

Geant 4 usage in ATLAS

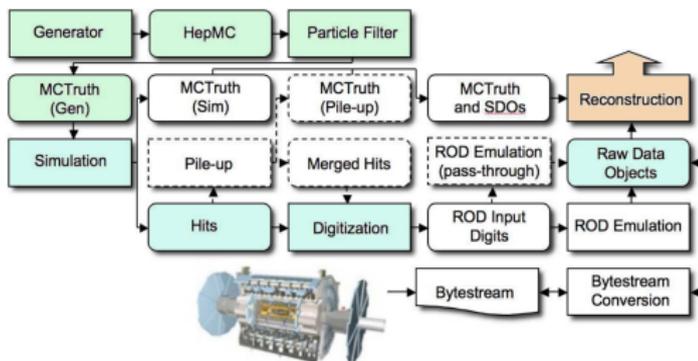
Andy Buckley
University of Edinburgh
for the ATLAS simulation team

Geant 4 technical forum, 2010-11-15

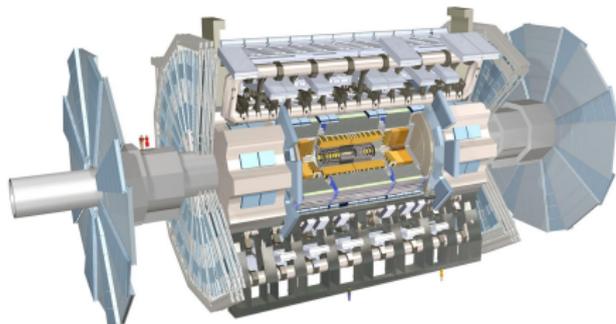


ATLAS simulation framework

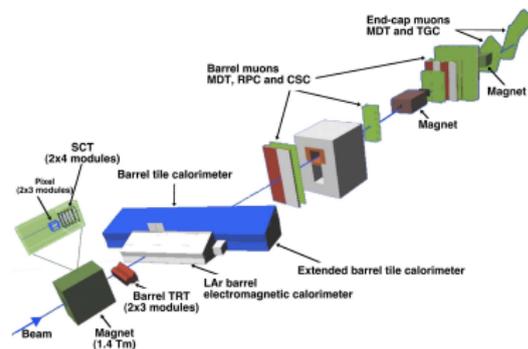
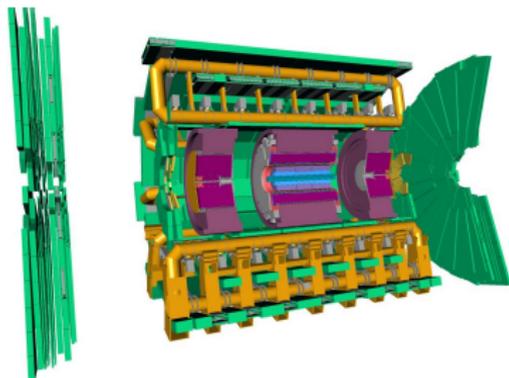
- ▶ Simulation of physics events / detector via common ATLAS software framework (Athena)
- ▶ Detector simulation based on Geant 4, geometry shared with reco
- ▶ Multiple layouts supported: ATLAS + test beam setups, etc.



ATLAS simulation layouts



ATLAS



ATLAS simulation production

- ▶ Full sim currently using **G4 9.2.patch02.atlas04** – ~ 12 patches incorporated for issues reported by/affecting ATLAS, incl. Bertini CPU. **Next major update: straight to G4 9.4.** 9.4beta in testing. Patches have made upstream version migration troublesome.
- ▶ Framework used for large scale (~ 500M event) production on LHC Computing Grid: ~ 8M event/day. MC10 production underway from October.
- ▶ Production physics list is QGSP_BERT.
- ▶ Failure rate $< 10^{-6}$. Data size is limiting factor.
- ▶ Current production on i686-slc5-gcc43-opt – GCC 4.5 etc. requirement anticipated.
- ▶ Next production MC11: schedule not finalised, possibly starting February 2011.
- ▶ **Special cases: cosmics, forward detectors, beam halo and cavern background (require extra particle transport); R-hadrons, stopped gluinos, Q-balls, monopoles...**

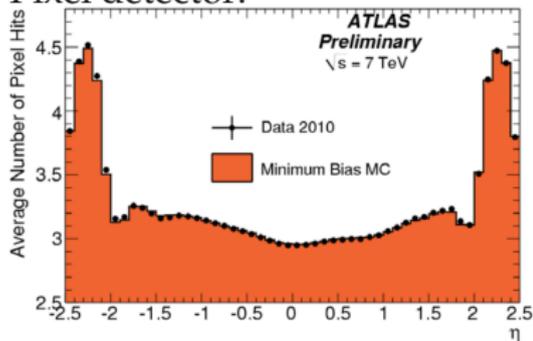
G4 sim open issues

- ▶ Stuck tracks have been a problem: 10k–10M steps taken by a single, barely-moving track. Kill heuristics difficult: ATLAS production uses a “looper killer” to detect tracks with $> 10M$ steps and abort the event. Small (?) bias? Small CPU hit $\sim 1\%$.
- ▶ Neutral hadron response: neutrons, K_S^0 , etc. – how to estimate uncertainty? Interest in investigating other physics lists, e.g. the new CHIPS-hybrid lists. Will these continue to be supported / developed?
- ▶ Examining use of G4 for cavern background simulation. Scoring and parallel navigation $\Rightarrow \sim 100\%$ CPU overhead. Plus need for HP physics list \Rightarrow factor of 5 in CPU.
- ▶ Scaling of G4 VMEM and RSS from 32 to 64 bit?

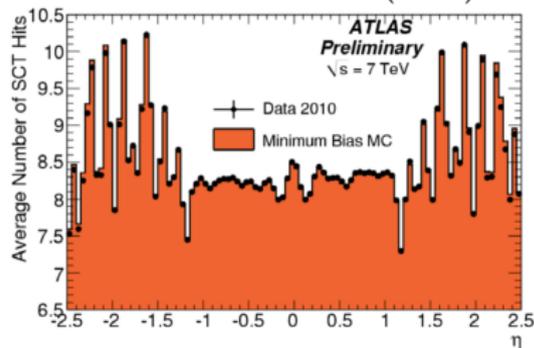
Simulation comparison to data

Excellent understanding of detector:

Pixel detector:



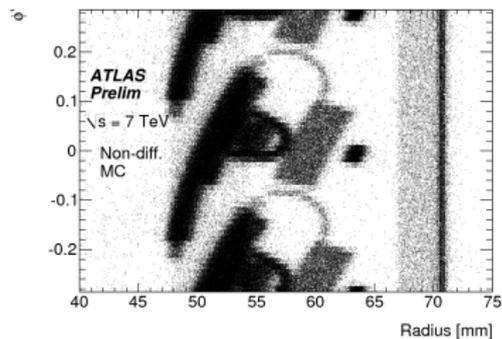
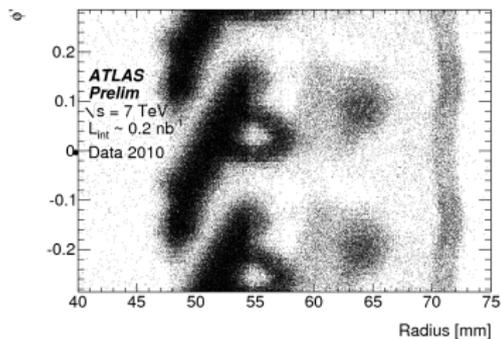
Silicon central tracker (SCT):



Simulation comparison to data

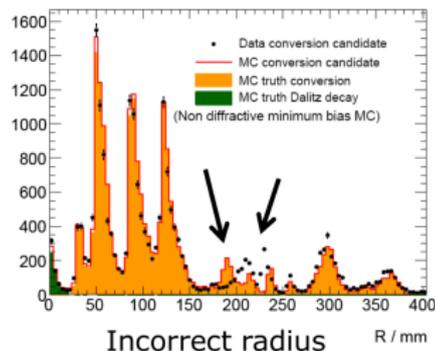
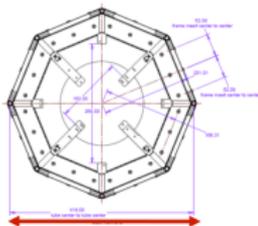
Excellent understanding of detector:

Close-up of secondaries in 1st pixel layer (data, sim):



Simulation tuning to data

Geometry fixes from design to correct sim photon conversion radius:

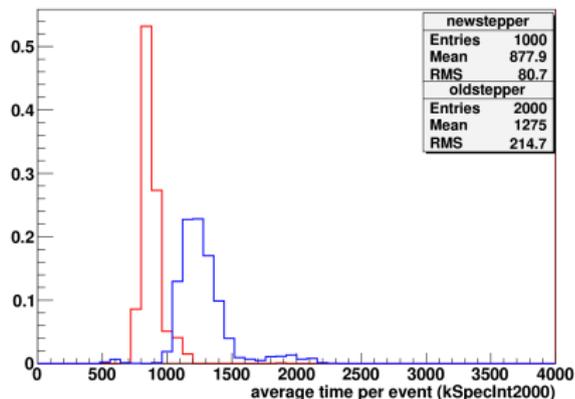


Also two fixes for anomalous G4 events with **energy non-conservation**:

- ▶ Jets at 55 and 67 GeV found in J0 ($p_{\perp} \in [7 - 14]$ GeV) slice! No truth match: energy not conserved in G4 $\gamma + \text{Pb} \rightarrow \pi^+ \pi^- + X$
- ▶ In $\pi^+ + \text{He} \rightarrow \text{pp} + X$, protons with 47 TeV each!
Pretty clearly a bug!
- ▶ G4-produced patches in production and in later G4 releases.

CPU focus: field stepper system

- ▶ RK4 adaptive steppers used for particle propagation. Calls to B field map $\Rightarrow \sim 20\%$ of sim CPU
- ▶ 11 calls in **ClassicalRK4** stepper \Rightarrow 4 using **AtlasRK4** stepper with analytic error calc
- ▶ **AtlasRK4** also has field-caching in a fixed radius: further field-call reduction
- ▶ Further reduction to only 2 calls possible with G4 NystromRK4 stepper: in commissioning



- ▶ Also “stepper dispatcher”: choose stepper based on region, track PID, energy, proposed length. Lengthy commissioning, message not 100% clear.

Summary

- ▶ Simulation framework very successful: very good detector description, improving performance: simulating $\sim 10\text{M}$ events per day in ATLAS MC production.
- ▶ ATLAS code performance optimisation and structural re-working ongoing.
- ▶ Migration to G4 9.4 in early 2011, particular interest in new physics lists. 9.3 as a backup in case of problems.
- ▶ Main platform currently SLC5 32 bit, GCC 4.3 but `icc` ATLAS builds starting. Newer GCC likely to be trialled and eventually used.
- ▶ “Stuck tracks” still an issue for ATLAS production.
- ▶ Interest in physics improvements, of course! Assessing systematics and constant data/MC review in development.
- ▶ ATLAS data/MC tuning workshop mid-December: K , \bar{p} response studies etc. Any requests?