Muon Isolation Optimisation Studies for Run-3 in ATLAS

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Qualification task

Title: Muon Isolation Optimisation with the Run-3 dataset

Description:

- Optimise and calibrate muon isolation working points for improved prompt/non-prompt discrimination in ATLAS Run-3 analyses.
- Study isolation performance as a function of muon kinematics and nearby jet activity through $\Delta R(\mu, \text{jet})$.
- Validate results across different MC generators and topologies, and provide recommendations for future analyses.

OTP task ID: 532774 sub-task ID: 556633

JIRA ticket : https://its.cern.ch/jira/browse/ATLASMCP-296

Proposed beginning of qualification: 01/02/2026

Introduction

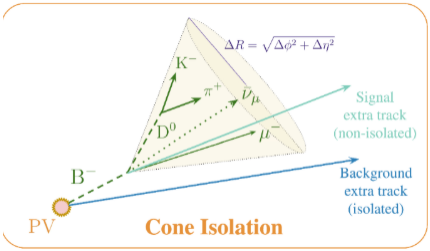
- This work is part of my ATLAS MCP qualification task, focusing on muon isolation studies.
- The goal is to optimise muon isolation working points for Run-3 conditions.
- As a first step, we aim to reproduce the results from the ATLAS note using Monte Carlo samples.
- The study is based on:
  - DAOD_MUON1 format
  - fastMuonChecker framework
  - MC samples (Pythia and Sherpa)

Key Observables Reproduced in This Study

- **Muon transverse momentum:** p_T^{μ}
- **Muon pseudorapidity:** η^{μ}
- **Distance to closest jet:**

$$\Delta R(\mu, \text{jet})$$

- **dimuon mass :** $m_{\mu\mu}$
- This reproduction step is essential before moving to Run-3 optimisation studies.



Technical details

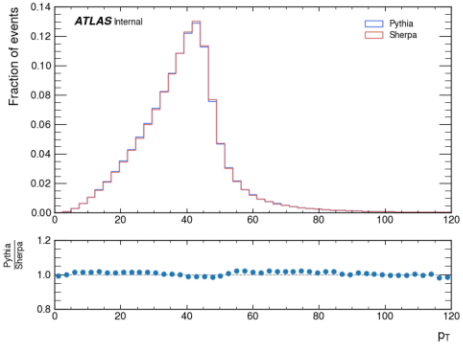
- **Software :** AnalysisBase
- **Release :** 25.2.88
- **ROOT version :** 6.36.02
- **Package :** fastMuonChecker
- **DAOD_MUON1 format**

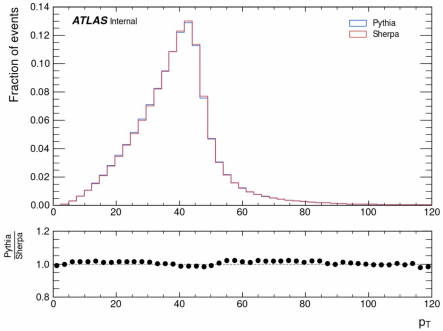
- **Datasets :** MC23e
  with number tag : r16083
- **MC generators :**
  . Pythia 8.245 –> DSID 601190

  . Sherpa 2.2.14 –> DSID 700789-700790-700791

Comparison with ATLAS Note: p_T^{μ}

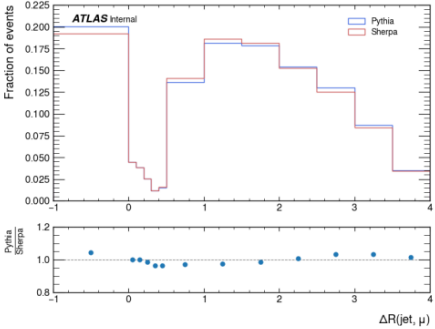
NB: lift plots: ATLAS note — Right plots: My work.

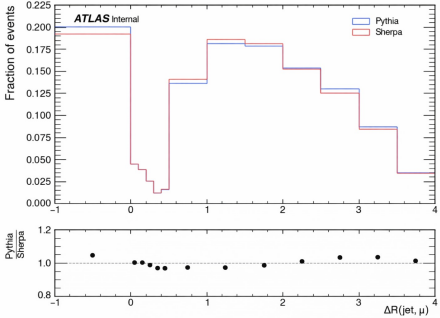




Comparison with ATLAS Note: $\Delta R(\mu, \text{jet})$

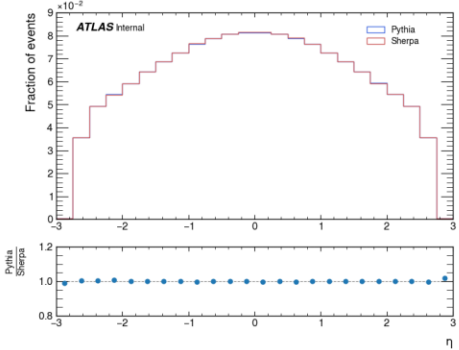
NB: lift plots: ATLAS note — Right plots: My work.

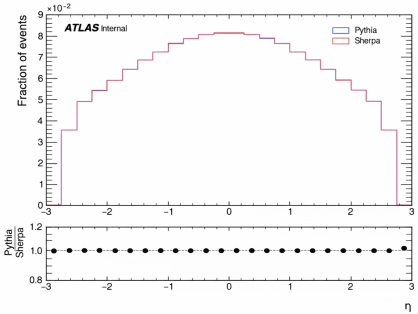




Comparison with ATLAS Note:η

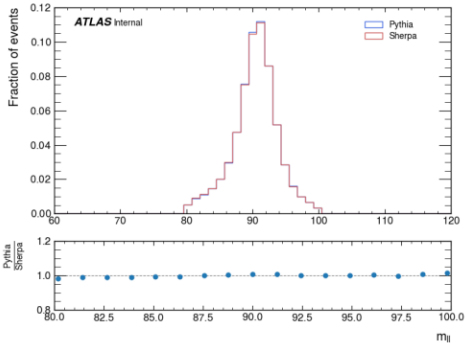
NB: lift plots: ATLAS note — Right plots: My work.

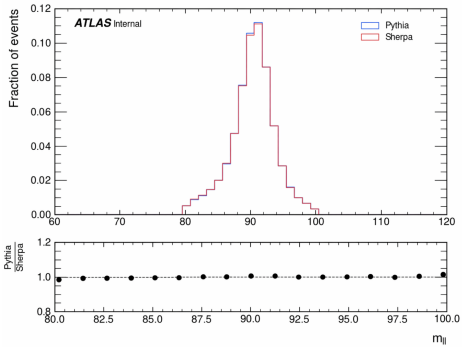




Comparison with ATLAS Note: $m_{\mu\mu}$

NB: lift plots: ATLAS note — Right plots: My work.





Progress Status and Workflow

Done

- Setup of ATLAS software environment
- Adaptation of `fastMuonChecker.py`
- First reproduction studies with Pythia & Sherpa $Z \to \mu\mu$
- Reproduction of ATLAS note plots:
  - p_T^{μ}
  - $\Delta R(\mu, \text{jet})$
  - $m_{\mu\mu}$
  - η^{μ}

Next steps

- Collecting Run-3 samples (Pythia/Herwig/Sherpa)
- Produce generator-comparison plots on Run-3 samples
- Evaluate isolation WPs (Loose, Tight)
- Efficiency & rejection vs p_T, η, $\Delta R(\mu, \text{jet})$
- Compare $Z \to \mu\mu$ vs $t\bar{t}$ topologies
- Derive optimisation inputs for MCP recommendations

Conclusion

- Muon isolation is essential for prompt/non-prompt discrimination in ATLAS.
- Framework successfully set up and used to reproduce ATLAS note results with `fastMuonChecker`.
- Good agreement with the official ATLAS note for all key distributions.
- Pythia 8 and Sherpa show consistent results across the main observables.
- Next: optimise isolation WPs on Run-3 samples ($Z \to \mu\mu$, $t\bar{t}$).
- Final goal: contribute to MCP Run-3 recommendations.

Thank you for your attention!

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