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Double-γ measurement and its implications on $0\nu\beta\beta$ decay

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Neutrinoless double-beta decay is a second-order decay process of atomic nuclei suggested by theories beyond the Standard Model. This decay would constitute the first observation of lepton-number conservation symmetry violation in the laboratory, showing that neutrinos are their own antiparticles. The neutrinoless double-beta decay rate depends on a Nuclear Matrix Element (NME), which is a key parameter to design experiments and fully exploit their results. Unfortunately, for each of the neutrinoless double-beta candidate nuclides the corresponding NME presents large uncertainties. A recent publication showed a very good correlation between the matrix elements of neutrinoless double-beta and double-gamma decay from the Double Isobaric Analog State (DIAS) of the initial double-beta state, i.e. the state carrying the same wavefunction except for a rotation in the isospin space, into the final double-beta state. Therefore, we could attack the lack of experimental data on the NME values by studying the two-photon decay process. The only neutrinoless double-beta candidate for which the DIAS is known is the ^{48}Ca isotope, which therefore constitutes the ideal study case to start with. Given the very small double-gamma decay rate expected for this nucleus, it is essential to characterize the contributions of all the competing processes and determine the optimal setup and data processing methods to maximise the double-gamma detection efficiency. For this reason a dedicated custom simulation program based on the GEANT4 framework was developed, in order to simulate the experimental setup and its response to the radiation emitted in the ^{48}Ti nuclear de-excitation. After validating the setup and the simulation outputs, different analysis methods were implemented to suppress the decay processes competing with the double-gamma decay. Promising results concerning both the identification of the double-gamma events and the associated NME extraction were obtained, supporting the feasibility of an experiment aimed at measuring this exotic process in ^{48}Ti. When performed, this measurement will provide the first experimental constraints on the ^{48}Ca neutrinoless double-beta decay NME.

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