A CONCEPT FOR THE SPANISH LIGHT SOURCE CELLS

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Abstract

In March 2003 the Spanish and Catalan Governments established a public Consortium for the construction, equipment and exploitation of a third generation synchrotron light source. The foundation was based upon a proposal to build a 2.5 GeV, 12 fold symmetry machine with a circumference of 250 m. In order to optimise the spectral characteristics of the synchrotron radiation a re-design of the light source is taking place. In the present paper we will give a project overview and explain key design decisions and overall schedule. Five beamlines will be designed and constructed in a first phase to cover the needs of the Spanish community. The definition of these beamlines will take place before summer 2005 after the process of consultation with the user community is over. This process is currently taking place through the Spanish Association of Synchrotron Light Users (AUSE). This is a body operating under the auspices of the Spanish Ministry for Education and Culture

INTRODUCTION

The Spanish Light Source is intended to provide Spain with a powerful light source up to x-ray energies. The project was formally approved in March 2002 by the Spanish and the Catalan Governments but it was not until 2003 that the legal body to construct the facility was established. Since the beginning of 2004 a team is being constituted with the goal of constructing and commissioning a source with 5 beamlines by 2009. The team has started its work by revisiting the previous design report which was finished in 1997 [1] and which has been used as a basis for the approved budget.

The re-design is based upon the following decisions:

1) the energy should be 3 GeV,

2) the emittance should be smaller than 5 nmrad,

3) four straight sections with a length of 8 m should be available,

4) twelve straight sections with a length of 4 m should be available,

5) a full-energy-injector will be used,

6) the topping-up injection mode has to be foreseen and

7) the 3 GeV booster synchrotron and the 3 GeV storage ring will be in the same tunnel.

SCIENTIFIC CASE

The Spanish Light Source is probably the last European middle energy 3rd generation light source. At the time of the first experiments all other sources will be in operation. Being the last ones we will learn from the others sources and should be able to complement other sources by introducing some originality.

At the moment Spain has a 4 % share of the ESRF, two CRG beamlines at ESRF: Spline for materials science (diffraction and absorption) and BM16 for protein crystallography. Spain will also be a partner of Soleil. Therefore, the choice of beamlines will have to take into account issues of complementarity.

Discussions with the users have already started [2] and several working groups have been created that will prepare scientific cases to be discussed with the Scientific Advisory Committee (SAC) in summer 2005.

DECISIONS

Energy

To extend the spectrum of the undulator radiation up to 20 keV the electron beam energy has been increased from 2.5 to 3.0 GeV.

With such an energy the brilliance at 20 keV reaches 10^{19} Ph/s/mm^2/mrad^2/0.1%BW for in-vacuum undulators with a 5 mm gap. Access to high energy X-rays could be provided with the use of superconducting multipole wigglers (see Figure 4).

Lattice layout

Earlier design work on the Spanish Light Source had been carried out on a 12 cell TBA lattice with a circumference of 250 m. The ring size has been preserved in the new design but the lattice periodicity has been increased to 16 cells with a 4-fold symmetry in order to increase the number of available straight sections.

The length of the straight sections has been used as a constraint in the lattice design. We require 4 straight sections of up to 8 m, two of which will accommodate injection and RF; and 12 straight section of up to 4 m to accommodate insertion devices.

The first lattice analysed in this new period was based on a QBA lattice with an emittance of 5.2 nmrad [3]. The optimisation of this lattice resulted in a DBA lattice with an emittance of 3.6 nmrad. A TBA lattice with the same four-fold symmetry and keeping the same circumference has a emittance smaller by a factor of 2. The main results for both lattices follow.

Table I summarises the main parameters of both lattices and figures 1 and 2 show the betatron functions for both lattices:

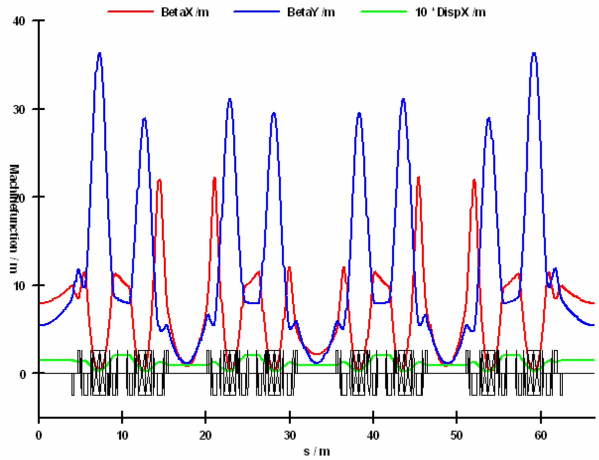

Figure 1 DBA betatron functions for ¼ of the ring

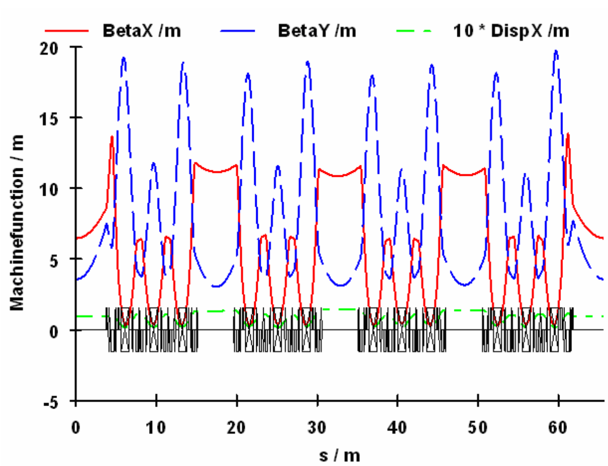

Figure 2 TBA Betatron functions for ¼ of the ring

Table I: Parameters for the studied magnetic lattices

Parameter	Units	DBA	TBA
Energy	GeV	3.0	3.0
Circumference	m	266.1	264.0
Hor. Emittance	nm.rad	3.6	1.8
N. of cells		16	16
N. of superperiods		4	4
N. of dipoles, max. field and grad.	T / T/m	32 1.32 / 5.5	48 1.32 / 8.8
N. of quadrupoles		136	136
max. grad	T/m	21	30
N. of sextupoles		128	160
Betatron tunes Qx Qy		 19.57 7.62	 21.25 7.26
Nat. Chromaticities Q'x Q'y		 -51.05 -33.42	 -40.35 -25.80
Mom. comp. factor		$8.10\cdot10^{-4}$	$6.52\cdot10^{-4}$
Beam size σ_x / σ_y Middle of 4 m straight Middle of bending	µm	 120 / 6.5 40 / 27	 210 / 7.5 33 / 17

The proposed TBA lattice requires magnets with large gradients, not only in the dipole but also the in quadrupoles. To achieve these gradients without saturation in the iron, apertures smaller than normally used which could compromise the vacuum lifetime of the electron beam are required. On the other hand the DBA lattice is more relaxed allowing larger apertures, especially in the vertical plane.

Also the dynamic aperture and the Touschek lifetime are larger, by a factor two, for the DBA than for the TBA.

In addition with the given circumference, the DBA is the only lattice of the two where mini-beta sections can be introduced in the straight sections. The introduction of mini-beta sections is of special interest to increase the photon flux density. In the present design mini-beta sections are introduced in all the 4 m long straight sections, see figure 1; although an approach including alternative mini-beta, high-beta with low divergence is also being studied.

Figure 3 compares the spectral flux density calculated in the middle of the 4 m long straight sections for a 3.5 T superconducting multipole wiggler with a length of 2 m and a conventional undulator with 80 periods and a period length of 25 mm for both lattices. The spectral flux density obtained from the bending magnet is also plotted for comparison.

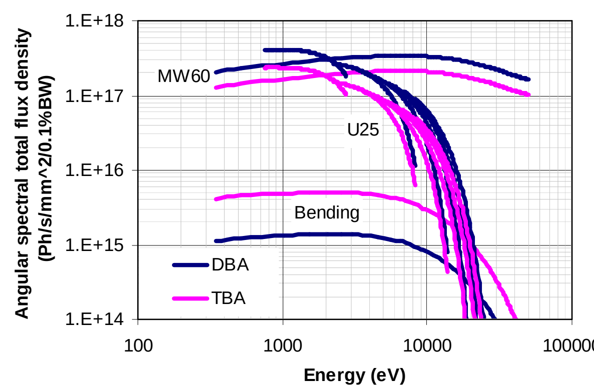

Figure 3 Spectral flux density for both lattices

The spectral flux density from the TBA bending magnet is higher than that of the DBA lattice because of smaller beam size at the bending magnet. In the case of the wiggler and the undulator the opposite is true and correspondingly the spectral flux density reached with the DBA lattice is larger. Also the beam is rounder at the bending magnets.

After careful analysis of both lattices the DBA has been the lattice of choice. On one hand the DBA lattice has more relaxed parameters for the gradients at the magnets, On the other hand the scientific case in Spain pushes for a light source providing high flux density.

Extensive lattice studies on the DBA structure have been performed and are reported on an accompanying paper [4].

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 SAC and the management of the laboratory decide which are the most suitable beamlines for the first phase. However we anticipate that the spectral range from the VUV up to the hard x-ray range will have to be covered.

By way of illustration figures 4 and 5 show the anticipated spectral output from the present design (DBA lattice) and for five generic IDs. A length of 2 m has been considered for all insertion devices to make the comparison easier. 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 = 2.6
- Conventional PPM undulator, period of 80 mm, minimum gap of 20 mm, maximum K = 6.6
- APPLE-II type undulator, period of 55 mm, minimum gap of 14 mm, K max = 3.9

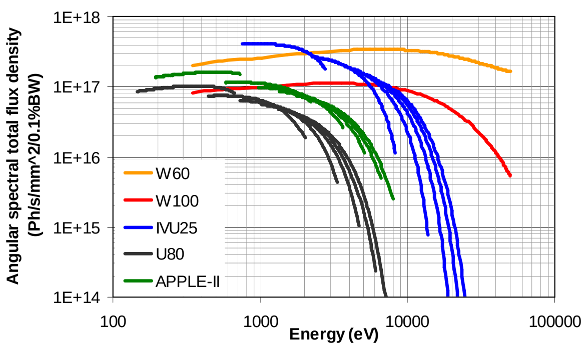

Figure 4 Spectral flux density for the first 5 insertion devices

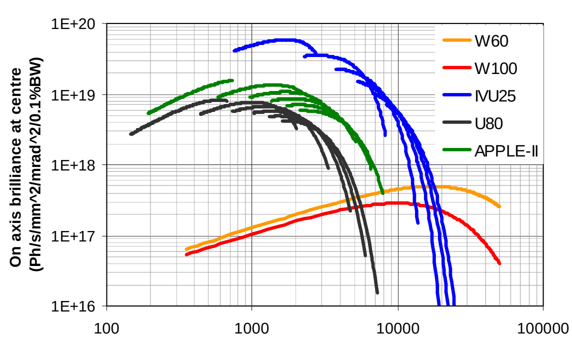

Figure 5 Expected on-axis brilliance for 5 generic insertion devices

MISCELLANEOUS

Injector

The injector system will be composed of a 100 MeV electron linac followed by a full energy [3 GeV] Booster synchrotron. The injector will be design to sustain top-up injection.

The design of the booster synchrotron is based on the following criteria:

- Full energy Booster
- Repetition rate between 3 and 5 Hz to ensure a high injection rate and at the same time to minimise eddy currents in the vacuum chamber
- Booster must be easy to operate
- Booster and Storage Ring sit in the same tunnel

The site/ The building

A site nearby the Autonomous University of Barcelona has been selected. Geotechnical studies to determine the composition of the ground as well as a vibrational study are under way. First results are expected later this year.

The call for tender for the building executive project has already been placed and the winner should be known by October of this year.

Time Schedule

The present schedule assumes that the site will be prepared to start construction in 2006 and that the building will be ready for installation in mid 2007. The goal is that commissioning of the storage ring starts in the middle of 2008.

CONCLUSIONS

The previous design report for the Spanish Light Source is being modified to better answer the present user requests and to integrate new developments.

ACKNOWLEDGMENTS

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