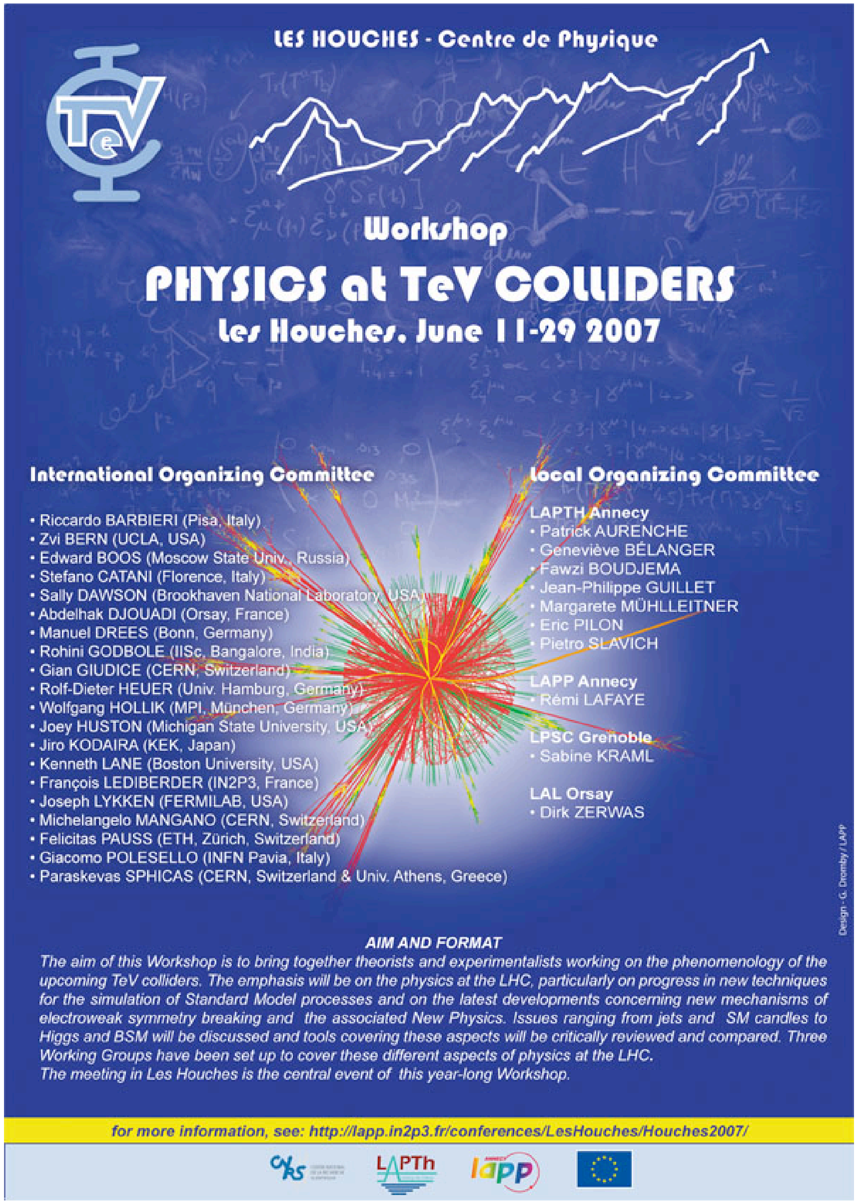
Summary: Session I NLM-MC Working Group



- J. Huston
  - Michigan State University
- B. Kersevan
  - Ljubljana University
- D. Soper
  - U. of Oregon
- Charge
  - integrating NLO calculations and MC's, NNLO issues,NLO wish list, contact with experiments, ...
- This talk
  - issues discussed
  - conclusions if any
  - worklist and plan for writeup

NLO calculation priority list from Les Houches 2005: theory benchmarks

G. Heinrich and J. Huston

process ($V \in \{Z, W, \gamma\}$)	relevant for	
1. $pp \to VV$+jet	$t\bar{t}H$, new physics	+
2. $pp \to H + 2$ jets	H production by vector boson fusion (VBF)	*
3. $pp \to t\bar{t}b\bar{b}$	$t\bar{t}H$	+
4. $pp \to t\bar{t} + 2$ jets	$t\bar{t}H$	
5. $pp \to VVb\bar{b}$	VBF$\to H \to VV$, $t\bar{t}H$, new physics	
6. $pp \to VV + 2$ jets	VBF$\to H \to VV$	
7. $pp \to V + 3$ jets	various new physics signatures	+
8. $pp \to VVV$	SUSY trilepton	*

Table 2. The wishlist of processes for which a NLO calculation is both desired and feasible in the near future.

*completed since list
+people are working

- Additions in 2007
  - pp->4b (T. Reiter + advisor)
  - NLO gg->WW
    - add LO code to existing Monte Carlos
  - NLO + EW VBF Higgs
- Interface issues
  - all NLO codes should be public and output 4-vectors in a convenient way
    - for example, in ascii or ROOT files
  - all experimenters should be encouraged to use the NLO codes (and to cite the proper papers when doing so)

indoctrinate the students early, for example in the ATLAS workbook

Conversely

- Experimenters need to quote the results at least at the hadron level and, if possible, with the corrections between parton and hadron level made explicit

TABLE I: Results for the inclusive jet cross section corrected to the hadron level, $d^2\sigma^{hadron}/dp_T dy$, and to the parton level, $d^2\sigma^{parton}/dp_T dy$ are shown for each bin together with the statistical (first) and systematic (second) errors. The correction factors, $C^{h\to p}$, applied to the hadron level cross section to obtain the parton level cross section are also shown. There is an additional 6% luminosity uncertainty.

p_T (GeV/c)	$\frac{d^2\sigma^{hadron}}{dp_T dy}$ (nb/(GeV/c))	$C^{h\to p}$	$\frac{d^2\sigma^{parton}}{dp_T dy}$ (nb/(GeV/c))
61-67	$(9.03 \pm 0.09\ ^{+1.26}_{-1.20}) \times 10^0$	$0.889 \pm 0.008 \pm 0.116$	$(8.02 \pm 0.11\ ^{+1.53}_{-1.49}) \times 10^0$
67-74	$(5.17 \pm 0.05\ ^{+0.70}_{-0.65}) \times 10^0$	$0.903 \pm 0.008 \pm 0.104$	$(4.67 \pm 0.06\ ^{+0.83}_{-0.80}) \times 10^0$
74-81	$(2.92 \pm 0.03\ ^{+0.39}_{-0.35}) \times 10^0$	$0.916 \pm 0.009 \pm 0.092$	$(2.67 \pm 0.04\ ^{+0.45}_{-0.42}) \times 10^0$
81-89	$(1.70 \pm 0.02\ ^{+0.23}_{-0.20}) \times 10^0$	$0.927 \pm 0.009 \pm 0.082$	$(1.57 \pm 0.02\ ^{+0.26}_{-0.23}) \times 10^0$
89-97	$(1.02 \pm 0.01\ ^{+0.14}_{-0.12}) \times 10^0$	$0.936 \pm 0.007 \pm 0.073$	$(0.95 \pm 0.01\ ^{+0.15}_{-0.13}) \times 10^0$
97-106	$(5.90 \pm 0.04\ ^{+0.83}_{-0.69}) \times 10^{-1}$	$0.945 \pm 0.007 \pm 0.064$	$(5.57 \pm 0.05\ ^{+0.87}_{-0.75}) \times 10^{-1}$
106-115	$(3.53 \pm 0.02\ ^{+0.51}_{-0.42}) \times 10^{-1}$	$0.952 \pm 0.007 \pm 0.057$	$(3.36 \pm 0.03\ ^{+0.53}_{-0.44}) \times 10^{-1}$
115-125	$(2.07 \pm 0.01\ ^{+0.31}_{-0.25}) \times 10^{-1}$	$0.958 \pm 0.007 \pm 0.050$	$(1.98 \pm 0.02\ ^{+0.31}_{-0.26}) \times 10^{-1}$
125-136	$(1.23 \pm 0.01\ ^{+0.19}_{-0.15}) \times 10^{-1}$	$0.963 \pm 0.007 \pm 0.044$	$(1.18 \pm 0.01\ ^{+0.19}_{-0.16}) \times 10^{-1}$
136-158	$(5.84 \pm 0.03\ ^{+0.94}_{-0.76}) \times 10^{-2}$	$0.970 \pm 0.007 \pm 0.035$	$(5.67 \pm 0.05\ ^{+0.94}_{-0.77}) \times 10^{-2}$
158-184	$(2.10 \pm 0.01\ ^{+0.36}_{-0.30}) \times 10^{-2}$	$0.977 \pm 0.007 \pm 0.026$	$(2.05 \pm 0.02\ ^{+0.36}_{-0.30}) \times 10^{-2}$
184-212	$(7.47 \pm 0.05\ ^{+1.36}_{-1.16}) \times 10^{-3}$	$0.983 \pm 0.007 \pm 0.019$	$(7.34 \pm 0.07\ ^{+1.35}_{-1.15}) \times 10^{-3}$
212-244	$(2.67 \pm 0.02\ ^{+0.52}_{-0.46}) \times 10^{-3}$	$0.987 \pm 0.006 \pm 0.014$	$(2.63 \pm 0.02\ ^{+0.52}_{-0.45}) \times 10^{-3}$
244-280	$(8.88 \pm 0.10\ ^{+1.89}_{-1.69}) \times 10^{-4}$	$0.990 \pm 0.006 \pm 0.009$	$(8.79 \pm 0.11\ ^{+1.87}_{-1.67}) \times 10^{-4}$
280-318	$(3.03 \pm 0.05\ ^{+0.72}_{-0.64}) \times 10^{-4}$	$0.992 \pm 0.007 \pm 0.006$	$(3.01 \pm 0.06\ ^{+0.71}_{-0.63}) \times 10^{-4}$
318-360	$(9.53 \pm 0.27\ ^{+2.57}_{-2.21}) \times 10^{-5}$	$0.993 \pm 0.006 \pm 0.004$	$(9.46 \pm 0.27\ ^{+2.55}_{-2.20}) \times 10^{-5}$
360-404	$(2.53 \pm 0.14\ ^{+0.79}_{-0.65}) \times 10^{-5}$	$0.994 \pm 0.008 \pm 0.003$	$(2.51 \pm 0.14\ ^{+0.79}_{-0.64}) \times 10^{-5}$
404-464	$(6.34 \pm 0.61\ ^{+2.42}_{-1.81}) \times 10^{-6}$	$0.994 \pm 0.010 \pm 0.002$	$(6.31 \pm 0.61\ ^{+2.40}_{-1.80}) \times 10^{-6}$
464-530	$(1.36 \pm 0.29\ ^{+0.65}_{-0.45}) \times 10^{-6}$	$0.994 \pm 0.013 \pm 0.002$	$(1.36 \pm 0.29\ ^{+0.64}_{-0.44}) \times 10^{-6}$
530-620	$(2.78 \pm 1.24\ ^{+1.64}_{-1.11}) \times 10^{-7}$	$0.994 \pm 0.008 \pm 0.003$	$(2.76 \pm 1.24\ ^{+1.63}_{-1.10}) \times 10^{-7}$

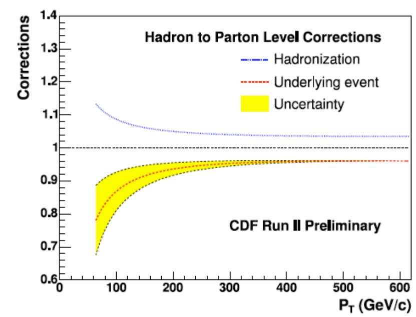


Figure 19: Fragmentation and underlying event corrections for the CDF inclusive jet result, for a cone size $R = 0.7$.

between the results from the 2 runs. The underlying event correction found in this adding approximately 1 GeV to the perturbative jet, crudely in agreement with the] definitions for the separate corrections are as follows:

$$C_i^{UE} = \frac{\sigma_i^{hadron(UE)}}{\sigma_i^{hadron(no-UE)}}, C_i^{had} = \frac{\sigma_i^{hadron(no-UE)}}{\sigma_i^{parton(no-UE)}}, C_i^{p\to h} = \frac{\sigma_i^{hadron(UE)}}{\sigma_i^{parton(no-UE)}}.$$

In these expressions, UE means MPI turned on, no-UE means MPI turned off. The beam-beam remnants

Parton showers + matching

- WG1 + MC (AdN): Parton Showers, Matrix Elements, and Matching:

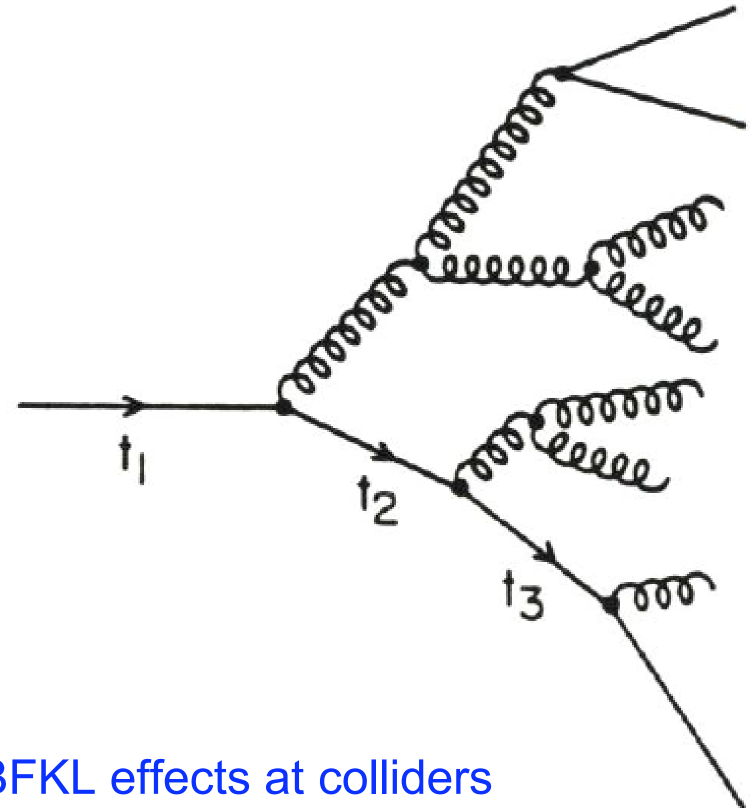
  * 9:15 Morning:
    o Introduction/Kickoff (Soper)
    o Matrix element matching at LO and NLO (Richardson)
    o Comparison of LO merging approaches (Schumann)
    o Matching from an experimentalist's point of view (Nilsen)

  * Afternoon: beyond the present (each person to deliver a provocateur for discussion)
    o SCET (Schwartz)
    o VINCIA (Skands)
    o ACOT-style Matching (Kersevan)
    o Parton Shower with Quantum Interference (Nagy)
    o BFKL at LHC (Andersen)
      + Update with comparison to CDF data
    o LLL subtraction and PS kinematics (Odaka)
    o Catani-Seymour shower (Schumann)

- Directions for new work
  - develop LO and NLO matching to matrix elements so that it can be more automatic.
  - modify splitting functions, momentum mappings, eg. Catani-Seymour shower (Schumann). This and other approaches can improve ease of matching and may improve the shower.
  - include more flexibility where choices are available, eg. VINCIA.
  - in principle, include quantum interference in spin and color. (Nagy)

Parton showers

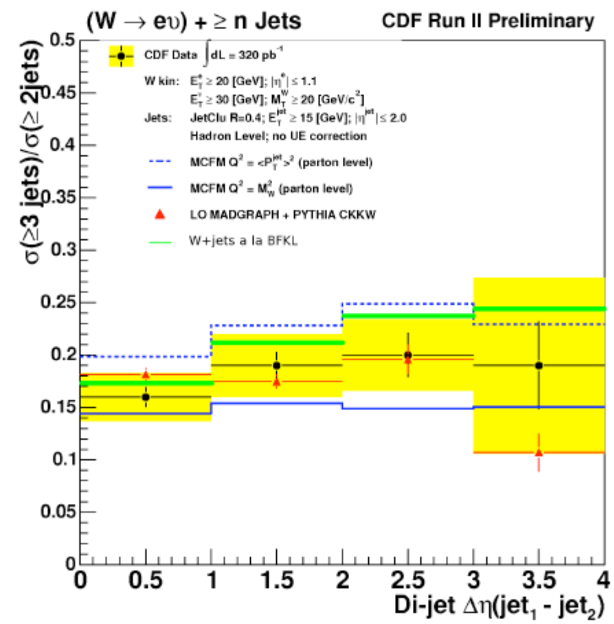
- Quantifying uncertainties
  - comparing/learning from SCET (M. Schwartz)
  - comparing angle-ordered versus p_T-ordered versus virtuality ordered showers for test processes such as pp->3 jets (Z. Nagy, J. Huston, Z. Kunszt, P. Skands, P. Richardson, D. Soper)
    - comparing showers to NLOJET++
    - are p_T/virtuality-ordered showers easier to match to LO/NLO calculations? what physics is in angle-ordered showers not in p_T/virtuality-ordered?
    - can proper color coherence be built in without resorting to angle ordering?

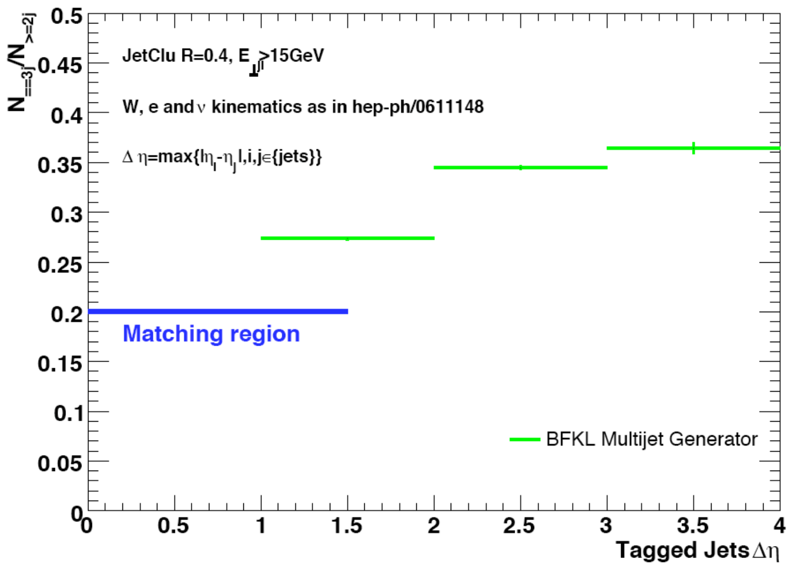


- BFKL effects at colliders
  - generating predictions for W+jets at Tevatron (comparing to existing data) and at LHC (J. Andersen, J. Huston)

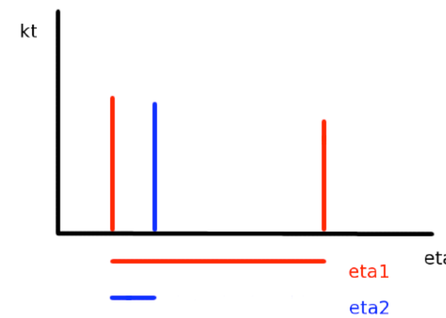
BFKL: J. Andersen

- Two jets that define the rapidity interval are the two highest p_T jets
  - reduces the impact of the BFKL logs
  - if instead define rapidity interval by most forward-backward jets, then BFKL effects more dominant
  - data will be re-analyzed to check





No adjustable parameters (except scale choice of α_s)



$\Delta\eta_1 = max\{|eta_i - eta_j|, i, j \in \{jets\}\}$

$\Delta\eta_2 = |eta_1 - eta_2|$

Extrapolate to the LHC

- And tendency of LHC to be *jetty* increases even further

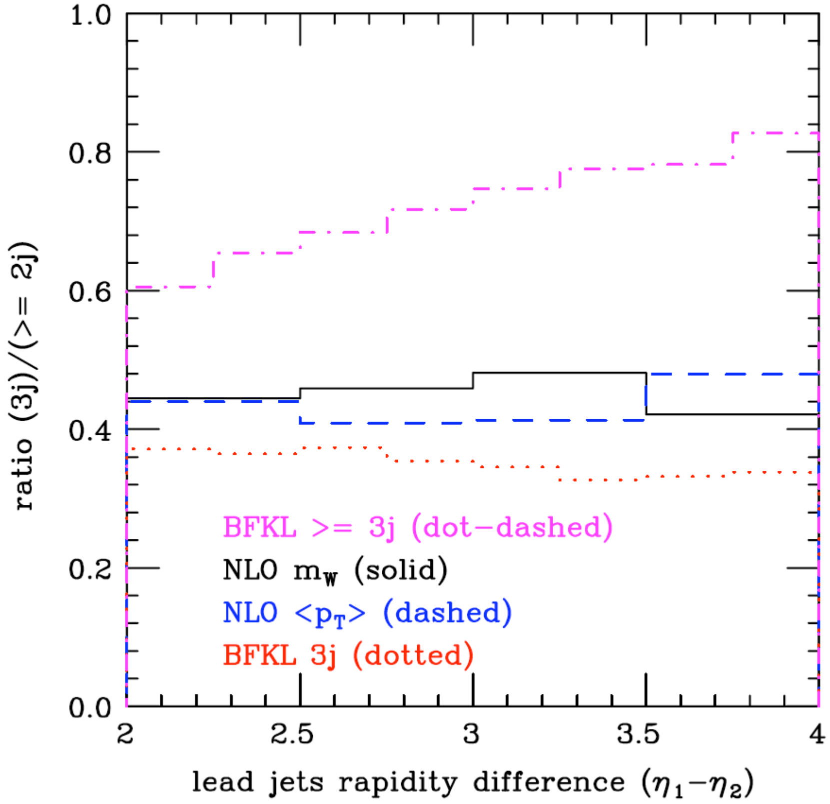
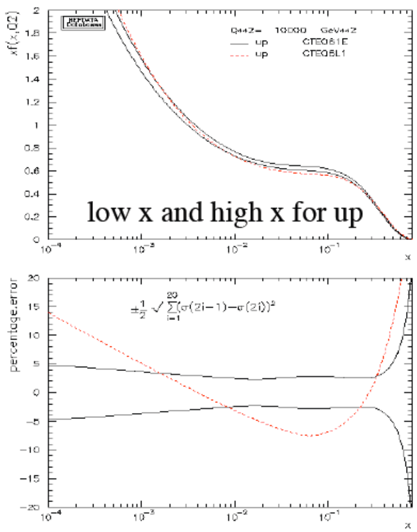


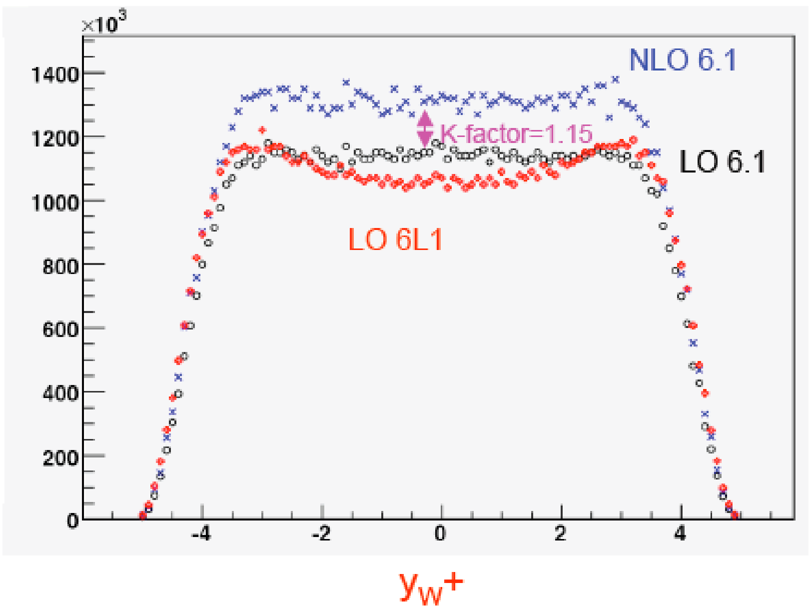
Figure 92. The rate for production of a third (or more) jet in $W+\geqslant 2$ jet events as a function of the rapidity separation of the two leading jets. A cut of 20 GeV has been placed on all jets. Predictions are shown from MCFM using two values for the renormalization and factorization scale, and using the BFKL formalism, requiring either that there be exactly 3 jets or 3 or more jets.

PDF's for Monte Carlos

- Experimenters tend to use LO Monte Carlos for everything, including for processes for which NLO information is available
  - see slide 2
- And what's worse, when they do use NLO tools, they reference the MC@NLO webpage rather than the original paper
- LO pdf's can create cross sections/acceptances that differ in both shape and normalization from NLO due to influence of HERA data
- Can we modify LO pdf's for Monte Carlos to reduce differences?



W+ rapidity distribution at LHC



Two approaches

- Modified LO pdf
  - relax momentum sum rule
  - fit LO pdf's to some benchmark processes that explore both low x and high x physics
    - W,Z production
    - bb
    - Low-mass Drell-Yan
    - VBF Higgs
    - gg->Higgs
  - how much does MSR need to be relaxed? Does this cause any problems in the Monte Carlos? Does this cause any interesting reactions from theorists in the audience?
- Split pdf's
  - NLO pdf's for matrix elements in Monte Carlo
  - LO pdf's for UE + parton shower
  - problems with matching, parton shower approaching both scales +
- J. Huston, C. Gwenlan, A. Shertsnev, J. Pumplin, T. Sjostrand, P. Skands, P. Richardson, S. Mrenna)

First approach

- Modified LO pdf
  - relax momentum sum rule
  - fit LO pdf's to some benchmark processes that explore both low x and high x physics
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    - Low-mass Drell-Yan
    - VBF Higgs
    - gg->Higgs
  - how much does MSR need to be relaxed? Does this cause any problems in the Monte Carlos? Does this cause any interesting reactions from theorists in the audience?

hep-ph/0706.2131 C. Gwenlan, A. Shertsnev, R. Thorne

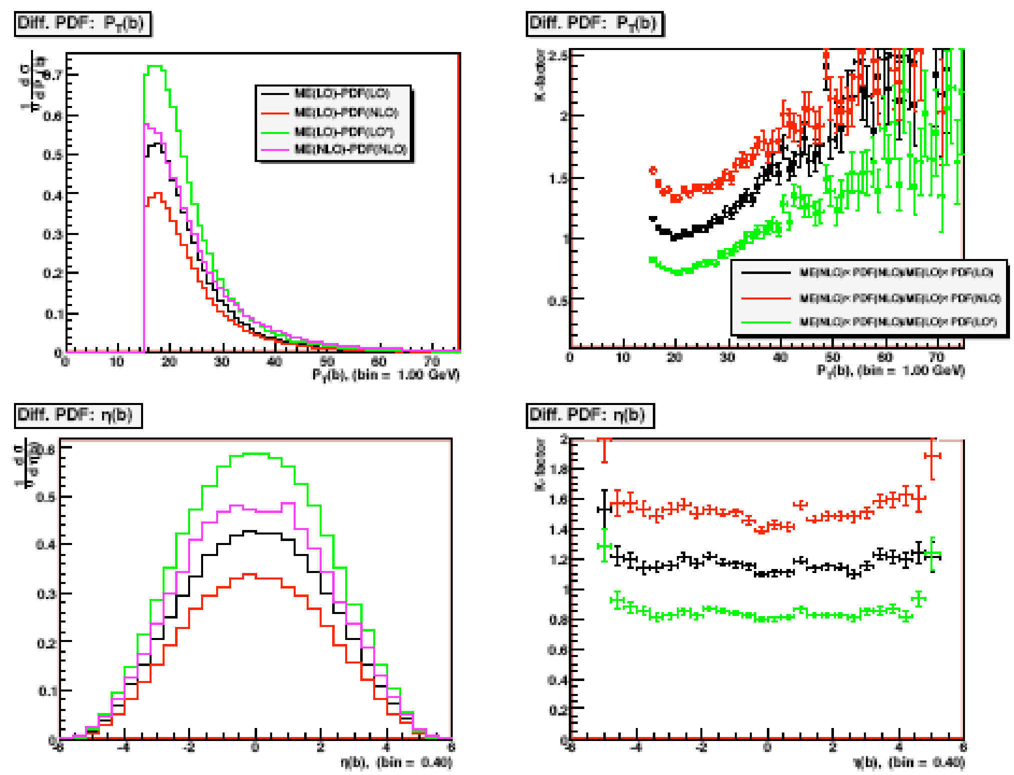

Figure 3: The b cross section at the LHC.

Summary

- No Les Houches Accord this year, but Les Houches A'cold is almost universal
- Many interesting projects identified at this workshop, with manpower identified to carry them out
- Goal is to have all contributions into writeup by end of year
- All in all, this Les Houches workshop was …