THE LATTICE FOR CELLS

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Abstract

CELLS is a new medium energy synchrotron light source to be build in Spain, in the Valles region, near Barcelona. The project has been approved in spring 2003. The basis of the approval was the conceptual design of the LLS, finished in 1997. According to the users requirements, the energy of the design has been upgraded to 3 GeV and a new, more performing lattice has been chosen. We review the main candidate for the lattice, describing the linear parameters and beam dynamics, and provide an estimation of the Touscheck lifetime.

INTRODUCTION

The construction of a synchrotron light source in the Valles region was approved by the Spanish and Catalan government in April 2003. The machine will work at energy of 3 GeV, and due to budgetary reasons should have a circumference less than 270 meters. In order to meet the requirements of the present Spanish user community, the emittance should be smaller than 5 nm-rad, include the possibility of top-injection, in-vacuum undulators and sub-micron stability. An overview of the project can be found in these proceedings [1].

After the investigation of 4 kind of lattices, the solution chosen is based in a DBA optics with distributed dispersion, with 16 cells, including 4 long straight sections of 8 meters. One of these sections is destined to injection and another one for RF. This provides us with 14 straight sections for insertion devices, including 2 of 8 meters, that can be used for long undulators covering the VUV spectral range.

After all it comes out, that the solution is similar to the one at Soleil [2], the main difference is the inclusion of quadrupolar component in the bending magnets. This is required to reduce the emittance and to reduce the total length used by the magnets. However, this component is quite large, and will produce a large amplification of position errors of bending magnetic. Another compromise adopted is the use of a pair of quadrupoles in place of a triplet in the straight section. This reduces the length of the basic cell and allows us to increase the number of periods, but we sacrifice some of the flexibility.

BASIC CELL

The basic cell consists of an arrangement similar to the one of the Theoretical Minimum Emittance cell, with a vertical focusing magnet and adjacent at each side horizontal focusing quadrupoles. Two of these units with a small straight section form the basic cell of the lattice. This short straight will be used for placing diagnostic equipment, kickers for the feedback system, and perhaps some RF cavities. Sextupoles with integrated dipole correctors are placed near the quadropoles (Figure 2). An additional quadrupole has been placed in the 8 meters long straight to help with the matching of the optical functions in the middle of it. The number and position of BPMs, as the placement of the magnets in girders are under study.
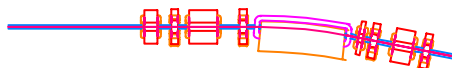

Figure 2: Basic magnetic cell of the proposed lattice.

Optical Functions

The lattice has been fitted to provide small beta functions at the location of the insertion devices, while providing a small emittance and trying to keep the vertical beta function at the bending magnet not to large.
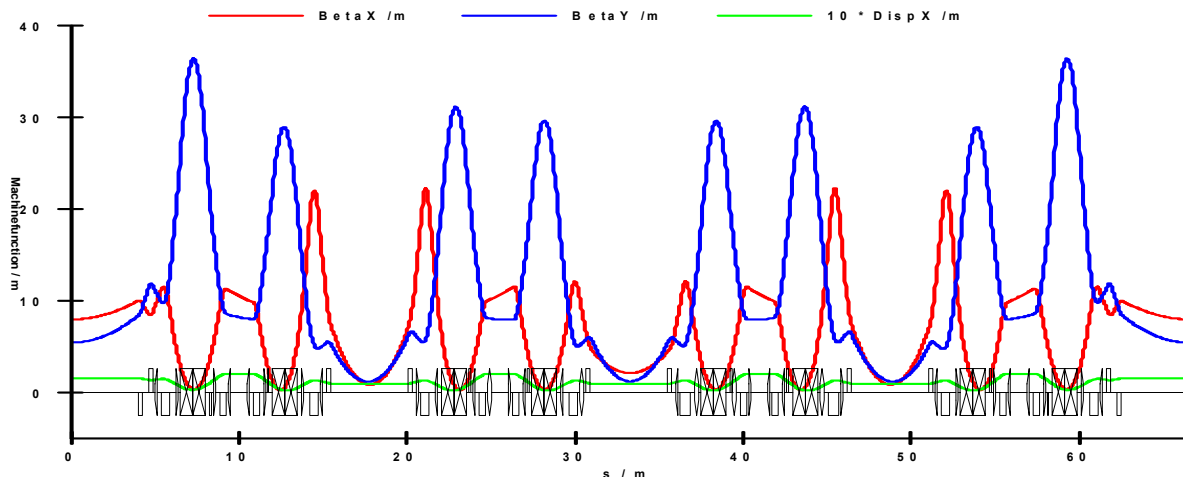

Figure 1: Optics functions for one quarter of the machine.

The optical functions for a quarter of the machine are show in Figure 1 and the main parameters in Table 1.

Table 1: Main Parameters

Parameter	Unit	Value
Energy	GeV	3
Circumference	m	266.4
Emittance	nm.rad	3.6
Current	mA	>250
No Cells		16
Q_x /Q_y		19.57/7.62
Q'_x/Q'_y		-51/-33
Beam sizes	μm	
Straight		120/7
Bending		40/27

We can make several comments about the linear parameters: a) The optimization of the working point is still on progress, using frequency map techniques to help in the election of the final one. The actual is very close to the half integer resonance. b) The emittance reached is very low and fulfil the requirements of the scientific programme. c) The natural chromaticities are high, but still in a range where is possible to compensate them and provide the required dynamic aperture and energy acceptance. d) The quadrupoles will be powered individually, in order to compensate the beta beating and restore the symmetry of the lattice. The short defocusing quadrupoles near the bending magnets will be used to compensate for the beta beat produce in the bendings, powered by a single power supply.

Nonlinear Parameters

To perform the chromaticity correction 8 families of sextupoles are available. As all the families are in places with finite dispersion, is it not possible to separate the sextupoles in two groups, one to correct the chromaticity and another to compensate for the nonlinear dynamics, and both tasks have to been done simultaneously. The tool used to evaluate the required strength of the sextupoles has been OPA, and the results are been cross checked with Tracy. We are in the process of performing the same process with BETA.

The Figure 3 shows the dynamic aperture in the middle of the long straight section. The dynamic aperture corresponds to 18 mm mrad in the horizontal and to 52 mm mrad in the vertical, for the on momentum particles, and remains large enough up to ±3% energy deviation.

Figures 4 and 5 show the tune shift with amplitude and energy deviation. The variations of the tune show a promising behaviour, and the present sextupole arrangement is a good starting point to perform the optimization once the definitive working point is selected

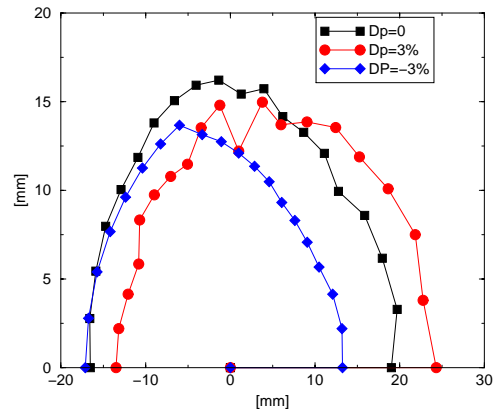and the effect of imperfections and high order multipoles is included.
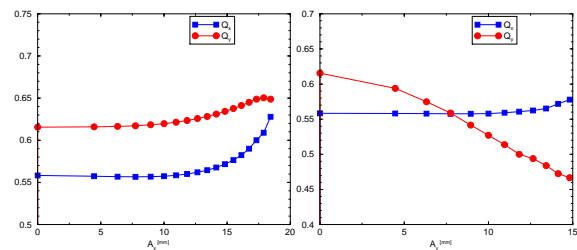

Figure 3: Dynamic Aperture.

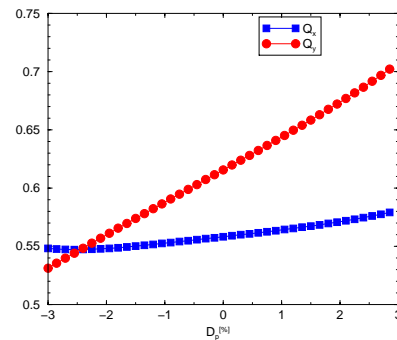Figure 4: Tune shift with the horizontal (left) and the vertical (right) amplitude.

Figure 5: Tune shift with the energy.

Touscheck Lifetime

One of the main limitations of modern synchrotron light sources is the lifetime, which is mainly determined by the Touscheck effect. The use of top-up operation and third harmonic RF cavities help to increase it, but a large enough lifetime (over 8 hours) is still needed to have a comfortable and safe operation of the machine.

The Touscheck lifetime is determined by the energy acceptance along the lattice. Again, OPA has been used to estimate the energy acceptance along the basic cell and the equivalent energy acceptance for the lattice. One of the limitations of OPA is that does not include error effects, so this calculation is very preliminary and the result is only a first approximation.

The parameters used for the calculation are:

- RF Frequency: 500 MHz

- RF Voltage 3.6 MV
- Current per bunch 0.7 mA
- 1% Coupling

With these conditions the effective energy acceptance of the lattice is 3%, similar to the one of the RF system, and the Touscheck lifetime is of 31 h. When other effects are included (errors, high order multipoles, etc) this value will be reduce, but we are confident that the value will be over 20 hours, and the total lifetime will be more than 10 hours.

SOURCE CHARACTERISTICS

Beam Sizes

The beam sizes along one quarter of the machine are show in Figure 6, for a 1% coupling. A nice characteristic of the optics is that the electron beam is almost round at the centre the bending magnets, which is one of users preferences.
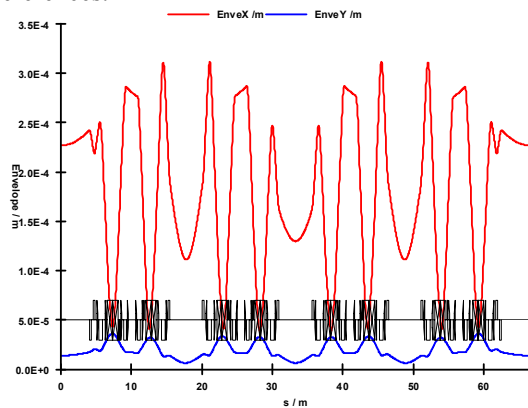

Figure 6: Beam sizes along the lattice.

Alternative Optics

Additional optic modes for the lattice are under study. The first one has been requested by our scientific division and consists of the change of the horizontal beta function in one of the straight sections to larger values (between 8 to 10 m), in order to decrease the beam divergence. We have chosen to do that in four of the straight sections and preserve the symmetry of the lattice, as show in Figure 7.
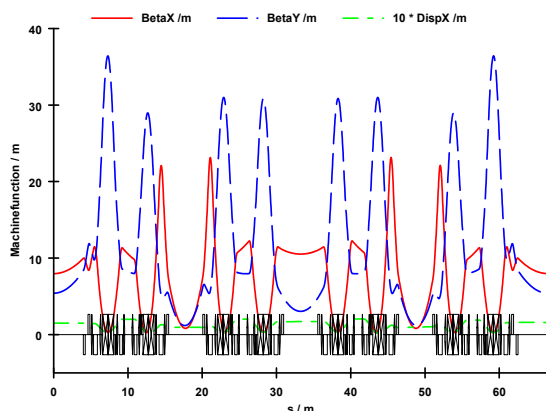

Figure 7: Alternative optics.

Insertion Devices

Five beamlines will be built together with the storage ring in the first phase. The final selection of which beamlines to build will not be ready until next year once the Spanish users have had extensive discussions and have come to an agreement.

Figure 8 shows the anticipated spectral output from the present design (DBA lattice) and the 5 ID's expected to be installed from day one. These five insertion devices have been considered to be:

- Conventional multipole wiggler, maximum peak field 2 T, period length 100 mm
- Superconducting multipole wiggler, maximum peak field 3.5 T, period length 60 mm
- In vacuum hybrid undulator, period of 25 mm, minimum gap of 5 mm, $K_{max}=3.08$
- Conventional PPM undulator, period of 80 mm, maximum K=4.88
- APPLE-II type undulator, period of 55 mm, minimum gap of 14 mm, $K_{max}=3.75$
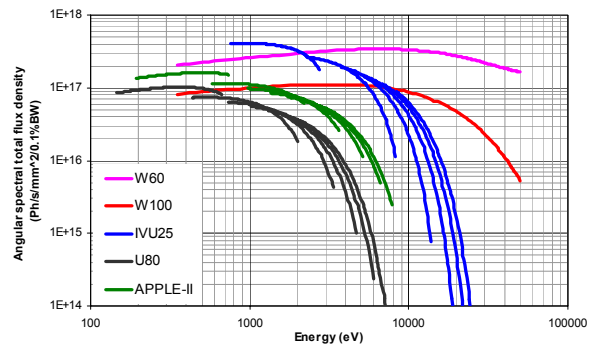
All insertion devices are 2 m long.

Figure 8: Spectral flux density for the 5 possible insertion devices.

CONCLUSIONS

The lattice presented in this paper fulfils the requirements of our scientific case, which give a large importance to high flux density. It has a low emittance while having large enough energy acceptance and dynamic aperture. A detailed study of the lattice is under progress, including high order multipoles and errors.

REFERENCES

[1] D. Einfeld et alt, "A concept for the Spanish Light Source", these proceedings

[2] J.L. Laclare et alt, "Optics for SOLEIL at 2.5 GeV", PAC 1997.