Next-to-Leading Order Calculations

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NLO parton level Monto-Carlo program

- Need to include both virtual corrections and real emission contributions.

- To describe fully differential distributions, we need to define "infrared-safe" observables.

- NLO parton level Monto-Carlo program. For example:
  - MCFM (mcfm.fnal.gov/)
    - It uses exact matrix element calculations up to NLO.

Project 4

Consider the production and decay of W-boson at the Tevatron Run-2, a proton-antiproton collider with center-of-mass energy 1.96 TeV, via

$$p\bar{p} \to W^+ X \to e^+ \nu_e X.$$

1. Use MCFM to calculate the following distributions at the leading order:

   $$P_T(W^+), \quad y(W^+), \quad P_T(e^+), \quad y(e^+), \quad \not{E}_T,$$

   where P_T denotes transverse momentum, y rapidity, and $\not{E}_T$ missing transverse energy.

2. Repeat the above calculation at the NLO with QCD corrections. (This is to calculate the inclusive production of W-boson.)

3. Discuss the qualitative difference in the results of the above two calculations.

Monto-Carlo Event Generators

- To effectively simulate full event signature at the particle (not just parton) level.

- It includes effects from both perturbative and non-perturbative physics.

- For example:
  - PYTHIA (home.thep.lu.se/~torbjorn/Pythia.html)
    www-cdf.fnal.gov/physics/lectures/pythia_Dec2004.htm
  - HERWIG (hepwww.rl.ac.uk/theory/seymour/herwig/)
    www.phys.psu.edu/~cteq/schools/summer00/seymour/

Project 5

Consider the production and decay of W-boson at the Tevatron Run-2, a proton-antiproton collider with center-of-mass energy 1.96 TeV, via

$$p\bar{p} \to W^+X \to e^+\nu_e X.$$

1. Use PYTHIA or HERWIG to calculate the following distributions without turning on either initial state or final state radiation (showering):

   $$P_T(W^+), \quad y(W^+), \quad P_T(e^+), \quad y(e^+), \quad \not{E}_T,$$

   where P_T denotes transverse momentum, y rapidity, and $\not{E}_T$ missing transverse energy.

2. Repeat the above calculation with both the initial and final state showering turned on.

3. Discuss the qualitative difference in the results of the above two calculations with those obtained in MCFM calculations (as done in Project 4).

4. Does the result of above calculation depend on whether the hadronization is turned on or not in the PYTHIA/HERWIG program?