CONSTRUCTION PROGRESS OF THE PHOTON FACTORY 2.5 GeV ELECTRON LINAC

J. Tanaka, I. Sato, A. Asami, H. Matsumoto, S.Osawa,
A. Enomoto and Y. Saito

National Laboratory for High Energy Physics
Oho-machi, Tsukuba-gun, Ibaraki-ken 305, Japan

Construction of the Photon Factory 2.5 GeV injector linac was started in April 1978. Assembling of the first sector (500 MeV) of the linac was almost completed in June 1981 and the first 500 MeV electron beam was accelerated in this sector in July 1981. Assembling of the remaining four sectors of the linac is in progress and acceleration of the full 2.5 GeV beam is scheduled for the end of 1981. Initial performance of the first sector and some technical developments are also described.

Introduction

The Photon Factory (PF), a synchrotron radiation facility at KEK, was funded in April 1978 on a four year program. The PF accelerator consists of a 2.5 GeV injector electron linac and a 2.5 GeV storage ring dedicated to synchrotron radiation research. The linac will be used not only for the injector of the 2.5 GeV storage ring but also for other purposes; as the injector for lower energy storage rings, as a picosecond and nanosecond range pulsed light source and as the electron and positron injector for "TRISTAN". The 6 GeV accumulator ring for the TRISTAN rings was authorized by the government during the 1981 fiscal year.

The linac was designed to be able to accelerate an electron beam current of 50 mA to the energy of 2.5 GeV with a total rf power of 840 MW and to 3.0 GeV with 1,200 MW of power. The main accelerator is divided into five sectors and each sector consists of eight acceleration units. The acceleration unit is composed of four 2m long accelerator guides (mounted on a cylindrical supporting girder), high power wave guide system, a 30 MW klystron and a modulator with controller.

Fig. 1 Building of the PF Linac.

Construction progress and test operation of the first sector

As the linac building was completed at the end of March 1980, installation of the acceleration units and klystron modulators began in April 1980. By the end of March 1981, more than seventy percent of the components had been delivered and some had been installed. The 30 MeV injector and the first sector of eight acceleration units with klystrons and modulators were almost completed by the end of June 1981.

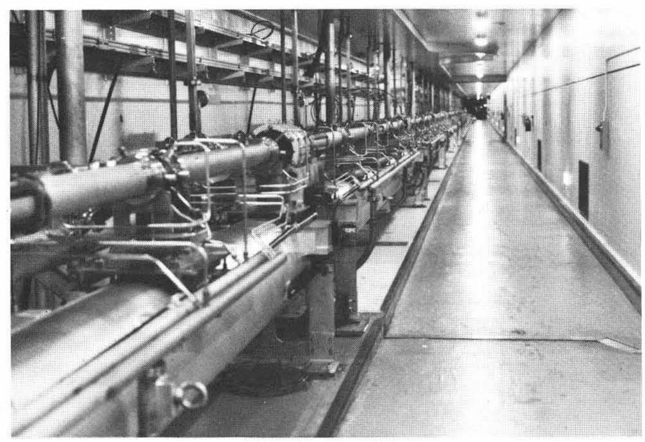


Fig. 2 View of the first sector.

In July, the first 500 MeV beam was accelerated at a beam current of 50 mA, and at 87 mA the beam energy was 470 MeV with a total rf power of 180 MW. During the test operation, since the control system was not complete except for the focusing system, phasing of the rf system could not be done well enough to get optimum performance.

Technical developments

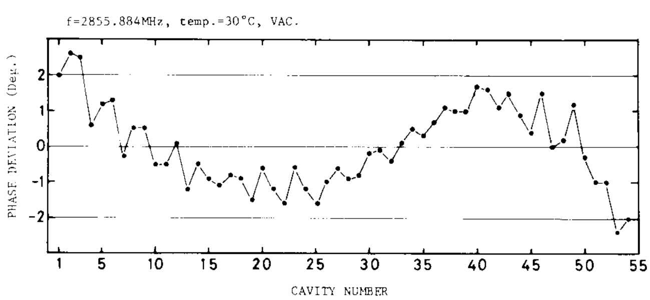
Accelerator guide

In order to facilitate mass production of the accelerator guides within the short time scheduled, a disk loaded traveling-wave type was chosen. The guide was designed with a quasi-constant gradient structure (that is the disk hole diameter decreases linearly along the length with a step of 75 μm). This makes automatic production of the guides and division of the guides into five different types easy. The first cell of each type guide starts from fifth cell of its predecessor. Consequently, the begining of each type guide has a different HEM_{11} mode characteristic. This reduces the cumulative beam blow-up effect caused by repetition of the same structure throughout the whole length of the linac.

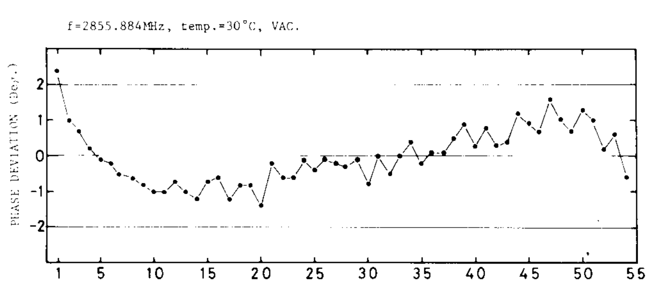
The accelerator guides have been made by means of an electroplating method. Improvements in machining have been realized recently enabling the final precision machining of the accelerator guide parts to be automated. Disks and cylinders have been machined by special lathes with diamond bits and vacuum chucks. Precision machining was accomplished by reducing rotational vibration of the lathe spindle by using hydraulic bearings. Overall dimensional accuracy of the disks and cylinders is within ±2μ and the surface roughness of the finished parts is less than 200 Å.

Due to the high precision machining and modified electroplating method, any tuning of the accelerator guides, for example dimpling of each cell of the guides was eliminated.

Fig. 3(a) shows an example of phase errors of the guides made at the begining of the fabrication period and 3(b) shows an example after the fabrication process had stabilized.



(a)



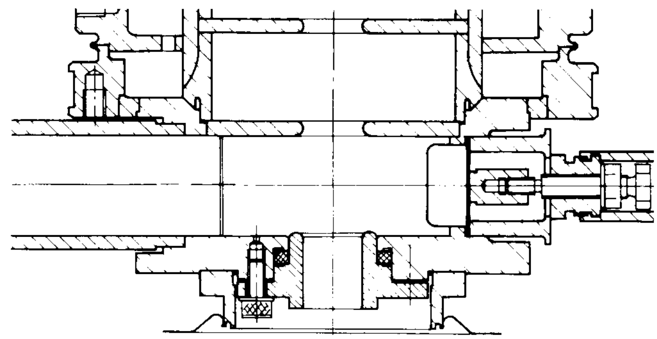
(b)

Fig. 3 Phase errors of the guides.

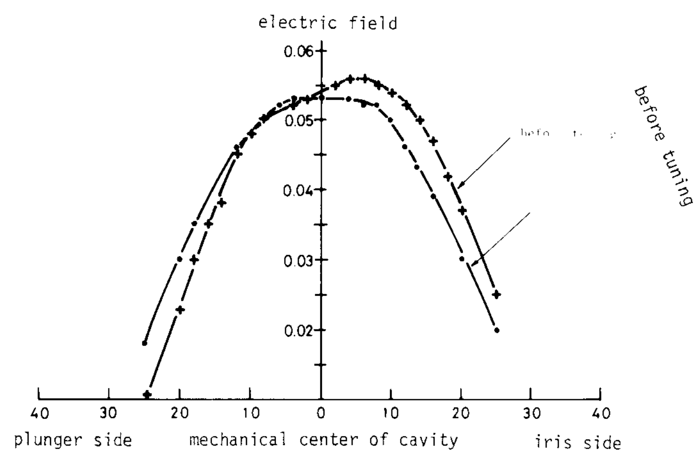
Coupler

The coupler for the accelerator guide is a cavity type with two semi-fixed plungers to tune the rf matching and to correct the electric field and phase distortions caused by asymmetry of the coupler cavity. The structure of the coupler, is shown in Fig. 4(a) and the measured electric field distributions are shown in Fig. 4(b). This makes it possible to simplify the structure of the wave guide feed system, that is connecting all of the wave guides on one side of the accelerator guides.

During the test operation of the first sector, no dominant direction of beam deflection was experienced.



(a)



(b)

Fig. 4 a) Structure of the coupler.
b) Electric field distributions of the coupler.

Electron gun

In order to produce faster and thinner electron beams, a new electron gun was developed. It involves the use of a grid-cathode assembly of a commercial planer triode. The assembly is composed of an oxide coated cathode 1cm in diameter and a mesh control grid with a thin kovar brim 3.2 cm in diameter which is used as a vacuum seal. (Fig. 5).

It is suitable for the emission of a very short pulse beam (<2ns) at a current of more than 5A, and has other notable advantages; the cost is very low, the replacement is very easy, the grid control voltage is within the range of semiconductors (<200 V) and the coaxial terminals can be exposed to the air.

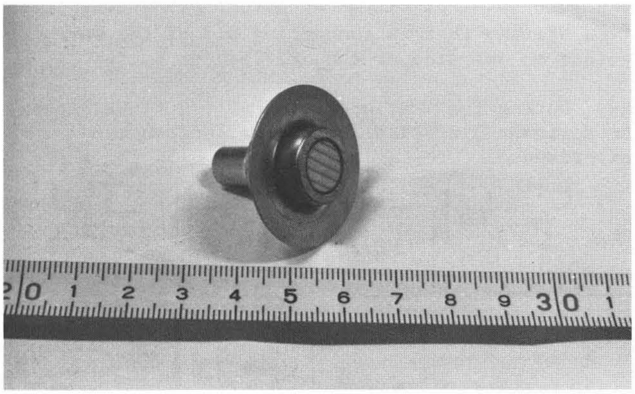


Fig. 5 Grid-cathode assembly of the gun.

Beam position monitor

As a microwave beam-position monitor, a TM_{110} cylindrical cavity which resonates at 2856 MHz, was developed.[1] Both horizontal (x) and vertical (y) displacements of the linac beam are simultaneously detected by the single cavity with X and Y rf output ports.

The basic concept is illustrated in Fig. 6. A compact microwave circuit module was also developed for this monitor. The block diagram of the circuit is shown in Fig. 6. Sensitivity of the monitor is about 0.1 V/mm and a 0.1 mm displacement of the beam is detectable.

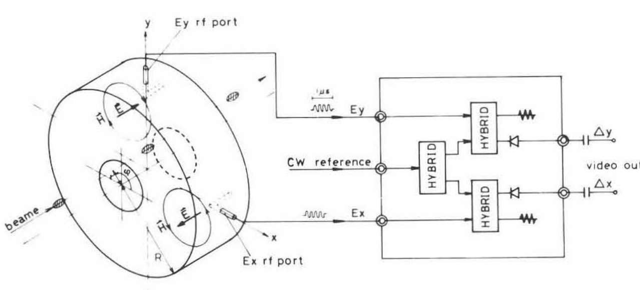


Fig. 6 Illustration of the beam position monitor. The excited field pattern depends on a beam position (r,ϕ).

RF dummy load

Ceramic type SiC has excellent properties as an rf absorber. A simple and low cost rf dummy load was developed using SiC plates. Such plates are available for use at high temperatures and have low out-gassing in vacuum.

Four SiC plates were mounted inside of a wave guide as shown in Fig. 7. Heat generated at the plates is conducted to the aluminum plate holder and absorbed through a water cooled waveguide wall. VSWR of the dummy load is less than 1.05 at room temperature and temperature variation of the load is shown in Fig. 8. The load can take a peak rf power of 10 MW and average power of 300 W in vacuum.

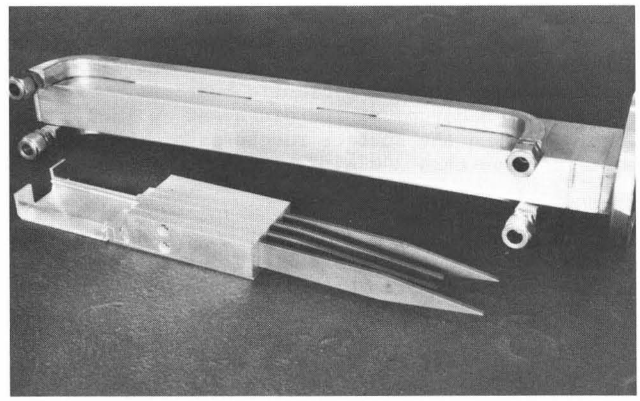


Fig. 7 Ceramic type SiC plates for rf dummy load.

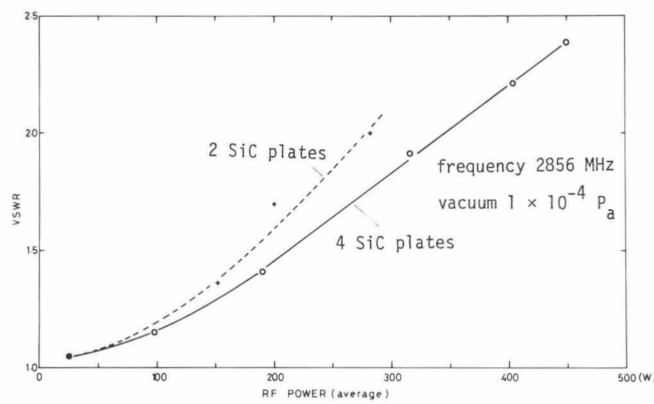


Fig. 8 VSWR of the dummy load depends on the temperature.

Reference

1. A. Enomoto et al
Research Report of Lab. of Nuc. Sci. Tohoku Univ. Dec. 1980 (Japanese).