



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>

Savannah Portal: <http://savannah.cern.ch/projects/simu/>

AFS: [/afs/cern.ch/sw/lcg/app/releases/GENSER](http://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

Test thoroughly!
Test quickly!

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

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> : 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

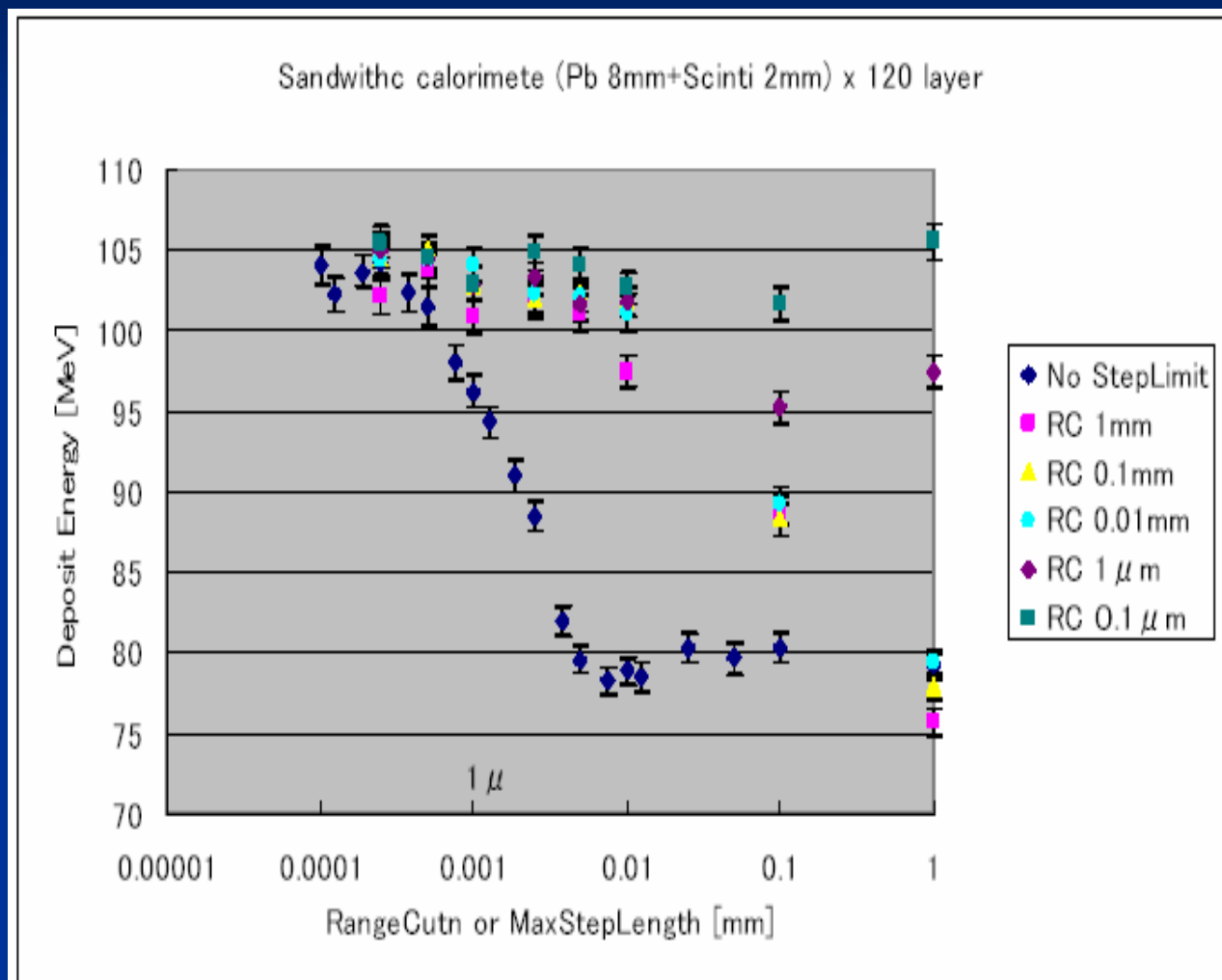
- Geant4 <http://geant4.cern.ch> is a toolkit for the simulation of the passage of particles through matter
- Last version is 8.0-Patch01
- Validation: <http://lcgapp.cern.ch/project/simu/validation>



Geant4: Recent developments

- **The range cut dependences** significantly improved after the **improvements of the multiple scattering** code.
- **The work done by** Laszlo Urban, Vladimir Ivanchenko, Michel Maire. Presented by Michel Maire 30 November 2005.

Sampling calorimeter : cut dependance



- Evis constant if msc off



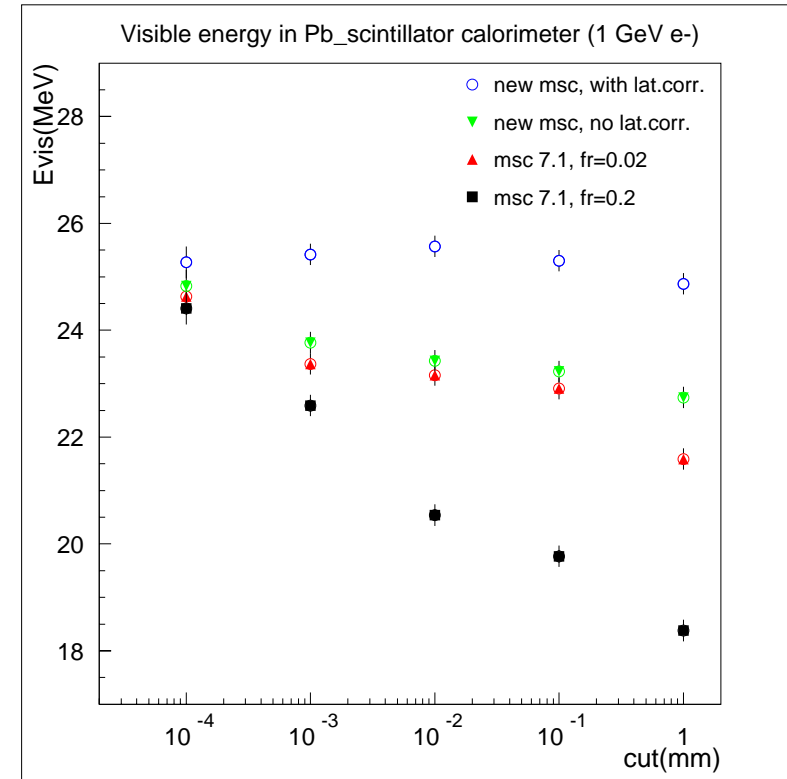
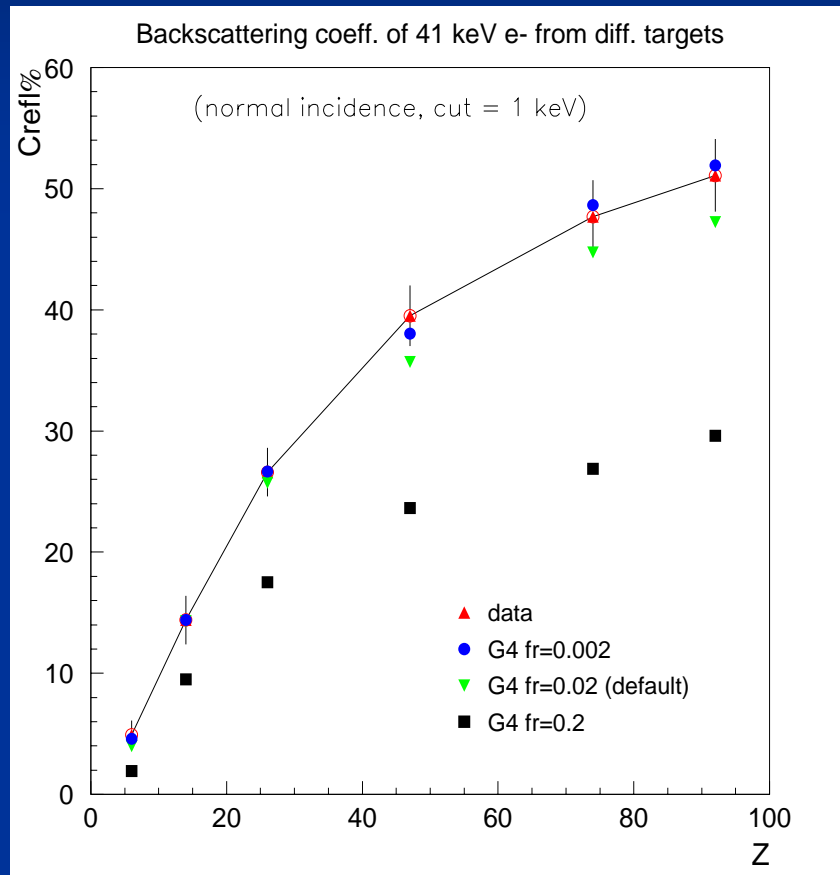
Step Limitation from MSC

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

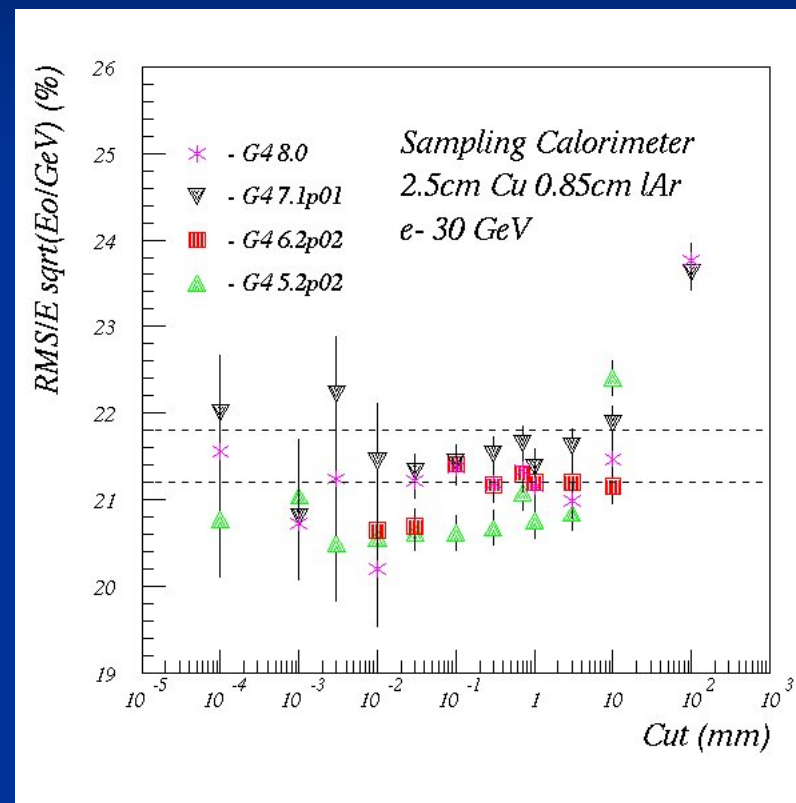
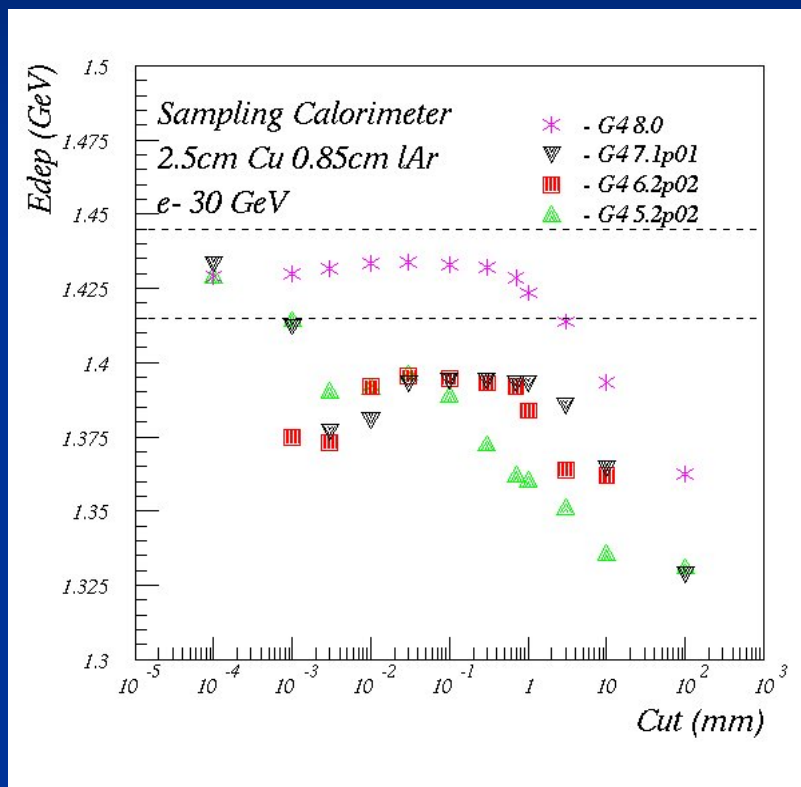
- Step = $fr \cdot \text{Max}(\text{range}, \text{lambda})$
 - New default $fr = 0.02$ (instead of 0.2)
 - Strong constraint only for low energy particles

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

Result of Upgrades

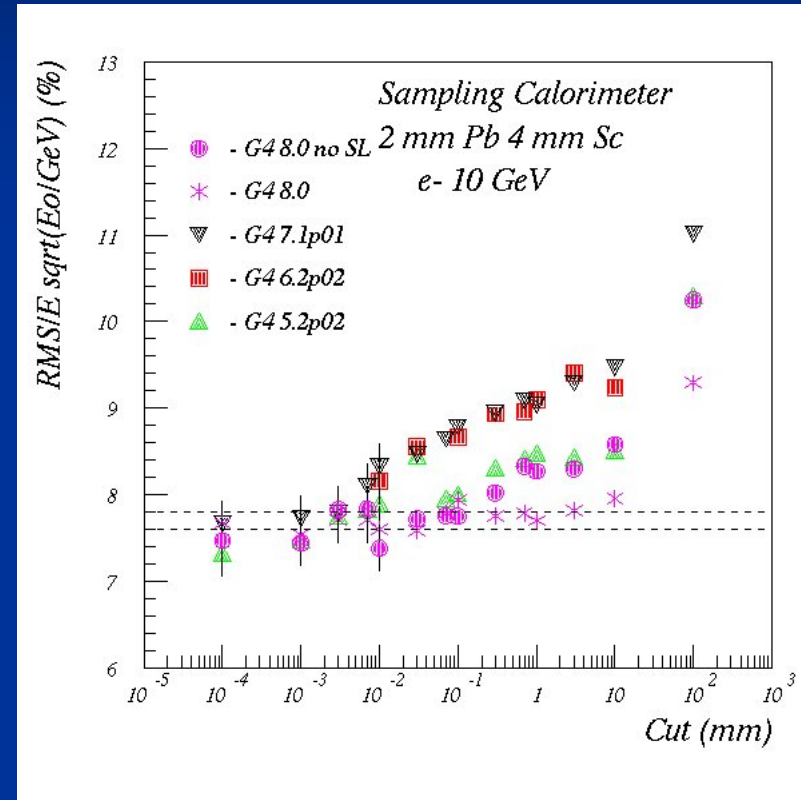
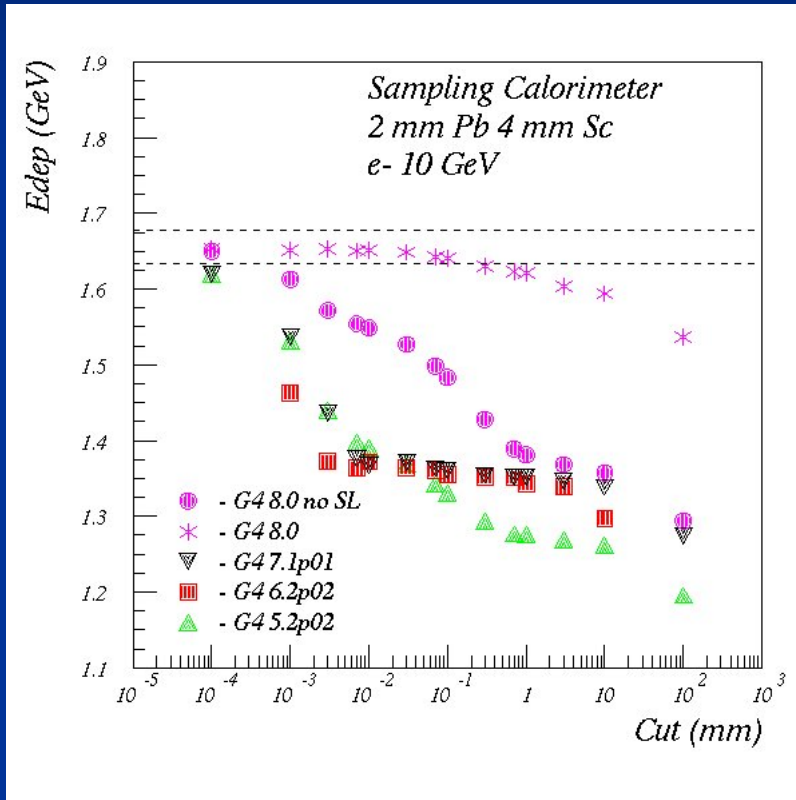


Atlas HEC : Cu(25mm)-lAr(8.5mm)



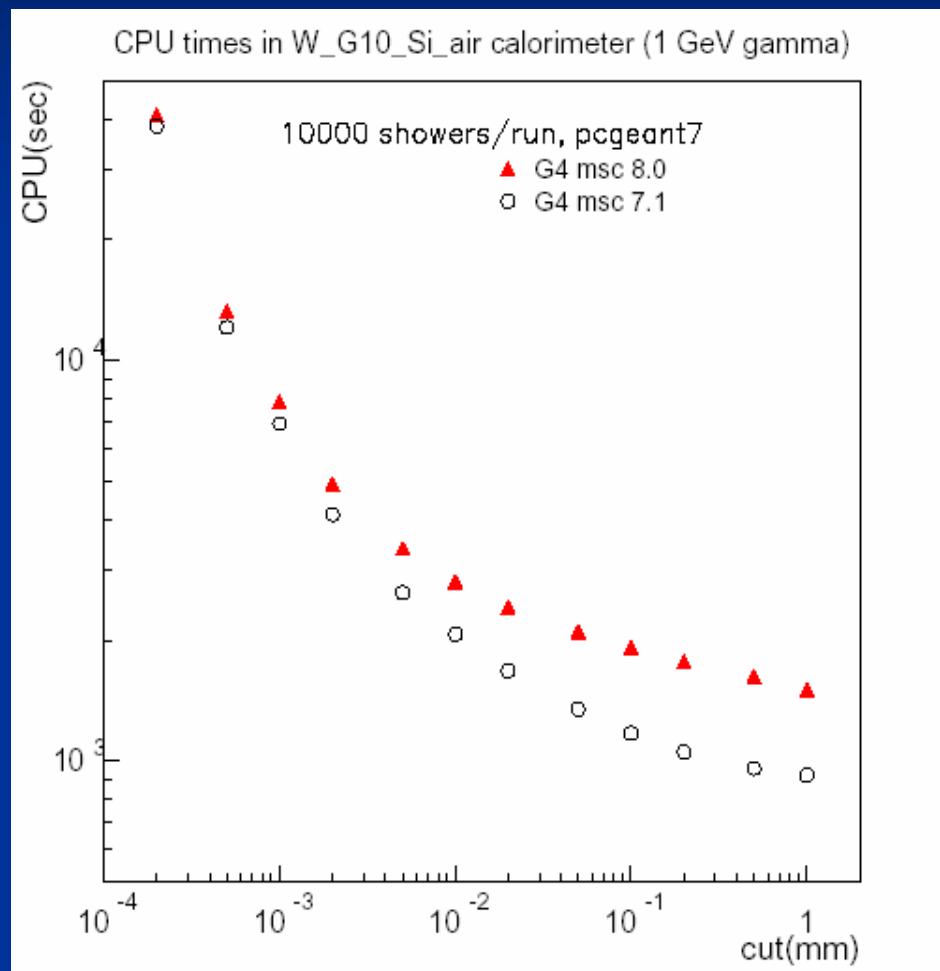
Most recent report by A Kiryunin May 10 2006.
Used Physics lists LHEP 5.0, QGSP 3.0, Packaging PACK 5.0

LHCb : Pb(2mm)-Sc(4mm)



ILC : W(2.5mm)-Si(0.32mm)

- cpu penalty :
 - 70 % at 1mm
 - 10 % at 1um





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.



Background slides



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

**In collaboration
with CMS**

➤ Production centre

➤ Configuration & Book-keeping

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

**Tested At Fermilab
Tested By CMS**

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