COMMISSIONING OF OPHéLIE : THE NEW ELECTROMAGNETIC CROSSED OVERLAPPED UNDULATOR AT SUPER-ACO*

M. Corlier[#], J.-C. Besson, P. Brunelle, J. Claverie, J.-M. Godefroy, C. Herbeaux, D. Lefebvre, O. Marcouillé, J.-L. Marlats, F. Marteau, J. Michaut, P. Peaupardin, A. Petit, M. Sommer, J. Vétéran and L. Nahon°, LURE, Univ. Paris Sud, Bât. 209 D, BP 34, 91898 Orsay Cedex, France

Abstract

OPHéLIE, the first electromagnetic Onuki-type undulator has been installed on the 0.8 GeV storage ring Super-ACO in February 1998. It consists in two identical 9-period crossed overlapped undulators whose magnetic fields (up to 0.12 T) are produced by conventional electromagnets. This insertion device is able to produce any kind of polarization in the VUV range with a potential polarization switching rate of 1 Hz. Measurements of focusing and closed orbit distortion show a very good agreement with magnetic measurements. A compensation scheme has been developped in order to make the operation of the insertion device as user-friendly as possible. First results obtained on photon beam are very promising. Photon energy calibration, flux optimization and polarization measurements are in progress.

1. INTRODUCTION

OPHéLIE (Onduleur Plan/Hélicoïdal du LURE à Induction Electromagnétique) [1] is the first Onuki-type undulator to be installed on a storage ring operating as a user facility (Fig. 1). This implies some severe constraints on the design and operation of such an insertion device in terms of non perturbation of other users. This is especially true if one considers the rather fast possible polarization switching at a speed of 1 Hz owing to its unique fully electromagnetic nature. We will present here the results of the magnetic measurements and the effects on the positron beam.

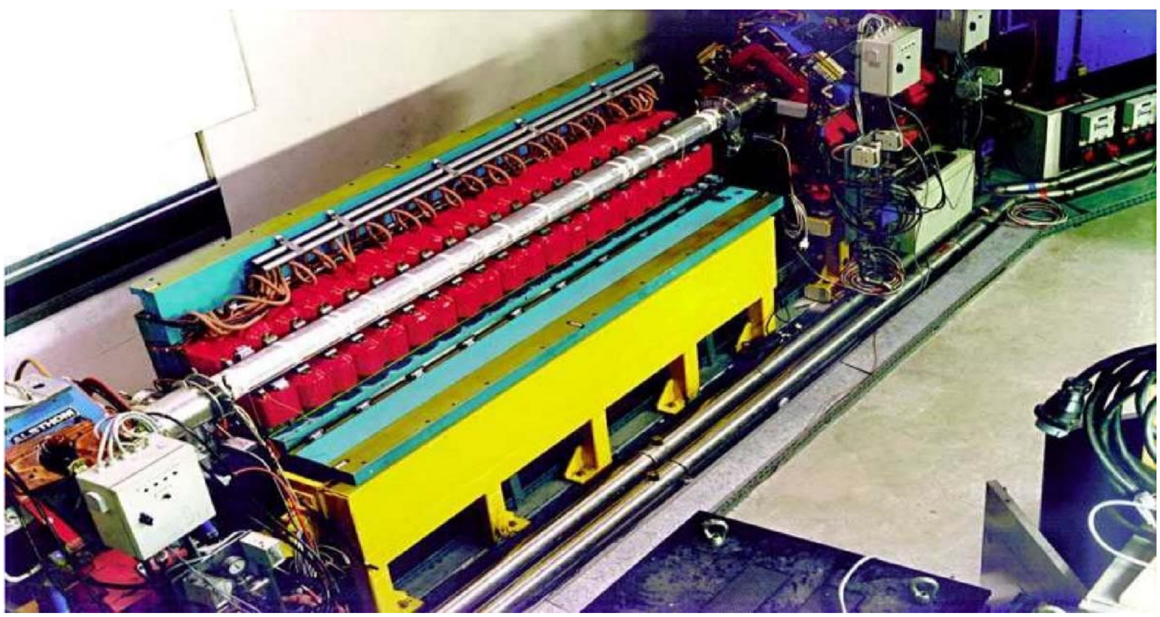

Fig. 1. View of one part of OPHéLIE in Super-ACO.

2. MAGNETIC DESIGN AND CONSTRUCTION

The device consists in two fixed-gap crossed overlapped undulators : a H-und. (resp. V-und.), which produces a horizontal field (resp. vertical field).

The V-und. can be translated along the longitudinal direction z. A $\phi = 90°$ phase corresponds to a 62.5 mm translation of V-und. Each undulator is made of 9 periods with $\lambda_o = 250$ mm and 2 main poles per period. The electromagnetic technology was chosen for its versatility of polarization switching (with a bipolar power supply). The maximum field induction is produced both in the horizontal (0.12 T) and vertical (± 0.12 T) planes at |Imax| = 210 A. Entrance and exit correctors have been designed [2] to center the positron trajectory in OPHéLIE.

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[#] Email : corlier@lure.u-psud.fr.

° also CEA/DRECAM/SPAM, Bât. 522, CE Saclay, F91191 Gif/Yvette.

This antisymmetric correction is realised with the help of two sets of correcting coils (i1 and i2 currents) located on the two first (resp. the two last) poles of the device (Fig. 2). These end poles were designed as small as possible in order to maximize the number of periods. Furthermore, each main pole is equipped with an additional compensation coil (ic current) (Fig. 2) able to compensate for a peak field spread up to 5 % [3]. Finally, these coils have been used to compensate for the residual field integral introduced by dephasing.

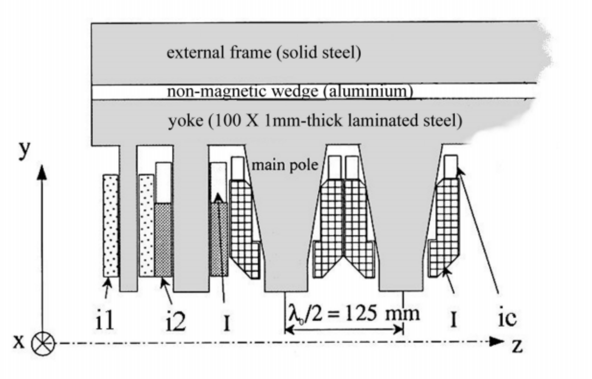

Fig. 2. End view of the V-und. upper part.

3. MAGNETIC MEASUREMENTS

Magnetic measurements were performed by Sigmaphi and LURE, using a Hall probe (Fig. 3 and Table) and a Pulsed Wire Technique (PWT) installed by LURE [4].

Due to the low saturation of the main poles, the peak field has a perfect linear dependance with the main current I. When the V-und. dephasing varies, the interaction with horizontal poles results in mutual flux capture. This leads to both an increase of the peak field value and in the appearance of a residual field integral.

In order to avoid any photon beam displacement during the vertical field switching, the positron beam has to be centered inside the insertion. The small size of end poles induces saturation and implies a complete calibration of i_1 and i_2 over the whole main current range of both undulators. The PWT [5] was used for this purpose because it provides a fast measurement of the 2nd field integral and allows to adjust quickly the correction currents (Fig. 4).

Central positions and angles of the trajectories (Fig. 4) remain within the tolerances : ± 40 µm and ± 40 µrad. In order to compensate for the saturation effect in poles 2 and 21, a simple variation law was chosen for i2 (Fig. 5). The double "S" curve (V-und.) shows how the hysteresis effect changes i1 adjustments. A similar behaviour was found for the H-und. : a "U" curve in the 0-200 A range.

Finally, all the above characteristics : low peak field dispersion, low saturation in main poles and identity of the undulators were confirmed by the tests on photon beam. An example is shown in figure 6. The spectral flux is centered at 7 eV for several combinations of main currents (K = cste).

4. EFFECTS ON POSITRON BEAM

- Closed orbit correction for $\phi = 0$: i1 and the compensation current on end pole # 20 (i20) were optimized in order to limit the closed orbit excursion to less than 0.1 mm in both planes everywhere in the machine. The agreement with magnetic measurements is better than 6 % for the two undulators (Fig. 5). Presently, average curves allow faster operation with good orbit correction.

- Closed orbit correction for $\phi \neq 0$: As predicted by magnetic measurements, the dephasing between the two undulators modifies the field integrals. The defects, located at one end of each undulator, depend on both the main current and the phase and have opposite signs for opposite phases. Compensation coils (poles 3-4-18-19) have been used to compensate for these defects. An empirical law was found in order to limit closed orbit excursions to less than 0.5 mm [4]. The dynamic feedback system on beam position [6] will then completely cancel the residual distortion.

- Additional focusing : Each of the two undulators introduces additional focusing in its magnetic field plane and a parasitic focusing in the perpendicular plane depending on the transverse field homogeneity [4]. The experimental tune variation with main current for the V-und. (measured after closed orbit correction) is given on figure 7. The agreement with magnetic measurements, in terms of peak field value and transverse homogeneity, is very good for both undulators. The working point of Super-ACO is located near coupling resonance, in order to maximize vertical beam size and Touschek lifetime. Then, rather small tune shifts must be compensated to avoid beam size variations. A fast feedback on tunes [7] will be used during OPHéLIE's operation.

	$\lvert B_o \rvert$	$\sigma B_o / B_o$	$\Delta B/B_o = f(x)$	$B_o = f(I)$	$\Delta B/B_o = f(\phi)$
H-und. and V-und.	0.12 T @ 210 A	0.4 %	6 % @ 10 mm	$5.84\ 10^{-4}$ T/A r = 0.999	0.08 %/ deg.

5. CONCLUSION

OPHéLIE, the first entirely versatile crossed undulator in the VUV was successfully installed on Super-ACO. The behaviour of the device with the positron beam is very close to the one predicted by magnetic measurements. Two feedback systems on the machine will complete the compensation scheme of the undulator and allow an independant control of the device by the users. The magnetic measurements have demonstrated the very good quality and identity of the H and V undulators. Photon beam characterization including polarization measurements is in progress as well as the commissioning in the AC switching mode.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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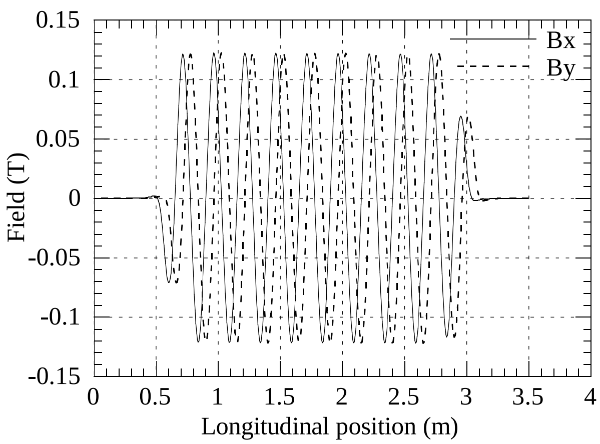

Fig. 3. Measured fields for 200 A at ϕ = 90° (Hall probe).

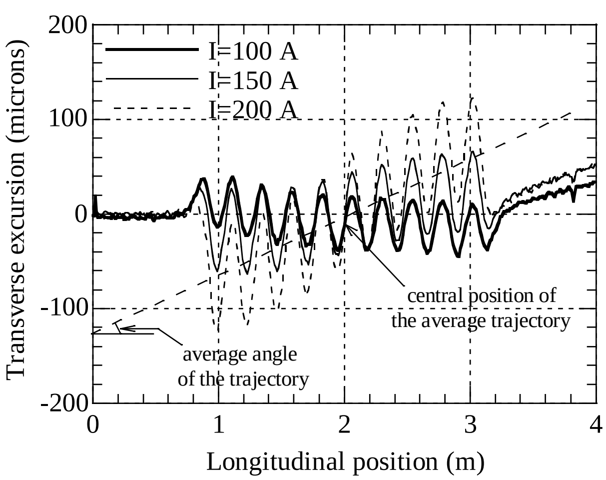

Fig. 4. V-und. optimized beam trajectories (PWT) for ϕ = 0.

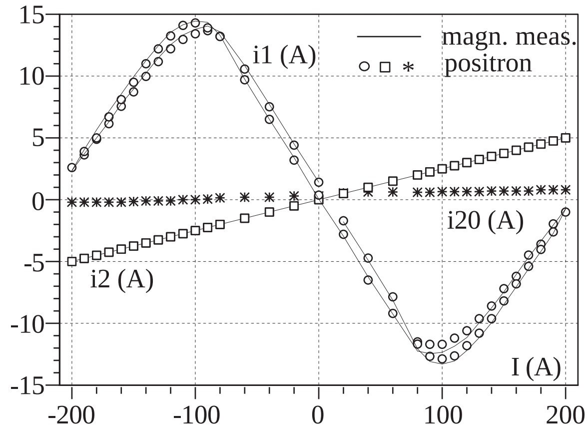

Fig. 5. V-und. variation of correction currents (ϕ = 0).

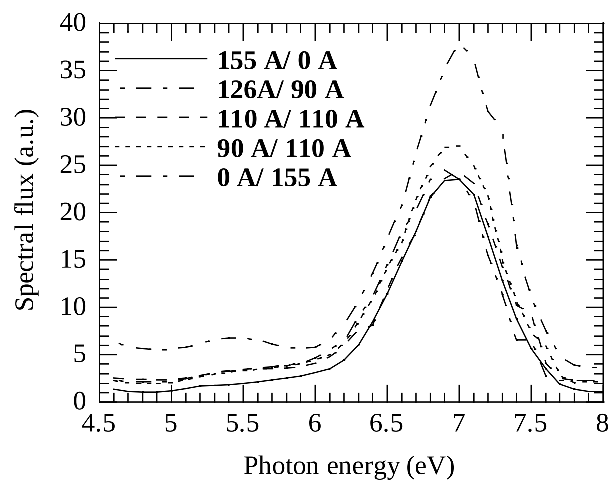

Fig. 6. Observed spectral flux for different currents (ϕ=0). The amplitudes of spectra differ from each other because the vertical polarization reflectivity of mirrors differs from the horizontal one.

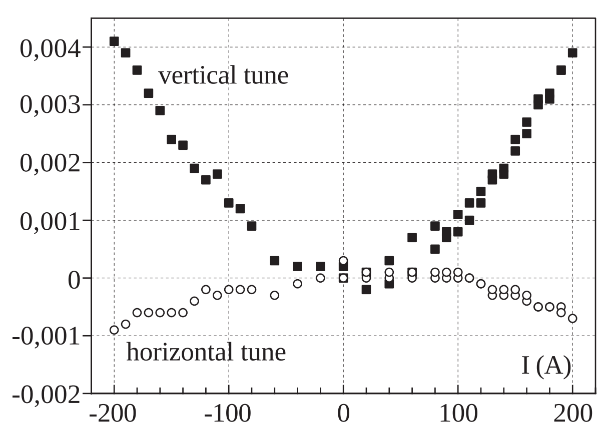

Fig. 7. Tune variation with main current (V-und.).