



# 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 in ATLAS and CMS.

# 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 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 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.
  - **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

## ➤ Validation Framework

- ✓ JetWeb: in production
- ✓ LCG-UK (U.C.London)
- ✓ <http://jetweb.hep.ucl.ac.uk/>

**[[Comp. Phys. Comm. vol 153/2 164-178 \(2003\)](#)]**

**Database of Data, MC & Comparisons**  
**Web interface, Job submission**

**To be switched to GENSER**



# 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>

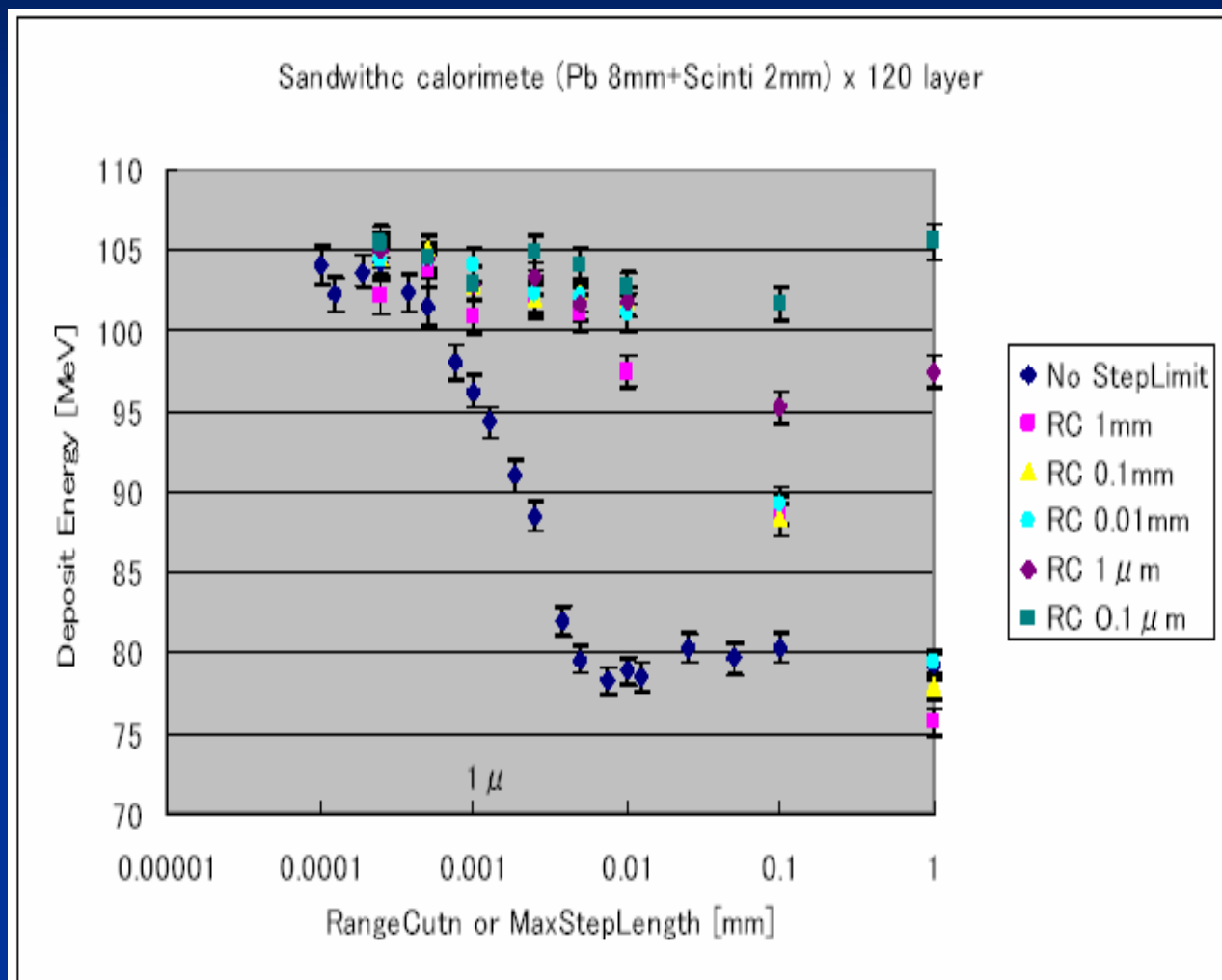


# Geant4: Recent developments

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



# Sampling calorimeter : cut dependance



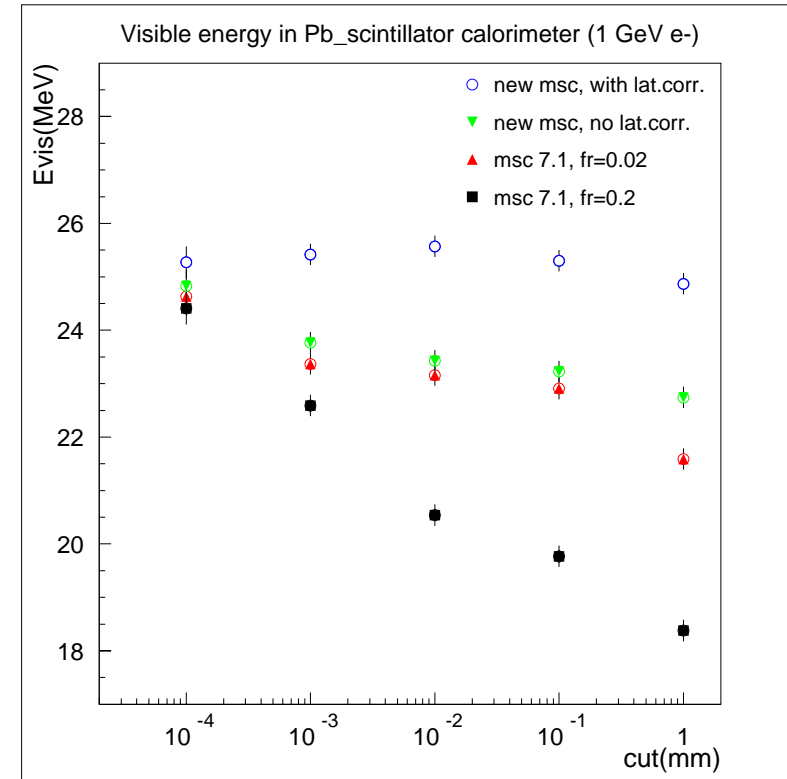
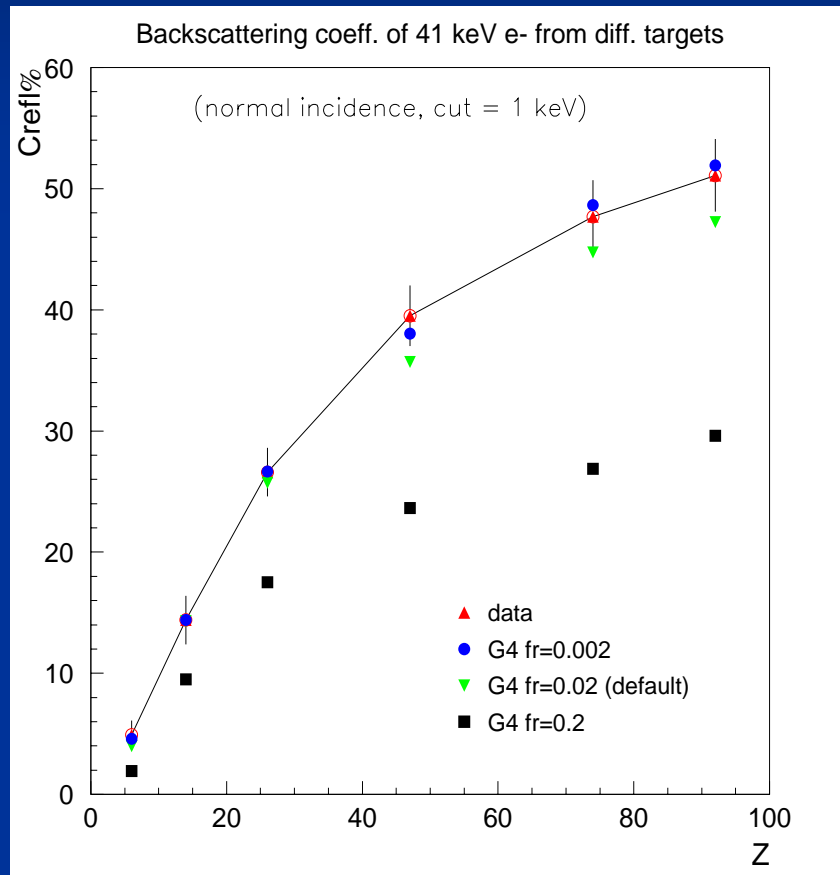
- Evis constant if msc off



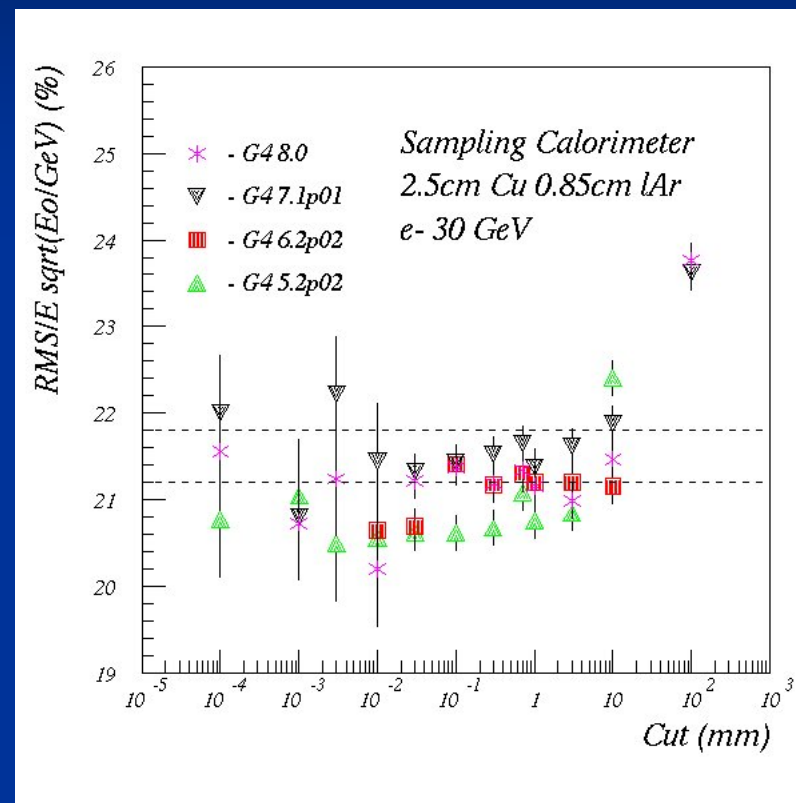
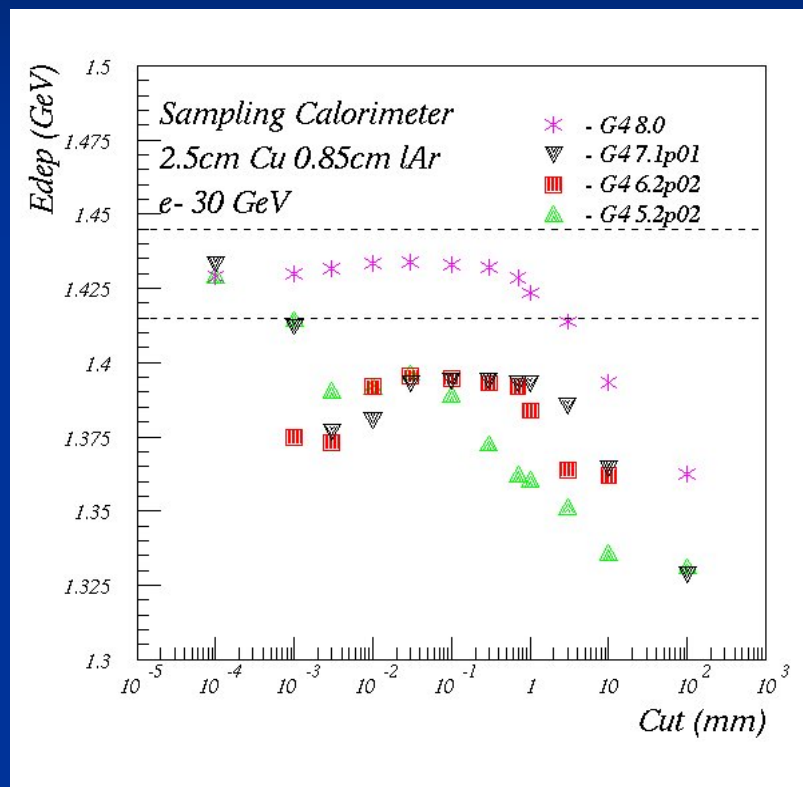
## Step Limitation from MSC

- 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

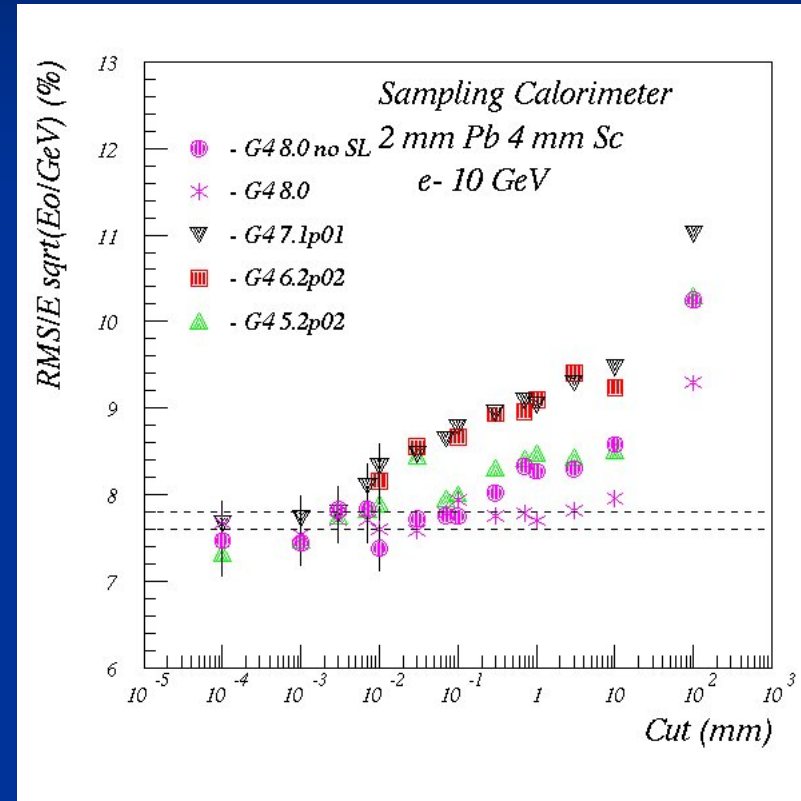
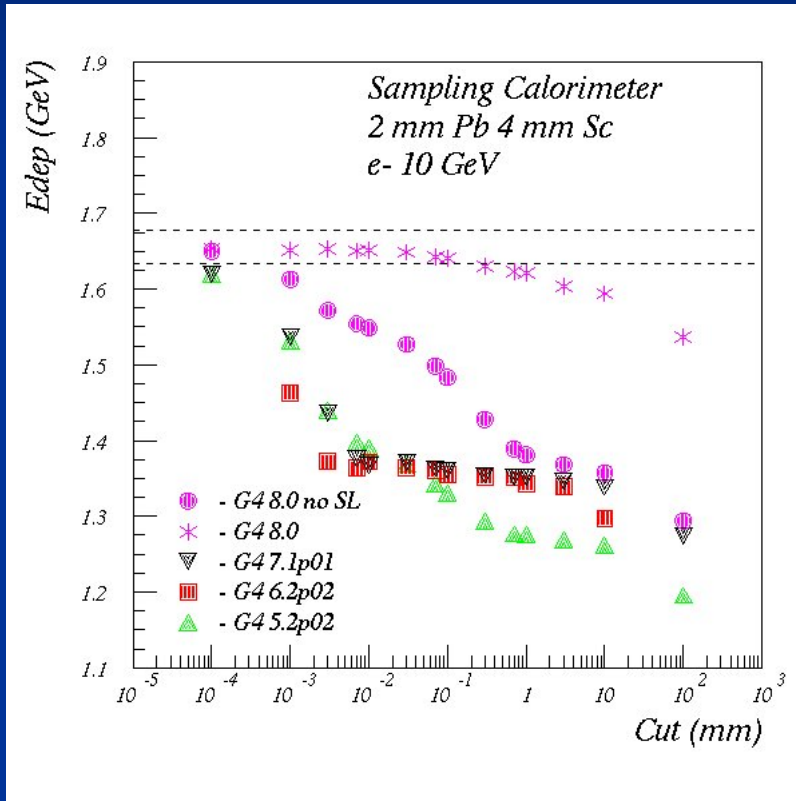


# Atlas HEC : Cu(25mm)-lAr(8.5mm)



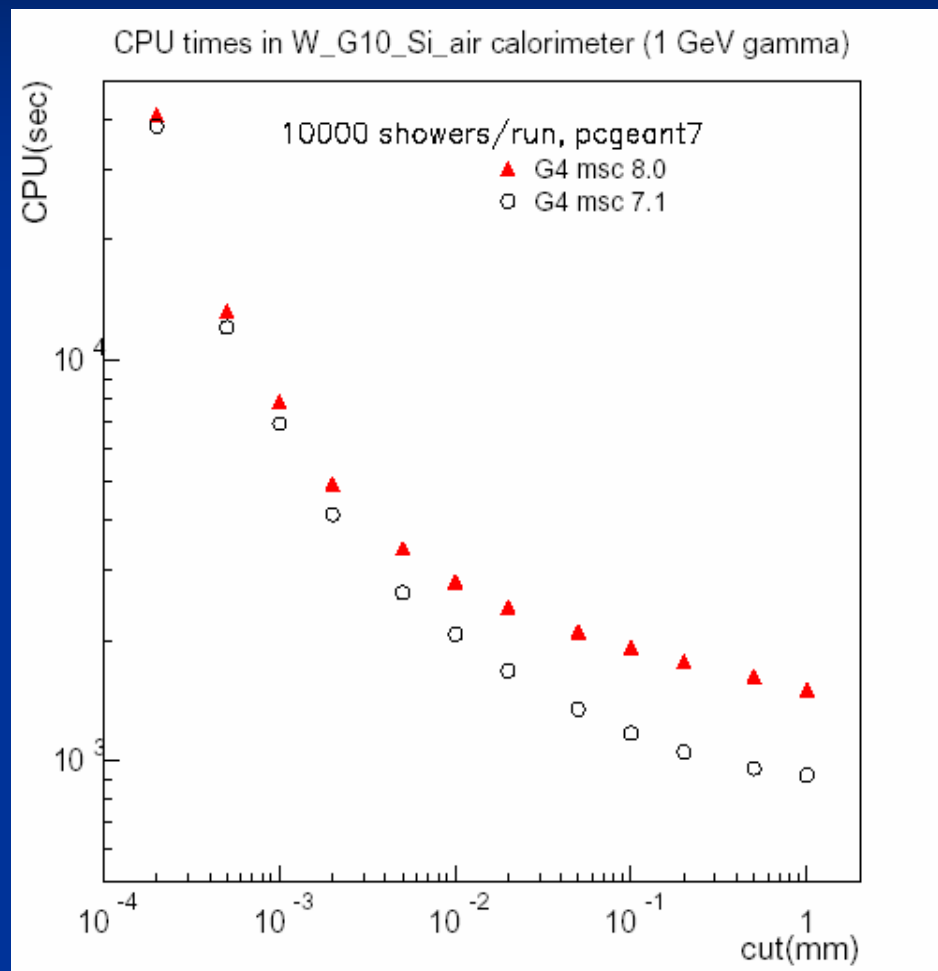
Most recent report by A Kiryunin May 10 2006.  
Used Physics lists LHEP 5.0, QGSP 3.0, Packaging PACK 5.0

# 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](mailto:project-lcg-simu@cern.ch)

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