IR Magnets and Cryo' System Optimization for Push-Pull

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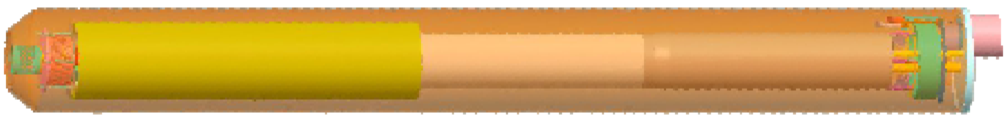
BDS KOM, SLAC 12.10.2007

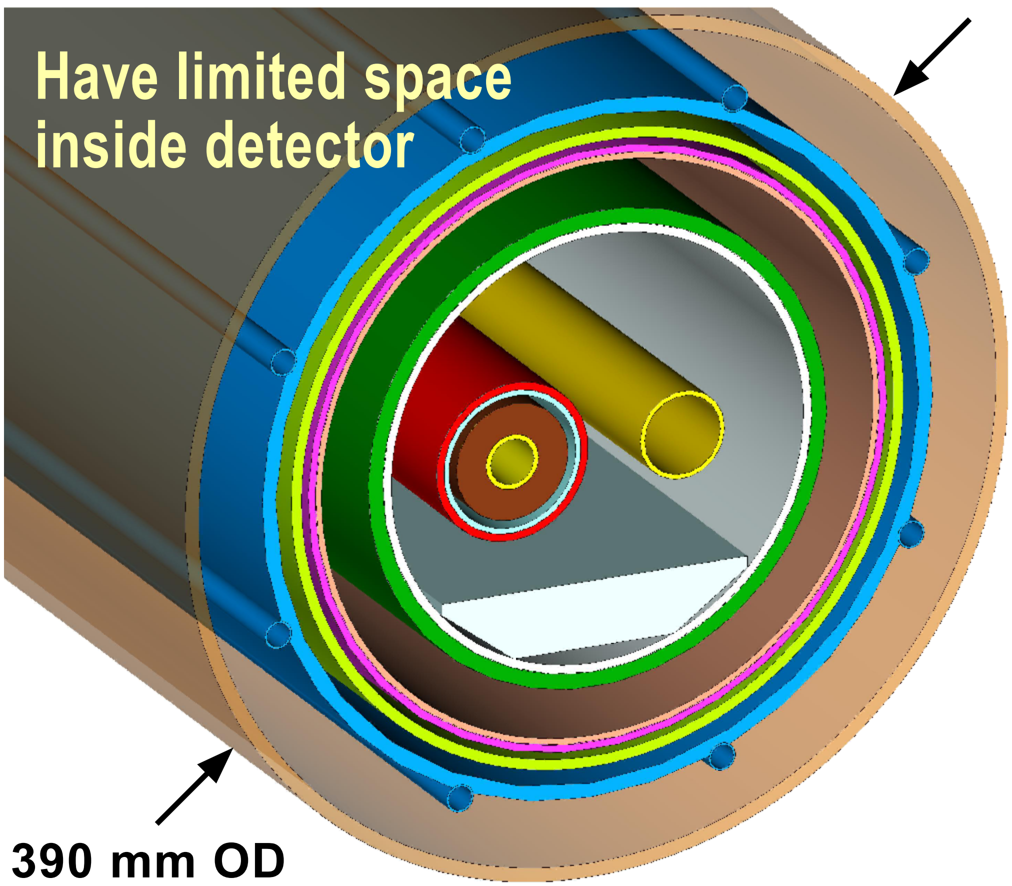
Outline & Introduction

- Review essential features of the 14 mr magnet/cryo' design.
- Identify some magnet & cryogenic performance/cost drivers.
- Outline present understanding of a few areas where further optimization is likely to be most fruitful (requirements/constraints).
- Highlight some specific cryogenic issues/options.
- Briefly review the ongoing 14 mr IR magnet work.

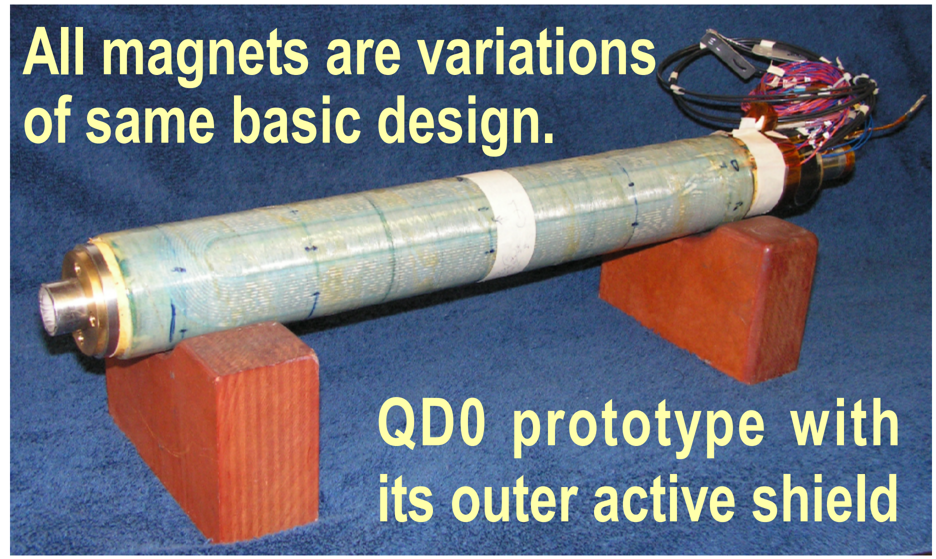
14 mr Compact Superconducting Magnets

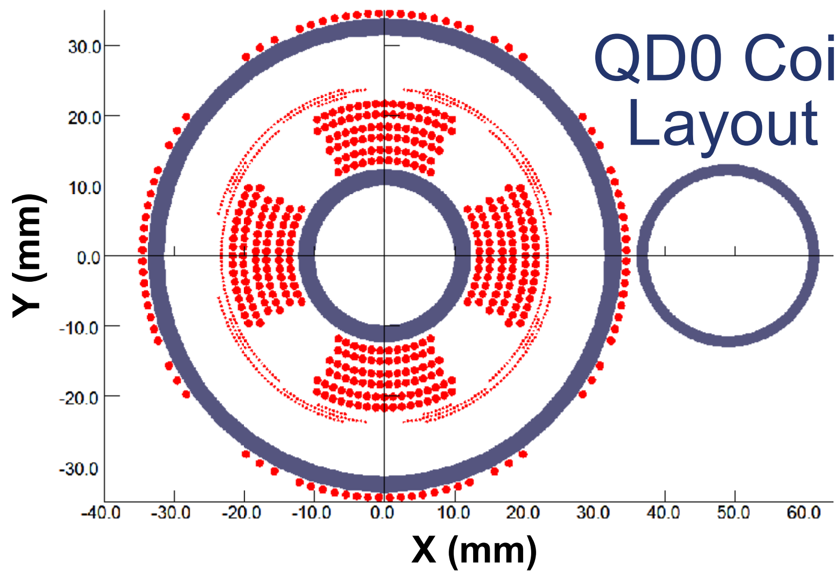
QD0 Cryostat design for L* = 4.5 m.



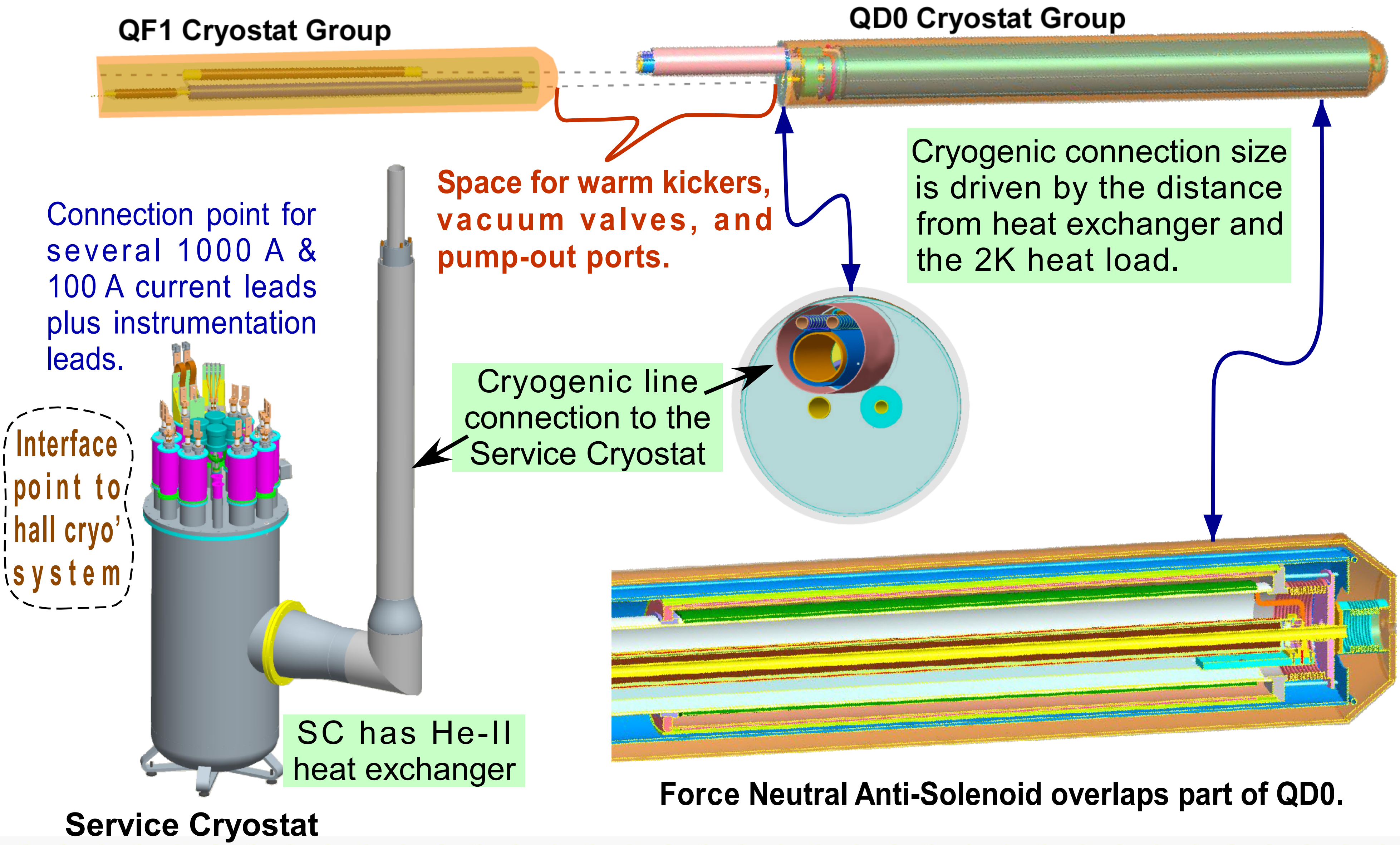


390 mm OD





Magnet & Cryo' System Components



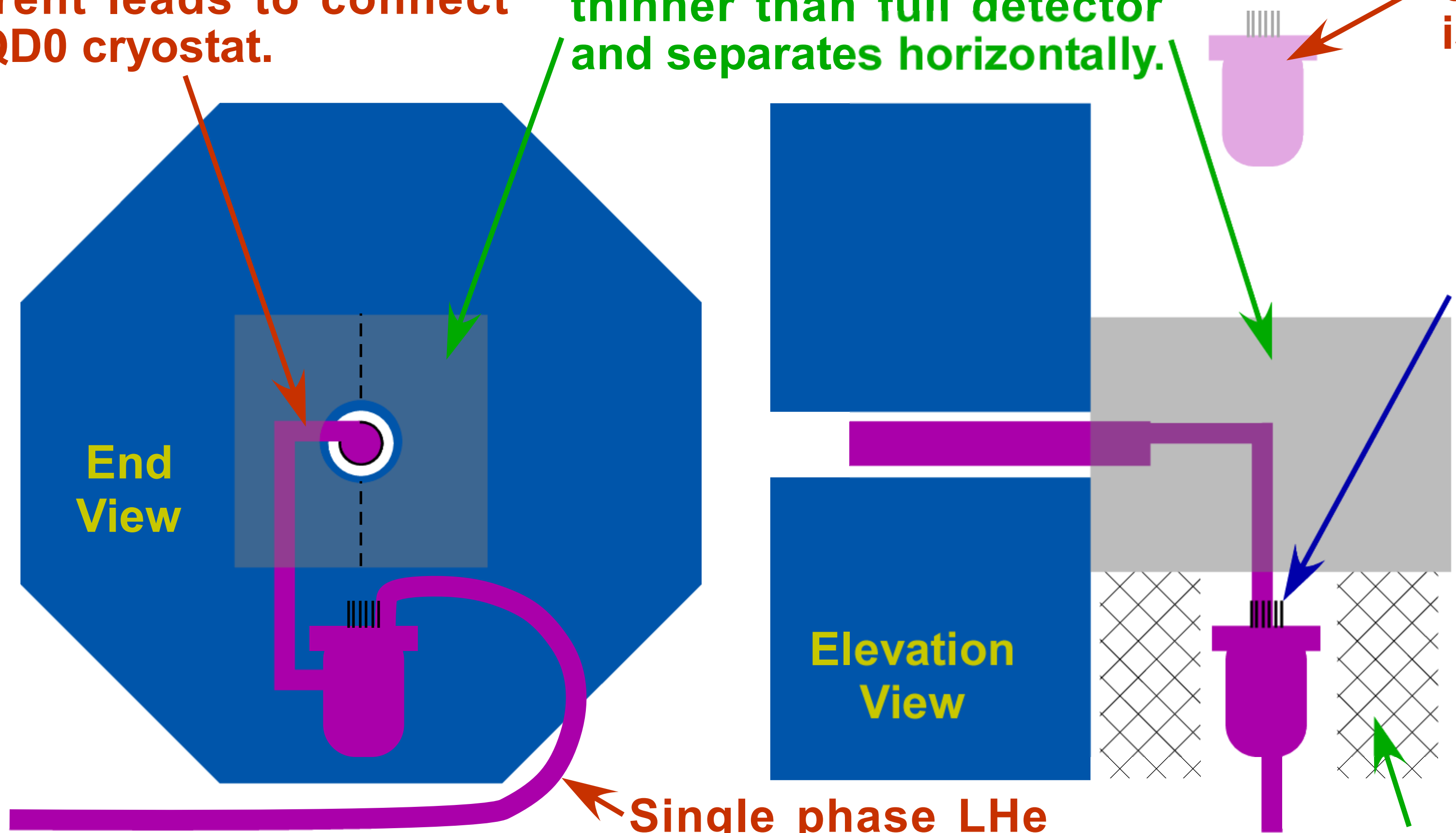
Cryogenic “Straw Man” Design

Line with 1 bar He-II and current leads to connect to QD0 cryostat.

Pacman shielding is thinner than full detector and separates horizontally.

Putting service cryostat above is also possible.

Instrumentation and magnet current leads connection point.

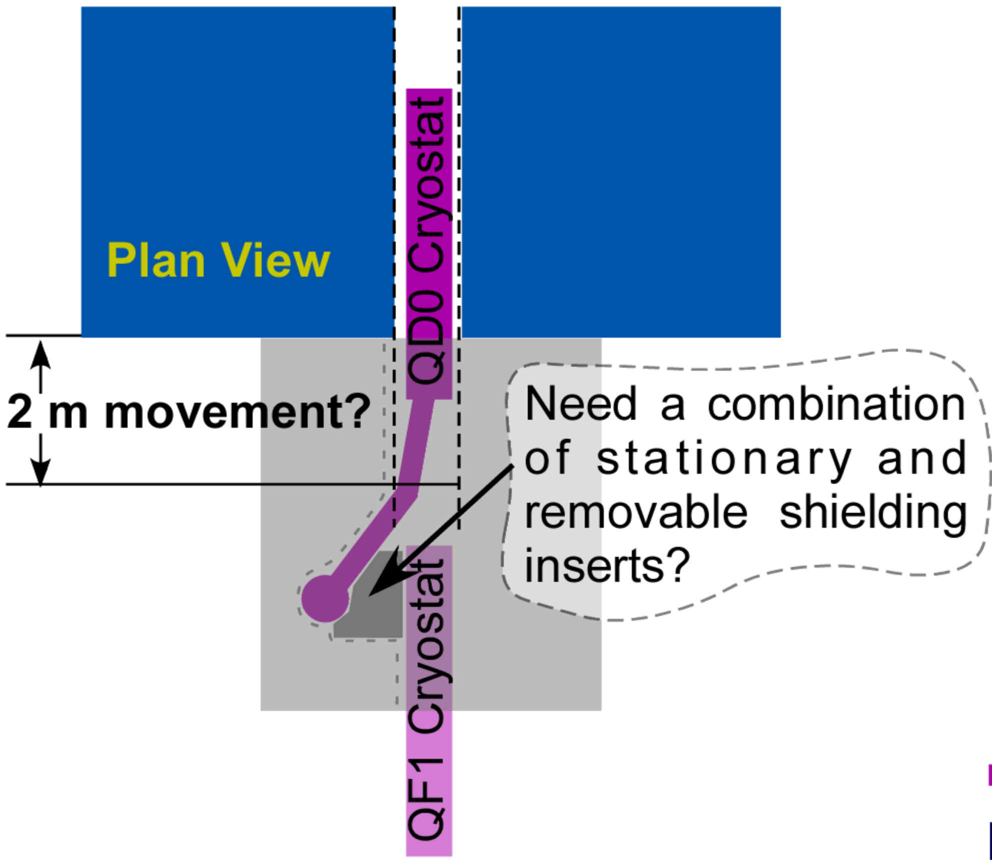


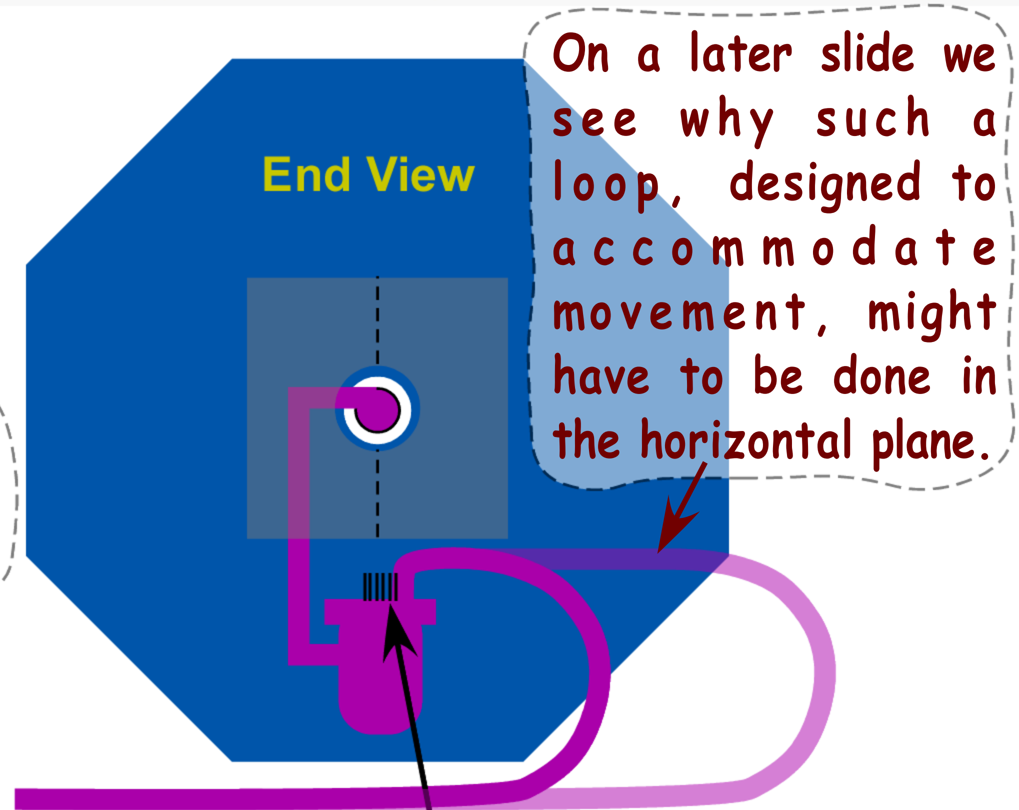
Single phase LHe supply and low pressure He return.

Pacman supported so that shielding can be moved out of the way when detector is opened.

These cartoons were refined at IRENG07.

Design Constraints: Push-pull plus opening the detector door 2 m for access & compatibility with radiation shielding.



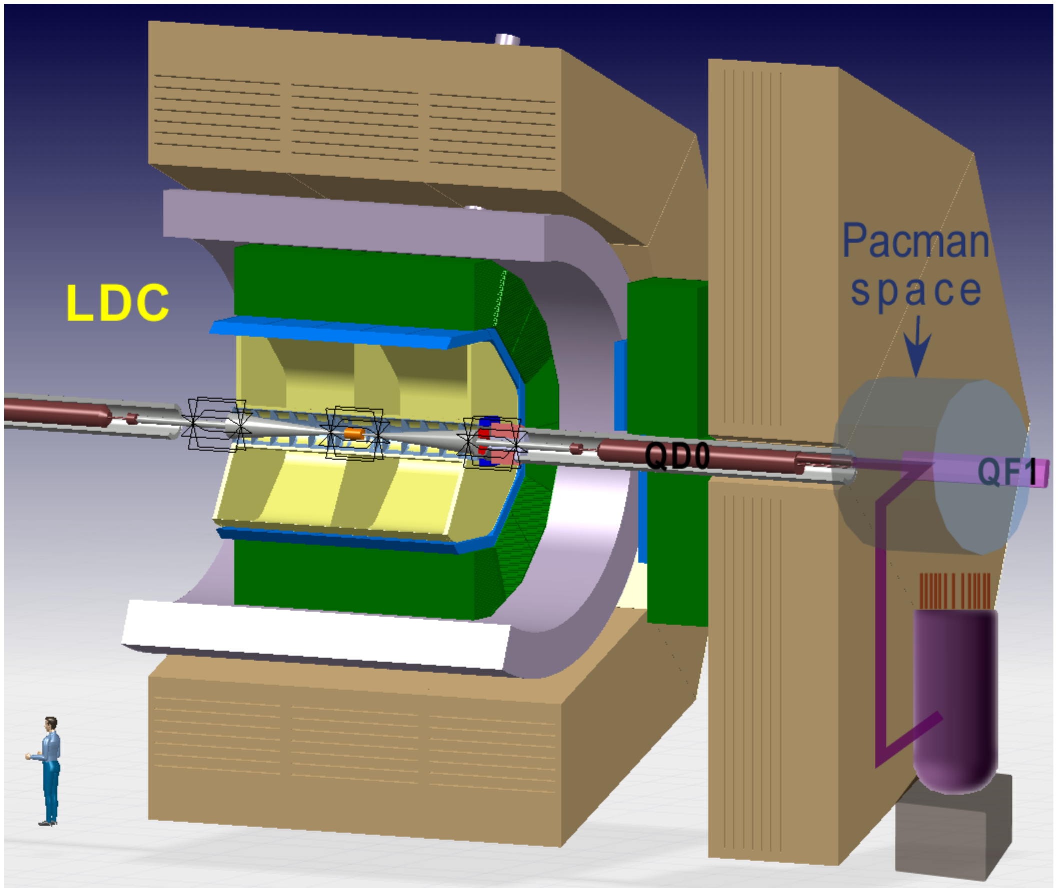


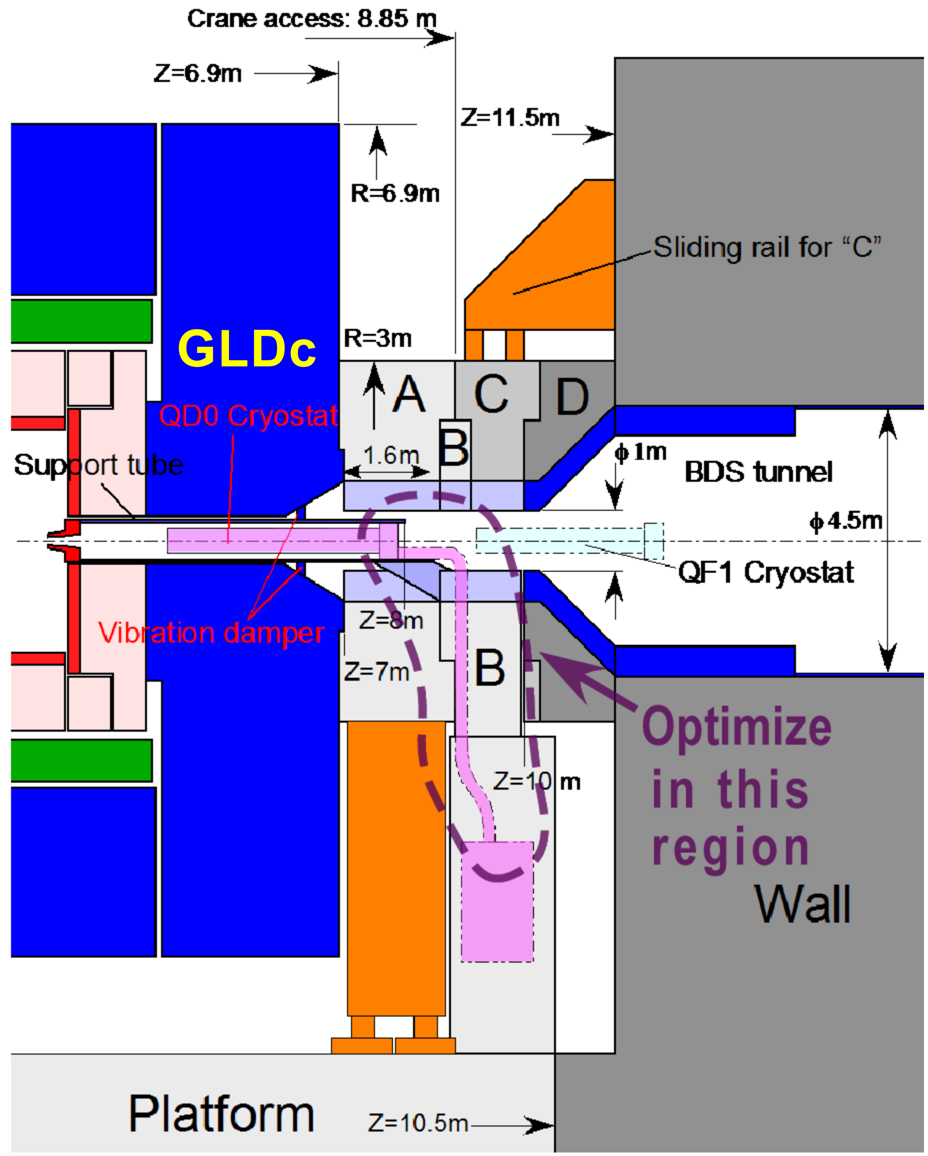
QD0-Service Cryostat connection line has to permit 2 m opening by door but vertical section must not point directly to incoming/outgoing beamlines.

Make the current lead, instrumentation, process gas, vacuum line, etc. connections outside to minimize penetration of pacman.

(Mirror cryogenic layout for two experiments)

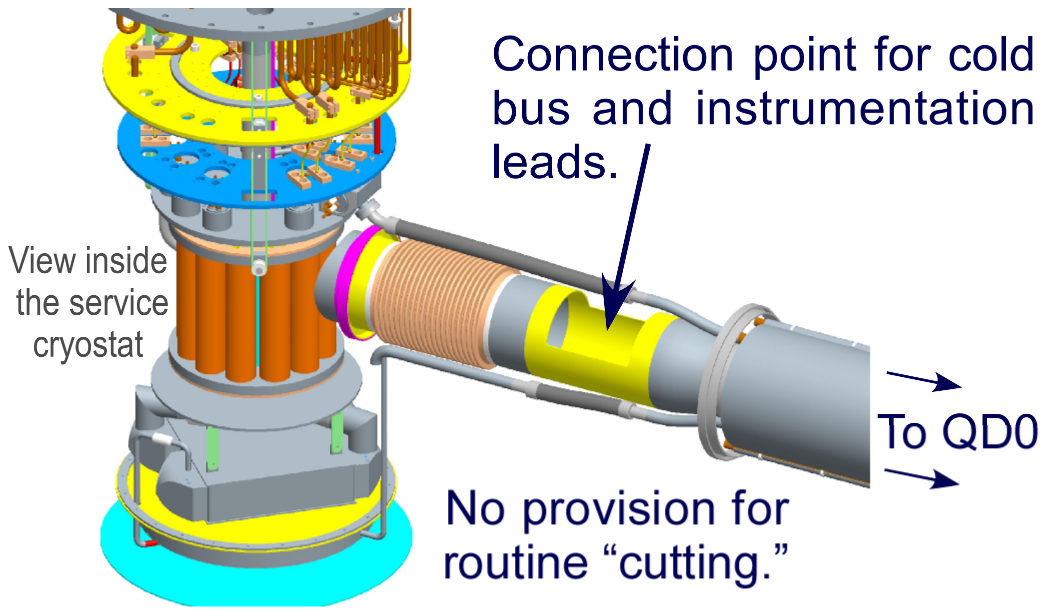
For Push-Pull, many seemingly small details can impact technical system access, crane coverage and even hall size.





Horizontal opening up of pacman is strongly favored. Design requirements are being worked out with each detector concept.

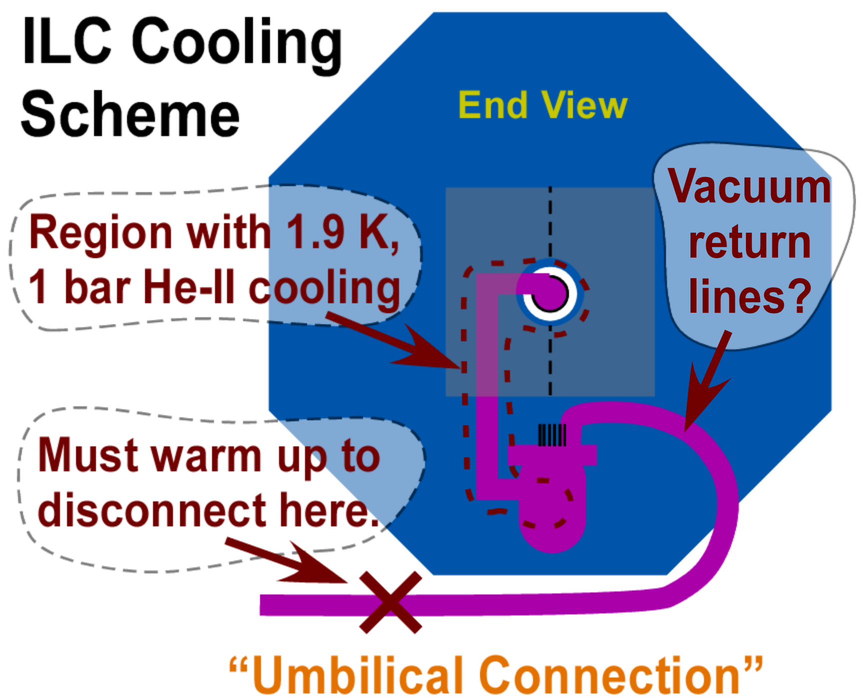
Cryogenic Considerations & Push-Pull



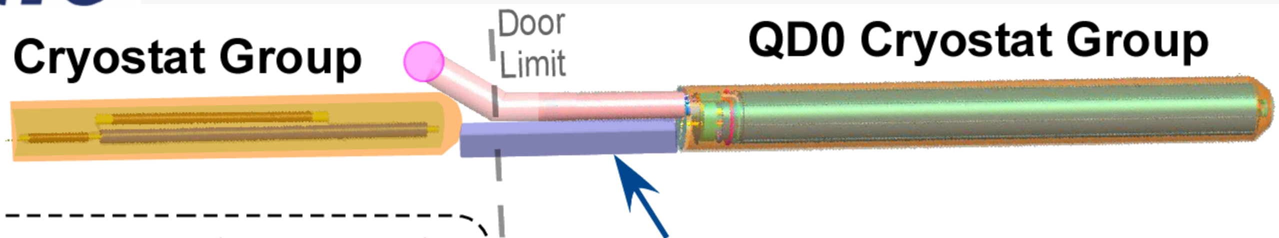
For rapid push-pull we need to move the magnets “cold.” This implies some type of extended flexible umbilical connection that may or may/not be shared with the detector. It is a simple matter to de-energize the IR magnets; arguments exist both ways for powering down the detector solenoid or not.

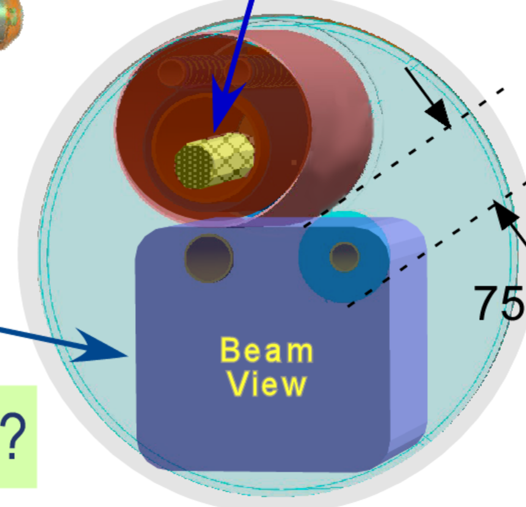
HERA-II IR magnets took 6-8 hours to warm up and again to cool down to 4.35 K. But ILC magnets, transfer line and service cryostat must fill with 1.9 K He-II (requires even more time). Our ILC case could easily take more than 1 day.

ILC Cooling Scheme



Cryogenic Considerations & Push-Pull





Remember we have similar space constraint in the "garage position" unless we cut into transfer line (say for major repair or upgrade).

Only this space available for beamline flanges, kicker body, vacuum pumps and valves.

Maybe asked to open 2.5-3 m?

For **sizing the connection** between QD0 and the service cryostat we take the maximum 1.9K heat load to be 15 watts (14 static + 1 dynamic). Note that QD0 is conduction cooled and when the area for He-II gets very small then small changes in parameters, such as the size of the cable bundle, can make a big difference in performance and cool down time.

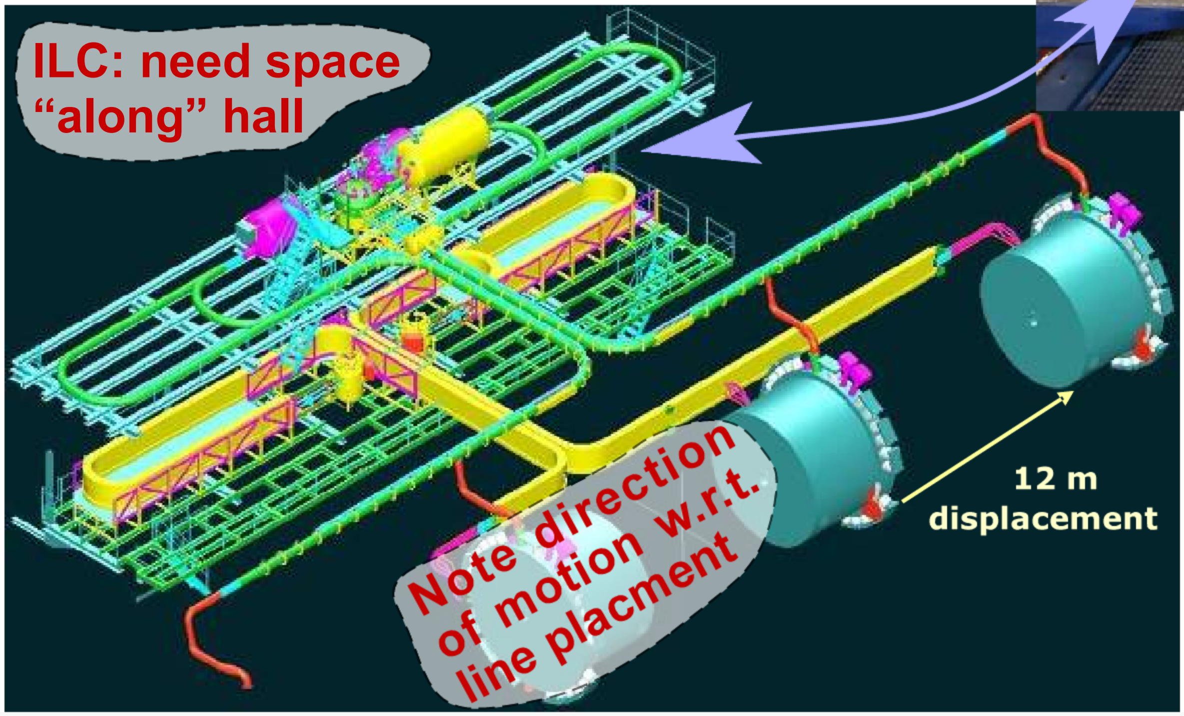
By adopting a 1 watt budget for dynamic heat load we had better be sure to consider all possible energy deposition scenarios (beam tuning, upsets, wakefield heating etc.).

To date design parameters (line size etc.) are driven by desire not to take up too much space in the detector.

Flexible Cryogenic Line Technology

Use flexible chain support and constrained semi-flexible transfer lines, in a controlled way, to enable linear motion of cryogenic components.

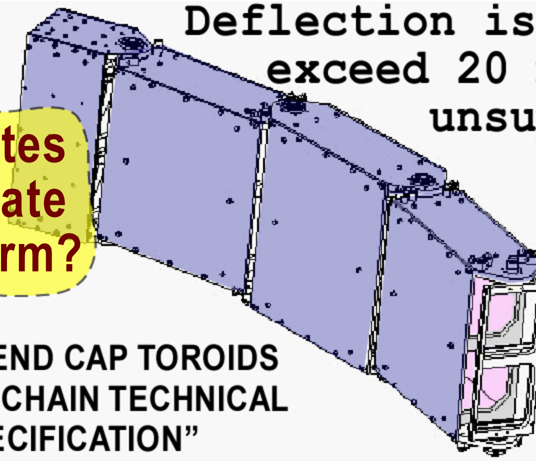
Ruggero Pengo, **Status of the cryogenics project (LAr, He, N2)** at Glasgow Meeting, *July 10th, 2007*



- ILC push-pull needs an even larger range of motion.
- Note that total cryogenic path length is several times longer than the range of motion.

Flexible Cryogenic Line Technology

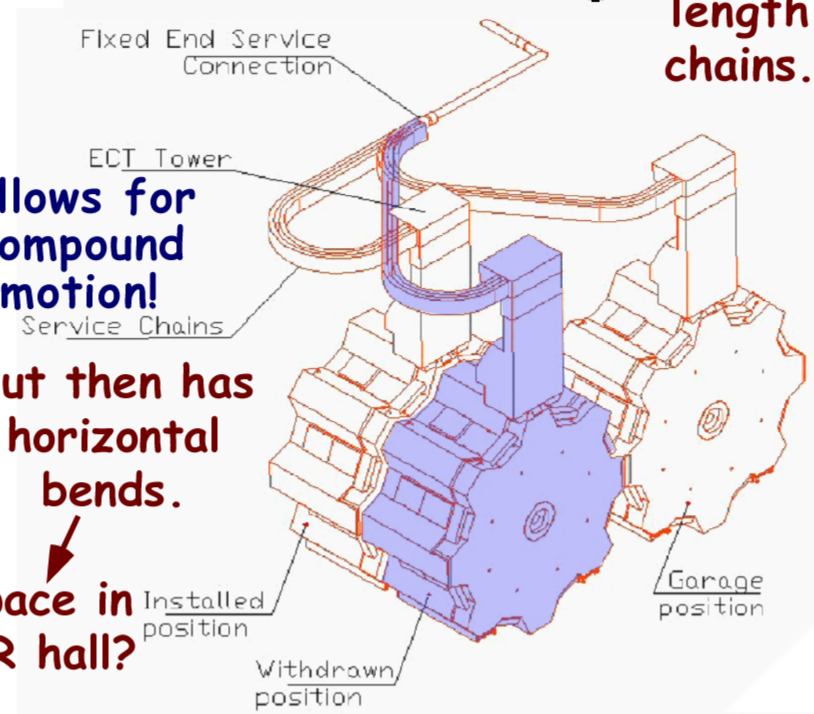
Overhead chain routing complicates crane access; can we get adequate bend radius in trench under platform?



Deflection is not to exceed 20 mm over unsupported 9 m.

"ATLAS END CAP TOROIDS SERVICE CHAIN TECHNICAL SPECIFICATION"

ILC IR will need longer length chains.



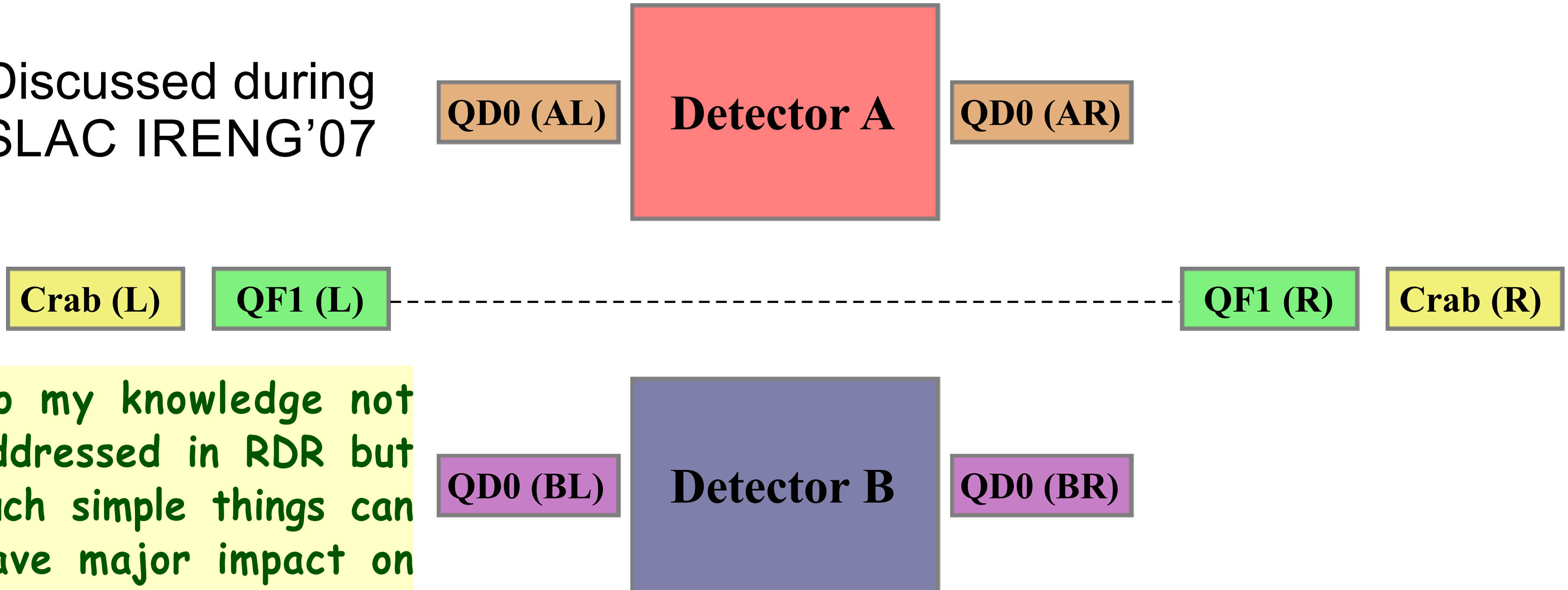
Allows for compound motion!

But then has horizontal bends.

Space in IR hall?

Systems coded the same color may be operated in common.

Discussed during SLAC IRENG'07



To my knowledge not addressed in RDR but such simple things can have major impact on the cryo' system design.

Systems not the same color must be operated independently*.

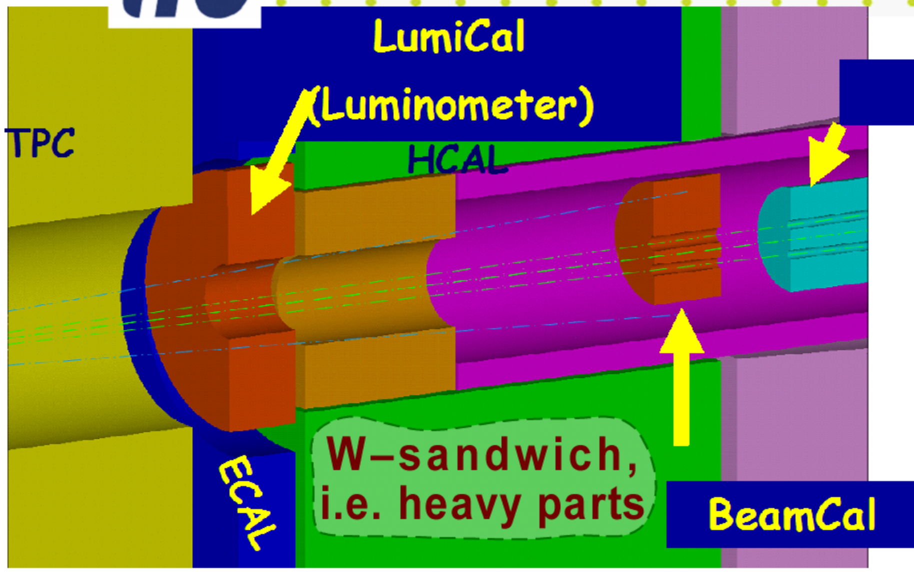
*Here independent means a given system can be warmed up/cooled down without impacting another system.

IRENG'07 WG-B, Cryogenics Summary*

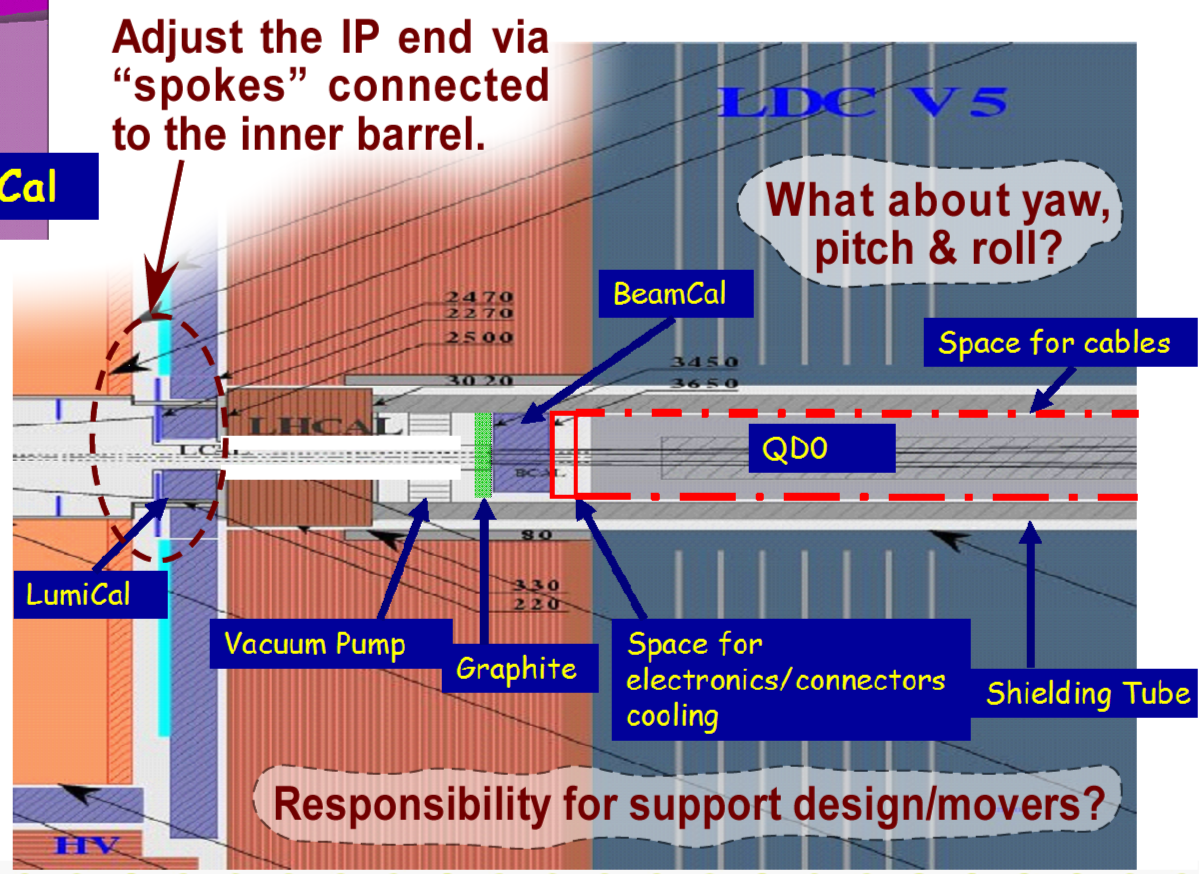
- Each detector will need sufficient LHe storage (ala CMS) that can be gravity driven to cool the detector solenoid during a controlled ramp down to avoid quenches in the event of a total refrigeration failure.
- Warm helium compressors located on the surface & Cold Box(es) in IR Hall.
- Periodic use of LN2 as part of the refrigeration cycle is expected.
- At present level of detail, cryogenic requirements are basically independent of detector choice. (e.g. no LAr, no He-II detector solenoids).
- Moving detectors while cold certainly possible with proper design & planning.
- In order to move forward on the number and size of refrigerators, more detailed studies needed, 2 or more working groups should be established.

***"Overall agreements on IR cryogenics system and how to move further," workshop summary presented by John Weisend II, URL:**
http://ilcagenda.linearcollider.org/materialDisplay.py?contribId=89&sessionId=17&materialId=slides&confId=2169

QD0 support is a bit “up in the air.”

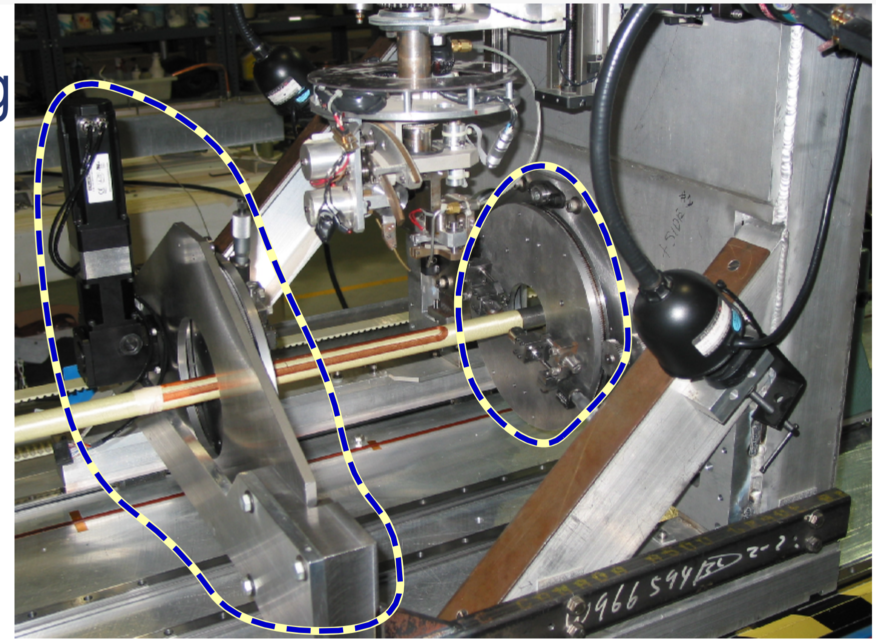


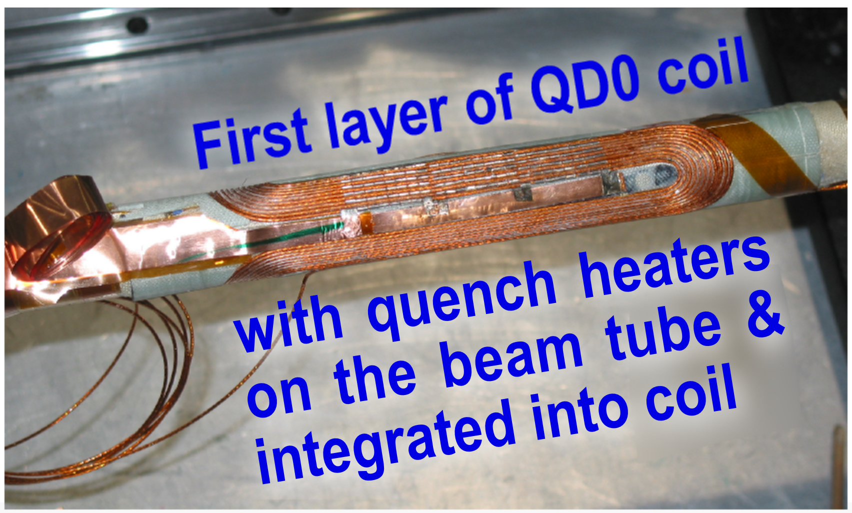
After a push-pull detector swap we assume rough alignment is good at the millimeter level, but we want to get the magnet centers back closer than this to an “ideal” position to minimize luminosity retuning. Maybe 10-100μm (TBD)?



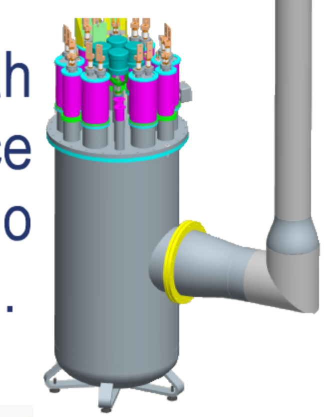
QD0 Prototype Ongoing ART R&D at BNL

Present winding machine is fitted with general purpose machine controlled guide supports





Make and test prototype with QD0 Cryostat above & Service Cryostat below in a pit to match detector configuration.



Beam Delivery System ART R&D Program – QD0 Prototype Goals, Resources

- FY07-FY10 Plan Summary:
  - Design & build tooling for full length, small diameter direct-wind coils
  - Build & vertically cold test full length QD0 / SD0 prototype coil assembly (verifies quench & field characteristics)
  - Design & build ILC Insertion Region helium vessel & cryostat
    - Configured for later inclusion of all final focus and extraction line elements
    - Build a mechanical model first, to validate vibration msmt system
  - Design and build a sub-cooled helium heat exchanger & lead vessel
  - Install QD0/SD0 prototype, other coil "structures" into cryostat, and perform preliminary horizontal cold test:
    - Validate coil performance using actual accelerator hardware
    - Validate heat exchanger performance
  - Complete the IP design / magnet integration work
  - Iterate accelerator magnet design based on testing, optics, etc.
  - Perform coil quench threshold tests
  - Continue vibration studies

Beam Delivery System ART R&D Program – QD0 Prototype Summary

- Anti-Solenoid Integrated into QD0 Magnet
  - Saves ~$X M production costs
  - Negligible increase to QD0 costs (due to other savings)
  - Easier integration with Detectors
- Design matured significantly
  - Transfer line, service cryostat location configured smartly for push-pull
  - Service cryostat revised for anti-solenoid, location, cryo' infrastructure
- Major Milestones retained despite scope creep, budget cuts
  - QD0 coil cold test in FY08
  - SD0 (+ QD0) coil cold test in FY09
  - QD0 cryostatted magnet horizontal cold test in FY10
  - Engineering Design complete in FY09
  - Vibration studies complete in FY10
- Funding at levels needed essential to success