IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4, August 1983

THE 500-MeV, 2½% DUTY FACTOR LINEAR ELECTRON ACCELERATOR (MEA)

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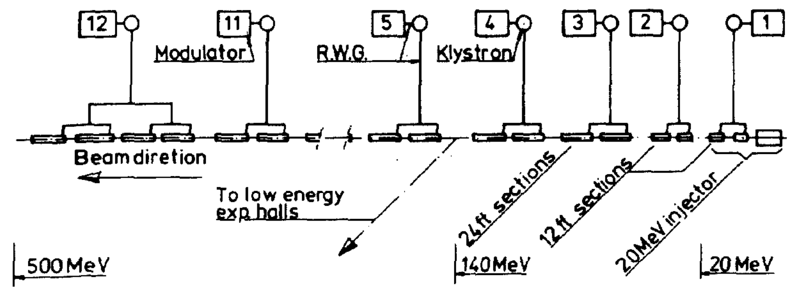

Fig. 1 Main components of the 500 MeV Linac

INTRODUCTION

Although the intermediate energy electron accelerator in Amsterdam has not reached completely its design specifications, since early 1981 a fully grown scientific program has developped using beams with an energy ranging from 20 to 120 MeV in the 140 MeV substation (for radio-chemistry and low-energy electron scattering over 180^0) and from 70 to 400 MeV in the high energy stations for electron scattering and physics with pion and muon beams.

A brief description of the MIT-type accelerator and its performance will be given with emphasis on typical features of the machine. Some examples will be given of recently obtained scientific data from which can be derived that the quality of the beam is in full accordance with the high performance level of the scientific equipment, involving a complex beam transport system and a pair of spectrometers for high resolution (1×10^{-4}) work.

MACHINE DESCRIPTION AND PERFORMANCE

The characteristics of the accelerator (in more detail described in refs. 1 and 2) are very similar to the MIT-BATES accelerator. The layout of the central beamline components is indicated in fig. 1. Some constructional aspects are rather typical for the Amsterdam machine:

a: The klystron modulators are of the line type (50 μsec), built up with solid state devices instead of high voltage switch tubes (see fig. 2).

b: The design of the modulators as well as the cooling and control systems are based on a modular principle. A full description of the rather special modulator design is given in refs. 3, 4 and 5.

c: The accelerator is computer controlled (see fig. 3 and for more details ref. 6).

d: A full power test facility is available for testing, repair and improvement programs.

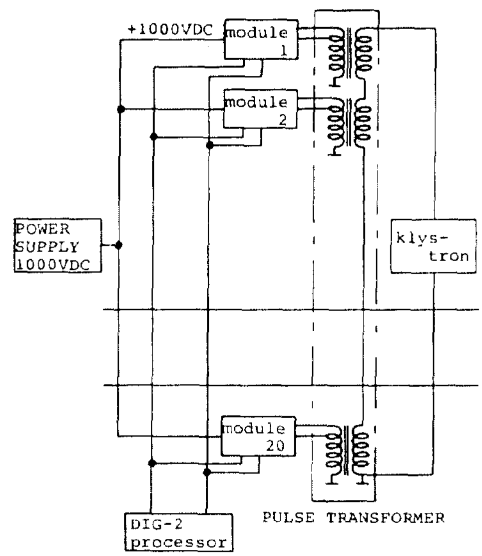

Fig. 2 Modulator block diagram

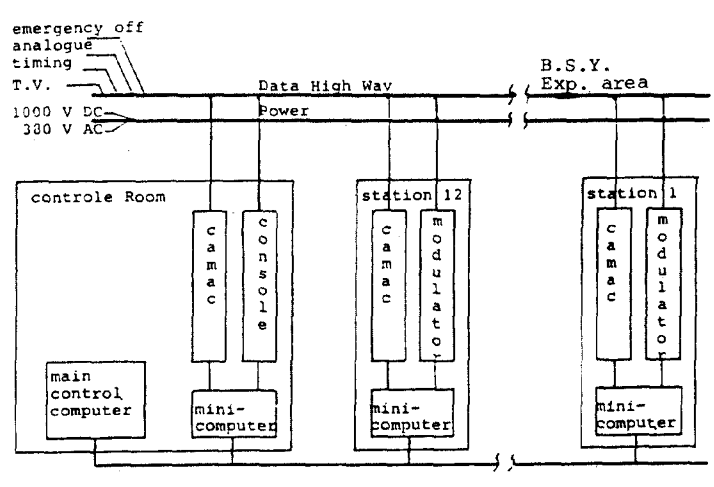

Fig. 3 Computer Control System

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Table 1: Beam specifications

		design	obtained
Max. energy	(MeV)	500	400
Injector energy	(MeV)	20	20
Beam current peak	(mA)	20	20
in .3% en. bin	(μA)		50
Pulse width	(μs)	50	40
Rep. rate	(Hz)	2000	500
Energy spectrum	(%)	1	0.3
Beam loss	(%)	0.1	0.1
Emittance	mm.mr	1	0.3
Duty factor	(%)	2.5	2

ACCELERATOR PERFORMANCE

A comparison of the beam design values with those obtained so far is given in table 1. Some remarks on the major accelerator components will now be given.

INJECTOR: The 20 MeV injection system, consisting of a 400 kV dc gun, a chopper-prebuncher system, a buncher- and a short accelerating section, is performing extremely well.

MODULATORS: All 12 accelerator stations and one modulator for testing operations have now been put into service. The pulse flatness on the first two klystrons has been improved to .1% by means of a special filter on the pulse transformer. The reliability of the transformer shorting circuit and the klystron filament transformer limits so far the maximum repetition rate to 500 Hz and the klystron RF power output to 2 MW. An improvement program to increase these values to 2000 Hz resp. 4 MW is underway.

KLYSTRONS: Although the klystrons have been operated at reduced power levels (2 MW at 500 pps), their performance so far justifies the expectation that their life time will be satisfactory.

DRIVE LINE: RF drive power for the klystrons is provided by an RWG system fed by the first klystron. The good performance (1^0 phase stability) has been obtained by temperature control to $.03^0$, pressure control to 1.5 torr and RF pulse flatness to .1%.

WINDOWS: Several of the rectangular RF waveguide windows failed due to multipactoring. Circular BeO windows have now been tested with good results. Gradual replacement is being executed.

COOLING SYSTEMS: The modulator FREON cooling system (ref. 2) is modified from liquid to vapor cooling. This will extend full power linac operations into the hot summer months.

COMPUTER CONTROL: Systematic debugging and frequent maintenance has reduced the failure rate of the computer control systems, which are now in their final configuration. The response time is satisfactory. A major improvement in "beam set-up time" has been obtained by the implementation of SARAS. This program allows storage and retrieval of the important control data (power supplies, modulators, rf, etc.) and reduces the beam set-up time considerably (appr. 10 minutes).

Considerable effort has been given to the improvements of the beam quality. The installation of a stabilizer for the HV gun power supply will further reduce the energy fluctuations, caused by small current instabilities from the injector. Nevertheless high quality beam transport with energies from 50 MeV upwards can now be obtained.

RESULTS

Most of the experimental program so far has taken place in the electron scattering facilities at the 140 MeV point and beyond the end of the accelerator. Therefore we present some of the results in that program.

In fig. 4 the analyzing equipment in the 500 MeV end station is shown. The QDD spectrometer is designed for high (1×10^{-4}) resolution (e,e') experiments. The QDQ is especially suited for those experiments where a large solid angle is important. This combination and the special features of the detection telescopes allow to perform coincidence experiments with very low missing energy and timing resolution. Both those quality factors and the duty factor of the beam are imperative to perform those experiments at an advanced level. It will be apparent that other accelerator beam properties (phase space, energy spread) are equally important for optimum results.

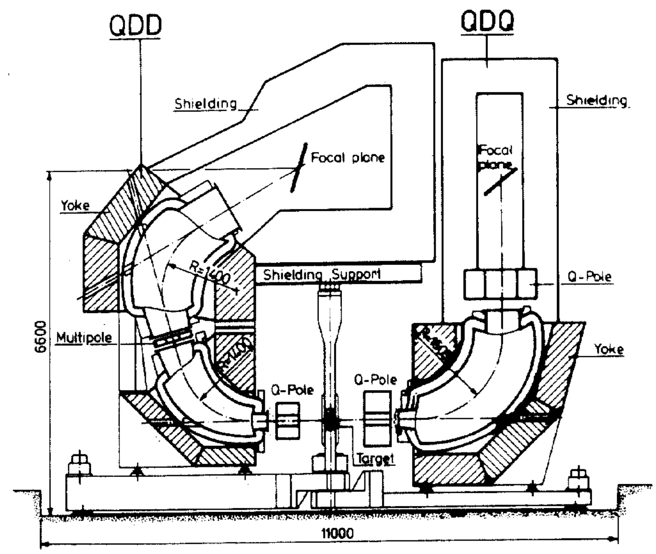

Fig. 4 The spectrometer pair installed at NIKHEF-K

A spectrum of the scattered electrons as measured with the QDD is shown in fig. 5. This is an indication that during the measurement time the long range stability of energy, energy spread and phase space must have been excellent. Fig. 6 shows one of the most gratifying results achieved at NIKHEF-K, namely coincidence spectra involving simultaneous detection of the scattered electron and the knocked out proton. It is especially for those types of experiments that the machine has been built.

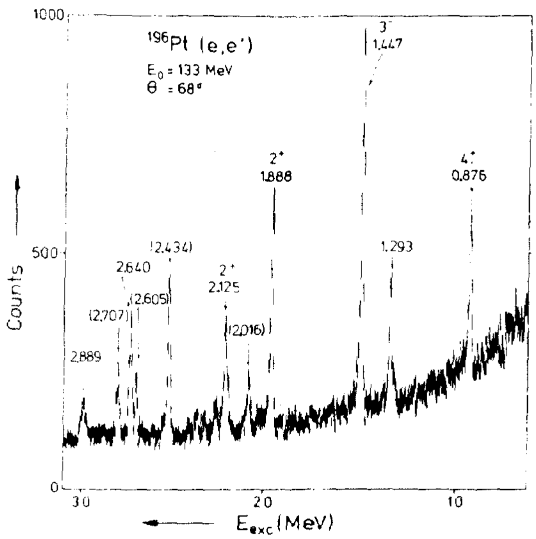

Fig. 5 Inelastic spectrum from ^{196}Pt taken at 1.5×10^{-4} resolution

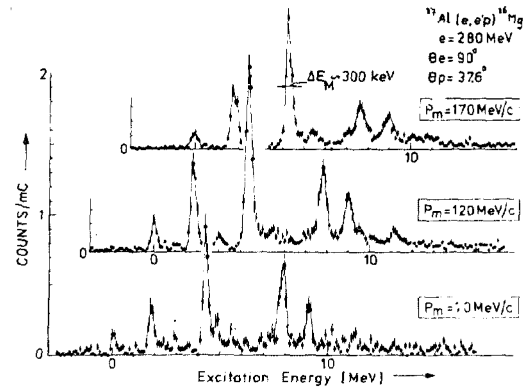

Fig. 6 Missing energy spectra obtained by coincidence measurements

FINAL REMARK

Internationally the interest in coincidence experiments is growing to the extent that several leading laboratories around the world aim at 100% duty factor electron accelerators to further extend this advanced type of nuclear physics experiments. Also at NIKHEF-K an update of the MEA accelerator in this respect is anticipated in the not too far future. Design studies are made to add a pulse stretching magnetic device for which MEA will serve as a low duty factor (0.1%) injector. Slow extraction of the circulating beam from this device will allow experiments with a beam duty factor of 80%.

ACKNOWLEDGEMENT

We gratefully acknowledge the valuable contributions of the members of the various departments. The work described in this paper is part of the research program of the National Institute for Nuclear and High Energy Physics, section Nuclear Physics (NIKHEF-K), made possible by financial support from the Foundation for Fundamental Research on Matter (F.O.M.) and the Netherlands Organization for the Advancement of Pure Research (Z.W.O.).

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