DESIGN OF AN INTENSE THZ LIGHT SOURCE BASED ON FEMTO-SECOND ELECTRON BUNCHES

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Abstract

A new facility is under construction at the Shanghai Institute of Applied Physics (SINAP), to generate femto-second electron bunches and intense coherent THz radiation pulses. A 20~30MeV linac will be integrated with a thermionic rf-gun and a α magnet. At the end of this linac, an Elliptically Polarizing Undulator (EPU) will be used to produce intense coherent radiation pulses in the region from 0.3THz to 3 THz. The design and status of this facility will be presented.

INTRODUCTION

The THz-Source facility is under construction at Shanghai Institute of Applied Physics to produce intense, coherent and polarized radiation pulses in the region from 0.3THz to 3 THz. It is based on the coherent emission from femto-second electron bunches, and may produce high brightness radiation compared with the synchrotron radiation and black body radiator in the THz region. This radiation can be used for medical diagnostic and treatment, life sciences, material sciences, information sciences and other basic and applied research.

The SINAP THz source is similar to the SUNSHINE facility at Stanford University [1] and the SURIYA facility at Chiang Mai University [2]. The radiation will be studied in the form of Coherent Transition Radiation (CTR), Coherent Synchrotron Radiation (CSR) and coherent undulator radiation from an Elliptically Polarizing Undulator base on femto-second electron bunches. A Laser Synchrotron Source (LSS) facility is considered by collision of the laser beam and this electron beam for long-term project.

ACCELERATOR

A 20~30MeV linac is under constuction as the femto-second electron beam source, which mainly consists of a thermionic RF gun, α magnet, and a SLAC type accelerating tube The α magnet is used to compress the bunches produced by the thermionic RF gun. Then the electron beam is transported through the gun-to-linac beam line and finally accelerated up to 20~30MeV by a SLAC type tube.

Thermionic RF gun

There are two choices for generating ultra-short electron bunches. One is a thermionic RF gun with a α magnet, and the other is a photo-cathode RF gun with chicane. For the purpose of low cost and simple operation, we choose the former.

A 1.6 cells thermionic RF gun has been already developed and operated successfully at APS[3], SUNSHINE[1] for ultra-short electron bunches. We have made our design base on the APS one [4]. This RF gun is operated at π/2 mode with a side couple double period structure. It has been developed and optimised through numerical simulation codes such as SUPERFISH [5] and PARMELA [6]. The cross section of the RF gun is shown in figure 1.

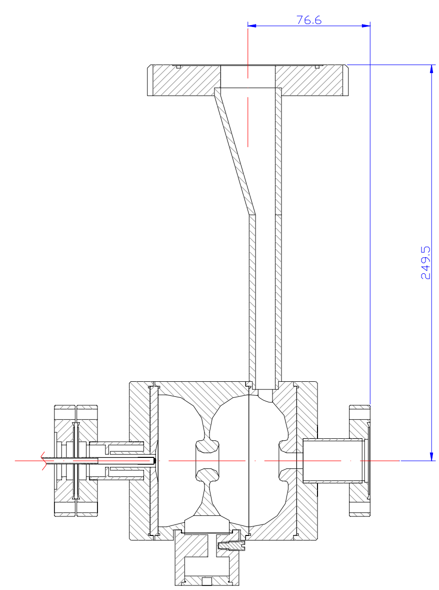

Figure 1: Cross section of the RF gun

The manufacture of this gun is in the collaboration with the Accelerator Lab of Tsinghua University and No. 12 Research Institute of CECT. Now two sets of parts of RF gun have been made, one for zero power measurements, and the other for high power operation. The following picture (figure 2) shows some parts of the RF gun.

After modification, the ratio between the peak fields of two accelerating cavities is close to the design value 1.7. Figure 3 shows the field profile of the two accelerating cavities.

The finally assembly of the RF gun will be performed in May this year. A RF power system established for the PS linac can be used to share the RF power for the high power operation of this gun.

Figure 2: Some parts of the RF gun. (The coupler and the side cavity has been brazed to the first cavity and the second cavity respectively)

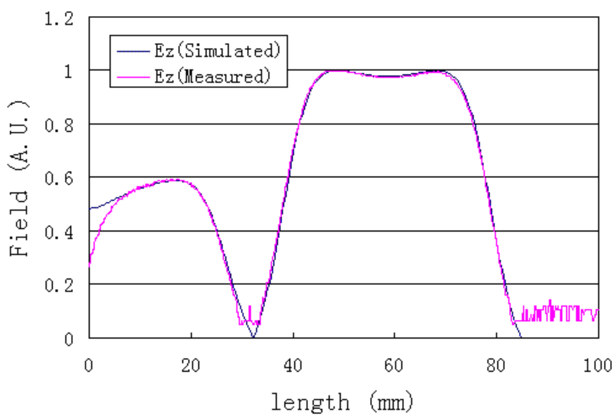

Figure 3: The field profile of RF gun at π/2 mode.

Gun To Linac (GTL) transport line

In order to produce ultra-short electron beam, a α magnet is used to compensate the different path length in the drift space caused by the different momentum from the RF gun (figure 4). After compression, a femto-second electron bunch is expected to obtain at the end of GTL. The particle distribution in longitudinal space is shown in figure 5.

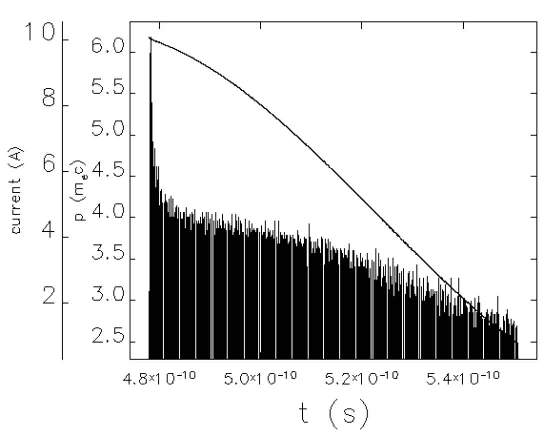

Figure 4: The particle distribution in longitudinal space at gun exit

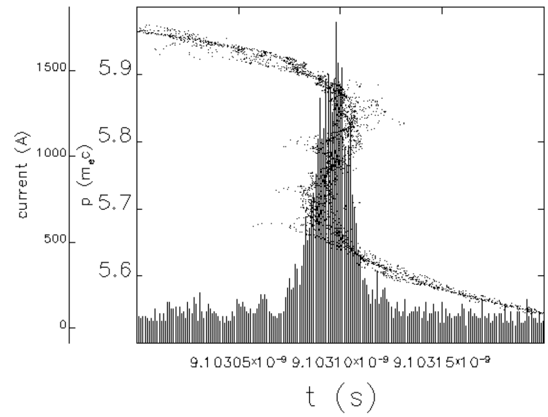

Figure5: The particle distribution in longitudinal space at GTL exit (by ELEGANT [7])

To match the gun characteristic in longitudinal space and the total length of the GTL, the maximum field of the α magnet is designed to be 500 Gauss/cm. The design of this magnet has completed by POISSON [5]. After manufacture, the magnet field has been measured as figure 6 shows. Some quadrupole magnet is used to match beam in transverse space from gun to linac. An x-y corrector is integrated into the quadrupole magnet. The total lattice of GTL is shown in figure7.

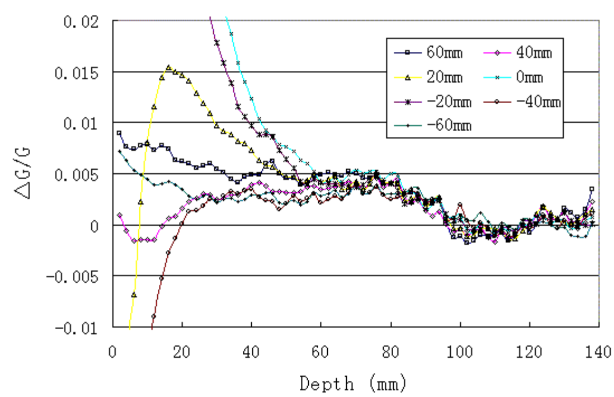

Figure 6: Different field along the depth orientation in the symmetry plane. (Different set of data shows the different horizontal position measured.)

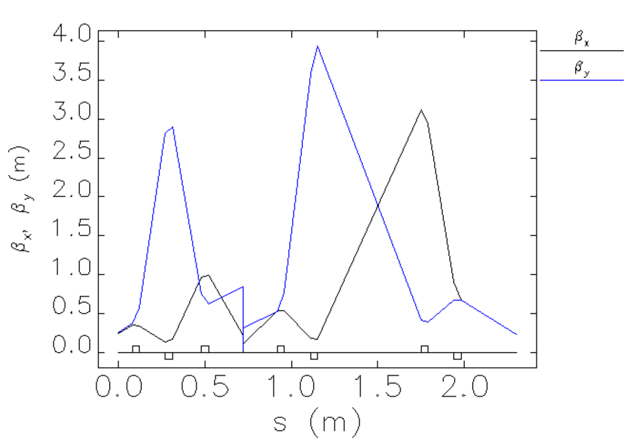

Figure 7: The lattice of GTL (by ELEGANT [7])

A straight section is reserved for a beam chopper for single bunch operation. Two Beam Current Monitors, a Beam Position Monitor are used to measure the beam current and position respectively.

Linac

A SLAC type tube is installed downstream GTL transport line to accelerate the electron bunches up to 20~30MeV with a input power of 10MW.

RADIATORS

At the first stage, three kinds of radiators are designed for the THz source, including CTR, CSR and CUR. The spectral flux of CTR, CSR, and coherent elliptically polarizing undulator (EPU) radiation [8] are shown in figure 8.

LAYOUT

This facility will be installed in the same well shield tunnel of PS linac. The RF power system has been installed in the same building just above the tunnel, while the control room is on the same floor outside the tunnel. Figure 9 shows the layout of the linac.

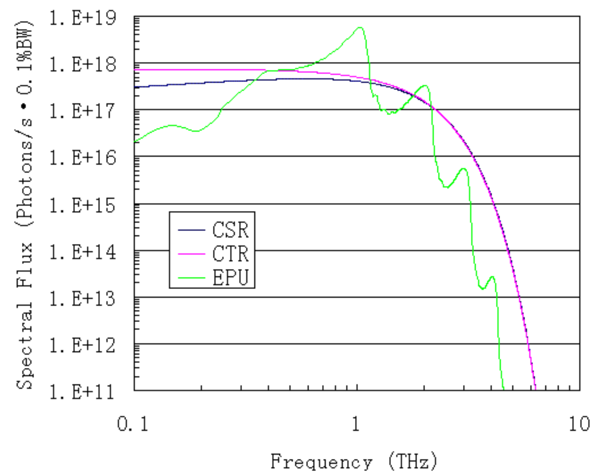

Figure 8: The THz radiation brightness from CTR, SR and EPU.

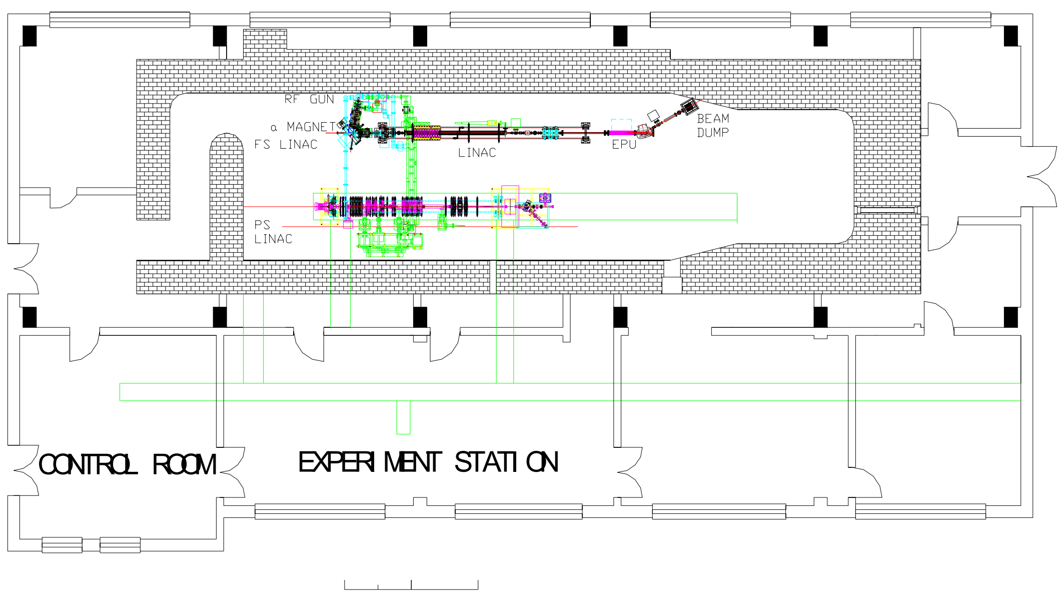

Figure 9: Layout of the THz source facility.

ACKNOWLEDGMENT

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