Simulation Project Overview
(Very condensed)

Torre Wenaus, BNL/CERN
Simulation Project Leader

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

LHCC Comprehensive Review of the LCG
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BROOKHAVEN
NATIONAL LABORATORY

Simulation Project

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

Andrea Dell'Acqua

- Incorporates longstanding CERN/LHC **Geant4** work
  - Aligned with and responding to needs from LHC experiments, physics validation, generic framework

John Apostolakis

- **FLUKA** team participating
  - Framework integration, physics validation

Alfredo Ferrari

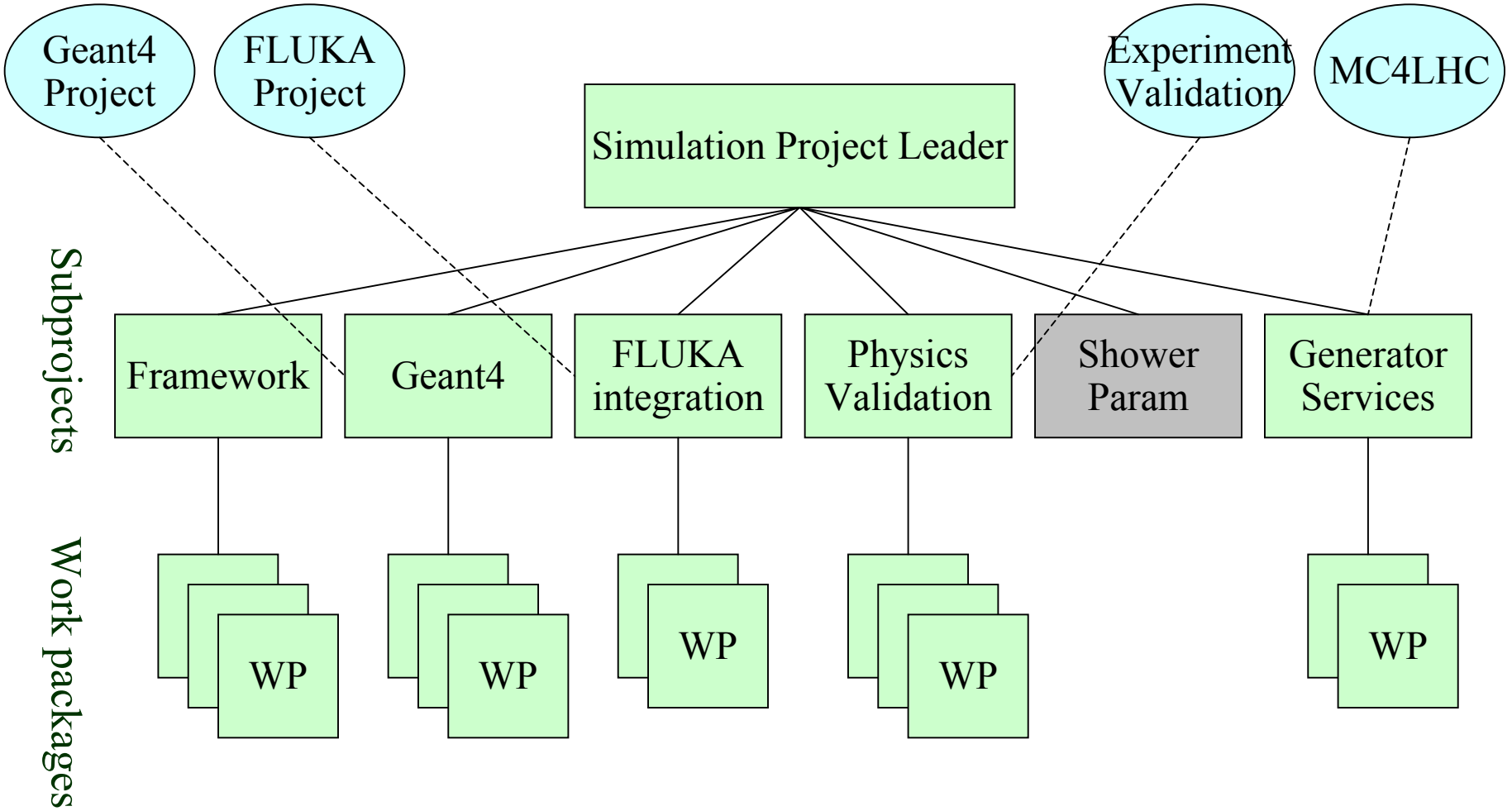
- Simulation **physics validation** subproject very active
  - Assess adequacy of simulation and physics environment for LHC and provide the feedback to drive needed improvements

Fabiola Gianotti

- **Generator services** subproject also very active
  - Generator librarian; common event files; validation/test suite; development when needed (HEPMC, etc.)

Paolo Bartalini

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

  $\Rightarrow$ 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 tables
  - 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 strenghts/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
- Drive progress with G4 hadronic physics via validation results, e.g.
  - Improved pion shower profiles in the ATLAS HEC
  - Pion energy resolution in CMS ECAL+HCAL prototype
  - ATLAS-validated QGSP list being tried by CMS with test beam data
- 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 GENSER with requested generators
  - Add new generation (C++) generators to GENSER
  - Support GENSER 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
  - Significant hadronic physics improvements driven by testbeam validation and simple benchmark results
- 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)

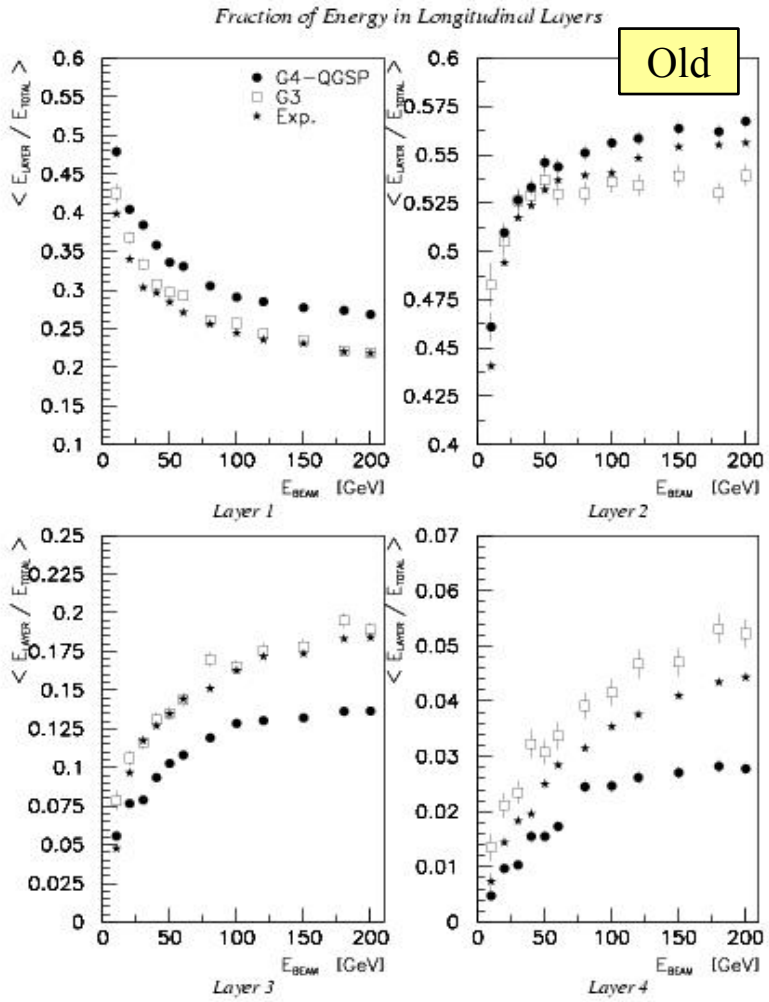
Simulation Project Major Milestones

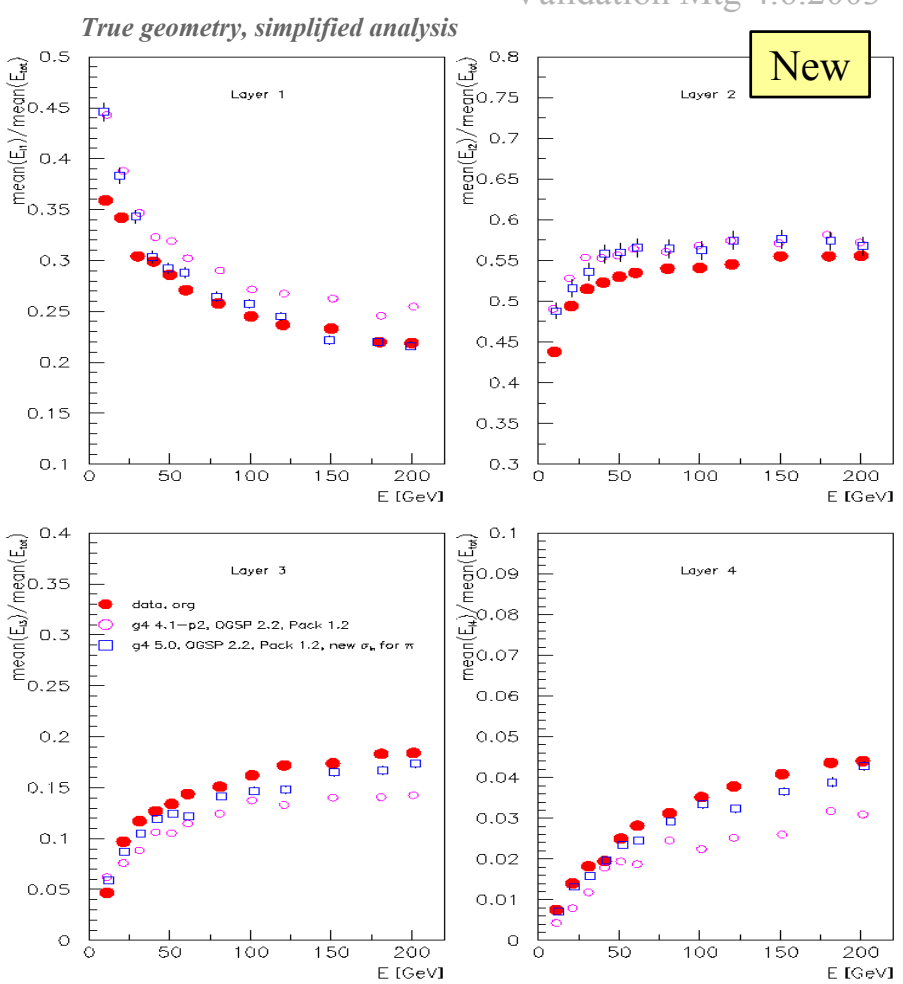
- 2003/6: **Generator librarian** and first library version in place
- 2003/9: 1st cycle of **EM physics** validation complete
- 2003/9: GENSER **generator package library** beta version released
- 2003/12: Generic **framework prototype** with G4, FLUKA engines
- 2003/12: Simulation **physics requirements** 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

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

J.P. Wellisch, Physics Validation Mtg 4.6.2003

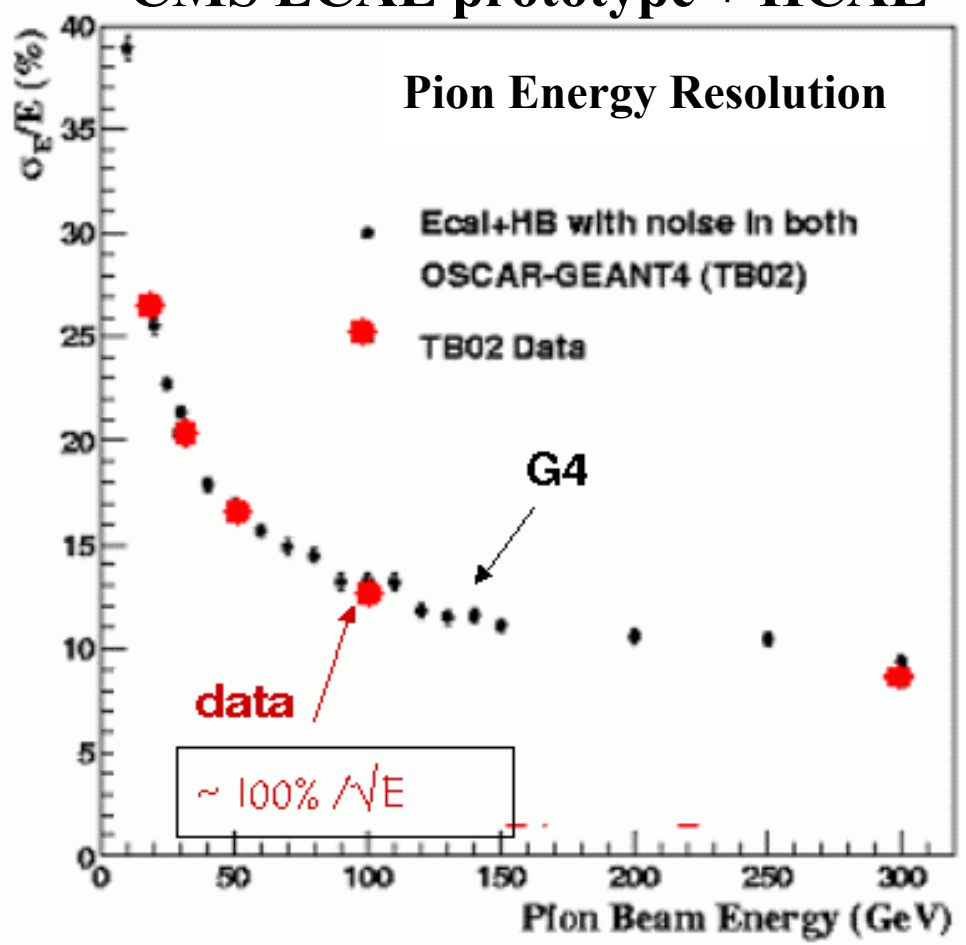




Pion Energy Resolution in CMS

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
G4 activity subset FTEs of interest:		
Infrastructure, mgmt (approx)	3.20	
Hadronic physics effort (approx)	4.25	
Tracking, biasing, geom (approx)	1.25	
G4 support subset FTEs of interest:		
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
ALICE VMC (non-project)		1.60
Total		**16.65**

As of Oct 1