Muon Isolation Optimisation Studies for Run-3 in ATLAS

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Outline

Qualification task

Reproduced Plots

Conclusion

Qualification task

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: 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

Technical details

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

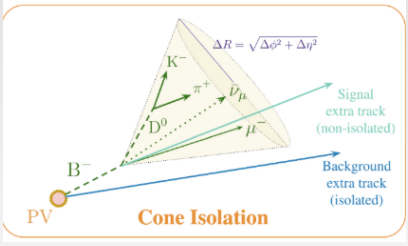
Datasets	Tag
MC23d	r15530
MC23e	r16083

Table 1: Overview of the $Z \to \mu\mu$ and $t\bar{t}$ simulations used.

Process	Additional info	DSID	Generator	Showering
$t\bar{t}$	single lepton filter	601229	Powheg Box 2	Pythia 8.245
$t\bar{t}$	dilepton filter	601230	Powheg Box 2	Pythia 8.245
$Z \to \mu\mu$	–	601190	Powheg Box 2	Pythia 8.245
$Z \to \mu\mu$	–	700789–700790–700791	Sherpa 2.2.14	Sherpa

Key Observables for This Work

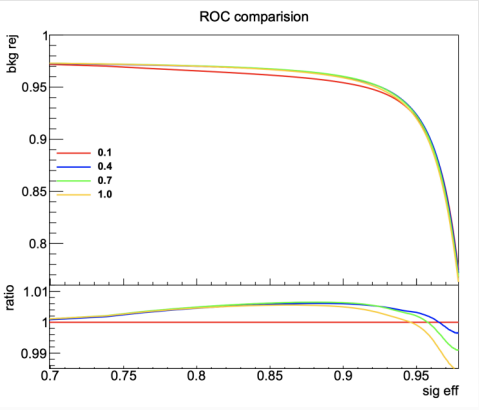
- **ROC curves** Signal efficiency vs background efficiency for different isolation weights.
- **Isolation WP efficiency** Loose and Tight working points performance.
- **Muon transverse momentum** p_T^{μ}
- **Muon pseudorapidity** η^{μ}
- **Distance to closest jet** $\Delta R(\mu, \text{jet})$

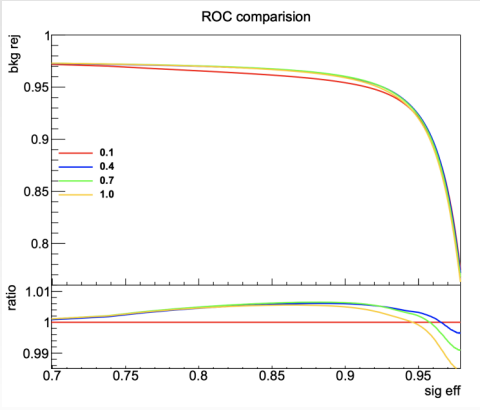


Reproduced Plots

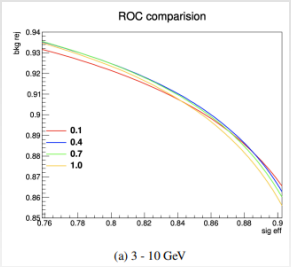
ROC curves of signal efficiency vs background efficiency with different weighting factors of the PFlow isolation variable.

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

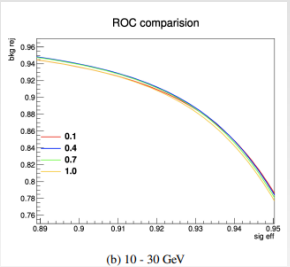




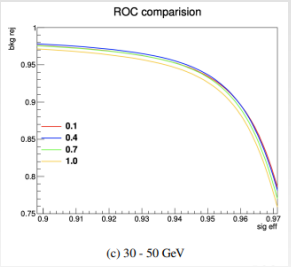
ROC curves with different weighting factors of the PFlow isolation variable for different muon p_T bins.
NB: up plots: ATLAS note — Down plots: My work.



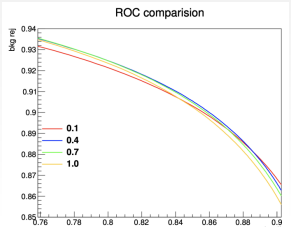
(a) 3 - 10 GeV

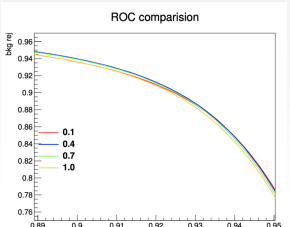


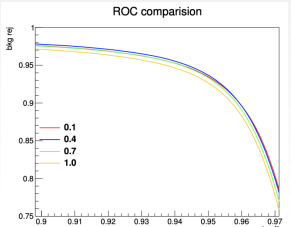
(b) 10 - 30 GeV



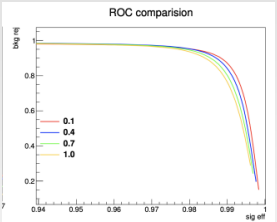
(c) 30 - 50 GeV



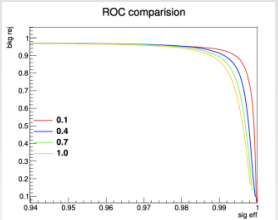




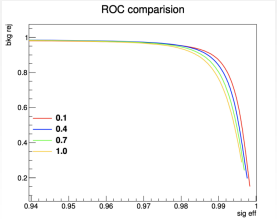
ROC curves with different weighting factors of the PFlow isolation variable for different muon p_T bins.
NB: up plots: ATLAS note — Down plots: My work.



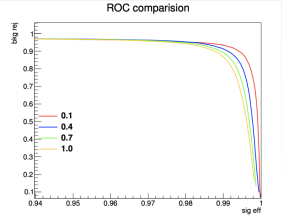
(d) 50 - 100 GeV



(e) 100 - 500 GeV



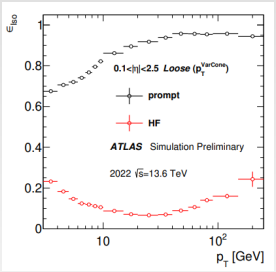
(d) 50 - 100 GeV

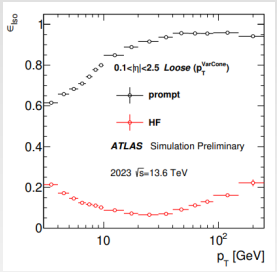


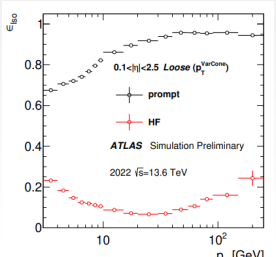
(e) 100 - 500 GeV

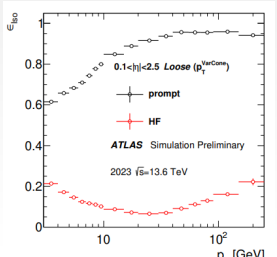
Muon Isolation Efficiency vs p_T

NB: up plots: ATLAS note — Down plots: My work.



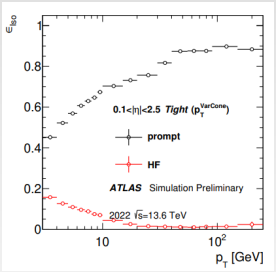


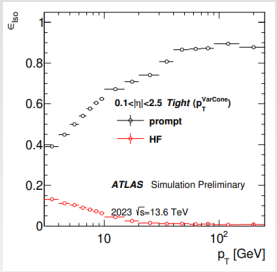


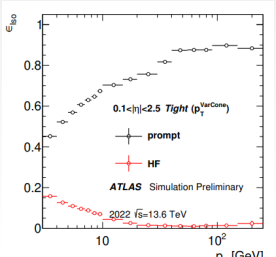


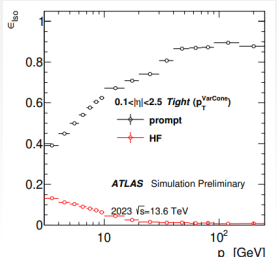
Muon Isolation Efficiency vs p_T

NB: up plots: ATLAS note — Down plots: My work.



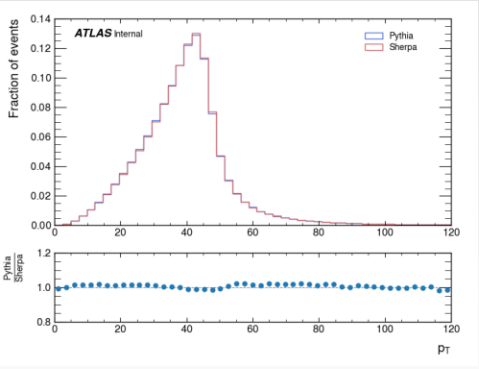


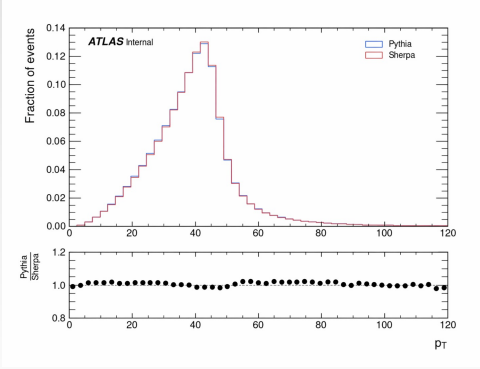




Comparison with ATLAS Note: p_T^μ

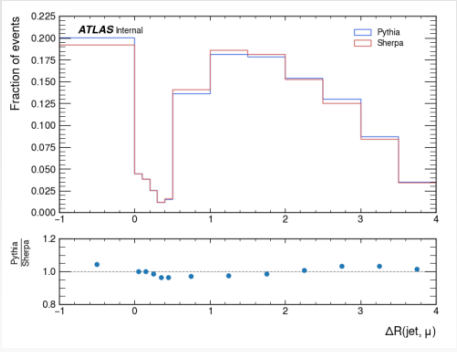
NB: Left plots: ATLAS note — Right plots: My work.

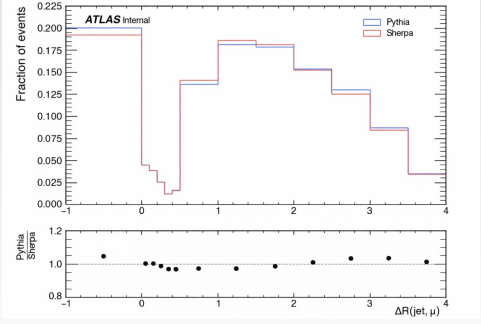




Comparison with ATLAS Note: $\Delta R(\mu, \text{jet})$

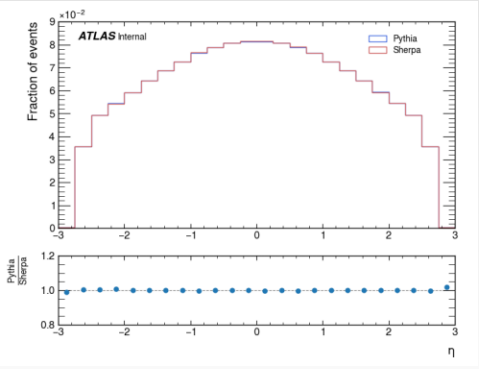
NB: Left plots: ATLAS note — Right plots: My work.

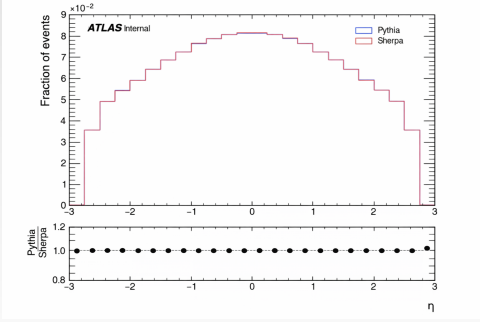




Comparison with ATLAS Note: η

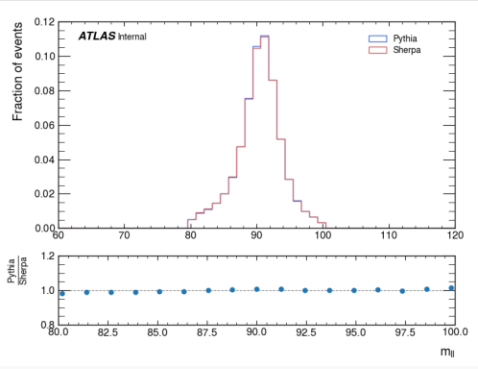
NB: Left plots: ATLAS note — Right plots: My work.

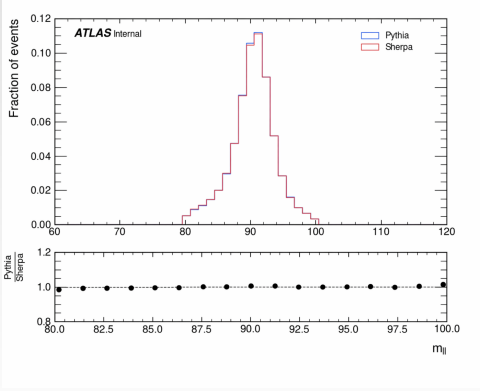




Comparison with ATLAS Note: $m_{\mu\mu}$

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





Conclusion

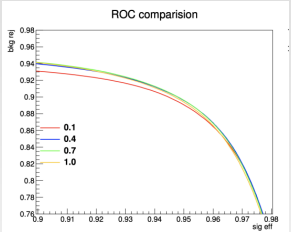
Conclusion

- Successfully reproduced the main ATLAS note distributions using the `fastMuonChecker` framework.
- ROC studies show the sensitivity of the PFlow isolation variable to different weighting factors.
- Good overall agreement observed for:
  - p_T^{μ} , η^{μ} , $\Delta R(\mu, \text{jet})$, $m_{\mu\mu}$
- Loose and Tight isolation working points provide efficient prompt-muon selection with strong heavy-flavour rejection.
- This validation step is essential before the full Run-3 muon isolation optimisation.

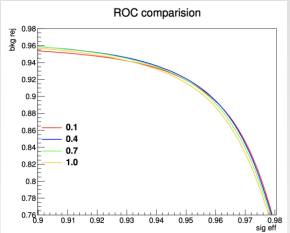
Thank you for your attention

Back up

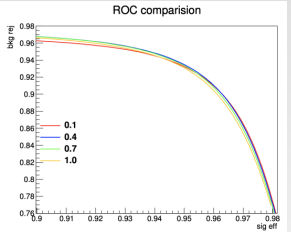
ROC curves with different weighting factors of the PFlow isolation variable for different muon $|\eta|$ bins.



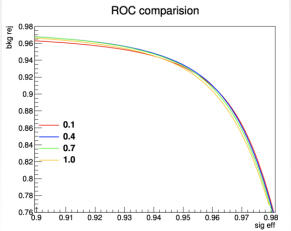
(a) (-2.4, -1.5)



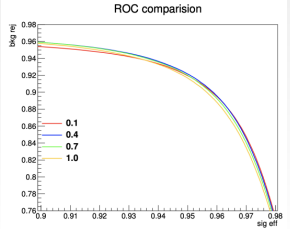
(b) (-1.5, -1.0)



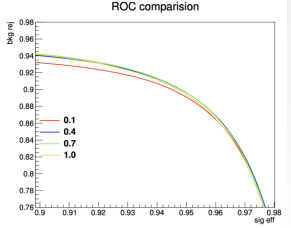
(c) (-1.0, 0)



(d) (0, 1.0)



(e) (1.0, 1.5)



(f) (1.5, 2.5)