ENERGY SLIT SYSTEM FOR THE PF 2.5-GEV LINAC

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Abstract

Computer-controlled variable-aperture slits and collimators have been fabricated for energy-analyzing stations (EAS) of the KEK 2.5-GeV linac. The collimators, which are located in front of the analyzing magnet, were designed so as to decrease the beam energy to be less than 1% of the incident beam. On the other hand, the slits, which are located after the analyzing magnet, were designed so as to intercept cascade showers to be less than 1% of the incident beam. Tantalum is intensively used to minimize the thickness of the slit block.

The controller of the slits and collimators comprises an industrial personal computer and a cpu-controlled communication unit which enables communication with the existing control system by a bit serial communication loop.

Introduction

Improvements to the monitoring system of the KEK 2.5-GeV linac have been undertaken in order to realize stable operation and fast beam recovery in the case of trouble.[1]

As one part of the improvements, four energy-analyzing stations (EAS) have been built and installed on the accelerator at the following locations (see Fig. 1): (1) a target EAS which analyzes the beam at the end of the high-current electron linac just before the positron production target (~200 MeV); (2) a 30° BT EAS at the end of the positron acceleration linac (~250 MeV) ; (3) a 35-MeV EAS at the 35-MeV point of the 2.5-GeV linac immediately after the injection system; and (4) 2.5-GeV EAS at the end of the 2.5-GeV linac.

An energy-analyzing station consists of collimators, an analyzing magnet, a slit, profile monitors and current monitors. This paper describes the design considerations of collimators and slits for each EAS as well as performance tests and their control system.

Design considerations

The specifications of the slits and collimators for each EAS are shown in Table 1.

The collimators, which are located in front of the analyzing magnet, were designed using Eq. (1) so as to decrease the beam energy to be less than 1% of the incident beam:

$$E/E_0 = \exp(-\rho t/x_0), \tag{1}$$

where E_0: incident energy of an electron or a photon upon a layer of matter.
ρ: density of matter.
X_0: radiation-length of matter.
t: depth from its point of incidence.
E: energy of an electron or a photon at a depth t.

On the other hand, the slits, which are located after the analyzing magnet, were designed so as to intercept cascade showers to be less than 1% of the incident beam. The depth of each slit was chosen in
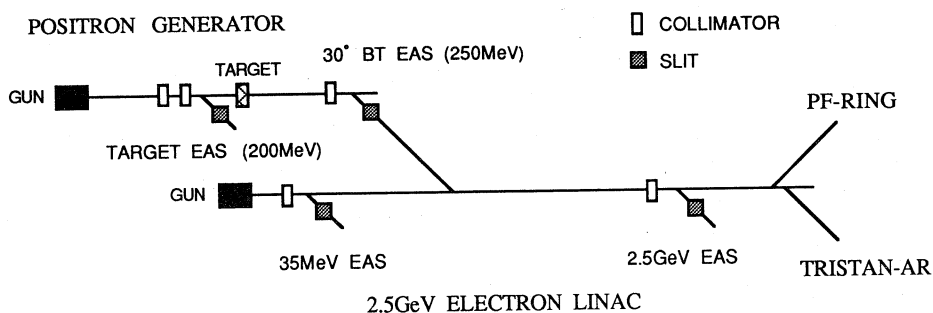

Fig. 1 Location of energy-analyzing stations (EAS) in the 2.5-GeV linac.

Table 1

Specifications of collimators and slits for each energy-analyzing station

Parameters	35 MeV EAS	2.5 GeV EAS	Target EAS	30° BT EAS
Maximum current	100 mA	100 mA	15 A	15 A
Energy resolution	< 0.02%	< 0.1%	< 0.1%	< 0.02%
Thickness/material for Collimator	20 mm/Ta	70 mm/Cu	70 mm/Cu 60 mm/Ta	70 mm/Cu
Thickness/material for Slit	50 mm/Ta	130 mm/Ta	90 mm/Ta	110 mm/Ta

consideration of the results shown in Fig. 2.[2,3] Tantalum is intensively used to minimize the thickness of each slit block, since one radiation-length of copper (1.45 cm; 13 g/cm^2) is longer than that of tantalum (0.42 cm; 6.9 g/cm^2).
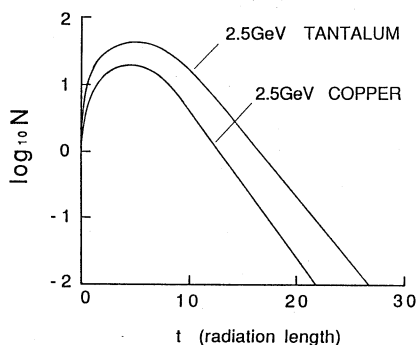

Fig. 2 The total number of electrons in a shower initiated by an electron of (energy) 2.5 GeV, N, as a function of (thickness) t.

Fig. 3 shows a conceptual drawing of the slit. The block movement is guided by slide bearings fixed to the vacuum chamber. Both blocks are water cooled through a coaxial stainless-steel tube brazed onto the blocks. A picture of an installed collimator on the linac is shown in Fig. 4.
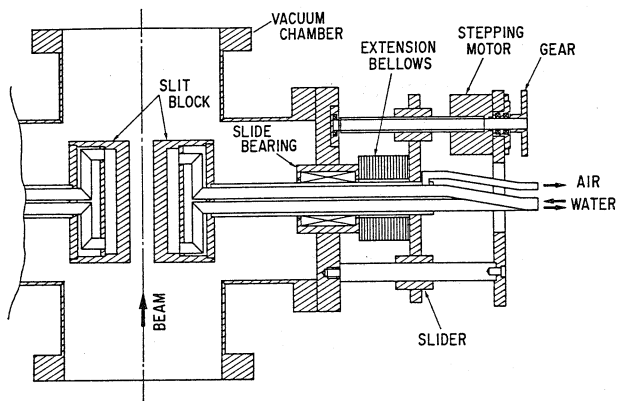

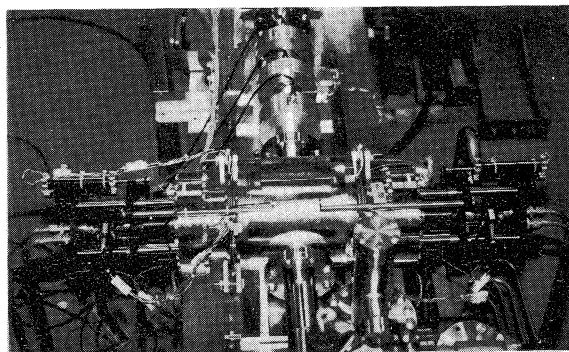Fig. 3 Conceptual drawing of a slit.

Fig. 4 Overall assembly of a collimator installed on the accelerator.

Results of performance tests

The temperature increase of collimator blocks was measured at the target EAS. An incident beam power of 340 W (with a peak current of 1.7 A, a pulse duration of 40 ns, a pulse repetition rate of 25 pps and an energy of 200 MeV) was fully stopped. As shown in Fig. 5, the temperature of the blocks settled to 87°C after 10 minutes of irradiation. Since the locations of the thermocouples are quite close to the beam irradiated spot (see Fig. 6), collimator blocks are sufficiently cooled using a 2 l/min water flow.
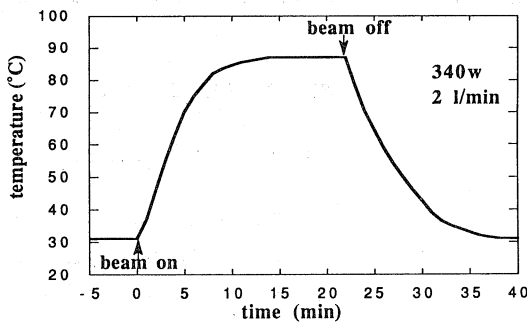

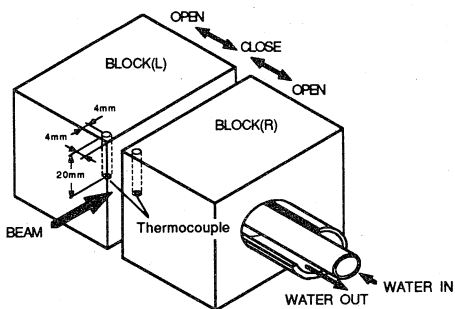Fig. 5 Temperature increase of collimator blocks when a beam power of 340 W was fully stopped.

Fig. 6 Location of thermo-couples for temperature measurement in collimator blocks.

The energy spectra of electron and positron beams at the newly added energy-analyzing stations were measured. As an example, the energy spectrum of a short-pulse electron beam at the target EAS is shown in Fig. 7 (with a pulse duration of ~1.5 ns and a peak current of 9 A; energy ((I_{MAG} = 38 A) = 250 MeV). Six peaks appear; each peak corresponds to a beam bunch and seems to have a different energy spread.[4] Since the six peaks are clearly resolved, it seems that the designed energy resolution of this station is quite sufficient.
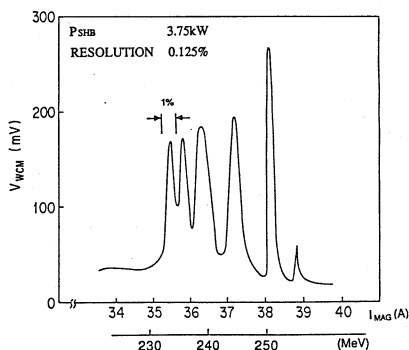

Fig. 7 Energy spectrum of a high-current electron beam measured at the target energy-analyzing station.

Control system of slits and collimators

The controller of slits and collimators comprises an industrial personal computer and a cpu-controlled communication unit which enables communication with the existing control system through a bit serial communication loop. A block diagram of the control system for collimators and slits is shown in Fig. 8. The collimators and slits have been quite successfully operated from the main operator's console.
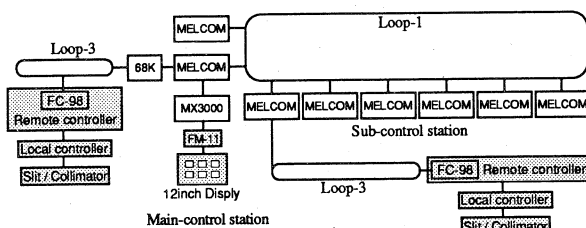

Fig. 8 Block diagram of the control system for collimators and slits.

References

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