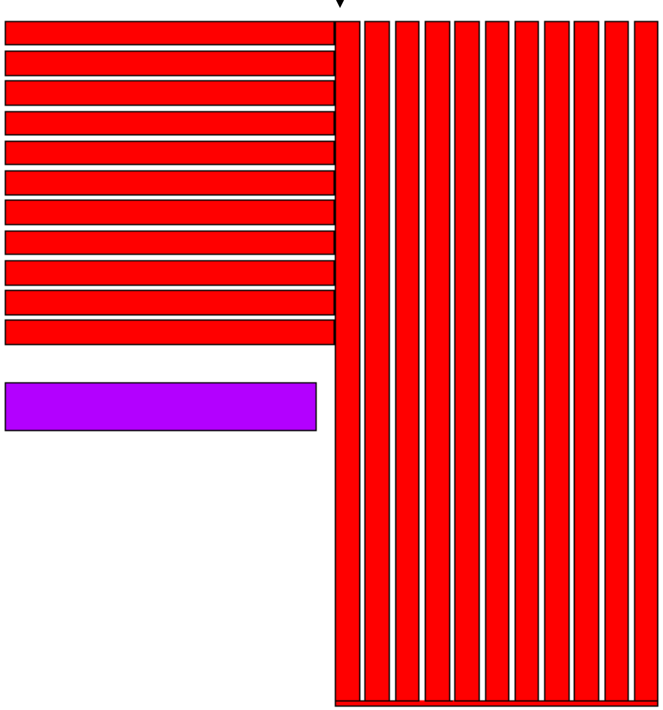
Fringe Filed Improved

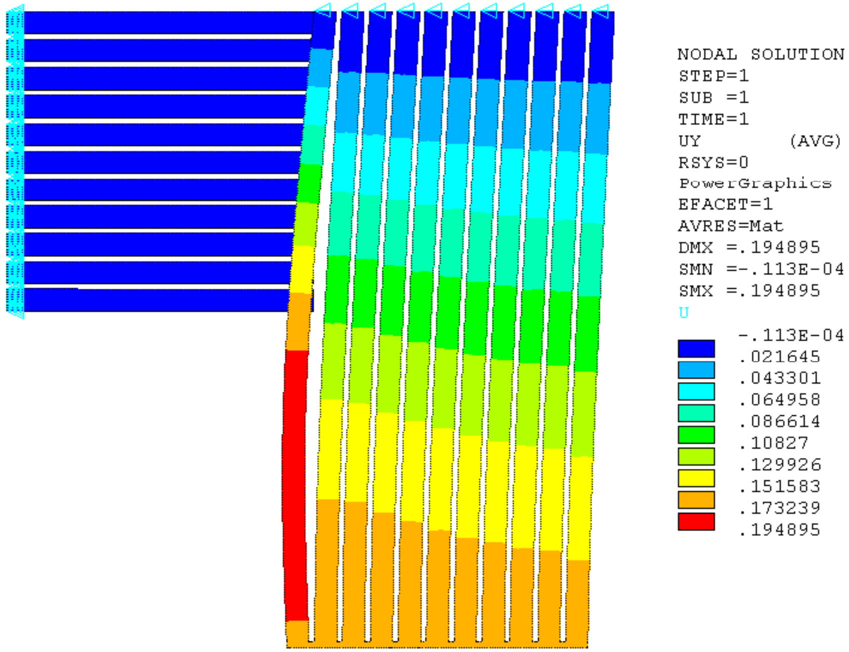


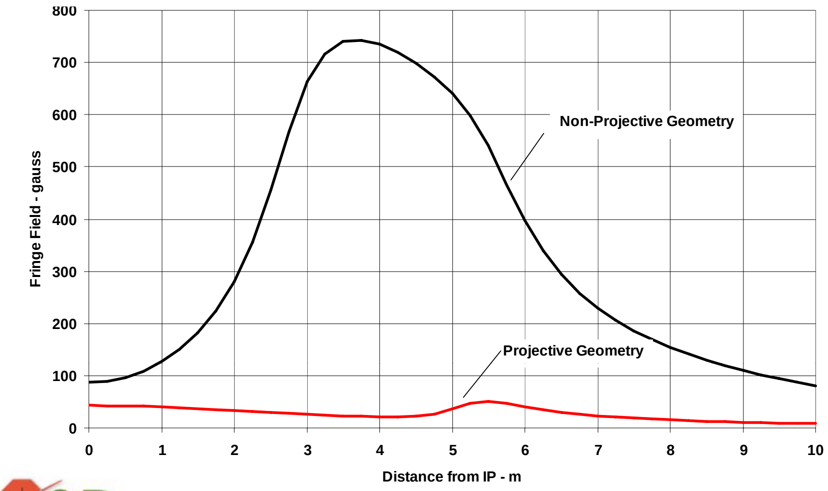
Magnetic Field

clearance is 1 cm

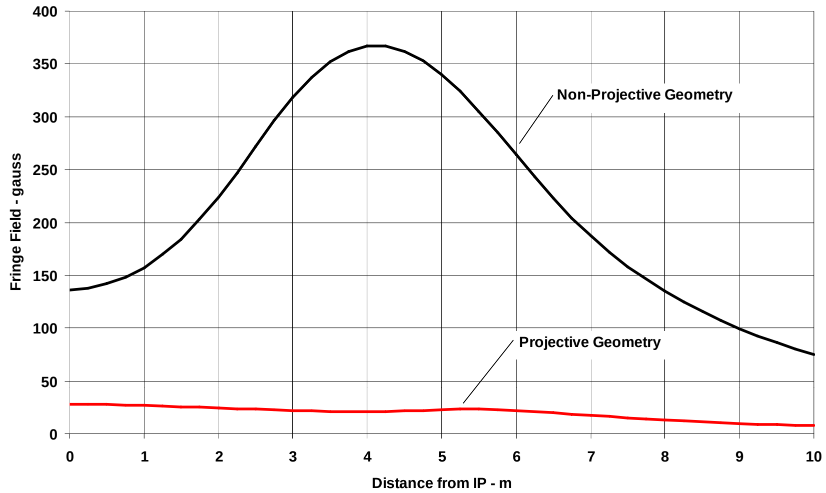
plates are 20 cm; gaps are 5 cm





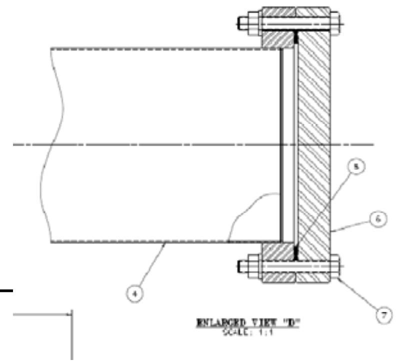


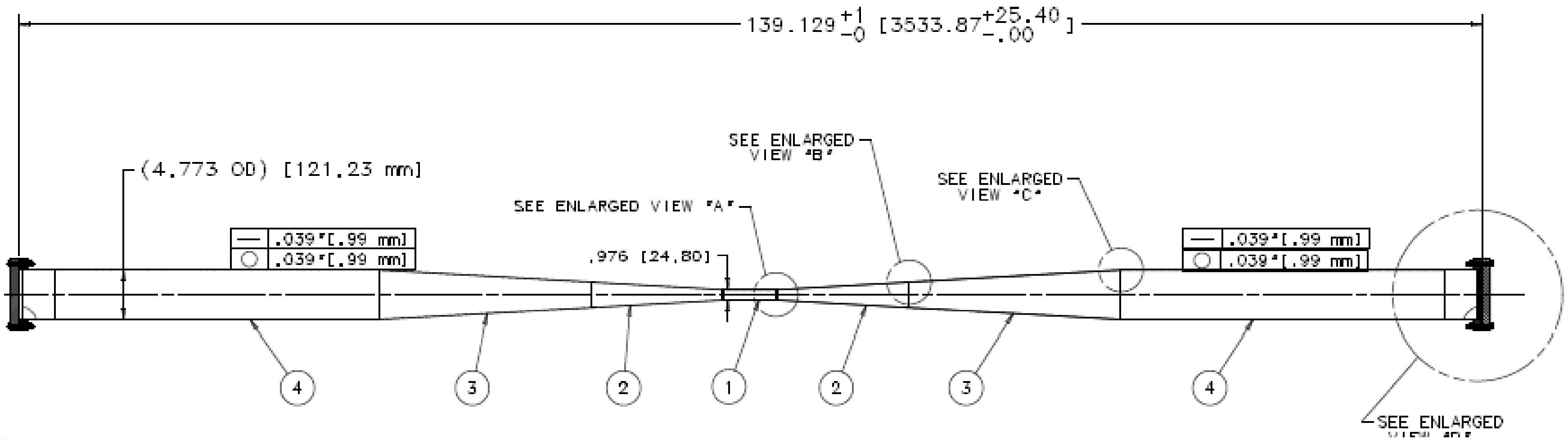
Fringe Fields at R = 7.5 m (~1.5 m outside barrel)



Beam Pipe Fabrication

- Stainless steel beyond Z = 759 mm.
  - That allows more standard welding and fabrication techniques.
  - Beryllium to stainless transitions should be done by the fabricator of beryllium portions, but the stainless steel portions could be made by a different vendor
- Brush-Wellman visit: Be up to flange at LUMICAL
- CMS-like foldable ion pumps behind LUMICAL if needed
  - Expected that MDI group relaxes vacuum spec at IP





The interface document or EPAC08 Paper

to be Improved by Warsaw then Chicago LCWS

CHALLENGES AND CONCEPTS FOR DESIGN OF AN INTERACTION REGION WITH PUSH-PULL ARRANGEMENT OF DETECTORS – AN INTERFACE DOCUMENT*

B.Parker (BNL), A.Herve, J.Osborne (CERN), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY), B.Ashmanskas, V.Kuchler, N.Mokhov (Fermilab), A.Enomoto, Y.Sugimoto, T.Tauchi, K.Tsuchiya (KEK), J.Weisend (NSF), P.Burrows (Oxford Univ.), T.Markiewicz, M.Oriunno, A.Seryi, M.Sullivan (SLAC), D.Angal-Kalinin (STFC), T.Sanuki, H.Yamamoto (Tohoku Univ.)

Abstract

Two experimental detectors working in a push-pull mode has been considered for the Interaction Region of the International Linear Collider [1]. The push-pull mode of operation sets specific requirements and challenges for many systems of detector and machine, in particular for the IR magnets, for the cryogenics system, for alignment system, for beamline shielding, for detector design and overall integration, and so on. These challenges and the identified conceptual solutions discussed in the paper intend to form a draft of the Interface Document which will be developed further in the nearest future. The authors of the present paper include the organizers and conveners of working groups of the workshop on engineering design of interaction region IRENG07 [2], the leaders of the IR Integration within Global Design Effort Beam Delivery System, and will also include representatives from each detector concept submitting the Letters Of Intent.

INTRODUCTION

The process of finding an acceptable technical solution for Interaction Region involves searching a balance between complex and often contradictory requirements coming from machine or detector. An Interface Document was thought as a way to keep track of the achieved agreements and assumption, and also as the way to highlight existing contradictions and focus the efforts for their resolution. The latter imposes the present Interface Document to be an evolving entity. The first attempt of creation of the Interface Document was undertaken at the IRENG07 workshop. The paper presented represents the next draft, which will be further developed as an integral part of LOI preparation.

FUNCTIONAL REQUREMENTS

In this section, the minimal functional requirements, to which all detector concepts are bound, are summarized. These requirements are closely related to fundamental properties of design and less dependent on site location and similar specifics. In contrast, the next section will describe more detailed specification and outline the present working models and likely technical solutions.

The list of minimal functional requirement starts with the need to have two detectors in a single collider hall, able to work in turns, in push-pull mode.

The speed of push-pull operation is the first defining assumption. We set as the goal that hardware design should allow the moving operation, reconnections and possible rearrangements of shielding to be performed in a few days, or less than a week.

The range of detector sizes considered in the design include detectors with half size of 6-7 meters, performing optimally if the IP to start of QD0 quadrupole (L* parameter) would be in the range of 3.5-4.5 meters (different L* is allowed for different detectors), while the distance from IP to the second quadrupole QF1 is 9.5 meters, which drives many parameters of the design, including the hall width.

The off-beamline detector is shifted in transverse direction to a garage position, located 15m from the IP. The radiation and magnetic environment, suitable for people access to the off-beamline detector during beam collision, are to be guaranteed by the beamline detector using their chosen solution.

The IR and detector design is to satisfy the beam parameters defined in the RDR [1] including nominal, Low N, Large Y and Low P parameter sets.

INTERFACE SPECIFICATIONS

The superconducting final doublets, consisting from QD0 and QF1 quadrupoles (and associated sextupoles SD0 and SF1) are grouped into two independent cryostats, with QD0 cryostat penetrating almost entirely into the detector. The QD0 cryostat is specific for the detector design and moves together with detector during push-pull operation, while the QF1 cryostat is common and rests in the tunnel.

Radiation shielding is essential with two detectors occupying the same Interaction Region hall. Detector should either be self-shielded or need to assume responsibility for additional local fixed or movable shielding (walls) to provide area accessible for people near the second detector when the first is running with beam. The radiation criteria to be satisfied are for normal operation and for accident case. In the normal operation, the dose anywhere near non-operational second detector

*Work supported in part by US DOE contract DE-AC02-76-SF00515.

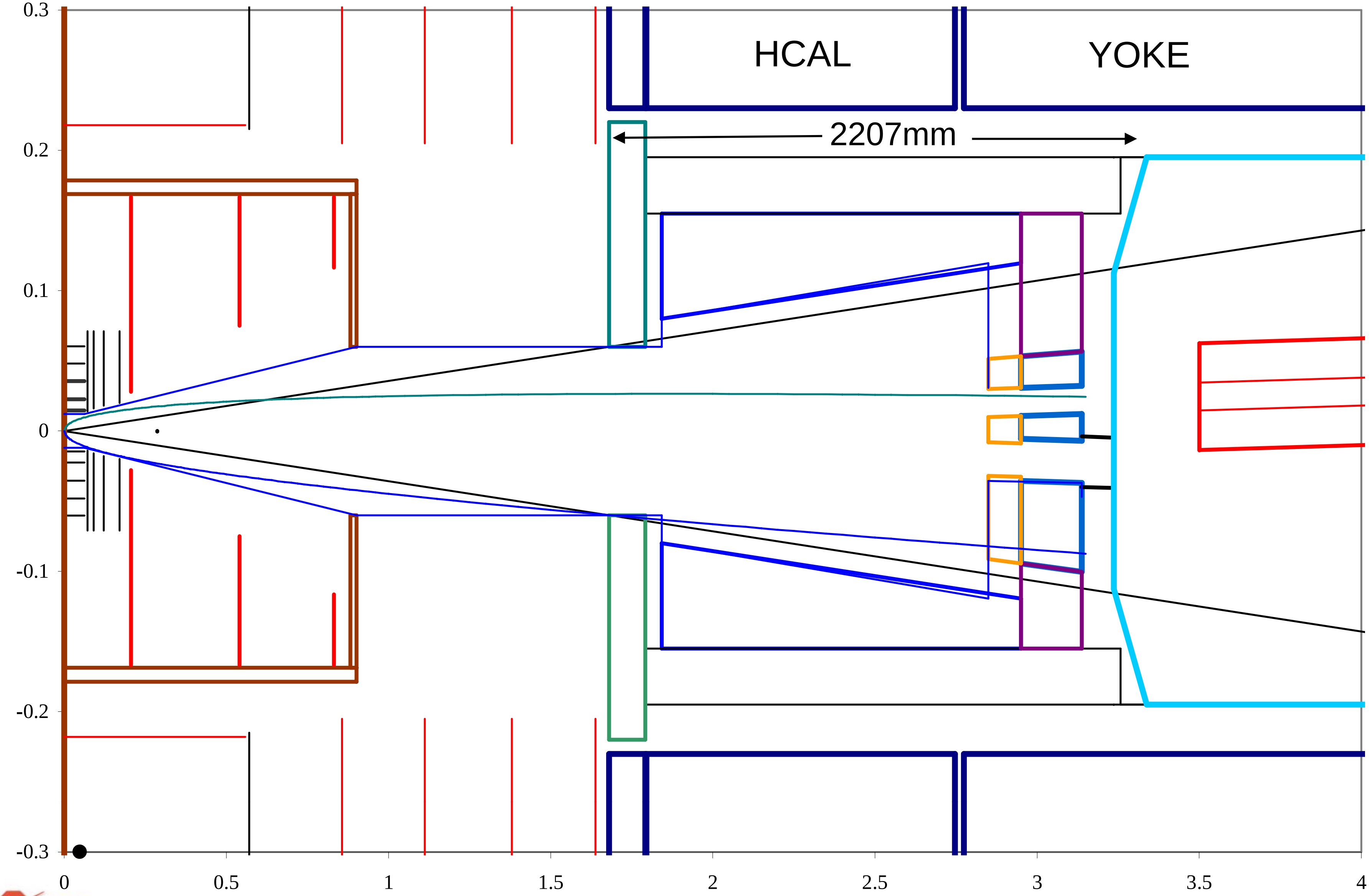
List of functional requirements

1. Two detectors in a single collider hall, able to work in turns, in push-pull mode.
2. The hardware design should allow the moving operation, reconnections and possible rearrangements of shielding to be performed in a few days, or less than a week.
3. The IP to start of QD0 quadrupole (L* parameter) would be in the range of 3.5-4.5 meters (different L* is allowed for different detectors), while the distance from IP to the second quadrupole QF1 is 9.5 meters.
4. The range of detector sizes considered in the design include detectors with half size of 6-7 meters, performing optimally
5. The off-beamline detector is shifted in transverse direction to a garage position, located 15m from the IP.
6. The radiation and magnetic environment, suitable for people access to the off-beamline detector during beam collision, are to be guaranteed by the beam line detector using their chosen solution.
7. The IR and detector design is to satisfy the beam parameters defined in the RDR [1] including nominal, Low N, Large Y and Low P parameter sets.

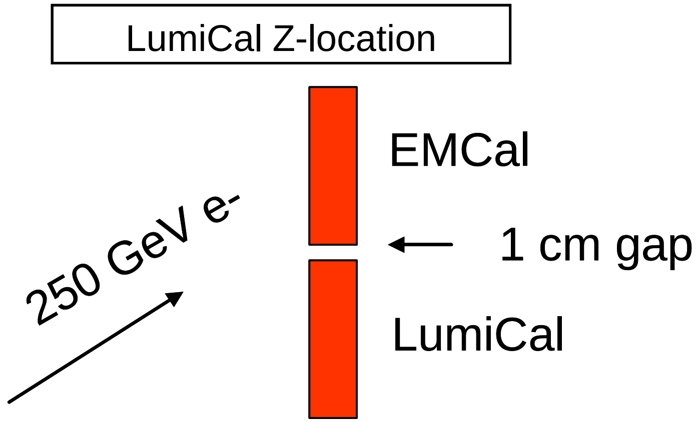
SiD specific MDIs

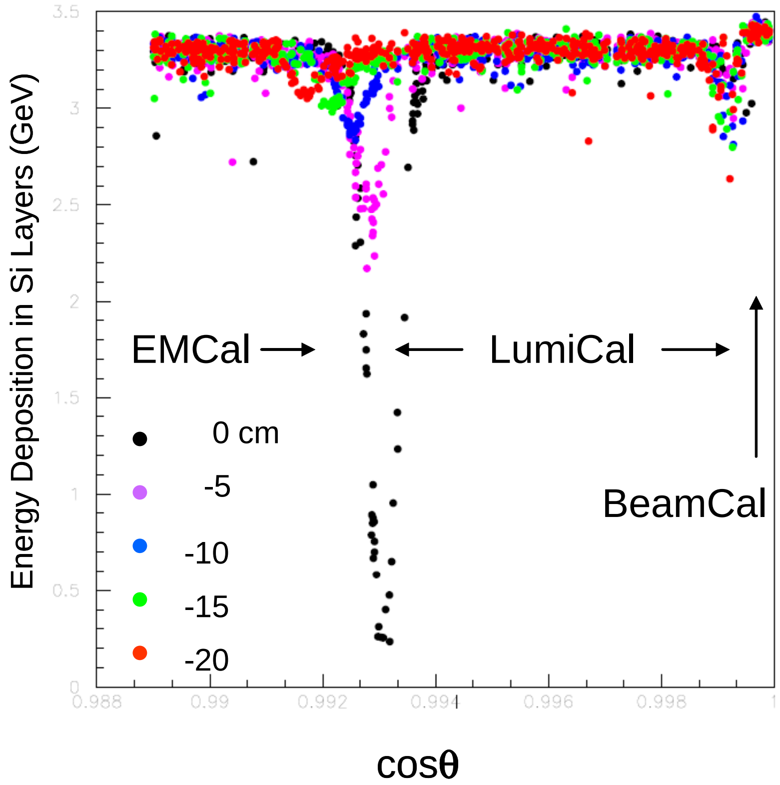
- Engineering in the FCAL Region
- QD0 support
- Pacmen Shielding
- Experimental Vacuum Chamber
- Push pull without platform
- Detector Assembly

SiD r<50cm, L*=3.664m, 14mrad, Push-Pull, QF@9.5m, Door Closed

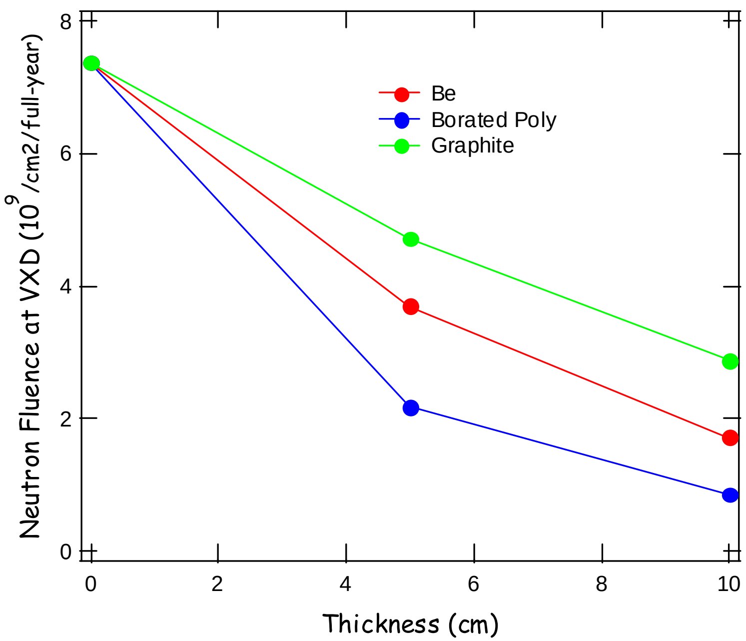


M.Oriunno, SLAC





ILC 500 GeV Nominal + DID
Neutrons from Pairs

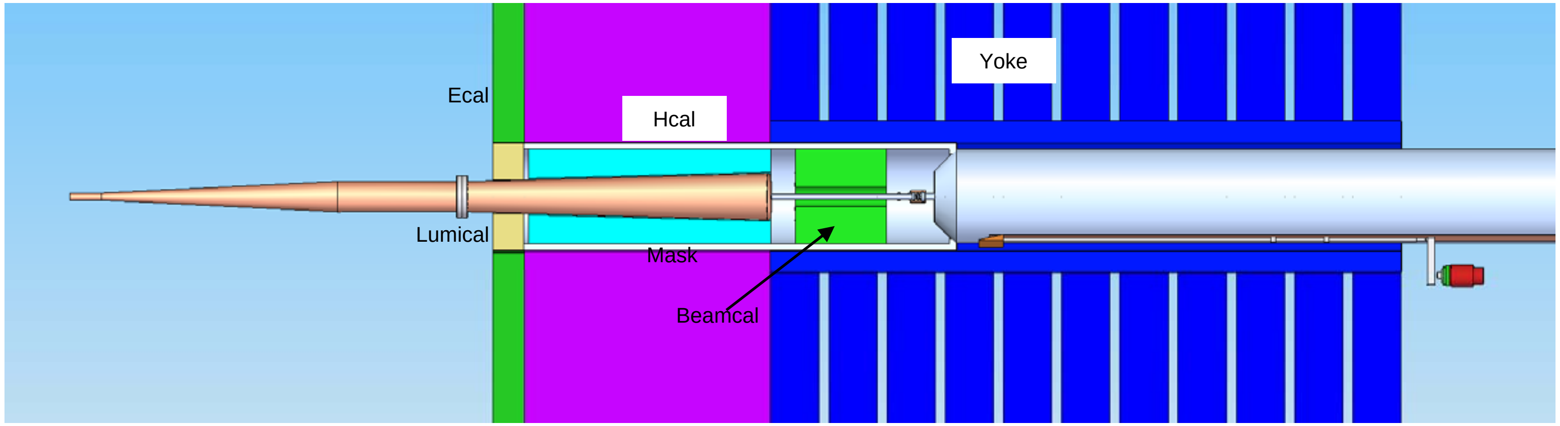


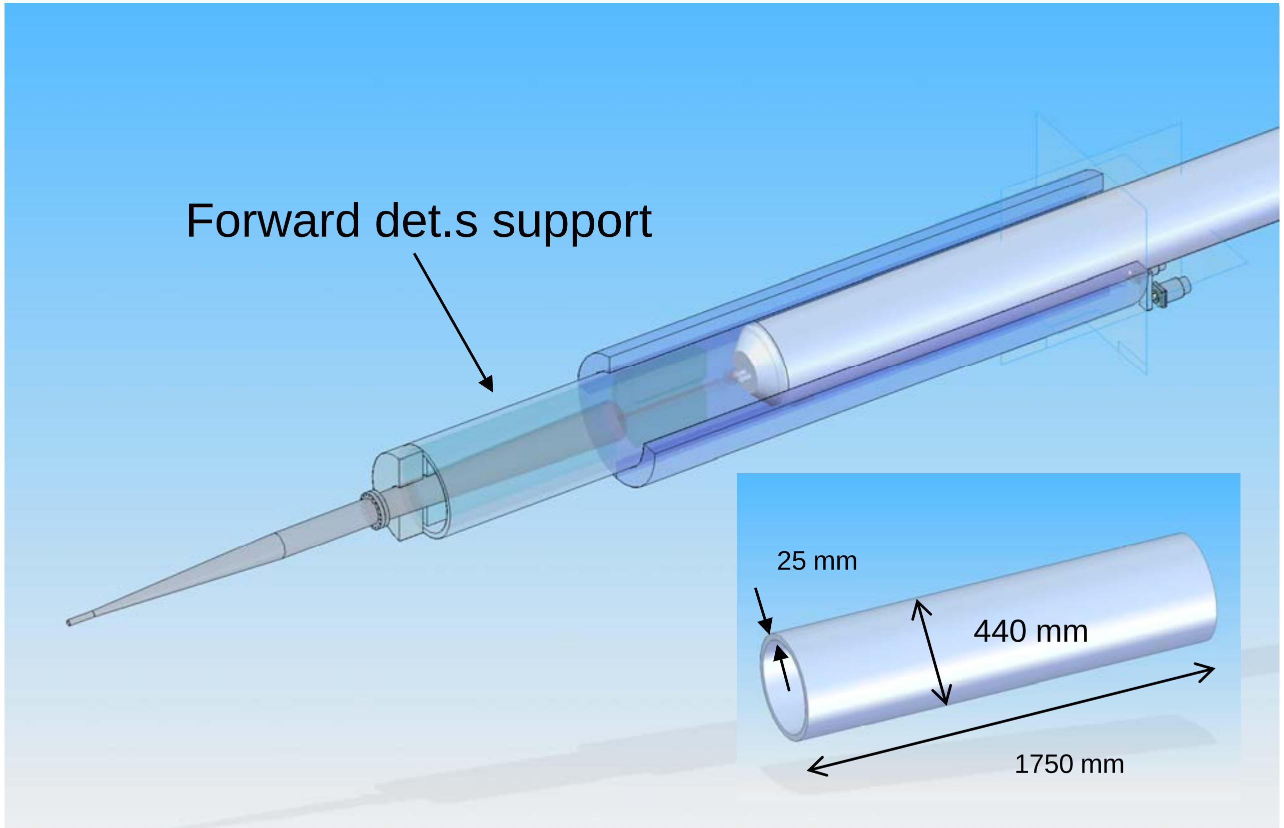
- Low Z layer in front of BeamCal to absorb low energy e+/e- coming out of BeamCal
- 10 cm thick Be ($0.28X_0$)
- Other material to absorb neutrons as well

	Density (g/cm^3)	X_0 (cm)
Be	1.8	35.3
Graphite	2.0	18.8
Borated Poly	0.9	45.6

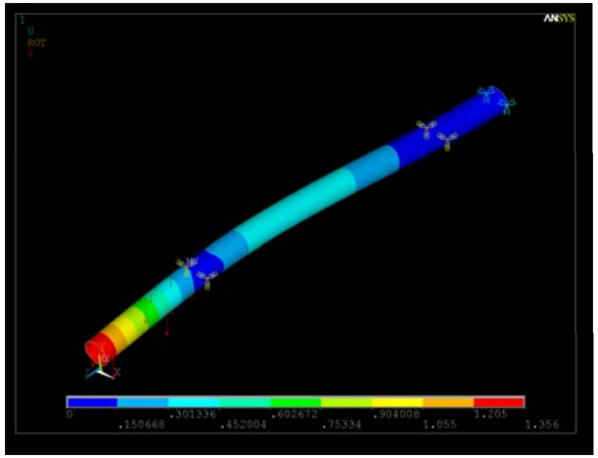
Borated Poly is more effective in absorbing neutrons.

Forward Detectors Integration





Det. Support FEA

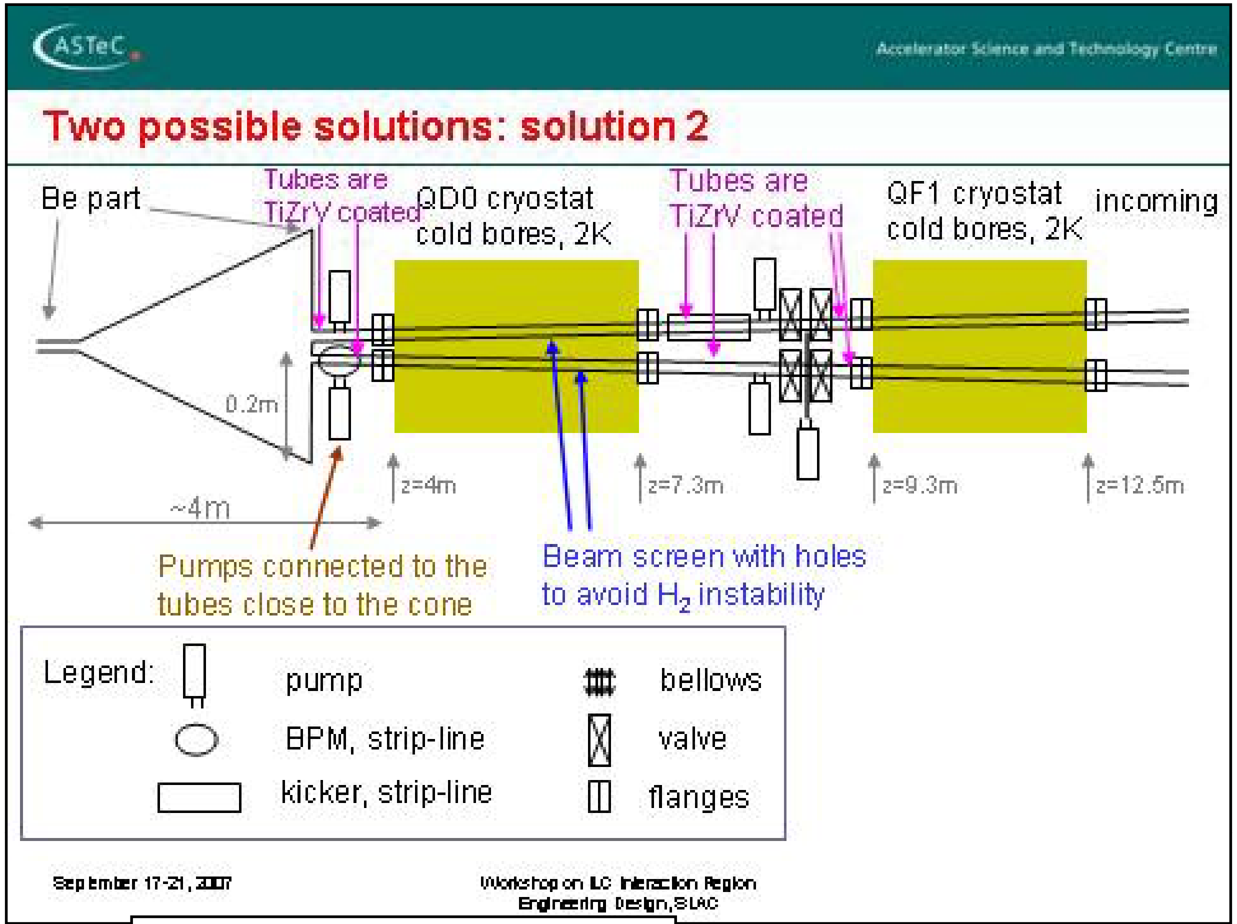


Max vertical deformation 1.3 mm

Vacuum Integration

The beam tube in the experiment must be compatible with the tracker and the vertex performances-integration

Historical tight integration region : pumps, beam instrumentation, flanges, bellows etc.



Present vacuum requirements :

P < 1nT in the BDS

P < 100nT in the experimental region

- We may rely on the cryopumping from QD0
- We do not need extra pumps
- We do not need periodic bake out *in situ.*

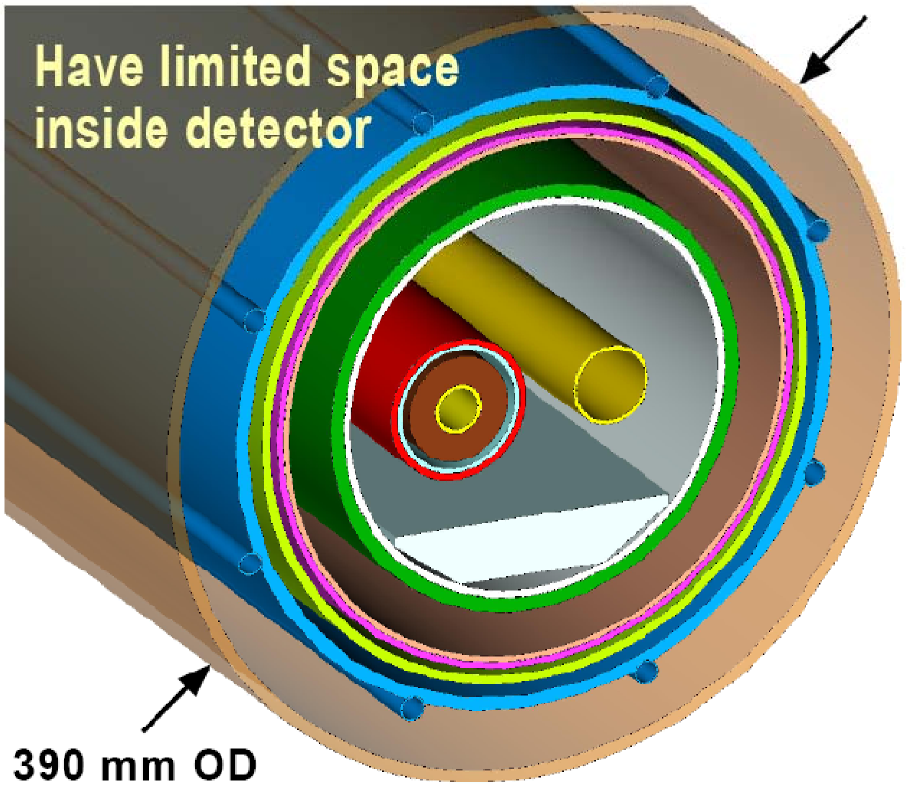
Open point :

- The beam instrumentation required
- Shut-off valves

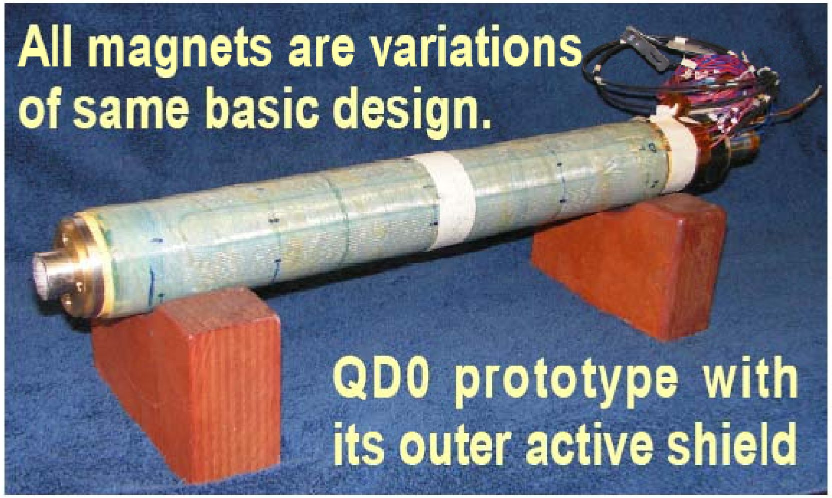
Discussed at IRENG07

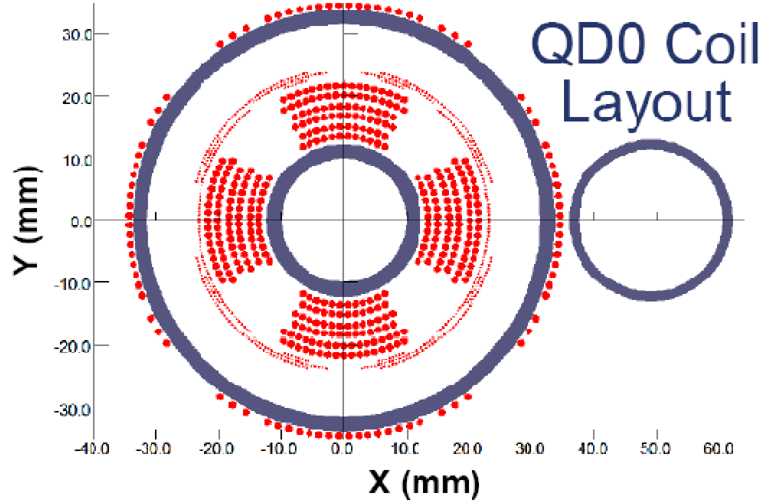
14 mr Compact Superconducting Magnets

QD0 Cryostat design for L* = 4.5 m.

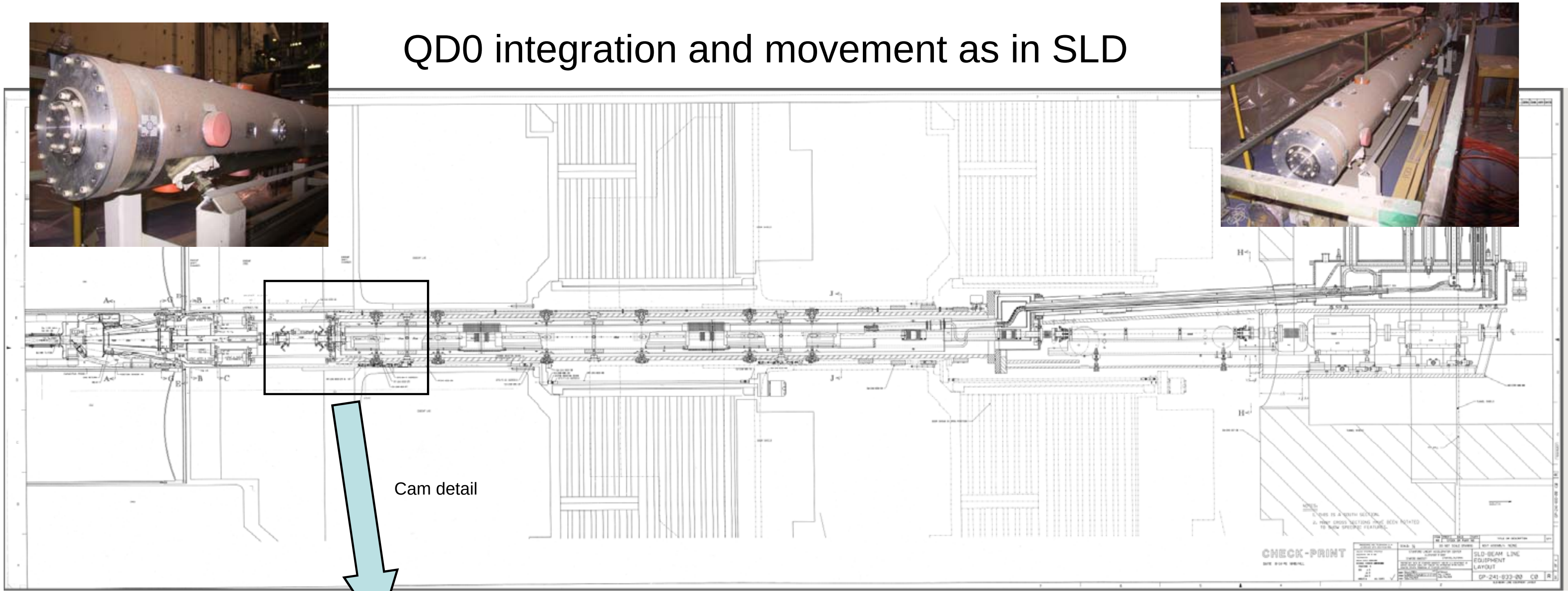


390 mm OD

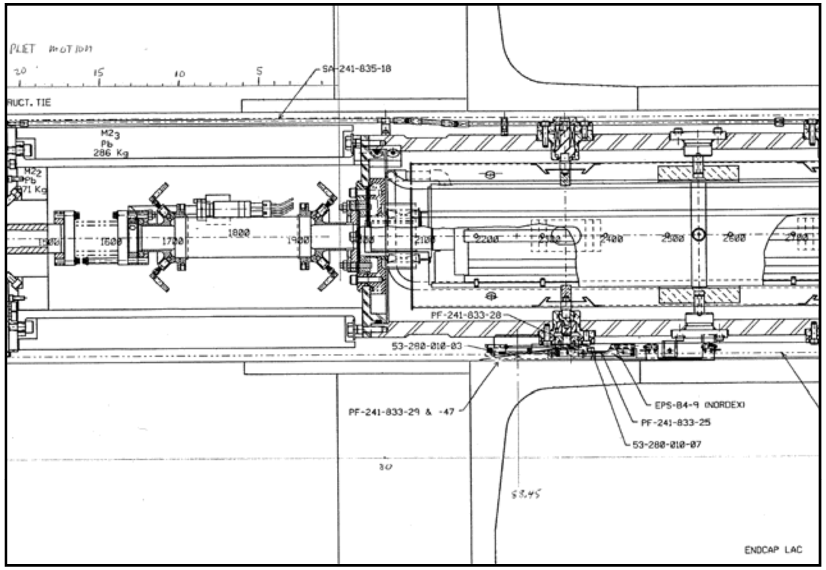


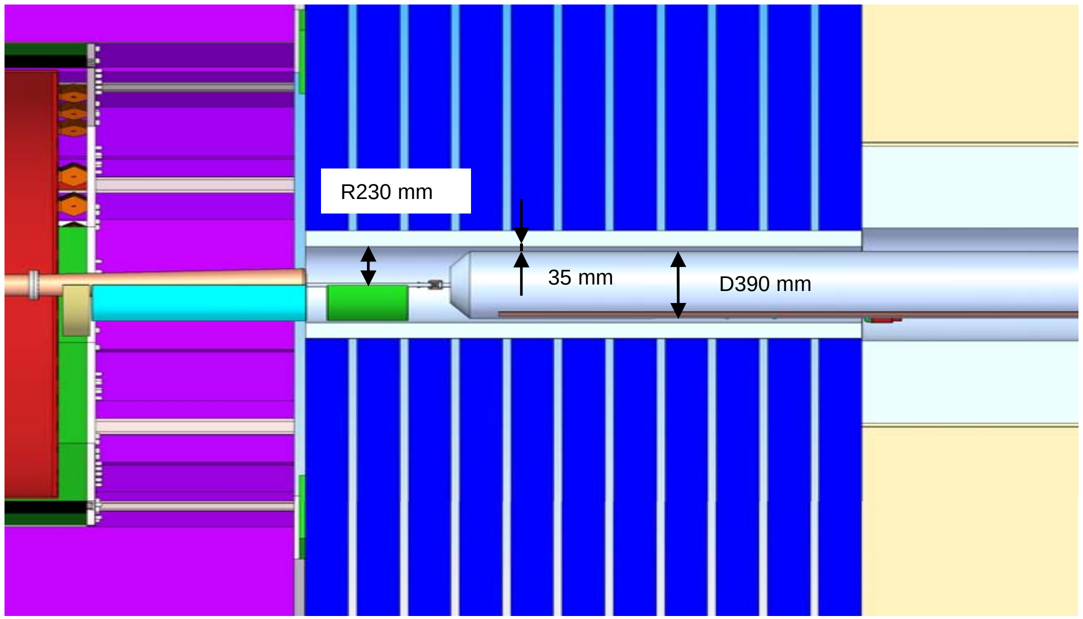


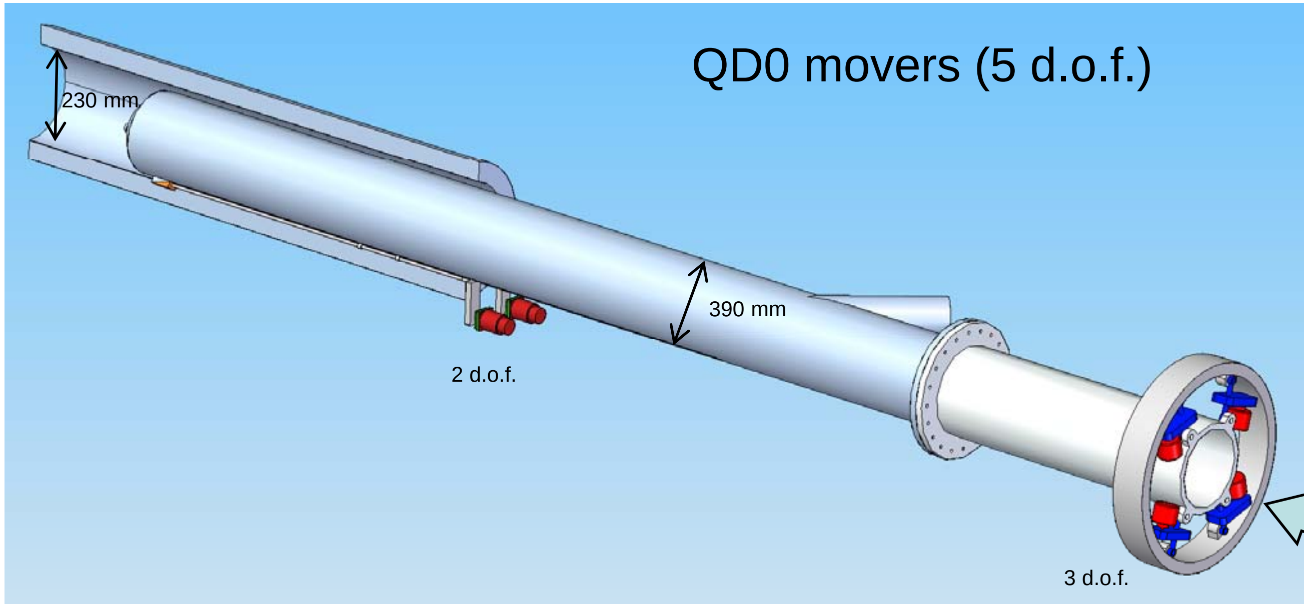
QD0 integration and movement as in SLD

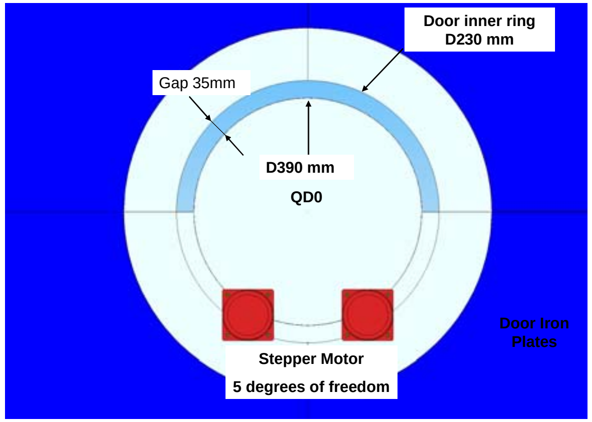


Cam detail

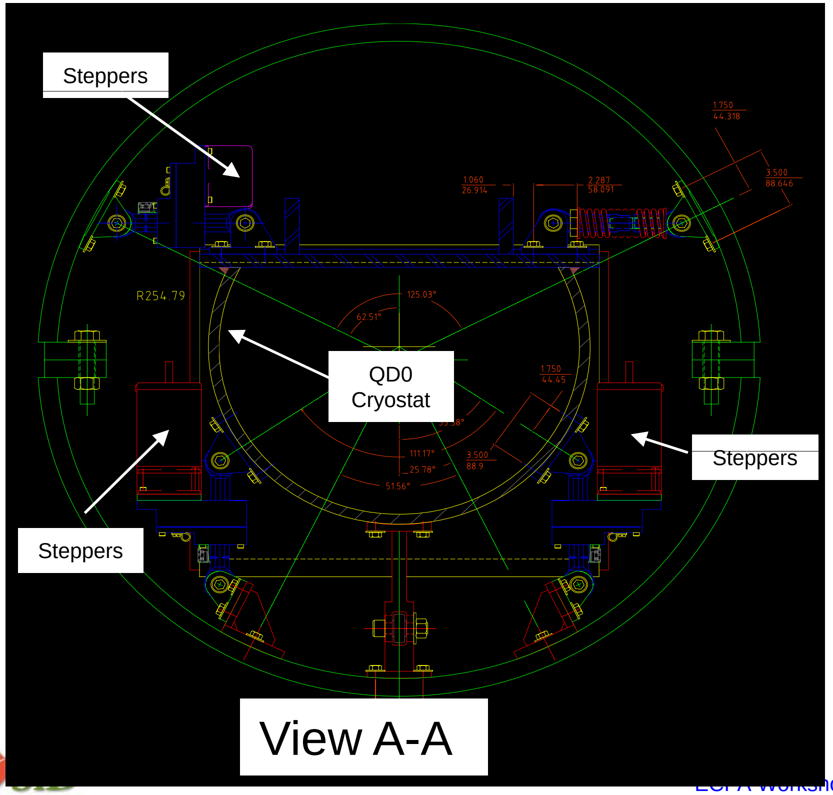


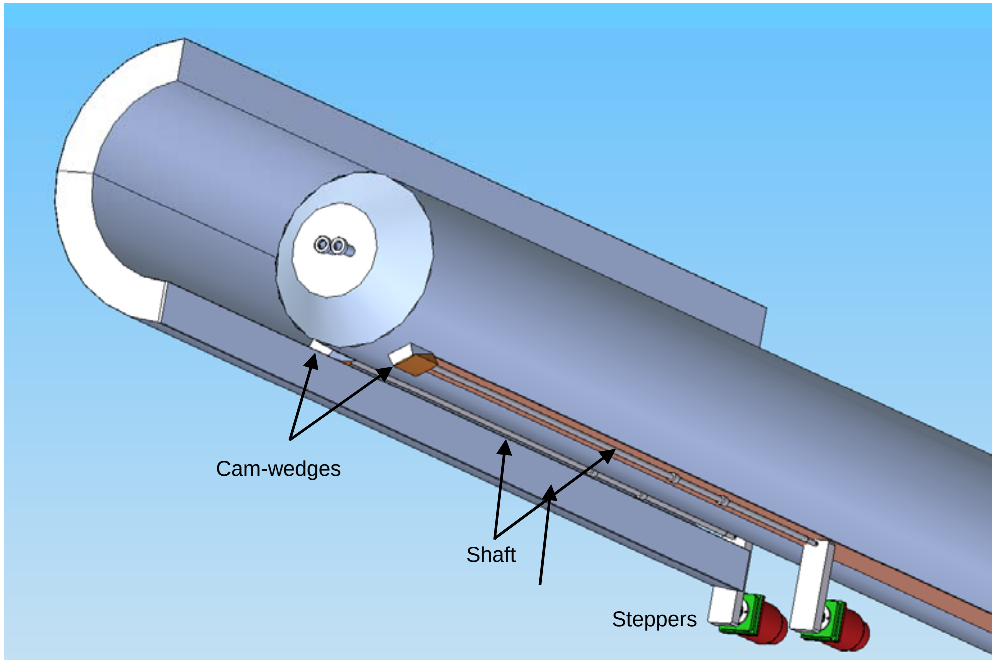


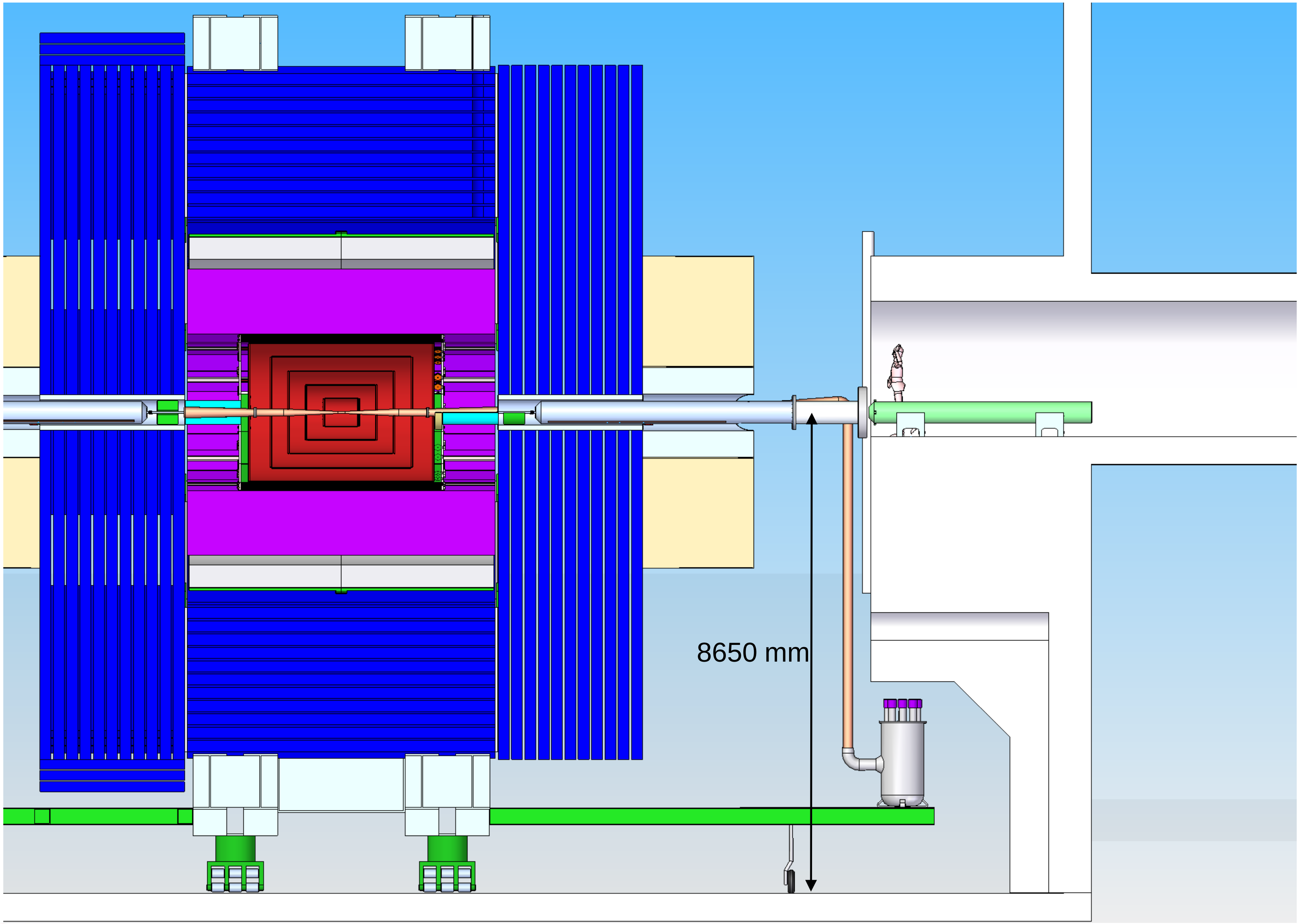

QD0 movers (5 d.o.f.)
230 mm
390 mm
2 d.o.f.
3 d.o.f.

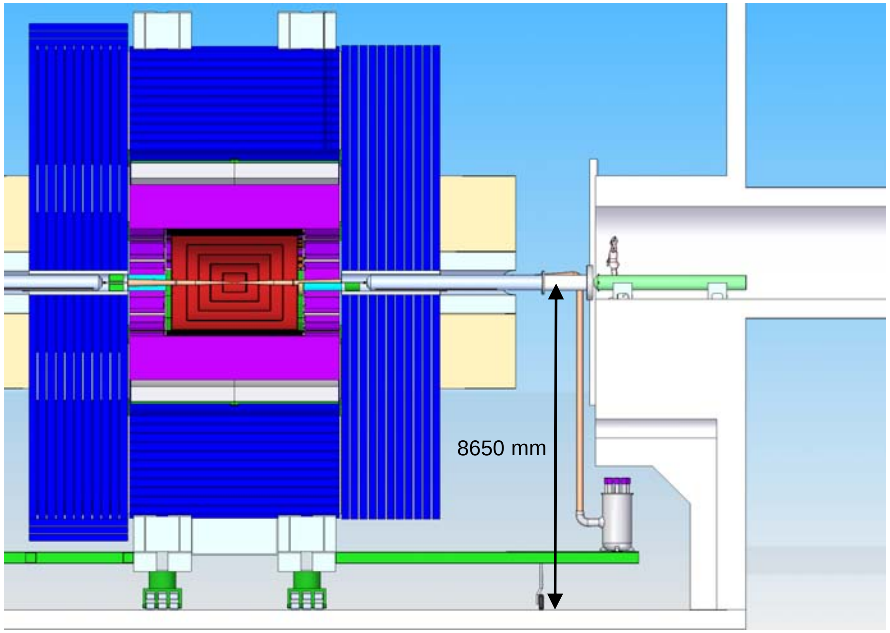

Door inner ring
D230 mm
Gap 35mm
D390 mm
QD0
Door Iron
Plates
Stepper Motor
5 degrees of freedom

View A-A

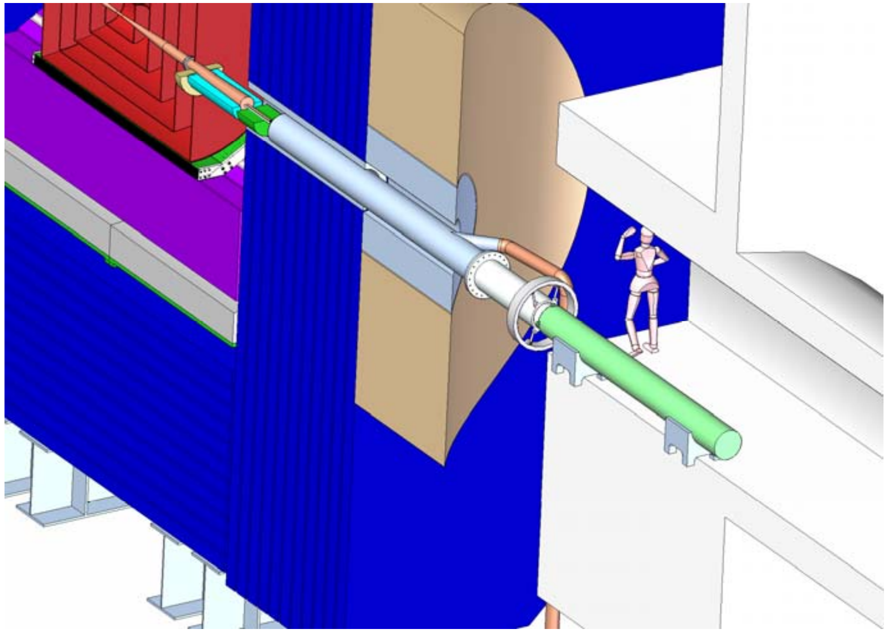

Steppers
R254.79
QD0
Cryostat
Steppers
Steppers
View A-A

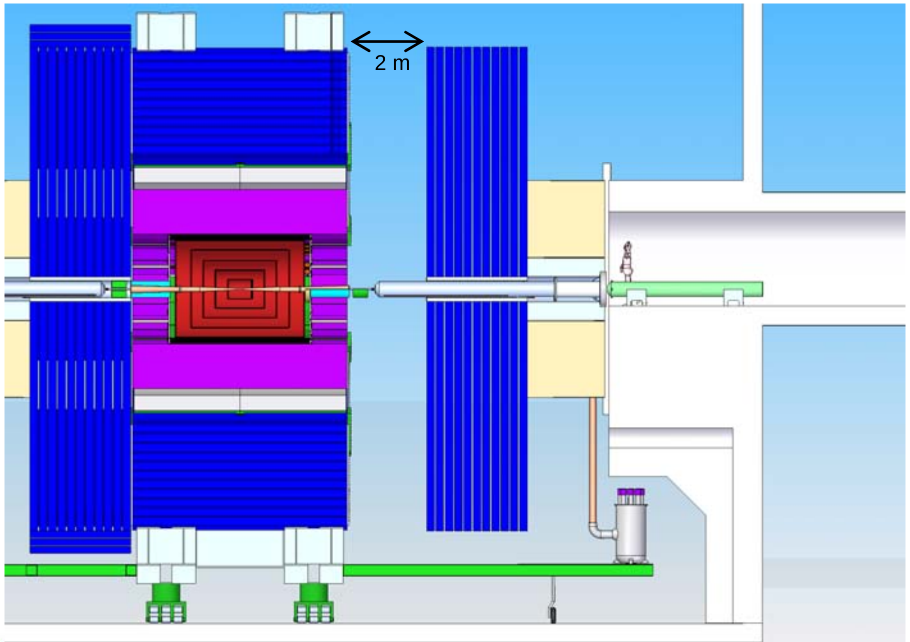

Cam-wedges
Shaft
Steppers


8650 mm

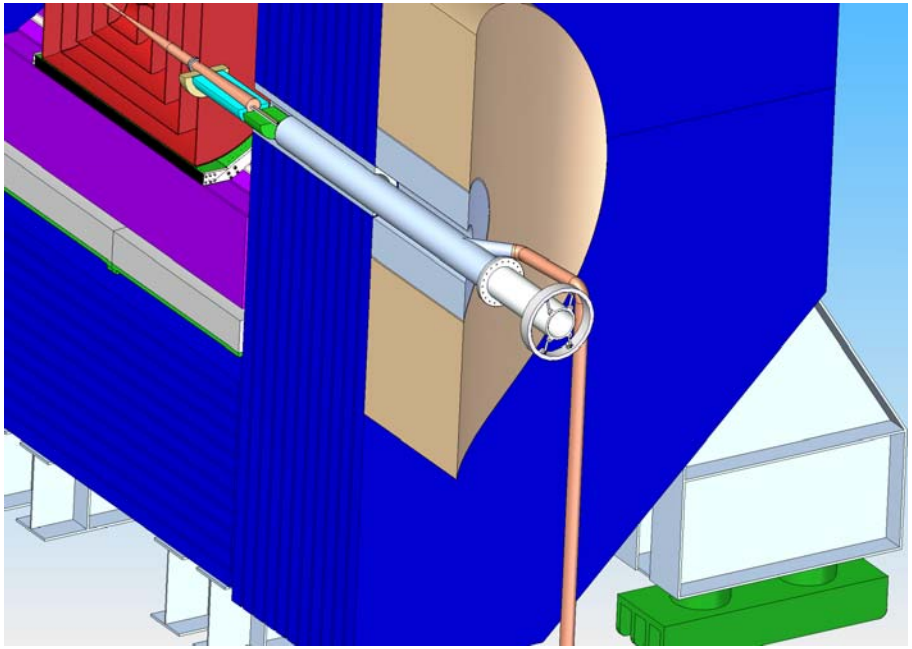


Close Position

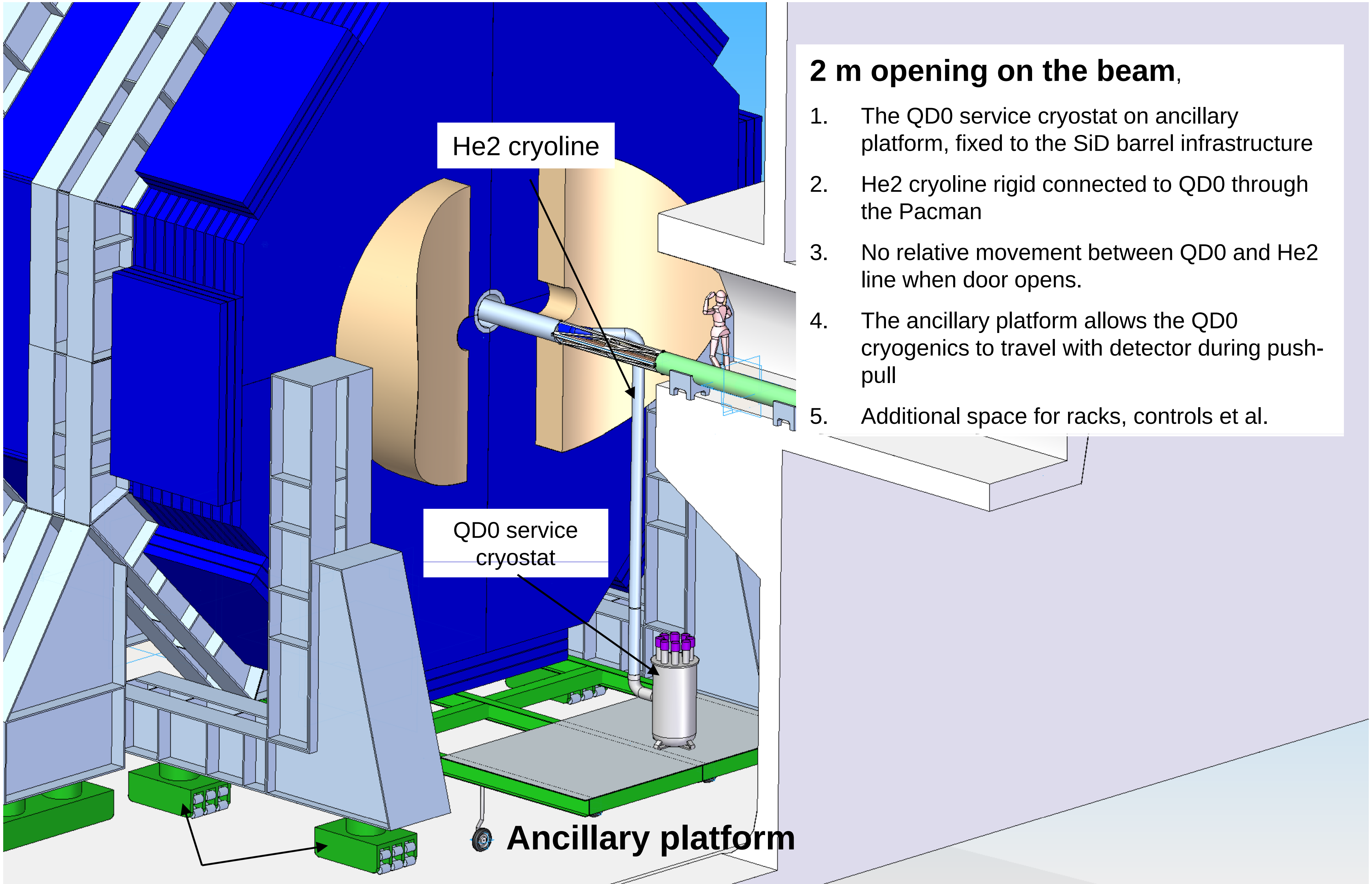

Close Position on the beam



2 m Open Position


Close Position off the beam

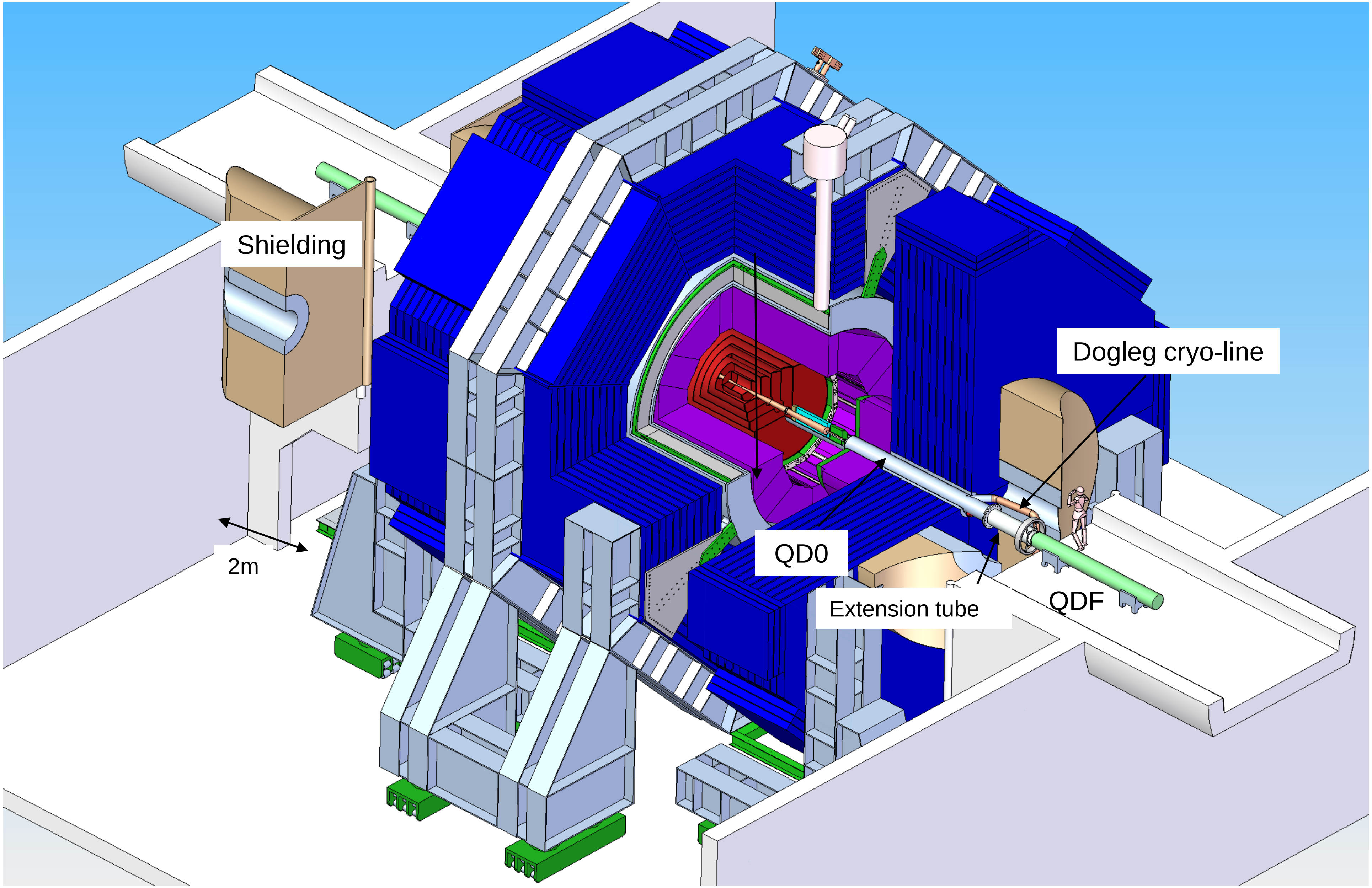
Integration of the QD0 cryoline



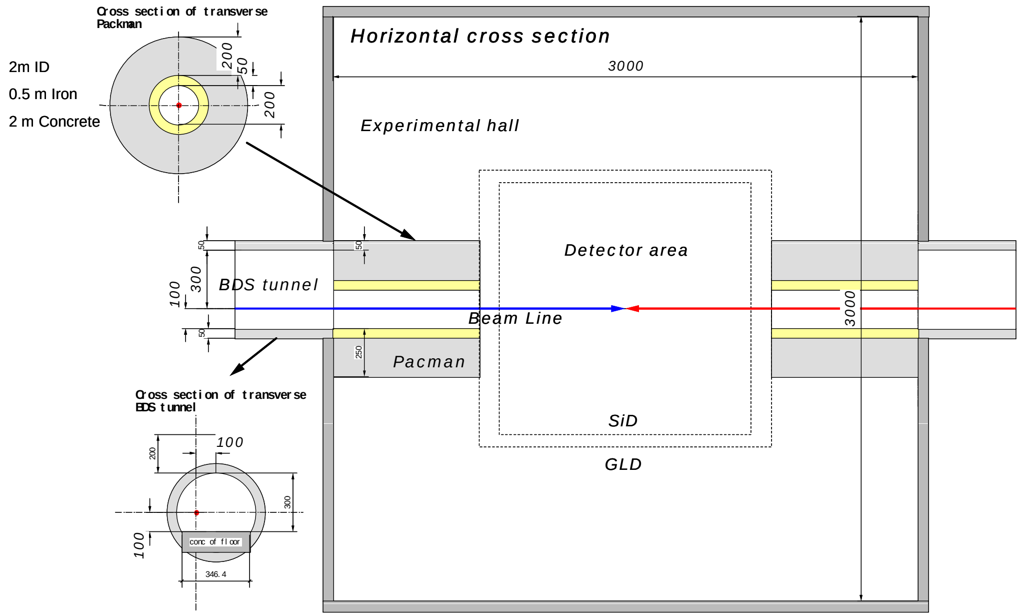
2 m opening on the beam,

1. The QD0 service cryostat on ancillary platform, fixed to the SiD barrel infrastructure
2. He2 cryoline rigid connected to QD0 through the Pacman
3. No relative movement between QD0 and He2 line when door opens.
4. The ancillary platform allows the QD0 cryogenics to travel with detector during push-pull
5. Additional space for racks, controls et al.

2m Door opening Procedure, on the beam



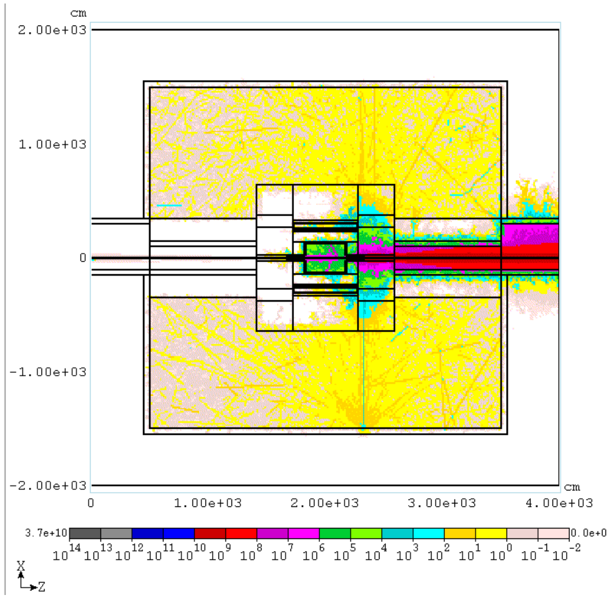
Pacman Radiation Physics requirements

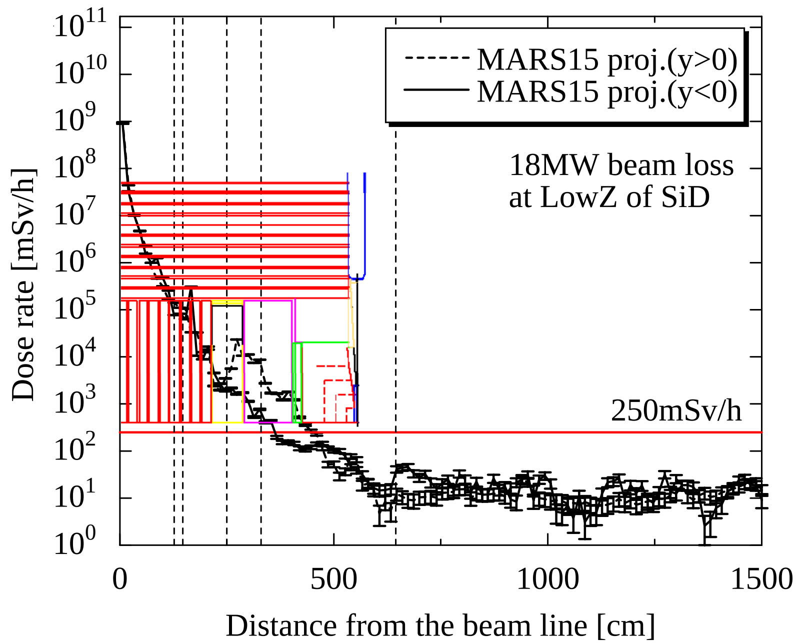


From T.Sanami, IRENG'07

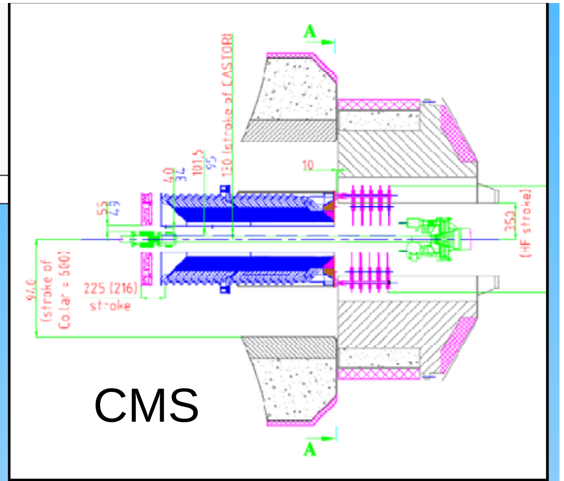
Keywords :

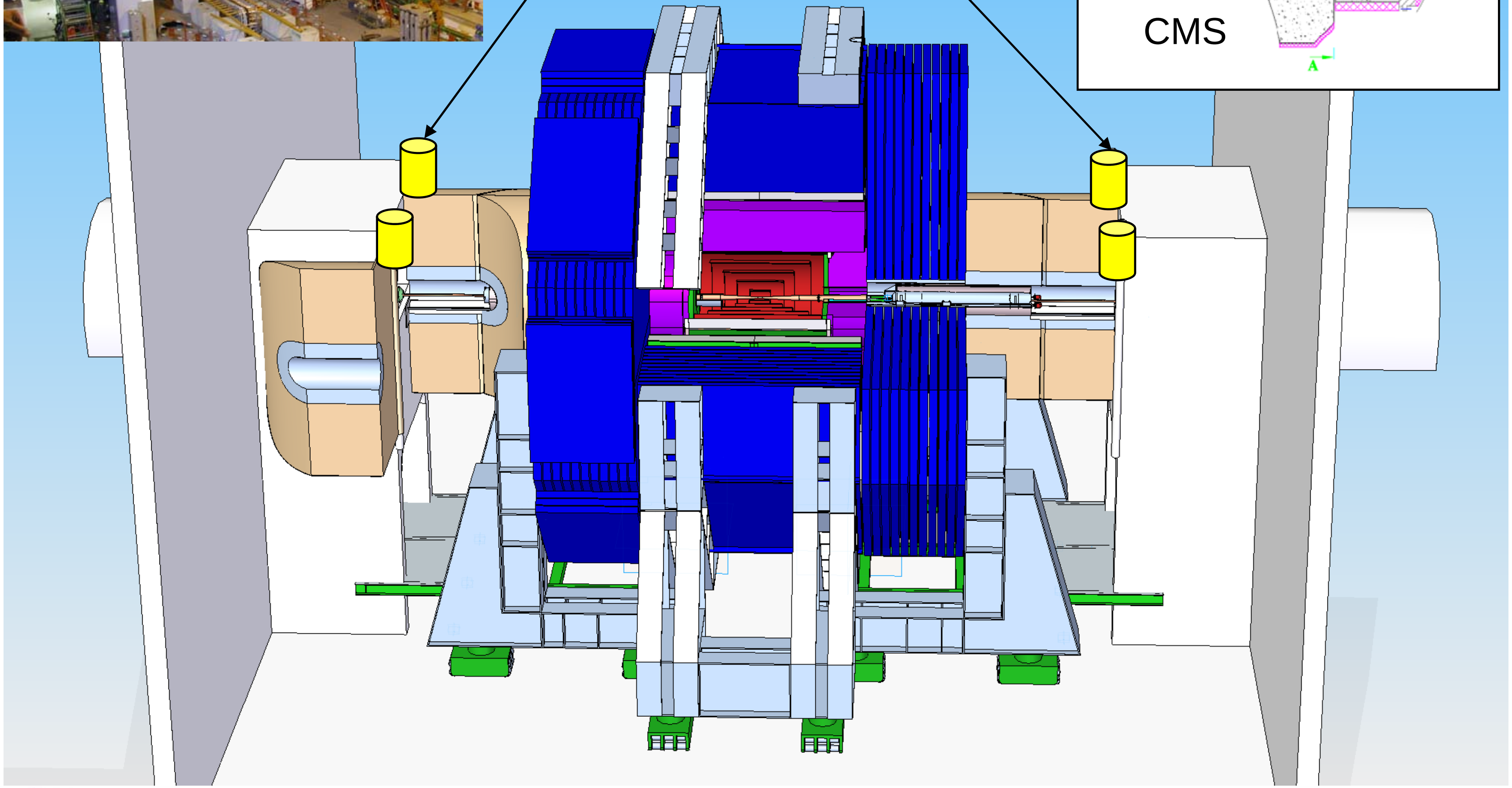
- Self-Shielding Detector
- Adjusting pacman to reduce dose below 250mSv/hr

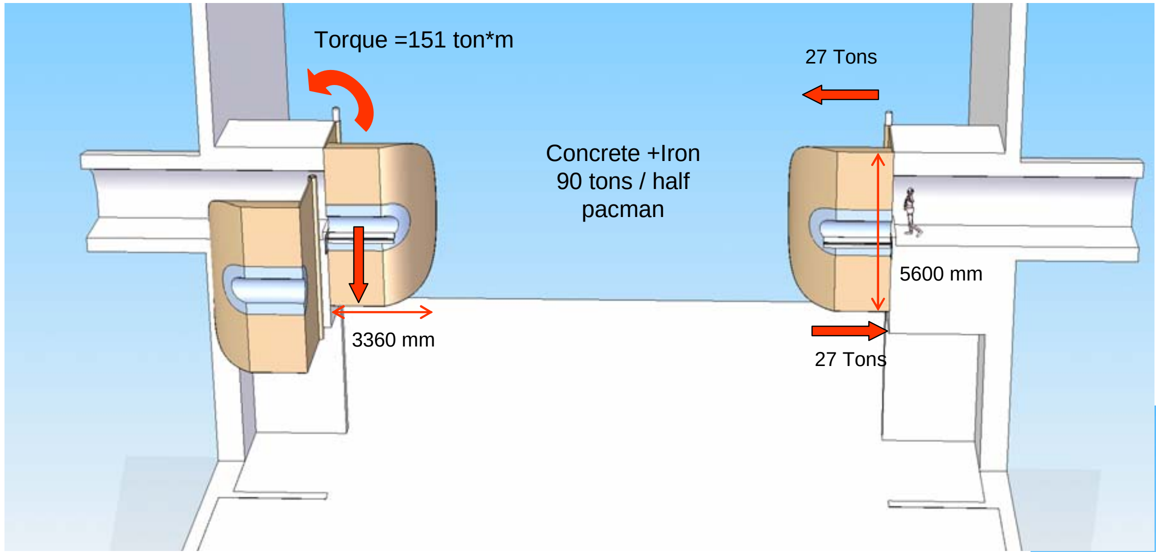


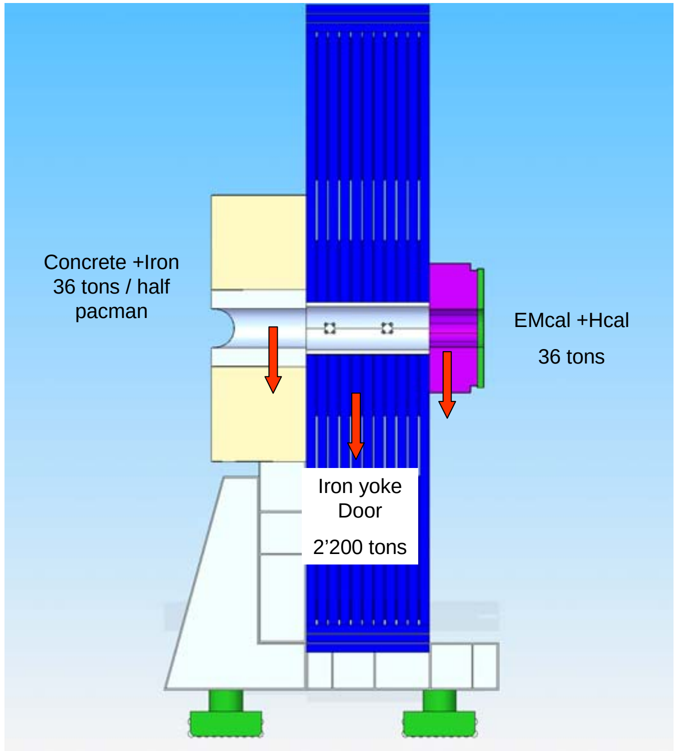


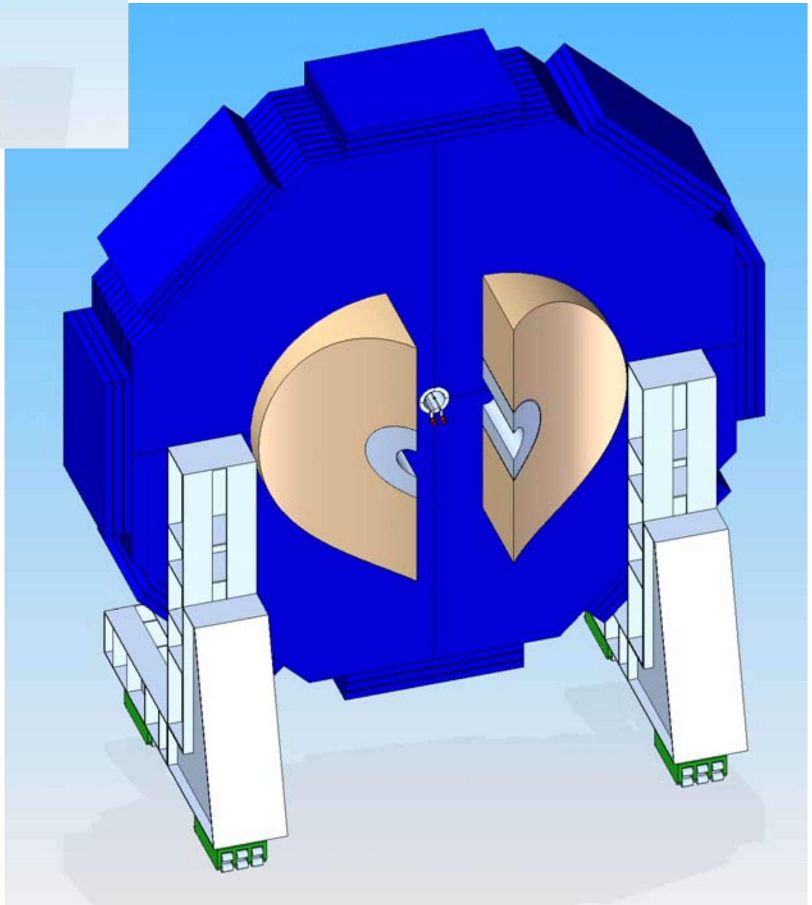
Rotating Pacmen



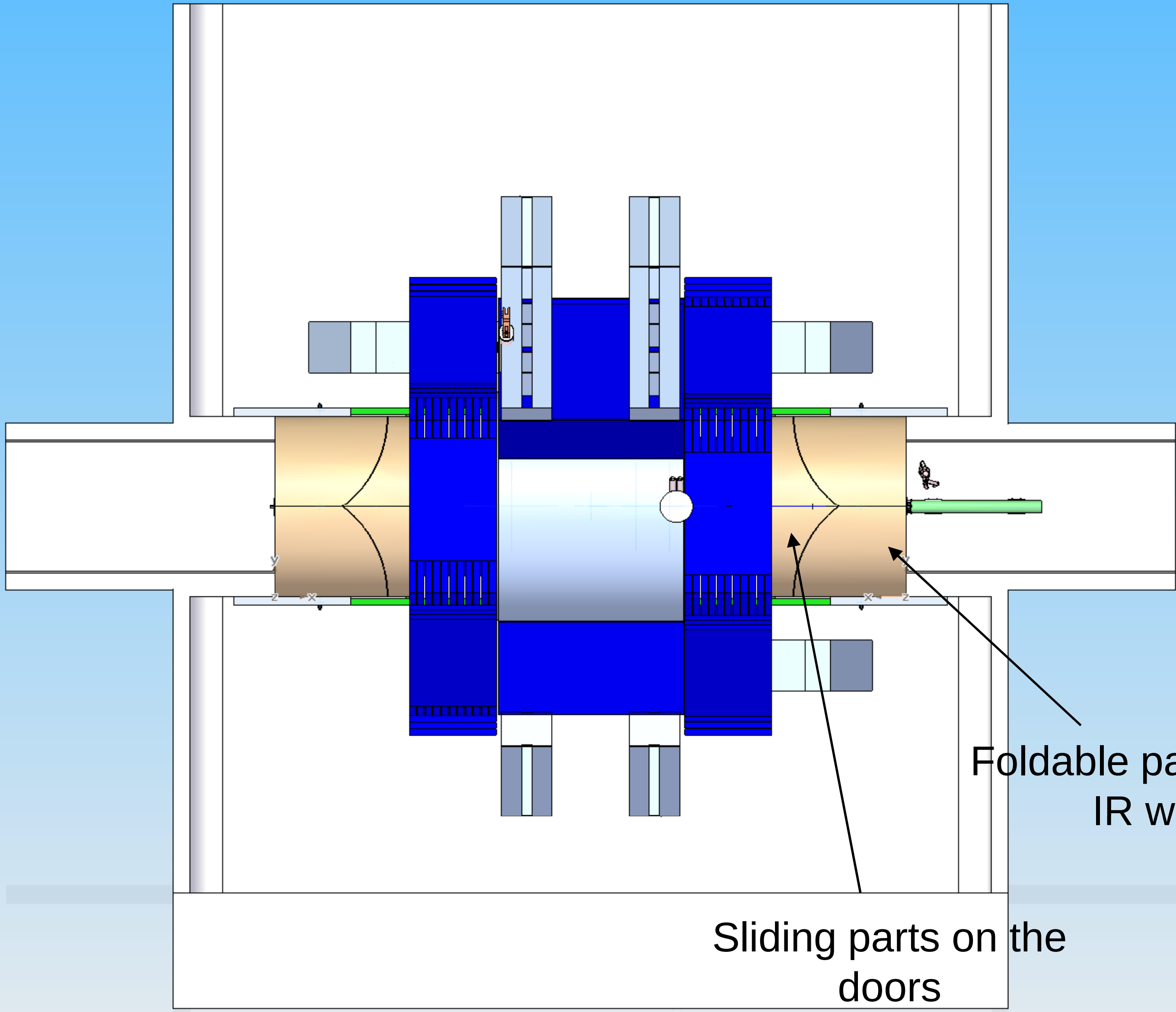



Torque =151 ton*m
27 Tons
Concrete +Iron
90 tons / half
pacman
5600 mm
3360 mm
27 Tons

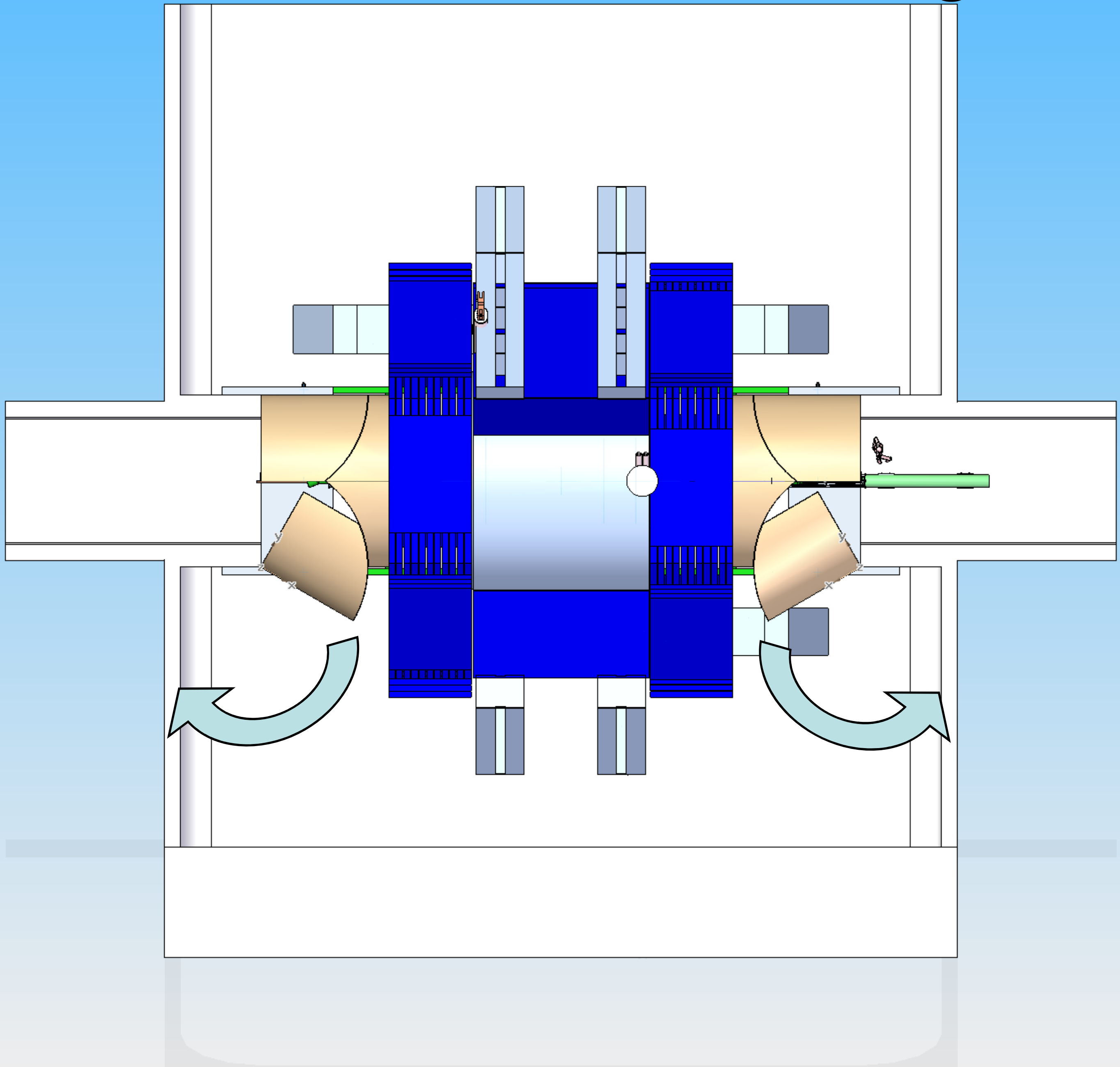

Concrete +Iron
36 tons / half
pacman
EMcal +Hcal
36 tons
Iron yoke
Door
2'200 tons



SiD Forward Shielding



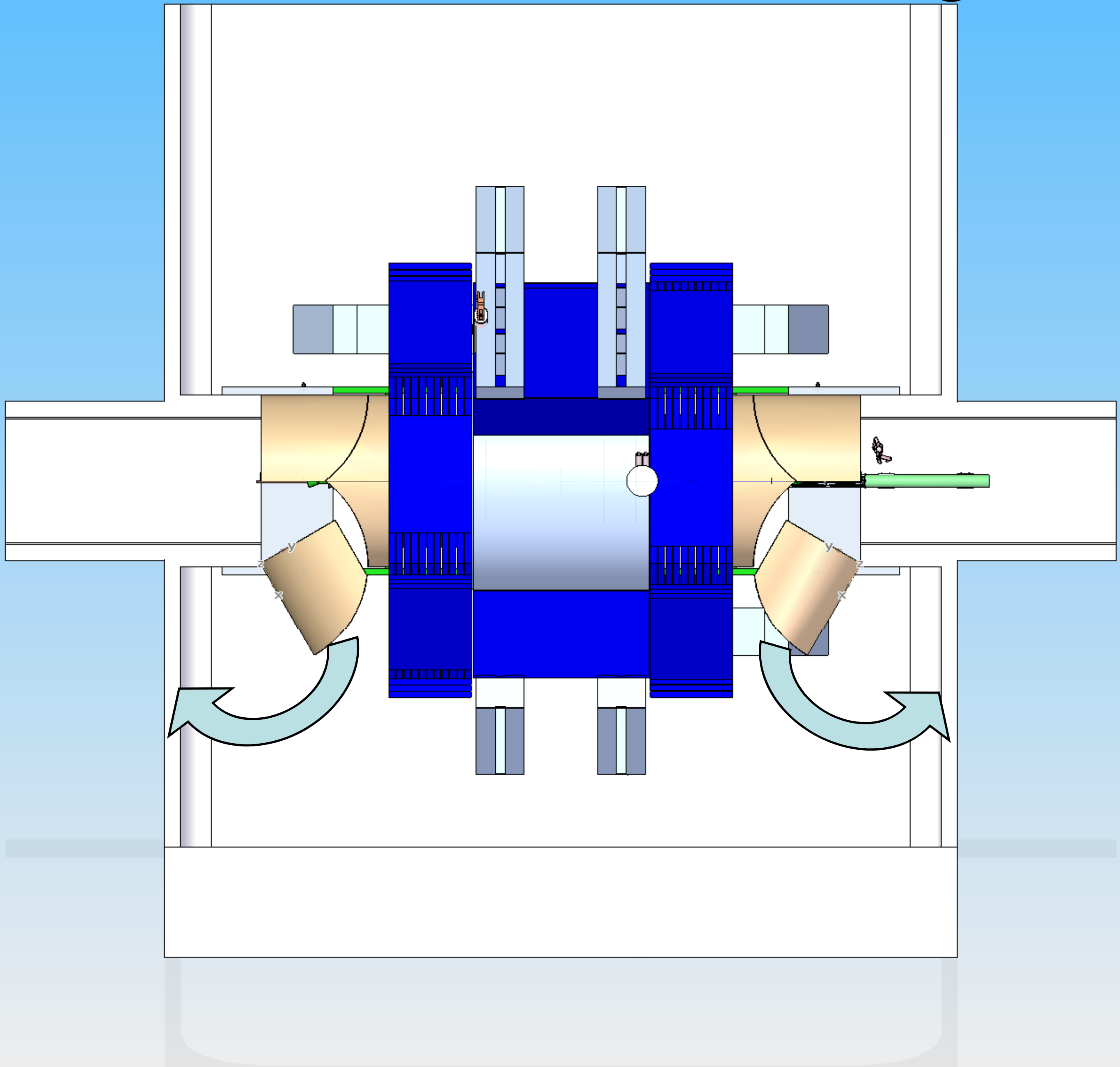
SiD Forward Shielding



SiD

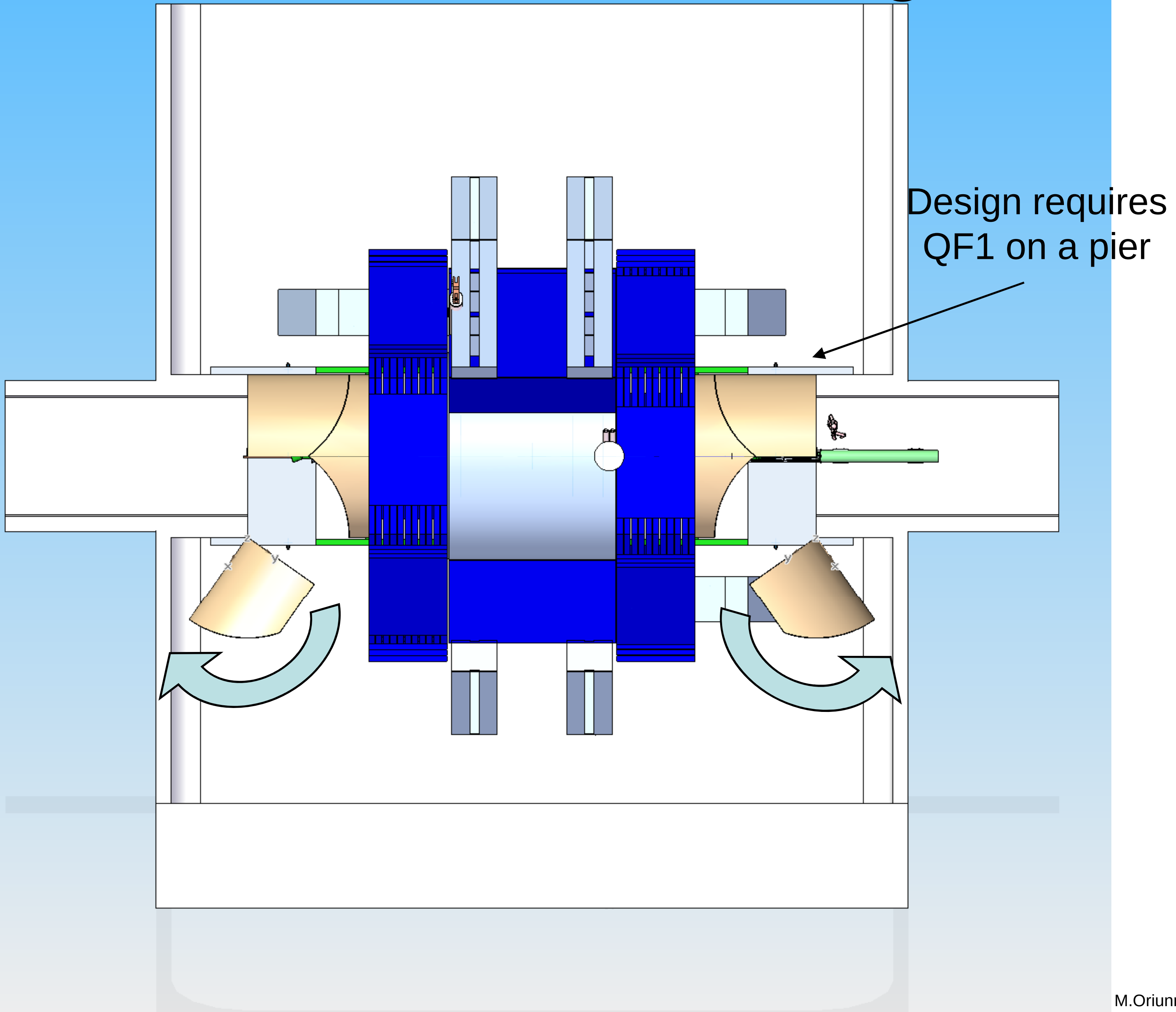
M.Oriunno, SLAC

SiD Forward Shielding

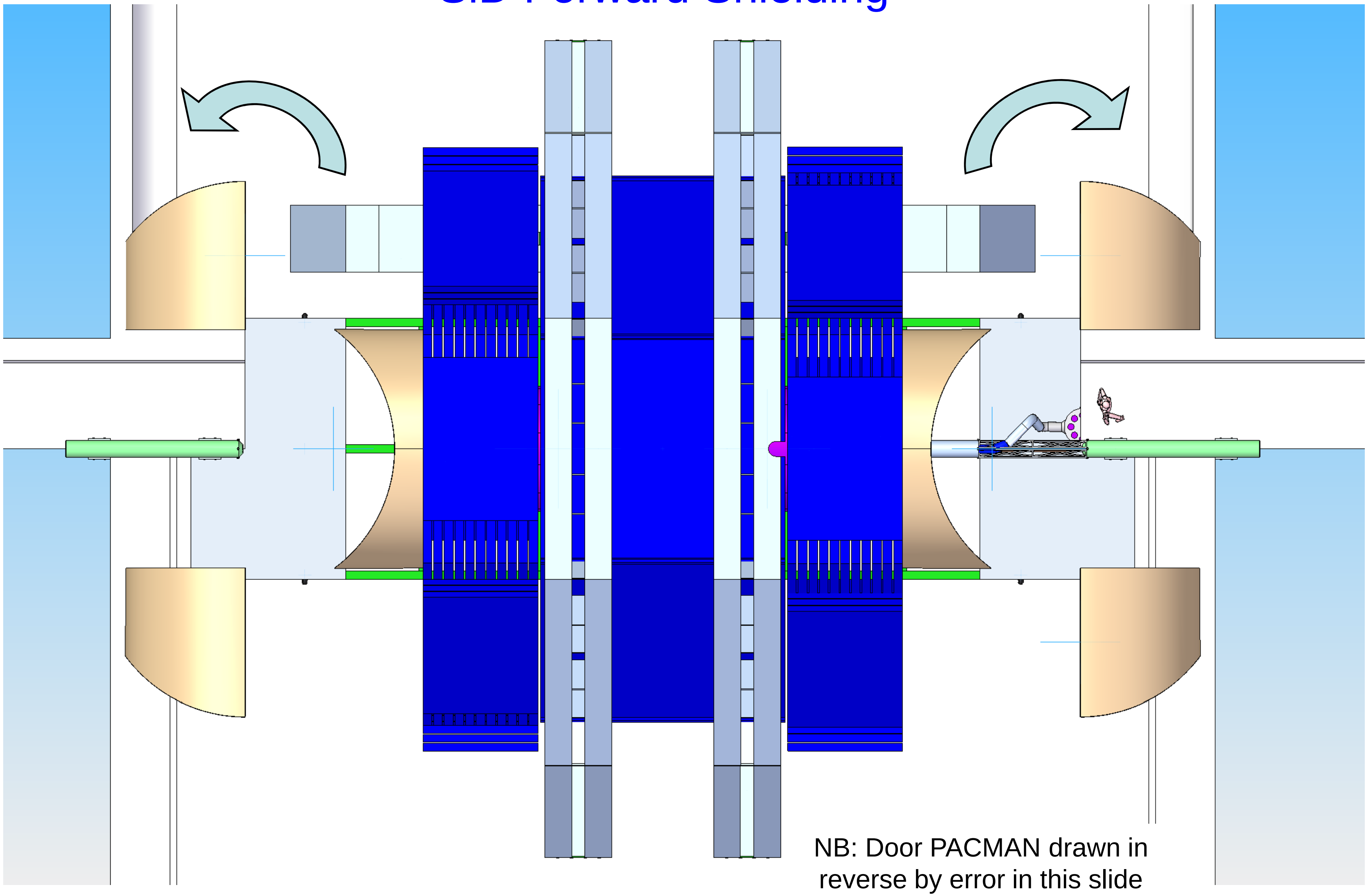


M.Oriunno, SLAC

SiD Forward Shielding

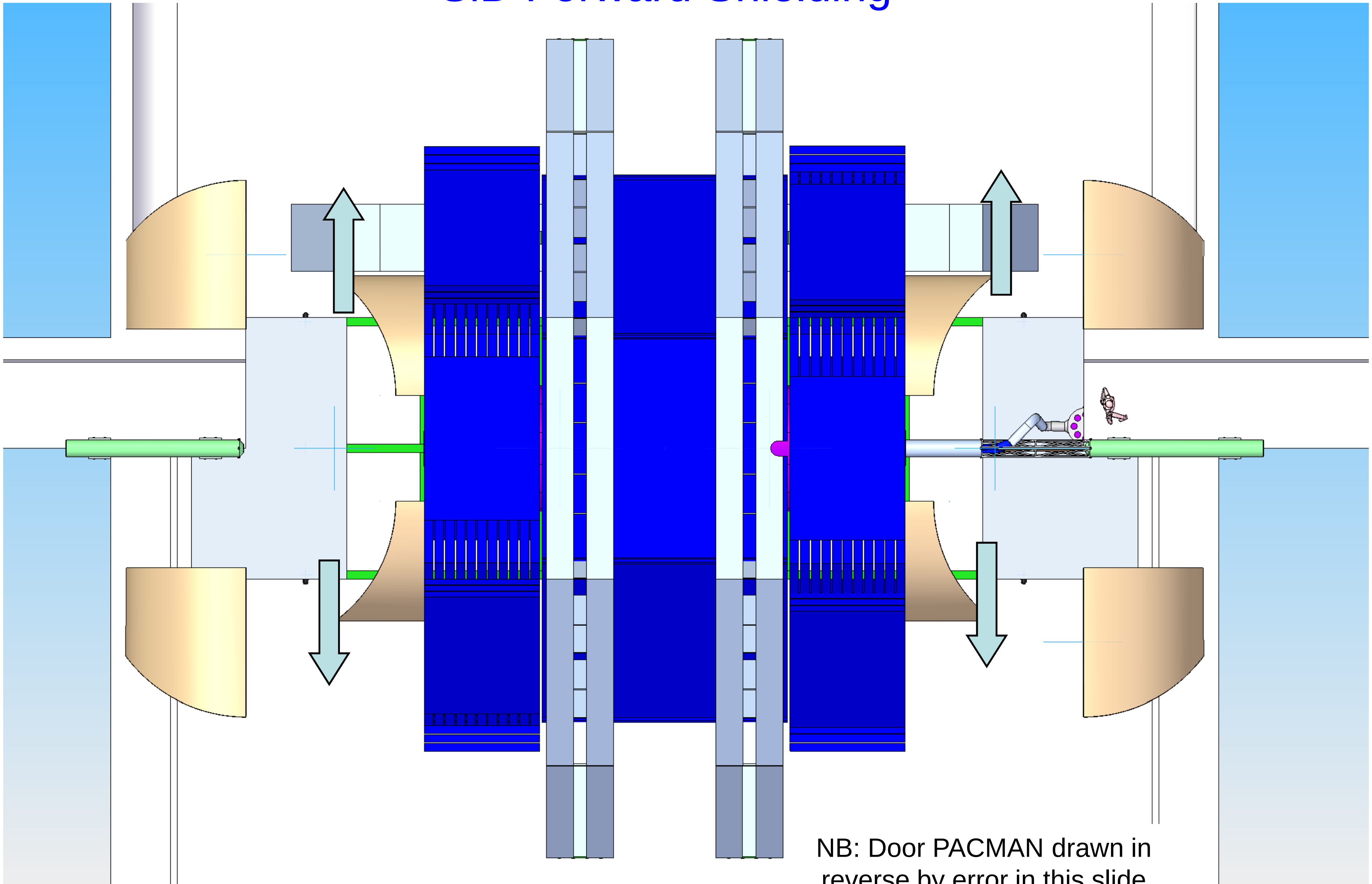


SiD Forward Shielding



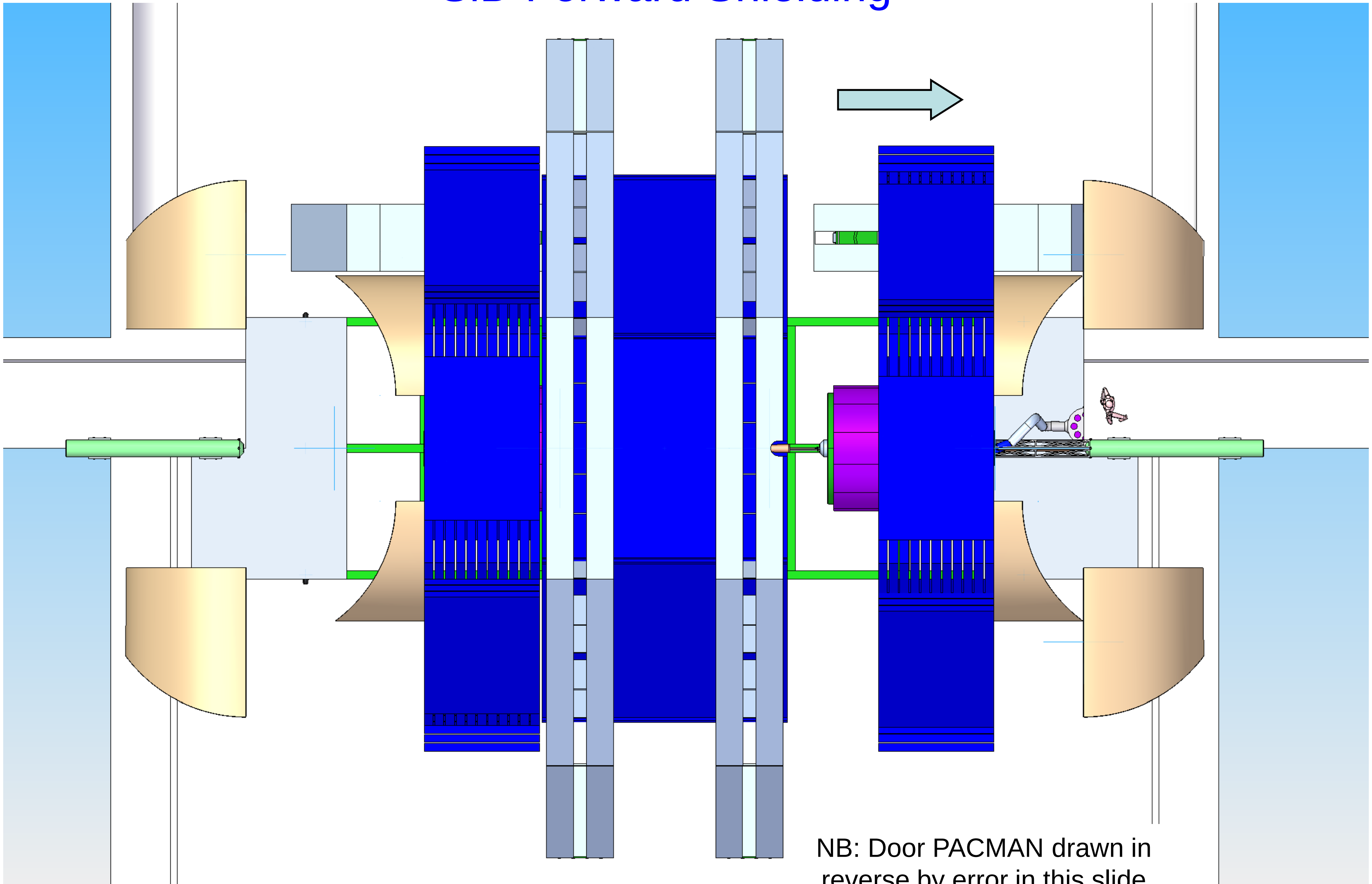
NB: Door PACMAN drawn in reverse by error in this slide

SiD Forward Shielding



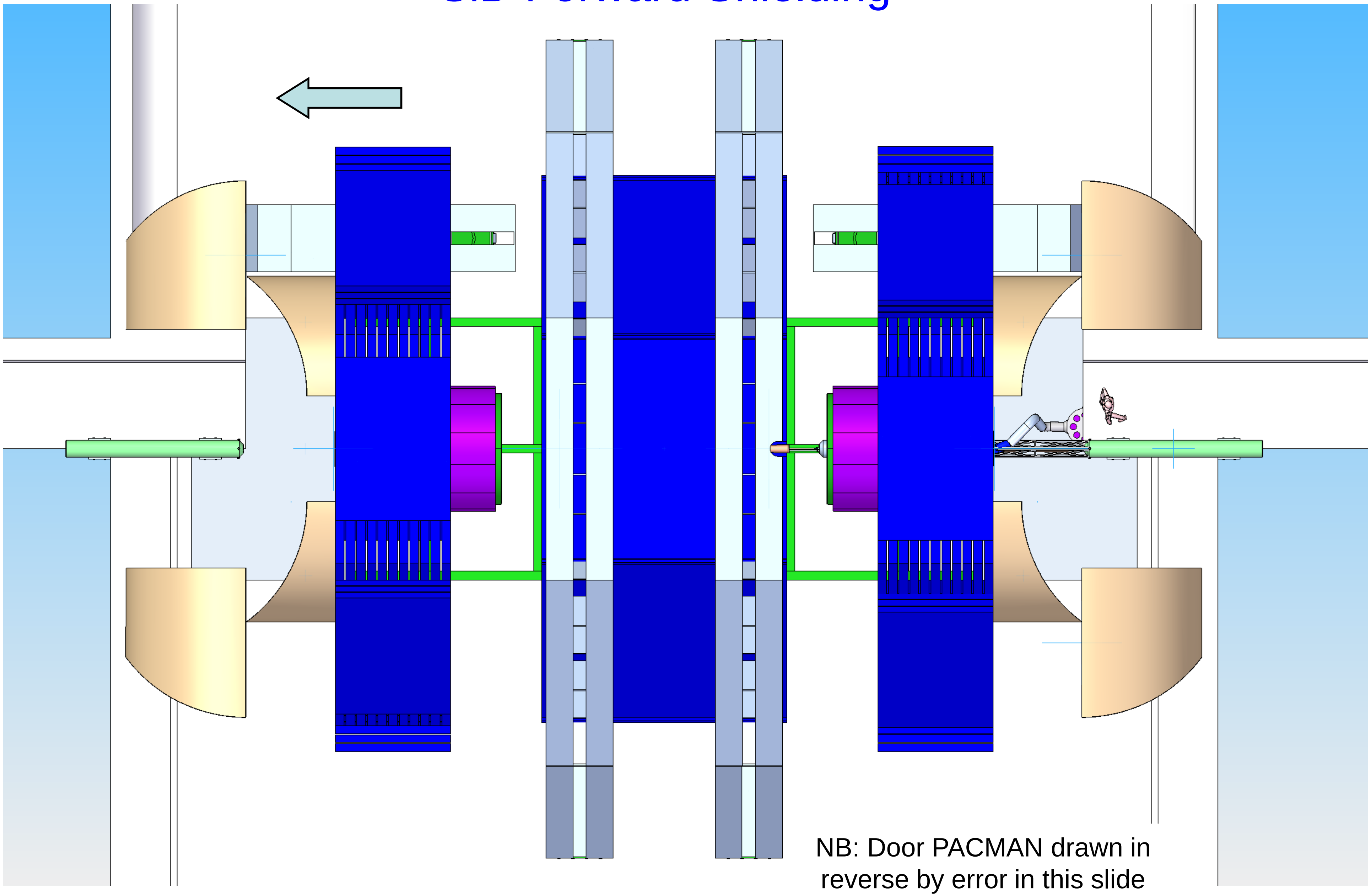
NB: Door PACMAN drawn in reverse by error in this slide

SiD Forward Shielding



NB: Door PACMAN drawn in reverse by error in this slide

SiD Forward Shielding

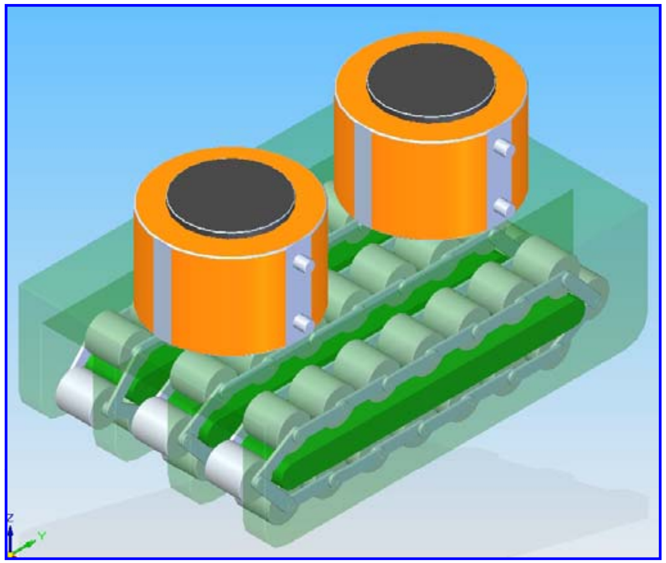


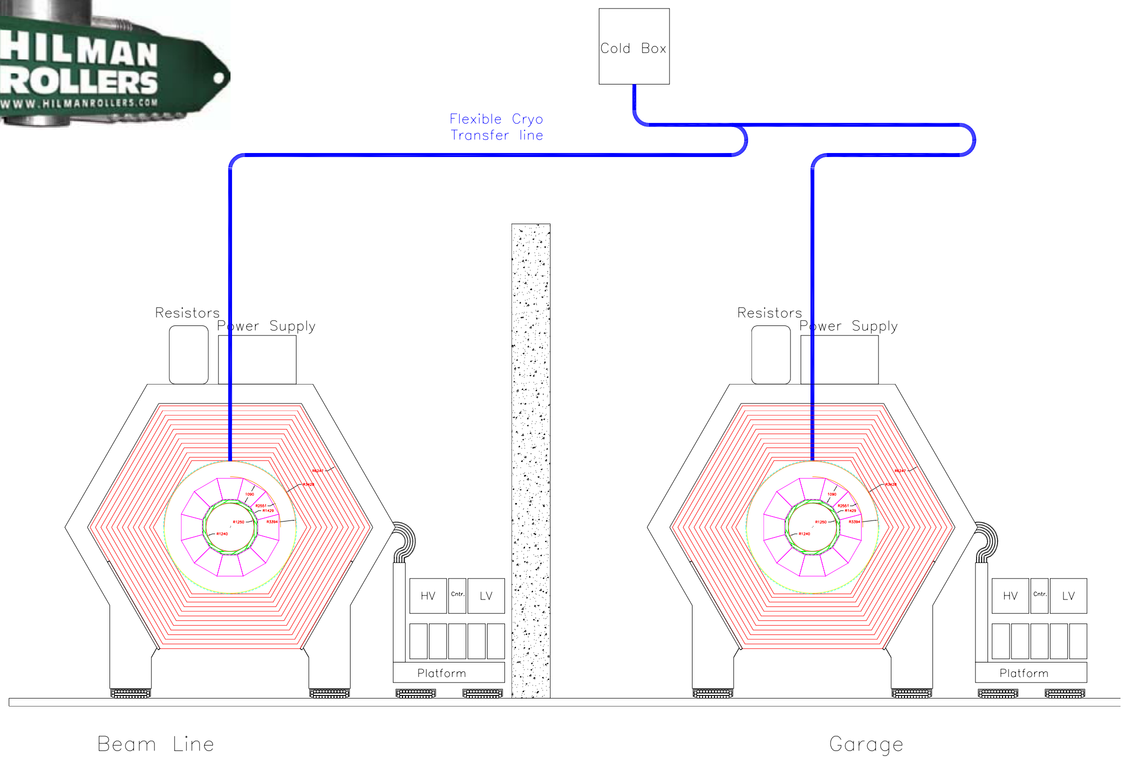
NB: Door PACMAN drawn in reverse by error in this slide

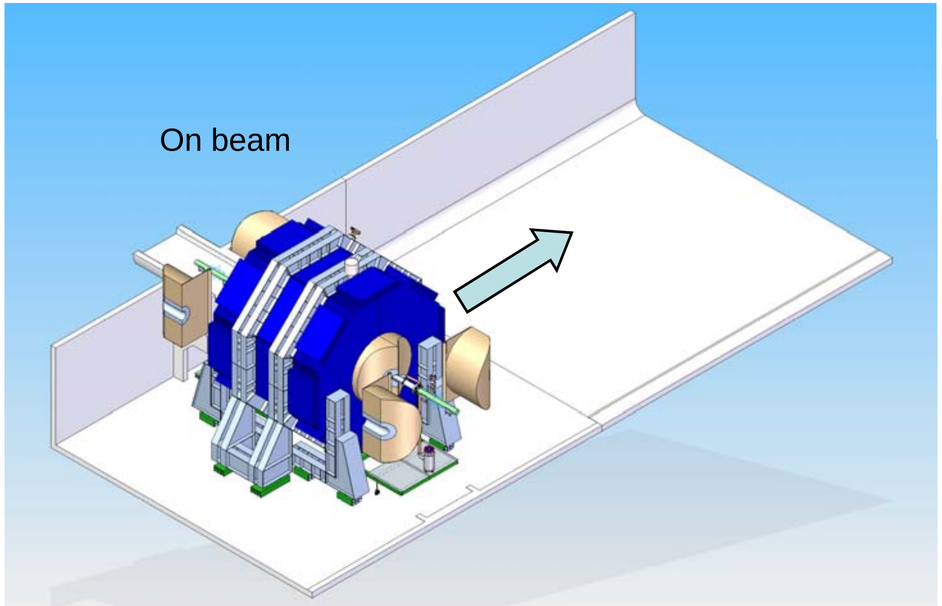
IR Hall Assumptions

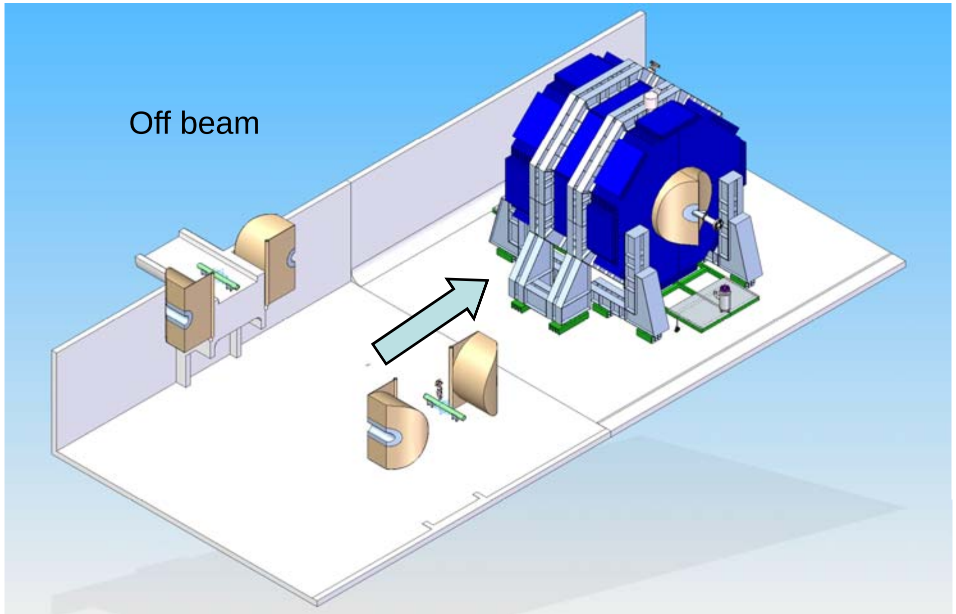
1. Push-Pull and doors opening with Hilman Rollers
2. Racks and ancillaries on SiD or on a side platforms (location driven by the the fringe field)
3. Cold Box off detector (in the hall)
4. Flexible cryogenic transfer line (100mm OD) Solenoid-Cold box
5. He compressors remote

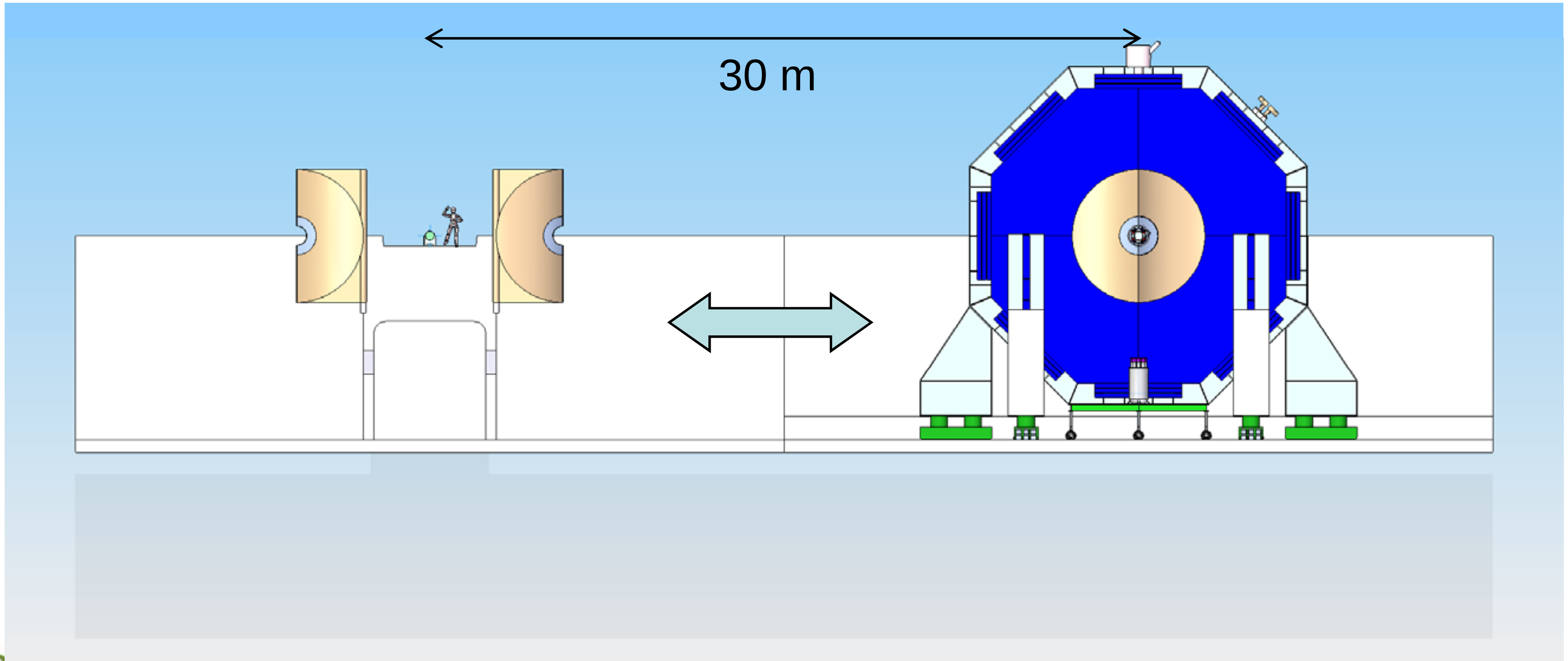
3.5 kton capacity
recently manufactured



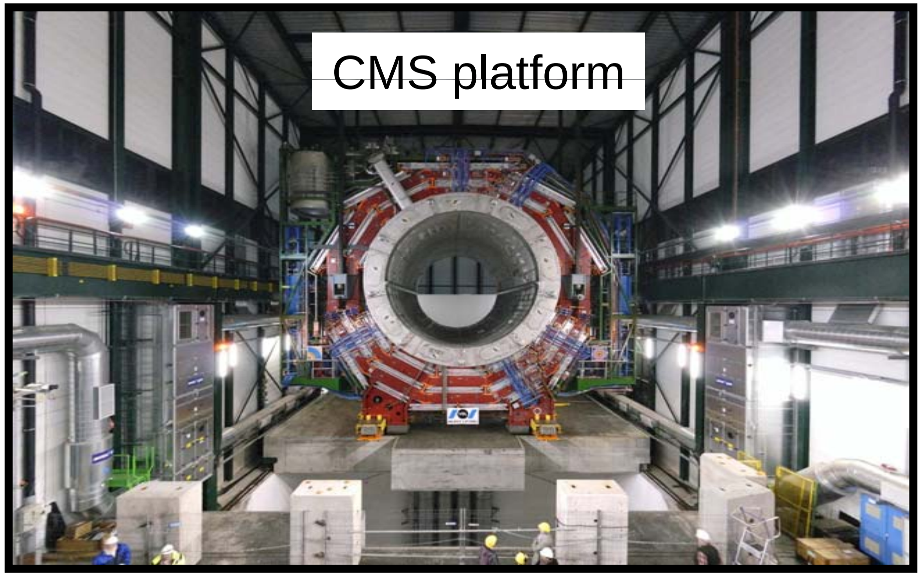


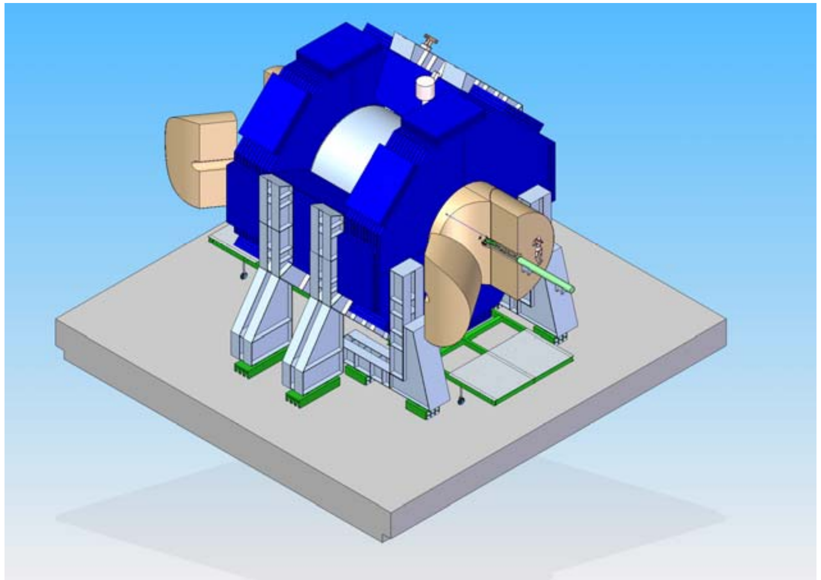

On beam


Off beam

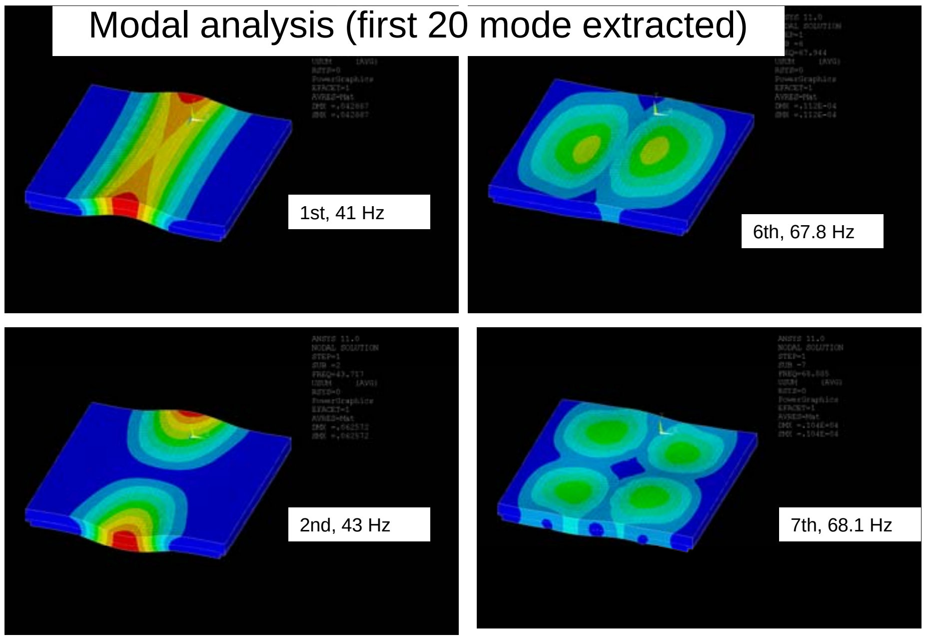

30 m

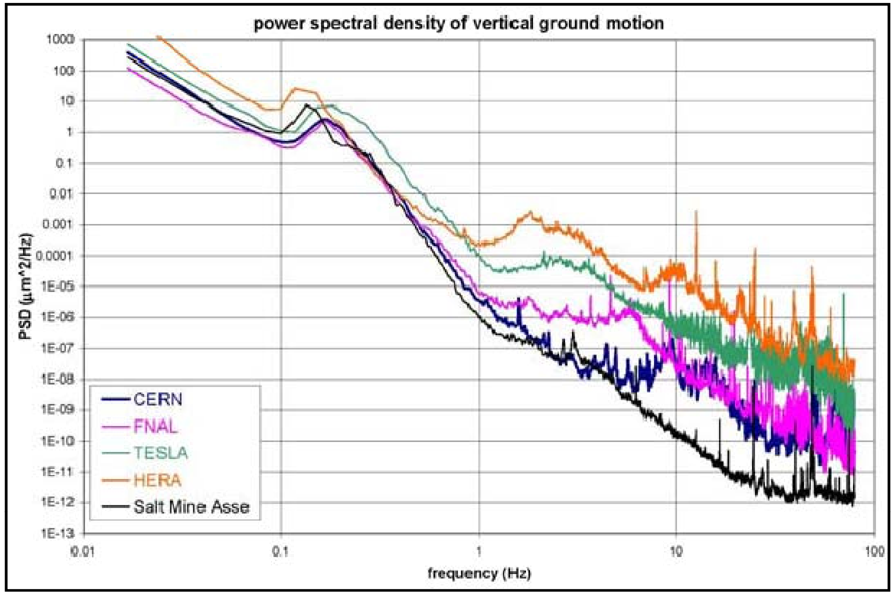
Platforms, vibration and nanometric machines



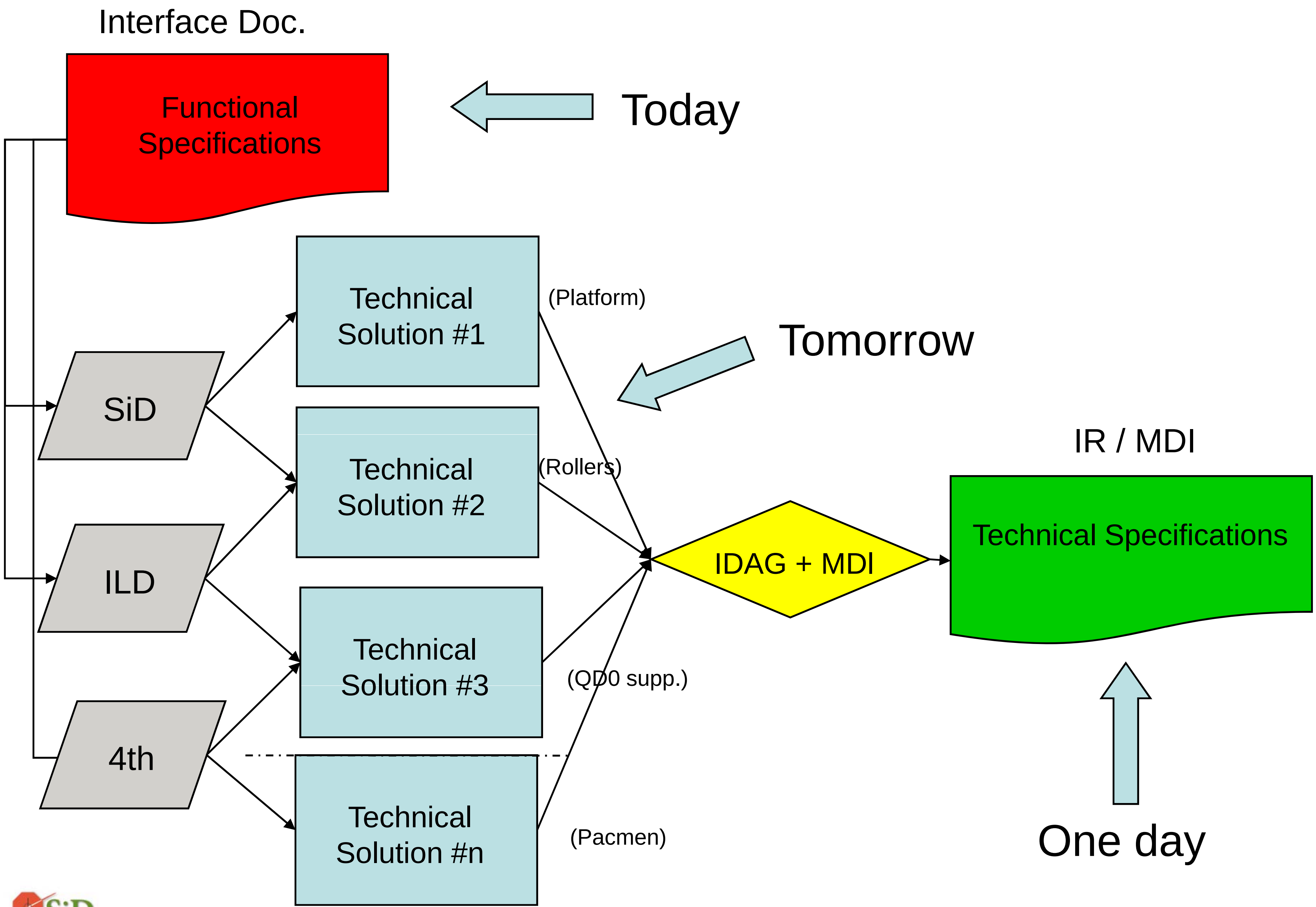


Modal analysis (first 20 mode extracted)





MDI specs decision flow



Thanks for your attention!