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Concept of Laser Fusion Power Plant Based on Fast Ignition

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This paper introduces new concept of laser fusion that is expected to demonstrate energy generation based on inertial fusion in the near future. In the fast ignition (FI) scheme, a spherical hollow solid deuterium-tritium fuel is compressed to a high density of 1000 times solid density with tens nano-second laser pulses from a compression laser and the compressed fuel core is directly heated to 5 keV with a ten pico-second laser pulse from a heating laser. This FI scheme enables us to design an IFE power plant with a 1MJ-class, compact laser whose output energy is 1/4 of previous central ignition scheme. Recent progress on cooled Yb-YAG ceramic laser revealed that highly efficient compression and heating lasers can be constructed using this laser material with acceptable construction cost including laser diodes for pumping and the refrigerator. New reactor scheme for a liquid wall reactor that has no stagnation point of ablated gas and a rotary shutter system to protect the final optics are proposed.

Current computer simulation indicates thermonuclear gain of 160 will be achieved with 1.1 MJ / 10 ns compression lasers and a 100 kJ / 10 ps heating laser. A diode-pumped, cooled, Yb-YAG ceramic-laser is the prior candidate for the compression laser operated at 16 Hz rep rate. The conversion efficiencies from electricity to laser are 9.5% for the compression laser, 3.5% for the heating laser, and 6.9% in total including cooling power, respectively.

The power plant consists of 4 module reactors powered by one laser system. One module reactor has 32 compression beams, one heating laser, and two target injectors as shown in Fig. 1. Each beam port has a rotary shutter and an electro magnet to prevent the final optics from neutral vapor and ions, respectively. The panels of the first wall are tilted by 30 degree to avoid stagnation of evaporated vapor at the chamber center. The focus position is vertically off set to simplify the protection mechanism of the ceiling.

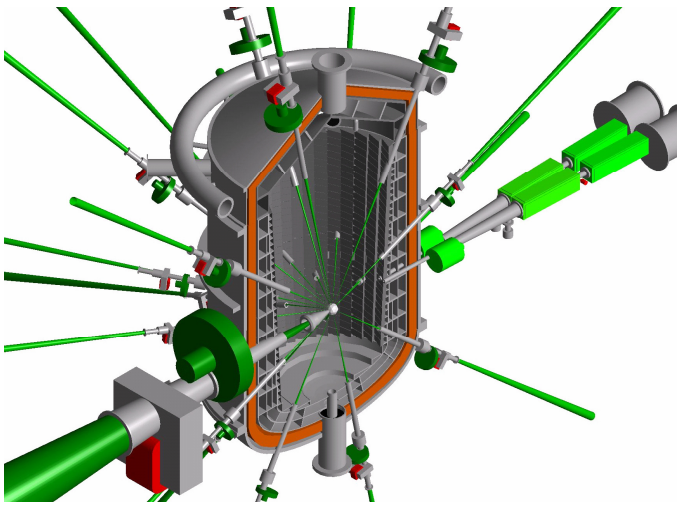

Fig. 1 Cross sectional view of chamber. The target is enlarged by 150 for visibility.