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#08-141 Simulation of the physical processes associated to the detection of beta particles with scintillating fibres

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In this study, we present an exhaustive model to simulate the detection of beta particles with scintillating fibres, based on a chronological follow-up of the information carrier. We manufactured a detector composed of a bundle of 100 BCF-10 scintillating fibres, which will be used to compare simulation and experimental results. A Monte-Carlo simulation model of the detector was generated using the MCNP6.2 code. To simulate more accurately the generation of scintillation photons inside the detector, particle tracking was used which allows us to use the incident beta particle stopping power instead of the energy deposition. A small energy deposition from a high-energy beta particle should not be processed as an incident low energy beta particle, as they will not yield the same number of scintillation photons. Using stopping power over energy deposition for beta particles enables to use theoretical scintillation laws, which take into account the ionisation quenching effect. Indeed, for low energy electrons, there is a discrepancy of the scintillation linearity. By integrating the quenching ionisation law into our model, we can evaluate more precisely the expected experimental spectrum at very low incident energies. Based on the literature, a more detailed photon trapping efficiency is calculated, which was found to be underestimated in the scintillating fibre technical sheet. The manufacturer value corresponds to a trapping efficiency based on meridional rays solely, while the calculated value also factors in the skew rays. Self-absorption in the fibre was estimated using an exponential loss at the scintillation wavelength. Interface between the fibre and the photomultiplier was evaluated using Fresnel and transmission equations. Finally, the probability distributions associated with the photocathode quantum efficiency and the photomultiplier gain were both taken into account to generate expected acquisition spectra. To do so, we used the thermionic signal, comparable to the amplification of a single photoelectron, to evaluate the photomultiplier gain distribution. This model will help in evaluating the detector applicability to specific experimental scenarios such as nuclear decommissioning and dismantling operations.

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