Improving our Understanding of the Standard Model Using Tevatron Data

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Talk Outline

Part I

- Where does the data come from?

  → *Tevatron Overview*

  → *CDF Detector Overview*

Part II

- Measurements and Errors

  → *What can we do with the data*

  → *How are PDF uncertainties reflected in measurements*

  → *What measurements can be used to reduce PDF uncertainties*

Tevatron Upgrades for Run II

Run I (1992 - 1996)	Run II (2001 - ?)
$\sqrt{s} = 1.8$ TeV	$\sqrt{s} = 1.96$ TeV
6×6 bunches (3 μs spacing)	36×36 bunches (396 ns spacing)
3×10^5 crossings/s	25×10^5 crossings/s
$\mathcal{L}^{\text{inst}} = 1.89 \times 10^{31}$ cm^{-2}s^{-1}	$\mathcal{L}^{\text{inst}} = 30 \times 10^{31}$ cm^{-2}s^{-1}
Delivered about 140 pb^{-1}	Expect 4 - 8 fb^{-1}
	~30-60 × Run I

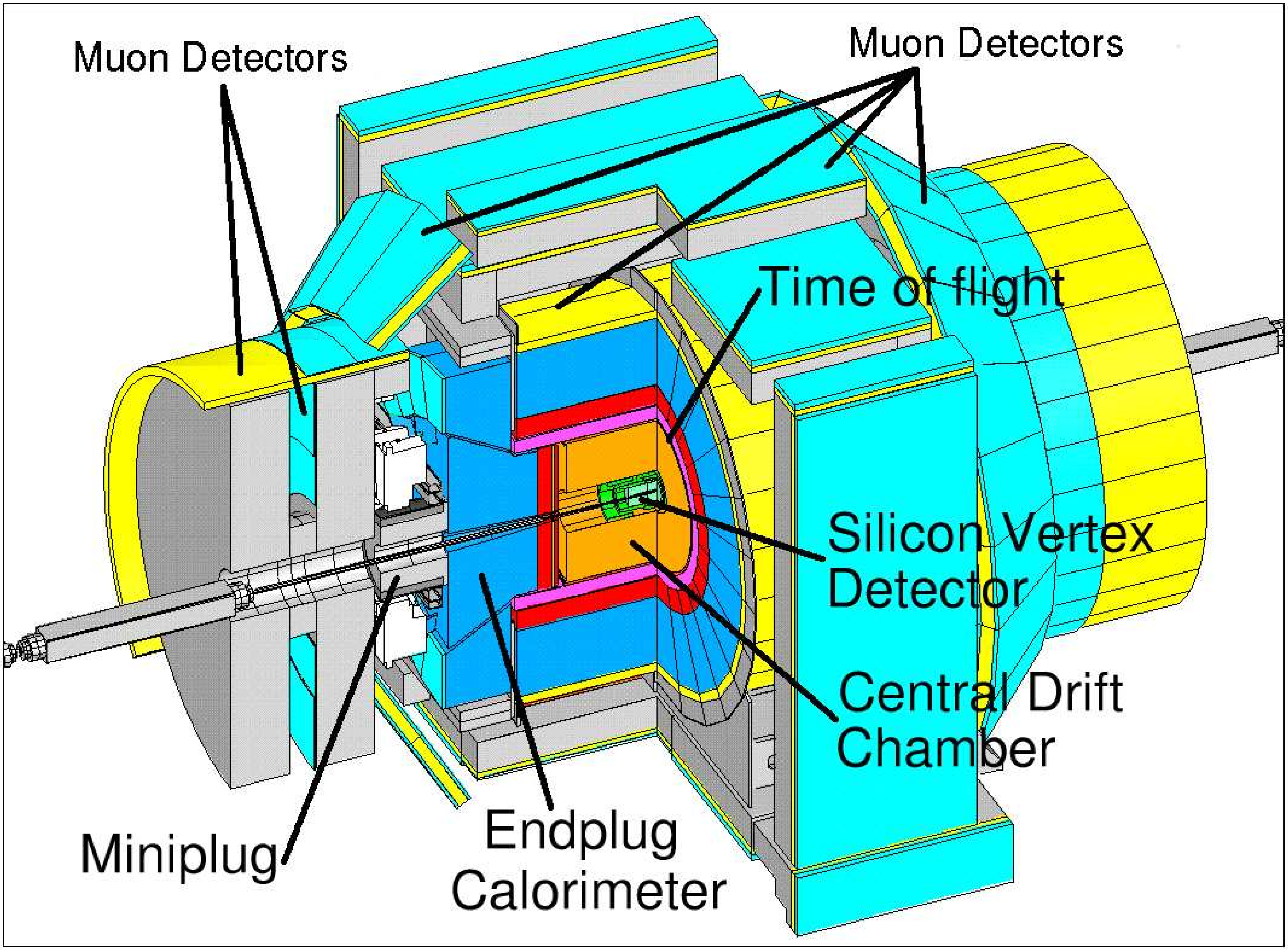
Detector upgrades build on the experience from Run I

→ *Better detectors*
→ *Improved acceptance*
→ *New trigger capabilities*

Need to be able to cope with the higher data rates and shorter beam crossing times

→ *More precise measurements, becoming systematics limited*

CDF Detector Upgrades for Run II

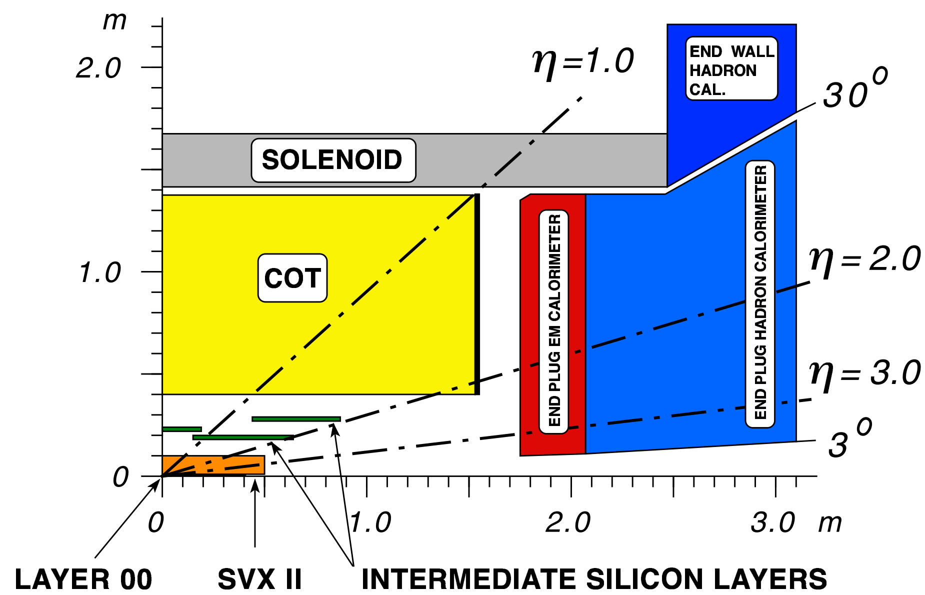


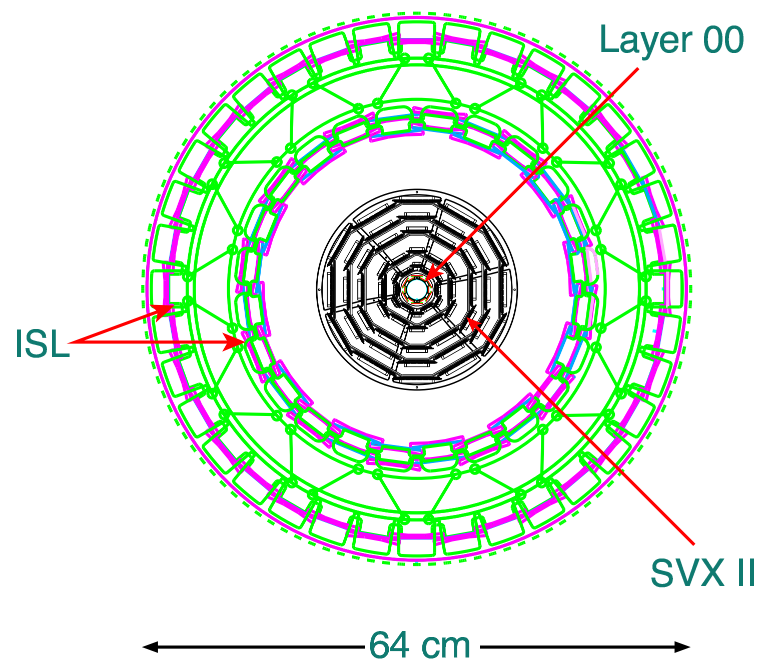
New Silicon Detectors: L00, SVXII, ISL

Covers $\sim 2.5\sigma$ of the luminous region

Extending the well measured region to $|\eta| < 2$

Doubles acceptance for particles with good tracking and vertexing.





Improved b tagging for top events

Improved electron ID ($W \to e\nu$)

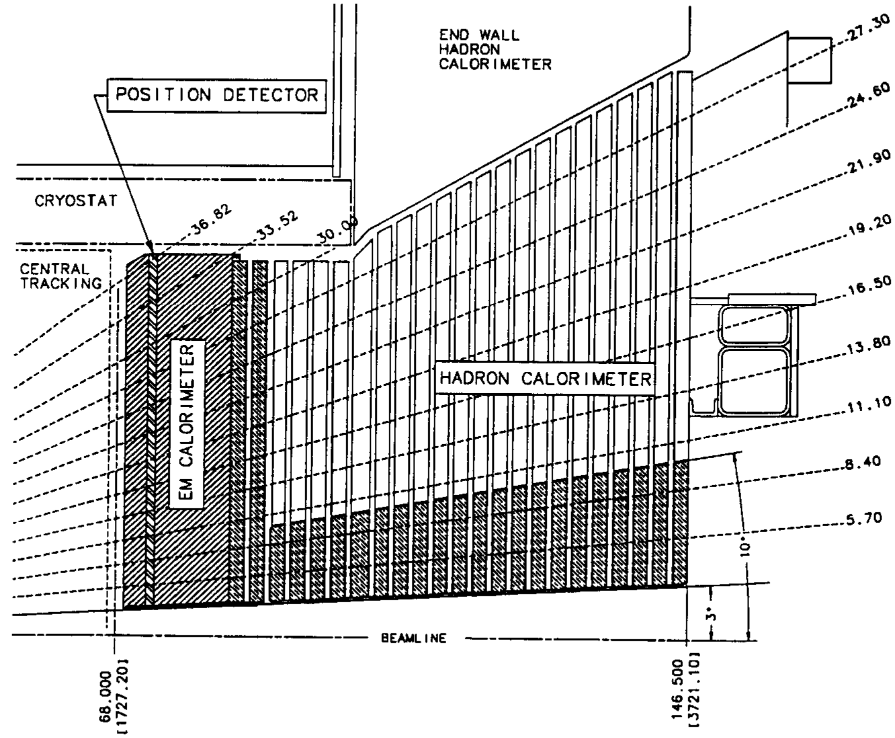
Improved soft lepton tagging

Triggering on a displaced tracks $\to$ richer B physics program

New Plug Calorimeter

Extended pseudorapidity (η) coverage, improved jet energy resolution and electron identification.

Segmented into a *electromagnetic* and *hadronic* sections, aiding particle identification.



Muon system

New detectors and more complete $\eta - \phi$ coverage enables better identification of primary muons from W decays and low p_T muons from semi-leptonic b decays.

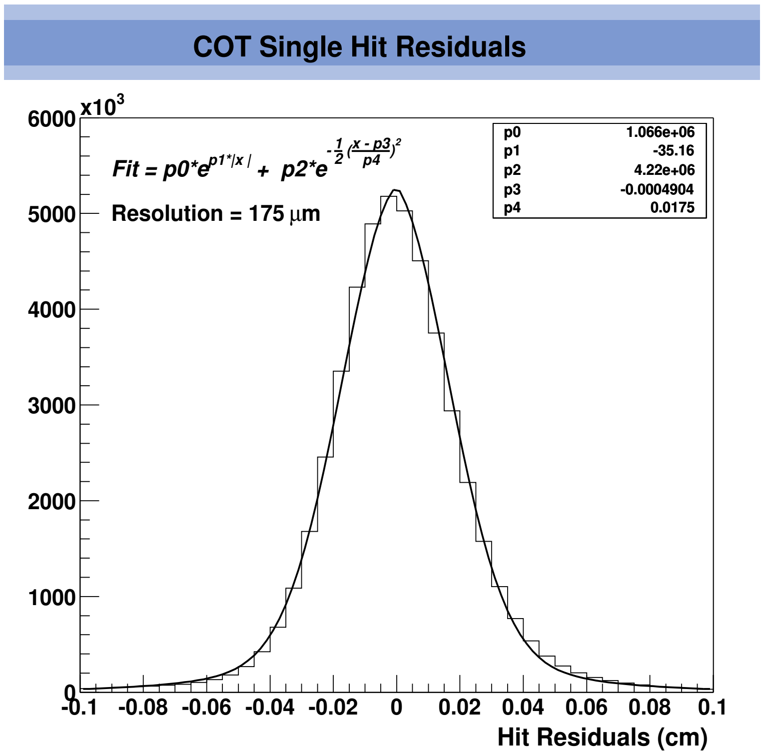
$\rightarrow$ *Filled in gaps resulting in an increase in the total acceptance for top events by 12%*

COT Upgrade

Reduced cell size and faster gas results in $< 100ns$ drift time

96 layers, increased number of stereo measurements (determines z coordinate) from 24 to 48, full coverage up to $|\eta| < 1$

Better momentum resolution and more complete coverage



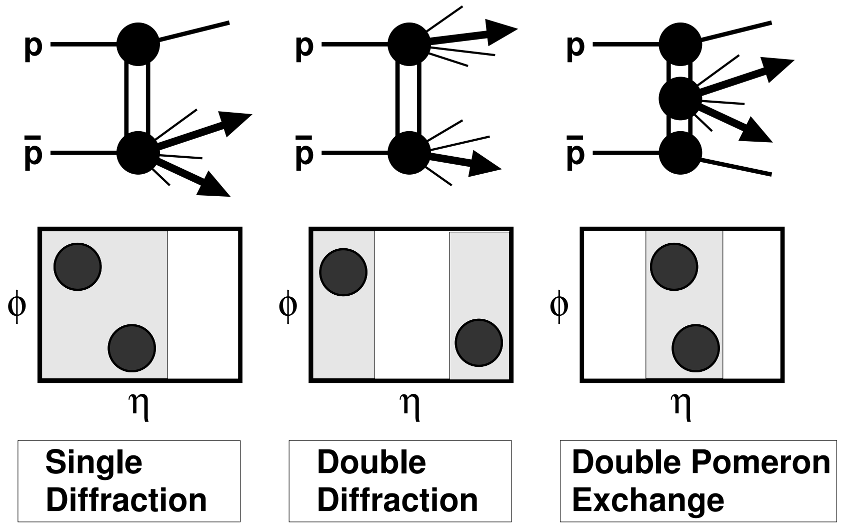
Measured tracking efficiencies:

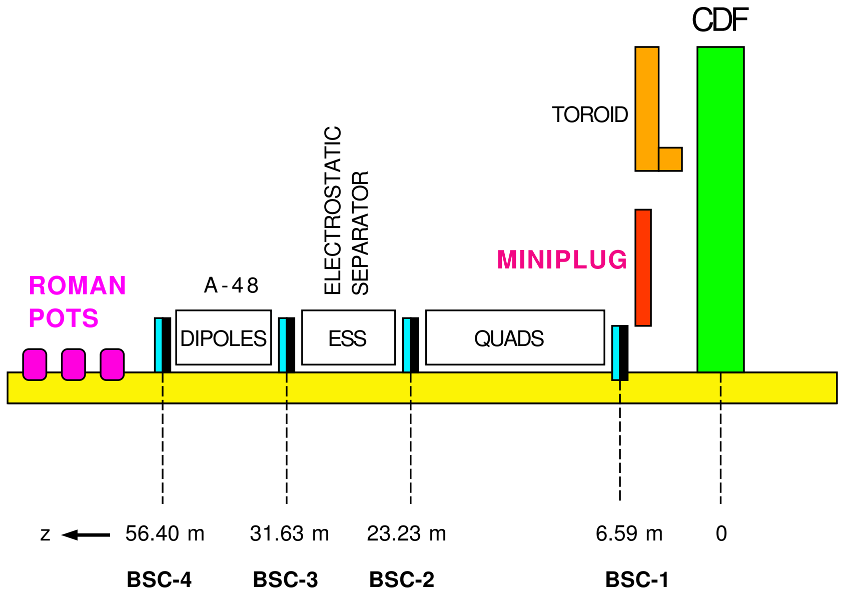
$\epsilon = 99 \pm 1\%$ (L3/offline)
$\sigma(1/p_T) < 0.13\%/\text{GeV}$ (offline)

$\epsilon = 96.1 \pm 0.1\%$ (L1 trigger)
$\sigma(1/p_T) = 1.74\%/\text{GeV}$ (L1 trigger)

Working well, used at the L1 trigger with excellent efficiency for triggering on tracks with p_T down to 1.5 GeV.

Forward Detectors





Single Diffraction
$\longrightarrow$ measurement of the diffractive structure function

Double Diffraction
$\longrightarrow$ jet-gap-jet at large η, tests of BFKL.

Double Pomeron Exchange
$\longrightarrow$ F_{JJ}^{D} vs gap width
$\longrightarrow$ exclusive dijet/$b\bar{b}$ production
$\longrightarrow$ low mass exclusive states

MiniPlug $3.5 < |\eta| < 5.5$
$\longrightarrow$ identify rapidity gaps and very forward jets

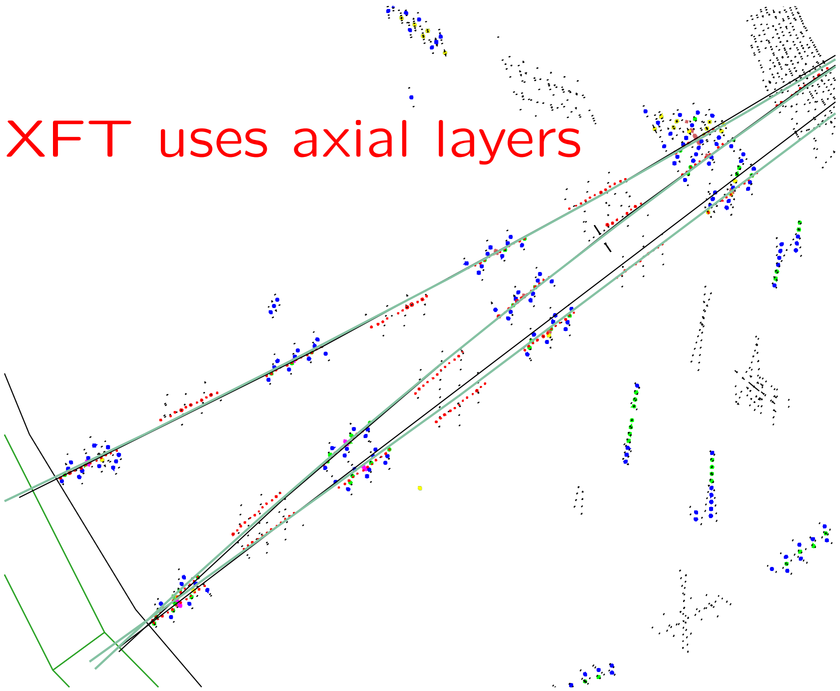
Beam Shower Counters $5.5 < |\eta| < 7.5$
$\longrightarrow$ detect particles at very small angles, identify rapidity gaps

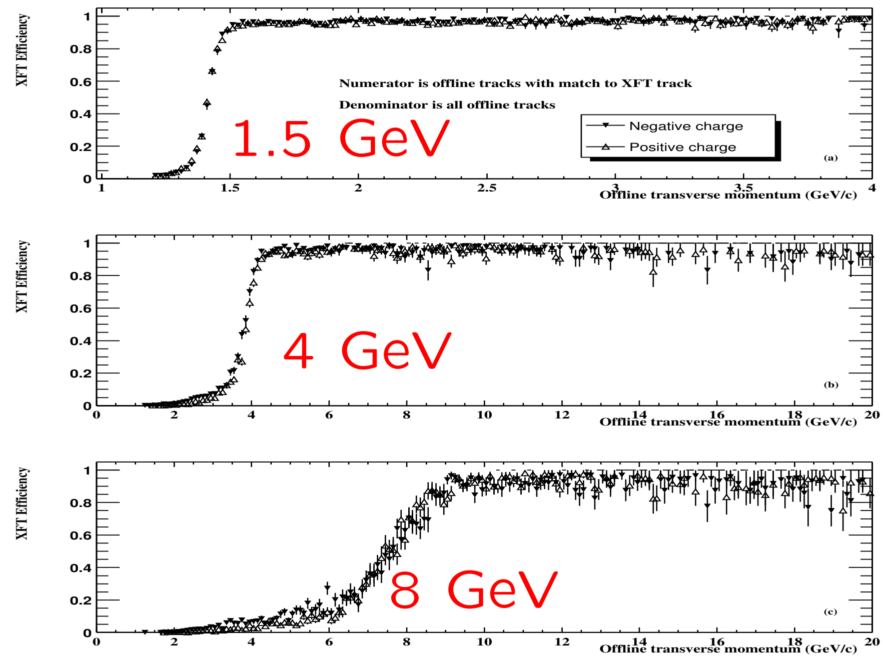
Roman Pot Spectrometers
$\longrightarrow$ detect leading $\bar{p}$

Extremely Fast Tracker (XFT Trigger)

Tracking trigger at L1! Enhances our physics capabilities, able to collect large samples used for in situ calibration.

XFT uses axial layers





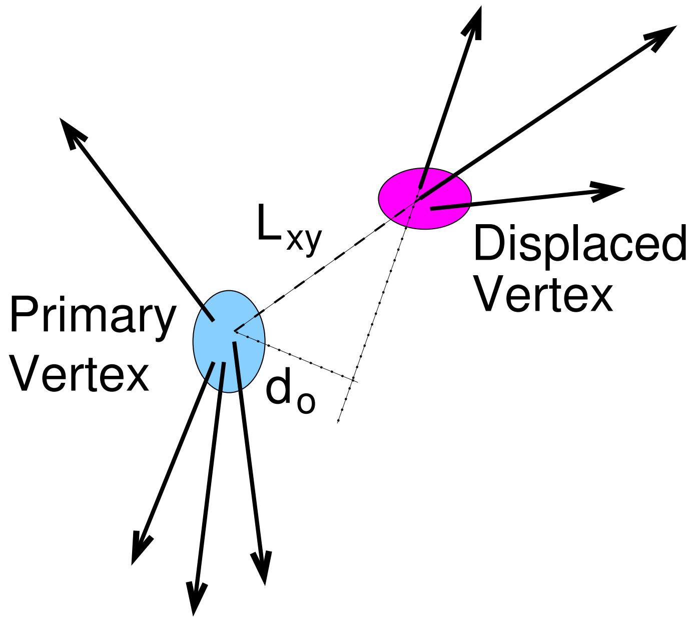
XFT tracks (green) compared with offline tracks (black).

Performance exceeds design specification.

$\longrightarrow$ Measured momentum resolution $(\Delta p_T/p_T^2) = 1.65\%$.

$\longrightarrow$ Measured angular resolution 5.1 mR.

Silicon Vertex Tracker (SVT Trigger)



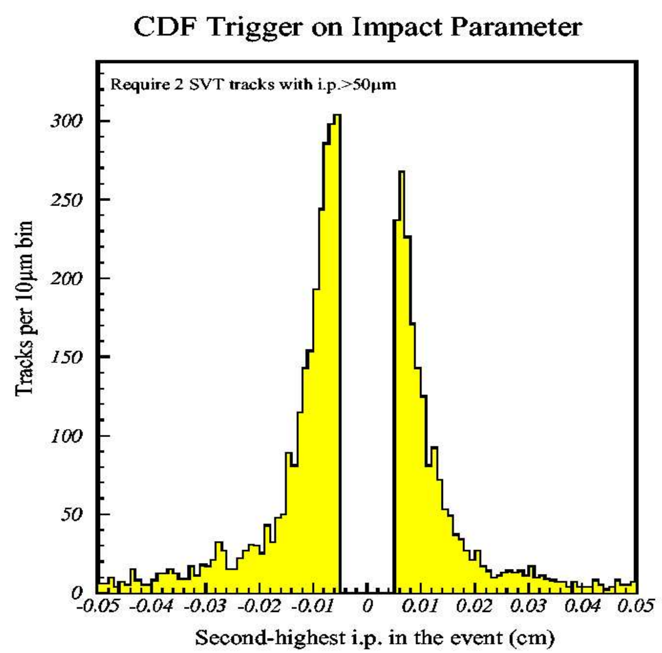
Many important physics signatures involve b quarks: Higgs searches, top studies, constraining CKM matrix...

B particles have long lifetimes $\tau(b) \sim 1.5ps \quad (c\tau \sim 450\mu m)$

Combine silicon hits with L1 tracks (XFT)

Select events with two tracks $d_o > 120\mu m$

Using impact parameter (d_o) to detect secondary vertices at the Level 2 trigger significantly increases both our physics potential and calibration sample.



Able to better select $Z \rightarrow b\bar{b}$ over the QCD background. Used for resolution and mass scale systematics when determining the top mass.

B decay studies greatly improved. Allows study of hadronic decay modes ($B^o \rightarrow \pi^+\pi^-$...) that are difficult to trigger on.

Allows triggering on hadronic B decays for measurements such as B_s mixing.

Recent B_s flavor oscillation result is an example of an analysis which exploits the new trigger capabilities (SVT)

Trigger and Data Acquisition System

The online "trigger" is used to select an event rate of about 75 Hz from the 2.5 MHz (396 ns crossing) beam crossing rate.

L1 Trigger

Calorimeter, Muon, Forward Detectors and Tracking triggers (XFT)

Typically about 60 L1 triggers

L2 Trigger

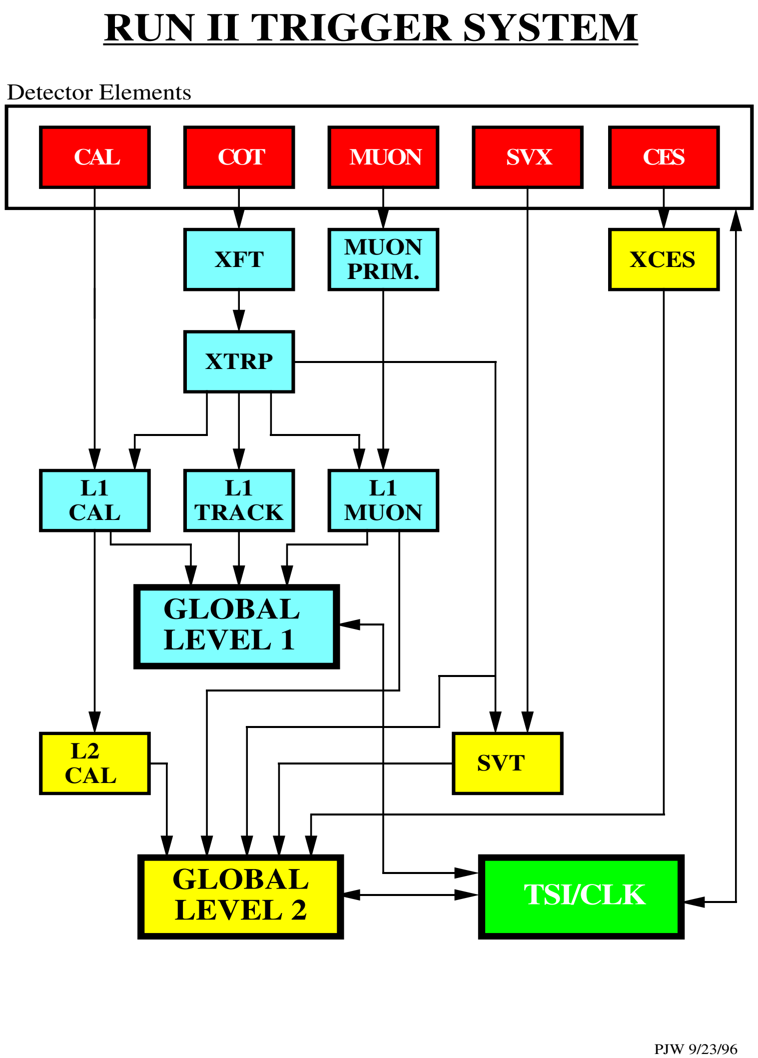
Calorimeter, *Muon* and Impact parameter triggers (SVT)

Typically about 130 L2 triggers

L3 Trigger

Full offline reconstruction

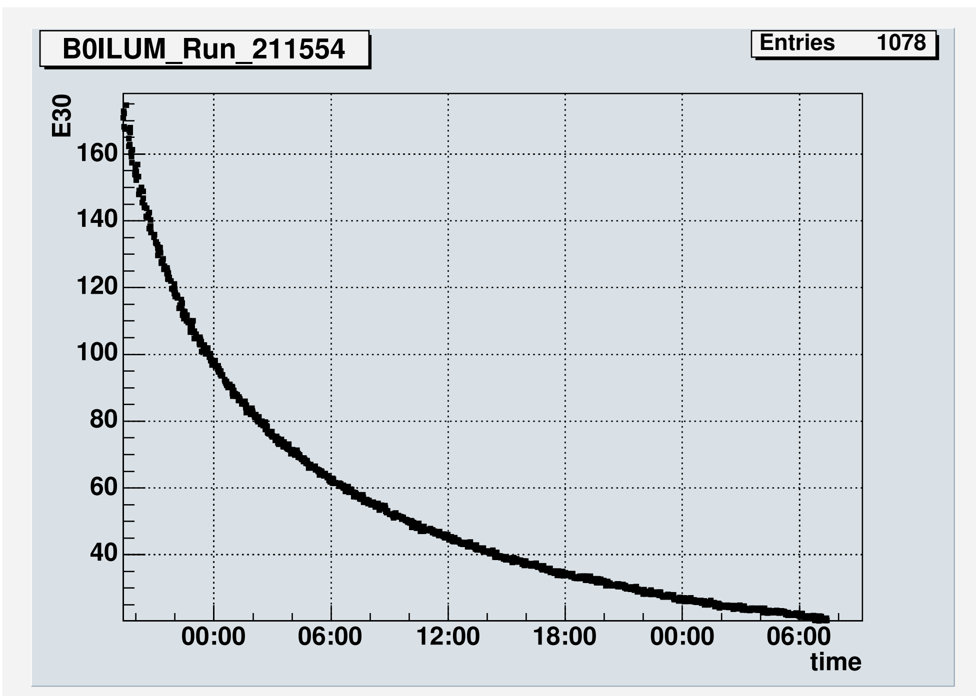
Typically about 182 L3 triggers



L1 triggers are based on primitive information
$\rightarrow$ *number of calorimeter cells above some threshold*

Rate of *"uninteresting events"* is high and we need to prescale the triggers (accept every 100th trigger for example) in order to avoid "deadtime".

Typically rate limits: L1 $\sim$30 KHz, L2 $\sim$600 Hz, L3 $\sim$100 Hz



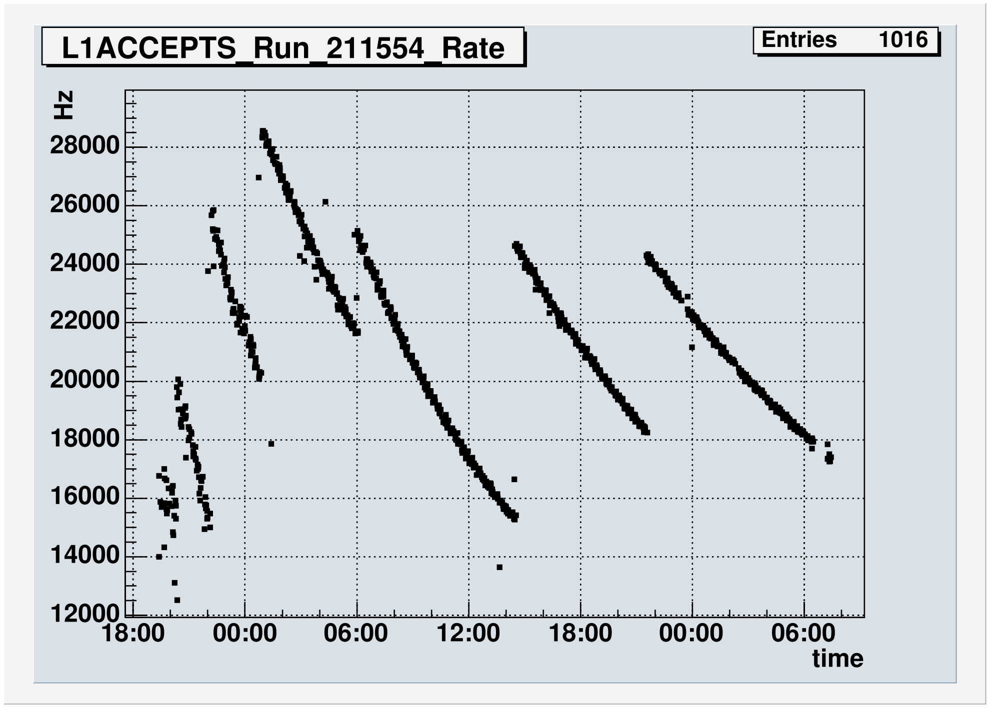
Luminosity during a store

$\rightarrow$ *Started at* 17.6×10^{31}

$\rightarrow$ *As beam conditions deteriorate the rates quickly drop*

Want to dynamically adjust the prescales in order to fill up the available bandwidth

As the luminosity drops the trigger rates drop and we have the capacity to accept more of the triggers that were prescaled.



Using *"Dynamic Prescaling"*

Some physics is difficult to trigger on, *low purity at L1*

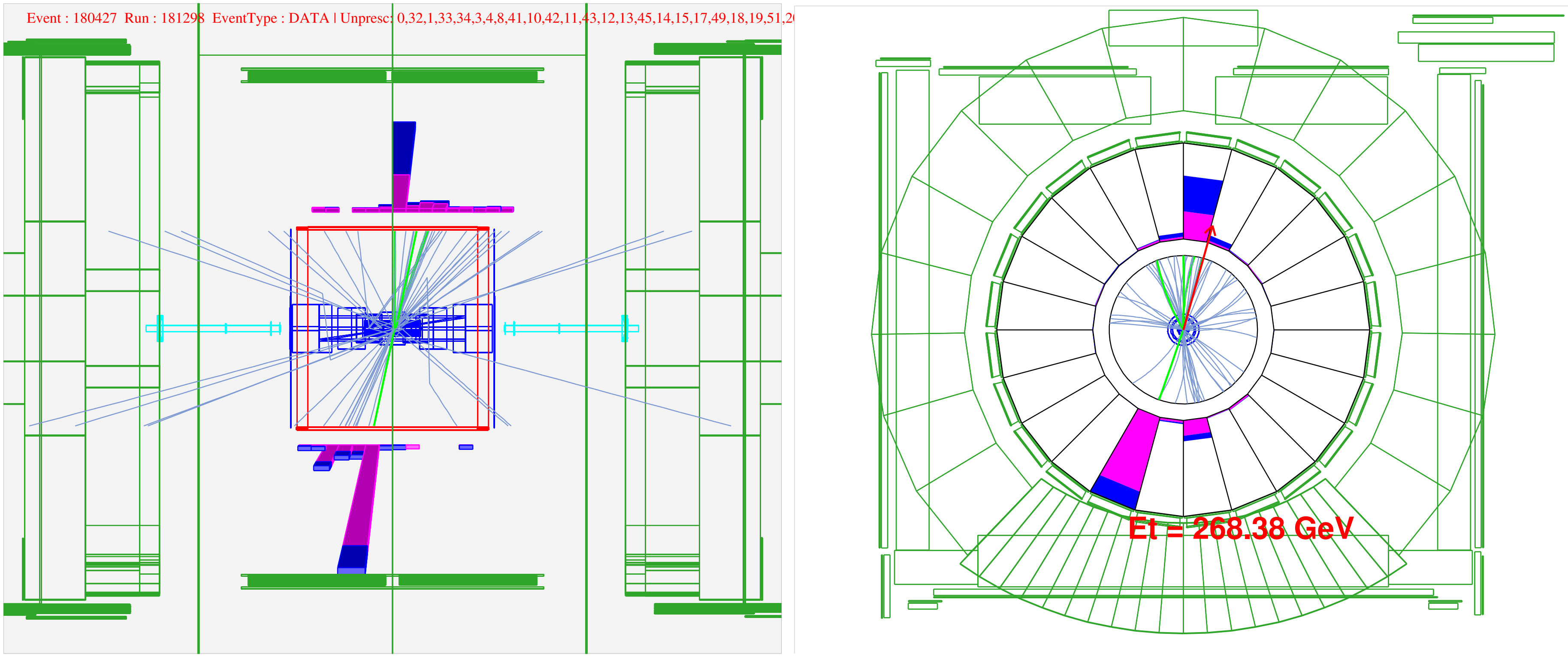
→ *high L1 trigger rates*
→ *clean up the sample at the higher level triggers*

L1 rate adjusted in order to fill up the bandwidth.

→ *Detector upgrades take full advantage of the increased luminosity and are working well*

→ *New results based on* $1 fb^{-1}$ *are now being published*

What Does An Event Look Like



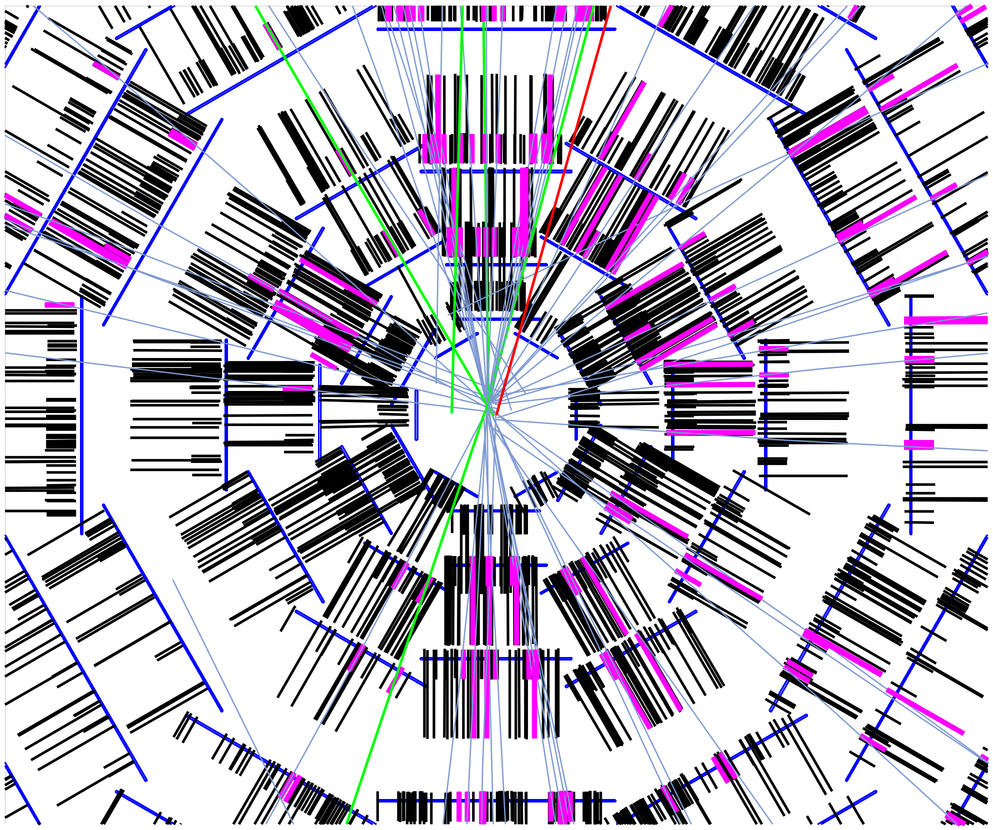
Different physics has different signatures...

QCD DiJet event

$\longrightarrow$ Proton/Antiproton breaks up into a spray of particles (jets)

$\longrightarrow$ Balanced in transverse momentum

Handles to select event: Tracks, Calorimeter energy (electromagnetic/hadronic), Muon chambers, secondary event vertex...



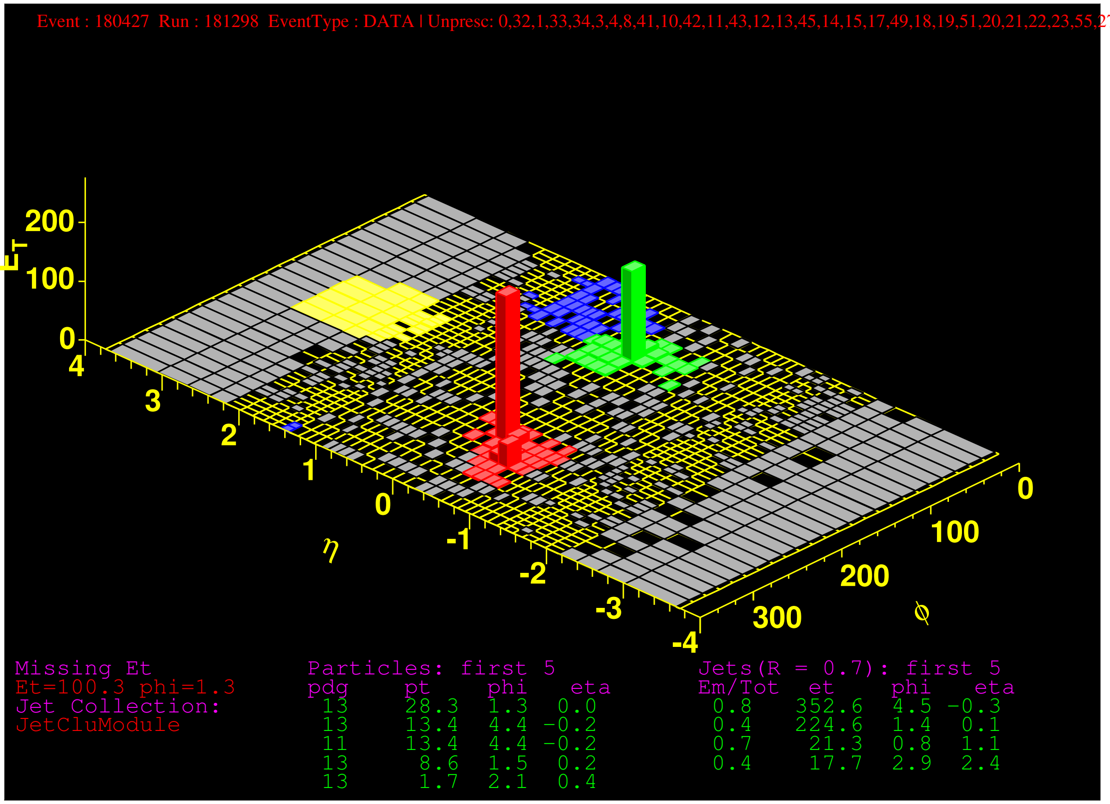
Zooming in the $r-\phi$ view to see the details of the silicon tracker

Allows us to identify long lived particles which decay away from the primary event vertex

Essential tool used in the B physics program and used to identify top events.

→ Data volume and readout presents a challenge for the Data Acquisition System

→ Keeping the silicon detector operational (calibrated, monitoring for dead channels...) requires considerable effort



Towers above 100 Mev

Towers shown in color have been clustered into jets

→ *Different clustering algorithms (MidPoint, Kt) can lead to different reconstructed jet properties*

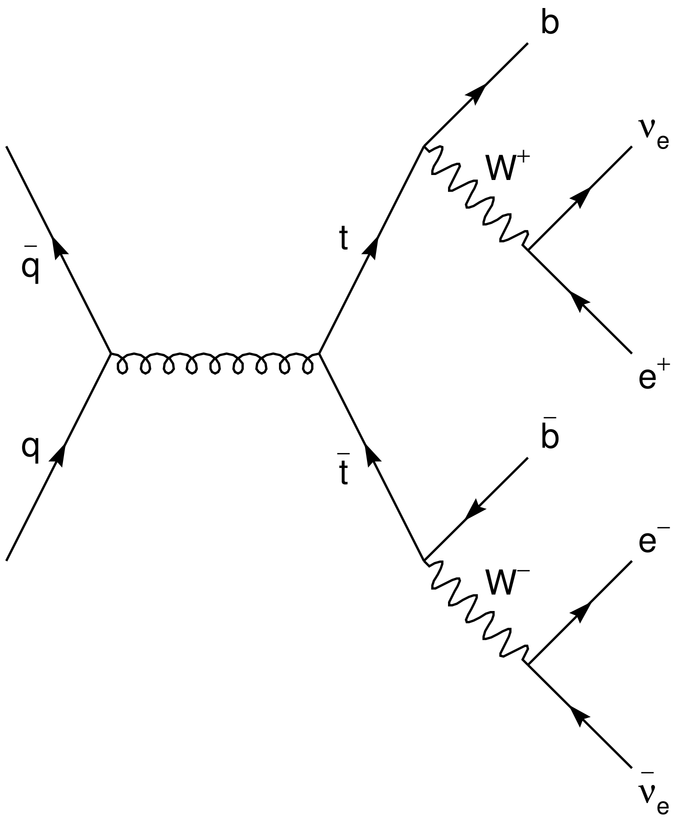
Try to keep the online selection cuts fairly loose

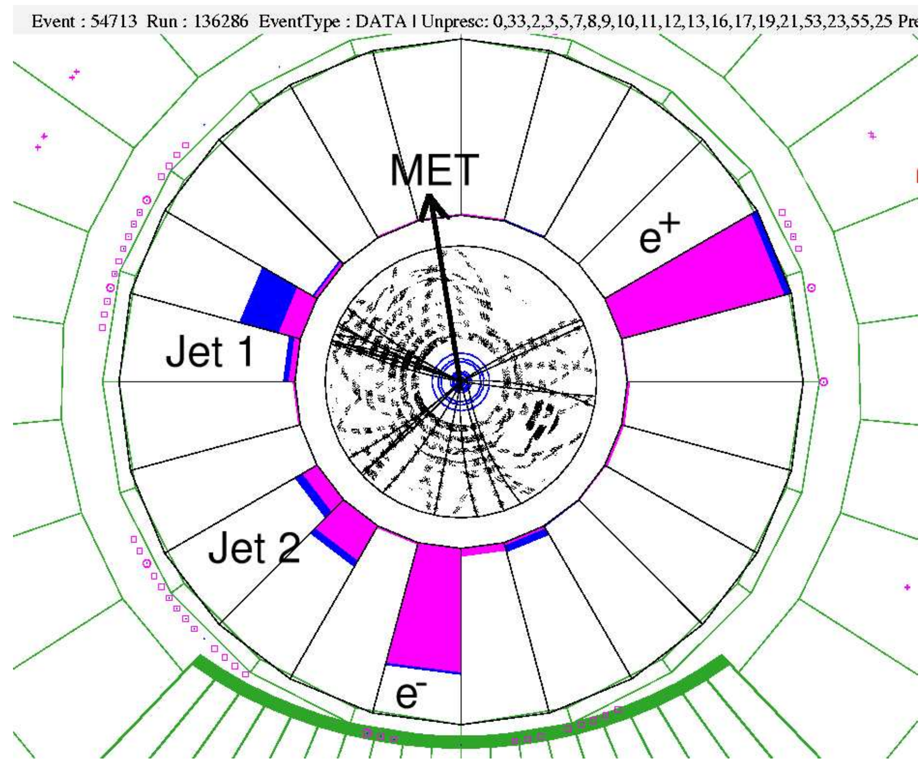
→ *For jet reconstruction we assume $z = 0$ and use a low trigger tower threshold*

Event selection is tightened up offline...

→ *Offline we reconstruct the jet using the event vertex obtained from tracking and use a higher E_T threshold so that we are nearly fully efficient*

Signature Consistent With Top Production





Event selected using the characteristics the decay signature

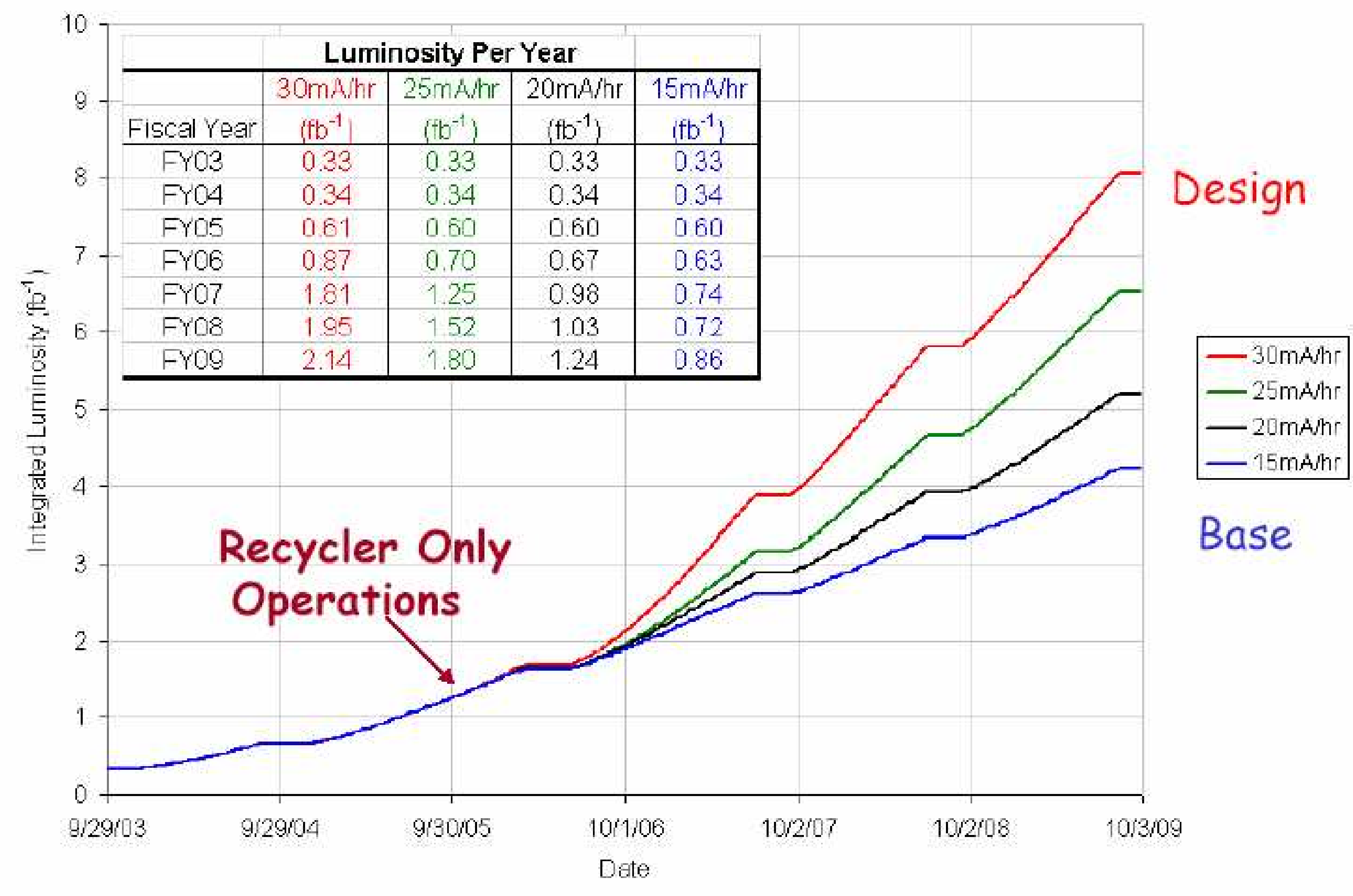
→ *Silicon tracker essential for identifying b jets*

→ *Particle charge determined by curvature in COT*

→ *Particle id aided by electromagnetic section of calorimeter*

→ *Hermetic calorimeter allows determining missing transverse energy*

The Tevatron has delivered more that 1 fb^{-1} of data and is projected to deliver between 4 - 8 fb^{-1} by the end of 2009.



Fiscal Year	30mA/hr (fb^{-1})	25mA/hr (fb^{-1})	20mA/hr (fb^{-1})	15mA/hr (fb^{-1})
FY03	0.33	0.33	0.33	0.33
FY04	0.34	0.34	0.34	0.34
FY05	0.61	0.60	0.60	0.60
FY06	0.87	0.70	0.67	0.63
FY07	1.81	1.25	0.98	0.74
FY08	1.95	1.52	1.03	0.72
FY09	2.14	1.80	1.24	0.86

To put this in context, the LHC is expected to accumulate $\mathcal{O}(10)$ fb^{-1} of data by **2009**.

"What are the advantages of running the Tevatron until the end of 2008 (2009) and accumulating 6(8) fb^{-1} before the LHC has a comparable amount of data?"

A goal for Run II should be the establishment of a "complete" description of Standard Model backgrounds to new physics.

$\longrightarrow$ *To expand beyond our current knowledge, this means obtaining a good understanding of the single top and diboson production processes and an excellent understanding of the $t\bar{t}$ process.*

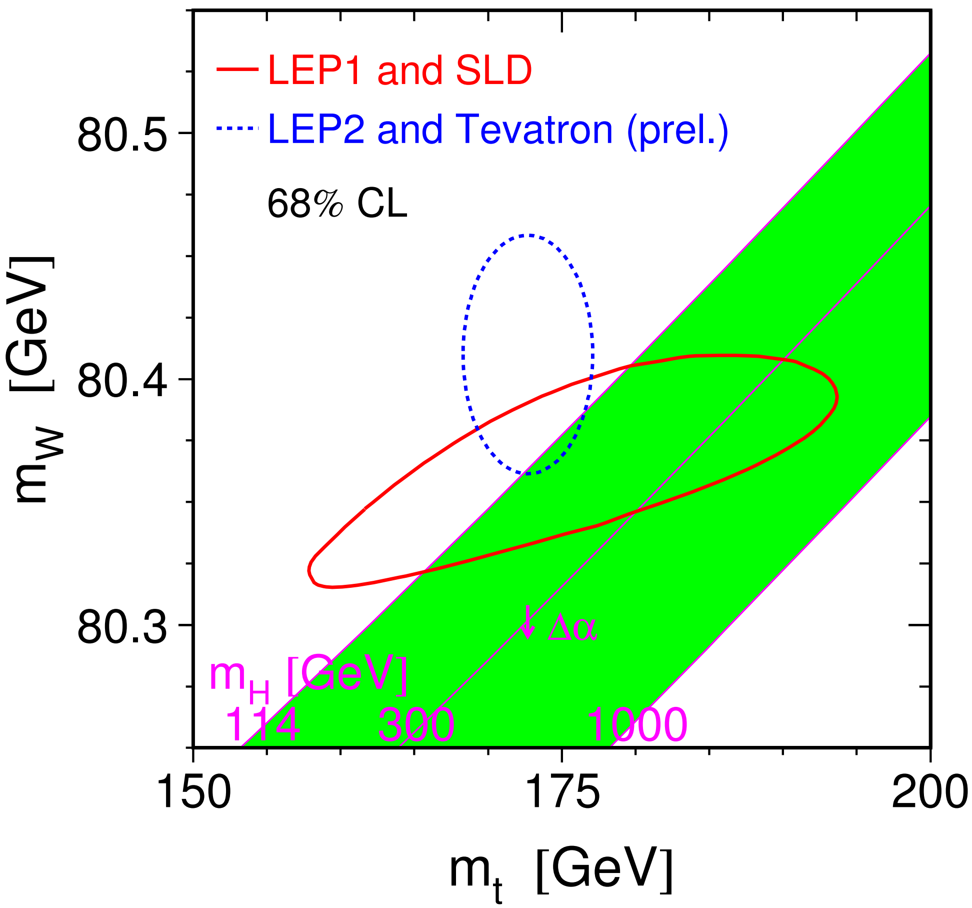
$\longrightarrow$ *Understand background processes to new physics*

$\longrightarrow$ *Extract as much information from the Tevatron as we can in order to reduce uncertainties on PDFs*

$\longrightarrow$ *Tune MC generators in preparation for LHC*

Precision Electroweak Measurements

A key test of the Standard Model, once (if) we discover the Higgs, is to look for consistency between the W, Top and Higgs mass.



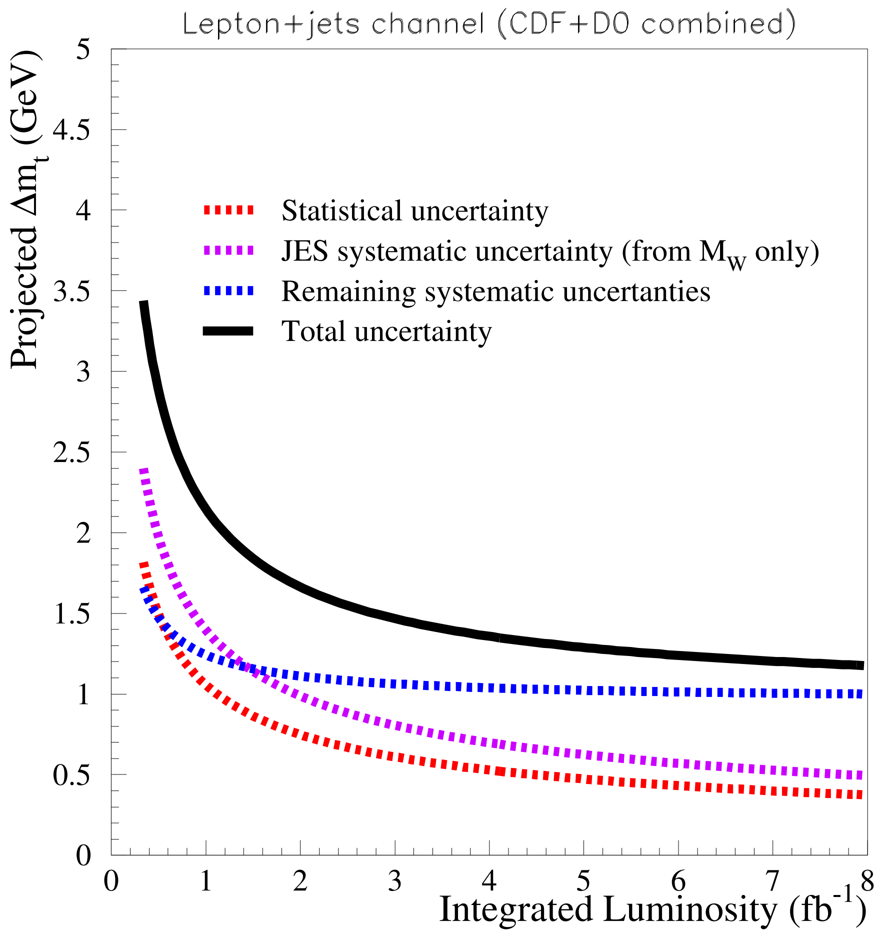
Any inconsistency could be an indication of new physics

In order to constrain the SM Higgs mass need to measure both m_W and m_t

With 8 fb^{-1} of data, the Tevatron can provide a competitive measurement of the top mass to what is expected from the LHC.

LEP EW WG web pages

Top Mass Measurement: $\delta m_t \sim 1.5$ GeV



Similar to the uncertainty on the top mass using the basic analysis at the LHC

4 fb^{-1} : $\delta m_t = 1.4$ GeV

8 fb^{-1} : $\delta m_t = 1.2$ GeV

Projected at LHC 1.5 GeV (hep-ph/0412214)

Perhaps as good as 1.0 GeV (hep-ex/0403021)

Expect to take several years to commission and fully understand the new LHC detectors and to process the data before precision measurements will be available...

Sources of systematic errors

Source	Δm_t (GeV/c^2)
Jet Energy Scale	$2.5 \rightarrow 0.7$
BG shape	$1.1 \rightarrow 0.3$
b-jet modeling	0.6
FSR	0.6
Method	$0.5 \rightarrow 0.2$
ISR	0.4
MC statistics	$0.3 \rightarrow 0.1$
PDFs	0.3
Generators	0.2
b-tagging	0.1

Adapted from Tomura, HCP2005

Jet energy scale: derived from $W \rightarrow qq'$, detector resolution

Background: systematic uncertainties in modeling the dominant background sources

b-jet modeling: variations in the semi-leptonic branching fraction, b fragmentation model, differences in color flow between b-jets and light quarks.

ISR, FSR: modeling

Method: Fit method, MC statistics b tagging efficiency

Generator: differences between PYTHIA or ISAJET and HERWIG when modeling the $t\bar{t}$ signal

Can reduce some errors with more data

Reducing others requires improved modeling

$\rightarrow$ Iterate on models and PDFs, new data has not yet been used

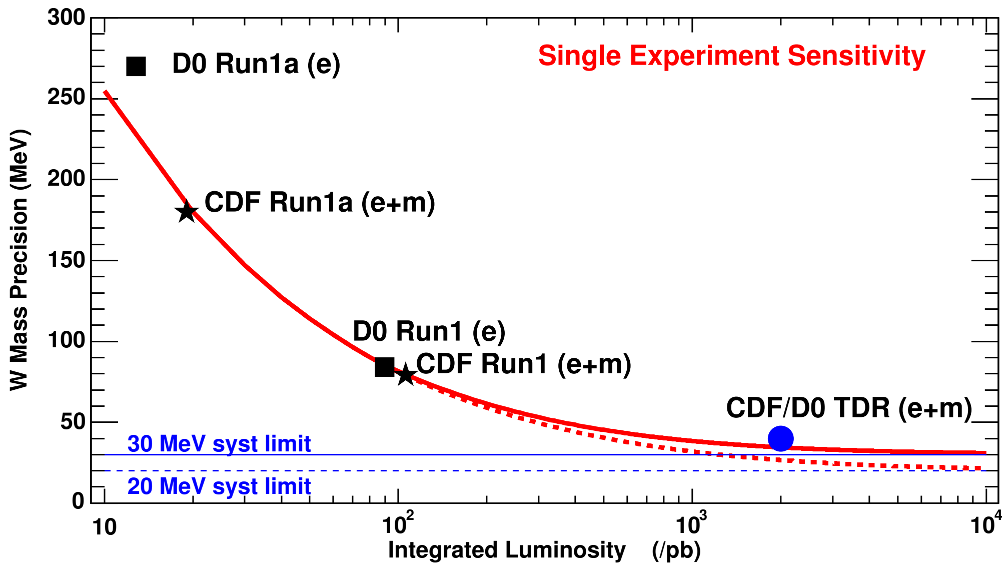
W mass measurement: $\delta m_W \sim 20 - 30$ MeV

Uncertainties assumed to scale with luminosity

- Statistical uncertainties
- Systematic uncertainties such as: Energy and momentum scale and Hadron Recoil against W

Uncertainties assumed not to scale with luminosity

- W production and decay: PDFs, $d(\sigma_W)/d(p_T)$, higher order QCD/QED effects (Assumed to be between 20 - 30 MeV)



LHC expectations are:

$\delta m_W \sim 10 - 20$ MeV

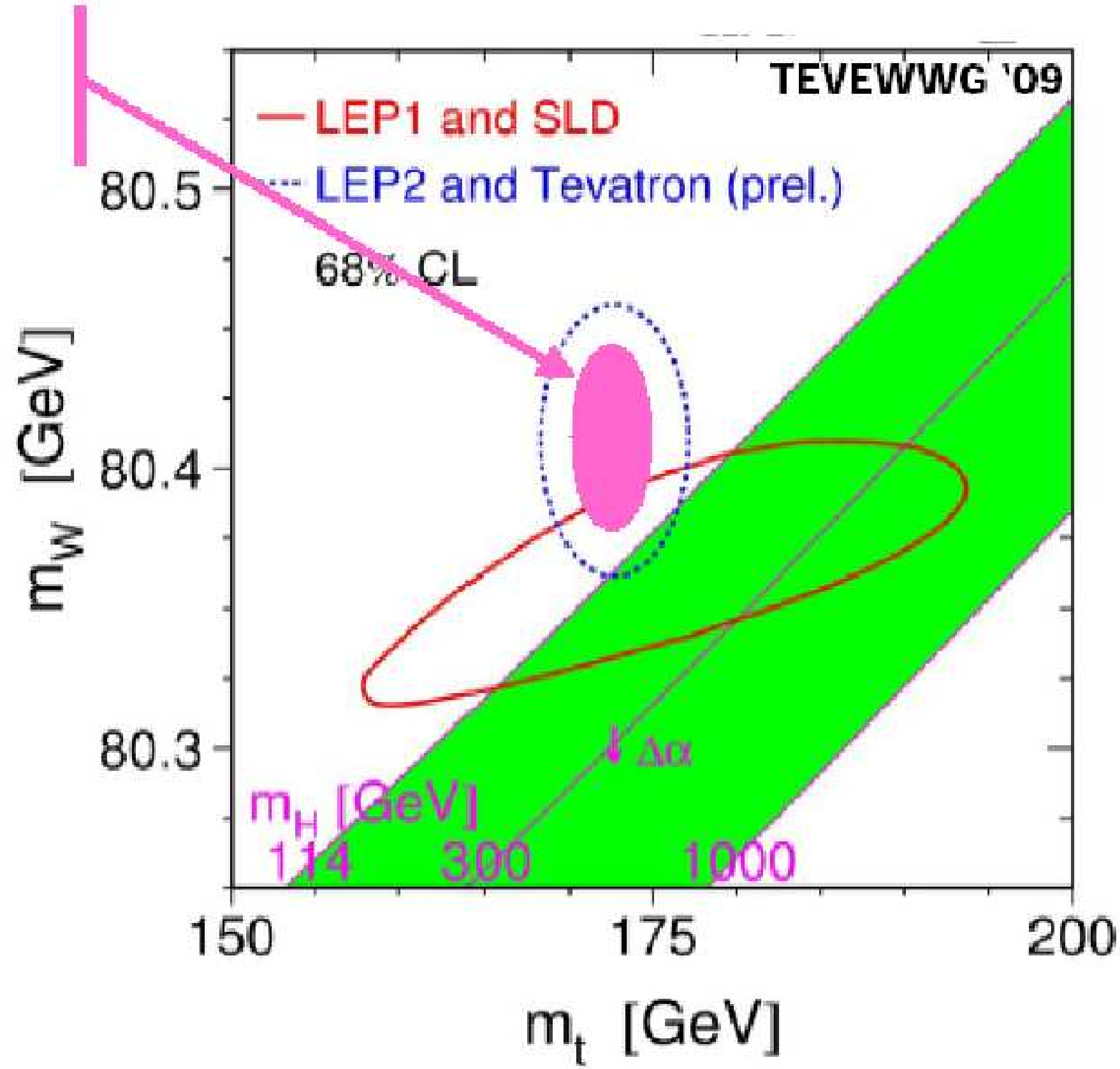
Requires:

→ *low luminosity running*

→ *good understanding of the detector*

Prospects from reducing the errors on m_t and m_W

$\delta m_t = 1.2$ GeV
$\delta m_W = 24$ MeV

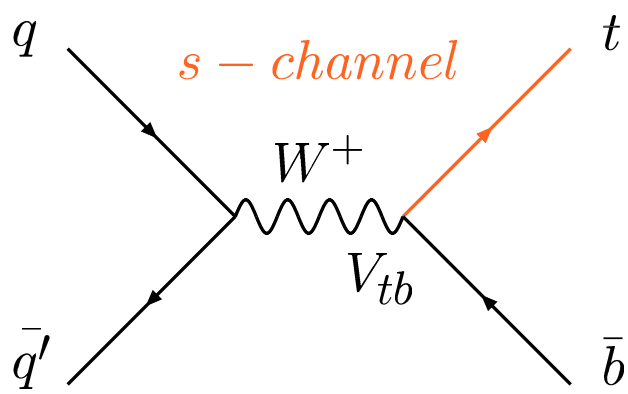


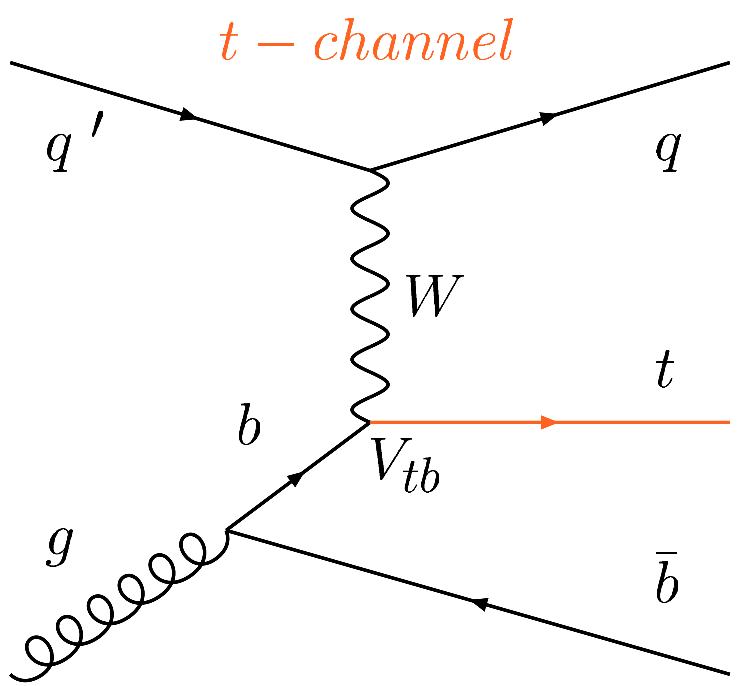
→ *Provides tighter constraints on the SM Higgs*

→ *Could be available near the start of LHC physics running*

J. Hobbs, presentation to P5

Single top production





→ Tests the SM, search for new physics

→ Important to fully understand top production (probes V_{tb})

→ Important for Higgs searches

→ Probes the heavy flavor content of the proton

SM Predictions:

$\sigma(\mathrm{s-channel}) = 0.88 \pm 0.14$ pb

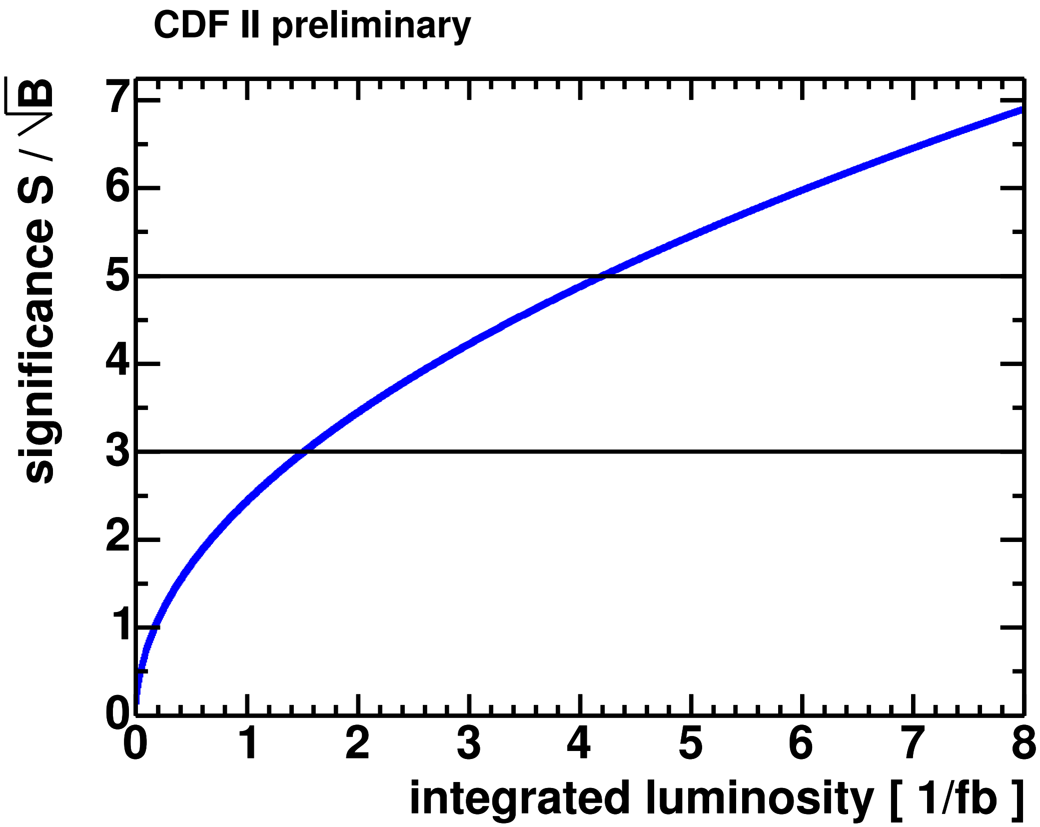
$\sigma(\mathrm{t-channel}) = 1.98 \pm 0.30$ pb

Currently published bounds:

s-channel: $\sigma < 6.4$pb

(DØ 230 pb^{-1})

t-channel: $\sigma < 5.0$pb



Combined channel likelihood for SM single top production.

With 4 fb^{-1} (2007/8?), we expect an event sample of about 75 events and should have a 5 σ signal to claim discovery.

A doubling or quadrupling of the data will allow for multi-variate fits, increasing our confidence that we are observing pure Standard Model single top production.

→ *The LHC is expected to have a significant sample of single top events by 2008.*

→ *Need to make sure that quality data gets on tape...*

Di-Boson Production

Di-Boson cross section measurements provides tests of the SM and probes boson self couplings.

ZZ/ZW production probes the triple guage boson couplings.

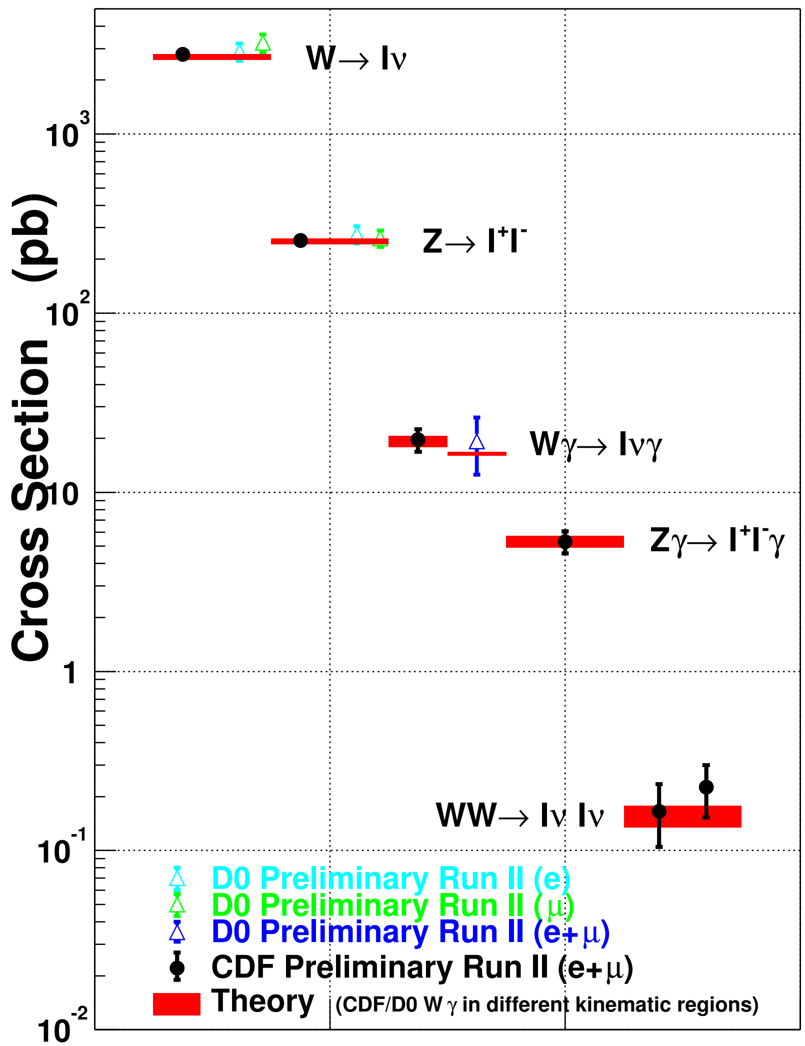
$\longrightarrow$ *The presence of unexpected neutral triple-guage-boson couplings (ZZZ and $ZZ\gamma$) can lead to enhanced ZZ production.*

$\longrightarrow$ *Anomalous WWZ coupling can increase the ZW production rate above the SM predictions.*

A good understanding of di-boson production is needed to estimate the background for other important physics.

$\longrightarrow$ *In $t\bar{t}$ events when the Ws decay leptonically signature is similar to WW production.*

$\longrightarrow$ *The production of WZ and ZZ boson pairs is a significant background in searches for the SM Higgs.*



Uncertainty on the cross section for the WW process is $6-7\times$ the theoretical uncertainty.

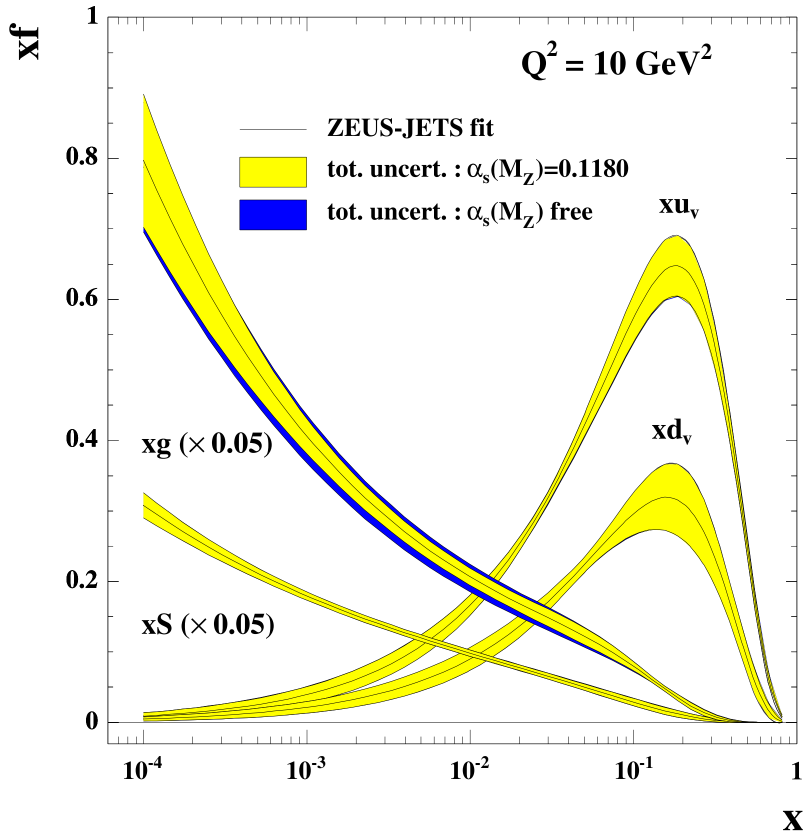
With 194 pb^{-1} of data CDF set a 95% confidence level upper limit of 15.2 pb on the cross section for ZZ plus ZW production, compared to the standard model prediction of 5.0 ± 0.4pb (hep-ex/0501021).

Similar footing as single top production, and needs comparable statistics for a good description.

hep-ex/0405026

With more data, Di-Boson measurements could soon become "precision measurements"...

Parton Density Functions (PDFs)



Particle structure is parameterized by PDFs → gives the probability of probing a parton of a given type

PDFs (up, down gluon, sea) are parameterized as a function of the kinematic variables (x, Q^2)

x : momentum fraction carried by the struck parton
Q^2 : the square of the momentum transferred

The Standard Model (QCD, electroweak...) describes how the partons interact with each other.

→ Cross sections (predictions) can then be calculated once you know the probability of probing particular partons

Once you know the x dependence of the partons at a given Q^2 you can evolve the PDFs to a new Q^2 using the DGLAP equations.

$\rightarrow$ Can make predictions in different regions of phase space

Assumptions:
$\rightarrow$ *about the content of the proton*
$\rightarrow$ *about the functional form of the parameterization*

PDF sets are determined by fitting the available data across many experiments to determine consistent fits to the parameters

CTEQ, MRS among others perform global fits to the data
$\rightarrow$ *Extremely important contribution to the field*

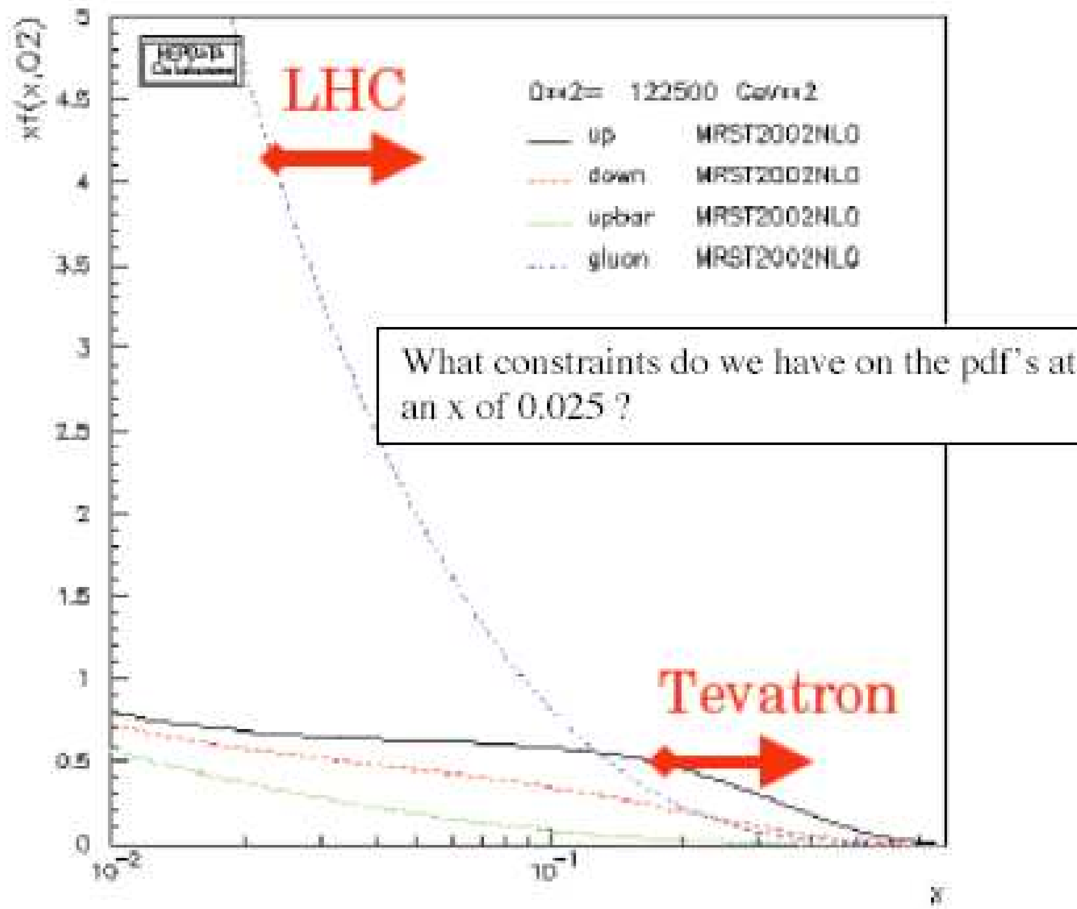
Many complications with handling data across experiments
$\rightarrow$ *Consistency between datasets/experiments*
$\rightarrow$ *Proper treatment of errors*
$\rightarrow$ *Data not always in easy to use form*

Tevatron and LHC access different kinematic regions

→ *Tevatron valence quark dominated*

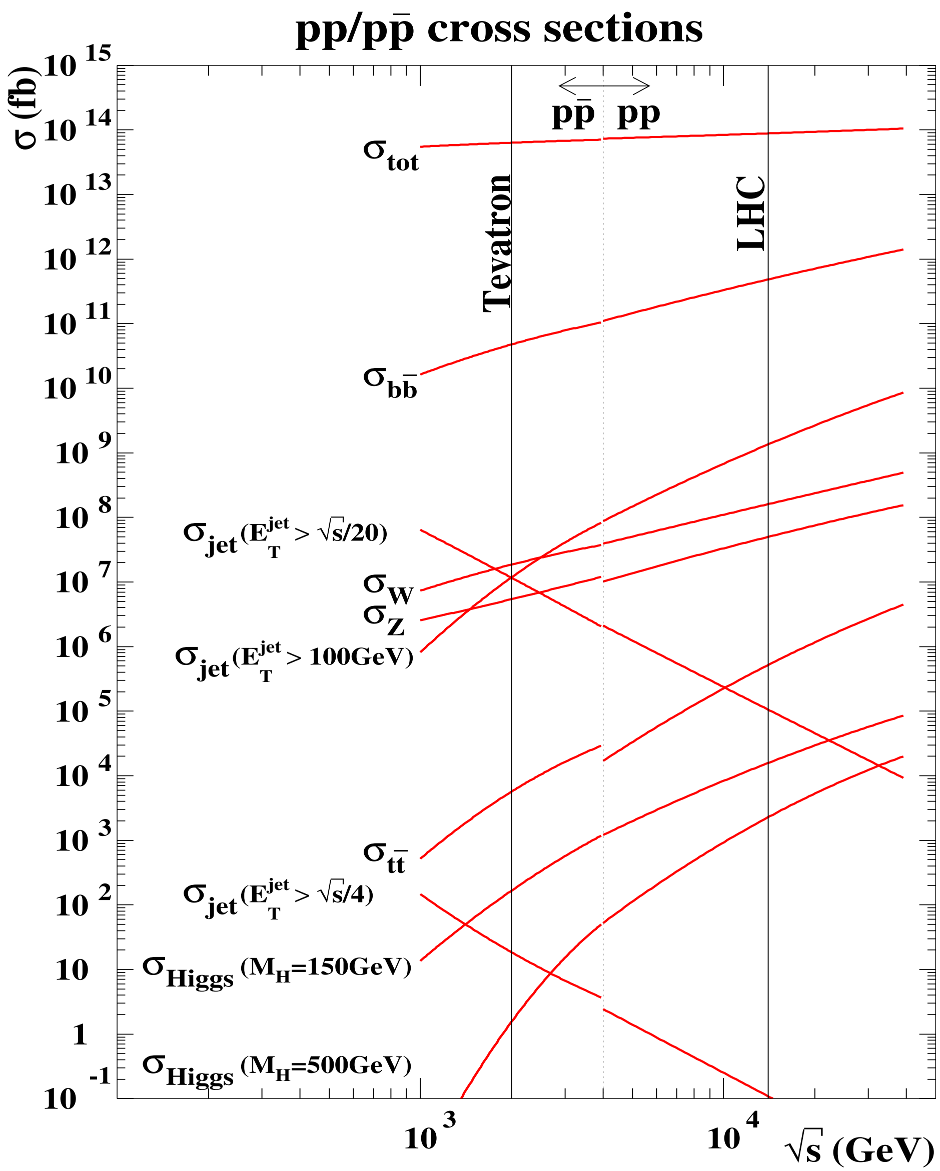
→ *LHC sea quark dominated*

The ability to distinguish new physics from Standard Model predictions depends on how well we can extrapolate predictions to the new kinematic region



An important aspect of the Tevatron program is to provide data that can be used in new global QCD fits to produce refined sets of PDFs with reduced uncertainties

Understanding the Backgrounds



New physics is expected to have small cross sections and is swamped by standard physics background

Standard physics processes have relatively large uncertainties

→ *Need to have an accurate prediction for the background in order to claim a discovery*

Details of the Underlying Event

The underlying event (UE) is an unavoidable background to many measurements at the Tevatron and the LHC.

There is also interesting QCD physics in the UE which contains particles originating from initial and final state radiation, beam-beam remnants, and multiple parton interactions.

Don't think we have a satisfactory description of the UE in MC

→ *PYTHIA has only a few parameters available to tune UE*

→ *PYTHIA 6.3 provides additional handles*

→ *No handles in HERWIG*

→ *Add JIMMY to HERWIG*

Can we find "universal tunes"... HERA → Tevatron → LHC

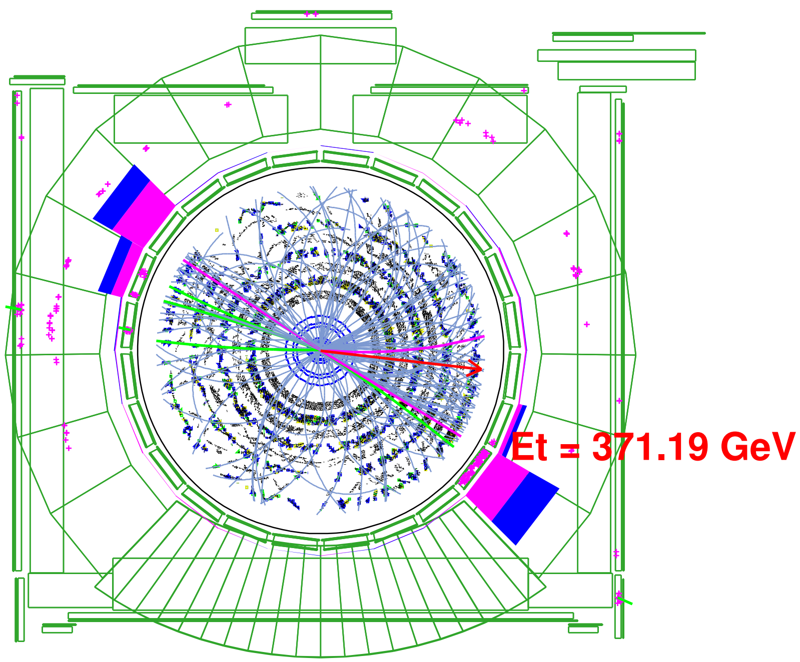
Do have the possibility to help tune the models...

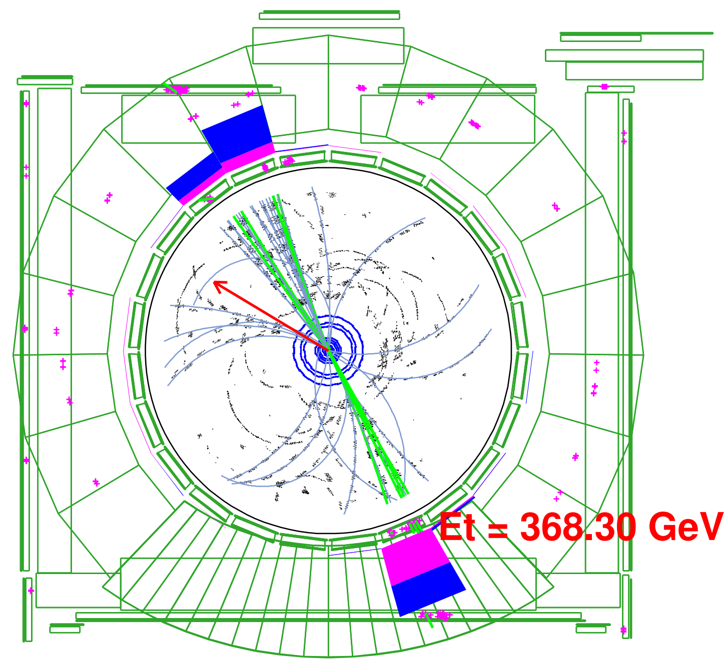
→ *Measure the cross-section for multiple-parton collisions and establish precisely how much it contributes to the UE in various processes.*

→ *Multiplicity distributions in W, Z, Drell Yan, WW, ZZ, and WZ*

→ *Study the UE in color singlet production (Z-boson and Drell Yan processes). Compare to the UE in high p_T jet production.*

→ *Determine rate of vector boson fusion (VBF) and study rapidity gaps.*

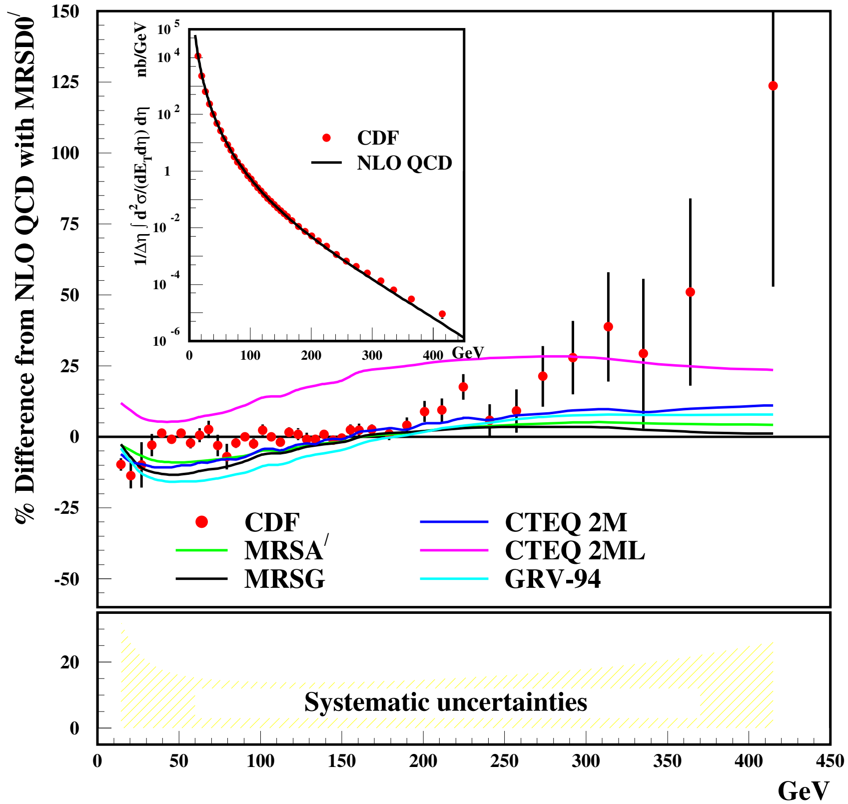




Understanding of the UE will be among the first things needed at the LHC. *Also probably one of the first things studied...*

Underlying event studies and MC tuning being driven by R. Field (U of F)

New Physics or Old?

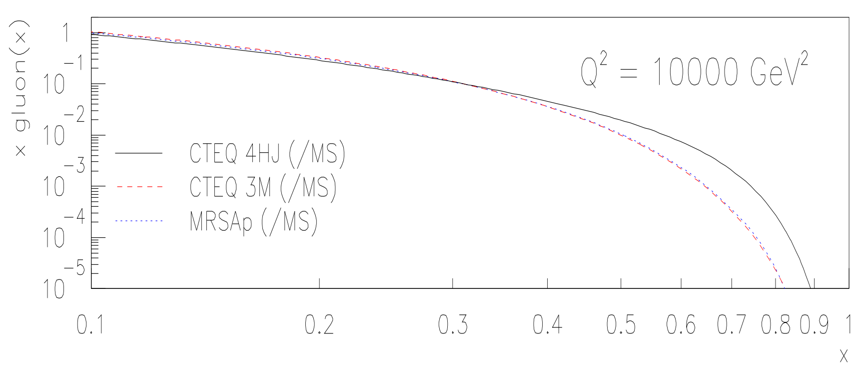


In Run I we observed an excess of events at high jet E_T when the data was compared to then-current PDF sets

Models of quark compositeness predict a higher cross section at high E_T

$$x_{1,2} = \frac{E_T}{\sqrt{s}}(e^{\pm\eta_1} + e^{\pm\eta_2})$$

$$Q^2 \sim 2E_T^2 \cosh^2\eta^*(1 - \tanh\eta^*)$$



But... this effect can be accommodated by enhancing the gluon density at high x

PDF Uncertainties

Errors on PDFs can influence the measurement at several stages

$$\sigma_{\text{meas}} = \frac{\epsilon}{\mathcal{L}}(N_{\text{obs}} - N_{\text{bkg}})$$

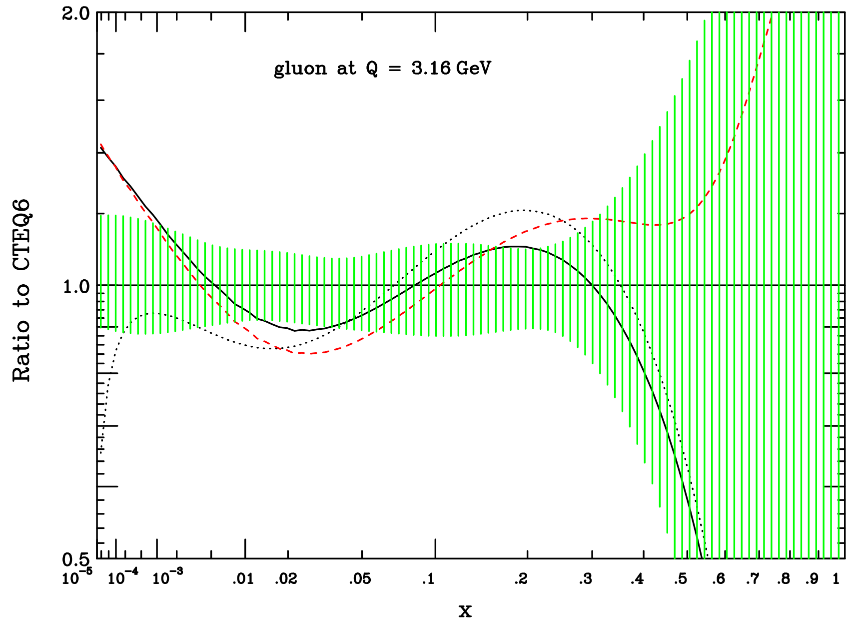
Calculation of acceptance (ϵ), luminosity ($\mathcal{L}$), event selection (N_{obs}), background estimate (N_{bkg})

$$\sigma_{\text{theory}} = \text{PDF}(x_1, x_2, Q^2) \otimes \sigma_{\text{hard}}$$

Theory calculation includes:

- Experimental errors when fitting measured data
- Theoretical errors resulting from input parameters (flavor threshold, α_s...) uncertainties on the theoretical modeling (scale errors, nonperterbative effects, PDF parameterization...)

Input to PDFs - What is Unknown



hep-ph/0201195

Gluon distribution

→ *Inclusive jet, forward jets*

Shaded band shows the CTEQ6 gluon uncertainty at $Q^2 = 10$ GeV^2

Ratio of CTEQ5M (solid), CTEQ5HJ (dashed) and MRST2001 (dotted) to CTEQ6

Strange and anti-strange quarks, strange asymmetry

→ *Tagged final states* $W/Z/\gamma + c/b$

Details in the u, d quark sector, u/d ratio

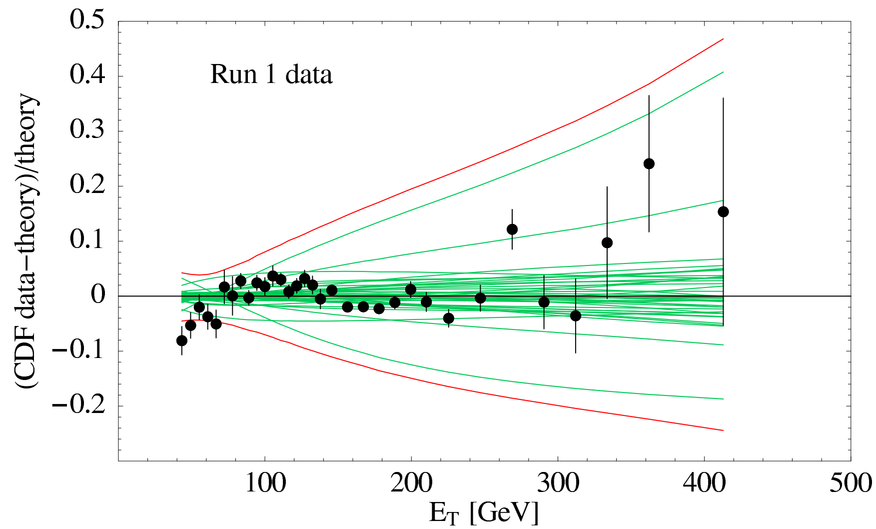
→ W *charge asymmetry*

→ W *rapidity distribution*

Heavy quark distribution

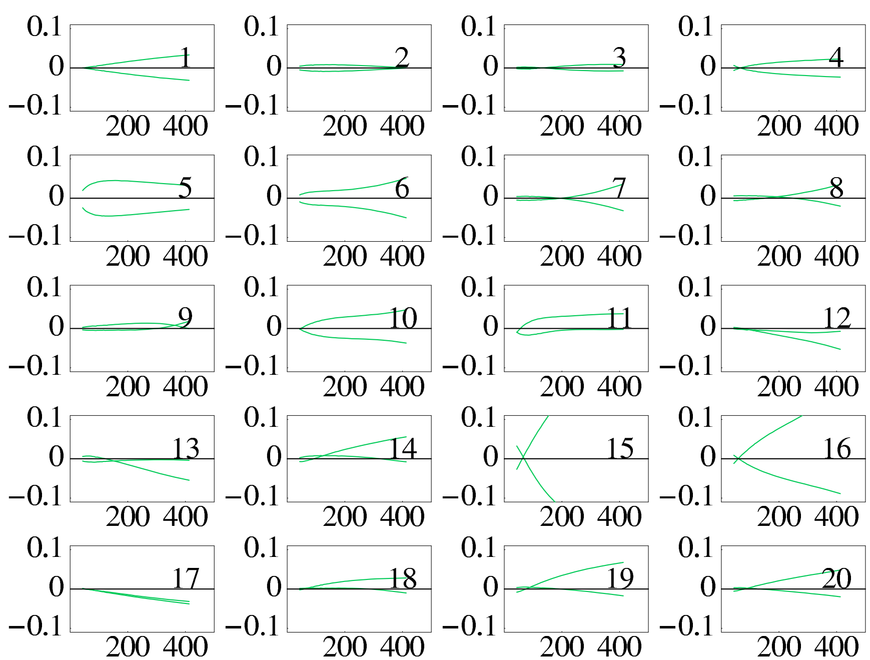
→ *Tagged final states* $W/Z/\gamma + c/b$

Run I Inclusive Jet Cross Section



Cross section is calculated using the central PDF and for each error PDF, errors added in quadrature $\Delta\sigma^{\pm} = \sqrt{\sum_i \sigma_i^{\pm 2}}$

40 sets for CTEQ, 30 for MRST



New tools ("Hessian Method" and "Lagrange Multipliers") being employed to allow a more statistically correct treatment of errors.

Can "reweight" the MC

Previously error estimates were determined by taking the difference of the predictions obtained using PDF sets

PDF sets could use very different data sets, functional form and assumptions...

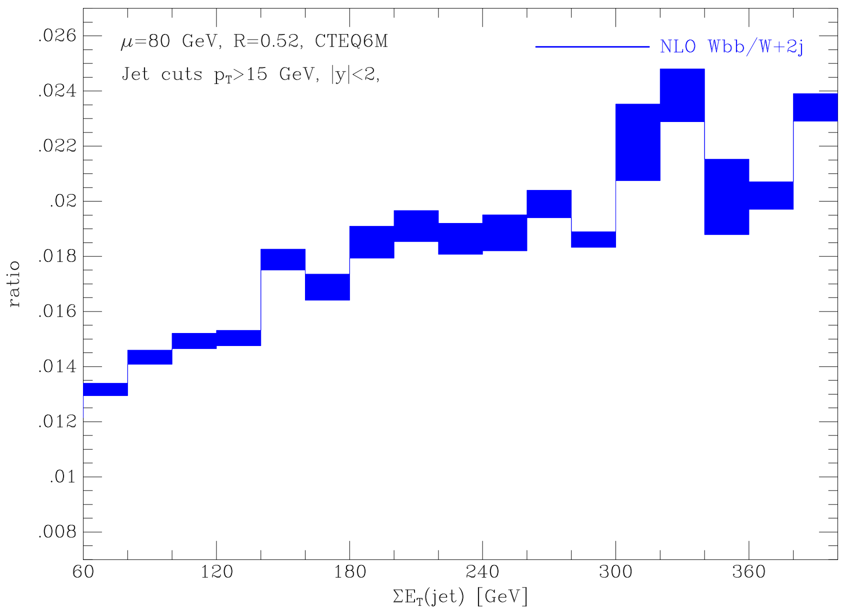
hep-ph/0303013

Using PDF Error Estimates

Need to make the errors on PDFs available in a form that can be generally used

Les Houches Accord Parton Density Function Interface (LHAPDF)

"...enable the usage of Parton Density Functions with uncertainties in a uniform manner."



hep-ph/0405276

Uncertainty on the $Wb\bar{b}/W + 2$ jet ratio as a function of ΣE_T(jet)

Generate events with central PDF

Keep track of PDF $\times$ PDF weight for each error PDF

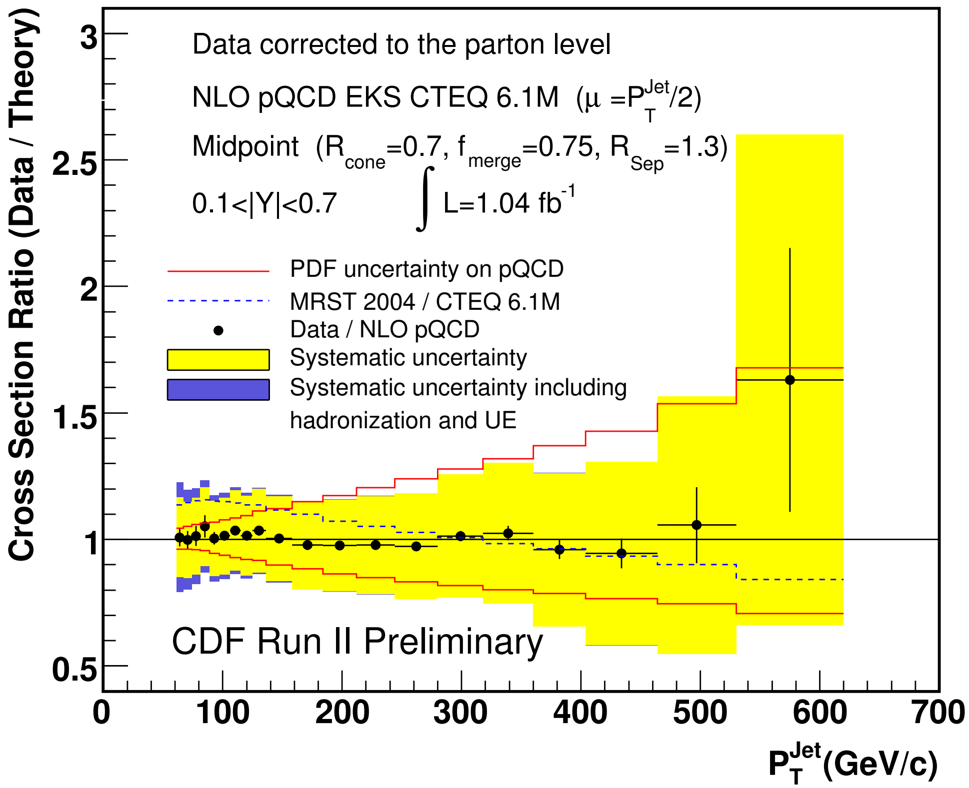
Reweight MC to see the effect on observable

Statistical errors not shown...

Make the tools easy to use and readily available

Input to PDF Fits

Inclusive jet cross section using the cone based MidPoint jet algorithm → *probes the high x gluon distribution*



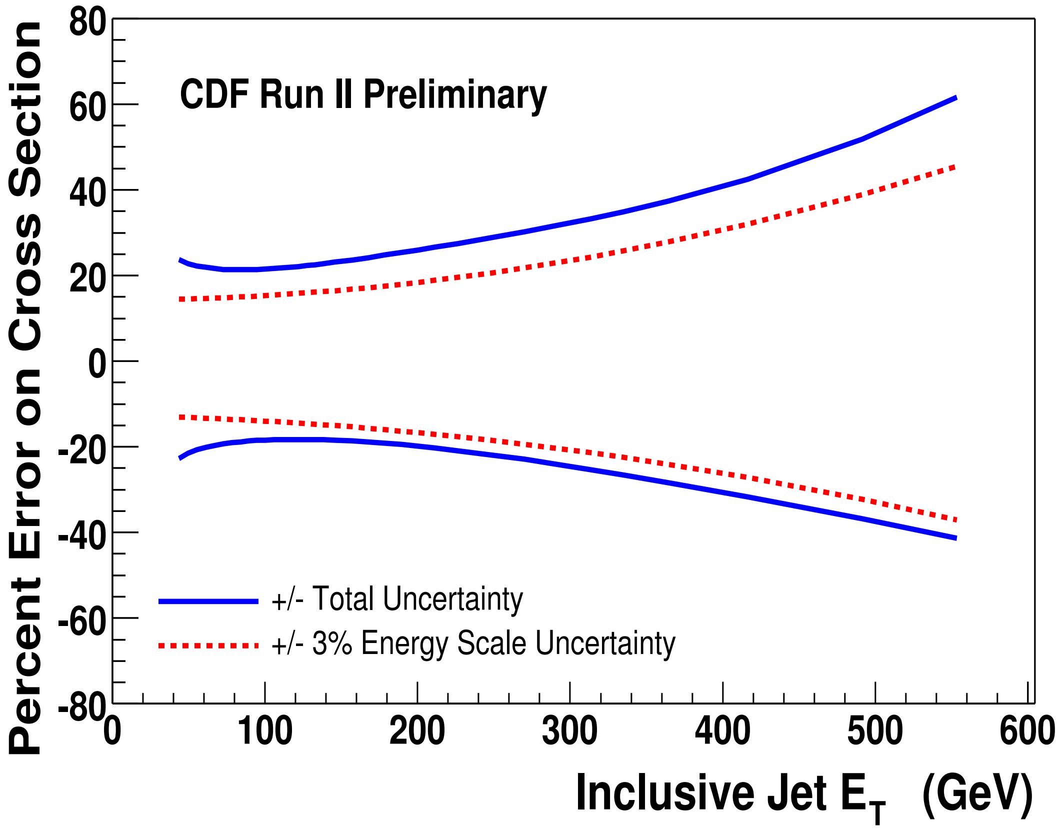
Results based on 1.04 fb^{-1}

Extends Run I results by $\sim$ 150 GeV

Analysis performed by C. Group (U of F)

New data will provide tighter constraints on PDFs, in particular the high x gluon distribution

Uncertainty in the energy scale is the dominant source of systematic error for the inclusive jet cross section measurement



The effect of a 3% energy scale uncertainty (dashed line) contribution to the total systematic error (solid line)

→ *Challenging to improve this...*

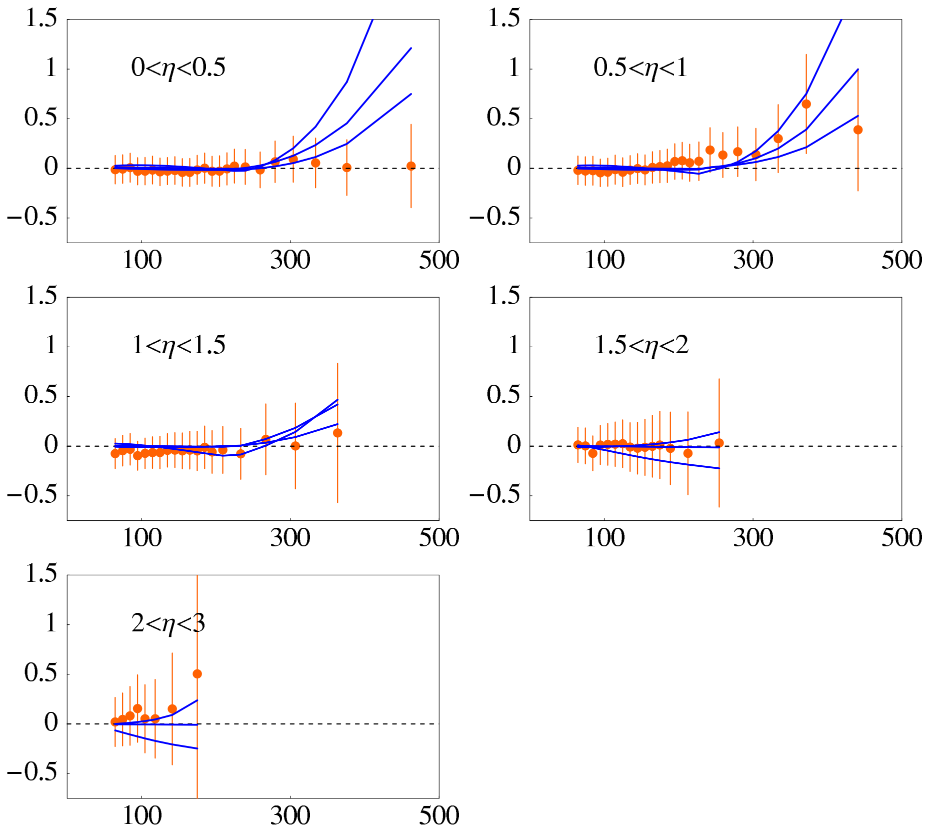
Uncertainty on the cross section due to the energy scale gets larger in the forward region because of the faster falling spectrum

May be able to reduce systematic uncertainties by measuring ratios (inclusive: forward/central, dijet: SS/OS...)

New Physics could show up as a deviation from the SM predictions at high E_T in the inclusive jet cross section.

Flexibility in the PDF parameterizations could accommodate deviations in the central inclusive jet cross section at high E_T

Run I DØ data, inclusive jet cross section binned in rapidity (last bin $2 < |\eta| < 3$)

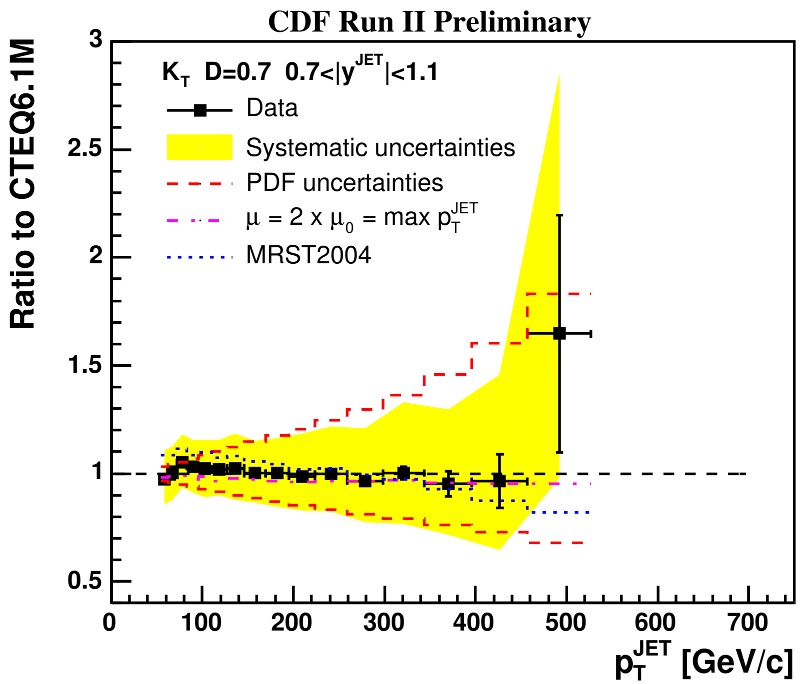


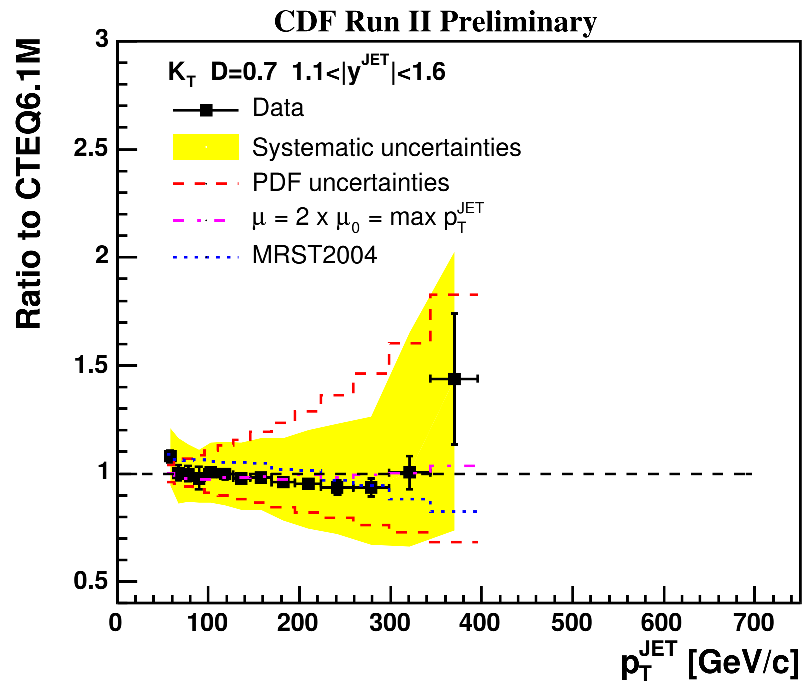
Usually look at the angular distribution between two leading jets

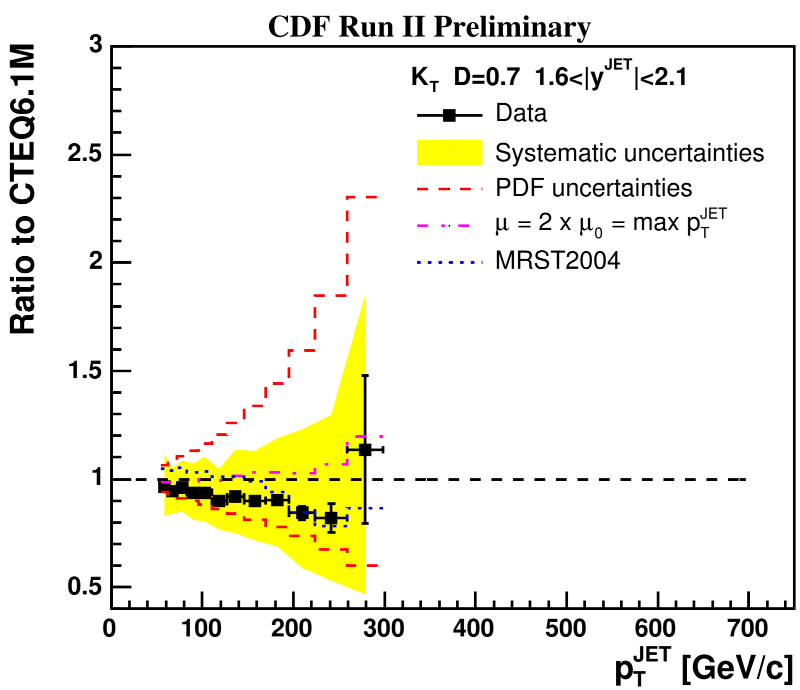
More general to include forward jets in the global fit

Curves show the result of a global fit including a contact interaction in theory with $\Lambda = 1.6, 2.0, 2.4$ TeV

Stump et al., hep-ph/0303013







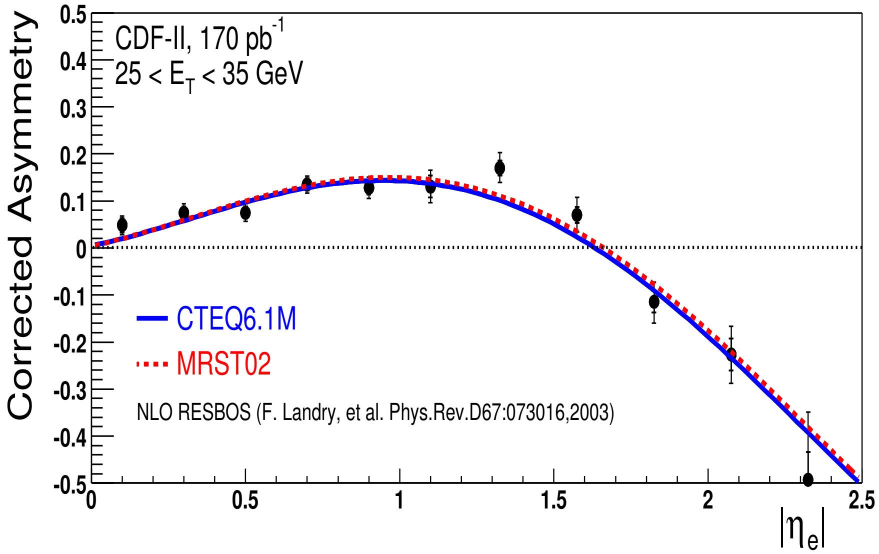
CDF Run II Preliminary results based on 0.98 fb^{-1} of data.

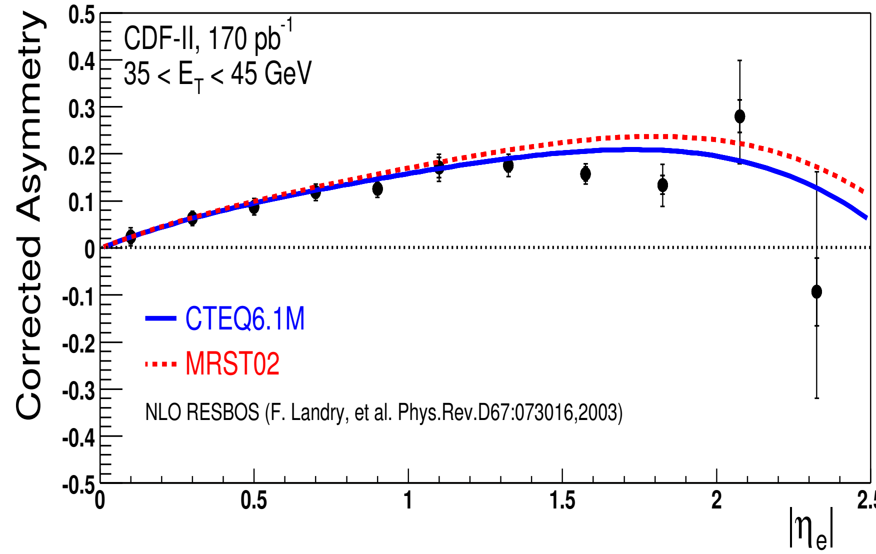
Forward ($|y| < 2.1$) Jet Data using the k_T Clustering algorithm

→ *With more data we will be able to use finner rapidity bins and better study the cross section shape*

W Charge Asymmetry

$$A_{ch}(\eta) = \frac{d\sigma(e^+)/d\eta - d\sigma(e^-)/d\eta}{d\sigma(e^+)/d\eta + d\sigma(e^-)/d\eta} \sim \frac{d(x, M_W)}{u(x, M_W)}$$





hep-ex/0501023

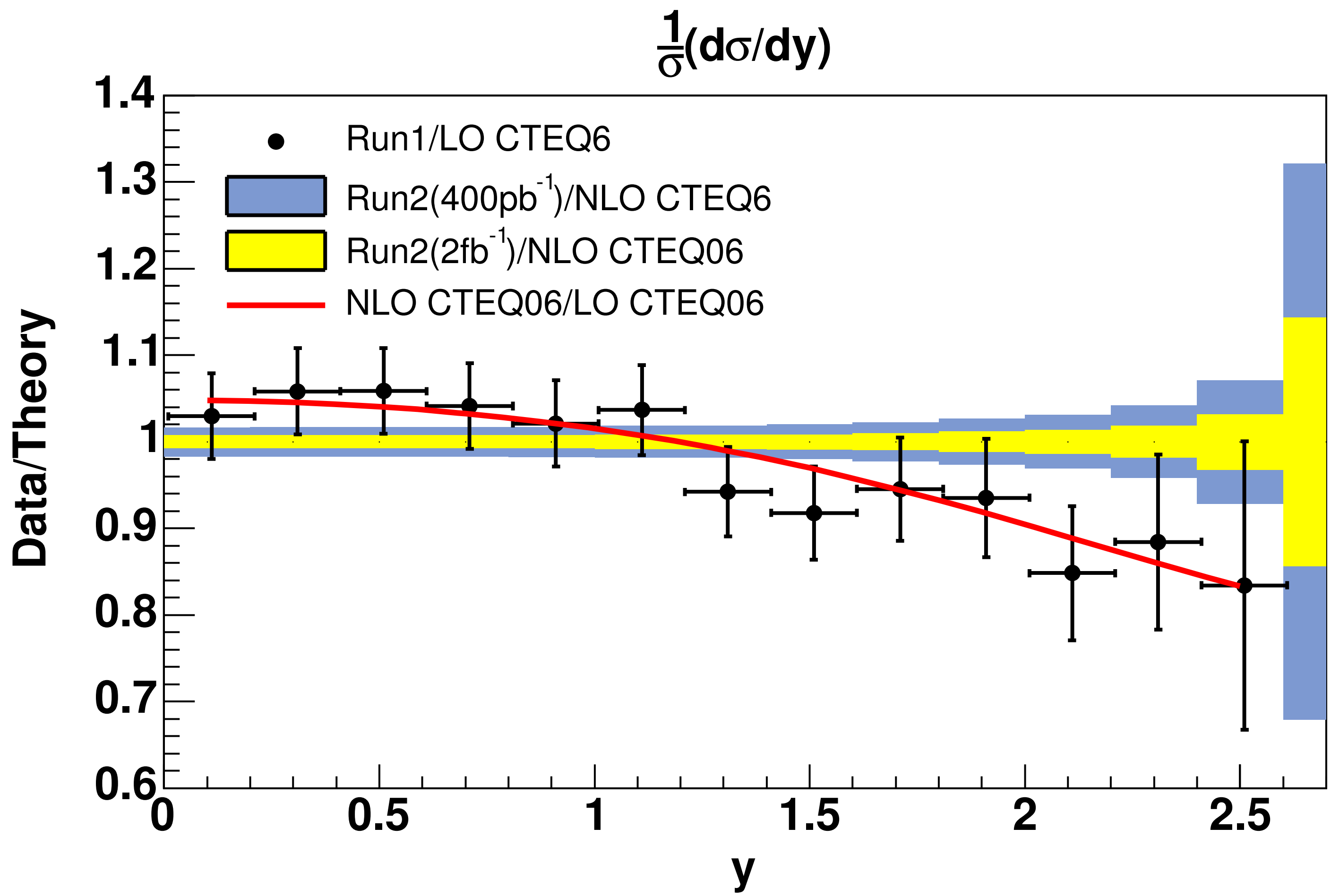
In Run II we now have two E_T^e bins
$\rightarrow$ now able to explore the E_T^e dependence

Differences start showing up at high rapidities...

In general for global QCD fits it is better to have differential distributions (more bins in η, E_T^e)...

Z Rapidity Distributions

The shaded bands show the expected reduction in the statistical error for $400pb^{-1}$ and for $2fb^{-1}$



Currently not being used in fits... but may be promising

Intrinsic Heavy Quark

Relatively small contributions to conventional standard model processes that are used in the global QCD fits.

Very little direct experimental input

$\longrightarrow$ *All c and b distributions in existing PDF sets are generated by gluon splitting (radiatively generated)*

$\longrightarrow$ *No degrees of freedom are associated with the heavy flavor in the global QCD fits*

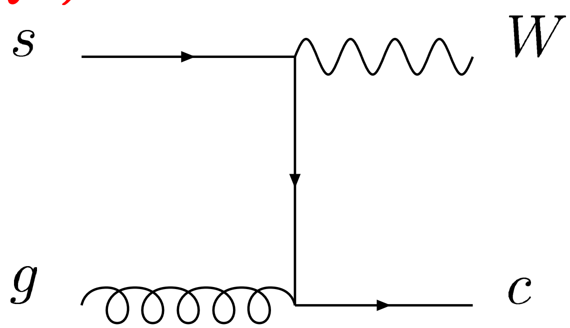
Number of models for heavy flavor parton distributions (especially the charm)

$\longrightarrow$ Influence on physics analysis of the next generation of experiments is expected to be increasingly important

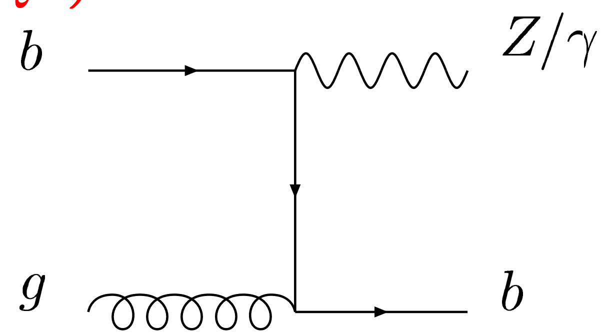
Need to probe new channels

Probe sea quark distributions with tagged final states $W/Z/\gamma+c/b$

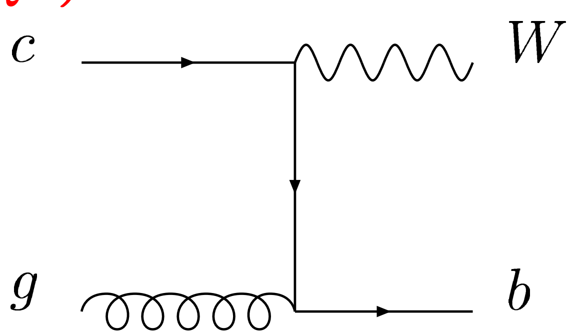
$s(x,Q^2)$

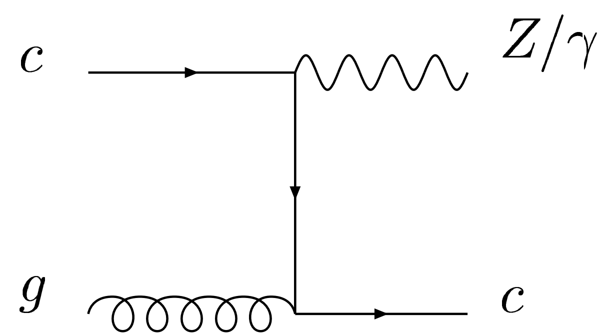


$b(x,Q^2)$

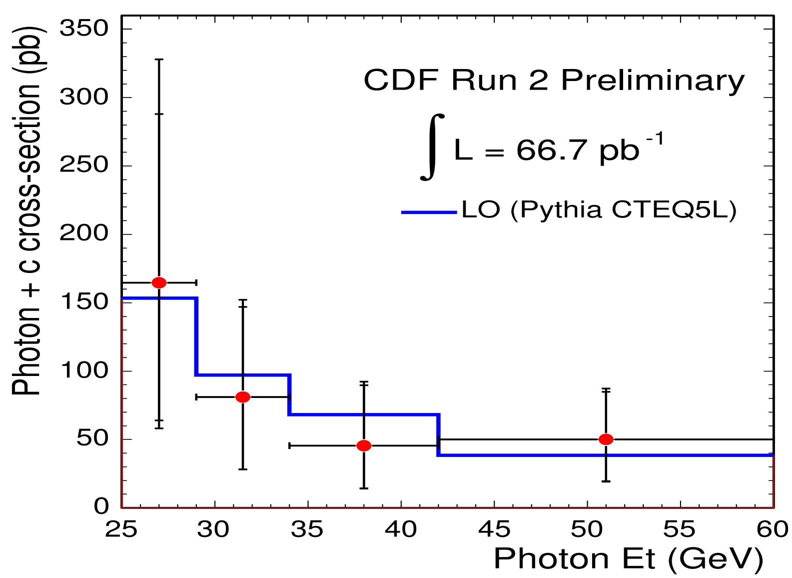


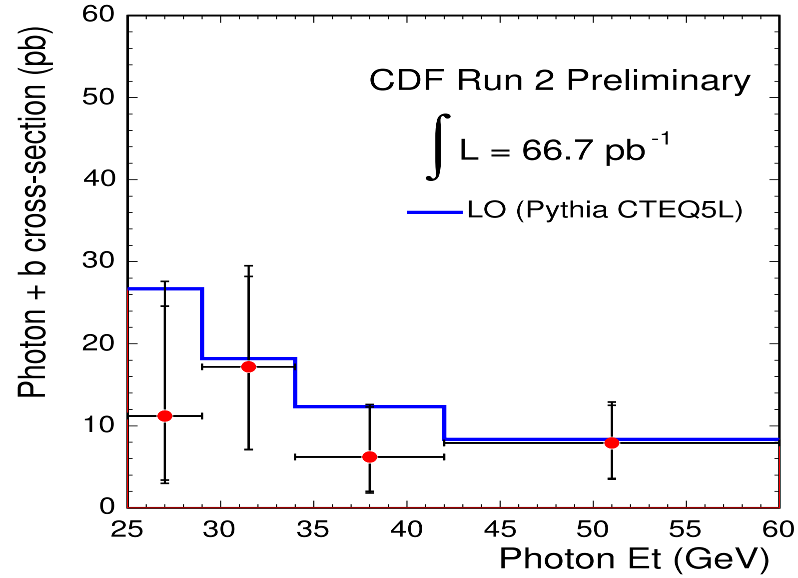
$c(x,Q^2)$





γ plus Tagged Heavy Flavor





Dominated by statistical errors

Largest systematic errors

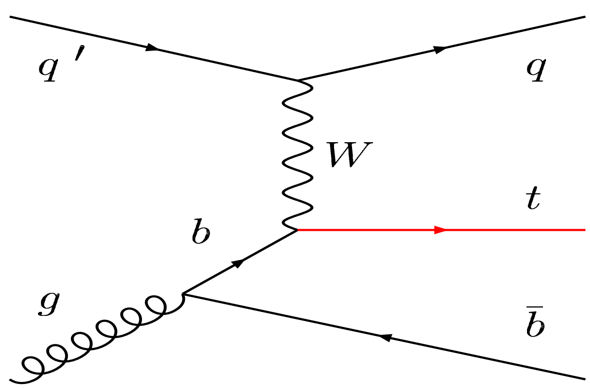
$\longrightarrow$ *Energy scale*

$\longrightarrow$ *Tagging Efficiency*

$\longrightarrow$ *Trigger*

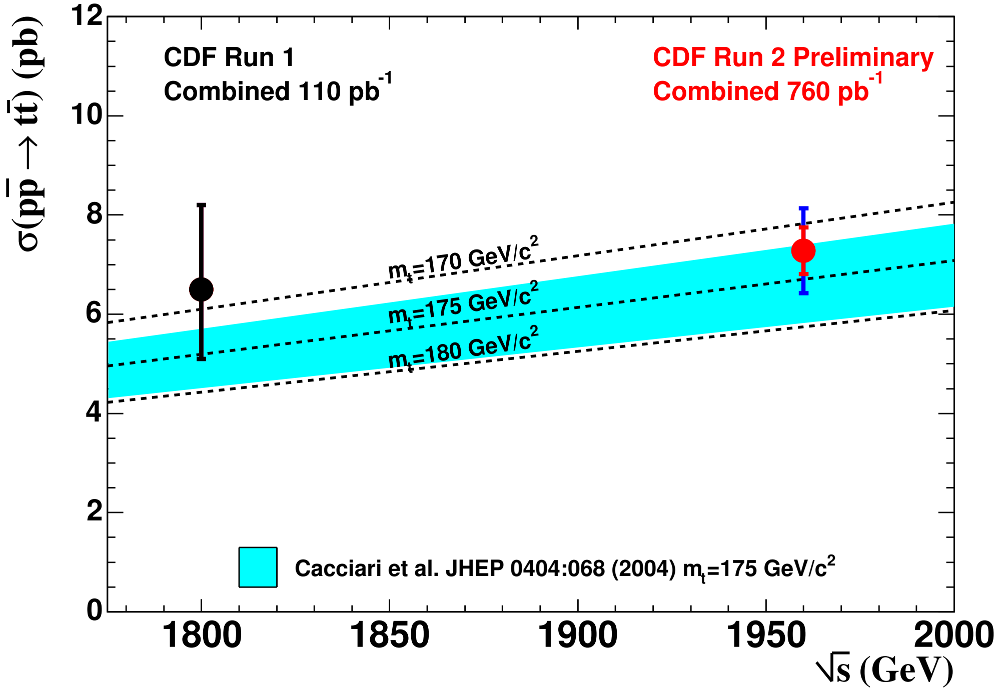
Can we constrain intrinsic heavy flavor at the Tevatron?

Single top production also probes b quarks at high x



Top Cross Section

Inclusion of full PDF systematics leads to a more realistic estimate of the top cross section uncertainty



For $m_t = 175$ GeV

$\sigma = 6.70 \pm 0.45$ pb $(CTEQ6M)$

$\sigma = 6.76 \pm 0.21$ pb $(MRST2001)$

$\rightarrow$ Dominated by PDF and α_s uncertainties

Cacciari et al (hep-ph/0303085)

$\pm 3 - 6\%$ error mainly arising from uncertainty of large-x gluons

$\rightarrow$ *Measurement error approaching the size of the error on the calculation...*

Higgs Cross Section

Cross section uncertainty calculated for main production processes of the SM Higgs (*Djouadi and Ferrag hep-ph/0310209)*

$q\bar{q} \to VH$	associate production with W/Z
$qq \to Hqq$	massive vector boson fusion
$gg \to H$	gluon fusion
$gg, q\bar{q} \to t\bar{t}H$	associate production with top quarks

Get very different results when using different PDF sets:

$\longrightarrow$ *Choice of data used as input to fits*

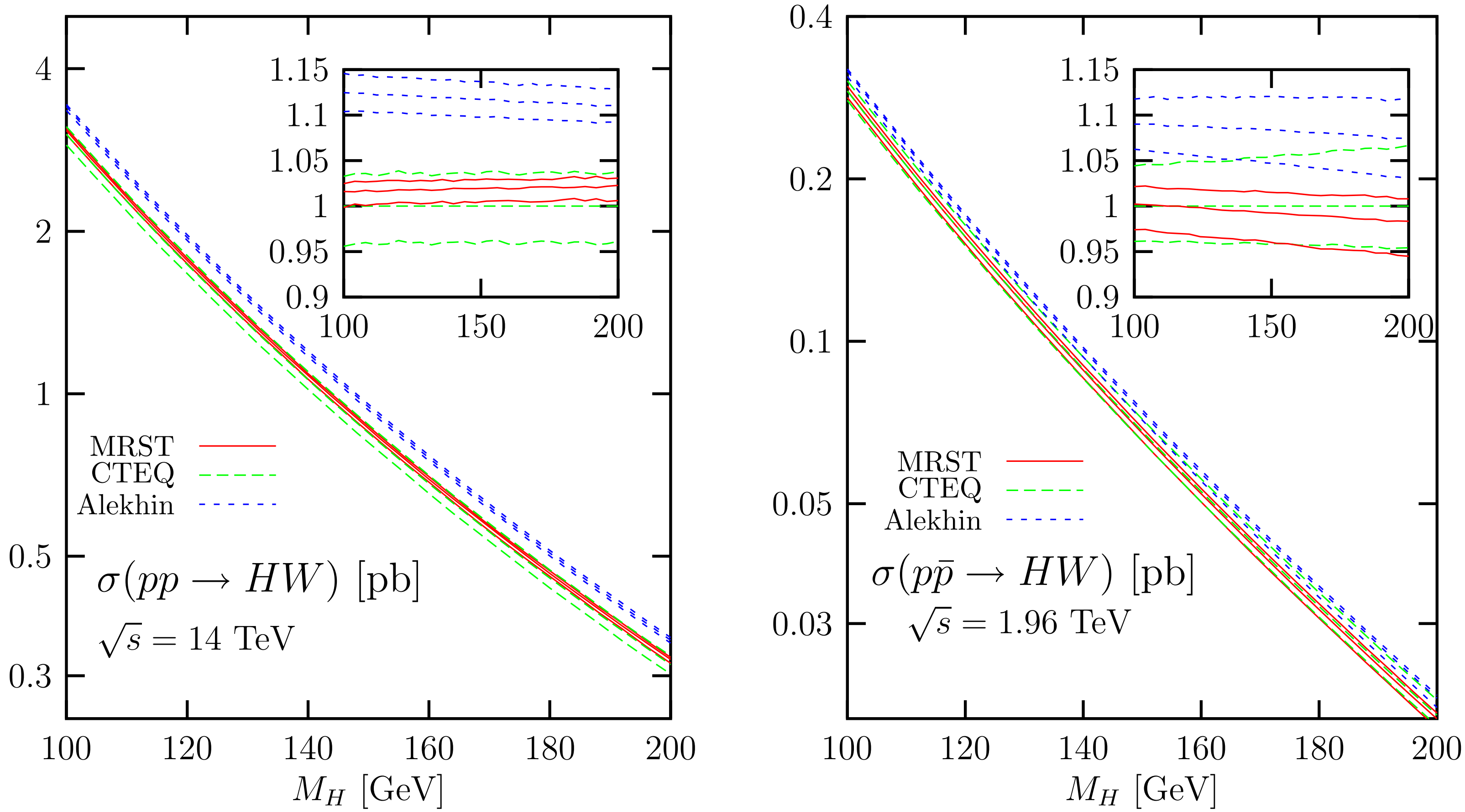
$\longrightarrow$ *Treatment of errors*

$\longrightarrow$ *Parameterization of parton distributions*

$\sim 15\%$ spread between PDF sets at Tevatron and LHC energies

$\sim 5\%$ uncertainty for a given PDF

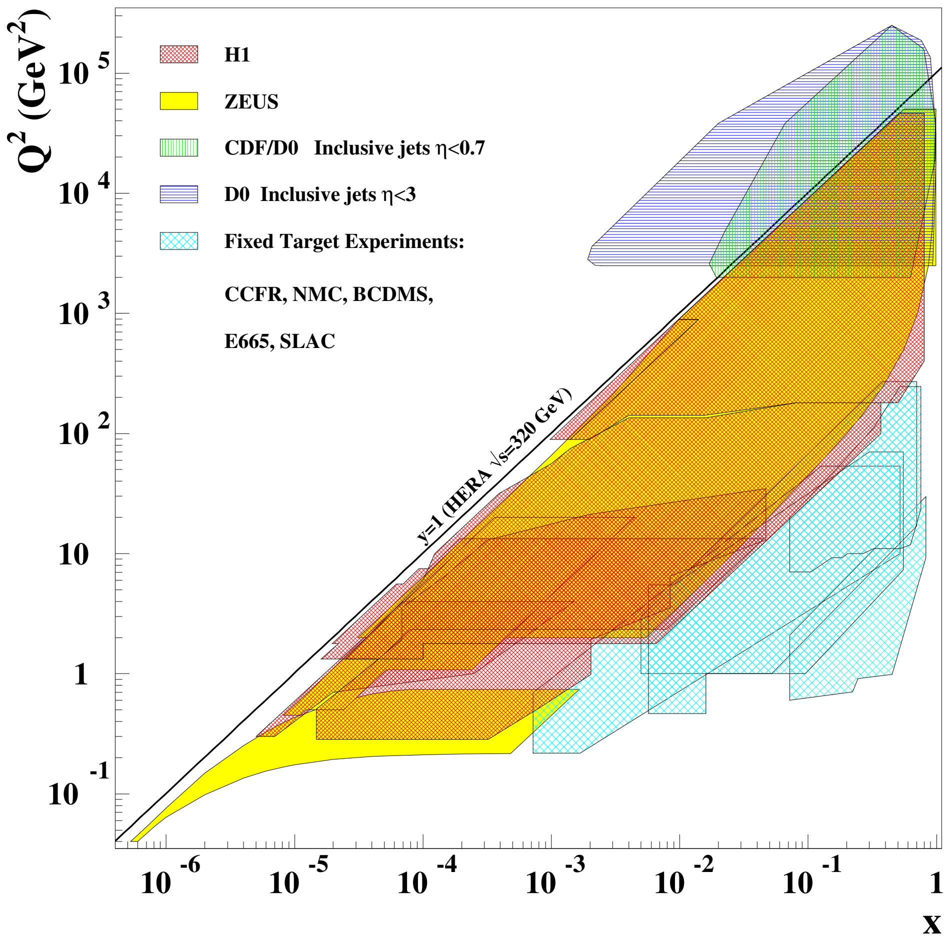
Large error arises from the uncertainty of the gluons



Djouadi and Ferrag hep-ph/0310209

$\rightarrow$ *For a discovery it is important to have a precise understanding of the backgrounds...*

PDFs are Universal



PDFs can lead to different predictions depending on parameterizations and on datasets used in the fits

→ *Should include as much data in the global fit as possible*

→ *Try to span the kinematic phase space*

The challenge is to demonstrate consistency between measurements in different regions of phase space as well as between different processes

Summary

- New detector/trigger capabilities provide opportunities to measure new observables over a wider kinematic region, *forward jets, Z rapidity, Z/γ plus tagged heavy flavor...*

- With more data we can expect improved measurements which will be *competitive and complimentary* to those at the LHC.

- PDF uncertainties creep up in a number of places: *acceptance, luminosity, background estimates, comparison to theory...*

- New techniques to estimate errors enable a better understanding of the impact of the uncertainties on measured observables, *make these tools easier to use*

- Make full use of Run II Tevatron data to refine models, tune MCs and produce new PDF sets. *Standard Model needs to describe physics across many experiments and over the entire phase space...*