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Measuring the half-life of Po-215 by low-level liquid scintillation counting

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The radioactive isotope of ^{215}Po is a part of the decay chain historically known as the actinium series, which starts with the naturally occurring ^{235}U and ends in the stable isotope of ^{207}Pb . When neglecting ^{215}At , which is only present in insignificant amounts, ^{215}Po is the progeny with the shortest half-life (of about 1.8 ms) in the decay chain.

Due to the limited time scale, a simple half-life determination by measuring the diminishing activity of a chemically separated sample as function of time is not feasible. Instead, one has to apply the so-called delayed coincidence method, in which the distribution of the lifetimes of individual ^{215}Po nuclei is measured. In previous experiments, this was achieved by e.g. placing a thin ^{227}Ac sample in between two silicone surface barrier detectors and measuring the elapsed time between the alpha decay of ^{219}Rn and the following alpha decay of ^{215}Po itself.

In this paper, we present an alternative approach using liquid scintillation counting (LSC) in combination with digital data acquisition and offline data analysis. The use of LSC simplifies sample preparation and handling but provides limited energy resolution compared to silicone surface barrier detectors. However, due to the fact that all other members of the actinium series have half-lives which are several magnitudes longer than the one of ^{215}Po , the discrimination between different alpha energies is not strictly necessary. By limiting the source activity so that the average time gap between two alpha decays becomes considerably longer than the half-life of ^{215}Po , an indirect selection of alpha events can be achieved. On a timescale equivalent to 10-15 half-lives of ^{215}Po , the time difference distribution of event pairs related to the same ^{215}Po nucleus would result in Poisson statistics, whereas uncorrelated alpha decays observed on the same time scale would contribute to a constant background.

For our experiment, a single LS sample was prepared from aqueous solution of ^{227}Ac in standard 20 mL polyethylene vials using Ultima Gold AB scintillator. The initial ^{227}Ac activity was approximately 0.5 Bq. The vial was then measured in a custom-built triple-to-double coincidence ratio (TDCR) counter, equipped with 3 photomultiplier tubes (PMT). During the measurement all observed events were recorded in list-mode format by a fast digitizer. The half-life determination took place offline by studying the time difference distribution of triple coincidence events, where all PMTs fired within 40 ns.

The measurement is still ongoing, but the obtained preliminary half-life of 1.779 (7) ms (based on data taken over a period of 40 days) is in good agreement with the currently recommended value of 1.781 (4) ms for ^{215}Po . This shows the feasibility of the above-described approach. Further details of the measurement and the final result will be presented at the conference.

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