LINAC ENERGY TUNING BY PHASE CONTROL OF LAST CAVITY

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The RILAC (RIKEN Linac) is a heavy-ion linac with six tunable (17$\sim$45 MHz) cavities. With the request of many applications for different energies, at RILAC, the beam energy can be varied by the following schemes:

1) turning off the later cavities,

2) changing the acceleration frequency, and

3) adjusting the input beam phase of the last cavity.

The first scheme, which is normally used in multi-tank linacs, provides a few discrete energies. When the second sheme is used in addition to the first one, the energy becomes continuously variable over a wide range (0.01 $\sim$ 4.1 MeV/n). However, to operate the linac with change of the acceleration frequency, most of the parameters of the linac including its injector have to be readjusted and it takes much time to do this. For fine step tuning of energy, the third scheme is more useful than the others

Fig. 1 a) shows the variation of energy with change of the input beam phase at the first acceleration gap of the last cavity (cavity #4, in this case). The circle points in the figure denote the experimental values. The energy was measured with a dipole magnet while the input beam phase was estimated from an rf-phase difference between the cavity in concern and the former ones. The solid line in the figure shows the result of the calculation. A fairly good agreement between the calculation and the measurement is observed. In Fig. 1 b), the result of calculation is shown about the output beam phase corresponding to the input beam phase with regard to the cavity #4.

As shown in Fig. 1 a), using the phase-control scheme, the beam energy is decreased smoothly down to 65% of the design value which corresponds to a smaller value than the input energy. We can say, therfore, that the combination of the scheme 1) and 3) provides continuous energies without changing the acceleration frequency. The procedure to change the energy in this way is simpler than those including the change of acceleration frequency, because an operator has to adjust only an rf phase of the last cavity and parameters of magnetic devices set in the later portion of the linac.

An acceleration frequency can be determined in view of M/q value of ions to be accelerated and of energy slightly over the energy in concern. There is no need of the exact frequency setting procedure for each energy.

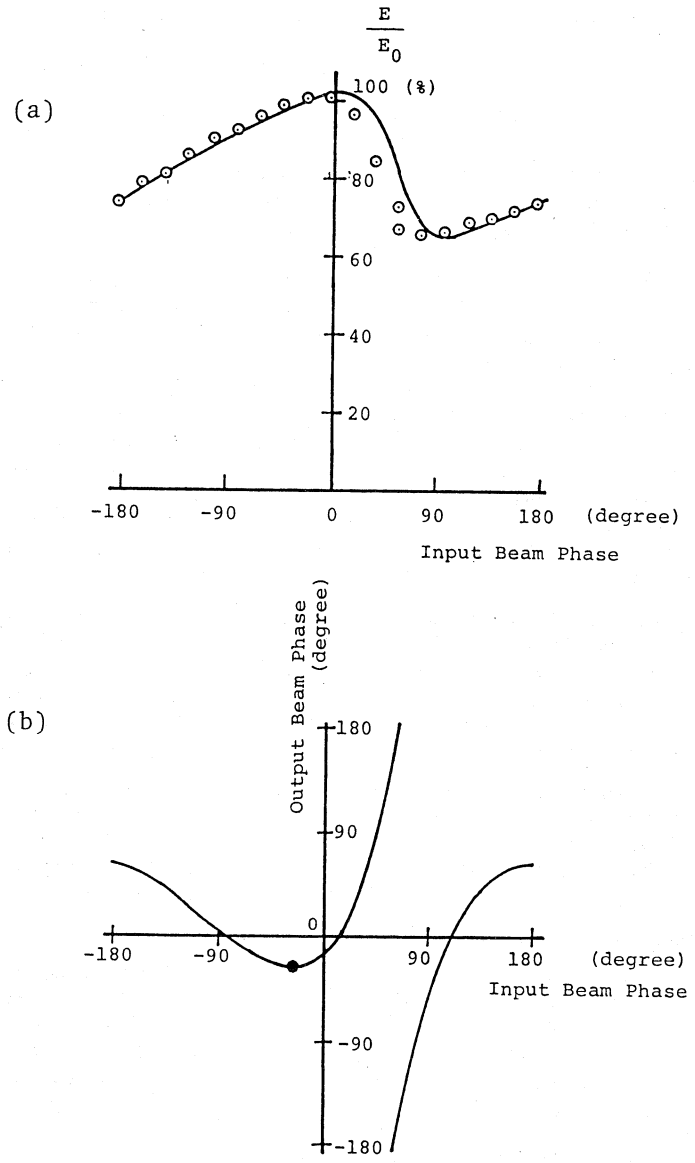

Figure 1 (a)
The variation of output beam energy vs the rf phase where the beam is injected into the first gap of the cavity #4. E_o is the design value of output beam energy. The rf frequency is 22.3 MHz and the beam is Ar^{4+} ($M/q = 10$). The cavities #1, #2 and #3 are in a normal operation and the cavities #5 and #6 are turned off.

(b) The beam phases at the final gap of the cavity #4 corresponding to the input beam phases. A solid circle denotes the scycronous phase; -25 degrees.