A Monte Carlo - GEANT4 Web application to support the Intra-Operative-Electron-Radio-Therapy technique

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Abstract

In the last decade, the use of IntraOperative Electron Radiotherapy (IOERT) has continuously grown. IOERT is an advanced radiation therapy technique that allows treatment of tumours after surgery, directly in the surgery room, delivering a high dose to the target (Veronesi *et al* 2001). The electron beam is produced through dedicated and mobile accelerators, such as NOVAC7 (NRT, Aprilia, Italy).

Monte Carlo simulations are the most accurate tools in the fields of medical radiation physics and in particular of advanced radiation therapy. For the case of IOERT, we have developed a specific Monte Carlo application, called *iort_therapy*, based on the GEANT4 toolkit (Allison J. *et al* 2006) of which it is one of the official advanced examples (starting from 9.5). The application simulates the electron beam and the collimation system of the linac NOVAC7 and addresses several technical and clinical issues related to the IOERT technique such as: (i) the design and optimization of the collimation system; (ii) the study of radio-protection aspects; (iii) the optimization of the therapeutic dose distribution (Russo *et al* 2012), and (iv) the development of procedures for the verification of the linac specifications (Björk *et al* 2004).

The *iort_therapy* tool is an embarrassingly-parallel software which needs a full installation of GEANT4 and of some additional libraries (for a total of 2.2 GB). It also requires large computing power to achieve results with sufficient statistics (100 million of histories). The tool reproduces the collimator of the beam line system of a typical medical mobile linac, the phantom, the detector and the composite metallic shielding disc. By means of external macro commands, it is possible to change the physic models, the collimator beam line, the phantom, the detector and shielding disc geometries, the visualization, the beam particle characteristics, and to activate the Graphical Users Interface (QT libraries are requested). The typical output file produced by the tool is a dose distribution in a volume of 300 x 300 x 140 voxels. The size of these output files can vary considerably from few MBs to tens of GBs. From a

computational viewpoint, the application's workflow is a highly demanding problem. On a single CPU (with 3 GHz core) it would require about 200 days of CPU time to produce the dose distribution with the required precision. On the other hand, this is also an embarrassingly parallel problem: the same Monte Carlo computation must be repeated many times starting from the same input file which contains the macro commands to reproduce the collimator beam line system.

Grid infrastructures are perfect platforms to tackle these problems in that a large number of computing resources can be used to execute relatively simple calculations. In order to ease the access and the use of the *iort_therapy* tool on Grid infrastructures, a thematic Science Gateway based on the Catania Science Gateway framework has been developed for this purpose. Before to start to use the computing grid resources, the *iort_therapy* software tool, *as any GEANT4 application*, has been re-compiled as a stand-alone executable which has been deployed on the computing Grid infrastructure with the Software Manager tools included in the gLite middleware.

In this contribution we will describe the porting of the *iort_therapy* software on the Consorzio COMETA's Grid infrastructure in Sicily and the development of a thematic Science Gateway which allows the submission of a large number of Monte Carlo simulations.

Thanks to the collaboration between Consorzio COMETA and the technical support coming from INFN, *iort_therapy* produces about 2 GB of compressed data for each simulation. These results are then post-processed using MATLAB sub-routines. This post-analysis is performed offline and does not involve any Grid resources. Using the COMETA Grid infrastructure, the computing time consumed by the *iort_therapy* software went significantly down to 10 CPU hours per run.

References

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