THE NEW BOOSTER SYNCHROTRON FOR SOLEIL

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Abstrac

The injection system of the synchrotron light source SOLEIL [1] is composed of a 100 MeV electron Linac pre-accelerator followed by a full energy (2.75 GeV) booster synchrotron. In view to ease the top-up injection operation, a new lattice design has been adopted leading to a lower emittance as well as a lower magnet power supply requirement. This later allows to use the flexible and economic ramping switched mode procedure cycled up to 3 Hz.

1 INTRODUCTION

Based on the previous booster lattice [2], FODO structure with missing magnet, a lower emittance and lower magnet power supply requirement are obtained by increasing the number of bending magnets from 24 to 36. With a circumference of 157 m and low field magnets (0.74 T), the new achieved equilibrium emittance is of 150 nm.rad (instead of 350) at 2.75 GeV.

2 LATTICE OF THE BOOSTER

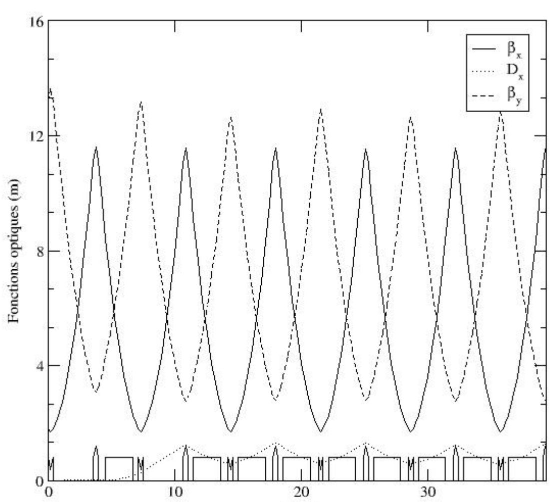

Figure 1 : Optical functions

We adopt a configuration of 2 periods composed of 22 cells with 4 without magnet. Injection and extraction scheme will be inserted in the free drift sections.

Injection energy	0.1 GeV
Extraction energy	2.75 GeV
RF Frequency	352.202 MHz
Circumference	156.6 m
Period	2
Cycling frequency	3 Hz
Horizontal emittance	1.5 10^{-7} m.rad
Energy spread	6.6 10^{-4}
Energy losses by turn	409 keV
Betatron tunes (ν_x , ν_z)	6.4 , 4.4
Momentum compaction	3.19 10^{-2}
Natural chromaticities (ξ_x , ξ_z)	-1.14, -1.32
Damping times (τ_x , τ_z , τ_s)	6.3, 5.7, 2.7 ms
Number of dipoles	36
Bending radius	12.376 m
Dipole length	2.16 m
Field min/max	0.027 / 0.74 T
Number of quadrupoles	44
Quadrupole length	0.4 m
Maximum gradient	10.3 T/m
Number of sextupoles	28
Sextupole length	0.15 m
$\frac{1}{2}.\frac{\partial^2 B_z}{\partial x^2}$ maximum	16 T/m^2

Table 1 : Main parameters of the booster

The betatron phase advance per cell has been chosen to cancel the dispersion function in the drift section with only two quadrupoles families. In addition, we have also two families of sextupoles to correct the chromaticity at injection. The optical functions are shown in the figure 1 and the main parameters are summarized in table 1.

3 CLOSED ORBIT CORRECTION

We plan to correct the closed orbit (C.O.) at injection only with 22 beam position monitors (BPM) and 44 dipolar correctors (one per quadrupole). Figure 2 shows the C.O. distortion for one standard deviation with field errors and misalignments summarized in table 2. With a maximum correctors strength of 1.5 mrad, the C.O. is reduced by a factor of 2.

Dipole

$\Delta BL/BL$	10^{-3}
Δx	1 mm
Δz	0.5 mm
Δs	1 mm
$\Delta\phi_s$	0.5 mrad

Quadrupole

$\Delta GL/GL$	$5\ 10^{-3}$
Δx	0.2 mm
Δz	0.2 mm

Table 2 : rms fields errors and misalignments.

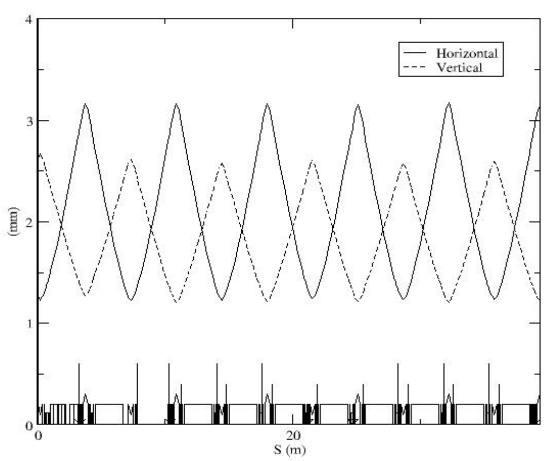

Figure 2 : rms C.O. distortion

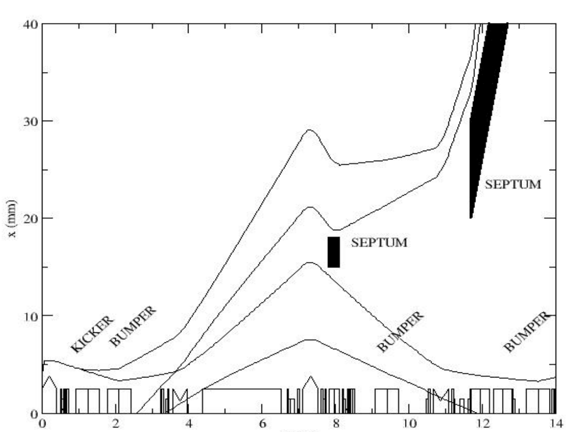

Figure 3 : Extraction scheme

4 INJECTION AND EXTRACTION

The 100 MeV beam coming from the linac is injected on the axis with a 131 mrad septum and a 12 mrad fast kicker [3]. After a local closed orbit bump set with 3 low kickers, the circulating beam is extracted in one turn using a fast kicker and two pulsed septum magnets. The extraction scheme is presented in the figure 3 and the different element characteristics are summarized in table 3.

Fast Kicker	1
Length	0.6 m
Nominal field @ 2.75 GeV	0.023 T
Nominal deviation	1.5 mrad
Slow Kicker	3
Length	0.6 m
Nominal field @ 2.75 GeV	0.044 T
Nominal deviation	2.4 mrad
Passive Septum	1
Length	0.3 m
Nominal Field @ 2.75 GeV	0.214 T
Nominal deviation	7 mrad
Septum thickness	3 mm
Active Septum	1
Length	1 m
Nominal Field @ 2.75 GeV	1.01 T
Nominal deviation	110 mrad
Septum thickness	12 mm

Table 3 : Extraction characteristics.

5 BEAM STAY CLEAR

The linac emittances and energy spread vary following the ring filling operation. A maximum emittance of 1 mm.mrad and energy spread of 1.5 % enclosing 90 % of the particles is obtained in top-up operation [3].

The vacuum chamber sizes are determined in each element taking the maximum between:

1. Injected beam + 2 rms corrected C.O. (96 %)
2. 4 rms equilibrium beam at 2.75 GeV + 2 rms uncorrected C.O.

The good field region of each element is then :

Element	Horizontal	Vertical
Dipole	48 mm	18 mm
Quadrupole	52 mm	20 mm

To avoid the expensive use of reinforcement ribs, the vacuum chamber thickness has been increased to 1 mm.

6 EDDY CURRENT EFFECTS, AND CHROMATICITIES CORRECTION

With a repeating rate of 3 Hz and 1 mm beam pipe thickness, the induced field errors from the Eddy current are not negligible. In the dipole, the main perturbation is a sextupole field [4]. We present in figure 4 the variation of the sextupole strength as well as the induced chromaticity during the cycle. The large chromaticity induced at injection is corrected by means of 28 sextupoles

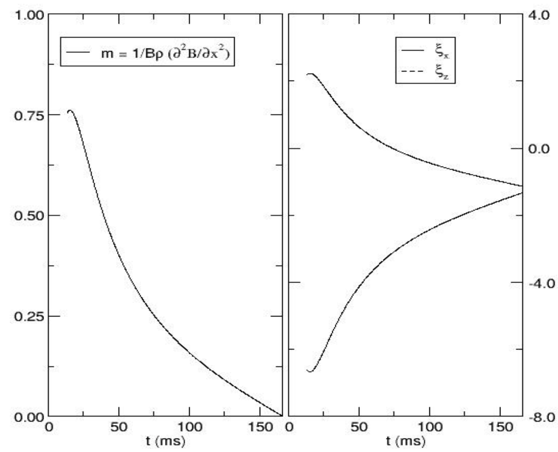

Figure 4 : Chromaticity induced by the Eddy current

7 FIELD TOLERANCES

Tolerances on systematic field distortions have been determined (table 4) to have the smallest dynamic aperture (figure 5) compatible with the injected beam size for particles having 1.5 % of energy spread.

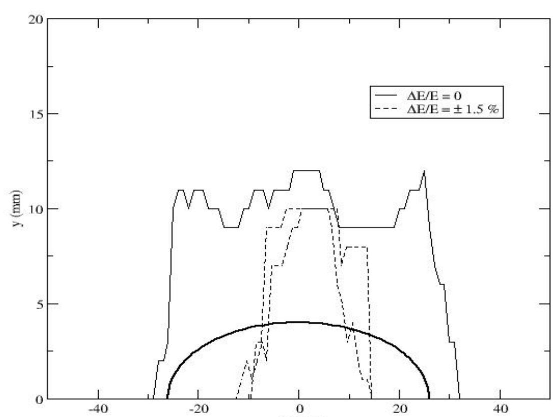

Figure 5 : Dynamic aperture at injection including Eddy current and multipole effects

Field	Dipole	Quadripole
Gradient $\frac{1}{B}\frac{\partial B}{\partial x}$	$5\ 10^{-2}$	
$\frac{\Delta B}{B}$ (Good field region)	$1.2\ 10^{-3}$	
Multipole components $\frac{\Delta B}{B}$ (Good field region)	$5\ 10^{-4}$	$2\ 10^{-3}$

Table 4 : Field tolerances in the good field region

8 MAGNETS AND POWER SUPPLY

The H dipoles are top opening curved magnet. In view of reducing at maximum the dipole power supply requirement, we reduce the dipole gap down to 22 mm together with 80 mm pole width. The quadrupoles as well as sextupoles designs remain unchanged. The main characteristics of the magnets are listed below.

	Length (m)	B max	I max (kA)	R total (mΩ)	L total (mH)
Dipole	2.16	0.74 T	1.15	250	78
Qpole	0.4	11 T/m	0.31	560	144

In biased sine wave cycle at 3 Hz, the low dipole field together with the small pole gap allows to keep the maximum required voltage below 1 kV. This low magnet power supply requirement is well suited to use the flexible and economic ramping switched mode procedure [5].

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