Report from HEP Collider Experiments

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Replacing G. Cosmo

Focus and Content

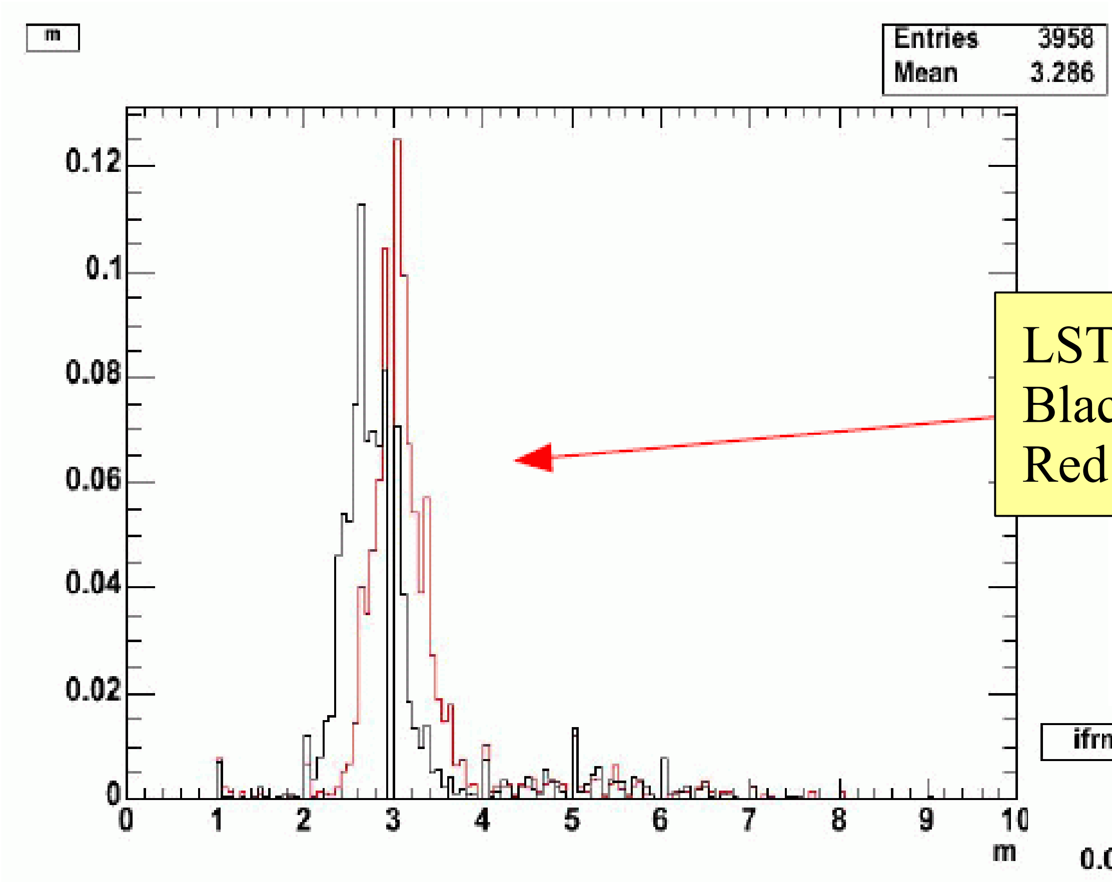
- Focus on status and newest issues
  - Not covering
    - Validation (in detail)
    - Requirements/issues already raised in Technical Forums
- Content
  - Report from BaBar
  - Emerging matters
  - (My) selection of slides from IEEE presentations
    - ATLAS
    - CMS

BaBar Simulation Production Status

- Simulated events produced as of October 2005: 7.0×10^9
  - currently using Geant4 6.1 ref 00
  - using Bertini cascade instead of LEP for p, n, pi
- Production goal: #MC events / # real events = 3
  - Pep luminosity still increasing. Recently (October 05): 1.0×10^{34}
- Bug in G4hIonisation caused 1.2×10^9 events to be discarded
  - fixed by 6.2, but not clear from Release Notes exactly when, and bug not clearly specified
  - BaBar requirement: provide a detailed description of bug fixes in Release Notes
- Simulation upgrade – move to 7.1 by end of year, use Bertini cascade for all strange particles

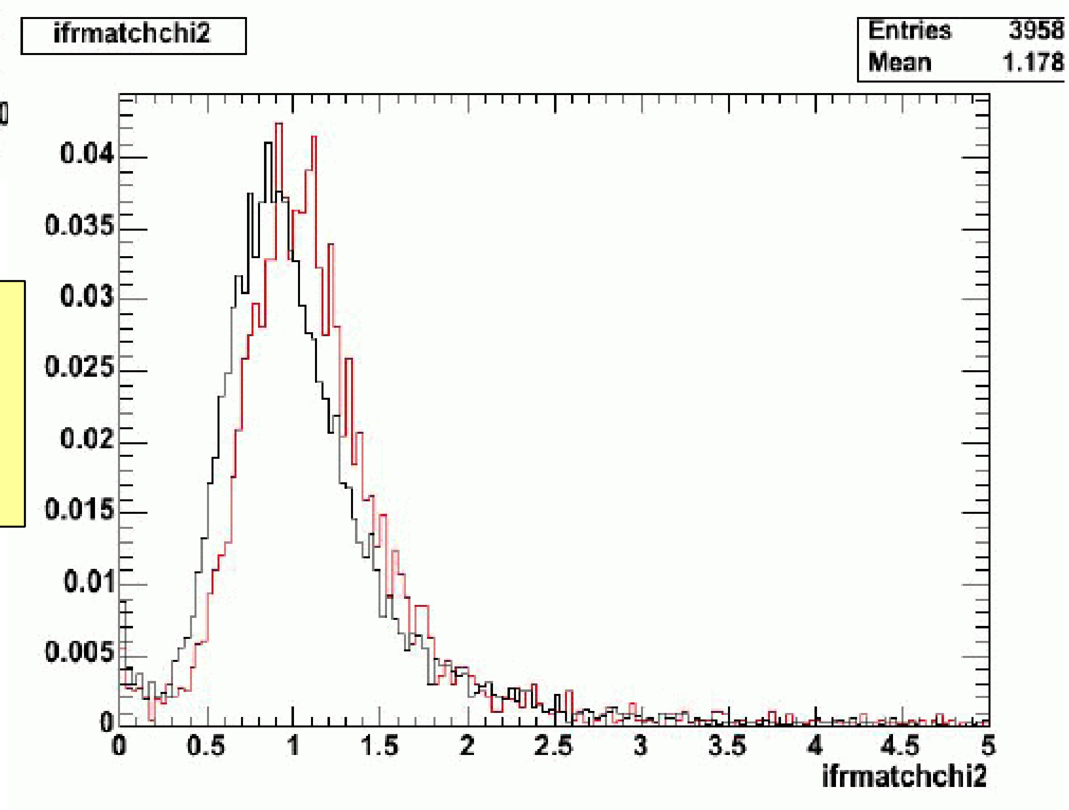
Validation (IFR, EMC)

- EMC (electromagnetic calorimeter)
  - shower width still 15-20% narrower than data
  - a possible material model problem – currently under study
- IFR (instrumented flux return)
  - LSTs now replace RPCs in top, bottom sector
  - long-standing problem of muon chi-squared agreement now understood
  - looking at muons from e+ e- -> mu+ mu- gamma
  - LST multiplicity (plot on next page) reflects a double counting of delta rays in the analysis of MC data – this causes track chi-square to be higher than in data
  - Geant4 EM processes now appear to be OK here



LST multiplicity
Black: data
Red: Monte Carlo

Muon track chi-square
Black: data
Red: Monte Carlo



Emerging matters

- Continued joint effort on GFLASH parameterization
  - E. Barberio (ATLAS) & Joanna Weng (CMS/G4)
  - G4 implementation of GFLASH evolving
    - Adding sampling fractions
  - Under evaluation / utilized in studies in Atlas, CMS
- Commissioned new Monte Carlo ‘truth’
  - Potential for common/LCG effort
  - A few ‘small’ requirements
    - Quick, non-string, process id;
  - Interest in documenting use case, addressing resulting requirements
- Feedback on use of magnetic field (Atlas)
  - Found deviations in momentum reconstructed in Rome production
  - Need for choice (tuning) of precision parameters

CMS: Overview

- *CMS changed from GEANT3 to GEAN4-based simulation end 2003*
- *So far the CMS OSCAR simulation package has delivered ~100 M physics events for CMS 2004 Data Challenge and on-going Physics TDR studies*
- *OSCAR is being adiabatically replaced by a new suite (referred to as here as SimG4), based on the new Event Data Model Software Framework*

- CPU: SimG4 < 1.5 x SimG3 - with lower production cuts!
- Memory: ~110 MB/evt for pp in SimG4 vs. ~100 MB in SimG3
- Robustness: from ~$1/10^4$ crashes in pp events (mostly in hadronic physics) in DC04 to < $1/10^6$ crashes in latest productions

M. Stavrianakou, IEEE/NSS October 2005

CMS: Interfaces and services (III)

- Event generation and Monte Carlo truth
  - HepMC::GenEvent converted to G4Event
  - Choice of specific generator (Pythia, Herwig, gun etc) and event format (ASCII, Pool, etc) run-time configurable
  - Na
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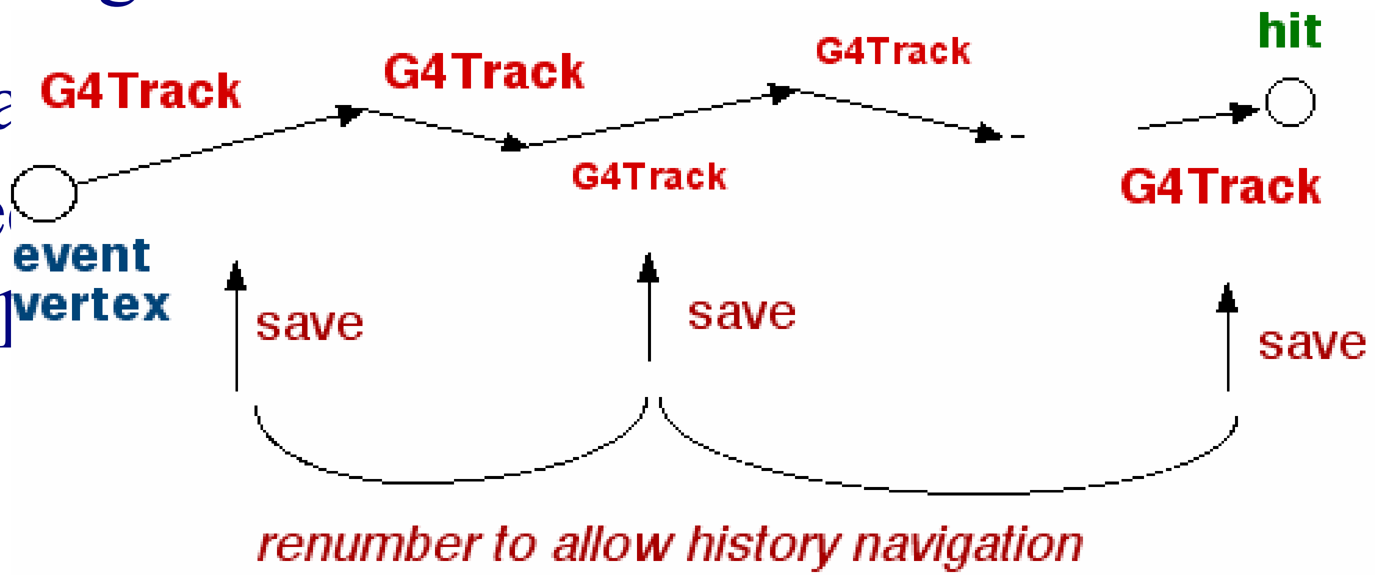
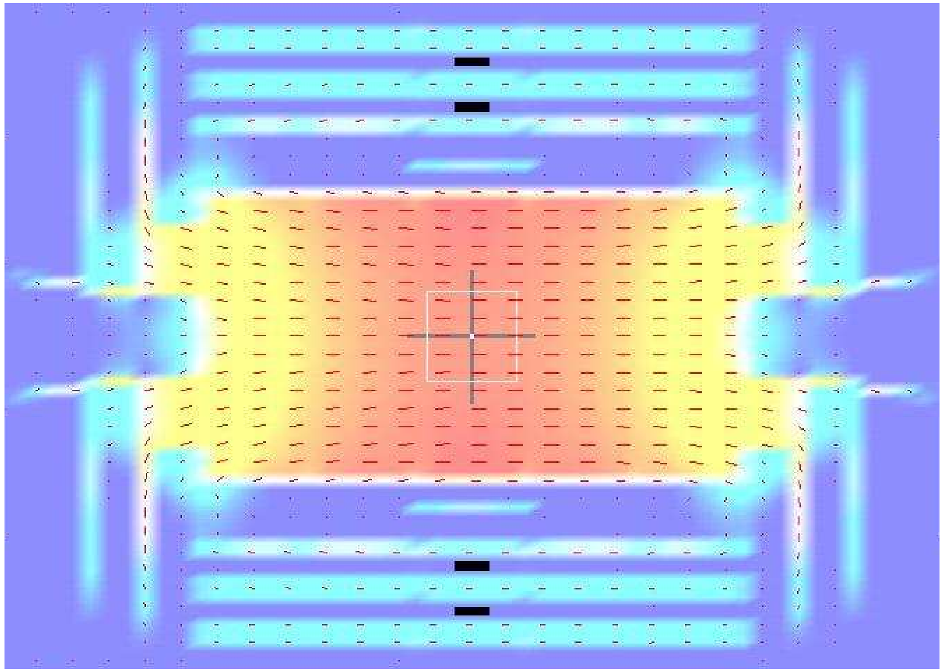


CMS Magnetic Field

Field Map - TOSCA calculation



Designed to optimize simulation and reconstruction

Based on dedicated geometry of "magnetic volumes"

Decouple volume finding and interpolation within a volume

Time spent in magnetic field query (P4 2.8 GHz) for 10 minimum bias events 13.0 vs 23.6 s for G3/Fortran field

Þ new field ~1.8-2 times faster than FORTRAN/G3

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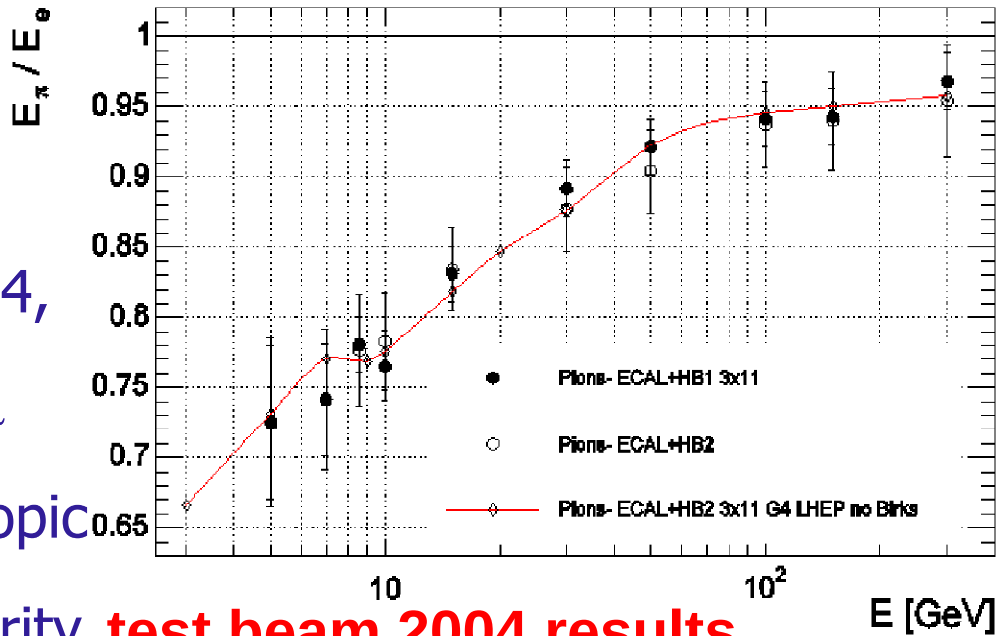
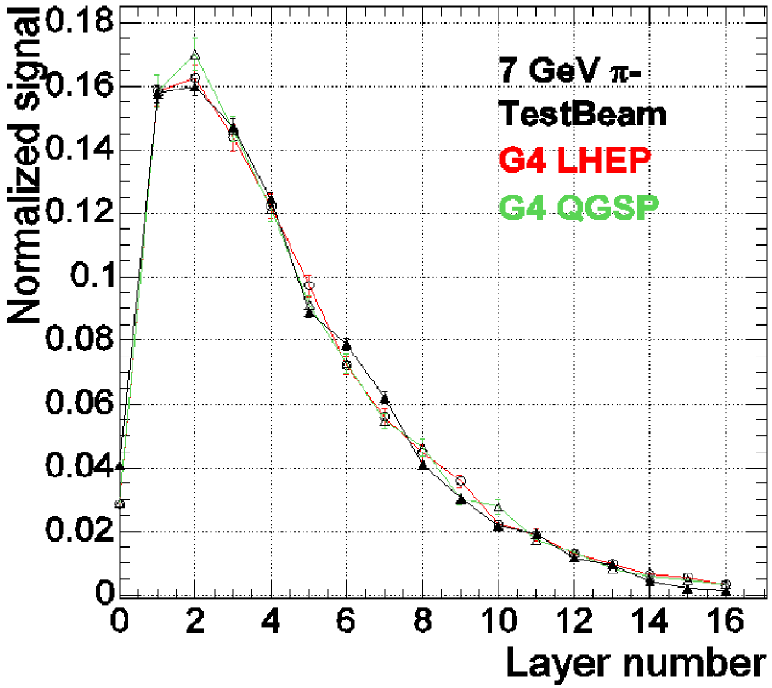
CMS Hadronic Calorimeter (HCAL)

- HCAL studies on energy resolution and linearity, e/π ratio, and shower profile instrumental in G4 hadronic physics validation
- Comparisons between single particle measurements in test beam: 2002-2004, different HCAL modules, preceded by ECAL prototype, to beams of π, e and μ over large energy range - G4 hadronic physics parametric (LHEP) and microscopic (QGSP) models
- π energy resolution and response linearity as a function of incident energy in good agreement with the data within the large systematic uncertainties in the latter
- Transverse and longitudinal shower profiles studied in 1996 and 2004 test beam
- π showers predicted by G4 narrower than those by G3
- Showers predicted by QGSP (v 2.7) shorter than those by LHEP (v 3.6) list, with LHEP predictions closer to those from G3/Geisha



test beam 2004 results



Parameterized Simulation (I)

- detailed simulation of e/m showers CPU intensive Þ parameterization of spatial energy distribution of e/m shower, based on probability density functions, allows speed up without compromising simulation accuracy
- GFlash model (G. Grindhammer, S. Peters), based on three probability density functions (originally developed and used by H1) used to parameterize electrons and positrons in CMS barrel and endcap e/m calorimeter

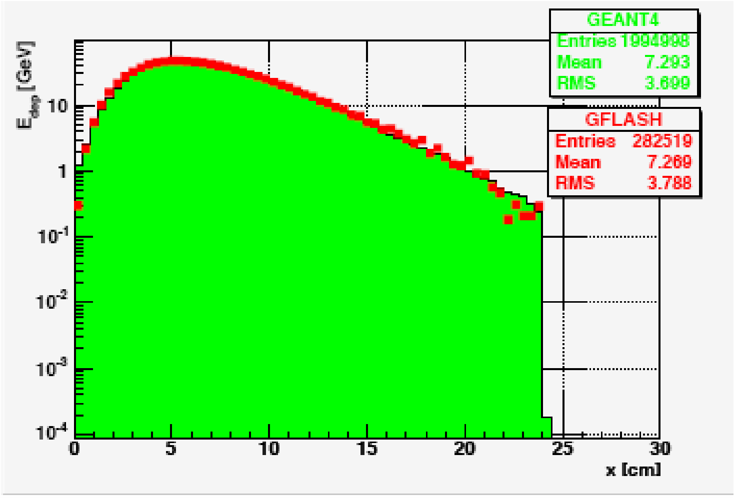
comparisons between GFlash-based and full simulation

- energy depositions in central crystal, 3x3, 5x5 matrices: agreement to ~1%
- transverse and longitudinal shower profiles: agreement to ~1-3%
- speed increases by factors 3-10 depending on event type, particle energy and detector region

examples

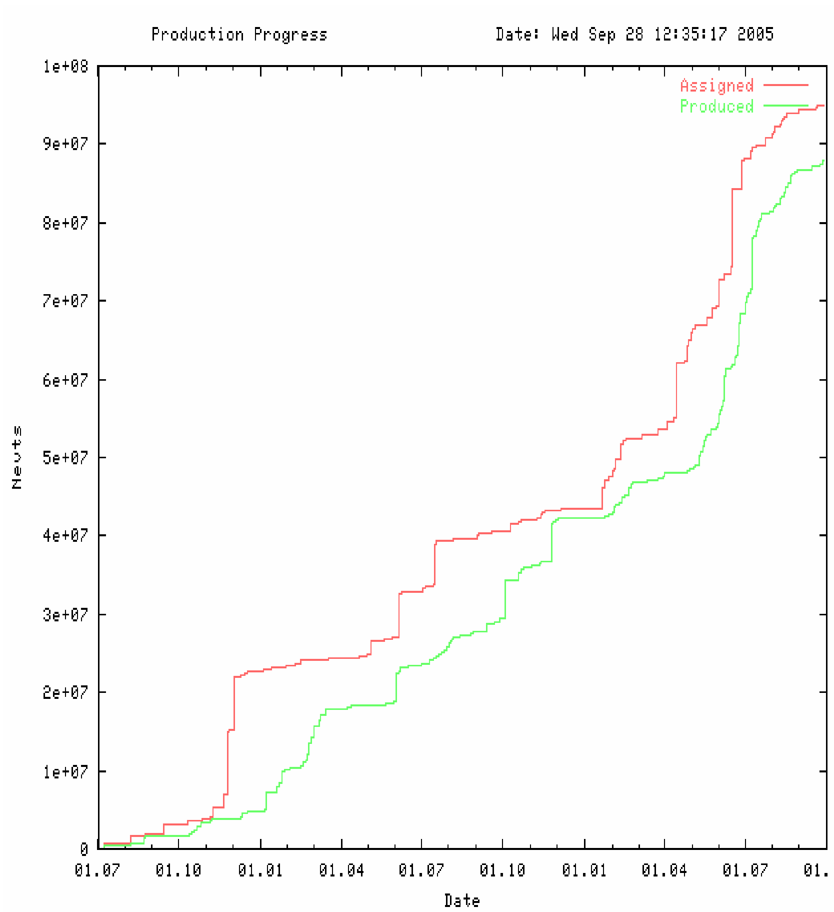
- single e or γ with E=100 GeV in ECAL barrel: factor ~10 speed-up
- large extra dimensions full signal event, with single γ > 1000 GeV: factor ~4

- Parameterisation



CMS Production

- 11/2003 - 10/2005:
  ~100 M physics events
  simulated by production team
- Failure rate: ~1/10^4 - 10^6 events
- Performance for typical signal event:
- ~250 MB memory
- ~100-200K Si2K (*) CPU
- ~1 MB output data
- CMS Computing Model: same amount of simulated as real data, ~1.5 x 10^9 events/year ⇒ mix of full and fast simulation will be used to manage required resources



(*) typical 3 GHz CPU is ~1.7 K Si2K, so 200K Si2K is 2 minutes on such a CPU; Si2K ratings scale more or less linearly with CPU speed

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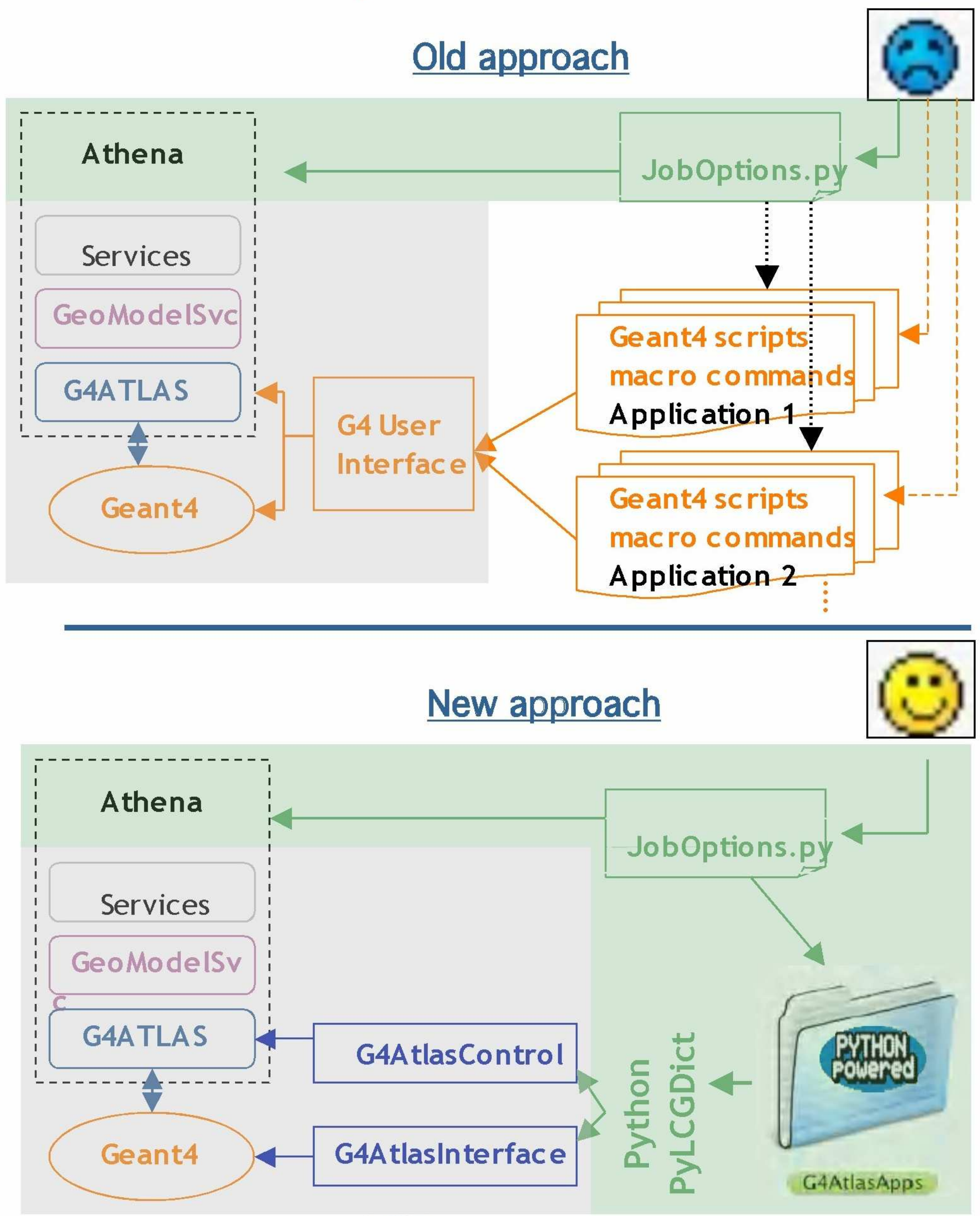
G4ATLAS simulation

- Replaces and extends the old Geant-3 simulation in use during the ATLAS detector design phase. ✔
- It is in full operational mode and it has been used in massive GRID productions: ✔
  - 2005 Rome Production (8.6 Mevents) <--- *Latest ATLAS physics workshop*
  - 2005 Combined Test Beam production (4 Mevents) <--- *Crucial for detector performance studies*
  - 2004 Data Challenge 2 (12 Mevents) <--- *Large scale production*
- It handles in a very similar way different scenarios: full ATLAS simulation, ATLAS cosmic setups, 2004 ATLAS Combined Test Beam and old standalone test beams. In this way: ✔
  - the consistency and validation effort is kept throughout all the applications
  - the user can switch from one application to other with minimal effort
- Nowadays is preparing for the non-ideal detector description: geometry for detector as installed, misalignment, material services ....

The Python G4Atlas interface

- G4 has not a native Python interface.
- To configure G4 simulations the user pass macro-commands to the G4 User-Interface.
- The macro-commands interface does not integrate well in the Python Athena environment. The other issues are:
  - lack of flexibility
  - difficult maintenance
- Since May 2005, G4Atlas has a newly developed Python interface (PyG4Atlas) which:
  - provides enormous flexibility for configuring and maintain different setups
  - improves the usability by adding interactivity and introspection
  - preserve the final user customization "window" with a full traceability
- PyG4Atlas is a Python module that uses the **PyLCGDict** binding to the LCG C++ dictionaries (by LCG-SEAL) to a limit number of user interaction classes.



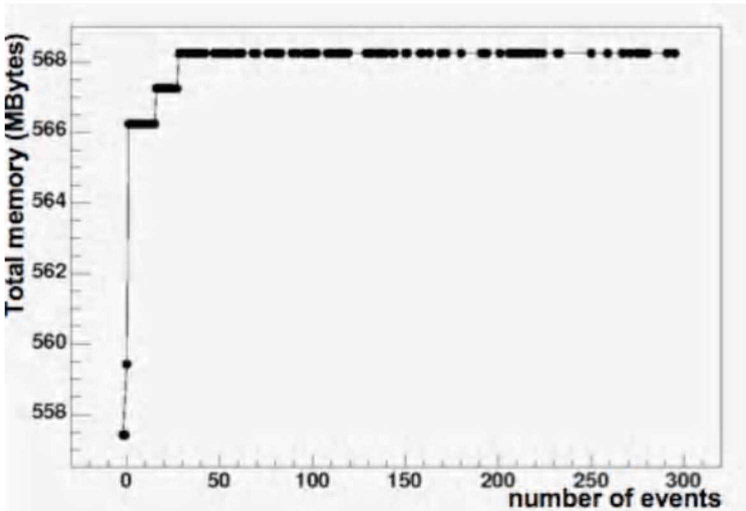
The validation effort

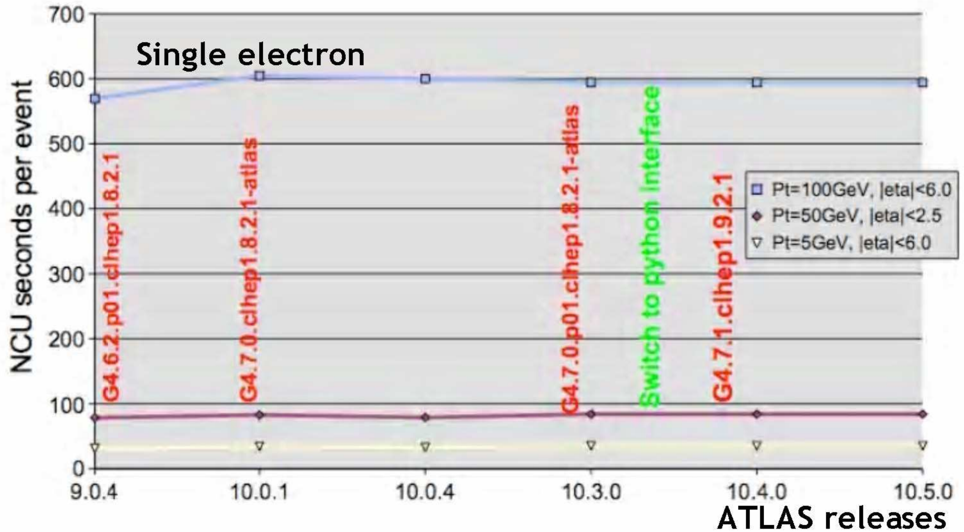
- Process parallel to the simulation development
- The aim is to spot as soon as possible any non optimal performance, internal inconsistency or inaccurate description of the detectors or physical process.
- Split in three main domains:
  1. continuous measurement of the performance in terms of the CPU time and memory consumption.
  2. comparison with real data from:
     - old stand-alone test beams for the different sub-detectors
     - ATLAS combined test beam (CTB-2004)
     - in a near future cosmic ray tests
  3. physics performance studies by reconstruction of full physical events

Performance

- CPU time per event and memory usage at run-time is monitored in each ATLAS sw nightly building.
- Memory usage as a function of the event number is also monitored in during performance tests.
- Detailed measurements for single particles and physical events are done in each new release.

Results for 1000 events	Time per event (kSI2K)	Event size (KB)
Single muons		
Pt=200GeV, |eta|<6.0	75,74	10,5
Pt=50GeV, |eta|<3.0	1,93	7,9
Pt=5GeV, |eta|<6.0	1,97	3,2
Single pions		
Pt=200GeV, |eta|<6.0		
Pt=50GeV, |eta|<3.2	63,13	34,25
Pt=5GeV, |eta|<6.0	17,43	33,19
Single electrons		
Pt=100GeV, |eta|<6.0	604,52	
Pt=50GeV, |eta|<2.5	82,8	14,43
Pt=5GeV, |eta|<6.0	34,32	56,64



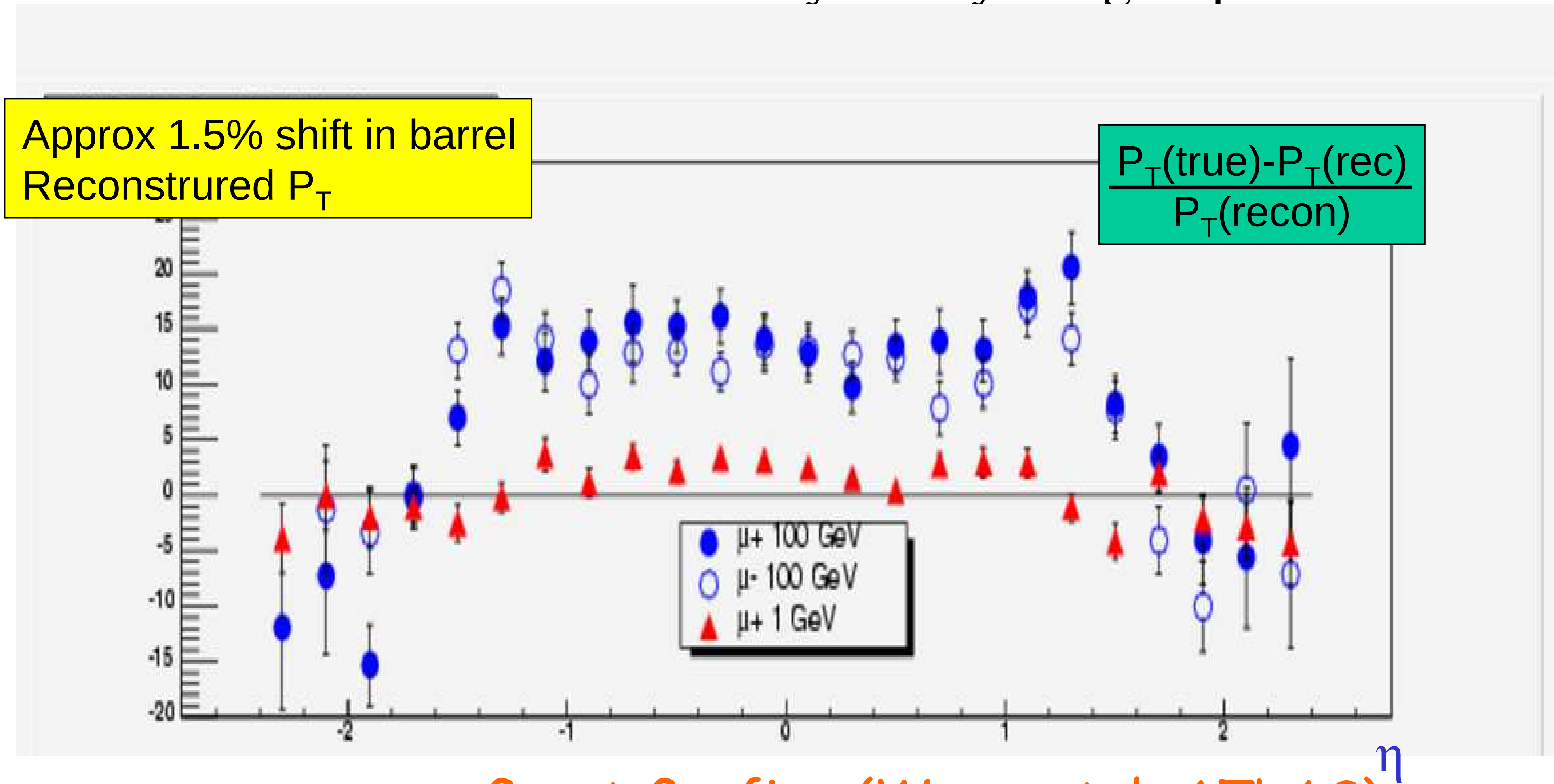


ATLAS: Conclusions of IEEE talk

- G4Atlas is the Geant4-based simulation framework of the ATLAS experiment. It has been successfully and largely used in several massive GRID productions.
- The detector geometry description is done by GeoModel and automatically translated to G4 (other clients as for instance the reconstruction use it directly). The detector description is being described according with the reality (detector as installed and misalignment).
- The newly delivered PyG4Atlas Python interface provides the flexibility and configurability required for the full ATLAS and test beam setups. The maintenance for the several available configurations and usability were achieved.
- The use of the LCG dictionaries together with the Python language is as powerful approach.
- The G4Atlas performance is continuously monitored in terms CPU time and memory usage per event.
- The data from the Combined Test Beam is a good source for the study of detector performance and Geant4 Physics Validation. The simulation of full physical events shows also good results.

ATLAS Momentum Shift Problem

- Momentum shifts seen in Rome data
  - Also mass shifts seen by B-Physics group.



Grant Gorfine (Wuppertal, ATLAS)

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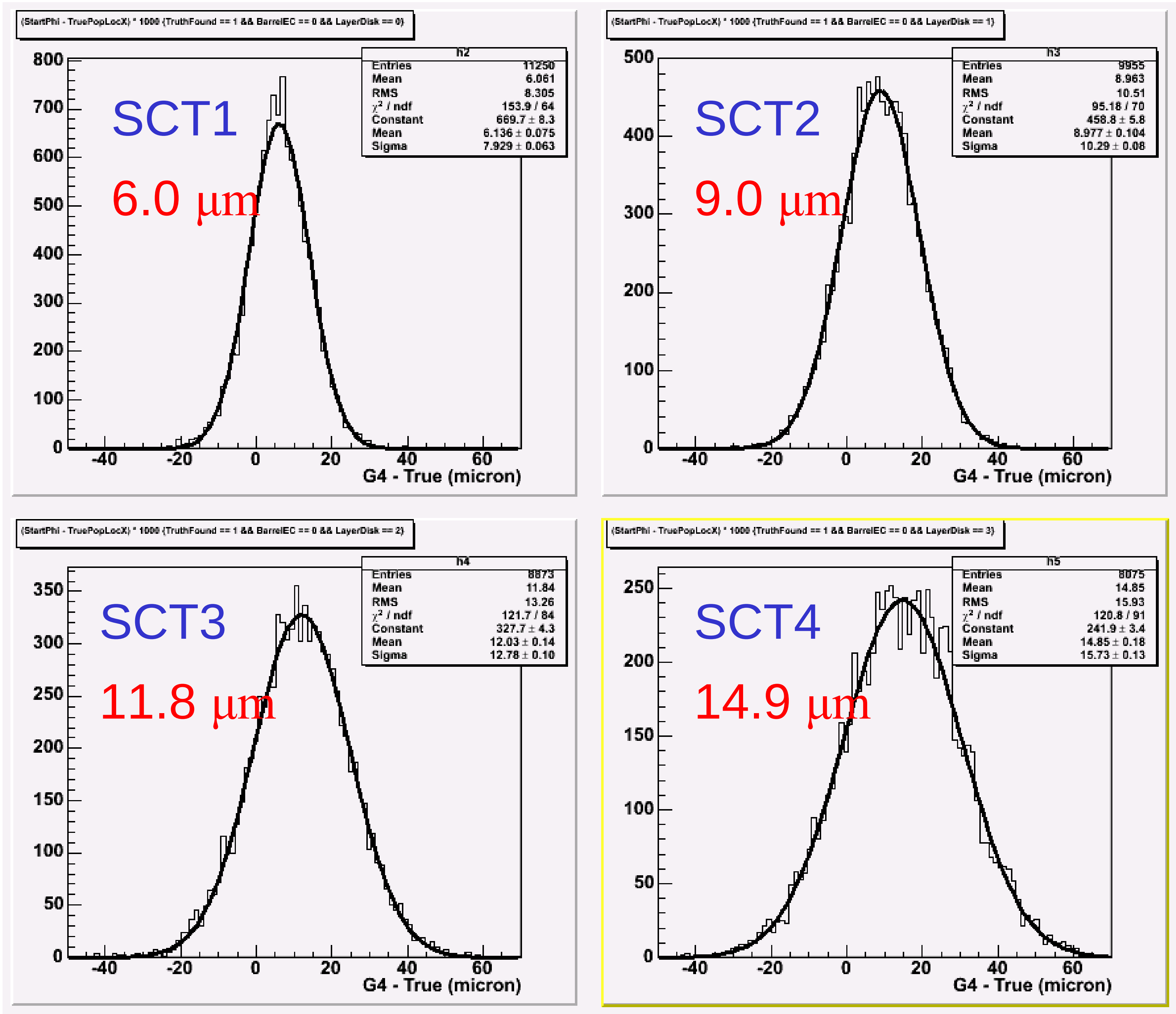

Grant Gorfine (Wuppertal, ATLAS)

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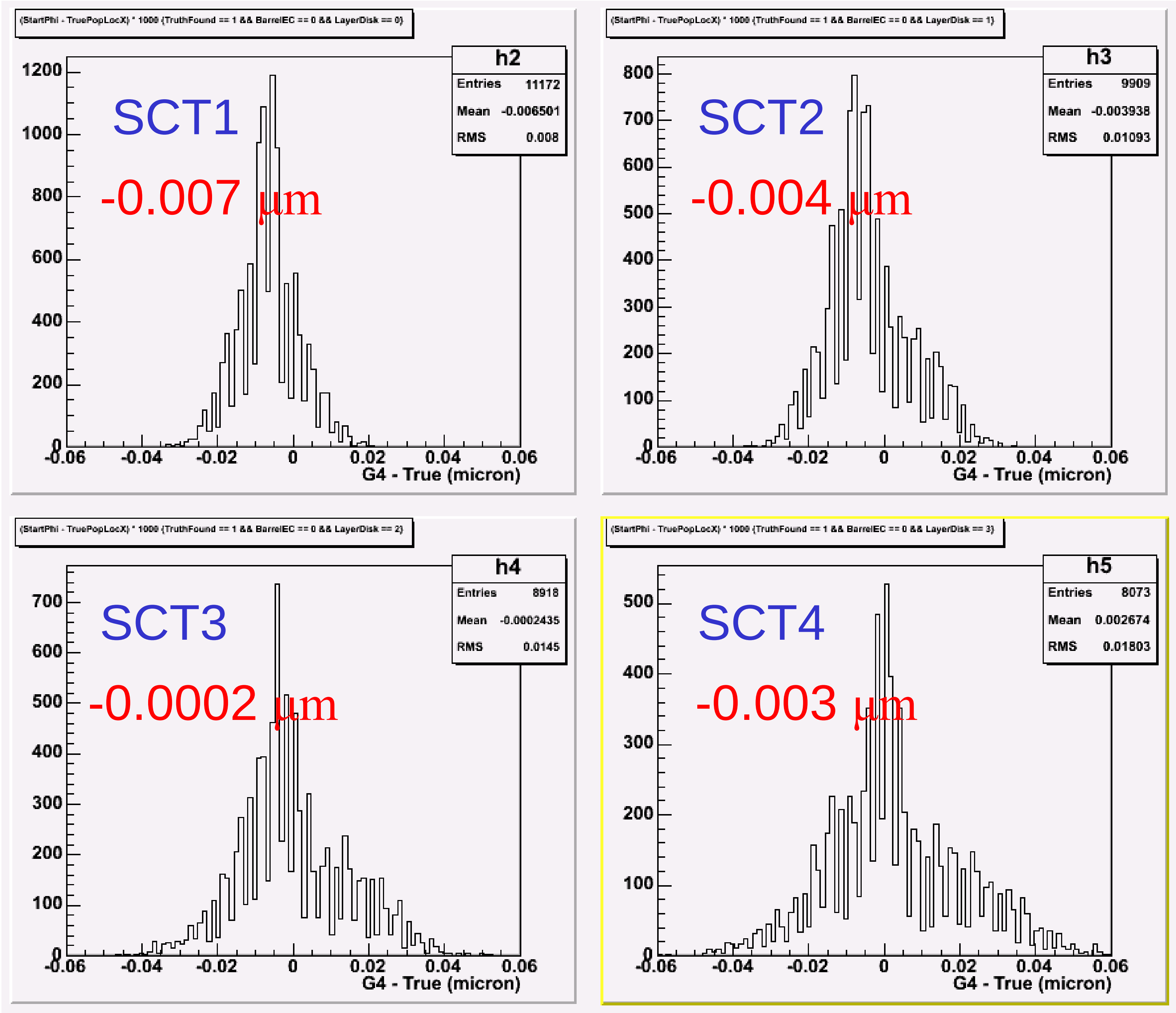
Set C

DeltaIntersect = 0.001 µm

DeltaOneStep = 0.01 µm



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CPU impact (Andrea Di Simone)

- Timing for single muons 100 GeV. (secs/event)
  - Timing studies also done for different particles and energy. Similar conclusions.

	Default	Set A	Set B	Set C	Set D	Set E
DeltaIntersect	1 um	0.1 um	0.01 um	0.001 um	0.01	0.01
DeltaOneStep	10 um	1 um	0.1 um	0.01 um	1 um	10 um

	Default	Set A	Set B	Set C	Set D	Set E
ID Only	0.138	0.157	0.238		0.232	0.178
Calo Only	1.038	1.061	0.987		1.037	1.089
Muon Only	0.461	0.592	0.520		0.465	0.612
All	2.099	2.403	2.147		2.168	2.026