EXTENSION PROGRAM OF KEK PROTON LINAC

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Abstract

Multicusp H^- ion source was developed and H^- charge-exchange injection was tested successfully with the injection energy of 20 MeV. As energy loss and multiple scattering are greatly reduced by increasing injection energy to 40 MeV, an Alvarez linac of 20 MeV to 40 MeV is being designed.

1. Introduction

H^- charge-exchange injection is a trend in high intensity proton synchrotrons.[1,2,3,4] It increases accumulated protons in a synchrotron with lower beam loss at injection. In principle, there is no limitation on accumulated beam intensity. In practice, however, the beam intensity has an upper limit which is determined by energy loss and emittance dilution due to multi-transversing a stripping foil. When the injection energy rises from 20 MeV to 40 MeV, the energy loss decreases from 2.8 to 1.6 keV for a 120 $\mu g/cm^2$ carbon foil and multiple scattering from 6.3 to 3.2×10^{-4} rad/turn. If the beam intensity of Booster Synchrotron is limited not by the injected beam current but by Booster itself, conversion from protons to H^- improves Booster beam intensity little, and the improvement will be achieved by upgrading of the injector linac.

2. H^- ion source

It is clear that recent development of high intensity ion sources has contributed greatly to the trend of H^- charge-exchange injection. Various negative ions have been widely used in Tandem Van de Graaff accelerators for nuclear physics. The synchrotron, however, needs much higher intensity beam because the injection duration is very short.

There are three types of the H^- ion source: a) charge-exchange of protons to H^- with H_2 or Alkali atom vapor, b) H^- production on cesiated surface and c) volume production.[5] Although mechanism of the surface production is not yet fully understood, so far the highest intensity is attained by sources of b). As the magnetron source is too tiny to be equipped with cooling system of its electrodes, it seems suitable for low duty operation.

Thus a multicusp H^- ion source was made (Figs. 1, 2).[6] Its operating parameters are shown in Table 1. After careful conditioning of the molybdenum converter, it could yield 20 mA H^- beam with 95 % emittance of 0.17 π cm•mrad. However, two difficulties still remain for longer term operation. One is consumption and feeding of cesium and contamination of the accelerating column, the other is its cathode life. The latter is urgent. The cathode of multicusp or bucket source should work in temperature limit condition, otherwise the anode voltage decreases and no sufficient ionization occures. At present, the cathode is made of tungsten or its alloys. When a tungsten filament of 1 mmϕ was heated by 50 Hz ac, the beam intensities scattered from pulse to pulse and its life is very short. The beam became stable by dc heating and the filament lasted much longer. Nevertheless, the life might be not long enough for 10 day operation.

3. H^- charge-exchange injection trial

The multicusp ion source was mounted to the accelerating column, polarity of Cockcroft Preinjector was reversed and H^- ions were accelerated to 20 MeV. 20 mA was injected to Linac whereas 8.5 mA was detected by Faraday cup at the end of 20 MeV beam line. Although RF system was not at its best, Booster set a new record of 7.13×10^{11} protons/pulse.

4. New Alvarez tank and RF design

Layout of the tank is shown in Fig. 3 with its RF system. Main parameters are already reported.[7,8] Post couplers and ALNICO Q magnets are tested with models.[9,10] RF power is to be coupled to the tank by two feed system. The power from a TH516 is divided by a power splitter and fed to the tank through circulators with dummy loads. A power splitter was made and tested up to 1 MW. When its outlets were terminated with high power dummy loads, the VSWR was less than 1.03 at its input. No breakdown or other trouble was observed.

References

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Table 1
Multicusp H^- ion source parameters

arc current	60 - 80 A
arc voltage	90 - 110 V
H_2 pressure	3 - 5 × 10^{-4} Torr
cathode filament	1.2 ϕW
filament current	150 A
filament voltage	8 V
Cs reservoir temp.	160°C
beam duration	200 μs
repetition rate	20 Hz
H^- beam current	20 mA

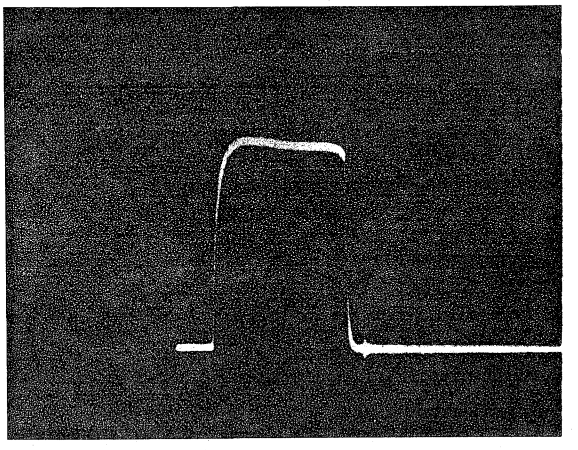

Fig. 2 20 MeV H^- ion beam.
X: 50 μs/div.
Y: 2.5 mA/div.

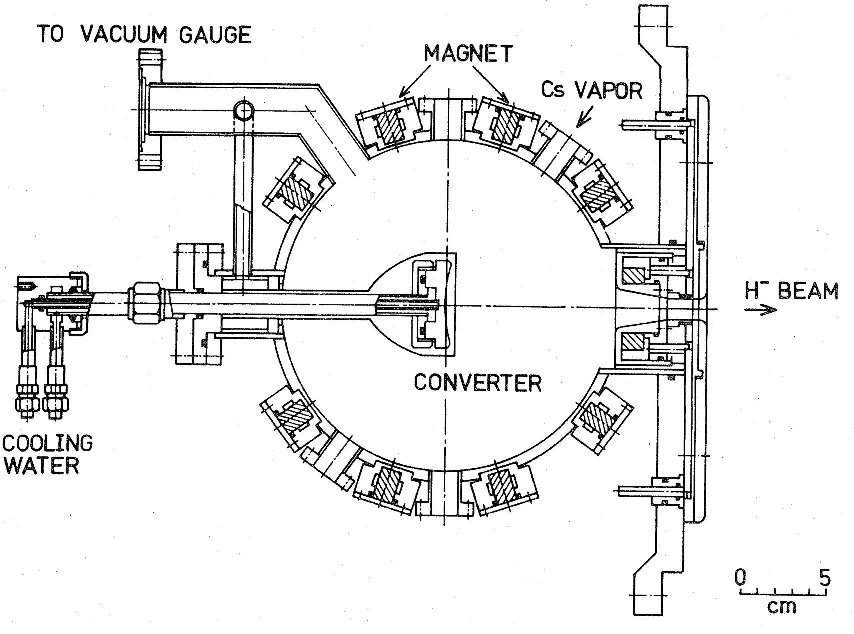

Fig. 1 Schematic diagram of multicusp H^- ion source.

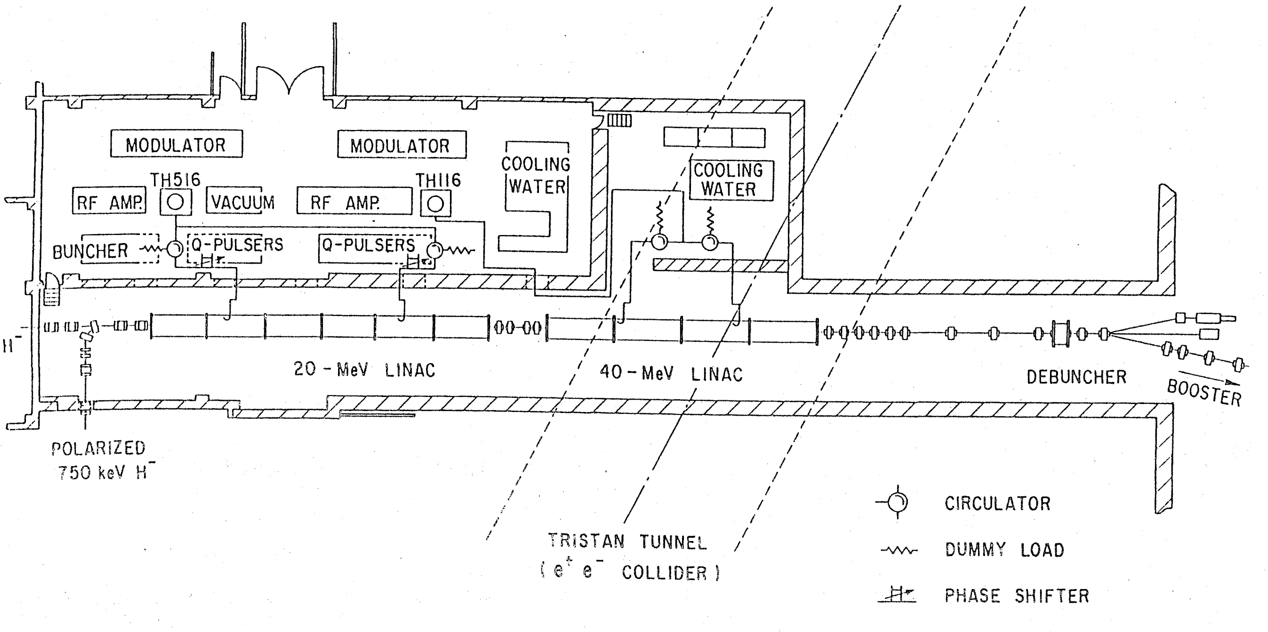

Fig. 3 Layout of 40 MeV injector linac with modified RF system.