Electron Beam Generation from Laser Plasma Interactions at KERI

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1. Introduction

It is well known that a focused high-power (>1 TW) laser beam has an ultrastrong electric field, but the electric field is transverse so that it can not be used efficiently for acceleration of charged particles. If the laser pulse is sent into a plasma, however, the transverse field can be converted into a longitudinal electric field. The longitudinal electric field from the laser plasma interaction is so strong that it can accelerate electrons to a MeV level over 1 mm or less, which is several orders of magnitude higher than that of conventional RF-based accelerators. We have a laser accelerator research program at KERI (Korea Electrotechnology Research Institute) using a table-top terawatt laser, and the results are introduced.

2. Experiments and Results

The self-modulated laser wakefield acceleration mmethod is simplest among lasaer acceleration mechanisms, so we started with it. For this experiment, we used the 2 TW Nd:glass/Ti:sapphire hybrid laser system of KERI. The laser can deliver 1.4 J/pulse to the laser plamsa interaction chamber and the pulse duration is 700 fs. The overall schematic for the experiment is shown in Fig. 1. The 2 TW focused laser beam is sent to the supersonic He gas jet to generate laser-accelerated electrons and the high energy electrons are diagnosed with several tools to measure the charge, energy, emiottance, etc, and the plasma channel shape and density are measured with CCD cameras and a spectrometer.

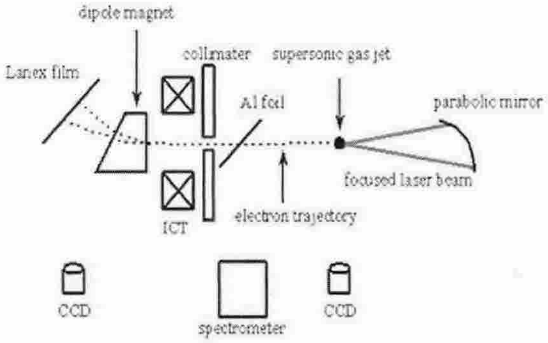
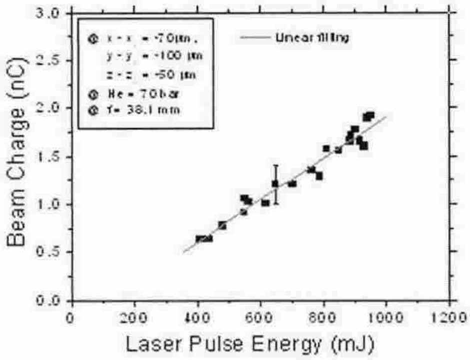


Figure 1. Overall schematic of the experiment for the self-modulated laser wakefield acceleration.

For the experiment the beam charge was measured as a function of the laser beam energy. Figure 2 shows the result when the collimator was removed. Thus the charge is a total charge passing through the ICT (integrating current transformer).

The result shows that the electron charge almost linearly increases as the laser energy increases. For this measurement we used a parabolic mirror with a focal length of 3.8 cm and a backing He pressure of 70 bars. Figure 2 shows that extension of the linear fitting does not pass the origin in the graph, so the result implies that there is a minimum threshold (laser) energy for electron beam generation. In addition to the e-beam charge and laser energy relation, several other important parameters such as the beam energy, emittance and plasma density were measured, and they will be presented at the workshop.



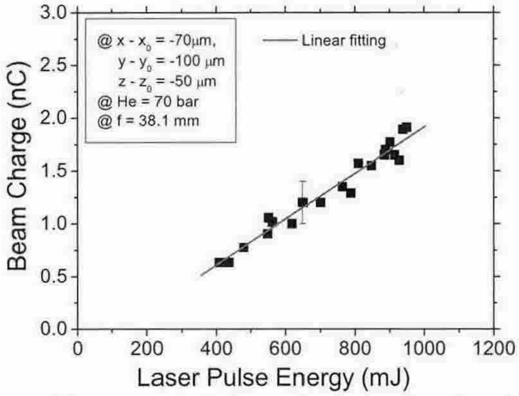


Figure 2. Measurement of a beam charge as a function of the laser pulse energy.

It seems that the laser-accelerated electron beam has many interesting properties. One of them is that the beam from the laser-plasma interaction is extremely space-charge-dominated as the beam has the following approxmate parameters: Q~ a few nC, initial beam size ~ 10 μm, pulse duration ~ laser pulse duration, and energy ~ MeV level. Thus, the beam expands almost explosively as it propagates. Some interesting features of the laser-accelerated beam will be presented at the workshop.

3 Conclusion

Laser plasma interactions can produce high charge (>1 nC), high energy (>1 MeV), high quality (emittance < 1 mm-mrad), ultrashort (<1 ps) electron beams.

REFERENCES

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