NTuples with BlackHat and Sherpa

The purpose of this tutorial is to generate Root NTuples which store NLO fixed-order events that can be reweighted in order to change scales and PDF's. The tutorial is composed of two parts:

- The production of NTuples
- The usage of existing NTuples in a Rivet analysis

Root NTuples are a convenient way to store the result of cumbersome fixed-order calculations in order to perform multiple analyses.

When using NTuples, one needs to bear in mind that every calculation involving jets in the final state is exclusive in the sense that a lower cutoff on the jet transverse momenta must be imposed. It is therefore necessary to check whether the event sample stored in the NTuple is sufficiently inclusive before using it. Similar remarks apply when photons are present in the NLO calculation or when cuts on leptons have been applied at generation level to increase efficiency. Every NTuple should therefore be accompanied by an appropriate documentation.

In this tutorial we will generate NTuples for the process

$$pp \to l\nu\, j$$

where $l \in \{e^+, e^-, \mu^+, \mu^-\}$ and $\nu \in \{\nu_e, \bar{\nu}_e, \nu_\mu, \bar{\nu}_\mu\}$. We identify parton-level jets using the anti-k_T algorithm with $R = 0.4$. We require the transverse momentum of these jets to be $p_{T,j} > 20$ GeV. No other cuts are applied at generation level.

The tutorial takes about one hour.

NTuple production

Source the environment file to set the appropriate paths

```
. /afs/cern.ch/project/theory/LPCC_MC_Workshop/tutorial2/env2.sh
```

Copy the necessary files from

```
/afs/cern.ch/project/theory/LPCC_MC_Workshop/tutorial2/setups/NTuples/
```

Start Sherpa using the command line

```
Sherpa -f Run.B-like.dat
```

Sherpa will first create source code for its matrix-element calculations. This process will stop with a message instructing you to compile. Do so by running

```
./makelibs -j4
```

Launch Sherpa again, using

```
Sherpa -f Run.B-like.dat
```

Sherpa will then compute the Born, virtual and integrated subtraction contribution to the NLO cross section and generate events. These events are analyzed using the Rivet library and stored in a Root NTuple file called `NTuple_B-like.root`. We will use this NTuple later to compute an NLO uncertainty band.

The real-emission contribution, including subtraction terms, to the NLO cross section is computed using

```
Sherpa -f Run.R-like.dat
```

Events are generated, analyzed by Rivet and stored in the Root NTuple file `NTuple_R-like.root`

The two analyses of events with Born-like and real-emission-like kinematics need to be merged using the following command

```
aidaadd Analysis/HTp/BVI.aida Analysis/HTp/RS.aida -o HTp.aida
```

The result can then be plotted and displayed

```
rivet-mkhtml HTp.aida
<your favourite browser> plots/index.html
```

Usage of NTuples in Sherpa

Next we will compute the NLO uncertainty band using Sherpa. To this end, we make use of the Root NTuples generated in the previous steps.

First we re-evaluate the events with the scale increased by a factor 2:

```
Sherpa -f Reweight.B-like.dat
Sherpa -f Reweight.R-like.dat
```

Then we re-evaluate the events with the scale decreased by a factor 2:

```
Sherpa -f Reweight.B-like.dat SCF:=0.25 -A Analysis/025HTp/BVI
Sherpa -f Reweight.R-like.dat SCF:=0.25 -A Analysis/025HTp/RS
```

The two contributions are combined using

```
aidaadd Analysis/4HTp/BVI.aida Analysis/4HTp/RS.aida -o 4HTp.aida
aidaadd Analysis/025HTp/BVI.aida Analysis/025HTp/RS.aida -o 025HTp.aida
```

Now we can display all three analyses on the same plots

```
rivet-mkhtml HTp.aida:Title=1 4HTp.aida:Title=4 025HTp.aida:Title=0.25
```