The DESIRE Geant4 GDML Columbus and ISS geometry models

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The aim of the DESIRE project[1] is to simulate the radiation environment inside the Columbus module of the ISS. Thus, a 3-D model of Columbus specifying the geometry and materials is necessary. Because the presence of the ISS modifies the radiation field incident on Columbus, an ISS geometry model is also required. Such Geant4 geometry models have been implemented with various levels of detail, and are described and compared in [1], [2]. Furthermore, the models have been used for detailed studies of the Columbus radiation environment in [1], [3], [4].

The geometry models have been implemented as C++ code. This is the de facto standard way of specifying geometries for a Geant4 simulation application. However, due to the complexity of C++ code this easily leads to difficulties in transferring the geometry to other simulation projects. GDML (Geometry Description Markup Language, see [5]) is a file format supporting input/output of Geant4 geometry specifications that offers a portable and easy-to-use format for transferring geometries. Currently, such files can be used by the Geant4 and ROOT toolkits. Additionally, due to the open-source nature of GDML it should be possible to implement interfaces also to other toolkits.

The DESIRE Geant4 geometry models have been exported as GDML-files and are available from the author upon request. Three Geant4 geometry models of Columbus have been implemented in the DESIRE project. The models are labeled C1, C2 and C3, in order of increasing level of detail:

C1: Consists of 10 volumes with a total mass of about 4400 kg. It models the approximate boundary dimensions of Columbus as a cylinder.

C3: The most detailed of the Columbus models. It consists of about 750 volumes and has the correct total mass of 16750 kg.

C2: Consists of only 23 volumes and has the correct total Columbus mass. It is a simplified version of C3.

A model of the ISS has also been implemented. The DESIRE ISS model corresponds to ISS in the so-called 14A configuration. The mass of ISS (excluding Columbus) in this configuration is 352 metric tons and the model consists of about 350 volumes. For several simulation studies in the DESIRE project a truncated version of the ISS model was used. This model implements only

[1] Dose Estimation by Simulation of the ISS Radiation Environment. See also: http://www.particle.kth.se/desire/

the ISS modules closest to Columbus and has a mass (excluding Columbus) of 136.5 metric tons. The full ISS model is labeled I2 and the truncated one is labeled I1. The label I0 denotes no ISS geometry model present.

The following GDML-files are available:

C1I0.gdml: The simplest Columbus geometry model. No ISS geometry model.

C1I1.gdml: The simplest Columbus geometry model. The truncated ISS geometry model.

C1I2.gdml: The simplest Columbus geometry model. The full ISS 14A geometry model.

C2I0.gdml: The intermediate Columbus geometry model. No ISS geometry model.

C2I1.gdml: The intermediate Columbus geometry model. The truncated ISS geometry model.

C2I2.gdml: The intermediate Columbus geometry model. The full ISS 14A geometry model.

C3I0.gdml: The most advanced Columbus geometry model. No ISS geometry model.

C3I1.gdml: The most advanced Columbus geometry model. The truncated ISS geometry model.

C3I2.gdml: The most advanced Columbus geometry model. The full ISS 14A geometry model.

In the DESIRE project, dose and dose equivalent rates were simulated by the use of so-called ICRU-spheres placed inside the Columbus cabin. The GDML-files above do not contain those spheres. However, they do contain some tracking surfaces used for simulation of fluxes. A second version of the GDML-files which contain the ICRU spheres are also available.

References

[1] T. Ersmark, "Geant4 Monte Carlo Simulations of the International Space Station Radiation Environment," PhD Thesis (2006).

[2] T. Ersmark, et al., "Influence of geometry model approximations on Geant4 simulation results of the Columbus/ISS radiation environment," submitted to Rad. Meas (April 2006).

[3] T. Ersmark, et al., "Geant4 Monte Carlo Simulations of the Belt Proton Radiation Environment On-board the International Space Station/Columbus," submitted to IEEE Trans. Nucl. Sci. (Oct. 2006).

[4] T. Ersmark, et al., "Geant4 Monte Carlo Simulations of the Galactic Cosmic Ray Radiation Environment On-board the International Space Station/Columbus," submitted to IEEE Trans. Nucl. Sci. (Jan. 2007).

[5] R. Chytracek, "The geometry description markup language," CHEP01 (2001). (See also http://gdml.web.cern.ch)