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TITLE LOS ALAMOS NATIONAL LABORATORY PLANS FOR A LABORATORY MICROFUSION FACILITY

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LOS ALAMOS NATIONAL LABORATORY PLANS FOR A LABORATORY MICROFUSION FACILITY

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Los Alamos National Laboratory is actively participating in the National Laboratory Microfusion Facility (LMF) Scoping Study. We are currently performing a conceptual design study of a krypton-fluoride laser system that appears to meet all of the driver requirements for the LMF. A new theory of amplifier module scaling has been developed recently and it appears that KrF amplifier modules can be scaled up to output energies much larger than thought possible a few years ago. By using these large amplifier modules, the reliability and availability of the system is increased and its cost and complexity is decreased. Final cost figures will be available as soon as the detailed conceptual design is complete.

The national LMF study is seriously considering three drivers possibilities for the LMF; the KrF laser, the Nd:glass laser, and light-ion accelerators. Heavy-ion accelerator proponents are also participating in the LMF study, but the technology is not thought to be sufficiently advanced to be ready in the time for the LMF. Additionally, both direct and indirect drive are being considered by the study as methods of imploding the target.

The KrF laser proposed by Los Alamos is the least developed of the three LMF driver candidates. Our Aurora laser, now under construction, is the first end-to-end demonstration of a KrF laser for inertial confinement fusion (ICF). The first demonstration of laser energy propagated through the entire amplifier chain is scheduled for late this year. Greater than one kilojoule is expected to be delivered to the target plane. Early next year we will perform experiments to determine the ultimate potential of KrF lasers for ICF applications.

The KrF laser appears to satisfy all of the LMF requirements. It is a *uniquely* attractive LMF driver for the following reasons:

1. It should have the lowest driver-energy requirements for the LMF because the 250-nm fundamental wavelength is near-optimum for target coupling.
2. The KrF laser is suitable for both direct and indirect drive because the natural broad bandwidth and short wavelength make it the only candidate for echelon-free induced spatial incoherence.
3. Delivery of any desired pulse shape to the target is straightforward because it is not a storage laser and pulse-shape distortion due to gain saturation can be controlled so that a pulse shape generated in the front end can be propagated through the amplifier chain without change.
4. The KrF laser is relatively simple to adapt to repetitively pulsed commercial and military applications because it is a gas laser.

I would like to expand on the importance of a driver being able to do both direct and indirect drive. The main difference between the two approaches is that in direct drive the laser deposits its energy directly on the pellet surface whereas in indirect-drive the driver energy is first converted to x rays, which are then used to ablate the pellet surface and cause implosion. Clearly the extra step required by the indirect-drive approach makes it less efficient and results in a lower gain. Both approaches have uncertainties as to whether or not they will achieve high gain with acceptable driver energies. If direct drive works, then the yield goal of the LMF can be achieved with less driver energy, resulting in a substantial cost reduction for the LMF over the indirect-drive approach. It needs to be determined which approach is better. We at Los Alamos have a development plan designed to resolve this issue *before* construction of the LMF.

There are two major areas of risk involved with the LMF: the driver and the targets. As to the drivers, no ICF driver has demonstrated both the cost and performance required for the LMF. Light-ion accelerators require an extrapolation of greater than an order of magnitude in energy to go from PBFA II to the LMF. In addition, there remain significant issues with respect to accomplishing pulse shaping and focussing with the required standoff distance. Nd:glass lasers are often described as the most developed ICF driver, but Nova, Lawrence Livermore's seventh generation Nd:glass laser is over a factor of 500 away from the LMF driver energy requirement, based on current performance. Also, the unit cost of Nova is approximately a factor of 50 higher than the LMF cost goal. KrF lasers require a factor of approximately 2000 scale up to go from current levels to the LMF requirement. It is obvious that scaling a laser system up by three orders of magnitude in energy has too great a risk to gamble one- to two-billion dollars on.

ICF targets also have many risks and uncertainties, ranging from their manufacture to ignition requirements. Past and current ICF drivers have provided much information about target physics. Unfortunately, there are some issues that cannot be addressed with current devices. These issues include certain laser-plasma interactions that appear only at large scale-lengths and target ignition physics not yet demonstrated in the laboratory. These issues contribute directly to an uncertainty in the required LMF driver energy, which at this time cannot be specified to an accuracy greater than a factor of two or more.

The Los Alamos KrF laser development plan is designed to simultaneously reduce the driver and target risks associated with the LMF and to provide detailed specifications for the driver and target. The first step in the development plan is to operate Aurora for several years. This will allow us to obtain experience with operating a KrF laser-fusion system and to resolve issues. During operation of Aurora, we plan to design and build a large power amplifier module that will serve as a prototype for future KrF systems. The second step in the development plan is to construct and operate an intermediate facility that we call the Ignition Physics Facility. Los Alamos is the only laboratory proposing this intermediate step. This step will

- provide a step between current drivers and the LMF so that such extreme extrapolations are not required,
- demonstrate that the LMF driver performance and cost estimate is achievable at a substantially lower cost, and
- demonstrate target physics at the ignition level where plasma scale-lengths are comparable to those of the LMF.

After operation of the Ignition Physics Facility, we will have sufficient data to embark on the construction of the LMF with acceptable risks.

In summary, Los Alamos is actively participating in the LMF Scoping Study and is currently performing a conceptual design study using a KrF laser for the driver. The LMF Scoping Study is very important because it is leading to a decision on *which* driver or drivers the ICF program will continue to pursue. The LMF driver decision must be made carefully. We are all aware of the haunting specter of the idle $372-million Magnetic Fusion Test Facility.

We believe that the KrF laser offers several unique advantages as an LMF driver: the KrF laser has the ability to satisfy both target drive approaches; it's short wavelength and broad bandwidth make it nearly ideal for target coupling; it is capable of delivering pulse shapes generated in the front end to the target without distortion; and it is readily adaptable to repetitively pulsed applications.

The Los Alamos KrF laser development plan calls for an intermediate step between current facilities and the LMF. We believe that the risk is too high to proceed directly to an LMF without verification of target performance and driver performance and cost. After operation of an Ignition Physics Facility, the exact driver and target specifications for the LMF will be known, and the LMF can be built with acceptable risks.