

NLOLIB - A Common Interface for Fixed-Order Calculations

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Abstract

We present the current status of the NLOLIB framework which provides an interface to various higher order perturbative calculations, thus allowing for simple comparisons of these calculations with each other and with measured distributions. We show, as a newly included example of the NLOLIB abilities, a comparison of calculations for jet production in deeply inelastic ep scattering.

1 Introduction

Progress in particle physics relies, to a large extent, on the comparison of data to theoretical predictions. Most commonly, the theoretical calculations are available to the experiments in the form of Monte Carlo event generators producing event records that contain all generated particles, their four-momenta, the decay trees etc. in a commonly adopted format. The events that represent the outcome of such a prediction can be used directly by experiment-specific detector simulation and analysis software in order to perform detailed comparisons with experimental data.

Due to complications in the involved mathematical techniques most programs providing higher order electroweak or QCD calculations, however, require large numbers of events to be generated with positive and negative weights. These can not be easily used in simulations because the meaning of the cancellation of positive and negative weights in combination with detector influences is not overly clear. In addition, producing the necessary numbers of events is extremely time-consuming. Nevertheless the results are very useful for comparisons to data and they are used in a variety of experiments to perform, for example, precision measurements of standard model parameters like the strong coupling parameter, α_s .

Although many such programs have been developed for a variety of physical processes, and sometimes even more than one program exist for the same purpose, the usage and the presentation of the results has not been unified so far. This leads to a number of unnecessary technical problems for the user who wants to compare the predictions of more than one program to some measured distribution. To be more specific, the user has to learn, for each single program he or she wants to use, how to install and compile the program, how to implement the specific distributions or processes of interest, and how to extract the results. It should be noted that the programs are also implemented in different programming languages, mostly *FORTRAN* and *C++*.

NLOLIB seeks to simplify the physicists' life by unifying the steering and providing a common framework to implement new quantities and to extract the results. A first version of NLOLIB was developed in the workshop on 'Monte Carlo Generators for HERA Physics' 1998/99 and aimed to integrate and compare three different programs for next-to-leading order calculations in electron-proton scattering [1]. Now this scope will be extended to include also proton-(anti)proton and electron-positron collisions.

2 Implemented programs

RacoonWW provides tree-level cross-sections to all processes where an electron-positron collision yields four fermions in the final state. In addition, it contains a number of higher order corrections, see [2] for details.

DISENT [3] is a next-to-leading order calculation for the production of one or two jets (processes up to $\mathcal{O}(\alpha_s^2)$) for deep-inelastic ep scattering. It uses a subtraction scheme [4] for the cancellation of divergencies. DISENT is the standard program for DIS jet production at HERA and has been used in a variety of analyses.

DISASTER++ [5] offers more possibilities to separate different terms in the derivation of the cross sections; otherwise it provides a functionality similar to DISENT. It also employs the subtraction method.

JetViP [6,7] is a next-to-leading order calculation for jet production in deep-inelastic ep scattering and e^+e^- collisions that contains processes up to $\mathcal{O}(\alpha_s^2)$ and implements both direct and resolved contributions to the cross-section. The cancellation of divergencies is performed using the phase-space slicing method [8] which leads to dependencies of the resolved contribution on the unphysical slicing parameter, y_{cut} . The direct predictions of JetViP have been shown to be compatible [7,9] with those of DISENT and DISASTER++. So far, only the implementation into NLOLIB of the direct photon ep scattering part of JetViP has been thoroughly tested; the resolved photon part is implemented in principal but needs more testing. The implementation of the e^+e^- part into NLOLIB has just started.

MEPJET [10] was the first complete next-to-leading order calculation available for deep-inelastic ep scattering and is based on the phase-space slicing method in combination with the technique of crossing functions [11]. The predictions of MEPJET show some discrepancies with respect to the results of DISASTER++, DISENT and JetViP [9].

NLOJET++ [12] incorporates next-to-leading order predictions for ep, pp and $e+e-$ scattering using the subtraction method. Due to its very different way of allowing users to implement their favourite quantities, an integration into NLOLIB on the same footing as for the other programs seems not to be feasible. However, it will be tried to achieve an approach as similar as possible. Currently, only the original version of NLOJET++ in its unchanged form is included.

FMNR [13]: FMNR is a program for the calculation of next-To-leading order photoproduction jet cross-sections with heavy quarks in the final state. The implementation of FMNR into NLOLIB has only just begun.

3 Getting started

Once, a new release is finished, a compressed tar archive will be made available like it is done already now on <http://www.desy.de/~nlolib>.

Since the way in which NLOLIB is installed has changed considerably in the course of this workshop from the original version [1], some short instructions on how to get started are given here.

Originally, the make tool together with a set of perl scripts containing hardware-specific settings were used. However, this procedure was not easily maintainable, so it was decided to employ the GNU autotools [14]. For this to work automake versions 1.7 or higher and autoconf versions 2.57 or higher are needed. In addition, the CERN libraries including a version of PDFLIB [15] and the HzTool [16] libraries as available from our web page are required.

When these conditions are met, the following scheme should be followed for installing NLOLIB:

- Retrieve the NLOLIB source code from the web page at DESY (at a later stage it will also be downloadable from the CVS server in Karlsruhe) and copy it to your working directory (assumed to be `~/nlolib` in the following).
- In `nlolib.sh` (for c-type shells in `nlolib.csh`) set the correct paths to the PDFLIB and the CERNLIB libraries (`libpdflib.a` or `libpdflib804.a`, `libkernlib.a`, `libpacklib.a`), the HzTool libraries (`libhztool.a`, `libmyhztool.a`) and the directories where to put the NLOLIB binaries and libraries, typically `~/nlolib/bin` and `~/nlolib/lib`.
- Go to the working directory and source `nlolib.sh` (or `nlolib.csh`):
`~/nlolib > source nlolib.sh`

- Usually, the following three steps can be skipped. But in case the `configure` script below fails, it has to be recreated by doing:
 - `~ \nlolib > aclocal`
 - `~ \nlolib > automake`
 - `~ \nlolib > autoconf`
- `~ \nlolib > ./configure`
- This step can be skipped if a complete recompile is not necessary/wanted:
 - `~ \nlolib > make clean`
- `~ \nlolib > make`
- `~ \nlolib > make install`

Since the running of NLOLIB depends on the simulation program required by the user no general rules can be given here concerning the NLOLIB execution.

4 Jet cross-sections in ep NC DIS

As a new check of the NLOLIB framework we tested the predictions of the DISENT and JetViP programs for deep-inelastic ep scattering single-inclusive jet production against the stand-alone versions of the programs and against data published by the H1 collaboration [17]. The phase-space of the measurement is determined by two requirements on the scattered electron: the energy of the scattered electron E' must be larger than 10 GeV, and its polar angle must be larger than 156° . In addition, two kinematic cuts are applied to select well-reconstructed low- Q^2 DIS events: $5 < Q^2 < 100 \text{ GeV}^2$ and $0.2 < y < 0.6$.

Jet reconstruction for the selected events is performed in the Breit reference frame with the longitudinally invariant k_\perp algorithm [18] in the inclusive mode [19]. Jets are selected by requiring their transverse energy in the Breit frame to be larger than 5 GeV, $E_T^{Breit} > 5 \text{ GeV}$, and their pseudorapidity in the laboratory frame, η^{lab} , to be between -1 and 2.5 .

4.1 Comparison of calculations and data

We first present a comparison of event and jet quantities between the stand-alone versions and the versions implemented in NLOLIB of DISENT and JetViP. For this purpose 1 million events have been generated with each of the four programs using CTEQ4M as proton PDFs and Q^2 as renormalization and factorization scale. Figure 1 shows the differential cross-sections as functions of Q^2 , y , E_e and θ_e for the four predictions. A very good agreement between the predictions is observed.

Also the comparison of the various predictions for the jet pseudorapidities in the Breit and laboratory reference frames, η^{Breit} and η^{lab} , and for the jet transverse energy in the Breit frame, E_T^{Breit} , shows satisfactory agreement. There are, however, small discrepancies between the two JetViP and the two DISENT predictions in the η^{Breit} distribution and a rather large discrepancy between the stand-alone JetViP prediction on the one hand side and the other three calculations on the other hand side for η^{lab} , see Fig. 2.

Figure 3 finally compares the four predictions to the published H1 data which are presented as inclusive jet cross-sections as functions of E_T^{Breit} in different ranges of η^{lab} . Also for these published observables the agreement of the various predictions is reasonable.

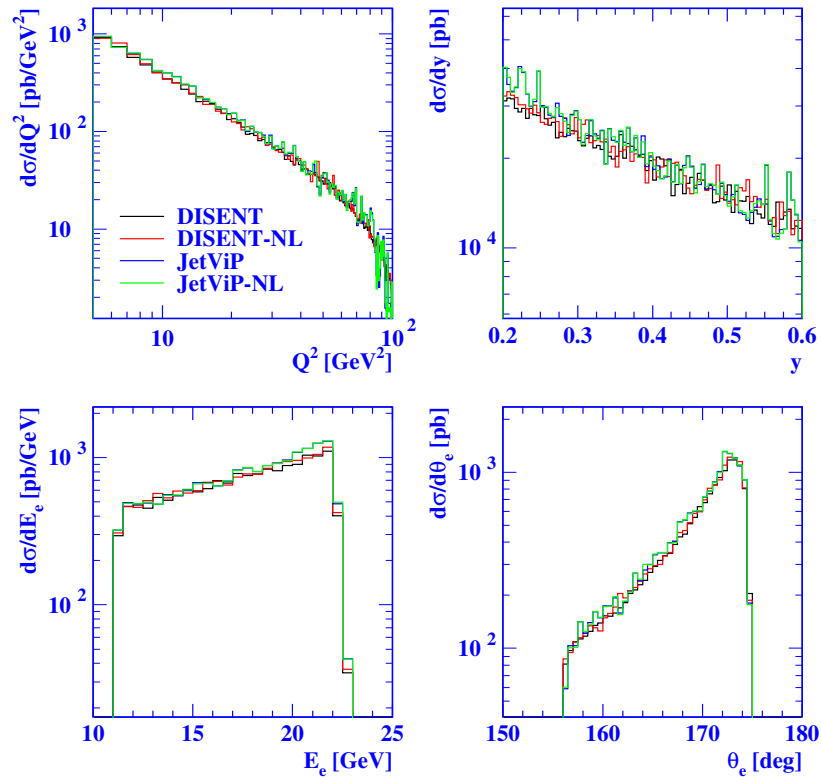


Fig. 1: Cross-sections as functions of Q^2 , y , E_e and θ_e for the different DISENT and JetViP predictions.

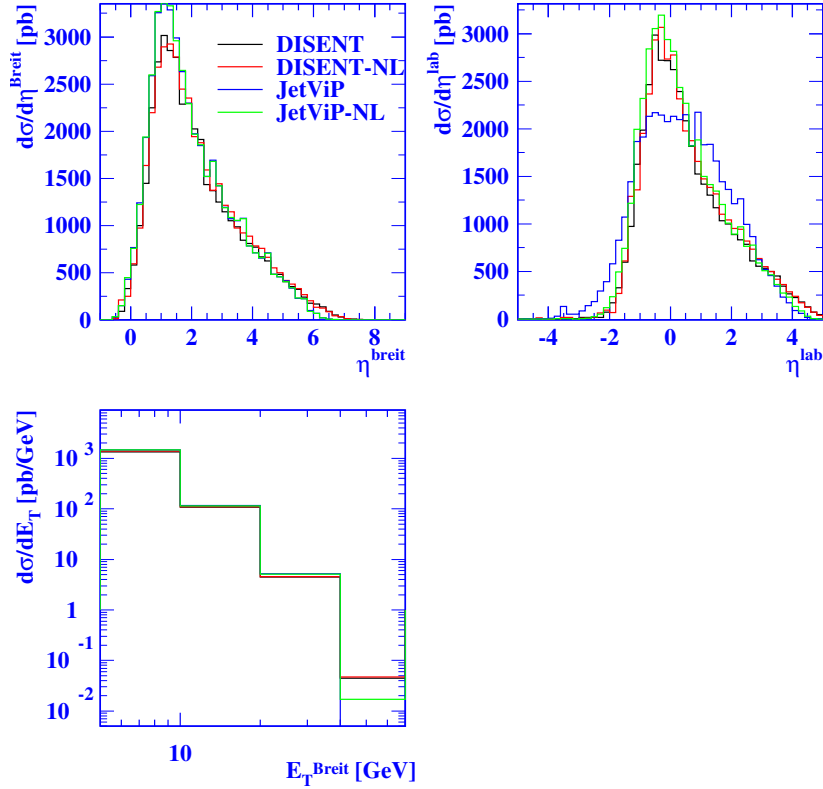


Fig. 2: Inclusive jet cross-sections as functions of η^{Breit} , η^{lab} and E_T^{Breit} for the different DISENT and JetViP predictions.

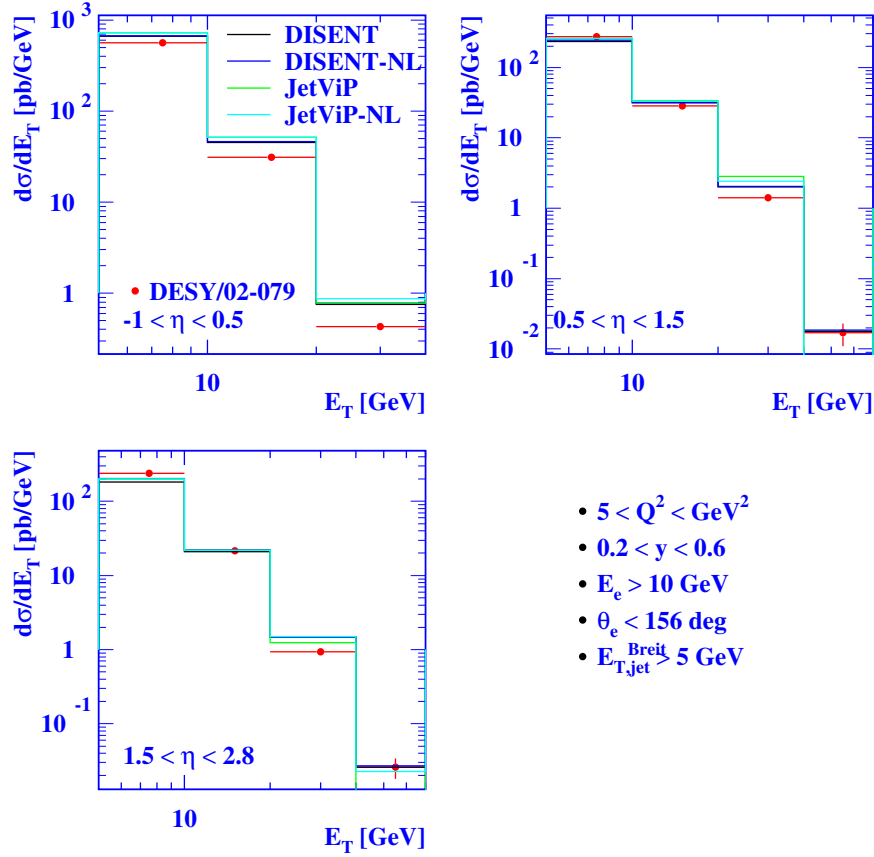


Fig. 3: Inclusive jet cross-sections as functions of E_T^{Breit} in different ranges of η^{lab} . The H1 data are compared to the different DISENT and JetViP predictions.

4.2 How to obtain the theoretical distributions

The NLOLIB calculations shown in this section have been obtained by running DISENT and JetViP via the HzTool interface in NLOLIB and using the HzTool routine for the H1 data analysis, hz02079.f. The steering files for the DISENT and JetViP job can be found in nlolib/steering and are called dis02079.t for DISENT and jv02079.t for JetViP. The command to run the DISENT job is thus (assuming the command is issued in the nlolib directory)

```
~ \nlolib > bin/hzttol < steering/dis02079.t
```

for JetViP the command is

```
~ \nlolib > bin/hzttol < steering/jv02079.t
```

In both cases a HBOOK file test.hbook is created that contains, in subdirectory 02079, the results of the calculation and the published H1 data points. A PAW macro epjets.kumac that creates the plots shown here will soon be available.

5 Summary

Some results with recently implemented higher order calculations have been shown, but clearly many items on our agenda unfortunately are still to be done.

For the implementation of JetViP into NLOLIB first, and most importantly, the e^+e^- mode has to be implemented and tested — so far only the ep mode has been done. Secondly, the resolved photon contribution has to be tested more thoroughly and the discrepancies between DISENT and JetViP in the pseudorapidity distributions need to be sorted out.

Concerning NLOJET++ a similar approach like for the other programs has to be set up and thoroughly tested in an all-program comparison, for example of event shapes or jet cross-sections in deep-inelastic scattering. Then, jet cross-sections in hadron-hadron collisions can be derived with NLOJET++. In addition, the use of PDFLIB will be replaced by LHAPDF [20].

Finally, the work on the implementation of more programs, for example FMNR or further proton–(anti)proton programs, needs to be followed up.

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