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Is there a practical benefit in 3D radiation protection applications?

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1. Introduction

Radiation protection often uses numeric values and words to describe radiation fields in amount, shape and size. The effort of making sketches, especially for the training of workers is rarely taken. The paper examines the additional value that 3D-model-based approaches may have in communication of radiation hazards in complex environments in the practical application.

2. Description of research problem

More and more applications using 3D-modelling in radiation protection are coming up on the markets.
The question in practical terms of radiation protection during the decommissioning and waste management is if the benefit weights out the additional effort in 3D-modelling and scenario set up. Also, it was to be investigated whether the communication with workforce and experts can be supported by using these technologies.

3. Methodology

In a practical approach, the 3D-model based software VRDose ® has been consequently used in two decommissioning and waste management projects, where iUS were engaged as radiation protection experts. We have investigated the following questions:

(1) Is the result of point-kernel-models accurate enough in these environments?
(2) Is there a benefit in communication, training and understanding of complex radiation fields among experts and between experts and workforce?

4. Application: Waste sorting station

Together with Equans, iUS have designed for PreussenElektra a high dose rate sorting station. It is intended for the remote controlled sorting of waste with dose rates of around 1 Sv/h. The station consists of a sturdy steel confinement, the drums are additionally shielded by lead shielded casks.
This required a calculation of various configurations (loading/unloading, sorting, interventions) in different rooms with different usage. Ensuring low dose rates at adjacent walkways was an important factor for optimisation (cf. Fig 1).

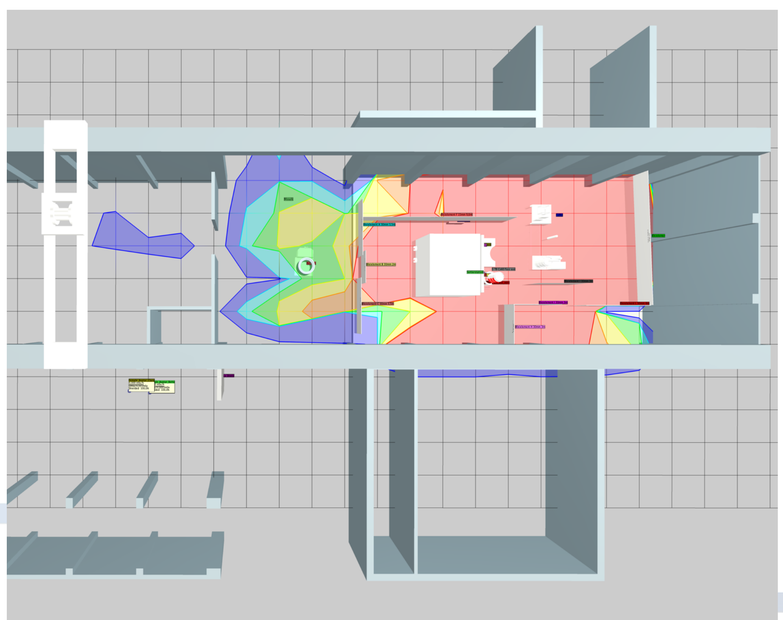

Fig. 1: Model of the emplacement of the sorting station and radiation field during loading process. Radiation fields in the walkways can be identified and communicated and the emplacement of lead mat shielding walls can be optimized.

In a further step, the accuracy for this application was investigated using MCNP 6 to determine the influence of skyshine and reflexion, which are not calculated in point-kernel models. The results are depicted in Fig 2.

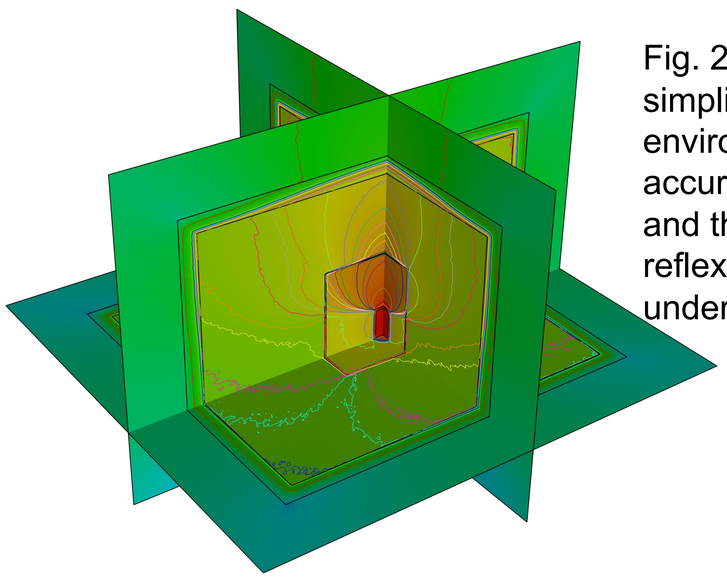

Fig. 2: 3D isolines of dose rates of a simplified model of the station and its environment to determine the accuracy of the point-kernel model and the influence of skyshine and reflexion. The latter was below 5% under the given circumstances.

5. Application: Packaging of waste

Together with AtkinsRealis, iUS have modelled the packing of underwater cut reactor internals at an RWE site. In this case, there was not a static modelling but a scenario model that also showed the changes and superposition of radiation fields during the process. A static picture is shown in Fig 3.

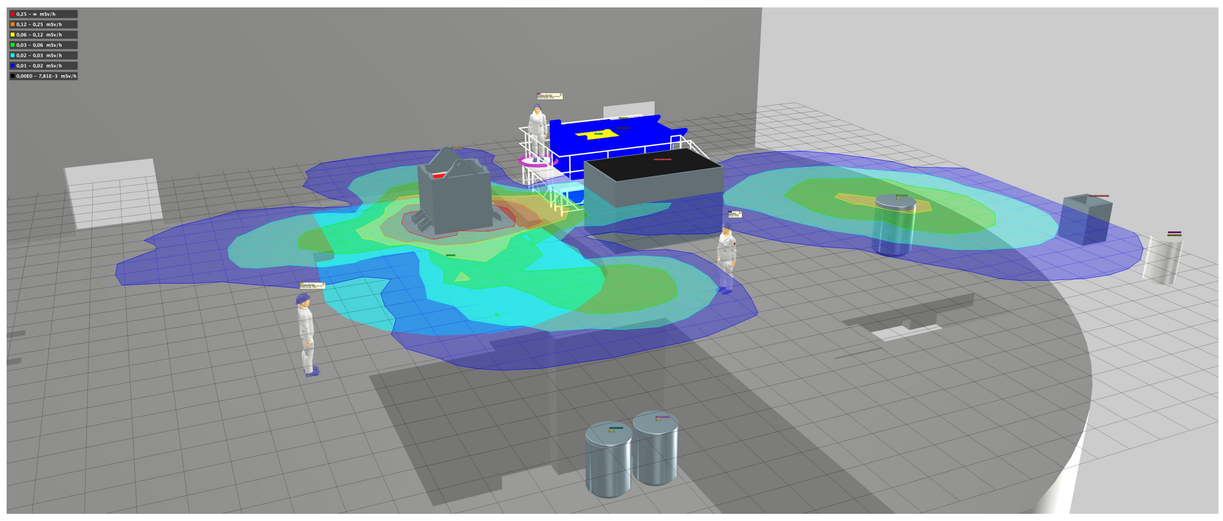

Fig. 3: Scenario for dose estimations and training. The scenario is applied for the dry loading of containers. The calculations show the high variation of the radiation fields during the process within a few metres. The model-based training allows the execution personnel to be aware of these variations.

6. Results

The application of the 3D-modelling tool allowed us to very quickly adapt configurations and emplacement. This was even possible during the discussions with the plant's radiation protection department. Various shielding options (lead mats, bricks, concrete walls) were tested and evaluated on the fly. The application in the communication of complex environments and processes was very appealing also for the workforce. It has significantly enhanced the bidirectional communication.

7. Conclusions

The application of 3D-modelling in radiation protection applications shows – despite the additional effort for the modelling – an effective and efficient way not only to optimize but also to communicate radiation fields and their changes during processes. Nevertheless, professional caution has to be applied regarding the modelling constraints and the resulting deviations in the representation.