Geant4 requirements from High Energy Physics (HEP)

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ATLAS (1/2)

ATLAS Requirements: Release Support

- Support for Geant4 9.4 until mid-2014
  - On the following platforms:
    - gcc43 slc5 32/64
  - No new compiler configurations required.
- Support for Geant4 9.6 until mid-2016/foreseeable future
  - On the following platforms:
    - gcc43 slc5 32/64
    - gcc47 64 slc5/slc6
    - gcc48 64 slc6
    - icc 64 slc6 [experimental]
    - clang 64 slc6 [experimental]
  - Initial tests with G4 9.6.patch02 gave an estimated crash rate of 1e-4 (based on a 2M events).
- ATLAS will attempt builds with new versions (and candidates), but we do not expect them to run in production before ~2016.

ATLAS (2/2)

ATLAS Requirements

- A summary of the validation for processes significantly revised in Geant4 9.6 (e/gamma nuclear, stopping particles, …)
  - a gallery of key results
  - a status of the physics performance and known issues
- It would be great if the ATLAS geometry (provided in GDML format) could be used in robustness and performance testing.

CMS (1/4)

Status of Production

- 2011:
  - 7 TeV Monte Carlo production ~$3 \cdot 10^9$ events
  - Geant4 9.4 (+ few fixes)
  - Slc5_amd64_gcc434
- 2012 :
  - 7 TeV Monte Carlo production $0.24 \cdot 10^9$ events
    - Geant4 9.4p03
    - Slc5_amd64_gcc434
  - 8 TeV Monte Carlo production
    - $6.5 \cdot 10^9$ events produced
    - Started with Geant4 9.4p03 and CHIPS stopping fix
    - slc5_amd64_gcc462
- Production Physics List QGSP_FTFP_BERT_EML
  - Few alternative Physics Lists are available with bremsstrahlung and multiple scattering backported from Geant4 9.5
- Legacy MC re-production for 2011 & 2012 data
  - EM improvements are backported
  - slc5_gcc462_gcc462 & slc6_gcc472_gcc472
  - May run for long time, current plan to produce ~10^9 events

CMS (2/4)

Current Developments

- Production version for 2013 CMS upgrade studies 9.5p02
  - Similar physics and CPU performance as in 2012
  - slc5_amd64_gcc472
- Geant4 9.6p02 is the current development version
  - slc5_amd64_gcc481
  - Slc6_amd64_gcc481
  - Some differences with Geant4 9.5 are seen in tracker (momentum resolution singnificantly worse) and in jet spectra
- Plan to adopt Geant4 10.0 in 2014
  - Start from sequential build and slc6_amd64_gcc481
  - Parallel development with MT build and TTB

CMS (3/4)

CMS requirements to Geant 10.0

- New challenges for 13 TeV run:
  - higher energy, higher multiplicity, higher pileup
  - larger integral luminosity
- Geant4 physics should not be compromized but even improved if possible in sensitive areas, so detailed validation from Geant4 side is required:
  - Calorimeter simulation
  - Tracking in field
- CPU speedup of Geant4 simulation is needed, there is a list of Geant4 classes leading in time profiler
  - see details report at parallel session
  - Hadronic cross sections
  - Fluctuations of energy loss
  - Fast math library will allow to spead up simulation

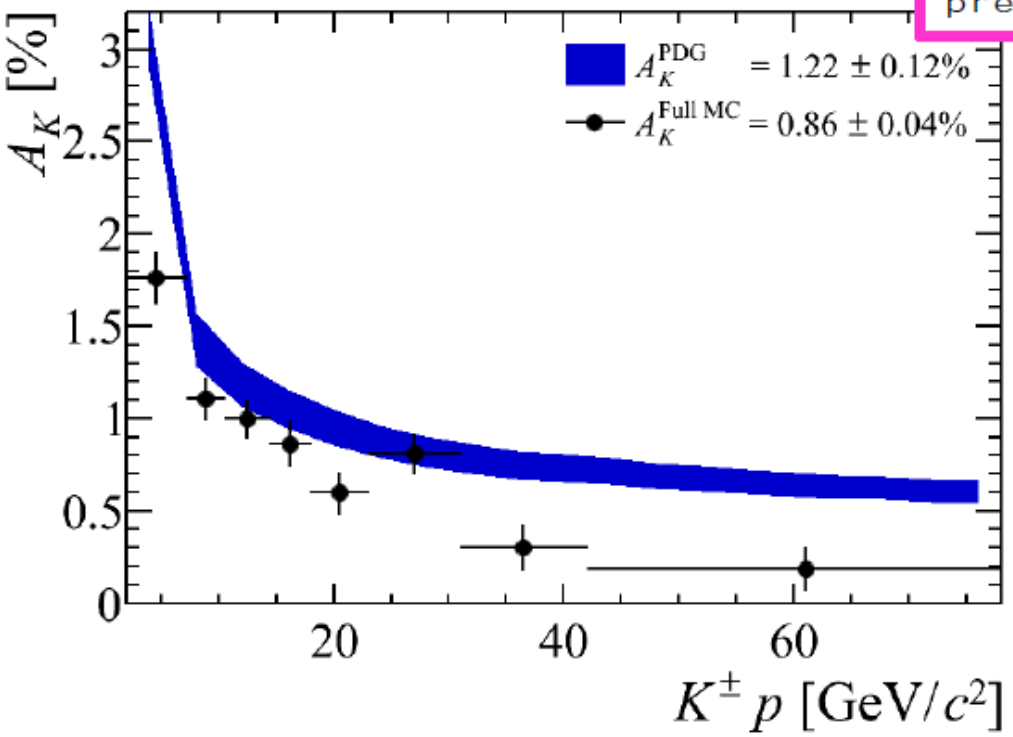
LHCb (1/2)

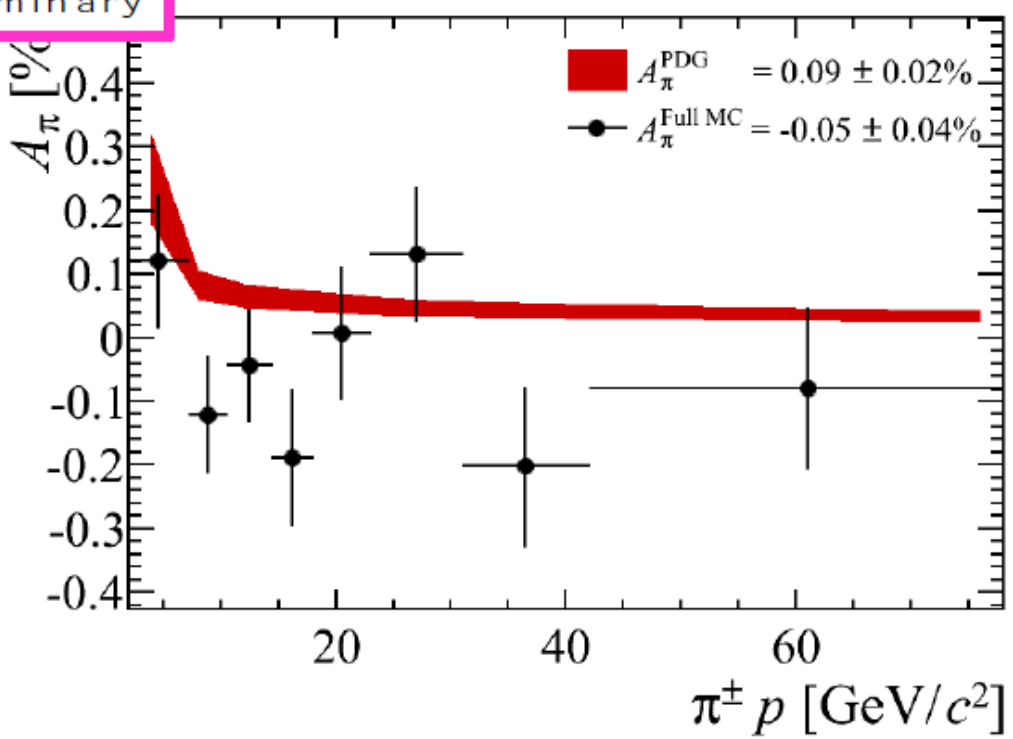
- The **asymmetry** in **FTFP_BERT** physics list between the Kaon+ and Kaon- hadronic inelastic cross sections is **not** good enough for LHCb
  - it was better in LHEP
  - for pion+ and pion- it is good in FTFP_BERT (better than in LHEP)
- Requested by LHCb at the Geant4 Technical Forum (March 2013)
- Waiting for their input to scale the Kaon+ or Kaon- hadronic inelastic cross sections in Geant4
  - It is a small effect (~1 %), so it is well below the uncertainties of our kaon cross sections (extracted from CHIPS)
  - No problems for all other users!

LHCb (2/2)

Sim08 (FTFP_BERT) asymmetries

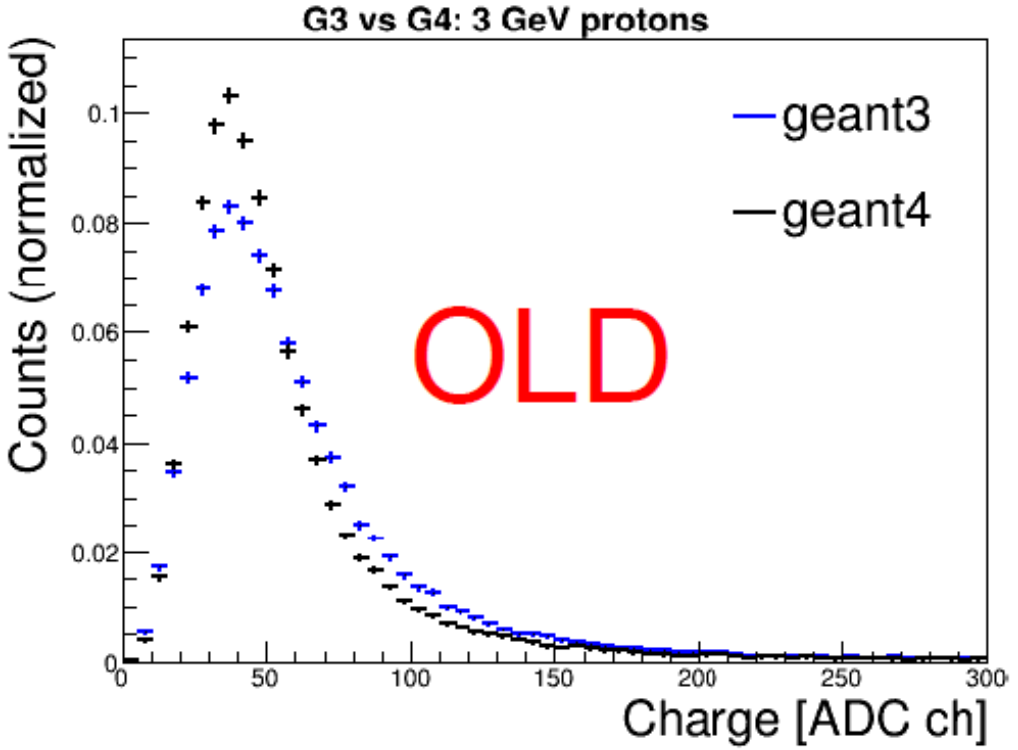
preliminary

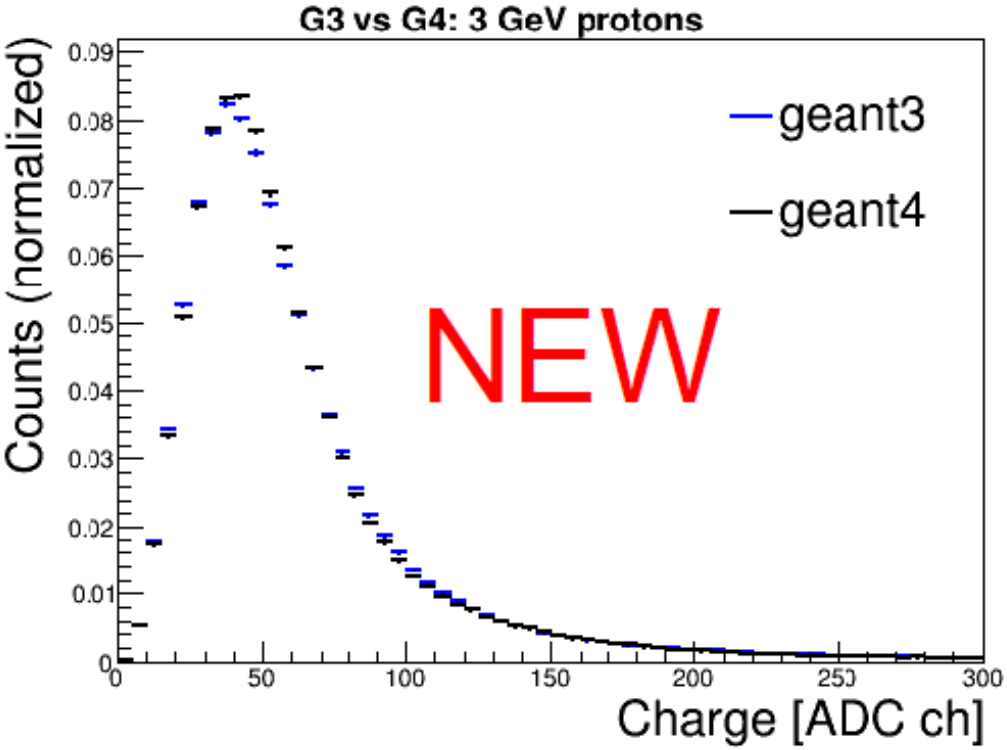




- Using 9.5.patch02 setup in LHCb (FTFP_BERT list)
- Kaon asymmetry too low (esp. for high momentum).
- Pion asymmetry is ok now (note changed A_π scale cf. previous slide)

ALICE





- Solved the problem of the TPC response in G4 simulations
  - G3 uses a special ALICE/NA49 model which describes well the test-beam data
- The last remaining critical issue is the CPU overhead of G4 vs G3 ALICE simulations
  - Originally a factor of ~ 3
  - Work in progress to reduce it (see S. Wenzel talk at Parallel Session 3A)

CALICE (1/4)

Questions / Requests

- A “technological” request:

  As our analyses get more sophisticated, it is more often required to determine the origin of individual energy deposits, e.g. from

  - em subshowers
  - relativistic and non-relativistic charged hadrons
  - neutron-induced processes (evaporation, capture, ...)

  at the moment this requires quite complicated custom implementations, which are often lost when a student leaves etc.

  ⇨ It would be nice to have something like this implemented centrally (for example accessible through the step, just as the energy deposition). This will also improve the comparability of different studies, since it provides unambiguous definitions which everybody can use

CALICE (2/4)

Questions / Requests

- A “practical” issue:
  When we publish results, the simulations used are often not the latest GEANT4 versions, since it takes some time to finalize the analysis, review the results and prepare the publication: How far back (in versions) does it make sense to go? At what point should we re-do the simulation studies?
  - Some examples:
    - Hadron shower timing studies currently being prepared for publication use 9.4p3 (during the analysis, 9.5 was available, but had a problem with the timing of some particles, and was thus not used)
    - A study of hadronic showers (hadronic interactions, shower profiles) in the SiW ECAL which is currently being finalized uses 9.3

Note: Quite often the papers are based on thesis work by students, which by the time of the publication have left the collaboration (or physics altogether), so redoing the simulations might result in significant delays, or even in not publishing an analysis at all...

CALICE (3/4)

Status / Prospects

- Only a very small selection of results that are now available from CALICE (see references given on slides for more results)
  - Available in published papers or analysis notes with comparison to MC:
    - Reconstructed energy & resolution in Steel/Scintillator, Tungsten/Scintillator
    - Hadronic shower profiles (longitudinal, radial) in Tungsten/Silicon, Steel/Scintillator, Tungsten/Scintillator
    - Sub-structure of hadronic showers (track segments) in Steel/Scintillator
    - Time structure of hadronic showers in Steel/Scintillator, Tungsten/Scintillator
  - In progress:
    - All of the above also for Steel/RPC, Tungsten/RPC (timing with RPCs only with Tungsten at present)

Some Members of GEANT4 are also CALICE Members: It would be nice to take more advantage of this connection already during the analysis and discussion phases - For example at the CALICE Meetings:

The next meeting is planned for **Mid-March 2014 at Argonne**

Thanks

J. Chapman (ATLAS)

V. Ivanchenko (CMS)

N. Watson (LHCb)

A. Morsch (ALICE)

F. Simon (CALICE)