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THE BEAM INSTRUMENTS FOR HIMM@IMP

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Abstract

The beam diagnositics(BD) devices for HIMM（Heavy Ion Medical Machine） are designed and produced by IMP BD department .An overview of the integrated devices is presented, and the common beam parameters in the different parts of the accelerator facility are reviewed including intensity measurement, beam profile, emmitance, energy, beam loss and so on with the related detectors such as the View Screen, Faraday Cup, Radial Detector, Multi-wires, Phase Probe, Wire Scanner, DCCT, ICT, BPM, Schottky, Slit, Beam Stopper, Beam Halo Monitor, Multi-channel Ionization Chamber. Additionally, the RF-KO for beam extraction, the strip foil with automatic control system as well as the detectors for terminal therapy are described.

INTRODUCTION

HIMM is a synchrotron based accelerator for cancer therapy in Wuwei city, China. It is composed of 2 ion sources, LEBT, cyclotron, MEBT, a synchrotron, HEBT and therapy terminals. The commissioning of HIMM is completed. The layout of the machine is shown in Fig. 1. At present, electrical safety, electromagnetic compatibility and performance testing of medical devices have been passed, and now enters the clinical tests phase.

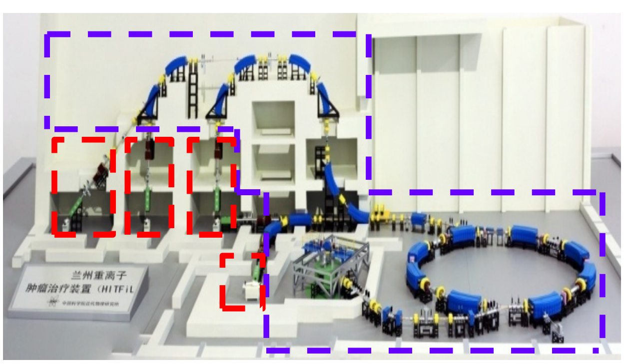

Figure 1: Layout of HIMM.

RADIAL PROBE

HIMM selects a cyclotron as its primary accelerator. Two radial probes have been installed to measure the beam intensity in the central area of the cyclotron. The target includes integrating and differential figures shown in Fig.2 and the beam turn measurement is displayed in Fig.3. What's more, in order to obtain the intensity distribution of different radius, it is necessary to synchronize motion control and data acquisition.

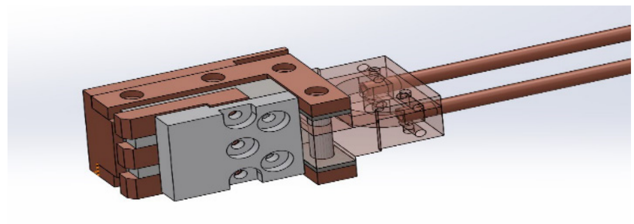

Figure 2: Target of radial probe.

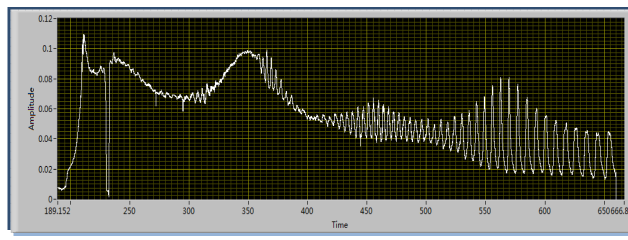

Figure 3: Intensity distribution of different radius.

VIEW SCREENS

View Screen (VS) is a commonly used profile detector, especially in the early stage of the commissioning. 13 VS are installed in the MEBT, Synchrotron and MEBT. In order to measure the beam profile at different tracks, the servo motor is used, and the repeatability of positioning accuracy is better than 0.1mm comparing its mechanical installation precision which is less than 0.5mm. The signals from CCD are read in two ways, one is the release video transmitted on the internet after video compression, and the other is to use video capture card. After digitalization, the FWHM and the centre position of the beam are obtained through software analysis. The captured photos and its analysed profile information is displayed in Fig. 4.

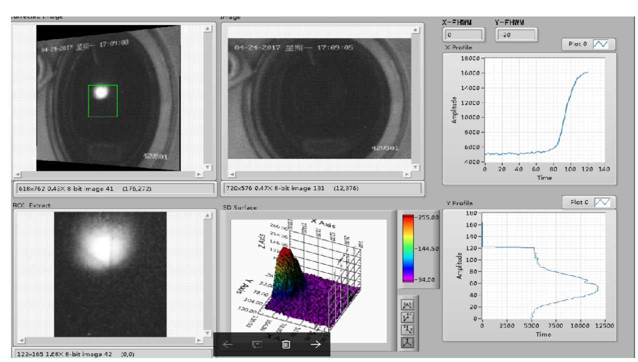

Figure 4: Beam profile and digital results.

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FARADAY CUP

Faraday Cup (FC) is a commonly used intensity detector. It is installed in the LEBT, MEBT and Synchrotron. We carried out the heating analysis, and optimized the cooling water and ceramic insulation structure. Pico ammeter is used for signal acquisition, data can be read directly through RS-232, or acquired with the data acquisition card, in which the sampling rate is much faster in order to monitor some rapid changes in the beam structure. The beam current measurement with FC by fast data acquisition system is shown in Fig. 5.

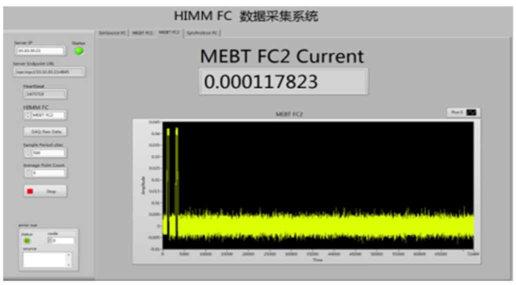

Figure 5: Beam intensity within 0.1ms.

SEM-GRID

SEM-GRID is installed in MEBT to measure the beam profile. Electronics adopts integral gate control circuit and cyclic structure to realize weak current signal processing. The singal sampling period is adjustable from 200 µs to 100ms, and its dead time is less than 50 µs. The beam profile and its fitting profile at horizontal and vertical direction tested at MEBT are shown in Fig. 6.

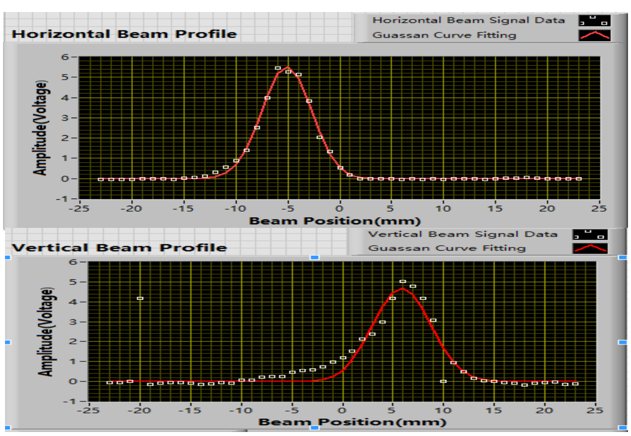

Figure 6: Beam profile measurement with SEM-GRID at MEBT.

EMITTANCE

Emittance is an important parameter for characterizing beam quality. Slit-grid method,quadrupole variation method and three grid method are often used in beam lines [1, 2]. We use these three methods to measure the emittance of the cyclotron beams in MEBT illustrated in Figs. 7-9. In each of these three figures the right part of the figure shows the horizontal beam emmitance while the left part of which shows the vertical beam emmitance. Furthermore, the three sets of beam emmitance results are consistent.

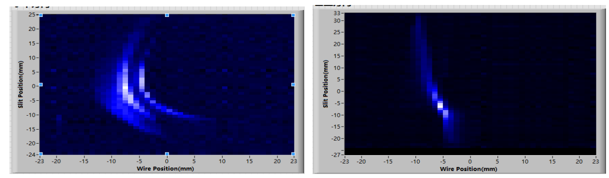

Figure 7: Slit-grid method,x:34.0mm.mrad,y:23.6 mm.mrad.

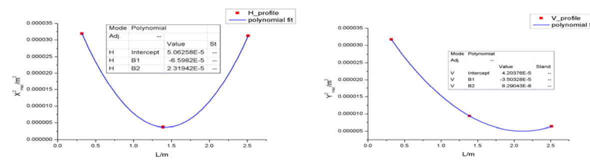

Figure8: Three-grid method,x:37 mm.mrad.1y:25.8 mm.mrad.

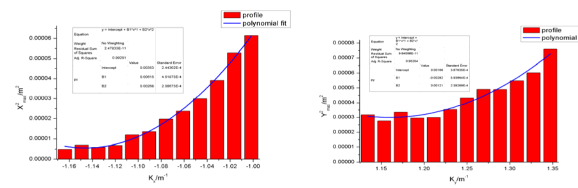

Figure 9: Quadrupole variation method, x: 33.5 mm.mrad, y: 21.2 mm.mrad.

ICT

ICT is installed in MEBT as an on-line intensity monitor. The probe is bought from BERGOZ Instrumentation,and an lock-in amplifier is used with the RF signal from the cyclotron. The resolution is 10nA for continuous beam, and the shortest beam width can be measured is about 100µs.Fig.10 shows the detector and the beam current measuremnt at MEBT with ICT.

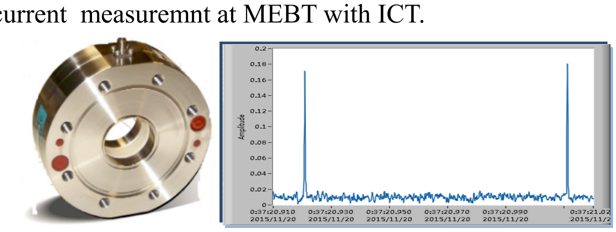

Figure 10: ICT probe and measuring result.

PICK-UP

We use pick-up as on-line energy monitor in MEBT. The distance between the two detectors is accurately measured,and the electronics length of cables also needs precise measurement [1, 2]. According to Fig. 11 and the calculation, the beam energy extracted from the Cynlotron is 6.323 Mev/u.

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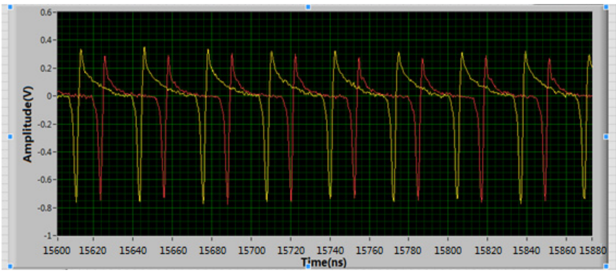

Figure 11:Energy measurement with pick-ups.

STRIP FOIL

A carbon foil is used to change the charge state of the injected ions.The function of this device is to move the foil to the beam orbit, and the automatic foil exchange is necesary. We designed a four axis drive structure to achieve this goal. At present, it realizes automatic changing in vacuum and the mechanical design is shown in Fig.12.

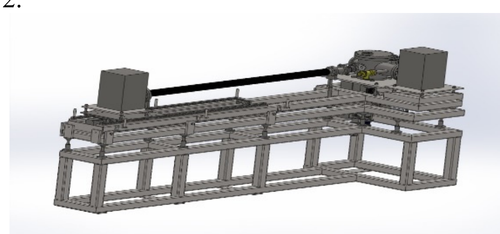

Figure 12: Mechanical of Strip foil.

DCCT

A DCCT is installed in the synchrotron to measure the beam intensity. The resolution is 0.5 μA/Sqrt(Hz) which is also purchased from the Bergoz Instrumentation. The detector and the beam current measured at Synchrotron is shown in Fig. 13

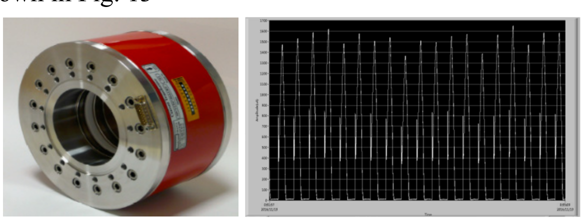

Figure 13:DCCT probe and measuring result.

BPM

8 shoe-box type beam position monitors(BPM) is installed in the synchrotron which are used for orbit measurement, and the resolution is 0.2mm. Before the installation, calibration was carried out in the laboratory[3] shown in Fig. 14.

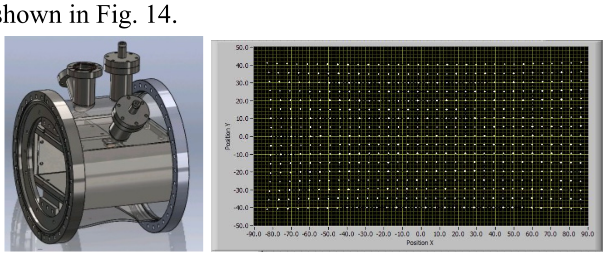

Figure 14: BPM probe and mapping result.

RF-KO

HIMM adopts 1/3 resonance slow extraction, RF-KO provides a transverse extraction electric field.Amplitude and frrequency modulation are used for the extraction signals. At the same time, a feedback system based on excitation and fast quadrupole is adopted. Through the above methods, the uniformity of beam extraction is greatly improved compared in Fig.15.

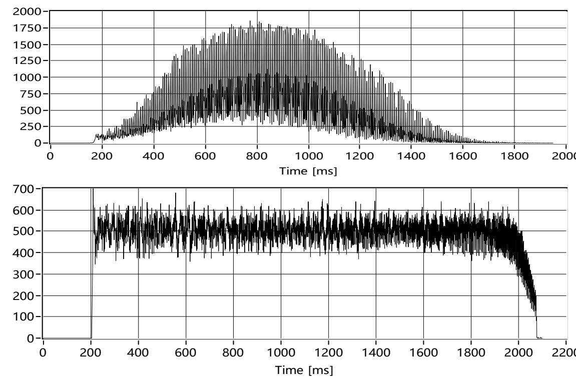

Figure 15: Beam structure improvement with RF-KO.

MULTI-CHANNEL IONIZATION CHAMBER

For slow extracted beam fom a synchrotron,the current is too low to be measured by a SEM-grid. As a result the Multi-channel Ionization Chamber(MIC) is designed to measure the profile in HEBT. The effective area of which is 100 mm*80 mm, and the singal sampling period is adjustable f 1ms to 100 ms. The beam profile measured at HEBT is dispalyed in Fig. 16 where the horizontal and vertical profile are dispayed at the left and right part respectively.

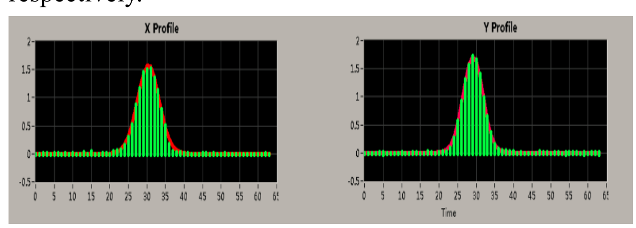

Figure 16: Profile measured by MIC.

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