European Organization for Nuclear Research
ATLAS Experiment
Supervisors: Stylianos Angelidakis [a], Rosy Nikolaidou [a]

Development of Validation Tools for MCP Scale Factors and Efficiencies in ATLAS

Vicente Ignacio Valenzuela Osses [a,b,c]

Report CERN Summer School 22nd August of 2025

(a) European Organization for Nuclear Research (CERN) , (b) Millennium Institute for Subatomic physics at high energy frontier - SAPHIR, (c) Instituto de Física, Pontificia Universidad Católica de Chile

Abstract
This work was done in the context of the CERN Summer Student Programme in 2025, it presents the development of validation scripts for MCP recommendations, focusing on Scale Factors and efficiencies. The tools allow direct access to ROOT files on CVMFS and provide visualisation of statistical and systematic uncertainties, as well as comparisons across years, releases, and working points. A dedicated module was implemented to scan all available years, while additional scripts handle uncertainty bands and cross-checks between recommendations. Together, these tools offer a flexible and reproducible script to ensure the robustness of MCP inputs for physics analyses.

Introduction

This project is dedicated to the development of validation scripts for MCP recommendations. The recommendations are accessed directly from ROOT files available on CVMFS, which contain all the necessary information for the validation process. The initial focus is placed on the recommendations for Scale Factors (SF) and efficiencies, as these represent key components for physics analyses within the collaboration.

The implemented scripts provide a systematic and reproducible way to visualise the recommendations, together with their associated systematic uncertainties. The script is designed to handle different releases, working points, and years, thereby ensuring fle-

xibility and completeness in the validation.

Furthermore, the project includes tools for the direct comparison of recommendations across different conditions, such as year, release, or working point. This functionality enables the identification of possible discrepancies or unexpected variations, and ultimately contributes to ensuring the reliability and consistency of the MCP recommendations used in physics analyses.

Scripts

The work began by modifying the initial script so that it could plot the Scale Factors (SF) and efficiencies as a function of η, divided into nine bins in the range $-2.50 < \eta < 2.50$. This first script takes as input the year, the working point, and the recommendation to be studied. It produces plots of the mentioned quantities, including both statistical and systematic uncertainties, together with the Monte Carlo prediction and its associated uncertainty.

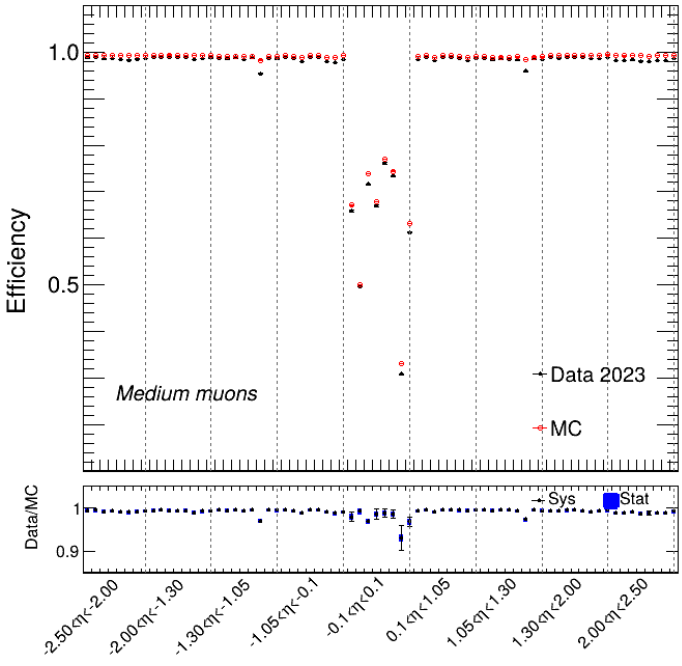

Fig. 1: Scale Factors and efficiency of *Reco Medium Z* for the year 2023.

Building on this, a module was developed to automatically scan the available years for a given working point and recommendation, and to call the previously described script for each of them, thus producing the corresponding plots. As input, the module requires the working point and the recommendation, while the list of years can either be provided manually or inferred automatically.

Subsequently, an additional script was implemented to compare two recommendations. This script overlays results for the same year and working point, including statistical and systematic uncertainties, as well as the Monte Carlo prediction. It takes as input the year to analyse, the working point, and the two recommendations to be compared.

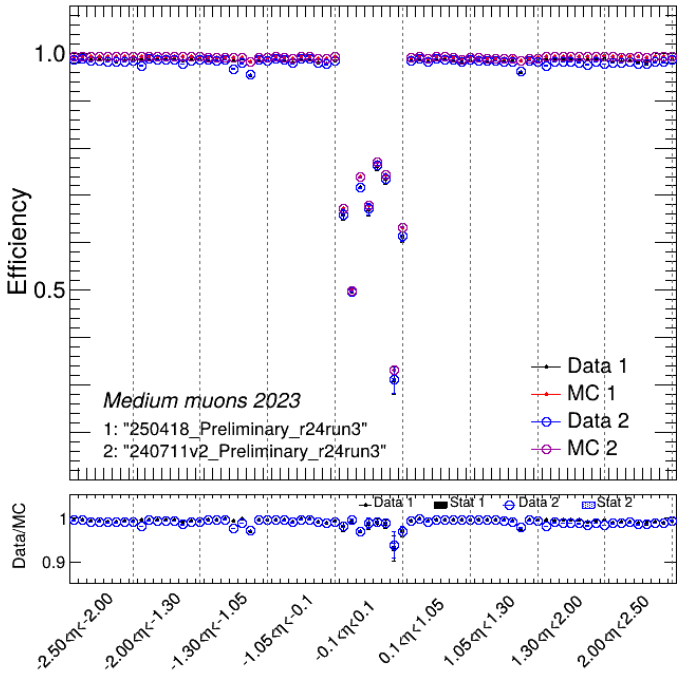

Fig. 2: Comparison of *Reco Medium Z* in 2023 between two different recommendations.

A further script was then developed to visualise only the systematic uncertainties, represented as continuous bands across the bins. This script takes as input the year, the working point, the recommendation, and the type of plot. It can produce three different outputs depending on the chosen option: the systematic uncertainties of the SF, of the efficiency, or both displayed in the same pad.

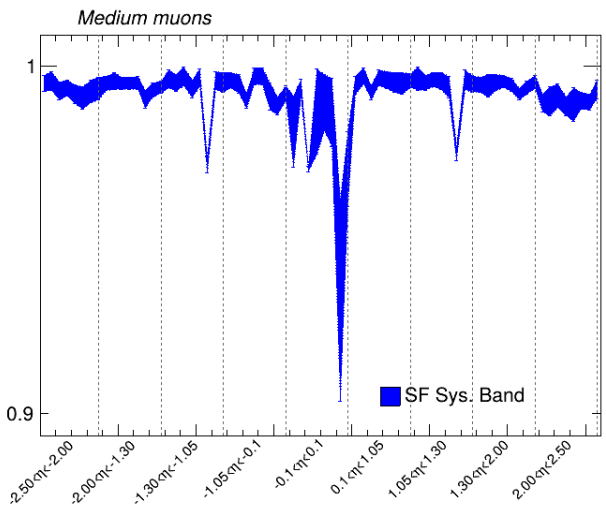

Fig. 3: Systematic uncertainties of the Scale Factor for *Reco Medium Z* in 2023.

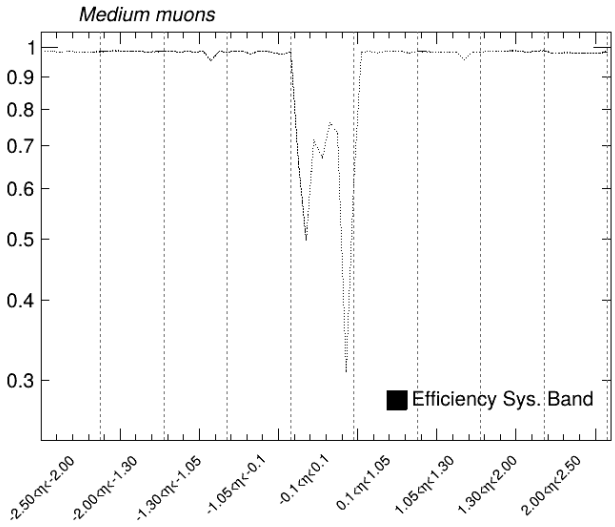

Fig. 4: Systematic uncertainties of the efficiency for *Reco Medium Z* in 2023.

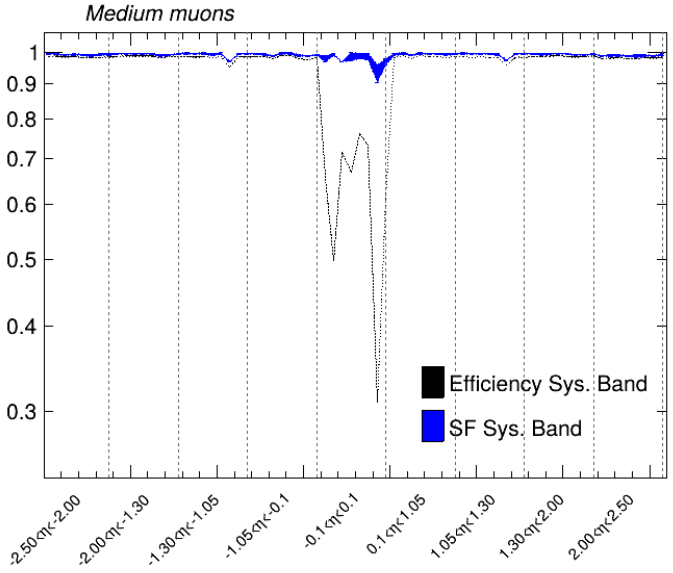

Fig. 5: Systematic uncertainties of both the Scale Factor and the efficiency for *Reco Medium Z* in 2023.

Finally, another script was developed to compare the systematic uncertainty bands of two different recommendations. This script also takes as input the year, the working point, the two recommendations, and, as in the previous case, the type of plot to be produced.

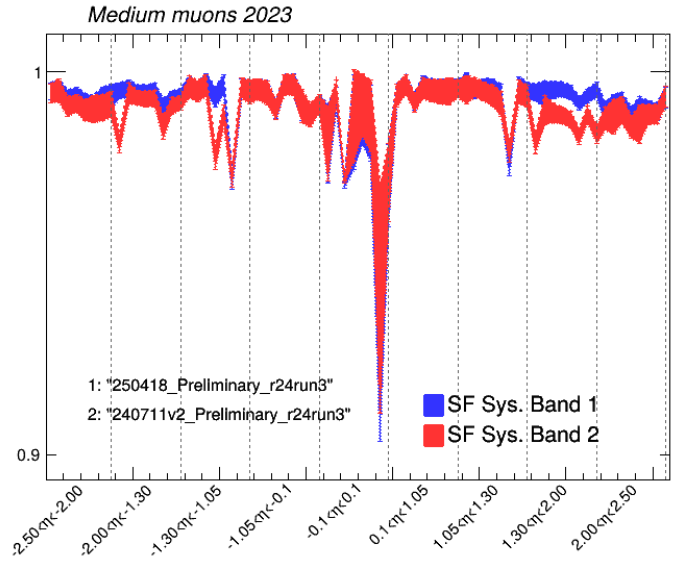

Fig. 6: Systematic uncertainties of the Scale Factor for *Reco Medium Z* in 2023 from two different recommendations.

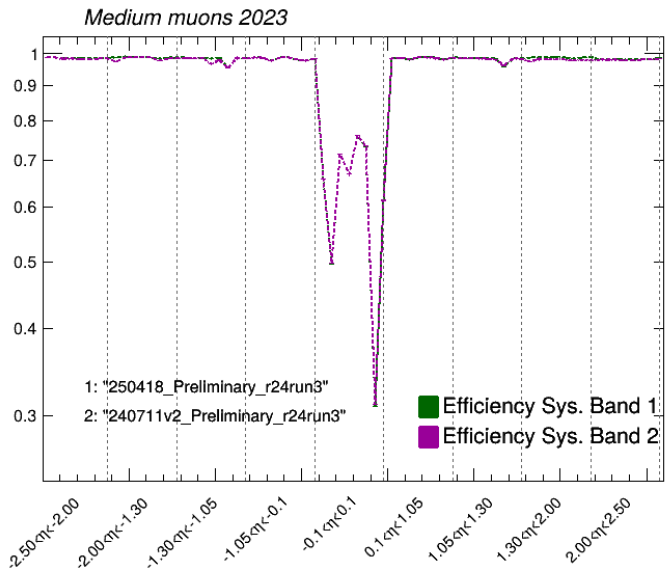

Fig. 7: Systematic uncertainties of the efficiency for *Reco Medium Z* in 2023 from two different recommendations.

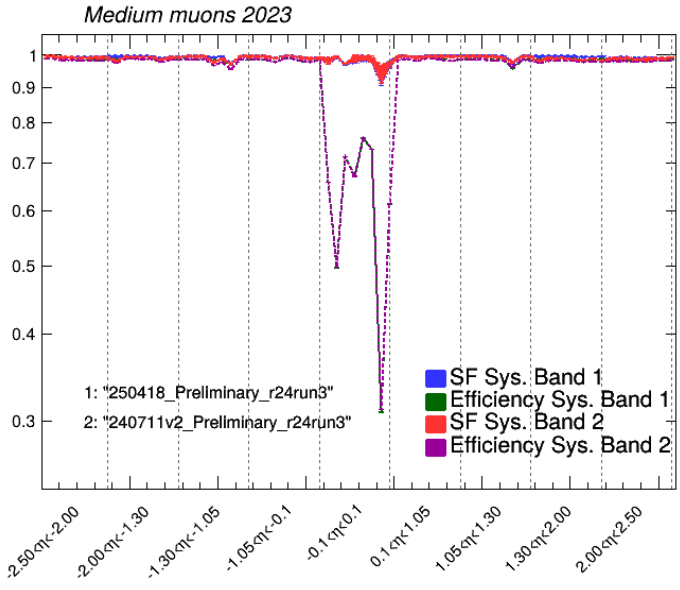

Fig. 8: Systematic uncertainties of both the Scale Factor and the efficiency for *Reco Medium Z* in 2023 from two different recommendations.

Conclusions

In this work, a set of validation tools for MCP recommendations was developed, starting from a basic prototype and progressively extending its functionality. The final script includes both the improvement of the initial script and the implementation of new scripts addressing specific validation needs.

A dedicated module was created to automatically scan and visualise recommendations across all available years, ensuring a systematic and efficient validation procedure. In parallel, additional scripts were developed to visualise systematic uncertainties, to compare different recommendations, and to overlay uncertainty bands. These tools provide complementary perspectives and allow for the identification of potential discrepancies between recommendations in a transparent and reproducible way.

Overall, the developed script establishes a flexible set of scripts and modules that enable the validation of Scale Factors and efficiencies, including their statistical and systematic uncertainties, across different years, releases, and working points. This work contributes to reinforcing the robustness and consistency of the MCP recommendations used in physics analyses within the collaboration.

Acknowledgments

I would like to thank my supervisors, Rosy Nikolaidou and Stylianos Angelidakis, for their guidance throughout this work.
I am also grateful to Marta, José, Leonor, Vicente, and Diego for making this experience even more rewarding than I could have imagined, and for their support during these two months.
Finally, I would like to thank my family and friends in Chile, especially Matías and Katy, for their invaluable emotional support during my time abroad.

Appendix

Here is the list of the scripts and the command that was used to run them:

For 1 it was used the script `Eff_SF.py`:

```
python Eff_SF.py --year 2023 --
   file Reco_Medium_Z.root --
   release /home/vicente/
   Summer_Student_Project/250418
   _Preliminary_r24run3
```

For 2 it was used the script `Eff_SF_V2.py`:

```
python Eff_SF_V2.py --year 2023
    --file Reco_Medium_Z.root --
   release1 /home/vicente/
   Summer_S
tudent_Project/250418
   _Preliminary_r24run3 --
   release2 /home/vicente/
   Summer_Student_Project/240711
   v2_Preliminary_r24run3
```

For 3 it was used the script `Sys_un.py`:

```
python Sys_un.py --year 2023 --
   file Reco_Medium_Z.root --
   release /home/vicente/
   Summer_Student_Project/250418
   _Preliminary_r24run3 --plot-
   type sf
```

For 4 it was used the script `Sys_un.py`:

```
python Sys_un.py --year 2023 --
   file Reco_Medium_Z.root --
   release /home/vicente/
   Summer_Student_Project/250418
   _Preliminary_r24run3 --plot-
   type eff
```

For 5 it was used the script `Sys_un.py`:

```
python Sys_un.py --year 2023 --
   file Reco_Medium_Z.root --
   release /home/vicente/
   Summer_Student_Project/250418
   _Preliminary_r24run3 --plot-
   type both
```

For 6 it was used the script `Sys_un_V2.py`:

```
python Sys_un_V2.py --year 2023
    --file Reco_Medium_Z.root --
   release1 /home/vicente/
   Summer_S
tudent_Project/250418
   _Preliminary_r24run3 --
   release2 /home/vicente/
   Summer_Student_Project/240711
   v2_Preliminary_r24run3 --plot
   -type sf
```

For 7 it was used the script `Sys_un_V2.py`:

```
python Sys_un_V2.py --year 2023
    --file Reco_Medium_Z.root --
   release1 /home/vicente/
   Summer_S
tudent_Project/250418
   _Preliminary_r24run3 --
   release2 /home/vicente/
   Summer_Student_Project/240711
   v2_Preliminary_r24run3 --plot
   -type eff
```

For 8 it was used the script `Sys_un_V2.py`:

```
python Sys_un_V2.py --year 2023
    --file Reco_Medium_Z.root --
   release1 /home/vicente/
   Summer_S
tudent_Project/250418
   _Preliminary_r24run3 --
   release2 /home/vicente/
   Summer_Student_Project/240711
   v2_Preliminary_r24run3 --plot
   -type both
```