Open and New Requirements for HEP experiments

25th Geant4 Collaboration Meeting

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Many thanks to..

- **LHCb:** Gloria Corti, Michal Kreps, Adam Davis, Dominik Muller
- **ALICE:** Ivana Hrivnacova, Sandro Christian Wenzel, Andreas Morsch
- **CMS:** Vladimir Ivantchenko
- **ATLAS:** John Derek Chapman, Michael Duehrssen, Zachary Marshall

LHCb Requirements (1/5)

Parametrized volume description

- LHCb is working on making its simulation faster.
  - One way is to replace the Geant4 simulation of the detectors taking the longest time with fast simulation, e.g. of ECAL using the Geant4 hook
- Simulation of the major CPU consumers, RICHEs and Calorimeters, is being addressed. The next on the list is the VErtex LOcator (VELO)
  - BUT a precise and detailed simulation of the VELO is needed for the LHCb physics program
- LHCb developed a parameterised description of the material in the VELO – and in particular the RF foil - as measured in data to be used for physics analysis assigning probability of interactions within the material
  - We would like to investigate coupling this to Geant4 that would take care of the physics processes

G4 developers suggested similarity to plugging in an external navigator

We welcome guidelines and help on how to do it

LHCb Requirements (2/5)

Physics processes

- A variety of LHCb physics measurements rely on good knowledge of asymmetry aspects in the detectors and in particular between detection of particles vs. anti-particles
  - A revision of hadronic cross sections for proton and anti-protons as there are more precision analysis with them in the final states would be highly appreciated

- In Run3 the VELO will approach the beam to 5 mm (from 7 mm in Run1&2) hence b and c hadrons will have a higher chance to interact with the material before decaying
  - Availability of hadronic physics processes for b-hadrons and c-hadrons will become more important and would be appreciated

LHCb Requirements (3/5)

Making new particles known to Geant4

- In order to introduce new b-hadrons we need to first make it known to Geant4 and then make it known as an ionizing particle in our physics list
  - It would be helpful to have an easy way to do this at run time rather than modifying the Geant4 PL.

- When producing Heavy Ions collisions with dedicated generators we may have beam remnants that may 'travel' and have a PID code of the form 1000xxxxx. These ions are known to Geant4 internally as they may be produced with similar codes in hadronic processes but we need to add them explicitly to our list of known particles
  - It would be helpful to have an easy way to make ions from the generators known to Geant4 at run time since a big variety could be produced in the collisions

We are not aware if this already exists, if it does we welcome guidelines and help

LHCb Requirements (4/5)

CPU and R&D

- LHCb is working on making its simulation faster
  - Any improvement in speeding up the code base will be highly appreciated – it is understood that tuning is the responsibility of the experiment
  - Appreciate continuing support on more complex fast simulation integration

- LHCb will have access to new and varied computing resources, e.g. GPUs at the HLT farm. It will be more and more important to be able to access heterogenous resources for the simulation
  - Happy to be exposed early on to R&D, e.g. on new technologies and willing to act as testers
  - Grateful to receive information/guidelines on other users' experience and solutions

LHCb Requirements (5/5)

Feedback and validation

- In LHCb we sometimes need to modify the G4 code, e.g. Physics list. We appreciate G4 maintains one for us.
- We also sometimes need to deploy patches provided to use by G4 developers in production (thanks!)
  - It would be nice to have an easier way to provide the code back directly to the G4 repository – clearly with a review acceptance process
  - It would be nice to also get the patch directly from the repository rather than via private communication
- When we introduce new release we do a set of tests with our LHCbPR infrastructure that includes distributions at Geant4 level
  - It would be helpful to be have an easy direct access to G4 validation plots for release tests to have a preview and be able to cross-check against ours. This would also help debug problem and find them faster

ALICE Requirements

- One pending requirement for the support for “sub-event" parallelism across G4 threads (already included in G4 requirements list).
- No new requirements

CMS Requirements (1/2)

- Provide an option to make a new vertex in the case of high energy bremsstrahlung or pair production by muons
  - Before Run-1 Geant4 implemented a possibility to stop e+- track and create new vertex in the case of high energy bremsstrahlung
  - Energy threshold is EM parameter
  - The same feature is requested for muons
- Geant4e software is not thread safe, new exceptions are observed by CMS experts trying to use Geant4e for detector alignment with Geant4 10.6.p01
  - Exception messages are cryptic
  - Review and update of this sub-package is required

CMS Requirements (2/2)

- Geant4 in CMSSW can not currently make use of GPUs or other hardware accelerators
  - CMS software needs to use heterogeneous computing systems efficiently.
  - It is important for CMS to be able to leverage accelerators for Geant4 based simulation.
- Geant4 is a sizeable component of the CPU needed today and for HL-LHC for CMS production.
  - CMS expects to have substantial GPU resources available for Monte Carlo production (starting already in Run 3 at HPCs and the CMS HLT farm).
  - The long-term approach to using heterogeneous computing in CMS software is on-going R&D, the results of which can of course be shared as useful.
- It is important to provide a plan of the future traditional optimisations for CPU, which will enter Geant4
  - For 2021 and beyond

ATLAS Requirements (1/3)

- Ensuring that particles "known" to Geant4 have basic processes like ionisation defined
  - We know it is in progress, is the plan to include this feature in Geant4.10.7?
- Support for zero-lifetime particles or more generally a refactoring/ improvement of the mechanisms for pre-defined decays in G4Event
  - Unfortunately the patch provided some time ago didn't solve the issue
- Help understanding the longer lifetimes observed for particles with pre-defined decays
  - Vladimir and John are already helping us with this issue
- Improvement of the G4Command interface
  - Many commands could silently fail without reporting either a warning in the log or returning an error code.
  - Was this improvement already included in Geant4.10.6?

ATLAS Requirements (2/3)

- Improved agreement of EM shower shapes - long-running
  - What test could we provide to be used in tuning? FullSimLight?
- Improving G4Material interface (addElement)
  - Different methods when adding an element to the material
    - by fraction or number of atoms
- Making the threading-model in G4 more like Gaudi/Athena
- Ensuring all processes respect range cuts (particularly for EM particles)
  - Compton scattering could create EM secondaries below the range cut thresholds.
- Allowing more configurable builds of Geant4
  - i.e. to optionally not include DNA processes in G4 libraries (not used in ATLAS)
- Geant4 on heterogeneous resources ->how do we go there?
  - In ATLAS we have R&D towards running our software on GPUs/Heterogeneous resources
  - What are the plans for G4?

ATLAS Requirements (3/3)

- What are the plans of the collaboration about CPU/memory optimization improvements?
  - What the goals are, which areas of the code will be targeted?
- Make G4 as modular as possible:
  - i.e. being able to call G4 hadronic interaction code without having a full G4 setup such that we can use it out of Fatras
  - There is an example that Alberto created, that needs to be properly tested
  - Is the plan to include it in the advances examples for Geant4.10.7?
- Support for interactions of b (and c) hadrons with detector material
  - support for charm and bottom hadrons is included in Ref08, with some bug fixes already introduced in Ref09, so it will be included in Geant4.10.7
  - Thanks!

Common Highlights

- Support for charm and bottom hadrons
- Big interest in CPU/memory optimization improvements in Geant4
  - What the goals are, which areas of the code will be targeted?
- Heterogeneous hardware interest is rising in all experiment collaborations
  - Intensive R&Ds ongoing
  - Plans of Geant4 Collaboration?

Thanks to the Geant4 developers for their constant support and precious help!

Thanks for your attention.

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Backup slides