The Status of 14 MeV Short Pulse High Current Electron Linac

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Summary

The IAE 14 MeV travelling wave electron linac has been designed as a prototype for the proposed 100 MeV linac.[1] The first beam was accelerated on the IAE 14 MeV TW electron linac on December 22,1980.[2] An idea of the arrangement of the IAE 14 MeV linac can be obtained from Fig.1.

For maximum research utility, it is essential that the proposed 100 MeV linac have certain characteristics which are well matched with the experimental requirements for undertaking study in neutron physics and nuclear photoreactions. In this case, some experiments that have been, or will be carried out on the IAE 14 MeV linac are supposed to be necessary. Among them, an understanding of the beam phenomena at transient state is interesting.

A brief description of the proposed experiments on the IAE 14 MeV linac is also given in this paper.

System Components

The system is shown schematically in Fig.2.

Basic Disk-loaded Waveguide

The characteristics of the buncher and the accelerating waveguide are summarized in Table I below.

The soft, annealed copper waveguide is supported by a stainless steel jacket, with the spacers arranged between the guide and the jacket to allow the water to cool the waveguide. The temperature of the water is controlled in $30^0 \pm 0.15^0$C.

Disk-loaded waveguides are evacuated to 10^{-7}torr by ion pumps.

Radio Frequency Power

The drive power originates from a quartz-oscillator WSY-11 with frequency stability of about 1 in 10^6. A TW-Amplifier BM-235 provides a pulse drive power up to 1 KW to the klystron.

The klystron, D-4009, is a five cavity structure fixed tuned. It is rated at 15 MW(peak) and derated to 12 MW for this machine.

Splitting of power is as shown in Fig.2. The rectangular r.f. guides from the klystron to the accelerator are evacuated to 10^{-6}torr.

The klystron is pulsed by a conventional line type modulator with the PFN composed of 9 sections. The repetition rate of the modulator is 50 pps.

Injector

Electrons are generated by a coaxial type gun(2.5cm diameter cathode). A current of 3 Amps has been achieved at -75 KVdc with pulse lengths ranging from 15 to 50 ns, and 2 Amps with pulse length of 1.5 ns.

TABLE I

CHARACTERISTICS OF WAVEGUIDES

Quantities	Buncher		Accelerating Waveguide
l(electrical length of TW field)cm	54		259
	45	9	
r(shunt impedance)megohms/m	17.9-57.9	57.9	55.6
I(attenuation coefficient)nepers/m	0.333-0.122	0.122	0.119
V_g /c(normalized group velocity)	0.011-0.0177	0.0177	0.0182
f(nominal operating frequency)MHz	2856		2856
Q(figure of merit)2 /3 mode	8256-13889	13889	13843
V_p /c(normalized phase velocity)	0.5336-1	1	1
structure	const.gradient (at no-load)	const.impedance	const.impedance

The synchronization pulses for the cathode pulser are provided by means of light pulses from a light emitting diode which are transmitted across the -75 KVdc potential by a light pipe to a photo diode receiver.

The pulser is a conventional thyratron switching a coaxial PFN into a coaxial transmission line terminated at the grid-cathode surfaces. For the operation at the shorter pulse widths an additional pulse shaping is provided by ferrite loaded lines.

Focussing System

The entire beam line is enclosed in a magnetic field developed by Helmholtz coils. The current in each Helmholtz coil set is independently adjustable. A maximum axial field of 1.6 KG is available in operation.

Operation at Transient State

Experiments at transient state have been made to observe the limit of the charge per pulse of the electron beam[3] for buncher.

Measured Values

The operation parameters under the experimental condition are as follows:

Power for buncher(MW)	4.3±0.43
Power for accelerating waveguide(MW)	5.6±0.56
Beam Injected	
pulse length(ns)	44±0.4
beam current(A)	5.79±0.3
Gun voltage(KV)	75±0.75

At the output of the acceleration, measured values of the charge per pulse are 0.195± 0.006 microcoulombs(by current transformer) and $0.192^{+0.010}_{-0.002}$ microcoulombs(by Faraday cup).

Computer Program[4]

The theory for transient state has been developed by referring to the reference 5 which has been applied to beam dynamics for steady state.

The pulse length of the beam is divided into 88 intervals for computing accuracy of the field induced by electron beam.

When the electron beam enters into the buncher, every microwave period is divided into 100 phase intervals for computing accuracy of capture efficiency.

The diagram of the computed spectrum is shown in Fig.3. The computed value of the charge per pulse is 0.2026±0.001microcoulombs.

Acknowledgements

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References

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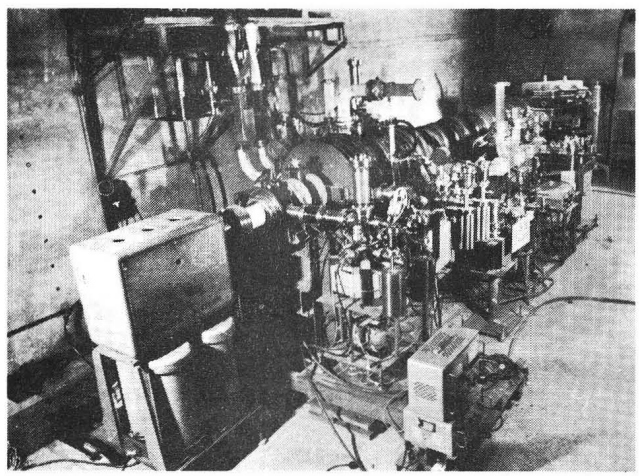

Fig.1. IAE 14 MeV TW electron linac

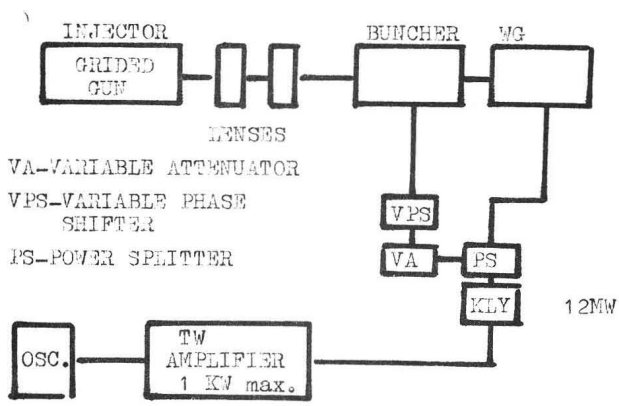

Fig.2. Schematic of linac system

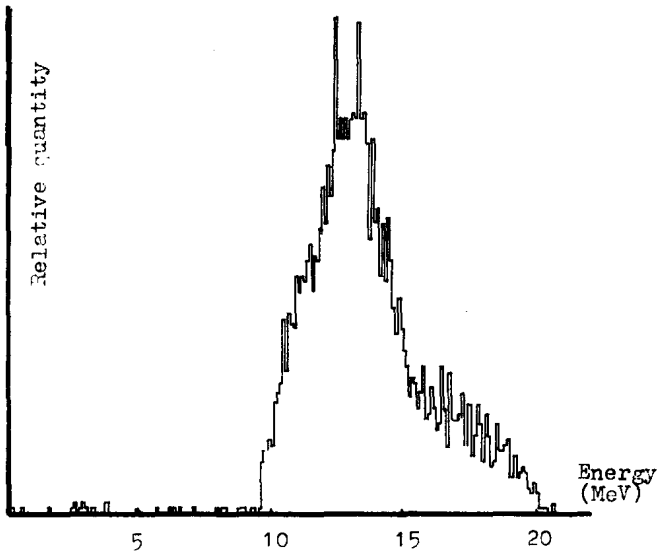

Fig.3. The diagram of the spectrum