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Far-Field Monitoring of Reactor Antineutrinos for Nonproliferation

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Numerous experimental efforts have shown that antineutrino-based monitoring provides a non-intrusive means to estimate the fissile content and relative thermal power of nuclear reactors for nonproliferation. However, close proximity to the reactor core is required in order to collect relatively high-statistics data needed for such applications. This has limited the focus of most studies to the so-called 'near-field', up to about 200 meters from the reactor core. Until now, there have been no experimental demonstrations dedicated to exploring the nonproliferation potential of large detectors required for long-range monitoring. In this low-statistics regime detailed measurements of the fissile fuel content are not practical, but remote monitoring and discovery of reactors may be achievable. The goal of the Advanced Instrumentation Testbed (AIT) program is to test novel methods for the discovery of reactor cores, specifically in the mid-field to far-field, beyond 200 meters and out to tens or hundreds of kilometers, using kiloton-scale to megaton-scale detectors. The main physical infrastructure of the AIT consists of an underground laboratory, expanding the Boulby Mine Underground Laboratory in Northern England. The site is located at a 25 km standoff from the Hartlepool Reactor Complex, which houses two 1.5 GWth advanced gas-cooled reactors. The first detector to be deployed at the AIT is the WATer CHerenkov Monitor of ANtineutrinos (WATCHMAN). WATCHMAN will use ~6,000 tons of gadolinium doped water in order to detect a few reactor antineutrinos per week from the Hartlepool reactor complex. WATCHMAN will focus on understanding the signal efficiency, radiological backgrounds, and the operational pattern recognition for reactor antineutrinos arising from a single reactor complex with two cores. Here, the nonproliferation goals are to understand the sensitivity for discovery of one reactor in the presence of another, the discovery of any reactor operations above a well-understood background, and the sensitivity to confirm the declared operational cycles of both reactors. Uniquely, AIT-WATCHMAN also offers a flexible platform at which nascent technologies such as water-based scintillator and fast photomultiplier tubes can be tested in real-world conditions. We present the AIT-WATCHMAN program and status.

Collaboration name

AIT-WATCHMAN

Primary authors: Dr BERNSTEIN, Adam (Lawrence Livermore National Laboratory); SMITH, Gary (University of Edinburgh)

Presenter: SMITH, Gary (University of Edinburgh)

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