MDI Functional Requirements for the LOI

Tom Markiewicz/SLAC

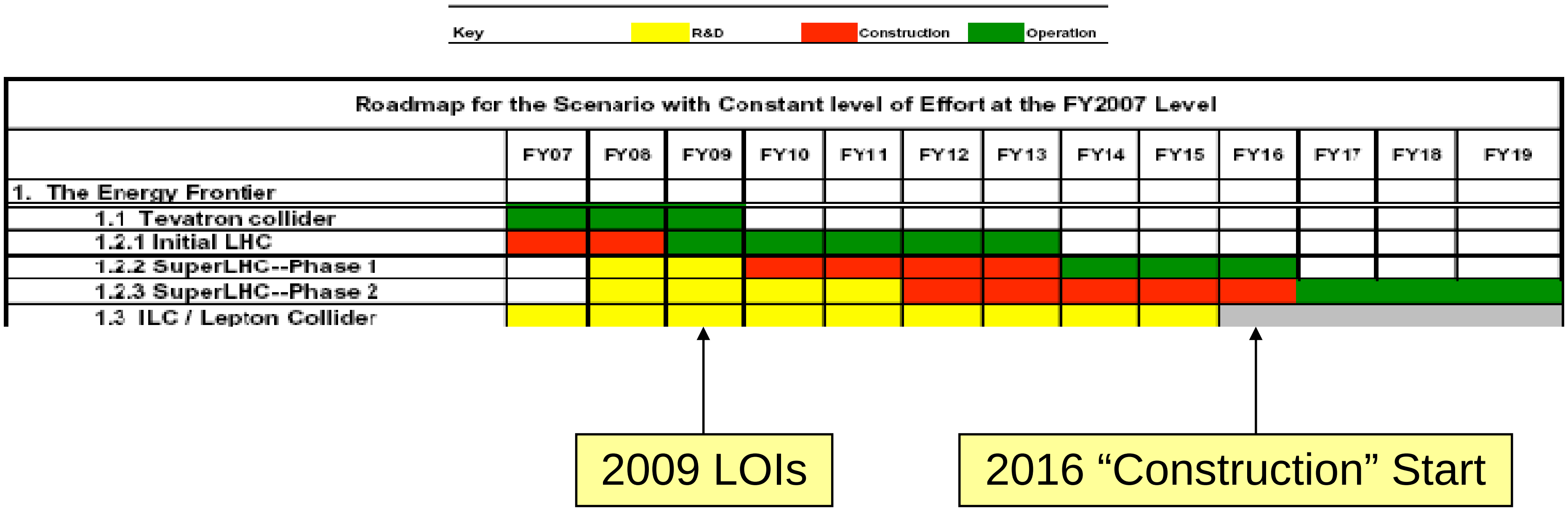
LCWS'08, UIC, Chicago

17 November 2008

Outline

- Context
  - **ILC Cost Reduction: Push-Pull**
  - **Aggressive EDR Timeline**
    - Above Ground Assembly
    - Need for a complete and cost-able design
  - **Current Climate: US P5 report, TDP-I, TDP-II, etc.**
- Proposed Philosophy:
  - **Minimal Functional Requirements for the LOI**
    - On_Beam_Detector-to-Machine Requirements
    - On_Beam_Detector-to-Off_Beam_Detector Requirements
  - **Collaboratively developed solutions and interfaces**
    - SiD-ILC-ILD & SiD-ILC-4th & ILD-ILC-4th
- Technical Solutions
  - **Sept-2007 IR Engineering Workshop**
  - **"Baseline" IR Design**

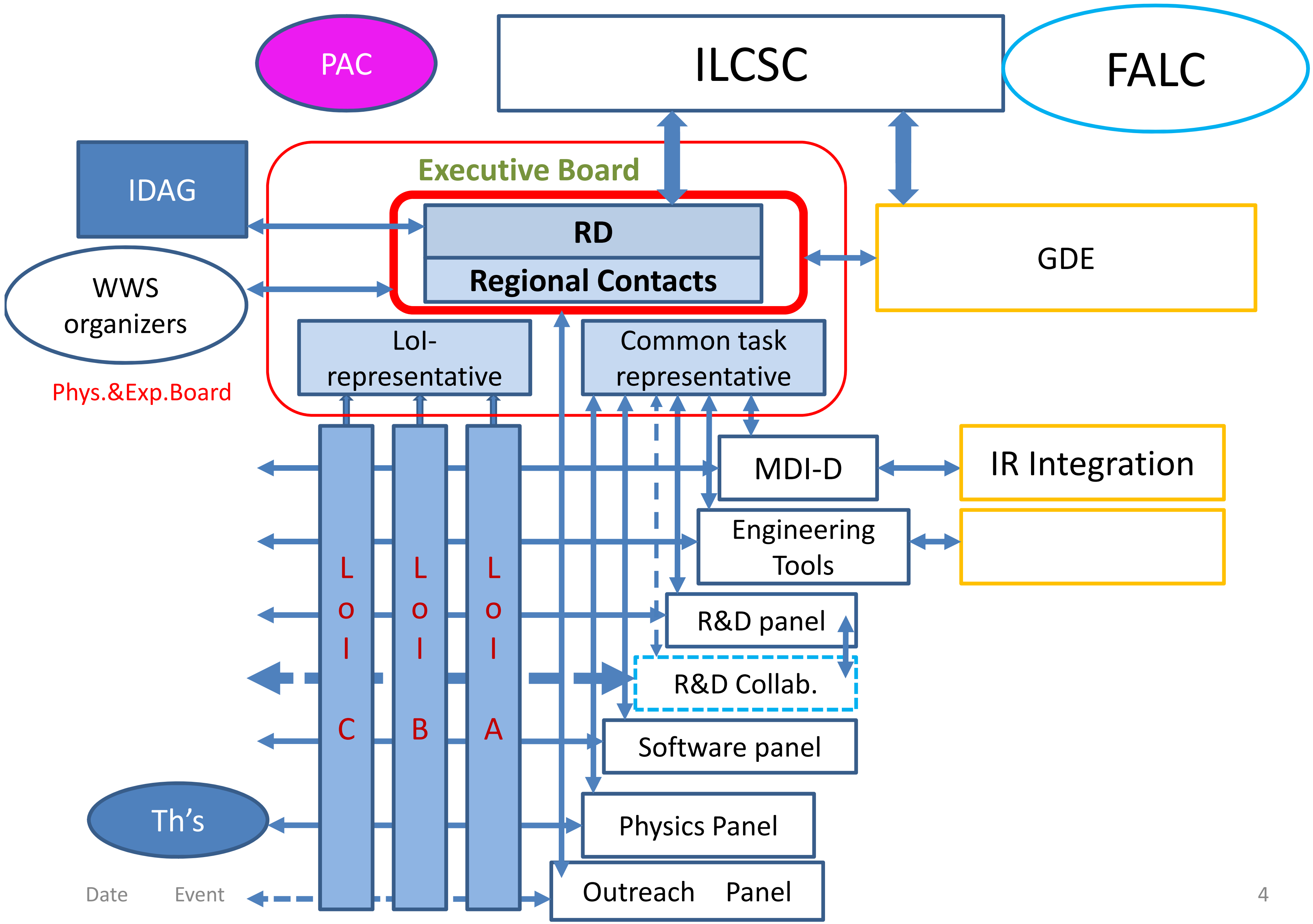
US P5 Pre-Budget Cut Plan



My opinion:

- Relevant time horizon for this audience is LOI
- Simplify, generalize & do not be exclusionary

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
Date
Event
L o I C
L o I B
L o I A

Names

- MDI-D Common Task representatives
  - ILD: Karsten Buesser (DESY) & Toshiaki Tauchi (KEK)
  - SiD: Phil Burrows (Oxford) & Marco Oriunno (SLAC)
  - 4th: Bill Ashmanskas (FNAL) &
    Alexander Mikhailichenko (Cornell)
- GDE IR Integration
  - BDS Leader: Andrei Seryi (SLAC)
  - BDS WP04 Integration Task Leaders:
    - Brett Parker (BNL) & Tom Markiewicz (SLAC)
- IR Engineering Workshop Working Group Leaders
  - A. Herve, J. Osborne, V. Kuchler, N. Mokhov, A. Enomoto, Y. Sugimoto, K. Tsuchiya, J. Weisend, M. Sullivan, D. Angel-Kalinin, T. Sanuki, H. Yamamoto

Recent History & Future Goals

- 2007-Sept IR Engineering Workshop @ SLAC
  - **Work done in preparation & presented form rich picture of technical issues & possible engineering solutions**
- 2008-March ACFA-GDE meeting @ Tohoku, Japan
  - **The need to provide a clear set of ground rules to concepts so the MDI sections in their LOIs conform to agreed specifications leads to proposal of a "IR Interface Document" to accompany LOIs**
  - **Suggested that a paper summarizing IRENG07 "Baseline Design" be considered as draft of this "IR Interface Document" with authors those listed on previous slide**
- 2008-May-14
  - **1st and only "MDI Common Task" & GDE IR phone/webex meeting**
- 2008-June ECFA @ Warsaw
  - **First face-to-face discussions of how to proceed, identification of interface incompatibilities and plans for resolution**
  - **Agreement on role and text of EPAC paper**
    - Some fear of "signing off" on not-agreed-to baseline has been expressed
- 2008-Nov LCWS @ Chicago
  - **Draft of common "IR Interface Document"**
- 2009-March LOI
  - **Final interface document and LOIs with compatible MDI solutions**

EPAC08 Paper

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

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

Minimal Functional Requirements vs. evolving complete "Baseline" for LOIs

- "IR Interface Document" as 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**
    - Eg. Deep versus shallow
  - **Suggest that detector-to-detector issues be worked out as 3 bi-lateral discussions, with BDS IR representation**
- EPAC paper draft is more of a complete set of engineering parameters to define IR region
  - **Changeable, but always as complete as possible**
  - **"Baseline IR Model"**

Draft “Minimal Functional Requirements” Paper

ILC-Note-2009-nnn
March 2009
Version 0, 2008-11-16

Functional Requirements on the Design of the Detectors and the Interaction Region of an e^+e^- Linear Collider with a Push-Pull Arrangement of Detectors

B.Parker (BNL), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY), B.Ashmanskas (Fermilab), T.Tauchi (KEK), P.Burrows (Oxford Univ.), T.Markiewicz, M.Oriunno, A.Seryi (SLAC)

Abstract

The Interaction Region of the International Linear Collider [1] is based on two experimental detectors working in a push-pull mode. A time efficient implementation of this model sets specific requirements and challenges for many detector and machine systems, in particular the IR magnets, the cryogenics and the alignment system, the beamline shielding, the detector design and the overall integration. This paper attempts to separate the functional requirements of a push pull interaction region and machine detector interface from the conceptual and technical solutions being proposed by the ILC Beam Delivery Group and the three detector concepts [2]. As such, we hope that it provides a set of ground rules for interpreting and evaluation the MDI parts of the proposed detector concept’s Letters of Intent, due March 2009. The authors of the present paper are the leaders of the IR Integration Working Group within Global Design Effort Beam Delivery System and the representatives from each detector concept submitting the Letters Of Intent.

Draft will be posted on ILCDOC: http://ilcdoc.cern.ch/

Push-Pull Detectors

Fundamental Assumption for "Rapid" Switch

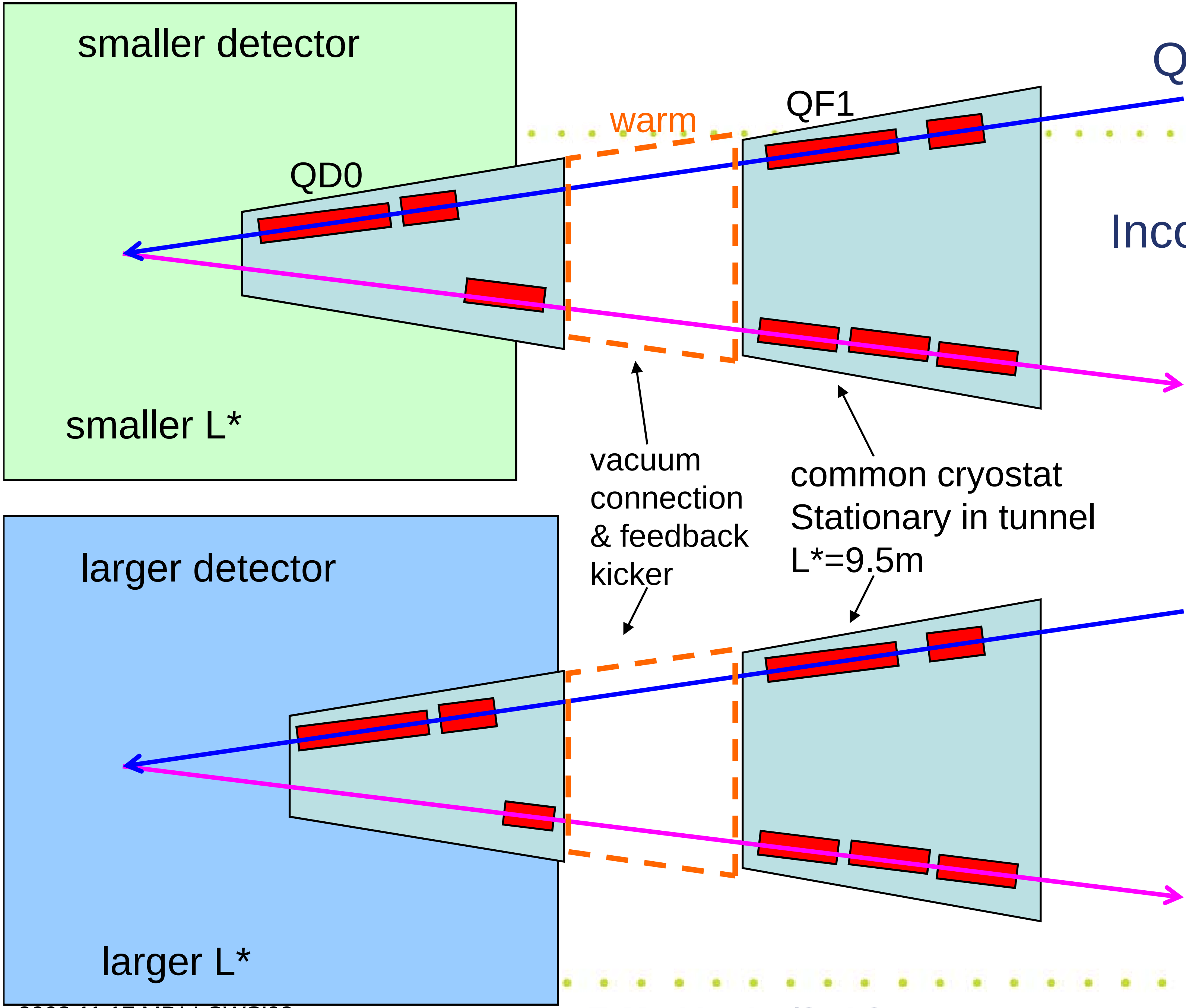
- QD0 moves with and is supported by detector
  - **L* optimized for each detector but 3.5 < L*<4.5m**
- QF1 stationary in tunnel or on pier at L^*_{QF}=9.5m

Passion-generating non-fundamental (imho) choices:

- Self-Shielding vs. Shield Walls vs. Access Restrictions
- Vertically-split endcaps vs. Non-split endcaps
- Platforms vs. rollers vs. airpads
- Crane capacity, shaft diameters, hall sizes

Important but "merely" technical design:

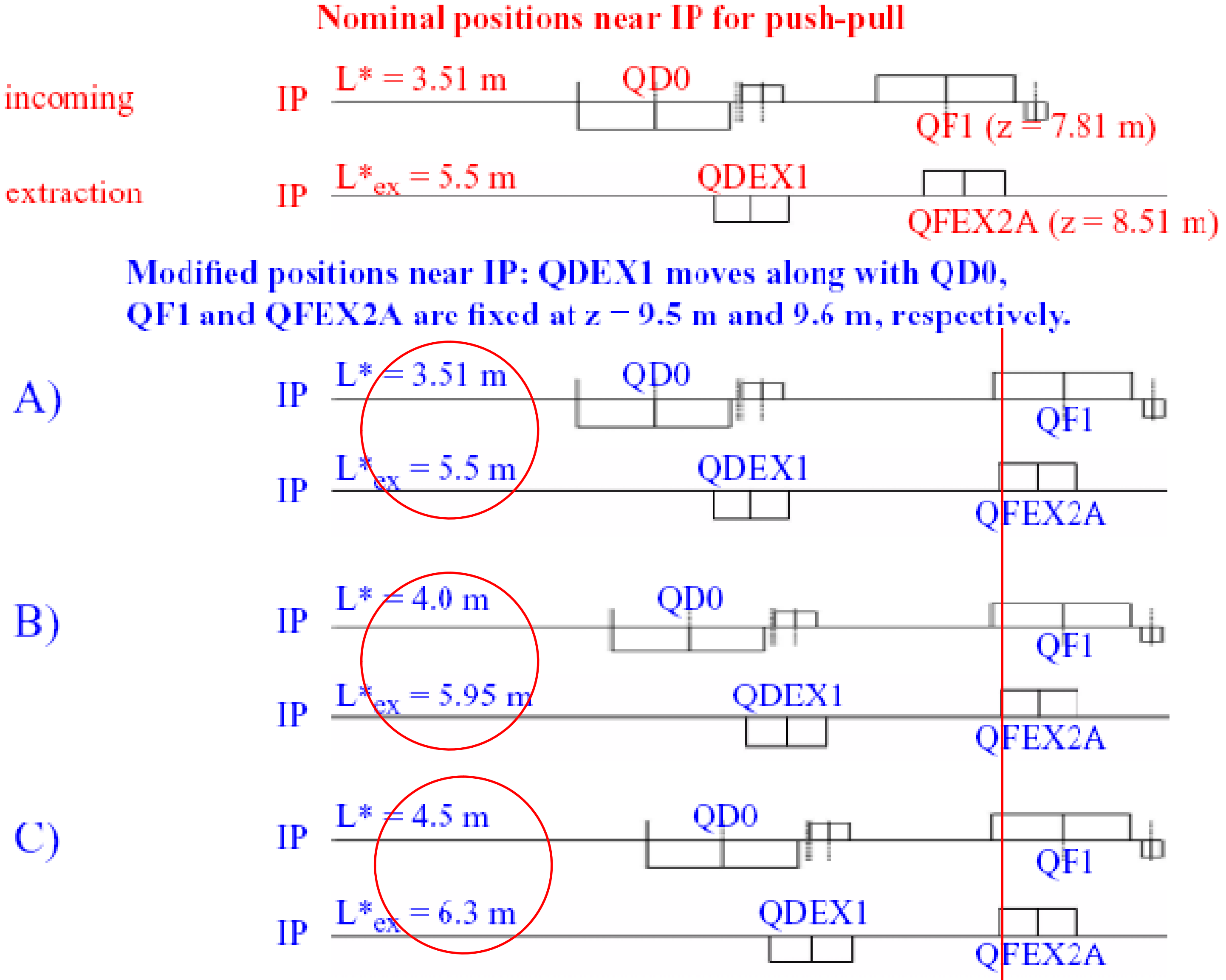
- **cryo plant, cable plant, electronics volume & heat load etc.**



QD and QF Cryostats Contain Incoming and Outgoing Magnet Packages

Seryi

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

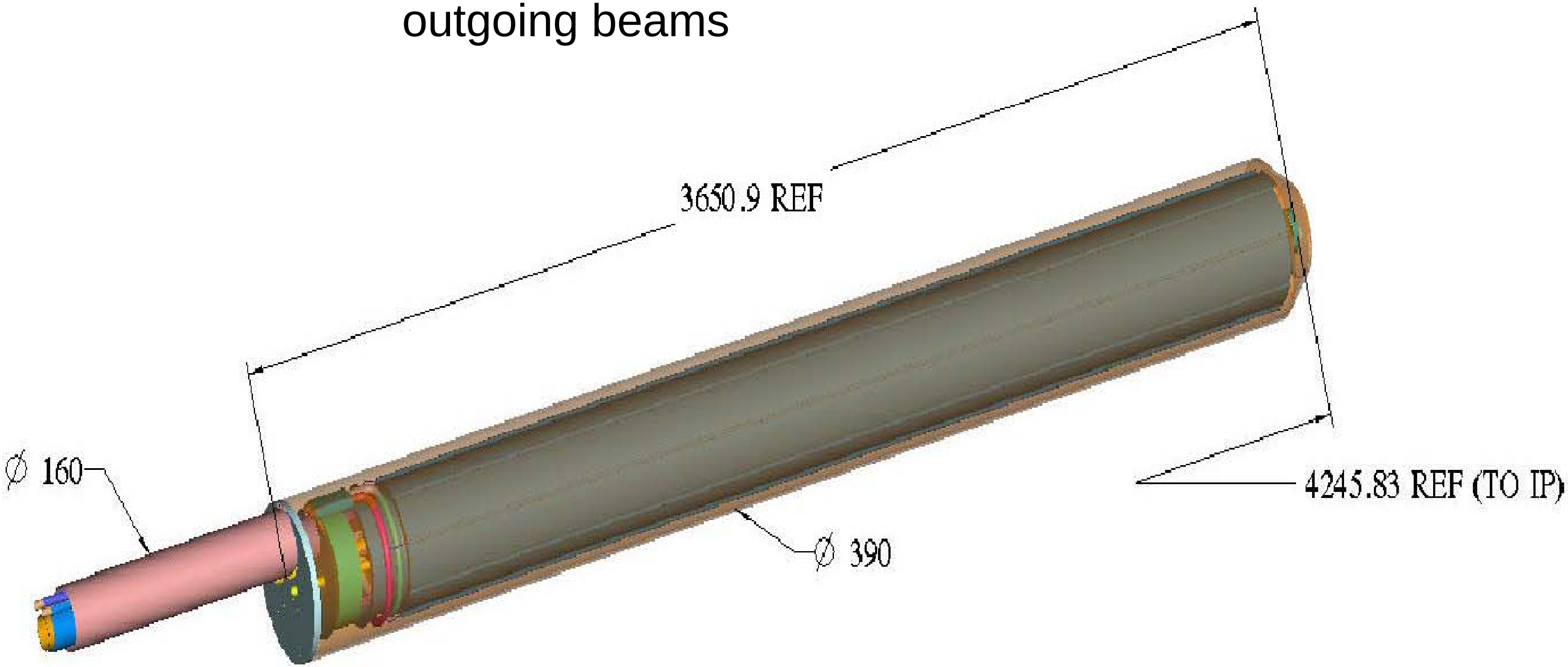


A. Seryi, Y.Nosochkov, SLAC

QD0 CRYOSTAT @ IRENG'07
39cm constant radius

B. Parker et al, BNL

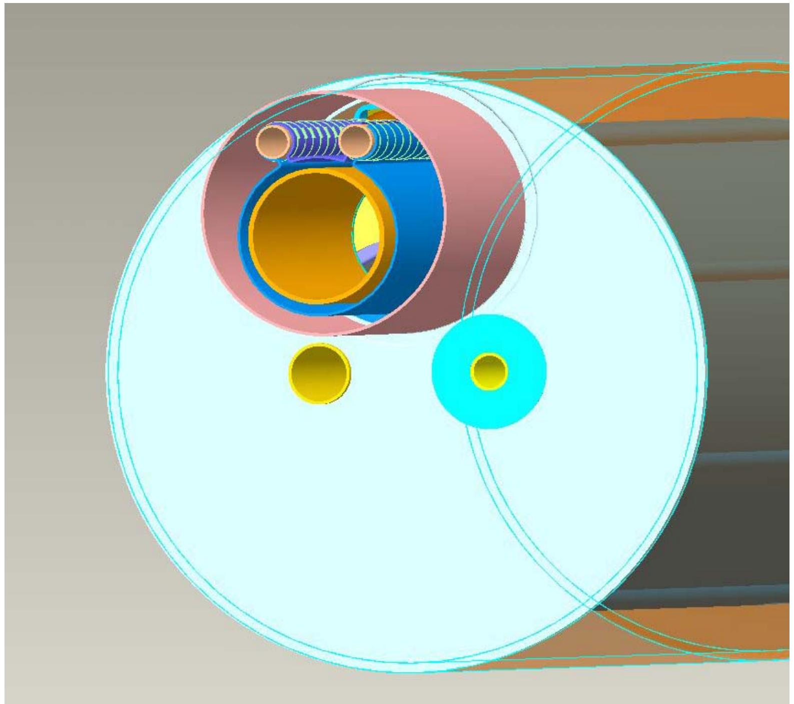
Key Detail Permitting Realization of Baseline Model is the Fully Engineered Compact Magnet Group Housing the Magnetic Elements of incoming & outgoing beams



- Overall dimensions of cryostat for QD0 designed for 4.5m L*
- Cryostat extends 254mm beyond cold mass towards IP

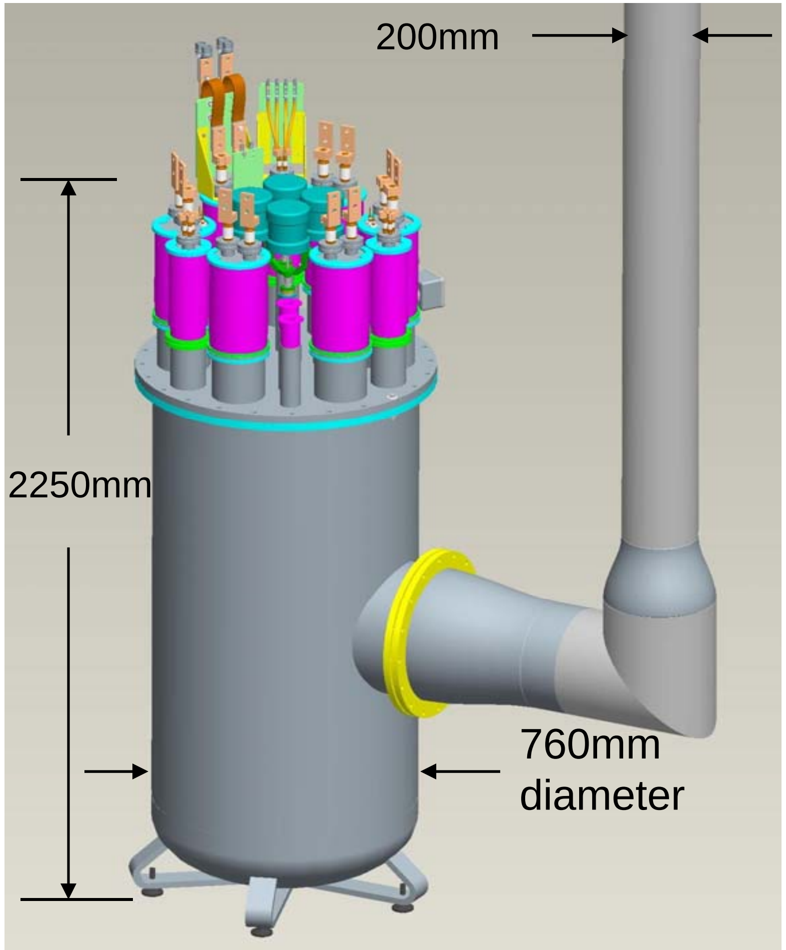
Detailed Cryo-engineering Based on Similar Magnets Built for HERA

Back End of QD0



B. Parker et al, BNL

Local "Service Cryostat"



Overall service cryostat dimensions

Suggested Set of Minimal Constraints (imho)

- IP Beam parameter range set by ILC Project Mgmt.
- Hall width on beamline set by mandated 9.5m L* of QF
- Garaged position begins a fixed distance from beamline (15m?)
- Bare reinforced floor and bare walls in ±15m around beamline; all required services enter and leave with detector
- Radiation & magnetic environment in garage zone to be guaranteed at agreed on levels by the beamline detector using their chosen solution
- Time elapsed for push out/ pull consistent with chosen solutions
- QD0 support alignment range, accuracy, stability set by BDS
- QD0 cryo-connections respected during detector maneuvers
- Any other compatibility issues between concepts developed in up to 3 bilateral agreements
  - **Shielding interfaces, common cryo plants, etc.**

Implication

Each concept's design should be evaluated by the IDAG

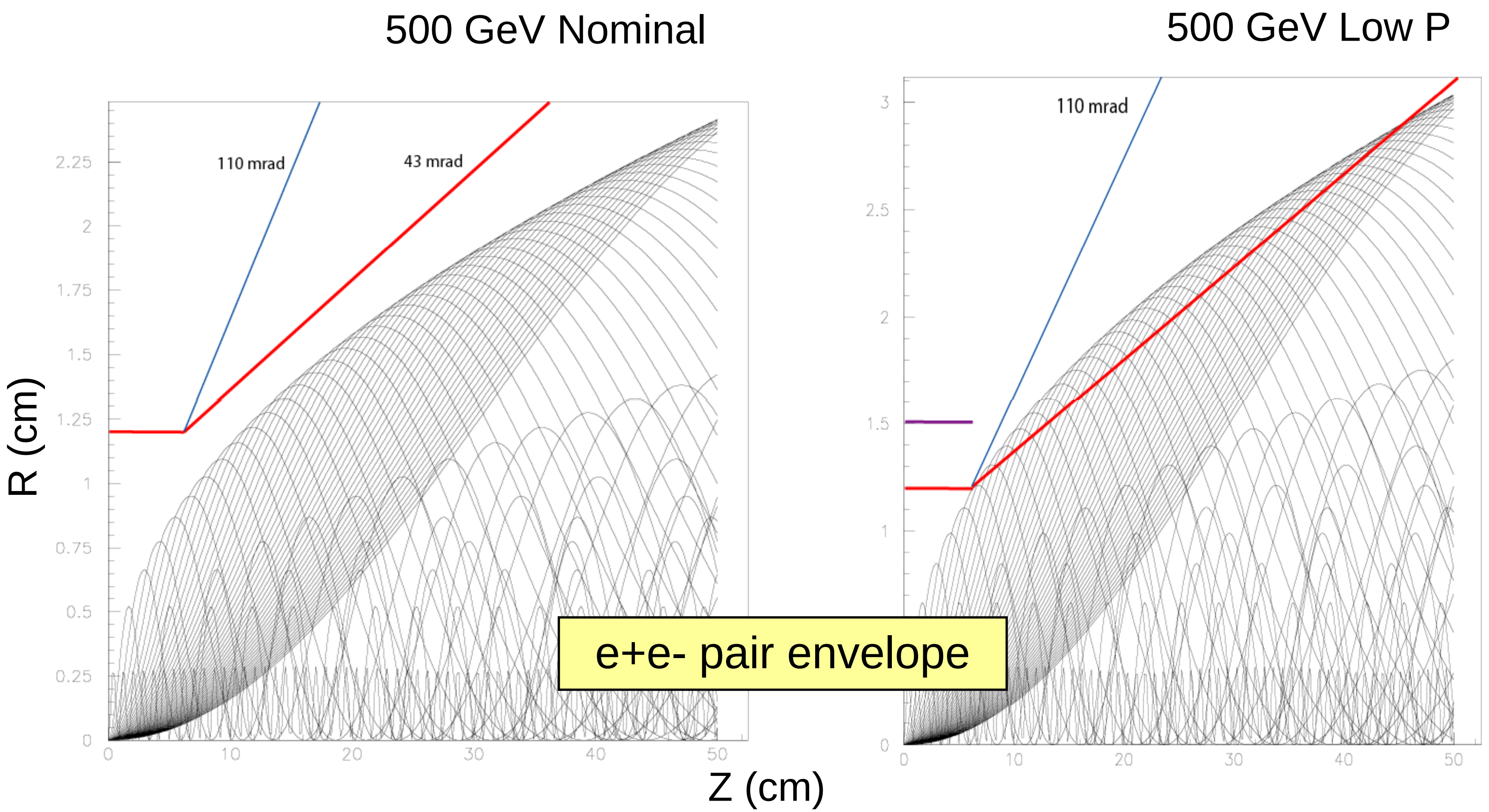
(or IDAG appointed consultants)

as to whether it complies with functional requirements

Beam Parameters

- "Parameter Plane" of Beam Parameters at IP defined in RDR Table 2.1-2 as "Nominal", "Low Charge", "Large Vertical Beamspot" and "Low Power" each yield L=2E34/cm^2/sec but stress out a different part of the ILC
  - **Low Power & Large Y Spot need "Large Disruption" at IP to recover luminosity and resulting "disruption" blows up beam after collision more than "nominal" or "low charge"**
- Sad that we are still discussing this, but I know that the beam pipe radius at the IP, for certain concepts, and even that currently proposed extraction line diagnostics do not respect "Low Power" parameter set
- Need a "final word" on whether the parameter plane must be respected by the LOI designs

Example: Current SiD Beam pipe is designed for ILC 500 GeV Nominal + 5 Tesla



For Low P: SiD beam pipe: 43mrad BP → 110 mrad and R= 1.2 cm → 1.5 cm

IR Hall Dimensions at the Beamline

- Stationary QF1 defines width of hall along beamline
  - **B field begins 9.5m and cryostat begins 9.24m from IP**
- Transverse distance from beamline to land “owned” by partner detector negotiable
  - **Working number 15m**
- Beam height above reinforced floor contentious as affected by
  - **Largest concept selected**
  - **Detector support & moving system selected**
  - **Working number 10m**

Time Required for Detector Switch

Abandon the concept of “working numbers that concepts will try to satisfy” in favor of concept of “Figure of Merit based on a realistic plan” for concept evaluation

- **Push Out: clock for new detector starts when in garage**
- **Pull In Time: counts against beam-time allotted**

Obviously benefits everyone to minimize time

- **Credibility of push/pull concept**
- **Will determine # data periods/detector/year**
- **Shielding scheme preferred by concept**
  - Shielding that moves with the detector moves faster that a separate system but as long as time boundary respected concept should be free to choose what it needs
- **Time to reestablish luminosity assumed constant**
- **Re-Calibration time at expense of working detector**

QD0 Constraints

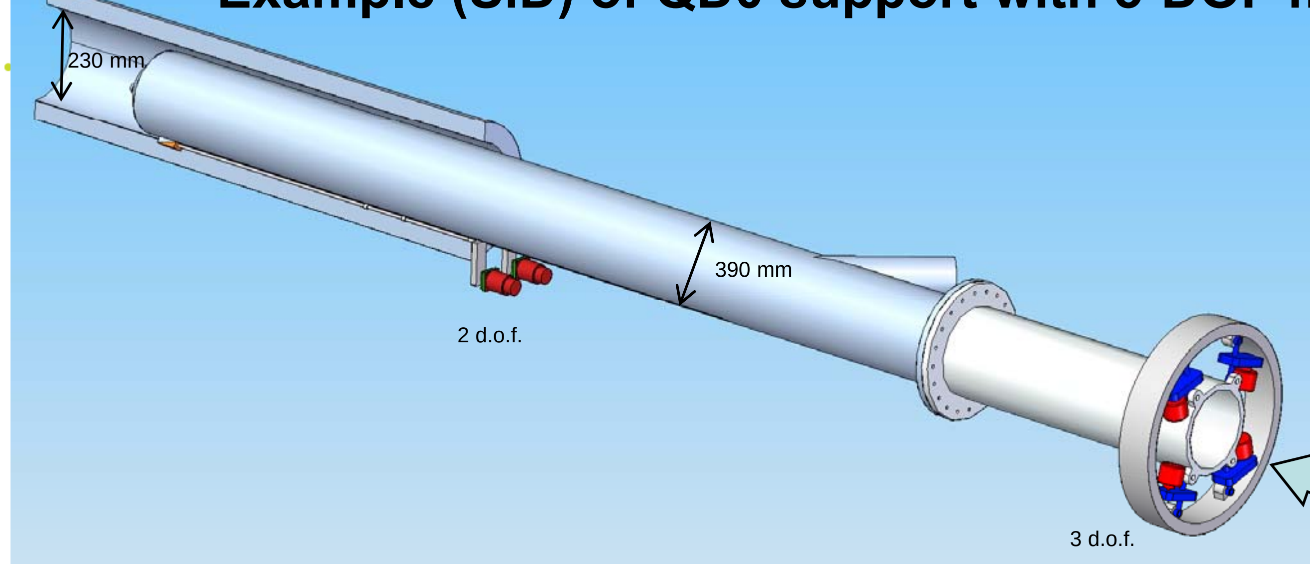
Uncontroversial but pose engineering challenges

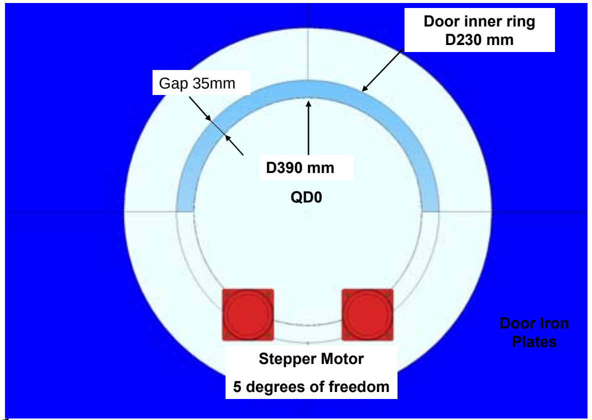
How to judge if constraint is met?

Does QD0 motion couple to FCAL position through chosen support scheme?

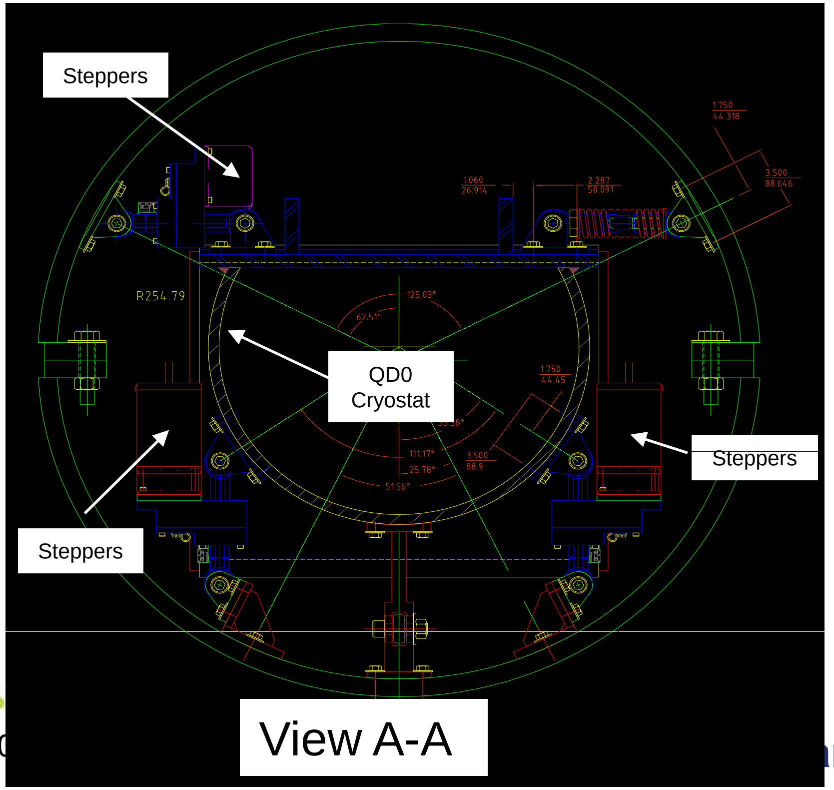
Z position of QD0 Cryostat	3.5-4.5m from IP
Detector axis	± 1mm from line determined by QF1s
QD0 Alignment range	± 2mm
QD0 Alignment Accuracy	± 200um from line determined by QF1s
QD0 Stability	50nm, Δ(QD(e+)-QD(e-)), within 1ms pulse
# alignment DOF	5
Optical Access to QD0 ???	4 paths to each cryostat and the floor

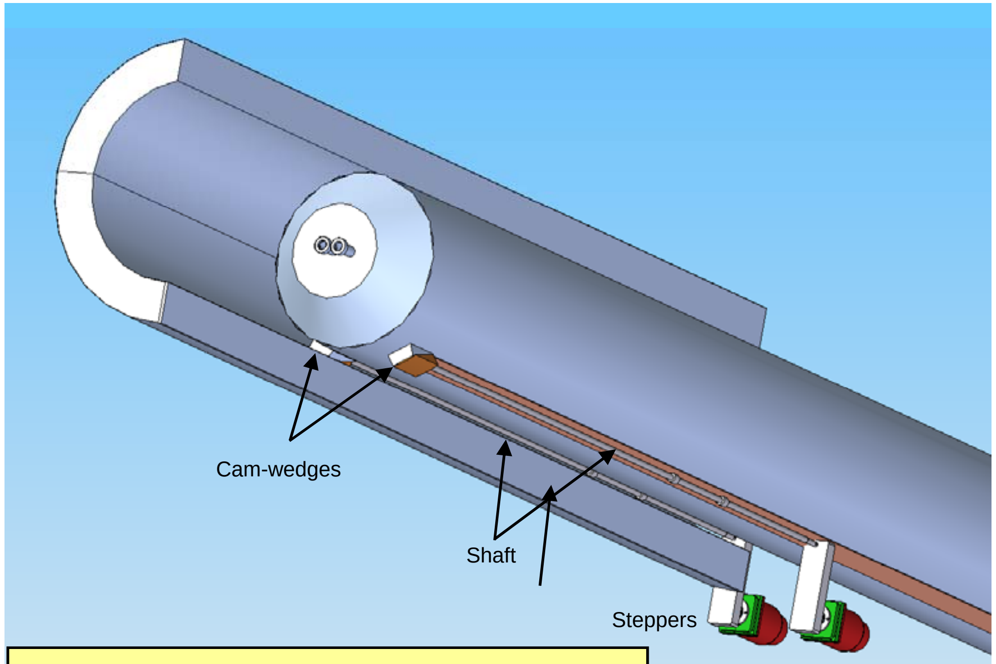
Example (SiD) of QD0 support with 5-DOF magnet mover system





View A-A

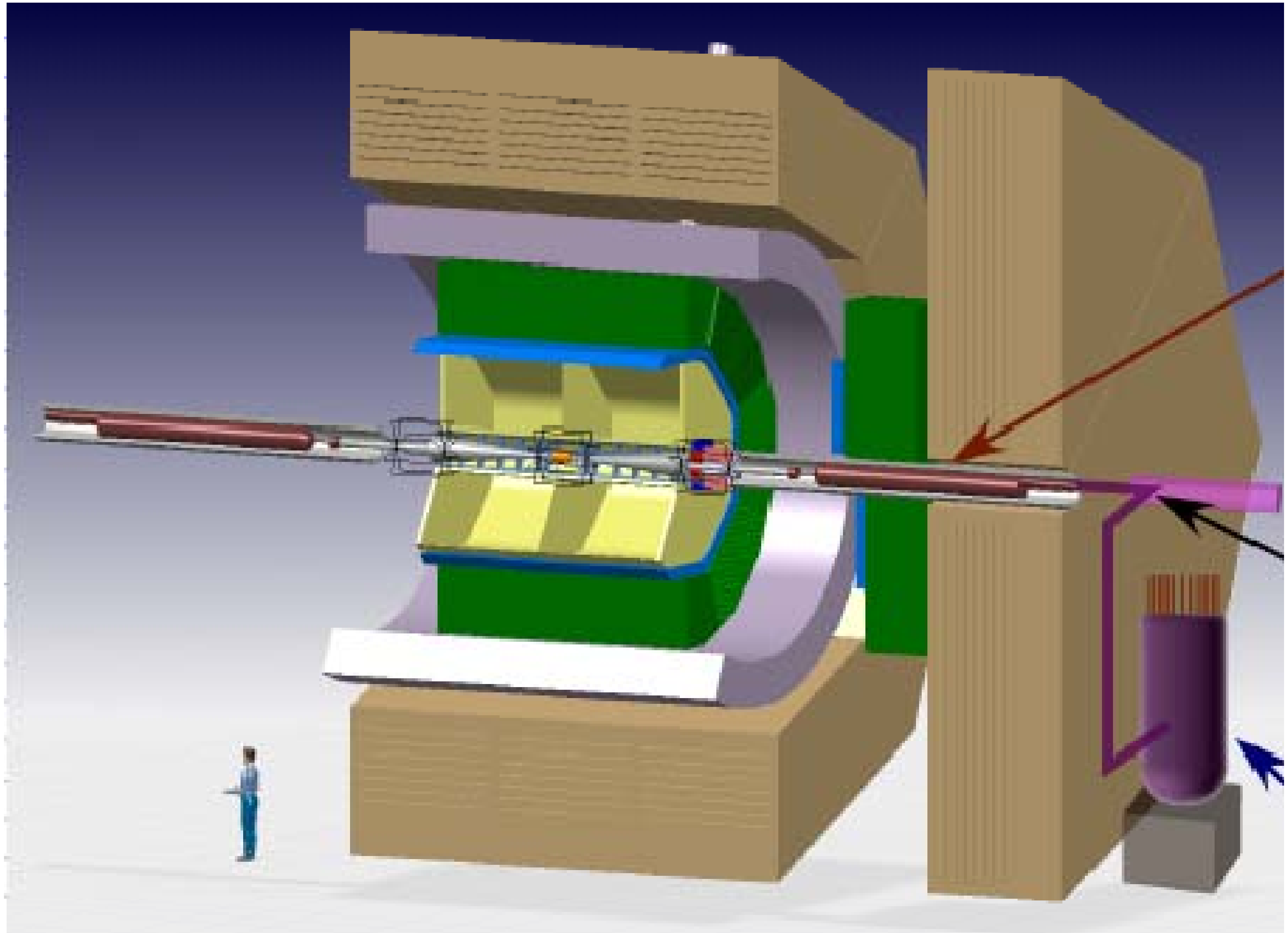




QD0 Service Cryostat

- Connected to QD0 via rigid pipes and assumed to rarely if ever be disconnected. Depending on shielding scheme, pipes must not provide a radiation leakage path
  - **Assumed to move with detector**
  - **Assumed to be limiting factor for detector access after connected and cold**
- Sized assuming 14W static and 1 W dynamic heat load at 1.9°K
- Connected to external cryo system via flexible line carrying single phase liquid He and low pressure He return gas

Interference Between Movable Door & QD0 Service Cryostat



B. Parker et al, BNL

Environment Imposed on Off-Beamline Detector

- Off-beamline detector “owned” space begins at agreed on distance (15m?) from beamline and users have complete access
- Static magnetic field < 100 Gauss (?)
  - **Speaks to amount of iron or degree of compensation for the iron free design**
  - **Equivalent requirement that field from the Off-Beamline detector must not distort On-Beam detector’s field more than 10^{-4}**
- Radiation
  - **Normal Operation and Accident Protection must be provided to the off-beamline region**
  - **Limit values regionally dependent & under discussion**

Contentious Issues
Probably only a partial list

Shielding Walls versus Self-Shielding

- **As long as radiation requirements met it is up to concept to come up with their preferred shielding and or administrative controls (lack of access)**
- **Crane capacity, block storage location, etc. to be proposed by concept advocating given solution**
- **Time to demount consistent with agreed switch time**

Common PACMAN Interface

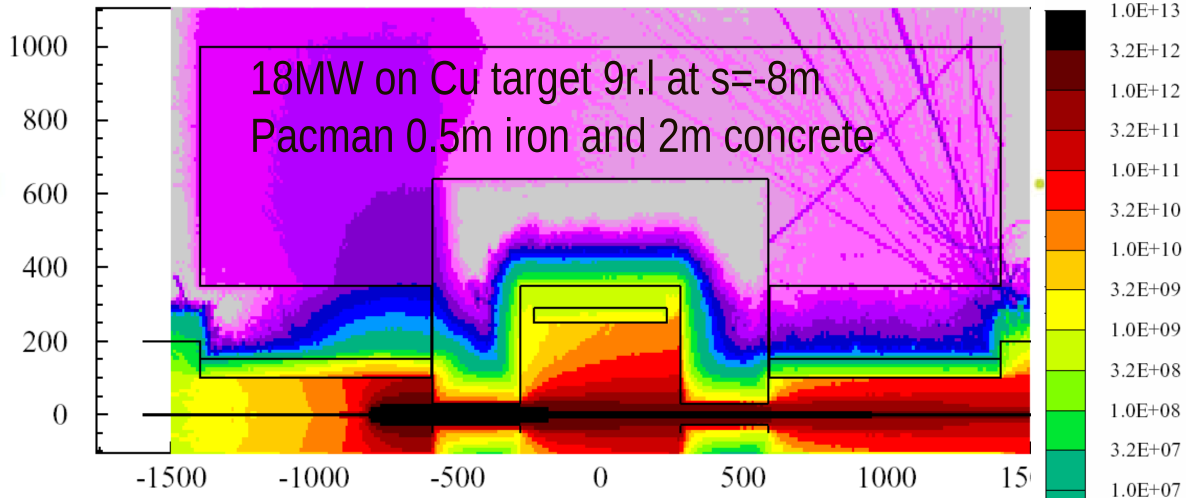
- **To be developed in collaboration with other concepts**

Air pads versus platforms versus rollers

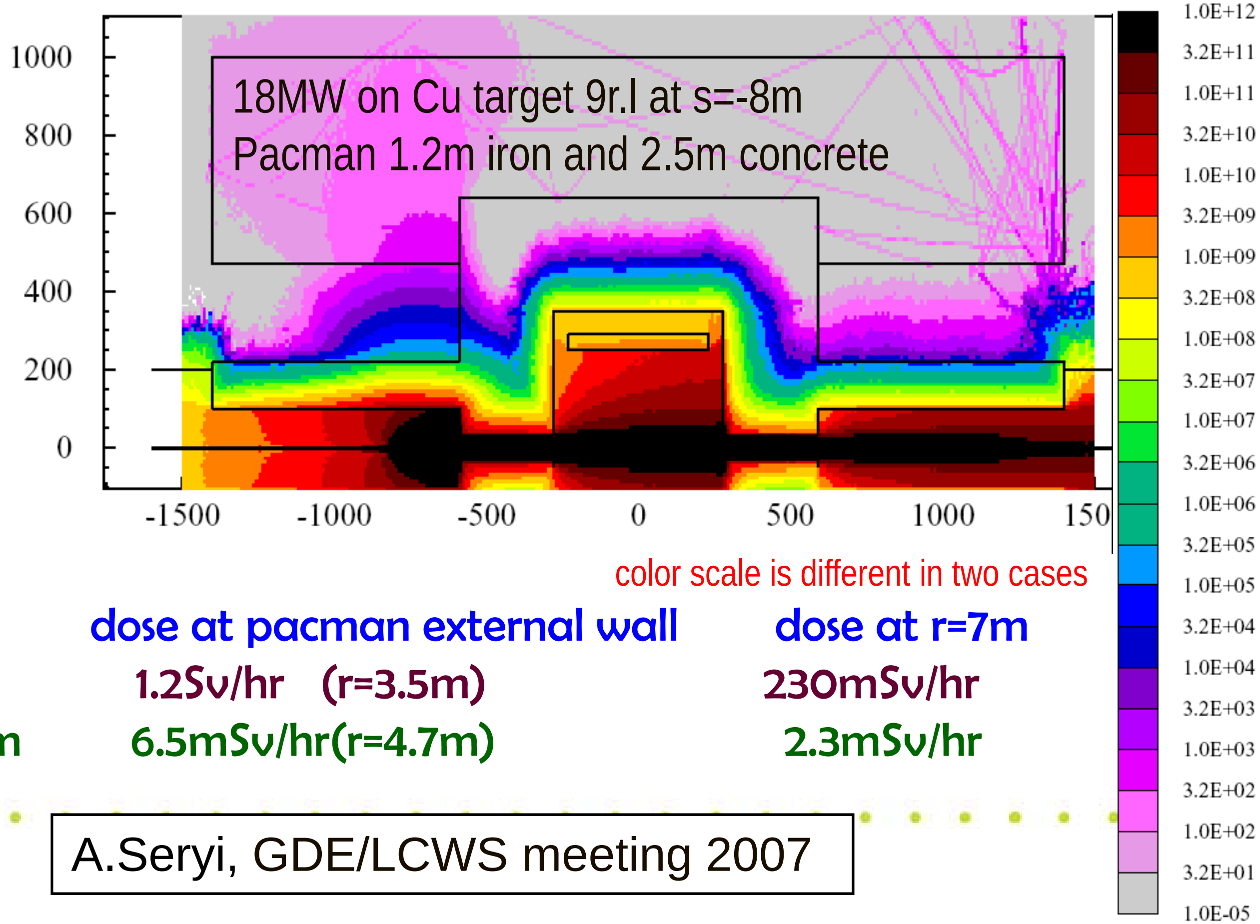
- **Proposal is that a bare floor and walls must be left by the vacating detector**
  - All support services (power, cryo, water, gases,..) must be pulled in and out on flexible lines
- **Unless final two concepts agree on a different common solution**

Self-shielding Example

Adjusting pacman to reduce dose below 250mSv/hr



Desired thickness is in between of these two cases

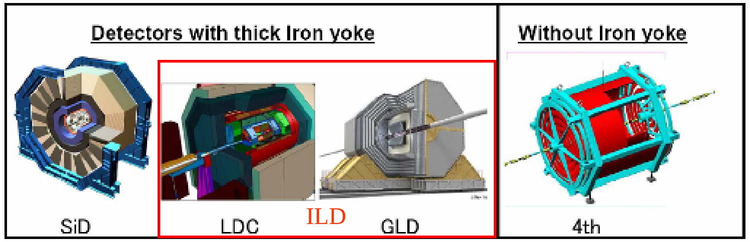


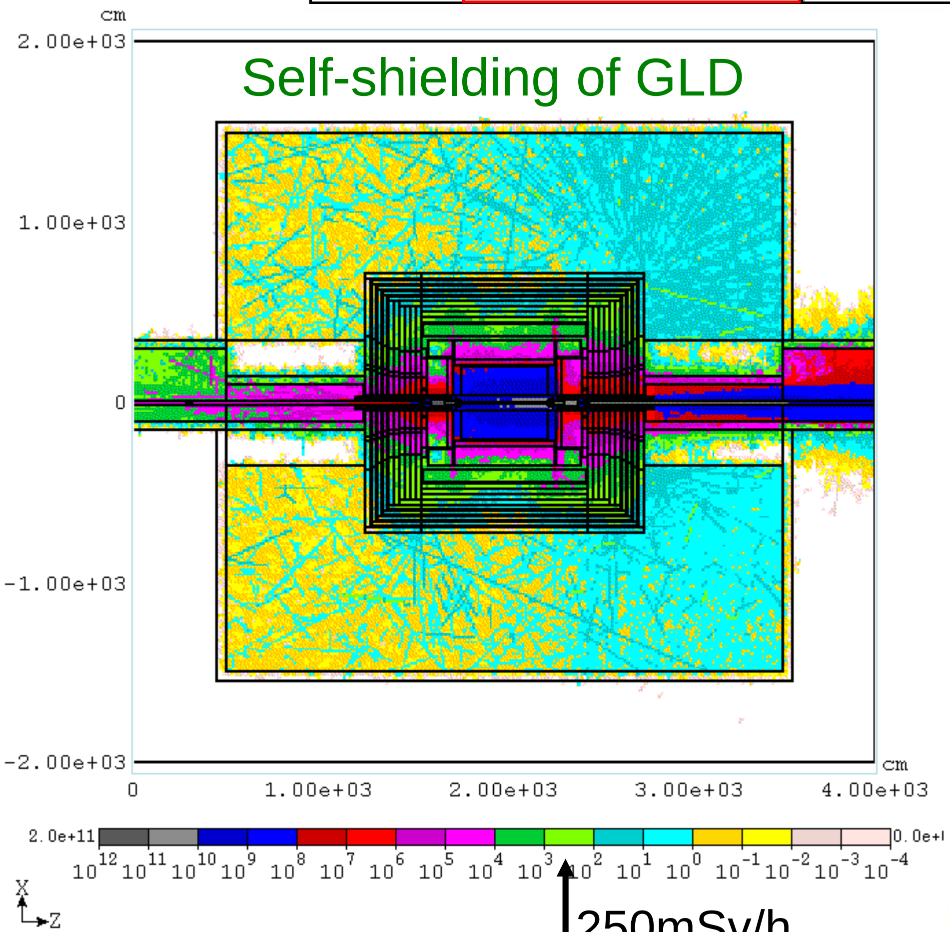
color scale is different in two cases

18MW at s=-8m: Packman	dose at pacman external wall	dose at r=7m
Fe: 0.5m, Concrete:2m	1.2Sv/hr (r=3.5m)	230mSv/hr
Fe: 1.2m, Concrete: 2.5m	6.5mSv/hr(r=4.7m)	2.3mSv/hr

A.Seryi, GDE/LCWS meeting 2007

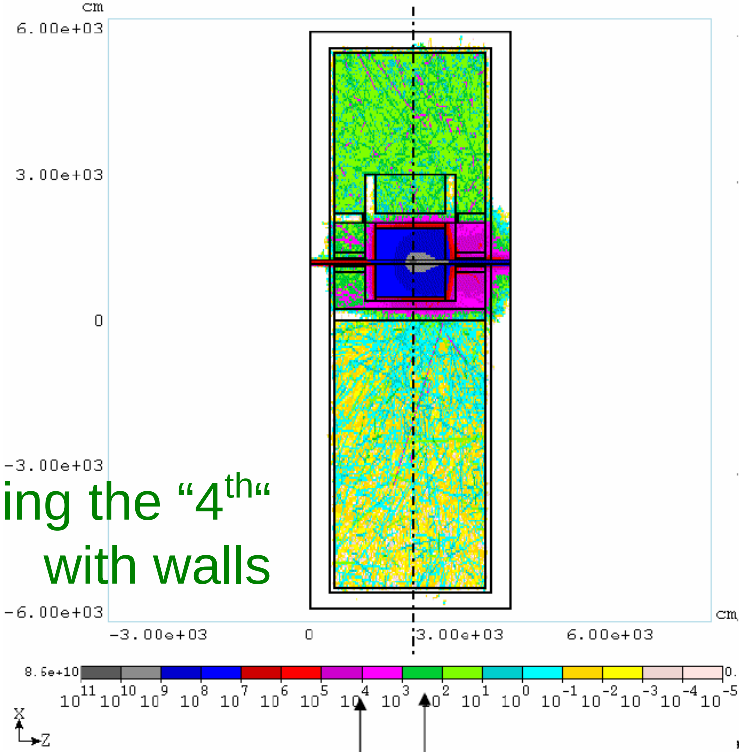
Shielding the IR hall



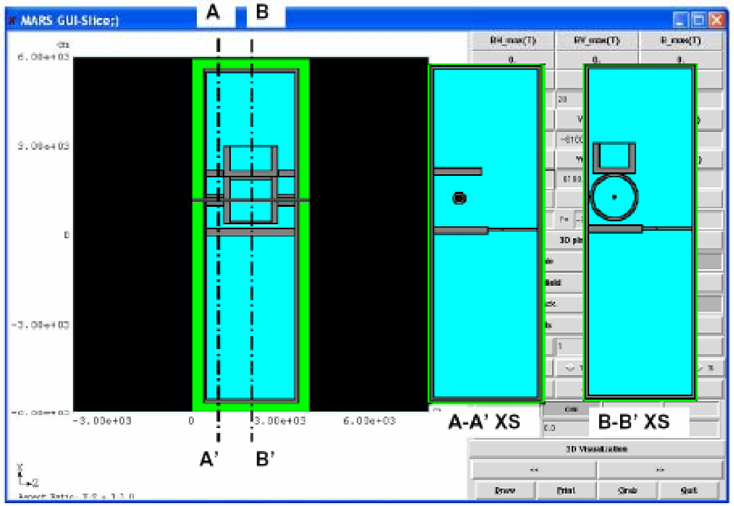


250mSv/h

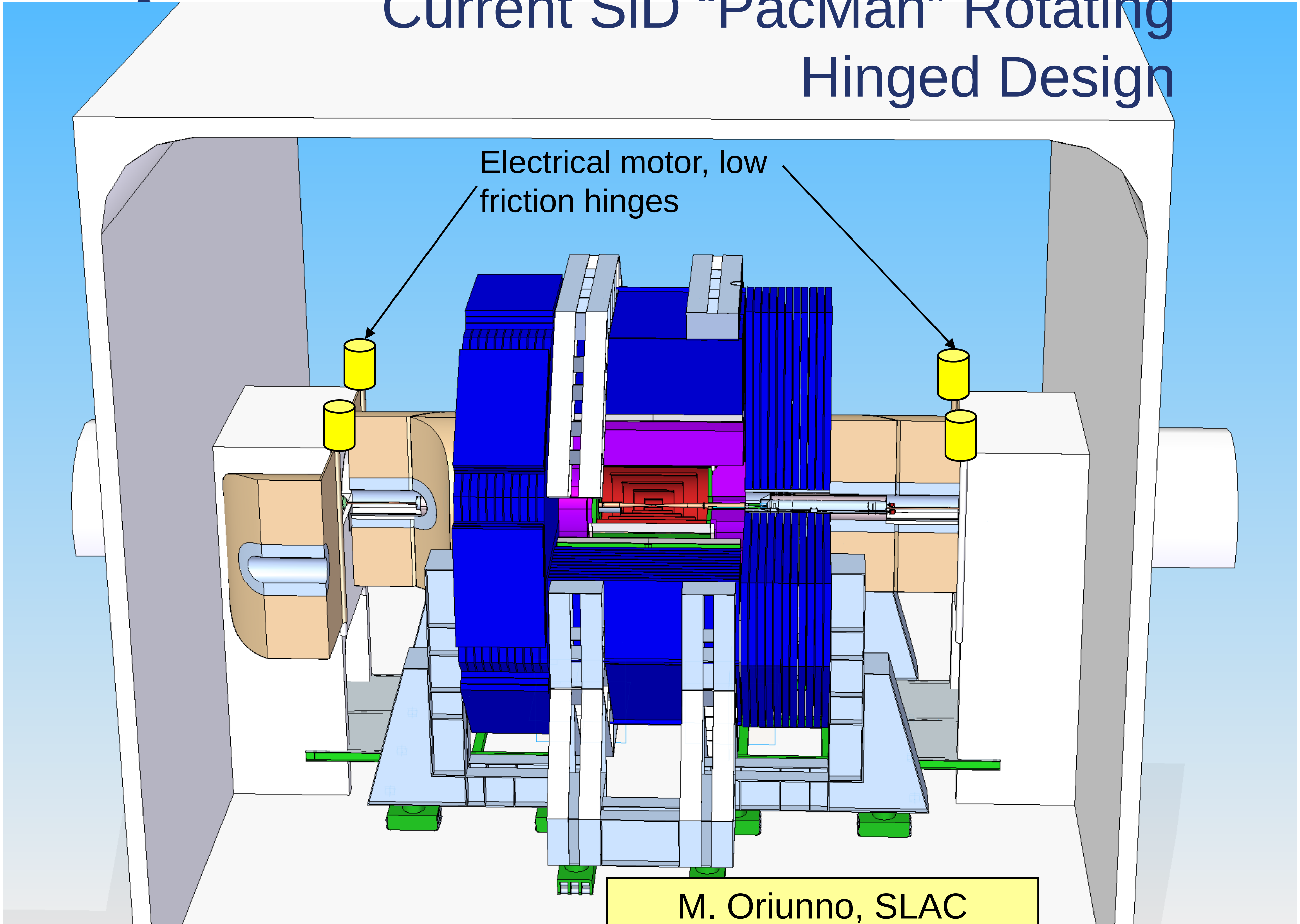
Shielding the "4th" with walls



25rem/h@18MW



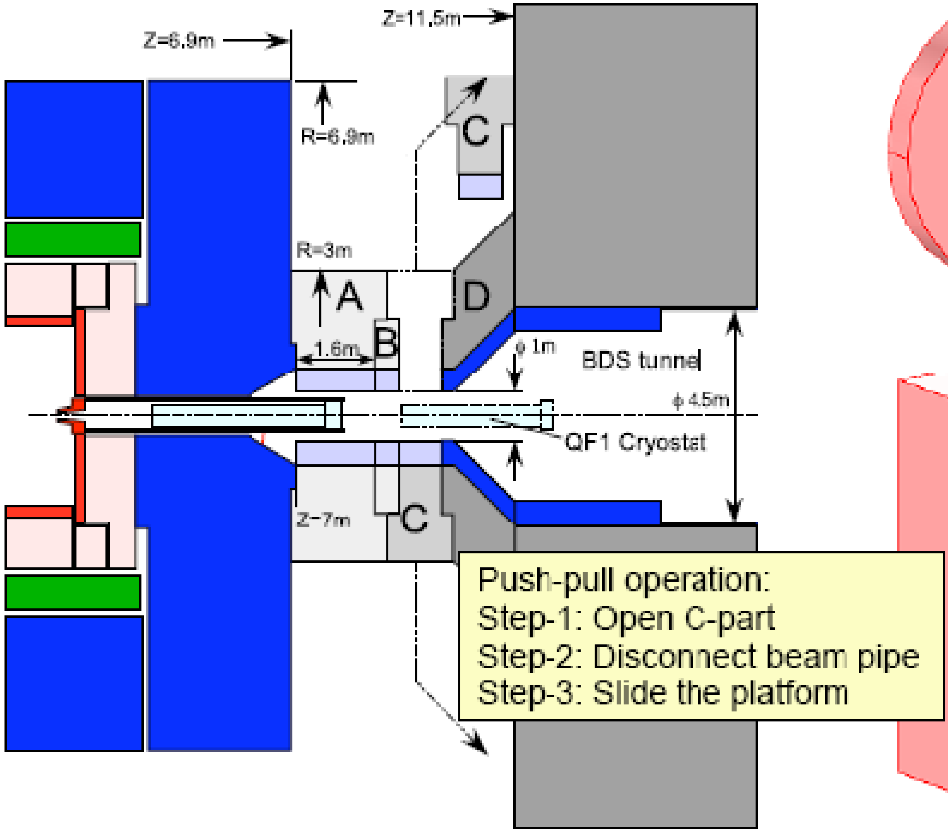
Current SiD "PacMan" Rotating Hinged Design

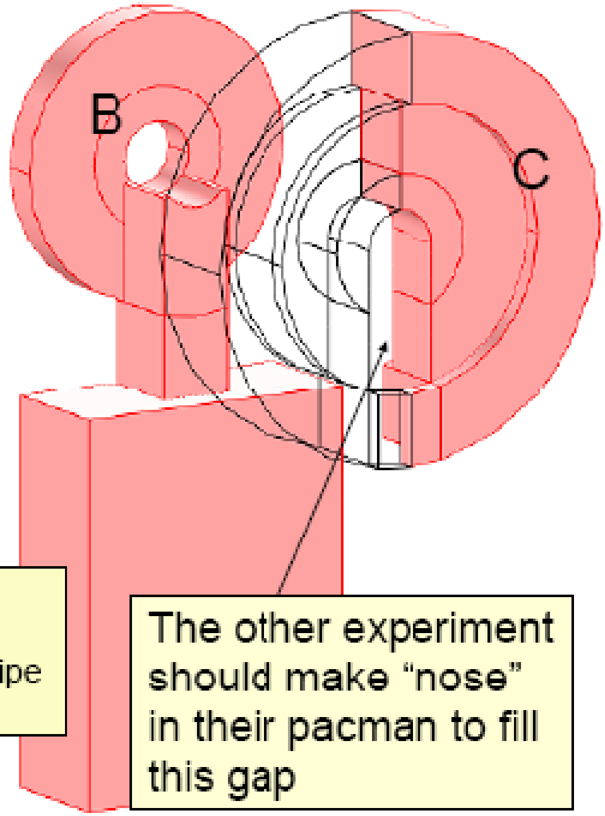


M. Oriunno, SLAC

Disassembly of GLDc PACMAN for Push-Pull

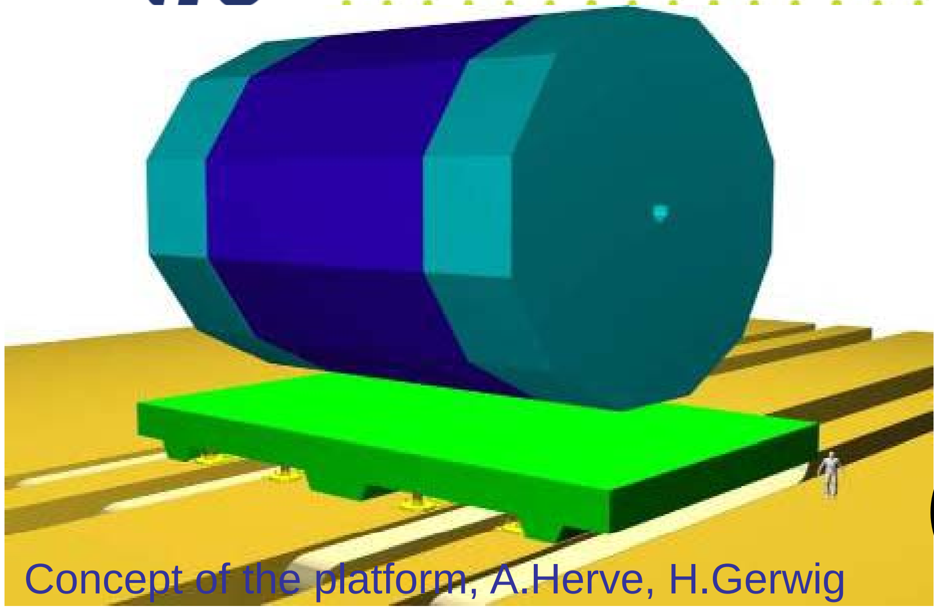
- Plan view
- 3D view



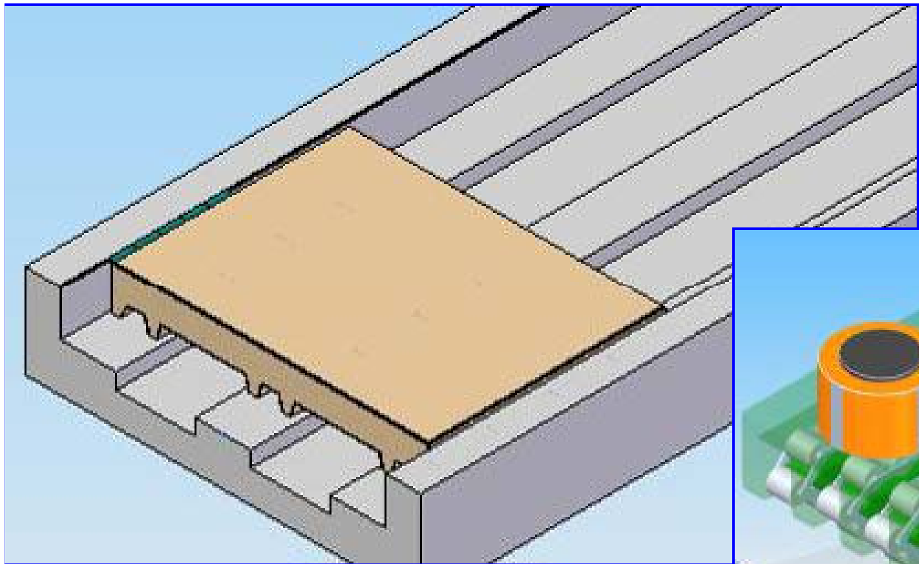


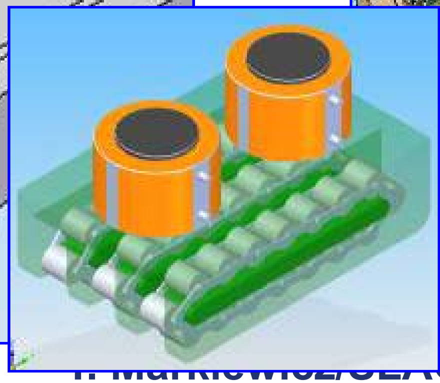
Can ILD & SiD agree to a common solution for size/shape/motion of shielding permanently mounted to IR wall?

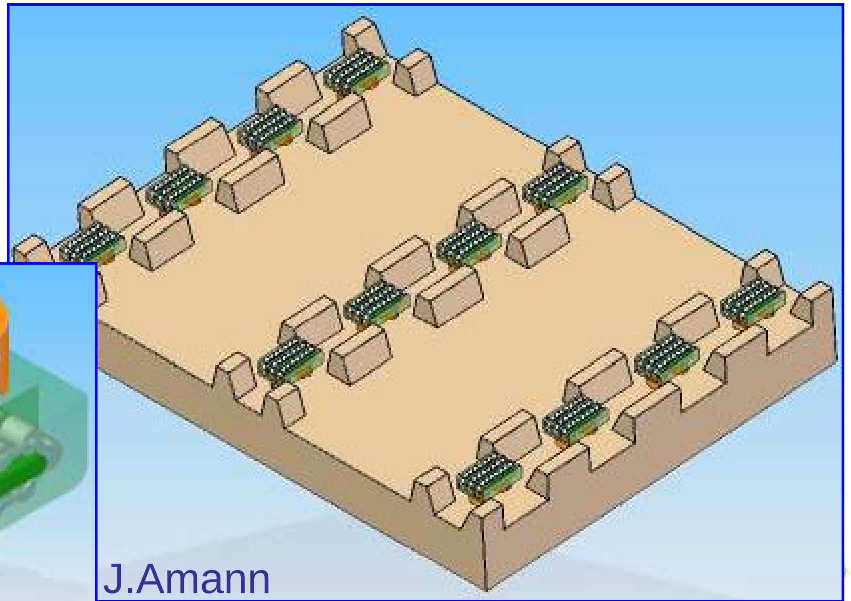
Platform possibility for moving the detector


Concept of the platform, A.Herve, H.Gerwig

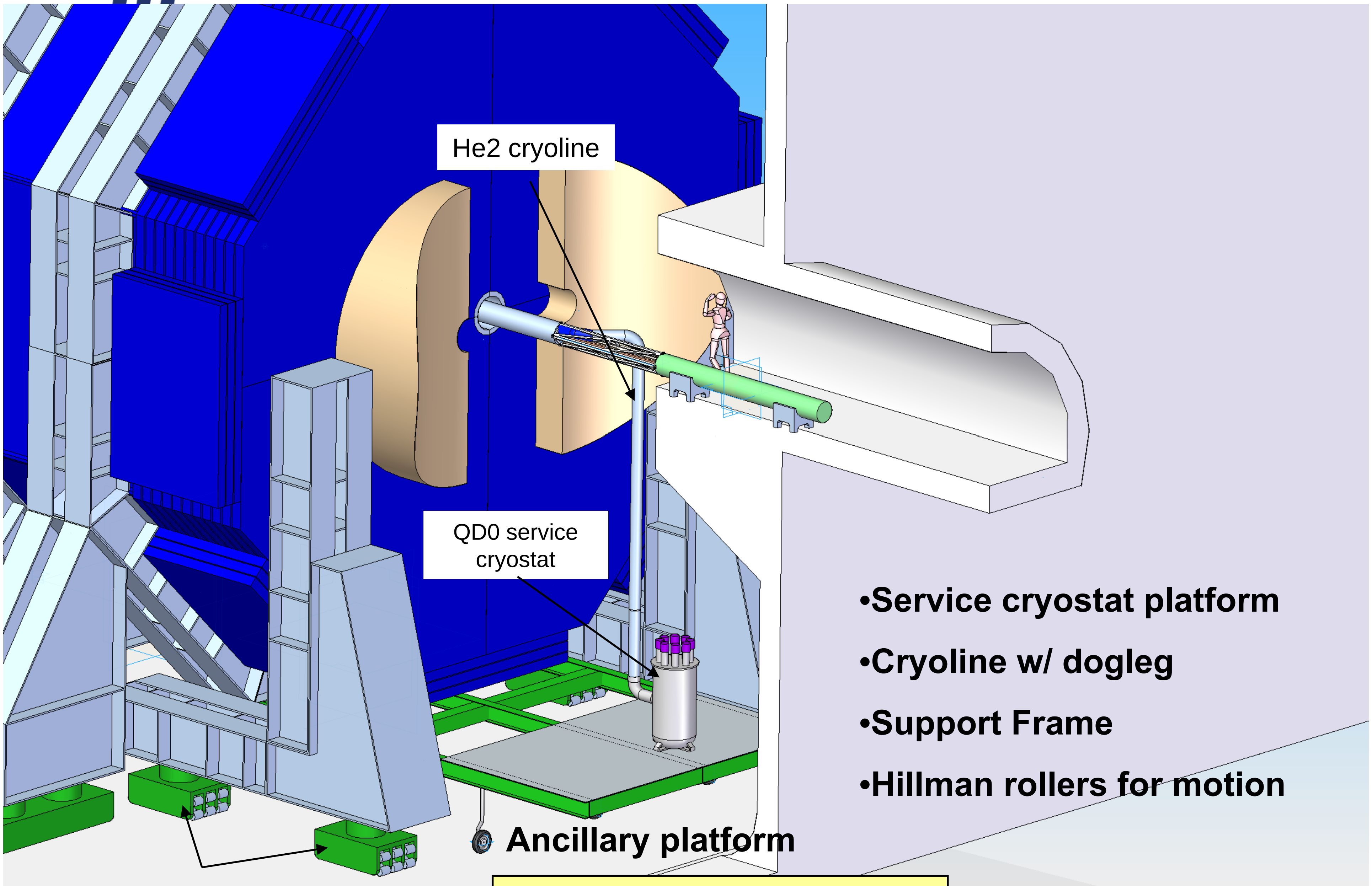

Air-pads at CMS – move 2000k

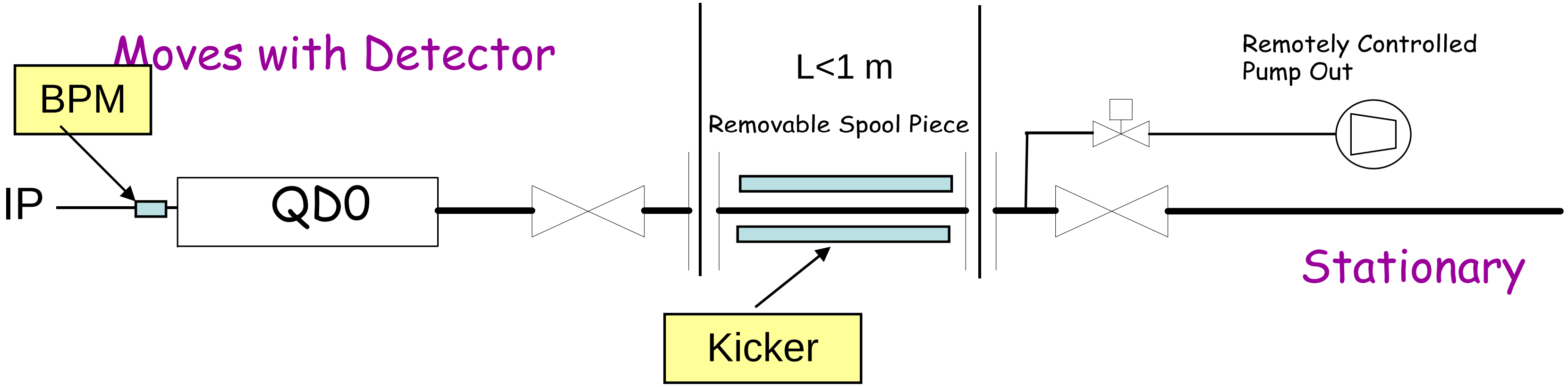


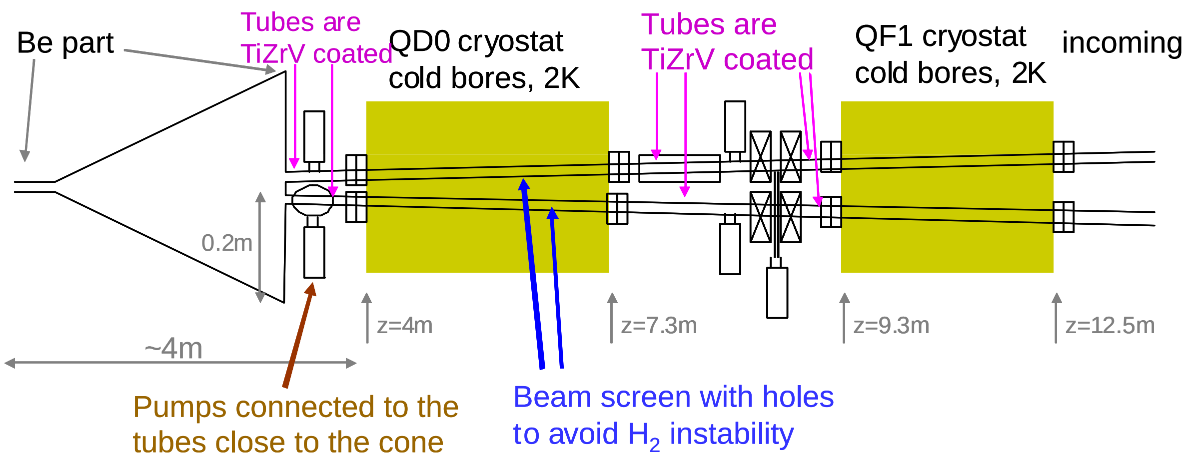



J.Amann

Platform Free Example (SiD) for Moving the Detector







IRENG07 Workshop

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

Steps Forward

Concentrate on Minimal Functional Requirements

- As a group determine parameters and working values
- Three teams of 2 concepts plus BDS develop consistent conceptual solutions for interface and dictate design
  - **Begin this process immediately after LCWS Chicago**

Leave everything else not needed explicitly for the LOI:

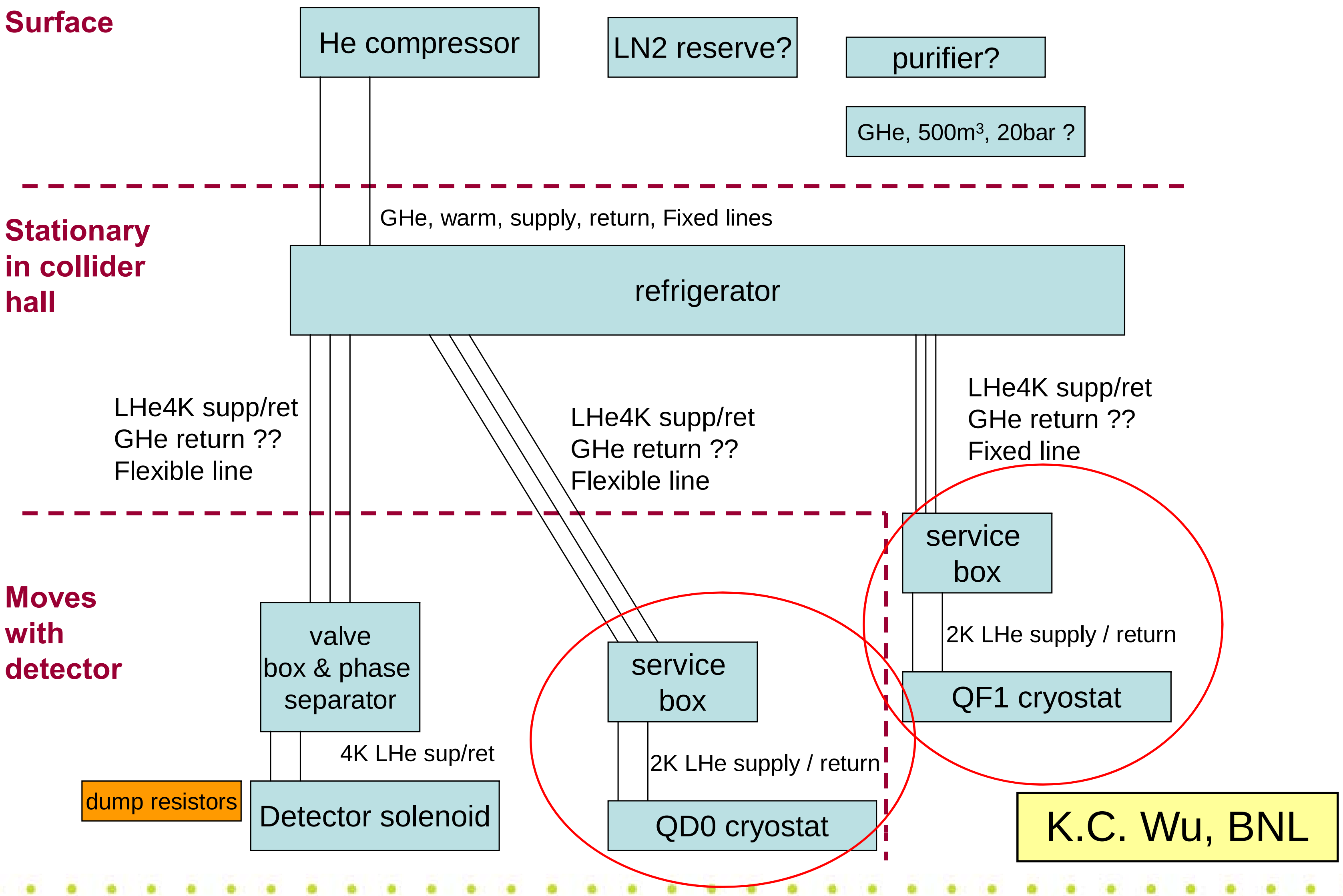
garage sizes, crane capacities, shaft sizes, etc.

to be filled in 'in the fullness of time'

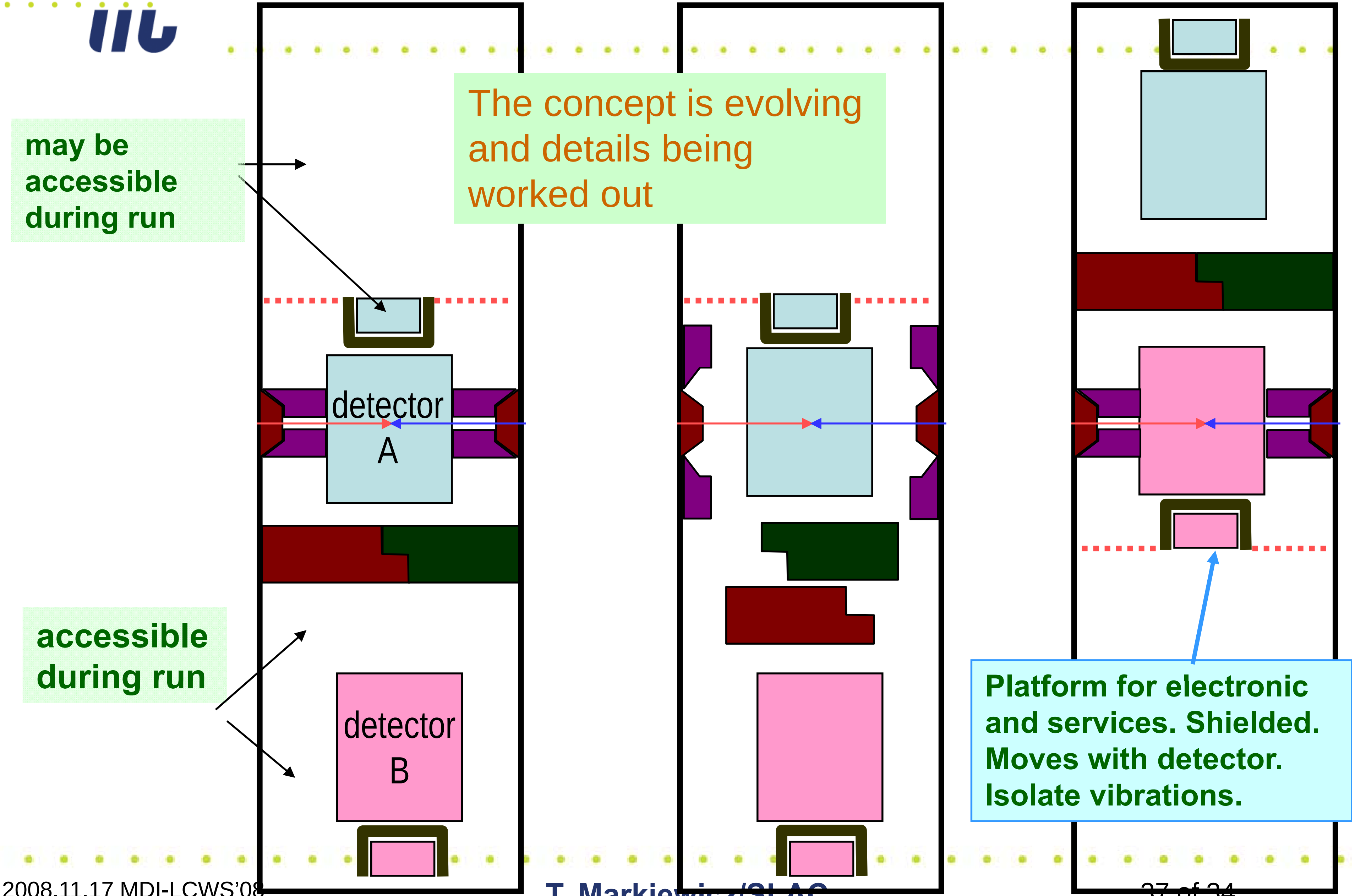
This doesn't preclude maintaining several working models of what the entire IR complex would look like or investigating changes to fundamental assumptions (L* completely outside the detectors, near-surface geology, etc.)

Backup Slides Follow

Cryogenic Block Diagram in ILC IR Hall
What could be common has not yet been discussed

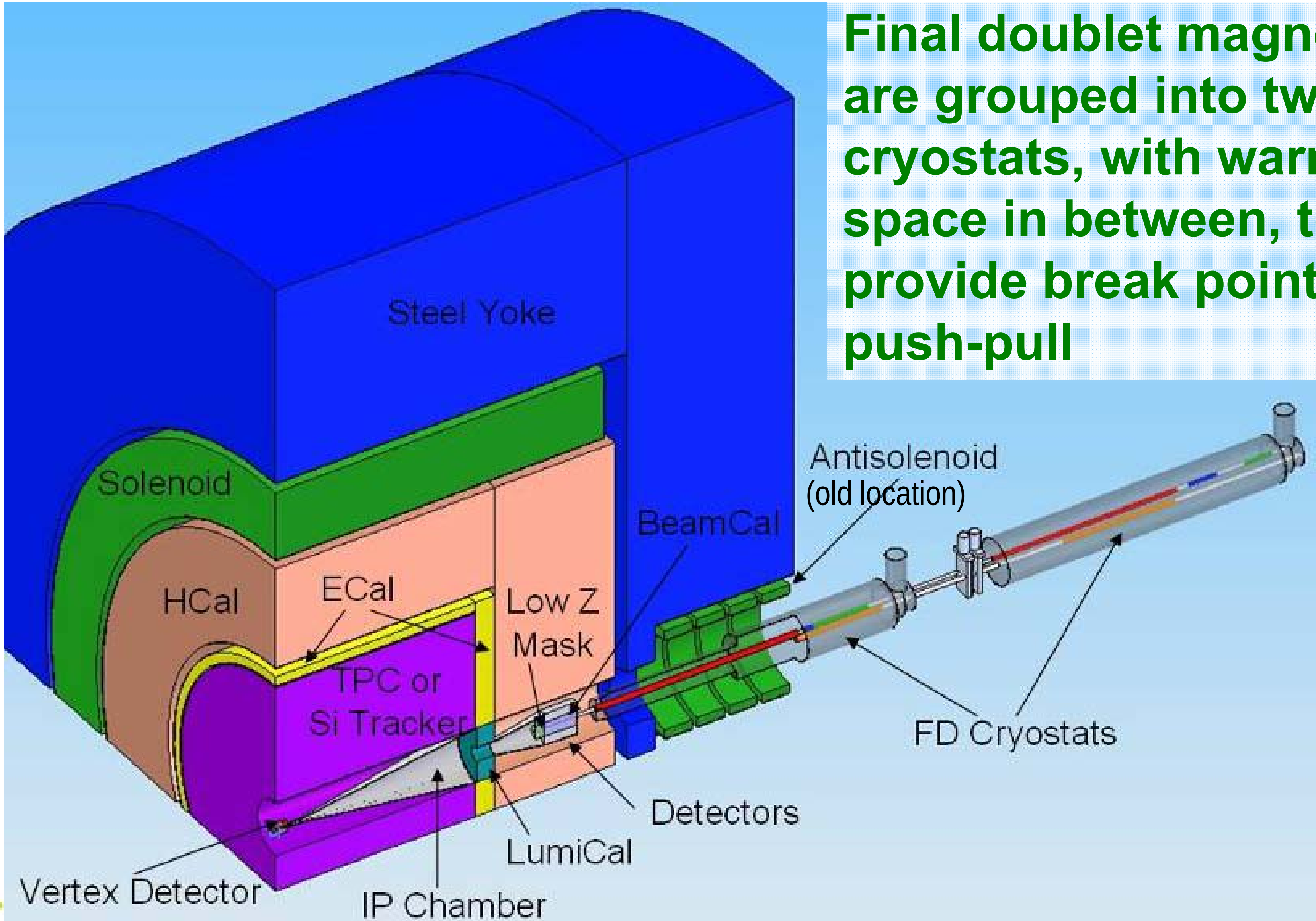


Concept of single IR with two detectors

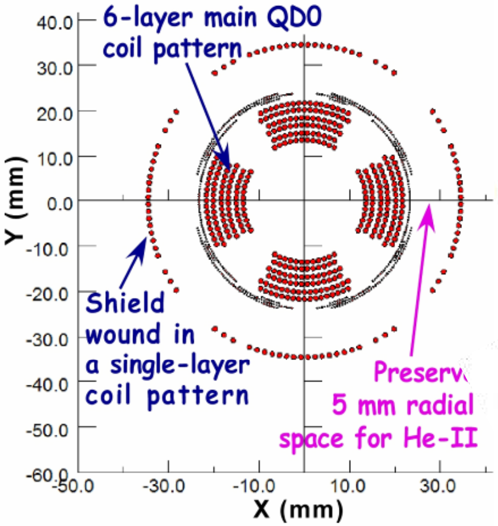


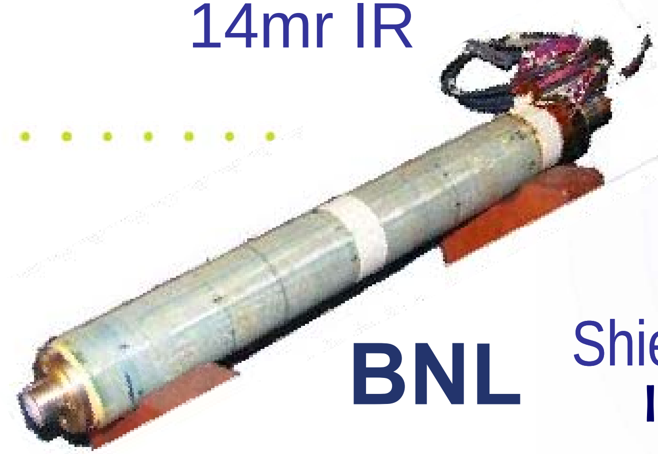
IR integration

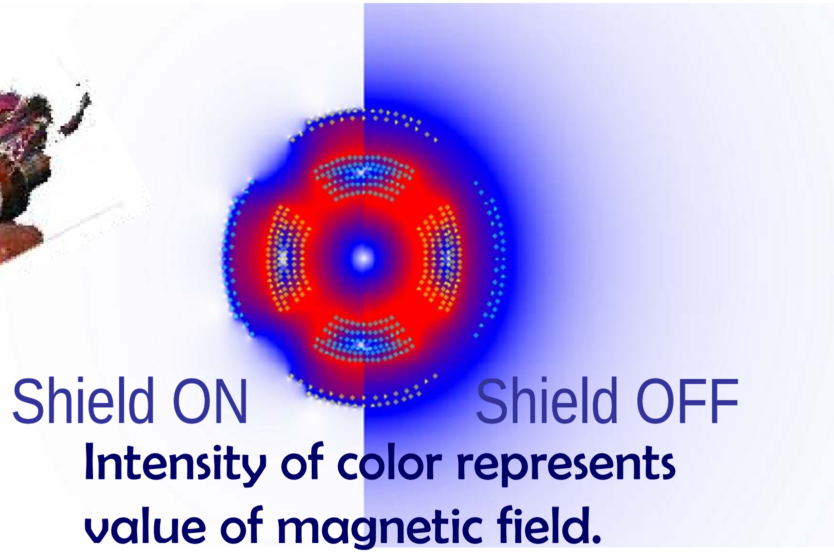
Final doublet magnets are grouped into two cryostats, with warm space in between, to provide break point for push-pull

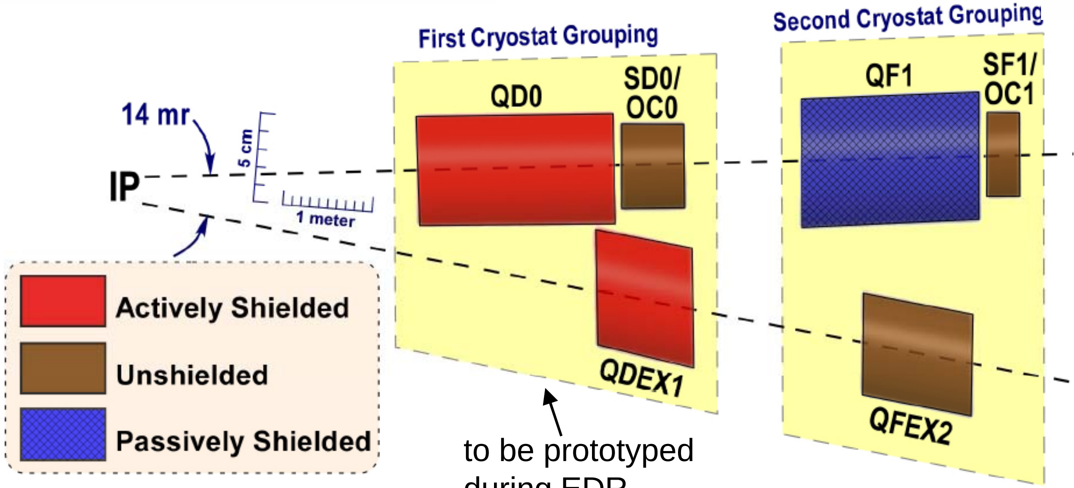


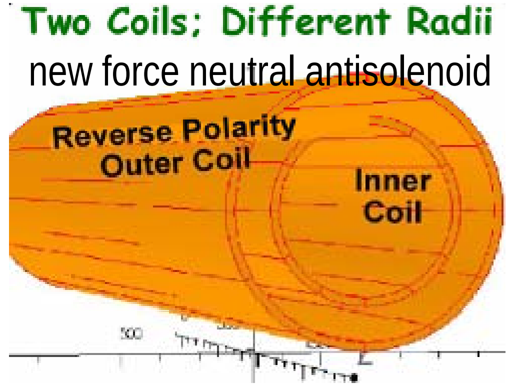
14mr IR





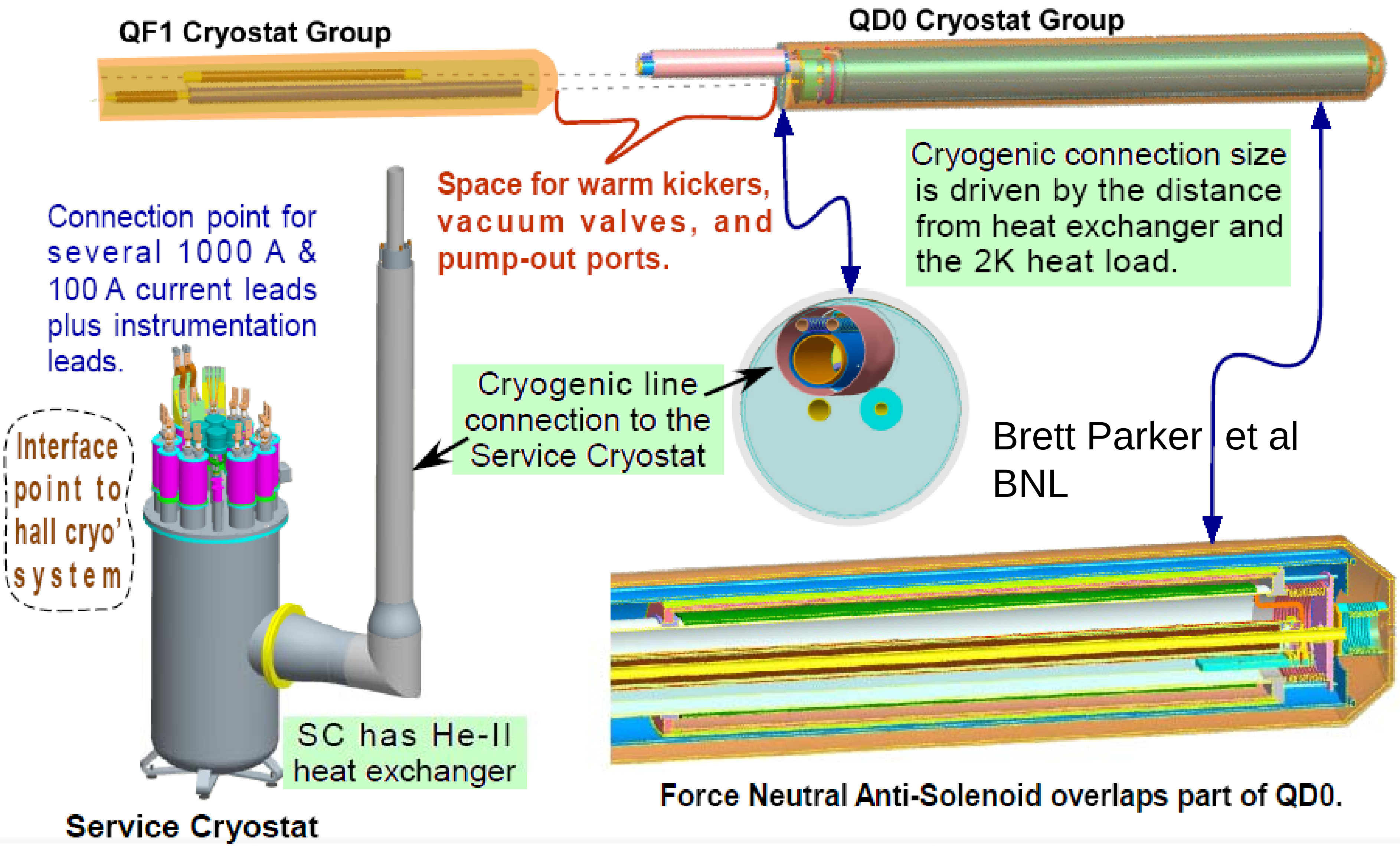




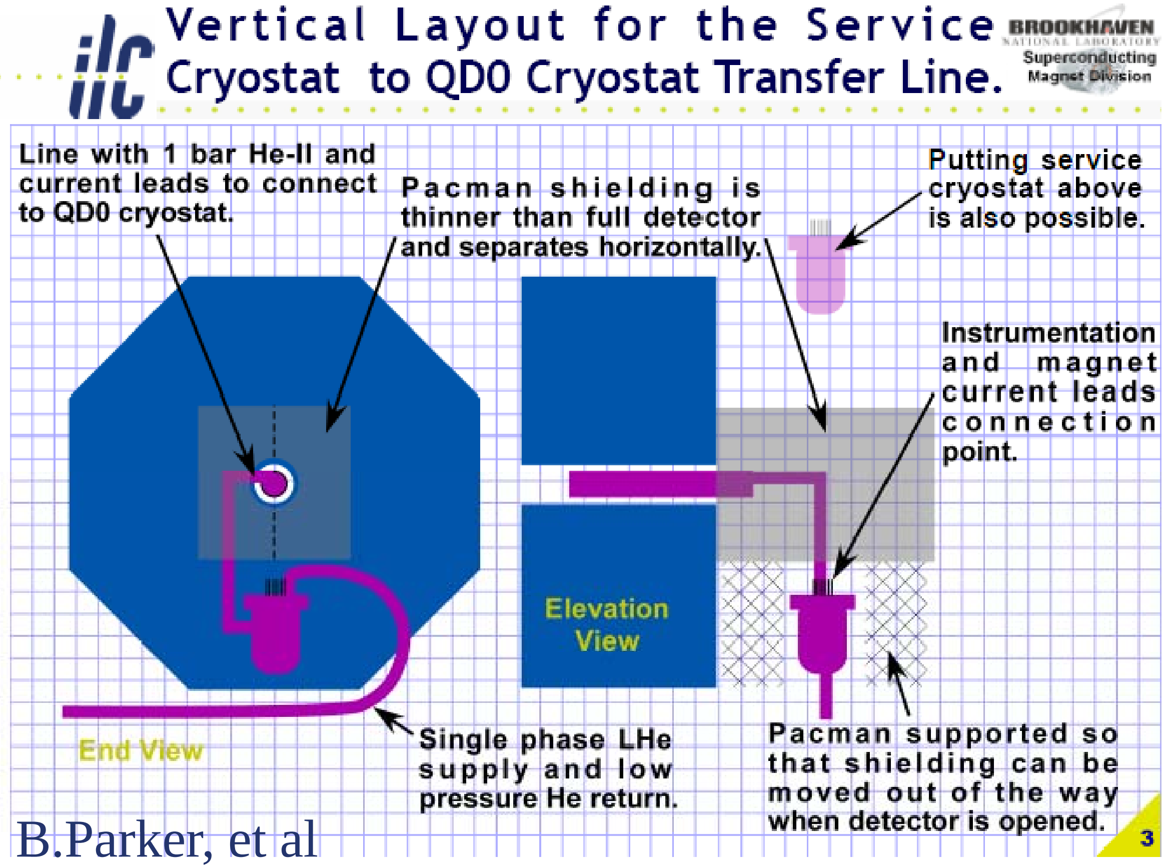


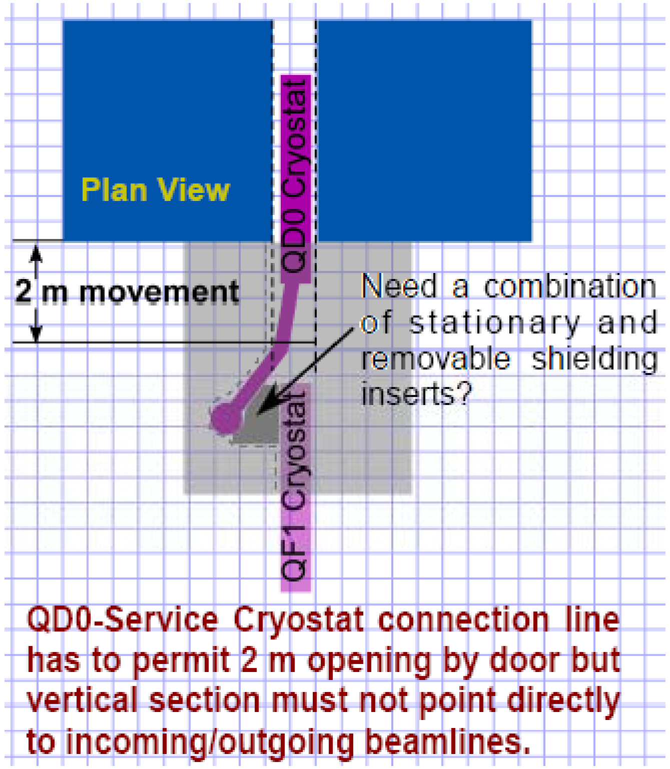
- Interaction region uses compact self-shielding SC magnets
- Independent adjustment of in- & out-going beamlines
- Force-neutral anti-solenoid for local coupling correction

SC final double & its cryo system



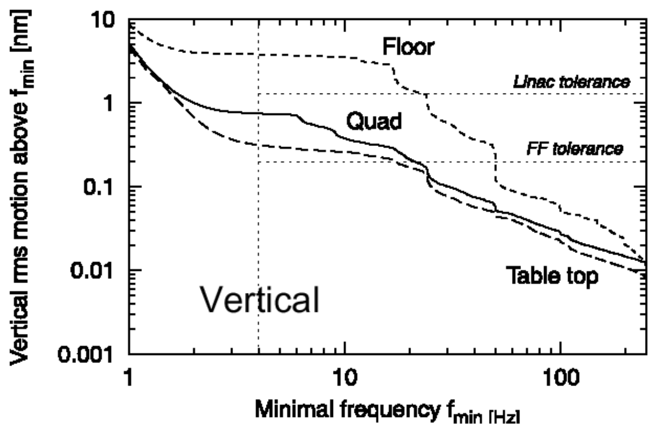
Present concept of cryo connection





L(L*); achievements & sizes of hardware

Quadrupole vibration:



On magnet top:

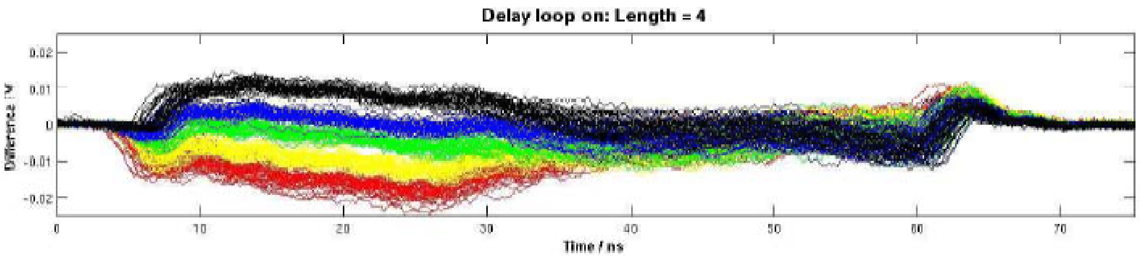
X: (0.4 ± 0.1) nm

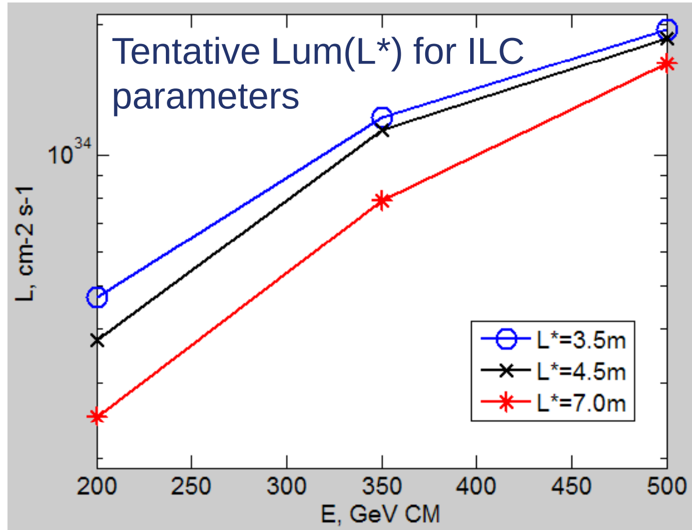
Y: (0.9 ± 0.1) nm
(0.3 nm on table top)

Z: (3.2 ± 0.4) nm

without cooling water.

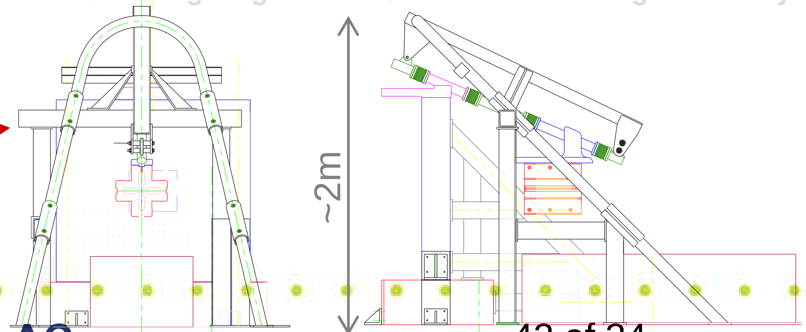
R.Assmann et al, Stabilization with STACIS give ~10 reduction of tunnel floor vibration





P.Burrows et al, FONT3 demonstrated latency of 23ns, including 10ns of irreducible time-of flight

Monitoring Alignment & Stabilisation with high Accuracy

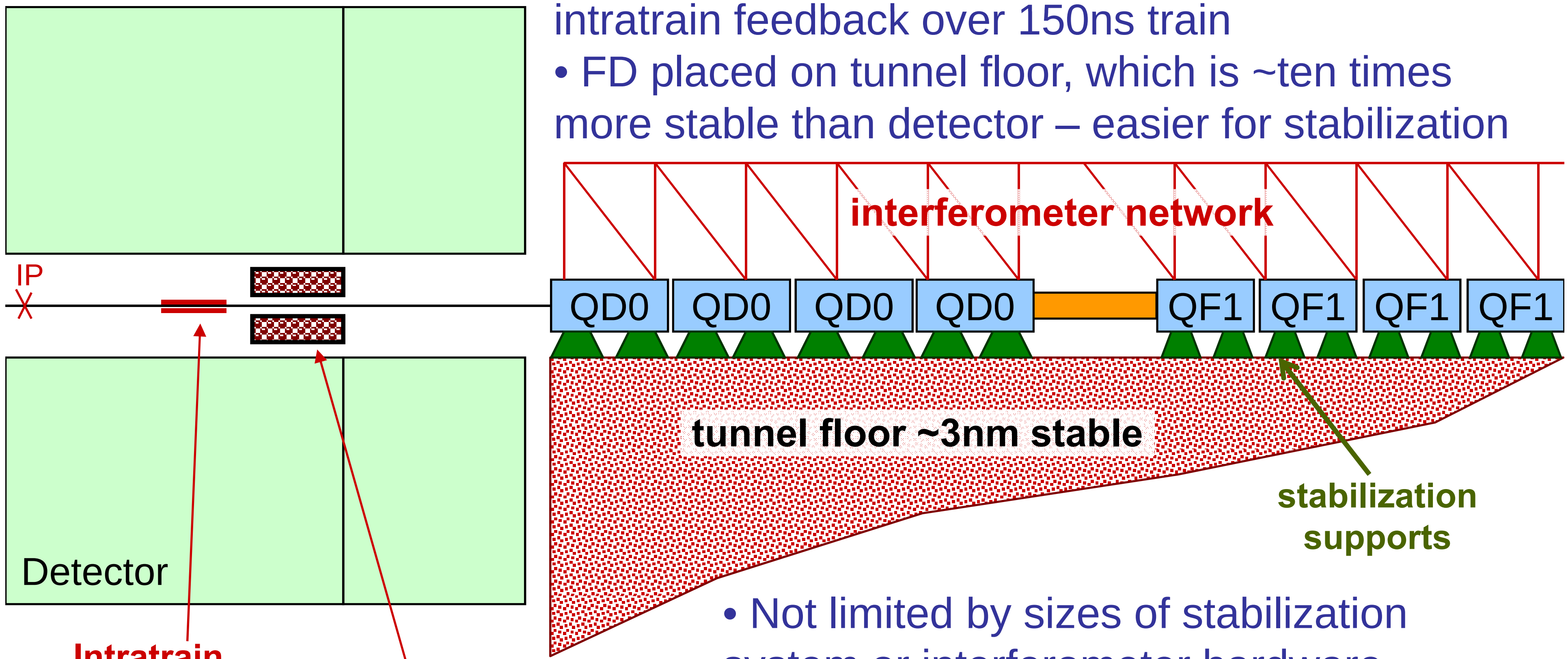


D.Urner et al, MONALISA interferometer system for ATF2 final doublet: space availability matters

From BDS summary talk, TILC08, March 6, 2008, Sendai, Japan

Discussed an approach to CLIC IR stability

- Slower than 1/L* dependence of Lum =>↑L*
- Reduced feedback latency – several iteration of intratrain feedback over 150ns train
- FD placed on tunnel floor, which is ~ten times more stable than detector – easier for stabilization



- Not limited by sizes of stabilization system or interferometer hardware
- Reduced risk and increased feasibility
- May still consider shortened L* for upgrade

From BDS summary talk, TILC08, March 6, 2008, Sendai, Japan

Back End of QD0

B. Parker et al, BNL