GEANT4 History: one perspective

Geant4 Review

June 2001

Geant4 timeline 1994-2001

- Dec ’94 - Project start
- Sept ’95 – Proof of concepts
- Apr ’97 - First alpha release
- Jul ’98 - First beta release
- Dec ’98 - End of RD44.
  Start of new Geant4 collaboration (MoU)
- Jan ’1999 - December 2000
  - First period of MoU
- December 2000 - MoU renewal

Goals

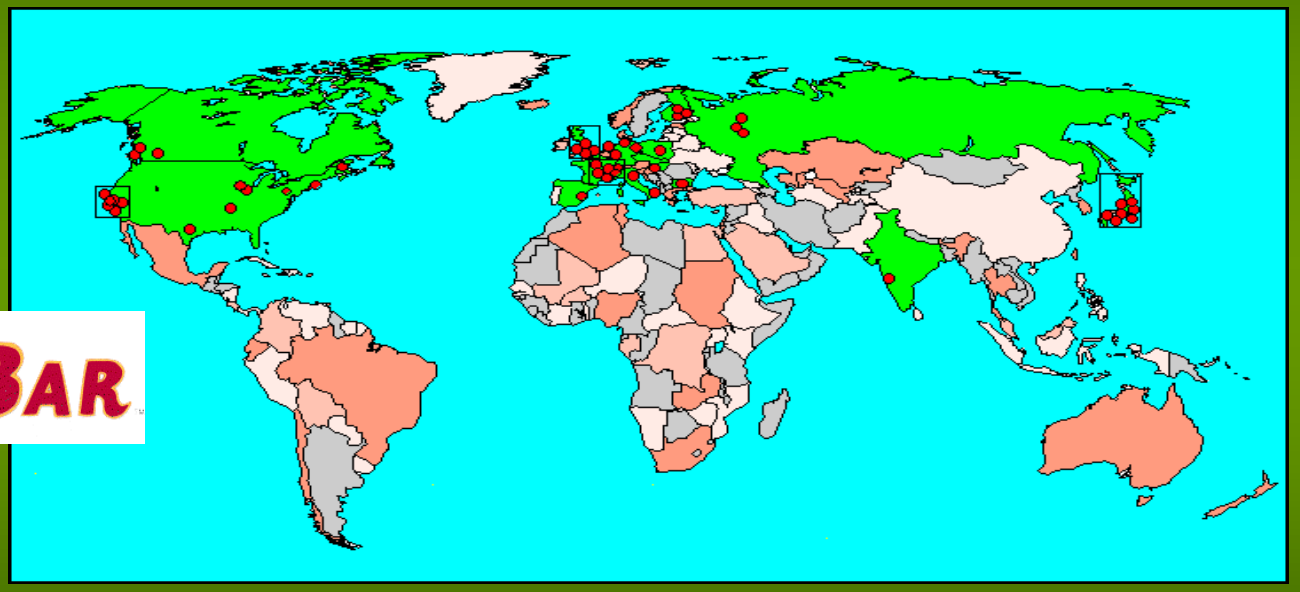
P58/RD44

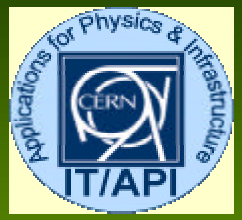
- Detector simulation toolkit for HEP
- World-wide collaboration
- Requirements from physicists in:
  - LHC
  - heavy ions, CP violation, cosmic rays, medical and space science applications
- Software Engineering and OO technology

P58/RD44 1994

RD44 Collaboration

ALICE





FNAL

LPNHE

Collaborators also from non-member institutions, including
IHEP Protvino
MEPHI Moscow
Pittsburg University

Objectives 94-97 *RD44*

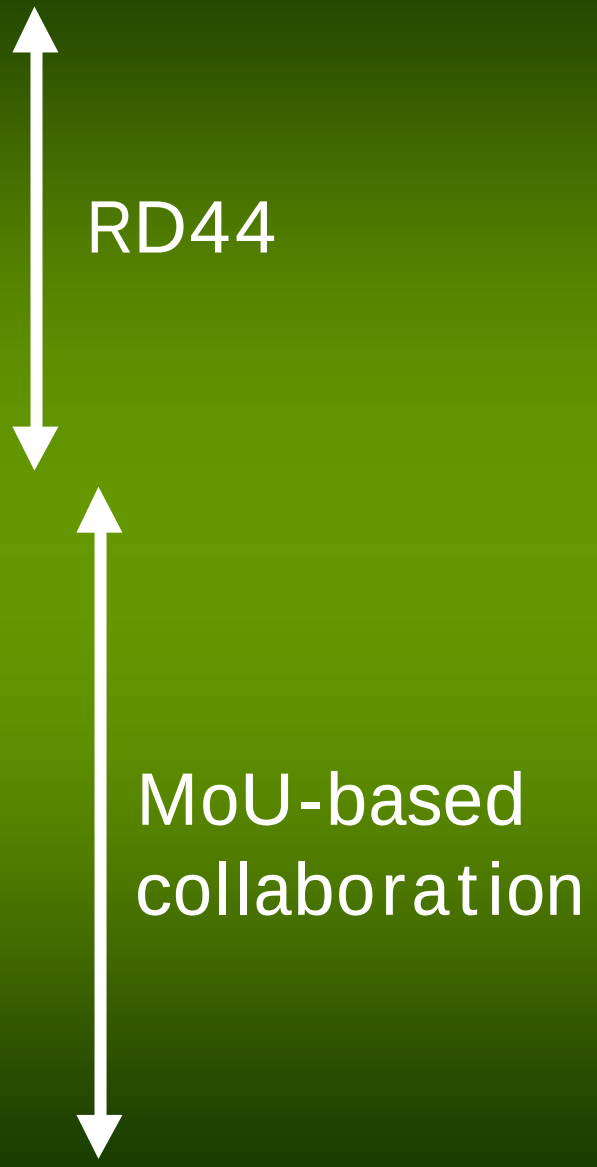
- Major objectives reached in 1995
  - Problem domain decomposition and OOA&D
  - Geometry&tracking prototype + benchmarks
- Major objectives reached in 1996-7
  - α-version, functionality comparable to G3
  - Persistency via RD45 (hits) + benchmarks
  - Transparency of physics processes & models
  - User Requirement Document v 0.6

Geant4 releases: history

- Dec ’94 - Project start
- Sept ’95- Proof of concepts
- Apr ’97 - First α release
- Jul ’98 - First β release
- Dec ’98 - Geant4 0.0 release
- Jul ’99 - Geant4 0.1 release
- …
- Dec ’00 - Geant4 3.0 release

Two scheduled public releases per year

Monthly reference releases for internal collaboration users



Workplan: scope *RD44 PEP*

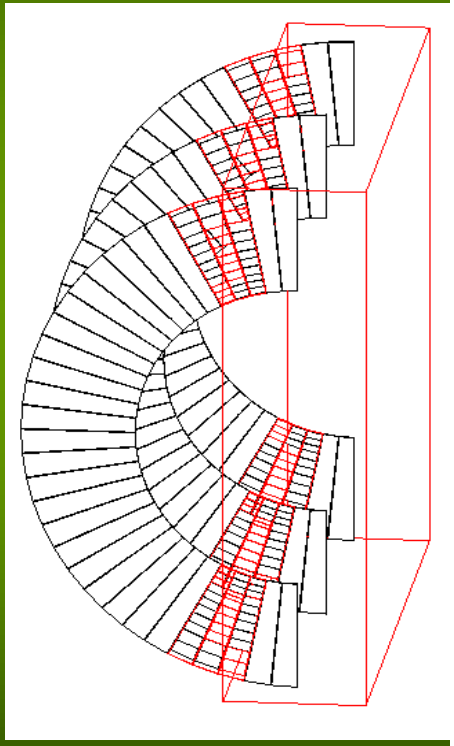
- Problem domain analysis -> subdomains
- Working groups for G4 subdomains:
  - Digi/Hits, Run/Events, Geometry/CAD, UI/GUI, Hadronics, E.M., Low Energy Physics, Tracking, Visualization, Particles/Materials, Fast Parameterizations
- Working groups for software:
  - User Requirements, ODBMS, QA, Parallelism
- Reviews: DRDC 94, LCRB 95, LCB 97
- Re-use: EventDisplay, Reconstruction, CAD

Workplan: methodology *RD44*

- Software Engineering
  - URD: *PSS-05*; OOA&D: *Booch*; CASE: *Rose*
- Testing: test-cases per class; 400 for hadronics
- Standards:
  - STEP, ODMG, OGL, VRML, CVS, C++, RW/STL
- Assumptions:
  - LHC++
  - strategy for free and commercial software on www

Deliverables *RD44*

- User Requirement Document
- Class Category Diagram
- Class and Object/Scenario Diagrams
- Source code of GEANT4 detector simulation toolkit:
  - physics range from cold and thermal energies to TeV*s*
- Documentation



Organization RD44

- RD44 was managed by an executive board:
  - CERN, Japan (KEK+Univ.), Canada (TRIUMF+Univ.), USA (SLAC/BaBar, FNAL, BNL), ATLAS and CMS were represented.
- Progress review and planning:
  - General workshops: CERN 95, TRIUMF 96, SLAC 97, Niigata-JP 98
  - Specific workshops: per sub-domain or group
- Formal reports:
  - DRDC 94, LCRB 95, LCB 97, LCB 98

Responsibilities *RD44 PEP*

- *Working groups* are responsible for design and implementation work in specific sub-domains:
  - Digi/Hits - Hiroshima
  - Events/Tracks+Tracking - Hiroshima, KEK, Kyoto
  - Geometry - CERN
  - GUI/Visualisation - Naruto, Manchester
  - Hadronics - TRIUMF, Aachen
  - E.M. - TRIUMF, LAPP
  - Persistency - SLAC, KEK
  - FastMC - PNHE, SLAC
  - QA/Tools - CERN, KEK, SLAC, TRIUMF

Hadronic physics (end 1998) RD44

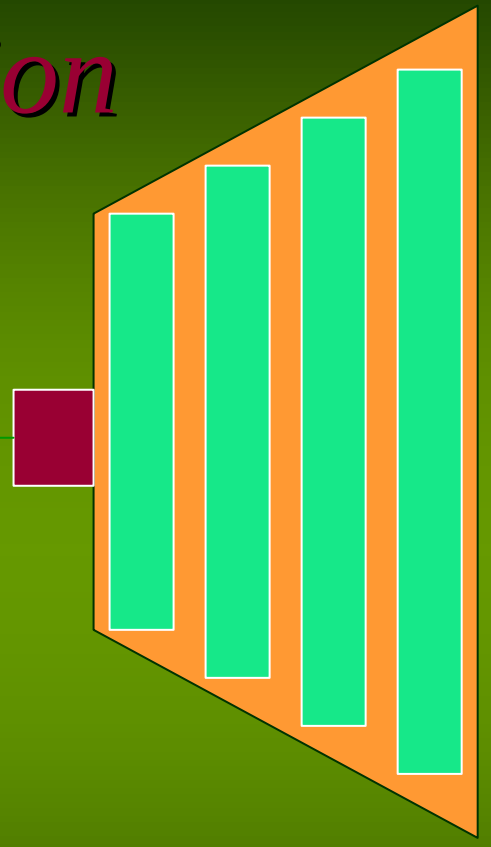
- Inelastic and coherent elastic scattering
- Capture of neutral, strongly interacting particles by nuclei, and neutron-induced fission
- Processes at rest for long-living, stopping particles
- New parameterisations:
  - total cross-section p/n-N (0/14MeV to 20GeV), differential cross-section p-p (0.1MeV to 3GeV)
- Neutron transport (ENDF/B-VI)
- High E extensions using techniques used in heavy ion generators+pre-equilibrium+evaporation
- Many other small improvements

Class Category Diagram (1998)

Quality assurance *RD44*

- Insure++ and Logiscope for software reliability and metrics
- CASE Rose (also with reverse engineering) for design reviews
- Coding guidelines automatic checking
- Code inspections within subdomains
- Code and design inspection for categories interfaces

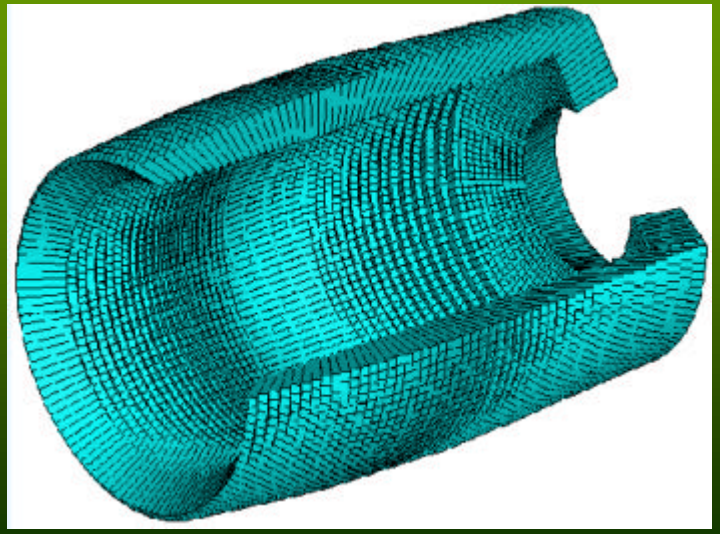
Examples and Documentation



- Six novice examples
  - simple detectors
  - different experiment types
  - demonstrate essential capabilities
- Documentation (6 documents):
  - Getting started & installation guide
  - User guide for application & toolkit developers
  - Software & physics reference manuals
- G4 URL: http://cern.ch/geant4

The new Geant4 collaboration

- The MoU
  - Geant4 Production service and User support
- Organisation
  - Collaboration Board
  - Technical Steering Board
  - Workshops
    - ESTEC, Holland 1999
    - LAL, France 2000
    - Genova, Italy 2001



New members

In 1999

- Inst Theor Phys JW Goethe Univ (Frankfurt, Germany)
- Jefferson Laboratory (US)
- TERA Foundation (Italy)

In the year 2000:

- Karolinska Institute (Sweden)
- HARP (CERN)
- PPARC (UK)

Working Groups: 1999-now

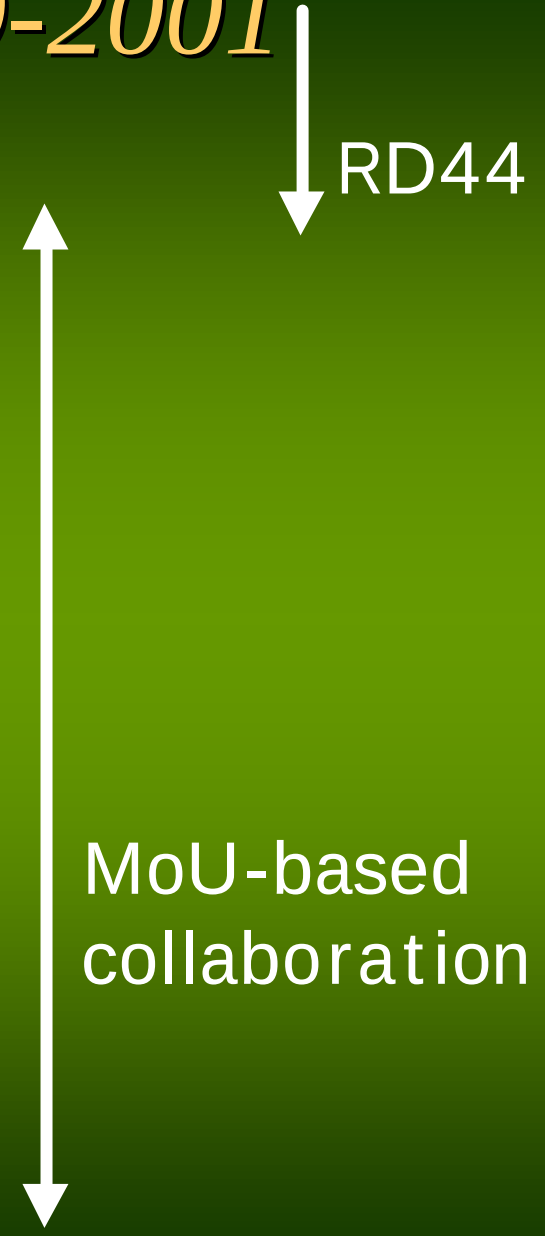
- For G4 subdomains
  - Run, Events & Detector Response
  - Tracking
  - Geometry & Transportation,
  - Generic Processes & Materials
  - Hadronic Physics,
  - E.M. Physics ("Standard"),
  - Low Energy EM Physics (since 2000)
  - User and Category Interfaces
  - Visualization
- For software:
  - Software Management
  - Testing & QA
  - Documentation Management

Geant4 releases: 1999-2001

- Dec 1998 - Geant4.0.0 release
- July 1999 - Geant4.0.1 release
- Dec 1999 - Geant4 1.0 release
- Mar 2000 - Geant4 1.1
- June 2000 - Geant4 2.0 release
- Dec 2000 - Geant4 3.0 release
- April 2001 - Geant4 3.1
- June 2001 - Geant4 3.2 release

Two public releases per year.

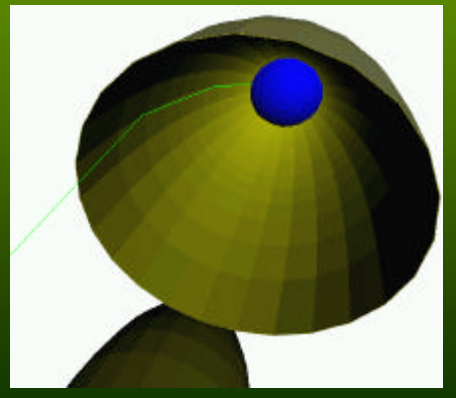
Monthly reference releases for collaboration users



Release 4.0.1 (July 1999)

It included

- STL to replace RW Tools.h++
  - user could still choose to use Rogue Wave (default)
  - Objectspace STL (except on Linux - native)
- Additions
  - low Energy EM (e-, γ down to 250eV)
- new UserAction class signatures
- patch released early November 1999



Geant4 1.0 (December 1999)

It contained

- new hadronic physics models
- low energy EM processes for protons, ions, anti-protons
- improvements in other areas,eg.
  - “Energy Loss Plus”: optional Ionisation process
    - generates secondaries that could escape a volume, even if they are below the production threshold
- all available problem fixes

Requires STL (Ospace, except Linux native)

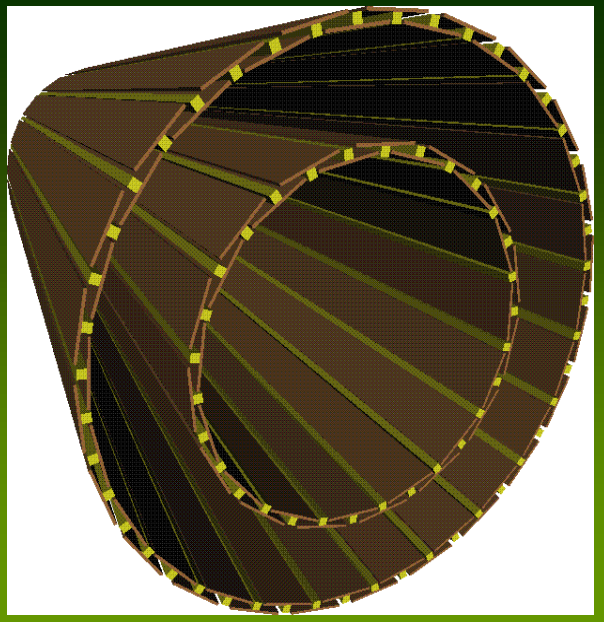
Geant4 1.0: New/Improved Physics

- Neutron isotope production models (NEW)
  - up to 100 MeV (J.P. Wellisch)
- Low energy hadron and ion ionisation (V. Ivantchenko)
- Additional string model
  - for proton induced reactions
- Multi-fragmentation
  - redesign & refinement (V. Lara)
- X-section classes for n, p induced reactions

Monthly tags instituted

- From January 2000, agreed to “publish” to Geant4 members *one reference tag per month* containing
  - all tested problem fixes
  - improvements
  - new development
- Experiments distribute them internally

Milestones 2000



- Joint Comparison Projects
  - Atlas projects on Calorimeters
    - (EM Barrel , FCAL/HEC, Tilecal)
  - BaBar project on Vertex/Drift Chamber
- Training Kits
  - 3 kits
- Software Process Improvement
  - Design process review, QA, testing tools

Geant4 1.1 minor release (March 2000)

- No new functionality
- Problem fixes, improvements

- Support for ISO C++ compilers
  - enabling use with namespaces
  - keeping support for older compilers (for now) using native STL

Geant4 2.0 (June 2000)

- New models for Transition Radiation
- Model for proton-induced isotope production
- UI: text terminal with auto-completion
- Ray Tracer for visualization using tracking
- Upgraded NIST STEP Reader to SCL 3.2 and ported to ISO C++
- Ionisation generating secondaries (below cut) that escape current volume is default.

Geant4 3.0 (Dec. 2000)

- New module: analysis
  - manager for histograms; drivers; for using AIDA
- General Particle Source
- e+/- Bremsstrahlung
  - new cross section and energy-loss parameterization
- New "advanced" examples:
  - X-ray and γ-ray telescopes, brachytherapy

Geant4 3.1 minor release (April 2001)

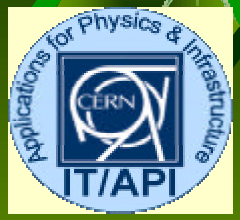
- "Minor" new functionality
- Problem fixes, improvements

- Also
  - migration to direct use of STL in many areas

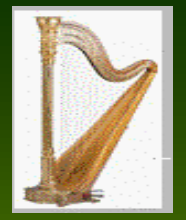
Geant4 platforms today

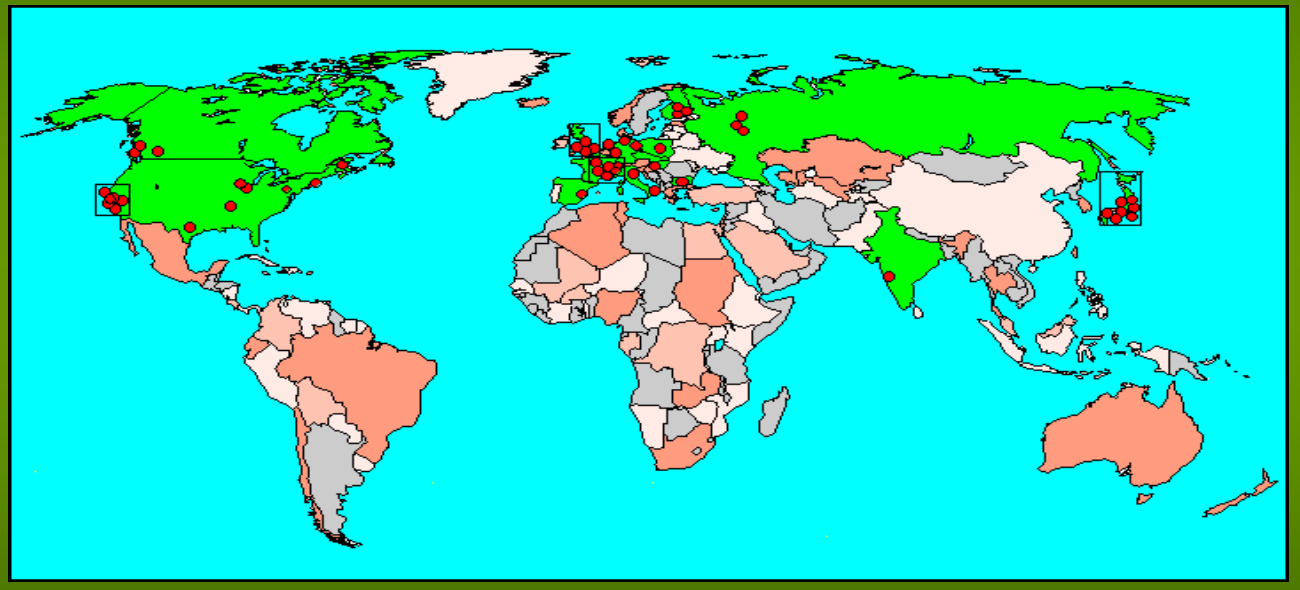
- Requires STL (Ospace, except Linux native)
- Platforms supported:
  - SUN, DEC, Linux, Windows NT
  - HP (to drop end 2001)
- Not Supported
  - SGI, AIX

Geant4 Collaboration



Stanford Linear Accelerator Center





Collaborators also from non-member institutions, including
Budker Inst. of Physics
IHEP Protvino
MEPHI Moscow
Pittsburg University