4π-MODE ACCELERATION IN THE KEK 20 MeV LINAC

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Abstract

Acceleration of deuterons and heliums in a proton linear accelerator is performed by 4π-mode operation. According to simulation of deuteron acceleration, a preliminary acceleration test of H_2^+ beam was done without a change of the accelerating field distribution along the linac tank and with a slight increase of rf field level. A linac beam of 0.7 mA was obtained at the position of 4.75 m behind the linac tank.

The KEK 20 MeV linac has satisfactorily run with a high intensity beam of about 150 mA. Recently, interest for acceleration of light ions such as deuteron and helium having a charge to mass ratio Z/A = 0.5 is expressed. Such acceleration is possible by 4π-mode operation in a proton linear accelerator.[1),2)] In this operation, conventionally, the lowering of the transit time factor in the first gaps is compensated by an increase of the rf field level in the same gaps. In practice, Fig. 1 shows the measured transit time factors for protons (Tp) and for deuterons (Td) in the KEK 20 MeV linac.[3)] The ratio of Tp to Td varies greatly along the tank as seen in Fig. 1. Then, the accelerating fields calculated by the synchronous conditions for protons and deuterons are shown in Fig. 2. A large change in the existing field distribution is necessary to accelerate deuterons with the conventional method.

Otherwise, there is a request for acceleration of a high intensity proton beam. Therefore, alternating acceleration of protons and light ions is discussed. However, because of change of the accelerating field distribution the acceleration mode mentioned above is very difficult.

The another 4π-mode acceleration is researched with simulation of deuteron acceleration[4)] according to the preliminary results pointed out by S. Ohnuma and Th. Sluyters.[1)] This simulation shows that three stable areas for injection energy between 350 keV and 700 keV are obtained without a change of the existing field distribution and with an increase of rf field level. The results calculated are shown in Figs. 3 and 4. As seen in Fig. 4, if the injection energy spread is better than ± 3 keV and the accelerating field level is increased by a factor of 1.3, the stable area around the injection energy of 555 keV gives the phase acceptance of 180°.

H_2^+ beam acceleration in 4π-mode operation was tried with a 1.15 higher rf field level. A linac beam was observed with the 50 Ω matching type monitor,[5)] which was placed at the position of 4.75 m behind the linac tank. Two stable areas near 400 keV and 560 keV were measured. The results observed around injection energy of 560 keV are shown in Fig. 5 with the capture efficiency calculated. As seen in Fig. 5, the accepted half energy spread was within ± 3 keV and a linac beam of 0.7 mA (10 mA at the entrance of the linac) was obtained. The capture efficiency measured is not so large but it would be improved by the adjustment of the Q-magnets in the low energy beam transport line because the transverse input acceptance is different from one calculated for the usual protons.

References

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3) S. Okumura and D.A. Swenson: KEK report, KEK-74-15 (1975).
   S. Inagaki et al. reported the transit time factors for protons in KEK-79-7.
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5) Z. Igarashi et al.: private cominucation.

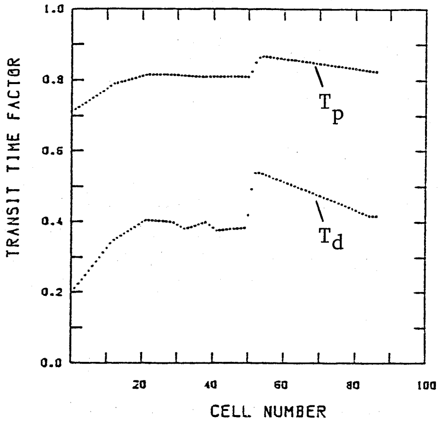


Fig. 1 Measured transit time factors (Tp and Td) in the KEK 20 MeV linac

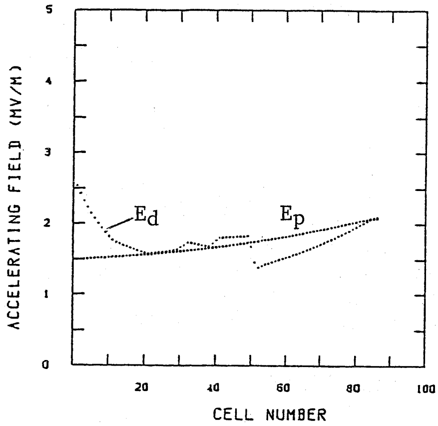


Fig. 2 Designed accelerating field for protons (Ep) and calculated accelerating field for deuterons (Ed)

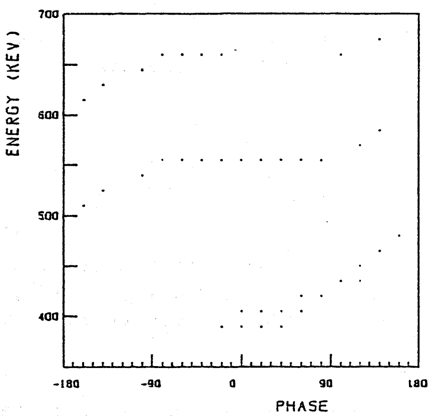


Fig. 3 Longitudinal acceptance in the proton field level × 1.3

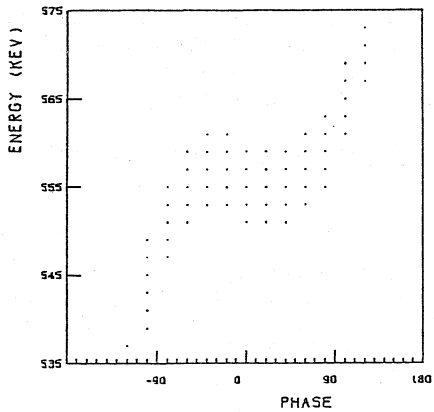
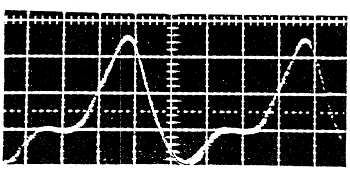


Fig. 4 Details of longitudinal acceptance around 555 keV in the proton field × 1.3



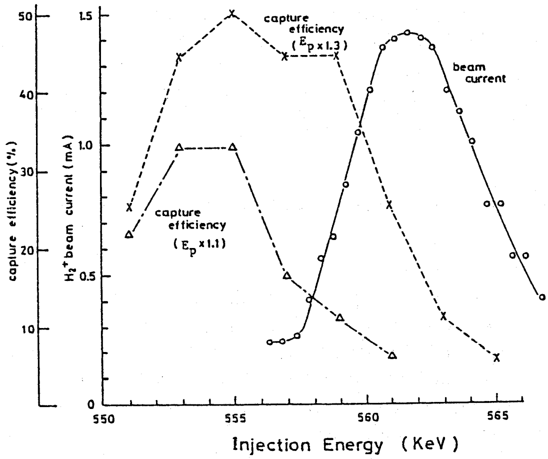


Fig. 5 Bunch shape (X=1ns/Div) ↑, measured linac beam intensity and calculated longitudinal capture efficiency →.