The Fast Simulation Chain in the ATLAS experiment

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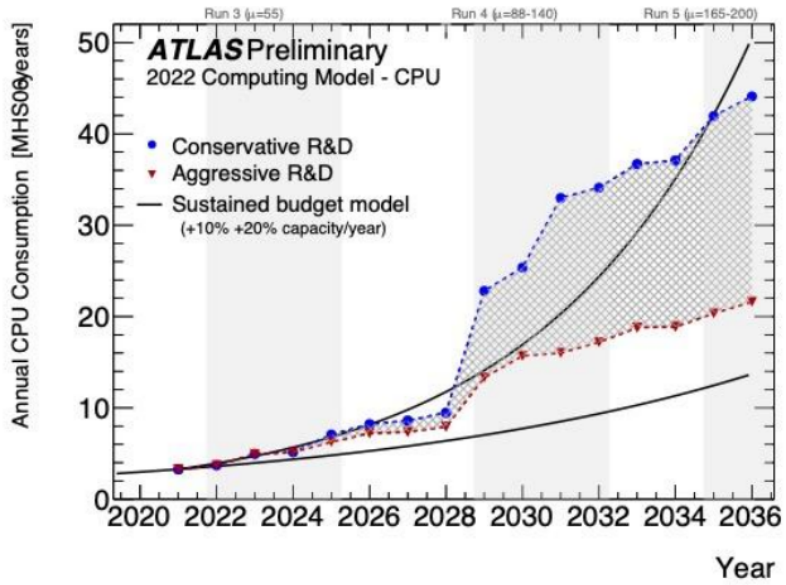
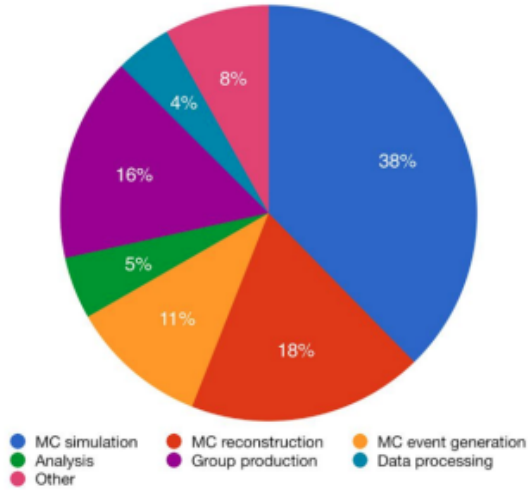
Computing challenges

- Requirements for large-scale MC production will increase significantly in the upcoming years (Run3 & HL-LHC) which will present a challenge to the computing resources

- Fast Chain aims to address this problem by designing and developing fast alternatives to the algorithms used in the standard MC production chain

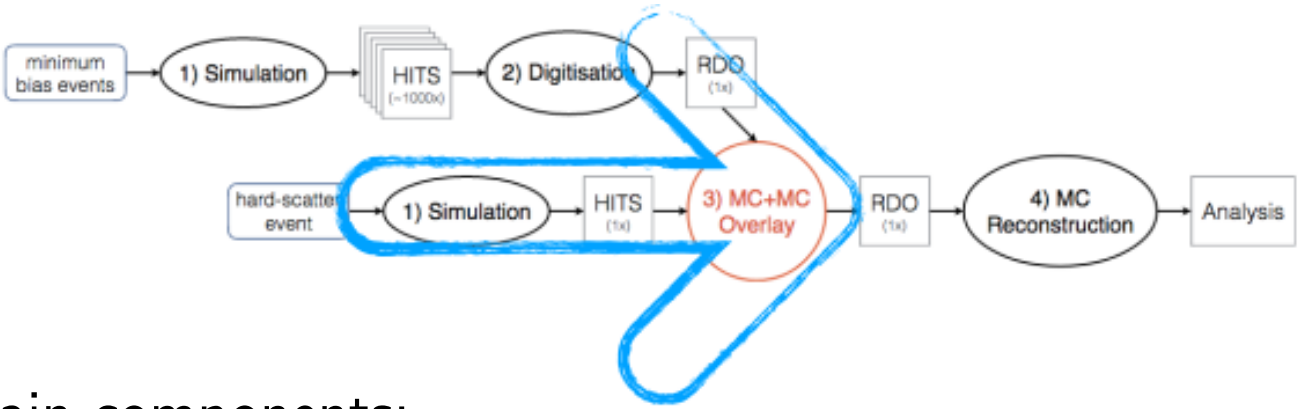




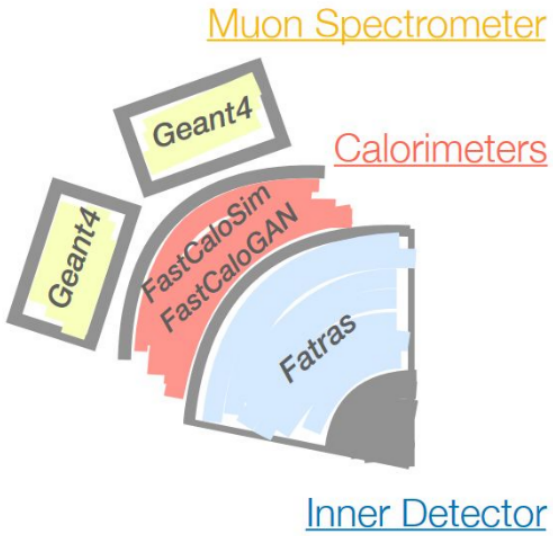
- Simulation of the ATLAS detector is the biggest CPU resource consumer

Fast Chain overview

- Fast Chain: combine fast and full simulation tools in a single workflow to meet computing and modelling accuracy requirements
- Fast Chain: run simulation and Digitization in a single job



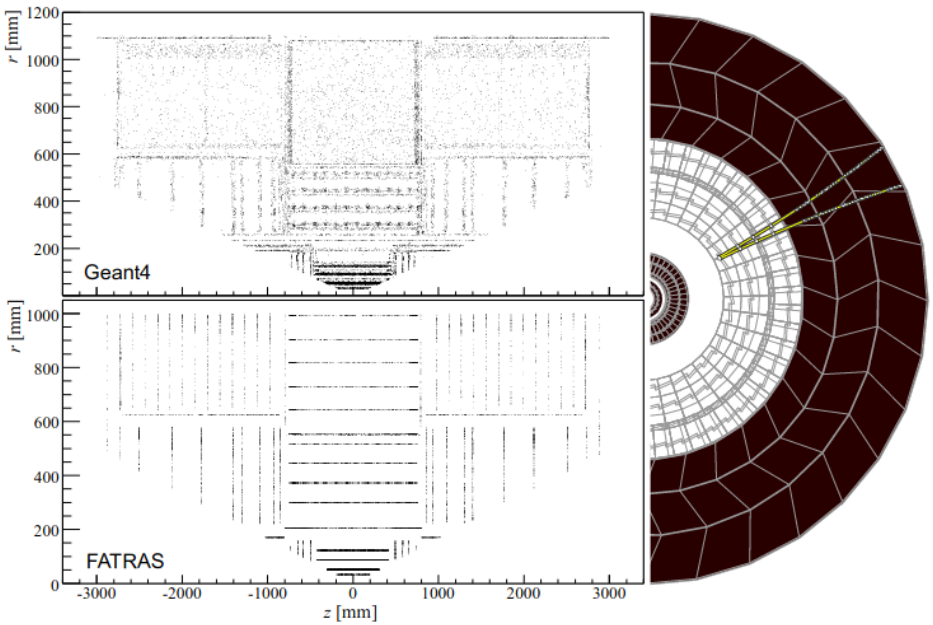
- Fast Chain components:
  - FATRAS
  - Fast Digitization
  - RDO & Track-Overlay
- FastCaloSimV2: Parametrized modelling
- FastCaloGAN: Generative Adversarial Network



Fast ATLAS Track Simulation (FTRAS)

- FATRAS produces a fast Monte Carlo simulation of the inner tracking detector based on the simplified physics parametrization and a simplified geometry instead of the standard ATLAS full geometry.

- Physics parameterization
  - Ionization: Bethe-Bloch
  - Radiative loss: Bethe-Heitler
  - Multiple Coulomb scattering: Gaussian Mixture Model
- Nuclear Interactions: GEANT4



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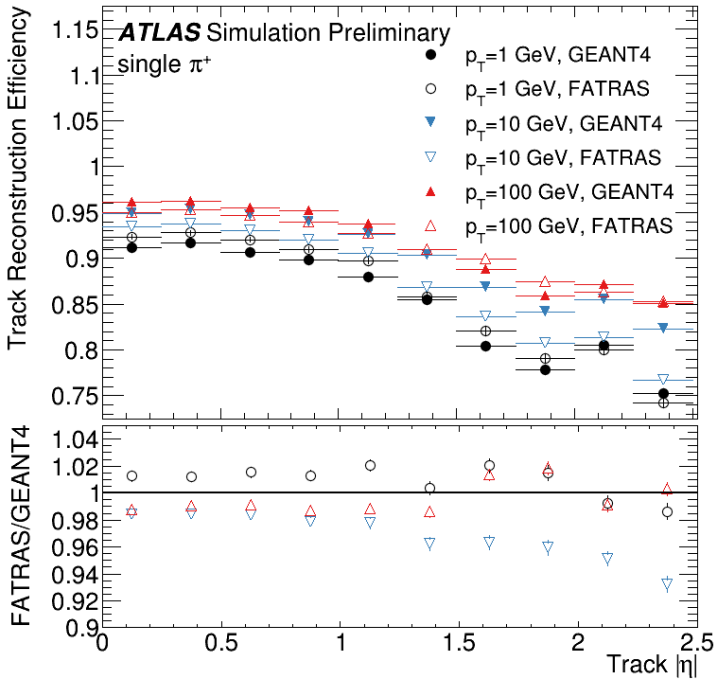

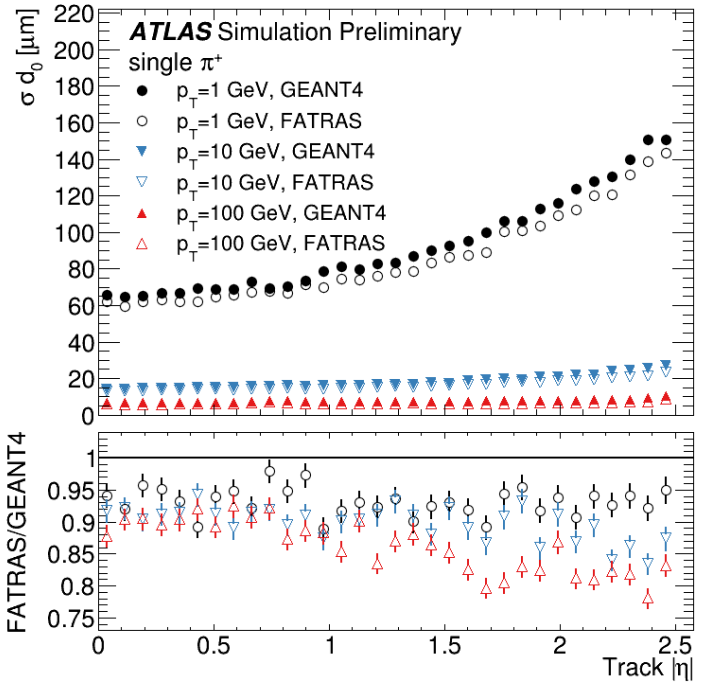

- The largest mis-modelling is observed for 10 GeV pions for which FATRAS yields up to about 5% lower efficiency.
- FATRAS yields about 5% (15%) better resolution compared to GEANT4 for 1 GeV (100 GeV) pions.

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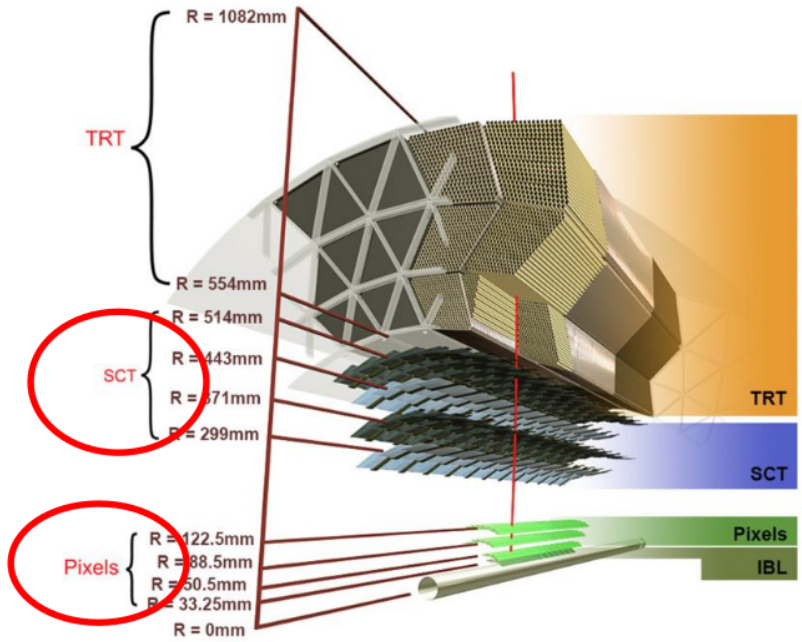
Fast Digitization

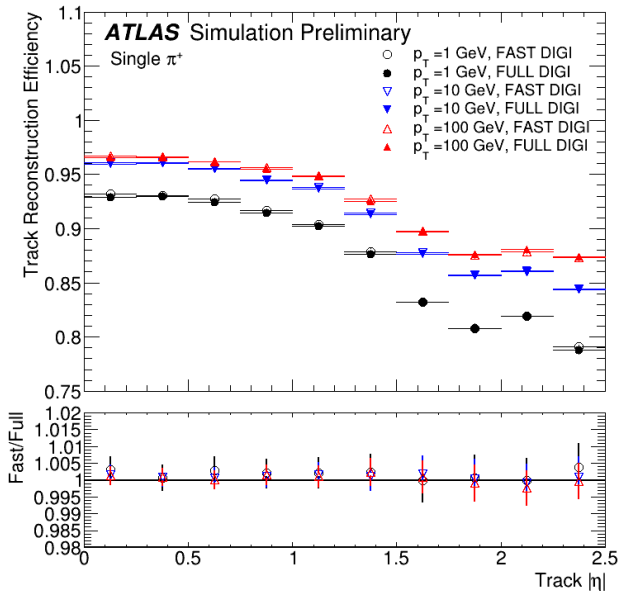
- The Fast Digitization of the Inner Detector is a parametric simulation of the conversion of the energy deposited in each sensor of the Pixel and Strip detectors into digital signals.

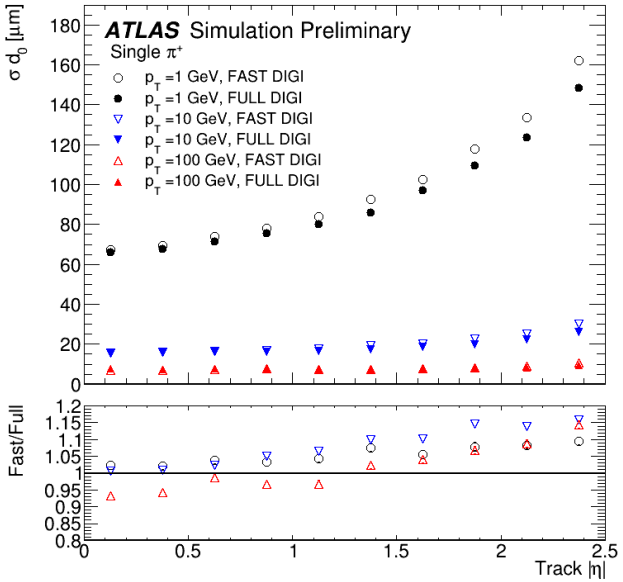
The Digitization approach steps:

- Estimate the energy deposition per channel.
- Project the simulated track length onto read-out surface for each read-out channel.
- Create clusters directly from track information ⇒ Saves CPU time!



Fast Digitization





- The Fast Digitization efficiency is in sub % agreement with the Full Digitization
- The Fast Digitization yields up to about 10-15% worse resolution in the forward region ($|\eta| > 1.5$)

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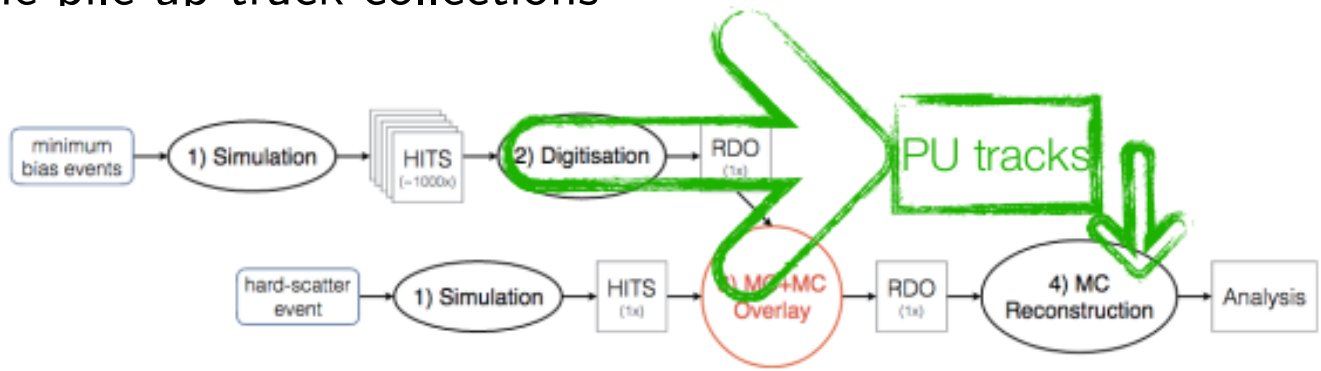
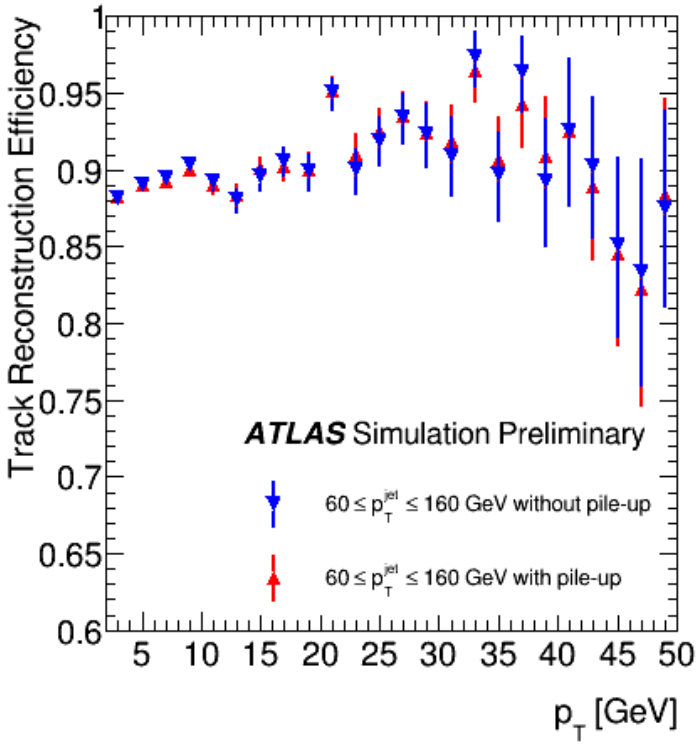
RDO & Track Overlay

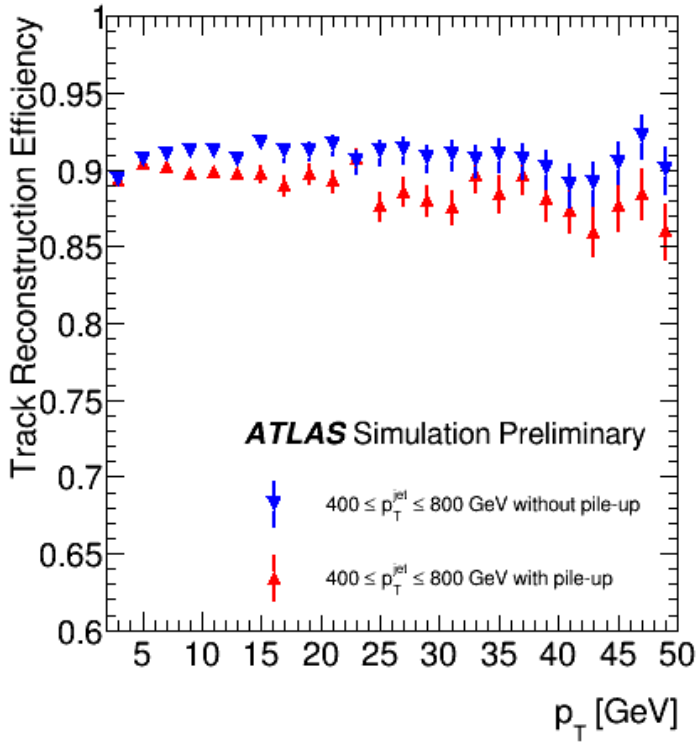
- RDO Overlay
  - Pre-sampling: produce large pile-up sample from simulated minimum bias events during a separate digitisation step
  - Overlay: digitise simulated hard-scatter event and combine them with an event from these pile-up dataset

- Track Overlay
  - Pre-sampling: reconstruct pile-up tracks in a separate job
  - Overlay: combine independently reconstructed hard-scatter tracks with the pile-up track collections



RDO & Track-Overlay





- The track overlay is feasible, when hard-scatter track reconstruction is not strongly affected by the pile-up events. This holds for events with low p_{T} jets (left), but not for events with high p_{T} jets (right)

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Conclusion

- Monte Carlo production needs to be more faster for Run3 and HL-LHC
- Fast Chain aims to provide a faster alternative to the standard MC production chain with more efficient handling of I/O and CPU resources.
- Several faster components have been developed
  - FATRAS
  - Fast Digitization
  - Track-Overlay
- These fast components are currently undergoing physics validation

Thank you for your attention!