RFQ and IH linac for SLOWRI post accelerator

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A post accelerator for SLOWRI [1)] has been conceptually designed [2)]. This accelerator has a 100% duty factor and is a normal conductive linear accelerator complex composed of a 79-MHz split-coaxial RFQ, a medium-energy beam transport, and a 158-MHz interdigital-H (IH) linac. In the review of this design, the following tasks have been performed: 1) the vane length of RFQ was made as short as possible without change of input and output energies and 2) the output beam energy of the IH linac was increased from 1.5 to 5 MeV/u. In order to shorten the vane length of RFQ, the maximum value of the mass-to-charge ratio (A/q) was changed from 9 to 8, the synchronous phase was changed from -30 to -25º, and the vane voltage was changed from 65.1 to 81.5 kV. On the other hand, the normalized emittance of the RFQ beam was increased to 0.06 π cm·mrad to ensure a capture efficiency higher than 90% of the beam from an ion source. As a result of the new design [3)], the vane length of the RFQ was decreased by about 2 m, as indicated in Table 1.

Table 1. Main RFQ parameters of the 1st and 2nd versions

Parameter	1st version	2nd version
Mass to charge ratio: *A/q*	9	8
Normalized emittance (π·cm mrad)	0.047	0.06
Input and output energy (MeV/u)	0.005 and 0.5	0.005 and 0.5
Output synchronous phase (deg.)	-30	-25
Vane voltage (kV)	65.2	81.5
Kilpatrick factor	1.57277	1.6573
Transmission (%)	92.2	93.4
Number of cells	290	244
Vane length (m)	7.193	5.1925
Mean bore radius (cm)	0.541	0.6415
Cavity diameter (cm)	30	40
Number of cavity modules	18	15
RF power loss (kW)	186	179

In the new design, the IH linac accelerates ions with an A/q of 8 or less from 0.5 to 5 MeV/u. The IH linac comprises 18 tanks and 18 quadrupole doublets to make the output energy variable. Quadrupole doublets are placed in a short space of 42 cm between the tanks. The main parameters of the IH linac are listed in Table 2. The gap voltage of each tank was determined to be between 140 and 250 kV because X-rays due to electron field emission are controlled to a relatively low intensity. The gap length of each tank was determined to ensure that the gap electric field is 100 kV/cm. The phase spread of bunches along the beam axis depends on the number of gaps in each tank, especially in the low-energy region. To ensure that the phase spread is within ±25º around a synchronous phase of -25º, the number of gaps from the 1st to 6th tanks is determined to be 16, 8, 12, 12, 13, and 14. The number of gaps beyond the 6th tank is determined automatically to be as large as possible under the limit that the maximum number of gaps is 15 and the maximum tank length is 1 m. Transverse motion of the beam is controlled with quadrupole doublets. Phase advance of the betatron oscillation per focusing period composed of a tank and a quadrupole doublet is set at 54º, except for 36º at the 2nd period. The maximum magnetic field of the quadrupole doublet is about 5 kG/cm at the 18th focusing period. The four transverse ellipse parameters (α_x, α_y, β_x, β_y) should be varied smoothly over all focusing periods. Therefore, by using the four quadrupole magnets set in the 1st and 2nd periods, four parameters at the end of the 2nd period are adjusted to be equal to them at the beginning of the 3rd period. In the same manner, between the 4th and 5th periods, etc., four parameters are connected smoothly. Fig. 1 shows the results of beam simulation using 1000 particles.

Table 2. Main parameters of the IH linac

Parameter	Value
Mass to charge ratio: *A/q*	8
Normalized emittance (π·cm mrad)	0.06
Input and output energies (MeV/u)	0.5 and 5
Transmission (%)	99.9
Synchronous phase (deg.)	-25
Gap voltage (kV)	140 - 250
Gap length (mm)	14 - 25
Kilpatrick factor	0.74293
Drift-tube bore radius (mm)	10 - 14
Tank radius (mm)	190 - 203
Tank length (mm)	300 - 1008
Number of tanks	18
Quadrupole magnet (kG/cm)	3.22 - 5.05
RF power loss (kW)	1270

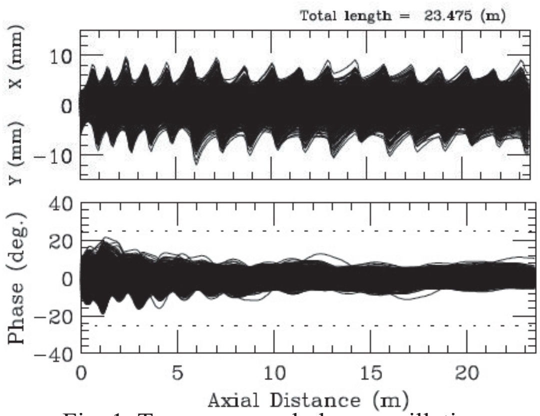

Fig. 1. Transverse and phase oscillations.

References
1) M. Wada et al., Hyp. Int. **199**, 269 (2011).
2) S. Arai, M. Wada, RIKEN Accel. Prog. Rep. **47**, 206 (2014).
3) S. Arai, RIKEN-NC-AC-3, 2016.

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