A GENERAL VIEW OF IDS TO BE INSTALLED AT ALBA ON DAY ONE

J. Campmany,* D. Bertwistle, J. Marcos, Z. Martí, V. Massana, F. Becheri, and D. Einfeld
CELLS, P. O. Box 68, 08193 Bellaterra, Catalonia, Spain

Abstract

The new 3rd generation synchrotron radiation source ALBA to be built nearby Barcelona is planned to start operation in 2009 with several different insertion devices installed in the storage ring either from "day one" or within the first year of operation. The list of high-priority insertion devices includes: 2 planar PPM SmCo in-vacuum undulators with the period of 21.3 mm; 2 Apple-II type PPM NdFeB undulators with periods of 62 mm and 71 mm respectively; 1 superconducting planar wiggler with the period of 31 mm and a maximum field of 2.1 T, and 1 conventional wiggler. The emission of these undulators covers wide spectral range extending from hard X-rays to UV. Pre-design of the IDs was done by ALBA.

ALBA will set up a magnetic measurement laboratory for the acceptance tests. The paper will present peculiarities of the magnetic design and calculated maximum-flux spectra.

INTRODUCTION

The synchrotron radiation source ALBA is a new third generation 3 GeV electron storage ring which is currently under construction in Cerdanyola del Vallès (near Barcelona) in Spain [1]. The facility can allocate up to 20 insertion devices (IDs) which will serve for user beamlines specializing in scientific applications of UV, VUV, soft- and hard X-ray range radiation. According to the priorities stablished by the future ALBA users and the budget availability, the IDs in phase I are six. To feed the beamlines dedicated for UV, VUV and soft X-rays, elliptical undulators with variable polarization have been selected; for medium X-rays beamlines, a conventional wiggler and two planar in-vacuum undulators will be used. Finally, for hard X-rays beamline a superconducting device is planned. Table 1 lists the IDs required for the phase I. Their names include their period lengths in millimeters.

The magnetic design and optimisation of all the IDs was done using the computer codes Radia [2], XOP package [3] and SRW [4]. The effects of the IDs on the electron beam were studied numerically using the particle tracking codes BETA and TRACY as shown elsewhere in these proceedings [5].

* campmany@cells.es

The procurement of all IDs will be done through industrial companies and institutions with production capabilities. The delivery of the devices is expected at the end of 2008, and the installation in the ring is foreseen to start in spring 2009.

A magnetic measurements laboratory is currently being set up at ALBA. The laboratory includes the adaptation of an old Hall-probe bench [6], a flipping coil bench manufactured by ESRF, a Helmholtz Coil bench built by Elettra and a Fix stretched wire bench “petit train” built in house.

Table 1: ALBA Insertion Devices for the phase I

ID	Type	Spectral range	Polarization
HU62	PPM-Apple	90 - 1200 eV	Elliptical
HU71	PPM-Apple	50 - 1100 eV	Elliptical
IVU21	PPM-in vacuum	1 – 20 keV	Planar
MPW	Hybrid - planar	2.4 – 34 keV	Planar
SC-W31	superconducting	5 – 40 keV	Planar

APPLE-II UNDULATORS

To provide high flux of circularly polarized radiation in the soft X-ray spectral range, the construction of two APPLE-II undulators [7] is planned at ALBA. These undulators will operate out of vacuum, with minimum magnetic gap of 15.5 mm.

The first APPLE-II undulator has a period of 62 mm. In this undulator, NbFeB magnet blocks of square cross-section (33 mm x 33 mm) with a remanence of ~1.2 T, are used. The undulator contain 23 full periods for a total length of 1.5 m; the vertical magnetic field is symmetric in longitudinal direction. The maximum K value achievable with this device is 5.12 (horizontal polarization), 3.67 (vertical polarization) and 2.98 (circular polarization). The energy range of the first harmonic is 90-1200 eV in linear horizontal polarization.

The second APPLE-II undulator has a period of 71 mm. NbFeB magnet blocks with ~1.2 remanence are used as well, in this case with a rectangular cross-section (34 mm x 30 mm). The undulator contain 22 full periods for a total length of 1.675 m; the vertical magnetic field is also symmetric in longitudinal direction. The maximum K value achievable with this device is 6.19 (horizontal polarization), 4.73 (vertical polarization) and 3.78 (circular polarization). The energy range of the first harmonic is 50-1100 eV in linear horizontal polarization.

In both cases, the end sections are Elettra type [8] and will use magic fingers to compensate multipole effects.

The design, construction and commissioning of these undulators is currently being agreed to be made through a collaboration between ALBA and ELETTRA.

Figure 1 shows calculation results of the maximum spectral flux through finite aperture, which can be emitted by the undulator HU71 at circular left, linear horizontal and linear vertical polarizations. The optimisation for the flux was made versus vertical gap and longitudinal shift of the magnet arrays, based on the results of magnetostatic computation, at a given constraint on minimal acceptable polarization rates.

The HU62 undulator will be installed in a medium-size straight section of ALBA, for the soft Xray beamline CIRCE (PEEM and photoemission near ambient pressures). The HU71 undulator will be installed in a long-size straight section of ALBA, in a non-centered downstream position, for POLUX beamline (circular magnetic dichroism). The installation of this ID in the long straight section leaves open the possibility to install a a fast switch operation scheme using a second device placed upstream in the same straight.

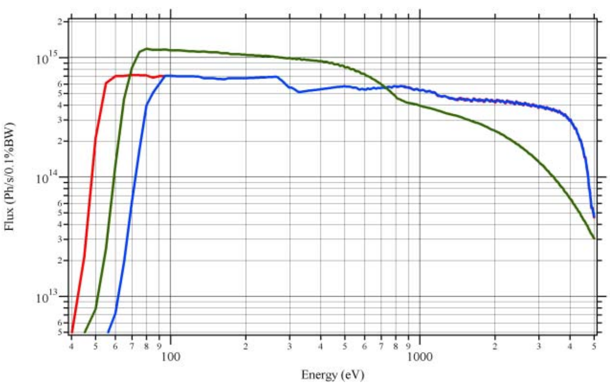

Figure 1: Spectral flux through an aperture 0.6 mradH x 0.6 mradV optimised vs vertical gap and longitudinal shift of magnet arrays of the undulator HU71. Horizontal polarization (red), vertical (blue) and circular (green) cases are showed. Electron intensity I=400 mA. Contribution from odd harmonics are included.

SUPERCONDUCTING WIGGLER

To provide flux in the hard X-rays spectral range, the construction of one superconducting wiggler is planned at ALBA. This wiggler will operate at different current intensities in the coils, depending on the application. BNIP, on request of ALBA, has made a feasibility study and has proposed a conceptual design for this ID [9].

Although the concept can be based in vertical helical windings or vertical race-track coils, our design based the design in flat horizontal race-track coils, which have been successfully used at MAX-lab [10], ELETTRA [11] and Canadian Light Source.

According to the state of the art of the superconducting technology of IDs, the maximum achievable field is limited by the critical current of available superconducting wires.

The poles have racetrack coils and the yoke has been modelled with the low-carbon steel RADIA built-in material. The coil dimensions have been selected according to the available wire successfully applied to CLS wiggler [9]: wire diameter of 0.91 mm (with insulation), ratio of NbTi:Cu of 1.4, 312 filaments per coil and the critical current is 510-550 A at 7 Tesla.

The limit in the design current is that the total power delivered by the device should be <20 kW. To this end, nominal current in the coils has to be set to 823 A, with a current density in each coil of 970.5 A/mm^2. The magnetic field reached in the centre is 2.315 T, thus the period is 31 mm, the magnetic gap 12.4 mm, the number of turns in each coil is 105, the coil cross-section being 16.8 mm height x 5.3 width.

The magnetic design is symmetric and has 121 complete poles. End sections are single normal poles magnetized with ~40% the current of central poles.

The SC-W31 wiggler will be installed one in a medium-size straight section of ALBA, for the hard ray beamline PX (Power Diffraction).

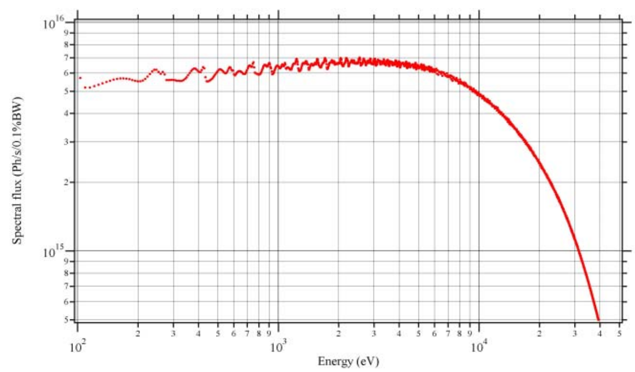

Figure 2: Spectral flux through an aperture 2 mradH x 1 mradV for the superconducting wiggler SC-W31.

IN-VACUUM UNDULATORS

For an electron storage ring with an energy of 3 GeV, the production of high flux hard X-rays within a small angle (less than a half mrad) requires small period undulators with ~1 T peak magnetic fields. This leads to the use of in-vacuum undulators, operating at very small magnetic gap (~5 mm) [12].

ALBA will have two in-vacuum undulators with a period of 21.3 mm to feed two beamlines: MX (Macromolecular diffraction) and NCD (Non-crystalline diffraction), specialized in protein crystallography and small-angle X-ray scattering. The undulator structure is of PPM type, with permanent magnets made of Sm_2Co_{17} and poles made of vanadium permendur. The length of the undulator is 2 m, the minimum magnetic gap 5.5 mm and the maximum peak field 0.806 T.

The calculated maximal spectral flux, which can be emitted by this undulator by adjusting gap for each photon energy, is shown in Figure 3. The calculation takes into account contributions of both odd and even harmonics of the undulator radiation.

The procurement of these two in-vacuum devices will be carried out in collaboration with SOLEIL. All in-vacuum undulators will be installed in medium straight sections of the storage ring, which allow for small vertical gap and can accommodate only one undulator segment.

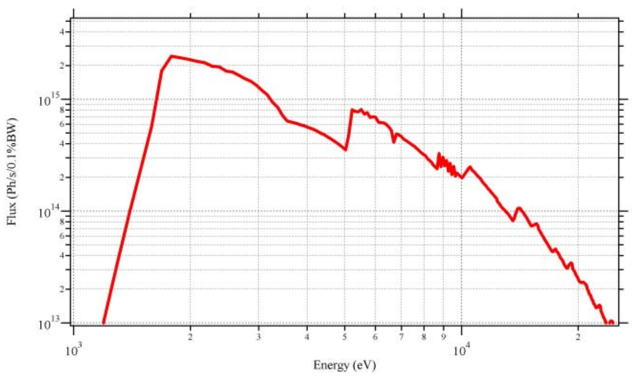

Figure 3: Maximal spectral flux through finite aperture 0.6 mradH x 0.6 mradV produced by IVU21.

CONVENTIONAL WIGGLER

To cover the requirements of a high performance EXAFS beamline, a conventional wiggler will be installed in a medium-length straight section. The main constraints in this application come from the power limitation deposited on the mirror (~1 kW) and the maximum power transmitted to the monochromator (~0.7 kW), as well as the need of a smooth spectrum (ripple <3.4%)in order to allow the automatic scanning of spectra. The period length and magnetic field of this device are now under study, but the requirements point to a conventional wiggler with an hybrid design using NdFeB magnets and Vanadium permendur poles. Such a device should produce a flux through a 2.5 mradH x 0.37 mradV slit of $>10^{15}$ Ph/s/0.1%BW at 2.4 keV and $> 10^{11}$ Ph/s/0.1%BW at 34 keV. This device will be procured through a tendering process.

ID LABORATORY

In addition to the described insertion devices, ALBA will have a complete ID laboratory to characterize and produce in the future the devices needed to satisfy the scientific community requirements.

The laboratory will be provided with an old Hall-probe bench [6] in which the on-the-fly measurement mode has been implemented. The whole control system of this bench has been updated and implemented using TANGO tools. Also, the Hall probe calibration range has been extended to small magnetic fields and to measure the Hall probes offset a zero field chamber has been installed.

Apart from the Hall probe bench, the ID laboratory has a “turn key” flipping coil bench manufactured by ESRF, a “turn key” Helmholtz Coil bench built by Elettra and a Fixed stretched wire bench “petit train” built in house and described elsewhere [13].

ACKNOWLEDGMENTS

We would like to acknowledge valuable contribution to ALBA undulator projects from Dr. J. Chavanne and Dr. P. Elleaume (ESRF), Dr. D. Zangrando and Dr. B. Diviacco (ELETTRA), Dr. N. Metsenzev (BINP) Dr. J. M. Filhol and Dr. O. Chubar (SOLEIL) and Mr. C. Colldelram (ALBA Engineering Division).

REFERENCES

[1] M. Muñoz, E. Al-Dmour, J. Campmany, D. Einfeld, F. Pérez, M. Pont. “Status of the ALBA Project”. These proceedings.

[2] P. Elleaume, O. Chubar, J. Chavanne, "Computing 3D magnetic fields from insertion devices", PAC’97, p. 3509; O. Chubar, P. Elleaume, J. Chavanne, Journal of Synchrotron Radiation, 5 (1998) 481.

[3] M. Sanchez del Rio, R. J. Dejus, “XOP: A Multiplatform Graphical User Interface for Synchrotron Radiation Spectral and Optics Calculations,” SPIE Proc., 3152 (1997) 148.

[4] O. Chubar, P. Elleaume, "Accurate and efficient computation of synchrotron radiation in the near field region", EPAC’98, p.1177.

[5] M. Belgroune, M. Muñoz, “Effects of Phase 1 IDs on the Beam Dynamics at the ALBA Project”, These proceedings.

[6] D. Beltran, J. Bordas, J. Campmany, A. Molins, J. A. Perlas, M. Traveria “An instrument for precision magnetic measurements of large magnetic structures”, Nuclear Instruments and Methods A, 459 (2001) 285.

[7] S. Sasaki, "Analyses for a planar variably-polarizing undulator", Nuclear Instruments and Methods A, 347 (1994), 83.

[8] B. Diviacco, R. Bracco, D. Millo, R.P. Walker, M. Zalateu, D. Zangrando, “Development of elliptical undulators for elettra”, EPAC’2000, p. 2322.

[9] N. Mezentsev, V. Repkov, V. Shkaruba, S. Khrushchev, V. Tsukanov, E. Miginskaya, V. M. Syrovatin, V. H. Lev, “Report on feasibility study and a conceptual design of a superconducting multipole wiggler for CELLS”, Novosibirsk 2006.

[10] G. LeBlanc, E. Wallen, M. Eriksson, “The MAX wiggler”, PAC’01, p. 2476.

[11] A. Batrakov, V. Jurba, S. Khrushchev, G. Kulipanov, E. Kuper, M. Kuzin, A. Medvedko, N. Mezentsev, V. Shkaruba, D. Zangrando, B. Diviacco, R. P. Walker, “A superconducting 3.5 t multipole wiggler for the Elettra storage ring”, EPAC’02, p. 2634.

[12] T. Schmidt et. al., “Insertion devices at the Swiss Light Source (phase I)”, Nuclear Instruments and Methods A, 467-468 (2001) 126.

[13] J. Marcos, J. Campmany, D. Einfeld, “The Study of Errors of ALBA Fixed Stretched Wire Bench”, These proceedings.