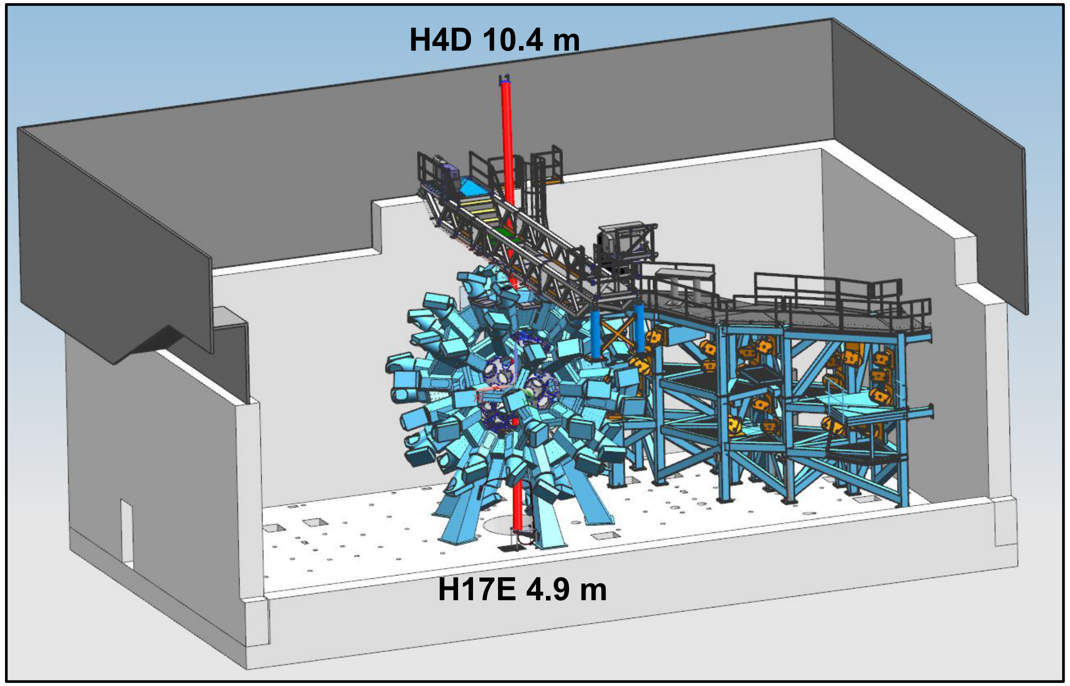
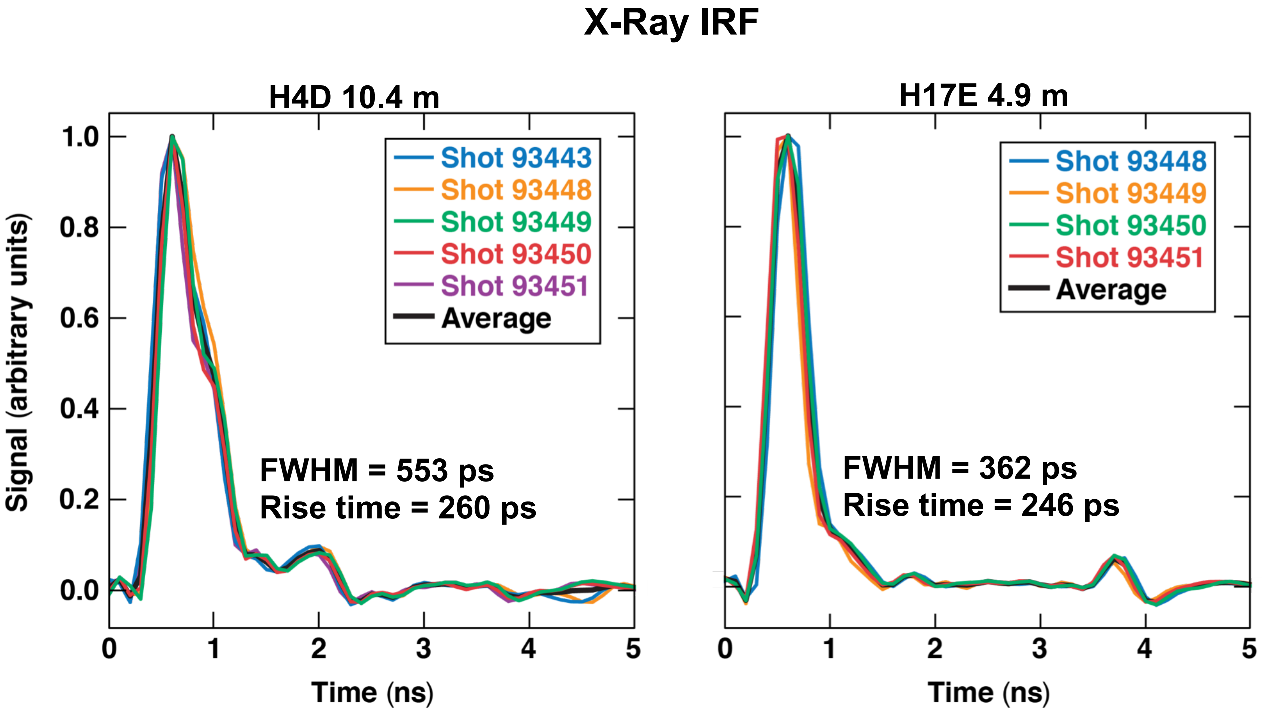
New Fast Neutron Time-of-Flight Detectors with Subnanosecond Instrument Response Function for DT Implosions on OMEGA





TC15232

V. Yu. Glebov
University of Rochester
Laboratory for Laser Energetics

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Summary

Two fast neutron time-of-flight (nTOF) detectors were recently deployed on OMEGA for hot-spot flow velocity measurements

UR LLE

- **The detectors use 10-mm-diam Hamamatsu microchannel-plate photomultiplier tubes (MCP-PMT's) without any scintillator**
- **The two PMT nTOF detectors are located along the H4D and H17E antipodal lines of sight (LOS) at 10.4 m and 4.9 m from the target chamber center (TCC)**
- **The PMT nTOF detectors measure hot-spot flow velocity,* DT yield, and DT ion temperature from 1×10^{13} to 2×10^{14} yield range**

* S. Regan *et al.*, YO5.00002, this conference.

Collaborators

C. J. Forrest, J. P. Knauer, O. M. Mannion, S. P. Regan, M. H. Romanofsky, T. C. Sangster, and C. Stoeckl

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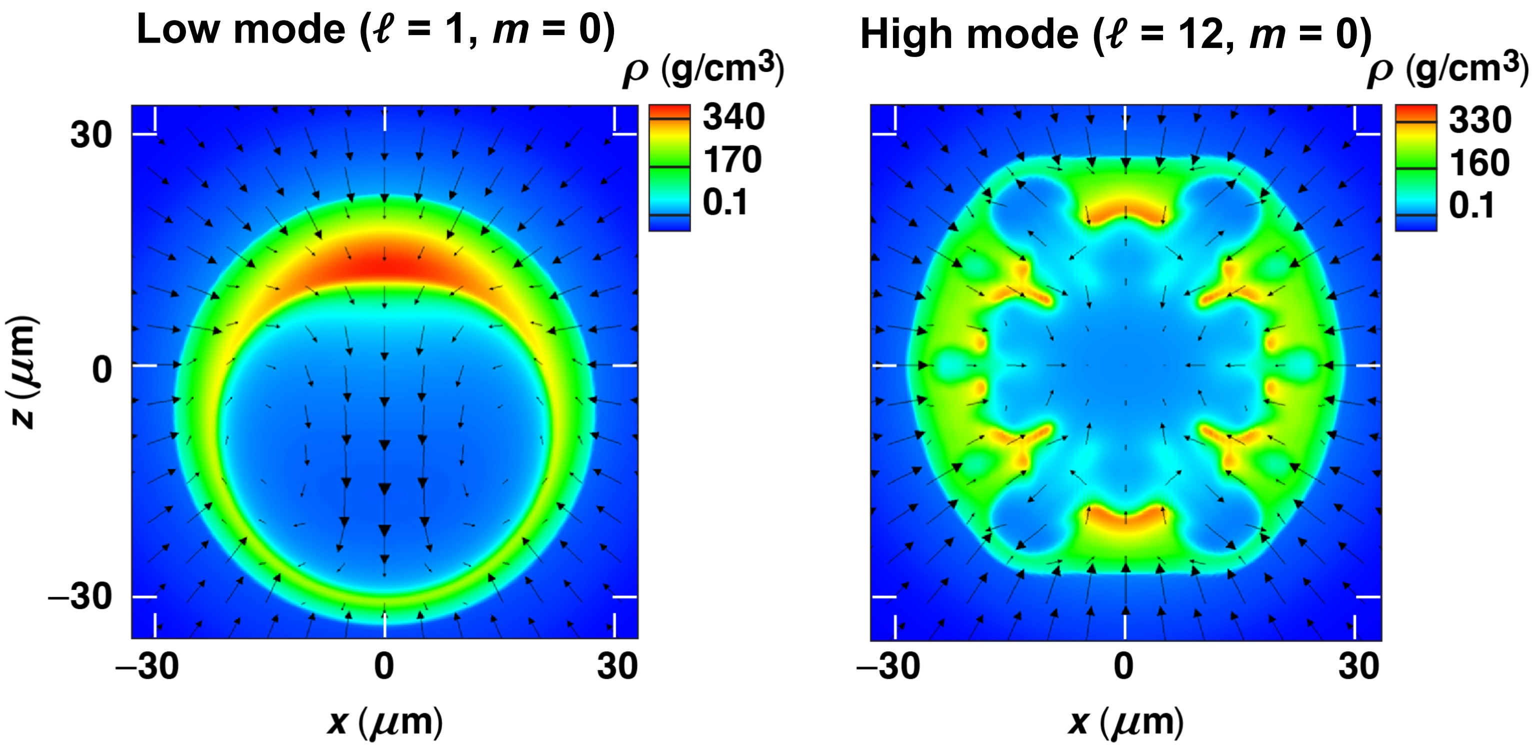
Reconstruction of the hot-spot velocity vector is key to understanding cryogenic implosion performance and assessing 3-D behavior

*DEC3D** hydrodynamic simulations



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- Asymmetric compression leads to incomplete stagnation and residual kinetic energy (RKE)
- Low modes (ℓ < 10)
  - bulk collective motion of the hot spot
- High modes (ℓ ≥ 10)
  - variations in the flow within the hot spot

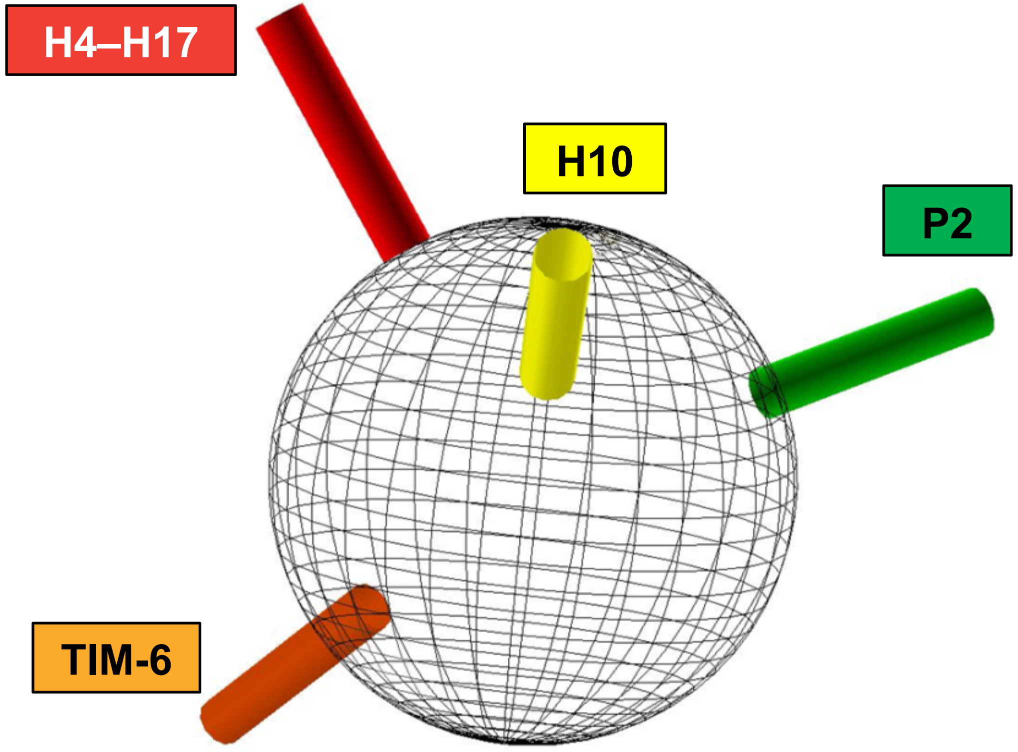
* K. M. Woo, UI2.0002, this conference (invited); K. M. Woo *et al.*, Phys. Plasmas 25, 052704 (2018).

The fast PMT detectors in H4 and H17 LOS completed the 3dnTOF suite* with four quasi-orthogonal LOS to measure the hot-spot flow velocity

The 3dnTOF detector suite uses a variety of detector technologies

- **H10** 22-m Petal (scintillator + PMT)
- **P2** 5.8-m CVD and 15.8-m CVD
- **H4–H17** 10.4-m PMT and 4.9-m PMT
- **TIM-6** 13 m-Petal (scintillator + PMT)

3dnTOF lines of sight



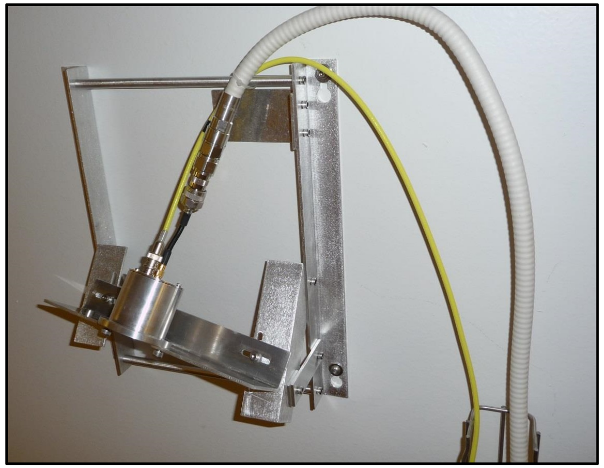
Independent measurements in four separate LOS are necessary to infer the hot-spot flow velocity**

CVD: chemical-vapor deposition
TIM: ten-inch manipulator

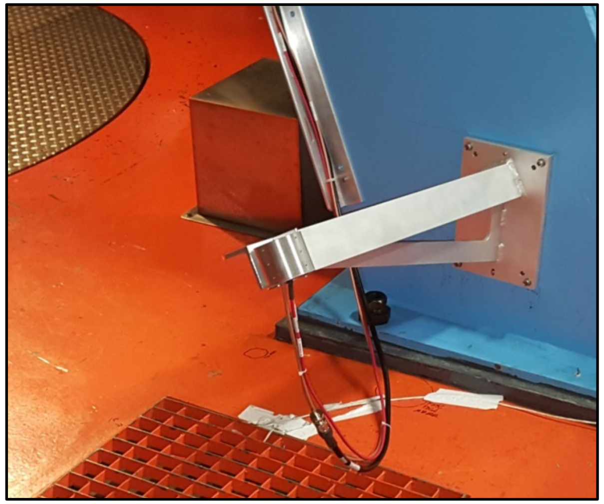
*O. M. Mannion *et al.*, "A Suite of Neutron Time-of-Flight Detectors for Measurements of Hot Spot Motion in Direct Drive Inertial Confinement Fusion Experiments on OMEGA," to be submitted to Nuclear Instruments and Methods.
** R. Hatarik *et al.*, Rev. Sci. Instrum. 89, 10I138 (2018).

The two 10-mm-diam Hamamatsu PMT's were installed in the H4D and H17E antipodal LOS at 10.4 m and 4.9 m from TCC

H4D 10.4 m
R3809U-52
ungated



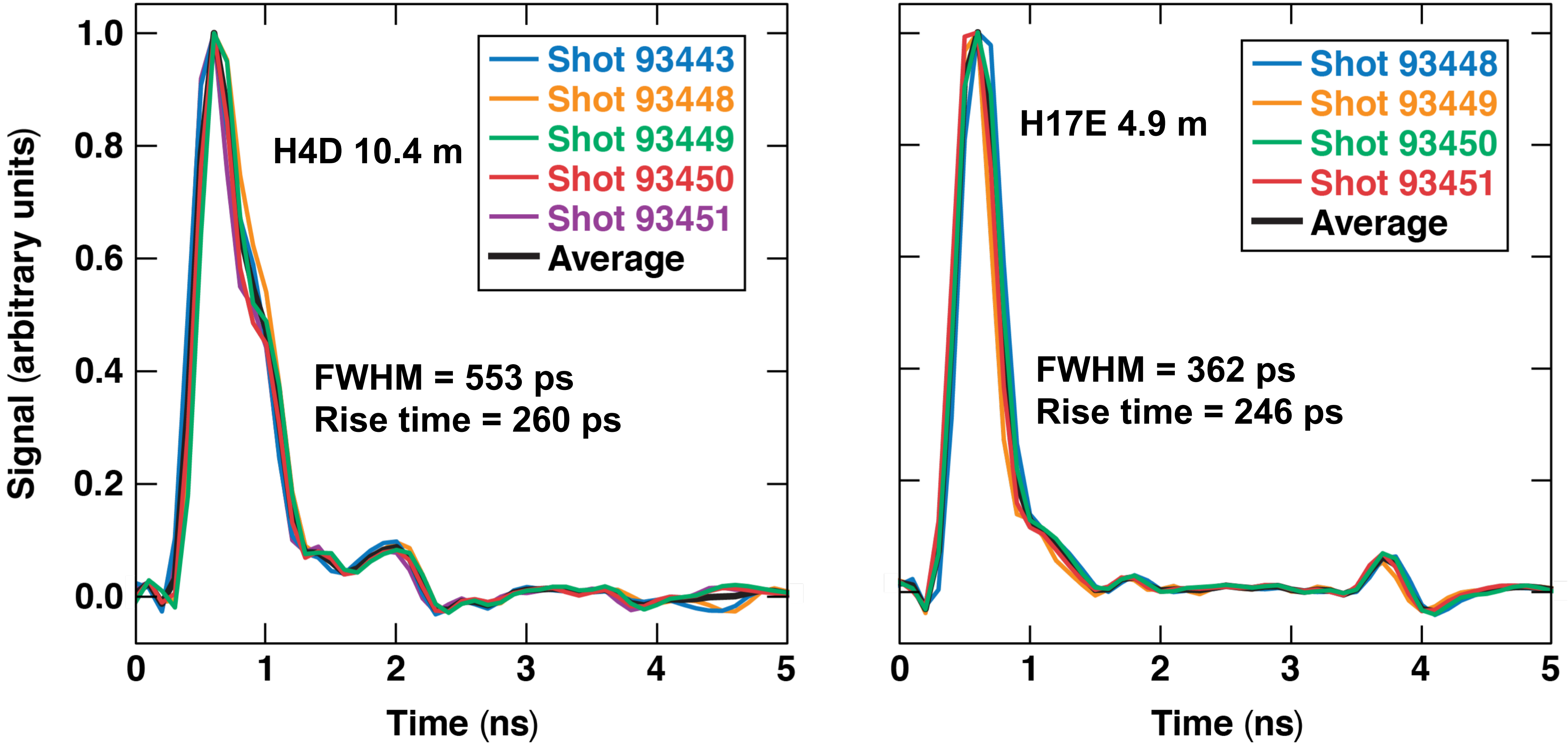
H17E 4.9 m
R5916U-50
gated



- Each PMT was installed in a thin aluminum housing without a scintillator
- Two-stage MCP with gain up to 10^6
- 15-m HV and signal cables
- Keysight DSOS254A 2.5-GHz, 20-Gs/s scope
- SRS PS-300 HV power supply
- SRS DG535 delay generator for gate pulse
- Signal split into three scope channels
- An optical fiducial in fourth scope channel

HV: high voltage

The x-ray instrument response function (IRF) for H4D and H17E nTOF detectors were measured with a 100-ps laser pulse on a gold target



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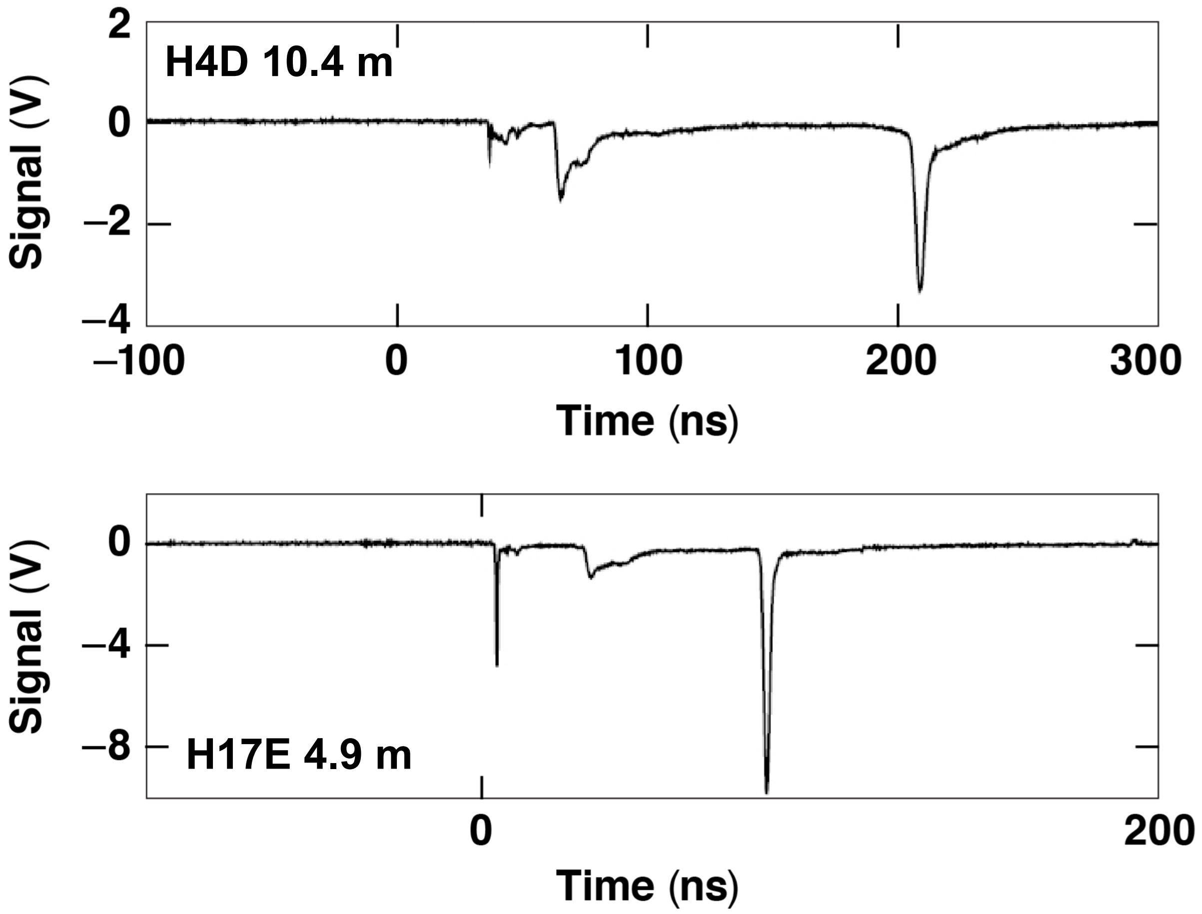
The PMT nTOF detectors are sensitive to hard x rays, gammas from (n,γ) interactions, and DT neutrons



Shot 93868, $Y = 1.4 \times 10^{14}$, $T_i = 9.2$ keV

In order to have low signals from the x–rays and gammas and not saturate the PMT, we run the PMT at a very low gain of about 100.

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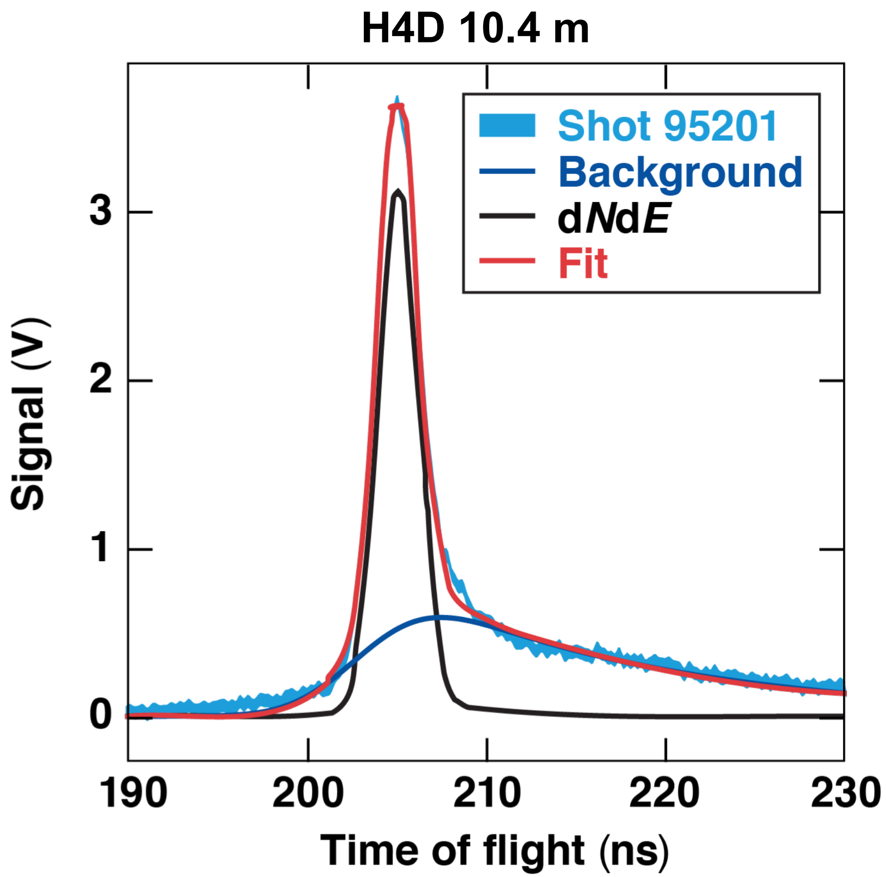
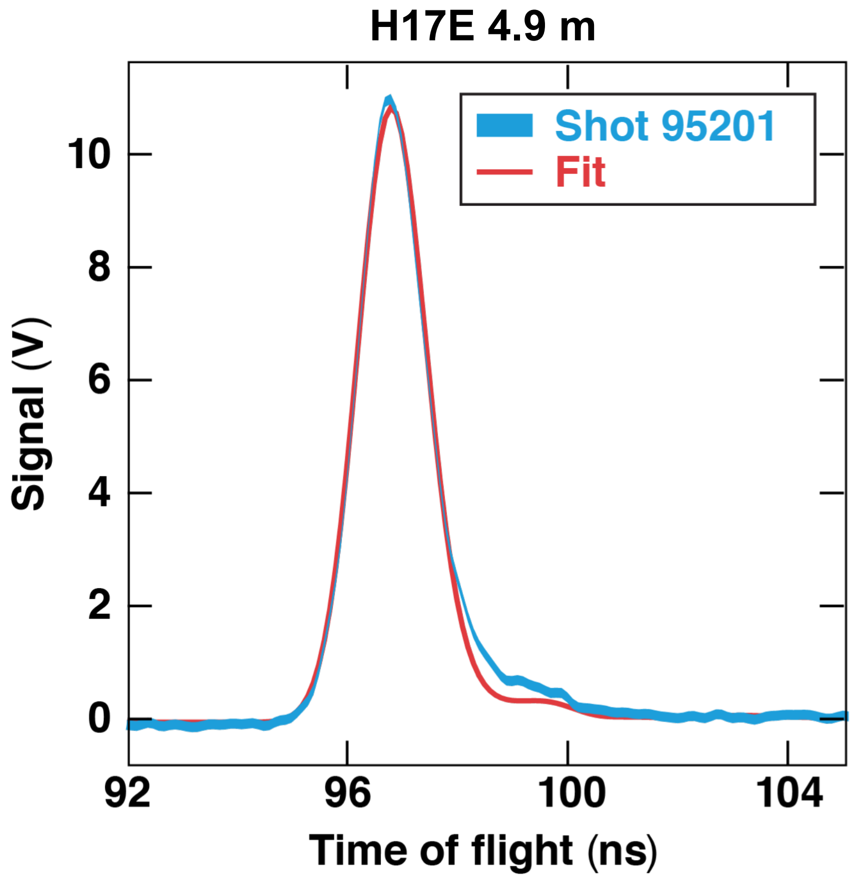
The hot-spot flow velocity from the H4D and H17E nTOF detectors was calculated by the forward-fitting method





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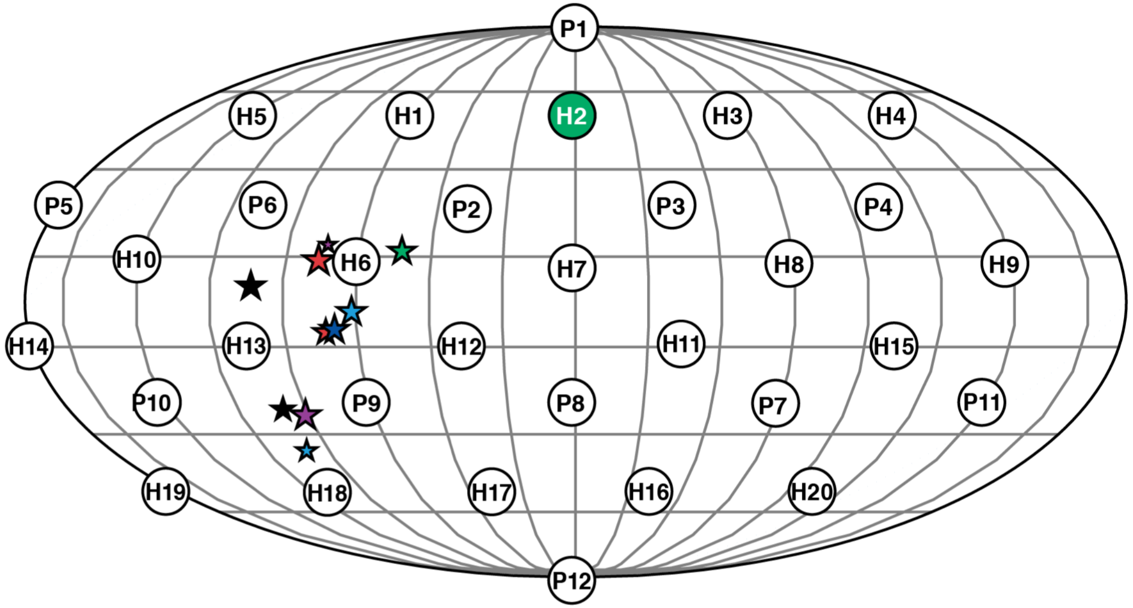
The (n,γ) interactions with the wall produced an additional background

There is a very small background in the H17E location

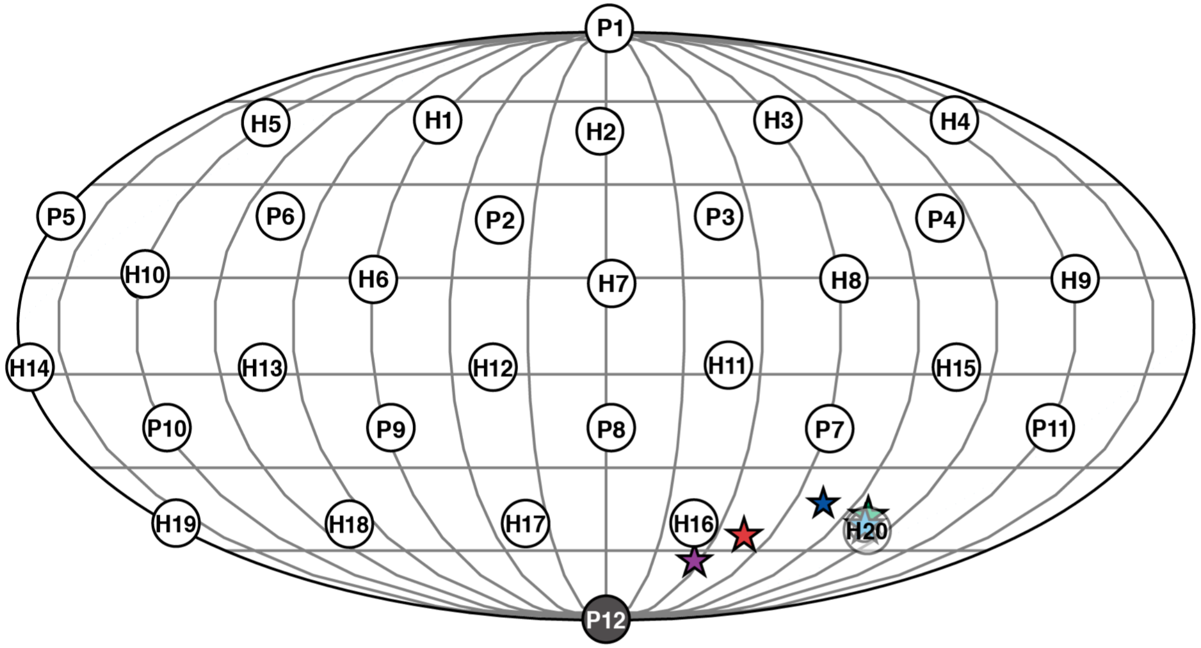
The hot-spot flow velocity is now measured on OMEGA for DT cryogenic and room-temperature target implosions

Exploding pusher 07/25/19 shots



- Stalk (TPS2)
- Shot 94510 flow direction (64.2 km/s)
- Shot 94512 flow direction (43.9 km/s)
- Shot 94513 flow direction (27.7 km/s)
- Shot 94514 flow direction (80.5 km/s)
- Shot 94516 flow direction (82.6 km/s)
- Shot 94517 flow direction (75.3 km/s)
- Shot 94519 flow direction (98.8 km/s)
- Shot 94520 flow direction (83.7 km/s)

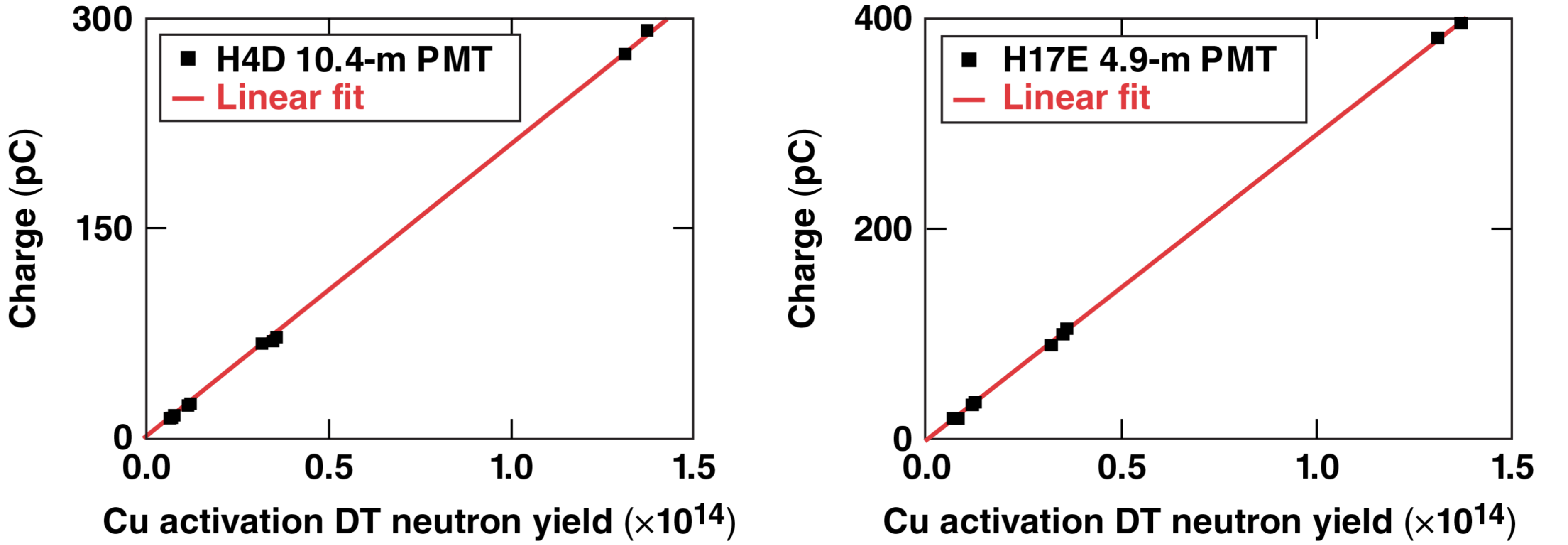
Cryogenic 07/09/19 shots



- Stalk
- Shot 94341 flow direction (76.8 km/s)
- Shot 94343 flow direction (119.6 km/s)
- Shot 94346 flow direction (105.0 km/s)
- Shot 94348 flow direction (131.3 km/s)
- Shot 94350 flow direction (99.0 km/s)

TC15231

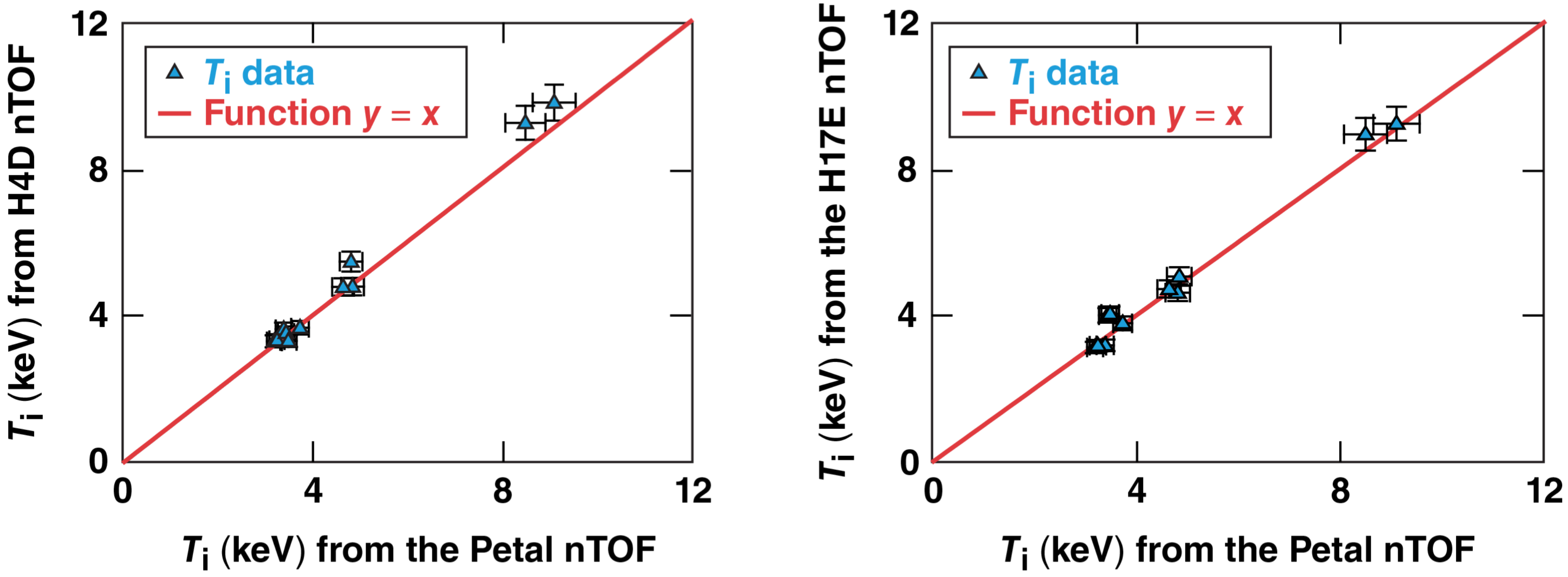
The H4D and H17E nTOF detectors were calibrated for DT yield on OMEGA against the Cu activation diagnostic in room-temperature targets with high-adiabat implosions



TC15177

The operational yield range for these detectors is 1×10^{13} to 2×10^{14}.

The T_i measured by the H4D and H17E nTOF detectors in room-temperature shots were compared with the T_i measured by the Petal nTOF detector



TC15178

Two fast neutron time-of-flight (nTOF) detectors were recently deployed on OMEGA for hot-spot flow velocity measurements

UR LLE

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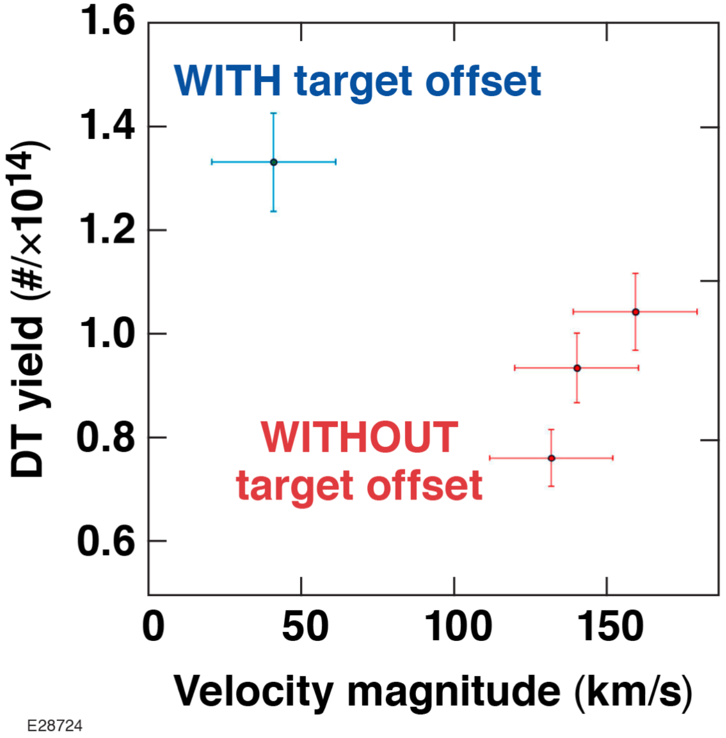
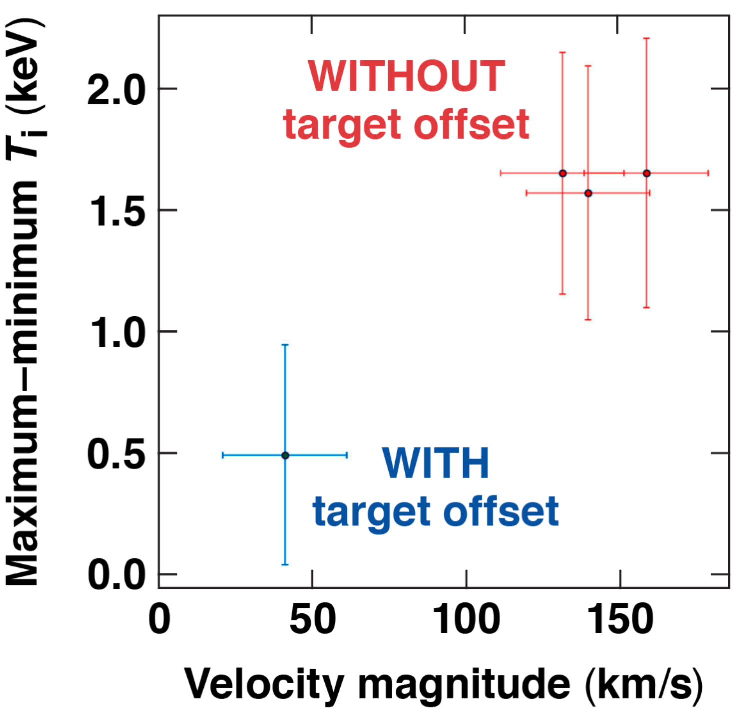
Backup

Counteracting hot-spot flow velocity by imposing an $\ell = 1$ drive asymmetry with an initial target offset improves target performance at stagnation

DT neutron yield versus hot-spot flow velocity



$T_{i\ p\text{–}v}$ versus hot-spot flow velocity



3-D measurements provide insight to improve the implosion symmetry.

* S. Regan *et al.*, YO5.00002, this conference.