# THE MEASUREMENT AND CONTROLLING SYSTEM OF BEAM CURRENT FOR WEAK CURRENT ACCELERATOR

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*Abstract*

For some detectors' calibration, a very weak electron current provided by accelerator is necessary. In order to control the beam current to the detector, 8 movable slits in which the position resolution of the stoppers is better than 5µm are installed along the accelerator. For the weak current measurement, 9 movable current monitors based on scintillator are installed along the beam line. These monitors can measure the very weak current, even to several electrons. The monitors can be pulled away the beam axis when the electron beam goes to the downstream.

## INTRODUCTION

In order to calibration some detectors, a small linac is designed and installed in the campus of IHEP. This accelerator consists of a weak current electron gun, a RF chopper, a 1.0m-long accelerator tube and a 3.0m-long accelerator tune, 8 movable slits, 9 current monitors, and other systems. It can provide 0.1~5MeV beam and 5~50MeV beam. These two kinds of beams are sent to the same target chamber by the bending magnets. The schematic diagram of weak current is shown in Fig. 1.

For the charge of pulse is above 1nC, ordinary monitor is enough. In pC region, a charge sensitive and low noise detector has been development. In fC region, thermo luminescence dosimeters (TLD) and two dimensional radiation dosimeters would be candidates [1]. For aC region, that means there are only several electrons in the pulse, plastic scintillator is used to detector the electron, the detailed description is in this paper.

## THE SELECT OF MATERIAL AND THICKNESS OF STOPPER

In order to step by step decrease the beam intensity, 8 movable slits are installed along the accelerator. Slit 1 is horizontal and Slit 2 is vertical, they can decrease the beam intensity to 1/20 with the help of solenoid because of the space change. Slit 3 and Slit 4 have the same effect. Slit 5 also decrease the beam intensity with the RF chopper because of time change. Other horizontal slits cooperate with the bending magnet to decrease the beam intensity. In order to effectively block the electrons, the material of stopper is carefully selected and the thickness is needed to calculate. Lead target, aluminium target and tungsten target are calculated by FLUKA program. Tungsten target is effect to block the electron and avoiding other effects. The result is showed in Fig. 2. For the 50MeV electrons，90 percent energy are deposited in tungsten target, the thickness is not more than 2.25cm, so all the stoppers, 2.25cm thickness tungsten is used. Other target needs thicker material, it is not easy to design and manufacture.

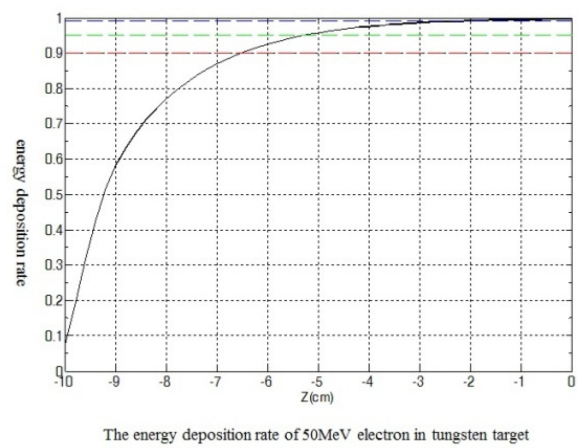


Figure 2: The energy deposition of 50MeV electron in tungsten target.

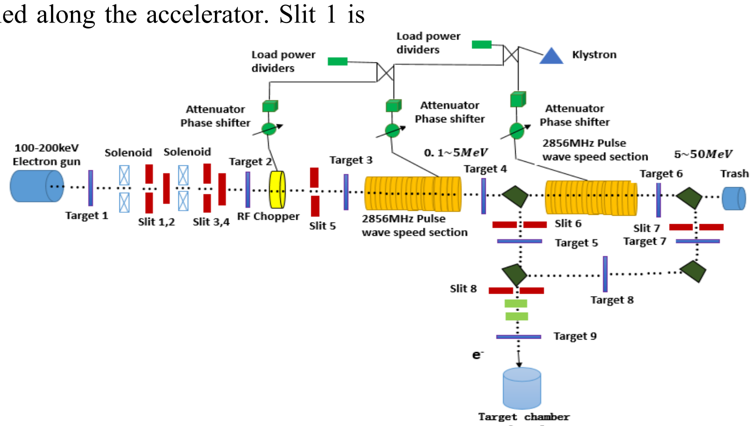


Figure 1: The Schematic diagram of weak current accelerator.



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## CURRENT MEASUREMENT SYSTEM BASED ON PLASTIC SCINTILLATOR

The current of electron gun is μA level. The beam current is lower in other place of accelerator, so convention methods cannot be used to measure the beam current. In pC region, a beam monitor using a charge sensitive amplifier and a two dimensional monitor using a scintillator and a CCD camera are developed at Osaka Prefecture University [1].

In this paper, plastic scintillator is used to measure ultra-low beam intensity. Plastic scintillator has such advantages as quickly response, high energy resolution, and high photon yield. Plastic scintillator coupled with PMT by light guide. The electron goes through the scintillator and produces light, small PMT whose peak response is 400~430nm is used to match the wavelength of the light produced by scintillator. Pulse produced by PMT to be sent to the pre-amplifier and the amplifier, and then is digitized by ADC. Because light intensity is linear with beam intensity, so using the calibration coefficient, beam current can be derivate. The schematic diagram of weak current measurement is shown in Fig. 3.

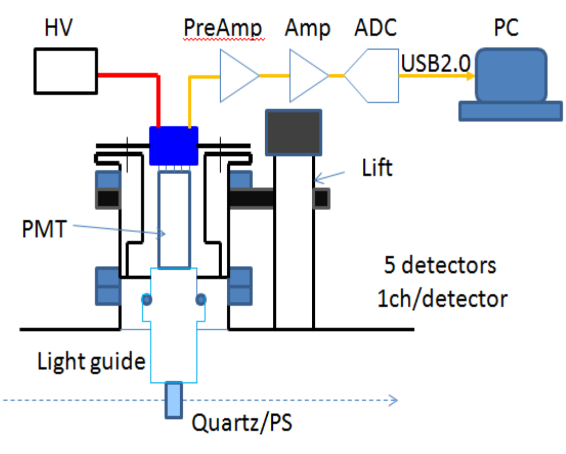


Figure 3: The schematic diagram of weak current measurement.

## SLIT AND CURENT MONITOR MOVING SYSTEM

Every slit has two stoppers, every stopper need to be moved by motor, in order to precisely control the beam intensity, the moving step of stopper is 5μm. The repeat location accuracy of scintillator will be 20μm. Motion Controller NI PXI-7334 is used to control the motor. Signal Acquiring card NI PXI-6602 to read the data of grating-rule to insure the accuracy position. 1μm position resolution Sino grating ruler KA-500 is to be used. Fig. 4 and Fig. 5 are shown testing of slits and movable monitors in the lab.

Figure 4: The slits were tested in the Lab.

Figure 5: The current monitors were tested in the Lab.

## CALIBRATION RESULT

Before the scintillators are used to measure the beam intensity, calibration needs to be done by radioactive source. Here β source $^{207}$Bi is used to calibration the monitor. Fig. 6 shows the output waveform from the electronics, the pulse produce by PMT is negative.

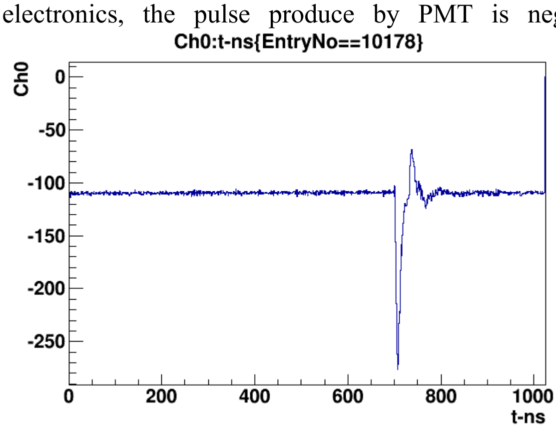


Figure 6: The pulse output from electronics.

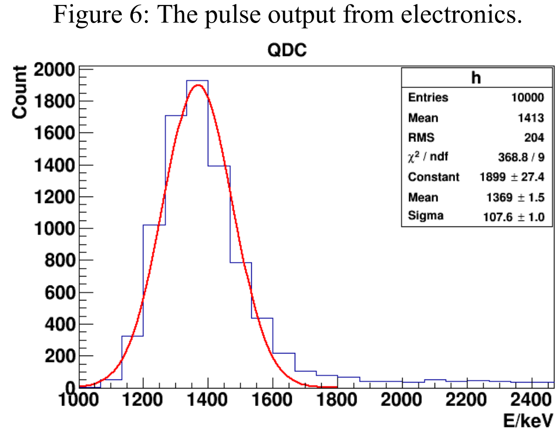


Figure 7: Calibration result of plastic scintillator by $^{207}$Bi.



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The statistical result is shown in Fig. 7, 1369keV in the Figure 7 correspond to the 976keV (we know the energy of beta beam of $^{207}Bi$ is 976keV), so there is a coefficient of 976/1369.

## PRELIMINARY MEASURE RESULTS

The pulse waveforms produced by monitor 1- 4 are shown in the Fig. 8. The clear beam current signal can be acquired by the oscilloscope. In the first phase, the task is let the beam goes through the entire accelerator and arrive to the target chamber to check the design and other instruments. In the next phase, decreasing the beam intensity along the accelerator and need to know how many electrons pass through the monitor are important.

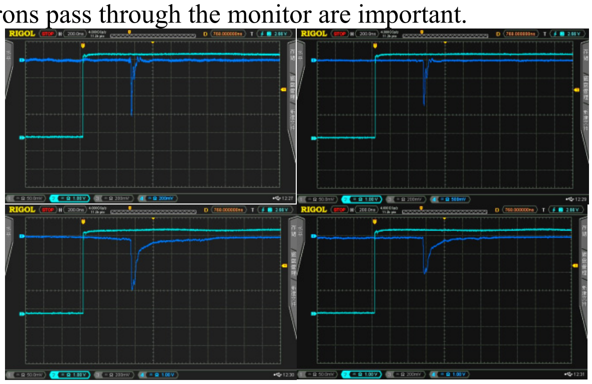

Figure 8: Pulse waveform produced by Monitor 1-4.

## CONCLUSION

In this paper, the beam current measurement and controlling system and some preliminary results have been shown. 8 movable slits are used to control the current, 9 monitor based on plastic scintillator are used to measure ultra-lower beam intensity. The preliminary result shows the current monitor can response to ultra-low intensity beam pulse, but some further study is need to be done.

## REFERENCE

[1] S.Okuda, Y.Tanaka, R.Taniguchi, T.Kojima, “Low Intensity Electron Beam Monitoring and Beam Application at OPU”, in *Proceedings of Linac 2006*, Knoxville, Tenessee, USA, August 2006, paper TUP018, pp.286-288.



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