BTCF INJECTOR R&D PROJECTS

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Abstract

The feasibility of building the BTCF [1] on the BEPC site is being studied, but many technical difficulties remain. For the injector, full energy injection and very high beam current are still challenging problems for the BEPC linac. A lot of R&D work remains: on the S-band pulse compressor, on the high current multibunch electron gun and on the subharmonic buncher etc.

1 INTRODUCTION

The BTCF (Beijing τ-charm Factory) is an e^+e^- collider operating in the center of mass energy range of 3.0~5.0GeV with peak luminosity of $10^{33}cm^{-2}s^{-1}$ at about 4GeV. BEPC has a very good opportunity for China to make a significant contribution to high energy physics. The machine has been operational for more than ten years and the physics is almost completed. If we want to continue our research and also make a great contribution to world physics, BTCF will be a unique chance to save money and still do some very interesting physics !

Table 1 Parameters of the Present BEPC Linac

e^-energy for striking the positron target	140	MeV
e^-current for striking the positron target	2.4	A
Beam pulse length	2.5	ns
Repetition frequency	12.5	Hz
Positron Beam Energy With ED Without ED	 1.4 1.0	 GeV GeV
e^+ number per pulse	7.8×10^7	
e^+ number per second	9.75×10^8	
Transfer line efficiency for e^+ beam	60%	
Injection efficiency	40%	
Normalized beam emittance e^- beam e^+ beam	 300 4000	 πmm.mrad πmm.mrad

Table 1 and table 2 show the parameters for both BEPC Linac and BTCF Linac. From these tables, it is obvious that we have to take some additional measures to increase the e^+ particle number by about a factor of 70, in order to satisfy BTCF injector time of 5 minutes. For example, (1) adopt the bunch train mode (43 bunches in one macrobunch); (2) increase the repetition rate from 12.5Hz to 25Hz (limited by damping time); (3) improve the existing positron production system; (4) decrease the energy spread at the end of linac by using an energy compressing system etc.

Table 2 Parameters of the BTCF beam

Gun Macro pulse length Macro pulse repetition Micro pulse length Micro pulse current Micro pulse repetition	 0.53 25 1 5 79.3	 μs Hz Ns A MHz
Frequency of sub. Buncher	476	MHz
Bunch length at the entrance of prebuncher	150	Ps
Bunch length at the end of Linac	10	Ps
Number per bunch for striking target	1.87×10^{10}	
e^- beam energy for striking target	>170	MeV
Captured e^+ efficiency at the end of Linac	0.02	e^+/e^- GeV
e^+ number per bunch at the end of Linac	6.36×10^7	
e^+ transfer and injection efficiency	24%	
e^+ number in storage ring in 1 second	1.64×10^{10}	
e^+ number in storage ring in 5 min.	4.92×10^{12}	

A bunch train scheme is essential. For energy upgrade, it's a difficult to increase e^+ energy up to 2.0GeV without SLED. We can add another unit (4 sections, 12m) to the end of the existing Linac and replace all klystrons with 65MW tubes. The 13 (65MW) klystrons placed downstream of the positron source will accelerate e^+ beam to 2.0GeV. This method is simple, but expensive. The other option is recirculation. The reinjection point will be at the entrance of unit 5. Traveling time of particles from first injection to next injection is 1.1 μs, so there is enough kicker time. The RF pulse width needed for this scheme is 2.6μs, which is compatible with the existing system. This method is very complex, so careful design work is needed. We can also use the booster, but it's complex and expensive. We can apply RF compression techniques to multibunch train mode, making the energy upgrade scheme easier. Many new RF compression techniques have been developed for next generation linear collider. Therefore, we should adopt some of them for our s-band multibunch train operation mode.

2 R&D PROJECTS

2.1 High current multibunch electron gun

The electron gun will need to generate a beam of 43 bunches within 0.53 μs. The electron gun structure is

similar to original one (cathode-grid assembly type Y824, EIMAC). EGUN code was used to design the thermionic gun focusing electrode and anode and the gap between them. The pulsed current is 5A at 80KV DC with a normalized emittance of 17π.mm.mrad.
The simulation result is shown in Fig.1.

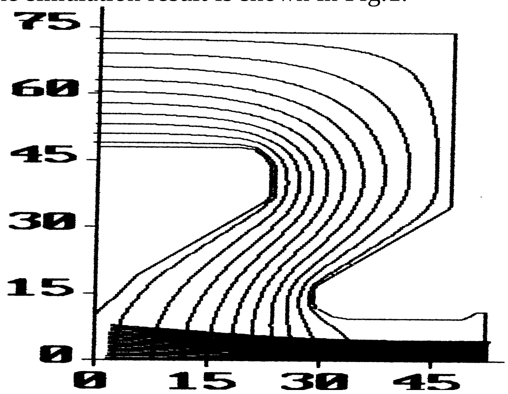

Fig 1 Simulation of electron gun beam envelope

The grid is driven by a new pulser system. The signal from a 476MHz master oscillator is divided into 79.3MHz by a frequency divider. After being modulated by a 0.53 μs macro pulse (at the repetition rate of 25Hz), it is sent to the 1ns pulser by RF transmitter/receiver. The final output of the pulser (inside one macro pulse) is 43 pulses (1ns wide) at the repetition rate of 79.3MHz. This signal is amplified by a solid state amplifier and applied on the grid. The signal flow chart is shown in Fig.2.

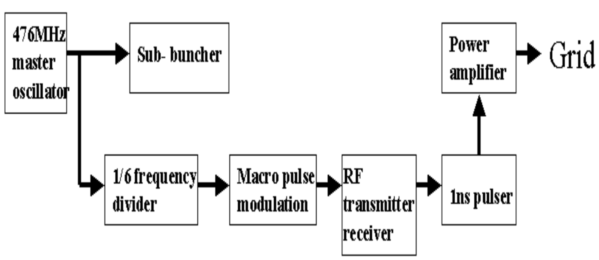

Fig 2 Signal flow chart of the pulser system

2.2 New type S-band rf compressor

We use 13 sets of SLEDs on our present BEPC linac. They can not be used in multibunch operation mode, because of their exponentially falling pulse shape. RF pulse compression techniques for x-band have been developing very fast, for example: SLED-II; BPC; SLED-III; DLDS; VPM etc. Each has been designed and tested with very good results. Currently, no new RF pulse compression techniques have been designed for S-band multibunch operation. We can adopt some of X-band RF pulse compression techniques for our S-band RF Pulse compressor. SLED-II, BPC, and DLDS would be too bulky for s-band. The most promising scheme is SLED-III. The system architecture of new S-band new type RF pulse compressor is shown in Fig.3.

The phases of the two klystrons are tuned in opposite directions. By combining the klystron's output power in a 3dB 180^0 hybrid coupler, we can get an arbitrary amplitude modulated wave form. This was proposed by T.Shintake[2]. It is called phase modulation - amplitude modulation conversion. When specific amplitude modulated waveform pulse is applied to the input of SLED, we get a ramping pulse or a flat top pulse at the output of SLED. This is suitable for S-band multibunch operation. Fig 4 shows the simulation results of SLED output when an amplitude modulated pulse in applied at the input. Parameters of the present BEPC SLED are used in this simulation. The pulse width is 5.6μs, when we want to attain an energy multiplication factor of 1.5. The simulation code is made by T.Shintake of KEK.

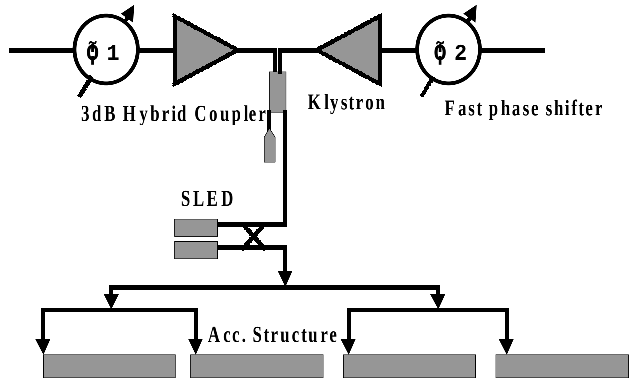

Fig 3 RF system architecture

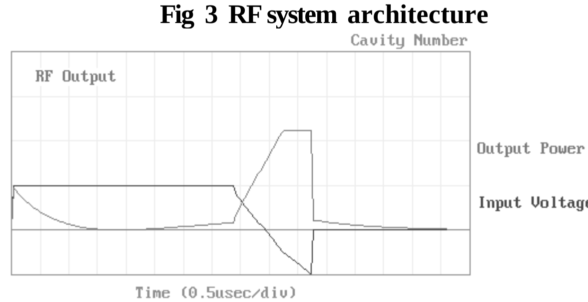

Fig 4 Input voltage and output power wave form

2.3 Subharmonic buncher

It's very difficult for a conventional electron gun to provide low emittance (single bunch) beams. Nevertheless, this is a necessity for all high luminosity machines. Just like other existing machines (including KEKB and PEPII), we will also use one or two subharmonic bunchers. Since main ring RF frequency is about 500MHz, subharmonic buncher frequency will be 476MHz which is 1/6 of linac frequency. A new technique on this frequency has been developed. In addition, RF power is commercially available. However, we need to move electron gun slightly back in order to install the bunchers. Currently, a detailed design is in progress.

3 REFERENCES

[1] ‘Feasibility Study Report on Beijing TAU-CHARM Factory’, IHEP internal report, October,1996.

[2] T.Shintake et al, ‘A New RF Pulse Compressor Using Multi-Cell Coupled-Cavity System’, KEK prerint 96-71.