



# Future Perspectives

Maria Grazia Pia, INFN Genova  
in rappresentanza del gruppo Geant4-INFN

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

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# 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
  - 1<sup>st</sup> 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 “10<sup>th</sup> 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
  - 1<sup>st</sup> “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.



# 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!