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WIRE SCANNER MEASUREMENTS AT THE PAL-XFEL*

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Abstract

The PAL-XFEL, an X-ray Free electron laser user facility based on a 10 GeV normal conducting linear accelerator, has been operational at Pohang, South Korea. The wire scanners are installed for transverse beam profile measurement at the Linac and the Hard X-ray undulator section. The wire scanner is a useful device for emittance measurements in the Hard X-ray undulator section. In this paper, we describe the details of the wire scanner and the results of the measurements.

INTRODUCTION

In order to operate an accelerator more stably and efficiently, it is necessary to adjust the operation conditions of the apparatus to the designed conditions. In order to perform this operation, it is important to obtain the accurate emittance of the electron beam by the transverse beam size measurement. At the PAL-XFEL are installed 54 screen monitors and 13 wire scanners for beam profile measurement. As shown in Fig. 1 the wire scanner is mainly located at the end of the linear accelerator and the undulator section. This is used to measure the emittance to optimize the FEL generation condition for the undulator section. The wire material is a 34 μm thick carbon wire suitable for the undulator line because it generates lower radiation when it is hit by electron beam [1]. This paper describes device configuration and beam commissioning results using wire scanner.

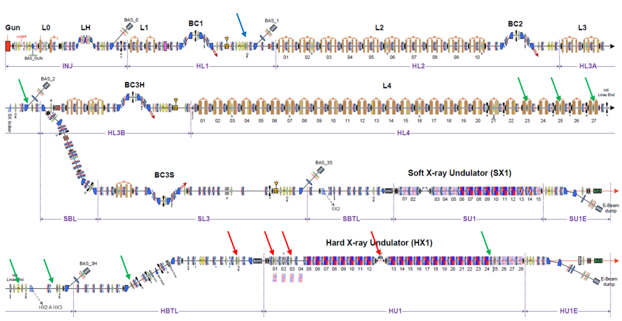

Figure 1: The layout of the PAL-XFEL. The arrows shows the location of the wire scanner. And the red arrow indicates the location of the device where the 34 μm carbon wire is installed.

HARDWARE FEATURES

The wire scanner measurement system consists of a motion stage and a radiation measuring device. The motion device is used to adjust the position of the wire causing the interference with the electron beam. The radiation measuring device measure the amount of energy loss caused by the interference of the electron beam with the wire.

Motion Stage

The wire scanner assembly is mounted on its 45° motion stage with linear motor. As shown in Fig. 2(a), the wire card is equipped with three wires (x, y, u) and an RF shielding tube. It has been reported that the position of the electron beam changes due to the changing of the magnetic field from the linear motor [1]. The linear motor is equipped with an ironless linear motor which is designed not to have attractive force. The wire material is based on the tungsten and carbon wire was selected to minimize the radiation damage to the undulator magnet. The wire scanner with carbon 34 μm wire is installed between after the dogleg section and the last undulator.

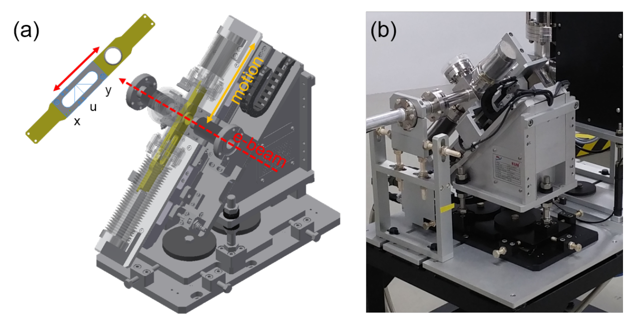

Figure 2: The wire scanner mounted on its motion stage. (a) The 3D modeling of the wire card and motion stage, (b) Installation of the wire scanner.

Beam Loss Monitor (BLM)

The Beam loss detectors are based on the idea of using optical fibers as a Cherenkov light radiator. The optical fiber used as the radiator is a plastic scintillating fiber of BCF-20 with 250 μm diameter which has 492 nm peak emission wavelength and 2.7 ns decay time [2]. The fiber is shielded from external light and connected directly to the PMT. It was installed by direct winding to the chamber as shown in Fig. 3(a) to measure the generated signal. The photomultiplier tubes (PMT) module uses the Hamamatsu H10722-110 as show in Fig. 3(b). It has 230 – 700 nm spectral response range with voltage output. As shown in the figure, a certain space is required for installation of optical fiber-based BLM. Because of the limited installation space of the undulator section, the wire scanner was measured using the BLM for Undulators [3].

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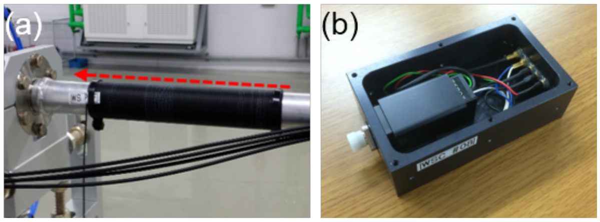

Figure 3: The beam loss detector with optical fiber. (a) fiber wrapped around the chamber, (b) PMT and housing.

CONTROL SYSTEM

As shown in the Fig. 4, the control system is required to control the power and gain of the PMT as well as the position of the motor, and is configured to acquire the beam loss and beam position value for the measurement. And also the beam loss signal and position value are acquired and controlled based on EPICS and beam synchronous acquisition (BSA) which is working on event timing system. The BLM and BPM IOCs are operated on a timing system based platform. The beam position value that is acquired during the measurement is used to correct the position jitter.

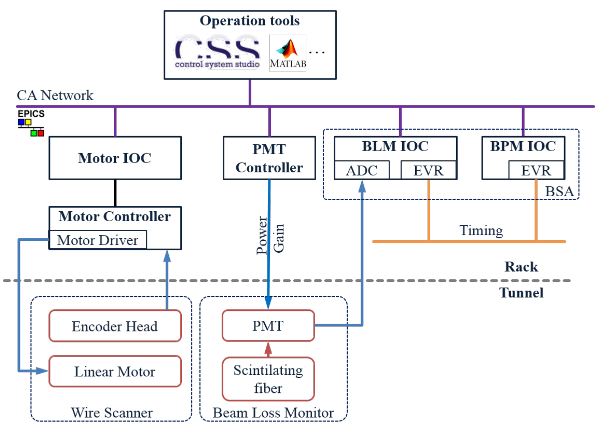

Figure 4: Control layout for wire scanner measurement.

The MATLAB program is used to measure the beam profile with a wire scanner as shown in the Fig. 5. This program is modified for PAL-XFEL, which was used in LCLS.

BEAM MEASUREMENTS

Results from Commissioning

In order to find the optimal BLM installation position which is based on optical fiber, the intensity of the signal according to the position was measured. It can be seen from the Fig. 6 that a relatively large signal is detected around 35 and 90 m irrespective of the position of the device. This position was found to be located behind a bipolar electromagnet which is used to change the trajectory of the electron beam.

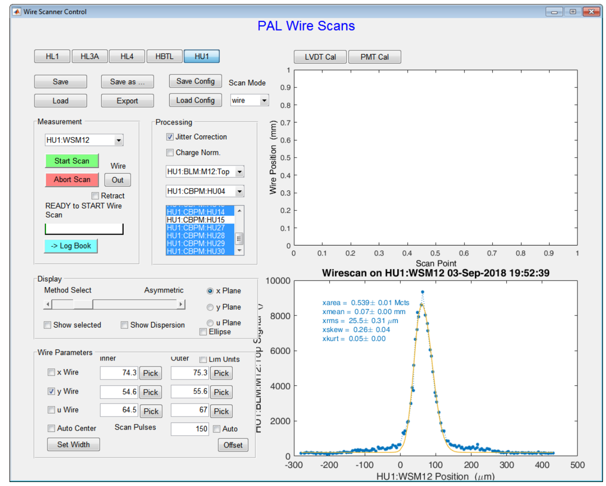

Figure 5: Wire scanner measurement GUI.

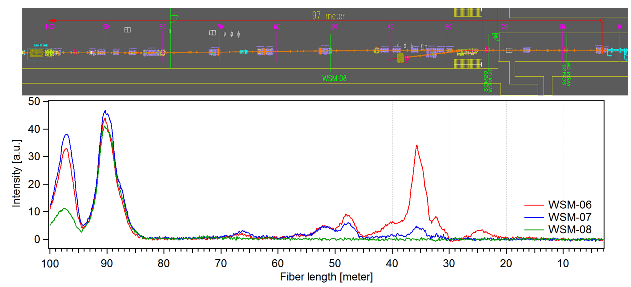

Figure 6: The beam loss intensity distribution along distance at the end of Linac.

Results from Machine Tuning

If the beam becomes unstable during the measurement process, it is subjected to a correction process using the electron beam position in the measurement. Figure 7 shows the results before and after correction with beam position. It shows that there is a 10 % error in beam size before correction.

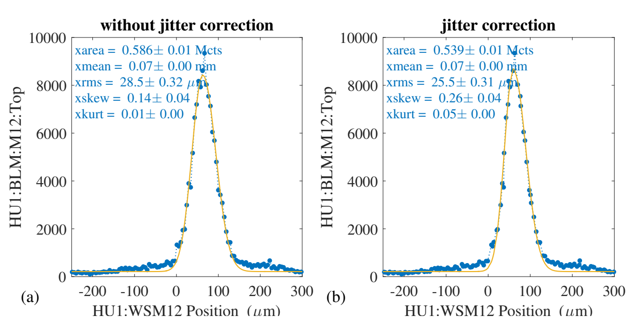

Figure 7: The results of the wire scanner measurement depend on the beam position jitter correction. Beam profile (a) without jitter correction, and (b) with jitter correction.

The wire scanner measurement is used to measure the emittance of the undulator section and to optimize the undulator section. Figure 8 shows the result of the beam size

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and emittance measurements with five wire scanners in the undulator section.

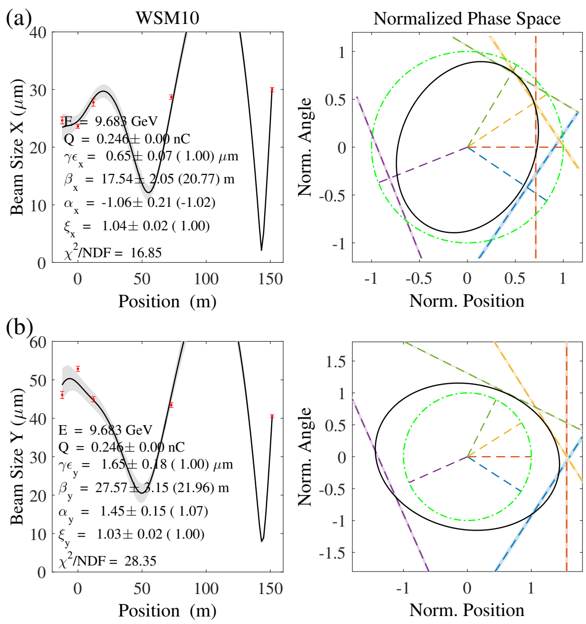

Figure 8: The emittance measurement using five wire-scanners. (a) X-plane, (b) Y-plane.

SUMMARY

The emittance measurements results with five wire scanners in the undulator section is used for matching of the e-beam to the design lattice by using quadrupoles. The wire scanner is very useful device for diagnosing and optimizing the equipment in the PAL-XFEL.

ACKNOWLEDGEMENTS

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