STATUS OF PNC HIGH POWER CW ELECTRON LINAC

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Abstract

A high power CW electron linac is being developed at PNC to treat high-level radioactive nuclear wastes[1]. The first phase is to develop a test linac (10MeV, 100mA and duty factor 20%). Key components had been developed. The injector test was finished in August 1996. A 100mA beam with 3ms pulses length and 0.1Hz repetition rate had been accelerated to 3MeV successfully. The beam had a good energy spectrum. Now all accelerator components have been installed. Next we will test all accelerator system with full duty factor to get a low emittance and small energy spread beam. This paper puts emphasis on the injector test.

1 INTRODUCTION

The PNC high power electron test linac shown in Fig.1 consists of a gun, chopper, prebuncher, buncher, seven accelerator sections, beam dump, two klystrons and waveguide system. The main specifications of the test linac[2] are shown in Table 1.

Table 1. Main specifications of PNC test linac

Energy	10 MeV
Beam Current	100 mA
Pulse Length	4 ms
Pulse Repetition	50 Hz
Duty Factor	20 %
Frequency	1249.135 MHz
Klystron Power	1.2 MW
Number of Klystron	2
Number of Accelerator sections	8
Length of Accelerator section	1.2 m
Gun Voltage	200 kV
Gun Beam Current	300 mA
Energy Spread	< 0.5 %
Bunch Width	<5 deg.
Emittance	<50π mm mrad
Efficiency	70 %

For such kind of long pulse high beam current linac, PNC had developed all key components which were: an L-band 1.2MW CW Klystron with long pill-box beryllia

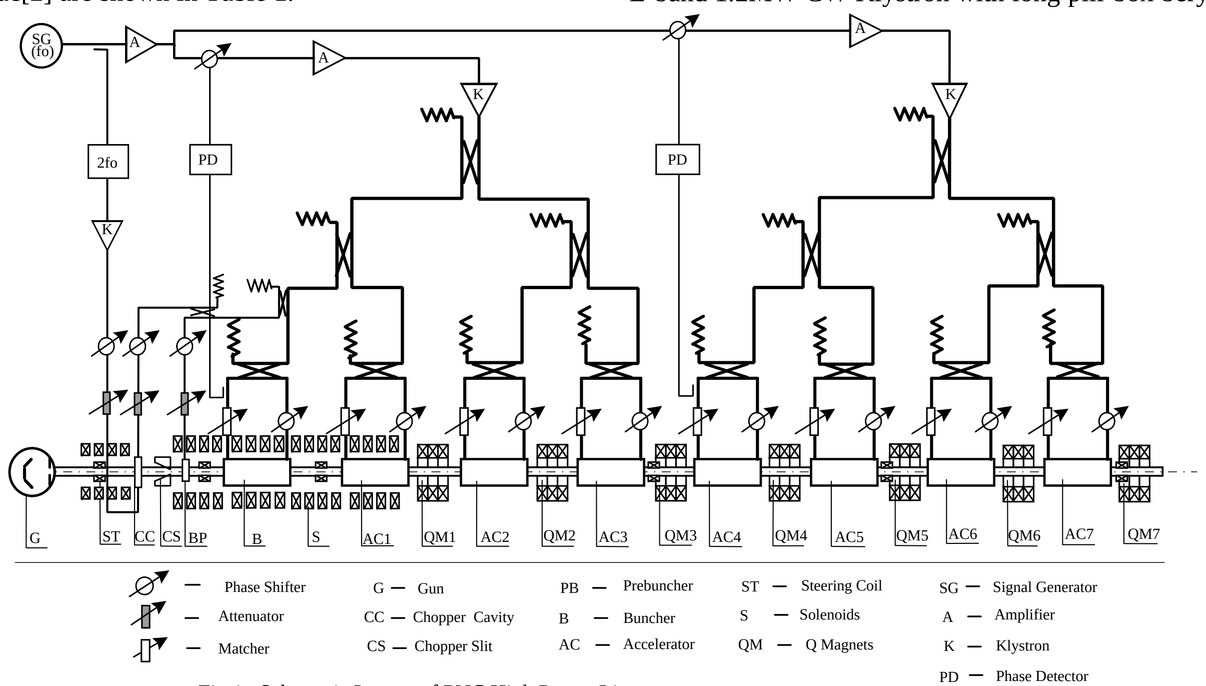


Fig.1, Schematic Layout of PNC High Power Linac ceramics window[3], 200kV, 300mA electron gun with two aperture grids[4], chopper system with low emittance growth[5], constant gradient accelerator structures equipped with TWRR (traveling wave resonant ring)[2], 10MeV 200kW beam dump[6] and control and data acquisition system[7].

2 INJECTOR TEST

The injector test bench is composed of a gun, chopper, prebuncher, buncher, No.1 accelerator section with a traveling wave resonant ring, energy analyzer and beam dump. All parts of injector were installed by end of 1995. The injector test was finished in August 1996. The beam current from electron gun is 300mA. After chopper system it is 100mA. The chopper system only let the beam pass through in 120 degree phase interval during each microwave period. The chopped beam is bunched to 25 degree by prebuncher. Then the beam will be further bunched to 5 degree and accelerated to 3MeV by the buncher and No.1 accelerator. The beam and RF phase relationships are shown in Fig.2

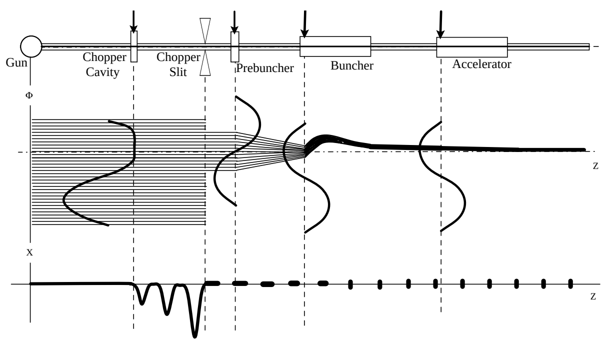


Fig.2 Beam and RF Phase Relationship in the Injector

2.1 *Chopper system*

The chopper system consists of a chopper cavity and slit. The cavity is driven at frequency f_0 (1249.135MHz) TM_{210} mode and $2f_0$ TM_{410} mode and added DC magnetic bias. Adjusting their amplitude and phase, a superposed magnetic field can be equal to zero on beam line in 120 degree phase length. Fig.3 shows the waveform of the superposed field in the chopper cavity by a sampling oscilloscope CSA 803. It means that the chopper system has very little emittance growth and larger acceptance phase angle. Fig.4 shows the beam profiles in process of the chopper system adjusting: (a), without any field; (b), with f_0 TM_{210} mode field; (c), added DC magnetic bias; (d), with f_0, $2f_0$ and DC fields and (e), setting the slit equal to beam diameter. After that, 100mA beam current can be got after chopper slit.

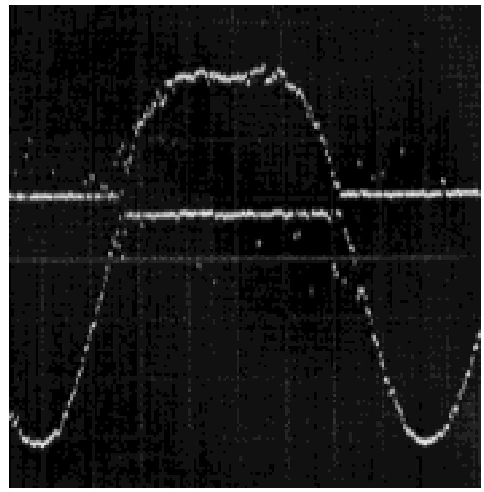
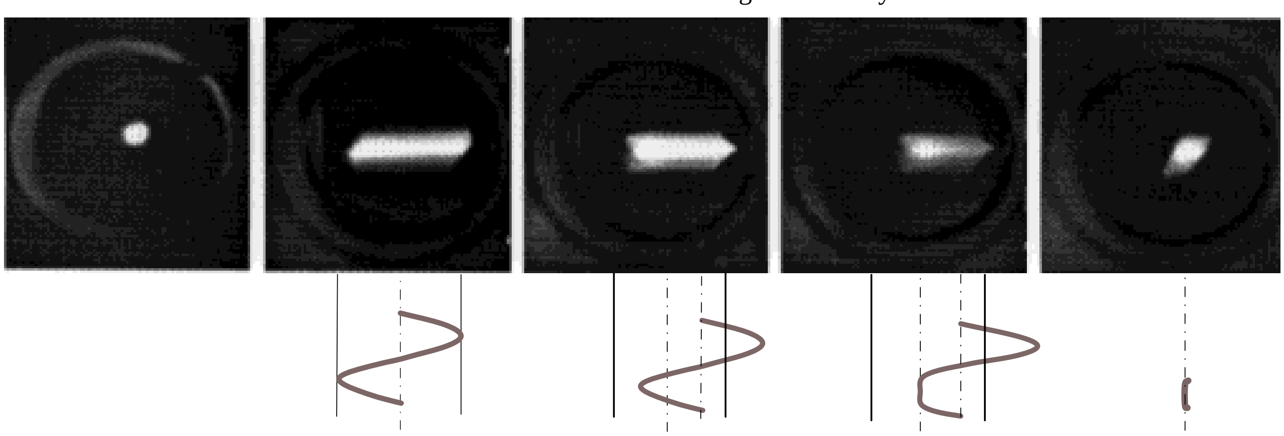


Fig.3 Waveform in the chopper cavity

2.2 *Prebuncher*

Because the prebuncher cavity is located at after the chopper system, the chopped beam induced field must be canceled by detuning cavity. Fig.5 shows a beam induced field and detuning function: (a), the amplitude and phase of RF field in the cavity when I=0, (b), when I=100mA without detuning and (c), when I=100mA with detuning. The cavity was detuned about 0.4MHz and



(a) without any field
(b) with Bfo field
(c) with Bfo and Bbias field
(d) with Bfo,B2fo and Bbias field
(e) with Bfo,B2fo and Bbias field close slit

Fig.4 Beam profile change during the chopper system adjusting detuned angle ψ=55 degree. At first, we adjusted the amplitude and phase to make the beam optimal bunching when the beam current was very small (induced field could be neglected), then increased beam current to 100mA with cavity detuning. The optimum could be kept all along.

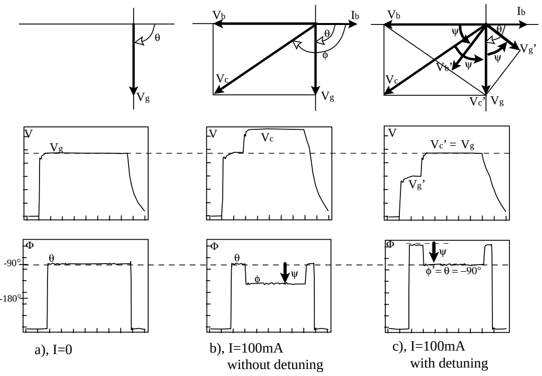


Fig.5 Prebuncher Cavity with Beam Loading and Cavity Detuning

2.3 Buncher and accelerator

According to the maximal beam loading in RF waveform we adjusted the amplitude and phases in the buncher and accelerator section to make the good energy spectrum. When the bunch is in correct phase, a maximal energy is delivered to the beam. So the RF power reduction is a maximum. Fig.6 shows the RF waveforms in the traveling wave resonant ring of No.1 accelerator section. The field multiplication factors without and with beam loading are M_0=3.002 and M_b=2.128 respectively. The energy spectrum is shown in Fig. 7. The energy spread (FWHM) was 1.5%. The measurement data are in good agreement with the design data.

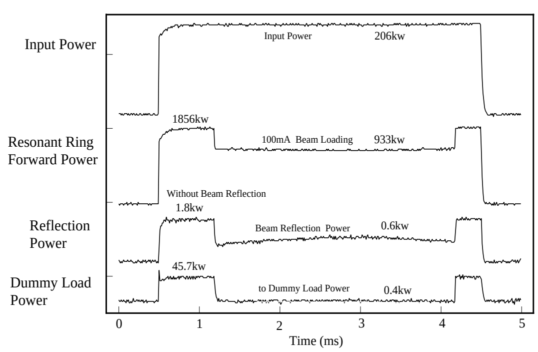


Fig.6 RF Waveform under beam loading in accelerator section

3 SUMMARY

The injector test shows important results that the accelerator structure with TWRR for 100mA 3ms pulse beam and the chopper system with low emittance growth are well handled.

Now all accelerator components have been installed in the accelerator room. Soon we will test PNC high power electron test linac. The first step is to accelerate 100mA beam to 10MeV with low duty factor (4ms 0.1Hz) to measure the energy spectrum and beam emittance. The second stap is to accelerate 100mA beam to 10MeV with 20% duty factor (4ms 50 Hz) to check thermal dissipation and stability. The final aim is to get stable 10MeV 100mA beam with 20% duty factor and small energy spread and low emittance.

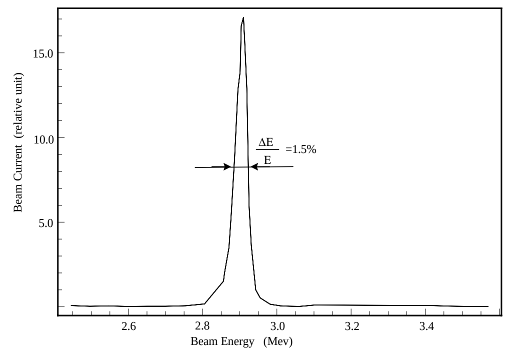


Fig.7 Injector Energy Spectrum

4 ACKNOWLEDGMENTS

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