**The ATLAS Fast Monte Carlo Production Chain Project**

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Summary: ATLAS’s new integrated simulation framework (ISF) allows a flexible mixture of full and fast detector simulation techniques within the processing of one event. The thorough achieved possible speedup in detector simulation of up to a factor 100, makes subsequent digitization and reconstruction the dominant contributions to the Monte Carlo (MC) production CPU cost. In digitization due to the complexity to model the detector readout in detail and in reconstruction due to the combinatorial nature of the problem. Alternative fast approaches have been developed for these components, which are presented here. All components have been, together with the ISF, integrated into a new fast MC production chain, aiming to produce MC simulated data with acceptable agreement with fully simulated and reconstructed data at a processing time of seconds per event, compared to several minutes in full simulation.

**Fast Detector Simulation**

- **Why?**
  - Grid CPU usage dominated by MC production.
  - Precise detector simulation is needed.
  - But highly CPU intensive.
  - MC takes up large fraction of Grid disk space.
  - Limits available MC statistics, can limit sensitivity for physics analysis!
  - Larger MC production needed and bigger challenge for reconstruction!
  - Just simulate in detail what is really needed for physics:
    - That’s why a faster chain is necessary for Run-2!

- **How?**
  - Resource usage dominated by accurate detector simulation, digitization & reconstruction.
  - Sacrifice some level of accuracy for speed by:
    - Use fast simulation approaches,
    - Only fully simulate when needed,
    - Use parametric digitization,
    - Skip track reconstruction!
  - And, go from event generator output to analysis input (ROOT files) in one go:
    - No intermediate output files (minimizes file I/O overhead and disk space!)

**Fast Digitization**

- **Why?**
  - Stable, precise & fully validated simulation for Run-2.
  - But, very high CPU consumption (up to 15 minutes/event).
  - Mostly in electromagnetic (EM) calorimeter.
  - Every microscopic particle interaction within detector material simulated.
  - Simulation of ~30M volumes.

- **How?**
  - Digitization: from simulated hits to detector readout.
    - Needs to be sub-detector specific and handle treatment of pileup correctly.
    - ~50% CPU consumption from emulating Inner Detector.
    - Linear dependence on pileup.

**Fast Reconstruction**

- **Why?**
  - Reconstruction: find particles trajectories from digitized hits.
  - Significant CPU usage even in full MC chain.
  - Naturally combinatorial problem, explodes with high pileup!
  - Main consumer Inner Detector reconstruction.

- **How?**
  - Need to preserve effects of reconstruction for signal event.
  - Combinatorics only getting worse for high pileup.
  - Just skip most time consuming steps for pileup:
    - Pattern recognition.
    - Track seeding.
    - Ambiguity treatment.

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**References:**

- FastCaloSim: ATL-PHYS-PUB-2010-013
- FATRAS: ATL-SOFT-PUB-2004-001
- Truth based Reconstruction: CERN-THESES-2013-194

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**Possible speedup in simulation when using ISF:**

<table>
<thead>
<tr>
<th>ISF simulation setup</th>
<th>Speedup</th>
<th>Achieved</th>
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</thead>
<tbody>
<tr>
<td>Geant4</td>
<td>1</td>
<td>best possible</td>
</tr>
<tr>
<td>Geant4 with FastCaloSim</td>
<td>~25</td>
<td>approximated calorimeter</td>
</tr>
<tr>
<td>Fatras</td>
<td>~750</td>
<td>all subdetectors approximated</td>
</tr>
<tr>
<td>Fatras with FastCaloSim simulate only particles in cores around photons</td>
<td>~3000</td>
<td>all subdetectors approximated event simulated only partially</td>
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</tbody>
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