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Data-driven background model for the CUORE experiment and measurement of the two-neutrino double beta decay of Te-130

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Neutrinoless double beta decay ($0\nu\beta\beta$) is a lepton-number-violating nuclear transition beyond the Standard Model. If detected, it would unequivocally demonstrate that neutrinos are Majorana particles. This process is expected to be extremely rare, therefore very low background tonne-scale experiments are necessary for its observation. The Cryogenic Underground Observatory for Rare Events (CUORE) is one such experiment, searching for $0\nu\beta\beta$ in ^{130}Te. The CUORE detector is composed of 988 TeO_2 crystals, operating as cryogenic calorimeters at around 15 mK in the Gran Sasso National Laboratory (Italy).

Characterizing the remaining experimental backgrounds is crucial for discovering a rare process like $0\nu\beta\beta$. This complex task is accomplished through comprehensive material screenings and assays, combined with a detailed set of Monte Carlo simulations to model the CUORE data. As a result, contaminant activities distributed in several components of the experiment can be measured with sensitivities as low as 10 nBq/kg and 0.1 nBq/cm^{-2} for bulk and surface contamination, respectively. Many studies concerning the spatial and temporal distribution of the background sources can also be performed. Additionally, the outcomes represent essential inputs for the background budget of the next-generation experiment, CUPID, which will be operated in the same cryogenic facility.

We will describe the model of the CUORE background data, presenting the results of the 1 ton·yr data reconstruction performed using a simultaneous Bayesian fit of several energy spectra. This will include a discussion about the determination of the background component activities. We will also show dedicated studies that have been conducted to achieve the most precise determination of the $2\nu\beta\beta$ decay half-life of ^{130}Te, as well as investigations into the decay's spectral shape to explore nuclear physics parameters.

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