R & D ON A COMPACT EC-ITC RF GUN FOR FEL

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Abstract

This Paper described a novel EC-ITC RF Gun (External Cathode Independently Tunable Cells RF gun) for FEL. Some simulating results of the beam dynamic in the gun and a test facility for measuring the beam performance were described. Simulation shown that the gun can produce a electron beam with 0.2nC, 5ps, 2MeV and normalized emittance less than 5 mm mrad without compensation coil. The RF power and its phase fed to the two cavities can be independently adjustable so that the beam performances can be better. After RF power exercising a week, the electric field in the cavities surface was reached 100MV/m and dark current was disappearance. Main parameters measured are given here.
Keyword: EC-ITC RF Gun, emittance, energy spread, external cathode

INTRODUCTION

The high brilliance electron beam has been adopted wide for FEL . Due to its simplicity in Manufacture, the thermionic RF gun is expected to have potentials to generate high brilliance and short-pulse beams. But, the conventional thermionic RF gun has some disadvantages, such as its back-bombardment (BB) effect, large pulse length and energy spread and so on. If an α-magnet is employed, its energy spread can be reduced, but its size will be getting larger[1].

Recently, an independently tunable cells (ITC) RF gun is proposed[2,3], which showed some simulation results to be better, but test results haven't published so far.

We advanced an external injecting ITC RF gun (EC-ITC-RF gun) structure, which compared to [3], the EC-ITC –RF Gun can increase beam current, and decrease energy spread. At the same time, it cancels the BB effect near completely also. Our simulation results shown that the micro-pulse current can be as high as 18A, with an energy spread less than 2‰.

The gun has been run well, after exercising a week, its surface electric field strength reached 100MV/m, and the beam performance is better enough.

GENERAL DESCRIPTION OF THE GUN

The external injection ITC-RF gun consists of a diode gun and two cavities as shown in fig.1. A convergent electron beam extracted from the dipole gun injecting into the first cavity were bunched, then accelerated by second cavity. The mechanical structure is depended on beam dynamics parameters. After simulating beam dynamics in the gun, we choose their shape and its size.

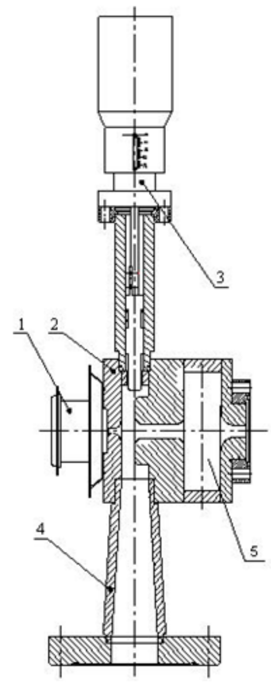

Figure 1: Cross section of EC-ITC- RF Gun
1, diode gun; 2, cavity 1#; 3, tune plug; 4, coupler1#; 5, cavity 2#

The two couplers is perpendicular each other so that its assembly can be easy and the whole gun is to be compact. The plug, which is at opposite to the coupler of the first cavity, is employed for adjust the cavity resonance frequency precisely.

Some simulating results by means of PARMELA are shown in fig.2. According to the results, we found that the beam performance is better enough: bean energy is of 1.91MeV, pulse current is of 18A, pulse length is of 4.5ps, energy spread is of 0.2%, normal emittance (without compensation) is of 4.71mm.mrad.

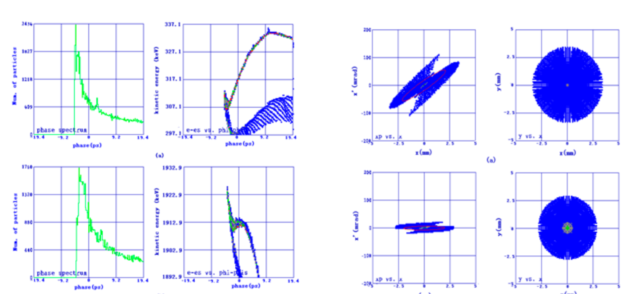

Figure 2: simulating results: bunch length and energy, emittance (left), beam size (right)

PARAMWTERS MEASUREMENT

According to the beam parameters optimized by means of simulation, we design the Gun as shown in Fig. 1. Then it was manufactured in NSRL workshop. Fig.3 is a photograph of the gun (without diode gun) and measurement apparatus for measuring the RF parameters. Table.1 list the main RF parameters measured and compared with the results simulated[4].

Table 1: main RF parameters

	measurement		calculation	
	Cell 1	Cell 2	cell 1	Cell 2
β	1.61	1.48	1.43	1.47
Q_L	2315.9	5198.2	2265.4	4752.2
Q_0	6051.2	12902	6054.7	13116
Z_s/Q	8046.7	8744.4	7455.7	8413.6

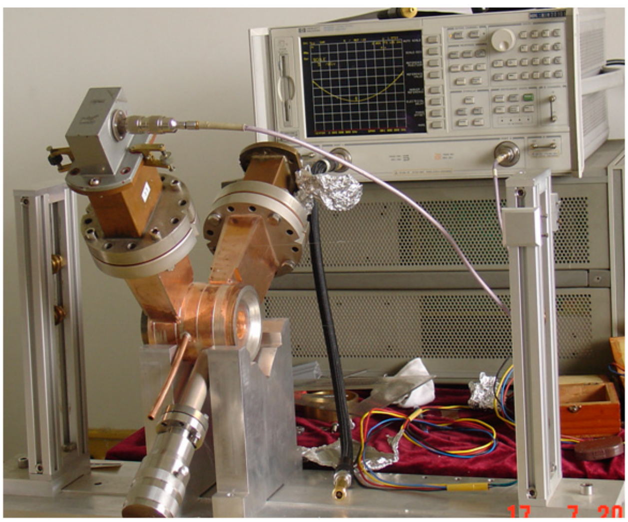

Figure 3: Photograph of the gun and measuring apparatus

TEST FACILITY

In order to get the performance parameters of the beam, a test facility was established. Fig.5 is the schematic layout of the facility for measuring beam performance parameters. The test facility is main compose of the following parts: 1,EC-ITC-RF GUN; 2, Toroid, which is used for measuring the current of macropulse; 3,Flag, used for observing the beam size and its shape; 4,LINAC,which will be used for measuring beam bunch length; 5, OTR ; 6, analysis magnet; which is used for measuring beam energy ,energy spread and beam length ; 7,fluorescent target; 8,shifter; 9, 10, power divider; 11, attenuator, 12, sputter-ion pump. The microwave power of 10 MW is provided by a klystron and its modulator.

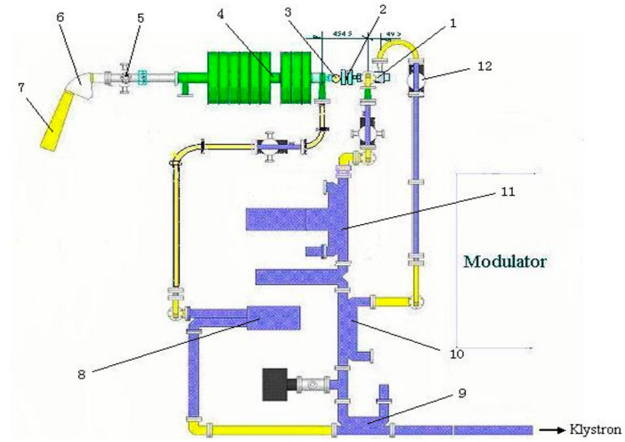

Figure 5: layout of the test facility

MEASUREMENT OF BEAM PARAMETERS

In order to measure the beam length, we advanced a method which is by means of a relation of electron energy and its phase in the LINAC as fig.6. When beam located at the "0" phase, the energy spread will change less. If the beam phase located in φ which is different from the "0", their energy spread will change and larger than initial energy spread. This change depend on beam length, so measuring these energy, energy spread and their phase, we can get pulse width. Some measuring results are shown in fig.7. Table 2 lists the measurement results of the gun.

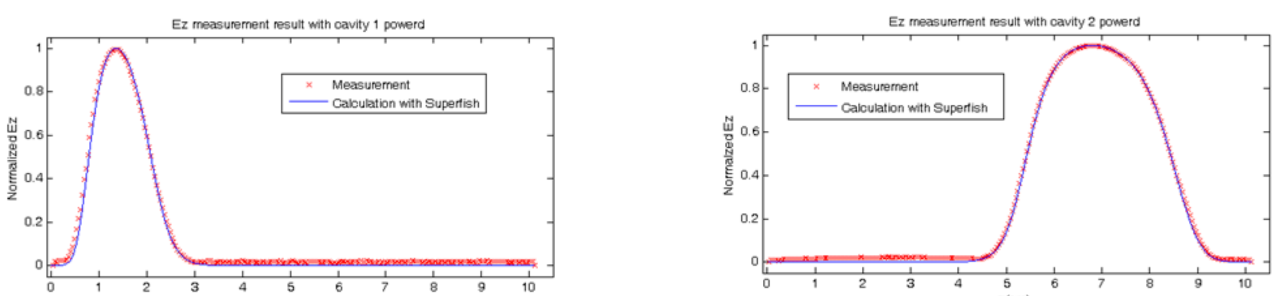

Figure 4: E-field distribution in the cavity axis both measured and calculated by superfish

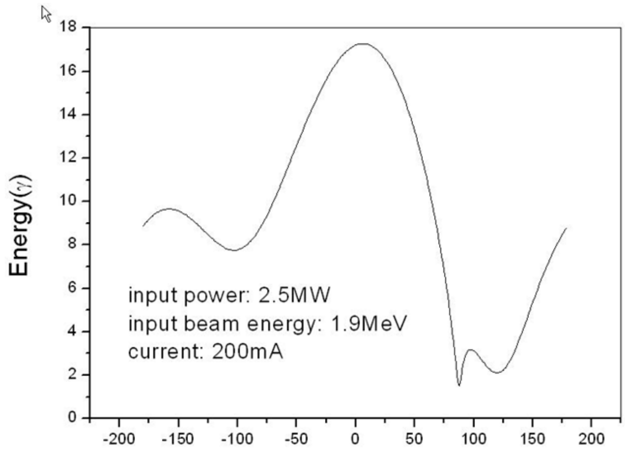

Figure 6: Energy vs. Phase

Table 2, main beam parameters measured

Energy	1.9-2.1MeV
Beam current (macropulse)	280mA
Pulse width (macropulse)	1.0μs
Bunch length	6.8 ps
Micropulse current	18A
Energy spread	0.50%
Input power cavity 1#	0.3MW
Cavity 2#	1.24MW

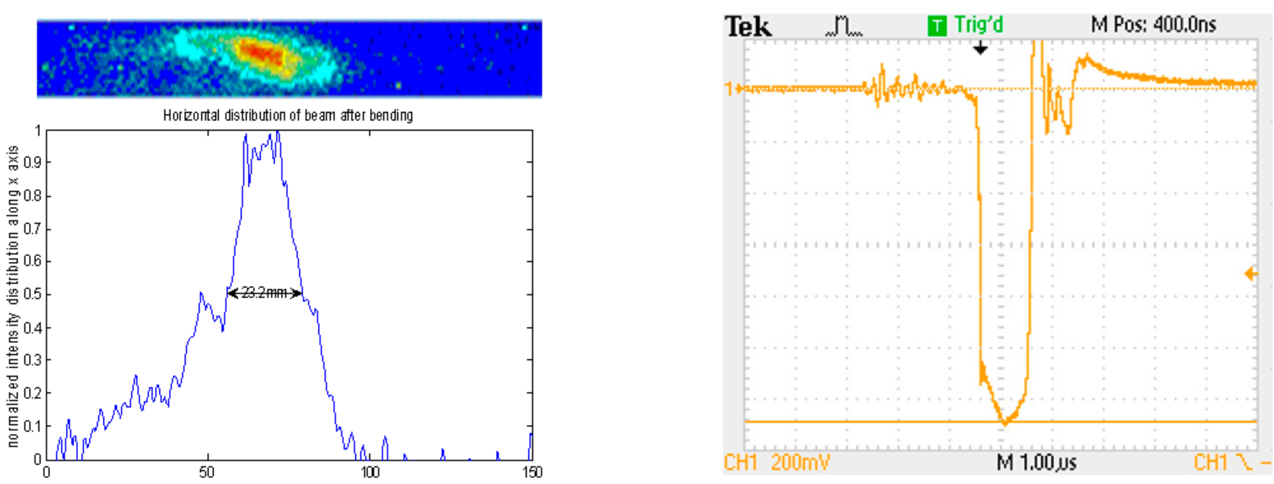

Figure 7: beam spot at the fluorescent located at the end analysis magnet (left), Macro pulse current waveform (right)

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