Neutrino Factory Magnet Layout Comparison

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NF-IDS Videoconference

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Purpose

- Compare the geometric parameters of the Cryostat 1 magnets in the Neutrino Factory Study 2 and Study 2A documents
- Compilation of magnet geometry data

Study 2 Table 3.2

Table 3.2: Solenoid coil geometric parameters.

	z (m)	Gap (m)	Δz (m)	R_i (m)	ΔR (m)	I/A (A/mm^2)	nI (A)	nIl (A-m)
Fe	0.980	0.980	0.108	0.000	0.313	0.00	0.00	0.00
	1.088	0.000	0.312	0.000	0.168	0.00	0.00	0.00
Cu coils	1.288	−0.112	0.749	0.178	0.054	24.37	0.98	1.26
	1.288	−0.749	0.877	0.231	0.122	19.07	2.04	3.74
	1.288	−0.877	1.073	0.353	0.137	14.87	2.18	5.78
SC coils	0.747	−1.614	1.781	0.636	0.642	23.39	26.77	160.95
	2.628	0.100	0.729	0.686	0.325	25.48	6.04	32.23
	3.457	0.100	0.999	0.776	0.212	29.73	6.29	34.86
	4.556	0.100	1.550	0.776	0.107	38.26	6.36	33.15
	6.206	0.100	1.859	0.776	0.066	49.39	6.02	30.59
	8.000	−0.065	0.103	0.416	0.051	68.32	0.36	1.00
	8.275	0.172	2.728	0.422	0.029	69.27	5.42	14.88
	11.053	0.050	1.749	0.422	0.023	75.62	3.00	8.18
	12.852	0.050	1.750	0.422	0.019	77.37	2.61	7.09
	14.652	0.050	1.749	0.422	0.017	78.78	2.30	6.22
	16.451	0.050	1.750	0.422	0.015	79.90	2.07	5.59
	18.251	0.050	2.366	0.422	0.013	-0.85	2.53	6.80

Study 2 Table 3.13

Table 3.13: Parameters of the hollow-conductor magnets.

	H-C 1	H-C 2	H-C 3
Avg. current density (A/mm^2)	244	191	149
Winding inner radius (cm)	17.8	23.2	35.3
Winding outer radius (cm)	23.2	35.3	49.0
Radial build of windings (cm)	5.4	12.2	13.7
Upstream end, z_1 (cm)	-71.2	-71.2	-71.2
Downstream end, z_2 (cm)	3.7	16.5	36.1
Coil length, $z_2 - z_1$ (cm)	74.9	87.7	107.3
Volume of windings (m^3)	0.052	0.196	0.389
Approx. peak field (T)	20.0	18.6	16.1
Avg. hoop tension (MPa)	118	124	115
Conductor fraction (%)	33.2	32.9	33.4
Copper fraction (%)	48.9	48.3	49.2
Structural fraction (%)	11.2	12.1	10.7
Copper mass (tons)	0.243	0.893	1.77
Stainless steel mass (tons)	0.048	0.194	0.334

Study 2 Table 3.14

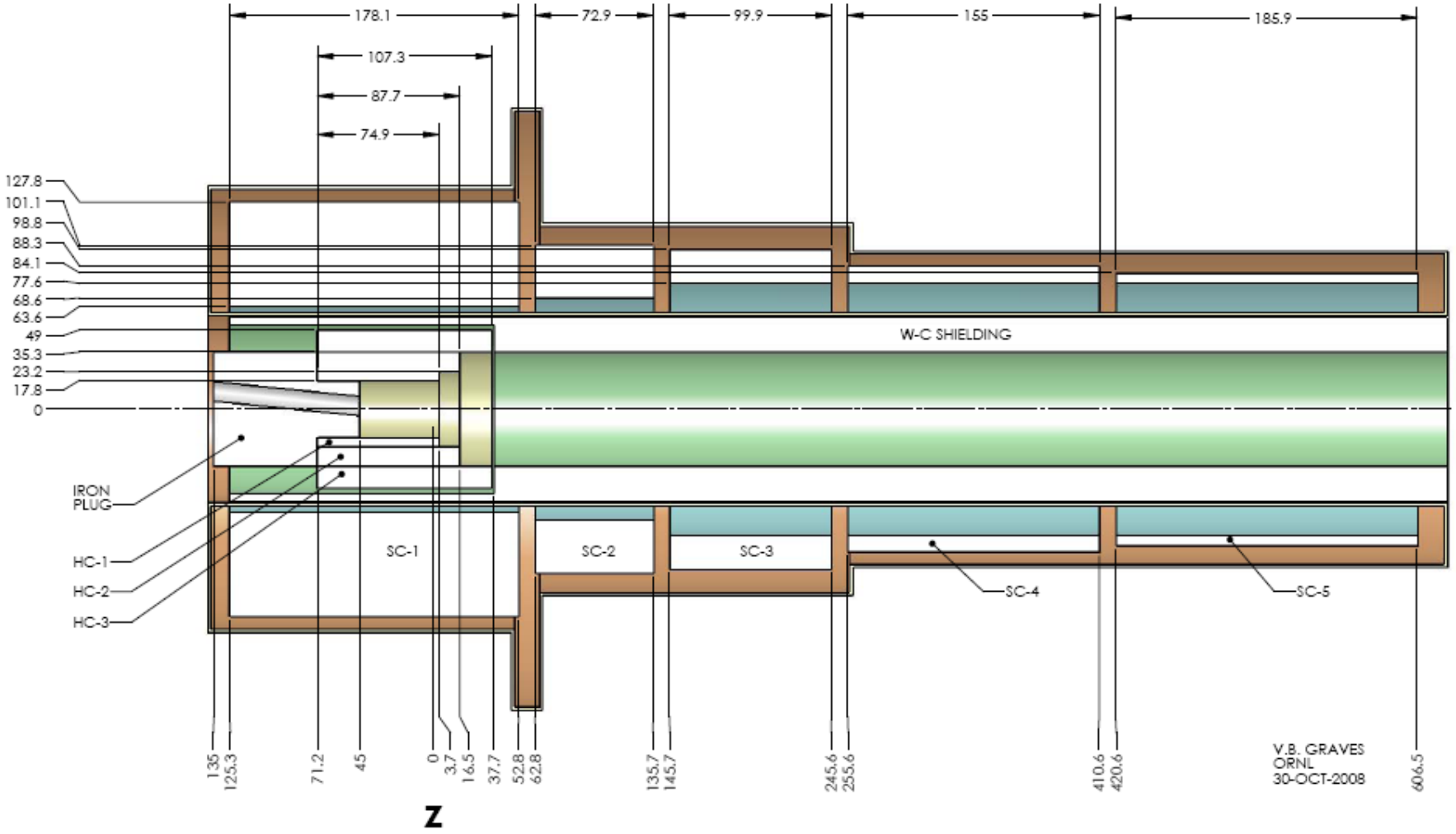
Table 3.14: Parameters of the upstream eight superconducting solenoids of the pion capture system.

	SC 1	SC 2	SC 3	SC 4	SC 5	SC 6	SC 7	SC 8
Avg. current density (A/mm^2)	234	255	297	383	484	679	705	705
Winding inner radius (cm)	63.6	68.6	77.6	77.6	77.6	42.4	42.2	42.2
Winding outer radius (cm)	127.8	101.1	98.8	88.3	84.1	45.1	45.9	45.9
Radial build of windings (cm)	64.2	32.5	21.2	10.7	6.56	2.69	3.69	3.69
Upstream end, z_1 (cm)	−125.3	62.8	145.7	255.6	420.6	600.8	657.7	720.7
Downstream end, z_2 (cm)	52.8	135.7	245.6	410.6	606.5	643.7	707.3	770.3
Coil length, $z_2 - z_1$ (cm)	178.1	72.9	99.9	155.0	185.9	42.9	49.6	49.6
Volume of windings (m^3)	6.88	1.26	1.17	0.866	0.619	0.032	0.051	0.051
Approx. peak field (T)	14.0	11.8	8.74	6.21	4.33	3.33	3.03	3.03
Avg. hoop tension (MPa)	209	206	201	184	163	96	90	90
Conductor fraction (%)	7.8	6.2	5.3	5.5	6.2	8.2	8.3	8.3
Copper fraction (%)	10.4	10.9	12.1	16.4	21.8	38.5	39.9	39.9
Structural fraction (%)	31.8	32.9	32.6	28	22	3.4	1.8	1.8
Vol. of superconductor (liters)	538	79	62	48	38	3	4	4
Copper mass (tons)	6.42	1.24	1.28	1.27	1.21	0.11	0.18	0.18
Stainless steel mass (tons)	17.1	3.24	2.98	1.89	1.06	0.01	0.01	0.01

Study 2 MARS Data

```
# This is a data file describing the positions and
# geometry of the SC solenoids.
#
# Number of SC Solenoids:
13
#
# Z0[cm]   dZ[cm]   R0[cm]   dR[cm]
-120.3d0  178.1d0   63.6d0   64.2d0
  67.8d0   72.9d0   68.6d0   32.5d0
 150.7d0   99.9d0   77.6d0   21.2d0
 260.6d0  155.0d0   77.6d0   10.7d0
 425.6d0  185.9d0   77.6d0    6.6d0
 605.0d0   10.3d0   41.6d0    5.1d0
 632.5d0  272.8d0   42.2d0    2.9d0
 910.3d0  174.9d0   42.2d0    2.3d0
1090.2d0  175.0d0   42.2d0    1.9d0
1270.2d0  174.9d0   42.2d0    1.7d0
1450.1d0  175.0d0   42.2d0    1.5d0
1630.1d0  236.6d0   42.2d0    1.3d0
1871.7d0 3128.0d0   42.2d0    1.2d0
```

NF Cryostat 1 Study 2 Layout



Based on Study II Tables 3.13, 3.14
Dimensions in cm

Study 2A Table 1

TABLE I: Magnetic Lattice Components: target, capture, matching, drift sections

Target and Capture Section					
No. (Type)	z–position (m)	Length (m)	Radius (m)	Thick^{ness} (m)	Curr^{ent} density (A/mm^2)
1 (SC)	-1.252	0.683	0.640	0.640	52.87
2 (Fe)	-0.846	0.326	0.430	0.010	29.29
3 (Fe)	-0.726	0.206	0.150	0.010	46.36
4 (Cu)	-0.500	0.948	0.160	0.070	16.52
5 (Cu)	-0.500	1.320	0.240	0.100	19.69
6 (Cu)	-0.500	1.791	0.350	0.160	20.96
7 (SC)	-0.400	0.690	1.000	0.210	26.23
8 (SC)	0.310	0.640	0.800	0.210	52.95
9 (SC)	1.070	0.850	0.800	0.210	63.02
10 (SC)	1.940	0.880	0.800	0.150	47.09
11 (SC)	2.840	1.160	0.800	0.090	56.74
12 (SC)	4.100	0.470	0.673	0.070	45.97
13 (SC)	4.590	1.127	0.800	0.050	65.18
14 (SC)	5.803	1.070	0.740	0.050	44.00
15 (SC)	6.910	1.360	0.849	0.050	39.77
16 (SC)	8.500	0.990	1.000	0.050	45.69
17 (SC)	9.800	1.900	1.000	0.050	32.01
18 (SC)	12.180	0.470	1.000	0.100	42.96

Neutrino Factory Magnet Geometry Comparison																
Study 2A Nomenclature		Z-position (m)				Length (m)				Radius (m)				Thickness (m)			
No	Type	Study 2 T3.2	Study 2 T3.14	Study 2 MARS	Study 2A	Study 2 T3.2	Study 2 T3.14	Study 2 MARS	Study 2A	Study 2 T3.2	Study 2 T3.14	Study 2 MARS	Study 2A	Study 2 T3.2	Study 2 T3.14	Study 2 MARS	Study 2A
1	SC	0.747	-1.253	-1.203	-1.252	1.781	1.781	1.781	0.683	0.636	0.636	0.636	0.640	0.642	0.642	0.642	0.640
2	Fe	0.980			-0.846	0.108			0.326	0.000			0.430	0.313			0.010
3	Fe	1.088			-0.726	0.312			0.206	0.000			0.150	0.168			0.010
4	Cu	1.288			-0.500	0.749			0.948	0.178			0.160	0.054			0.070
5	Cu	1.288			-0.500	0.877			1.320	0.231			0.240	0.122			0.100
6	Cu	1.288			-0.500	1.073			1.791	0.353			0.350	0.137			0.160
7	SC	2.628	0.628	0.678	-0.400	0.729	0.729	0.729	0.690	0.686	0.686	0.686	1.000	0.325	0.325	0.325	0.210
8	SC	3.457	1.457	1.507	0.310	0.999	0.999	0.999	0.640	0.776	0.776	0.776	0.800	0.212	0.212	0.212	0.210
9	SC	4.556	2.556	2.610	1.070	1.550	1.550	1.550	0.850	0.776	0.776	0.776	0.800	0.107	0.107	0.107	0.210
10	SC	6.206	4.206	4.256	1.940	1.859	1.859	1.859	0.880	0.776	0.776	0.776	0.800	0.066	0.656	0.066	0.150
11	SC	8.000	6.008	6.050	2.840	0.103	0.429	0.103	1.160	0.416	0.424	0.416	0.800	0.051	0.269	0.051	0.090
12	SC	8.275	6.577	6.325	4.100	2.728	0.496	2.728	0.470	0.422	0.422	0.422	0.673	0.029	0.369	0.029	0.070
13	SC	11.053	7.207	9.103	4.590	1.749	0.496	1.749	1.127	0.422	0.422	0.422	0.800	0.023	0.369	0.023	0.050
14	SC	12.852		10.902	5.803	1.750		1.750	1.070	0.422		0.422	0.740	0.019		0.019	0.050
15	SC	14.652		12.702	6.910	1.749		1.749	1.360	0.422		0.422	0.849	0.017		0.017	0.050
16	SC	16.451		14.501	8.500	1.750		1.750	0.990	0.422		0.422	1.000	0.015		0.015	0.050
17	SC	18.251		16.301	9.800	2.366		2.366	1.900	0.422		0.422	1.000	0.013		0.013	0.050
18	SC			18.717	12.180			31.280	0.470				1.000			0.012	0.100

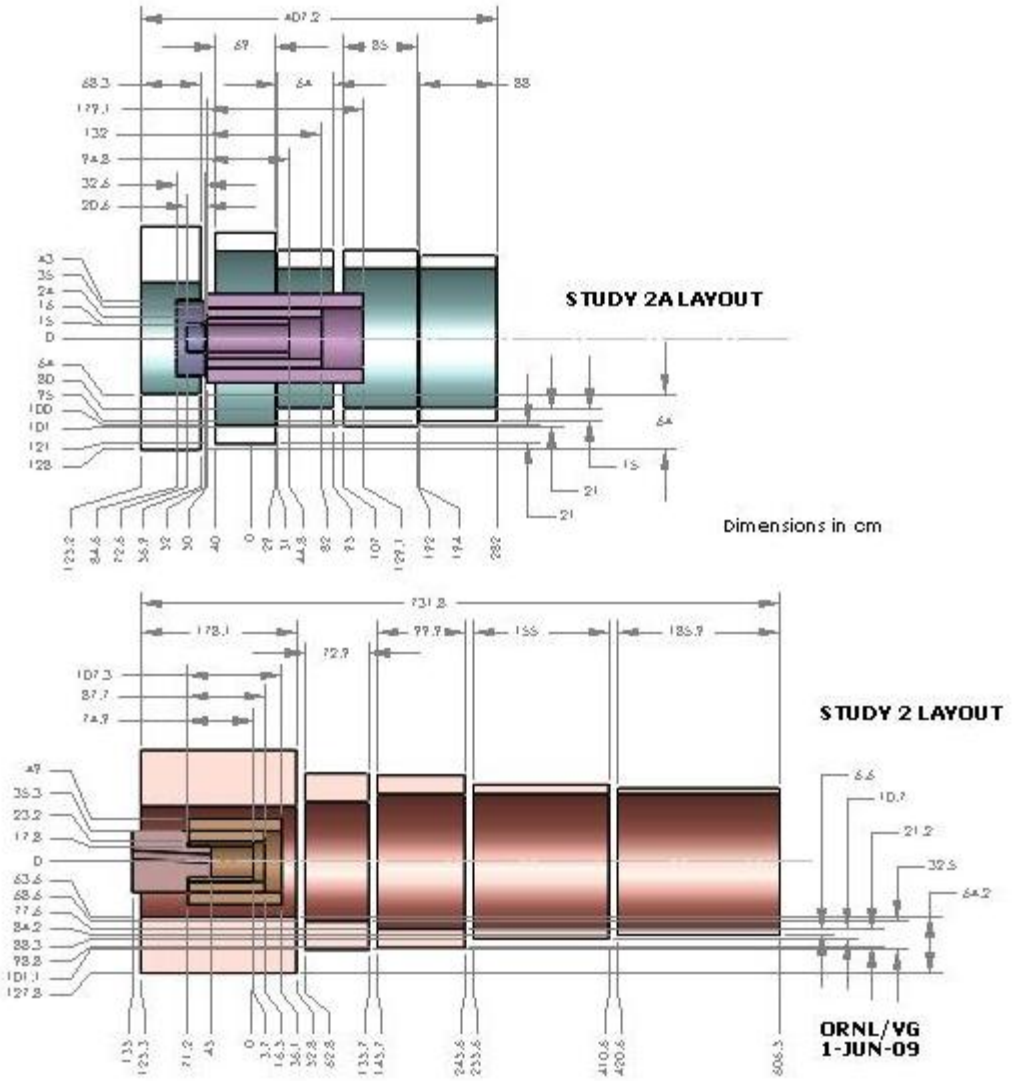
Notes:

1. Study 2 data taken from Tables 3.2 and 3.14
2. Study 2A data taken from http://www.cap.bnl.gov/mumu/study2a/rf-properties.pdf
3. Study 2 Z0 defined as 0.6m downstream of nozzle. Nozzle at Z=-60cm. Magnetic center at Z=-30cm. Jet/beam intersection at Z=-15cm.

- Magnet nomenclature changed in Study 2A - magnet numbers independent of type
- Values differ even within Study 2 Tables 3.2 / 3.14
- SC magnet geometry identical for Study 2 & Study 2 MARS
- Z0 references for all cases are different
- Study 2A Iron Plug geometry (thickness) not clear
- SC magnet lengths differ greatly between Study 2 & Study 2A

Geometry Comparison

- Significant geometry differences
- Jet/beam interaction in Study 2A in second or third SC magnet
- Data needs to be reviewed



Issues

- Z0 needs to be defined for NF-IDS so that mechanical layouts and computer simulations are in geometric agreement
  - Recommend that a physical location on a "permanent" item be chosen
- Magnet nomenclature changed from Study 2 to Study 2A – choose conventions for future work