BEAM TEST OF THE RFQ LINAC 'TALL'

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ABSTRACT

Beam test of the RFQ linac TALL was done by using proton beam. Transmission exceeding 90% was obtained. Energy and its spread of the ouput beam were measured by an analyzer magnet as T = 825 keV and $\Delta T/T$ = 1.6% in FWHM. They agree with calculated values.

INTRODUCTION

A heavy ion synchrotron-cooler ring 'TARN-II' is under construction at INS. The ring is designed to accelerate protons up to 1.3 GeV and heavy ions with charge to mass ratio q/A of 1/2 up to 450 Mev/u.[1] The RFQ linac 'TALL' was constructed as the first stage of an injector linac system for the TARN-II. The RFQ linac is best for the stage because it can accept low velocity beam and has bunching function. The machine can accept ions with q/A of 1~ 1/7. By using an ECR ion source it can accelerate heavy ions such as Xe and W. Injected ions at 8 keV/u are accelerated up to 825 keV/u.

ACCELERATION CAVITY

The acceleration cavity is of four vane structure driven with a loop coupler. The cavity is 58 cm in diameter and 730 cm in length. Detailed descriptions of the structure and alignment are given in other papers.[2,3] Two sets of vanes are prepared for the TALL. One is for low power operation. It is made of aluminum and has no cooling channel. The other is made of copper and has cooling channels for high power operation. The beam test were done with the aluminum vanes.

On the input and output ends, a part of each vane end is removable in order to vary the inductance of the cavity ends. The end wall has four movable capacitive end tuners. Each quadrant has four movable side tuners. They will compensate the resonant frequency shift due to thermal elongation. Aluminum cylindrical blocks of 100 mm in diameter and various thicknesses are inserted through side holes to vary transverse inductance.

The field distribution was tuned roughly by varying the shape of the vane ends. Then fine tuning was done by using the side inductive and end capacitive tuners. The electric field distribution near the vane tops was measured by use of a dielectric pertubator moving guided by the vanes. A field uniformity within a deviation of ± 2% azimuthally and ± 5% longitudinally was obtained, by using two dozen side tuners of fixed length and three end capacitive tuners. The TE210 mode was tuned at 101.3 MHz. The closest mode is TE111, which has 0.93 MHz higher resonant frequency. The separation of 0.93 MHz is satisfactory.

BEAM TEST

Ions extracted from a microwave ion source at 8 keV are transported to a magnet with two einzel lenses. Protons are separated form other ions with the magnet. They are focused into the RFQ entrance with a triplet of electric quadrupole lenses and an einzel lens. The output ions are focused with a triplet of quadrupole magnets on an object point of an analyzer magnet.

The energy of the output beam was measured by the magnet as T = 825 keV/u. The calculated value is 800 keV/u at 100 MHz. Considering that the frequency is tuned at 101.3 MHz, the measured energy is reasonable. The energy spread was measured as $\Delta T/T = 1.6\%$ in FWHM. It agrees with a computer simulation by PARMTEQ.

Transmission efficiency was measured for input proton beam of 10 μA. The emittance and intensity of the input beam were measured just in front of the entrance or, downstream of the final einzel lens. The intensity of the output beam was measured at the object point. Transmission exceeding 90% was obtained (Fig.1).

The beam test was done in pulse operation. The duty factor was 16.7% (2 ms duration/12 ms repetition period). The proton acceleration required rf power of 4.6 kW (peak). The unloaded quality factor Q_0 was measured at 7100. It is about 70% of a caluculated value for the aluminum vanes. With the loop coupler the cavity was stably operated up to the full power of 25 kW of a power supply now available.

CONCLUSION

Transmission exceeding 90% was obtained. The measured energy and its spread agree with the calculation. On the basis of the experiment the shape of the end part of the high power vanes were determined. The aluminum vanes were replaced by them. Field tuning and rf characteristics study with the new vanes are done.

ACKNOWLEDGMENT

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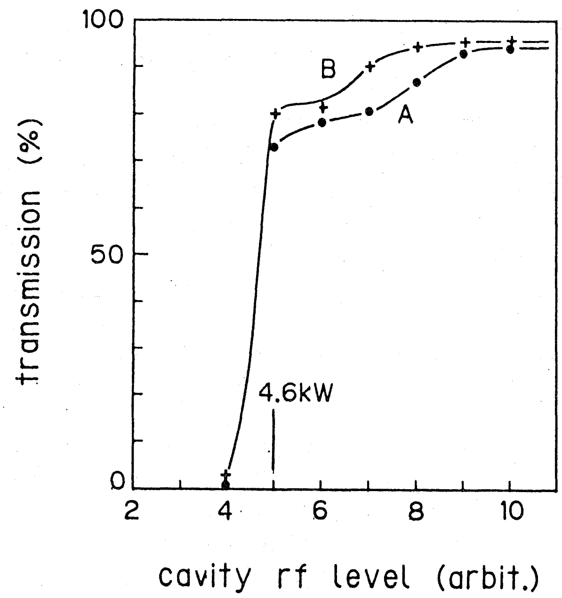

Fig.1. Transmission vs. cavity rf level for input proton beam of 10 μA. Input beam emittance for A and B is given in Fig.2.

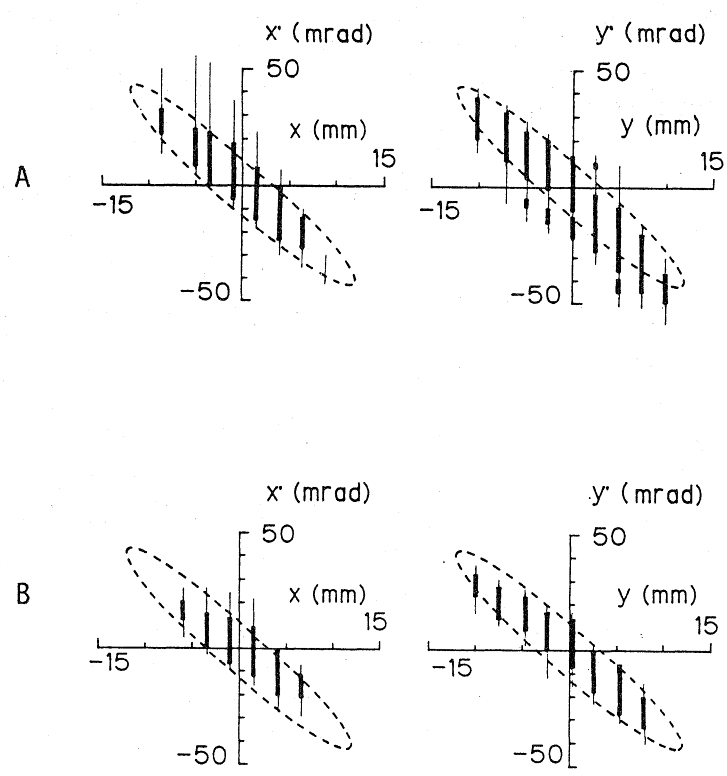

Fig.2. Emittance of the input proton beams of 10 μA measured at 21 cm upstream the RFQ entrance. Thick and thin bars cover 95% and 100% of the beam, respectively. The ellipses are ones for RFQ acceptance at the design voltage. The area is 145π mm·mrad, or 0.6π mm·mrad normalized. A and B are for beams limited by apertures of 13 and 8 mm dia., respectively, inserted between electric quadrupole lenses.