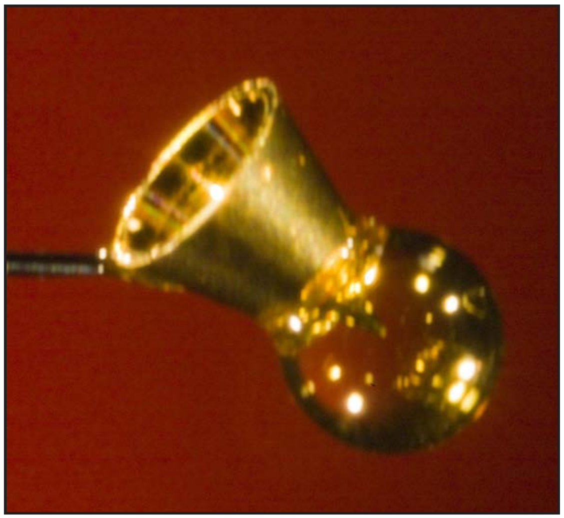
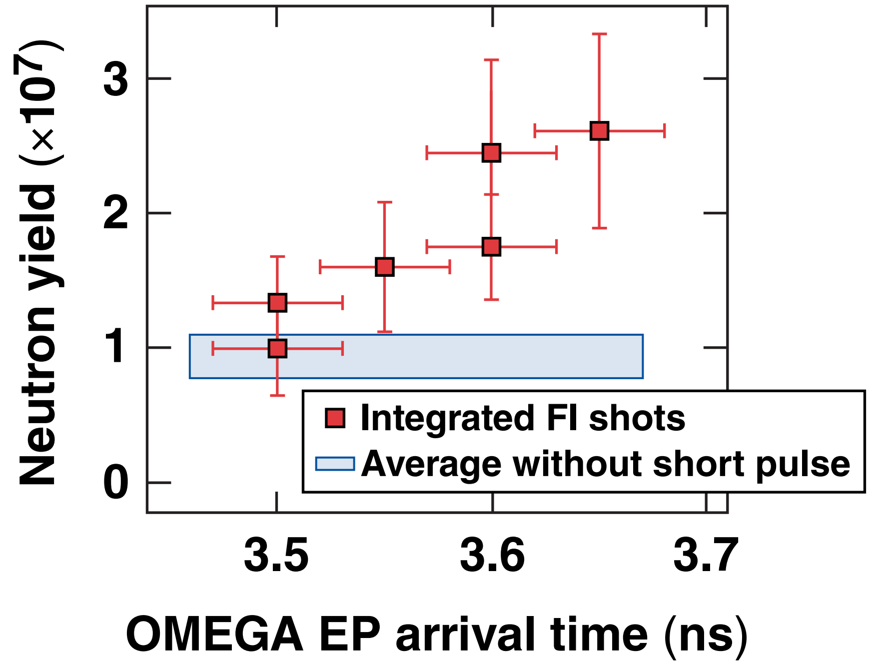
Integrated Fast-Ignition Experiments on OMEGA





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Summary

Cone-in-shell fast-ignition experiments on OMEGA/ OMEGA EP have doubled the neutron yield with a 1-kJ, 10-ps laser pulse

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- A new neutron time-of-flight detector with a gated PMT and O_2-enriched liquid scintillator reliably measures neutron yields in fast-ignition experiments
- The short-pulse laser produced up to $1.7 \pm 0.5 \times 10^7$ additional neutrons with proper beam timing
- Initial *DRACO*/*LSP* simulations calculate ~2×10^7 neutrons produced by short-pulse heating for 10% conversion efficiency

Collaborators

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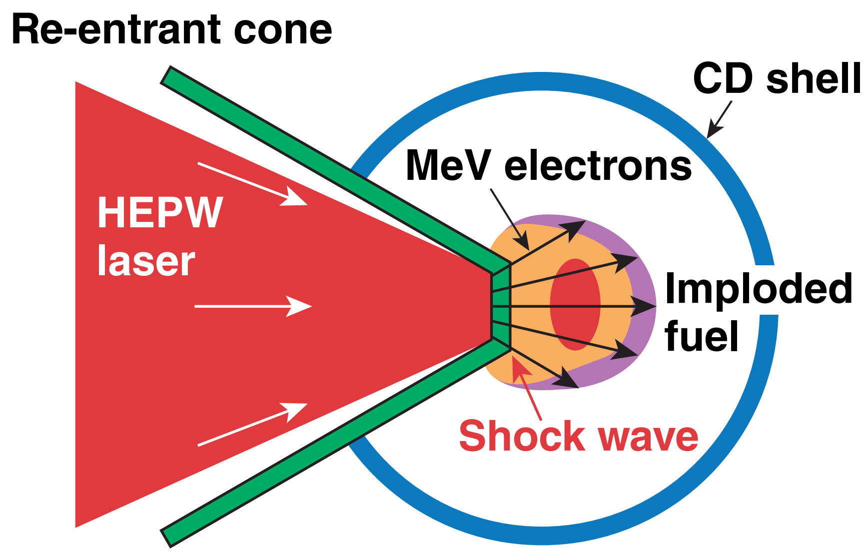
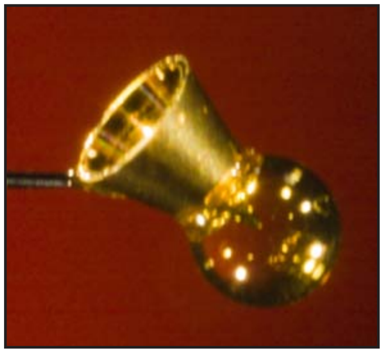
Integrated re-entrant cone fast-ignition experiments allow core heating and electron coupling to be studied in compressed shells

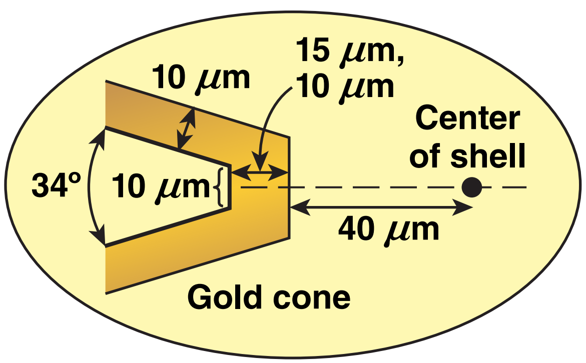


- Coupling efficiency depends on
  - laser conversion to electrons
  - energy spectrum of electrons
  - collimation of electron transport
  - cone tip to dense plasma separation
  - cone shape
  - transport efficiency through cone tip and plasma

Integrated fast-ignition experiments with re-entrant cone targets have begun at the Omega/Omega EP Laser Facility



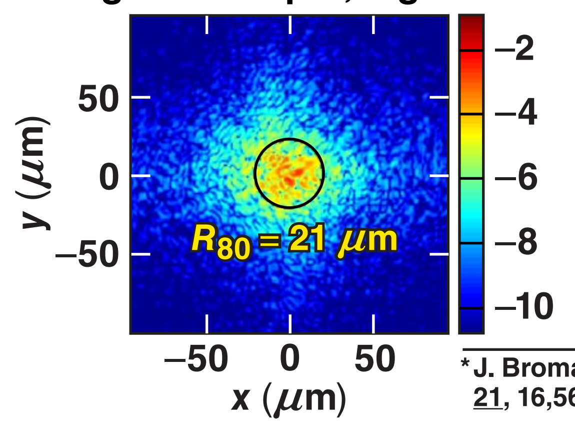
Shell material	CD
Shell diameter	~870 μm
Shell thickness	~40 μm



Implosion

Energy	~18 kJ (54 beams)
Wavelength	351 nm
Pulse shape	Low-adiabat, $\alpha \approx 1.5$
Pulse duration	~3 ns
Implosion velocity	~2×10^7 cm/s

Target focal spot, log scale*



*J. Bromage *et al.*, Opt. Express 21, 16,561 (2008).

Heating beam

Energy	~1.0 kJ
Wavelength	1053 nm
Pulse duration	~10 ps
Intensity	~1×10^{19} W/cm^2

Relative timing varied

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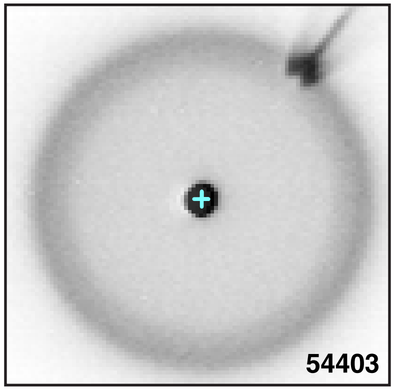
Pointing and timing of the short-pulse beam was achieved with ~20-μm and ~50-ps accuracy

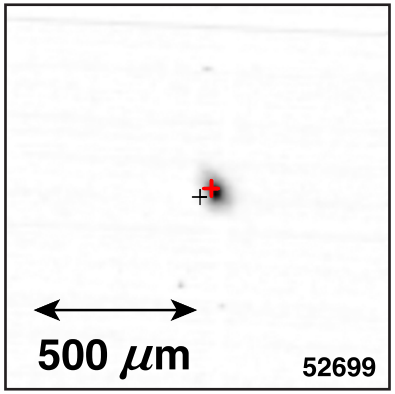
Drive laser only (18 kJ, spherical shell)



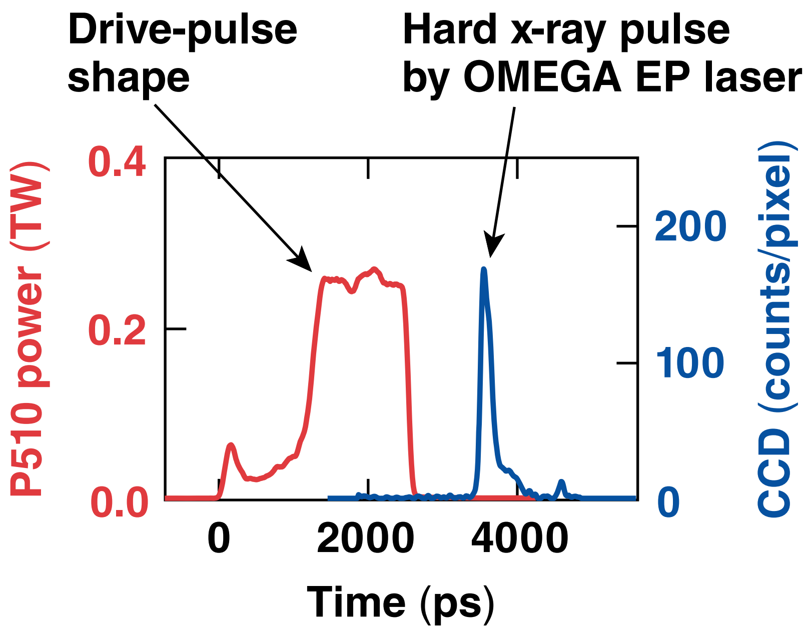
Short pulse only

Black + target chamber center

Red + nominal OMEGA EP pointing



Two orthogonal x-ray pinhole camera views provide the spatial information



The neutron temporal diagnostic operating in hard x-ray mode provides temporal information

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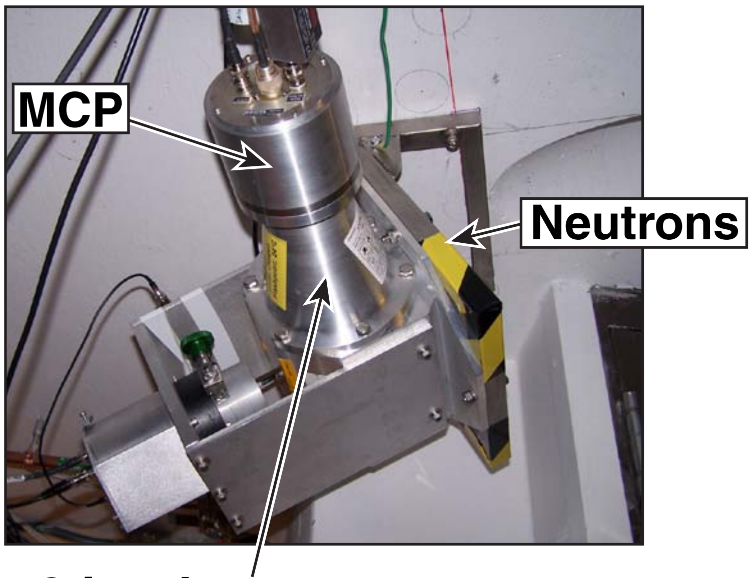
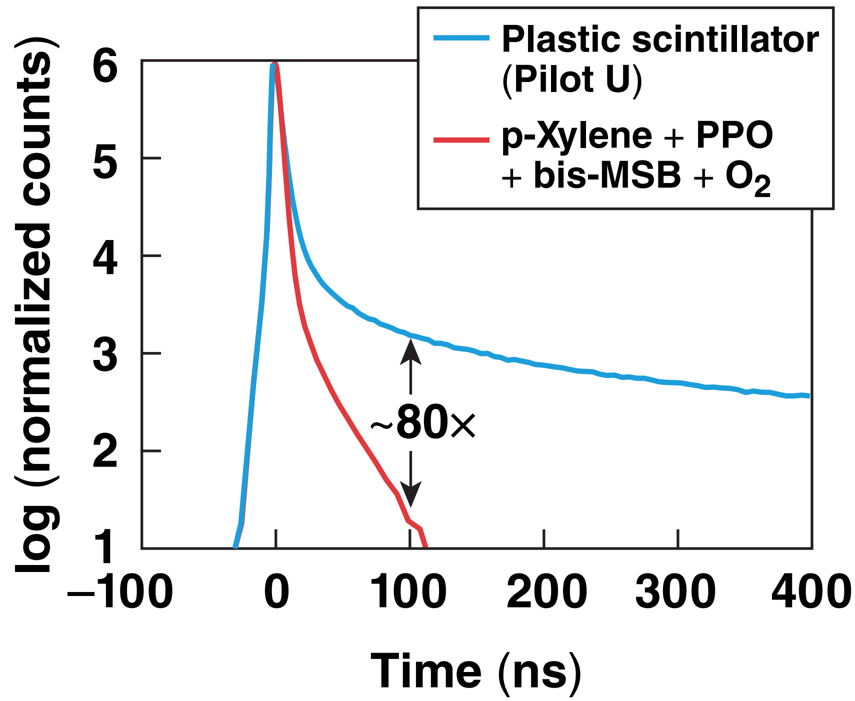
A new detector was developed that measures reliably neutron yields in FI-cone experiments



~3-L volume
Xylene + PPO + bis-MSB + O_2



Liquid scintillators enriched with an O_2 quenching agent have a fast decay time—the γ-ray-induced fluorescence is efficiently suppressed.

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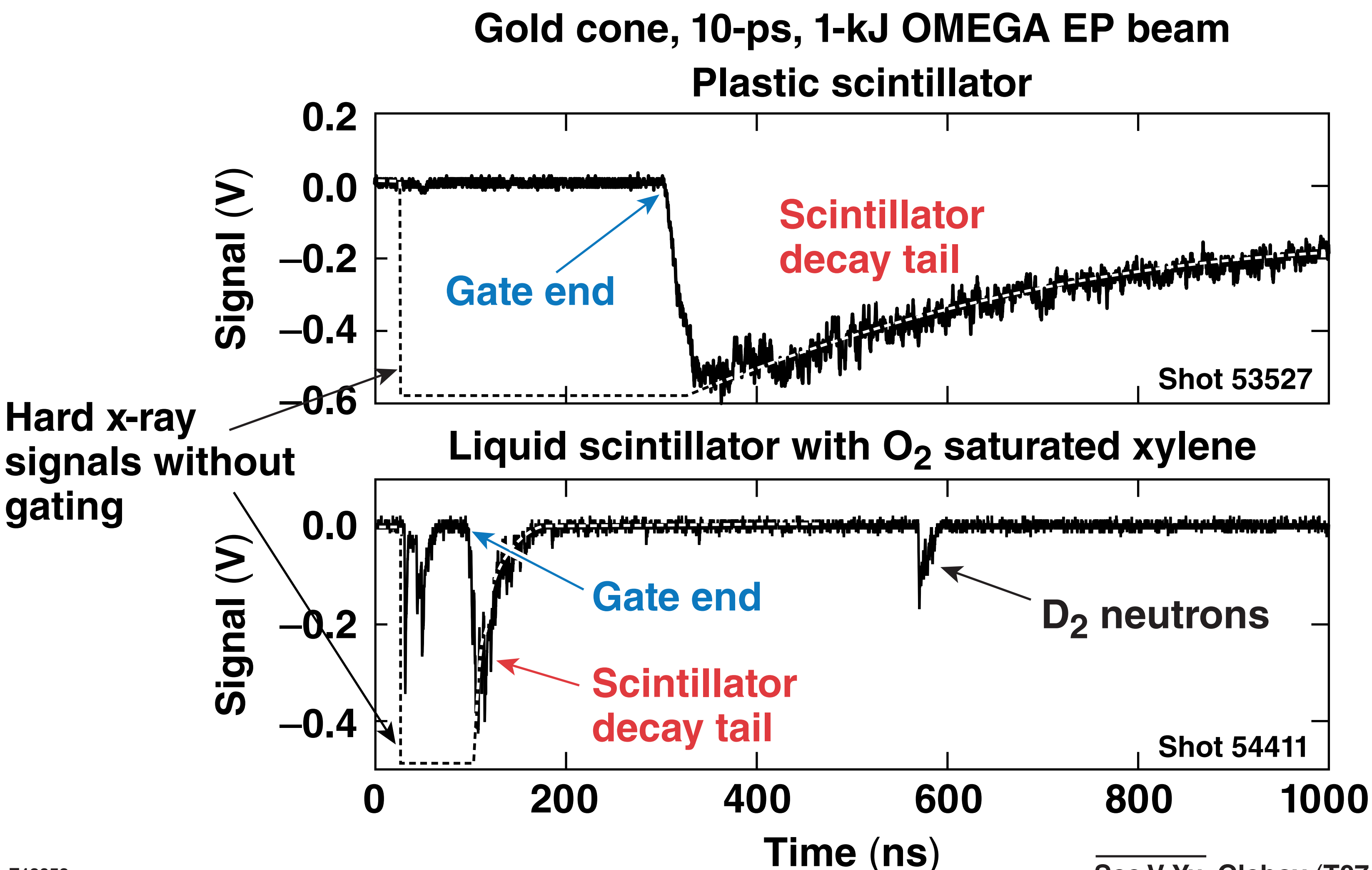
R. Lauck *et al*., IEEE Transactions on Nuclear Science 56, 989 (2009).

The neutron time-of-flight detector with a liquid scintillator showed no long decay tail from an intense hard x-ray pulse



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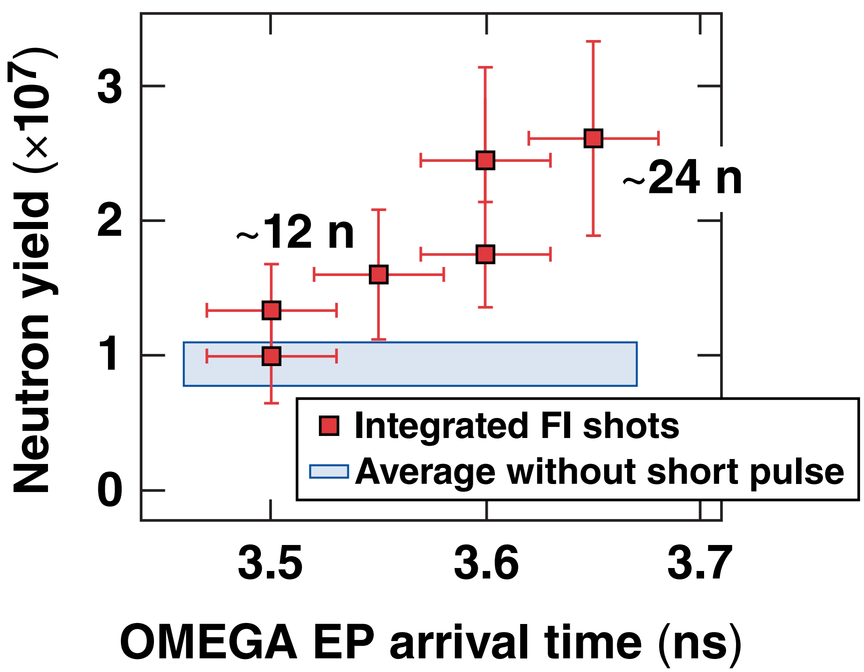
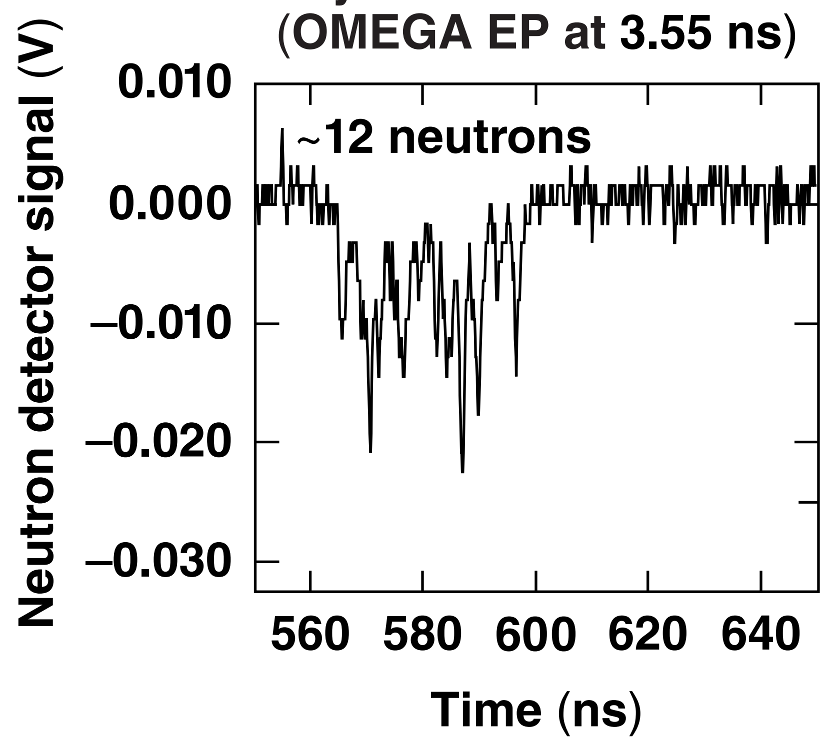
See V. Yu. Glebov (T07.0006).

The neutron yield increased more than a factor of two with an appropriately timed OMEGA EP beam

The yield was measured as a function of the short-pulse time delay



Measurements limited by neutron statistics (OMEGA EP at 3.55 ns)



1.7±0.5 × 10^7 additional neutrons were produced with the short-pulse laser.

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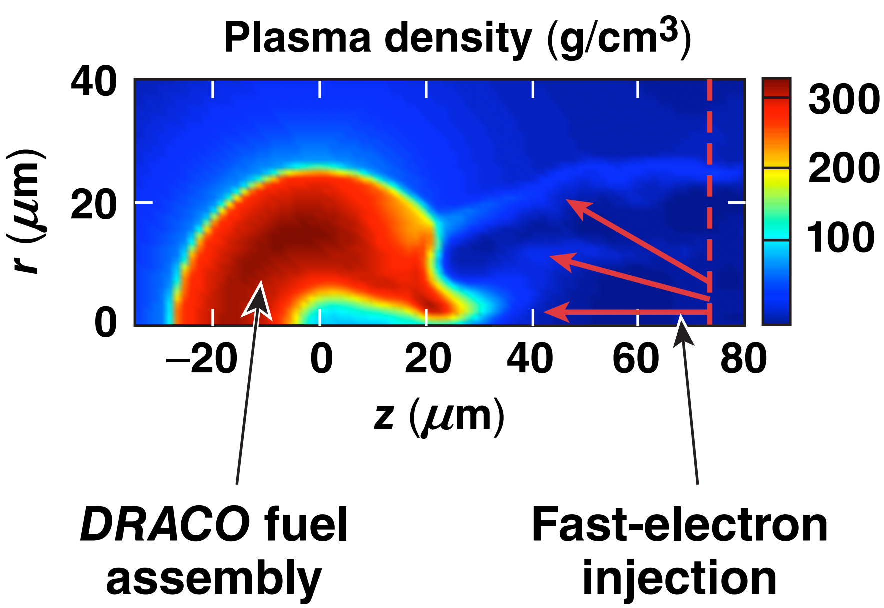
Initial *DRACO*/*LSP* simulations[1] were performed to study core heating

- The 2-D hydrodynamic code *DRACO*[2] was coupled to the hybrid PIC code *LSP*[3]



Simulations for 1-kJ, 10-ps, 40-μm focus

Fast-electron conversion efficiency	Increase in neutron yield
10%	2.3×10^7
20%	8.4×10^7

The simulated implosion neutron yield is ~100× higher than in the experiment

[1] A. A. Solodov *et al.*, Phys. Plasmas 15, 112702 (2008); ibid. 16, 056309 (2009).
[2] P. B. Radha *et al.*, Phys. Plasmas 12, 056307 (2005).
[3] D. R. Welch *et al.*, Phys. Plasmas 13, 063105 (2006).

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Future experiments will exploit heating with higher short-pulse energies and advanced targets

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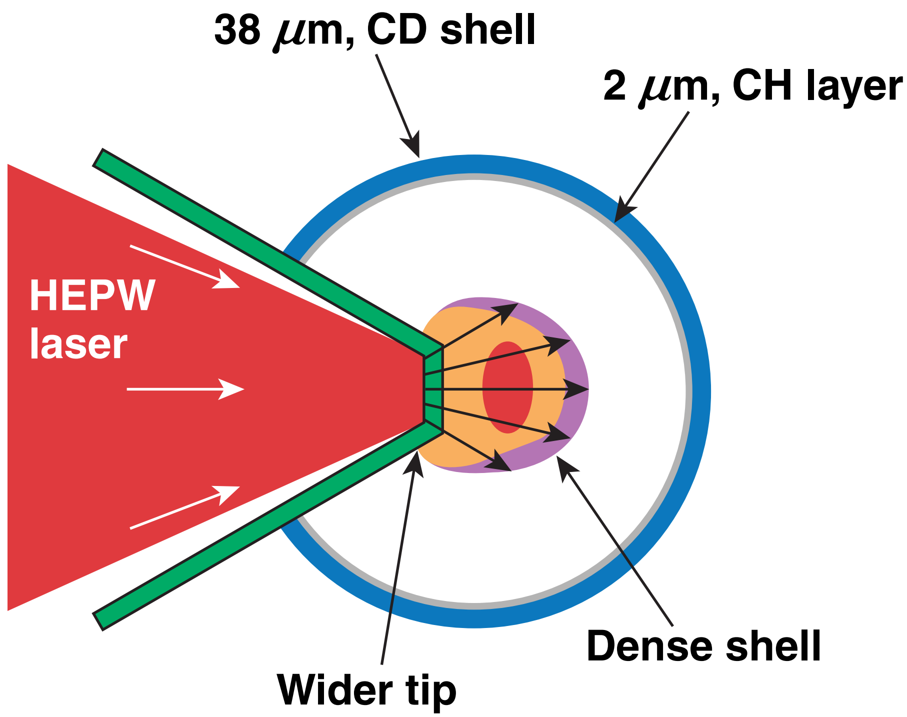

- Quench implosion yield through thin inner CH layer
- Lower-*Z* cone materials may improve the coupling efficiency
- Explore fast-electron collimation with materials having different electrical resistivity

Summary/Conclusions

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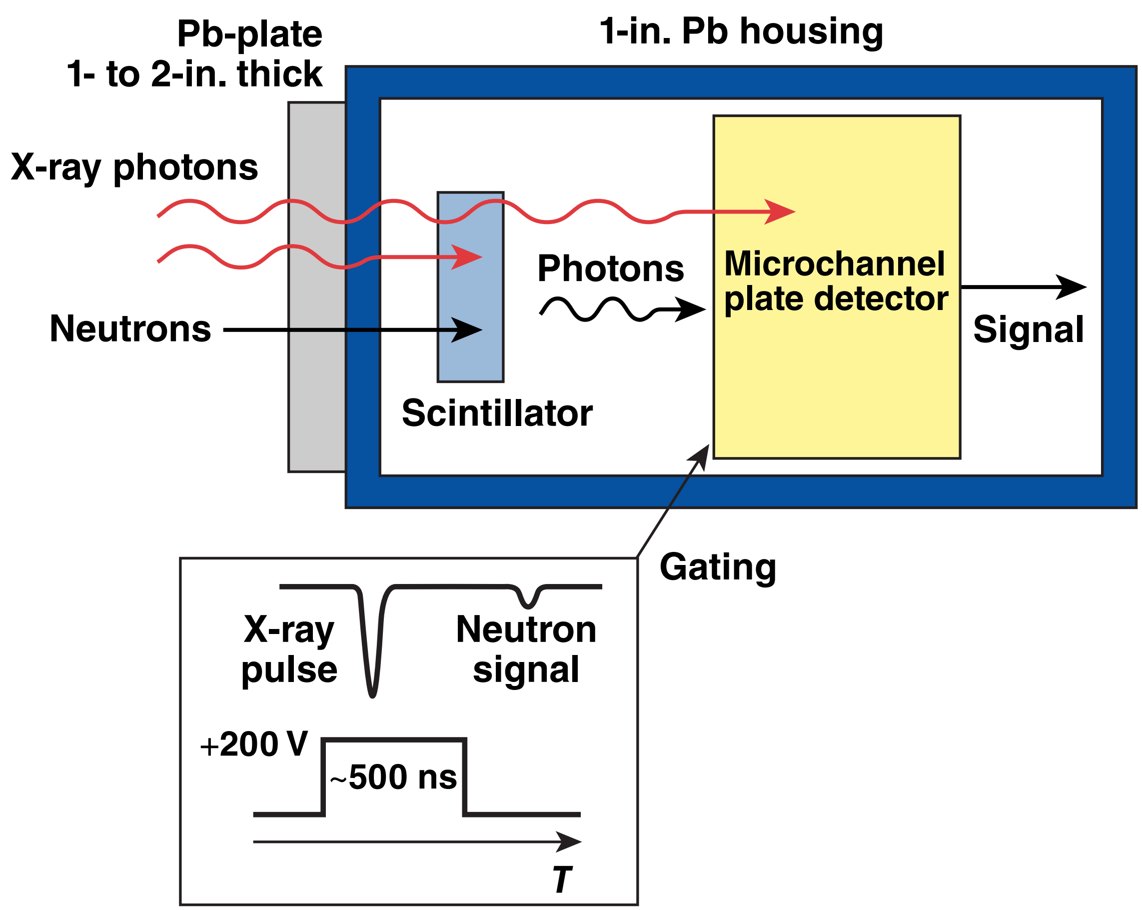
Neutron time-of-flight detectors were strongly shielded against hard x-ray radiation



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