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ABSTRACT

In May,1996, we demonstrated the production over a petawatt of peak power in the Nova/Petawatt Laser Facility, generating 620 J in ~ 430 fs. Results of the first focused irradiance tests, and recent deployment of a novel targeting system will be presented.

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We recently demonstrated the production of over a petawatt of peak power in the Nova/Petawatt Laser Facility, generating 620 J in ~ 430 fs. The Petawatt Laser Project was initiated to develop the capability to test the fast ignitor concept[1] for inertial confinement fusion (ICF), and to provide a unique capability in high energy density physics. The laser was designed to produce near kJ pulses with a pulse duration adjustable between 0.5 and 20 ps. At the shortest pulse lengths, this laser will produce > 10^{21} W/cm^2 when focused at F/3.

The laser system begins with a Ti:sapphire chirped pulse amplification system operating at 1054 nm. The pulse is stretched to ~ 3 ns and is amplified up to 50 mJ in the titanium-sapphire section with minimal bandwidth narrowing. Further amplification in mixed phosphate glass rod amplifiers produces a spectrally-shaped 10 J pulse. This pulse is further amplified up to the near kilojoule level by a series of disk amplifiers. Near diffraction-limited beam quality is achieved by utilizing only the central 80% of the disk amplifiers and the use of adaptive optics to correct any residual thermal or pump induced aberrations. Following amplification, the chirped nanosecond pulse is compressed by a pair of large aperture diffraction gratings arranged in a single pass geometry. The pulse length can be adjusted easily from 0.43 - 20 by varying the length of the pulse stretcher. Pulse compression occurs in vacuum with a compressor throughput of 84%. Currently, the system produces nominally 600 J pulses for routine operation in a 46-cm beam. Expansion of the beam to 58-cm with the installation of 94-cm gratings will enable 1 kJ operation. Near field and focused irradiance, spectrum and autocorrelation are measured on each shot using a transmission through a leaky mirror into a full aperture diagnostic station.

Target experiments with petawatt pulses will be possible either integrated with Nova 10-beam target chamber for fast ignition experiments, or in an independent target chamber for single beam experiments. For long pulse (~20 ps) experiments, the beam is focused by an on-axis parabolic mirror, which is protected from target debris by a full aperture debris shield. For short pulse experiments, however, a conventional 1-cm thick fused silica debris shield would produce an accumulated nonlinear phase retardation of ~ 28 radians, double-passed! To protect the parabola from line-of sight debris without incurring a large nonlinear phase retardation, a secondary "plasma mirror" is used in conjunction with the primary parabola.[2] For irradiances > 10^{14} W/cm^2, short pulse radiation creates a critical density plasma on the surface of a dielectric substrate, with a demonstrated reflectivity > 90%. For incident pulses on the order of 500 fs, the plasma has insufficient time to undergo hydrodynamic expansion, producing a reflected wavefront comparable to the original optical surface. This novel targeting system will enable the production of ultrahigh contrast pulses, with an easily varied effective focal length by changing the curvature of the secondary mirror.

The first target experiments in the single beam chamber measured electron transport and heating in multilayer targets, as well as x-ray and neutron yield. Experiments were performed using the 20 ps pulse length required for fast ignition experiments, achieved 10^{19} W/cm^2. Measurements of the focused irradiance demonstrated a focal spot round focal spot, approximately 15 μm in diameter. These results indicate that a focal irradiance of > 10^{21} W/cm^2 will be achievable with the Petawatt operated at 450 fs. Results of the short pulse focused irradiance tests with the plasma mirror at 500 J in 450 fs will be presented.

References:

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