DESIGN OF AN INTENSE HEAVY-ION LINAC SYSTEM

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Abstract

An intense Heavy-Ion Linac sysem was propsed for experiments of heavy ion beam pumped laser and heavy ion inertial fusion. The system consists of an RFQ and an IHQ. The first stage linac, RFQ, was designed to accelerate particles with charge to mass ratio of 1/16 up to 200 keV/amu. Its transmission efficiency is 92% neglecting space-charge effects. Some new techniques concerning the RFQ vanes are presented.

introduction

We are planning to constract accelerator system for the experiments of heavy ion pumped laser and heavy ion inertial fusion at Tokyo Institute of Technology. The system consists of two linear accelerators. The first one is a four-vane RFQ and the second one is an IHQ (Interdigital H structure with RF Quadrupole focusing type linac). The final output energy is 600kev/amu. We report the design of the RFQ including beam optics.

RFQ type linac

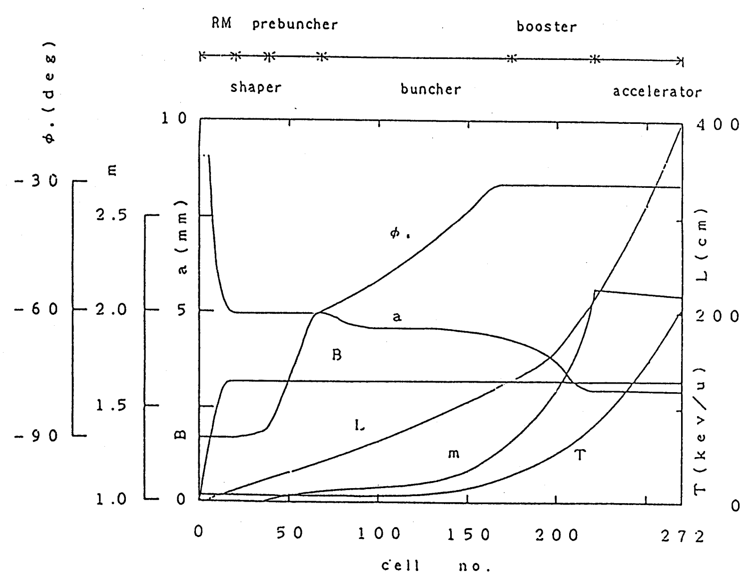
FOR the RFQ, we need the forrowing conditions.
①Charge to mass ratio, $q/A \geq 1/16$.
②Total cavity length $\leq$ 4meters.
③Output energy $\geq$ 200keV/amu.
④For intense beam current (10mA), beam transmission $\geq$ 70% .

The condition ② comes from the limited available costs and place of the system. The condition ③ is necessary for heavy ion beam punped laser, and necessary for injection of particle into the IHQ linac; IH structure with fingared drift-tube is not suitable for beam accelerations at low velocities.
For the reasons mentioned above, a four-vane structure driven at 80MHz was adopted to the first linac.
Under these conditions, the optimum cell parameters were searched in order to optimize the output energy and beam transmission. The computer code PARMTEQ was used to simulate the particle motion in the RFQ. The computer code GENRFQ, generator of the vane parameters for PARMTEQ, which was programmed at INS, was used for the optimization. The obtained design parameters are shown in Table 1. In Fig. 1 these parameters are plotted as a function of the cell number. The machine will accelerate ions with q/A of 1/16 from 5 up to 200 keV/amu. The total vane length is 394 cm which corresponds to 272 cells including 20 cells of the radial matching section. The transmission is expected to be 92% for the beam current of 0 mA and 72 % for that of 10 mA.

Principal Parameters of the TIT RFQ

Charge-to-mass ratio, ε		≧1/16
Operating frequency (MHz)		80
Input energy (keV/amu)		5
Output energy (keV/amu)		202
Normalized emittance, ε_n (cm·mrad)		0.05π
Cavity length (cm)		400
Cavity diameter (cm)		70
Vane length (cm)		394
Total number of cells		272
Characteristic bore radius, a_{min} (cm)		0.30
Minimum bore radius, a_{min}/a_{beam}		1.1
Maximum modulation, m_{max}		2.1
Focusing strength, b		3.2
Maximum defocusing strength, Δ_b		-0.048
Synchronus phase, ϕ_s (deg)		-90→-30
Maximum field (Kilpat.)		2.2
Shunt impedance (MΩ/m)		27.8
Transmission (%)	(0mA input)	92
	(5mA input)	83
	(10mA input)	72
	(15mA input)	53

Table 1



Vane parameters for TIT RFQ as a function of cell number.

Fig. 1

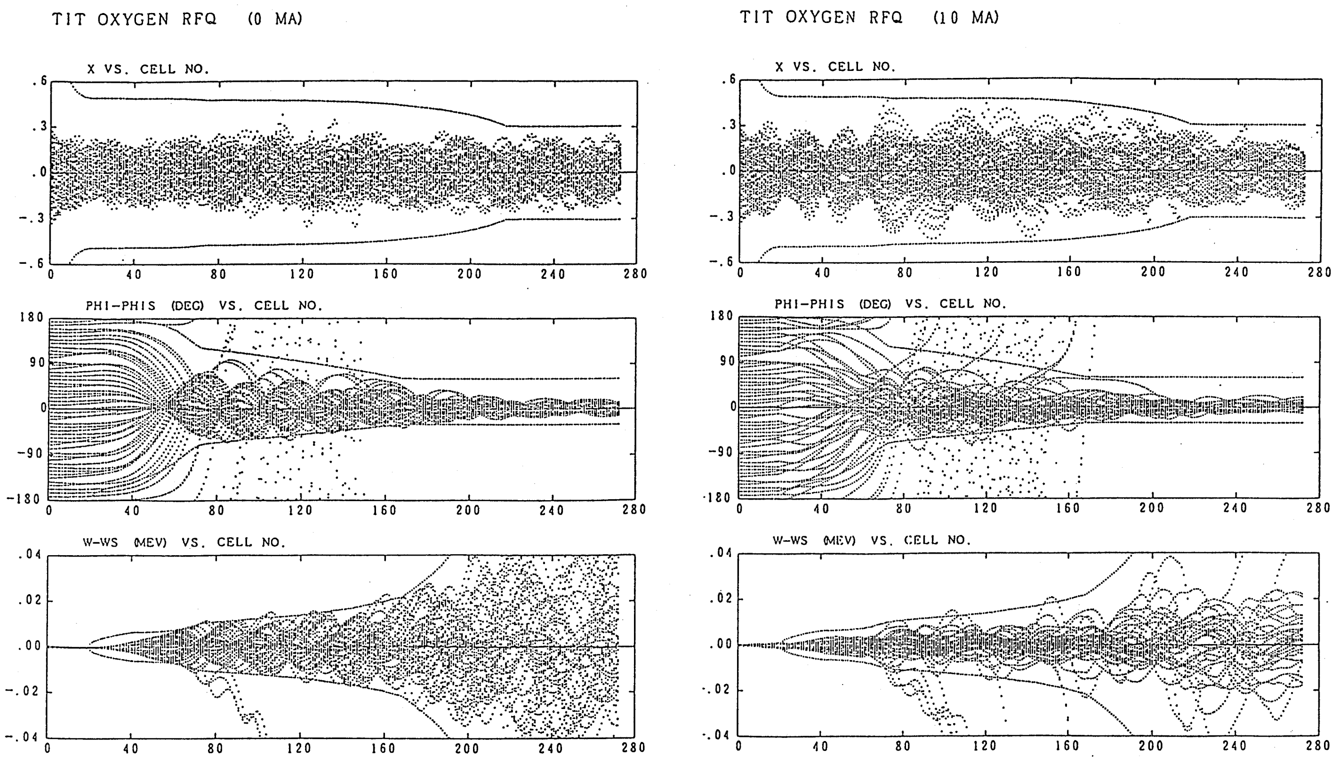


Fig. 2 PARMTEQ simulation. Top:Particle position is given in cm. The dashhed lines are the envelope of the minimum vane aparture.
Middle: The dashed lines show the phase width of the longitudinal separatrix.
Bottom: The dashed lines show the enerugy width of the separatrix.
The total enerugy is 3.2 MeV at cell-272 for q/A = 1/16.

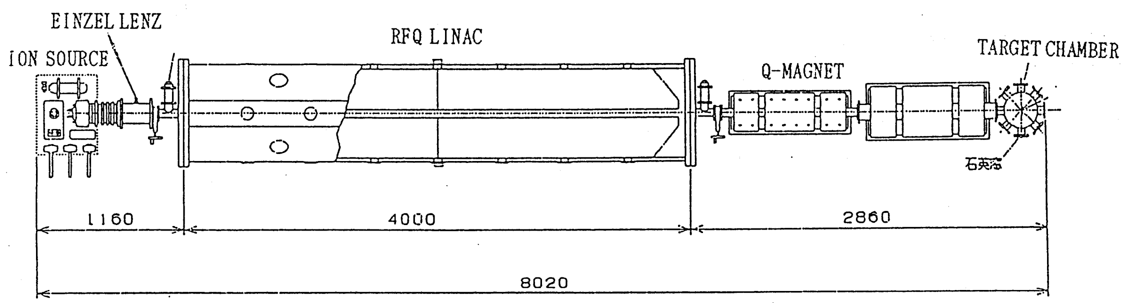


Fig. 3 Schematic drawing of the TIT RFQ structure.

The vane-top shape

The vane top is machined with a numerically controlled (NC) mill. Two dimensional machining reduces time of machining. In order to obtain a high shunt impedunce and a high sparking limit between vanes, "thin" vanes with a vane-top curvature of $0.75r_0$ (r_0=average bore radius). This configuration, however, can distort the linearity of the intervane field. Quadrupole field is distorted. We are now investigating the function of higher-order harmonics in the potential and its beam-dynamical effects.

The next subject

For the RFQ linac, model-test to analyze end-cut regions of the vanes is being prepared. For the IHQ we are now in process of a computer simulations of beam optics including space charge effect.

Reference

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