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Beam Transport for SPring-8 Linac Future Plan

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Abstract

A triple bends and a double bends nondispersive magnet systems are designed for beam transport lines to the assembly hall and to the New SUBARU storage ring. The triple bends system can be tuned as an isochronous system.

1 Introduction

The 1.2GeV SPring-8 linac was completed in August 1996 as the injector for the large synchrotron radiation facility and now provides the electron beam to the booster synchrotron. In October 1997, the use of public beamline of the storage ring will be started. Then the linac will be operated twice a day for the beam injection to the booster synchrotron. In the rest of the time, there are some future plans of linac utilization for various applications. For example, a New SUBARU storage ring [1] beam injection, an inverse Compton scattering [2], a parametrix X-ray generation and a slow positron generation are planned using present linac electron beam. After the improvement of beam characteristics, a single pass FEL operating in the Self Amplified Spontaneous Emission (SASE) [3] mode will be challenged. This paper describes the present and preliminary design of beam transport line where ~1.2GeV electron or positron beam can be utilized.

2 Buildings

Three buildings are being constructed in order to utilize the electron beam of the linac. One is a machine experimental building where the ~250MeV electron beam can be utilized. The others are an assembly hall and the New SUBARU building where the ~1.2GeV electron beam can be utilized. The beam transport line to the assembly hall is called L3 beam transport (L3BT) line, and the one to the New SUBARU storage ring is called L4 beam transport (L4BT) line.

The walls have the thickness of 3m for the L3BT line and the thickness of 1m for the L4BT line respectively for radiation protection. The difference of wall thickness is due to the beam duty. The duty for the L3BT line is average current of 1.6nA (1.2GeV-1ns-1.6A-1pps) with total beam time of 22 minutes per week. While the duty for L4BT line is average current of 12μA (1.2GeV-2μs-100mA-60pps) with total beam time of 17 hours per week.

The construction of the machine experimental building and the assembly hall have been completed. The construction of the New SUBARU building will be completed in fiscal 1997. However the construction of L3 and L4 beam transport building has not been started in September 1997. Figure 1 shows a schematic layout of the SPring-8 linac facility complex. And Fig. 2 is the photograph of present status. The L3 and L4 transport building has extra room for klystrons and modulators which will be used for bunch compressors in the future.

3 Beam Optics

On designing a beam transport line it is necessary to assume the beam characteristics. In the case of the present linac whose electron gun is a conventional thermionic gun, absolute 90% emittances and an energy deviation will be properly assumed as 1πmm·mrad and $\pm$0.5% respectively. Absolute 90% emittances x and y were measured as 0.1~0.7πmm·mrad at the end of the linac. Therefore the value of assumption, 1πmm·mrad, has appropriate margin compared with the actual emittance. If we require a better emittance beam, we can scrape the beam halo using a slit at the nondispersive point. On the other hand an energy deviation will be physically restrained within $\pm$0.5 % using another slit at the dispersive point. This slit will be installed at the large dispersive section where its value of dispersion function is ~2m.

3.1 L3 Beam Transport Line

The L3BT line is designed as a triple bends nondispersive magnetic system. There are three identical 30° bending magnets, and the total bending angle is 90°. These three bending magnets are excited in series. The reason for the triple bends nondispersive magnetic system is to obtain the various characteristics of the electron beam when we utilize the electron beam in the assembly hall. The figure of merit is that we can choose various compression factors. If we want a high peak current beam, this system tuned as a bunch compressor. While if we want small energy deviation beam, this system tuned as an energy compressor.

At present this system is tuned as an isochronous nondispersive system. Its betatron and dispersion functions from the end of the linac to the beam dump are shown in Fig. 3. In this figure the dispersion function x takes negative value around the second bending magnet. And the dispersion function y takes finite value at the beam dump because the electron beam is bent to the beam dump which is installed under the floor.

The magnetic parameters in the dispersive section

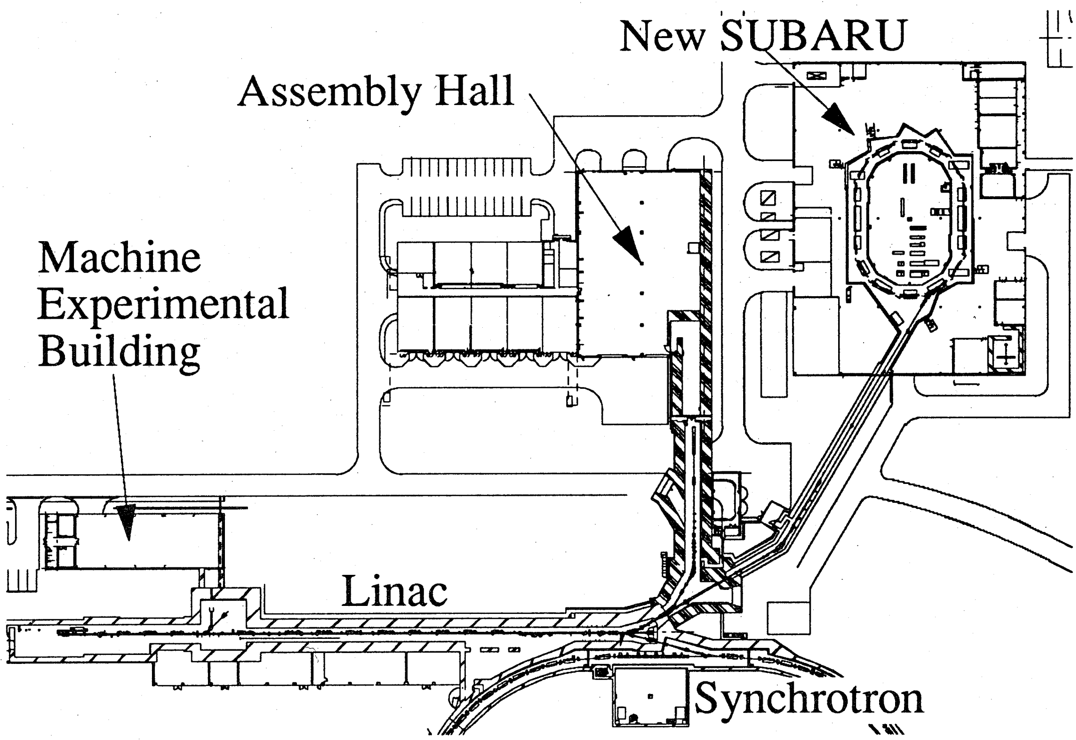

Fig. 1 Schematic layout of the SPring-8 linac facility complex

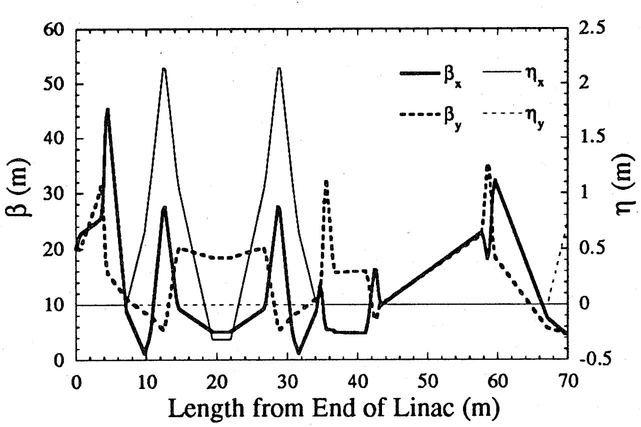

Fig. 3 Betatron and dispersion function of L3 beam transport line

are shown in Table 1. As a principle the magnetic parameters are determined not to exceed more than 30m in betatron function. However in Fig. 3, the value of betatron function exceeds more than 30m. Because a 15° switching bending magnet to the booster synchrotron exits, there is no place to install quadrupole magnets for matching of twiss parameters. The length of this drift space becomes ~2.75m. The bending radius is 4.85m. We apply the maximum magnetic field of 1.25T for this bending magnet, therefore maximum magnetic rigidity becomes 6.07T·m.

3.2 L4 Beam Transport Line

The L4BT line is designed as a double bends nondispersive magnetic system. There are two identical 30° bending magnets, and the total bending angle is 60°. These two bending magnets are excited in series.

On the way of the L4BT line there are a reference point and a border point. The border point is called P-point. The reference point is the optically connecting point between the linac and the New SUBARU storage ring where α_x and α_y are set as 0 (double waist point) and the values of betatron function x and y are ~8m. On the other hand the border point is the mechanical connecting point between the linac and the New SUBARU storage ring. There is a ceramic break for electric insulation. All elements on the upstream of the border are under control of the linac system, and all elements on the downstream of the border are under control of the New SUBARU system. The this system is designed under following concept. One is the stable and apparent connection point. And one is easy operation for parameter survey when the electron beam is injected into the New SUBARU storage ring.

The betatron and dispersion functions from the end of the linac and to the reference point are shown in Fig. 4. And its magnetic parameters in the dispersive section are also shown in Table 1. In order to reduce the number of quadrupole magnets, the dispersion function becomes relatively large.

4 Conclusion

The preliminary design of the L3BT and the L4BT

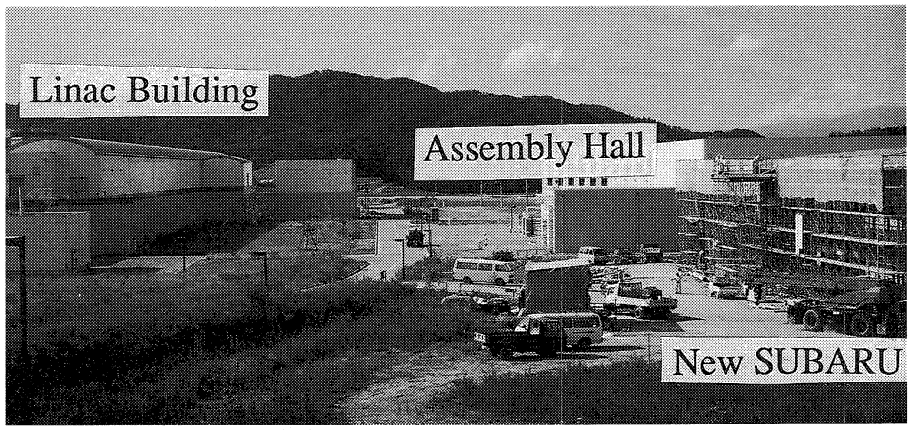

Fig. 2 Present status of around the L3 and L4 beam transport building

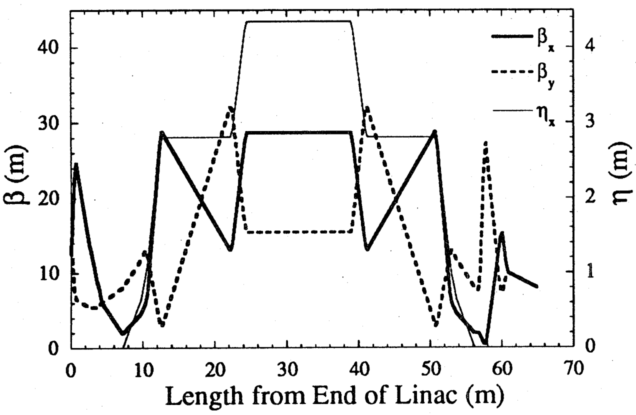

Fig. 4 Betatron and dispersion function of L3 beam transport line

lines were determined. The construction of this transport line will be started soon. Because of the budget problem or things like that, there may be change of the design. However we will construct these beam lines along the concept described in this paper.

References

[1] A. Ando et al., Proc. Particle Accl. Conf. (1997) to be published.
[2] A. Mizuno et al., "Studies of Laser-Beam Interaction at SPring-8 Linac", Proc. of the 11th Sympo. on Accel. Sci. and Tech., Harima Sci. Garden City, (1997) to be published.
[3] K. Yanagida et al., "SPring-8 linac single pass FEL", Proc. of the 18th Int. Free Electron Laser Conf., Rome 1996, to be published.

Table 1
Magnetic parameters for L3BT and L4BT lines in the dispersive section

Element	L3BT Element Length (m)	L3BT ρ (m) K (m^{-2})	L4BT Element Length (m)	L4BT ρ (m) K (m^{-2})
BM	2.540	4.851	2.540	4.851
Drift	0.640		0.640	
QD1	0.300	-0.300	0.300	-1.200
Drift	1.700		1.700	
QF1	0.300	1.801	0.300	1.065
Drift	1.700			
QD2	0.300	-0.900		
Drift	4.725			
BM	2.540	4.851		
Drift	4.725			
QD2	0.300	-0.900		
Drift	1.700			
QF1	0.300	1.801		
Drift	1.700			
QD1	0.300	-0.300		
Drift	0.640			
BM	2.540	4.851		
Drift			9.520	
QD2			0.300	-0.900
Drift			1.700	
QF2			0.300	0.595
Drift			14.422	
QF2			0.300	0.595
Drift			1.700	
QD2			0.300	-0.900
Drift			9.520	
QF1			0.300	1.065
Drift			1.700	
QD1			0.300	-1.200
Drift			0.640	
BM			2.540	4.851