BEAM MEASUREMENTS OF COMPACT SR RING "AURORA-2S"

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Abstract

AURORA-2S (A2S) being operated successfully[1], we have measured beam position and beam profile routinely since July 1999. Drift of electron beam positions was observed about 0.5 mm horizontally and 0.3 mm vertically during eleven months. However, in each operation electron beam positions changed less than 0.15 mm and we observed any inexpediency so far on our experiments. Measured SR positions were the same trend with electron beam positions. We consider the major cause of such beam drift is temperature change of structural materials and environment. The beam sizes obtained with both the profile monitor and the SR interferometer are in good agreement. Under typical operating condition, beam size is controlled about 1.0 mm both in the horizontal and in the vertical.

1 INTRODUCTION

The A2S monitor system consists of two electron beam position monitors, two SR position monitors, a beam profile monitor, an SR interferometer via measurement of spatial coherence, a beam current monitor and two hall probes measuring high field of the main magnets. The Schematic diagram of the A2S monitor system is shown in Fig. 1.

A2S whole storage ring was covered completely for self-radiation shield with lead and polyethylene[2]. As a result, temperature of the storage ring rose with operating the ring. In order to suppress rising in temperature, inside of the radiation shield has been air-conditioned since April 2000.

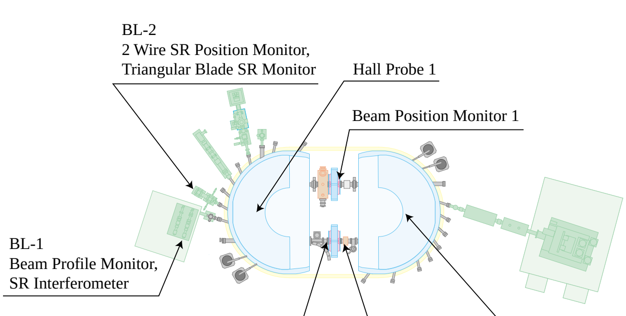

Fig. 1: Schematic diagram of A2S monitor system.

2 MONITOR SYSTEM

2.1 Electron Beam Position Monitor

We measured electron beam position using the button monitors which are placed inside the quadruple magnets[3]. To avoid disturbing magnetic field, the button monitors are made of non-magnetic materials. We selected a signal frequency 380 MHz to detect which was double of RF fundamental frequency to keep out of mixing noise. We used SUHNER S04272B as signal cables that has high shielding performance and Bergoze BPM as detectors. We calibrated the button monitors by scanning the button monitor ducts, while a wire stood still inside the duct to which 380 MHz sine wave was applied. In the central area 2 mm x 2 mm of ducts, RMS deviations of the wire position to the calibration curve under the approximation of button electrode output in proportion to the wire position were 0.012 mm in the horizontal and 0.027 mm in the vertical. The standard deviations of measured electron position for 30 minutes were 4 μm in the horizontal and 6 μm in the vertical.

2.2 SR Position Monitor

We measured SR position using two kinds of monitors. One is the wire-type that consists of two gold-coated φ0.1 mm tungsten wires positioned upper and lower sides of the SR beam. The other is blade-type that consists of two metal blades cut rectangle with a diagonal. We detected quantity of emitted secondary electrons from two wires or two blades. By scanning wires and blades, we made calibration curve of a 3rd order polynomial for the wire-type and a linear function for the blade-type. RMS deviations of the SR position to the calibration curves were 1.3 μm in the wire-type and 13 μm in the blade-type.

2.3 Beam Profile and Size Monitor

The schematic diagram of the beam profile monitor and the SR interferometer are shown in Fig. 2[4][5].

We obtained beam size from image acquired with the profile monitor by using image processing. In the case of measurement using the SR interferometer, the complex degree of the spatial coherence are Fourier transform of the beam profile (Van Cittert-Zernike theorem), therefore we calculated complex degree from the interferogram.

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And we obtained vertical beam size with approximation the beam profile with a Gaussian shape.

We applied the SR interferometer to measure only vertical beam size because the method using the SR interferometer suit to measure small beam size

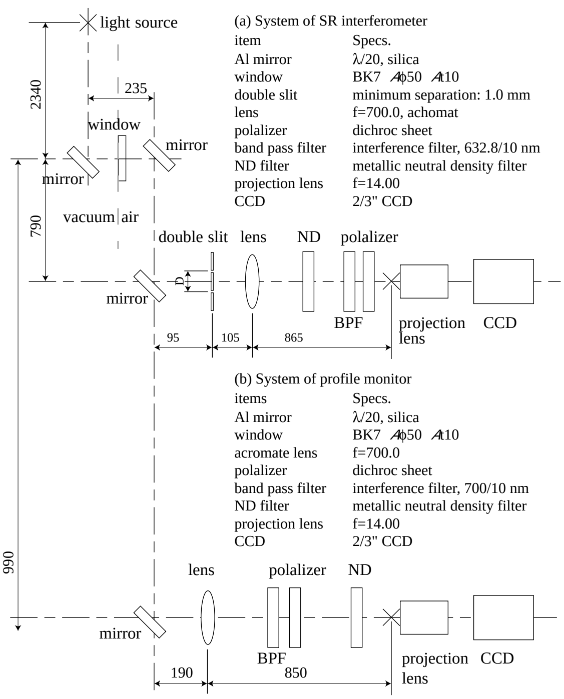


Fig. 2 Schematic diagram of the beam profile monitor and the SR interferometer.

3 RESULTS

3.1 Electron Beam Position

Electron beam positions measured from July 1999 to the recent are shown in Fig. 3. Both trends of horizontal and vertical beam position are simply drifted till January 2000. We think that temperature of the storage ring became higher due to the operating-time elongation in this period. In April 2000, we air-conditioned inside the radiation shield to keep temperature constant. Since then horizontal beam position looks like pausing drift and vertical beam position returned previous value.

Typical fluctuation of beam position in a day depending on stored current is shown in Fig. 4. The changes of positions were 0.05 mm in the horizontal and 0.02 mm in the vertical.

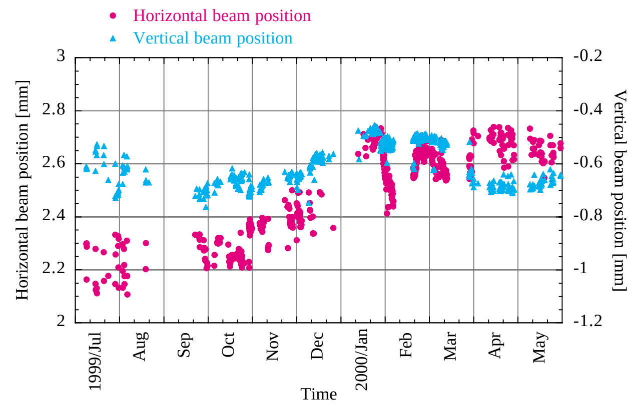


Fig. 3: Change of electron beam position since July 1999.

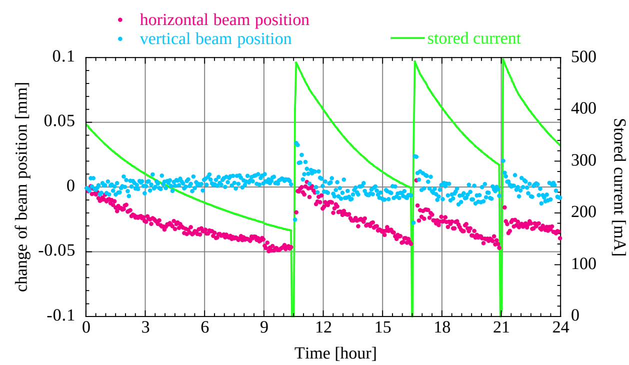


Fig. 4: Typical fluctuation of electron beam position in a day.

3.2 SR Position

SR positions measured with two types of monitors are shown in Fig. 5. Those measured with the wire-type monitor show same trend with electron vertical beam positions. The one measured with the blade-type, however, changed the trend since air-conditioning inside the radiation shield. The reason of such change is not resolved yet.

Typical fluctuation of SR positions in a day is shown in Fig. 6. The measured one with the blade-type monitor jumped at re-injection. We think that the reason of such jump is an over load to the blade.

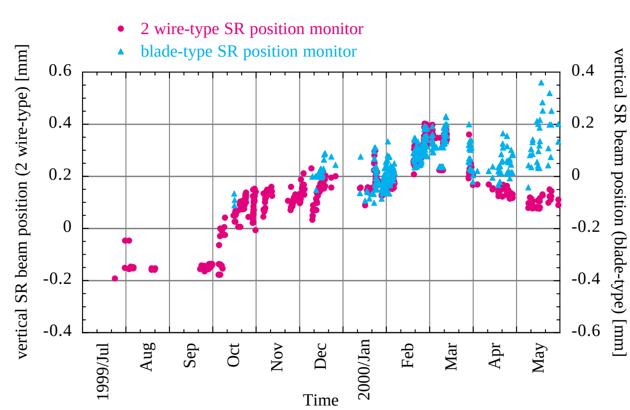


Fig. 5: Change of SR beam position since July 1999.

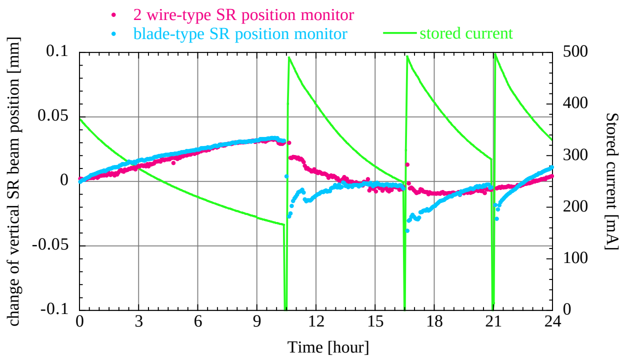


Fig. 6: Typical fluctuation of SR beam position in a day.

3.3 *Beam Profile and Size*

The beam profile under operating typical condition is shown in Fig. 7. We have controlled vertical beam size to extend lifetime. We have applied RF which frequency is near the betatron oscillation's to ion clearing electrodes. In this case, horizontal beam size was 1.19 mm and vertical beam size was 1.0 mm.

Two images of interferogram obtained with the SR interferometer are shown in Fig. 8. The complex degree obtained by changing double slit separation is shown in Fig. 9. In this case, vertical beam size with the SR interferometer was 0.193 mm and with the beam profile monitor was 0.199 mm. The both results were in good agreement.

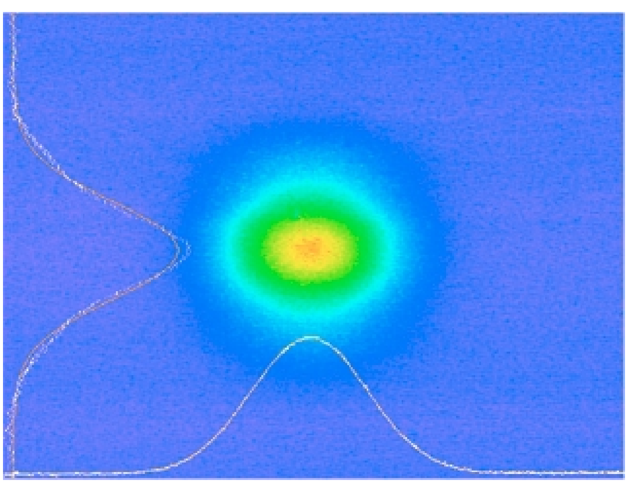
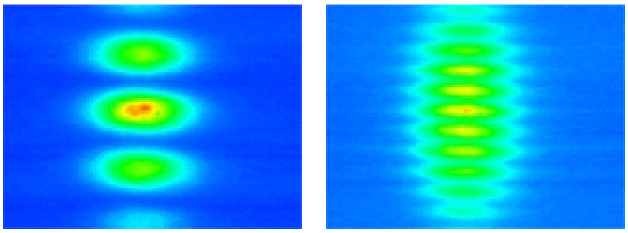


Fig. 7: Beam profile under typical operation condition. Vertical beam size expanded by applying RF.



(a) double slit separation is 2.0 mm. (b) double slit separation D = 4.0 mm

Fig. 8: Interferogram with changing double slit separation.

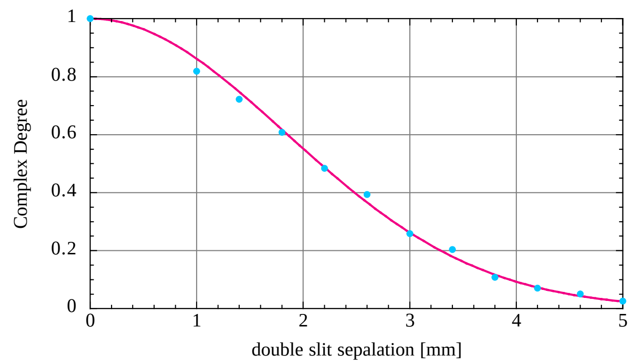


Fig. 9: Complex degree vs. double slit separation.

4 CONCLUSION

We have measured beam position, profile and size for about one year, and obtained consistent results with the various types of monitors. Though A2S has no room to install steering magnet for closed orbit correction, our X-ray lithography team has obtained excellent result even when beam position fluctuated above-mentioned[6]. We are confident that such the fluctuation of beam position does not cause any inconveniences. We will further investigate the influence of beam position and profile variations on the X-ray lithography

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