Improvements of the Beam Characteristics of the 7 MeV Proton Linear Accelerator

Akira Noda, Hideki Dewa, Hirokazu Fujita, Masaki Kando, Masanori Ikegami, Yoshihisa Iwashita, Shigeru Kakigi and Makoto Inoue

The beam intensity of the ion linear accelerator has been gradually increased although the space charge effect limits the transferable current at the Low Energy Beam Transport (LEBT). The beam emittance are measured at LEBT and at the section between RFQ and Drift Tube Linac (DTL) and after the DTL. It is found that no emittance blow up has occurred in the cavities of the linac up to the present intensity. Beam profiles are also measured at the same sections with use of fluorescent screens. As the beam intensity has been increased to the order of mA, preparation for the beam irradiation tests has been initiated.

Keywords: Ion Source/ Space Charge/ LEBT/ RFQ/ DTL/ Emittance/ Beam Profile

The main effort this year of our group has been made in order to increase the beam intensity of the ion linear accelerator. For this purpose, various beam diagnoses have been applied. Formerly the beam current in LEBT has been limited up to ~1 mA because of the strong repulsion due to space charge force because beam energy is rather low (50 keV). This situation was promoted by the former beam optics which focuses the beam to the small size at several points in LEBT in order to clear the small aperture of the existing Mixing Magnet, which bended the 50 keV proton with the deflection angle of 45°. So as to modify this situation, the Mixing Magnet was replaced by the one with wider gap of 60 mm and beam optics was also modified to such a one which has rather smoother and wider beam envelope. Vertical edge focusing is also used at the entrance of the Mixing Magnet so as to avoid too small horizontal beam size at the exit of the magnet due to radial focusing [1, 2].

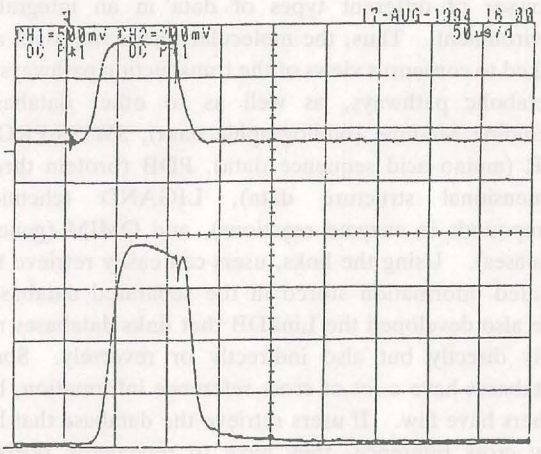


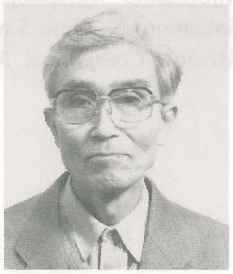
Figure 1. The beam signal at the entrance of the RFQ (lower trace, 2 mA/div.) shown together with the arc signal of the ion source (upper trace, 50 A/div.) Horizontal scale is 50 μs/div.

NUCLEAR SCIENCE RESEARCH FACILITY —Particle and Photon Beams—

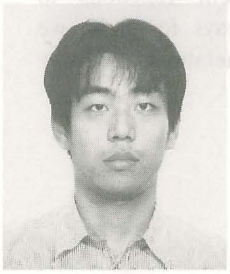
Scope of research

Particle and photon beams generated with accelerators and their use both for fundamental research and practical applications are studied. The main subjects are:beam dynamics in high intensity accelerators: beam handling at injection and extraction process of the accelerator ring: beam diagnoses in accelerators: radiation mechanism of photons from an electron storage ring: interactions in the few-nucleon systems: development of a compact accelerator dedicated for cancer therapy; and irradiation of materials with particle and photon beams.

Professor
NODA, Akira
(D Sc)



Associate Professor
KAKIGI, Shigeru
(D Sc)



Instructor
SHIRAI, Toshiyuki

Lecturer (part-time):
HATTORI, Toshiyuki
(Associate Prof. of Tokyo Institute of Technology)
Guest Scholar:
GRIESER, Manfred
(Max-Planck Institut für Kernphysik, Heidelberg)
Students:
IKEGAMI, Masanori (DC)
KANDO, Masaki (MC)
SUGIMURA, Takashi (MC)

In addition to the above modification, the geometry of the extraction electrode was changed to increase the extracted current and 20 mA of beam is extracted at the straight section before the Mixing Magnet, among which 8 mA is H^+ beam needed for acceleration with the linac. In Fig. 1, the beam signal guided to the entrance of the RFQ is shown together with the arc signal of the ion source. In this case, arc current is more than 90 A so as to increase the fraction of H^+ by increasing the plasma density in the chamber of the ion source. So as to increase the plasma density much more, it is needed to improve the magnetic confinement of the plasma by replacing with much stronger permanent magnets, which requires further studies.

The transverse phase space matching is further to be completed with use of axially symmetric magnetic lenses made of permanent magnets [3]. As the focusing at the entrance of the RFQ is not strong enough at the moment without above lenses, the transmission through the RFQ is not high enough (less than 74%).

The beam emittance at the LEBT has been measured with combination of moving slits and view screen made of alumina ceramic doped with chromium oxide. The measured 100% unnormalized emittance is 170 πmm·mrad [4]. With the same method the beam emittance is also measured after the RFQ and measured 90% unnormalized emittance is 30 πmm·mrad.

For the purpose of monitoring the beam current continuously, a pulsed beam current monitor with a toroidal core has been fabricated and installed in front of the DTL. The beam current causes the change of the magnetic flux in the toroidal core, which results in the current in the secondary winding of the core. By detecting this current, the beam current can be measured. Application of negative impedance enabled high enough gain of the system with long enough decaying time. Its sensitivity is calibrated with the beam. It is found that the monitor can be used in a wide range of beam current from 30 μA to 10 mA, with the frequency range of 30 Hz to 1 MHz [5]. The monitor can represent the beam signal quite well as shown in Fig. 2. The accuracy of absolute value of current measurement is better than 10%.

After the DTL, the beam emittance of 7 MeV proton is also measured with use of conventional method which utilize moving double slits and Faraday cups. However, the method is usually only applied to continuous beam. In the present measurement, high gain and rather fast amplifier is developed to enable the emittance measurement for pulsed beam with duration of 50 μs. The measured rms emittance is 5 πmm·mrad [6].

Summarizing the above results, accelerated beam current has reached the order of mA and its diagnosis system at each stage of the accelerator system has been safely started its operation, although further studies are needed in order to realize much higher intensity of the order of few tens of mA. Based on these results, material irradiation is to be started soon and the vacuum chamber for measurement of neutron production rate from various alloys has been fabricated and installed. In order to realize easy access to the target materials to be irradiated, the vacuum system separated from the one for the accelerator cavities by a gate valve is prepared. After the test experiment, the facility is to be ready for open use of outside users.

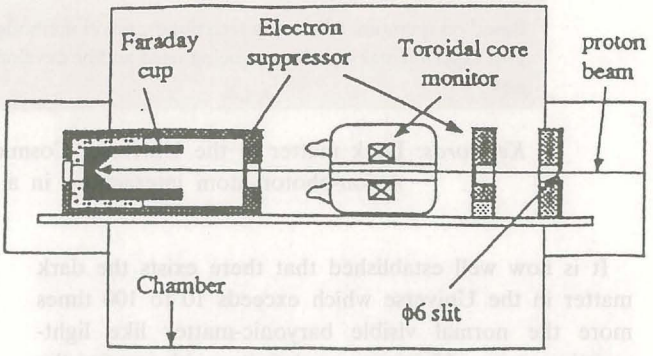


Figure 2(a). Configuration of the calibration of the toroidal core monitor.

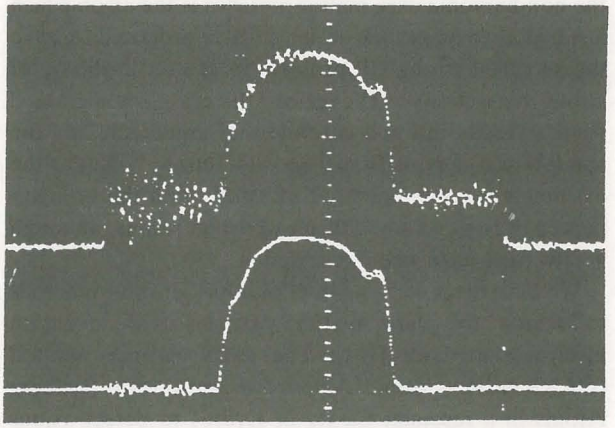


Figure 2(b). Figure 2(b). Beam signals from the core monitor (upper trace) and the Faraday cup (lower trace).

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