Measurements of $D_2$ Neutron Yield and Ion Temperature in DT Implosions on OMEGA

![Graph showing the DT/D$_2$ yield ratio versus DT ion temperature (keV) with Theoretical prediction, nTOF20-Spec6, and Charge-particle spectrometer data.]

- **Theoretical prediction**
- **nTOF20-Spec6**
- **Charge-particle spectrometer**

- **SiO$_2$**
- **Cryo**
- **CH**
- **CH**

- D:T = 58:42
- D:T = 64:36

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The $D_2$ neutron yield and ion temperature in DT implosions have been measured on OMEGA

- A dedicated neutron time-of-flight (nTOF) detector and a collimated line of sight were developed on OMEGA to measure $D_2$ neutron yield and ion temperature in DT implosions

- The independently measured DT and $D_2$ ion temperatures are consistent with a single thermal source

- The experimentally measured ratio of DT to $D_2$ neutron yields is in good agreement with LILAC simulations of DT cryogenic implosions, and somewhat higher than the prediction of an ice-block model

Related talks: N06.00004, N13.00005
Collaborators

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The measurement of $D_2$ yield and $T_i$ in DT implosions required a new detector and a collimated line of sight

- To record a small $D_2$ signal after a DT signal that is 350 to 1000× higher, the following requirements must be satisfied:
  - the nTOF detector has a gated PMT to eliminate the DT peak and avoid photomultiplier tube (PMT) saturation
  - the time separation between DT and $D_2$ peaks is larger than the PMT gate recovery time
  - low-afterglow scintillators like oxygenated xylene\textsuperscript{1}, EJ-399-17 ("Liquid A")\textsuperscript{2}, and bibenzyl crystal\textsuperscript{3} are used

\textsuperscript{1}C. Stoeckl et al., Rev. Sci. Instrum 81, 10D302 (2010).
\textsuperscript{2}www.eljentechnology.com
\textsuperscript{3}N. Zaitseva et al., LLNL-JRNL-414904 (2009).
The nTOF20-Spec6 detector* filled with oxygenated xylene is being used for DT/D₂ ratio measurements

- Gated PMT 240 records the D₂ neutron signal
- Ungated PMT 140 records the DT neutron signal

The nTOF20-Spec6 detector was calibrated *in-situ* in D$_2$ shots on OMEGA with the same gate as in DT shots.
A typical scope trace from the gated PMT-240 in a DT implosion clearly shows the D₂ neutron peak.

Shot 63659

\( Y_{DT} = 3.7 \times 10^{12} \)

\( Y_{D_2} = 2.6 \times 10^{10} \)

\( T_i = 2.2 \text{ keV} \)
The measured DT/D₂ yield ratios are somewhat higher than the prediction of an ice-block model.

An ice-block model assumes constant \( n_d, n_t, T_i \), and a fixed D to T ratio in the fuel.

- 36% T is a recent measurement
- Value to be confirmed by LLNL experts
- Systematic error now being determined
- 10% systematic error in T fraction is possible
There is good agreement between data and *LILAC* simulations of the DT/D$_2$ yield ratio in cryogenic shots.

Only recent shots with 25-μm target offsets are shown.
The independently measured DT and D₂ ion temperatures are consistent with a single thermal source.
**Summary/Conclusions**

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- The independently measured DT and $D_2$ ion temperatures are consistent with a single thermal source

- The experimentally measured ratio of DT to $D_2$ neutron yields is in good agreement with *LILAC* simulations of DT cryogenic implosions, and somewhat higher than the prediction of an ice-block model