Boosting CPU Efficiency in ATLAS Inner Detector Reconstruction with Track Overlay

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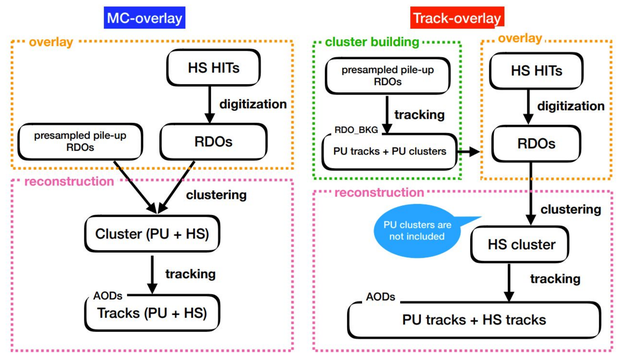
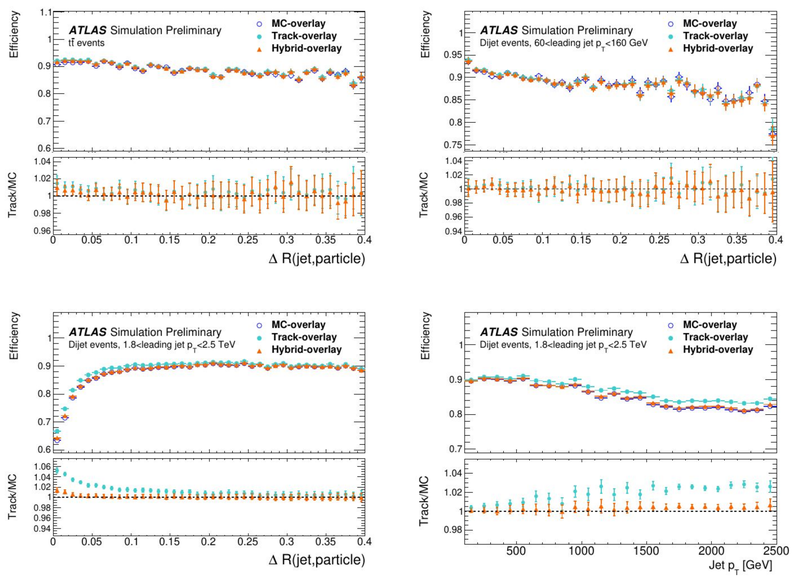
ATLAS pile-up model

- Aiming to increase the efficiency of the ATLAS reconstruction chain by optimising the treatment of pile-up
- Currently use **MC Overlay**
  - Pile-up overlaid after digitization
- Main ideas of **Track Overlay**:
  - Reduce reconstruction time by **reusing initially reconstructed tracks**
  - Good approximation as long as hard-scatter (HS) tracks don't pick up pile-up hits



Validation of Track Overlay

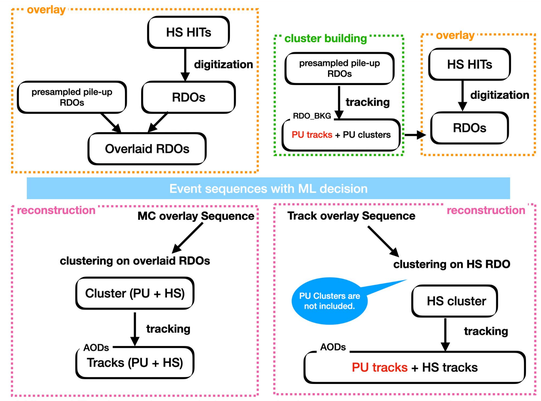
- Track Overlay is validated in numerous physics processes
  - QCD Multi-jet events
  - Top quark pairs
  - W'→Wh→lvbb (for $m_{W'}$ = 3 TeV)



- Significant differences between Track-Overlay and MC Overlay in certain regions of phase space (particularly in dense environments)

Hybrid overlay

- Use **Deep Neural Network (DNN)** to decide on an event-by-event basis if Track Overlay or MC overlay should be used.
  - Train on labeled data
  - Input features:
    - Kinematics of generator-level particles
    - Event topology (i.e.local track density)
    - Pile-up information
  - DNN assigns score to each track to determine if track is likely impacted by pile-up activity
- Negligible degradation in physics performance compared to MC overlay
  - QCD multijets (high p_T): 35.3% of events are sent to track overlay
  - QCD multijets (low p_T): 93.5% of events are sent to track overlay
  - Top quark pairs: 86.4% of events are sent to track overlay



MC- and Track-overlay work the same in the muon spectrum and calorimeter.

CPU benchmarking

- Using track overlay provides a significant reduction in reconstruction time:
  - Reduction of around 45% with respect to MC overlay
- No loss in performance due to modification of workflow (i.e. inclusion of ML decision)
- Evaluated under Run 3 conditions (i.e. having approximately 50-60 pile-up collisions per event)

Configuration	Overlay	Reconstruction
MC Overlay	2.34s	4.86s
Track Overlay	3.26s	2.72s

Configuration	Overlay	Reconstruction
Hybrid Overlay (All to MC Overlay)	3.33s	4.93s
Hybrid Overlay (All to Track Overlay)	3.25s	2.65s
Hybrid Overlay (ML)	3.30s	2.71s

Performance is stated in HS06/events

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