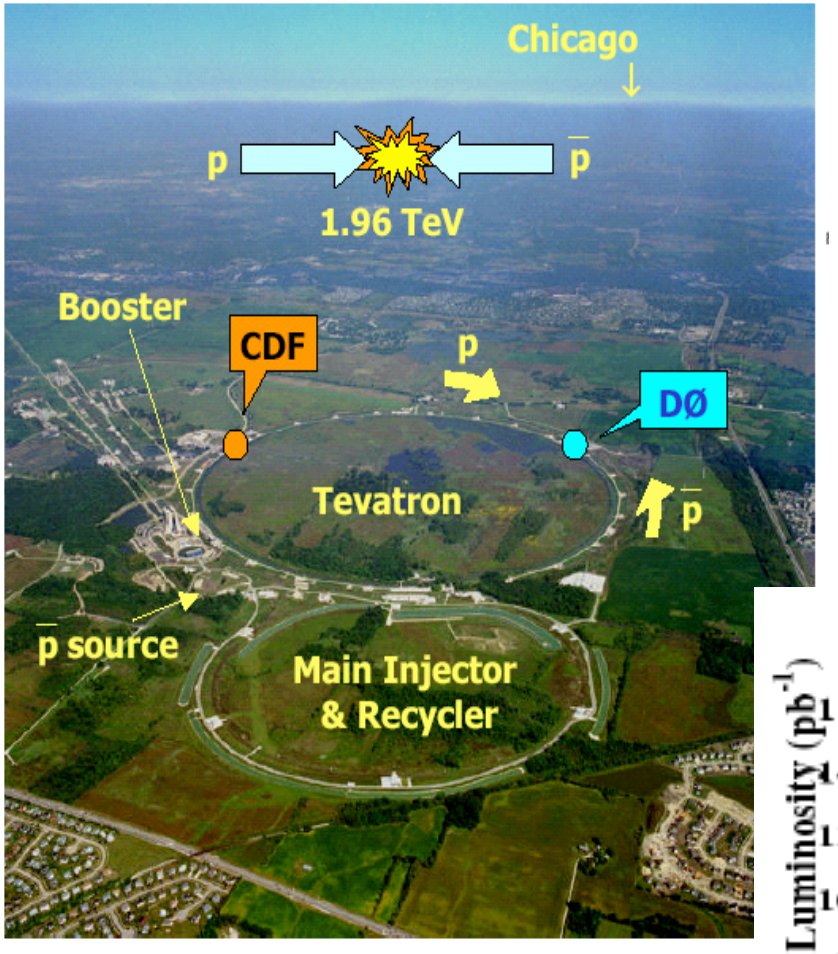
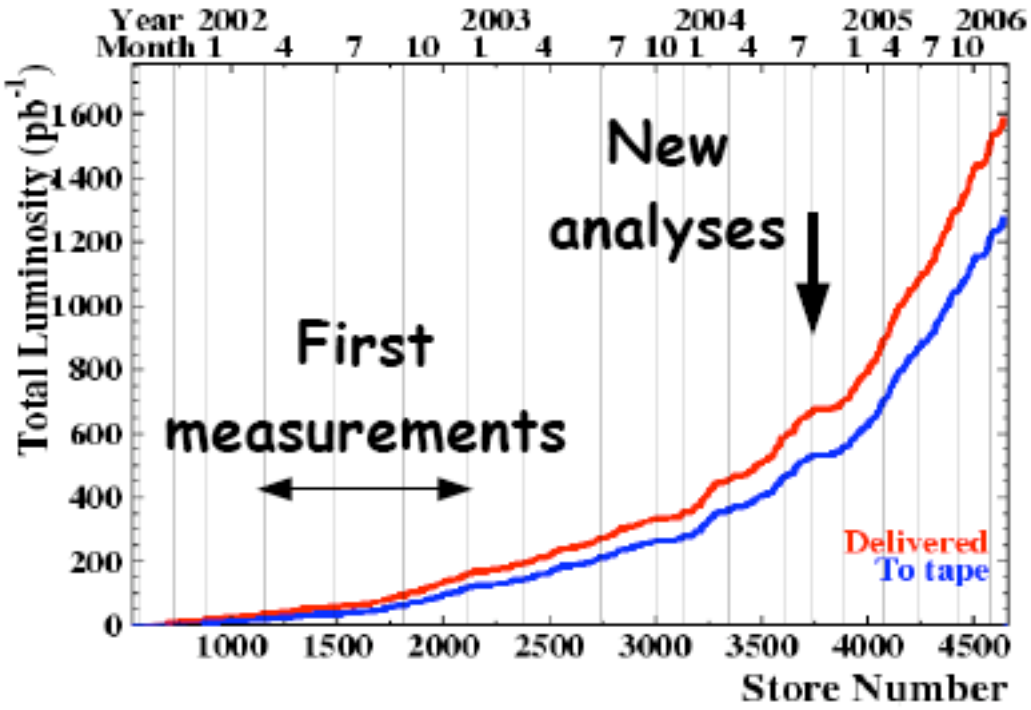
Utilizzo dei generatori ME per l'analisi: confronto con i dati del Tevatron

Andrea Messina
INFN - Roma

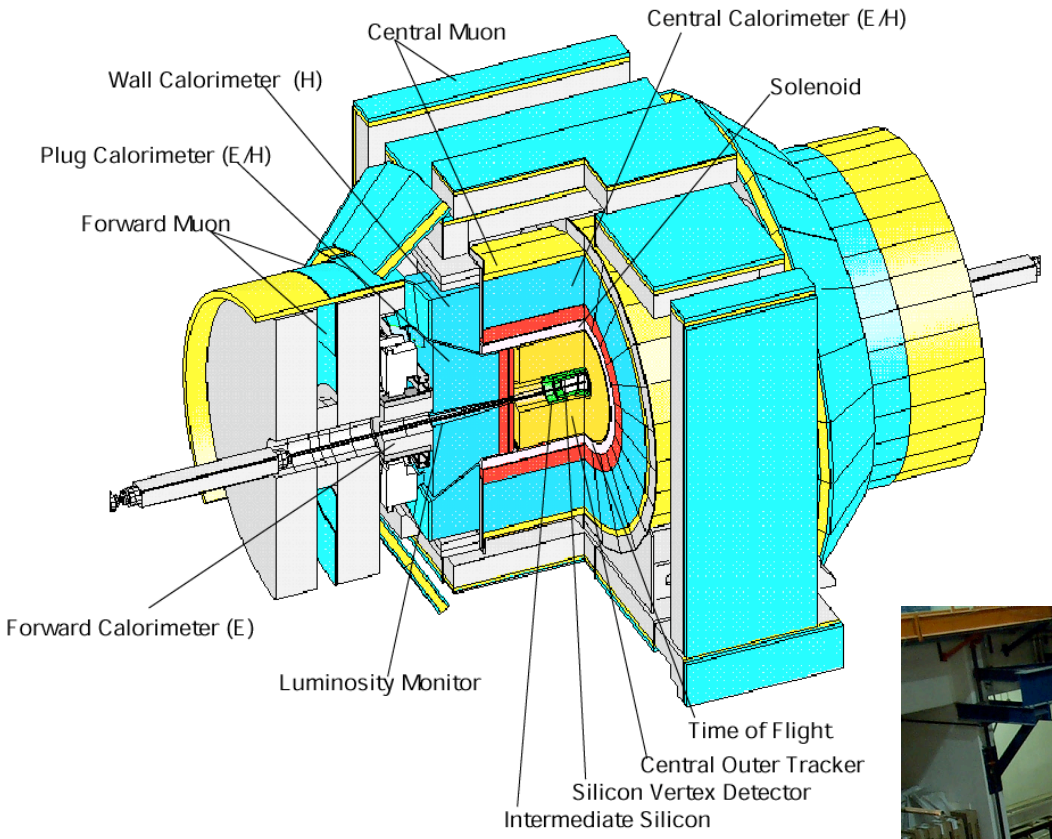
Workshop sui Monte Carlo, la fisica e la simulazione di LHC
Frascati, 27-28 Febbraio 2006



- Proton-Antiproton collisions
- sqrt(s) = 1.96 TeV
- 36 bunches: 396 ns crossing time
- Peak luminosity 2 x $10^{32}cm^{-2}s^{-1}$

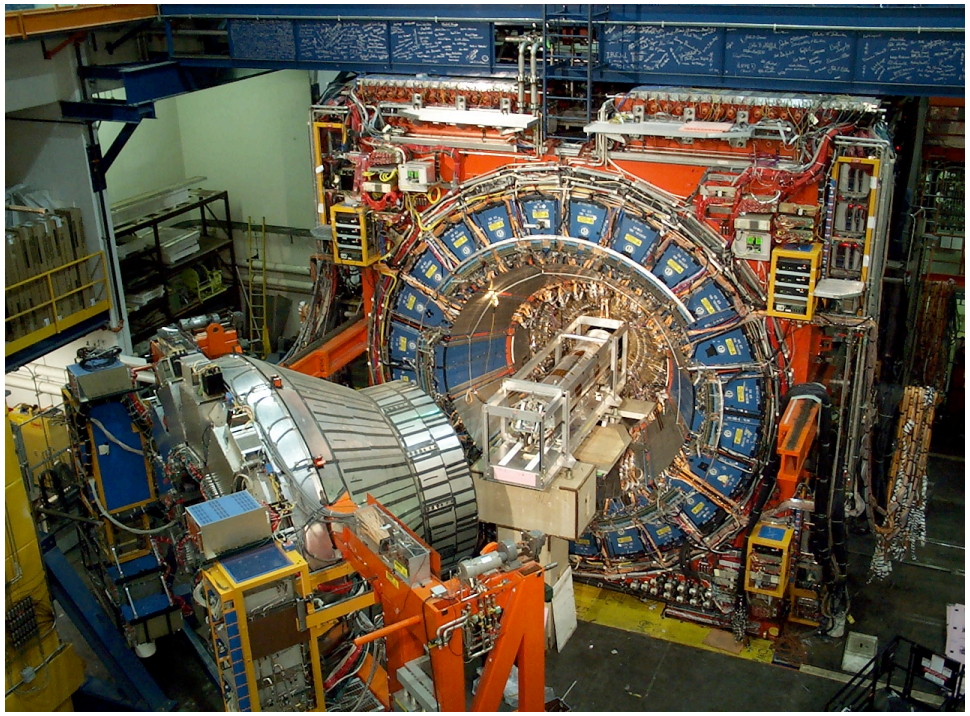


- 1.3 fb^{-1} per experiment on tap
- 1.6 fb^{-1} delivered luminosity



Run II upgrades

- New silicon tracking
- New drift chamber
- Upgraded muon chambers
- New plug calorimeters
- New TOF



Data taking efficiency > 85 %

More than 1 fb^{-1} on tape

Introduction

Larger data sample than ever

Measurements start being dominated by systematic errors

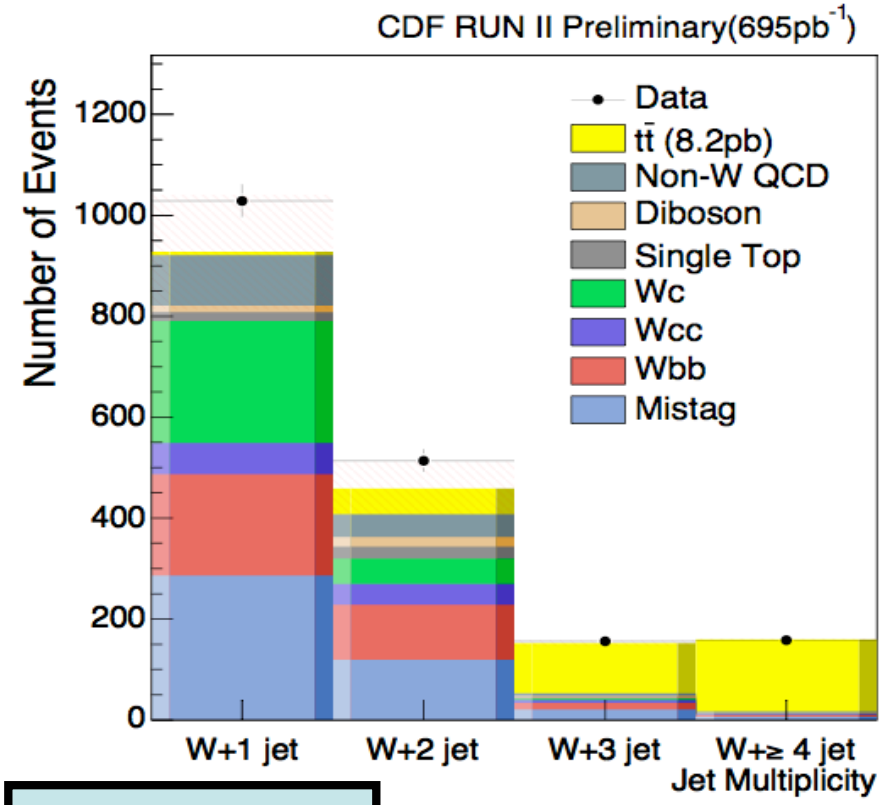
For high p_T physics is crucial to have under control the backgrounds and the Monte Carlo tools for signal & backgrounds modeling

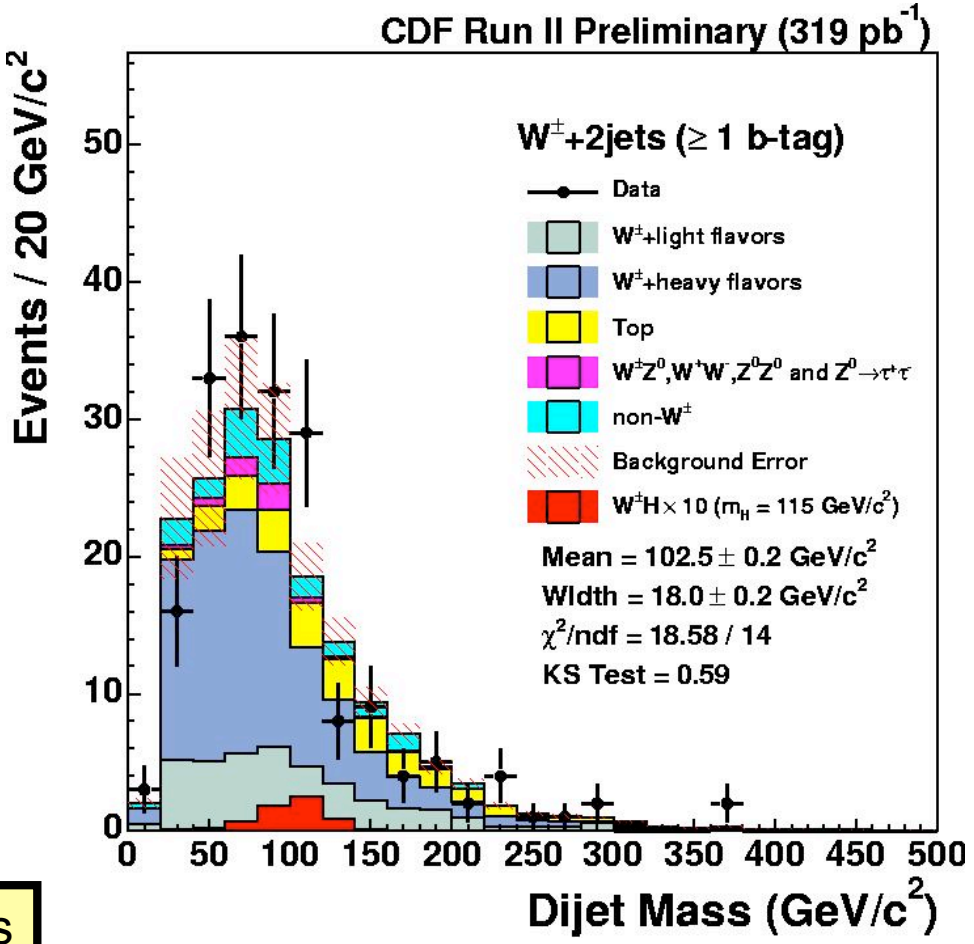
A key process: boson+jets

- Testing ground for pQCD in multijet environment
  - Presence of the boson ensures high Q^2 - pQCD
  - Key sample to test latest LO and NLO ME and parton showering predictions
  - Many MC models now available; ALPGEN, CKKW, MCFM, MC@NLO without stringent validation on data

- Main background to a number of high P_T analyses; precision Top measurement, Higgs searches.
  - Always reliant on MC description of W+Jets

As an example Top & Higgs





Background

Wbb,Wcc,Wc

- HF frac from MC
- Normalized to W+jets data

W+light (mistags)

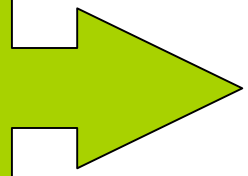
- Mistag from jet sample
- Applied to W+jets data

Systematics

B-Tagging: 5.2%
Lepton Isolation: 5%
W+Heavy Flavor: 4.4%
Luminosity: 5.9%
Total: 11%

The systematic on the top measurement and the sensitivity to new physics receives a substantial contribution from the background knowledge

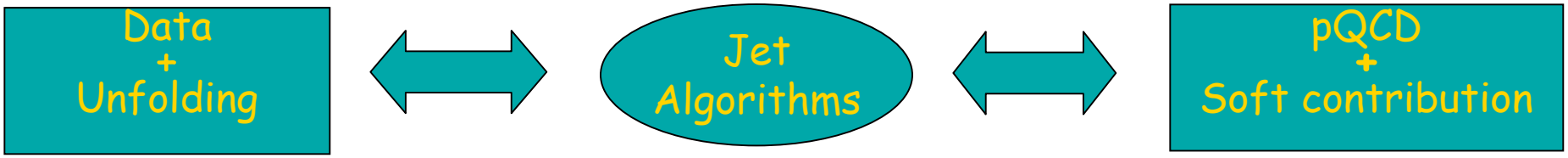
How do we plan to improve the W + jets background Knowledge.



Use available data

Jets:

The meeting point between measurements and pQCD



A jet is a composite object:

Complex detector properties
- non-linear detector properties
- non-instrumented regions

Correct to particle level
- pile up
- detector efficiency/resolution

Complex underlying physics
- events contain spectator interaction
- processes connected via color
- hadron fragmentation
- different type of jets: q, g, b/c

Model dep. correction
- underlying event
- parent parton energy

Jets energy correction:

Correction for detector effects:

- Tune the detector simulation on the real calorimeter

  ⇒ response to individual particle: type momentum direction

- Simulate jet using a jet fragmentation model

  ⇒ particle composition, momentum and multiplicity distribution in a jet

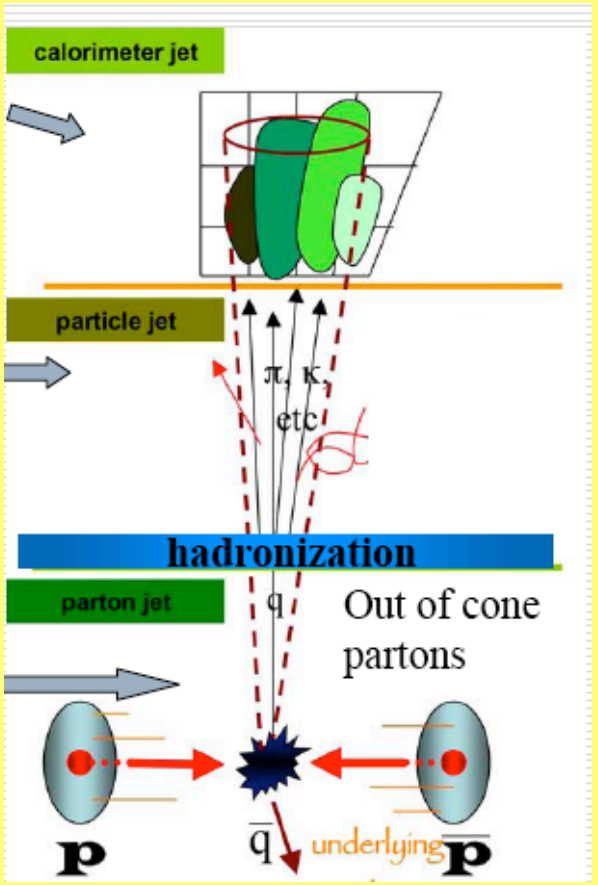
- Run them through detector simulation

- Cluster particle (particle jet) & calorimeter tower (calorimeter jet), use P_T correlation for correction

Correction for physics effects:

- tune MC generator to data in the "transvese region" (sensitive to the underlying event)

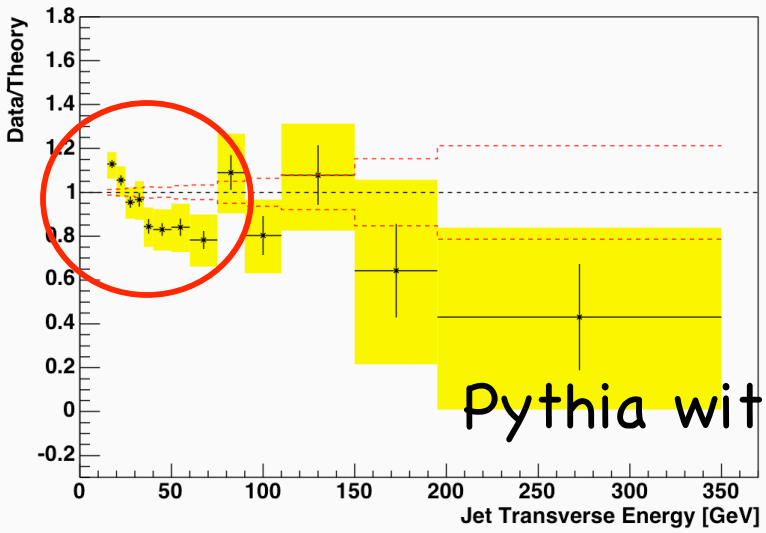
- correlate P_T of the particle jet and its parent parton in the tune MC generator

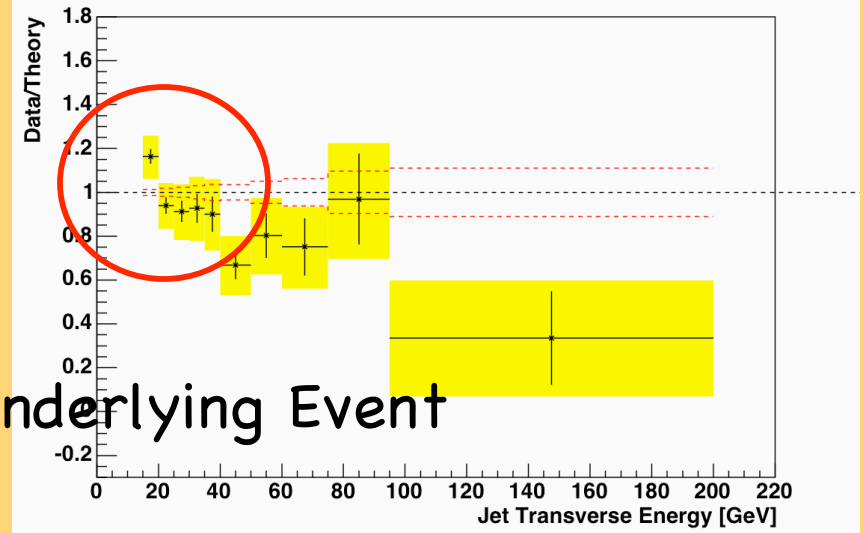


Effect of the Underlying event:

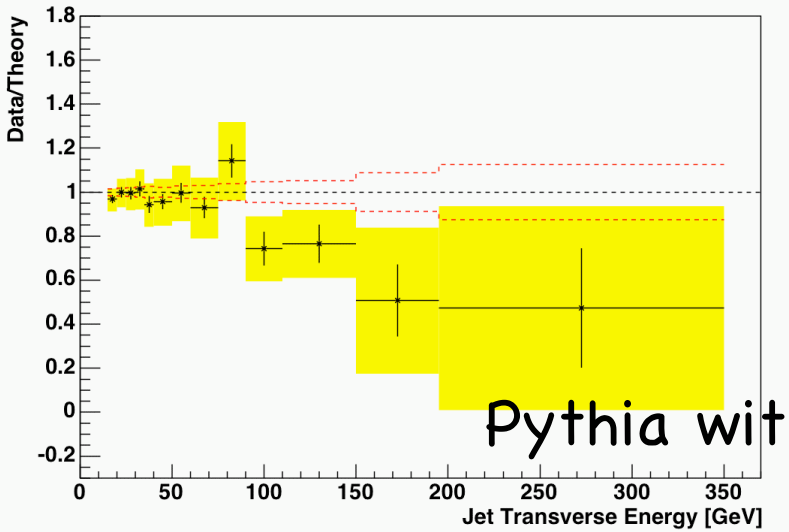
W+1 jet

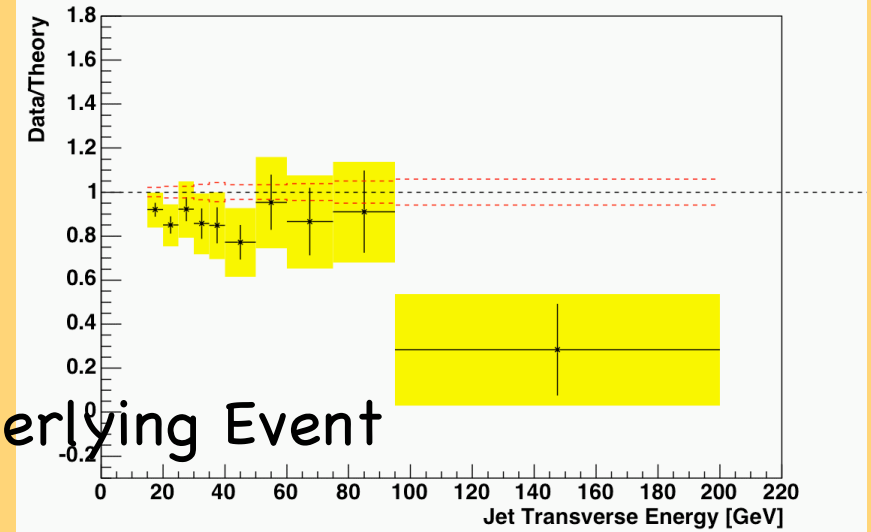
W+2 jet





Pythia without Underlying Event





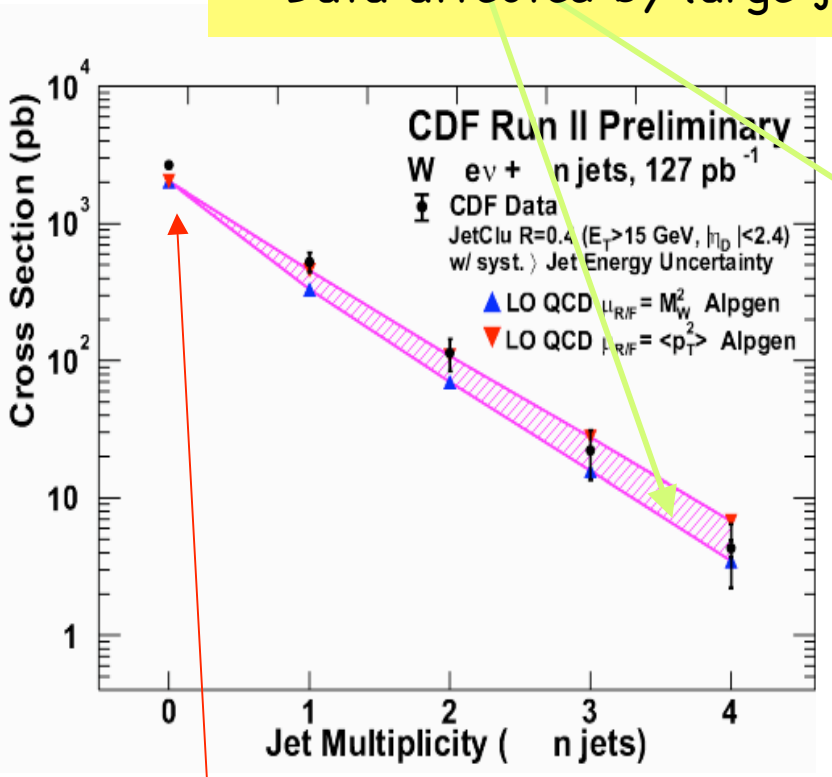
Pythia with Underlying Event

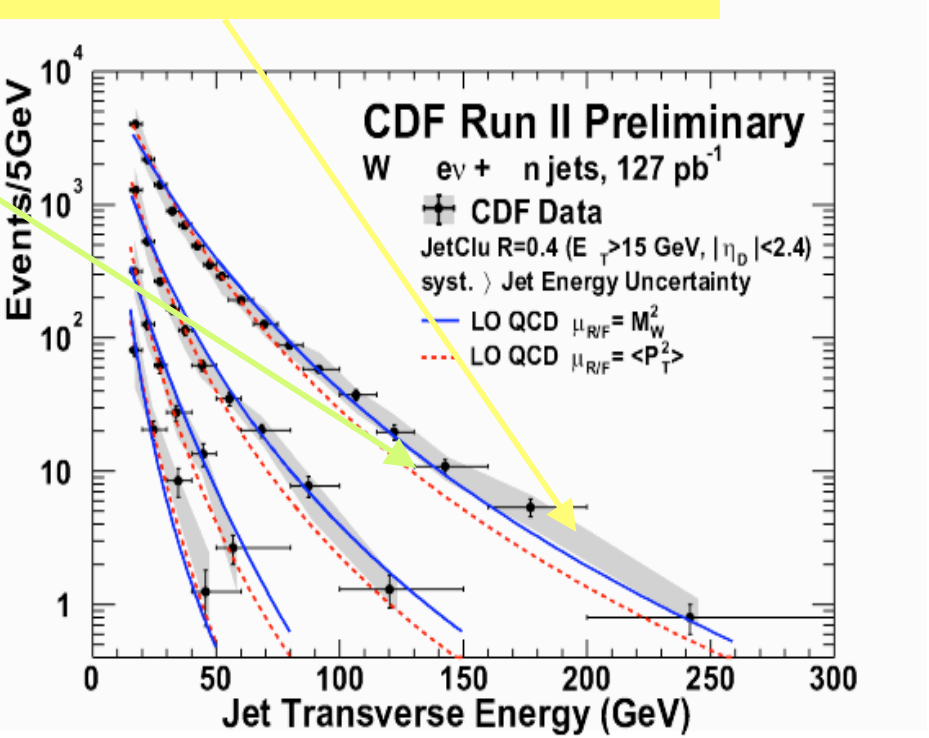
Boson + jets

CDF W+jet measurement:
comparison with Alpgen

MC sensitive to parton level cuts & Q^2 scale.

Data affected by large jet energy correction systematic.

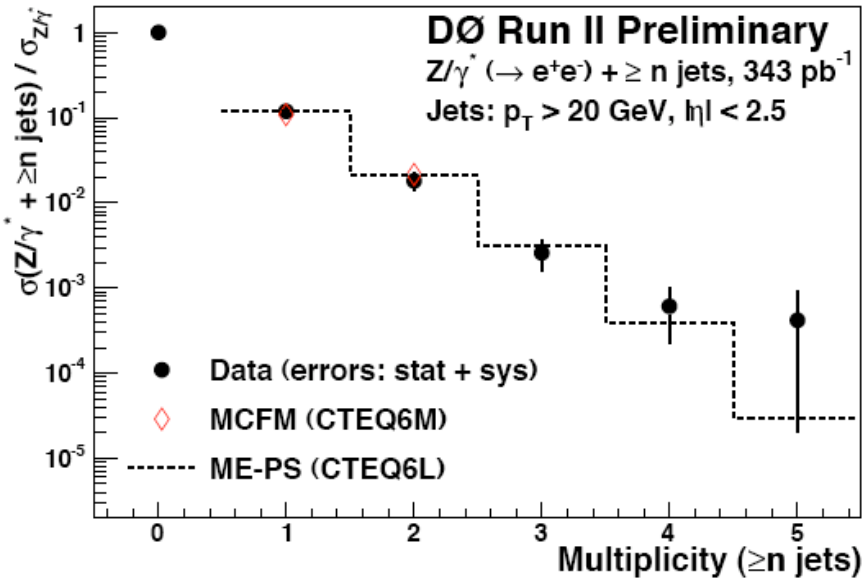


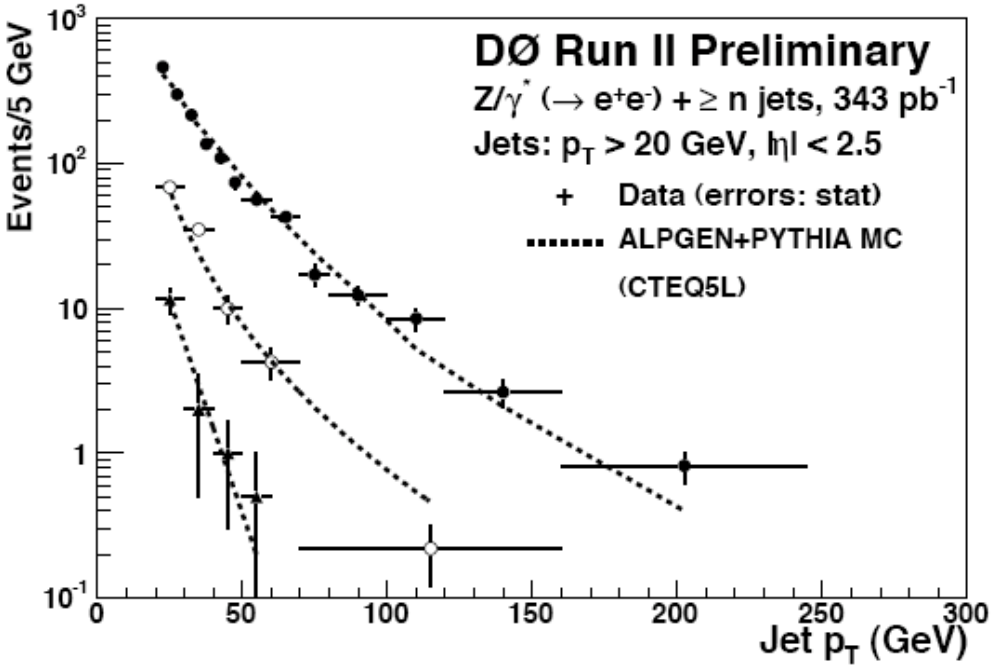


LO nature of MC -> σ lower by 10-20%

DO Z+jet measurement:
comparison with MCFM & Alpgen

Alpgen Z+np LO + Pythia





MCFM Z+n p NLO (n<=2)

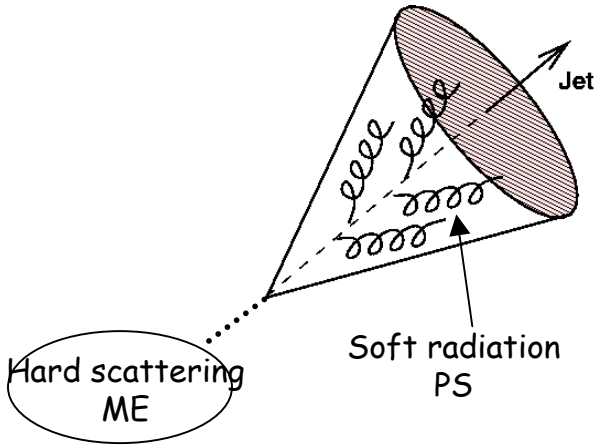
MadGraph Z+np LO + Pythia (CKKW)

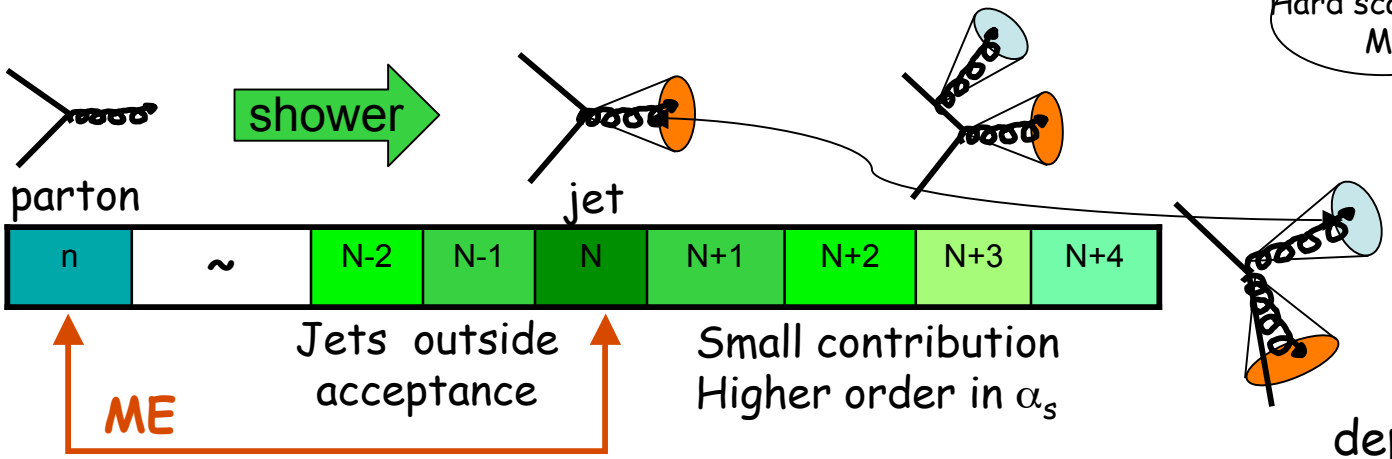
MC issues

Naïve: W+n p (ME)+(PS) ~ W + ≥ N jet

W+(n+1) p (ME)+(PS) ~ W + ≥ N+1 jet

...





2 topologies ~ $O(\alpha)$
Same jet multiplicity

double counting
dep. on parton-level cuts

Problems:

how to generate the whole n jet spectrum avoiding double counting ?
how be sure that the selected jet is coming from the ME and not PS ?

Goal:

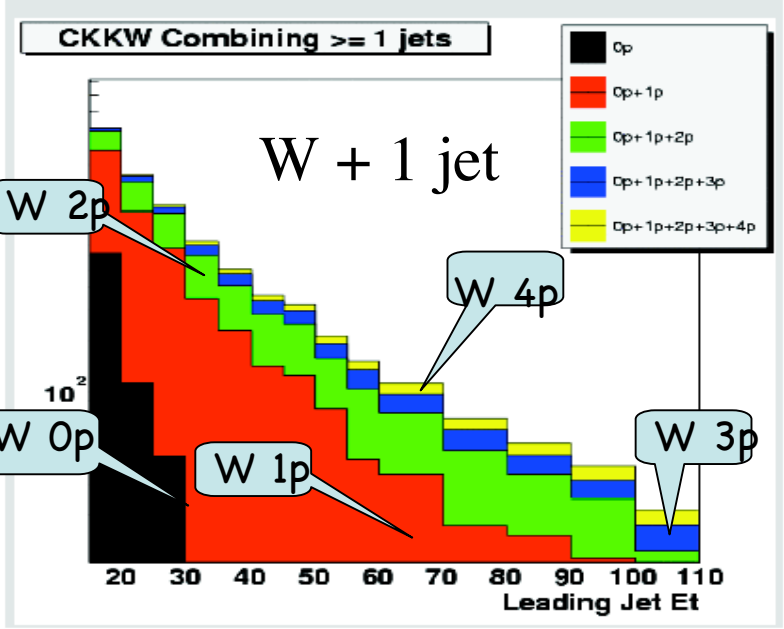
have a prescription to safely merge different MC multiplicity samples
reduce the dependence on parton lavel phase-space

…new merging tools

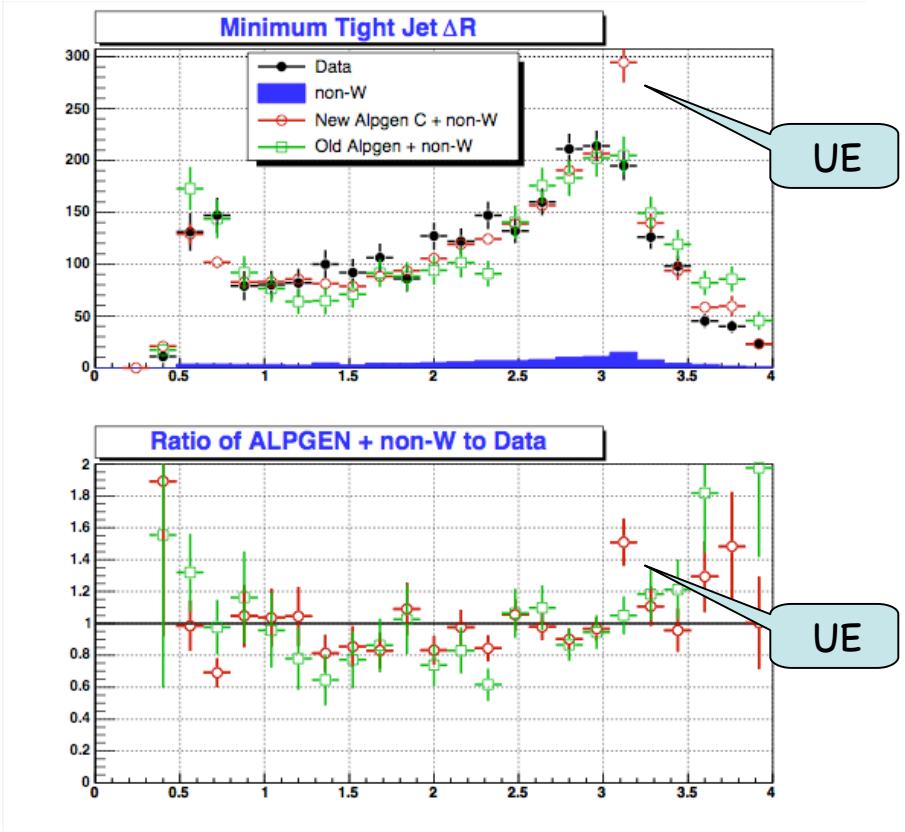
Separate multijet phase-space
- Matrix element domain
- Parton shower domain

LO ME calculation interfaced with parton shower MonteCarlo

CKKW prescription
Catani, Krauss, Kuhn, Webber



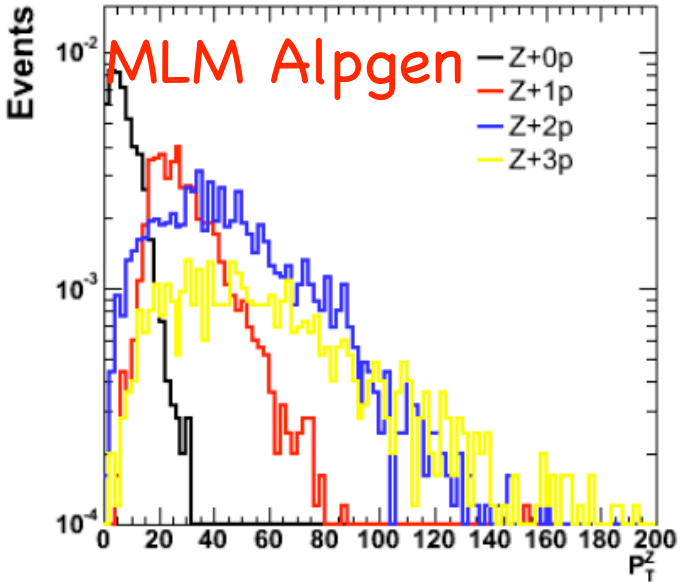
MLM's matching
Michelangelo Mangano

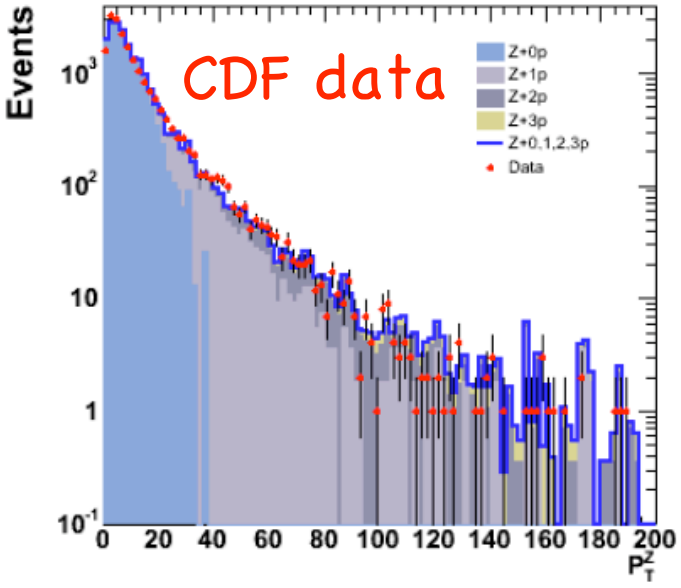


Have to be validated & tuned on data

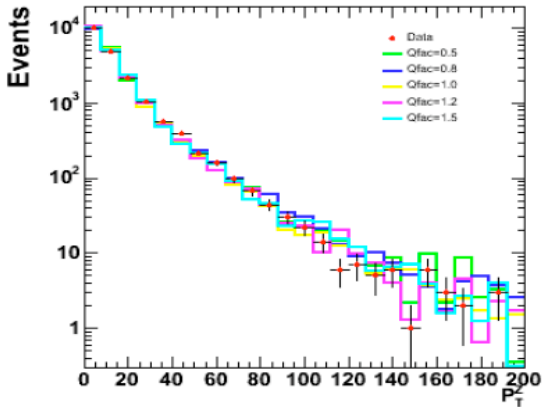
Z+jet Alpgen MLM

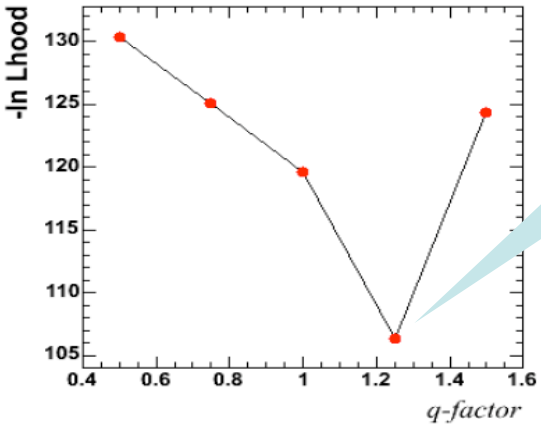
Scan the Q^2 sensitivity of the pQCD by comparing it to data





Different Q^2 scales

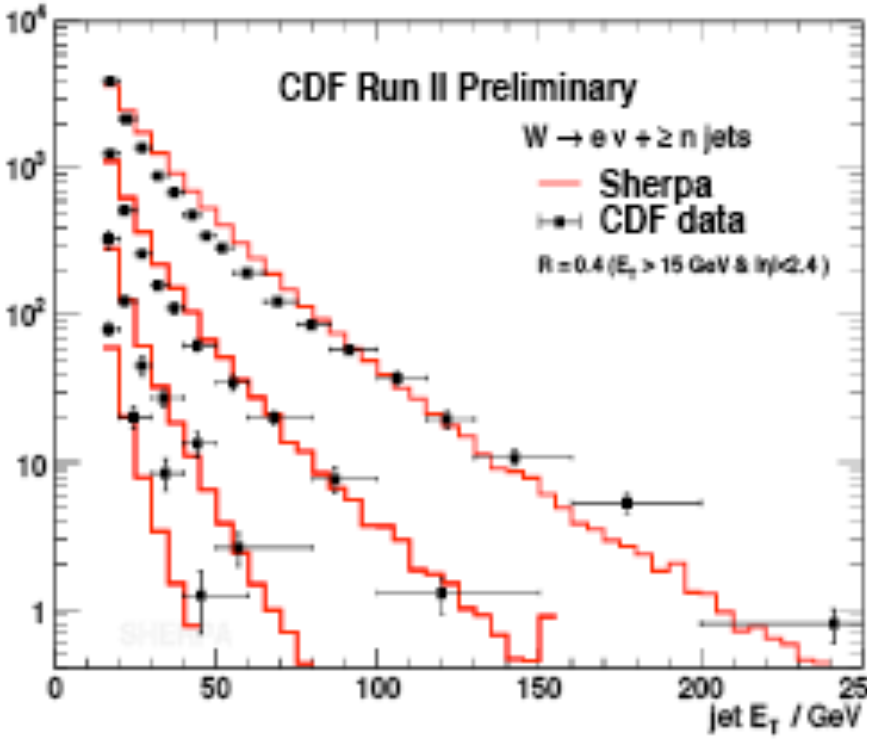


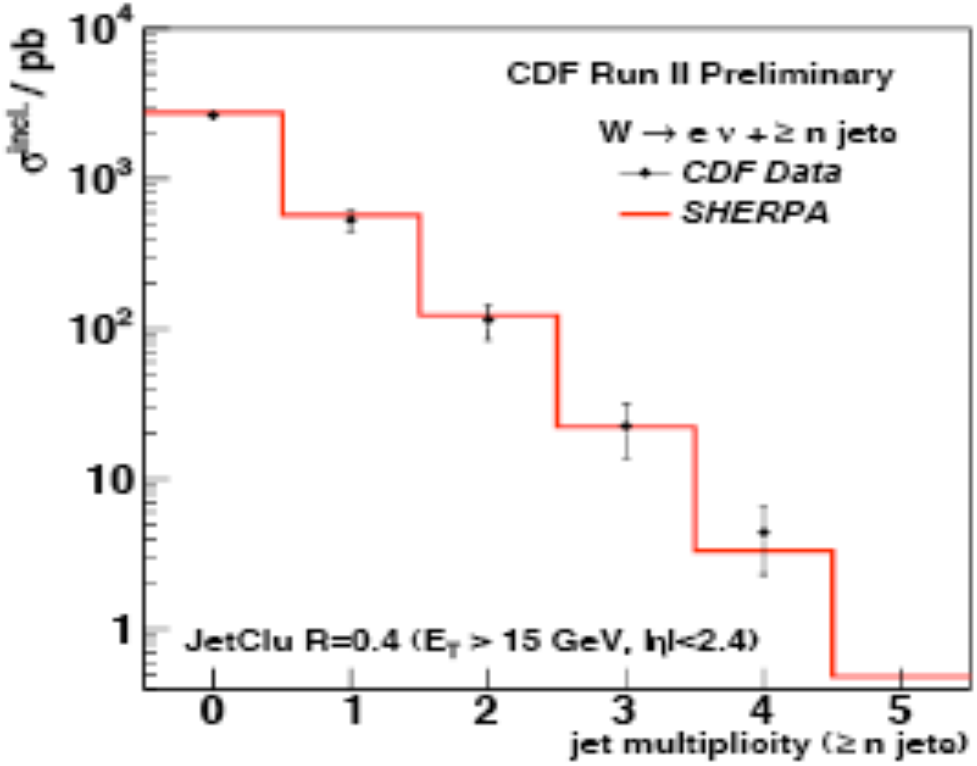


Better fits data

CDF W+jet measurement:

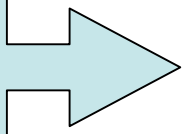
comparison with CKKW (Schalicke,Krauss, JHEP 0507:018,2005, hep-ph/050328)





Next step:
new set of measurements more suitable to be compared with pQCD

tune the new tools on data by making measurement model independent and easily usable to test new models.



What we want to measure:

New CDF W+jet measurement 2/06

- W->eν + jet cross-section wrt jet E_T, jet-jet DR and invariant mass.
- Be as much as possible independent of the detector and theoretical models used.
- This is not an EWK measurement - the W is a clean signal for high Q^2 events within which we can examine jet kinematics.

$$\frac{\delta\sigma\left[\begin{array}{l} P_T^e > 20, M_T > 20 \\ P_T^\upsilon > 30, \eta^e < 1.1 \end{array}\right]}{\delta E_T^j}$$

→ Restrict W xsec to the measurable phase space

→ Jets corrected hadron level
JETCLU 0.4
E_T^{corr}>15 GeV; $|\eta^D|$<2.4

Best prescription for theoretical comparisons

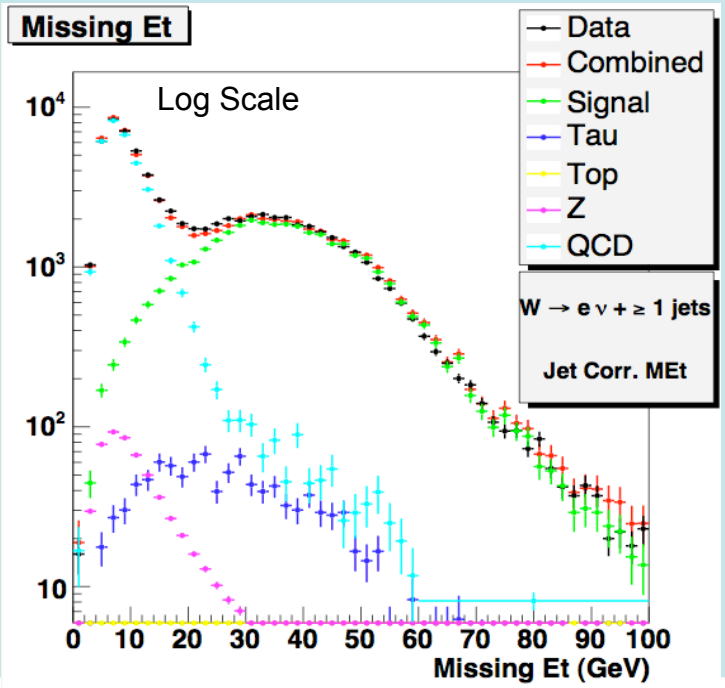
- σ(W|e>20; ν>30;η<1.1; MT>20) well defined both theoretically & experimentally (understanding of detector resolutions).
- Jet kinematic phase space the largest possible at CDF.

Analysis outline

High P_T electron trigger 320pb^{-1} ⇒ Identify W event, reconstruct jets

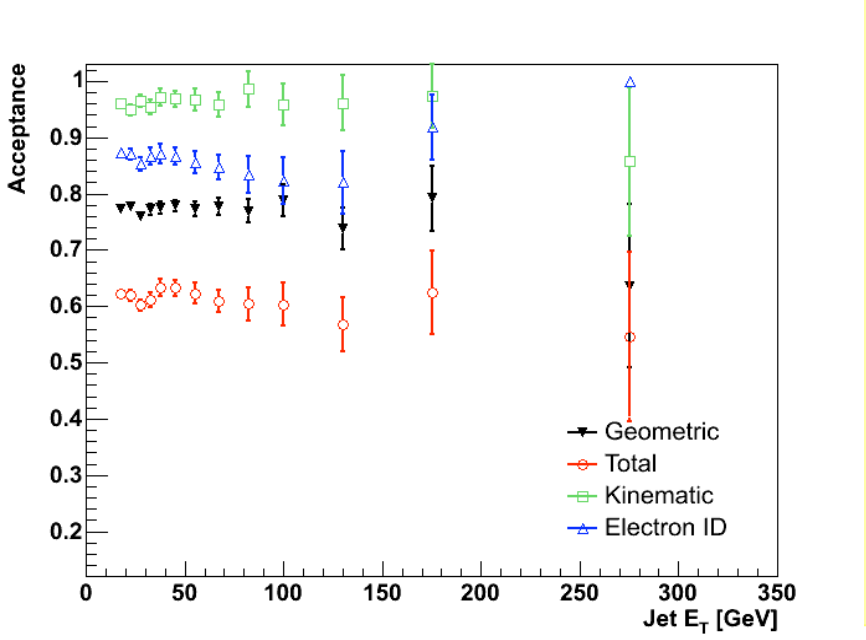
Backgrounds:

- QCD from data: anti-electron method
- W-like from MC
- Promotion from Minimum Bias
- relative normalization from template fit to ME_T to data



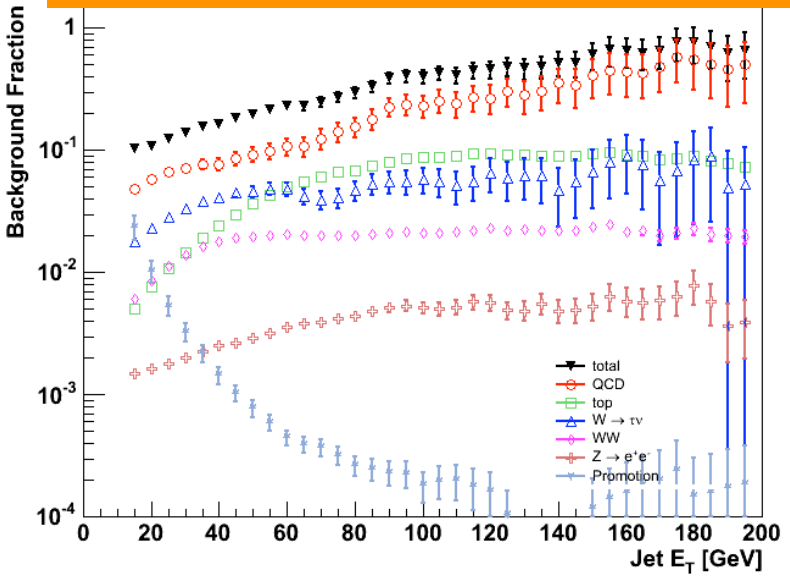
Acceptance:

- Defining σ wrt W detector acceptance:
  - correct only for detector resolution effects - independent of th model
- Use W+np MC for acceptance & ID
- Validation: ID on Z data, acceptance by studying different MC.



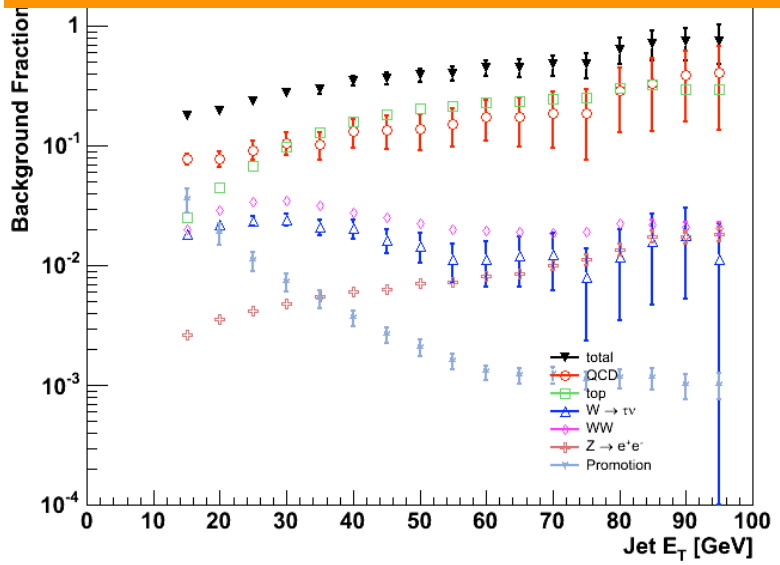
Background picture

W+1j integrated E_T spectrum

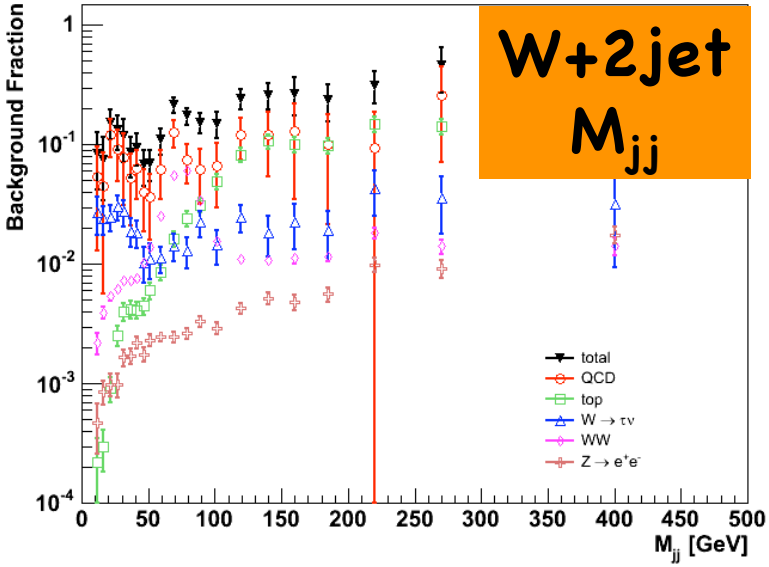


Tot
QCD
Top
W->tv
WW
Z->ee
promo

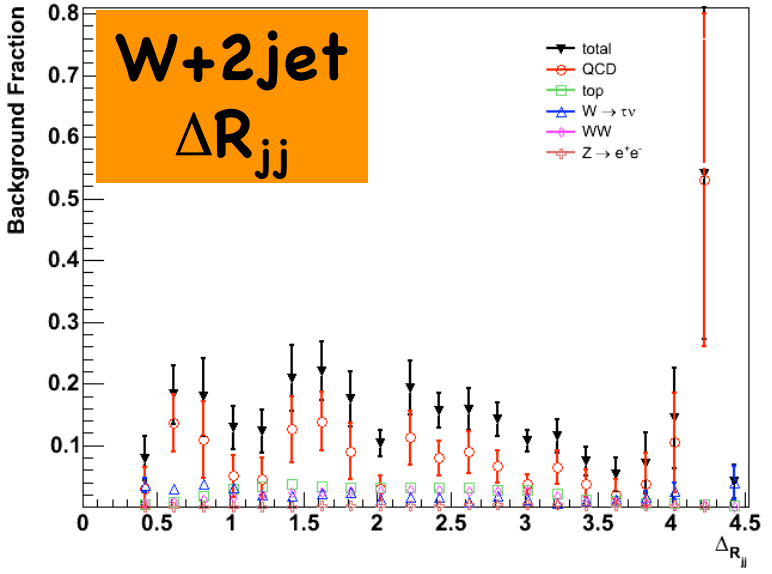
W+2j integrated E_T spectrum



W+2jet M_{jj}

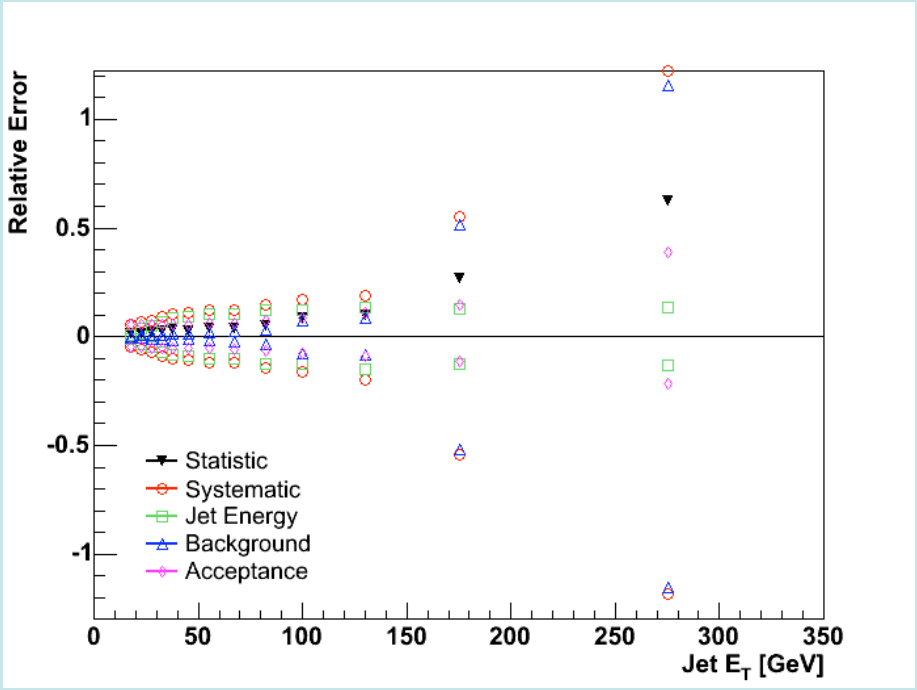


W+2jet ΔR_{jj}

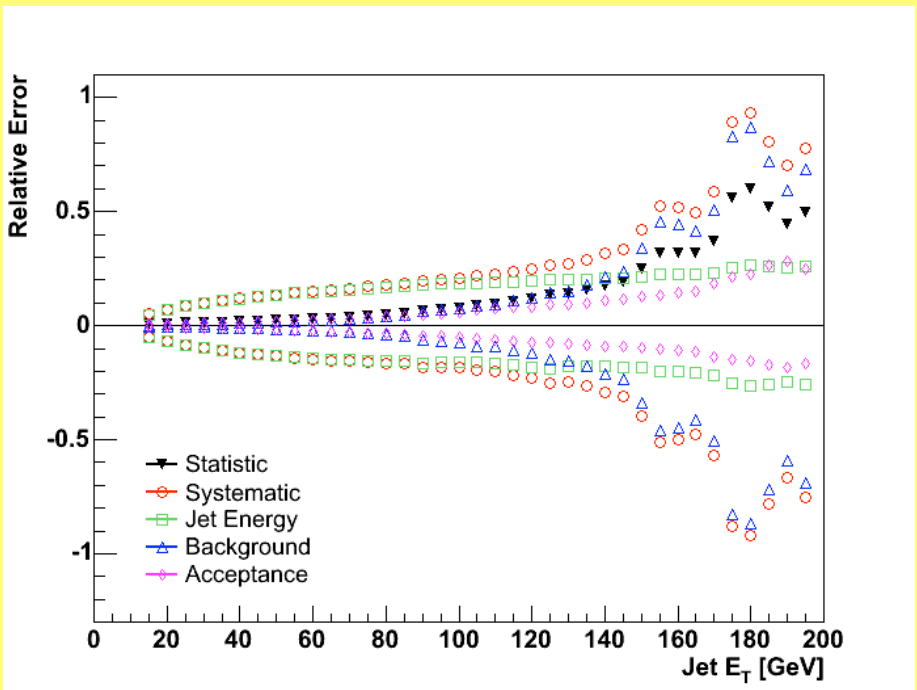


Errors picture

A representative behavior of the errors in the measurement



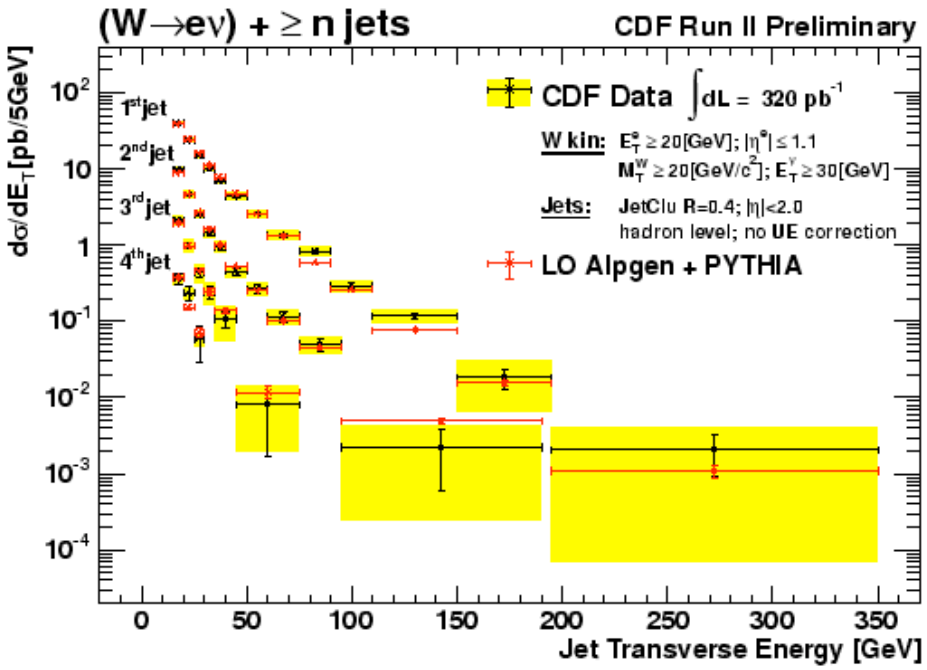
Leading jet differential cross section statistical and systematic errors. Systematic dominated by background subtraction.



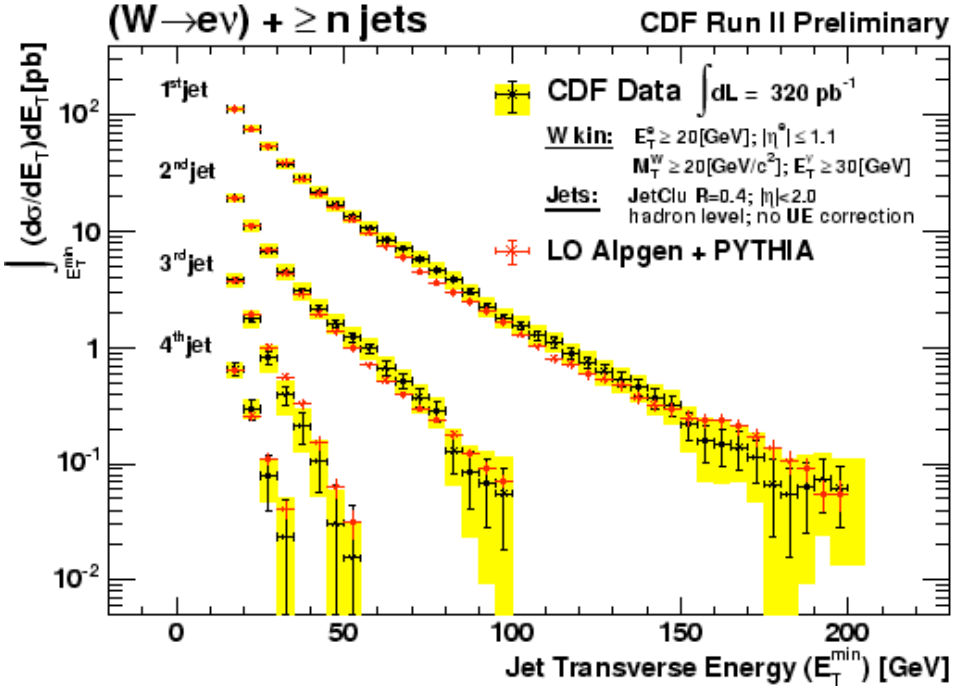
Leading jet integrated cross section statistical and systematic errors. Systematic dominated by jet energy scale

CDF Preliminary results

Differential xsec wrt jet E_T in each of the 4 W+ n jet inclusive samples



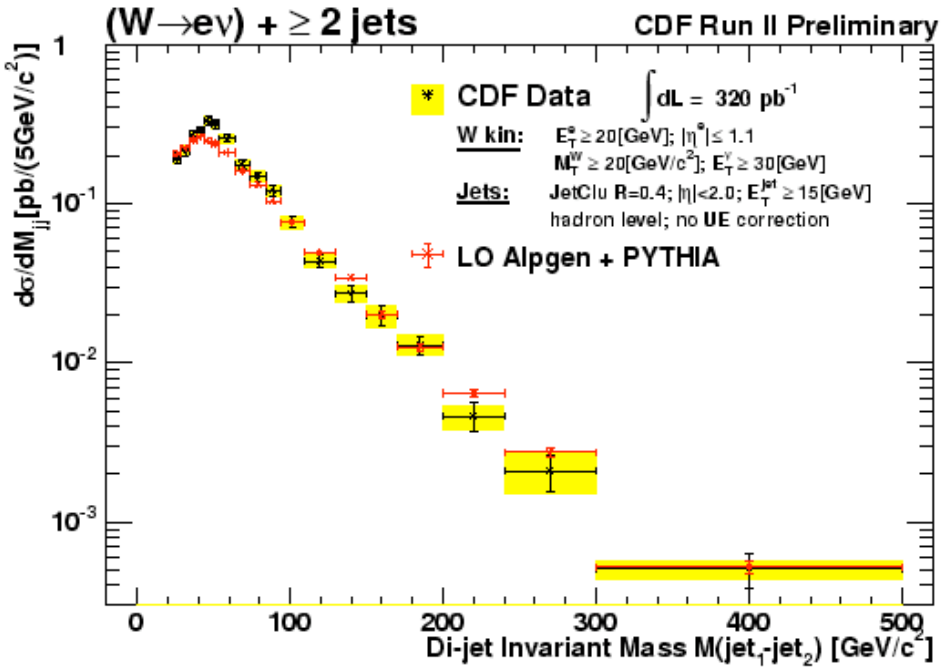
Integrated xsec wrt jet E_T in each of the 4 W+ n jet inclusive samples



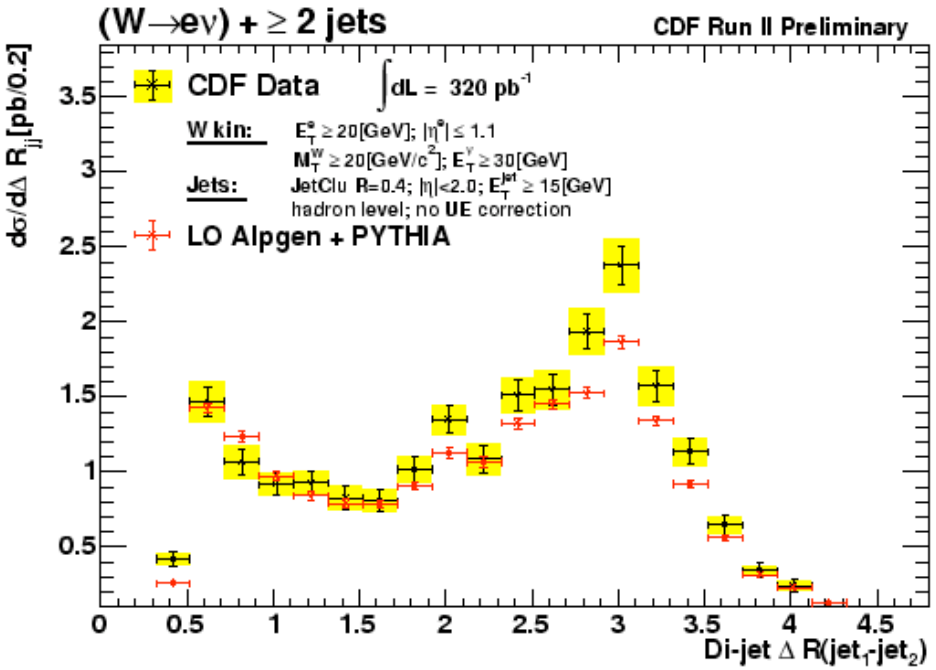
Caveat: this is not a full theory to data comparison. MC have been normalized to data inclusive cross section in each jet multiplicity sample!

CDF Preliminary results

Differential xsec wrt di-jet invariant mass in the W+ 2 jet inclusive samples



Differential xsec wrt di-jet ΔR in the W+ 2 jet inclusive samples



Caveat: this is not a full theory to data comparison. MC have been normalized to data inclusive cross section in each jet multiplicity sample!

Conclusions

- The systematic error on many high p_T measurements receives substantial contribution form multi-jet background knowledge
- There are many LO/NLO ME with/without parton shower able to simulate such processes.
  - are not exact
  - may work in different regimes
  - parameters need to be tuned on data
- New boson + jets measurements from Tevatron more suitable for data/theory comparison
  - measurement at the hadron level
  - Reduced model dependence on acceptance/efficiency corrections
- We'd be happy to collaborate with MC authors
  - parameters tuning
  - systematic scan
  - measure relevant observables