TRISTAN PROJECT

Y. Kimura

National Laboratory for High Energy Physics

An electron-proton colliding beam project, TRISTAN, was proposed at KEK as early as 1974 and has been described at various conferences. In the previous version of TRISTAN it was planned to construct a collider of 16 GeV electron beam and 180 GeV proton beam using superconducting magnets for the proton ring. Recently, however, strong arguments have arised among particle physicists to extend the TRISTAN to the region of higher momentum transfer square. Then, we have been revising the accelerator design towards the energy as high as possible.

The circumference of the ring of the new version is 3016 m, the largest size the present KEK site can accomodate. It is possible to accelerate electrons to about 25 GeV with 200 m RF cavity section and protons to about 300 GeV at the bending field of 4.5 Tesla. Together with revising accelerator design, the scenario of the entire project has also been modified. At first we construct the electron ring as early as possible. At the same time, we develop the superconducting magnet for proton ring but it is anticipated that the full development will take several years. So, till the completion of superconducting magnet, the electron ring will be operated as an electron-positron collider.

The layout of the TRISTAN on the KEK site is shown in Fig.1. The electron and positron beams are provided by the 2.5 GeV electron linac which is now under construction for the synchrotron radiation research and is to be completed by the end of 1981. However, the beam energy of 2.5 GeV is too low for injection into the TRISTAN ring because of the long damping time, beam losses due to the Touschek effect and longitudinal or transverse beam instabilities. Then, we construct an intermediate accumlator of 6 GeV between the 2.5 GeV linac and TRISTAN.

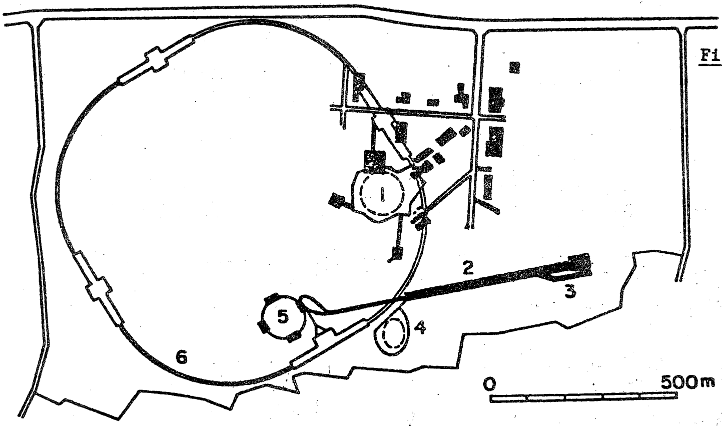


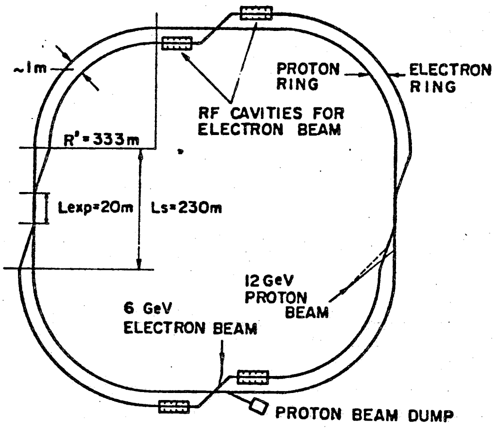
Fig. 1 Plan view of TRISTAN.

1. 12 GeV P.S..
2. 2.5 GeV electron linac.
3. 0.2 GeV linac for e^+ generation.
4. 2.5 GeV electron storage ring for synchrotron radiation research.
5. 6 GeV $e^\pm$ accumulator ring.
6. TRISTAN ring.

As the proton injector the present 12 GeV synchrotron is used. However, some problems associated with superconducting magnets, for instance, the uniformity of the low field at 12 GeV injection or the crossing of the transition energy, make it difficult to inject 12 GeV proton directly to the TRISTAN proton ring. Therefore, it is necessary to preaccelerate the 12 GeV proton to energies higher than about 30 GeV before the injection into the superconducting ring. This can be done either by constructing an additional ring of conventinal magnet or by sharing use of the electron ring for the preacceleration of proton.

In the previous design we mainly studied a scheme to collide bunched electron beams with unbunched proton beams since bunched proton beams were thought to be easily affected by instabilities. However, besides this point, bunched proton scheme is favored rather than unbunched scheme for many reasons, for instance, small aperture of magnets, high luminosity, low beam current and so on. Further more, recent investigations on the instabilities of proton beams at CERN and Fermilab seem to give very encouraging results in storing bunched protons. Therefore in the present design we choose bunched proton beams. The number of bunches of proton and electron is determined to be 40 in each beams. Since in the bunched proton case the revolution frequency of both beams should be adjusted to be precisely equal, the energy of protons is limited above 90 GeV. Then the collision energy covered by TRISTAN ranges from 6 GeV to 25 GeV for electrons and from 90 GeV to 300 GeV for protons.

The configuration of the electron-proton colliding rings is illustrated in Fig.2. The machine has roughly a fourfold symmetry. Four long straight sections of 230 m long are joined by four curved sections with a mean radius of 333 m. Each curved section of proton (electron) ring is consisted of 18 (36) identical cells of FODO structure as shown in Fig.3.



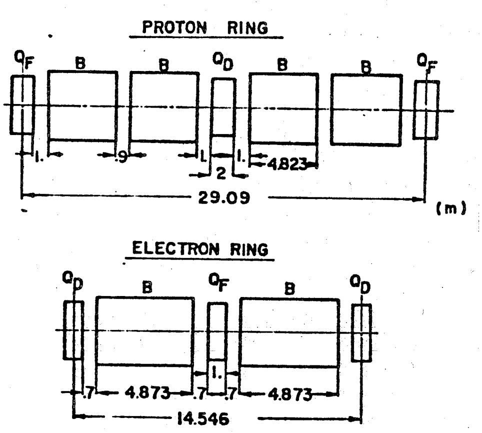


Fig. 2 Layout of the TRISTAN e-p collider.

Fig. 3 Normal cell structure of the TRISTAN ep collider.

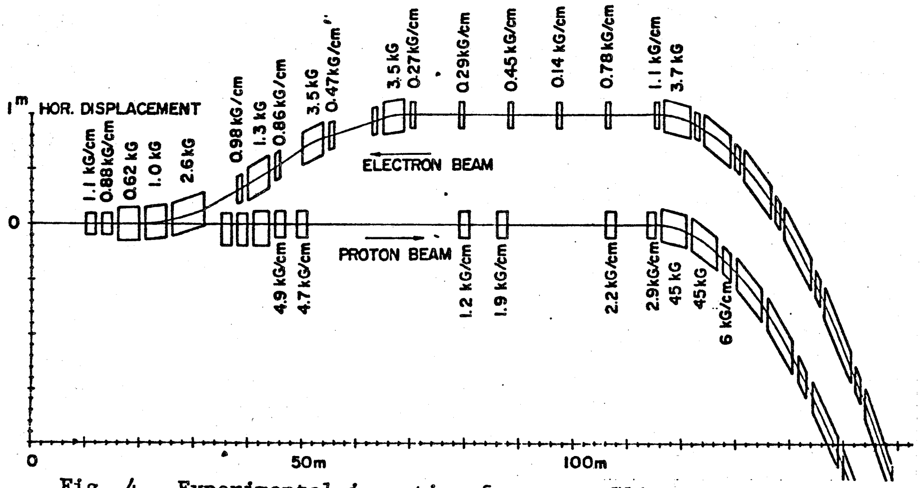


Fig. 4 Experimental insertion for e-p collision

Three of the four straight sections will be used for colliding experiments and the remaining one for the beam transfer and dump exclusively. The layout of the magnet system in the straight section is shown in Fig.4. A free space of 10 m is provided on each side of the interaction point to install particle detectors for colliding experiments.

Electrons (positrons) in a storage ring are known to polarize untipararel (pararel) to the magnetic field by the effect of spin-flip synchrotron radiation. The build-up time is only a few tens of minutes for TRISTAN above 15 GeV. Since the longitudinal polarization is preferred in the weak interaction physics, a system to rotate the electron (positron) polarization has been designed, an example of which is illustrated in Fig.5.

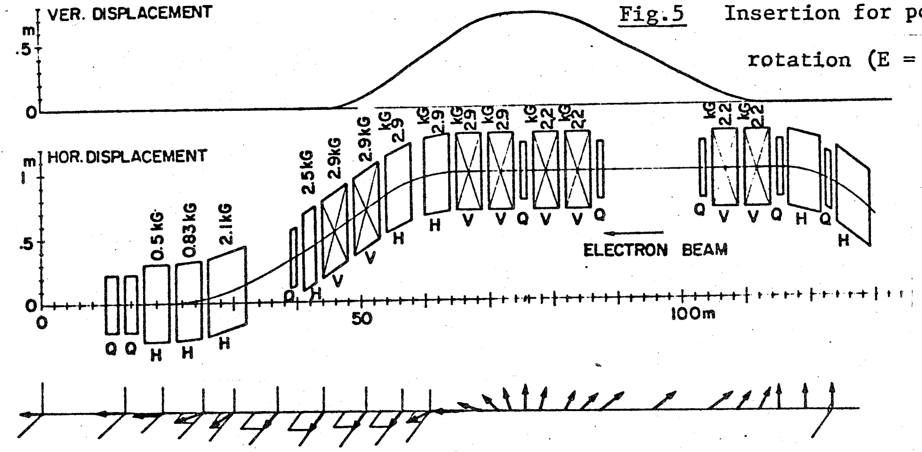


Fig.5 Insertion for polarization rotation (E = 20 GeV).

The expected luminosity of TRISTAN as a function of energy is shown in Fig.6 for both electron-proton and electron-positron collider.

In the TRISTAN project the most urgent developments are required for the techniques of superconducting magnets and cryogenic system on a large scale. We have started a full-scale development program last year. The cross-section of the first 1 m model magnet is shown in Fig.7. It is a warm bore and warm iron type. In the first excitation test, the field has reached 4.2 Tesla.

Another region which requires further developments is superconducting RF cavities. A small scale program has been going on at KEK since 1971. In 1978 we constructed a nine-cell structure of C-band cavities and succeeded in accelerating electron beams with accelerating field of 3 MV/m. This year we started a program to develop superconducting RF accelerating structure for the TRISTAN ring and are making a niobium spherical cavity as a first model. Its cross-sections and picture are shown in Fig.8.

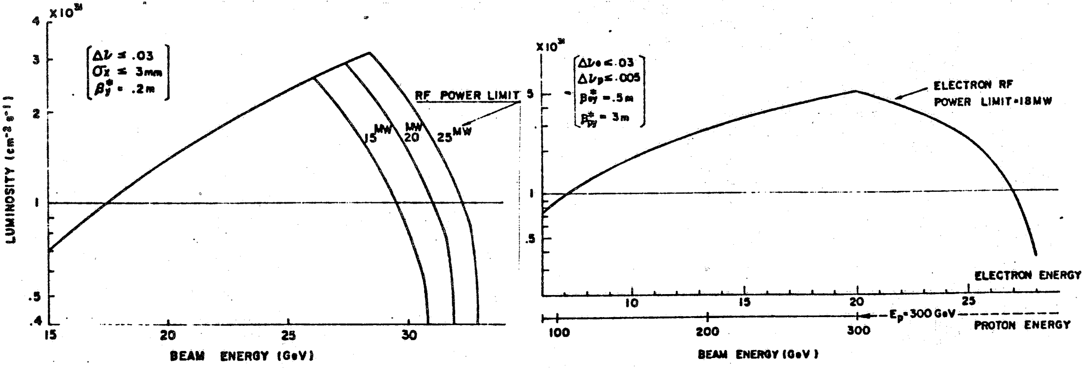


Fig.6 Luminosity of the TRISTAN as e-p (left) and $e^+ - e^-$ (right) collider

Developments of ultra high vacuum techniques for storage accelerators are also making progress at KEK. A new structure, shown in Fig.9, has been proposed for linear pumps used in a long aluminum chamber and it has given the pumping speed of 15 ℓ/sec and 60 ℓ/sec per unit element at the magnetic field of 350 G and 800 G, respectively.

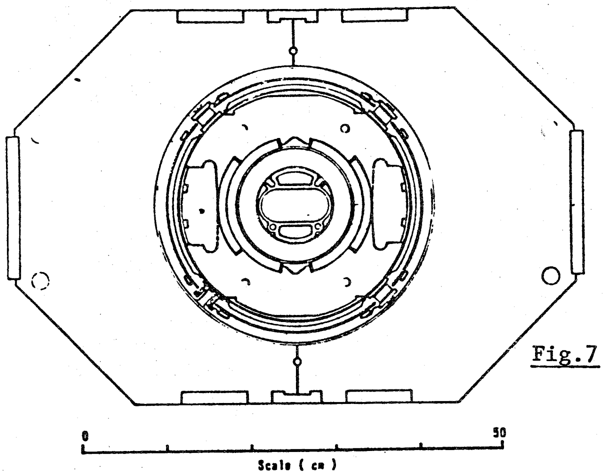


Fig.7 Cross-section of the model superconducting dipole.

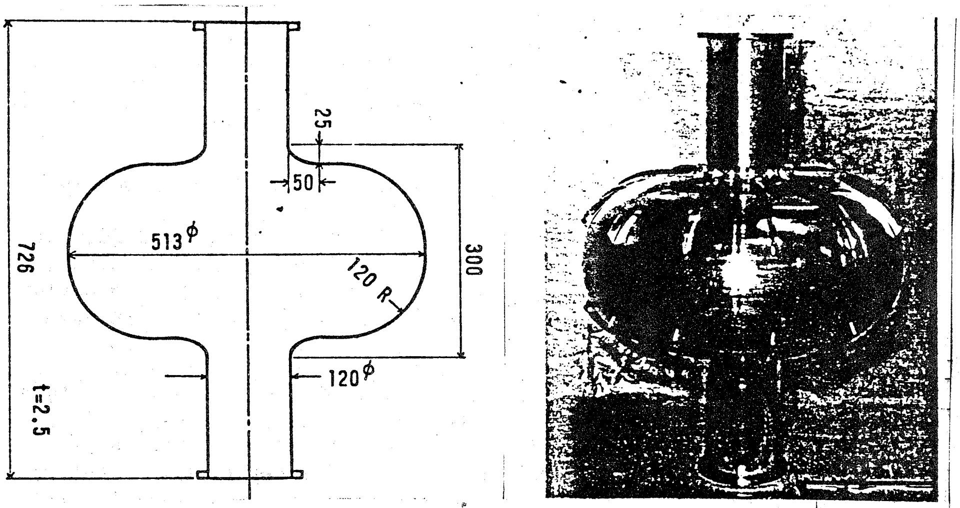


Fig.8 500 MHz niobium spherical cavity.

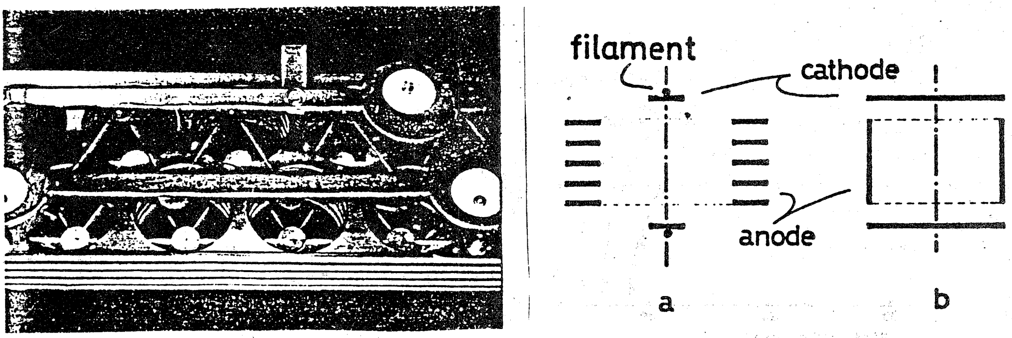


Fig.9 Structure of the new pump. (a) New pump (b) aridinary Penning structure.