

# **Global Coordinates of the SNS Accelerator Complex**

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In this note, the global coordinates of a few key points of the SNS accelerator complex are determined using the official coordinate system. Due to the fact that the lattice files of different parts don't necessarily overlap. Engineering drawings and design reports are used to bridge the gaps.

As described in SNS Accelerator Division Document Transmittal #JE-051800-01, the origin (Central Monument 00, MON00) of the coordinate system is located at the intersection of the plane that contains the linac and is perpendicular to the plane of the ring and the line that goes through the center of the ring and is parallel to the injection straight. The Z-axis is defined as the line that is parallel to the linac line, with its positive direction pointing towards the target building. The X-axis is the line that goes through the center of the ring with its positive direction pointing to the ring. The Y-axis is the line that is perpendicular to both the X-axis and Z-axis, with its positive direction defined in the way such that the three axes form a right-handed coordinate system. Due to the fact that the ring lies in the horizontal plane, the positive direction of the Y-axis points up. The coordinates of MON00 are defined as (20,000.0, 10,000.0, 2,000.0), in meters and the order of z, x, and y. The order and unit of the coordinates remain unchanged throughout the note.

There is no single lattice file that covers the entire accelerator system. Four lattice files cover the linac, HEBT, ring and RTBT, respectively. The PARMILA input file of the linac and HEBT (provided by H. Takeda) starts at the beginning of MEBT and ends at the end of HEBT. Yet only the part HEBT before the first dipole magnet can be used because PARMILA does not provide the global coordinates of devices. Nonetheless, it is very helpful to have part of the downstream line in the file, which is used as the interface between the two sections. The TRANSPORT input file of the HEBT (provided by D. Raparia) starts from the center of the first quadrupole magnet in the HEBT line (HEBT.QV1) and ends at the stripping foil location. The relative position and orientation between the end of the HEBT line and the midpoint of the injection straight of the ring are obtained from BNL/SNS Technical Note 076, D. Raparia and engineering drawing provided by J. Negrin. Specifically, the reference orbit at the end of the HEBT line is parallel to the injection straight and the position of the end of HEBT relative to the midpoint of the injection straight is (-0.14, -0.605, 0.046). The floor layout of the ring is obtained from the MAD input file provided by Y. Papaphilippou. The TRANSPORT input file of the RTBT line (provided by D. Raparia) starts at the first dipole magnet after the vertical bends and ends at the target. The relative position and orientation between the ring and RTBT are obtained from the engineering drawing provided by J. Negrin. At the beginning of RTBT, the reference orbit is parallel to the extraction straight (in X-Z projection). The position of the start of the extraction septum relative to the midpoint of the extraction straight is (0.0, -3.437611, -0.225415). The Y coordinate of the starting point is not very useful, because it is in the middle of the slope after the extraction kicker. After the vertical bend magnet RTBT.DV1, the beamline is leveled at the altitude of -0.2286 m (Y coordinate). Between the magnets RTBT.QH2 and RTBT.QV3, there is a vertical dogleg that raises the level of the beamline to -0.1826 m. Since the RTBT lattice ends at the front surface of the target, an extra 0.206096m (obtained from interface document provided by T. McManamy) was added to the lattice to reach the target center.

Last but not least, D. Raparia provided the lattice files (TRANSPORT input) of the linac, injection and extraction dump lines. The linac dump file starts at the beginning of the HEBT, the injection dump file starts at the foil and the extraction dump file starts at the beginning of the RTBT. Due to the fact that there are two beams in the injection dump line, the center of the line is defined as that which lies in between the two beams. Specifically,  $H^0$  goes through INJBND3 with no bending while  $H^-$  goes through INJBND3 with 2.406422 degrees of bending. The center of the beam line is defined as the one that coincides with the centers of both beams before INJBND3 and is bent by 1.203211 degrees after it. Instead of 10 degrees bending marked in the X-2 drawing, the septum bends the reference particle (center of the beam line) by 8.796789 degrees.

With the information described above, the coordinates of any point on the reference orbit can be determined. Table 1 displays the coordinates of a few key points, whose locations are shown in Figure 1. Note that the coordinates of a magnet are those of the center of it. All magnets are aligned parallel to the X-Z plane. To describe the orientation of magnets in the X-Z plane, an angle phi is defined with respect to the Z-axis. The range of phi is [-90 degrees, +90 degrees] and a positive value of phi corresponds to a line with a positive slope. All magnets before the first dipole magnet in HEBT are aligned along the Z-axis (phi = 0). Phi of the first quad in HEBT equals to 81.24500 degrees. Phi of QVA12 and QVC12 equal 90 degrees. Phi of QVB12 and QVD12 equal 0. Phi of the first quad in RTBT is -73.20140 degrees. Phi of the last quad in RTBT is -56.40152 degrees. Phi of the linac dump is 0, phi of the injection dump is -77.35293 degrees and phi of the extraction dump is -73.20140 degrees. Table 2 provides additional coordinates to further define the lattice.

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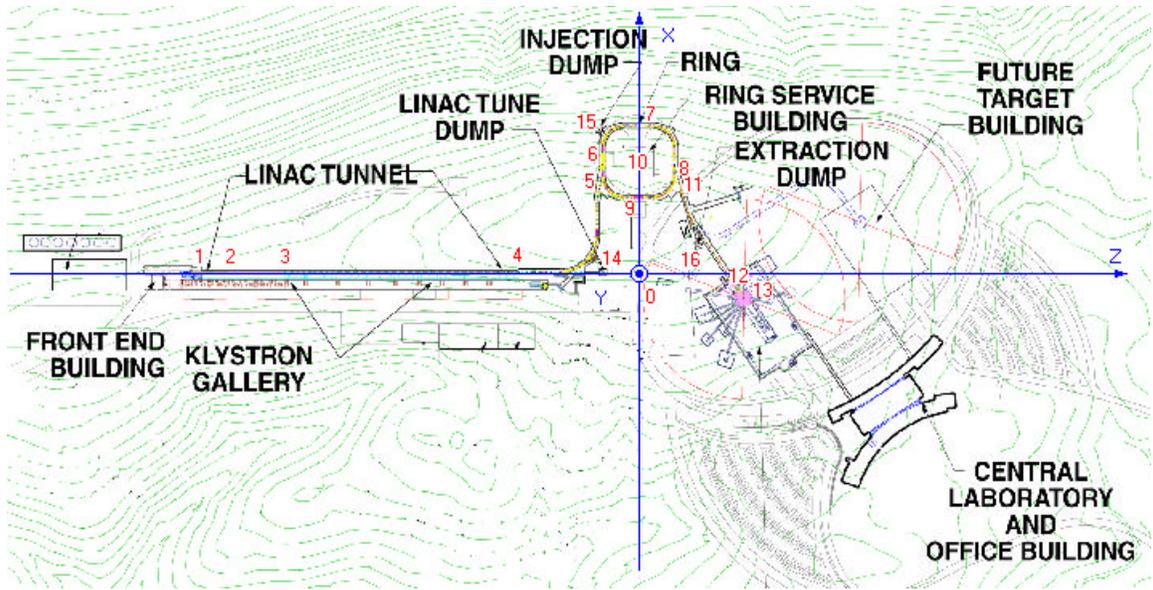


Figure 1: SNS site map with the key points marked

Table 1: Coordinates of key points along the reference orbit

#	Name	Location	Z	X	Y
0	Complex center	Central Monument 00 (MON00)	20,000.000000	10,000.000000	2,000.000000
1	FE end	Last quad in MEBT (QM14)	19,549.720844	10,000.000000	2,000.046000
2	DTL end	Quad between DTL and CCL	19,586.684608	10,000.000000	2,000.046000
3	CCL end	Last quad in CCL-SC Region	19,643.268831	10,000.000000	2,000.046000
4	HEBT beginning	First quad in HEBT (HEBT.QV1)	19,881.174844	10,000.000000	2,000.046000
5	HEBT end	Last quad in HEBT (HEBT.QH34)	19,963.886411	10,102.299981	2,000.046000
6	Ring section A	First quad after foil (QVA12)	19,964.669100	10,117.136218	2,000.000000
7	Ring section B	QVB12	20,006.525000	10,145.942118	2,000.000000
8	Ring section C	QVC12	20,035.330900	10,104.086218	2,000.000000
9	Ring section D	QVD12	19,993.475000	10,075.280318	2,000.000000
10	Ring center	Center of ring	20,000.000000	10,110.611218	2,000.000000
11	RTBT beginning	First quad in RTBT (RTBT.QV1)	20,036.790003	10,101.093419	1,999.771400
12	RTBT end	Last quad in RTBT (RTBT.QH30)	20,098.564592	9,982.566321	1,999.817400
13	Target center	Center of target	20,104.489012	9973.648848	1,999.817400
14	Linac dump	Center of the linac dump	19959.047844	10,000.000000	2,000.046000
15	Injection dump	Center of the injection dump	19,958.312442	10,142.496311	2,000.046000
16	Extraction dump	Center of the extraction dump	20059.017116	10027.467146	1,999.817400

Table 2: Expanded Coordinate Listing

Description	Name	Z	X	Y
Complex center	MON00	20000.000000	10000.000000	2000.000000
Last quad in MEBT	QM14	19549.720844	10000.000000	2000.046000
First quad in DTL	DTL1_Mag:QH0	19549.963344	10000.000000	2000.046000
Quad between DTL and CCL	CCL0_Mag:QH	19586.684608	10,000.000000	2,000.046000
Last quad in CCL	CCL4_Mag:QH12	19643.268831	10000.000000	2000.046000
Midpoint of the last quad doublet in the linac		19873.388831	10000.000000	2000.046000
First quad in HEBT	HEBT.QV1	19881.174844	10000.000000	2000.046000
	HEBT.QV11	19921.674844	10000.000000	2000.046000
Beginning of HEBT bend	HEBT.DH11	19922.424844	10000.000000	2000.046000
	HEBT.QH12	19928.950180	10000.765804	2000.046000
	HEBT.QV13	19935.936315	10002.936241	2000.046000
	HEBT.QH14	19942.364790	10006.427903	2000.046000
HEBT bend center	HEBT.QV15	19947.988549	10011.106606	2000.046000
	HEBT.QH16	19952.591485	10016.792550	2000.046000
	HEBT.QV17	19955.996705	10023.267229	2000.046000
	HEBT.QH18	19958.073346	10030.281824	2000.046000
	HEBT.QV19	19958.741601	10037.566765	2000.0460006
End of HEBT bend	HEBT.DH18	19958.741601	10036.316765	2000.046000
HEBT dog leg (bend point)	HEBT.DH25	19958.741601	10068.892794	2000.046000
HEBT ring intersection		19964.669100	10107.382274	2000.046000
Last quad in HEBT	HEBT.QH34	19,963.886411	10102.299981	2000.046000
Ring arc A begin	QVA1	19985.000000	10075.280318	2000.000000
Beginning of Ring arc A bend	DHA1	19983.750000	10075.280318	2000.000000
Ring arc A center	QVA5	19970.623882	10081.235100	2000.000000
End of ring arc A bend	DHA9	19964.669100	10094.361218	2000.000000
Ring arc A end	QVA9	19964.669100	10095.611218	2000.000000
First ring quad after foil	QVA12	19,964.669100	10117.136218	2000.000000
Ring arc B begin	QVB1	19964.669100	10125.611218	2000.000000
Beginning of ring arc B bend	DHB1	19964.669100	10126.861218	2000.000000
Ring arc B center	QVB5	19970.623882	10139.987336	2000.000000
End of ring arc B bend	DHB9	19983.750000	10145.942118	2000.000000
Ring arc B end	QVB9	19985.000000	10145.942118	2000.000000

	QVB12	20,006.525000	10145.942118	2000.000000
Ring arc C begin	QVC1	20015.000000	10145.942118	2000.000000
Beginning of ring arc C bend	DHC1	20016.250000	10145.942118	2000.000000
Ring arc C center	QVC5	20029.376118	10139.987336	2000.000000
End of ring arc C bend	DHC9	20035.330900	10126.861218	2000.000000
Ring arc C end	QVC9	20035.330900	10125.611218	2000.000000
	QVC12	20,035.330900	10104.086218	2000.000000
Ring arc D begin	QVD1	20035.330900	10095.611218	2000.000000
Beginning of ring arc D bend	DHD1	20035.330900	10094.361218	2000.000000
Ring arc D center	QVD5	20029.376118	10081.235100	2000.000000
End of ring arc D bend	DHD9	20016.250000	10075.280318	2000.000000
Ring arc D end	QVD9	20015.000000	10075.280318	2000.000000
	QVD12	19,993.475000	10075.280318	2000.000000
Center of Ring		20000.000000	10110.611218	2000.000000
First quad in RTBT	RTBT.QV1	20,036.790003	10101.093419	1999.771400
RTBT ring intersection		20035.330900	10105.926628	1999.771400
RTBT dog leg (bend point)	RTBT.DH13	20050.923958	10054.275353	1999.817400
Last quad in RTBT	RTBT.QH30	20,098.564592	9982.566321	1999.817400
Center of target		20104.489012	9973.648848	1999.817400
Center of linac dump		19959.047844	10000.000000	2000.046000
Injection dump Ring inters.		19964.669100	10114.167495	2000.046000
	IDUMP.Q1	19962.767948	10122.640060	2000.046000
Center of injection dump		19958.312420	10142.496311	2000.046000
Center of extraction dump		20059.017116	10027.467146	1999.817400

All coordinates listed above are those of the centers of the magnets unless specified otherwise. Note that the coordinates of HEBT.DH11, DHA1, DHB1, DHC1, and DHD1 are those of the upstream ends. The coordinates of the HEBT.DH18, DHA9, DHB9, DHC9, DHD9 are those of the downstream ends.