

Simulation Project Overview

(Very condensed)

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Simulation Project Leader

<http://lcgapp.cern.ch/project/simu>

LHCC Comprehensive Review of the LCG
November 25, 2003



Simulation Project

◆ Generic simulation framework

Andrea
Dell'Acqua

- ◆ Generic interface to multiple simulation engines (G4, FLUKA), building on existing ALICE work (VMC)

◆ Incorporates longstanding CERN/LHC **Geant4** work

John
Apostolakis

- ◆ Aligned with and responding to needs from LHC experiments, physics validation, generic framework

◆ FLUKA team participating

Alfredo
Ferrari

- ◆ Framework integration, physics validation

◆ Simulation **physics validation** subproject very active

Fabiola
Gianotti

- ◆ Assess adequacy of simulation and physics environment for LHC and provide the feedback to drive needed improvements

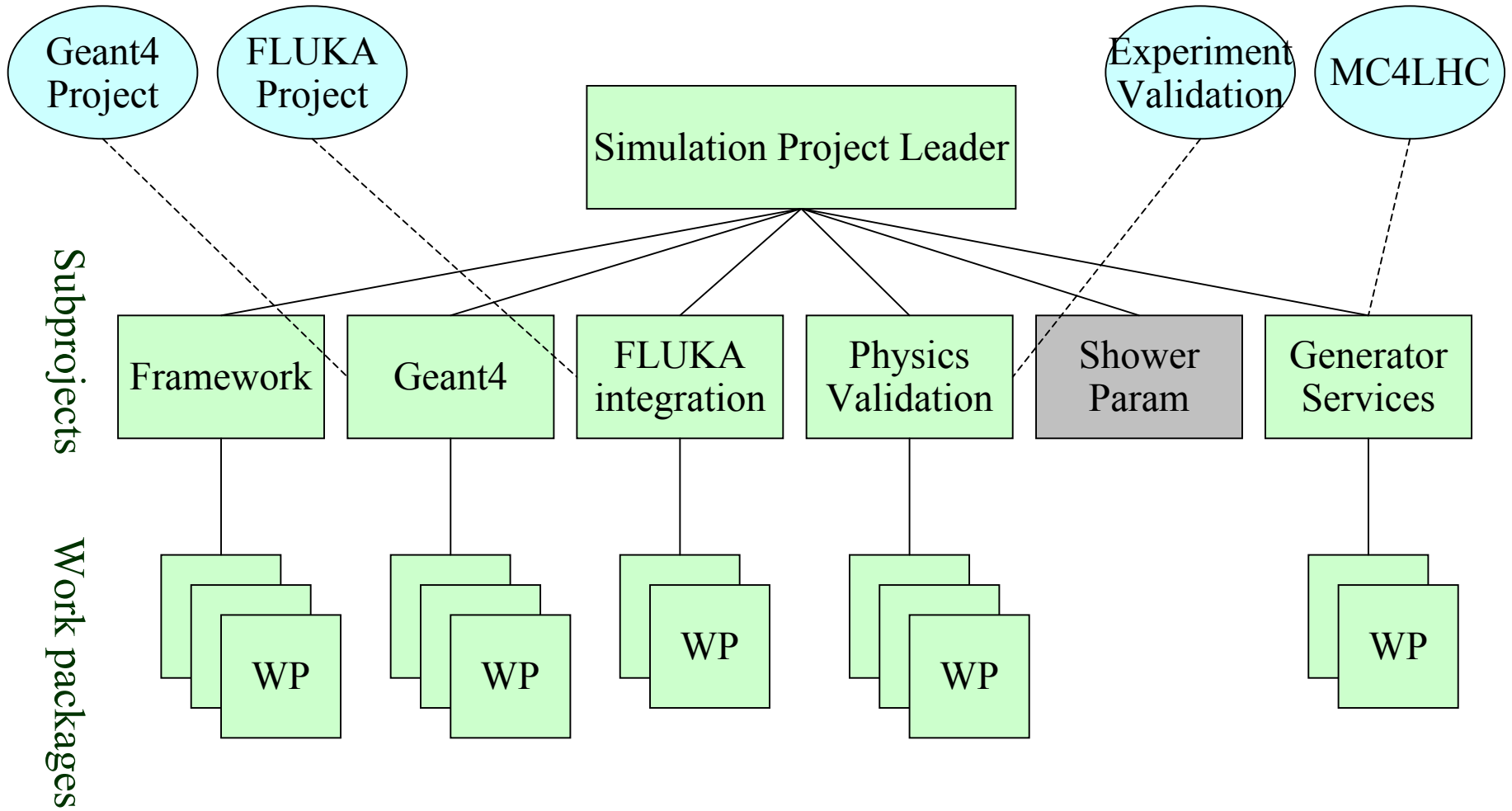
◆ Generator services subproject also very active

Paolo
Bartalini

- ◆ Generator librarian; common event files; validation/test suite; development when needed (HEPMC, etc.)



Project Organization



Generic Framework – Short Term

Now – 2004Q2

- ◆ Immediate priority: support the physics validation activities and test beam simulations
 - ◆ They can make immediate use of an infrastructure able to drive Geant4 and Fluka simulations off of one common geometry
 - ◆ Experiment full detector simulation interest is longer term
- ◆ Agreed approach: set up a simulation infrastructure based on Geant4 and Fluka via Flugg (which uses the Geant4 geometry)
 - ◆ Existing G4 benchmarks/simulation packages can be run with Fluka with minimum fuss
- ◆ Begin evaluation of the VMC, comparing functionality with Flugg
 - ◆ Reproduce G4+Fluka+Flugg based simulations with VMC and compare



Generic Framework – Longer Term

2004Q2+

- ◆ Evaluate the VMC as soon as it provides a fully operational interface to Fluka (expected early in 2004)
 - ◆ Does it fulfill the requirements of the four experiments
 - ◆ Can development be carried forward collaboratively to meet any missing requirements
- ◆ Need to converge from distinct geometry description mechanisms in the experiments into common geometry models useable by the simulation engines
 - ◆ Point of commonality at this point for the experiments not currently using VMC: they all provide G4 geometry descriptions
 - ⇒ Provide mechanism to go from G4 geometry to VMC/ROOT geometry
- ◆ (Help) develop a link between the ROOT geometry and G4
 - ◆ Initial approach: use a persistent stage, an exchange format, which G4 can write and ROOT can read



Generic Framework – Immediate Goals

- ◆ Complete a G4+FLUKA+FLUGG prototype to meet physics validation needs
 - ◆ Milestone for end 2003
 - ◆ Should have two workers in December (manpower has been major problem) and reasonable chance of delivering close to the milestone date
- ◆ Establish a persistent exchange format and use it to link G4 and ROOT geometry
 - ◆ Such a format and tool exists, GDML, developed in G4
 - ◆ Development motivated by several uses: debugging, visualization, low-overhead geometry exchange, ...
 - ◆ Can be generalized to cover geometry systems other than G4 (e.g. ROOT)
 - ◆ Proposal along these lines will be presented to the SC2 in December
- ◆ Develop concrete milestones for a 2004 plan reflecting the program just presented
 - ◆ The program described makes maximum use of existing work and makes minimum new manpower demands
 - ◆ But manpower needs are non-zero, and manpower so far in this project has been very close to zero
 - ◆ Will improve in Jan when a new LCG hire will take this project as their first priority



Geant4

- ◆ Responsible for CERN/LHC participation in Geant4
 - ◆ Focusing the CERN/LHC effort on LHC priorities
 - ◆ While supporting CERN's long-standing and valuable role as the international 'home' of Geant4 with a leading role in management and infrastructure
- ◆ Workplan is integrated with overall Geant4 plan
 - ◆ Infrastructure, management, coordination
 - ◆ Hadronic physics
 - ◆ Geometry, tracking, em physics
- ◆ Employs substantial personnel resources (~9 FTEs)
 - ◆ ~3:3:1 distribution among management/infrastructure, hadronic physics, and the rest (geometry, tracking, em physics)
- ◆ Strong cooperation with Physics Validation (to which ~1.5 FTEs were transferred)
 - ◆ Improvements, updates based on validation feedback
- ◆ Working with the generic framework team on architecture and integration
- ◆ Working on shared infrastructure (testing, portal) with SPI



The Geant4 'big picture' for LHC users

- ◆ Largest goals & activities in 2003
 - ◆ Cuts-per-region capability
 - ◆ Robustness improvements for production usage
 - ◆ Particularly geometry, hadronic physics
 - ◆ Support for urgent problems, questions
 - ◆ System testing and releases
- ◆ Important goals
 - ◆ Development based on new requirements, and refining existing functionality
 - ◆ Investigating feedback from physics comparisons
 - ◆ Improving testing framework; system testing increasingly important
 - ◆ Collecting & analyzing new requirements



Geant4 Plans for 2004

- ◆ *ATLAS, CMS and LHCb will use Geant4 for production in 2004 (CMS already is)*
 - ◆ *Project plans reflect this*
- ◆ **Support and maintenance**
 - ◆ Will require an even larger portion of effort
 - ◆ Balance between development and support/maintenance will shift to the latter in 2004
 - ◆ Responding to feedback, supporting production usage of Geant4 in data challenges
- ◆ **Further improvements**
 - ◆ Physics modeling refinements particularly in hadronic physics
 - ◆ Creating an acceptance suite
 - ◆ Pending requirements & requests
- ◆ **Addressing new requirements**
 - ◆ for flexible restoring of physics lists
 - ◆ For capability to extend volume ‘stores’



Fluka Integration

- ◆ Fluka development proper is not a project activity, though it has recently received strengthened support as a CERN activity
 - ◆ CERN effort supplied to Fluka team (1 FTE, recently started)
 - ◆ Fluka source code will be opened in ~12 months
- ◆ Participation involves
 - ◆ Integration of Fluka as a simulation engine in the generic framework
 - ◆ FLUGG in the short term, VMC in the longer term
 - ◆ Expect very little new work needs to be done, thanks to existing work done by FLUKA-ALICE
 - ◆ Physics validation of Fluka
 - ◆ Working with the physics validation subproject – simple benchmarks, test beam (slow start due to low manpower)
- ◆ Activity is led by the CERN-resident Fluka project leader, Alfredo Ferrari



Physics Validation

- ◆ Validation based mainly on
 - ◆ Comparisons with LHC detector test beam data
 - ◆ Simulations of complete LHC detectors
 - ◆ “Simple benchmarks”: thin targets, simple geometries
- ◆ Coordinates a lot of work being done in the experiments, G4, FLUKA
 - ◆ Plus some direct LCG effort to fill high priority cracks (~3 FTEs)
 - ◆ Foster cooperation, coherence, completeness
- ◆ Output of the project
 - ◆ Certification that simulation packages and framework/environment are OK for LHC physics
 - ◆ Understanding strengths/weaknesses/uncertainties of G4, Fluka
 - ◆ Contributions to systematic errors of measurements
 - ◆ Recommended optimized physics lists
 - ◆ Simulation benchmark suite for validation and performance monitoring
 - ◆ Final report summarizing the work



Physics Validation – So Far

- ◆ Physics validation studies made by experiments revisited
- ◆ Monitor and assess progress with G4 hadronic physics, e.g.
 - ◆ Improved pion shower profiles in the ATLAS HEC
 - ◆ Pion energy resolution in CMS ECAL+HCAL prototype
- ◆ First cycle of EM physics validation completed
 - ◆ G4 at least as good or better than G3 in testbeam comparisons
- ◆ First simple benchmark study completed
 - ◆ Predictive power of simulations rest on correct simulation of microscopic interactions: use simple benchmarks to probe this level
 - ◆ Double differential (p,xn) cross sections with G4, Fluka
 - ◆ Continuation of earlier ALICE work
 - ◆ Infrastructure for future benchmark studies established
- ◆ Monthly meetings presenting and coordinating experiment and project work
- ◆ Information, results gathering on web page



Physics Validation – Ongoing and Future Work

- ◆ Two FLUKA activities starting – requiring the generic framework prototype
 - ◆ Update ATLAS tilecal testbeam simulation
 - ◆ Hadronic interactions in ATLAS pixel testbeam
- ◆ Second simple benchmark study, pion absorption below 1 GeV
- ◆ Radiation background studies in LHCb comparing G4, Fluka, GCALOR
- ◆ Complete revisiting of simulation physics requirements
- ◆ Complete testing of refined G4 physics lists in all experiments, and complete first cycle of hadronic physics validation
- ◆ New extensive round of comparison results based on 2003 testbeams
- ◆ Validation workshop in early 2004
 - ◆ Validation item by item across experiments
 - ◆ E.g. electron energy resolution, hadronic shower profile,...
- ◆ First version of simulation test and benchmark suite in spring 2004
- ◆ Physics validation document circa end 2004



Generator Services

- ◆ Responsible for
 - ◆ Generator librarian services
 - ◆ Tuning and validation of event generators
 - ◆ Common generator event files, event database
 - ◆ Event storage, interface and particle services
- ◆ Guided and overseen by the MC4LHC group of generator/physics analysis experts from all four experiments
- ◆ Active program of broad monthly meetings
- ◆ Useful input from the large MC generator workshop in July 03
- ◆ Personnel (1-2 FTEs) from LCG (Russia)
 - ◆ Discussions underway with Italy, Spain on participation



Generator Services – So Far

- ◆ **GENSER generator package library (public since September)**
 - ◆ Now includes all top priority packages
 - ◆ HERWIG, HIJING, ISAJET, PYTHIA
 - ◆ Starting to add the second tier (LHAPDF ...)
 - ◆ Common central installation, distribution and documentation
 - ◆ agreed versions, all required patches, LCG-agreed platforms
 - ◆ Under test by ATLAS, ALICE, CMS
 - ◆ ATLAS will start using it soon, initially for one generator
- ◆ **Event storage, interfaces and particle services**
 - ◆ Agreement on HepMC as MC truth interface
 - ◆ Agreement on two persistent event formats, specifics to be worked out
 - ◆ Low volume – XMLHEP
 - ◆ High volume production – POOL/ROOT
- ◆ **Common event files, event database**
 - ◆ Agreement on MCDB as an event catalog and lookup tool
- ◆ **Tuning and validation**
 - ◆ Report on a first HIJING validation being finalized
 - ◆ Bugs uncovered and a patched version provided in GENSER



Generator Services – Ongoing and Future Work

- ◆ Continue to populate GENSERVER with requested generators
 - ◆ Add new generation (C++) generators to GENSERVER
 - ◆ Support GENSERVER integration and usage in experiments
- ◆ Develop proposal for MCDB deployment in LHC environment
- ◆ Evaluate MC-Tester and JetWeb validation/tuning tools
- ◆ Finalize formats for generator event storage
- ◆ Deploy MCDB and a generator event production infrastructure to build standard generator event library
 - ◆ Using experiment production infrastructure
- ◆ Establish event generator validation framework and program
- ◆ Find additional contributions to fulfill this program!

- ◆ Specific milestones are on the web schedule



Concluding Remarks

- ◆ Very active program in physics validation delivering results and conclusions
 - ◆ Coordinating and leveraging much experiment work, but with the LCG still filling priority voids in the work
 - ◆ First cycle of EM physics validation completed
- ◆ Large Geant4 program well aligned towards LHC needs and experiment support, and working closely with other simulation/LCGAA projects
 - ◆ Increasing shift of focus and effort to supporting production application of Geant4 in experiment data challenges
- ◆ Very active new program in generator services developing a common library of validated generators and planning a common generator event database
- ◆ Generic simulation framework program now more concretely scoped to make maximal use of existing software and meet the reality of minimal available manpower
 - ◆ With a focus on delivering first, and quickly, for physics validation
- ◆ Fluka team contributing and eager to contribute more, but Fluka integration/validation feeling effects of slow progress due to low manpower (physics validation, generic framework)



Simulation Project Major Milestones

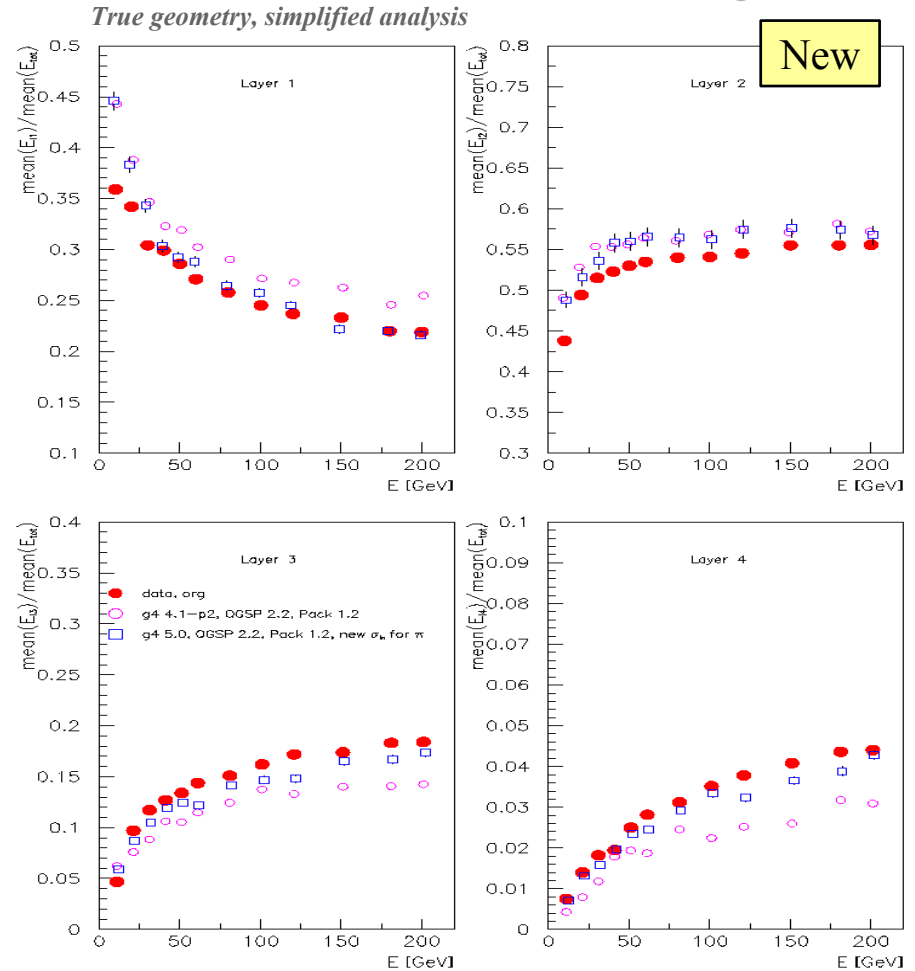
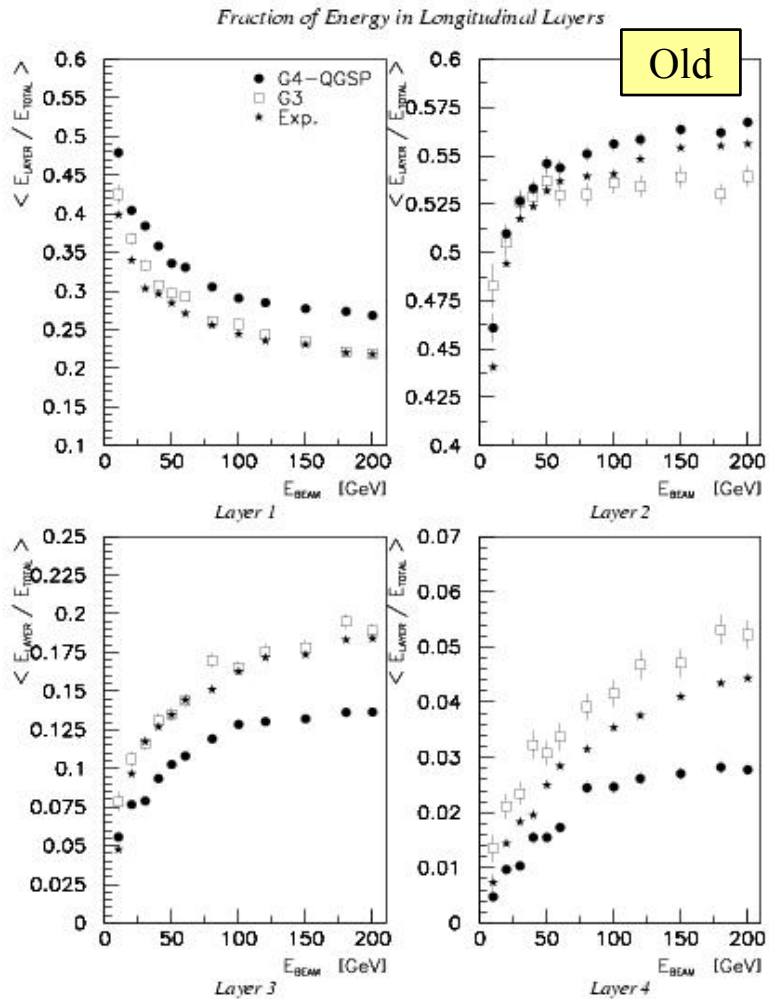
- ◆ 2003/6: **Generator librarian** and first library version in place
- ◆ 2003/9: 1st cycle of **EM physics** validation complete
- ◆ 2003/9: **GENSER generator package library** beta version released
- ◆ 2003/12: Generic **framework prototype** with G4, FLUKA engines
- ◆ 2003/12: Simulation **physics requirements** revisited
- ◆ 2004/2: 1st cycle of **hadronic physics** validation complete
- ◆ 2004/4: Simulation **test and benchmark suite** available
- ◆ 2004/5: MCDB beta in production as **generator event library**
- ◆ 2004/10: First generic **simulation framework production** release
- ◆ 2004/12: **Physics validation document** complete



Pion Shower Profile in the ATLAS HEC

J.P. Wellisch, Physics
Validation Mtg 4.6.2003

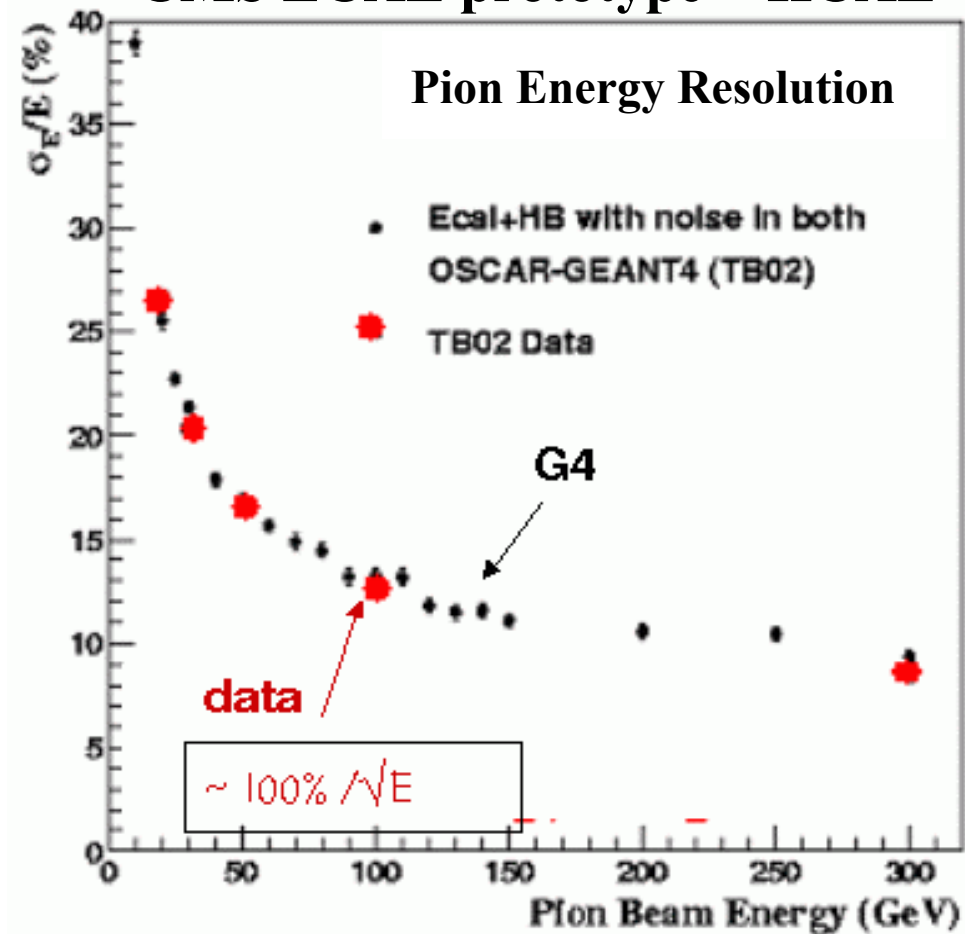
- ◆ Improvement in pion shower profile after fixing 10% mismatch in σ_π



Pion Energy Resolution in CMS

V.D. Elvira, Physics
Validation Mtg 14.5.2003

CMS ECAL prototype + HCAL



A breakdown of simulation manpower

Generic simulation framework	1.30
Geant4	8.90
<i>G4 activity subset FTEs of interest:</i>	
Infrastructure, mgmt (approx)	3.20
Hadronic physics effort (approx)	4.25
Tracking, biasing, geom (approx)	1.25
<i>G4 support subset FTEs of interest:</i>	
CERN staff	4.20
CERN fellows, associates	3.25
LCG	0.45
Physics validation	3.30
Generator services	1.30
FLUKA integration	0.00
Management	0.25
<i>ALICE VMC (non-project)</i>	1.60
Total	16.65

As of Oct 1

