PERFORMANCE OF THE INS RFQ LINAC 'LITL"

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ABSTRACT

The radio-frequency quadrupole (RFQ) linac 'LITL' was constructed and accelerated ion beams of H^+, H_2^+, H_3^+, $^3He^+$, $^6Li^+$ and $^7Li^+$. The linac was designed to accelerate particles with charge to mass ratio (q/A) of 1 ∿ 1/7 injected at 5 keV/u up to 138 keV/u. The acceleration cavity of four vane structure with 100 MHz resonant frequency is 56 cm in diameter and 138 cm in length. Transmission exceeding 90% was obtained for proton beam of 80 μA. The acceleration characteristics agreed well with the computer simulation by PARMTEQ. To accelerate $^7Li^+$ ions, an rf power of 22 kW was fed with a loop coupler in cw operation, where an electric field of 205 kV/cm was applied on the vanes. This corresponds to 1.8 times the Kilpatrick's criterion at 100 MHz. A maximum field of 2.0 times the criterion was achieved in pulse operation with 5 ms width and 25 ms repetition period.

The radio-frequency quadrupole (RFQ) linac[1,2] has the following advantages;

1. A low voltage injection is possible without lowering a space charge limit.
2. An ability of adiabatic bunching results in capture efficiency exceeding 90% and minimal loss of input dc-beam.

Based on the studies on beam dynamics design[3,4,5,6,7], machine structure[8]

Table 1. Parameters of the INS RFQ Linac LITL.

Ion		q/A = 1 ∿ 1/7
Injection Energy		5 keV/u
Output Energy		138 keV/u
Operation Frequency		100 MHz
Normalised Emittance at Input		0.6π mm·mrad
Vane Length		122.3 cm
Number of Cells		132
Characteristic Bore Radius	r_0	0.41 cm
Minimum Bore Radius		0.25 cm
Focusing Strength	B_0	5.0
Maximum Defocusing Strength	Δ_0	-0.11
Intervane Voltage for q/A= 1/7		62 kV
Maximum Field		205 kV/cm
Transmission for q/A= 1/7		94% (0 mA)
		92% (2 mA)
		64% (10 mA)

and rf system of RFQ linac, we have constructed the RFQ linac 'LITL'. The parameters of LITL are given in Table.1. Fig. 1 shows the acceleration cavity. Fig. 2 shows the vane parameters vs. cell number. The detailed description of LITL is given elsewhere[9].

Beam test was performed using ion beams of H^+, H_2^+, H_3^+, $^3He^+$ and $^{6,7}Li^+$. Momentum spectra for the ion beams accelerated at the designed values of intervane voltage are shown in Fig. 3. Fig. 4 shows the momentum spectra of H^+ beam for various values of intervane voltage Vn (normalised by the design value). Fig. 5 shows the output current of ion beams as a function of intervane voltage. Fig. 6 shows the transmission for H^+ beam as a function of normalised intervane voltage Vn. Transmission exceeding 90% was obtained.

Singly charged ion beams up to $^7Li^+$ were successfully accelerated by RFQ linac 'LITL'. the acceleration characteristics agreed well with the computer simulation by PARMTEQ.

Acceleration of higher intensity beam, where space charge and beam loading effects are important, is now under preparation.

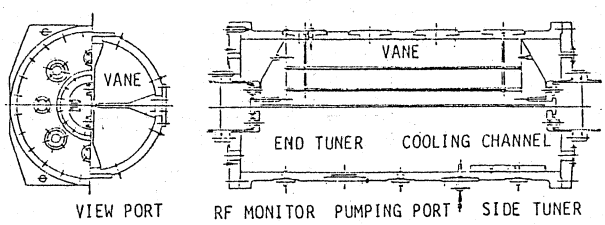


Fig. 1. Schematic drawing of the acceleration cavity of LITL.

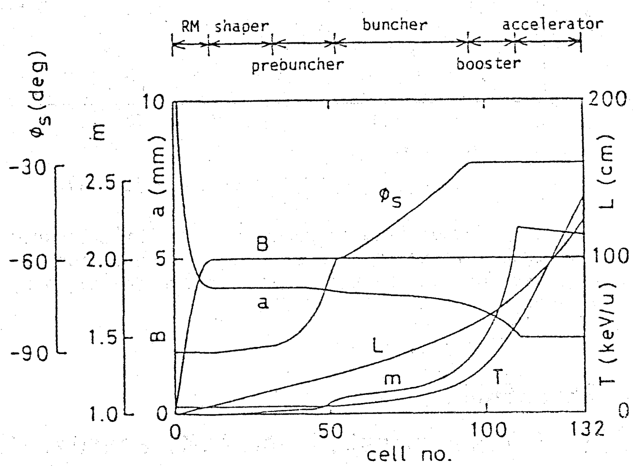


Fig. 2. The vane parameters of LITL vs. cell number.

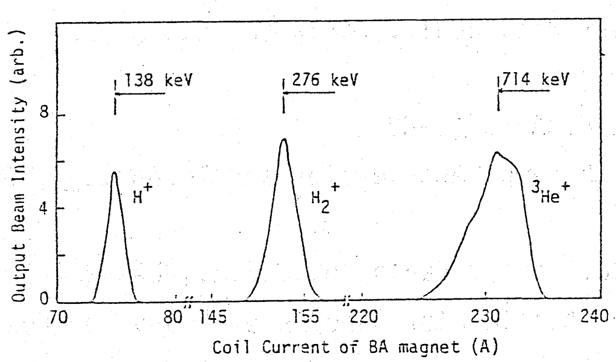
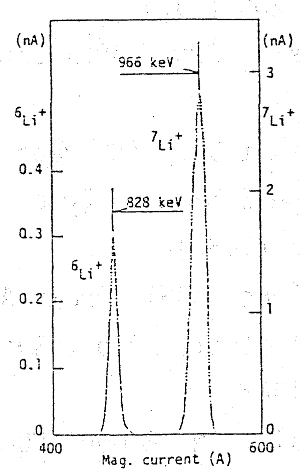


Fig. 3. Momentum spectra for H^+, H_2^+ and $^3He^+$ beams.



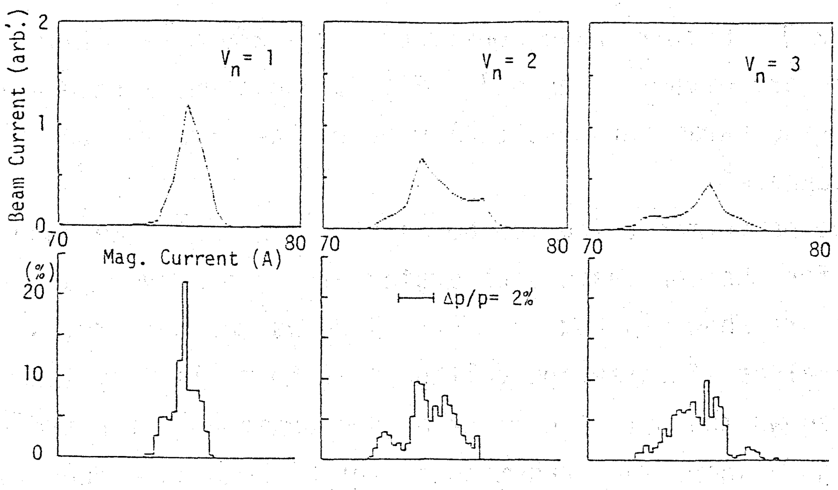


Fig. 4. Momentum spectra for H^+ beams accelerated at the various intervane voltages (upper) and PARMTEQ results (lower).

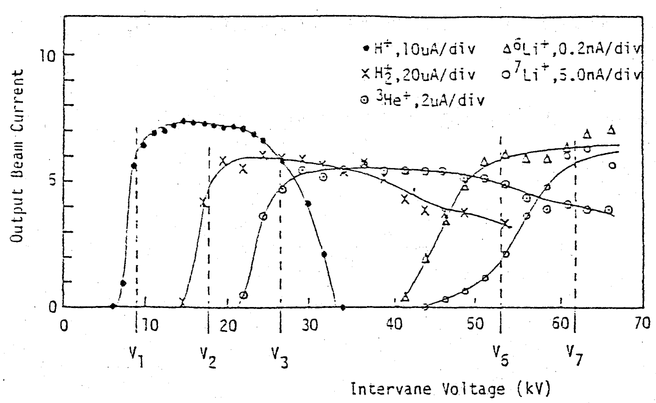


Fig. 5. Output beam currents of $H^+ \sim {}^7Li^+$ measured as a function of the intervane voltage. The design values required for each beam acceleration are indicated by $V_1 \sim V_7$.

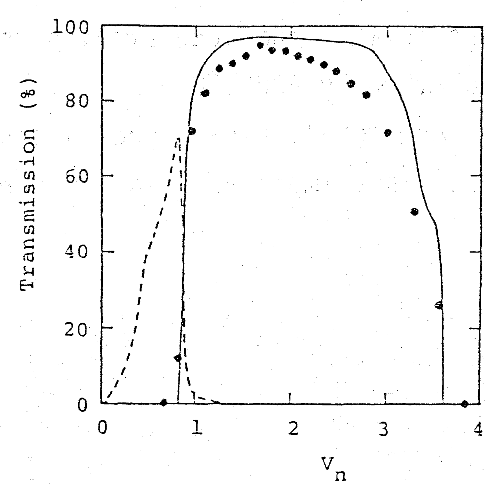


Fig. 6. Transmission for H^+ beam plotted as a function of the normalized intervane voltage. The solid line shows calculated transmission and the broken line is that for non-captured beam.

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