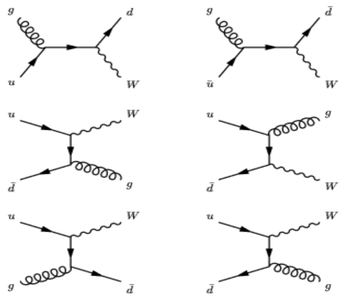
Test of enhanced leading order QCD in W plus jets events from 2 TeV $p\bar{p}$ collisions

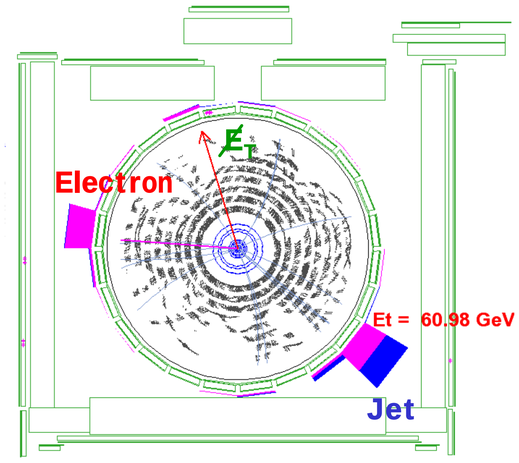
1. Introduction

The production of W bosons in $p\bar{p}$ collisions at the Fermilab Tevatron collider provides the opportunity to test perturbative QCD at large momentum transfers.
A sample of 31,726 W candidates collected from 72 pb^{-1} of accumulated data is used to study the kinematic properties and the production rates of high energy hadronic jets in association with W bosons.



The jets are the manifestation of high-energy partons (quarks and gluons) after the hard collision. The figure shows some of the leading-order processes which produce a W boson and a jet.
The electroweak decay W → eν of the W boson gives an efficient identification of W candidates with low background contamination. This channel provides sufficient statistics to study the QCD production characteristics for W + ≥ 0 to ≥ 4 jets event samples.
Besides the relevance of testing perturbative QCD al large momentum transfers, these processes are among the preeminent search channels in very high energy particle collisions. Within the Standard Model (SM), the top quark was discovered and its mass measured in the W + ≥ 3 jets with at least one jet identified as a b-jet. The W + 2 jets, with both jets identified as b-jet, is used to search for the Higgs boson and single top production. The W + jets channels is also relevant in many SM extensions which predict new particles decaying into W boson accompanied by jets.
Precise understanding of the W + n jets channels is then particularly important for many high-P_T physics analyses.

2. Event Selection



Luminosity : 72 pb^{-1} (Mar.2002 ~ Jan.2003)

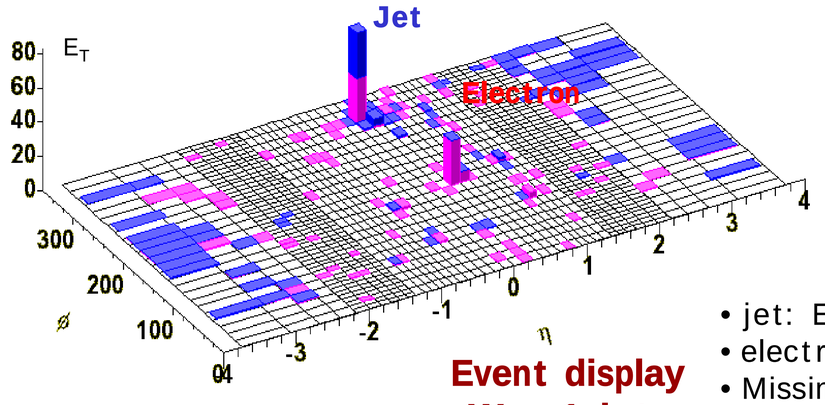
Trigger Path : High E_T Electron Trigger, E_T > 18 GeV

Kinematic : Ele E_T > 20 GeV, P_T > 10 GeV; $\not\!\!E_T$ > 30 GeV

Geometric : |η| < 1.1 & fiducial

Identification : Had/Em < 0.055, E/P < 2, Isolation < 0.1, tower-track matching, shower profile, conversion veto

W candidates : 31,726 events



Jet Selection

Cone jet algorithm (JETCLU)
Jet fully corrected:
- relative & absolute energy scale
- out of cone & underlying event

E_T > 15 GeV ,|η| < 2.4, R_{cone} = 0.4

- jet: E_T = 91 GeV, η = 0.1 , φ = 5.54
- electron E_T = 31.8 GeV, η = 0.45 , φ = 3.07
- Missing E_T E_T = 53 GeV, φ = 1.94
- W transverse mass = 87.2 GeV

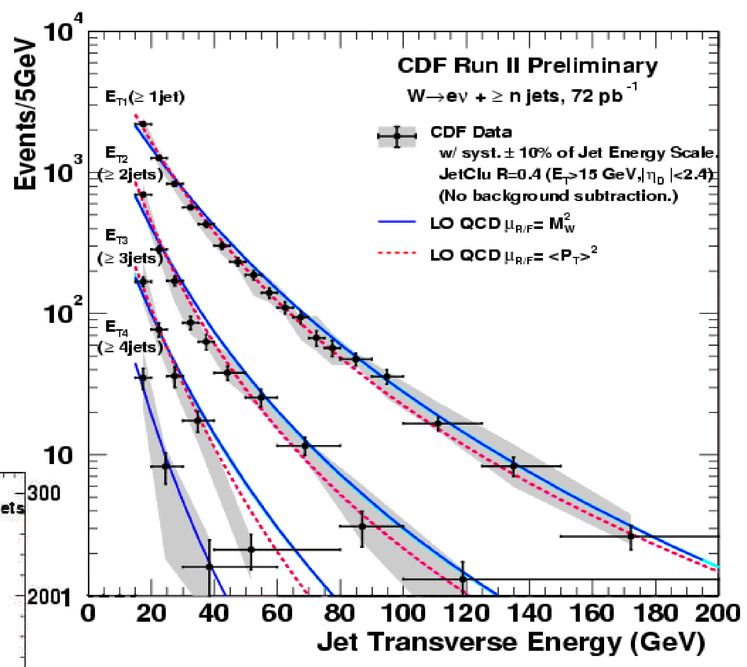
3. Kinematic Distributions

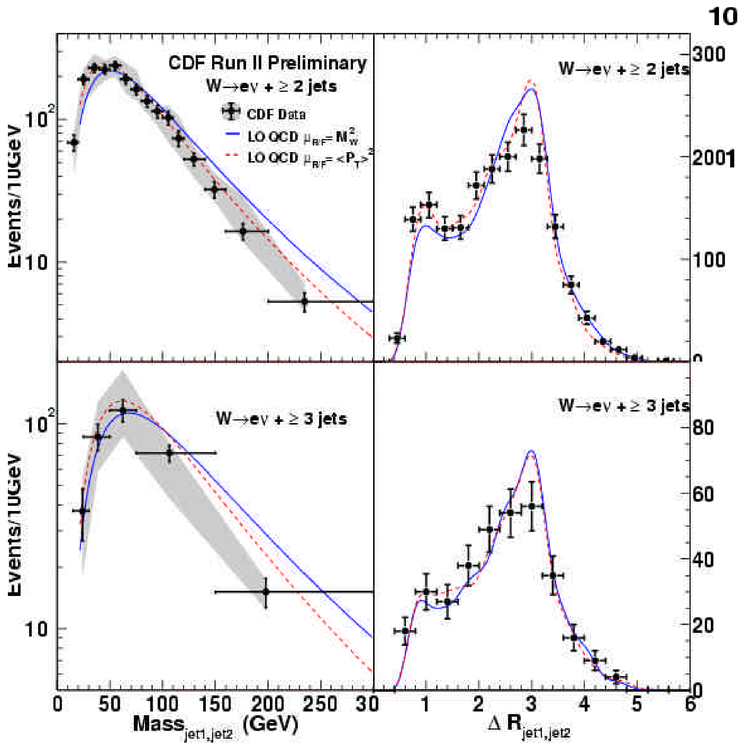
Theory:

- GR@PPA & ALPGEN LO calculation interfaced with the HERWIG shower Monte Carlo
- full detector simulation to include efficiency and acceptance effects
- theory distributions normalized to the total number of events in the data and fitted with an analytic function
- two different renormalization scales: M_W^2 (static), $\langle P_T \rangle^2$ (dynamic)

Jet E_t Distribution

- the highest E_T jet in W + ≥ 1 jet
- the second highest E_T jet in W + ≥ 2 jets
- the third highest E_T jet in W + ≥ 3 jets
- the fourth highest E_T jet in W + ≥ 4 jets





Dijet Mass and ΔR Distributions

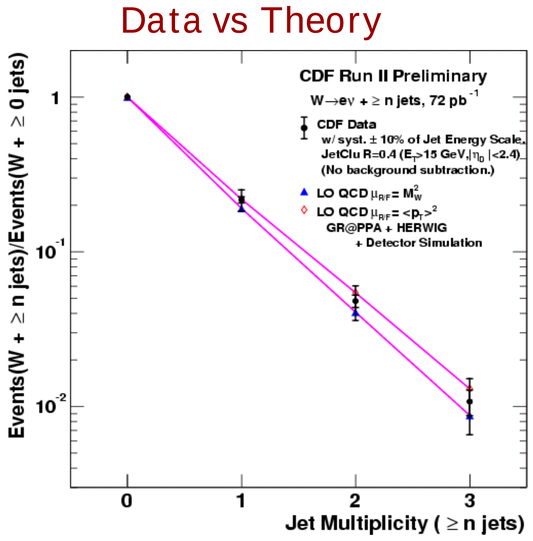
The plots on the left show the distribution for the invariant mass of the two highest E_T jets in W + ≥ 2 jet events (top), and W + ≥ 3 jet (bottom). The plots on the right show the separation in η-φ space for the same jets used on the left side distributions.

4. Fraction of Jets

Parton – Jet Matching:

- defined as "each jet generated by one and only one parton"
- reduced dependence on the generation cuts: P_T & ΔR
- partial reduction of the "double counting problem"

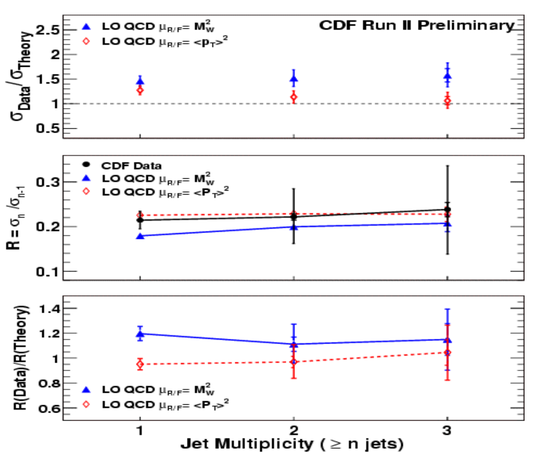
Data vs Theory



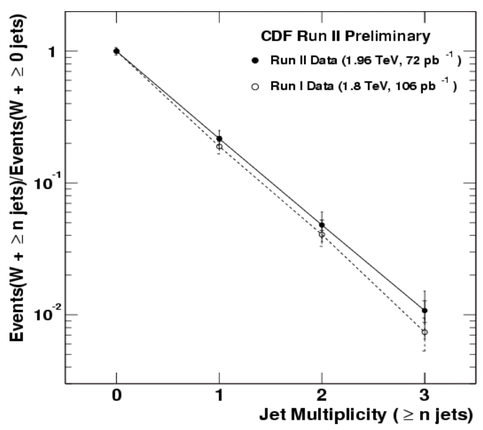
Good agreement data and theory

Ratio of Jet Multiplicity

- some systematics cancel out
- data/theory ~ constant
- n/n-1 ~ 0.2 ⇨ σ drops by a factor ~ 5 for each additional jet



Run II vs Run I



Run II higher jets activity

5. Conclusion

- The LO QCD predictions have been compared to CDF Run II Data
- Theory well reproduce the kinematic behavior of W + ≥ n jet
- The large q^2 dependence indicates the importance of high order corrections

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Andrea Messina – for the CDF Run II Collaboration
University of Rome "La Sapienza" & INFN Sezione di Roma