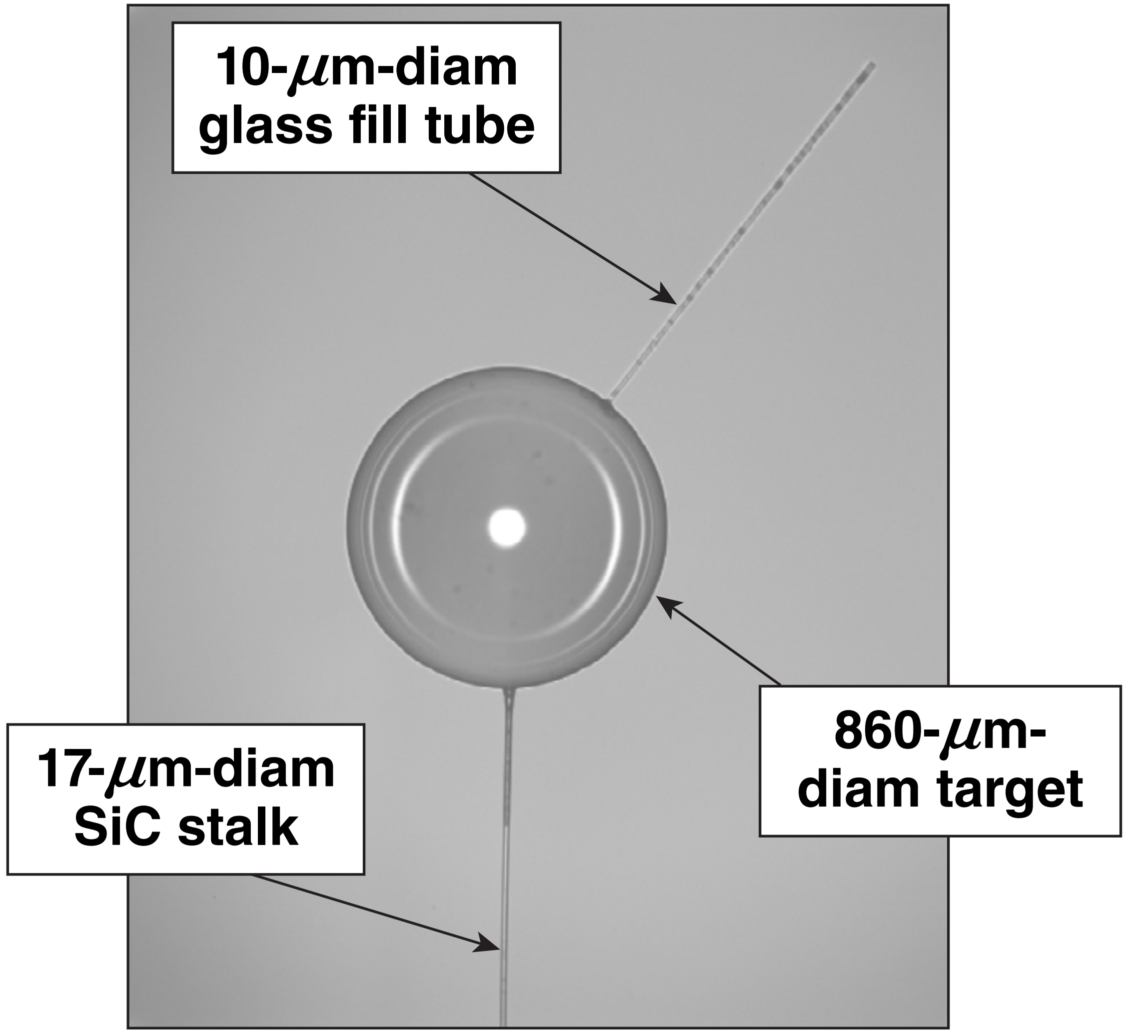
Direct-Drive DT Cryogenic Implosion Performance with a Fill Tube

Stalk-mounted, direct-drive DT cryogenic target with added fill tube



S. P. Regan
University of Rochester
Laboratory for Laser Energetics

59th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Milwaukee, WI
23–27 October 2017

Summary

A small reduction in implosion performance was observed when a fill tube was added to a stalk-mounted target for an $\alpha = 4$, DT cryogenic implosion on OMEGA

UR LLE

- These look-ahead experiments were performed for the DT cryogenic fill-tube target being developed for the 100-Gbar Campaign on OMEGA
- The measured neutron yield, areal density, and ion temperature were studied with and without the added fill tube for implosions with 1-D calculated $\alpha \sim 4$, IFAR* ~ 17, and CR** ~ 23
- Gated x-ray images show evidence of the fill tube perturbing the imploding shell and the shape of the hot spot at stagnation

Future experiments will study the sensitivity to the fill tube by examining lower-α implosion performance for a target supported solely by a fill tube (i.e., no stalk).

α: adiabat
*IFAR: in-flight aspect ratio
**CR: convergence ratio

TC13904

Collaborators

D. Cao, V. N. Goncharov, K. S. Anderson, R. Betti, M. J. Bonino, E. M. Campbell, T. J. B. Collins, R. Epstein, C. J. Forrest, V. Yu. Glebov, D. R. Harding, S. X. Hu, I. V. Igumenshchev, J. A. Marozas, F. J. Marshall, P. W. McKenty, D. T. Michel, P. B. Radha, T. C. Sangster, and C. Stoeckl

University of Rochester
Laboratory for Laser Energetics

M. Gatu Johnson, J. A. Frenje, and R. D. Petrasso

Plasma Science Fusion Center
MIT

R. W. Luo, A. Tambazidis, M. E. Schoff, and M. Farrell

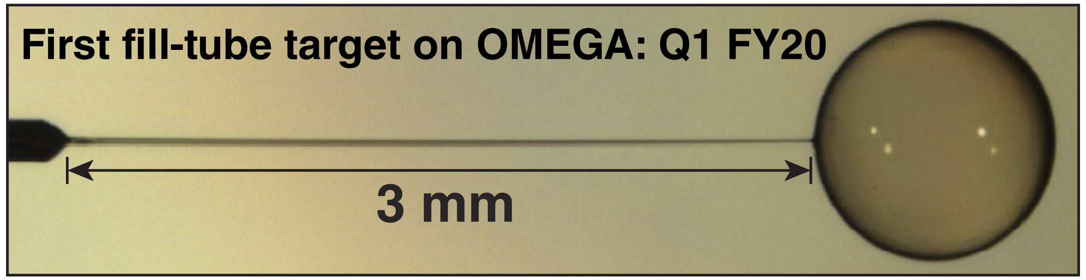
General Atomics

Motivation

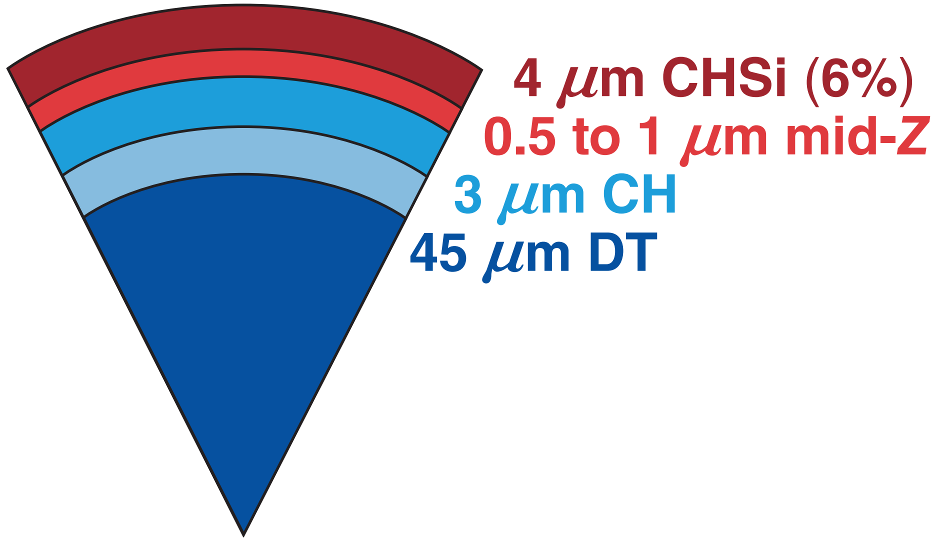
Look-ahead experiments were performed for the DT cryogenic fill-tube target being developed for the 100-Gbar Campaign on OMEGA

- Nonpermeable capsules are needed to optimize ablator and laser–plasma interaction mitigation*
- Minimizing target debris and defects
- Minimizing radiation damage to the ablator (exposure reduced from weeks to days)

A prototype OMEGA fill-tube target (10-μm diam)



Nonpermeable multilayer ablator



Effects of engineering features (e.g., fill tube, stalk, debris, vacuoles) on target performance are being examined.

*V. N. Goncharov *et al.*, Phys. Plasmas 21, 056315 (2014)

I2521b

Hydrodynamic simulations show the stalk/fill tube can cause a jet of cold material from the ablator or shell to be injected into the hot spot*

X-ray image diagnosing overlapped laser drive

3-D *ASTER* simulation**

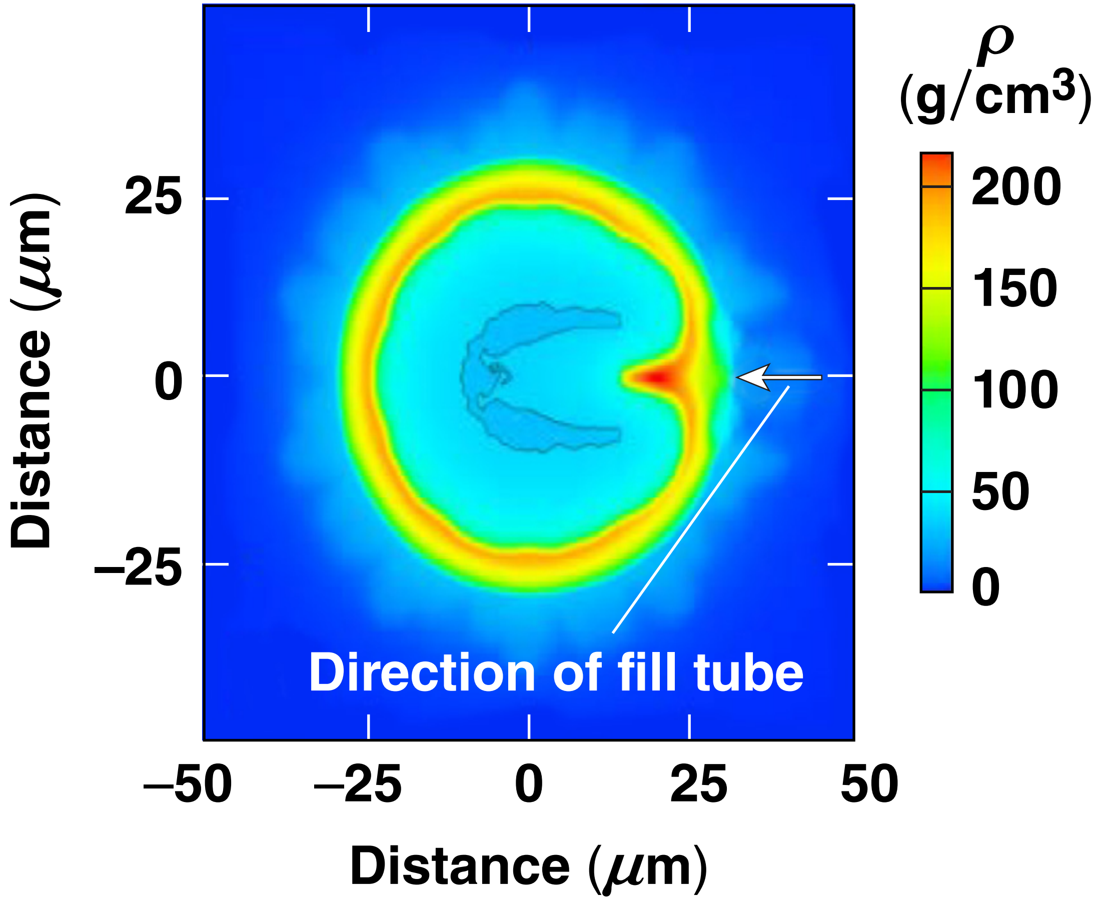
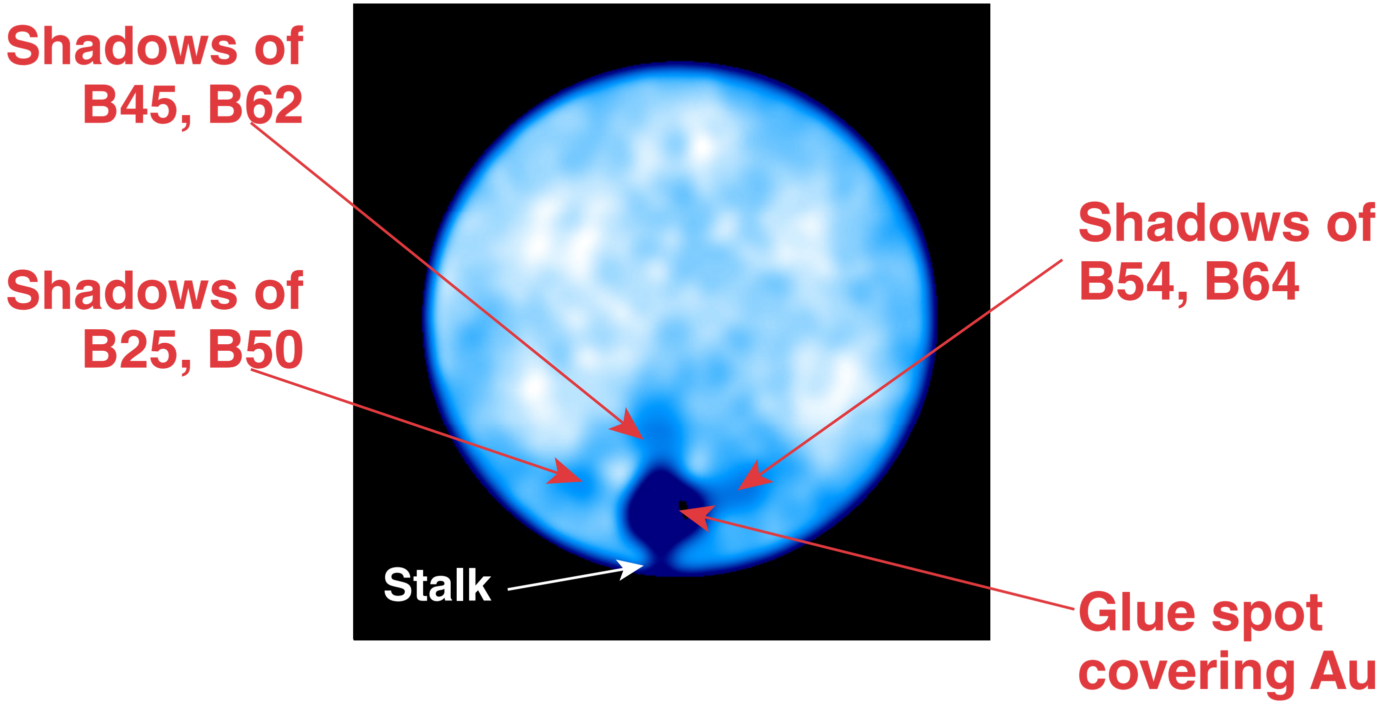


Image from TIM†-3 XRPC‡
OMEGA shot 84492



- **Laser nonuniformity from stalk/fill-tube shadow is not simulated**

*I. V. Igumenshchev *et al.*, Phys. Plasmas 16, 082701 (2009).
**I. V. Igumenshchev *et al.*, Phys. Plasmas 23, 052702 (2016).
†TIM: ten-inch manipulator
‡ XRPC: x-ray pinhole camera

TC13906

A stalk-mounted, DT cryogenic target with an added fill tube was imploded

Schematic of target

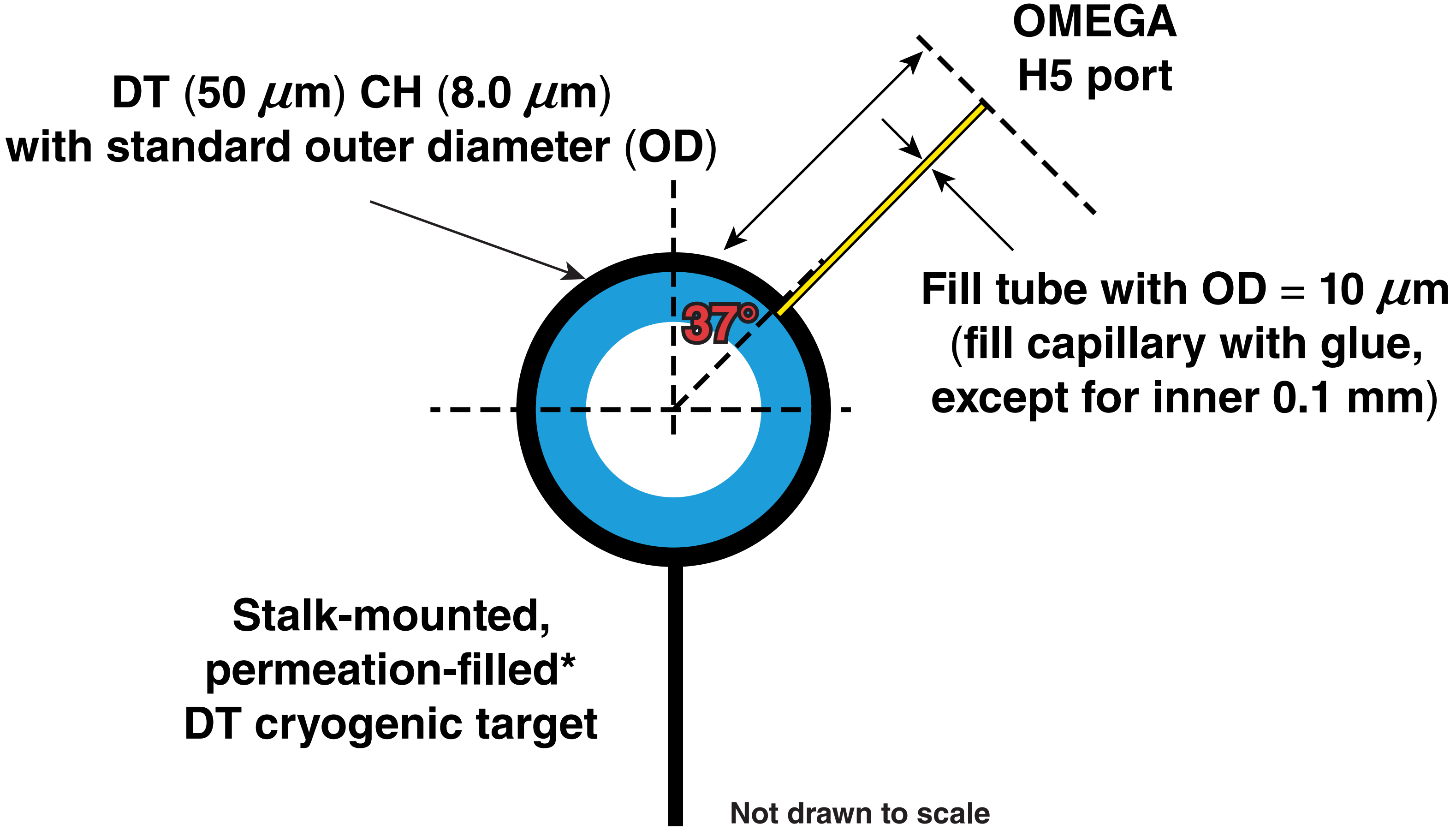
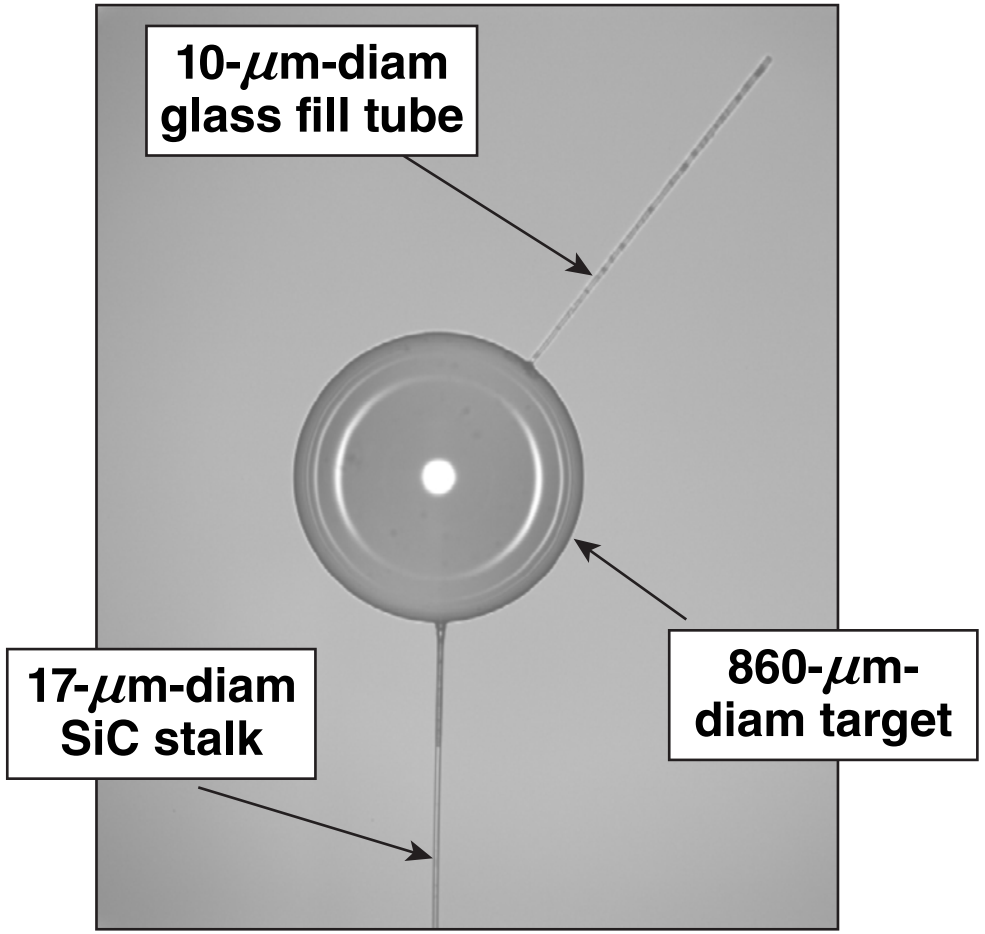


Image of target taken before DT fill

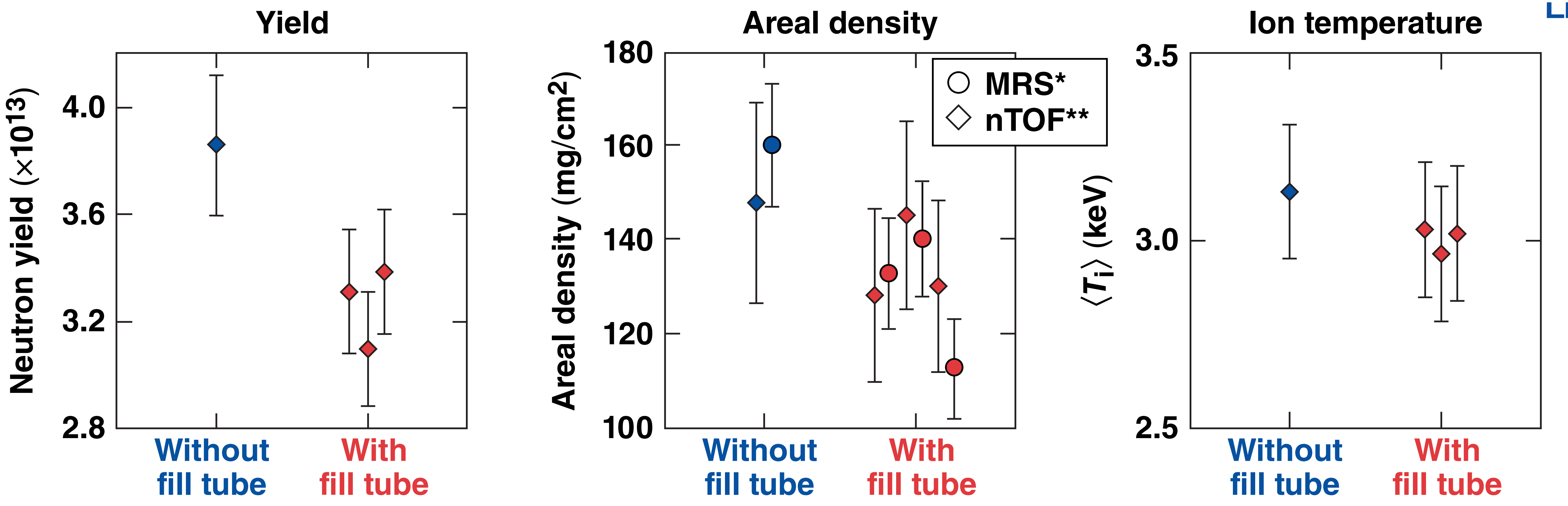


The 1-D calculated implosion parameters are α ~ 4, IFAR ~ 17, and CR ~ 23.

TC13907

*D. R. Harding *et al.*, Phys. Plasmas 13, 056316 (2006); LLE Review Quarterly Report 81, 1 (1999).

Small changes to the measured neutron yield, areal density, and ion temperature caused by the fill tube were observed for $\alpha = 4$ DT cryogenic implosions



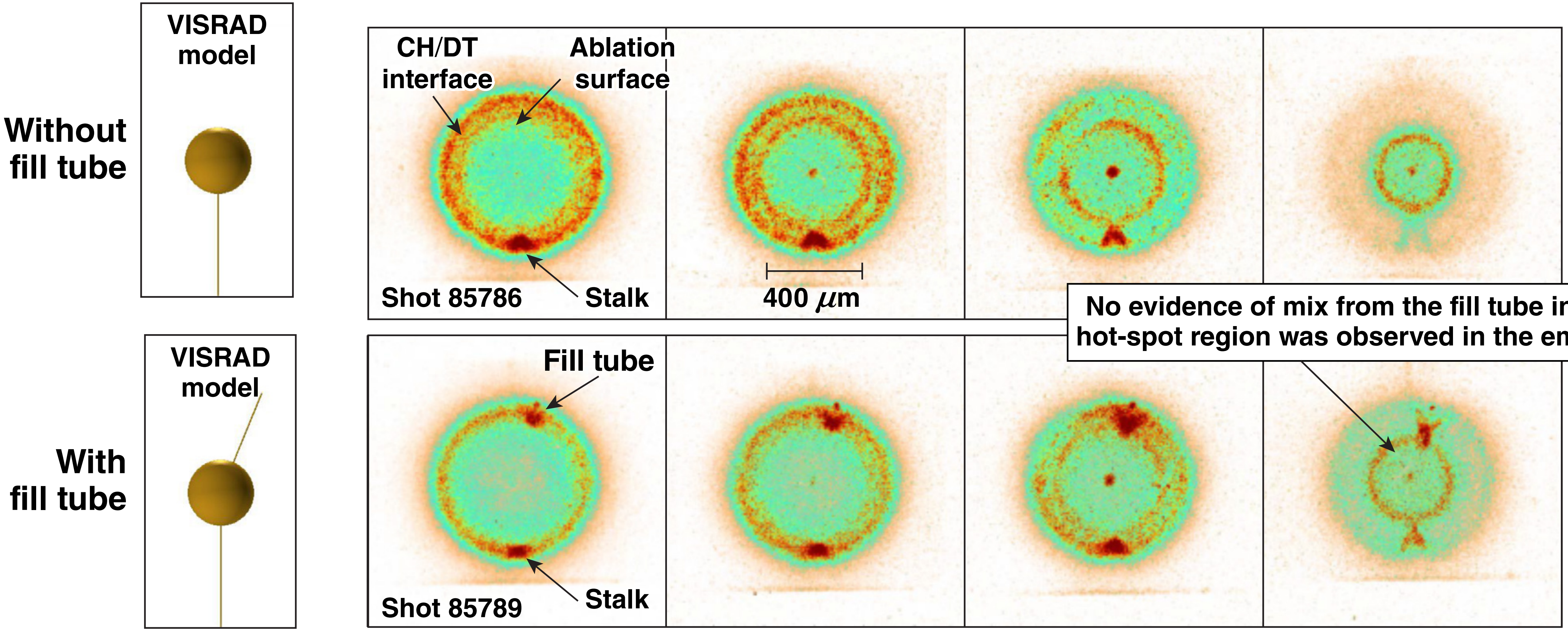
$Y_{exp}/Y_{1\text{-}D} \sim 35\%$

Future experiments will study the sensitivity to the fill tube by examining lower-α implosion performance for a target supported solely by a fill tube (i.e., no stalk).

*MRS: magnetic recoil spectrometer: J. A. Frenje *et al.*, Phys. Plasmas 17, 056311 (2010).
**nTOF: neutron time-of-flight detector: C. J. Forrest *et al.*, Rev. Sci. Instrum. 83, 10D919 (2012).

I2523b

Gated x-ray images recorded during the acceleration phase at photon energies down to ~1 keV* show evidence of the fill tube perturbing the imploding shell



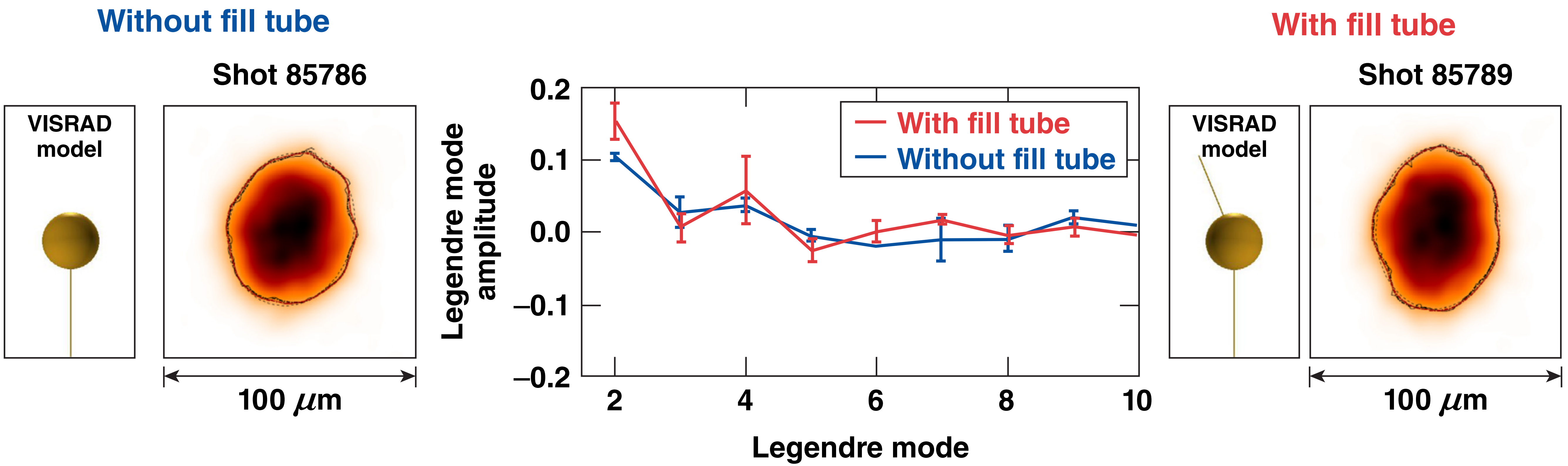
No evidence of mix from the fill tube into the hot-spot region was observed in the emission

I2522b

*D. T. Michel *et al.*, Rev. Sci. Instrum. 83, 10E530 (2012).

Gated x-ray images in the 4- to 8-keV* range recorded at stagnation show a slight change in the shape of the hot spot caused by the added fill tube

UR LLE



The fill tube slightly increases the amplitude of the $\ell = 2$ mode.

*F. J. Marshall *et al.*, Rev. Sci. Instrum. 88, 093702 (2017).

Summary/Conclusions

A small reduction in implosion performance was observed when a fill tube was added to a stalk-mounted target for an α = 4, DT cryogenic implosion on OMEGA

- These look-ahead experiments were performed for the DT cryogenic fill-tube target being developed for the 100-Gbar Campaign on OMEGA
- The measured neutron yield, areal density, and ion temperature were studied with and without the added fill tube for implosions with 1-D calculated α ~ 4, IFAR* ~ 17, and CR** ~ 23
- Gated x-ray images show evidence of the fill tube perturbing the imploding shell and the shape of the hot spot at stagnation

Future experiments will study the sensitivity to the fill tube by examining lower-α implosion performance for a target supported solely by a fill tube (i.e., no stalk).

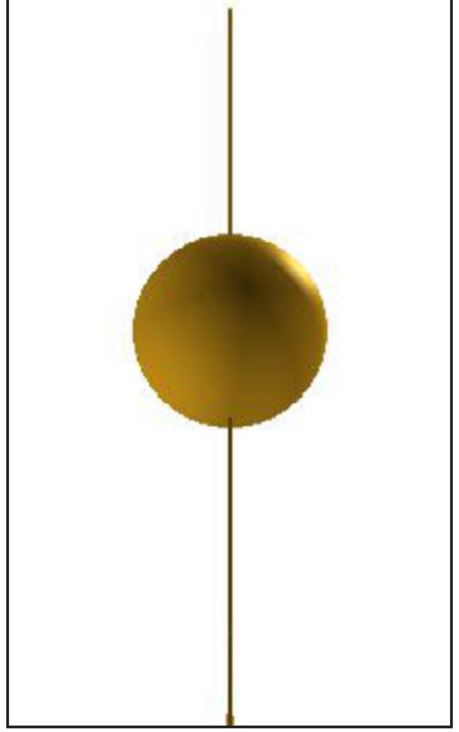
α: adiabat
*IFAR: in-flight aspect ratio
**CR: convergence ratio

TC13904

MRS and nTOF probe different parts of the compressed shell

Diagnostic line of sight
for MRS

VISRAD
model



Diagnostic line of sight
for nTOF

VISRAD
model

MRS measures forward-scattered neutrons, while nTOF measures primarily backscattered neutrons.

TC13911