TRISTAN

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TRISTAN[1] is a KEK future project which aims at high-energy colliding beam physics of various types such as $e^{\mp}p$, pp, $e^{-}e^{+}$ and $p\bar{p}$ by constructing a set of intersecting storage accelerators. The nickname of TRISTAN comes originally from "Tri-Ring Intersecting Storage Accelerators in Nippon". In the initial design, three rings are to be constructed in the same tunnel; two superconducting storage accelerators of 180 GeV in maximum energy and a conventional magnet ring of about 50 GeV. The proton injector for TRISTAN is the present KEK 12 GeV proton synchrotron. The conventional magnet ring serves as a proton booster for the superconducting storage accelerators. After the proton stacking is completed in the superconducting storage accelerator, the conventional magnet ring can be filled with, for example, an electron beam to provide a possibility of ep collisions. The TRISTAN project is divided into two stages, Phase I and Phase II, from consideration of financial and technical feasibilities.

The initial design was followed by extensive discussions among the particle physicists and the accelerator physicists, resulting in a general agreement that $e^{\mp}p$ collisions have the first priority in the Phase I of TRISTAN. As for an electron injector, we will make use of the 2.5 GeV electron linac[2] of the Photon Factory project,[3] which is to be constructed in KEK site. With the 12 GeV proton synchrotron now launched off[4] and the 2.5 GeV electron linac at hand, our next step is to realize high-energy $e^{\pm}p$ collisions.

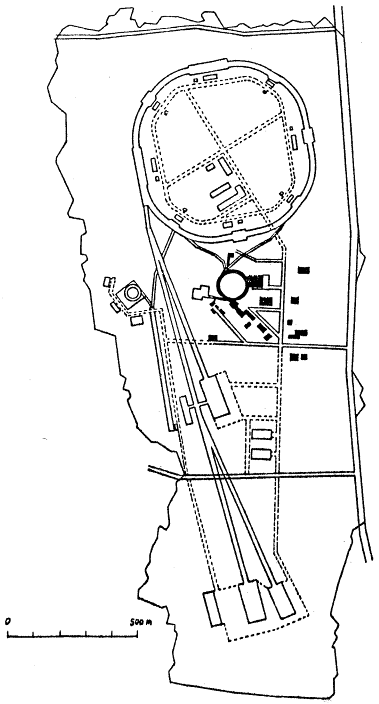

Fig.1 Layout of TRISTAN

Design works on TRISTAN have been undertaken by many people, covering various fields of accelerator science. A detailed description of TRISTAN ep facility will be found in "TRISTAN Design Report I".[5] In the following we shall present an outline of TRISTAN ep facility briefly.

Outline of TRISTAN ep Facility

In the Phase I of TRISTAN, we will have two rings, Ring I and Ring II, which are assumed to be placed on the same horizontal plane. Fig.1 shows a general layout of TRISTAN rings in the KEK site, together with the 12 GeV proton synchrotron (hereafer abbreviated as KEK-PS) and the Photon Factory facility. Protons extracted from KEK-PS are injected into Ring I, accelerated from 12 GeV to 70 GeV, and rf-stacked in Ring II. When the required number of protons is stacked in Ring II, electrons or positrons are filled in Ring I from the 2.5 GeV linac up to the required intensity, accelerated to 16 GeV, and stored in Ring I. Then, the two beams in Ring I and Ring II are made to collide.

At present, the general consensus lies in that Ring II also is made of conventional magnets in view of relatively slow developemnt of superconducting magnet technology in Japan. Afterwards, one or two superconducting magnet rings will be added in the same tunnel to raise the proton energy to 180 GeV.

The mean radius of the ring is chosen to be R = 324 m = 6 times the mean radius of KEK-PS, identically for Ring I and Ring II. There are four intersecting insertions of 100 m in length. Three of them are used for physics experiments and the remaining one is reserved for beam handlings such as beam transfer of protons from Ring I to Ring II and beam extraction from TRISTAN for the stationary target experiments. The two rings are made to cross at an angle of 20 mrad, so that they are separated by about 1 m in curved sections. Each ring has four service insertions of 50 m in length. These are used for injection, beam dump, installing rf cavities and wiggler magnets, and so on. Since the proton bunches, while being accelerated in Ring I, will probably suffer from interactions with the electron rf cavities, we place electron rf bypasses in two service insertions of Ring I. Fig.2 shows an allocation of intersecting and service insertions.

From lattice considerations, the radius of curvature in the bending magnet is chosen to be ρ_0 = 127.3 m. Then the maximum energy of protons is 70 GeV for the bending field of B = 18.6 kG. As for the proton beam intensity stored in Ring II, a 14 A coasting beam current (6×10^{14} protons) is expected. Meanwhile, the maximum energy of electron (positron) beam and its intensity are determined mainly from rf considerations, and a 200 mA electron (positron) beam is expected at 16 GeV. Collisions between these two beams will result in the maximum luminosity of 6×10^{31} $cm^{-2}s^{-1}$. The center-of-mass energy available in the ep system is $\sqrt{s}$ = 67 GeV for 16 GeV electrons and 70 GeV protons; the equivalent electron energy is 2.4 TeV. If the superconducting storage accelerator of 180 GeV in energy is available for Ring II in the Phase I of TRISTAN, the center-of-mass energy is $\sqrt{s}$ = 107 GeV and the equivalent electron energy is 6.1 TeV. Table 1 summarizes the basic parameter values in the Phase I of TRISTAN.

Acknowledgments

This note is based on works done in collaboration with my colleagues in the KEK Accelerator Department while I was employed in KEK.

References

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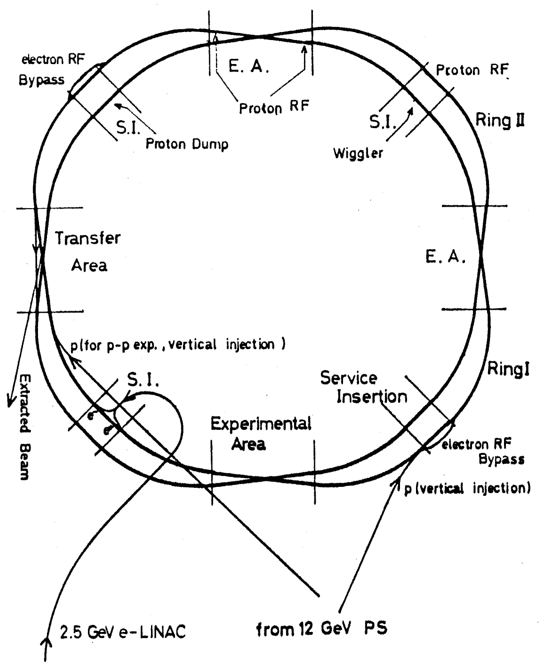

Fig.2 Allocation of intersecting and service insertions.

Table 1 Parameters of TRISTAN ep Project (Phase I)

	e^- or e^+	proton
Circumference of Ring	2036 m	2036 m
Average Radius	324 m	324 m
Number of Intersecting Points	4	
Crossing Angle	20 mrad	
Length of Intersecting Insertion	100 m	100 m
Length of Service Insertion	50 m	50 m
Average Radius of Curved Section	229 m	229 m
Bending Radius	127 m	127 m
Horizontal Tune	26.25	26.25
Vertical Tune	24.25	24.25
Tune of Curved Section	20	20
Beam Energy	16 GeV	70 GeV
Center of Mass Energy	67 GeV	
Equivalent Electron Energy	2.4 TeV	
Bending Field	4.2 kG	18.6 kG
Magnet Power Loss	25 MW	30 MW
Beam Current	200 mA	14 A
Number of Particles	8.5×10^{12}	6.0×10^{14}
RF Frequency	476 MHz	(8.0 MHz)*
Harmonic Number	3232	(54)*
Maximum RF Voltage	71 MV	(20 kV)*
Radiation Power Loss	9.4 MW	
Electron RF Power	15.0 MW	
Maximum Luminosity	6×10^{31} $cm^{-2}s^{-1}$	
Injector	2.5 GeV Linac	12 GeV KEK-PS

* These values refer to the proton stacking rf system.