Muon Isolation Optimisation Studies for Run-3 in ATLAS

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April 23, 2026

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) - $t\bar{t}$ non-all-hadronic

Key Observables Reproduced in This Study

- ROC curves of prompt-muon efficiency versus non-prompt background efficiency.
- Performance comparison using different weighting factors in the PFlow isolation variable.
- ROC studies in different muon transverse momentum (p_T) regions.
- ROC studies in different pseudorapidity ($|\eta|$) regions.
- Evaluation of the optimal isolation working point for signal/background separation.

Technical details

- **Software :** AnalysisBase
- **Release :** 25.2.88
- **ROOT version :** 6.36.02

- **Package :** fastMuonChecker
- **DAOD_MUON1 format**
- **Datasets :** MC23d with number tag : r15530

Table 1: Overview of the $t\bar{t}$ 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

Main Modifications

- Muon quality changed from `Medium` to `Loose`.
- Isolation cut removed for unbiased ROC studies.
- Applied $p_T > 3$ GeV selection.
- Kept TTVA cuts: $|d_0/\sigma(d_0)| < 3$, $|z_0 \sin\theta| < 0.5$.
- Stored raw isolation variables for optimisation.
- Added prompt / heavy-flavour labels using IFF.
- Enabled support for Run-2 / Run-3 formats.

Large-Scale Grid Production Ongoing

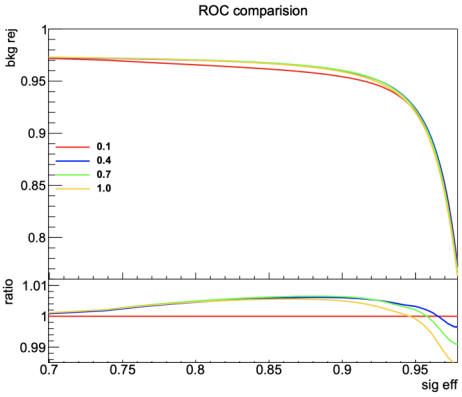
- Grid jobs launched for full MC statistics.
- Samples:
  - `ttbar dilepton`
  - `ttbar single-lepton`
- Test jobs validated successfully.
- Final plots are being prepared after full completion.
- Production required additional Grid time.

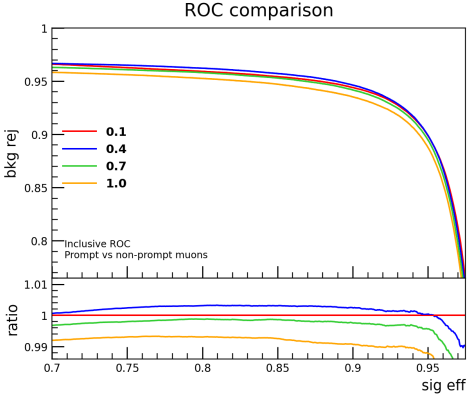
Task ID	Task name	N files total	N files done	N files failed	%	Status (JEDI)	D
49897451	user.skhoulak.601230.dileptons.testdb1/	4601	235	0	5	running	
49897447	user.skhoulak.601230.dileptons.testdb/	4601	2718	0	59	pending	
49897405	user.skhoulak.601229.singlelep.roc.test50files.v2/	50	45	0	90	running	

Final ROC curves will be updated once all jobs are finished.

Preliminary ROC Comparison Using a Single ROOT File

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





Progress Status and Workflow

- Analysis framework prepared and validated.
- fastMuonChecker updated for isolation optimisation studies.
- Preliminary ROC curves produced using a test ROOT file.
- Grid test jobs completed successfully.
- Full MC production currently running.
- Final plots and optimisation studies in progress.

Next step: merge outputs, produce final ROC curves, and compare with ATLAS note.

Conclusion

- Preliminary muon isolation studies have been successfully established.
- Analysis framework and workflow are fully operational.
- Large-scale Grid production is ongoing to increase statistics.
- Final optimisation and comparison with the ATLAS note will follow after completion.

This work represents an important step toward Run-3 muon isolation optimisation in ATLAS.

Thank you for your attention!

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