05aE61P

# 超高強度レーザー生成プラズマ放射硬X線の分光観測
# Characterization of Relativistic Electron Beams Generated by Intense Laser Pulses with High Energy X-ray Spectrometer

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Fast ignition is a way to directly heat a dense fuel with an ultra-short high intensity laser pulse. In this scheme, laser energy is converted to a few MeV electron beam at the laser-plasma interaction region, and the beam heats the fuel at its maximum compression. Efficient heating highly demands controlling energy distribution function and divergence angle of electron beams. Electron spectrometer (ESM) has been widely used to measure energy spectrum of relativistic electrons emanating from a laser-irradiated target. However, measured hot electron spectrum is substantially affected by a plasma potential so that ESM will not provide direct information on electrons at the interaction and propagation regions. High energy x-ray spectrometer (HEXS) was therefore developed to characterize energetic electrons inside the target via bremsstrahlung x rays emitted from targets.

Twelve pairs of absorption filter and imaging plate (IP) are piled in HEXS as shown in Fig. 1 [1]. The filters are selected to cover x-ray energy range from 10keV to 700keV. Geant4 code [2], which is a Monte Carlo code to calculate energy deposition and transport of particle through matter, is used to estimate x-ray spectrum from IP signals.

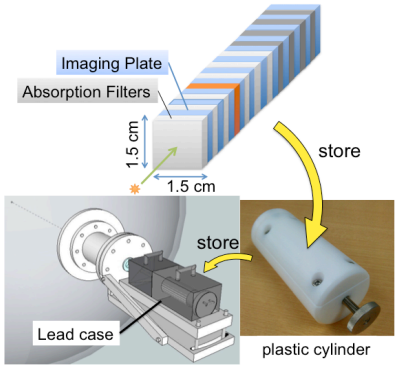


Fig.1 Schematic diagram of high energy x-ray spectrometer (HEXS). The major part of HEXS is composed of twelve pairs of x-ray absorption filters and imaging plates (IP).

Absolute sensitivity of HEXS to energetic x-ray photons was calibrated with radioisotopes and LINAC. In the calibrations, the spectrometer was exposed to γ-rays from $^{137}$Cs and $^{60}$Co. HEXS was also calibrated with bremsstrahlung from a Pb plate irradiated by an electron beam from LINAC. The calibrations were conducted to confirm the Geant4 predictions. Good agreements in the cases were obtained between the experiment and the calculation.

HEXS was introduced to the fast ignition experiment with Gekko XII and LFEX lasers. The target was a tantalum cube attached with a gold cone and a CD hemi-sphere. The CD hemi-sphere was driven with Gekko XII, and LFEX laser irradiated the inside of the gold cone at the maximum compression of the sphere. Two HEXSs were used. One was set at 20.9 degrees from LFEX axis, corresponding to the cone axis, and the other was at 69.1 degrees. Geant4 code simulated the experiment. In this calculation, a single Maxwellian electron and plausible angular distribution of electrons are supposed to propagate from the cone tip to the tantalum cube. The best fit between the experiment and the calculation was obtained when 2.3 MeV slope temperature and Gaussian divergence of σ=30 degrees [3] are assumed. The energy conversion efficiency from laser to hot electrons in this case was estimated to be 41 %.

[1] C. D. Chen et al., Rev. Sci. Instrum. **79**, 10E305 (2008)
[2] Geant4 code, http://geant4.cern.ch/
[3] F. Perez et al., Phys. Plasmas **17**, 113106 (2010)