



GEANT4

in the Simulation project

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S Sadilov and JP Wellisch

LCG Application Area Internal Review, 22 October 2003



Overview

- The biggest issues for LHC users and LCG in 2003
 - Key deliverables from 2002
- The Structure & Work Packages
 - Highlights of the work items
- Interactions
 - With other simulation 'streams'
 - With other LCG projects



The G4 'big picture' for LHC users

- Largest goals & activities in 2003
 - Release with 'cuts-per-region'
 - Tackling problems for robustness (CMS production)
 - Support for urgent problems, questions, (ATLAS, LHCb, ..)
- Important goals
 - Creating new developments and refining existing functionality
 - To enable advanced users to use G4 effectively
 - Investigating feedback from physics comparisons
 - Addressing issues that arise
 - Improving testing framework
 - With the increasing importance of system testing
 - Assisting in collecting & analyzing new requirements



A few highlights from 2002

- Hadronic Cascade models
 - Binary cascade (G Folger, JP Wellisch)
 - Verification suite (V Ivanchenko, JPW, and D Wright SLAC)
 - Also from HIP: Bertini cascade (A Heikinnen)
- Physics Lists for hadronic use cases
 - First release Sep 2002
- EM refinements
- Event biasing: 'importance biasing'



Structure

Work packages

1. Geometry, Field and Transportation
2. Software Management, System Testing and Releases
3. EM Physics and error propagation
4. Hadronic Physics
5. Coordination



Work packages and people

1. Geometry, Field and Transportation

- G Cosmo (resp., ~40%), V. Grichine (60% from July), J. Apostolakis (~5%), O. Link (new July)
- M. Dressel (left Sept), G. Daquino (new May, shared with Validation),

2. Software Management, System Testing and Releases

- G Folger (resp, 40%), S. Sadilov, G Cosmo (~60%), I. McLaren (~20%)

3. EM Physics and error propagation

- V. Ivantchenko (resp, ~90%), V. Grichine (~40%), P. Mendez (left Sept)

4. Hadronic Physics

- J.P. Wellisch (resp), G. Folger (~60%), M. Kossov (from July), V Ivantchenko (~10% in 2003)
- A. Ribon (part, shared with Validation)

5. Coordination

- J. Apostolakis



Geometry, Field and Transportation

- **Regions** for the “Cuts per region” functionality
 - Release (April, G4 5.1) & further refinement (5.2) **G. Cosmo**
- Performance in Magnetic **Field** tracking
 - Evaluation and improvements (June, G4 5.2) **J. A.**
- Event **biasing**
 - weight roulette (G4 5.2, Q2) **M. Dressel**
 - weight window (Q3)
- Creation of a new **solid**: twisted trapezoid **O. Link**
 - Identified solution. Implementation Q4
- Contributing to creation of new **divisions**
G Cosmo from development of **P.Arce**

Geometry, .. (cont)

- Improvements to overlap detection tool
 - Response to request from ATLAS & CMS G. Cosmo
- Maintenance and Support V. Grichine
 - LHCb problem reports
 - Safety and boolean solids
 - CSG solid implementation revision
- Currently under development G. Cosmo
M. Dressel
 - Abstract Navigator (BaBar, Alice req.)
 - Design and prototype implementation
 - Further improvement in field O. Link
J. Apost.
 - Using feedback from performance studies

P. Arce, A. Ribon

Software Management, System Testing and Releases

- Provision of all system testing & releases
 - Including Geant4 5.1 (April), 5.2 (June)
 - Patches: 5.1p1, 5.2 patches 1 (Aug) & 2 (Oct)
 - Monthly development tags & two public betas.
- Provision of CERN installations
 - For releases, patches and dev tags.
- Production system improvement
 - Bugzilla: Improved responsibility assignment
 - Bonsai: porting for different browsers (developed)
 - All: a security assessment & first fixes

S Sadilov

G Cosmo

I McLaren

S Sadilov

Software Management, System Testing and Releases (continued)

○ Testing

- Integration of further advanced examples
 - Simplified version of LHC test beams
 - LHCb Rich, CMS Composite_calorimeter, ATLAS LAr-calorimeter
- First support for statistical test50.

S Sadilov

○ Improvements

- To installation script
- To automation of testing system ([Bonsai](#)/Tinderbox)

S Sadilov

○ Discussions with SPI project

- Feedback on savannah and agreed prototype use
 - with view to have it replace Problem Reporting system (which is based on Bugzilla)
- Make trial use of cppunit/oval testing tools for some new tests

EM Physics and error propagation

- Cuts per region capability
 - First development tag Jan 2003
 - Monthly improvements to release 5.1 (Apr) and 5.2 (Jun)
 - Testing in single and multiple region use cases
 - Lifted 'global' last-step limitation in ionization
 - Now specialized per region
 - As a result overcame performance penalty for multi-region detectors (eg CMS, ATLAS, ..)
- Model approach
 - Development: design & implementation refinement
 - Testing on 6 EM sub-system tests, in BaBar and CMS
 - Release as default in September ref-tag.
 - Further improvements

V. Ivantchenko with M. Maire (LAPP), L. Urban (MPFI)

EM & err. Prop. (cont)

- Geant4e error propagation module
 - Design & implementation refinements undertaken
 - Presented in AA mtg & G4 workshop P. Mendez with P. Arce (Madrid CMS/CERN)
 - Working code at level of first prototype
 - further validation of the current prototype now depends on external effort
 - Release date is under review
- Statistical test of Atlas FCAL test beam
 - with the assistance of FCAL team
 - ➔ for use of test beams in regression
 - in regular testing & acceptance testing P. Mendez

Hadronic Physics

○ Review of pion cross-sections

JP.Wellisch

- Reaction X-section data for π^+/π^- : Be to U, $E < 1.4$ TeV.
- Below 1 GeV added data for π^+/π^- X-section differences.
- Verified X-section data-sets, and adjusted physics lists.
→ Much improved shower shape in ATLAS HEC calorimetry.

○ Extended robustness testing of electro and gamma-nuclear physics

J.P. Wellisch, M. Kosov

- Ran 50PeV EM energy flow in calorimeter set-ups.
→ Prepared CMS production use.

○ Extended electro-nuclear reactions beyond 50 GeV

- Folded approximate function for γ -N X-section over 50 GeV with equivalent photon flux
→ Direct response to a CMS production need.

M.Kosov

Hadronic physics continued

- Light ion reactions in **binary cascade** (G. Folger, J.P. Wellisch, summer student B. Trieu)
 - First step towards use of binary cascade for fragmentation code after string model.
- **Pion induced** reaction in binary cascade (JP Wellisch)
 - Included t-channel resonance de-excitation.
 - Created absorption engine (quasi-deuteron assumption)
 - Tuning of microscopic absorption cross-section now ongoing.
 - Alternative microscopic model for pion nuclear scattering.
- **Verification suite:** (now mostly external contributions)
 - Numerous extensions for particle production and activation, in proton and pion scattering in the cascade energy range

Hadronic physics continued

- Extended 'technical verification' in cascade region (robustness, reproducibility) **A.Ribon, J.P. Wellisch**
 - Used both cascade models to run mass-production on typical calorimeter geometries.
 - Reproducibility of event sequences
 - from **D. Wright, W. Pokorski** (external)
 - ➔ Established production quality robustness.
- Included **recoils** in final states of coherent elastic scattering.
 - ➔ Necessary to enable methods calculation of NIEL
- ➔ First release of **Hadronic Physics lists** targeted for LCG / **LHC** experiment requirements **J.P. Wellisch**
 - See <http://cmsdoc.cern.ch/~hpw/GHAD/LCGPage>
 - ➔ Basis of the validation process

Hadronic physics continued

- Development of **leading particle biasing** and **cross-section biasing** for hadronic use cases. **J.P. Wellisch**
 - Design iteration of the implementation frameworks
 - to decrease coupling to track
 - porting of all hadronic code (400k LOC).
 - Implemented cross-section and leading particle biasing.
 - FOM estimate performed for a typical use-case.
 - ➔ State of art technique; enables specialized studies, eg CLIC.
- Reviewed the packaging, and restructured the code organization (**JPW, external contributions: V. Lara, P.Truscott,, F. Lei, D. Wright, ..**).
 - ➔ Structure now SCRAM compliant with small modifications.



Coordination

- Collaboration with other projects, SI 'streams' and Geant4 collaboration (see next slides)
- Direct communication on new requirements
 - And encouraged participation in Geant4 Workshop (Sept at TRIUMF)
- Participation in new Geant4 Technical Forum
 - Encouraging the users to bring forward their requirements
 - Run/Event issues, Physics Lists release, ..
 - Hosting of second TF meeting (Oct 7th at CERN)



Interactions and collaboration

with other SI 'streams'

- Validation
 - Monthly meetings on validation
 - Feedback on physics comparisons
 - Providing improvements and updates on them & on new functionality
- Framework
 - Discussions with Andrea & subproject members
 - Follow-up of relevant requirements

with other LCG projects

- SPI
 - Test-bed use of savannah agreed
 - Trial use of testing tools planned in new tests.
- PI
 - Continued use of AIDA for tests
 - Uptake of statistical testing tools, that utilise AIDA underway.
- SEAL
 - Continued use of CLHEP
 - First use of python 'driver' under study



Collaboration with Geant4

- Very important to maintain the good collaboration in Geant4
- In many areas of work CERN and external contributors collaborate strongly
 - EM physics, Hadronic Physics
- For other areas CERN contributes a large part of the effort (but not all)
 - Geometry, system testing, software management
- For several areas, only external expertise
 - Run/Event, particle, track, visualisation, UI, ..



Further upcoming work items

- Restructuring for Cuts-per-region
 - And deleting of obsolete parts (thanks to H. Kurashige, Kobe Univ.)
- Fixes
 - Intersecting boolean solids
- Release 6.0 (December) including for the first time in a release
 - RunManager refinements (thanks to M Asai, SLAC)
 - 'Model' approach for "Standard" EM as the default
 - The old implementation still available



Plans for 2004

- Support and maintenance
 - Will continue to require a large portion of effort
 - Will address issues for large experiments, ..
- Open issues
 - Combination of string models with cascade for nuclear fragmentation
 - Investigation of exceptions (CLHEP)
- Further improvements
 - Physics modeling refinements
 - Creating an acceptance suite
 - Pending requirements & requests
- Addressing new requirements
 - for flexible restoring of physics lists
 - For capability to extend volume 'stores'



Summary

- Created release with Cuts-per-Region capability
 - Priority to enable CMS production
- Large effort in support in geometry, hadronic physics
 - Robustness issues raised by CMS, LHCb
- New requirements
 - From Atlas, CMS
 - Some already have been addressed in development tags & will be in 6.0
 - Others require longer term effort
- Turnover of people