DESIGN OF THE BEAM PROFILE MONITORS FOR THZ SOURCE BASED FEL*

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Abstract

To meet requirements of high performance THz-FEL, a compact FEL facility was proposed. In order to characterize the beam, some beam profile monitors were designed. There are four Flags for beam profiles in LINAC，one pop-in monitor for high precision beam profile inside a small-gap undulator, and two screens to measure the beam energy spread and emittance of Linac. On one hand, we need to use software to control the position of these profile monitors, on the other hand, we need screens to display the results. This paper describes how to design and control these monitors, as well as the beam profile image acquisition system.

INTRODUCTION

The operation of short wavelength Free Electron Lasers(FELs) requires the usage of electron beams with extraordinary beam quality. HUST(Huazhong University of Science and Technology) and NSRL(National Synchrotron radiation Laboratory)/USTC(University of Science and Technology of China) are cooperating to set up the facility. The purpose is to meet strict requirements of high performance of electron beam for THz source based FEL and the facility get compact[1]. The facility is composed of a ITC-Gun, constant gradient travelling wave LINAC, microwave power system, vacuum system, control system, beam diagnostics system and so on. The beam diagnostics system consists of three beam current transformers, one stripline beam position monitor, and a set of beam profile monitors.
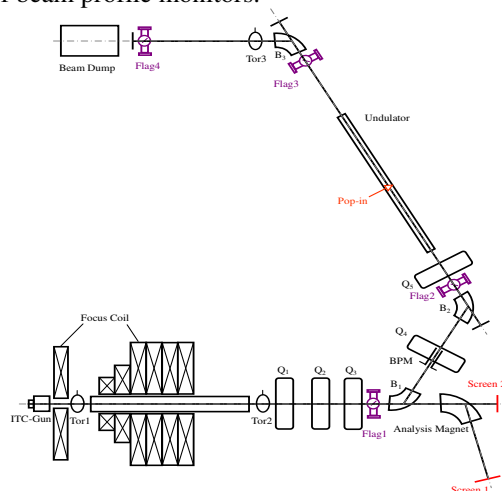

Figure 1: Layout of the beam profile monitors.

These beam profile monitor include four Flags, one pop-in monitor and two screens. The layout of these equipments are shown as Fig. 1.

As these beam diagnostic devices will stop the beam through if the devices always stay in the beam line, we need to control these devices keep away from the beam line when we don't want to get the beam parameter. We select a new style motor to control the beam profile monitor.

FLAG

There are four Flags in Linac for beam profiles[2]. As the Flags exist, we can know whether there is beam in the orbit or not. The structure of the Flag is shown as Fig. 2. The Flags have two selectable YAG/optical transition radiation(OTR) screens[3-4]. The YAG screen and OTR screen are shown in Fig. 3. After collision with the beam, both screens emits lights, but their nature differs, YAG screen emits light by scintillation, the OTR screen emits light by Transition Radiation. In both cases, a lens system brings the light to the CCD screen, where the image is collected.
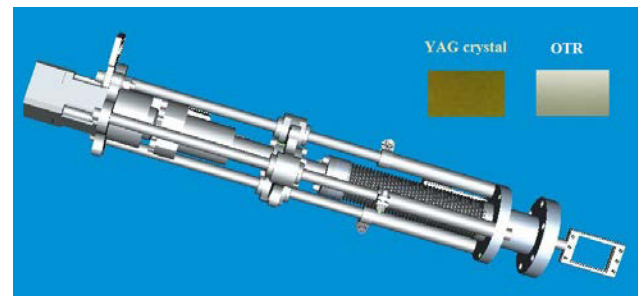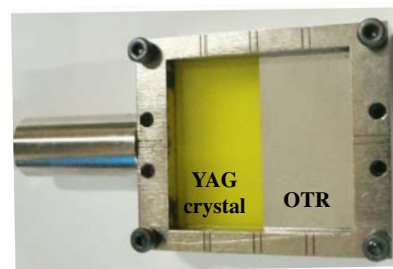

Figure 2:   Structure of flag.

Figure 3: YAG/OTR screen.

We adopted the solution of YAG and OTR screens in the same setup to obtain a proper beam image for the cases of low and high beam charges. The YAG screens

usage is appropriate for low beam charges because these screens produce a lot of light, the usage of OTR screens is convenient when its drawback is the saturation at high charges. The OTR screen can be also used to the micro-pulse width by the streak camera [5].

POP-IN MONITOR

There is a pop-in monitor inside a small-gap undulator, The pop-in monitor can get high precision beam profile[6-7]. Its size and schematic diagram are shown as Fig. 4. It has three kinds of working condition.The first working condition is the beam hitting the YAG target, then a lens system brings the light to a CCD, and we can measure the beam's information by analysis of the light collected by the CCD, the second working condition is the beam through the hole in the reflector in order to insure the facility installed correctly, the third working condition is the facility run away from the beam, the facility works in this situation when we don't want to measure the beam's information.
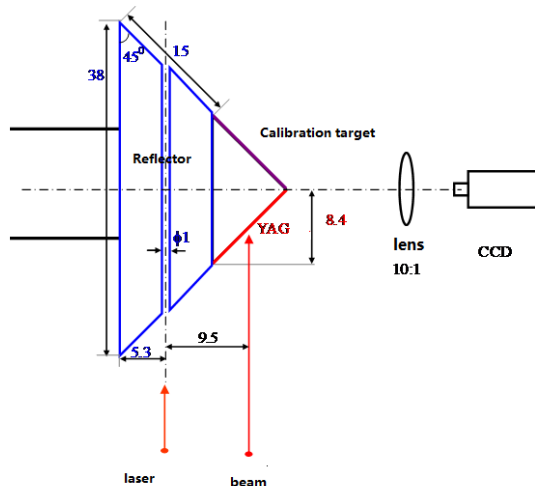

Figure 4: Pop-in monitor.

IMAGE ACQUISITION SYSTEM

The beam profile image acquisition system consists of seven GE680 prosilica cameras[8], a industrial PC with LabVIEW and gigabit Ethernet. The block diagram of hardware configuration is shown as Fig. 5.

The software environment is developed based on LabVIEW running on a industrial PC, includes a GigE Vision digital camera driver, Ethernet communication, image processing and analysis, and beam status displays, and the different profiles switch. One of the beam profile display interface panels in LabVIEW is shown as Fig. 6.

Once the electronic gun emitting a bunch, the camera will receive a trigger signal with a suitable delay time and gather a picture immediately. Then the camera sent this picture to LabVIEW. The image acquisition program on LabVIEW will process this picture and acquire the beam sizes information.
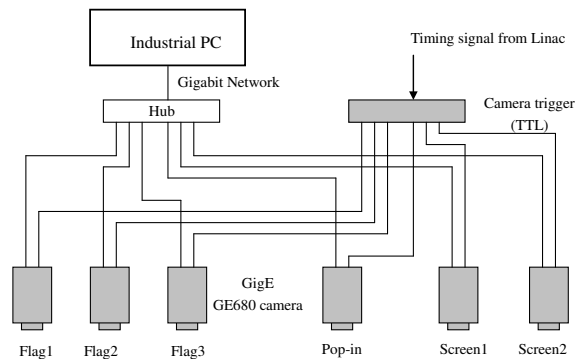

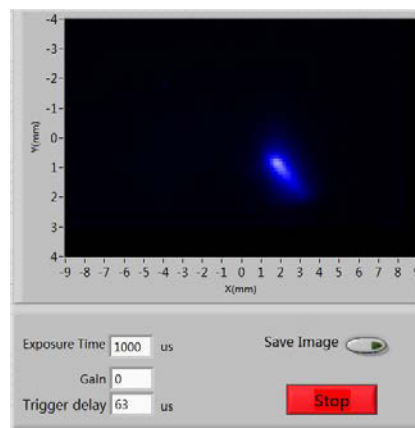Figure 5: The block diagram of hardware configuration.

Figure 6: Beam profile display interface panel in LabVIEW.

PROGRAM TO CONTROL STEPPER MOTOR

High stiffness due to the nature of the stepper motor combined with the highly responsive serve control, the motor can easily pull out the screen quickly off the beam line without the help of deceleration mechanism. In this case, a program is needed to help us to control these devices.

The stepper motor type is 56BYG250D produced by China. Figure 7 shows the overview of the integrated step servo motor.

Figure 7: The overview of the stepper motor.

Flow diagram of the motor control program is shown as Fig. 8.
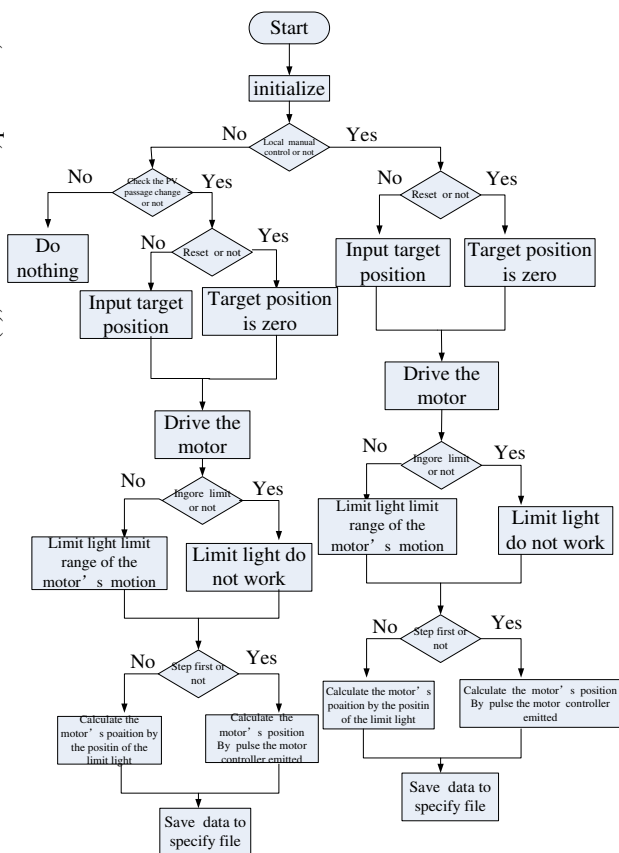
Figure 8: Flow diagram of the motor control program.

The front panel of the motor control program is shown as Fig. 9 and Fig. 10. It has two layout options.

When run the program, we can select whether local manual control or remote control. After select the motor which we want to control and input the target position, the motor will run to the destination, at the same time, the status of the motor and the limit light will be displayed in the right part of the front panel. If emergency happen, we can click the "urgent stop" button to make the motor stop immediately. The "save" button means we can save the information to a specified file.
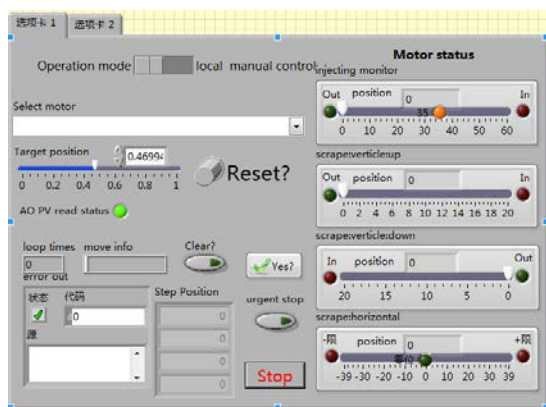

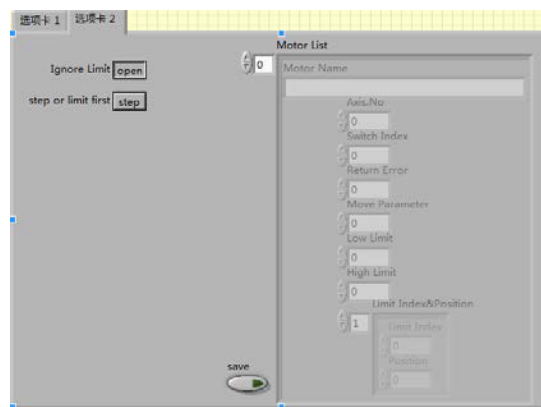Figure 9: The first layout option.

Figure 10: The second layout option.

CONCLUSION

In this paper, we designed the beam profile monitors for THz source based FEL. We also designed the beam profile image acquisition system and the control program of the stepper motor. These beam profile monitors will be on-line tested.

ACKNOWLEDGEMENT

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