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ATLAS Simulation readiness for first data at LHC

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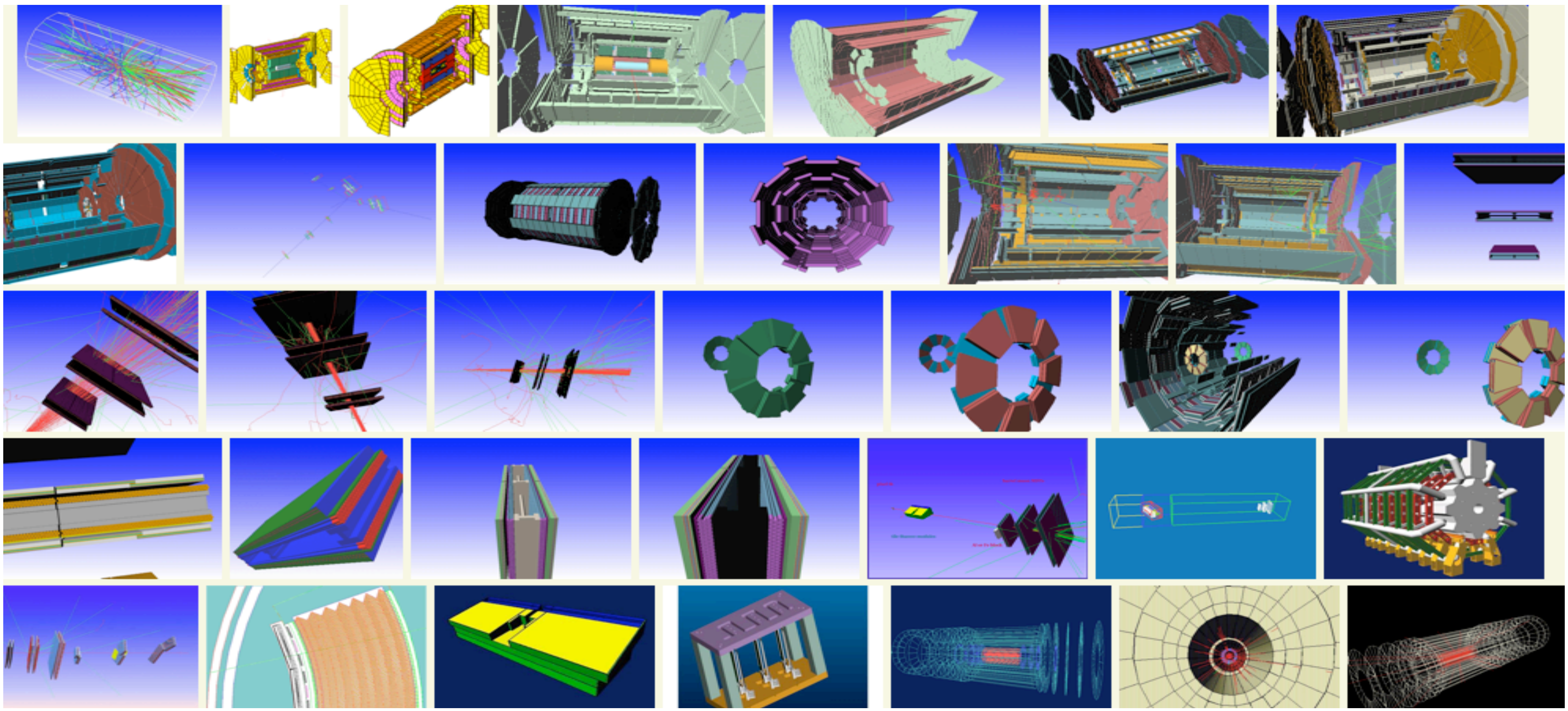
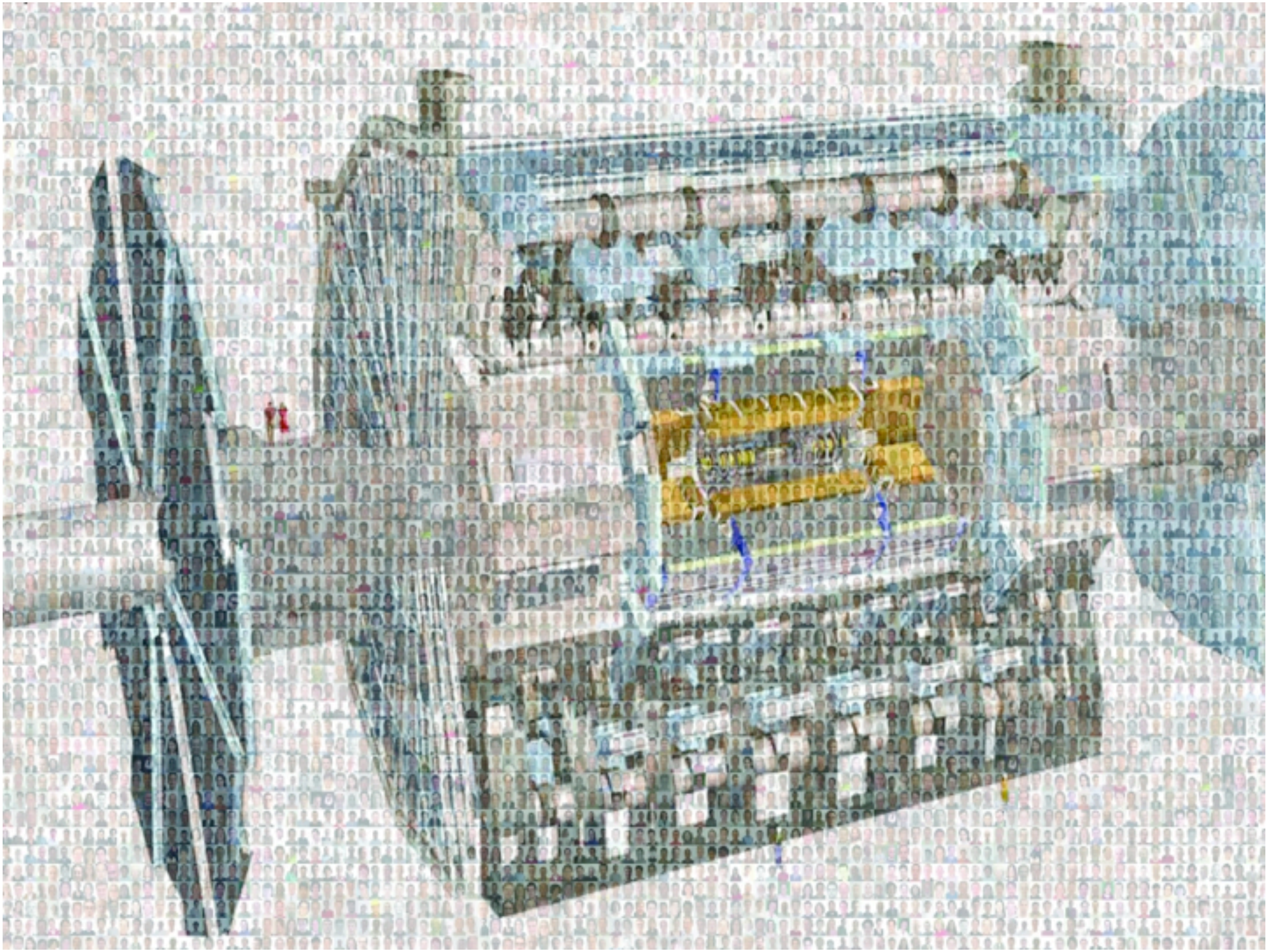


Introduction

- ATLAS detector entering the final phases of construction and commissioning
  - *LHC commissioning run in 2007*
  - *Physics runs from 2008*
- Understanding of the experiment performance from the beginning is essential to efficiently debug the detector and assess its physics potential in view of the physics runs
- The ATLAS Detector Simulation programs have been developed since the ATLAS inception (O(10 Years))for easing the detector optimization and construction
  - *further developments to the simulation suite have recently been introduced to cope with essential factors*
    - *misalignment, inefficiencies, apparatus imperfections*
  - *still maintaining a high level of efficiency and operability to serve the ongoing production exercises*

This talk

- *recent developments*
- *validation and production strategies*
  - *performance figures*
  - *robustness*
  - *maintainability*
- *what's left before first data*



Recent developments in ATLAS Simulation

- On the common framework for event processing (Athena) for ATLAS
the Simulation application is
  - *Assembled and configured @runtime*
  - *Steered using Python scripts*
    - *Providing interactivity to the C++-based applications*
    - *Better maintainability and robustness*
- Infrastructure quite stable in the past Year
  - *Flexibility and robustness extensively tested*
  - *It can handle*
    - *Combined mode*
    - *Photon beams*
    - *Material studies*
    - *eta scans*
    - *Calibration*
    - *Ancillary detectors*
- Validation in progress using single particle and physics events in restricted samples for a quick feedback or larger samples for validation activities (using also reconstruction)

Baseline as of August 07

- Geant4 version 8.3
  - Physiscs list: QGSP_EMV
    - *QGSP physics with the new MSC model which is **not** allowed to limit the step. Physics-wise this list behaves like QGSP_GN under G4 7.1, from the CPU viewpoint we assist to a increasing degradation (in 8.2 QGSP_EMV is about 20% slower than QGSP_GN in 7.1)*
  - *QGSP - Standard QGSP list with the new MSC model. this provides the best EM performance with a CPU penalty of the order 1.6/2.0 with respect to QGSP in G4*
  - *QGSP_EMX - same a QGSP but "optimized" for performance. Even performance-wise there is very little difference between QGSP_EMX and QGSP*
  - *QGSP_BERT - same as QGSP for EM physics, Bertini cascade added in the hadronic package. Bertini gives a definite improvement for hadronic physics (both for LAr and Tile) with a corresponding CPU penalty (20%-50%) with respect to QGSP*
  - Range cuts
    - *coherent revision done in subdetectors for performance optimization:*
    - *ID : 50 um (1 mm in rel 12), MS: 50 um (5 um in rel 12), Calos : 30 um (as before)*

Physics lists studies & comparisons

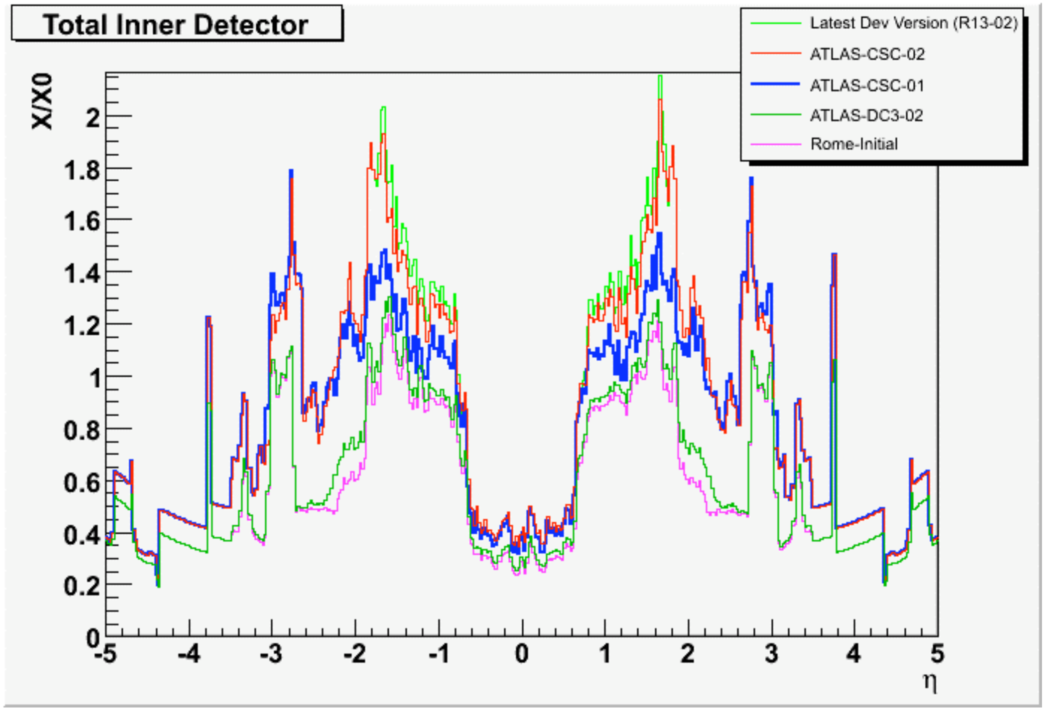
- 300 full events/sample, for preliminary evaluation only

CPUtime per event (kSI2K)					
physics channels	G4.7/QGSP_GN	G4.8/QGSP_EMV	G4.8/QGSP	G4.8/QGSP 1mm	G4.8/QGSP_BERT
susy	921.64	1123.82	1956.42	1560.52	2594.16
Zee	949.58	1107.58	1944.05	1546.41	2432.79
Ztautau	668.64	831.19	1429.71	1361.49	2129.3
H(130)4l	776.72	1067.55	1793.55	1468.79	2334.59
MB	263.35	332.66	584.2	509.29	805.98
jets	765.06	920.77	1480.34	1328.76	1957.11

	Ratios				
physics channels	QGSP_EMV/QGSP_GN	QGSP/QGSP_EMV	QGSP1mm/QGSP_GN	QGSP_BERT/QGSP	QGSP_BERT/QGSP_EMV
susy	1.22	1.74	1.69	1.33	2.31
Zee	1.17	1.76	1.63	1.25	2.2
Ztautau	1.24	1.72	2.04	1.49	2.56
H(130)4l	1.37	1.68	1.89	1.3	2.19
MB	1.26	1.76	1.93	1.38	2.42
jets	1.2	1.61	1.74	1.32	2.13

Geometry descriptions

- Full ATLAS with flavours
  - *Ideal/regular*
    - *(ATLAS-CSC-02-00-00)*
  - *Misaligned*
    - *(ATLAS-CSC-02-01-00)*
  - *Misaligned with material distorsions*
    - *(ATLAS-CSC-02-02-00)*



    - Not all detectors take parameters from DB
      - ✓ Only MS
      - ✓ Tile no misalignements
      - ✓ ID and Lar use COOLDB

        ATLAS-CSC-02-00-00 + OFLCOND-CSC-00-01-00

        ATLAS-CSC-02-01-00 + OFLCOND-CSC-00-01-00
- Cosmic setup
  - *ATLAS-COMM-00-00-00 first commissioning layout*
  - *ATLAS-COMM-01-00-00 current version*
  - *ATLAS-COMM-02-00-00 specific for ID*
- Combined testbeam facilities
  - *CTB 2004 with active and passive material*

Detector description

- simulation, digitization and reconstruction applications all use the same geometry built at runtime
- description is optimized for large numbers of volumes (~10^6) with extensive use of parameterized volume based solutions

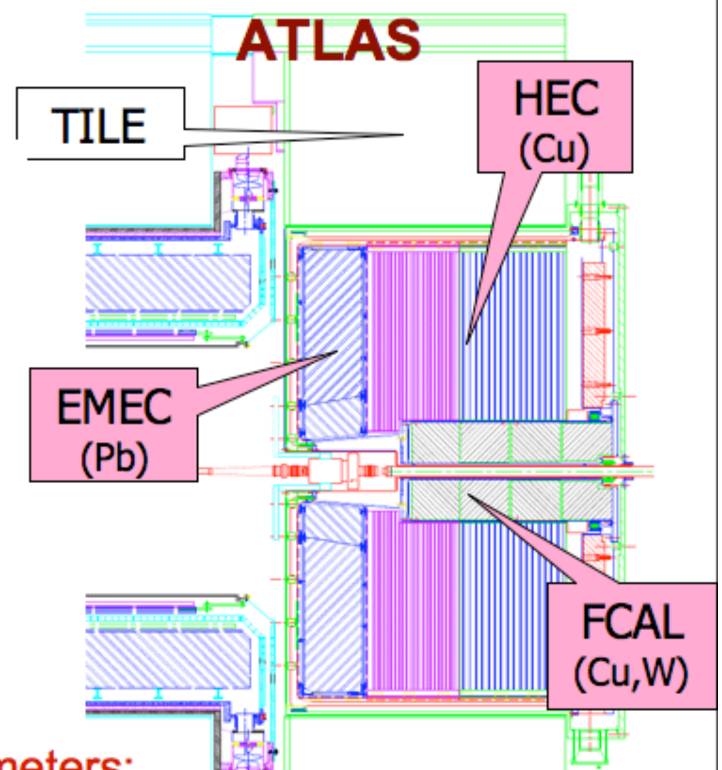
- two hierarchical trees are present in memory at the same time
  - *GeoModel*
    - *provides a transient geometry representation built from primary numbers and alignment constants*
    - *database solution adopted is Oracle and versioning is in place*
  - *Geant4*
    - *In the initialization phase, this geometry is translated into the GEANT4 geometry and placed into resizeable and moveable GEANT4 envelopes*

Particles in Calorimetry

- Electrons
  - *In ATLAS Lar Barrel: good description of energy response, resolution*
  - *longitudinal and radial profile*

  - *In ATLAS HEC: steady improvement, resolution a bit too good*
- Muons
  - *ATLAS Barrel: Tile and Lar calorimeter energy distribution and mean energy deposit well described (~2%)*

- Pions and protons
  - *ATLAS/HEC: energy response QGSP ok* resolutions ok (QGSP and LHEP) Bertini created problems with energy response and resolution
  - *QGSP starts and ends too early in ATLAS/HEC, ATLAS/Tile*
  - *Shower profile: ATLAS/HEC: LHEP starts to early, ends too late*
  - *ATLAS/Tile: LHEP ok, but strange energy behavior*
  - *Bertini nuclear cascade model widens shower longitudinally and laterally*



LAr Calorimeters:

- em Barrel : (|η|<1.475) [Pb-LAr]
- em End-caps : 1.4<|η|<3.2 [Pb-LAr]
- Hadronic End-cap: 1.5<|η|<3.2 [Cu-LAr]
- Forward Calorimeter: 3.2<|η|<4.9 [Cu,W-LAr]

- ~190K readout channels
- Hadronic Barrel:
- Scintillating Tile/Fe calorimeter

Tile calorimeter and Hadronic Physics

- Comparisons between Geant4 and Fluka wrt data
  - *Using common source of geometry (Tile 2002)*
  - *Same format of digitization output allowing common digitization/analysis*
  - *Use GDML+FLUGG+FLUKA (Fortran-C++ interface) to create FLUKA-hits with the material and geometry extracted from the G4 simulation of the TB*
  - *Reuse as much as possible the work done for the Geant4 and data comparisons (ntuples, macros for analysis)*
  - *Readout geometry as in G4 SD not imported*
  - *But same TileHitVector produced in both Fluka and G4*
  - *Results*
    - *Electrons - G4 has the better agreement with data*
    - *Pions - the mean values for G4+ Bertini and fluka are in agreement within 2% with data*
    - *Shower shape - longitudinal: Bertini and Fluka give reasonable agreement with data - lateral: G4 without Bertini has significant less E in shower halo*
  - *Geant4 needs Bertini to reproduce the characteristics of an hadronic shower*

Shower Parameterization

Subsystem	Full [s]	Fast [s]
Tracker	38	35
Electromagnetic Barrel	87	24
Electromagnetic Endcap	399	110
Forward Calorimeter	144	39
Hadronic Barrel	17	16
Hadronic Endcap	50	39
Muon System	16	11
Other Systems	117	79
Event Total	**867**	**353**

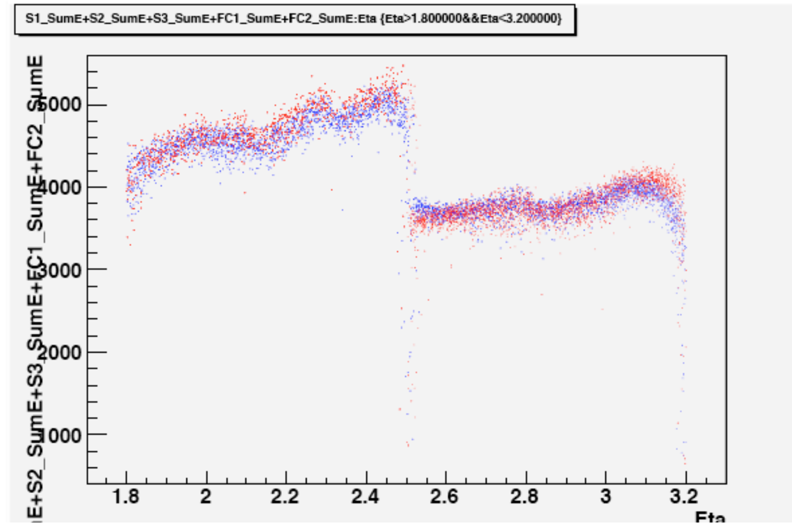
- Strategy
  - *Very simple deposition for $e^{+/-}$ under 10MeV*
    - *A few spots in a line*
  - *Shower libraries for $e^{+/-}$ and γ below ~1 GeV*
  - *parameterization for high energy $e^{+/-}$*
    - *Low end cut off based on timing that varies by region*

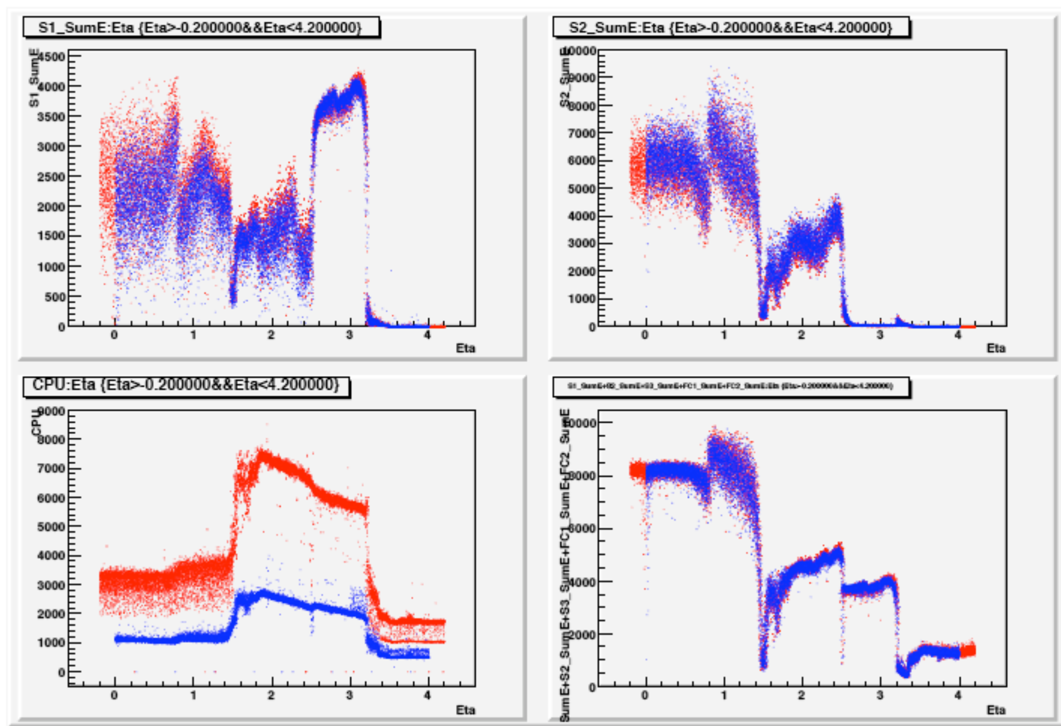
      EMB: 11 GeV, EMEC: 6 GeV, FCAL: 4 GeV
- Code solidifying
- Continuing validation of various options
  - *4 validation levels*
    - *Code functions, no crashes*
    - *Physics appears ok*
    - *Physics tested at reco level*
    - *Full analyses appear ok (MET, MZ..)*
- Preparing for first major production
  - *Via samples production for most physics channels paired with full simulation samples*

Shower Parameterizatior

Shower width in e/γ container

- Simulation time partly driven by cracks
- Lumps caused by containment check. For low energy if electron fails containment, step forward, check again. If fluctuation goes low deposit energy

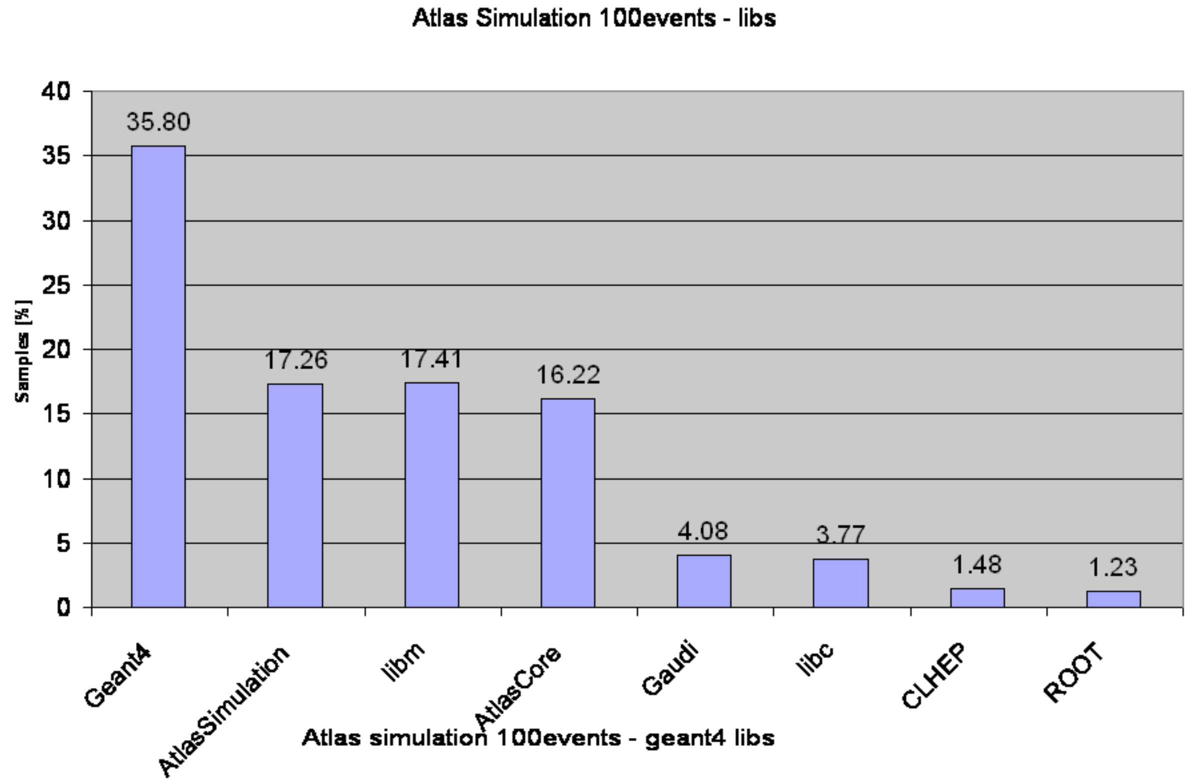


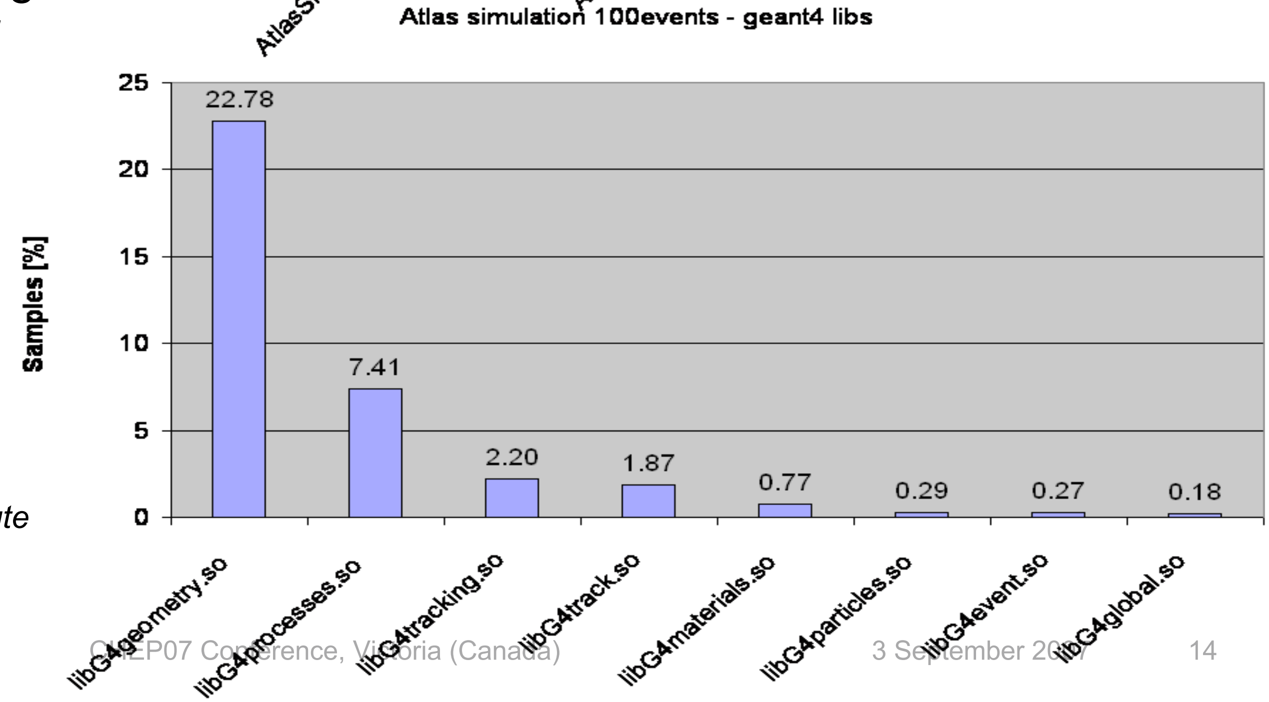


- 50 GeV electrons - Full simulation Fast simulation (kill only)

Performance

- Studies towards an optimization are undergoing
  - *Currently 15-20% of simulation time in going into tracking through field*
  - *Try and understand if it is possible to track in calorimeters with Magnetic field off*
- Performance profiling
  - *Summary for libs and for geant4*
    - *64-bit mode*
    - *Woodcrest (Core 2 Duo) 2.66GHz*
    - *theApp.EvtMax = 100*
    - *started from ApplicationMgr::executeRun(int)*
    - *execution time 585s*

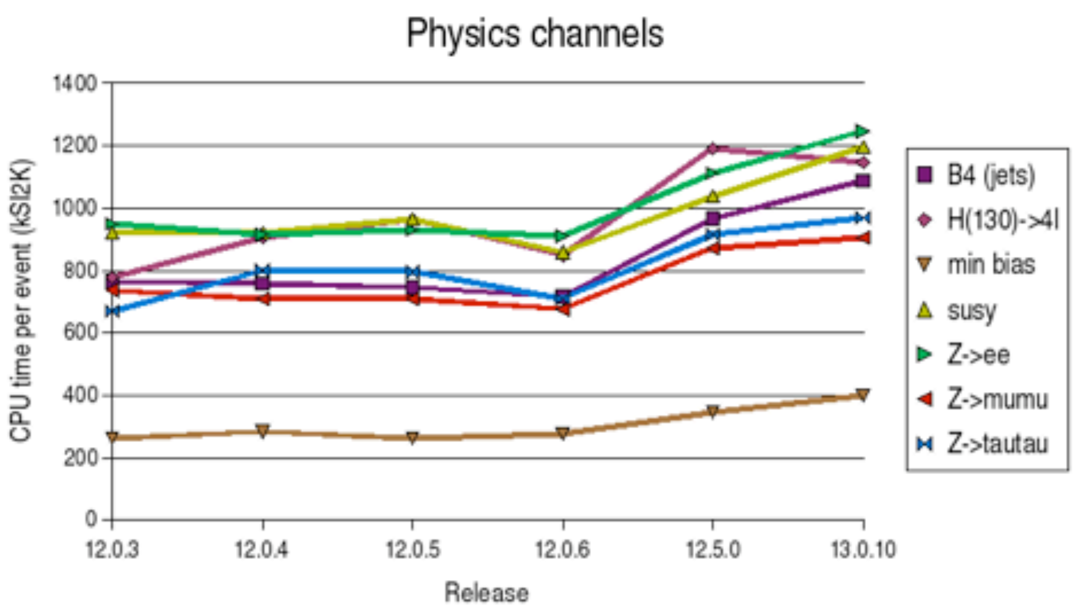




Release validation

- RTT (RunTimeTests) and ATN (ATNight)
  - *Check memory consumption and cpu timing after each release*

CPU timing



12.0.6 G4 7.2p01
12.5.0 G4 8.2
13.0.10 G4 8.2p01

- Physics list QGSP_GN has been used for 12.0.X.
- Physics list QGSP_EMV is used for 12.5.0 and 13.0.10.

Beyond the present release

- Lar Calorimeter
  - *Revision of entire endcap region*
    - *Material, positions, dimensions, contraction*
  - *Sagging pear geometry implementation*
  - *Revision of H6 and inclusion of H6 2004*
  - *Imperfections throughout the calorimeter*
  - *MC Truth information*
    - *Classify 4 types of energy instead of one for each cell*
    - *Abstract class for hit merger needed*
  - *Introducing HV imperfections*
    - *Uniform interface for all 4 LAr subdetectors*

- Tile Calorimeter
  - *Description of distorsions*
- Muons
  - *Active and passive material overlaps curing*
- Forward detectors
  - *Simulation finalization*

What else?

- validation

Backup slides

- Digitization
- Hits in global reference system

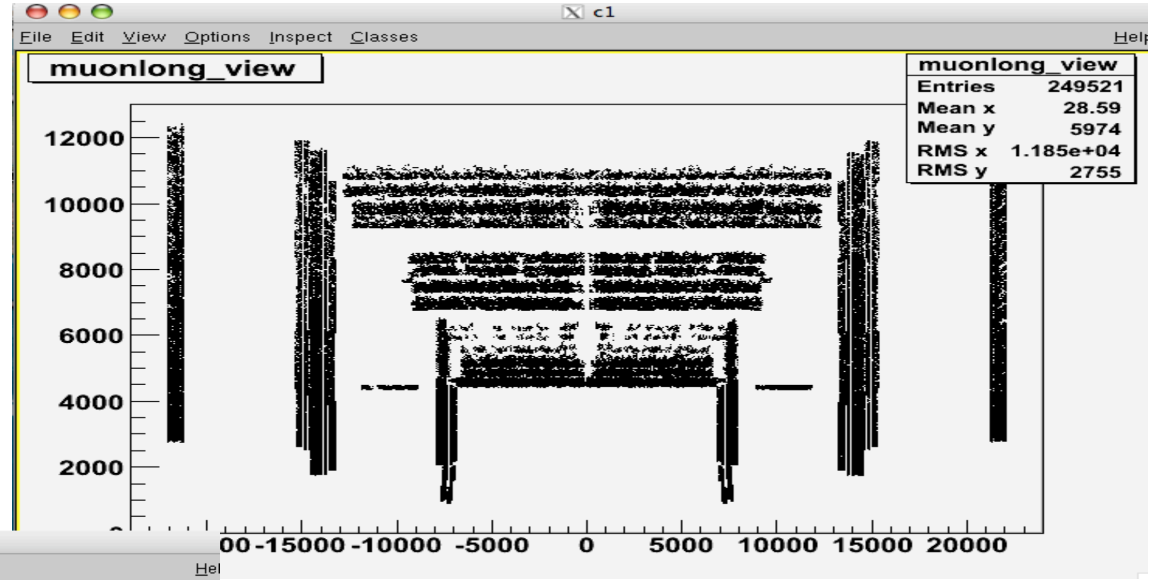
Digitization

- All of digitization (all subdetectors, production transform, pileup & cavern) runs without crashing, produces RDOs
- Random Numbers in Digitization
  - *Report to the SPMB for switch random number service between 13.0.10 to 13.0.20*
- In release 12 and earlier, no random number policy enforced in digitization
  - *every sub-detector different*
    - *Used different random number services: AtRndmGenSvc, RndmGenSvc(=Gaudi!), CLHEP directly*
    - *Initialized seeds in different ways: same in each job, set based on run/event number, in jobOptions, in C++, or not at all*
  - *general problems once can expect from this:*
    - *lack of randomness (e.g. identical noise in empty events, repetition in parallel jobs)*
    - *lack of "*repeatable *randomness", which is desirable for debugging*
  - *Test AtRanluxGenSvc / Ranlux64 with 13.0.10*
    - *Check "sufficient randomness" in empty events, parallel jobs*
    - *Check repeatability with same seeds*
    - *(Check different platforms)*
  - If above tests OK, then switch all digitization to use AtRanluxGenSvc for 13.0.20 (= one-line change in jobOptions)
  - *If not OK, try to fix remaining issues promptly*
  - *Fallback solution: Stay with AtRndmGenSvc/Ranecu, but keep new seeding scheme (no worse than seeding based on event+run number used in C++ in 12.0.x)*

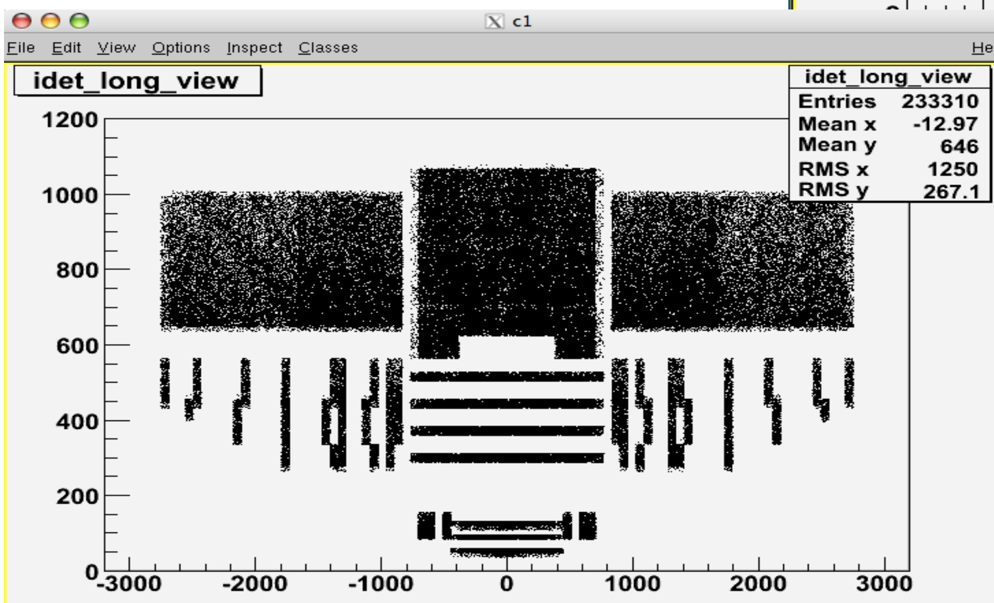
Digitization S.Vahsen,BERKELEY LAB

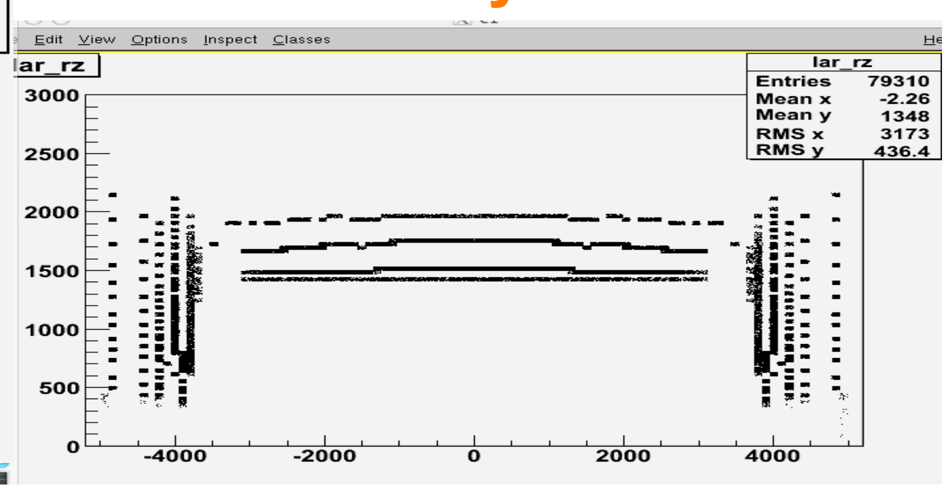
- Production with 13.0.10.x
  - *Will request designated Monte Carlo sample from production system, to validate changes in digitization random number use*
  - *Most likely reuse 12.0.x HITS, single electrons & muons from "SampleA"*
  - *Digitize with 13.0.10.x twice: AtRanluxGenSvc and AtRndmGenSvc*
  - *Compare two RDO samples against each other and against 12.0.x digitization*
  - *Can also re-run part of sample with same seeds, to check repeatability*
- New job configuration
  - *Sub detectors migrated to configurables*
  - *Steering: digitization flags → jobProperties*
  - *Some work remains.*
    - *Aim is to completely remove old-style flags and python variables (which would force all topOptions to migrate.)*
- Digitization looking good in release 13.0.10, no major problems
- Detailed RDO validation with 13.0.10.x test production still to be done

Hits in global reference system



Muon System





Lar Calo

Inner Detector