Optimization of W+jets sensitivity to NLO electroweak corrections at the LHC

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Introduction

When searching for new physics and new particle using particle accelerators such at the Large Hadron Collider (LHC) at CERN, the phenomena being investigated must be reconstructed from a shower of decaying and recombining particles. Different processes and different initial particles might produce the same final product particles. which acts as noise, obscuring our reconstructive process of the physics we actually want to investigate.

One of the biggest sources of background at higher energies, which is the current domain for investigating new physics, is W+jets events. Current predictions for W+jets processes at the LHC do not include higher order (NLO) electroweak corrections. These adjustments have marginal impact at very low energies, but the corrections could account for 40% of the error at energies of about 1 TeV. Understanding W+jets event and the effect of NLO electroweak correction is vital for being able to distinguish the signal coming from new physics from the background interference inherent to particle accelerator experiments.

The precise effects and impact of the electroweak corrections is masked, however, by systematic uncertainty such as Quantum Chromodynamic (QCD) effects and detector effects. Quantifying and reducing this systematic uncertainty is explained in the Methodology section.

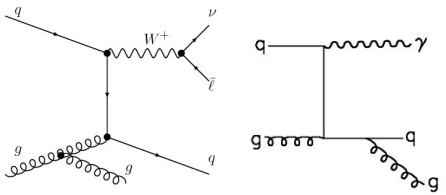

Fig 1: Two example Feynman diagrams of a W+jets interaction (left) and a Gamma+jets interaction (right)

Methodology

The main methodology used to eliminate systematic uncertainty in this study is to investigate a ratio of different physics processes with similar uncertainties. If the systematic uncertainties are positively correlated between the numerator and the denominator of the ratio, they will cancel out, with higher correlations resulting in larger cancellations.

The ratio chosen for this study is W+jets/Photon+jets. This ratio would cancel out a large number of QCD effects such as renormalization scale and parton distribution function uncertainties, while leaving intact electroweak higher-order virtual and QED real emission corrections, which is what we want to investigate in the first place.

This ratio and its sensitivity to electroweak correction was calculated in this study with data generated through Monte Carlo simulations. The PYTHIA event generator is the primary software used to run these Monte Carlo simulations.

Once a ratio has be calculated, the systematic uncertainties can be found through altering the physics parameters (tunes, scale, etc) and models (parton shower model, etc) used in the Monte Carlo simulation. Calculating the relative deviations between the nominal ratio prediction and the systematic shifted one gives us a measure of the systematic uncertainty.

Once all the systematic and statistical uncertainties inherent to our ratio have been quantified, the effects of electroweak corrections can be homed in on. By comparing Monte Carlo samples with QCD and EWK effect to samples with QCD effects alone, the electroweak corrections can isolated and quantified specifically.

Results

The progress made on this project so far mostly falls into the category of preliminary data collection and refining the methodology

- Large Monte Carlo samples have been generated for W+jets, Gamma+jets and Z+jets
- Sample slicing and phase space bias has been trialed and implemented
- The distribution of the particle variables (transverse momentum, pseudorapidity, etc) have been found and coded in
- Some preliminary W+jets/Gamma+jets ratio plots have been made (see **Fig 2**)

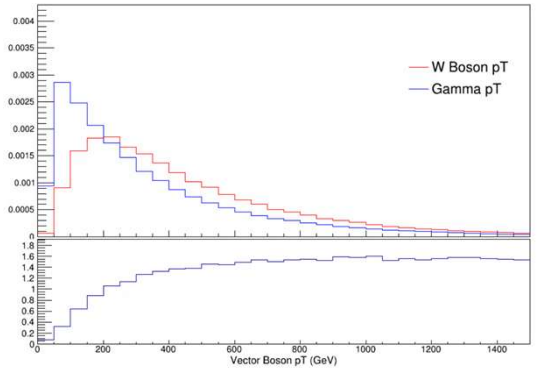

Fig 2: W+jets and Gamma+jets vector boson pT plots and associated ratio plot

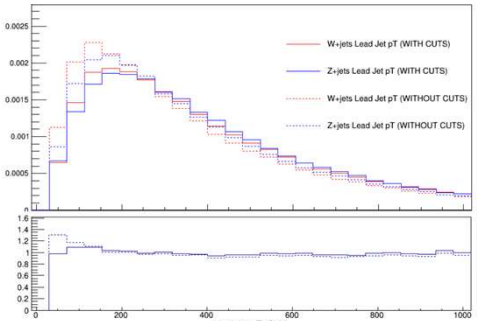

Fig 3: Cut comparison plots and associated ratio of W+jets/Z+jets leading jet pT

The current focus of my research most recently is doing a cut flow analysis to validate the cuts imposed on the particle variables. The cuts on the W+jets events are being validated by comparing the W+jets/Z+jets ratio with and without cuts (see **Fig 3**). As Professor Hugo Beauchemin has already calculated this ration in his R_{jets} paper (see references), this gives a good baseline to compare the effects of my cuts to. Once the cuts have been validated we can know if the shape of the ratio plot is physically meaningful or an artefact of the event selection process

Future Work

This research project is still in the preliminary stages. Before any work can be carried out on directly measuring the electroweak corrections, we need to be sure that ratio methodology is having the desired effect of reducing the systematic uncertainty.

Quantifying the systematic and statistical uncertainty is thus the primary focus of this research project in the coming weeks. Once this is complete the sensitivity of the ratio to electroweak corrections can be fully studied.

Acknowledgements

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References

The ATLAS Collaboration, *A measurement of the ratio of the production cross sections for W and Z bosons in association with jets with the ATLAS detector*, accepted by Eur. Jour. Phys. C: EPJC-14-08-090 (2014)