

Design studies of a 100 MeV proton linear accelerator

P SINGH, R MYTHILI and M G BETIGERI

Nuclear Physics Division, Bhabha Atomic Research Centre, Bombay 400 085, India

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Abstract. Design details of a 100 MeV proton linear accelerator (Alvarez system) operating at a resonating frequency of 400 MHz have been studied. Increase in the linac operating frequency has become feasible with the possibility of injecting protons from a radio frequency quadrupole accelerator with energies higher than the conventional pre-injectors. Various electrical parameters of such a system have been calculated and compared with the existing linac injectors operating at 200 MHz.

Keywords. Linac design calculation; radio frequency quadrupole-Alvarez combination; proton linear accelerator.

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1. Introduction

In most of the proton linear accelerators operating in the world (Cole 1971; Wheeler *et al* 1979; Michaelis 1975) the configuration follows a familiar pattern in which protons from a d.c. source, usually a Cockcroft-Walton generator of 750 kV, are bunched and injected into an Alvarez type linear accelerator (linac) operating around 200 MHz. The choice of the exciting frequency of the Alvarez linear accelerator depends on the velocity of the proton beam (β) being injected into the linear accelerator. It has been shown (Smith 1959) that as long as the quantity $2\pi a/\beta\lambda \ll 1$, the longitudinal transit time factor is insensitive to the choice of the wavelength. For $2\pi a/\beta\lambda \gg 1$, the transit time factor falls exponentially and hence the effective shunt impedance of the structure drops rapidly. However, for $2\pi a/\beta\lambda = 1$, the transit time factor is 0.79 which is still a reasonable value for design purposes. Therefore, for a drift tube bore radius a of 1 cm and $\beta = 0.04$ (corresponding to the 750 keV protons), the wavelength works out to 157 cm or a frequency of 191 MHz and hence the choice of 200 MHz for the exciting frequency in the existing linacs is not far from the calculated value.

However, on increasing the energy of the proton beam to be injected into the linac structure, two distinct advantages may be visualized. (i) Higher incident energy would allow injection of the proton beams into an Alvarez structure being operated at higher frequency. For $\beta = 0.08$, which corresponds to a 3 MeV proton beam, the frequency for the Alvarez system would be 400 MHz. Higher operating frequency is expected to lead to lower rf losses. (ii) The injected protons are subjected to strong radial rf defocussing forces in the first stages of the linac cavity. The effect of these forces would be stronger for small velocities of the injected protons. Hence at a higher incident energy the requirements on the quadrupole magnets enclosed within the drift tubes are expected to be less stringent.