Calibration factors and minimum detectable activities in the lung of radionuclides released in the case of a nuclear power plant accident

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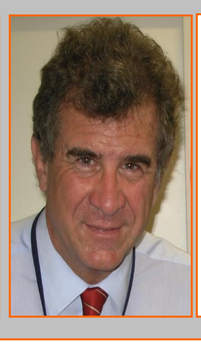
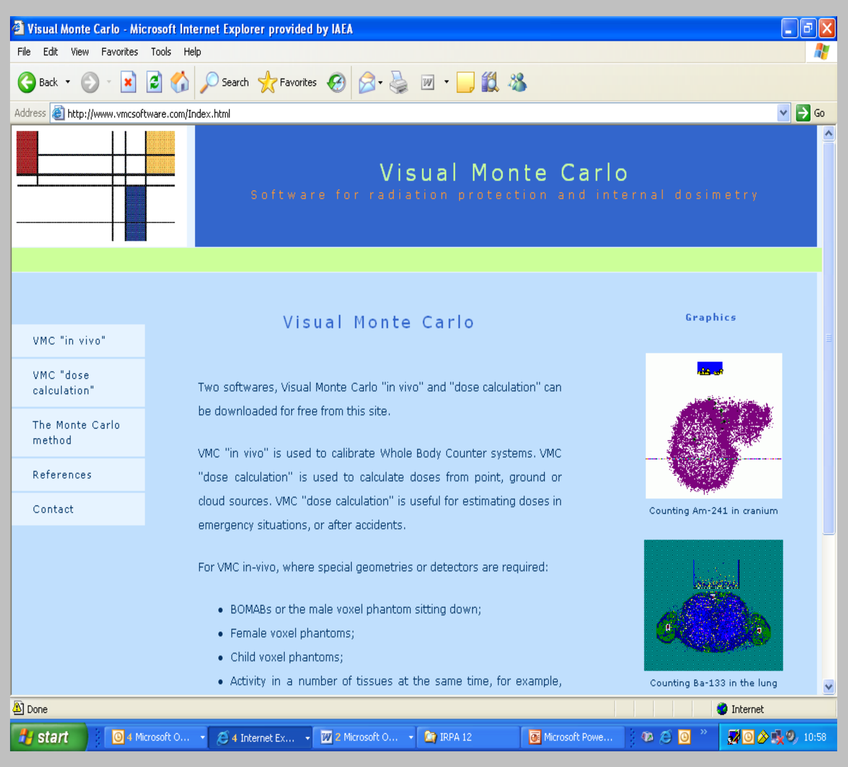
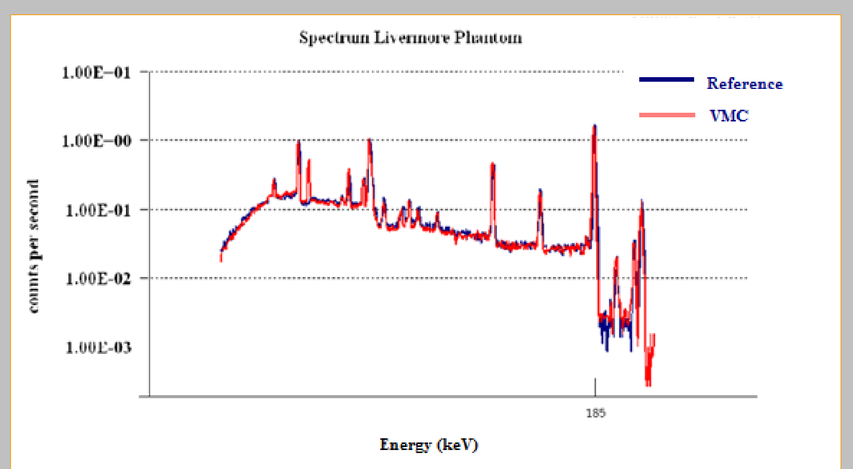




VMC in-vivo free download from vmcsoftware.com – considerable update will be available in July 2012

INTERCOMPARISON RESULTS

VMC results for the 2010 EURADOS intercomparison of Monte Carlo methods – counting enriched uranium in the lung with four germanium detectors



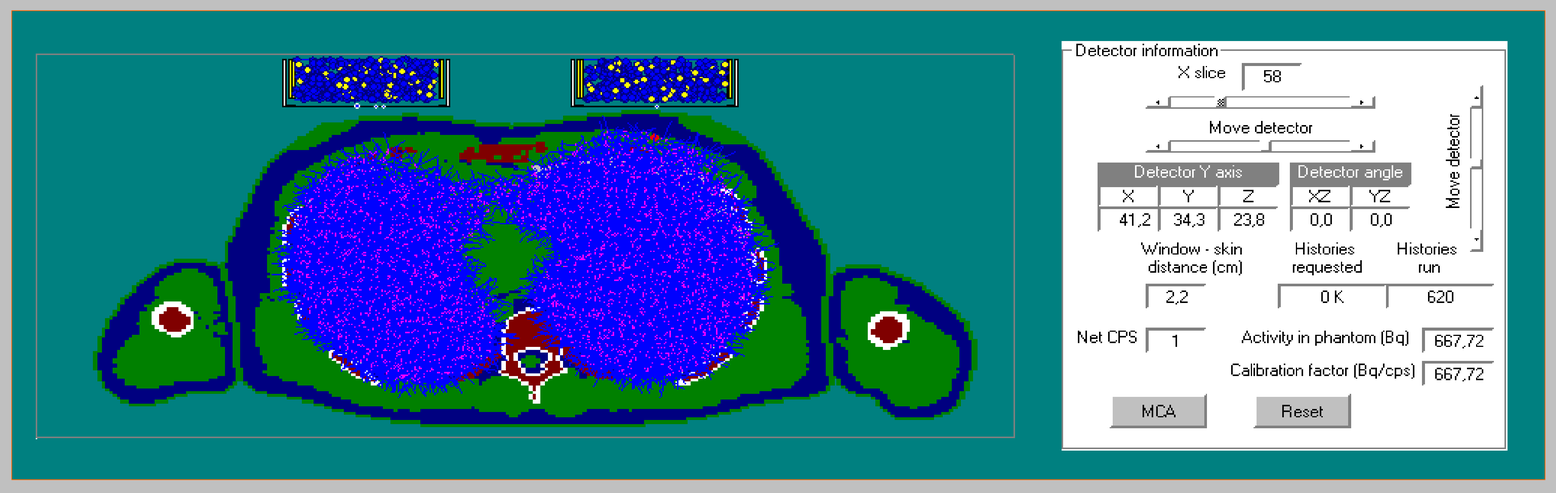
INTRODUCTION

The Monte Carlo program Visual Monte Carlo in-vivo (VMC in-vivo) was used to calculate calibration factors and minimum detectable activities (MDAs) for radionuclides that would be released after a serious accident at a Nuclear Power Plant, deposited in the lung.

MATERIALS AND METHODS

VMC in-vivo simulates a nuclear transformation of the radionuclide in the tissue of interest, transports the photons through the ICRP male voxel phantoms, and then simulates the detection. VMC is written in Visual Basic version 6 . The counting geometry involved two BE-5030 germanium detectors from Canberra placed over the lungs as shown in the figure below. For the MDA results, a background count for a non-contaminated person for 900 seconds in a room shielded with 1 cm of steel was used. The equation used to calculate the MDA was:

$$MDA = \frac{4.65 \times \text{Calibration factor} \times (\sqrt{Background\ counts} + 3)}{\text{Counting time (s)}}$$

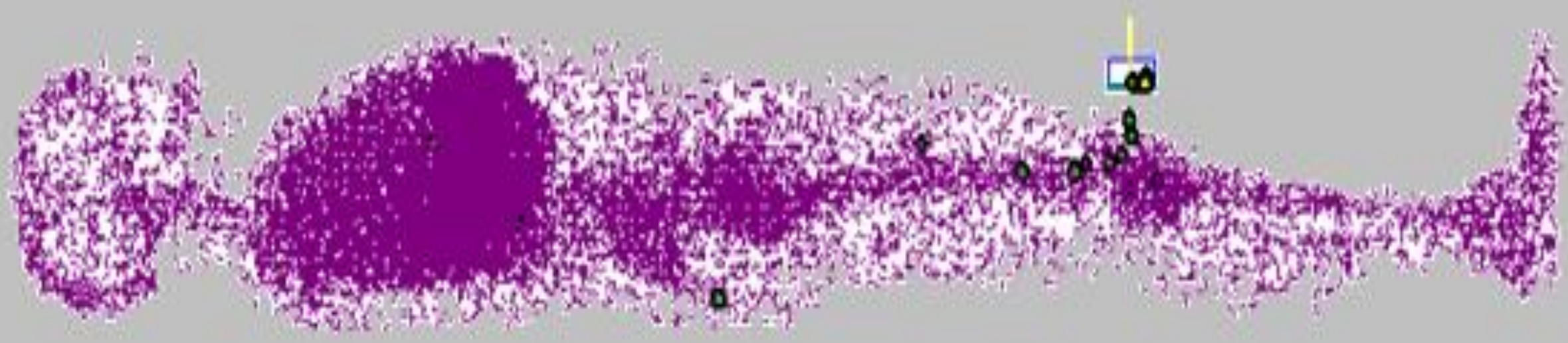


RESULTS

The results of the simulation are as follows:

Radionuclide	Photopeak energy	Yield	Calibration Factor[(a)]	BG [(b)]	MDA
	keV	%	Bq/cps	counts	Bq
^{137}Cs	662	85	417	4.8	11
^{134}Cs	605	98	331	4.8	9
^{95}Zr	757	55	716	4.9	19
^{95}Nb	766	99	401	3.5	10
^{106}Ru/^{106}Rh	511	20	1377	8.7	42
^{124}Sb	602	98	330	5.1	9
^{192}Ir	317	87	183	13	6

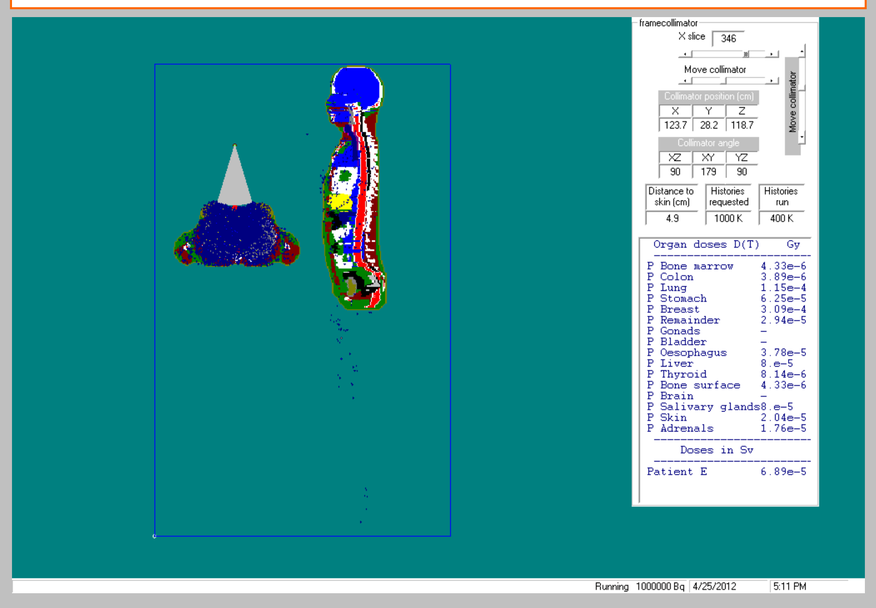
[(a)]The cps in the calibration factor is the sum of the cps in the photopeak for the two detector spectra.
[(b)]The BG is the sum of the background counts from the two detectors for 900 seconds in the same Region of Interest as the photopeak



OTHER WORK WITH VMC

DOSE CALCULATIONS IN FLUORSCOPY

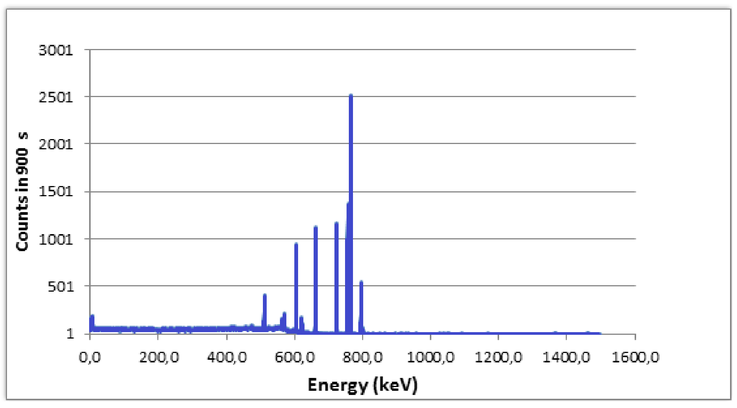
Irradiation of the heart region of the patient with a 70 kV X-ray spectrum, 1 mGy entrance dose, square collimator 10 cm x 10 cm. The program calculates the dose to the doctor and to the patient.



MORE RESULTS

Assuming a “Chernobyl” release mixture of radionuclides as in the table below, the simulated spectrum obtained from the radionuclide mixture plus background is shown in the graph. A 20,000 Bq total activity of the radionuclide mixture was counted in the above mentioned lung geometry (2 detectors) for 15 minutes.

Radionuclide	Percentage
^{134}Cs	8.8
^{137}Cs	13.9
^{95}Zr	32.0
^{106}Ru	13.1
^{95}Nb	32.1
^{124}Sb	0.1



CONCLUSIONS

With VMC in-vivo it is possible to quickly determine calibration factors and MDAs for radionuclides and geometries for which no physical phantom is available, mainly due to the short half-life of many of the radionuclides involved.