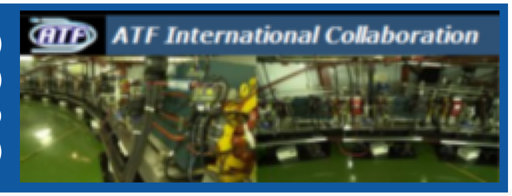
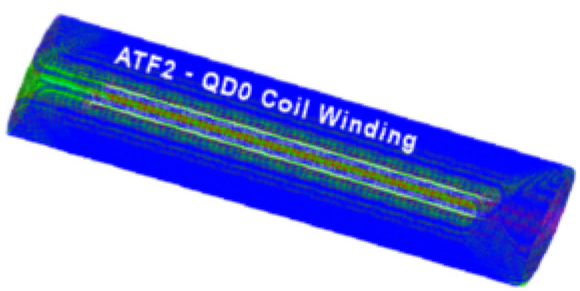
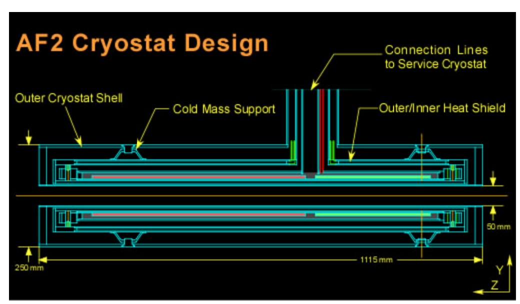
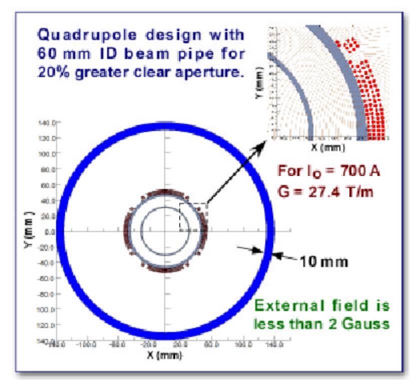


A Superconducting Magnet Upgrade of the ATF2 Final Focus

Co-Leaders: Brett Parker (BNL) and Andrei Seryi (SLAC)







A Superconducting Magnet Upgrade of the ATF2 Final Focus

ATF2 Super Upgrade Goals:

- Gain experience operating ILC-like superconducting final focus magnets.
- Take advantage of opportunity to make improvements to ATF2 final focus optics (reduced IP β).
- Demonstrate feedback and final focus system vibration stability performance required for ILC.
- With these tests extrapolate and compare to CLIC IR specs.
- Finally look for opportunities to improve (maybe simplify) super-conducting final focus magnet design.

Tentative Collaboration:

Michael Anerella, John Escallier, Ping He, Animesh Jain, Andrew Marone, Brett Parker & Peter Wanderer (BNL)

Claude Hauviller & Rogelio Tomas (CERN)

Toshiaki Tauchi, Kiyosumi Tsuchiya, & Junji Urakawa (KEK)

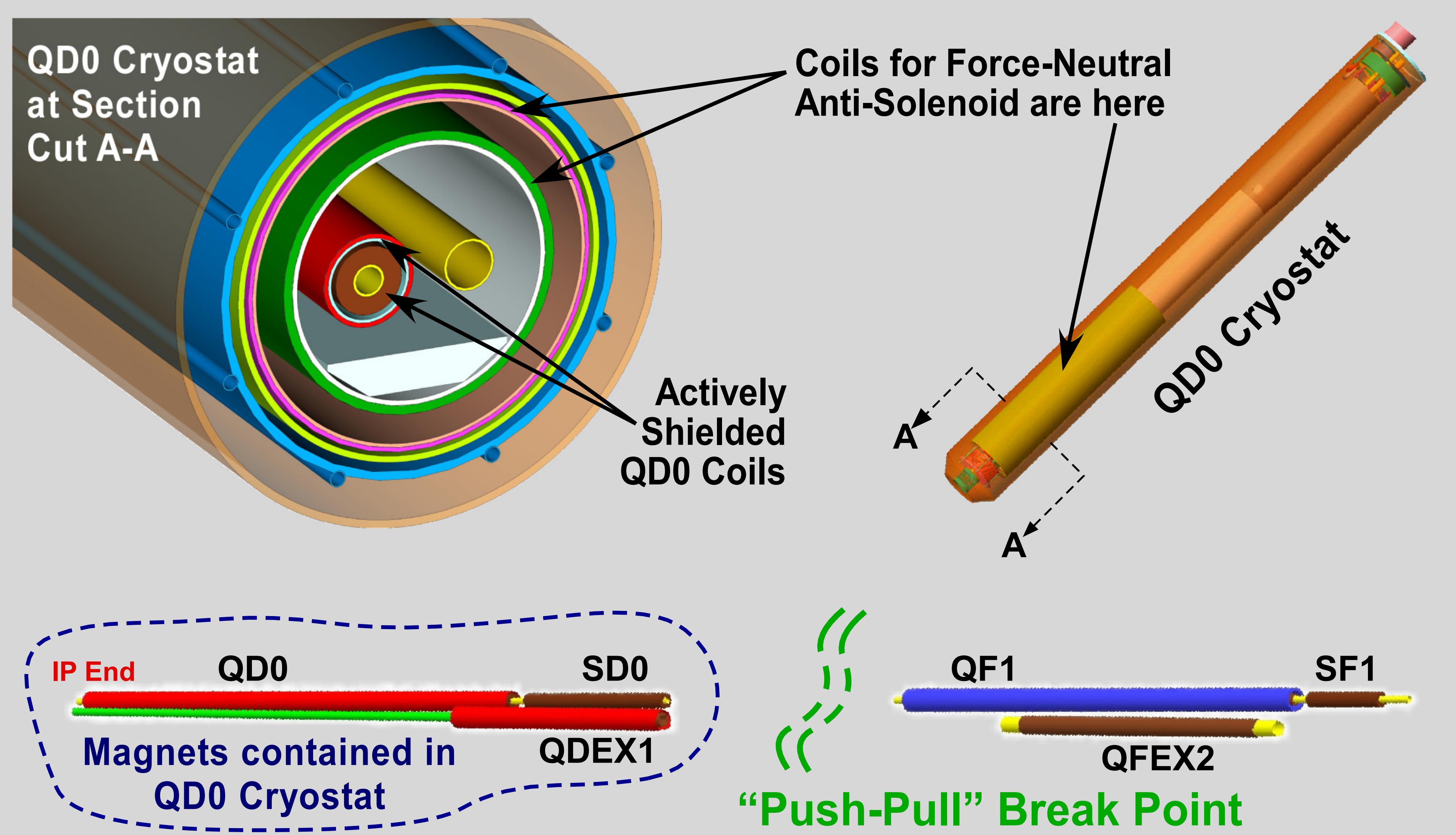
Benoit Bolzon & Andrea Jeremie (LAPP)

David Urner (Oxford University)

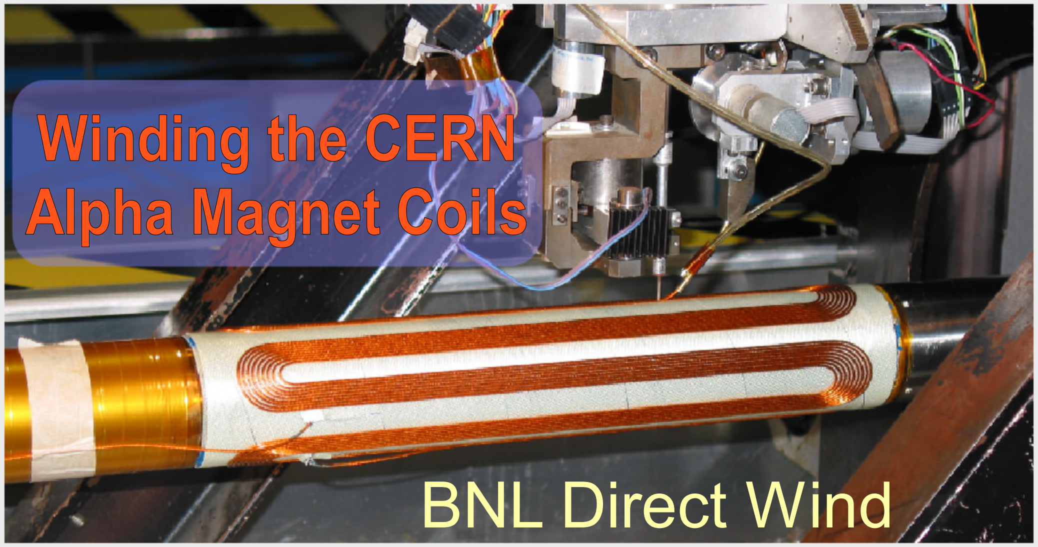
Andrei Seryi (SLAC)

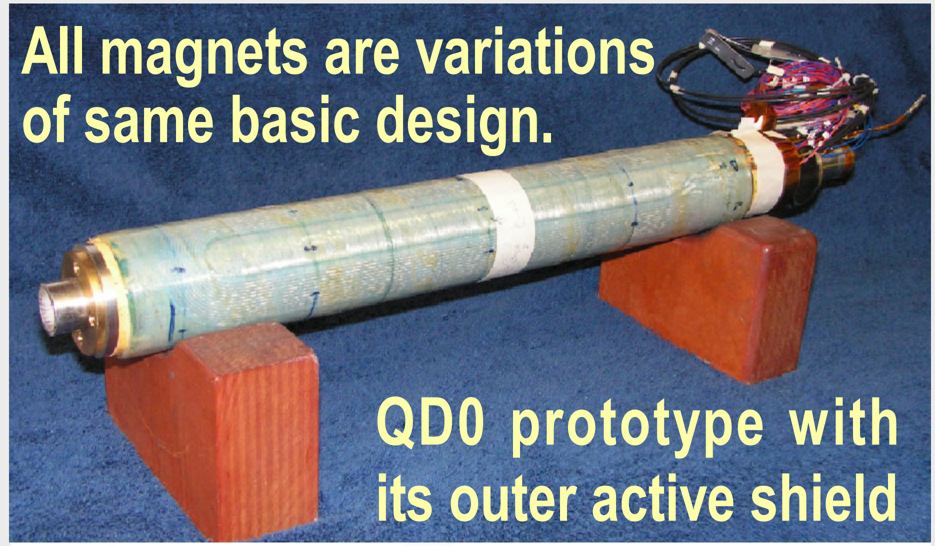
We are at an early stage with the collaboration still forming. Many active discussions are underway and design parameters are being iterated.

ILC 14 mr IR Magnet Design Highlights.

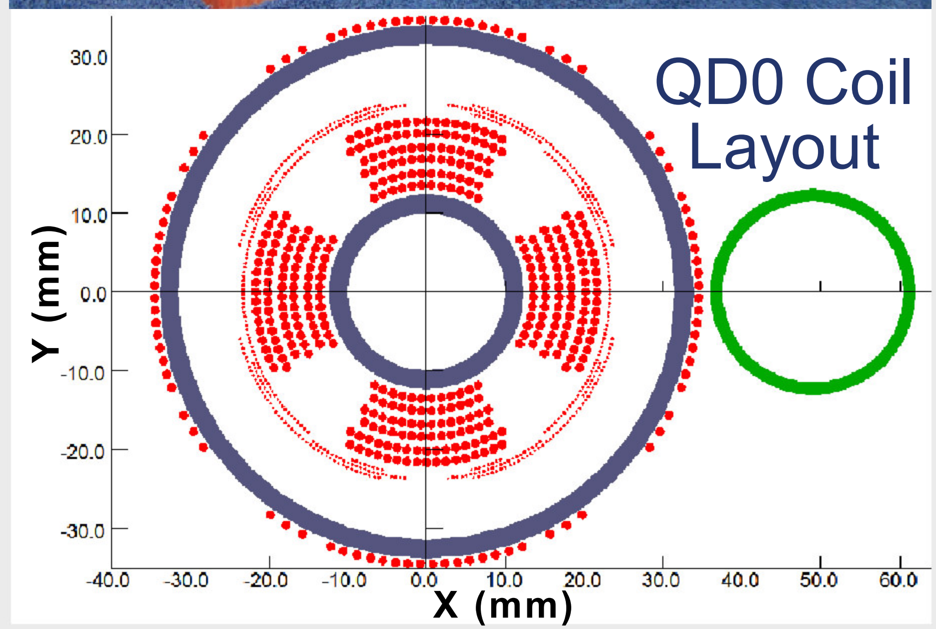


Production of Compact Superconducting Magnets Used in the ILC 14 mr IR Layout.



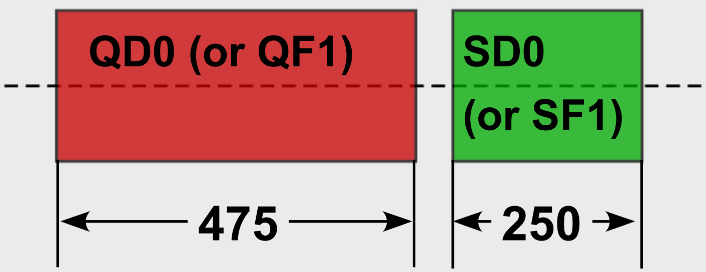


- 14 mr crossing angle via compact self-shielded QD0 coil windings.
- Extracted beam passes just outside coil into separate focusing channel.
- Cryostat to fit within limited space inside detector at L* = 3.5 to 4.5 m.



Preliminary Design Parameters for ATF2.

Proposed Magnetic Lengths (mm)



50 mm ID Warm Bore

G_{QD0} = 31.4 T/m @ 700 A

B_{SD0} = 0.234 T @ 700 A
and R = 25 mm

QD0 has dipole correctors

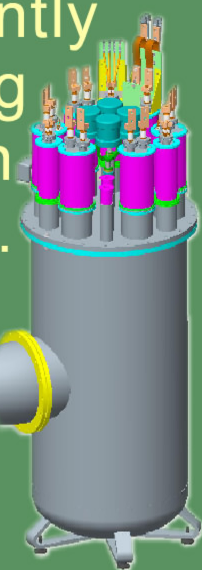
SD0 has skew-sextupole, quad and skew-quad

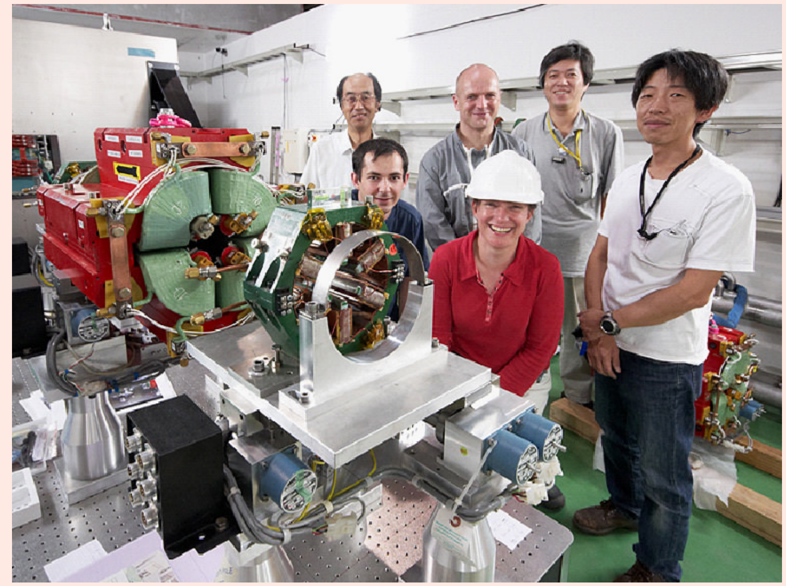
- Only produce one quadrupole/sextupole magnet combination (in common cryostat).
- No self-shielding or anti-solenoid (simple).
- KEK Cryogenic system (major challenge).
- 50 mm aperture but with a warm bore (optimize to reduce cold mass heat leak).
- Minimum degrees of freedom (correctors).
- Found it easy to match all corrector coil magnetic lengths to their main coils.

ATF2 Upgrade Cryogenic Considerations.

QD0 Prototype Magnet & Service Cryostats

No cryogenic system presently on the floor at ATF2; getting approval for a new setup in Japan could be challenging. Will look to go with a small stand alone system. Critical to minimize heat load (cryostat, current leads etc.).



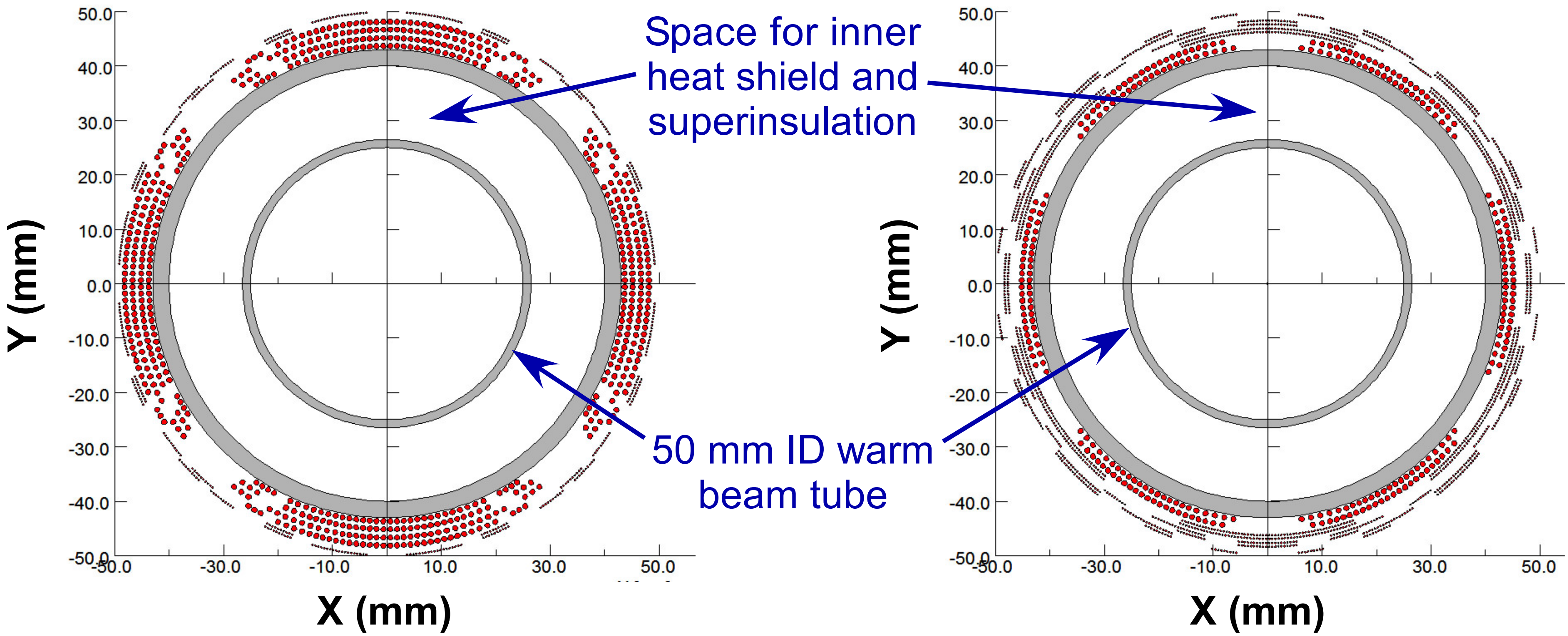


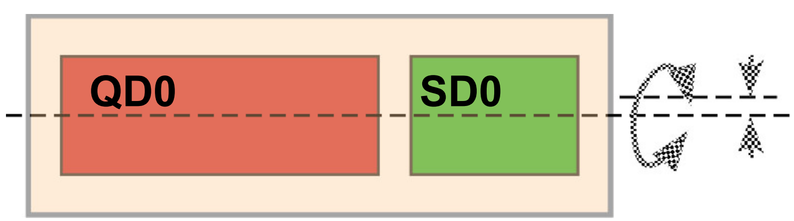
ATF2 Final Focus Magnets

Take advantage of design work, production and testing of a full length QD0 prototype at BNL to make magnets appropriate to ATF2.

Preliminary ATF2 Coil Configuration.

ATF2 - QD0: All Layers Are Shown **ATF2 - SD0: All Layers Are Shown**

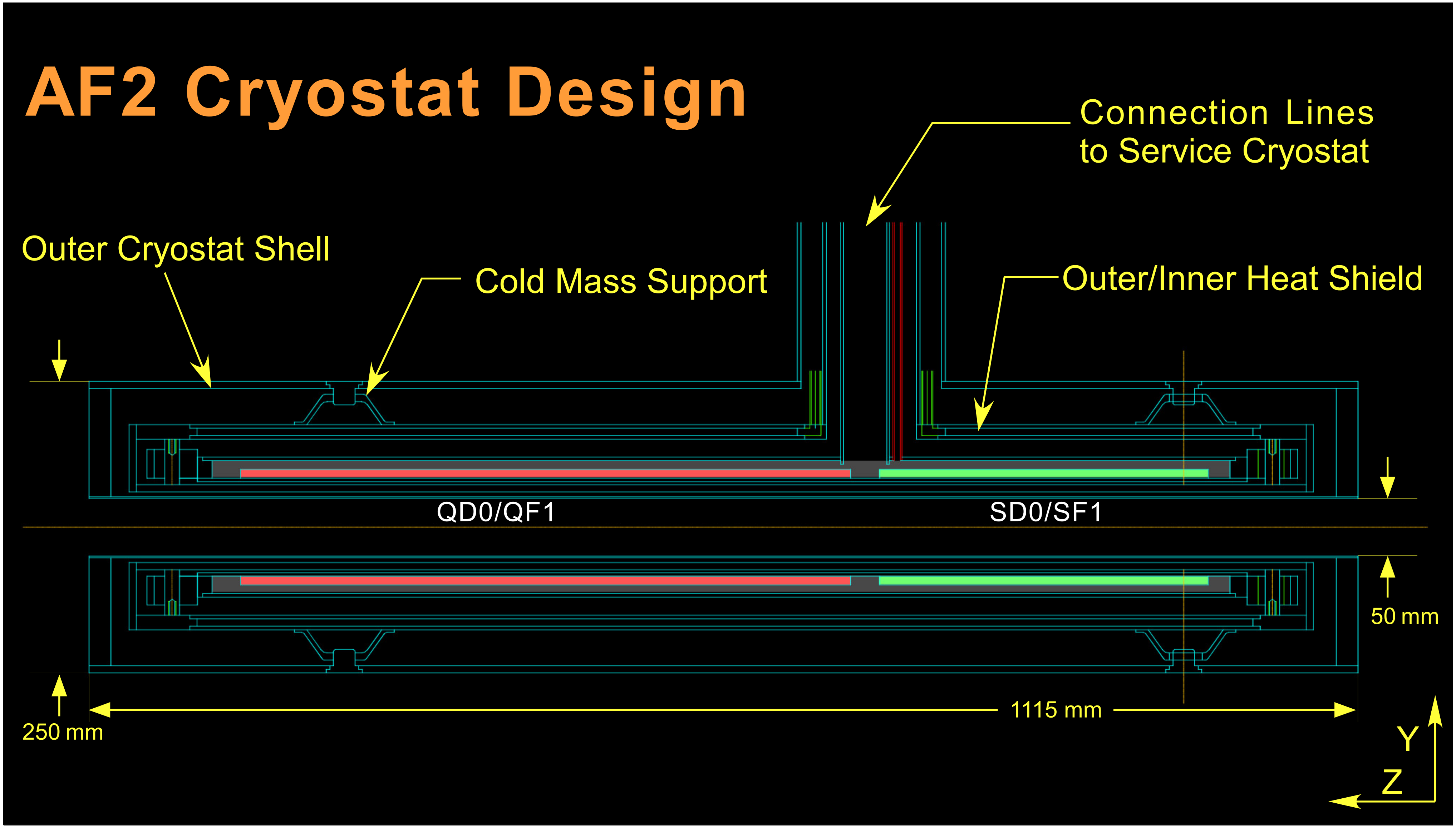




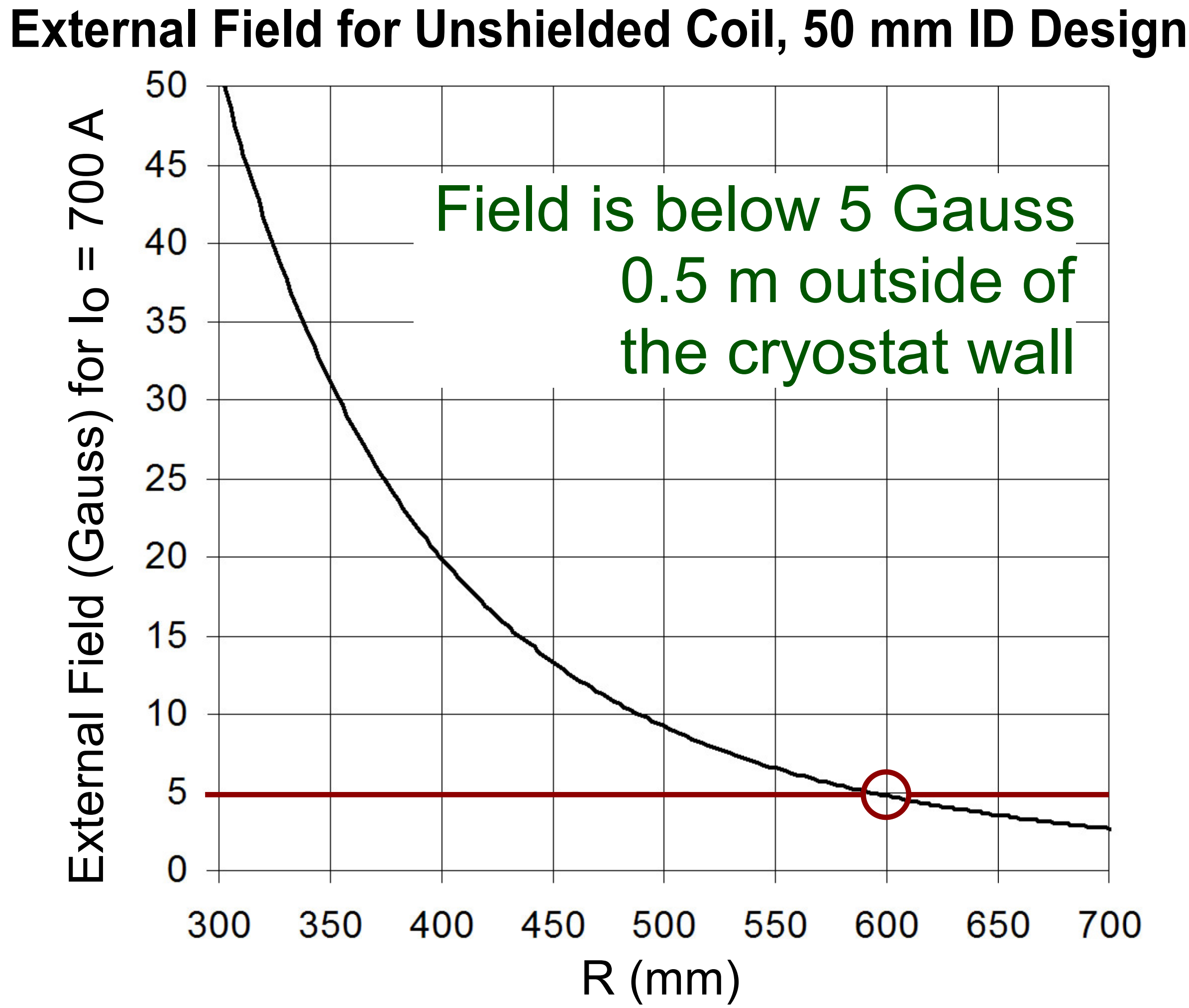
QD0 and SD0 in a Common Cryostat

With the proposed correction coils, we have magnetic degrees of freedom to both alter their relative offset and give an effective rotation between QD0 & SD0 (inside common cryostat).

Preliminary Cryostat Design for ATF2.



External Field from Unshielded Quad Coils.

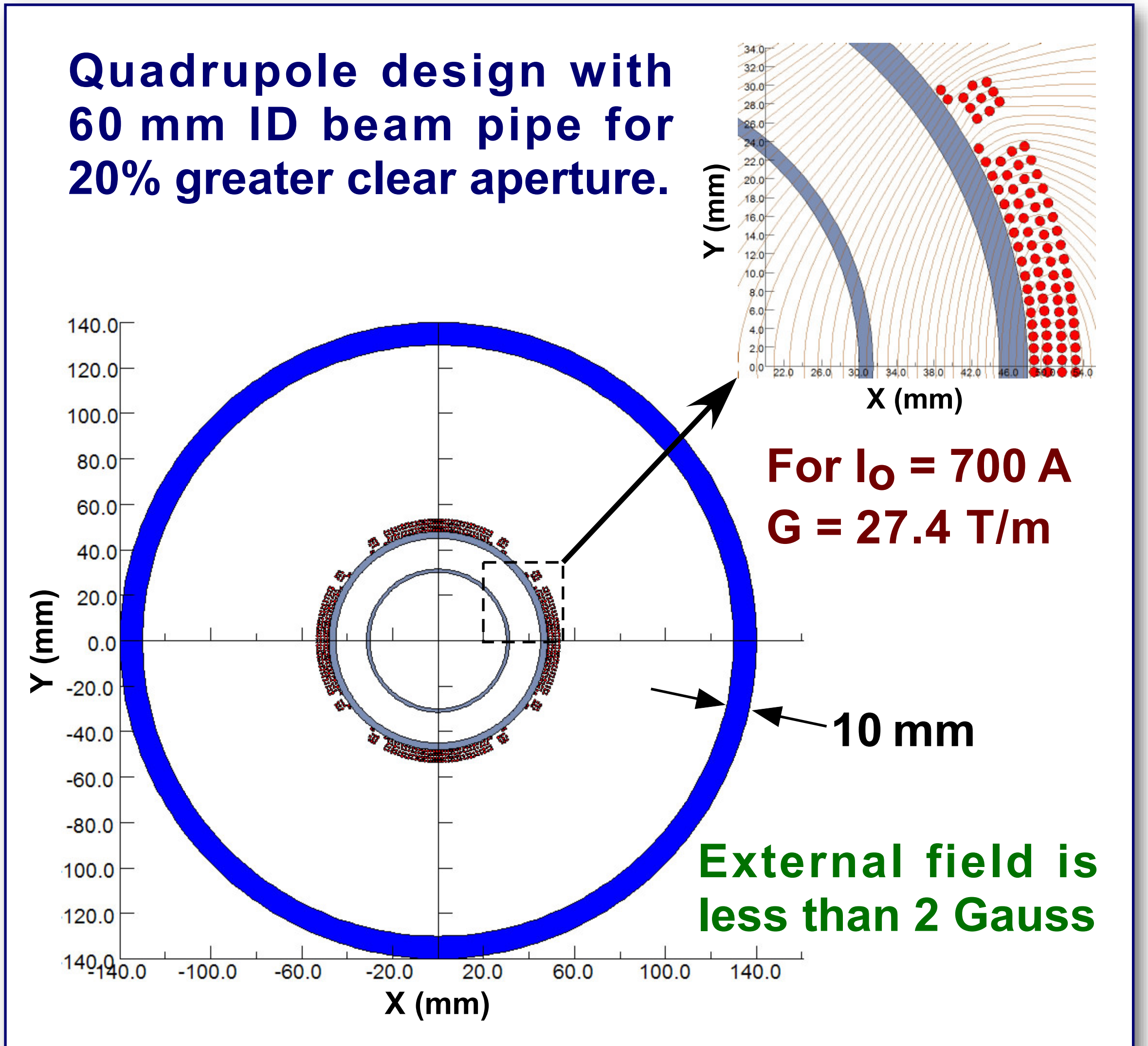


For quadrupole coils, the external field drops as $(R_{coil}/R)^3$ (longest range component), so for a given gradient the external field from a increased radius coil is starts larger (i.e. higher coil field) and then falls off more slowly with distance (larger scale factor).

Also there is a concern that iron pieces (nuts, bolts and plates) in ATF2 might impact field quality.

What happens if we want to increase the coil radius?
What if we want to attach geophones to the cryostat?

Look to Increase Quadrupole Aperture and to Implement Passive Shielding.

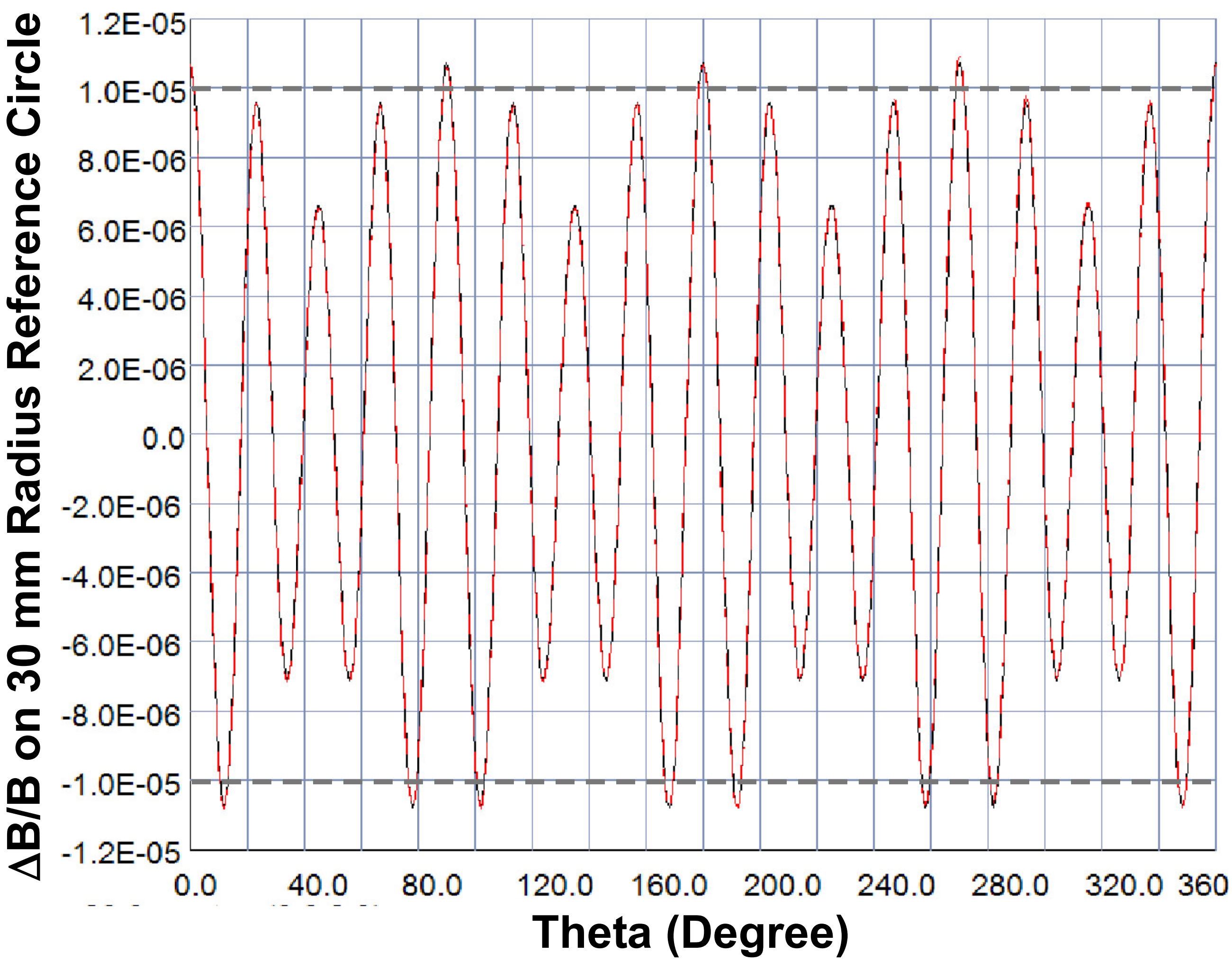


Shield also protects beam from external influences.

In thinking about ultra-low β* optics, it may be desirable to increase system aperture for lower background and we must pay attention to field quality. But increasing the coil size also increases the fringe field. We can mitigate this with a simple shield that also will prevent field from coupling to any magnetic materials in the ATF2 environment. The shield shown here only adds 2.4% to the transfer function and does not impact the field harmonics.

Field Harmonic Sensitivity to Shield Offset.

|B| Uniformity of a part in 10^5 at 30 mm (2d)



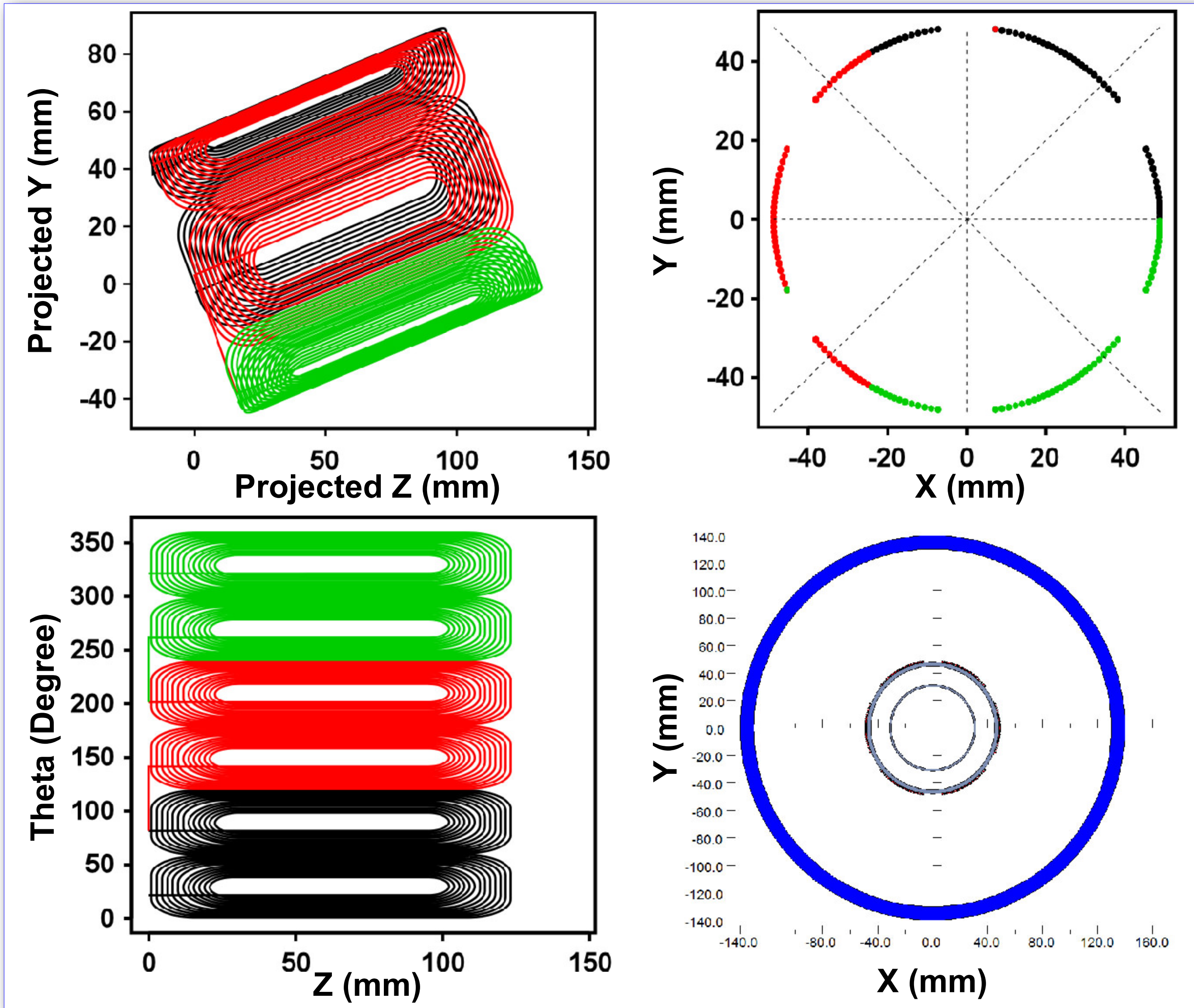
ΔB/B with zero yoke offset on 30 mm radius circle with zero vertical offset.

ΔB/B with 0.254 mm (0.0100") vertical offset on a 30 mm radius circle offset in Y by 0.00676 mm (0.0003").

Note that since the yoke only adds 2.4% to quad's transfer function, giving the yoke a small offset hardly changes the harmonic content once we take into account the much smaller effective magnetic center shift.

Field uniformity is virtually unaffected by small shifts of the shield.

A Single Layer Sextupole Design with Increased Aperture and a Shorter Coil.

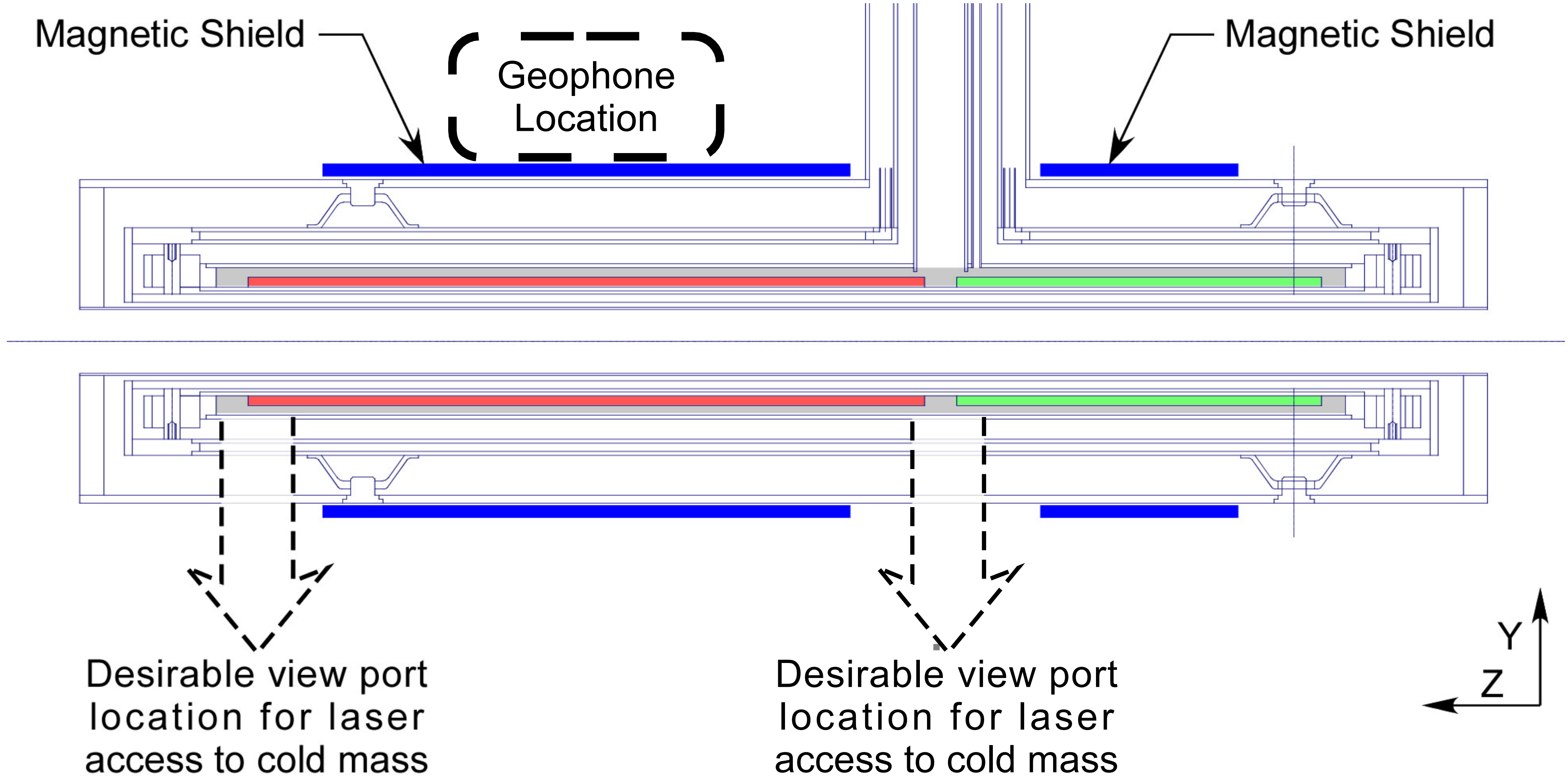


Single Layer Sextupole

30 mm radius beam tube
L_{coil} = 124 mm
$L_{magnetic}$ = 100 mm
For I_o = 700 A we have
B = 0.097 T at R = 25 mm

In addition to increasing the sextupole's aperture it was recently suggested to reduce its magnetic length to lessen system aberration. Fortunately the proposed integrated strength is small enough to allow this even while going from two layers to a single layer coil winding.

Next Steps: ATF2 Cryostat Design.



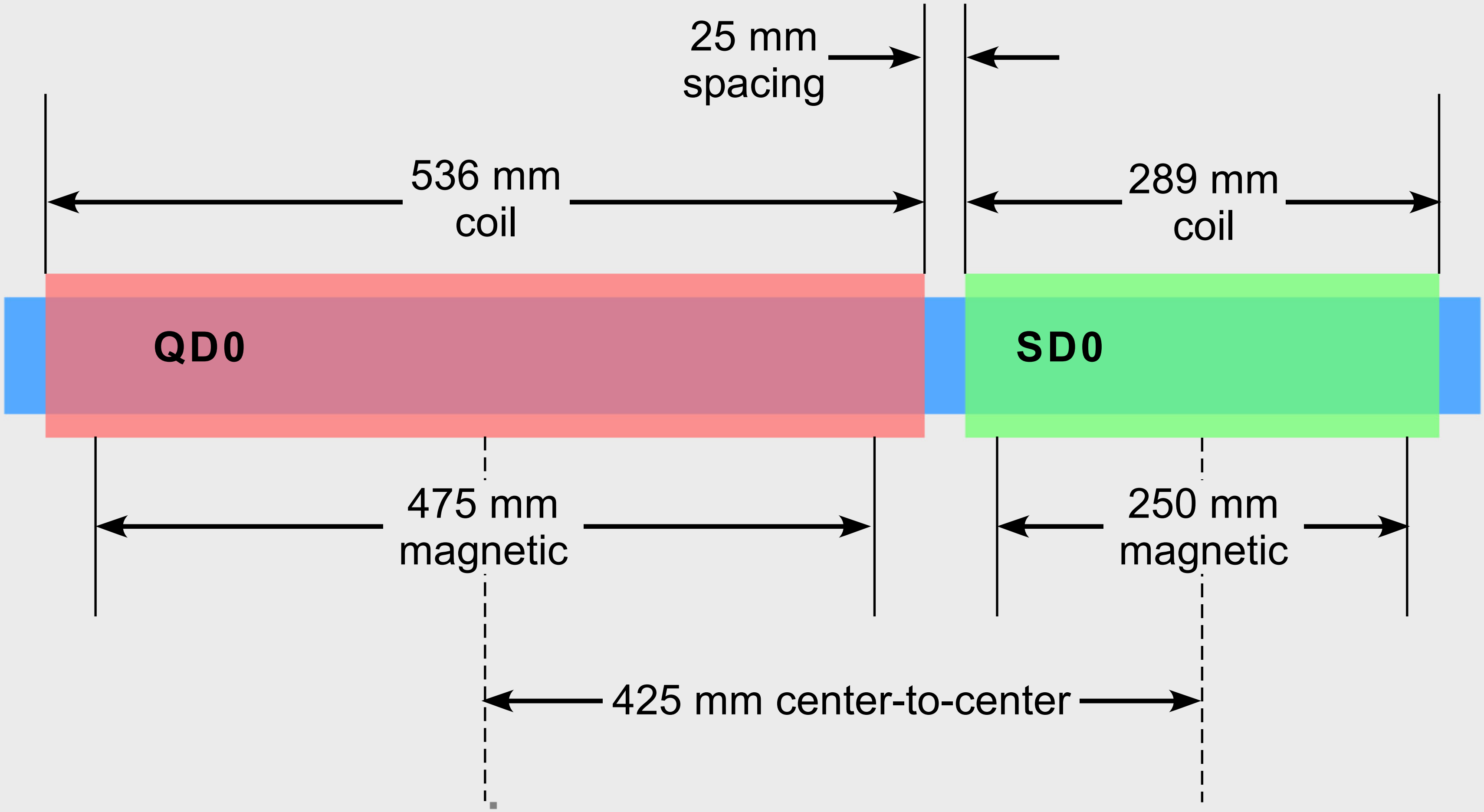
Remember: We may want to increase aperture to 60 mm & shorten sextupole coil.

Next Steps: Work of the Collaboration.

- At this point we have had only a limited discussion of our ideas for making vibration stability measurements with a Monalisa like system (and cross checks) but there is also some interest within the collaboration to actively stabilize superconducting magnets... these plans should be firmed up ASAP.
- From the perspective of making various optics tests, ultra-low β^*, longer/shorter L* and higher chromaticity or traveling focus, we find reasons to modify the magnet design parameters. We need to review these ideas within the collaboration and come to agreement on a final design configuration and tests.
- We are close to having a first pass cryogenic design and the information (for example heat load) that will be needed to assess the cryogenic system impact for KEK.
- By the end of January 2009 look to make first pass on proposal baseline estimate of resources needed and viable schedule.

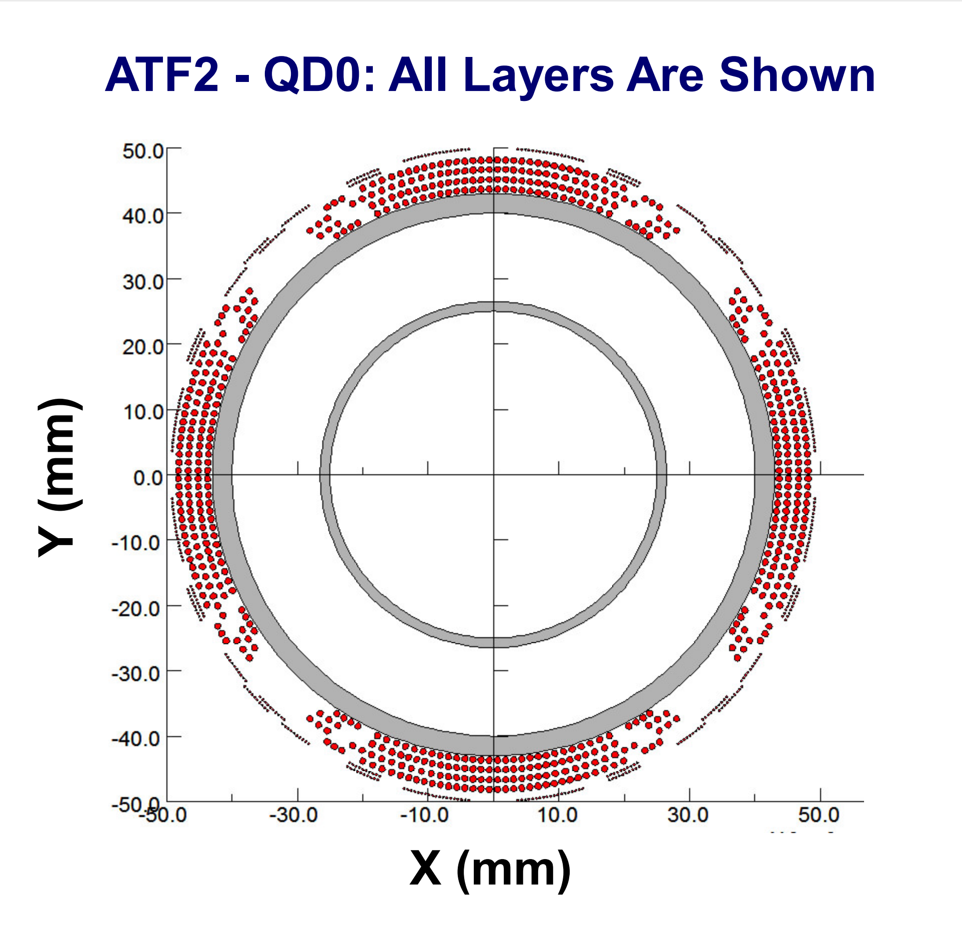
Supplemental material starts after this slide.

Proposed ATF2 - QD0/SD0 Coil Layout.



Parameters based upon the 06-Oct-08 ATF2 coil design files.

Proposed ATF2 - QD0 Coil Parameters.



SS warm beam tube 50 mm ID (clear bore) with 1.5 mm wall

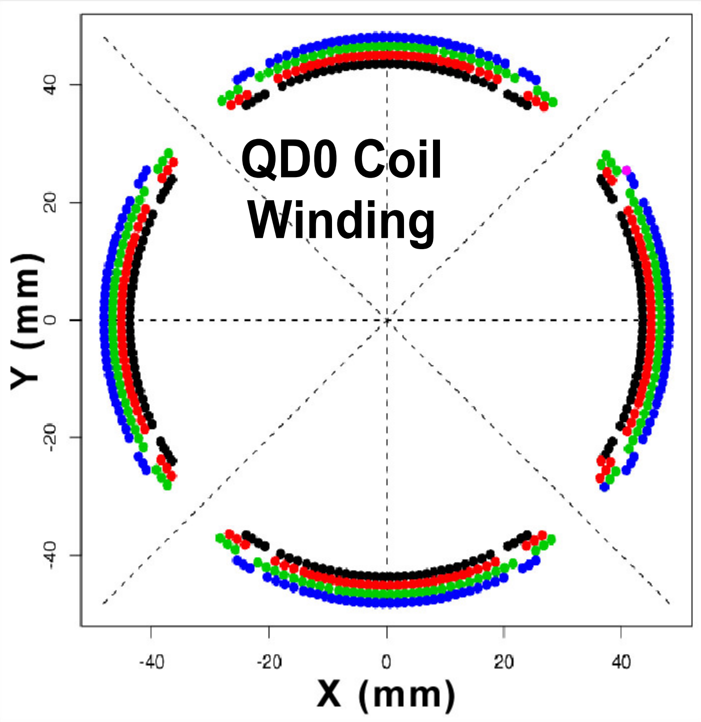
SS cold support tube 80 mm ID (clear bore) with 3 mm wall

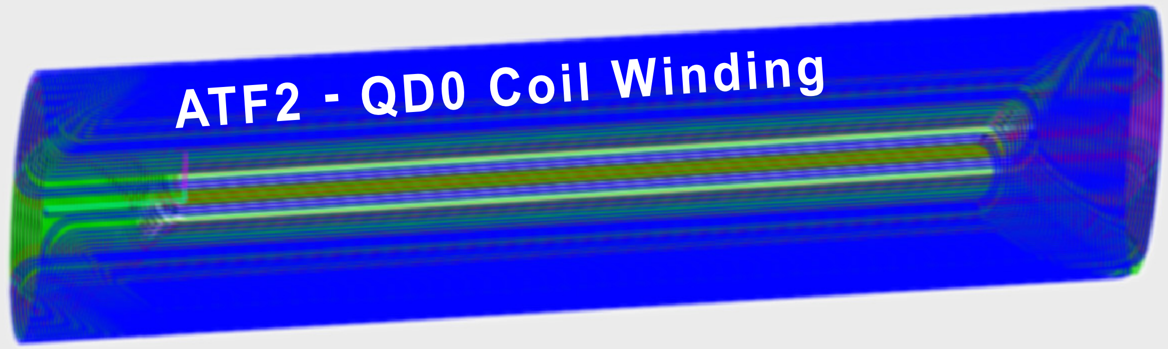
QD0 coils with 7-strand cable four layers with cable centers at R_{cond} = 43.70, 45.15, 46.70, 48.15 mm

Single strand dipole corrector one layer with wire center at R_{cond} = 49.30 mm

Single strand skew-dipole corrector one layer with wire center at R_{cond} = 49.95 mm

ATF2 Superconducting Upgrade: QD0.

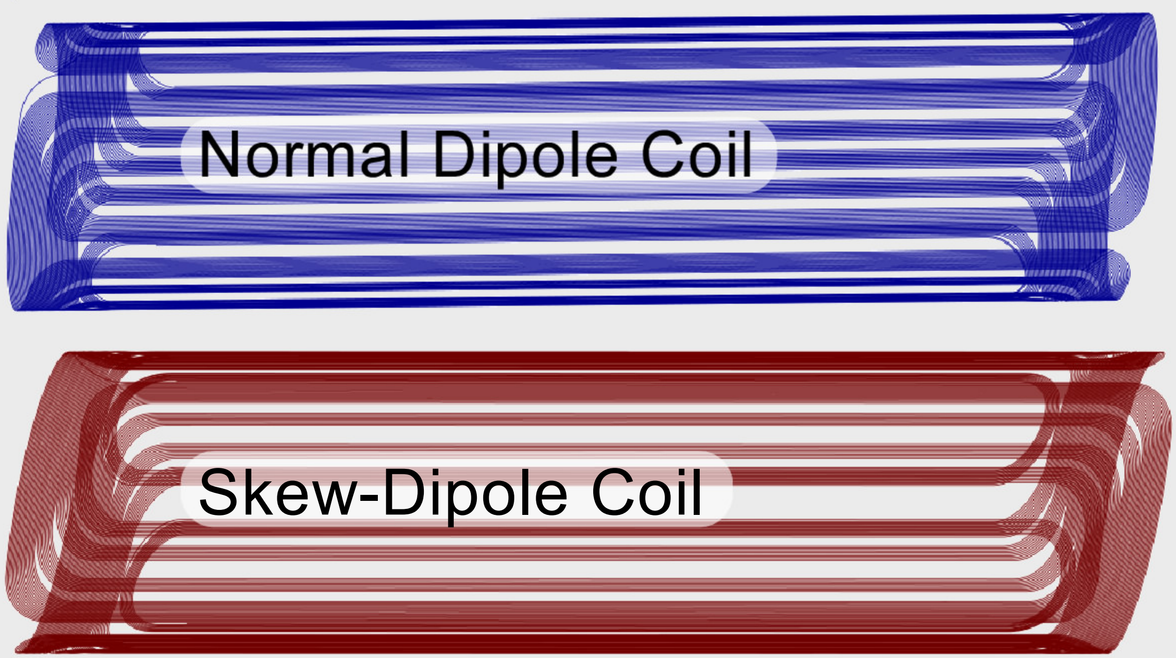


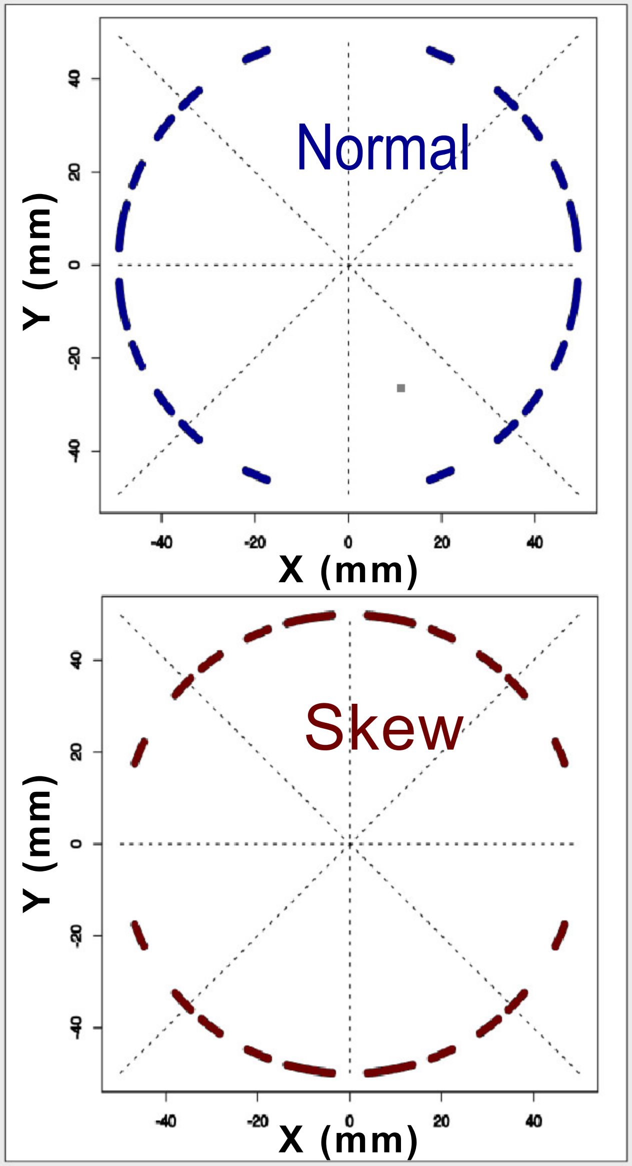


Design has four layers of 6-around-1 cable, in two Serpentine coil sets, with a 536 mm pattern length and 475 mm magnetic length.

- *Excellent design harmonics out to edge of warm bore, R = 25 mm.*
- *Two coil sets; do field angle/harmonic correction during production.*
- *Space is budgeted for intermediate heat shield and a warm bore.*
- *Next slide for co-wound dipole and skew-dipole correction coil info'.*

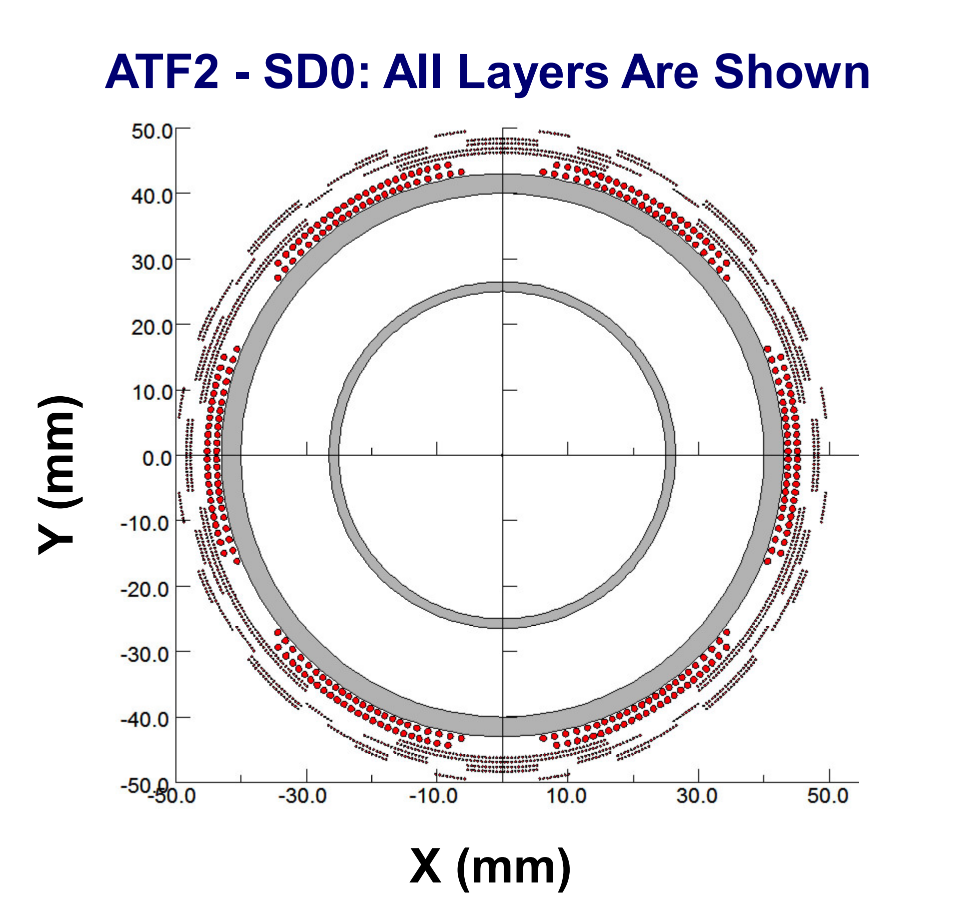
ATF2 Superconducting Upgrade: QD0.





Wind single layer dipole and skew-dipole correction coils atop QD0, using single-strand wire, with parameters carefully matched to QD0's physical & magnetic length.

Proposed ATF2 - SD0 Coil Parameters.



SS warm beam tube 50 mm ID (clear bore) with 1.5 mm wall

SS cold support tube 80 mm ID (clear bore) with 3 mm wall

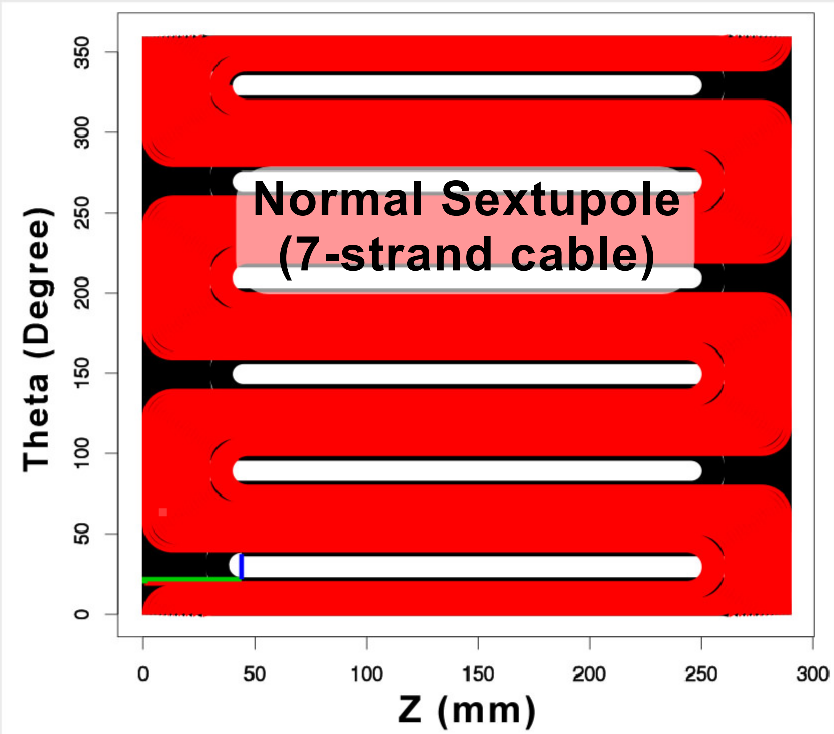
SD0 coils with 7-strand cable two layers with cable centers at R_{cond} = 43.70, 45.15 mm

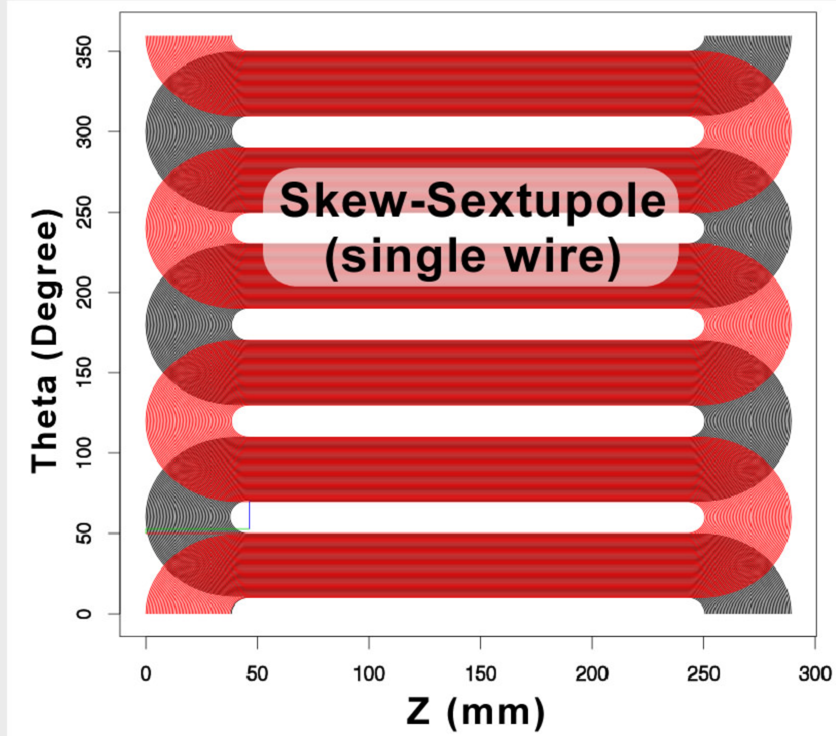
Single strand skew-sextupole corrector two layers with wire centers at R_{cond} = 46.25, 46.90 mm

Single strand quad corrector two layers with wire centers at R_{cond} = 47.70, 48.35 mm

Single strand skew-quad corrector two layers with wire centers at R_{cond} = 49.15, 49.80 mm

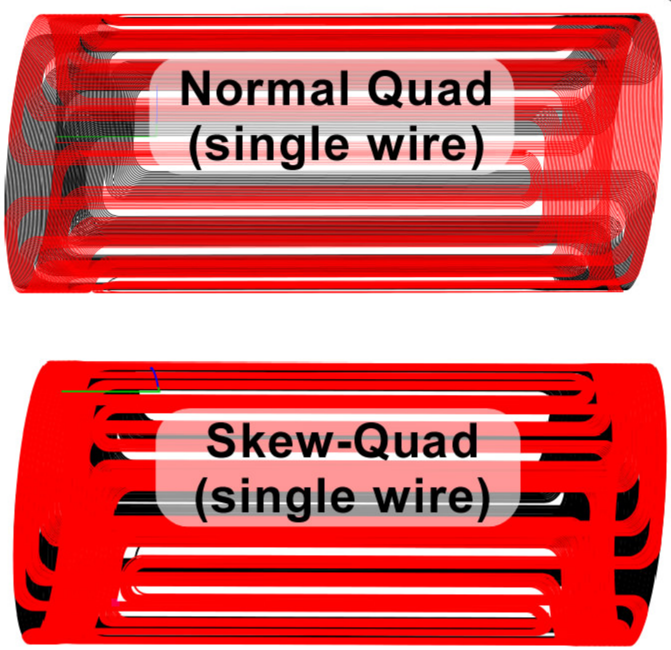
ATF2 Superconducting Upgrade: SD0.





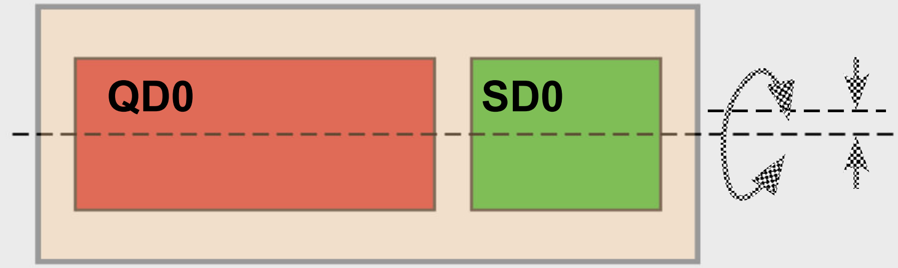
- *Single two-layer Serpentine coil sets for normal and skew-sextupole.*
- *Excellent design harmonics out to edge of warm bore, R = 25 mm.*
- *Wind sextupole first, before doing QD0, on same tube and measure.*
- *Next slide for co-wound quad and skew-quad correction coil info'.*

ATF2 Superconducting Upgrade: SD0.



Normal and skew-quadrupole coil windings are matched to the SD0 sextupole total pattern & magnetic lengths.

QD0 and SD0 in a Common Cryostat



Note: With the proposed correction coils, we have magnetic degrees of freedom to both alter their relative offset and give an effective rotation between QD0 and SD0 (inside their common cryostat).

Need to check proposed field strengths against the reduced-beta* scenarios & start engineering design.