Workshop Program

International Multidisciplinary Workshop on Geant4

June 15th – 16th, 2017
Ton Duc Thang University, Ho Chi Minh City, Vietnam

Committee

Worshop Chairs:

Dr. Sebastien Incerti	CNRS, France, and Ton Duc Thang University, Vietnam (co-chair)
Dr. Tran Ngoc Hoang	Ton Duc Thang University, Vietnam and CEA-Saclay, France (co-chair)
Dr. Pham Quang Trung	108 Military Central Hospital, Hanoi, Vietnam (co-chair)

Keynote Speakers:

Dr. Dousatsu Sakata	University of Bordeaux, France
Dr. Sebastien Incerti	CNRS, France, and Ton Duc Thang University, Vietnam
Dr. Tran Ngoc Hoang	Ton Duc Thang University, Vietnam and CEA-Saclay, France

Organizing Committee:

Dr. Sebastien Incerti	CNRS, France, and Ton Duc Thang University, Vietnam
Dr. Tran Ngoc Hoang	Ton Duc Thang University, Vietnam and CEA-Saclay, France
Dr. Pham Quang Trung	108 Military Central Hospital, Hanoi, Vietnam

Local organizer

Dr. Le Van Ut	Ton Duc Thang University, Vietnam
Mr. Ha Trong Nghia	Ton Duc Thang University, Vietnam
Mr. Tran Tien Quang	Ton Duc Thang University, Vietnam

Preface

Dear Worshop Participants

Welcome to the **International Multidisciplinary Workshop on Geant4**, occurring on June 15th – 16th, 2017 at Ton Duc Thang University, Ho Chi Minh City, Vietnam.

This international workshop aims at bringing together for the first time in Vietnam professors, researchers and scholars from around the globe in order to present and discuss various simulation applications of the Geant4 toolkit (http://geant4.org), not only in particle physics and nuclear physics, but also in interdisciplinary sciences (such as medical physics, radiobiology, space sciences...), where there is a strong need for Monte Carlo simulations of particle-matter interactions. Validation activities will be presented as well.

Initiatives from Vietnam will be strongly encouraged and we also expect to attract participants from neighboring countries in Asia, where Geant4 activities are emerging. We are grateful to the prominent scientists from prestigious institutions who have accepted to serve in the workshop scientific committee. In addition, one keynote speaker will present new Geant4 related applications in nanomedicine.

We express our gratitude to all the members of the Programm and Organizing Committees, and to volunteers who have worked diligently to prepare the workshop. We would also like to thank our keynote speaker and chairs of sessions. We hope that this first **International Multidisciplinary Workshop on Geant4** in Vietnam will be successful and enjoyable to all participants.

Chairs

Dr Sebastien Incerti	CNRS, France, and Ton Duc Thang University, Vietnam
Dr Tran Ngoc Hoang	Ton Duc Thang University, Vietnam and CEA-Saclay, France
Dr Pham Quang Trung	108 Military Central Hospital, Hanoi, Vietnam

Workshop Information

I. Location:

Campus Tan Phong - Ton Duc Thang University
No. 19, Nguyen Huu Tho St., Tan Phong Ward, District 7, Ho Chi Minh City, Vietnam.

II. Reception Desk:

The reception desk is located on the First Floor, Room A101 – Building A and opens from 8:00 to 17:30 from June 15th – 16th, 2017.

III. Language

All sessions will be presented in English.

IV. Badges

Admittance to the venue is restricted to participants wearing their name badges. The wearing of badges is compulsory both inside the venue and at all events organized with its context.

V. Worshop Room's Location

Worshop will be held in room **A101 of Building A**.

VI. Worshop Room's Equipment

Worshop room will be equipped with an overhead projector and a notebook computer.

VII. Rules of Procedure for Meeting

Talks will last 30 minutes, including 5 minutes for questions. Session chair will inform each speaker 5 minutes in advance before the end of the allocated talk. Participants are requested to bring a copy of their slides in PowerPoint and PDF formats. These slides will not be put on the workshop website.

VIII. Transportation

- Tan Son Nhat International Airport ⇔ Ton Duc Thang University (TDTU)
  - ✓ BUS: Take No. 152 air-con airport bus to Ben Thanh Market and then take bus No. 86 to Ton Duc Thang University.
    - Time required: 60 minutes;
    - Working Time: 06:00 ~ 18:30, Running Frequency: Every 30 minutes
    - Ticket price is 5.000 VND (approx. US$ 0.25)
    - Terminal stop - Ben Thanh Market (city center, bus 152), Ben Thanh market - Ton Duc Thang University (bus 86)
  - ✓ TAXI: It takes about US$ 15-20, and about 30 minutes to arrive at Ton Duc Thang University.

IX. Parking

Participants with the Worshop invitation can park their cars at campus parking lots.

X. Contact

Dr. Tran Ngoc Hoang
Email: tranngochoang@tdt.edu.vn

Worshop Venue

Ton Duc Thang University
No. 19, Nguyen Huu Tho Street, Tan Phong Ward, District 7, Ho Chi Minh City
Telephone: (84-8) 37 755 035

TON DUC THANG UNIVERSITY
"For accomplishment in human development and a society with sustainable, stable growth"

Ton Duc Thang University (TDTU) is a public and autonomous university. Established in 1997, it is situated in the center of Ho Chi Minh City - the commercial hub of Vietnam. The university has five campuses, in Ho Chi Minh City (two campuses), Nha Trang City, Lam Dong Province and Ca Mau Province. The main campus is located in an area of 11,000 m^2 in Tan Phong Ward, District 7, Ho Chi Minh City, Vietnam.

TDTU is a young and dynamic provider in the higher education sector and is one of the largest universities in Vietnam. The university is committed to Vietnam's sustainable development of human resources. It strives to be a leading research-oriented university regionally and internationally.

The university has been fostering a unique culture which distinguishes itself from the others. Aiming to provide optimal opportunities for quality education, the university is devoted to the promotion of students' learning and research activities. All aspects of the university strive to constantly maintain an effective and efficient academic community for talents to be developed.

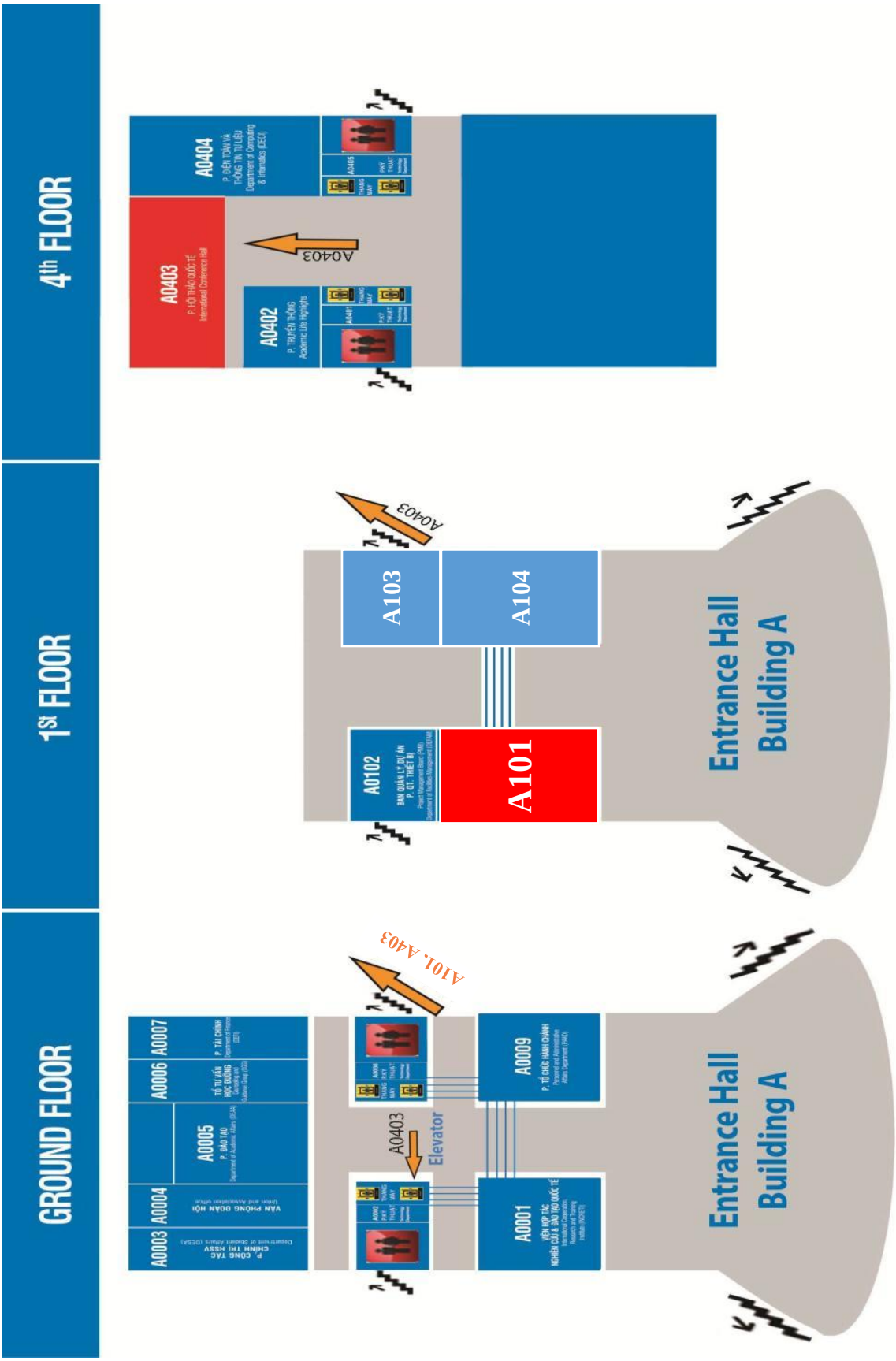
After nearly 20 years of development, TDTU has become one of the fastest growing universities in the country. Currently, the university has 16 faculties, 12 centers for technology applications, 2

institutes, 1 foundation for science and technology, and several laboratories. The university offers over 60 programs at the vocational, undergraduate and postgraduate levels. There are approximately 22,000 students pursuing their study at the university.

Equipped for more than just studying, TDTU also provides facilities for post-study workouts. The main campus affords a sport complex in which lots of indoor games such as badminton, tennis, volleyball, basketball and many other activities can be played. Furthermore, there is a swimming pool and a FIFA 2-star football stadium. There are two fully equipped dormitories which can accommodate up to 2,160 students.

TDTU considers the connection with international partners through strategic cooperation as an important prerequisite for its sustainable development. Thus, more and more research projects have been initiated, established and conducted in the university with the leadership of internationally recognized experts. The partnerships with nearly 60 universities from different parts of the world also allow the university to exchange students, staffs and training collaborations.

As a young and vibrant institution with numerous learning pathways for students internationally and diversified opportunities for academic development, TDTU is committed to being the best choice of students, academic staffs, researchers and all stakeholders.


4th FLOOR
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Elevator
A0009
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A0003
Entrance Hall
Building A

AGENDA

1st day (Room A101) Thursday, June 15th, 2017

Tutorial 1 **09:00-10:30**	**Geant4 introduction and basic structure of an application** **Example hands-on**	**Dr. TRAN Ngoc Hoang** Ton Duc Thang University, Vietnam and CEA-Saclay, France
Break (10:30-10:45)		
Tutorial 2 **10:45 – 12:15**	**Hadronic process in Geant4** **Example hands-on**	**Dr. TRAN Ngoc Hoang** Ton Duc Thang University, Vietnam and CEA-Saclay, France
Lunch (12:15-14:00)		
Tutorial 3 **14:00 – 15:30**	**Electromagnetic process (standard)** **Example hands-on**	**Dr. PHAM Quang Trung** Center of Oncology and Nuclear Medicine 108 Military Central Hospital, Hanoi, Vietnam
Break (15:30-15:45)		
Tutorial 4 **15:45- 17:00**	**Electromagnetic process (low energy and Geant4-DNA)** **Example hands-on**	**Dr. PHAM Quang Trung** Center of Oncology and Nuclear Medicine 108 Military Central Hospital, Hanoi, Vietnam

2nd day (Room A101) Friday, June 16th, 2017

Session 1 (09:00 - 10:40)		
09:00 - 09:10	**Welcome**	**Prof. NGUYEN Thoi Trung** Vice-President Ton Duc Thang University, Vietnam **Dr. INCERTI Sebastien** CNRS, France and Ton Duc Thang University, Vietnam **Dr. TRAN Ngoc Hoang** Ton Duc Thang University, Vietnam and CEA-Saclay, France

		Dr. PHAM Quang Trung Center of Oncology and Nuclear Medicine 108 Military Central Hospital, Hanoi, Vietnam
9:10 – 09:40	**Overview of the Geant4-DNA project**	**Dr. INCERTI Sebastien** CNRS, France and Ton Duc Thang University, Vietnam
09:40 – 10:10	**Implementation of EM physics for nano scale gold electron simulations**	**Dr. SAKATA Dousatsu** University of Bordeaux, France
10:10 – 10:40	**Inelastic mean free path and stopping power of electron and proton in liquid water**	**Dr. NGUYEN Truong Thanh Hieu** Ton Duc Thang University, Vietnam
Break (10:40 - 11:00)		
Session 2 (11:00 - 12:30)		
11:00 – 11:30	**Integration and validation of the new Geant4-DNA physics models into the GATE simulation platform**	**Ms. NGUYEN THI MAI Huong** Danang Cancer Hospital, Vietnam
11:30 – 12:00	**Comparison of number SSB and DSB of DNA irradiated by FF and FFF photon beams (TrueBeam) by using Monte-Carlo Simulation**	**Mr. PHAM Hong Lam** Center of Oncology and Nuclear Medicine 108 Military Central Hospital, Hanoi, Vietnam
12:00 – 12:30	**Development of a compact thermal neutron source based on high-intensity proton beams of energy less than 20 MeV**	**Dr. TRAN Ngoc Hoang** Ton Duc Thang University, Vietnam and CEA-Saclay, France
Lunch (12:30 - 14:00)		
Session 3 (14:00 - 15:30)		
14:00 – 14:30	**Applications of Geant4 Simulations at the PBP-CMU Linac Laboratory**	**Mr. SUKARA Supasin** Chiang Mai University, Thailand
14:30 – 15:00	**Research Activities at the PBP-CMU Linac Laboratory and Potential GEANT4 Applications at Chiang Mai University**	**Dr. RIMJAEM Sakhorn** Department of Physics and Materials Science, Faculty of Science Chiang Mai University, Thailand
15:00 – 16:00	**Brainstorming**	

Keynote Speakers

Dr. Sebastien Incerti
Research director of CNRS
Visiting Researcher at Ton Duc Tang University
Geant4-DNA coordinator
Geant4 low energy electromgnetic physics coordinator

Keynote Talk
Friday June 16th, 9:10

Talk title: Overview of the Geant4-DNA project

Biography
Dr. Sebastien Incerti is a senior CNRS researcher, France, coordinating since 2008 the low energy electromagnetic Physics developments of the Geant4 toolkit, as well as the Geant4-DNA collaboration. He is also collaborating with the Division of Nuclear Physics of Ton Duc Thang University. His research activities are focused on the investigation of biological effects of ionizing radiation in a variety of application domains, including radiobiology, medical physics and space science.

Dr. Dousatsu Sakata
Post-doctoral fellow at Bordeaux University in France
Geant4-DNA collaborator

Keynote Talk
Friday June 16th, 09:40

Talk title: Implementation of EM physics for nano scale gold electron simulations

Biography
Dr. Dousatsu Sakata received his PhD from Tsukuba University, Japan, in 2013, working on the ALICE experiment at the CERN Large Hadron Collider. He then joined the medical physics community first at the University of Tokyo Hospital and then at he Japanese Foundation for Cancer Research. He is now a post-doctoral fellow at Bordeaux University, France, extending the Geant4-DNA toolkit for investigating the usaege of nanoparticles in radiation therapy.

Dr. Tran Ngoc Hoang
Division of Nuclear Physics of Ton Duc Thang University
Post-doctoral fellow at CEA-Saclay in France
Geant4-DNA collaborator
Geant4 collaborator

Keynote Talk
Friday June 16th, 12:00

Talk title: Development of a compact thermal neutron source based on high-intensity proton beams of energy less than 20 MeV

Biography
Dr. Tran Ngoc Hoang received his PhD from Bordeaux University, France, in 2012. In 2013, he joined the Division of Nuclear Physics of Ton Duc Thang University. Currently, he is working as a postdoctoral fellow at CEA-Saclay in France. He is member of the Geant4 and Geant4-DNA collaborations. Dr. Tran's research focuses on medical physics applications and neutronics using Geant4 simulations.

Workshop Abstracts

We indicate below the list of provided abstracts.

Talk: Overview of the Geant4-DNA project

Speaker: Sebastien Incerti, CNRS, France, and Ton Duc Thang University, Vietnam

Modeling accurately biological damage induced by ionizing radiation at the scale of the DNA molecule remains a major challenge of today's radiobiology research[1]. In order to provide the community with an easily accessible mechanistic simulation platform, the general purpose and open source "Geant4" Monte Carlo simulation toolkit[2] is being extended in the framework of the "Geant4-DNA" project[3] with a set of functionalities allowing the detailed simulation of particle-matter interactions in biological medium. These functionalities include physical, physico-chemical and chemical processes that can be combined with nanometer size geometries of biological targets in order to predict early DNA damage. We will present an overview of the Geant4-DNA project and discuss on-going developments.

The main developments undertaken by the Geant4-DNA collaboration[3-5] cover three main areas:

- *Physics processes*: several sets of physics processes are available in order to describe the dominant discrete physical interactions of electrons, protons, hydrogen atoms, alpha particles and their charged states in liquid water, the main component of biological medium. These can be combined with existing Geant4 processes for the description of other processes, such as photon interactions.
- *Physico-chemistry and chemistry processes*: such processes can simulate water radiolysis from physical interactions, that is the creation, the diffusion and mutual reactions of molecular species in liquid water, up to 1 microsecond after irradiation.
- *Detailed geometries of biological targets*: benefiting from Geant4 geometry modeling capabilities, it is now possible to simulate accurate geometries of biological targets, such as the DNA molecule (eg. from data of the Protein Data Bank™ database[6]).

These developments can be combined in order to predict early DNA damage. In particular, on-going developments will lead to the prediction of indirect damage in bacteria and cells and pave the way to the inclusion of repair mechanisms, extending simulation capabilities well beyond the microsecond.

All features described above are fully accessible[7] through the Geant4 simulation toolkit and can be run using a freely downloadable Linux™ CentOS™ virtual machine[8]. We hope that this platform and its future developments will be useful for the further mechanistic understanding of ionizing radiation effects in biological targets, especially when high spatial resolution (nanometer) and low energy (few electonsVolts) simulations are required.

1. "Monte Carlo role in radiobiological modelling of radiotherapy outcomes," Phys. Med. Biol., 57, pp. R75-R97 (2012).
2. http://geant4.org

3. "Track structure modeling in liquid water: A review of the Geant4-DNA very low energy extension of the Geant4 Monte Carlo simulation toolkit," Phys. Medica, 31, pp. 861-874 (2015).
4. "Comparison of Geant4 very low energy cross section models with experimental data in water," Med. Phys., 37, pp. 4692-4708 (2010).
5. "The Geant4-DNA project," Int. J. Model. Simul. Sci. Comput., 1, pp. 157-178 (2010).
6. http://www.rcsb.org
7. http://geant4-dna.org
8. http://geant4.in2p3.fr

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Talk: Inelastic mean free path and stopping power of electron and proton in liquid water

Speaker: Truong Thanh Hieu Nguyen, Ton Duc Thang University, Vietnam

Inelastic mean free path (IMFP) and stopping power (SP) are important quantities for studies of charged particle transport in matter by Monte Carlo method. Here, we present some recent developments on determinations of IMFP and SP for electron and proton in liquid water. Related applications with Geant4-DNA are also mentioned.

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Talk: Integration and validation of the new Geant4-DNA physics models into the GATE simulation platform

Speaker: Huong Nguyen Thi Mai, Danang Cancer Hospital, Vietnam

GATE (Geant4 Application for Tomographic Emission) is an open-source Monte-Carlo simulation platform based on Geant4 (GEometry And Tracking) simulation toolkit, widely used for many medical physics applications. The applications of GATE are expanded to the field of radiobiology when the Geant4-DNA physics models were integrated into GATE version 7.0. In the latest version 10.03 of Geant4, there are more than new Geant4-DNA Physics Lists that have not been incorporated in the GATE version 8.0; therefore we implemented the integration of this new Geant4-DNA Physics Lists into the GATE version 8.0. Moreover, we add two more new Mixed Physics Lists in the GATE version 8.0. In order to validate the correct implementation of the integration of the new Geant4-DNA Physics Lists into the GATE version 8.0, we calculated the DPKs (Dose Point Kernels) of a point-isotropic source of 10 keV electrons in a spherical water phantom with the diameter of 400 mm. The results are compared with those obtained from EGSnrc. It is illustrated that the new improvement results in moderate agreement with the well-validated code EGSnrc. For the verification of the operation of the new Mixed Physics Lists in the GATE version 8.0, the spectrum of a mono-energetic proton point source in three different targets made of liquid water with the thickness of 50 μm was recorded. It was demonstrated the new Mixed Physics Lists were activated in GATE version 8.0.

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Talk: Comparison of number SSB and DSB of DNA irradiated by FF and FFF photon beams (TrueBeam) by using Monte-Carlo Simulation

Speaker: Hong Lam Pham, Center of Oncology and Nuclear Medicine, 108 Military Hospital, Vietnam

Flattening filter free (FFF) beams generated by medical linear accelerators (LINAC) have been using widely in radiotherapy clinical practice. Such beams present fundamental differences with respect to the standard filter flattened (FF) beams. However, biological effects of FFF photon beams is not still studied popularly, if there is a significant difference in number SSB (Single Strand Breaks) and DSB (Double Strand Breaks) of DNA irradiated by FF and FFF beams, to investigate we use Monte-Carlo simulation.
First step, using GATE v8.0 (Geant4 Application for Tomographic Emission) to simulate beamline of the 6MV FF and FFF, 10MV FF and FFF photon beams of TrueBeam STx linear accelerator, Geant4 Standard option3 physical models is used. The result obtain by simulation will be compared and validated with the measurement data, included percent depth doses (PDD) and profiles by using gamma index.
Second step, phase space (above result simulation) will be used as the source to study radiobiological effects by using Monte-Carlo simulation to estimate the number of SSB and DSB of DNA caused by both FFF and standard FF photon beams. PDB4DNA example will be used to calculate the number SSB and DSB of DNA by using Geant4-DNA physical models and Protein Data Bank (PDB).
Prediction and perspectives:
- The delivery of FFF beams might increase the number of SSB and DSB of DNA more than FF beams.
- With the higher energy FFF beam, it might increase in DNA damage, especially an increase in DSB
The result will help clinical researcher understand more clearly about radiobiology effects of FFF photon beams from radiotherapy Linac.

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Talk: Development of a compact thermal neutron source based on high-intensity proton beams of energy less than 20 MeV

Speaker: Ngoc Hoang Tran, Ton Duc Thang University, Vietnam and CEA-Saclay, France

With the development of high-intensity accelerators, it is now envisaged to build compact high-intensity neutron sources for applications, which are up to now mainly performed at nuclear research reactors. Many applications leading to major industrial or societal challenges can be expected such as nuclear data measurements for nuclear industry, fundamental solid state physics studies with neutron scattering experiments, neutron radiography especially for industry materials qualification and also medical purposes like isotope production and neutron-capture therapy. At CEA-Saclay, we have started a project named SONATE to promote such technology based on the existing 100 mA IPHI proton injector. We have focused our interest on low-energy proton-induced reactions (less than 20 MeV) in beryllium target to provide an economical way of neutron production and also to limit the radiological constraints. An optimization of the target-moderator-reflector assembly was performed in order to maximize the neutron rate for the measurements. These studies are mainly done by using validated simulation tools. In this paper, the development status of the compact source based on GEANT4-based simulation tool is presented, as well as its validation in comparison with gold foil activations in experiment for simplified polyethylene moderator. We also describe basic ideas and a proposed simple geometry of target-moderator-

reflector (TMR) assembly based on efficiencies of different reflector materials which needed for maximizing the thermal flux (less than 100 meV) at neutron port.

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Talk: Applications of Geant4 Simulations at the PBP-CMU Linac Laboratory

Speaker: Supasin Sukara, Chiang Mai University, Thailand

A radio-frequency (RF) linear accelerator system at the PBP-CMU Linac Laboratory of the Plasma and Beam Physics Research Facility, Chiang Mai University, Thailand, can produce electron beams with an energy up to 20 MeV. The radiation in x-rays regime may be produced in a form of Bremsstrahlung radiation while the electrons hit metal targets or vacuum chambers of the accelerator's components. Thus, the program Geant4 is used to simulate the x-rays attenuation in order to design the shielding system of the accelerator. Furthermore, Geant4 is used to simulate the radiation attenuation in gamma rays regime from a Cs-137 radioactive source. The simulation results are agree well with the experimental data and the XCOM database. In addition, the DNA package of Geant4 is studied for using to simulate the effects of electron beam and x-rays, which are produced from our accelerator. This work aims to investigate the future feasibility of the Geant4 DNA package in applications of electron beams and radiation with the biomolecules at the PBP-CMU-Linac laboratory.

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Talk: Research Activities at the PBP-CMU Linac Laboratory and Potential GEANT4 Applications at Chiang Mai University

Speaker: Sakhorn Rimjaem, Chiang Mai University, Thailand

This talk will present about the overview of the projects and research activities at the PBP-CMU LINAC Laboratory of the Plasma and Beam Physics Research Facility, Chiang Mai University, Thailand. In our laboratory, we focus on two main projects. The first one relates to the electron radio-frequency (RF) linear accelerator for generation of an intense THz radiation from femtosecond electron pulses and free-electron laser technology. The produced radiation will be used for THz spectroscopy and imagine applications. Short x-ray pulses based on parametric x-ray radiation (PXR) are also possible be produced from our electron beams. The second project is the development of the electron accelerator system for processing of polymeric materials. Therefore, we are interested on utilizing GEANT4 for studying the interactions of electron beam and its radiation in various samples. GEANT4 can also be used to design the radiation protection for our accelerators. Moreover, we would like to use the DNA package of Geant4 to study the effects of electron beam and x-rays in DNA, water and biomolecules.

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