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Establishing Antineutrino-based Safeguards Using the State-level Concept

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Antineutrino detection systems have potential to safeguard the next generation of nuclear reactors. In theory, these systems can be implemented for status verification, reactor power monitoring, and special nuclear material diversion detection. Previous studies have investigated the applicability of this technology using models and simulations, but are often heavily reliant on various situational assumptions, such as diversion pathways and detection probability limits. As antineutrino-based detection systems continue to be considered for future nuclear reactor safeguards, researchers need a coherent and flexible method to adjust system parameters to match the current International Atomic Energy Agency (IAEA) framework.

In this work, we develop a methodology for selecting detection probability limits for antineutrino-based safeguards. Detection probability, or the probability of detecting a diversion scenario, is a key metric for assessing current antineutrino-based safeguard capabilities. Highlighting the IAEA's utilization of State-level safeguards approaches, our detection probability threshold values are quantified by State-specific factors, or factors used by the IAEA in establishing safeguards activities. We interpolate between the various State-specific factors and user-given weighting parameters to quantify reasonable detection probability limits. This detection probability can shift drastically depending on a wide-range of situational parameters, including reactor and facility design. Our results indicate that antineutrino-based safeguards would perform best as a complementary safeguard, regardless of reactor design.

Abstract title

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