

Geant4 History

From P58/RD44 to Today

Geant4 in production: past, present and future

15 December 2004 @CERN

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(KEK)

Overview of the Talk

- Perspective view of Geant4 History.
- Not to try to be exhaustive but to pick up major scenes during the early stage to the present of the Geant4 collaboration.
- Apology
 - I may introduce a biased view....
 - A historical scene important for you might be ignored....

Introduction

■ What is Geant4?

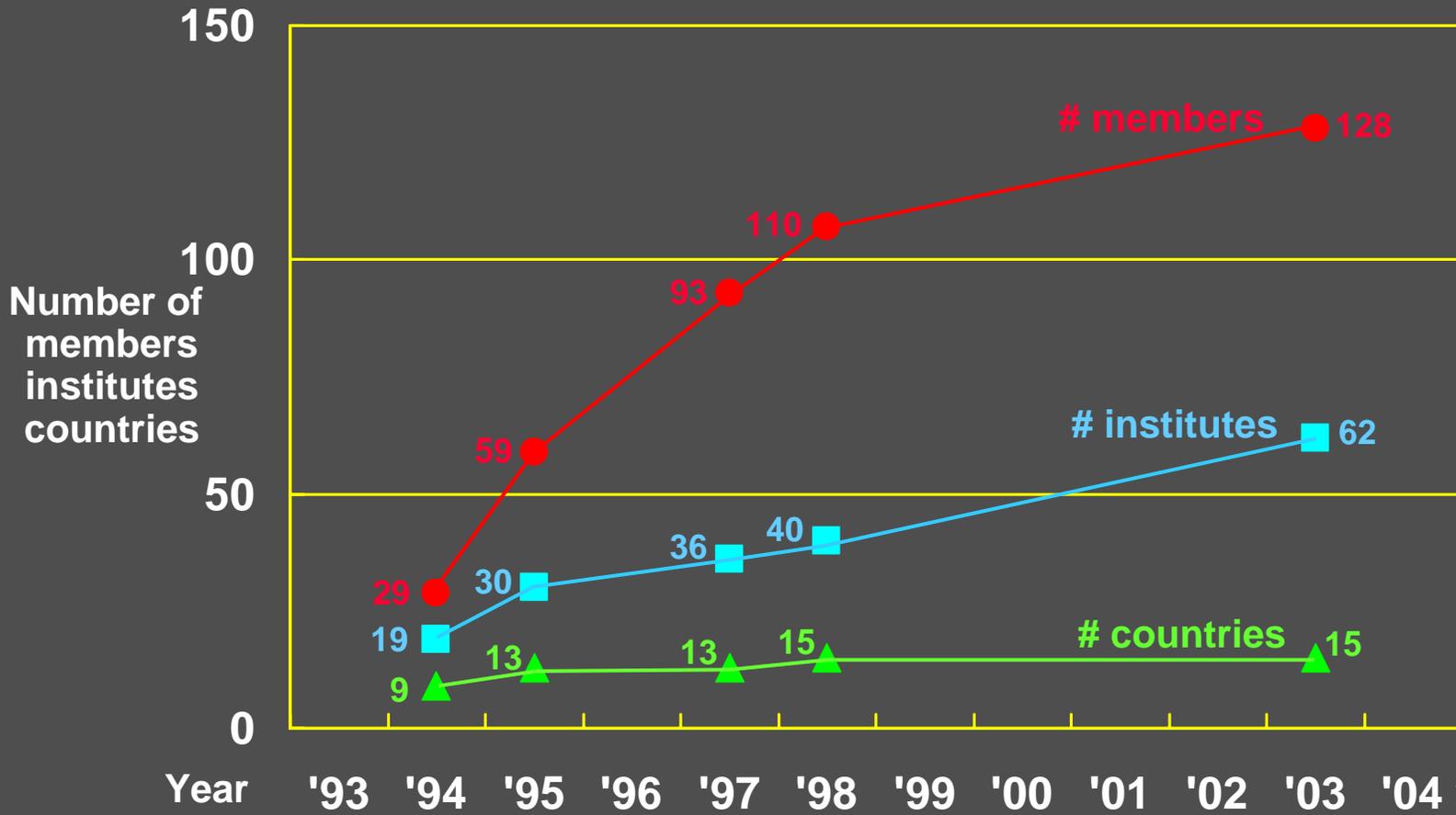
- It is a toolkit for simulation not only to HEP but also to space, radiation, nuclear, medical... applications.

■ What is Geant4 Collaboration?

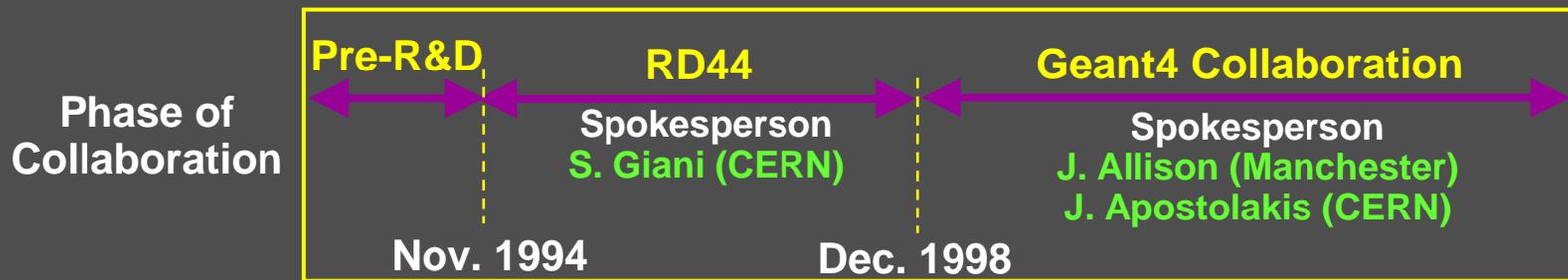
- It is an international organization to develop and to maintain Geant4 software.
- It is operated under the Memorandum of Understanding (MoU) signed by laboratories, agencies, national institutes, research institutes, universities and experiment groups.
 - ◆ The spirit of the collaboration is just like one of international collaboration of HEP experiments.



Evolution of Geant4 Collaboration Members



Geant4
10 Years
Old !!



Pre R&D Phase

1992/1993 ~ 1994

An Old Tale

■ Mini-workshop on Object-Oriented GEANT

- 24-27 Aug. 1993 at CERN
- Agreed to held this just after CHEP92 at Annecy
- Participants just
 - ◆ CERN/CN/AS members
 - ◆ KEK Physics Department and Computer Center members

■ Seeds of Geant4

- Object-Oriented Analysis and Design of GEANT at KEK (ProdiG project)
- Investigation of class hierarchy for GEANT at CERN

■ Outcome

- Agreed to merge two activities

Agenda of the workshop

Imko Vrsckoki
27.08.1993

MINI-WORKSHOP ON OBJECT ORIENTED GEANT

Held 24-27 August 1993 at CERN/CN/AS

SLIDES

SPEAKERS:

Tuesday 24.08.1993

Katsuya Amako	: The ProdiG project
Yoshi Tahaime	: Introduction of KEK activities on OO-GEANT
Felix Brun	: The evolution of CERNSIS environment
Federico Garimati	: GEANT status and plans for the geometry

Wednesday 25.08.1993

Simone Ghani	: Investigation of class hierarchy for GEANT
Alfred Nathaniel	: General views on OOP. Ideas for I/O
Fons Kudevakers	: C++ evolution
Imko Vrsckoki/ Jarmo Saarila	: An OO method for manipulating geometries

Thursday 26.08.1993

Demonstrations

Friday 27.08.1993

Wrap-up

An Old Tale - *continued*

■ However.....

- It took more than a half year since the mini-workshop to start a concrete collaboration.
 - ← A reorganization of CERN/CN was going on during this period.

■ CHEP94 at San Francisco (*April 1994*)

- Object-Oriented Analysis and Design of GEANT at KEK (ProdiG project) presented.
- Reconfirmation of the collaboration made at the conference.

P58 Proposal

■ Informal meeting in June 1994 at CERN

- Agreed to merge CERN class design and KEK OO design
- Agreed to submit OO GEANT proposal to DRDC/CERN
- Agreed to name the project: GEANT4
- Agreed to make a call for joining to the project in Europe, U.S. and Japan.

■ Proposal submission

- Submitted to DRDC in August 1994
- Spokesperson: Simone Giani (CERN)
- Proposal name: DRDC/P58
- 29 persons/19 institutes/9 countries
 - ◆ International collaboration
- Referee: Richard Mount

Front page of P58 proposal



#Members=29
#Institutes=19
#Countries=9

P58 Proposal

- The motivation and purpose of the project (from the proposal)
 - For the LHC and heavy ion experiments, an even larger degree of functionality and flexibility is required in GEANT, thus making necessary a re-design of the program.
 - Investigate the use of object-oriented techniques to enable us to meet these goals.
 - The philosophy (of the design) should not be 'GEANT simulates all the known physical processes at any energies', but it should rather be 'the simulation of any physical process at any energy can be easily plugged into GEANT by any user'.
 - GEANT is increasingly requested for application such as tomography, dosimetry, space science, etc. and the enhancements could also be used to advantage by people working in those fields.

RD44 Phase

1994 ~ 1998

RD44: Kick-off (1994)

■ Approval of P58

- P58 was approved by DRDC in October/November 1994
 - ◆ Geant4 was born
 - ◆ *10 years old this year (10th anniversary!)*
- Project name: RD44

■ Milestones for the 1st year set by DRDC

- Produce a global object-oriented analysis and design for the Geant4 simulation toolkit.
- Develop a C++ prototype of the geometry and tracking in order to evaluate its performance in comparison with GEANT3.

RD44 : 1st Year - OO Analysis

■ OO Analysis: Steps and products:

1. To collect user's requirements
 - User Requirements Document (*ESA PSS-05*)
2. To identify major objects/classes in the problem domain based on URD (adopted the Booch methodology).
 - Various methodologies were studied before choosing Booch.
3. To produce a central model (object diagrams) for each object/class found in the above step.
 - Object diagrams
 - Scenario (Object Interaction) diagrams
4. To cluster classes which have closely coupled relation
 - Class category diagrams

RD44 : 1st Year - OO Design

■ OO Design: Key aspect in the worldwide collaboration

- 'Class Category Diagram' had a fundamental importance in the Geant4 collaboration.

→ Cohesive and loosely coupled nature enabled us to implement each category relatively independent.

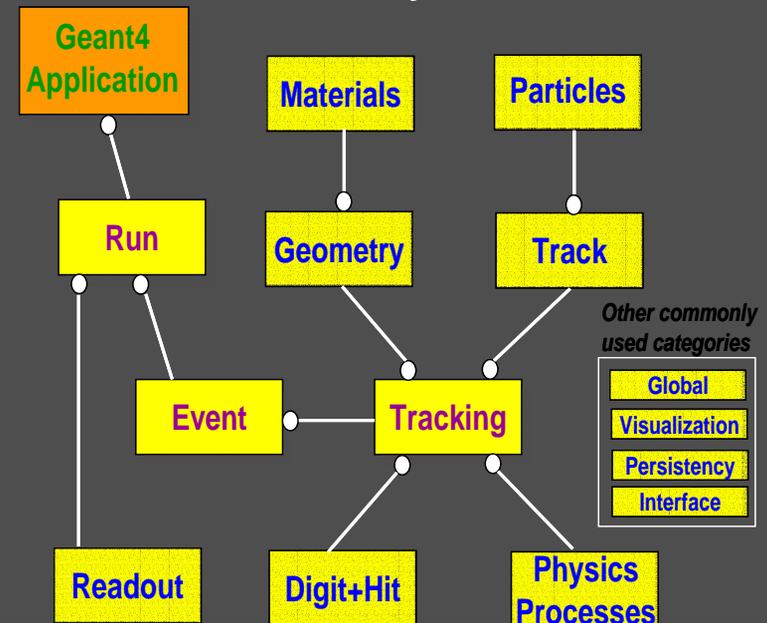
→ We used each class category as a unit to share tasks in OOD (and also in the implementation phase)

→ *Essential for worldwide collaboration*

- The basic design of the G4 kernel was created by delegating detail design works to each category group (works shared worldwide).

Category Diagram (Ver. 1998)

Note: Most categories defined in the 1st year



OO Design: A Fundamental Decision

■ *Most fundamental/critical and challenging design in Geant4*

- How to design 'particle' and 'interaction' in OO way?

■ *OO purist vs. pragmatist view*

- Purist: Particle is obviously an object in the real/natural world. Why not to mimic the nature?
 - ◆ Fly by itself, interact by itself, decay by itself,,,,
 - ◆ Active object!
- Pragmatist: Simulation is not the real world
 - ◆ The user wants to access to simulation information on fly.
 - ◆ The user wants to control artificially the particle fate.
 - ◆ Passive object!

■ *Decision – Take the pragmatist's approach*

- Not enough time to explain details, but it took long a time to settle down the debate
- This decision introduced the design pattern you often find in Geant4:
 - ◆ A passive object managed by an active object manager
 - ✦ Step/SteppingManager, Track/TrackingManager
 - ✦ Event/EventManager, Run/RuntManager
 - ✦ Process/ProcessManager, Visualisation/VisualisationManager
 - ✦

RD44 : 1st Year - Prototype code and Performance

■ Prototype code

- Based on the OO design, the kernel part of the C++ code implemented
 - ◆ Codes developed independently were merged during the workshop at CERN in the 1st week of September 1995.
 - ✦ Tracking (Japan) and geometry (CERN) codes were merged without a serious problem just in one day.
 - ✦ Many collaborator convinced that we were in the right direction.
 - ✦ PIIM (electromagnetic processes) codes were merged after the workshop

■ Bench mark executed

- Comparison of G3 and G4 minimal driver (geometry)
- Geantino full comparison (geometry + tracking)
- Muon events comparison (geometry + tracking + piim)
- Demonstrated that G4 is faster than G3

■ Status report submitted to LCRB

- 18 Oct. 1995
- CNER/LHCC/95-70, LCRB Status Report/RD44

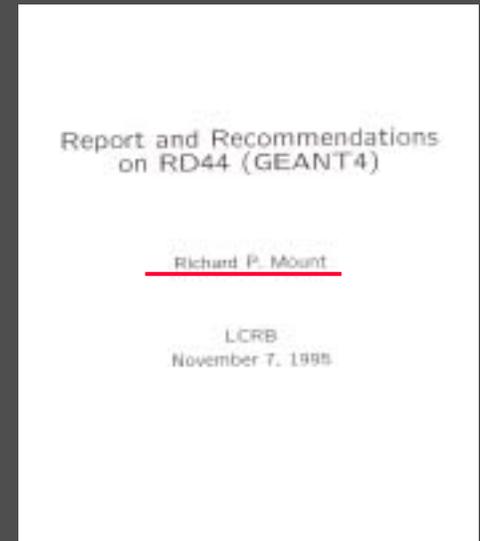
RD44 : 1st Year – LCRB Recommendations

■ Success

- Decomposition of the task into sub-domains to make effective use of the skills of the collaborators.
- Efficient intercontinental collaboration.
- Attraction of new collaborators with complementary skills and interests.
- Appropriate use of consultancy
- A convincing indication that GEANT4 will be faster than GEANT3.

■ Recommendation – Major milestone

- Release a first version of GEANT4 with geometry, tracking and electromagnetic physics at least equivalent to GEANT3 for the simulation of events in LHC detectors.
- This milestone to be reached by early 1997.



RD44 : Geant4 Alpha Release

■ Geant4 Alpha Version

- Released in April 1997
- Met the milestones set by DRDC in 1995.
- Released to alpha testers (major experiment groups in the G4 collaboration)

■ Major characteristics of the release

- Comparable functionality to GEANT3 for geometry, tracking, electromagnetic physics, and high/medium energy hadronic physics
- Persistency of Geant4 hits objects to ODBMS available by RD45.
- The design and implementation of all physics processes allow the user to easily understand – and eventually modify – the underlying physics models.

■ Report submitted to LHCC

- CERN/LHCC/97-40, LCB Status Report/RD44

CERN/LHCC/97-40



#Members=93
#Institutes=36
#Countries=13

RD44 : Toward the Final Goal

■ Geant4 Beta Version

- Released in July 1998
- Major characteristics of the release.
 - ◆ Open beta-version of the full Geant4 system together with documentation, examples and tutorials.
 - ◆ Provided the concept that STEP compliant CAD models can be directly used for physics simulation
 - ◆ Extended further the physics validation range, and provided low energy neutron transfer for radiation studies.
 - ◆ Optimized and evaluated the physics and speed performance of the system

■ Geant4.0.0 Production Release

- Released in December 1998
- Major characteristics of the release
 - ◆ The first full production version with detailed documentation, examples and tutorials.

■ *RD44 closed at the end of 1998*

RD44 : Conclusions

Quotation from the S. Giani's final report to LCB in 1999

- **Software Process:**

World-wide distributed OO design and development is possible and is convenient for LHC.

- **Technology:**

Object-Oriented methods and languages (C++, Java) are optimal for LHC.

- **Physics:**

Transparency of design and implementation improves reliability of results for LHC.

- **GEANT4:**

A toolkit for simulation of HEP, space, radiation, nuclear, medical... applications.

Geant4 Collaboration Phase

1999 ~ present

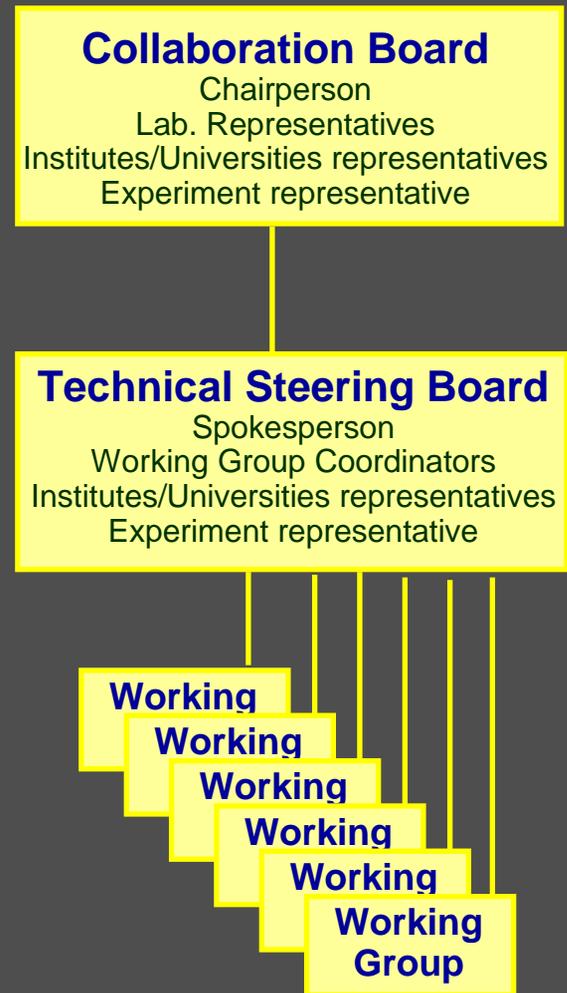
Geant4 Collaboration: Birth

■ New organization

- International Geant4 Collaboration started immediately after the close of RD44 - January 1999
- It is based on the Memorandum of Understanding (MoU) signed by laboratories, institutes and experiment groups over the world.

■ MoU

- To define a distribution of management, support and development of G4 software
- The parties signed at the kick-off:
 - ◆ CERN, ESA, KEK, SLAC, TRIUMF, INFN, LEBEDV, LPNHE, ATLAS , BaBar, CMS, LHCb
 - ◆ More in the later stage



Geant4 Collaboration: Birth and ICFA

■ Organization proposed by G4 Collaborators

- How to establish/extend the organization structure of the RD44 phase was discussed extensively in the last year of RD44.

■ Proposal to ICFA – Feb. 1998

- G4 Executive Board submitted a proposal for discussion in ICFA at Paris for the possibility to organize the Geant4 collaboration under ICFA.

■ The conclusion from ICFA (from the minutes)

- “ICFA commends CERN for initiating this work (Geant4 project), but notes that it has evolved to the point where a more formal structure may be needed...”
- ICFA continued their discussions after the Paris meeting.

■ Outcome

- CERN wanted to organize as a MoU base (like an experiment) – not under the ICFA umbrella.
- April 1998 we gave up the idea of an organization under ICFA and adopted the MoU based one.



Geant4 Code Release History

■ Basic policy of release

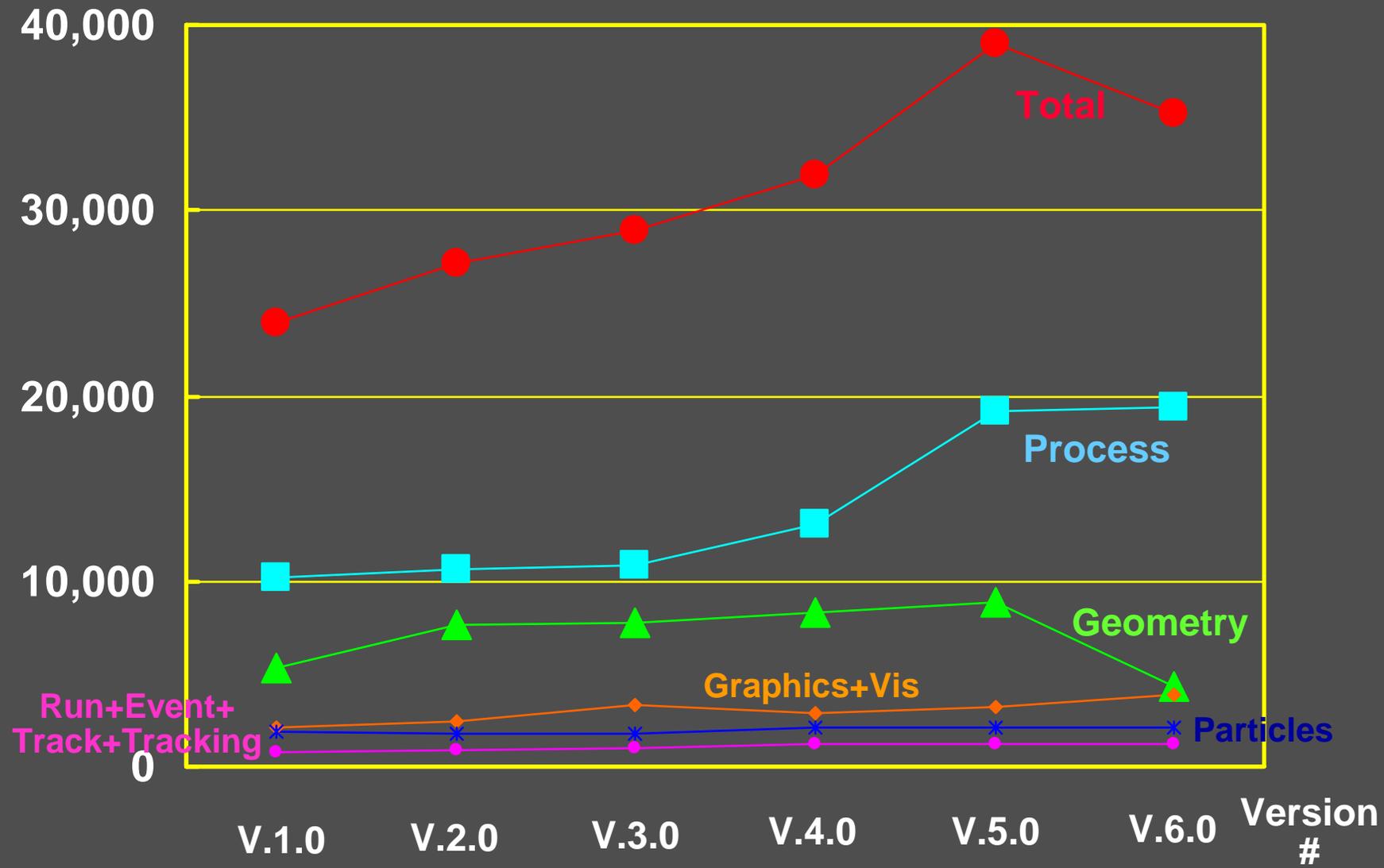
- Two to three public releases per year
- Monthly development tags for collaboration users

■ History (*showed only main public releases*)

- Dec 1998: Geant4 0.0 release (*RD44*)
- Jul 1999: Geant4 0.1 release (*1st release in the G4 Collab. Phase*)
- Dec 1999: Geant4 1.0 release
- Jun 2000: Geant4 2.0 release
- Dec 2000: Geant4 3.0 release
- Dec 2001: Geant4 4.0 release
- Dec 2002: Geant4 5.0 release
- Dec 2003: Geant4 6.0 release
- Dec 2004: Geant4 7.0 release (*coming!*)

Size Evolution of Geant4 Source Code

Size
(MByte)



Geant4 Reviews

■ Independent review

- G4 Collaboration Board decided to convene periodic external reviews.

■ **Independent Review in June 2001** (*from Executive Summary*)

- The Geant4 project has been a tremendous success in its two and a half years of existence: the Geant4 simulation toolkit is gaining widespread acceptance as the tool of choice....
- A quite numbers of concrete recommendations submitted

■ **Independent Review in October 2002** (*Reviews Conclusions*)

- The international collaboration Geant4 has been very successful in creating both the Geant4 simulation toolkit, and the community behind it.
- The future success of Geant4 crucially depends on the board acceptance by the user community, in particular the High Energy Physics experiments. Geant4 has responded well to the committee's previous recommendation for greater openness and possible customer support. We congratulate them on their efforts.

Summary

- The history of Geant4 starts from the two R&D object-oriented software projects initiated independently at CERN and KEK.
- The approval by DRDC/CERN to the P58 proposal was the birth of Geant4.
 - Geant4 is 10 years old this year!
- Through the phases of 'RD44' and 'Geant4 Collaboration', Geant4 has grown to a product used not only in HEP but also in space, radiation, nuclear, medical... applications.
 - This is the goal we set at the start of RD44.
- The Geant4 project is the first example of developing a large scale software in a world-wide collaboration of more than 100 members in the HEP community.
- Fundamental success is based on
 - OO technology
 - Mutual trust among the members in the international collaboration
 - Strong supports from the user communities, major laboratories and institutes/universities over the world.