INJECTION SYSTEM OF H^- BEAM IN KEK BOOSTER SYNCHROTRON

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Abstract

We have a plan of H^- ion beam injection into KEK booster synchrotron. After the acceleration by the pre-injector and the linac, the H^- ion beam is converted to proton beam with a carbon film stripper at the entrance of the booster, and injected into the booster ring. The merit of this injection scheme is to capture the linac beam of long duration in the booster.

Design

1. Magnet and monitor arrangement

The arrangement of magnets and monitors for the injection scheme is shown in Fig.1. The H^- beam from the 20 MeV linac is injected onto an injection orbit, which is formed by distorting a portion of the central orbit with bump magnets 1, 2, 3 and 4 as shown in Fig.1. The H^- beam is converted to a proton beam by passing through a carbon film stripper set on the injection orbit. After one turn revolution, the proton beam meets the H^- beam from the linac at the stripper position. Owing to the difference of the charge states, it is possible to occupy the same position in a phase space by the proton and H^- beam. As the proton beam circulating in the booster passes through the carbon film repeatedly during the H^- beam injection, its betatron amplitude is increased by the scattering of carbon atoms and the decreasing of its momentum. When this amplitude reaches the acceptance of the booster, the multi-turn injection of the H^- beam is turned off and the magnetic fields of all bump magnets fall off to zero rapidly. As the proton beam begins to take betatron oscillation along the booster central orbit at this time, it does not collide with the carbon film any longer and the increase of the betatron amplitude ceases. In order to make fine tuning of the beam orbit, six profile monitors (Pr. 1 ∿ 6) which are secondary emission type multi-wire detector are installed in the line.

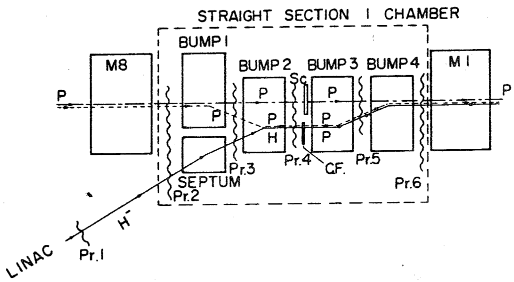

Fig.1 H^- ion beam injection system in KEK booster (arbitrary unit)

BUMP 1 ∿ 4:	Orbit bump magnet
SEPTUM:	Septum magnet
Pr. 1 ∿ 6:	Secondary emission type multi-wire profile monitor
C.F.:	Carbon film
Sc.:	Scraper

2. Bump magnets and their power supply

As all bump magnets (BUMP 1 ∿ 4) always have to be the same field, they should be constructed with same sizes and connected in series. The design values of the bump magnet and its power supply are shown in Tables 1 and 2 respectively.

Bump Magnet Design

Length		(mm)	350
Gap	height	(mm)	40
	Width	(mm)	160
Coil Turn			1
L		(μH)	1.76
B		(kG)	2.8

Table 1 Design values of bump magnet 1 ∿ 4

Bump Magnet Power Supply

Peak Current (I) (KA)	8.9
Flat top Time (T) (μs)	70
Falling Time (T_f) (μs)	10

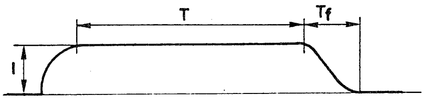

Table 2 Design values of power supply connected to bump magnet 1 ∿ 4 in series

Measurement and Simulation

Thin carbon films are on the market and they are easily obtained. We inserted alternately two carbon films with different thickness into the central orbit of the present booster and measured the beam life. The results are quite in agreement with the computer simulations. (Fig.2)

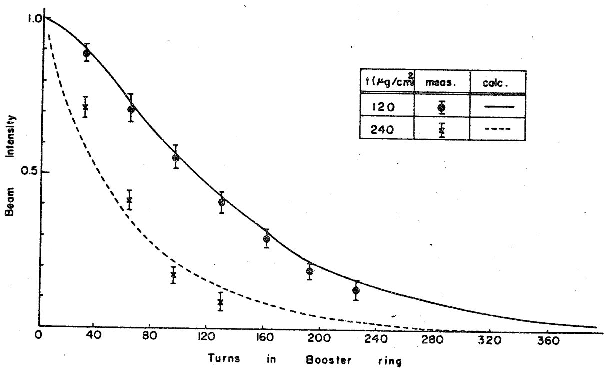

Fig.2 Beam life with inserting carbon film into central orbit of present booster

Estimation of beam intensity with H^- injection scheme

Using the same simulation technique as above one, we calculate the intensity of the beam which is captured in the booster. The design values of the horizontal and the vertical acceptance are (50 mm × 15 mr × π) and (20 mm × 13 mr × π) respectively. But taking account of the closed orbit distortion, the values are estimated to be (35 mm × 10 mr × π) and (15 mm × 10 mr × π) respectively. We take some assumptions that the emittance of the H^- ion beam from the linac has a Gaussion density distribution whose twice standard deviation is 40 πmm·mr, and the intensity is 10 mA. When such H^- beam is injected to the booster with a carbon film of 120 μg/cm^2 thickness, the captured proton numbers per pulse is expected to be 2.4 × 10^{12} ppp. This value is about 4 times as much as the present one with the multi-turn injection scheme.

Reference

1) C. Hojvat, et al. "The multiturn charge exchange injection system for the Fermilab booster accelerator IEEE NS-26, No.3, p.3149, 1979.
2) K. R. Bourkland, "A 34 KA rapid cycling PFN power supply for driving injection magnets", IEEE NS-26, No.3, p.3974, 1979.