PROOF-OF-PRINCIPLE TO UNFOLD AN ANGLE-ENERGY DEPENDENT NEUTRON SOURCE FROM MEASUREMENTS AND ADJOINT DISCRETE-ORDINATES CALCULATIONS*

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Since 1986 there has existed a discrepancy between the measured and calculated neutron responses at Hiroshima. The problem is that the calculated thermal-neutron results have a steeper slope than the measured results. Several reasons for the discrepancy have been suggested, all of which would have allowed more higher-energy neutrons to contribute to the thermal responses: the air-transport cross sections were in error; the iron cross sections used in calculating the neutron leakage through the bomb's case were in error; the bomb's case cracked prior to or during the explosion; or the tail section separated from the weapon. New source calculations, additional cross-section measurements, and other activation measurements were made, but the anomaly has persisted. Comparisons of calculations that used the updated cross sections to other weapon data seem to have vindicated the cross sections. Since the measurement data has been accepted, and the cross-section data has been improved/approved, a novel approach to calculating the source using an unfolding technique has been tested. Flux unfolding has been used extensively in the laboratory where the flux at the detector has been unfolded using the detector dosimetry cross sections. However, the unfolded source, which produced the flux, had to be determined by transporting, in the adjoint mode, the dosimetry cross sections back to the source point. These "pseudo-dosimetry cross sections" have been input to an unfolding code to produce the source of interest. The local shielding environment was simulated through varying the thickness of concrete, stone, and iron, which were placed around the detector materials to evaluate the changing spectrum ultimately seen by the detector. The dosimetry cross sections used in this study were the thermal neutron-photon reactions in Cl-35, Ca-40, Co-59, Ni-62, Eu-151, and Eu-153; the fast neutron-proton reactions were those for S-32 and Cu-63. Discrete-ordinates codes were used to transport the dosimetry cross sections in the adjoint mode, and a well known least-squares unfolding code, along with covariance matrices associated with each of the input data sets, was used to unfold the angle-energy dependent neutron source.

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