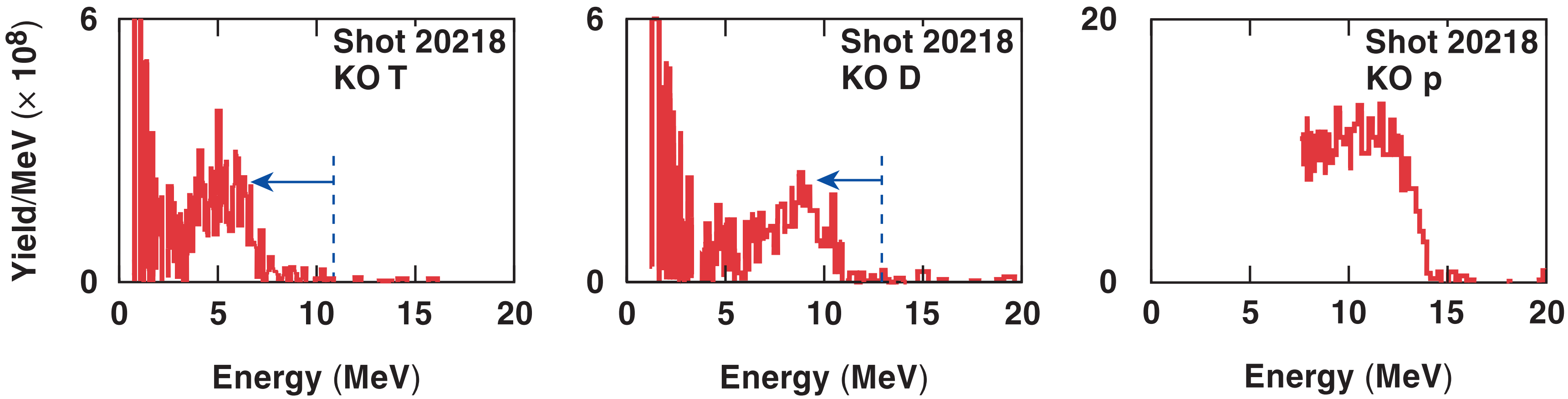
Study of Direct-Drive, DT-Gas-Filled Plastic Capsule Implosions Using Nuclear Diagnostics on OMEGA



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Measurements of Areal Densities and Temperatures from DT Capsule Implosions on OMEGA

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Spectral measurements were made of 14.1-MeV neutron knock-on particles from imploded DT-filled CH shells on OMEGA. Fuel ρR is inferred from the spectra and yields of D and T knock-ons, while shell ρR is determined from the measured yield of ρ knock-ons from the CH. Shell electron temperature (T_e) is uniquely determined by using the downshift of the endpoint energies of knock-ons from the fuel. This is possible because knock-on yield is independent of T_e while the energy downshift is a function of both shell ρR and shell T_e. In addition, CD and CH shells were shot. From such implosions, a complex set of multiple particle spectra are obtained simultaneously. This work was performed in part at the LLE National Laser Users' Facility (NLUF), and was supported in part by the U.S. DOE Contract #DE-FG03-99SF21782, LLE subcontract #PO410025G, LLNL subcontract #B313975, and by the U.S. DOE Office of ICF under Coop. Agree. No. DE-FC03-92SF19460.

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Summary

Target performance is improved with the increase of irradiation uniformity

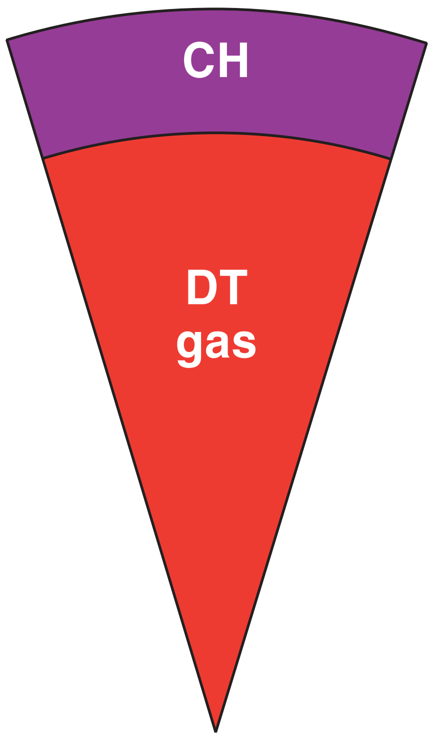
- Recent experiments have achieved moderate convergence ratios (10 to 20) with fuel $\rho R \approx 15\ mg/cm^2$ and shell $\rho R \approx 65\ mg/cm^2$.
- Using 1-THz SSD and polarization smoothing, rather than 0.3-THz SSD, the fuel ρR and shell ρR increased by ~60% and ~40%, respectively.
- Comparisons of experiments to 1-D simulations provide useful information to characterize the improvement in target performance.

E10638 *Also see talks BI3.003, HO1.005, HO1.007, and HO1.008.

Outline

- DT capsules and experimental conditions
- Experimental results
  - primary neutron yields and ion temperatures
  - fuel areal densities and convergence ratios
  - shell areal densities and electron temperatures
- Comparison to 1-D simulations

Capsules and experimental conditions



Capsules:

- DT-gas-filled ~ 11 to 15 atm
- CH shell ~ 19.5 to 20 μm

Experimental conditions:

- laser energy ~ 21 to 24 kJ
- beam energy ~5%
- 1-ns square pulse

0.3-THz SSD
1.0-THz SSD with PS

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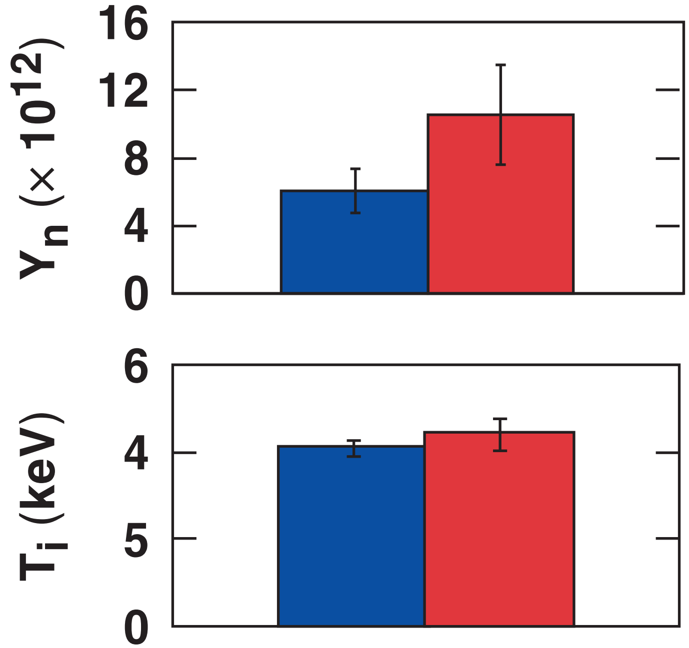
Primary neutron yields, ion temperatures, and DT burns are measured using neutron diagnostics



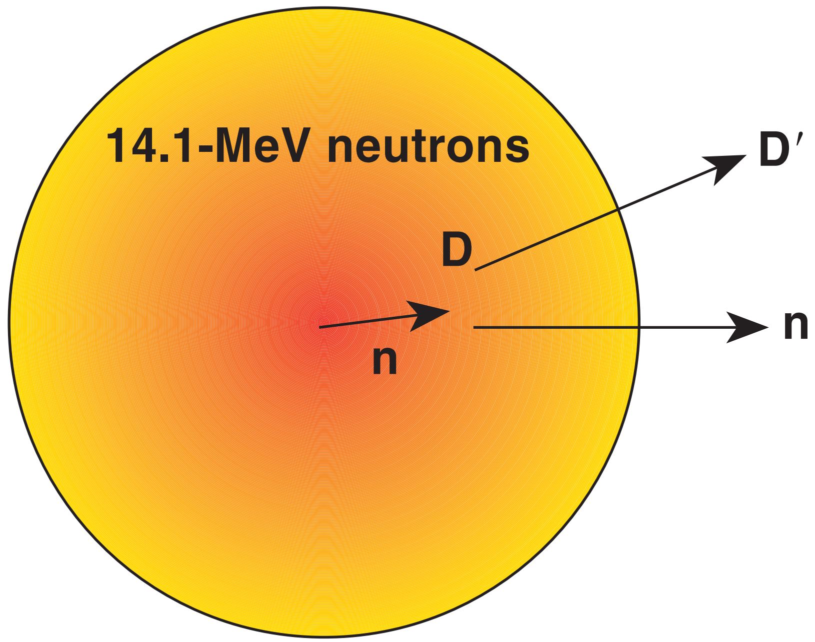
- $Y_n \sim 3 \times 10^{12}$ to 1.5×10^{13}
- $T_i \sim 4$ to 5 keV
- Bang time 1750 to 1920 ps
- With rms uniformity increase using 1-THz SSD + PS
  - Y_n increases ~80%,
  - T_i is slightly higher.

3 color cycles, 0.3-THz SSD

1 color cycle, 1-THz SSD + PS

E10641

Charged particles that are elastically scattered by 14.1-MeV neutrons provide unique information about the cores and shells of the imploded DT capsules



n + D → n′ + D′ (<12.5 MeV)

n + T → n′ + T′ (<10.6 MeV)

n + P → n′ + P′ (<14.1 MeV)

Number of knock-ons ∝ <ρR> Y(neutron).

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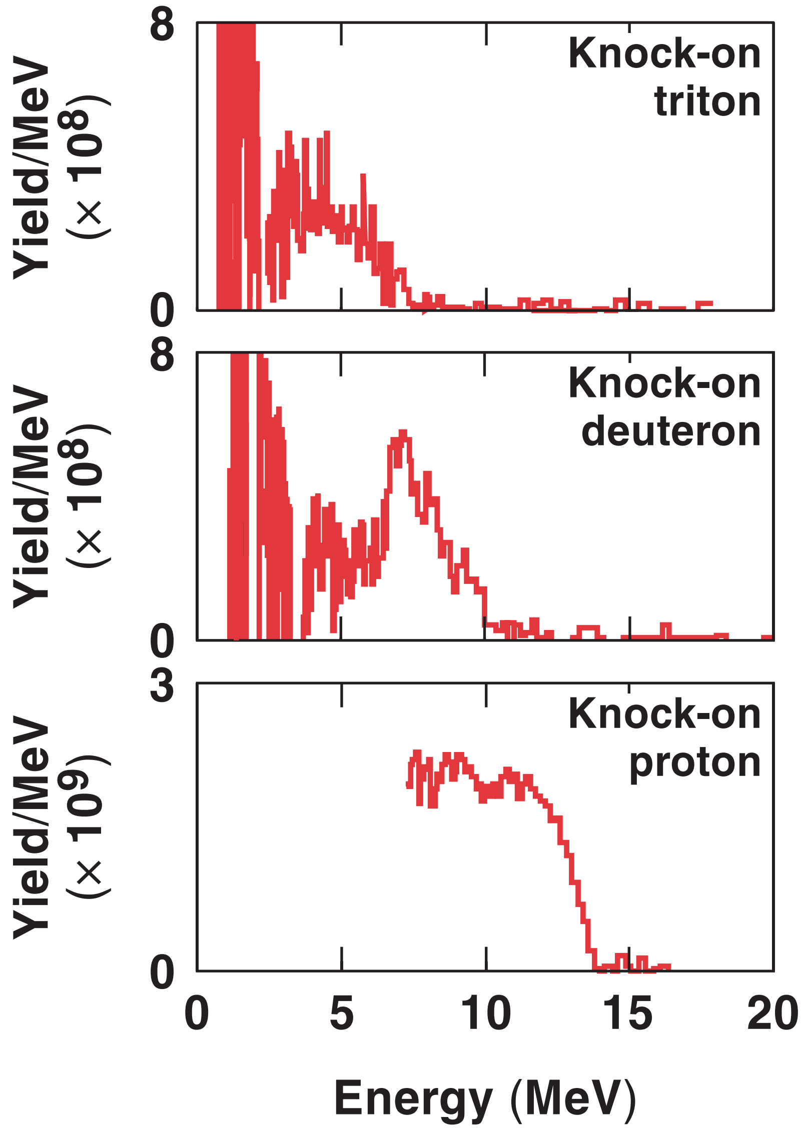
Fuel and shell areal densities, as well as shell electron temperatures, are inferred by knock-on D, T, and p



Shot 20698

Laser energy: 23.8 KJ

1-THz SSD + PS

$\rho R_{fuel} \approx 13$ mg/cm^2

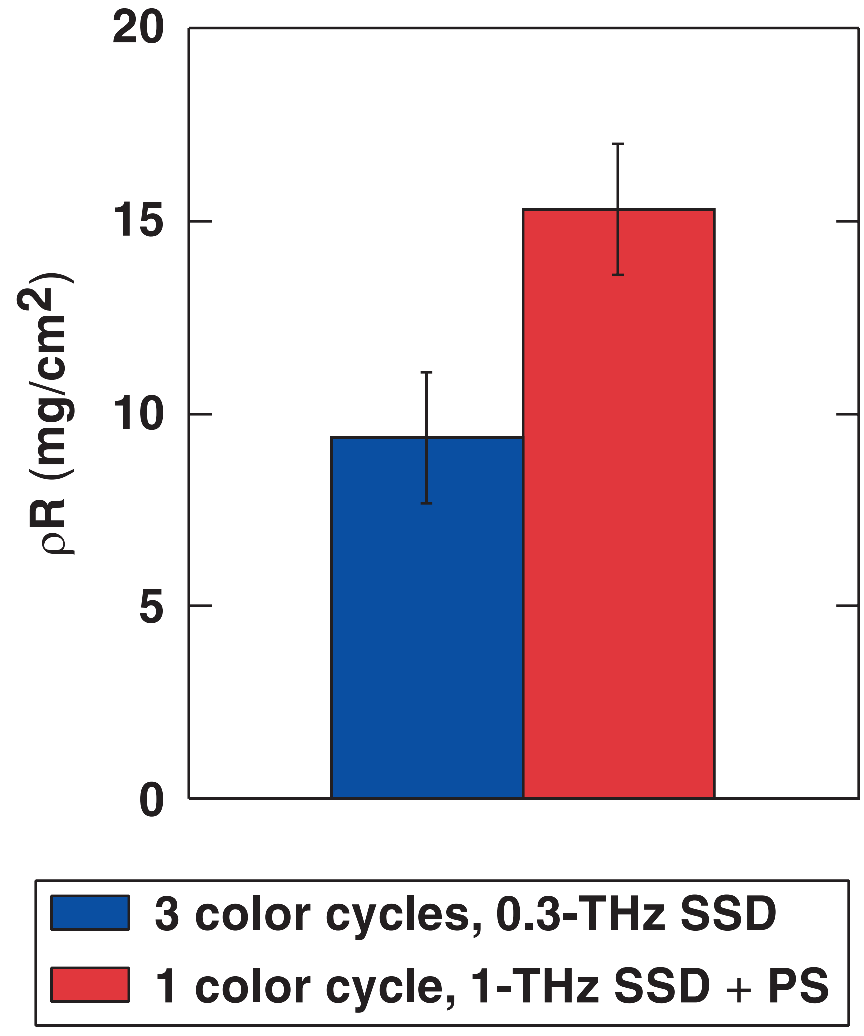
$\rho R_{shell} \approx 65$ mg/cm^2

$C_r \approx 17$

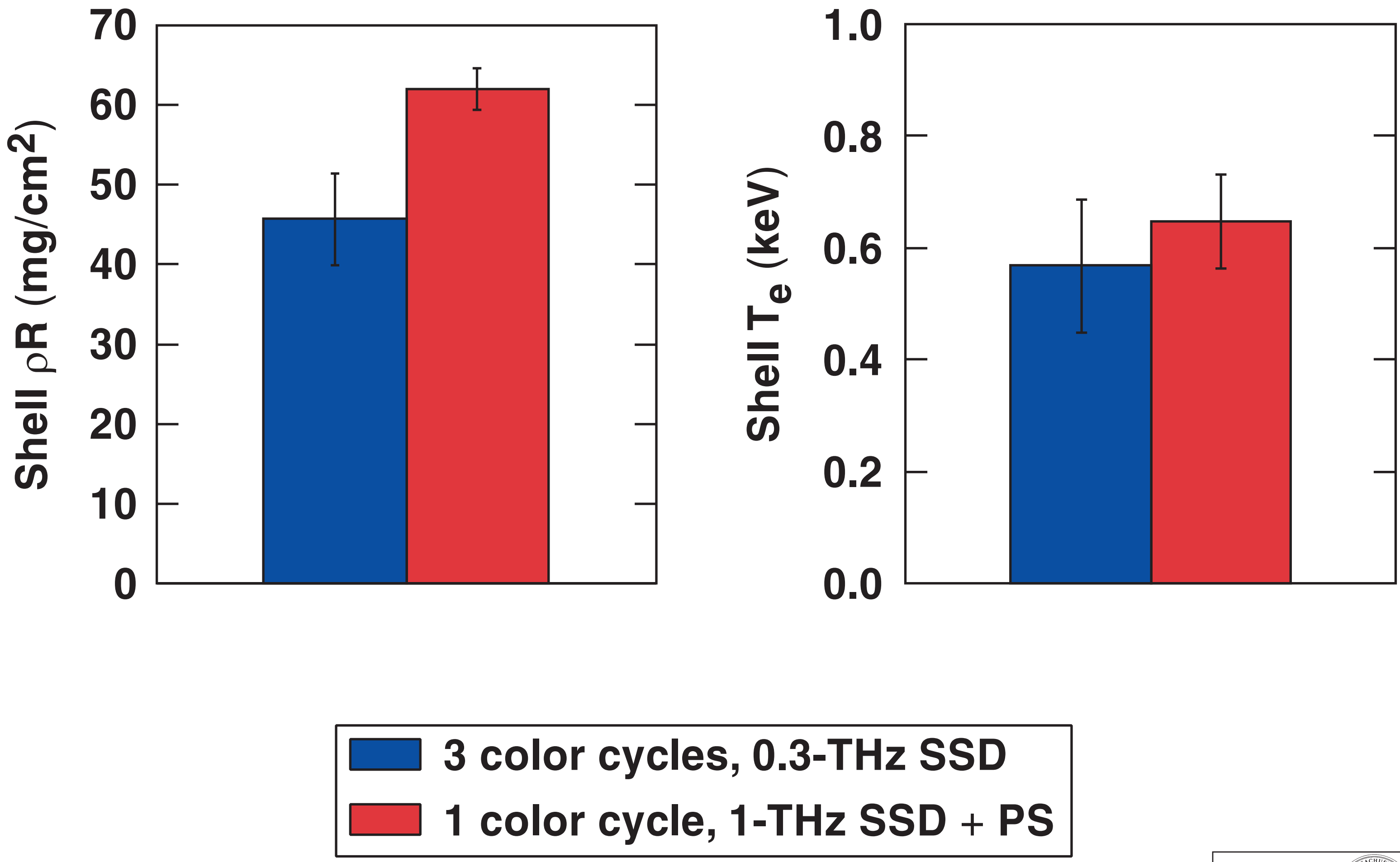
$T_e \approx 0.6$ keV (shell)

E10642

Fuel ρR increases ~60% with improvement in rms uniformity using 1-THz SSD + PS



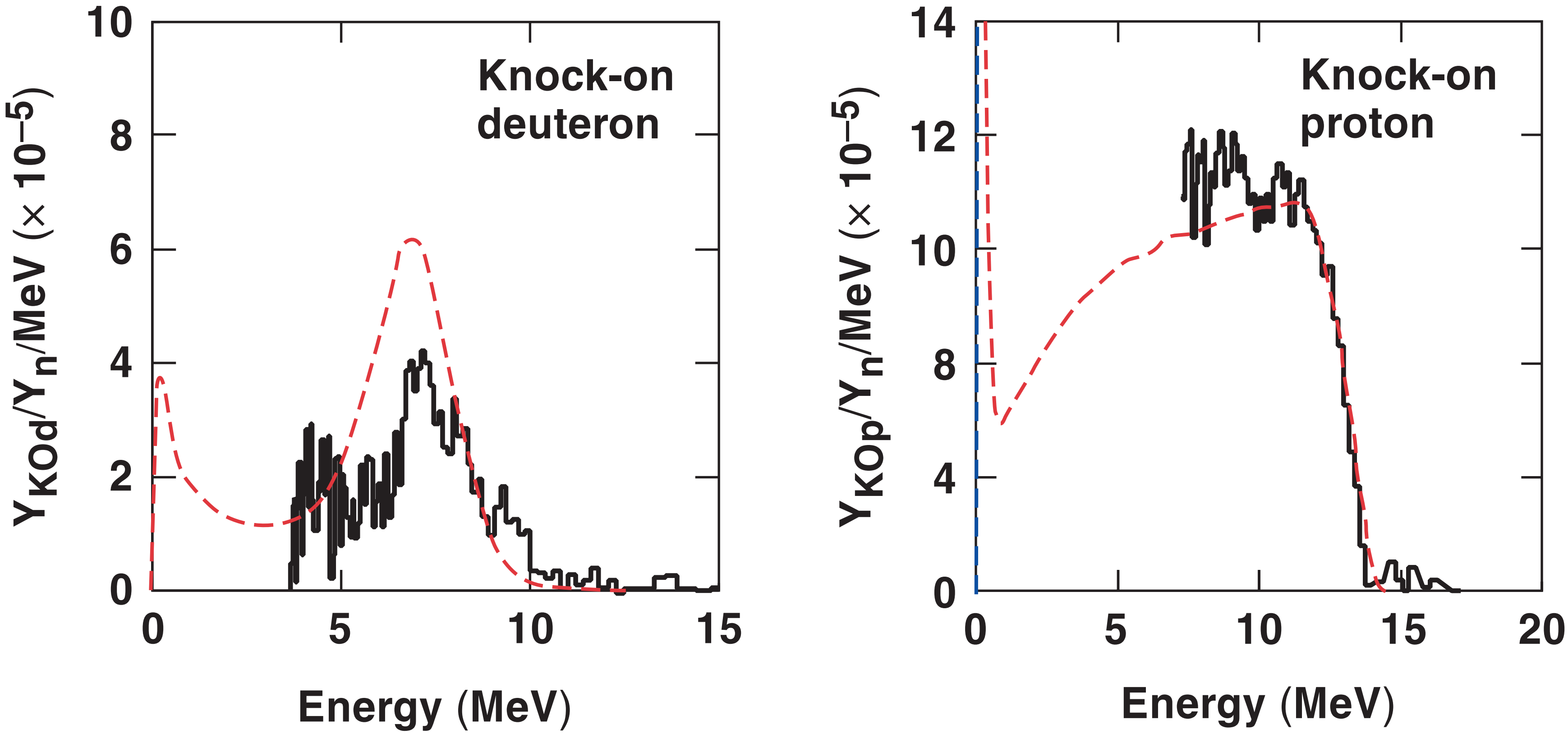
Shell compression increases ~40% with improvement in rms uniformity using 1-THz SSD + PS



E10644

With full smoothing, measured knock-on spectra are close to 1-D simulations

Shot 20698



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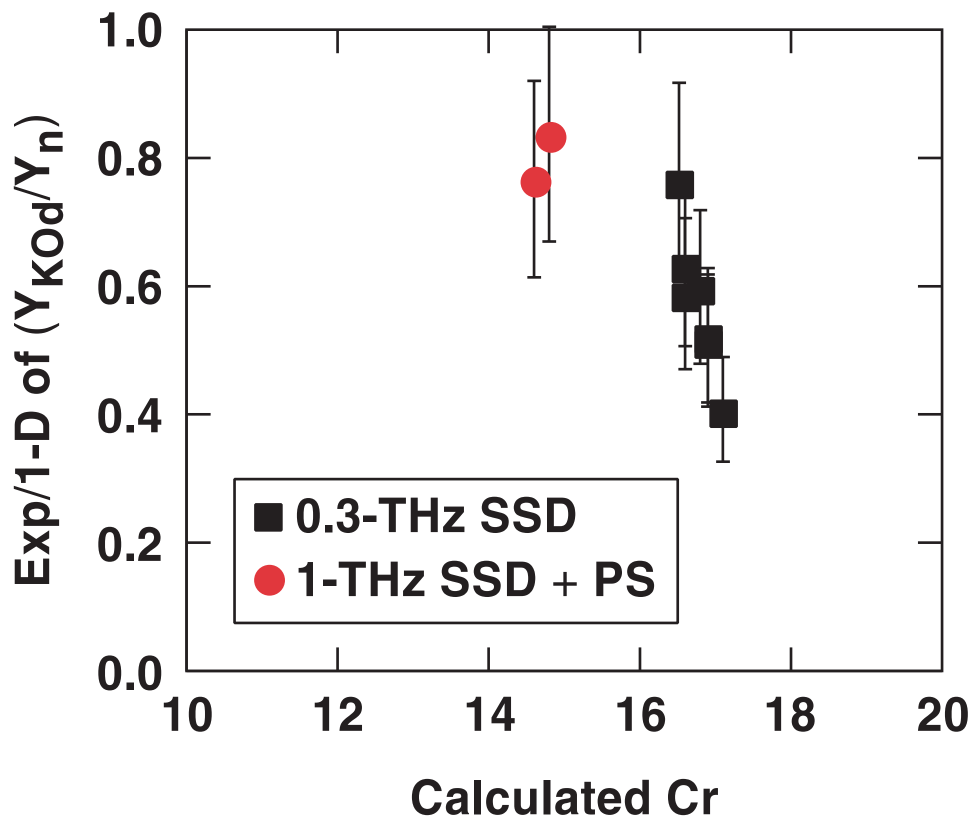
The ratio of knock-on D yield to primary neutron yield is closer to the 1-D predictions for 1-THz SSD + PS (~80%) than for 0.3-THz SSD (~60%)



E10647

Summary/Conclusions

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