Diagnosing up-scattered DT neutrons produced in burning plasmas at the NIF

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In the push to higher performance fusion plasmas, two critical quantities to diagnose are alpha-heat deposition and impurities mixed into the plasma periphery. In high-density, highly-collisional ICF burning plasmas there is a significant probability that DT fusion products – 14 MeV neutron, 3.5 MeV alpha particle – will collide with and deposit energy onto ("up-scatter") surrounding deuterium and tritium fuel ions. These upscattered DT fuel ions then undergo fusion while in-flight and produce an upscattered neutron (15-30 MeV). These reaction-in-flight (RIF) neutrons can then be uniquely identified in the measured neutron energy spectrum. The magnitude, shape, and relative size of this spectral feature can inform on the stopping-power of the DT plasma and hence is directly proportional to alpha-heat deposition. In addition, using sub-percent levels of activated dopants in the plasma the RIF spectrum can be related to mix into the burning fuel, particularly relevant for high-Z shell and other emerging NIF platforms. The neutron time-of-flight diagnostic upgrades needed to obtain this small signal – ~10^{-5} times the primary DT neutron peak – will be shown. Results from several Gain > 1 implosions will be shown and compared to previous RIF spectra. Evaluation of the "hardness" of the RIF spectrum will be made and its implications discussed. Finally, comparisons of experimental data to a simplified computational model will be made.

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