

The Transport Line from MAIRA to the LNLS UVX Electron Storage Ring

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Abstract

The magnet lattice of the transport line from the 100 MeV linear accelerator (MAIRA) to the LNLS UVX electron storage ring is described. Two operation modes of the transport line to match the phase ellipse parameters for the matched and mismatched injection modes are calculated. Orbit distortion and correction have also been simulated.

I. INTRODUCTION

The electron beam from the linear accelerator MAIRA[1] is transported by an underground transfer line - MU - and is brought into the LNLS UVX[2] storage ring by a 14° horizontal thick septum magnet and a 2.9° horizontal thin septum magnet.

The linac building is outside the ring building and the linac centre is 1.2 m above the ground, whereas the UVX beam centre is 20 cm higher. In order to keep the experimental hall free, the beam is transferred through a tunnel 4 meters under the ring.

The proposed line is composed of a quadrupole triplet after MAIRA, an achromatic system to transfer the beam to underground level, a FODO section, one horizontal achromatic system to rotate the line 90° anticlockwise, a quadrupole triplet, another achromatic system to bring the beam up to the storage ring level, a quadrupole doublet and finally another horizontal achromatic system to match the phase ellipse parameters of the beam to the injection parameters. See fig. 1.

Two operation modes, for the matched injection and the mismatched injection[3], are presented.

II. BEAM DIMENSIONS

The maximum values of the optical function in MU were determined to ensure a good transmission of the beam. The

following parameters were used to calculate the transmission efficiency:

- Diameter of the vacuum chamber: 36 mm
- linac r.m.s. emittance, $\epsilon_L = 6.7 \times 10^{-7}$ rad.m.
- r.m.s. energy dispersion, $\Delta p/p = 2\%$.

The r.m.s. beam envelope is given by:

$$\sigma = \sqrt{\beta\epsilon_L + \eta^2 \left(\frac{\Delta p}{p}\right)^2}$$

The first term is the emittance contribution and the second is the dispersion contribution to the envelope σ .

A maximum of 35 m for the β functions in both planes and of 60 cm for the dispersion functions guarantees the transmission of 3 standard deviations of the beam, the limitation being in the dispersive regions of the lattice. This corresponds to about 85% transmission efficiency.

III. MAGNET LATTICE

MU matches the phase ellipse parameters at the end of MAIRA and at the injection point of UVX for two injection modes. Table 1 gives some parameters of the line.

Table 1: Main parameters of MU

	Matched	Mismatched
Length (m)	86.592	
# of dipoles	11	
# of quadrupoles	34	
# of septa	2	
Horizontal phase advance (2π)	3.000	3.864
Vertical phase advance (2π)	3.213	3.875

The β -functions for the two operation modes (matched and mismatched injection) are shown in figures 1 and 2. Figure 3 shows the dispersion function (for x and y direction), for both modes.

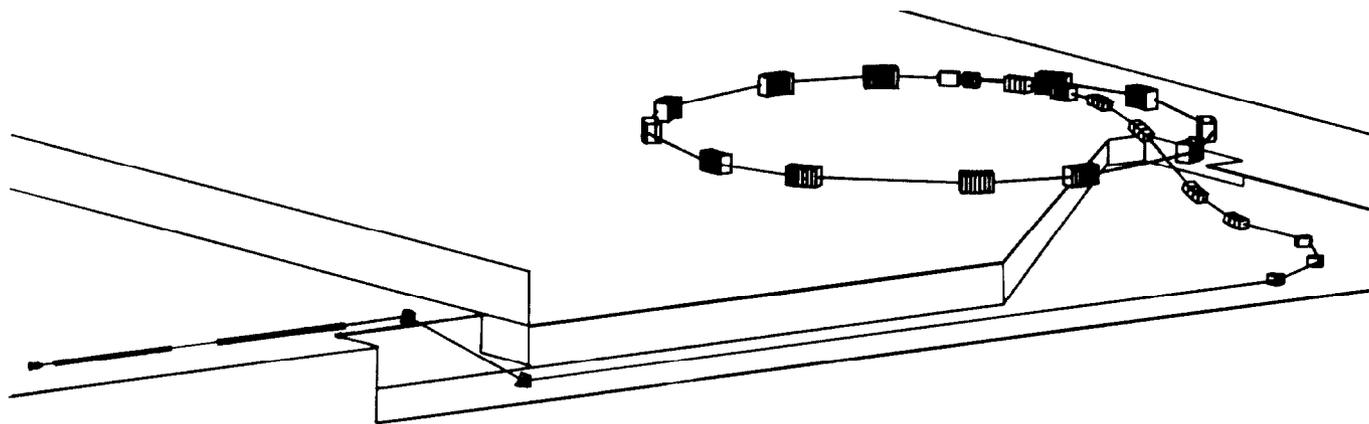


Figure 1. Layout of the transport line - MU.

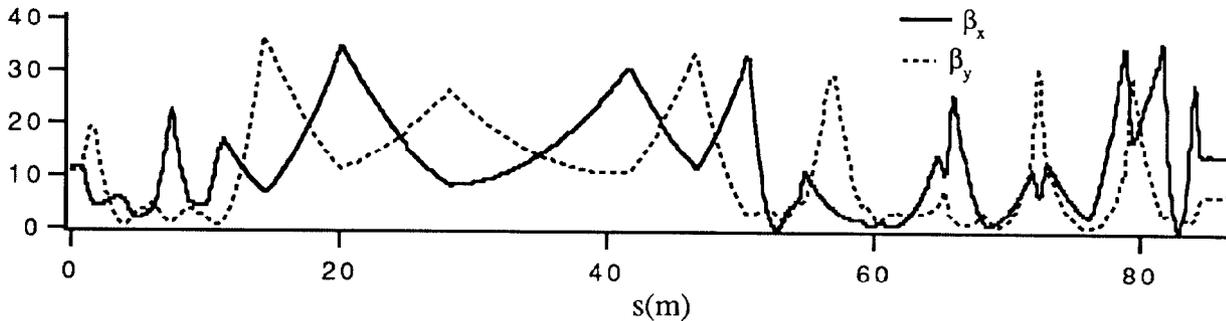


Figure 2. β -Functions for MU in the matched injection mode

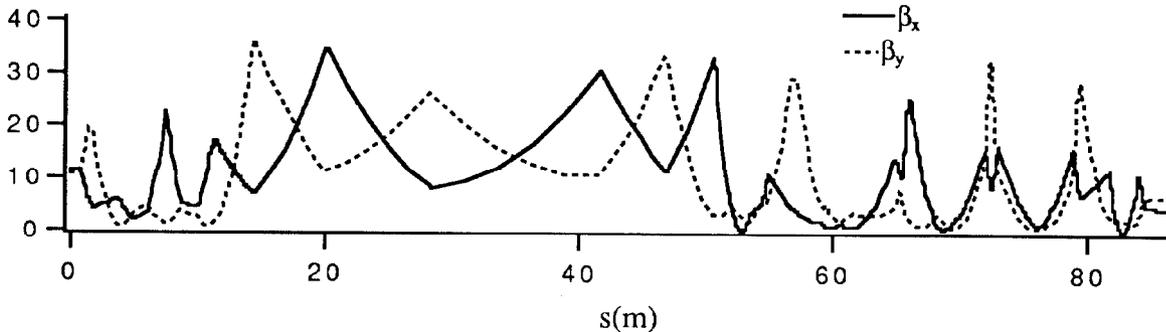


Figure 3. β -Functions for MU in the mismatched injection mode

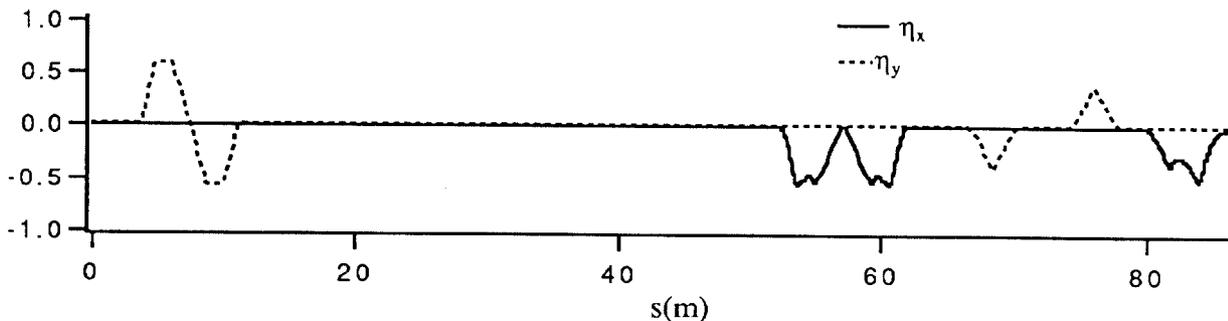


Figure 4. $\eta_{x,y}$ -Functions for MU in the matched and mismatched injection modes

IV. ORBIT DISTORTION AND CORRECTION

We have simulated orbit distortion in MU to determine the number and distribution of monitors and correctors, as well as the necessary strengths of these elements. The simulation was done for the matched injection mode.

The correction scheme is straightforward: the orbit displacement is corrected exactly at the monitor position by a steering dipole (corrector) upstream of it. The horizontal and vertical planes are independent for correction elements.

Care has been taken to position the elements for the best sensitivity. The monitor controlling a corrector is placed approximately a quarter betatron wavelength downstream. All correctors are inside the quadrupoles and dipoles. The monitors can perform both horizontal and vertical readings. We have 10 horizontal correctors, 12 vertical ones and 17 position monitors.

Alignment errors and relative field errors are assumed to follow random Gaussian distribution truncated at two standard deviations. One standard deviation of the errors distribution in all dipoles and quadrupoles are given in table 2.

Table 2: Alignment and strength random errors (one standard deviation) in magnetic elements.

Alignment errors		$\frac{\Delta S}{S}$
$\sigma_x = \sigma_y$	σ_α	
0.2 mm	0.02°	0.02%
0.2 mm	0.02°	0.02%

The correction of orbit distortion uses a new procedure that was developed for transport lines[4]. The basic idea is to use a transformation matrix that can represent the motion from $s=0$ to s including the distorted central orbit. Considering the uncoupled case, the vector $(x, x', 1)$ is transported by the matrix:

$$M = \begin{pmatrix} S & C & p \\ S' & C' & p' \\ 0 & 0 & 1 \end{pmatrix},$$

where p represent a particular solution of the inhomogeneous equation of motion in presence of alignment errors.

A table of central orbit distortions, without correction, for 3 independent initial conditions is given by MAD[5]. This

table is used to obtain the matrix M between the position of all monitors and correctors and the value of the correctors is evaluated to correct exactly the orbit distortion at the monitors. This uncoupled first order matrix approach is iterated 3 times to give zero distortion at monitors within the accuracy used by MAD.

Ten different sequences of random values have been generated; for each sequence orbit correction has been simulated. A statistical analysis of the results is presented in table 3. Note that multipole errors have not been considered.

Table 3: Maximum absolute and average value of the correctors for ten simulations

$\langle C_x \rangle$	0.07 ± 0.67	mrad
$ C_x _{\max}$	1.41 ± 0.77	mrad
$\langle C_y \rangle$	-0.01 ± 0.51	mrad
$ C_y _{\max}$	1.26 ± 0.37	mrad

Figure 5 shows the distorted and corrected orbit in horizontal and vertical planes before and after correction in MU for one of the sequence of random errors.

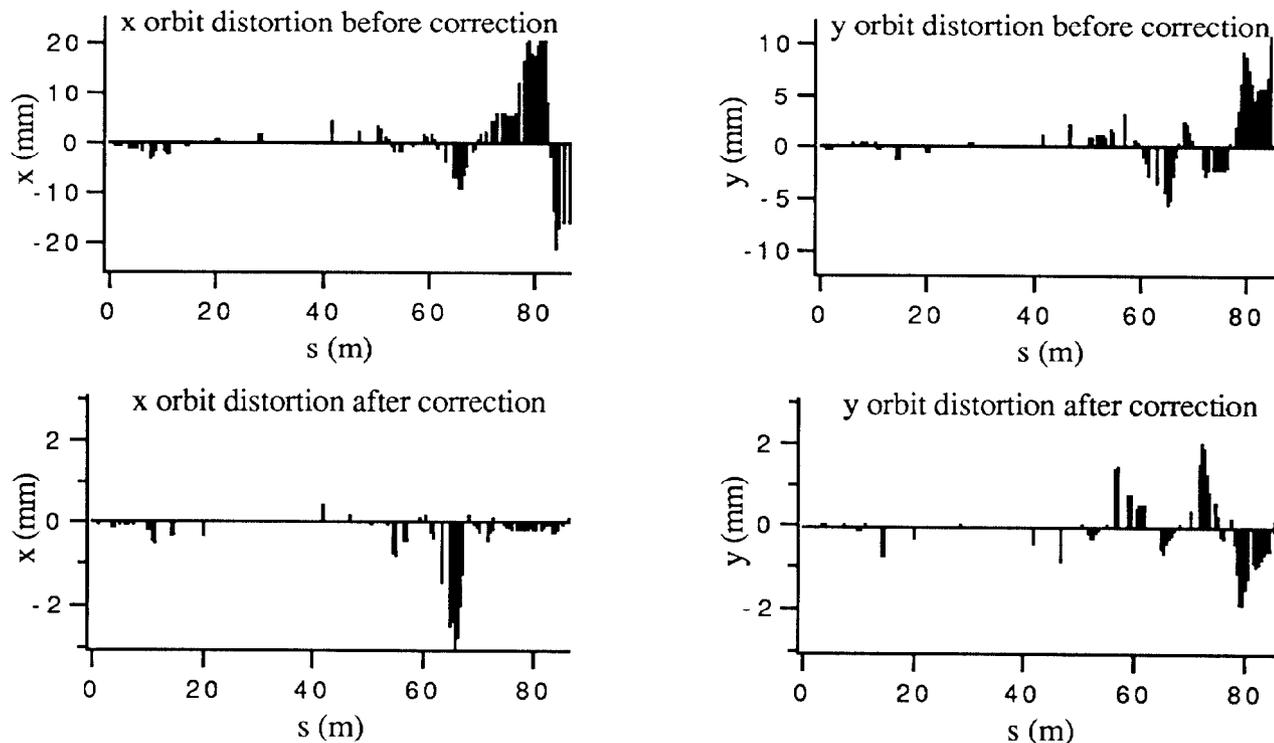


Figure 5. Distorted and corrected orbit in horizontal and vertical planes before and after correction in MU.

V. REFERENCES

- [1] A. R. D. Rodrigues and D. Wisnivesky, 'Commissioning of the LNLS Injector Linac', 1990 EPAC.
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