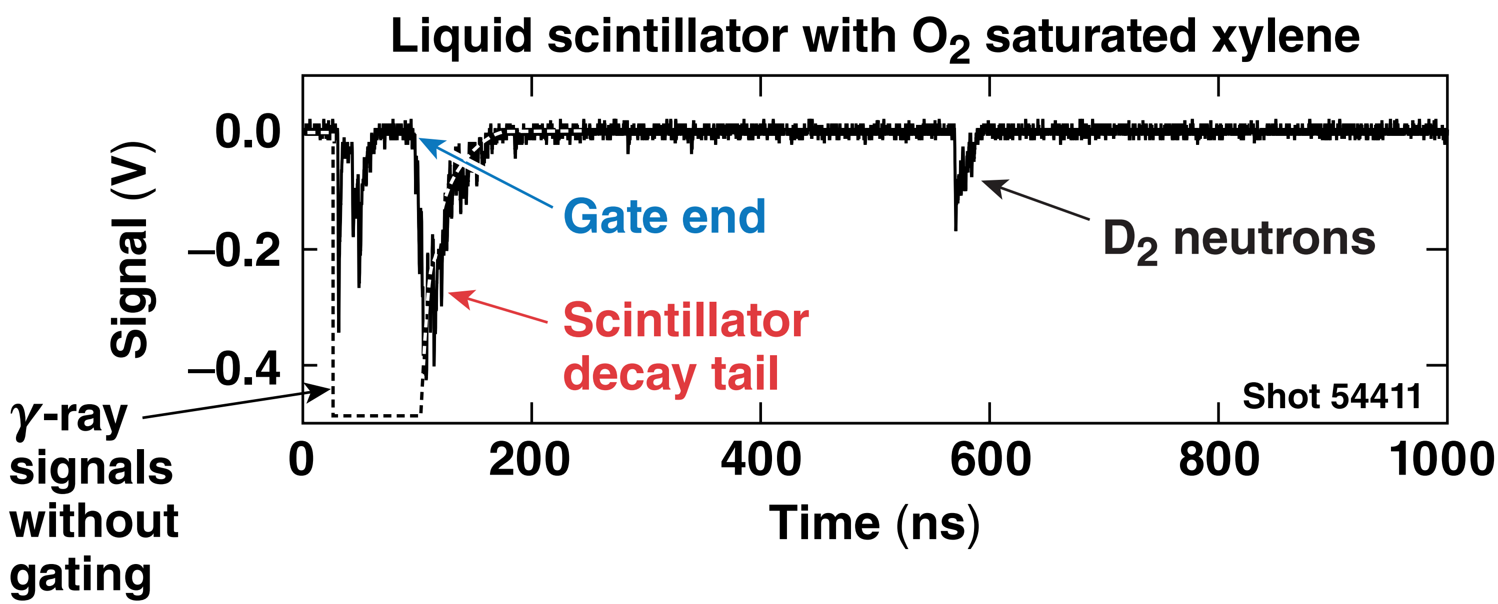
Development of Scintillator Detectors for Fast-Ignition Experiments and Down-Scattered Neutron Measurements



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

51st Annual Meeting of the
American Physical Society
Division of Plasma Physics
Atlanta, GA
2–6 November 2009

Summary

Scintillator detectors have been developed for fast-ignition experiments and down-scattered neutron measurements

UR LLE

- A small signal must be recorded after a very large DT or hard x-ray signal in a neutron time-of-flight detector to measure down-scattered neutrons in cryogenic-DT implosions or to measure neutron yield after gamma flesh in fast-ignition (FI) experiments.

- Several detectors with plastic and liquid scintillators were tested at the Omega/Omega EP Laser Facility for cryogenic-DT implosions and integrated fast-ignition experiments.

- Only nTOF detectors with an oxidized liquid scintillator and gated PMT outside a direct line of sight are suitable for FI experiments and down-scattered neutron measurements.

Collaborators

C. Stoeckl, W. Theobald, T. C. Sangster, K. L. Marshall, M. Cruz, M. J. Shoup III, T. Buczek, A. Pruyne, M. Fox, and T. Duffy

University of Rochester
Laboratory for Laser Energetics

M. J. Moran

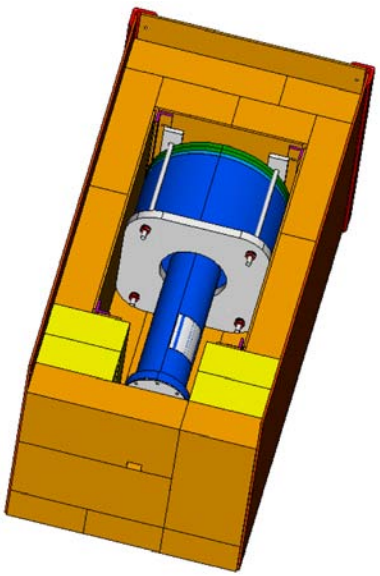
Lawrence Livermore National laboratory

R. Lauck

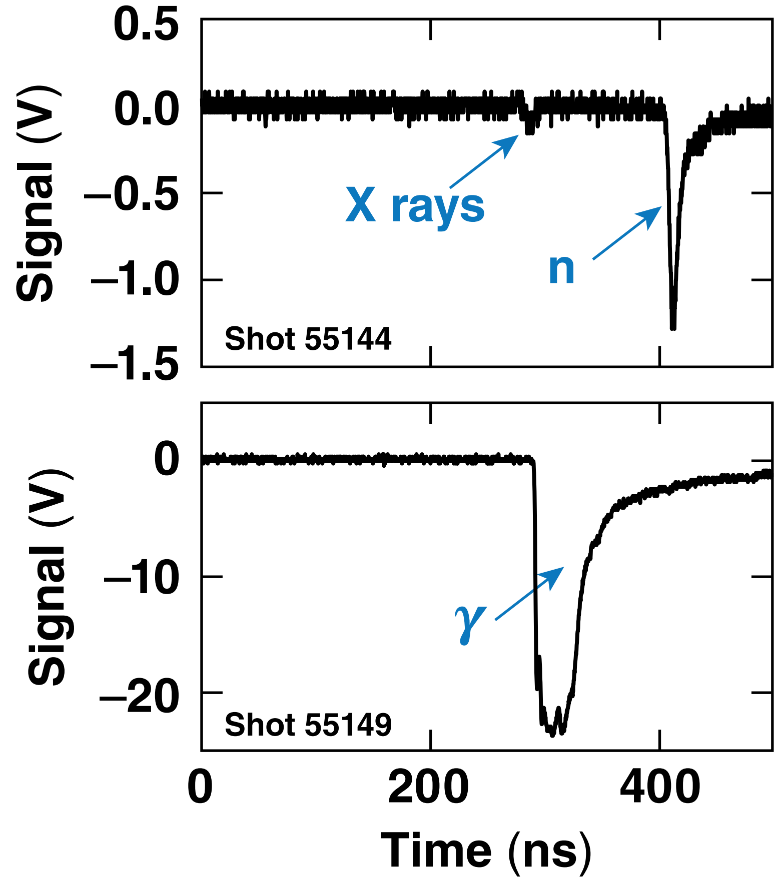
Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Thick lead is an ineffective scintillator shield in FI-cone experiments and down-scattered neutron measurements

A thick-lead shielded detector



Pilot B plastic scintillator
17.78-cm diam, 10-cm thick
XP2020 PMT, gain 10^6
at 2 m from a target



Au cone + CD
$Y_{D_2} = 1.1 \times 10^7$
No fast beam

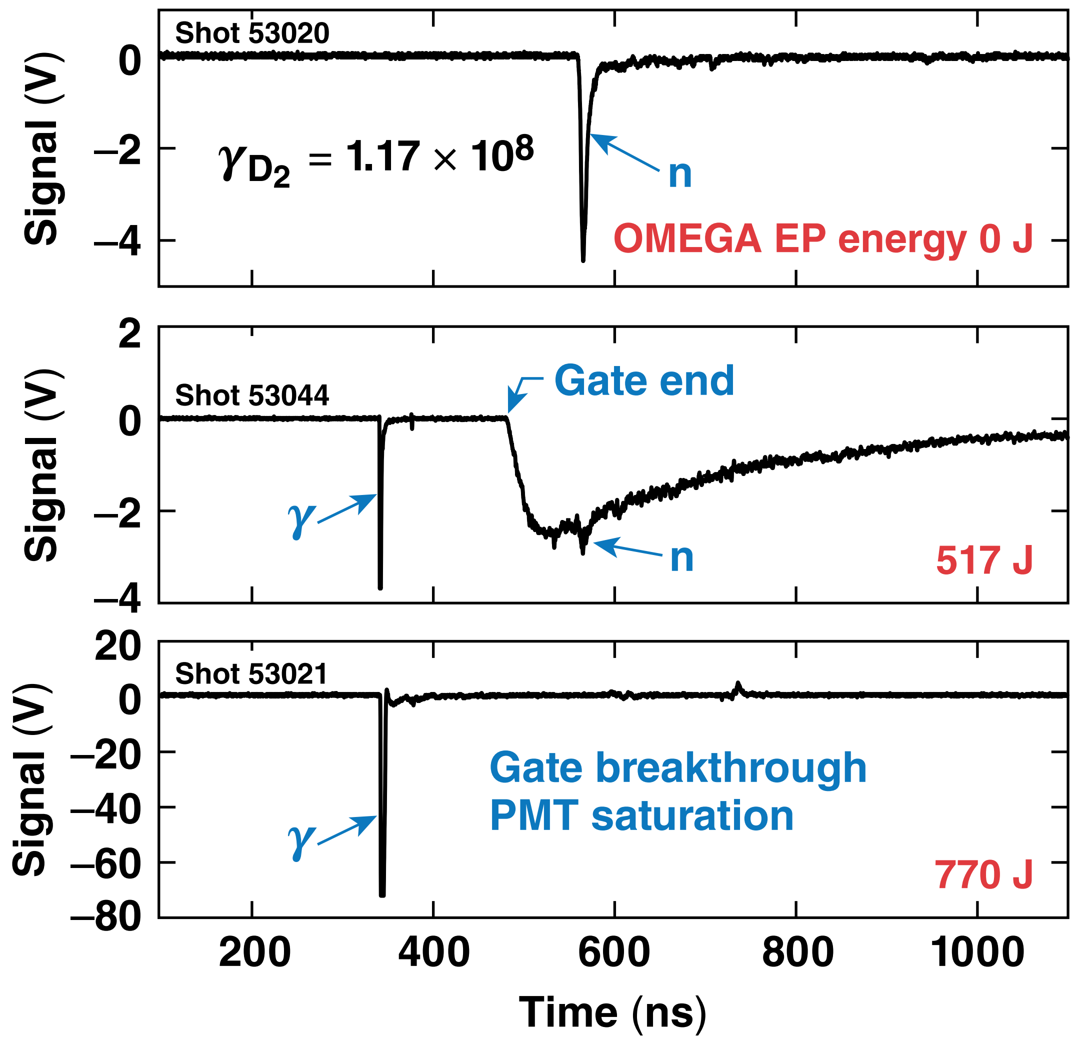
Au cone + CD
$Y_{D_2} = 1.6 \times 10^7$
10-ps, 1-kJ
OMEGA EP beam
PMT is saturated

In FI experiments gammas penetrate lead and saturate the PMT. Lead does not shield the 14.1-MeV neutrons in down-scattered measurements.

A gated PMT in direct line of sight operates only for low energy of the short-pulse laser or low DT yield

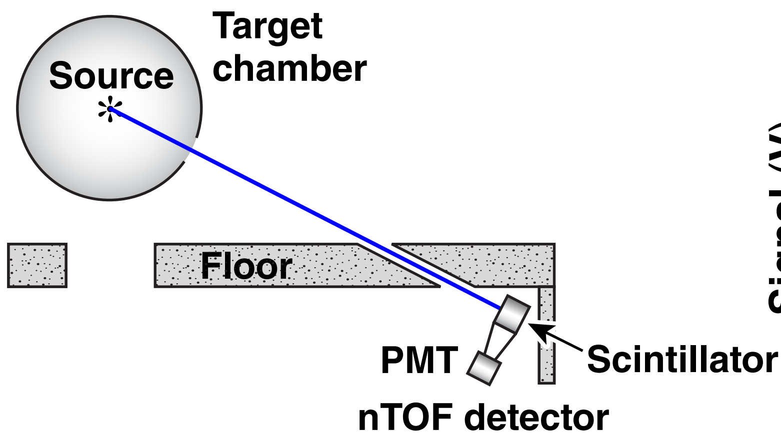
UR LLE

BC-422 plastic scintillator
40-mm diam, 20-mm thick
Photek PMT-240 gated PMT
Two-stage MCP, gain 10^6
At 5.2 m from a target
1-in. Pb shielding all around

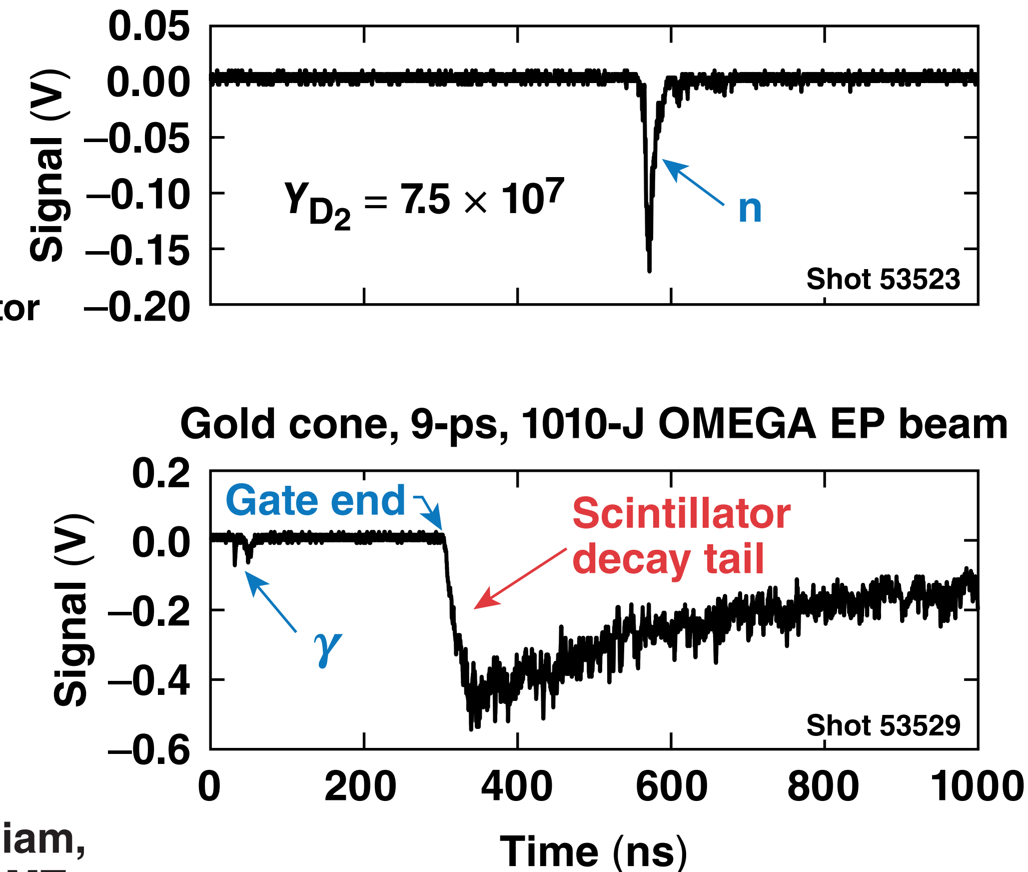


E18371

A nTOF detector with gated PMT outside direct line of sight operates at any energy of the short-pulse laser



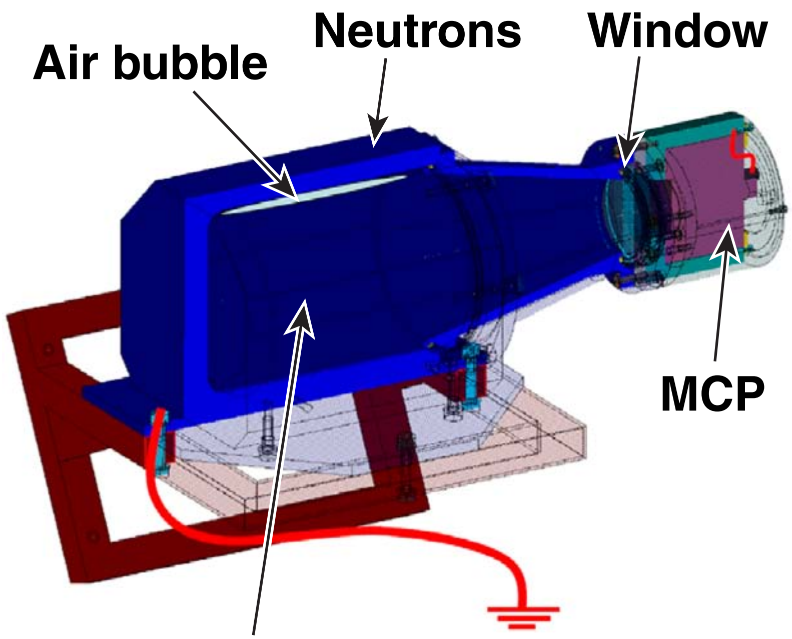
Pilot B plastic scintillator, 17.78-cm diam, 10-cm thick, Photek PMT-240 gated PMT two-stage MCP, gain 10^6 at 12.4 m from a target

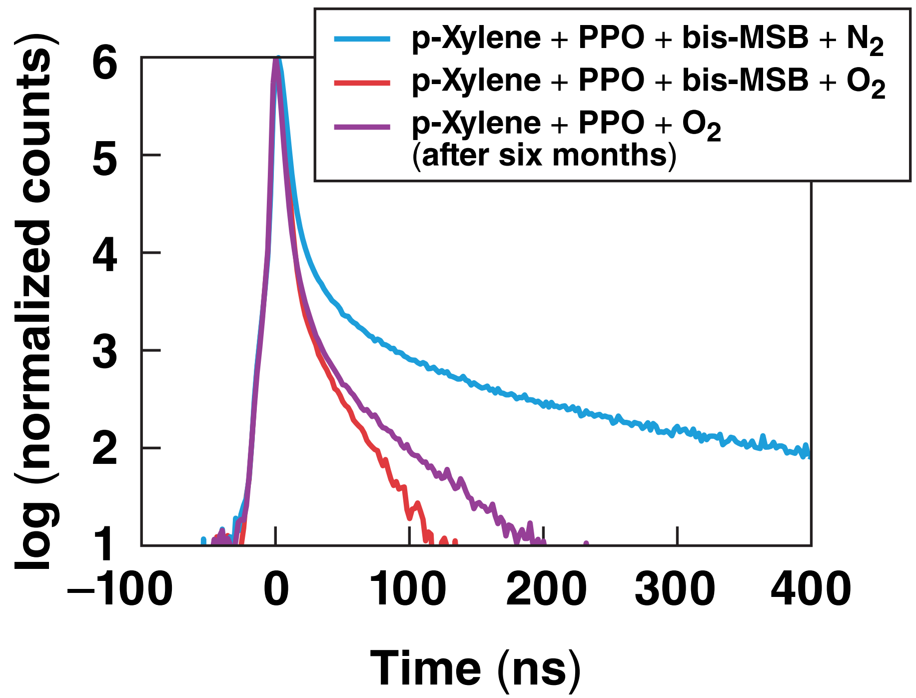


The main problem of this nTOF detector is a long scintillator decay tail.

E18372

A new nTOF detector with an oxidized liquid scintillator and gated PMT measures neutron yields in FI experiments

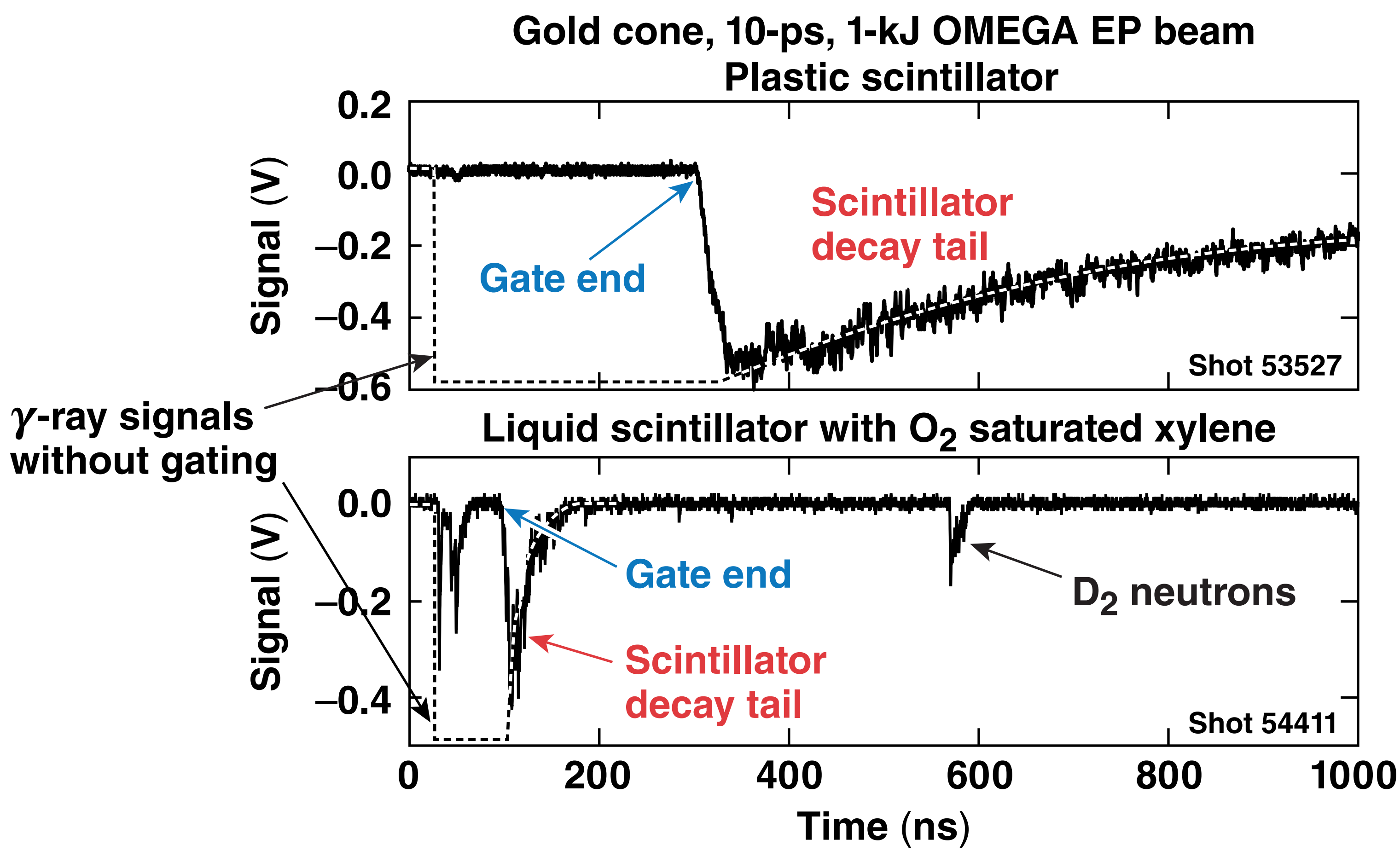




Liquid scintillators enriched with an O_2 quenching agent have a fast-decay time—the γ-ray-induced fluorescence is efficiently suppressed.

R. Lauck *et al.*, IEEE Transactions on Nuclear Science 56, 989 (2009).

The nTOF detector with an oxidized liquid scintillator has no long decay tail from a strong γ-ray pulse



This nTOF detector was used in FI experiments to measure the D_2 neutron yield.

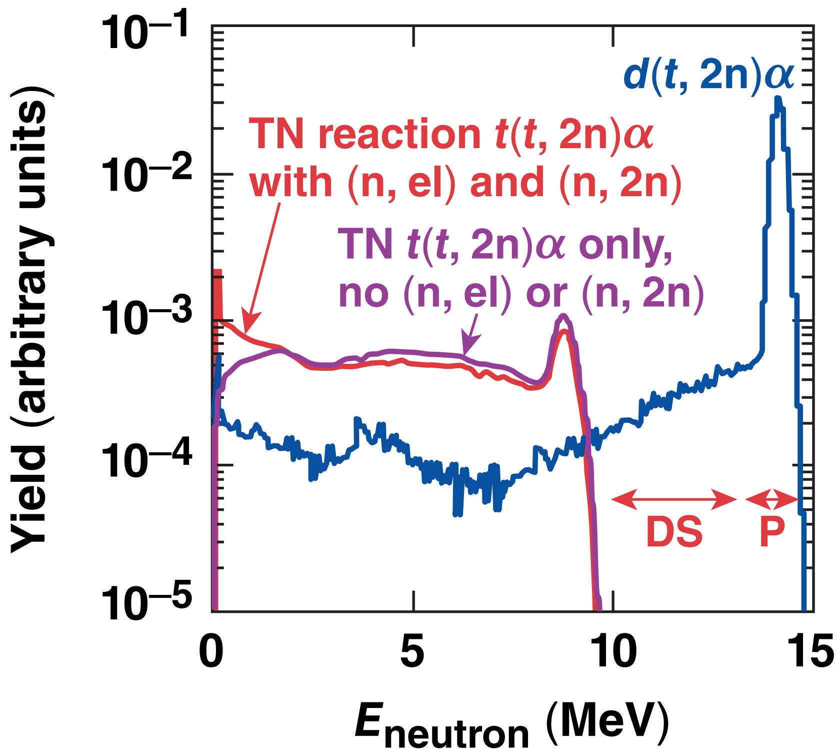
E18058d

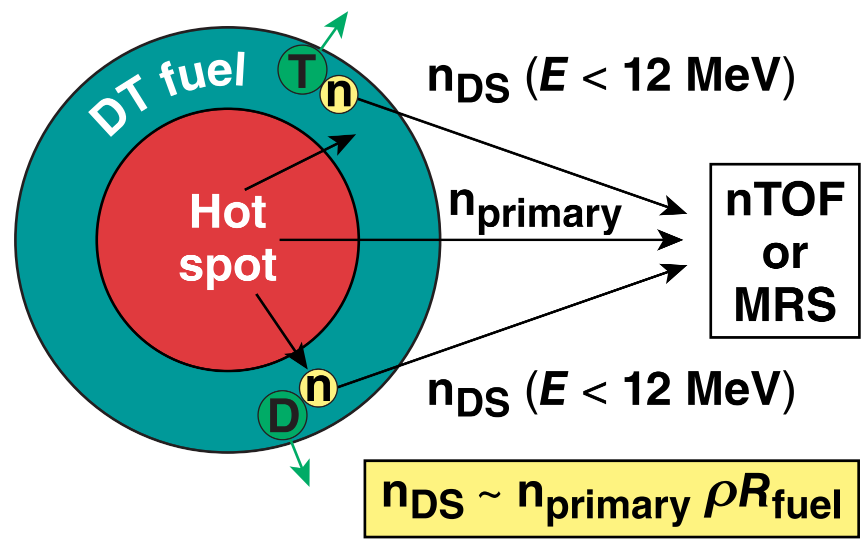
See W. Theobald (N05.00003)

The only way to infer the ρR on the NIF in 2010 will be the primary neutrons "downscattered fraction"

UR LLE

The NIF will use Tritium:Hydrogen:Deuterium (75:23:2) fuel (THD) for the at-scale parameters tuning of ICF implosions

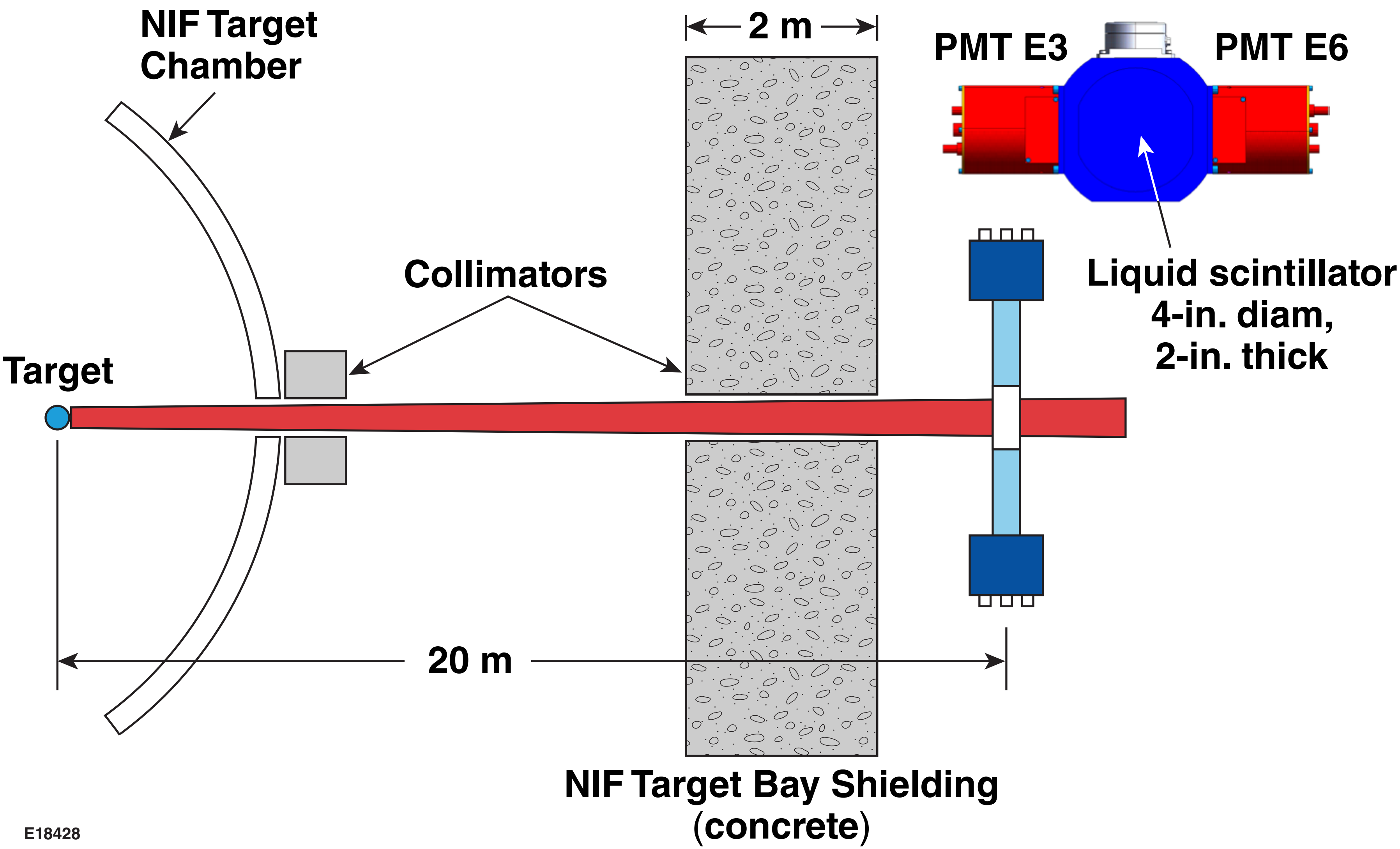




Much of our recent effort has focused on how to measure the "down-scatter fraction" using nTOF techniques—we are testing a solution now!

E18152b

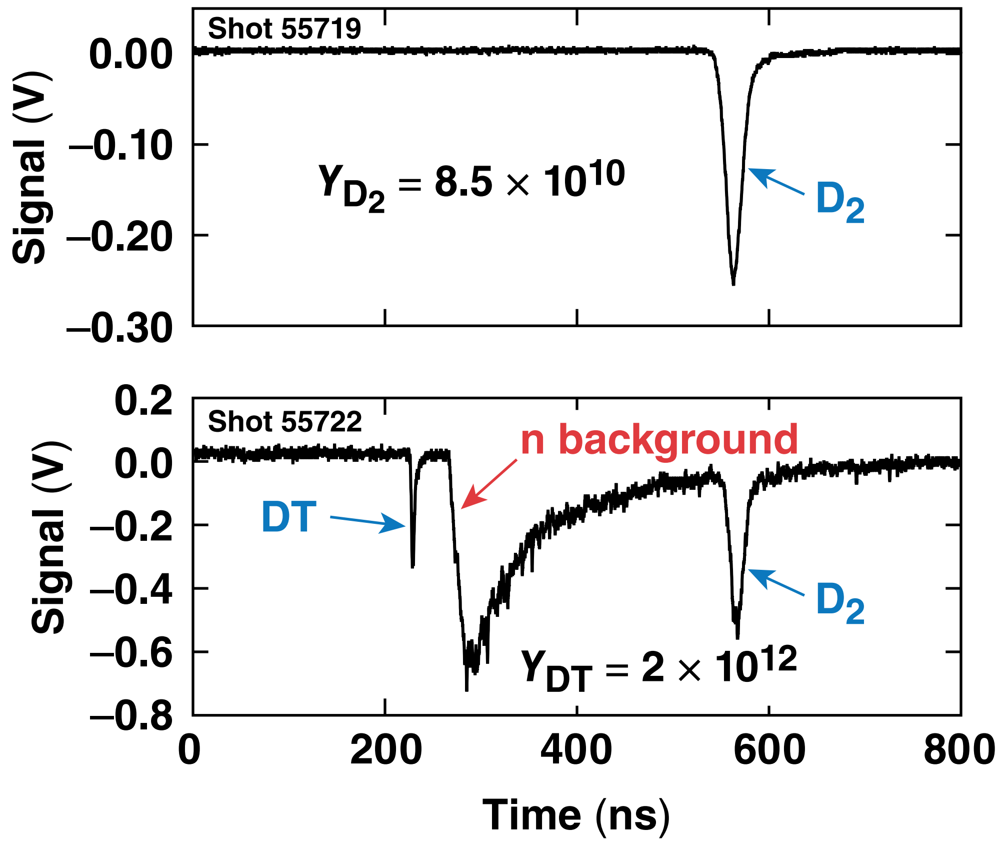
The NIF nTOF20-Spec system will consist of the two collimators and a large scintillator with two gated PMT



E18428

Testing and calibration of nTOF20-Spec detectors is ongoing on OMEGA

nTOF20-spec prototype on OMEGA



Calibration of the two NIF nTOF20-Spec detectors will be completed on OMEGA before February 2010.

Summary/Conclusions

Scintillator detectors have been developed for fast-ignition experiments and down-scattered neutron measurements

UR LLE

- A small signal must be recorded after a very large DT or hard x-ray signal in a neutron time-of-flight detector to measure down-scattered neutrons in cryogenic-DT implosions or to measure neutron yield after gamma flesh in fast-ignition (FI) experiments.

- Several detectors with plastic and liquid scintillators were tested at the Omega/Omega EP Laser Facility for cryogenic-DT implosions and integrated fast-ignition experiments.

- Only nTOF detectors with an oxidized liquid scintillator and gated PMT outside a direct line of sight are suitable for FI experiments and down-scattered neutron measurements.