ILC QD0 R&D Update

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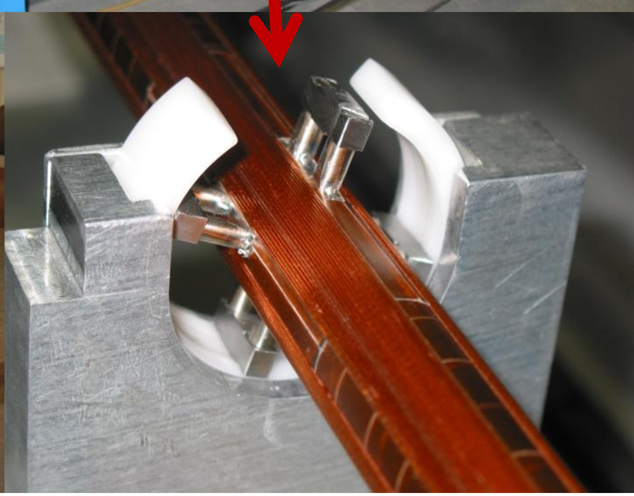
20 October 2010

ILC QD0 R&D Update - Outline

- R&D Timeline
- Present Status
- Next Steps

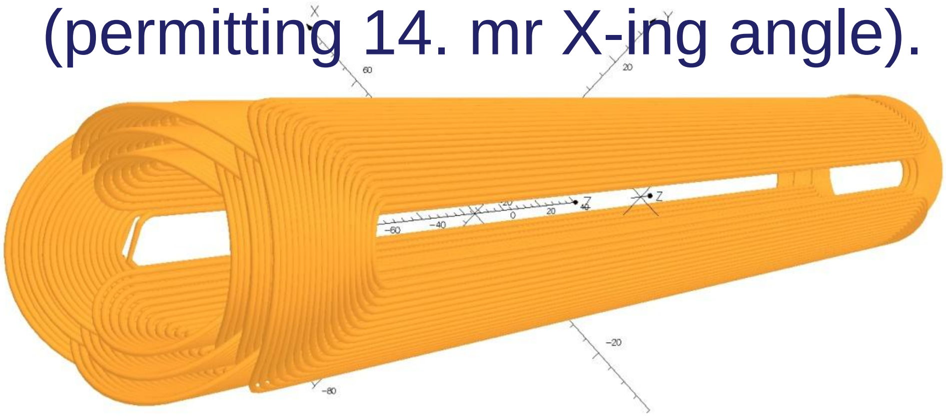
ILC QD0 R&D Timeline – Step 0

- “NLC days” 2.2 m QD0 coil was wound using single strand wire.
- Note central rotating support to counter support tube deflection.
- In this scheme, dipole correction coils must either have very large mid-plane gaps or be wound as two separate coils.



ILC QD0 R&D Timeline – Step 1

- Had to meet challenge to wind octupole coils, with very tight bends, for the α anti-hydrogen trap experiment at CERN.
- After we learned to wind these tight cable bends, we created a compact coil with active shield (permitting 14. mr X-ing angle).



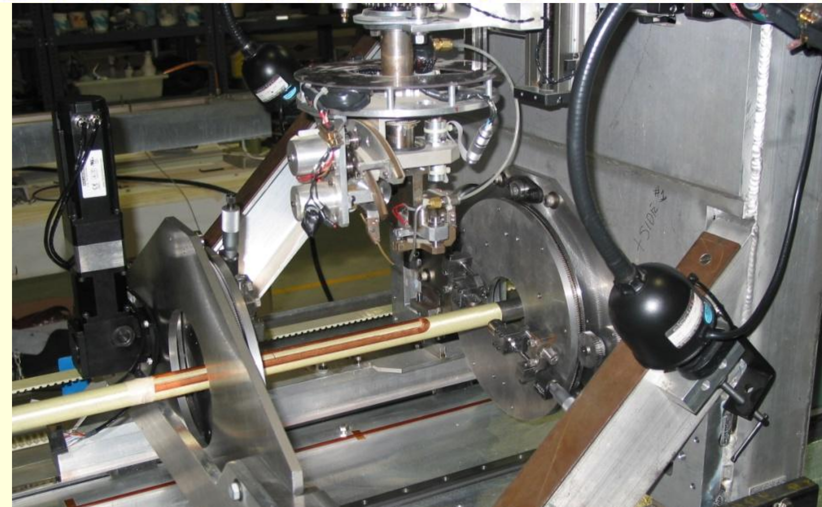
ILC QD0 Coil Pattern Concept
(multi-layer, 7-strand cable winding)

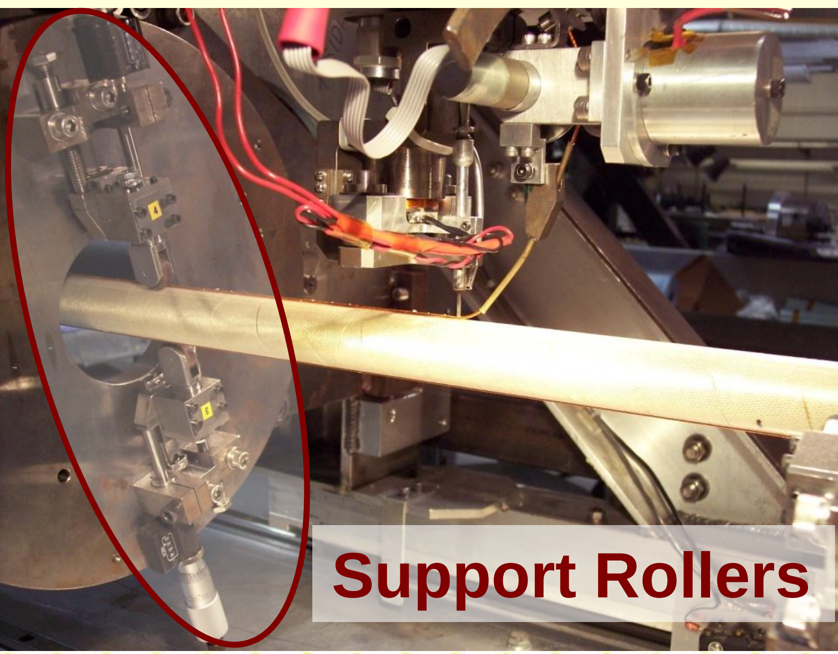
After winding CERN α-Magnet…

we redesigned QD0 using cable.

ILC QD0 R&D Timeline – Step 2

- Wound short quad and sextupole prototypes with very good field quality and quench performance.
- Looked to implement a moving coil support scheme with pairs of rollers.
- After "Black Friday" priority to ATF2.

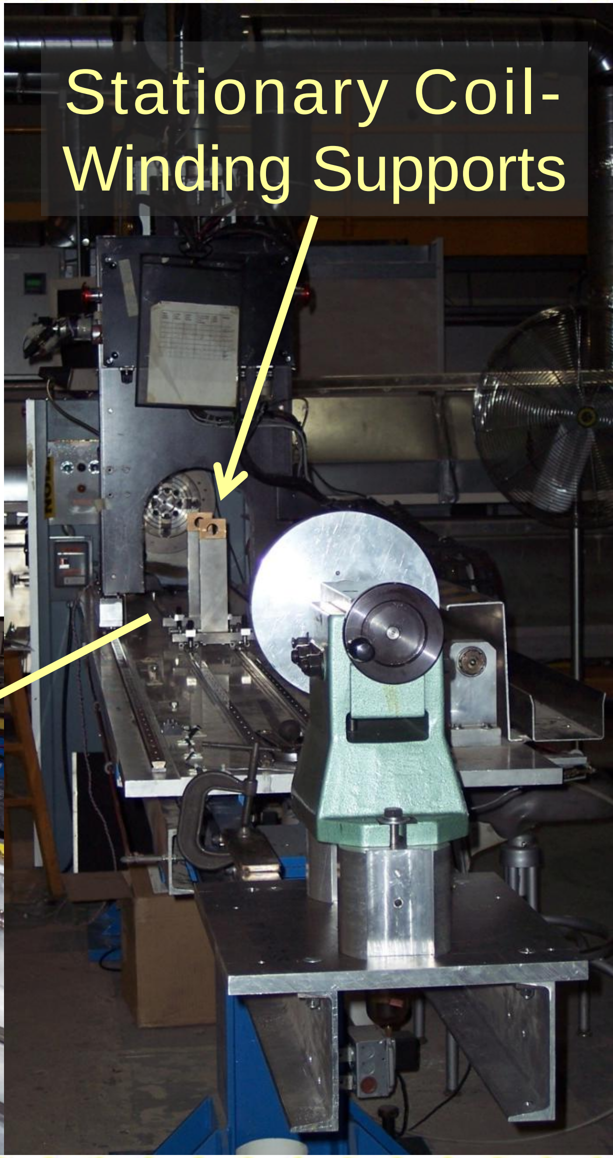




Coil went to short sample while in 7. T background solenoidal field.

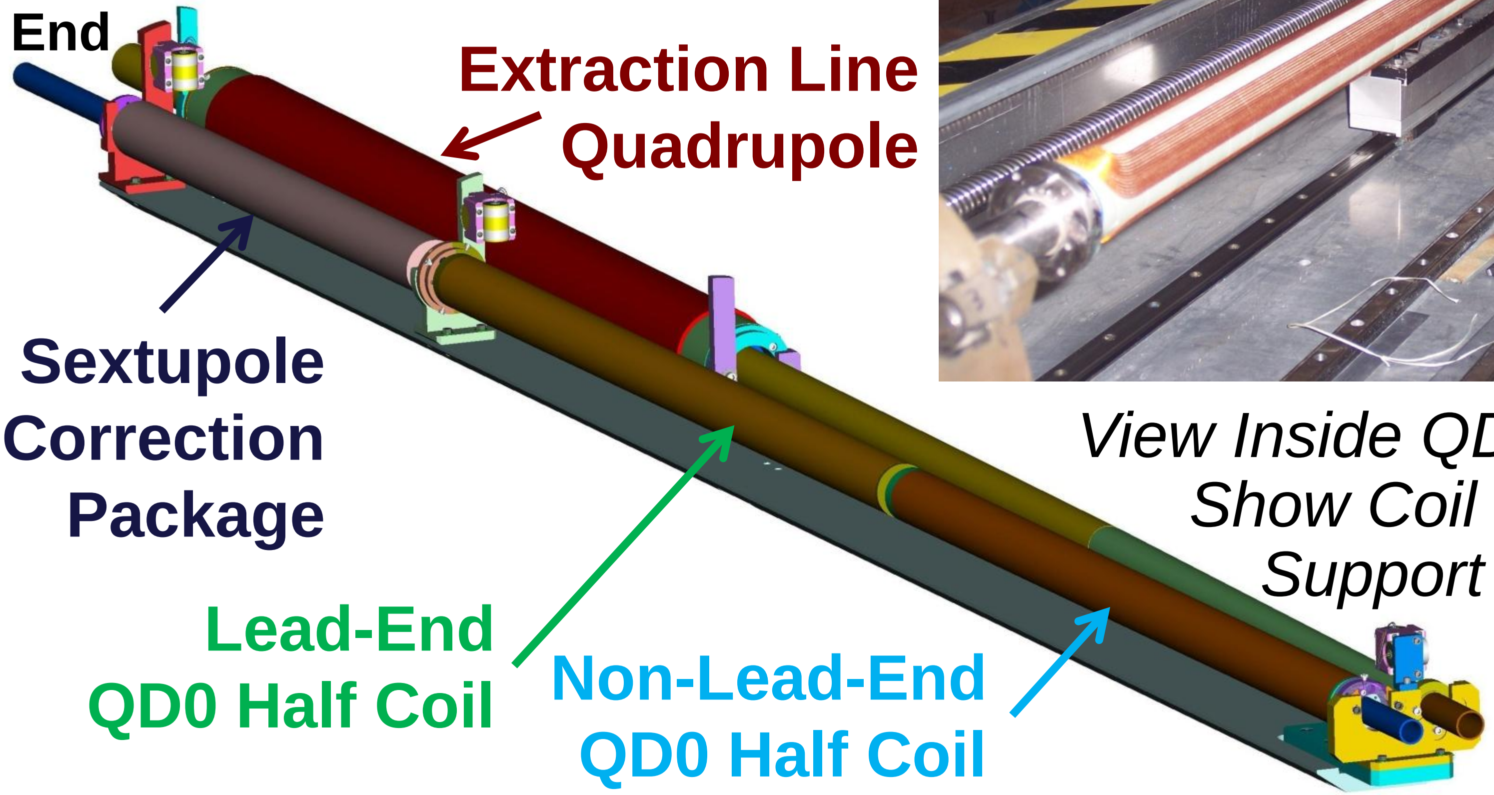
ILC QD0 R&D Timeline – Step 3

- By the end of US–FY09, wound two QD0 coil sets… but even with improvements found tube position is not well controlled.
- Decided to go back to fixed tube supports (implies splitting quad coil into two halves).
- Use laser alignment from another project.
- Wound ATF2 quad and sextupole coils with very good field quality (via compensation).



QD0 Split Coil Winding Implementation

QD0 split coil variant may be useful for low-energy running as a Universal Final Focus.



View Inside QD0 Cryostat to Show Coil Positions and Support Infrastructure

Integral Field Quality in ILC QD0 Prototype: Harmonics are in "Units" of 10^{-4} of main field at 5.0 mm radius.

Normal	Lead End Half Run 49	Non-Lead End Half Run	Both Halves (Vector sum)
I.T.F. (T/kA)	211.893	209.168	421.05
Fld. Ang. (mr)	9.8	2.8	6.3
Leff(m)	1.069	1.069	--
b1	--	--	--
b2	10000.0	10000.0	10000.0
b3	-1.4	-7.7	-4.5
b4	-0.4	-1.9	-1.1
b5	0.2	-0.3	-0.1
b6	0.2	0.0	0.1
b7	-0.1	-0.1	-0.1
b8	0.0	0.0	0.0
b9	0.0	0.1	0.0
b10	-0.2	-0.2	-0.2
b11	0.0	0.0	0.0
b12	0.0	0.0	0.0
b13	0.0	0.0	0.0
b14	0.0	0.0	0.0
b15	0.0	0.0	0.0

Skew	Lead End Half Run 49	Non-Lead End Half Run	Both Halves (Vector sum)
I.T.F. (T/kA)	211.893	209.168	421.05
Fld. Ang. (mr)	9.8	2.8	6.3
Leff(m)	1.069	1.069	--
a1	--	--	--
a2	--	--	--
a3	-1.1	-19.3	-10.2
a4	-2.2	-3.2	-2.7
a5	-0.4	-0.8	-0.6
a6	0.6	0.2	0.4
a7	0.0	0.1	0.1
a8	0.1	0.0	0.1
a9	0.0	0.0	0.0
a10	0.1	0.0	0.1
a11	0.0	0.0	0.0
a12	0.0	0.0	0.0
a13	0.0	0.0	0.0
a14	0.0	0.0	0.0
a15	0.0	0.0	0.0

Summary of Integral Field Quality in ATF2 Magnet

- Because field harmonics change rapidly with reference radius, we recalculated the measurements for R_{ref} = 10 mm (for easy comparison to the present ATF2 magnets).
- The poorest quad harmonics (b3,a3), are now only **49. parts per million**.
- The areas highlighted in blue are all **smaller than 200 parts per billion**.

	Quadrupole	Sextupole
I.T.F.	26.959	194.00
Fld. Ang. (mr)	-12.5	14.8
Leff(m)	--	--
b1	--	-1.6
b2	10000.0	--
b3	0.49	10000.0
b4	-0.20	0.3
b5	0.025	-0.133
b6	0.018	0.006
b7	0.000	0.005
b8	0.000	0.004
b9	0.000	0.002
b10	0.000	0.000
b11	0.000	0.000
b12	0.000	0.000
b13	0.000	0.000
b14	0.000	0.000
b15	0.000	0.000
a1	--	-53.8
a2	--	--
a3	-0.49	--
a4	-0.35	-0.79
a5	-0.016	-0.238
a6	0.001	-0.270
a7	0.002	-0.010
a8	0.001	0.002
a9	0.000	0.001
a10	0.000	0.000
a11	0.000	0.000
a12	0.000	0.000
a13	0.000	0.000
a14	0.000	0.000
a15	0.000	0.000

Summary of Integral Field Quality in ATF2 Magnet (QH0LC5)

Harmonics are in "Units" of 10^{-4} of the main field at 10 mm radius

Harmonics reported are as seen from the lead ends of respective magnets

(This also accounts for the opposite sign of field angle in the two magnets)

I.T.F for Quadrupole is in T/kA; ITF for Sextupole is in T/m/kA

(Integral of B" in sextupole is two times the value reported for the I.T.F)

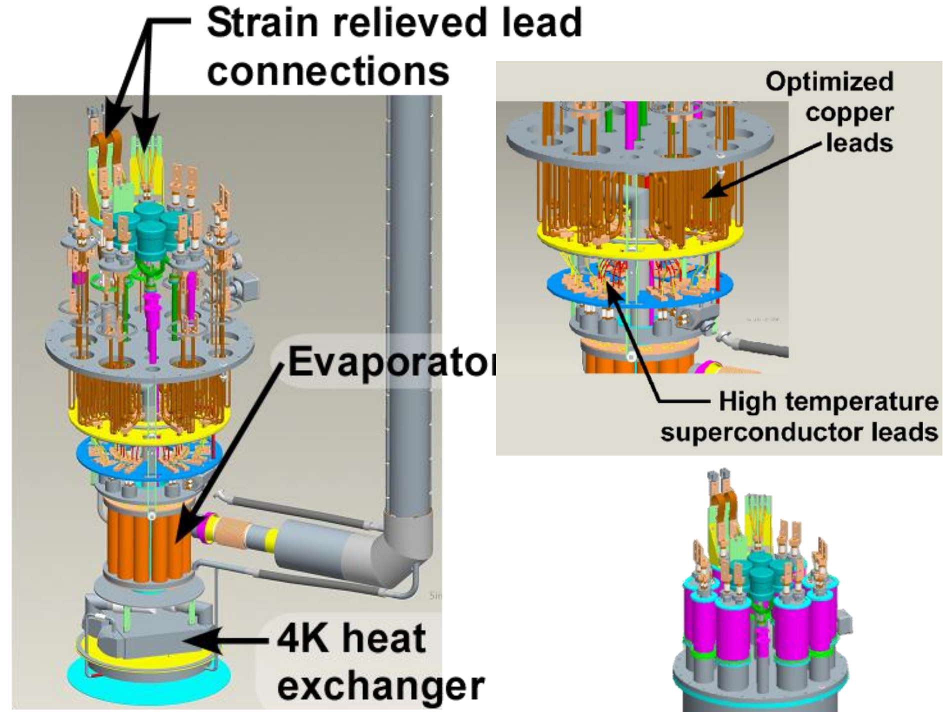
QD0 R&D Production Discussion

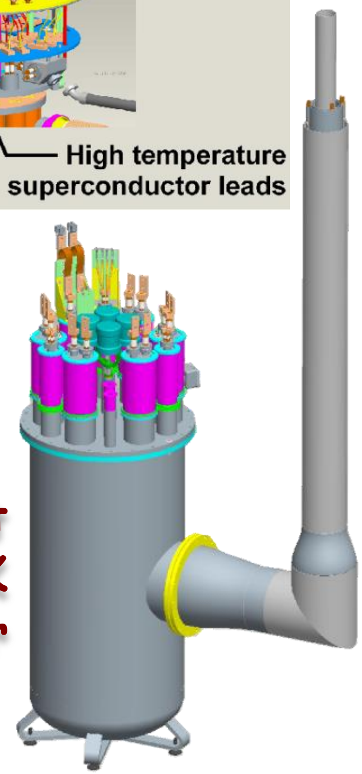
- Based on experience winding the first two (of three) coil sets, we might have expected to see the QD0 harmonics to be ≤ 1. unit at R_{ref} = 5. mm.
- Looking back we uncovered a file input error that troubled the non-lead-end coil more than the lead-end one generating spurious low order harmonics.
- Rather than losing time removing this last coil set to lay it down correctly, we have decided to push on with production in order not to delay vertical and horizontal cold testing.
- We still need to wind the main sextupole coil along with the octupole correction coil.

QD0 R&D Tests and 2012 Time Scale

- Parallel to finishing QD0 R&D coil winding we are producing the Magnet and Service Cryostats needed for horizontal testing.
- Look to have operational experience on 2012 (TDR) time scale.
- Recently new ideas were put forth on measuring the field centers & vibrations.
- Also address issues for new Universal Final Focus.

Service Cryostat Under Construction at BNL

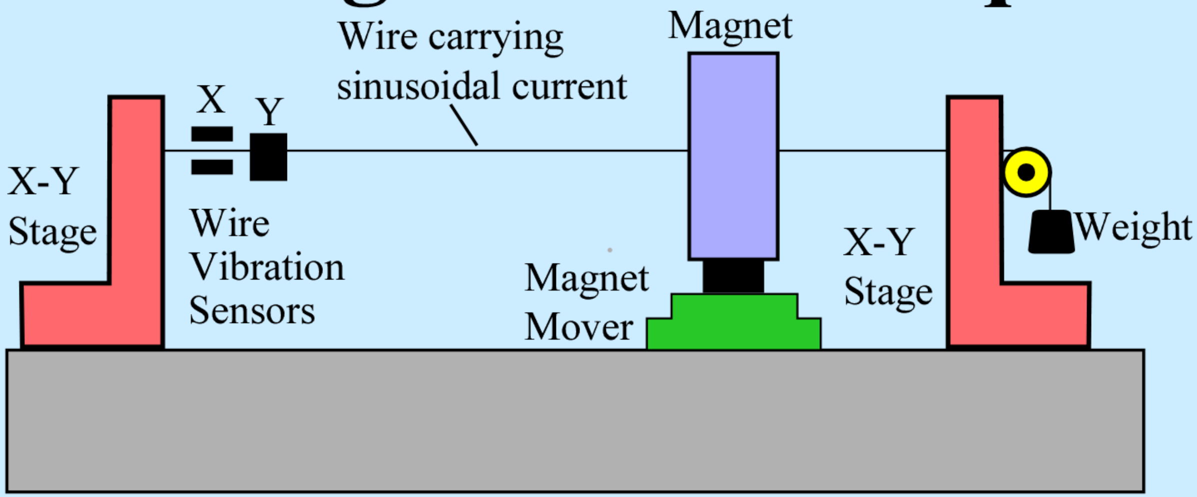




R&D Goal: Make and test Service Cryostat with 1.9K cryogenic transfer line for ILC-like running conditions.

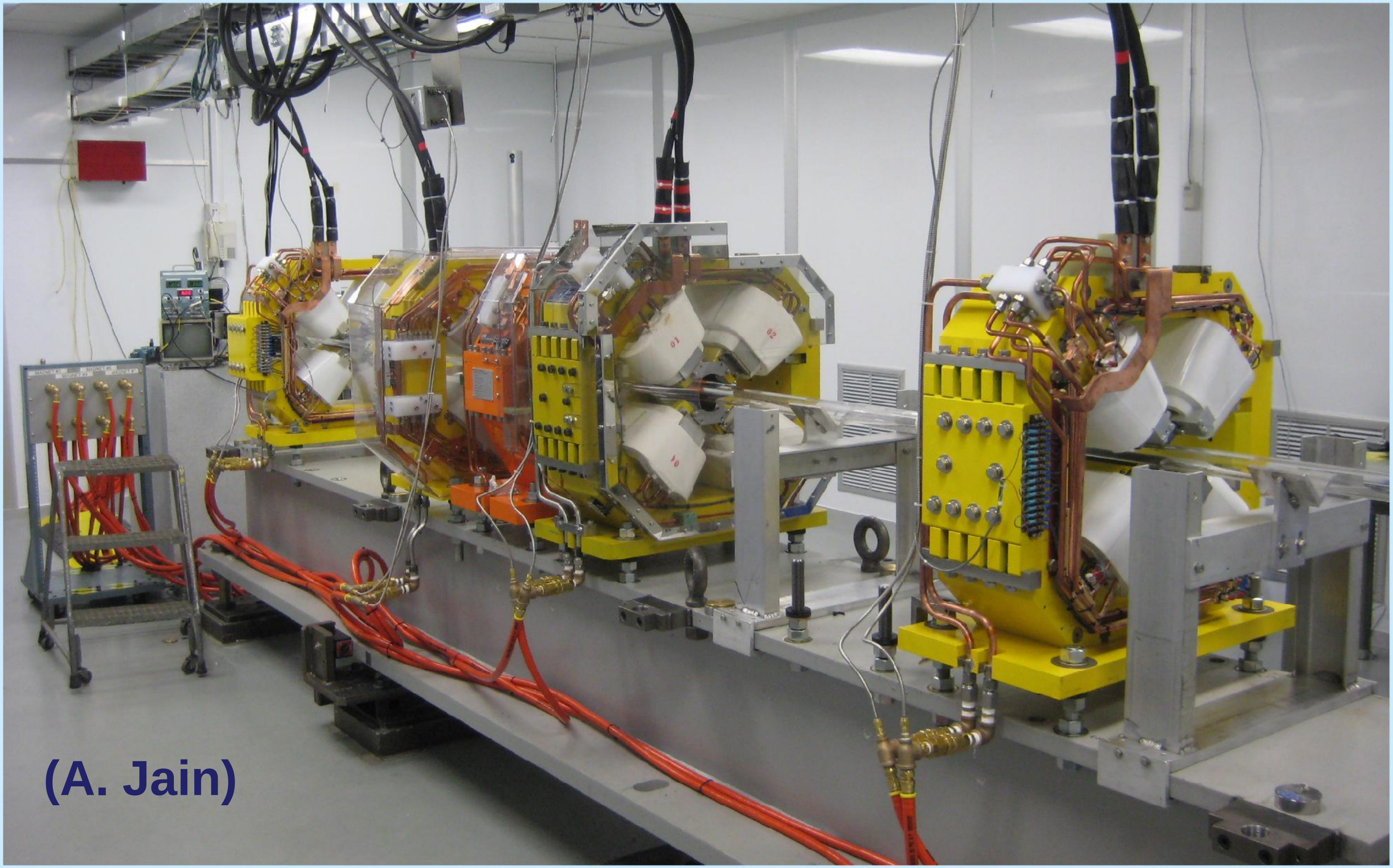
The Vibrating Wire Technique: Basics

(A. Jain)



- An AC current is passed through a wire stretched axially in the magnet.
- Any transverse field at the wire location exerts a periodic force on the wire, thus exciting vibrations.
- The vibrations are enhanced if the driving frequency is close to one of the resonant frequencies, giving high sensitivity.
- The vibration amplitudes are studied as a function of wire offset to determine the transverse field profile, from which the magnetic axis can be derived.

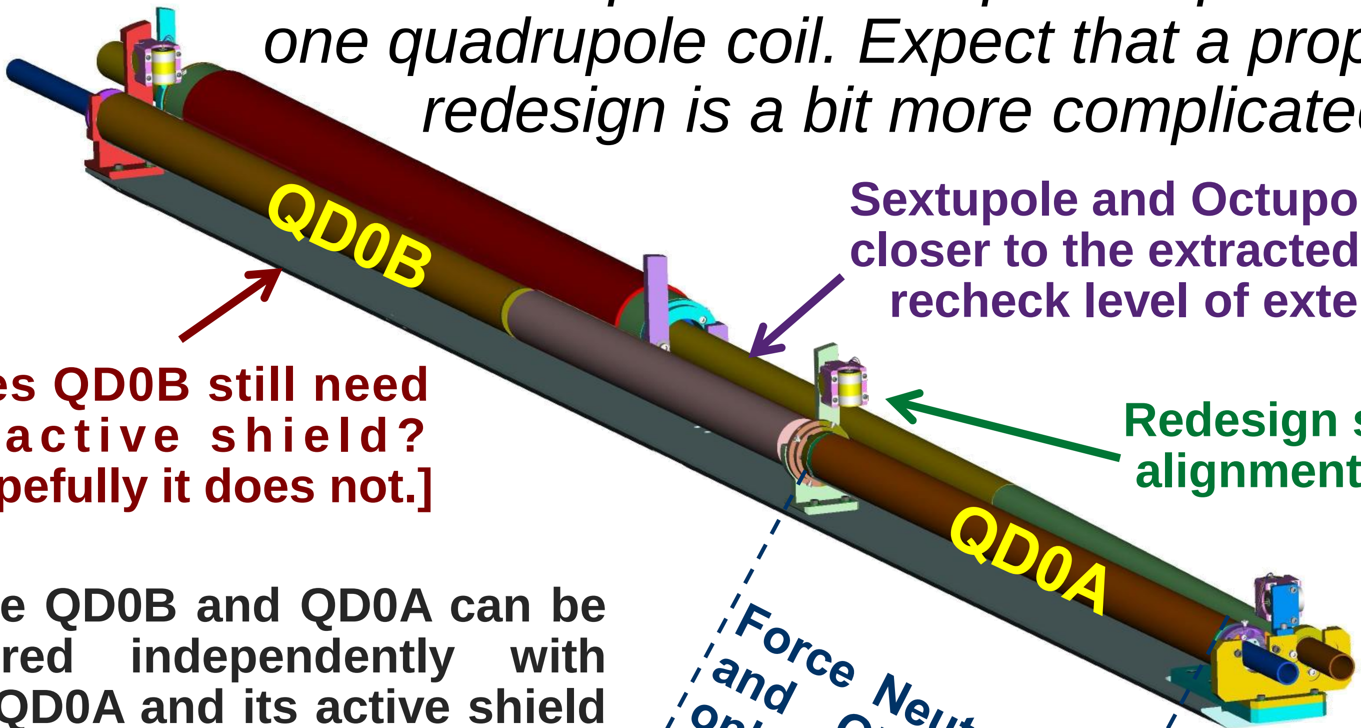
NSLS-II Prototypes in Vibrating Wire Test Stand



(A. Jain)

Universal Final Focus (Cartoon) Issues

Here I took the CAD layout from slide #7 and did cut/paste to swap sextupole and one quadrupole coil. Expect that a proper redesign is a bit more complicated.



Sextupole and Octupole coils are now closer to the extracted beam; so must recheck level of external B-field.

Does QD0B still need an active shield? [Hopefully it does not.]

Redesign support & alignment scheme.

Force Neutral Anti-Solenoid and QD0A Active Shield only need to extend over this region?

Maybe QD0B and QD0A can be powered independently with only QD0A and its active shield run in series?

Do QD0A and QD0B have to have the same coil structure and magnetic length?

ILC QD0 R&D Timeline – Step n

- I believe that we know how to make high-quality QD0 coils; what is of interest to me now (and relevant to ILC TDR) is to learn how well we can align the quad/octupole/sextupole coils on their common support tube.
- Naively the present "flawed" QD0 coils match the desired "NLC field quality" and there seems to be no RDR field harmonic specification; we need to come up with a defensible field quality goal, especially in light of the newest Universal Final Focus and traveling focus optics concepts.

ILC QD0 R&D Timeline – Step n+1

- Given a common desire to have R&D information in hand relevant to finalizing the TDR and new ILC concepts for cost savings and low energy running, we should reevaluate ways to maximize R&D return given limited remaining time and resources (i.e. plan for TDR endgame).
- Hopefully we can set homework goals to be reported on at the SLAC BAW in January 2011.
- In summary we have learned important lessons re. producing long, thin QD0 coil windings and now have a chance to prioritize the R&D feedback we want to see re. proposed ILC baseline changes.