Validation of simulation packages in LCG

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Plan of the talk

- LCG Generator project: event generators in the LHC era
- Validation of Geant4
**LCG Generator**

**GOAL:** to guarantee the generator support for LHC

**WP1:** GENERATOR SERVICES LIBRARY (GENSER)

**WP2:** EVENT FORMATS AND EVENT INTERFACES

**WP3:** SHARED EVENT FILES: FRAMEWORK & DATA BASE (MCDB)

**WP4:** TUNING AND VALIDATION

- Florida (Coordination)
- CERN (Library, Event Interfaces)
- LCG-Russia (Library, Data Base)
- LCG-Spain (Framework)

Collaboration with independent projects: LCG-UK (Validation, New MCs)

Contact persons/Collaborators in MC Projects and LHC Experiments

**Started May 2003**

**Long Term Project**
WP1. The LCG Generator Library (GENSER)

GOAL: to replace the obsolete CERN Library for what concerns the Generator Services

→Mandate:
  ❖ To collaborate with MC authors to prepare LCG Compliant Code
  ❖ To maintain older MC packages on the LCG supported platforms

→Clients:
  ❖ Addressed to LHC experimentalists and theorists both at CERN and in external laboratories (Other users welcome!)

 ✓ CVS Repository, AFS Distribution
 ✓ MC Packages & Example/Test Package
 ✓ Tested by all the LHC experiments
 ✓ Quarterly Release Scheme + bugfix (“light”) releases once per quarter.

ATLAS & LHCb PRODUCTIONS RELY ON GENSER
CMS Joining… Others welcome

Documentation: http://lcgapp.cern.ch/project/simu/generator
AFS: /afs/cern.ch/sw/lcg/app/releases/GENSER
WP1. The GENSER Team

- Liaisons with authors and LHC experiments ~.25 FTE
  - A. Ribon (CERN) based at CERN
  - P. Bartalini (University of Florida) based at CERN

- Coordinator of GENSER Releases (Librarian) ~.25 FTE
  - A. Pfeiffer (CERN) based at CERN

- GENSER Integrators & MC Experts ~1FTE
  - M. Kirsanov INR (Moscow) Master Integrator
  - I. Katchaev IHEP (Protvino) Integrator
  - A. Toropin INR (Moscow) Integrator
  - S. Slabospitsky IHEP (Protvino) MC Expert
  - O. Zenin IHEP (Protvino) Integrator (new)
WP1. GENSER status and plans 2006

- **GENSER_1_3_0** – last major release, March 2006. 27 packages.
  - Pythia8 and Herwig++ inside GENSER (M.Kirsanov)
  - Two levels of release tests, development of level 1 (M.Kirsanov, O.Zenin)
  - Heavy ions generators: HIJING, PYQUEN, HYDJET
  - Release policy and tools (A.Pfeiffer)

Number of generators starts to saturate; accent being shifted towards **convenience, tests, validation**

- Further development of procedures for **Light Bug Fix Releases**
- Develop the package TESTS
- User support (versions 1_3_0 – 1_4_0)
- Increase support for Makefiles
- Continue testing with gcc 4
- **Migrate to HepMC in the package TESTS** to provide a general approach to c++ and Fortran generators.
- Update of already introduced Sub-package versions
  - Requests from the LHC experiments are welcome
WP1. New compilers

- **gcc4.** Default CERN Linux SLC4 is built on it.  
  G77 → gfortran. Not all Fortran 77 features supported.

- Small problems in **PYTHIA**, a lot of problems with  
  **HERWIG** (return to label, entry points). GENSER team  
  collaborated with authors. **gcc4 compliant** versions prepared  
  by **GENSER release 1.2.1**. Preliminary tests made. Note  
  that platforms with gcc4 are not yet supported by LCG,  
  hence by GENSER, but we prepare to them beforehand

- Other generators and packages to be tested with gcc4. Work  
  started (Rafael Yaari at CERN)

- 64 bits platforms come soon. Tests will be needed (heard  
  about problems with fortran codes)
WP1. Testing

Large scale MC productions involve a lot of manpower, they are expensive.

A bug in MC generator, depending on its severity, can make a production mostly useless.

Detailed validation of MC, comparison of distributions with previous versions and data, can take a lot of time.

Several levels of tests and validations can help.

Test thoroughly! Test quickly!
WP1. Testing

- **Level 0** test. Special script checks the existence of libraries according to definite rules (one, several or no libraries should correspond to the generator (the latter in case of external generator))

- **Level 1** test. Dedicated package in GENSER. It compiles one or several applications for each generator to be tested and runs them one by one. Each applications writes some numbers in a file. At the end this file is compared with the standard file, the problems and differences are reported.

- Next tests are outside WP1. Additional levels can be used.

- **Level 2** tests. Dedicated projects (WP4).

- **Level 3** tests. Tests inside the experiments.
WP1. Level 1 testing, more details

- **Dedicated package** in GENSER: TESTS, additional dependencies, like ROOT, moved here
- The results are often correct, but not identical, even if random numbers sequence is repeated: it is Monte Carlo! Need to look for significant changes, taking into account statistical errors.
- Comparison is made by a program. It detects missing results in case of test crash and continue
- **10 most important generators out of 27** are now involved in this testing. The work is to be continued. The plans for 2006 are to increase the number of tests by a factor of 4 (at least)
- The full testing takes about 1 hour (shared and archive libraries are tested separately, generators with HEPEVT common block with sizes 10000 and 4000 also separately)
- In 2005 – 2006 at least **4 bugs** and unexpected “features” found with level 1 testing, at least one bug in PYTHIA found with level 3 (CMS). GENSER is going to take part of the latter to level 1.
WP1. Improve/centralize bug reports

- The GENSER meeting in May was devoted to this
  http://agenda.cern.ch/fullAgenda.php?ida=a06930

- Sjostrand: The authors of the generators have to process a lot of information, most of which (> 70%) is useless

- ThePEG/Herwig++ use Hepforge:
  http://hepforge.cedar.ac.uk/

- GENSER adopted the wide use of savannah portal
  http://savannah.cern.ch/projects/simu/

- Filtering the problems (many problems are related to the experiments SW)
WP2. Event Formats and Event Interfaces

GOAL: standardize interfaces, support the new OO MCs

- The MC truth Interface
  - **HEPMC**: HEP event format, widely used by experiments and developers
    - January 2006: installed in LCG external, based on the version 1.26 from M. Dobbs. Interfaces to generators split in a separate library. Further development started
    - Discussion about the migration to MathCore vectors instead of CLHEP ones. No decision yet. Painful
  - **HEPML** (XML - Les Houches Agreement compliant)
    - Meta-data format facilitating automated documentation
    - Intensive discussions in preparation of the proposal. The same manpower as MCDB (WP3).

- The modularization
  - Basic idea in ThePEG, HERWIG++, SHERPA
  - From April 2004 LCG Generator participates to the development of ThePEG
    - ThePEG is in GENSER (internally used by Herwig++)
WP4. Monte Carlo Validation and Tuning

GOAL: to cross-check MCs and compare with data

Reference distributions (multiplicities, $P_T$ Spectra etc.)

Promoting common LHC activity on MC Tuning

Standalone Studies

✓ Work on GENSER subpackages
✓ ALPGEN Validation (Perugia) → Essential to verify ALPGEN in GENSER
✓ HIJING Validation (JINR, Dubna) → Encouraged to contribute to JetWeb

Generator analysis framework (together with CMS) H. Naves, Oviedo. Working prototype, limited number of generators. In future GENSER could switch partly to it in testing.

JetWeb [http://jetweb.hep.ucl.ac.uk](http://jetweb.hep.ucl.ac.uk) : Automated data comparisons

Comp. Phys. Comm. vol 153/2 164-178 (2003). In production. Moving under CEDAR. To be switched to GENSER for libraries and codes

HZTOOL: next talk
Conclusions on Generators

- GENSER and MCDB in production
- Validation package TESTS in GENSER taking shape
- Fruitful collaboration with generators authors
- Activity smoothly moving from integration to testing, validation and user support.
- Feedback, requests from users are welcome.
Geant4

- Geant4 [http://geant4.cern.ch](http://geant4.cern.ch) is a toolkit for the simulation of the passage of particles through matter
- Last version is 8.0-Patch01
- Validation: [http://lcgapp.cern.ch/project/simu/validation](http://lcgapp.cern.ch/project/simu/validation)
Geant4: Recent developments

- **The range cut dependences** significantly improved after the improvements of the multiple scattering code.

Sampling calorimeter: cut dependance

- Evis constant if msc off
Step Limitation from MSC

- Limit the step from the beginning of track
  - Not only after a boundary

- Step = $fr \cdot \text{Max (range, lambda)}$
  - New default $fr = 0.02$ (instead of 0.2)
  - Strong constraint only for low energy particles

- Ensure that a track always does few steps in any volume
  more than 1
Result of Upgrades

Backscattering coeff. of 41 keV e- from diff. targets

(normal incidence, cut = 1 keV)

Visible energy in Pb_scintillator calorimeter (1 GeV e-)

Backscattering coeff. of 41 keV e- from diff. targets

(normal incidence, cut = 1 keV)
Atlas HEC : Cu(25mm)-lAr(8.5mm)

Most recent report by A Kiryunin May 10 2006.
Used Physics lists LHEP 5.0, QGSP 3.0, Packaging PACK 5.0

M. Kirsanov, HERA – LHC Workshop, CERN, June 08 2006
LHCb : Pb(2mm)-Sc(4mm)
ILC : W(2.5mm)-Si(0.32mm)

- cpu penalty:
  - 70% at 1mm
  - 10% at 1μm
The problem

- At high energies (> 100 GeV) shower shape is not reproduced well
  - LHEP is best
  - QGSP is much worse
- We are investigating the causes, current candidates
  - Cross sections
  - Neutron production
  - Multiplicities
  - Hadron elastic scattering
- The data from CMS test beam are used: The talks by J.Damgov, S.Piperov, S.Kunori, T.Yetkin.
Approach

- **Shower development**
  - Improve understanding of key components of shower
- **Physics Models in various physics lists**
  - Document how interactions are modeled
- **Cross sections**
- **Hadron elastic scattering**
  - Revision started end 2005
- **General checks of processes**
  - Energy conservation, …
Conclusions on Geant4

- First cycle of the electromagnetic physics validation is completed at the percent level.
- Significant improvements in the multiple scattering code since 8.0 (dynamic step limitations and other changes, without changing the model).
- Concentrating on the hadronic physics validation (more difficult). Develop criteria for the validation for LCG: what can be the maximal allowed disagreement? (Check within physics analyses in experiments, use fast simulation etc.)
- First round of validations shows good results for the most popular observables: e/pions, energy resolution.
- Problems with shower profile: too short in QGSP at energies above 30 – 50 GeV.
- Detailed study of the models, the revision of some of them underway: checking particles spectra, energy conservation etc.
WP3. The MCDB Team

- **MCDB developers**
  - L. Dudko (SINP MSU Moscow)
  - S. Makarychev (ITEP Moscow)
  - S. Belov (JINR Dubna)

- **Other contributors (previous shifters, designers etc.)**
  - A. Kryukov, I. Seluzhenkov, A. Sherstnev, A. Vologdin (SINP MSU Moscow)
  - P. Bartalini (Florida U.)
WP3: Production of Shared Event Files

**GOAL:** to produce certified generator level events

- Use them for **benchmarks, comparisons & combinations** in LHC W.G.
- **Improve the quality of shared samples** with respect to LEP W.G. era !!

**Production framework**

- Proposal June 2004
- Design Available. Prototype Stage
- Active institutions: CERN, Santander, Oviedo

**Production centre**

**Configuration & Book-keeping**

- ~ 0.75 FTE from LCG Russia (MSU, ITEP, JINR)
- LCG-MCDB: Deployed!

In collaboration with CMS

Tested At Fermilab
Tested By CMS

M. Kirsanov, HERA – LHC Workshop, CERN, June 08 2006
WP3. Monte Carlo Data Base (MCDB)

- **Motivations**
  - To Provide Configuration, Book-keeping, Documentation, Storage for the Shared Event Files
  - To keep track of the full generation chain, Exploiting the Competences of Monte Carlo Experts and Monte Carlo Authors

- In Production. Some things to be finalized. To be populated.
Organisational Issues

WEB page
http://lcgapp.cern.ch/project/simu/generator

→ Links to relevant documentation, CVS repository, release.notes etc.

CDS Agenda Home > Projects > LHC Computing Grid > Physics Generators

→ Minutes of meetings, slides of presentations

Meetings:
→ First Tuesday of the month at 5 PM in CERN-32-1-A24 & VRVS

Simulation project mailing list:
project-lcg-simu@cern.ch

Permanent Forum on Physics and Software Issues related to Monte Carlo development & usage