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An antineutrino-based detection concept for non-intrusive site-wide reactor monitoring

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Future advanced reactor designs may use liquid fuel or uncountable numbers of small fuel elements. Such designs will be difficult or impossible to monitor for safeguards via traditional item accountancy techniques. One way to address this issue, being pursued by the U.S. Dept of Energy, Office of Nuclear Energy Material Protection Accounting and Control Technologies (MPACT), is to develop instruments that can operate directly inside the core. To this end, diagnostic tools are being developed that can withstand the extreme temperature and radiation conditions near the fuel inside a reactor. Generally, however, due to the harsh conditions, compromises to sensitivity must be considered in favor of long-term survivability. Another approach is to monitor from a safe distance is via antineutrino detection. Above ground tools are being developed to monitor antineutrino flux (PROSPECT, miniCHANDLER and MAD). However, these tools must be placed where the reactor flux is high enough to overcome the high rate of cosmogenic backgrounds present above ground. For low flux scenarios such as low power reactor monitoring, or in situations where infrastructure around the reactor does not permit a close in deployment, larger liquid-based detectors deployed a few meters underground may be required to reduce the hadronic component of the cosmogenic background. For detector target volumes greater than about ~10 tons, it is worth considering simple monolithic detector designs that can be deployed quickly. By reducing channel count and making use of novel scintillator formulations that can improve background rejection, it may be possible to improve deployability and decrease overburden compared to the state-of-the-art monolithic detectors, such as Double-Chooz and Daya Bay detectors. Here we present the results of a MC-based analysis of a simple design that can provide from between 10-100 tons of fiducial target, while limiting overall non-fiducial detector size. The results indicate that the chosen design can deliver excellent background suppression and energy resolution.

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Abstract title

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