White Paper for *Frontiers of Plasma Science Panel*

Date of Submission:	***6/19/2015***

Indicate the primary area this white paper addresses by placing "P" in right column.
Indicate secondary area or areas by placing "S" in right column

	"P", "S"
• Plasma Atomic physics and the interface with chemistry and biology	S
• Turbulence and transport	
• Interactions of plasmas and waves	P
• Plasma self-organization	
• Statistical mechanics of plasmas	S

Indicate type of presentation desired at Town Hall Meeting.

	"X"
Oral	X
Poster	
Either Oral or Poster	
Will not attend	

Title:	**Deep Ultraviolet, High Energy, Rapid-Shot Laser Facility**
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(Limit text to 3-pages including this form. Font Times Roman size 11.
1 page of references and 1 page of figures may also be included. *Submit in PDF format*.)

- ***Describe the research frontier* and importance of the scientific challenge.**
- ***Describe the approach to advancing the frontier and indicate if new research tools or capabilities are required.***
- ***Describe the impact of this research on plasma science and related disciplines and any potential for societal benefit***

Exploration of laser-matter interactions has been driven by concurrent trends towards higher energies and shorter wavelengths. The former allows the creation of an ever larger parameter space, such as higher densities and temperatures, larger spatial scales, stronger shocks, greater compression, and higher energy radiography. Adoption of shorter wavelengths has allowed higher thresholds for the onset of laser-plasma instabilities (LPI) that can impede and even prohibit realization of experimental objectives. Beam smoothing techniques allowed the efficiency and simplicity of direct laser ablation for driving hydrodynamic and equation of state experiments. Although the primary endeavor for this field has been inertial confinement fusion (ICF), research has expanded into a host of topics from high energy density physics (HEDP) to

nonlinear optical processes. This paper seeks support for these frontiers with a new facility that will advance operations deeper into the ultraviolet regime at energies commensurate with the current state-of-the-art and with features that would revolutionize experimentation in this area in several ways.

The oversubscribed time on the existing high energy lasers such as the NIF and OMEGA demonstrates the high demand in this area. These facilities have enabled incredible new experiments. However, they suffer from the following limitations: low shot rate, leading to high cost per shot and scarcity of data; fixed or difficult to change parameters such as bandwidth and focal spot size; laser-plasma instabilities concomitant with increasing drive intensity.

Outstanding features available with krypton-fluoride (KrF) gas lasers would address these limitations and enable new fundamental science efforts. First, the deep ultraviolet wavelength (248 nm) of these systems allows for increased laser absorption and higher thresholds for laser-plasma instabilities. Hence, the greater coupling efficiency allows greater ablation pressures and higher target and shock velocities, both key to HEDP and ICF. Secondly, KrF lasers can utilize a form of beam smoothing (induced spatial incoherence) that provides the highest uniformity illumination of any high energy laser system. The high spatial uniformity of the focal profile can be essential for many types of experiments ranging from studies of hydrodynamic instabilities to precise equation of state experiments. Third, KrF lasers have a low nonlinear index in the amplifiers which allows imaging of a profile from the low-energy stage through the entire system and onto the target. This feature means that the profile can be routinely and quickly changed for a given shot (no phase plates) as well as the ability to change the profile dynamically during the laser pulse (focal zooming)[1]. In either form, this will greatly enhance the productivity of the laser and may prove essential for studies such as cross-beam energy transport. Fourth, KrF systems have an inherently large bandwidth (dw/2pi ~ 3 THz) and don't require harmonic conversion, and thus can easily have their output spectrum manipulated independently of the pulse shape or focal profile. This combined flexibility is unique among current high energy systems.

Finally, the gas laser medium of the KrF laser lends itself more easily to high shot rate operation. Moderate energy (up to 700 J) KrF systems have been operated at high repetition rates (up to 5 Hz), when appropriate cooling functions are included[2]. While such capability is essential for the energy application, shot-on-demand operation (10 shots/hour) is straight-forward to implement with rudimentary cooling and would allow many more iterations of laser and target parameters to be explored and standardized during any particular experimental campaign. This new style of operation would significantly increase the scientific productivity.

The proposed next-step KrF facility can be envisioned as a moderate scale-up of the systems already developed and operating and with a community oriented framework that allows a large number of external users. The primary change in technology is a general scaling of the current systems from routine 3 kJ operation[3] to the 20-30 kJ regime with advanced pulse shaping. KrF architecture allows for amplification of short (down to 1 ps) pulses multiplexed with long (ns) duration beams, giving the facility simultaneous short and long pulse capability[4,5]. Although the core goals of the facility would likely be related to the ICF mission, operations would accommodate rapid experimental turnover. KrF architecture inherently provides a large number of beams, allowing illumination flexibility. To allow the highest possible directed intensities, the target chamber geometry would emphasize two opposing cones of beams (up to 96 beams in each cone), although reconfiguration would be supported for particular experimental needs, such as x-ray backlighting.

A large number of experiments already being performed on existing glass laser facilities would benefit from high shot rates, significantly increased maximum ablation pressures, high-uniformity drive and lack of or reduced deleterious hot electron production that would be offered by the proposed facility, without the complexities or impeded diagnostic access of a hohlraum. A number of new experiments would be enabled that otherwise would not be feasible. Some examples include low adiabat acceleration to ultra-high velocities (>1,000km/s) for generating >1Gbar impact pressures and thermonuclear temperatures in open geometry[6,7], high intensity laser-matter interaction experiments with 1/4 μm short wavelength light, high precision fundamental high pressure hydrodynamics studies, as well as high precision measurements of equation of state.

References (Maximum 1 page)

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