Measuring Neutron-Induced d-Breakup Reactions Using High-Yield DT Implosions on OMEGA: Large inertial confinement fusion (ICF) facilities can be used to provide data with accuracies comparable to or exceeding what can be done on accelerators.[1,2] Persisting discrepancies between experimental and theoretical models of the energy cross section from neutron-induced deuterium-breakup d(n,2n) p reactions [Fig. 1(a)] warrant a new approach to accurately measure this cross section.[3] Theoretical calculations suggest that if the strong force includes three-nucleon force (3N) contributions, an enhancement in the total d(n,2n)p differential cross sections for the neutron-deuteron scattering will be present.[4] The majority of the available d(n,2n)p cross-section values at a neutron energy of 14.1 MeV are inferred from the proton spectrum and are considerably larger than the predictions of rigorous 3N calculations based on realistic nucleon–nucleon (NN) interactions. Initial OMEGA experiments examined the neutron-induced breakup reaction of deuterium. The targets used for this experiment were 1050-μm-diam, 2.5-μm-thick SiO_2 shells filled with an equimolar concentration of deuterium–tritium. Neutron yields of up to 6×10^{13} are produced with 30-kJ, 1-ns-square laser pulses. High-resolution neutron time-of-flight (nTOF) spectroscopy is used on OMEGA to study the deuterium breakup reaction signal from an interaction vessel (NIV) filled with either D_2O or H_2O located close to the implosion target—the source of the primary 14.1-MeV DT fusion neutrons [Fig. 1(b)]. A highly collimated nTOF detector positioned 13.4 m from the target chamber center is used to record the signal from the interaction of the primary neutrons with the D_2O or H_2O. The vessel is constructed from thin-wall (2-mm) aluminum to minimize neutron scattering. Modeling the experimental setup using a neutron transport code [Monte Carlo N-Particle (MCNP)][5] indicated that a measurable signal from the breakup process would be present in the nTOF detector. The advanced nTOF detector fielded on OMEGA has a very large dynamic range (10^5) so that the primary DT fusion yield does not overwhelm the much smaller spectral features at lower energy. Two DT implosions with similar primary DT yields are shown in Fig. 2, confirming the MCNP signal level predictions. The spectral differences prior to 500 ns are caused by the deuterium in the NIV. The two spectra are normalized to the DT fusion yield. These spectra will be used to determine the absolute d(n,2n) spectrum. The scattered protons were measured using a charged-particle spectrometer. These data are expected to corroborate the shape of the breakup spectrum. An analysis that uses calculated differential cross sections as an input to an MCNP simulation is being developed to compare theoretical models to the experimental data.

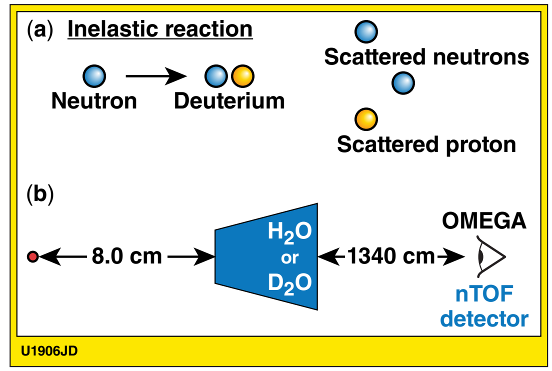

Figure 1. (a) Illustration of the inelastic deuteron breakup reaction. (b) A schematic of the nuclear interaction vessel (NIV) positioned on OMEGA. nTOF: neutron time of flight.

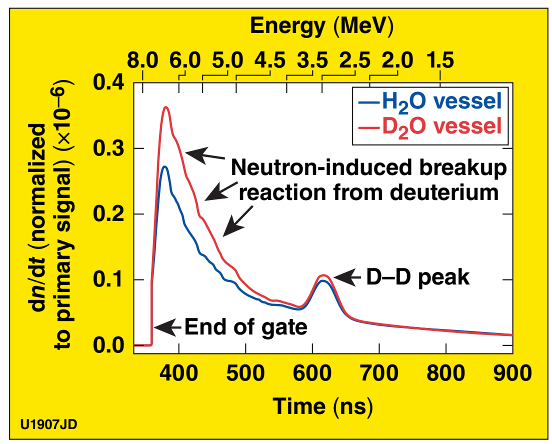

Figure 2. Time-of-flight spectra from ambient implosions with D_2O- and H_2O-filled interaction vessels are shown.

Omega Facility Operations Summary: The Omega Laser Facility conducted 191 target shots in August 2015, with an average experimental effectiveness of 93.5% (115 on OMEGA and 76 on OMEGA EP with experimental effectiveness of 95.7% and 90.1%, respectively). The ICF program accounted for 43 target shots taken for experiments led by LLE, LLNL, and SNL. The HED program had 46 shots for LLNL and LLE led experiments. Ten target shots were taken for the DTRA program. NLUF experiments led by MIT, University of California, Berkeley, University of California, San Diego, and Princeton accounted for 42 shots. Forty-two shots were also taken for LBS experiments led by LLNL and LLE. One CEA experiment had eight target shots.

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