Radioactivity and the limits of Standard Model

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In addition to high energy experiments, precision measurements in nuclear β decay provide sensitive tests of electroweak model, one of the building blocks of the Standard Model (SM) of elementary particles. The study of nuclear decay modes has played a crucial role in the determination of the basic structure of fundamental interactions and, before the real development of particle physics, a number of basic foundations of the standard electroweak model, i.e. the assumption of maximal parity violation, the 2-componant theory of the neutrino and the vector-axial-vector character of the weak interaction, were discovered in nuclear β decay processes.

The strength of the method lies in the fact that distributions of expected events can be derived from the fundamental theory using a few controlled hypothesis. The clearness of the theoretical approach allows the search for a new physics beyond the SM, even if the "exotic" processes manifest in rare events, which requires to perform high precision measurements including a relevant management of systematic effects and of theoretical corrections.

The development of advanced techniques in nuclear physics, especially atom and ion traps, has recently renewed the interest of low energy communities worldwide in such researches. As a consequence new constraints are expected on the SM limits, with the hope of potential breakthrough discoveries in fundamental physics.

The first part of the lectures will be dedicated to the introduction of theoretical concepts, starting from Dirac equation to reach the "ft" values expressions. The way is long and only some basic elements will be detailed to understand the main issues.

In a second part, technical aspects of the experiments will be described, covering correlation measurements to test the *V-A* theory of the SM, the *CVC* hypothesis in mirror decays or the fundamental symmetries violation. Neutrinos are key particles in β decays and experiments aiming to determine their nature will also be discussed.

Expected prerequisites:

- Quantum mechanics: equations of Schrödinger, Klein-Gordon and Dirac, equation of continuity
- β decay: kinematics, selection rules, Fermi theory.

Review papers:

- N. Severijns et al., Rev. Mod. Phys. **78** (2006) 991.
- N. Severijns & O. Naviliat-Cuncic, Phys. Scr. **T152** (2013) 014018.
- E. Liénard, Habilitation à Diriger des Recherches (in french), Hal Id: tel-00577620.