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X-ray dosimetry: comparing Monte Carlo simulations and experimental data

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Abstract

IBA is operating an X-ray irradiation facility located in Bridgeport, New Jersey. This facility is equipped with a Rhodotron® TT300 and three separated beam lines delivering high-intensity electron beams with 5, 7, and 10 MeV energy. X-ray targets are mounted on the 5 and 7 MeV beam lines to produce high-intensity X-ray fields. During the installation, operation, and process qualifications of the X-ray irradiation system, use has been made of the GEANT Monte Carlo simulation toolkit to predict the results from these tests. These Monte Carlo predictions are compared to the experimental data measured in the various qualification phases.

Keywords: X-ray; Process qualification; Monte Carlo simulations

1. Introduction

IBA is actively involved in the development of X-ray irradiation systems for medical devices sterilization and food pasteurization. In the recent years, IBA has installed and is now operating the Bridgeport facility located in New Jersey, USA. This facility is equipped with multiple beam paths corresponding to beam energies ranging from 5 to 10 MeV and allowing the irradiation of products in E-beam and X-ray modes.

The X-ray irradiation system has started to be used in production in 2002. To assist the processes of installation qualification (IQ), operation qualification (OQ), and process qualification (PQ), a Monte Carlo (MC) simulation tool has been developed. This MC simulation is based on the GEANT 3.21 toolkit (CERN, 1994) from CERN, the European Organization for Nuclear Research. It allows a detailed simulation of the interactions between electron/photons and materials disposed in complex geometries. GEANT is able to simulate all the dominant electromagnetic processes that occur in the energy range from 10 keV to 10 TeV.

The predictions of the MC simulation are compared to the experimental results obtained during the IQ, OQ and PQ phases. These comparisons have been proven to be very useful to better understand the properties of the X-ray irradiation system and to demonstrate its good behavior. Thanks to the good agreement obtained between measured data and MC predictions, this simulation tool is also extensively used to design new X-ray irradiation systems and optimize their performance for medical devices irradiation and food pasteurization (Stichelbaut et al., 2003).

2. The Bridgeport X-ray irradiation system

The IBA irradiation center located in Bridgeport, New Jersey, is equipped with a Rhodotron® TT300 (Jongen et al., 1993) and allows the irradiation of products both in E-beam and X-ray modes (Rose, 2003). The warehouse is divided into two separated parts. The X-ray and E-beam beam paths have separate conveyor systems that operates independently from each other.

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