PULSE MAGNETS FOR THE EXTRACTION FROM TRISTAN AR AND THE INJECTION INTO TRISTAN MR

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

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

ABSTRACT

Pulse magnets for the extraction from TRISTAN AR and the injection into TRISTAN MR have been successfully designed and constructed. The fieid measurements have been performed by using pick-up coils and a Hall-probe.

INTRODUCTION

In TRISTAN Accumulation Ring (AR), electron and positron beams are accelerated up to 8 GeV at most, then extracted from AR, transported in the transport line and finally injected into Main Ring (MR). The whole system of the extraction from AR and the transportation to MR was described in the previous paper [(1)].In this paper we report designs and characteristics of pulse magnets for extraction from AR and injection into MR. The extraction system from AR and the injection system into MR are designed almost symmetrically for electron and positron. Therefore in the following description we will mention only about pulse magnets for electrons for simplicity.

REQUIREMENT TO MAGNETS

For the extraction from AR or the injection into MR, two different types of pulse magnets are used; *i.e.* kicker and septum. Kicker magnets in the AR ring kick out a electron bunch from AR to a aperture of a septum magnet. At this time, DC magnets called bump ,which make closed bump orbit near the extraction point, are also excited in order to reduce the deflecting angles of kickers. The electron bunch kicked out from AR is deflected by the septum magnets and guided to the transport line. The electron bunch is carried along the transport line and deflected again by other septum magnets to be guided to the injection orbit in MR. On the other hand kicker magnets in MR are used to make closed bump orbit near the injection point in MR together with the bump magnets and to reduce injection error.

The maximum deflection angle required to the kickers and septums are listed in Table 1. These required values were determined by considering the optics used in AR, MR and the transport line, locations of kickers in AR or MR, the size of bump orbit made by the bump magnets and the geometrical design of the connection of the transport line to AR or MR. In addition to these requirement it is also required that the fields of kickers in AR must rise up in about 1.26 μsec (the revolution period of AR) and the rise and decay time of those of kickers in MR must be about 10 μsec (the revolution period of MR). Furthermore it is also demanded that the coils of the septum should be as thin as possible in order to reduce the deflection angles of kickers in AR or the injection error in MR and that the stray field of the septums outside the coil should be suppressed so as not to influence circulating beams.

DESIGN OF MAGNETS

The pulse magnets for AR extraction and MR injection system were designed in accordance with the requirements mentioned in the previous section. Table 2–4 show design parameters of the magnets. In designing magnets, we paid attention to following respects:

AR extraction kicker

Window frame type was chosen as the magnet core type because of ease and reliability in construction. For the core material ferrite (TDK PE12C) was adopted because of good characteristics for high frequency, since considerably fast rise time of magnetic field is demanded (about 1.26 μsec).

MR injection kicker

The design of MR injection kicker is very similar to that of AR extraction kicker except that laminated silicon steels with 0.1 mm in thickness are chosen for the core material rather than ferrite and that the coil is 4 turns. These differences come from the following respects; rather high magnetic field is required compared with AR extraction kicker (see the previous section) and required field is not achievable by using kickers with ferrite cores due to saturation. The use of laminated silicon steels is possible because the required time characteristics is rather slow (about 10 μsec of rise and decay time).

AR extraction septum

Three septum magnets were constructed for electron extraction, in which two of three magnets are septum II and the rest one is septum I. Main difference between two types is that septum I has one turn coil, but the coil of septum II is two turns. This is because septum I is installed very close to the AR ring and its coil is necessary to be as thin as possible for the reaseon mentioned above. The coil thickness is 4 mm. The core material is laminations of silicon steel with 0.35 mm in thickness. A laminated silicon steel with 0.5 mm in thickness is attached to the coil and plays the role of shielding the magnetic field. The coil is cooled by water in order to prevent the coil from heating by synchrotron light from AR.

MR injection septum

The designs of MR injection septums are almost the same as those of AR extraction septums except for the following two points. The first difference is that coils are cooled not by water but only by air, because the transported beam is injected into MR from inside the ring and so it is not necessary to consider the heating by synchrotron light from MR. The second is that the core length of septum II is longer than that in the case of AR extraction, since larger total deflection angle by septums are required than that by AR extraction septums.

FIELD MEASUREMENTS

Kicker magnet

To check field quality of kickers, following three kinds of measurements have been performed.

(1) Excitation curves were taken by using a short pick-up coil(5 ϕ,10 turns).
(2) Measurements to get Bl values were measured with a long pick-up coil(500 mm in length and 3.5 mm in width, 1 turn).
(3) Fringe field distributions were measured with the short coil.

In these measurements fields were measured only in the horizontal planes which contain the centers of the apertures. Signals from pick-up coils were integrated by a passive integrator, amplified by a differential amplifier(TEXTRONIX AM 503) and analyzed by a multi-channel analyzer(CANBERRA MODEL 3100). The relative errors of measurements with this system would be less than 1 %. The absolute values of the fields were not measured, since a Hall- probe is not avalable in this type of magnets. (At the first beam test with these kickers, it was comfirmed that the magnetic field excited by those kickers are consistent with the designed values.) The pick-up coils were driven by pulse mortors(NIPPON PULSE MOTOR PJ80). The position resolution of the coils were less than 0.1 mm. The pulse currents of AR extraction and MR injection kickers were monitored by Rogowski coils and current transformers in power sources respectively and the errors of the monitored values would be less than a few percents. Fig. 1-3 show the results of field measurements.

Septum magnet

The following four types of field measurements have been done for septum magnets.

(1) The exitation curves were taken using a Hall-probe (Siemens FA 22 e).
(2) Fringe field distributions were measured with a short pick-up coil.
(3) Field distributions in transverse direction were also measured with the short pick-up coil.
(4) The stray fields outside the coils were measured using the short pick-up coil.

The measuring system with the short pick-up coil is almost the same as that for the kickers. The errors of the measurements by using the Hall-probe would be less than a few percents. The pulse currents were monitored by current transformers in power sources and the errors of monitored values would be less than a few percents.

Fig. 4-6 show the results of measurements. As is shown in Fig. 6, it was comfirmed that the stray field outside the coils scarcely influence circulating beams.

REFERENCE

1) M.Kikuchi et al. Proc. 5th Simpo. on Accelerator Science and Technology, Sep. 1984 (KEK, Tukuba, 1984) p.306.

Table 1

Maximum Deflection Angles

kind of magnet	No. of magnet	max. deflection angle
AR ext. kicker	3	1 mrad
MR inj. kicker	4	3 mrad
AR ext. septum I	1	40 mrad
AR ext. septum II	2	40 mrad
MR inj. septum I	1	43 mrad
MR inj. septum II	2	61 mrad

Table 2

Design parameters for kickers

AR extraction kickers

core length	300 mm
pole width	114 mm
gap height	68 mm
max. peak current	7000 A
max. peak field	1.3 kGauss
number of turns	1 turn
inductance	1.6 μH

MR injection kickers

core length	300 mm
pole width	198 mm
gap height	72 mm
max. peak current	5500 A
max. peak field	3.8 kGauss
number of turns	4 turns
inductance	20 μH

Table 3

Design parameters for AR extraction septums

septum I

core length	1200 mm
pole width	75 mm
gap height	16 mm
max. peak current	11400 A
max. peak field	0.90 T
number of turns	1 turn
inductance	6.7 μH
cooling	water
pulse width	2 msec

septum II

core length	800 mm
pole width	75 mm
gap height	16 mm
max. peak current	8600 A
max. peak field	1.35 T
number of turns	2 turn
inductance	19 μH
cooling	water
pulse width	5 msec

Table 4

Design parameters for MR injection septums

septum I

core length	1200 mm
pole width	75 mm
gap height	16 mm
max. peak current	14500 A
max. peak field	1.14 T
number of turns	1 turn
inductance	7.2 μH
cooling	air
pulse width	2 msec

septum II

core length	1200 mm
pole width	75 mm
gap height	16 mm
max. peak current	10000 A
max. peak field	1.57 T
number of turns	2 turn
inductance	28 μH
cooling	air
pulse width	5.5 msec

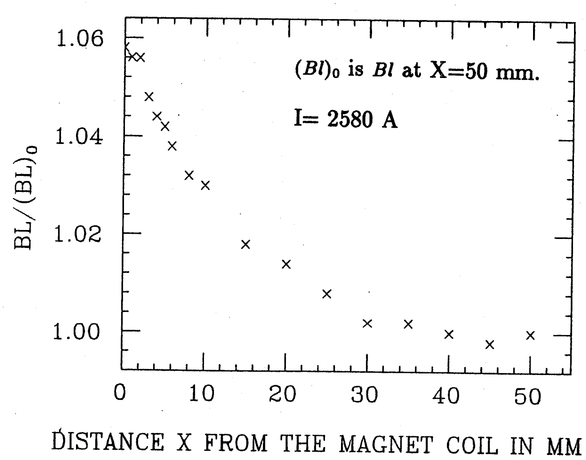

Fig. 1 *Bl* value of AR extraction kicker

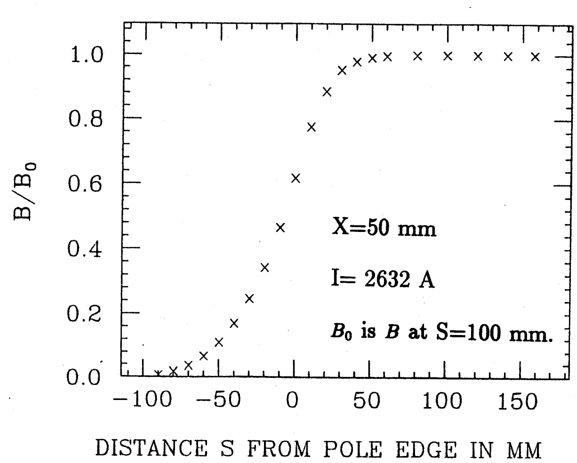

Fig. 2 Fringe field distribution for AR extraction kicker

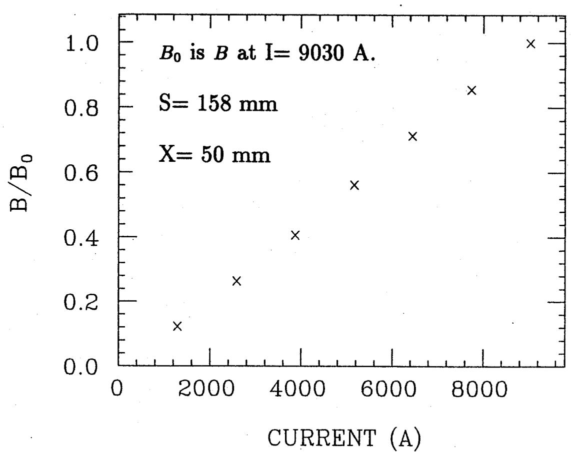

Fig. 3 Excitation curve for AR extraction kicker

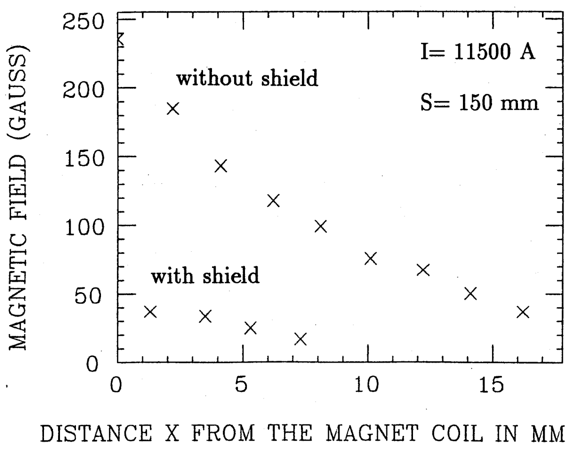

Fig. 6 Stray field outside the coil for AR extraction septum I

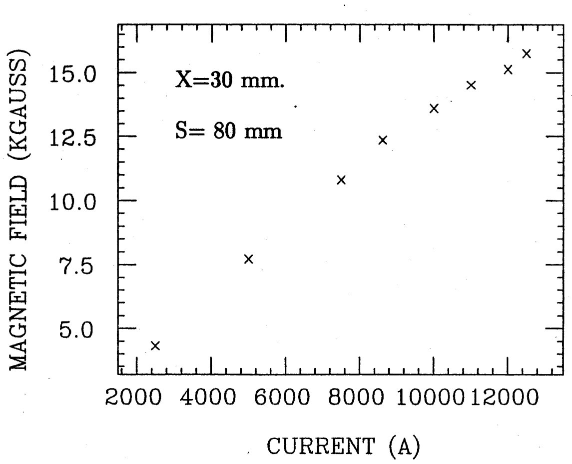

Fig. 4 Excitation curve for AR extraction septum II

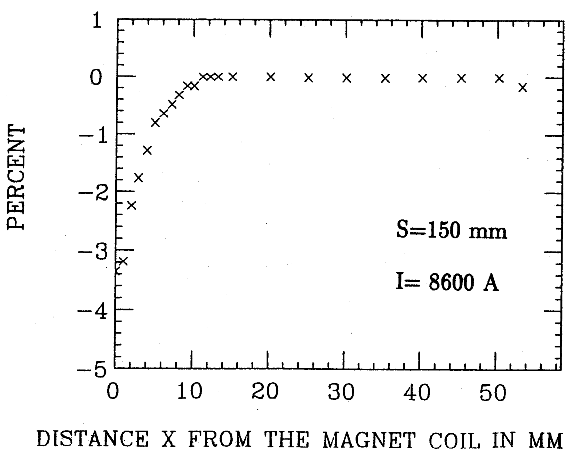

Fig. 5 Fringe field distribution for AR extraction septum II