

Laser-Accelerator Research Activity at AIST

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Our research program on a laser accelerator was begun in 1994 at Electrotechnical Laboratory (ETL) and has been continued after the reorganization of our institute, AIST, in 2001. By taking opportunity of rearrangement, we moved our experimental setup to a larger lab and began to improve performance of a TW-laser system.

Recent activities at AIST are focused on studies of particle accelerations by using intense laser pulses, and their applications as well. We are performing experiments on laser interaction with plasma well as theoretical works on laser acceleration.

1. Research;

High-energy particle sources produced by an intense laser pulse;

The objective of the program is to study interaction of intense laser pulses with plasmas for developing laser-accelerators, and bright x-ray sources as well. We are performing experiments at higher electron density than the critical value of the relativistic self-focusing of $2 \times 10^{19} \text{ cm}^{-3}$ for 2 TW laser pulse.

After improvement of a beam quality of the laser system, maximum electron energy of 30 MeV, which was limited by an energy spectrometer, was obtained by focusing a laser pulse with peak power of 2 TW on an edge of a supersonic dense gas jet. An electron density was estimated to be $1 \times 10^{20} \text{ cm}^{-3}$ from a measured gas density. The vacuum focus intensity was $5 \times 10^{18} \text{ W/cm}^2$ ($a_0=1.5$). An energy spectrum consisted of two-temperature Boltzman-like distribution. An effective temperature of high-energy component was 4.5 MeV possessing obvious energy humps around 6-MeV. We are now conducting experiment to clarify the origin of energy humps.

Incidentally, the maximum energy of the electron beam was 2 MeV at the laser power of 2 TW of previous system. The energy spectrum of the electron beam was a power-law dependence of $E^{-3.5}$. One of the most different parameters is an intensity distribution in a focus. The poor beam quality of the previous laser system gave the vacuum intensity of $7 \times 10^{17} \text{ W/cm}^2$.

In order to help understanding physics of acceleration, we are developing a 2-D PIC simulation code.

The program is financially supported by the budget for nuclear research of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), based on the screening and counseling by the Atomic Energy Commission (AEC) of Japan.

Diagnostics of plasma cathode;

The objective is to develop plasma diagnostic techniques to investigate plasma cathodes, which are driven by intense laser pulses. Since optical short pulses are effective diagnostic tools for investigating both density modulations and temperatures of underdense plasmas, we are developing the optical probing technique. A part of laser pulse is divided from an amplifier chain of the TW-laser system and compressed to form the short probe pulse. At first, the shadowgraph technique using the short laser pulse was used to observe the evolution of the plasma channel formed by the relativistic self-focusing, and a complex structure of a density modulation produced by the previous laser system as well. Since the appearance of the complex structure was well coincided with the high-energy electron generation in the previous experimental setup, we supposed that electrons were stochastically accelerated and estimated the contribution of the stochastic acceleration on the observed energy spectrum.

Recently, the probe pulse is amplified to use the laser scattering experiment to diagnose density modulations of the wake field as well as to know a structure of an electron bunch.

The program is a part of the Advanced Compact Accelerator Project under the collaboration with the National Institute of Radiological Sciences (NIRS).

2. Experimental setup;

Our laser system was largely reorganized in 2003. A beam quality of an output pulse has been improved by replacing an oscillator, pulse stretcher, regenerative amplifier, preamplifier, relay optics, and installing a pulse compressor in a vacuum as well. The Schematic layout of the laser is shown in Fig.1. The maximum power of 6-7 TW will be delivered in 2004 by pumping the main amplifier with fully equipped YAG lasers.

Figure 2 is a picture of an interior of a target chamber. The main laser pulse is focused on the gas jet by the off-axis parabolic mirror. The electron beam and the forward scattered laser light are measured on the laser axis. The direction of the probe pulse is changed between normal and collinear to the main pulse.

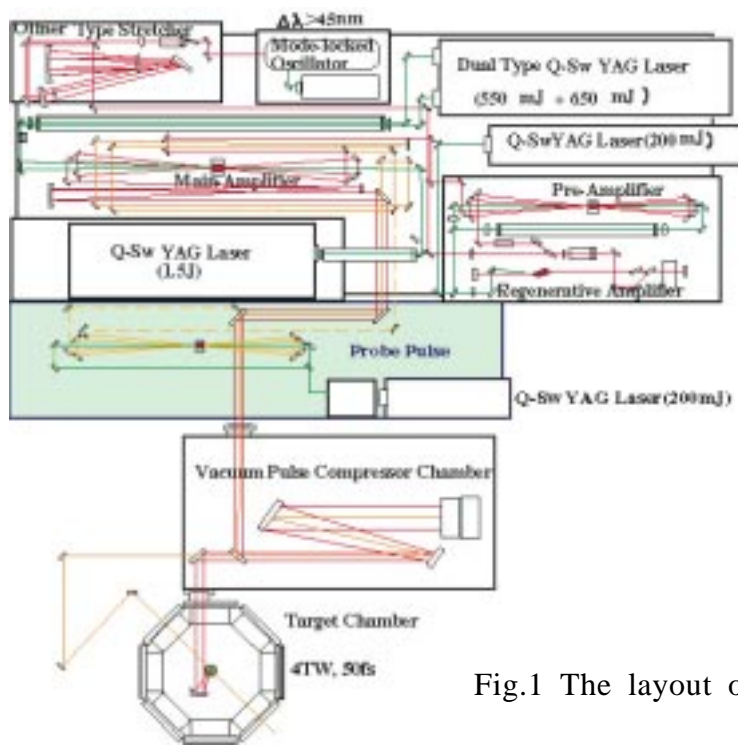


Fig.1 The layout of the laser Ti: sapphire laser

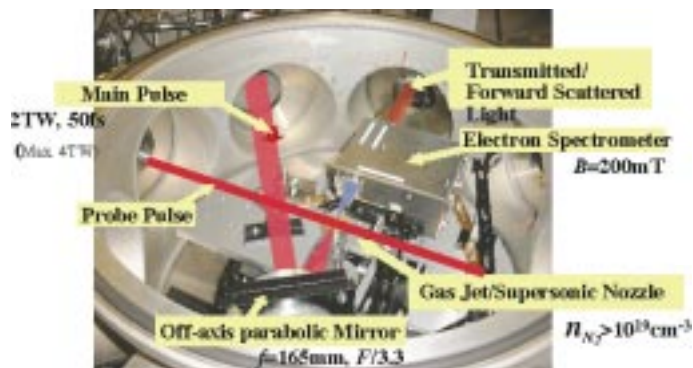


Fig.2 Interior of the target chamber.

3. Publications;

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