Studying Jet Cross Section Measurements of ATLAS Experiment

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Introduction

- \( p^+ - p^+ \) collisions with CM energy of 13 TeV.

- Jets are sprays of hadrons and their interaction is governed by the strong force and described by QCD.

- Initiated by a parton (quarks and gluons) that radiates other partons and produces a quark and gluon shower that then turns into hadrons observed in detectors.

- Focus on jet production
  - Study QCD predictions
  - Search for new physics
  - Study partonic structure of proton

- Frequently produced and complex
  - Secondary parton interactions (Underlying event)
  - Multiple proton interactions (Pileup)
  - Top quark, W/Z/H bosons produced (EW resonances)
Introduction

- Cross section is probability that an interaction occurs.
  - Measured experimentally
  - Calculated theoretically
- Calculation in perturbative QCD:
  \[ \sigma = \sum \alpha_s(Q^2) \int dx_1 \, dx_2 \, dQ^2 \, ME(x_1, x_2, Q^2) \, f_{q/p}(x_1, Q^2) \, f_{q/p}(x_2, Q^2) \]
  - \( \alpha_s \) is the strong coupling constant
  - \( x_1 \) and \( x_2 \) are momentum fractions of each \( p^+ \)
  - \( Q^2 \) is the transverse momentum transfer squared
  - \( f_{q/p}(x_1, Q^2) \) and \( f_{q/p}(x_2, Q^2) \) is the probability to find a parton in each \( p^+ \) (PDF)
  - ME\((x_1, x_2, Q^2)\) is the matrix element which describes the hard scattering process

- Types of interactions
  - Leading Order (LO): 2 – 2
  - Next to Leading Order (NLO): 2 – 3
  - Next to Next to Leading Order (NNLO): 2 - 4
We want to use a program to calculate ME and store the values in a lookup table for the scientific community.

- Compare theoretical cross section with experimental cross section values.

- Fix ME values so that only the PDFs values \((f_{q/p}(x_1,Q^2) f_{q/p}(x_2,Q^2))\) and the \(\alpha_s\) are altered to agree with theory.

- Check if this approach works by comparing (for the same \(\alpha_s\) and \((f_{q/p}(x_1,Q^2) f_{q/p}(x_2,Q^2))\) cross section results when using the lookup table and without using it.
Project Details

- NLO QCD calculation: 1992
  NLOJET program: 2002
- NNLO QCD calculation: 2018
  NNLOJET program: Not available for public
- NNLOJET generates events and calculates cross section.
  - Warmup: Generates boundaries
  - Grid: Creates a grid for each $p_T$ bin defined and generates random events.
  - Production: Optimizes the boundaries depending on the events generated to give non-empty grids.
- Variables: Interaction type (LO, NLO, NNLO), Number of events, Seed number and dijets/inclusive jets, among others.
- Calculations are different for dijets (fill grids per events) and inclusive jets (fill grids per jet).
- Takes a long time
  - 8 hours for dijets (NLO): 700,000 events
  - 8 hours for inclusive jets (NLO): 1,600,000 events
Set up NNLOJET with the help of Mark Sutton and learned to run the program, change runcards and plot results.

Ran NNLOJET for all interactions (dijet) with little statistics.

Adapted runcards to run NNLOJET for inclusive jets.

Learned about bash programing and Python and am writing a program to run NNLOJET without manually changing runcards.

Tasks:
- Run NNLOJET for dijets with more statistics
- Run NNLOJET for inclusive jets with more statistics
- Compare NNLOJET results with lookup table calculations
- Compare NNLOJET and NLOJET
- Use CIJET to calculate NLO CI contributions

Final goal: produce NNLO lookup table for published jet cross section for scientific community.
Other Activities

- Joined CERN’s Boxing Club
- Gym
- Geneva’s Natural History Museum
- Geneva’s Art History Museum
- Old Geneva (saw light show)
- Jet d’Eau
- Barcelona
- UN
Thank you!