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ABSTRACT

One of the applications of template matching for arms control/warhead dismantlement transparency regimes is for monitoring facility-to-facility transfers. In 1999, three highly enriched uranium (HEU) weapons components for which the Nuclear Materials Identification System (NMIS) signatures had been obtained at the shipper's site were received at the Y-12 National Security Complex. The NMIS signatures obtained upon receipt of these items were compared with those at the shipper's site to confirm the identity of the item received. This paper describes the use of NMIS for these shipper-receiver confirmations.

INTRODUCTION

Nuclear Materials Identification System (NMIS) is an active interrogation mode¹ developed for HEU and uses an external source to excite the subject fissile material with neutrons. This activation initiates fission chain-reactions in the material under inspection. Two or more detectors placed in the vicinity of the item under inspection acquire neutron and/or gamma radiation emerging from the item. The detected radiation arises from three processes: direct transmission, scattering, and induced fission. For passive interrogation NMIS uses the same detectors, but omits the external source. Instead, NMIS relies upon the spontaneous emission of neutron and/or gamma radiation from the item being examined and thus is useful for plutonium measurements. Real-time acquisition and correlation of the source and detector signals, with 1-nanosecond resolution, produces a set of signatures that depend on the particular fissile material configuration.

Numerous applications of NMIS to fissile material have demonstrated its high sensitivity to small changes in the item under interrogation. In many cases, radiation from nearby materials does not present a problem since, in active interrogation, background is not correlated to the source; this simplifies the use of NMIS in storage configurations. In its various modes of operation NMIS is capable of providing a large number of signatures (including multiplicities) that characterize the item being examined. This large number of varied signatures makes NMIS very difficult to deceive.

NMIS uses both time- and frequency-analysis techniques to characterize fissile material. Time-domain signatures characterize the time distribution of neutrons and gamma rays resulting from direct transmission, scattering, and induced fission. Frequency-domain signatures decompose these time-dependent distributions into periodic components to analyze their "spectral" content. The frequency spectra are used in much the same way as acoustic signatures for voice or naval vessel identification, and they have the added advantage of being robust to some types of instrumentation drift. Because these signatures form a fingerprint that is multidimensional, sensitive, and robust, the

resulting identification is difficult to defeat. Comparisons with calibration can provide very reliable identification. NMIS signatures have recently been successful in extracting attribute, mass and thickness of Pu, from NMIS measurements at the All-Russian Scientific Research Institute of Experimental Physics (VNIIEF).²

FACILITY-TO-FACILITY TRANSFER MEASUREMENTS

NMIS is currently being used at the Y-12 National Security Complex for confirmation of weapons components in containers both for inventory and for receipts. For these applications, it has been used in the template matching mode with the reference templates acquired from NMIS measurements on known weapons components in containers at the Y-12 National Security Complex. During the year 1999, Oak Ridge National Laboratory (ORNL) personnel had the opportunity to perform NMIS measurements at a facility other than the Y-12 Complex for weapons components in containers that were to be shipped to the Y-12 Complex. These components were of two types, A and B. There were two type A parts and one type B. In this case, the reference templates were acquired off-site when the weapons components were packaged for shipment. When they were received at the Y-12 Complex, they were measured again with NMIS as part of the receipt confirmation program. This was the first use of NMIS for facility-to-facility transfer. The NMIS measurement system used for the off-site measurements is shown in Figure 1 and consisted of two plastic scintillation detectors and a somewhat portable NMIS processor weighing ~20 lbs. The ²⁵²Cf source (not shown) was shipped commercially off-site meeting DOT regulations. For the NMIS measurements at Y-12, a cart-portable system was used. The signatures for these three items upon receipts at the Y-12 Complex are compared with those obtained off-site in Figures 2, 3, and 4. This comparison was performed by dividing the signatures acquired on receipt by the reference signatures obtained off-site. The magnitude of the cross power spectral density (CPSD) between a detector and a source as a function of frequency was used for template matching. The CPSD for the two type A items upon receipt are compared in Figures 2 and 3 and that for item B in Figure 4. These signatures, the correlation of detector counts with ²⁵²Cf source for the items at Y-12, agree with those acquired off-site.



Figure 1: Photograph of the NMIS System Used Off-site Excluding the ²⁵²Cf

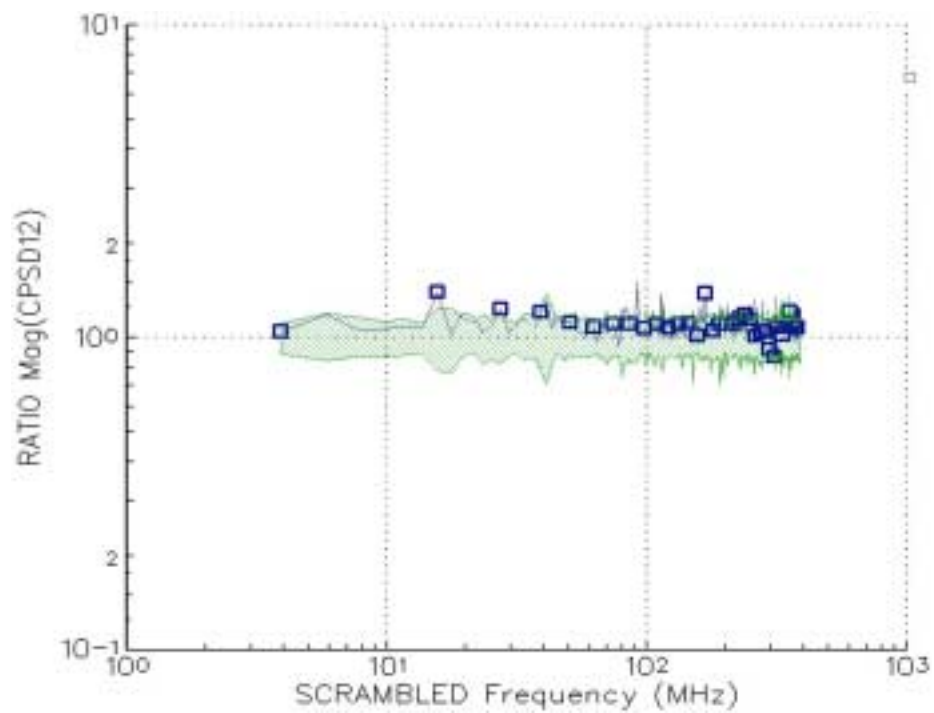


Figure 2. Type A (#1) vs. Type A Reference

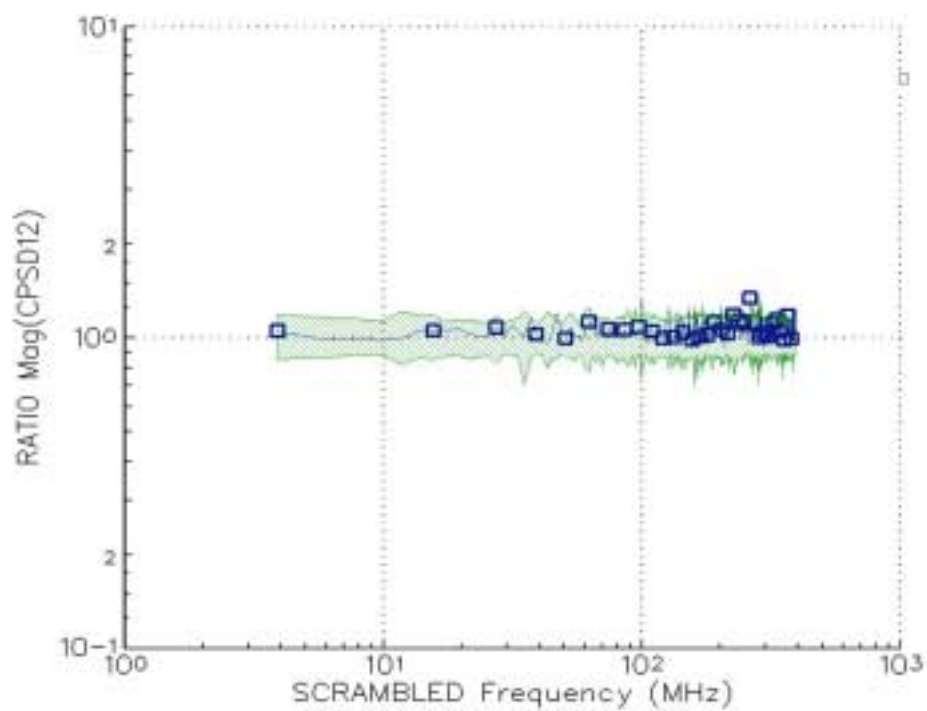


Figure 3. Type A(#2) vs. Type A Reference

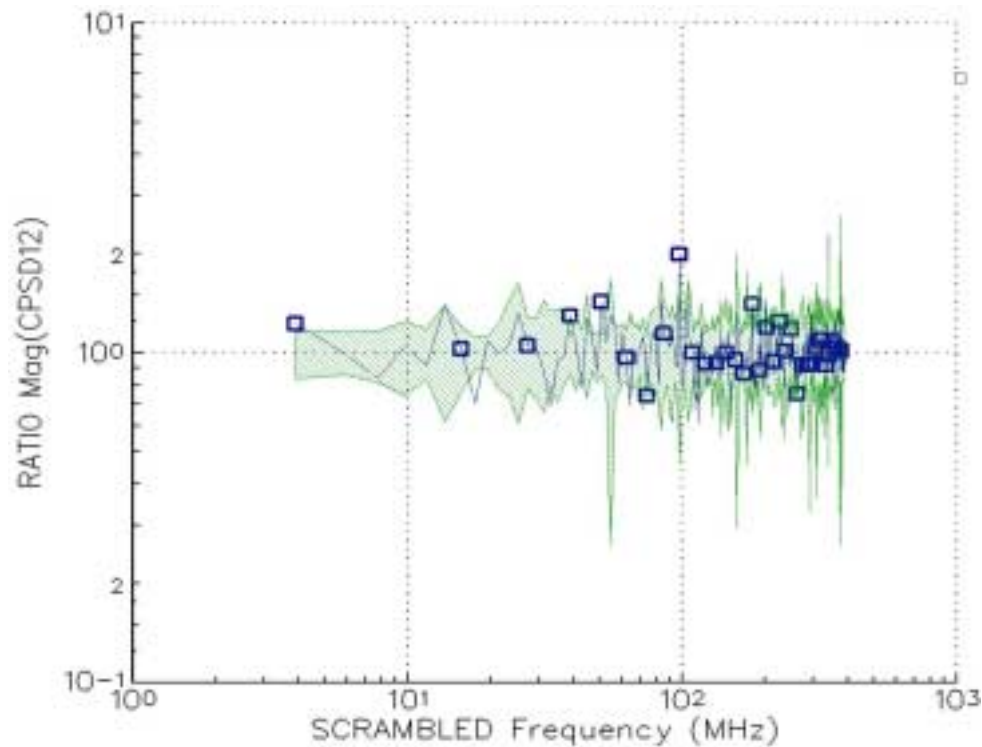


Figure 4. Type B vs Type B Reference

CONCLUSIONS

This is the first use of NMIS to compare NMIS data on weapons components received at the Y-12 National Security Complex with NMIS data acquired for the same components at the shipper. Although different ^{252}Cf sources with different intensities and different NMIS systems were used, the NMIS data at the shipper agreed with that acquired upon receipt at the Y-12 Complex. This work illustrates how the NMIS can be used for facility-to-facility transfer to track nuclear weapons/components from one facility to another and thus could be used for such tracking in arms control and treaty applications.

REFERENCES

- [1] J. T. Mihalczo, J. A. Mullens, J. K. Mattingly, and T. E. Valentine, "Physical Description of Nuclear Materials Identification System (NMIS) Signatures," *Nuclear Instruments & Methods in Physics Research A*, 450 (2000) 531-555.
- [2] Joint paper for the INMM 2001 Meeting on attributes, VNIIEF-Oak Ridge by Dubinin, et al.