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Abstract

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Abstract. ALBA is a 3GeV synchrotron light source located in Barcelona. Currently it has 7 beamlines fully operational since 2012. Currently, the design of new beamlines has started, and up to 8 have been priorized. Two of them (Phase II) are currently under construction phase (2014-2018). Only one insertion device is foreseen for this phase, namely, an aperiodic helical undulator. The specificities of foreseen applications, specially the capability to reject high harmonics, lead to two possible technical solutions: aperiodic Apple-II or Electromagnetic. Both are presented in this paper. The Phase III will be built according to the funding allowance. Five of them have IDs as light sources. Regarding phase-III beamlines, they include In-vacuum undulators, very narrow gap undulators (<5 mm gap) and single-pole wiggler.

PROPOSED INSERTION DEVICES FOR PHASE II AND PHASE III

Two new beamlines have been approved for ALBA Phase-II, and are described elsewhere [1,2]:

- MIRAS: Infrared microspectroscopy with synchrotron radiation, using the ALBA bending magnet.
- LOREA: Low energy ultra-high resolution angular photoemission for complex materials, using an elliptical undulator in the range of 10 to 350 eV.

The beamlines foreseen for ALBA Phase-III have been presented in the ALBA 19th Scientific Advisory Committee Meeting [3]:

- (mu)MX: Microfocus diffraction for macromolecular crystallography, using an hybrid in-vacuum undulator in the range 5-20 keV.
- NOTOS: Instrument Development and Innovation, using the ALBA bending magnet.
- FAXTOR: Fast X-ray tomography and radioscopy, with a single pole wiggler in the 30 - 50 keV range.
- Skiron: Chiroptical spectroscopy beamline, using the ALBA bending magnet.
- SDFA: Submicrometer beam diffraction, fluorescence and absorption beamline, using an hybrid in-vacuum undulator in the range 2-20 keV.
- SIRENA: Surface-interface diffraction beamline, using an in-vacuum undulator in the range 4.25-25 keV.

LOREA INSERTION DEVICE

The main requirement for the photon source for LOREA beamline is to produce a minimum photon flux of 10^{14} Ph/s/0.1%BW through an aperture of 1 x 1 $mrad^2$ in the range of 10 to 350 eV in linear and circular polarizations. Two options have been considered [4]: an electromagnetic undulator, and a conventional Apple-II undulator.

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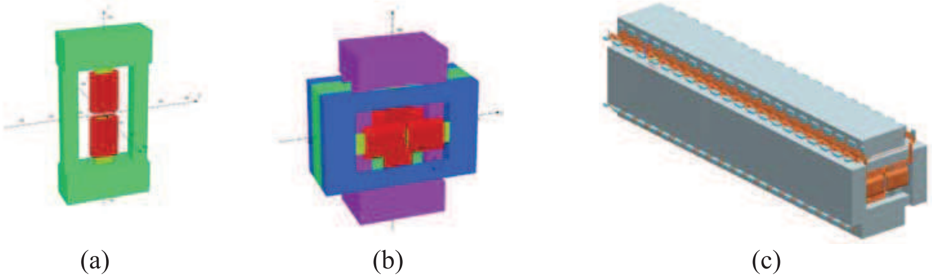
Electromagnetic Undulator for LOREA Beamline

The proposal is a device with a period length of 250 mm, using the same design for vertical and horizontal poles. With this approach, the device has identical performance for vertical and horizontal polarizations, and can extend the useful range in the low energies for circular polarization. The final design leads to a very compact device that should be installed in a cylindrical vacuum chamber of 20 mm diameter. Impedance calculations have been done in order to ensure the Storage Ring performance will not be affected by this geometry. Magnetic structure is completed by edge poles delivering ½ of peak field in order to compensate for the field integrals.

In Table 1 we present the main parameters of this device, and in Figure 1 we show the pole, period and full undulator. Calculations have been done using OPERA-3D code [5].

TABLE 1. Main parameters of electromagnetic device proposed for LOREA beamline.

Magnitude	Value	Magnitude	Value
Nominal effective on axis field	0.35 T	Hollowed Cu wire cross-section	4 x 3 mm^2
Period length	250 mm	Current intensity per conductor	90 A
Number of pole pairs @ full field	9	Electrical power consumption	46 kW
Number of pole pairs @ ½ field	2	Pressure drop per pancake	0.9 l/min
Magnetic gap	25 mm	Switching time (estimated)	18 s
Total device length	2.25 m	E_0 for H polarization	9.5 eV
Yoke material	ARMCO steel	E_0 for V polarization	9.5 eV
Hollowed Cu wire turns per coil	164	E_0 for Circular polarization	5.0 eV



(a) (b) (c)

FIGURE 1. Pole (a), period (b) and full structure (c) of the electromagnetic undulator proposed for LOREA beamline

Apple-II Undulator for LOREA Beamline

The main reason to go for an electromagnetic undulator is the possibility of fast switching. However, as specified above and using conventional power sources with a speed rate of 10 A/s, the switching time is very high. After consulting the interested community, fast switch was discarded and therefore the possibility of using an Apple-II device was explored. The main parameters of proposed design are presented in Table 2. Model of Apple-II undulator has been done using RADIA code [6]. In Figure 2 we present the performances of electromagnetic and Apple-II designs in terms of Photon flux calculated with Spectra code [7].

TABLE 2. Main parameters of Apple-II proposed for LOREA beamline.

Magnitude	Value	Magnitude	Value
Effective field on axis H polarization	1.14 T	Magnetic gap	13 mm
Effective field on axis V polarization	1.06 T	Total device length	2.3 m
Effective field on axis C polarization	0.77 T	Switching time (estimated)	12.5 s
Block size (HxVxL)	32 x 32 x 31 mm^3	E_0 for H polarization	7.6 eV
Period length	125 mm	E_0 for V polarization	8.8 eV
Periods full size	16	E_0 for Cpolarization	8.3 eV

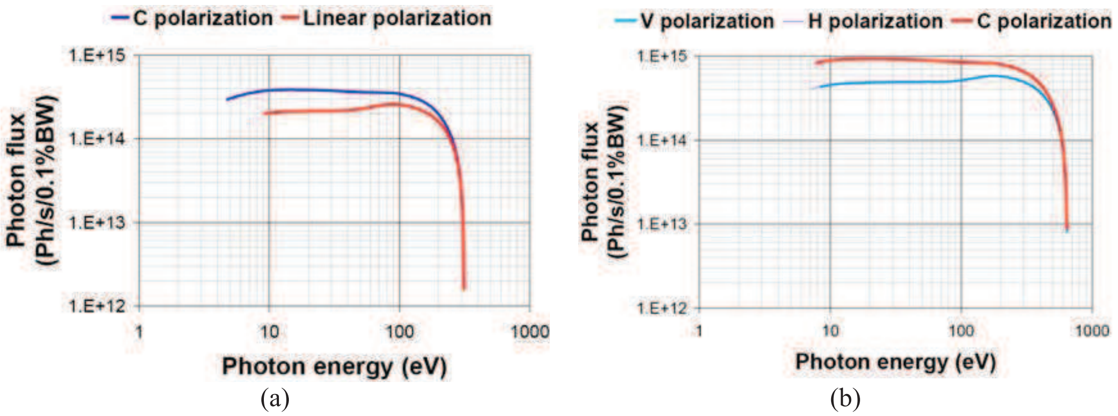


FIGURE 2. Flux through a 0.7x0.7 mrad^2 aperture of proposed EM (a) and Apple-II (b) IDs at 200 mA of Storage Ring current

Given the excellent performance of Apple-II device as compared with the electromagnetic. In general, Apple-II is better regarding power consumption, energy range and Photon flux, whilst electromagnetic can be better regarding the beam dynamics effects and the possibility to involve Spanish companies in the construction. After examining all the pros and conts, the Apple-II design has been adopted for LOREA Beamline.

In addition to that, a new feature has been considered for the final design of the device: the aperiodicity, in order to have a good rate of harmonics rejection especially at low energies. We have adopted the Elettra approach [8], and in Figure 3 we present the performance of an Apple-II aperiodic undulator of 125 mm period at minimum gap.

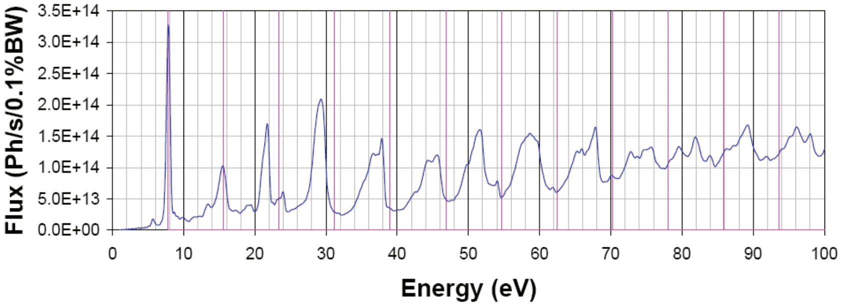


FIGURE 3. Spectrum of aperiodic EU125 in H mode at 13 mm gap and an aperture of 0.75x0.75 mrad^2 with a current of 250 mA in the Storage Ring. Pink lines mark the energy of the integer multiples of first peak. Harmonic rejection is ~30%

INSERTION DEVICES PROPOSED FOR PHASE-III

Insertion Devices for ALBA Phase-III beamlines are not still fully detailed, but some approaches are contained in the approved proposals that we present below. In Figure 4 we present the performances of all proposed devices. All have been calculated using Spectra code, and assuming a current in the Storage Ring of 100 mA.

Hybrid in-vacuum undulator for (mu)MX beamline

Undulator will be made of NdFeB magnet blocks and Permendur-type poles. The period length of the device is 20.4 mm, will have 98 periods full size and the effective maximum magnetic field will be 0.864 T, with a K parameter of 1.645. Performance is shown in Figure 4(a).

Single pole hybrid wiggler for FAXTOR

The device will have a single strong pole in the centre and two half-poles at edges. Central pole size made of permendur-type steel (WxHxL) will be 55 x 55 x 25 mm^3. Side main magnetic blocks made of NdFeB size

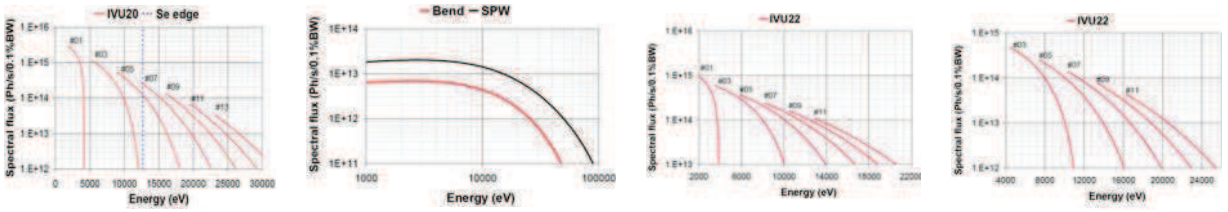
(WxHxL) will be 90 x 70 x 87.5 mm^3, and central side magnetic blocks size (WxHxL) will be 17.5 x 70 x 25 mm^3. The length of full device will be 0.5 m, and the peak field 2.74 T. The magnetic force between arrays at the minimum gap (8 mm) will be 11 kN. Performance is shown in Figure 4(b).

Hybrid in-vacuum undulator for SDFA

Undulator will be made of NdFeB magnet blocks and Permendur-type poles. The period length of the device is 22 mm, will have 90 periods full size and the effective maximum magnetic field will be 1.054 T, with a K parameter of 2.15. To this end, minimum gap will be 4.8 mm and the optical functions of Storage Ring will be modified to operate with low beta function in the ID straight section. Performance is shown in Figure 4(c).

PPM in-vacuum undulator for SIRENA

Undulator will be made of NdFeB magnet blocks. The period length of the device is 22 mm, will have 90 periods full size and the effective maximum magnetic field will be 0.877 T, with a K parameter of 1.8 at a minimum gap of 5.7 mm. Performance is shown in Figure 4(d).



(a) (b) (c) (d)

FIGURE 4. (a) Spectral photon flux, in the central emission cone, delivered by undulator U20 proposed for (mu)MX beamline, (b) Flux emitted within a horizontal acceptance of 1 mrad, for SPW compared to ALBA bending magnet for FAXTOR beamline (c) Flux in central cone for the proposed in-vacuum undulator for SDFA beamline and (d) Flux in central cone for proposed undulator for SIRENA beamline. All fluxes have been calculated for a Storage Ring current of 100 mA.

CONCLUSION

Two insertion devices proposed for LOREA beamline, included in ALBA Phase-II, have been proposed and discussed, and the final design has been presented. Regarding ALBA Phase-III, the guidelines for the insertion devices have also being presented. The final conceptual designs of these beamlines have not yet been finished, but the presented devices can be considered as the first approach to their light sources.

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