Computational algorithm for deterministic quantification of the contribution of radiation reflected from large surfaces

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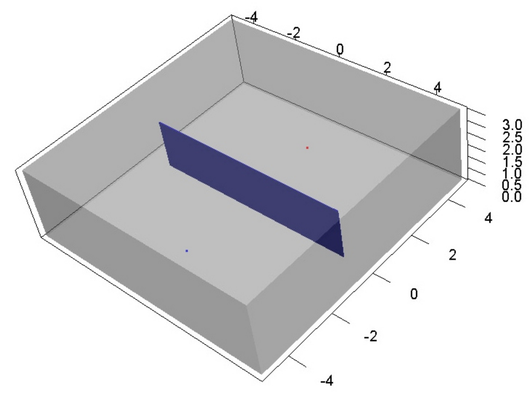
1. Introduction

Based on our measurements indoor nuclear environments, we can say, that, in general, dose from reflected radiation is 2 percent towards the dose from the direct radiation if no additional shielding is applied to the radiation sources.

When dose is mainly originating from low-power sources in the line of sight, the contribution of albedo is, in average, non-significant. However, if high-power sources, behind non-continuous, but strong shields (e.g. behind a low wall) are present, then neglecting reflected radiation may lead to serious underestimation.

2. Objectives

Our primary goal of this study is to develop time efficient computerized algorithms, to calculate dose from shielded gamma sources, including contribution of the radiation "reflected" from large surfaces, e.g. walls of a room. The more general aim is improvement of the Halden Planner, a sophisticated software tool, created for characterization and monitoring in nuclear environments, developed at the Institute for Energy Technology in Norway, within the frame of the OECD Halden Reactor Project.



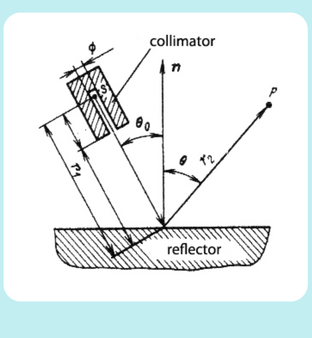
3. Methods

We have developed a software tool that permits rapid assessment of dose from shielded gamma sources. The dosimetric code is written in R-language. For visualization of the simulation process we use the capabilities of OpenGL.

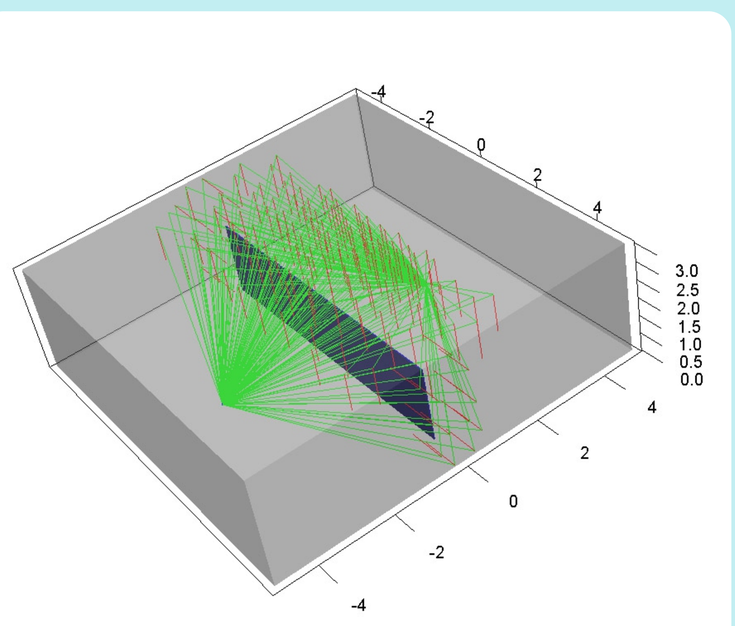
In the calculations, we take into account single-scattering from walls, floors, ceilings, and other objects with large surfaces inside a room. Scattering in the air is ignored.

Objects, in our model, are represented by 3D meshes, they have a simple transcription, and can easily be created using common 3D editors.

Our technique is based on a semi-empirical formula from “Gusev N.G., Klimanov V.A., Mashkovich V.P., Suvorov A.P. (1989) Shielding from Ionizing Radiation. Vol.1. Physical Fundamentals for Shielding from Radiation”, which calculates the albedo (reflected component) of a mono-directional beam of gamma quanta, from semi-infinite media.



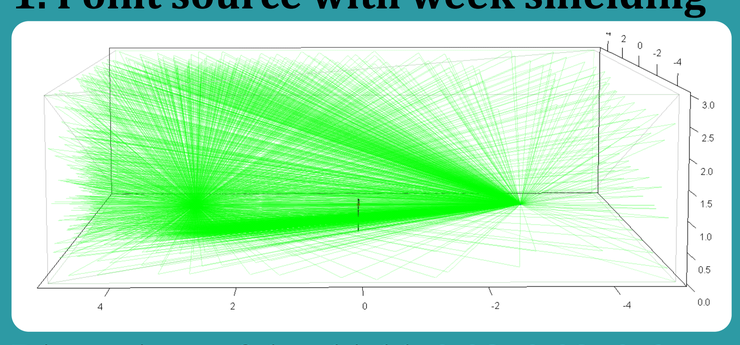
Radiation emitted by isotropic point sources is represented by a superposition of collimated beams, using a regular polyhedrons model. We track the path of each "collimated" beam, and perform calculation for the scattered radiation dose. In the calculations we take into account both, single scattering, and multiple quantum "walk" in the reflecting matter.



Are visible only those rays that have come from the source to the detector, singly reflected from the walls.

4. Results

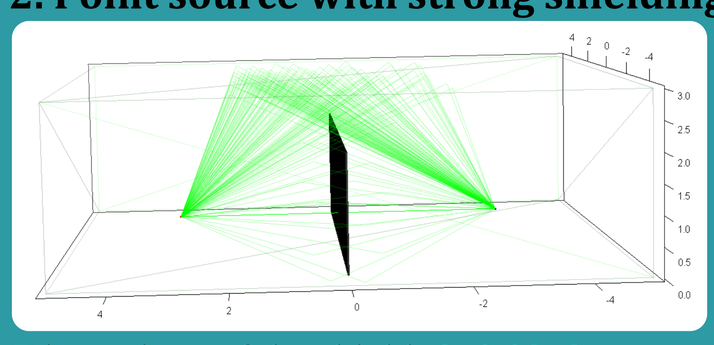
1. Point source with week shielding



Dimensions of the shield: 0,08x0,03x0,6 m
Dimensions of the room: 10x10x3 m

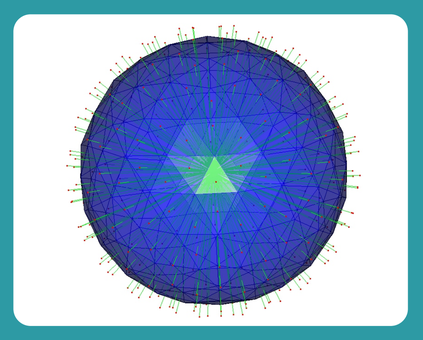
Albedo = $2.3*10^{-1}$ mSv/h
Direct dose rate = $5.5*10^{-2}$ mSv/h

2. Point source with strong shielding



Dimensions of the shield: 8x0,03x2 m
Dimensions of the room: 10x10x3 m

Albedo = $4.2*10^{-2}$ mSv/h
Direct dose rate = $5.5*10^{-2}$ mSv/h



Number of rays	Albedo value, mSv/h
80	0.03638442
320	0.03434581
1280	0.04165379
5120	0.03691834
20480	0.03578292

The model radiation source is an isotropic point source. The result of our calculations is sensitive to the resolution applied for simulating the emitted radiation as a superposition of mono-directional beams, that is, the number of the faces of the icosahedron applied.

5. Conclusions

In rooms, where gamma sources are behind (but not enclosed by) shields of large thicknesses (> 3 cm of lead), the contribution of reflected radiation is comparable with dose from the direct beam and thus, radiation reflection may become critical, in designing protection of personnel, indoors. Actual doses of the staff could reach 2 times the doses calculated with no reflection.

Application of our algorithms permits optimization of shielding configurations in situations, where reflected radiation is not negligible.

6. Acknowledgements

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Statens strålevern
Norwegian Radiation Protection Authority

IFE Institute for Energy Technology

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http://www.ife.no/departments/visual_interface_technologies/projects/DRIVE
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