Gamma-Ray Spectroscopy for 2011 OLUG Report
By H.W. Herrmann, 11/10/11

Gamma-rays in the 1-20 MeV range are emitted from various nuclear processes in ICF implosions. They offer the opportunity to learn a great deal about implosion performance as well as the basic Nuclear Plasma Physics which has bearing on the closely related fields of high energy density physics, nuclear astrophysics and basic nuclear physics.

These gammas are directly emitted from fusion reactions (e.g., DT, HT, D3He, etc.) and are induced through various neutron & alpha reactions with nuclei in the fuel (e.g., D(n,γ)T) and ablator (^{12}C(n,n'γ)), as well as components surrounding the capsule such as hohlraum, thermomechanical package, nearby diagnostic snouts and the chamber wall. In addition, materials of particular interest can be doped into capsules (e.g., ^{169}Tm), or placed near the target in the shape of a puck (e.g., Al, Si, C, etc.) for cross-section investigations.

Many of these processes have already been studied at both OMEGA and NIF using gas Cherenkov detectors which offer energy thresholding as a crude means of spectroscopy. However, to get better energy resolution, gamma ray spectrometers are highly desired.

Figure 1 shows an example of how complicated the spectrum can be in indirect-drive. This is a simulated spectrum representing our best understanding of the gamma-ray-producing nuclear processes, however, uncertainties exist and our ability to extract information from individual lines in limited. For instance, a spectrometer that is able to isolate the Doppler-broadened 15.5 MeV line from D(n,γ)T may prove valuable as a fuel areal density diagnostic.

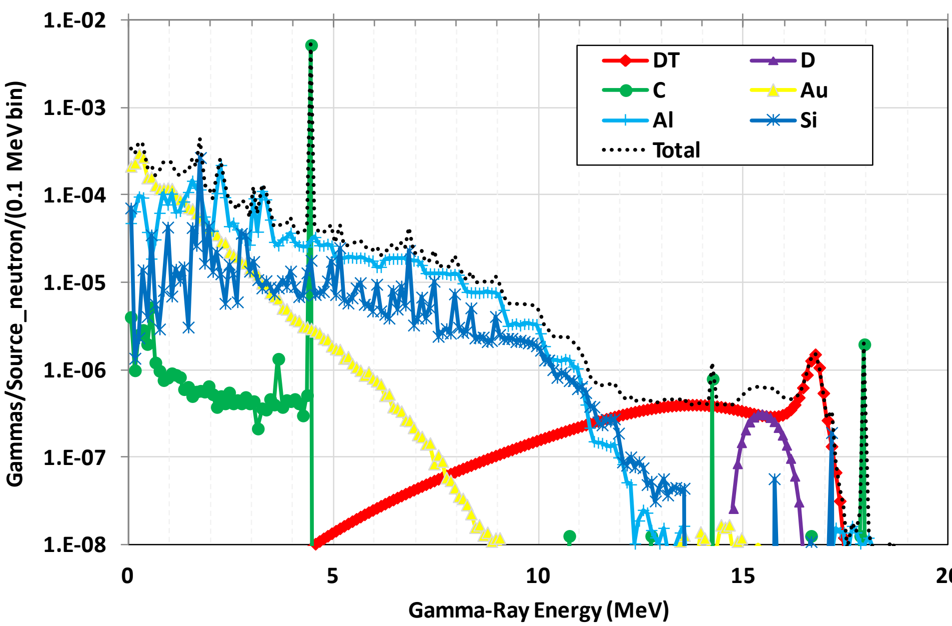

Figure 1: Simulated prompt gamma-ray spectrum for indirect drive DT implosions at NIF

In addition to laboratory fusion ignition, ICF provides a unique high energy density environment that is very similar to that found in stellar interiors. This enables laboratory-based measurements of cross sections responsible for the generation of energy, and also the formation of heavy elements in the stellar interiors for the first time. As quoted in the ReNeW Report [1], a high quality gamma-ray spectrometer can address very important questions about stellar s-processes.

Design studies are underway to determine the feasibility of implementing various concepts, such as a Gamma Compton Spectrometer (GCS) which relies on Compton conversion to electrons followed by magnetic dispersion, and a highly pixilated array of single-hit detectors located far from the target chamber. Trade-offs include sensitivity, energy resolution, temporal response and background isolation. Such factors will determine whether such an instrument can be fielded on OMEGA, or if the higher yields of NIF will be required.