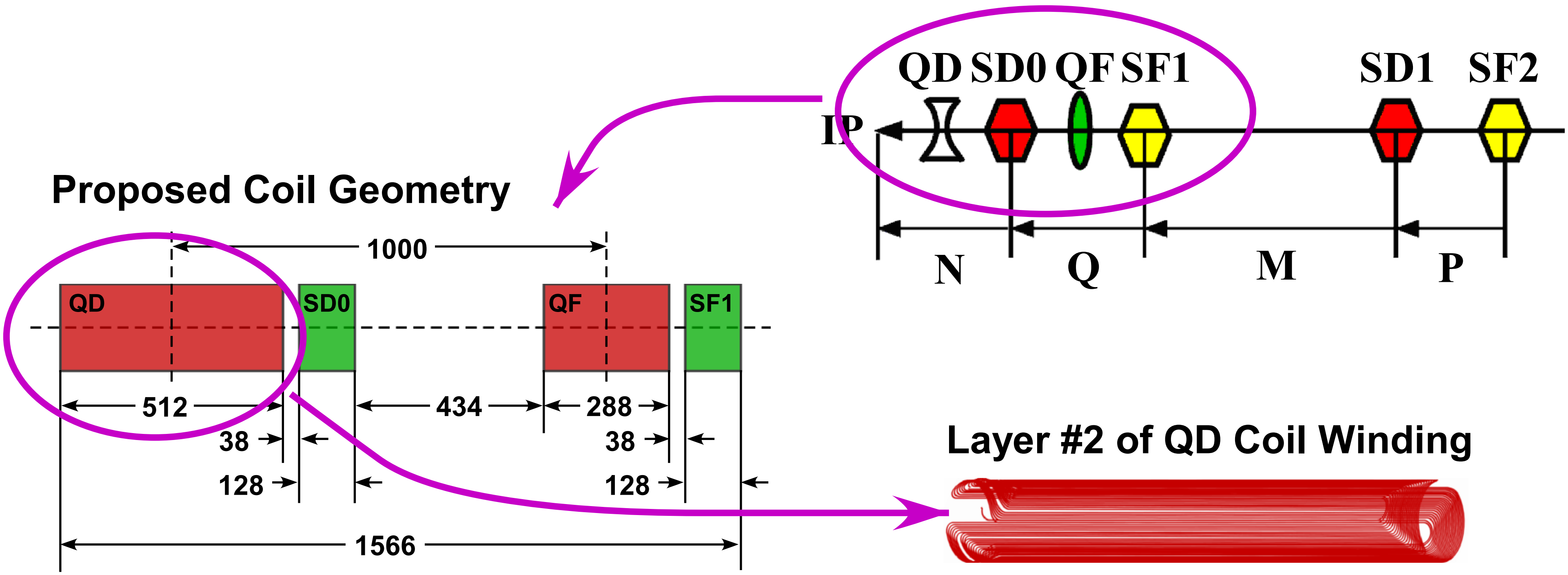
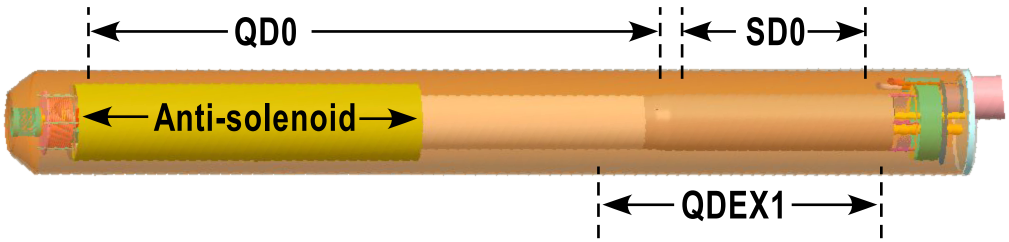
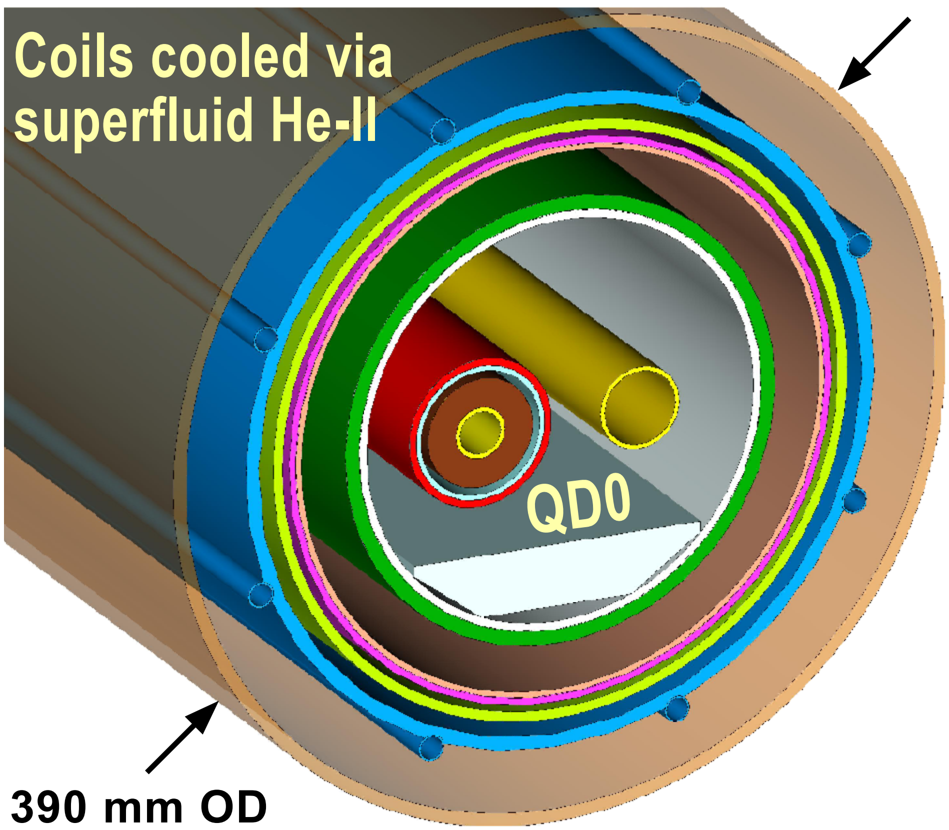
Superconducting Final Focus for ATF2

Brett Parker for the BNL Superconducting Magnet Division



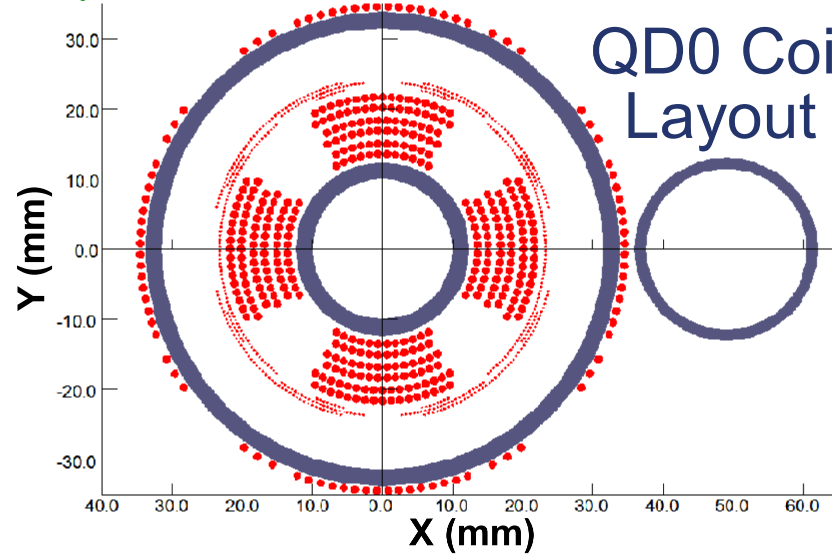
Features of Baseline 14 mr IR Magnets

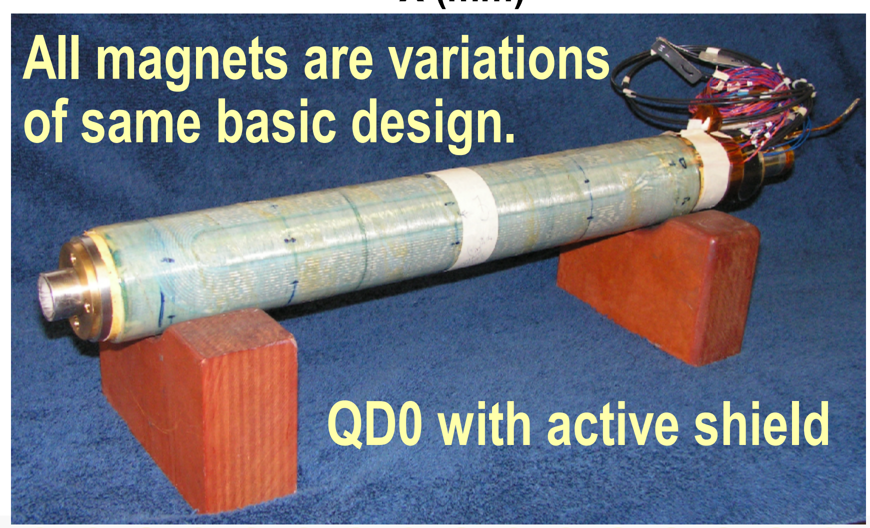




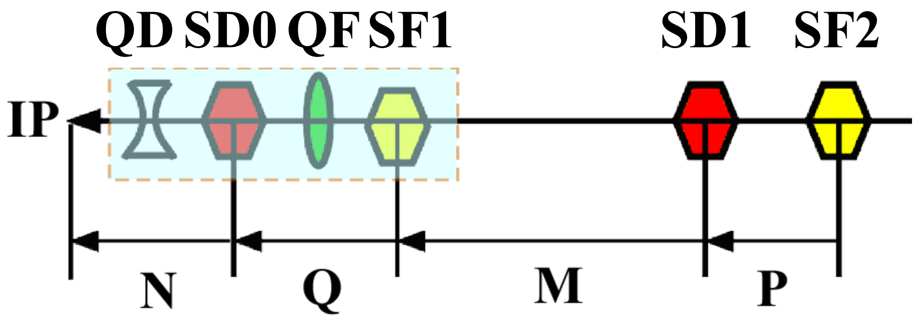
QD0 Cryostat Design for L* = 4.5 m

Actively Shielded Quad with Dipole & Skew Correction Coils





Superconducting Final Focus for ATF2

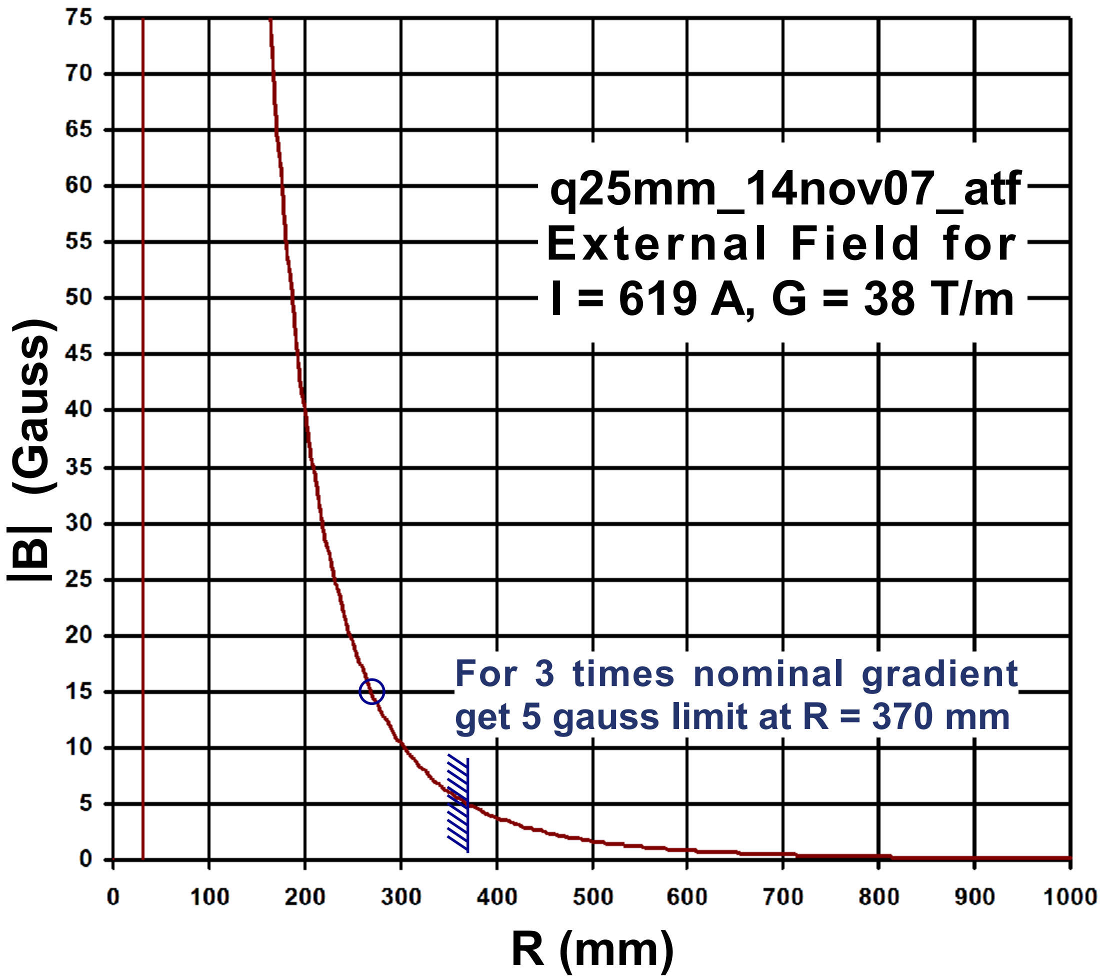


Considered cooling coils in a simple 4.2°K helium bath, but then what we are testing does not look (or act) much like the actual ILC FF system.

To keep with a He-II system there is a big advantage if we can reuse the Service Cryostat from the QD0 R&D prototype.

- Need both QD and QF but not the extraction line quads; same number of main quads as in R&D prototype.
- Combine the FF magnets in common magnet and service cryostats (save).
- No detector solenoid -> so no point in having an anti-solenoid (saves leads).
- Can reach desired SD0/SF1 fields with a low-current conductor (saves leads).
- No need for active shielding (Slide #4).
- With all of the above, it looks like we can reuse the R&D Service Cryostat.

ATF2 QD/QF Without Active Shielding

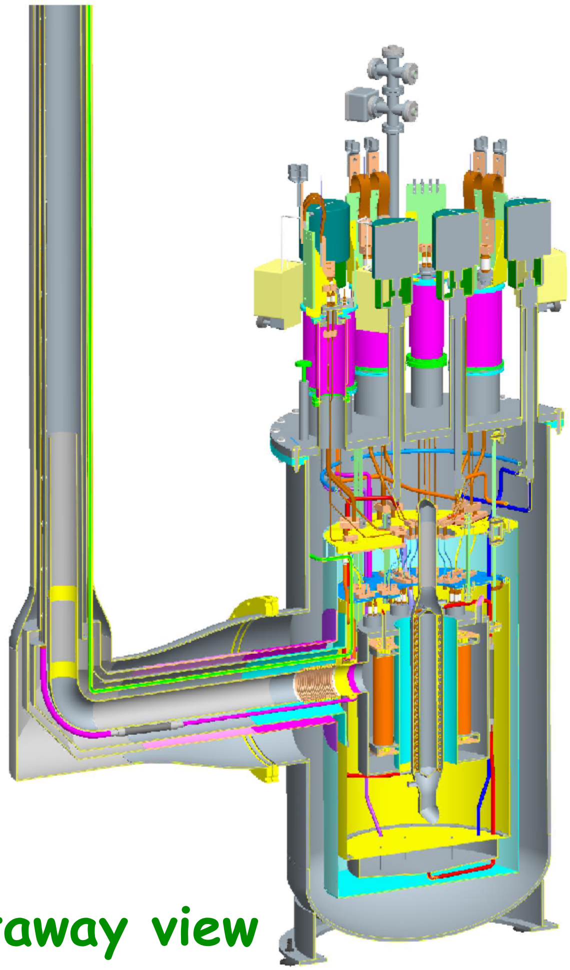


In order to simplify the QD and QF coil designs (to reduce cost) we produce them without active shields.

Limit personnel access in immediate region next to magnet to ensure that magnetic field exposure is smaller than 5 gauss.

"Three times nominal gradient" was suggested as a goal if we ever want to further reduce β^* in the future.

Reuse R&D Prototype Service Cryostat for ATF2

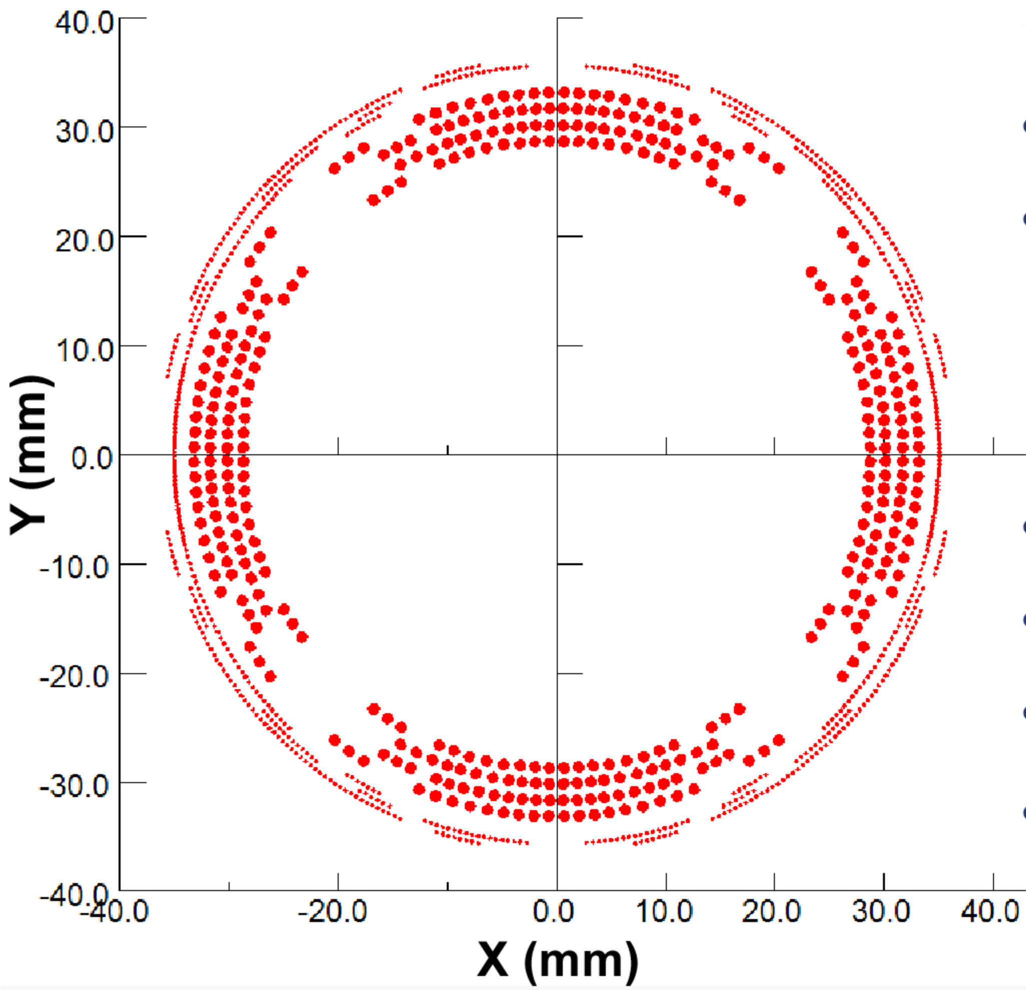


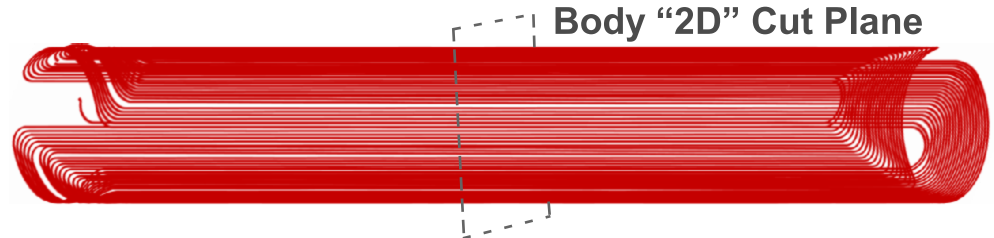
Cutaway view of Service Cryostat for the QD0 R&D Prototype

- Enjoy cost savings by making few new parts.
- Test a system much like the actual ILC final focus (He-II heat exchanger & transfer line).
- With 12 high-current leads & 24 low-current leads, has enough to power the ATF2 FF coils.
- Simple well defined interface for cryogenics.
- Can put feed point well away from magnets.
- Does not require source of He-II but rather done locally in the Service Cryostat itself.
- Take advantage of experience commissioning the QD0 R&D Prototype.

ATF2 QD/QF Coil Design Summary

Coils are wound from both seven-strand cable & single-strand wire

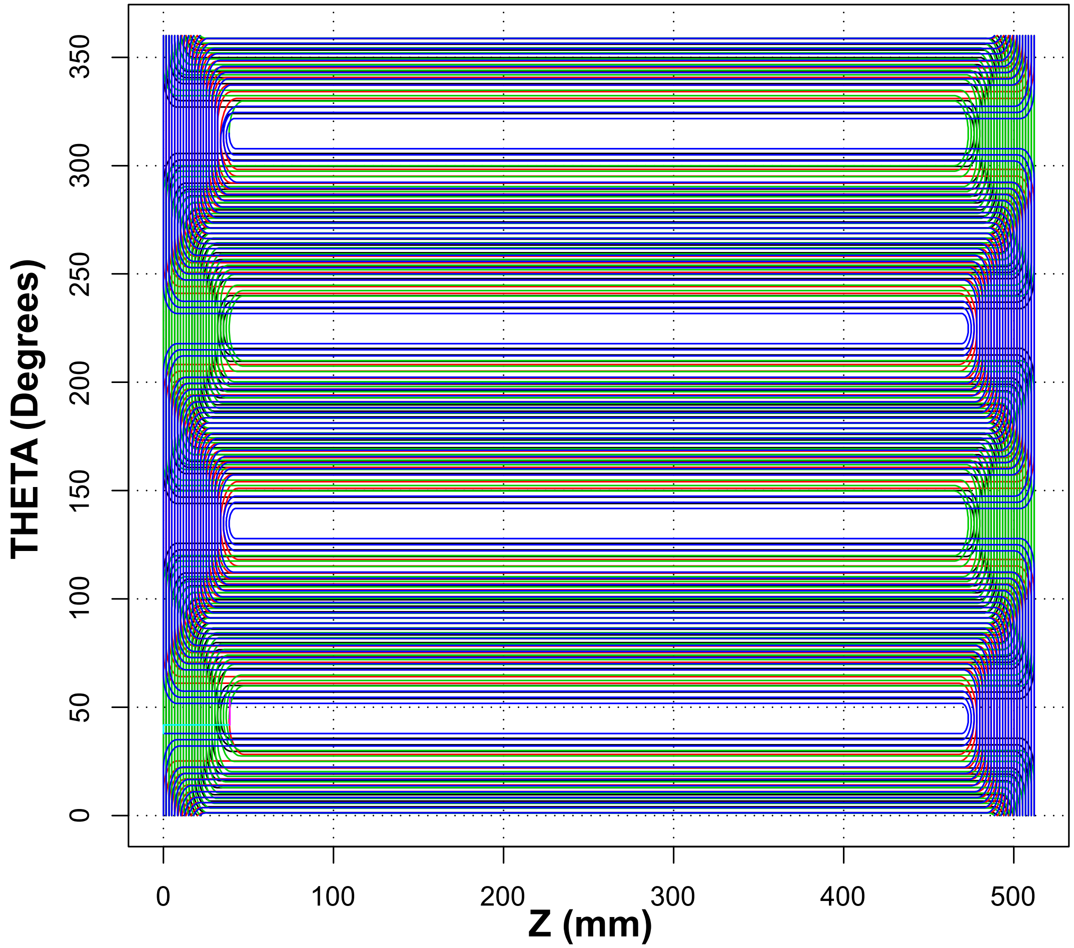


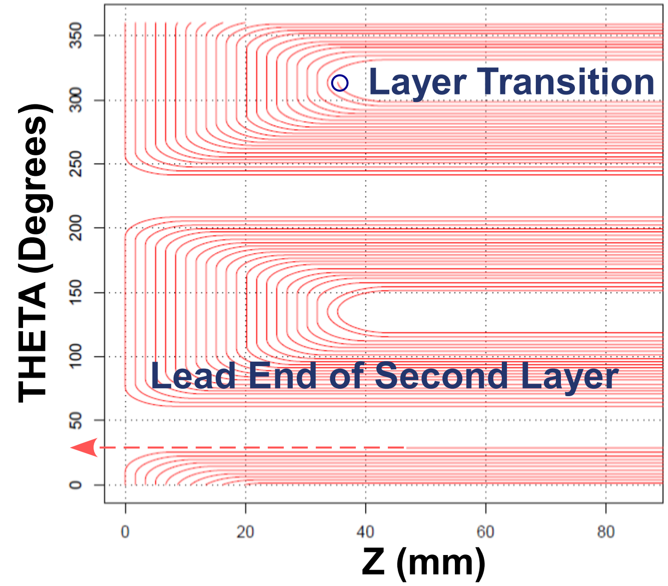


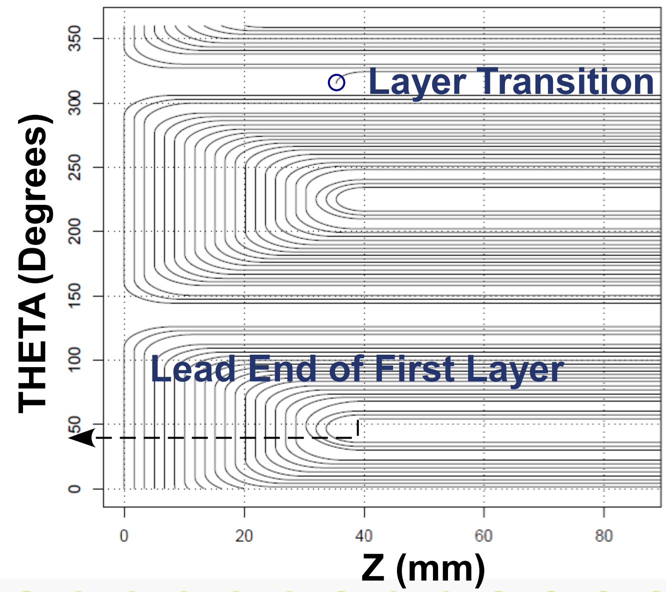
- 4 Layer Quadrupole Winding
- Single Layer:
  - Dipole Corrector Winding
  - Skew-Dipole Winding
  - Skew-Quadrupole Winding
- 50 mm ID Clear Aperture
- 3 mm Wall Thickness
- QD: L_{coil} = 512 mm, L_{mag} = 475 mm
- QF: L_{coil} = 288 mm, L_{mag} = 250 mm

ATF2 QD Quad Coil Winding Scheme

Full QD Coil Showing All 4 Cable layers







Full coil is made from pairs of Serpentine style coil windings

ATF2 QD Integral and Body Harmonics

QD design with integral harmonics smaller than 10^{-4}, "one unit," of the fundamental at 15 mm reference radius

q25mm_14nov07_atf Integral Harmonics
B2(T,meter) ITF = 0.0291893 (T/A)
Harmonics @ rRef = 15.0 mm

m	bm	am
1	6.635	-3.268
2	10000.000	-2.422
3	-0.633	-0.913
4	-0.478	-0.119
5	-0.190	0.103
6	-0.029	0.087
7	0.200	0.112
8	0.042	0.048
9	-0.013	0.009
10	0.042	-0.268
11	-0.014	-0.008
12	-0.007	-0.005
13	-0.002	-0.002
14	-0.009	-0.023
15	0.000	0.000
16	0.000	0.000
17	0.000	0.000
18	0.001	-0.002

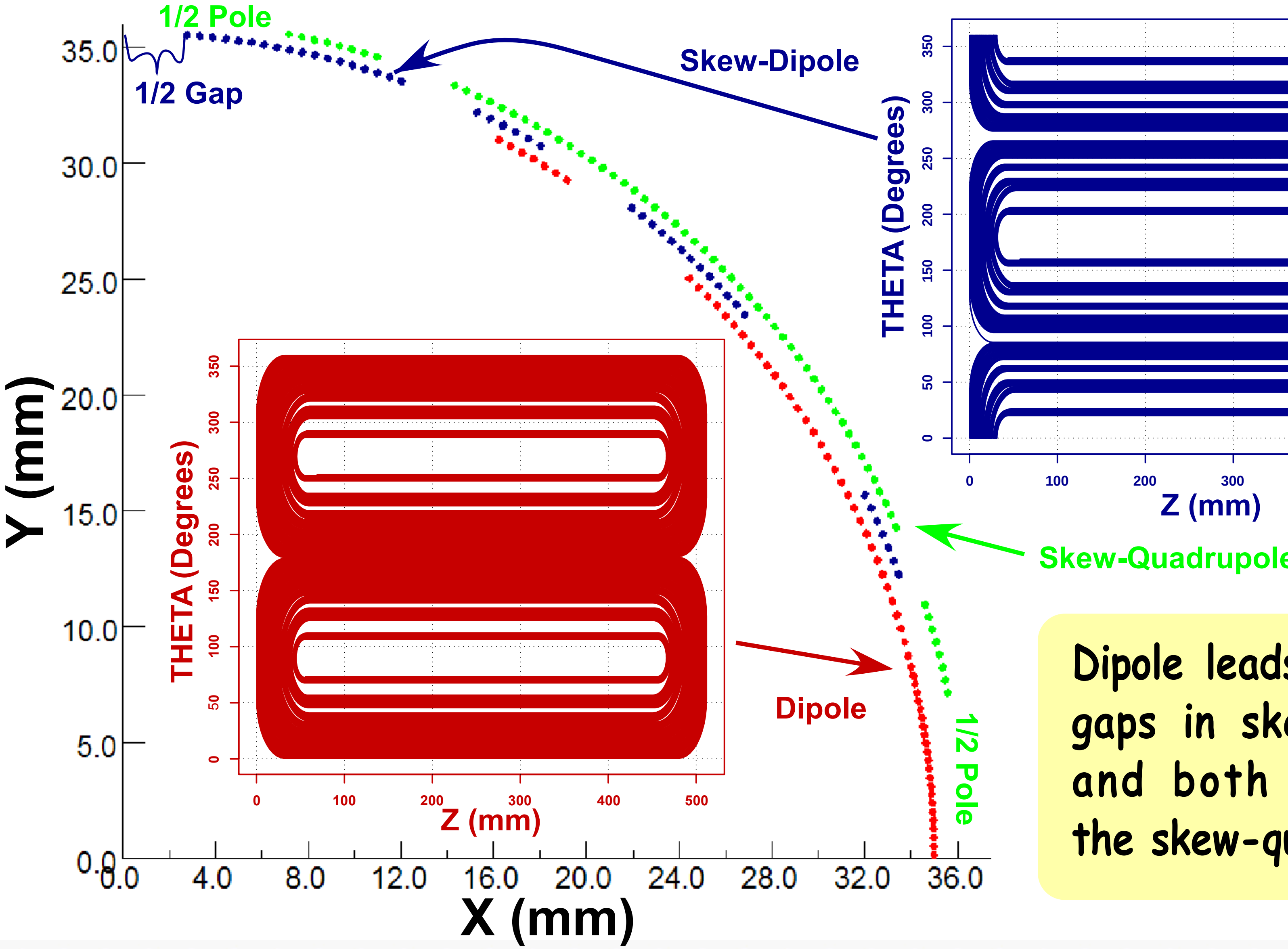
q25mm_14nov07_atf Body Harmonics
B2(T,meter) TF = 0.0614421 (T/m/A)
Harmonics @ rRef = 15.0 mm

m	bm	am
1	0.190	0.426
2	10000.000	0.538
3	-3.653	0.417
4	-2.474	0.165
5	-1.332	-0.015
6	-0.390	-0.097
7	-0.001	-0.004
8	-0.000	-0.003
9	0.000	-0.002
10	0.047	-0.265
11	-0.000	-0.000
12	-0.000	-0.000
13	-0.000	-0.000
14	-0.009	-0.023
15	0.000	-0.000
16	0.000	-0.000
17	0.000	-0.000
18	0.001	-0.002

L_{coil} = 512 mm, L_{mag} = 475 mm, G = 38 T/m @ I_o = 619 A

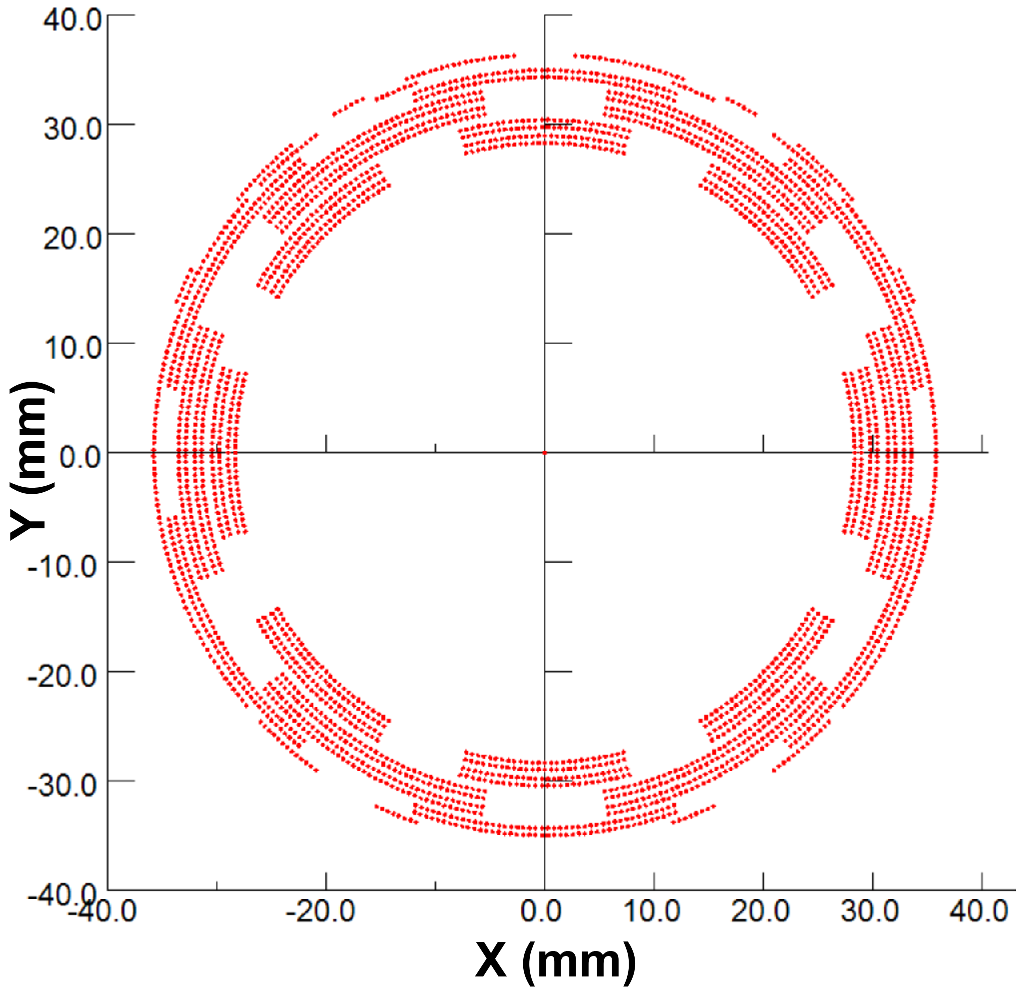
Clear Aperture = 50 mm (i.e. 3 times nominal gradient)

ATF2 QD/QF Corrector Wiring Scheme



Dipole leads exit via gaps in skew-dipole and both exit via the skew-quad poles.

ATF2 SD0/SF1 Coil Design Summary

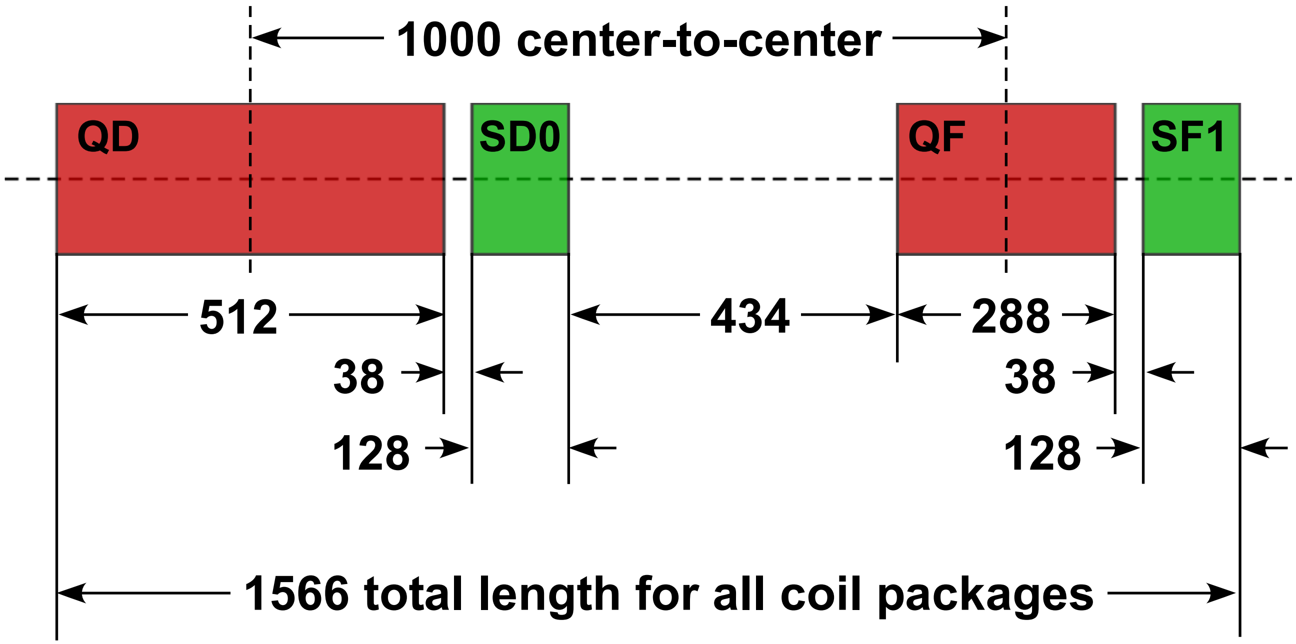


Here all coils are wound using single-strand wire -> low-power current leads

- 4 Layer Octupole Winding
- 4 Layer Sextupole Winding
- 2 Layer Skew-Sextupole Winding
- Single Layer Dipole & Skew-Dipole
- 50 mm ID Clear Aperture
- 3 mm Wall Thickness
- SD0 and SF1 wound the same
- SD0/SF1: L_{coil} = 128 mm,
  L_{mag} = 100 mm
- Low current operation through use of single-strand conductor

Proposed ATF2 FF Coil Physical Layout

Physical Coil Layout with Dimensions in mm



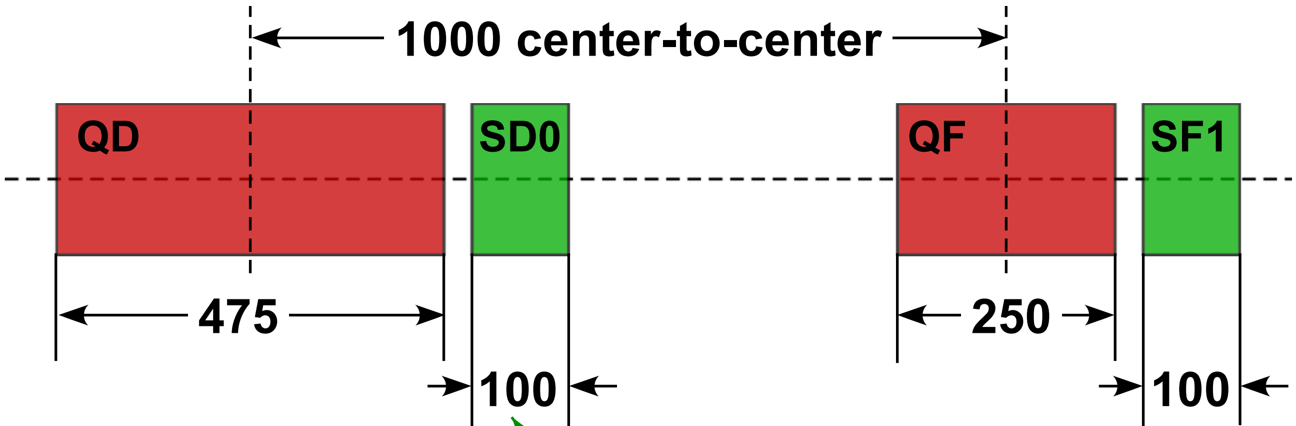
- Wind all coils on a common support tube.
- Note: The magnetic (effective) lengths are a bit less than the coil physical lengths.

Coil layout shown here is just a suggestion; it is quite easy to redesign for other coil lengths.

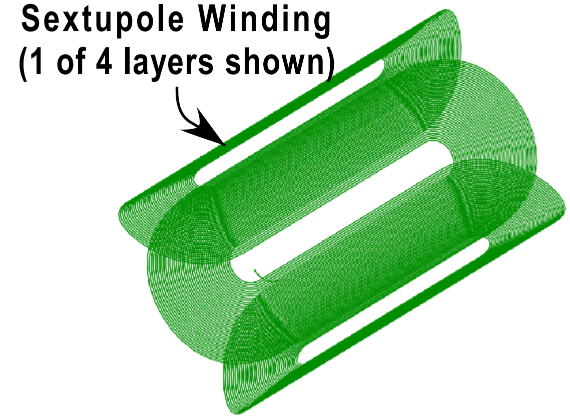
These numbers were chosen to keep maximum operating currents in the desired range, to reuse the R&D Service Cryostat and for simple magnetic lengths, i.e. 475, 250, 100 mm, for main coils.

Proposed ATF2 FF Magnetic Design

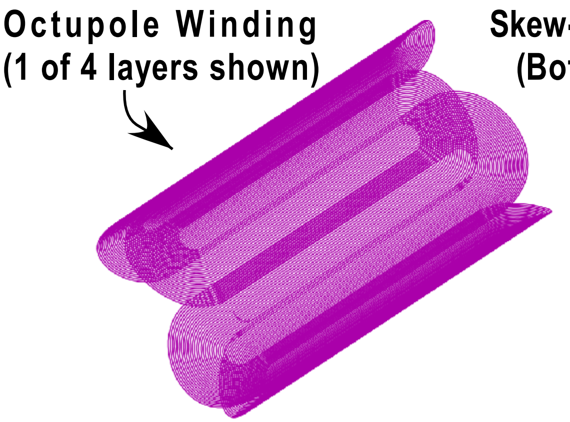
Proposed Magnetic Lengths with Dimensions in mm



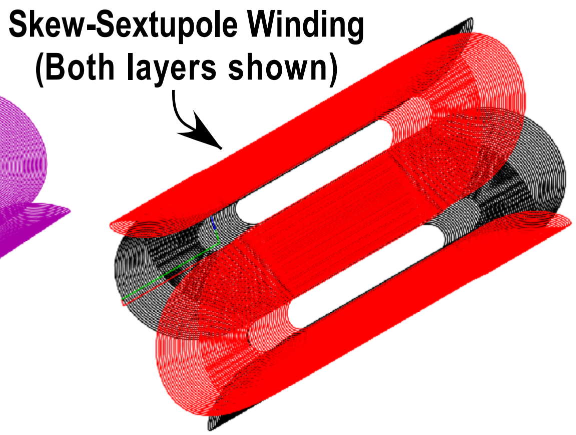
3D coil designs were made for all magnets



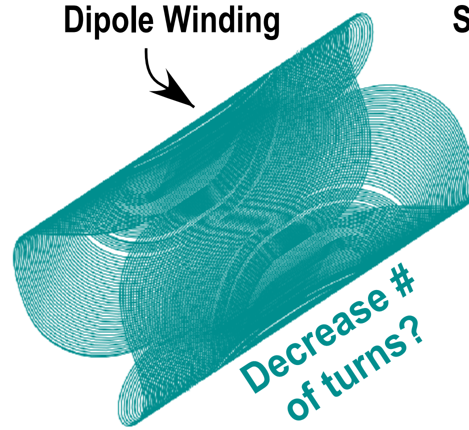
L_{mag} = 100 mm



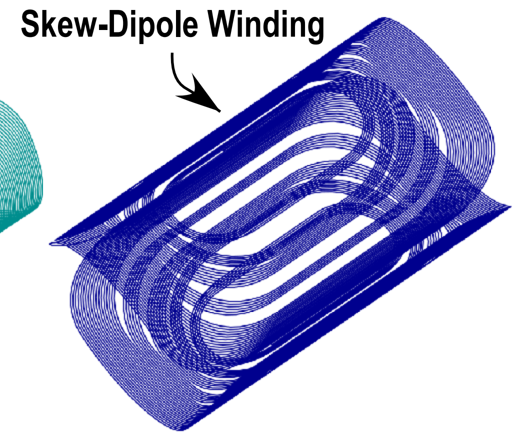
L_{mag} = 110 mm



L_{mag} = 98 mm



L_{mag} = 76 mm



L_{mag} = 88 mm

Have proposal for coil layout of superconducting ATF2 final focus, QD/QF magnets retaining key features of 14 mr baseline IR design (correction coils, He-II cooling, Service Cryostat interface, etc.) that is done as economically as possible.

- Confirm/iterate coil parameters, layout, operating assumptions etc.
- Develop cryogenic supply interface/requirements (we expect that cryogenic safety approval has a long lead time).
- Collect diagnostic requirements wish list (for example should we include laser beam ports through cryostat to see the cold mass?).
- Start preliminary engineering considerations of magnet support structure (support design/active stabilization) and connection to service cryostat (location/path of connection line through shielding).
- What was left off from the the above list?