BEAM POSITION AND ANGULAR MONITOR FOR UNDULATOR BY USING SR MONITOR TECHNIQUE

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Abstract

We have presented a beam position monitor for undulator by using SR monitor technique in PAC05. In this monitor, we applied a focusing system to observe a beam position in the undulator through a position of optical image of the electron beam. We continue a further study of this monitor, and we add the afocal system like a Kepler type telescope to measure the angular variation of the electron beam. This system converts the angular variation of optical axis of input ray into positional variation, and we can measure an angular variation through a position of optical spot on the CCD. The performance of the monitor is tested at BL27 at the Photon Factory. We succeeded to measure positional variations and angular variations of the electron beam by this monitor.

INTRODUCTION

Monitoring the undulator radiation is still one of important problem in the SR facilities. Many designs of photon beam position monitor based on photoemission type are developed for the monitoring undulator radiation. Since radiations from up-and down stream bending magnet edge are superimposed in the radiation from the undulator, it is difficult to monitor the undulator radiation independently [1]. This problem is very serious in the VUV undulator., because the spectrum of the both radiation is almost in the same energy range. In our previous work [2], to separate the undulator radiation from the bending radiation, we applied focusing system as like as in the visible SR profile monitor. Because conjugation distances from the source points of the bending magnets and undulator are different each other, we cannot focus on the source points into the same focusing plane. Using this technique, we separated the undulate radiation from the bending radiation. The position of the electron beam inside of the undulator was measured by measuring the position of beam image. Performance of this monitor was tested by using the BL5 undulator beamline. In the present work, a second optical system is added for a measurement of angular variation of the electron beam. To measure an angular variation of the electron beam is just same problem to measure an angular variation of optical axis of SR from the source point. Since the afocal system like a Kepler type telescope [3] converts an angular variation of optical axis of input ray into an positional variation, we can measure an angular variation through a positional variation of light spot on the CCD camera. We tested this monitor in the SR monitor beamline at BL27 (bending source) instead of BL5 due to serious floor vibration at the BL5. For this monitor, there exist no difference between undulator source and bending source except above mentioned separation technique [2]. The results of these systems for monitoring a beam position and angle are described in this paper.

OPTICAL SYSTEMS FOR THE OBSERVATION OF POSITION AND AMGLE OF ELECTRON BEAM

Two types of optical system are set for the observation of position and angle of the electron beam. One is a focusing system to make an image of the electron beam for the observation of its position. The other is so called afocal system for the observation of angle of the electron beam. Setups of both optical systems are illustrated in figure 1.

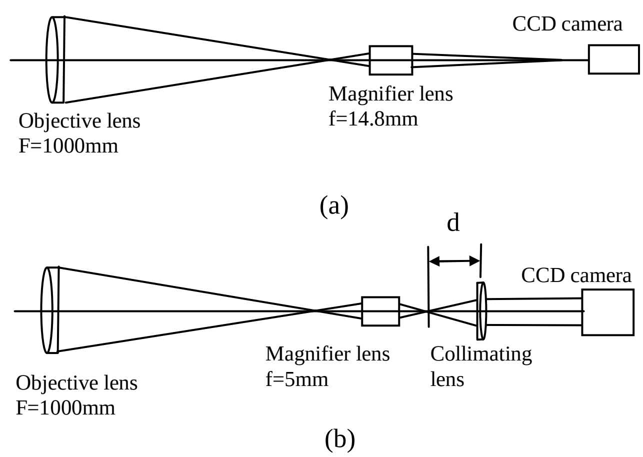


Figure 1: Focusing system (a) for the observation of the beam position and afocal system (b) for the observation of beam angle.

Let us denote the transverse magnification of the focusing system (a) be β, then the angular magnification γ is given by $\gamma=1/\beta$. In the normal set up of the focusing system, we will set larger transverse magnification for the observation of the image or its position. Oppositely, the angular magnification becomes smaller in this system. In present time, we set a transverse magnification $\beta=10$. In the afocal system, we will set a small transverse magnification for the focusing system in the first stage of the total system to increase an angular magnification. In the next stage of focusing system, a collimating lens is set to make the afocal condition. As shown in figure 2, the angular variation θ of input optical axis converts into the positional variation x of the optical axis on the CCD camera. Namely, x is given by;

$$x = d \cdot \theta$$

where d is distance between focal plane of the first stage optics and collimating lens.

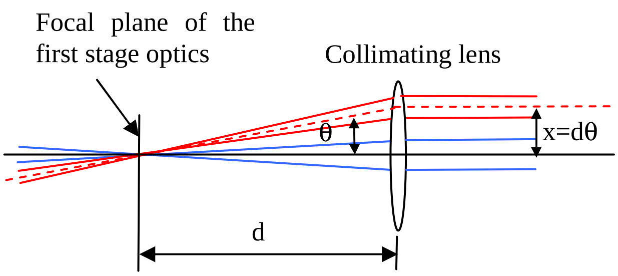


Figure 2: Collimating section in the afocal system.

The angular variation of the optical axis will convert into the positional variation in this stage. In the present time, we set an angular magnification γ=200 for the first stage focusing system. Since the transverse magnification is 1/200, we can neglect positional variation of the image at the focal plane of the first stage optics. The focal length of collimating lens is 50mm. With this condition, an angular variation 50μrad will give a position variation 0.5mm on the CCD. The spectrum of the input light for the both system is limited by 10nm at 550nm by a band-pass filter. The σ component is chosen by dichroic sheet polarizer. The results taken by the focusing system and the afocal system are shown in figures 3 and 4 respectively.

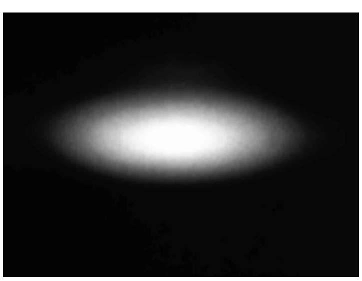


Figure 3: Electron beam image produced by the focusing system.

Figure 4: Intensity distribution of the light beam at the afocal system.

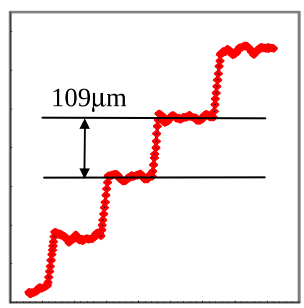
CALIBRATION OF BEAM POSITION AND ANGLE

A calibration of system is necessary to know the absolute values of the positional variation and angular variation of the electron beam. In the previous work [2], an optical beam shifter was used for the calibration of transverse positions of the electron beam. In the present work, a movable mirror which is set at 3m downstream from the source point is used for both calibrations of positional variation and angular variation of the electron beam. The positional variation Δp and angular variation $\Delta\phi$ is given by following equations;

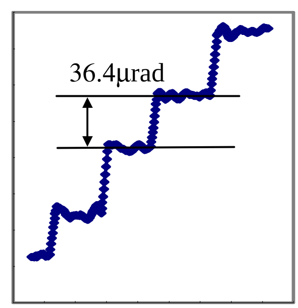
$$\Delta p = 2 \cdot L \cdot \theta$$

$$\Delta\phi = 2 \cdot \theta$$

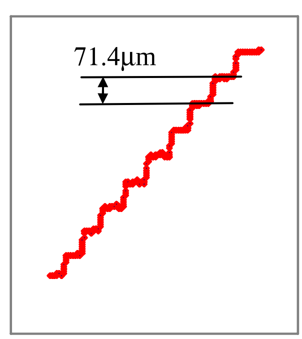
where L denotes distance between the source point and the mirror, and θ denotes rotation angle of the mirror. Since two optical systems have a rotational symmetry around the optical axis, calibration factors for the vertical and the horizontal direction must be same. But actually, aspect ratio of the CCD camera is not precise enough. We calibrate both of the vertical and the horizontal directions via step-scanning of the mirror in both directions. The results of the calibrations are shown in figure 5.



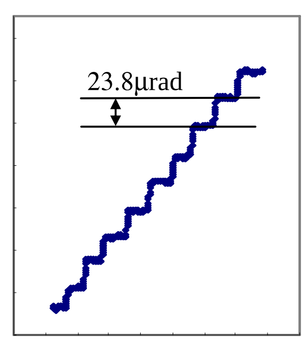
(a) Horizontal position



(b) Horizontal angle



(c) Vertical position



(d) Vertical angle

Figure 5: Result of calibrations; (a): horizontal position, (b): horizontal angle, (c): vertical position, (d): vertical angle.

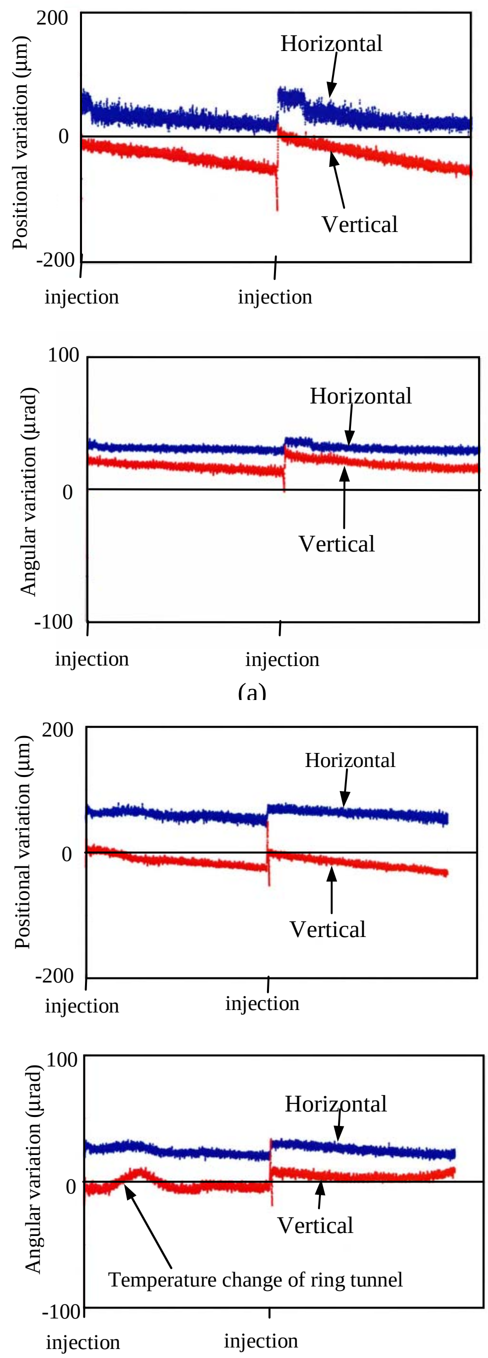
For the position sensing of the beam spots of light on the CCD camera in this calibrations are performed by two steps; 1.to make vertical and horizontal projections of beam spot, 2.to analyze the positions of each projections by fitting a Gaussian profile by least squire fitting method. The scanning steps θ of the mirror in the vertical and the horizontal are 11.9μrad and 18.2μrad respectively. The steps of angular variations are twice of these angles, namely 23.8μrad in the vertical and 36.4μrad in horizontal. Corresponding step of beam position variations in the vertical and the horizontal are 71.4μm and 109μm, respectively.

OBSERVATION OF BEAM POSITION ANDANGLE

The monitor is experimentally operated at BL27. The positional variation and angular variation of the electron beam are continuously recorded by every 1sec. Two examples of 24 hours recording of the positional variations and the angular variations are shown in figure 6. Since we inject two times a day, positional variations and angular variations in figure 6 have two discontinuous points in 24 hours. In the example (a), a sudden change of horizontal position and angle was observed at two hours after the injection. This sudden change is not observed in the example (b). In the example (b), effect of a temperature change of ring tunnel is observed as a vertical angular variation. A large fluctuation in the positional variation is observed in the example (a) compare with the example (b). In the both examples, a tendency of systematic drift in the data is also observed.

CONCLUSIONS

A beam position and angular monitor by using the optical SR monitor technique has been developed at the Photon Factory. A focusing system is used for the detection of positional variation, and an afocal system is used for the detection of angular variation of the electron beam. Due to floor vibration, the performance of the monitor is tested at BL27 bending source. We succeeded to measure positional variations and angular variations of the electron beam. Combining the techni1que to observe undulattor source point in the previous work [1], this monitor is fully applicable for the observation of electron beam position and angle in the undulater. In other hand, this monitor also can provide the electron beam position and angle at the bending source. The time interval for data taking is typically one second. If we replace the CCD camera by faster device such as four-quadrant photodiode, this monitor can work like a phase space monitor. In other hand, a systematic drift in the data is observed in this monitor. We consider some systematic motion should exist between the source point and the optical system. The monitor will be installed in BL17 which source point is short period undulator.



(b)

Figure 6: Two example of 24 hours recordings of beam positions and angles

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