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

Liquid scintillator with O₂ saturated xylene

 γ-ray signals without gating

Signal (V)

0.0

-0.2

-0.4

Gate end

D₂ neutrons

Scintillator decay tail

0 200 400 600 800 1000

Time (ns)

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Summary

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

• 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


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

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

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

\[ \gamma_{D_2} = 1.17 \times 10^8 \]

OMEGA EP energy 0 J

Gate breakthrough
PMT saturation

\[ \gamma = \frac{c}{\tau} \]

\[ D_2 = 1.17 \times 10^{8} \]

\[ \gamma = 517 \text{ J} \]

\[ \gamma = 770 \text{ J} \]
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.
A new nTOF detector with an oxidized liquid scintillator and gated PMT measures neutron yields in FI experiments.

Liquid scintillators enriched with an O₂ quenching agent have a fast-decay time—the γ-ray-induced fluorescence is efficiently suppressed.

The nTOF detector with an oxidized liquid scintillator has no long decay tail from a strong $\gamma$-ray pulse.

This nTOF detector was used in FI experiments to measure the D$_2$ neutron yield.
The only way to infer the $\rho R$ on the NIF in 2010 will be the primary neutrons “downscattered fraction.”

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!
The NIF nTOF20-Spec system will consist of the two collimators and a large scintillator with two gated PMT.
Testing and calibration of nTOF20-Spec detectors is ongoing 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.

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