DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

Frascati, May 23, 1997

Note: **MM-27**

COMPARISON OF MAGNETIC AND MECHANICAL CENTER POSITIONS OF THE LARGE QUADRUPOLES AND SEXTUPOLES IN THE DAΦNE MAIN RINGS

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1. Introduction

The magnetic measurements on the 28 "large" quadrupoles and 18 "large" sextupoles of the DAΦNE Main Rings are described in [1,2]. These measurements included also the position of the magnetic center of each magnet, while the determination of the mechanical center positions has been performed later, directly in the Main Rings Hall. We present here the results of both kinds of measurements and the comparison between them. The details of the methods adopted to determine the optimum alignment of the magnetic elements on the machine are described in [3]. Here we discuss only the differences between the procedures followed for the large multipoles and the small ones. In all the Tables the prototype magnets are indicated as Serial#0.

2. Magnetic and mechanical center positions

As a consequence of the cooling system layout in the DAΦNE Main Rings, the large quadrupoles and sextupoles have been built with two different geometries of the coil: looking at the magnet from the electrical and cooling connection side, half of the quadrupoles and sextupoles have the water hoses on the right, the other half on the left. According to the position of the hoses, the magnets are called "right" or "left" in the following.

The large quadrupoles and sextupoles are equipped with alignment tables [3] similar to those of the small ones. However the positions of the A and B Taylor-Hobson spheres with respect to the electrical and cooling connection side of the magnet is the opposite: in the small magnets the A sphere is on the side of the electrical and cooling connection, while in the large ones the A sphere is on the opposite side.

In order to avoid having the cooling tubes passing above or below the rotating coil measuring system of the magnetic measurement laboratory, the "right" magnets have been placed on the measuring system with the electrical and cooling connections on the encoder side of the rotating coil, while the "left" ones have been rotated by 180° to have the cooling hoses on the right side. For those magnets the electrical and cooling connections were therefore on the stepping motor side of the rotating coil.

Due to the opposite position of sphere A with respect to the magnet, the large "left" magnets are equivalent to the small quadrupoles and sextupoles, from the point of view of all the variables defined in [3]. For the "right" multipoles it is necessary to change the sign of ΔXA and ΔXB (see Section 4 in [3]). Summarizing:

"right" quadrupoles and sextupoles ΔXA = XAmec - XAmag
ΔXB = XBmag - XBmec

"left" quadrupoles and sextupoles ΔXA = XAmag - XAmec
ΔXB = XBmec - XBmag

All other variables defined in [3] do not change their meaning. However, a difference exists in the interpretation of the shifts between mechanical and magnetic centers and rotations of the horizontal symmetry plane (see next Section), namely:

a positive sign for Shift X (ShiftXC) indicates that the magnetic center is on the right with respect to the mechanical one, when the "right" multipoles are observed from the electrical and cooling connection side

a positive sign for Shift X (ShiftXC) indicates that the magnetic center is on the left with respect to the mechanical one, when the "left" multipoles are observed from the electrical and cooling connection side

when the sign of Φ is positive the "right" multipoles must be rotated counterclockwise to bring the horizontal magnetic symmetry plane on the horizontal symmetry plane of the ring, when the magnet is observed from the electrical and cooling connection side

when the sign of Φ is positive the "left" multipoles must be rotated clockwise to bring the horizontal magnetic symmetry plane on the horizontal symmetry plane of the ring, when the magnet is observed from the electrical and cooling connection side

The final tables in Section 5 are properly modified to give simple indications on the alignment on the ring with no difference between "right" and "left" magnets.

Due to the particular design of the large quadrupole and its alignment tables, the Taylor-Hobson sphere centers are at a height of ≈508 mm above the magnet axis. As a consequence, the laser beam of the rotating coil system [4] (set at the nominal distance of 500 mm from the rotating coil axis) hits the diode matrix inside the measuring sphere rather far from its center. We have therefore checked the linearity of the system on the whole sensitive range of the device and found that a calibration in the neighbourhood of the operating region was necessary. The output of the laser system has therefore been calibrated by changing the position of the sphere in both directions by means of micrometric positioning slits, and the data corrected accordingly. The alignment table is in the correct position for the sextupoles.

Tables QR1 and QL1 show the results of the magnetic center position measurements for the right and left quadrupoles respectively. Tables SR1 and SL1 are the corresponding ones for the sextupoles. The rotation of the magnetic horizontal symmetry plane with respect to the mechanical one in these tables shows the original output of the rotating coil system before its recalibration (see Section 5 in [3]).

There are no differences with respect to the small multipoles in the procedures followed to determine the mechanical center positions. The results of the mechanical measurements are given in Tables QR2, QL2, SR2 and SL2.

3. Comparison between mechanical and magnetic center positions

The magnetic measurements have been performed with the alignment tables Q1 and S1. Following the procedures described in [3], including correction for the rotation angle around the longitudinal symmetry axis of the magnets, we have calculated the shifts and the tilts of the magnetic centers with respect to the mechanical ones. The results for each magnet are given in Tables QR3, QL3, SR3 and SL3 with the warnings on the sign mentioned in Section 2.

Figure 1 shows in an XY plane the distance between the magnetic and mechanical axes of the quadrupoles. It can be noticed that there is systematic displacement in the horizontal plane: the average shift and its standard deviation are +0.00 mm and 0.13 mm respectively. In the vertical plane the average is on the axis as well and the standard deviation is 0.08 mm. Figure 2 shows the same result for the sextupoles: in this case we find in the horizontal plane an average of -0.02 mm with a standard deviation of 0.11 mm, in the vertical one -.02±.02 mm.

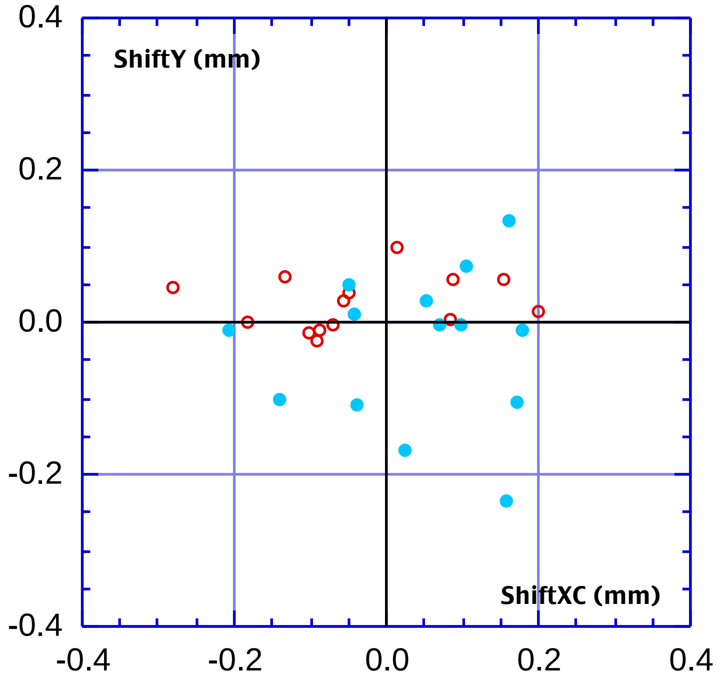

Figure 1 - Distance between magnetic and mechanical axes for the quadrupoles (empty dots = right quads, full dots = left quads)

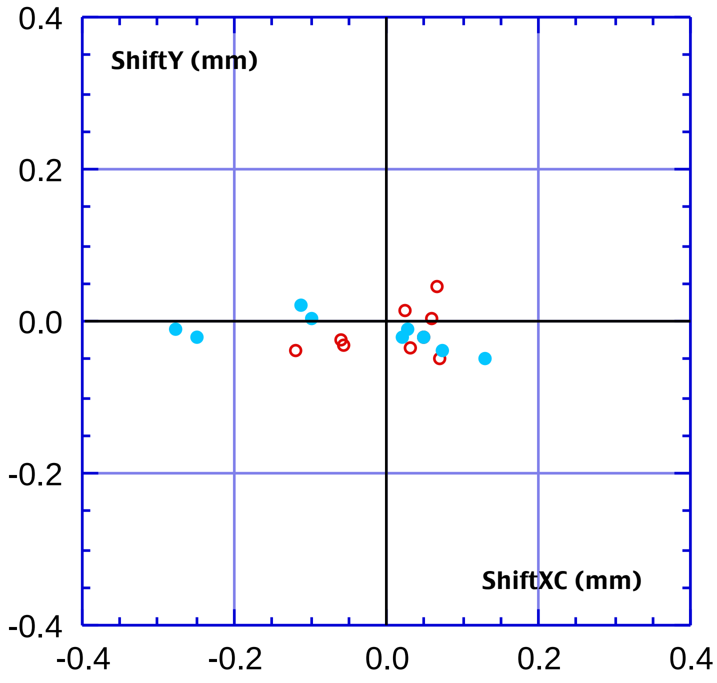

Figure 2 - Distance between magnetic and mechanical axes for the sextupoles (empty dots = right quads, full dots = left quads)

4. Recalibration of the azimuthal rotating coil offset

As already mentioned in [1] the rotating coil for the measurement of the quadrupoles has been recalibrated after all the magnets were measured.

An offset of 0.7±0.2 mrad was found, and the rotation angles in Tables QR1 and QL1 must be corrected accordingly. We recall, however, that the rotating coil system rotates the quadrupoles around the longitudinal axis by the uncorrected values of Φ, and that the correction of the shift for the quadrupole rotation is therefore performed with the same uncorrected value of Φ.

Figure 3 shows the distribution of the corrected value of Φ among the quadrupoles after applying the calibration correction.

The corrected values are also given in Table Q5. The average is 0.04 mrad and the standard deviation 0.40 mrad. Figure 4 shows the result for the sextupoles, for which no recalibration was necessary: the average is 0.10 mrad, the standard deviation 0.45 mrad. The rotation angles are also listed in Table S5. In both these tables, for sake of simplicity, the angles are indicated for all the magnets, irrespective of the "right" or "left" type. A positive sign of the angle means that the magnet, seen from the electrical and cooling connections side, must be rotated counterclockwise in order to bring the magnetic horizontal symmetry plane on the ideal horizontal plane of the ring.

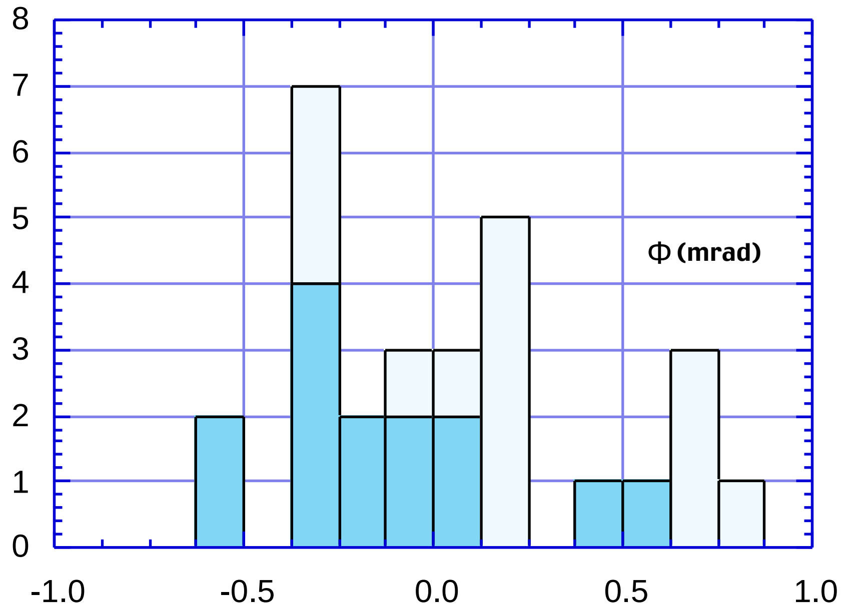

Figure 3 - Distribution of the angle between the magnetic and mechanical horizontal symmetry planes of the quadrupoles (dark bars = right quads, light bars = left quads)

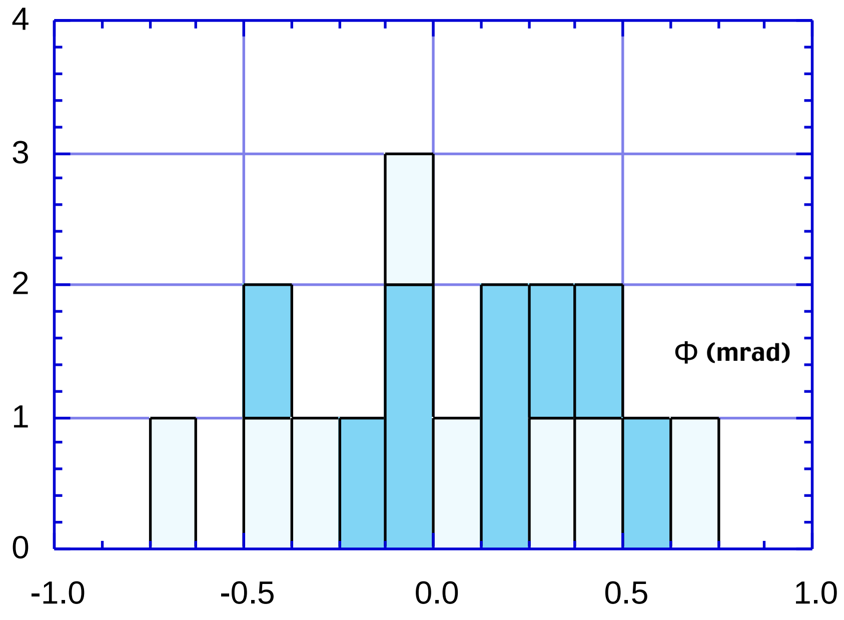

Figure 4 - Distribution of the angle between the magnetic and mechanical horizontal symmetry planes of the sextupoles (dark bars = right sextupoles, light bars = left sextupoles)

5. Operating instructions for the alignment of the magnets on the rings

From the above described measurement we extract in this Section the essential information to align the large quadrupoles and sextupoles on the DAΦNE Main Rings. As done for the small multipoles [3], we take into account two possibilities:

a) alignment without compensation of the azimuthal rotation of the magnets

b) alignment with compensation of the azimuthal rotation to minimize the coupling between the betatron oscillations in the horizontal and vertical planes (it is a first order effect for the quadrupoles, a second order one for the sextupoles).

<u>5a) Alignment without compensation</u>

Applying the same procedure followed for the small magnets [3], we must again take into account the difference between the right and left multipoles. The formulas for the setting of the slits become in this case:

"right" quadrupoles and sextupoles Slit A = XAmec - ShiftXC
Slit B = XBmec + ShiftXC

"left" quadrupoles and sextupoles Slit A = XAmec + ShiftXC
Slit B = XBmec - ShiftXC

For the vertical plane there is no difference between the right and left multipoles. We have always:

HeightA = YAmec + ShiftY
HeightB = YBmec + ShiftY

Table Q4 shows the slit positions and the heights of the Taylor-Hobson spheres above the ideal trajectory of the beam for the alignment of the magnets on the ring. The magnets are grouped together, irrespective of their "right" or "left" type. Table S4 is the corresponding one for the sextupoles.

<u>6b) Alignment with compensation of the magnet rotation</u>

Obviously, a method of aligning the magnets taking into account the rotation of the magnets is to set them as described in 4a) and then perform an azimuthal rotation of the magnet by the angle Φ indicated in Tables Q5 (where the recalibration of the coil is taken into account) and S5, keeping the position of the longitudinal axis fixed. However, this method may be rather unpractical in real life.

An alternative method is to perform, as a preliminary operation, an azimuthal rotation by the angle Φ with respect to the ideal horizontal plane of the ring, and then to adjust the positions of the sphere centers to the values indicated in Tables Q5 (for the quadrupoles) and S5 (for the sextupoles). The values in this tables take into account the recalibration of the coil and the different average height H of the Taylor-Hobson spheres from the mechanical center of the magnet. We have therefore, for the large multipoles:

"right" quadrupoles and sextupoles Slit A = XAmec - ShiftX + H ΔΦ
Slit B = XBmec + ShiftX - H ΔΦ

"left" quadrupoles and sextupoles Slit A = XAmec + ShiftX - H ΔΦ
Slit B = XBmec - ShiftX + H ΔΦ

H is 508 mm for the quadrupoles, 500 mm for the sextupoles , ΔΦ is 0.7 mrad for the quadrupoles, 0 for the sextupoles. For the vertical plane, HeightA and HeightB are obtained exactly as described in 4a). When the sign of Φ is positive the magnet, observed from the electrical and cooling connections side, must be rotated counterclockwise.

6. Conclusions

For the large quadrupoles and sextupoles the difference between the measured magnetic centers and the mechanical ones has a symmetric distribution around zero in both planes, with r.m.s. widths of the order of the overall alignment tolerance.

In the case of the large sextupoles the situation is the same in the horizontal plane, while in the vertical one the agreement between the magnetic and mechanical center positions is much better.

References

[1] B. Bolli, F. Iungo, F. Losciale, N. Ganlin, M. Preger, C. Sanelli, F. Sardone "Field quality of the large quadrupoles for the DAΦNE Main Rings" - DAΦNE Technical Note MM-24 (22/4/97).

[2] B. Bolli, F. Iungo, F. Losciale, N. Ganlin, M. Preger, C. Sanelli, F. Sardone "Magnetic measurements on the large sextupoles for the DAΦNE Main Rings achromats" - DAΦNE Technical Note MM-21 (22/1/97).

[3] B. Bolli, N. Ganlin, F. Iungo, F. Losciale, M. Paris, M. Preger, C. Sanelli, F. Sardone, F. Sgamma, M. Troiani "Comparison of magnetic and mechanical center positions of small quadrupoles and sextupoles in the DAΦNE Main Rings" - DAΦNE Technical Note MM-23 (19/3/97).

[4] F. Iungo, M. Modena, Q. Qiao, C. Sanelli "DAFNE magnetic measurement systems" - DAΦNE Technical Note MM-1 (4/11/93).

Table QR1 - Magnetic center position of the right quadrupoles (alignment table Q1)

Serial #	XAmag	XBmag	YAmag	YBmag	Φ(mrad)
5	12.72	12.09	508.13	508.05	0.11
7	12.89	12.62	508.36	508.30	0.71
10	12.60	12.23	508.34	508.19	0.78
11	11.70	11.96	508.25	508.17	1.09
12	12.27	12.05	507.94	507.88	0.61
14	13.09	12.80	508.24	508.17	0.65
15	12.33	11.91	508.31	508.25	0.55
18	12.37	12.13	508.47	508.42	1.29
19	13.22	12.22	508.19	508.14	0.37
20	12.80	12.17	508.05	507.99	0.54
22	13.15	12.45	508.08	508.02	0.15
23	12.76	12.30	508.17	508.11	0.40
24	12.29	11.58	507.88	507.87	0.35
25	12.36	11.83	508.25	508.24	0.33

Table QL1 - Magnetic center position of the left quadrupoles (alignment table Q1)

Serial #	XAmag	XBmag	YAmag	YBmag	Φ(mrad)
0	13.22	11.68	508.24	508.24	0.33
1	13.22	10.71	507.71	507.73	1.44
2	13.15	11.08	508.14	508.14	1.33
3	12.59	11.06	508.04	508.02	0.79
4	12.89	10.58	507.84	507.84	1.42
6	13.28	11.30	508.20	508.22	0.95
8	13.44	11.48	508.01	508.02	0.90
9	14.01	12.15	507.99	508.01	0.93
13	13.57	11.24	508.13	508.14	1.49
16	13.18	11.95	508.10	508.11	0.34
17	13.20	11.59	507.94	507.96	0.91
21	12.90	11.59	508.05	508.08	0.33
26	12.74	11.44	508.11	508.11	0.66
27	13.43	12.02	507.84	507.87	0.92

Table SR1 - Magnetic center position of the right sextupoles (alignment table S1)

Serial #	XAmag	XBmag	YAmag	YBmag	Φ(mrad)
0	12.52	12.45	500.09	499.96	0.21
1	12.42	13.02	500.15	500.12	0.48
2	12.53	12.75	500.34	500.28	-0.03
3	12.33	13.06	500.00	499.97	0.35
4	12.68	12.36	499.99	499.96	-0.50
5	12.34	12.85	500.05	500.00	0.18
6	12.60	12.47	499.95	499.93	-0.17
7	12.20	13.26	500.12	500.09	0.60
8	12.46	12.89	500.14	500.11	-0.02

Table SL1 - Magnetic center position of the left sextupoles (alignment table S1)

Serial #	**XAmag**	**XBmag**	**YAmag**	**YBmag**	**Φ(mrad)**
9	12.45	12.57	500.19	500.16	-0.69
10	13.06	12.66	500.05	500.05	0.26
11	12.92	11.84	500.02	500.01	1.05
12	12.77	12.54	500.11	500.11	0.63
13	13.16	12.88	500.12	500.11	-0.37
14	12.67	12.76	500.14	500.13	0.03
15	13.27	12.93	500.07	500.07	-0.04
16	12.43	12.44	500.09	500.08	-0.48
17	13.35	12.53	500.03	500.05	0.42

Table QR2 - Mechanical center position of the right quadrupoles (alignment table Q1)

Serial#	**XAmec**	**XBmec**	**YAmec**	**YBmec**
5	12.35	11.29	508.04	508.03
7	12.60	11.21	508.31	508.32
10	12.60	11.26	508.14	508.28
11	12.33	11.32	508.20	508.21
12	12.13	11.39	507.88	507.86
14	12.34	11.36	508.10	508.11
15	12.16	11.55	508.29	508.27
18	12.49	11.14	508.47	508.45
19	12.58	11.32	508.13	508.14
20	12.40	11.40	508.02	508.07
22	11.95	11.66	508.00	508.01
23	12.19	11.50	508.14	508.16
24	12.26	11.46	507.77	507.86
25	12.29	11.57	508.23	508.27

Table QL2 - Mechanical center position of the left quadrupoles (alignment table Q1)

Serial#	**XAmec**	**XBmec**	**YAmec**	**YBmec**
0	12.31	11.42	508.48	508.47
1	12.18	11.48	507.80	507.85
2	12.15	11.35	508.10	508.16
3	12.08	11.27	508.12	508.16
4	12.21	11.38	508.02	508.00
6	12.30	11.49	508.21	508.22
8	12.40	11.49	508.02	508.02
9	12.22	11.41	507.94	508.00
13	12.63	11.40	508.14	508.15
16	12.13	11.57	508.00	507.94
17	12.07	11.59	507.83	507.92
21	12.20	11.58	508.08	508.07
26	12.13	11.41	508.04	508.08
27	12.26	11.50	507.95	507.96

Table SR2 - Mechanical center position of the right sextupoles (alignment table S1)

Serial#	XAmec	XBmec	YAmec	YBmec
0	12.27	12.10	500.01	500.10
1	12.18	12.25	500.07	500.17
2	12.21	12.32	500.30	500.42
3	12.13	12.45	499.96	500.08
4	12.00	12.08	499.97	500.02
5	12.22	12.42	499.90	500.06
6	12.35	12.27	499.85	500.02
7	11.95	12.65	500.16	500.13
8	12.02	12.59	500.07	500.23

Table SL2 - Mechanical center position of the left sextupoles (alignment table S1)

Serial#	XAmec	XBmec	YAmec	YBmec
9	12.54	12.02	500.16	500.21
10	12.32	12.28	499.97	500.17
11	12.55	12.02	499.96	500.11
12	12.20	12.38	499.98	500.20
13	12.52	12.02	500.16	500.15
14	12.46	12.03	500.04	500.25
15	12.36	12.24	500.10	500.14
16	12.69	12.02	499.97	500.19
17	12.67	12.31	500.04	500.08

Table QR3 - Distance (mm) and tilt (mrad) between magnetic and mechanical axes for the right quadrupoles

Serial#	Shift X	Shift Y	Tilt X	Tilt Y	Shift XC
5	0.21	0.05	-7.79	0.47	0.16
7	0.56	0.01	-11.30	0.47	0.20
10	0.48	0.05	-6.49	1.93	0.09
11	0.64	0.01	-0.03	0.60	0.08
12	0.26	0.04	-5.33	0.27	-0.05
14	0.34	0.10	-14.56	0.53	0.01
15	0.10	0.00	-3.53	0.27	-0.18
18	0.55	-0.01	-5.83	0.20	-0.10
19	0.13	0.03	-10.30	0.40	-0.06
20	0.18	-0.03	-7.80	0.73	-0.09
22	-0.20	0.04	-13.23	0.47	-0.28
23	0.11	-0.01	-9.10	0.53	-0.09
24	0.04	0.06	-1.00	0.67	-0.13
25	0.10	-0.01	-2.17	0.33	-0.07

Table QL3 - Distance (mm) and tilt (mrad) between magnetic and mechanical axes for the left quadrupoles

Serial#	Shift X	Shift Y	Tilt X	Tilt Y	Shift XC
0	0.32	-0.24	7.77	-0.07	0.16
1	0.90	-0.10	1.80	0.20	0.17
2	0.63	0.01	4.90	0.40	-0.04
3	0.36	-0.11	1.97	0.40	-0.04
4	0.74	-0.17	-0.80	-0.13	0.02
6	0.58	-0.00	5.27	-0.07	0.10
8	0.53	-0.00	6.90	-0.07	0.07
9	0.52	0.03	16.90	0.27	0.05
13	0.55	-0.01	5.17	-0.00	-0.21
16	0.33	0.13	9.57	-0.47	0.16
17	0.57	0.07	7.53	0.47	0.11
21	0.35	-0.01	4.70	-0.27	0.18
26	0.29	0.05	4.27	0.27	-0.05
27	0.33	-0.10	11.30	-0.13	-0.14

Table SR3 - Distance (mm) and tilt (mrad) between magnetic and mechanical axes for the right sextupoles

Serial#	Shift X	Shift Y	Tilt X	Tilt Y	Shift XC
0	0.05	-0.03	-6.00	2.20	-0.06
1	0.27	0.01	-10.10	1.30	0.03
2	0.06	-0.05	-7.50	1.80	0.07
3	0.21	-0.03	-8.10	1.50	0.03
4	-0.20	-0.02	-9.60	0.80	0.05
5	0.16	0.04	-5.50	2.10	0.07
6	-0.03	0.01	-4.50	1.90	0.06
7	0.18	-0.04	-8.50	0.00	-0.12
8	-0.07	-0.03	-7.40	1.90	-0.06

Table SL3 - Distance (mm) and tilt (mrad) between magnetic and mechanical axes for the left sextupoles

Serial#	Shift X	Shift Y	Tilt X	Tilt Y	Shift XC
9	-0.32	-0.01	4.55	0.80	0.03
10	0.18	-0.02	11.20	2.00	0.05
11	0.28	-0.02	1.90	1.60	-0.25
12	0.20	0.02	7.25	2.20	-0.11
13	-0.11	-0.04	15.00	0.00	0.07
14	-0.26	-0.01	9.35	2.20	-0.28
15	0.11	-0.05	15.90	0.40	0.13
16	-0.34	0.00	1.50	2.30	-0.10
17	0.23	-0.02	9.00	0.20	0.02

Table Q4 - Alignment values without compensation of azimuthal rotation
for the quadrupoles (Method 4a)

Serial #	Slit A	Slit B	Height A	Height B
0	12.47	11.26	508.24	508.23
1	12.35	11.31	507.70	507.74
2	12.11	11.39	508.11	508.17
3	12.04	11.31	508.01	508.05
4	12.23	11.36	507.85	507.83
5	12.19	11.45	508.10	508.08
6	12.40	11.39	508.21	508.22
7	12.40	11.41	508.32	508.33
8	12.47	11.42	508.02	508.02
9	12.27	11.36	507.97	508.03
10	12.51	11.35	508.20	508.33
11	12.25	11.40	508.21	508.21
12	12.18	11.34	507.92	507.90
13	12.42	11.61	508.13	508.14
14	12.33	11.37	508.20	508.21
15	12.34	11.37	508.29	508.27
16	12.29	11.41	508.14	508.08
17	12.18	11.48	507.90	507.99
18	12.59	11.04	508.46	508.43
19	12.64	11.26	508.16	508.17
20	12.49	11.31	507.99	508.04
21	12.38	11.40	508.07	508.06
22	12.23	11.38	508.04	508.05
23	12.28	11.41	508.13	508.15
24	12.39	11.33	507.83	507.92
25	12.36	11.50	508.23	508.26
26	12.08	11.46	508.09	508.13
27	12.12	11.64	507.85	507.86

Table Q5 - Alignment values with compensation of azimuthal rotation
for the quadrupoles (Method 4b). The rotation angle is in mrad.

Serial #	Slit A	Slit B	Height A	Height B	Phi
0	12.28	11.45	508.24	508.23	0.37
1	12.73	10.93	507.70	507.74	-0.74
2	12.43	11.07	508.11	508.17	-0.63
3	12.09	11.26	508.01	508.05	-0.09
4	12.60	10.99	507.85	507.83	-0.72
5	12.49	11.15	508.10	508.08	-0.59
6	12.53	11.26	508.21	508.22	-0.25
7	12.40	11.41	508.32	508.33	0.01
8	12.57	11.32	508.02	508.02	-0.20
9	12.39	11.24	507.97	508.03	-0.23
10	12.47	11.39	508.20	508.33	0.08
11	12.05	11.60	508.21	508.21	0.39
12	12.22	11.30	507.92	507.90	-0.09
13	12.82	11.21	508.13	508.14	-0.79
14	12.35	11.35	508.20	508.21	-0.05
15	12.42	11.29	508.29	508.27	-0.15
16	12.11	11.59	508.14	508.08	0.36
17	12.28	11.38	507.90	507.99	-0.21
18	12.29	11.34	508.46	508.43	0.59
19	12.80	11.10	508.16	508.17	-0.33
20	12.57	11.23	507.99	508.04	-0.16
21	12.19	11.59	508.07	508.06	0.37
22	12.51	11.10	508.04	508.05	-0.55
23	12.43	11.26	508.13	508.15	-0.30
24	12.57	11.15	507.83	507.92	-0.35
25	12.55	11.31	508.23	508.26	-0.37
26	12.06	11.48	508.09	508.13	0.04
27	12.23	11.53	507.85	507.86	-0.22

Table S4 - Alignment values without compensation of azimuthal rotation for the sextupoles (Method 4a)

Serial #	Slit A	Slit B	Height A	Height B
0	12.33	12.05	499.98	500.07
1	12.15	12.28	500.08	500.18
2	12.14	12.39	500.25	500.37
3	12.10	12.48	499.92	500.04
4	11.95	12.13	499.95	500.00
5	12.15	12.49	499.95	500.10
6	12.29	12.33	499.86	500.02
7	12.07	12.53	500.12	500.09
8	12.08	12.53	500.04	500.21
9	12.57	11.99	500.15	500.20
10	12.37	12.23	499.95	500.15
11	12.30	12.27	499.94	500.09
12	12.09	12.49	500.00	500.22
13	12.60	11.95	500.12	500.11
14	12.18	12.31	500.03	500.24
15	12.49	12.11	500.05	500.09
16	12.59	12.12	499.97	500.20
17	12.69	12.29	500.02	500.06

Table S5 - Alignment values with compensation of azimuthal rotation for the sextupoles (Method 4b). The rotation angle is in mrad.

Serial #	Slit A	Slit B	Height A	Height B	Phi
0	12.22	12.15	499.98	500.07	0.21
1	11.91	12.52	500.08	500.18	0.48
2	12.15	12.37	500.25	500.37	-0.03
3	11.92	12.66	499.92	500.04	0.35
4	12.20	11.88	499.95	500.00	-0.50
5	12.07	12.58	499.95	500.10	0.18
6	12.37	12.25	499.86	500.02	-0.17
7	11.77	12.83	500.12	500.09	0.60
8	12.09	12.52	500.04	500.21	-0.02
9	12.22	12.34	500.15	500.20	0.69
10	12.50	12.10	499.95	500.15	-0.26
11	12.83	11.75	499.94	500.09	-1.05
12	12.40	12.18	500.00	500.22	-0.63
13	12.41	12.13	500.12	500.11	0.37
14	12.20	12.29	500.03	500.24	-0.03
15	12.47	12.13	500.05	500.09	0.04
16	12.35	12.36	499.97	500.20	0.48
17	12.90	12.08	500.02	500.06	-0.42