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EXTENSIVE USE OF MONTE CARLO SIMULATION IN THE DESIGN OF A NEW PET CYCLOTRON FACILITY

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BACKGROUND-AIM

In planning of a new cyclotron facility knowledge of the radiation field around the accelerator is necessary for the design of shielding, the classification of areas and the protection of workers, public and environment. Available guidelines are based on analytical methods that not allow for a realistic description of source term and geometry. Monte Carlo (MC) simulations have been increasingly used to predict the radiation field around these accelerators. In this work, FLUKA MC simulation was used in planning the new PET facility at "Sacro Cuore–Don Calabria" Hospital in Negrar (Verona, Italy).

METHODS

The cyclotron modeled is the TR19 (ACSI), a external ion source cyclotron that accelerates negative hydrogen ions to 19 MeV with a maximum current of 300 ¤A, provided of two extraction ports each with a target selector and local shields composed of a proprietary mixture that allow a significant reduction of the dose field around the target selectors. MC model was created in FLUKA, a fully integrated particle physics MC simulation package, using the supporting packages SimpleGeo and Flair. Physical and transport parameters were set on the basis of a previous experimentally validated MC model previously published; simulations were performed at high statistic (10^9 primary particles). The design of the required thickness of the cyclotron vault was conducted by the assessment of the ambient neutron dose equivalent H*(10) around the accelerator in a dual beam irradiation; an optimization of ducts trough the vault walls was then performed. Activation of air within the bunker was studied to assess the production of ^{41}Ar due the secondary neutrons as well as the activation of shielding and cyclotron components to plan decommission strategies as requested from the Italian national regulation on radiation protection.

RESULTS

Ambient neutron dose equivalent H*(10), 90° - 1m from target, with and without local shield was found to be 3.7 and 432 mSv/¤Ah respectively; the attenuation factor of local shield resulted 116 ± 10. Simulations allowed to perform an accurate positioning of ducts through the vault walls: critical situations were studied and optimized, in according to mechanical requirements, to avoid transmission of radiations. The amount of ^{41}Ar produced in 1h-1¤A dual beam irradiation, without ventilation within the bunker, was 5.48E-02 Bq/dm3*¤A; taking into account the ventilation rate and a conservative irradiation current the release of ^{41}Ar in atmosphere were found to be significantly lower than the limit recommended by the Italian national regulation of 1 Bq/g. Finally, long-term activation of local shields and walls were studied to assess the order of magnitude of activity after 10 years in operation and to plan strategies of decommissioning.

CONCLUSION

In conclusion, systematic use of MC simulations is the state of the art tool for planning relatively complex facilities like PET centres, taking into account realistic geometry conditions and an accurate description of the radiation source.