DEVELOPMENT OF AN ENHANCED, PERMANENTLY-INSTALLED, NEUTRON ACTIVATION DIAGNOSTIC HARDWARE FOR NIF

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Neutron activation diagnostics are commonly employed as baseline neutron yield and flux measurement instruments at the National Ignition Facility. Up to 19 activation samples are distributed around the target chamber. Currently the samples must be removed to be counted, creating a 1-2 week data turn-around time and considerable labor costs. An improved system consisting of a commercially available lanthanum bromide scintillator is under development. A machined zirconium-702 cap over the detector is the activation medium. The detectors are located at the current neutron activation diagnostic sites and monitored remotely. Since they collect data in real time yield values are returned within 10 minutes after a NIF shot.

Currently the reaction $^{90}Zr(n,2n)^{89}Zr$ is used to measure the neutron yield. ^{89}Zr has a 78.41 hour half life (909 keV), allowing time for transport out of the target bay to the counting facility. In addition to measuring the absolute yield, the 19 samples measure the spatial distribution of the neutrons. Differences in activation are due to the bulk motion of the core Doppler shifting the neutron spectrum, changing the $^{90}Zr(n,2n)^{89}Zr$ cross section, or differences in scattering, such as that caused by a nonuniform fuel areal density [1].
Since the new detector system collects data in real time, short-lived products can be observed to determine the neutron energy distribution as well as absolute yield. ^{89m}Zr has a 4.16 minute half life (588 keV). The $^{89}Zr/^{89m}Zr$ ratio is highly dependent on neutron energy. ^{89}Y with a 15.66 second half life (909 keV) is also observed from the $^{90}Zr(n,np)^{89m}Y$ reaction. This reaction can be used in a similar manner to determine the neutron energy based on cross section. Another observed reaction is $^{79}Br(n,n')^{79m}Br$ (5.1 second half life, 207 keV), resulting from the Br in the detector (Figure 1). Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344.

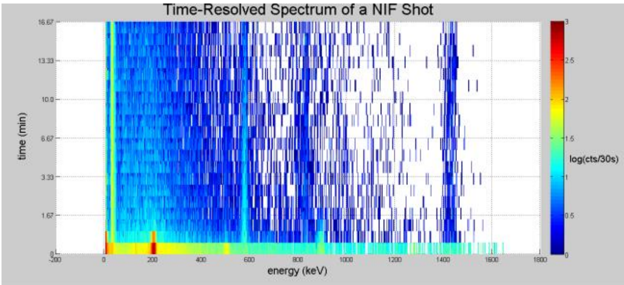

Figure 1. Spectrum of a NIF shot. Isotopes with short half lives are observed with the new detector system.

[1] C.B. Yeamans, D.L. Bleuel, and L.A. Bernstein, "Enhanced NIF neutron activation diagnostics," Review of Scientific Instruments, vol. 83, 2012.