Nuclear and radiation backgrounds for the BUTTON anti-neutrino detector testbed at Boulby

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The sensitivity of antineutrino detectors is ultimately limited by radiological and cosmogenic backgrounds that populate the low-energy region relevant for inverse beta decay detection. A detailed understanding of these backgrounds is essential for both detector optimisation. The Boulby Underground Technology Testbed for Observing Neutrinos (BUTTON), located 1.1 km underground at the Boulby Laboratory, provides a uniquely low-background environment in which such studies can be undertaken.

This presentation focuses on the identification, measurement, and modelling of the dominant background sources relevant to water-based and hybrid antineutrino detectors. We discuss intrinsic radioactivity from detector materials and surrounding infrastructure, including contributions from uranium and thorium decay chains, potassium-40, and radon progeny, and their impact on trigger rates.

Despite the substantial cosmic-ray attenuation at Boulby, residual muons remain an important source of correlated backgrounds. We present ongoing and planned studies of muon-induced neutron production in the surrounding rock and detector materials, including spallation and muon-induced fission processes. Particular emphasis is placed on cosmogenic neutrons, their transport, moderation, and capture, and the resulting delayed backgrounds that can mimic antineutrino signals.

Monte Carlo simulations incorporating underground muon transport and detailed detector response are used alongside in situ measurements to validate background models and inform shielding, veto strategies, and detector media choices. These studies provide essential input for scaling hybrid antineutrino detectors toward practical reactor monitoring applications.