Introducing Monte Carlo based calibrations at the whole body counter of the Swedish Radiation Safety Authority

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SUMMARY

A Monte Carlo model of the whole body counter located at SSM was set up in the framework of SSM activities addressed to develop and implement methods for responding to nuclear and radiological emergencies. The modelling showed an accuracy of 10 % which was considered acceptable.

The model is compatible with the software MCNPX [1], version 2.4.0 or newer. The MCNPX definitions of the IRINA phantom were taken from previous model built and tested at KIT [2].

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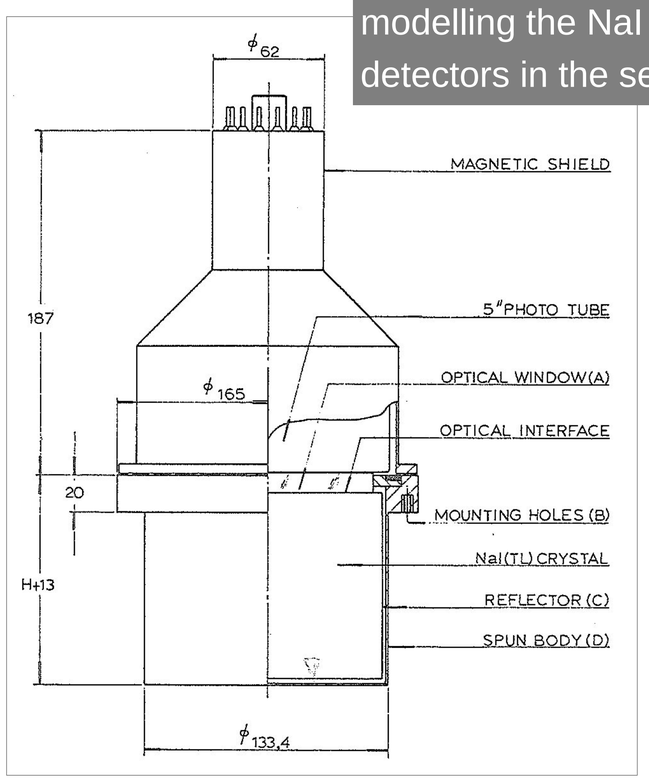
METHOD

Step 1: Modelling of the 3 NaI(Tl) detectors, stretcher and chamber. The detectors and stretcher were modelled according the manufacturer data, the chamber was modelled according measurements on site. The modelling of the chamber helped with providing a reference world where the phantoms could be more accurately placed.

Step 2: Measurements of point sources and of all phantom configurations.
Step 3: Iterative correction of the MCNPX model to reduce the deviations between simulations and measurements: the value of the density of Al_2O_3 for detectors windows was obtained from similar detectors and then adjusted to improve the final agreement.



Specifications for modelling the NaI detectors in the set up

Setup used for the measurement of the IRINA phantom configuration P4. In the left up corner the MCNPX model of the two detectors on top of the stretcher is shown.

MEASUREMENTS

Two different kinds of measurements were performed: point sources and phantom (extended) sources. The point sources were ^{137}Cs and ^{22}Na. They were placed on the surface of the stretcher, directly below the detector “Legs”. The MCNPX model was modified appropriately until the measurement and simulated data matched with the desired accuracy.

The acquisition of experimental data was performed for ^{137}Cs, ^{60}Co and ^{40}K for the phantom configurations weighting 61.5, 77.8 and 95.2 kg (P4, P5 and P6, respectively). The position of phantom and detectors had to be checked for correctness. The foam covering the stretcher was affected by the weight of the phantom, which was compensated by correcting its thickness in the model. Another correction was applied to compensate the bent of the back of the stretcher also caused by the weight of the phantom.

RESULTS

DEVIATION SIMULATIONS/MEASUREMENTS FOR CONFIGURATION P5 OF IRINA (%)

Detector:	Legs	Chest	Back	SUM
^{137}Cs	-10.7	-2.4	-12.9	-9.2
^{60}Co	10.6	9.0	-0.5	5.3
^{40}K	3.7	11.2	6.1	6.9

CONCLUSIONS

Measurements of point sources were used to improve the initial model and phantom measurements were used for further correcting the model. The overall measured detection efficiency is within 10% from the values calculated with MCNPX simulations. The model is then suitable for providing a mathematical calibration in the event of emergencies.

REFERENCES

[1] Pelowitz D B (editor). MCNPX User’s Manual version 2.6.0. Los Alamos National Laboratory Report LA-CP-07-1473 (2008)

[2] Sessler S, Studienarbeit II – Grundlegende Betrachtungen zur numerischen Simulation des Karlsruhes Ganzkörperzahlers. Forschungzentrum Karlsruhe, 2007.