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BEAM OPTICS OF RISP LINAC USING DYNAC CODE*

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Abstract

The RISP (Rare Isotope Science Project) [1,2] is developing a superconducting linac which accelerates uranium beams up to 200MeV/u with the beam power of 400kW. The linac consists of an injector which includes an ECR ion source and an RFQ, and superconducting cavities which include SCL1 with QWR (Quarter Wave Resonator) and HWR (Half Wave Resonator), and SCL1 with two types of SSR (Single Spoke Resonator). Multiple charge state beams will be accelerated to achieve the required beam power and the charge stripper will be used to obtain the higher acceleration efficiency. This work focuses on the beam dynamics by using the DYNAC code[3] in order to study a possibility that the code can be used as an online model of RAON linac. We compared the results with the calculation by TRACK code [4].

INTRODUCTION

The DYNAC code is a good candidate for the online model of RAON Linac because it can simulates multiple charge states and fast enough. The beam specification of RAON diriver linac is summarized in Table 1. We focus on the uranium beam in this study.

Table 1: Beam Specification for the Driver Linac

Parameters	H^+	O^{8+}	Xe^{54+}	U^{79+}
Energy [MeV/u]	600	320	251	200
Current [pμA]	660	78	11	8.3
Power on target [kW]	>400	400	400	400

LEBT

The injection energy of RAON RFQ is 10 keV/u and we need to inject two charge states, 33+ and 34+ of uranium beams in order to achieve 400 kW of beam power on target. We will use a multi-harmonic buncher (MHB) and velocity equalizer in RAON LEBT to achieve it. The MHB uses three harmonics with 40.645 MHz and its two higher harmonic frequencies. The particle distributions in Δϕ-ΔW/W are given in Fig. 1 just after MHB. The rms beam envelope is given in Fig. 2. We found that the profile is consistent with TRACK simulation except bending magnet region.

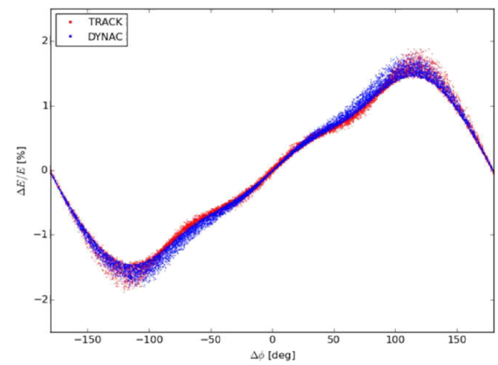

Figure 1: Particle distribution of DYNAC (blue) and TRACK (red) simulations in Δϕ-ΔW/W space.

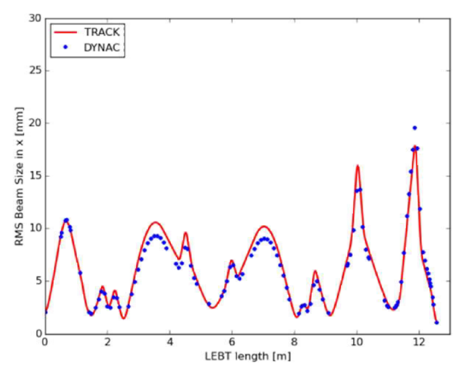

Figure 2: The rms beam envelope through RAON LEBT by DYNAC and TRACK codes.

The particle distribution at the entrance of the RFQ is given in Fig. 3 in the transverse phase space. The transverse beam parameters, twiss parameters and emittance, are summarized in Table 2.

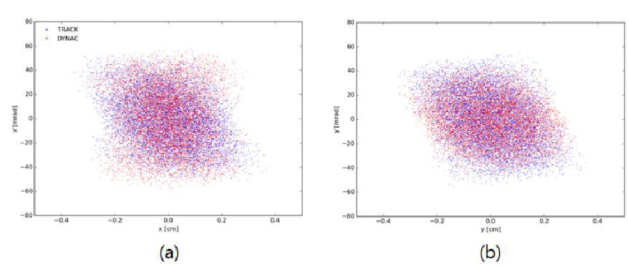

Figure 3: Particle distribution of DYNAC (blue) and TRACK (red) simulation results at the entrance of RFQ.

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Table 2: Beam Parameters at the Entrance of RFQ in Horizontal and (Vertical) Directions

Parameters	Unit	TRACK	DYNAC
Twiss α	-	0.31 (0.34)	0.13 (0.21)
Twiss β	m/rad	0.059 (0.058)	0.046 (0.068)
Emittance	mm-mrad	0.11 (0.11)	0.12 (0.11)

SCL1

The SCL1 uses two different type of cavities: QWR (quarter wave resonator) and HWR (half wave resonator). The SCL1 parameters are summarized in Table 3. The field profiles on beam axis are given in Fig. 4 which is used for DYNAC simulation.

Figure 5 shows the energy increase in TRACK and DYNAC codes. The rms beam envelopes are compared in Figure 6 in horizontal and vertical directions. The particle distributions in transverse and longitudinal phase spaces are given in Fig. 7 at the end of SCL1. We found that the simulation results are consistent with each other.

Table 3: SCL1 Parameters

Parameters	Unit	QWR	HWR1	HWR2
Frequency	MHz	81.25	162.5	162.5
# of CM	-	22	13	19
# of Cavity/CM	-	1	2	4
Cavity Length	mm	220	250	250

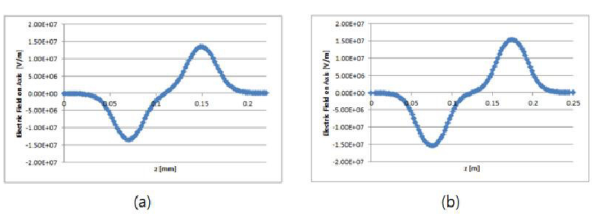

Figure 4: Field profile on beam axis for (a) QWR and (b) HWR cavities.

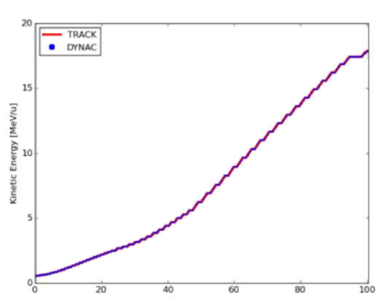

Figure 5: Energy increase through SCL1 cavities.

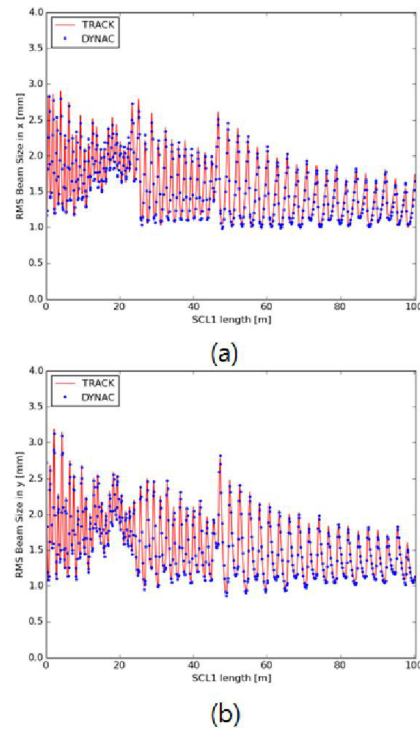

Figure 6: The rms envelop through SCL1 cavities in (a) horizontal and (b) vertical directions.

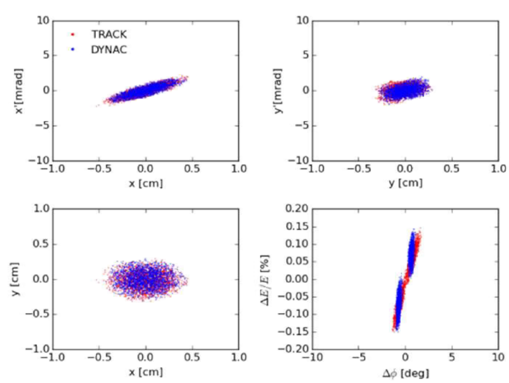

Figure 7: Particle distributions in x-x', y-y', x-y, and Δϕ-ΔW/W spaces at the end of SCL1.

SCL2

The SCL2 uses two different types of SSR (single spoke resonator) cavities. It accelerates 5 charge states of uranium beams simultaneously. The SCL2 parameters are summarized in Table 4 and the field profiles on beam axis are given in Fig. 8 for DYNAC simulation.

Fig. 9 shows the energy increase in TRACK and DYNAC codes. The particle distributions in phase spaces are given in Fig. 10 at the end of SCL2. The rms beam envelopes are presented in Figure 11 in horizontal and vertical directions. The simulation results of two codes are consistent with each other.

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Table 4: SCL2 Parameters

Parameters	Unit	SSR1	SSR2
Frequency	MHz	325	325
# of CM	-	23	23
# of Cavity/CM	-	3	6
Cavity Length	mm	344	500

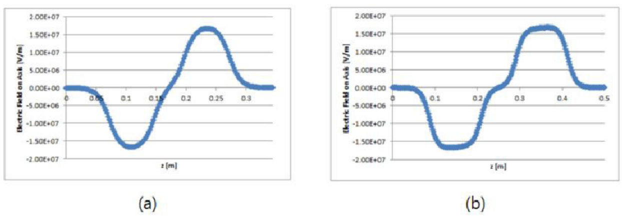

Figure 8: Field profile on beam axis for (a) SSR1 and (b) SSR2 cavities.

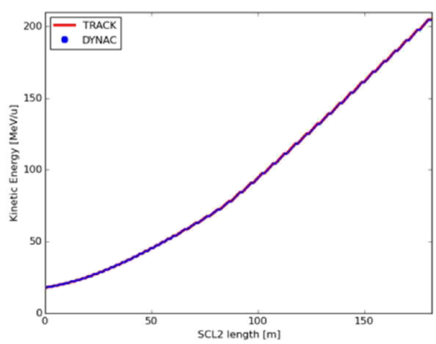

Figure 9: Energy increase through SCL2 cavities.

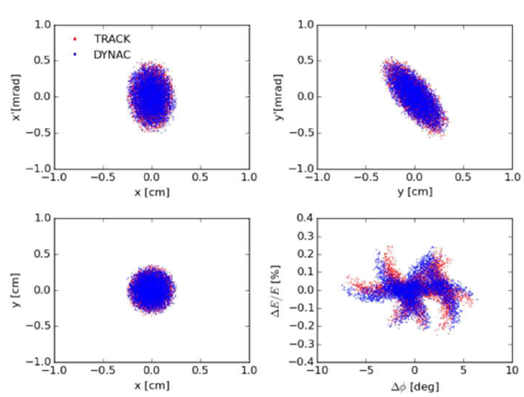

Figure 10: Particle distributions in x-x', y-y', x-y, and $\Delta\phi$-$\Delta W/W$ spaces at the end of SCL2.

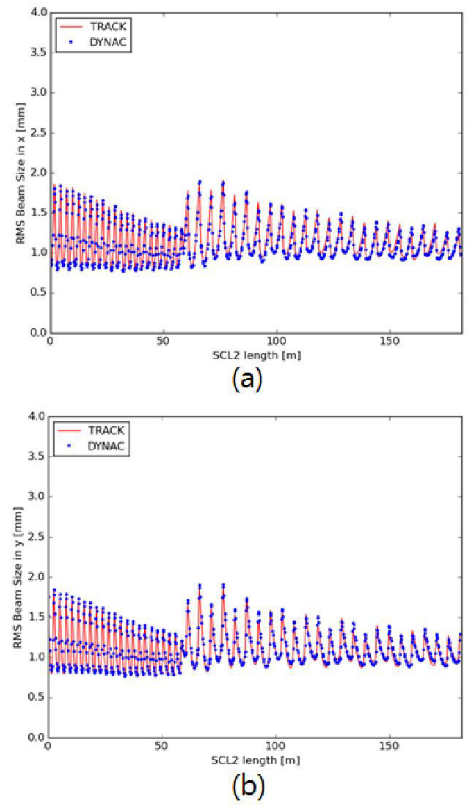

Figure 11: The rms envelop through SCL2 cavities in (a) horizontal and (b) vertical directions.

CONCLUSION

We studied beam dynamics in RAON LEBT and superconducting linac by using DYNAC code and compared the result with TRACK simulation. We found that the results of two codes are consistent with each other. The beam dynamics study of RFQ and bending sections including charge stripping are under progress. We will also study the steering effects of QWR cavities. Because DYNAC code can simulate the multiple charge states, fast enough, and consistent with TRACK simulation, it should be a good candidate of the online model of RAON linac.

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