Proton Temporal Diagnostic for ICF Experiments on OMEGA

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Summary

We developed a proton temporal diagnostic (PTD) to record a fusion reaction history of protons in a D$_3$He implosion

- PTD is a TIM diagnostic based on a fast scintillator, optical system, and optical streak camera with an instrumental resolution of 25 ps.

- PTD is used to determine shock time and $\rho R$ evolution in D$_3$He implosions. (J. A. Frenje, F12.004)

- The neutron bang time and total $\rho R$ can be inferred from PTD data in D$_2$ implosions.

- The PTD can operate as a fast hard-x-ray detector with an x-ray cutoff energy between 10 keV and 100 keV.
The PTD is based on a fast scintillator, optical system, high-speed streak camera, and OMEGA fiducial system.
A 100-µm Ta filter is close to optimum for PTD

PTD signal
100 µm Ta

PTD signal
200 µm Ta

Shot #29807
D₂(3)CH[19.3]
1-ns square pulse
Yₙ = 3.1 × 10¹⁰

Shot #29808
D₂(3)CH[19.3]
1-ns square pulse
Yₙ = 3.3 × 10¹⁰
A 100-μm Ta filter is close to optimum for PTD

PTD signal
100 μm Ta

Protons

Shot #28935
$^3$He(12)D$_2$(6)CH[19.8]
Shaped pulse with $\alpha = 5$
$Y_n = 3.7 \times 10^9$

PTD signal
50 μm Ta

Protons

Shot #28936
$^3$He(12)D$_2$(6)CH[19.9]
Shaped pulse with $\alpha = 5$
$Y_n = 4.0 \times 10^9$
PTD timing calibration was performed with 100-μm Al filter and 100-ps laser pulse on a gold ball target.

Comparison of PTD and neutron temporal diagnostic (NTD) signals suggests the presence of hot electrons with energies of 100 to 300 keV.
PTD is used to measure shock time and infer $\rho R$ evolution in $D^3He$ implosions.

$D^3He(18)\ CH[24]$

Shock peak is much more evident in PTD data than in NTD and WRF data.
The ratio of proton shock yield to compression yield in a D\textsuperscript{3}He implosion is a function of shell thickness.
In D$_2$ implosions PTD can measure neutron bang and burn width almost as well as NTD*.

* Neutron temporal diagnostics (NTD); R. A. Lerche et al., RSI 66 (1), 933 (1995).
The total $\rho R$ can be inferred from secondary protons energy downshift measured by PTD in D$_2$ implosions.

Energy downshift is measured from the time-of-flight difference between secondary protons and primary neutrons.
The PTD can operate as a fast hard-x-ray detector with a x-ray cutoff energy between 10 and 100 keV.
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- PTD is a TIM diagnostic based on a fast scintillator, optical system, and optical streak camera with an instrumental resolution of 25 ps.
- PTD is used to determine shock time and $\rho R$ evolution in D$_3$He implosions. (J. A. Frenje, FI2.004)
- The neutron bang time and total $\rho R$ can be inferred from PTD data in D$_2$ implosions.
- The PTD can operate as a fast hard-x-ray detector with an x-ray cutoff energy between 10 keV and 100 keV.