EXTENSION PLAN OF KEK PROTON LINAC

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ABSTRACT

To increase intensity of the KEK Proton Synchrotron reducing beam loss at injection to the booster, conversion from p to H^- of the linac beam is in progress. For charge-exchange injection, higher energy is preferable. Thus, upgrading of the linac is examined. 40 MeV, twice of the present energy, seems to compromize requirements. Main parameters of the second linac tank are, 12.82 m long, 0.90 m inside diameter, 35 cells and drift tubes with ALNICO permanent quadrupole magnets.

1. Introduction

To accumulate many protons in a synchrotron, multi-turn injection system has been widely used. This system, however, has an inherent disadvantage of poor capture efficiency, so that modern high intensity synchrotrons are or will be equipped with charge-exchange injection system(1). At KEK, about a half of the injected 20 MeV protons is lost at the multi-turn injection and a half of the remainder vanishes later during bunching by accelerating RF. Although it is difficult to predict the maximum intensity in the synchrotron, so called incoherent space charge limitted current is proportional to $\beta^2\gamma^3$.

As restriction of the Liouville's theorem does not work for the charge-exchange injection, H^- can be injected until beam loss due to multiple scattering by a stripper foil becomes intolerable. According to computer simulation, 100 turns are effectively accumulated in KEK booster for 200 turn injection(2). It means a 120 μS injection of 4 mA H^- is equivalent to the five turn injection of 160 mA p. The multiple scattering and energy loss due to the foil decrease with increasing the injection energy and the carbon stripper lasts longer. Thus upgrading of the 20 MeV injector linac has been studied(3).

2. Linac Extension

The most serious problem for upgrading is lack of the space for new RF high power system. This will be solved, in principle, as follows.

The present 20 MeV linac is equipped with two TH-516 amplifier systems. The exciting power is about 1 MW, while the beam power is 3 MW for 150 mA. The total power required is 4 MW and should be supplied by two feed system. If 30 mA H^- beam is accelerated, the beam power is 0.6 MW and total power amounts to 1.6 MW. This power can be supplied by one TH-516 amplifier system. The other can feed the new tank. The equal energy gain of the second tank is plausible. It is practical to follow the established fablication process of the first tank, such as electroplating of copper, and to install two feed system. The main parameters are shown in Table 1.

A permanent quadrupole magnet was mounted to the last cell of the 20 MeV linac and it has worked satisfactory(4). As the necessary field gradient is not so high, an ALNICO-9 magnet with magnetizing coils is acceptable. It has an advantage over a rear-earth magnet: magnetizing and demagnetizing can be done after installation to the tank.

A 400 MHz, 12 cell model cavity is being prepared. It will confirm characteristics of post couplers(5). They will be required because the resonance of the second tank should be tuned to that of the first tank with a tuner avoiding appreciable change in field distribution.

Dual mode operation of high current H^- and polarized H^- is feasible. That of protons and α-particles or other light ions is being investigated.

Layout of the new 40 MeV tank is shown in Fig. 1 with the 20 MeV linac.

References

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Table 1 Main parameters of the second linac

Energy	20.40 — 40.48	MeV
Frequency	201.070	MHz
$\beta\lambda$	0.3060 — 0.4244	m
$\beta^2\gamma^3$	0.04491 — 0.09195	
Tank	Steel, copper plated	
Length	12.82	m
Inside diameter	0.90	m
Number of cells	35	
Drift tube	Stainless steel, copper plated	
Outer diameter	16	cm
Bore diameter	3	cm
Quadrupole magnet	permanent (ALNICO-9)	
Aperture	3.4	cm
Length	16	cm
Outer diameter	13.5	cm
Field gradient	2.2 — 2.25	kG/cm
Synchronous phase	- 30°	
Average axial field	2.2	MV/m
Shunt impedance	74.34 — 72.51	MΩ/m
Transit time factor	0.8519 — 0.7915	
Effective shunt impedance	53.95 — 45.43	MΩ/m
Exicitation power	0.845	MW
Beam poewr (for 30 mA)	0.60	MW
Total RF power	1.445	MW
RF coupling	Loop, two feeds	
Stabilizer	Post couplers	
Vacuum system		
Main pump	Ion pump (1000 ℓ/s × 8)	
Auxiliary pump	Turbomolecular pump (500 ℓ/s × 2)	
Temperature regulation	± 0.1	°C

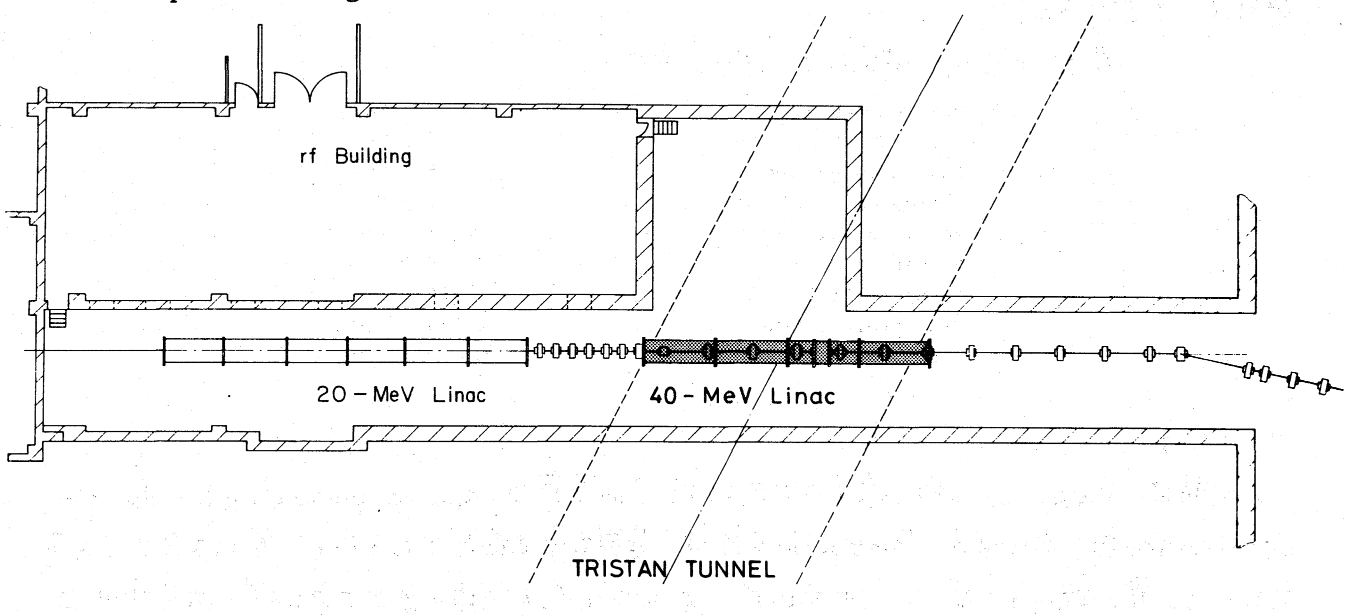

Fig. 1 Layout of injector linac of 12 GeV proton synchrotron.