UCRL-JC-128870
PREPRINT

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This paper was prepared for submittal to the
Conference on Lasers and Electro-Optics '98
San Francisco, CA
May 5-7, 1998

November 4, 1997

Lawrence Livermore National Laboratory

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Performance of Smoothing by Spectral Dispersion (SSD) with Frequency Conversion on the Beamlet Laser for the National Ignition Facility

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Abstract: Simulations and ongoing measurements indicate that SSD results in small degradation to the near field beam quality. The measured effect of SSD bandwidth on conversion to the third harmonic and smoothing of the target illumination will also be described.

This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

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Inertial confinement fusion (ICF) utilizing direct or indirect laser drive requires the target illumination to be uniform over a wide range of spatial frequencies. A number of approaches have been suggested to achieve the desired level of illumination uniformity.[1-4] Angular dispersion of phase modulated (FM) light (termed smoothing by spectral dispersion - SSD)[4] is attractive for ICF using glass lasers, since pure phase modulation preserves the uniform intensity profiles necessary for high power laser amplification. 1D SSD has been demonstrated on the NOVA laser,[5] however the National Ignition Facility (NIF) will require much more efficient and reliable operation. Therefore, it is of interest to investigate the performance of 1D SSD on the Beamlet laser, which is a NIF prototypical multipass laser system.

Numerical simulations of the Beamlet laser using PROP92 have been performed for 1 ns pulses with ±200 μrad main cavity spatial filter pinholes. These simulations show that the critical parameter for the laser performance is the amount of additional divergence imposed on the beam by SSD in comparison to the size of the spatial filter pinholes. Figure 1 shows the results of the PROP92 calculations of the contrast of the near field intensity at 1ω as a function of pulse energy and SSD divergence. One sees that the degradation of the beam is enhanced slight with increasing amounts of SSD. For example, with SSD divergence of 25 μrad, the contrast calculated is the same as a beam without SSD, but with pulse energy less by about 5%.

Figure 2 shows measurements of the 1ω Schlieren far field taken on Beamlet for a 3.5 KJ, 1 ns pulse with (left) and without (right) SSD present. In this measurement the divergence of SSD was ~25 μrad. One sees that frequency components generated by Gibbs phenomena near the pinhole edge (indicated by the circle) are not significantly enhanced with or without SSD present. Near field measurements at this pulse energy also show that SSD does not significantly impact the beam contrast, as predicted in Fig. 1. The only effect of SSD which is clearly apparent in Fig. 2 is that the speckle structure in the far field is smoothed in the vertical SSD direction, which is the desired effect on the illumination in the target plane. Measurements of the 1ω laser performance at higher energies and the ~ 20 ns pulse lengths required for ignition will also be described.

The 1.053 μm beam is converted to the thrid harmonic by a 11/9 mm pair of type I KDP / type II KD*P crystals. It is expected that the harmonic conversion efficiency will be reduced by the addition of the large bandwdith associated with SSD. Figure 3 shows the calculation[6] of the peak conversion efficiency in the presence of SSD bandwidth for a fundamental input intensity of 3.0 GW/cm2. Measurements of the conversion efficiency, bandwidth at the third harmonic, and the effect of SSD on the Beamlet focal distribution (smoothing of speckle and broadening of the focal envelope) will also be discussed.

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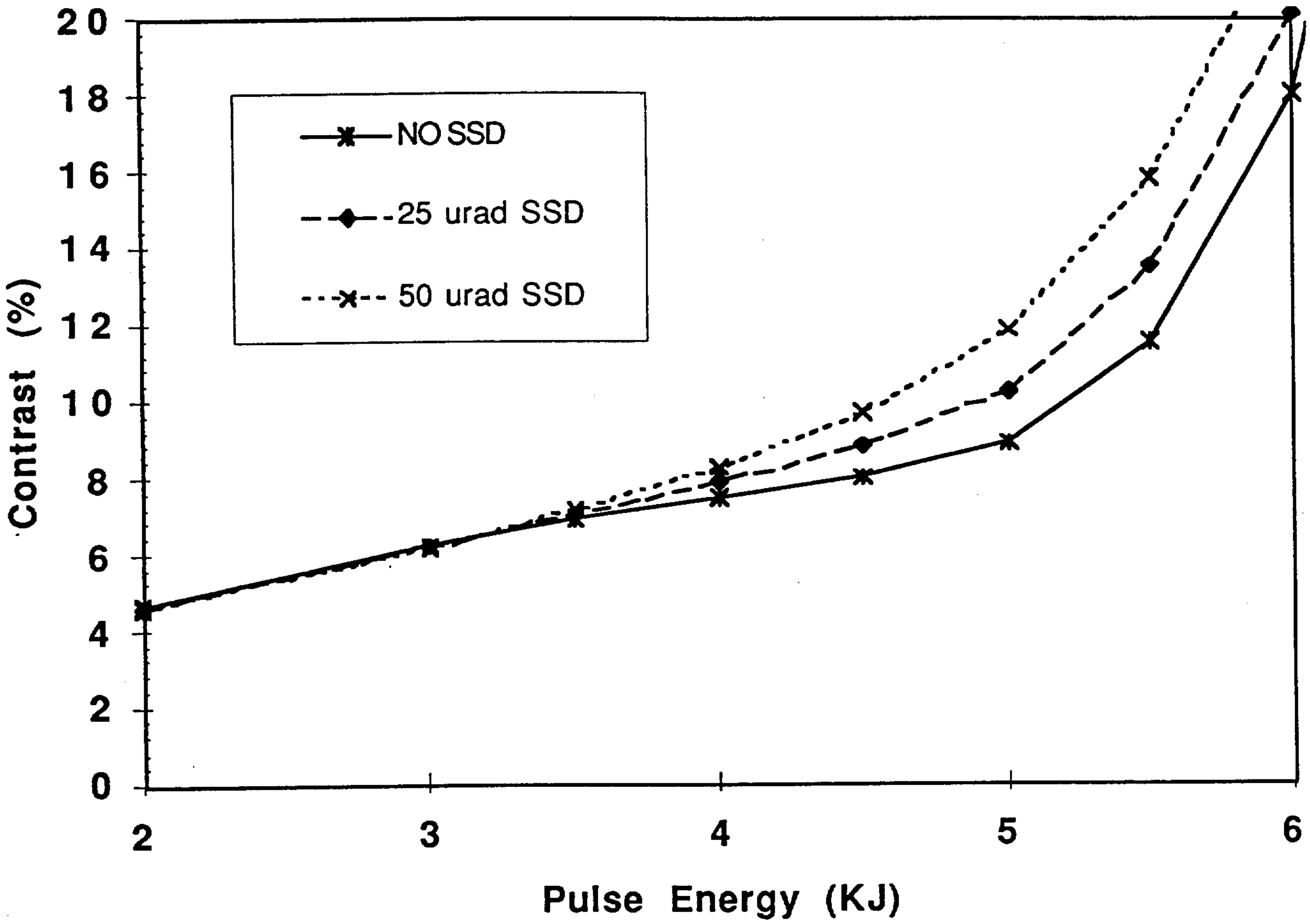
Figure Captions

Figure 1: PROP92 calculations showing the contrast (RMS variation as a fraction of the average) of the near field intensity just after the transport spatial filter, at the end of a 1 ns pulse of varying energy, and with the indicated amount of SSD divergence. The cavity spatial filter is assumed to use ±200 μrad pinholes. The effect of SSD is to reduce the effective pulse energy where breakup occurs -- by ~ 5% for 25 μrad of SSD and by ~10% for 50 μrad of SSD.

Figure 2: Measured Schlieren far field images of 1ω Beamlet beam for a 3.5 KJ, 1ns pulse with (left) and without (right) SSD present. The ring shows the location of the cavity spatial filter pinhole edge. No additional nonlinear enhancement of angular components near the pinhole edge is apparent with SSD implemented. However, one sees the effect of smoothing of the speckle structure in the vertical SSD direction.

Figure 3: Calculation of the conversion efficiency from 1.053 μm to 351 nm at 3.0 GW/cm^2 as a function of the bandwidth at 1.053 μm, using a 11 mm type I KDP doubler and 9.0 mm type II KD*P tripler.



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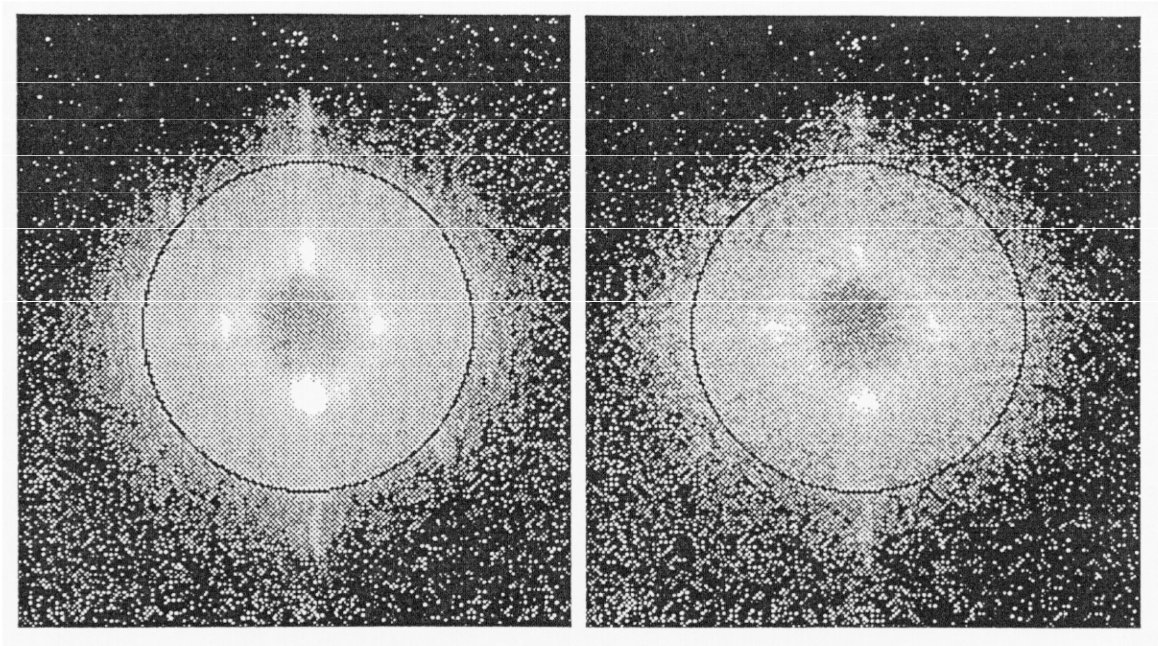

With SSD Without SSD

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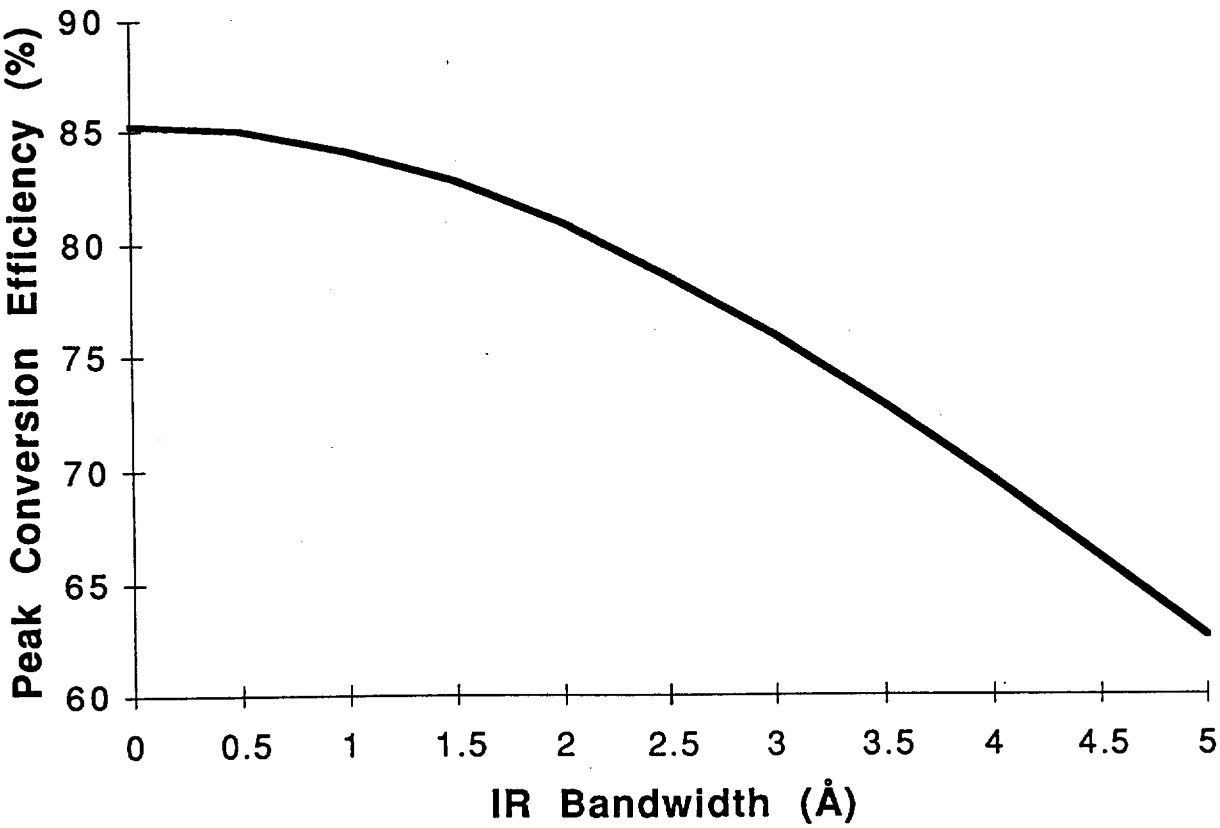

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