DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **L-24**

MAIN RING ORBIT CORRECTION MONITORS AND CORRECTOR DEFINITION

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1. Introduction

The Main Ring orbit correction has been simulated for the Day One configuration (named **DD** in the note L-22 [1]), using the definitive layout of pick-ups, correctors and magnetic elements, slight different from the one used in the first orbit correction analysis [2,3].

The correction has been performed using the code MAD and applying the "n most efficient corrector" method.

Two machine conditions have been considered: sextupoles off (called *machine start-up*) and sextupoles on (*stored beam*), with and without monitor errors in both cases. The main idea is to show if it is possible, at the beginning without sextupoles, to adjust the beam with a suitable orbit inside the vacuum chamber; after that sextupoles can be turned on and the beam accumulated, starting now from a smaller closed orbit that could be furthermore corrected.

The initial orbit was simulated misaligning magnets with big errors, while small errors have been used in the simulations for the second part in order to have a smaller starting orbit.

The correction is based on the monitor and corrector positions included in the last parameter list (November 1996), but these positions must be verified in real life in order to compare simulations and real measured orbit.

2. Correction

The computer code MAD has been used to generate Gaussian random error distributions in the ring elements and calculate the resulting closed orbit deviation (cod). See [2] for more details in the definition of the method.

The correction scheme uses 4 Horizontal and 55 Horizontal-Vertical closed orbit monitors; everywhere *BPM* have been used but for the low-beta regions where *Striplines* are located adjacent to some quads (see Graphic below); in the simulations monitors are point-like.

The correctors are 3 horizontal, 8 vertical and 20 horizontal-vertical dipole magnets of different length from 10 cm to 32.8 cm ; some of them will be also used for local bumps, as vertical beam separation at the IP or adjustments of the orbit at the Splitter magnet for different crossing angles.

Figure 1 shows a diagram of the correction scheme; only two machine halves are reported (ES1 and EL2).

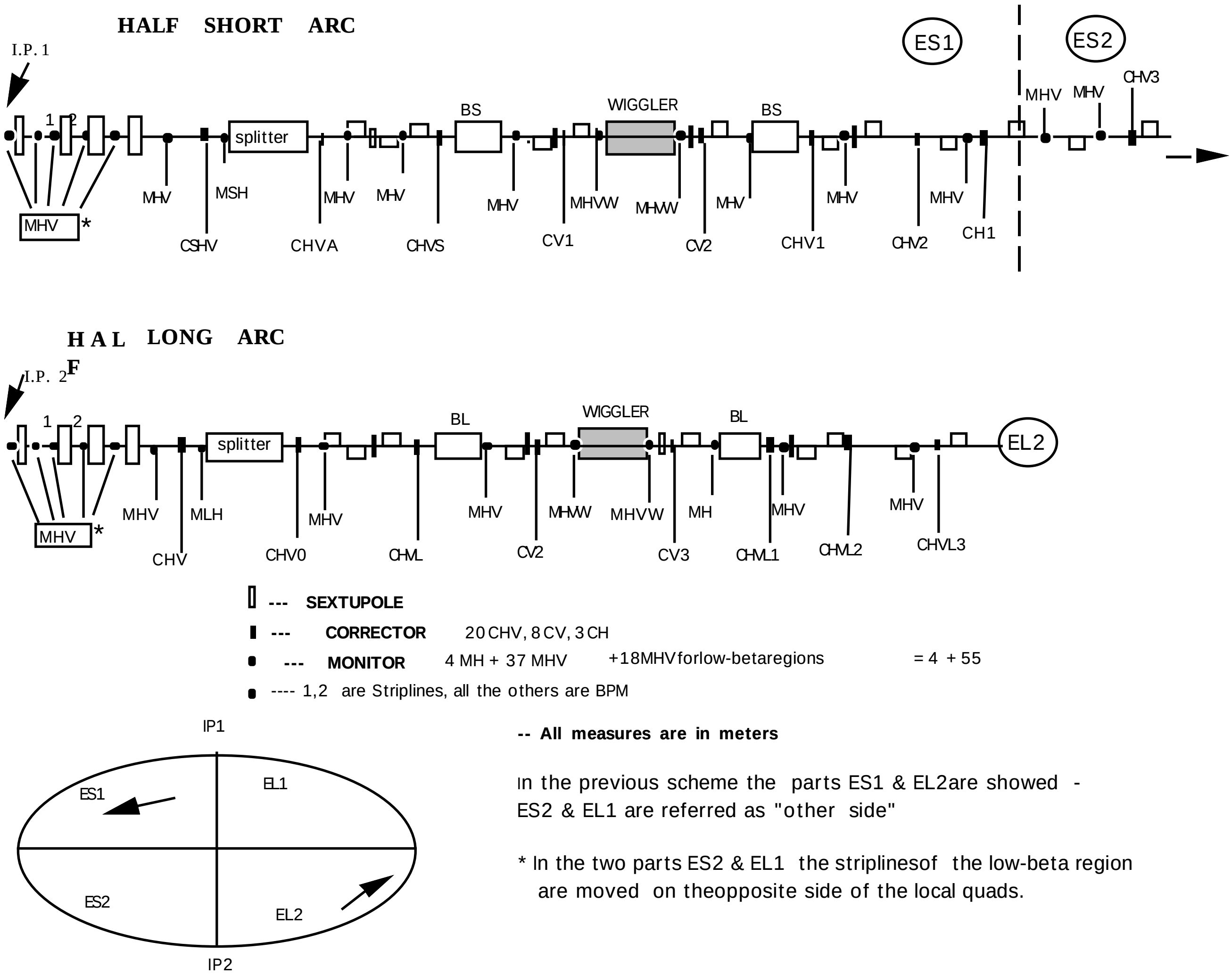

Figure 1 - Correction scheme for main rings - DAY ONE MACHINE/Nov 1996.

The main requirements for the orbit correction scheme are:

- Small vertical orbit in the sextupoles in order to get very low coupling factor in the rings;
- small vertical orbit in the wigglers, where the vacuum chamber aperture is small;
- very good orbit control in the Interaction Regions (IRs) where the beams with 20 μ vertical beam size, coming from two different rings, travel on horizontally separated orbits and must cross at the interaction point.

To fulfill these requirements a large number of monitors has been used, specially in IRs (26 monitors). Mainly in the latter regions, but also everywhere else, the number of correctors is smaller (4 in IRs) due to lack of space and to the fact that, if necessary, part of the orbit correction can be performed by mechanical adjustments of the magnetic elements.

The presently used scheme will be the same also for the other lattice configurations except for the Interaction Regions, where interference with the detectors allows a smaller number of monitors.

Tables Ia-Ib show the positions of correctors and monitors, in meters, from the center of the long injection straight section starting from EL1 --> ES1 --> ES2 --> EL2. Positions are referred to the element exit. For each element two names reported: the first one is used in MAD files, while the second one, in parenthesis, refers to the parameter list.

Two different working points have been studied, which differ mainly in the horizontal tune:

a) **Q_x= 5.09, Q_y= 6.07**

b) **Q_x= 4.53, Q_y= 6.06**

For each case four tables are shown: *Machine start-up* and *Stored beam*, assuming monitors without and with alignment and processing errors in both transverse planes.

TABLE Ia - Corrector Position (m)

CHVL3(chvel101)	2.442588	CHV3(chves201)	52.029345
CHVL2(chvel102)	4.372588	CHV1(chves202)	53.515345
CHVL1(chvel103)	6.833588	CV2(chves203)	55.944345
CV3(chvel104)	9.482588	CV1(chves204)	59.466031
CV2(chvel105)	13.004274	CHVS(chves205)	62.330031
CHVL(chvel106)	16.088274	CHVA(dhces201)	64.935031
CHV0(dhcel101)	18.693274	CSHV(chveI201)	67.256531
CLHV(chveI101)	21.014774	CLHV(chveI202)	76.915531
CSHV (chveI102)	30.673774	CHV0(dhcel201)	79.325031
CHVA(dhces101)	33.083274	CHVL(chvel201)	81.802031
CHVS(chves101)	35.560274	CV2(chvel202)	84.786031
CV1(chves102)	38.324274	CV3(chvel203)	88.307717
CV2(chves103)	41.845959	CHVL1(chvel204)	91.056717
CHV1(chves104)	44.374959	CHVL2(chvel205)	93.417717
CHV2(chves105)	47.660959	CHVL3(chvel206)	95.347717
CH1(chves106)	48.595152		

TABLE Ib - Monitor Position (m)

MHVL8(bpbeL101)	2.5311	MHVS3(bpbes202)	50.036
MHVL7(bpbeL102)	6.2501	MHVS1(bpbes203)	52.733
MHVL4(bpbeL103)	8.8076	MHVC2(bpbes204)	55.269
MHVW4(bpbeL104)	9.8026	MHVW5(bpbes205)	56.264
MHVW3(bpbeL105)	12.129	MHVW1(bpbes206)	58.591
MHVL3(bpbeL106)	13.914	MHVC1(bpbes207)	60.376
MHVL2(bpbeL107)	16.701	MHVM2(bpbes208)	62.942
MHVL1(bpbeL108)	18.301	MHVM1(bpbes209)	64.542
MLHV(bpbei101)	20.674	MSHV(bpbei201)	66.916
MHV4(bpbi1001)	23.384	MHV4(bpbi2001)	69.626
MHV3(bpbi1002)	24.164	MHV3(bpbi2002)	70.406
ML2(bpsi1001)	24.274	MS2(bpsi2001)	70.516
ML1(bpsi1003)	24.974	MS1(bpsi2003)	71.216
MHV1(bpbi1004)	25.418	MHV1(bpbi2004)	71.660
MHV0(bpbi1005)	25.724	MHV0(bpbi2005)	71.966
MHV1(bpbi1006)	26.030	MHV1(bpbi2006)	72.272
MS1(bpsi1005)	26.174	ML1(bpsi2005)	72.416
MS2(bpsbi1007)	26.774	ML2(bpsi2007)	73.016
MHV3(bpbi1008)	27.284	MHV3(bpbi2008)	73.526
MHV4(bpbi1009)	28.064	MHV4(bpbi2009)	74.306
MSHV(bpbei102)	30.774	MLHV(bpbei202)	77.016
MHVM1(bpbes101)	33.148	MHVL1(bpbeL201)	79.389
MHVM2(bpbes102)	34.748	MHVL2(bpbeL202)	80.989
MHVC1(bpbes103)	37.314	MHVL3(bpbeL203)	83.776
MHVW1(bpbes104)	39.099	MHVW3(bpbeL204)	85.561
MHVW2(bpbes105)	41.426	MHVW4(bpbeL205)	87.888
MHVC2(bpbes106)	42.421	MHVL4(bpbeL206)	88.883
MHVS1(bpbes107)	44.957	MHVL6(bpbeL207)	91.440
MHVS2(bpbes108)	48.190	MHVL5(bpbeL208)	95.159
MHVS4(bpbes201)	49.092		

Tables II and III show the rms values assumed for the errors indicating with Δx and Δy the misalignments, $\Delta\Theta$ and $\Delta\Phi$ the rotations and $\Delta B/B$ the relative field error in the magnets.

TABLE II - DAY-ONE configuration (Q_x = 5.09, Q_y = 6.07)

Machine start-up without sextupoles and without monitor errors

large errors: Δ**x** = Δ**y** = **.15 mm**; $\Delta\Theta$ = $\Delta\Phi$ = **0.5 mrad**; ΔB/B = **5e**$^{-4}$

	Xmax (mm)	Xrms (mm)	Ymax (mm)	Yrms (mm)	αx-max (mrad)	αx-rms (mrad)	αy-max (mrad)	αy-rms (mrad)
before correct.	29 ± 12	12 ± 5	33 ± 30	13 ± 12				
after correct.	2.1 ± 1.3	.30 ± 0.13	1.4 ± 0.3	.19 ± 0.05	2.0 ± 0.8	0.7 ± 0.2	1.1 ± 0.2	.38 ± .06

with monitor errors (Δ**x** = Δ**y** = **0.5 mm**)

	Xmax (mm)	Xrms (mm)	Ymax (mm)	Yrms (mm)	αx-max (mrad)	αx-rms (mrad)	αy-max (mrad)	αy-rms (mrad)
before correct.	29 ± 12	12 ± 5	33 ± 30	13 ± 12				
after correct.	3.1 ± 1.3	.54 ± 0.12	1.9 ± 0.4	.56 ± 0.11	2.5 ± 0.9	0.9 ± 0.3	1.9 ± 0.4	.77 ± 0.14

Stored beam with sextupoles errors and without monitor errors

small errors: Δ**x** = Δ**y** = **.015 mm**; ΔB/B = **5e**$^{-5}$
$\Delta\Theta$ = $\Delta\Phi$ = **0.05 mrad**; $\Delta\Theta$ = $\Delta\Phi$ = **0.1 mrad** (sextupoles)

	Xmax (mm)	Xrms (mm)	Ymax (mm)	Yrms (mm)	αx-max (mrad)	αx-rms (mrad)	αy-max (mrad)	αy-rms (mrad)
before correct.	2.8 ± 1.1	1.1 ± 0.5	3 ± 3	1.2 ± 1.1				
after correct.	.21 ± .13	.03 ± .01	.14 ± .04	.02 ± .01	.20 ±.08	.07 ± .02	.11 ± .02	.04 ± .01

with monitor errors (Δ**x** = Δ**y** = **.1 mm**)

	Xmax (mm)	Xrms (mm)	Ymax (mm)	Yrms (mm)	αx-max (mrad)	αx-rms (mrad)	αy-max (mrad)	αy-rms (mrad)
before correct.	2.8 ± 1.1	1.1 ± 0.5	3 ± 3	1.2 ± 1.1				
after correct.	0.5 ± 0.2	.10 ± .02	.28 ± 0.06	.09 ± .01	.37 ± 0.13	.14 ±.04	.31 ± 0.09	.13 ± .03

TABLE III - DAY-ONE configuration (Q_x = 4.53, Q_y = 6.06)

Machine start-up without sextupoles and without monitor errors

large errors: Δ**x** = Δ**y** = **.15 mm**; $\Delta\Theta$ = $\Delta\Phi$ = **0.5 mrad**; $\Delta B/B$ = **5e^{-4}**

	Xmax (mm)	Xrms (mm)	Ymax (mm)	Yrms (mm)	αx-max (mrad)	αx-rms (mrad)	αy-max (mrad)	αy-rms (mrad)
before correct.	8 ± 3	3.1 ± 1.1	40 ± 30	16 ± 14				
after correct.	2.0 ±1.3	.29 ± 0.13	1.4 ± 0.3	0.19 ± .05	2.0 ± 0.8	0.7 ± 0.2	1.1 ± 0.3	.37 ± .07

with monitor errors (Δ**x** = Δ**y** = **0.5 mm**)

	Xmax (mm)	Xrms (mm)	Ymax (mm)	Yrms (mm)	αx-max (mrad)	αx-rms (mrad)	αy-max (mrad)	αy-rms (mrad)
before correct.	8 ± 3	3.1 ± 1.1	40 ± 30	16 ± 14				
after correct.	3.2 ± 1.3	.56 ± 0.12	1.8 ± 0.4	.48 ± 0.07	2.4 ± 0.9	1.0 ± 0.3	1.7 ± 0.4	.73 ± 0.17

Stored beam with sextupoles errors and without monitor errors

small errors: Δ**x** = Δ**y** = **.015 mm**; $\Delta B/B$ = **5e^{-5}**
$\Delta\Theta$ = $\Delta\Phi$ = **0.05 mrad**; $\Delta\Theta$ = $\Delta\Phi$ = **0.1 mrad** (sextupoles)

	Xmax (mm)	Xrms (mm)	Ymax (mm)	Yrms (mm)	αx-max (mrad)	αx-rms (mrad)	αy-max (mrad)	αy-rms (mrad)
before correct.	0.8 ± 0.3	.30 ± 0.11	4 ± 3	1.5 ± 1.2				
after correct.	.20 ± 13	.03 ± .01	.14 ± .03	.02 ± .01	.20 ± .08	.07 ± .02	.11 ± .02	.04 ± .01

with monitor errors (Δ**x** = Δ**y** = **.1 mm**)

	Xmax (mm)	Xrms (mm)	Ymax (mm)	Yrms (mm)	αx-max (mrad)	αx-rms (mrad)	αy-max (mrad)	αy-rms (mrad)
before correct.	0.8 ± 0.3	.30 ± 0.11	4 ± 3	1.5 ± 1.2				
after correct.	0.5 ± 0.2	.10 ± .02	.28 ± 0.06	.09 ± .01	.41 ± 0.15	.16 ± .05	.31 ± 0.08	.13 ± .03

The obtained horizontal and vertical closed orbit distortion around the ring, before and after correction, are given reporting the maximum and rms values, averaged over all the cases simulated. In the final four columns the related corrector deflection angles, α, are given for both planes.

The presence of monitor errors, clearly, makes the correction worse, especially in the vertical plane, due to the high beta value in the interaction regions. The correction is satisfactory also turning sextupoles with monitor errors.

The residual closed orbit distortion in a sample machine is reported in Fig. 2 together with the behavior of the lattice optical function β, for both transverse planes. The example chosen is a corrected orbit obtained after inserting big errors, also in monitors, for the machine configuration (b) without sextupoles. Half machine is shown in the plot.

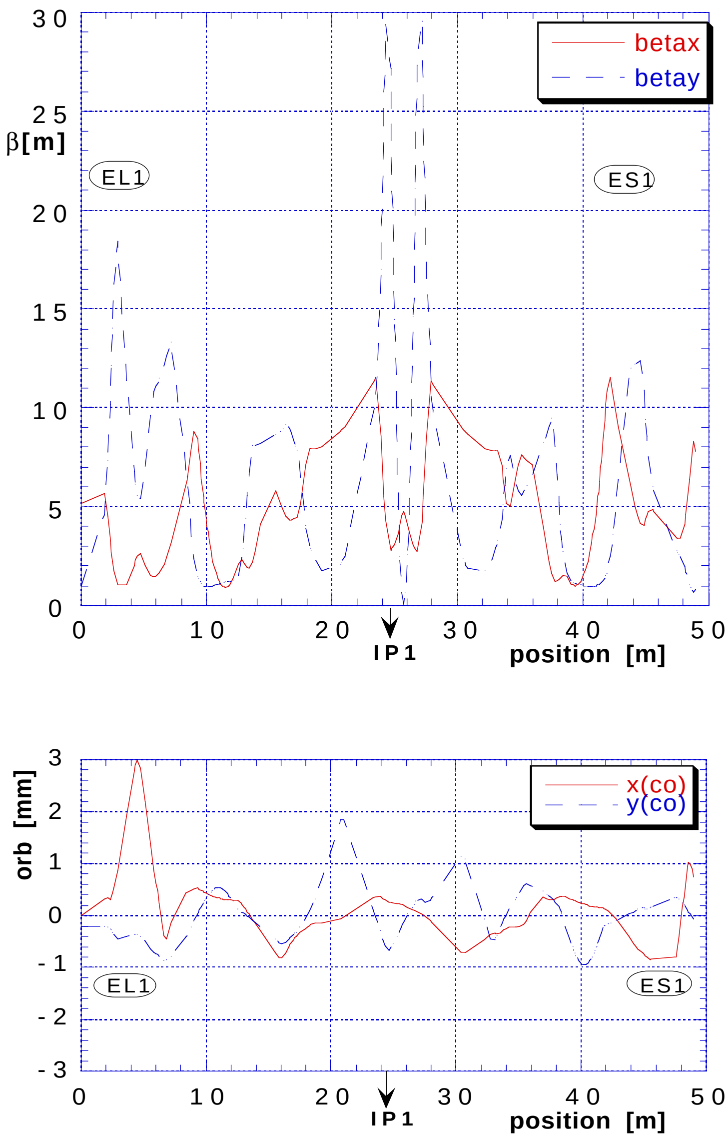

Figure 2 - Sample corrected closed orbit along half machine: Q_x = 4.53 - Q_y = 6.06. Big errors , configuration without sextupoles.

3. References

[1] M.E. Biagini, C. Biscari, S. Guiducci, "DAΦNE Main Rings Lattice Update" - DAΦNE Tech. Note **L-22**, Mar. 1996.

[2] M.R. Masullo, "Orbit Correction Analysis for DAΦNE Lattice" - DAΦNE Tech. Note **L-3**, Apr.1991.

[3] M.E. Biagini, C. Biscari, S. Guiducci, J. Lu, M.R. Masullo, G. Vignola, "Review of DAΦNE Lattices" - DAΦNE Tech. Note **L-9**, Oct. 1993.