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Development of a PHITS simulation technique and a numerical method to optimize measures against radioactive sources/線源対策最適化のための PHITS シミュレーション技術及び数値計算手法の開発

Thursday, 16 November 2023 15:00 (2 hours)

We have developed the radiation dose evaluation system for indoor environments named 3D-ADRES-Indoor, which is especially designed for two applications: the estimation of radioactive source distributions with the machine learning technique and the planning of measures against estimated radioactive sources [1,2]. 3D-ADRES-Indoor mainly uses Particle and Heavy Ion Transport code System (PHITS) [3] for the ambient dose rate calculation required for these applications. In this work, a PHITS simulation technique and a numerical method for the latter application have been developed.
For a better planning of measures against radioactive sources, it is necessary to repeat the simulations with different geometrical models that incorporate various measures. However, it generally takes long computational times to execute whole new PHITS simulations with different geometrical models. Therefore, we have developed a PHITS simulation technique to construct the dose rates with specific models using those obtained from the smaller scale simulations that only account for the difference of models. The point of the technique is the decomposition of dose rates using the "counter"feature and the simulation using the "dump source" feature. While this technique requires the decomposed dose rates and dump data obtained by the normal simulation with a prior model, the computational times of the simulations with the models that incorporate various measures to the prior model are significantly reduced compared to the normal simulations.
We consider four kinds of measures against radioactive sources: the decontamination, removal, relocation of contaminated structures, and shielding. Except for the decontamination, the technique explained above is applied. As for the decontamination, a numerical method to optimize decontamination rate of each radioactive source that achieve target dose rates with the minimum cost for the decontamination. In this method, a constrained optimization problem with the loss function composed of the cost function and the penalty function to achieve target dose rates is solved. To solve this numerical optimization problem, Particle Swarm Optimization (PSO) method has been employed.
Users of 3D-ADRES-Indoor can set conditions of four kinds of measures by GUI operations.
PHITS input required for the present techniques are automatically generated depending on the measures. Users can try more variations of measures with the advantage of the present technique.

References

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[3] T. Sato, Y. Iwamoto, S. Hashimoto et al., "Features of Particle and Heavy Ion Transport code System (PHITS) version 3.02", J. Nucl. Sci. Technol. 55(5-6), (2018), pp. 684-690.

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