Status of TRISTAN-II Project

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Abstract

TRISTAN-II (B-Factory) project at KEK aims at constructing an accelerator complex which enables us to detect the CP-violation effect at B-mesons. It is a 3.5 x 8 GeV electron-positron collider in the existing TRISTAN tunnel. The eventual luminosity goal is 10^{34} cm^{-2}s^{-1}. Progress of design work and present status of R&D are reported.

I. INTRODUCTION

The design of the B-Factory at KEK has converged to that on the basis of existing TRISTAN[1], hence the name TRISTAN-II: Two rings of the TRISTAN-II are to be installed in the existing TRISTAN tunnel and the infrastructure of TRISTAN should be maximally utilized. The 2.5 GeV electron linac will be upgraded to 8 GeV in order to inject 3.5 GeV positrons and 8 GeV electrons directly into TRISTAN-II and to produce a sufficient positrons necessary for TRISTAN-II.

We plan to increase the luminosity of the B-Factory in two steps[2]. We first employ a small-angle (± 2.8 mrad) crossing scheme (step 1). In this step we cannot fill the whole bucket with beam, since we need a length for separation of electrons and positrons to avoid spurious collisions; therefore, every fifth bucket is filled with beam. Three meter bunch spacing in this case is long enough to install beam separation equipment, such as separation dipole magnets. The luminosity of step 1 is 2×10^{33} cm^{-2}s^{-1}. In the second step, we fill every bucket with beam by introducing a large-angle crossing (~± 10 mrad) with crabbing[3,4]. The luminosity will be increased by a factor 5 to 10^{34} cm^{-2}s^{-1}. The machine parameters for both steps are essentially unchanged except the bunch spacing and the total current. The same lattice is used for both steps with minor changes of the interaction region. The main parameters are given in Table 1. The values in parentheses correspond to those for step 1.

As shown in Fig.1 the detector will be installed at Fuji Experimental Hall of TRISTAN, which is occupied now by VENUS detector. The superconducting solenoid magnet and outer-layer ion structure of VENUS will be used for the B-Factory detector with some slight modifications; inner part of the detector will be completely renewed. Electrons and positrons are injected from the upgraded linac to TRISTAN-II at straight sections on both sides of the collision point. Figure 2 illustrates the cross sections of the tunnel for TRISTAN-II.

II. RF SYSTEM

A. Normalconducting RF cavity

To prevent the coupled bunch instabilities we need a special cavity which has small HOM impedance. We have been studying a two-cell damped cavity[5], which was first proposed by R. B. Palmer[6]. The basic idea of the damped cavity is that the HOM field is guided to waveguides attached to the side of the cavity through slots cut on the disk between cells; the cutoff frequency of the waveguide is set higher than the fundamental accelerating mode frequency.

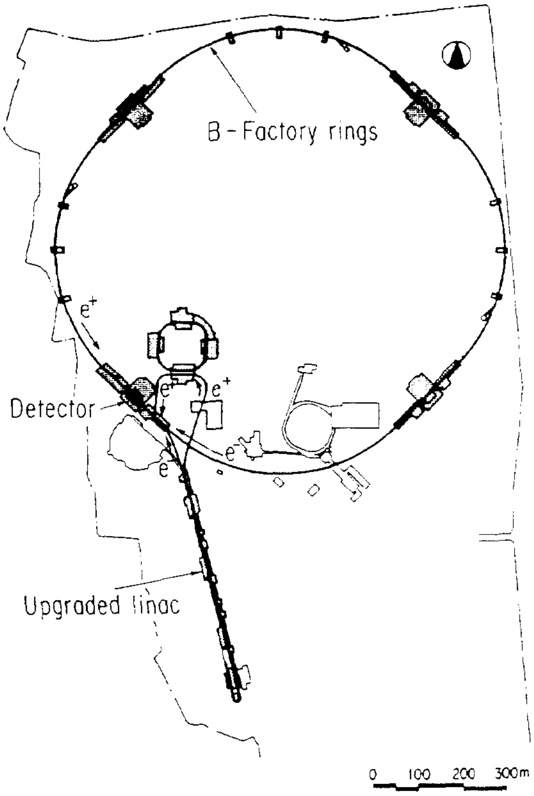

Fig. 1. Layout of TRISTAN-II within the KEK site.

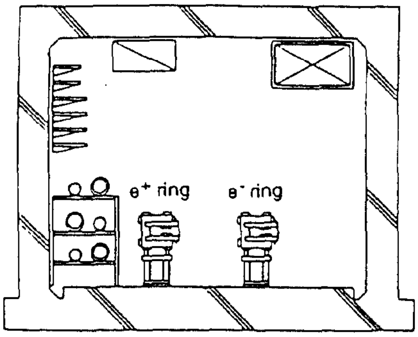

Fig. 2. Cross sections of the tunnel for TRISTAN-II.

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Table 1 Main parameters of TRISTAN-II

	LER	HER	
Energy	3.5	8.0	GeV
Circumference	3018		m
Luminosity	$1\times10^{34}(2\times10^{33})$		$cm^{-2}s^{-1}$
Tune shifts	0.05/0.05		
Beta function at IP	1.0/0.01		m
Beam current	2.6 (0.52)	1.1 (0.22)	A
Natural bunch length	0.5		cm
Energy spread	7.8×10^{-4}	7.3×10^{-4}	
Bunch spacing	0.6(3.0)		m
Particles/bunch	3.3×10^{10}	1.4×10^{10}	
Emittance	19/0.19		10^{-9}m
Synchrotron tune	0.064	0.070	
Betatron tune	~ 39	~ 39	
Momentum compaction	8.8×10^{-4}	1.0×10^{-3}	
Energy loss/turn	0.91	4.1	MeV
RF voltage	20	47	MV
RF frequency	508		MHz
Harmonic number	5120		
Damping decrement	2.6×10^{-4}	5.1×10^{-4}	
Bending radius	15.0	91.3	m
Length of bending magnet	0.42	2.56	m

Values in parentheses are for step 1.

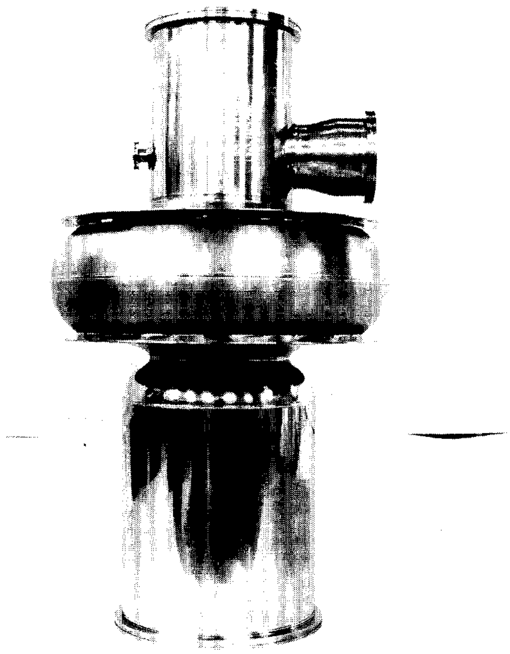

Fig. 3 Full-size Nb model cavity.

The first prototype damped cavity has been completed and a low-power test is now under way. Q-values of the most dangerous modes, TM110-π and TM011-π, were found to be as small as 41 and 14.

As an alternative of the two-cell damped cavity, the design of the choke-mode cavity[7] is under way at KEK.

B. Superconducting RF Cavity

After having determined the optimized shape of the cavity by computer calculation a full-size aluminum model was manufactured and resonance spectra of the cavity were measured with and without ferrite absorbers (TDK IB-004). The loaded Q values of most modes were ~ 100 or less with absorbers, except two harmless quadrupole modes, TM210 and TE211.

A full-size Nb model with this optimized shape was constructed (see Fig. 3) and tested in a vertical cryostat. The maximum accelerating field obtained was 11 MV/m with the Q value of 10^9 (see Fig. 4).

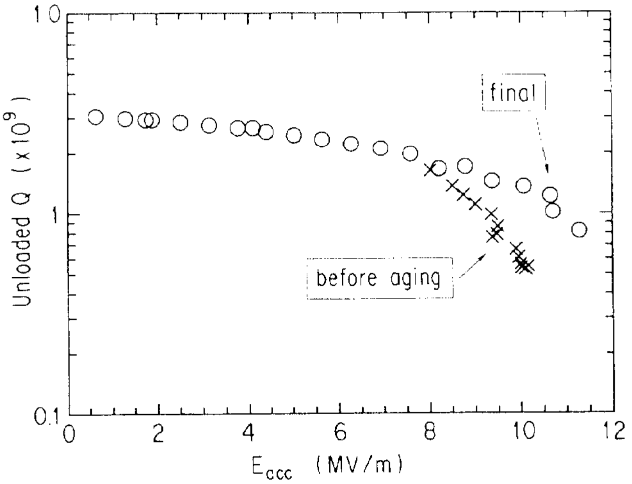

Fig. 4. The result of the vertical test of the prototype Nb cavity.

C. Energy Storage Cavity

Extremely heavy beam loading to the cavity, together with the small revolution frequency, leads to a quite violent longitudinal coupled-bunch instability due to the fundamental mode of accelerating cavities. The most straightforward way to avoid this instability is to employ superconducting cavities, since a large storage energy mitigates the beam loading. T. Shintake of KEK proposed to add an energy storage cavity to the accelerating cavity cell[8]. This storage cavity effectively enlarge the stored energy and makes the cavity system stronger against beam loading; no RF feedback[9] is necessary even for normal conducting cavities. We are investigating the feasibility and applicability of the idea to TRISTAN-II.

III. VACUUM SYSTEM

A trial model duct was fabricated. The duct is straight and 3.7 m long and consists of a beam channel (100 mm in width and 50 mm in height), a pump channel and a cooling channel. The duct material is Oxide Free Copper provided from HITACHI Cable, Ltd. Each channel was independently extruded in a circular pipe shape with a proper size and then extracted to its design shape. They were welded each other by EBW. The thermal gas desorption rate and photodesorption coefficient of the duct were measured[10].

IV. SEPARATION DIPOLE MAGNET

The separation superconducting dipole magnets will be installed close to the vertex detector and the precision drift chamber. In order to reduce the leakage field, this magnet has two layers of $\cos\theta$ windings[11]. As shown in Fig. 5, the leakage field from the longitudinal end part of the magnet at the detector is less than 50 Gauss.

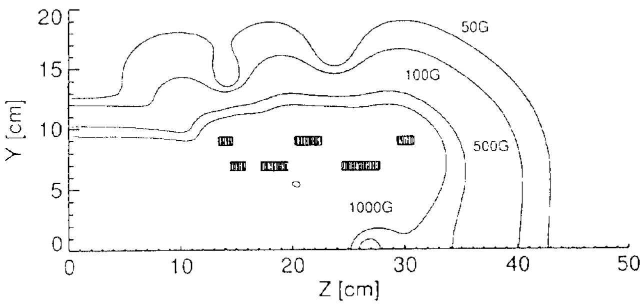

Fig. 5. Leakage field near the longitudinal end part of the separation superconducting dipole.

V. LINAC UPGRADE

Present 2.5 GeV linac will be upgraded by adding accelerating structures and changing 20 MW klystrons to 60 MW ones. SLEDs are used to increase the field gradient. After this upgrade, the linac can accelerate 8 GeV electrons, which will be injected directly into HER. Positrons are produced by 4 GeV electrons and accelerated up to 3.5 GeV before being injected directly to LER. If we assume a normalized yield of positrons to be 2%/1 GeV electron, the intensity of positrons produced by 4 GeV electrons of 4×10^{10} per pulse amounts to 3.2×10^{9} per pulse; this corresponds to 1000 sec injection time to LER.

VI. MACHINE STUDY PLAN

A. Beam Test of RF Cavities and Feedback Systems at the TRISTAN AR

Three-month long beam test is planned to be held in spring of 1995 by the use of TRISTAN Accumulation Ring (AR). We plan to store more than 500 mA electron beam in AR with a multibunch mode at 2.5 GeV. The bunch spacing is 10 nsec and the total number of bunches amount to 128. To accumulate this high current, the existing APS type RF cavities will be removed temporally from the ring and a normal conducting damped cavity and a single cell superconducting cavity will be installed. The transverse and the longitudinal feedback systems will be also installed. An IR beam pipe close to the one used for TRISTAN-II will be installed to check the heating due to the beam.

B. Dynamic Aperture Study

We plan to adopt the non-interleaved sextupole scheme for the purpose of keeping enough (transverse) dynamic aperture[12]. Since this sextupole scheme has never been adopted in real machines, we must be very careful introducing this scheme. We have a plan to carry out a machine study on this scheme in this autumn at TRISTAN which needs a dedicated machine time of about a month. Measured and calculated dynamic aperture will be compared.

VII. PROSPECTS

TRISTAN-II project at KEK is regarded as the third phase of TRISTAN. After having pursued the energy frontier by increasing the beam energy from 25 GeV to 32 GeV, the TRISTAN has stepped into its second phase from February 1990, where we put the stress on accumulating as large an integrated luminosity as possible at a modest energy (29 GeV). The goal is to accumulate 300 pb^{-1} integrated luminosity. By the end of 1994 this goal will be reached. We envision that construction of TRISTAN-II will start from April 1994 and by the end of 1998 the commissioning will take place.

VIII. REFERENCES

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