Measurement of beam size at Pohang Light Source

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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 a 8.9 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. 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. The emittance is related to the brightness of synchrotron radiation. It is calculated by the electron beam size.

Set-up of interferometer in PLS beam line

We use a mirror to guide light to the hutch slit. The light is passed through lens and polarized light filter, a 650 nm 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 pattern 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. 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. This picture 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.

Formula for beam size measurement

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

\[ I(x) = 2I_0 \left( \sin \left( \frac{\pi x}{R_D} \right) \right) \left( 1 + \gamma \cos \left( \frac{\pi x}{D} \right) \right) \]

where \( \omega \) is width of the slit, \( D \) is separated distance of slits, \( R \) is distance from CCD to slit, \( \lambda \) is wavelength of the light and \( \gamma \) is visibility. The relation between beam size and visibility is given by

\[ \sigma_{\text{beam}} = \frac{\lambda}{2\omega} \frac{\ln \gamma}{\gamma} \]

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 other method called the min/max method uses the minimum and maximum of interference pattern. Before measuring the beam size, we subtract background from data. After subtracting background from data, we perform the fitting.

The measured beam size information in real-time is directly transferred to the control room.

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 shut off the light. We measured the background at intervals of two hours and eight days.

Background study

The difference of between (a) and (b) is about 0.4 μm. This difference is negligible.

We also compared the results by fitting method with min/max method. Results of beam size measurement by fitting method is around 42 μm estimation by the fitting and min/max methods are similar.

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.

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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

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