SiD MDI & IR Design

Tom Markiewicz/SLAC

SiD Collaboration Meeting, Cosener’s House, Abingdon UK

16 April 2008

Acknowledgements

FCAL/QD0 Engineering Model due to Marco Oriunno:

- *Jan 2008 Talk at SiD CM*
- *April 11, 2008 Update for this meeting*

Integration & Drive: Andrei Seryi
Co-SiD-MDI Leader: Phil Burrows

SiD Assembly Concept: Marty Breidenbach
Tracking & VXD Design: Bill Cooper et al
FCAL & Beampipe Design: Bill Morse et al

IRENG'07 IR Push-Pull Model

- *Brett Parker & BNL for QD0 design*
- *CERN CFS for Hall & Shaft Layout*
- *Many others for vacuum, backgrounds, cryo,…*

Talk Outline

- Evolution of PowerPoint Engineering to Real Engineering in the FCAL/QD0 Region
  - **Discussion of what physics requires of engineering versus the historical design**
    - The R20 vs. R30 vs. R40 vs. R50 question
    - An invitation to discuss what to use for the LOI
- IR Integration Required for the LOI
  - **What does SiD deem essential?**
- Review of SiD assembly scheme & IR model based on IRENG'07 and prior work
  - **Much of this (imho) is arbitrary and can be decided much later in the timeline of the ILC**
  - **Existence, however, puts "meat" on the design**

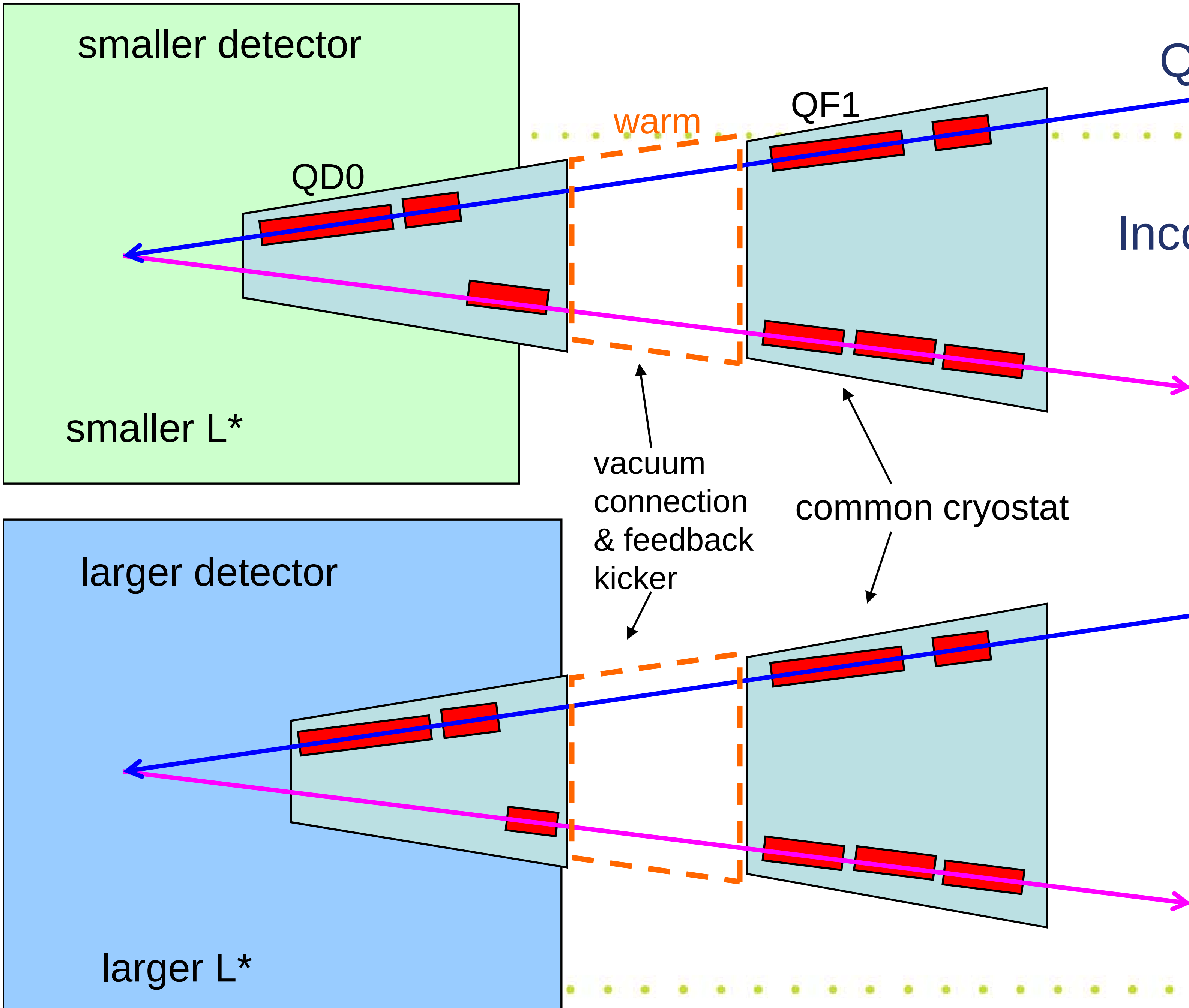
Push-Pull Detectors

Fundamental Assumption for “Rapid” Switch

- QD0 moves with and is supported by detector
  - **L* optimized for each detector but 3.5 < L*<4.5m**
- QF1 stationary at L^*_{QF}=9.5m

Passion-generating non-fundamental choices:

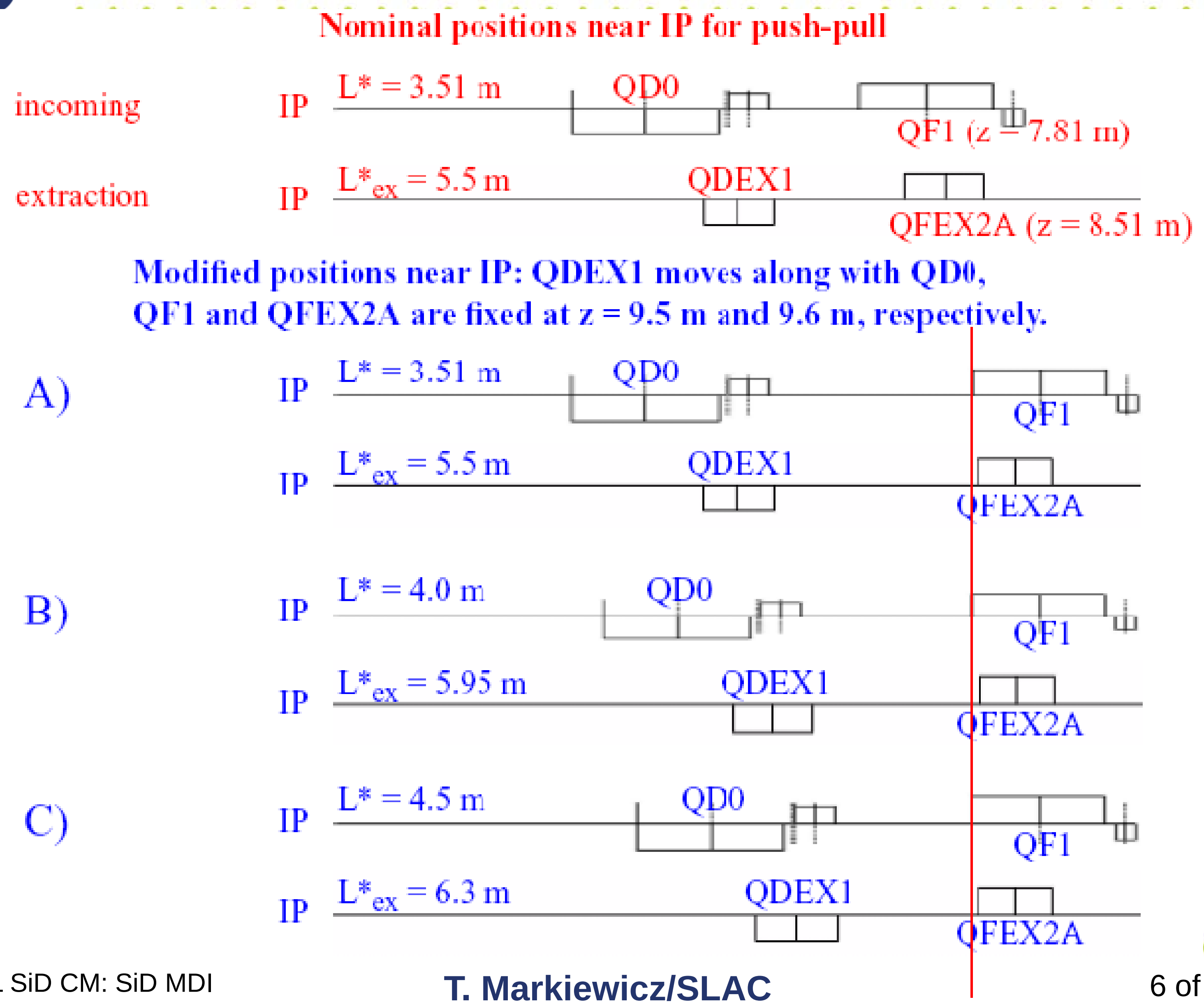
- Self-Shielding vs. Shield Walls vs. Access Restrictions
- Split-able endcaps vs. Non-split endcaps
- Platforms vs. rollers vs. airpads
- Crane capacity, shaft diameters, hall sizes
- Technical design:
  - **cryo plant, cable plant, electronics volume & heat load etc.**



QD and QF Cryostats Contain Incoming and Outgoing Magnet Packages

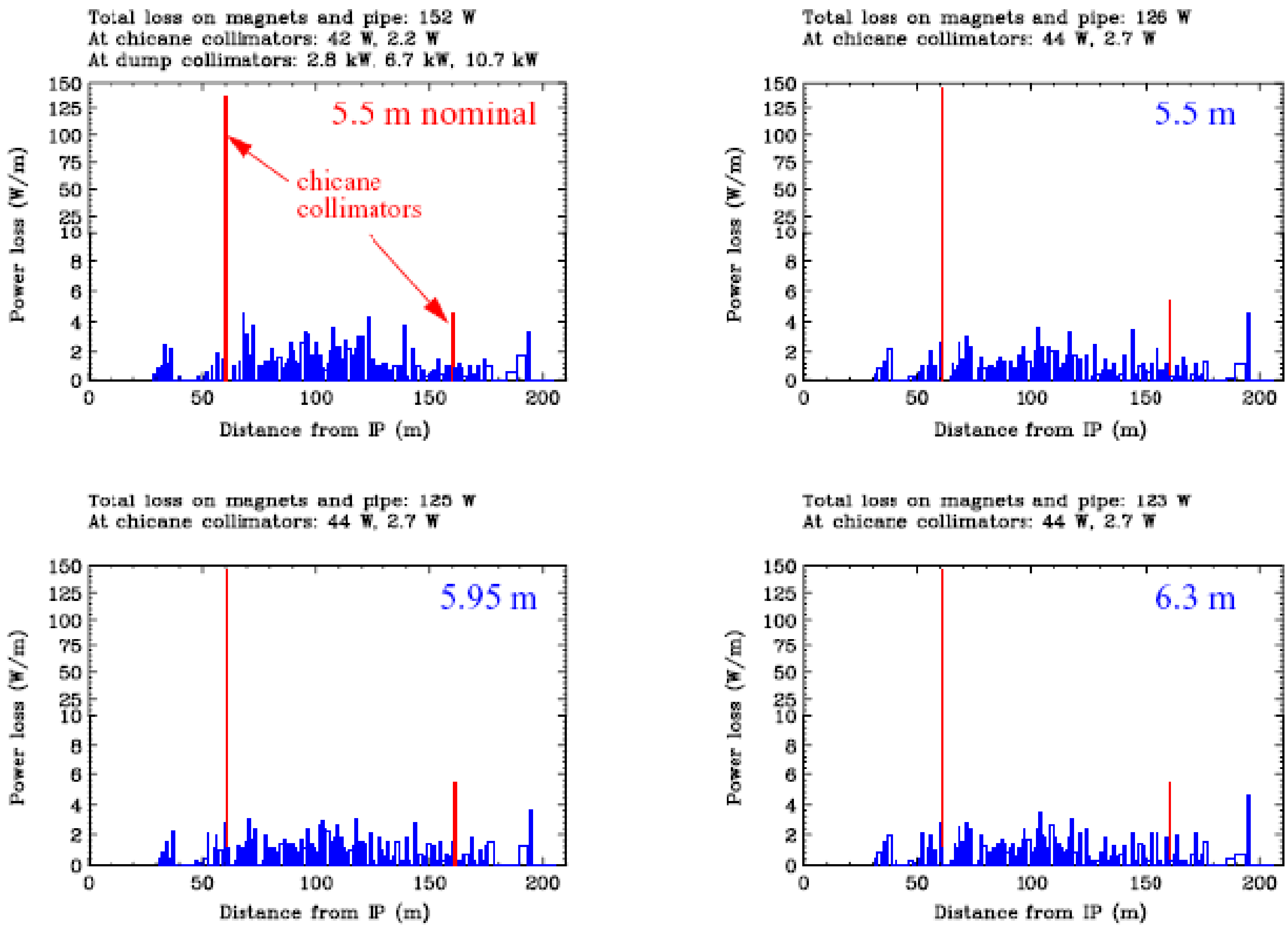
Seryi

Nosochkov/Seryi: Fix QF1 @ 9.5m, L* chosen by Detector Concept: Study **Extraction Losses, Collimation & Optics Sensitivity**



Incoming Beam & Extracted Beam Look OK for Each Solution

Disrupted beam loss for 250 GeV low beam power option (cs14)



SiD IR & MDI Design Philosophy

SiD has traditionally tried to incorporate self-consistent IR/MDI design based on assumptions that detector would

- **Have solid endcap doors and be self-shielded**

We have assumed push-pull would require

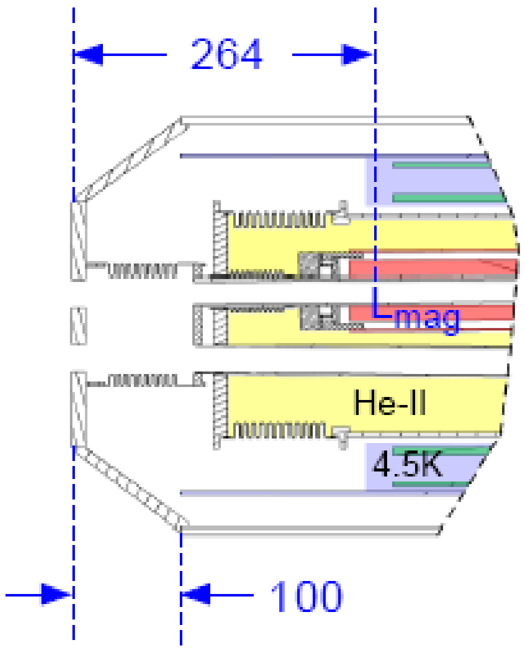
- **No connection of FCAL/Doublet support structure to a fixed point other than the detector**

We have tried to

- **Minimize diameter of the FCAL/Quad package**

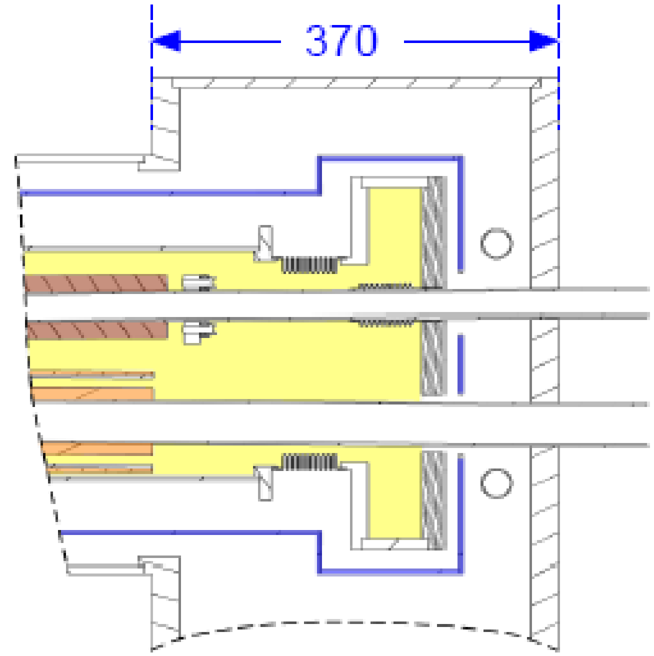
But until recently (M. Oriunno & SiD Eng. Group) only “PowerPoint engineering” was possible

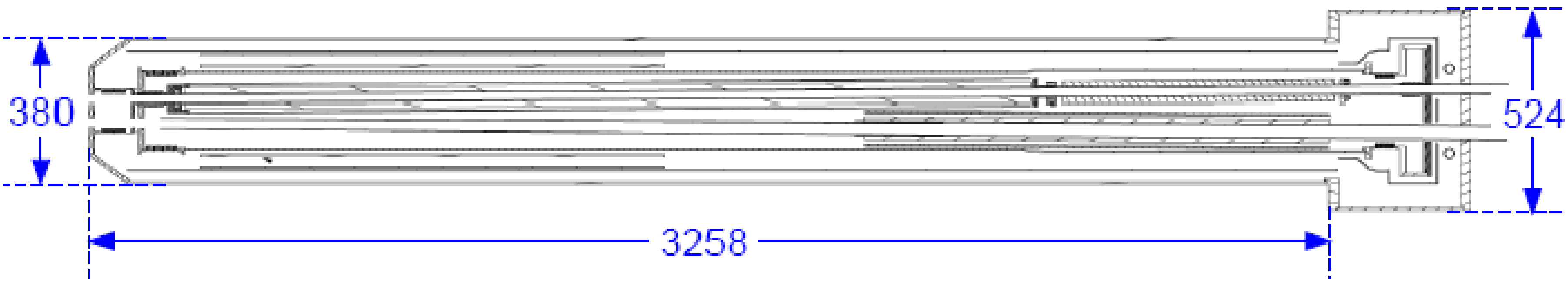
Pre-IRENG'07 QD0 Design: 38cm O.D. with 52.4cm O.D. Back End



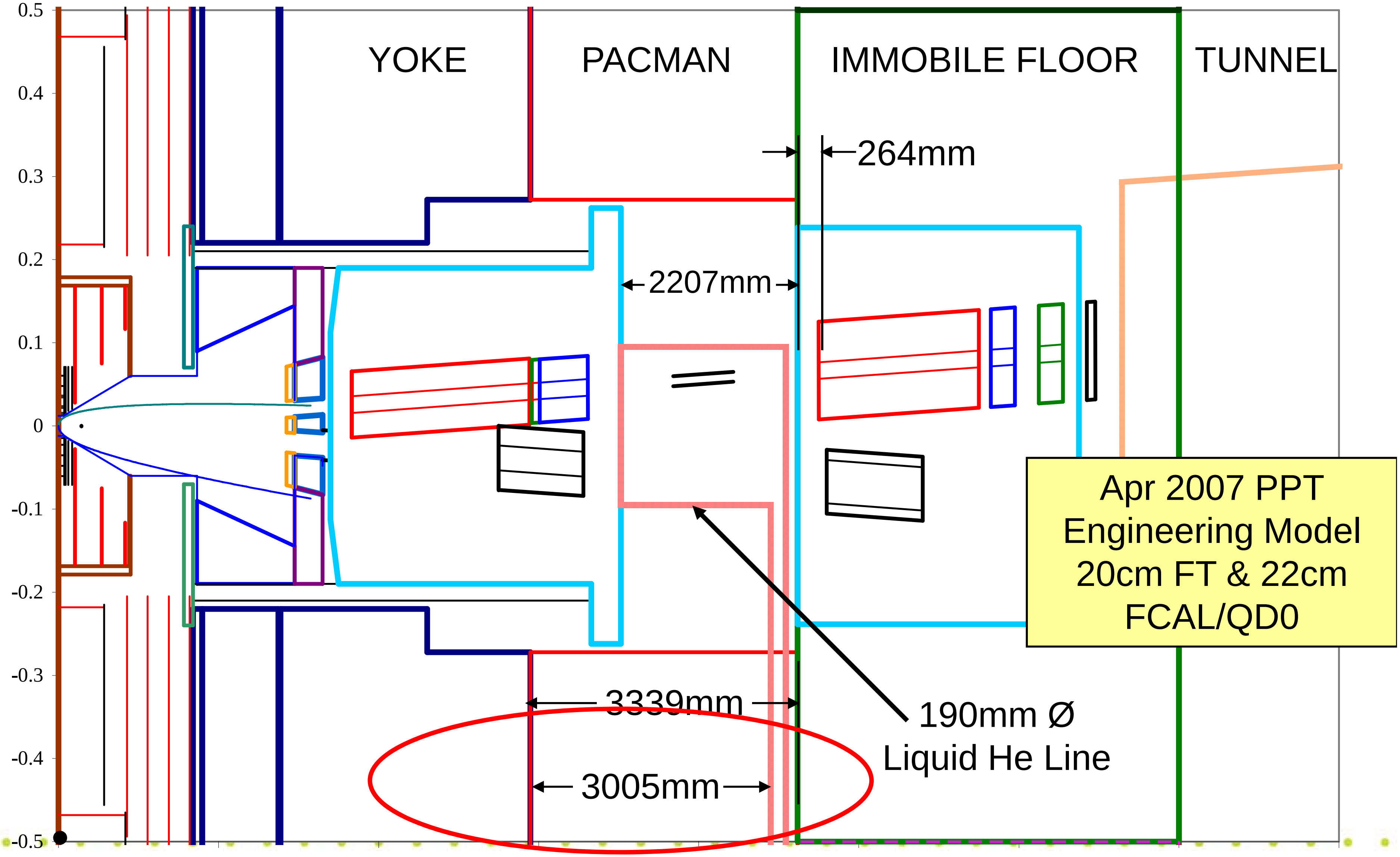
QD0 cryostat with a force neural anti-solenoid compatible with L* of up to 4.5 m.

Plan views are drawn at beams' common midplane; dimensions are as indicated in millimeters.

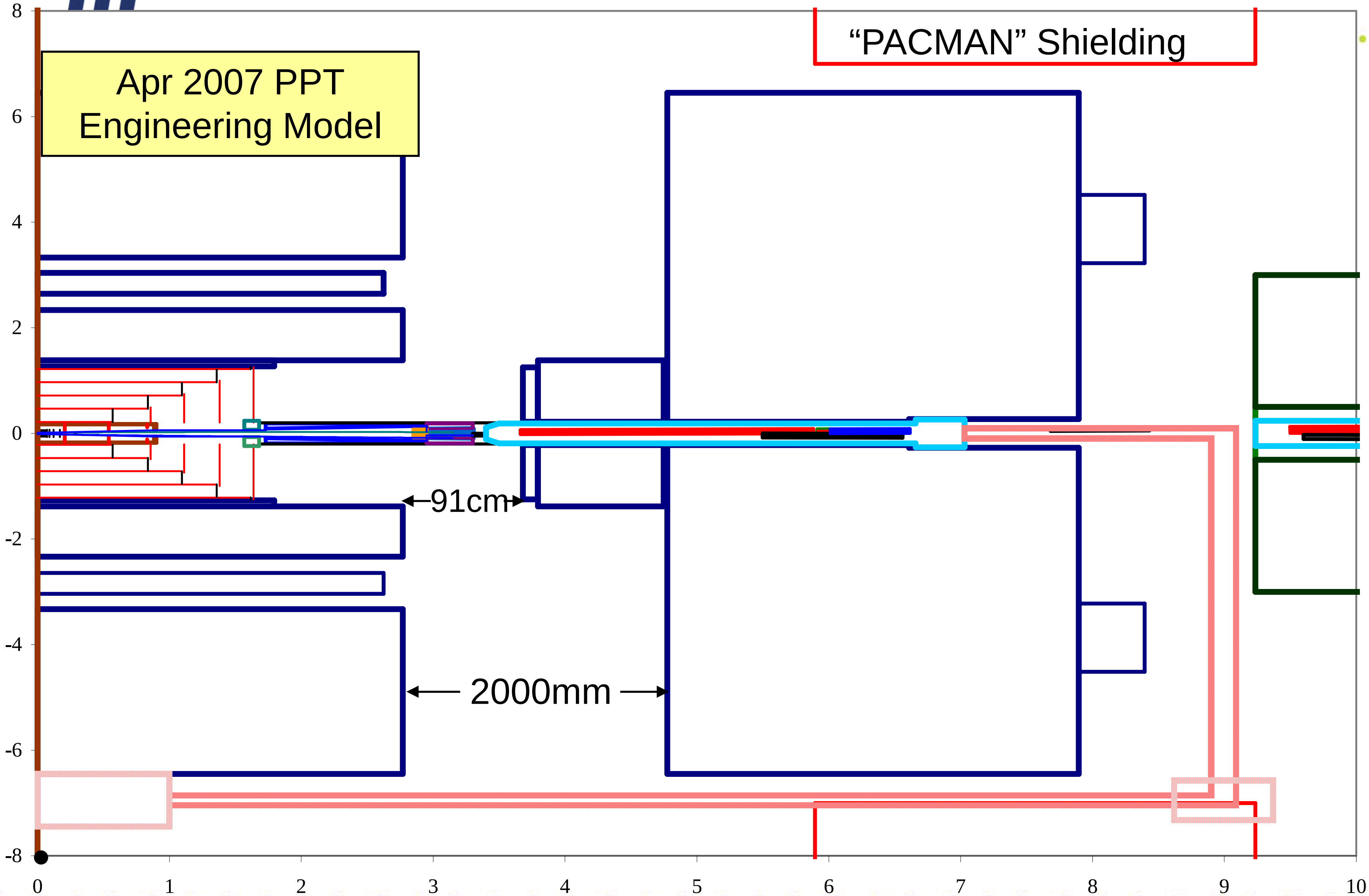




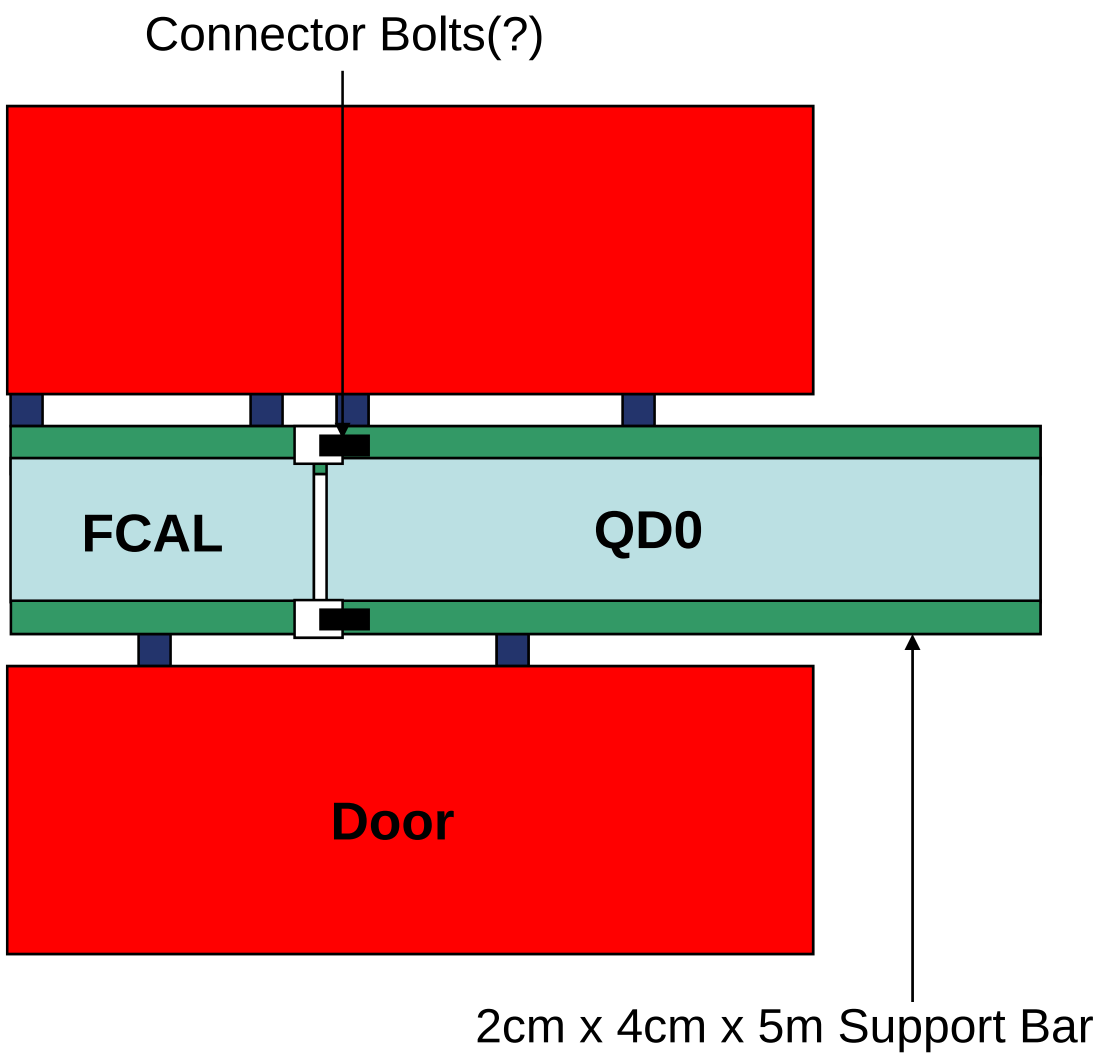
SiD r<50cm, L*=3.664m, 14mrad, Push-Pull, QF@9.5m, Door Closed



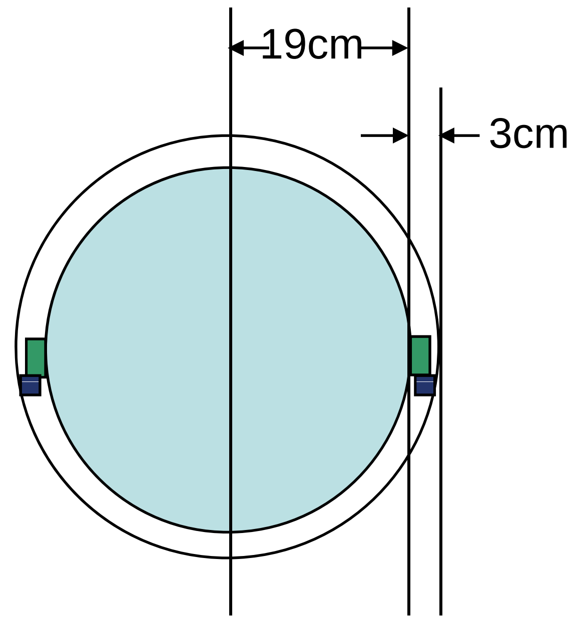
Door Open, Permanent QD0 Liquid He Line



FCAL/QD0 Supported with Door Closed



44cm Diameter Hole in Door



Apr 2007 PPT Engineering Model

Deflections of 2cm x 2cm Support Bars when Door Opens 2m

- Support points with rollers were assumed at front and rear of HCAL (Z = 3820, 4770 mm).
- Forward calorimeters supported at their ends as dead weights
- QD0 weight ignored

4 - 20 mm x 20 mm bars

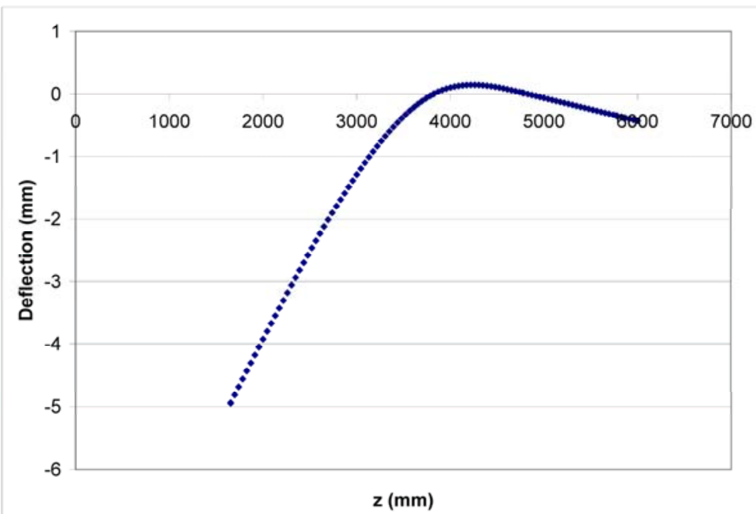
Deflection at front of Lumi-CAL = 4.9 mm

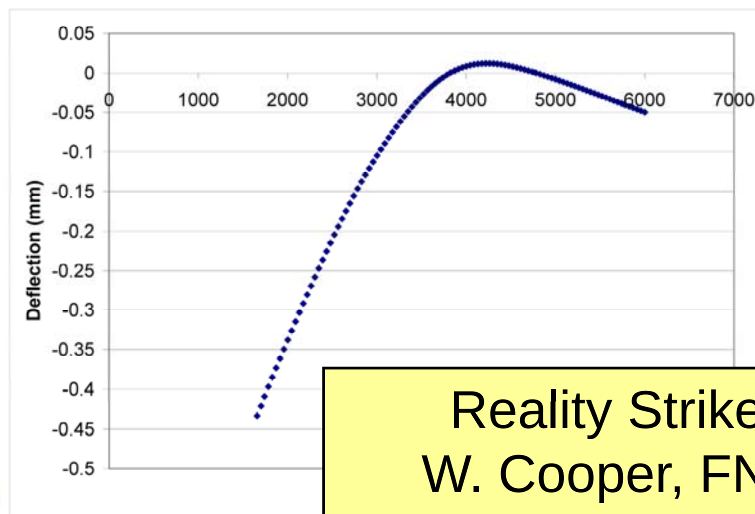
Stress in bars = 12.7 ksi

Stepped cylinders (3, 10, 20 mm walls)

Deflection at front of Lumi-CAL = 0.43 mm

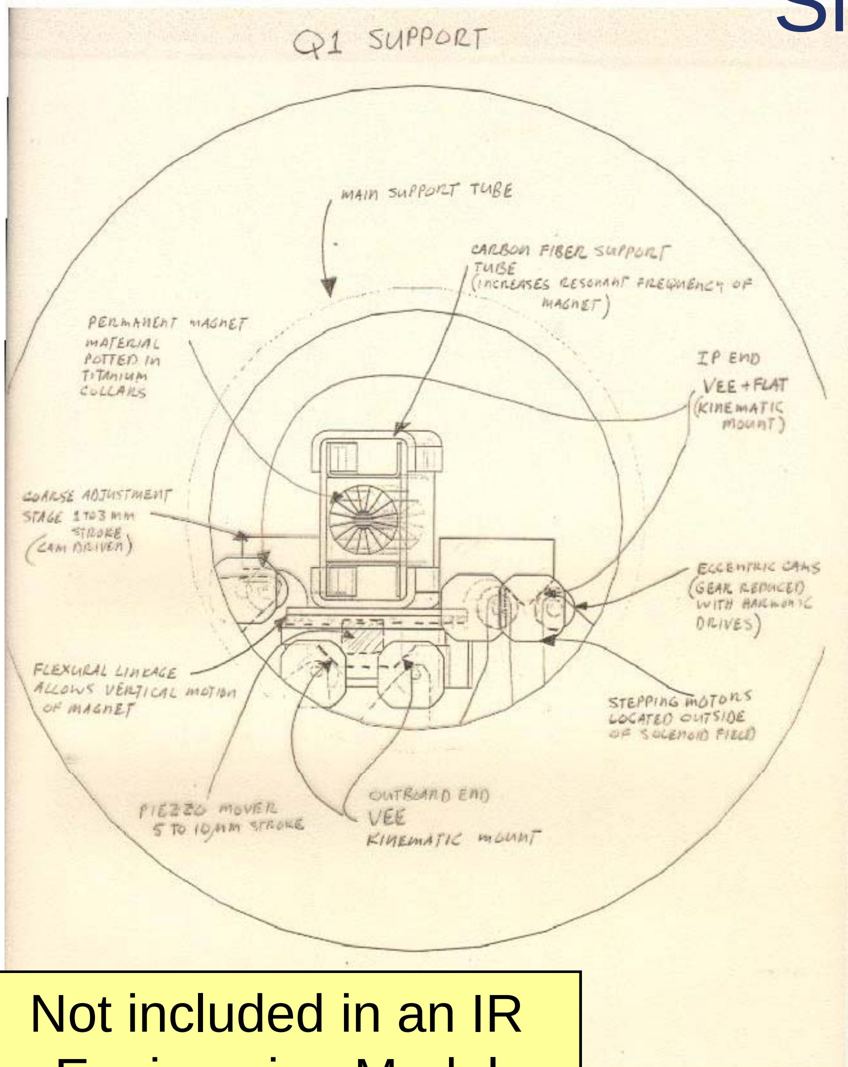
Stress in cylinders = 1.0 ksi



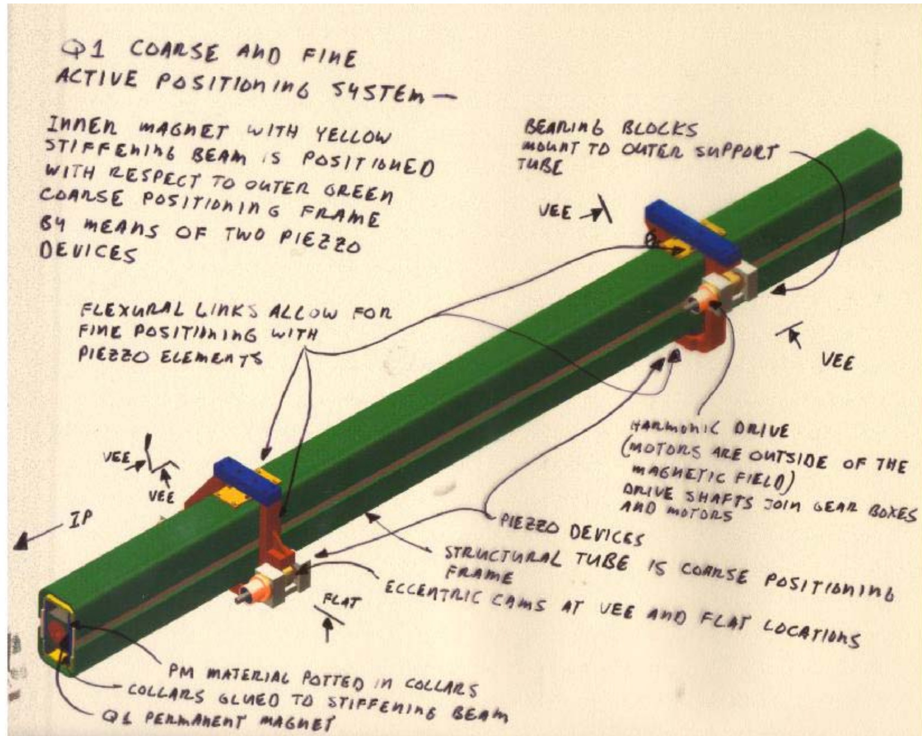


Reality Strikes:
W. Cooper, FNAL
Oct 2007 ALCPG Mtg

QD0 Package Adjustment Mechanism Likely to Require Significant Radial Space

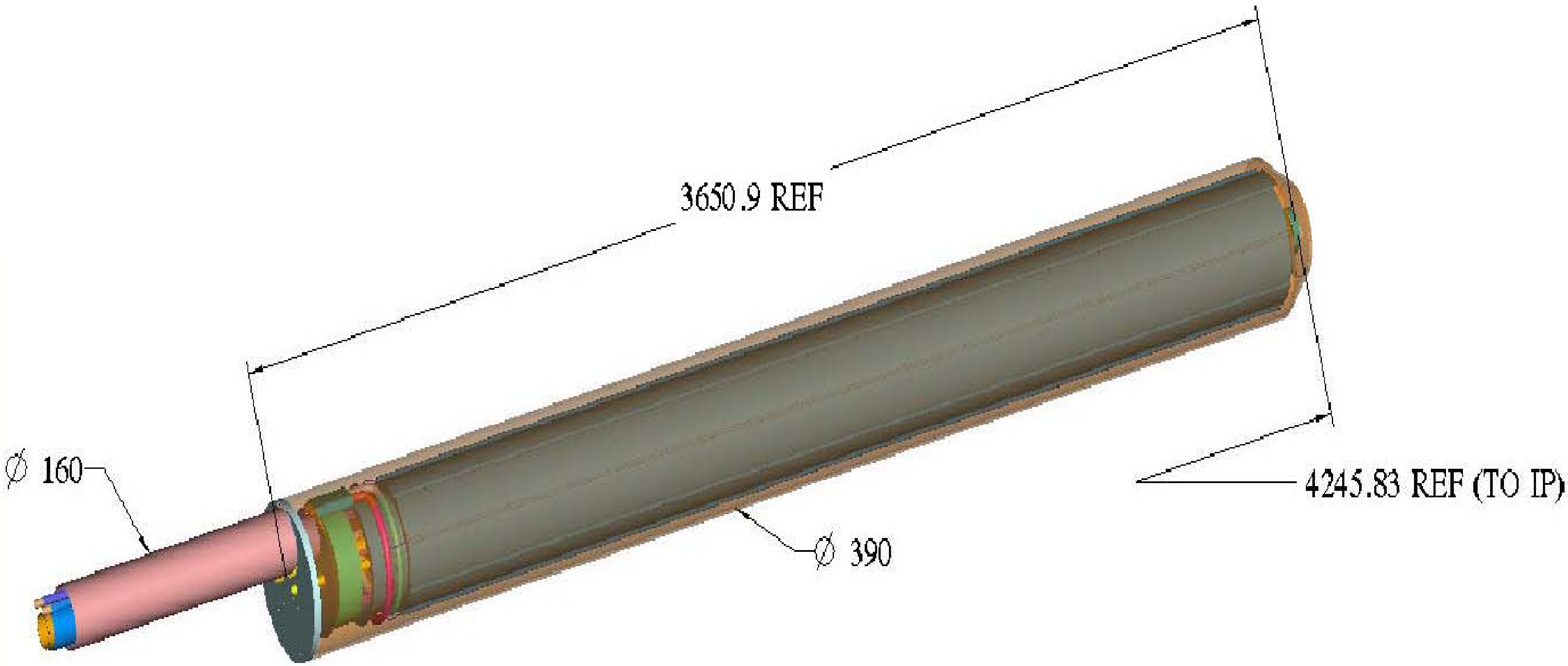


Knut Skarpaas 2000 Design of Integrated Coarse/Fine Cam/Piezo Mover System for a stiffened PM QD0



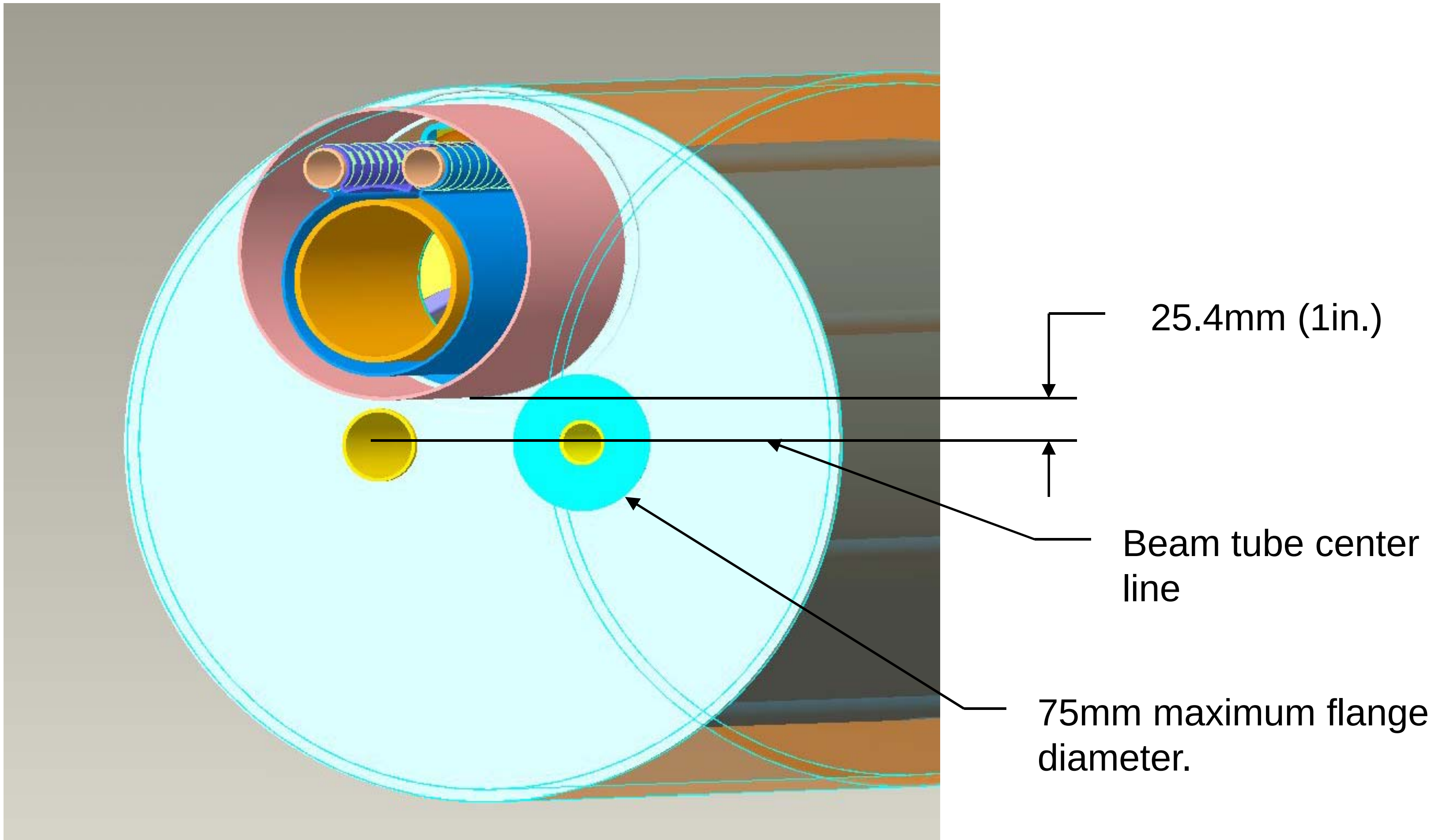
Not included in an IR Engineering Model since 2000

QD0 CRYOSTAT @ IRENG'07
39cm constant radius

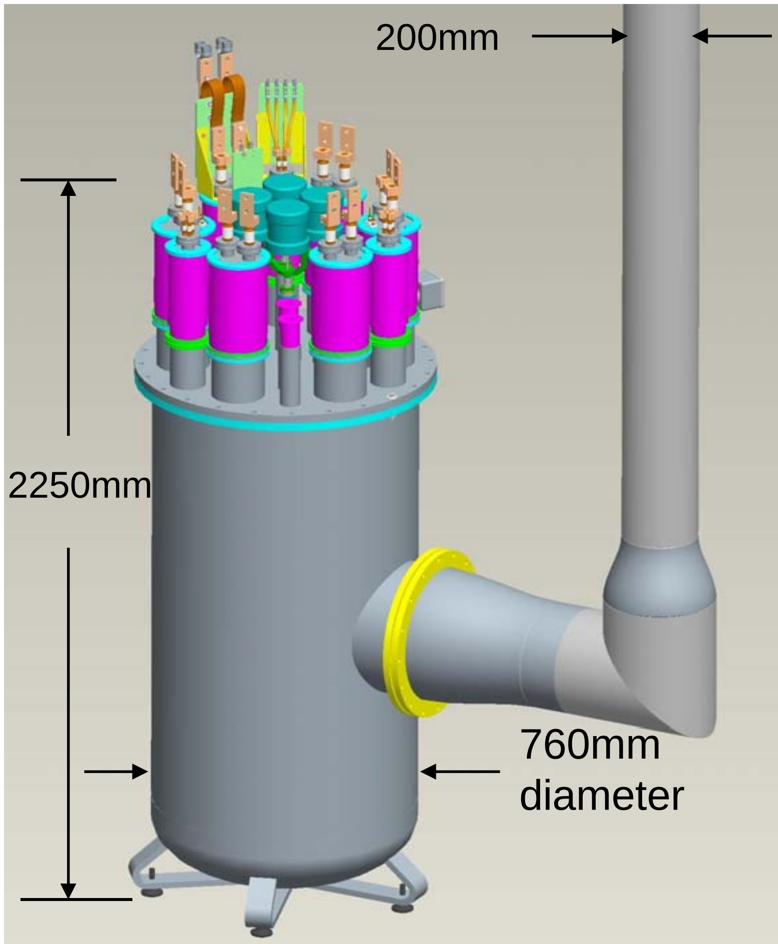


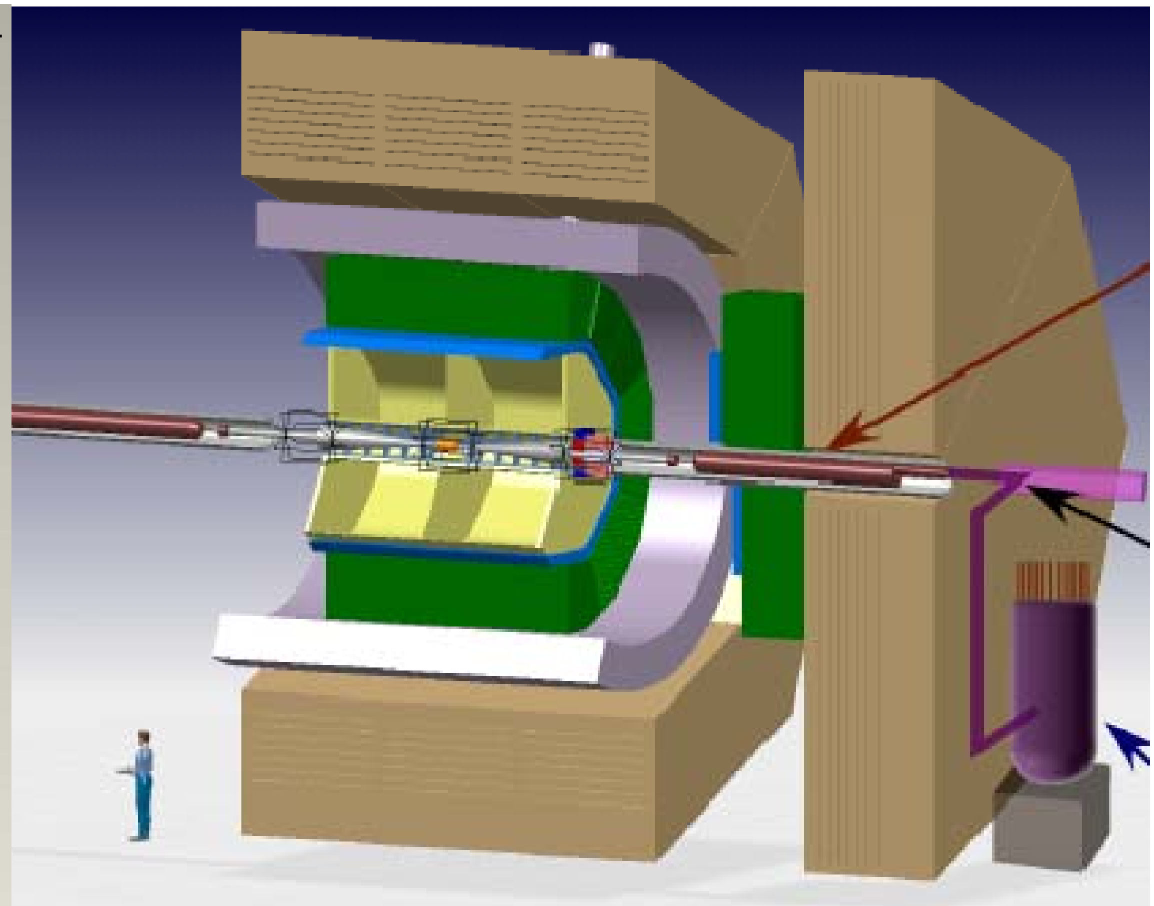
- Overall dimensions of QD0 cryostat.
- For L*= 3500mm distance to IP would be 3245mm

Back End of QD0



Interference Between Movable Door & QD0 Service Cryostat

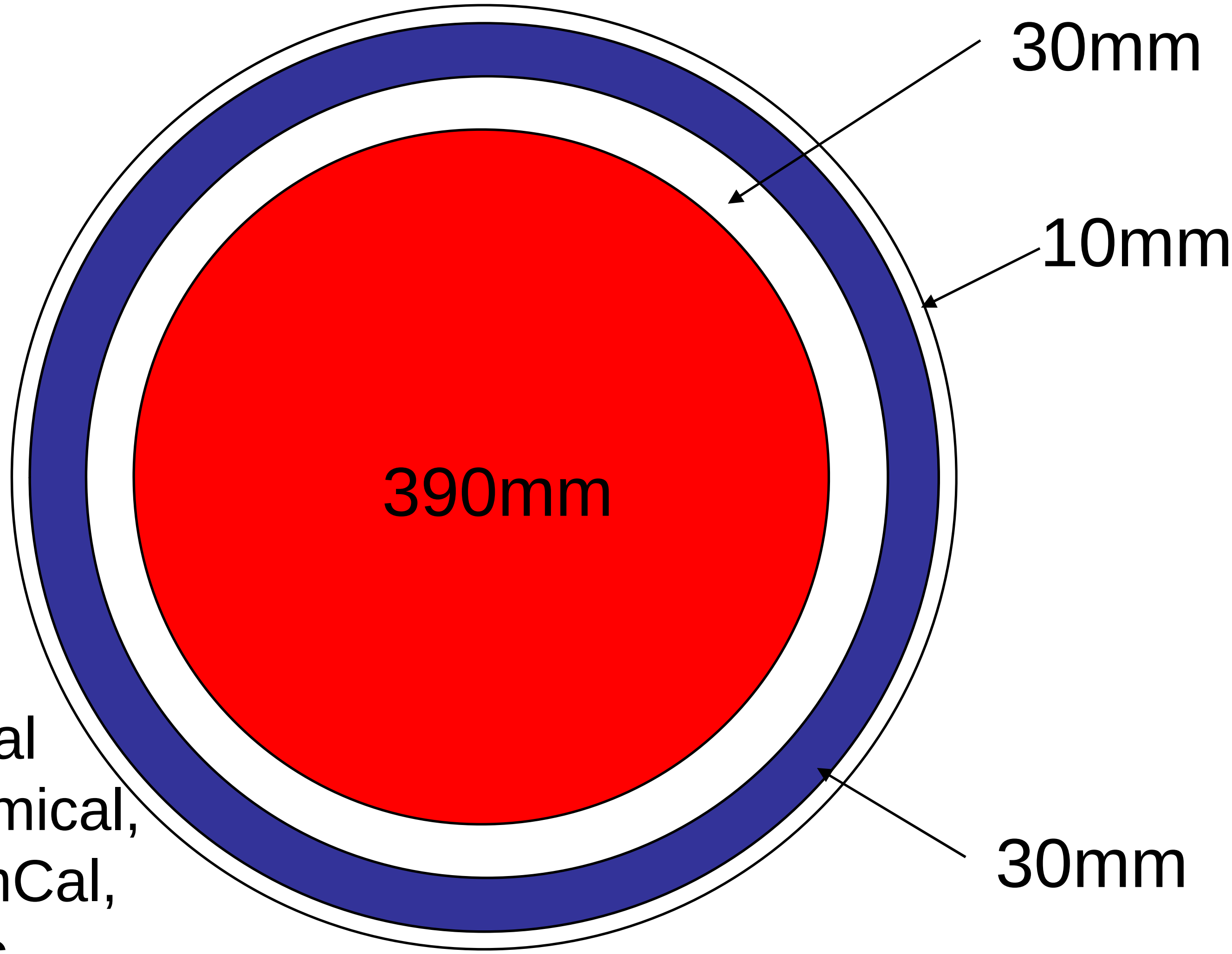




Overall service cryostat dimensions

390mm QD0 + 2 x 30mm Support Tube Wall
+ 2 x 30mm space for adjustment mechanism
+ 2 x 10mm clearance = 530mm hole in door

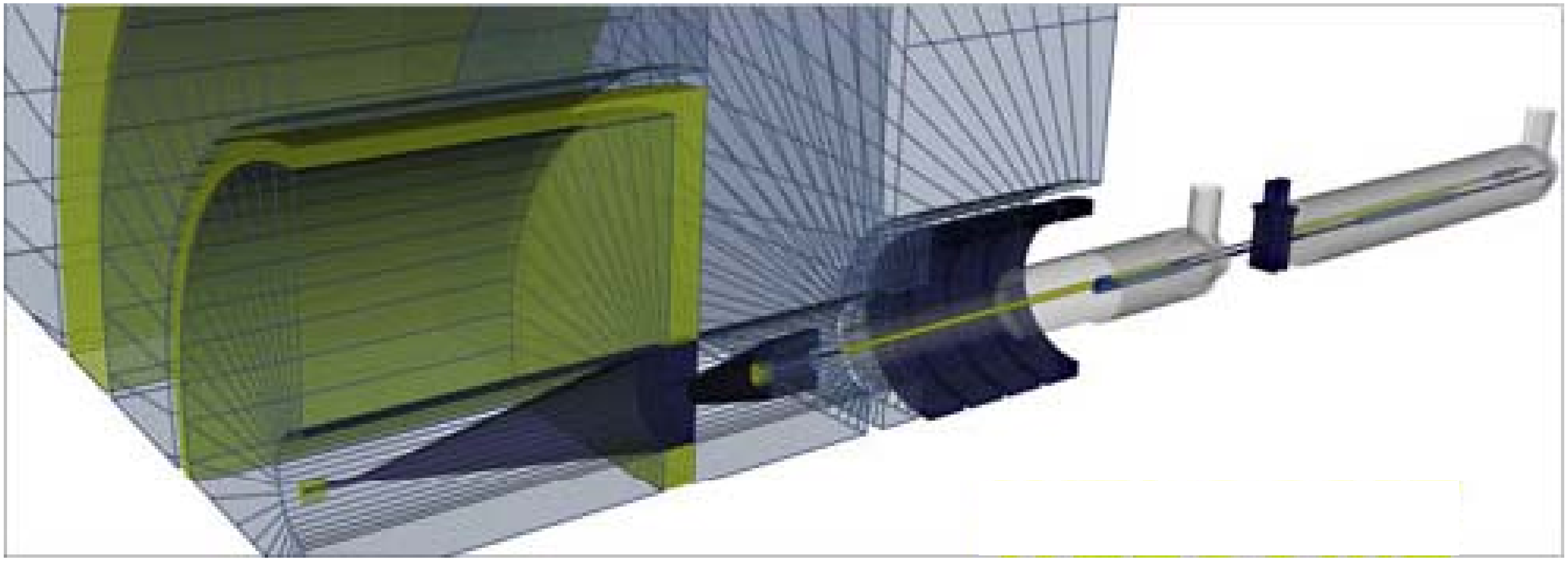
TWM Proposal to SiD Oct 2007 ALCPG to enlarge FCAL/QD0 radial space



530mm total diameter of Lumical, FHCAL, BeamCal, Masks, etc.

SiD Collaboration Meeting

January 28-30, 2008
Stanford Linear Accelerator Center

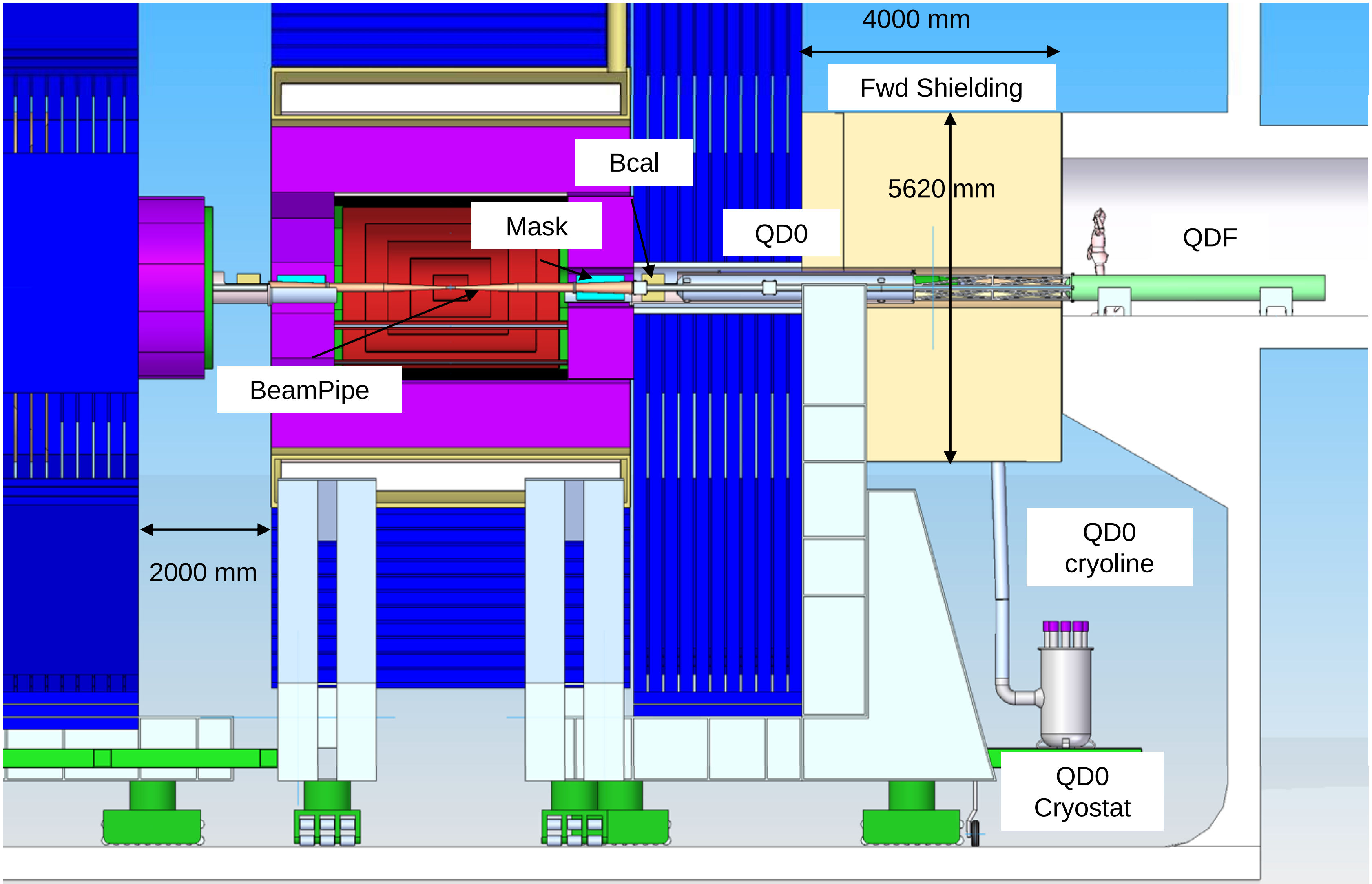


Forward Region Engineering

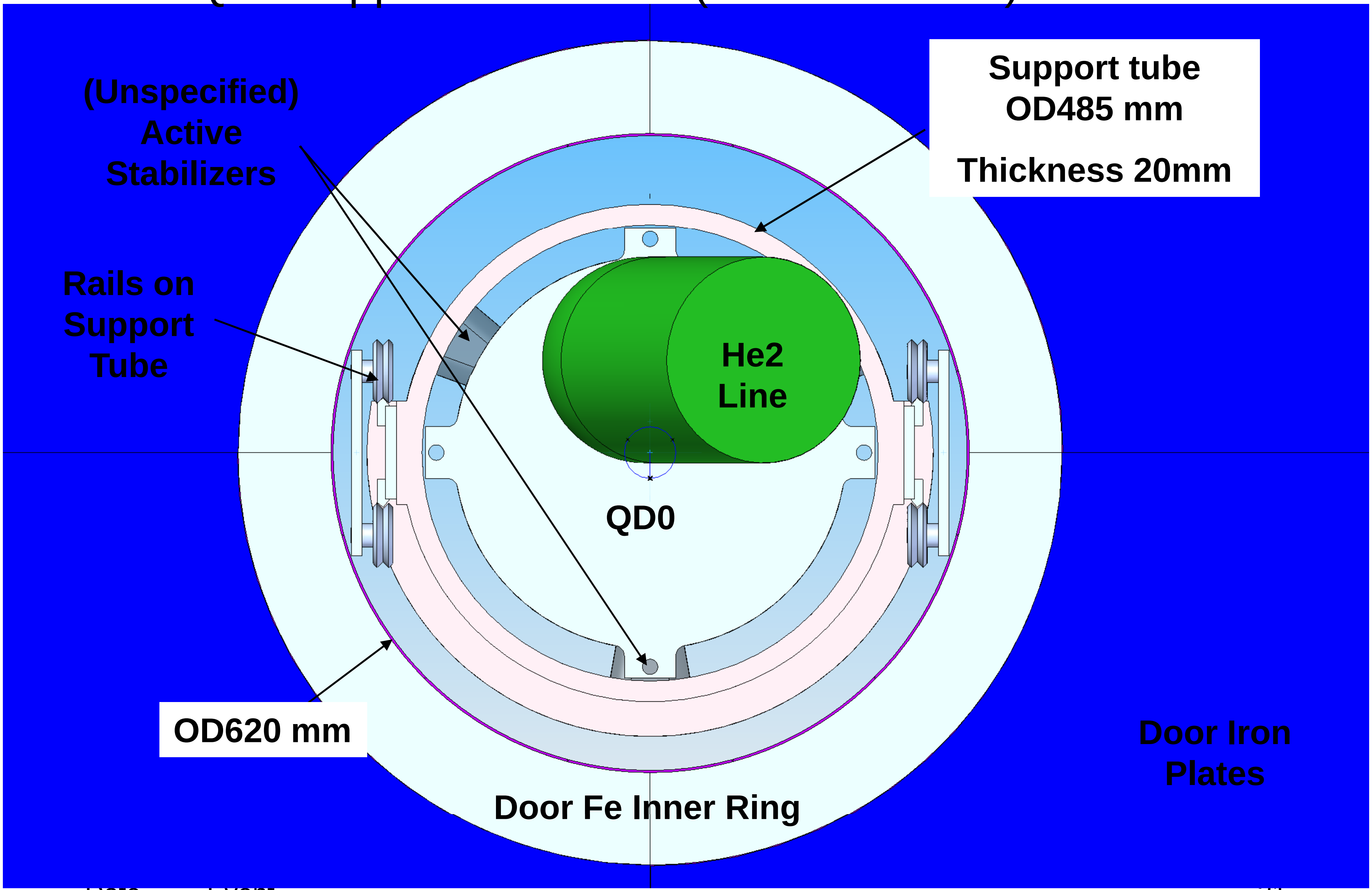
Marco Oriunno, SLAC

Machine-Detector Interfaces

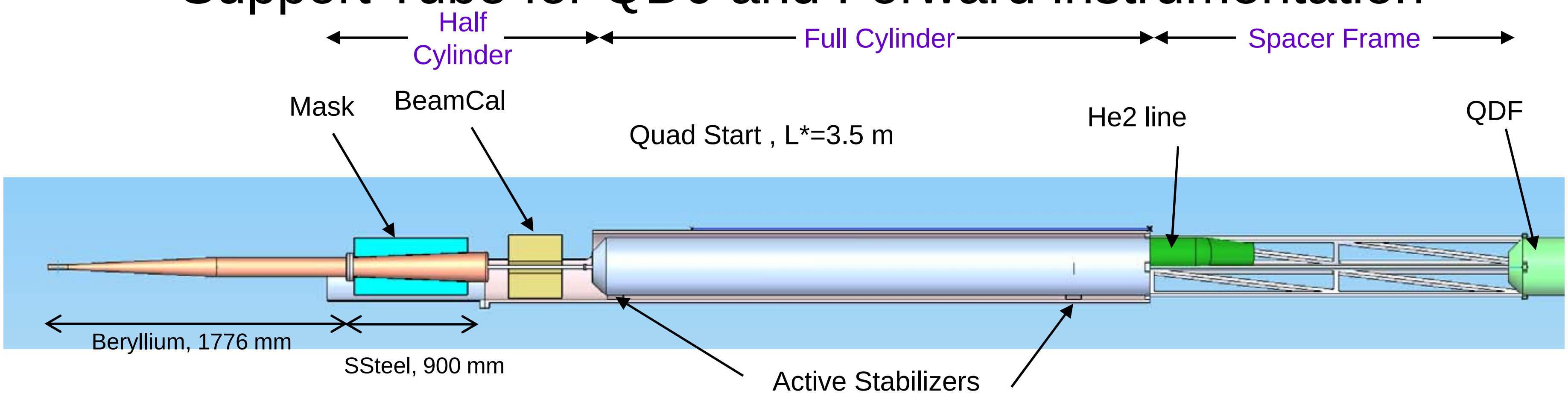
The first step is to translate the parameters in an engineering model, formulating technical solutions, clearances and components integration

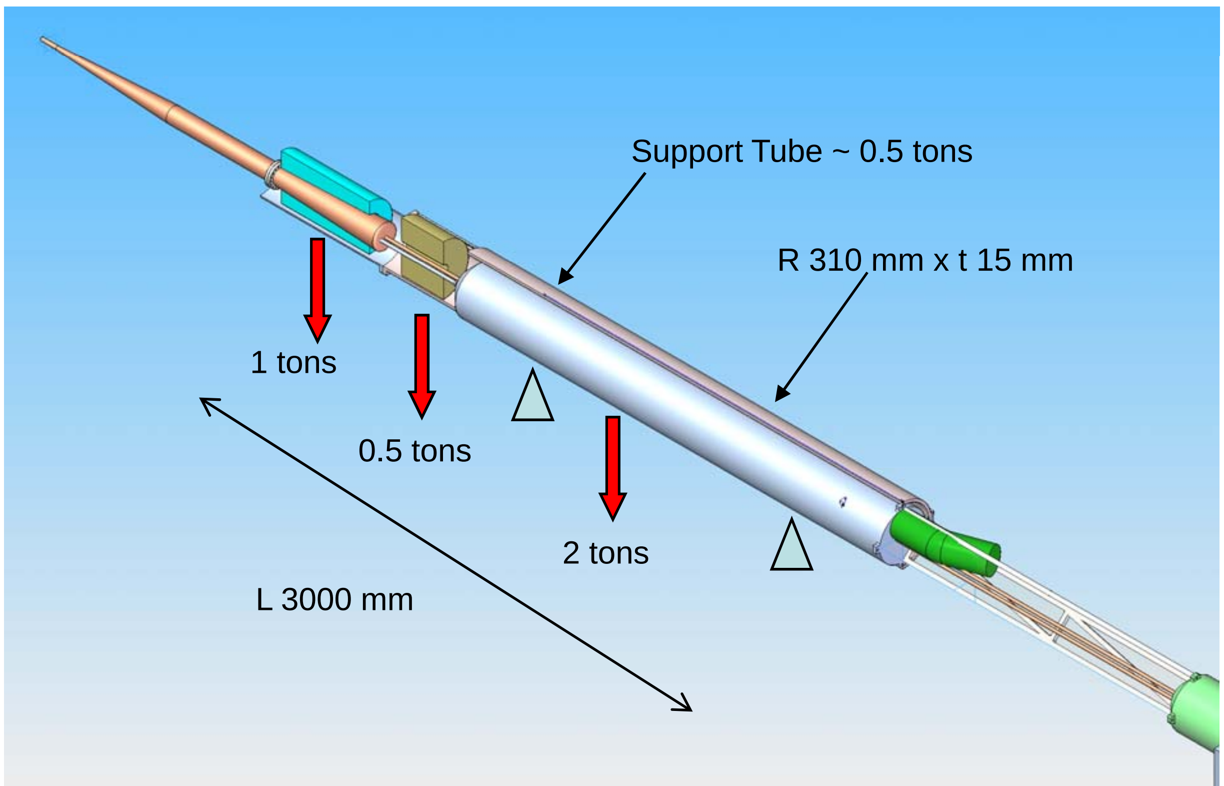


QD0 support in the door (view toward IP)-Jan. 2008



Support Tube for QD0 and Forward instrumentation

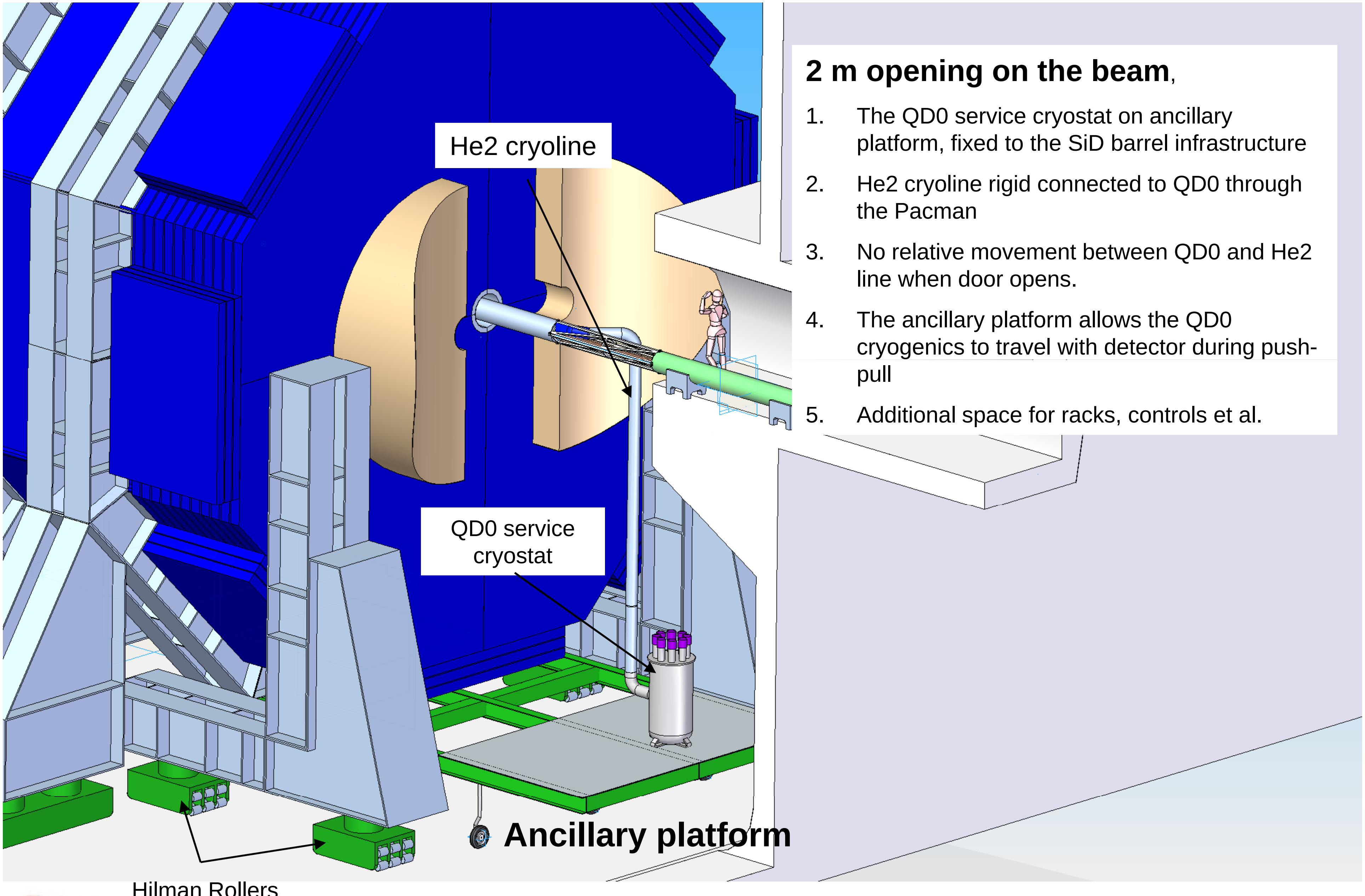




- The support tube provides an interface to the door to support QD0, the vacuum chamber, the beam instrumentation and the forward detectors

- An alternative option has sliding rails directly on the QD0 cryostat and the vacuum and detector instrumentation cantilevered from the front of QD0 with actuators directly on the door.

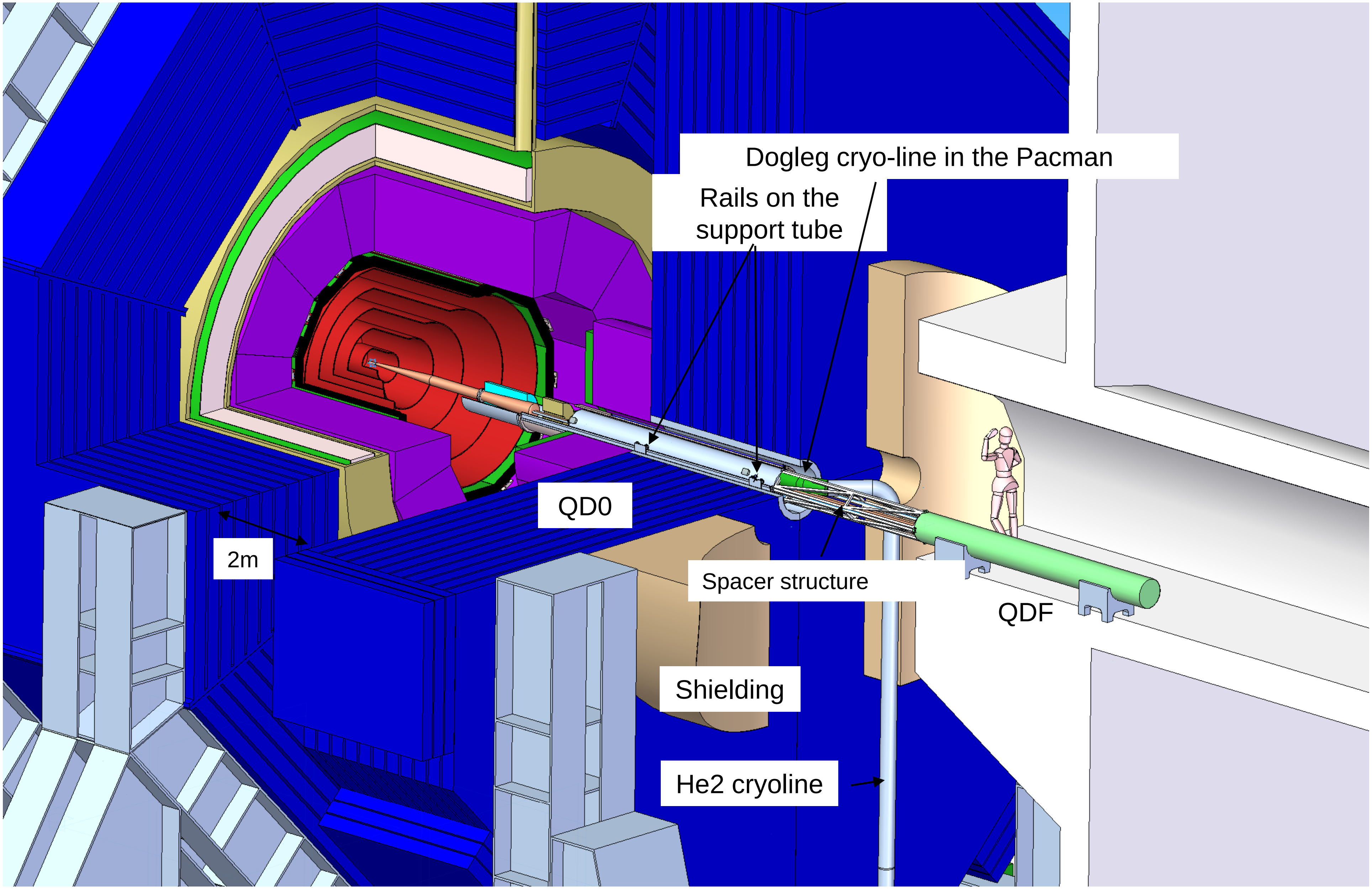
Integration of the QD0 cryoline



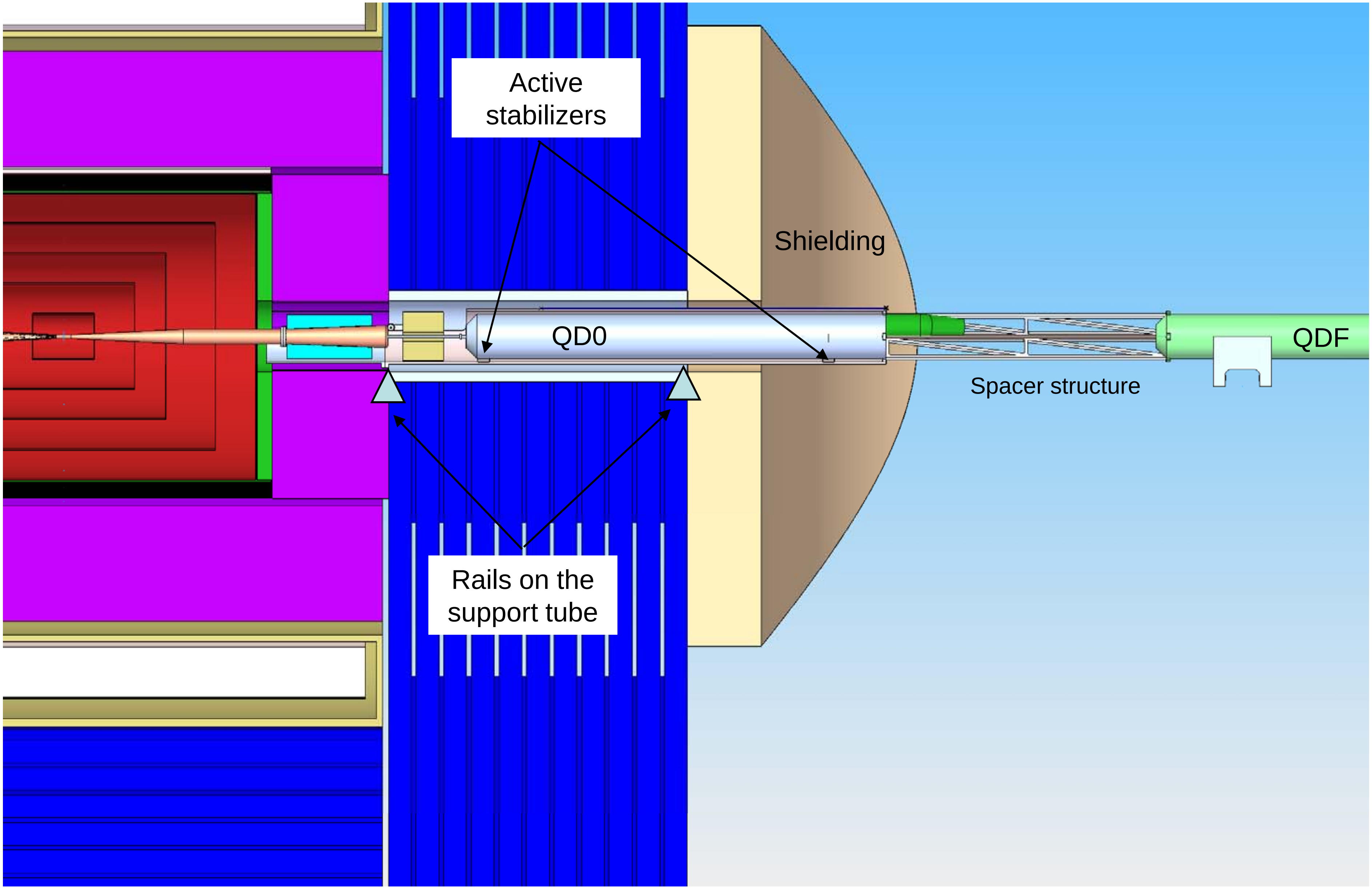
2 m opening on the beam,

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.

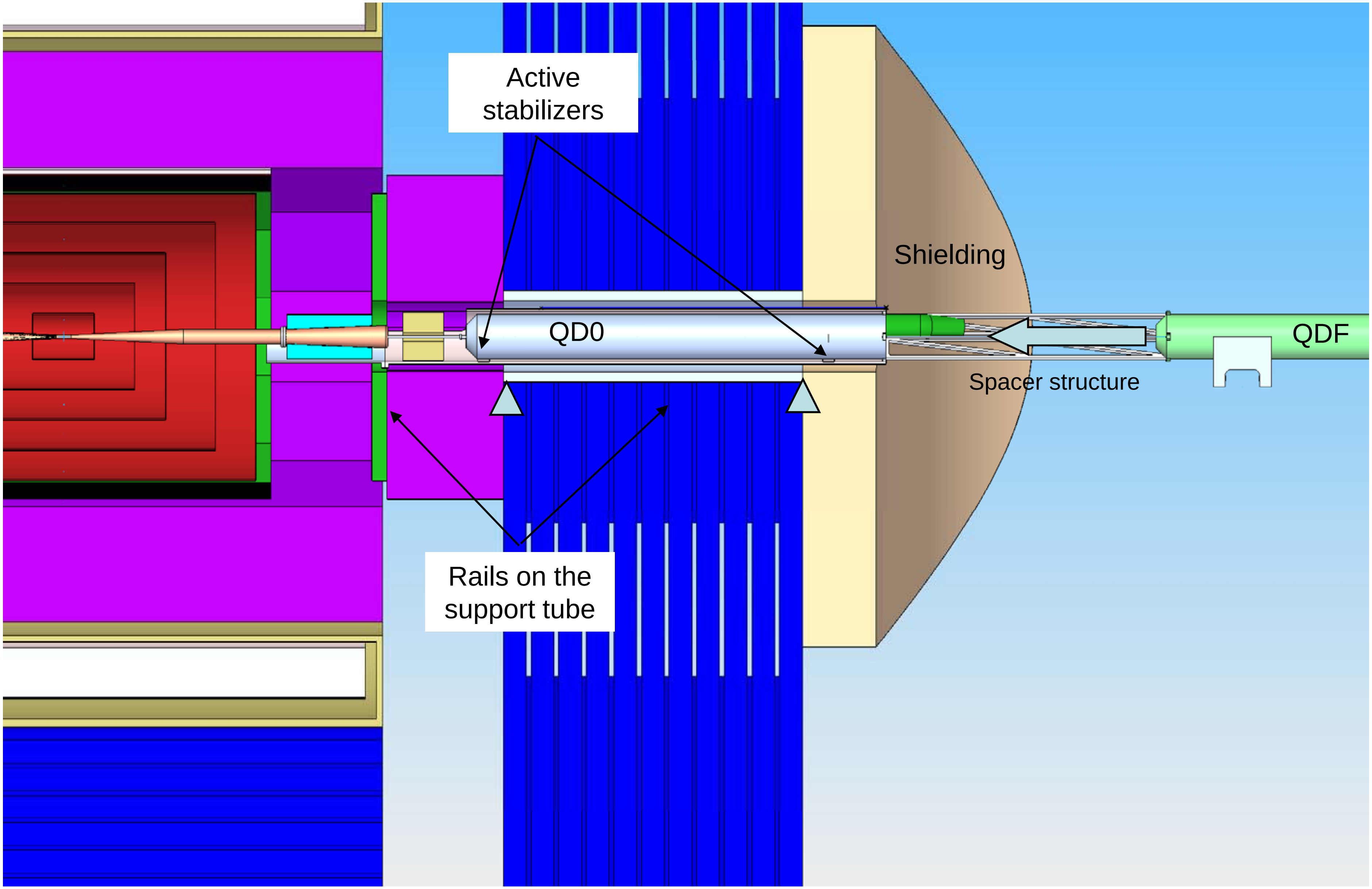
2m Door opening Procedure, on the beam



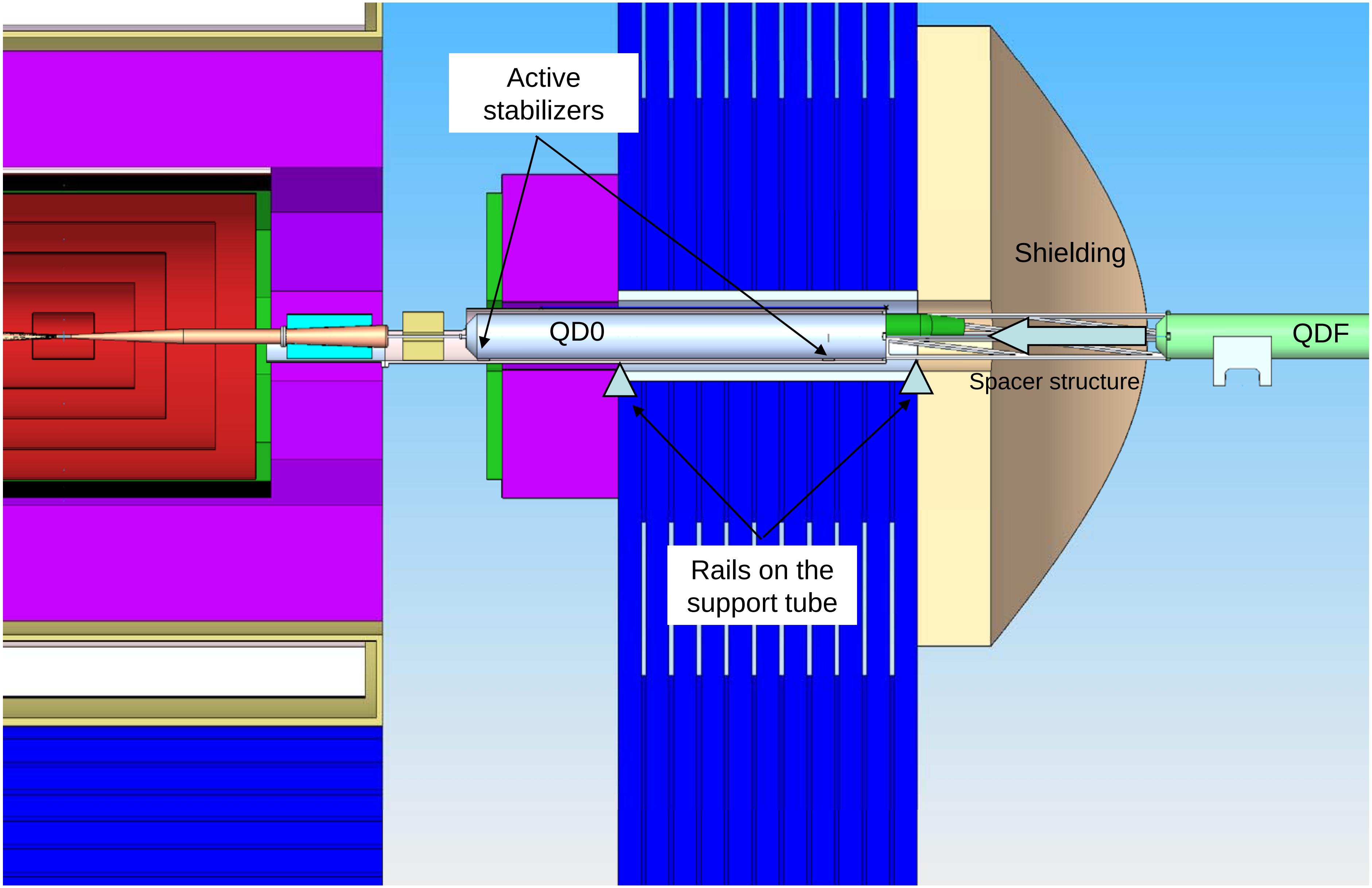
2m Door opening Procedure, on the beam I



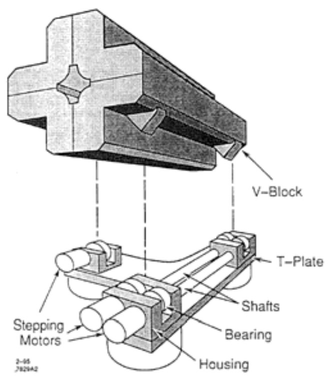
2m Door opening Procedure, on the beam II

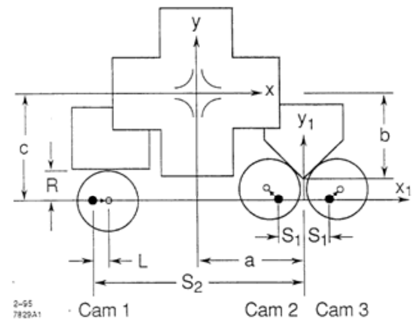


2m Door opening Procedure, on the beam III

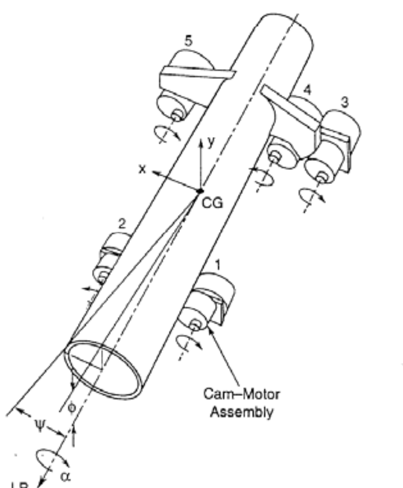


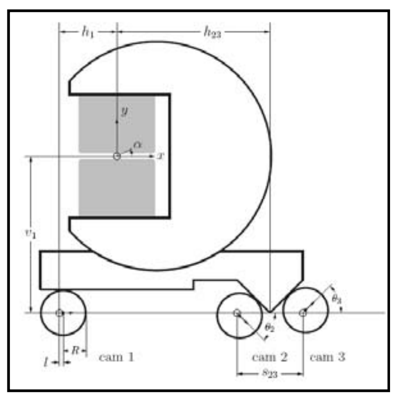
NEW: “Glue” LCLS 5 DOF Magnet Mover System into SiD

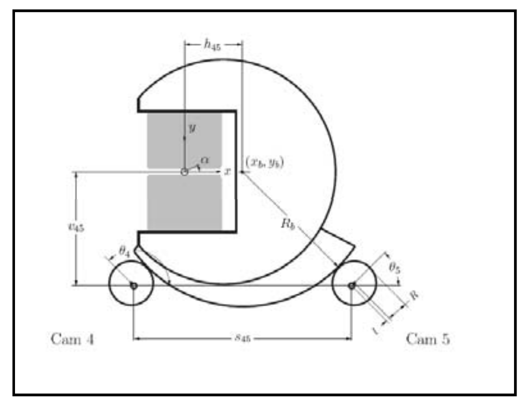




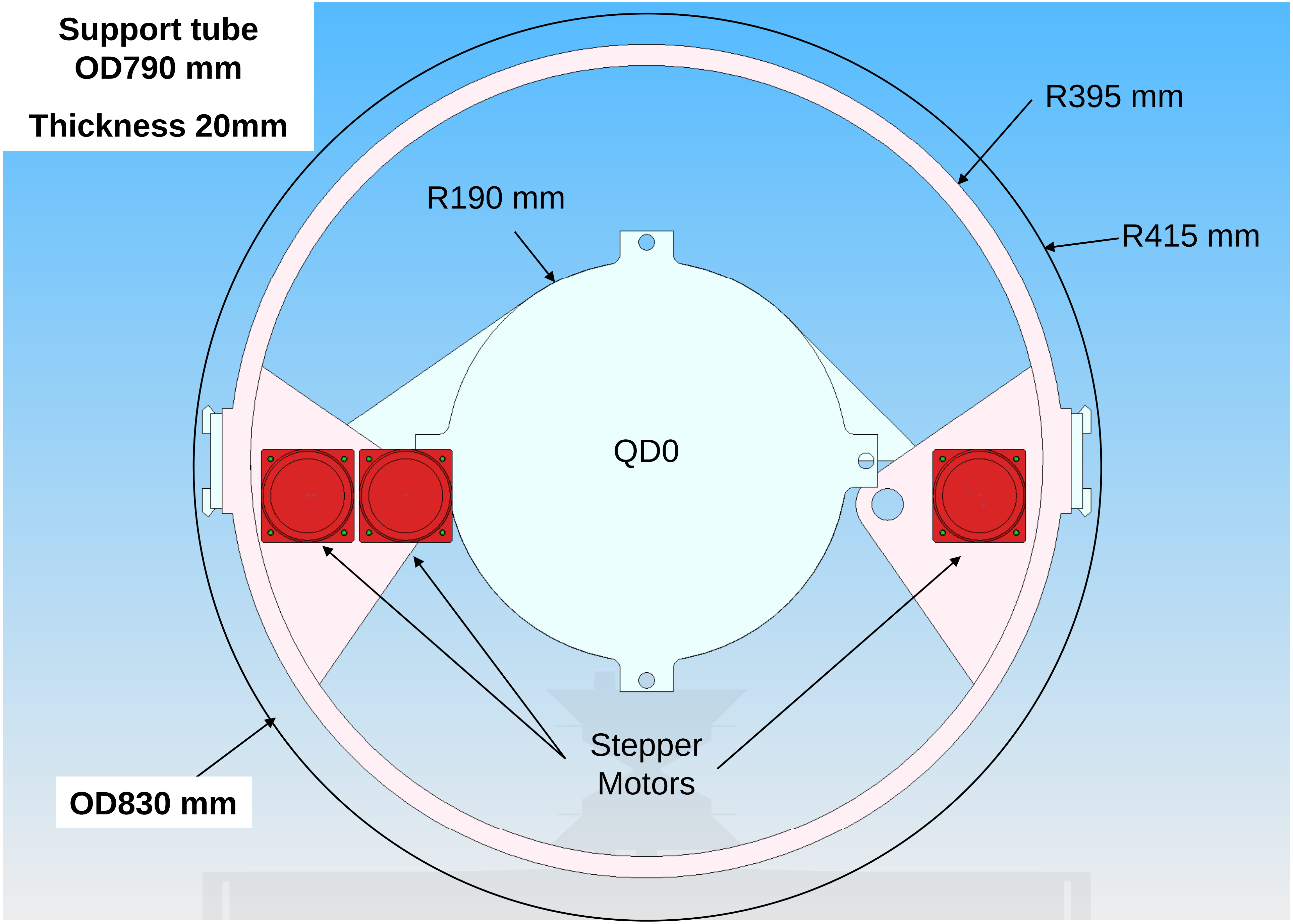
3 Degrees of Freedom
Magnet Mover System from
FFTB’95 now at ATF2
(G.Bowden, P.Holik, R.Wagner,
Heimlinger and R.Settles ‘95)



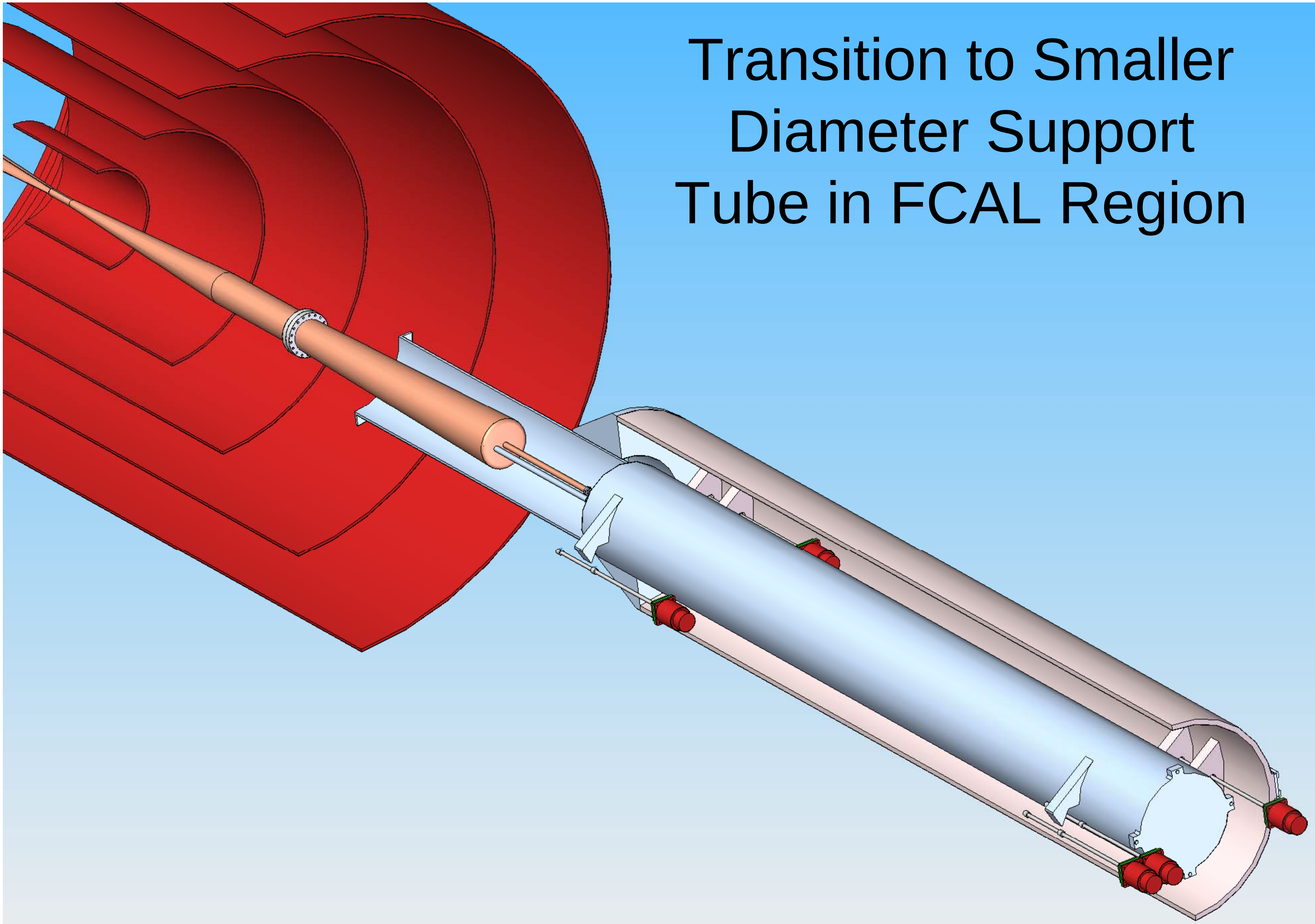




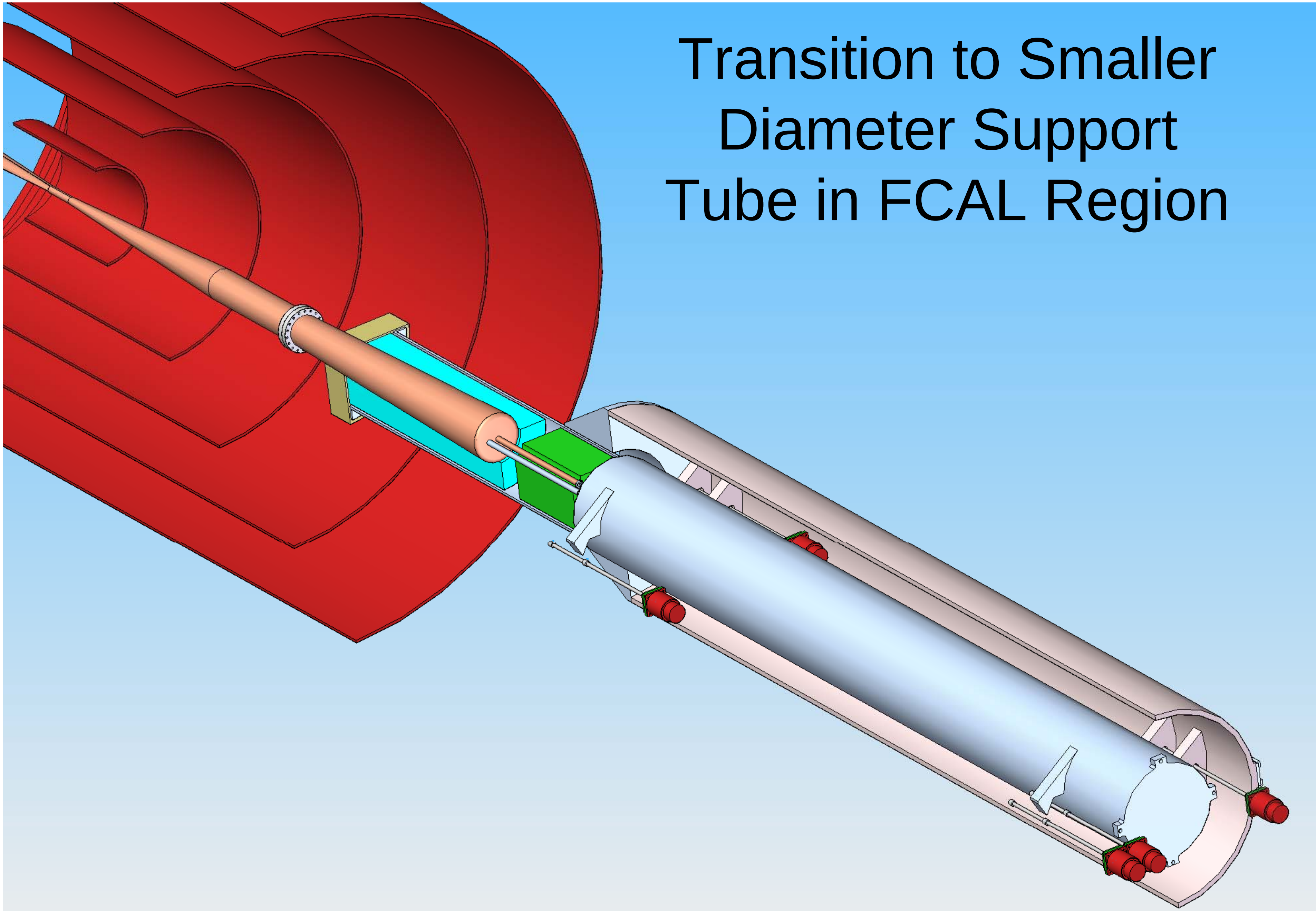
5 Degrees of Freedom (presently developed for LCLS undulators

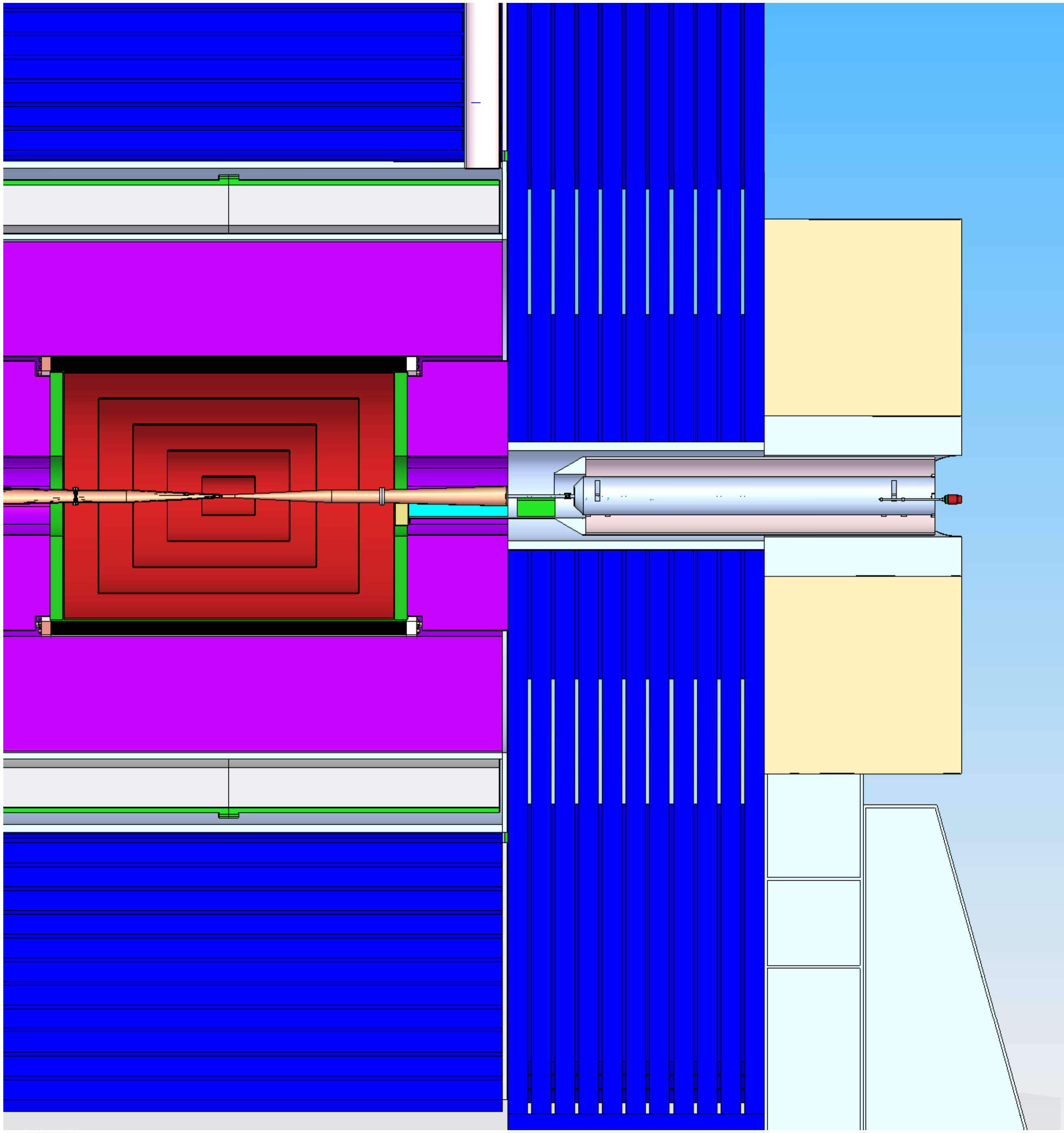

Support tube
OD790 mm
Thickness 20mm
R395 mm
R190 mm
R415 mm
QD0
Stepper
Motors
OD830 mm

Transition to Smaller Diameter Support Tube in FCAL Region

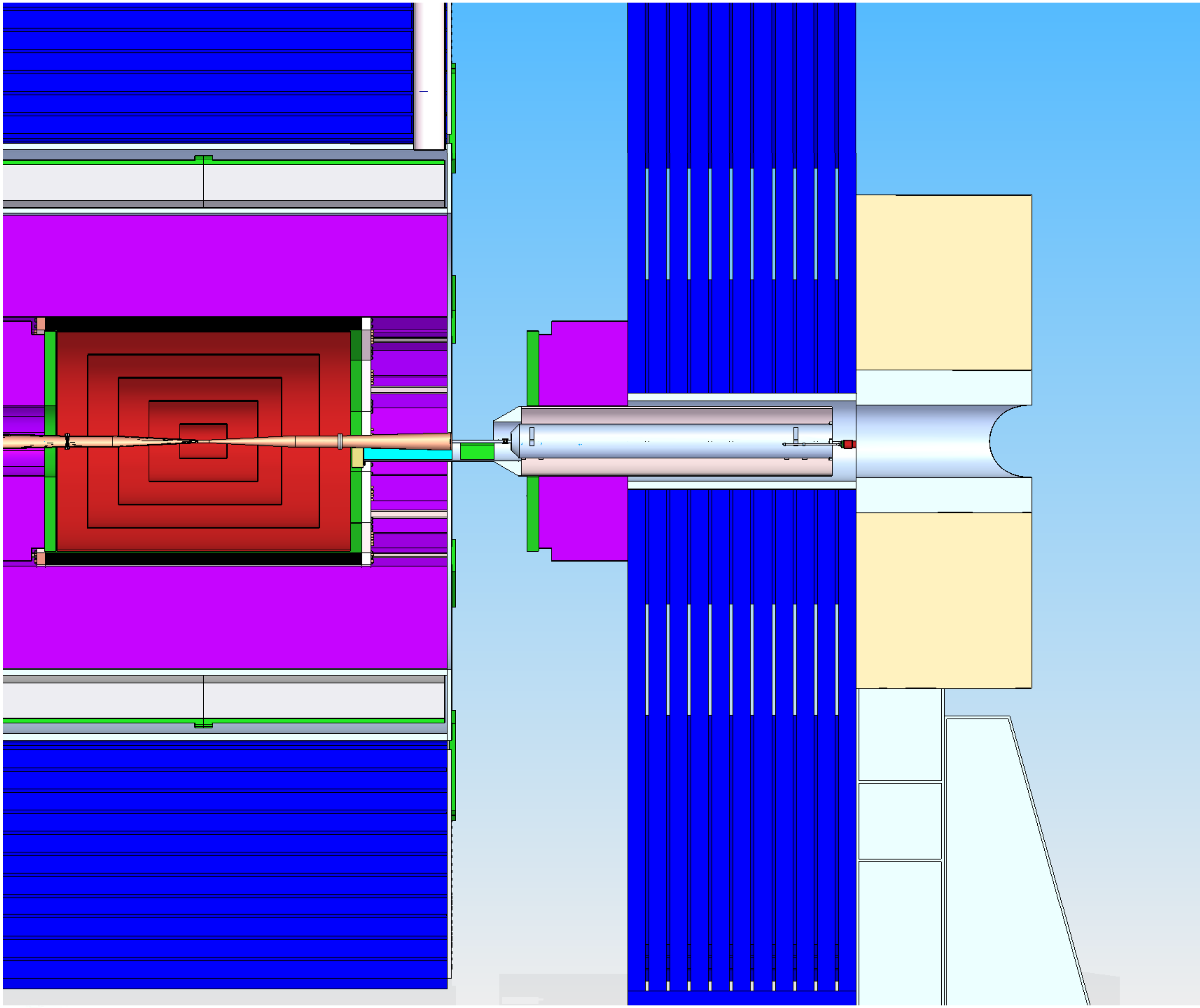


Transition to Smaller Diameter Support Tube in FCAL Region

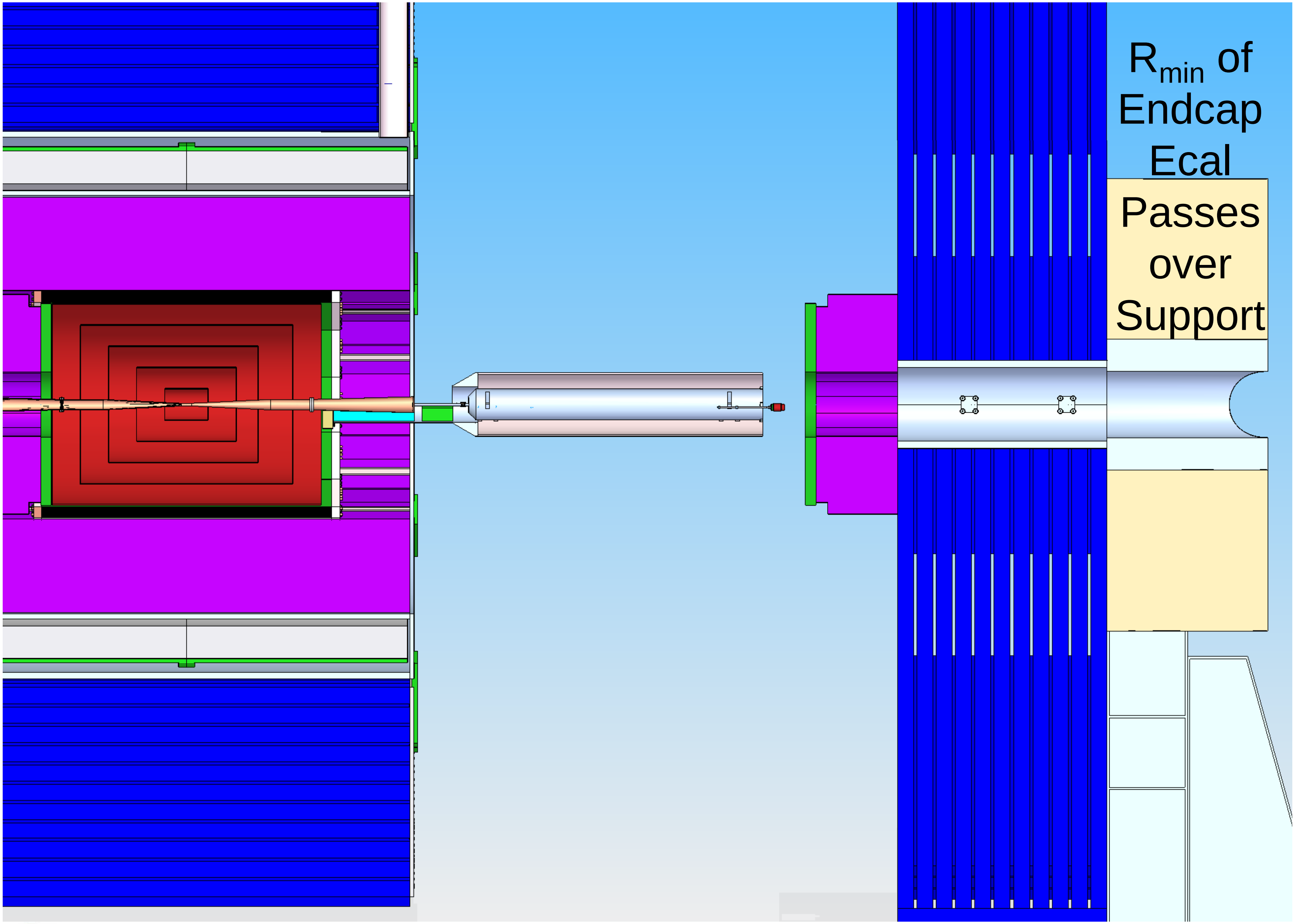




R_{min} of Endcap Ecal Passes over Support

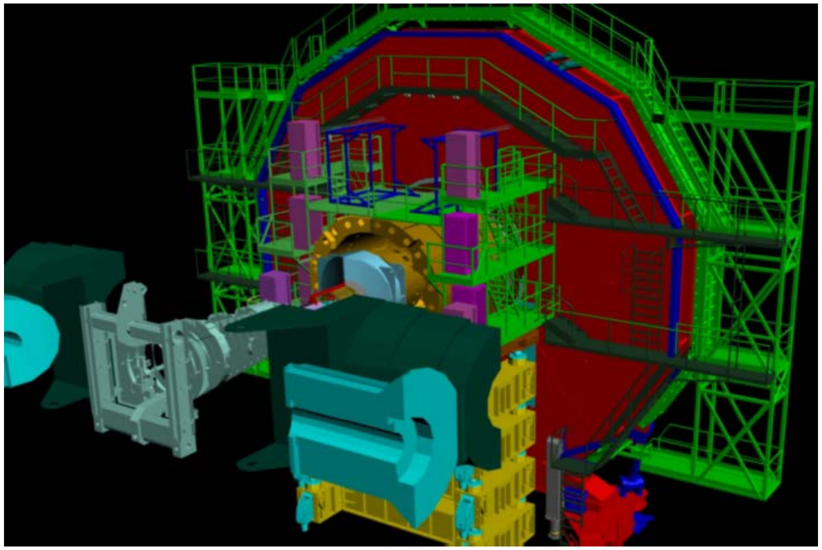


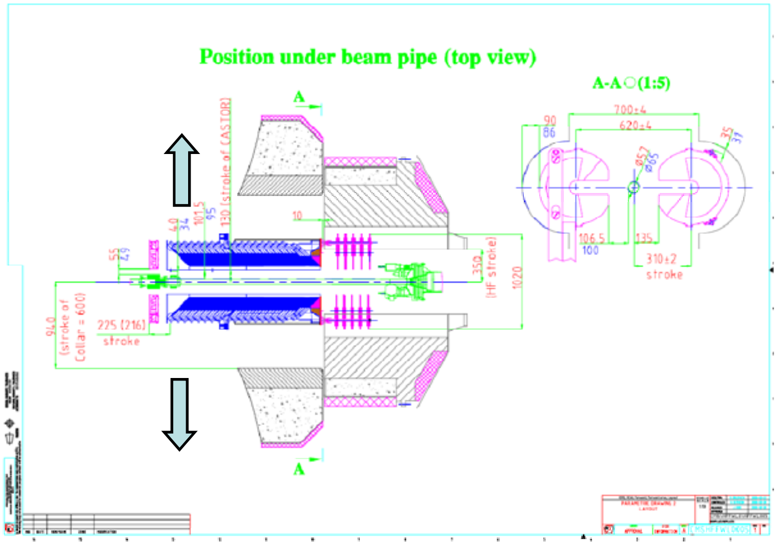
R_{min} of Endcap Ecal Passes over Support

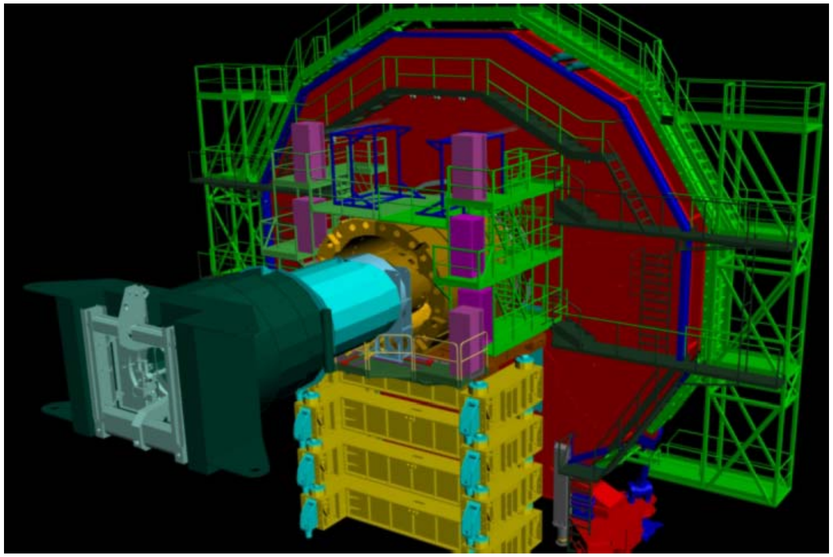

R_{min} of Endcap Ecal
Passes over Support

Forward Shielding (Pacmen)

SiD Design inspired by CMS Rotating Shielding



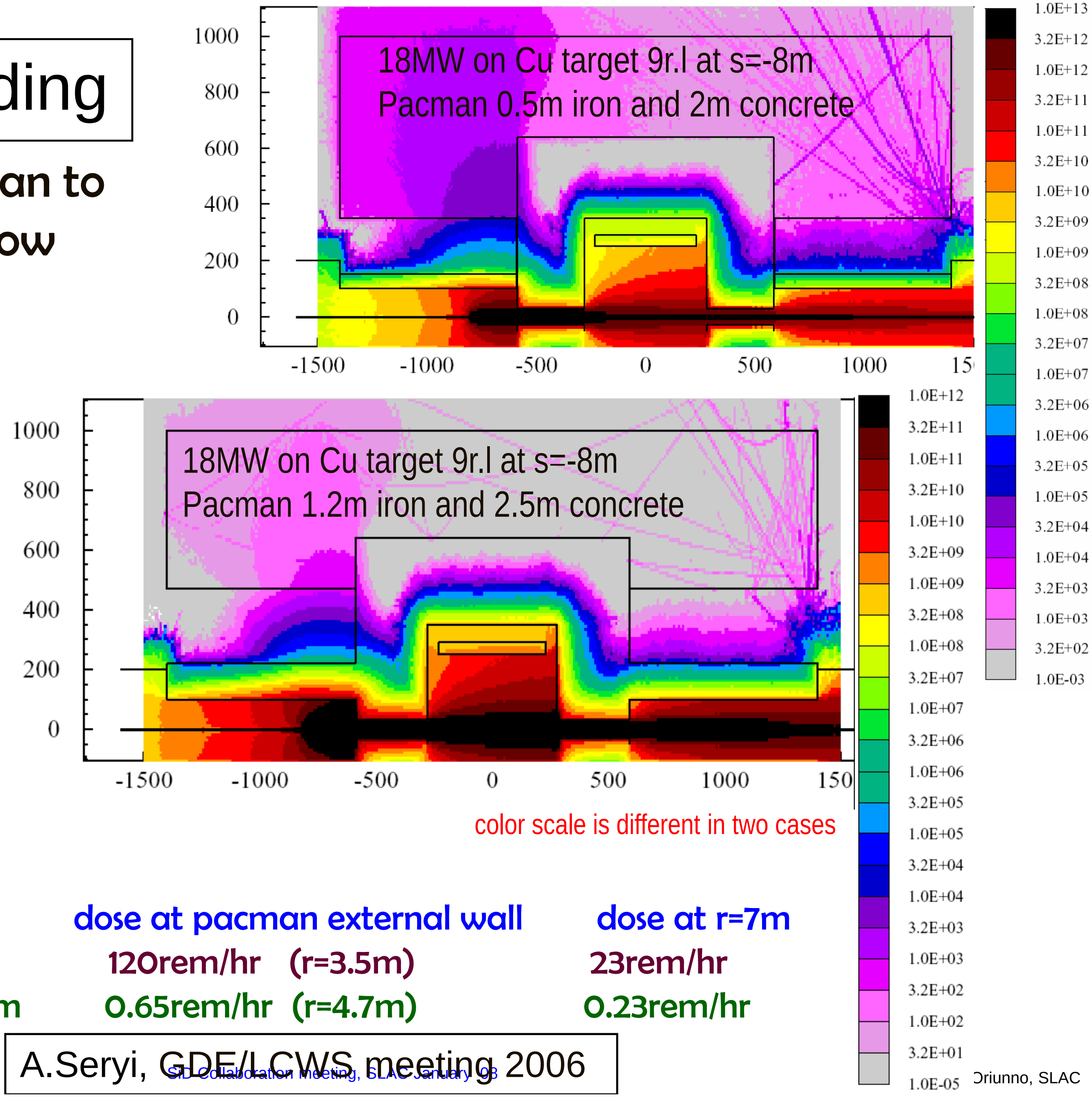




Self-shielding

Adjusting pacman to reduce dose below 25rem/hr

Desired thickness is in between of these two cases



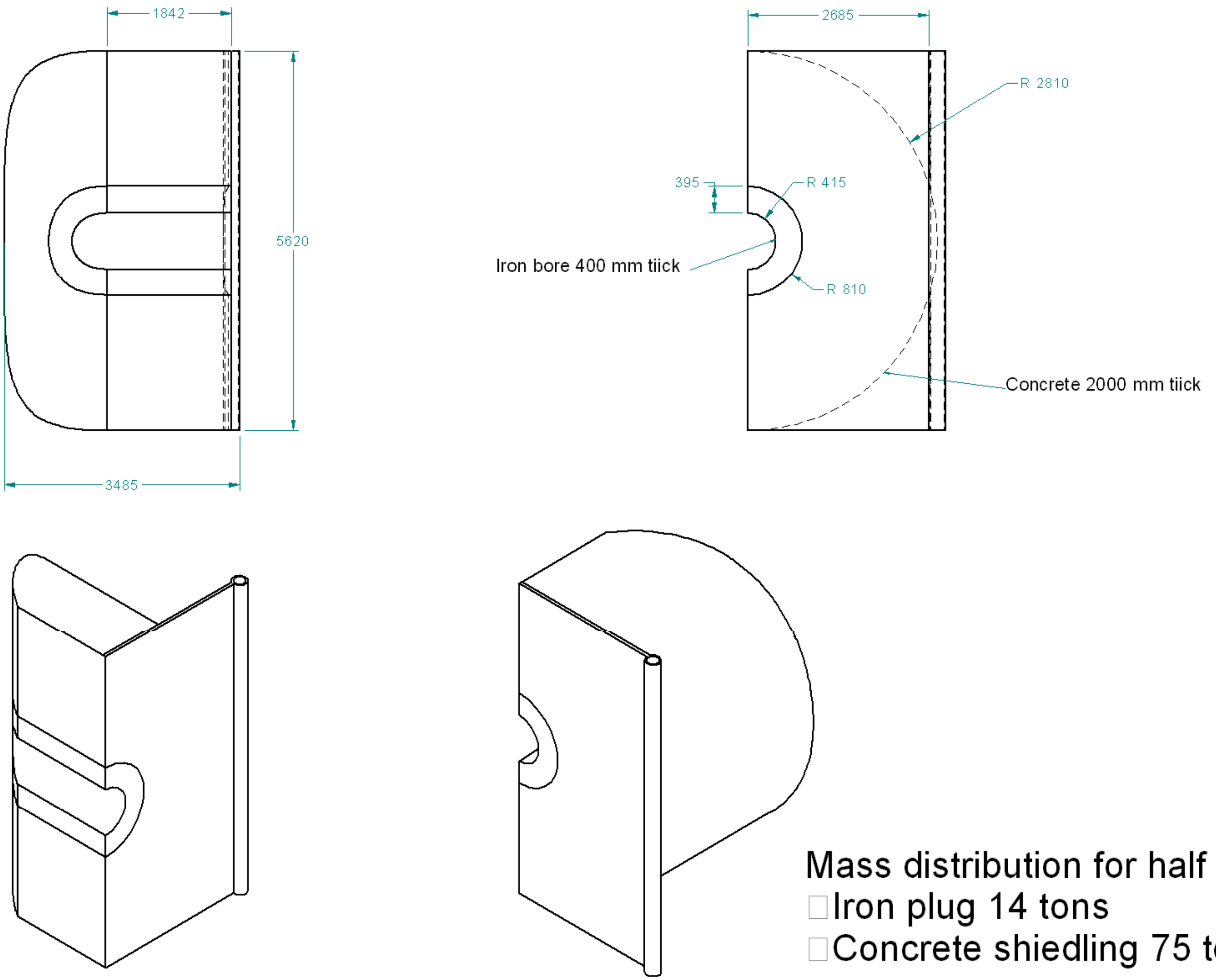
color scale is different in two cases

18MW at s=-8m:

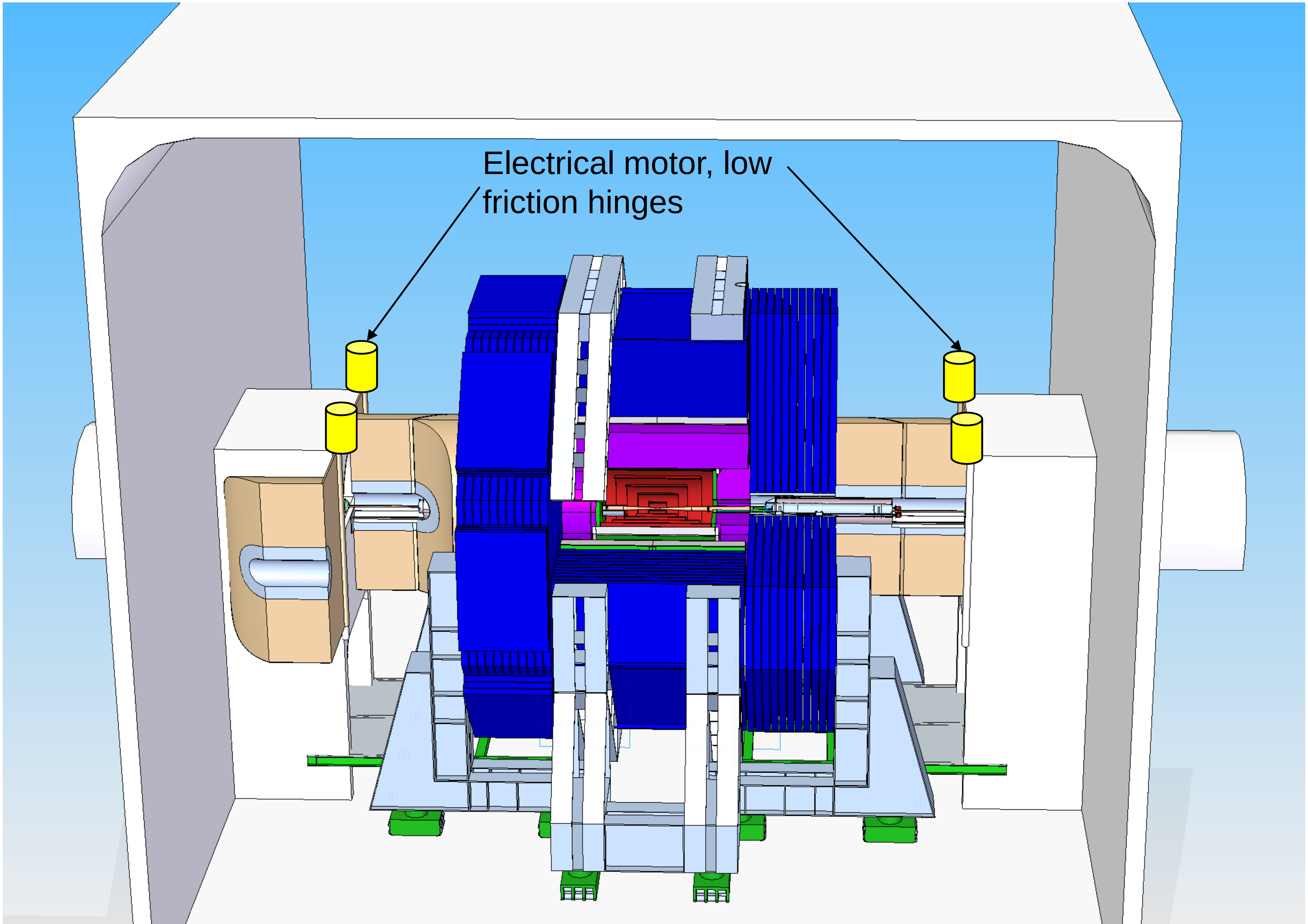
Packman	dose at pacman external wall	dose at r=7m
Fe: 0.5m, Concrete:2m	120rem/hr (r=3.5m)	23rem/hr
Fe: 1.2m, Concrete: 2.5m	0.65rem/hr (r=4.7m)	0.23rem/hr

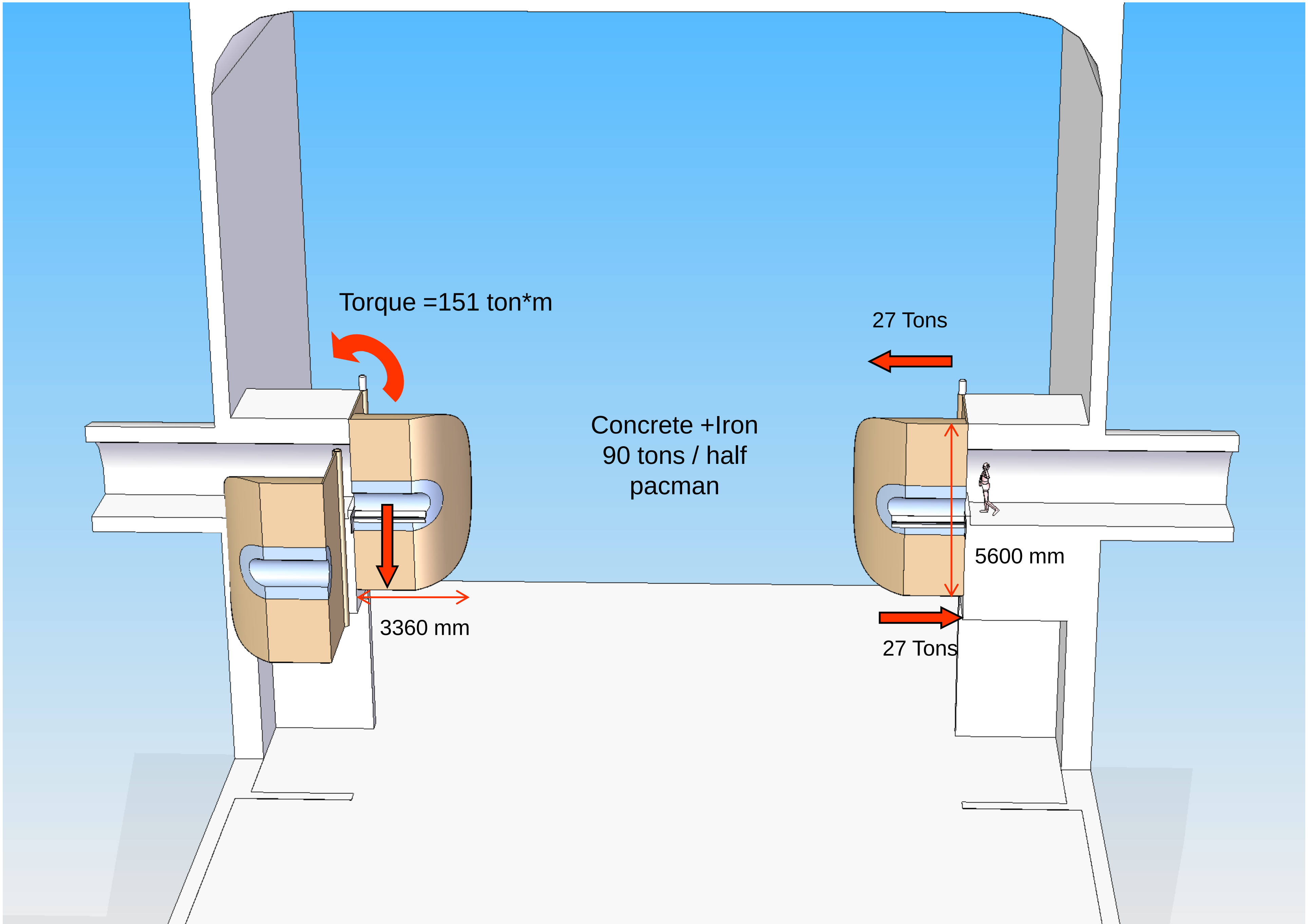
A.Seryi, GDE/LCWS meeting 2006

Oriunno, SLAC

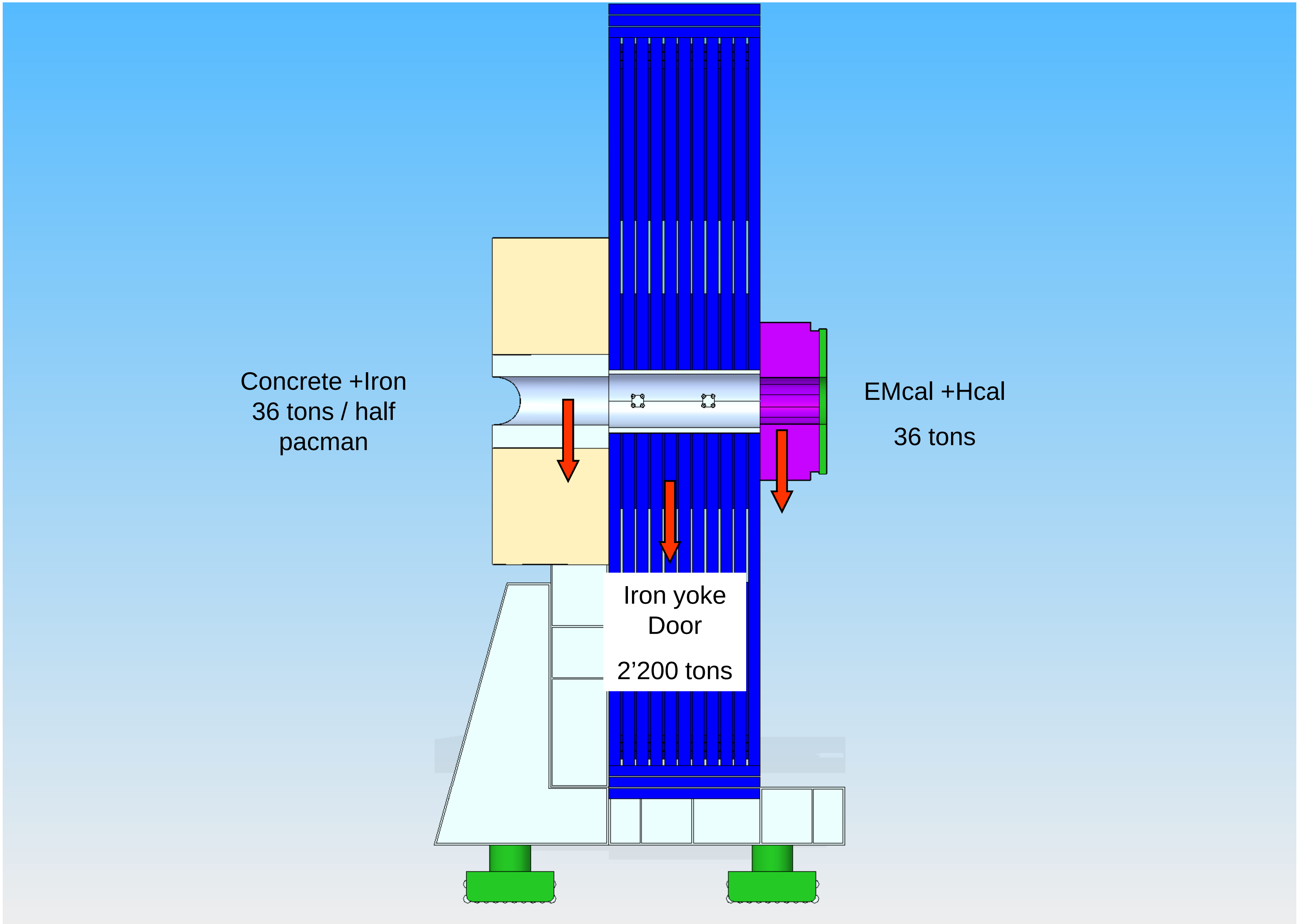


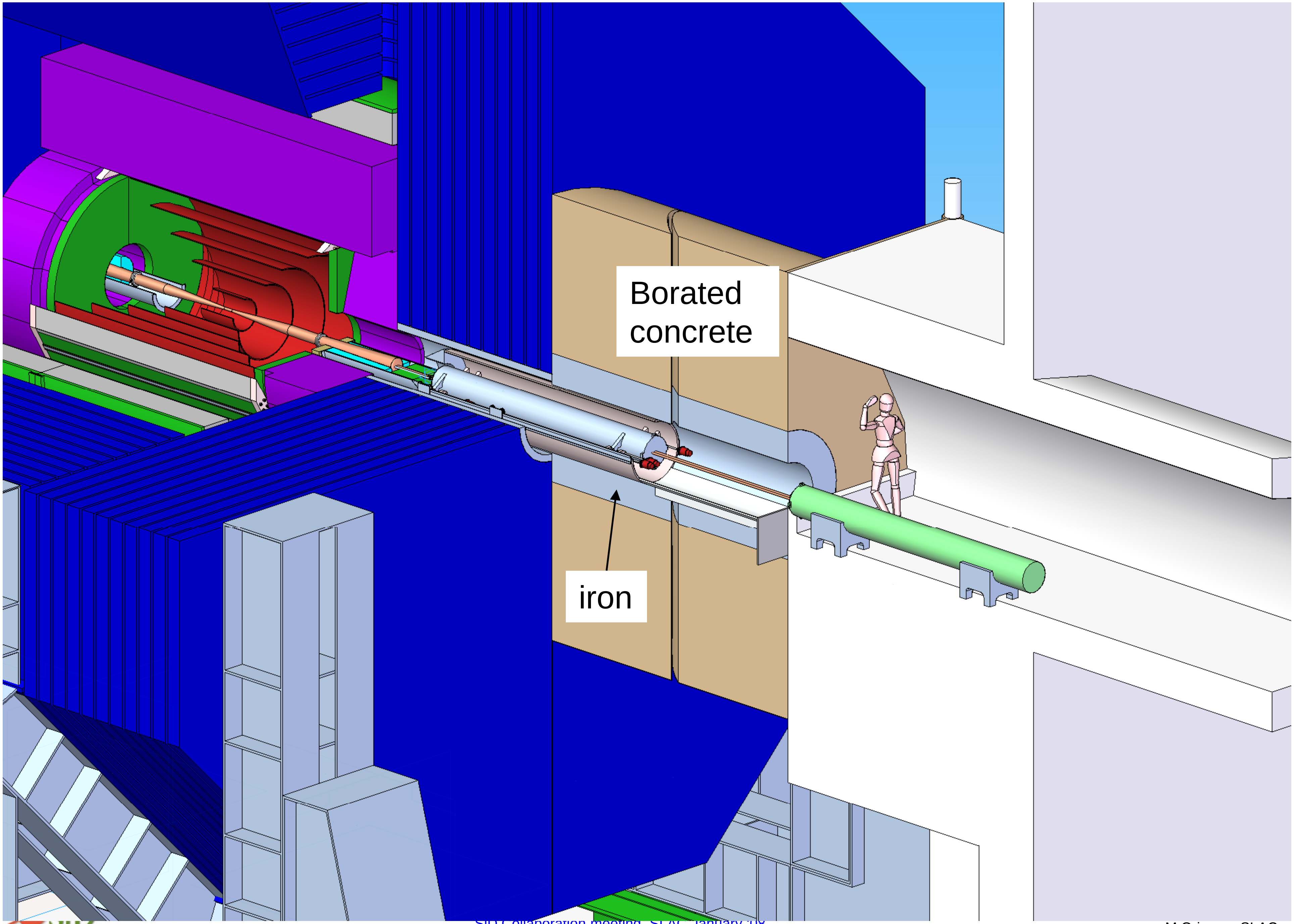
Mass distribution for half Pacman:
- Iron plug 14 tons
- Concrete shiedling 75 tons


Electrical motor, low friction hinges

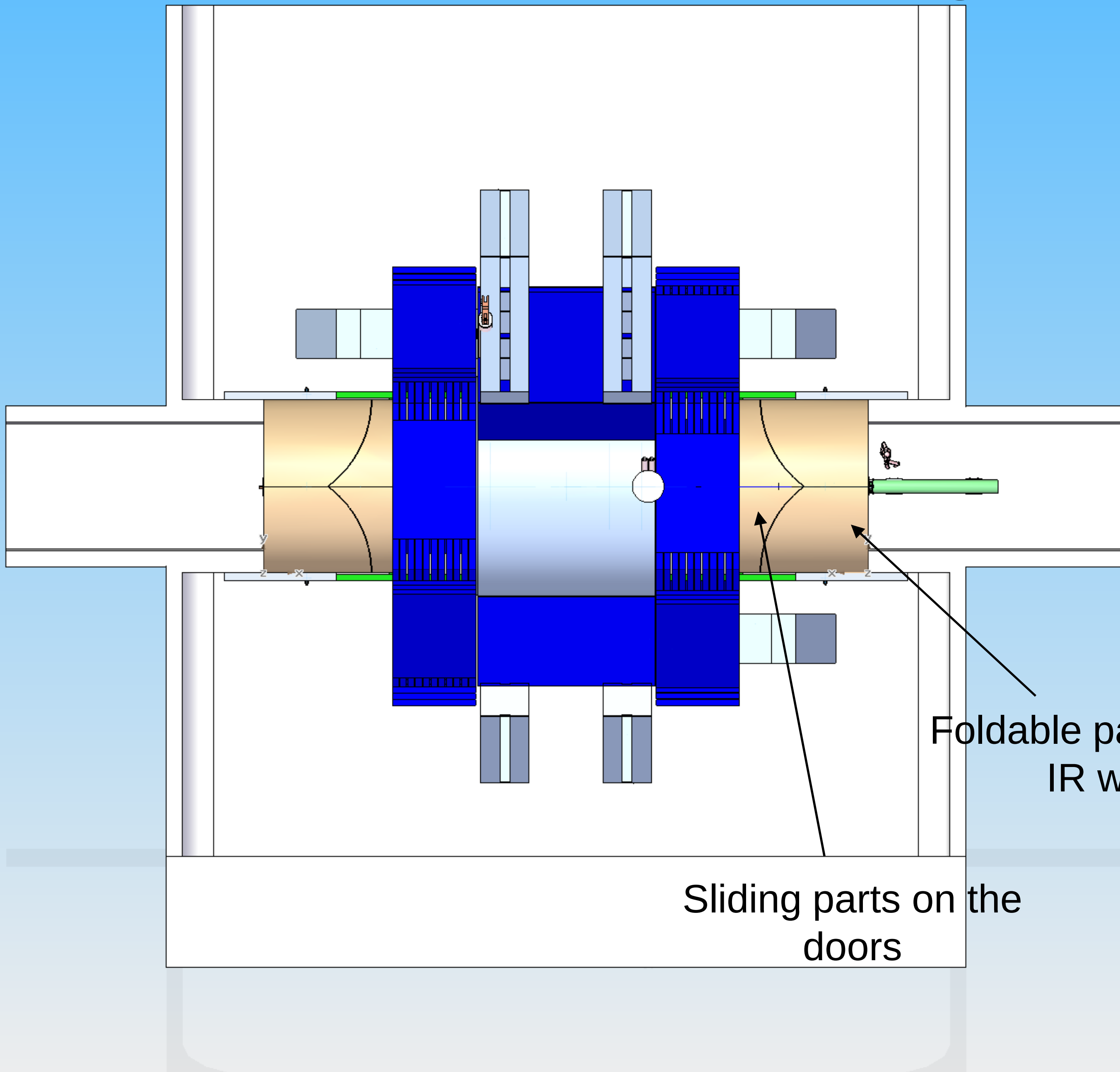

Torque =151 ton*m
27 Tons
Concrete +Iron
90 tons / half
pacman
5600 mm
3360 mm
27 Tons

Mass distribution on the door

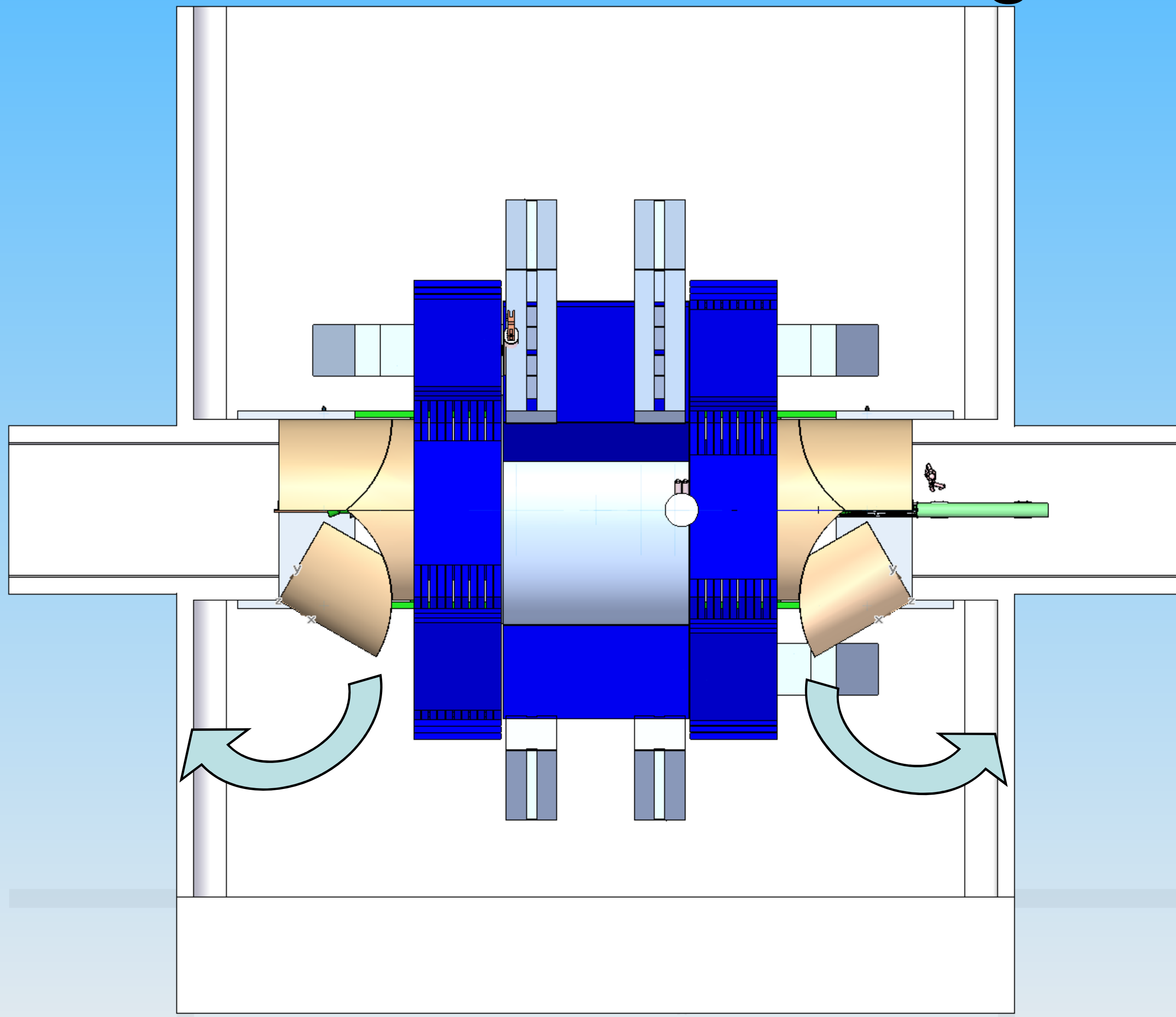



Borated
concrete
iron

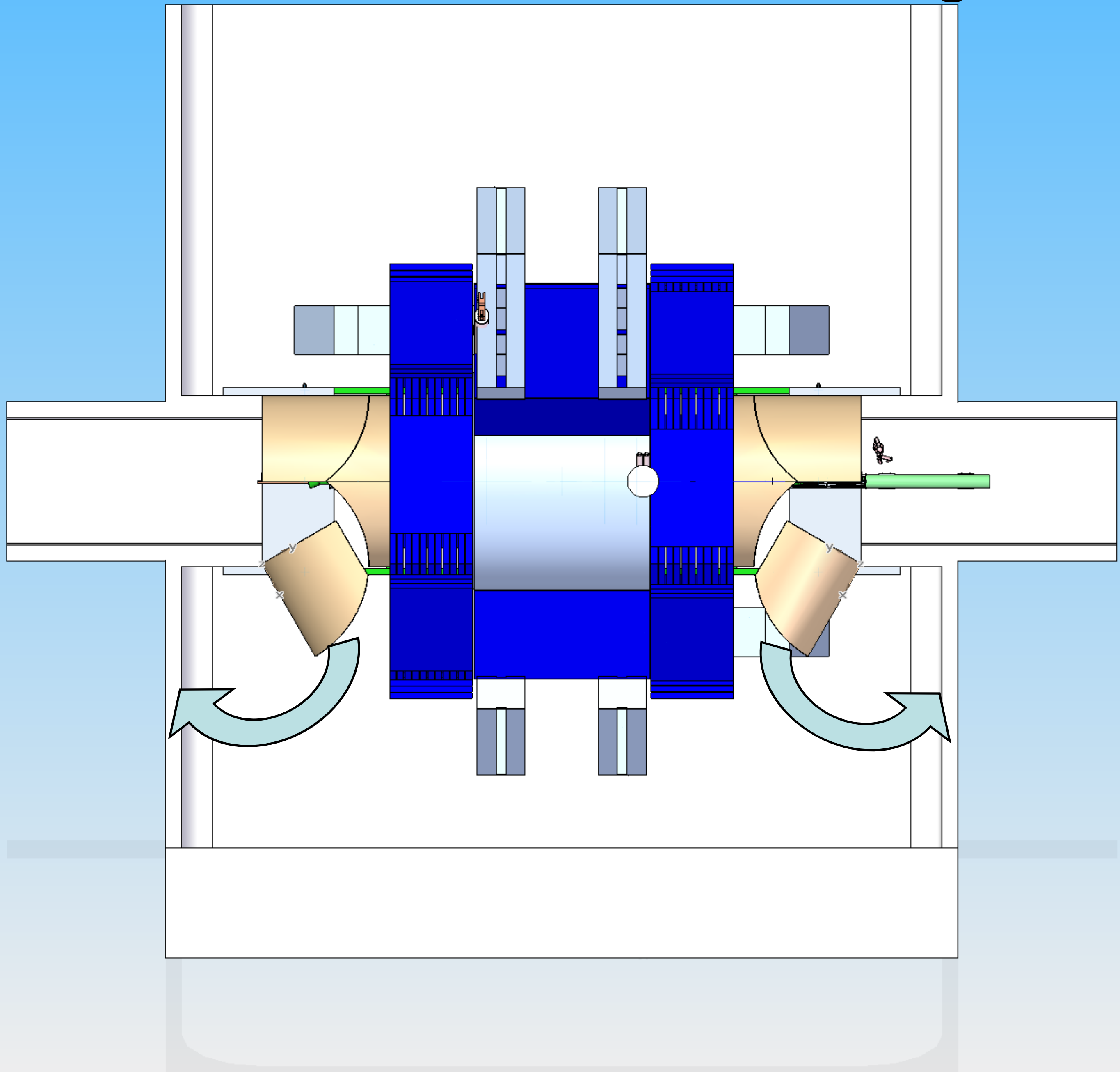
SiD Forward Shielding



SiD Forward Shielding

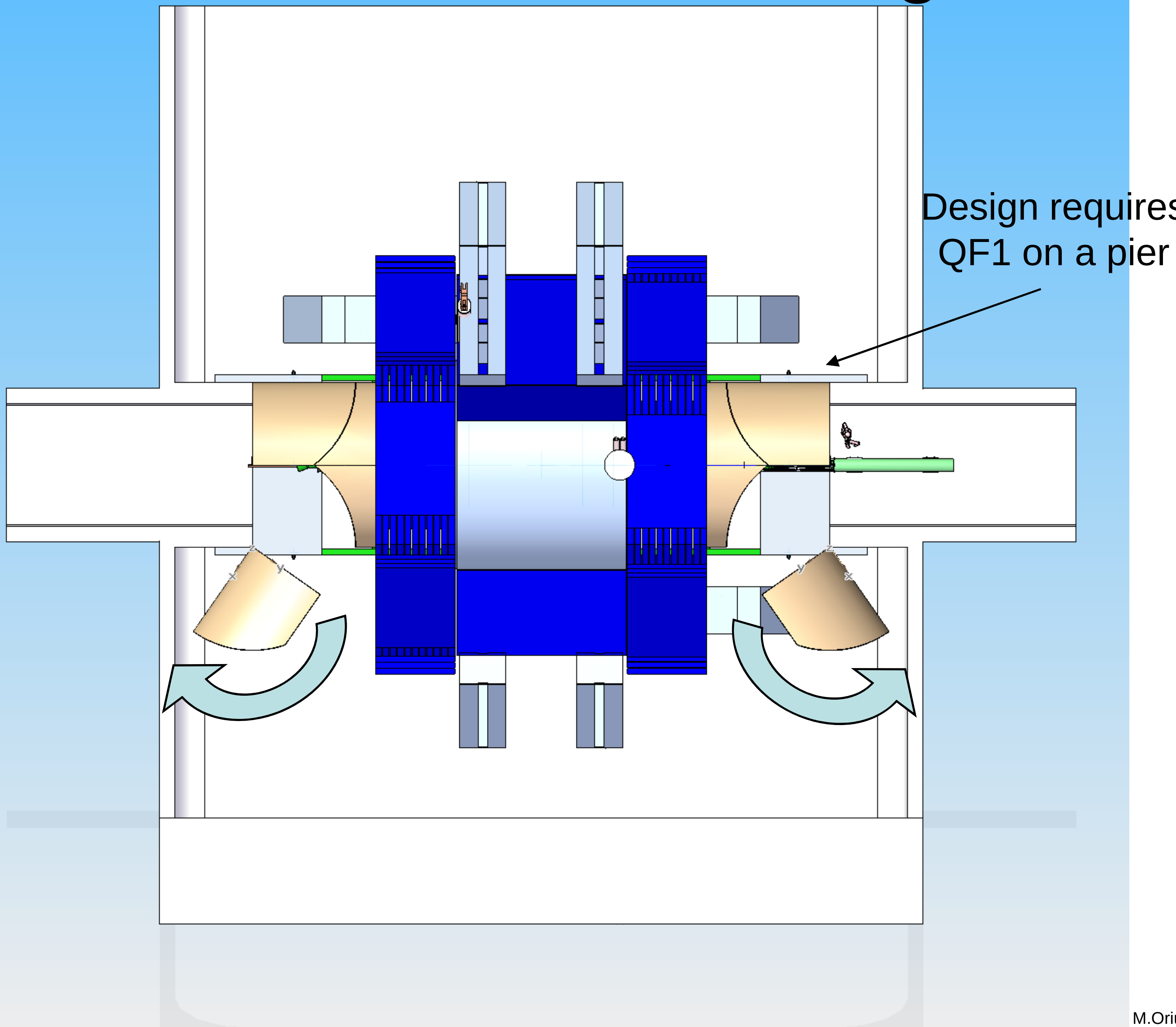


SiD Forward Shielding

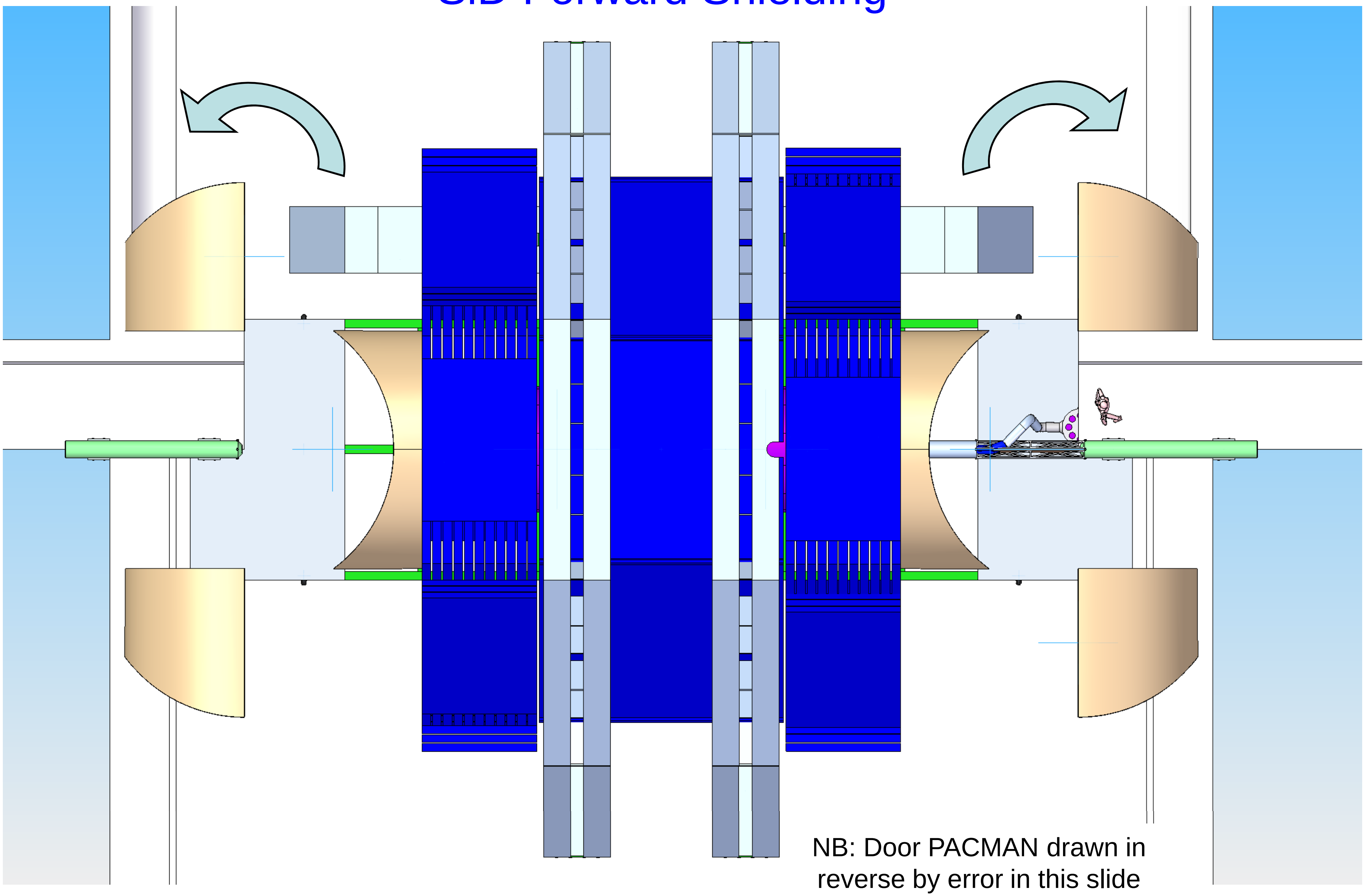


M.Oriunno, SLAC

SiD Forward Shielding

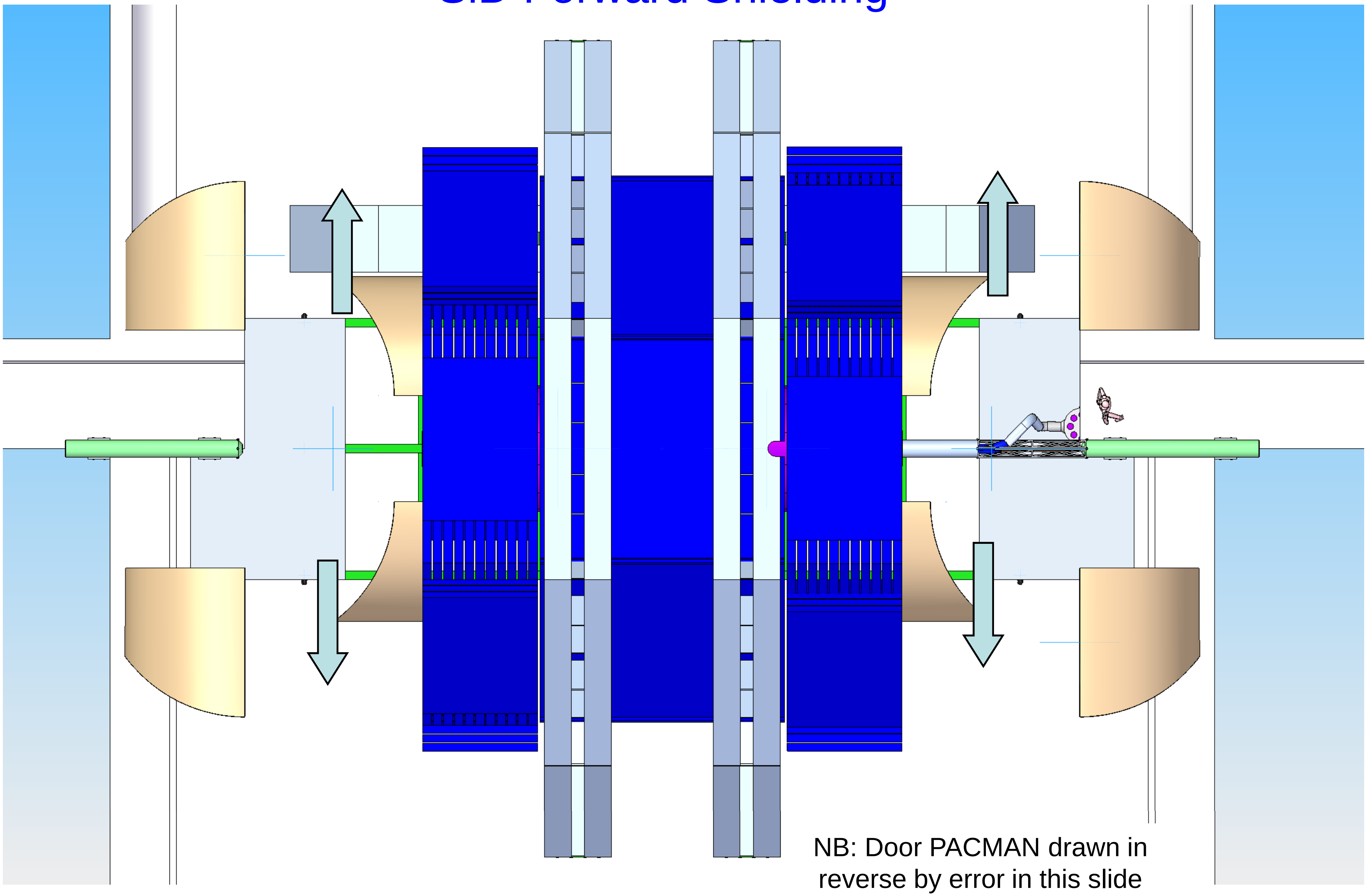


SiD Forward Shielding



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

SiD Forward Shielding



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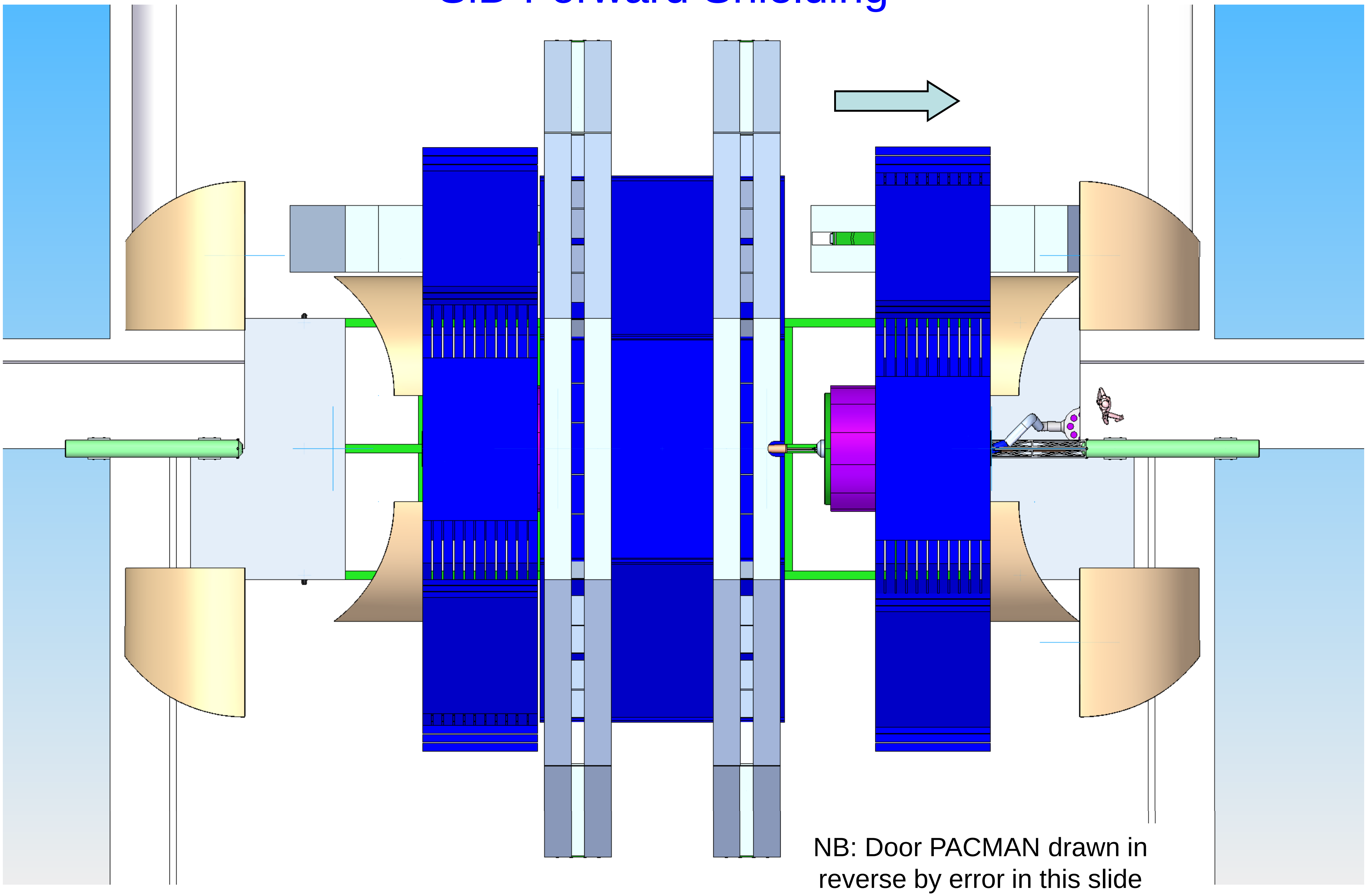

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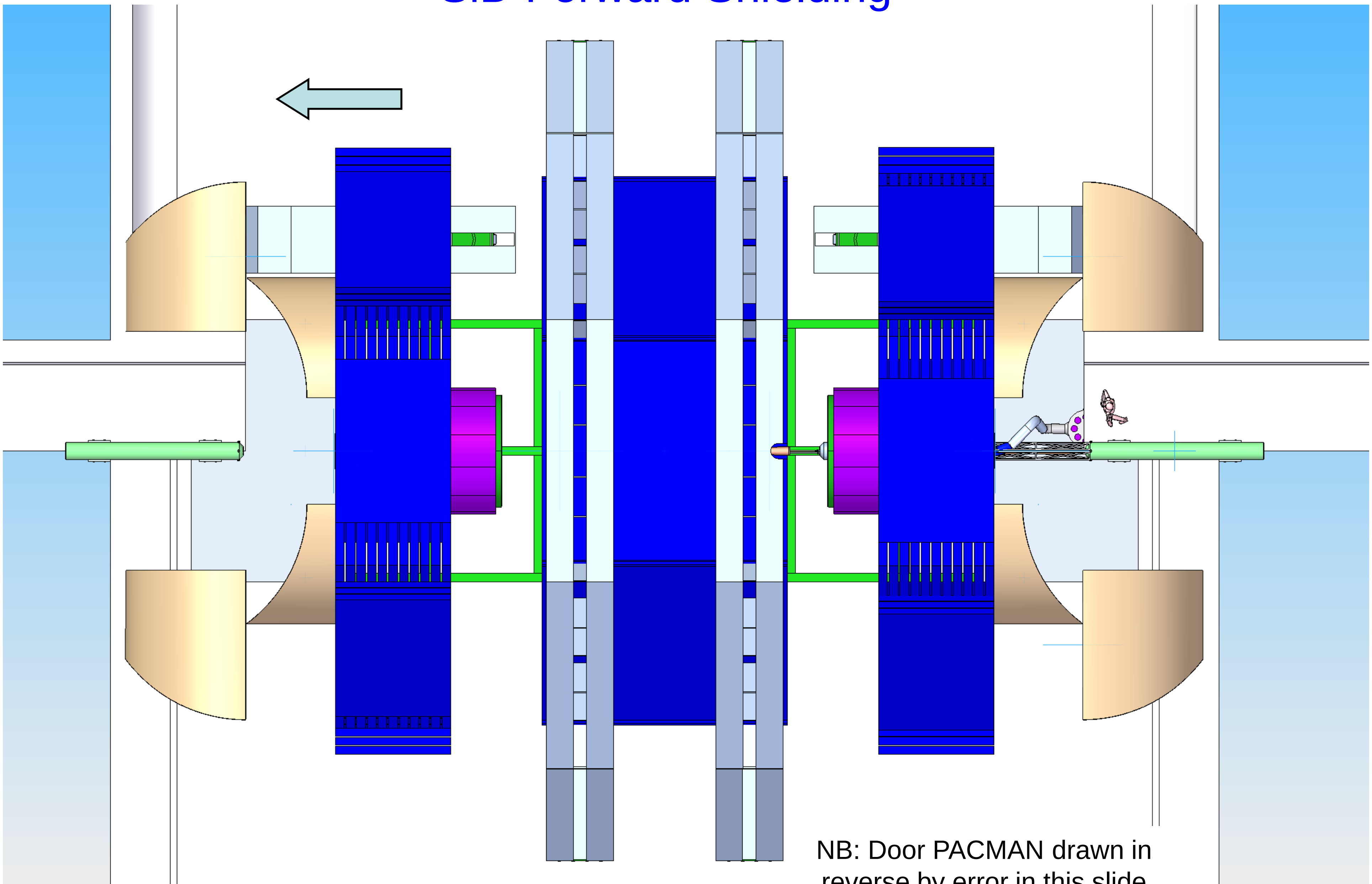
SiD Forward Shielding



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

Marco's Comments

The direct applications of the technical solutions developed for FFTB and ATF2 create an undesirable large space inside the door

New effective compact mechanisms to be studied

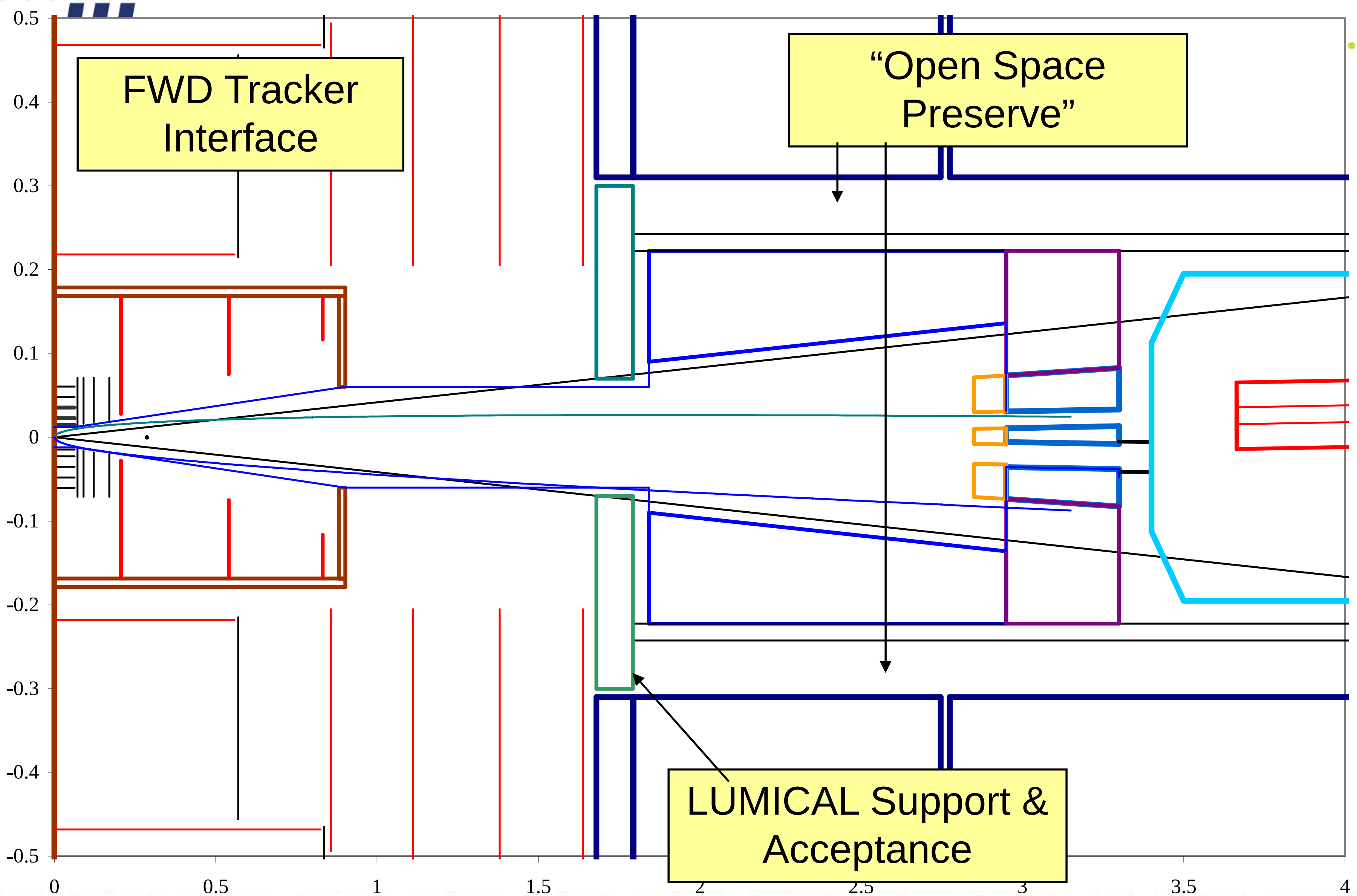
The use of stepper motors inside the doors is not possible due to still high magnetic field 1-2 Tesla close to door-barrel interface, few thousand gauss at the pacman –door interface

Different motors should be considered, compressed air or hydraulic motors ?

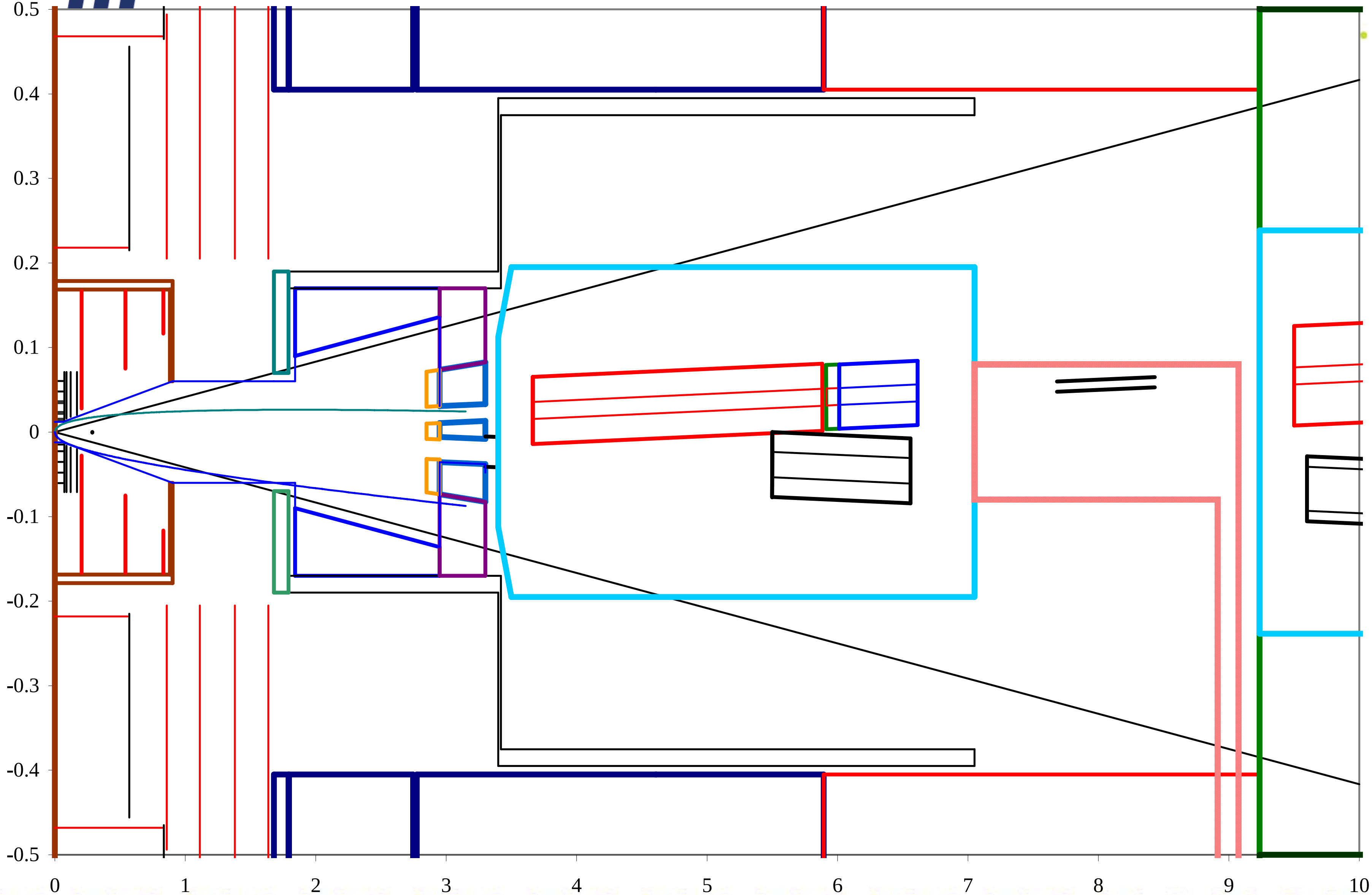
The large aperture inside the doors are required only at the QD0 region

In the present scheme, the forward detectors region can be optimized to be still compatible with a slide of the central tracker, when the maintenance of the pixel is required

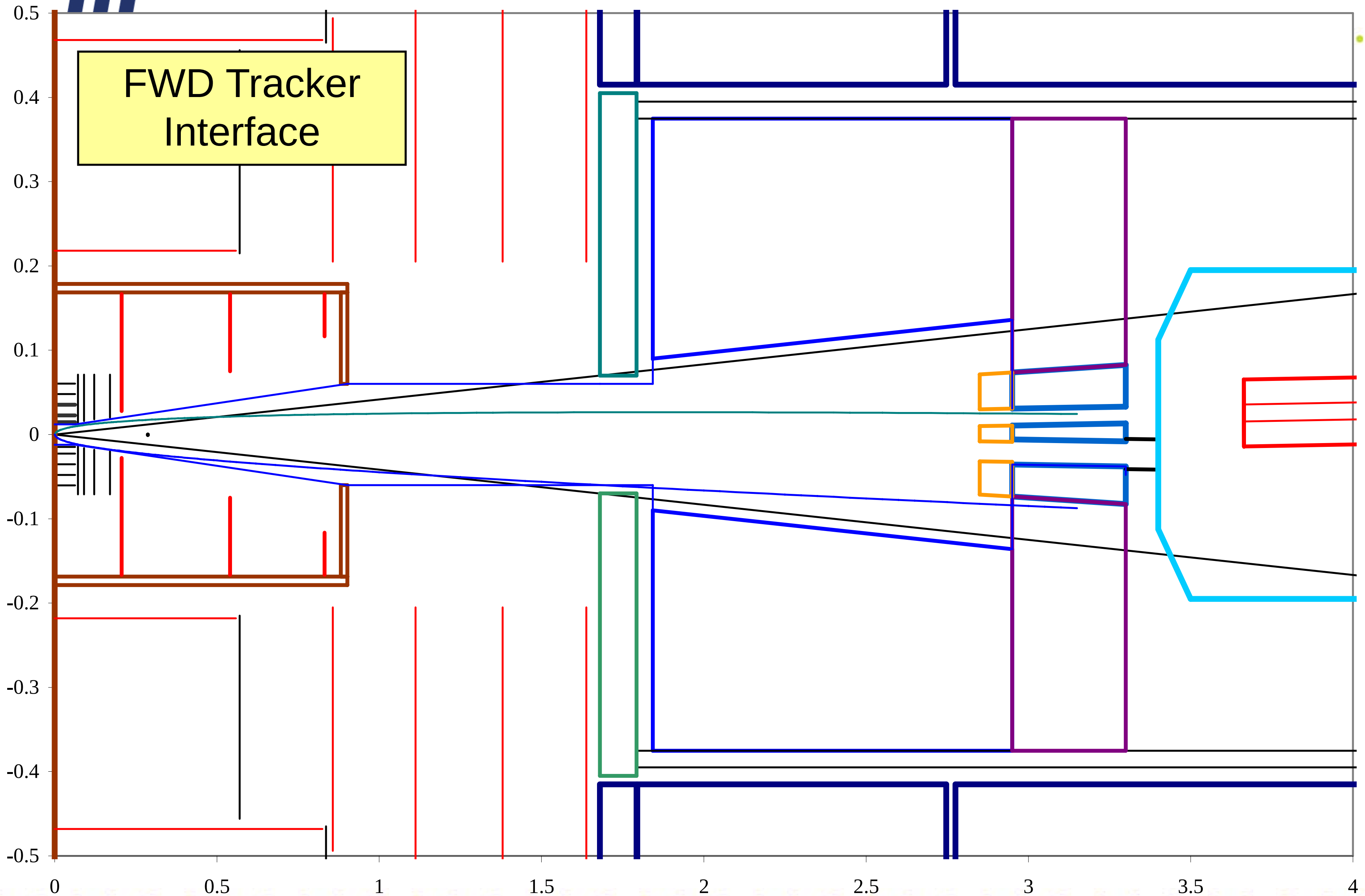
EXCEL pix of Marco's January 2008 Design



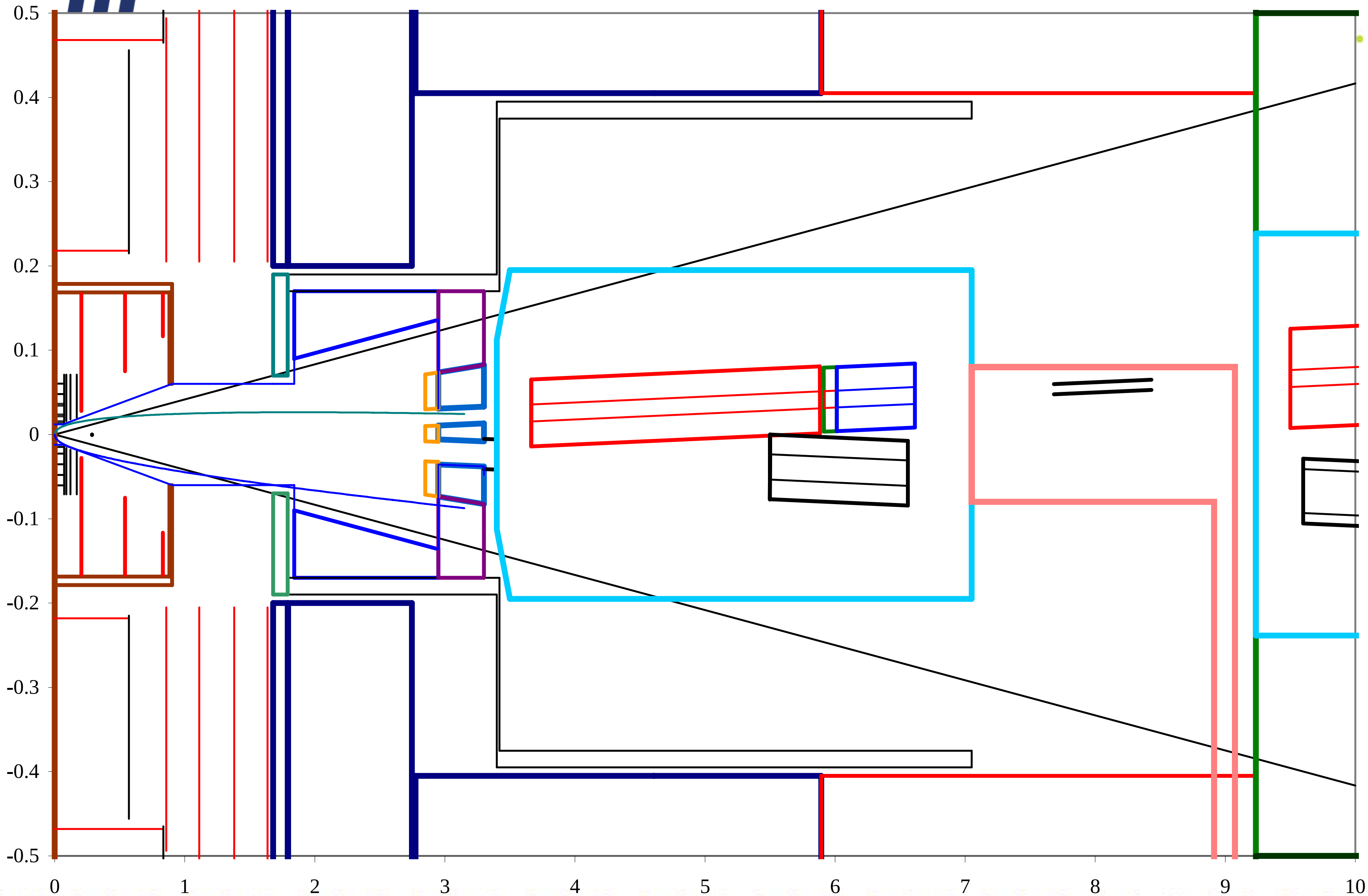
EXCEL pix of Marco's April 2008 Design respecting FT but ignoring Hermaticity



EXCEL pix of Marco's April 2008 Design Modified for Full Calorimetry

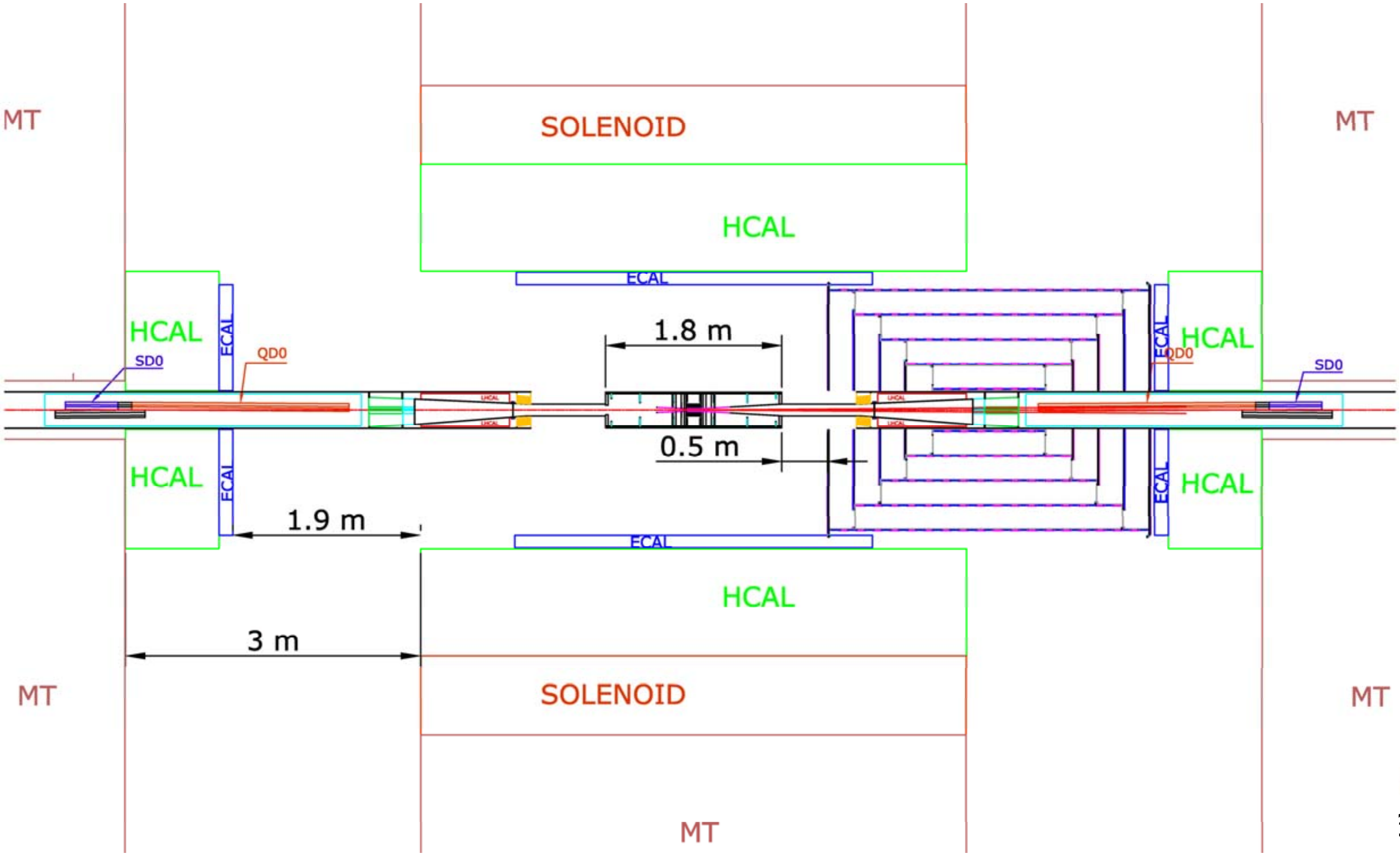


EXCEL pix of Marco's April 2008 Design Modified for Limited Door Opening



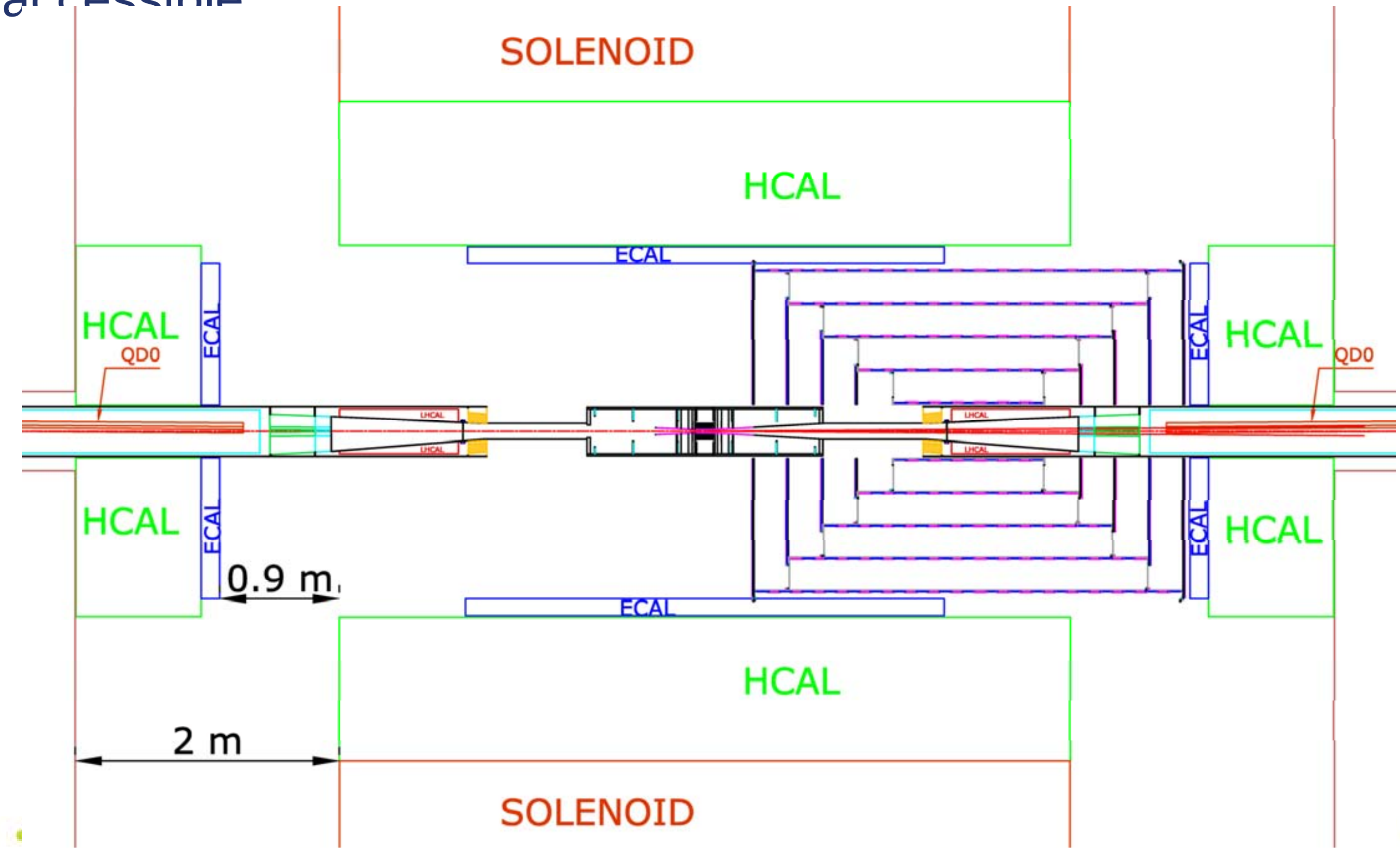
Servicing Vertex Detector & Tracker

- Detector open 3 m for off-beamline servicing
- Vertex detector can be removed / replaced.



Servicing Vertex Detector & Tracker

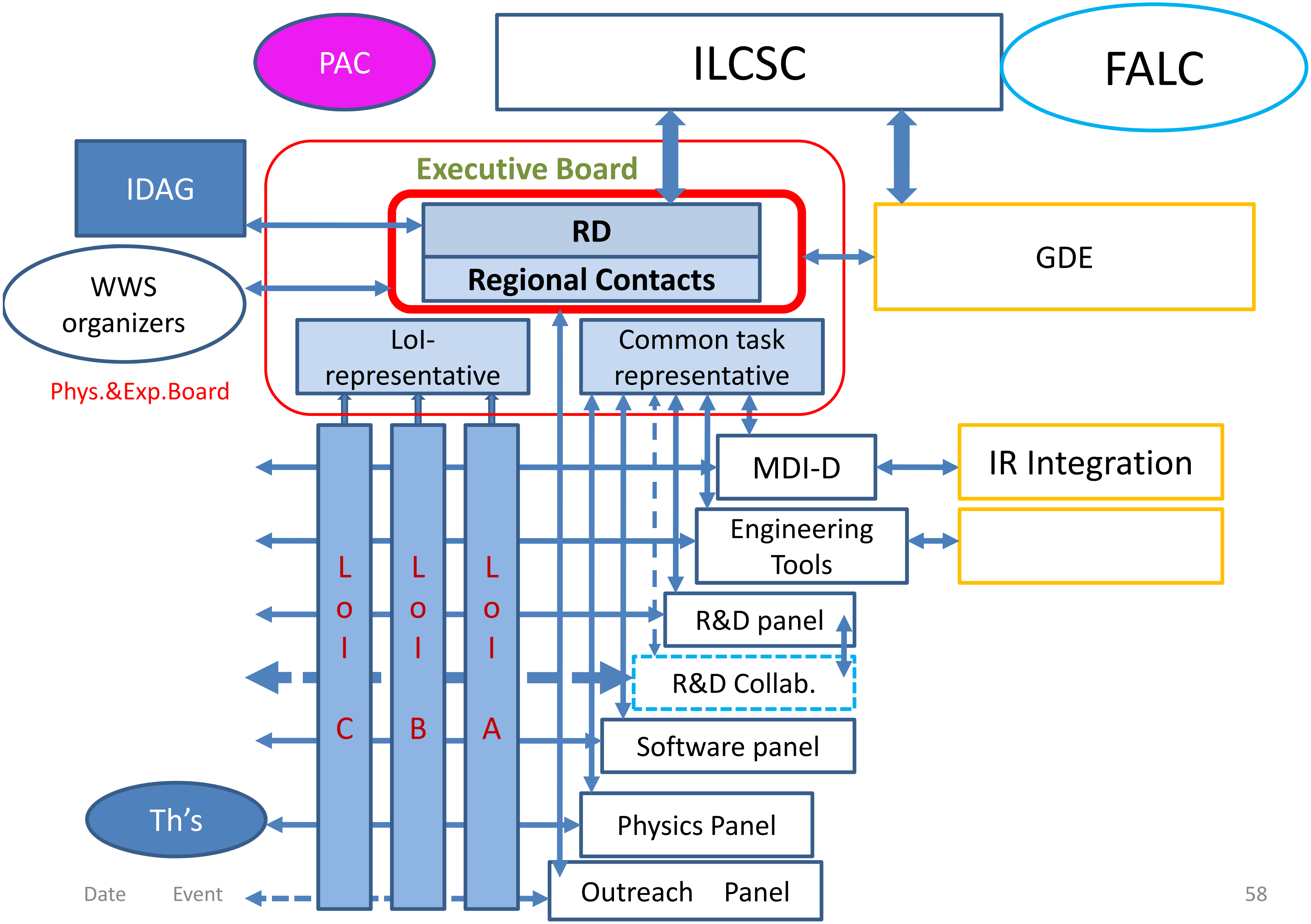
- Detector open 2 m for on-beamline servicing
- Ends of tracker and outer surfaces of vertex detector are accessible



MDI For the LOI

- Yamada's MDI Organization
  - **Brett Parker & Tom Markiewicz on GDE "IR Integration" Box**
    - With Andrei Seryi really driving work
  - **On SiD?: Phil Burrows and Marco Oriunno (?)**
- "MDI Interface Document"
  - **My conception was of a written minimal set of agreed on parameters to bound the MDI design for each concept**
    - Leave details for down the road and for the detector collaborations, especially if site dependent
  - **Andrei's conception is more of a complete set of engineering parameters to define IR region**
    - Changeable, but complete
    - "Baseline IR Model"

Jan.09,2008


PAC
ILCSC
FALC
IDAG
Executive Board
RD
Regional Contacts
GDE
WWS organizers
Phys.&Exp.Board
LoI-representative
Common task representative
MDI-D
IR Integration
Engineering Tools
R&D panel
R&D Collab.
Software panel
Physics Panel
Outreach Panel
Th’s
L o I C
L o I B
L o I A

Draft EPAC 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), V.Kuchler, N.Mokhov (Fermilab), A.Enomoto, Y.Sugimoto, K.Tsuchiya (KEK), J.Weisend (NSF), T.Markiewicz, A.Seryi, M.Sullivan (SLAC), D.Angal-Kalinin (STFC), T.Sanuki, H.Yamamoto (Tohoku Univ.)

Abstract

QD0 and QF1 quadrupoles (and associated sextupoles

BDS IR-related CF&S master table

Item	SiD	LDC	GLD	CMS	Vancouver WBS (for each hall)	For Valencia Config.A (for single common hall)	Config.B (for single common hall)	Determined by
Parameters that define the underground hall volume								
IR Hall Area(m) (W x L)	28x48 (18x48)	30x45	25x55	26.5 x53 max	32x72	25x110	25x110	Detector concepts
Beam height above IR hall floor (m)	7.5	8	8.6	8.79 m	8.6	8.6	8.6	Concepts, BDS
IR Hall Crane Maximum Hook Height Needed(m)	5m above top of detector	19	20.5	18m	30	20.5	20.5	Detector concepts
Largest Item to Lift in IR Hall (weight and dimensions)	100t PACMAN shielding	55t, 3m x 3m x 1,5m, E/HCAL end cap quadrant	Pieces of yoke 400t	20t install tool 7x4 m		400t	100t	Detector concepts
IR Hall Crane	100t/10t aux.	80t (2x40t)	400t	20t	20t x 2	400t +2*20t	100t +2*20t	Detector concepts
IR Hall Crane Clearance Above Hook to the roof (m)	TBD by engineering staff	6	TBD	5 m	5	14.5 (includes arch)	12.5 (includes arch)	CF&S group
Resulted total size of the collider hall (W x L x H)	28x48x30 (18x48x30)	30x45x25	25x55x35	53x26x25	32x72x35	25x110x35	25x110x33	Concepts & CF&S group
Parameters that define dimensions of the IR hall shaft and the shaft crane								
Largest Item; Heaviest item to Lower Through IR Shaft (weight and dimensions)	Coil package 600t – size End-dors 2000t each/halfs	Central Part ~2000t; 12-14m x 7m;	270t coil 9*9m Iron-15m	1950 t		9*9m 400t	4*16m 2000t	Detector concepts

MDI Interface Items from SiD Perspective

Essential Items:

- QD0 L* and QF1 L*
- Interface between Pit Wall Mounted PacMan Shielding and Detector Mounted Shielding
- Height Difference in ILC and SiD and Question of Moving Platform vs. Hillman Rollers
- ?

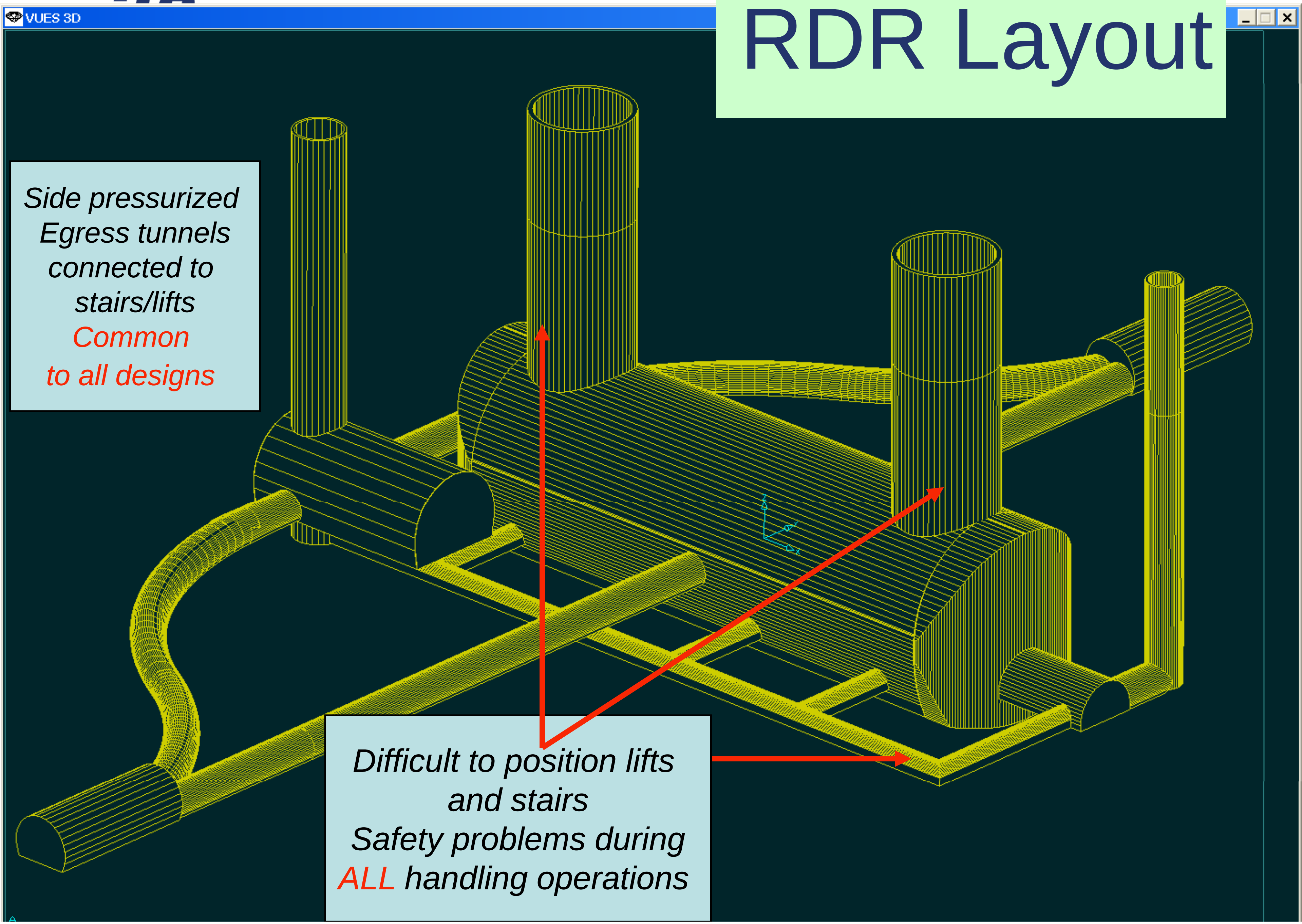
Matters of Secondary Importance:

- Crane Capacity Above & Below Grade
- ?

Baseline IR design

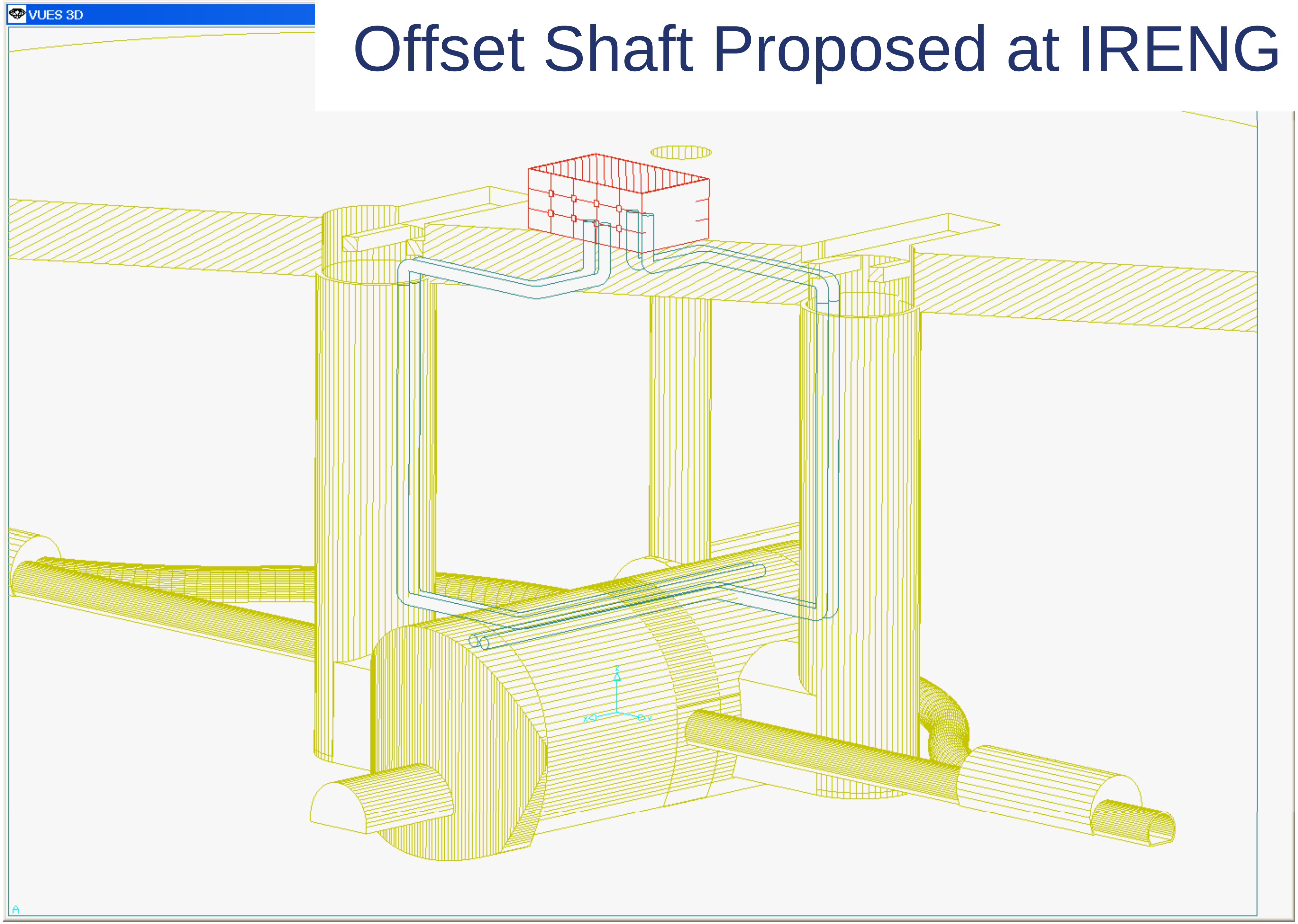
- Hall sized in width for GLDc
- Shaft diameter & crane/gantry capacity sized for GLDc/LDC
- RDR layout shows shafts over assembly hall and an asymmetric service cavern layout
- IRENG'07 version with offset shafts and symmetric service caverns will be submitted for change control
- All CERN produced civil x-sections show platform as mechanism for push-pull motion and boundary between detector and accelerator systems
- All BDS produced civil hall x-sections show a shielding wall separating the two detectors

RDR Layout



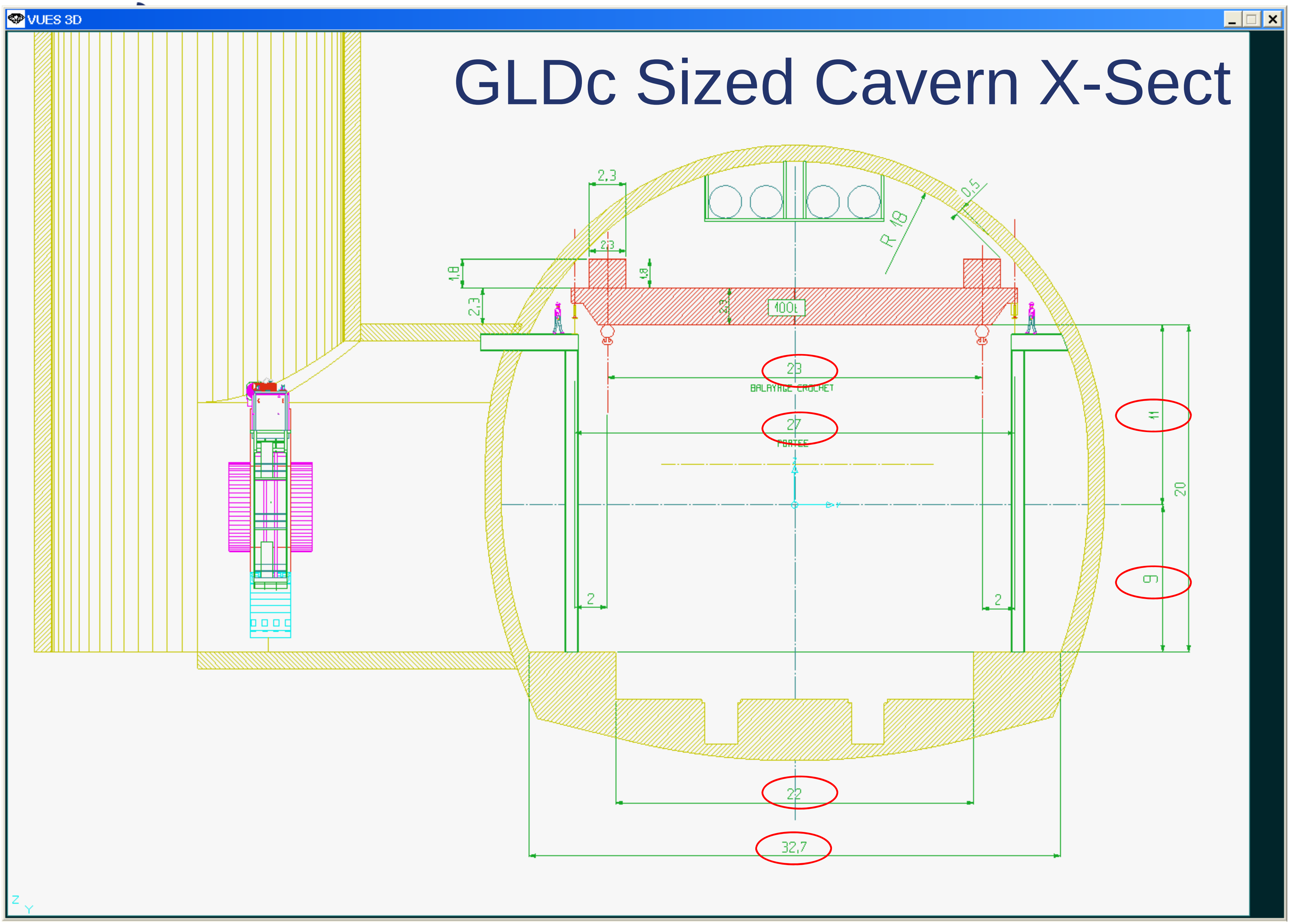
VUES 3D
Side pressurized Egress tunnels connected to stairs/lifts
Common to all designs
Difficult to position lifts and stairs
Safety problems during ALL handling operations

Offset Shaft Proposed at IRENG

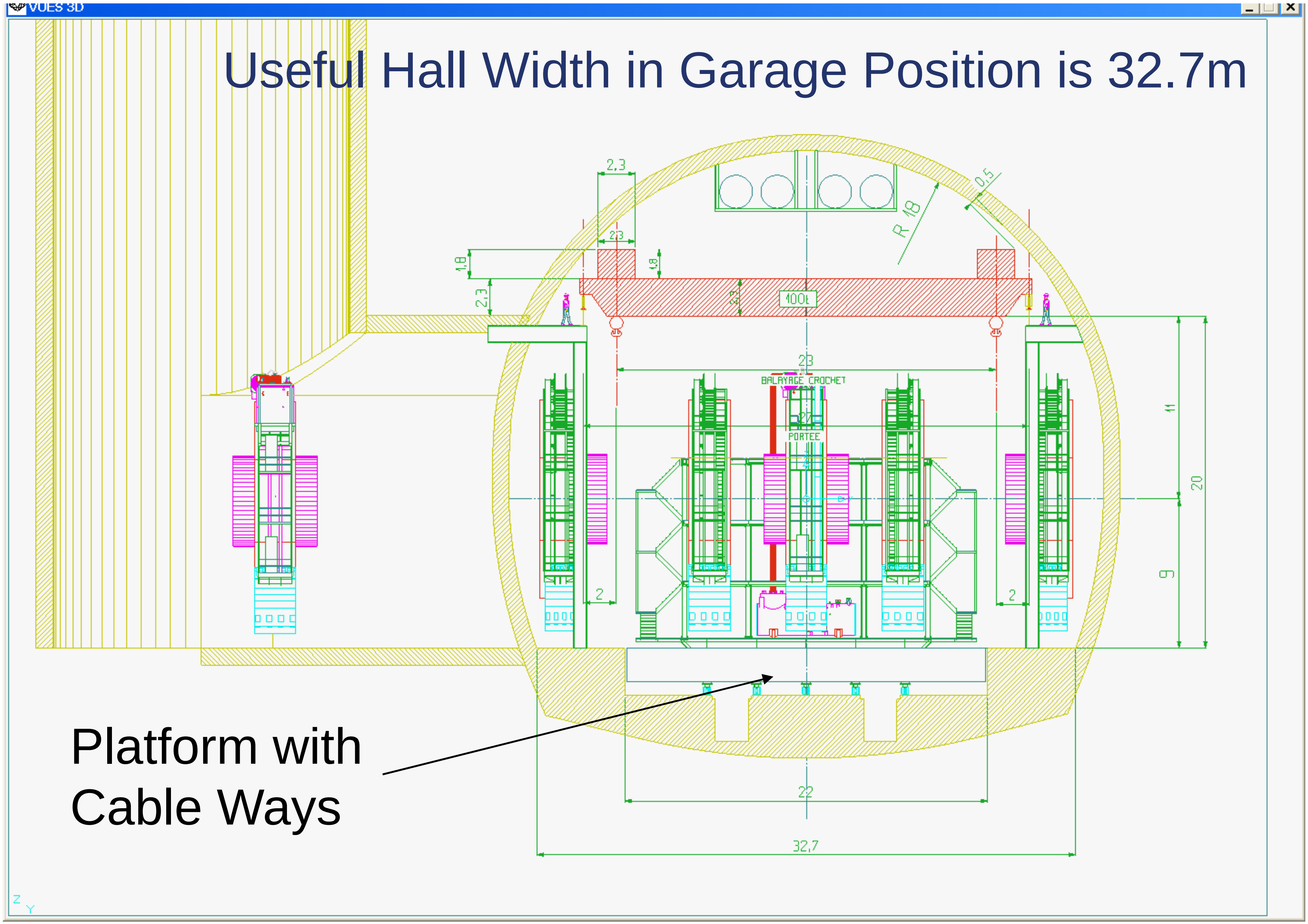


Proposal for 2 Parallel Surface Assembly Buildings

GLDc Sized Cavern X-Sect

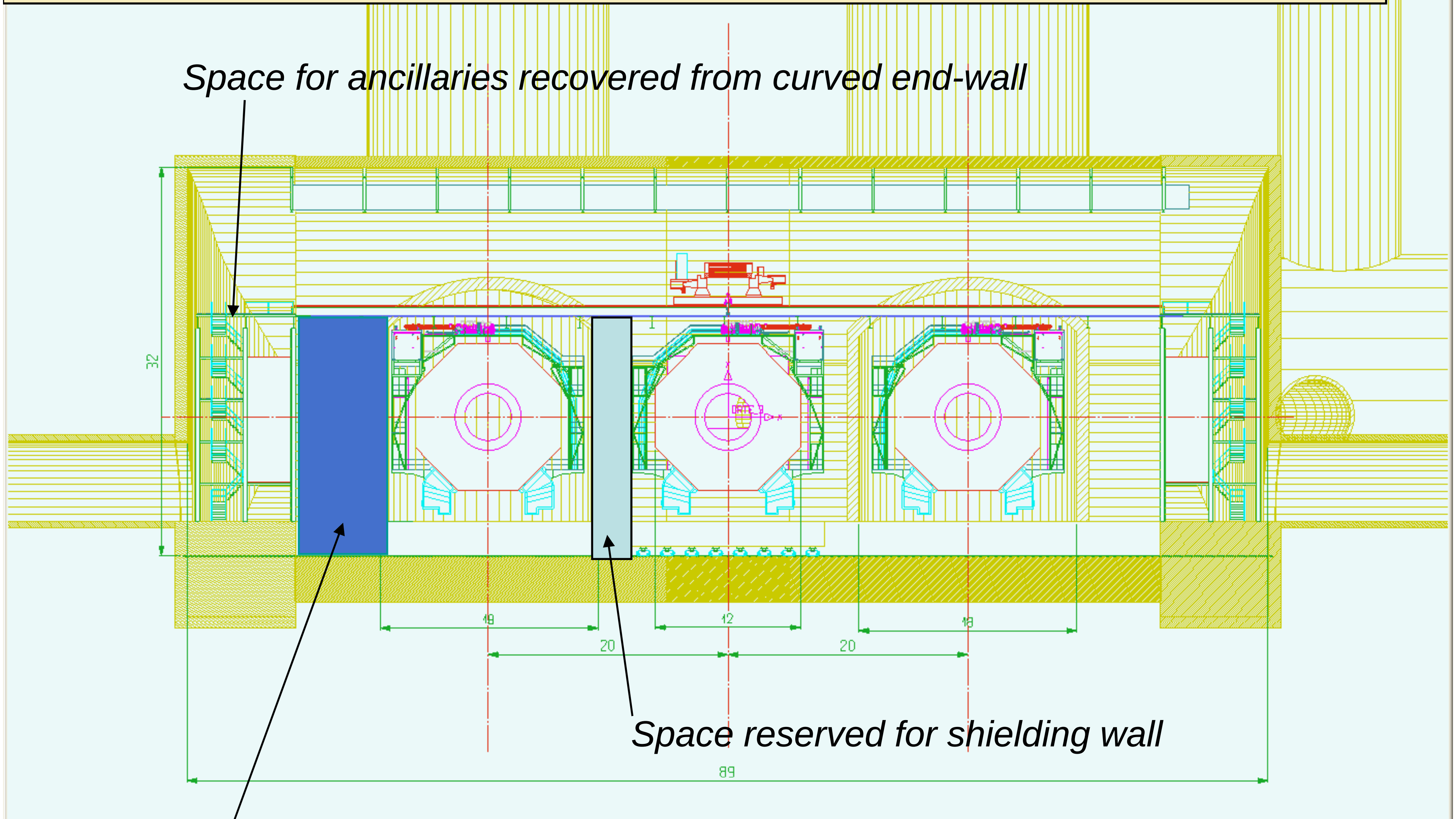


Useful Hall Width in Garage Position is 32.7m



Platform with
Cable Ways

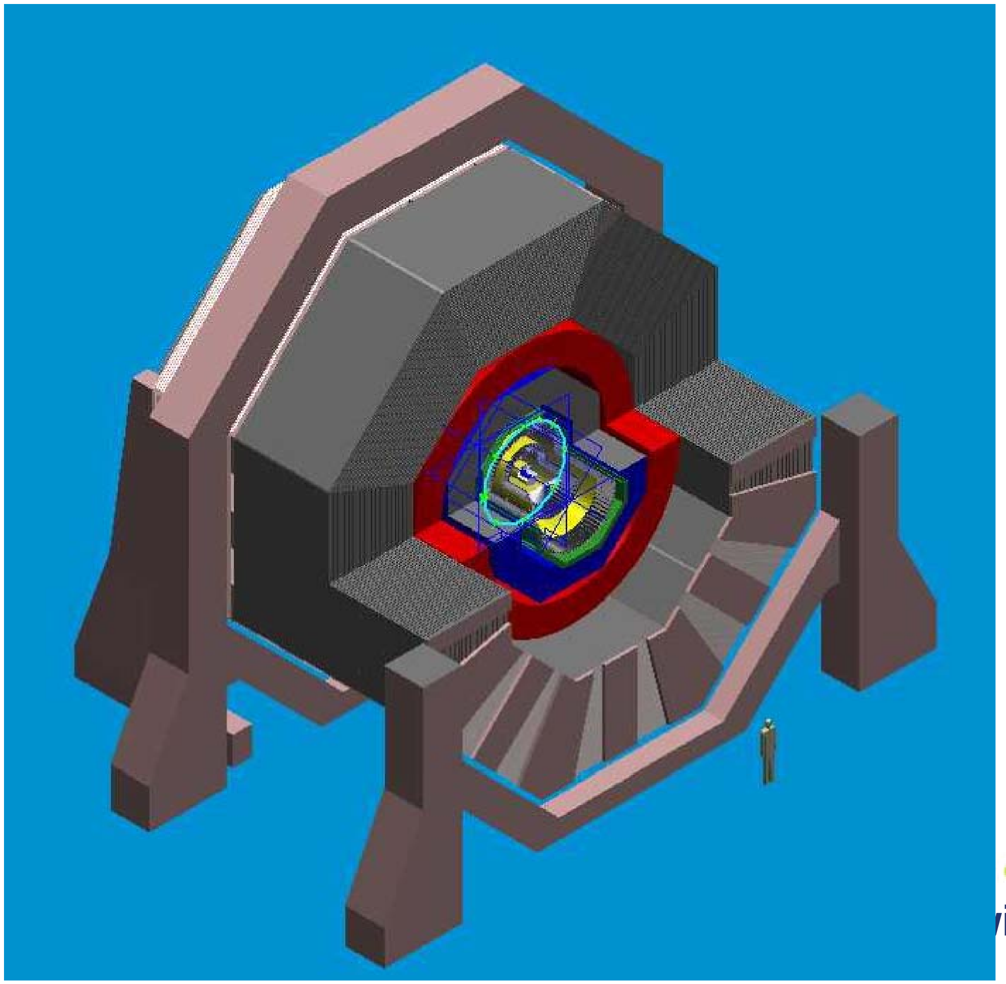
Hall Parameters - Length around 90 m

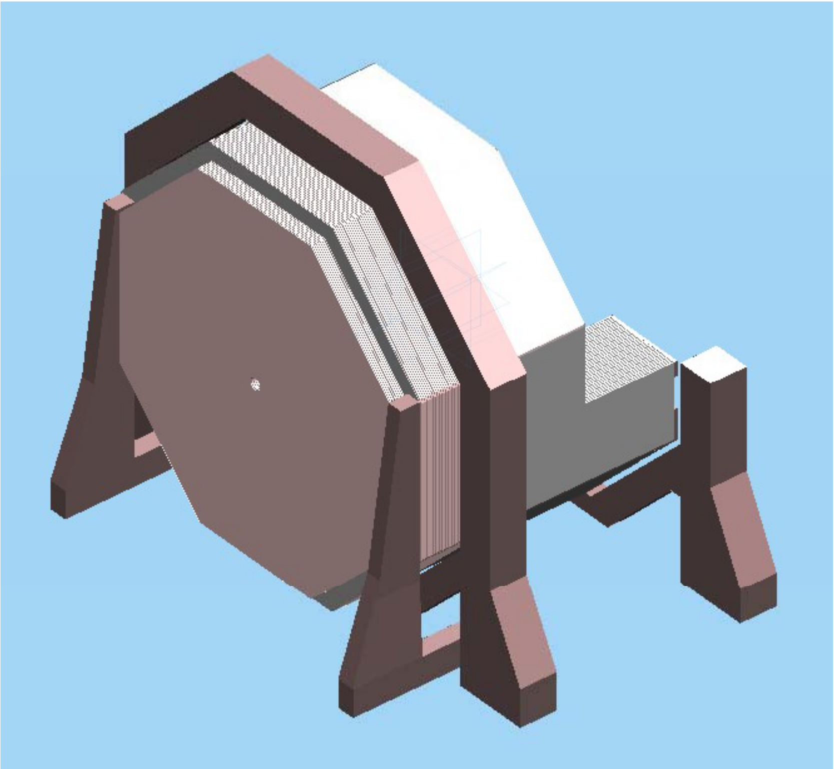


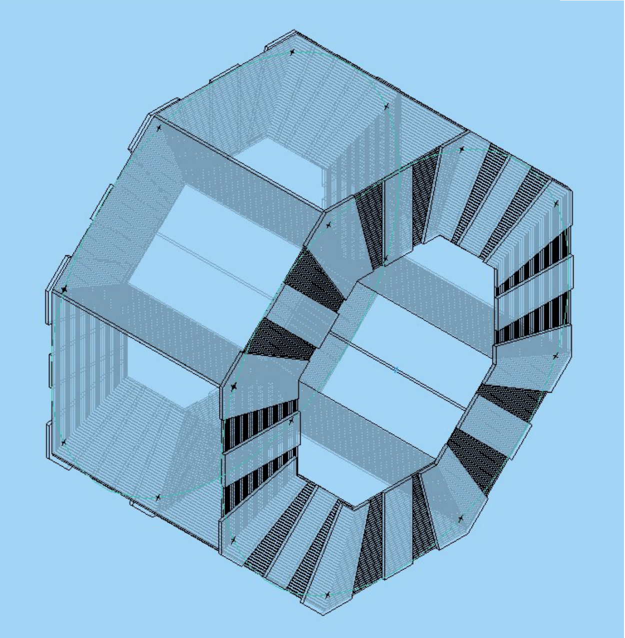
8 m working corridor, could be from 0 to 100% on any one side of experiment in 2-m increments, using 'working platforms' to fill the gaps

SiD surface assembly considerations (Marty)

Solid Edge Model







Sequence of Operations

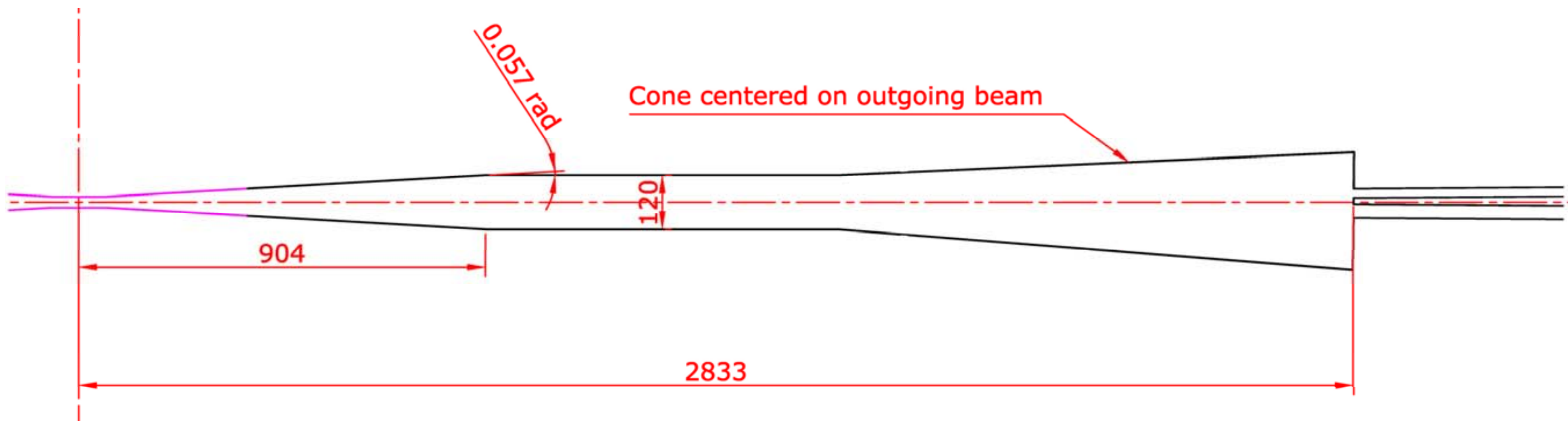
- **Detector subassembly construction & surface tests**
  - **Octants** of muon chamber instrumented **barrel yoke**, barrel Hcal, barrel Ecal
  - **Fou**r sub-modules of **EC return flux** instrumented with muon chambers, donut Hcal, Ecal
  - Tracker, vertex and FCAL packages
- **Surface Magnet test**
  - Assemble barrel support and the bottom 5/8 flux return octants
  - Drop in coil & cover with remaining 3/8 octants
  - Assemble two door legs and 4 360° (180 °?) plates of flux return
  - Test magnet and disassemble
- **Lower detector**
  - Reassemble lower barrel with supports below ground
  - Load barrel HCAL and ECAL modules into coil cryostat via threaded beam
  - Lower loaded coil package and capture with upper barrel yoke segments
  - Depending on crane capacity
    - **Lower fully assembled door**
    - **Lower door pieces, the last plate with the Endcap Ecal & Hcal, and reassemble**
- **Tracker, VXD and FCAL installed below ground at last minute**

A Surface Assembly Scenario for SiD
M. Breidenbach -1 August 2006

M-Tons	Stainless HCAL Radiator		Tungten HCAL Radiator	
	Barrel	Endcap x2	Barrel	Endcap x2
EM Cal	59	19	59	19
HCAL	354	33	367	46
Coil	160		116	
Iron	2966/8= 374.5	2130/4= 532.5	1785/8= 223.125	1284
Support x 2 (each ~5%Fe)	150	110	90	65
Total to Lower	Loaded Coil=573	Assembled Door=2402	Loaded Coil=542	Assembled Door=1479
Shaft Diameter(m)	8.3m	10.4+2.0m		

Beam Pipe Fabrication

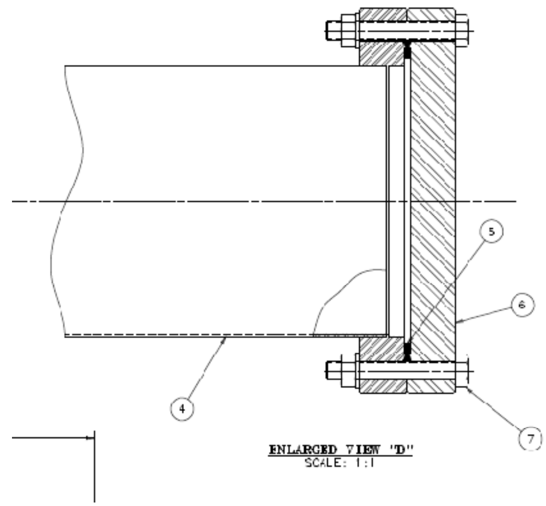
- The October 2007 SiD design assumed stainless steel beyond Z = 759 mm.
  - **That allows more standard welding and fabrication techniques.**
  - **Beryllium to stainless transitions should be done by the fabricator of beryllium portions, but the stainless steel portions could be made by a different vendor.**

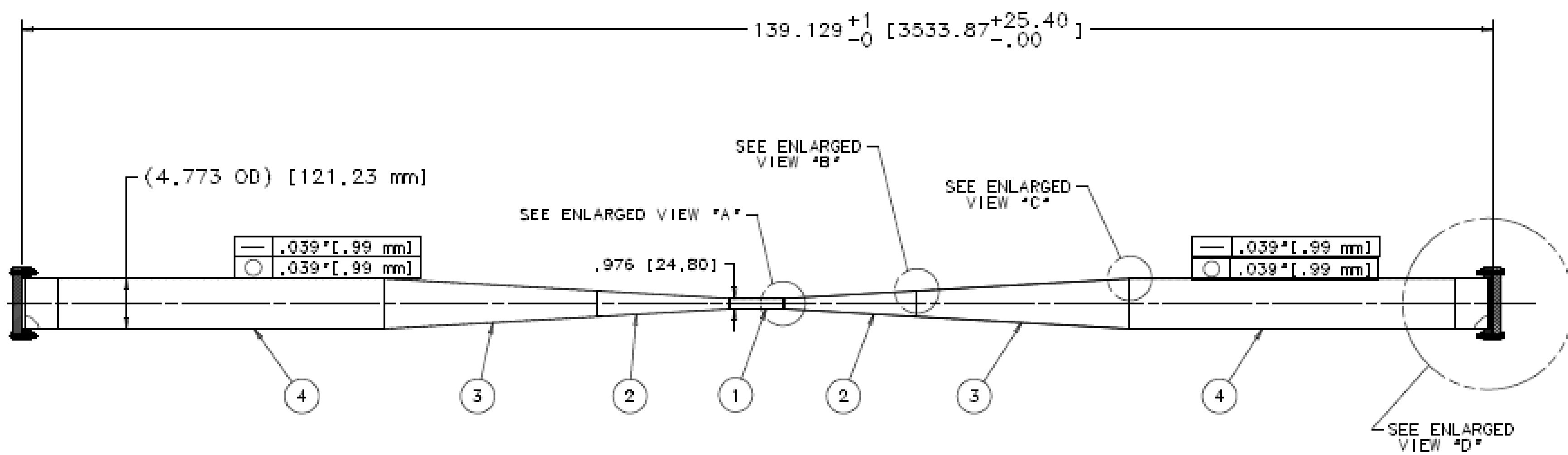


W. Cooper, FNAL

Beam Pipe Fabrication

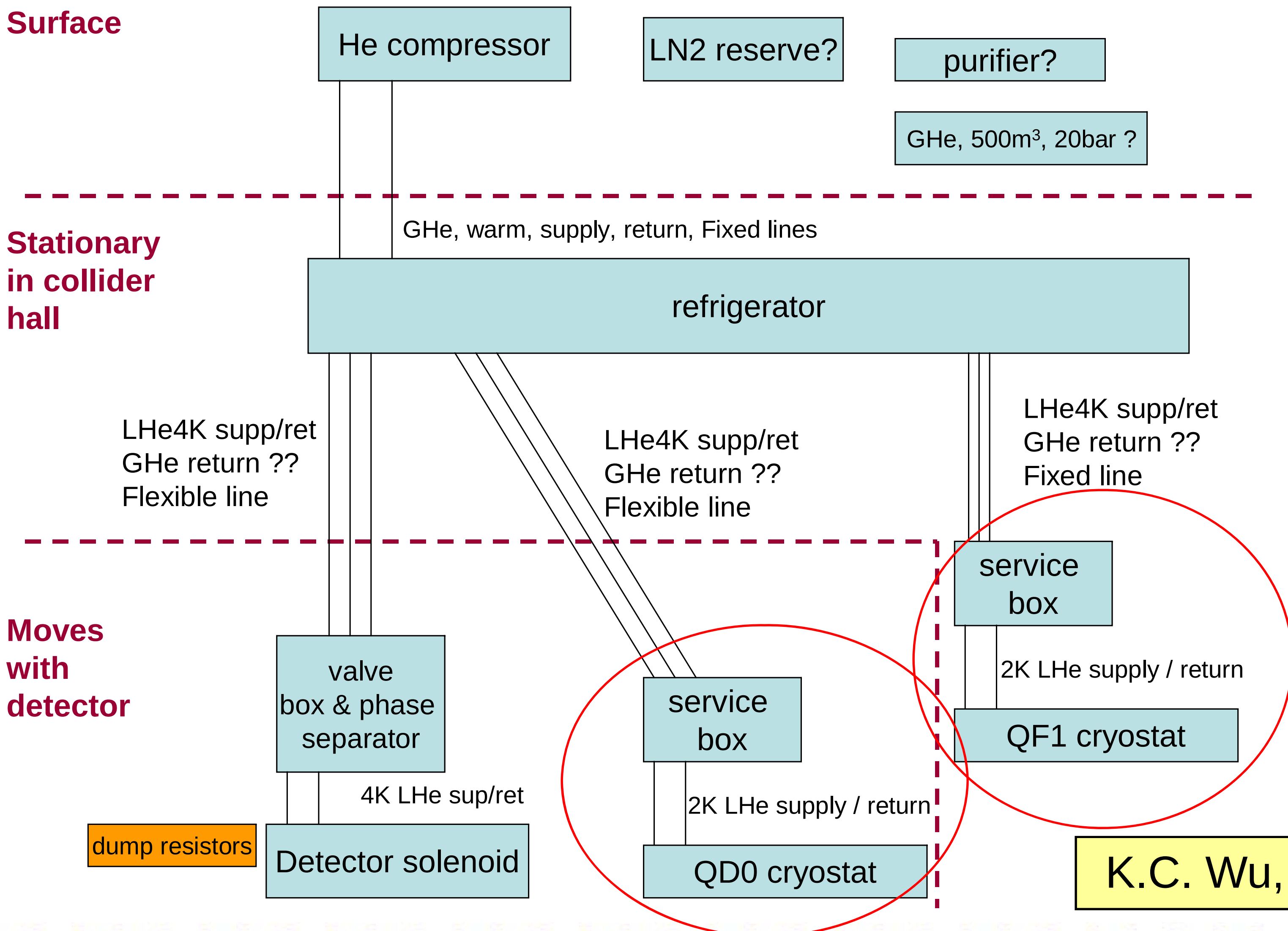
- Brush-Wellman visit: Be up to flange at LUMICAL
- CMS-like foldable ion pumps behind LUMICAL if needed
  - **Expected that MDI group relaxes vacuum spec at IP**





K. Krempetz, FNAL

Cryogenic Block Diagram in ILC IR Hall

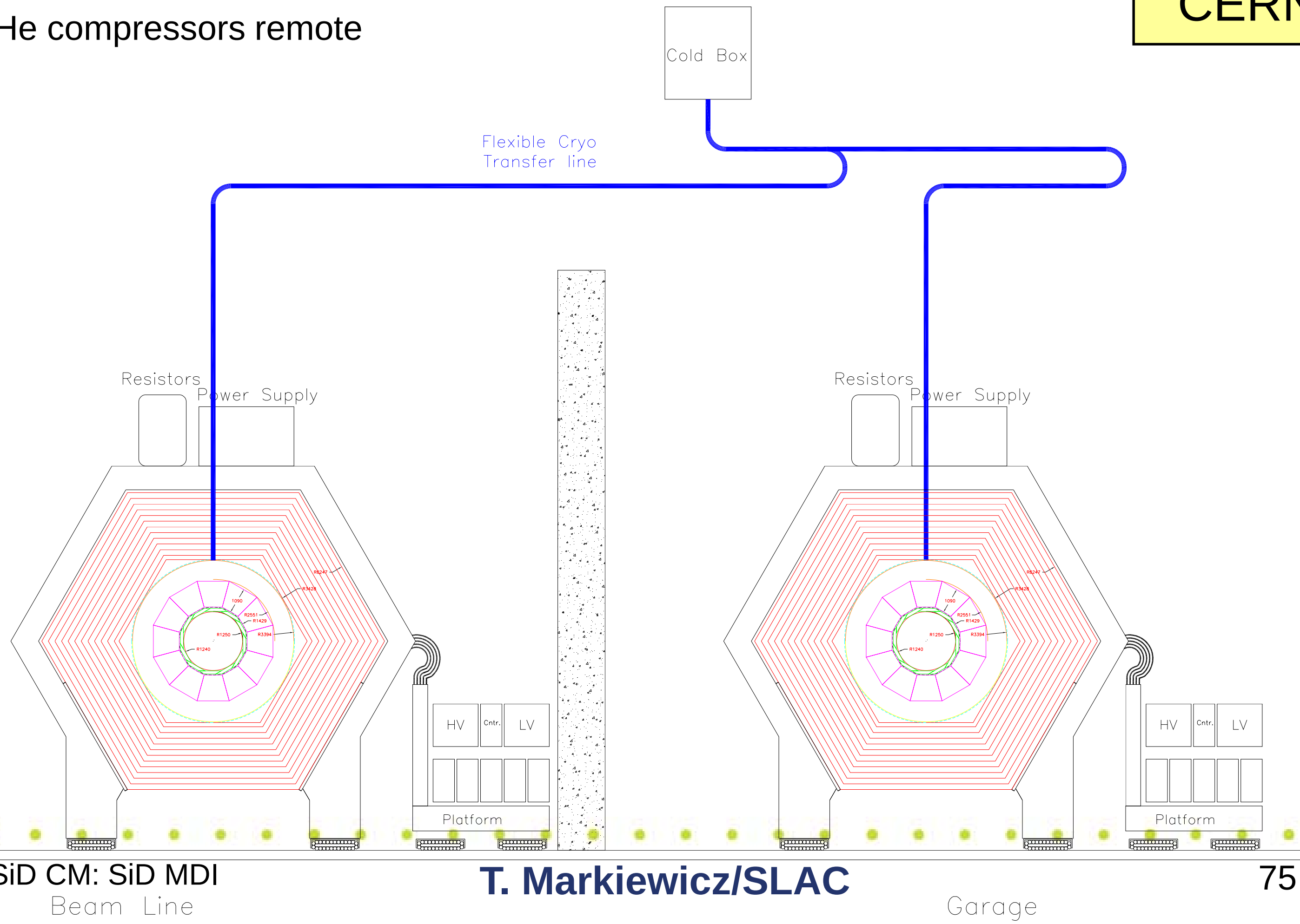


K.C. Wu, BNL

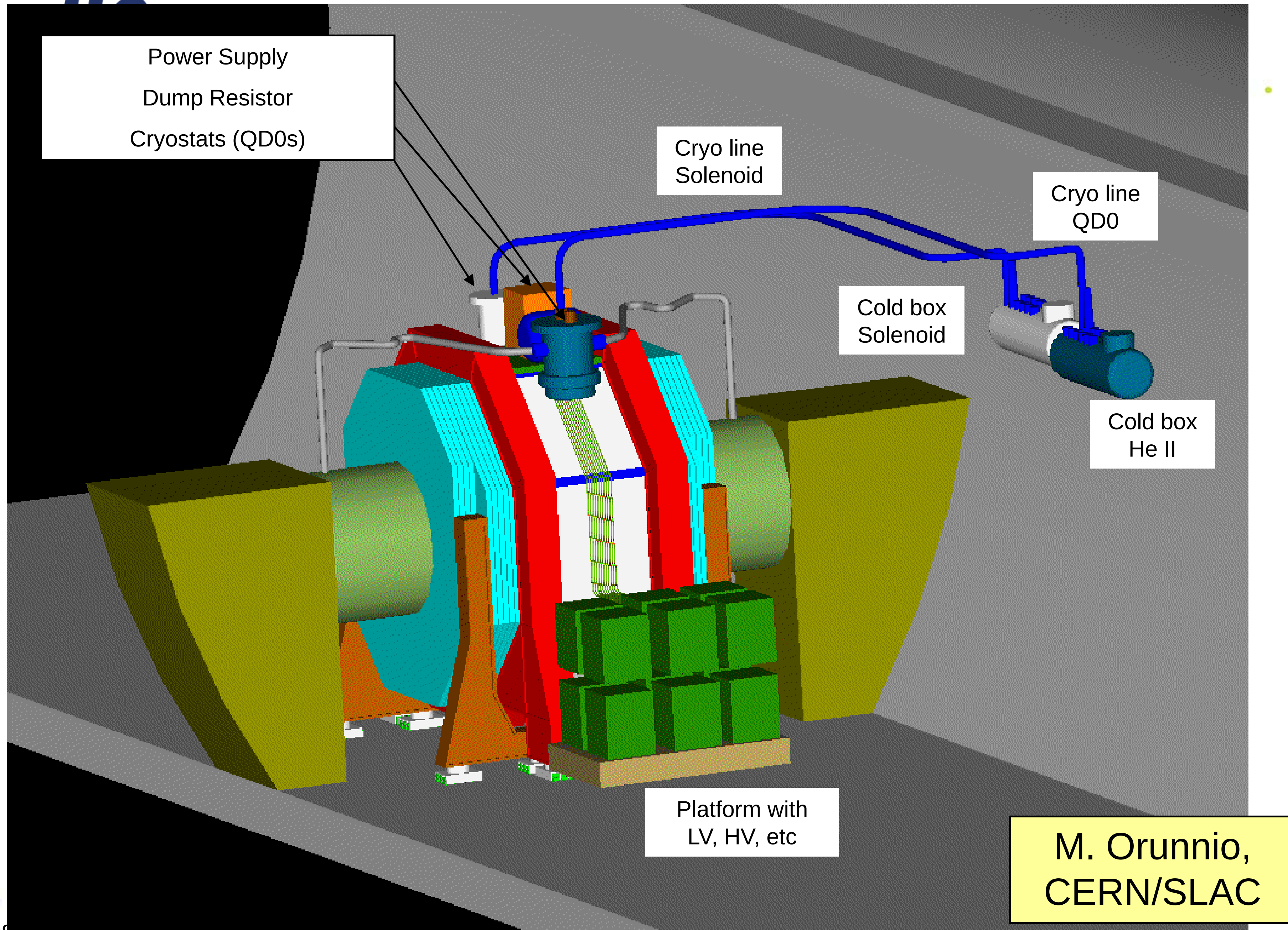
SiD IR Hall Assumptions

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

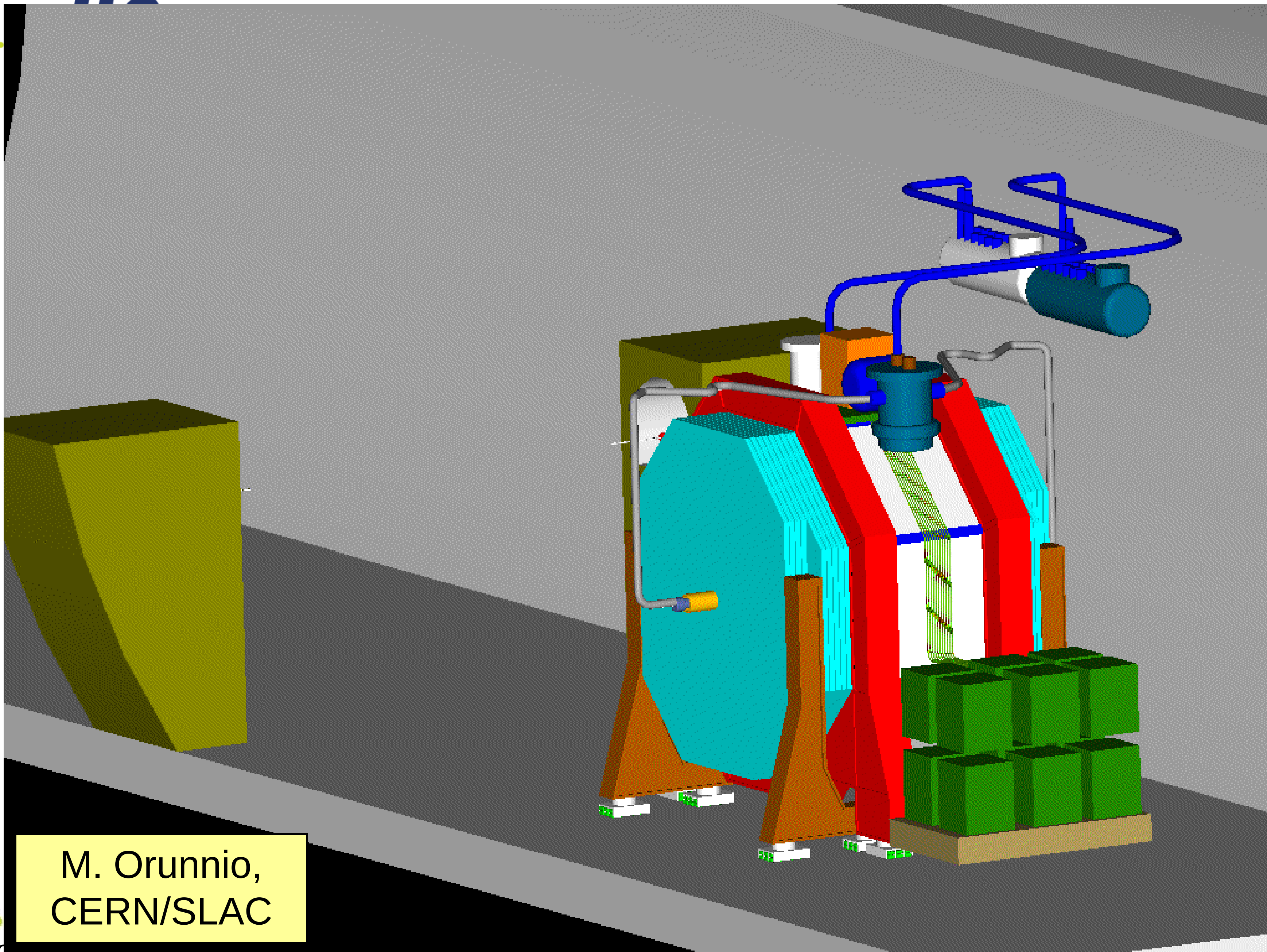
M. Orunnio, CERN/SLAC



SiD closed on the beam

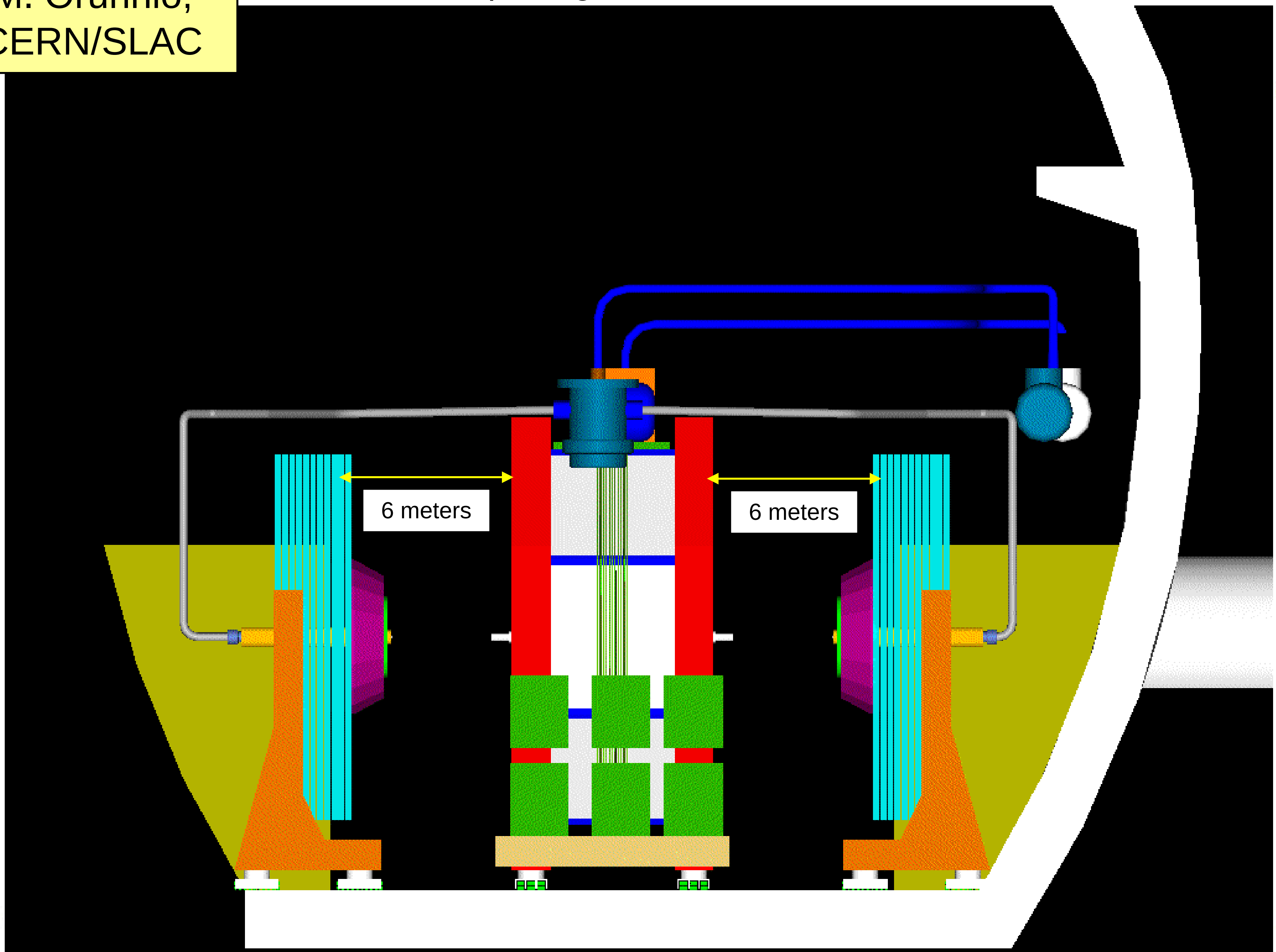


SiD push-pull (30 meters stroke)

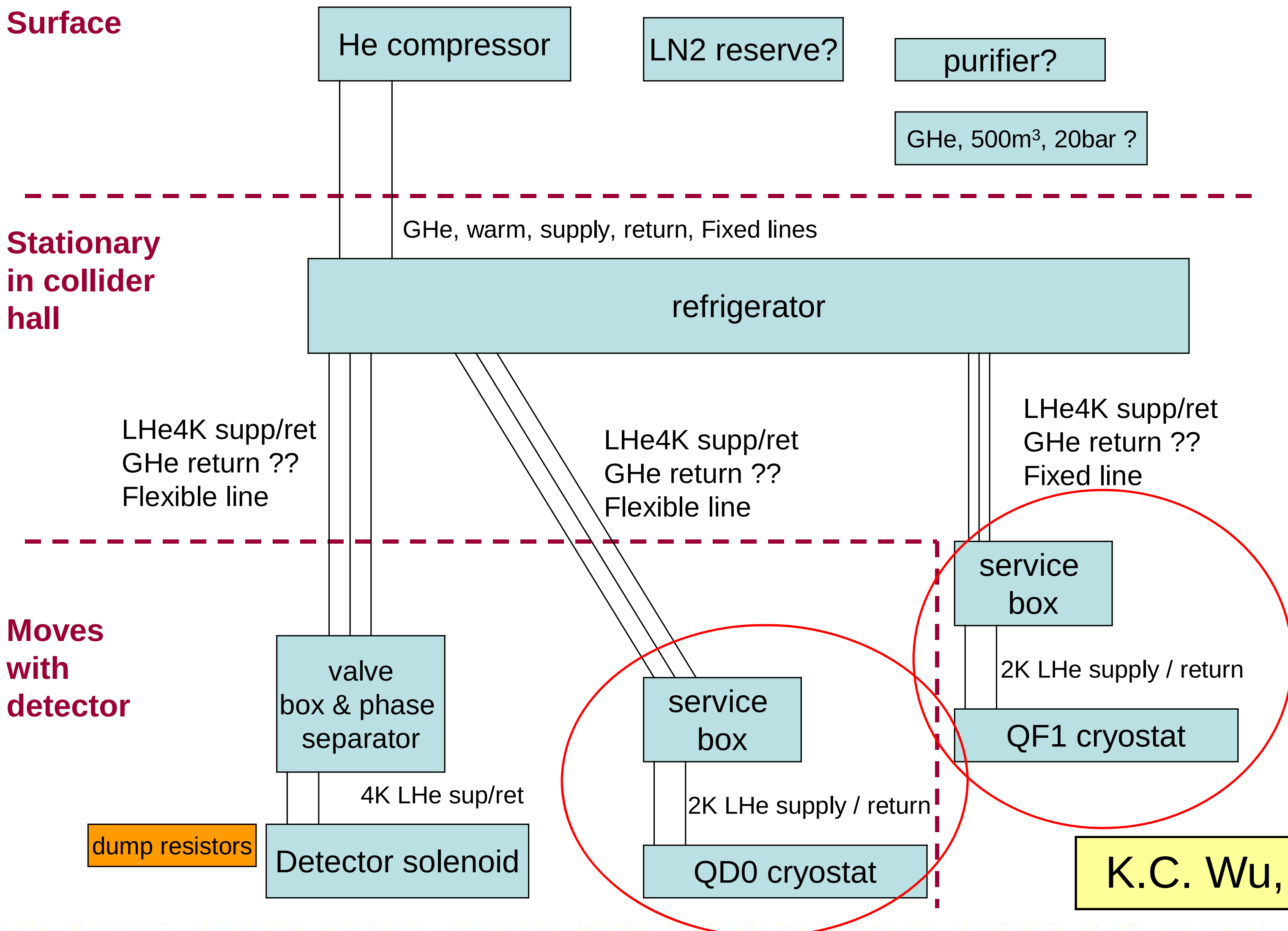


M. Orunnio,
CERN/SLAC

SiD opening @ 6 m off the beam



Cryogenic Block Diagram in ILC IR Hall



K.C. Wu, BNL

SiD IR Hall Assumptions

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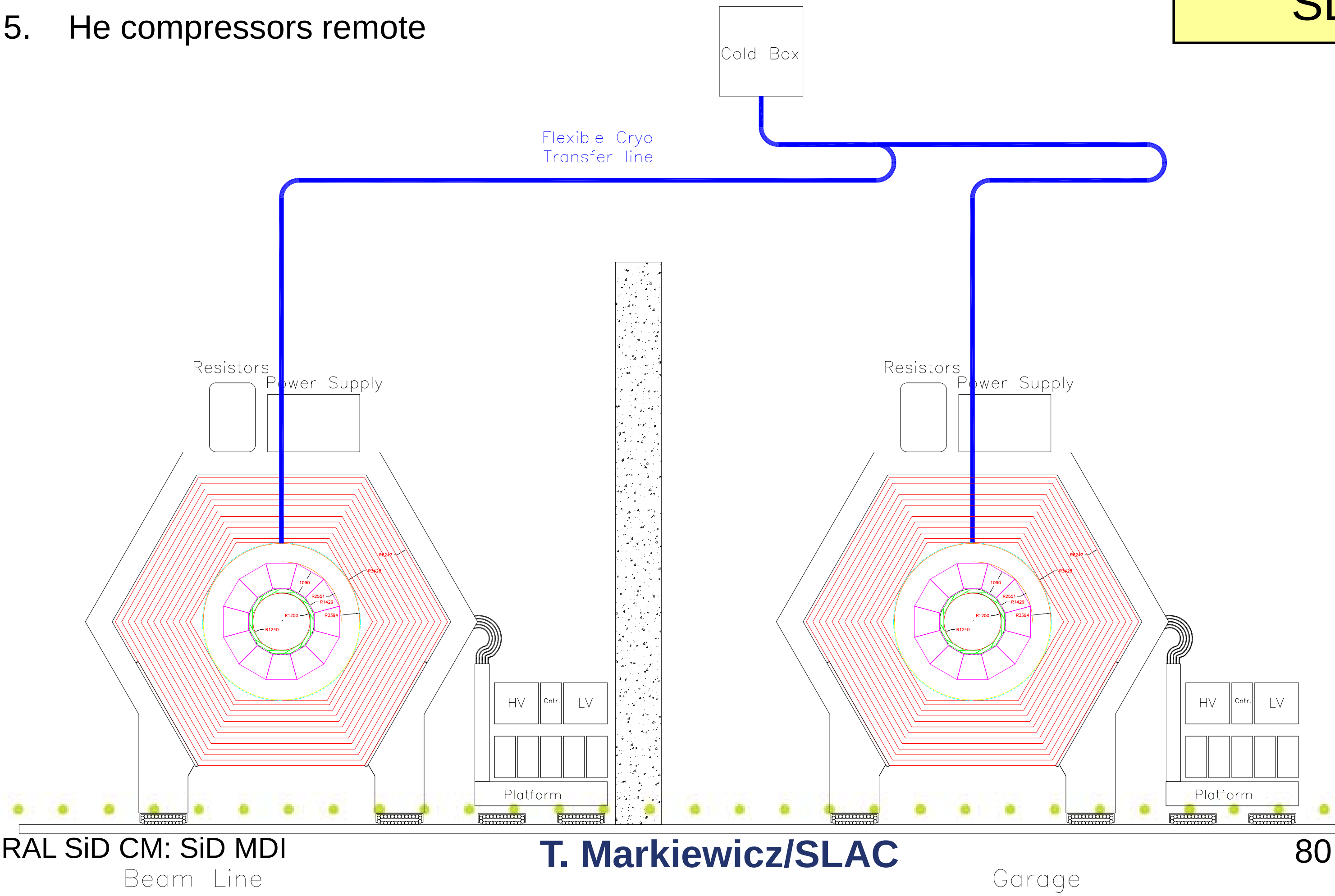
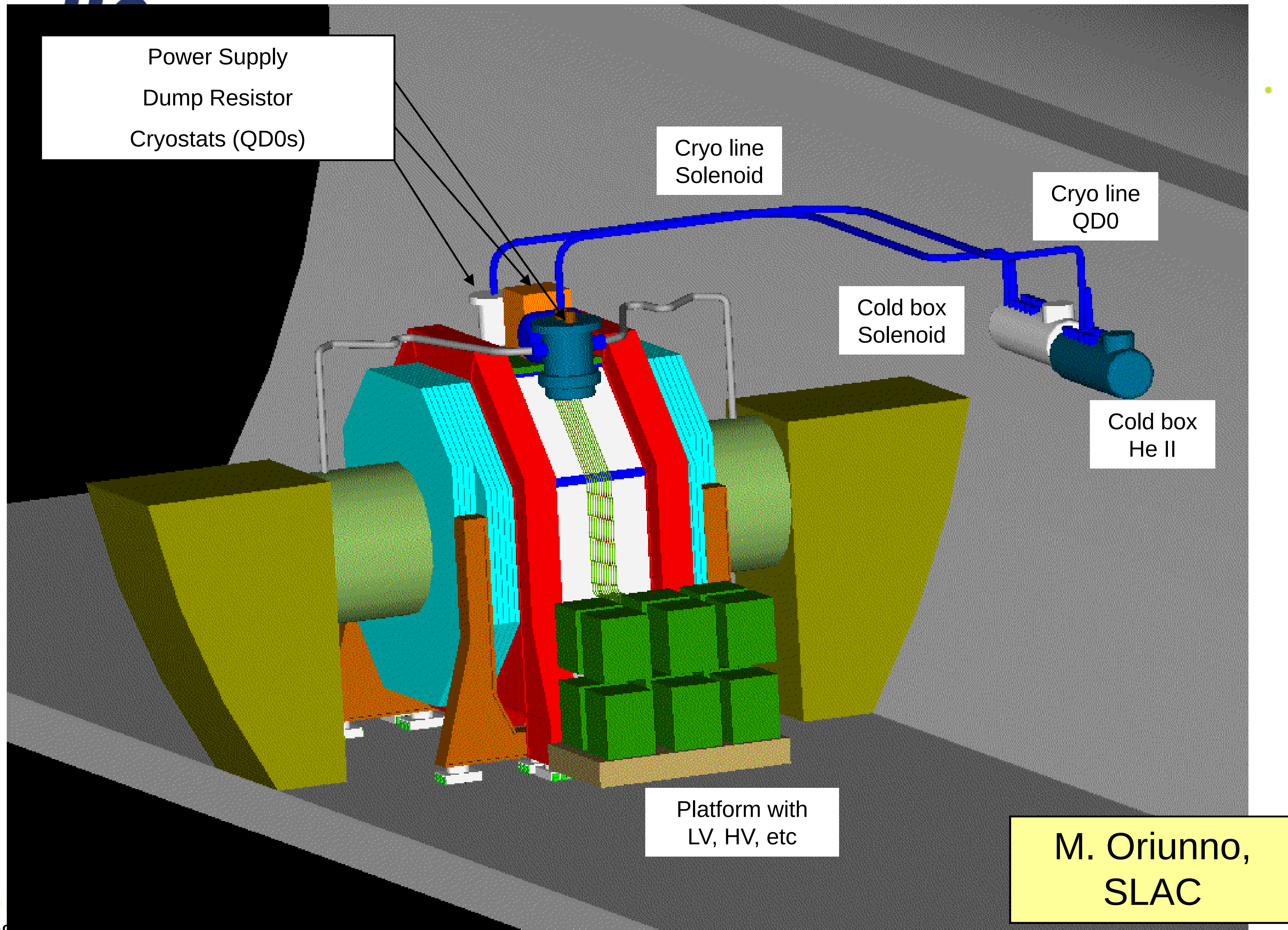
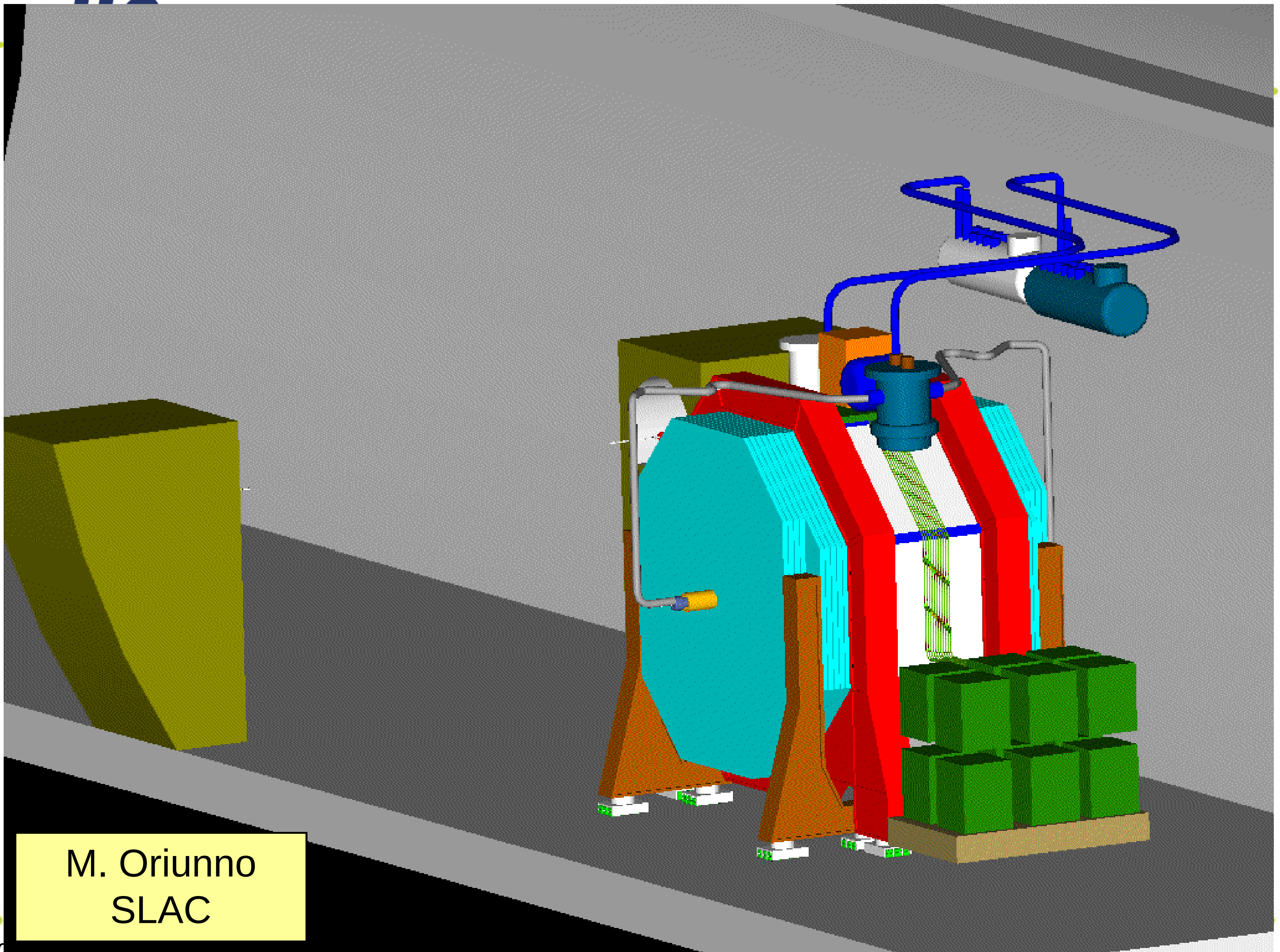
M. Oriunno, SLAC



SiD closed on the beam

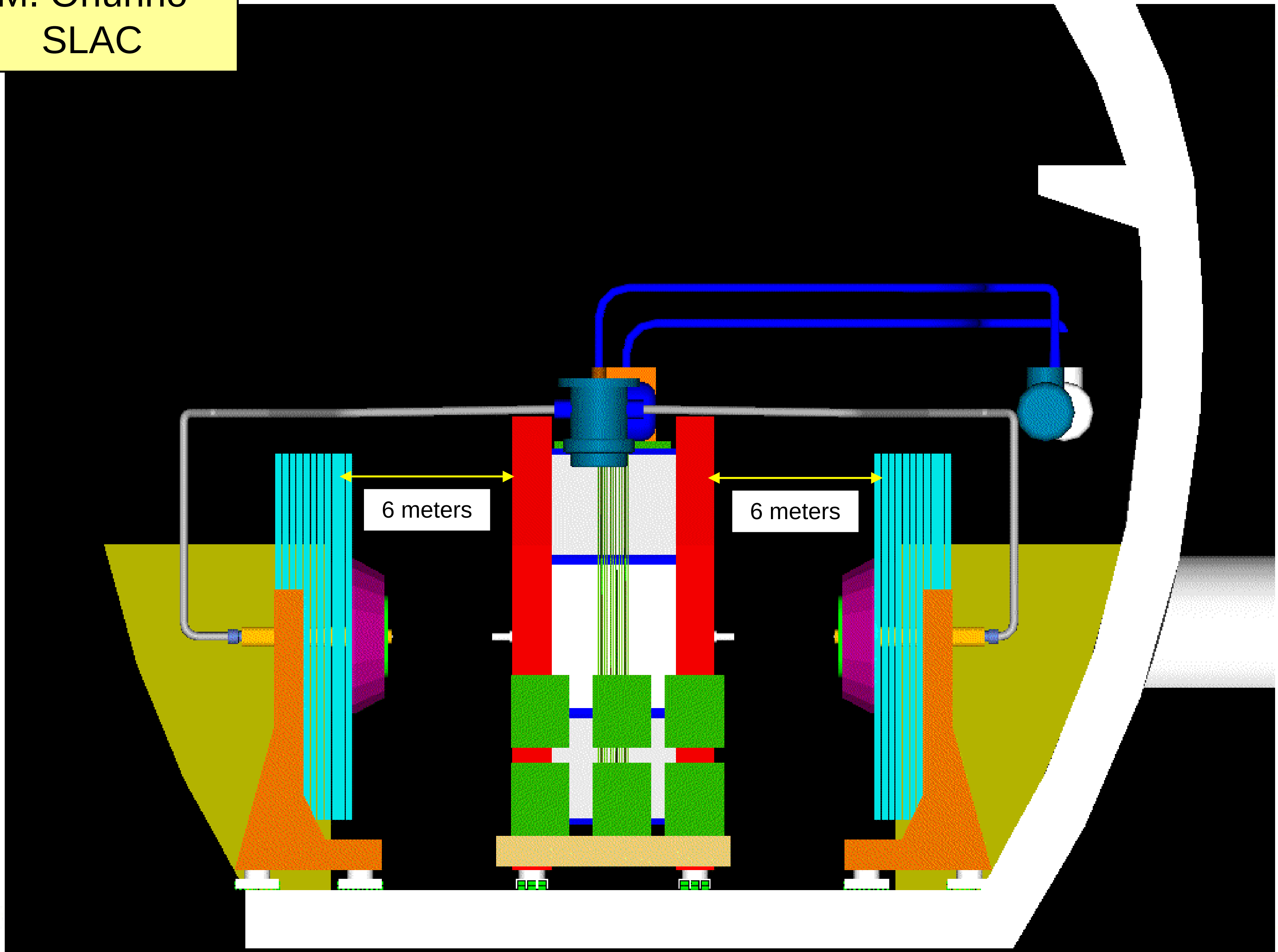


SiD push-pull (30 meters stroke)



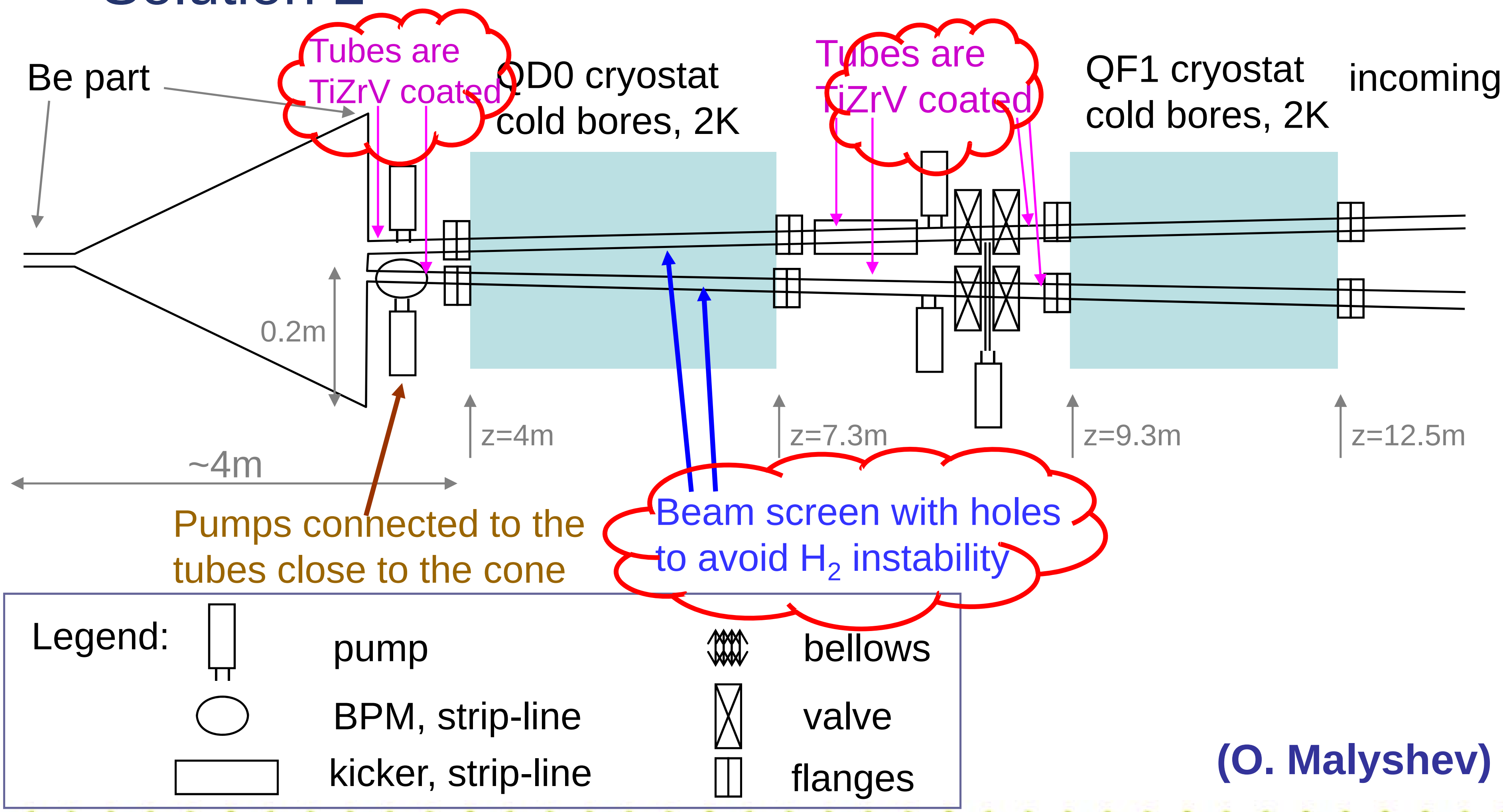
M. Oriunno
SLAC

SiD opening @ 6 m off the beam



IR Vacuum_12: Potential Big Deal

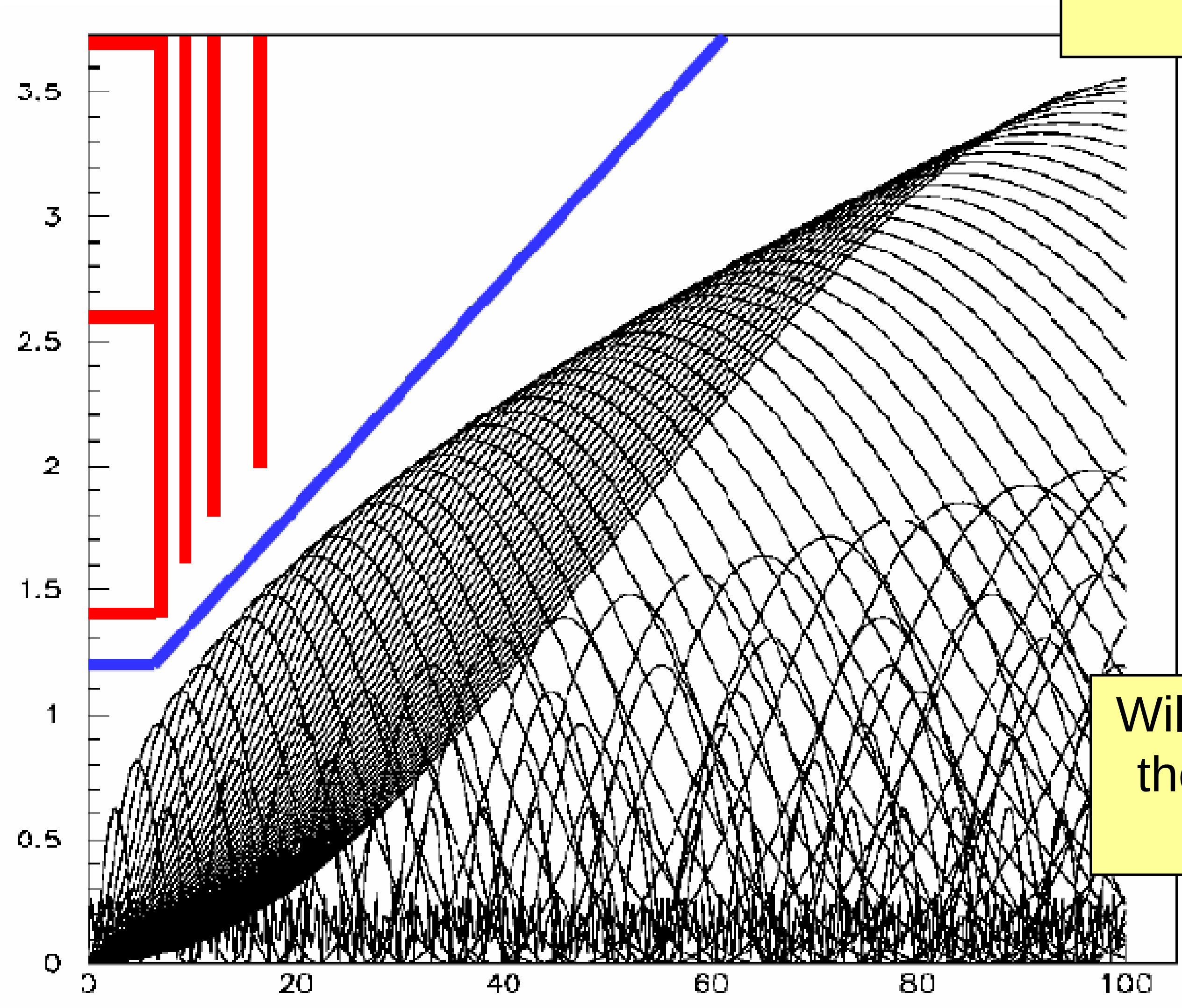
- Solution 2



(O. Malyshev)

12mm Beam Pipe and VXD Detail

T. Maruyama
SLAC



Will this be the the last word for LOI?

Conclusions

In the FCAL/QDO zone, it will likely require more radial space than 20cm built into current ECAL & Tracker designs to support and align package

- SiD Exec Committee Choice

A discussion of interface issues will need to begin once Yamada-san has announced the MDI contacts and the BDS Integration Team

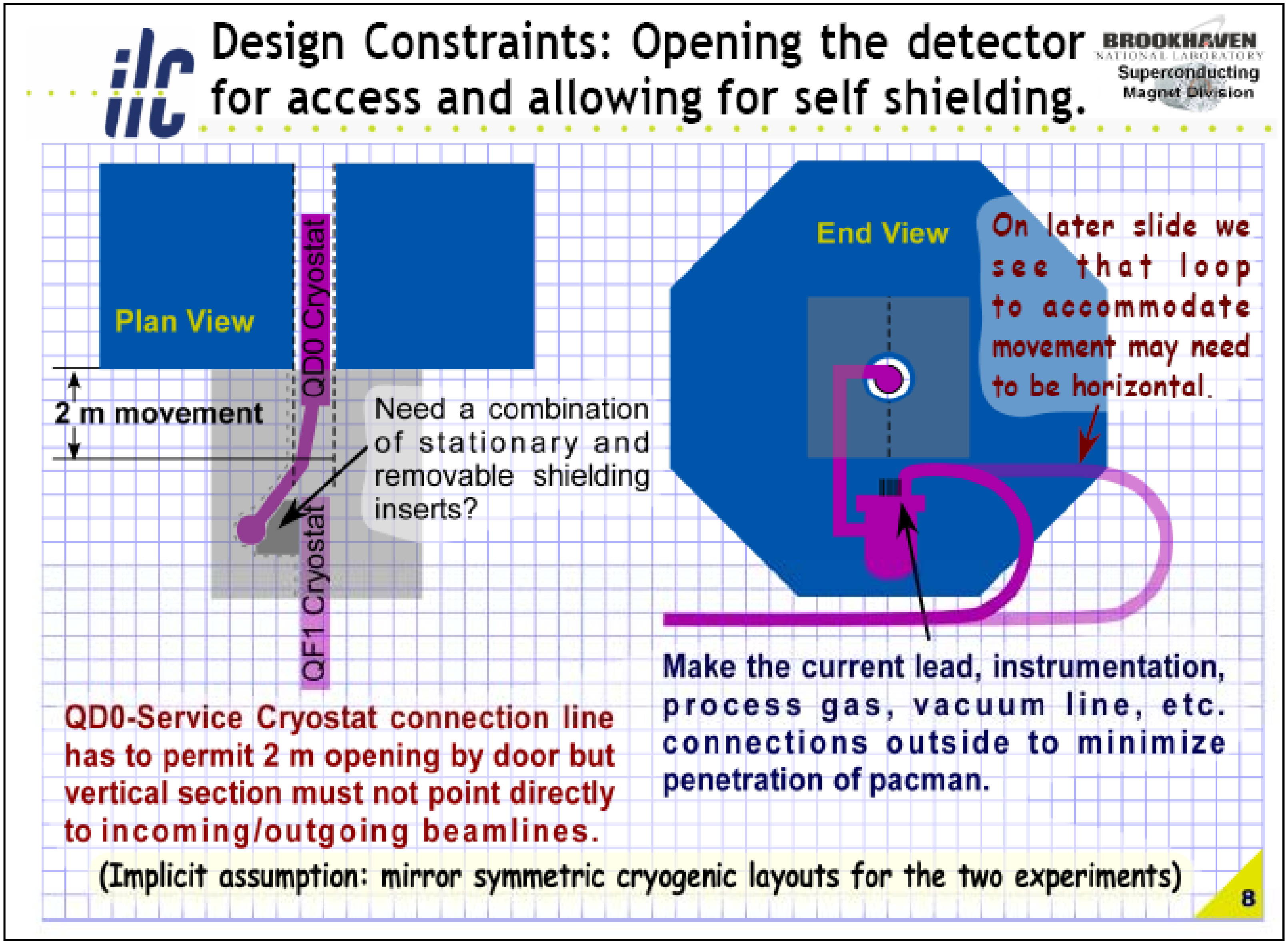
- PacMan Interface Platform and hall depth

Other major SiD-FCAL questions related to MDI are

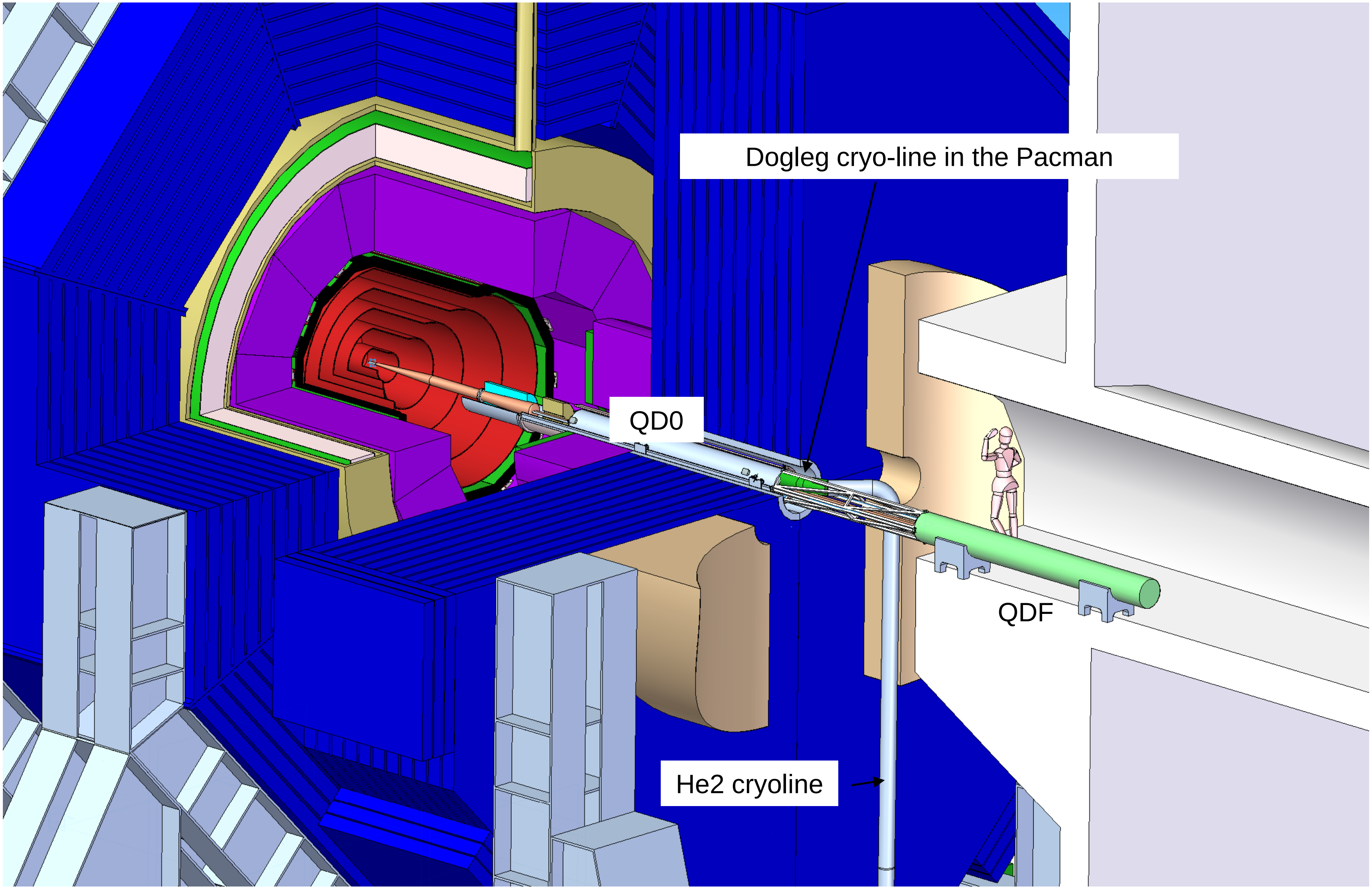
- FCAL geometry (OD, ID) of Lumical and Beamcal
- Beam Pipe shape, flange & bellows and pump locations

BackUp Slides

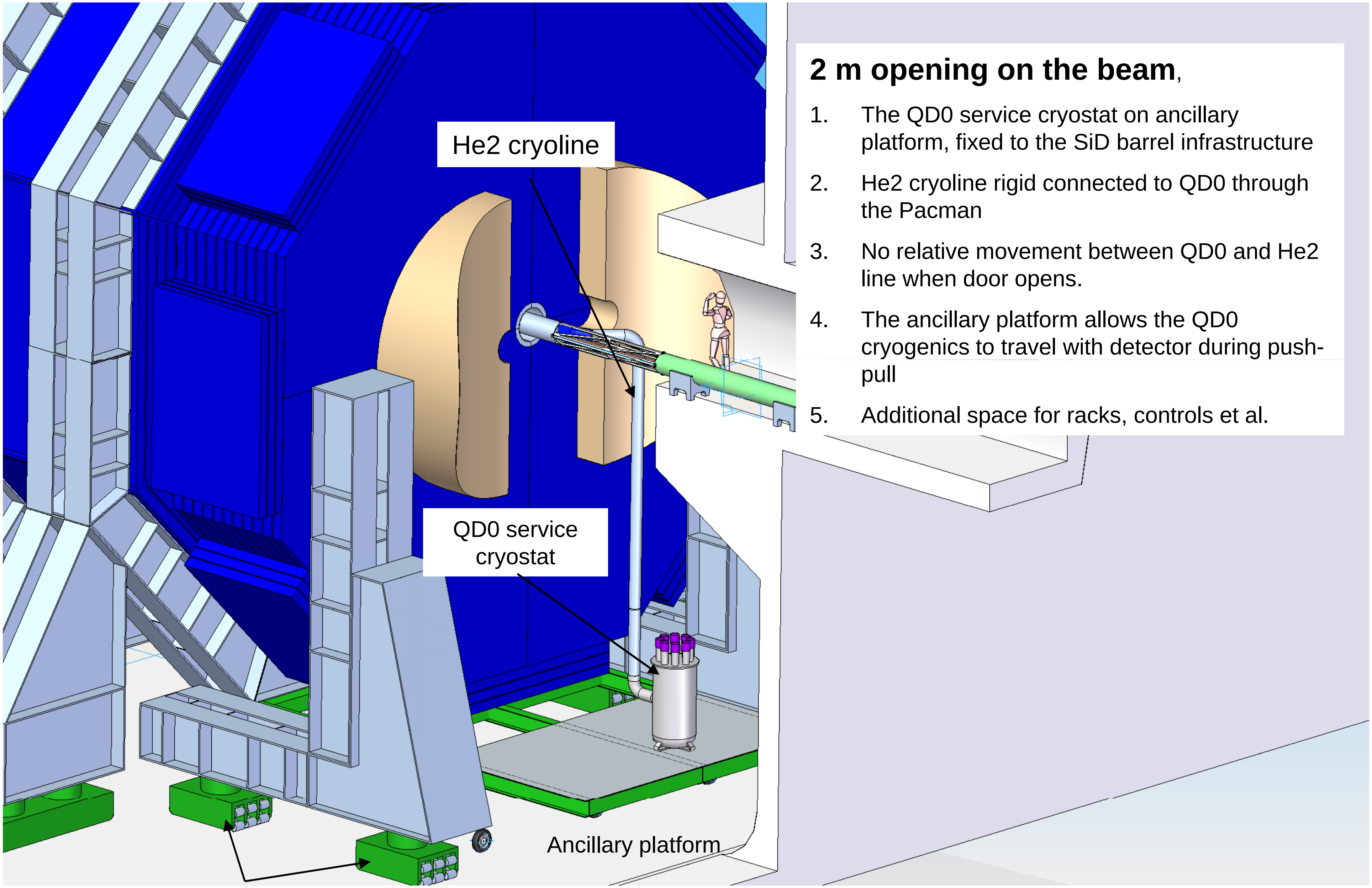
QD0 and He2 line design, B.Parker, IRENG07



Integration of the QD0 cryoline



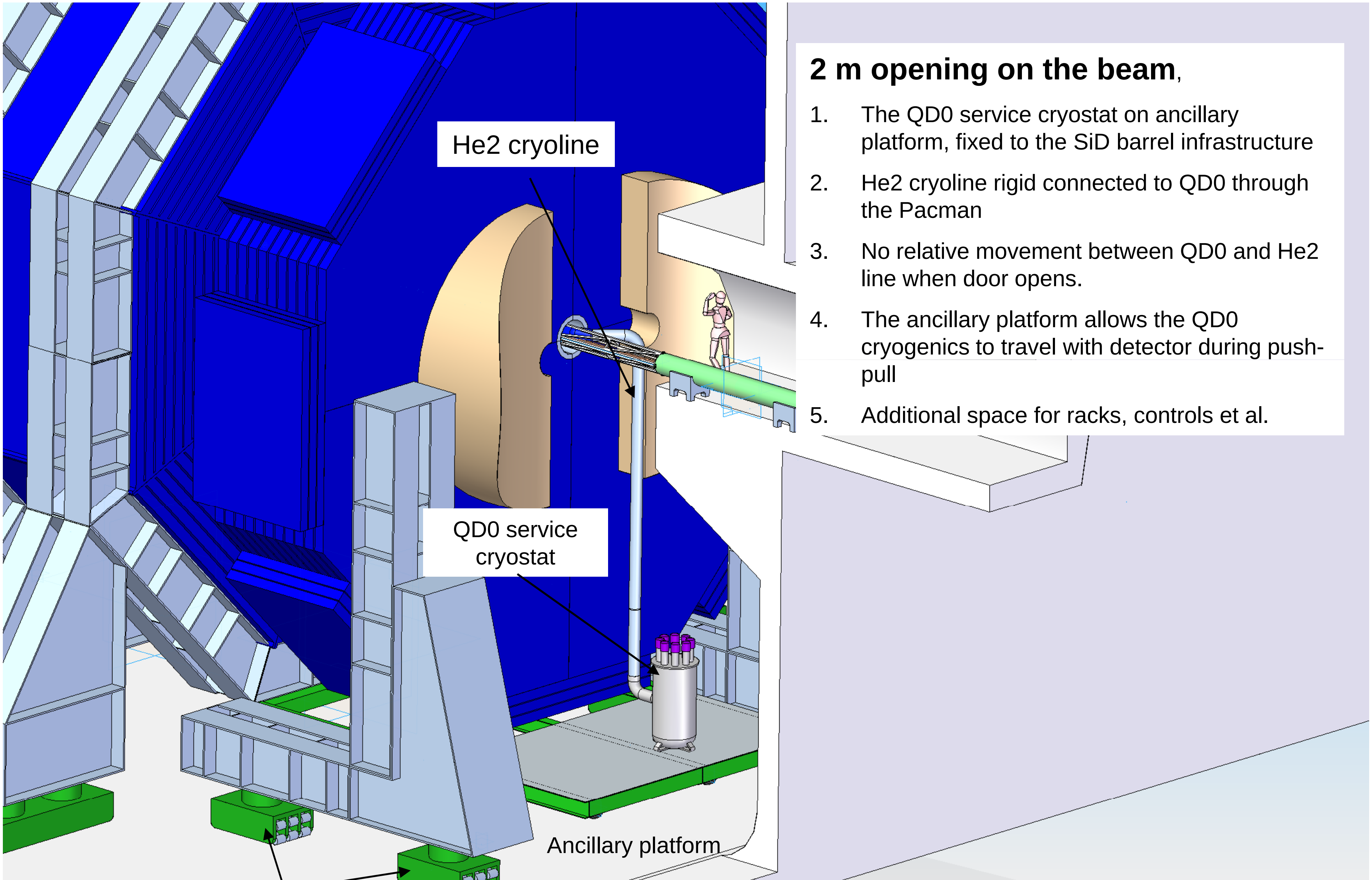
Integration of the QD0 cryoline



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.

Integration of the QD0 cryoline



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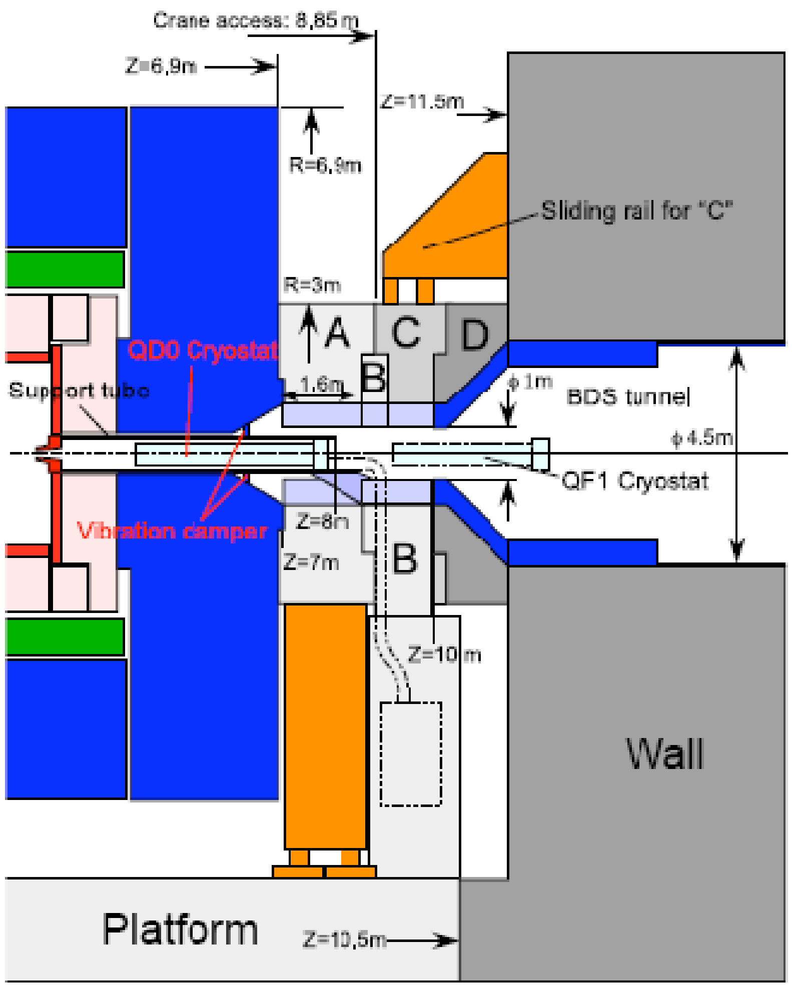
Interaction with the BDS Group

- A number of IR design choices were made for the RDR which were not optimized from the SiD perspective
- Major contributions of CERN civil group to layout/cavern/assembly/platform/access discussion beginning after LCWS'07 in preparation for IRENG'07 via detailed layout schematics motivated by LEP and LHC experience
- Machine CFS group constantly asking for engineering details of detector when only concepts exist
- Detector Engineering lags Machine Engineering
- Fear growing that IR design decoupling from Si D and being driven by GLDc/LDC consortium

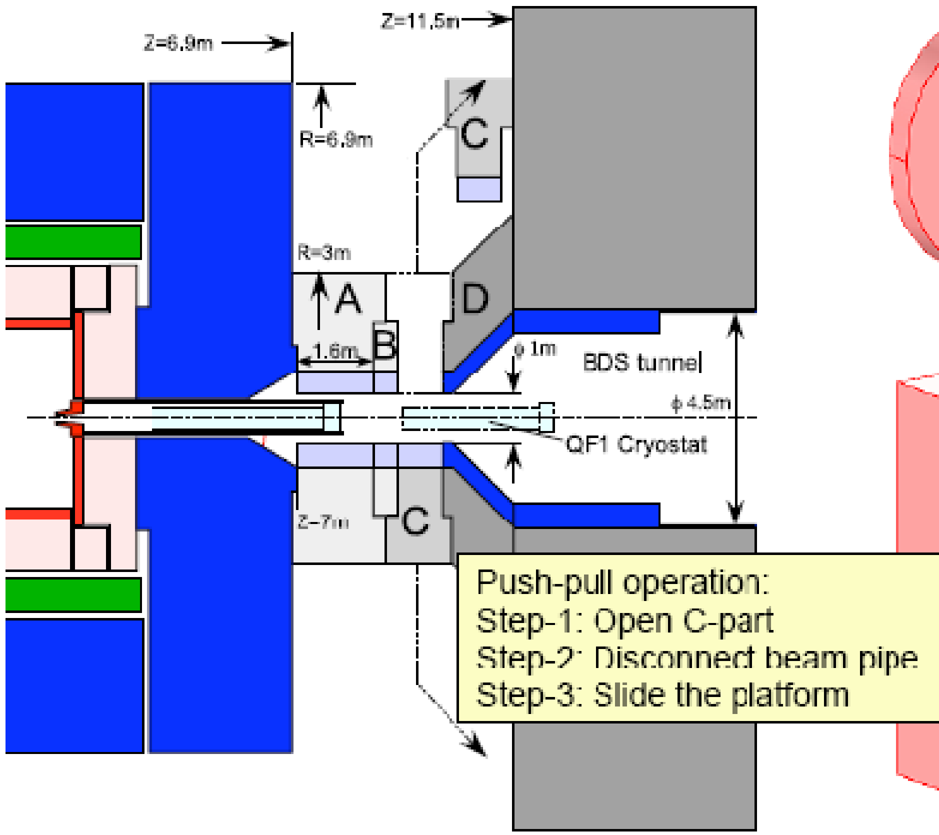
GLDc QD0 Support Based on Cantilevered Support Tube with Base on 2 x 10.5m wide Platform

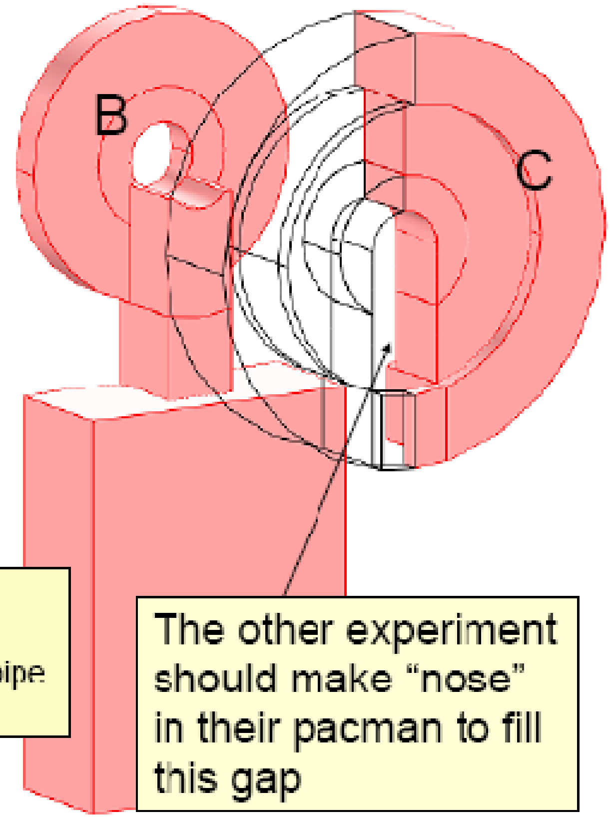


- A: slide sideway using air pad
- B: supported from the floor of platform
- QD0 cryostat is supported by the support tube and the support tube is supported from B
- We can put additional support for the support tube at the entrance of endcap yoke to damp the vibration, if necessary
- Upper part of B (~10 ton) must be removable by crane for installation and removal of the support tube
- C: slide along the wall (D) (common to both experiments) ~50 tonx2
- D: part of the wall
- Wall distance can be as small as 11.5 m from IP, if the crane can access to 2.65m from the wall
- Construction of C is done by a mobile crane (CMS style)
- Inner radius of pacman should be determined after design of gate valve etc. between QD0 and QF1 is fixed

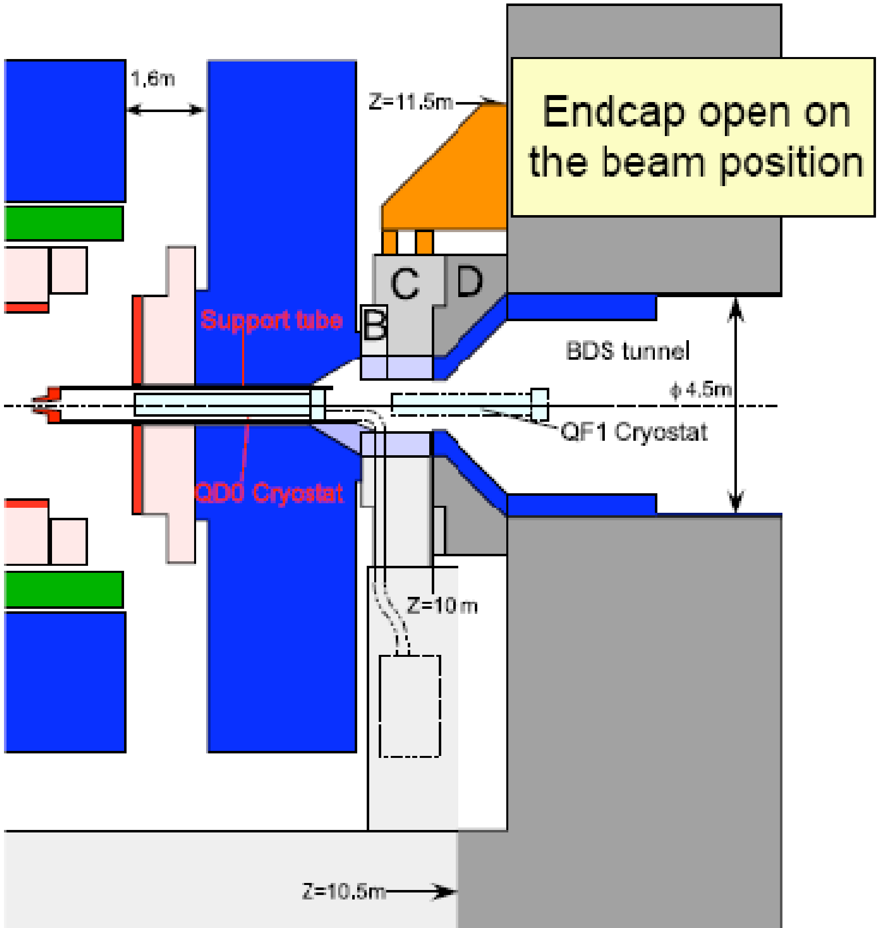
GLDc Disassembly of PACMAN for Push-Pull

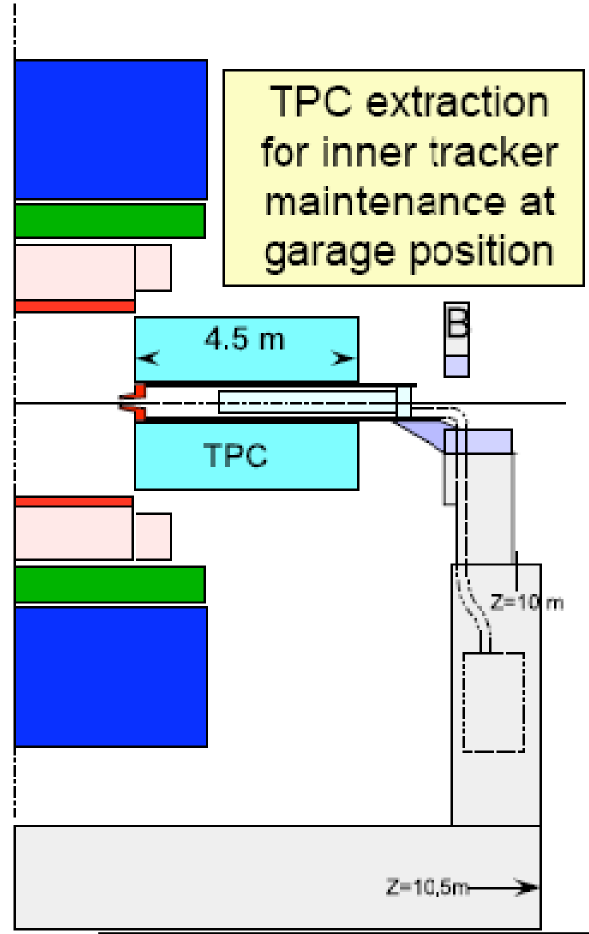
- Plan view
- 3D view





GLDc On-beamline & Off-beamline Access





"A" Pacman split back and unsplit door rolls to tube support pillar

"A" & "B" Pacmen and Endcap Door split back

Concept which does not rely on self-shielding detector