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# Emittance Measurement by Using Electric Sweep Scanner

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## 1. Introduction

A microwave ion source was developed for the Proton Engineering Frontier Project (PEFP) proton accelerator. It consists of 2.45GHz microwave system including magnetron, microwave window, plasma chamber, solenoid magnet and triode extraction electrodes [1]. The energy of the ion source is 50-keV and its beam current is 20mA. The microwave ion source was installed as shown in Fig. 1 and operates for the 20MeV proton accelerator. A low energy beam transport (LEBT) system was installed between ion source and radio frequency quadrupole (RFQ) to match the beam from the ion source to the RFQ. It is important to measure the beam properties such as beam emittance to adjust the matching parameter of the LEBT. An electric sweep scanner was used to measure the beam distribution in phase space. From the measurement, beam properties such as beam emittance, beam profile and proton fraction could be calculated.

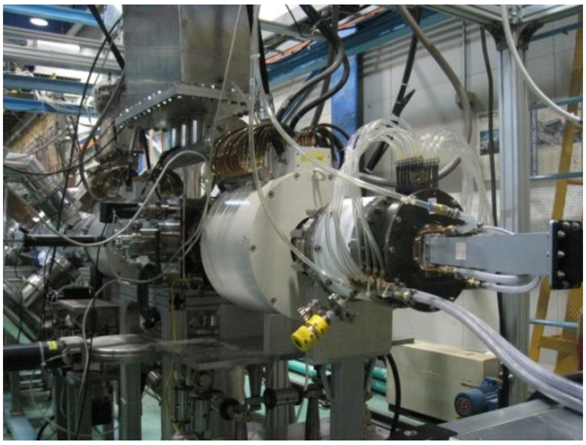

Fig. 1: Microwave ion source installed at PEFP 20-MeV proton accelerator.

## 2. Electric Sweep Scanner

An electric sweep scanner was designed and fabricated to measure the beam density in phase space [2]. The design parameters of the scanner are summarized in Table 1. It was designed to accommodate the beam size at 130A of the solenoid magnet current. The fabricated emittance scanner was installed at the vacuum box which is located at the center of the two LEBT solenoids. The 3ea. vacuum feedthrus were installed for the measurement: One was for the plate voltage, another was for the bias voltage, the third was for the collector signal. A BOP (Bipolar Operational Amplifier) and current amplifier were used as a plate voltage sweep source and an output signal conditioner respectively. The data acquisition system was implemented with LabView.

Table 1: Design Parameters

| | |
|---|---|
| Chamber length | 65mm |
| Electrode length | 57mm |
| Plate margin | 4mm |
| Slit width | 0.1mm |
| Beam voltage | 50keV |
| Gap distance | 2.5mm |
| Maximum voltage | 600V |
| Maximum analyzable angle | 68.5mrad |
| Mechanical angular resolution | 1.5mrad |
| Maximum beam radius | 60mm |

## 3. Measurement

The beam distribution was measured in x-x' phase space. During the measurement, the operating conditions of the ion source were such that the microwave power was 500W, solenoid current was 80.5A, which was slightly higher than the ECR conditions at the window position. The vacuum pressure at the vacuum box of the LEBT was $1.7\times10^{-5}$ Torr. The solenoid magnet current of the LEBT was adjusted at 130A, which produced nearly parallel beam at the scanner position. The step between measurements in x direction was 2mm and in angle was 2.3mrad. The beam current during measurement was 13mA and maintained within 1% variation. The beam pulse length was 2ms and stabilized after 200us from the trigger signal. The beam data after 1.5ms were used for the calculation which is the trigger timing of the RF signal to the RFQ.

## 4. Results

The measured signal is shown in Fig. 2. The measured distribution looks discrete, which explains that the step in angle was not enough small for the main distribution stretched from left to right in near horizontal position. The main distribution was that of H+ and also H2+ distribution was shown clearly. The H+ distribution has rotated tails due to the aberration of the LEBT solenoid. From the measurement, an emittance was calculated. A SCUBEEx algorithm was used to get the emittance value [3], which included the background signal effects. The calculated normalized rms emittance was 0.35 π mm mrad. Proton fraction was deduced from the beam profile. The beam signals of each species (H+, H2+) were clearly separated at the edge position. At the center where signals of the two species were mixed, the H2+ signal was deduced on the assumption that it has nearly constant value, which seems to be reasonable from the Fig. 3. The calculated proton fraction was 77%.

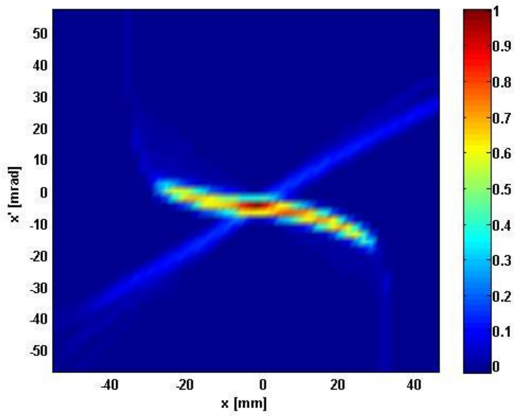


Fig. 2: Beam distribution in phase space

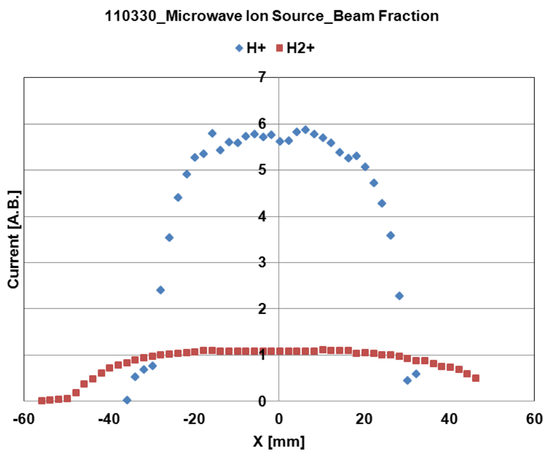


Fig. 3: Beam current signal profile of the two species (H+, H2+)

### 4. Conclusion and Future Works

The beam properties such as an emittance and proton fraction of the PEFP microwave ion source were measured by using an electric sweep scanner. The measured emittance was 0.35 π mm mrad which was higher than the design value. In fact, the beam properties are strongly dependent on the operation conditions of the ion source such as gas flow, microwave power and magnetic field intensity. Therefore, we are going to measure the beam emittance and proton fraction at various operating conditions of the ion source to find optimum values.

### Acknowledgement

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### REFERENCES

[1] Y. S. Cho, Proton Injector for the Proton Accelerator, Workshop on the Ion Source, Korea Nuclear Society Autumn Meeting, Jeju, Korea, 2010.

[2] P. W. Allision, J. D. Sherman, D. B. Holtkamp, An Emittance Scanner for Intense Low Energy Ion Beams, IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4. p.2204, 1983.

[3] M. P. Stockli, R. F. Walton, Self-consistent, Unbiased Root-Mean-Square Emittance Analysis, Review of Scientific Instruments, Vol. 75, No. 5, 2004.