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#7-185 A spectroscopic gamma ray scanner/imager system for radioactive waste (re)conditioning

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The Proximity Imaging System for Sort and Segregate Operations (PI3SO) is a gamma radiation proximity scanner table for radioactive waste that aims at speeding up the waste management (re)cycle while reducing direct human intervention. The system exploits proximity imaging to detect hot-spots, then in a second step it performs a medium resolution spectrum analysis for a coarse isotopic recognition preliminary to sorting and separate of radioactive waste. The gamma image, with a color scale indicating the measured counting rate, can be superimposed to the corresponding visible image produced by a hovering videocamera. Such a semi-quantitative data, along with the quantitative spectral data, can be stored for archival purposes.
The large amount of existing nuclear waste, as well as the predicted amount from future decommissioning processes, represent a significant task to the nuclear decommissioning program. Such an amount varies depending on when the dismantling operations are completed. Delaying it could increase the quantity of Very-Low-Level Waste (VLLW) that can be exempt from regulatory control while decreasing the amounts of Intermediate-Level Waste (ILW) and Low-Level Waste (LLW). Sorting and segregating radioactive waste, in particular ILW and LLW, are the first steps in the process of safely and economically rehabilitating nuclear facilities while respecting both people and the environment. These materials are usually bundled into specialized drums and stored in near-surface disposal sites. They include gamma emitters of various activities whose identification is crucial to manage radioactive waste properly and essential for safety and regulatory compliance.
To reduce costs and accelerate the implementation of decommissioning plans, innovative solutions are required that allow waste to be moved more quickly and efficiently, along with detailed records and traceability of all operations and decisions made during the nuclear waste management process. A crucial feature of potential novel solutions is the emphasis on operator safety, with a strong effort to reduce direct human engagement in waste management activities by maximizing the use of existing or emerging technology. In such tough nuclear-related circumstances, the PI3SO strategy promises to improve the safety and well-being of operators while reducing errors in waste investigations caused by human mistakes.
An easy-to-use automated system can considerably reduce the need of human operators near active materials by adhering to the "As Low As Reasonably Achievable" criterion (ALARA). Similar systems using a single germanium detector sliding over the material under investigation have recently been proposed. While they offer high energy resolution, they are slow, bulky, and expensive. However, speed is critical to accomplish results as soon as possible, because of the vast amount of the already existing and foreseen waste that must be (re)conditioned.
Our scanning system, conceived for sorting and segregation operations of ILW, LLW, and VLLW, is based on two linear arrays of 64 CsI(Tl) scintillators of 1x1x1 cm3 coupled with silicon photomultipliers (SiPMs). They are installed on a motorized bridge that slides horizontally over and below a thin and robust table covering an active area of 64cm x 108cm. Accurate information on the location and amount of radioactive elements can be obtained by producing a gamma image that displays gamma-emitting sources placed on the table. Furthermore, the identification of radioactive isotopes is made possible by the spectroscopic features of the CsI(Tl) scintillators which achieve an interesting 5% energy resolution at the 662 keV reference peak of 137Cs.
Many successful tests have been performed by using radioactive sources, proving that the minimum detectable activity (MDA) is of the order of a few hundred Bq. Quite recently a few parts of the old dismantled electrostatic deflector of the INFN-LNS superconducting cyclotron were examined. The produced images highlighted

the presence of active hot-spots, and the immediately following spectroscopic investigation, compatibly with the energy resolution of the CsI(Tl) PI3SO detectors, showed the presence of peaks presumably related to 44Ti, 44Sc, 22Na, 60Co, 133Ba. A subsequent comprehensive examination with a germanium detector validated these hypotheses, demonstrating the effectiveness of the system.
In conclusion, PI3SO is suitable for the quick semi-automatic sorting and segregation of low- and intermediate-level radioactive waste, required for the decommissioning of nuclear power plants and for the (re)conditioning and packaging of radwaste, possibly removing exempt waste thus releasing costly storage room.

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