Beam Position Monitor and Synchrotron Radiation Interferometer

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Abstract

This experiment aims to understand the principles and performance of the Beam Position Monitor (BPM), which measures the position of electron beams in an accelerator, and the Synchrotron Radiation Interferometer (SRI), which characterizes photon beam properties. Using a current-carrying wire in place of an electron beam, we examined BPM sensitivity and linearity. For SRI, we observed changes in interference fringes depending on slit spacing, verifying the relationship between spatial coherence and beam size.

1 Introduction

Due to the extremely short mean free path of electron beams in air, they must be accelerated in ultra-high vacuum environments. As a result, directly measuring beam parameters—such as position, energy, size, and pulse length—is challenging. Diagnostic devices like BPM and SRI provide indirect yet reliable measurements. This experiment explores the use of a Stripline BPM to determine beam position and an SRI to estimate photon beam size based on interference patterns.

2 Beam Position Monitor (BPM)

2.1 Principle

A BPM detects the image current induced on the chamber wall as a charged particle beam passes through a vacuum pipe. Different types of BPMs include Stripline, Button, Cavity, and PBPM. In this experiment, a Stripline BPM was tested using a wire test stand that simulates the passage of an electron beam using a steady current-carrying wire.

2.2 Method

Instead of an electron beam, a wire carrying electric current was fixed at the center of the BPM. The BPM body was moved laterally using a precision motor, and the induced signals from the striplines were measured. The linearity and accuracy of the measured beam positions in both X and Y directions were analyzed by comparing motor positions with BPM-calculated positions.

2.3 Results

The data showed high linearity near the BPM center, while nonlinearity increased as the wire approached the electrodes. This confirms the geometric limitations of Stripline BPMs and emphasizes the need for calibration within the linear operating region.

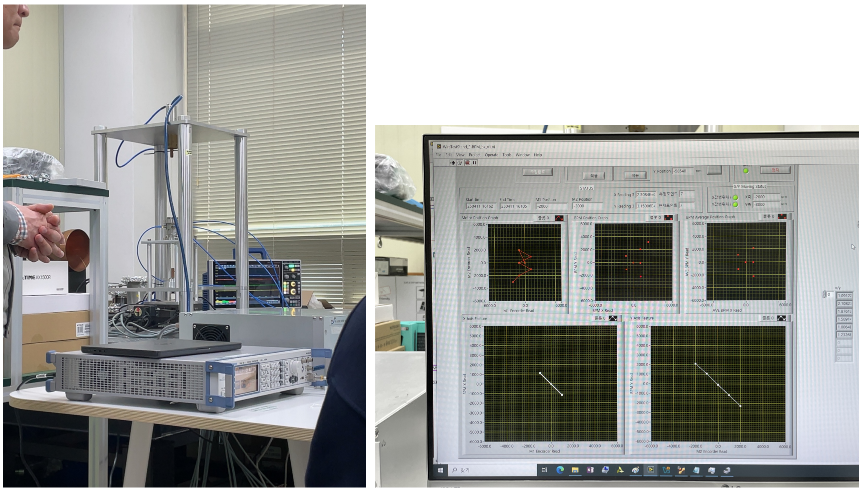


Figure 1: (a) BPM equipment setup. (b) Measurement interface and results from the Wire Test Stand.

3 Synchrotron Radiation Interferometer (SRI)

3.1 Principle

An SRI measures beam size based on interference caused by two slits. Ideally, a point source yields distinct interference fringes, while a finite-size source results in an envelope-shaped decay in fringe intensity. By analyzing these interference patterns, the transverse size of the photon beam can be estimated.

3.2 Method

Using the SRI installed at the 1B diagnostic beamline, the vertical slit spacing was varied among 18 mm, 22 mm, 35 mm, and 40 mm, while the horizontal slit spacing was fixed at 15 mm. The resulting interference patterns were recorded and compared.

3.3 Results

As the vertical slit spacing increased, the spatial frequency of the fringes also increased (i.e., fringe periods became shorter). This is consistent with the wave interference theory, where slit separation is inversely proportional to fringe spacing, indicating higher resolution for larger slit distances.

4 Conclusion

This experiment demonstrated the crucial role of BPMs in real-time beam diagnostics. The wire test stand allowed us to verify the BPM's linearity and sensitivity, particularly near the center where measurements are most accurate.

The SRI experiment provided insight into the relationship between slit spacing and interference pattern frequency, reinforcing the principle that beam size can be inferred from spatial coherence. Together, these diagnostic tools are essential in modern accelerator physics for monitoring and controlling beam dynamics.

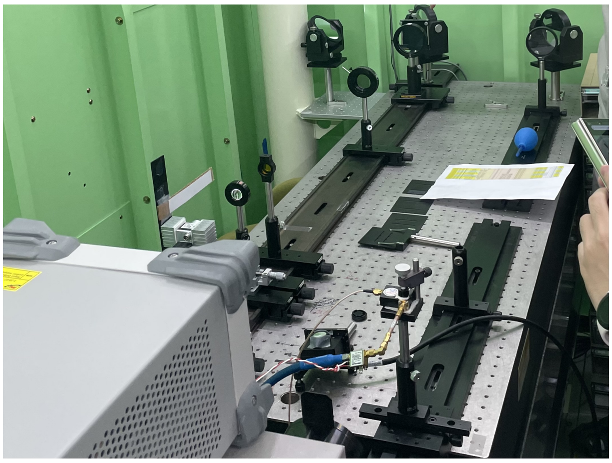
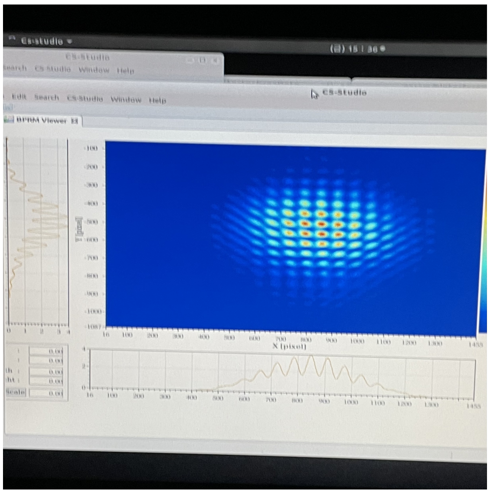
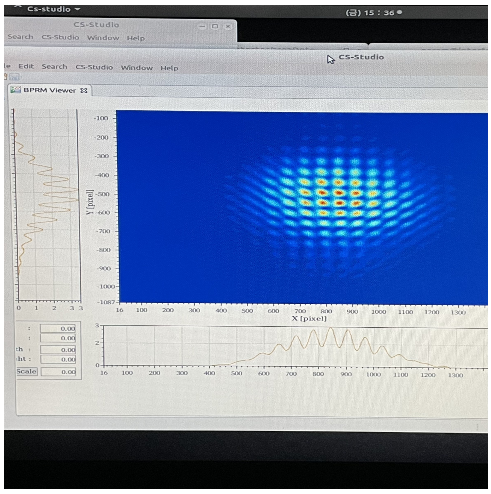


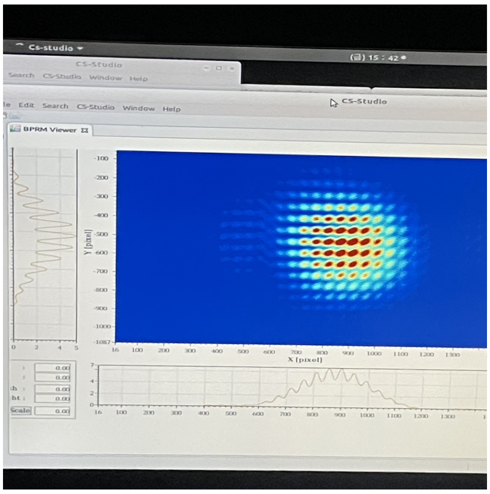
Figure 2: Schematic of Synchrotron Radiation Interferometer at 1B beamline



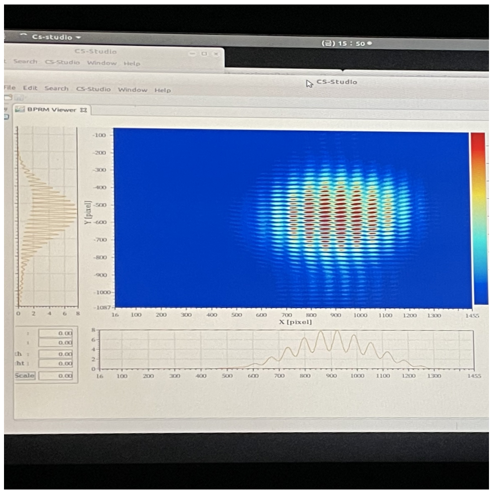
(a) Slit: 18 mm



(b) Slit: 22 mm



(c) Slit: 35 mm



(d) Slit: 40 mm

Figure 3: Fringe patterns for different vertical slit spacings

References

[1] Changbeom Kim, *Lecture Notes on NUCE719P*, Division of Advanced Nuclear Engineering, POSTECH, PowerPoint presentation, 2025.