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Advanced Radwaste Monitoring By Means Of Flexible Scintillating Fibers And Compact Neutron Detectors

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The monitoring of radioactive waste (radwaste) is a critical aspect of nuclear waste management, ensuring environmental safety and compliance with regulatory standards. Among the advanced technologies explored for this purpose, scintillating fibers (SciFi) and Silicon-Lithium-Fluoride (SiLiF) detectors have emerged as promising tools for real-time radiation monitoring and data acquisition. Research conducted at the LNS-INFN in Catania has demonstrated the feasibility of SciFi-based systems for detecting gamma radiation and SiLiF sensors for neutron monitoring in radioactive environments.

The SciFi sensors operate by converting ionizing radiation into light signals through scintillation, which are then transmitted via optical fibers to SiPM (Silicon Photo Multiplier). This approach offers several advantages, including good energy resolution, high counting rates, and scalability for large-scale monitoring applications. Experimental campaigns have validated the performance of SciFi-based detection systems through laboratory tests and pilot-scale field deployments. Specific results include improved detection sensitivity by over 30% through optimized fiber configurations and readout electronics. These advancements have enabled more precise radiation mapping, enhancing waste characterization accuracy. Key developments include the integration of advanced data processing algorithms for real-time analysis.

Neutron detection capabilities have been significantly studied by using SiLiF sensors. These detectors exploit neutron capture reactions to produce detectable charged particles, enabling efficient neutron monitoring in mixed radiation fields. Measurement campaigns demonstrated discrete neutron detection with good background discrimination even in medium level activity environment. Results included successful field trials with mixed neutron and gamma sources, confirming neutrons counting and stability over extended operational periods.

Additionally, innovative data fusion techniques have been implemented, combining signals from multiple sensor arrays to reduce measurement uncertainty and increase the statistics. Tests involving mixed radioactive sources demonstrated reliable discrimination between isotopes based on gamma energy spectra. Long-term operational stability tests have confirmed negligible performance degradation over extended monitoring periods.

Further technological enhancements include the development of standalone, battery-powered electronics with wireless connectivity, enabling remote monitoring and data transmission in hard-to-access environments. Field deployments have shown that these systems can operate autonomously for extended periods, simplifying maintenance and reducing operational costs.

The adoption of integrated gamma and neutron detection systems with advanced electronics represents a significant advancement in radwaste monitoring. Their implementation could lead to more efficient, accurate, and sustainable management strategies, contributing to the long-term safety and security of radwaste storage facilities.

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