PULSED BEAM DEFLECTION AND TRANSPORT SYSTEMS OF THE ETL LINAC

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ABSTRACT

The pulsed beam deflection and transport systems have been designed and constructed to deliver the electron beam from the linac to the low energy experimental room. Some characteristics of the systems and some results on the performance are presented.

INTRODUCTION

For the multipurpose use of the electron beam, pulsed beam deflection and transport systems are designed at the three energy sections, that is, low, medium and high energy sections[1]. The pulsed beam deflection systems[2] are operated to split out the pulsed electron beam alternatively and to have no effect of the residual magnetic field on the electron beam in the succeeding accelerating sections. The program of the standadization of the electron absorbed dose in low energy range is now planning and good focused electron beams are required in this experiment. At low energy section, the pulsed beam deflection system combined with a beam transport system provides the electron beam to the low energy experimental room. The systems are controlled to have a point imaging on the entrance of a water bath for the calorimetric measurement of absorbed dose.

PULSED DEFLECTION SYSTEM

The plan view of the pulsed beam deflection and beam transport systems is illustrated in Fig. 1. PC refers to 7.5° pulsed deflection system, DL-I and DL-II dipole magnets (bending angle 42°), QE quadupole singlet, Q-1~3 quadrupole doublets, SL the energy-defining slit system,TR-1~ 3 beam position monitors using optical transition radiation[3] and FC-1 ~ 3 Faraday cups. The pulsed deflection system is designed to deflect electron beam of momentum up to 80 MeV/c by an angle of 7.5°. This system is set at the loction between 4 th and 5 th accelerating tubes. The coil pair consists of two saddle shaped coils with a length of 36 cm and a width of 12 cm and is set with a ceramic beam duct of 7.6 cm dia. compactly. The advantage of this shape is to obtain sufficiently strong magnetic field to deflect electron beam in a very short distance and to reduce the backward magnetic field in the fringe of the pulsed coils. However, this structure slightly sacrifices the uniformity of the magnetic field in the off-axis part of the coils. The pulsed coils are excited by a silicon controlled rectifier pulser which produces a current in a half sinusoidal wave of 300 Hz at variable repetion rates from 25 pps to 100 pps The exciting pulse current circuit oscillates for little more than a half cycle and overshooting is prevented by a simple crowbar circuit as shown Fig. 2. Approximately 50 % of the pulse energy is returned to a capacitor bank by the crowbar circuit. Fig. 3 shows the wave of exciting current. The flattop is maintained within 0.4 % for 50 µsec. The stability of peak current is mainly limited by the thermal change of the charging capacitor bank and estmated to be 0.5 % for one hour. The pulsed coils are wounded by copper braid insulated with heat-treated glass fiber. To prevent mechanical self-destruction and movement induced by excitation, the coils are clamped by massive wooden frames and bolts inserting insulation pads between the coil and the frames. The magnetic field strength needed to deflect 60 MeV electrons by an angle of 7.5° is 725 gauss and the corresponding pulse current is 179 ampere. This mgnetic field is lower by 16 % than that estimated from the experiment in the case of the dc current exciting. It is due to the eddy current loss in the coils. Since the coil pair is excited by pulse current, the beam duct installed between the saddle shaped coils shoud have high electrical resistance to keep eddy-current loss low and should have a high mechanical strength. Fig. 4 illustrates the arrangement of the pulsed coils and the ceramic beam duct. The ceramic vacuum duct used here have a length of 40 cm, an overall diameter of 7.6 cm and wall thickness of 0.7 cm and its inside surface is coated with a low resistivity titanium compound. Fig. 5 shows the wave form of RF power measured at a water dummy of the 9 th accelerating tube. The linac is operated in a pulse repetition rate of 50 pps. The patern of beam loading shows that a half of the pulses of electron beam are deflected. The deflection system has no effect on the electron beam accelerated in the succeeding accelerting tubes.

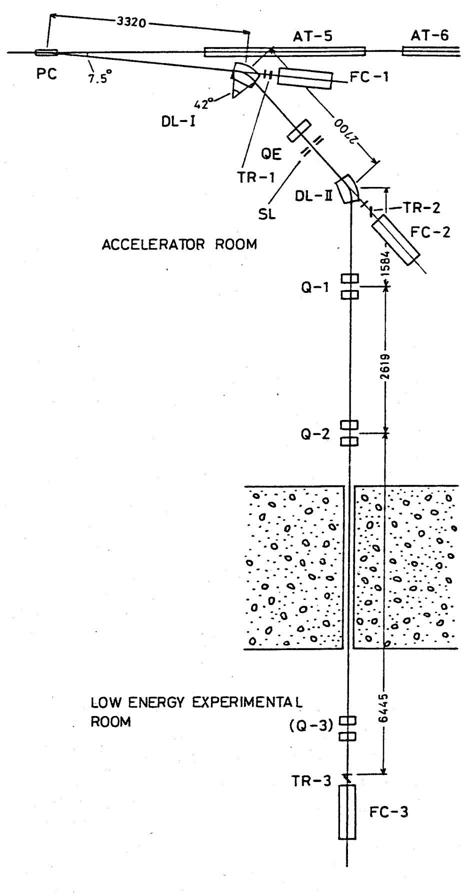

Fig. 1 Plan view of the pulsed deflection and transport systems.

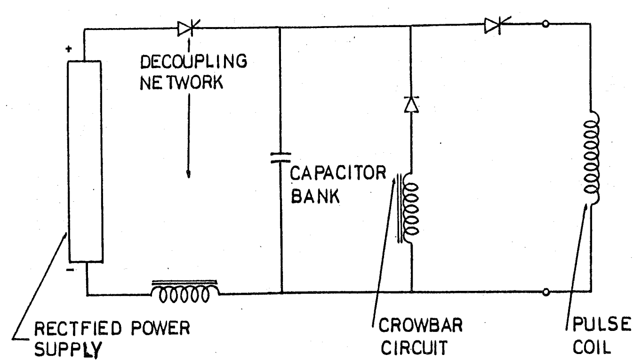

Fig. 2 Schematic diagram of the exciting pulse current circuit.

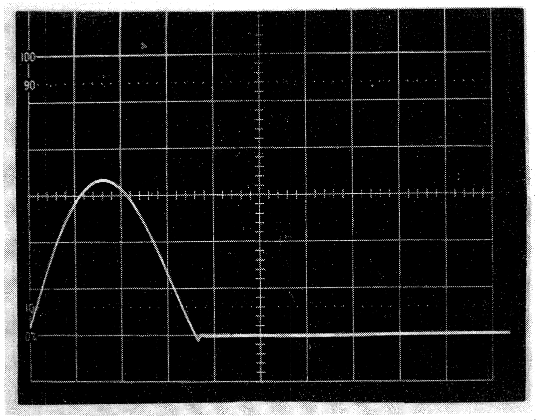

Fig. 3 The wave form of excitin pulse currnt. 1 V/div, 0.5 msec/div

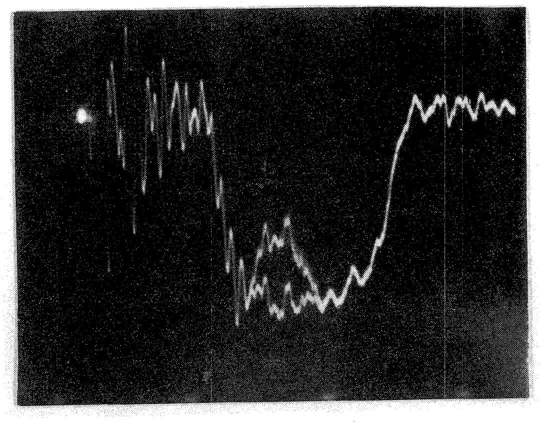

Fig. 5 The wave form of Rf power measured at a water dummy of 9 th accelerating tube.

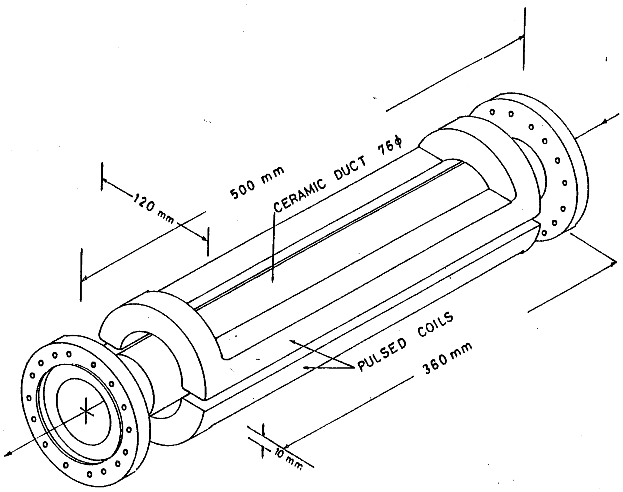

Fig. 4 Shematic view of the arrangement of the pulsed coils and the ceramic beam duct.

Table 1

Main parameters of magnetic elements

Dipole magnets (DL)	
Radius (m)	0.6087
Deflection angle (deg)	42
Maximum field (T)	0.63
Gap (mm)	60
Effectivc length (m)	.4462
Quadrupole magnet (QE)	
Bore radius (cm)	7
Effective length (m)	0.21
Maximum field gradient (T/m)	2.98
Quadrupole magnets (Q1 3)	
Bore radius (cm)	4
Effectiv length (m)	0.186
Maximum field strength (T/m)	3.6

BEAM TRANSPORT SYSTEM

The purpose of the beam transport system is twofold;it delivers efficiently the electron beam from the linac to the low energy experimental room and also makes fine preselection of momentum of the electron beam. Table 1 shows the main parameters of the magnetic elements in the beam trnasport system. Two C-type sector magnets for 42° deflection are used. They have homogeneous magnetic field with a same entrance and exit angle of 11.7° . The advantages of this design are the following: the fabrication of the homogeneous-field magnets is of couse easy and this magntic structure is equivalent to a structure with a field index n = 0.5 at magnetic field along radial direction and without edge focusing. Two types of quadrupole magnet are used; the bore radii of 7 cm for a singlet and 4 cm for three doublets. The quadrupole singlet QE is placed midpoint between two bending dipole magnets DL-I and DL-II and also provides a control for varying the beam dispersion over wide range at the slit location. The symmetry arrangement of DL-I - QE - DL-II is for the purpose of making the beam achromatic in the beam transport system. Quadrupole doublets Q -1~3 limit the horizontal extent of the beam through dipole magnet DL-II and cotrol the beam size in both horizontal and vertcal planes at the exit of the transport system. All magnet power supplies have a long term stability of 1×10^{-5}.

SYSTEM OPERATION

To find out the optimum operation point of the pulse deflection and transport systems, beam positions are monitored by observing optical transition radiation from Al plates . Electron beam profiles are also measured by the use of the pattern of discolored spot of polyvinyle chloride film caused by electron irradiation. Fig. 6 shows the momentum spread of electron beam into a Faraday cup at the exit of the analysing tube of the DL-I. Optically considering,the pulsed beam deflection and transport systems originate from the position of the

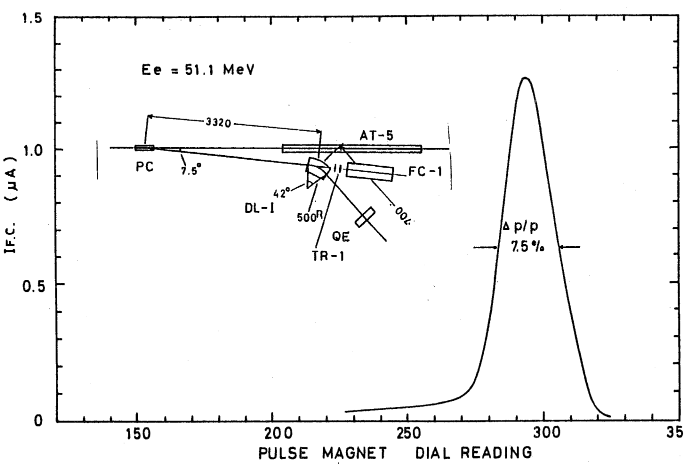

Fig. 6 The momentum spread of electron beam into a Faraday cup.

pulsed coils where the accumulation of beam matrix starts. For the calculation of the beam envelope of the systems,we use the following accelerator beam specifications; dimensions x = y = 3 mm, divergences θ = ϕ = 0.1 mrad and momentum spread $\pm$ 3 %. Fig. 7 shows the beam half width fo both holizontal and vertical planes. Fig. 8 shows a beam profile caused by electron irradiation on polyvinyle chloride film which was set at the exit window of the beam transport system. It shows that the electron beam is well-focussed and the pulsed beam deflection and transport systems have the unique capability in the beam control for the low energy experimental facilities.

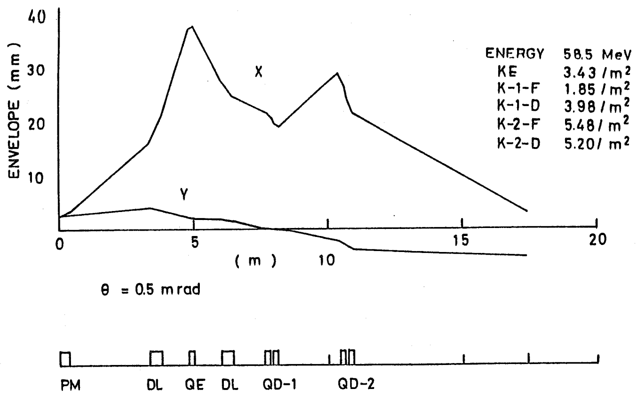

Fig. 7 Beam half width of horizontal and vertial planes.

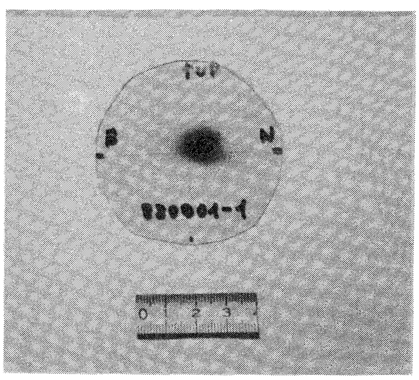

Fig. 8 A beam profile measured by th use of the pattern of discolored spot of polyvinyle film at the exit window of the beam transpot system.

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