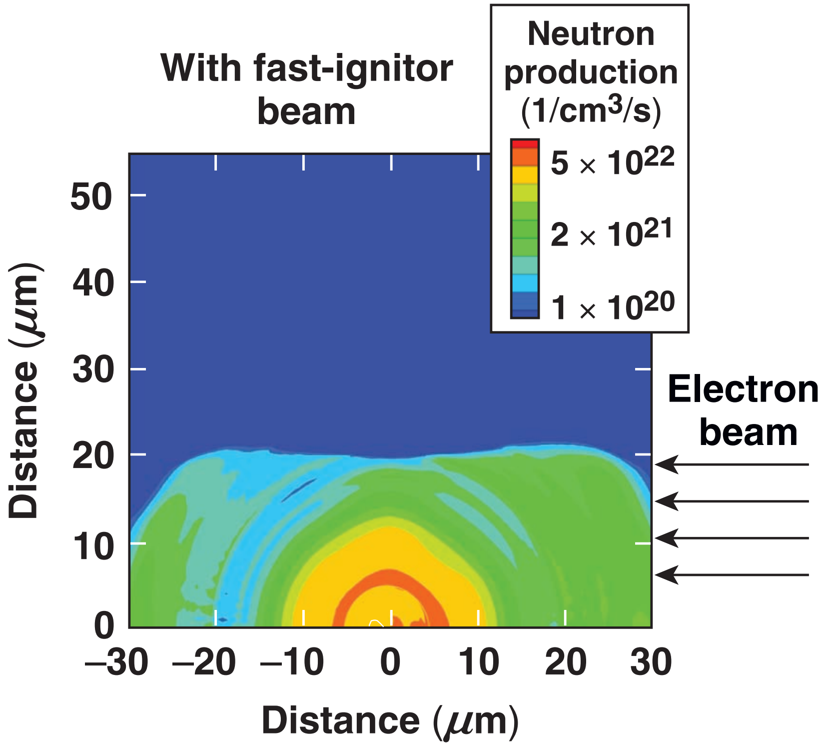
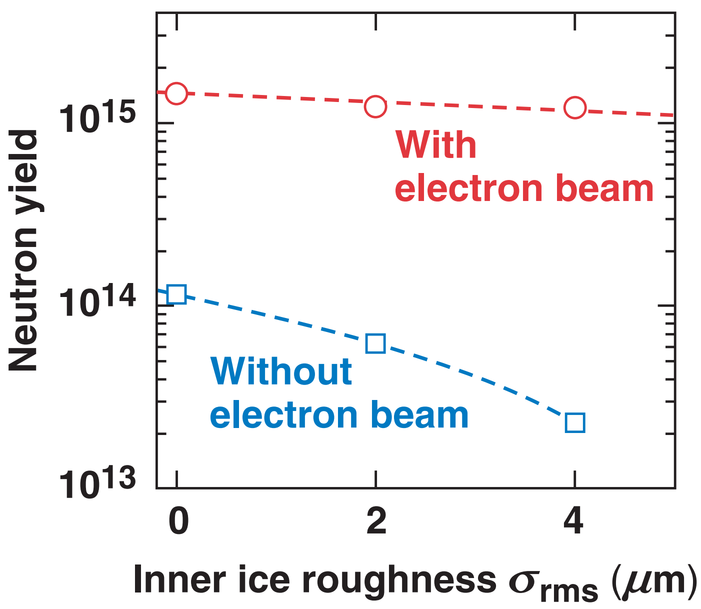
Hydrodynamic Simulations of Integrated Experiments Planned for OMEGA/OMEGA EP Laser Systems


With fast-ignitor beam


Effect of electron beam on neutron yield

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Summary

Enhanced neutron yield due to the OMEGA EP beam is unaffected by increasing levels of nonuniformity

- The OMEGA EP laser will add a short-pulse (2.6 kJ in 10 ps), high-intensity beam ($>10^{19}$ W/cm^2) to OMEGA to study the physics of fast ignition.

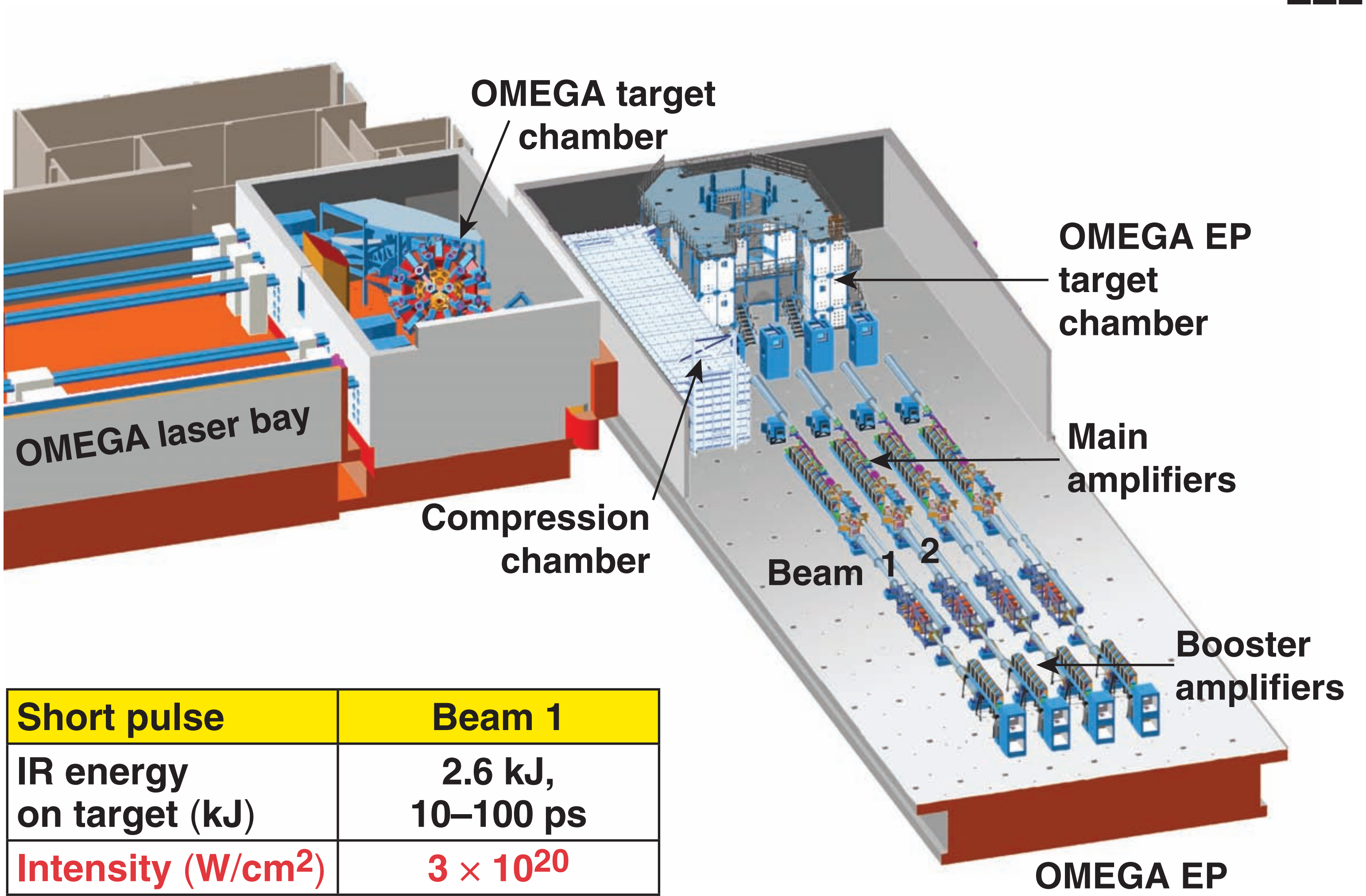
- The simulations were carried out with a range of realistic electron sources for two implosion uniformity conditions: beam illumination pattern and ice roughness.

- Results indicate at least a 25 fold increase in yield.

Collaborators

- C. Stoeckl
- J. Myatt
- S. Skupsky
- V. N. Goncharov

The OMEGA EP laser will produce relativistic electrons that will heat the imploded core



Short pulse	Beam 1
IR energy on target (kJ)	2.6 kJ, 10–100 ps
Intensity (W/cm^2)	3 × 10^{20}
Focusing (diam)	>80% in 20 μm

A straight-line model was added to *DRACO* to compute the energy deposited by the relativistic electrons

It is simple and fast.

- **Assumes electrons are created in a given direction (parallel to the beam axis in present simulations) and travel in that direction until stopped or leave the target**

- **An improved energy loss formulation by Li and Petrasso[1] is used.**

$$\frac{dE}{ds} = -\frac{2\pi r_0^2 m_0 c^2 n_i Z}{\beta^2}\left[\ln\left(\frac{(\gamma-1)\lambda_D}{2\sqrt{2\gamma}\, r_0}\right)^2 + 1 + \frac{1}{8}\left(\frac{\gamma-1}{\gamma}\right)^2 - \left(\frac{2\gamma-1}{\gamma}\right)\ln 2 - \ln\left(\frac{1.123\beta}{\sqrt{2kT/m_0c^2}}\right)^2\right]$$

- **The model does not include electric or magnetic fields and Joule heating by the return current.**

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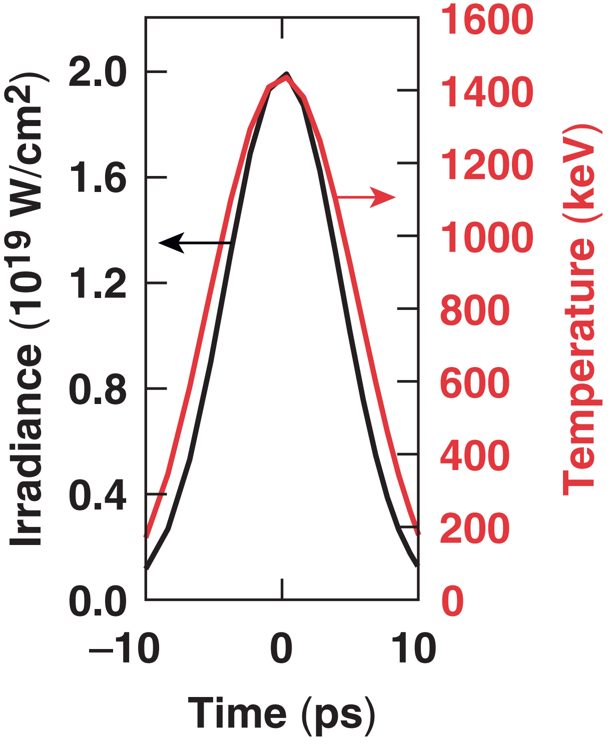
[1] C. K. Li and R. D. Petrasso, Phys. Rev. E 70, 067401 (2004).

The electron source is a one-dimensional Maxwellian distribution computed from the laser intensity and a conversion efficiency

2.5 kJ, 20-μm radius, 10-ps FWHM



$T = 511 * [(1 + I/1.37 \times 10^{18})^{0.5} - 1]$ (keV) → slope of Maxwellian (from Wilks*)

TC6500c

* S. C. Wilks *et al*., Phys. Rev. Lett. 9, 1383 (1992).

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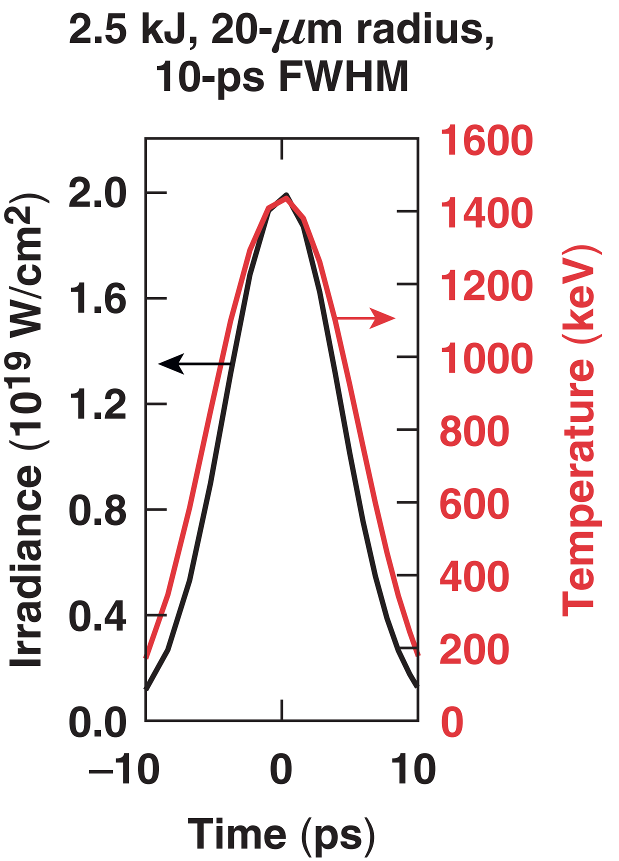

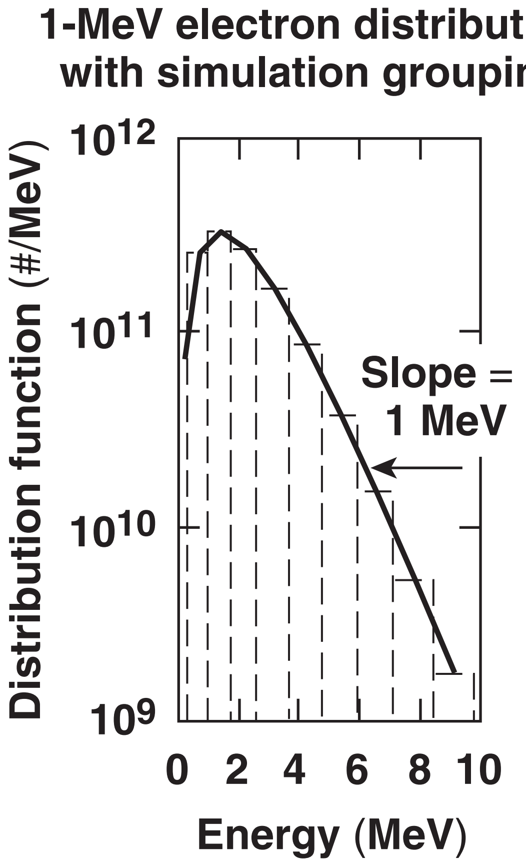

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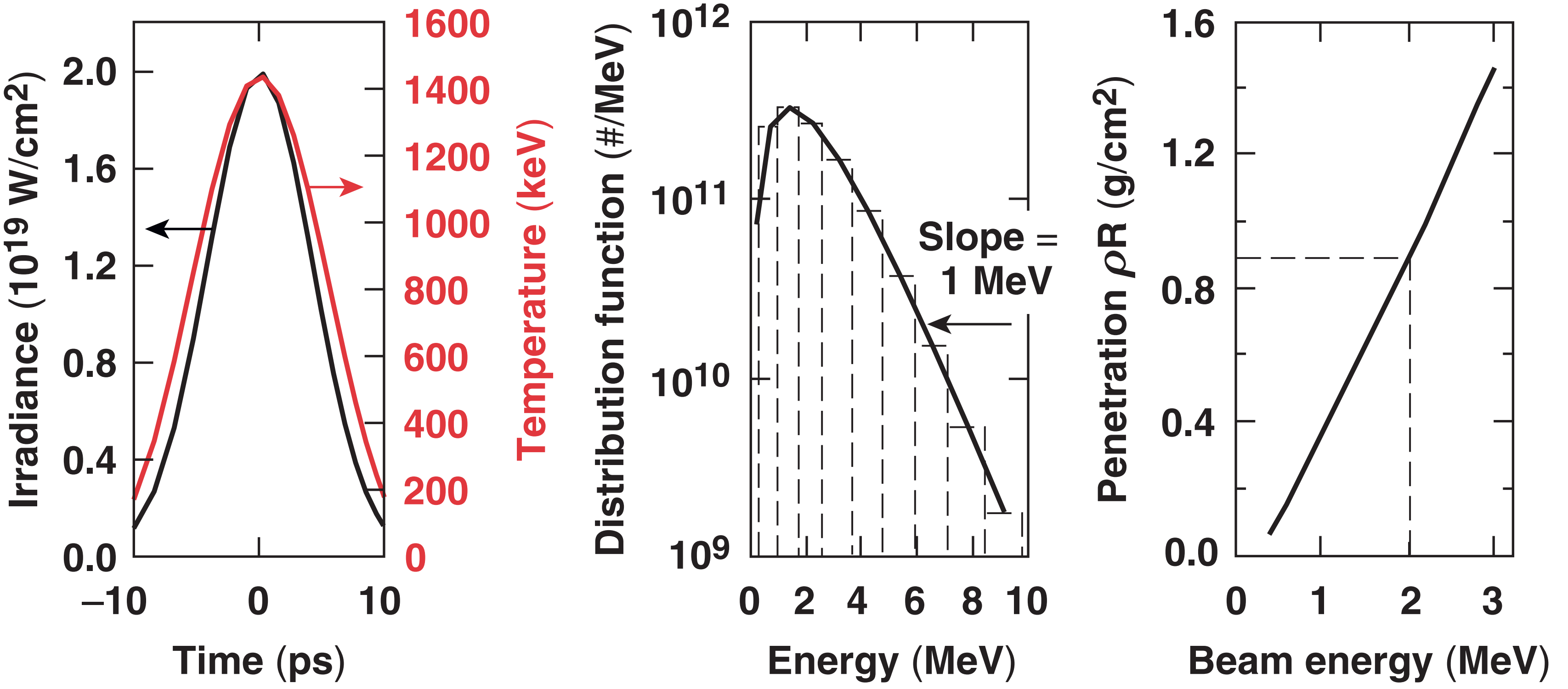
1-MeV electron distribution with simulation grouping

Penetration depth 300 g/cm^3, 5 keV



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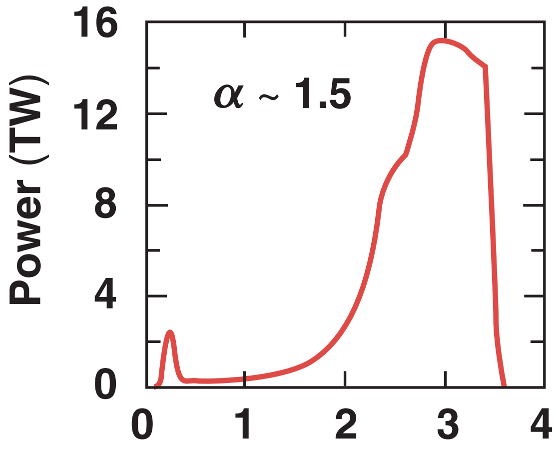
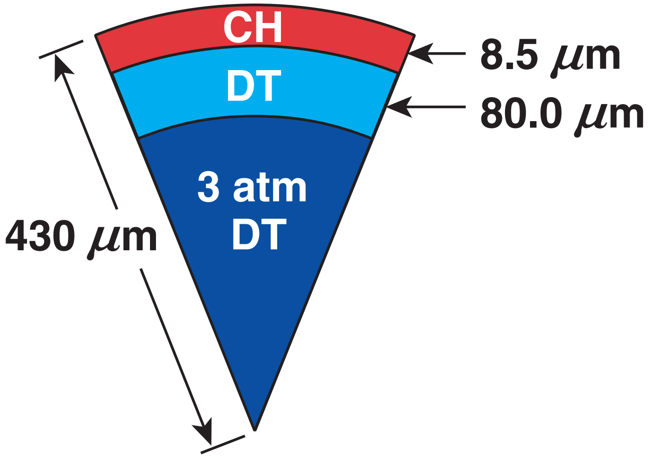
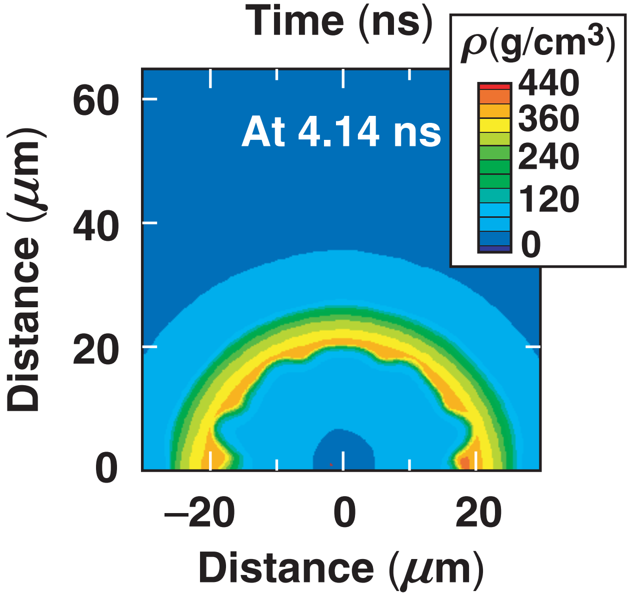
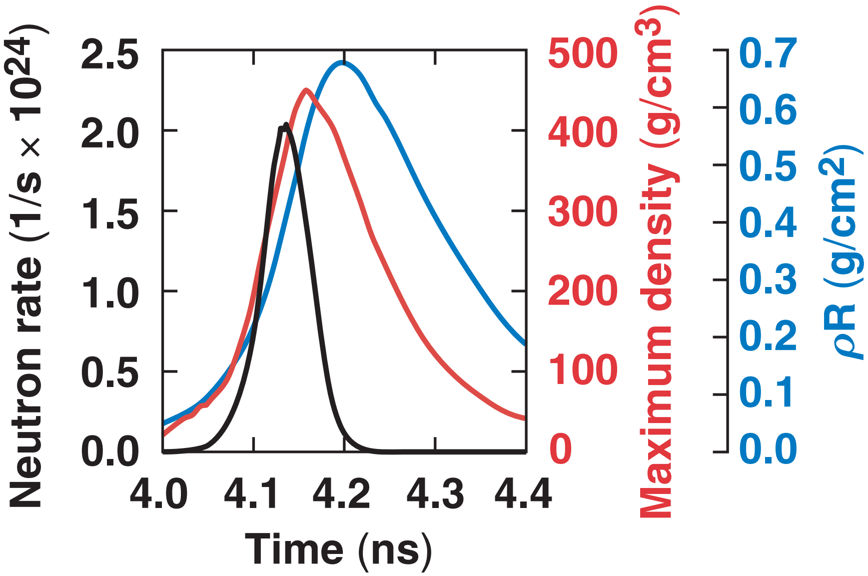
DRACO 2-D simulations were carried out with nonuniformity due to OMEGA illumination pattern



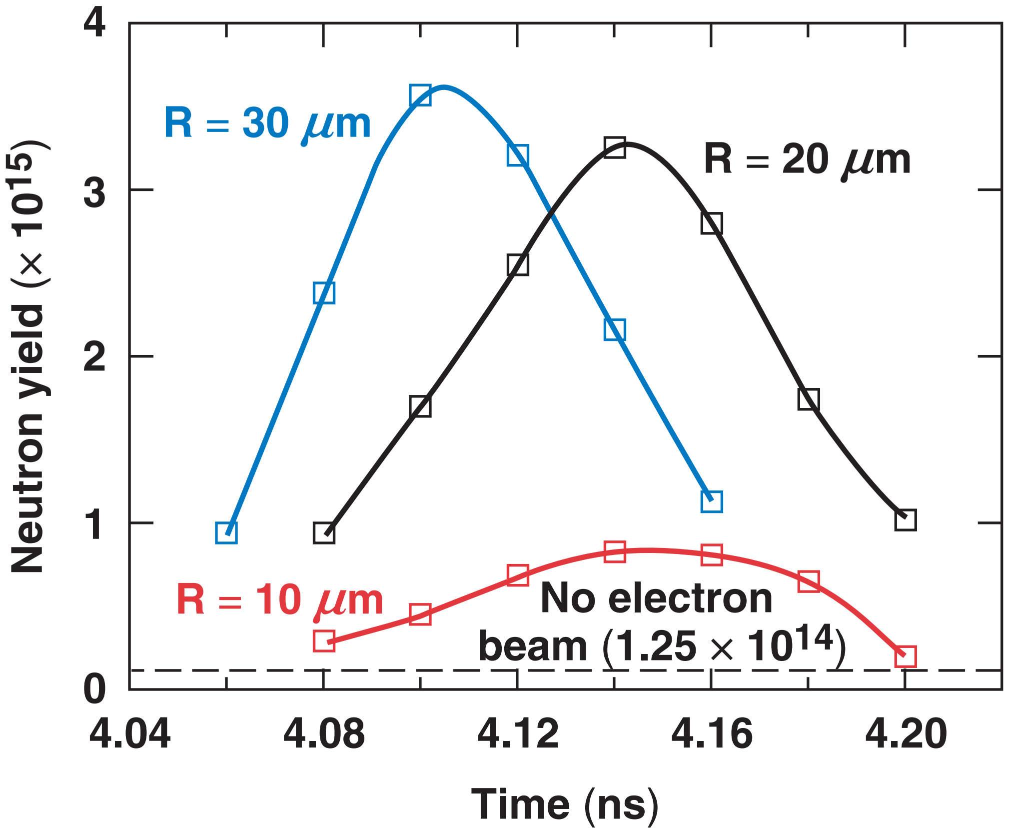






The timing of the ~25-fold enhancement of the neutron yield depends on the beam radius

2.5 kJ, 10 ps FWHM,
~30% energy deposition



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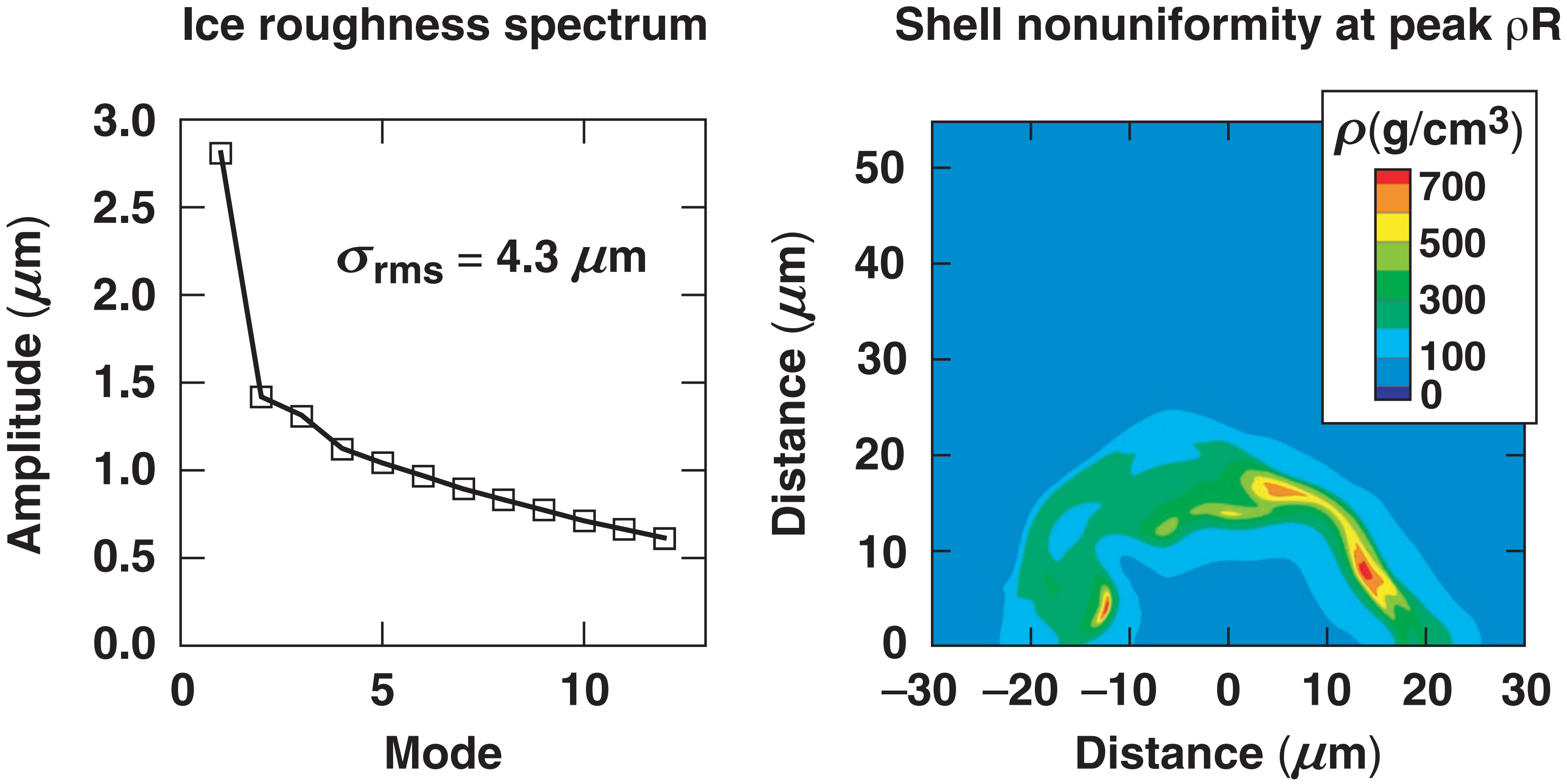
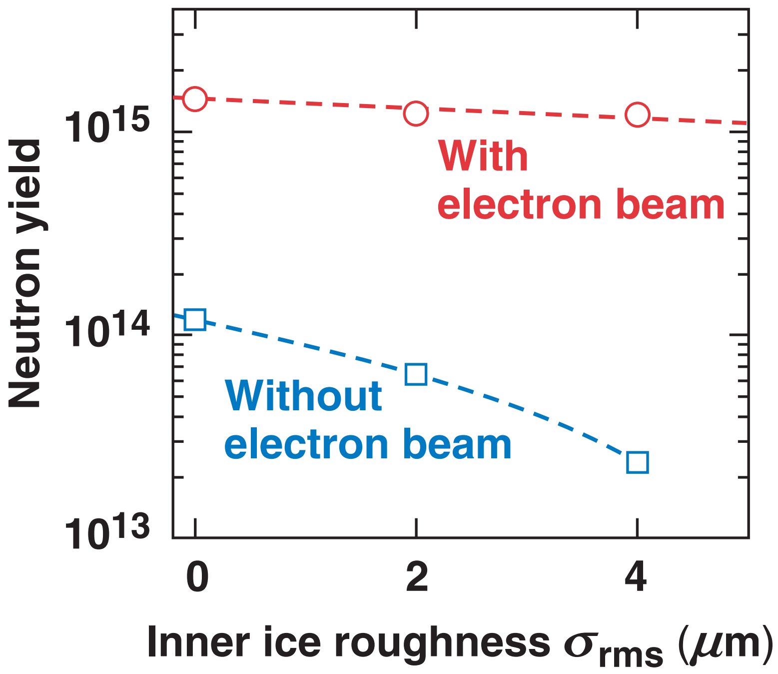
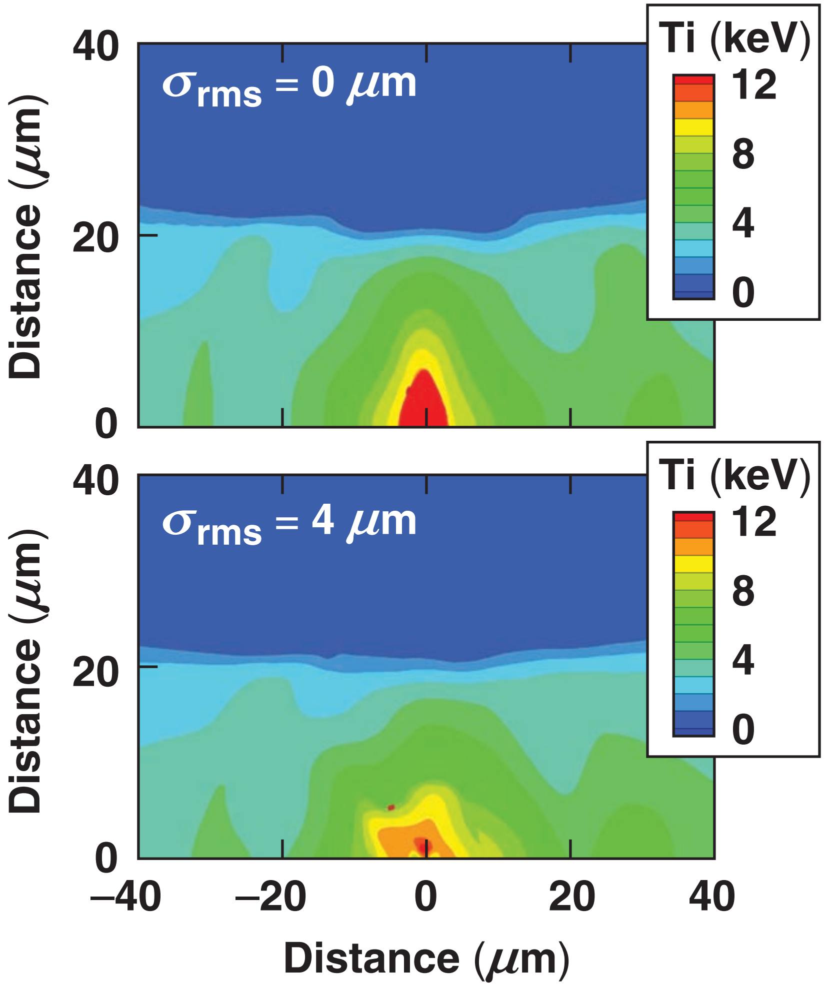
Simulations with varied ice roughness produce realistic core nonuniformities



Introducing the electron beams increases and maintains the neutron yield in excess of 10^{15} over all uniformity levels

Effect of electron beam on neutron yield





The yield remains constant because the same amount of core material is heated in all cases of ice roughness.

Summary/Conclusions

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