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Title:

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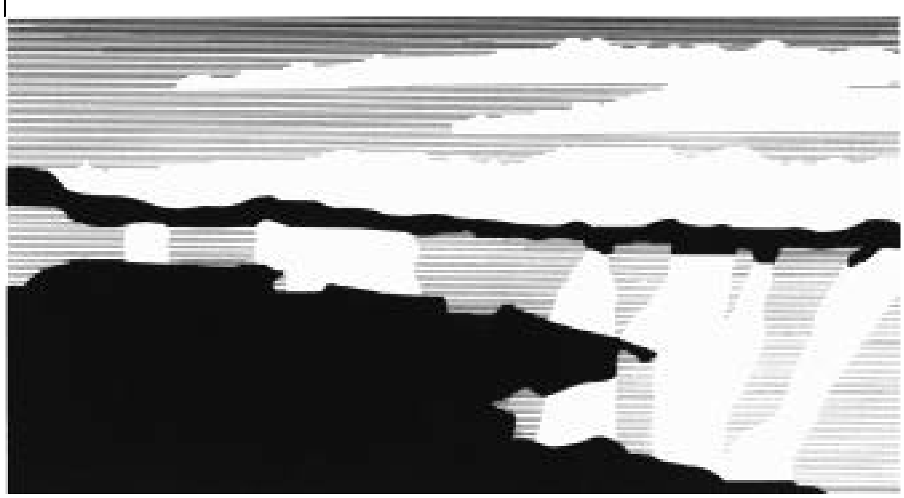

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Possible Hohlraum Geometries for Trident-Upgrade

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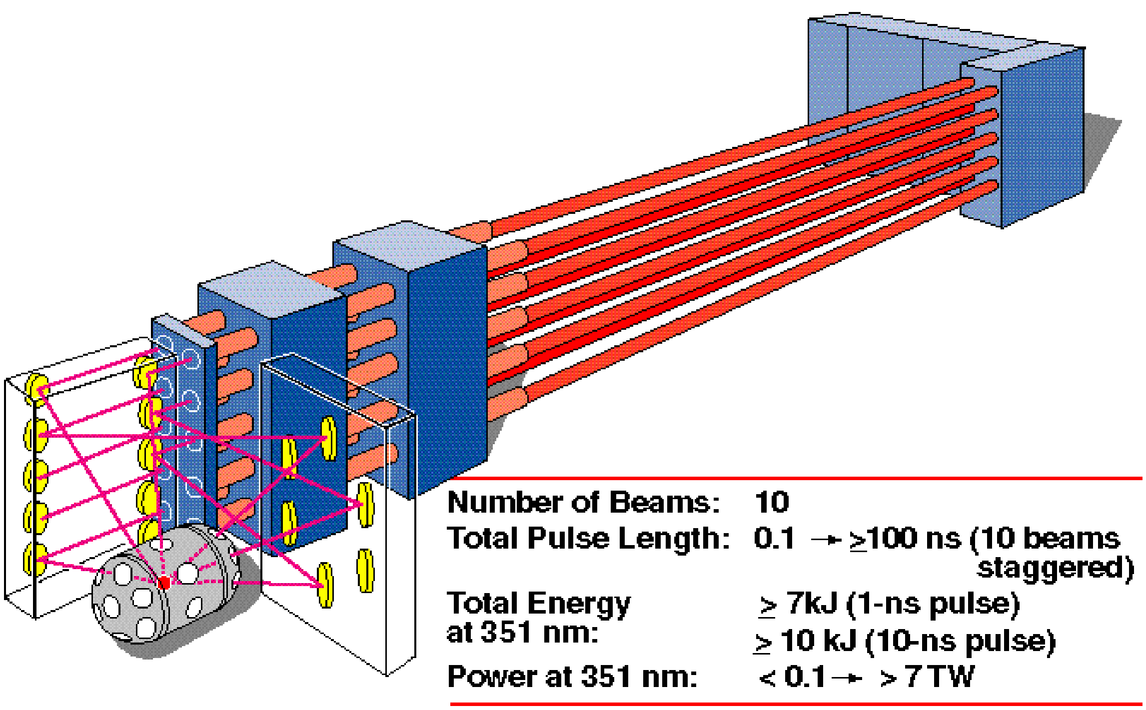
Abstract

The proposed geometry of the Trident-Upgrade beams does not provide for illumination of cylindrical hohlraums in a manner identical to that on Nova or NIF. However, a number of alternate indirect-drive geometries are possible and should be considered when evaluating the usefulness of the proposed laser system for x-ray drive experiments. Some of these alternate hohlraum geometries are discussed here.

I. Introduction

Indirect-drive geometries for Trident-Upgrade are being developed based on the proposed beam port locations. The assumptions being made for the beams are that they are f/6, and that they have a minimum beam diameter of 100 μm. It is assumed that the target chamber will provide six beam ports on each



end, with a half angle of 22.5°, and that there will be eight evenly spaced beam ports around the equator. It is further assumed that no more than 10 of these beams will be available at any given time to drive a hohlraum.

II. Design guidelines

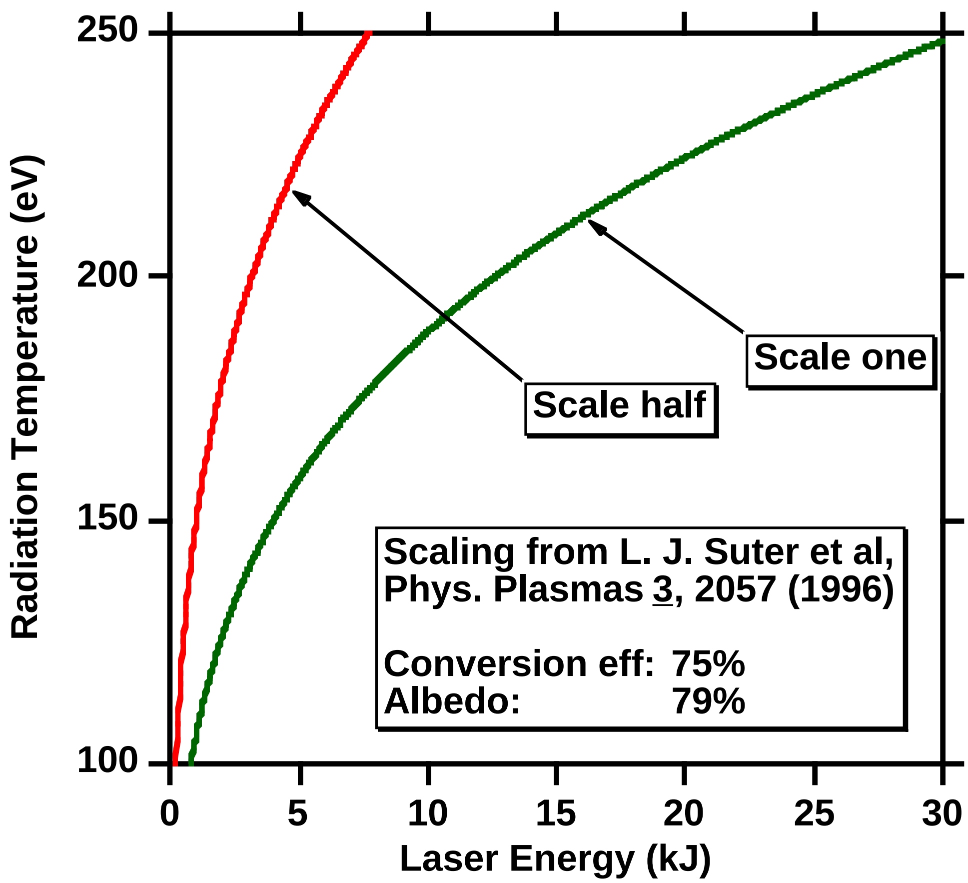
The hohlraums are designed to fulfill the mission of Trident-Upgrade. They are designed for driving foils and hydrodynamics experiments, for example, rather than for performing implosion experiments.

Since Trident-Upgrade will be able to provide approximately 25% of the energy on target that is currently available on Nova, the targets are being designed at approximately one-half the scale of Nova hohlraums so that Nova-type radiation temperatures may be obtained. This, of course, requires Nova-type conversion efficiencies as well.

A simple power balance model can be used to predict the radiation temperature of a Trident-Upgrade hohlraum by equating the sources and losses to give [Suter 96a]:

$$\eta P_L = \sigma T_R^4 [(1-\alpha) A_{wall} + A_{LEH} + A_{diag}],$$

where P_L is the laser power, T_R is the radiation temperature, σ is the Stephan-Boltzmann constant, and A_{wall} , A_{LEH} , and A_{diag} are the wall, laser entrance

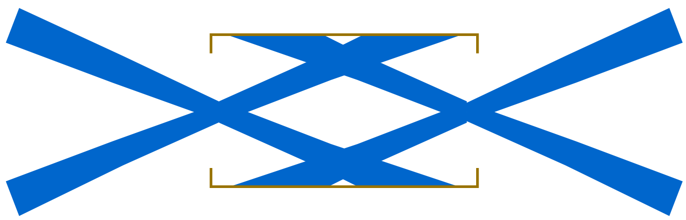


hole, and diagnostic hole areas, respectively. In the figure below, the comparisons are calculated using this formula and the values for conversion efficiency (η=0.75) and albedo (α=0.79) used in reference [Suter 96a] for Nova hohlraums.

III. Example designs

A. Nova scale-1/2 cylindrical hohlraum

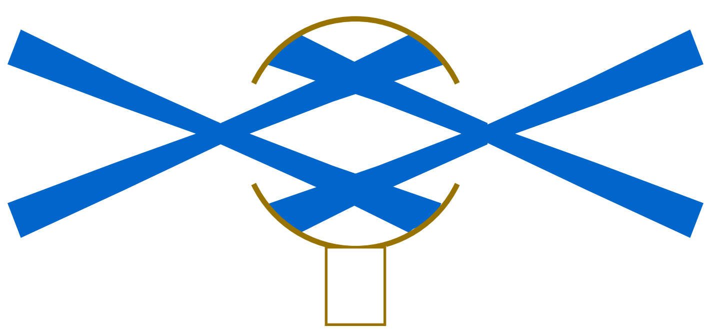
The obvious first choice for a half-scale hohlraum would be a Nova hohlraum scaled to exactly one-half in every dimension. The hohlraum would then be 800 µm in diameter and about 1350 µm long, with 600-µm-diameter laser entrance holes. Similar hohlraums have been used for implosion experiments [Nishmura 93]. Due to the reduced cone angle of the beams, the beams would strike the inside of the hohlraum wall on the opposite side of the hohlraum from which they entered.



This hohlraum geometry is the closest to what has been used in the past, but has the obvious disadvantage that the beams strike at a shallow angle (67.5° from perpendicular), and conversion efficiency would be expected to suffer.

B. Spherical hohlraum

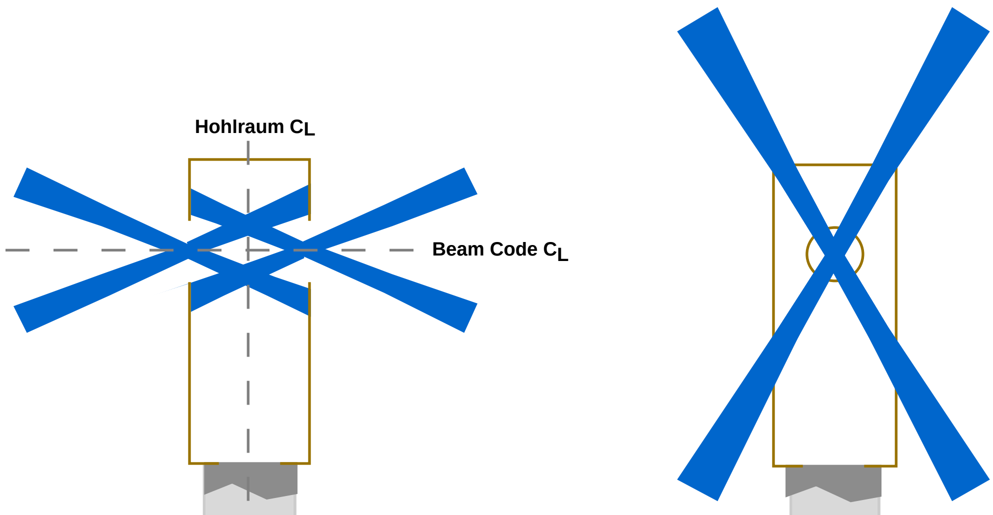
The angle of incidence may be increased over that of a Nova scale-1/2 hohlraum by utilizing a spherical hohlraum instead. A spherical hohlraum with a diameter of 1200 µm and laser entrance holes of 600 µm diameter will have approximately the same wall and LEH area as the scale-1/2 hohlraum.



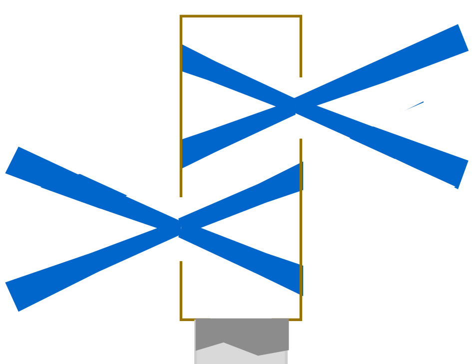
By changing to a spherical geometry and pointing the beams so that they cross at the laser entrance hole, the angle of incidence decreases to 22.5° from perpendicular.

C. Helen-type hohlraum

Hohlraums need not be driven from the ends. Side-driven hohlraums could be utilized as well. In the “Helen-type” geometry, a cylinder of 800 µm diameter and arbitrary length is illuminated with the two beam cones through holes in the side of the hohlraum.



Depending on the details of the design, these hohlraums might have reduced illumination uniformity on the experimental package. In addition, for the design shown above, the laser entrance hole size is limited by the size of the circle of beam spots formed around it.

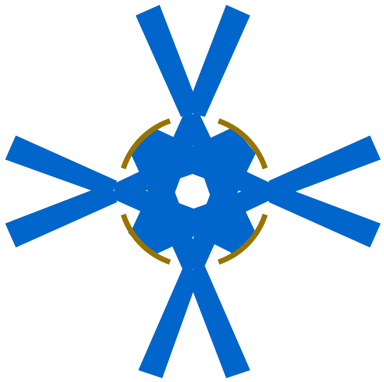


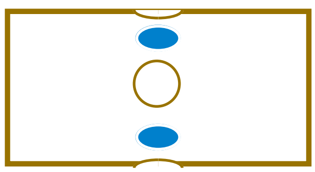
Depending on the details of the design, these hohlraums might have reduced illumination uniformity on the experimental package. In addition, for the

design shown on the left, the laser entrance hole size is limited by the size of the circle of beam spots formed around it.

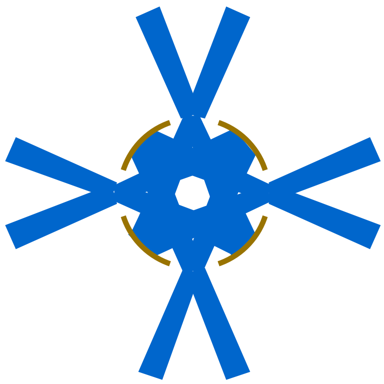
D. Equator-driven hohlraum

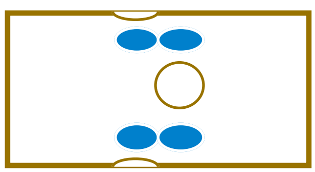
Hohlraums might also be driven using the beams on the equator of the target chamber. Eight beams could be used to illuminate a cylindrical hohlraum with four holes equally spaced around the midplane of the cylindrical hohlraum. However, the LEHs would need to be small to allow a sufficiently large region for the beams to strike.





Alternatively, if the beams are not directly on the midplane of the target chamber, or if the LEHs are staggered so that two are closer to each end, then a larger LEH can be used, or greater distance from the beam spots to the LEHs could be realized.

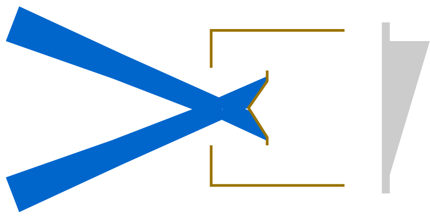




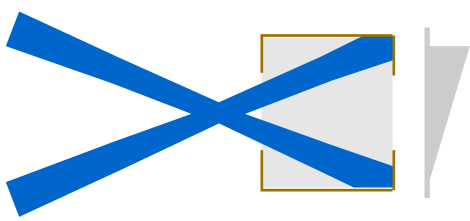
E. Labyrinth hohlraums and Suter Forward Radiators

Single-sided illumination has been used on the current Trident laser for materials work and diagnostic testing. Similar techniques can be used on the Trident-Upgrade, and may be desirable for applications where the irradiance from gold M-band x-rays or from reflected laser light must be minimized. Using six beam ports from one side of the hohlraum, the target could be driven while allowing four beams on the equator to be used for backlighters.

The major disadvantage of this type of irradiation is the inefficiency of coupling x-rays to the opposite end of the hohlraum from the LEH, but these hohlraums can be used to generate very smooth drive.



In addition, there are ideas for advanced geometries, termed “forward radiators,” [Suter 96b] that could be tested on Trident as well.



References

[Suter 96a] L. J. Suter, R. L. Kauffman, C. B. Darrow, A. A. Hauer, H. Kornblum, O. L. Landen, T. J. Orzechowski, D. W. Phillion, J. L. Porter, L. V. Powers, A. Richard, M. D. Rosen, A. R. Thiessen, and R. Wallace, *Phys. Plasmas* **3**, 2057 (1996).

[Nishimura 93] H. Nishimura, H. Shiraga, T. Endo, H. Takabe, M. Katayama, Y. Oshikane, M. Nakamura, Y. Kato, and S. Nakai, *Laser Particle Beams* **11**, 89 (1993).

[Suter 96b] Larry Suter, *Bull. Am. Phys. Soc.* **41**, 1422 (1996).