Proton Fraction Measurement of the PEFP Proton Injector

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1. Introduction

A 20MeV proton accelerator was developed and is being tested at Proton Engineering Frontier Project (PEFP). To investigate the beam property from the proton injector, the proton fraction was measured at low energy beam transport (LEBT). In general, the proton fraction is measured with bending magnet. But, in this study, the proton fraction was calculated from the beam profile and phase space configuration. The beam profile along the x-axis was measured by using slit-collector and the x-plane emittance was measured by using Allison type emittance scanner. The H+ and H2+ could be separated in the phase space measurement in PEFP LEBT, because there is solenoid magnet to focus the beam in the LEBT as shown in Fig. 1. Therefore, the proton fraction can be calculated with the combination of the beam profile measurement results and emittance measurement results.

Fig. 1: Layout of the PEFP LEBT

2. Beam Profile Measurement

The proton beam profile was measured between two solenoids of the PEFP LEBT. The slit-collector system was used to measure the beam profile. The slit width was 0.1mm and -200V bias voltage was applied during measurement to suppress the effect of the secondary electrons. The slit-collector system is shown in Fig. 2 and scanned along the x-plane by the linear motion controlled by the LabView. The measured result is shown in Fig. 3. The operating condition during measurement was such that the arc current of the ion source was 10A, the solenoid current was 130A, and the steering magnet current was 0A. The measured profiles changed with time evolution because of the finite time required to neutralize the background gas at LEBT. The profile includes mainly two beam species which are H+ and H2+.

Fig. 2: Slit-collector system

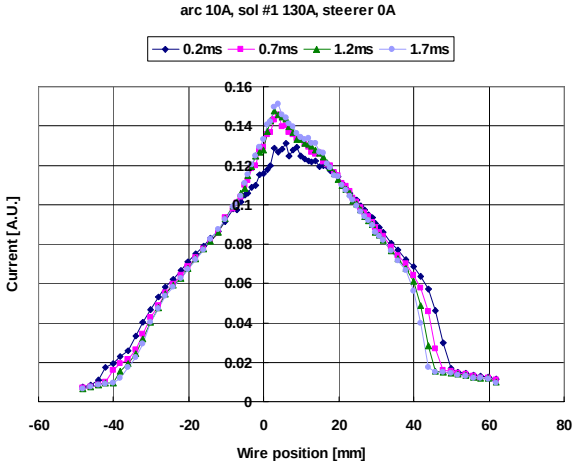

Fig. 3: Beam profile along the x-plane

3. Beam Emittance Measurement

The beam distribution in phase space was measured to get the beam emittance value at the proton injector. An Allison type emittance scanner was used [1]. The design parameters of the emittance are summarized in Table 1 [2-3].

Table 1: Design parameters of the emittance scanner

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

The measurement location was the same with that of the slit-collector system. The measurement result is shown in Fig. 4 with the same operating conditions of the beam profile measurement which are 10A arc current, 130A solenoid current and 0A steering magnet current. The separation of the H+ and H2+ beam in the phase space was very clear except at the core beam position.

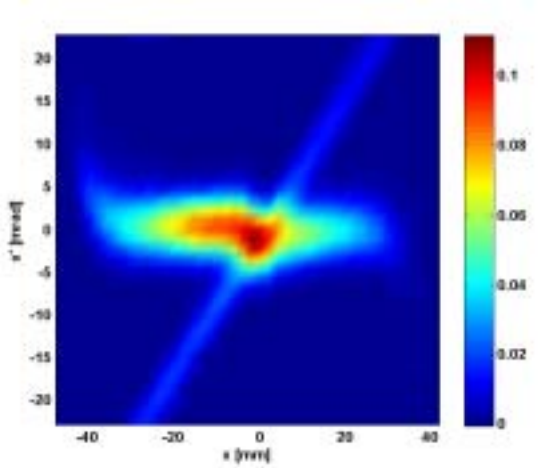

Fig. 4: Beam distribution in phase space (x-plane)

4. Proton Fraction

Two measurement results were compared to get the proton fraction as shown in Fig. 5. The problem is to separate the H2+ from the H+ in the core beam in which two species are mixed as shown in the colored region of the graph.

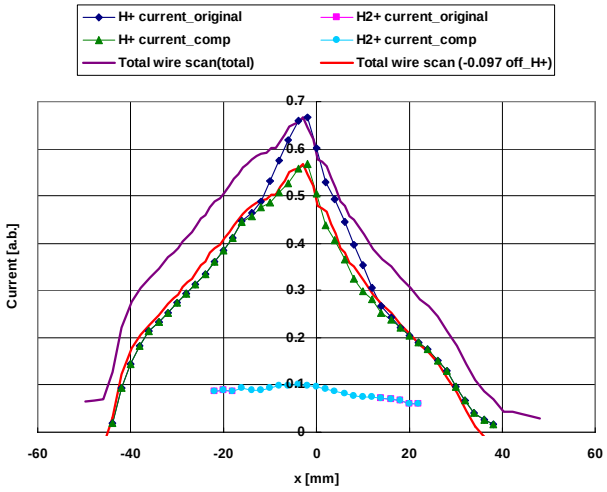

Fig. 5: Measured beam profile both from the slit-collector system and emittance scanner

The two results are plotted in the same graph with the scaling factor to each other to facilitate the comparison. The beam profile data from the emittance measurement was obtained that all currents were added at the same position. In the graph, the H+ current_original, H2+ current_original and total wire scan (total) are measurement data. From the Fig. 5, if 0.097 are subtracted from the total wire scan data, the result is nearly coincident with the H+ current_original data at the outside of the core beam. Moreover, if 0.097 is maintained only in the core beam region, the result is coincident with that of H+ measurement data with the assumption that all core beam is H+. Therefore, we can conclude that the H2+ beam distribution is nearly constant along the x-plane as shown in the H2+ current_comp data of the Fig. 5. The proton fraction can be obtained using this method, and the calculated proton fraction was 74.6%.

5. Conclusion

The beam profile and emittance were measured at the center of the two solenoid magnets in PEFP LEBT. The proton fraction was calculated from the two measurement results. The calculated proton fraction was 74.6%. In this case, the fraction of the H3+ was not included in the result because we cannot measure the H3+ current by using the Allison type emittance scanner.

Acknowledgement

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