A Proposed Emittance Measurement with an X-ray Pinhole Array on the SPring-8 Storage Ring

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To achieve the designed low emittance and small transverse emittance coupling ratio of the SPring-8 storage ring, it is essential to have a precise monitor for non-destructive emittance diagnostics. One promising solution is to observe the emittance of photon beams from undulators.

The emittance of the photon beam is the convolution of electron beam emittance and the emittance of emitted photon. The size and angular spread of the photon beam is expressed as,

$$\Sigma = \sqrt{\sigma_e^2 + \sigma_p^2},$$

and

$$\Sigma' = \sqrt{\sigma_e'^2 + \sigma_p'^2}.$$

The size of photon σ_p is negligibly small, and the size of the photon beam Σ is equal to the size of the electron beam σ_e. The limit of emittance measurement is imposed by the angular spread of emission σ_p'. With the length of undulator L and the optical wavelength λ, the measurement limit of emittance is given as,

$$\varepsilon \sim \lambda \beta / L$$

where β is the beta function at the undulator.

We have studied the optimum pattern of the pinhole array and the effective area and position resolution necessary for the detector. The designed values of the emittance of 5.5 nm rad and a transverse emittance coupling ratio of 10 % are assumed. The undulator is installed in the high beta straight section where the beta functions are β_x = 24 m and β_y = 12 m [1]. The length of the undulator and the optical wavelength are chosen to be 4.5m and 1 Å, respectively. The locations of the pinhole array and the detector are assumed 35 m and 70 m from the undulator, respectively. Figure 1 shows the pattern of the pinhole array. The size of each pinhole is 30 μm by 10 μm. The phase ellipse of the photon beam at the position of the pinhole array is shown in fig. 2. The dashed lines in the figure correspond to pinholes. The angular distributions of photons at position coordinates sampled by pinholes are measured as spatial distributions on position sensitive detectors (Fig. 3). The effective area and position resolution necessary for the detector are 7 mm (x) × 4 mm (y) and 10 μm, respectively.

References

[1] SPring-8 Project, Facility Design 1991, JAERI-RIKEN SPring-8 Project Team.

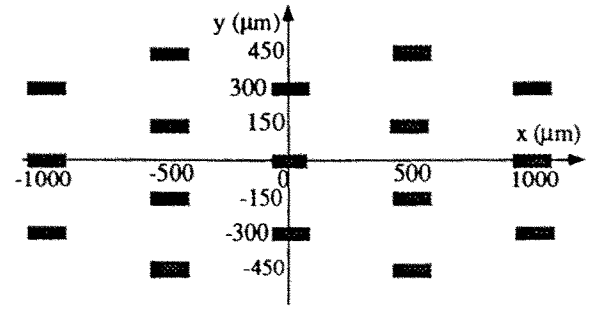

Fig. 1. Pinhole array. The size of each pinhole is 30 μm (x) × 10 μm (y).

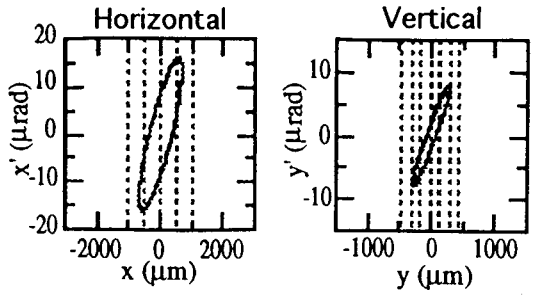

Fig. 2. Phase ellipse of the photon beam at the position of the pinhole array. The dashed lines correspond to pinholes.

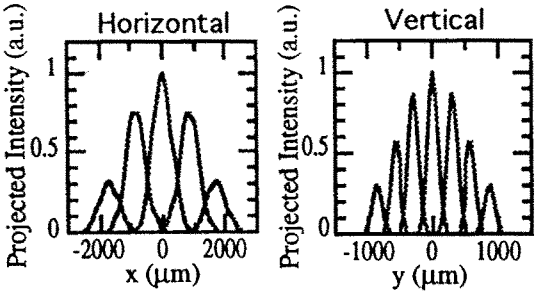

Fig. 3. Intensity distribution on the detector projected on the horizontal and vertical axes.