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AM-OTech: Antineutrino-Based Reactor Monitoring with LiquidO Opaque Scintillator Technology

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The AntiMatter-OTech (AM-OTech) project, funded by the European Innovation Council (EIC) and UK Research and Innovation (UKRI), is a pioneering initiative in nuclear security and reactor diagnostics. Led by a collaboration of European academic institutions and EDF, AM-OTech explores the use of antineutrinos from nuclear fission as a non-intrusive, real-time probe for monitoring industrial nuclear reactors. The project is based at EDF Chooz-B, a key site in neutrino research.

Traditional reactor diagnostics primarily rely on thermal and neutron flux measurements. Antineutrinos, which are produced in vast numbers during nuclear fission, offer a unique, uninterrupted signature of a reactor' s power output and fuel composition. By exploiting antineutrino detection, AM-OTech aims to complement existing reactor diagnostics, enhancing safety and operational efficiency.

At the core of AM-OTech's innovation is LiquidO, an opaque scintillator-based detection technology. Unlike traditional transparent scintillators, LiquidO exploits stochastic light confinement in a highly scattering medium, enabling self-segmentation of the detection volume without dead materials and significantly improving event topology reconstruction and particle identification.

AM-OTech will be deployed at an ultra-near detector site, within 35 meters of the Chooz reactor cores. The 5–10 ton LiquidO detector consists of an opaque scintillator medium embedded with over 10,000 wavelength-shifting fibres, achieving a designed light yield exceeding 200 photoelectrons per MeV. The implementation of LiquidO technology enables precise identification of inverse beta decay (IBD) antineutrino interactions and unprecedented rejection of cosmic-ray-induced backgrounds, achieving a signal-to-background ratio exceeding 100 during reactor operation and remaining above unity even during reactor shutdowns. This exceptional performance allows for high-precision reactor antineutrino flux measurements with uncertainties below 1%, facilitating stringent tests of reactor antineutrino models and enabling validation of reactor predictions during ON-OFF transitions.

Author: TUCCORI, Nicolo

Presenter: TUCCORI, Nicolo

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