Multi-Detector Array for Measuring Tertiary Neutron Anisotropies in DT ICF Targets

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Experimental Goals

- Develop a diagnostic to measure DT neutron anisotropies in an ICF burn at the NIF.
- The diagnostic will be composed of eight ultrapure graphite disks used as tertiary neutron detectors

Efficiently measure the back 511 keV gamma rays created by positron decay of the radioactive 11C using eight on Axis pairs of NaI(Tl) detectors. Also to limit the number of accidental coincidences, minimize ambient background gamma ray counts, and maximize geometric counting efficiency.

From this diagnostic determine the yield and distribution of tertiary neutrons resulting from an ICF reaction.

Graphite Purification

- Surface contaminants are removed with an ethanol wash.
- Internal contaminants are removed by baking the graphite at 1000 °C for 1 hour under a 20 micron vacuum, air and other volumetric contaminants like hydrocarbons are removed from the sample. Once cooled to room temperature the vacuum is backfilled with argon gas.
- The graphite is packaged in an argon environment at STP which prevents air infiltration.

Graphite Activation and Positron Annihilation

DT fuel in an ICF reaction produces 4He and a primary neutron (n),

\[ D + T \rightarrow 4He + a + n \]

Primary neutrons are roughly 14.1 MeV knock-ons

\[ D + T \rightarrow a + n \]

Producing 12 - 30 MeV tertiary neutrons

The number of tertiary neutrons is related to (p+p) or (p+d)

Graphite is ideal for the detection of tertiary neutrons for several reasons:

- Only tertiary neutrons from the burn contribute to the 12C(n,2n)11C reaction
- Sensitive to the fuel density-radius product (r^2)
- Robust
- Sensitive

During acquisition, an activated C11 source is placed in the center of each the detector pair. The detectors are shielded with lead to reduce background radiation and accidental coincidences between off-axis pairs. Sixteen single spectra, one for each NaI(Tl) detector pair system was used to develop the counting system and determine the effect of different lead shielding configurations about the detector pair by measuring accidental coincidences and background counts. This helped to determine the appropriate amount of lead shielding to minimize background counting.

Graphite samples will be placed around the equatorial plane and polar regions of the NIF chamber on port flanges. Graphite may also be placed at other latitudes including 45° from the equatorial plane.

Data Acquisition

During acquisition, an activated C11 source is placed in the center of each detector pair. The detectors are shielded with lead to reduce background radiation and accidental coincidences between off-axis pairs. Sixteen single spectra, one for each NaI detector, are acquired along with eight 2D coincidence spectra, one for each on axis pair of detectors.

Minimizing Background Data with Na-22 and Cu-64 at SUNY Geneseo

A single NaI detector pair system was used to develop the counting system and determine the effect of different lead shielding configurations about the detector pair by measuring accidental coincidences and background counts. This helped to determine the appropriate amount of lead shielding to minimize background counting.

Summary

A nuclear diagnostic that is sensitive to (p+p) and anisotropies in the tertiary neutron distribution produced from an ICF burn at the NIF is being developed at SUNY Geneseo. Hopefully the detector array will be built, tested, calibrated and deployed at the NIF in the near future.

Multi-Detector Array at SUNY Geneseo

Three NaI detector pairs encased in lead of the 8 element array have been constructed at SUNY Geneseo. The optimal NaI detector configuration, which reduced accidental coincidences, minimized background gamma counts and maximized geometric counting efficiency, was determined with this test bench in preparation for the construction of the full 8 NaI paired detector array.