STUDY OF DRELL-YAN Z-BOSON PRODUCTION IN pPb COLISSION AT $\sqrt{s_{NN}} = 5.02TeV$

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Abstract

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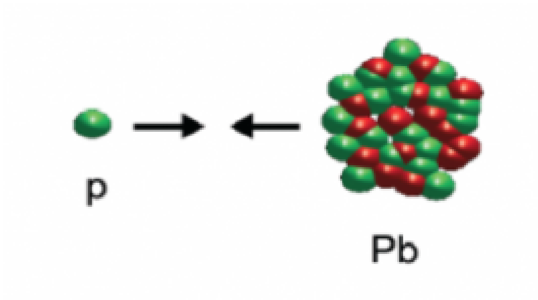
1 Introduction

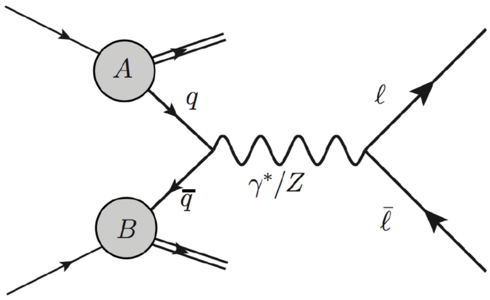
LHC, there is a growing interest in the examen and analysis of the results in the ALICE, ATLAS and CMS detectors. This interest in such asymmetric systems is due to the possibilities, on the one hand, of establishing some references for lead-lead collisions and, on the other hand, to gain insight into the behavior of the medium itself.

One also has in mind, that in particular, the parton distribution functions (PDFs) of a free proton in comparison to the PDFs corresponding to the bound nucleons, the so-called nuclear parton distribution functions (nPDFs) should behave differently. In this regard, the analysis of the data in both cases can allow the understanding of the PDFs under different regimes.

Besides, it is well recognized the presence of initial and final state effects in proton-nucleus collisions [1]. For example, in the case of ion-lead collisions, the interaction with the plasma can leads to the jet quenching or the dissolution of the quarkonia. In this last case, one has two possibilities: Is this an end-state effect of things that can be hidden or absorbed in the plasma or an initial state effect of things that do not occur at the initial state? In the case of a proton-nucleus collision, one is in the presence of a cold system known as cold nuclear matter and therefore, it is possible to disentangle the initial and final state effects.



proton lead collision



Drell-Yan diagrams

Figure 1: Diagrams of Drell-Yan process

The motivation for this research during the summer school was precisely the study of the initial state in proton-lead collisions at 5.02 TeV using the Drell-Yan process [2] wich diagrams is shown in the Figure 1. We chose this process because the inclusive lepton production is a clean process independent of the color degree of freedoms and therefore, of the strong interaction. We consider an extension of the Glauber model [3, 4] to express the cross section $\sigma_{pA} = \sigma_{pp}^{Hard}$ where A is the nuclear mass and describe the modification factor due to the nuclear media. In the case of the Drell- Yan process, one can consider $\sigma \approx 1$ and the cross section for Z boson production, σ_{pA}, simple scales with A in relation to σ_{pp}^{Hard}.

Under this approach, we can examine the initial vertex of the hard process describing by pp and apply the usual calculations through the factorization theorem. In particular, we focused on the analysis of the pt distribution and compared the role of different factorization schema in the behavior of the distribution at low pT.

2 Theory

The dileptonic decays of Z boson have mass spectrum show in Figure 2 for the electronic and muonic chanels.

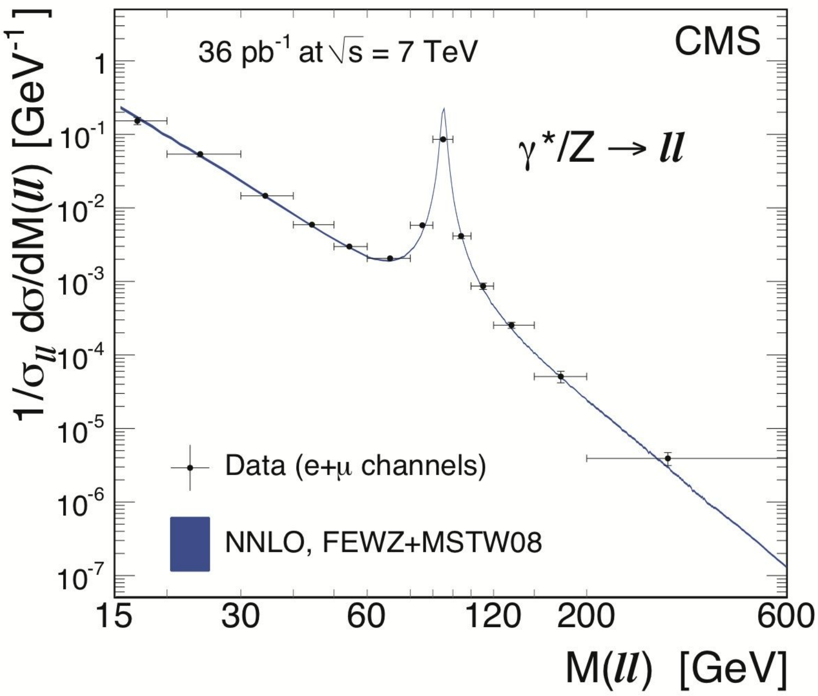
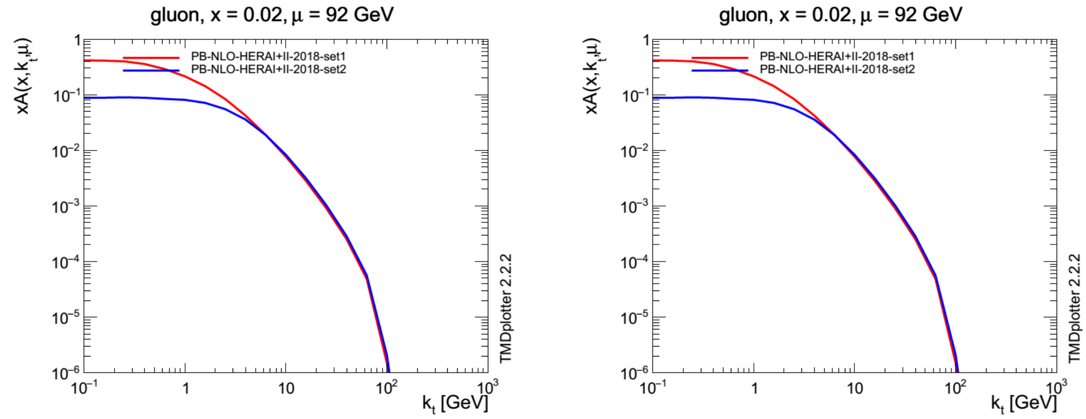


Figure 2: Dilepton mass cross section in a collision pp at $\sqrt{s_{NN}} = 7TeV$

Figure 3 shows a kT distribution for different sets. The most important point here that in a low pT region there is a huge difference between one set and another. Because of this, the pTsqmin is used to constrains where TMD are going to work when CASCADE is used. The idea is to use the TMD that actually have a better physical explanation for the initial state of the parton to reproduce that Pythia has been done using the parton shower.



a) b)

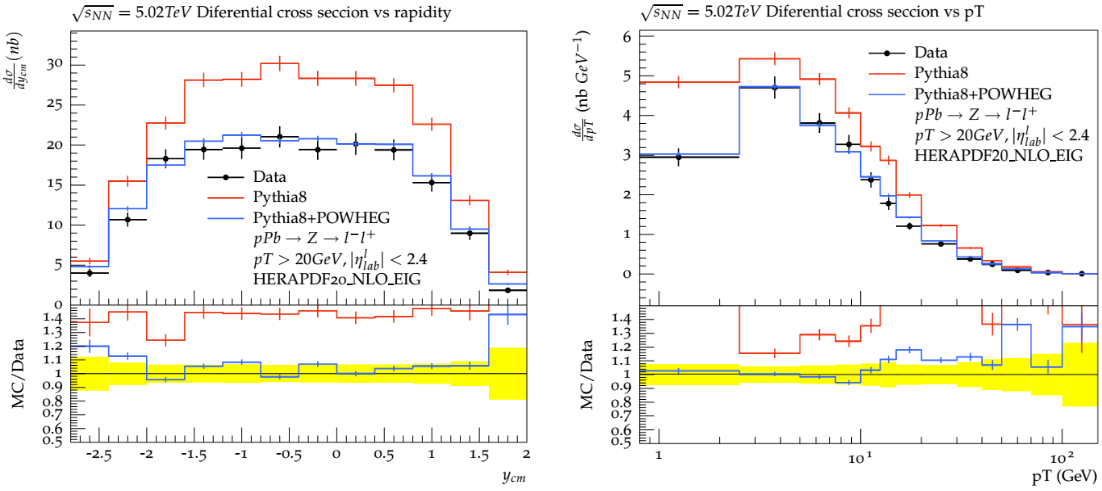
Figure 3: kT distribution of dbar and gluon for a typical x value of 0.02 at a scale of the z-mass.

3 Results

3.1 Pythia8+POWHEG: LO and NLO calculation

Once all calculation has been done the rapidity and transversal momentum plots were constructed. To achieve the correct match on rapidity distribution is necessary to take account the difference between what the event generator does and which were the real collision to obtain the experimental data. The collision studied is a proton-lead collision meanwhile Pythia8 "collides" two protons beams. This not only has an impact on the scale of the cross-sections but also have an impact on the angular distribution due to the asymmetry of the colliding beams. This is the reason why it's was used a shift on rapidity $\Delta y = 0,465$ reported by [**??**]. Exist a different way to get the same result that is differencing the beams energies using XX and the result are the same for rapidity distribution without significative change on pT cross-section.

For the LO calculation using Pythia8, the red line in Figure 4 there is a wide mismatching between the experimental data and the simulation. This mismatching in the high of bins is obtained even using the number of nucleons inside the Pb ion as a scale factor. After this, is evident that is necessary include de NLO calculation that was done using POWHEG-BOX. In the first place, all calculation of the matrix elements were constructed using the default values of POWHEG-BOX.
The parameters that we are interested in exploring are the ptsqmin and hdamp. Due to hdamp did not show significative influence on the behavior of the pT distribution on the low region the work focused on the ptsqmin parameters. Is interesting show what really does this "pT cut". The Figure **??** for different values of the pTsqmin the behavior of the pT distribution calculated with Pythia8 without the parton shower. In order to see how pTsqmin really work we constructed a plot of pT distribution with different values of this pT cut in Figure 5. The deepness on the low pT region before the pT cut it's



a) b)

Figure 4: Cross section dependecy with a) rapidity and b) transversal momentum. LO and NLO Pythia+POWHEG

suppose to be filled by the parton shower from Pythia.

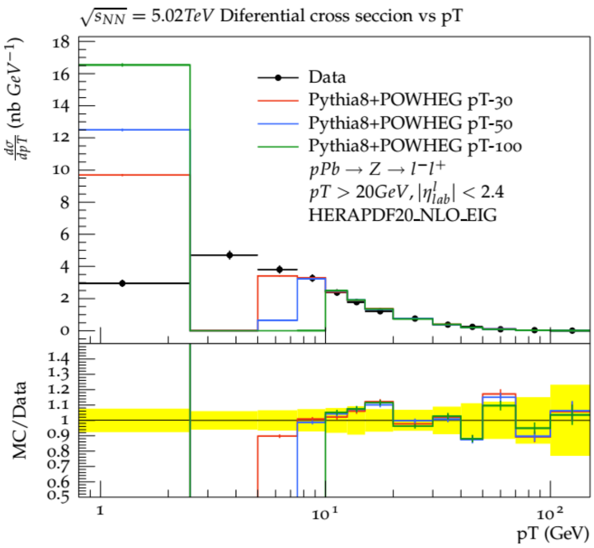
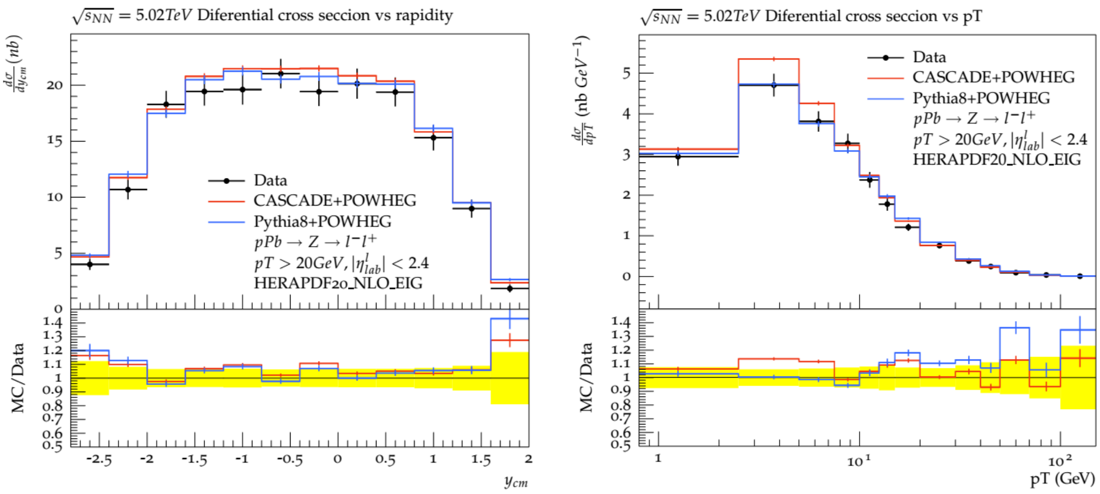


Figure 5: pT distribution with different values of this pT cut with parton shower OFF

3.2 CASCADE: including TMDs PDF

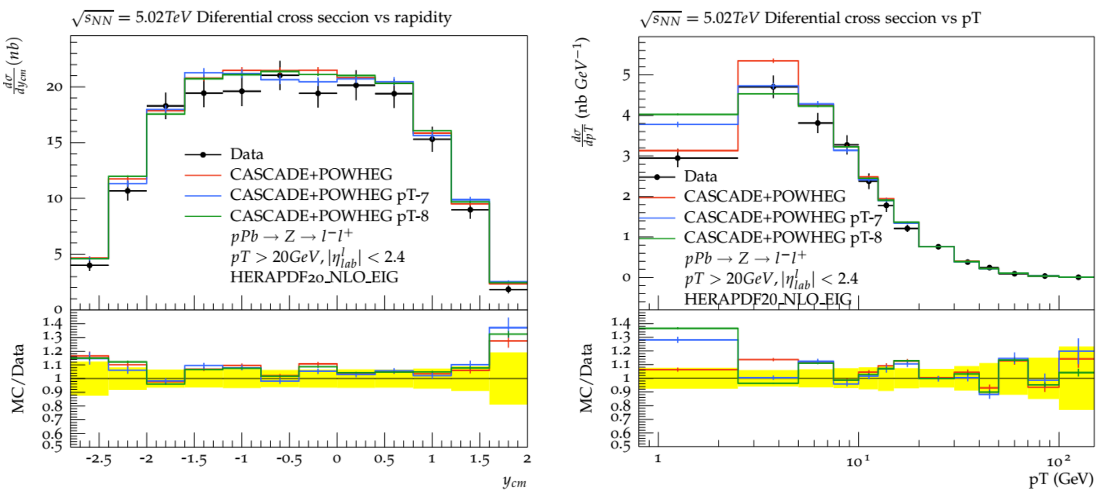
The Figure 6 show the behavior of cross-section for the rapidity and the transversal momentum for Pythia8 and CASCADE. For the default values of the POWHEG package, there is only a little difference in the low pT region. It's possible to conclude that TMD can reproduce that has been done for the parton shower from Pythia. There is a hidden detail and the importance of the TMD works depend on the scale factor that is taken now as a pT cut. Then is not possible see how really are working due to pTsqin default value is $0.8 GeV$.



a) b)

Figure 6: Cross section dependecy with a) rapidity and b) transversal momentum. CASCADE+POWHEG(standard) NLO calculation

In the Figure 7 is easy to see how sensible is the pT spectrum with pTsqmin variation.



a) b)

Figure 7: Cross section decency with a) rapidity and b) transversal momentum. CASCADE+POWHEG NLO calculation. Dependency with pt cut

3.3 CASCADE vs Pythia

Figure 8 and Figure 9 show a comparison plot between Pythia8 and CASCADE in pT cross-section distribution. In the first one, practically all for CASCADE is comming from POWHEG calculation due to the low values of pT cut.

Even is evident that a better tune is needed it to reach a correct behavior in the low pT region is importance notice that TMDs play an important role when the pT cut take high enough values. Then all the unfilled region by parton shower from Pythia is now done by CASCADE.

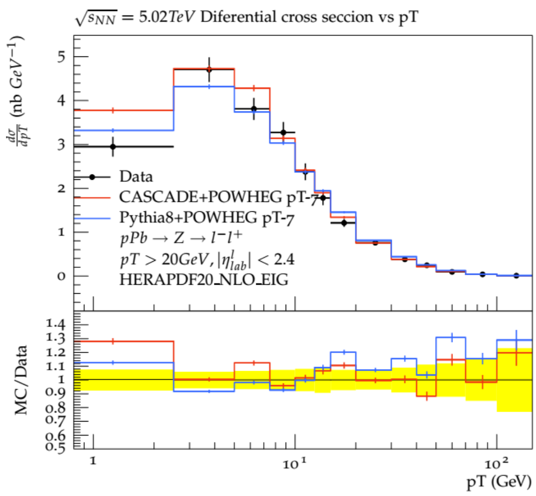


Figure 8: Comparison between Pythia8+POWHEG and CASCADE +POWHEG at pT cut = 7 GeV

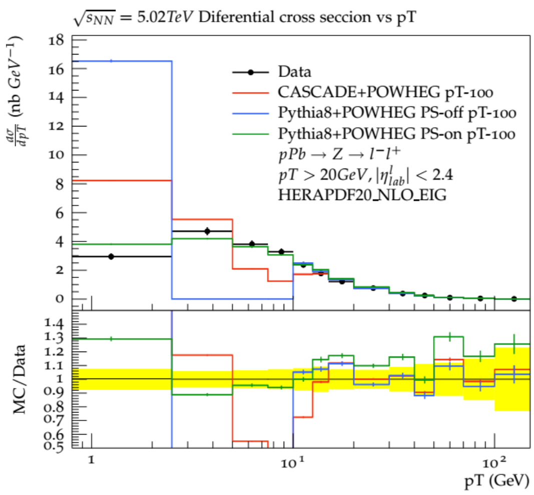


Figure 9: Comparison between Pythia8+POWHEG and CASCADE +POWHEG at pT cut = 100 GeV

4 Conclusion

A rivet plugin to analyze the Drell-Yan process in pPB collisions was written, and predictions were generated matching and merging NLO calculations with CASCADE, a Monte Carlo generator that uses TMD PDFs, and PYTHIA 8. In both cases, two parameters corresponding to the NLO calculation of the Matrix Elements with POWHEG were used to combine the NLO accuracy with PS resummation.

Our main conclusion is that the low pT region can be filled with a better physical interpretation by TMD PDFs using CASCADE. Moreover is possible to improve the results refining the tune with other parameters and setting the scale of the TMD in Z boson mass order instead of the pTsqmin value, that is done using the update of CASCADE.

References

[1] J.W.Cronin et al., Phys. Rev. D 11, 3105 (1975)

[2] Drell, S.D. and Yan, T.-M. (1970)., Phys. Rev. Lett., 25 (5): 316320

[3] R.J. Glauber and G. Matthiae, Nucl. Phys. B 21 (1970) 135

[4] D. D'Enterria., arXiv:nucl-ex/0302016 (glauber)