Detector design optimization for push-pull IR and for surface assembly and corresponding IR requirements

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SLAC BDS Kick-Off-Meeting

12 October 2007

Charge: System integration and optimization

Quantify the worth/cost value, discuss cost drivers, evaluate performance/cost derivatives, review design decisions in terms of cost impact and discuss possibilities of further refinement.

- Aim to identify the performance driven specifications for accelerator components and especially CFS and discuss how engineering cost-performance trade-offs will be performed.
- Should include discussion of machine-detector connection and optimization, and specifically include discussion of the integrated engineering of push-pull IR, based on IRENG07 workshop, aimed to reduce the risk of performance and cost of this solution.

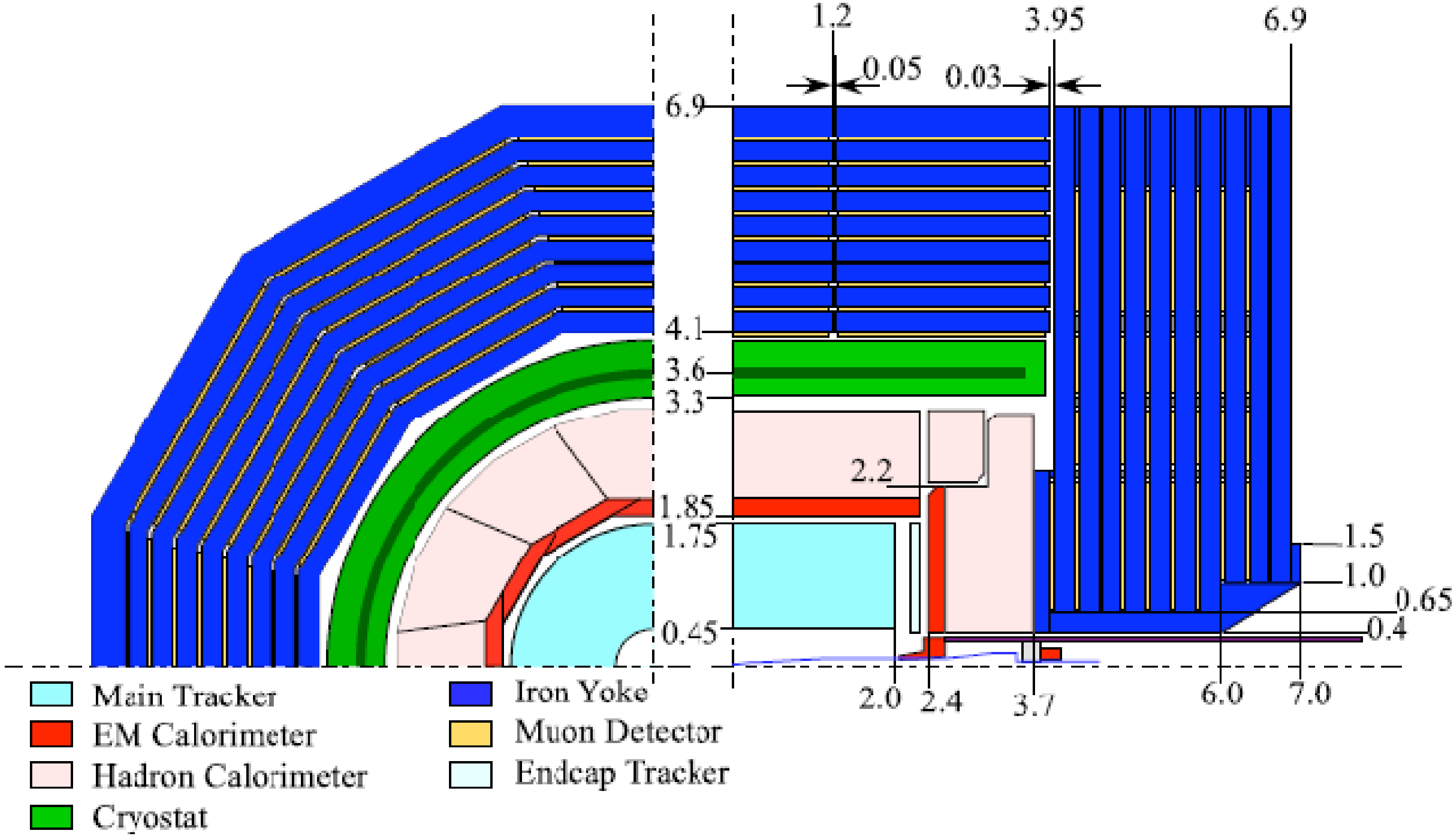
Detector Truths (IMHO)

- There are no detectors yet, only concepts
  - **Letters of intent are forthcoming**
  - **Detector Engineering lags Machine Engineering**
- GLDc, LDC, & SiD are seriously treating Push-Pull (P-P) & Surface Assembly (S-A)
- Most discussions at IRENG'07 regarding detectors concepts and P-P / S-A touched
  - **Civil: Cavern & surface layout, cranes, services**
  - **Cryo: 2K/4K Refrigerators for QD0 & plumbing**
  - **These will be discussed by Osborne/Parker**
- Will review IRENG'07 detector presentations for comments independent of civil & cryo

3 Major Developments Since LCWS’07 (DESY)

- GLDc design introduced which incorporates a self-consistent model for push-pull and surface assembly
- Major contribution of CERN civil group to layout/cavern/assembly/platform/access discussion via fabulous layout schematics
- Formation of ~10 member Si D Engineering team

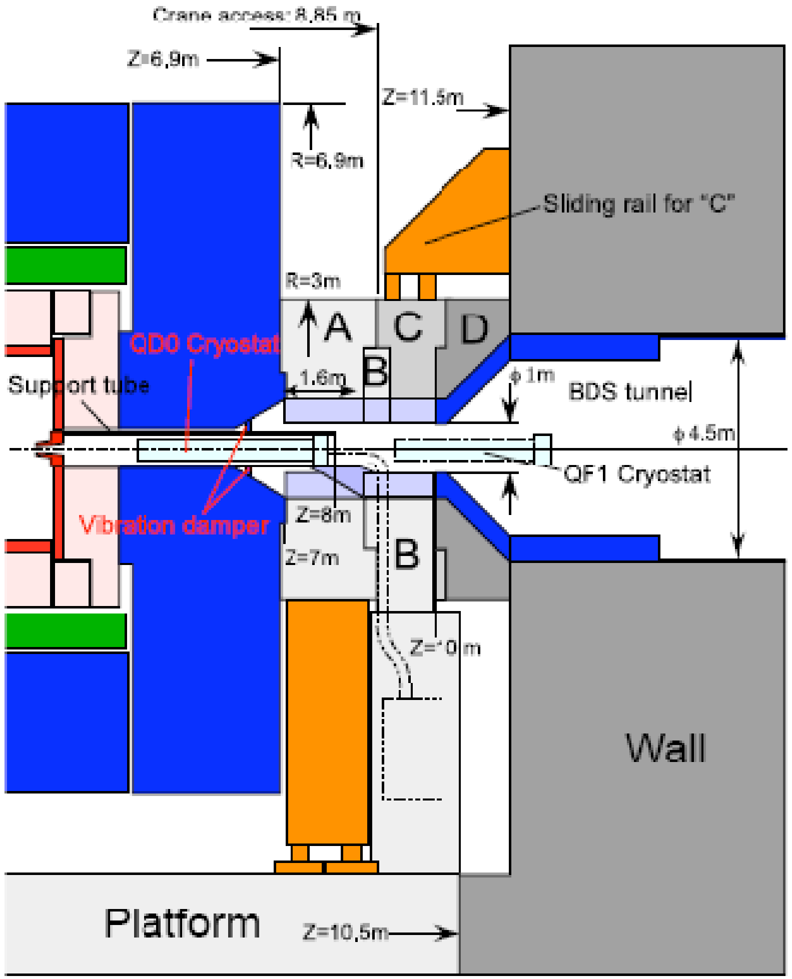
Compact GLD = GLDc



GLDc Assembly: 7 major pieces

- Barrel part (Yoke+ECAL+HCAL)
  - **5080+1130 T = 6210 T**
  - **Pure CMS style assembly can be done by splitting the barrel part into 3 rings**
- Each Door (Yoke + ECAL+HCAL)
  - **3050 T + 270T = 3320 T**
  - **and splitting each end cap part into two halves**
- Cranes:
  - **50~100 T underground depending on Pacman design**
  - **2,000 T crane for the shaft**
  - **80 T crane in the surface assembly hall**
    - set by 24 Fe yoke octants
- Shaft sizes, crane access and underground vault sized by CFS for GLDc as discussed by J. Osborne

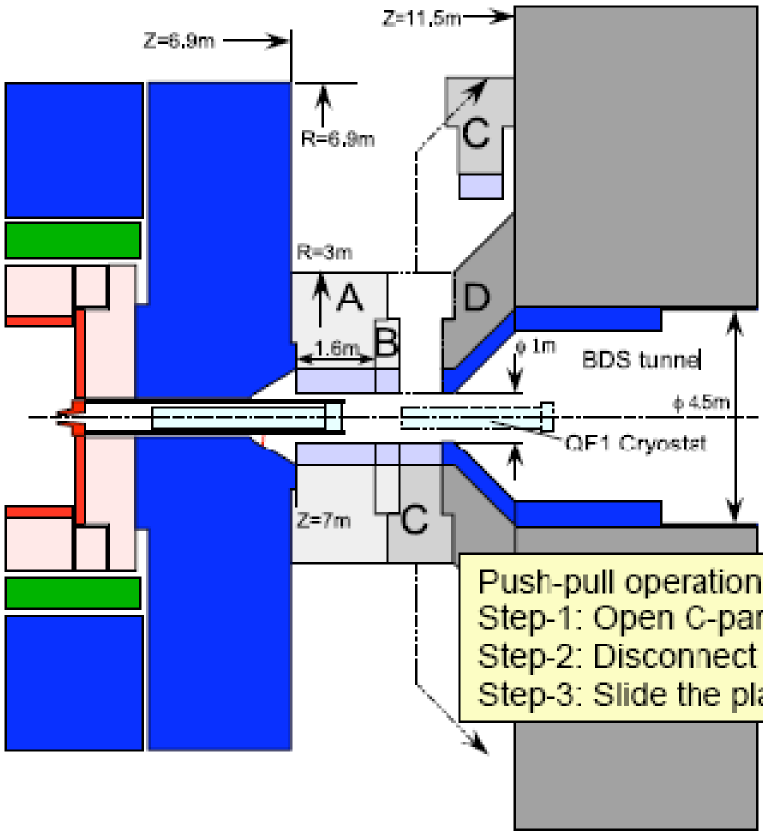
GLDc QD0 Support Based on Cantilevered Support Tube with Base on 2 x 10.5m wide Platform



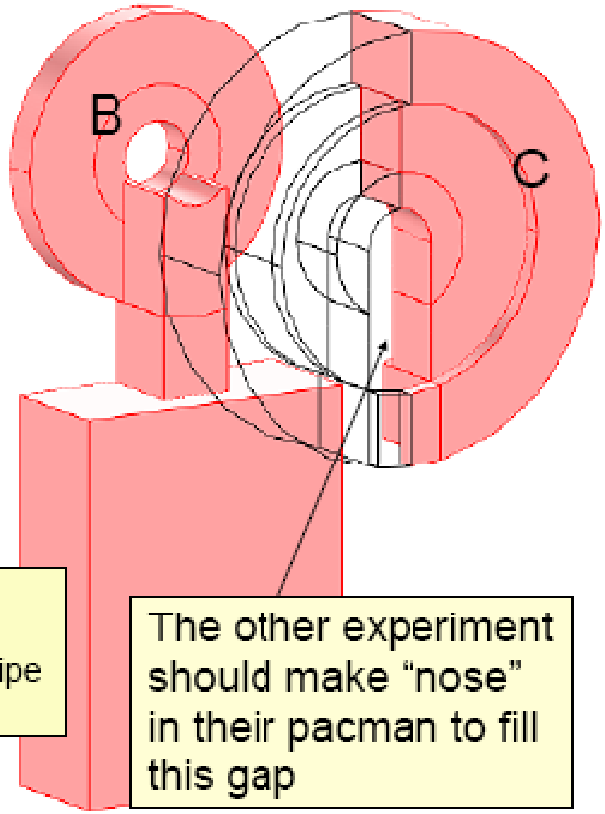
- A: slide sideway using air pad
- B: supported from the floor of platform
- QD0 cryostat is supported by the support tube and the support tube is supported from B
- We can put additional support for the support tube at the entrance of endcap yoke to damp the vibration, if necessary
- Upper part of B (~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

Disassembly of PACMAN for Push-Pull

- Plan view
- 3D view

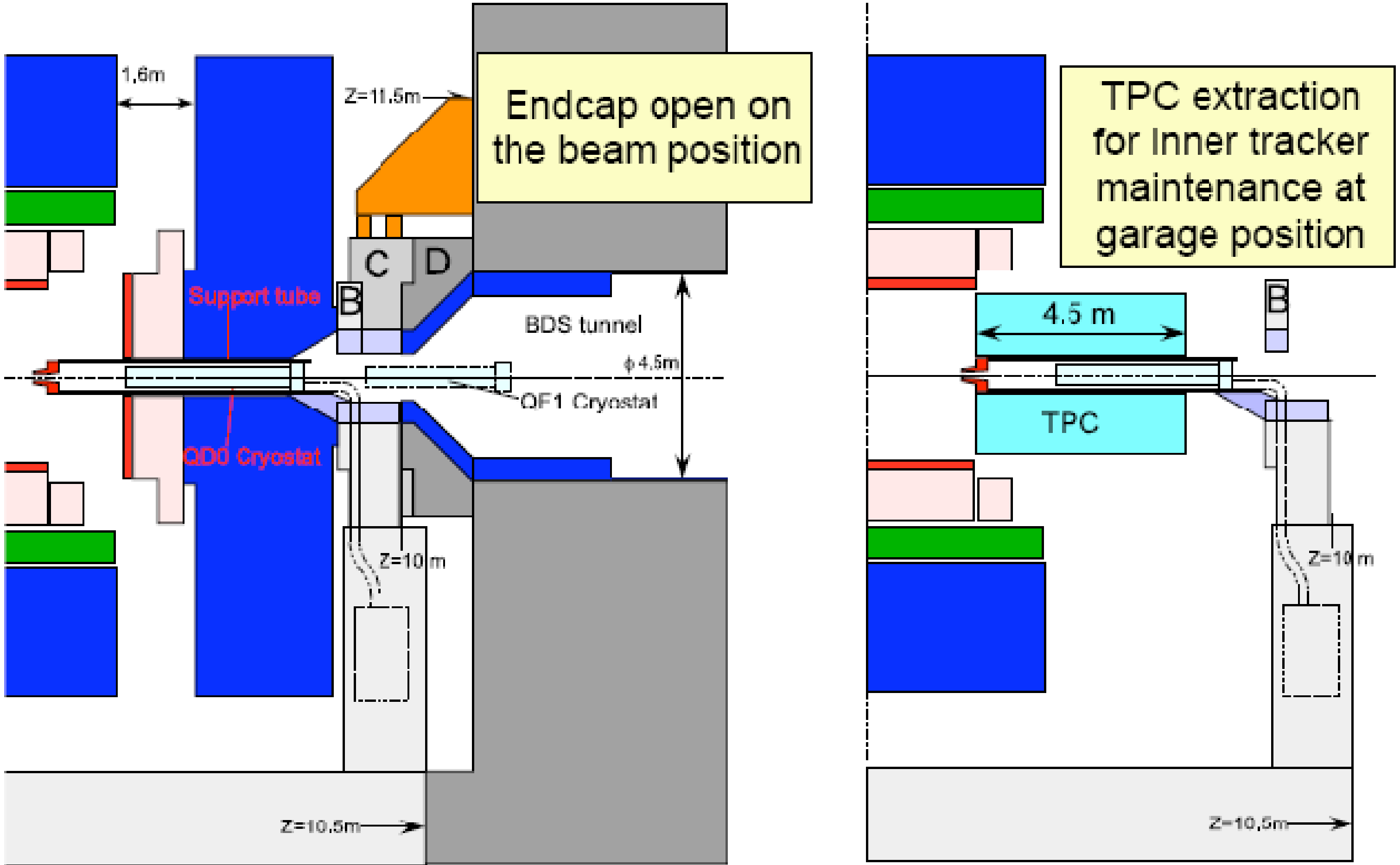


Push-pull operation:
Step-1: Open C-part
Step-2: Disconnect beam pipe
Step-3: Slide the platform



The other experiment should make "nose" in their pacman to fill this gap

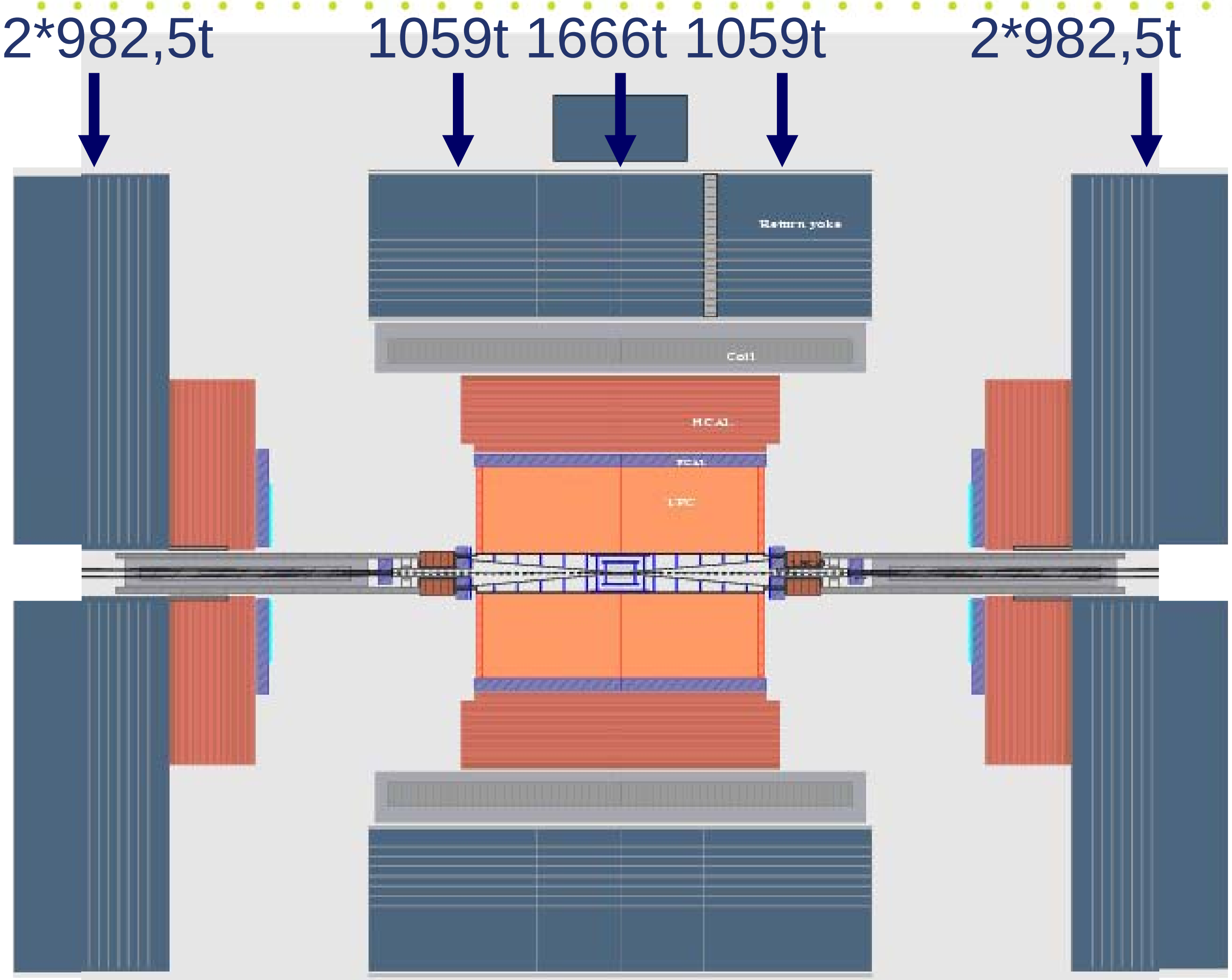
On-beamline & Off-beamline Access



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

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

LDC Assembly & Access Model Similar to GLDc



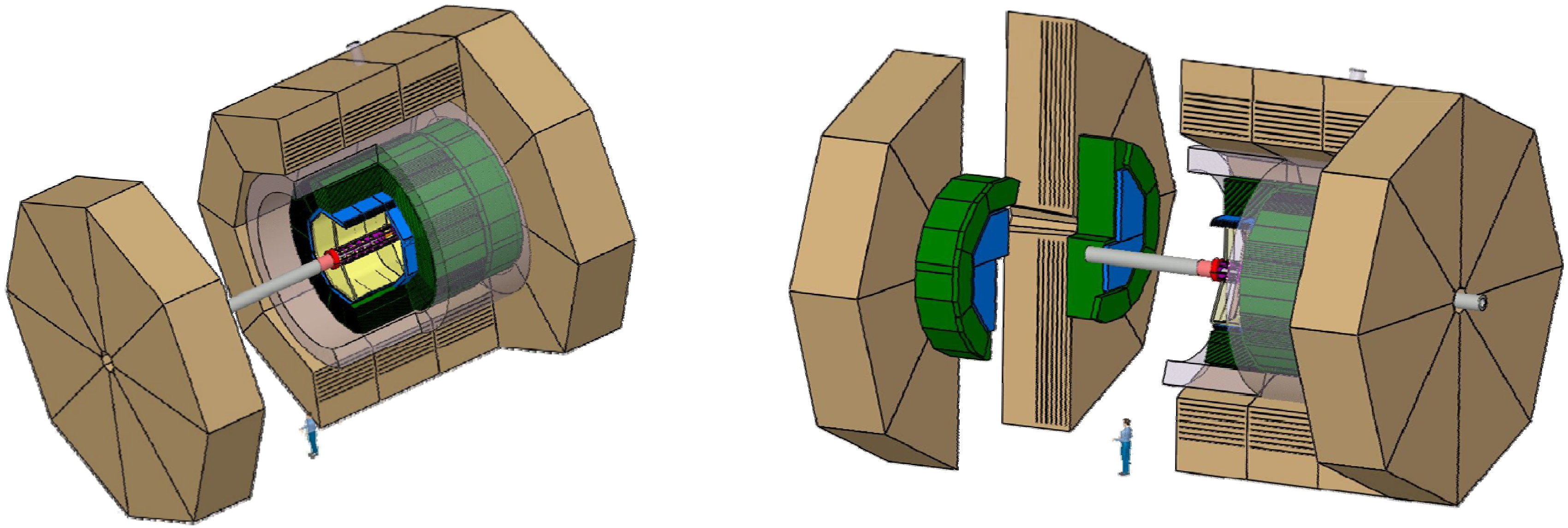
If not split the end cap pieces would be the heaviest part to be lowered!

Split Endcaps not Fundamental to Design

Under Study!

- The structure of the detector should allow both.

  Factor 2 more bending if split!

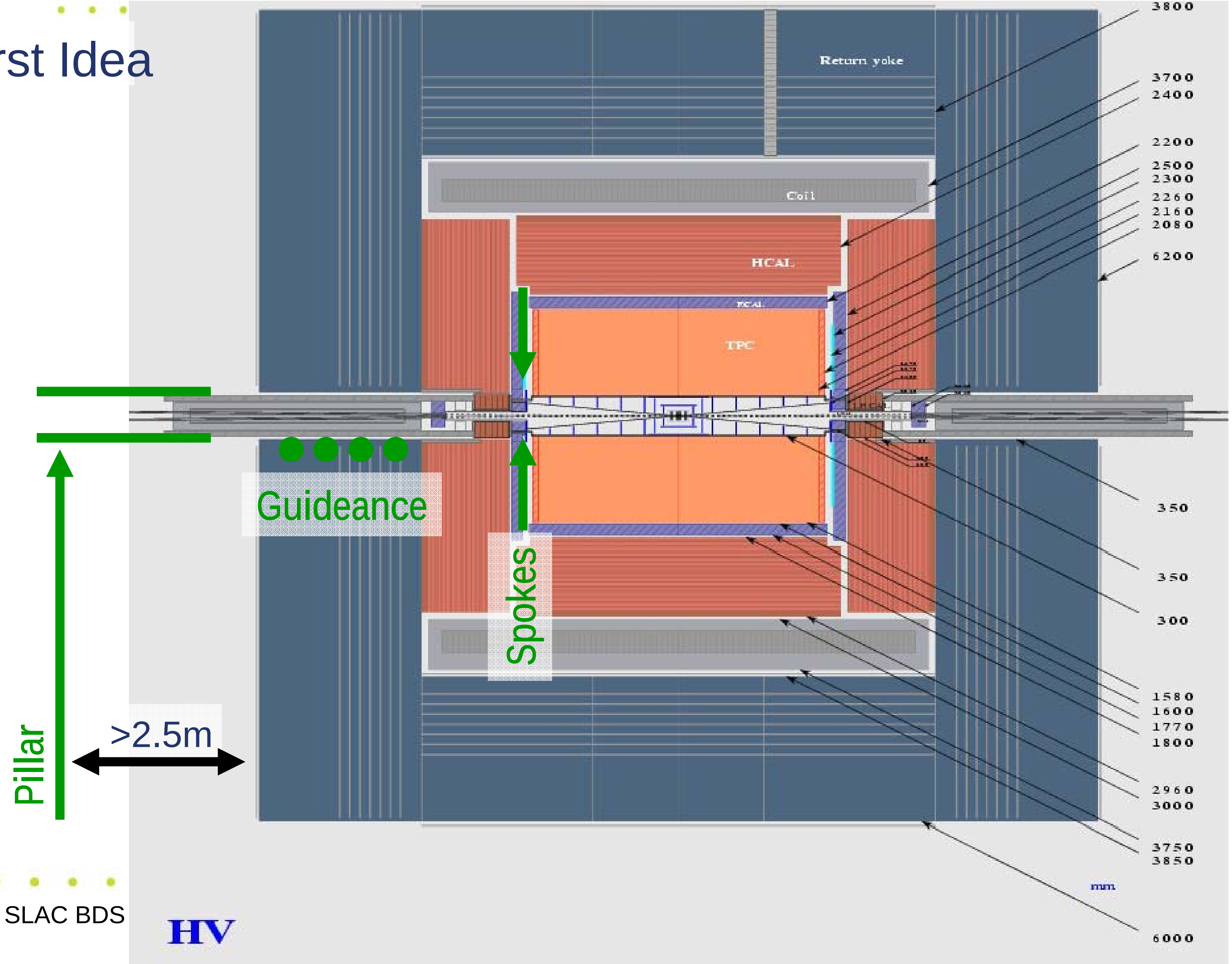


At the moment we prefer end cap halves bolted together with the possibility to open in an major operation if necessary!

QD0/FCAL Held in Support Tube
Support Tube Pillar Sets Max Door Opening

Tube Guided in EndCap and Held by Spoke Arrangement at TPC/ECAL Juncture

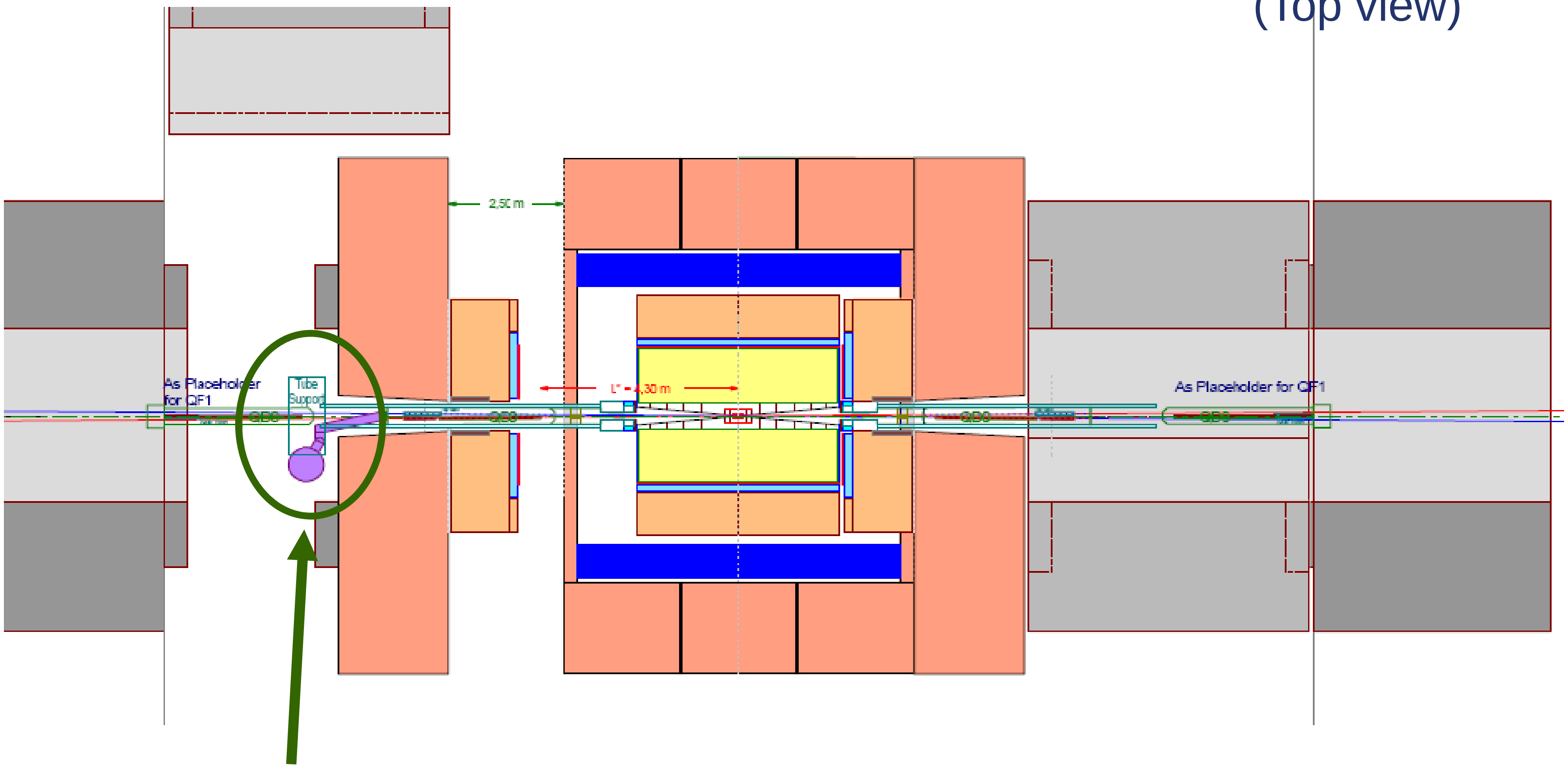
First Idea



LDC Opens On-Beamline Via Split PacMan

Need 2.5-3m to access the detector

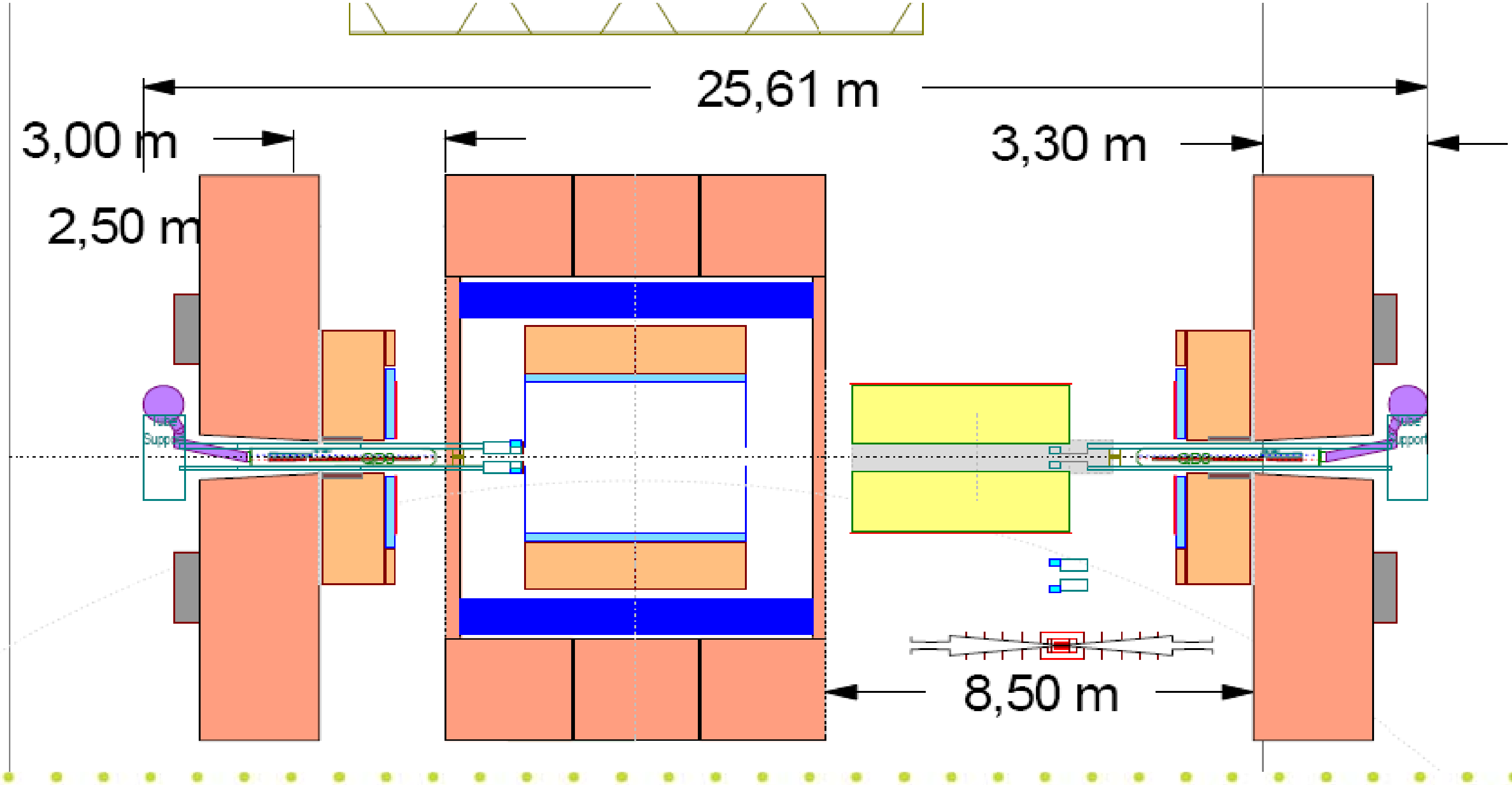
(Top view)



- Support Structure Support
- Service Cryostat
- Supply Line close to QF1

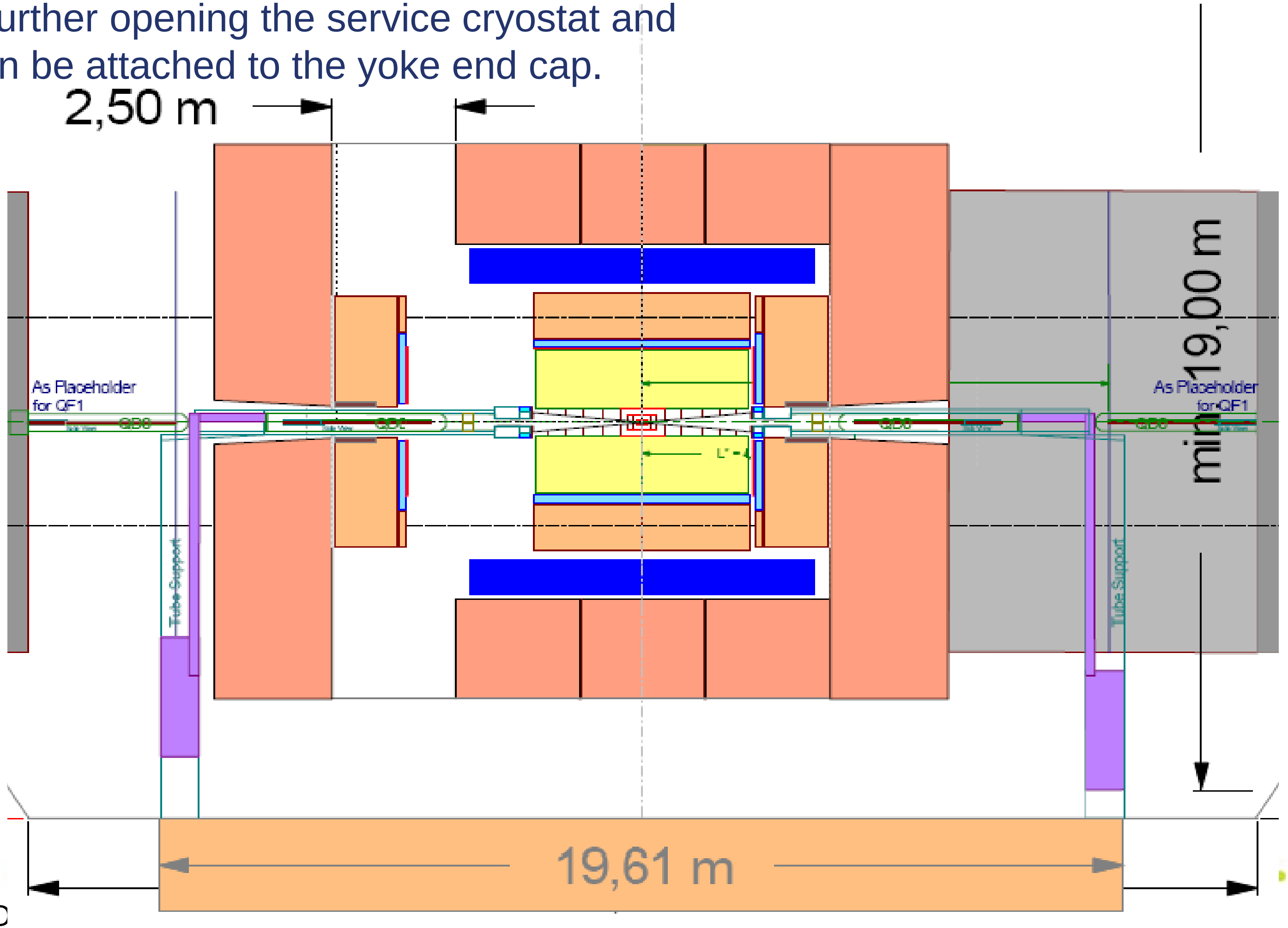
TPC Exchange Off Beamline

- If not split, the end cap yoke has to be moved 8,5m longitudinal (or aside) for TPC exchange!
  - ➔ QD0 and service cryostat have to go with the end cap yoke while the Helium supply line is not cut!



Similar Width "Platform" to GLDc

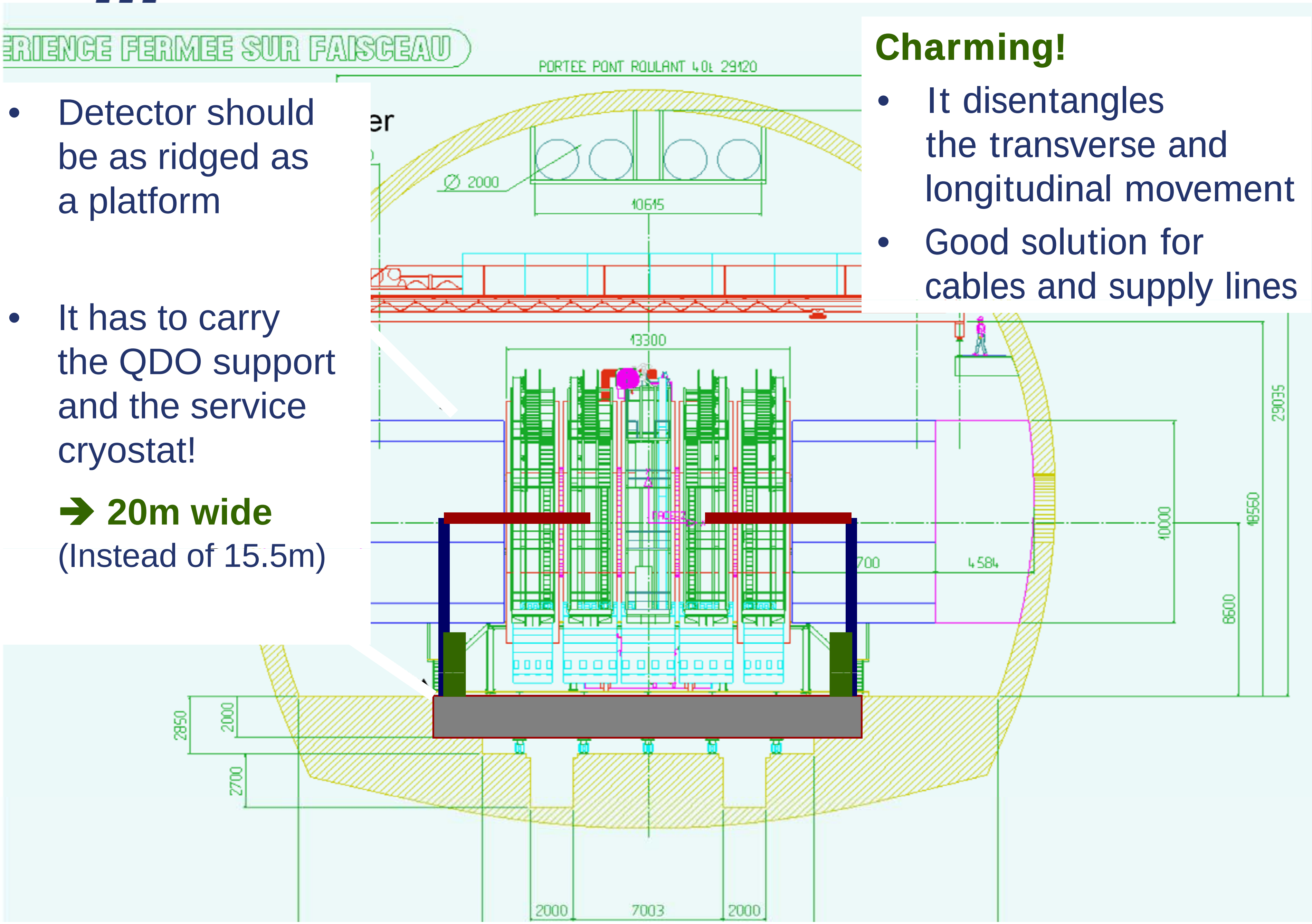
- The supply lines from the service cryostat to the QD0s go from the bottom through the shielding.
- The cryostats are connected via flexible lines to Helium supply.
- To allow a further opening the service cryostat and the QD0 can be attached to the yoke end cap.



Relative Merits of Platform Under Discussion

- Detector should be as ridged as a platform
- It has to carry the QDO support and the service cryostat!

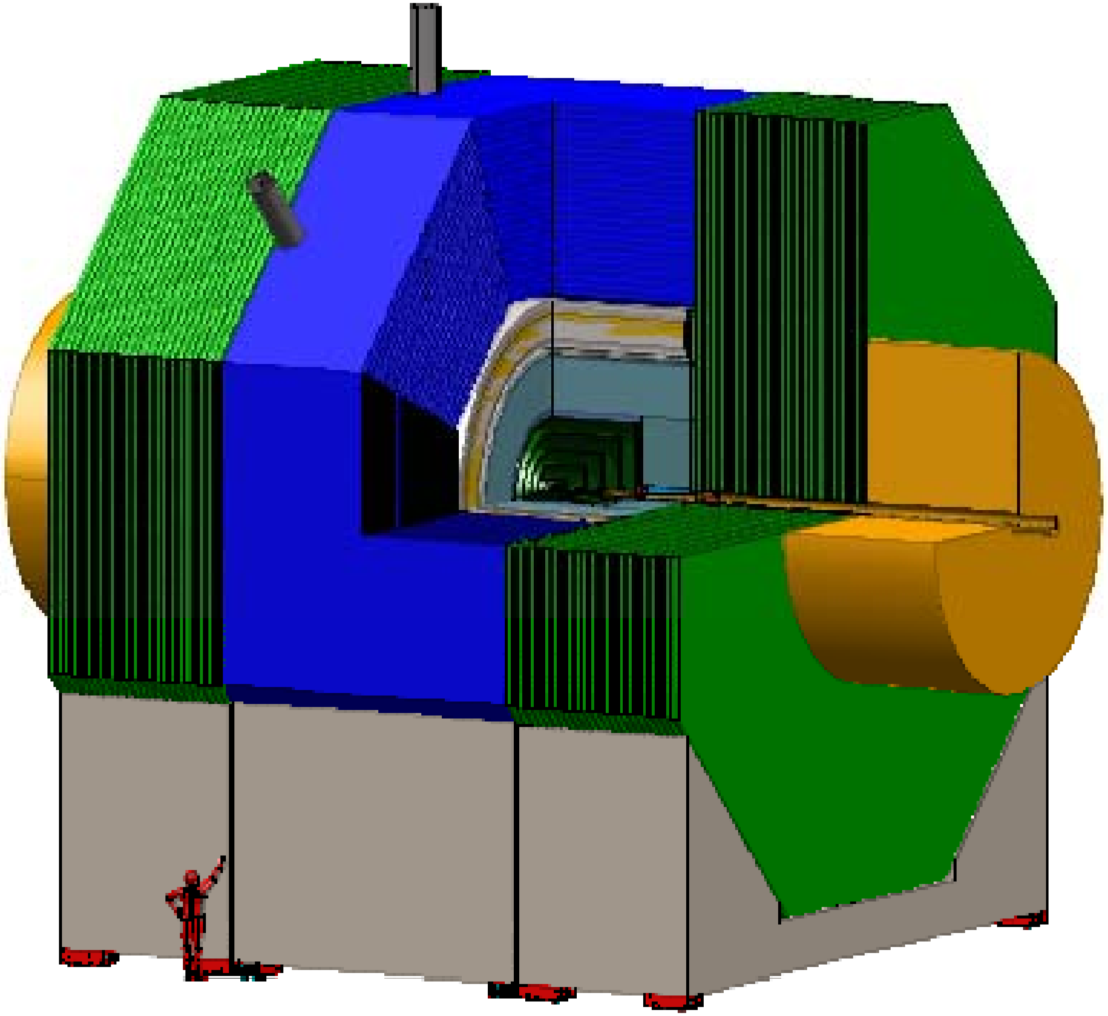
  ➔ **20m wide**
  (Instead of 15.5m)



Charming!

- It disentangles the transverse and longitudinal movement
- Good solution for cables and supply lines

SiD: Doors & Barrel Are Not Split
Minimum of 3 pieces to lower



"Pure CMS" concept gantry requirements:

- 4000T Barrel
    - Arch supports, Yoke, H/E-cals, coil
- 2500 T Doors
    - Yoke, H/E-cals

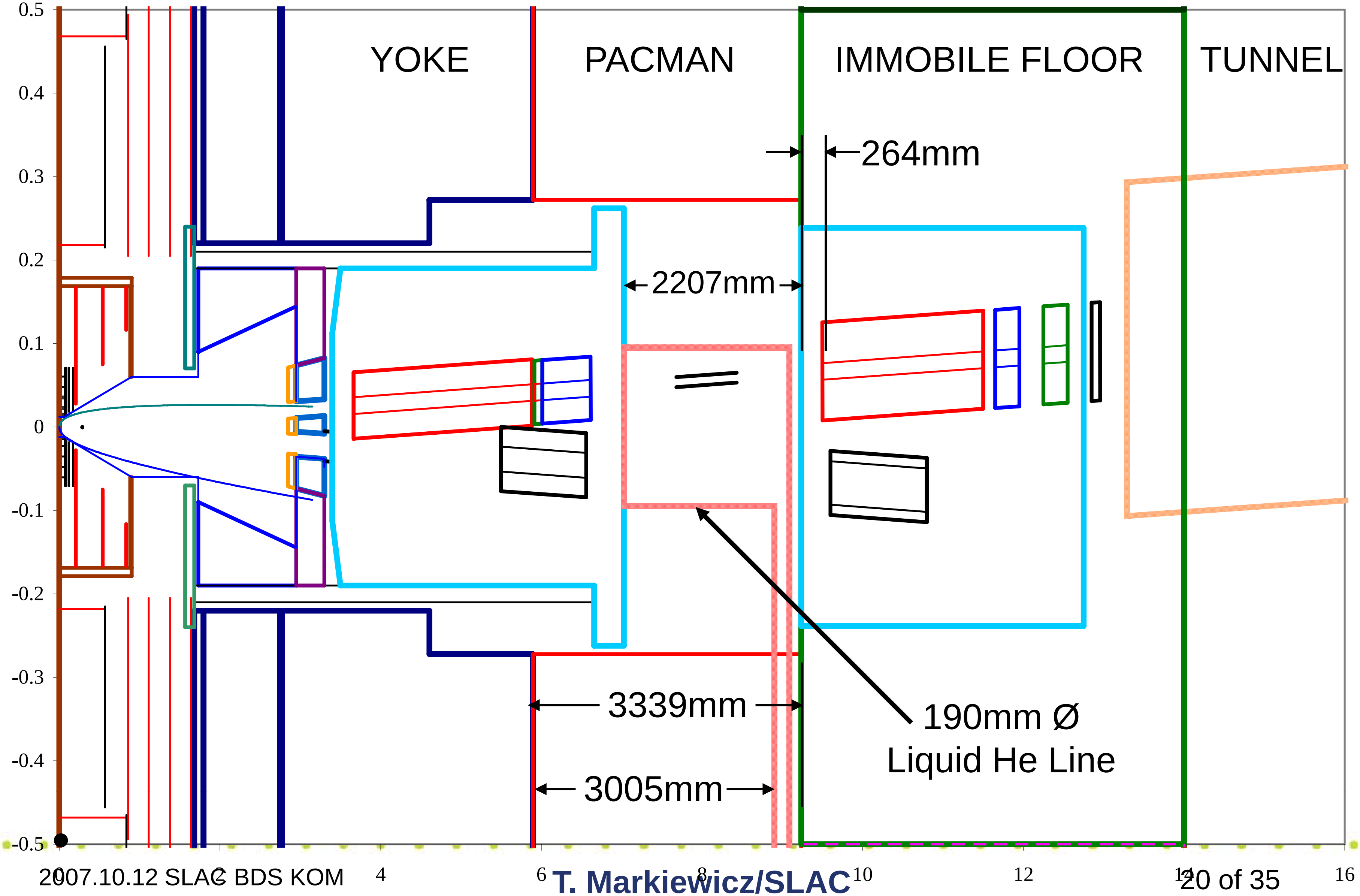
Sequence of Operations for Surface Assembly/Test & Underground Reassembly

- **Detector subassembly construction & surface tests**
  - Octants of muon chamber instrumented barrel yoke, barrel Hcal, barrel Ecal
  - Four 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**

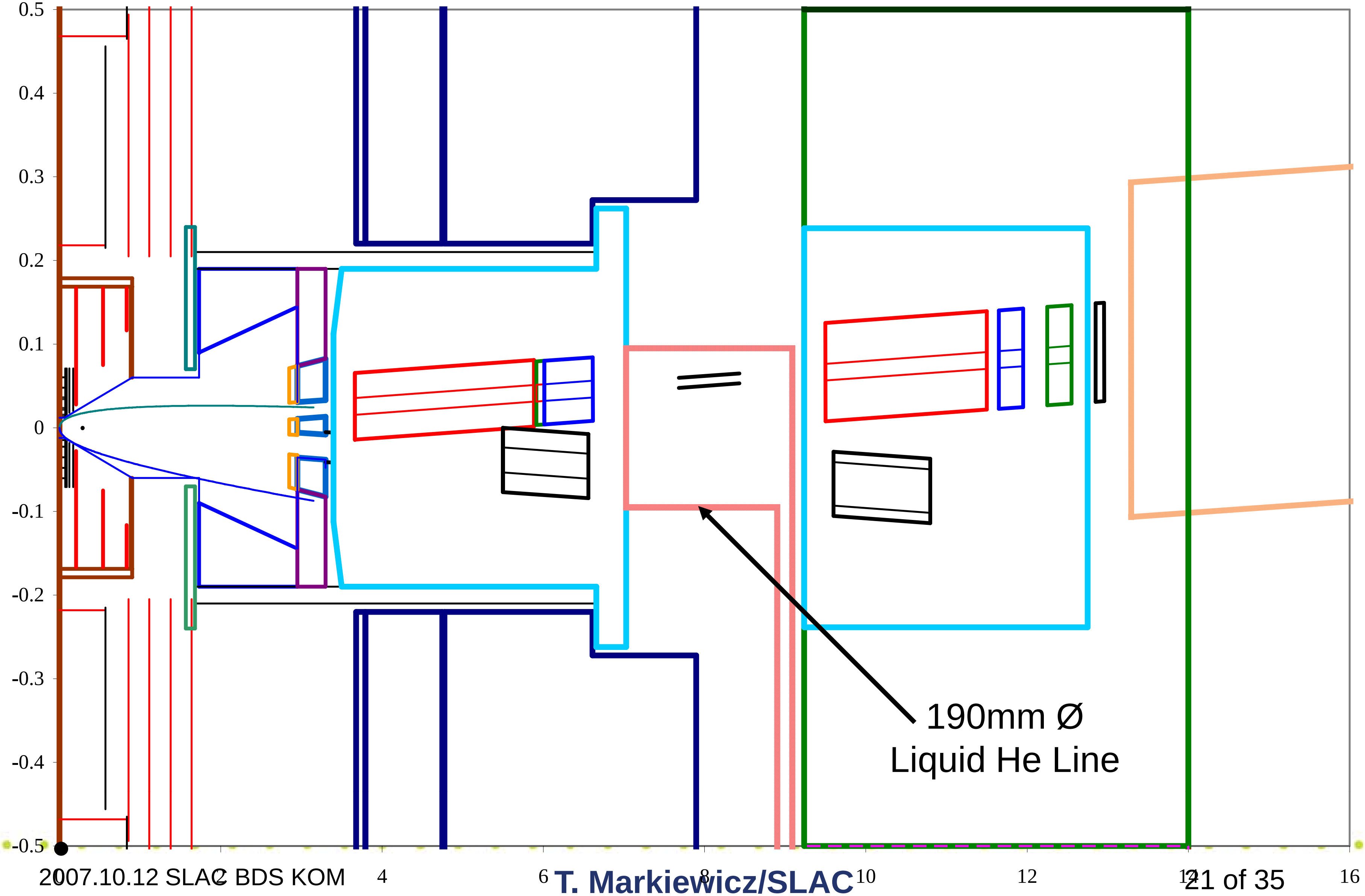
A Surface Assembly/ Underground Reassembly Scenario for SiD
600T Surface crane & No Gantry

M-Tons	Stainless HCAL Radiator		Tunsgten 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		

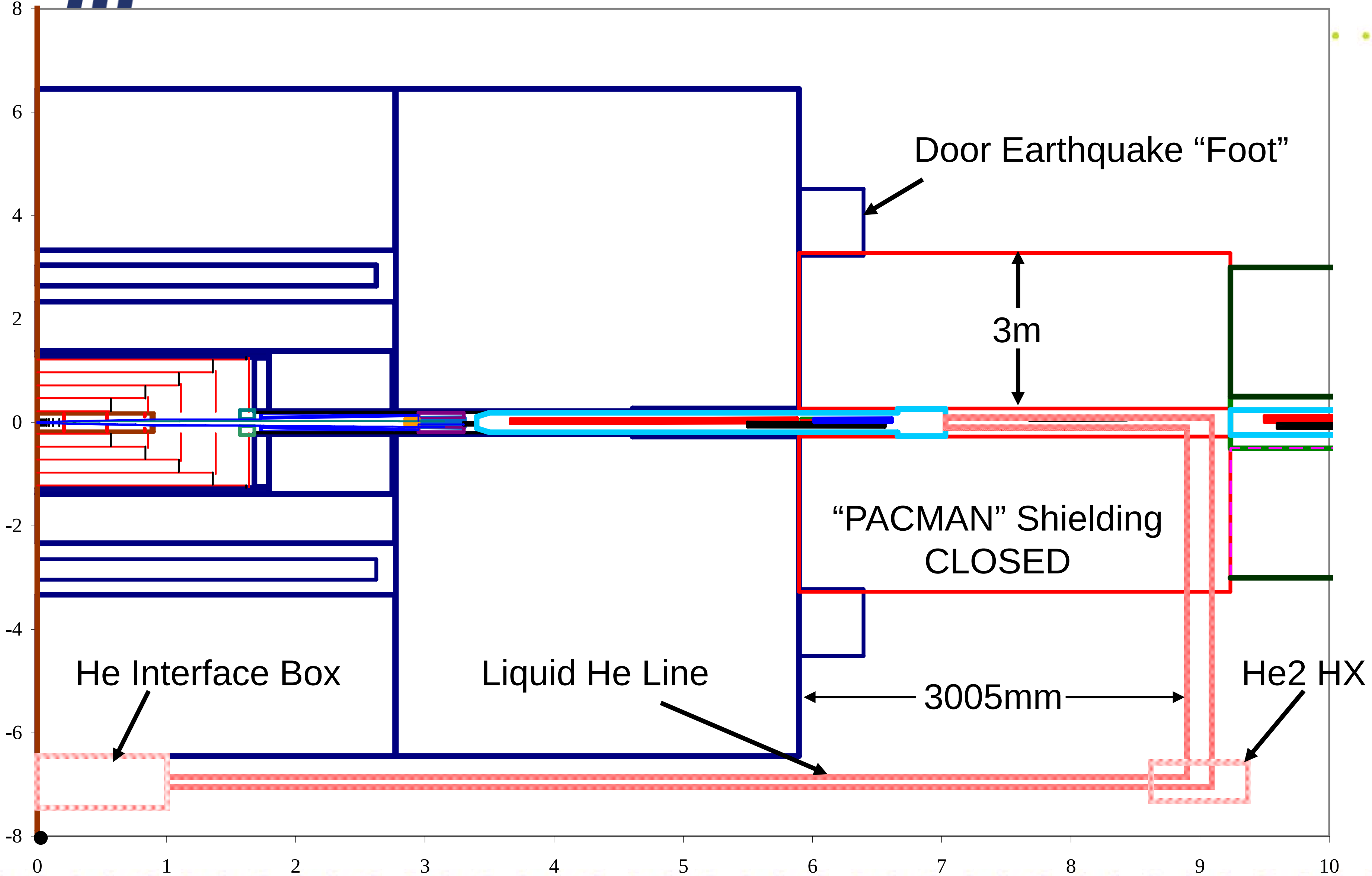
SiD r<50cm, L*=3.664m, 14mrad, Push-Pull, QF@9.5m, Door Closed



SiD r<50cm, L*=3.664, 14mrad Crossing Angle, Push-Pull, Door **Open 2m**



Door Closed, Permanent QD0 Liquid He Line



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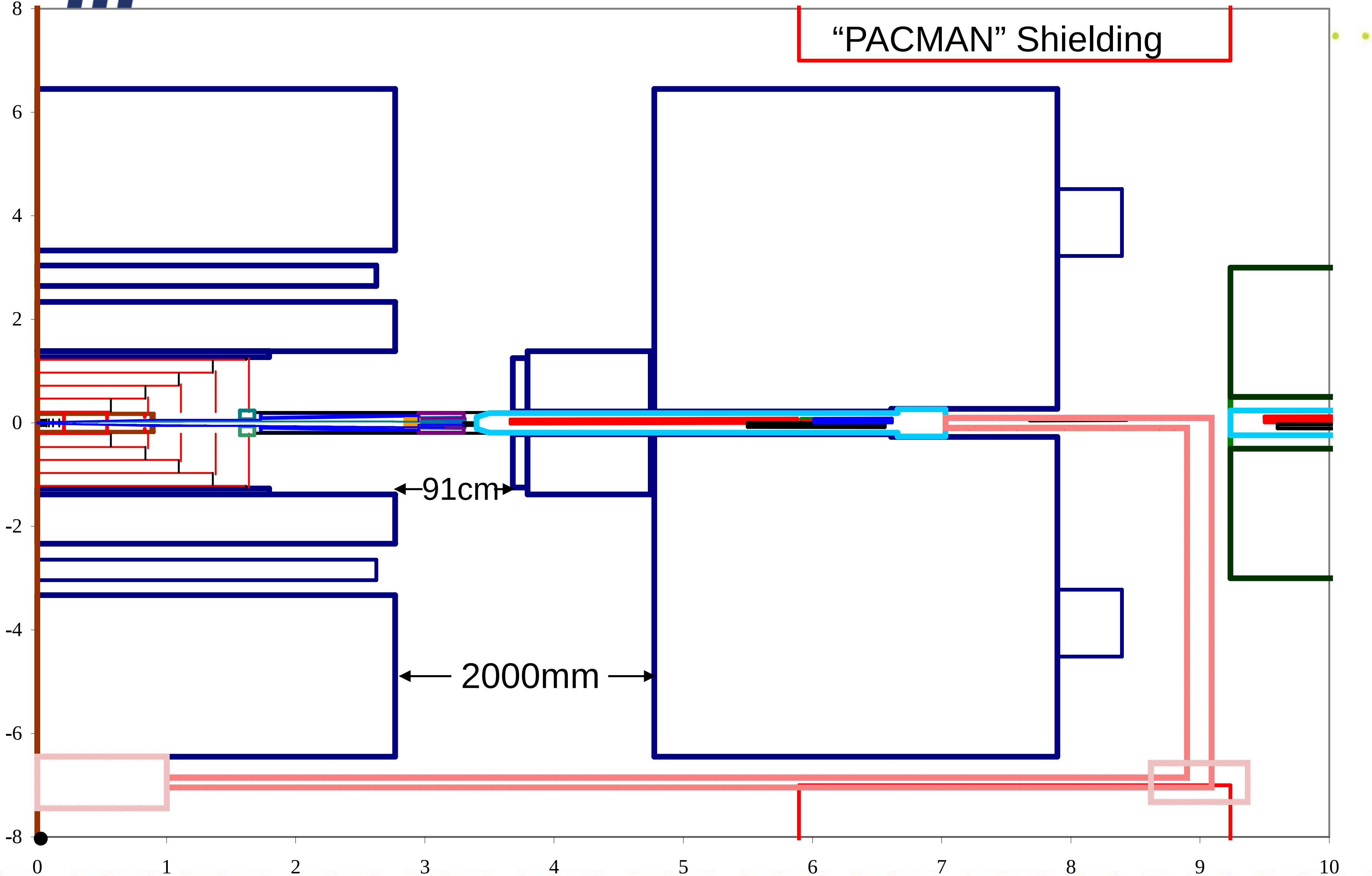
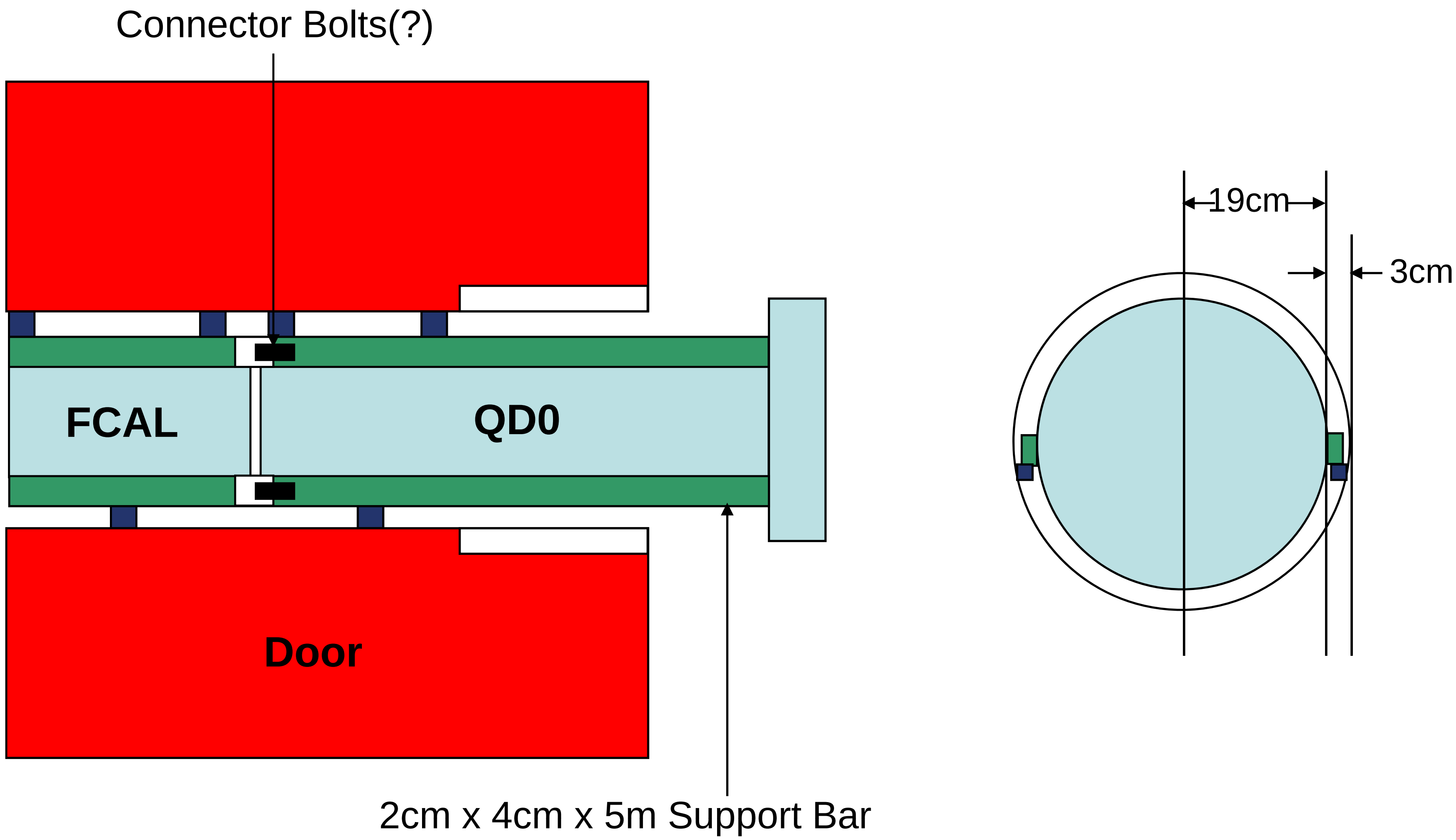
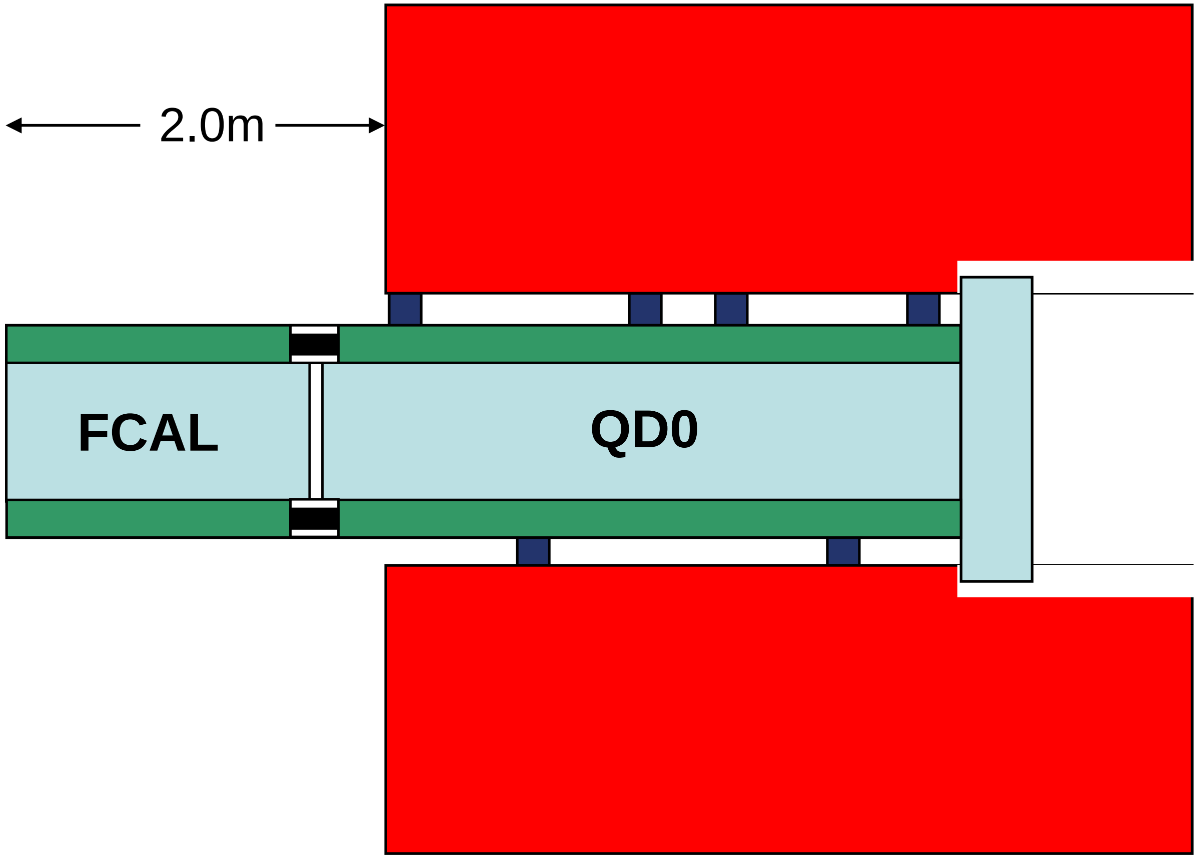


FCAL/QD0 Supported with Door Closed



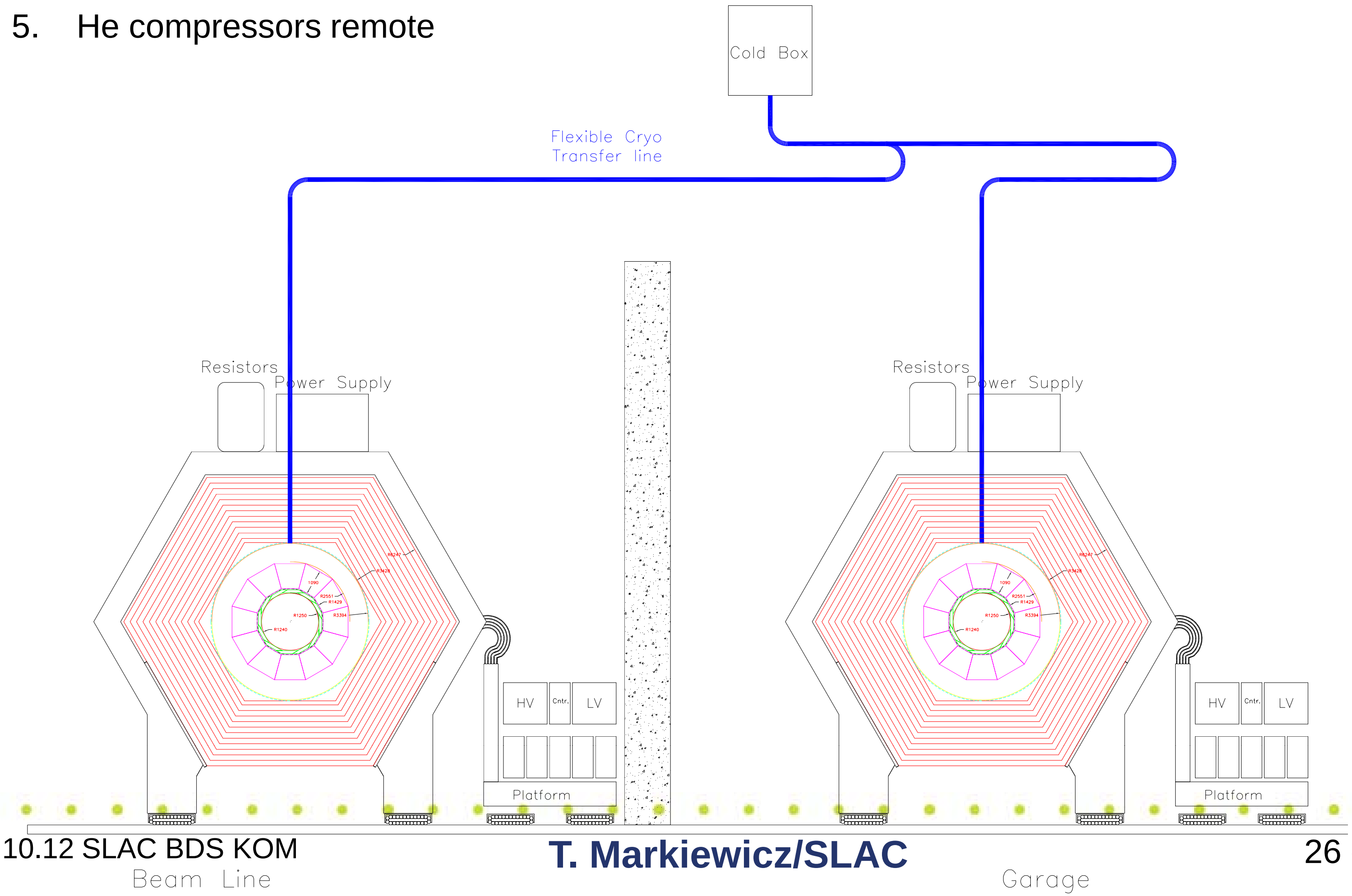
FCAL/QD0 Supported with Door Open



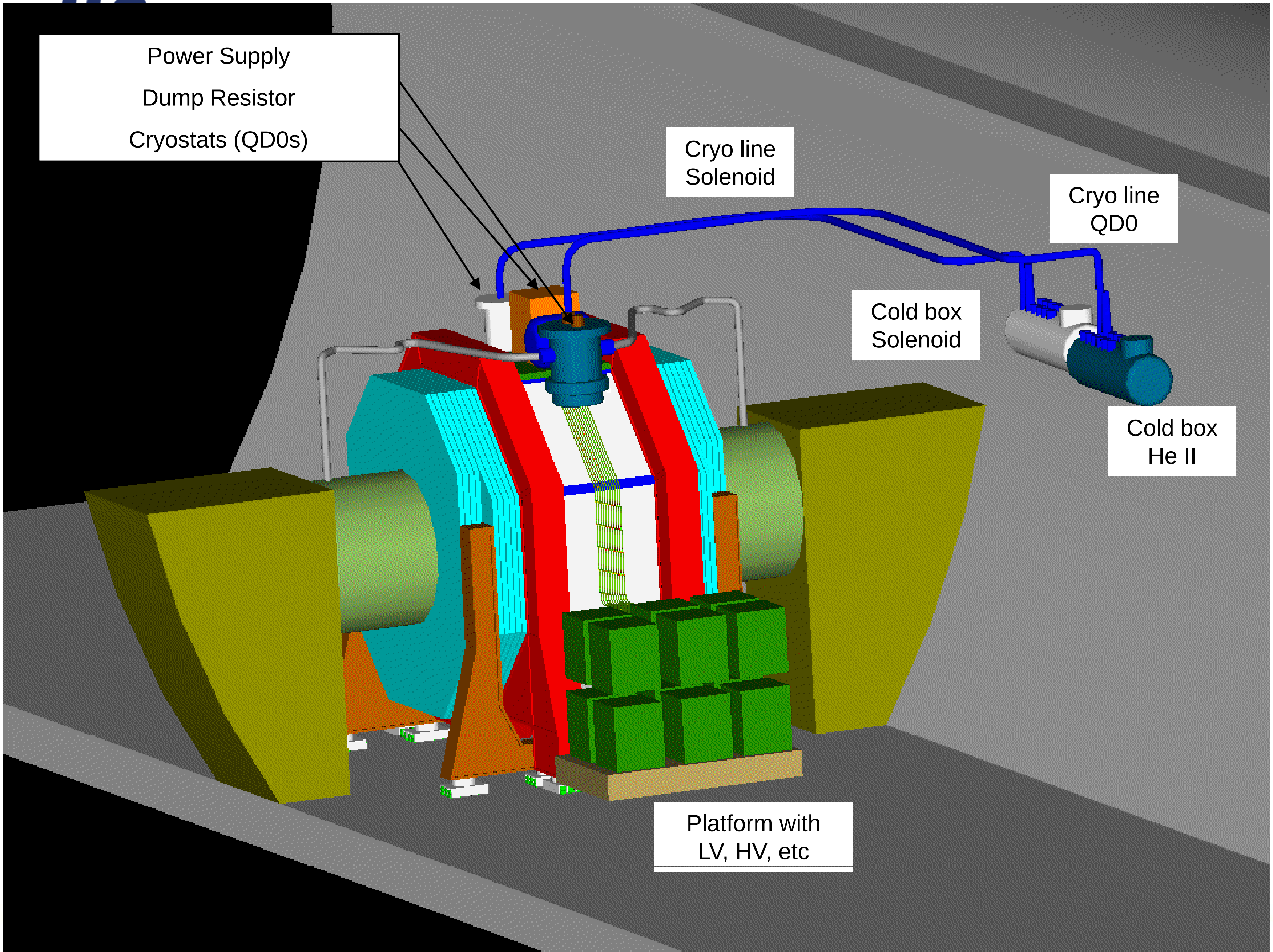
Whether Spider or tube used for Support, SiD has assumed it will be completely supported by door (not cantilevered off a post to the ground) but has not proposed a way to fix it in z when door opens

SiD IR Hall Assumptions

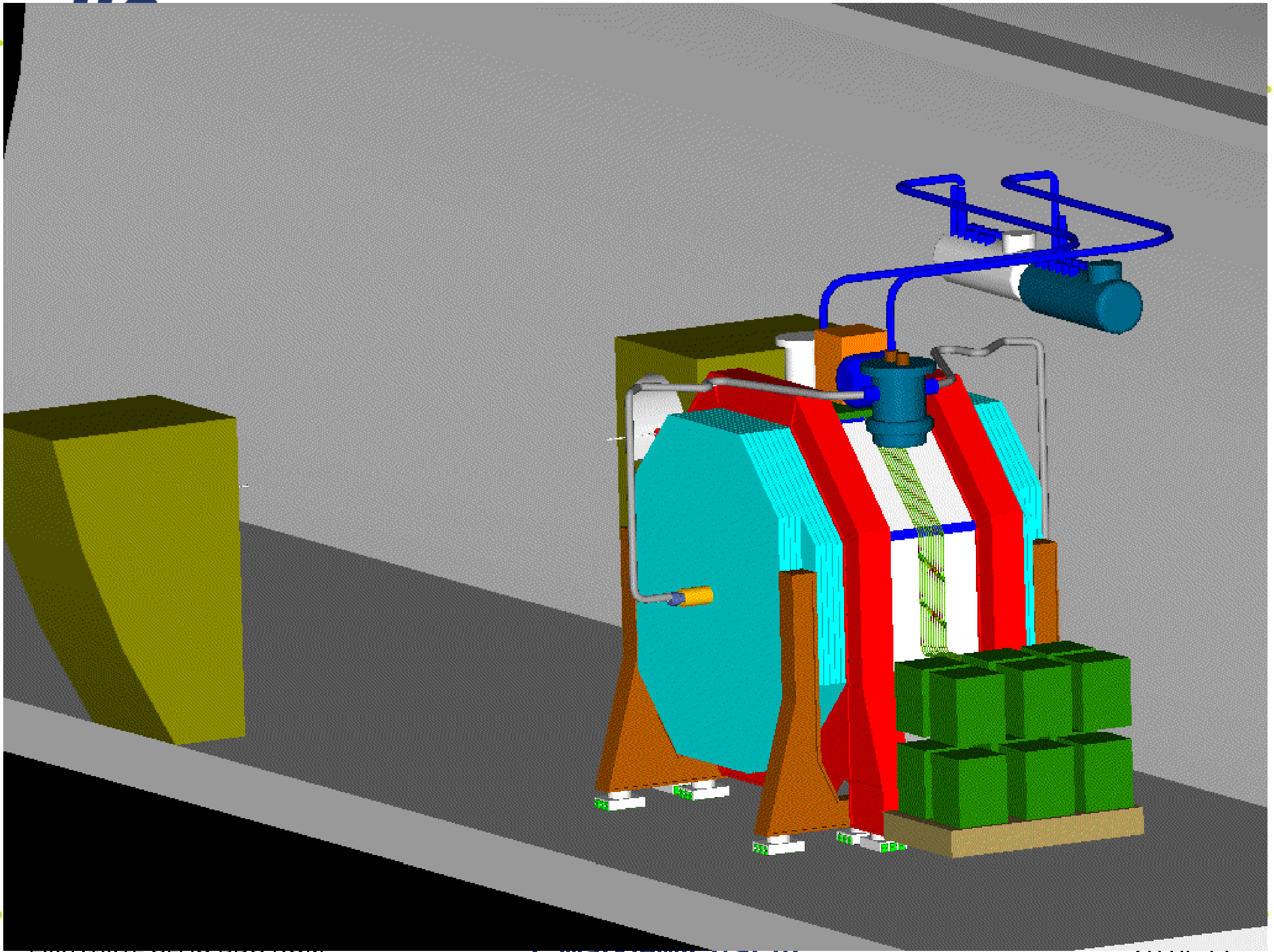
1. Push-Pull and doors opening with Hilman Rollers
2. Racks and ancillaries on SiD or on a side platforms (location driven by the the fringe field)
3. Cold Box off detector (in the hall)
4. Flexible cryogenic transfer line (100mm OD) Solenoid-Cold box
5. He compressors remote



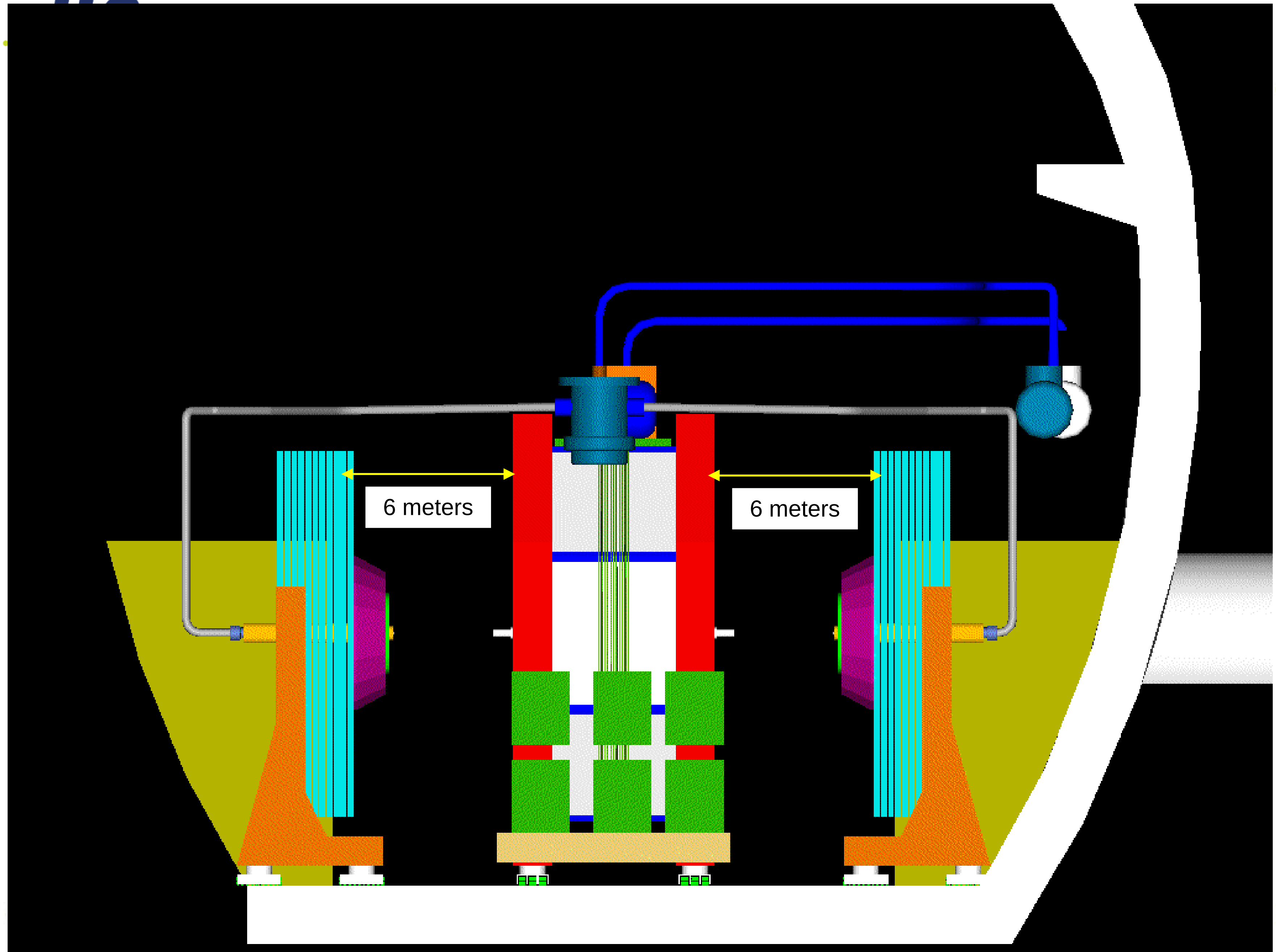
SiD closed on the beam



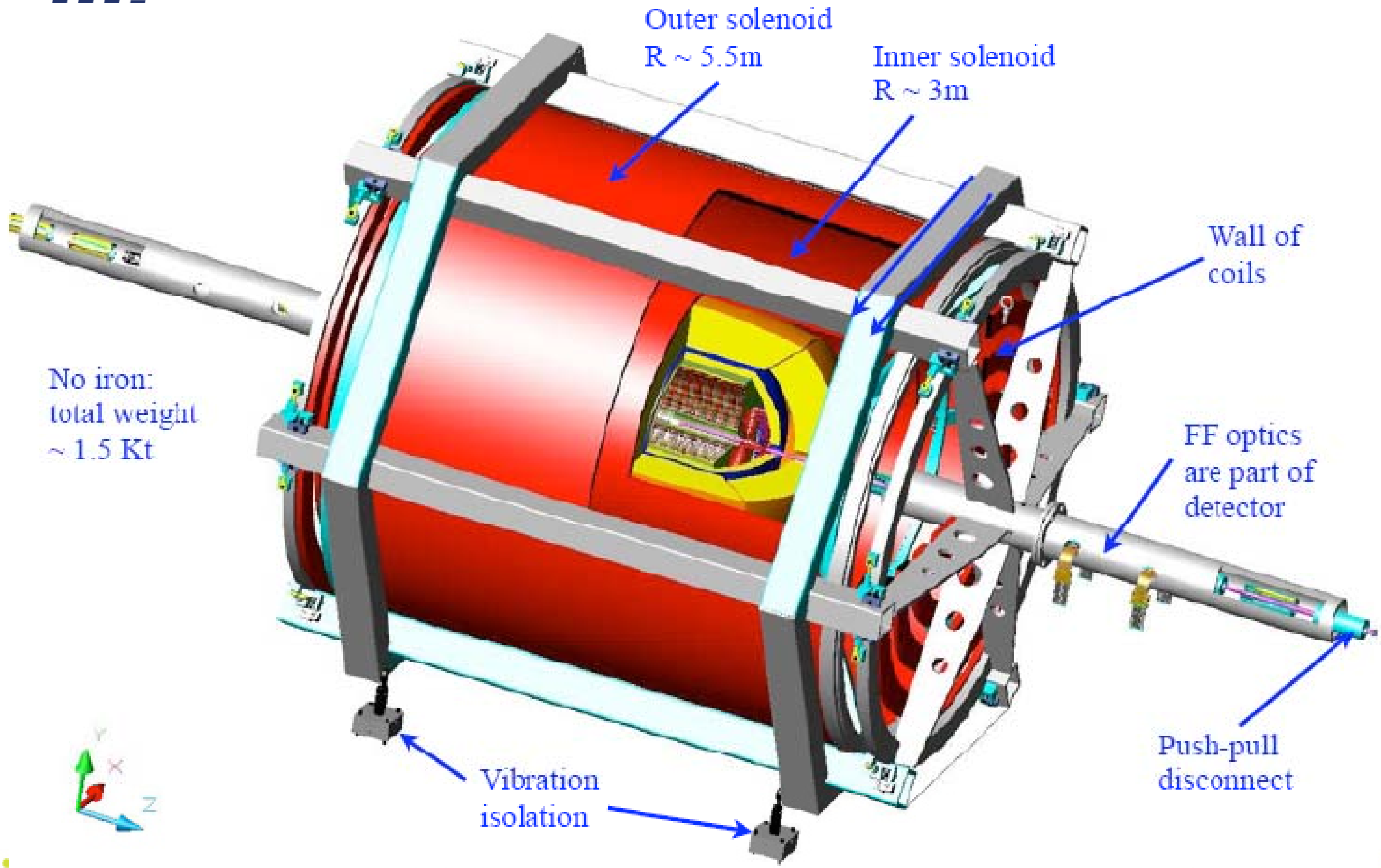
SiD push-pull (30 meters stroke)



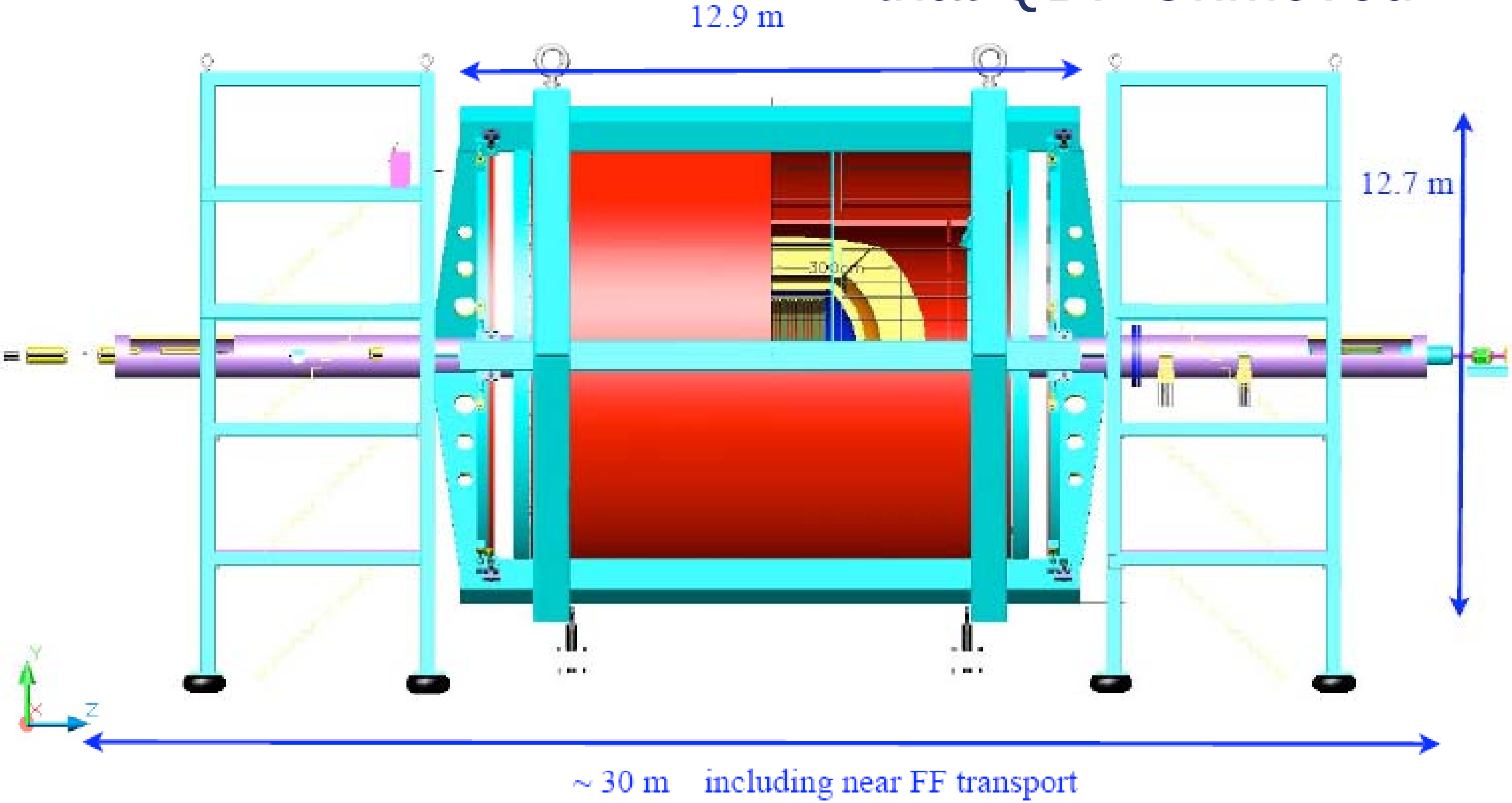
SiD opening @ 6 m off the beam



4th Detector Concept

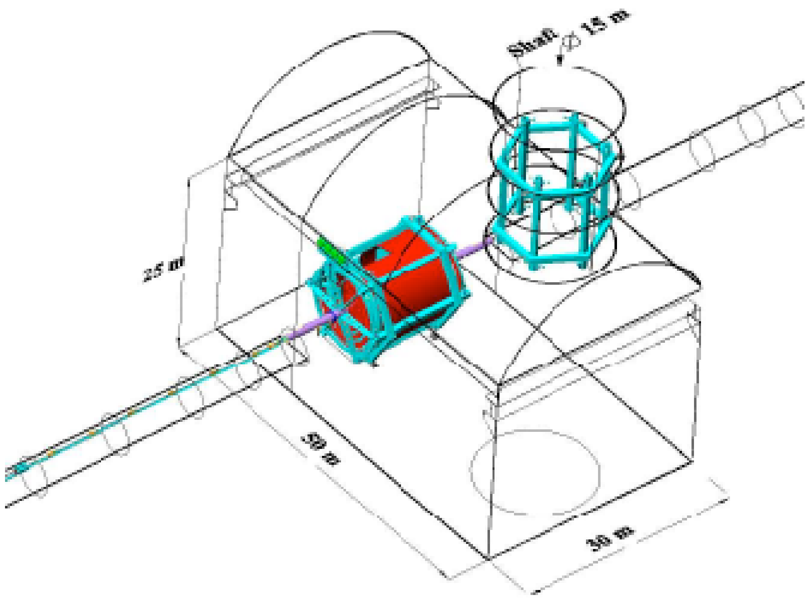


Gross Dimensions
4th Does not respect BDS Requirement that QDF Unmoved



4th Underground Assembly
"CMS" Surface Assembly not addressed

- **Space and volume**
  - 30m x 50m x 25m is ample space
- **Crane**
  - 225 t (~ CMS coil cold mass) - this is maximum
  - Calorimeter in 10t wedges
- **shaft size**
  - 15 m diameter
- **disassembly and access**
  - Titanium frame;
  - wall of coils
  - muon chambers
  - calorimeter wedges



To Open 4th On-Beamline

I do not understand "move Lumi/Beam cals out"

- on beamline
  - **move Lumi/Beam-Cals out**
  - **move wall-of-coils out 2m**
  - **lift muon spectrometer chambers out vertically**
  - **move calorimeter modules out axially**
- At this point, the interior and the tracker ends are accessible. The FF support has not been moved.
  - **the tracking chamber can be 'push-pulled' to the other end**
  - **vertex chamber is moderately accessible in this position**

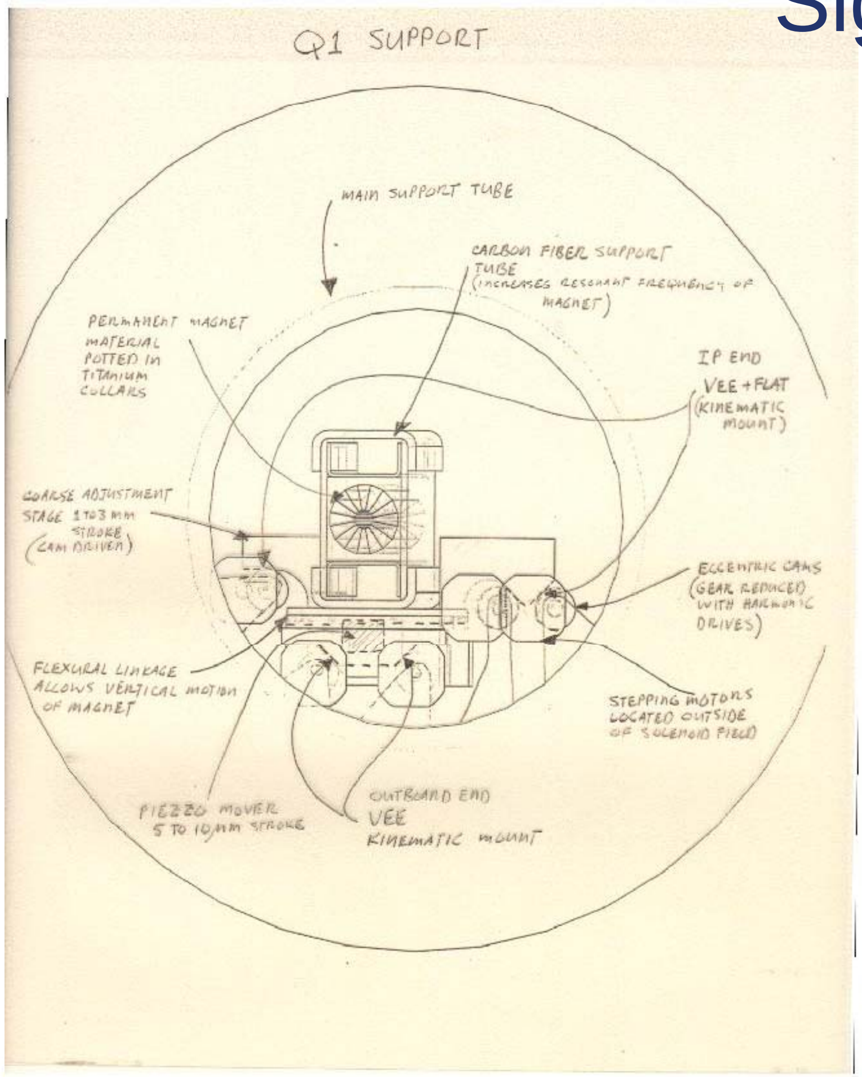
Summary of Push Pull & Surface Assembly Aspects of MDI

- GLDc and LDC have similar designs with similar crane/shaft requirements wherein FCAL/mask/QDO package supported in a tube off cantilevered off a pillar to ground (or platform)
- GLDc shows a moving platform while LFC says either platform or rollers would work
- SiD requires 2x gantry capacity for “CMS” surface assembly
  - **not convinced that non-CMS-like underground assembly is better**
  - **Feels (MIB at least) that platform is expensive solution germaine to CERN geology & LHC detector complexity**
- SiD FCAL/mask/QDO package supported in a spider or tube directly from doors
  - **Needs to address how z motion of support tube is controlled**
- 4th does not consider surface assembly and wants to translate the QF1-QD0-Detector-QD0-QF1 package in push/pull

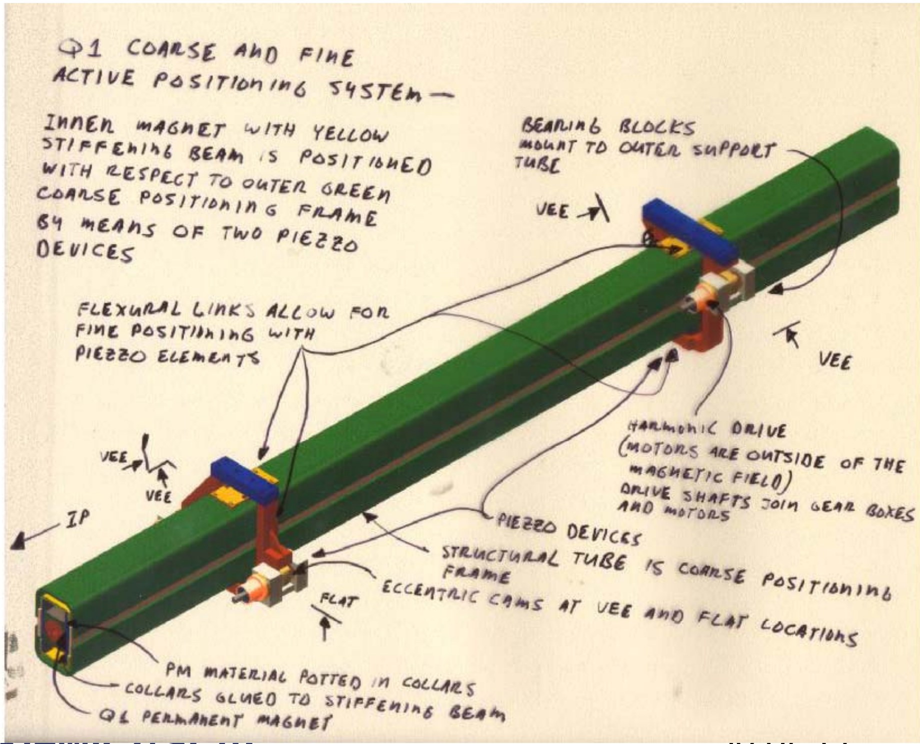
Interface Issues

- 1st order self-consistent PACMAN shielding invoked by GLDc, LDC, SiD. However, engineering required
  - **To see underground crane capacity required**
    - GLDc shows 0.5m Fe / 2.0m concrete from r=0.5m
    - SiD shows 1.0m Fe/ 2.0m concrete from f=0.25m
    - Rad Phys calculation done for 0.5 m Fe / 2.0m Con from r=1.25m
  - **To understand where detector A to detector B PACMAN interface occurs**
  - **To understand how to remove detector A specific PACMAN shielding "trapped" on detector B side of the beamline**
    - Hinged to the doors of detector A?
- Platform A, platform B, Floor, detector A, detector B interfaces
  - **If "A" needs/desires moving platform solution, must "B" adopt as well**

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



Hall Parameters - Length around 90 m