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Author(s): R.O. Nelson

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Illuminating Photon Production with GEANIE at LANSCE

R.O. Nelson, LANL (for the GEANIE collaboration*)

GEANIE is a multi-detector, high-resolution gamma-ray spectrometer that is operated as a collaborative effort between Lawrence Livermore National Laboratory and Los Alamos National Laboratory. The WNR high-energy spallation neutron source at the Los Alamos Neutron Science Center (LANSCE) provides GEANIE's beam. GEANIE enables new measurements of neutron-induced reaction cross sections and fission fragment studies with neutrons with incident energies from 1 to 200 MeV and excellent γ-ray energy resolution. Results of first studies are aimed at providing information for such diverse areas as improved cross section data for stockpile stewardship needs and calibration of high-energy neutron fluence monitors for applications in Accelerator Production of Tritium and Accelerator Transmutation of Waste.

GEANIE currently is configured with 26 Ge detectors, of which 11 have planar geometry and 15 have coaxial geometry. The planar Ge detectors have excellent γ-ray energy resolution at low energies and are essential for studies of actinides and odd-mass nuclei. The coaxial detectors have much higher efficiencies for higher-energy γ-rays than the planar detectors. Combined, these two types of detectors provide good γ-ray energycoverage with excellent resolution over a photon-energy range from about 10 keV to over 4 MeV.

Because the incident-neutron energies are determined by time-of-flight techniques, detector timing is important. GEANIE is sited on a 20-m flight path. Typical detector timing is presently 12 ns (FWHM) at $E_\gamma = 122$ keV for the planar detectors and somewhat greater for the coaxial detectors. Neutron energy resolution at 10 MeV is about 5% (FWHM). The ability to measure excitation functions over a wide energy range simultaneously is a major strength of this system.

Current efforts with GEANIE are focused on determining the ^{239}Pu(n,2n)^{238}Pu reaction cross section from threshold to 15 MeV from γ-ray measurements. Because of the large fission-neutron background, this reaction is difficult to measure by neutron detection techniques. Only two direct measurements of this cross section as a function of neutron energy from threshold to higher energies have been reported, with large differences in the results. By measuring many partial γ-ray cross sections in the decay cascade, and modeling the reaction with a sophisticated preequilibrium-plus-Hauser-Feshbach computer program (GNASH), we expect to achieve an absolute cross section measurement of 10% accuracy or better. Key to current efforts has been the production of a very pure ^{239}Pu sample with almost all ^{241}Am removed.

As a test of our methods, and for other interests, we are measuring the ^{235}U(n,n'γ) and (n,2nγ) cross sections and ^{238}U(n,xnγ) reactions. Preliminary excitation functions have been obtained for $^{239}Pu(n,2n\gamma)$, $^{235}U(n,xn\gamma)$, and $^{238}U(n,xn\gamma)$ reactions. The viability of our technique for (n,xn) cross section measurements in previously difficult cases appears very promising. The current results are important for stockpile stewardship, applications of high-energy neutrons, and have basic physics interest also.

We are starting a program of fission fragment studies with French† collaborators to look at spontaneous fission and neutron-induced fission. Fission fragment mass and charge distributions and spectroscopy of fragments are of interest, including a search for isomeric states in fission products. Recent efforts involve the examination of fission products via γ-ray and fission-fragment-γ-ray-x-ray coincidence studies. Spontaneous fission from ^{252}Cf has been used to test the fission fragment-γ-ray-x-ray coincidence setup, and thick-sample neutron-induced fission data have been acquired with the ^{238}U sample. A preliminary analysis of the fission data has been performed.

* J.A. Becker (LLNL), L.A. Bernstein (LLNL), P.E. Garrett (LLNL), G.D. Johns (LANL), C. McGrath (LLNL), D. McNabb (LLNL), R.O. Nelson (LANL), W.S. Wilburn (LANL) and W. Younes (LLNL).

†Th. Ethvignot and Th. Granier (CEA, Bruyères-le-Châtel, France) and R. Lucas (CEA, Saclay, France).