14th Geant4 Users and Collaboration Workshop

Thursday 15 October 2009 - Thursday 22 October 2009

Laboratori Nazionali del Sud - INFN

Book of Abstracts

Contents

Parallel Session IV - Underground / **2**

Muon Spallation Products in KamLAND

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The study of the muon spallation products is essential for rate event detection in neutrino detectors, double beta decay experiments, and dark matter searches. In the KamLAND detector, energetic muons interact mainly with 12C in the liquid scintillator and generate neutrons and isotopes by electromagnetic or hadronic processes. The neutron production yield is evaluated to be (2.8 +- 0.3) x 10^-4 n / (mu (g/cm2)). For other isotopes, the production yields are measured from the observed time correlation related to known isotope lifetimes.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Parallel Session III - Medical / **3**

Skin Dosimetry in MRI-guided Radiotherapy (MRIgRT)

Author: Bradley Oborn[1]

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Geant4 has been used to simulate in high-resolution (10 micron thick voxels) the skin doses below 0.5 mm depth occurring in MRIgRT (6 MV photon beam, Varian 2100C). On the entry side lepton contamination removal has been studied to show potential skin dose reductions (at low magnetic field strengths). At high magnetic fields (>2 T) skin dose increases (up to 30% of dmax). In the exit region the Electron Return Effect (ERE) gives rise to massive skin dose increases (>100%). The use of exit bolus is investigated for reducing these increases.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Parallel Session I - Hadronic Physics Validation / **4**

Nuclear beams in extended media: issues of nuclear fragmentation

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Co-authors: Alexander Botvina [2]; Igor Mishustin [3]; Walter Greiner [4]

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We study the validity of nucleus-nucleus collision models of Geant4 describing fragmentation of light and medium-weight nuclei (from ^{3}He to ^{58}Ni) in tissue-like media. Depth-dose distributions and yields of secondary fragments produced by nuclear beams were calculated and compared against experimental data. The Light-Ion Binary Cascade model and the Wilson abrasion model were used to simulate the initial stage of nucleus-nucleus collisions. The both models were successful in simulating the transport of light nuclei, e.g. ^{12}C, while the cascade model overpredicts the dose from heavy energetic nuclei, possibly due to underpredicting the attenuation of the initial beam due to fragmentation.

The calculations were performed with and without the Fermi break-up model and the Statistical Multifragmentation model for multifragment decays of excited light and medium-weight residual nuclei at the final stage of collisions in addition to evaporation model. This allowed us to estimate the role of multifragment decays on the depth-dose, depth-yield and charge distributions of secondary fragments produced in extended media. While the energy deposition is not very sensitive to decay mechanisms of excited nuclei, the fragment yields can not be properly described without accounting for multifragment decays.

The validity of the Statistical Multifragmentation model of Geant4 has been confirmed in a set of stand-alone tests, following several fixes introduced to G4StatMF. These corrections improved the stability of the model and consistency of simulation results with the FORTRAN implementation of the model. Comparisons to experimental data on multifragmentation of hot nuclei in central collisions of nuclei at low energies are also presented.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Plenary Session I - Goals, Challenges and Performance / **6**

Workshop Goals

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7

Emerging requirements from user domains

Plenary Session I - Goals, Challenges and Performance / **8**

Emerging requirements from user domains - Nuclear Physics and Underground experiments

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Plenary Session I - Goals, Challenges and Performance / 9

Emerging requirements from user domains - HEP

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Plenary Session I - Goals, Challenges and Performance / 10

Emerging requirements from user domains - Astrophysics and Space Applications

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Plenary Session I - Goals, Challenges and Performance / 11

Emerging requirements from user domains - Medical applications

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Plenary Session I - Goals, Challenges and Performance / 12

Emerging requirements from user domains - Shielding and industrial applications

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Plenary Session I - Goals, Challenges and Performance / 13

On improving Geant4 performance, robustness and easing code maintenance

Author: Krzysztof Genser[1]

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Fermilab Geant4 Performance Group Activities and related matters
will be presented together with some suggestions and reminders regarding C++ coding techniques and style

14

Event Biasing - work plan

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Parallel Session VIII - Kernel / 15

Parallel world navigation - status and work plan

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Parallel Session VIII - Kernel / 16

BREP solids by curve revolution and extrusion

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Parallel Session I - Hadronic Physics Validation / 19

Test of Hadronic Models in GEANT4 using the BESIII Data

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The BESIII detector is a conventional solenoidal magnetic spectrometer and operating at the upgraded Beijing Electron-Positron Collider (BEPCII). Since the start of commissioning run in Aug. 2008, about 100M psi(2S) data and 200M J/Psi data have been collected with BESIII detector.
Using 10M psi(2S) data taken in 2008, we compare hadronic shower energy, profile and fake photons in the electromagnetic calorimeter with several hadronic models in GEANT4. We find that for pions and protons at low energy (<0.7 GeV) the Bertini model with high precision neutron tracking (QGSP_BERT_HP) is the best among the hadronic models compared, though it takes more simulation time. For anti-proton, the elastic cross section seems to be suppressed and needs to be improved. We also try to replace GHEISHA by CHIPS model in QGSP_BERT_HP for anti-proton inelastic, marked with CHIPS+HP. Although the comparison result of CHIPS+HP is slightly better than other models, it is also not reasonable.

Are you a Memeber of the Geant4 Collaboration (yes/no):

No

Parallel Session VIII - Kernel / **21**

Reverse MC - status

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Parallel Session VII - Nuclear and Space Physics / **22**

GEANT4 simulation project on the AMS facility, ARTEMIS, at LMC14 in Saclay, France

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A project of Ion Beam Simulation on the ARTEMIS Accelerator Mass Spectrometer is carried out at LMC14. The tool GEANT4 is used to take into account all physical processes and predict and control the settings of such a facility.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

14C dating, Accelerator Mass Spectrometer (AMS), Ion Beam Line Simulation

Summary:

The ARTEMIS facility is an Accelerator Mass Spectrometer (AMS) installed in 2003 at Saclay in France and dedicated to radiocarbon dating. It routinely measures 3800 samples per year for French organizations covering a large field of research (e.g environmental science, archaeology, geology⋯). Because of the very low 14C abundance, we need high efficiency and transmission of the beam to avoid isotopic fractionation due to particle loss to get the best quality of measurement. That's why, since Octobre 2008, a PhD project on beam optic simulation on the ARTEMIS NEC Pelletron AMS of the LMC14 was carried out to improve the technical factors involved.
A first step of work was to use TRANSPORT tool to get a global view of the beam emittance behaviour. In a second part, we want to take into account all the physical processes involved, by using GEANT4 tool.
After a full examination of the facility, we propose to define how we project to use GEANT4 as a tool to find the most sensitive points of the machine and those where an improvement could be made. The aim of such a project is to predict and control the settings of the facility to find the most relevant ones for each kind of measurement.

Parallel Session III - Medical / **23**

From imaging to dosimetry: Geant4-based study on the application of Medipix2 to neutron personnel dosimetry.

Authors: D. G. Marinaro[1]; J. Uher[2]; M. Petasecca[3]; M.A.R. Othman[3]; S. Guatelli[3]

Co-authors: A. B. Rosenfeld [4]; D. L. Cutajar [3]; D. Prokopovich [5]; J. Jakubek [6]; M. Lerch [3]; Mark Reinhard [7]; S. Pospisil [6]

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A Geant4 simulation study is performed to optimise a novel neutron personnel dosimeter, developed at the Centre of Medical Radiation Physics (CMRP), University of Wollongong, consisting of a silicon pixelated detector device - Medipix2- covered with a polyethylene converter on top.
In this talk we would like to illustrate the Geant4 simulation developed to optimise the novel neutron dosimeter and its validation. First results of the optimization study of Medipix2 polyethylene converter will be shown as well.

Are you a Memeber of the Geant4 Collaboration (yes/no):

yes

Keymords:

Neutron dosimeter, Geant4, validation.

Summary:

The application of Si detectors with polyethylene converter for fast neutron personal dosimetry is well known [1]. An ideal dosimeter should be simply based on counting recoil protons only while the energy is independent for dose equivalent measurements. Adjustment of the energy response can be achieved by varying the thickness of the converter, however this is limited for a single detector [1].
Recent developments of Si pixelated detectors with multichannel readout chip coupled with a detector brought flexibility in design of neutron personal dosimeters. The novel approach, conceived at CMRP,

consists of adding a converter of polyethylene on top of the sensitive volume of the pixelated Si detector device –Medipix2 [2, 3] - configured into segments with varying converter thickness.

A Geant4 simulation was developed to characterise the novel neutron dosimeter. In particular, the goal of the Geant4-based study is to optimize the number and thickness of the segments of Medipix2 polyethylene converter, to make the dosimeter energy independent for 0.3-15MeV neutrons in terms of counts/mSv.
The Geant4 simulation results were first compared to the theoretical predictions by Eisen et al. [1]), showing satisfactory agreement.
This activity is complemented with the validation of the Geant4 simulation with respect to experimental measurements, performed at ANSTO and CSIRO, where Medipix2 has been irradiated with three different neutron sources (14 MeV D-T neutron, Am-Be and Cf-252 source). Results with 14 MeV D-T neutron beam show a good agreement between Geant4 simulation results and experimental measurements. The validation activity is still on going for the Am-Be and Cf-252 sources.
First results of the optimization study of Medipix2 polyethylene converter will be shown as well.

References:
[1] Eisen, Y., Engler, G., Ovadia, E., Shamai, Y., Baum, Z. and Levi, Y.: A small size neutron and gamma dosemeter with a single silicon surface barrier detector. Radiat. Prot. Dosim. 15, 16, 1986.
[2] Llopart, X., Campbell, M., Dinapoli, R., San Segundo, D. and Pemigotti, E.: Medipix2: a 64-k pixel readout chip with 55-μm square elements working in single photon counting mode. IEEE Trans. Nucl. Sci. 49, 5, 2002.
[3] Llopart, X.: Design and characterization of 64K pixels chips working in single photon processing mode. (Sundsvall: Mid Sweden University), 2007.

Parallel Session III - Medical / 24

Geant4-based studies to characterise the tissue-equivalence of SOI and diamond microdosimeter detectors, under development at CMRP.

Authors: A.B. Rosenfeld[1]; P. Lazarakis[1]; S. Dowdell[1]; S. Guatelli[1]

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Silicon On Insulator (SOI) microdosimeters have been under investigation for the past ten years as a possible alternative to tissue equivalent gas counters for microdosimetric measurements in medical physics and radiation protection in earth labs, aviation and space, at Centre of Medical Radiation Physics, University of Wollongong.
In the last 5-6 years, extensive Geant4-based simulation studies have been performed to characterise the novel SOI detector.
This talk is meant (1) to be a review of the past Geant4-related activities in silicon microdosimetry and (2) to show current Geant4-studies in microdosimetry at CMRP.

Are you a Memeber of the Geant4 Collaboration (yes/no):

yes

Keymords:

Silicon and diamond microdosimetry, tissue-equivalence, Geant4.

Summary:

Silicon On Insulator (SOI) microdosimeters [1] have been under investigation for the past ten years as a possible alternative to tissue equivalent gas counters for microdosimetric measurements in medical physics and radiation protection in earth labs, aviation and space.
Extensive Geant4-based simulation studies have been performed at the CMRP to characterise the novel

silicon detector in radiation fields of interest, for proton therapy and radiation protection [2-6]. The Geant4 capability for microdosimetry has been studied through an extensive validation activity [2-5], based on the comparison of experimental data and Geant4 simulation results. A review of the Geant4-based study on SOI microdosimeter concept will be presented at the workshop.
Currently at CMRP we are studying a novel microdosimeter concept, where diamond is used, as the sensitive detector material rather than silicon because of its improved tissue-equivalence [7].
Geant4 simulations are currently being performed to characterise the tissue equivalence of this new detector, for proton therapy. First results will be shown at the workshop.
In the Geant4 simulation experimental set-up, the incident proton beam is generated isotropically on a sphere with radius 10 mm. The energy of the incident proton beam corresponds to the energy of the beam at the beginning, raising curve and Bragg peak position, of a 150 MeV proton therapy beam. The diamond sensitive detector is a sphere with diameter 10 m, set in the outer sphere with radius 10 mm. The physics processes were chosen based on the study by Zacharatou Jarlskog and Paganetti [8]. The result of the simulation is the energy deposition per event in the sensitive detector, deriving from the interaction of both primary and secondary particles. Simulations are performed with water and diamond as material of the sensitive detector, to (1) quantify differences in the energy deposition spectra and to (2) eventually identify a methodology to convert microdosimetric spectra obtained in diamond to water.
The same Geant4 simulation set-up is adopted in a second current project in microdosimetry, aimed to study the tissue-equivalence of phantoms, commonly used in protontherapy facilities. In this case the energy deposition spectra obtained in silicon sensitive volume are compared when they are placed in different tissues and phantom materials. Differences in the chemical composition lead to variation in the contribution of delta electrons and nuclear recoils to the normalised energy deposition spectra. First results of this project will be shown as well.

[1] A. L. Ziebell, et al., "A novel cylindrical Silicon-on-Insulator microdosimeter for the characterisation of deep space radiation environments", IEEE Trans. Nucl. Sci., vol. 56(3), pp. 1637-1641, 2009.
[2] A. J. Wroe, et al., "Microdosimetry simulations of solar protons within a spacecraft", IEEE Trans. Nucl. Sci., vol. 52, no. 6, pp. 2591-2596, 2005.
[3] A. B. Rosenfeld, et al."Analysis of inelastic interactions for therapeutic proton beams using Monte Carlo simulation", IEEE Trans. Nucl. Sci, vol. 51, no. 6, pp. 3019-3025, 2004.
[4] A. Rosenfeld, et al., "Method of Monte Carlo simulation verification in hadrontherapy with non-tissue equivalent detectors", Rad. Prot. Dosim., vol. 119, pp. 487-490, 2006.
[5] D. A. Prokopovich, et al. , "SOI microdosimetry for mixed field radiation protection", Rad. Meas., vol. 43, pp. 1054-1058, 2008.
[6] S. Guatelli, et al., " Tissue Equivalence Correction in Silicon Microdosimetry for Protons Characteristic of the LEO Space Environment", IEEE Trans. Nucl. Sci. , vol. 55 (6), pp. 3407-3413, 2008
[7] B. Planskoy, "Evaluation of diamond radiation dosemeters,"Phys. Med. Biol, vol. 25, no. 3, pp. 519–532, 1980.
[8] C. Zacharatou Jarlskog, and H. Paganetti, "Physics Settings for Using the Geant4 Toolkit in Proton Therapy,"IEEE Trans. Nucl. Sci., vol. 55, no. 3, pp. 1018-1025, 2008.

25

MAGE - a GEANT4-based Monte Carlo Application Framework for Low-background Germanium Experiments

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We describe a physics simulation software framework, MAGE , that is based on the GEANT4 simulation toolkit. MAGE is used to simulate the response of ultra-low radioactive background radiation detectors to ionizing radiation, specifically the MAJORANA and GERDA neutrinoless double-beta decay experiments. MAJORANA

and GERDA use High-purity Germanium technology to search for the neutrinoless double-beta decay of the 76Ge isotope, and MAGE is jointly developed between these two collaborations. The MAGE framework contains simulated geometries of common objects, prototypes, test stands, and the actual experiments. It also implements customized event generators, GEANT4 physics lists, and output formats. All of these features are available as class libraries that are typically compiled into a single executable. The user selects the particular experimental setup implementation at runtime via macros. The combination of all these common class into one framework reduces duplication of efforts, eases comparison between simulated data and experiment, and simplifies the addition of new detectors to be simulated.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

Low background, germanium detectors, double-beta decay, dark matter

Summary:

User's Workshop

Parallel Session IV - Underground / 26

MonteCarlo Simulations with GEANT4 for the XENON100 Detector

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The XENON100 detector is a dual phase (liquid-gas) xenon time-projection chamber for direct dark matter detection. The total amount of liquid xenon is 165 kg, of which 65 kg are in the active target enclosed in a teflon/copper structure, the rest being in the surrounding active veto volume.
UV light signals are produced by particle interactions and detected by 242 PMTs (178 in the target and 64 in the veto).
In this talk, the importance of MonteCarlo simulations for the complete understanding of the detector performance and the expected sensitivity of the experiment will be discussed. We will report simulation results and comparison with the experimental data, including light simulation and background predictions.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

Dark Matter, Background Radiation, Scintillation Light, MonteCarlo, Xenon

Summary:

A high precision model of the XENON100 detector has been created within the GEANT4 toolkit.
GEANT4 has been used to simulate the transport of the optical photons produced in the detector medium by particle interactions. This is done in order to estimate light collection efficiency in the different detector regions, to model its response, and to develop an algorithm for the 3 dimensional event vertex

reconstruction.
In addition, electron and nuclear recoil backgrounds from various sources are predicted, based on the results of the MonteCarlo simulations with the GEANT4, SOURCES, and MUSUN toolkits.

Parallel Session VIII - Medical / 27

New physics processes dedicated to nanometric scale track structure in the Geant4 toolkit

Author: Ziad Francis[1]

Co-authors: * On behalf of the Geant4 low energy working group [2]; * and the Geant4-DNA collaboration [2]

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[2] *Geant4*

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Track structure simulation using the Monte-Carlo method has become increasingly important not only on the macroscopic scale but also on the nanometric and the molecular simulation level. Many studies (mostly done by Nikjoo et al., and Goodhead et al.) showed that damage clustering in cell nucleus is related to the energy deposits distribution inside the cell. However, experimentally it is impossible to guess the exact position of each energy deposit point inside irradiated cells. Monte-Carlo simulations can reproduce the ionizing particle track taking into account all the interactions according to calculated cross sections. Many nano-level codes were developed so far, but generally these codes are dedicated for private use and for a very specific application (Partrac, PITS, OREC$\cdots$) which makes their access practically difficult and sometimes even impossible due to lack of information, user-support or a simple users manual.
The Geant4-DNA project comes as a free open source set of physics processes that can handle nanometric level simulations for electrons (8.22 eV –1 MeV), protons (100 eV –100 MeV) and alpha particles (1 keV –10 MeV). Users can benefit from dedicated documentation, forums and necessary amount of support for new users through workshops and tutorials.
This study shows the recent developments in Geant4 concerning the inelastic and the elastic interactions of these particles in liquid water, as water is considered to be the dominant component in a living cell. Models of inelastic scattering cross sections are based on the First Born Approximation (FBA) theory. For low incident energies the FBA becomes inapplicable, correction terms are then used for electrons and semi empirical models (Rudd model for ionisation) are used for Alpha particles and protons. Charge transfer process is also taken into account according to Dingfelder's model. Relativistic dynamics were recently added for high energy (20 keV –1 MeV) electrons cross sections.
Validation results are still in progress and are not shown in this work. However, a comparison shows a good agreement between microdosimetric calculations (proximity functions and clustering results) obtained using Geant4-DNA and results obtained by other nano-level codes (Nikjoo et al., Chen and Kellerer).

Are you a Memeber of the Geant4 Collaboration (yes/no):

yes

Keymords:

Geant4-DNA, Monte-Carlo, Microdosimetry, Inelastic Cross-sections, Elastic Cross-sections, First Born Approximation, energy deposits clustering, DNA level.

Summary:

This work describes the Geant4-DNA physics processes set. Processes concern electrons, protons and alpha particles interactions in water. The First Born Approximation (FBA) was used for inelastic cross sections. At low energies, in the case of electrons the FBA becomes inaccurate and should be corrected by several terms (exchange cross section and Coulomb field correction). For protons and alpha particles no corrections were used the theory was replaced by the Rudd semi-empirical model below a certain

energy threshold. Electron elastic scattering was calculated using two different models; the Champion model and the screened Rutherford model. Validations showed good agreement with experimental data. Relativistic kinematics were added for electrons cross sections extending the possibility to simulate electrons up to 1 MeV of incident energy. Clustering algorithms showed good agreement with published microdosimetric calculations in the literature

Parallel Session IV - Underground / **28**

GEANT4 simulation of the Borexino solar neutrino experiment.

Author: Igor Machulin[1]

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The BOREXINO experiment measures the MeV and subMeV Solar neutrinos with the Borexino low background liquid scintillator detector at Gran Sasso National Laboratory. A GEANT4 based simulation was developed and used to model the physical characteristics of the Borexino detector. Object oriented structure of GEANT4 is very suitable to describe the full detector geometry and different physical processes in the Borexino detector . The code is used for debugging and inspection of energy and spatial reconstruction algorithms, simulation of neutrino and
background effects , energy scale calibration.
The code structure , it's performance and the comparison of the
Monte-Carlo simulation results with the experimental data from the
operating detector are presented.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

solar, neutrino, GEANT4, Borexino, simulation

Summary:

The BOREXINO experiment measures the MeV and subMeV Solar neutrinos with the Borexino low background liquid scintillator detector. A GEANT4 based simulation was developed and used to model the physical characteristics of the Borexino detector and the backgrounds. Object oriented structure of GEANT4 is very suitable to describe the full detector geometry and different physical processes in the Borexino detector . The code structure , it's performance and the comparison of Monte-Carlo simulation results with the experimental data from the operating detector are presented.

Plenary Session II - SVN and multi-core / **29**

Migration to SVN

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Plenary Session II - SVN and multi-core / 30

Multi-core & multi-threading: Report from pilot prototyping project

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Plenary Session II - SVN and multi-core / 31

Multi-core & multi-threading: Tips on how to write ”thread-safe” code in Geant4

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Parallel Session II - EM Physics: Validation and Applications / 32

Complete Monte Carlo simulation of the optical response of the WArP detector for direct Dark Matter search

Author: Francesco Di Pompeo[1]

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WArP is a double phase Dark Matter experiment using Liquid Argon as a target. In order to efficiently collect the 128 nm scintillation light a very careful light collection system, made by a wavelength shifter and a dielectric mirror, is used. A detailed & complete GEANT4 simulation of the detector has been performed, from particle interaction to PMTs photon detection. Optical photons tracking as well as wavelength shifting and boundary optical processes on the light collection system surface have been implemented. A dedicated C++ code, simulating the electronics and DAQ systems, has been also used to obtain WArP like data starting from the PMTs photon hits.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

Dark Matter, Optical Photon, Boundary Processes

Summary:

A GEANT4 simulation of the 100 liter WArP detector has been performed. Scintillation properties as well as tracking of optical photons and boundary processes have been implemented. DAQ and electronics response have been taken into account by means of a dedicated C++ code. Simulated signals have been used to test WArP analysis softwares.

Parallel Session VIII - Medical / 33

Geant4 simulation of the attenuation properties of plastic shields for beta radionuclides employed in internal radiotherapy

Author: Domenico Lizio[1]

Co-authors: Ernesto Amato [1]; Sergio Baldari [1]

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We developed a simulation in Geant4 to compare the attenuation properties and the bremsstrahlung radiation yield of different types of plastic materials employed as shield of beta radioactive sources. Code validation results against Sandia and NIST data are presented. We discuss the influence of cuts in range, step limits and multiple scattering step limitations, for the three physics packages available. For polypropylene, polystyrene, polyamide nylon-6, poly-methyl methacrylate, polycarbonate, polyethylene terephthalate, polyvinyl chloride and polytetrafluoroethylene we evaluated the mean and maximum ranges for electrons originating from 90Sr and 90Y, as well as the number and the spectrum of the bremsstrahlung X-rays produced. Significant differences appear between the various materials, and the choice of the best one depends also on the physical properties requested for each specific application.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

beta radionuclides, plastic shields, range electrons

Summary:

We developed a simulation in Geant4 to compare the attenuation properties and the bremsstrahlung radiation yield of different types of plastic materials employed as shield of beta radioactive sources. Code validation results against Sandia and NIST data are presented. We discuss the influence of cuts in range, step limits and multiple scattering step limitations, for the three physics packages available.
For polypropylene, polystyrene, polyamide nylon-6, poly-methyl methacrylate, polycarbonate, polyethylene terephthalate, polyvinyl chloride and polytetrafluoroethylene we evaluated the mean and maximum ranges for electrons originating from 90Sr and 90Y, as well as the number and the spectrum of the bremsstrahlung X-rays produced. Significant differences appear between the various materials, and the choice of the best one depends also on the physical properties requested for each specific application.

Plenary Session III - Medical and Physics Lists / 35

Applications of Geant4 in Proton Radiotherapy at the University of Texas M.D. Anderson Cancer Center

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36

Best practices

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Plenary Session III - Medical and Physics Lists / 37

Physics Lists

38

WG overview of recent developments and workplan

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Parallel Session VI - Low-energy EM / 39

Future developments and validation of G4LowE extensions: proposed projects by CMRP

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Parallel Session VI - Low-energy EM / 40

Very low energy activities at AIT

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Parallel Session VI - Low-energy EM / 41

General discussion about workplan and contributions

Parallel Session VI - Low-energy EM / 42

Extended cross sections for microdosimetry

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Parallel Session IX - Multiple scattering and single scattering / 43

Incorporation of Goudsmit-Sounderson electron transport theory into Geant4

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Parallel Session IX - Multiple scattering and single scattering / 44

Multiple scattering model upgrade

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Parallel Session IX - Multiple scattering and single scattering / 45

MSC benchmarking

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Parallel Session IX - Multiple scattering and single scattering / 46

Discussion on MSC configuration

Parallel Session VIII - Medical / 51

USE OF GEANT4 CODE FOR VALIDATION OF RADIOBIOLOGICAL PARAMETERS OBTAINED AFTER PROTON AND CARBON IRRADIATIONS OF MELANOMA CELLS

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Series of numerical simulations with the GEANT4 code were carried out to verify and better interpret radiobiological parameters and biological effects obtained after irradiation of HTB140 human melanoma cells. Irradiations were performed at INFN-LNS with the 62 MeV proton beams at the full energy Bragg peak as well as along the spread out Bragg peak (SOBP) and its distal fall-off part. HTB140 cells were also exposed to the beams of the 62 MeV/u 12C ions, along the Bragg curve including its distal declining edge. The doses ranged from 2 to 24 Gy. The surviving fractions at 2 Gy (SF2) and the corresponding relative biological effectiveness (RBE) obtained with respect to gamma-rays, differed along the proton full energy and the spread out Bragg peak (SOBP), as well as along the carbon Bragg peak. These variations were analysed and compared through the proton and carbon depth dependant dose, fluence, energy and linear energy transfer (LET) distributions produced by numerical simulations. For carbon ions these distributions were also followed for the secondary particles. Depth dependent distributions of fluence and LET revealed different damages in the sense of the ratio of irreparable to reparable breaks that were caused by distinct radiation types. This enabled a more in-depth interpretation of cell proliferation results witch reflect the quality of life of irradiated cells and was particularly useful for the assessment of the events at the distal declining edge of the Bragg curves.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

GEANT4, simulations, experiments, protons, carbom ions, melanoma cells, RBE, LET, fluence

Summary:

Series of numerical simulations with the GEANT4 code were carried out to verify and better interpret radiobiological parameters and biological effects obtained after irradiation of HTB140 human melanoma cells. Irradiations were performed at INFN-LNS with the 62 MeV proton beams at the full energy Bragg peak as well as along the spread out Bragg peak (SOBP) and its distal fall-off part. HTB140 cells were also exposed to the beams of the 62 MeV/u 12C ions, along the Bragg curve including its distal declining edge. The doses ranged from 2 to 24 Gy. The surviving fractions at 2 Gy (SF2) and the corresponding relative biological effectiveness (RBE) obtained with respect to gamma-rays, differed along the proton full energy and the spread out Bragg peak (SOBP), as well as along the carbon Bragg peak. These variations were analysed and compared through the proton and carbon depth dependant dose, fluence, energy and linear energy transfer (LET) distributions produced by numerical simulations. For carbon ions these distributions were also followed for the secondary particles. Depth dependent distributions of fluence and LET revealed different damages in the sense of the ratio of irreparable to reparable breaks that were caused by distinct radiation types. This enabled a more in-depth interpretation of cell proliferation results witch reflect the quality of life of irradiated cells and was particularly useful for the assessment of the events at the distal declining edge of the Bragg curves.

Parallel Session IV - Hadronic Code Improvement / 52

Migration to integer Z and A

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Parallel Session IV - Hadronic Code Improvement / 53

Final state rotation

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Parallel Session IV - Hadronic Code Improvement / 54

Using standard Geant4 features, code speed-up

Corresponding Author: dennis.herbert.wright@cern.ch

Parallel Session IV - Hadronic Code Improvement / 55

Hadronic process clean-up, initialisation of models

Corresponding Author: vladimir.ivantchenko@cern.ch

Parallel Session IV - Hadronic Code Improvement / 56

Discussion and hands on

57

Geant4 studies in the context of dual readout calorimetry simulations

Authors: Adam Para[1]; Hans Wenzel[1]; Krzysztof Genser[1]

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We will present results of simulations of total absorption
calorimeters in the context of dual (Cerenkov/Scintillation) readout
calorimetry studies.
Using various conditions and geometries we will show simulation
aspects related to the underlying physics processes,
especially the hadronic ones.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

physics lists, physics processes

Summary:

Using various conditions and geometries we will show simulation
aspects related to the underlying physics processes,
especially the hadronic ones.

Parallel Session VII - Nuclear and Space Physics / 58

Simulation of MEDEA Response to Neutrons

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Co-authors: antonio del zoppo [1]; domenico santonocito [1]; giorgio bellia [2]; paolo finocchiaro [1]; rosa alba [1]

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An application of GEANT4 version 9.2p01 to 4π Medea detector will be presented.
MEDEA (1) is a working array aimed at the gamma and light charged particle detection in the range of intermediate energies (up to 100 MeV/A), installed at LNS. MEDEA is made of 180 BaF2 detectors, arranged in a spherical shape of 22 cm radius. Each module is made of 2 separated crystals in optical contact.
The interest in neutron detection to extend the knowledge of the reaction dynamics has triggered a study of a possible shortening of a few MEDEA modules with the aim of increasing path length for neutron detection, therefore improving their energy calculation through Time Of Flight determination.
The MEDEA geometry has been implemented in the GEANT4 framework and the response of the whole system to sources of monochromatic neutrons up to 18 MeV, impinging on a module has been studied. Results and experienced problems will be shown.

1) E.Migneco, Nuclear Instruments and Methods, A314(1992)31

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

BaF2, neutron

Summary:

A study of the response of MEDEA array to neutron up to 20 MeV, based on GEANT4 will be presented. Results will be discussed.

Parallel Session III - Medical / 59

Implementation of a Monte Carlo - GEANT4 Simulation for the dosimetric study of electron beams produced by a mobile accelerator for IORT

Author: Giorgio Russo[1]

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In the last few years the use of ionising radiation has obtained a relevant role as a remedy for many types of tumour pathologies. Among the different radiation techniques the Intra Operative radiation therapy (IORT) is a new way to treat some tumours [1,2,3,4], consisting of exposing the surrounding involved tissues to a single high radiation dose during surgery after the obliteration of the tumour [5,6,7]. Many studies have highlighted the success of this approach, especially to treat breast lesions. The employment of conventional linear accelerators (linac) needs complex procedures and offers several limitations making very difficult its adoption in terms of time and money [8]. In the last years, a new generation of linac has been developed specifically for the IORT, characterized by limited energy, limited field size, no bending magnet and high mobility. The design of these linacs is optimized for minimal radiation leakage allowing them to be operated in an unmodified surgery room.
Our study is focused on one of these linacs, the NOVAC7 (New Radiant Technology S.p.A.). The aim is to study the dose distribution inside a water phantom changing the dimension and shape of collimators, and the dimension, shape and material of beam stopper generally localized beyond the target in the breast lesion treatments.
The first step of our study is to develop a Monte Carlo application using GEANT4 toolkit to simulate the complex geometry of NOVAC7 and the electron beam characteristics, and to compare the dose distribution in the standard dosimetrical configuration with the experimental data, measured using the linac installed at the LATO HSR Giglio (LAboratorio di Tecnologie Oncologiche) at Cefalù (PA).

[1] Garton G R, Gunderson L L, Webb M J, Wilton T O, Cha S S and Podratz K C, Intraoperative radiation therapy in gynecologic cancer: update of the experience at a single institution, Int. J. Radiat. Oncol. Biol. Phys. 37 893-43 1997
[2] Krempien et al Long-term results of intraoperative presacral electron boost radiotherapy (IOERT) in combination with total mesorectal excision (TME)and chemoradiation in patient with locally advanced rectal cancer Int. J. Radiat. Oncol. Biol. Phys. 66 1143-51 2006
[3] Roeder F et al. Patterns of failure and local control after intraoperative electron boost radiotherapy to the presacral space in combination with the total mesorectal excision in patients with locally advanced rectal cancer Int. J. Radiat. Oncol. Biol. Phys. 67 1381-8 2007
[4] Tran et al Long-term survivors using intraoperative radiotherapy for recurrent gynecologic malignancies Int. J. Radiat. Oncol. Biol. Phys. 69 504-11 2007
[5] R.Orecchia et al. Intraoperative electron beam radiotherapy (ELIOT)to the breast: a need for quality assurance programme , The Breast 14, 541-546 2005
[6] Merrick III HW et al. Future directions in radiation therapy Surg. Oncol. Clin. N. Am. 12, 1099-105 2003
[7] Willet CG et al. Intraoperative radiation therapy Int. J. Clin. Oncol. 6 209-14 2001
[8] Rapporti ISTISAN 03/1 IT

Are you a Memeber of the Geant4 Collaboration (yes/no):

yes

Keymords:

IORT, Simulation, Monte Carlo, Geant4, Electron beam

Summary:

Many studies about the Intra Operative Radiation Therapy (IORT), a new radiation techniques, have highlighted its success to treat some tumors, especially the breast lesions. Our investigation aims are to study the dose distribution inside a water phantom changing the dimension and shape of collimator, and the dimension, shape and material of beam stopper (generally localized beyond the target in the breast lesion treatment) of linac NOVAC7. We develop a Monte Carlo application using Geant4 toolkit to simulate the complex geometry of the NOVAC7.

Parallel Session VI - Medical / 60

The new version of the GATE simulation platform

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Monte Carlo simulation is an important tool in medical physics to understand and analyse data taken from medical devices. It is also useful to assist the development of new medical devices and optimise their use.

GATE, a Geant4 Application, has been developed since 2001, initially for emission tomography (PET and SPECT) simulations. It encapsulates the GEANT4 libraries in order to achieve a modular, versatile, scripted simulation toolkit adapted to the field of nuclear medicine. In particular, GATE provides the capability for modelling time dependent phenomena such as detector movements or source decay kinetics, thus allowing the simulation of time curves under realistic acquisition conditions. It includes well-validated physics models, geometry modelling tools convenient for complex scanner geometries, models for detector electronic.

The version 6 of the GATE simulation platform is built on the previous developments and will be released publicly at the end of 2009. The code has been consolidated and the computational efficiency of GATE has been enhanced. The platform has also been extended to new applications such as modelling of CT imaging or radiotherapy and hadrontherapy treatments. For these applications, new tools have been developed, for example, to easily calculate the deposited dose distribution inside a patient described by a CT image following an intensity modulated radiation therapy (IMRT) photon beam, or a proton/carbon ion beam irradiation. The Geant4 hadronic physic processes with flexible models and cross-section selection are included and tested towards complete simulation of IMRT hadrontherapy. GATE v6 should thus become an invaluable simulation tool for assisting in the development of imaging-assisted radiotherapy and on-line dose control strategies.

Keymords:

GATE, PET, SPECT, radiotherapy, hadrontherapy, CT imaging

Summary:

The version 6 of the GATE simulation platform will be released publicly at the end of 2009. The code has been consolidated and the computational efficiency of GATE has been enhanced. The platform has also been extended to new applications such as modelling of CT imaging or radiotherapy and hadrontherapy treatments.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Plenary Session I - HEP and Hadronics / **61**

Geant4 Hadronic Physics Performance: Recent validation and developments

Plenary Session II - Space and Physics / **62**

Geant4 EM Physics Performance: Recent developments and validation

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Parallel Session VIII - Medical / 64

INVESTIGATING THE ACCURACY OF HADRONIC MODELS FOR CARBON ION THERAPY

Author: Till Tobias Boehlen[1]

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Introduction:
An accurate prediction of radiation fields resulting from therapeutic carbon ions in the patient is needed in order to evaluate correctly their biological effectiveness.

Materials and Methods:
Hadronic models of the Monte Carlo transport codes: Geant4 and Fluka, are benchmarked for regimes relevant for therapeutic carbon ions. The ability of the Monte Carlo codes to reproduce measured
fluencies of secondary fragments for a thick-target experiment at differing depths in water is evaluated by simulating the detailed experimental set-up and time-of-flight measurement techniques. Integral and double-differential fluencies are compared. The Geant4 models: BIC, QMD, Fermi Breakup, and Multifragmentation
are tested.

Conclusions:
Agreement within approximate limits of 50% is found for both codes for integral fragment fluencies. Discrepancies between simulations and measurements are specially for forward-directed fragments (0-2 degree). Geant4 tends to underestimate small-angle fluencies whereas larger angles tend to be overestimated.

Are you a Memeber of the Geant4 Collaboration (yes/no):

currently under consideration

Keymords:

validation study, hadron therapy, carbon ion, fragmentation, hadronic models

Summary:

-

Parallel Session III - Medical / 66

The role of Geant4 in the production of a database for an ion therapy Treatment Planning System

Authors: Ada Solano[1]; Faiza Bourhaleb[1]; Germano Russo[1]

Co-authors: Abdolkasem Ansarinejad [1]; Andrea Attili [2]; Cristiana Peroni [1]; Elke Schmitt [1]; Flavio Marchetto [2]; Marco Donetti [3]; Maria Adelaide Garella [3]; Roberto Cirio [1]; Roberto Sacchi [1]; Simona Giordanengo [1]; Vincenzo Monaco [1]

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In radiotherapy with carbon ions, the beam interaction with tissues has to be carefully estimated, since the spatial changes in the radiation quality due to fragmentation, energy loss and multiple scattering imply variations in the local radiobiological effectiveness. The information of dose deposition pattern alone is not sufficient to predict the biological effect of treatment: a detailed three-dimensional description of beam composition in terms of ion species, kinetic energies and energy releases is needed to estimate the outcome on tumoral and normal cells.

In the newly Italian Treatment Planning System (TPS) project, funded by the Istituto Nazionale di Fisica Nucleare (INFN) and the Ion Beam Accelerators (IBA), this knowledge is gathered by simulating the beam propagation by means of both Fluka and Geant4 codes.

In this talk will be presented the way this task is accomplished using Geant4, pointing out some apparent irregularities we are finding in the results.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

radiotherapy, carbon ion, Treatment Planning System, radiobiology, clinical beam, fragmentation

Summary:

The TPS kernel algorithm needs to access a lookup table where the information about the physical and radiobiological characteristics of the beam are contained.

To produce such information we are simulating with the version 9.2 of Geant4 the propagation of pencil beams in a water phantom. The phantom dimensions are automatically set depending on the primary beam energy. To record the quantities of interest, we are placing perpendicular to the beam axis a certain number of slices 10 um wide, more densely grouped in proximity of the Bragg peak, that are used as SensitiveDetectors. As an alternative, we are trying a different geometry setup that makes use of a ReadOutGeometry, such that readout is decoupled from tracking.

The recorded Hits are elaborated in the EventAction class and then saved in binary files prior to the uploading in a MySQL database for successive elaboration.

The trials we have performed up to now have revealed some apparent anomalies in the simulation: using Standard physics we have found that the position of the Bragg peak varies markedly with the setting of maximum step, while with the Low Energy physics the energy loss behavior doesn't seem compliant with the Landau-Vavilov theory.

These problems have to be analyzed and solved to allow the use of Geant4 in the production of a clinical database for carbon ion therapy.

Parallel Session VIII - Medical / 67

Physical and Biological investigations using Geant4 Monte Carlo simulation of the beam delivery line components in particle therapy.

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Co-authors: Abdul kasem Ansarinejad [1]; Ada Solano [1]; Alfredo Mirandola [2]; Andrea Attili [3]; Cristiana Peroni [1]; Elke Schmitt [1]; Flavio Marchetto [3]; Francesco DiRosa [4]; Francesco Romano [4]; Germano Russo [1]; Luigi Raffaele [5]; Marco Donetti [6]; Matia Adelaide Garella [6]; Pablo Cirrone [4]; Roberto Cirio [1]; Roberto Sacchi [1]; Silvia Molinelli [2]; Simona Giordanengo [1]; Vincenzo Monaco [1]

[1] *University of Turin, Dpt experimental physics and INFN, Torino, IT*

[2] *CNAO (Centro Nazionale di Adroterapia Oncologica) Foundation, Milano, IT*

[3] *INFN (Istituto Nazionale di Fisica Nucleare), Torino, IT*

[4] *INFN Laboratori Nazionali del Sud, Catania, Italy*

[5] *U.O.Radiologia e radioterapia, Az. Policlinico dell'Universita, and INFN LNS, Catania, IT*

[6] *CNAO (Centro Nazionale di Adroterapia Oncologica) Foundation, Milano, IT and INFN Torino*

Background: The importance of Monte Carlo (MC) simulations in the field of advanced radiation therapy increases with the necessity to investigate the effect of detectors, monitoring systems and ripple filters at the design phase. In this work we present our investigations using MC simulations of the effects of each of the elements in a beam delivery line of a particle therapy facility.
Methods and Materials: A full beam delivery line of the national center of oncologic hadrontherapy (CNAO) is simulated with the Monte Carlo package Geant4 to get the actual distribution of particles and fragments and the corresponding energies, in the treated volume. The evaluation of biological effects was studied using a code based on the Local Effect Model (LEM). The monitoring system on the beam delivery line was fully simulated, as well as the ripple filters and range shifters. The computational effort was performed using the distributed INFN Grid computing resources.
Measurements were done within the facilities of INFN Laboratori Nazionali del Sud to compare physical data of the lateral distribution of the beam and the Bragg peak curve (energy loss in depth curve) to MC simulations. The measurements were performed to test the design of the ripple filters to be used at CNAO. We calculated also the corresponding biological effect to evaluate the biological equivalent dose.
Results: A good agreement between simulations and experimental measurements for protons was obtained. The test for the design of new filters was successfully realized.
Given this good agreement we are confident about other improvements of the nozzle based on the simulation results. We modeled the effect of both ripple filters and monitoring system defining the corresponding transfer functions optimized the design of the monitoring system and especially for the design and test of ripple filters improving some of their features. We provided as well a tool to estimate both the physical and the biological equivalent dose distribution with the definition of corresponding transfer functions.
Conclusion: MC simulations using Geant4 helped for the design of the monitoring system and especially for the design and test of a new ripple filters to be installed at CNAO, improving some their features. We provided as well a tool to deduce both the physical and biological equivalent distribution determining their corresponding transfer functions.
Physical dose simulated data was largely verified. We are expecting the verification of the biological equivalent dose from future biological measurements using ripple filters.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

MC simulations, ripple filters, beam delivery line, particle therapy

Summary:

The importance of Monte Carlo (MC) simulations in the field of advanced radiation therapy increases with the necessity to investigate the effect of detectors, monitoring systems and ripple filters at the design phase. In this work we present our investigations using MC simulations of the effects of each of the elements in a beam delivery line of a particle therapy facility.

Parallel Session VI - Medical / 68

Recent developments and features in Hadrontherapy advanced example

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Co-author: Kaitaniemi Pekka [2]

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[2] *CEA/Saclay*

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Hadrontherapy is an advanced example of Geant4 toolkit. Hadrontherapy application was originally developed to simulate a well specified proton therapy facility: the passive transport beam line installed at Laboratori Nazionali del Sud (INFN) in Catania, Italy. In the recent past, Hadrontherapy went through different modifies. Nowadays, Hadrontherapy is a multifaceted and more flexible application showing many additional capabilities in the ion radiotherapy field. Our idea is to transform Hadrontherapy into a multi-modules application able to retrieve information of interest for proton-ion radiotherapy. The multi-modules scheme is a power tool that permits to use and integrate different independent components. For example, the source module is dedicated to simulate the characteristics of the initial beam. The geometrical module consents to employ different geometrical setups completely interchangeable switching between different geometrical configurations: passive/active proton beam line and a radiobiological carbon beam line. In the actual version only a 'passive beam line set-up' is available but new geometrical setups will be added in the next future. The detector module allows the simulation of a typical radiotherapy phantom divided in voxel. In the physics module are implemented the electromagnetic and hadronic physical model. And, in the data module all the physical and biological information (like dose, fluence, LET, etc) are collected

Are you a Memeber of the Geant4 Collaboration (yes/no):

yes

Keymords:

Hadrontherapy, Radiotherapy, LET

Summary:

Recent improvements have been introduced in Hadrontherapy advanced example as the possibility to calculate the LET and to switch between different geometrical configurations for proton and ion radiotherapy

Parallel Session VII - Nuclear and Space Physics / 69

The radiation hardness assurance tests at INFN-LNS Catania

Authors: Andrea Papi[1]; Behcet Alpat[1]; Dario Vazzana[2]; Diego Caraffini[2]; Ercan Pilicer[1]; Fabrizio Bizzarri[2]; Francesca Renzi[2]; Haluk Denizli[3]; Marco Petasecca[2]; Mauro Menichelli[1]; Postolache Vasile[2]

Co-authors: Francesco Ferrera [4]; Marcello Lattauda [4]; Pablo Cirrone [4]; Paolo Finocchiaro [4]; Pierpaolo Figuera [4]

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This work presents the features of a monitoring system developed for radiation hardness studies on electronics components and systems at Superconducting Cyclotron at INFN-LNS (Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud, Catania, Italy). Relevant beam parameters as flux, 3-D beam profile and energy are measured with high accuracy with double sided 1.5 mm thick microstrip silicon detector which act as calorimeter. All monitoring setup is fully automatic to perform Single Event Effects studies with heavy ions. In this study gaseous ions Ne20, Ar40, Kr84 and Xe129 with 20 MeV/n energy are used.
The operation in air, which means less complication in test setup and faster execution times provides also the advantage of using the air thickness in front of Device Under Test (DUT) as degrader hence to fine tune the energy values available at the DUT surface.
A careful evaluation of energy loss in air and of the energy spread at DUT surface is carried out through a full Monte Carlo simulation of test setup and comparing the results with data.
The results of careful investigations for beam flux uniformity in space and time as well as effects of fragmentation which may happen in air are also discussed.
We have exposed during the same session, two beam calibration systems, the "Reference SEU monitor" developed by ESA/ESTEC and the beam monitoring and dosimetry setup developed by our group. The results are compared and discussed here.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

Radiation effects, radiation test, dosimetry, heavy ion accelerators, Linear Energy Transfer, Monte Carlo simulation

Summary:

We have developed a fully automatic dosimetry system to demonstrate the validity of beam characteristics of LNS sites for SEE and DD tests. Therefore, a Geant4 code has been created to observe the contribution of fragmentations, which may be produced in air, into total ionizing energy deposition and LET values for DUT, and to calculate the range in DUT.

Parallel Session II - Model development and comparison with experiments / 70

Developments in INCL/ABLA

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Parallel Session II - Model development and comparison with experiments / 71

Progress in GEM and Precompound Models

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Parallel Session II - Model development and comparison with experiments / 72

QMD Update

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Parallel Session II - Model development and comparison with experiments / 73

The ENDL Neutron Interface

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74

Binary Cascade Update

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75

Discussion: hadronic requirements when LHC data arrives

Plenary Session III - Hadronic modeling and validation / 76

New developments for Bertini cascade

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Plenary Session III - Hadronic modeling and validation / 77

Recent developments for CHIPS

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Plenary Session III - Hadronic modeling and validation / 78

Recent developments for FTF

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Plenary Session III - Hadronic modeling and validation / 79

Validation of Geant4 models in transition energy region

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Plenary Session III - Hadronic modeling and validation / 80

Discussion

Parallel Session III - Medical / 82

Geant4 based simulation of the Leksell Gamma Knife for treatment planning validation

Authors: Francesco Romano[1]; Giacomo Cuttone[1]; Giorgio Russo[2]; Maria Gabriella Sabini[3]; Vincenza Mongelli[3]

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The Monte Carlo code Geant4 has been used to simulate the Leksell Gamma Knife® and to verify its treatment planning system Leksell GammaPlan® (LGP). By means of this radiosurgical technique, intracranial lesions can be treated in a single session with high precision and critical brain structures can be protected. Radiation from 201 60Co sources comes through a collimation system to the target area, focusing on the isocenter, where the maximum dose amount is released. Simulations were employed to calculate the dose distribution in a spherical water phantom, the same we used for the validation measurements. In order to simplify the code, we simulated just one single source, rotating the phantom at 201 angular positions, the same of the sources in the device. We validated the simulation by measuring the dose distribution with radiochromic films HS, for all the available collimators (4, 8, 14, 18 mm). Good agreement has been found between experimental data and results of Monte Carlo simulations. Then we used the simulation to verify the dose calculated by LGP. Comparisons between Geant4 and LGP outputs in one and two dimensions were performed at different planes (axial, coronal and sagittal) and depths. The outcomes show that LGP calculates correctly the dose distribution in a homogeneous phantom. Different results were found when different density materials are also included, because LGP assumes the phantom only composed by water. Moreover a complete clinical treatment with a multi-shots configuration has also been simulated and also in this case the results were compared with LGP. Some methods for the optimization of the code and the reduction of calculation time are in progress, in order to possibly propose the application as an advanced example of the Geant4 toolkit.

Are you a Memeber of the Geant4 Collaboration (yes/no):

yes

Keymords:

Gamma Knife, radiosurgery, gamma, treatment planning system

Summary:

The Monte Carlo code Geant4 has been used to simulate the Leksell Gamma Knife® and to verify its treatment planning system Leksell GammaPlan® (LGP). By means of this radiosurgical technique, intracranial lesions can be treated in a single session with high precision and critical brain structures can be protected. Radiation from 201 60Co sources comes through a collimation system to the target area, focusing on the isocenter, where the maximum dose amount is released. Simulations were employed to calculate the dose distribution in a spherical water phantom, the same we used for the validation measurements. In order to simplify the code, we simulated just one single source, rotating the phantom at 201 angular positions, the same of the sources in the device. We validated the simulation by measuring the dose distribution with radiochromic films HS, for all the available collimators (4, 8, 14, 18 mm). Good agreement has been found between experimental data and results of Monte Carlo simulations. Then we used the simulation to verify the dose calculated by LGP. Comparisons between Geant4 and LGP outputs in one and two dimensions were performed at different planes (axial, coronal and sagittal) and depths. The outcomes show that LGP calculates correctly the dose distribution in a homogeneous phantom. Different results were found when different density materials are also included, because LGP assumes the phantom only composed by water. Moreover a complete clinical treatment with a multi-shots configuration has also been simulated and also in this case the results were compared with LGP. Some methods for the optimization of the code and the reduction of calculation time are in progress, in order to possibly propose the application as an advanced example of the Geant4 toolkit.

Parallel Session XI - EM - new models and validation / 83

Range validation for electrons, protons and alpha particles

Author: Christina Zacharatou Jarlskog[1]

Co-authors: Michel Maire [2]; Vladimir Ivantchenko [3]

[1] *Niels Bohr Institute, Copenhagen*

[2] *LAPP*

[3] *CERN, ESA*

Corresponding Authors: christina.zacharatou@cern.ch, michel.maire@lapp.in2p3.fr, vladimir.ivantchenko@cern.ch

Parallel Session XI - EM - new models and validation / 84

ICRU'73 stopping powers

Author: Anton Lechner[1]

[1] *Atominst. der Oest. Universitaeten - Technische Universitaet Wien*

Corresponding Author: anton.lechner@cern.ch

Parallel Session XI - EM - new models and validation / 85

Fluctuation model modifications

Author: Laszlo Urban[1]

Co-authors: Michel Maire [1]; Vladimir Ivantchenko [2]

[1] *Unknown*

[2] *CERN, ESA*

Corresponding Authors: laszlo.urban@cern.ch, michel.maire@cern.ch, vladimir.ivantchenko@cern.ch

Parallel Session XI - EM - new models and validation / 86

New test on silicon detectors

Author: Frederic Dupertuis[None]

Co-author: Vladimir Ivantchenko [1]

[1] *CERN, ESA*

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Parallel Session XI - EM - new models and validation / 87

Discussion - Physics List options for 9.3

Author: Vladimir Ivantchenko[1]

[1] *CERN, ESA*

Corresponding Author: vladimir.ivantchenko@cern.ch

Parallel Session VIII - Medical / 88

Simulation studies of a therapeutic proton beam delivery system

Author: Jungwook Shin[1]

Co-authors: Dongho Shin [1]; Dongwook Kim [1]; Myeong geun Yoon [1]; Se Byeong Lee [1]; Sung-Yong Park [1]; Sung-whan Ahn [1]; Young Kyung Lim [1]

[1] *National Cancer Center, Korea*

We have been developing a Monte Carlo simulation software to be applied in clinical usage.
To apply a Monte Carlo simulation in clinical support, the reproducibility of real irradiation is prerequisite. From modeling the therapeutic nozzle to mimicking treatment scheme, we have successfully modeled our beam delivery system which is using rotation modulation wheels to generate a spread-out Bragg peaks(SOBP). The initial beam energy for Monte Carlo simulation was estimated based on the Bragg peak comparisons with measurement and used to simulate SOBPs resulting good agreement with measured SOBPs.In this presentation, we will summarize our status of development and introduce user studies applying the developed software.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

Proton therapy, SOBP, modulation wheel

Summary:

In order to apply Monte Carlo simulation to clinical support, the authors have been developing the Monte Carlo simulation for the proton therapy based on the Geant4 simulation toolkit.

Parallel Session V - HEP / 91

ALICE Experience with Geant3, Fluka and GEANT4

Author: Eva Sicking[1]

[1] *Institut fuer Kernphysik-Westfaelische Wilhelms-Universitaet Mun*

Corresponding Author: eva.sicking@cern.ch

Parallel Session V - HEP / 92

The Geant4 Simulation of the ATLAS Experiment

Author: Zachary Marshall[1]

[1] *Columbia University*

Corresponding Author: asai@slac.stanford.edu

Plenary Session V - EM Physics Validation and Development / 93

New developments and validation for standard EM

Author: Vladimir Ivantchenko[1]

[1] *CERN, ESA*

Corresponding Author: vladimir.ivantchenko@cern.ch

Plenary Session V - EM Physics Validation and Development / 94

Migration of low-energy physics to common EM design

Author: Luciano Pandola[1]

[1] *Unknown*

Corresponding Author: luciano.pandola@lngs.infn.it

Plenary Session V - EM Physics Validation and Development / 95

New high energy models and validation tools

Author: Andreas Schaelicke[None]

Corresponding Author: andreas.schaelicke@cern.ch

Plenary Session V - EM Physics Validation and Development / 96

Simulating Scintillator Light Collection Using Measured Optical Reflectance

Authors: Martin Janecek[None]; William Moses[None]

Corresponding Author: gum@triumf.ca

To accurately predict the light collection from a scintillating crystal through Monte Carlo simulations, it is crucial to know the angular distribution from the surface reflectance. Current Monte Carlo codes allow the user to set the optical reflectance to a linear combination of backscatter spike, specular spike, specular lobe, and Lambertian reflections. However, not all light distributions can be expressed in this way. In addition, the user seldom has the detailed knowledge about the surface that is required for accurate modeling. We have previously measured the angular distributions within BGO crystals and now incorporate these data as look-up-tables (LUTs) into modified Geant4 and GATE Monte Carlo codes. The modified codes allow the user to specify the surface treatment (ground, etched, or polished), the attached reflector (Lumirror, Teflon, ESR film, Tyvek, or TiO paint), and the bounding type (air-coupled or glued). Each LUT consists of measured angular distributions with 4 deg by 5 deg resolution in theta and phi, respectively, for incidence angles from 0 deg to 90 deg, in 1 deg steps. We compared the new codes to the original codes by running simulations with a 0.3x1.0x3.0mm**3 BGO crystal coupled to a PMT. The simulations were then compared to measurements. Light output was measured by counting the photons detected by the PMT with the 0.3x1.0, 0.3x3.0, or 1.0x1.0 mm**2 side coupled to the PMT, respectively. Our new code shows better agreement with the measured data than the current Geant4 code. The new code can also simulate reflector materials that are not pure specular or Lambertian reflectors, as was previously required. Our code is also more user friendly, as no detailed knowledge about the surfaces or light distributions is required from the user.

Plenary Session V - EM Physics Validation and Development / 97

General Discussion

Parallel Session II - EM Physics: Validation and Applications / 98

Validation of Geant4 EM physics for gamma rays against the SANDIA, EPDL97 and NIST databases

Author: Zhang Qiwei[1]

[1] *INFN-LNS*

From version 9.2 of Geant4, the LowEnergy electromagnetic processes (Livermore and Penelope) have been migrated to the design introduced for the Standard EM models. In the new approach there is only one process and multiple models that can be registered to the process. We present

a validation of the migrated Geant4 electromagnetic photon models for elements and compounds with respect to several libraries based on experimental data (SANDIA, EPDL97 and NIST). The cross section of all the photon models agrees with NIST within 10%.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

Em physics, validation, data

Summary:

From version 9.2 of Geant4, the LowEnergy electromagnetic processes (Livermore and Penelope) have been migrated to the design introduced for the Standard EM models. In the new approach there is only one process and multiple models that can be registered to the process. We present a validation of the migrated Geant4 electromagnetic photon models for elements and compounds with respect to several libraries based on experimental data (SANDIA, EPDL97 and NIST). The cross section of all the photon models agrees with NIST within 10%.

Plenary Session I - HEP and Hadronics / **99**

Geant4 applications in high-energy physics

Corresponding Author: margar.simonyan@gmail.com

Plenary Session I - HEP and Hadronics / **100**

Geant4 applications for astroparticle and rare-event physics

Author: Markus Horn[1]

Co-author: Henrique Araujo [2]

[1] *Ph.D.student*

[2] *Unknown*

Plenary Session IV - News from Geant4 and Computing Performance / **101**

News from Geant4: Recent Developments (non-physics)

Author: Ivana Hrivnacova[None]

Corresponding Author: ivana.hrivnacova@cern.ch

Plenary Session IV - News from Geant4 and Computing Performance / **102**

News from Geant4: Best Practices

Plenary Session IV - News from Geant4 and Computing Performance / 103

News from Geant4: Demo of Visualization Capabilities

Author: John Allison[None]

Corresponding Author: john.allison@cern.ch

Plenary Session IV - News from Geant4 and Computing Performance / 104

News from Geant4: Upcoming Geant4 Releases

Author: Gabriele Cosmo[None]

Corresponding Author: gabriele.cosmo@cern.ch

Plenary Session IV - News from Geant4 and Computing Performance / 105

Topic C: Computing Performance - Presentation

Author: Daniel Elvira[1]

[1] *Fermi National Accelerator Laboratory (FNAL)*

Corresponding Author: daniel.elvira@cern.ch

Plenary Session IV - News from Geant4 and Computing Performance / 106

Topic C: Computing Performance - Discussion

Parallel Session I - Hadronic Physics Validation / 107

Beam Test and Simulation Results with Highly Granular Calorimeters for the ILC

Author: Benjamin Lutz[1]

[1] *Deutsches Elektronen-Synchrotron (DESY)*

Corresponding Author: benjamin.lutz@cern.ch

To evaluate technologies for ILC calorimetry, the CALICE collaboration has constructed a prototypes of highly granular sampling calorimeters. These detectors have been tested extensively in particle beams at DESY, at CERN and at Fermilab. The imaging capabilities of these detector provide three dimensional information of hadronic showers with unprecedented resolution and will thus help to constrain hadronic shower models in simulations.
We present results from the analysis of hadronic events including studies of the longitudinal and transverse shower profiles. The results are compared to simulations

with a variety of different models. We put particular emphasis on the comparison of our data to the new physics lists proposed by the G4-hadronic team.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

hadron
calorimetry
ILC
CALICE

Parallel Session III - Medical / 108

Dosimetric study of photon dose distribution in lungs under different respiratory phases: comparison with GEANT4 simulations

Authors: Antonella Soriani[1]; Barbara Caccia[2]; Claudio Andenna[3]; Gianluca Frustagli[2]; Giuseppe Iaccarino[1]; Lidia Strigari[1]; Maurizio Mattia[2]; Stefano Valentini[2]; Valeria Landoni[1]

[1] *Medical Physics Laboratory, Istituto Regina Elena and INFN, Roma (Italy)*

[2] *Technologies and Health Dept. Istituto Superiore di Sanità and INFN, Roma (Italy)*

[3] *DIPIA –ISPESL and INFN, Roma (Italy)*

The advances in oncological research have had an important impact on cancer patients survival, but there
has been no major or dramatic improvement in long-term survival in the lung cancer despite more innovative treatment techniques and protocols implemented in radiation oncology. The problematic concerning dose calculation in the presence of in-homogeneities has already been afforded by several authors
but a new challenge has been rising since radiation therapies based on respiratory gating systems have been
introduced in the clinical practice. The MonteCarlo (MC) algorithms have already been proven to be a
realistic alternative to analytical algorithms in those regions where charged particle equilibrium does not
hold. The aim of this work is to evaluate the capability of GEANT4 respect to some commercial treatment
planning systems to provide dose calculation maps with high level of accuracy also when lung densities are
changing (i.e. during different respiratory phases, from breathing out to deep inspiration). GEANT4 simulations have been compared to dosimetric data measured by radiochromic films.
In this study, a 6 MV beam from a 2100 Clinac Varian was modeled with a GEANT4 MC code.
The reported results were obtained with a modified version of the GEANT4 Advanced Example MedLinac.
Preliminary measurements were carried out for different square field sizes (20x20 cm2, 7.5x7.5 cm2 and 3x3
cm2) with SSD=84 cm. To study the dose distribution a series of three phantoms were constructed and
simulated, each characterized by a different lung density according to the following values: 0.030, 0.080
and 0.40 g/cm3.
The MC simulation jobs were run on a dedicated Beowulf cluster located in the Technology and Health
Department of the Italian National Institute of Health.
Two different algorithms released for clinical application from two commercial TPS were included in our

study: Varian Eclipse TPS (PB-EqTAR pencil beam with EqTAR algorithm for heterogeneities correction)
and Philips Pinnacle TPS (CCC Collapsed Cone Convolution).
Results obtained by the MC simulation and calculated data obtained from commercial TPS have been compared with measurements performed with radiochromic films (GafchromicTM EBT). The films were
exposed at different depths perpendicularly and parallel to the beam axis at different distances. Images were
acquired with a Epson Expression 10000 XL flatbed scanner and analyzed with Picodose X PRO software.
Results show a good agreement between GEANT4 simulations and dosimetric data.

Are you a Memeber of the Geant4 Collaboration (yes/no):

no

Keymords:

Geant4, Dosimetry,

Summary:

The advances in oncological research have had an important impact on cancer patients survival, but there
has been no major or dramatic improvement in long-term survival in the lung cancer despite more innovative treatment techniques and protocols implemented in radiation oncology. The problematic concerning dose calculation in the presence of in-homogeneities has already been afforded by several authors
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introduced in the clinical practice. The MonteCarlo (MC) algorithms have already been proven to be a realistic alternative to analytical algorithms in those regions where charged particle equilibrium does not
hold. The aim of this work is to evaluate the capability of GEANT4 respect to some commercial treatment
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cm2) with SSD=84 cm. To study the dose distribution a series of three phantoms were constructed and simulated, each characterized by a different lung density according to the following values: 0.030, 0.080 and 0.40 g/cm3.
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Two different algorithms released for clinical application from two commercial TPS were included in our
study: Varian Eclipse TPS (PB-EqTAR pencil beam with EqTAR algorithm for heterogeneities correction)
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acquired with a Epson Expression 10000 XL flatbed scanner and analyzed with Picodose X PRO software.
Results show a good agreement between GEANT4 simulations and dosimetric data.

Parallel Session VI - Medical / 109

PTSsim Framework for Radiotherapy Monte Carlo

Author: Takashi Sasaki[1]

[1] *KEK*

PTSsim Framework for Radiotherapy Monte Carlo

Are you a Memeber of the Geant4 Collaboration (yes/no):

Yes

Keymords:

Geant4 Monte Carlo

Summary:

PTSsim Framework for Radiotherapy Monte Carlo

Parallel Session VI - Medical / 110

GAMOS Framework for Medical Monte Carlo

Author: Pedro Arce[1]

[1] *CIEMAT*

GAMOS Framework for Medical Monte Carlo

Are you a Memeber of the Geant4 Collaboration (yes/no):

Yes

Keymords:

GAMOS, Monte Carlo

Summary:

GAMOS Framework for Medical Monte Carlo

Parallel Session V - HEP / 115

Geant4 Results from CMS

Author: Sunanda Banerjee[1]

[1] *Fermilab*

Corresponding Author: sunanda.banerjee@cern.ch

116

Detailed vs Simplified Neutron Capture Models

Parallel Session II - Model development and comparison with experiments / 117

Discussion: Detailed vs. Simplified Neutron Capture Models

Parallel Session VII - Hadronics validation and testing / 118

Total Cross Section Tests at Process Level

Author: Mikhail Kosov[1]

[1] *CERN, ITEP(MOSCOW)*

Parallel Session VII - Hadronics validation and testing / 119

Hadronic Generator Tests for Spallation and Low Energies

Author: Vladimir Ivantchenko[1]

[1] *CERN, ESA*

Parallel Session VII - Hadronics validation and testing / 120

The Validation Effort at FNAL

Author: Sunanda Banerjee[1]

[1] *Fermilab*

Parallel Session II - Model development and comparison with experiments / 121

Ion-ion Validation from Catania

Authors: Daniele Sardina[None]; Francesco Romano[1]; Giacomo Cuttone[2]; Pablo Cirrone[3]

[1] *INFN Laboratori Nazionali del Sud, Catania, Italy*

[2] *Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali del Sud, Catania, Italy*

[3] *Unknown*

Parallel Session VII - Hadronics validation and testing / 122

Geant4 Hadronic Validation Framework

Author: Julia Yarba[1]

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Corresponding Author: yarba_j@fnal.gov

Parallel Session VII - Hadronics validation and testing / 123

Plans and Discussion

Plenary Session II - Space and Physics / 124

Applications of Geant4 in space

Corresponding Author: giovanni.santin@esa.int

Plenary Session II - Space and Physics / 125

Physics performance: topical discussion

Plenary Session IV - Physics Lists and Metrics / 126

Metrics for comparing Simulation against data

Plenary Session IV - Physics Lists and Metrics / 127

Physics Lists improvement and documentation

Topics
- Status of Physics Lists (Production HEP, Application Area / Advanced Example)
- Improving Physics Lists: development and experimental Physics Lists
- Documentation: News, ongoing actions, needs
- New Requirements

Summary:

Status of physics lists (highlights, developments)
Improvement of Physics Lists
Development of new Physics lists vs revising existing
How to test new Physics Lists
Documentation
New requirements

128

slic & lcdd: A Detector Response Simulation Program

Author: Norman Graf[1]

[1] *SLAC*

129

Evaluation of absorbed fractions for beta-gamma radionuclides in ellipsoidal volumes of soft tissue through Geant4

Parallel Session II - EM Physics: Validation and Applications / 130

Evaluation of absorbed fractions for beta-gamma radionuclides in ellipsoidal volumes of soft tissue through Geant4

Authors: Domenico Lizio[1]; Ernesto Amato[1]; Sergio Baldari[1]

[1] *University of Messina*

We developed a simulation in Geant4 to calculate the absorbed fractions for monoenergetic and beta electrons emitted by 199Au, 177Lu, 131I, 153Sm, 186Re and 90Y and for photons between 10 keV and 1 MeV, emitted by sources uniformly distributed in ellipsoidal volumes of soft tissue. Code validation results with respect to reference data for doses, ranges and absorbed fractions in spheres are presented. We discuss the influence Monte Carlo parameters on average energy deposition for the three physics packages available.
An analytical relationship between absorbed fraction and a “generalized radius”is introduced, and the dependence of its parameters rho0 and s from average electron or photon energy is discussed. A generalization for the estimation of absorbed fractions for other radionuclides is also proposed. Such results can be useful to improve accuracy and easiness of calculation in dosimetry of beta-gamma emitting radionuclides.

Summary:

We developed a simulation in Geant4 to calculate the absorbed fractions for monoenergetic and beta electrons emitted by 199Au, 177Lu, 131I, 153Sm, 186Re and 90Y and for photons between 10 keV and 1 MeV, emitted by sources uniformly distributed in ellipsoidal volumes of soft tissue. Code validation results with respect to reference data for doses, ranges and absorbed fractions in spheres are presented. We discuss the influence Monte Carlo parameters on average energy deposition for the three physics packages available.
An analytical relationship between absorbed fraction and a “generalized radius”is introduced, and the dependence of its parameters rho0 and s from average electron or photon energy is discussed. A generalization for the estimation of absorbed fractions for other radionuclides is also proposed. Such results can be useful to improve accuracy and easiness of calculation in dosimetry of beta-gamma emitting radionuclides.

Parallel Session V - HEP / 131

Geant4 Studies in the Context of Dual Readout Calorimetry Simulations

Authors: Adam Para[1]; Hans wenzel[1]; Krzysztof Genser[1]

[1] *Fermilab*

Parallel Session I - Hadronic Physics Validation / 132

slic & lcdd: A Detector Response Simulation Program

Author: Norman Graf[1]

[1] *SLAC*

Opening / 133

Workshop Logistics

Authors: Daniele Sardina[None]; Pablo Cirrone[1]

[1] *Unknown*

Opening / 134

Workshop Goals and Opportunities

Parallel Session X - Configure tool / New system testing / 135

System testing using nightlies

Plenary Session VI - Testing, Analysis and CAD/GDML / 136

Getting CAD Geometries into Geant4 - Discussion

Author: Joseph Perl[None]

Parallel Session I - Particle tables and processes / 137

Context of session - and proposed agenda

** Focus **
Proposed as a working session - focusing on:
* understanding the current use cases for Physics tables (in sequential Geant4 applications)
* understanding the characteristics (and limitations) when used in a multi-process (copy on write) application;
* understanding the characteristics and requirements in the use case of a prototype multi-threaded Geant4 application;
* clarifying the requirements for Physics table(s) coming from multi-process and multi-core extensions;
* discussing potential ways to overcome these current weaknesses
* summarising our considerations, as a starting point for a deeper examination and potential revision of the design of the Physics tables to cope with the new requirements.

Summary:

Potential agenda
* Brief introduction to Physics Tables
(focusing on use cases, requirements) - talk of 3-4 slides, (˜ 5 minutes)
- Memory cost of Physics tables
*Considerations and challenges of multi-core (˜ 30 minutes)
Mini-presentation: Maximum 10 slides [15 minutes]
- Why share physics tables - either as pages of memory or as objects ?
- Current difficulties in multi-core (mixing of read-only and read-write addresses)
- How are physics tables (and client classes) treated in Xin's Multi-Threaded prototype
Discussion [˜ 15 minutes]
- Challenge of multi-threading (explanation of context in M/T prototype)
- Are there potential benefits for ordinary G4 (sequential) from revising the PhysicsTable implementation?
* Clarification of use case(s) - with focus on multi-core/multi-threading (˜ 20 minutes)
* Distillation of requirements, potential constraints (˜ 20 minutes)
* Potential solutions (˜ 10 minutes)

Parallel Session X - Configure tool / New system testing / 138

Replacing Configure/metaconf by modern tool(s)

Author: Ben Morgan[1]

[1] *University of Warwick*

Corresponding Author: ben.morgan@warwick.ac.uk

Plenary Session VI - Testing, Analysis and CAD/GDML / 139

test49:Geant4+ROOT

140

test19:Geant4+ROOT

141

test49:Geant4+Root

Author: Mikhail Kosov[1]

[1] *CERN, ITEP(MOSCOW)*

Plenary Session VI - Testing, Analysis and CAD/GDML / 142

A stable interface to read and write IAEA phase-space files in Geant4

Author: Miguel A. Cortes-Giraldo[1]

Co-authors: Jose M. Quesada [1]; Roberto Capote [2]

[1] *University of Sevilla*

[2] *IAEA Nuclear Data Section*

Plenary Session VII - Summary from the parallel sessions / 143

I - Physics Tables - and Multi-core

Plenary Session VII - Summary from the parallel sessions / 144

II - Model development and comparison with experiments

Corresponding Author: kosov@cern.ch

Plenary Session VII - Summary from the parallel sessions / 145

III - Performance of Brachytherapy Realistic Application (work session)

Corresponding Author: perl@slac.stanford.edu

Plenary Session VII - Summary from the parallel sessions / 146

IV - Hadronic Code Improvement

Corresponding Author: vladimir.ivantchenko@cern.ch

Plenary Session VII - Summary from the parallel sessions / **147**

V - Physics lists : documentation and X - Configure tool / New system testing

Corresponding Author: gunter.folger@cern.ch

Plenary Session VII - Summary from the parallel sessions / **148**

VI - Low-energy EM

Plenary Session VII - Summary from the parallel sessions / **149**

VII - Hadronics validation and testing

Corresponding Author: vladimir.ivantchenko@cern.ch

Plenary Session VII - Summary from the parallel sessions / **150**

VIII - Kernel

Plenary Session VII - Summary from the parallel sessions / **151**

IX - Multiple scattering and single scattering

Corresponding Author: vladimir.ivantchenko@cern.ch

152

X - Configure tool / New system testing

Corresponding Author: gunter.folger@cern.ch

Plenary Session VII - Summary from the parallel sessions / **153**

XI - EM - new models and validation

Corresponding Author: andreas.schaelicke@cern.ch

Plenary Session VIII - Future developments and challenges / **154**

Next release

Author: Gabriele Cosmo[None]

Corresponding Author: gabriele.cosmo@cern.ch

Plenary Session VIII - Future developments and challenges / **155**

Architecture review

Author: Makoto Asai[1]

[1] *SLAC*

Corresponding Author: asai@slac.stanford.edu

Plenary Session VIII - Future developments and challenges / **156**

Outlook

Author: John Apostolakis[1]

[1] *CERN*

Corresponding Author: john.apostolakis@cern.ch