

PRELIMINARY ID DESIGNS FOR THE LSB STORAGE RING

X. Queralt[†], CLRC Daresbury Laboratory, Warrington, WA4 4AD, UK

Abstract

In order to cover the photon energy range required for the Spanish scientific community, two undulator and two multipole wiggler designs are proposed. According to the LSB machine specifications, the insertion devices are designed for optimum operation in the 0.1-4.0 keV range, for the undulator case, and 1.0-40.0 keV for the multipole wigglers. The magnetic configuration of the insertion devices has been carried out using the Poisson/Superfish code. Also, the optical output is given for all of them, the integrated intensity for the multipole wigglers and the brightness in the central cone for the undulators.

1 INTRODUCTION

Once the electron beam energy and the dipole magnetic field for the bending magnet has been decided, the radiation coming from these magnets is unchangeable. In a 3rd generation synchrotron radiation source the characteristics of the radiation depends strongly on the type of the insertion device (ID) located in the storage ring straight sections.

For such devices one can adjust the radiation output according to the beamline specifications. For that reason the insertion devices proposed for the LSB cover, as well as possible, the photon energy range user requirements and provide enough output radiation to satisfy the Spanish scientific community [1].

As a first attempt to cover these needs we propose two pure permanent magnet undulators, in the 0.1-4.0 keV range, and two hybrid multipole wigglers (MPWs), for 1.0-40.0 keV photon range.

2 GENERAL INSERTION DEVICE PARAMETERS

2.1 User requirements

Figure 1 shows the photon energy range required by the Spanish scientific community. This distribution has a maximum at 4.0-10.0 keV range, and there is a significant number of groups that are in the 0.1-30 keV region.

Although there is an important community that will use the synchrotron radiation in the visible and UV region, these groups can use the radiation from the bending magnets or from the multipole wigglers, if they do not need a very small source size.

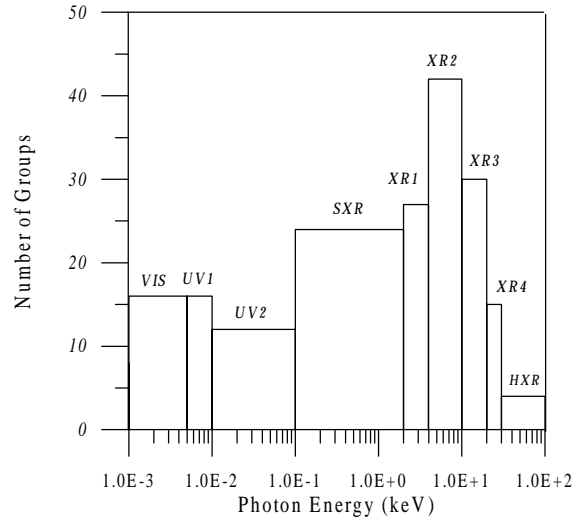


Figure 1: Number of the future LSB user groups as a function of the photon energy range required.

2.2 Lattice constraints

The synchrotron radiation quality generated in an insertion device depends strongly on the machine specifications: particularly on the electron beam energy, beam current, equilibrium emittance, energy spread and on the optical functions in the straight sections and the length of the free space in these sections.

Table 1: Machine parameters used to compute the output spectra for the insertion devices. (E: electron energy, I: electron beam current, σ_E : energy spread, χ : coupling, ϵ_0 : equilibrium emittance and $\beta_{H,V}$: horizontal and vertical values of the beta functions in the centre of the straight sections)

E	I	σ_E	χ	ϵ_0	β_H	β_V
[GeV]	[mA]	[]	[%]	[rad.m]	[m]	[m]
2.5	250	8.7E-04	5	8.3E-09	15.6	4.7

In Table 1 is given the values of the LSB machine main parameters in the straight section where are located the insertion devices [2]. Also a 2 cm ID gap is assumed for all of them.

A basic scheme of the free space straight section is given in Figure 2. The total length available is 7.3 m (between the two sextupoles SF), and a 6 m insertion device is feasible.

[†] Permanent address: Laboratori del Sincrotró de Barcelona - IFAE, Edifici Cn, Universitat Autònoma de Barcelona, E08193 Bellaterra (SPAIN)

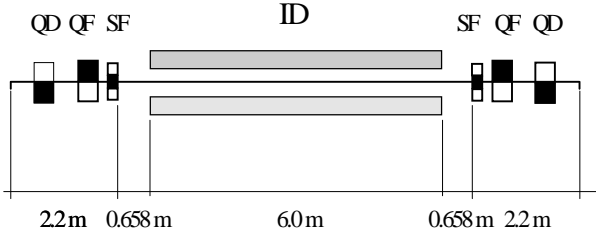


Figure 2: Basic sketch of a lattice straight section, indicating the position of the insertion device (ID), the quadrupole doublet (QD and QF), and the sextupole family (SF).

2.3 Undulator parameters

Due to the fact that the undulators must cover a photon energy range of 0.1-4.0 keV, we have to choose the optimum values of undulator period and magnetic field on axis (optimum K value), that will cover this energy range. To establish the K values we also consider that up to the 9th harmonic will be achievable; also important is the undulator tunability and the prevention of energy gaps between harmonics.

Taking into account these considerations and from the graph of the first and ninth harmonic photon energy as a function of the undulator period (Figure 3), the undulator periods chosen are 4.6 cm (U46) and 6.0 cm (U60). The basic parameters for these IDs are given in Table 2.

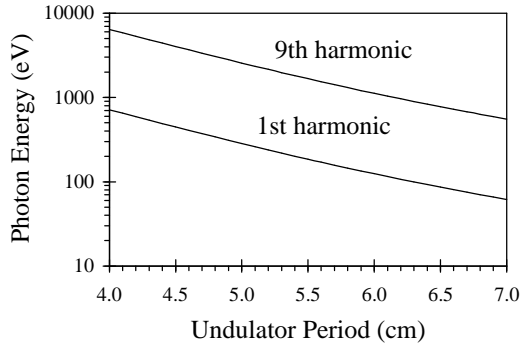


Figure 3: Photon energy (1st and 9th harmonics) as a function of the undulator period length.

2.4 Multipole wiggler parameters

In the MPW case the main parameter is the maximum magnetic field on axis (B_0), which determines the value of the critical photon energy, and the period length. To decide the B_0 value, we have considered that B_0 must be higher than the dipole magnetic field ($B_{BM} = 1.01$ T) and smaller than 2.0 T [3].

Under these constraints the MPW periods chosen are 9.5 cm (W95) and 18.0 cm (W180). Their main parameters are given in Table 2.

3 MAGNETIC CONFIGURATION

Since the geometry and the magnetic specifications of the ID are determined according to the user requirements and the lattice specifications, now it is needed to check if it is possible to construct such a device. For that reason we have used the Pandira code (Poisson/Superfish code) [4] to determine how feasible are these IDs (in the 2D case).

Table: 2 List of the basic parameters for the insertion devices proposed for LSB. ($\lambda_{u,w}$: period, B_0 : magnetic field on axis, K: insertion device constant, NP: number of periods and L: total length).

Name	$\lambda_{u,w}$ [cm]	B_0 [T]	K	NP	L [m]
U46	4.6	0.484	2.1	130	5.98
U60	6.0	0.665	3.7	100	6
W95	9.5	1.2	10.7	63	5.985
W180	18.0	1.9	31.9	33	5.94

3.1 Pure permanent magnet undulator

We have assumed rectangular pure permanent magnet (PPM) blocks (made of NdFeB), with B_r close to 1.1, and each period formed by 4 blocks. The height of the blocks is half of its period length. Due to the fact that the magnetic field for this kind of configuration follows an analytical equation [5], it is straight forward to determine the dimensions that give the desired K value.

3.2 Hybrid multipole wiggler

For the MPWs we have chosen the hybrid solution. The hybrid structure is based in a steel-PPM configuration (Figure 4). The steel used has been permendur [6], and NdFeB as PPM. For this kind of magnetic configuration there is not any analytical equation which gives the geometrical dimension of the steel and the PPM blocks, to achieve the magnetic field value. In our problem we have varied the block dimensions and the steel shape, the result is shown in Figure 4. The permendur pieces are shorter than the PPM ones, and they have been shimmed to increase the magnetic field on axis. In Table 3 are presented the geometrical parameters for each MPW.

Table 3: List of the geometrical parameters for the different blocks in the MPW. The meaning of each parameter is shown in Figure 4.

Name	W_{PPM} [cm]	W_{St} [cm]	h_{PPM} [cm]	h_{St} [cm]
W95	2.75	1.0	5.0	11.0
W180	4.75	2.125	3.0	13.0

The vertical magnetic field on axis distribution for the MPWs is not as sinusoidal as in the undulator case. This is not a very important fact, because the critical energy

depends mainly on the magnetic field value, and depending on the beamline acceptance angle, on the field distribution.

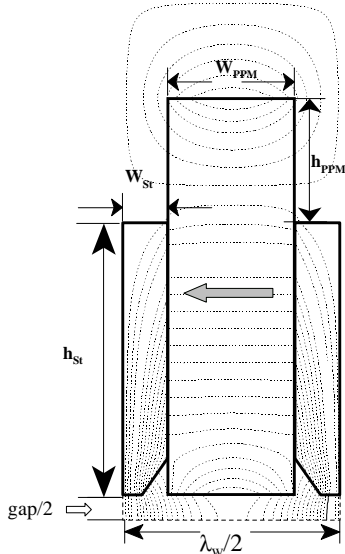


Figure 4: Configuration of the hybrid multipole wiggler, showing one half of a period, indicating the steel pole pieces with a shimmed part close to the gap, the PPM material is in the centre.

4 MULTIPOLE WIGGLER INTEGRATED INTENSITY

Figure 5 shows that for energy smaller than 10.0 keV the W95 is better, but for the range 10.0-40.0 keV, the longer period MPW has higher integrated intensity values. For both MPWs the value of the integrated intensity is higher than for the bending magnet case.

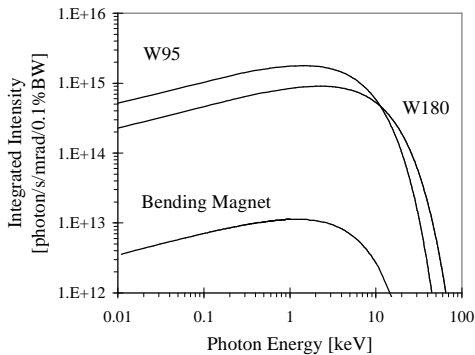


Figure 5: Multipole wiggler integrated intensity as a function of the photon energy, for the two multipole wiggler proposed (W95 and W180) and for the LSB bending magnet.

5 UNDULATOR BRIGHTNESS

The machine parameters used to compute the brightness (for the undulators) and the integrated intensity (for the MPWs) are given in Table 1.

In Figure 6 are given the brightness for the two undulators considered. The photon energy range covered

by U46 is 0.4-6.0 keV. The first 3 harmonics are quite tuneable, and there is not any energy gap between them.

For the U60 case, the energy range is 0.1-4.0 keV. In this case the tunability is higher, but the maximum brightness is slightly smaller.

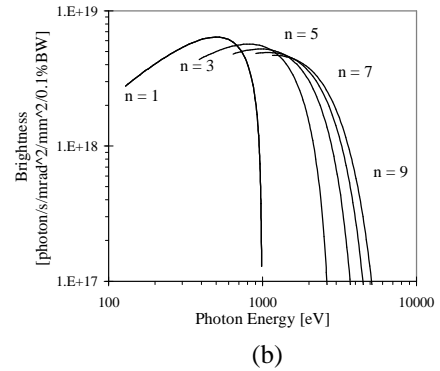
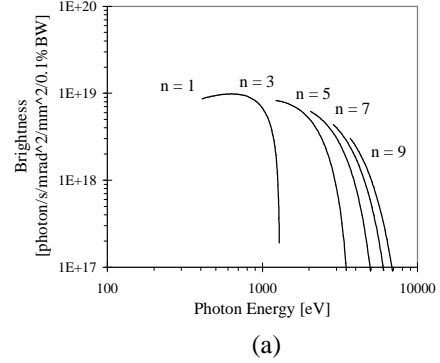


Figure 6: Undulator brightness in the central cone (for the first 5 harmonics) as a function of the photon energy, for (a) U46 and (b) U60 undulators.

6 CONCLUSIONS

From the LSB lattice constraints it is possible to define four insertion devices (two undulators and two multipole wigglers) to cover the photon energy range required for the Spanish user community. A reliable design has been found using a 2D magnet code. Finally, the optical output from these insertion devices shows that the photon energy range and the integrated intensity (for the multipole wigglers) and the brightness (for the undulators) covers the users' needs.

REFERENCES

- [1] 'User Requirements for a Synchrotron Facility in Spain', J. Campmany, Internal Report, LSB 0195ER.
- [2] 'Linear Lattice for the LSB Storage Ring', M. Muñoz, in these Proceedings.
- [3] 'Magnet System Design for the Storage Ring of the LSB', M. Pont, in these Proceedings.
- [4] 'Poisson/Superfish Group Code', Los Alamos Accelerator Code Group, LA-UR-87-126.
- [5] K. Halbach, J. Chin and E. Hoyer, IEEE Trans. Nucl. Sci. NS-28 (1981), p3136.
- [6] 'Magnetic Materials and their Applications', C. Heck, Butterworth (London), 1974.