1 Input parameters

W-boson production at Tevatron Run II (LHC) for a centre of mass energy of 1.96 (14) TeV is considered. The PDF set used for all analyses is cteq6l. The value of α_S is chosen according to the value taken for the PDF, namely 0.118. For the running of the strong coupling the corresponding two-loop equation is used. Jets or initial partons are restricted to the light flavor sector, namely g, u, d, s, c. In fact these flavors are taken to be massless and the Yukawa couplings of the quarks are neglected throughout the entire analysis.

1.1 SM input parameters

The SM parameters are given in the G_μ scheme:

$$\begin{aligned} &m_W = 80.419 \text{ GeV}\,, \quad \Gamma_W = 2.048 \text{ GeV},\\ &m_Z = 91.188 \text{ GeV}\,, \quad \Gamma_Z = 2.446 \text{ GeV},\\ &G_\mu = 1.16639 \times 10^{-5} \text{ GeV}^{-2},\\ &\sin^2\theta_W = 1 - m_W^2/m_Z^2,\\ &\alpha_s = 0.118 \end{aligned} \tag{1}$$

The electromagnetic coupling is derived from the Fermi constant G_μ according to

$$\alpha_{\rm em} = \frac{\sqrt{2}\, G_\mu\, M_W^2\, \sin^2\theta_W}{\pi}. \tag{2}$$

The constant widths of the electroweak gauge bosons are introduced via the fixed-width scheme. CKM mixing of the quark generations is neglected.

2 The Tevatron case

We consider the production of $W^\pm$-bosons at $\sqrt{s} = 1960$ GeV.

2.1 Cuts and jet criteria

For the jet definition a cone size of $R = 0.7$ is used in addition to cuts on pseudorapidity and transverse momentum,

$$p_T^{\rm jet} > 10 \text{ GeV}, \quad |\eta^{\rm jet}| < 2. \tag{3}$$

The parameters relevant to define the GETJET routine are:

`NCY=50, YCMIN=-2.5D0, YCMAX=2.5D0, NCPHI=60.`

2.2 Observables

The data corresponding to each of the observables will be stored in individual files, whose names are given below. The format of each row of each file should be

$$X \quad Y \quad Z \tag{4}$$

where X is the central value of the bin, Y the rate, and Z is a dummy entry (which could contain, e.g., the estimated error if available). In the following we specify the normalization for each observable. For plots normalized to 1, it is understood that the sum of the entries (i.e. of the Y values) should be equal to 1/`bin size`, for the specified bin size. For plots normalized to pb/bin, the sum of the entries should coincide with the cross section.

2.2.1 Lepton and jet observables

- Jet p_T, in the range $[10, 250]$ GeV, bins of 5 GeV, normalization: pb/bin. File names: `jets_pt_i`, i=1,. . . ,4.
- Jet η, in the range $[-2, 2]$, bins of 0.2, normalization: pb/bin. File names: `jets_eta_i.dat`, i=1,. . . ,4.
- Jet η for $p_T^{\rm jet} > 50$ GeV, in the range $[-2, 2]$, bins of 0.2, normalization: pb/bin. File names: `jets_heta_i.dat`, i=1,. . . ,4.
- p_T of the W, in the range $[0, 250]$ GeV, bins of 5 GeV, normalization: pb/bin. File names: `wpt.dat`.
- p_T of the W, in the range $[0, 50]$ GeV, bins of 0.5 GeV, normalization: pb/bin. File names: `lowwpt.dat`.
- The Zeppenfeld variable (with η_i the η of the $i^{\rm th}$ hardest jet)

$$\eta^* = \eta_3 - \frac{\eta_1 + \eta_2}{2} \tag{5}$$

  for $|\eta_1 - \eta_2| > 2.0$ and $\eta_1 < \eta_3 < \eta_2$ or $\eta_2 < \eta_3 < \eta_1$, in the range $[-2, 2]$, bins of 0.2, normalization: pb/bin. File names: `etaZ.dat`.
- For $p_T^{\rm jet1} > 30$ GeV, 40 GeV, and 50 GeV
  - $|\eta_W - \eta_{\rm jet1}|$, in the range $[0, 5]$, bins of 0.25, normalization: 1. File names: `deta_W_jet1_X.dat`, X=30, 40, 50.
- For E_T jet pairings $[ij]$=[12],[13],[14],[23],[24],[34]:
  - $|\eta_i - \eta_j|$, in the range $[0, 4]$, bins of 0.2. File names: `jets_deta_ij.dat`.
  - $|\phi_i - \phi_j|$, in the range $[0, \pi]$, 20 bins. File names: `jets_dphi_ij.dat`.
  - ΔR_{ij}, in the range $[0, 5]$, bins of 0.2. File names: `jets_dR_ij.dat`.

    normalization: 1 for all distributions
- For $[ij]$=[12]:
  - $|\eta_i - \eta_j|$, in the range $[0, 4]$, bin size 0.2
  - $|\phi_i - \phi_j|$, in the range $[0, \pi]$, 20 bins
  - ΔR_{ij}, in the range $[0, 5]$, bins of 0.2

    each of the above distributions for:
    - $40\,{\rm GeV} < p_T^{\rm jet1} < 80\,{\rm GeV}$. File names: `jets40_80_dX_12.dat`;
    - $80\,{\rm GeV} < p_T^{\rm jet1} < 150\,{\rm GeV}$. File names: `jets80_150_dX_12.dat`;
    - $p_T^{\rm jet1} > 150\,{\rm GeV}$. File names: `jets150_dX_12.dat`;

    where `X=eta, phi, R`, respectively.

    normalization: 1 for all distributions
- $H_T = E_T^{\rm miss} + p_T^{\rm lep} + \sum p_T^{\rm jet}$, in the range $[0, 600]$, bins of 10 GeV, normalization: pb/bin. File names: `ht.dat`.
- $k_\perp$-jet rates according to the Run II $k_\perp$-algorithm (arXiv:hep-ex/0005012) with $D = 1$ and only partons with $|\eta| < 2.5$ included. Plots should be provided for the parton and the hadron level.

- $k_\perp$-jet differential distributions ($0 \to 1$, $1 \to 2$, $2 \to 3$), in the range $[0, 250]$ GeV, bins of 2.5 GeV, normalization: 1. File names: `jets_X_dN.dat`, where `X=had,par` and `N=1,2,3`.
- $k_\perp$-jet differential distributions ($0 \to 1$, $1 \to 2$, $2 \to 3$), in the range $[1, 250]$ GeV, plot vs $\log_{10}(p_T)$, 50 bins, normalization: 1. File names: `jets_X_dN_log.dat`, where `X=had,par` and `N=1,2,3`.

2.2.2 The internal jet structure (skipped for this round)

- E_T profile for the four hardest E_T jets :
  $\mathrm{d}E_T/\mathrm{d}R$, in the range $R = [0, 0.7]$, bins of 0.05, and $E_T^{\mathrm{jet}} > 10$, 20, 50 GeV (yields three plots per jet, the center of the cones is defined by the jet-vector as reconstructed by the GETJET routine). File names: `jetsET_detdr_N, ET=10, 20, 50` and `N=1,...,4`.
- Total n-jet rates ($n = 0, 1, 2, 3, 4$) vs. R:
  $\sigma_{n-\mathrm{jet}}(R)/\sigma$, for $R = [0.4, 1.0]$, bins of 0.1, for $E_T^{\mathrm{jet}} > 10$, 20, 50 GeV. `jetsET_sigR_sig_N, ET=10, 20, 50` and `N=1,...,4`.

2.3 Study of systematics

Aim is to give an uncertainty band for each approach. There are two steps to do:

- Variation of the matching scale, i.e. the matrix element generation cut, from 10 GeV, 20 GeV to 50 GeV.
- Try to give an estimate of the uncertainty native to each approach, this is a code specific issue.
  - Alpgen, multiply the scales in the α_S reweighting of the matrix elements by factors of 0.5 and 2.
  - Sherpa, vary scales in the α_S reweighting of the matrix elements and in the parton shower using common factors of 0.5 and 2.
  - Ariadne, change the initial state radiation suppression factors μ and α.

For all the different settings plot the differential $k_\perp$-jet rates and the inclusive jet spectra both with the binning agreed on.

3 The LHC case

We consider the production of a W^+-bosons at $\sqrt{s} = 14$ TeV.

3.1 Cuts and jet criteria

For the jet definition a cone size of $R = 0.4$ is used in addition to cuts on pseudorapidity and transverse momentum,

$$p_T^{\mathrm{jet}} > 20\ \mathrm{GeV}, \quad |\eta^{\mathrm{jet}}| < 4.5 \tag{6}$$

The parameters relevant to define the GETJET routine are:

```
NCY=100, YCMIN=-5D0, YCMAX=5D0, NCPHI=60.
```

3.2 Observables

The file names for the observables defined below match those used for teh Tevatron, possibly adjusting the different E_T cut labels.

3.2.1 Lepton and jet observables

- Jet p_T, in the range $[20, 500]$ GeV, bins of 5 GeV, normalization: pb/bin
- Jet η, in the range $[-4.5, 4.5]$, bins of 0.2, normalization: pb/bin
- Jet η for $p_T^{\text{jet}} > 100$ GeV, in the range $[-4.5, 4.5]$, bins of 0.2, normalization: pb/bin
- p_T of the W, in the range $[0, 500]$ GeV, bins of 5 GeV, normalization: pb/bin
- p_T of the W, in the range $[0, 50]$ GeV, bins of 0.5 GeV, normalization: pb/bin
- The Zeppenfeld variable (with η_i the η of the i^{th} hardest jet)

$$\eta^* = \eta_3 - \frac{\eta_1 + \eta_2}{2} \tag{7}$$

  for $|\eta_1 - \eta_2| > 4.5$ and $\eta_1 < \eta_3 < \eta_2$ or $\eta_2 < \eta_3 < \eta_1$, in the range $[-4.5, 4.5]$, bins of 0.2, normalization: pb/bin.

- For $p_T^{\text{jet1}} > 40$ GeV, 50 GeV, and 60 GeV.
  - $|\eta_W - \eta_{\text{jet1}}|$, in the range $[0, 9]$, bins of 0.25, normalization: 1
- For E_T jet pairings $[ij]$=[12],[13],[14],[23],[24],[34]:
  - $|\eta_i - \eta_j|$, in the range $[0, 9]$, bins of 0.2
  - $|\phi_i - \phi_j|$, in the range $[0, \pi]$, 20 bins
  - ΔR_{ij}, in the range $[0, 5]$, bins of 0.2

    normalization: 1 for all distributions
- For $[ij]$=[12]:
  - $|\eta_i - \eta_j|$, in the range $[0, 9]$, bin size 0.2
  - $|\phi_i - \phi_j|$, in the range $[0, \pi]$, 20 bins
  - ΔR_{ij}, in the range $[0, 5]$, bins of 0.2

    each of the above distributions for:
    * $40\,\text{GeV} < p_T^{\text{jet1}} < 80\,\text{GeV}$
    * $80\,\text{GeV} < p_T^{\text{jet1}} < 150\,\text{GeV}$
    * $p_T^{\text{jet1}} > 150\,\text{GeV}$

    normalization: 1 for all distributions
- $H_T = E_T^{\text{miss}} + p_T^{\text{lep}} + \sum p_T^{\text{jet}}$, in the range $[0, 1000]$, bins of 10 GeV, normalization: pb/bin
- $k_\perp$-jet rates according to the Run II $k_\perp$-algorithm (arXiv:hep-ex/0005012) with $D = 1$ and only partons with $|\eta| < 5$ included. Plots should be provided for the parton and the hadron level.
  - $k_\perp$-jet differential distributions ($0 \to 1$, $1 \to 2$, $2 \to 3$), in the range $[0, 500]$ GeV, bins of 2.5 GeV, normalization: 1
  - $k_\perp$-jet differential distributions ($0 \to 1$, $1 \to 2$, $2 \to 3$), in the range $[1, 500]$ GeV, plot vs $\log_{10}(p_T)$, 100 bins, normalization: 1

3.2.2 The internal jet structure (skipped for this round)

- E_T profile for the four hardest E_T jets:
  $\mathrm{d}E_T/\mathrm{d}R$, in the range $R = [0, 0.4]$, bins of 0.05, and $E_T^{\mathrm{jet}} > 20$, 50, 100 GeV (yields three plots per jet, the center of the cones is defined by the jet-vector as reconstructed by the GETJET routine)
- Total n-jet rates ($n = 0, 1, 2, 3, 4$) vs. R:
  $\sigma_{n-\mathrm{jet}}(R)/\sigma$, for $R = [0.2, 1.0]$, bins of 0.1, for $E_T^{\mathrm{jet}} > 20$, 50, 100 GeV

3.3 Study of systematics

- Vary the matching scale from 15 GeV, 20 GeV, 30 GeV to 60 GeV.
- Try to give an estimate of the uncertainty native to each approach, this is a code specific issue.
  - Alpgen, multiply the scales in the α_S reweighting of the matrix elements by factors of 0.5 and 2.
  - Sherpa, vary scales in the α_S reweighting of the matrix elements and in the parton shower using common factors of 0.5 and 2.
  - Ariadne, change the initial state radiation suppression factors μ and α.

For all the different settings plot the differential $k_\perp$-jet rates and the inclusive jet spectra both with the binning agreed on.