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DATA ANALYSIS FOR NEUTRINOLESS DOUBLE BETA DECAY

Double-Beta Decay (ββ) is a rare transition between two isobars, involving the change of the nuclear charge Z by two units. In Nature we have several even-even nuclei for which this is the only allowed decay mode. While the transition where 2 electrons and 2 neutrinos are emitted (2νββ) does not imply ”special” properties for the neutrinos (and has been observed for various isotopes), this is not the case for the neutrinoless channel (0νββ). Indeed, despite being energetically possible, the neutrinoless transition violates the lepton number by 2 units and is possible only if the neutrino is a massive Majorana particle. 0νββ -decay searches have been pursued for more than half a century and today they experience a renewed interest, thanks to the discovery of neutrino oscillations. However oscillations are not enough to investigate the very heart of neutrino physics i.e.
why neutrinos are extraordinary light and which is their nature (Dirac or Majorana). Several theoretical speculations point toward a mass generation mechanism that implies a Majorana character of neutrinos, and that indicates the 0νββ process as the unique tool with a discovery potential.
The 0νββ transition could proceed through different mechanisms among which the simplest and favorite one is the ”pure Majorana mass”. In that case the 0νββ -decay observation would not only provide evidence of lepton number violation and of the Majorana character of this particle, but would result in a measurement of the Majorana effective mass, which is sensible to the different neutrino mass hierarchy.
0νββ decay results for ^{130}Te have, since many years, a story strictly connected with bolometric detectors.
The concept of a single particle bolometric detector is that of an ideal calorimeter for which all the energy of the incident radiation is converted into heat, giving rise to a temperature variation of the detector’s body. Such a temperature rise is then measured by means of a proper transducer, in our case a semiconductor thermistor whose resistance increases exponentially with temperature, providing a measurement of the energy released by the impinging particle.
This kind of detectors search for 0νββ -decay processes with the so-called ”source= detector” approach, where the candidate is contained inside the active mass of the detector itself.
In this thesis work the whole statistics collected with the CUORICINO experiment (this was operpated between 2003 and 2008, with a total 130Te exposure of 19.75 kg· y) have been analyzed and used to obtain the final result of the CUORICINO experiment for the 0nDBD of 130Te: a lower bound on the ^{130}Te 0νββ half-life limit of 2.8 1024 years at 90% C.L. The corresponding upper bound on the neutrino Majorana mass is in the range 300-710 meV depending on the adopted nuclear matrix element evaluation.
CUORICINO bolometers contain the isotope ^{130}Te (i.a. 33.8%) which is a ββ -decay candidate with a rather favorable factor of merit and the signature of the decay consist in a monochromatic peak appearing in the energy spectra of the

bolometers at an energy equal to the Q-value of the decay: 2527.5± 0.013 keV.

This result and the details of the analysis are the subject of the final publication of the CUORICINO Collaboration which is submitted now to Astroparticle Physics.

The steps that lead to the production of the final 0nDBD results include:

- new and original developments of algorithms for the data processing of the signals collected with a bolometer
- the test and optimization of these algorithms on Cuoricino data
- their use in the framework of the official Cuoricino software for the full processing of the entire data-sets.
- the optimization of the technique used for the identification of the 0nDBD signal and for the evaluation of the half-life limit, including a detailed analysis of efficiencies and the systematic uncertainties

As a conclusion of this work, we present different tools implemented in order to reach this result, such as pulse-shape analysis, resolution enhancement by means of optimal filtering and the development of a new algorithm for Monte Carlo simulations of bolometric noise.
A study on a natural way of presenting prior-free results on bayesian limit with example on Monte Carlo simulation is also presented as a summary of all the lessons learned thanks to CUORICINO.