Muon Isolation dependency on pileup

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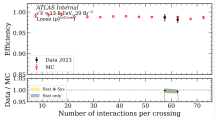
Technical supervisor: Matteo Bauce



May 14, 2026

Outline

Qualification task

Title: Optimisation of isolation WPs in Run3

Description

- Distinguish muons from prompt sources from non-prompt and fake ones.
- Improve robustness against higher pile-up while maintaining good performance for prompt muon selection.
- explore possible dependencies on event topology such as $Z \to \mu\mu$ process and $t\bar{t}$ events.

OTP task ID: 532774 sub-task ID: 556633.
Proposed beginning of qualification: 01/02/2026
https://its.cern.ch/jira/browse/ATLASMCP-295

Introduction

In this presentation, I worked on section 8, "Muon Isolation" from the documentation:
ATLAS Note reference: ATL-COM-PHYS-2025-020

Variables

- We measure the isolation efficiency of muons from $Z \to \mu^+\mu^-$ decays as a function of the average number of interactions per crossing ($\langle\mu\rangle$).
- We measure the efficiency of muons from $t\bar{t}$ decays as a function of transverse momentum (p_T).
- Distributions of the dimuon invariant mass $m_{\mu\mu}$, muon transverse momentum p_{T} , muon pseudorapidity η, and angular distance ΔR between a muon and its closest jet.
- Working points: Loose, Tight, PFlowLoose, PFlowTight.

Technical details

- Software: AnalysisBase,25.2.89
- ROOT Version: 6.36.04
- MC23d, r15530, DAOD_MUON1 format, DSID: 601190, 601229.
- Generator:Pythia ,Sherpa
- Data23, Run number: 451094, Stream: physics_Main, physics_BphysDelayed, calibration_BphysPEB Period: 2023 F.
- Package:fastMuonChecker

Isolation efficiencies for prompt and non-prompt muons

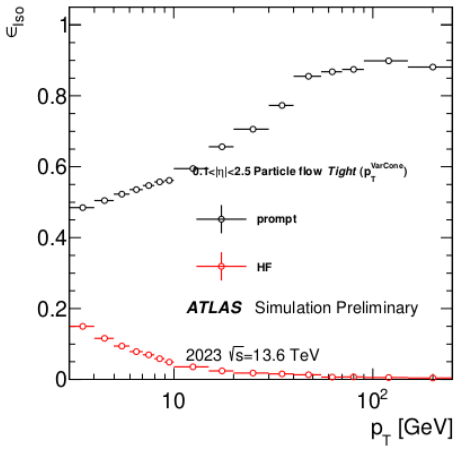


Figure: Original plot

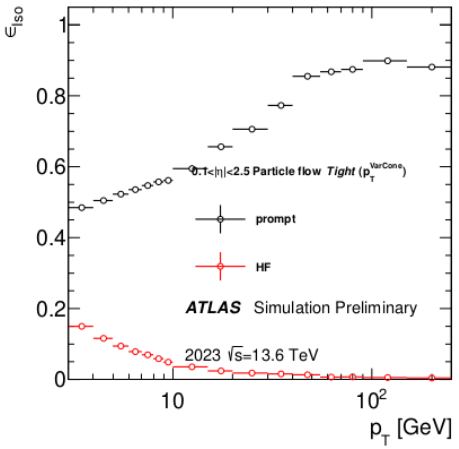
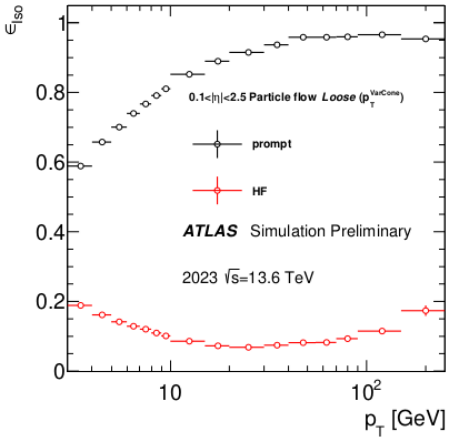


Figure: Reproduced plot

Isolation efficiencies for prompt and non-prompt muons



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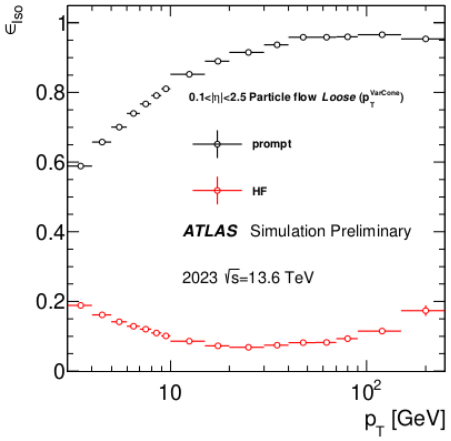


Figure: Reproduced plot

Isolation efficiency for interactions muons satisfying the PFlowTight isolation criteria

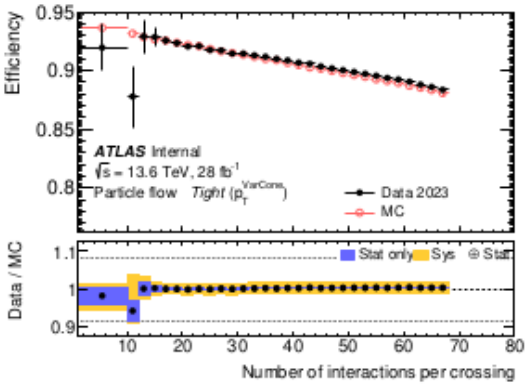


Figure: Original plot

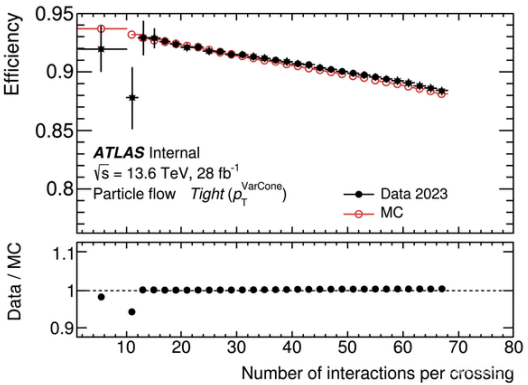


Figure: Reproduced plot without systematics

Isolation efficiency for interactions muons satisfying the Tight isolation criteria

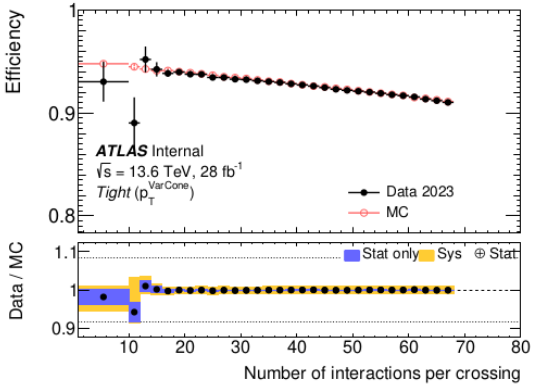
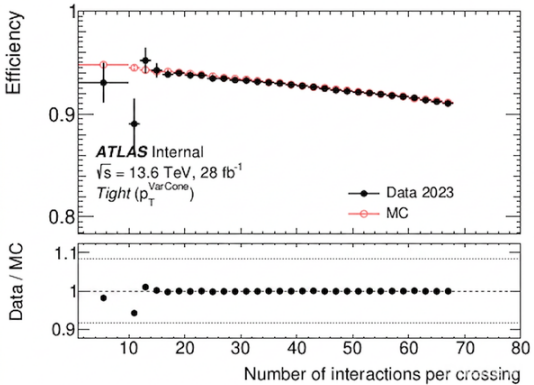


Figure: Original plot



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Isolation efficiency for interactions muons satisfying the PFlowLoose isolation criteria

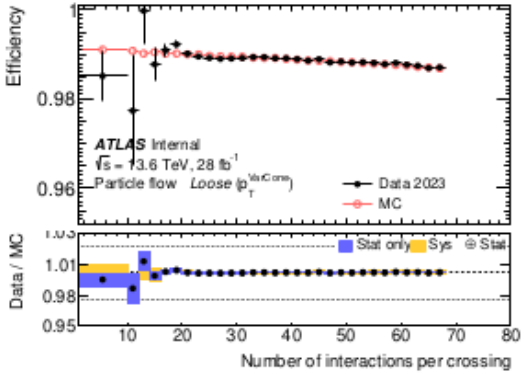


Figure: Original plot

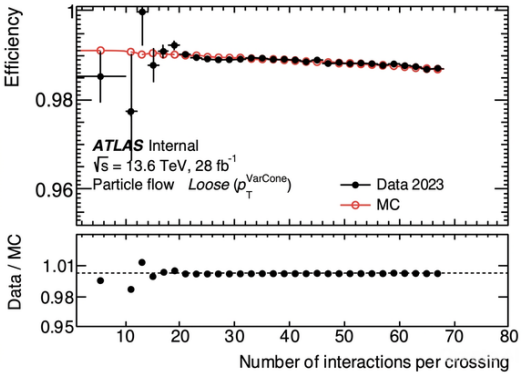
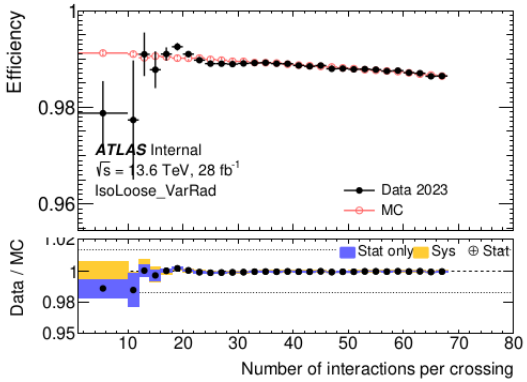


Figure: Reproduced plot without systematics

Isolation efficiency for interactions muons satisfying the Loose isolation criteria



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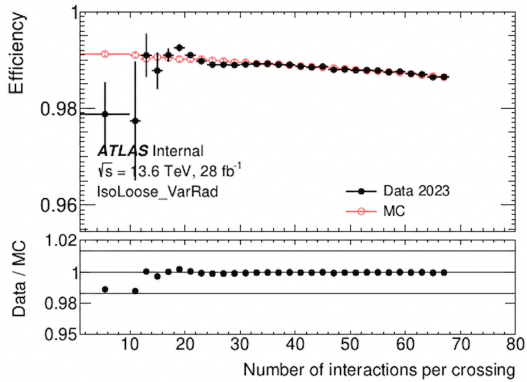
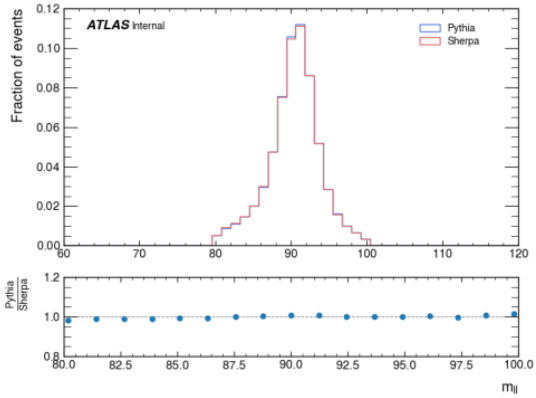


Figure: Reproduced plot without systematics

Distributions for the dimuon mass



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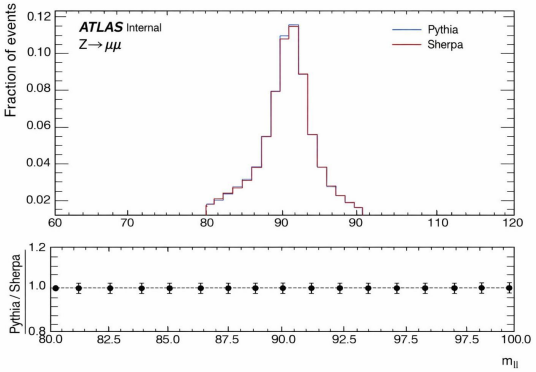
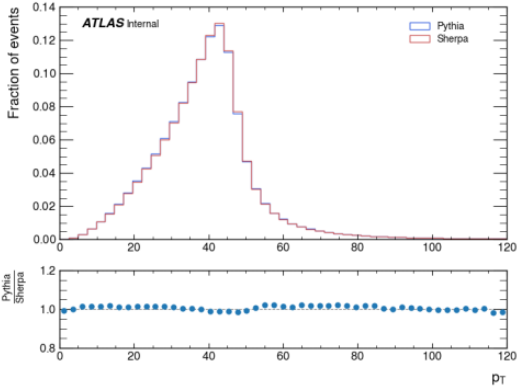


Figure: Reproduced plot

Distributions for muon transverse momentum



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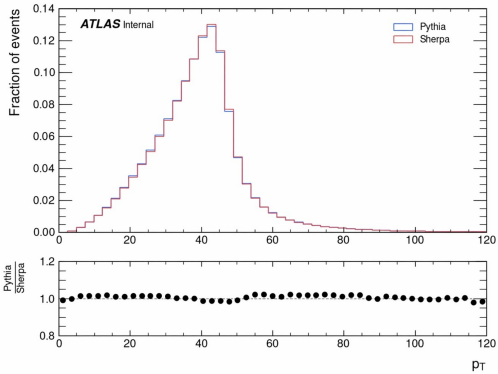
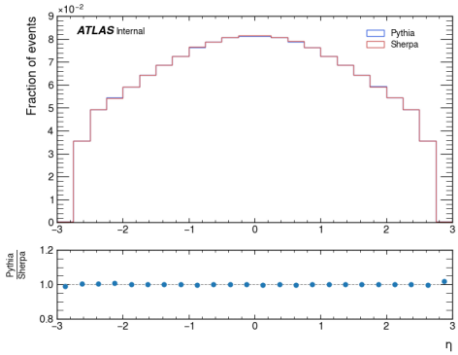


Figure: Reproduced plot

Distributions for muon pseudorapidity



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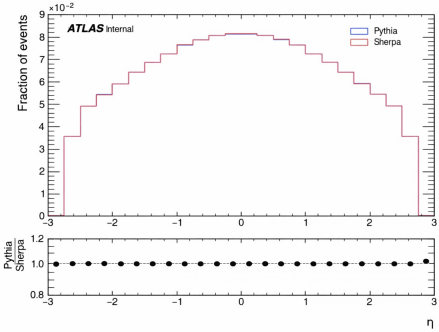


Figure: Reproduced plot

Distributions for angular distance between a muon and its closest jet

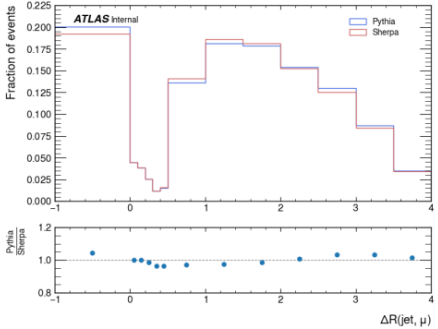


Figure: Original plot

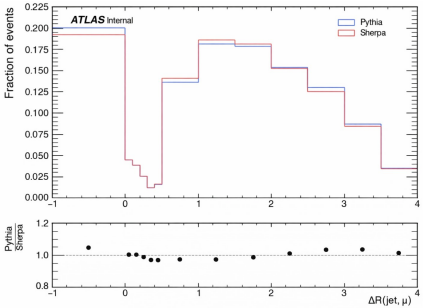


Figure: Reproduced plot

Distributions for the isolation variables divided by the muon p_T

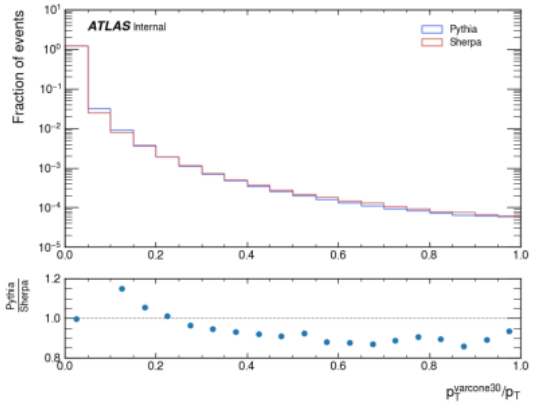


Figure: Original plot

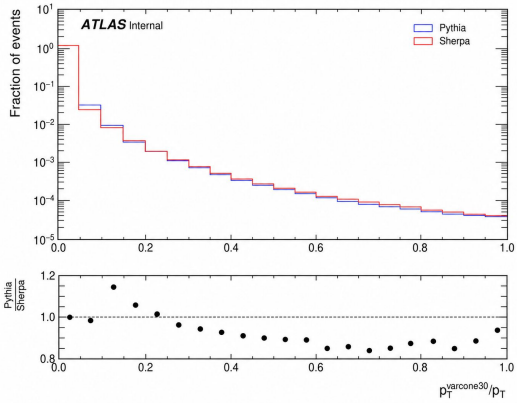
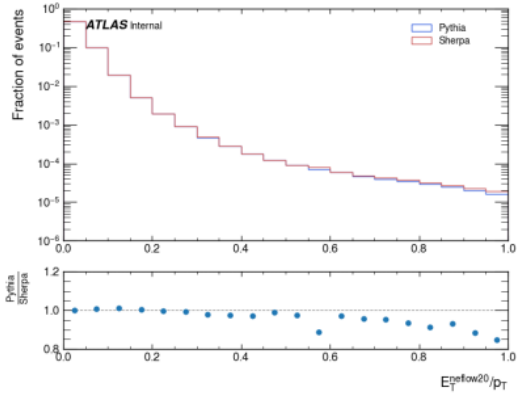


Figure: Reproduced plot

Distributions for the isolation variables divided by the muon p_T



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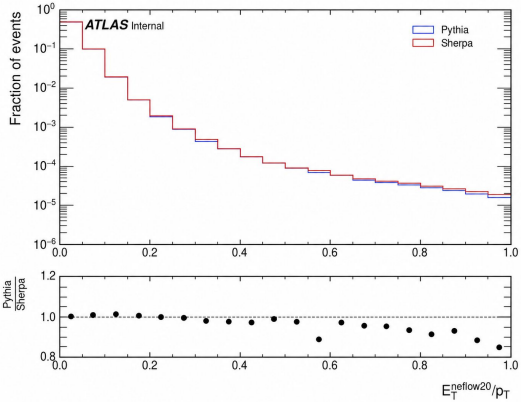

Figure: Reproduced plot

Conclusion

- The exercise of producing the plots in Section 8 of the ATLAS note has been completed successfully.
- As an outlook, what would be the recommended next step?

Back Up

The numerator is the number of selected muons in the same pileup bin that pass the isolation working point.

e.g. fastMuonChecker code

```
pass_PFlowLoose = bool(muon_iso_loose_tool.accept(muon_to_use))
```

The denominator is the number of selected muons in each pileup bin.

e.g. fastMuonChecker code

```
muon_selection_tool.accept(muon_to_use)
```

The isolation efficiency is defined as:

$$\text{efficiency} = \frac{\text{The numerator}}{\text{The denominator}}$$

```
mc23d:  mc23_13p6TeV.601190.PhPy8EG_AZNLO_Zmumu.deriv.DAOD_PHYS.e8514_e8528_s4159_s4114_r15513_r15514_p6026
```

```
data23_13p6TeV.00451094.physics_Main.deriv.DAOD_PHYS.r15774_p6304_p6700
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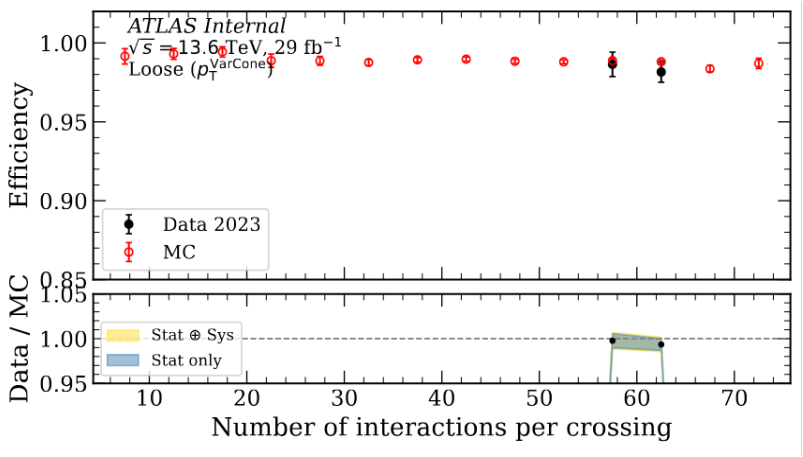
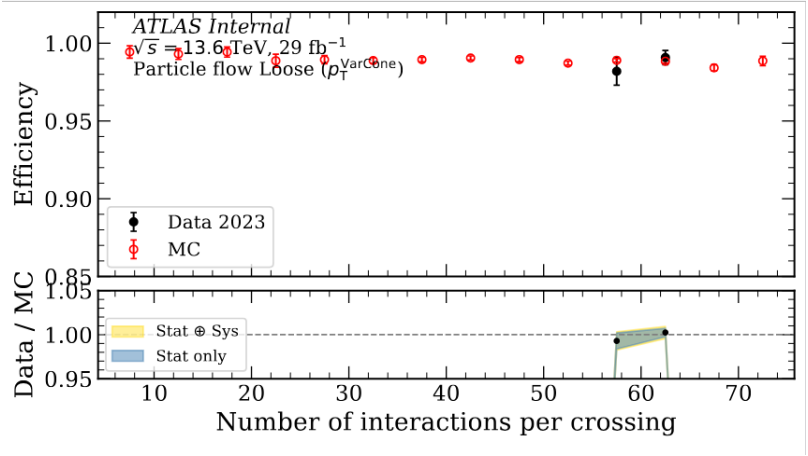


Figure: Reproduced plot for 1 file root of Data



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