A Multiple Cell Proportional Counter for Continuous Airborne Radon Assessment

Ph.D. THESIS

in

Nuclear and Industrial Safety

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To my wife Nacéra and our children: Cyria, Daniel and Maria-Luisa, who shared with me hard sacrifices during the performing of this work.

To my father and mother who permitted me to get instructed.

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Abstract:

A new proportional counter type, baptized Multiple Cell Proportional Counter (MCPC), intended for continuous airborne radon activity measurements is described and its operation principle presented. This gas-flow proportional counter, consisting in a pile-up of 20 separate proportional counters elements, uses an argon-propane (1%) as a binary gas mixture to which is admixed an appropriate fraction of ambient air, in which radon activity concentration has to be continuously measured through a periodic counting of the α particles emitted by $^{222}$Rn and its short-lived decay products within the sensitive volume. A Monte Carlo simulation code, RADON-MCPC, which takes into account the major physical processes that determine directly the detector performances, has been written and used for design optimization purposes. According to preliminary design calculations the MCPC model, should achieve a radon counting efficiency greater than 100 %. The simulation results show that the admixture of 10 % of ambient air seems to be sufficient to continuously assess radon concentration levels ranging from about 15 Bq/m$^3$ up to $1.5 \times 10^5$ kBq/m$^3$ for an integral counting period of 10 minutes, when setting the energy discrimination at 250 keV. The expected radon sensitivity is about 11 cpm /100 Bq·m$^{-3}$, achieving thus a measurement accuracy of ± 10 Bq/m$^3$ at a mean radon concentration level of 100 Bq/m$^3$ with a detector time response of 10 min. The preliminary experimental α spectra registered show a great agreement with those obtained through the simulation code.