A new simulation tool for hadrontherapy

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The use of proton and ion beams in the framework of the TERA project needs a very appropriate Monte Carlo program for beam and interaction simulations.
After a comparison between GEANT, a code developed at CERN, in which FLUKA is one of packages describing hadronic shower development, and FLUKA itself we obtained the following results: in the interesting energy range the minimum detector step for FLUKA is about three order of magnitude better than for GEANT.
The project we have started provides a interactive window under WWW in order to put all the data required by FLUKA in a very friendly way, allows an interactive help, provides a easier geometry configuration and gives the possibility to access to the available data from hadrontherapy for an on-line comparison.

Key words: Application programming; data bases; data presentation; simulation tools; WWW applications.

1 Simulation code in hadrontherapy

In the framework of TERA (TERapia con Adroni) [1] Collaboration we considered the possibility of using, in hadrontherapy, simulation codes, originally made for high energy physics experiments.

Simulations are necessary in order to know proton beam characteristics, proton interactions with different elements of the beam line, their interactions with tissue and the radiobiological mechanisms of radiotherapic interest. The idea of using simulation codes for hadrontherapy requires an accurate verification of their behaviour in the energy range of interest and the knowledge of admitted approximations of different quantities involved.

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GEANT [2] is a code developed at CERN able to simulate the dominant processes which can occur in the energy range from 10 KeV to 10 TeV for electromagnetic interactions. As far as hadronic interactions are concerned, the range of validity is connected with the hadronic package used, which usually does not extend below a few MeV.

To simulate the interactions of hadrons with nuclei of the traversed matter the users can choose between two alternatives: GHEISHA and FLUKA. Both are two "standalone" codes and only the subroutines dealing with hadronic interactions are included in GEANT: especially for FLUKA, they do not represent the latest versions. It is well known, on the other side, that GEANT allows a complex geometry description. Also the "standalone" FLUKA [3] code was originally made for high energy and it had been changed with particular regards to its hadrontherapic applications.

We have considered the behaviour of FLUKA and GEANT code with respect to stopping power at low energy [4]. We compared the obtained results with the two codes with data tabulated in ICRU [5]. Obviously, when thicknesses of materials considered in both simulations are different, we compared results of each one with ICRU data, calculated in the right point.

The verification has been done for the study of proton energy loss, from 0.01 MeV to 200.00 MeV, in hydrogen, oxygen and lead as elements and air, water and equivalent tissue as compounds. Although conclusions must be considered with particular care, the obtained data comparison leads us to affirm that the minimum volume width (in which calculate the absorbed dose) is 1 nm for FLUKA and 1 μm for GEANT. So FLUKA, three order of magnitude more accurate, gives better results for energy below 1 MeV.

2 An interactive window under WWW for FLUKA code

The FLUKA code has been considered a suitable instrument for simulation in the TERA Collaboration: it is thus necessary a friendly way to insert data for different simulations. The user must prepare a configuration data file putting inside all informations about the beam, the geometry, the involved materials and so on. This is often a very difficult and tedious job. To allow a more easy method for different process simulation, we have started a project providing under WWW an on-line version of the FLUKA manual, an interactive version of the program and some running examples.

In particular a user, surfing on the web via internet, can find instructions for the installation, the on-line FLUKA manual with an easy link to its different parts and interactive windows for inserting all the data required by the configuration running file. The correct FLUKA format is shown and, in many cases using pre-defined buttons, he/she can select the required options only filling data in the appropriate place. In this way he/she obtains a simulation input data file ready to run, a control of errors and an interactive help at any step of this work.

Among different sections in which simulation has been divided he/she can choose beam characteristics, transport of electrons, positron and photons, material definition and combinatorial geometry input. By using this section it is possible to insert different kind of geometries and to combine them by unions, subtraction and intersections. At the end, a series of simulation examples are available, just for check, and it is also possible downloading the code.

The use of the WWW, under Netscape Navigator vers. 3.0, makes also possible the information exchange among different people working in hadrontherapy simulation. Connected with this interactive FLUKA version a world wide data-base of physical and radiotherapic interest is also in progress to allow comparison between real and simulated data and remote consultation inside the TERA Collaboration.

References

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