DESIGN OF 14 MEV LINAC FOR THZ SOURCE BASED FEL

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Abstract

THz wave have many special performances, such as it can penetrate deep into many organic materials without the damage associated with ionizing radiation such as X-ray, it can be used to distinguish between materials with varying water content, because THz radiation is absorbed by water. In part researchers lacked reliable sources of THz, so develop new THz sources is important now. So far there were many kind of THz Source, one of them is THz source based a FEL that can produce high power (~kW). This paper will describe the design of a LINAC of 14MeV which is used for FEL to produce THz radiation. The LINAC is mainly composed of a novel EC-ITC RF gun, compensation coil, constant gradient accelerating structure, beam diagnostic system and so on. Main design parameters are given in this paper.

GENERAL DESCRIBED OF THE BEAM FACILITY

To meet strict requirements of high performance of electron beam for THz-FEL and the facility getting compact, HUST(Huazhong University of Science and Technology) and NSRL(National Synchrotron radiation Laboratory)/USTC(University of Science and Technology of China) are cooperating to do R &D and plan to set up such as the facility. The facility will be main composed of a novel EC-ITC RF gun, constant gradient travelling wave LINAC which input coupler with the electric field to be symmetry, and its focusing coil, beam diagnostics system, microwave power system ,vacuum system, control system and so on. The layout of the facility is shown as Fig.1. The main parameters of the LINAC are shown in Table 1.

Table 1: Main Parameters of the LINAC

Parameter	Unit	Value
Energy	MeV	4-15
Current	A	0.571 (macro pulse) 30~40 (micro pulse)
Width of beam	μs ps	1~5 (macro pulse) 1~10
Repeat frequency	pps	10-50
Charge per pulse	pC	>200
Energy spread	%	0.2-0.5
Nor. emittance	μrad	<10
RF frequency	MHz	2856
Input power	MW	20

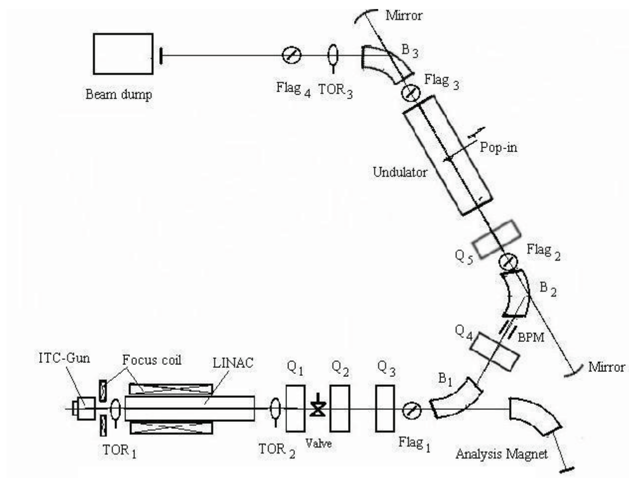

Figure 1: Layout of THz facility.

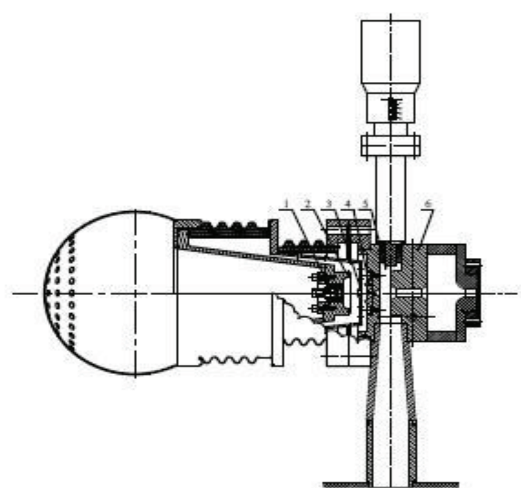

Figure 2: Drawing of the EC_ITC RF.

Electron Gun

In order to reduce the cost and complication of RF gun, a novel EC-ITC RF Gun was advanced and tested in NSRL[1,2]. Considering beam quality of the micro-pulse might be deteriorated when it transmits from EC-ITC RF gun to drift tube and travelling-wave accelerator due to space charge effect of high current beam, it's necessary to improve design targets of RF gun to guarantee high quality extracted bunches. To solve this issue, grid electron gun with double anodes is preferred to provide DC beam instead of diode electron gun, standing-wave cavity dimensions are optimized, and RF parameters are tuned independently as well. As a result, EC-ITC RF gun performances are enhanced substantially, main parameters

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of the EC-ITC RF gun was showed in Table 2, and Fig. 2 showed the design structures of the gun.

Table 2: ain arameters of the un[3]

Parameter	Target
Bunch energy	2.6 MeV
Micro-pulse width (FWHM)	~1.5 ps
Micro-pulse effective charge	201pC
Energy spread (FWHM)	0.27%
Energy spread(rms)	0.28%
Transverse emittance (rms)	6.5 πmm · mrad
Macro-pulse current	0.574A
Bunch radius	2.8 mm

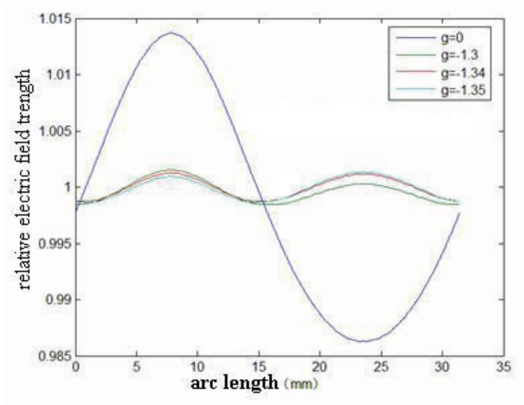

Figure 3: Field distribution in coupler.

Constant Gradient LINAC Structure

In order to reduce LINAC size, constant gradient, travelling wave, $2\pi/3$ mode and collinear load structure will be employed, which made the linac's out coupler to be removed so that the LINAC's radial size and the focusing coil size reducing. The input coupler of the LINAC will be adopt off-axial structure so that the electric field in the coupler will be symmetry near axial of the LINAC. Fig.3 showed the electric field distribution in the input coupler. According to the data Fig.3 shown, we choose off-axial distance is of 1.35mm.

BEAM DYNAMIC SIMULATION

The following are some results of simulation by means of Parmela code and others.:

EC-ITC RF Gun

When voltage applied on double anodes of the gun are -15kV and 20kV vs. ground respectively, beam current emitted from cathode is 4.5A. The beam are injected into the following ITC RF gun, when feed the microwave power are 0.78MW and 3.51MW respectively, adjust their phase, can got the main parameters as Table 2 showed and the diagraph of the energy spread and transverse phase space are showed in Fig.4.

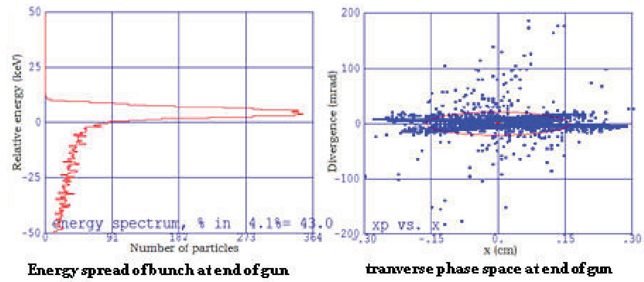

Figure 4: Energy spread and phase space at end the gun.

LINAC

As mentioned above, LINAC is a travelling wave, constant gradient structure, which consists of one input coupler, 19 normal accelerating cells with $2\pi/3$ mode and 4 collinear absorbing loads which coating wave-absorbing materials on cavity inner surfaces. When feed power is 15MW, injecting parameters of the beam from EC-ITC RF gun as showed in table 2, , the beam energy will be 14MeV more, energy gain curve and power distribution along the LINAC are as fig.5 shown. when chosen the magnetic field in the lens and LINAC focusing coil are as Fig.6, the beam energy spread , transverse emittance and beam size are as fig.7, which are gotten by means of using Parmela code etc[4].

According the results showed in fig.7, the beam parameters is listed in table 3.

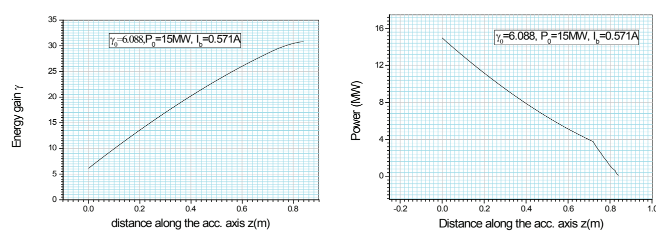

Figure 5: Energy gain curve and power distribution in LINAC.

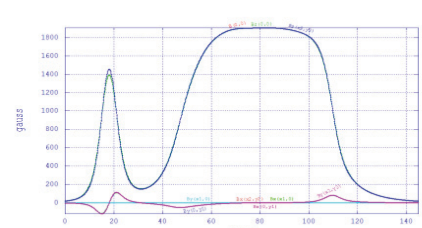

Figure 6: Magnetic distribution.

Table 3: Main Beam Parameters of 14Mev LINAC

Parameter	Target
Bunch energy	14.4MeV
Micro-pulse width (FWHM)	~4 ps
Micro-pulse effective charge	201 pC
Energy spread (rms)	0.22%
Transverse emittance (rms)	4.8 πmm·mrad
Macro-pulse current	0.574 A
Bunch spot radius	0.9 mm

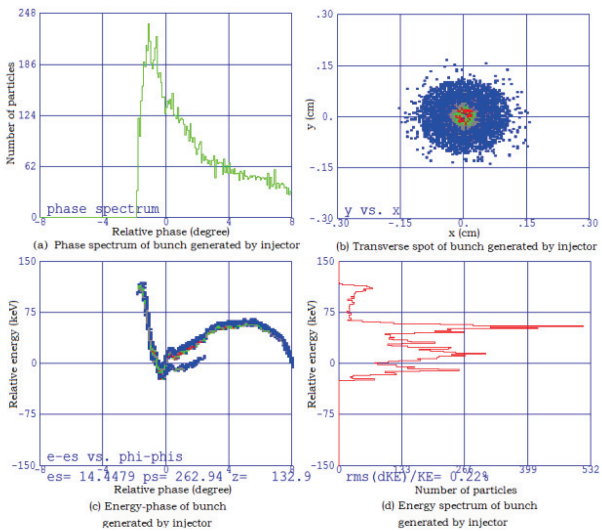

Figure 7: Energy spectrum, size, length of beam.

Beam Transport Line

The beam parameters must match with undulator and to be achromatic, to meet these requirements, two bend magnets and five quadrupoles are adopted in the transport line. when quadrupoles's parameters are chosen as shown in table 4, and bending angle of bend magnet is of 60°, the results of beam simulated using Parmela code are shown in fig.8,9[5].

Table4: Main Parameters of Quadrupoles

Quadrupoles	k	Unit
Q1	2.492	T/m
Q2	-2.165	T/m
Q3	3.590	T/m
Q4	3.229	T/m
Q5	1.608	T/m

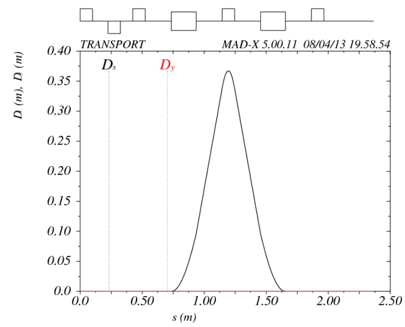

Figure 8: βx,y curve.

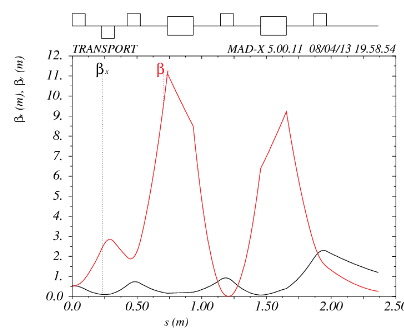

Figure 9: Chromatic function curve.

The facility as Fig.1 showed, the main parameters simulated show that it satisfies our requirements.

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