Status of TRISTAN MR

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Abstract

This paper describes the operation summary of TRISTAN MR in fiscal year 1992.

I. INTRODUCTION

TRISTAN main ring(MR) is an electron-positron colliding beam accelerator whose design energy is 30 GeV. Following a TRISTAN phase I operation(1986-1989) in the energy frontier, the operation of the TRISTAN entered in second phase in 1990[1,2]. The aim in phase II operation is to accumulate a luminosity of few hundred inverse pico-barns for precise experiments of electron-positron interactions. To achieve this goal our efforts are being concentrated on increasing the integrated luminosity as possible as we can.

In this paper the operation of the TRISTAN MR in FY 1992 run is summarized.

II. ACCELERATOR PERFORMANCE

The TRISTAN MR has a circumference of 3018 m. It has four fold symmetry in the lattice of magnets. Two electron and two positron bunches circulate in opposite directions and collide with each other at four collision points named Fuji, Nikko, Tsukuba and Oho. Three detectors, AMY, VENUS and TOPAZ are located at the Oho, Fuji and Tsukuba collision points respectively. RF cavities are installed near the collision points. In Nikko area super conducting cavities are located. In 1990 four pairs of super conducting quadrupole magnets(QCS) were installed to reduce the beta functions at the collision points by about half. Table 1 shows the main parameters of the TRISTAN MR.

Table 1
Main parameters of the TRISTAN MR

Nominal beam energy[GeV]	29
Injection energy[GeV]	8
Betatron tunes(ν_x/ν_y)	
injection	36.64/38.79
collision	36.63/38.72
Synchrotron tune(ν_s)	
injection	0.12
collision	0.11
Beta functions at collision point (β_x^*/β_y^*) [m]	1.0/0.04
Emittance at 29 GeV (RF frequency is shifted by 3kHz) [m]	8.0 x 10^{-8}

Fig.1 shows the operation statistics of the TRISTAN MR from 1986 to 1992. In FY 1992 the total operation time amounted to 4700 hours and the time devoted to the physics run increased by about 70 % as compared with that in previous years. The ratio of the time of machine study and tuning to the total operation time was 17%.

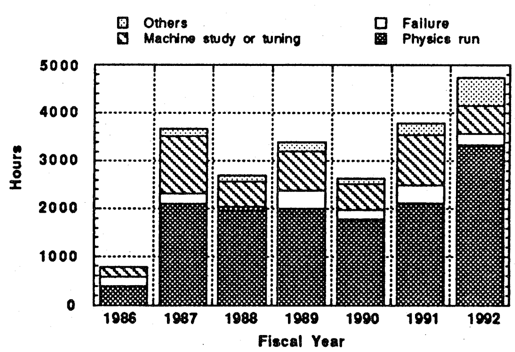

Figure 1. Operation statistics of the TRISTAN MR.

Fig. 2 shows the integrated luminosity over the past seven years. A notable increase of the luminosity from 1991 is due to the installation of QCS. In FY 1992 AMY, VENUS and TOPAZ group collected the integrated luminosity of 100.7, 100.1 and 85.6 pb^{-1} respectively.

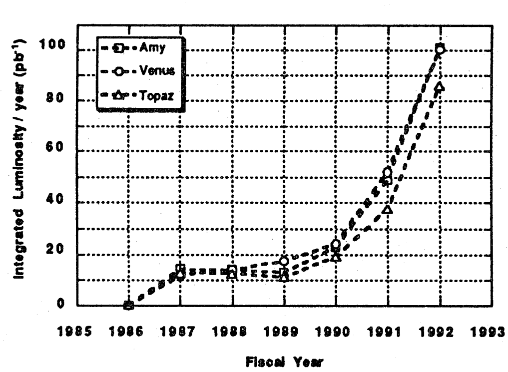

Figure 2. Integrated luminosity collected by the three experiment groups.

Fig. 3 shows the integrated luminosity in a day which was collected by the VENUS detector. In FY 1992 best luminosity in a day was recorded in May when the beam current and the coupling parameter were both in best condition as described later.

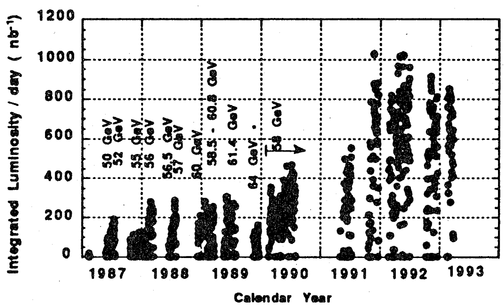

Figure 3. Integrated luminosity in a day collected by the VENUS group.

The nominal beam energy in FY 1992 run was 29GeV except for December. In this month the experiment groups took the data at eight different energies from 28.8 to 29.85 GeV so as to search a new $\gamma\gamma$ resonance. The RF frequency was shifted by 3kHz to reduce the emittance. This cause the energy to shift by -114 MeV from the nominal one.

As stated above the integrated luminosity is most important quantity in phase II operation. The some parameters related to the integrated luminosity are described as follows.

A. Beam current

Fig. 4 shows the total beam current at the beginning of collision in FY 1992. The beam current is limited by a beam instability at injection or the trip of the super conducting cavities.

At injection, when the single bunch current exceeds 4-5mA, the beam size becomes large and the beam life time becomes short. As the maximum storable bunch current is dependent on betatron tunes, RF voltage and the closed orbit, this instability might be caused by synchro-beta resonance. But the mechanism is not clearly explained yet. In the physics run operation orbit bumps are made at the collision points and symmetry points on trial and error. After finding a good orbit the orbit is stored as the standard orbit. At each beam fill the difference between the closed orbit and the standard orbit is corrected, because the closed orbit varies fill by fill. Unfortunately this procedure does not always work well. Then new standard orbit is searched again. As an attempt to understand this phenomena the dispersion correction is planned.

Another problem which limits the beam current is the trip of super conducting cavities[3]. Above the beam current of 13-14mA the trip rate becomes high and the shortage of RF voltage by the trip causes beam loss. This trip is dependent on the location of cavities and trip rate changes day by day. In a period the trip occurs at a fixed energy during acceleration. Speculating that the trip is caused by the synchrotron radiation whose condition is sensitive to the orbit, the quadrupole magnets in the Nikko straight section were realigned and a new movable mask was installed at the arc-side of the outermost cavity to decrease the scattered radiation from the fixed masks which are installed to prevent the radiation directly hitting cavities. After that the trip rate of some cavities becomes low, which is supposed the alignment is effective. But the movable mask has no effect on the trip rate. Thus the mechanism of the trip is not fully understood yet and will be extensively studied in 1993.

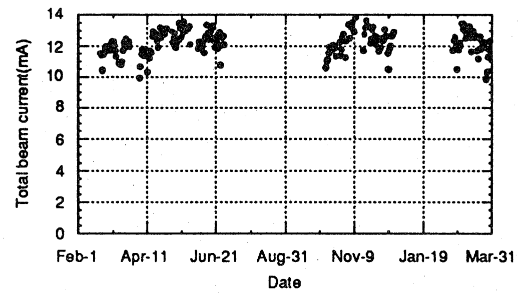

Figure 4. Total beam current in FY 1992 run.

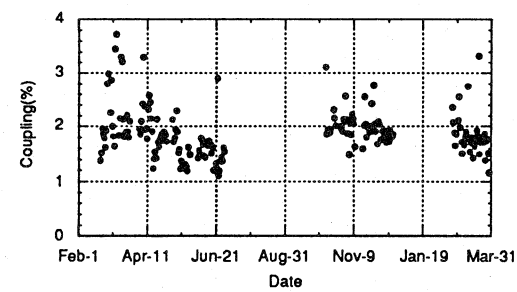

Figure 5. Coupling parameter in FY 1992 run.

B. Coupling parameter

Fig.5 shows the coupling parameter, i.e. horizontal-vertical emittance ratio, at the end of collision. As the TRISTAN does not reach the beam-beam limit, one method for the higher luminosity is to decrease the coupling. In theory the coupling is mainly produced by the vertical dispersion caused by vertical error kicks and the x-y coupling of betatron oscillation caused by residual skew quadreupole components in the ring. Furthermore the orbit difference between electron and positron beams and the residual vertical dispersion at the collision points effectively increase the measured coupling because the coupling is calculated by the data from the coherent beam-beam tune shift. At present we have no systematic way to minimize these effects. The way to reduce the coupling in beam tuning is the adjustment of the vertical orbit by the orbit bumps in almost all locations along the ring. Once the good orbit is found the orbit is stored as the standard orbit. During the physics run the difference between the closed orbit and the standard one is frequently corrected. Like as at injection this procedure begins to fail with time. Then another good orbit must be searched. As this work takes much time it seems that the goodness of the coupling depends on the effort of operators.

The orbit drift is very serious problem in the beam tuning and in the physics run operation, because the beam current at injection and the coupling are very sensitive to it : typically the change of the vertical orbit of 0.1-0.2mm affects them. To find the cause of the orbit drift the measurement of the ground motion and the temperature in the tunnel is in progress[4].

C. Beam lifetime

The beam lifetime in collision at 29GeV is about 180 minutes at the current of 12 mA. A machine study showed that the beam loss due to beam-beam Bremsstrahlung contributes to nearly a half of the beam lifetime as described later.

III. MACHINE STUDIES

A. Beam life time from beam-beam Bremsstrahlung

The beam lifetime was measured when the elecron and positron beam were separated at the four collision points by the electro-static separators and it was compared to that in the beam not being separated[5]. The result shows the beam life time at 12mA with and without beam separation are 400 and 180 minutes respectively. This difference is well explained by the particle loss by the beam-beam Bremsstrahlung process.

B. Measurement of machine aperture at injection

As described above the beam current at injection is limited by the beam instability. The increase of machine aperture may help to raise the beam current. The horizontal and vertical apertures were measured by observing the beam loss after the beam was kicked by kicker magnets. The longitudinal aperture was measured by observing the injection efficiency as the function of the RF phase. The result shows that the horizontal aperture is 2/3 of the calculated aperture by the computer code SAD and the vertical aperture is 1/2 of the calculated one. The longitudinal aperture agrees with the SAD calculation. To investigate the discrepancy between the measured and calculated transverse apertures further machine studies are planned in 1993.

C. Optics having smaller vertical beta function at the collision points

In physics run the vertical beta function at the collision points is 4 cm. To reduce the beam size at the collision points further an optics having β_y^* of 3.23 cm was tried. β_x^* was retained to 1m worrying about the increase of the detector background. The result shows that this optics is successfully transformed from the injection optics without beam loss and has enough beam lifetime in the tune range of $\Delta\nu_x$=0.04 and $\Delta\nu_y$=0.06. To serve this optics to the operation the shift of the waist of β_y around the collision points and the improvement of the coupling are to be studied.

D. Measurement of the beam energy

The beam energy was precisely measured by means of the resonant spin depolarization[6]. In this method the beam is excited with an oscillating horizontal magnetic field of the frequency f_d. If the resonant condition, $\nu\, f_r = n\, f_r \pm f_d$ (ν:spin tune, f_r :revolution frequency, n:integer), is fulfilled, the beam depolarization occurs. The beam energy is determined from the relation of ν = beam energy in GeV / 0.44065. The measured beam energy was 28887.639±0.11 MeV, while the design energy is 28886 MeV.

IV. ACKNOWLEDGMENTS

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