EXTRACTION SYSTEM OF TRISTAN ACCUMULATION RING AND TRANSPORT LINE TO MAIN RING

M. Kikuchi, K.Ebihara, H.Nakayama, Y.Sakamoto, and K. Satoh

KEK, National Laboratory for High Energy Physics
Oho, Tsukuba, Ibaraki, Japan 305

1. Introduction

In TRISTAN accumulation ring (AR), electrons and positrons are accerelated up to 8GeV, then extracted and transported to main ring (MR). The electron and positron beams have the same structure in magnet arrangements for extraction system and transport lines. (Fig.1). The level difference between AR and MR is 7.44 m, therefore in each transport line four vertical bending magnets are used to translate the beam without changing its direction.

In this paper we describe a basic design of beam extraction system from AR and the transport lines to MR. We restrict ourselves to the case of electrons because of a similarity of the extraction and/or the transport system for electrons and positrons.

2. Beam Extraction System

Extraction system has four different types of magnet i.e., bump, fast-bump, kicker, and septum magnets. The first three magnets are in the AR (Fig.2). Bump and fast-bump magnets are used to generate a closed bump orbit, which reduces the deflecting angles of kickers. These kicker magnets kick out the beam into the aperture of the septum magnet. Four bump magnets are DC magnets, three of which are the back-leg windings of bending magnets of AR. An available maximum bump at the extraction point is limited by a quantum life time τ_q and a duration time of bump orbit τ_b ; $\tau_q >> \tau_b$. The τ_q is governed by an aperture i.e.,the distance between the beam and vacuum chamber wall, through the equation

$$\tau_q = (\tau_x/2)(2/n^2)\exp(n^2/2),$$

$$n = A/\sigma_x$$

where A, σ_x and τ_x are the aperture, half-width and damping time of the beam, respectively. The values of σ_x and τ_x are σ_x = 3.54 mm at QC6 and τ_x =1.33 msec, which are the design values of AR at an 8 GeV operation. We assume that τ_b =2 sec. From these values we obtain the maximum bump of 27.3 mm. In order to get larger bump without significant beam loss, it is necessary to use pulse bump magnets, namely, 'fast-bump' of which pulse-width is several ten milliseconds.

The deflecting angle of three kickers are, using this bump system, about 3 mrad and the full pulse width is 1.26 μsec under the two-bunch operatin of AR. Three septum magnets must totally deflect the extracted beam by about 110 mrad to guide it to the transport line. The design value of the deflecting angle of these magnets are given in table 1. The bump, fast-bump, kicker and the extraction orbit are shown in Fig. 2.

3. Transport line

Transport line to MR consists of horizontal bending, vertical bending (VB), quadrupole and correction magnets. The inner diameter of the vacuum chamber is 47 mm.

Fig. 3 shows the betatron and dispersion functions calculated by the program 'MAGIC'. The value of the emittance and momentum spread of the extracted beam were assumed to be 0.5 mm mrad and 0.15 %. In this calculation, strength of thirteen quadrupoles were used as free parameters. Maximum beam width 3 σ was 21.3 mm. We evaluated Twiss parameter and dispersion at the entrance from that of the standard optics of AR taking into account of a finite aperture of QC6 located just before the extraction point. (We will discuss later on this effect.) We suppressed a vertical dispersion generated by VB to zero at the end of the last VB, by making this part of the line a perfect 2π-section. At the end of transport line, a horizontal dispersion was set to be zero, which is equal to that of injection point of MR. We did not match the emittance ellipse at the end of the line. If necessary, the last two quadrupoles can be used for this purpose.

The QC6 magnet at the extraction point, which is a focusing Q, has an effective aperture of x= 50 mm. On the other hand an extracted beam traverses the QC6 at x=65 mm (see Fig.2), therefore the beam effectively feels a weak defocusing Q-field and higher-order multipoles which distort the emittance ellipse. The effect of the weak defocusing Q-field could be compensated for mainly by the first two Q-magnets in the transport line. However, the effect of higher-order multipoles could not be compensated for by the transport line magnets. The latter effect was estimated by tracking calculations: less than 10 % of the beam may be lost in the transport line. If a beam loss of 10 % becomes a serious problem in actual operations, the QC6 should be replaced with a larger aperture Q-magnet.

Table 1
The parameter of the extraction magnets

kind of magnet	No. of magnet	max. deflection angle
bump	4	2.6 mrad
fast-bump	3	2.56 mrad
kicker	3	0.98 mrad
septum	3	38.8 mrad

Table 2
Magnet parameters of the transport line

kind of magnet	No. of magnet	magnet length	max. field strength
H. bend	14	1.0 or 1.8 m	1.13 T
V. bend	4	1.8 m	1.10 T
Quad.	24	0.6 m	13.4 T/m

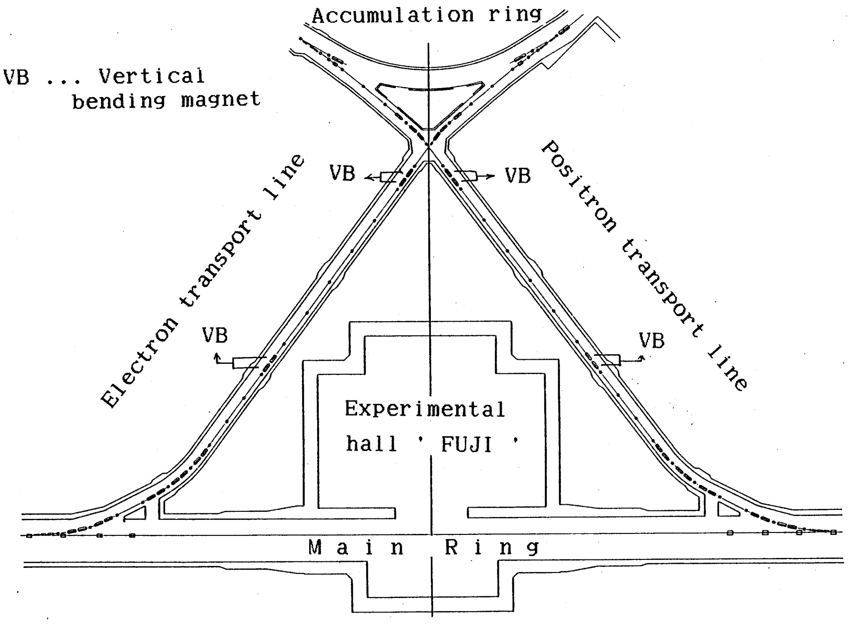

Fig. 1
Transport lines from accumulation ring to main ring

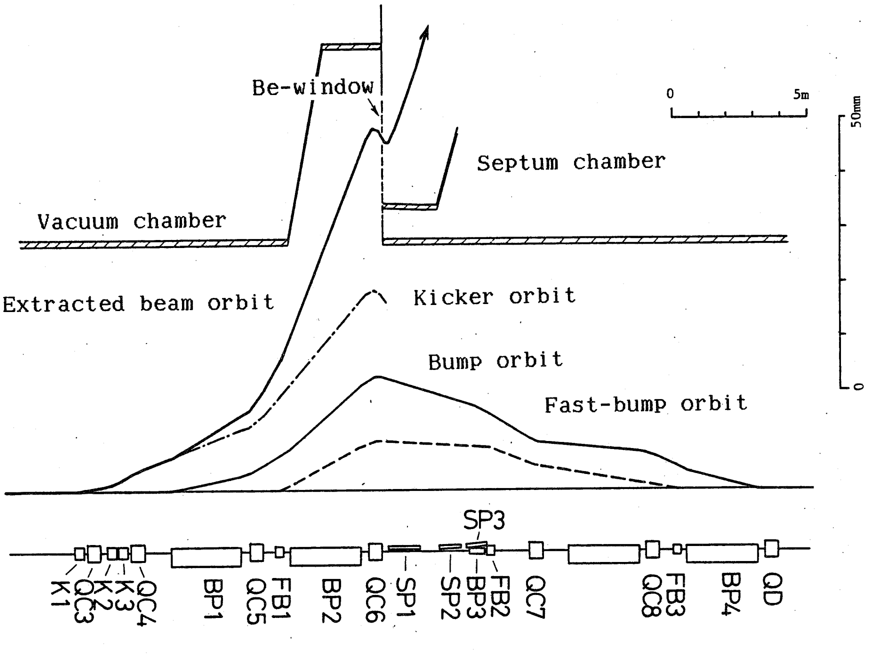

Fig. 2
The extraction system for electrons

SP ... Septum magnet
BP ... Bump magnet
FB ... Fast-bump magnet
K ... Kicker magnet
Q ... Quadrupole magnet

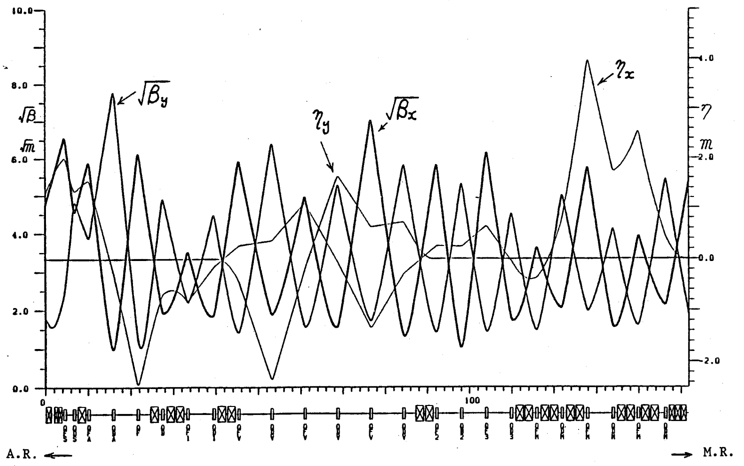

Fig. 3
Betatron and dispersion functions for electron transport line