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Study on Quantum Beam Science by using Ultra Short Electron Pulse, FEL, and Slow Positron Beam at ISIR, Osaka University

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Abstract

Three projects for quantum beam science, an ultra fast electron pulse, a free electron laser, and a slow positron beam, has been started by using 38 MeV L-band and 150 MeV S-band linacs at ISIR in Osaka University.

Both study on the production of three beams and study on quantum material science by using three beams will play an important role in the beam science.

1. Introduction

The new research system has been started since this April by the reorganization of the Institute of Scientific and Industrial Research (ISIR) at Osaka University. The Radiation Laboratory in ISIR will play an important role of studies on quantum beam science in collaboration with the division of quantum beam science and technology which is composed of two departments, department of accelerator science and department of beam material science.

Fig 1 shows a new project that three kinds of quantum beam, ultra short electron pulse, FEL, and slow positron beam, generated by using the electron linac are used for the quantum beam science.

Picosecond pulse radiolysis by using the ultra short electron pulse is very important for the elucidation of the primary process of the radiation chemistry which contributes to the material science. Infrared FEL is also important for the material analysis. The analysis of atomic and molecular structure near material surface can be achieved by using the slow positron.

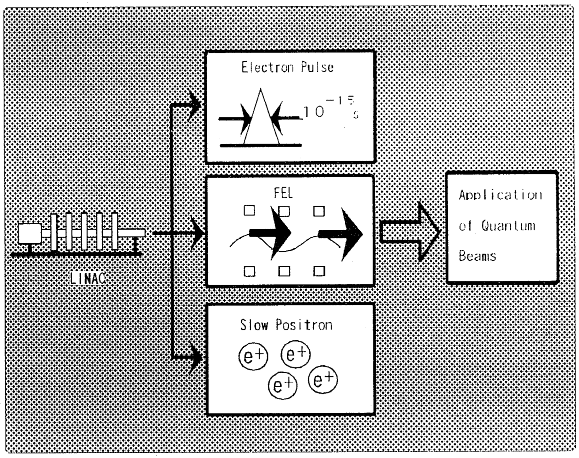

Fig. 1 Generation of Quantum beams and its application.

In this paper, the developments of three quantum beams and its application are described.

2. Quantum Beams Generation

The ultra short pulse is produced by the 38 MeV L-band linac with the pulse compressed system which is composed of two 1/12 sub harmonic prebunchers and a 1/6 sub harmonic prebuncher. The FEL is produced by using the L-band linac. The slow positron is generated by using 150 MeV S-band linac. Fig. 2 shows the location of the linacs and the experimental ports for the quantum beams.

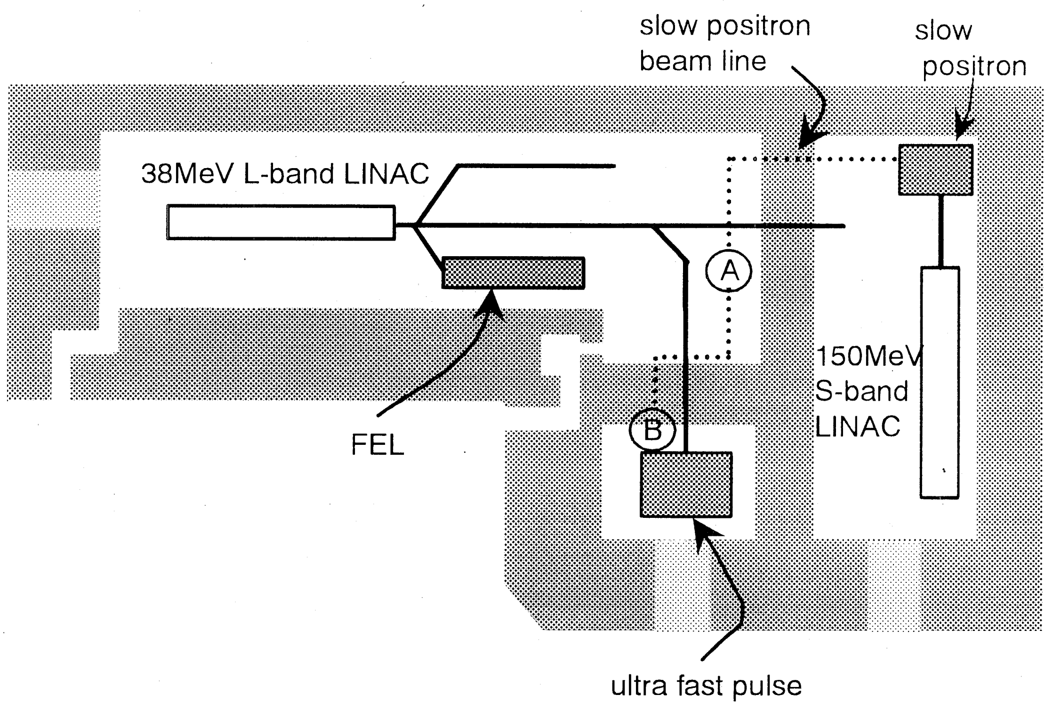

Fig. 2 The Location of S&L-band linacs and experimental ports for three beams.

3. Ultra Short Electron Pulse

A 20 ps single bunched beam from the L-band linac has the maximum charge of 67 nC, which is hundred times larger than that of typical S-band linac. The highly intended beam as irradiation source has many advantages for picosecond pulse radiolysis.

A new picosecond pulse radiolysis system[1] combined with a femtosecond laser is under development. Fig. 3 shows the block diagram of the new system. The femtoscond Ti-sapphier laser is used as the analyzing light instead of the Cherenkov light produced by the electron beam.[2] The laser analyzing light can cover the wide wavelength region from ultra violet to infrared by using the technique of second harmonic generation, third harmonic generation, and optical parametoric oscillation.

The important point to get the time resolution of picosecond is the timing jitters between the electron pulse and the laser pulse. The timing jitters is within 10 ps by synchronization of rf by which both the linac and the laser can be controlled.

The first experiment of the new system will start this autumn.

4. Infrared Free Electron Laser

FEL experiments in visible region by using linac have been succeeded at about 10 places in the world. For Infrared FEL, the development has been proceeded. At ISIR, the FEL lasing[3] in the region from 32 ~ 40 μm was succeeded in 1994 by using the L-band linac[4]. The estimated maximum

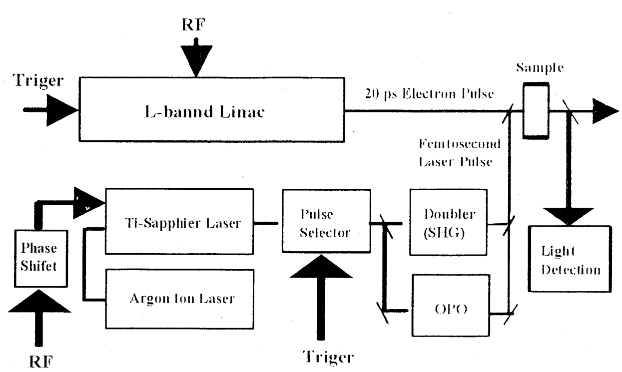

Fig. 3 A new picosecond pulse radiolysis combined with femtosecond laser.

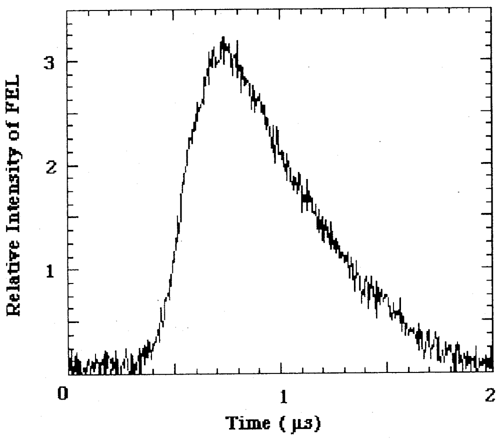

Fig. 4 The typical time profile of FEL monitored at 40 μm.

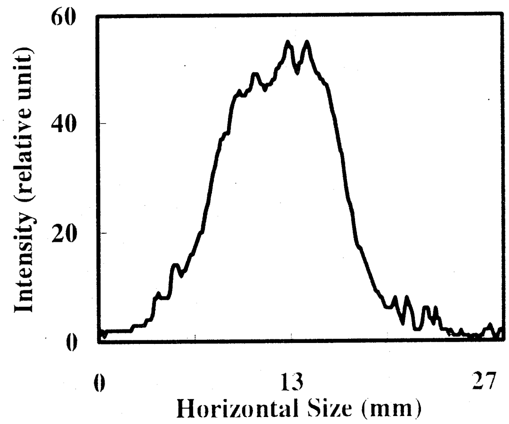

Fig. 5 The space profile of slow positron beam.

peak power at 40 μm was 8.3 MW.

Fig. 4 shows the typical time profile of the FEL at 40 μm monitored by a fast response far infrared detector. The net FEL gain obtained by the raise of the time profile and the optical cavity loss obtained by the decay after the electron pulse are 58 % and 6.2 %, respectively. The results have good agreements with the calculated values based on the two-dimensional model.

In order to get more high performance of the FEL, several improvements, such as the a newly designed electron gun of the linac, a variable gap system of the undulator, and an optimized optical cavity, will be required. The preparation of the experimental port for FEL application is under consideration.

5. Slow Positron Beam

Since the first image of the slow positron beam produced by the S-band linac was obtained in 1995, the measurement of numbers of positrons and extension of the slow positron beam line have been performed.[5]

The present position of the end of the slow positron beam line is point A in fig 2, where the performance of the slow positron beam is measured. The end position will be prolonged to the measurement room located over point B to avoid the interference with L-band linac.

Fig. 5 shows the space profile of the slow positron beam. The transport efficiency was improved by the optimization of the operation condition of the S-band linac, the moderator, and magnetic field. The estimated beam intensity of slow positron beam was 2×10^8 n/s.

The beam quality of the slow positron will improved by increasing the brightness of the beam. The dc and pulsed slow positron beam and their application will be started in near future.

references

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2) Y. Yoshida et al., Nucl. Instrum. Meth., A327, 41 (1993).
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5) Y. Honda et. al., Pro. 20th Linac Meeting in Japan, 50 (1995).