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A GEANT4-based Application to Support Intra-Operative Electron Radio-Therapy using the European Grid Infrastructure

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Impact

The European Grid Infrastructure (EGI) is a perfect platform 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 starting to use the computing resources of EGI, the iort_therapy software tool, as any Geant4 application, has been re-compiled as a stand-alone executable (170 MB of size) which has been deployed on the computing Grid infrastructure with the Software Manager tools included in the gLite middleware.
Thanks to the distributed computing resources of the Consorzio COMETA 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, which is part of EGI, the computing time consumed by the iort_therapy software went significantly down to 10 CPU hours per run. With this data rate, today, the application can fulfill Companies and Research Community requirements and, in the near future, we hope also Clinical ones and be used day-by-day in the hospitals.

Summary

Radiotherapy techniques consist in delivering ionizing radiations (X-rays, photons, electrons, protons, etc) inside cancerous tissues to block abnormal-cell growth. Ionizing radiations are mostly produced by conventional linear accelerators (linacs). Radiotherapy related activities, as the optimization of the therapeutic radiation dose to the patient, worker radioprotection, performance controls and technical innovations of linacs, are strongly based on the ability to predict the dose distribution. Monte Carlo simulations are the most accurate tools in this field but, unfortunately, require large computing power to achieve accurate results in reasonable times. Therefore, in the last years, cancer treatment research communities have adopted Grid infrastructures. In this contest, we have developed and tested a Grid application to support a new and advanced radiotherapy technique, the Intra-Operative Electron Radio-Therapy (IOERT).

URL

The multi-domain Science Gateway hosting the iort_therapy tool used in this study is available at http://gw.ct.infn.it/

Description

IOERT is an advanced radiation technique that allows treatment of tumours after surgery, directly in the surgery room, delivering a high dose to the target. The electron beam is produced through dedicated and mobile linacs, such as NOVAC7 (NRT, Aprilia, Italy). The LAboratorio di Tecnologie Oncologiche (LATO) developed a specific software, called iort_therapy, based on the Geant4 toolkit. The application simulates the electron beam and the collimation system of the NOVAC7 linear accelerator and may be used for the design and optimization of the collimation system, the study of radio-protection aspects, the optimization of the therapeutic dose distribution, and the development of procedures for the verification of the linac specifications. Iort_therapy offers a user-friendly graphical interface based on the Catania Science Gateway Framework and the possibility for the user to select the collimator beam line system, the phantom and detector dimensions, and the initial conditions of the electron beam. Nevertheless, like other pure Montecarlo codes, iort_therapy requires large running times to achieve results with sufficient statistics (100 millions of histories). Nowadays, iort_therapy is one of the official advanced examples supported by the Geant4 toolkit (ver. 9.5) and it can be downloaded ready for use by anybody for free. The application is embarrassingly parallel and needs a prior-installation of Geant4 as well as some additional libraries for a total of 2.2 GB. 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 output files vary from few MBs to tens of GBs. The application's workflow is a highly computing demanding problem. On a single CPU (with 3 GHz core) it would require about 200 CPU days to produce the dose distribution with the required precision. The same Montecarlo computation must also be repeated many times starting from the same input file which contains the macro.

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