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#07-212 Evaluation of the characteristics of CdZnTe-detectors for the quality of non-destructive assays of nuclear fuel using passive tomography methods

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Non-destructive assays (NDA), carried out to account for nuclear materials, generally include the measurement of the initial enrichment of fresh fuel, the burnup, the colling time and the initial enrichment of the irradiated nuclear fuel, and distribution of nuclear materials and fission products over the volume of fuel assemblies in order to identify the fact of extraction of nuclear materials. In addition, the distribution of fission products makes it possible to detect a damaged fuel rod during refueling of the reactor core. Now the amount of research aimed at developing such systems has increased significantly. One of the universal technologies for such control is passive reconstructive tomography. We have previously presented systems designed to solve the listed tasks in real-time based on spectrometric measurements with CdZnTe detectors. All implementations require a multi-detector system that is installed on the mast of the refueling r machine. It has been shown that the implementation of the SVD decomposition algorithm for passive reconstructive tomography using several energies allows for two to three orders of magnitude to improve the signal-to-noise ratio to improve the quality of measurements in comparison with traditional algorithms. Now there are publications that the use of machine learning methods can provide a similar result. However, the implementation of spectrometric measurements in real-time places high demands on hardware and software.
We have developed a method for evaluating and optimizing the parameters of the measuring cycle based on the analysis of the amount of information. At the first step, a measurement model is created that formalizes the relationship between physical quantities describing the measured object and the results of observations. As a rule, this is a system of equations in which the instrumental spectrum of one detector is represented by the sum of the products of the sensitivity and the radiation flux density in a given energy range, taking into account the background component. In this case, the measurement channel is understood as the digital radiation spectrum for one detector for a given spatial configuration of radiation sources. It is obvious that the complex dependences of per-channel sensitivities (here it is a complex indicator depending) on the parameters of the detectors and the measured fields limit the possibilities of obtaining them analytically. Therefore, the experimental results on the dependence of per-channel sensitivities were supplemented by simulations in GEANT. Then, for each experiment, we build an information matrix and use it to determine the amount of information in the experiment. The analysis of the previously obtained results showed that this matrix can be used to analyze the quality of NDA by passive tomography methods. In spectrometric measurements, the information matrix explicitly contains the registration efficiency, energy resolution, peak/Compton ratio, and the range of measured energies. In the future, we solve the optimization problem for one of the parameters. To check the obtained calculated dependences, laboratory experiments were carried out. The experimental setup consists of a fuel assembly simulator and a multi-detector measurement system. The fuel assembly simulator consists of aluminum tubes located at the vertices of a regular triangle and thorium sand, the number of tubes may vary. The measuring system is based on μSPEC micro spectrometers (ZRF Ritec SIA) and SDP310, SDP500 CdZnTe-detectors of several models with different values of the studied parameters. A detailed analysis of the obtained dependencies will be presented in the presentation.

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