Whatever You Experiment We Calculate

Computer simulation of radiation protection using the Geant4 toolkit

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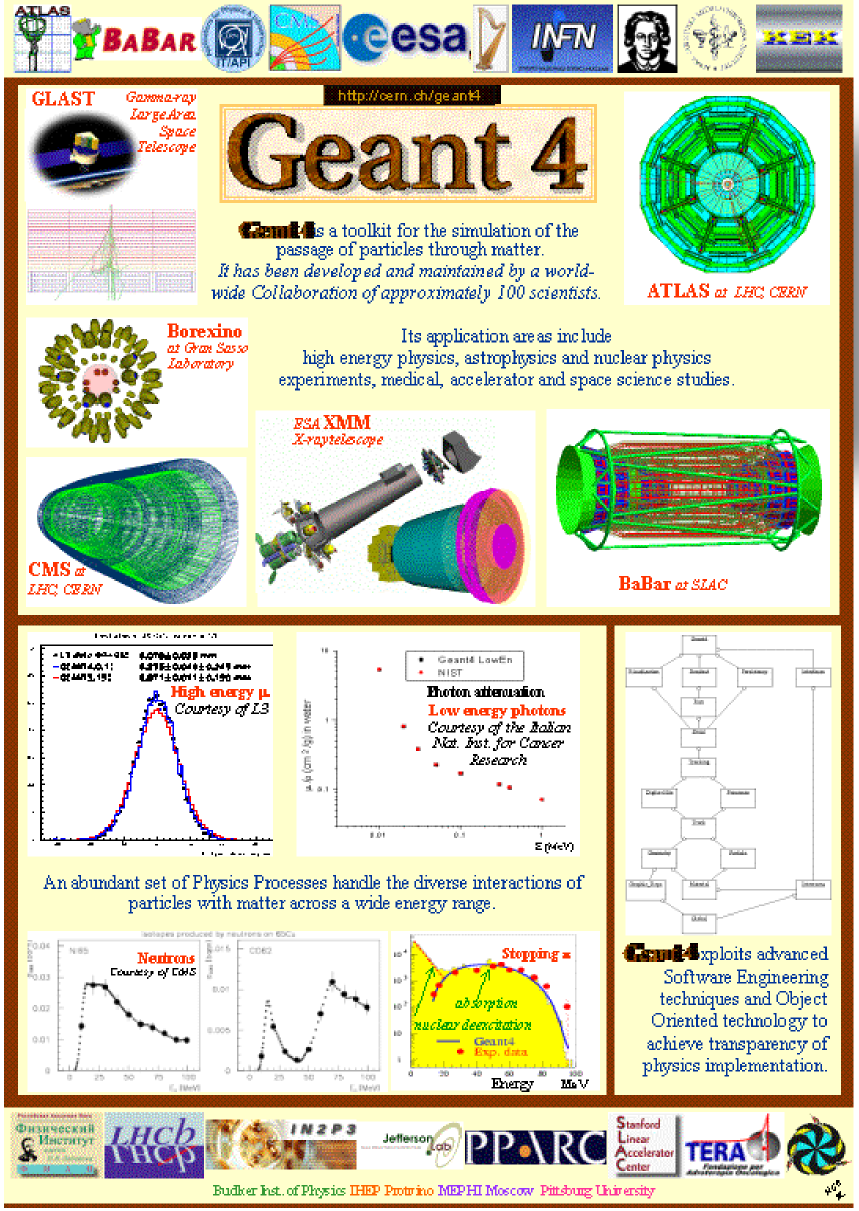
Computer simulation of radiation protection

AGENDA

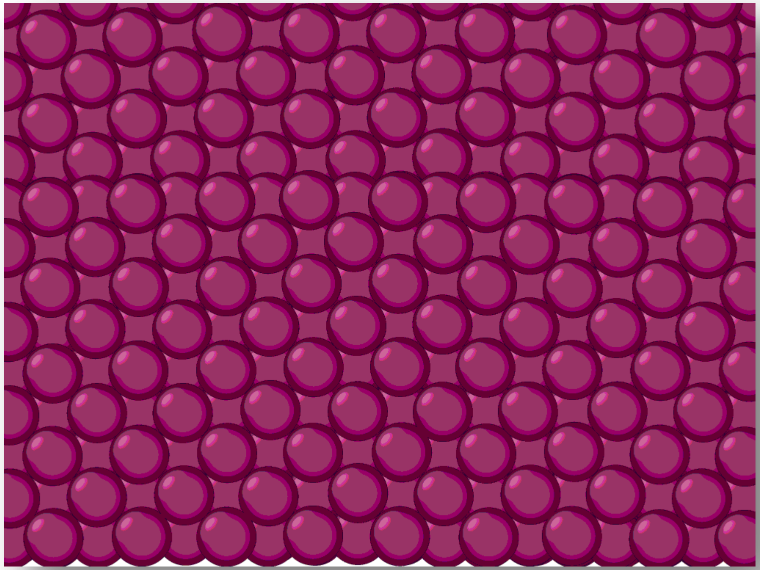
- **INTRODUCTION**
  - **GEANT4 Background.**
  - **The application of GEANT4 software.**
  - **Physical Simulation.**
- **AIMS & OBJECTIVES**
- **COMPUTATIONAL METHODOLOGY**
- **RESULTS & DISCUSSION**
- **CONCLUSION**



introduction

GEANT4 Background

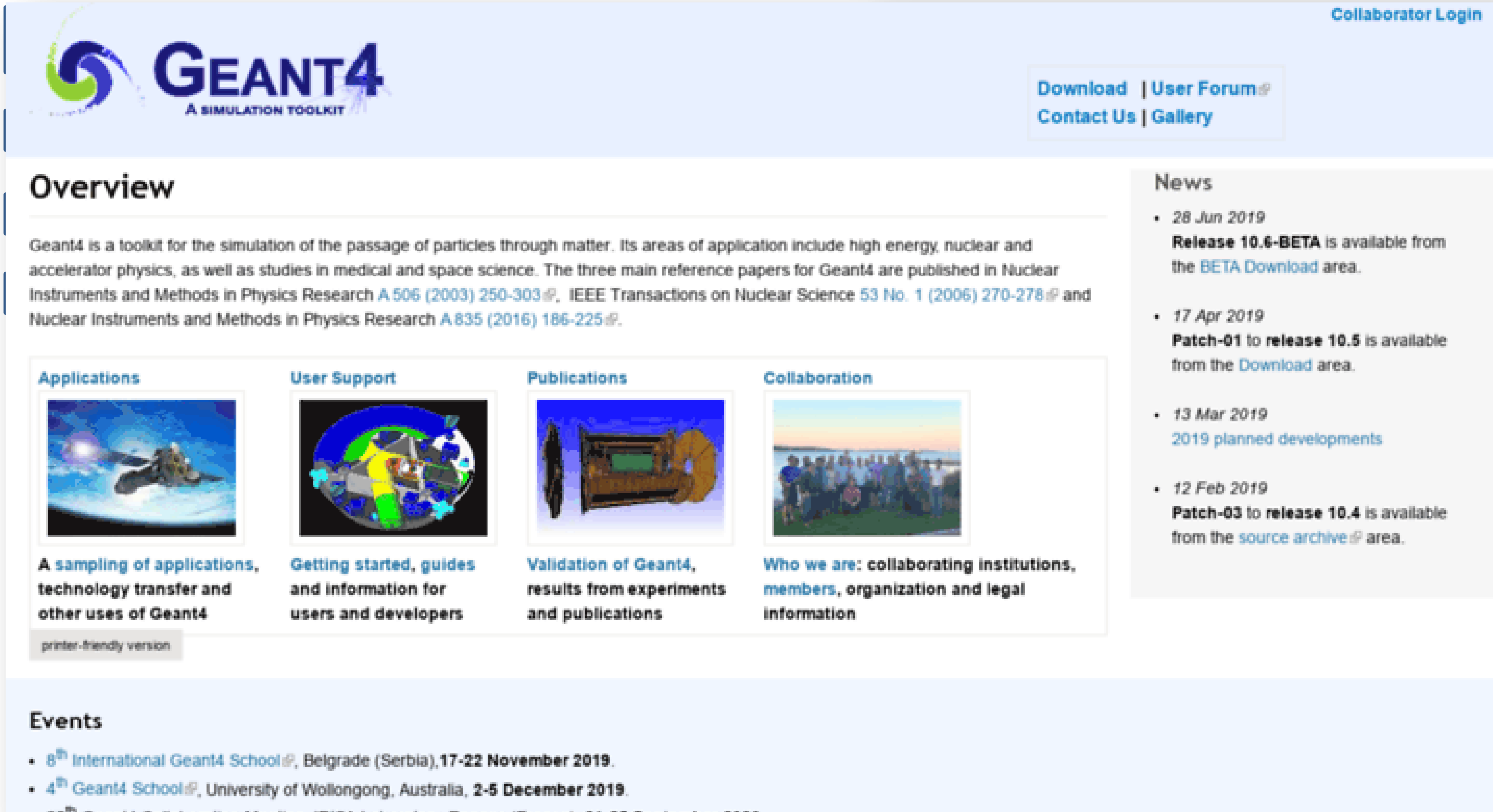
- GEANT4:- Geometry ANd Tracking .
- Geant4 is a toolkit for the simulation of the passage of particles through matter using Monte Carlo methods.
- Monte-Carlo method is a numerical method to solve applied mathematical problems by simulation of random variables and statistical analysis of their characteristics.



Computer simulation of radiation protection

introduction

GEANT4 Background



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GEANT4 A SIMULATION TOOLKIT

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Overview

Geant4 is a toolkit for the simulation of the passage of particles through matter. Its areas of application include high energy, nuclear and accelerator physics, as well as studies in medical and space science. The three main reference papers for Geant4 are published in Nuclear Instruments and Methods in Physics Research A 506 (2003) 250-303, IEEE Transactions on Nuclear Science 53 No. 1 (2006) 270-278 and Nuclear Instruments and Methods in Physics Research A 835 (2016) 186-225.

Applications
A sampling of applications, technology transfer and other uses of Geant4

User Support
Getting started, guides and information for users and developers

Publications
Validation of Geant4, results from experiments and publications

Collaboration
Who we are: collaborating institutions, members, organization and legal information

printer-friendly version

News

- *28 Jun 2019*
  Release 10.6-BETA is available from the BETA Download area.
- *17 Apr 2019*
  Patch-01 to **release 10.5** is available from the Download area.
- *13 Mar 2019*
  2019 planned developments
- *12 Feb 2019*
  Patch-03 to **release 10.4** is available from the source archive area.

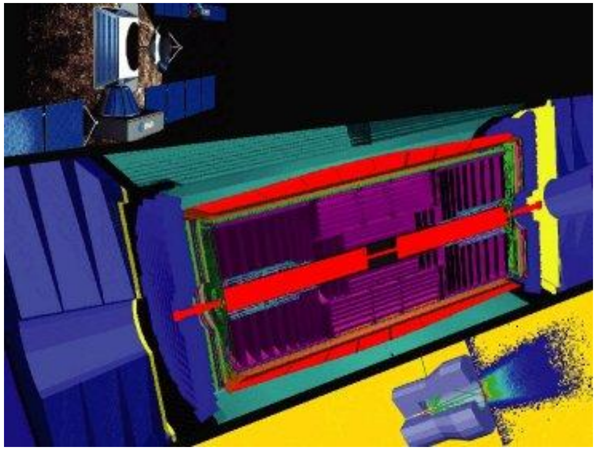
Events

- 8th International Geant4 School, Belgrade (Serbia), **17-22 November 2019**.
- 4th Geant4 School, University of Wollongong, Australia, **2-5 December 2019**.
- 25th Geant4 Collaboration Meeting, IRISA Laboratory, Rennes (France), **21-25 September 2020**

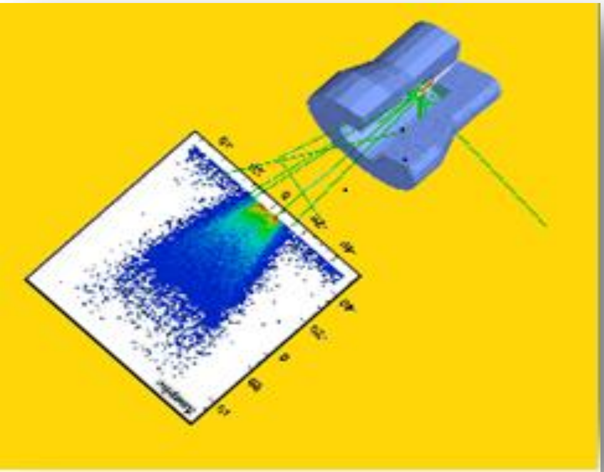
Computer simulation of radiation protection

introduction

GEANT4 application

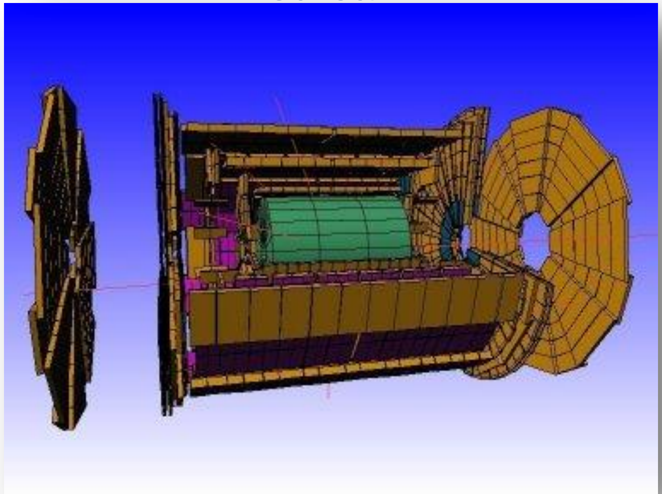


Transfer Technology



Medical

Space and radiation



High energy physics

Computer simulation of radiation protection

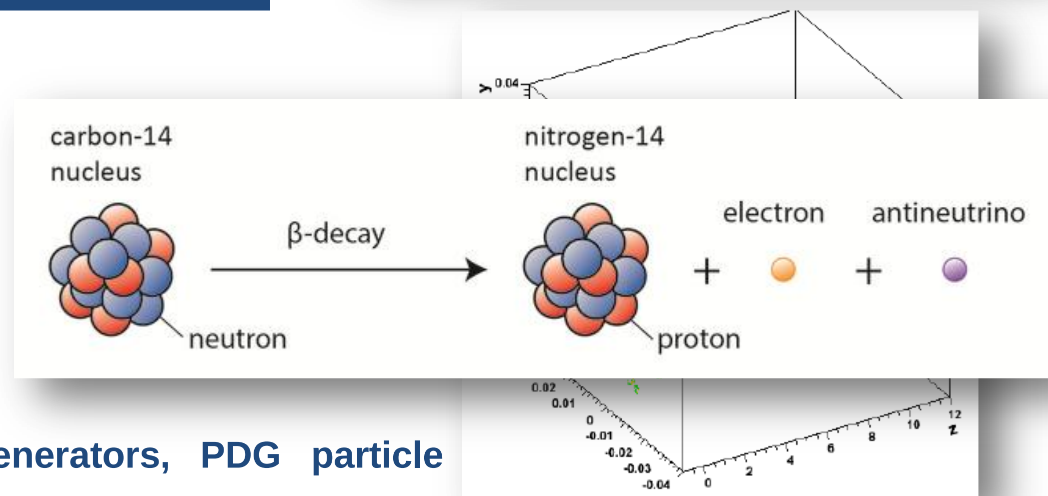
introduction

Physical Simulation

- **A physics simulation starts with a mathematical model whose variables define the state of the system at a given time.**
- **We simulate physical processes and detector response in an experiment being planned or conducted.**

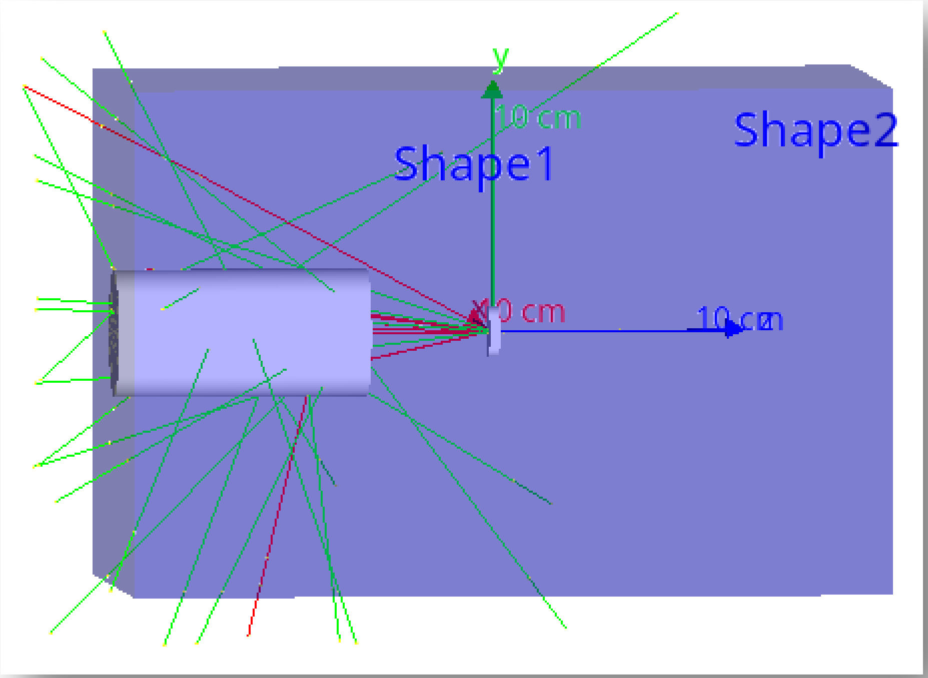
Basic requirements for a simulation system

- **Modeling the experimental set-up.**
- **Tracking particles through matter.**
- **Interaction of particles with matter.**
- **Modeling the detector response.**
- **Run and event control.**
- **Accessory utilities (random number generators, PDG particle information ….etc).**
- **Visualization of the set-up, tracks and hits.**



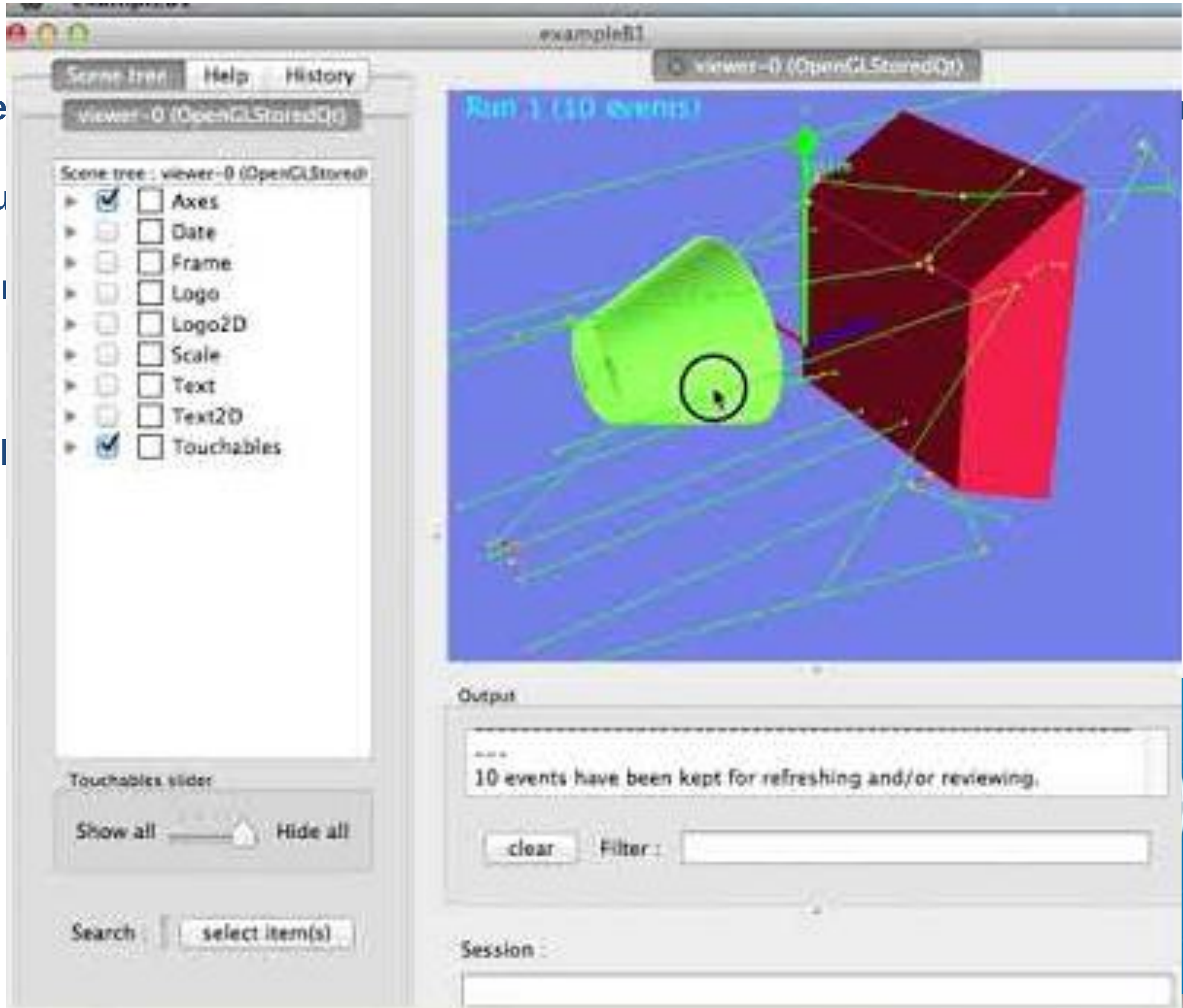
Aims & Objectives

- **Gain practical experience of using the Geant4 toolkit to solve typical problems of radiation protection.**
- **Calculate flux-to-dose equivalent factor for different radiation type and spectrum.**
- **Calculate of basic dosimetry quantities useful for radiation protection applications.**
- **Simulate shielding and radiation protection efficiency.**



Computational Methodology & software

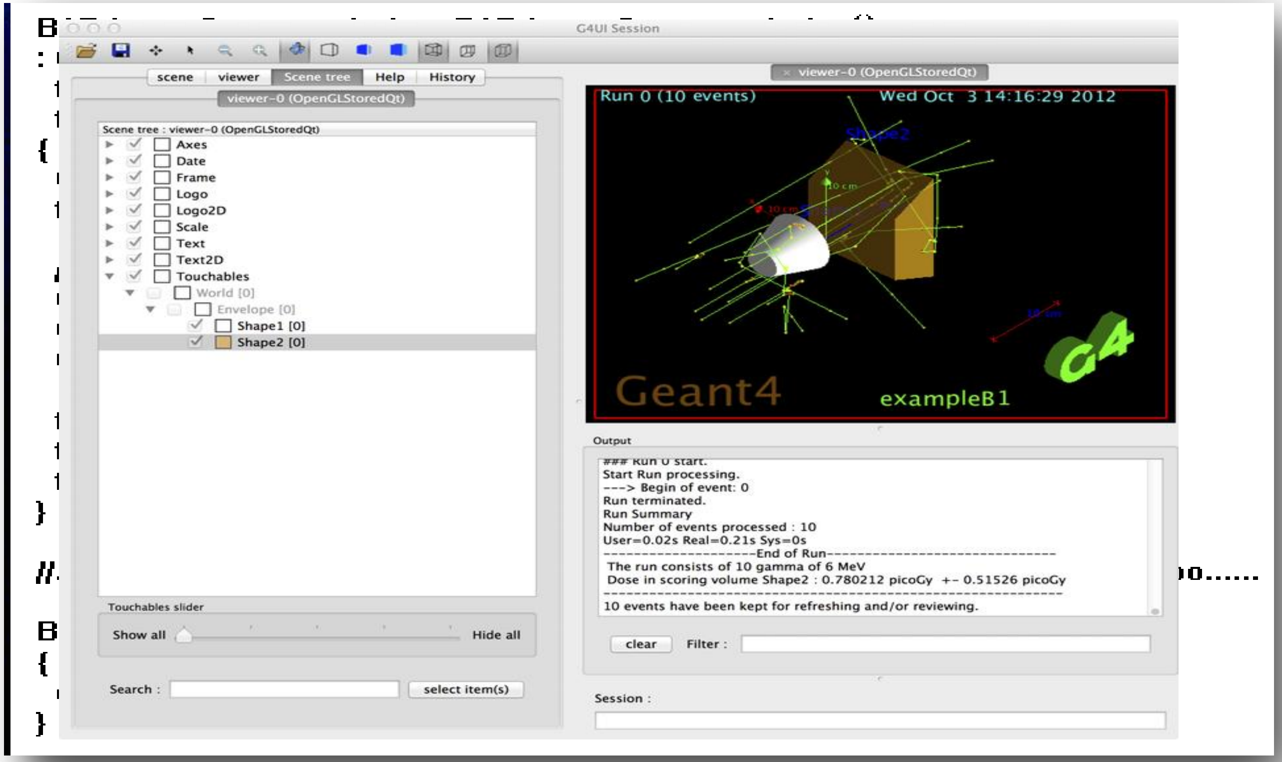
- C++:-
  - Ge ndatory.
- Unix/Linu
  - Ur
- Geant4:-
  - Al



Results & Discussion

Geant4 program

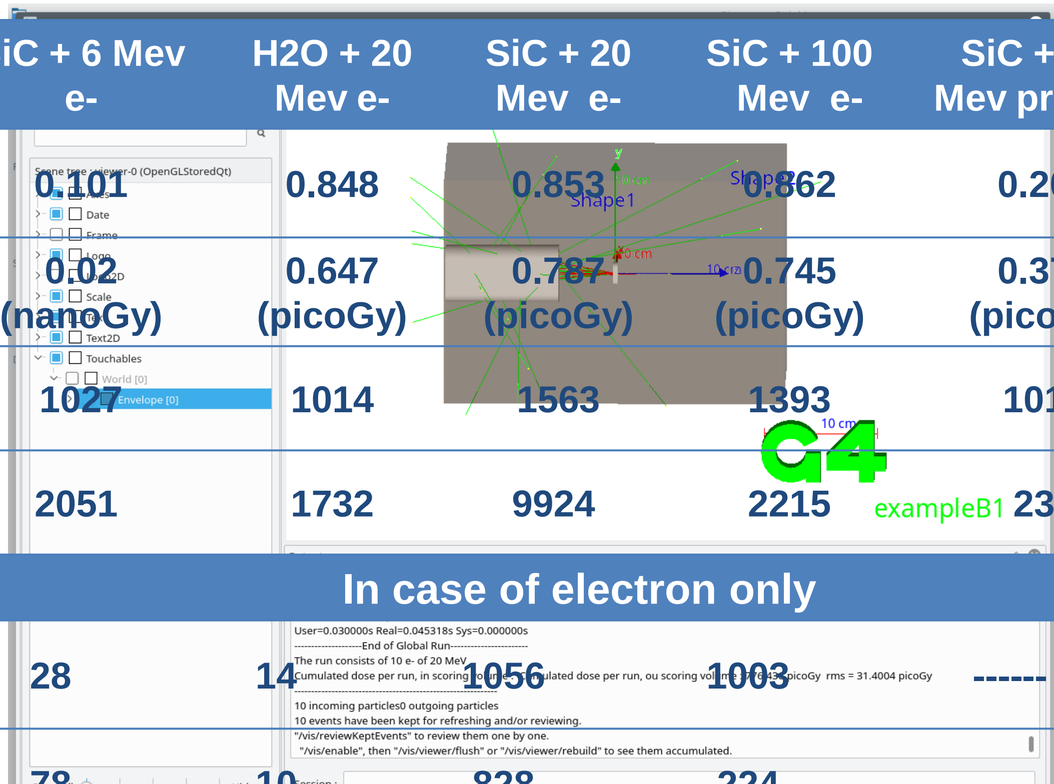
- **Task I:- Geometry Modification and running the simulation using Geant4.**
  - **Source ~/geant4/bin/geant4.sh**
  - **Kate .. /src/B1PrimaryGeneratorAction.cc**
  - **./exampleB1**
  - **/run/beamOn 10**



Results & Discussion

Geant4 program

- **Task II:- Radiation Treatment Dose Distributions using Geant4.**



1000 particles	SiC + 6 Mev e-	H2O + 20 Mev e-	SiC + 20 Mev e-	SiC + 100 Mev e-	SiC + 200 Mev protons	SiC + 20 Mev gamma
Dose (nanoGy)	0.101	0.848	0.853	0.862	0.202	0.192
RMS	0.02 (nanoGy)	0.647 (picoGy)	0.787 (picoGy)	0.745 (picoGy)	0.377 (picoGy)	0.436 (picoGy
Incoming particles	1027	1014	1563	1393	1014	544
Outgoing Particles	2051	1732	9924	2215	230	275
In case of electron only						
Incoming particles	28	14	1056	1003	------	------
Outgoing Particles	78	10	828	224	------	------

Results & Discussion

Geant4 program

10000 particles	SiC + 6 Mev e-	H2O + 20 Mev e-	SiC + 20 Mev e-	SiC + 100 Mev e-	SiC + 200 Mev protons	SiC + 20 Mev gamma
Dose (nanoGy)	0.100	0.850	0.852	0.860	0.204	0.195
RMS (picoGy)	0.40	0.20	0.23	0.22	0.17	0.14
Incoming particles	5245	13822	13838	10204	17266	15597
Outgoing particles	2716	21820	21843	99205	17266	20185
In case of electron only						
Incoming particles	3559	13822	10009	10499	------	------
Outgoing particles	647	21820	2284	741	------	------

Results & Discussion

Geant4 program

- **Task III:- The effect of changing the length of Faraday cup in the percentage value using Geant4.**

Faraday cup Length	20 mm	40 mm	60 mm	80 mm	100 mm
Incoming Particles	84	101	98	103	94
Outgoing Particles	76	36	30	29	26
Faraday cup efficiency	9.5 %	64%	69%	71%	72%

Conclusion

- **Geant4 clearly provides powerful radiation tools underpinned with comprehensive physics simulation.**
- **The dose rate for a given radiation source and distance were calculated.**
- **Shielding and radiation protection efficiency were simulated using Geant4 software.**
- **Geant4 will continue to be supported and activity developed for foreseeable future and we should look to take advantage of the new features.**

Acknowledgment

Thanks for your attention