

Present Status of the 7 MeV Proton Linac at ICR Kyoto University

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Abstract

The ICR 433 MHz linac which consists of an RFQ and an Alvarez cavities has successfully accelerated protons up to the goal energy of 7 MeV. The present intensity is about 200 μA without a buncher which is now under construction. Emittance and momentum of the beam has been measured at the end of the RFQ section.

I. INTRODUCTION

A compact proton linac accelerator has been designed and constructed at the nuclear science research facility of the Institute for Chemical Research, Kyoto University. The plan view is shown in Fig.1. After fabrication and assembling of the main part of the linac, we have had to improve step by step our linac

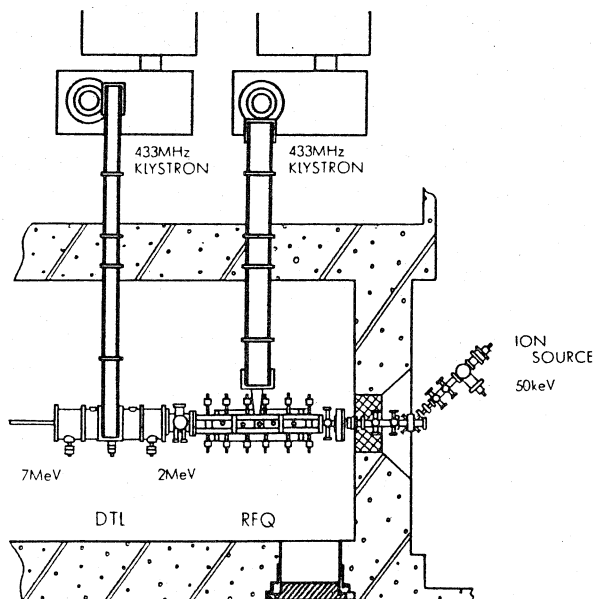


Fig. 1. Layout of the linear accelerators.

Improvements of the vacuum system including additional vacuum pumps and replacement of dirty gaskets by new ones have been made. Another essential improvement has been made in RF system. We have put a circulator and a dummy load in the wave guide of the RF feeding line. These devices have made it easy to feed high power in the RFQ cavity.[1]

After a full power operation at the RFQ cavity, the Alvarez cavity has been operated at a full power without a circulator system. Thus the proton beam was successfully accelerated up to 7 MeV in the evening of 22nd January 1992.

The intensity of the first beam was order of μA at peak. Since then our effort has been mainly concentrated into increasing of beam intensity and reliable operation of the total system.

II. ION SOURCE and LOW ENERGY BEAM TRANSPORT (LEBT)

A multi-cusp type ion source was so far operated by a DC power supply system. On the other hand the linac is operated by the pulsed power supply with a duty of 1% at most. Therefore we constructed a new pulsed power supply for the ion source. High peak-power arc operation of the ion source has been obtained with this pulsed power supply. Typical results are shown in Fig. 2.

Our low energy beam transport system which transports a beam from ion source to the RFQ linac consists of mainly electrostatic quadrupoles. The exceptions are a bending magnet which analyzed the beam and a magnetic solenoid which is located near entrance of the RFQ cavity. These elements have small aperture because of economical reason. This small aperture system is able to transport the 50 keV proton beam with intensity up to 1 mA, but it is difficult to transport higher intensity beams to the entrance of the RFQ linac because the space charge effect becomes too large at higher than 1 mA to make the beam size small. At the moment the beam intensity before the bending magnet is 10 mA and the analyzed proton (H^+) beam intensity just after the bending magnet is about 3 mA.[2]

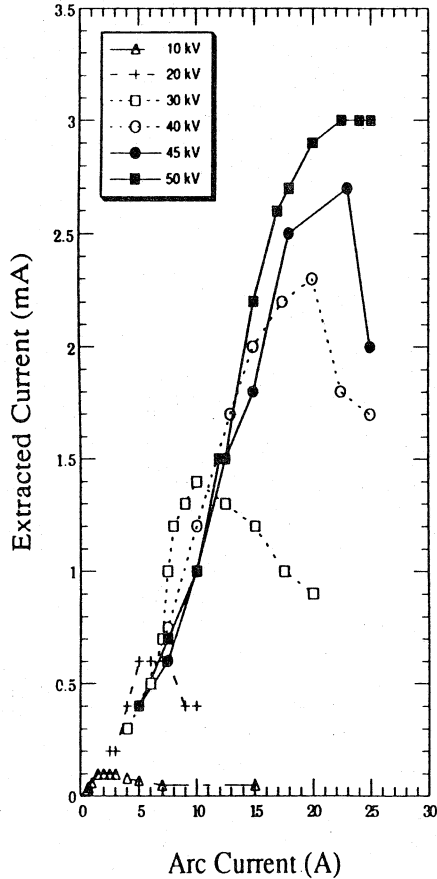


Fig. 2. Dependence of the extracted beam currents on the arc current for various extraction voltages

III. RFQ LINAC BEAM

Properties of the accelerated beam of the RFQ linac has been measured by a compact analyzing magnet and a profile monitor. The analyzing magnet should be designed to be very small because the transport section between the RFQ cavity and the Alvarez cavity is very short. Thus the pole tips are only situated in the vacuum region, but the magnet yokes and a coil are located outside of the vacuum chamber as shown in Fig.3. Because of small space for the coil it is difficult to use water cooling. Therefore a saw tooth shape pulsed current is applied to excite the magnet to avoid the heating up the coil. Fig.4 shows momentum spectra of output beams from the RFQ linac in which the RF power varies from zero to full power. The measured beam energy at the full power operation was 2.00 ± 0.02 MeV with a width of 80 keV FWHM. As shown in Fig. 4 low energy beams are accelerated at below full RF power level. This is not surprising because such beams are usually neglected by a limited energy window in case of the computer simulation.

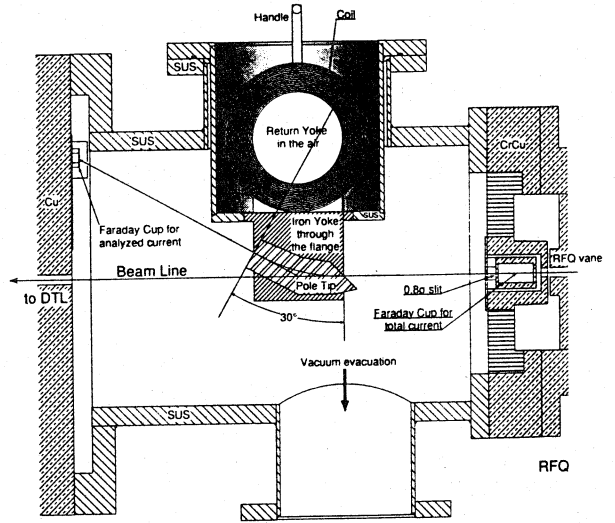


Fig. 3. Side view of the compact momentum analyzer.

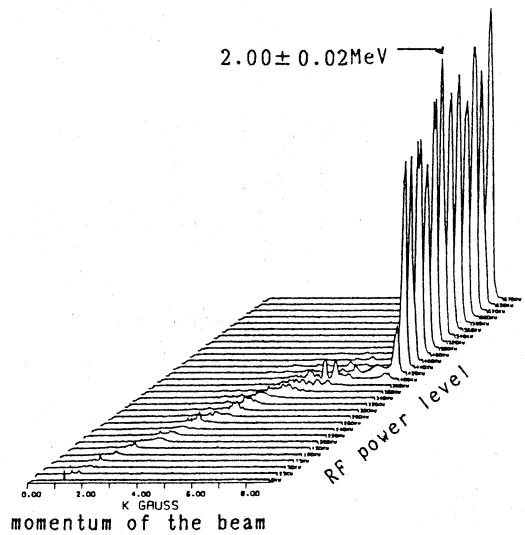


Fig. 4. Obtained momentum spectra of the RFQ linac beam depending on the RF power level.

The beam profile has been measured by a kind of fluorescent ceramic, Desmarquest, which is chromium-doped aluminium oxide and a CCD camera. Details of this system is reported in this symposium. Emittance of the beam out from the RFQ has been observed to be $42 \mu\text{mm}\cdot\text{mrad}$ and $30 \mu\text{mm}\cdot\text{mrad}$ for $x-x'$ and $y-y'$ planes.[3]

IV MEDIUM ENERGY BEAM TRANSPORT (MEBT) and ALVAREZ LINAC

Beam transport system between the RFQ and the Alvarez cavities should contain permanent quadrupole magnets and an RF phase buncher to match the output beam from the RFQ linac with the Alvarez linac. But the buncher is not so far installed. At the present the beam transmission from the exit of the RFQ cavity to the exit of the Alvarez cavity is about 30% without the buncher. Design and construction of a double gap buncher are now in progress. Conceptual drawing of the buncher is shown in Fig.5. The RF power test has been successfully done at a required power level of 5 kW.[4] Feeding the RF power into the Alvarez cavity is rather easy comparing with the RFQ cavity, but it is also desirable to insert a circulator and a dummy load in the wave guide system for a reliable operation of the linac. Thus a new circulator and a dummy load same as those of the RFQ system have been constructed.

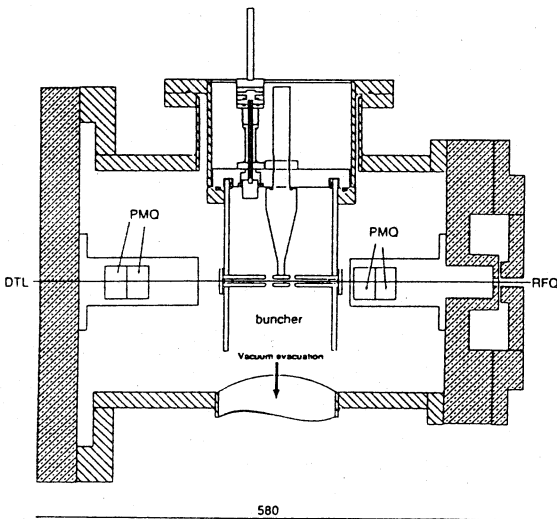


Fig. 5. The RF phase buncher.

The output current of the 7 MeV beam from the Alvarez linac is at present 240 μ A without the RF buncher.

The orbit planes (x and y) in the calculation in our case are rotated by 45° to the real horizontal and vertical planes for the sake of easy setting of the RFQ cavity. But this is inconvenient to transport the beam to the target stations in the real laboratory. Therefore

two sets of skew magnetic quadrupole doublets have been designed to get nearly parallel beams in the both planes. The skew quadrupole magnets are now under construction based on a calculated beam optics. The output beam transport from the linac with these skew quadrupole magnets is shown in Fig. 6.

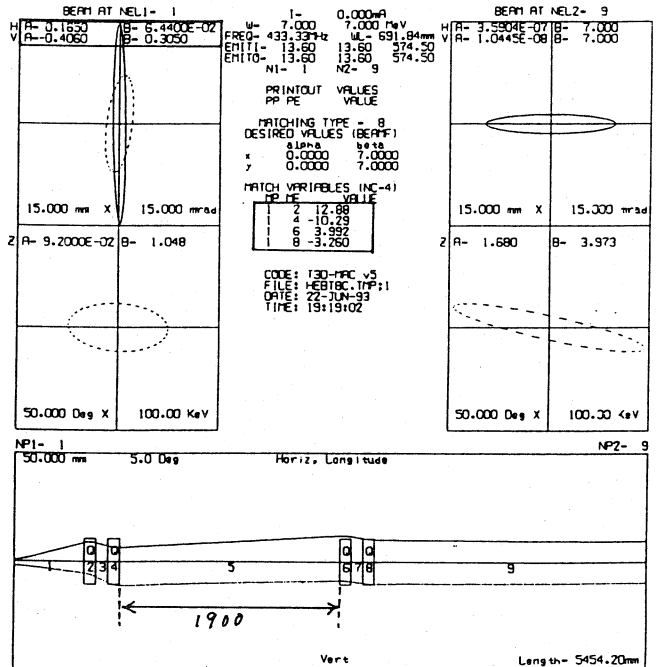


Fig. 6. Out put beam transport from the Alvarez linac with two quadrupole doublets. Left side is exit of the linac.

V. REFERENCES

- [1] T. Shirai et al., "High power circulator for the 433.3 MHz proton Linac", Nucl. Instr. Meth., A321, 429 (1992).
- [2] A. Noda et al., "Characteristics of the Ion Source and Low Energy Beam Transport of the Proton Linac at ICR", Bull. Inst. Chem. Res. Kyoto Univ., 71, 6 (1993).
- [3] T. Shirai et al., in these proceedings.
- [4] H. Dewa, master thesis, 1993.