7th Geant4 Space Users Workshop

Wednesday, 18 August 2010 - Friday, 20 August 2010

Hilton Hotel Seattle Downtown, Seattle, WA, U.S.A.

Book of Abstracts

Contents

Plenary session IV - Space radiation environment - / 4

Background Simulations with Geant4 for the General Antiparticle Spectrometer (GAPS) Balloon Experiment

Author: Philip von Doetinchem[1]

Co-authors: Atsushi TAKADA [2]; Charles HAILEY [3]; Florian GAHBAUER [4]; Hideyuki FUKE [2]; Isaac MOGNET [5]; Jason KOGLIN [3]; Jeffrey ZWEERINK [5]; Kaya MORI [3]; Nobutaka BANDO [2]; Norm MADDEN [3]; Rene ONG [5]; Steven BOGGS [1]; Tetsuya YOSHIDA [2]; Tracy ZHANG [5]; Tsuguo ARAMAKI [3]; William CRAIG [6]

[1] *UC Berkeley, Space Sciences Laboratory*

[2] *Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency*

[3] *Columbia University, Astronomy and Astrophysics*

[4] *University of Latvia, Atomic and Molecular Physics Laboratory*

[5] *UC Los Angeles, Physics and Astronomy*

[6] *Lawrence Livermore National Laboratory*

Corresponding Author: doetinchem@ssl.berkeley.edu

The GAPS experiment is foreseen to carry out a dark matter search using low energy cosmic ray antideuterons (< 0.3GeV/n) at stratospheric altitudes using a novel detection approach. The theoretically predicted antideuteron flux resulting from secondary interactions of primary cosmic rays, e.g. protons, with the interstellar medium is very low. So far not a single cosmic antideuteron has been detected by any experiment. Therefore a crucial task during the development of the GAPS instrument is to gain a good understanding of the large gamma and particle backgrounds which could spoil the antideuteron identification. This background is mainly composed of three components: cosmic rays, products of cosmic-ray interactions with Earth's atmosphere and products of interactions with the detector material itself. To study atmospheric interactions of cosmic rays with the atmosphere an adapted Geant4 based Planetocosmics simulation was developed. In addition, the Planetocosmics framework was also used to study the geomagnetic influence on the background rates. The results of these simulations were fed into a standalone Geant4 instrument simulation which is used to carry out a full GAPS detector simulation and reconstruction.
This presentation will give an overview of the GAPS instrument and the different simulation issues. It will mainly concentrate on the atmospheric simulations and discuss e.g. the implementation of the particle gun for a fast simulation, validation of the simulations with existing data and the interface to the instrument simulation.

Plenary session VIII - Semiconductor simulation - / 5

Phonon Transport in Geant4

Authors: Daniel Brandt[1]; Makoto Asai[1]

Co-authors: Blas Cabrera [2]; Dennis Wright [1]; Eduardo Do Couto e Silva [1]; Rudy Resch [1]; Steven Leman [3]

[1] *SLAC National Accelerator Laboratory*

[2] *Stanford University*

[3] *MIT*

Corresponding Author: dbrandt@slac.stanford.edu

We present preliminary results of a research and development effort to implement low temperature, quasidiffusive phonon transport in Geant4. In its current implementation the phonon transport code presented is capable of propagating ballistic phonons of Longitudinal (L), Slow Transverse(ST) and Fast Transverse (FT) polarization states. We present an overview of the physics processes under consideration and discuss the current level of implementation. The simulated and experimental

phonon focusing patterns in germanium crystals are in good agreement, and the simulated, polarization dependent group velocities along the principle crystal axis agree with values in the literature. One of many potential applications of the Geant4 phonon code is the rapidly growing field of cryogenic calorimeters and the design of calorimeter absorbers. We conclude with a short discussion of the technical challenges specific to the implementation of anisotropic phonon propagation in Geant4.

Plenary session IV - Space radiation environment - / 6

G4MRES A Geant4-based operational tool to evaluate space weather effects on satellites

Authors: Angela Rivera Campos[1]; Sergio Esteve Hoyos[2]; Sergio Ibarmia Huete[2]

Co-authors: Alessandro Donati [3]; Esther Parrilla [4]; Maria Jesus Enriquez [4]; Sandra Negrin [4]

[1] *INSA/INTA*

[2] *INTA*

[3] *ESA/ESOC*

[4] *Deimos Space S.L.U.*

Corresponding Author: angela.rivera@insa.es

G4MRES (Geant4 for Mission Radiation Effects Simulation), developed under the framework of SEISOP (Space Environment Information System for Operations) project, is designed, as an advanced tool, to cover the lack of data linking the Space Weather conditions and the direct effects on S/C sensitive components.

The final objective of G4MRES is the design of an operational tool capable to retrieve real-time SW information from a selected data provider and S/C orbital parameters from mission control centers, perform a realistic radiation analysis, and return the resulting effects estimations to mission operators and payload teams in order to provide them with useful information to understand possible anomalies induced by energetic radiation.

G4MRES core is based on Geant4 particle transport code, as it covers all the required capabilities in terms of radiation propagation and effects analysis and in particular, common radiation effects of interest for mission engineers, such as Total Ionising Dose (TID), Displacement Damage Dose (DDD), Linear Energy Transfer (LET), etc.

In terms of Geant4 code, G4MRES makes use of GRAS tool as main simulation and analysis engine, and MAGNETOCOSMICS as effective tool to estimate geomagnetic attenuations of particle fluxes for magnetically-shielded real orbits.

G4MRES is the next generation of a previous prototype, G4SESS, developed for SESS (Space Environment Support System) project and succesfully tested in ESAC. Currenlty G4MRES, together with SEISOP system, is under installation and testing phase at ESOC and it is expected to be ready for operations in the next months, providing support to current and future ESA missions.

Plenary session VII - Accelerator simulation - / 7

Geant4 and MCNPX: Comparison of Electron Beam Transport Simulation

Author: Shawn Kang[1]

Co-authors: Giovanni Santin [2]; Insoo Jun [3]; Petteri Nieminen [2]

[1] *Jet Propulsion Laboratory*

[2] *ESA*

[3] *JPL*

Corresponding Author: shawn.kang@jpl.nasa.gov

The Europa Jupiter System Mission (EJSM) would consist of two primary flight elements operating in the Jovian system: the NASA-led Jupiter Europa Orbiter (JEO) and the ESA-led Jupiter Ganymede Orbiter (JGO). JEO and JGO would execute a choreographed exploration of the Jupiter System before settling into orbit around Europa and Ganymede, respectively. The JEO concept is designed to follow-up on the major discoveries of the Galileo and Voyager missions at Europa, especially its ocean. Instruments on JEO mission would be subjected to intense radiation environments from high energy trapped electrons and protons in Jovian magnetosphere among others. As a part of detector shielding modeling efforts to support the JEO mission, electron beam simulations through slab geometry made of aluminum and tantalum were chosen to be performed using MCNPX and Geant4 computer code. This paper documents the measures taken in setting up physics models and selecting datasets in Geant4 and MCNPX, and reports the result of the analysis. As will be shown, when comparable physics models and data were chosen, results produced for electron, gamma, neutron fluxes and energy deposition by the two codes show good agreement.

Plenary session I - Opening address and general status report - / 8

Applications of Monte Carlo Radiation Transport Simulations Techniques for Predicting Single Event Effects in Microelectronics

Authors: Mendenhall Marcus[1]; Reed Robert[1]; Weller Robert[1]

[1] *Vanderbilt University*

Corresponding Author: robert.reed@vanderbilt.edu

MRED (Monte Carlo Radiative Energy Deposition) is Vanderbilt University's Geant4 application for simulating radiation events in semiconductors. Geant4 is comprised of the best available computational physics models for the transport of radiation through matter. Geant4 is a library of c++ routines for describing radiation interaction with matter assembled by a large and diverse international collaboration. Generally, MRED is structured so that all physics relevant for radiation effects applications are available and selectable at run time.

The underlying physical mechanisms for Single Event Effect (SEE) response are: 1) ionizing radiation-induced energy deposition within the device, 2) initial electron-hole pair generation 3) the transport of the charge carriers through the semiconductor device and 4) the response of the device and circuit to the electron-hole pair distribution and subsequent transport. Each of these occur on a different time scale and they are often assumed to be sequential, i.e., energy deposition determines the initial electron-hole pair generation, which in-turn impacts device and circuit response. In this discuss the current application of MRED that are intended to address emerging technology issues as they relate to the mechanisms listed above.

Plenary session VII - Accelerator simulation - / 9

Geant4 Simulation of Dynamitron Beam Uniformity and Energy Distribution

Author: Danielle Hohreiter[1]

[1] *Jet Propulsion Lab - California Institute of Technology*

Corresponding Author: danielle.l.hensen@jpl.nasa.gov

The Dynamitron is a ~MeV electron beam accelerator at the Jet Propulsion Laboratory. A calibration of the machine was required after a retrofitting. Simulations using Geant4, detailing the electron particle accelerator, have been performed. Geant4 was used to determine beam uniformity and energy distribution at the target plate after passing through various scattering foils made of aluminum, titanium or copper with thicknesses ranging from 1-5mils. The model included a 0.4 inch diameter circular electron beam with different scattering foils placed in front of the beam tube window, 32.5 inches in front of the target plate. It implemented the 'Standard' EM physics model with initial beam energies of 1-2 MeV. The energy measurements were used for machine energy calibration tests and the beam uniformity was compared to measured results.

Plenary Session IX - General - / 10

Symmetric branches of Geant4: How the medical and aerospace user communities bring common issues and solutions to the simulation toolkit

Author: Joseph Perl[1]

[1] *SLAC*

Corresponding Author: perl@slac.stanford.edu

Geant4 has long moved beyond its original problem domain of High Energy Physics. Similarities in the user requirements of the aerospace and the medical communities have brought valuable new features to both domains. From the aerospace community, advances such as the Geant4 General Particle Source and improved CAD to GDML geometry pathways have found users in radiation therapy. From the medical community, advances such as simplified scoring and new volume rendering tools have found users in aerospace. Common interests in lower-than-HEP energies and smaller-than-HEP distance scales enable additional valuable synergy. Beyond the technical issues of this fruitful symmetry, there are also sociological issues, ways in which aerospace and medical collaborations have much in common with each other but not so much in common, and hence different needs from, the HEP community where Geant4 began.

Plenary session IV - Space radiation environment - / 11

The Radiation Environment from Galactic Cosmic Rays in a Lunar Habitat

Author: Zi-Wei Lin[1]

Co-author: Yingcui Jia [1]

[1] *East Carolina University*

Corresponding Author: linz@ecu.edu

We have calculated how the radiation environment in a habitat on the surface of the Moon depends on the thickness of a habitat in the 1977 galactic cosmic-ray environment. Geant4.9.1 was used, and a hemispherical dome made of lunar regolith was used to simulate the lunar habitat. We have investigated the effective dose from both primary and secondary particles. The total effective dose showed a strong decrease with the habitat thickness. However, the effective dose values from secondary neutrons, charged pions, photons, electrons and positrons all showed a strong increase followed by a gradual decrease with the habitat thickness. The fraction of the summed effective dose from these secondary particles in the total effective dose increased with the habitat thickness, from about 5% for the no-habitat case to about 47% for the habitat with a thickness of 100 g/cm2. This work has

been published as Radiat.
Res. 173, 238–244 (2010).

Plenary session III - Aparatus simulation - / 12

SIXS module Dose Mapping and X-ray Detector - Bepicolombo mission

Author: Francisco Garcia[1]

Co-authors: Hans Andersson [2]; Juhani Huovelin [3]; Kukka Banzuzi [2]; Matias Roos [2]

[1] *Helsinki Institute of Physics*

[2] *Oxford Instrument Analytical Oy*

[3] *Observatory, University of Helsinki*

Corresponding Author: francisco.garcia@helsinki.fi

BepiColombo is European Space Agency's (ESA) mission to Mercury. It has been named after the Italian mathematician and engineer Giuseppe (Bepi) Colombo, known especially for his works on Mercury. The spacecraft will set off in 2013 on a journey lasting about six years.

One of the scientific instruments onboard the mission will be SIXS, Solar Intensity X-ray and particle Spectrometer. It is developed in a Finnish consortium headed by the Observatory of the University of Helsinki. The Sensor Unit of SIXS consists of two parts: an X-ray detector and a particle detector for protons and electrons. The X-ray part consists of three Silicon sensors, one of which will always see the sun. The particle detector package consists of a core sensor (CsI scintillator with a photodiode) surrounded by five thin Si surface sensors. The particle sensors are covered by a collimator.

Since SIXS measures the X-ray and particle fluxes coming from the Sun, its data are vital for the calibration of the MIXS (Mercury Imaging X-ray Spectrometer) instrument, which measures the X-ray fluorescence radiation coming from the surface of Mercury.
The Geometry description has been directly imported from SolidWrorks CAD models and then the Fastrad has been used to obtain the GDML files, which can be parsed to the Sector Shielding Analysis Tool (SSAT). In this presentation the results obtained using SSAT will be discussed.

Plenary session III - Aparatus simulation - / 13

Use of Geant4 simulations in understanding LRO/CRaTER observations

Author: Mark Looper[1]

Co-authors: Anthony Case [2]; Harlan Spence [3]; J. Bernard Blake [1]; Joseph Mazur [1]; Michael Golightly [3]

[1] *The Aerospace Corporation*

[2] *Boston University*

[3] *University of New Hampshire*

Corresponding Author: mark.d.looper@aero.org

The Cosmic Ray Telescope for the Effects of Radiation (CRaTER) has been in orbit around the moon aboard NASA's Lunar Reconnaissance Orbiter (LRO) for over a year. The purpose of CRaTER is to measure the radiation environment that will be experienced, in particular, by astronauts on and near the lunar surface; to that end, CRaTER consists of a stack of six silicon solid state detectors arranged in three pairs, with two large blocks of Tissue-Equivalent Plastic between pairs to represent

the shielding provided by the human body. The data we have collected to date are complex; in comparison with a simple stack of active elements observing cosmic radiation in free space, we see effects from the large volume of inert material between active elements, from albedo particles produced by cosmic-ray impacts on the nearby (50 km nominal altitude) lunar surface, and from cosmic-ray albedo particles produced on the LRO spacecraft itself. Understanding the observations has required extensive Geant4 modeling of the response of the sensor to many kinds of particles and of the lunar and spacecraft albedo environment. We will show how these modeling efforts have come together to help us understand the details of our observations to date.

Plenary session III - Aparatus simulation - / 14

The highly miniaturised radiation monitor

Author: Edward Mitchell[1]

[1] *Imperial College*

Corresponding Author: em909@ic.ac.uk

The highly miniaturised radiation monitor (HMRM) is a simple particle detector being developed for wide application on satellites in a broad range of orbits. The HMRM is a collaborative effort between the STFC Rutherford Appleton Laboratory and Imperial College London, aimed at addressing ESA's radiation monitoring strategy in the category of small, versatile, devices intended for alert and safeing functions and for support to platform and payload systems.

The HMRM uses an arrangement of silicon active pixel sensors to detect and identify electrons with energy 0.05 – 6.0 MeV and protons with energy 1.3 – 300 MeV. Individual particles are identified within the monitor, in real time, by measurement of the energy deposits in the sensor array. Species-specific dose measurements and particle energy spectra are produced, allowing in-flight assessment of danger to spacecraft operation and instrumentation posed by the radiation environment.

The low energy detection thresholds, together with the small volume and mass are potentially a significant improvement on existing radiation monitors.

We will present the methodology and GEANT4 simulations which were used to guide the HMRM design process and discuss its simulated performance in reconstructing realistic particle fluxes.

Plenary session VI - Geant4 developer's report - / 15

Updates and Perspectives of Geant4 Hadronic Physics for Space Applications

Author: Dennis Wright[1]

[1] *SLAC*

Corresponding Author: dwright@slac.stanford.edu

During the last few years, effort within the Geant4 hadronic working group has focused mainly on the expected needs of the LHC detector simulations. Thus, many improvements in hadronic models in the GeV to TeV range have been made. These will be covered briefly, as they are of interest to the cosmic ray community, but most of this presentation will deal with advances more closely related to the areas of radiation damage and space environment. These are in models which apply to the sub-GeV region, such as the precompound/de-excitation, high precision neutron, cascade and nucleus-nucleus models.

We will also discuss the extensive hadronic validation effort which includes a larger, more user-friendly validation suite, results from the IAEA cross-code comparison project, SATIF10, and some test-beam comparisons.

Finally we discuss plans for model and cross section improvement for the coming year.

Plenary session VII - Accelerator simulation - / 16

e-LINAC Beam Facility Characterization For Its Use For Space Detectors Performance Studies

Authors: Behcet Alpat[1]; Ercan Pilicer[1]

Co-authors: Diego Caraffini [2]; Eduardo Buono [3]; Francesca Renzi [2]; Leonello Servoli [1]; Marco Italiani [3]; Mauro Menichelli [1]

[1] *INFN Perugia*

[2] *Maprad SRL*

[3] *Terni Hospital*

Corresponding Author: ercan.pilicer@pg.infn.it

The aim of this work is to qualify and characterize beam of an electron LINAC of St. Maria Hospital which is located in Terni, Italy. The facility, of which its primary use is radiotherapy, will be used to test the performance of detector systems in particular those designed to operate in space (i.e. for European Space Agency based projects). The critical beam parameters are electron energy, profile and flux available at the surface of device to be tested. The present work consists in full simulation of the electron LINAC machine with changing parameters such as physics, particle production thresholds and step sizes. The energy range of electrons vary between 4 MeV and 20 MeV. The dose measurements have been performed by using an Advanced Markus Chamber which has a small sensitive volume, while the beam profile and flux are being measured by a double sided silicon micro-strip detector. A technique to convert the measured dosimetry values to beam energy and its validation with silicon detector data is also discussed.

Plenary session VI - Geant4 developer's report - / 17

Updates to Bertini Cascade

Author: Michael Kelsey[1]

Co-author: Dennis Wright [1]

[1] *SLAC National Accelerator Laboratory*

Corresponding Author: kelsey@slac.stanford.edu

Starting in January 2010, substantial modifications have been made to the Bertini Cascade code. Primarily internal software updates and class refactoring, the changes include improvements to the internal physics processes (cross sections, final states, and angular distributions, respect for conservation laws, and a dramatic reduction in the memory "churn" attributed to the Bertini cascade. After an introduction to the Bertini model, a discussion of the improvements will cover the various functional areas, and performance monitoring results will be shown.

Plenary session VIII - Semiconductor simulation - / 18

Creme: A new website providing advanced tools for modeling radiation-induced energy deposition

Author: Marcus Mendenhall[1]

Co-authors: Brian Sierawski [2]; Robert Reed [1]; Robert Weller [1]

[1] *Vanderbilt University EECS/ISDE*

[2] *Vanderbilt University ISDE*

Corresponding Author: marcus.h.mendenhall@vanderbilt.edu

Vanderbilt University is rolling out a new website, http://creme.isde.vanderbilt.edu, which provides access to an array of tools for modeling radiation-induced energy deposition in semiconductors. The site provides access to the creme86 and creme96 models, having taken over creme96 from the NRL website, which has been retired. The site so provides access to a new tool, creme-mc, which is a Geant4-based Monte-Carlo tool for modeling effects in smaller geometries and under other conditions than those for which creme96 is valid.

The presentation will provide a live demonstration of the capabilities of the site, along with time for user input and discussion about what features might be most useful in the future.

Plenary session II - General status report and aparatus simulation - / 19

Status of ESA Geant4 R&D activities

Author: Petteri Nieminen[1]

Co-author: Giovanni Santin [1]

[1] *ESA/ESTEC*

Corresponding Author: petteri.nieminen@esa.int

The European Space Agency (ESA) is currently supporting a number of R&D projects where the Geant4 software is either used or further developed. These include activities for radiobiology in the human spaceflight and exploration context; electron radiation effects and analysis software for Navigation constellation orbits; radiation effects analysis framework development for ESA Cosmic Vision science missions; and enhancement of generic capabilities for component microdosimetry and Single Event Effects analyses. In this presentation, an overview of these developments and future ESA Geant4 plans is given.

Plenary session IV - Space radiation environment - / 20

Background Simulations of the Wide Field Imager aboard the International X-ray Observatory

Author: Hauf Steffen[1]

Co-authors: Alexander Stefanescu [2]; Chris Tenzer [3]; Dieter H.H. Hoffmann [1]; Eckard Kendziorra [3]; Georg Weidenspointner [4]; Lothar Strueder [4]; Maria Grazia Pia [5]; Markus Kuster [6]; Philipp-M. Lang [1]

[1] *TU Darmstadt, Darmstadt*

[2] *MPI Halbleiterlabor, Munich, Johannes Gutenberg Universty, Mainz*

[3] *IAA Tuebingen, Tuebingen*

[4] *MPI Halbleiterlabor, Munich*

[5] *INFN Genova, Genova*

[6] *XFEL, Hamburg*

Corresponding Author: hauf@astropp.physik.tu-darmstadt.de

The International X-ray Observatory (IXO) is a planned high sensity next-generation X-ray telescope, jointly built by ESA, NASA and JAXA, which is projected to be launched in the 2020 timeframe. The main scientific goals of IXO include the study of AGN, the diffuse x-ray background as well as accretion discs around black holes and neutron stars which will aid the understanding of cosmic evolution and the physics of matter under extreme conditions. In order to achieve these goals IXO will need to surpass currently flighing or operating x-ray missions by at least an order of magnitude in terms of sensitivity while simultaneously extending the energy range for imaging observations up to 40 keV.

One of the main instruments aboard IXO will be the Wide Field Imager (WFI), which will employ DePFET technology for high resolution spectral imaging (1 arcsec, energy resolution of < 150 eV (FWHM) at 6 keV) in the 0.1-15 keV energy range, while at the same time achieving the low background rate of approx. 10E-4 cts/cm²/s/keV required for high sensitivity observations of faint sources.

A prerequiste for these low background rates is an optimized shielding concept which makes use of a graded-Z shield. As is common for many new satellite projects the Geant4 Monte Carlo tool kit was used for simulating the expected particle and background flux and optimizing shielding and other background reduction measures.

We present our current estimates of the IXO WFI cosmic proton induced background as well as an analysis of its constituents. We also present our current shielding design and background reducing postprocessing algorithms. Finally we point out problems within the simulation which have come to our attention while modelling a realistic WFI entrance window, which requires an accurate treatment of particle and photon interactions in material layers with a thickness of a few nanometers.

Plenary session VI - Geant4 developer's report - / 21

Reverse Monte Carlo in Geant4 and in GRAS

Author: Laurent Desorgher[1]

Co-authors: Fan Lei [2]; Giovanni Santin [3]; Makoto Asai [4]; Petteri Nieminen [3]

[1] *SapceIT GmbH*

[2] *QinetiQ*

[3] *ESTEC*

[4] *SLAC*

Corresponding Author: desorgher@spaceit.ch

The Monte Carlo (MC) method is very accurate for simulating the interaction of radiations with complex geometries. However MC simulations need most of the time a lot of computing power before reaching the expected precision of the simulation results. This represents an important drawbacks of the RMC method when it is used in engineering tool, as for example Spenvis,

where the time available for of a computation is rather limited. However different Monte Carlo biasing techniques can be used to reduce the computing time.

When the sensitive part of a geometry is small compared to its entire size and to the size of the source, a lot of computing time is spent in the simulation of particle showers that are not contributing to the computed signal.
This is typically the case in radiation simulation for space where only the effects of radiation on some specific components of the geometry have to be known.
In such case the Reverse Monte Carlo(RMC) biasing method, also known as the Adjoint Monte Carlo method, can be used.
In this method particles are generated in the sensitive volume of the instrument and then are tracked backward in the geometry till they reach the source surface, or exceed an energy threshold. By this way the computing time is limited to particle tracks reaching the sensitive part of the geometry and the simulation is much faster.

Within different projects, sponsored by the european space agency (ESA), we have implemented the RMC method in Geant4 for e-, proton and ion electromagnetic physics. The different reverse processes that are at the moment available in Geant4 are the reverse e-, ion, and proton ionization , the multiple scattering, the e- bremsstrahlung, the photo-electric effect, and the Compton scattering. Since the Geant4.9.3 realease the ReverseMC1 extended biasing example is available to illustrate the modification needed to a Geant4 application to use the Reverse MC mode. Recently we have extended the ESA GRAS tool in order to use the Geant4 Reverse Monte Carlo capability.
In this paper we will report on the status of our different Geant4 and GRAS RMC developments. We will illustrate how to use the Reverse Monte Carlo mode in a Geant4 application, by describing the ReverseMC01 G4 extended example, and in GRAS by describing a GRAS RMC application case. Comparison of results obtained with forward and reverse simulations will be also presented.

Plenary session IV - Space radiation environment - / 22

Geant4 modeling of radiation exposure in ultra-long-haul flights: a proposal

Author: SEBASTIEN INCERTI[1]

Co-author: LAURENT DESORGHER [2]

[1] *CNRS/IN2P3*

[2] *SPACEIT, Switzerland*

Corresponding Author: incerti@cenbg.in2p3.fr

A few commercial airlines now operate ultra-long-haul flights from Asia to America. Recent concerns have been raised related to the dose exposure of crews on these high latitude routes which fly close to the North Pole. We present in this talk a proposal to model with Geant4 the radiation environment encountered in such ultra-long-haul flights. This includes the modeling of the interaction of galactic and solar cosmic rays with the Earth's magnetosphere and atmosphere and the interaction of the resulting flux of secondary radiation with the aircraft itself. In order to perform this study technical information from commercial aircraft manufacturers would be required.

Plenary session III - Aparatus simulation - / 23

Physics models for the simulation of biological effects of radiation and shielding with the Geant4 toolkit: the ESA AO6041 project

Author: SEBASTIEN INCERTI[1]

Co-author: - The ESA AO6041 team [2]

[1] *CNRS/IN2P3*

[2] -

Corresponding Author: incerti@cenbg.in2p3.fr

The European Space Agency is supporting the extension of the Geant4 general purpose Monte Carlo simulation toolkit for the modeling of biological effects of radiation at the DNA and cellular scales for space applications, in the framework of the ESA AO6041 project. In this talk, we will describe the context of this research project and overview on-going developments. These developments include new Geant4 Physics and Chemistry processes and models as well as the simulation of the radiation environment aboard the International Space Station, following the outcome of the ESA DESIRE project. The preparation of an irradiation campaign of biochip samples aboard the ISS for the search of traces of life in the Solar System (exobiology) will also be presented.

Plenary Session IX - General - / 24

Organizing and Implementing Efficient Geometry Strategies for Geant4

Author: B. Charles Rasco[1]

[1] *Smarter Than You Software, JIHIR, ORNL*

Corresponding Author: charlie@smarterthanyou.com

Various approaches to organizing different geometries for efficient calculations will be discussed. Implementation details include ways to organize a large hierarchy of voxels in a binary tree like organization and simple placement rules of various logical volumes inside a mother logical volume. Specific results emphasize optical photon tracking, but the results are applicable to other simulations. All examples are from large scale scintillation detector arrays with optical photon tracking such as the MTAS (Modular Total Absorption Spectrometer) and LENS (Low Energy Neutrino Spectrometer).

Plenary Session IX - General - / 25

slic & lcdd: A Detector Response Simulation Program

Author: Norman Graf[1]

[1] *SLAC*

Corresponding Author: norman.graf@slac.stanford.edu

As the complexity and resolution of particle detectors increases, the need for detailed simulation of the experimental setup also increases. Designing experiments requires efficient tools to simulate detector response and optimize the cost-benefit ratio for design options. We have developed efficient and flexible tools for detailed physics and detector response simulation which builds on the power of the Geant4 toolkit but frees the end user from any C++ coding. The primary goal has been to develop a simulation program and I/O formats to allow physicists from universities and labs to quickly and easily contribute to detector design without requiring either coding expertise or experience with Geant4.

We have developed the Geant4-based detector simulation program, slic, which employs generic I/O formats as well as a textual detector description. Extending the pure geometric capabilities of GDML, LCDD enables fields, regions, sensitive detector readout elements, etc. to be fully described at runtime using an xml file. We provide executable programs for Windows, Mac OSX and Linux.

Plenary session V - Geant4 developer's report - / 26

Geometry: Current Status and Plans

Author: Norman Graf[1]

[1] *SLAC*

Corresponding Author: norman.graf@slac.stanford.edu

We present an update on the status of the Geant4 Geometry system as currently implemented in version 9.3 and current plans for features to become available in the next release.

Plenary session VI - Geant4 developer's report - / 27

Recent development of nuclues nucleus and low energy neutron interactions in Geant4

Author: Tatsumi Koi[1]

[1] *SLAC National Accelerator Laboratory*

Corresponding Author: tkoi@slac.stanford.edu

Radiation environment in a spacecraft is very complicated. A variety of high energy nucleus exists in cosmic rays. Some of them interacts with nucleus in the spacecraft and produces many secondary particles including neutrons. Therefore both nucleus-nucleus and neutron-nucleus interactions are important for the assessment of radiational damage of the devices flown on a spacecraft. Recent development of QMD model of Geant4 will be presented , especially an improvement on high energy

interactions. I also give a status report of development of a new low energy neutron transportation codes.

Plenary session V - Geant4 developer's report - / 28

General updates and perspectives

Author: Makoto ASAI[1]

[1] *SLAC*

Corresponding Author: asai@slac.stanford.edu

We introduce new features offered in Geant4 version 9.3 and also foreseen new features in version 9.4. This is a general overview which mainly covers functionality which won't be detailed in the following Geant4 developer talks. Also, perspective view of future Geant4 will be discussed.

Plenary session V - Geant4 developer's report - / 29

Overview of Geant4 electromagnetic physics developments

Author: SEBASTIEN INCERTI[1]

Co-authors: - Low energy EM Physics working group [2]; - Standard EM Physics working group [2]; VLADIMIR IVANTCHENKO [3]

[1] *CNRS/IN2P3*

[2] *Geant4 collaboration*

[3] *CERN, Ecoanalytica MSU, G4AI, Metz. U.*

Corresponding Author: incerti@cenbg.in2p3.fr

In this talk, the "standard" and the "low energy" electromagnetic Physics working groups of the Geant4 collaboration will present an overview of recent electromagnetic Physics developments.

Plenary session II - General status report and aparatus simulation - / 30

Geant4 simulation of the Low Earth Orbit radiation environment on the NHXM prompt X-ray background

Author: Valentina Fioretti[1]

Co-authors: Andrea Argan [2]; Andrea Bulgarelli [3]; Fulvio Gianotti [3]; Gianpiero Tagliaferri [4]; Giorgio Palumbo [5]; Giuseppe Malaguti [3]; Massimo Trifoglio [3]; Sandro Mereghetti [6]; Valentina Bianchin [3]

[1] *INAF/IASF - Bologna*

[2] *INAF/Headquarters*

[3] *INAF/IASF Bologna*

[4] *INAF/OAB*

[5] *University of Bologna - Astronomy Department*

[6] *INAF/IASF Milano*

Corresponding Author: fioretti@iasfbo.inaf.it

The X-ray background minimization is a science-driven necessity in order to reach deep sensitivity levels, which is one of the key scientific requirements for the New Hard X-ray Mission. As a first, fundamental step in the background evaluation, we developed a Geant4-based simulator that allows to evaluate the impact of the Low Earth Orbit radiation environment on the prompt background count rate. The Geant4 model is composed by an hybrid focal plane completely surrounded by a simplified passive and active shield.
The trapped electrons and positrons result to be the major source of background and active shield count rate. The total prompt background level, without the triggered events, is 1.5 x 10^-4 and 3.8 x 10^-4 cts cm^-2 s^-1 keV^-1 in the 0.5-20 keV and 5-100 keV energy range, respectively. They are mainly produced by photonic (>60%) and electronic (>20%) interactions.

Plenary Session IX - General - / 31

Towards High-Fidelity Simulations of Radiation Effects in Complex Systems

Author: Ashok Raman[1]

Co-authors: Alex Fedoseyev [1]; Marek Turowski [1]; Robert Arslanbekov [1]

[1] *CFD Research Corporation (CFDRC)*

Corresponding Author: ar2@cfdrc.com

Scientific evidence increasingly indicates that using an average approach (e.g. Linear Energy Transfer or LET) to approximate the energy deposition process due to a radiation event such as a heavy ion strike, is inadequate and/or erroneous. It is important to capture the complex microstructure of the energy deposition, and consequent charged species generation profile, to accurately model the system response in the spatial and temporal scales.

This paper primarily focuses on high-fidelity, three-dimensional (3D) simulations of radiation effects in modern, deep submicron electronic devices and circuits. We perform these simulations using an in-house, advanced, Technology Computer Aided Design (TCAD) solver called NanoTCAD. Recently, this solver has been enhanced with an interface to an external Monte Carlo (Geant4) based code to receive inputs of complex energy deposition microstructure (multi-track), efficiently filter in only the high energy tracks of interest, and perform adaptive mesh generation in an automated manner, to enable full-3D simulations of charge transport and resulting device response. NanoTCAD's overall capabilities have been further enhanced by means of a coupling with the Cadence Spectre circuit/system solver that permits the direct use of "as-designed" layouts and circuits and foundry process design kits (PDKs) in a mixed-mode manner (3D TCAD + external circuit netlist), to calculate the radiation response of real-world circuits. With appropriate enhancements to device physics and circuit compact models, these simulation tools have been utilized to characterize radiation effects in extreme (e.g., space) environment electronics.

Accurate analysis of the response of biological systems, such as cells and tissues, to incident high-energy radiation continues to be an important area of research in the scientific community. A related multi-scale computational framework developed for studies of the origin and progression of primary (bio-mechanical) and secondary (complex physico-chemical) injury mechanisms, will be briefly presented. The objective is to adapt current understanding of radiation events, and simulation capabilities from other related areas, to calculations of radiation response of biological systems.

Plenary session I - Opening address and general status report - / 32

Opening address

Corresponding Author: mark.o.anderson@boeing.com

Plenary session I - Opening address and general status report - / 33

JAXA activities

Corresponding Author: ozaki@astro.isas.jaxa.jp

Plenary session II - General status report and aparatus simulation - / 35

INTA activities

Corresponding Author: ibarmiahsa@inta.es

Plenary session II - General status report and aparatus simulation - / 36

discussion

Plenary session III - Aparatus simulation - / 37

discussion

Plenary session IV - Space radiation environment - / 39

discussion

Plenary session VII - Accelerator simulation - / 40

Overview of NASA/JPL activities

Author: Insoo Jun[1]

[1] *JPL*

Corresponding Author: insoo.jun@jpl.nasa.gov

Plenary session VII - Accelerator simulation - / 41

discussion

Plenary session VIII - Semiconductor simulation - / 42

CREME-MC demo

Author: Marcus Mendenhall[1]

[1] *Vanderbilt University EECS/ISDE*

Corresponding Author: marcus.h.mendenhall@vanderbilt.edu

Demonstrated CREME-MC Web page is here.

Plenary session VIII - Semiconductor simulation - / 43

discussion

Plenary Session IX - General - / 44

discussion

Plenary session X - Geant4 Technical Forum and general discussion - / 45

Geant4 Technical Forum and general discussion