ENERGY UP OF THE ETL ELECTRON LINAC BY KLYSTRON OPERATION EFFICIENCY UP

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One of the most simple and economical way for the energy up of linear accelerators is due to the improvement of klystron operation efficiency. Generally speaking, the operation efficiency of pulse klystrons used for linear accelerators is clearly low when compared with that of CW klystrons used for UHF-TV broadcasting; that is, most of the former are of the order of 30 % as shown in Fig.1 and the latter more than 60 %.[1] Main reasons for the low operation efficiency of the pulse klystrons seems to be due to mis-selection of the drift distances for bunching and their high-perveance gun.

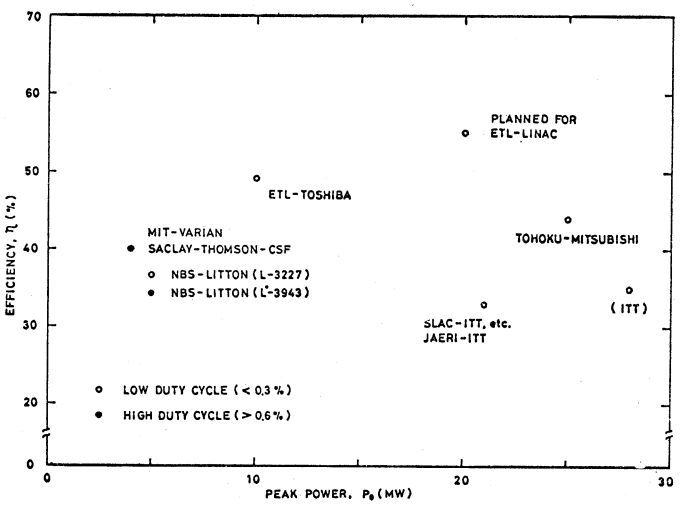

Fig.1 Efficiency of the commercially available klystrons.

The main components of the ETL linac consist of three constant impedance accelerating sections (each 1.22 m long) and two klystrons (Toshiba M4628, a 7 MW klystron with four RF cavities) as the RF power source of a frequency of 2856 MHz. The improvement of the klystron was tried in 1975 by adding the 5th RF cavity and rearranging drift distances but leaving the perveance of 2.0×10^{-6} $A \cdot V^{-3/2}$ as it was. Consequently the operation efficiency rises from 35 % to 50 % and the RF power output reaches near 10 MW as shown in Fig.1. Further effort is continued to develop a 20 MW klystron with an operation efficiency higher than 55 %, which will be used for a proposed 500 MeV ETL linac.[2]

Using the improved klystron, the maximum electron energy of the ETL linac is up to 40 MeV at the same electric power consumption as the former maximum designed energy of 25 MeV. The loaded electron energy is 31 MeV at 200 mA peak current. Fig.2 shows electron

energy and current characteristics of the ETL linac. Fig.3 shows typical electron energy spectra but not selected.

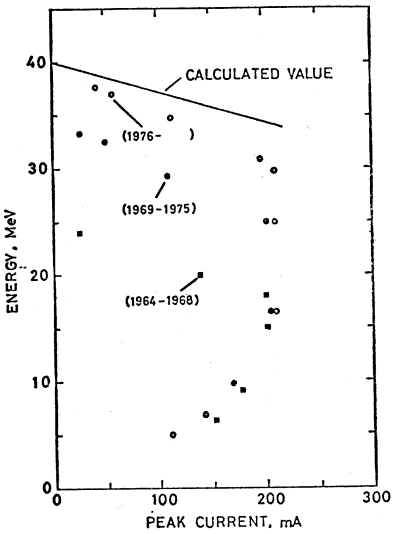

Fig.2 Electron energy and current characteristics.

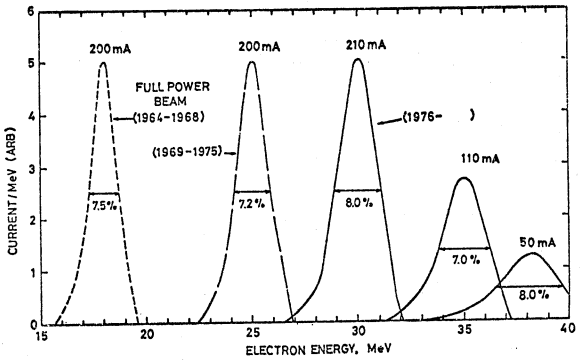

Fig.3 Typical electron energy spectra

The ETL linac is used to establish national standards of fluence and absorbed dose of high energy X-rays, electrons and photoneutrons and to obtain atomic and nuclear data needed for the standard establishment and shielding technology. It is also used for the studies of radiation damage, activation analysis and shielding technology, etc.

Anyway, the improvement of the pulse klystron operation efficiency is one of the important problems to be solved not only to save energy but also to realize low cost pion therapy in near future. For instance, by using improved klystrons with an efficiency of 55 %, the maximum electron energy of the Stanford 2-mile accelerator will be up to 30 GeV at the present electric power consumption.

The author would like to thank Mr. Yamazaki and his coworkers of electron Tube Engineering Dept. of Toshiba Co. for their cooperation to the author's proposal.

1) K. Ogura, T. Shimada, T. Zushi, K. Ohya, S. Miyake and K. Endo: Toshiba Review No.81, p.1 (May 1973)
2) T. Tomimasu: Bull. Electrotechnical Lab. Vol.42, No.1 (1978)