NANOBEAM 2002

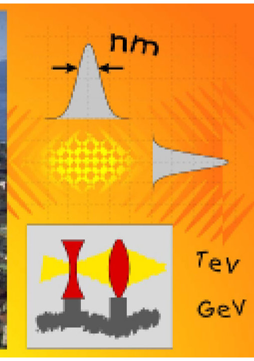
26th Advanced ICFA Beam Dynamics Workshop on Nanometre Size Colliding Beams

September 2-6, 2002, Lausanne, Switzerland

BROOKHAVEN NATIONAL LABORATORY

Superconducting Magnet Division

NLC - The Next Linear Collider Project



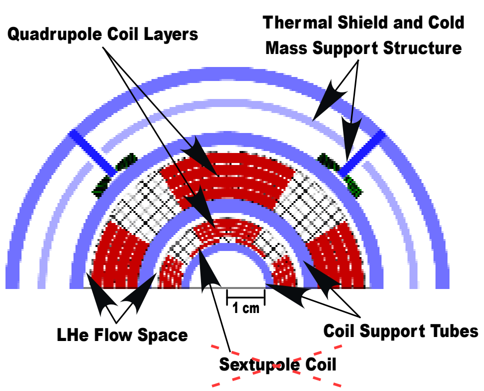
Session 4: Interaction Region Subgroup

Chairs: Fulvia Pilat, Tom Markiewicz

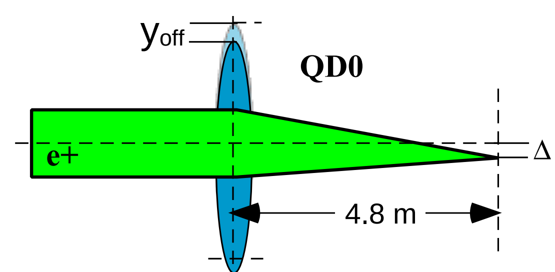
(Tuesday afternoon)

Superconducting Final Focus Magnet Issues

presented by Brett Parker for the BNL Superconducting Magnet Division



BNL Small Coil Test Winding



Linear Collider Final Focus Magnet Issues (Top Level).

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IR magnet design optimization (beam aperture, field requirements, coil/pm–material layout, vacuum, energy deposition, support etc.).

Getting magnetic center stable at the nm level (Vibration).

LCD-L2 (3T) with 3.8m L* Optics

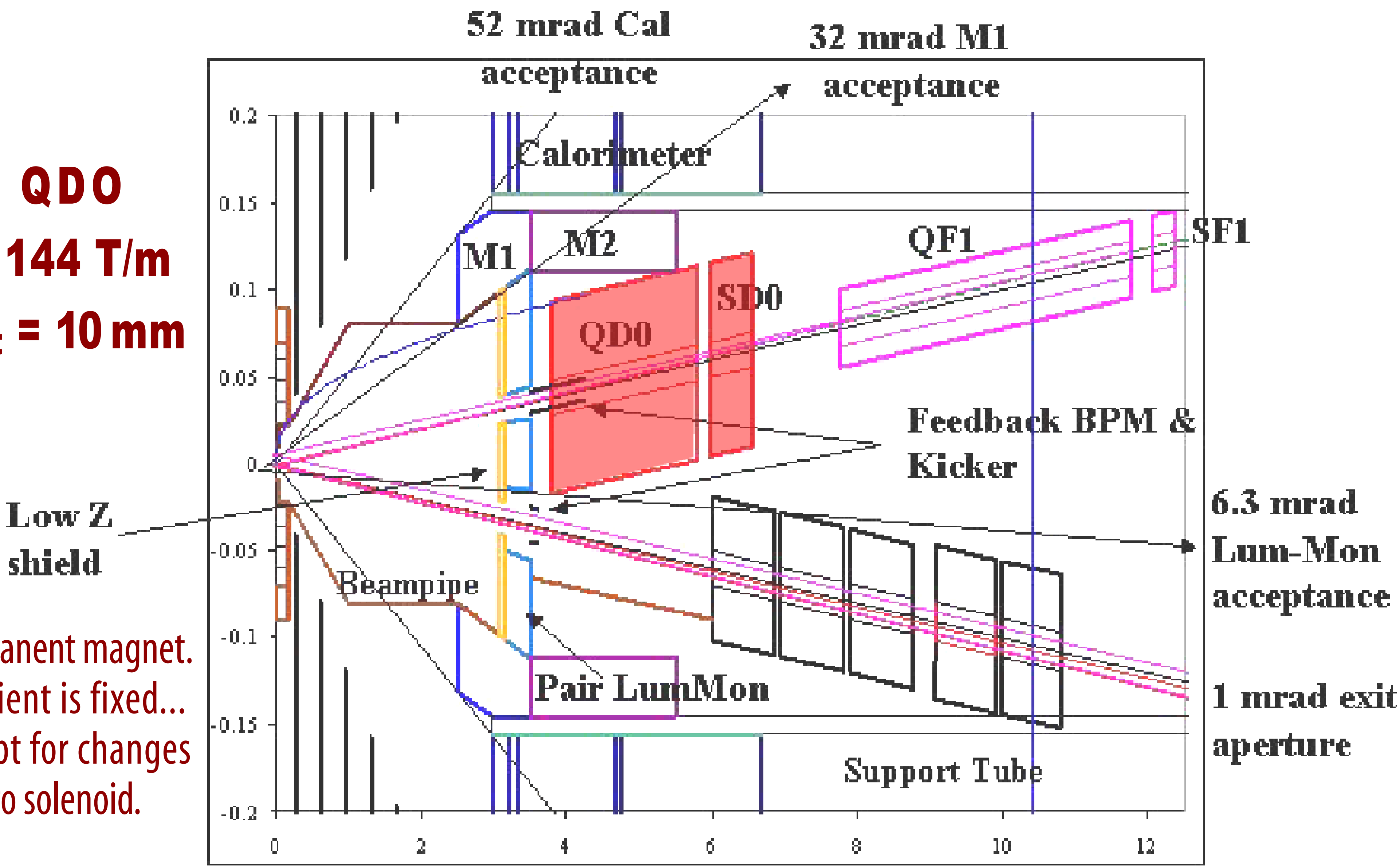
Separate (Easier?) Extraction Line θ_C=20 mrad

For QDO

G = 144 T/m

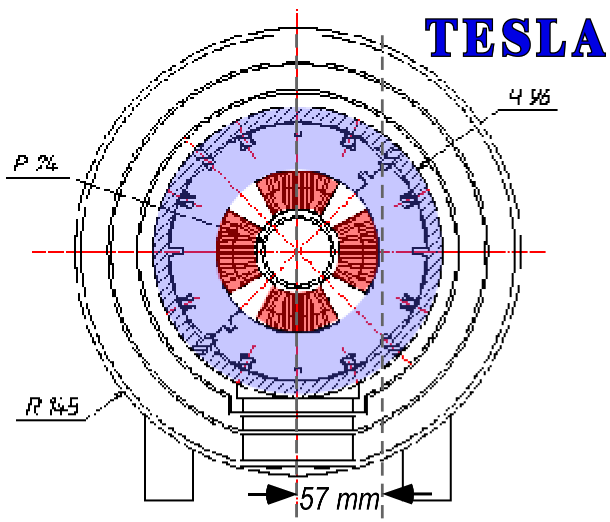
R_{apt} = 10 mm

- Permanent magnet.
- Gradient is fixed...
- Except for changes due to solenoid.

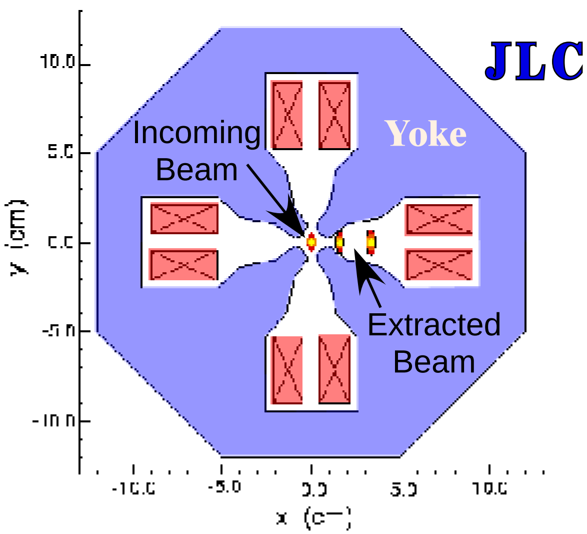


Tom Markiewicz

The TESLA and JLC Final Focus Quadrupole Concepts.



- Large aperture superconducting magnet (has both beams in the central region).
- Vertical extraction via electrostatic separator at 20 m and a shielded septum at 50 m.



- Iron magnet inside a superconducting compensator magnet (avoid saturation, buck out detector solenoid field).
- Extract the beam through coil pocket.

Recent Winding Tests on Small Diameter Support Tubes

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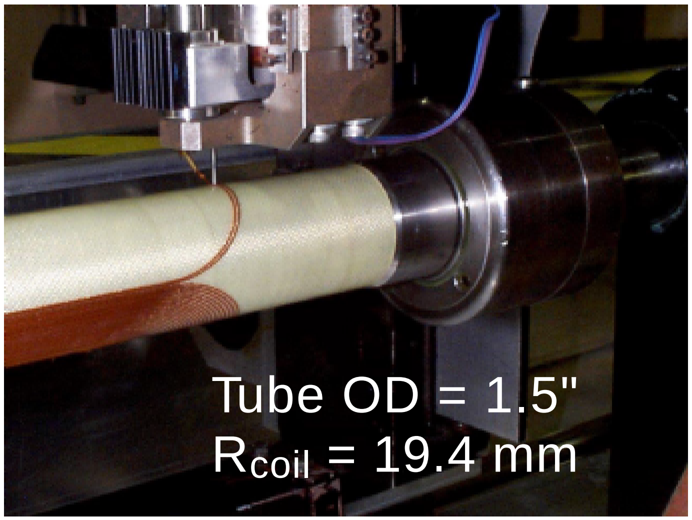

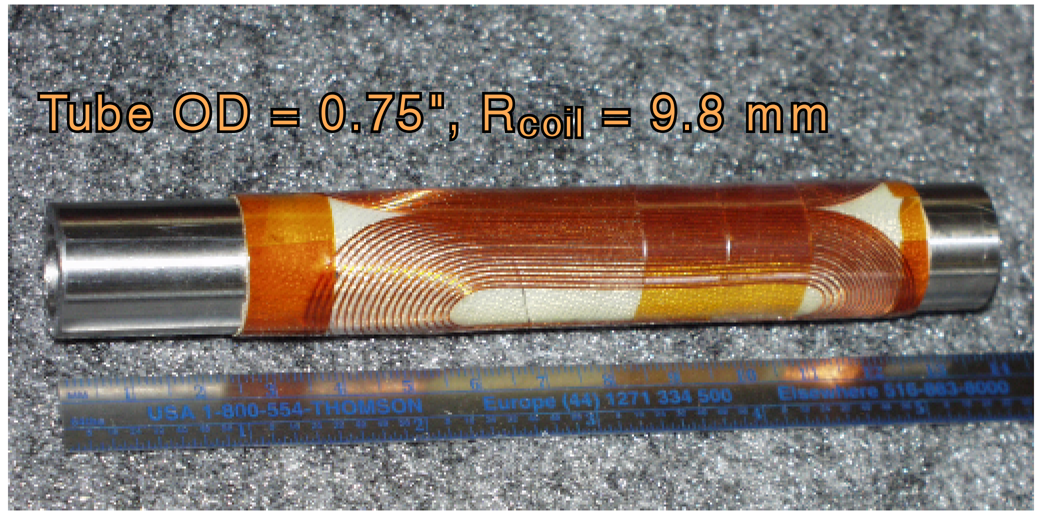

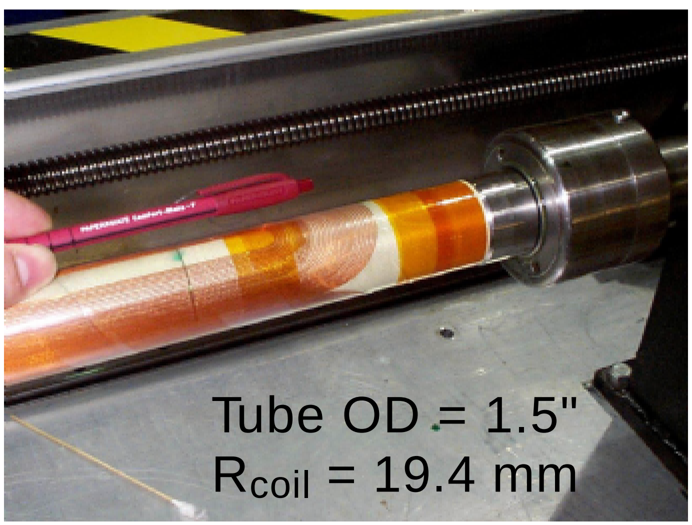

- Need to make small diameter coils (which then have tight bends).
- Wind with single strand conductor on inner layers and 6-around-1 cable for outer layers (see winding machine).
- Then can keep cryostat small enough to pass disrupted beam outside.

Superconducting Magnets for the HERA Luminosity Upgrade.

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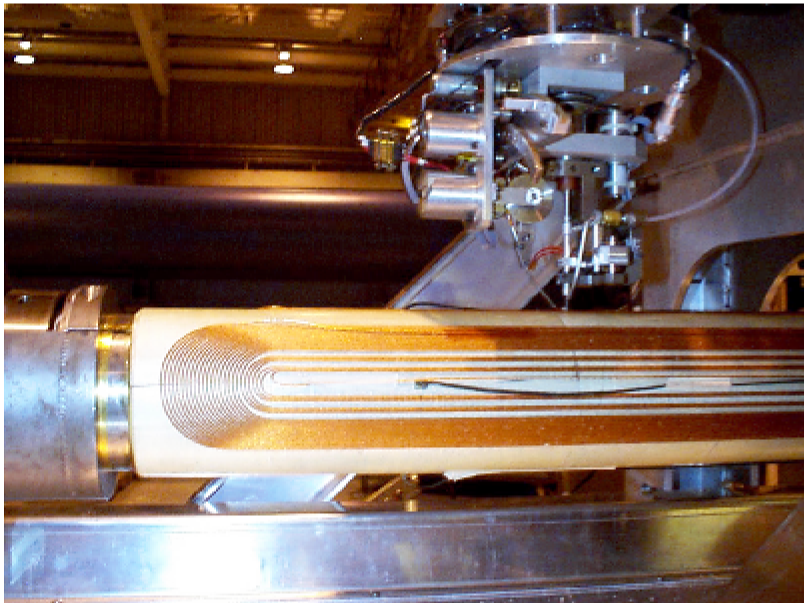
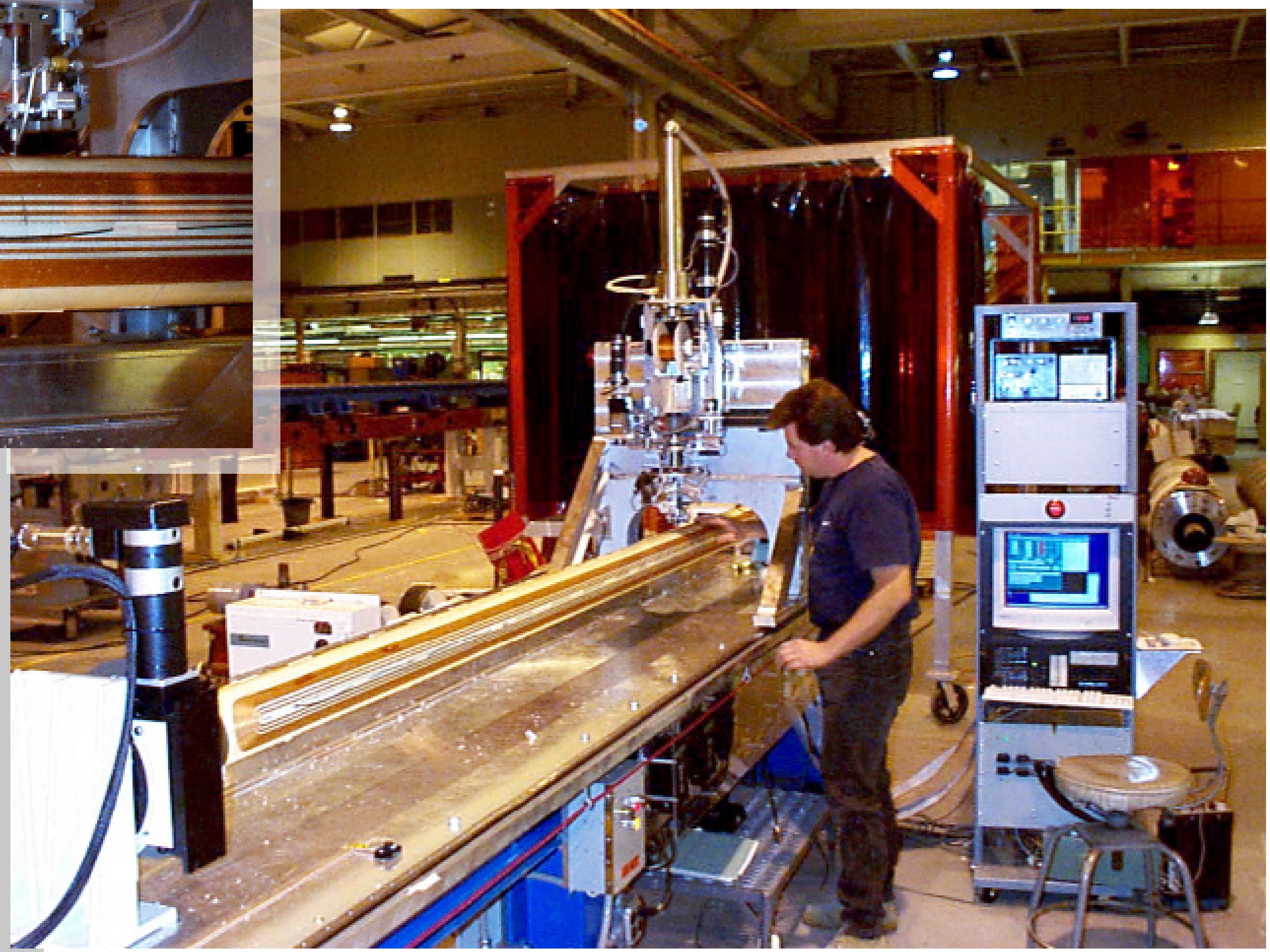


File used for field harmonics gives winding machine the path in space for the conductor.



Insulated conductor with b-stage epoxy coating is payed out under hollow stylus. Ultrasonic heating and rapid cooling leaves conductor bonded to substrate. Typically a coil goes next to magnetic measurements.

QD0 Cross Section with 4°K Beam Tube and Sextupole Winding.

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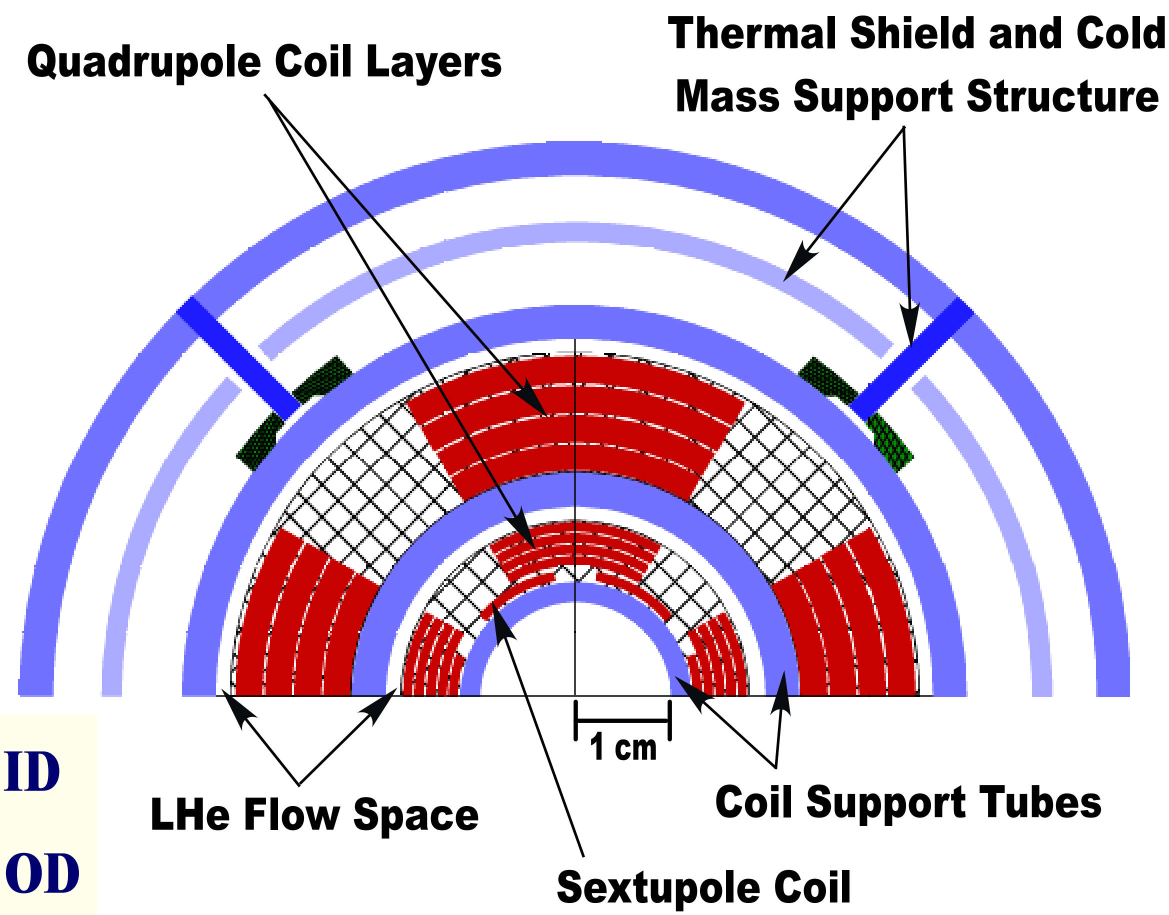
QDO Coil Parameters

Sextupole	1300 T/m²
Inner Quad	51 T/m
Outer Quad	93 T/m
Total Quad	144 T/m



Inner Beam Tube	20 mm ID
Outer Cryostat Tube	114 mm OD

Assume inner support tube is copper coated and also serves for beam vacuum.

Estimating the fringe field from NLC final focus quadrupoles.

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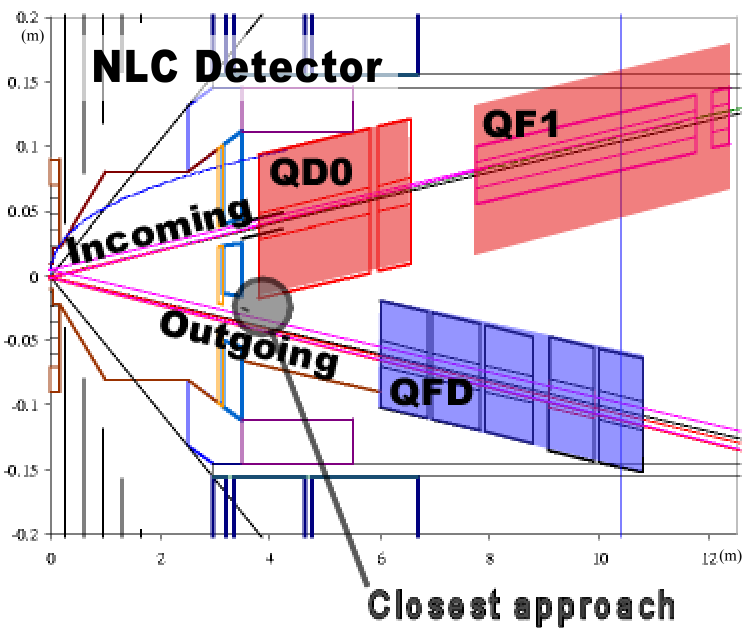
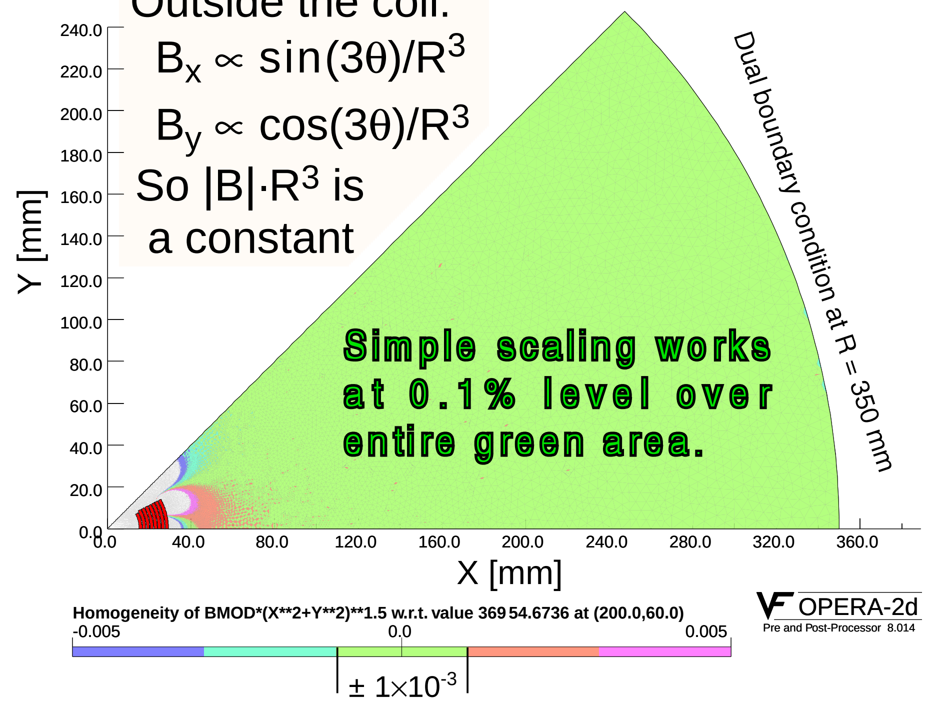
Outside the coil B-field is quite predicable and rapidly becomes small in magnitude.

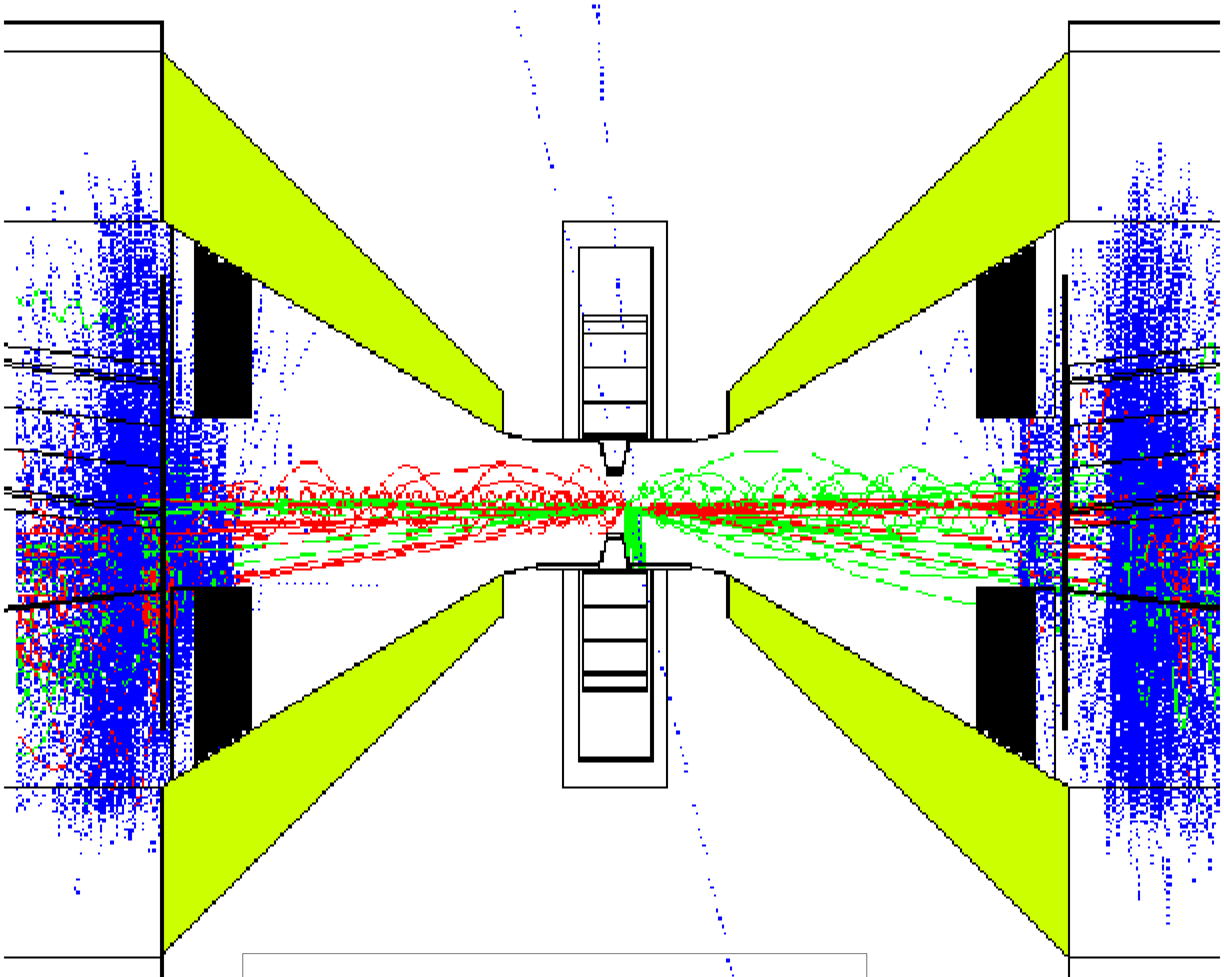


Outside the coil:
$B_x \propto \sin(3\theta)/R^3$
$B_y \propto \cos(3\theta)/R^3$
So $|B| \cdot R^3$ is a constant



Expect only a negligible effect on outgoing beam.

e+,e- pairs from beams. γ interactions



B_{SOL}, L*,& Masks

pairs scales w/ Luminosity

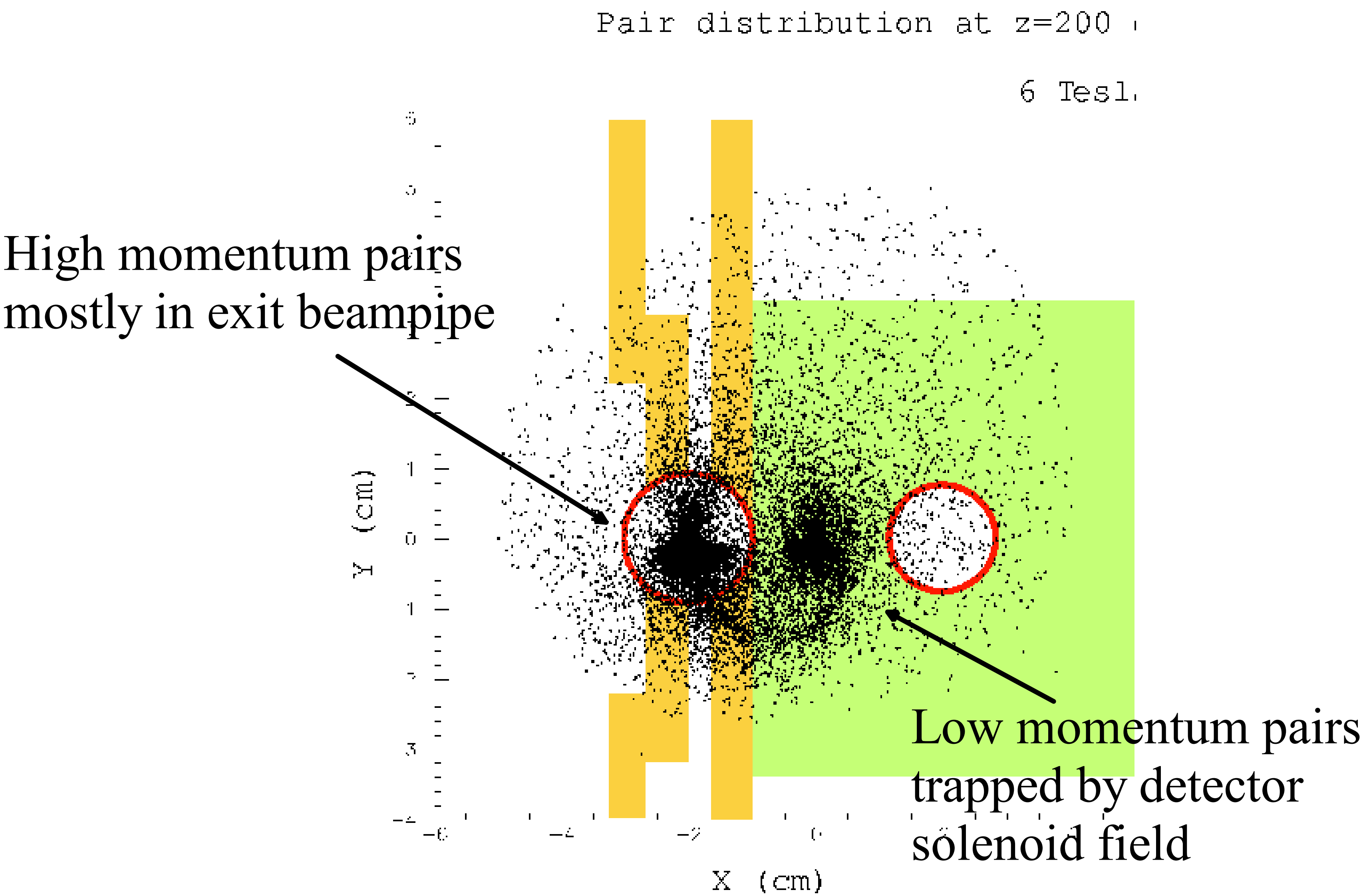
$1\text{-}2\times10^9$/sec

0.85 mW per side

Luminosity Monitor & Pair Monitor will Shield QD

Tom Markiewicz

e,γ,n secondaries made when pairs hit high Z surface of LUM or Q1



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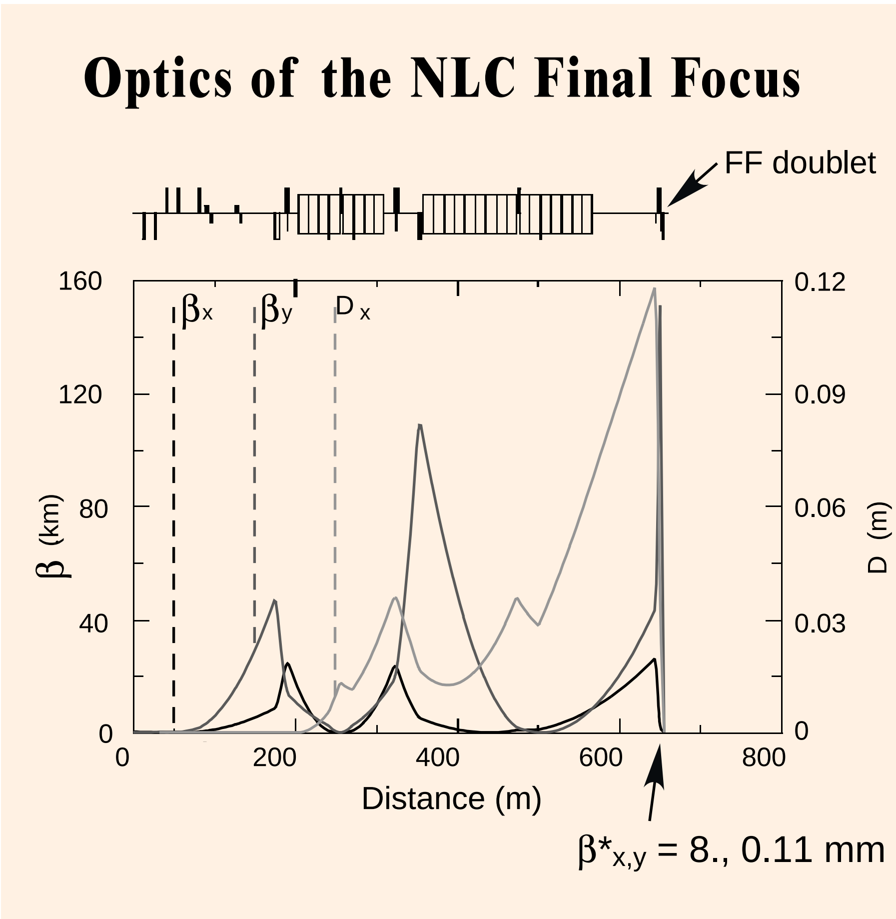
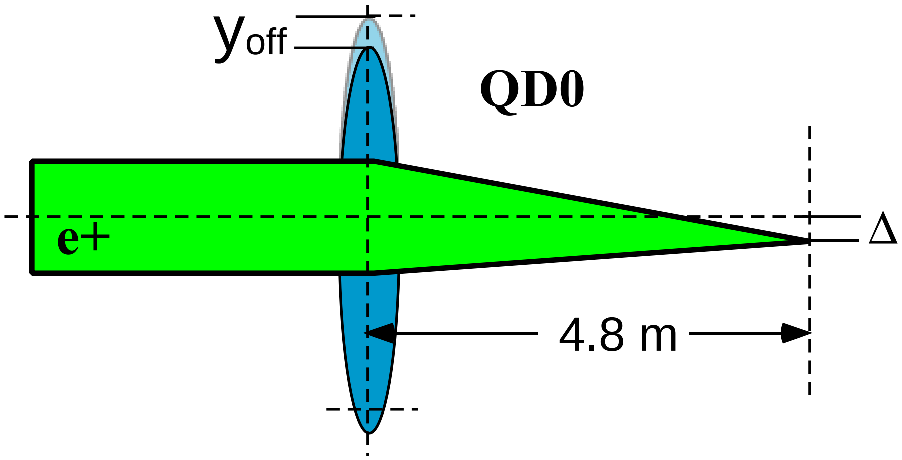
NLC Beam Delivery System: Final Focus Optics Summary.



- Extreme vertical demagnification at IP $(0.11\ \text{mm} \div 150\ \text{km})^{1/2} = 2.7 \times 10^{-5}$.
- Sextupoles needed to correct chromaticity (compensate for momentum spread).
- Beam sizes $\sigma_x/\sigma_y = 243./3.0$ nm at IP (but a few tenths of a mm in FF doublet).
- Small kicks in FF doublet can cause beams to miss each other (Y–offset sensitivity).

NLC Beam Delivery System: Quadrupole Offset Sensitivity.



Let y_{off} = 1 nm, then ΔB = 1.44e-7 T

$$\theta = \frac{2 \cdot 1.44\text{e-}7}{834} = 0.34\text{e-}9 \text{ radians}$$

$$\theta \cdot L = 4.8 \cdot 3.4\text{e-}10 = 1.6\text{e-}9 \text{ m}$$

P = 250 GeV/c

$B\rho$ = 834 T·m

G^{QD0} = 144 T/m

σ_y^{QD0} = 0.11 mm

$\Delta\theta_y^{QD0}$ = 0.74 nr

σ_y^{IP} = 3 nm

L* = 3.8 m

L_m^{QD0} = 2 m

With this simple model vertical quadrupole movement of 10^{-5} σ causes the beam to move by ≈ ½σ at the IP.

Seismic Isolation Issues (ground motion).

Many groups are actively working in this area. Independent of the type of magnet used there will have to be some system that will perform active seismic isolation. It will be assumed that any superconducting magnet system will be mounted on an active isolation platform.

Motion caused by the cryogenic system.

Various cryogenic system configurations will have to be investigated. These configurations will have to minimize any motion the cryogenic system might create in the cryostat and/or cold mass.

Different cooling schemes will have to be looked into to see which one will produce the smallest vibration. Some choices could be forced flow, 4.2°K helium, 1.8°K superfluid or conduction cooling for the magnet.

It will be important to develop a model of the mechanical system. This model can be used to investigate what influence the connection components (bellows, flex hoses, straps, posts etc.) will have in enhancing or minimizing vibration of cold mass relative to the cryostat.

Also passive isolation techniques should be incorporated in any design.

Active vibration isolation of the cold mass.

The choice of cooling scheme, mechanical design, and passive damping will be required to minimize vibration of the cold mass to a level that an active system can reduce further to the nanometer level. Use of existing nanometer positioning sensors, piezoelectric actuators, and low noise accelerometers will need to be investigated for use in a cryogenic system and in the presence of a moderate magnetic field.

These sensors and actuators are currently being used in active vibration isolation systems. The technology used in these sensors and actuators should allow them to perform in this environment but an active isolation system for the cold mass will require six degrees of freedom.

This will mean that many sensors and actuators will be needed and a DSP based control system will be needed for feedback, feed-forward, and sensor processing.