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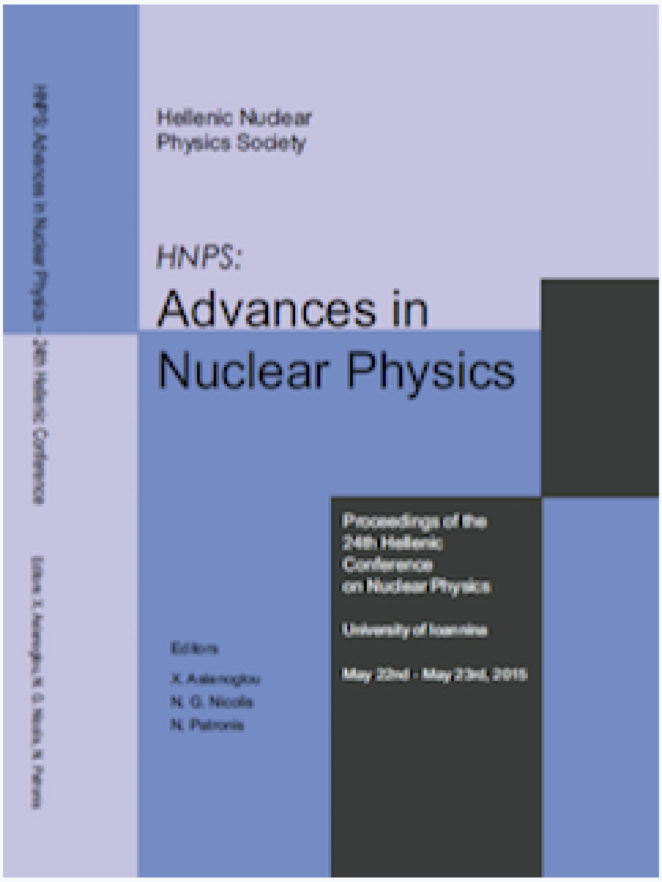

MCNP model of the EEAE ACCUSCAN Whole Body Counter

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MCNP model of the EEAE ACCUSCAN Whole Body Counter

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Abstract Monte Carlo simulations and verification measurements for the efficiency calibration of the ACCUSCAN shadow-shield type Whole Body Counter (WBC) of the Greek Atomic Energy Commission (EEAE) are presented. A model of the counter and RMC-II anthropomorphic phantom was developed using the MCNP code. Full energy peak efficiencies for different phantom positions were calculated for ^{60}Co and ^{137}Cs sources. The deviations between computational and experimental efficiencies were found to be less than 12 % for ^{60}Co and 4 % for ^{137}Cs for the Ge detector and less than 25 % for ^{60}Co and 4 % for ^{137}Cs for the NaI detector. This work contributes to the accurate quantification of internal contamination in individuals accidentally exposed in Greece by the Greek Atomic Energy Commission Laboratories and moreover demonstrates the effectiveness of using computational tools for understanding the calibration of radiation detection systems used for in vivo monitoring.

Keywords Whole Body Counter, Internal Radionuclide Contamination

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INTRODUCTION

Computational techniques for the calibration of Whole Body Counters (WBC) are important, since they provide a powerful tool for understanding of the counter response under the complex geometries representing the range of human body sizes, genders and ages, as well as the different radionuclides that may be encountered in a the case of a radiological accident with internal contamination. In the present work, Monte Carlo simulations and measurements for the efficiency calibration of the Greek Atomic Energy Commission (EEAE) ACCUSCAN shadow shield Whole Body Counter using the RMC-II anthropomorphic phantom are presented.

EXPERIMENTAL

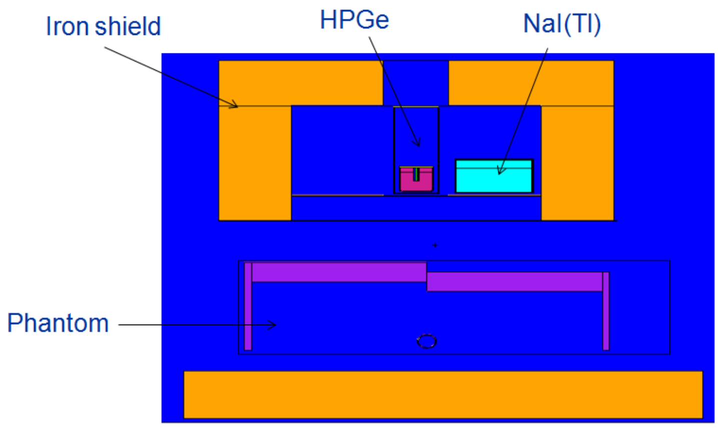
The EEAE WBC is a CANBERRA ACCUSCAN 2600 [1] shadow shield scanning bed type counter (Fig. 1). The counter employs two detectors: a high efficiency parallelepiped NaI(Tl) detector (7.6 cm x 12.7 cm x 40.6 cm) and a high energy resolution HPGe detector (25% rel. eff.). The detectors are shielded by low activity iron.

The RMC2 phantom [2] is a linear geometry calibration phantom manufactured by CANBERRA. The RMC2 phantom is constructed with acrylic glass slabs, with three plastic tubes for simulated internal source placement. For the purpose of our study point sources of ^{60}Co and ^{137}Cs were placed at the position representing whole body contamination.

Fig. 1 EEAE WBC and RMC2 phantom

SIMULATIONS

Simulations were performed using MCNP5 code and ENDF-B/VI cross section data library [3]. A detailed model of the counter including the detectors, iron shielding, scanning bed and phantom was developed. Detector response was calculated using pulse height tallies (F8) providing the photon energy dissipated in specified energy bins. About 10^8 source photon histories per run were utilized to obtain a relative error of better than 5% in the detector responses. The effective size and position of the detectors was optimized on the basis of a set of measurements performed using ^{60}Co and ^{137}Cs point sources in air. The model geometry of the WBC and phantom are shown in Figs. 2 and 3, respectively.



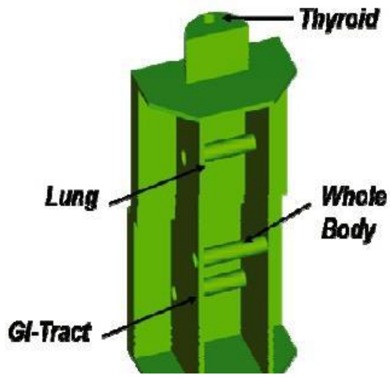


Fig. 2 WBC model geometry

RESULTS AND DISCUSSION

The calculated to experimental ratios (C/E) of full energy peak efficiencies for the ^{137}Cs and ^{60}Co sources as a function of phantom position for the Ge and NaI detectors are shown in Figs 4 and 5, respectively. The source was positioned in the phantom holder representing whole body contamination.

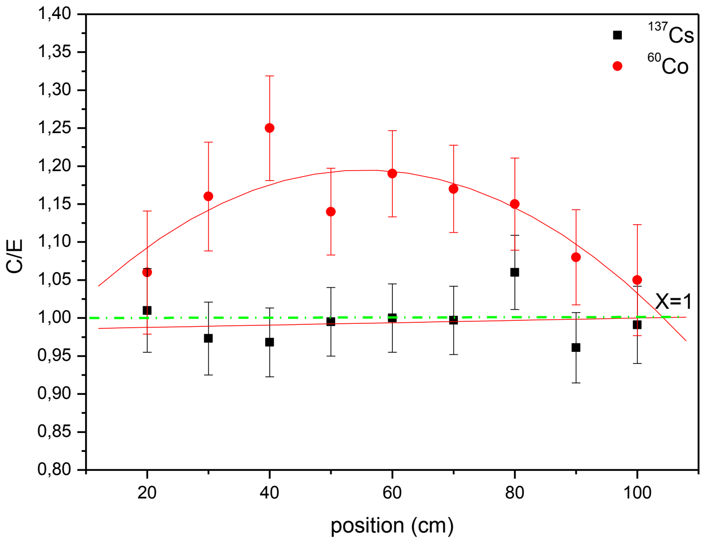


Fig. 4 Full energy peak efficiency C/E ratio with phantom position for the Ge detector

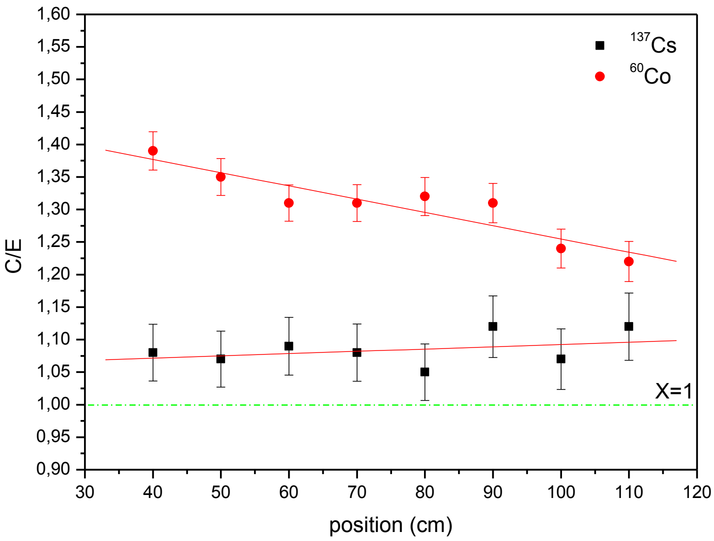


Fig. 5 Full energy peak efficiency C/E ratio with phantom position for the NaI detector

The maximum deviations between computational and experimental efficiencies were found to be less than 30% for ^{60}Co and -5% for ^{137}Cs for the Ge detector and less than 40% for ^{60}Co and 12% for ^{137}Cs for the NaI detector, respectively, for all phantom positions.

The derived C/E values can be considered as satisfactory for the in vivo ^{137}Cs determination in case of radiological accidents. Nevertheless, further work is required for the optimization of the ^{60}Co response, most particularly in the case of the NaI detector.

This work contributes to the accurate quantification of internal contamination in individuals accidentally exposed in Greece by the Greek Atomic Energy Commission Laboratories and moreover demonstrates the effectiveness of using computational tools for understanding the calibration of radiation detection systems used for in vivo monitoring [4].

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