THE COMMISSIONING RESULTS OF 1 M PROTOTYPE EPU5.6 IN SRRC

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Abstract

An "Apple-II" type structure was used for the EPU device that has been installed in the SRRC storage ring to test the performance on the different polarization mode. It is a variable polarized undulator such that it can produce the polarization radiation in the horizontal, vertical, right/left elliptical (circular), and the linear at $45^o/135^o$ by means of changing the different phasing modes. The electron and photon beam performances will be tested in the different phasing mode. The beam dynamics behavior will be surveyed by using the Electron Beam Position Monitor (EBPM). Meanwhile, the tune shift and beam size deviation will be measured on the different phasing operation modes. The deviation of the photon beam position and angle will be measured by the Photon Beam Position Monitor (PBPM) when operated in the various polarized radiation modes. The magnetic field measurement results were calculated to compare the photon flux behavior with the ideal field calculation. Finally, a global feedback algorithm associated with the two end correctors which located at the both end sides of EPU to correct the electron orbit and photon beam behavior.

1 INTRODUCTION

This paper is a description of the beam tests we have performed on the first realization of a 1 m prototype Elliptically Polarizing Undulator (EPU) with period of 5.6 cm [1] by using the "Apple-II" type structure [2]. Our device consists of four rows of NdFeB magnet blocks, two above and two below the midplane of the electron beam trajectory. The magnet array structure was shown in Fig.1 [3]. The EPU5.6 was installed on the SRRC storage ring in February 1998. The magnetic field and the polarization mode can be changed by different phasing mode[3] of this kind of EPU device. Due to a narrow region of the field uniformity in the "Apple-II" type structure, we will be very careful to align the EPU to locate at the on-axis when install the prototype undulator.

We try to test the EPU performance under the five different operation modes [3] which are: (1) the diagonal array (upper back and lower front) move in the same direction and the other diagonal array (lower back and upper front) are fixed, such that the right/left circular and elliptical, and the vertical and horizontal linear polarization will be radiated (mode 1). (2) the diagonal array (upper back and lower front) move in the opposite direction and the other diagonal array (lower back and upper front) are fixed, such that the linear polarization between 0^o and 90^o will be radiated (mode 2). (3) the diagonal array (lower back and upper front) move in the opposite direction and the other diagonal array (upper back and lower front) are fixed, such that the linear polarization between 90^o and 180^o will be radiated (mode 3). (4) the upper two arrays (upper back and upper front) move in the same direction and the lower two arrays (lower back and lower front) are fixed, such that the magnetic field can be changed to tune the photon energy (mode 4). (5) fixed at the circular polarization condition (z=17.9 mm) and then depend on the operation mode 4 (This mode will instead of changing gap) to tune the energy (mode 5). On the operation mode 4, the variation of the tune shift and the integral strength will be much smaller than that the gap was changed[4-5]. Therefore, the energy can be tuned in each kind of polarization mode by means of the forth operation mode (mode 4) to instead of opening gap.

The results we report here are those of experimental tests of our operation mode for any kind of polarization radiation. The important test of this prototype EPU5.6 at the five phasing mode are: (1) How does the EUP interact with the electron beam in the storage ring? (2) How does the deviation of the photon beam position and divergence? (3) What is the deviation of the vertical electron beam size? (4) How about the deviation of electron and photon beam position as well as the electron beam size fluctuation when turn on the global feedback system to compensate the field error? (5) What are the tune shift and physics phenomena?

2 EXPERIMENTS

The EPU we constructed was described in reference [1] and the magnetic field was measured by the three-orthogonal Hall probe [6] and a long loop coil measurement system [7]. It consists of 16 periods of pure NdFeB magnet. Each 56 mm period consists of 16 magnet blocks, 8 above and 8 below the electron beam. The magnetic gap of EPU was fixed at 28 mm (the peak field strength is about B_y =0.42 T and B_x =0.21 T) to test the performance in the storage ring. The spectral calculation results of the EPU5.6 with 16 periods on the circularly and elliptically polarized radiation was revealed in Fig. 2

and 3. The solid and dash line represent the magnetic field measurement and the ideal field simulation results, respectively. The flux spectra ratio between the field measurement and ideal field calculation is smooth decrease as the harmonic is increased. This is due to the rms phase error is about 5 degree such that the higher harmonic flux will be decreased. However, the flux of the first harmonic is almost the same. This spectra calculation is under the condition of 0.1% energy spread and no emittance.

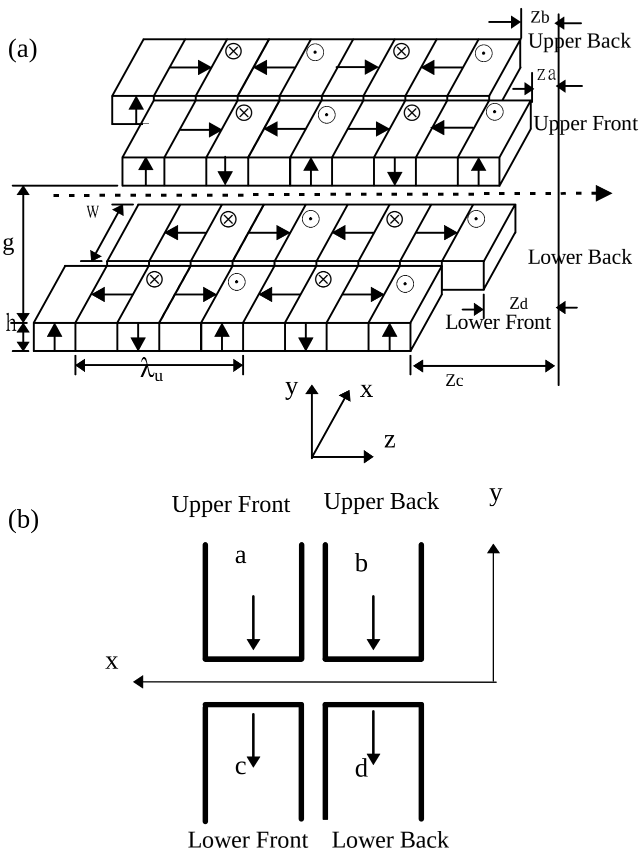

Figure1: (a) The schematic magnetic array structure of the EPU. (b) Location relation between a, b, c, and d four rows in the x-y plane.

Our first experiment was to compare the deviation of electron and photon beam with global feedback algorithm system in the SRRC storage ring. When the EPU phase change by dynamic tuning from the phase $\theta=0$ to $\theta=\pi/2$ to change the polarization mode or change energy, where the phase $\theta=2\pi z/\lambda_u$, z and λ_u are the phasing distance and period length, respectively. The electron orbit deviation as a function of phasing position and the entire EBPM position have been measured on the different operation modes. The horizontal and vertical corrector located at the both end sides of EPU were excited by the two independent power supply to compensate the horizontal and vertical integral field strength deviation. The two power supply were controlled by the global feedback system algorithm. After the field correction, the electron orbit deviation in the entire storage ring was measured by the EBPMs and the photon behavior was measured by the PBPMs. The

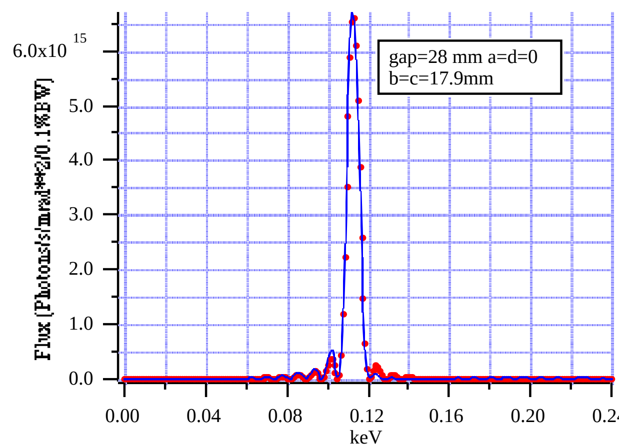

Figure2: Photon flux was calculated at the circularly polarized radiation (mode 1).

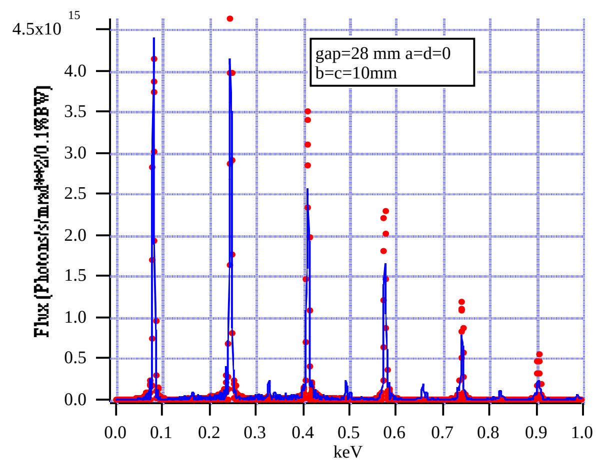

Figure3: Photon flux was calculated at the elliptically polarized mode (mode 1).

measurement results were shown in Fig. 4 and 5. The PBPMs were located at the B11B bending beam line to understand that when in the dynamic tuning by changing phase, the other users whether if has been disturbed. Figure 4 reveals that most of the electron orbital deviation can be kept within ±10 μm when the EPU phase was operated on the dynamic tuning mode. The different elliptically polarized rate (mode 1) can be changed in this mode. This orbit deviation are almost the same as that the EPU phase was kept to be fixed. Meanwhile, the orbit deviation were also measured from mode 2 to mode 5 and shows that there are no obvious difference. It means that when the EPU phase is changed dynamically to change the circularly or elliptically polarized radiation, or to change energy range in certain polarization mode, the electron orbit deviation almost keep as small as the phase was fixed. However, the photon position deviation seem to have a little difference (see in Fig.5).

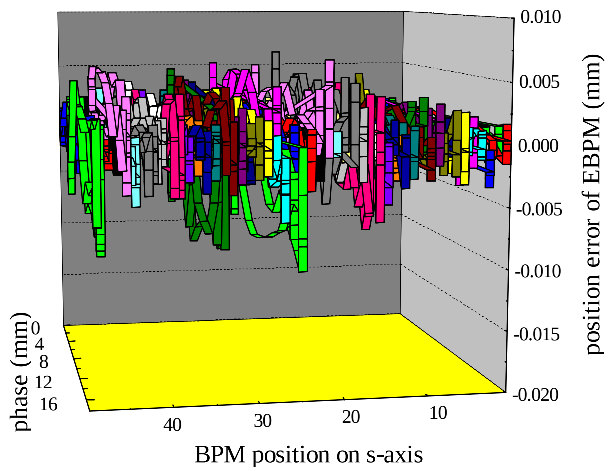

Figure 4: The electron orbit deviation is measured on mode 1. The phase change can get the optimize polarization rate in dynamic tuning.

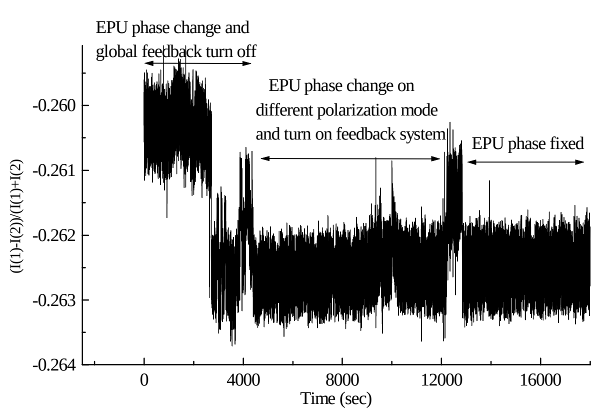

Figure 5: The photon flux variation when the EPU phase was operated at different polarization mode. Where I(1) and I(2) are the photon current of the two PBPMs.

The vertical and horizontal tune shift was measured and the results give us that the tune shift has no obvious change at the different operation modes. The resolution of the tune measurement is about 0.002 and the tune is always keep at ν_y=4.090 and ν_x=7.160. The vertical and horizontal electron beam size has been measured at the different operation mode. The results show that the beam size has not obvious changed.

3 DISCUSSION

Based on the field measurement of the elliptically polarized mode, the photon flux at the fifth harmonic is always kept beyond 80% compare with that the ideal field calculation. The electron orbit can be controlled close to the background deviation, but the photon position seems has a little difference compare with that the phase is fixed. Meanwhile, the vertical and horizontal tune shift nearly does not change. This is due to the total field strength is independent of the phase change. The horizontal and vertical beam size are also nearly does not change. Therefore the flux density variation can not be influenced by the beam size. In the near future, some experiments like as the different polarization radiation will be distinguished by the Wollaston prism. Meanwhile, a simple monochromator will be used to test the spectrum performance which can be compared with the field measurement results. Finally, the PBPMs should be calibrated to get the absolute variation of photon position and divergence. Meanwhile, the PBPMs can be used to measure the deviation of the photon position and angle of the EPU radiation light itself in the dynamic tuning.

4 ACKNOWLEDGES

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