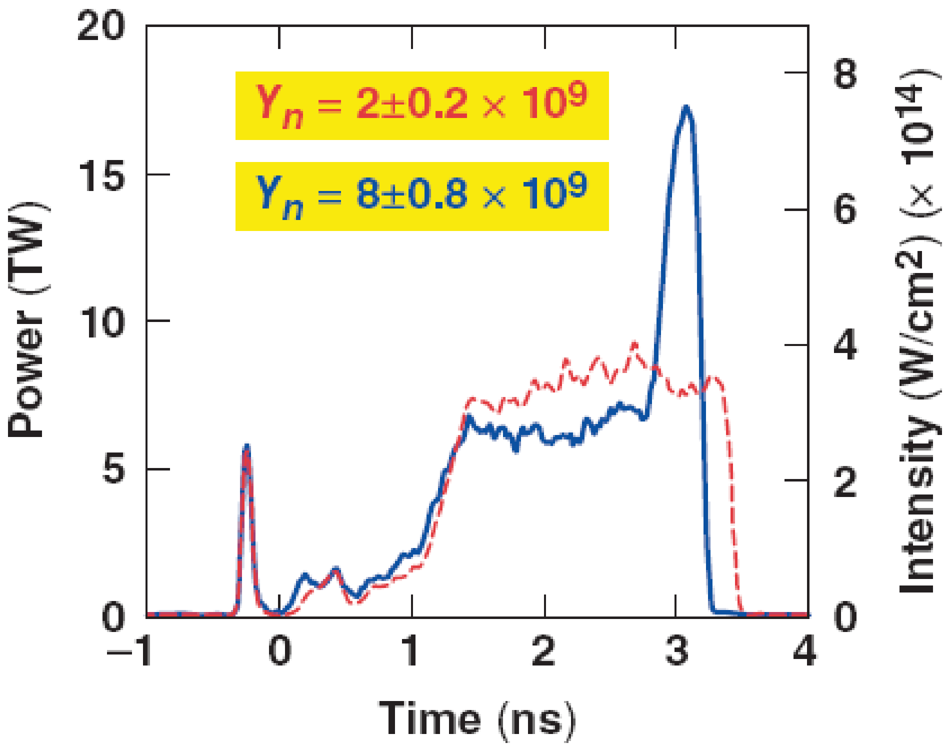
60-beam Shock-Ignition OMEGA Experiments and Simulations



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International Workshop
on ICF Shock Ignition
Rochester, NY
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Summary

Shock Ignition implosions with 60-beams on OMEGA have achieved higher yields and yield-over-clean than comparable no-shock implosions

- Systematic studies of low-adiabat (α ~1.5), warm-plastic-shell implosions were performed on OMEGA with short-picket and high-intensity spike pulses.
- The spike shock-generated CH-shell implosion showed a factor of ~4 enhanced fusion-product yields and higher $\langle \rho R \rangle \sim 0.2 g/cm^2$ indicating a higher compression and better stability.
- Initial shock-ignition experiments with cryogenic D_2 and DT targets were performed showing 1-D—like areal density and up to 12% yield-over-clean.

Collaborators

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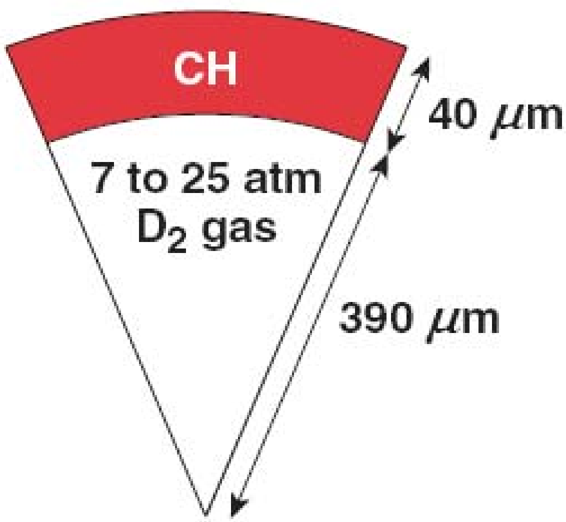
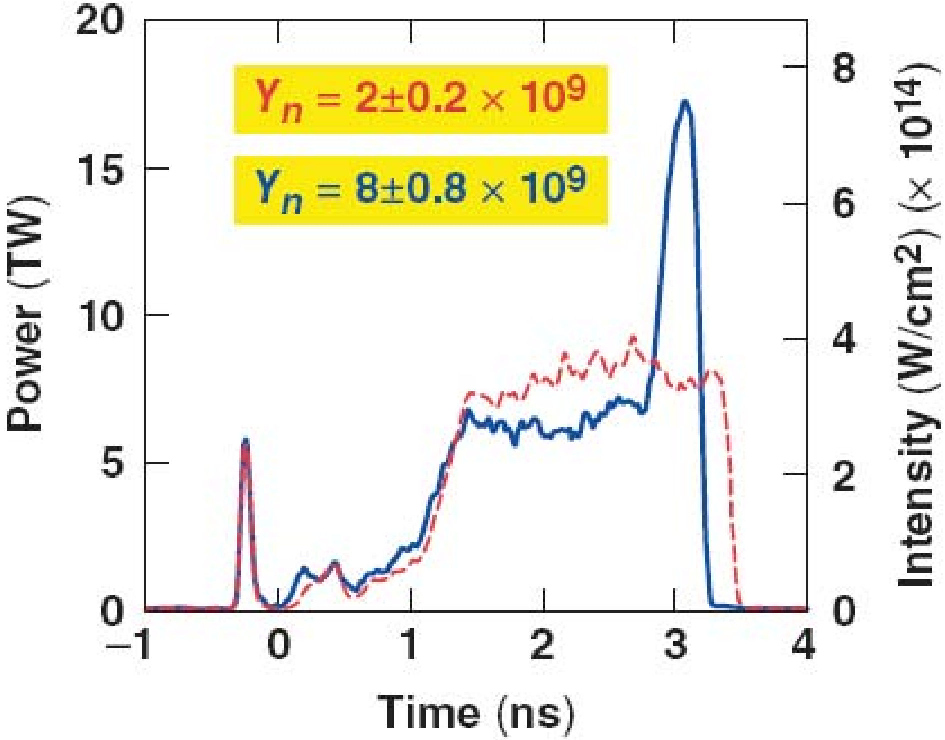
Three major shock-ignition issues are addressed in OMEGA laser experiments

- It is studied how the impulsive acceleration created by the ignition shock wave affects the fuel assembly.
- Varying the timing of the peaks in the laser pulse shape is used to study the timing of the shock waves and to optimize the implosion.
- Plastic-shell implosions were used to study how fuel–shell mixing affects the yield performance for shock-ignition pulse shapes.
- Only shocks with moderate strength can be launched at the end of the pulse on OMEGA.

CH shells have been imploded on OMEGA to test the performance of shock-ignition pulse shapes

E_L = 19 kJ, α = 1.3,
$V_i = 1.7 \times 10^7$ cm/s, SSD off

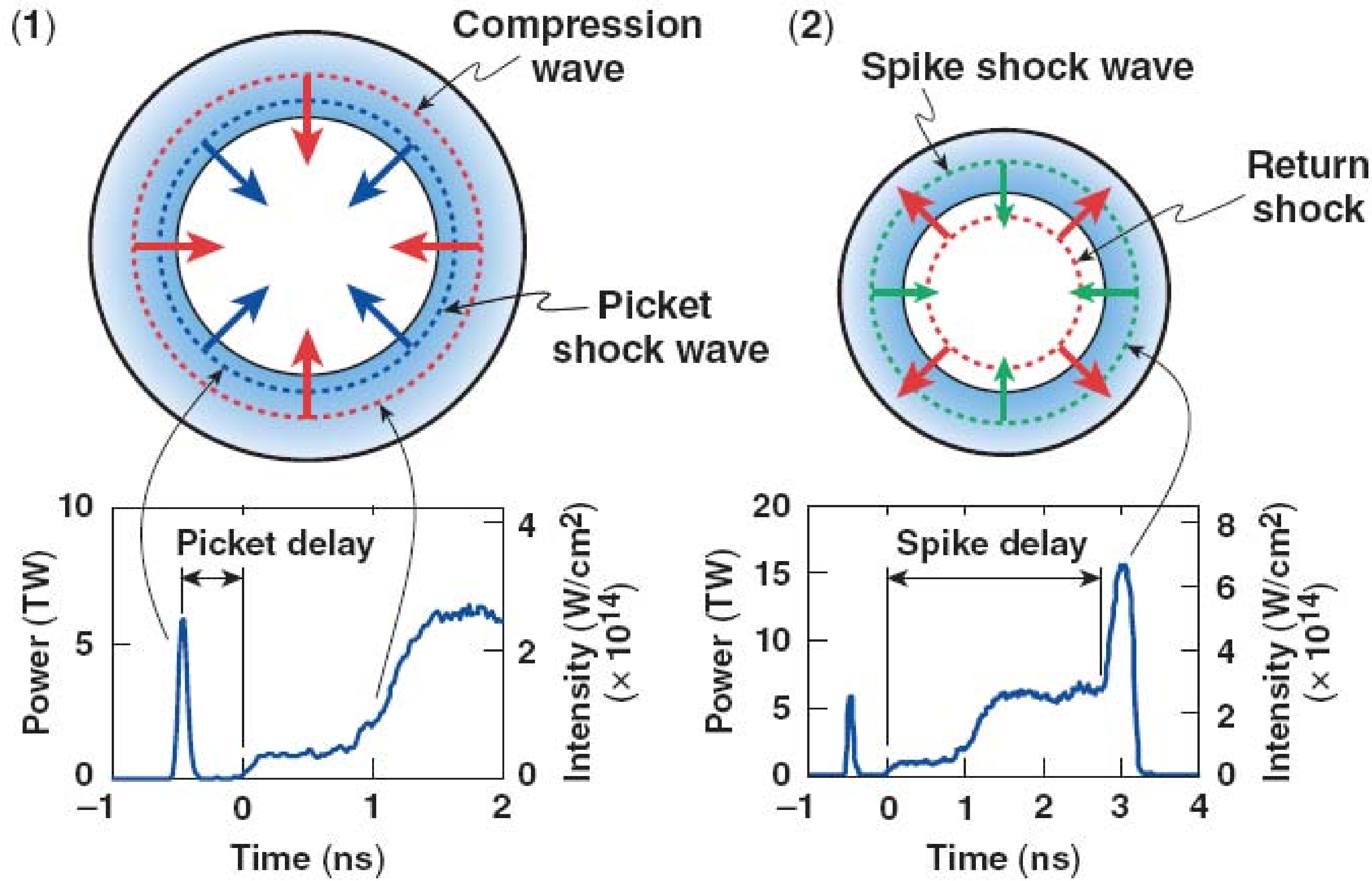




The neutron yield increases considerably when a shock is launched at the end of the pulse.

E16128b

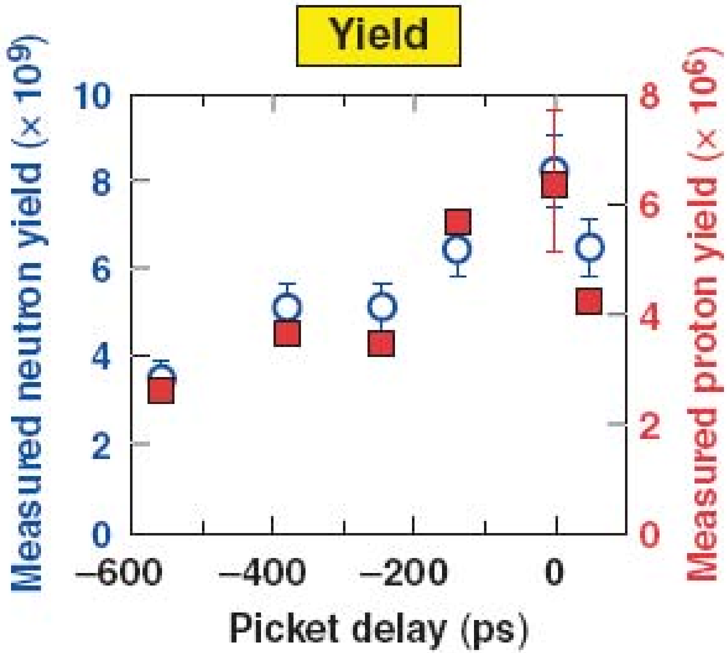
The correct timing of the shock waves is crucial for optimized implosion performance*

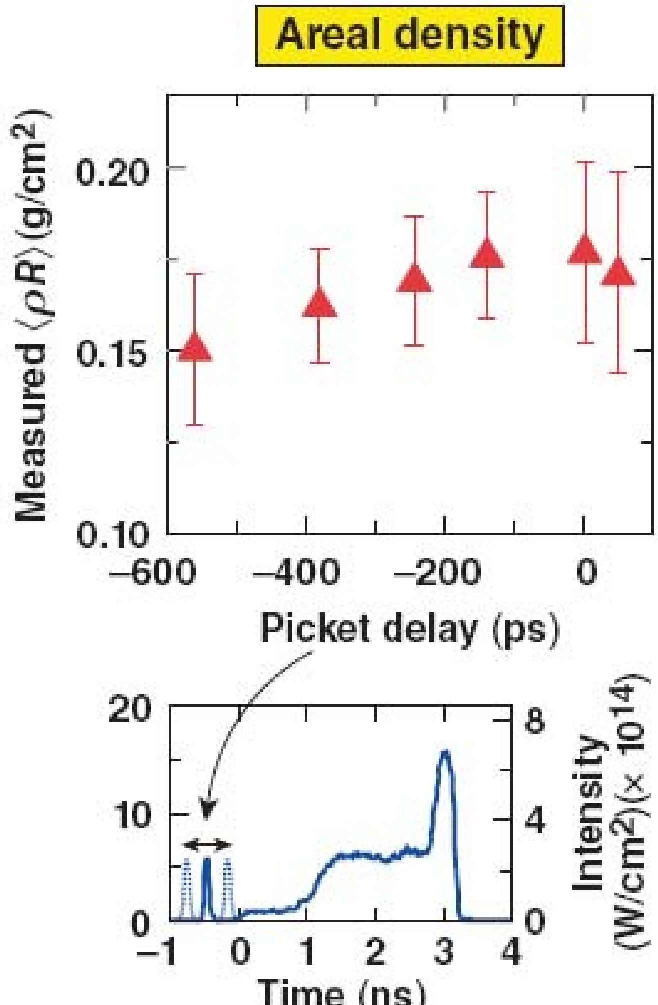


E16130a

*W. Theobald, Phys. Plasmas 15, 056306 (2008).

The implosion was optimized with respect to the timing of the picket pulse with fixed spike timing

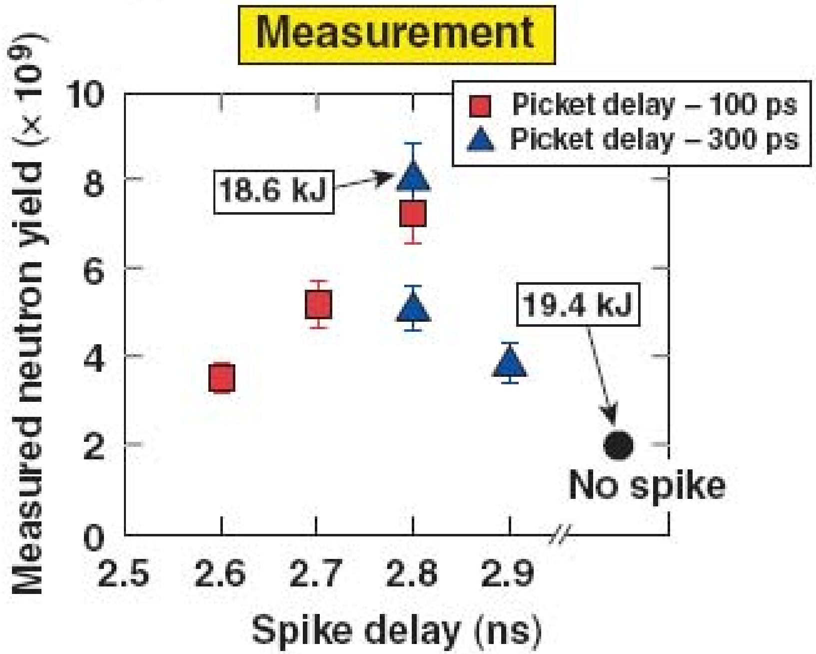


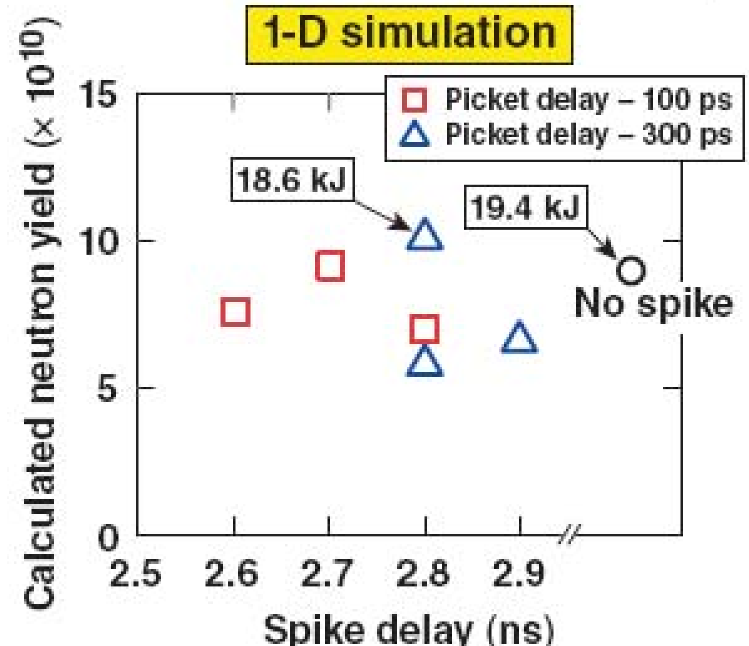


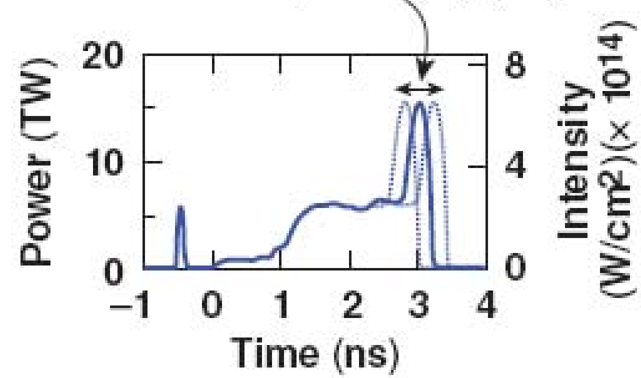
25-atm D_2, E_L ~ 17 kJ, spike at 2.8 ns

E16131

The spike timing has a significant effect on the measured neutron yield







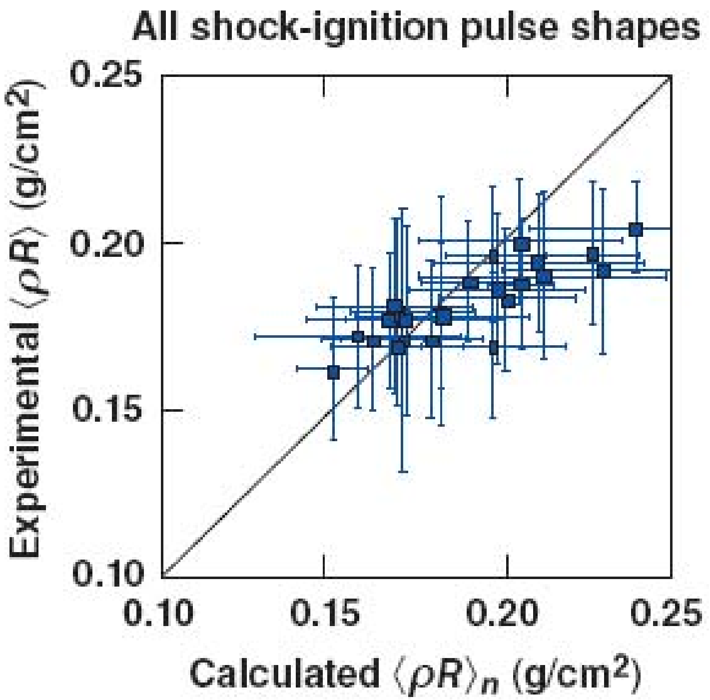
25-atm D_2, E_L = 17 and 19 kJ

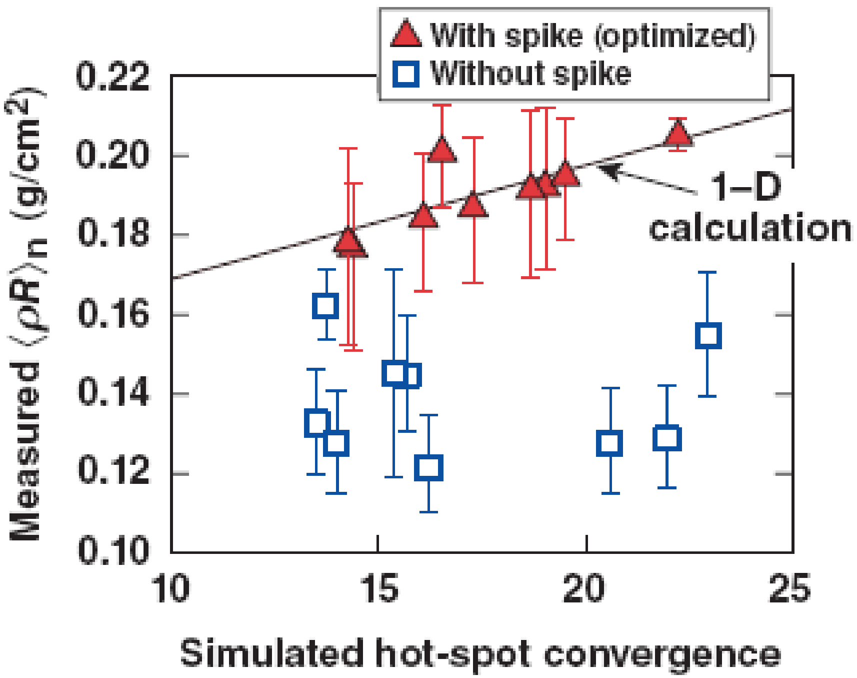
E16132

The fuel assembly is close to the one-dimensional predictions with the code *LILAC*

FSC

UR LLE

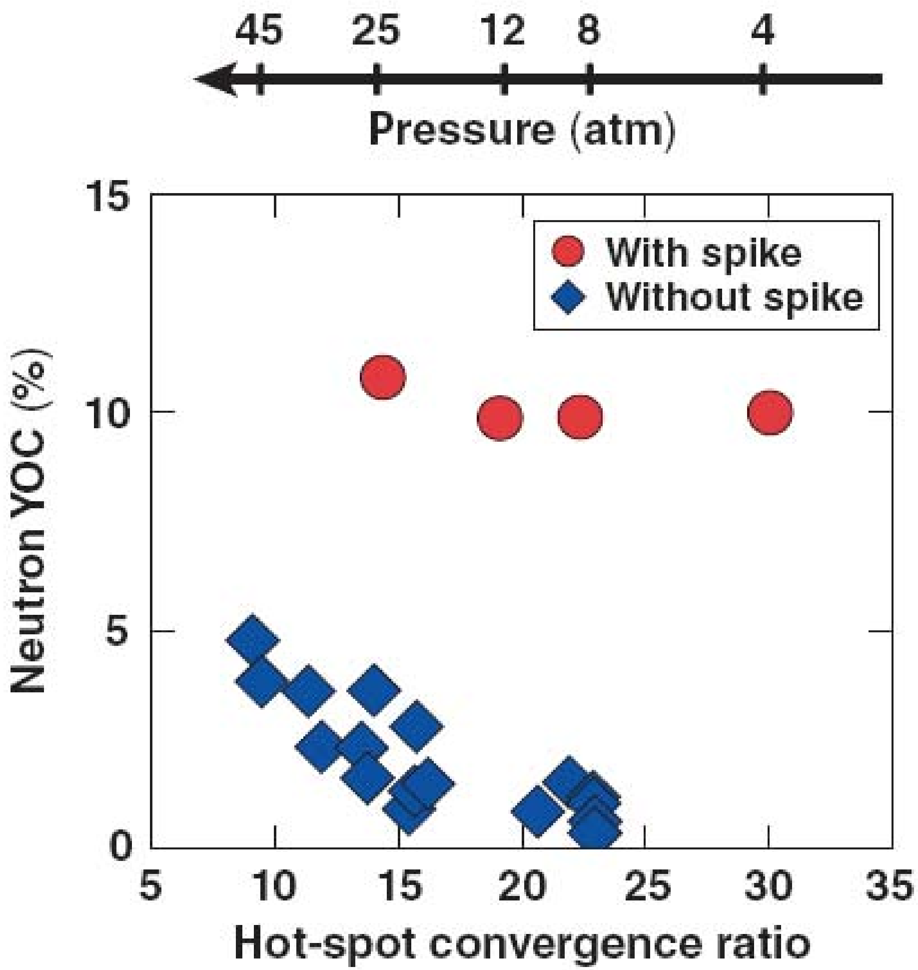




The shock-ignition implosions show higher areal densities than no-shock implosions

E16137

The high yield-over-clean at high convergence ratio shows better stability with shock-ignition pulse shape

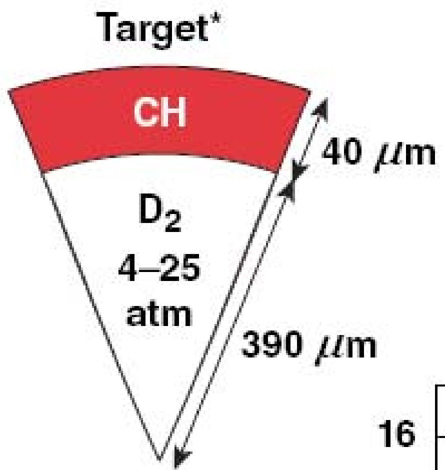


$$\mathrm{CR} = \frac{\text{Inner target radius}}{\text{Minimum hot-spot radius}}$$

The measured to calculated neutron-yield ratios are close to 10% for a hot-spot convergence ratio of 30.

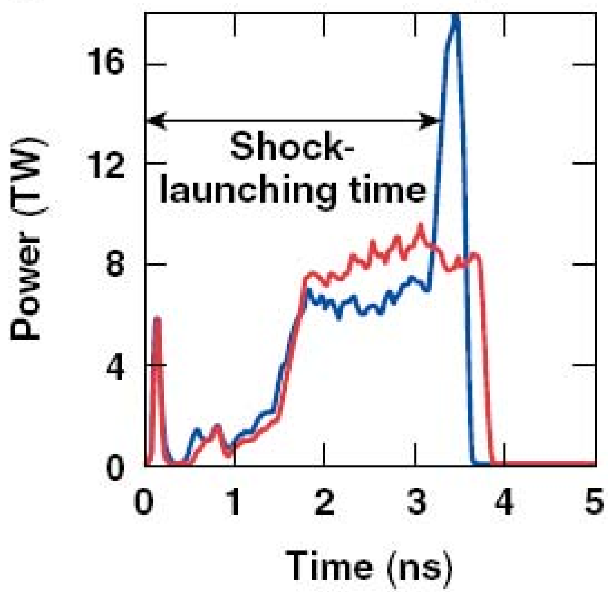
E16133

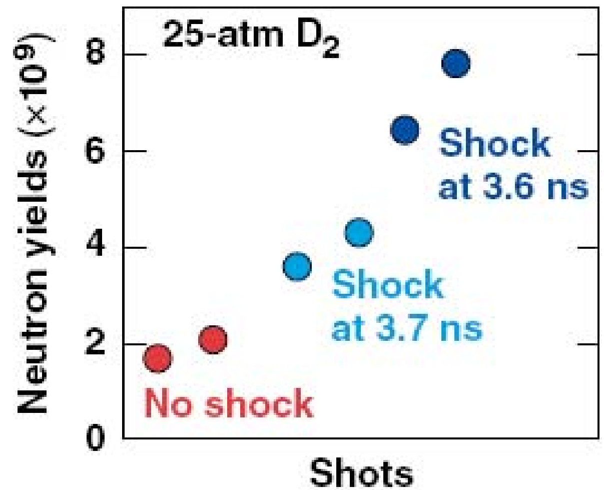
CH shells have been imploded on OMEGA to test the performance of shock-ignition pulse shapes



E_L = 17 to 18 kJ
α = 1.3

Pulse shape with and without shock spike





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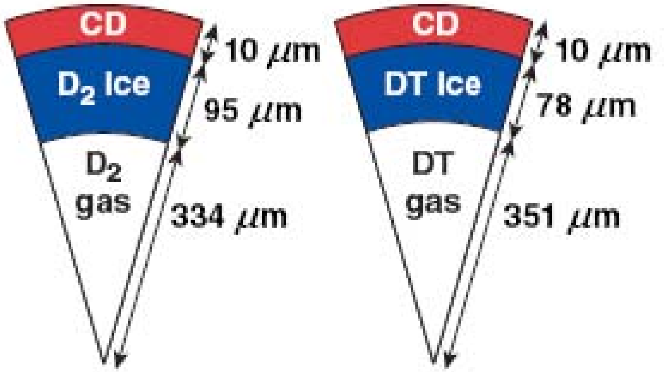
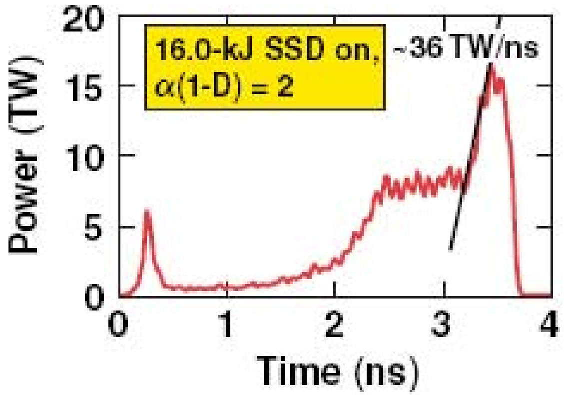
*W. Theobald and C. Zhou (UR-LLE)

Initial experiments of the shock-ignition concept were performed with cryogenic D_2 and DT targets

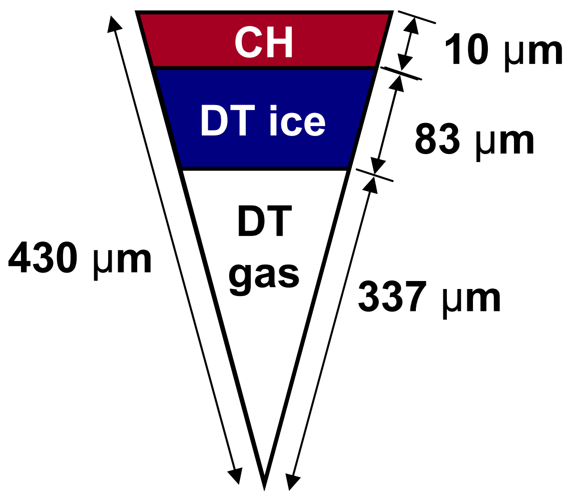


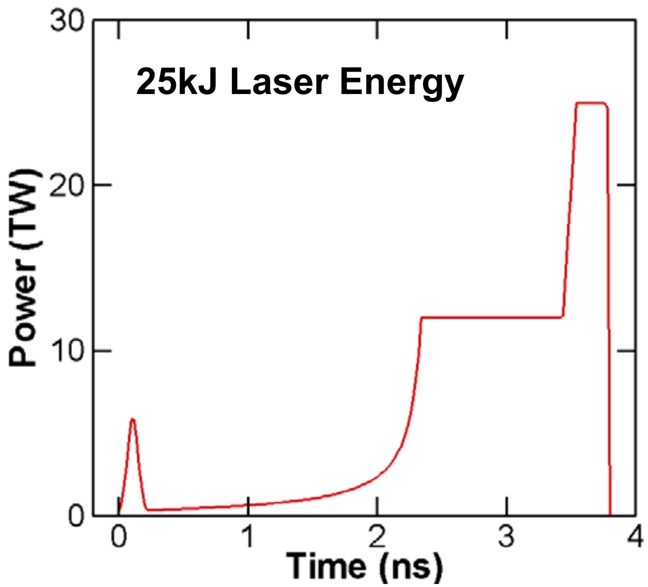


- The D_2 implosion measured $\langle \rho R \rangle = 0.18 \pm 0.05$ g/cm^2 achieving 90% of the 1-D prediction (0.20 g/cm^2).
- The neutron YOC's were 5% and 12% for the D_2 and DT implosions.
- The simulations show that no shock was produced by the spike pulse.

- The first few shock-ignition cryo-implosions on OMEGA were among the best performing (in terms of YOC and ρR) but did not yet exceed the performance of standard pulse shapes.
- Pulse shape with SSD is not optimal (spike rise time).

More cryogenic 60-beam shock-ignition—relevant implosions on OMEGA are scheduled for July 2011





1-D Yield	5.5e13
ρR	510 mg/cm^2
IFAR	27
v_{imp}	2.5e7 cm/s
α_{if}	1.2

Preliminary 2-D DRACO simulations indicate ~90% YOC with 1-µm rms ice roughness

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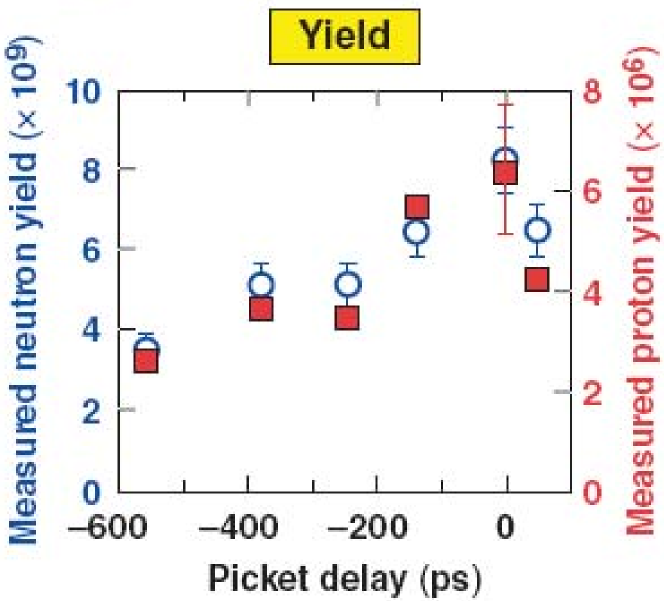

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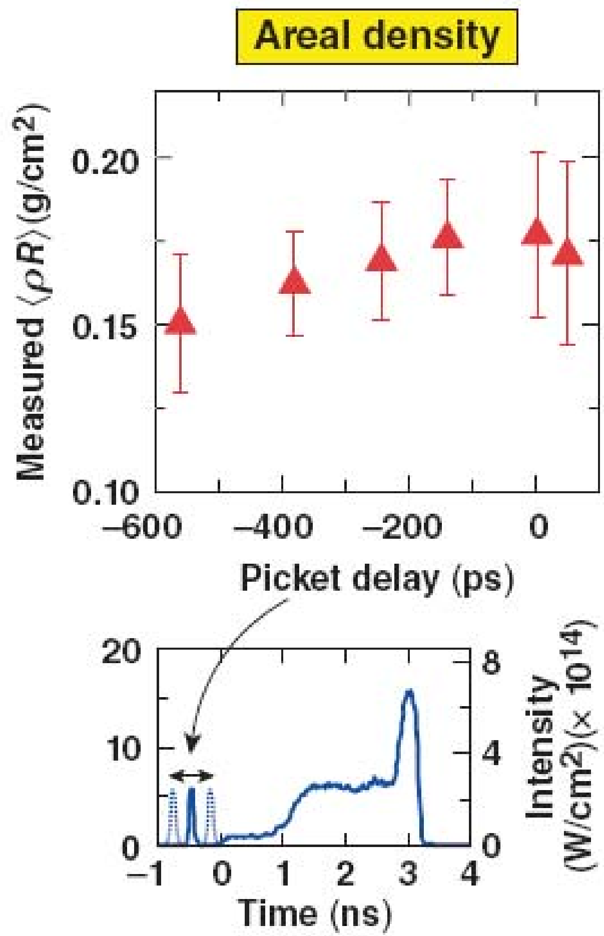

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