Subcritical Measurements with Multiple HEU Metal Castings

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INTRODUCTION

Experiments with the standard annular highly enriched uranium (HEU) metal castings at the Y-12 National Security Complex were performed in which up to five castings (~90 kg) were assembled in a tightly packed array with minimal spacing between castings. The fission chain multiplication process was initiated by a time-tagged ^{252}Cf spontaneously fissioning neutron source or by time and directionally tagged neutrons from a small portable DT neutron generator. The prompt neutron time behavior was measured with plastic scintillation detectors sensitive to the fast neutron (>1 MeV) and gamma ray without distinction. These experiments were performed to provide data to benchmark methods for the calculation of the prompt neutron time behavior. Previous measurements with a single casting have been reported. This paper presents the experimental results for multiple castings.

DESCRIPTION OF THE ACTUAL WORK

The prompt time decay was obtained by time coincidence correlation measurements between the detectors and the time-tagged neutron source emission (equivalent to randomly pulsed neutron measurements) and between pairs of plastic scintillation detectors (equivalent to a two-detector Rossi-alpha measurement).

These standard HEU storage castings at the Y-12 Complex had 5.000-in. outside diameter; 3.500-in. inside diameter; masses between 17,636 and 17,996 g; average impurity content of 992 ppm; density of 18.75 g/cm^3; and average enrichment of 93.16 wt % ^{235}U. The castings were in tight-fitting 0.025-in.-thick, 8.0-in.-high stainless steel (SS-304) cylindrical cans for contamination control. One can was annular in shape with an inside diameter of 3.0 in. so that the Cf source could be located on the axis of this casting. Four 1 × 1 × 6 in. plastic scintillators with the long dimension parallel to the axes of the castings and adjacent to the outer surface of the casting cans were used. The detectors were enclosed in 0.25-in.-thick lead shields on four 1 × 6 surfaces and on the 1 × 1 surface. The small surface of the lead shield was adjacent to the steel table. The assembly of five castings with the detectors is shown in Fig. 1. The DT generator can be seen in the background with the time-tagged neutrons aligned symmetrically around a line drawn from the generator through the target spot, and the center of the casting in the annular can is seen in the foreground.

RESULTS

The six time coincidence distributions between all four detector combinations are given in Fig. 2 for one detector-source casting configuration. The amplitude of the distributions depends on detector locations, but the time decay is independent of the detector pair.

CONCLUSIONS

These carefully performed and documented measurements with unreflected and unmoderated HEU castings can be used to benchmark calculational methods for the time decay of the fission chain multiplication process as measured with small (to minimize detector effects) detectors in close proximity to HEU metal castings. The use of a DT generator provided no additional information beyond that provided by a time-tagged Cf source inside one of the castings in the arrays of up to five castings. The generator has these disadvantages: (1) it cannot be located inside the assembly, and (2) the room return from 14-MeV neutrons persists longer, interfering more with the measurement of prompt neutron time decay.

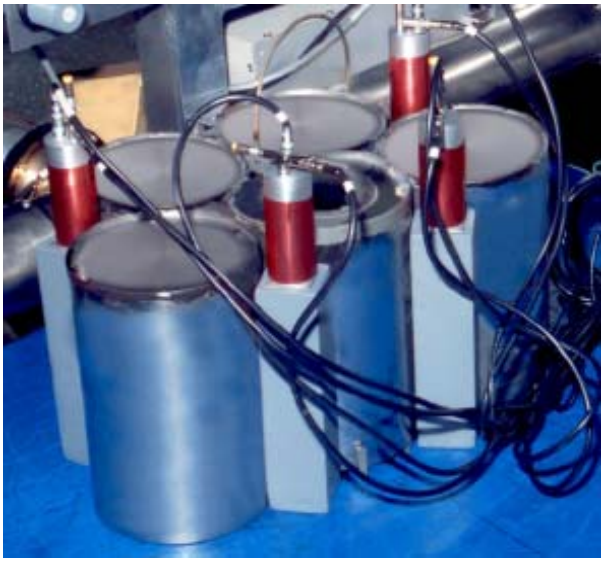

Fig. 1. Photograph of one of the DT source-detector configurations for a measurement with five castings on a 0.25-in-thick steel table, 40 in. above the floor.

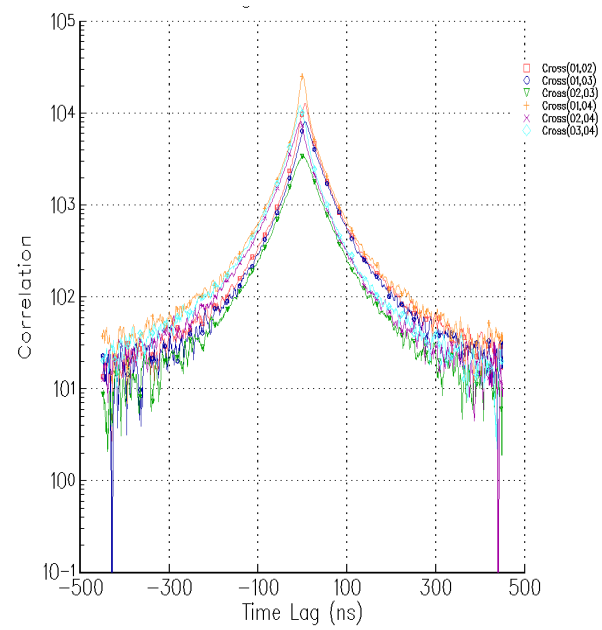

Fig. 2. Time distribution of counts in one detector with respect to a previous count in other detectors.