MEASUREMENT OF BEAM SIZE AT POHANG LIGHT SOURCE

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Abstract

The synchrotron-radiation interferometer has been employed to measure the beam size in the storage ring at 2.5 GeV Pohang Light Source [PLS]. We measured the beam sizes in vertical and horizontal directions using by fitting method by Mathematica and Root. We measured the background variations by passing time. In this paper, we will discuss the interferometer system, analysis of data and the measured results.

INTRODUCTION

The beam energy, circumference and beam current, emittance in PLS are 2.5 GeV, 280.56 m and 180 mA, respectively. SR interferometer with 18.9 nm-rad was developed in order to measure the spatial coherency of synchrotron radiation. Since the SR beam from a small electron beam has good spatial coherency, it is suitable for measuring a small beam size[1]. We can measure the beam sizes as small as ~ 10 μm in a non-destructive manner. Profile of the interferometer pattern is measured by visible light in typically 650 nm[2]. The emittance $(\varepsilon_x = \sigma_x\sigma_{x'}, \varepsilon_y = \sigma_y\sigma_{y'})$ is related to the brightness of synchrotron radiation. It is calculated by the electron beam size.

SET UP OF INTERFEROMETER IN PLS BEAM LINE

As shown in Figure 1, we use a mirror to guide light to the hutch slit. The light is passed through lens and polarized light filter, a 650nm filter, and CCD camera. The CCD camera is installed at the end of set-up for the measurement of the interference pattern from synchrotron radiation. The pc connected with CCD camera receives the interference pattern information.

OPTICS STRUCTURE

A quad-slit is used for the creations of horizontal and vertical interference patterns.

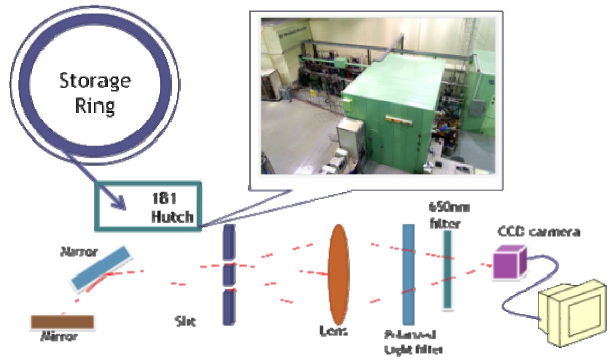

Figure 1: scheme of the interferometer in PLS

Figure 2 shows the quad-slit used at PLS. The advantages using the quad-slit are the following; cost down of additional installation of double-slit and the reduction of distortion of light waves due to beam splitter[3].

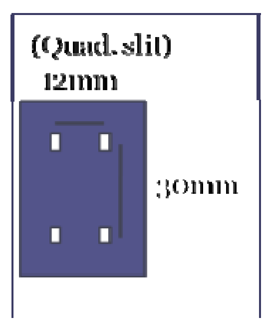

Figure 2: Quad-slit in interferometer

Figure 3 shows the beam size monitoring in PLS. We can measure the horizontal and vertical beam sizes in real-time. The measured beam size information in real time is directly transferred to the control room.

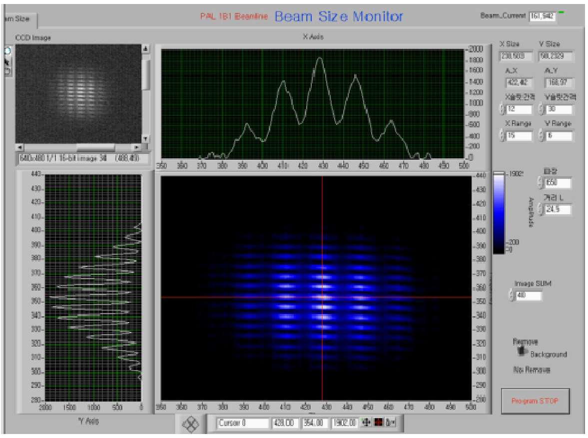

Figure 3: Horizontal and vertical interference patterns with the quad-slit.

FORMULA FOR BEAM SIZE MEASUREMENT

The intensity for ether horizontal or vertical interference pattern at the position of x at CCD is given bellow,

$$y(x) = 2I_0 \left[\frac{\sin(\frac{\pi\omega}{\lambda R} x)}{\frac{\pi\omega}{\lambda R} x} \right]^2 \left(1 + \gamma \cos\left(\frac{2\pi D}{\lambda R} x\right)\right),$$

where ω is width of the slit, D is separated distance of silts, R is distance from CCD to slit, λ is wavelength of the light and γ is visibility. The relation between beam size and visibility is given by

$$\sigma_{beam} = \frac{\lambda}{\pi} \frac{R}{D} \sqrt{\ln \frac{1}{\gamma}}$$

Figure 4 shows the visibility for 12mm slit distance and 650 mm wavelength as function of beam size.

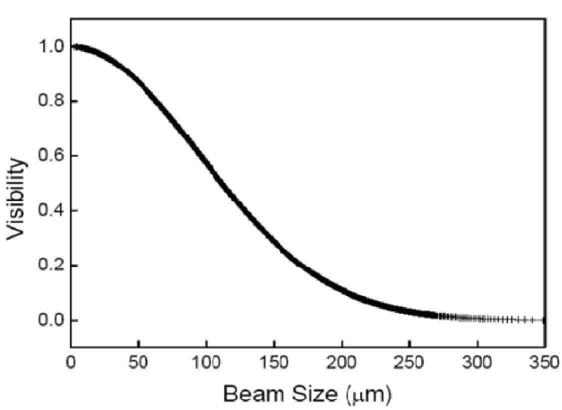

Figure 4: Relation of beam size and visibility(slit distance of 12 mm, wavelength of 650 nm).

BEAM SIZE MEASUREMENT

To measure the beam size, the visibility is extracted by two methods; one method called the fitting method is applied for fit to the data with the fitting function, y(x). The another method called the min/max method uses the minimum and maximum of interference pattern. Before measuring the beam size, we subtract background from data. The raw signal data and background are shown in Figure 5 and 6. After subtracting background from data, we perform the fitting. These results are shown in Figure 5 and Figure 6.

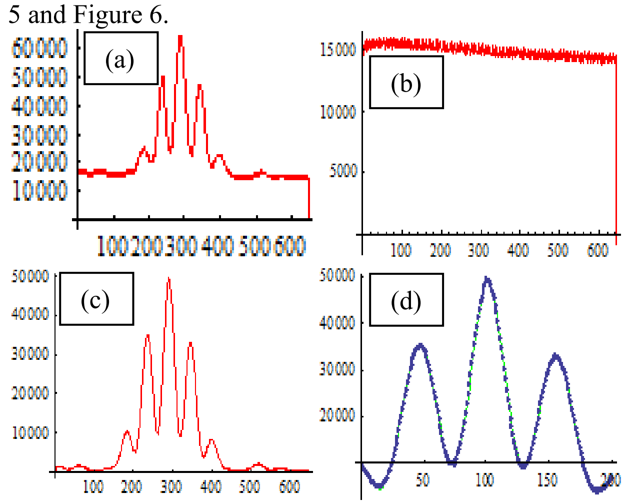

Figure 5: Horizontal interference pattern data (a) signal data. (b) background data. (c) subtraction of the background from data (d) fitting with data.

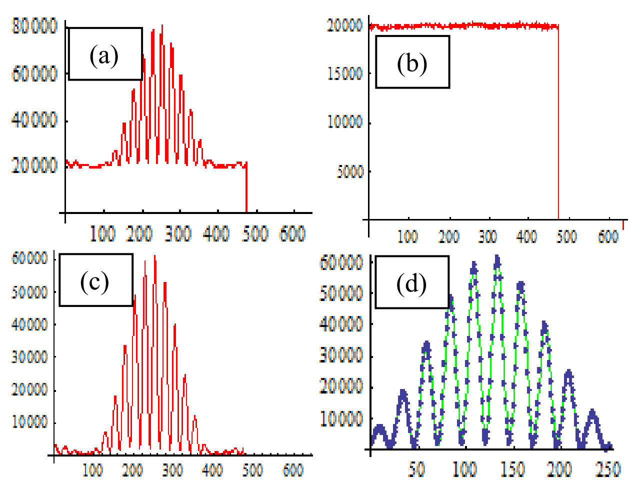

Figure 6: Vertical interference pattern data (a) signal data. (b) background data. (c) subtraction of the background from data (d) fitting with data.

We compared the results of the beam sizes calculated by fitting method using by both Mathematica and Root. The result showed a good agreement between Mathematica and Root. We also compared the results by fitting method with min/max method. As show in Figure 7, the vertical beam size is around 42 μm. Results of beam sizes estimation by the fitting and min/max methods are similar.

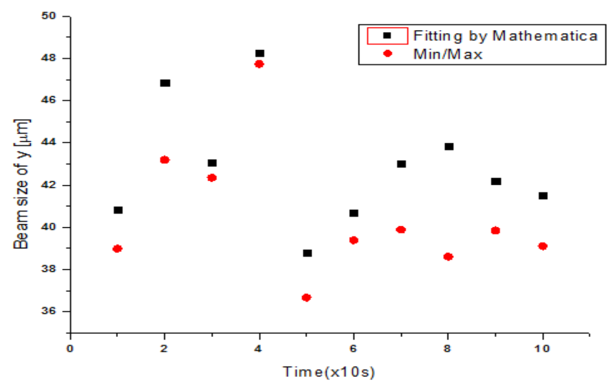

Figure 7: Results of the beam size by the interferometer are compared by the Fitting method with Min/Max method.

BACKGROUND STUDY

For beam size measurement, we subtract the background from data. We check the time dependency of the background. Background comes from dark current of CCD. To measure dark current in CCD, we take data from CCD by shutt off the light. We measured the background at intervals of two hours and eight days. The average of each background data is shown in Figure 8.

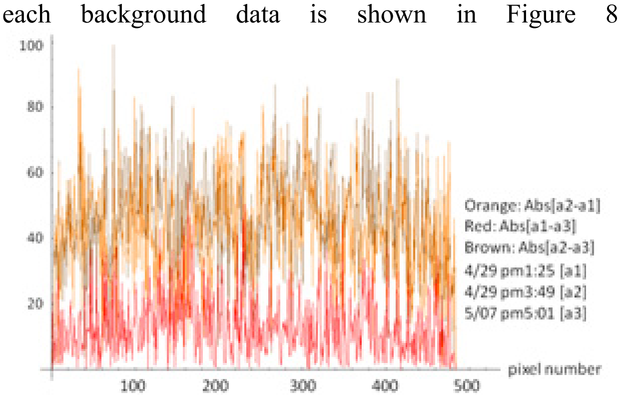

Figure 8: Time dependence of background data. The a1 data received at 1:30 pm, a2 data received at 3:50 pm on April 30 and a3 data received at 5 pm on May 7.

The difference of the background between eight days is similar to the difference of the background between two hours. Background is little changed for eight days. This result is shown in Figure 9.

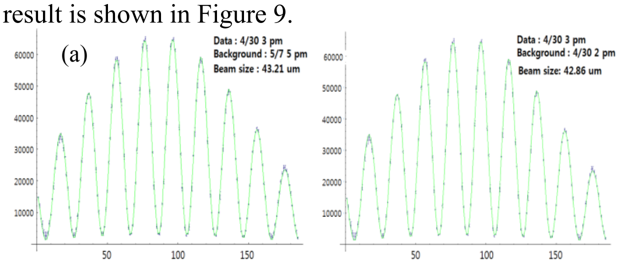

Figure 9: Comparison of the background change between eight days. Beam size estimated by fitting method with different background. (a) Background: 5pm in 7 May Signal: 3pm in 30 April (b) Background: 2pm in 30 April Signal: 3pm in 30 April

Figure 9, we shows the signal from background subtraction with different background data. The difference of between Figure 9 (a) and (b) is about 0.4 μm. This different is negligible.

CONCLUSIONS

We performed the measurements of beam size using by fitting and min/max methods. It is shown that the measurement of the beam size estimated by fitting method is reasonable. Fluctuation of beam size estimated by the fitting method is smaller than the Min/Max method. Beam sizes estimated by the fitting and min/max methods are in a good agreement. We also checked the time dependency of background. Background due to dark current of CCD was not varied for 8 days.

REFERENCES

[1] T. Mitsuhashi, Beam Measurement, Edited by S. Kurokawa, et al. (World Scientific, 1999)
[2] M. Born and E. Wolf, Principles of Optics
[3] J. Y. Huang, et al., "Design of Diagnostic Beamline for PLS", Proc. of 4th International Conference on Synchrotron Radiation Source.