ATF BEAM TRANSPORT LINE

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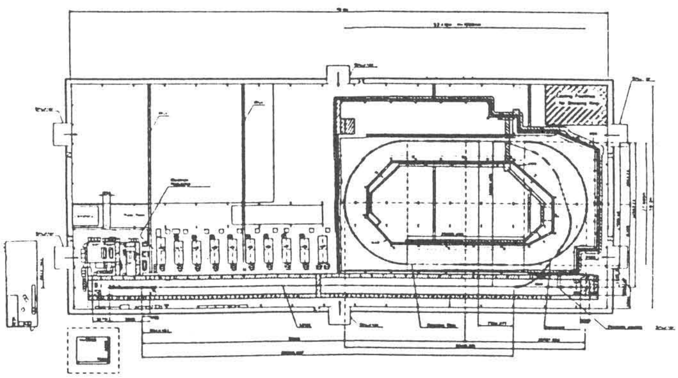

Figure 1: Layout of ATF

Abstract

Optical design of beam transport line, which connects the S-band injection linac and the damping ring of the KEK Accelerator Test Facility(ATF), has been almost finished. The emittance and energy spread of bunch train will be measured by four sets of wire scanners, strip line BPMs and screen profile monitors. Study of the injection system, which consists of kicker and septum magnets, has started with prototype magnets. The method of beam handling between the linac and the damping ring will be discussed.

1. Introduction

The ATF is being constructed at KEK [1]. The ATF has been designed to test the experimental feasibility of the accelerator sub-systems and to confirm the specification of the total accelerator system for JLC(Japan Linear Collider). The JLC is a future project and an electron-positron collider for the energy frontier physics in TeV region [2]. One of the characteristics of the present design of the JLC is to operate in a multi-bunch mode [3,4]. The ATF consists of a $1.54GeV$ S-band Linac, a Beam Transport Line, a Damping Ring, a Beam Test Area, a Test Station for Positron Production and a Computer Control System. Fig.1 shows the layout of the ATF. The 1.54GeV damping ring is the main sub-accelerator system of the ATF. The purpose is to acheive the vertical normalized emittance less than 5.0×10^{-8}radm with high intensity multi-bunch beam.

In the S-band linac we use sixteen 3m-accelerating structures to accelerate the electron multi-bunch beam up to $1.54GeV$ and two 3m-accelerating structures with a slight different RF to compensate bunch-to-bunch energy spread of $\pm 3\%$ due to multi-bunch beam loading until the energy spread less than $\pm 1.0\%$. Details of the ATF $1.54GeV$ linac are reported in other section of this proceedings [5].

The emittance and energy spread of bunch train should be measured to confirm the beam quality from the $1.54GeV$ linac. We are preparing two monitor sections in beam transport line. One is the monitor system which has several sets of wire scanner. Other is the monitor system for the optical matching with the damping ring optics.

The target values of the damping ring are decided as follows;

Beam Energy	$1.54GeV$
Repetition Rate	$25Hz$
Number of BunchesperTrain	20
Number of Trains	5
Number of Particles per Bunch	2×10^{10}
Maximum Total Current	$600mA$
Natural Emittance	$1.2nradm$
Bunch Length	$5mm$
Energy Spread	0.08%
Normalized Emittance with	$Hor.\ 5 \times 10^{-6} radm$
Intra − beam Scattering	$Ver.\ 5 \times 10^{-8} radm$[6]

In order to prevent multi-bunch instabilities we need to use a specially designed RF system. In addition, we would like to operate the ring below the longitudinal microwave instability threshold. To achieve this without increasing the longitudinal emittance significantly, the damping ring must have a very low impedance and a large momentum compaction. Details of the ATF damping ring are reported in [7].

Especially in this article, we would like to report about the beam transport line of the ATF accelerator, which is now intensively under construction.

2. Optics Design

$1.54GeVe^-$ beam from the S-band linac is injected to the damping ring through the beam transport line. The schematic view of the line is shown in Fig.2.

Magnets used are summarized as below;

Dipole magnet

	$length(m)$	$\theta(rad)$	$B(T)$
Horizontal bend	1.45	0.349	1.23
Vertical bend	1.00	0.236	1.20

Quadrupole magnet

$length(m)$	$\max.k(m^-)$	$max.B'(T/m)$
0.18	1.85	52.8

Prototype of these magnets are now under fabrication. The vertical bending magnets are used in the vertical chicane section, which is the first part of the line and to cross under the

Figure 2: Schematic View of the Beam Transport Line

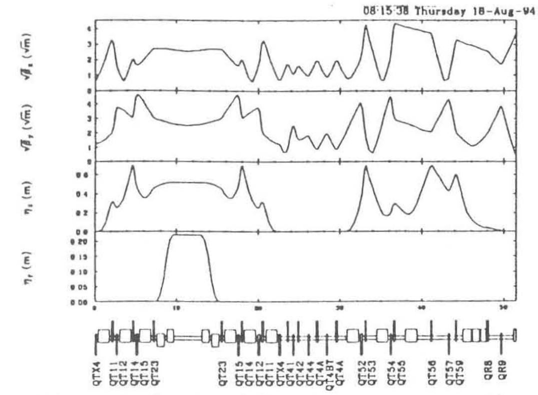

Figure 3: Optics of the Beam Transport Line

damping ring, Magnet configuration in the section is mirror symmetric with respect to the crossing point of the ring, and the vertical dispersion is eliminated except the chicane. In the middle of the line, there is beam diagnostic section. The wire scanners in each space between magnets measure the emittance of the beam. Finnally the e^- beam is injected to the damping ring through three DC septum magnets and a kicker magnet.

Optics of the beam transport line is designed with a computer code SAD developed in KEK [8]. Fig.2 shows the optical parameters along the line.

The phase advance in the diagnostic cell is selected as 90 degrees in both of horizontal and vertical direction. The maximal values of these optical parameters are summarized as follows;

$Max.\beta_x(m)$	$Max.\beta_y(m)$	$Max.\eta_x(m)$	$Max.\eta_y(m)$
18.8	21.7	0.70	0.22

The emittance of e^- from the S-band linac is assumed as $\gamma\epsilon = 3 \times 10^{-4}m$ in both of vertical and horizontal direction. The ATF damping ring has 9 times larger dynamic aperture than this emittance value, namely the dynamic aperture of the ring is 3 times larger in terms of beam size. When discussing about aperture, it shoud be better to use 3 times lager value than beam size(3σ) for safty. It corresponds to 9 times of the emittance($\gamma\epsilon = 2.7 \times 10^{-3}m$). Furthermore we apply a safty factor of 2, we adopt $\gamma\epsilon = 5.5 \times 10^{-3}m$ *i.e.* $\epsilon = 1.83 \times 10^{-6}m$ in the following calculation. With another assumption $\Delta p/p < \pm 0.35\%$ and the tabulated optical parameters above, we have

$$|\eta_x \Delta p/p| + \sqrt{\beta_x \epsilon} < 8.32mm$$

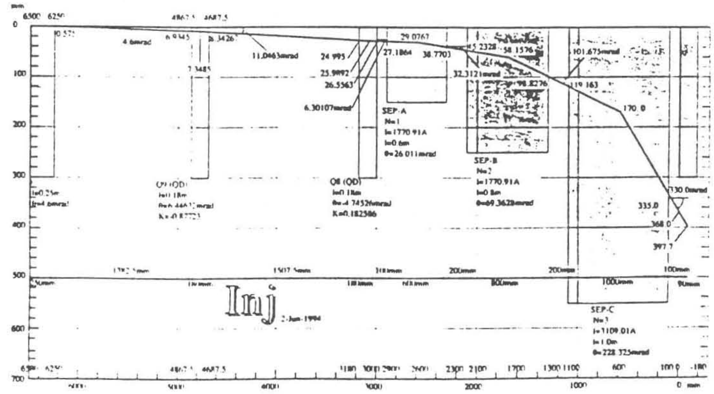

Figure 4: Schematic View of the Injection Section to the Damping Ring

$$|\eta_y \Delta p/p| + \sqrt{\beta_y \epsilon} < 7.07mm$$

Inner radius of the vaccum chamber is 14mm, so the above values allow a few mm orbit distortion.

3. Monitors and Beam Handling

Along the beam transport line, there are three screen monitors, ten strip line beam position monitors(BPMs) and eight wire scanners.

We can see the beam profile directly by the fluorescent light from the screen monitors. The information of the beam profile may be used for the optical matching between the S-band linac and the transport line. Since the screen monitor destroys the e^- beam, tuning with them will be unusual.

With strip line BPMs, beam orbit distortion can be measured. The orbit distortion is corrected with seven vertical corrector magnets and five horizontal corrector magnets. In addition to those magnets, we can utilize nine horizontal bending magnets and four vertical bending magnets, because these bending magnets have auxiliary coil and are adjusted independently. Measurement data from the BPM located at non-zero dispersion region also give an information about the energy deviation, which is useful for the energy tuning of the linac. The strip line BPM does not destroy the e^- beam, so the beam orbit tuning will be done anytime.

Finally we would like to measure the emittance of e^- beam before injection to the damping ring. The emittance measurement will be done by wire scanners in the diagnostic section [5]. In the section, a wire scanner located at each space between quadrupole magnets, so each scanner is separated by 45 degrees in phase advance each other. For emittance measurement, at least three wire scanners are needed. We start with four wire scanners, one of which is used for a cross-check. The number of the monitors will be increased to eight in the future.

4. Injection Section to the Damping Ring

Fig.4 shows the schematic view of the injection section to the damping ring, the end part of the beam transport line.

The section consists of three DC septum magnets and a kicker magnet. Between the final septum magnet and the kicker magnet, e^- beam goes through two quadrupole magnets of the damping ring.

A prototype of the final septum magnet(SEP-A) has been fabricated. Specification of the septum magnet is as follows;

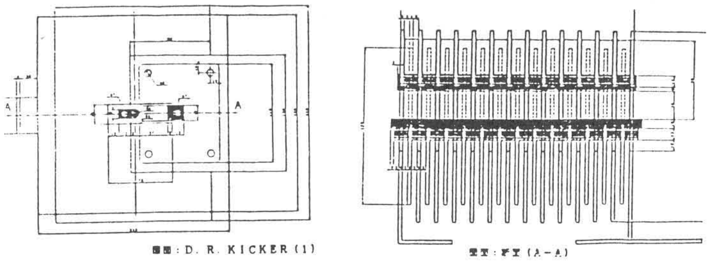

Figure 5: 2 Dimensional View of the Kicker Magnet

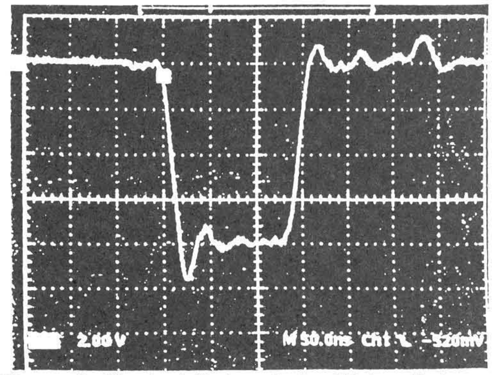

Figure 6: Typical Pulse of the Kicker Pulser

Septum Magnet A

Field Strength	$2.5kG$
Current	$2000Aturn$
Pole Length	$600mm$
Bending Angle	$23.5 \times 10^{-3} rad$
Pole Gap	$10mm$

Fig.5 shows 2 dimensional view of the kicker magnet. Specification of the kicker magnet is as follows;
Kicker Magnet

Gap Height	$17mm$
Gap Width	$32mm$
Length	$500mm$
Impedance	50Ω
Maximum Current	$800A$
Maximum Field Strength	$591G$
Filling Time	$30nsec$
Rise&Fall Time of B	$60nsec$
Maximum Voltage	$40kV$
Core Material	*Ferrite TDK PE*14

A prototype pulser for the kicker magnet has been tested to check the rise and fall time of the pulse. It is required to be less than 30nsec. Fig.6 shows an typical pulse of the pulser. The picture is scaled as 200A/div and 50nsec/div in vertical and horizontal direction, respectively. It shows the requiement for the rise and fall time of the pulse is satisfied. The pulse shape shown in the figure, however, is still ugly in flat-top and after-pule region. So we will continue study of impedance matching, pule-shaping and so on.

5. Summary

Design of the ATF beam transport line has been almost finished. Studies of the components such as monitors and magnets are in progress. Vacuum chambers are in fablication. Two thirds of the line except the injection section will be constructed by Autumn of 1995, and then study with real e^- beam will begin.

Acknowledgments

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