Future Perspectives

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in rappresentanza del gruppo Geant4-INFN

http://www.ge.infn.it/geant4/

Commissione Calcolo e Reti
Roma, 21-22 febbraio 2005
Geant4: the present

- **BaBar**
  - 2.2 billion events, 700 years, 84.5 TB disk production with Geant4 (reported at IEEE NSS, Roma, October 2004)

- **LHC experiments**
  - Geant4 used in Data Challenge productions (CMS, LHCb…)
  - Will be used in Physics TDR productions
  - Also test beam simulations and comparisons with data

- **Astroparticle**
  - Neutrino, dark matter, cosmic ray experiments

- **Astrophysics and space science**
  - NASA, ESA and Japan missions

- **Medical physics**
  - Radiotherapy, nuclear medicine, radioprotection

- **Technology transfer**
  - Several industries

- **etc.**
The past

- **December 1994**
  - start RD44

- **December 1998**
  - 1st Geant4 public release

- **Every year since 1999**
  - 2 public releases: June-December
  - minor releases, patches

- **January 1999**
  - Geant4 Collaboration: Memorandum of Understanding

- **2005**
  - New Collaboration Agreement (MoU)
The future

- **On-going discussions in the Collaboration**
  - Geant4 Workshop, INFN-LNS, Catania, October 2004
  - Geant4 “10th birthday”: LAPP, December 2004
  - Geant4 Technical Steering Board Meeting, 8 February 2005

- **Geant4 in the “production era”**
  - Maintenance, support, requirements from the experiments

- **How good is Geant4?**
  - Validation, applicability, performance

- **Geant4 as an engineering tool**
  - Not only as a scientific tool for experts

- **R & D**
  - physics
  - mathematics
  - software

- **…without forgetting the GRID**
Maintenance and Support

- A significant effort for most developers
- Huge user community worldwide, in many different domains

- Training courses
- Education to OO/C++ basics
Requirements

- Regular input of requirements from the experiments

- Requirements vary largely in their impact
  - Cuts per region: major design iteration in the kernel
  - Physics extensions
  - New functionality
  - Performance
  - etc.
Validation

Systematic, quantitative validation of Geant4 physics
- Rigorous statistical comparisons
- Document results as a reference for the experimental community
- Unprecedented effort: no MC code ever validated to such extent
- Geant4 Physics Book project
  - 1st “chapter” submitted for publication: validation of all Geant4 EM models against the NIST database reference (2 years from start to paper)
  - 2005-2006: EM final state distributions
    - multiple scattering, optical, low energy, high energy, muons etc.
- Hadronic Physics
  - ...

Different from activities in the experiments
- LCG Simulation Validation Project
- test beams
- collaboration with experimental groups
Geant4 application in experimental domains

- Geant4 is accepted as a mature production tool for HEP (BaBar, LHC)
- Demonstrate applicability in other areas
  - does it meet the experimental requirements?
  - is it the state of the art?
  - how accurate is it in such domains?
  - does it need any improvements/extensions?
- Radiation studies at accelerators
- Radiation studies in space
- “Underground” experiments
- Cosmic ray experiments
- Oncological radiotherapy and nuclear medicine
- Radioprotection
- Environmental physics (effect of “low doses”)
- New domains: antiprotons, antimatter etc.
- etc.

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Challenges of the LHC operation era

The requirements on MC precision get higher at the time when the MC is used for real physics production, in support to physics results for publication

- CMS Computing Model (LHC Computing review): produce as many MC data as real data → require unprecedented precision from MC

Not only LHC

- other high precision experiments: NA48?
Underground experiments

- Concerns (see L. Pandola’s report)
Radiation Background studies

- Collaboration with CERN accelerator teams
Medical Physics

- Meeting at Istituto Superiore di Sanita
- Precision
- Distributed computing
Micro/nano-dosimetry

- Challenge of physics at very low energies
  - assumption of free, fixed atoms does not hold any more

- Radiation damage to components

- Radiation effects to man
  - oncology
  - effects of low doses (cellular irradiation facilities, Legnaro)
  - future space missions, ISS
  - in progress: Geant4-DNA
Cosmic ray experiments

- High energy processes
- Fluorescence at molecular level
  - now: at atomic level only
Detector response

- Detector response modeling is now left to the users
  - everybody re-invents the wheel
- Common tools for detector modeling
Usability

- CAD
- GUI
- Web interface
- “Pythonization”

- Engineering Tool
  - industry
  - hospitals
  - engineering support activities (shielding etc.)

- Geant4 in the GRID era
Software

- What was “advanced” in 1994 is commonplace nowadays
- Cope with new technology
  - how technology can help physics
New MoU

- Collaboration management restructured
  - Steering Board composed by developers only
  - Technical Forum open to users, experiments, institutes
Major concern

- Manpower

- Current number of Geant4 authors: 63
- Huge workload

- Fellowships for young INFN developers?
Next 10 years

- Physics validation
- New domains of physics development and applications
- Precision, stability, performance
- Monte Carlo engineering tool
- Technology transfer
- Stay at the frontier of software!