BUNCHING PROPERTY OF HIGH CURRENT INJECTOR WITH SUBHARMONIC PREBUNCHER IN LINAC

Zhang Zhenhai, Chen Yinbao

China Institute of Atomic Energy
P.O.Box 275(17), Beijing 102413, China

ABSTRACT

The electron beam bunching property in the high current injector with a prebuncher operating at the twelfth subharmonic(SHB) of the accelerator frequency 1300Mhz has been studied in this paper. The longitudinal compression of the pulse varying with the beam current and the voltage excited by the prebuncher is discussed in detail. Finally, some numerical results taking account of the beam current distribution are given for L-band linac by using of the modified dynamical simulating code PARMELA.

1. Introduction

There are alternative schemes of the injectors of RF free-electron laser (FEL) facility. The first one is microwave-electron gun or photo emission electron gun. It is expected to acquire high quality electron beam, but difficult to develop; The second one is composed of a DC electron gun and a subharmonic buncher(SHB). It is rather easy to do but has difficulty in improving the electron beam quality. We prefer the later to the former in our FEL facility according to our technology limits. The bunching property of RF linac with SHB is discussed in detail in this paper. The prebuncher with SHB often consists of the following parts: high current DC-gun, one or two SHBs, a RF buncher, an accelerating section. The solenoid magnetic field must be used to overcome the space charge influence and BBU effect [1] . The high intensity injector in CIAE consists of a 80KV DC gun, one SHB with the frequency of 108.3MHz which is the twelfth subharmonic of the 1300 Mhz, a RF buncher with 7 cells accelerating the electron beam to 2 MeV and an accelerating segment. The drift distance between the SHB and RF buncher is 140 mm. The bunching properties of the SHB and RF bunhcher and the matching property between them are the main tasks of particle dynamics in high current injector.

2 Bunching property of the SHB

Suppose that the beam emitted by the DC gun is a Gaussian distribution bunch in longitudinal direction and uniform in the transvers phase space (x-x'-y-y'). According to the reference [2], it is convenient to produce the simulating beam which corresponds to that distribution in longitudinal as shown in Fig.1. PARMELA code is adapted to simulate this special beam. When particles pass through the SHB, their velocities are modified and the beam length is compressed in the drift space.

2.1 The influence of the beam current

Keeping the modified voltage(45KV) and beam length (2.8ns) constant, we made simulating calculations when the beam current is 2A, 4A, 5A respectively. It is interesting to find that bunching efficiency decreases rapidly with the beam current increasing but the location of longitudinal beam focus change a little as shown in Fig.2. By this virtue, we can expect the facility operating at great range of the beam current

2.2 The influence of modifed voltage

0-7803-1203-1/93$03.00 © 1993 IEEE

When modifed voltage of SHB increases, the bunhching efficiency decreases and the longituidinal beam focus moves forward as shown Fig.3; the oscillating amplitude of the beam transverse envolope damps with time. Beam transverse emittance increases because of the space charge effect. The beam longitudinal focus is in agreement with the peak of the transvers emittance as shown in Fig.4. This implies that transverse motion is coupled with the longitudinal motion.

2.3 Bunching property of the RF buncher

The beam transverse emittance increases rapidly in the RF buncher because of the drammatically longitudinal phase motion and the intensively coupling between the transverse and longitudinal motion. To avoid the excessive phase oscillating and constrain the increase of the transverse emittance,the phase velocity of RF buncher often rise rapidly to that of light with the pay of lower traawing efficiency.

2.4 Matching property between SHB and RF buncher

In order to obtain high quality beam, the matching property between SHB and RF buncher must be studided carefully. The two aspects interact with each other and have great influence in the quality of output beam. A set of parameters of the calculating results of the injector in CIAE are given as shown in Fig5 and Fig 6. The solenoid magnectic field must be used to restrain the motion of the transvers and BBU effect. the magnectic field have great influence on the transvers emittance and envelope of beam.

3 Conclusion

In the high current injector with subharmonic prebuncher, many conditions shound be took into considration to aquire high qulity beam such as beam current, the modified voltage of SHB, and the drift space length etc. There are some methods can be took to improve the beam quality : increasing the injecting energy of the DC gun , discreasing the longitudinal length of pulse emitted by the DC gun and using two SHBs and so on . Because of high beam current, the compressing ratio is about 3 when only one SBH is used; when two SHBs are used; one can get high compressing rate but it is more complicated and the its cost will increase . Finally, no matter wihch methods you take , the matching problem is very important if you want to obtain high quality beam.

Reference

[1] P.M. Lapostolle et al . Linear Accelerator, North Holland Publ. Co.,Amsterdam,1970.

[2] Zhang Xiaozhe, "Application of Marte Carlo Methods in Particle Transport", Beijing,

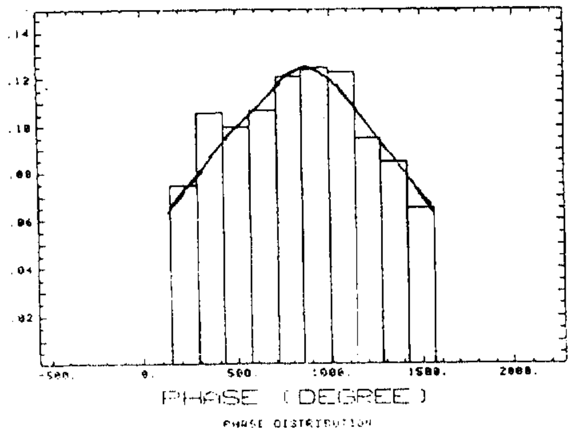

Fig 1. beam longitudinal distribution.

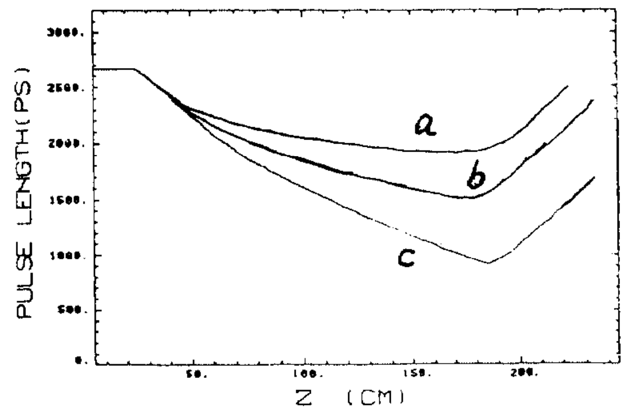

Fig 2. bunching efficiency varing with the beam current a) I= 5A, b)I= 4 A,c) I= 2.5 A.

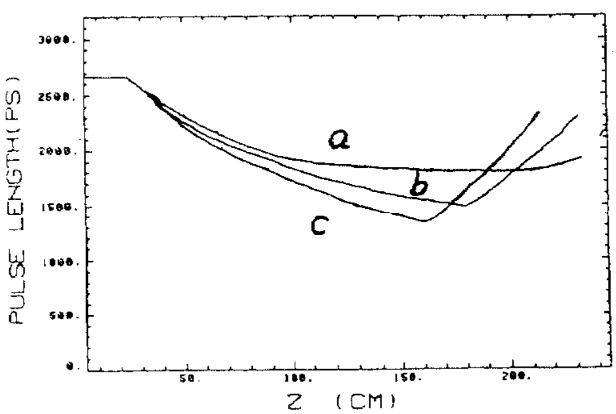

Fig 3. bunching efficiency varing with the modified voltage (a)V=40KV,(b)V=45KV,(C)V=50KV.

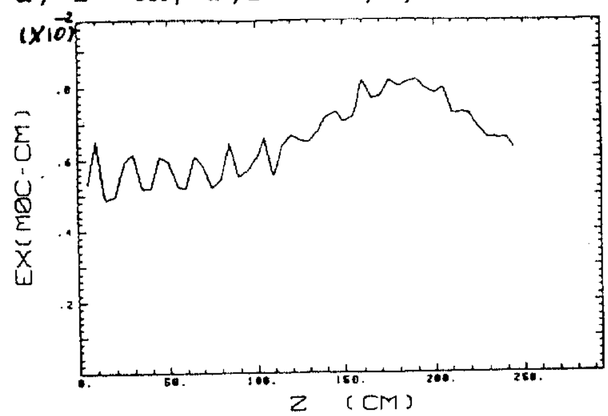

Fig 4. transverce emittance varing with the distance (no RF buncher) Egun=100 KeV, I= 2.5 A t = 3.0 ns.

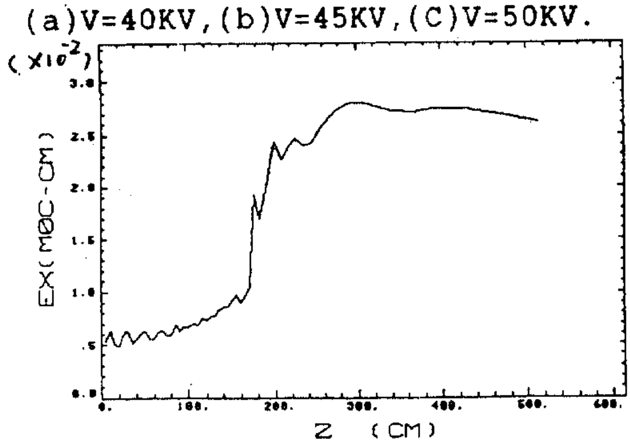

Fig.5 transvers emittance varing with the distance Egun = 100KeV I=2.5 A, t = 3.0 ns .

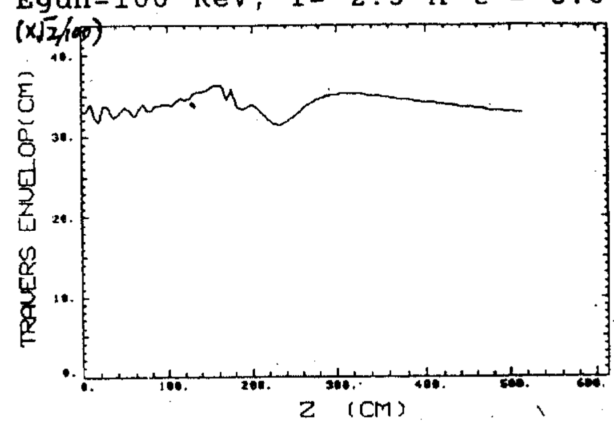

Fig.6 beam transvers envelope varing with the distance.