THPP36

PROTOTYPE DESIGN OF WIRE SCANNER FOR SHINE

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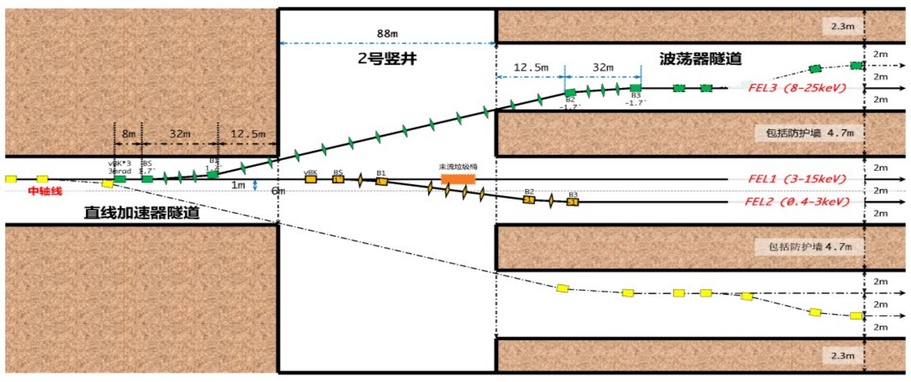
• Abstract

SHINE is a high repetition rate XFEL facility, based on an 8 GeV CW SCRF linac, under development in Shang-hai. In order to meet the requirements of measuring the beam profile of shine in real time and without obstruction, a new diagnostic instrument, wire scanner has been de-signed. This paper mainly describes the design of wire scanner in shine, and some simulation results are also shown and discussed.

• Introduction

• SHINE



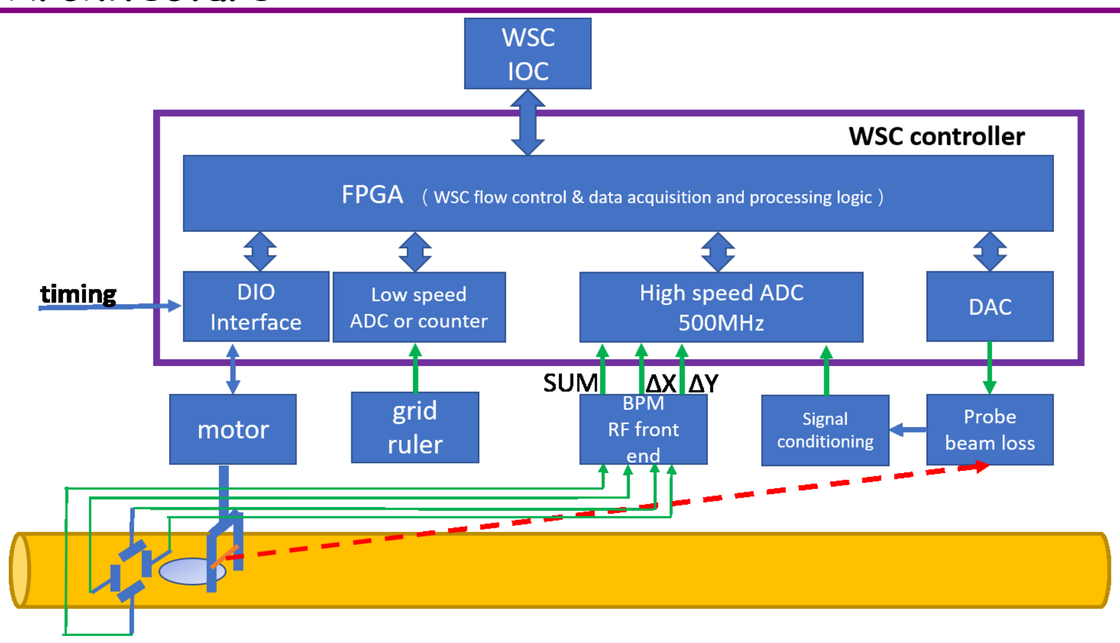
■ Main parameters:

- ✓Beam energy: 8 GeV
- ✓Bunch charge: 10~300 pC
- ✓ Pulse length(FWHM): ~3 fS
- ✓ Repetition rate: 1 MHz
- ✓Total facility length: ~3.2 Km
- ✓ FEL waveform: ~ 0.1 nm

SHINE has 3 undulator lines that consist of FEL-I, FEL-Il and FEL-Ill and 10 experimental stations in phase-I, it can provide the XFEL radiation in the photon energy range of 0.4 -25 keV.

Status: Compared to view screens, WSC offer a non-destructive monitoring of the beam transverse profile, and avoiding secondary particle damage to superconducting cavity. Prototype design scheme of WSC in SHINE has been completed. The specific equipment parameters, such as the material, diameter, scanning speed, scanning mode need to be determined according to simulation and performance.

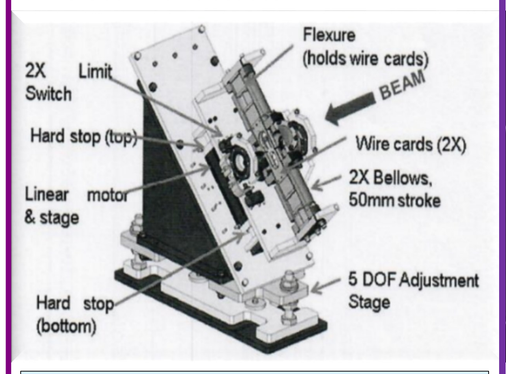
• Architecture



Wires in wire scanner detector driven by linac motor interacting with electron beam generates γ rays which are received by the PMT detector. Data acquisition electronics is to collect the PMT beam loss signal, wire position back-reading and BPM output. Data processing module is responsible for information extraction and Gaussian fitting, and remote monitor implements user interface and terminal control of WSC.

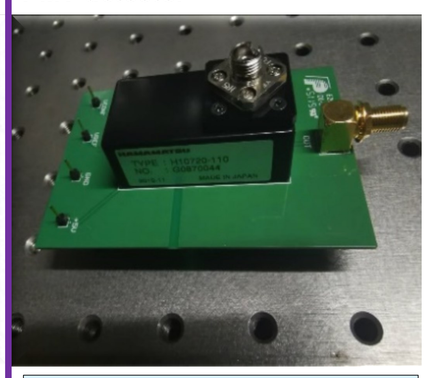
• Sections of WSC

Wire scanner detector



Wire scanner detector is driven by linear motor. The motion of the wire scanner detector has high reliability, and there is no movement stuck fault, and repetition accuracy of the motion is better than 20 μm. The wire scanner detector mainly includes a vacuum chamber with flange, flexure, linear motor and magnetic grid ruler, 45 degree mounting seat, and independent adjustable supporting base. We use 10 μm and 20 μm tungsten wires for test recently.

PMT detector

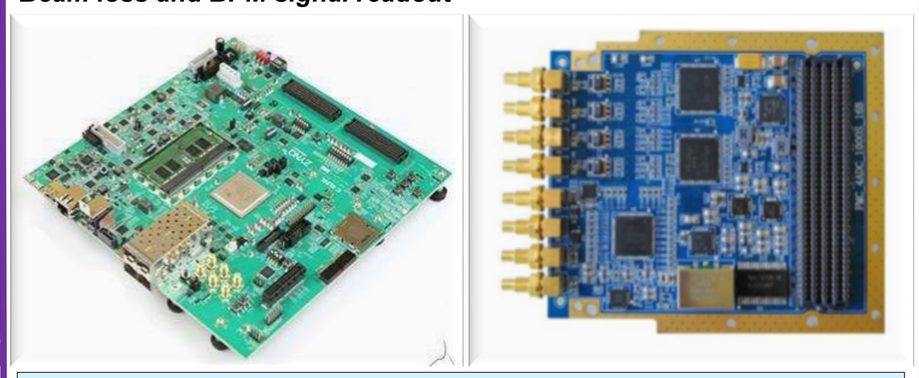


The duty of detecting gamma photons is accomplished by H10720-110. H10720-110 series are photosensor modules containing a metal package PMT and a high-voltage power supply circuit. The scintillator will be placed downstream of the wire target and outside the beam tube. The light generated by γ photon interaction with the scintillator is passed into the PMT through the optical fiber. The typical signal signal length is around 100ns.

Wire position measurement

Grating ruler as a third party measuring device may be helpful to work as position readout with low jitter in response delay. Grating ruler is installed outside of the vacuum chamber. Its slider is connected to the Wire Card, so that slider can move along with motor and grating keep fixed. Considering that grating ruler is easy to be damaged under radiation environment, lead shielding device will be installed to protect grating ruler.

Beam loss and BPM signal readout



FPGA will record a group of PMT beam loss signal sampling values and record the wire position values, record signal from BPM to calculate the central position bunch by bunch. QT7135 connected to ZCU102 evaluation board developed by xilinx through FMC HPC is used to sample PMT and BPM signals.

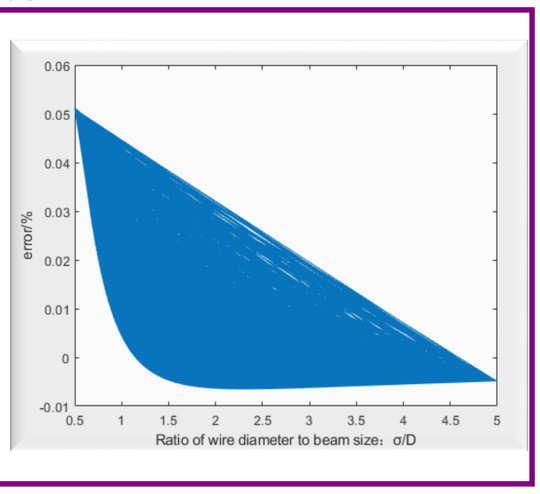
data processing modules and remote monitoring

Arm on zcu102 board will install Linus OS and be used as EPICS IOC. ARM retrieve the sampling value of beam loss signal from DDR, extract the beam loss value corresponding to each collision between wire and beam, and call the value of the wire position corresponding to the beam loss signal which will be modified by bunch by bunch central position extracted from BPM data. Then position data do Gaussian fitting with beam loss value and variance of this gaussian could be a measure of beam size. All the data in the embedded IOC are available as EPICS PVs and display on a Linux host which work as remote monitor.

• Preliminary simulation results

$$\left(1+\frac{e^{1.43\left(\frac{\sigma}{D}\right)^{-1.998}}}{100}\right)\bullet\sigma=\sigma_t \qquad (1)$$

Empirical formula Eq.(1) comes from simulation and is to modify the measured results of beam size base on remove wire diameter integral effect. But it cannot be proved before beam experiments. Then there is a simple test of it. Matlab simulate WSC measurement of beam size and result modify by Eq.(1). Right figure shows error between the modified result and default beam size at different wire diameters.



• Factors to consider

- ***Heating damage of tungsten wire under high repetition rate beam.***
- ***Vibration of tungsten wire in fast scanning mode,.***
- ***Selection of PMT probe position.***
- ***SNR of PMT beam loss signal.***
- ***Optimization of data processing algorithm.***
- ***…***

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