ATLAS Simulation Requirements and Requests

Detector Simulation Mini Workshop - 29th April 2021

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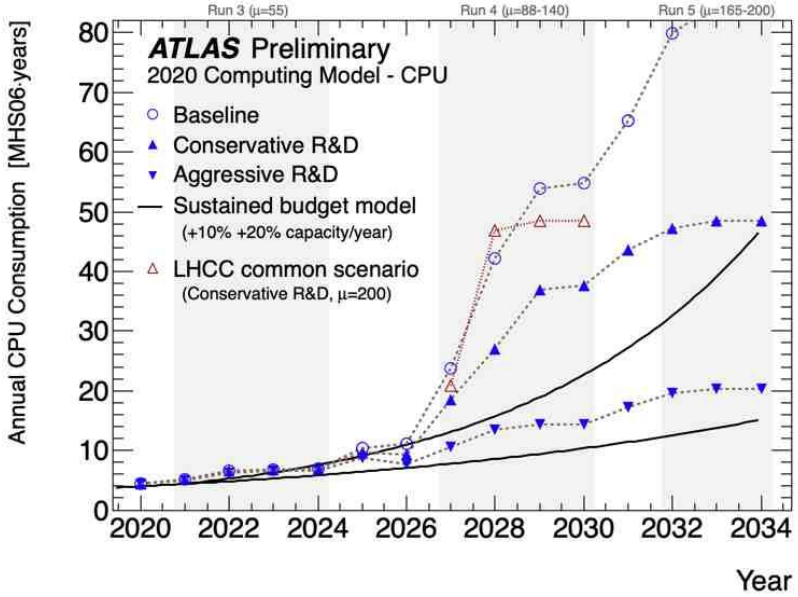
1. Parameters anticipated from HL-LHC computing models

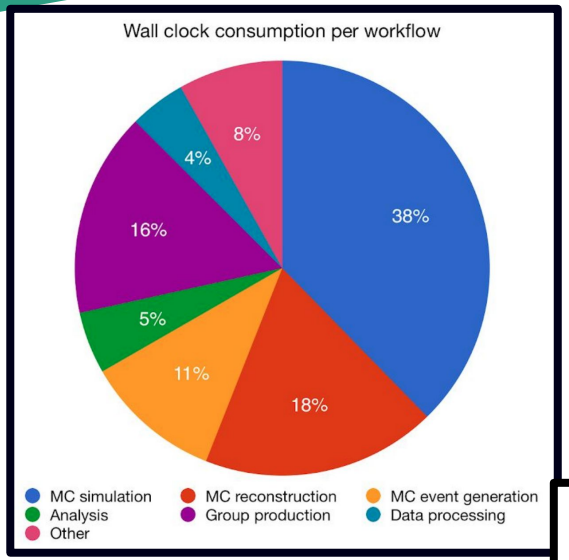
from ATLAS CCDR

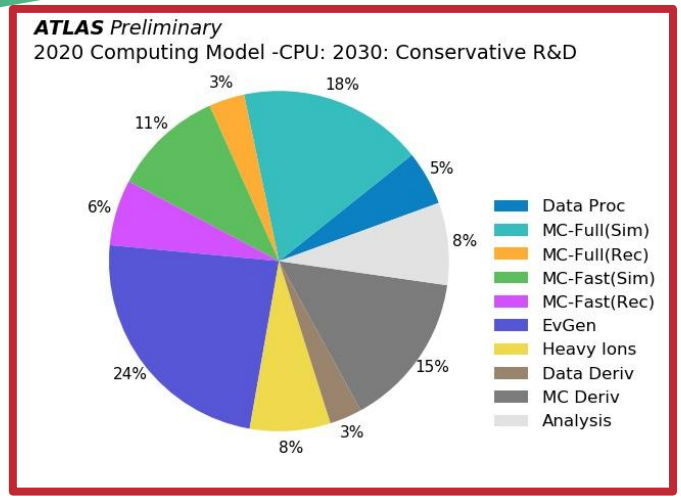
HL-LHC production parameters

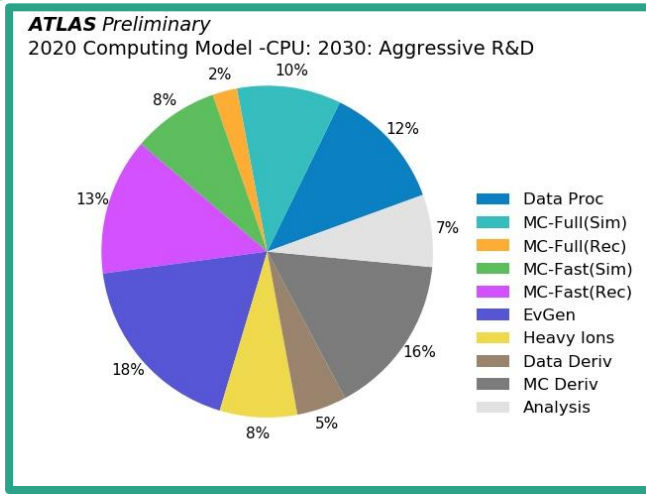


	Conservative R&D	Aggressive R&D
MC events produced/data events recorded	2.5	2
Fraction of Fast Simulation	75%	90%

HL-LHC production parameters







ATLAS CPU hours used by various activities in 2018

2.
ATLAS Requirements

Geant4 Simulation Physics Performance

- **Sensitivity to data-MC differences will increase due to new analysis techniques and comparison to >20 times more data than recorded today.**
- **Conservative R&D:** ATLAS will focus on fast simulation of the Calorimeter.
- **Aggressive R&D:** ATLAS will also use Acts Fatras for Inner Tracker fast simulation.
- **Requests:**
  - Improved physics quality of simulation
    - Boost effort to tune to experiment test beams (starting work on ATLAS test beams).
    - ATLAS + G4 to provide a reasonable benchmark for use in G4 testing and validation.
    - Intrinsic improvements to the models inside Geant4, …
      - G4 will be used to tune Fast Simulation models in all R&D scenarios.
  - Getting a better handle on systematic errors
    - Building on new options in 10.7 to vary x-sections; options to vary hadronic model parameters, angular distributions etc. could be introduced.

Quasi-stable particle Simulation

- **Working definition for Run 2 and Run 3**: *Particles considered unstable by the Generator, but which propagate through at least one sensitive detector layer.*
- **Requirements:**
  - Improved robustness of Geant4 when using pre-defined decay chains from Generators.
    - Perhaps implementing some kind of sanity checker for G4Events with pre-defined decays to spot potential problems. (Unknown particle types, particles with no physics models attached, zero lifetime particles.)
  - Establish conventions on consistency of decay models between G4 and Generators where there are overlaps?
    - Or possibly common work to directly integrate event generators for certain decays and interactions?
  - Dealing with hadronic interactions of oscillating neutral mesons.

Exotic particle Simulation

- **Many experiments need to simulate BSM particles. Individual experiments have implemented extensions to Geant4 to add support for additional particles and processes.**
- **Suggestion:**
  - Create a centralised repository for such modules that all experiments can benefit from/contribute to.
  - E.g. modules for R-hadrons, monopoles, quirks, etc.

Geant4 Simulation Technical Performance

- **Conservative R&D:** ATLAS will use Geant4 to simulate the Inner Tracker and Muon Spectrometer in 100% of samples and the Calorimeter in 25% of samples.
- **Aggressive R&D:** ATLAS will use Geant4 to simulate the Muon Spectrometer in 100% of samples and the Inner Tracker and Calorimeter in 10% of samples.
- **Requests:**
  - Factor of two improvement in simulation speed before HL-LHC with no loss of physics performance.

Fast Simulation Support

- **Conservative R&D:** ATLAS will focus on fast simulation of the Calorimeter.
- **Aggressive R&D:** ATLAS will aim to make use of Acts Fatras for Inner Tracker simulation.
- **Requests:**
  - Geant4 to focus on framework support and generic techniques such as biasing etc.
  - Flexible interfaces/frameworks for fast simulations (e.g. batching), not the fast simulation engines themselves which might be very experiment specific.
  - ML techniques typically require per detector training, so one-size-fits-all common models are probably not the best approach.

Support varying of detector geometry

- **Conservative R&D:** ATLAS would overlay simulated interactions on zero-bias Heavy Ion data events to capture the underlying event.
- **Aggressive R&D:** ATLAS could overlay hard-scatter MC events on zero-bias p-p data events to include the effects of pile-up.
- **Request:**
  - **Support varying detector geometry in G4 and/or fast simulations in a fast enough way to be used in production jobs.**
    - Increased use of data to model cavern/beam backgrounds and additional p-p collisions requires the simulation of the hard scatter to adapt event-by-event (or lumiblock-by-lumiblock) to the actual data taking detector conditions: alignment, beam spot, etc. in order to maintain consistency.

Common Digitization Models

- **Experiments will share some detector electronics in the HL-LHC era, so it may make sense to share code which simulates the readout.**
- **Request:**
  - **Common development for the simulation of the detector electronics and read-out could be considered.**
    - Response simulation of silicon tracking detectors under the influence of radiation damage.
    - Common digitisation models more broadly?

Support for varied architectures

- **When HL-LHC starts up the available resources may use a wide variety of architectures.**
- **Request:**
  - **We should aim to exploit available resources as efficiently as possible.**
    - Support for new architectures (e.g. ARM) not only GPUs and accelerators
    - Use of GPUs for particle tracking in calorimeters
    - How to deal with complications when using GPUs, e.g., hadronic interactions in the case of an EM GPU simulation
    - Use in fast simulation (including ML)

Backup

Credits

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