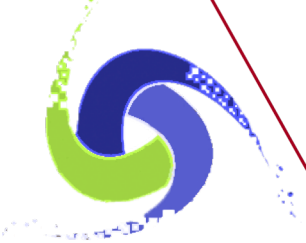


GEANT4
A SIMULATION TOOLKIT
Version 10.5

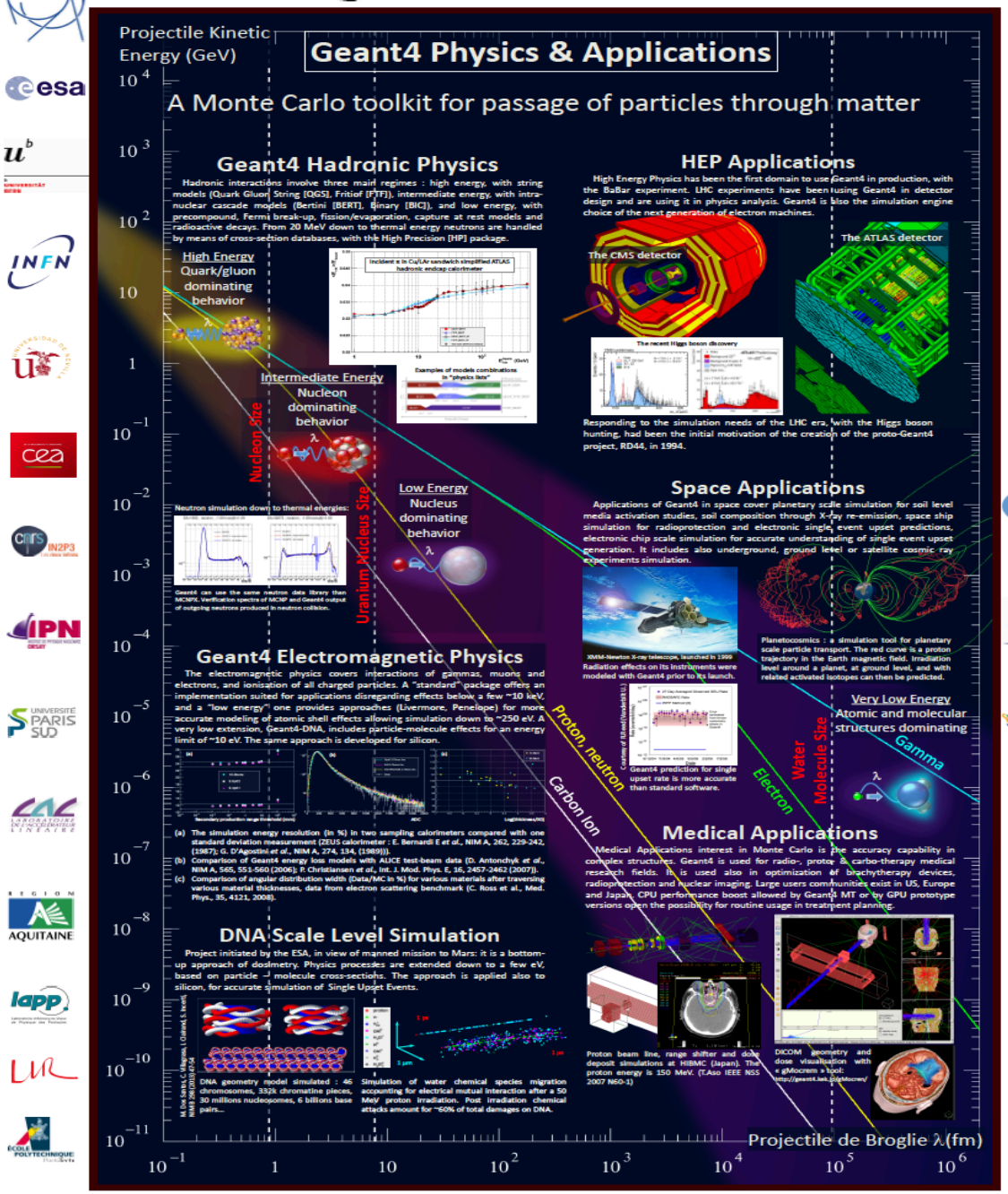
Concluding Remarks

Makoto Asai (SLAC)
Mihaly Novak (CERN)
Dennis Wright (SLAC)

Geant4 tutorial course @ São Paulo

Contents

- The tutorial lecture team sincerely hope you could enjoy our tutorial and you found it informative and useful.
- We also appreciate the organizers, Mauro, Mauricio and Marcelo, for providing us this wonderful opportunity.
- Let me add a few more slides for
  - Following up
  - Geant4 – the Future



Following up http://geant4.org/

- Please keep maintaining your Geant4 installation updated.
  - **Geant4 10.5 is the current version**
    - Soon or later “the current version” would be 10.5-patch01
  - Irregular patch releases may be more important than regular releases.
  - Check our web page regularly to find release news, or register to Geant4 announcement mailing list.
- If you have a question
  1. Look for our documents.
     - Users guides, Twiki pages, tips pages, examples and their READMEs
  2. Post your question on Geant4 HyperNews
     http://hypernews.slac.stanford.edu/HyperNews/geant4/cindex
     - Please make sure to do a bit of survey that no one has already asked the same question before you.
  3. As the final method, write us a mail.
     - Avoid anonymous mail account such as hotmail, gmail, etc.
  4. Or, catch us at meetings/conferences.

Geant4 – the Future

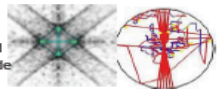
Geant4 Software

Introduction

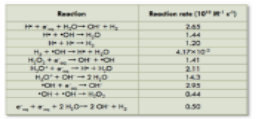
Geant4 is being used in many different fields where simulation of radiation passing through and interacting with matter is critical. User domains include: high energy and nuclear physics, medical physics and space engineering, shielding protection and more. Its abstract layers based on robust OO design enables flexibility and extendibility of the code, and its open-source code and open collaboration have allowed substantial extensions of the code. New features are constantly added to the code, while increasing attention is paid to improving software performance and robustness by employing cutting-edge software engineering technologies.

New physics

The flexibility and extendibility of Geant4 design allows it to be applied to new physics domains. These include the physics of condensed matter (phonon transportation in crystals, drift of electrons and holes in semiconductors) and processes for bio-chemical substances and DNA.

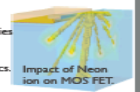


SuperCDMS Cryogenic Dark Matter Search seeks to directly detect dark matter. Geant4 models the caustic pattern in a Ge crystal (left) by tracking individual phonons (right)

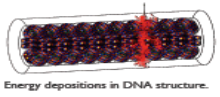


Reactions of radicals available in Geant4.

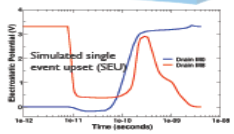
Geant4 performs mission critical studies of radiation and charging effects on spacecraft electronics.



Impact of Neon ion on MOS FET.

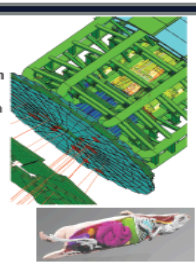


Energy depositions in DNA structure.



Geometry

The flexibility and extendibility of Geant4 design also enables handling rich collection of shapes including CSG (Constructed Solid Geometry), Boolean operation, Tessellated solid, etc. and the user can easily add new shapes. Geant4 geometry navigation can deal with setups up to billions of volumes with automatic optimization. In addition, geometry models can be 'dynamic', i.e. changing the setup at run-time, e.g. "moving objects".



Software quality assurance

Geant4 uses modern tools to manage the code and improve code quality: from handling issues with JIRA to continuous testing integration with CTest/CDash, profiler based optimizations, **Quality/Assurance (Coverity, Valgrind, etc.)**, and IDE integration (Xcode, Eclipse, VisualStudio).

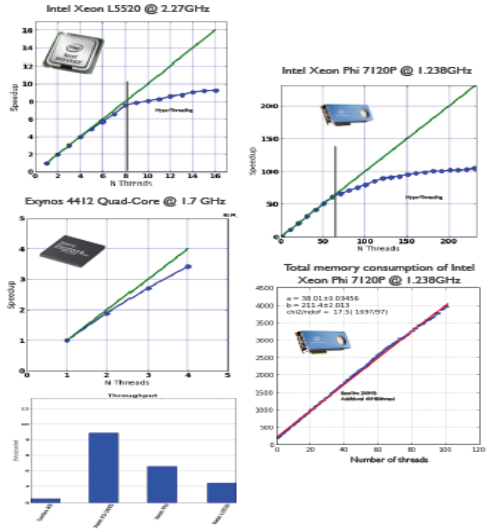
New era - Geant4 version 10 series

The new release of Geant4 – Version 10.0 (December 2013) include event-level parallelism via multi-threading. To efficiently use new computing architectures the workload of a single job is sub-divided to many worker threads each responsible for the simulation of one or more events. Version 10.0 has already shown good scalability on a number of different architectures: Intel Xeon servers, Intel Xeon Phi co-processors and low-power ARM processors

- Proof of principle
- Identify objects to be shared
- First testing
- API re-design
- Example migration
- Further testing
- First optimizations
- Further refinements

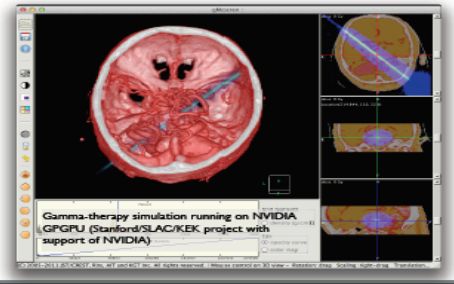
G4MT prototype-9.4 (2011) → G4MT prototype-9.5 (2012) → G4 10.0.beta (June 2013) → G4 10.0 (Dec. 2013) → G4 10 series (2014~)

- MT code integrated into G4
- Production ready
- Public release



Investments for the future

Geant4 collaboration members are participating in various explorations of emerging technologies. These technologies include GPU/CUDA, OpenCL, OpenACC, vectorization, DSL, etc.



Gamma-therapy simulation running on NVIDIA GPGPU (Stanford/SLAC/KEK project with support of NVIDIA)

New physics – new opportunities

- Physics of O(100TeV)
- Neutrino interactions
  - Should come with enriched event biasing options
- Electron/hole drift in semiconductor
- More phonon physics
- Channeling effects and physics with crystal structure in general
  - X-ray diffraction
- Single atom irradiation
- Target material polarization
- Chemical reactions of radicals in DNA-scale
- New domains ?

- Note : Geant4 kernel is robust enough over 20 years of evolution. This stability enables risk-free extensions to new physics.

New computing trends

- HPC and cloud friendliness
  - Seamlessly combining MPI and MT
  - Smart data collection from millions of threads
- Code re-engineering
  - Solid library, EM physics
  - Splitting transportation process
  - Sub-event level parallelization
- GPU as a co-processor
  - Off-loading some calculations to GPU, e.g. EM physics, thermal neutron physics, DNA physics and chemical processes, etc.

- Will be integrated into Geant4 with (hopefully) minimum API changes

To sum up

- Geant4 is a general purpose Monte Carlo simulation tool for elementary particles passing through and interacting with matter. It finds quite a wide variety of user domains including high energy and nuclear physics, space engineering, medical applications, material science, radiation protection and security.
- 2019 is the 20th year anniversary of Geant4 public releases. After 20 years with several architectural evolutions, Geant4 is still steadily evolving.
  - Latest major evolution was Geant4 version 10.0 released in December 2013 that is the first fully multithreaded general-purpose large-scale physics software in the world.
  - New physics models for coming experiments, e.g. hadronic model for multi-TeV regime (for energy frontier), specialized EM model for noble liquid (e.g. liq.Xe) and neutrino physics model (for intensity frontier)
- Given Geant4 is nowadays mission-critical for many users including all HEP experiments, space missions, medical applications, etc., Geant4 is to be kept maintained and still evolving for at least next decade.