HIGH INTENSITY PULSED BEAM ACCELERATION IN THE KEK 1.5MV TANDEM ACCELERATOR

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Abstract

A plasma sputter type of negative heavy ion source has been developed at KEK. High intensity pulsed beam acceleration in the 1.5MV tandem accelerator was tried with this ion source. In beam acceleration, the total ion current at the exit of the tandem accelerator was 1.3mA. Charge state distribution of the beam was also measured. When the total ion current was 500uA, the ion current for Cu^{+} was 124uA, 225uA for Cu^{2+} and the rest for Cu^{3+}.

Introduction

A 1.5MV tandem accelerator was installed at the pre-injector of the KEK 12GeV proton synchrotron in November 1989. It has been used for measuring the polarization of polarized negative hydrogen beam at Pre-injector. We have also tried carbon beam acceleration because we wanted to know this tandem accelerator capability. A plasma sputter heavy negative ion source [1] was used for high intensity carbon beam acceleration by the tandem accelerator.The ion source was placed at the front of the tandem accelerator and we tried copper beam acceleration. The total accelerated pulse beam intensity was achieved to 1.3mA at the maximum. Moreover, we set up an analyzer magnet at the exit of the tandem accelerator, which analyzed the charge states of the copper ion beam. Analyzed single charge copper Cu^{+} beam current was 124uA, Cu^{2+} beam current 225uA and Cu^{3+} the rest when the total copper beam current was 500uA.

Experimental apparatus

(a)Tandem accelerator

A 1.5MV tandem accelerator(NT1500S) used at KEK has a Schenkel type high voltage power supply. It is characterized at high current capacity over mA. Figure 1 shows a layout of the tandem accelerator and the ion source. Dimensions of the tandem accelerator are as follows; the full length is 4.5m and accelerator tube aperture 30mm, respectively. The length and the aperture of the Argon gas charge stripper is 700mm and 10mm, respectively. The vacuum pumps of 1500l/s TMP are placed at the upper side and the down side of the tandem accelerator. The argon gas pressure in the charge stripper cell is controlled by measuring the vacuum pressure at the down side TMP. The vacuum base pressure was less than 10^{-7}torr. Beam currents are measured by Faraday cups as shown in Fig. 1. The apertures of the Faraday cup at the entrance and the exit of the accelerator are 40mm and 34mm,respectively. An analyzer magnet is placed about 1m far away from the exit of the tandem accelerator. The beam duct inside of the analyzer magnet is a flexible tube so that beam bending angle can be selected freely. Equipments of the beam injection system is installed on the high voltage station. The Cu^{-} ion beam extracted from the ion source through a 10mm aperture extraction electrode. The Cu^{-} ion beam is focused by an einzel lens and steered two sets of electrodes as shown in Fig. 2. The einzel lens is a not decel. accel. type but accel. decel. type in order to avoid a beam blow-up by space charge. The distance between the ion source and the tandem accelerator are 1.5m.

(b)Ion source

A plasma sputter type of negative heavy ion source can generate high current negative ion beams. The shape of the ion source is cylindrical, the inner size is about 200mm and the length 300mm,respectively. There are two filaments. The filament is a helical type of LaB6 filament,which has a long life time. The Cu^{-} ions are generated by a Xenon sputtering at the source of the sputter target which is biased negatively. Xenon plasma is confined by a cusp magnetic field surrounding the ion source. The electrons extracted at same time with the Cu^{-} ion are completely removed by two dipole permanent magnet placed at the anode and the extraction electrode.

Experimental results

In Fig. 3, the beam configuration measured by a Faraday cup 1(FC-1) is shown. We have examined the influence of the beam extraction voltage of the ion source to the total beam current from the tandem accelerator. In Fig. 4, the measured dependence of the total accelerated ion beam current on the beam extraction voltage of the ion source is presented. In this measurement, the voltage of the tandem accelerator was 1.25MV, argon gas pressure 9.8×10^{-6}torr, respectively. Clearly seen from this figure, the exit beam intensity was increased by increasing extraction voltage. The ion source by optimizing the ion source the total copper ion beam current of 1.3mA was accelerated by the tandem accelerator(Fig. 5). The beam current was measured by a 50mm aperture Faraday cup placed at 1.5m far away from the exit of the tandem accelerator before installing the energy analyzing magnet.

Results of the charge state distribution measurement by the analyzing magnet are shown in Fig. 6. The total beam current was 370uA when gas pressure 1.5×10^{-6}torr and the beam current of about 500uA was obtained when gas pressure was 3.0×10^{-6}-1.0×10^{-5}torr. It shows that the ratio between Cu^{2+} and Cu^{+} depends on the stripper gas pressure of the tandem accelerator. Figure 7 is the beam configurations when the voltage of the tandem accelerator was 1.0MV and argon gas pressure was 5.6×10^{-6}torr. We are going to put slits before and after the analyzing magnet to increase the resolving power of the system.

Reference

1) G.D.Alton, Y.Mori, A.Takagi, A.Ueno and S.Fukumoto, Nucl. Instrum. Methods A270,194(1988), Y.Mori, G.D.Alton, A.Takagi, A.Ueno and S.Fukumoto, Nucl. Instrum.Methods A273,5(1988)

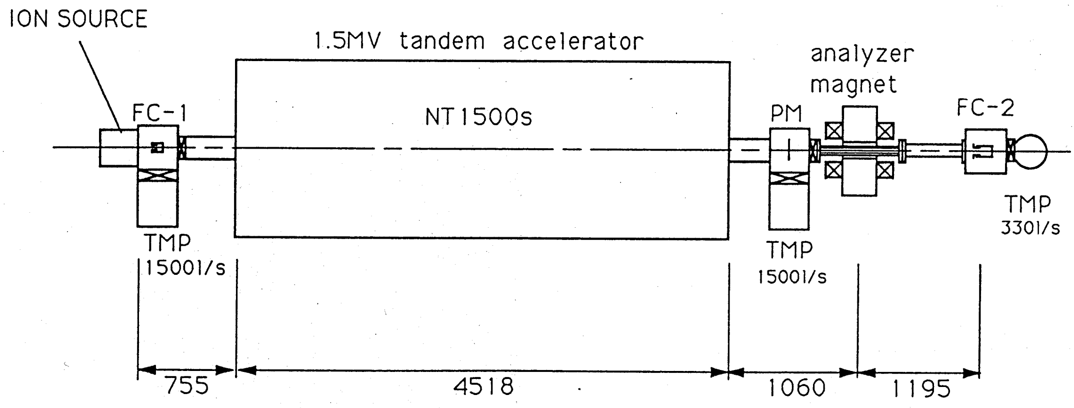


Fig.1 Layout of the tandem accelerator and the ion source

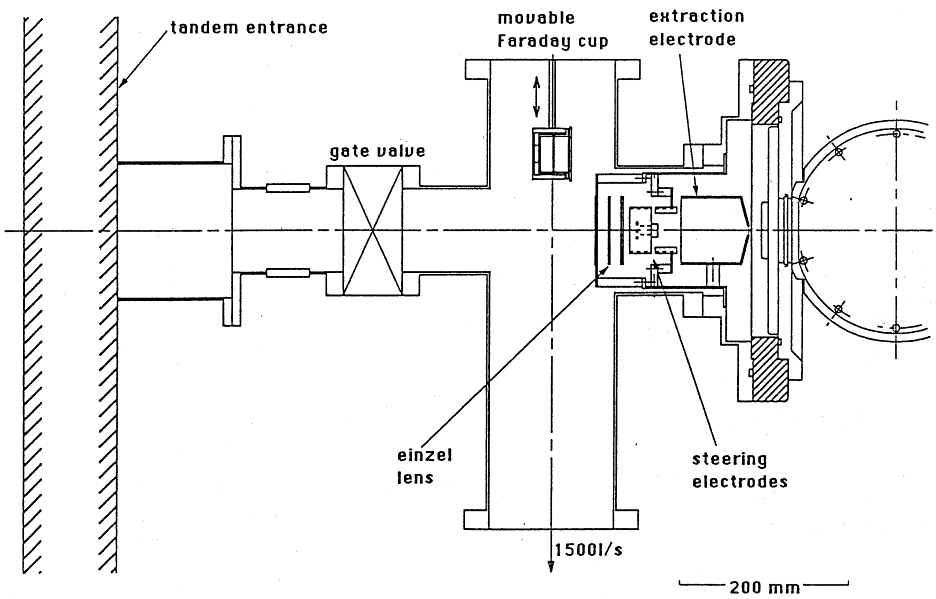


Fig.2 A section of the tandem accelerator injector

Cu^- beam
Tandem Accelerator
entrance

1.0mA/div.
50μs/div.
I=5.5mA

Fig.3 Beam configuration of the plasma sputter negative heavy ion source beam by the tandem accelerator entrance

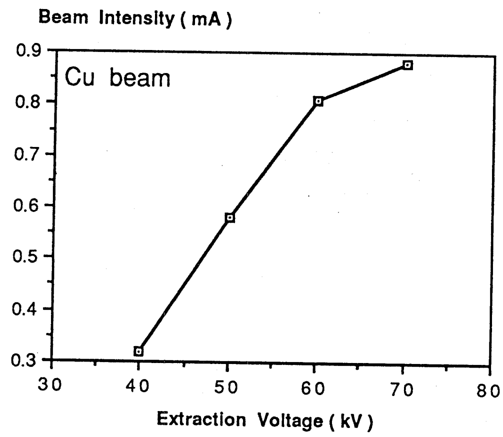
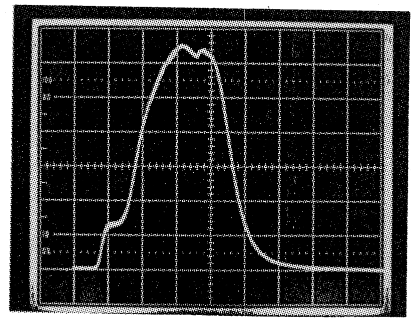


Fig.4 Influence of beam extraction voltage to total beam intensity from the tandem accelerator



C u beam(total)
Tandem Accelerator exit

0.2mA/div.
50μs/div.
I=1.3mA

Fig.5 Beam configuration of total beam current from the tandem accelerator

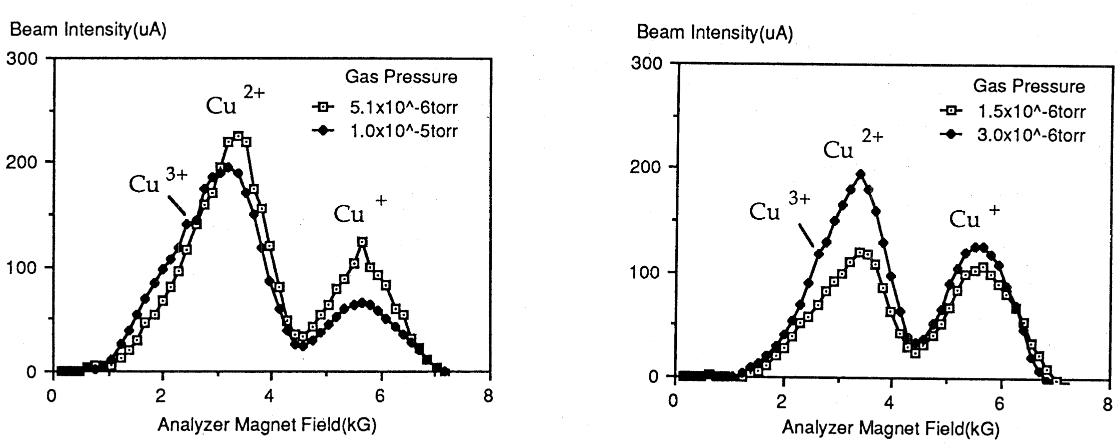
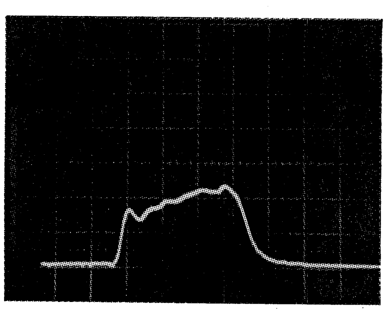
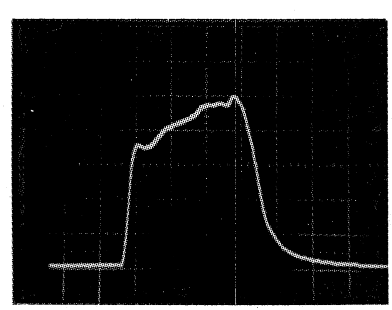


Fig.6 Analyzed ion beam by the analyzing magnet



C u^{+} beam
after Analyzer Magnet

50μA/div.
50μs/div.
I=110μA



C u^{2+}beam
after Analyzer Magnet

50μA/div/
50μs/div
I=240μA

Fig.7 Beam configuration of analyzed ion beam by the analyzing magnet