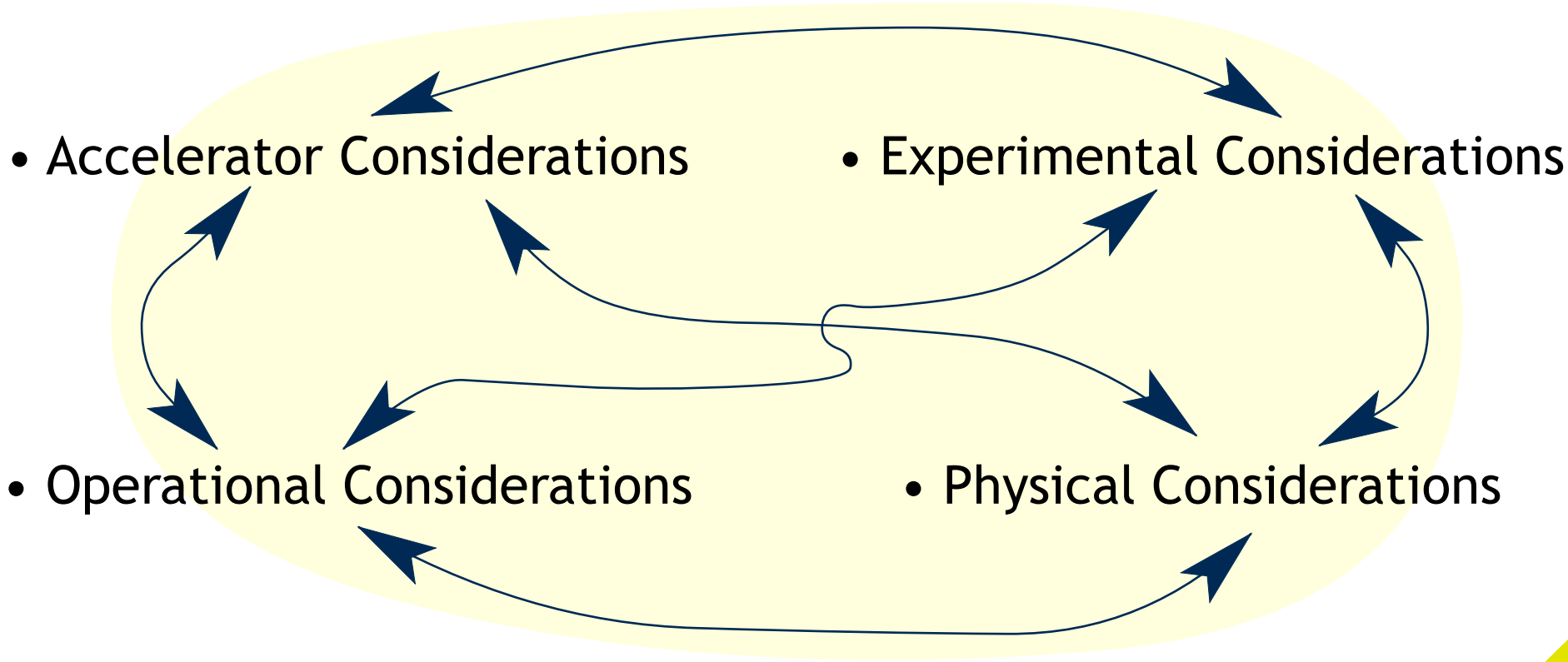
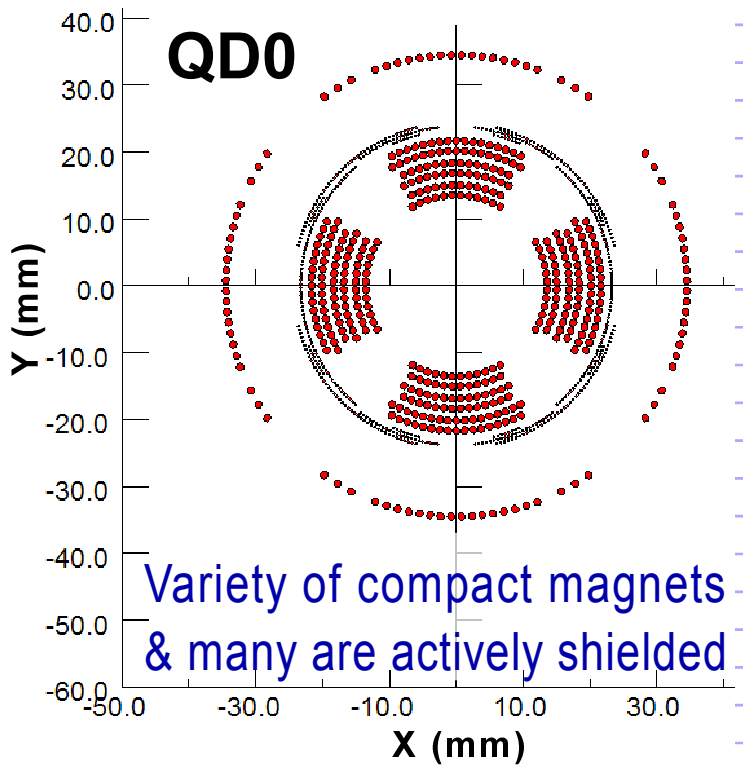
Final Doublet Magnetic Design & Connection Model

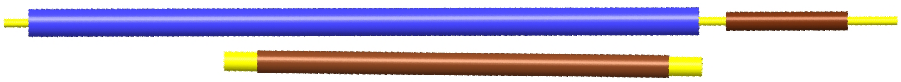
presented by: Brett Parker, BNL



Start with the basic 14 mr coil layout.



QD0 grouping with actively shielded quadrupole coils on incoming and extraction lines and dipole, skew-dipole, skew-quadrupole, sextupole, skew-sextupole and octupole correction capabilities.



QF1 grouping with a similar set of coils but quite different aperture and strength requirements. QF1 is outside detector field and has a thin magnetic yoke.

- Present coil layout attempts to minimize fields seen by incoming & outgoing beams (max. magnetic lengths for lower gradients & take account of 3D shielding effects at coil ends).
- Inside cryostat there are several coils & it is not practical to mechanically shift magnets independently; so we use coil integrated correction coils to electrically shift effective centers. This also avoids large field spikes at beam center with lumped dipole correctors.

Next we must dress the coils with cryogenic infrastructure.

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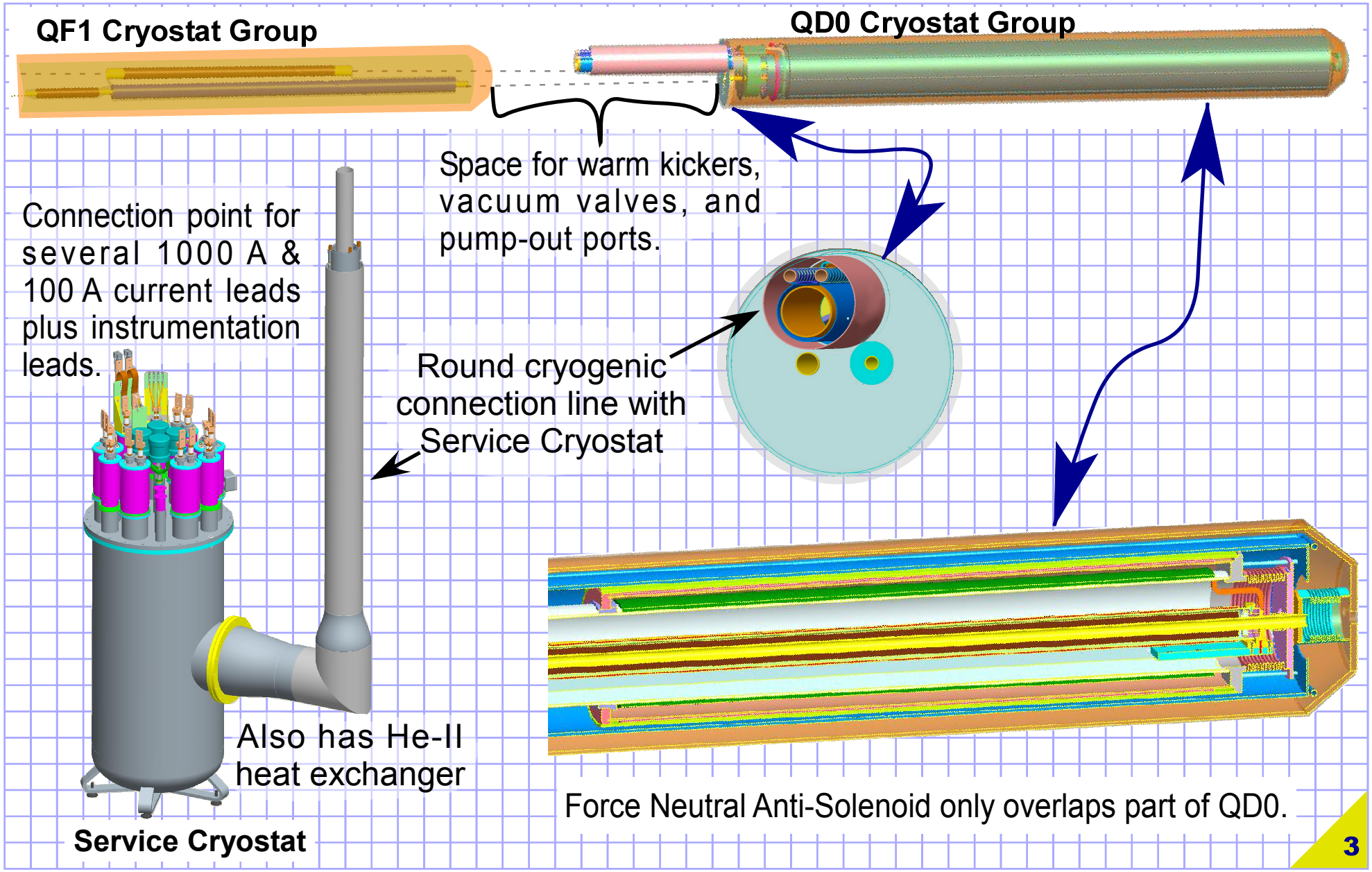

QD0 with Force Neutral Anti-Solenoid.

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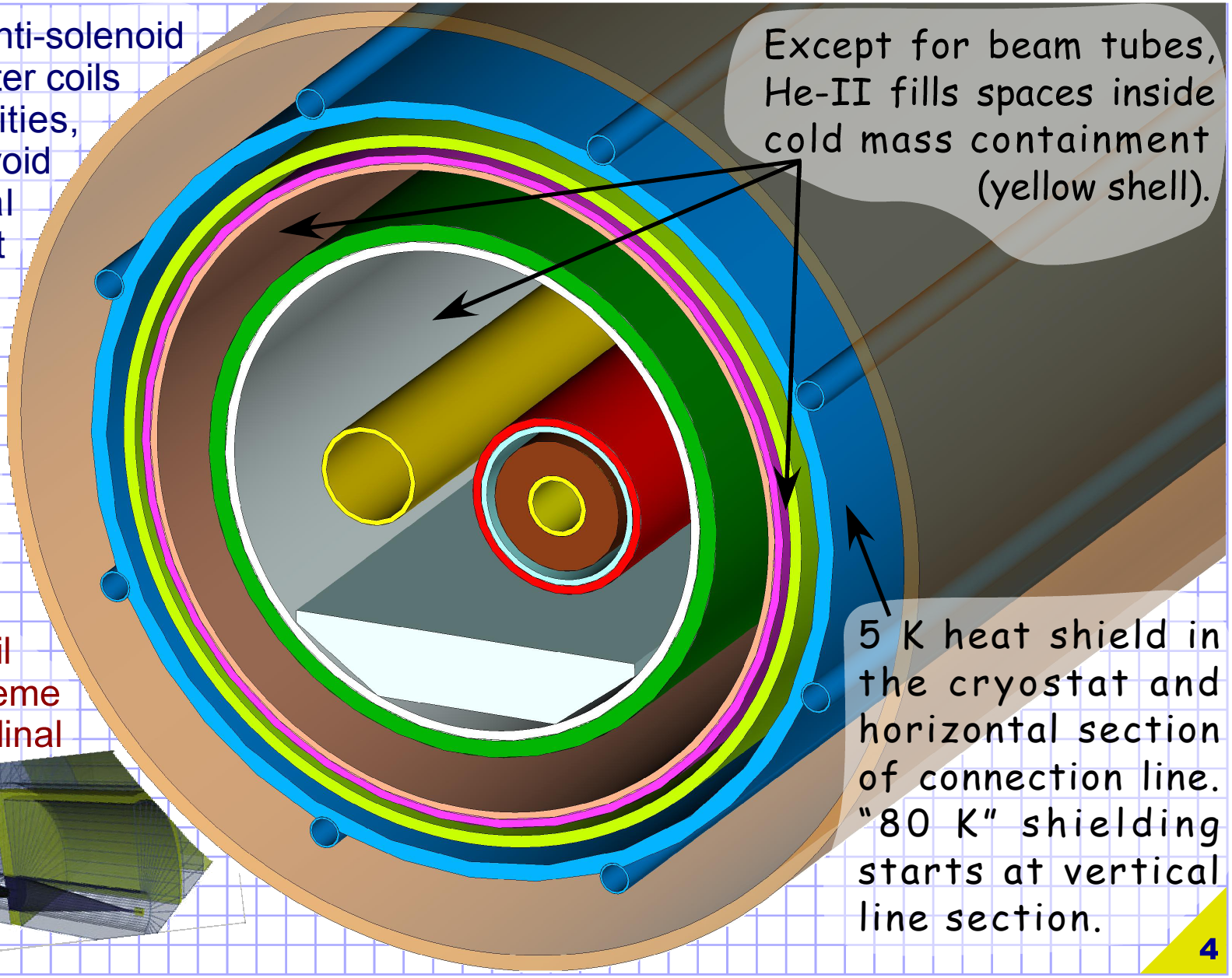
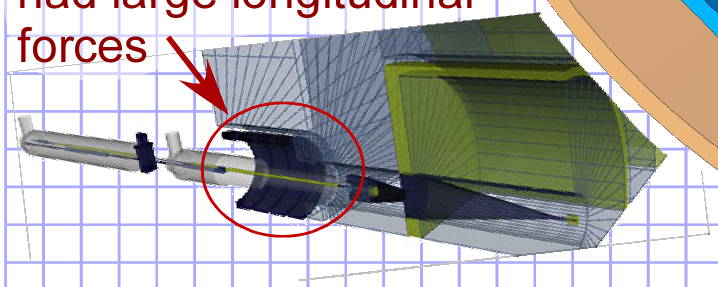
By constructing anti-solenoid with inner and outer coils of opposite polarities, it is possible to avoid large longitudinal net forces so that anti-solenoid can be combined with the other magnet coils inside QD0 cryostat (smaller impact on the detector design).



Previous large coil anti-solenoid scheme had large longitudinal forces



Magnet designs to maintain optics flexibility for incoming & extraction lines.

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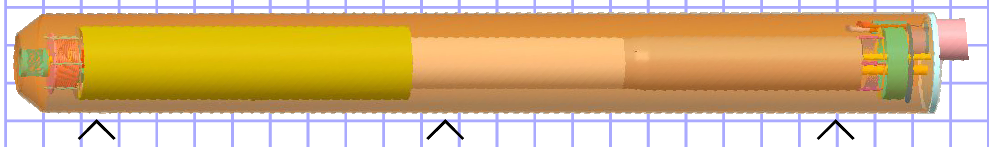
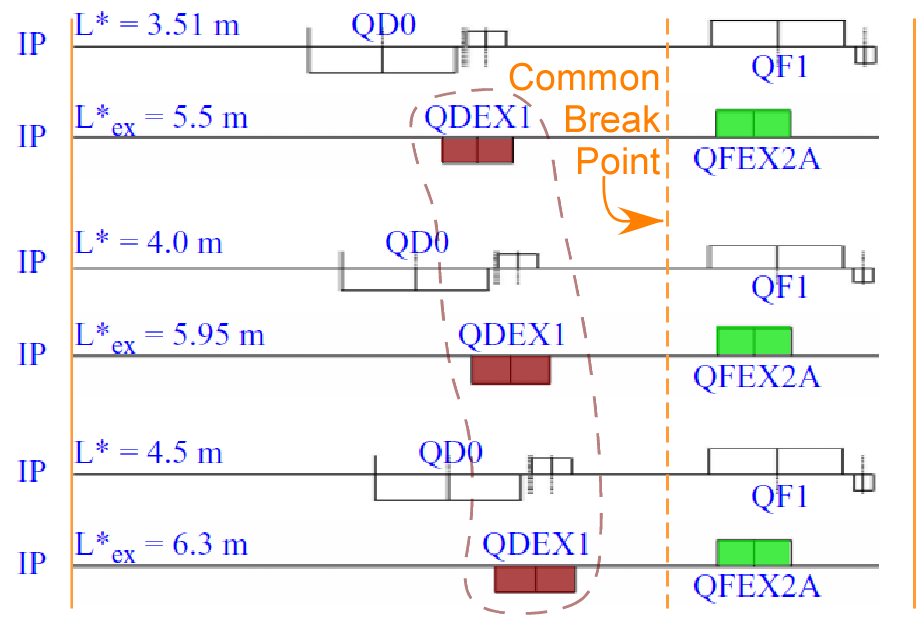
QD0 Cryostat design for L* = 4.5 m worst case.



There are many magnet designs to keep track of especially as we may end up with different L*s in different experiments.



Look for flexible magnet design scheme to accommodate different L*s in each experiment. Incoming beamline magnets are same but first extraction magnet differs.

Optimize anti-solenoid, QDEX1, attachment points/support structure and the cryogenic transfer line routing for each experiment?

Reduce Background with the "Anti-DID."

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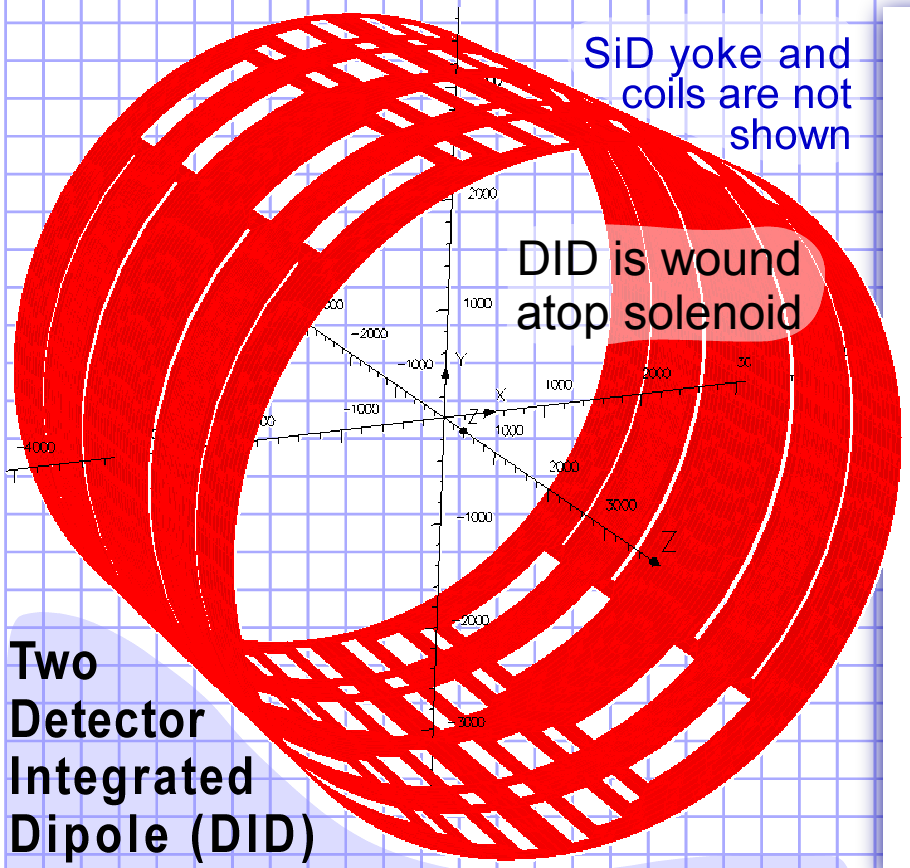
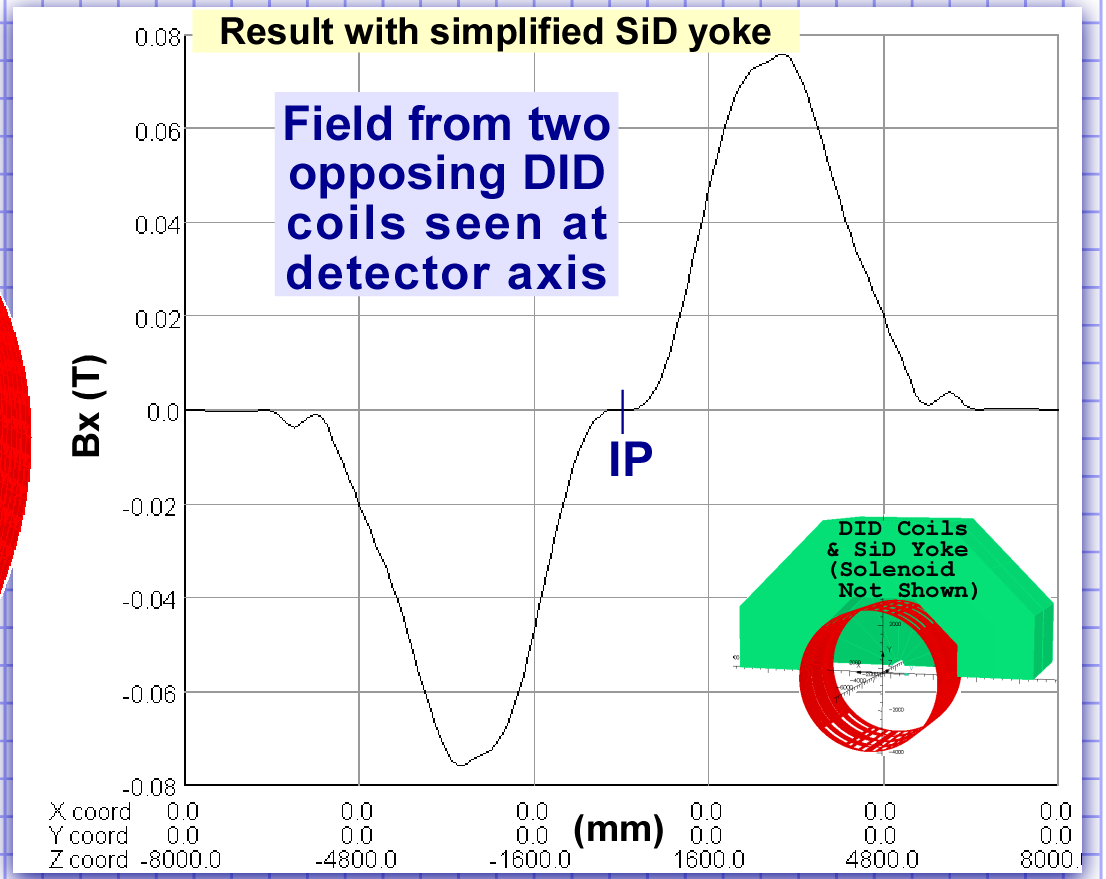
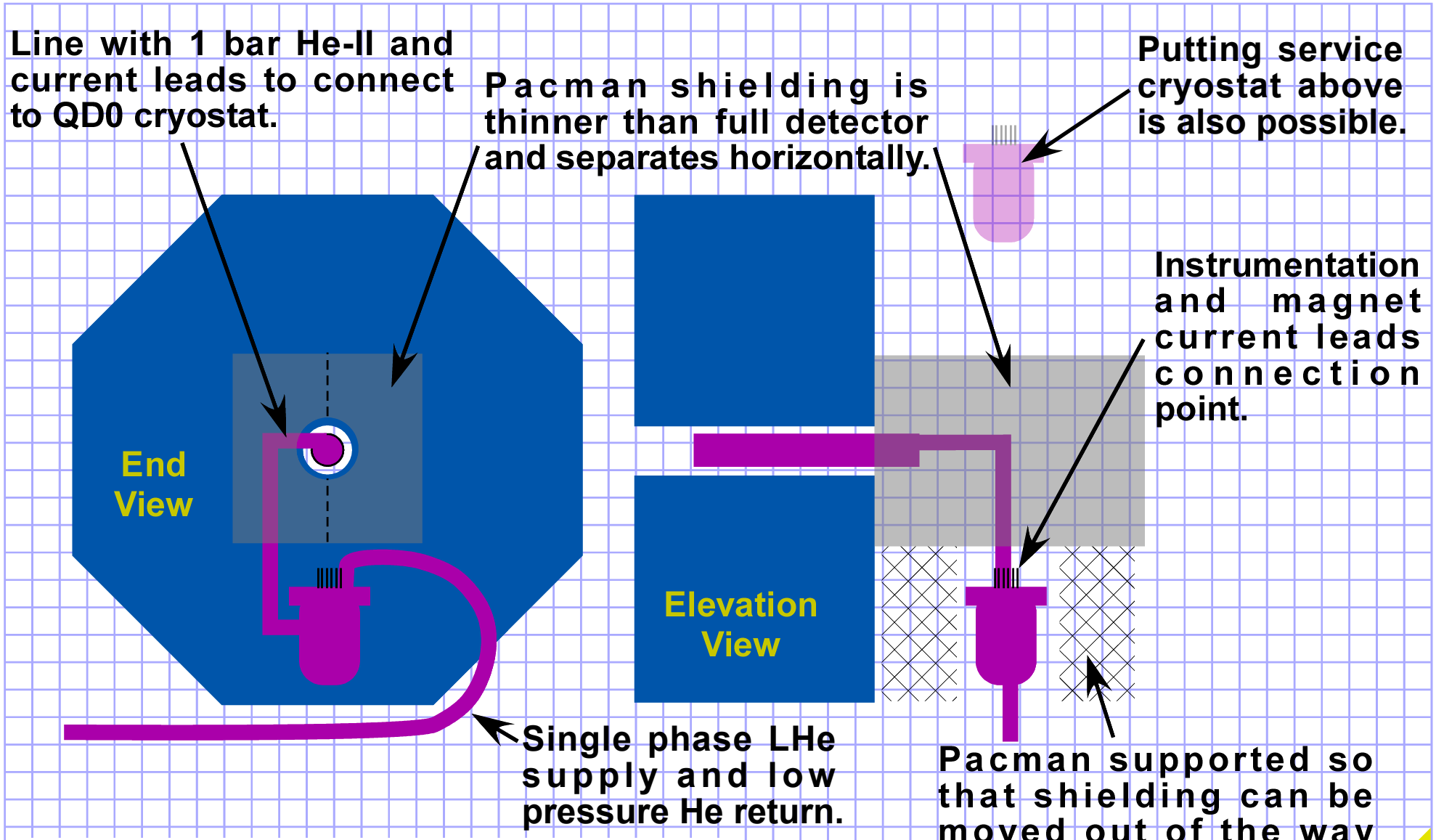




Two Detector Integrated Dipole (DID) coils can be used to improve the field uniformity near the IP (important for TPC based detectors).

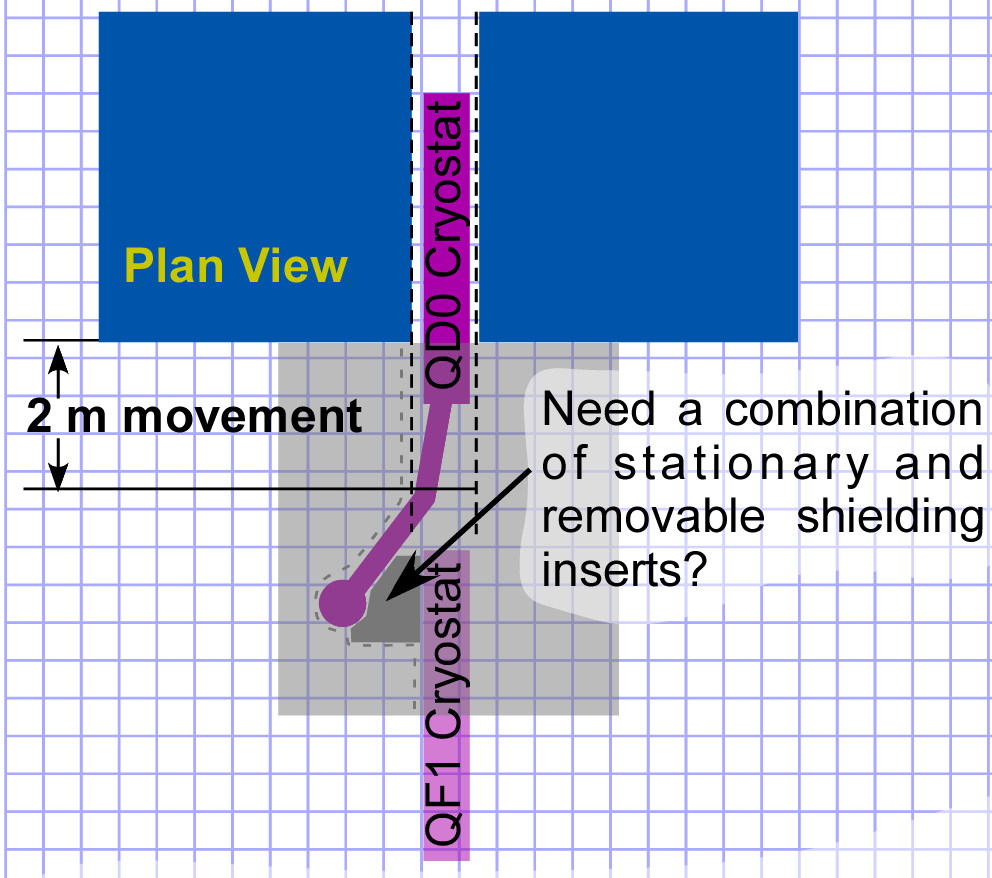
Long Term Goal: Generate field maps for the anti-solenoid and anti-DID for each detector concept.

Introduce cryogenic "straw man" design.

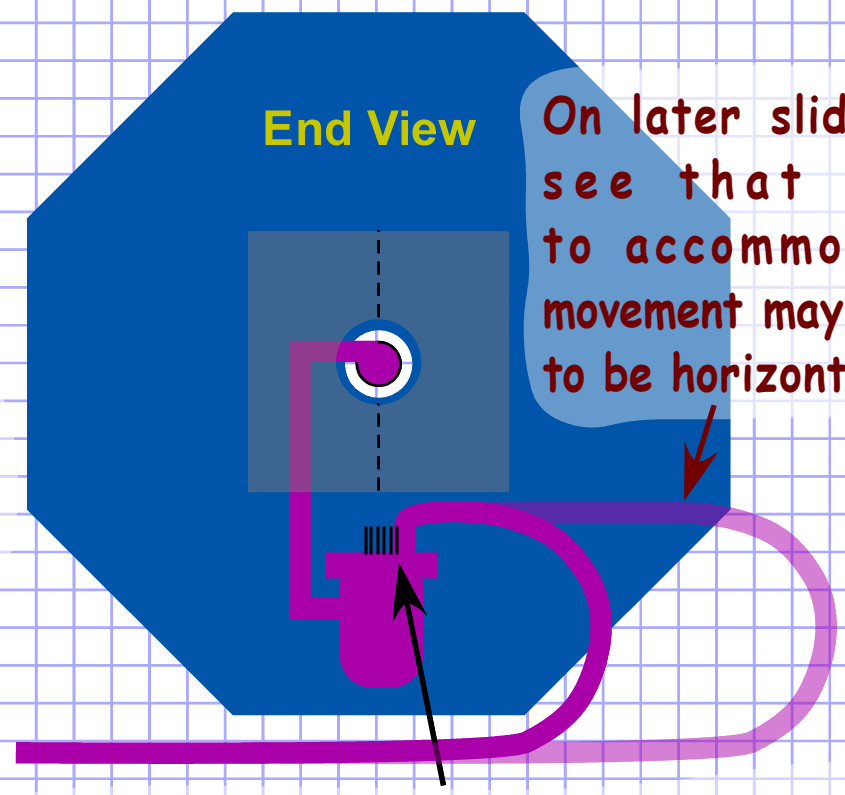


Refine these cartoons during IRENG07.

Design Constraints: Opening the detector for access and allowing for self shielding.



Need a combination of stationary and removable shielding inserts?



On later slide we see that loop to accommodate movement may need to be horizontal.

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

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

(Implicit assumption: mirror symmetric cryogenic layouts for the two experiments)

Implications for Pacman & Support Structure.

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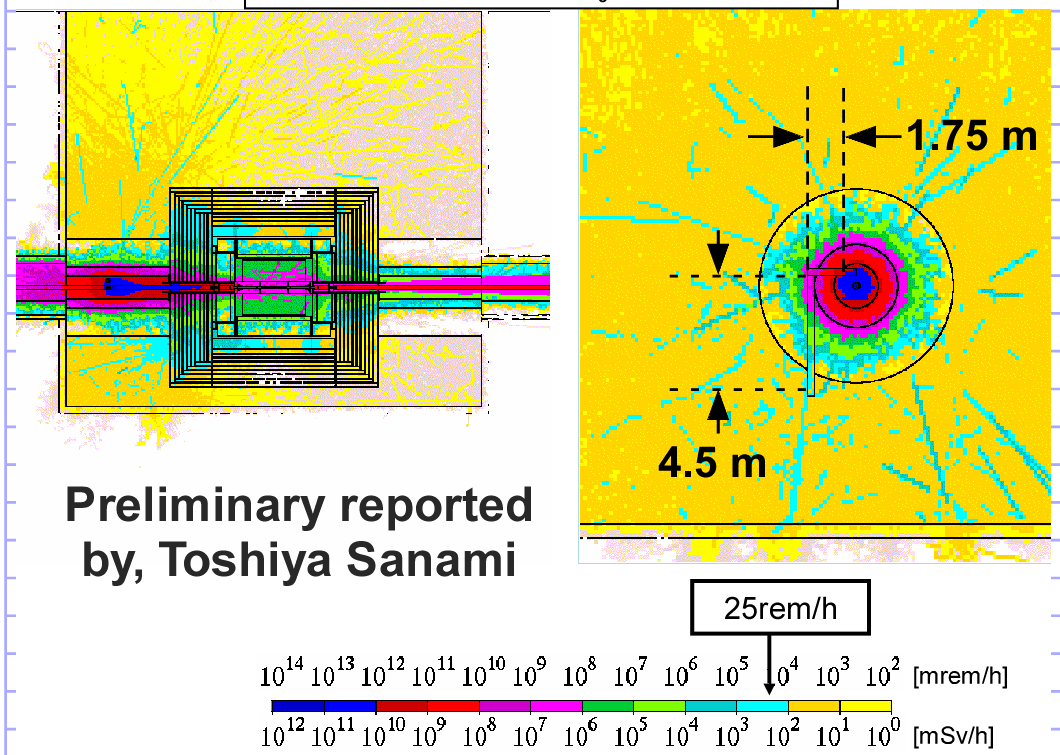
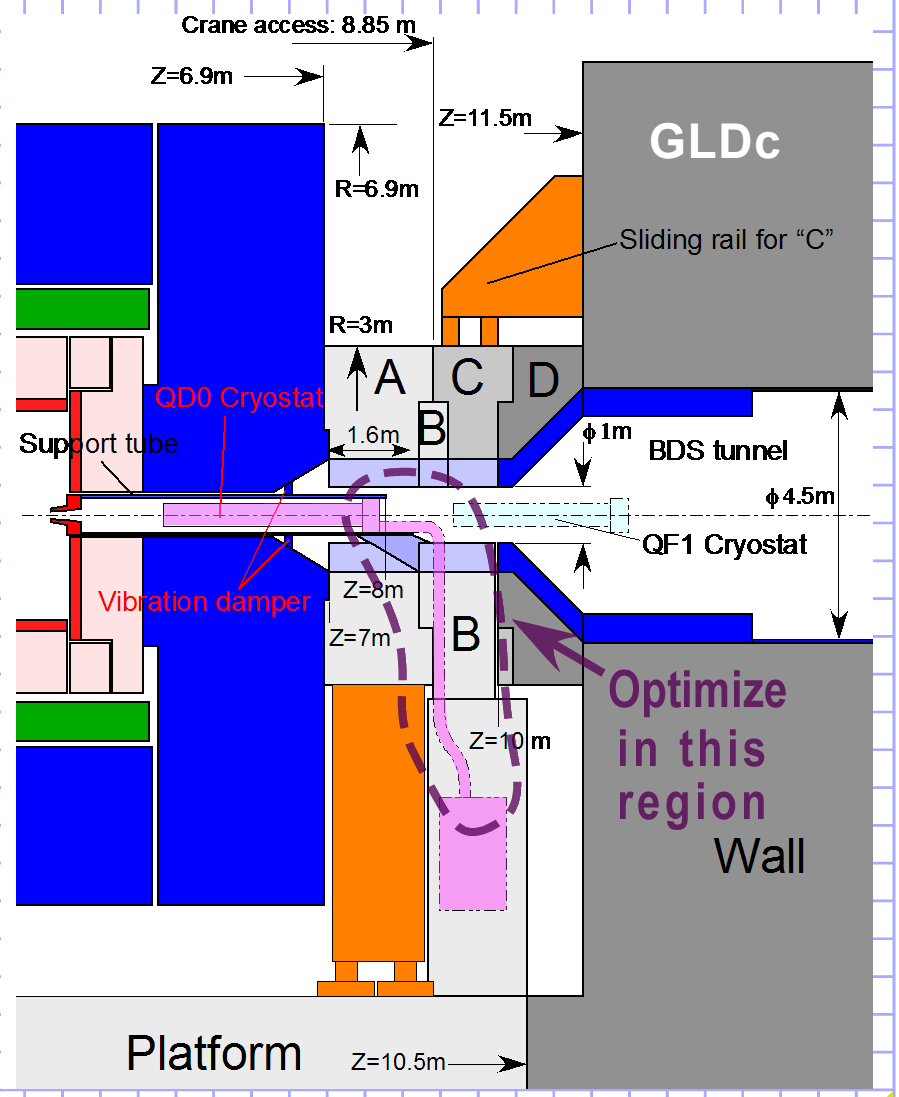
Reduce to 160 mm OD hor. & 200 mm OD vertical lines.

Dose rate for 25cm 1 knee

500 GeV, 18MW on $20X_0$ Cu cylinder



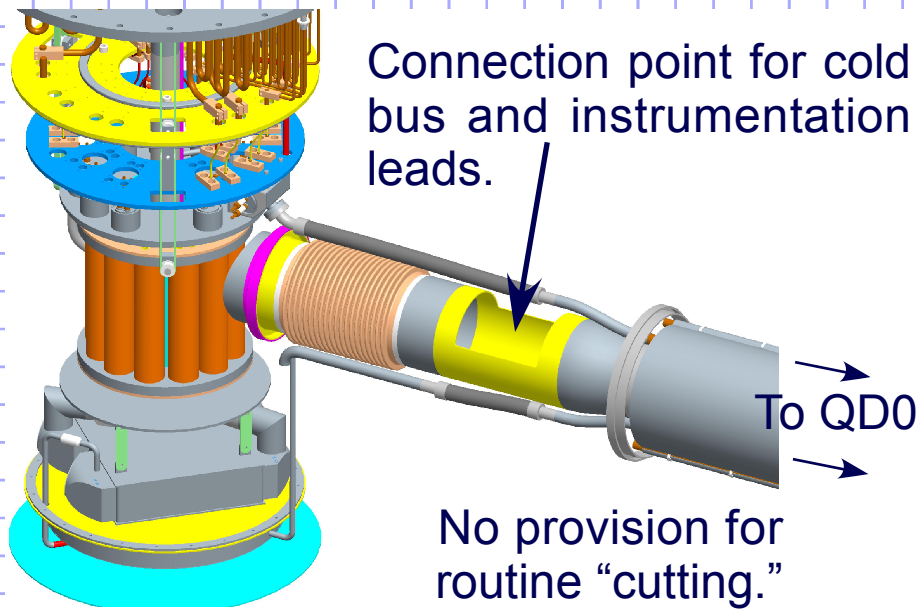
Preliminary reported by, Toshiya Sanami



It looks like we need at least one knee to keep radiation at acceptable level. Optimize the path and minimize cryo-line penetration size.

Preview of issues which should be addressed at this workshop.

Service cryostat connection is taken apart only a few times during lifetime.



There are a large number of cold bus conductors and instrumentation leads running between the service and QD0 cryostats in the 1.9 K He-II channel. Breaking/remaking these connections is a reliability issue. We do not assume that this is done for any routine operation.

Note this also has implications for detector access in the off-beam "park" position. If QD0 has to be moved, then the service cryostat has to move with QD0 even if the service cryostat is itself disconnected from its helium supply and vacuum return lines.

We assume warm up/cool down is done in the park position (i.e. magnets move cold).

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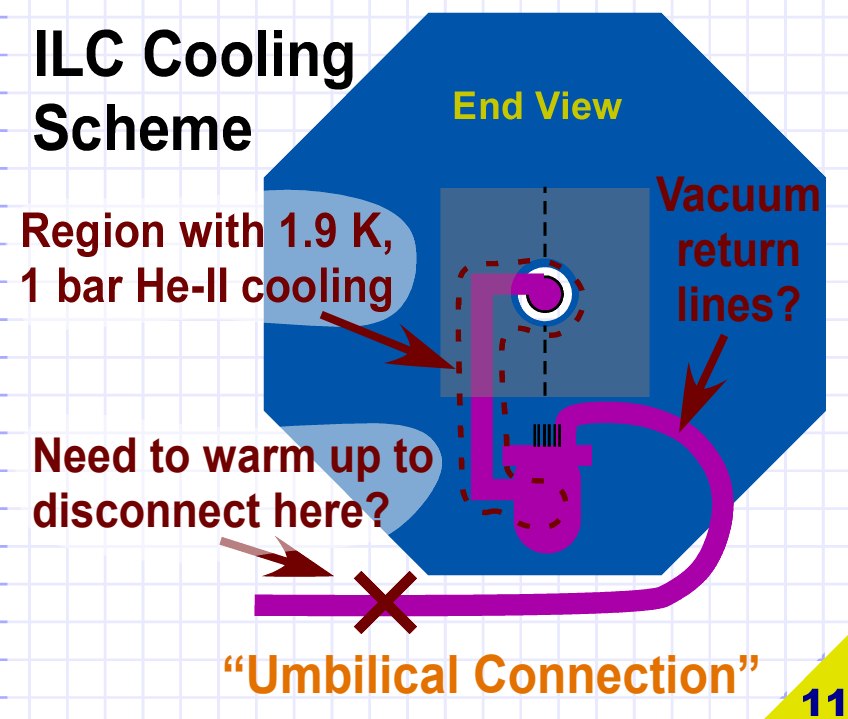
Predicting cool down and warm up times is not a simple task and can depend strongly on system details. We need to do estimates for ILC system to determine natural limitations and then can see what (if anything) can be done to speed things up.

Need stable ILC design configuration to make meaningful progress here.

The much simpler HERA-II magnets took 6-8 hours to warm up and again to cool down to 4.35 K with massive LHe flow. But ILC system also has to fill with 1.9 K He-II so it will require even more time (also add service cryostat). ILC case could easily take more than 1 day.

ILC Cooling Scheme



Assume heat load is dominated by static and not dynamic (beam related) effects.

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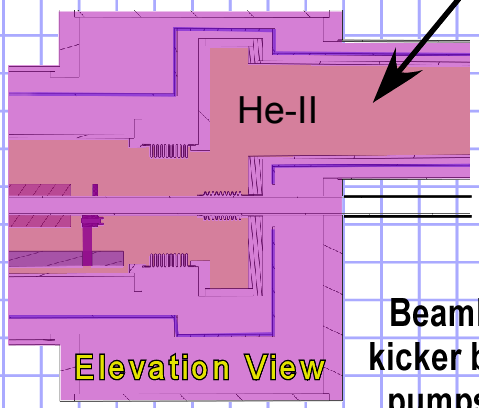
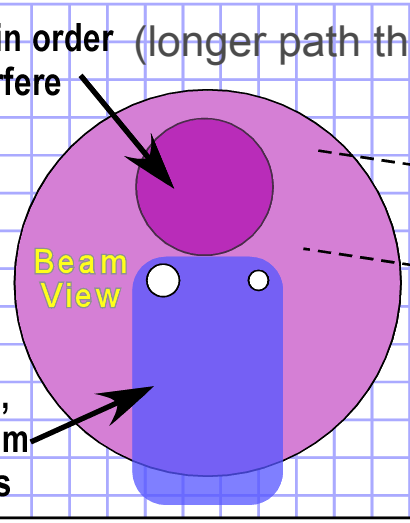
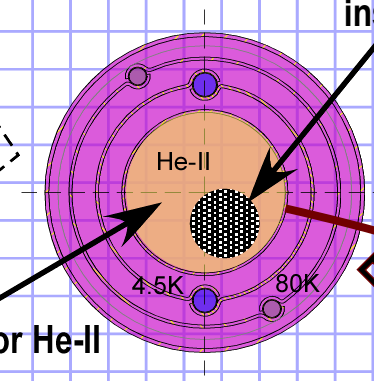
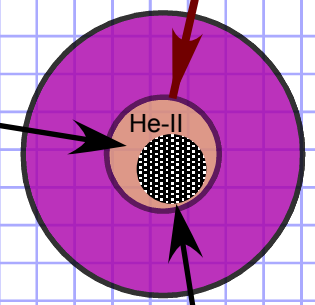






Reduce tube area by factor of 2.

Example



Temperature difference between magnet and heat exchanger depends both on cross sectional area for He-II and the path length.

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.).

See only a small change in transfer line size but big difference in area for He-II.

Cryogenic Supply and Distribution System: Some Operational Constraints.

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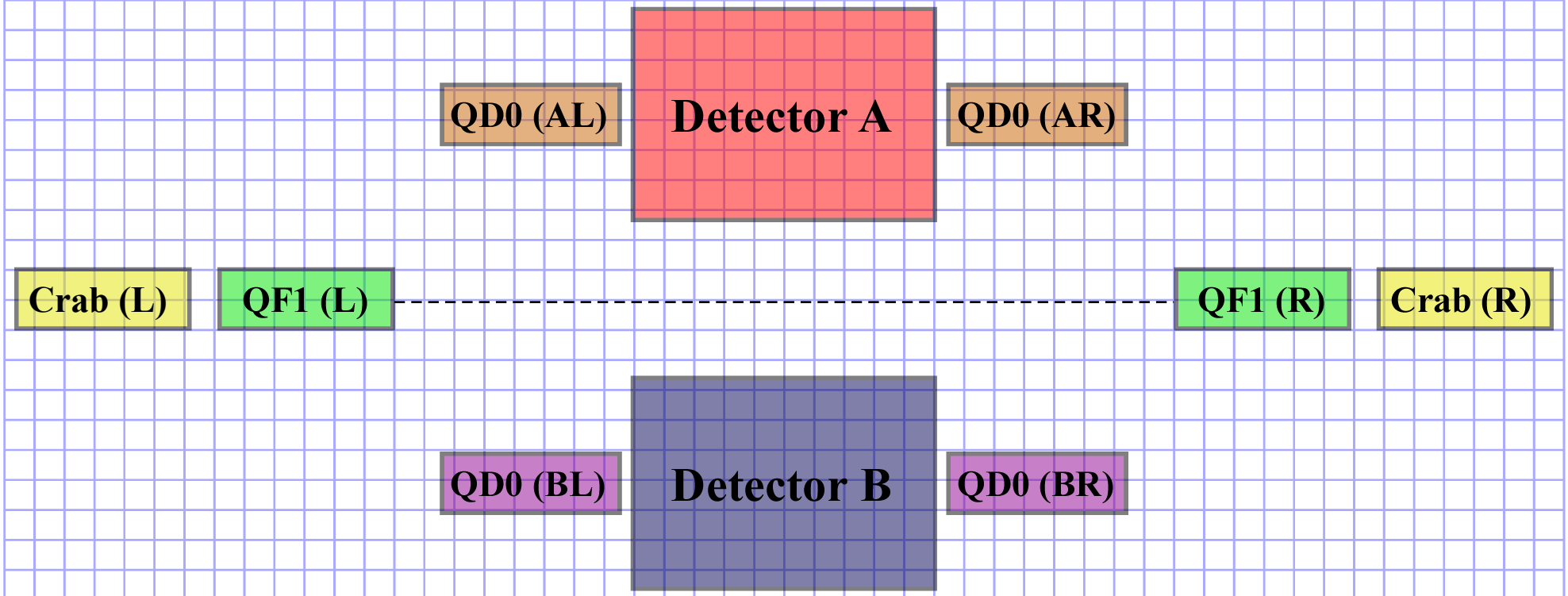
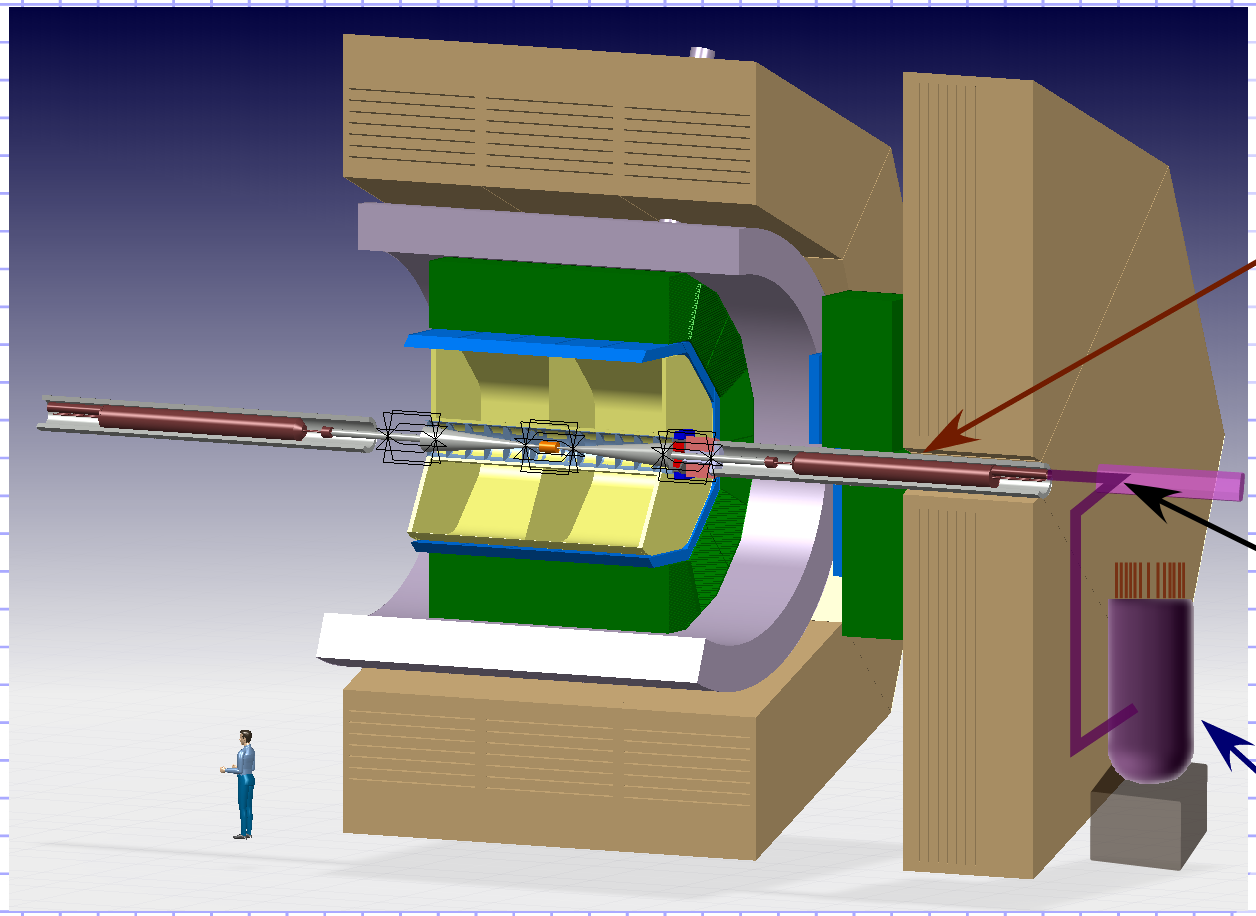
Systems coded the same color <u>may</u> be operated in common.



Systems not the same color <u>must</u> be operated independently*.

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

Finally we can start to see the tight spots.



In garage position, if door needs **routinely** to be pulled further out, then we need to come up with scheme for detaching beam pipe at IP end and sliding QD0 and Service cryostat as a single unit.

Watch for QF1 interference!

Every effort is taken to minimize width of Service Cryostat since it (along with QF1) limits how far door can be opened.

Much study is needed at both the on beam and garage positions.

Push-pull complications for cryogenic system.

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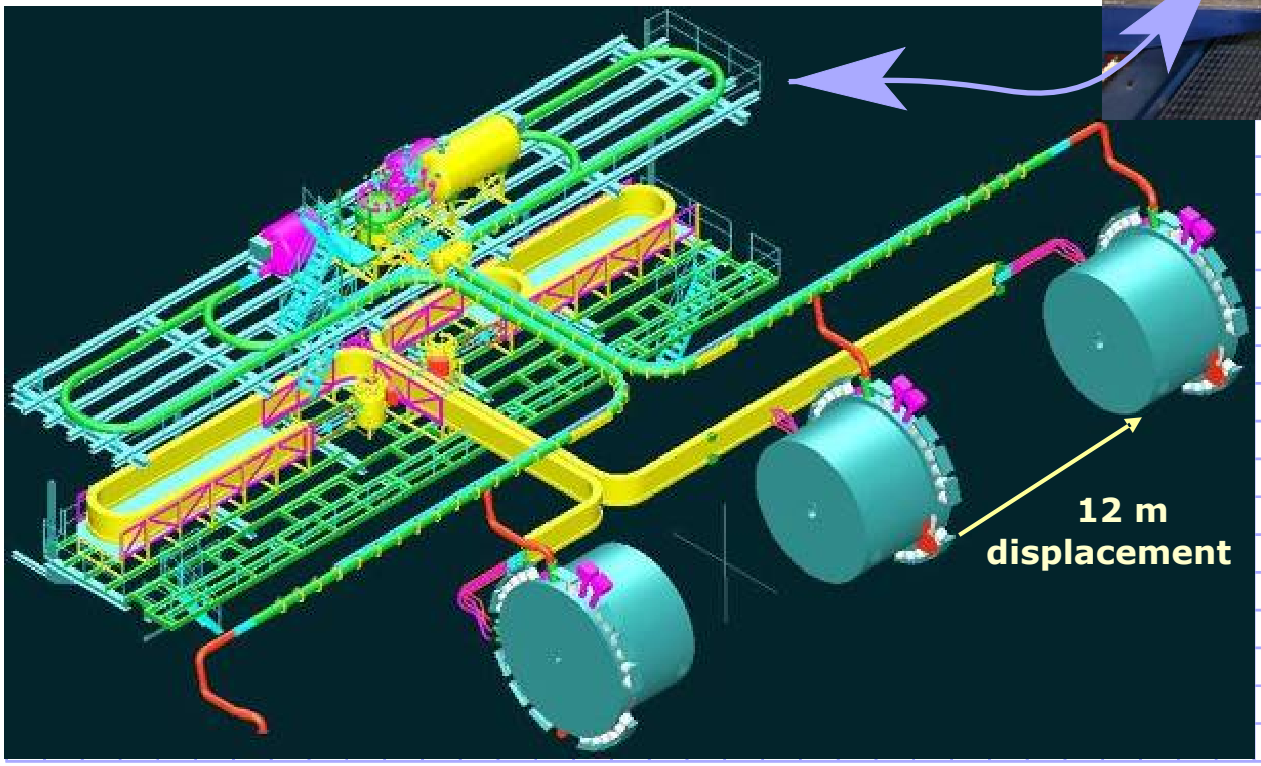
Use flexible chain support and constrained semi-flexible transfer lines, in a controlled way, to enable linear motion of cryogenic components.

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.

ILC IR push-pull makes greater demands than previous work with many subtle implications.

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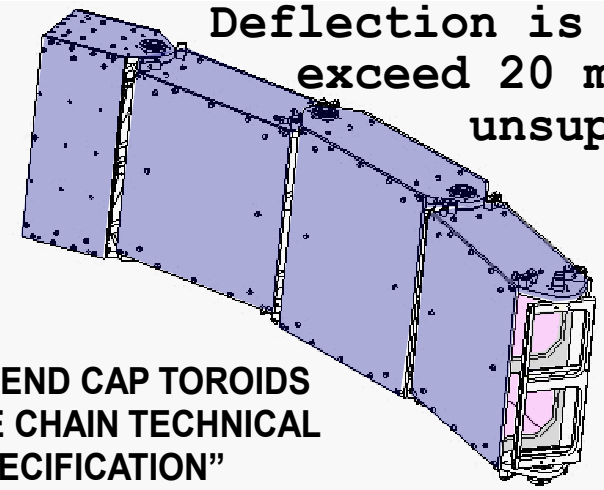
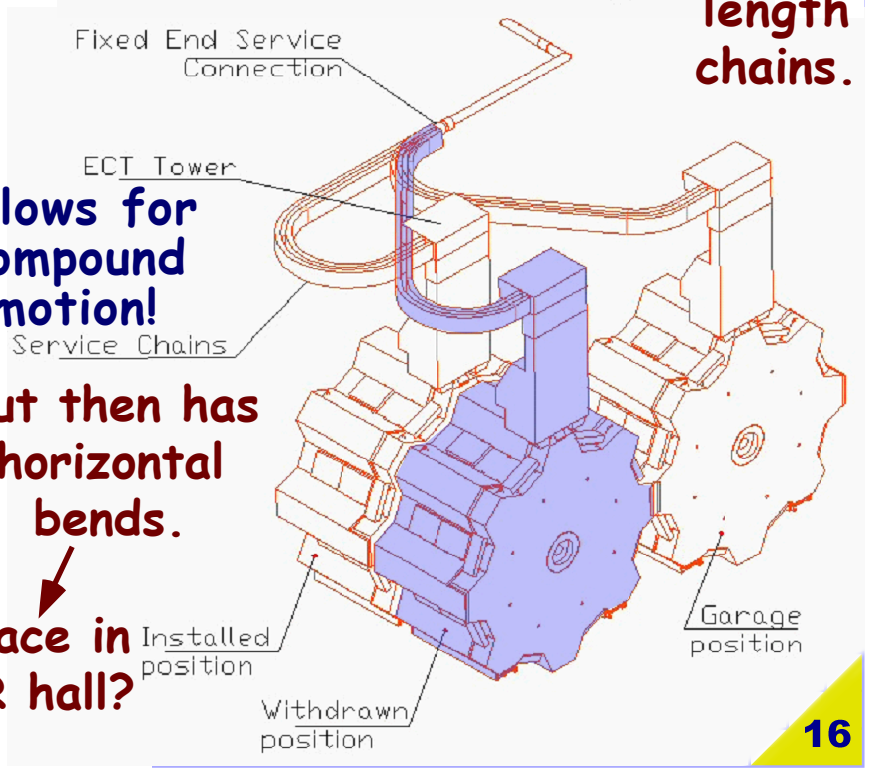


Deflection is not to exceed 20 mm over unsupported 9 m.

ILC IR will need longer length chains.

"ATLAS END CAP TOROIDS SERVICE CHAIN TECHNICAL SPECIFICATION"



Allows for compound motion!

But then has horizontal bends.

Space in IR hall?

Final Doublet Magnetic Design & Connection Model.

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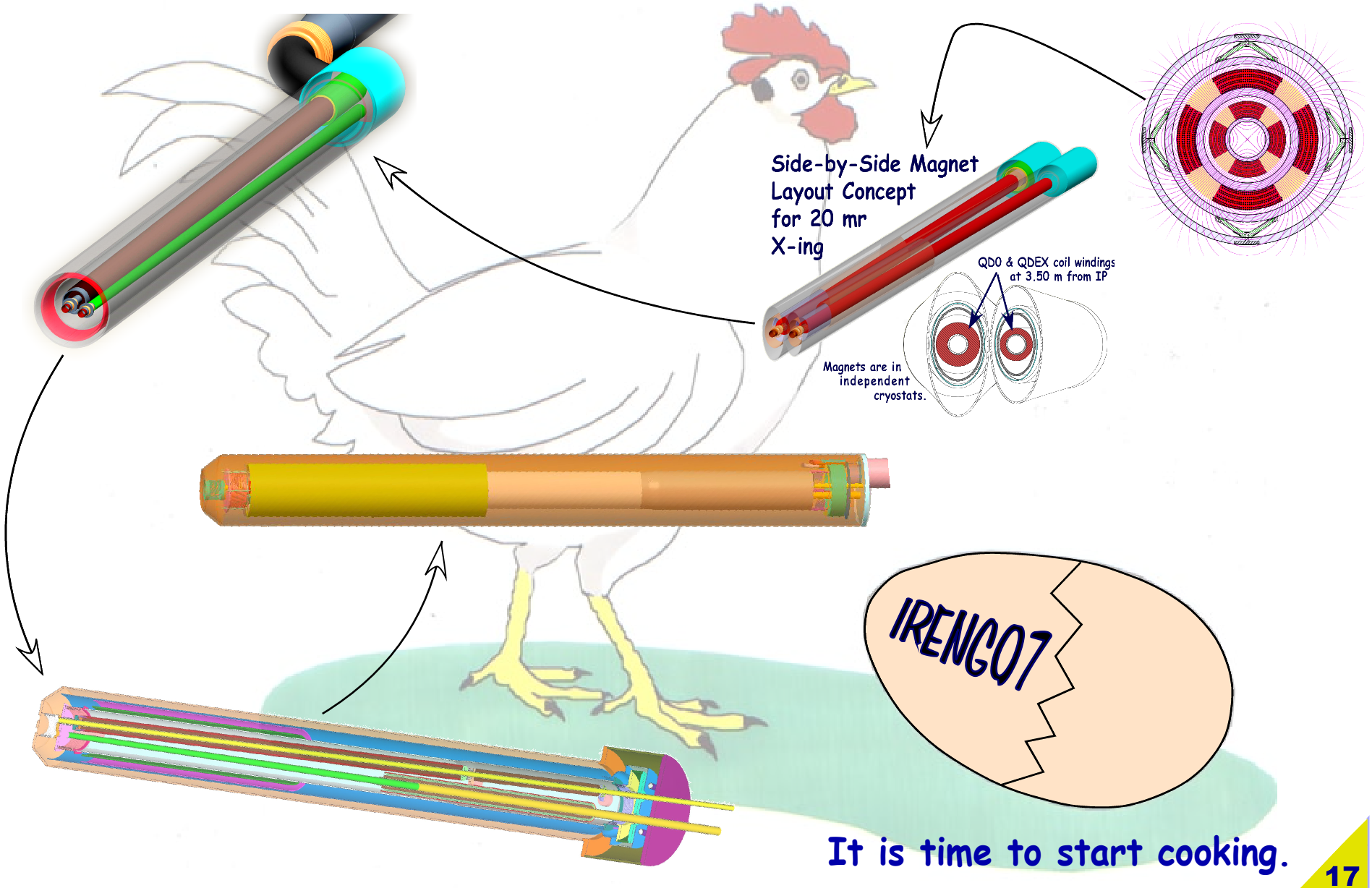

It is time to start cooking.