Beam Dynamics Study of the PEFP SCL Linac

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1. Introduction

A 1-GeV superconducting linac (SCL) is a plausible extension of the 100-MeV normal conducting linac developed in the proton engineering frontier project (PEFP) [1]. The main purpose of the SCL is the spallation neutron source. In this study, we corrected the geometric beta optimization and performed the beam dynamics study of the SCL from 100 MeV to 1 GeV.

2. Geometric Beta Optimization

This section includes the result of geometric beta optimization. This is the correction of the extended abstract for the Korean nuclear society autumn meeting, 2011 [2]. We corrects two points in Ref. [2]. One is the definition of $E_{acc.}$ It is E_0 times the transit time factor at the design beta. The other is that the SNS result in Fig. 2 of Ref. [2]. It represents E_{peak}/E_0. The qualitative results in this article are same as them in Ref. [2]. However the numerical values of the energy gain per cavity and the RF power per cavity become lower as shown in from Fig. 1 to Fig. 3. Fig. 4 shows the transit time factor (TTF) calculated by both the analytical model [3] and the POISSION/SUPERFISH code [4]. In the beam dynamics study, we used the 6-cell cavities in both the low beta of 0.50 and the high beta of 0.74 regions.

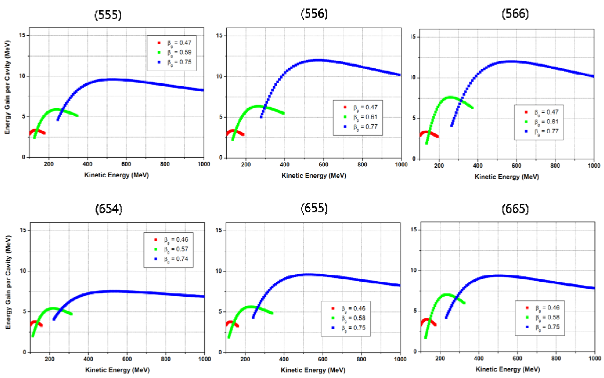

Fig. 1. Energy gain per cavity for 3 region case of β_g (number in parentheses are the number of cells in each β_g region).

3. Beam Dynamics

We used PARMILA code [5] for beam dynamics simulation with solenoid focusing. There are 2 solenoids and 4 cavities in a cryomodule for the low beta region, and 1 solenoid and 4 cavities in a cryomodule for the high beta region as shown in Fig. 5.

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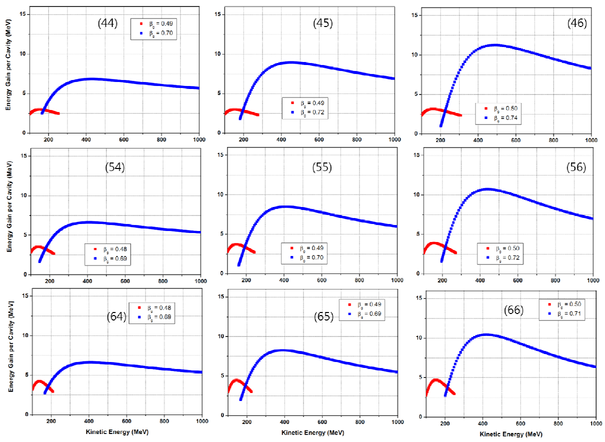

Fig. 2. Energy gain per cavity for 2 region case of β_g (number in parentheses are the number of cells in each β_g region).

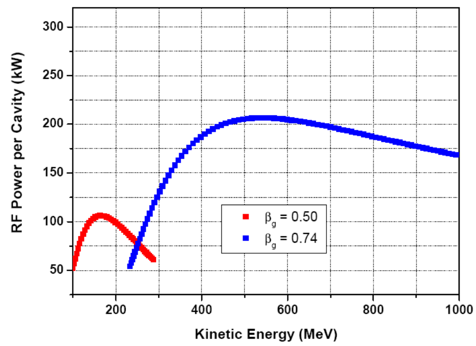

Fig. 3. RF power per cavity with 6 cells per cavity.

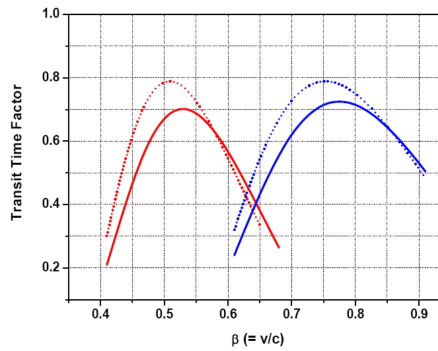

Fig. 4. Transit time factor (dotted lines for the analytical model and solid lines for the SUPERFISH results).

The SC routine in PARMILA can simulate the cavities only. The solenoid is the beam line transport element in PARMILA. Hence the PARMILA input file repeats the SC part including 2 accelerating cavities and the transport part including a solenoid. We found that the 1-GeV acceleration needs 9 cryomodules in the low beta region and 21 cryomodules in the high beta region. The transition energy is 262.2 MeV.

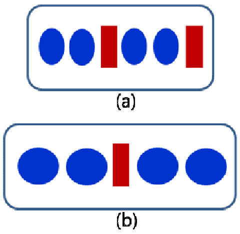

Fig. 5. Focusing structure of (a) low beta cryomodule and (b) high beta cryomodule. (ovals for cavity and rectangles for solenoids)

From the beta function study by using the matched input beam (Fig. 6), we could choose the solenoid field of 4 T in both beta regions. We changed the field of the last solenoid (4.22 T) in the low beta region and that of the first solenoid (5.21 T) in the high beta region for beam matching.

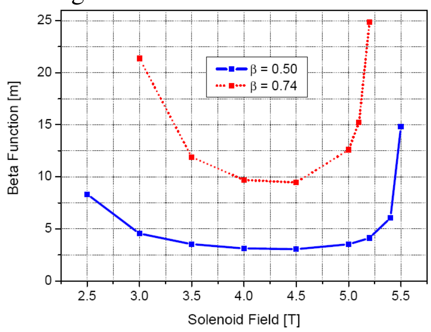

Fig. 6. Beta function of the matched input beam.

The cell phases of the SCL cavities are given in Fig. 7. The synchronous phases in the last 6 cavities are -25°, -15°, -5° in pairs. The phase is -30° for the other cavities. The synchronous phases were adjusted for suitable beam acceleration in the low TTF cavities.

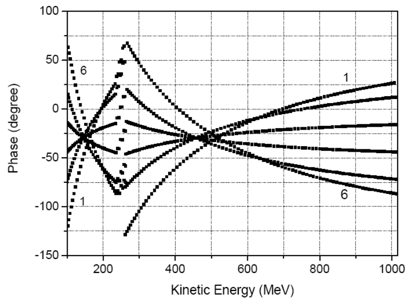

Fig. 7. Phases in each cell of the PEFP SCL cavities.

The information of the matched input beam is given in Table 1. Fig. 8 represents the configuration plot in x-, y-, and Δϕ-spaces. The beam size is less than 6.2 mm. The final beam energy is 1013.6 MeV. The output beam in the phase spaces of x-x', y-y', x-y, and Δϕ-ΔE is given in Fig. 9. Fig. 10 shows the transverse and longitudinal emittances in the normalized rms unit.

Table 1. Matched input beam parameters.

Parameters	Energy	α	β
Values	100 MeV	0.98	2.22 mm/mard

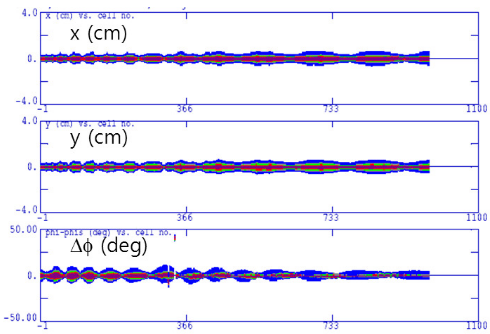

Fig. 8. Configuration plot in x-, y-, and Δϕ-spaces.

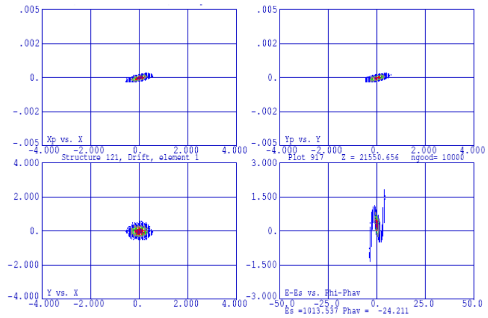

Fig. 9. Output beam in phase spaces.

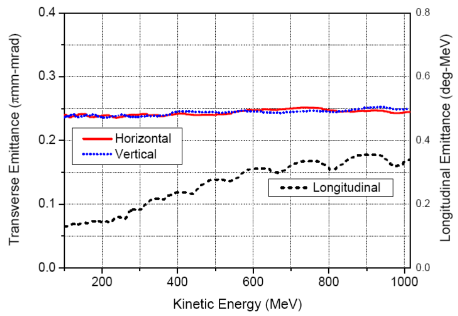

Fig. 10. Transverse and Longitudinal emittances.

3. Conclusions

We studied beam dynamics in the SCL for an extension plan of the PEFP 100-MeV Linac. We used 2 different regions of the design beta of 0.50 and 0.74 with the transition energy of 262.6 MeV. We found that the length of SCL is 216m for 1-GeV acceleration from 100 MeV.

REFERENCES

[1] H. S. Kim, "PEFP SRF R&D for Future Extension", The 15th International Conference on Accelerator and Beam Utilization (2011)

[2] J. H. Jang, H. J. Kwon, H. S. Kim, and Y. S. Cho, "Geometric beta optimization of the SCL for PEFP", KNS autumn meeting (2011) 747.

[3] T. P. Wangler, RF Linear Accelerators, Wiley-VCH, Weinheim, 2008.

[4] J. H. Billen and L. M. Young, "Poisson Superfish", LA-UR-96-1834, Revised September 5, 2002.

[5] H. Takeda, "PARMILA", LA-UR-98-4478.