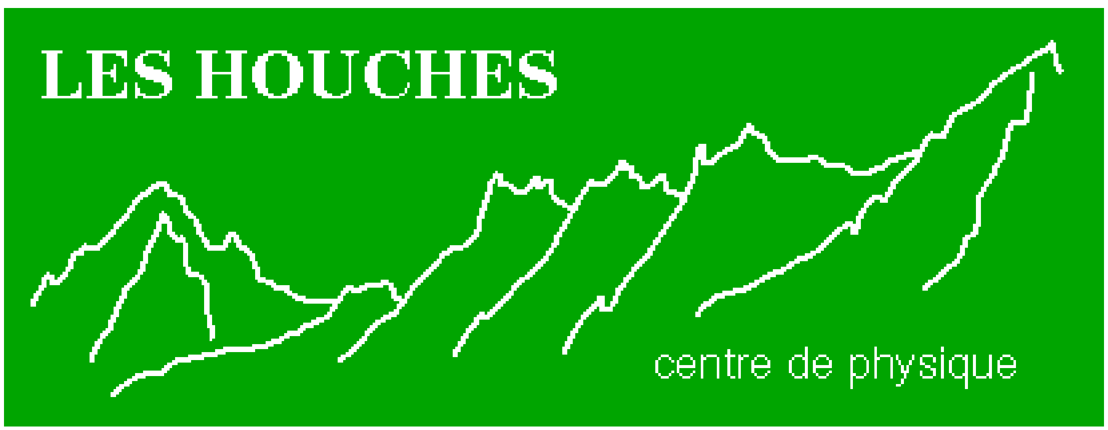
# What's happening at the Tevatron?

## …plus what I can sneak in from the TeV4LHC workshop

J. Huston
Michigan State University

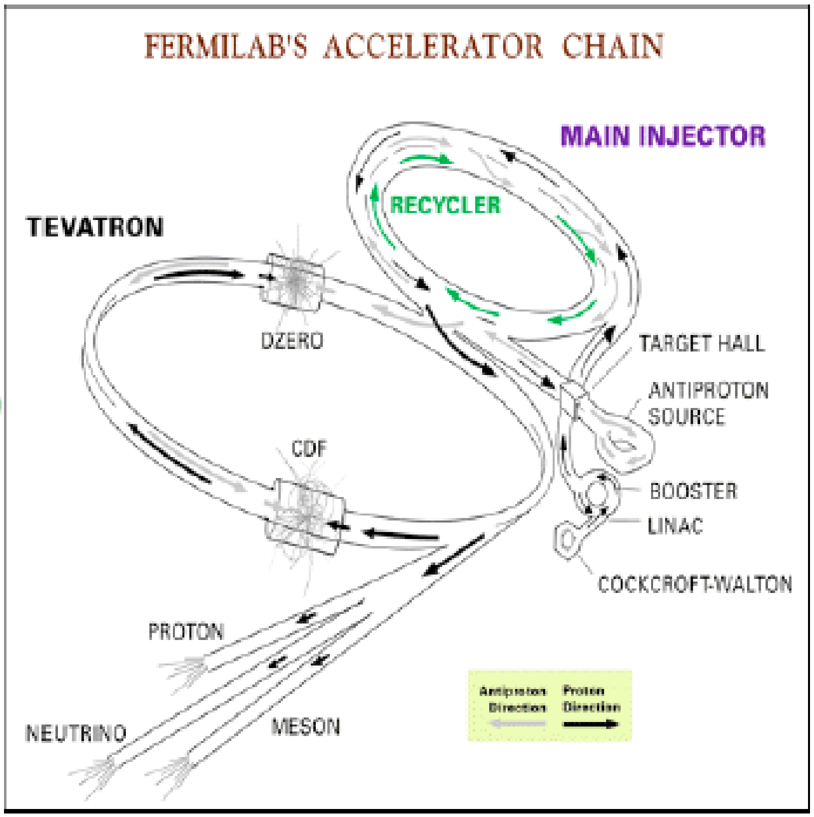


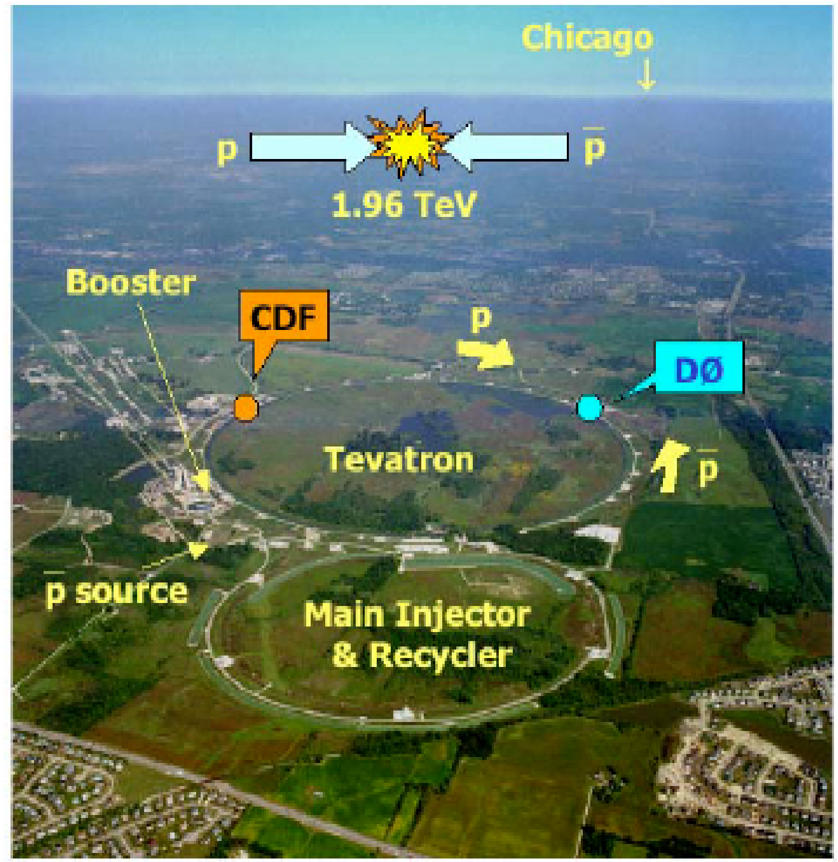

…thanks to Franco Bedeschi, Daniel Bloch, Florencia Canelli, Julien Domini, Zbenek Hubacek, Regis LeFevre, Giulia Manca, Mario Martinez, Christophe Royon, Dave Waters, Un-Ki Yang for letting me steal their slides

…apologies(1) to those who have heard a similar talk at CERN and (2) for a CDF-centric bias

# Tevatron in Run II

36 bunches (396 ns crossing time)

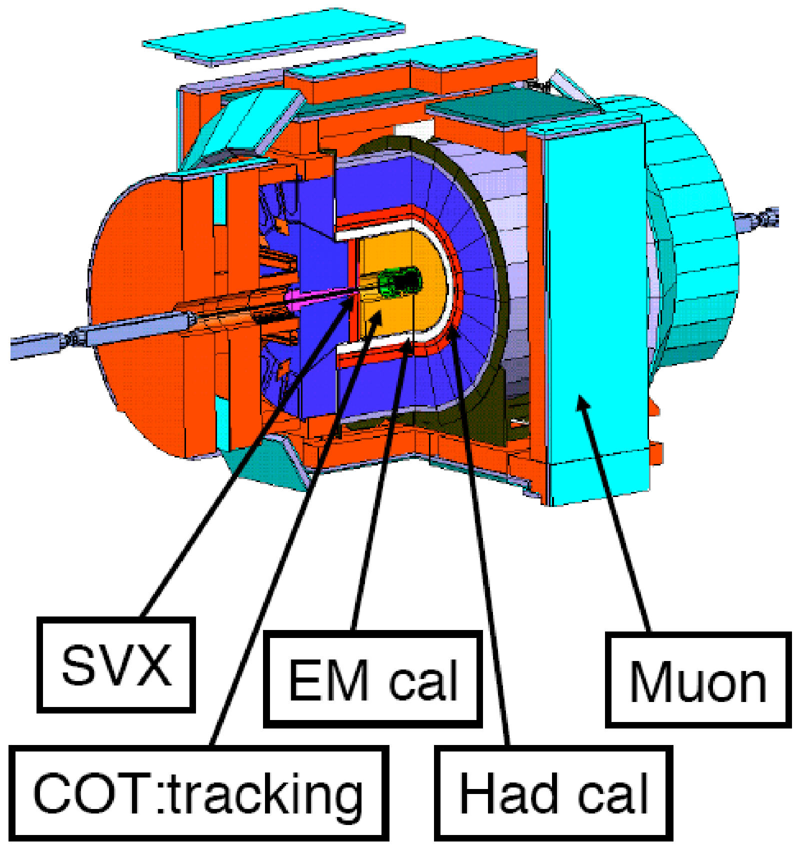



electron cooling this summer → 40% increase in luminosity

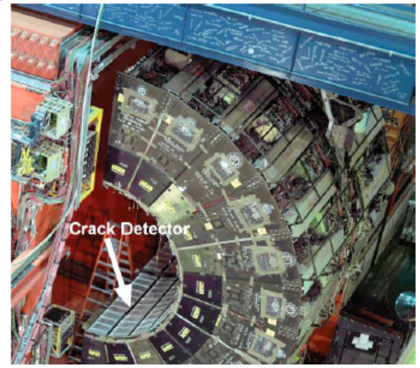
# CDF in Run II

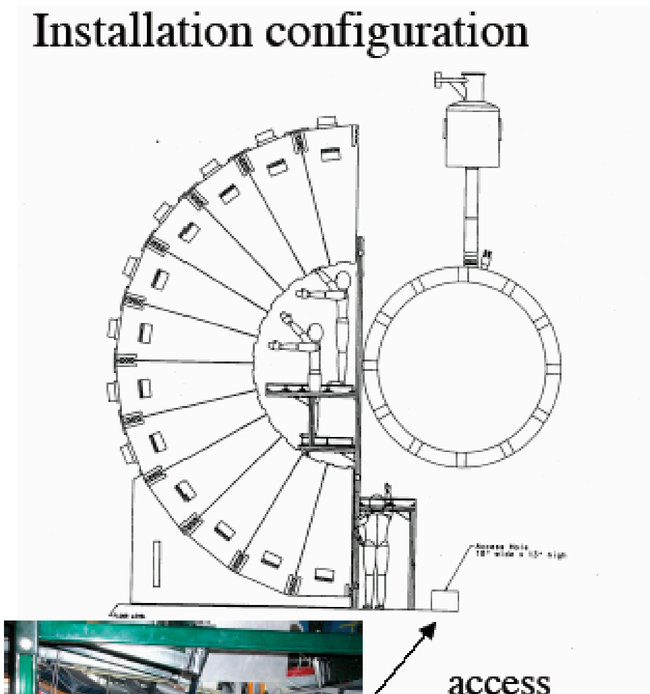
- Silicon detector (SVX):
  - top event b-tag: ~ 55%
- COT: drift chamber
  - Coverage: $|\eta|<1$
  - $\sigma_{Pt}$ / Pt ~ 0.15% $P_T$
- Calorimeters:
  - Central, wall, plug
  - Coverage: $|\eta|<3.6$
  - EM: $\sigma_E / E \sim 14\% /\sqrt{E}$
  - HAD: $\sigma_E / E \sim 80\% /\sqrt{E}$
- Muon: scintillator+chamber
  - muon ID up-to $|\eta|=1.5$

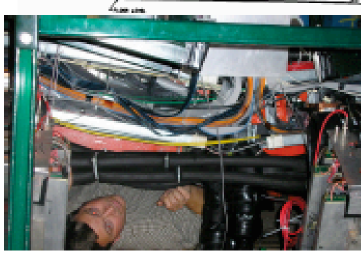


# New in 2005 (during fall 2004 shutdown)

- New scintillator-based central preradiator

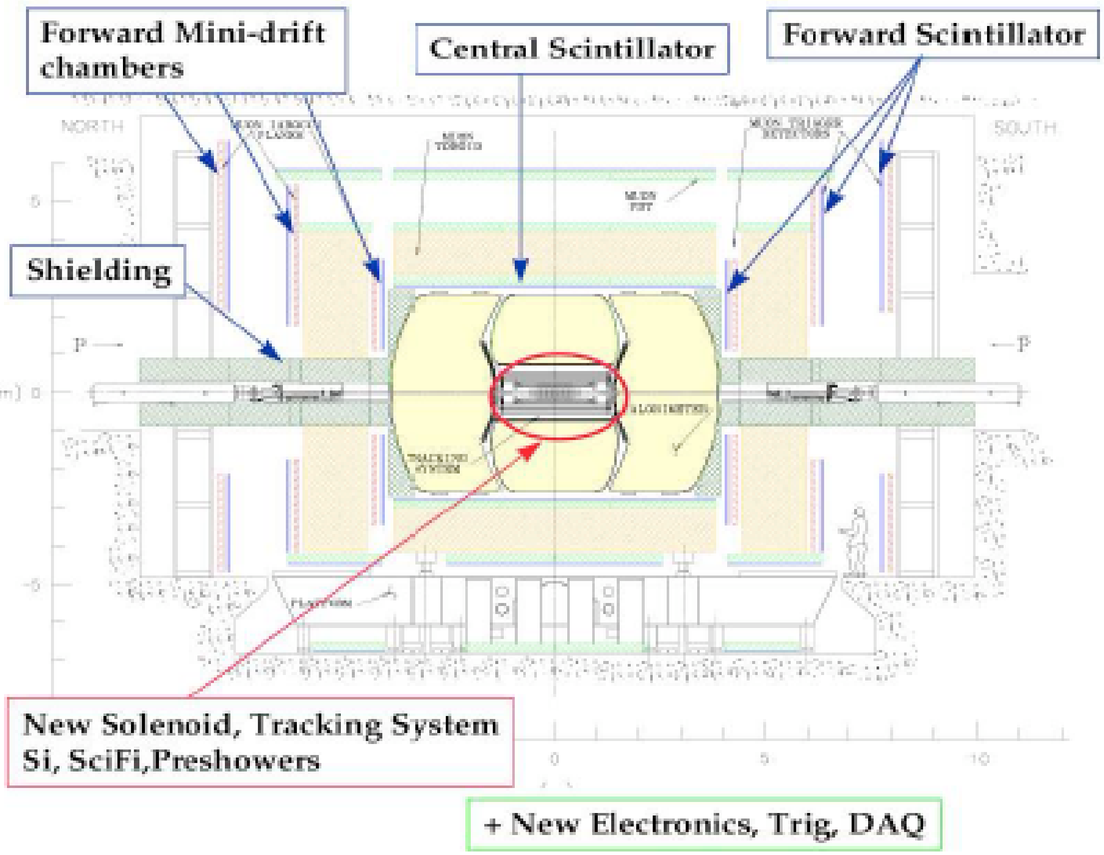


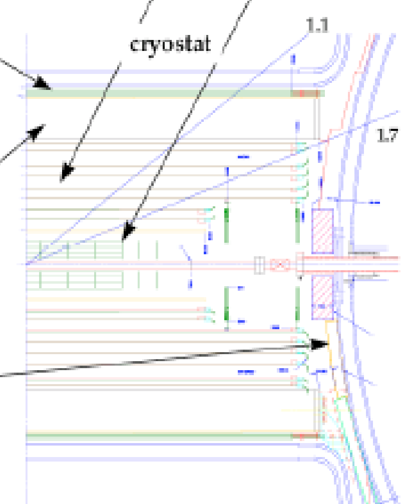
# D0 in Run II

## DØ Detector



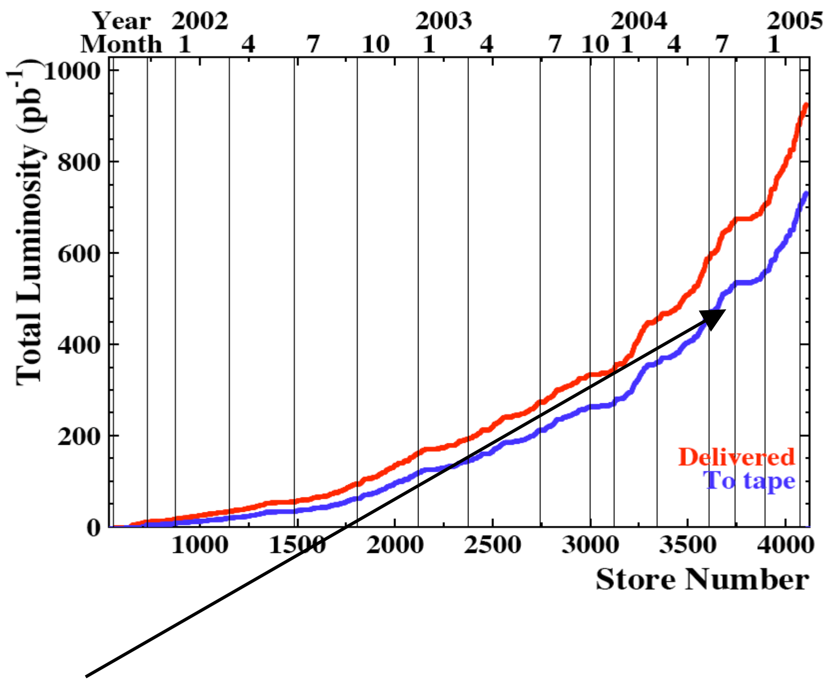

## DØ tracking detector

- **Silicon Tracker**
  - Four layer barrels (double/single sided)
  - Interspersed double sided disks
  - 840,00 channels
- **Fiber Tracker**
  - Eight layers sci-fi ribbon doublets (z-u-v, or z)
  - 74,000 830um fibers w/ VLPC readout
- **Central Preshower**
  - Scintillator strips, WLS fiber readout
  - 6,000 channels
- **Solenoid**
  - 2T superconducting
- **Forward Preshower**
  - Scintillator strips, stereo, WLS readout
  - 16,000 channels



# Tevatron Performance

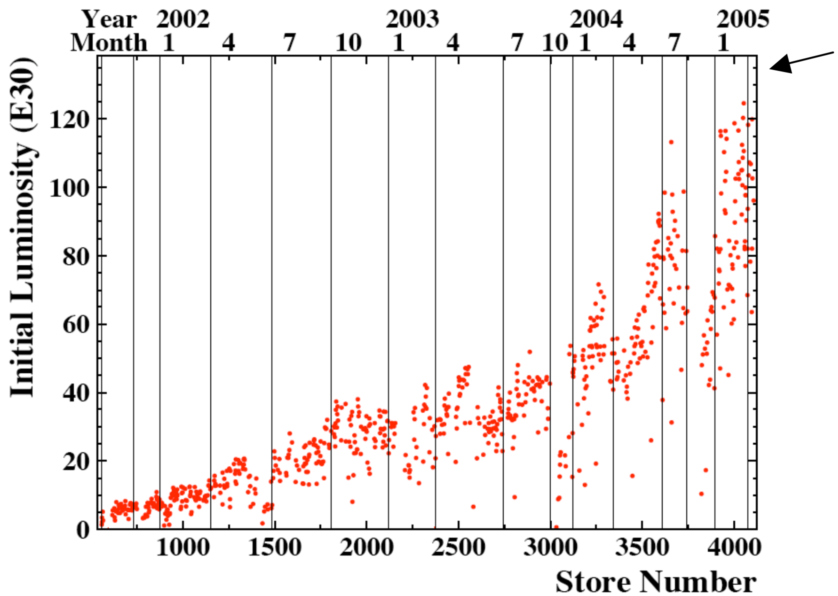
- Theme of this year's Les Houches workshop
  - "From 800 $pb^{-1}$ at the Tevatron to 30 $fb^{-1}$ at the LHC"
- …is accurate, at least for the first part

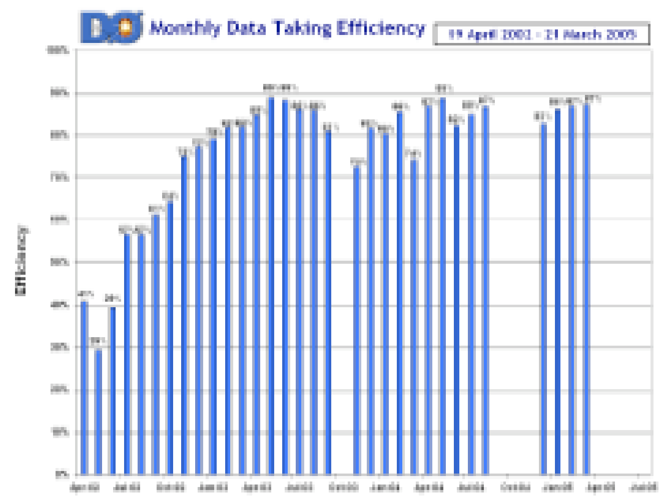


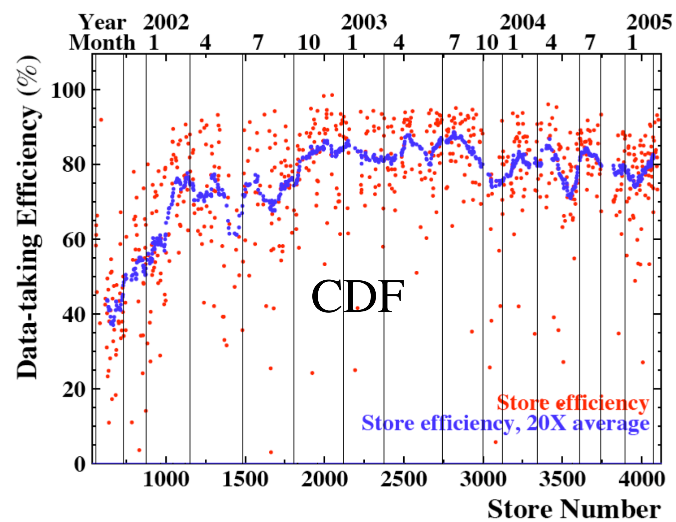

Shutdown: most blessed analyses based on ~400 $pb^{-1}$ before shutdown

# Tevatron Performance

- Tevatron, CDF and D0 all peforming well



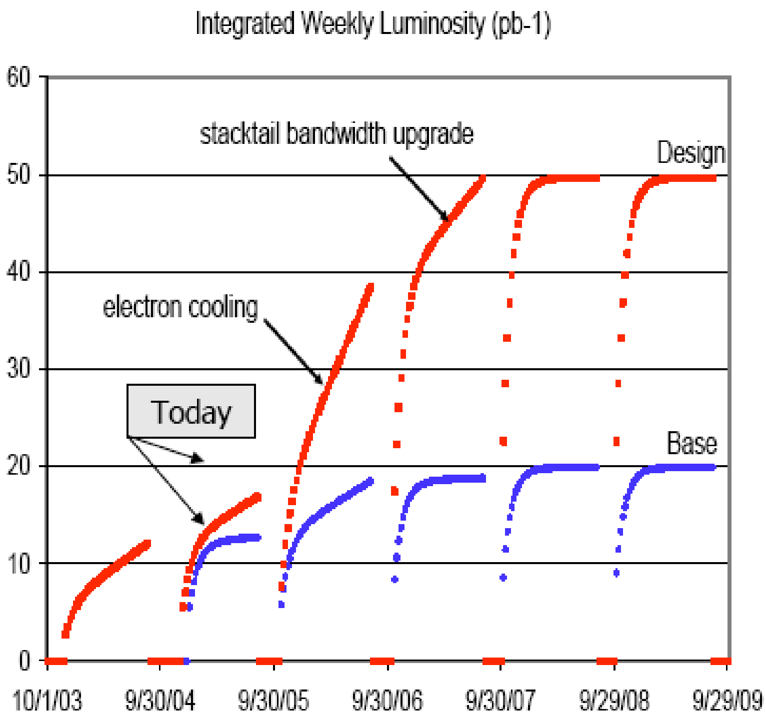

Logbook entry from last Friday:
Store 4118 started at 0951 hours, initial luminosity = 130e30 (stack=143e10, stash=124e10) -- a record

18.5 $pb^{-1}$ to CDF last week

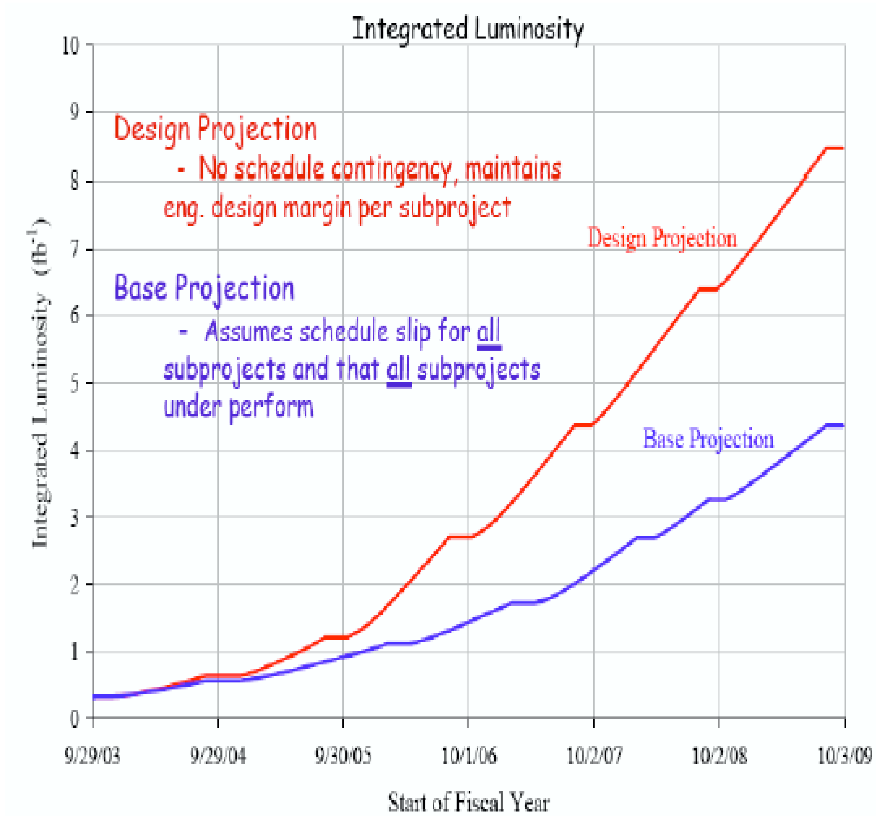
# Reminder: ultimate goals

**Increase in number of antiprotons**
**→ key for higher luminosity**

**Expected peak luminosity**
**→ $3 \cdot 10^{32}$ cm$^{-2}$sec$^{-1}$ by 2007**

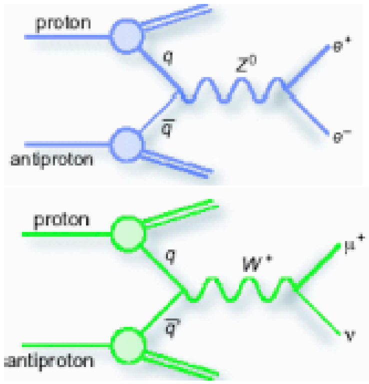


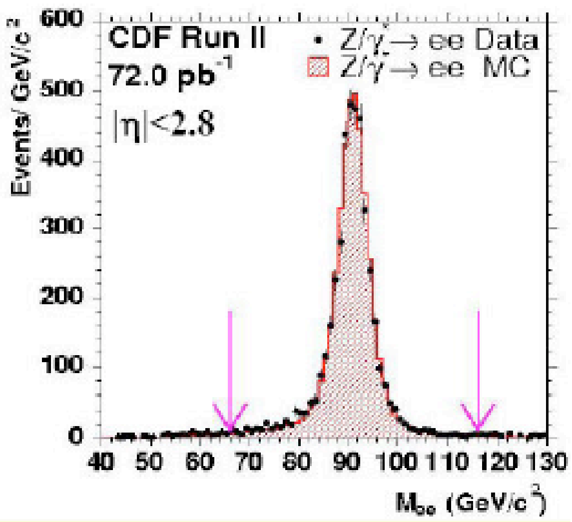

ultimately 4-9 fb$^{-1}$

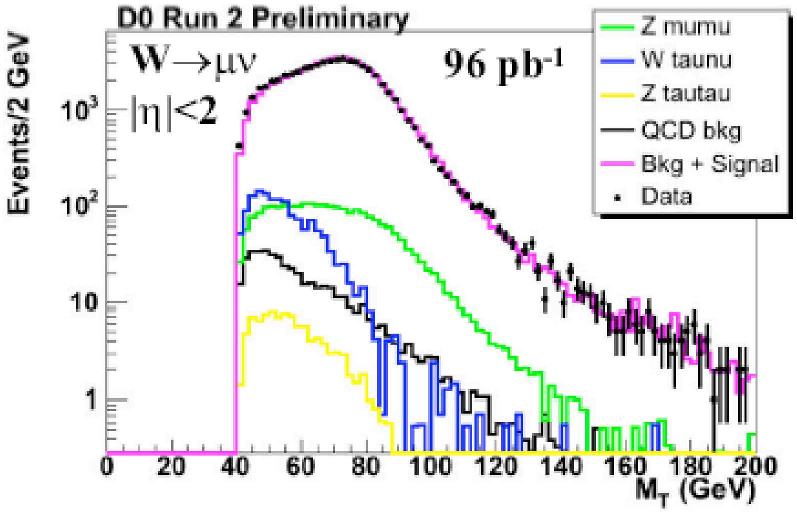


# W/Z Physics

- Test of standard Model
- Require high level of understanding of the detectors
  - e, μ and τ identifications
  - Backgrounds



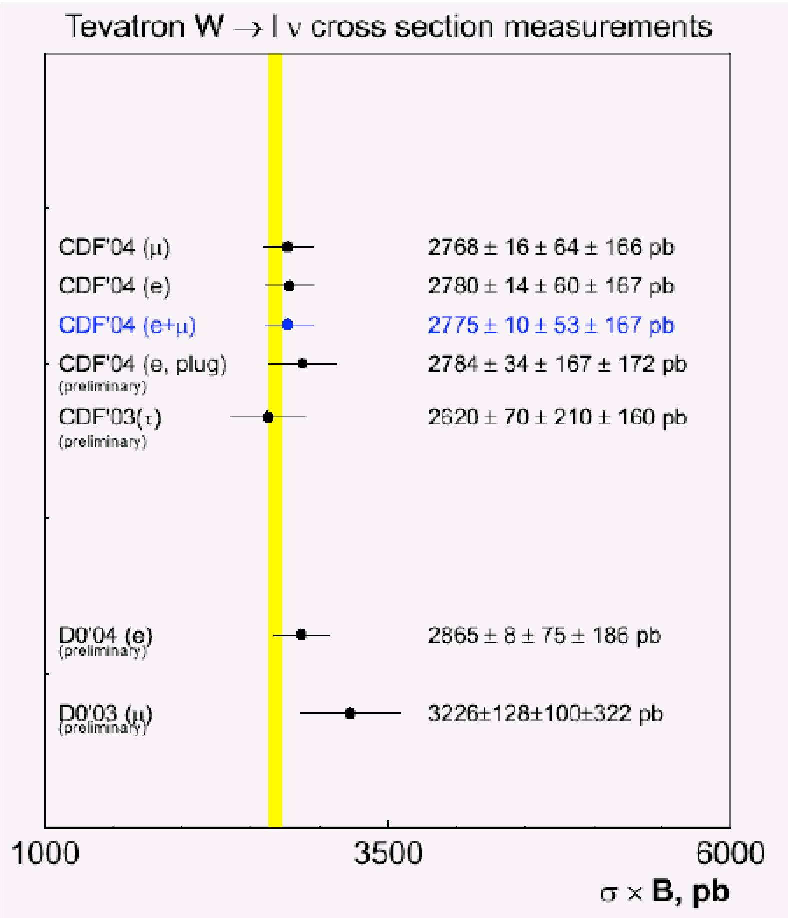



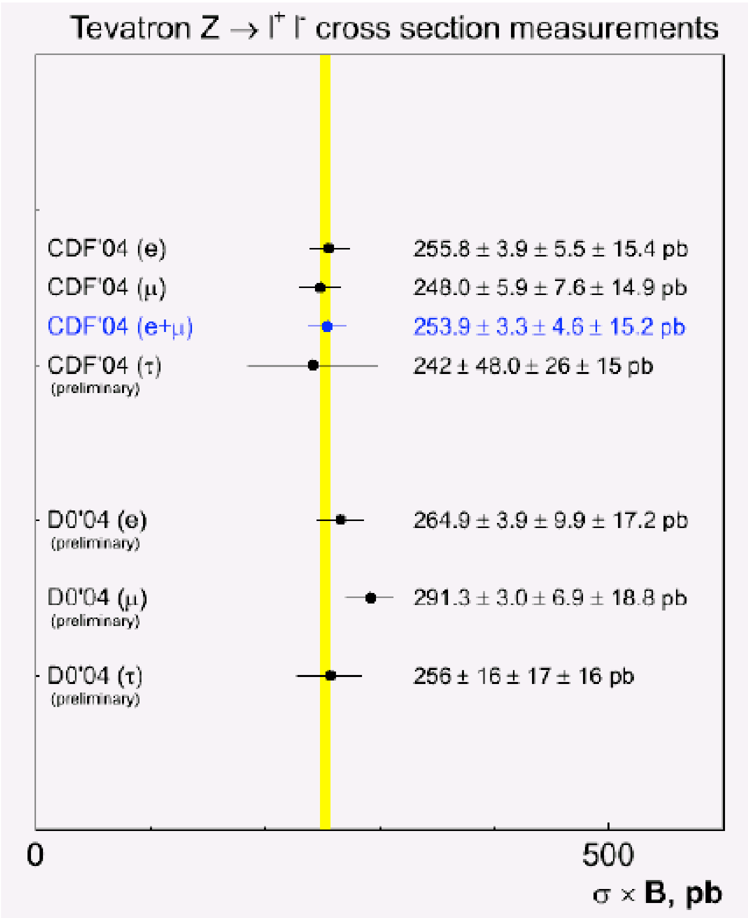




→ Efficiencies computed on data

→ QCD background evaluated on data

# W/Z cross sections at the Tevatron




- good agreement with NNLO predictions
- error dominated by luminosity error (6%)
- 2% systematics (pdf's (acceptance), efficiency) without L error

# W cross section as luminosity monitor

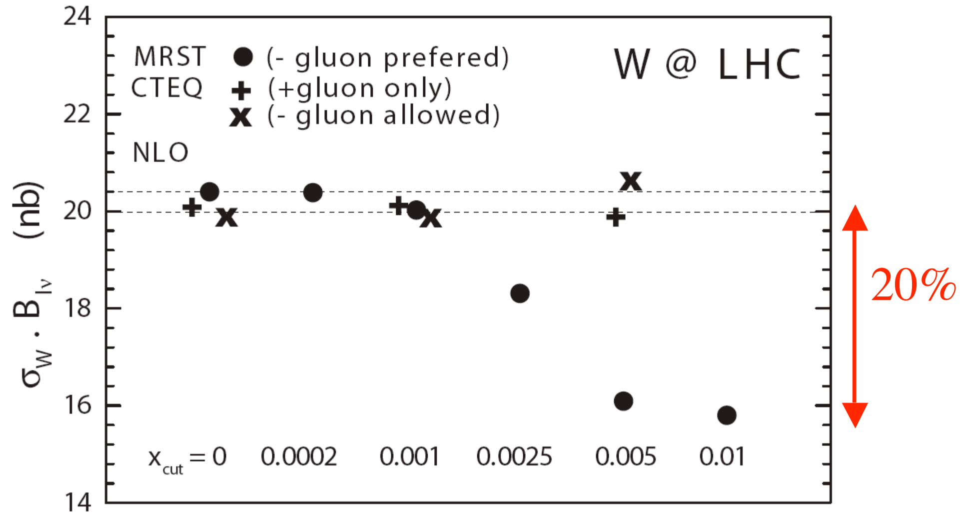
## W→ l ν as luminosity monitor

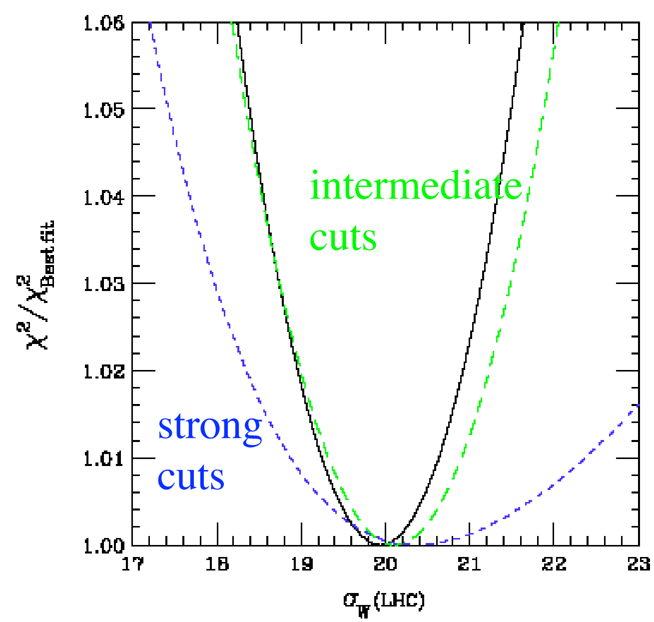
- Current method based on $\sigma_{inel}$(ppbar)= 61.7±2.4 mb @ 1.96 TeV (4%)
- Can we do better using the cross section for W→lν measurement?
- Recent paper by Frixione and Mangano (hep-ph/0405130) investigate contributions of uncertainties in acceptance calculation to the W →lν x-sec measurement (currently ~2%)
- Tevatron and LHC would benefit from experimental and theoretical work

…TeV4LHC project

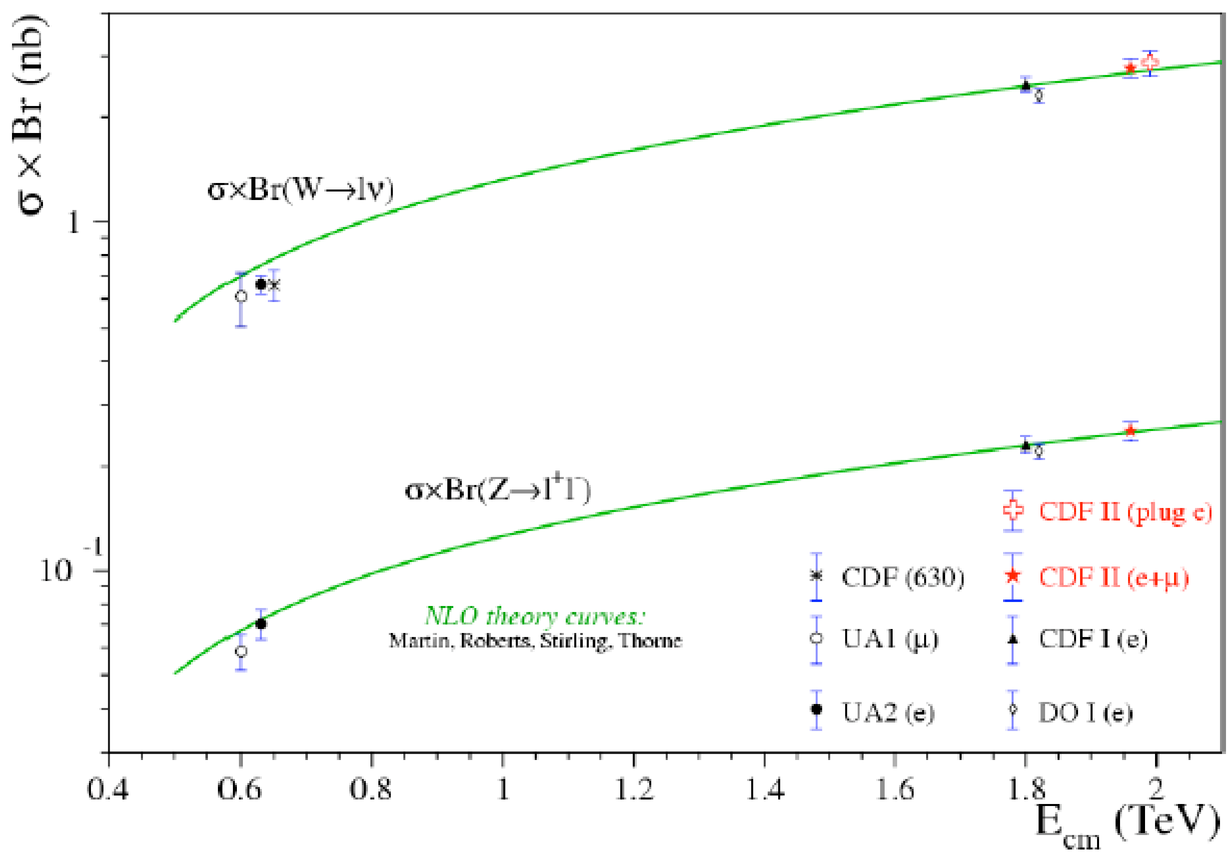
# Validity of NLO DGLAP at Tevatron and LHC

- Is there a *tension* between HERA and Tevatron data requiring NNLO DGLAP to resolve?
  - MRST study: hep-ph/0308087
  - W cross section at LHC drops 20% when data below x=.005 are removed from fit
  - implications for use of W $\sigma$ as luminosity benchmark
- Recent CTEQ study indicates as more severe cuts are made in x and $Q^2$ in global analysis, uncertainty on W cross section at the LHC increases but central value remains relatively constant
  - hep-ph/0502080
  - accepted by JHEP



# W/Z cross sections




$$R = \frac{\sigma_W \times BR(W \rightarrow l\nu)}{\sigma_Z \times BR(Z \rightarrow l^+ l^-)} = 10.92 \pm 0.15(\text{stat.}) \pm 0.14(\text{syst.})$$

- e, μ combined
- correlated systematics fully taken into account

# CDF: R(W/Z) and Γ

$$R = \frac{\sigma_W \times BR(W \to l\nu)}{\sigma_Z \times BR(Z \to l^+ l^-)}$$

$$= \frac{\sigma_W}{\sigma_Z} \frac{\Gamma_Z}{\Gamma(Z \to l^+ l^-)} \frac{\Gamma(W \to l\nu)}{\Gamma_W}$$

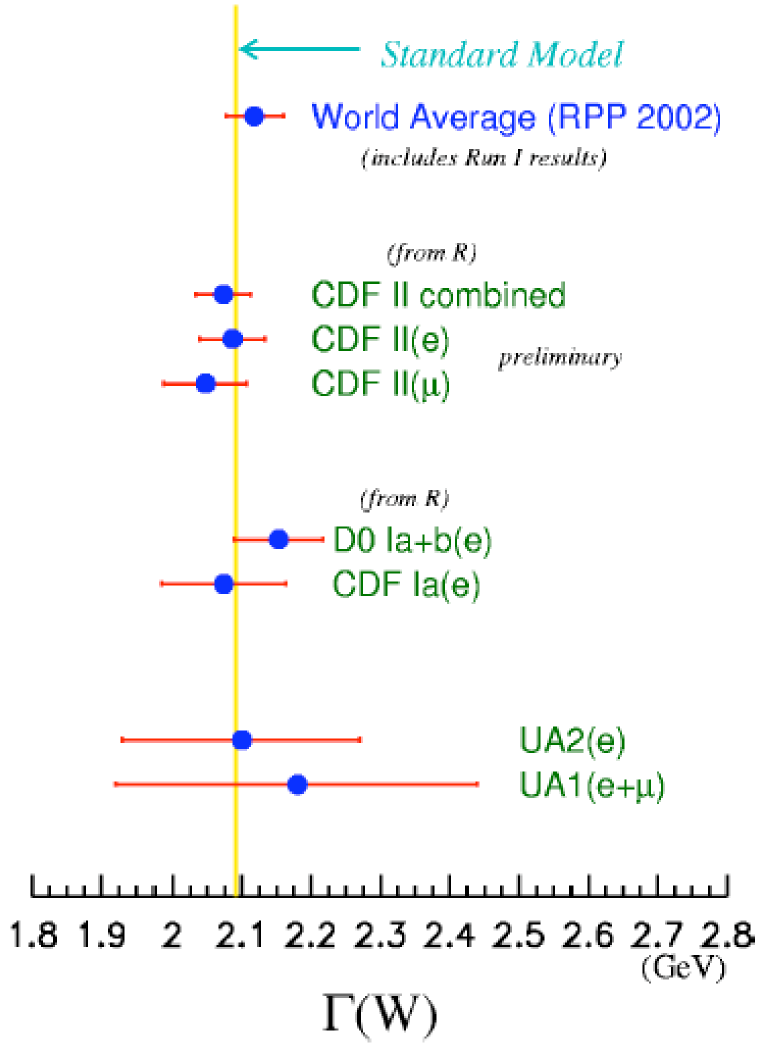
$\sigma_W / \sigma_Z$ → SM: $3.361 \pm 0.024$

$\Gamma_Z / \Gamma(Z \to l^+ l^-)$ → LEP

$\Gamma(W \to l\nu)$ → SM: $226.4 \pm 0.3$ MeV

$$\Gamma_W(\text{indirect}) = 2.079 \pm 0.041 \text{ GeV}$$

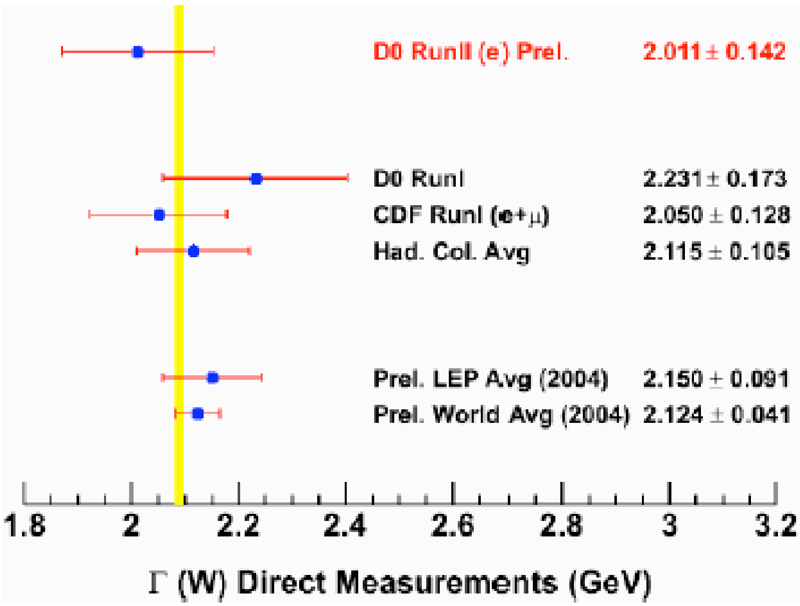
$$\Gamma_W(\text{WA}) = 2.118 \pm 0.042 \text{ GeV}$$

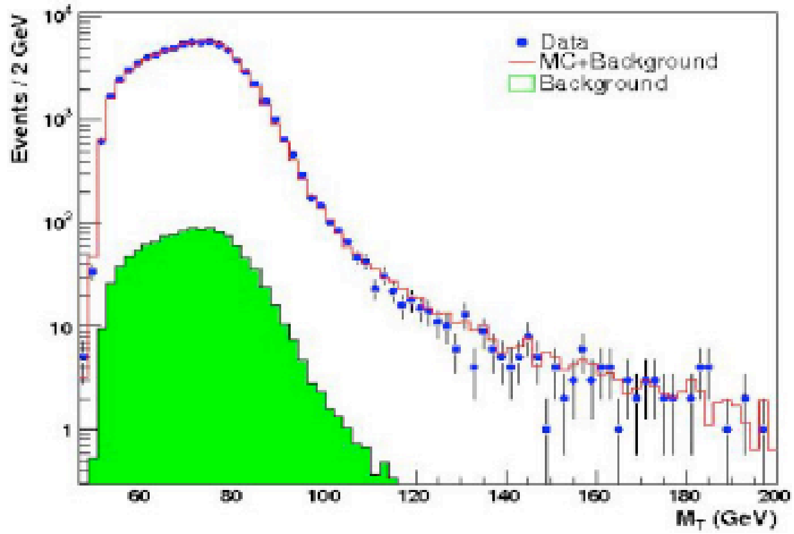


# D0: Direct measurement of $\Gamma_W$

## DØ: $W \to e\nu$ (177 $pb^{-1}$)

– Fit the transverse mass distribution in the region $100 < M_T(W) < 200$ GeV
  - 625 candidates in this range




## Main systematic uncertainties

– Hadronic response and resolution ~ 64 MeV

– Underlying event ~ 47 MeV

– EM resolution ~30 MeV

# W charge asymmetry

$$A(y_W) = \frac{d\sigma(W^+)/dy_W - d\sigma(W^-)/dy_W}{d\sigma(W^+)/dy_W + d\sigma(W^-)/dy_W}$$

$$A(y_W) \approx \frac{u(x_1)d(x_2) - d(x_1)u(x_2)}{u(x_1)d(x_2) + d(x_1)u(x_2)}$$

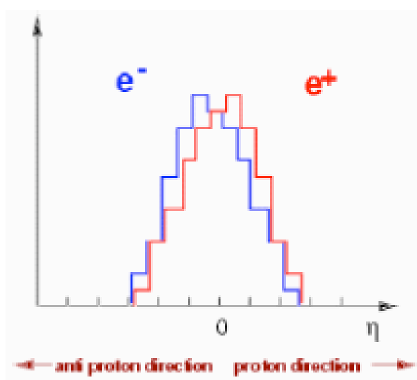
Rapidity charge asymmetry is sensitive to **d(x)/u(x)** ratio at high-**x** → primary interest of PDF fitters.

- cannot reconstruct $y_W$ directly
- measure charged lepton only

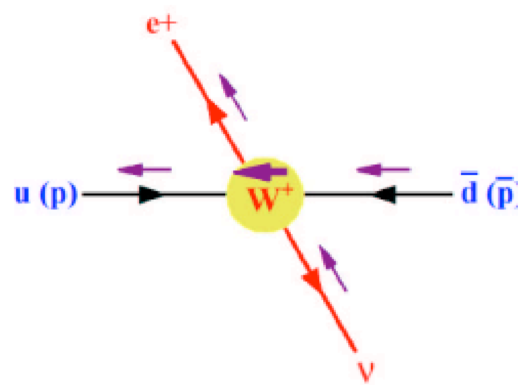
→

$$A(\eta_l) = \frac{d\sigma(l^+)/d\eta_l - d\sigma(l^-)/d\eta_l}{d\sigma(l^+)/d\eta_l + d\sigma(l^-)/d\eta_l}$$

$A(\eta_l) =$

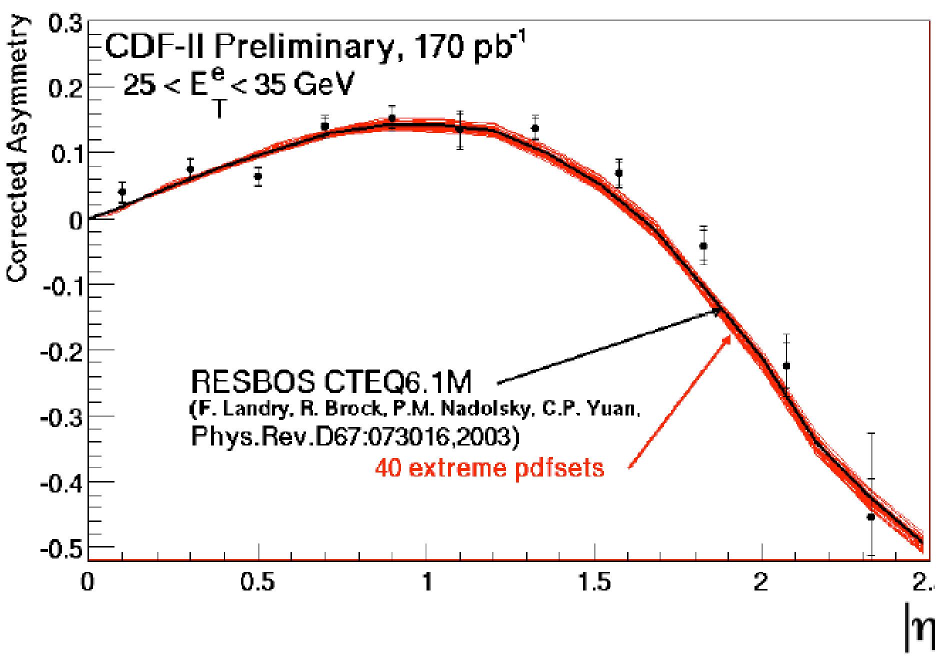



$\otimes$

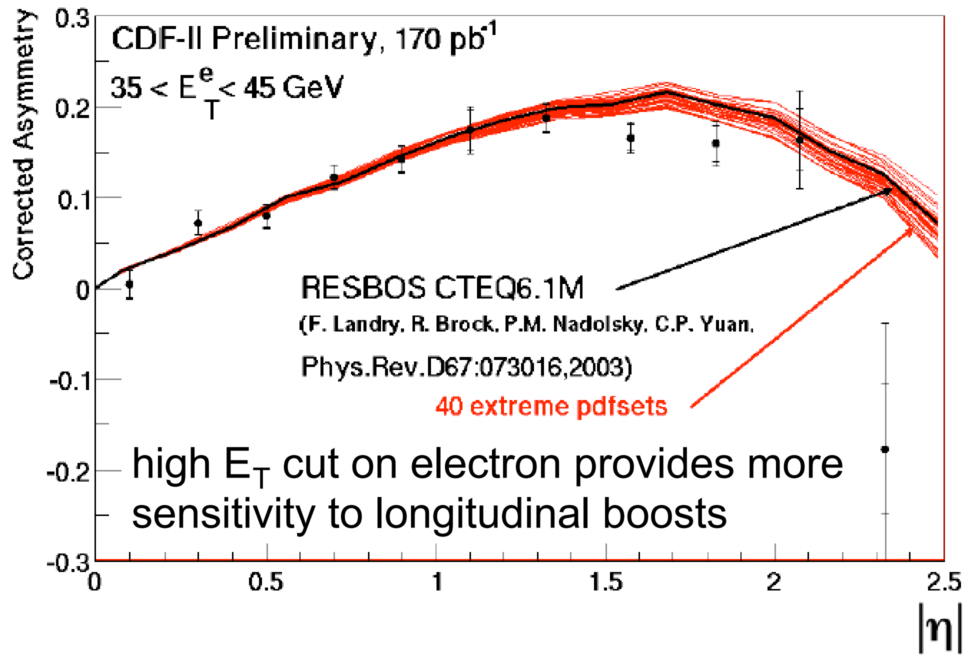


# CDF W asymmetry

**CTEQ6.1M with RESBOS at NLO**

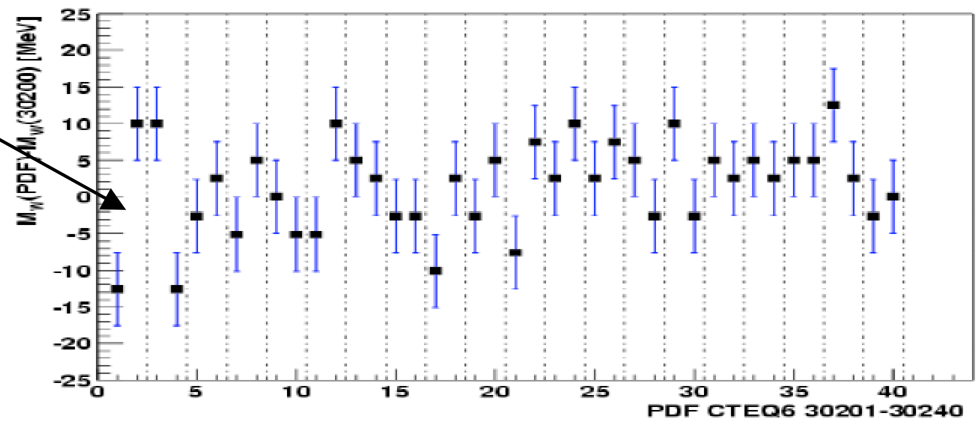



**CTEQ6.1M with RESBOS at NLO**



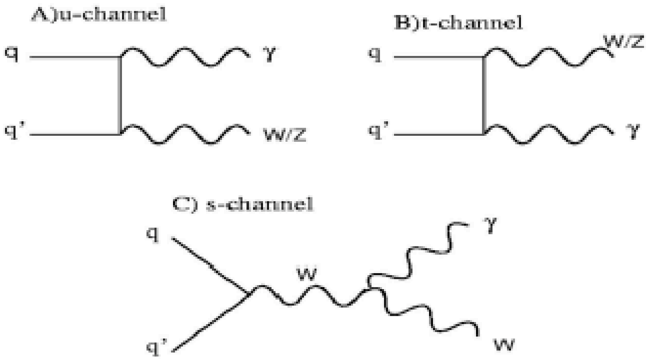

error pdf's that have largest impact on W mass uncertainty also cause large deviations at high η

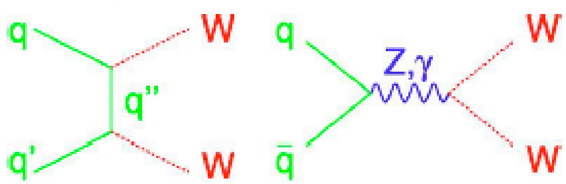
probe u and d valence dists



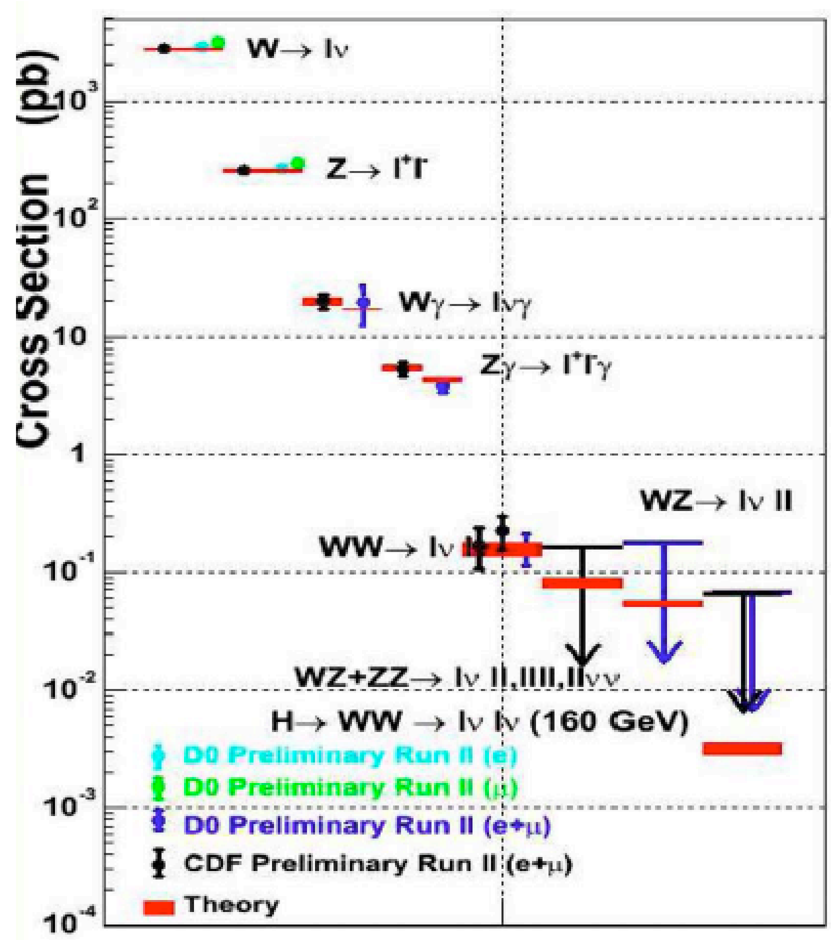
# D0: diboson final states

small cross sections
($10^{-2}$ to $10^{-3}$ of single boson)
analyses limited by statistics



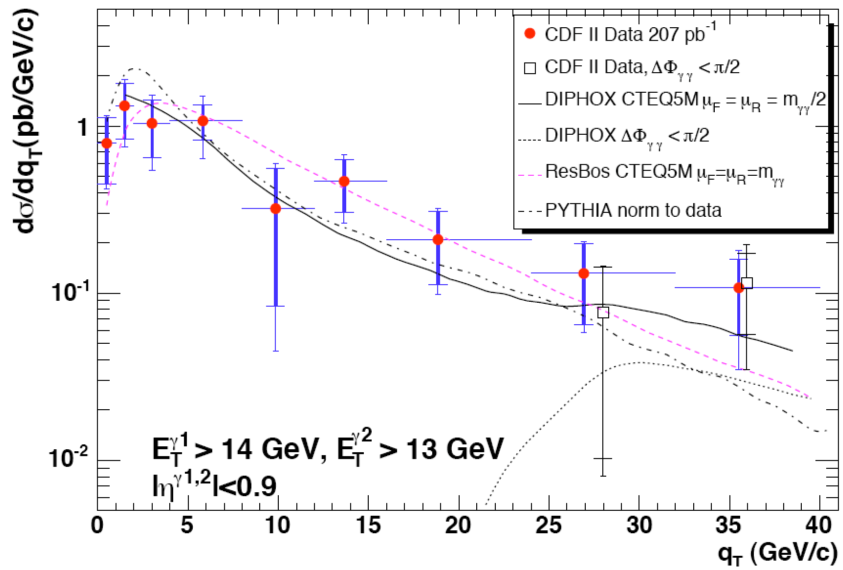

Results provided (with 200-300 $pb^{-1}$):
Wγ (hep-ex/0503048, PRD),
Z γ, ZZγ, Zγγ (hep-ex/0502036, PRL),
WW (PRL 94, 151801 (2005) ) and
WZ (hep-ex/0504019, PRL)
⇒ agreement with SM
and limits on anomalous couplings

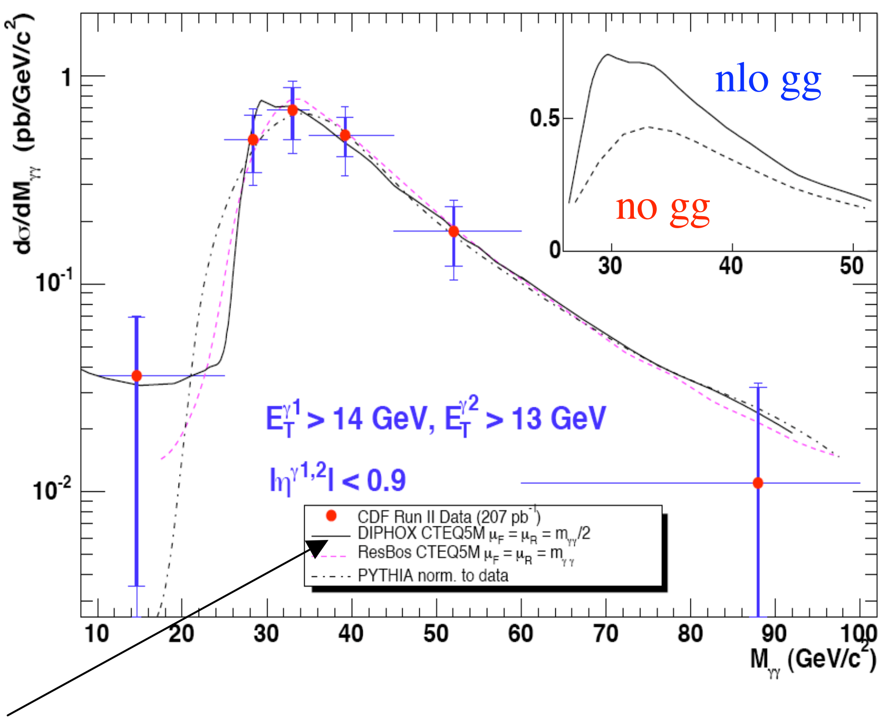


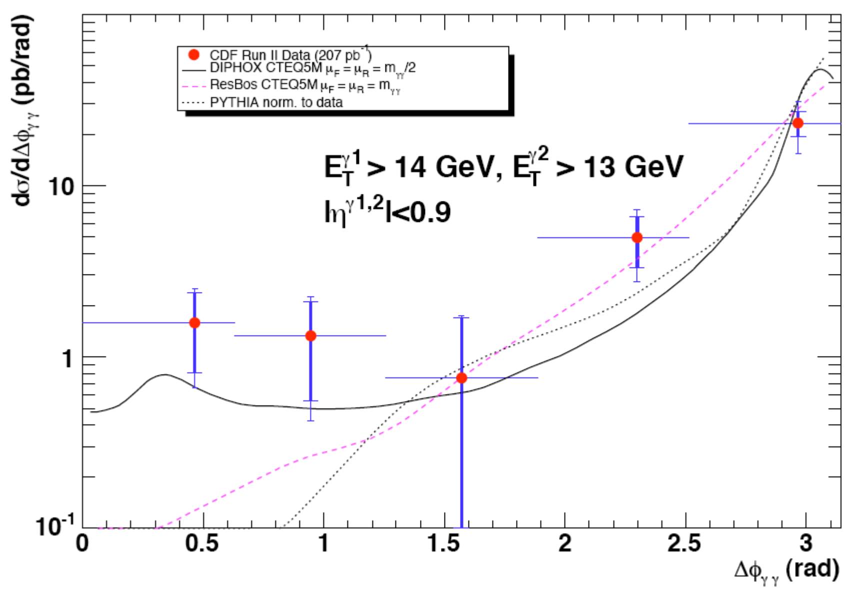

Daniel Bloch / IReS-Strasbourg

# CDF Diphotons in Run II

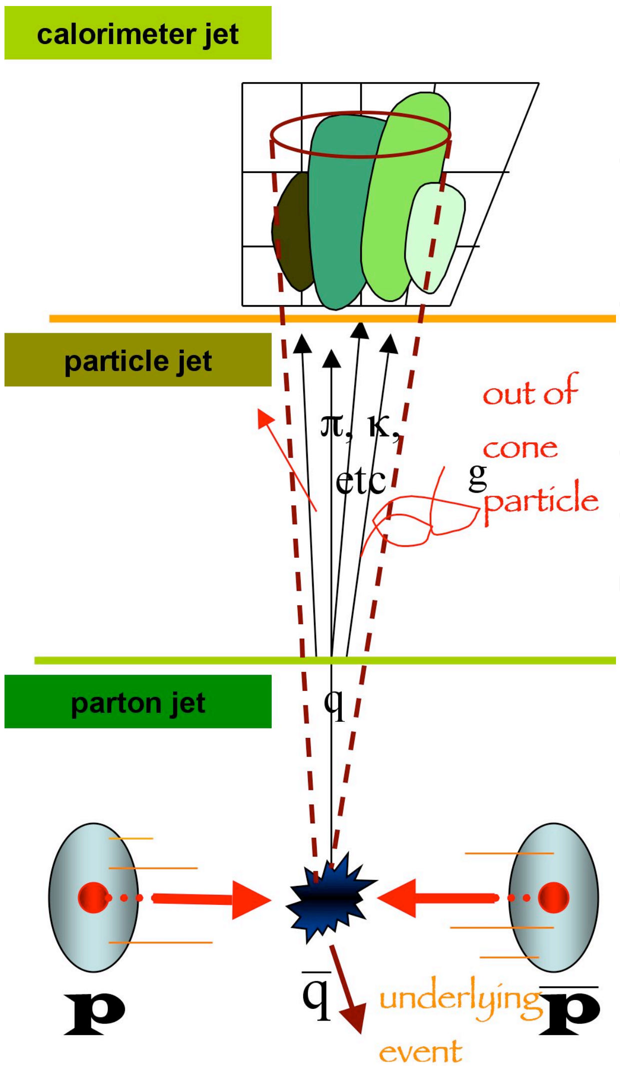
- small $q_T$, large $\Delta\phi$: effects of gluon resummation evident
- large $q_T$, small $\Delta\phi$: NLO fragmentation important

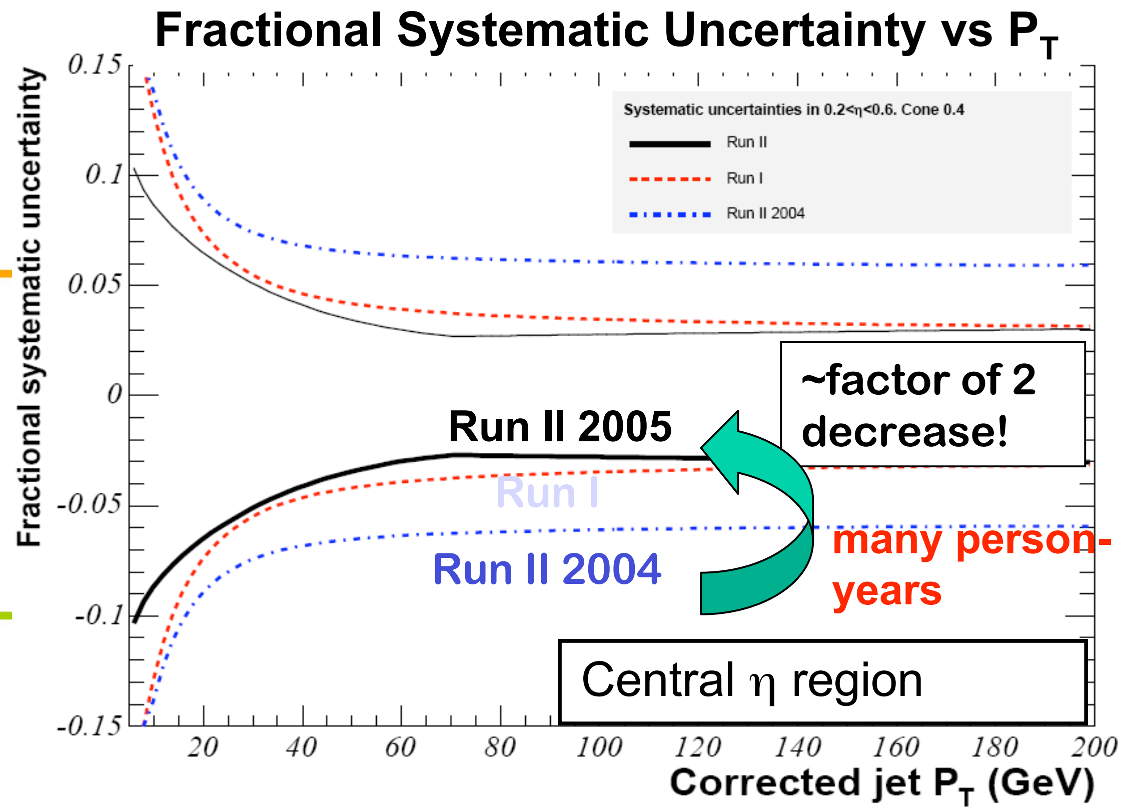


# CDF Jet Energy Scale: New

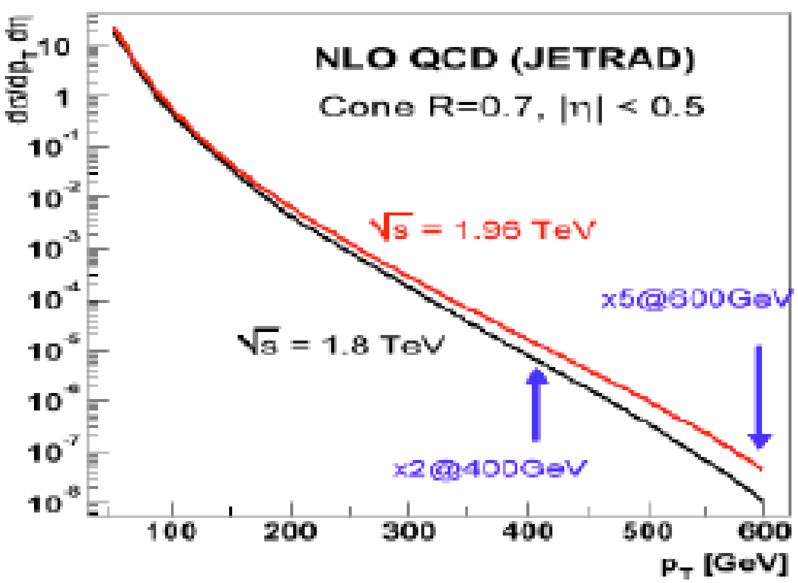


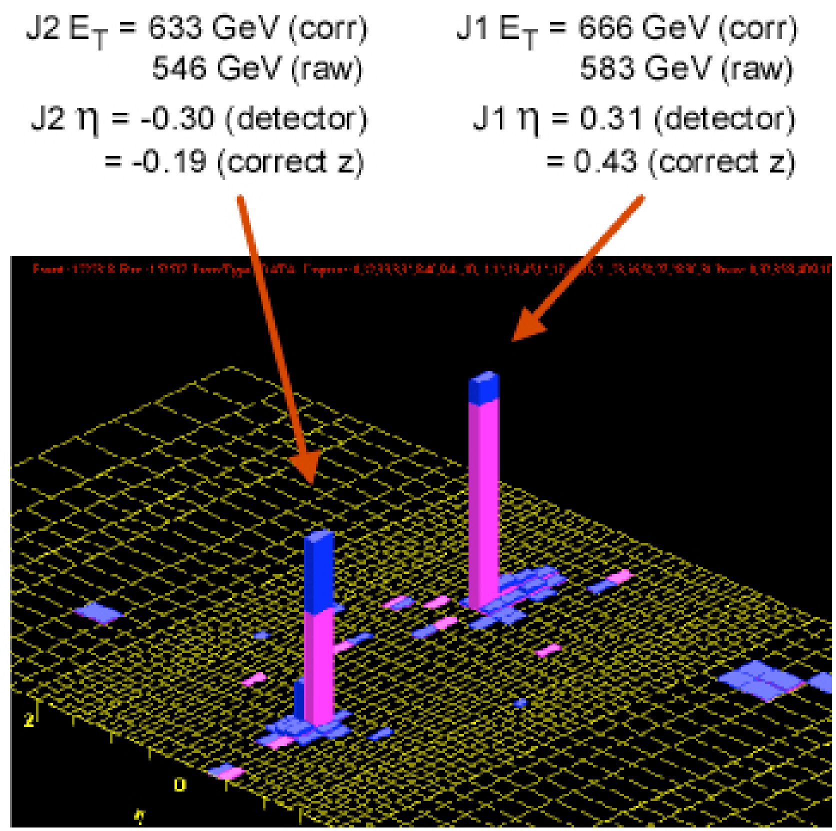




have to correct calorimeter energy depositions for detetector, algorithm and physics effects to obtain "true" jet energy

# Inclusive Jet Production

- Nowhere is the increase in center-of-mass energy more appreciated




CDF Run 2 Preliminary

# Jet algorithms

- Run II analyses in CDF use both cone and $k_T$ jet algorithm
  - CDF has used both JetClu (Run I) and midpoint (Run II) cone algorithms

midpoint improves perturbative behavior

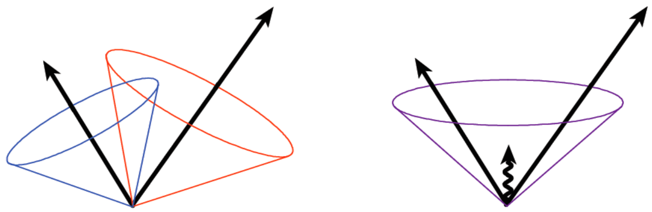
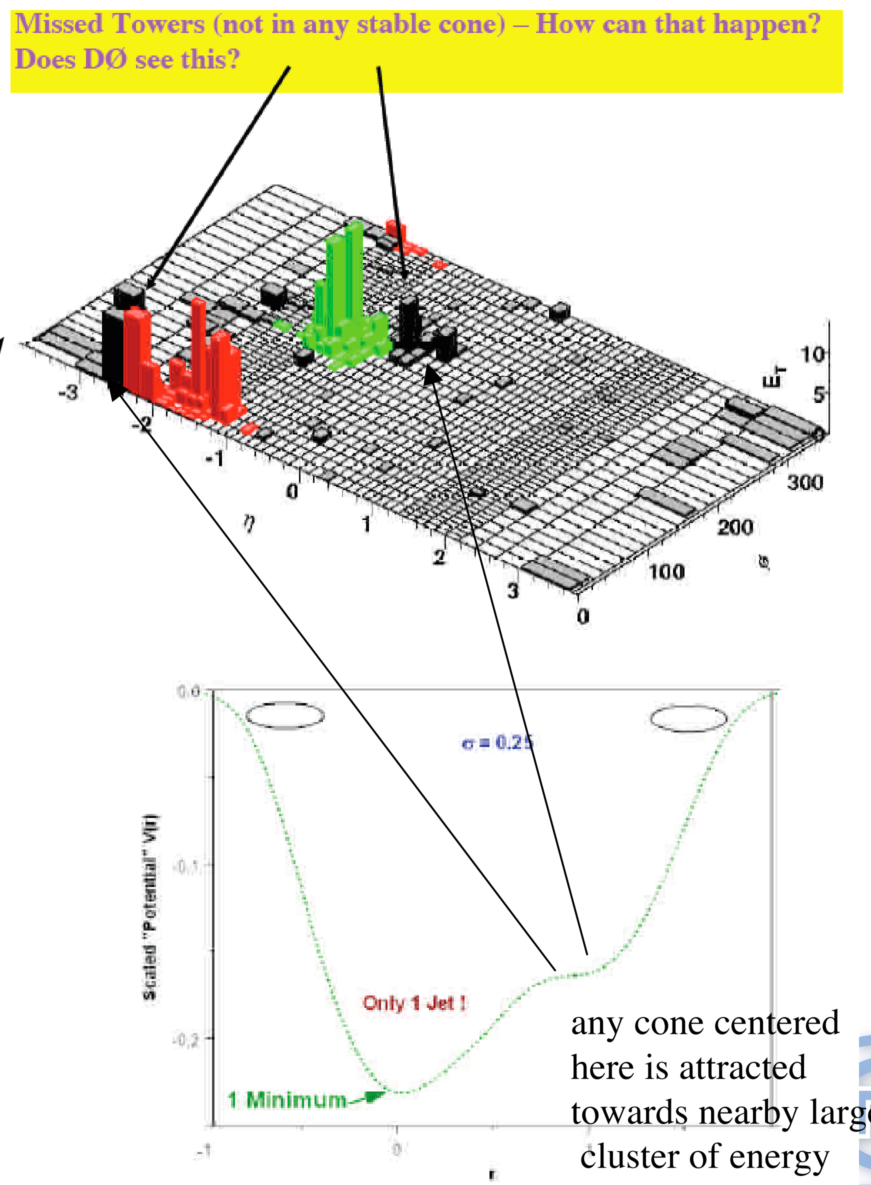


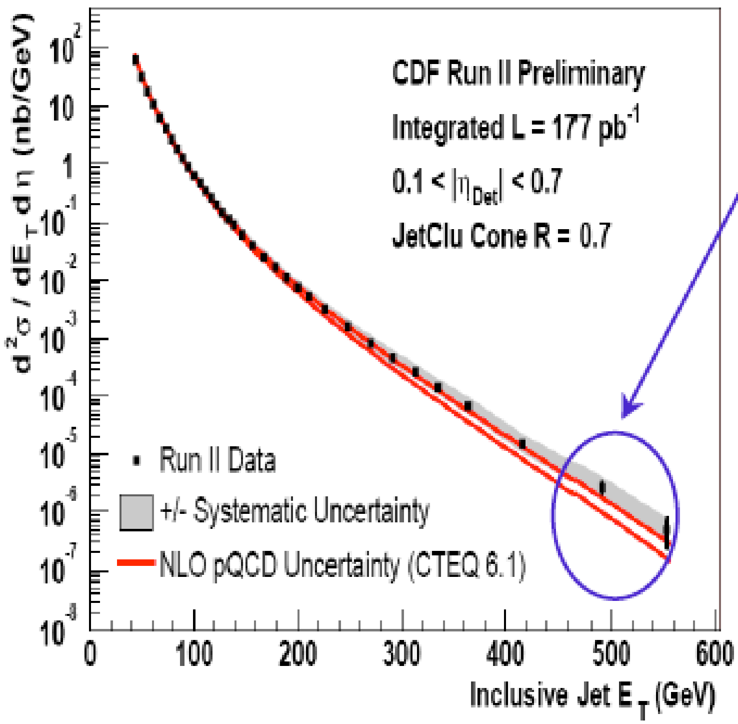
FIG. 1: Two partons in two cones or in one cone with a (soft) seed present.

- subtle issues regarding use of cone algorithms at hadron colliders
  - see hep-ph/0111434, S. Ellis, J. Huston, M. Tonnesmann, *On Building Better Cone Jet Algorithms*
  - under study in both Tevatron and LHC experiments as part of TeV4LHC workshop (and Les Houches)



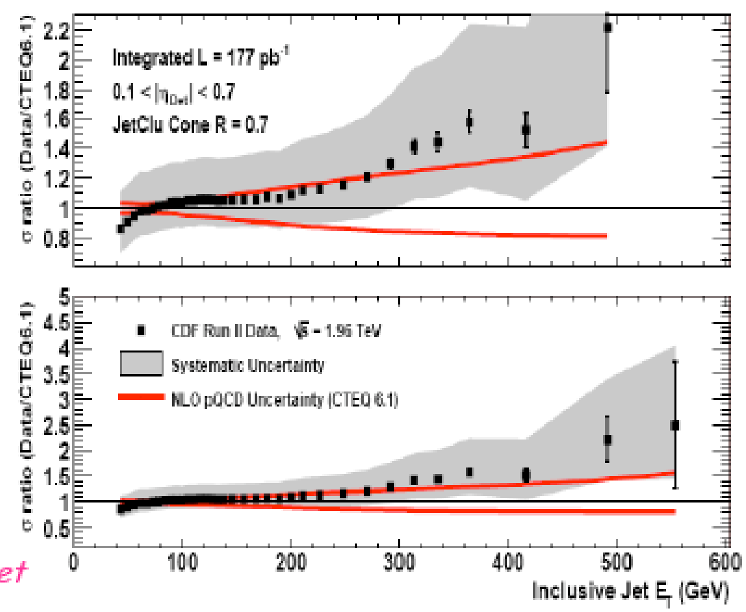
# CDF: old cone results

…working on blessing midpoint results (corrected to parton level) with ~380 $pb^{-1}$




- Using Run I cone algorithm & unfolding $E_T^{jet}$ range increased by ~150 GeV
- Comparison with pQCD NLO (JETRAD) (over almost nine orders of magnitude)

Shape of Data/NLO to be understood

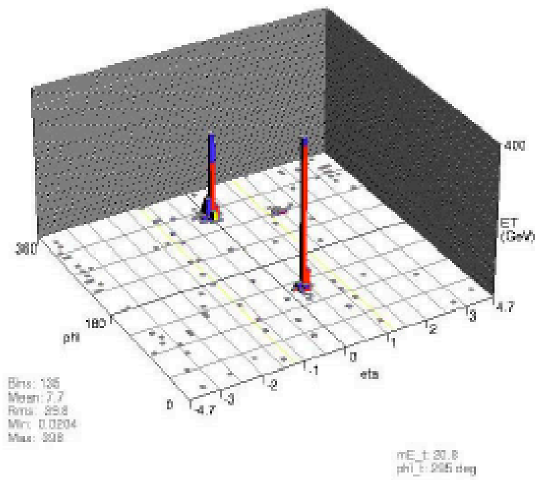


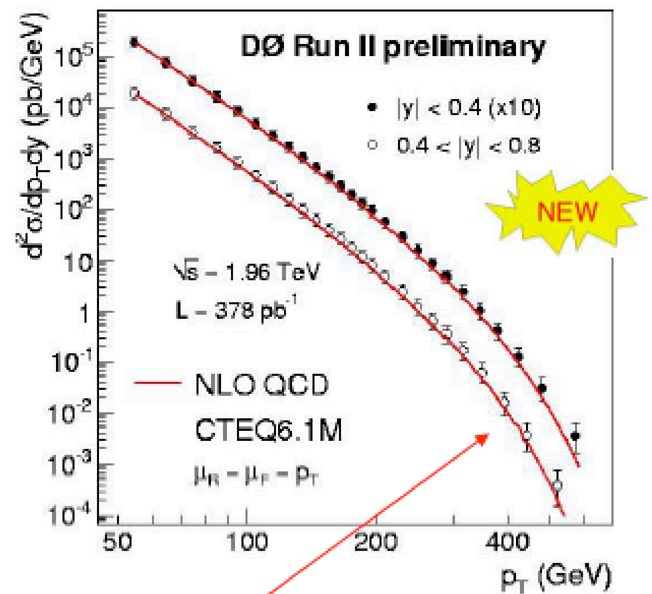

Data dominated by jet energy scale
NLO error mainly from gluon at high x

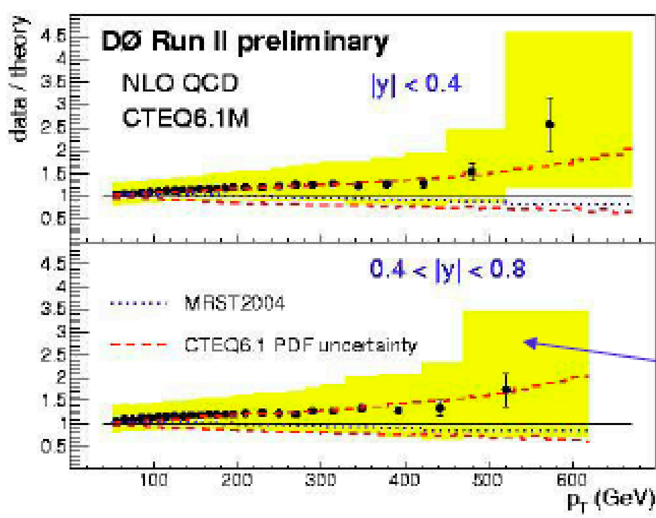
No hadronization corrections applied to NLO prediction → relevant @ low $E_T^{jet}$

# D0: central jet cross section (cone)

## QCD: central jet inclusive cross section



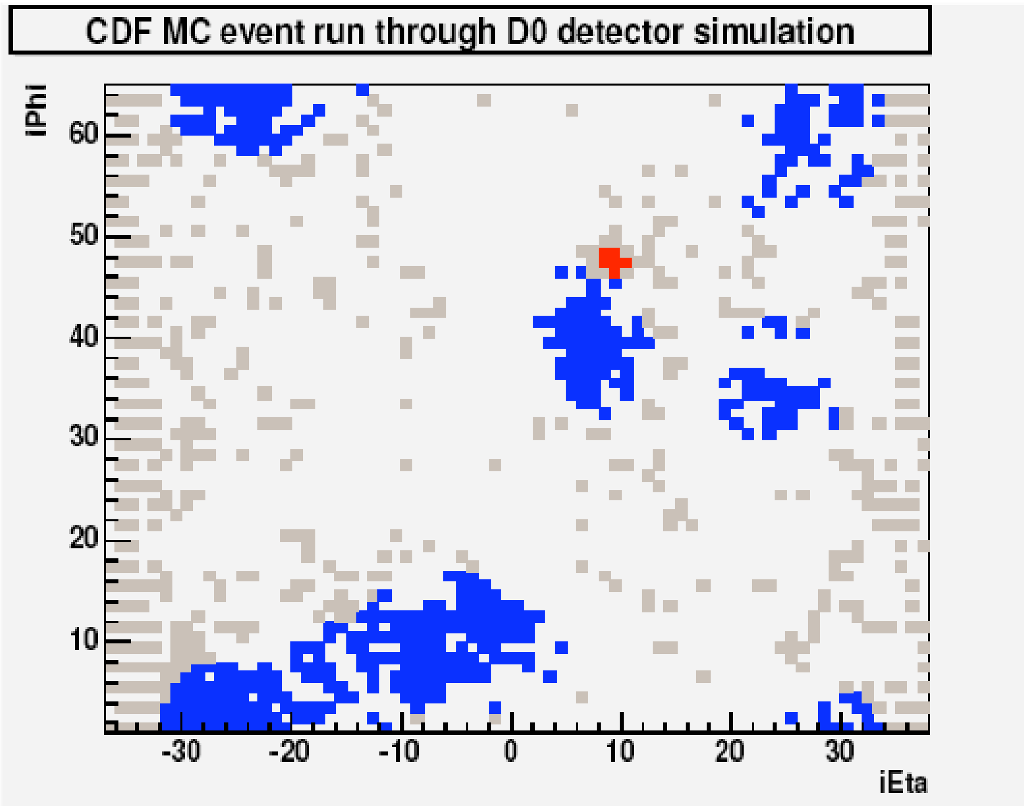



- good agreement with NLO QCD over 8 orders of magnitude
- exp. systematics dominated by jet energy calibration

# D0 study: Zbenek Hubacek

- To address CDF observation of unclustered $E_T$

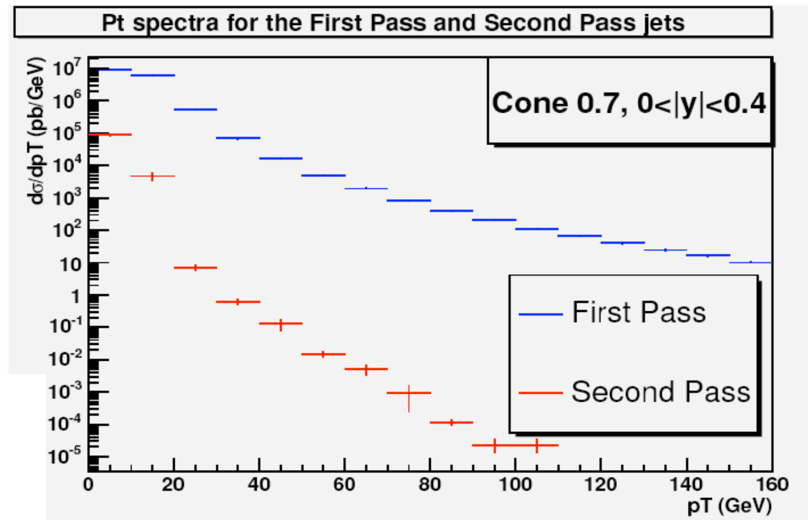



- RunII cone $R = 0.7$
- **Jet** towers
- **Unclustered** towers $pT < 2GeV$
- **Unclustered** towers $pT > 2GeV$

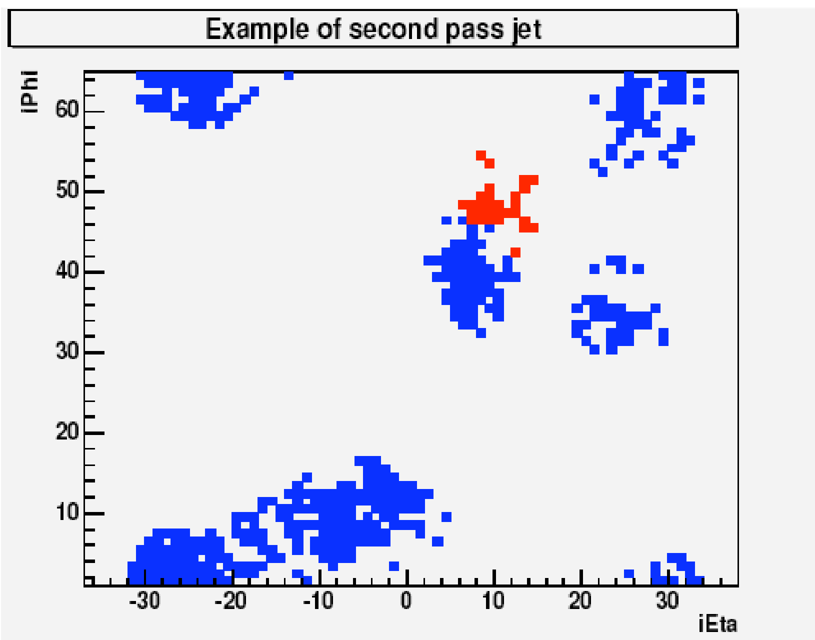
**We see it too!**

# D0 study

- After first iteration of jet-finding algorithm, remove found-jet towers and re-run jet clustering algorithm




Contribution to the cross-section is negligible




The unclustered energy made a second pass jet!

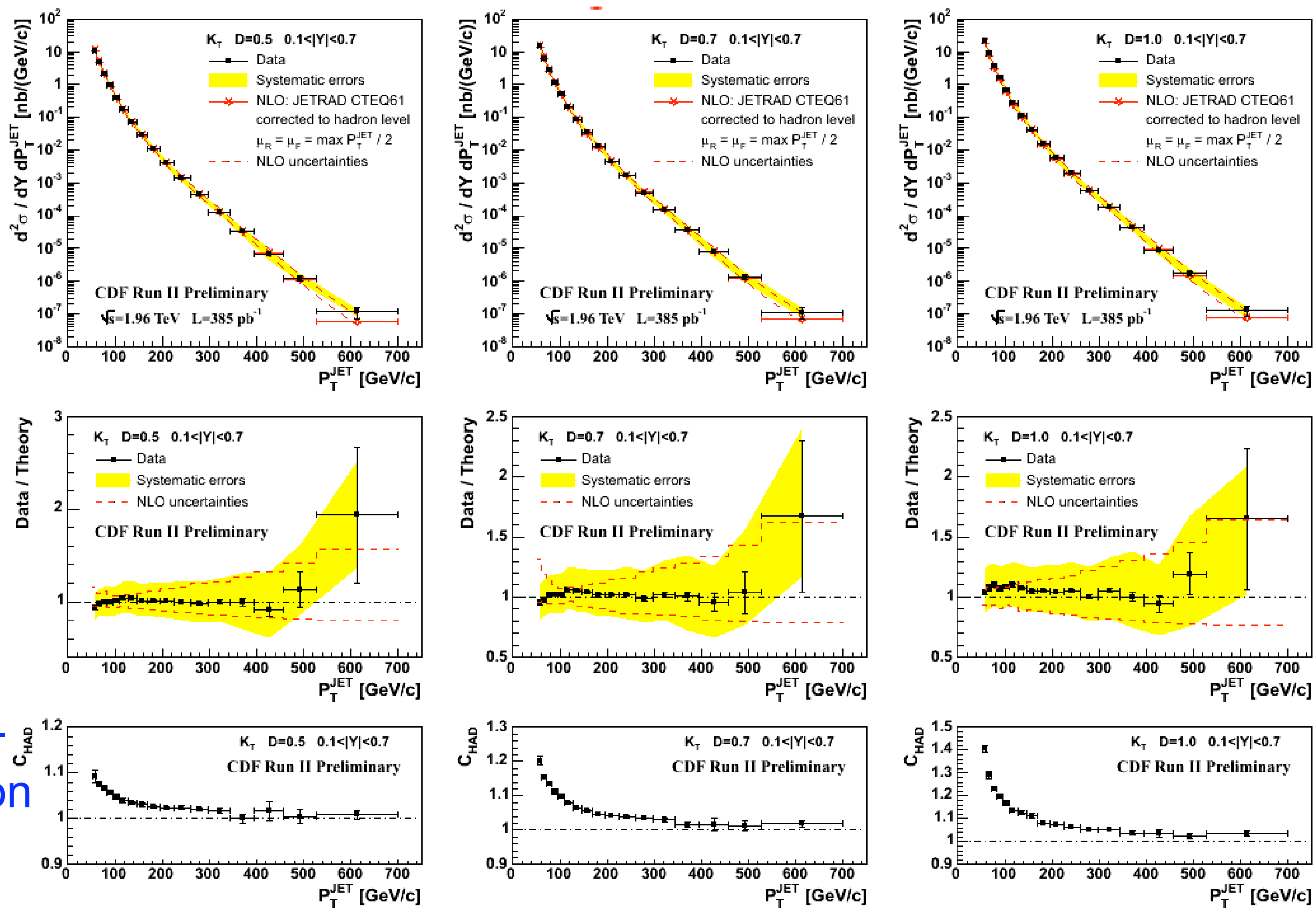
…but if unclustered energy is added to first pass jets (as is done for the modified CDF midpoint algorithm), contribution is not negligible

- NLO theory is agnostic on this point
- MC@NLO (with inclusive jet production) is not

# CDF: $k_T$ jet cross section results

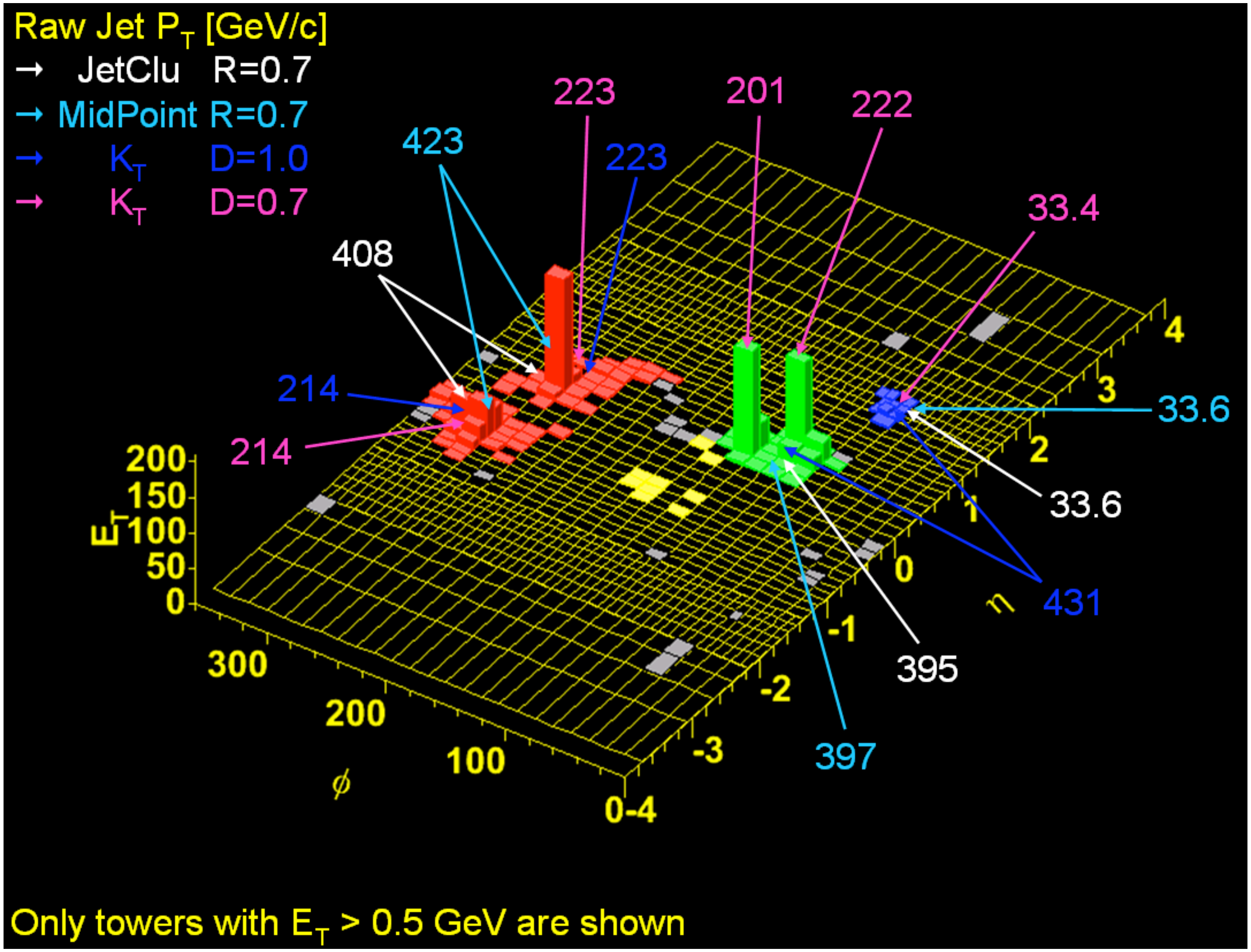
$$d_{ij} = \min(P^2_{T,i}, P^2_{T,j}) \frac{\Delta R^2}{D^2} \qquad d_i = (P_{T,i})^2$$

$k_T$ algorithm seems to work well at a hadron collider




underlying + hadronization correction

# Interesting event to study algorithm differences




…project in TeV4LHC to examine what different experimental algorithms (CDF, D0, ATLAS CMS) do with *interesting* events

# QCD ≠ SM

- In a recent paper (hep-ph/0503152), Stefano Moretti and Douglas Ross have shown large 1-loop weak corrections to the inclusive jet cross section at the Tevatron
- Up to 20% effect at the Tevatron
  - impact on pdf's and high x gluon?
- Effect goes as $\alpha_W \log^2(E_T^2/M_Z^2)$
  - may be substantially larger for high $E_T$ jets at the LHC
- Other (unsuspected) areas where weak corrections are important?

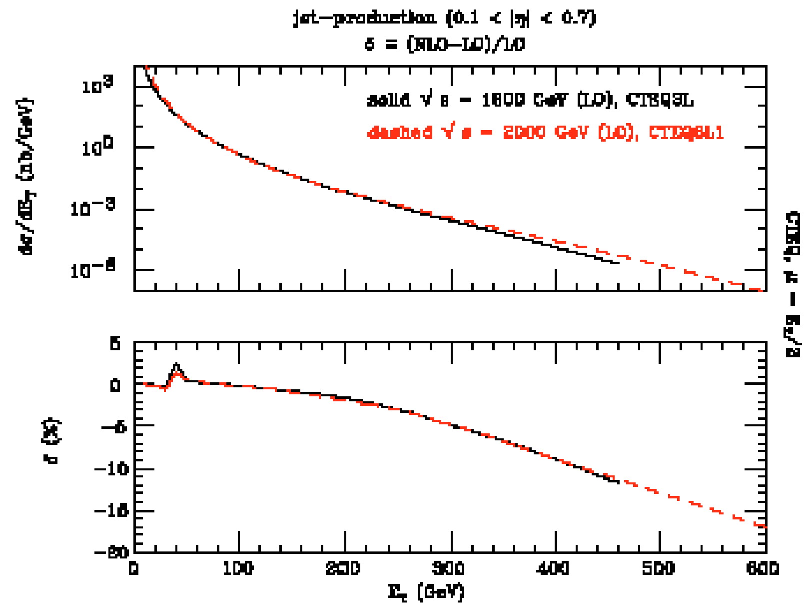



FIG. 1. The effects of the $\mathcal{O}(\alpha_S^2\alpha_W)$ corrections relative to the LO results for the case of Run 1(Run 2) in the presence of PDFs preceding(following) the gluon re-parameterisation at medium/large Bjorken $x$, CTEQ3L(CTEQ6L1) [26]([21]). They are plotted as function of $E_T$ for a choice of $\mu$. The cut $0.1 < |\eta| < 0.7$ has been enforced, alongside the standard jet cone requirement $\Delta R > 0.7$.

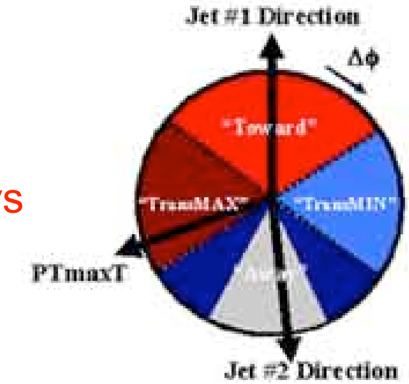
real W's and Z's as part of high $p_T$ jets?

This is a subject I would like to understand more of during Les Houches.

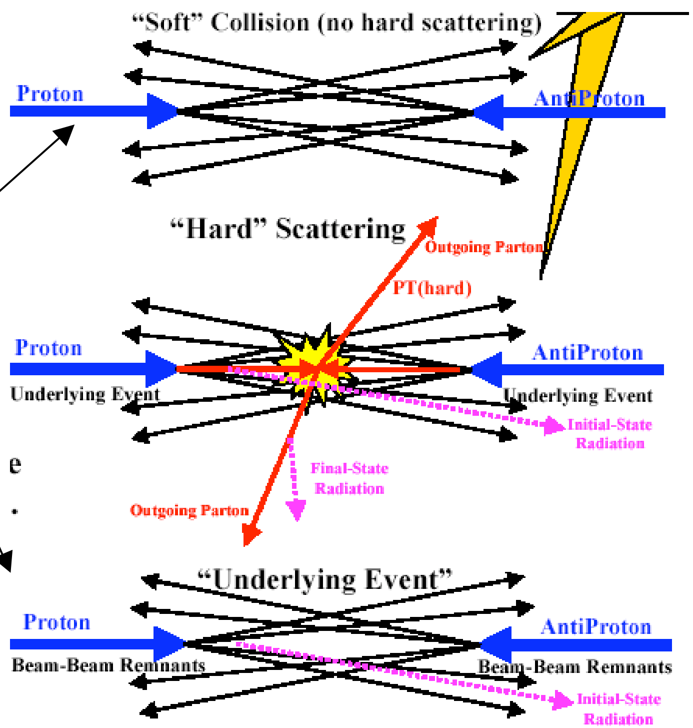
# Importance of underlying event

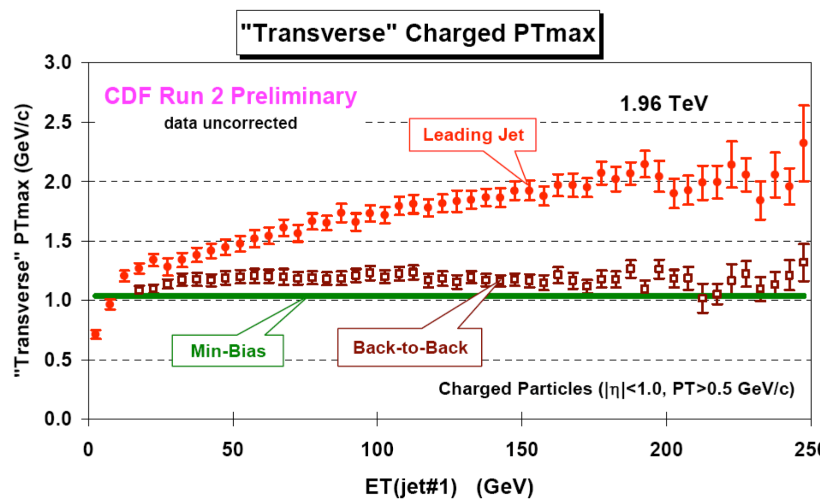
- Have to subtract underlying event from hard scatter in order to compare jet cross sections to parton-level calculations

$\Sigma p_T$ in max region increases as jet $E_T$ increases
$\Sigma p_T$ in min region stays flat, at level similar to min bias




how similar are these two?

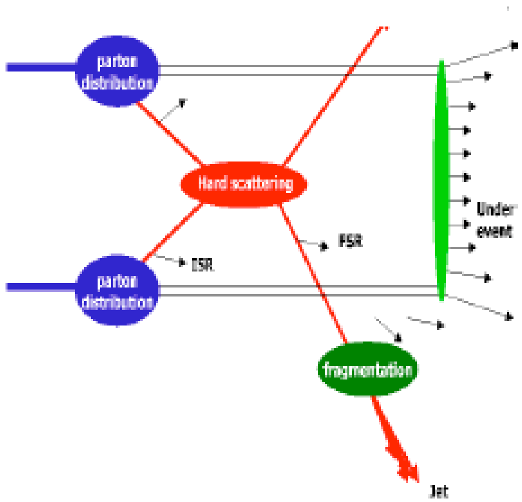


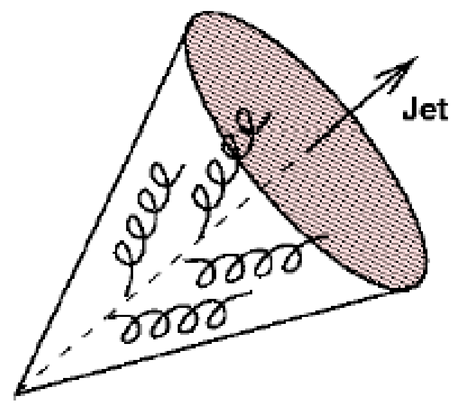



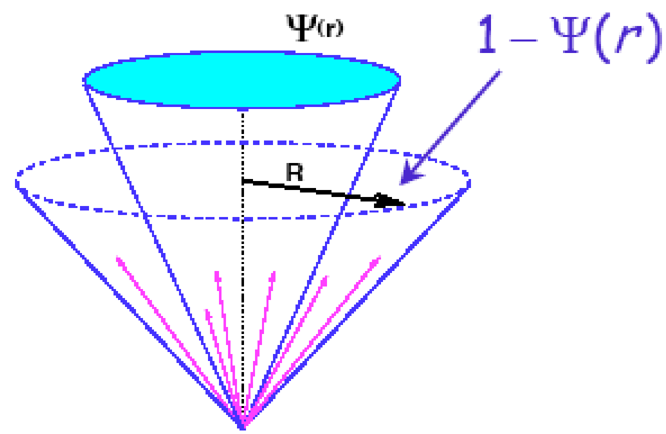

need inclusive jet production in MCatNLO->a TeV4LHC/Les Houches project

…a Tev4LHC project

# CDF:Jet Fragmentation



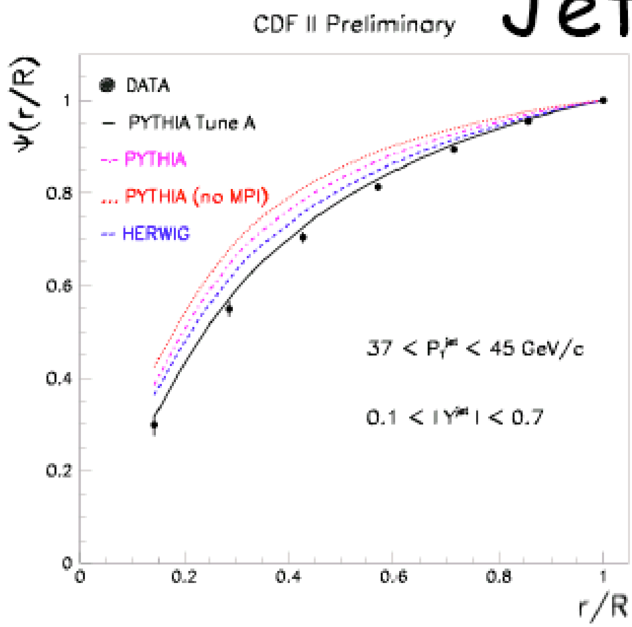



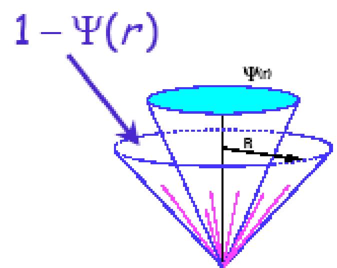

- Jet shape dictated by multi-gluon emission form primary parton
- Test of parton shower models and their implementations
- Sensitive to quark/gluon final state mixture and run of strong coupling
- Sensitive to underlying event structure in the final state

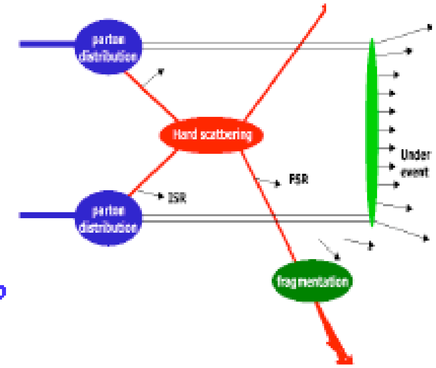
$$\Psi(r) = \frac{1}{N_{jets}} \Sigma_{jets} \frac{P_T(0,r)}{P_T^{jet}(0,R)}$$

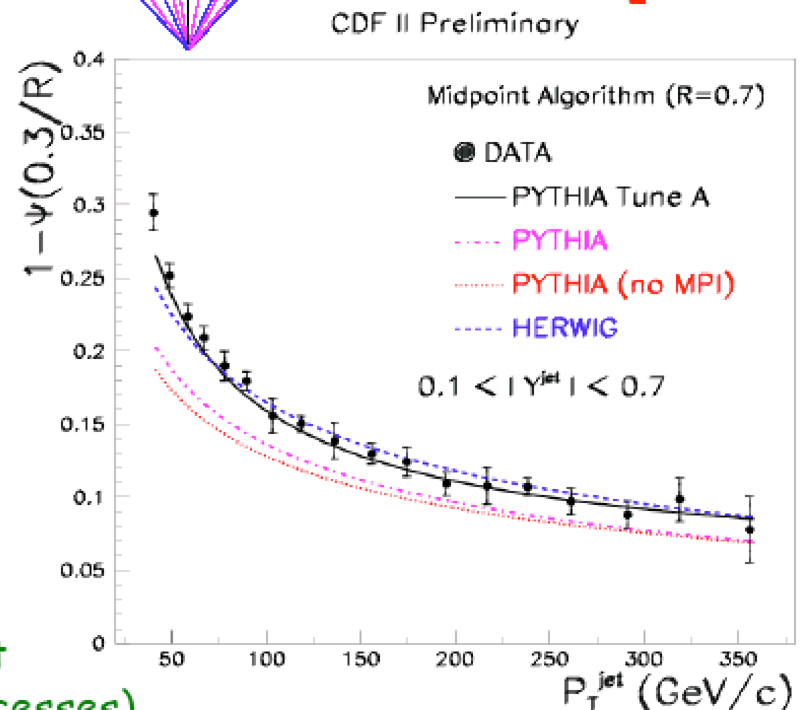
# Jet Fragmentation

## Jet shapes




- PYTHIA Tune A describes the data (enhanced ISR + MPI tuning)
- PYTHIA default too narrow
- MPI are important at low Pt
- HERWIG too narrow at low Pt

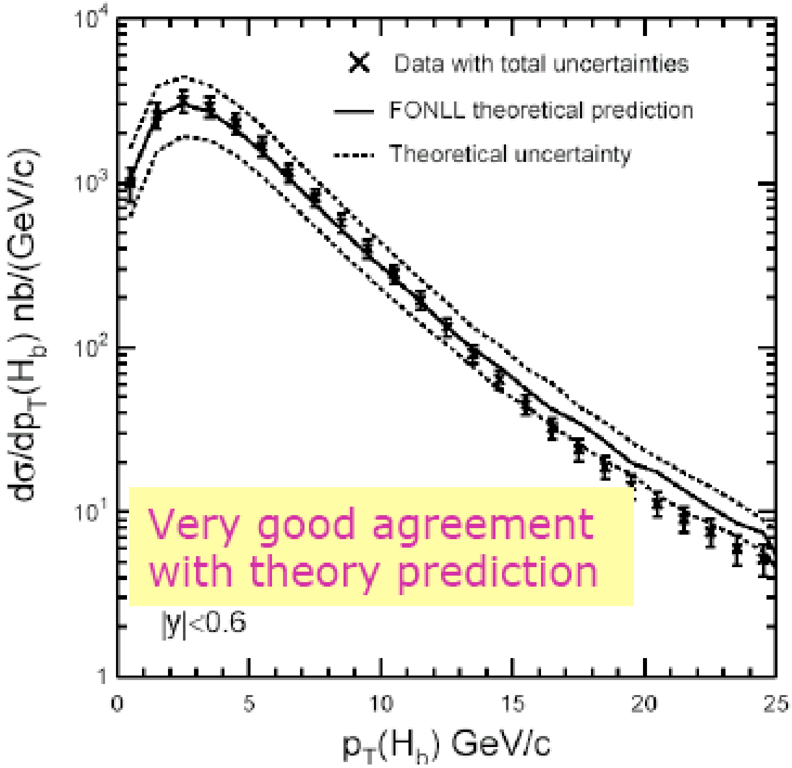
We know how to model the UE at 2 TeV (at least for QCD jet processes)

# CDF: B-hadron production

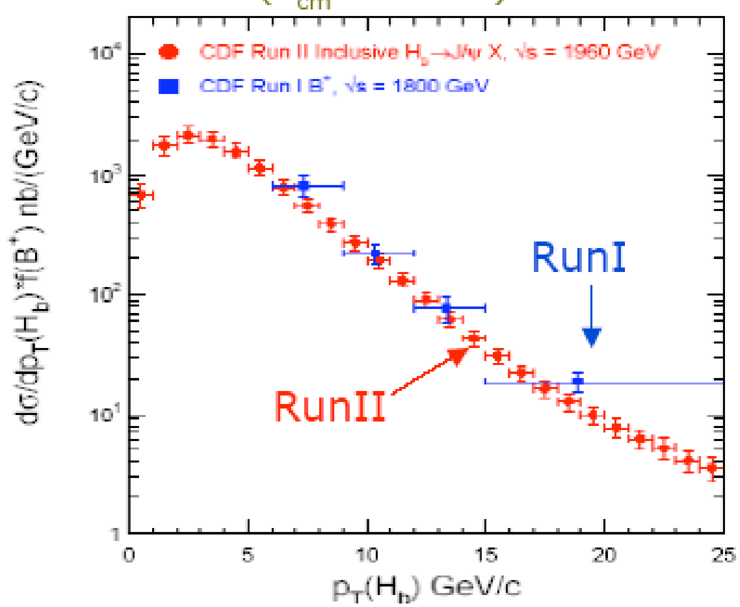
Total inclusive single b-hadron ($H_b$) cross section

$$\sigma(p\bar{p} \rightarrow H_b X, |y| < 0.6) = 17.6 \pm 0.4(stat)^{+2.5}_{-2.3}(syst)\ \mu\text{b}$$

considering $Br(H_b \rightarrow J/\psi X) = 1.16 \pm 0.10\%$ and $Br(J/\psi \rightarrow \mu\mu) = 5.88 \pm 0.10\%$

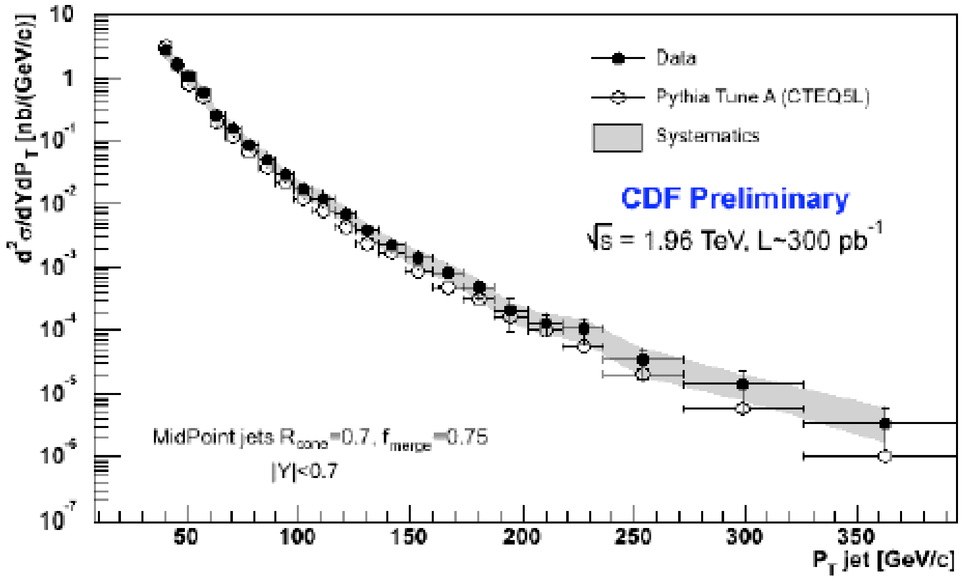



comparison with RunI data $|y(H_b)| < 1$, σ(RunII) multiplied by $B^+$ fragmentation=0.4 ($E_{cm}$ rescaled)



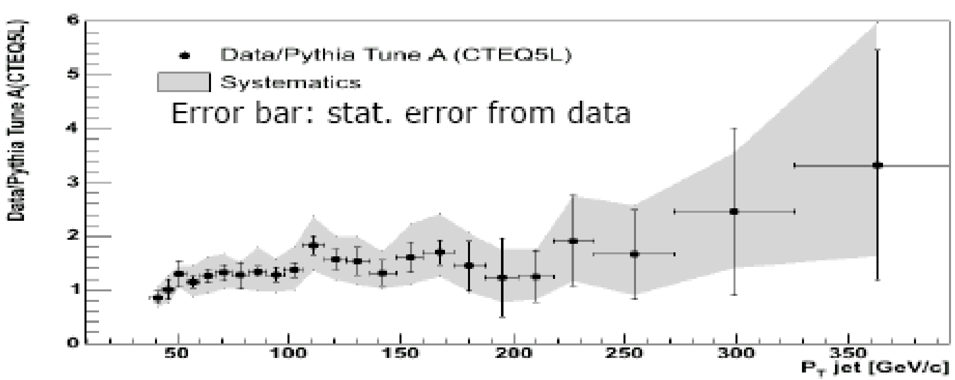
# CDF: b-jet production

use displaced tracks inside jet to tag heavy flavor; use secondary vertex mass to extract b fraction.




b-jet cross section as function of jet $p_T$ (Range 38-400 GeV/c)

| Systematic Error | low $P_T$ | high $P_T$ |
|---|---|---|
| Luminosity | 6% | 6% |
| Absolute Energy Scale | 15-20% | 40% |
| Jet energy resolution | 6% | 6% |
| B-tagging efficiency | 10% | 15% |
| B-tagged jets fraction | 10-15% | 40% |
| Unfolding | 8% | 8% |

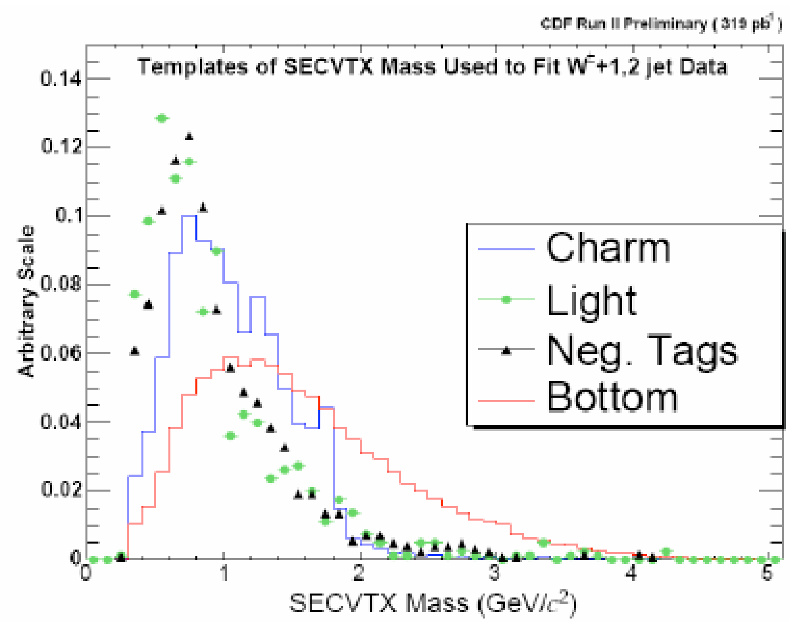



No comparison with NLO yet

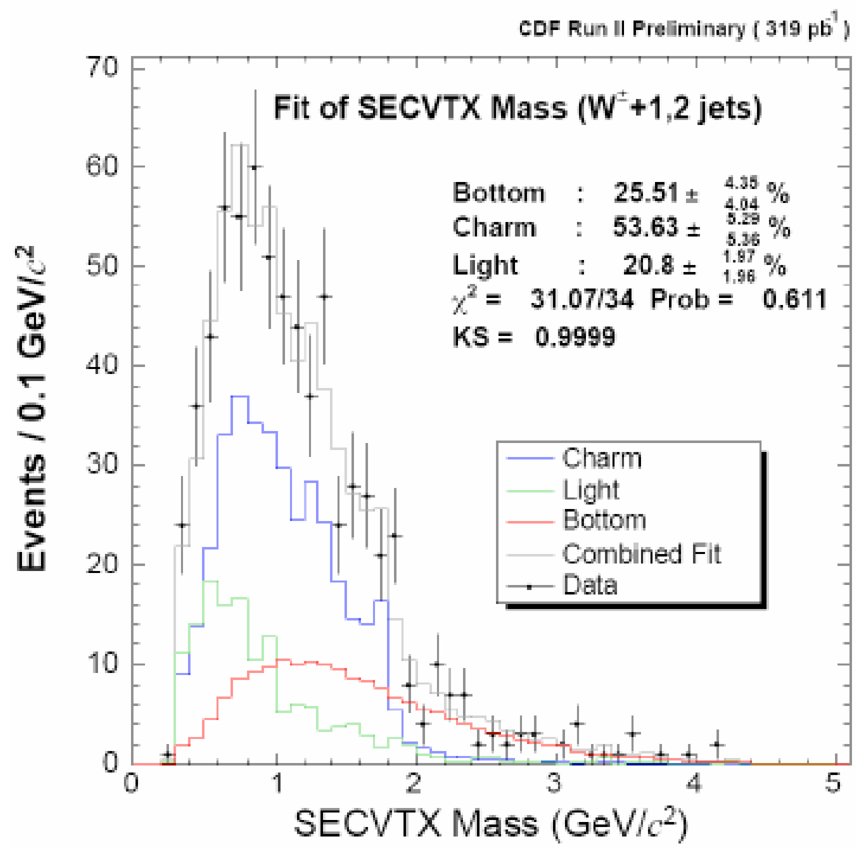
Data/Pythia Tune A ~ 1.4
in agreement
with expectations

# CDF: W+bb/W+j/jj

- Use secondary vertex mass to tag heavy flavor

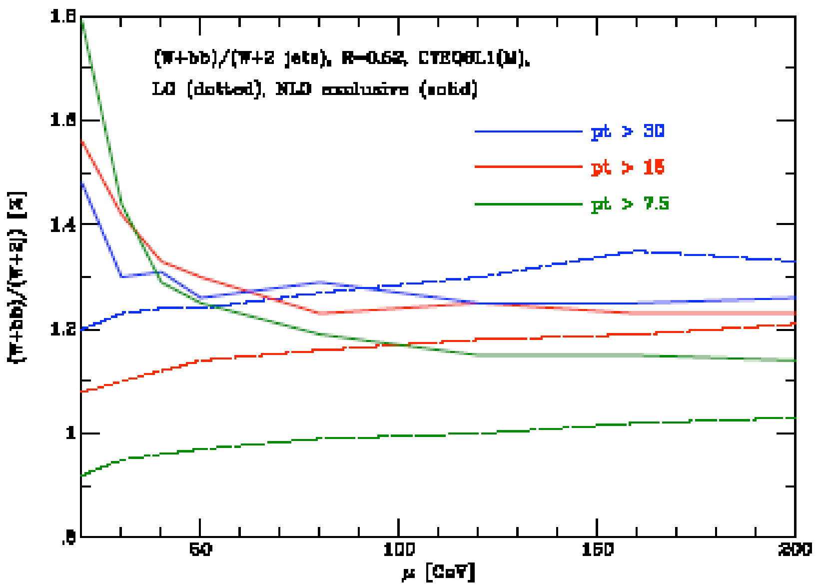



– Observed rate W+bb)/W+j,jj = 0.0072±0.0024(stat.)±0.0022(syst.)



# MCFM prediction for Wbb/Wjj

- At NLO, ratio is stable across a wide range of scales.




- For a $p_T$ cut of $15$ GeV and $\mu \sim M_W$, we have:

$$\left[\frac{\sigma(Wb\bar{b})}{\sigma(W+2\text{ jets})}\right]_{LO} = 1.16\%, \qquad \left[\frac{\sigma(Wb\bar{b})}{\sigma(W+2\text{ jets})}\right]_{NLO} = 1.23\%$$

J. Campbell and J. Huston, hep-ph/0405276 [PRD70 094021 (2004)]

# Understanding 'Not-Top'

Steve Mrenna:

**Understanding $W$+Jets is Critically Important**

- Signature $Wb\bar{b} + X$ is common to unconfirmed Standard Model processes and many new physics processes

$$X \Rightarrow \text{many boxes}$$

- we "know" that Standard Model top is there, thus we can study Not-Top

$$\text{Top} \equiv \text{Data} - \text{Not-Top}$$

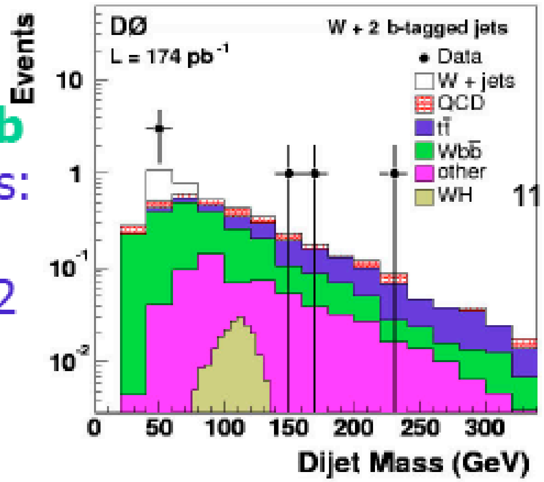
- Claim: understanding Not-Top is more important than understanding Top itself
  - Not-Top challenges our tools
  - Better tools = more challenging questions
- As JES uncertainty is reduced, understanding of Not-Top sets $\delta m_t$

A lot of work underway at CDF and in TeV4LHC on 'Not-Top'.

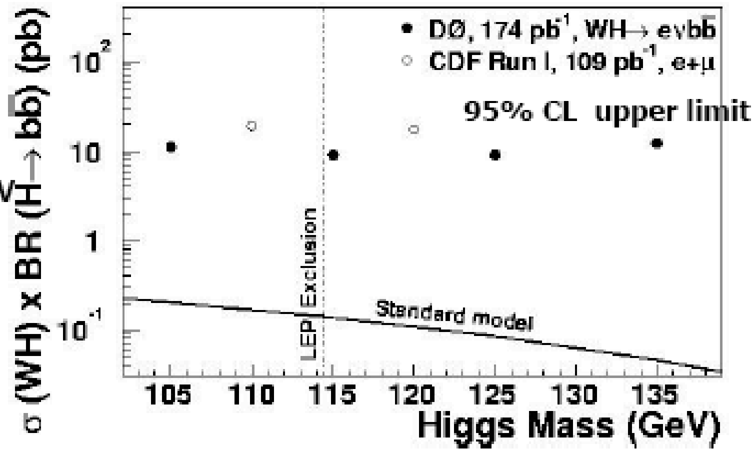
# D0: W/Zbb

PRL 94, 091802 (2005)

**W(→eν)+bb**
if 2 b-tag jets:
6 candidates
bkgd 4.4±1.2

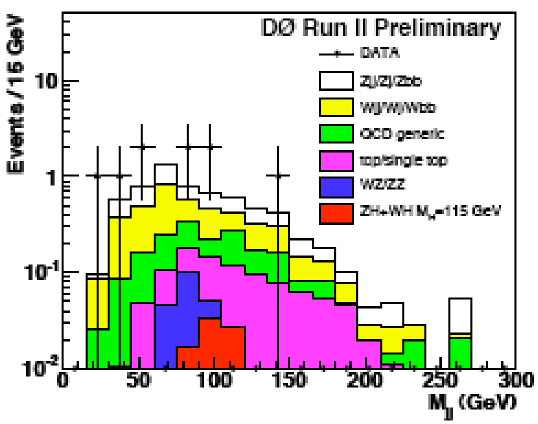


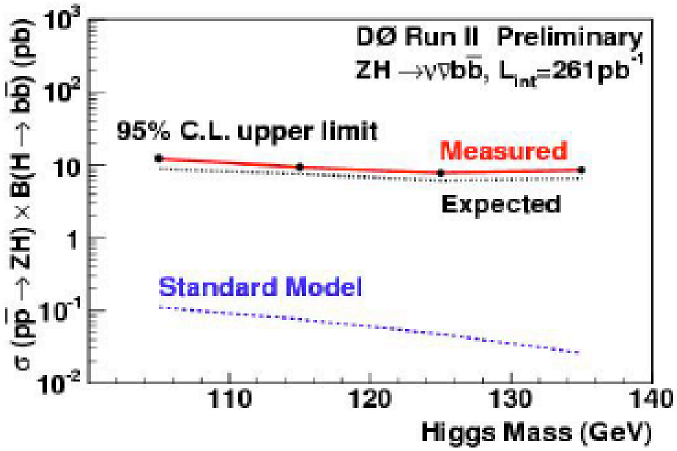

115 GeV




NEW

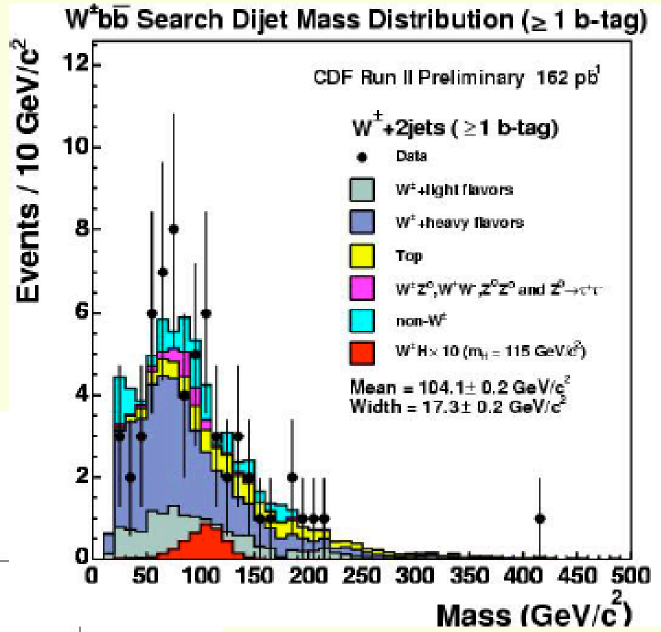
**Z(→νν)+bb**
if 2 b-tag jets:
9 candidates
bkgd 6.4±2.1

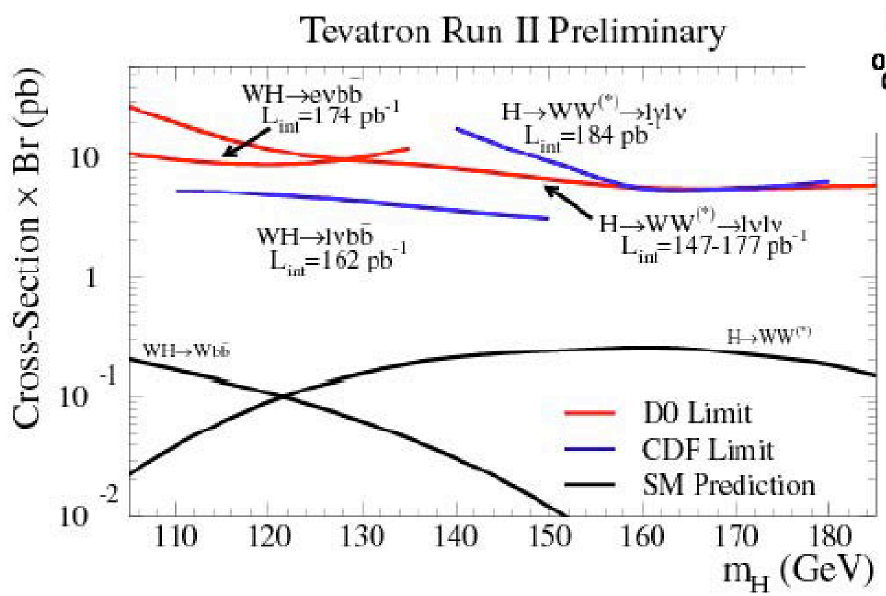


# Not-Top: Higgs searches

## Current status

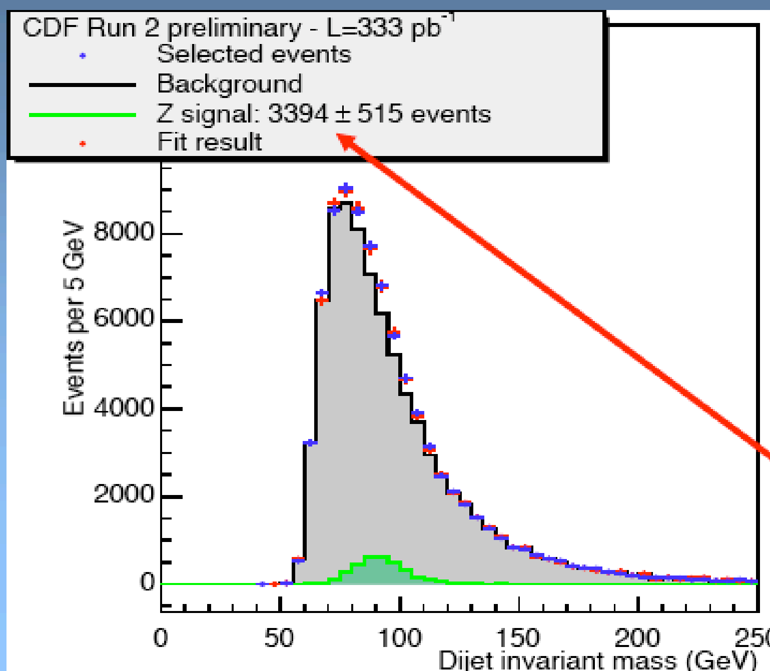


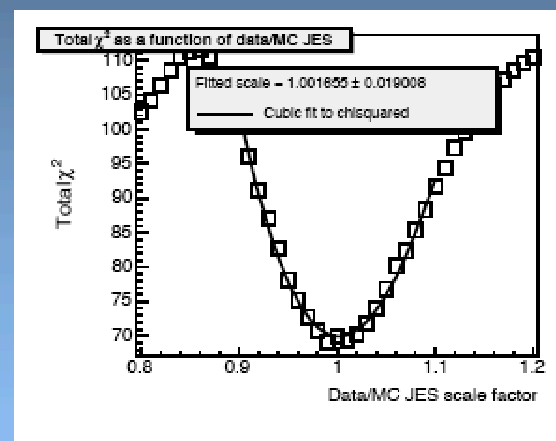



# CDF: Z->bb

## Fit and Data/MC Jet Energy Scale Factor

- ❑ We create **$Z \to bb$ signal templates with varying data/MC JES factors**
- ❑ We can then **fit the tagged data** to the sum of **background and signal templates**, for varying JES.
- ❑ The fit converges nicely and gives the JES and the **number of reconstructed Z's**



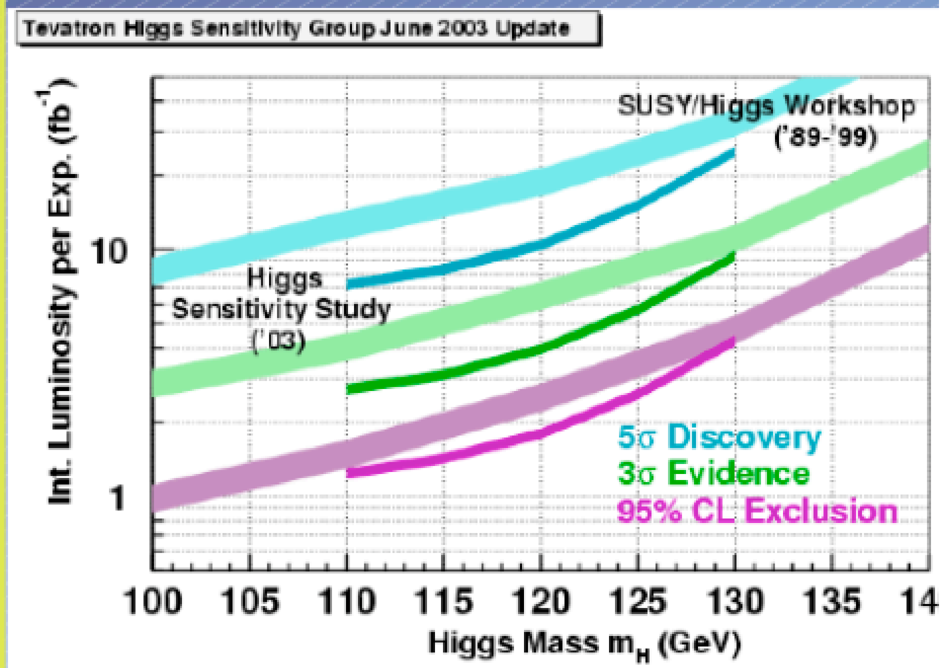

**Among 85,720 events selected ($L$=333pb$^{-1}$) CDF finds**
**3400 ± 500 év. $Z \to bb$ decays**

Julien Domini at TeV4LHC meeting

# Higgs searches

## Combined Results

- Combined DØ/CDF result
  - Assumes luminosity from two experiments
- 10% dijet mass resolution
- Run IIB silicon
- Width of HSG bands determined by method uncertainty
  - No systematics included
- Width of SHWG bands given by analysis uncertainty
- SHWG included $H \rightarrow WW$
  - contributes at high $m_H$

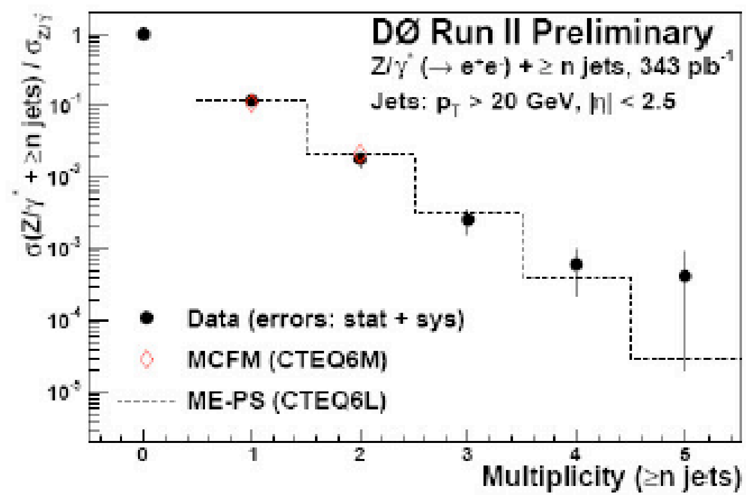


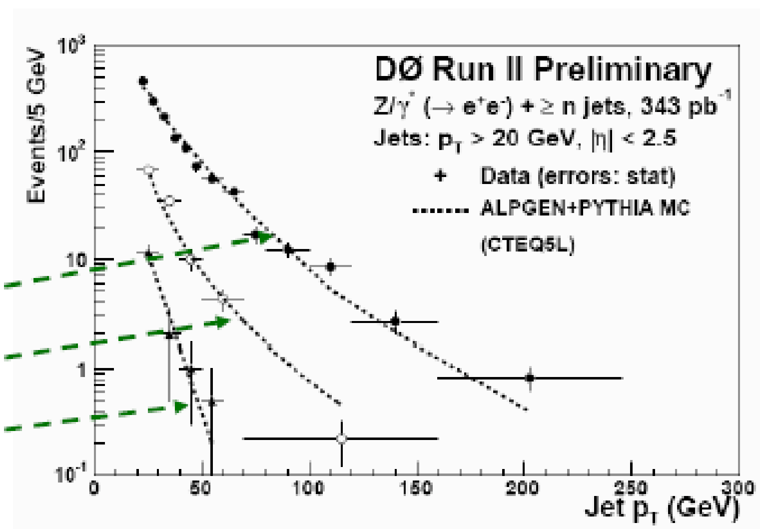

Low mass region 95% excl. or 3σ by 2008

This is difficult region at LHC

# D0: Z + n jets

- Test of pQCD at high $Q^2$ ($\geq M_Z$)
- Fundamental channel for SM and new physics processes
  - ZH
- MCFM
  - NLO up to Z + 2 partons
- ME-PS
  - Leading Order Matrix Element (Madgraph) + Parton Shower (Pythia)



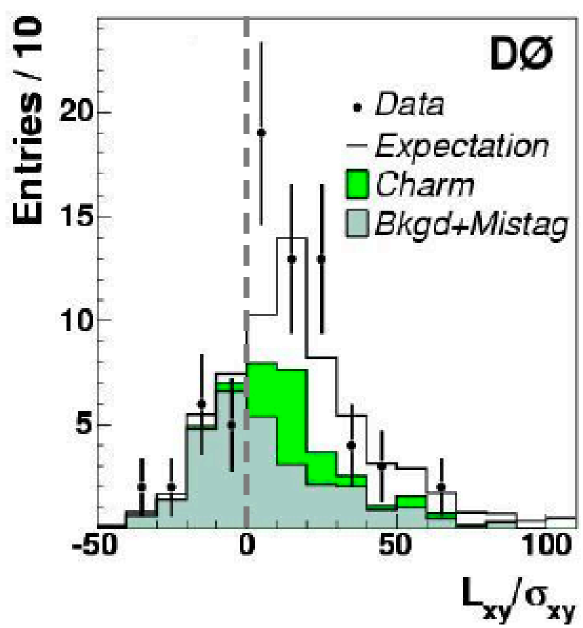




Avto Kharchilava: talk at TeV4LHC

# D0: Z +b

## σ(Z+b)/σ(Z+j) ratio

- Decay length significance of sec. vertices in transverse plane for b-tagged jets




Heavy flavor component in b-tagged candidate events is clearly seen !

- Measure cross section ratio Z+b/Z+j

**$0.021 \pm 0.004$ (stat) $^{+0.002}_{-0.003}$ (syst)**

- Prediction: 0.018±0.004

**J.Campbell, R.K.Ellis, F.Maltoni, S.Willenbrock, Phys. Rev. D69 (2004) 074021**

- Systematics studies

| **Source** (dominant) | **Uncertainty (%)** |
|---|---|
| Jet energy scale | +5.8 -6.9 |
| Bkgd. estimation | +5.7 -5.2 |
| Jet tagging | +4.6 -5.1 |
| Z+(QQ) vs Z+QQ | +1.7 -5.4 |
| σ(Z+c)/σ(Z+b) | +2.8 -2.8 |
| **Total** | **+10.4 -11.8** |

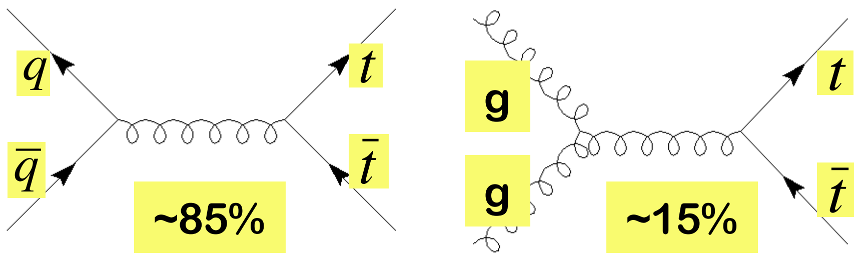
**PRL 94, 161801 (2005)**



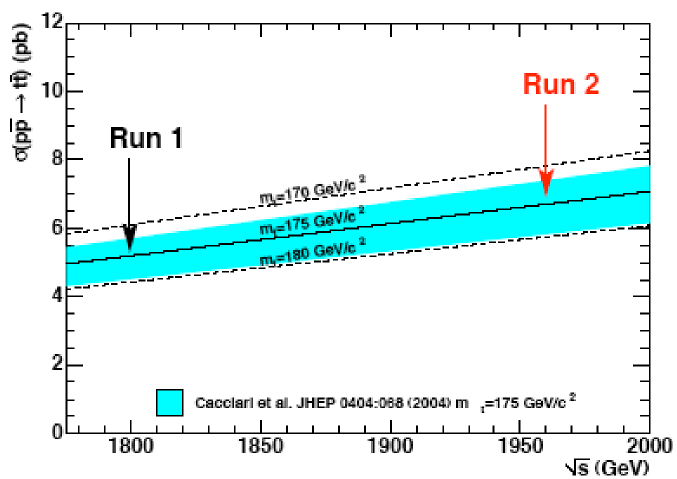
Avto Kharchilava: talk at TeV4LHC

# Top Physics

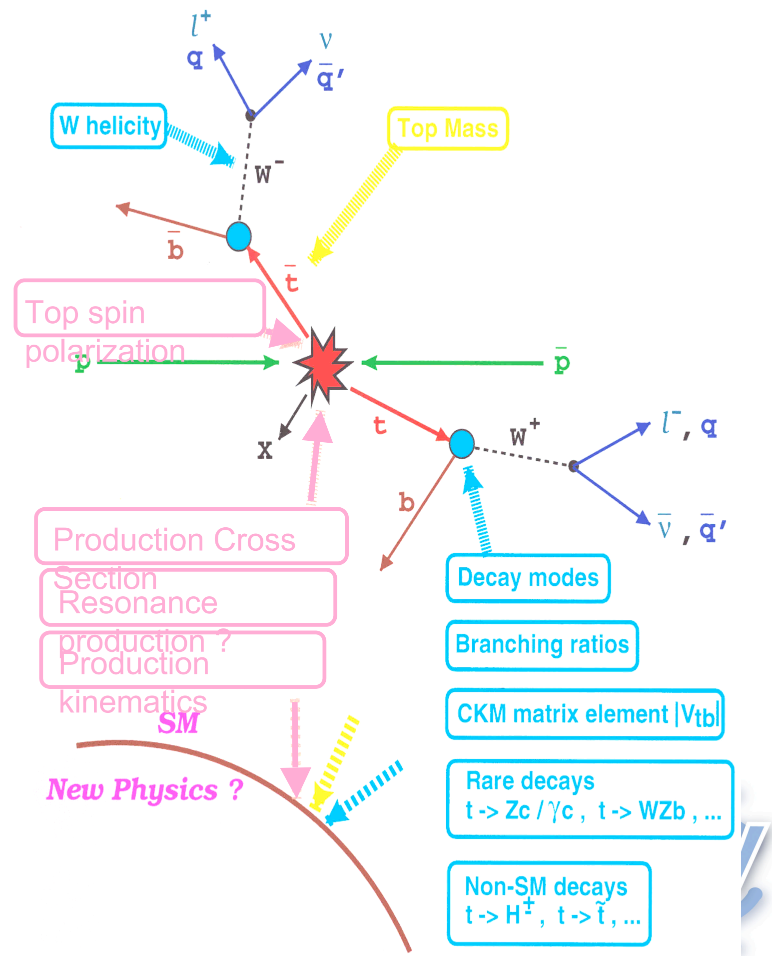
- At Tevatron, top quarks are produced mostly by qq
  - nb: if use Monte Carlos with LO pdf's, only 5% of production comes from gg




$$\sigma(\bar{p}p \rightarrow t\bar{t} \ @ \ M_{top} = 178GeV) \approx 6.1 \text{ pb}$$




- Wealth of physics possible with top quark analyses
  - both SM and probes of BSM

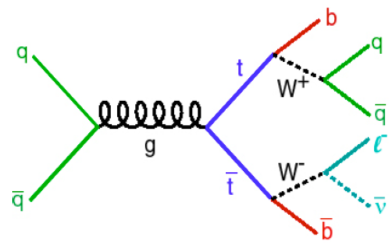


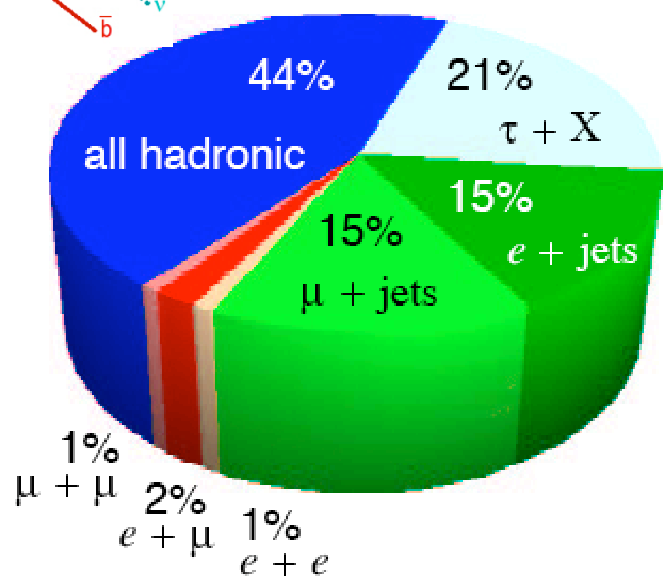
# Event signatures

Top quark decays to $W$ and $b$ at a rate of $\sim$100% $\quad \mathrm{Br}(t \to W^+ b) \simeq 1$

Decay channels of $t\bar{t}$

| | | | | |
|---|---|---|---|---|
| $t \to W^+ b$ | $b$ | $b$ | $b$ | $b$ |
| $\hookrightarrow$ | $\ell^+\nu$ | $q\bar{q}'$ | $\ell^+\nu$ | $q\bar{q}'$ |
| $\bar{t} \to W^- \bar{b}$ | $\bar{b}$ | $\bar{b}$ | $\bar{b}$ | $\bar{b}$ |
| $\hookrightarrow$ | $\ell^-\bar{\nu}$ | $\ell^-\bar{\nu}$ | $q\bar{q}'$ | $q\bar{q}'$ |




dilepton channel

$\Rightarrow$ 2 leptons, $\not{E}_T$, 2 $b$-jets

lepton+jets channel

$\Rightarrow$ 1 lepton, $\not{E}_T$, 4 jets (including 2 $b$-jets)

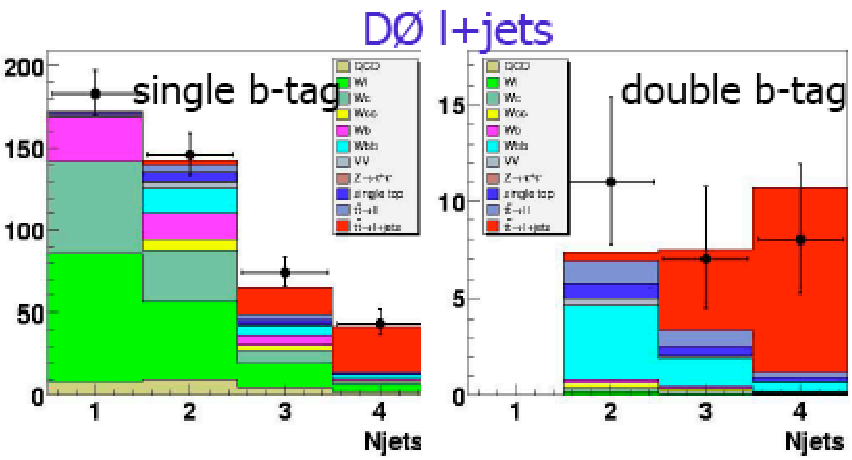
all hadronic channel

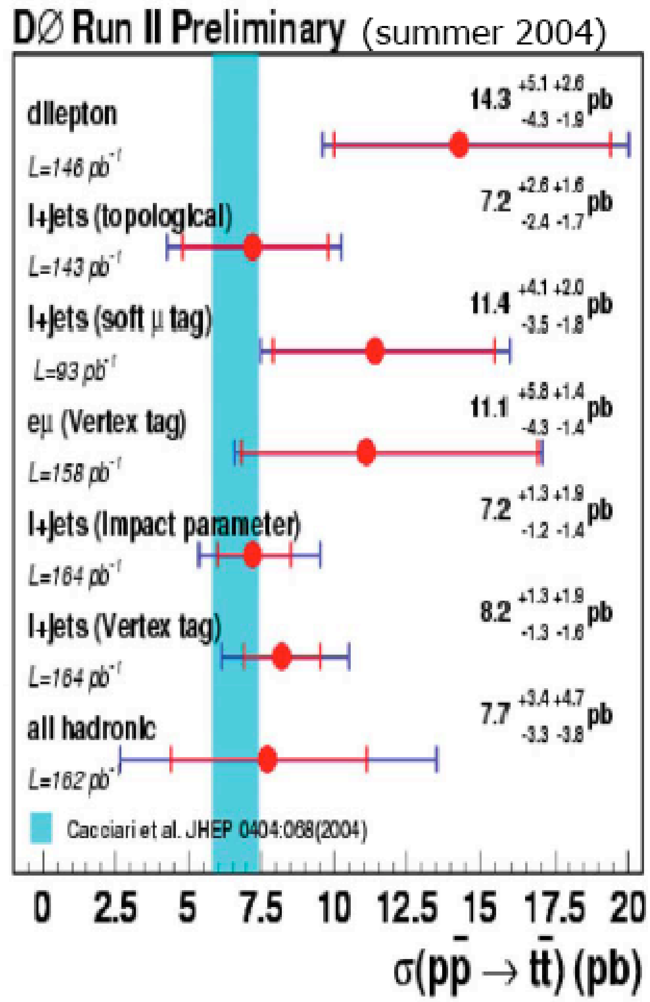
$\Rightarrow$ 6 jets (including 2 $b$-jets)

# D0: top cross section results

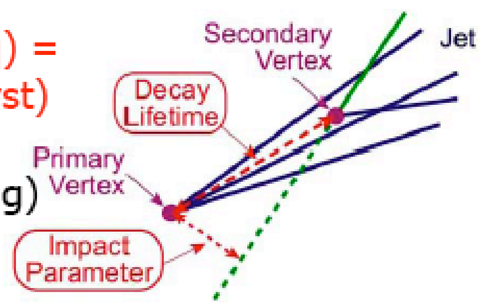
**various methods:** rely on ~150 $pb^{-1}$
di-leptons: cleanest but few events,
lepton+jets: topological or b-tagging
(both sent to PRL this week)
hadronic: with NN and b-tag

NEW



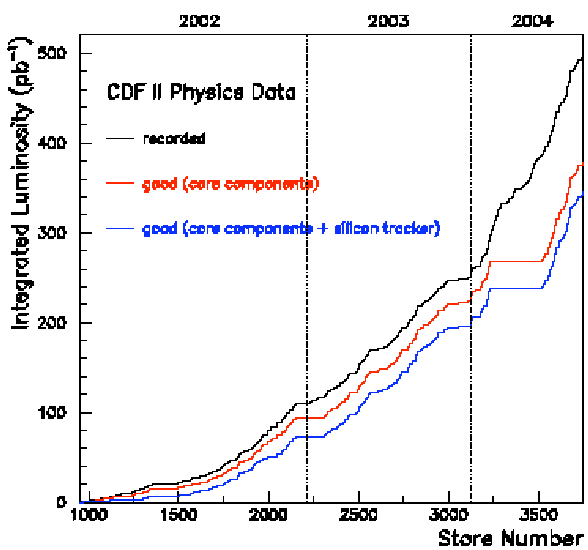



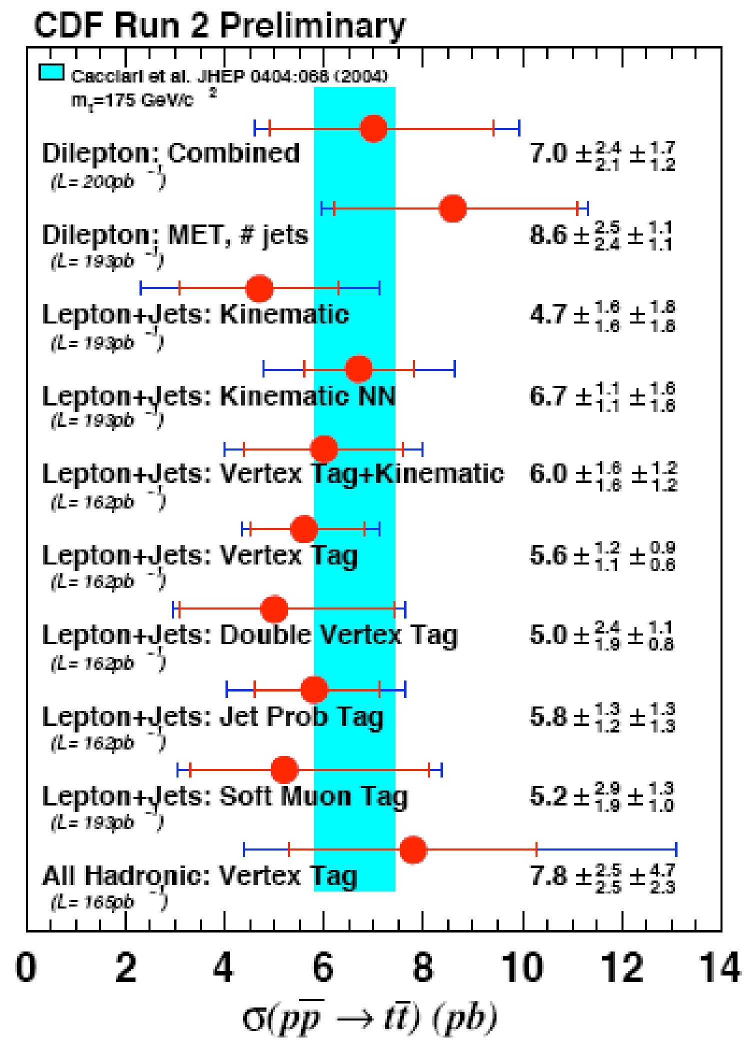

⇒ $Br(t\to Wb)/\ Br(t\to Wq) = 0.70\pm0.26(stat)\pm0.11(syst)$
(compatible with 1; from summer 2004 l+jets b-tag)



# CDF: Cross section results

- Variety of analyses
  - counting experiments
  - kinematic fits/neural networks
  - w/wo b-tagging (silicon available for most of data)

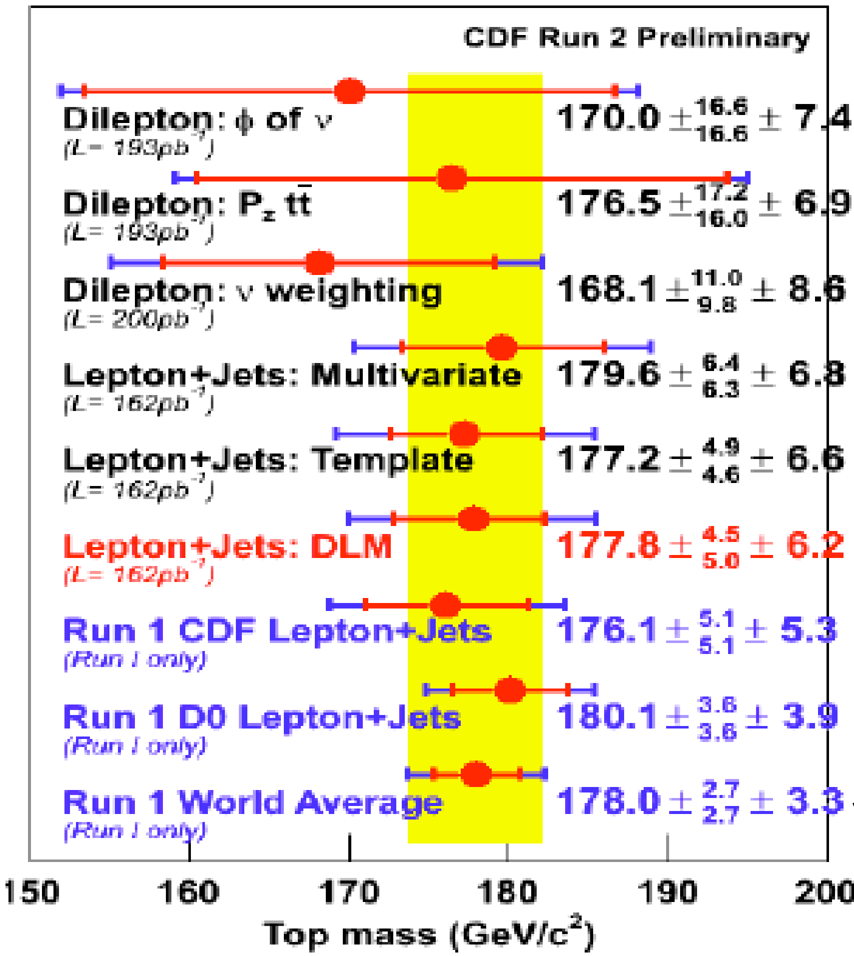


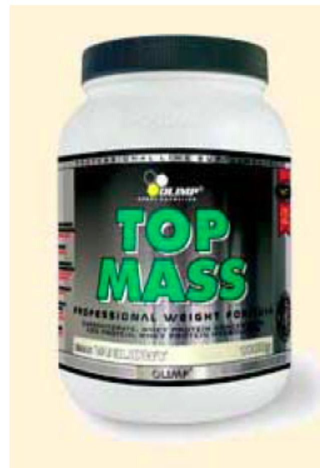



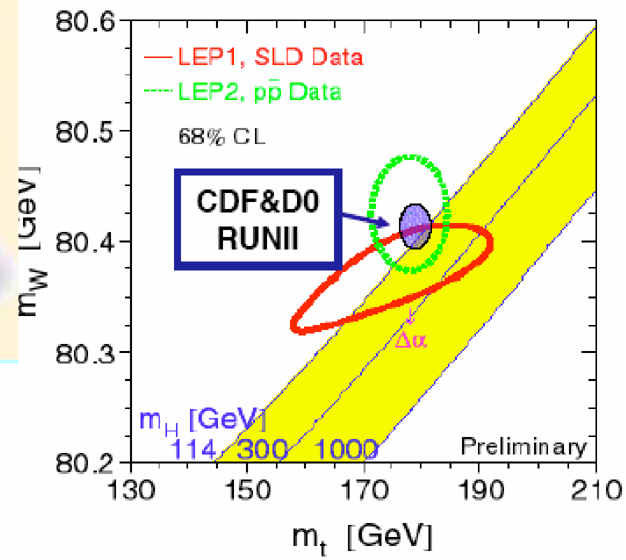

- All results consistent with each other, with D0 and with theory prediction

# Top Mass

- Results as of 2004



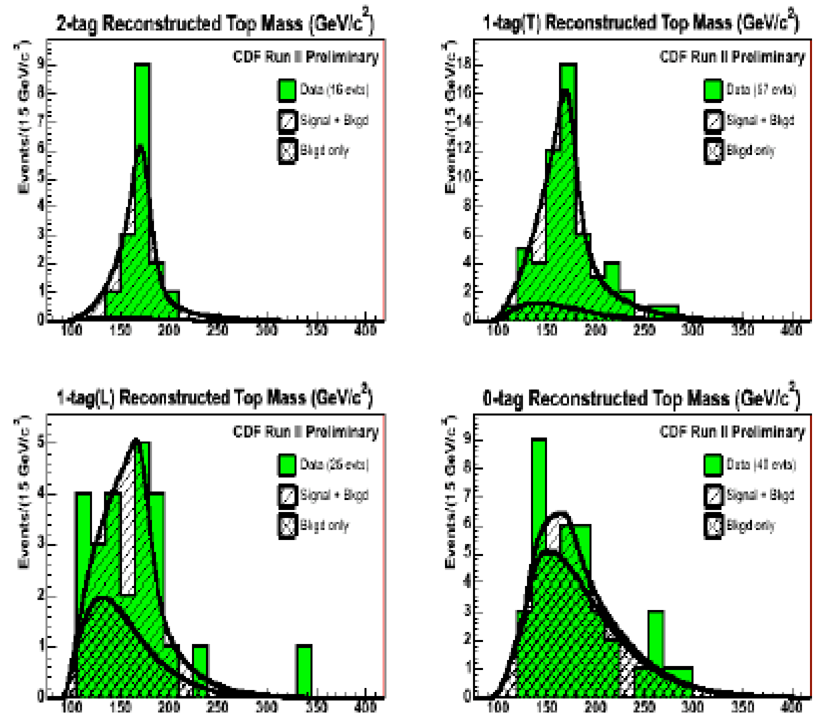



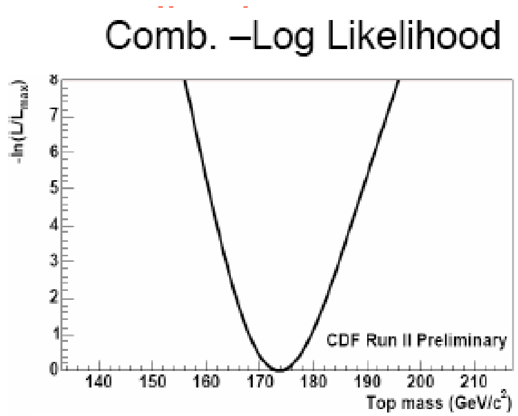

$$m_H = 114^{+65}_{-45}\ \mathrm{GeV}/c^2$$

goal with $2 fb^{-1}$: $\delta M_{top}$ = 2-3 GeV

# Run 2 template method

- Lepton + jets final state
  - $E_T$>15 GeV (8 GeV on 4th jet), $|\eta|$<2.0
  - 318 $pb^{-1}$ data sample
- $\chi^2$ mass fitter
  - find top mass that fits event best with 2 constraints (W mass, top mass)
- Likelihood fit
  - best signal + background templates to fit data with constraint on background



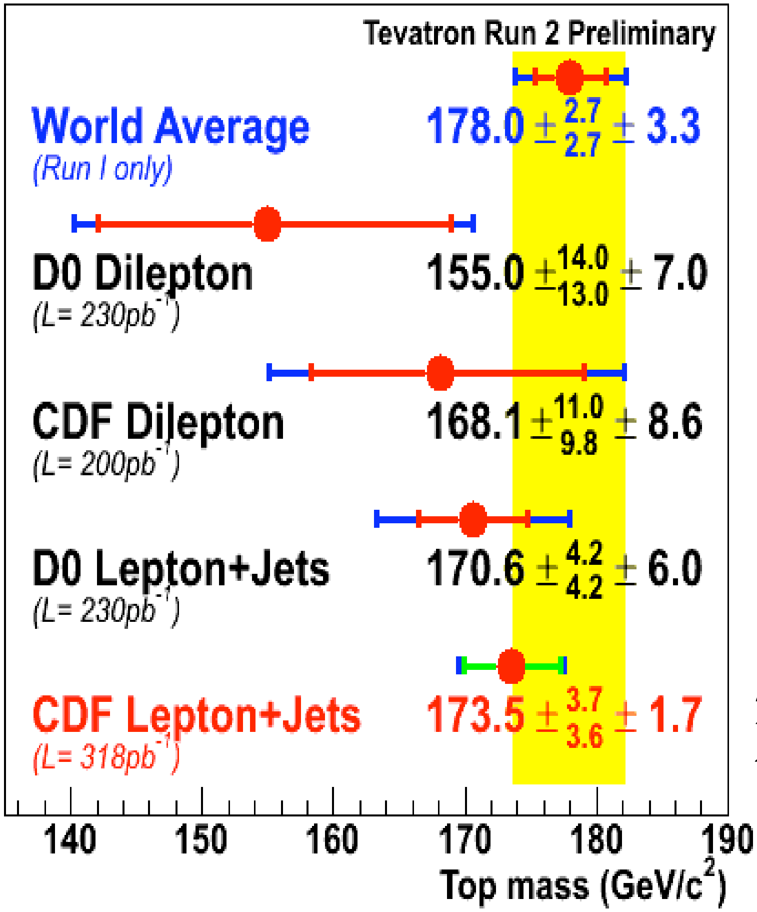

$$M_{top} = 173.2^{+2.9}_{-2.8}\,(stat)\ GeV/c^2$$

**The best single measurement**

1-D template fit
(+/- 3.4 GeV syst)

# Top Mass Results

- World's best top mass measurement has been made in the lepton + jets channel at CDF
  - world average will drop slightly as will predictions for Higgs mass
- Systematics due to jet energy scale and background shape to improve further




2-D template fit

# D0: single top search

- Use 11 topological variables (energy or angular/spin related, top mass)
- distinguish e or μ+jets, single or double b-tag, s or t channels
- 3 independent analyses: **sequential cuts, decision tree** and **Neural Network** (with 2 NN's: one against W+jets and one against ttbar)

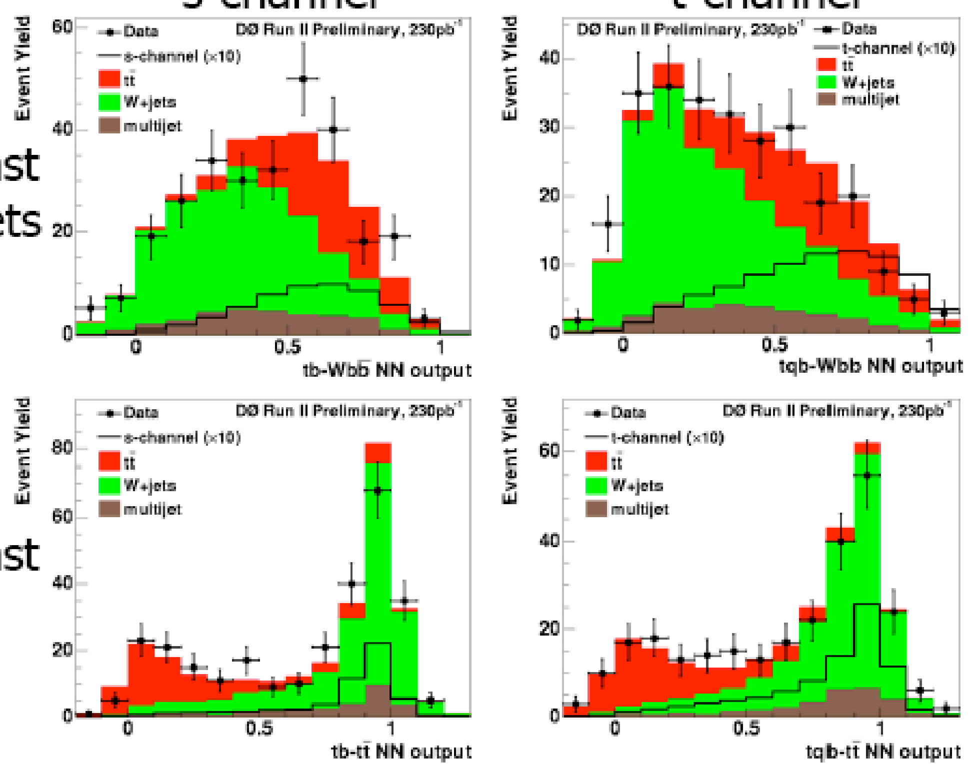
s-channel

t-channel

against W+jets

against ttbar

(based on 230 $pb^{-1}$)



# D0: single top results

NEW

Upper limits on production cross-section (pb) at 95% CL

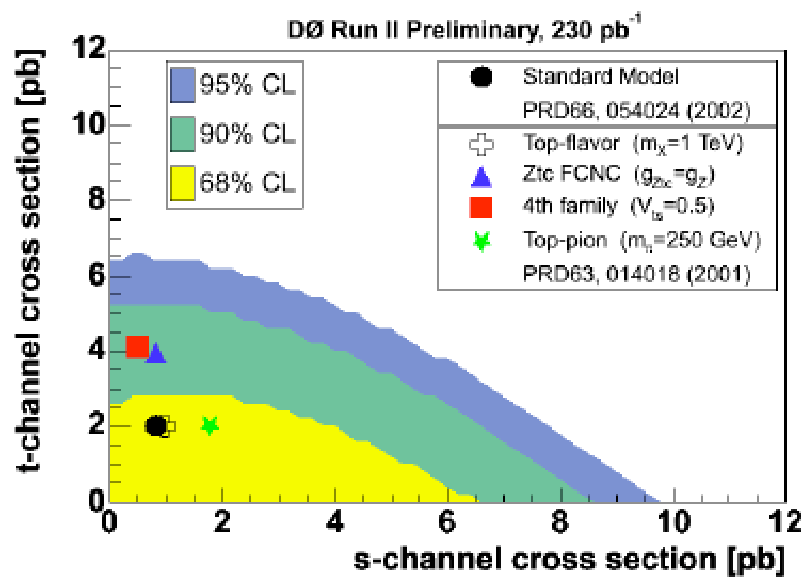
| | s-channel | t-channel |
|---|---|---|
| Cut-based | **10.6** (9.8) | **11.3** (12.4) |
| Decision Tree | **8.3** (4.5) | **8.1** (6.4) |
| Neural Network | **6.4** (4.5) | **5.0** (5.8) |

measured limit
(expected sensitivity)

(being to be published)

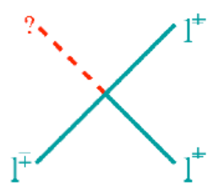
**world best limit so far**

but observation would need ~10 times more data, if no further improvement done

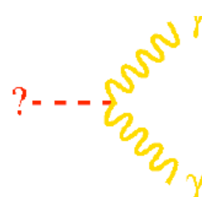


# Supersymmetry

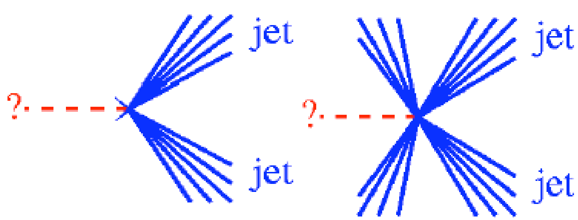
- Wide range of signatures
  - look for SUSY-specific signatures or excess in SM ones
  - RP: large missing $E_T$ from LSP's
  - isolated leptons



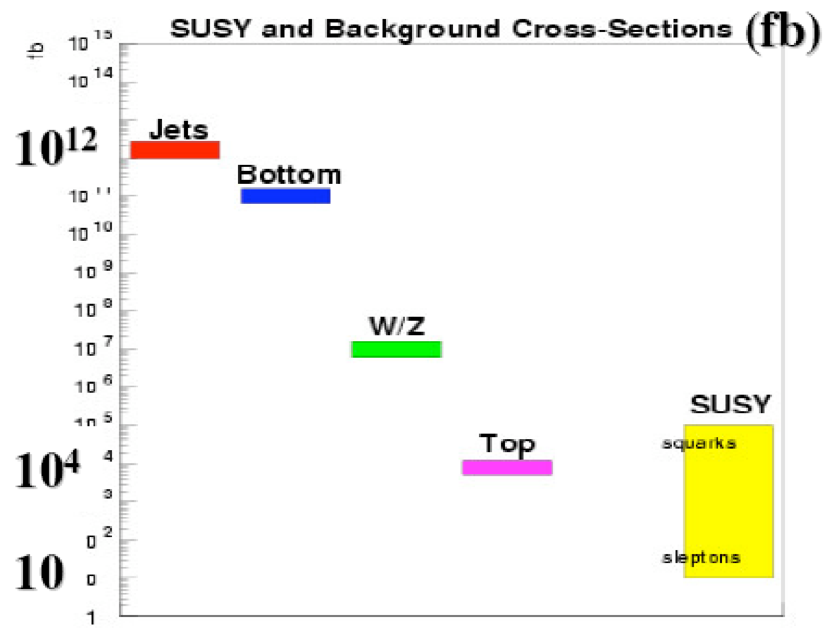

  - diphotons




  - multijets




very small cross sections




detector response has to be well-understood; detectors have to be highly efficient

# Example: chargino and neutralino in 3$l$ + $E_T$

## In mSUGRA: 3 leptons+$\not{E}_T$

➡ $\sigma$xBR~0.1 pb

SELECTION:

- -2 electrons+ $\ell$ ($\ell$ =e,$\mu$ ) |$\eta$|< 1
- large $\not{E}_T$
- 15<$M_{ll}$<76, >106 GeV/$c^2$
- |$\Delta\phi$|< 160°
- Njets(20 GeV) <2

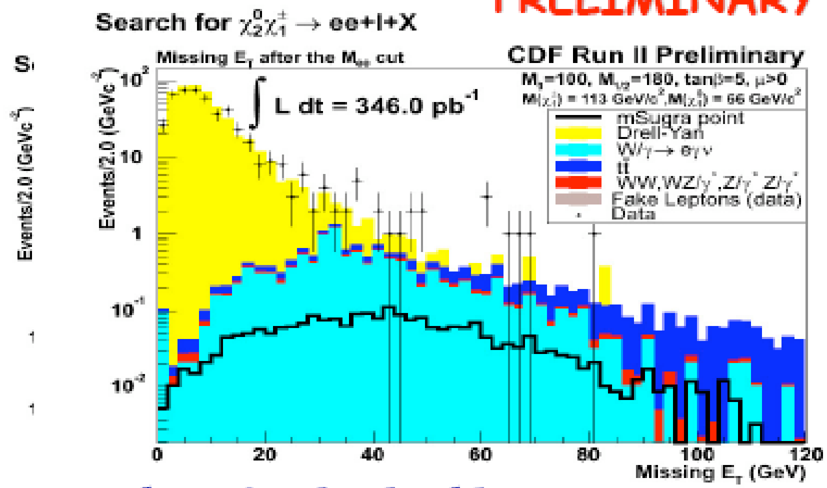
| | |
|---|---|
| ee+l (SUSY signal) | 0.5 |
| TOT SM Expected | 0.16±0.07 |
| OBSERVED | 0 |

VERY FIRST LOOK AT THE DATA!!

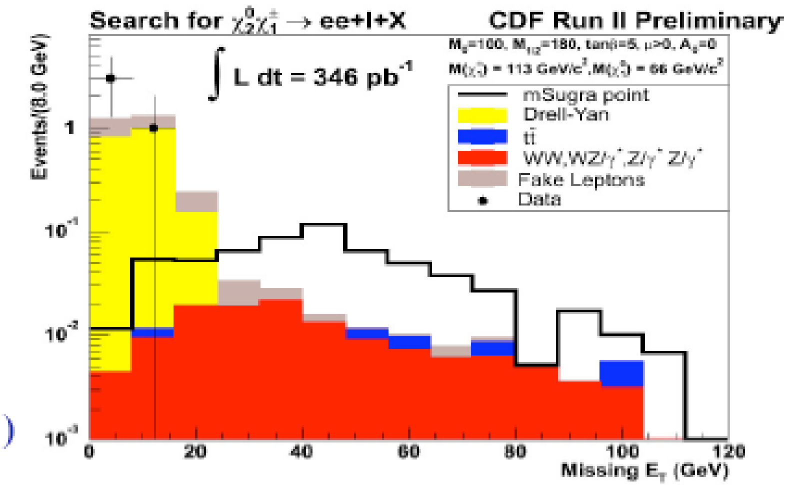
Still to do:

- improve acceptance adding the plug
- add the other channels (almost ready)

PRELIMINARY !!




*Asking for the third lepton:*

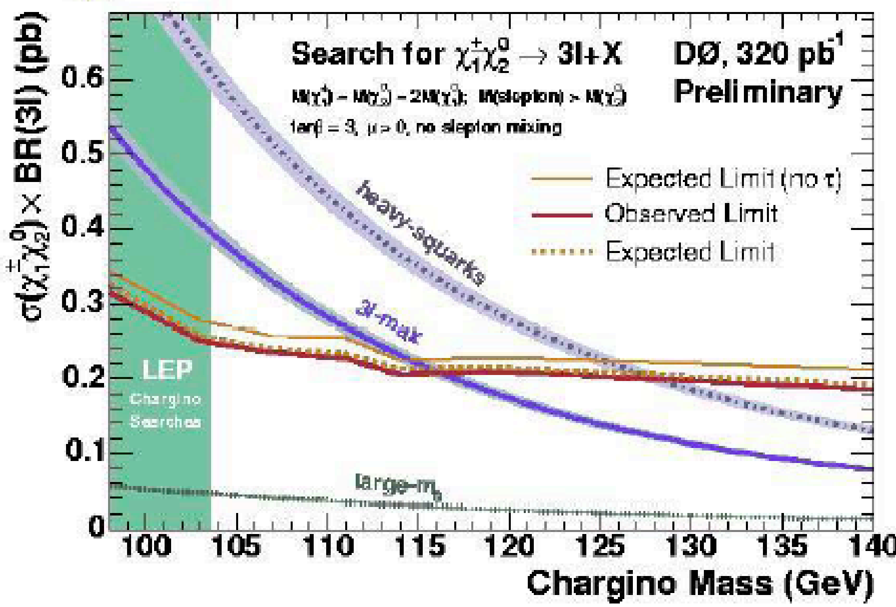


# D0: mSUGRA trileptons combined result

(hep-ex/0504032, to PRL)

NEW

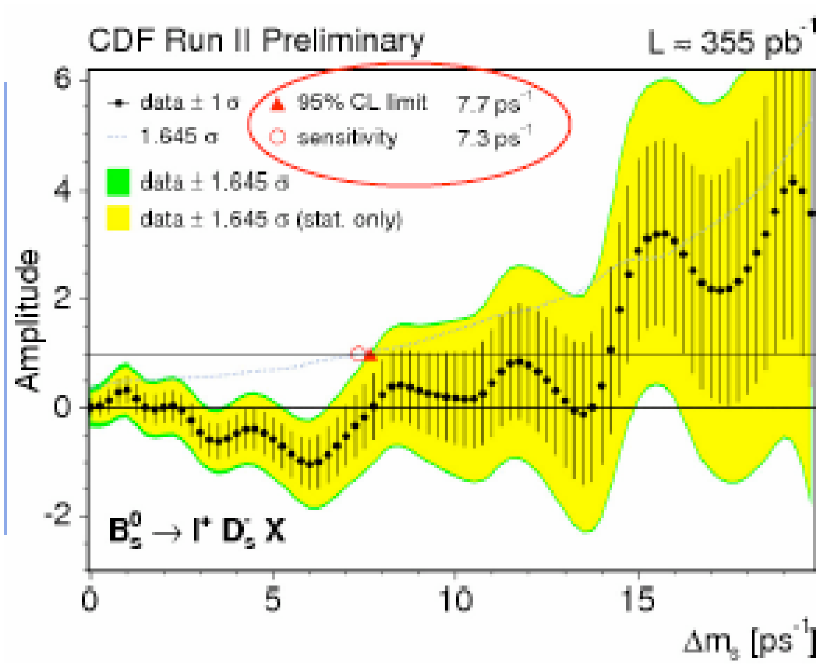
| | data | bkg |
|---|---|---|
| eel | 0 | 0.21 ± 0.11 ± 0.05 |
| eμl | 0 | 0.31 ± 0.13 ± 0.03 |
| μμl | 2 | 1.75 ± 0.37 ± 0.44 |
| $\mu^{\pm}\mu^{\pm}$l | 1 | 0.64 ± 0.36 ± 0.13 |
| eτl | 0 | 0.58 ± 0.11 ± 0.09 |
| μτl | 1 | 0.36 ± 0.12 ± 0.06 |
| total | 4 | 3.85 ± 0.57 ± 0.49 |




- limits provided within
  tanβ=3, μ>0, no slepton mixing
- and compared to 3 scenarios
  (Beenakker et al., PRL 83 (1999) 3780)
  - heavy squarks and light sleptons without negative interference at production)
  - 3lmax: light slepton mass > m($\chi^0_2$)
  - large m0: jaugino decay to virtual W*/Z* only
- adding taus help, even at low tanβ
- better than at Run I (limit ~1.5 pb)
- will still improve with higher luminosity

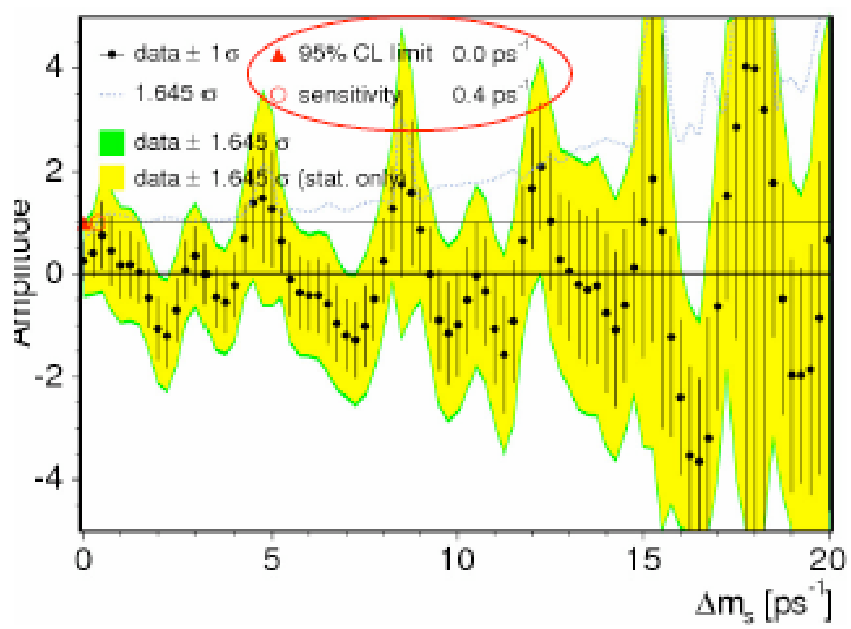
# CDF: $B_s$ mixing

$B_s^0 \to \ell^+ D_s^- X$




| | $N$ | $S/B$ |
|---|---|---|
| $D_s^- \to \phi\pi^-$ | $4355 \pm 94$ | 3.12 |
| $D_s^- \to K^{*0}K^-$ | $1750 \pm 83$ | 0.42 |
| $D_s^- \to \pi^+\pi^-\pi^-$ | $1573 \pm 88$ | 0.32 |

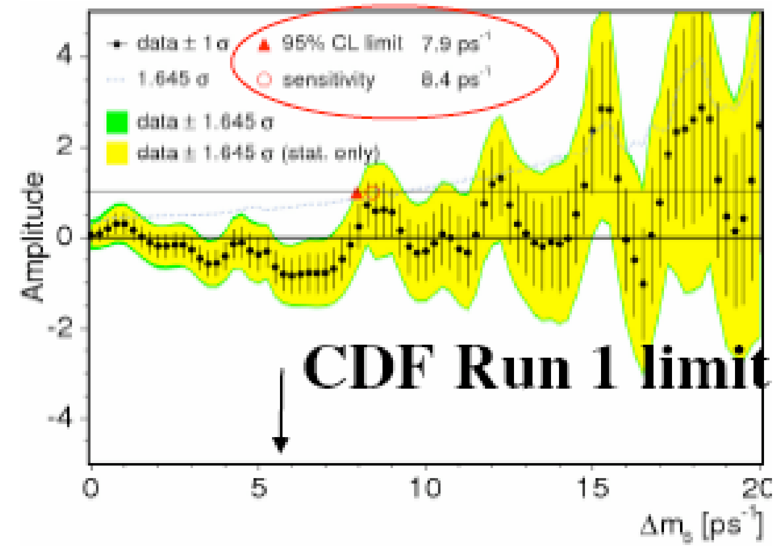
$B_s^0 \to D_s^- \pi^+$



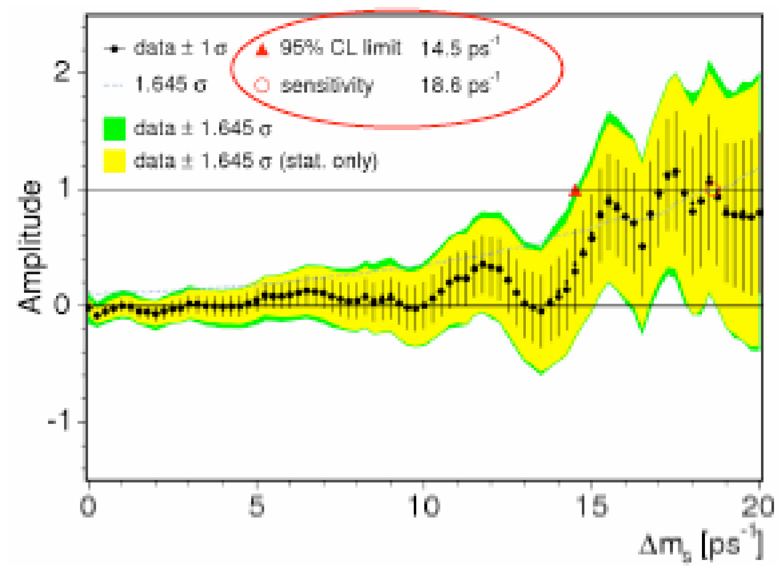

| Subsample | Yield | $S/B$ |
|---|---|---|
| $D_s^- \to \phi\pi$ | $526.2 \pm 33.2$ | 1.80 |
| $D_s^- \to K^*K$ | $253.6 \pm 20.5$ | 1.69 |
| $D_s^- \to \pi\pi\pi$ | $115.7 \pm 18.0$ | 1.01 |

# Impact on world average sensitivity

- Combined scan results
  - 7.9 ps$^{-1}$ 95% CL limit
  - sensitivity: 8.4 ps$^{-1}$
  - additional improvements could reduce statistical error by up to a factor of 2 with the same dataset



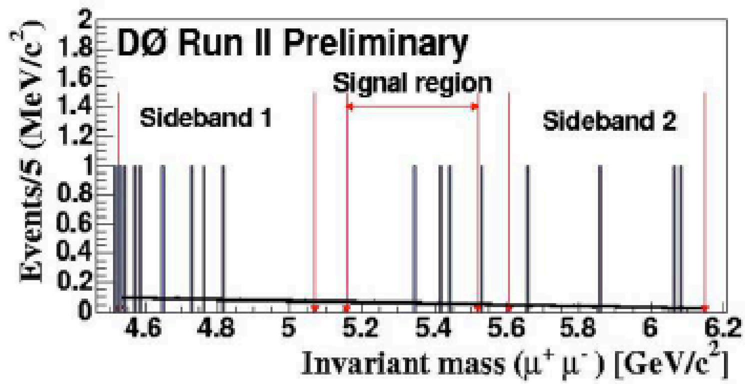

- Effect on world average:
  - limit: 14.5->14.5 ps$^{-1}$
  - sensitivity: 18.2->18.6 ps$^{-1}$

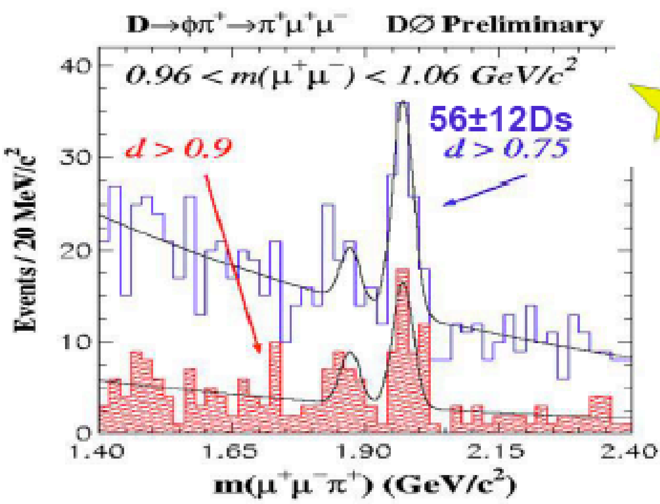


# D0: rare decays

**FCNC searches :**

Bs→μ+μ-
2004 analysis (PRL 94 (2005) 071802)
with 240 $pb^{-1}$: Br<5.0 10-7 (95%CL)
2005 update with 300 $pb^{-1}$:
. Br<3.7 10-7 (95%CL)



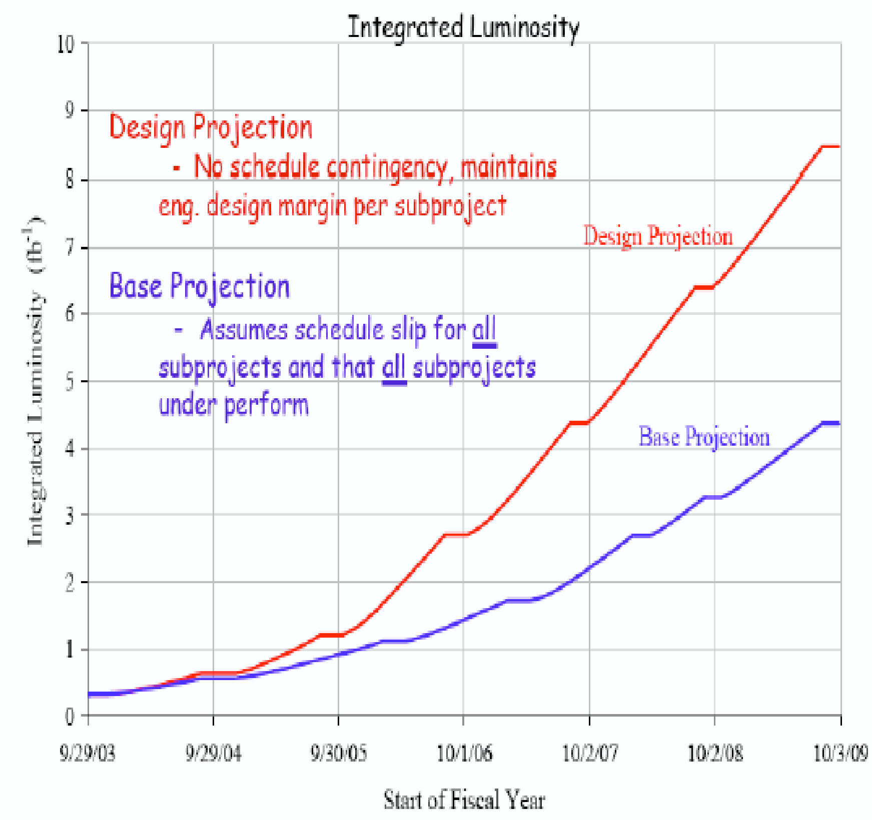

NEW

56±12 $D_s^- \to \Phi\pi^- \to \mu^+\mu^-\pi^-$ observed

upper limit on $D^- \to \Phi\pi^- \to \mu^+\mu^-\pi^-$
**with 508 $pb^{-1}$**: Br < 3.1 10-6 (90% CL)

# Summary

- Tevatron, CDF and D0 all working well
- ~800 $pb^{-1}$ down and > 8 $fb^{-1}$ to go
  - 2 $fb^{-1}$ by 2006
  - 4 $fb^{-1}$ by 2007
  - 8 $fb^{-1}$ by 2008



# Advertisement

SM benchmarks for the first year(s) of the LHC

See www.pa.msu.edu/~huston/_Les_Houches_2005/ Les_Houches_SM.html

* expected cross sections for useful processes
  + inclusive jet production
  + W/Z rapidity distributions
  + W/Z+jets
  + top pairs
  o what are the uncertainties? what are the limitations of the theoretical predictions?
  o to what extent are the predictions validated by current data?
  o what measurements could be made at the Tevatron and HERA before then to add further information?

PDF Uncertainties

* now/after HERAII + Tevatron Run II/after 1 year of LHC running
* differences between CTEQ and MRST predictions/uncertainties
* reliability of NLO QCD/progress towards NNLO

Many of these issues are also in common with the TeV4LHC workshop. See www.pa.msu.edu/~huston/tev4lhc/wg.htm .

First meeting Tuesday May 4 14:00-18:00 Auditorium

Discovering the SM at the LHC J. Huston

Higgs production at the LHC M. Grazzini

Final state predictions for the LHC S. Ferrag

…

# Websites and future meetings

- TeV4LHC: conferences.fnal.gov/tev4lhc/
- QCD
  - www.pa.msu.edu/~huston/tev4lhc/wg.htm
  - see also www.pa.msu.edu/~huston/tevqcdwg/wg.htm
- TopEW
  - www.hep.anl.gov/tait/tev4lhc/topew.html
- Higgs
  - www-clued0.fnal.gov/~iashvili/TeV4LHC_higgs/higgs.html
- Landscape

- Final meeting at Fermilab in the fall of 2005

# You're all wondering, How can I enlist?

- Four listserver mailing groups have been set up:

  tev4lhc-qcd

  tev4lhc-higgs

  tev4lhc-topew

  tev4lhc-landscape

- If you would like to subscribe to the working groups, here are the instructions:
  - To subscribe to a mailing list called MYLIST

    1. Send an e-mail message to listserv@fnal.gov

    2. Leave the subject line blank

    3. Type "SUBSCRIBE MYLIST FIRSTNAME LASTNAME" (without the quotation marks) in the body of your message.

# SM Physics

Before we publish new physics at the LHC, we need to understand SM physics. A lot of prior knowledge can come from the Tevatron.

## Backgrounds – Measuring and Calculating

At present, we rely on MC for signal and background estimates

There are uncertainties in rates from PDF's, higher order QCD

Most of these do no matter at the moment, They will matter once data appears

The MC/theory tools must match the experiments

Don't forget that the LHC will be a precision machine.

Some processes are not well understood: For these we need flexibility in the modeling

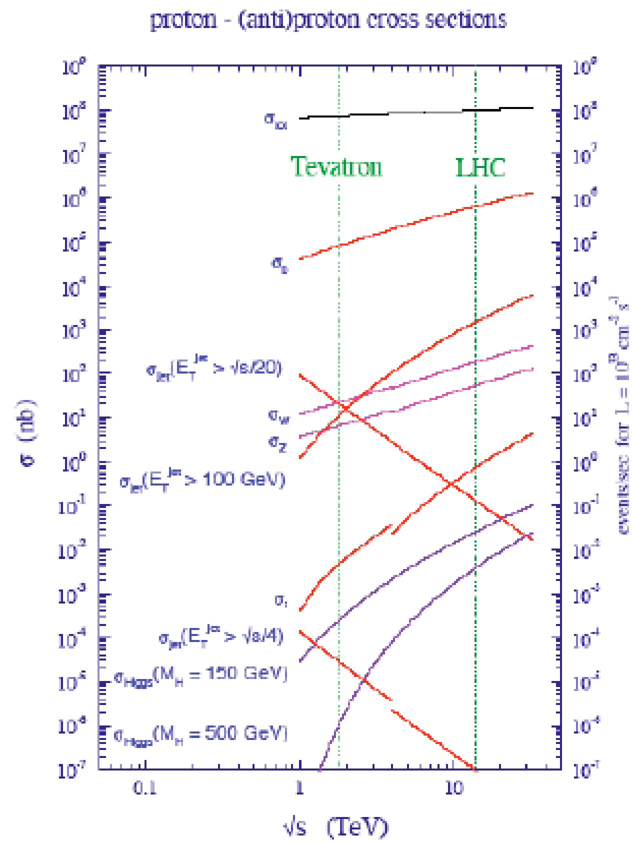
A concern: underlying and min-bias events

Affects process that need forward jet tagging *e.g.* *WW – scattering* or central jet veto *e.g.* extraction of objects produced by EW interaction

Will be measured once data exists and MC will be tuned to agree... But

Speech

Ian Hinchliffe from Brookhaven meeting



# Physics group goals

- QCD sub-groups
  - pdf's and event classification
    - extraction of pdf's purely at high-momentum transfers
    - establishment of jet contracts between experiments and theorists
    - subtleties and practicalities of jet algorithms
  - hard scattering and hadronization
    - testing of matrix element-parton showering matching
    - underlying event tunes and model development
    - tests of hadronization and tunes/universality of tunes
  - diffraction

- Top and Electroweak
  - top production and decay
  - analysis techniques
  - improved tagging strategies

great deal of overlap

…and that's why much of our time is always spent in joint meetings

# Jet Projects

1. inclusion of jet production in MC@NLO

   *Steve Ellis, Bill Kilgore, Stefano Frixione, Joey Huston*

   *work will begin in earnest at Les Houches.*

2. Practicing safe exclusive (jet) final states (jet vetos)

   *Steve Ellis*

3. jet algorithms at the Tevatron and LHC

   -impact of splitting/merging; understanding the effects of splitting/merging at the parton and hadron level

   -impact on boosted systems, e.g. W->jj in high $p_T$ top

   -understanding differences observed in jet reconstruction between CDF and D0 environments

-reconstruct sample of MC events that produce problems in the CDF environment using D0 and LHC algorithms

## From website

- A stand-alone CDF Fortran/C++ jet clustering routine is available here.
- Some descriptive text from Matthias Tonnesmann is available here.
- The Monte Carlo events that resulted in "dark towers" or "fat jets" in the CDF clustering are available here (along with some descriptive text from Matthias).

*Michael Begel, Frank Chlebana, Steve Ellis, Joey Huston, Alison Lister, Matthias Tonnesmann, Markus Wobisch, Marek Zielinski*

# Jet Projects

4. UE subtraction

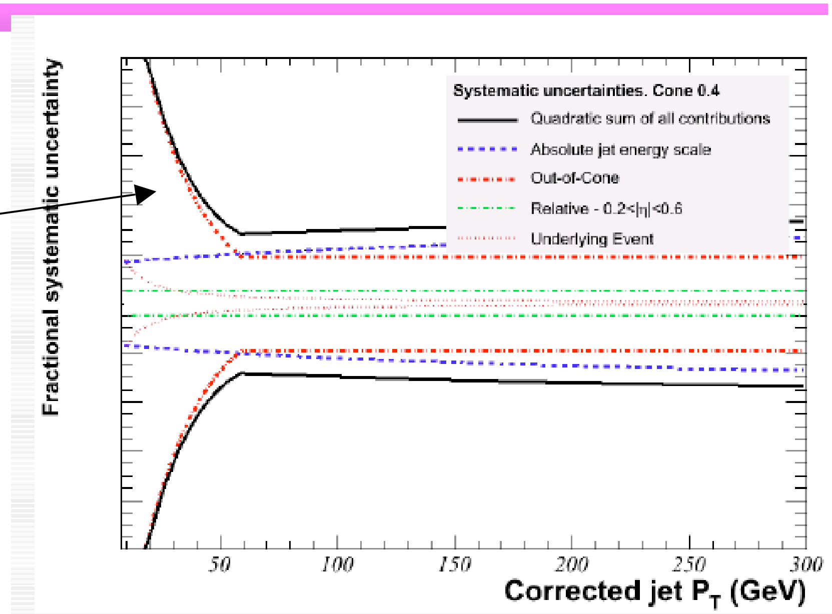
-definition of UE + uncertainty for comparisons of data to NLO

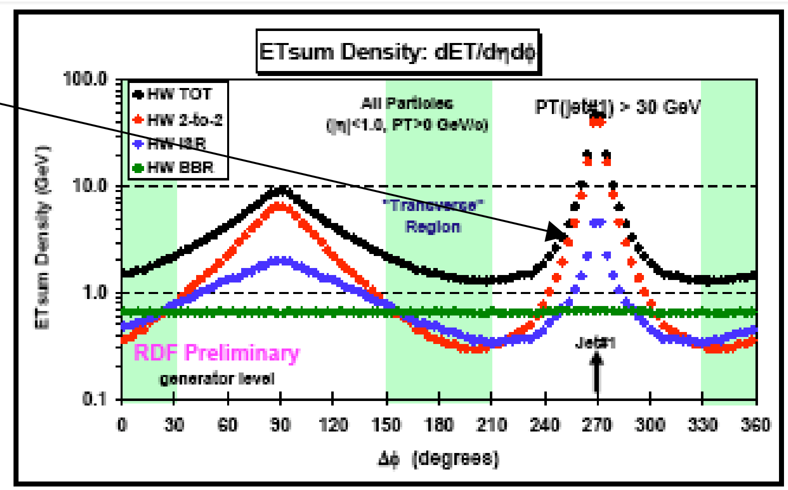
-impact of ISR on jets and jet predictions

->is there an ISR contribution not accounted for by NLO?

-operation in high multiple interaction environment

*Rick Field, Joey Huston, Peter Skands*




R. Field, TeV4LHC WG meeting in December

# PDF projects

1. benchmarks for NLO/NNLO fits (W/Z at Tevatron and LHC)

   *Dimitri BourilkovJoey Huston, Pavel Nadolsky*

2. validity of NLO DGLAP formalism

   *Joey Huston, Pavel Nadolsky*

3. pdf uncertainties

   -universal delta_chisquare

   -pdf weighting; impact of uncertainty of Sudakov FF's

   -mis-match between PS pdf evolution and DGLAP?

   -embedding LHAPDF into programs

   *Stefan Gieseke, Joey Huston, Pavel Nadolsky, Dimitri Bourilkov, Peter Skands*

4. inclusion of Tevatron data in global fits

   "back-of-the-envelope" studies

   -W+c

   -$\gamma$ +b/c

   -Z+b

   *Frank Chlebana, Mario Campanelli, Joey Huston, Pavel Nadolsky*

6. heavy flavor pdf's and their uncertainties

   *Pavel Nadolsky*

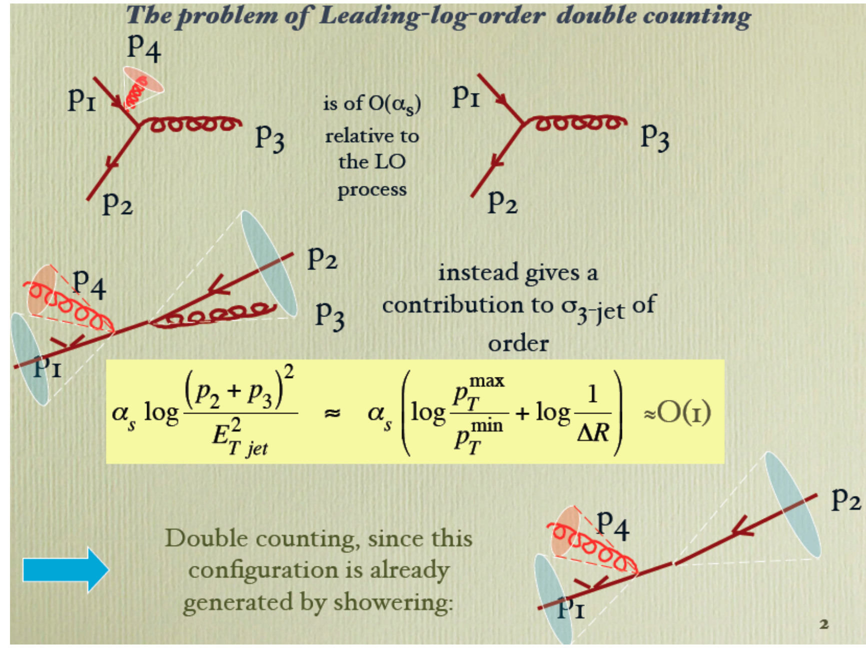
# ME/MC projects

1. W + jets comparisons at the Tevatron->predictions for the LHC
   - -NLO->MCFM
   - -CKKW
     - -Mrenna-Richardson
     - -Sherpa
   - **-backgrounds to WW->H, the "Zeppenfeld plots"**

   *Michael Begel, John Campbell, Ben Cooper, Joey Huston, Rachid Mazini, Steve Mrenna, Dave Waters, Dieter Zeppenfeld, Marek Zielinski*

2. parton shower/resummation
   - -predictions for tt, Higgs
   - -impact of new parton shower algorithms

   *Joey Huston, Steve Mrenna, Peter Skands, Torbjorn Sjostrand*




- need to control size of unwelcome logs when interfacing ME and PS
- mlm and CKKW approaches for controlling logs both in use at Tevatron

# UE/hadronization topics

1. UE tunes for Tevatron

   ->predictions for LHC

   -understanding color connections and their apparent promiscuity

   -Pythia 6.3

   -Jimmy

   *Rick Field, Peter Skands*

2. hadronization corrections for NLO processes
3. ISR/UE corrections->subtractions for NLO

   *Rick Field, Joey Huston*

4. understanding high interaction multiplicity environment

- To first order, hadronization corrections are a constant and of order of 1 GeV/c for reasonably high $E_T$ for a cone of 0.7 using Herwig
  - should be checked for other cone sizes, and with other Monte Carlos, i.e. Pythia
  - should be checked for lower values of $E_T$
  - and we should make a more detailed comparison of parton level jet shape to that from Monte Carlo, data