

GENERAL DESCRIPTION OF IDS INITIALLY INSTALLED AT ALBA

J. Campmany, D. Einfeld*, J. Marcos, V. Massana
CELLS, ctra. BP 1413, Km 3.3, 08290 Cerdanyola del Vallès, Catalonia, Spain

Abstract

The new 3rd generation synchrotron radiation source ALBA built nearby Barcelona is planned to start operation in 2010 with several different insertion devices installed in the storage ring either from the beginning or within the first year of operation. The list of first insertion devices includes: 2 planar PPM SmCo in-vacuum undulators with the period of 21.6 mm; 2 Apple-II type PPM NdFeB undulators with the periods of 62.36 and 71.36 mm respectively; 1 superconducting planar wiggler with the period of 30 mm and a maximum field of 2.1 T, and a 1 conventional wiggler with the period of 80.0 mm and a maximum field of 1.74 T. The emitted light of these IDs covers wide spectral range extending from hard X-rays to UV. Pre-design of the IDs was done by ALBA, but manufacturing has been outsourced. Production is now finished and they have been tested with magnetic measurements. The paper will present the final as build magnetic designs as well as the main results of magnetic measurements performed on the manufactured devices.

INTRODUCTION

The synchrotron radiation source ALBA has been constructed in Cerdanyola del Vallès (near Barcelona) in Spain [1]. In the first phase of operation, six of seven beamlines will receive light from insertion devices. These six beamlines are dedicated to Resonant absorption and scattering (BOREAS), Photoemission electron microscopy and near ambient pressure photoemission (CIRCE), X-ray macromolecular crystallography (XALOC), Non-crystalline diffraction (NCD), X-ray absorption spectroscopy (CLAESS), and Materials Science and Powder Diffraction (MSPD). Table 1 lists the IDs required for each one. Their names include their period lengths in millimeters.

Table 1: ALBA first Insertion Devices.

Beamline	Spectral range	ID	Type
BOREAS	80 - 3000 eV	EU71	PPM-Apple-II
CIRCE	100 - 2000 eV	EU62	PPM-Apple-II
XALOC	5 - 21 keV	IVU21	PPM-in vacuum
NCD	6.5 - 13 keV	IVU21	PPM-in vacuum
CLAESS	2.4 - 70 keV	MPW80	Hybrid
MSPD	8 - 50 keV	SCW30	Superconducting

Despite the main parameters of the insertion devices initially designed for these applications were presented in EPAC 2006 [2], some changes have been introduced during manufacturing to improve its feasibility, so we

present here the final parameters of our IDs as build. All IDs have been procured from industrial companies through commercial contracts and from research institutions through collaboration agreements.

Out vacuum devices have been measured at ALBA magnetic measurements laboratory. In vacuum devices have been measured at manufacturing facilities during Factory Acceptance Tests. In all cases, at least one fieldmap has been measured for each device at operating conditions. These fieldmaps have been used to check the behaviour of the ALBA storage ring lattice and the influence of the real IDs on the accelerator dynamics.[3]

CONTROL SYSTEM

The control system is based on Tango software. Tango has first been developed at ESRF and now it is a collaboration between five institutes: CELLS, ELETTRA, ESRF, Soleil and Desy.[4].

The control of the motors is carried out via the Icepap motor controller, a new device developed at ESRF implementing a wide range of capabilities [5]. CELLS has selected Icepap as a standard for motor controller for beamlines as well as accelerators.

Details of control system for Apple-II devices are described elsewhere.[6] Control system for in-vacuum and conventional wiggler are simplest, because they drive only two Phytron motors, one to move the gap and the other to set the taper through a planetary gear arrangement. Icepap is reeding a number of commercial encoders (absolute lineal from TR electronics, absolute circular from Renishaw and incremental lineal from Heidenhan) allowing real time closed-loop operation.

The control is done via an industrial PC running Tango over a Linux platform, acting as input-output controller (IOC). Communication between IOC and the Icepap is made via Ethernet. The IOC also controls the power supplies manufactured by OCEM of correction coils of each undulator.

Interlocking is carried out by twelve limit switches connected to the Icepap controller, to limit the travel of the girders. Twelve additional limit switches act as safety interlocks, and disable the power of the Icepap if they are overpassed. These additional switches (kill switches) are controlled via a PLC.

With respect to the control, Tango allows the definition of pseudo-motors in such a way that the user can directly drive the gap and the taper. The IOC, the motor controller and the PLC are connected to the network via ethernet, acting in fact as a fieldbus. Graphical user interface can run in the control room or in the beamline.

APPLE-II UNDULATORS EU62 AND EU71

Apple-II undulators have been built in collaboration with Sincrotrone Trieste (Elettra). Undulators are out of vacuum and have a minimum gap of 15.5 mm. Horizontal transversal separation between blocks is 1mm.

EU62 (see Figure 1), has a period of 62.36 mm and NbFeB magnet blocks of square cross-section (32 x 32 mm) with a remanence between 1.22 T and 1.26 T. Undulator contains 27 full periods for a total length of 1.77 m; the vertical magnetic field is symmetric in longitudinal direction. The maximum K value achievable with this device is 5.20 (horizontal polarization), 3.67 (vertical) and 4.24 (circular). The energy range of the first harmonic is 94.4-1300 eV in linear horizontal polarization.

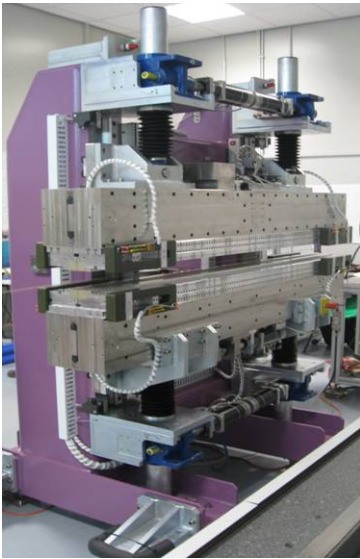


Figure 1: EU62 undulator

EU71 has a period of 71.36 mm. Magnet blocks are made of the same material and have the same cross-section as in the case of EU62. The undulator contains 22 full periods for a total length of 1.66 m; the vertical magnetic field is also symmetric in longitudinal direction. The maximum K value achievable with this device is 6.40 (horizontal polarization), 4.68 (vertical) and 5.34 (circular). Energy range of the 1st harmonic in linear horizontal polarization is 55.8-1100 eV. Both devices use magic fingers to compensate multipole effects.

Figure 2 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.

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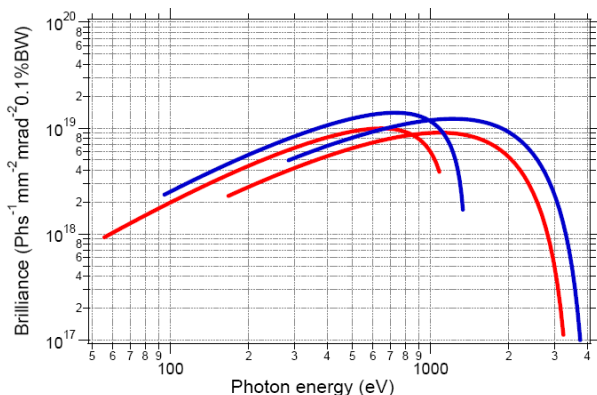


Figure 2: Brilliance curves for EU71 (red) and EU62 (blue) for horizontal polarization of the emitted light. Electron intensity in the accelerator $I=400$ mA.

For EU62, Phase error is lower than 3.7° at minimum gap. Multipole content fulfils specifications in the range ± 15 mm out of axis: absolute dipole component less than $2.5 \cdot 10^{-5}$ T·m, absolute quadrupole harmonic less than $1 \cdot 10^{-2}$ T and absolute sextupole component is less than $2.1 \cdot 10^{-1}$ T/m. For EU71, Phase error is always lower than 2.7° at minimum gap. Multipole content fulfils specifications in the range ± 15 mm out of axis: absolute dipole component less than $3.5 \cdot 10^{-5}$ T·m, absolute quadrupole harmonic less than $7 \cdot 10^{-3}$ T and absolute sextupole component is less than $1.2 \cdot 10^{-1}$ T/m.

In both cases, eight correction coils placed at both ends of undulator, and operating in pairs, allow the correction of first and second feidl integrals on axis.

SUPERCONDUCTING WIGGLER SCW30

To provide flux in the hard X-rays spectral range a superconducting wiggler (see Figure 3) with a very short period length has been procured. It has been built in collaboration with BNIP and uses a new superconducting wire made of NbTi/Cu with an external diameter of 0.55 mm, allowing the manufacturing of short poles. Critical current of this wire is 230 A at 7 T. Maximum field experimentally achievable in SCW30 is 2.3 T, whilst the operational field will depend on the current intensity in the accelerator, with a maximum of 2.15 T. It will deliver light in the hard X-Ray region (see Figure 4). Main limitations are the maximum heat load delivered to Front End (20 kW) and



Figure 2: SCW30 wiggler

to the Mono-chromator through the first mirror (900 W). Magnetic arrangement is symmetric and has 117 full field poles (near 1.755 m length). End sections are single normal poles fed with $\sim 50\%$ the current of central poles.

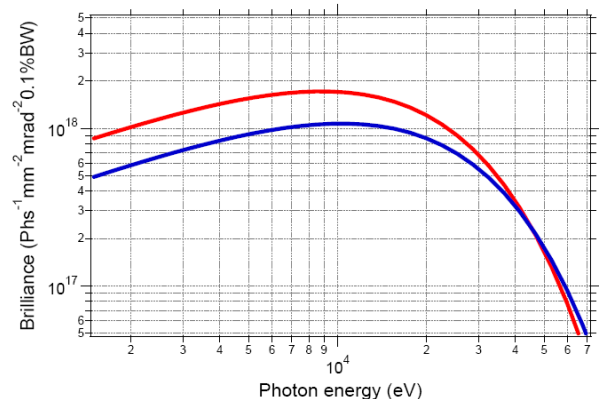


Figure 4: Brilliance delivered by SC-W30 operated at 1.8 T and a current of 400 mA in the accelerator (red) and at 2.15 T and a current of 250 mA in the accelerator (blue).

Cryostat has an excellent behaviour and can maintain the cold bore below 3.6 K. Pressure of He inside the cryostat is 0.5 bar, allowing recondensation after a single quench. Despite the calculated heat load coming from electron beam has been estimated in 10 W, described operative conditions can be maintained even for a head load deposited in vacuum chamber of 20 W.

IN-VACUUM UNDULATORS IVU21

In-vacuum undulators IVU-21 have been manufactured by Bruker Advanced Supercon (former Accel). They have a period length of 21.6 mm, a total of 92.5 full field periods and a length of 2 m. The undulator structure is of PPM type, with permanent magnets made of $\text{Sm}_2\text{Co}_{17}$. The minimum achievable mechanical gap is 5.5 mm, but the requirements (effective field of 0.806 T, effective K of 1.63) are already achieved at a mechanical gap of 5.8 mm. Vacuum chamber has a length of 2.5 m between flanges, and can reach 10^{-9} mbar. The device allows the tapering of the girders for correction, but it has not been needed.



Figure 5: IVU21 undulator

Phase error is lower than 2.5° and on axis first field integral is lower than 0.5 G·m without correction, as specified. Second field integral on axis is lower than 4 G·m² without correction. Multipole content fulfils specifications in the H range ± 15 mm: absolute dipole component is less than $1.1 \cdot 10^{-5}$ T·m, absolute quadrupole is less than $8 \cdot 10^{-4}$ T and

absolute sextupole component is less than $8 \cdot 10^{-2}$ T/m. Despite these low values, IVU21 undulators have six correction coils to null the first and second field integrals on axis, and compensate also the quadrupolar component.

Calculated maximal spectral flux emitted by IVU-21, accounting for contributions of both odd and even harmonics of the undulator radiation is shown in Figure 6.

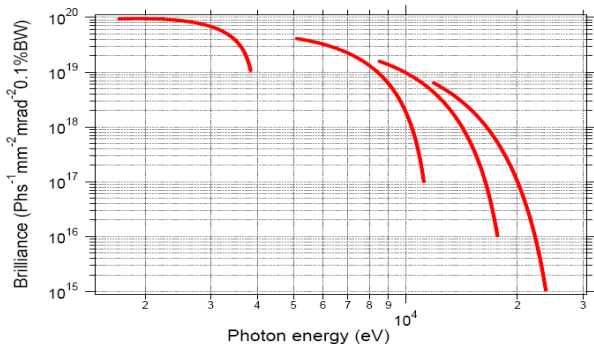


Figure 6: Brilliance of IVU21 up to 7th harmonic, for a current in the accelerator of 400 mA

CONVENTIONAL WIGGLER MPW80

MPW80 has been manufactured by Advanced Design Consulting Inc (see Figure 7). It delivers light in a smooth spectrum in the range between 2 and 3.4 keV.



Figure 7: MPW80 wiggler

Main constraints come from the power deposited on the mirror (~ 1 kW) and transmitted to the monochromator (~ 0.7 kW). So, it will operate in different modes depending on electron beam current (see Figure 8). To this end, it has motors to move the gap and correct the taper. Magnetically, MPW80 has a hybrid arrangement of NdFeB magnets and Vanadium permendur poles. Minimum gap is 12.9 mm, period is 80 mm and length is 1 m. Peak field at minimum gap is 1.74 T. Spectrum smoothness will require its operation with a taper of 250 μrad . In this condition, optical phase error is 5.7° , enough to guarantee the spectrum smoothness.

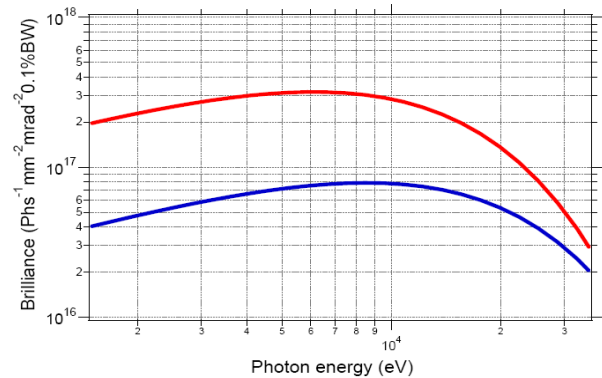


Figure 8: Brilliance of MPW80 at 18.9 mm gap and 400 mA of electron current (red) and at 12.9 mm gap and 100 mA of electron current (blue).

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