KEK 2.5-GEV ELECTRON/POSITRON LINAC STATUS AND RESEARCH ACTIVITIES

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Abstract

Even though the annual operation time has exceeded 4,500 hours for these three years, the operation rate reached more than 98 % in FY 1989 due to various improvements. A new attenuator & phase-shifter has been developed, and a considerable reinforcement of the positron focussing system is in progress. Construction of the Test Linac has begun, and research on the breakdown of alumina rf windows, multibunch instability in the linac, and plasma wakefield accelerators has begun.

Introduction

The KEK 2.5-GeV electron linear accelerator was completed in March, 1982, and was commissioned for synchrotron radiation research in June, 1982, TRISTAN AR tests began in September, 1983. Its first operational status is reported in ref. 1. The positron generator was under construction from 1982 to 1984; its construction and improvements are reported in refs. 2, 3.

In this report, recent operational status is first described, together with some of the improvements achieved. Second, two modifications presently taking place are described: one is the development of a new attenuator and phase shifter; the other is the reinforcement of the positron focusing system, aimed at increasing the positron intensity by a factor of two. Finally, some research programs, most of them undertaken recently, concerning the following subjects are mentioned: (1) construction of a small linac for advanced accelerator studies, (2) breakdown mechanism of high-power klystron rf windows, (3) multi-bunch instability caused by a transverse wakefield in the linac, and (4) plasma wakefield acceleration.

Operation status

The annual operation time during these eight years is summarized in Fig.1. The scheduled operation time expected in FY 1990 is also about 4,500 hours. In spite of such a long operation time, the operation rate has steadily improved, and reached more than 98 % in FY 1989. This high rate is the result of continuous efforts made to improve various instruments of the linac. In the following, these recent improvements are described briefly.

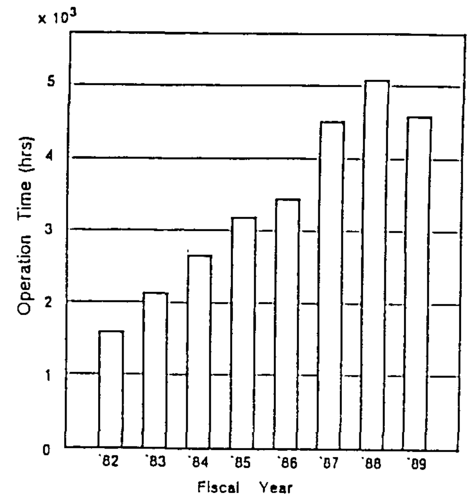

Fig. 1 Linac oeration time.

Since the initial operation of the linac, one of the most serious problems has been related to the main high-power klystrons.[4] In 1987, a new-type klystron, which has a Barium-impregnated (BI) cathode, was test-used, showing excellent characteristics. Since then, the old-type klystrons with oxide-cathodes have rapidly been replaced by new ones; at present there are thirty-nine klystrons with BI cathodes among a total of fourty-eight. Most of the klystrons with BI cathodes have demonstrated excellent characteristics, resulting in a much lower failure rate.

The energy analyzing and monitoring systems of the beam have been considerably reinforced.[5] Energy analysis of the beam is now possible at four positions along the accelerator, and the beam currents and profiles are more easily to measure. The monitors of the rf system have been also improved, and variation is more easily and widely detected for the rf phase and power.

In addition to these items, significant improvements have also been made on the control system[6] of the linac by introducing a CAVT system and an additional network (Ethernet) for man-machine interface enhancement. The DS-Link and beam-switching systems were also improved.

Development and Improvement

An attenuator and a phase shifter at high rf power are usually required in the injector section of the linac for optimum tuning of the accelerator. Though these two quantities should desirably be independent of each other, this is not the case, and the power variation is closely related to the phase change in the high-power attenuators currently used. This makes tuning of the machine very complicated and, therefore, the dependence of the beam characteristics on these quantities is often ambiguous.

To avoid this difficulty a new attenuator and phase shifter is being developed,[7] which enables us to vary the power or phase quite independently. This is a single device with a structure in which the usual attenuator and the phase shifter are combined as shown in Fig.2; it works both as an attenuator and a phase shifter. The details are described in ref. 7.

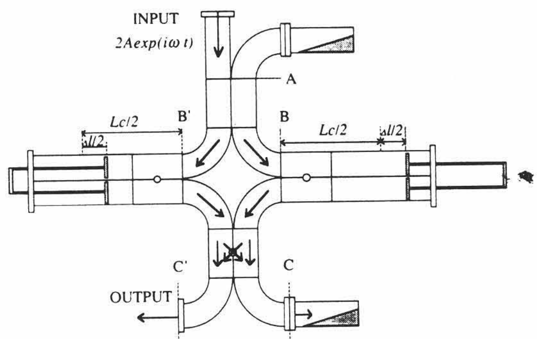

Fig. 2 Attenuator & phase-shifter for buncher.

As in TRISTAN, high-luminosity experiments started in 1990, and the TRISTAN group requested the linac group to supply more positrons. In order to meet this requirement, the positron source was examined and it was decided to reinforce the positron focussing system.[8] This system comprises a pulsed coil, a DC solenoid, and quadrupole magnets. Both the pulsed coil and the DC solenoid are to be replaced by components which are capable of producing a higher magnetic field than the present ones by almost twice. As for the quadrupoles, only those in the positron generator are to be altered at this time; and the remaing ones in the transport line and in the initial sectors of the 2.5 GeV linac will be altered the next FY. The present modification will be completed early next year. Details are given in ref. 8.

Research

In addition the work mentioned above to improve the accelerator, some research started recently, in the Linac Division. These are presented below.

For research concerning an advanced accelerator, it is important to have a suitable facility; and it was therefore decided to build a new small linac, the Test Linac.[9] The main parameters of the Test Linac are as follows: The maximum acceleration energy is to be 60 MeV at a 10 μa maximum average current; and its length is to be about 14 m. This linac is presently under construction and is expected to be completed soon. Some major subjects to be investigated are (1) high brightness beam production and acceleration, (2) RF gun, and (3) experiments on a free-electron laser.

In recent years the output rf power of klystrons has been steadily rising, while aiming at future advanced accelerators: for example, linear colliders. Breakdown of ceramic windows is still one of the major problems to be solved with those klystrons. An investigation of the breakdown mechanism has been intensively continued. It was recently shown that the puncture of an alumina disc is induced by localized surface melting which is caused by multipactor electron bombardment heating.[10] An example of simulation is shown in Fig. 3. It was also confirmed that a TiN coating is effective to suppress the multipactor.

In accelerating a high-current beam up to high energies in linear accelerators, it is

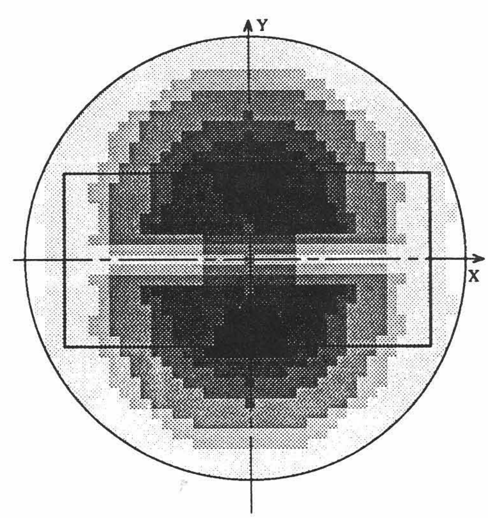

Fig. 3 Incident energy distribution weighted by impinging rate of multipactoring electrons on the alumina ceramic disk with an rf power of 30 MW.

important to know the properties involved and to suppress any wakefield effects caused by the beam. This problem will become more serious in future accelerators; the wakefield effect due to a multi-bunched beam is particularly important to such a collider as the Japan Linear Collider, since multi-bunched beam is to be used. In making use of the electron acceleration section of the positron generator, some preliminary

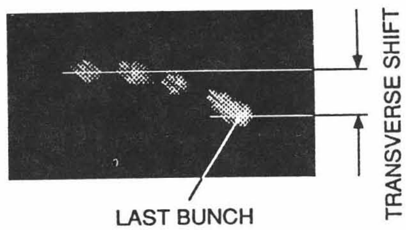

Fig. 4 Transverse (vertical) shift of the last bunch observed at a profile monitor.

measurements were performed,[11] since high-current, high-energy beams were available in the section. It was observed that the last bunch of the beam, comprising five bunches, was in fact appreciably deflected by a field caused by preceding bunches (Fig. 4). Details of preliminary results and analysis of the measurements are described in ref. 11.

In making use of similar electron beams as those mentioned above, another investigation has been progressing concering so-called plasma wakefield accelerators (PWFA).[12] A PWFA is one of the promising candidate for future high energy accelerators, since there is no insulator or wall material necessary, which usually imposes an upper limit to the accelerating gradient of conventional accelerators. It has been predicted

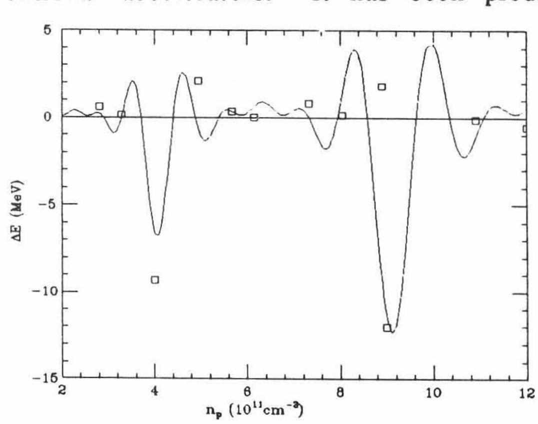

Fig. 5 Observed centroid energy shifts of the maximum bunch as a function of the plasma density.

in PWFA that it would be possible to obtain an extreemly high accelerating gradient.[13] At the end of the positron generator installed there was a chamber, in which 10^{11}-10^{13} cm^{-1} plasma was produced. Several electron bunches of 500 MeV energy with total charge of 5-10 nC were injected into the plasma; it was observed that the trailing bunch was shifted in energy by about 12 MeV.[12]

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