PROSPECTS FOR THE CONSTRAINING OF PDFS FROM ATLAS JET DATA

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An integration grid method was employed to allow NLO cross-sections to be generated quickly for an arbitrary PDF. The method is shown to be able to recreate the standard NLO calculation to an accuracy of 0.2%, for the inclusive jet cross-section at LHC energies for $0 < \eta < 3$. The grids were used to allow hadron-collider data to be entered into a global PDF fit. Predictions using ATLAS pseudodata suggest that the LHC will help to constrain the uncertainty in the gluon PDF, particularly at high x.

1. Introduction

The LHC will collide protons at a centre of mass energy of $\sqrt{s} = 14TeV$ providing the opportunity to explore physics at higher energies than previously accessible to hadron colliders. This immediately opens up the possibility for the discovery of new physics, however uncertainty in Standard Model backgrounds can mask its identification. Among the theroretical uncertainties associated with cross-section predictions at the LHC, the error on the PDFs (or initial state) can become dominant for high Q^2 and forward (high η) processes.

Obtaining accurate PDFs is hence crucial to understanding physics at the LHC, and deep-inelastic scattering experiments have contributed a great deal to this effort. However considerable uncertainty remains on the gluon distribution particularly at high (Bjorken) x [1]. Hadron collider data can assist in constraining this particular distribution by comparing experimental results with NLO predictions. A problem arises however due to the large CPU time associated with NLO calculations, which prohibits iterative PDF fitting techniques. One approach (adopted by CTEQ) is to

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reduce this CPU time by generating LO cross-sections and applying K-factors to approximate the NLO result. However even at LO a compromise has to be made between statistical accuracy and speed of calculation and the K-factors are dependent on the PDFs used.

This problem with PDF fitting using hadron-collider data can be avoided by using an integration grid to store the NLO weights calculated by a Monte-Carlo integration program. The grid can then be combined with an arbitrary PDF to produce a final cross-section in a fast step. This note will describe a grid implementation, its properties and an example of its use in a global PDF fit to constrain the gluon PDF using ATLAS pseudodata.

2. Grid Implementation

The integration grid stores the weight (equivalent to the parton matrix element convoluted with the phase space) from a NLO Monte-Carlo program, at a point (x_1, x_2, Q^2) where $x_{1,2}$ are the Bjorken x values of the partons undergoing the collision and Q^2 is the momentum transfer between them.A separate grid is required for each experimental variable (e.g. jet pT) that defines the cross-section which is to be reproduced.

The three-dimensional grids can only contain a finite number of bins in x_1, x_2 and Q^2 (owing to computer memory constraints) which leads to the introduction of a discrepancy between the standard NLO prediction and that found using the grid technique. This problem of finite grid spacing can be reduced by optimizing the ranges in x and Q^2 for a particular observable bin, applying a co-ordinate transform to the x and Q^2 and by the use of high order interpolation techniques between grid points.

A detailed description of the grid implementation used in this note is given elsewhere [2]. The grid software is based in C^{++}, makes use of ROOT libraries [3] and is currently interfaced to the NLOJET event generator [4].

3. Grid Performance

The inclusive jet cross-section for three pseudorapidity regions, $(0 < \eta < 1$, $1 < \eta < 2$ and $2 < \eta < 3)$ was chosen as a process to test the grids ability to reproduce the NLO cross-section. NLOJET was used to create weights which were used to produce a standard NLO cross-section (using CTEQ6.1) and and also to fill an integration grid. The grid was then combined in a fast step with the original PDF to generate the original cross-section. The ratio of these cross sections is shown in Figure 1.

As can be seen from the figure the grid is successful in reproducing the

NLO cross-section to an accuracy of better than 0.2% in the kinematic region chosen. This level of accuracy is probably in practise unnecessary as other theoretical uncertainties (such as higher order corrections) would be expected to dominate.

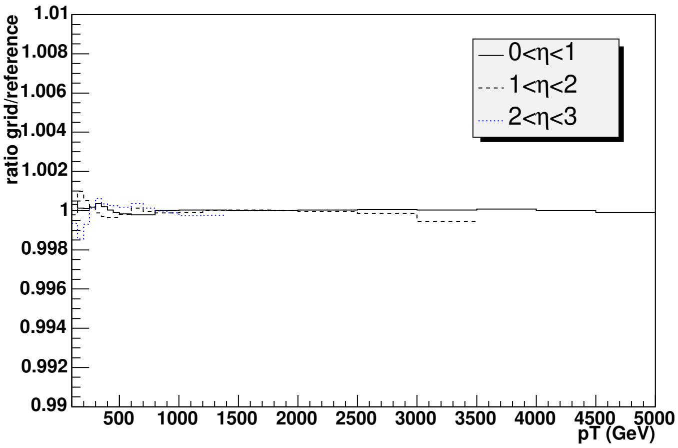

Figure 1. Ratio of grid/reference for the inclusive jet cross-section at ATLAS for three pseudorapidity regions, pT<5.0 TeV). Agreement is seen to be better than 0.2%

4. PDF Global Fits Using Grids

The grid technique was used to investigate whether the ATLAS experiment will be able to constrain the gluon PDF at high x. Grids were generated using NLOJET for the inclusive jet cross-section at ATLAS for $pT < 3TeV$ in three pseudorapidity ranges $0 < \eta < 1$, $1 < \eta < 2$ and $2 < \eta < 3$. ATLAS Pseudodata was generated using JETRAD [5] assuming an integrated luminosity of $10fb^{-1}$ and uncorrelated systematic uncertainty of 10% on the cross-section. The results are shown in Figure 2.

As can be seen from the figure the inclusion of ATLAS data decreases the uncertainty of the gluon particularly in the high x region. Further studies were carried out to discover the effects of varying the integrated luminosity and the uncorrelated systematic errors of the pseudodata. It was found that the constraint on the gluon PDF by the inclusion of ATLAS data is not strongly dependent on statistics above $1fb^{-1}$ and instead the systematic experimental uncertainty on the cross-section dominates.

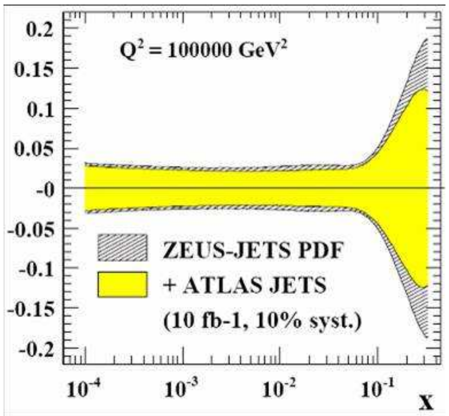

Figure 2. The uncertainty on the gluon PDF, the yellow band shows the effect of introducing ATLAS jet data from the inclusive jet cross-section for pT<3TeV for $0<\eta<3$. The ATLAS pseudodata assumes an integrated luminosity of $10 fb^{-1}$ and an uncorrelated systematic uncertainty of 10% on the experimental cross-section.

5. Summary

A grid technique to allow arbitrary PDFs to be coupled to a NLO QCD cross-section calculation in a fast step has been shown to recreate the standard NLO calculation to accuracies better than 0.2% (for the inclusive jet cross-section at ATLAS $0 < \eta < 3$, $pT < 5TeV$). This is of sufficient accuracy to allow the use of hadron-collider data in global PDF fits which use iterative techniques.

The effect of ATLAS jet data (from the inclusive jet cross-section for $pT < 3TeV$ for $0 < \eta < 3$) on constraining the gluon PDF in a global fit was studied and found to be useful in reducing the PDF uncertainty, particularly at high x. The constraining of the gluon PDF using ATLAS data is found to be limited by systematic errors for integrated luminosities above $1fb^{-1}$.

References

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