On the Best Position for External Calibration Source in Beta-Gamma Coincidence Measurements

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1. Introduction
Beta-gamma coincidence method is the basis for low-activity radioxenon analysis. An important task in accurate measurement is to precisely calibrate the system. Usually it is expensive or even impossible to find a reasonable amount of purified radioxenon gas for calibration purposes. A good alternative is to calibrate using an external gamma-rays source like $^{137}$Cs. The main question is where to place the source, to have a more accurate calibration measurement. There are several important factors in the simulation of response function of the system, in which radiation and optical simulations have a dominant role. We have developed an improved radio-optical simulation procedure for this purpose to have enough data resulted in external calibration process. The method is to match between radiation transport using MCNP code; and optical scintillation light transport using our home-made code ray-tracing code Optix. Results of the current study shows that there are several factors regarding the calibration source positioning which should be taken into account for every individual configuration/system. The concentration was on our proposed cylindrical well-type coincidence system.

2. Materials and Methods
Response of a scintillation detector to beta-particles and gamma rays were simulated using the well-known MCNP code. The relative amount off deposited energy were taken to find the results better Compton coincidence source. A macro program has been developed to provide the coincidence response of the detector. An important factor that affects the performance of every design is due to optical effects. The optical response of each component (plastic scintillator, and NaI cells) were modeled regarding their optical properties. Although we have neglected the differences between pulse shapes.

3. Results
Firstly the geometrical configuration of our proposed well-type coincidence system were modeled in both of MCNP and Optix (Fig. 1). Coincidence response of the detector has been evaluated using the MCNP code (Fig. 2). Changing the location of calibration source w.r.t. the distance from bottom one can observe that the central portion of the plastic cell will result in greater pulses (Figs. 3, 4). The relative light collection efficiency has been evaluated as a function of position (Fig. 5) which analyzing its distribution (Fig. 6) shows that there are to distinctly distributions of probabilities. Taking into account the light collection behavior of both of plastic and NaI cells, one may conclude that the central portion of the cell is well-suited to produce coincidence pulses.