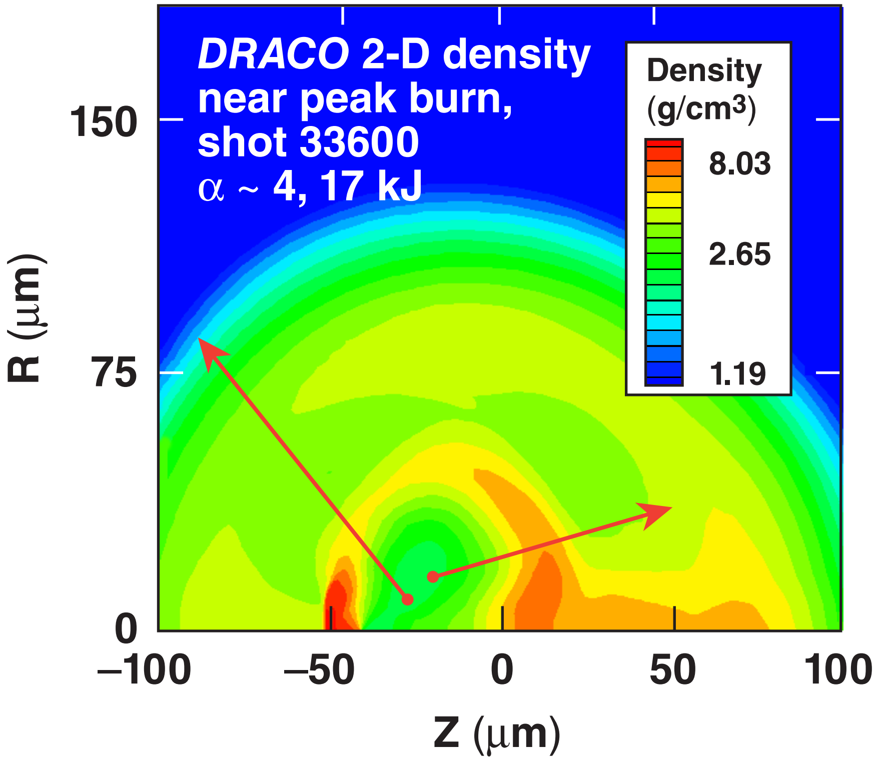
High-Areal Density Cryogenic D_2 Implosions on OMEGA



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Summary

High areal densities are achieved in low adiabat implosions of cryogenic fuel on OMEGA

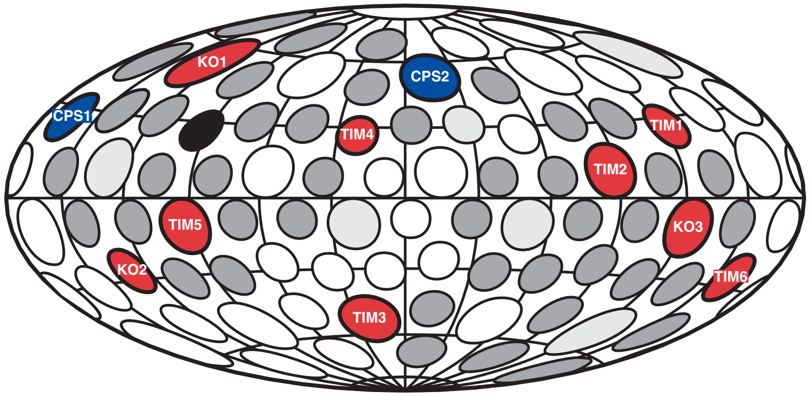
- **For $\alpha \sim 4$ to 6 pulses, the neutron averaged fuel areal density, $\langle\rho R\rangle_n$, approaches 100 mg/cm^2 and peak fuel ρR exceeds 100 mg/cm^2.**

- **For high adiabat drive pulses ($\alpha \sim 25$), the $\langle\rho R\rangle_n$ is 40 to 50 mg/cm^2, in good agreement with 1-D hydrocode predictions.**

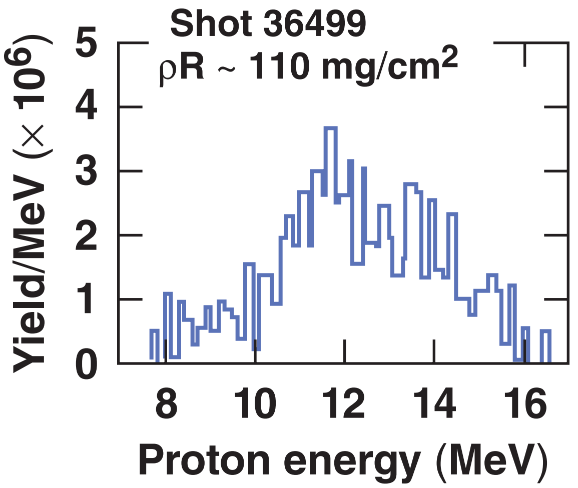
- **Ice roughness and target offset appear to be limiting the $\langle\rho R\rangle_n$ for the highest convergence implosions.**

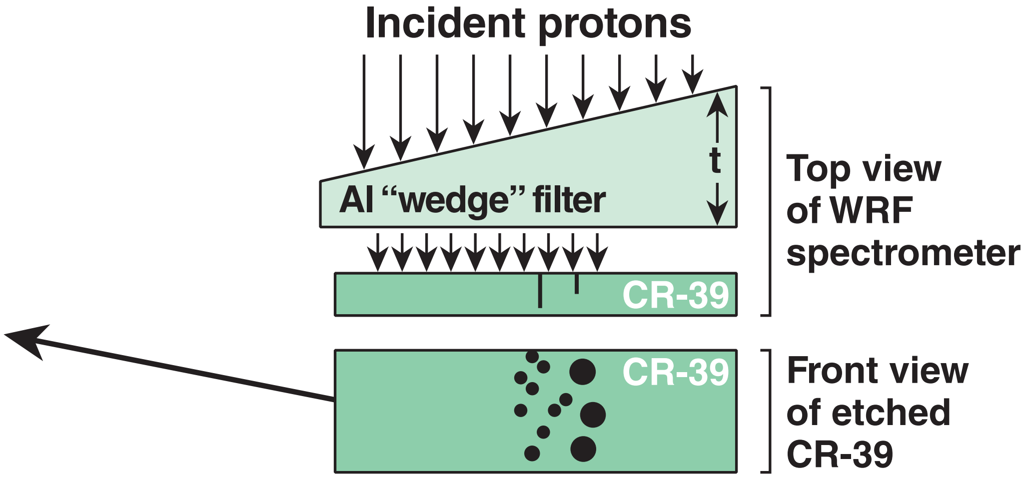
In cryogenic D_2 implosions, the total $\langle\rho R\rangle_n$ is inferred from the energy loss of secondary D^3He protons

Typically, 4 to 6 measurements per implosion



🔵 = Magnet-based CPS’s
🔴 = WRF spectrometers



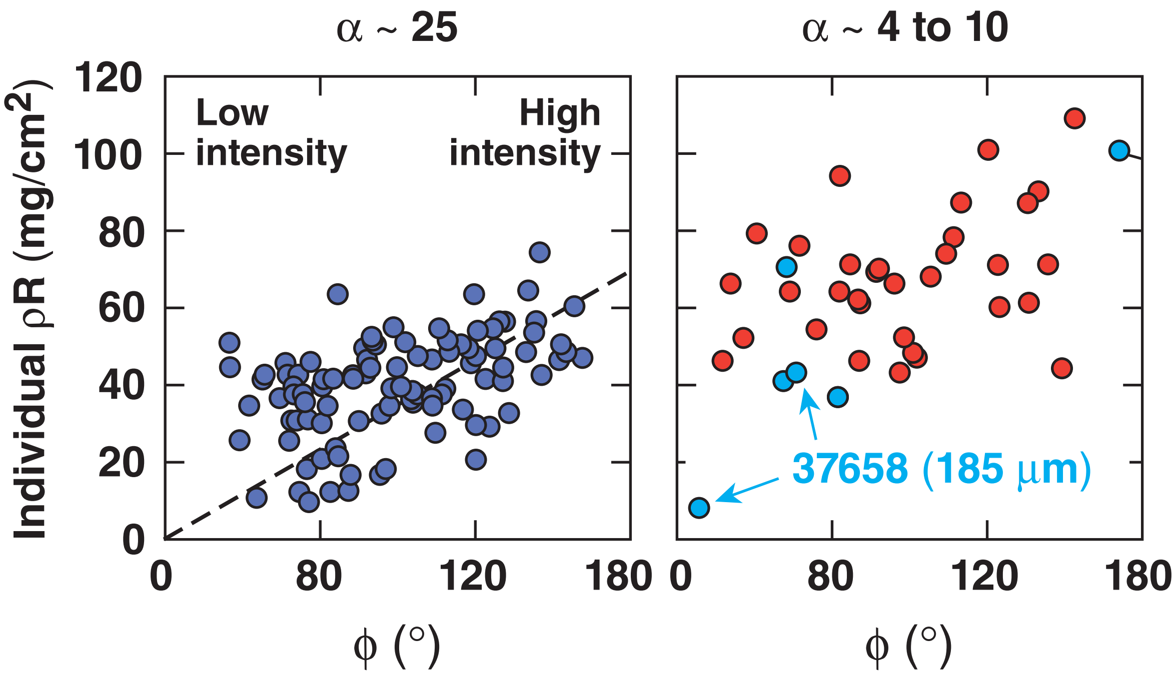


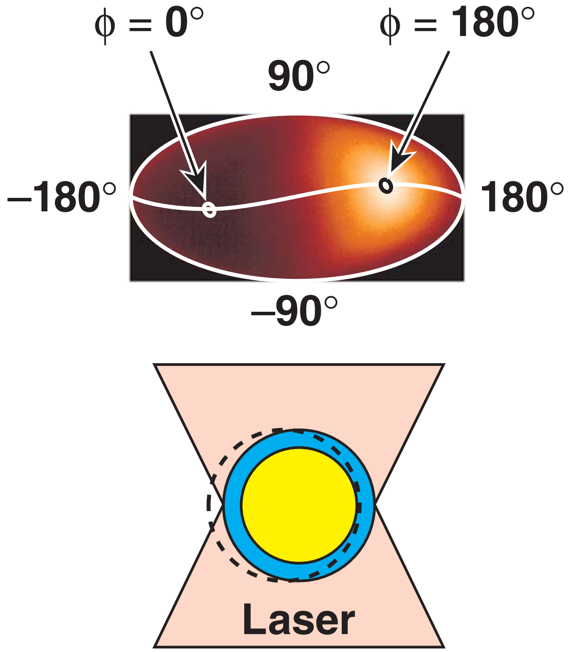
Top view of WRF spectrometer

Front view of etched CR-39

Target offset and a finite number of measurements can limit the accuracy of the $\langle\rho R\rangle_n$ on a single shot

There is a strong correlation between the individual measurements of ρR and the angle of the measurement with respect to the TCC offset.





Measurement angle with respect to TCC offset (°)

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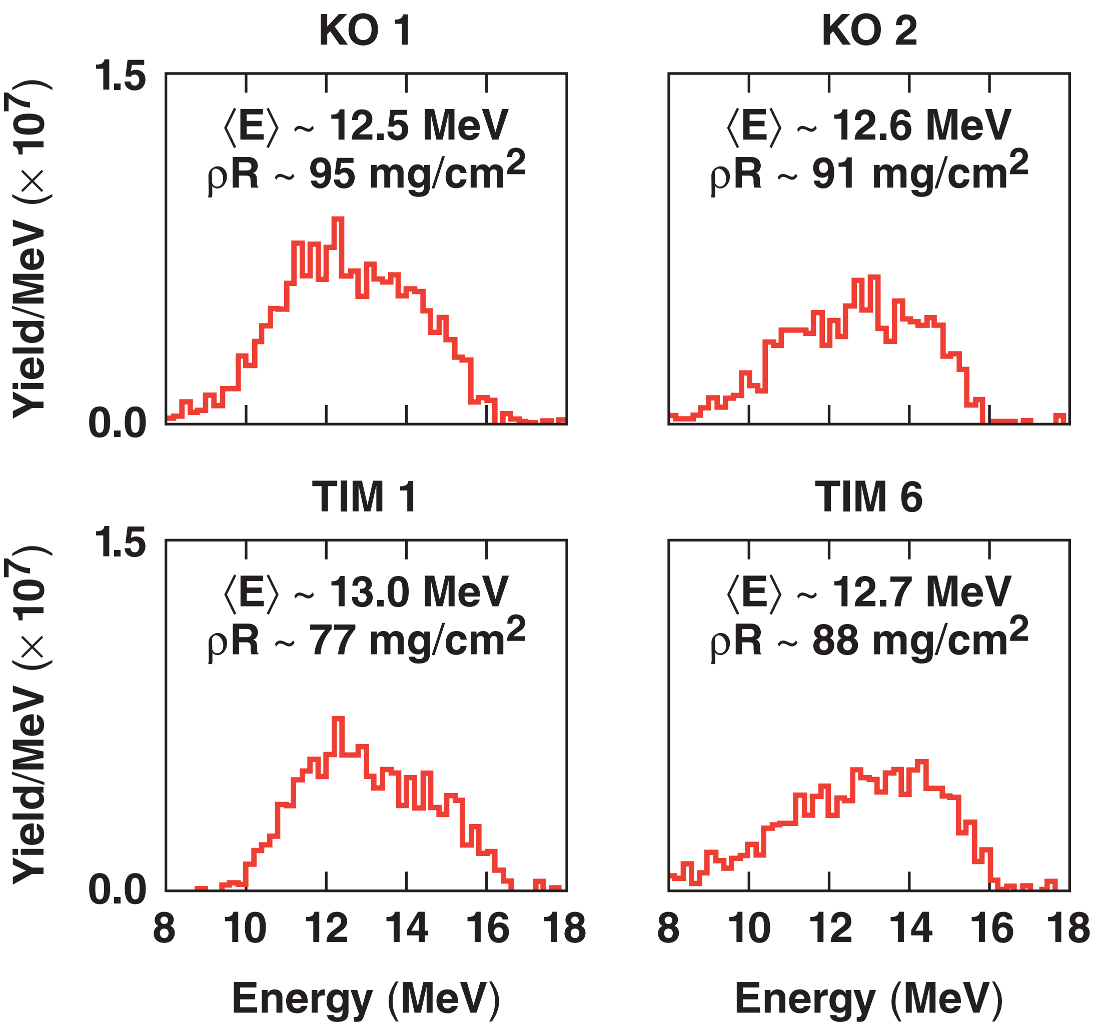
The highest average $\langle \rho R \rangle_n$ to date is 88±8 mg/cm^2



Shot 35713

$\alpha \sim 4$

Ice rms = 4.1 μm

$Y_{1n} = 1.61 \times 10^{10}$

$Y_{2n} = 2.55 \times 10^{8}$ (1.6%)

$Y_{2p} = 2.61 \times 10^{7}$

$\langle \rho R \rangle_n = 88 \pm 8$ mg/cm^2

$T_{ion} = 3.0$ keV

TCC offset = 15 μm

Recent implosions produced the highest individual ρR's and the highest $\langle \rho R \rangle_n$ to date

Shot 37967

ρR (mg/cm^2)		Angle with respect to offset
TIM1	>110	108°
TIM2	102	142°
TIM3	77	94°
TIM4	63	113°
TIM6	>97	67°
KO1	81	63°
KO2	62	17°
$\langle \rho R \rangle_n$	>85	

α2FM01P at 22.7 kJ (no SSD)

$\alpha \sim 3.5$

$Y_{1n} = 3.0 \times 10^{10}$ (YOC = 6%)

$Y_{2n} = 4.4 \times 10^8$ (2n/1n = 1.5%)

Ice = 3.7-μm rms

Offset = 67 μm

T_{ion} = 3.3 keV

Shot 37968

ρR (mg/cm^2)		Angle with respect to offset
TIM1	>131	168°
TIM2	107	149°
TIM3	83	49°
TIM4	82	58°
TIM6	>114	122°
KO1	>103	90°
KO2	68	63°
$\langle \rho R \rangle_n$	>98 (highest to date)	

α2FM01P at 23.0 kJ (no SSD)

$\alpha \sim 3.8$

$Y_{1n} = 3.9 \times 10^{10}$ (YOC = 8%)

$Y_{2n} = 6.5 \times 10^8$ (2n/1n = 1.7%)

Ice = 1.7-μm rms

Offset = 37 μm

T_{ion} = 3.4 keV

The measured $\langle \rho R \rangle_n$ is close to 1-D for all but the lowest adiabat implosions

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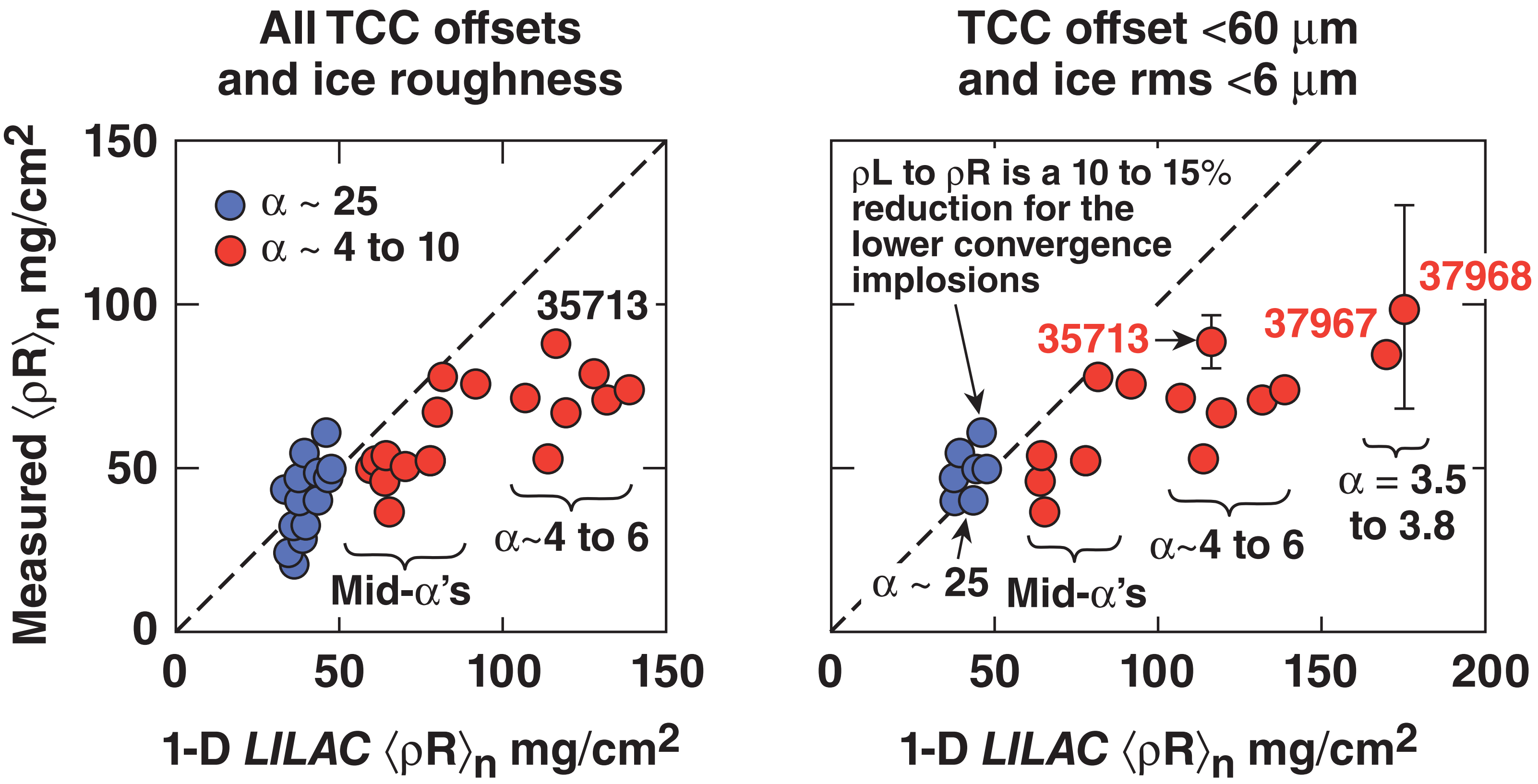
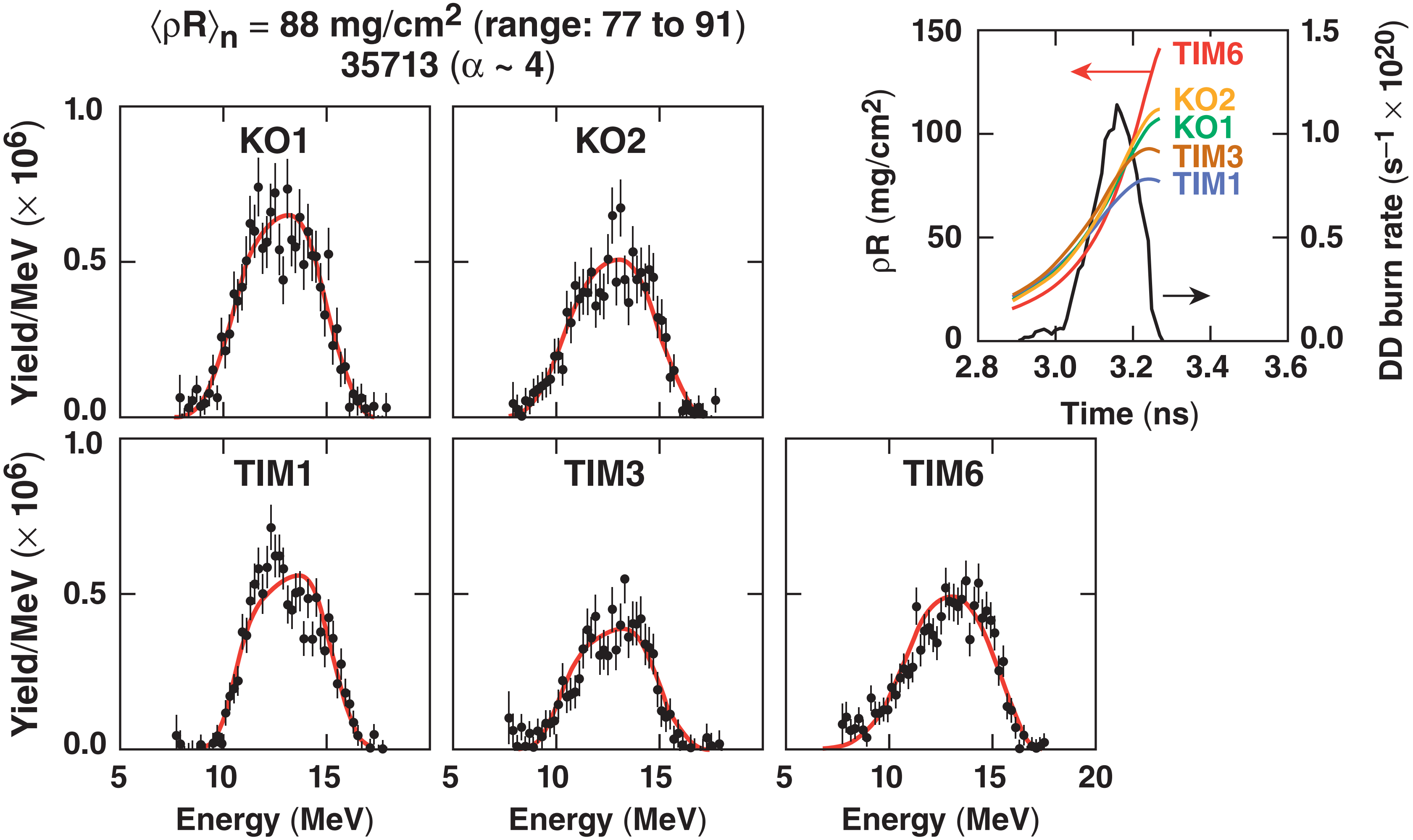


There is good agreement between 2-D predictions that take into account ice roughness and target offset and the measured $\langle \rho R \rangle_n$ for the higher convergence implosions.

The peak ρR at the end of the burn is inferred using the measured proton spectra and the burn history*

$\langle \rho R \rangle_n$ = 88 mg/cm^2 (range: 77 to 91)
35713 (α ~ 4)



Peak ρR is important for future fast ignition experiments.

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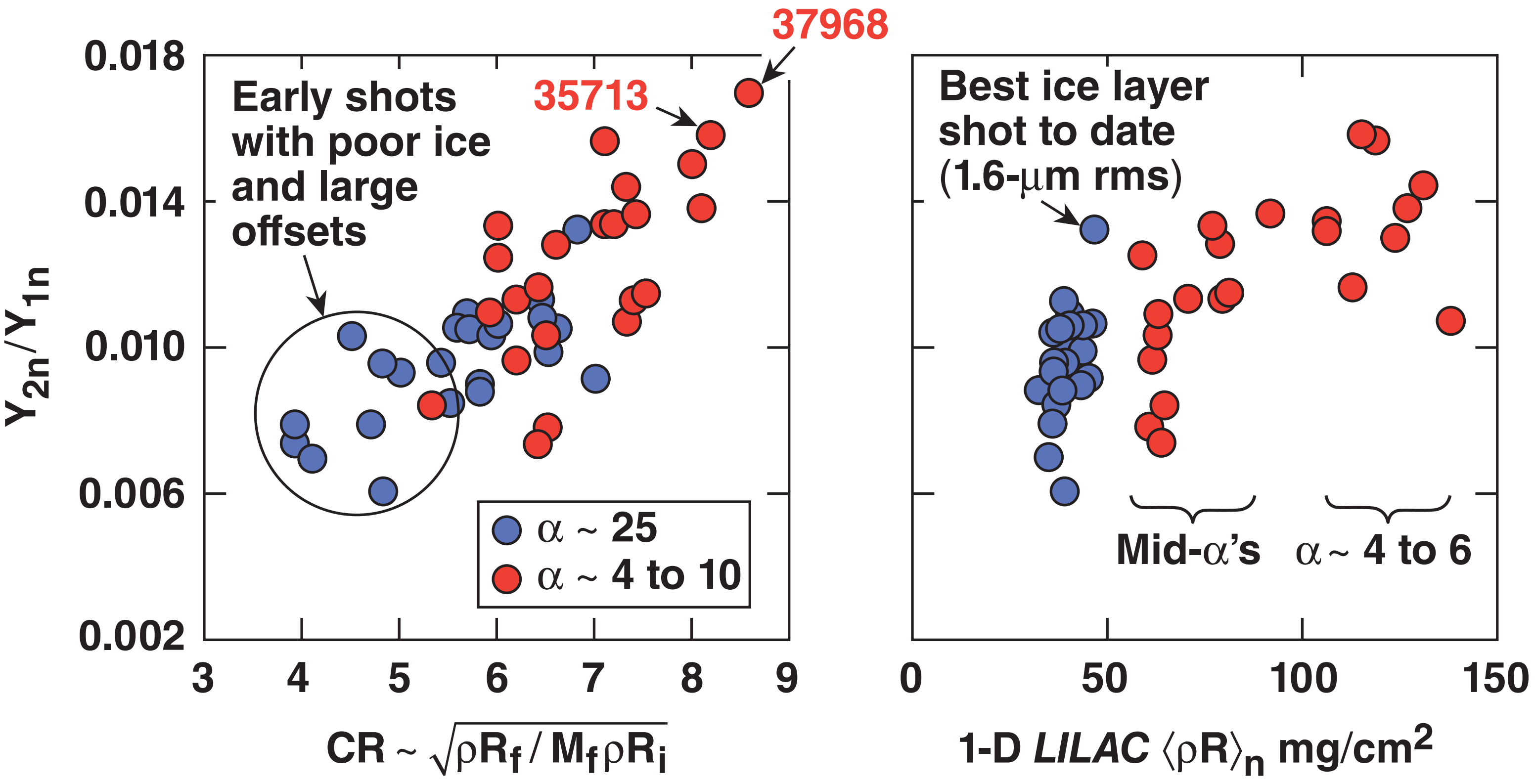
*V. A. Smalyuk *et al*., Phys. Rev. Lett. 90, 135002 (2003) and J. A. Frenje *et al*., Phys. Plasmas 11, 2798 (2004).

The secondary-to-primary neutron ratio correlates with the experimental convergence and 1-D $\langle \rho R \rangle_n$



Based on a hot-spot model,* a secondary ratio of 1.6% implies a minimum ρR of 70 to 80 mg/cm^2 for a 3-keV plasma at 50× liquid density—consistent with the measured total $\langle \rho R \rangle_n$!

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* M. D. Cable and S. P. Hatchett, J. Appl. Phys. 62, 2233 (1987);
H. Azechi *et al.*, Laser and Particle Beams 9, 119 (1991).

Summary/Conclusions

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