PROCEEDINGS OF SCIENCE

PYTHIA8 predictions to the underlying event measurements using different PDF sets

Nameeqa Firdous,[a,*] **Muhammad Faheem**[a] **and Malik Muhammad Junaid**[b]

[a] *GIFT University,*
Sialkot Bypass Road, Gujranwala, Pakistan
[b] *University of Innsbruck,*
Innsbruck Austria

E-mail: nameeqa@gift.edu.pk, mfaheem@gift.edu.pk, malikjunaid@gmail.com

In this study, we use PYTHIA 8.3 for the simulation of multiparton interactions using different sets of parton distribution functions (PDF). Altogether four parameters were selected for the final tune depending on their sensitivity to the selected observables at 7 TeV published by ATLAS Collaboration. Simulated experimental analysis data are obtained using the Rivet analysis toolkit. These tunes describe the selected data reasonably well. These tuning results are also compared with the other popular choice, i.e. Monash tune.

41st International Conference on High Energy physics - ICHEP2022
6-13 July, 2022
Bologna, Italy

*Speaker

PoS(ICHEP2022)963

1. Introduction

PYTHIA is a highly successful and well established Monte Carlo event generator and has improved a lot over the past decades with the experimental discoveries. This is a crucial tool which uses factorization to allows users to separate the treatment of many high energy collision processes into different regimes, according to the scales of momentum transfer involved. Thus, to describe a typical high energy physics process Monte Carlo event generator simulate several sub processes like:

- Hard Process: One parton from each colliding hadron undergoes a hard collision
- Initial /Final State Radiation: Radiation associated with the two incoming/outgoing partons.
- Multiple Parton Interactions: More than one parton pair may collide within one single hadronic collision.
- Beam Remnant: Incoming beam particles, which do not take active part in the initial state radiation or hard scattering process.
- Hadronization: Transition of colored objects into colorless hadrons

PYTHIA 8.3 [1] implements several phenomenological models to describe above processes [7] which have free parameters and need to be tweaked to describe the data well [6]. Different parameters are studied for tuning based on their sensitivity to the selected data. In this work, new tunings of the PYTHIA8 Monte Carlo event generator using Underlying Event (UE) data published by the ATLAS [2] are presented. Altogether four parameters are varied: three parameters of the multiple parton interaction (MPI) model and one Color Reconnection Model parameter. It is shown that LO PDFs behave almost in similar manner as compared to LO**. For the tuning we have made use of Professor tuning software [4].

2. Underlying Event data

The data used in this study are underlying event data at 7 TeV from ATLAS Collaboration. These data use the established form of UE observables in which the azimuthal plane of the event is separated into several distinct regions with differing sensitivities to the UE. The azimuthal angular difference with respect to the leading (highest-p_T) charged particle $|\Delta\varphi| = |\varphi - \varphi_{lead}|$, is used to define the regions [2] :

- $|\Delta\varphi| < 60°$, the towards region;
- $60° < |\Delta\varphi| < 120°$, the transverse region; and
- $|\Delta\varphi| > 120°$, the away region.

3. Results

Tuned values of four parameters considered for simultaneous variation in this paper are listed in Table 1 for three different PDF sets . Distributions used in this study are from underlying event data at 7 Tev published by ATLAS. Figure 1 shows the comparison plots of two new tunes along

Tuned Parameters			
Parameter	NNPDF2.3 [8]	MRSTLO**[9]	NNPDF[10]
Multiparton Interactions:coreFraction	0.156	0.106	0.50
Multiparton Interactions:coreRadius	0.419	0.107	0.40
Multiparton Interactions:pT0Ref	2.461	2.790	2.28
Colour Reconnection:range	2.461	1.018	1.80

Table 1: List of tuned parameters for three different PDF sets

with default tune using ATLAS charged particle multiplicity density distributions as function of the leading track p_T, Charged particle scalar p_T *sum* and standard deviation of charged particle multiplicity and scalar p_T *sum*.

4. Conclusion

New tunes of PYTHIA 8.3 to the underlying event data published by ATLAS Collaboration are presented using different PDF sets including LO, modLO and NLO. Data/MC comparison plots show that LO PDF NNPDF2.3 describe data quite well as compared to other tunes. To get better Data/MC description more sensitive parameters should be considered for tuning. It is shown that LO PDF set NNPDF2.3 describes all the distributions better than the other PDF sets including default tune i.e. Monash 2013 [5]. All the data Monte Carlo comparison plots have been created using the Rivet analysis tool [3].

References

[1] Bierlich C. *et al.* "A comprehensive guide to the physics and usage of PYTHIA 8.3.", (arXiv,2022), https://doi.org/10.48550/arxiv.2203.11601

[2] G Aad *et al.* [ATLAS] "Measurement of underlying event characteristics using charged particles in $\sqrt{s}$=900GeV and 7 TeV with the ATLAS detector", Phys. Rev. D **83** ((2011) 11201, doi:10.1103/PhysRevD.83.112001 /physrevd.83.112001

[3] Bierlich, C., *et al.* "Robust Independent Validation of Experiment and Theory: Rivet version 3.", *SciPost Phys*. **8** pp. 026 (2020) https://scipost.org/10.21468/SciPostPhys.8.2.026

[4] Buckley *et al.* "Systematic event generator tuning for the LHC.", *The European Physical Journal C*. **65**, 331-357 (2009,11), https://doi.org/10.1140/epjc/s10052-009-1196-7

[5] Skands, P. *ete al.* "Tuning PYTHIA 8.1: the Monash 2013 tune.", *The European Physical Journal C*. **74** (2014,8), https://doi.org/10.1140/epjc/s10052-014-3024-y

[6] Firdous, Nameeqa & Rudolph, Gerald "Tuning of PYTHIA6 to Minimum Bias Data.", *EPJ Web Of Conferences*. **60** pp. 20056 (2013), https://doi.org/10.1051/epjconf/20136020056

[7] Firdous, Nameeqa & Rudolph, Gerald "Investigation of phenomenological models implemented in PYTHIA6.", *EPJ Web Of Conferences*. **60** pp. 20009 (2013), https://doi.org/10.1051/epjconf/20136020009

[8] Ball, R., *et al.* "Parton distributions with QED corrections.", *Nuclear Physics B*. **877**, 290-320 (2013,12), https://doi.org/10.1016/j.nuclphysb.2013.10.010

[9] Sherstnev, A. & Thorne, R. "Different PDF approximations useful for LO Monte Carlo generators." (arXiv,2008), https://arxiv.org/abs/0807.2132

[10] Carrazza, S. *et al.*"Parton Distributions and Event Generators.", (arXiv,2013), https://arxiv.org/abs/1311.5887

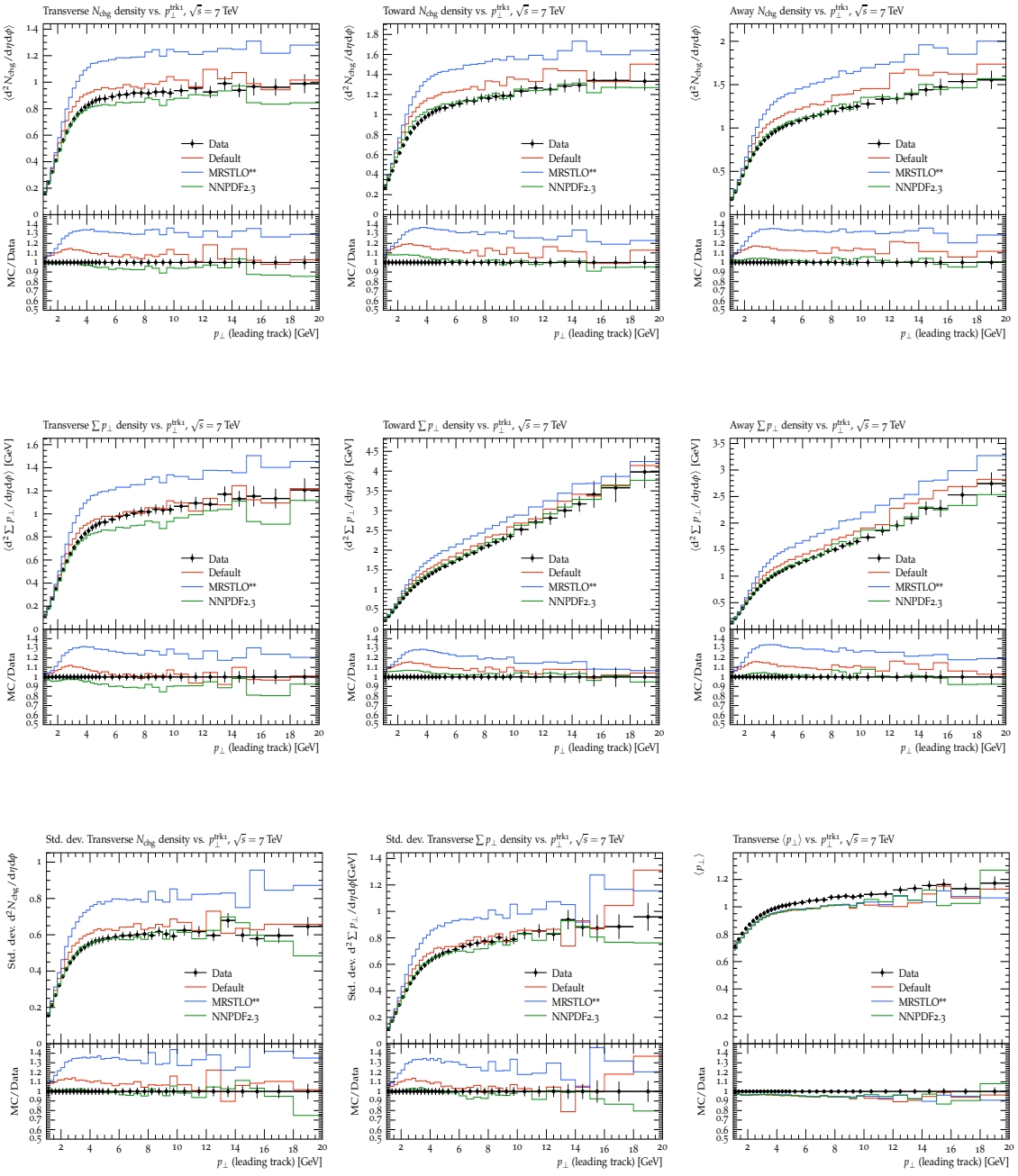

Figure 1: Data / MC comparison plots of charged-particle density (top row), summed scalar p_T (middle row), their standard deviations and average track p_T, as functions of the leading track p_T for the Transverse, Toward and Away regions of underlying events at 7 TeV [2]

.