40. Simulation study of the high intensity S-Band photoinjector

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In this paper, we report the results of simulation study of the high intensity S-Band photoinjector. The aim of the simulation study is to transport high bunch charge with low emittance evolution. The simulation result shows that 7nC bunch with rms emittance 22.3 π mm mrad can be outputted at the exit of photoinjector.

Key words: S-band, photoinjector, simulation

1.Introduction

The requirements of high quality electron beams (high brightness, low emittance) for advanced accelerator tests have made the photocathode RF gun an attractive source since the invention of RF gun in the mid eighties[1-3], variations of the concept have been used for laser wakefield acceleration (LWFA) experiments, short pulse x-ray generation via backward Thomson scattering, and SASE FEL. Photocathode RF gun development has been done in KEK with collaboration of KEK/U.Tokyo/JAERI/BNL/SHI. The gun can produce ~0.5nC, ~1 π mm mrad electron pulses owing to an emittane compensation solenoid magnet. A copper cathode is illuminated by an UV light of 263 nm with an incident angle of 68°, delivered from a compact all solid state Nd:YLF laser system. There is a S-band RF photocathode gun driven by 6MW, 50Hz, UV laser as an injector of 20MeV Linac in Tokyo University. Also, an S-band photoinjector was developed for the APR facility. Based on the research status of photocathode RF gun, we perform the high intensity case simulation study of S-band photoinjector, the highest space charge used in the simulation is 7nC.

2.RF photoinjector system in Univer. Of Tokyo

Upgraded twin S-band linac system with photoinjector is shown in Figure 1. It is made up of RF cavity, emittane compensation solenoid and 2m accelerating tube . The photoinjector replaced the past 90kV thermionic electron gun, subharmonic buncher and two prebunchers so that the injector section becomes simple.

RF cavity of the photoinjector is S-band 1.6 cells which works at π mode, 0 mode is near to π mode, the basic parameter of the cavity is as follow: f_π = 2857.79879 MHz, Q_π =15875.0, R_π = 47.701 MΩ/m, f_0 = 2854.32484 MHz,Q_0 =16668.9, R_0 = 54.859 MΩ/m.

The solenoid is used to decrease the bunch emittance, the typical magnetic distribution is shown in Figure 1. Following the photoinjector is 2m Linac booster, the phase velocity of the first few cells of the accelerating tube is less than light velocity, they are just bunching section used for the DC gun. The bunch energy at the exit of photoinjector is already relativistic, so there are mismatch between the photoinjector and the accelerating tube.

3.Simulation result

We use the present experimental values in the simulation of the photoinjectors, the typical parameters are: peak magnet field 1.3kG, average RF cavity gradient 90MV/m, cathode spot size 3mm, inititial bunch length 4pS.

Transport of 7nC bunch is simulated with respect to different cavity RF phase. As shown in figure 3, 107 degree is the best phase for charge transport. The best RF phase value is found to be 100 in the experiment, our simulation shows a good agreement with the experiment result.

Figure 2 lists the result of charge transport with different spot size for the condition of RF phase 107. Four cases with the cathode spot size equal to 3mm, 6mm, 9mm, 11mm are simulated. The result shows that the smaller spot size, the better the charge transport efficience and rms emittance.

RF phase 107 is better for the charge transport, but is not better for the particle acceleration. We have simulated the bunch evolution for the condition B=1.3kG, E=90MV/m, initial bunch length 4ps, initial bunch spot size=3mm, RF phase 50. Figure 3,Figure 4, Figure 5 and Figure 6 show the simulation result.

4.Discussion

We have intensively simulated the high intensity S-band photoinjector. In order to achieve both high bunch charge with low emittance, one should increase both the solenoid field and the RF cavity gradient. Under the current simulation condition, the smaller the cathode spot, the better the emittance and the charge transport.

1.The simulation result shows that 7nc bunch could be gained at the exit of photoinjector with emittance 22.3 πmm mrad.

2.The best RF phase for big bunch charge transport is found to be 107 degree. While this RF phase value is bad for the particle acceleration.

3.We also simulate the 10pS bunch length. In this case the bunch lengthening phenomenan becomes obvious. While in the 4pS case, this effect can be omitted.

Acknowledgement

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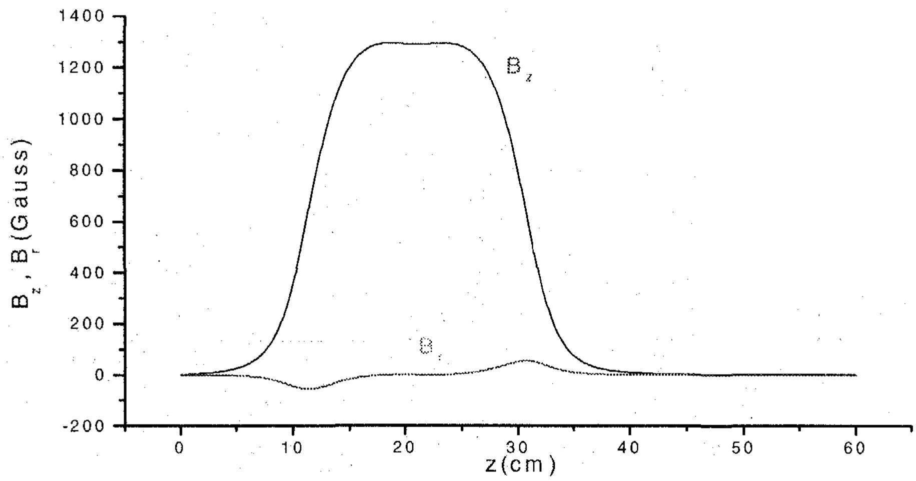

Figure 1. The field distribution of the solenoid

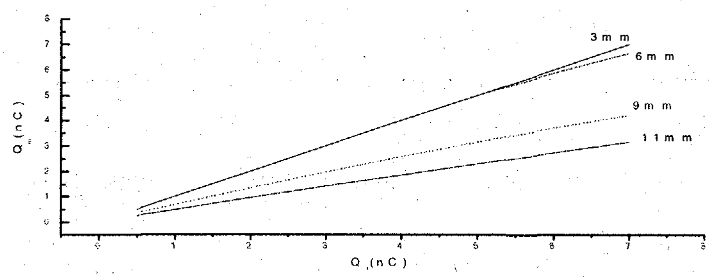

Figure 2.charge transport with different spot size

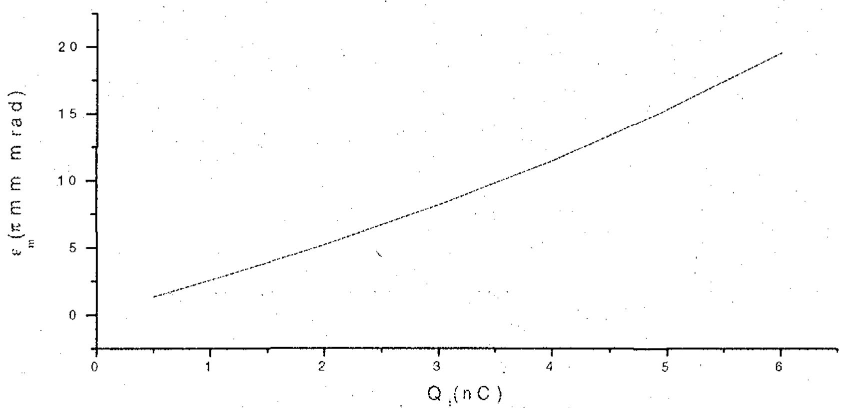

Figure 3. Bunch emittance with bunch charge

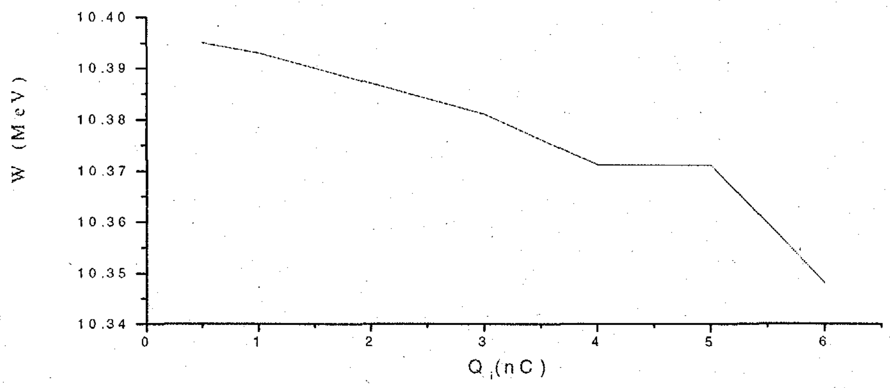

Figure 4. Bunch energy with bunch charge

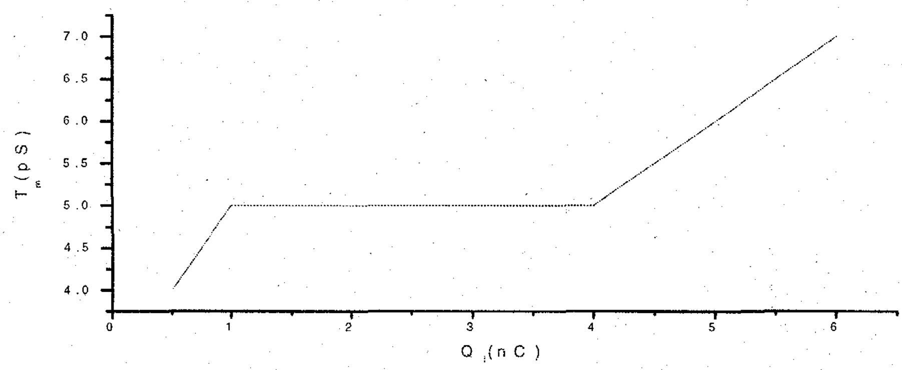

Figure 5. Bunch length with bunch charge

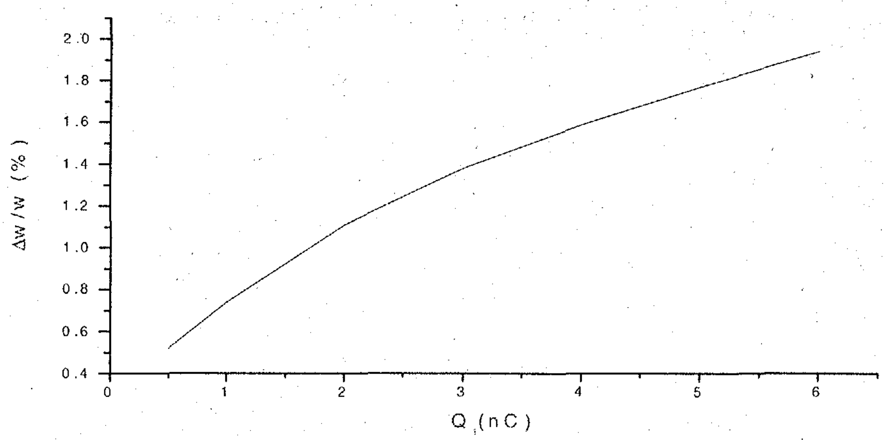

Figure 6. Energy spread with charge