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TeV4LHC

QCD WG

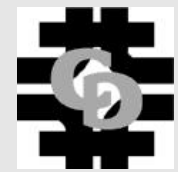
Report of the QCD Working Group

Impressions and Plans

Stephen Mrenna
representing TheRest^a

^aF. Chlebana, S. Ellis, W. Giele, J. Huston, B. Kilgore, W-K. Tung,
M. Wobisch, M. Zielinski





Many thanks to the parallel speakers for setting the right tone for the rest of the meeting.

Issues in PDFs (Wu-Ki Tung)

Jet definitions (Stephen Ellis)

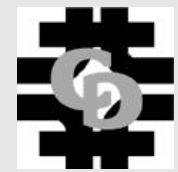
Hard Scattering Tools (B. Webber, F. Krauss, M. Seymour)

Test and Tuning of Generators (R. Field, M. Wobisch, M. Zielinski, B. Cooper)

We also benefited from informative plenary talks, particularly those on Hera4LHC and Jet/Top Physics.

(Albert De Roeck, Michael, Evelyn Thomson)





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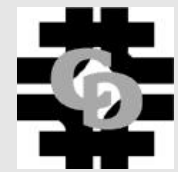
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Important Message

- The TeVatron is a laboratory to understand QCD
- What we understand at the TeVatron *could* lead to discoveries at the TeVatron (TeV4TeV?)
- Tendency to do “just enough” QCD, and then move on





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Issues in PDFs

TeVatron data will influence the state of PDFs at the start of the LHC.

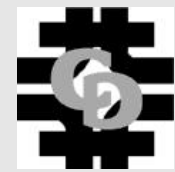
Should we consider PDF fits without HERA data?

PDFs and DGLAP are supposed to be universal

Low- Q data is important in fits

Prefer to add data to global fits and check for consistency of all data





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Are there PDF issues? Yes!

- Demand consistency of PDF errors

Which $\Delta\chi^2$?

CTEQ central value for $\sigma(W)$ outside of MRS error bands at TeVatron

- Use CDF/D0 data on $bZ, b\gamma, c\gamma$ to constrain PDFs

Check consistency with pure gluon evolution

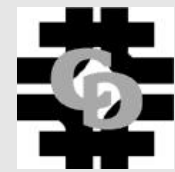
- W/Z/D-Y measurements are precision QCD tools

Point seems to be lost on experimentalists

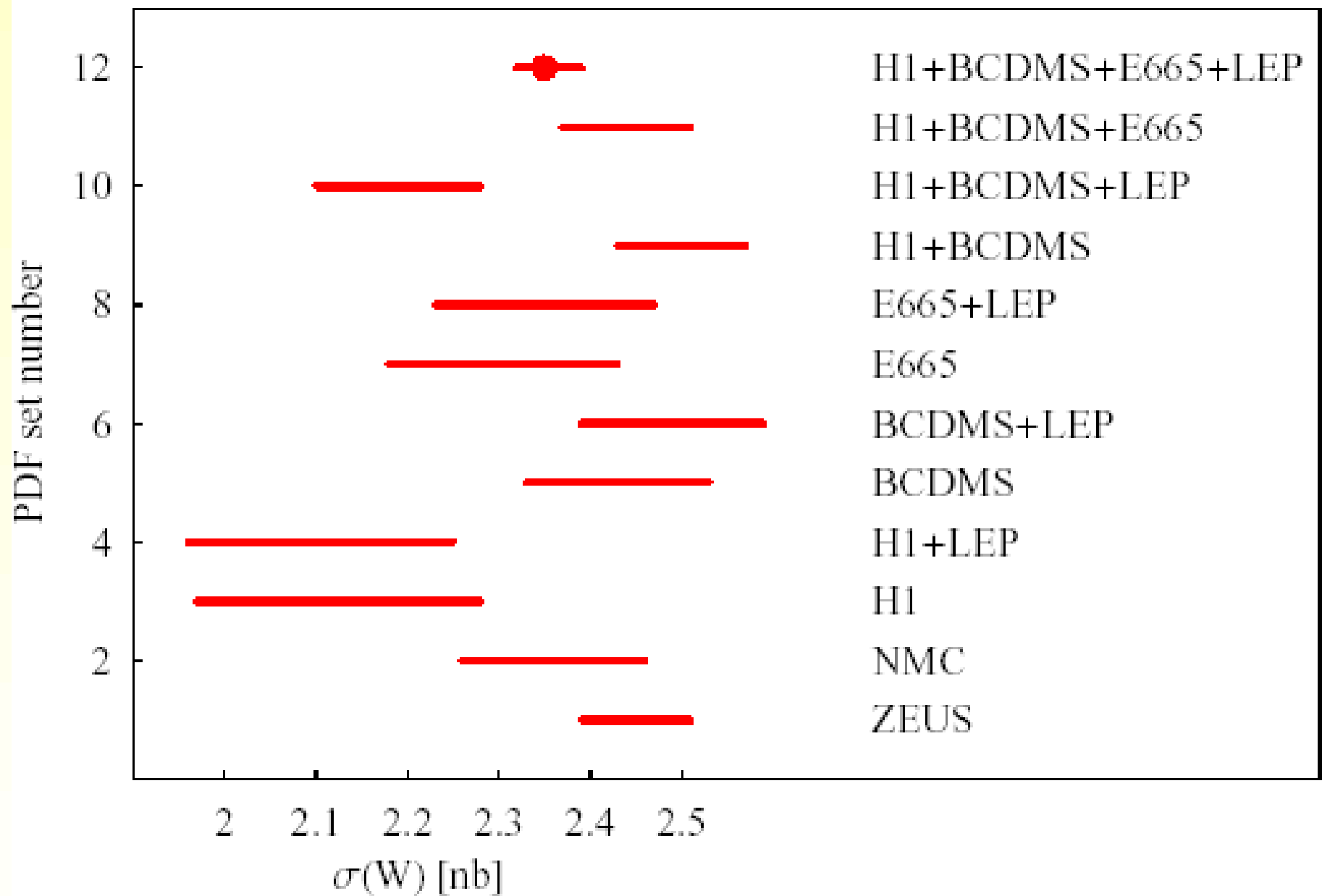
Not enough effort devoted to this subject

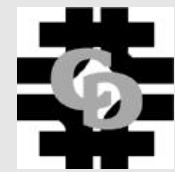
Low-mass Drell Yan pairs not used in fits





Tevatron W cross section





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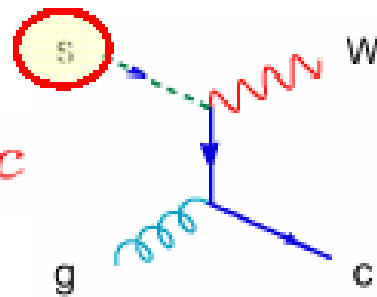
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Probing the Sea Quark PDFs: s, c, b using tagged final states $W/Z/\gamma + c/b$?

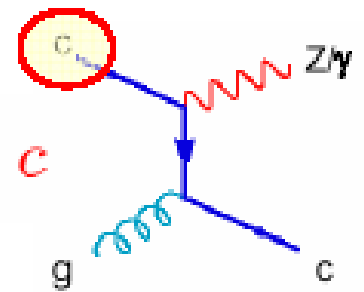
$s(x, Q)$:

$$g + s \rightarrow W + c$$



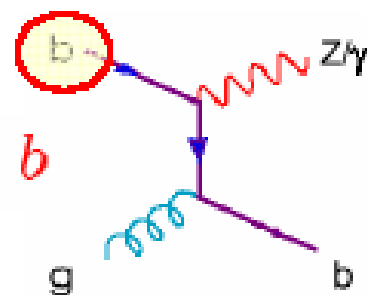
$c(x, Q)$:

$$g + c \rightarrow Z/\gamma + c$$

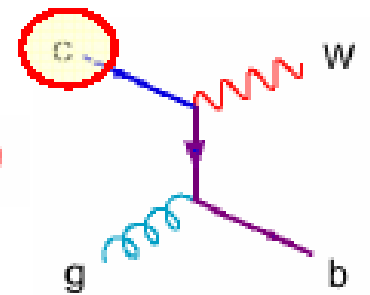


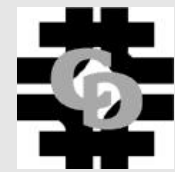
$b(x, Q)$:

$$g + b \rightarrow Z/\gamma + b$$



$$g + c \rightarrow W + b$$

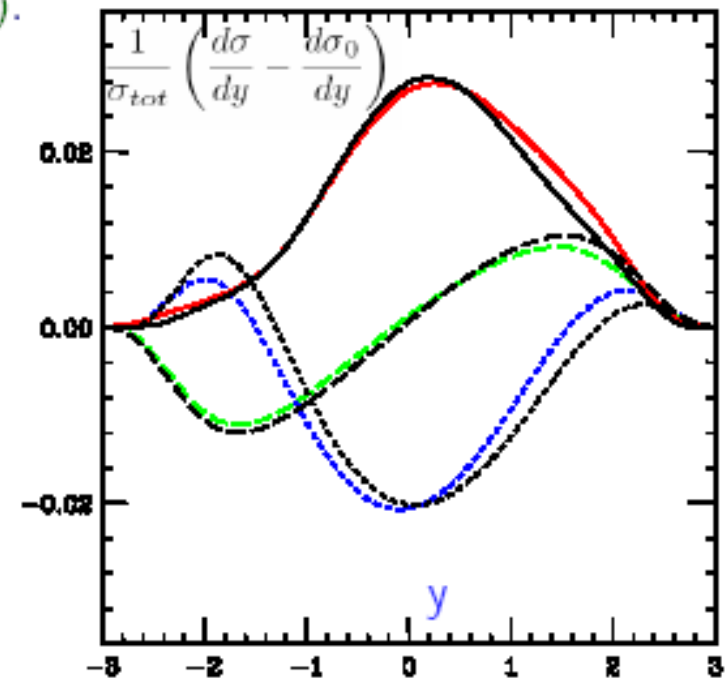
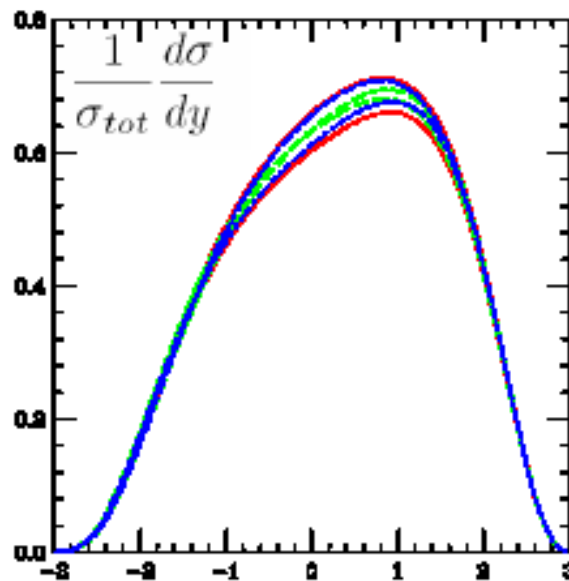




Precision PQCD phenomenology: W rapidity distribution at the Tevatron

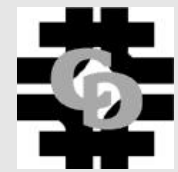
- Uniquely sensitive to x -dependence of $d(x)/u(x)$
(Can be important for precision W -mass measurement);
- Have been studied systematically by both the Hessian and the Lagrange methods (CTEQ).

Range of uncertainty



Hessian and Lagrange methods
yield the same results.





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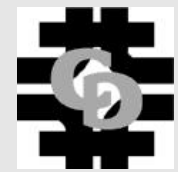
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Jet Issues

In many cases, objects called jets are the background that must be subtracted away, or the bumps that constitute the new physics. TeVatron data can lead to an essential understanding of these objects.

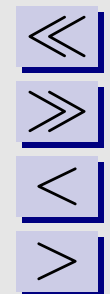
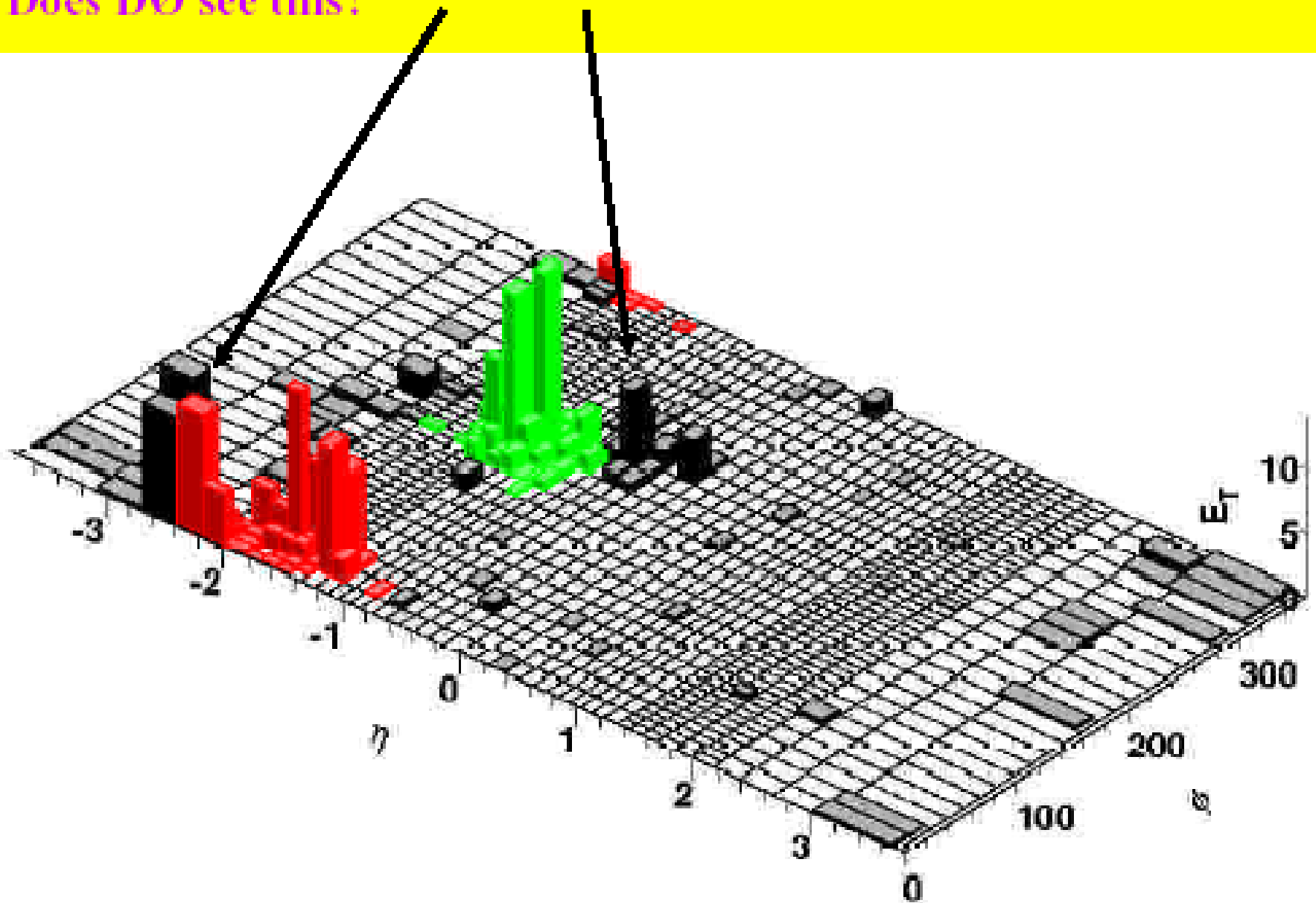
Our goal should be 1% jet physics (Run I was 10% physics)

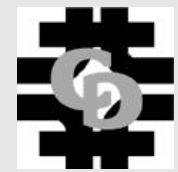




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Missed Towers (not in any stable cone) – How can that happen?
Does $D\phi$ see this?





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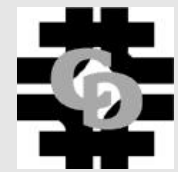
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(TeV4LHC) Jet Accord?

- Current algorithms are held together by duct tape
 - Differences in E_T definitions
 - Ratcheting and Seed dependence
 - Dependence on merging parameters
- Need to establish our commitment to a common (family of?) jet algorithm(s)
- Use workshop as a forum
- Have a clear statement of *what* the jet algorithm should be



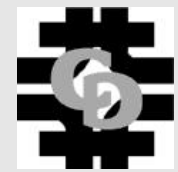


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Can we reach the original goal of precisely mapping experiment onto short-distance theory?

- MidPoint Cone algorithms (with duct tape?)
- Seedless Cone algorithms
- k_T algorithms
- Something New and Different





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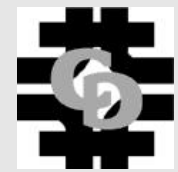
Should there be a Single Universal Jet Algorithm?

e.g. should the jets used to reconstruct the Top mass be the same jets used to identify W +jets background

Pick jet definition based on some figure of merit?

How to add additional information after jets have been found: tracking, preshower?





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Common Interfaces/Frameworks

Reminders about things we already knew about, but should know better

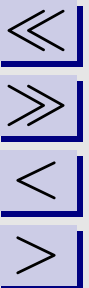
- LHAPDF: PDFs with errors, and easy to use
<http://durpdg.dur.ac.uk/lhapdf3/>

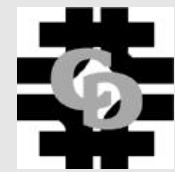
Push its use

- ThePeg: Modular way to generate events
- HZTools+JetWeb: Automated tuning

Can this work on a reasonable time scale?

Will data be corrected fast enough?





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New/Improved Event Generators

- Jimmy + HERWIG: MIs

Pythia-like model in Herwig

- MC@NLO: (N)LL Shower with NLO rate

- Sherpa: C++ generator with ME-PS matching

- Pythia 3: Sophisticated MIs, p_T -ordered showers

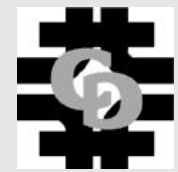
Fuzzy physics should have a simple model

We should try to understand as much as possible

Is it proven that p_T =Coherent?

People are working (hard) to improve our QCD predictions





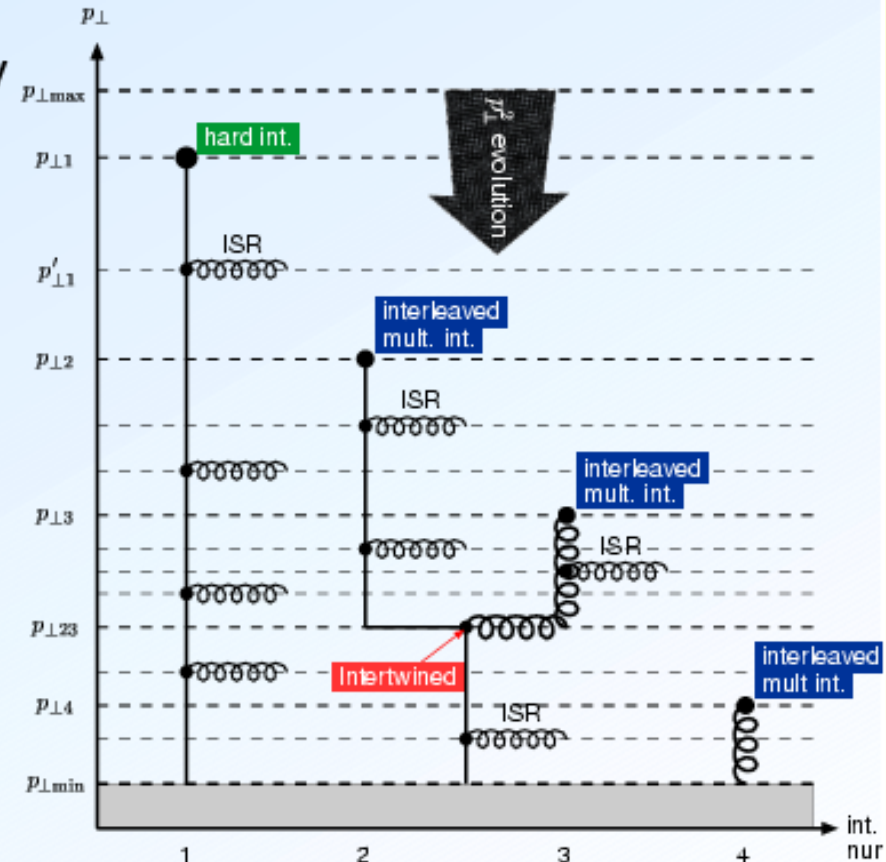
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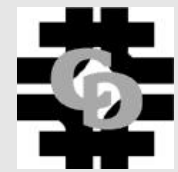
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The New Framework

- This led us to develop a new sophisticated model for UE (and min-bias) → JHEP 0403 (2004) 053.
- But still each interaction was considered separately, with *its* set of ISR and FSR.
- That's probably not the way it happens in real life...
- **The new picture**: start at the most inclusive level, **2 → 2**. Add exclusivity progressively by evolving *everything* downwards in *one* common sequence:
→ **Interleaved evolution**
- (→ also possible to have interactions **intertwined** by the ISR activity?)





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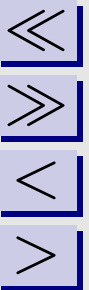
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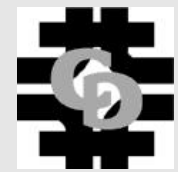
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Progress on MC Generators

MC@NLO (define a set of priorities):

- How to generalize to Pythia
- additional processes
- spin correlations
- person-power is needed





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New ideas

Comparisons of different methods of sewing together matrix element calculations (tree level) with parton showers

Old and improved methods are consistent when comparing to cone jets

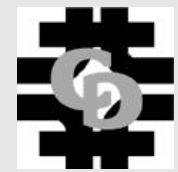
Cone jets are very forgiving?

See SM-PR study as well

Agreed on kinematic variables for comparisons of methods

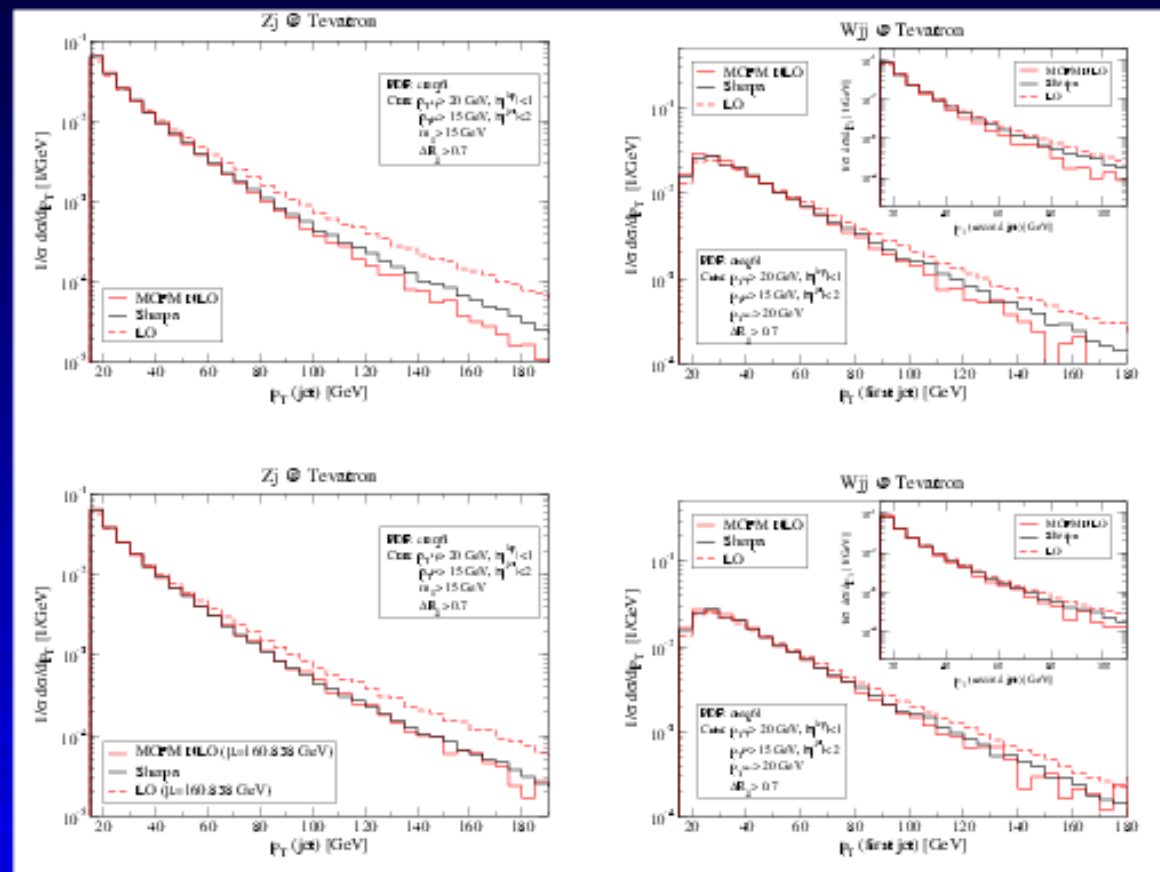
Most likely, new methods can out-predict any “ordinary” event generator prediction. Need to prove and document this.

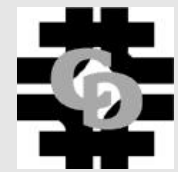




W/Z +jets at the Tevatron

Comparison with NLO calculation (MCFM, exclusive)





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Comparing data with Theory: Validating and Tuning

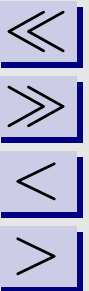
Experimentalists and Theorists don't always talk the same language

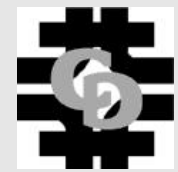
Write a primer of agreed upon conventions and definitions

- * underlying event
- * hadronization

Discussions of how experiments should present data

- * keep or subtract UE?





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Progress on Tuning MCs

D0 DiJet Azimuthal DeCorrelations

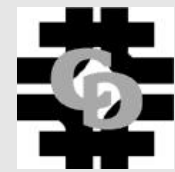
- * Herwig gives a nice description out of the box
- * Pythia Tuning only helps to a point
- * Test new pT-ordered Pythia

Tests of universality of UE event tunes A and B

- leading jet \Leftrightarrow lepton pair

How to trust extrapolation to LHC?





wobisch040916tev4lhc.pdf

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A last look at the Tevatron ...

1/ σ_{dijet} $d\sigma_{\text{dijet}} / d\Delta\phi_{\text{dijet}}$

Legend:
- - - NLO
— HERWIG
- - - PYTHIA (TeV-tuned)

Tevatron Run II

from top to bottom:
 $75 < p_T^{\text{max}} < 100$ GeV ($\times 8$)
 $100 < p_T^{\text{max}} < 130$ GeV ($\times 4$)
 $130 < p_T^{\text{max}} < 180$ GeV ($\times 2$)
 $p_T^{\text{max}} > 180$ GeV

$\Delta\phi_{\text{dijet}}$ (rad)

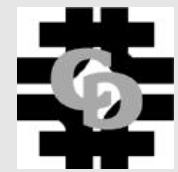
best description by PYTHIA for PARP(67) between D=1.0 and 4.0

- tune PARP(67) to NLO
- ⇒ result: PARP(67)=2.5 (D=1.0)
- ⇒ this setting is now referred to as “TeV-tuned”
- (ignore the peak region...)
- ⇒ good agreement: HERWIG \approx PYTHIA \approx NLO

Question:
Can this good agreement (and the tune) be transferred to the LHC?

Markus Wobisch, Fermilab MC Tuning from TeV to LHC TeV4LHC Workshop, 09/15/04 19





wobisch040916tev4lhc.pdf

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... and a first look at the LHC

1/σ_{dijet} dσ_{dijet} / dΔφ_{dijet}

Legend:
- - - NLO
— HERWIG
- - - PYTHIA (TeV-tuned)

LHC

from top to bottom:
180 < p_T^{max} < 500 GeV (×4)
500 < p_T^{max} < 1200 GeV (×2)
p_T^{max} > 1200 GeV

Δφ_{dijet} (rad)

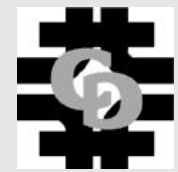
... a huge success!!! – ... expected??

- PYTHIA (TeV-tuned)
⇒ the good agreement with NLO at Tevatron Run II energies is reproduced at LHC energies!!
- HERWIG (default)
⇒ small differences:
broader at low p_T^{max}
narrower at large p_T^{max}

⇒ Both Monte Carlos are in good agreement with NLO predictions

Markus Wobisch, Fermilab MC Tuning from TeV to LHC TeV4LHC Workshop, 09/15/04 20





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Heavy Flavor

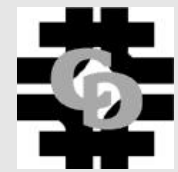
Are we relying on heavy flavor rates from Monte Carlo?
Can we?

What about bottom/charm ratio?

What theoretical and/or experimental studies can make
the picture clearer?

*We have some ideas on how to attack this – should
collaborate with Top-EW*





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Communication

<http://www.pa.msu.edu/~huston/tev4lhc/wg.htm>

list of QCD-related projects, the people interested,
progress reports etc

aim for (bi-?)monthly meetings at the TeVatron

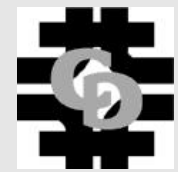
video for non-FNAL participants(?)

Huston-centric view of the universe:

This was the initial meeting of the TeV Joint QCD
Working Group

<http://www.pa.msu.edu/~huston/tevqcdwg/wg.htm>





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Summary

Participation was encouraging

Feeling that things are not business-as-usual

People see that the LHC is coming and that the TeVatron can make a difference

We have identified a number of projects that can be completed within the next year

