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# Development of the 1 kJ Nd:Glass Laser System for Basic Research on Quantum Engineering at KAERI

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## 1. Introduction

One of the purposes of high energy lasers, such as NIF, LMJ, Gekko XII and Shen-Guang III, is to investigate the principles of high energy density plasma science [1-5]. The high energy density plasma produced by the high energy lasers has received vast attention due to its fundamental sciences and variety of applications; laboratory astrophysics, the acceleration of high energy electron and proton, equation of state, and the fast ignition of inertial fusion research. The photo-nuclear radiation source by a high energy laser opens a new science field of quantum engineering.

The Korea Atomic Energy Research Institute (KAERI) is developing a high energy Nd:Glass laser facility for basic research on quantum engineering. KAERI laser facility (KLF) is based on the optical components of Gekko IV [6] which was transferred from the Institute of Laser Engineering (ILE) Osaka University. The system will deliver 4 beam lines with a clear aperture of 100 mm. Each beam will be more than 250 J at the nanosecond regime. The laser system consists of an oscillator, two pre-amplifiers, four double-pass rod amplifiers and four phosphate glass disk amplifiers at the final stage. For a wide application of the system, we plan to build the laser system to be operated as one kilo-joule laser at a nano-second or 50 TW at a pico-second. Combination of a nano-second high energy laser and a pico-second laser is expected to open a new physics area of high energy density plasma.

In this paper, we report current status of our project and on 400 J laser amplification experimental results.

## 2. Engineering Facility

We prepared a laser building in order to install the 1 kJ Nd:Glass laser and high energy density plasma chamber. The building presents about 480 $m^2$ of floor space on the ground level, reserved for the laser system and implosion chamber. The rooms on the ground level are equipped with class 10,000 clean rooms. For the cleaning of an optical component and laser cavity assembly, a class 100 clean room, of about 30 $m^2$, is also situated on the first floor of the building. The foundation is a 30 cm thick layer of concrete, which is separated from the building to avoid a vibration at the site. Capacitor bank and control room are located on the second floor of the building. A steel frame will serve to hold the optical components to provide a stable beam transport to the implosion chamber room. The building re-modeling was completed in June 2006.

In parallel to the building re-modeling, preparation for a laser installation was made. We designed a new laser amplification scheme in cooperation with ILE, Japan and SIOM, China and installed optical components on the laser frame. Figure 1 shows an installed laser amplifiers at the KAERI.

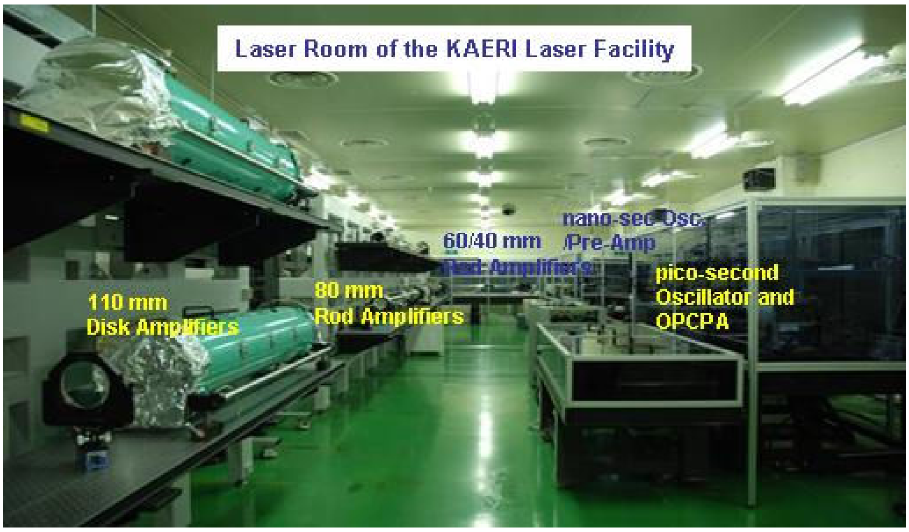
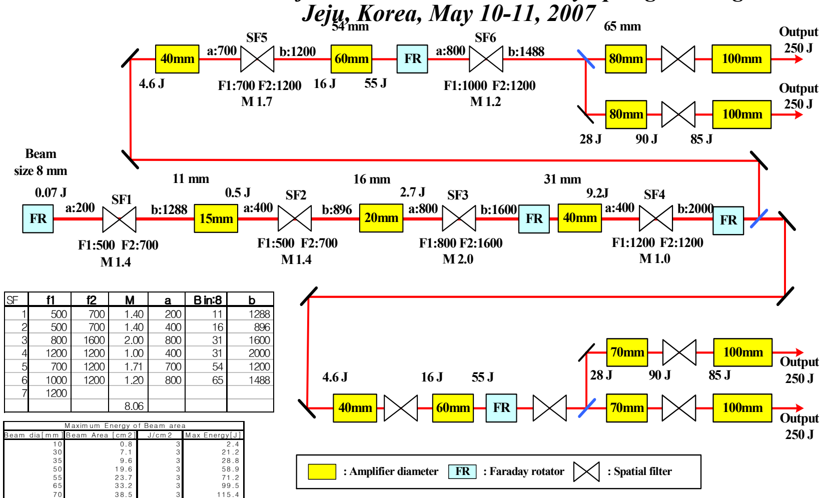



Figure 1. Photograph of KAERI laser facility (KLF).




| SF | f1 | f2 | M | a | B in:8 | b |
|---|---|---|---|---|---|---|
| 1 | 500 | 700 | 1.40 | 200 | 11 | 1288 |
| 2 | 500 | 700 | 1.40 | 400 | 16 | 896 |
| 3 | 800 | 1600 | 2.00 | 800 | 31 | 1600 |
| 4 | 1200 | 1200 | 1.00 | 400 | 31 | 2000 |
| 5 | 700 | 1200 | 1.71 | 700 | 54 | 1200 |
| 6 | 1000 | 1200 | 1.20 | 800 | 65 | 1488 |
| 7 | 1200 | | | | | |
| | | | 8.06 | | | |

| Maximum Energy of Beam area | | | |
|---|---|---|---|
| Beam dia[mm] | Beam Area [cm2] | J/cm2 | Max Energy[J] |
| 10 | 0.8 | 3 | 2.4 |
| 30 | 7.1 | 3 | 21.2 |
| 35 | 9.6 | 3 | 28.8 |
| 50 | 19.6 | 3 | 58.9 |
| 55 | 23.7 | 3 | 71.2 |
| 65 | 33.2 | 3 | 99.5 |
| 70 | 38.5 | 3 | 115.4 |
| 75 | 44.2 | 3 | 132.5 |
| 85 | 56.7 | 3 | 170.1 |
| 90 | 63.6 | 3 | 190.8 |
| 95 | 70.8 | 3 | 212.5 |
| 100 | 78.5 | 3 | 235.5 |

Figure 2. Optical layout of KAERI laser facility (KLF).

## 3. Results and Discussion

The optical layout of KLF is illustrated in Fig. 2. We used a broadband model to calculate optical damage of each stage and B-integration factor. In order to avoid optical damages, we designed laser fluencies less than 5 $J/cm^2$ and B-integration factor less than 5. The n-sec oscillator beam contains diffraction pattern from oscillator edge. By applying a new designed spatial filter with serrated aperture, we improved spatial beam profile of the oscillator from diffracted Gaussian to flat-top. In the pre-amplifier section, single pulses from the front-end lasers are amplified in a single passage through one 15 mm, one 19 mm and one 45 mm Nd:glass rod, pumped by flash lamps. Large aperture Pockels cells and Faraday isolators are used for pulse cleaning and isolation against back reflections. At the exit of the pre-amplifier the pulses reach energy of up to 10 J with an approximate super-Gaussian beam profile and a 30 mm diameter. The main-amplifier section is based on 40 mm, 60mm, 80 mm rod amplifiers and 110 mm aperture disc amplifiers. Near field burn pattern of laser beam from 80 mm is illustrated in Fig 2. We extracted laser energy up to 110 J from 1 beam line from 80 mm rod amplifier at 8 n-sec.

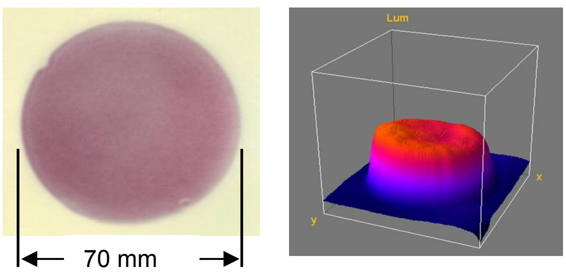



Figure 3. Near field patterns of laser beam from 80 mm rod amplifier. The energy of 1 beam line from 80 mm rod amplifiers was 110 J at 8 nsec.

## 4. Conclusion

The Korea Atomic Energy Research Institute (KAERI) is developing a high energy Nd:Glass laser facility for basic research on quantum engineering. In this spring, we extracted 400 J from rod amplifiers.

All mechanical constructions of the target chamber will be finished in early 2007 and the installation of the optical components including the focusing mirror around the chamber will be finished in the summer of 2007. This laser, consisted of 4 beam lines with clear aperture of 108 mm, will deliver 1 k J pulse energy at the nanosecond regime at the end of 2007.

## REFERENCES

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