Discussion

Jet Algorithms

(thanks to Gavin Salam, LPTHE for these ideas...)

"If all you need to do is a rough job (e.g. discover a huge 1 TeV Z' peak) then you needn't worry about how you define your jets."

Any jet algorithm will pick them out for you!

- Where details of jet finding matter:
  - Extracting precise masses and couplings

    (You need control over what you're measuring.)
  - Extricating complex signals from background

    (You need maximal information about each event.)
  - Comparing to NLO, NNLO

    (They may only make sense / converge with proper jet algs.)
  - Comparing between experiments

    (Compare apples to apples.)

Discussion

Jet Algorithms (cont.)

"I don't understand what all the fuss is about — why don't they [Tevatron] just use the k_T algorithm?" ...ex-director of a large French particle-physics lab

- There are a multitude of scales, and we must understand how they interact with each jet algorithm.
  - LEP: p_T (hadronic) ~ 0.5 GeV / unit rapidity
  - Tevatron: p_T (UE) ~ 2.5 — 5 GeV / unit rapidity
  - LHC: p_T (pileup) ~ 25 — 50 GeV / unit rapidity
- The choice is not restricted to simply k_T and "cone."
  - There are at least ~5 cone algorithms (UA1, iterative, JetClu, Midpoint, SISCone)
  - k_T can be used in a range of ways (inclusive, exclusive, subjets...)
- Different algorithms have complementary strengths and weaknesses
  - Choose the right one for the occasion — or use several, and gain robustness
  - We should understand the quantitative features of the algorithms, and use the information to help us do a better job.
- We really do need to stick to infrared and collinear safe tools

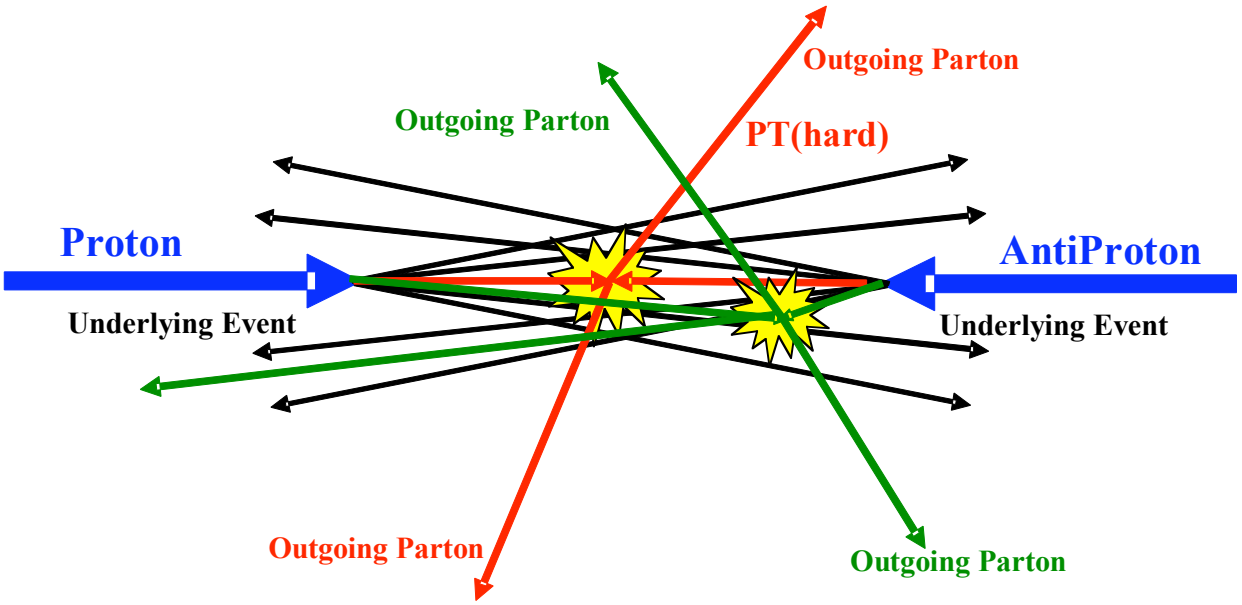
Discussion

- **Continuing to improve theoretical predictions…**
  - Need NNLO calculations for jets at HERA!
  - Combining parton shower with NLO
  - Heavy Flavor: for *b*-jets, using a good theoretical definition can reduce NLO uncertainties from 40-60% to 10-20% (Banfi, GPS & Zanderighi)
- **Forward Jets**
  - We need a model for LHC energies…
    - Do we need to go to higher order matrix elements?
    - Or does the evolution need to be changed?
- **Quark-Gluon Discrimination**
  - Various tools developed at LEP and HERA
  - Can they be used in (e.g. in searches) at the LHC?
    (Many signals: quark jets; backgrounds: gluon jets)
  - Can techniques be improved?

Discussion

Multiple Parton Interactions

(thanks to Rick Field, U. Florida for these ideas and plots...)

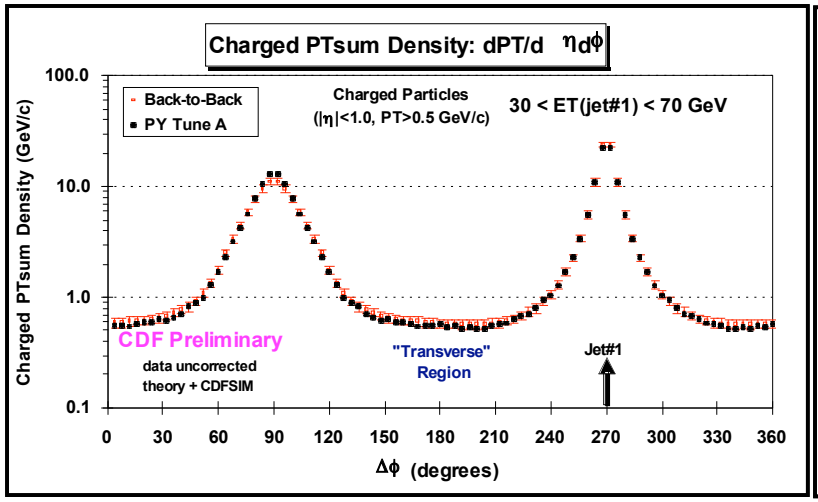


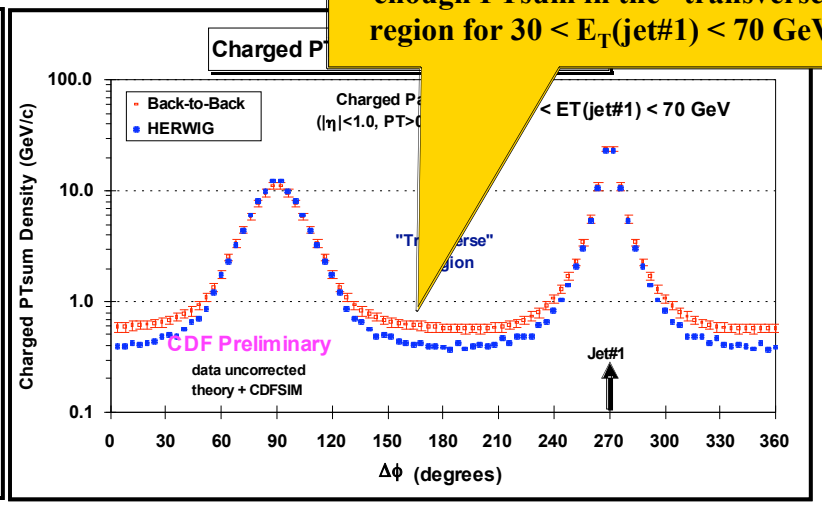
- Our understanding of MPI in our current data needs work...
- Measurement of MPI in 4-jet production at the Tevatron?
- Tuning of MPI in Monte Carlo continues...

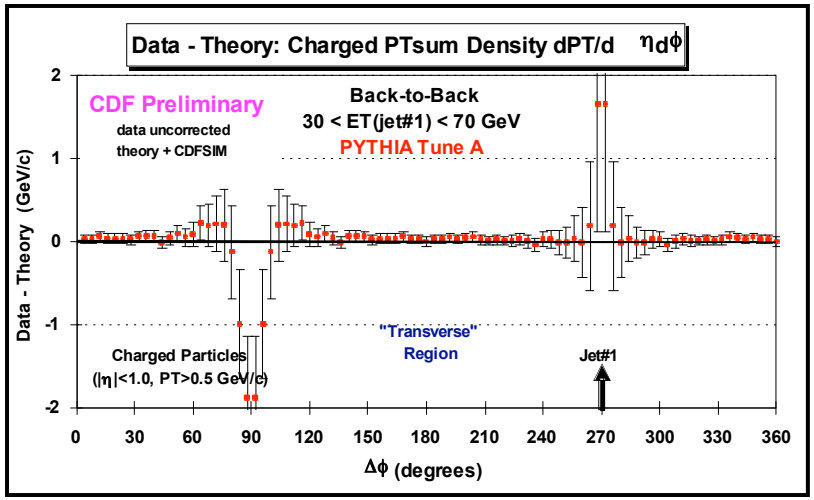
Discussion

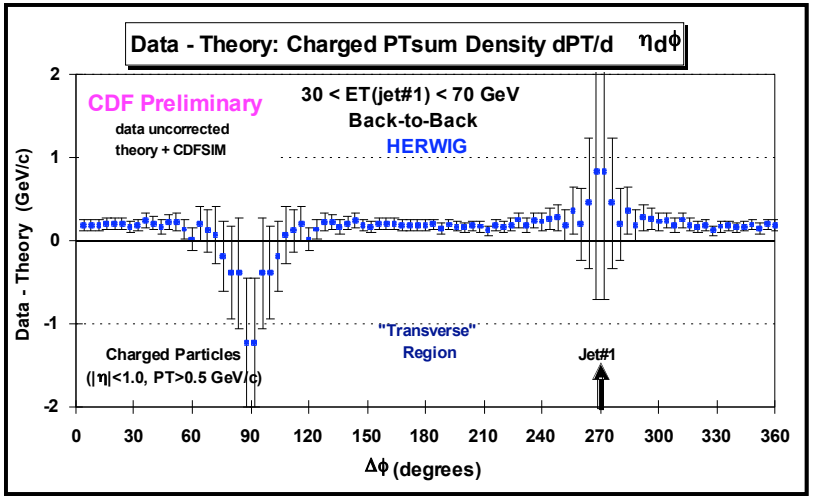
Multiple Parton Interactions (cont.)

HERWIG (*without multiple parton interactions*) does not produces enough PTsum in the "transverse" region for 30 < E_T(jet#1) < 70 GeV!





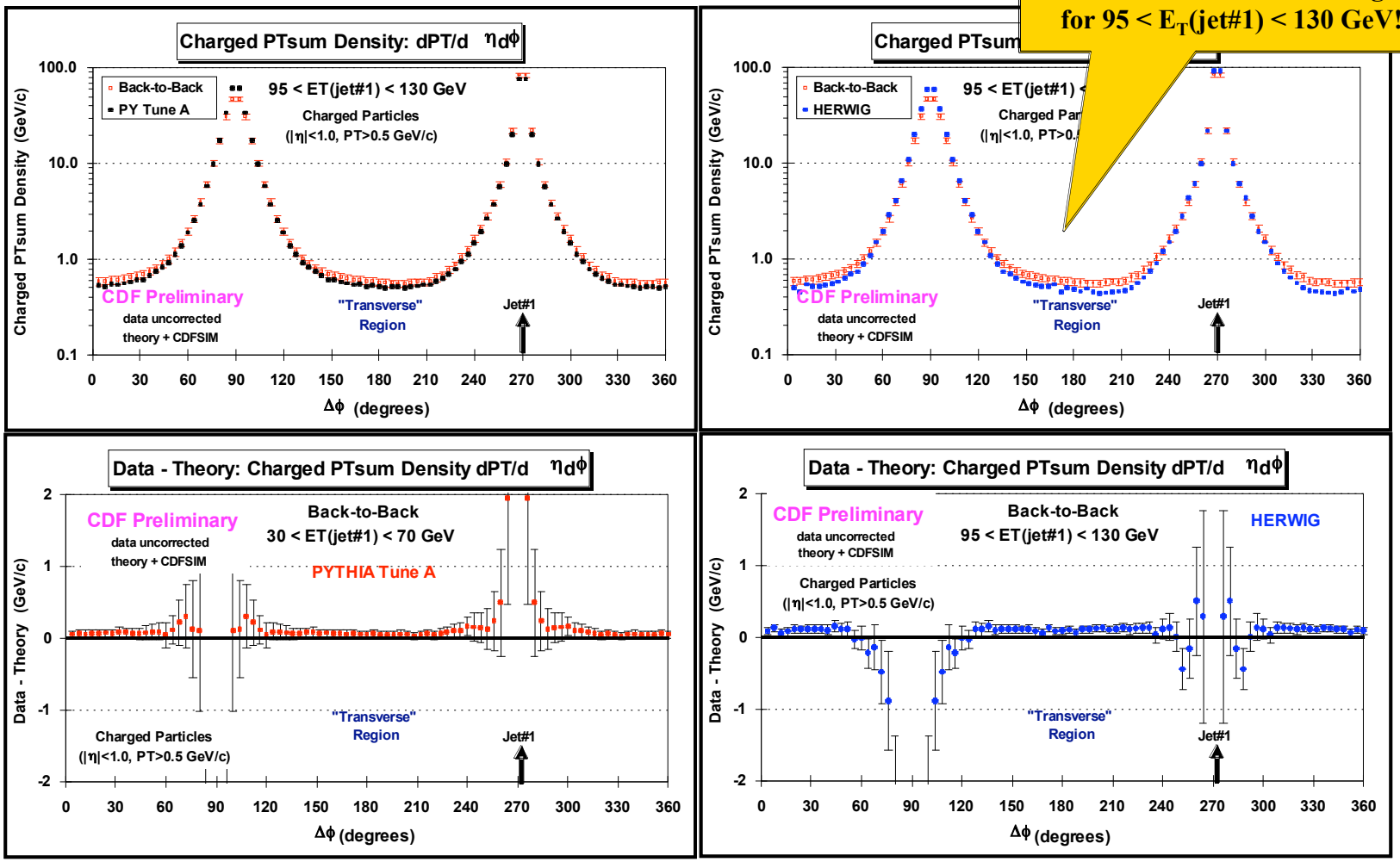




Discussion

Multiple Parton Interactions (cont.)

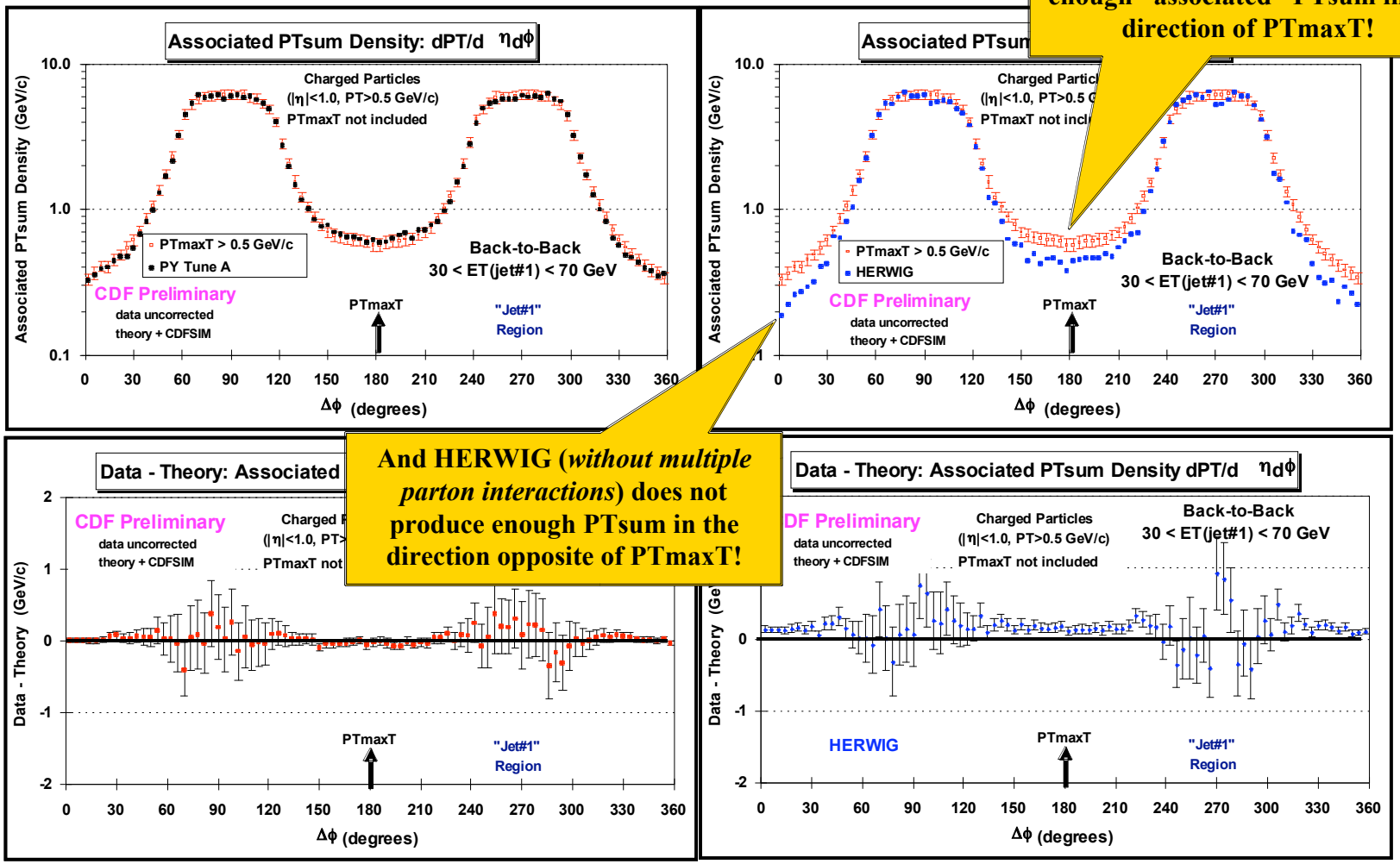
HERWIG (*without multiple parton interactions*) agrees much better in the "transverse" region for 95 < E_T(jet#1) < 130 GeV!



Discussion

Multiple Parton Interactions (cont.)

HERWIG (*without multiple parton interactions*) does not produce enough "associated" PTsum in the direction of PTmaxT!

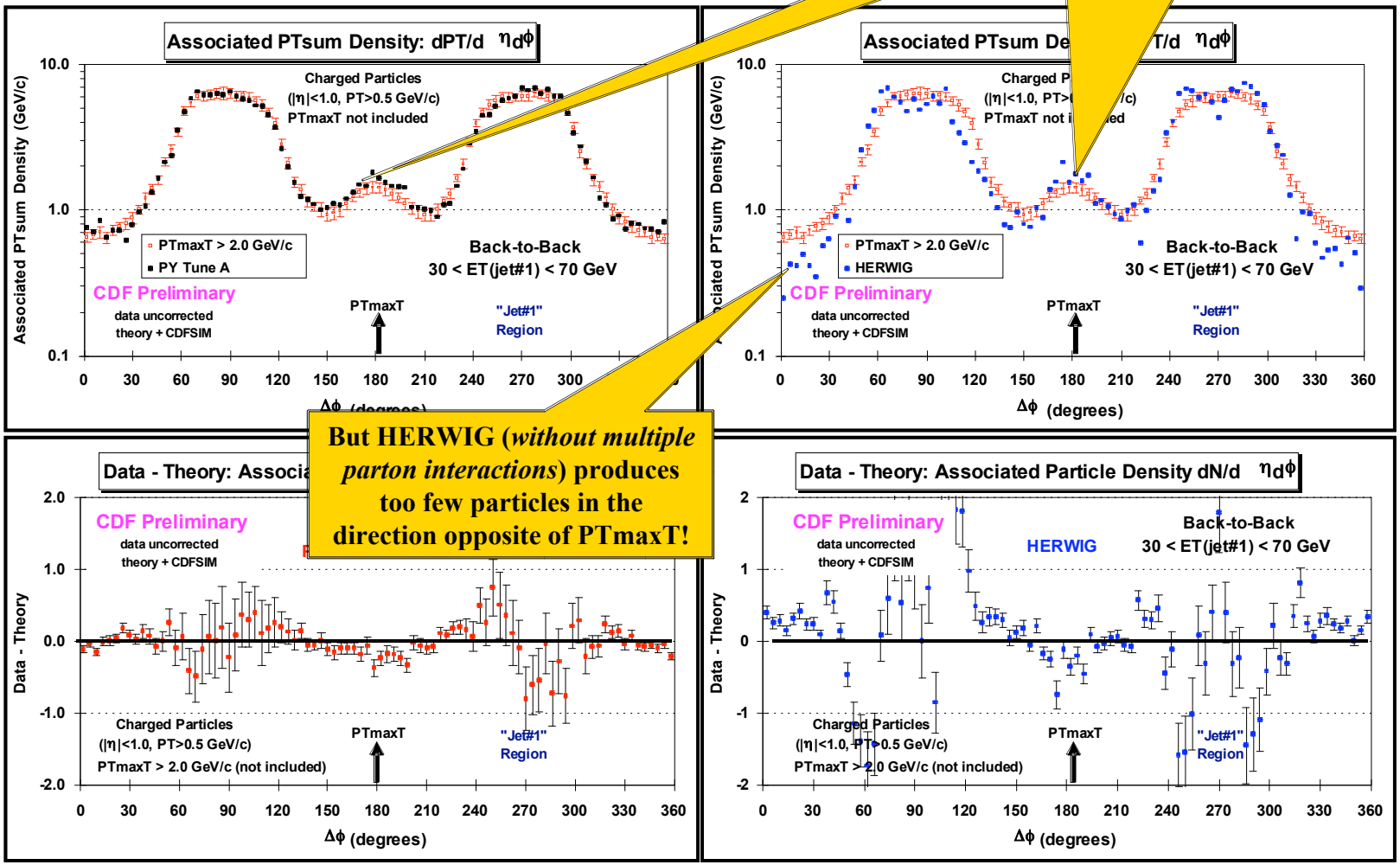


And HERWIG (*without multiple parton interactions*) does not produce enough PTsum in the direction opposite of PTmaxT!

Discussion

- **Multiple Parton Interactions (cont.)**

For PTmaxT > 2.0 GeV both PYTHIA and HERWIG produce slightly too much "associated" PTsum in the direction of PTmaxT!

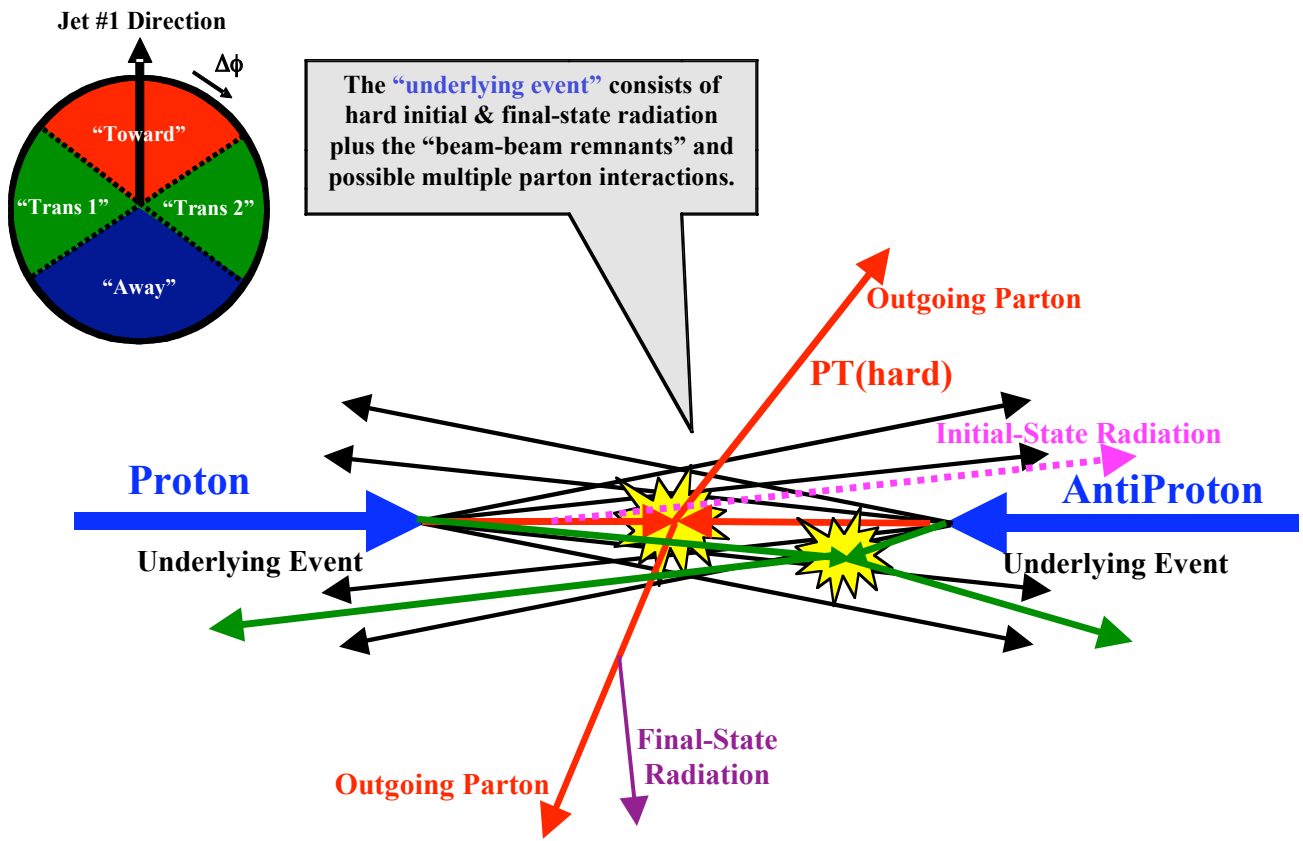


But HERWIG (*without multiple parton interactions*) produces too few particles in the direction opposite of PTmaxT!

Discussion

Underlying Event

(thanks to Rick Field, U. Florida for these ideas and plots...)



- We are making good progress in understanding and modeling the "underlying event".
  However, we do not yet have a perfect fit to all the features of the CDF "underlying event" data!

Discussion

Underlying Event (cont.)

PYTHIA 6.2 CTEQ5L

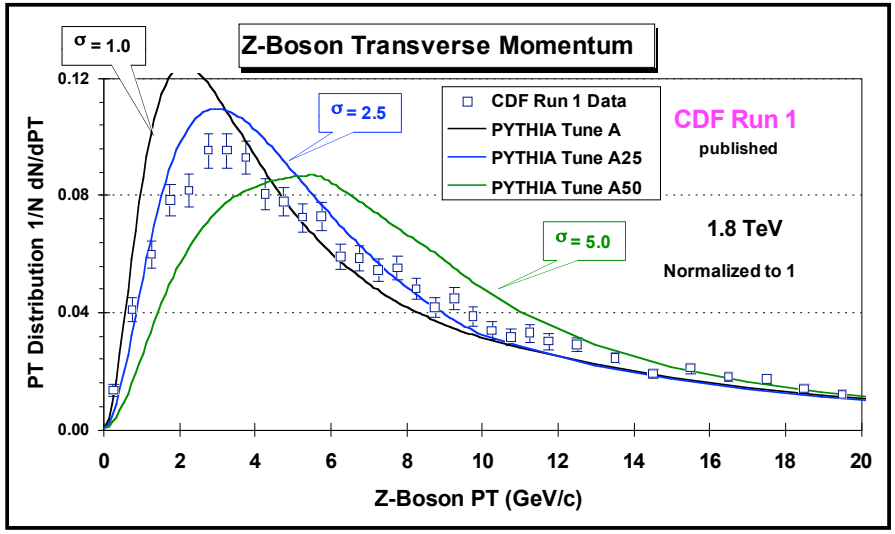
UE Parameters

ISR Parameter

Intrinsic KT

Parameter	Tune A	Tune A25	Tune A50
MSTP(81)	1	1	1
MSTP(82)	4	4	4
PARP(82)	2.0 GeV	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5	0.5
PARP(84)	0.4	0.4	0.4
PARP(85)	0.9	0.9	0.9
PARP(86)	0.95	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25	0.25
PARP(67)	4.0	4.0	4.0
MSTP(91)	1	1	1
PARP(91)	1.0	2.5	5.0
PARP(93)	5.0	15.0	25.0

Vary the intrinsic KT!



- Shows the Run 1 Z-boson p_T distribution ($\langle p_T(Z)\rangle \approx 11.5$ GeV/c) compared with PYTHIA Tune A ($\langle p_T(Z)\rangle = 9.7$ GeV/c), Tune A25 ($\langle p_T(Z)\rangle = 10.1$ GeV/c), and Tune A50 ($\langle p_T(Z)\rangle = 11.2$ GeV/c).

Discussion

Underlying Event (cont.)

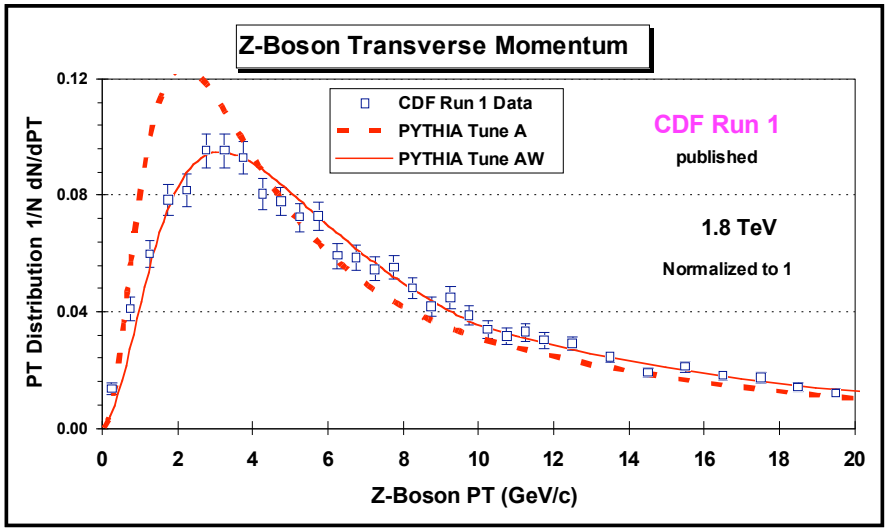
PYTHIA 6.2 CTEQ5L

Parameter	Tune A	Tune AW
MSTP(81)	1	1
MSTP(82)	4	4
PARP(82)	2.0 GeV	2.0 GeV
PARP(83)	0.5	0.5
PARP(84)	0.4	0.4
PARP(85)	0.9	0.9
PARP(86)	0.95	0.95
PARP(89)	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25
PARP(62)	1.0	1.25
PARP(64)	1.0	0.2
PARP(67)	4.0	4.0
MSTP(91)	1	1
PARP(91)	1.0	2.1
PARP(93)	5.0	15.0

UE Parameters

ISR Parameters

Intrinsic KT



➡ Shows the Run 1 Z-boson p_T distribution ($\langle p_T(Z)\rangle \approx 11.5$ GeV/c) compared with PYTHIA Tune A ($\langle p_T(Z)\rangle = 9.7$ GeV/c), and PYTHIA Tune AW ($\langle p_T(Z)\rangle = 11.7$ GeV/c).

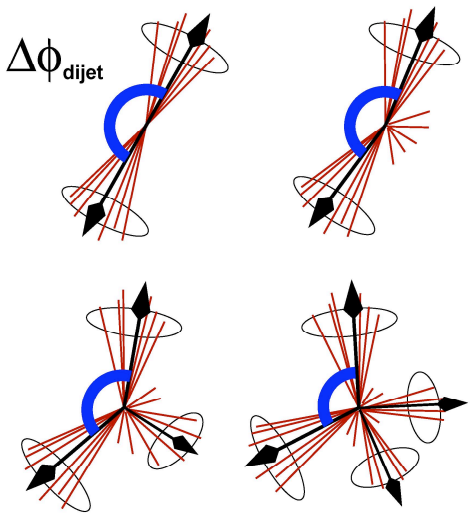
Effective Q cut-off, below which space-like showers are not evolved.

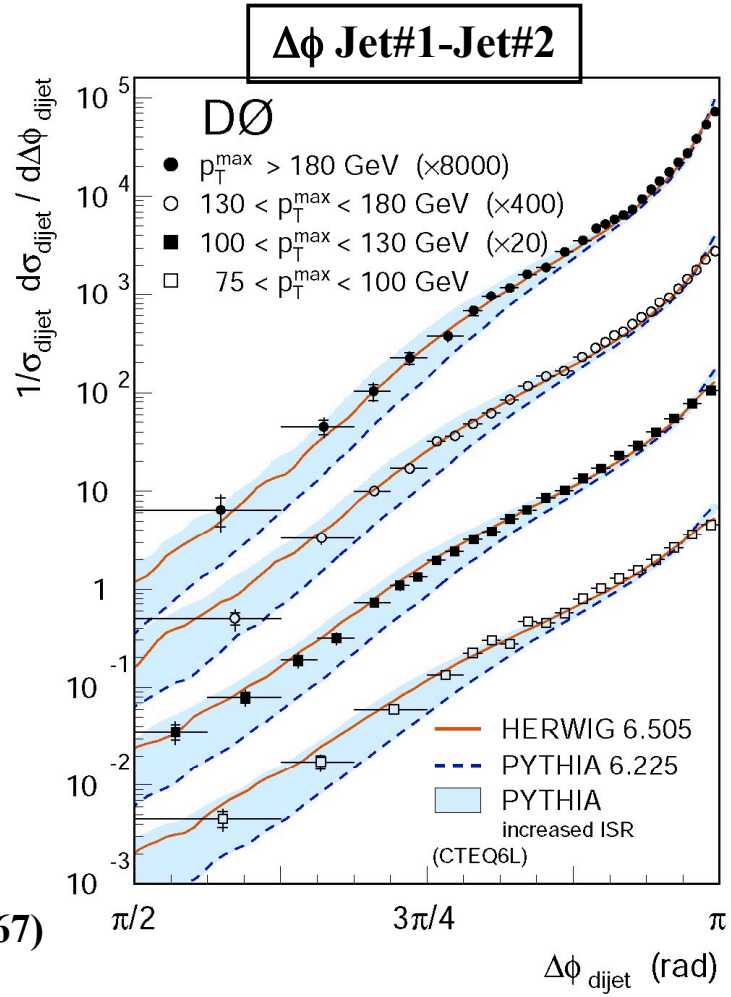
The $Q^2 = k_T^2$ in α_s for space-like showers is scaled by PARP(64)!

Discussion

Underlying Event (cont.)

Jet#1-Jet#2 Δϕ Distribution





- **MidPoint Cone Algorithm (R = 0.7, f_{merge} = 0.5)**
- ***L* = 150 pb^{-1} (Phys. Rev. Lett. 94 221801 (2005))**
- **Data/NLO agreement good. Data/HERWIG agreement good.**
- **Data/PYTHIA agreement good provided PARP(67) = 1.0 change to 4.0 (i.e. like Tune A, best fit 2.5).**

Discussion

Underlying Event (cont.)

PYTHIA 6.2 CTEQ5L

Parameter	Tune DW	Tune AW
MSTP(81)	1	1
MSTP(82)	4	4
PARP(82)	1.9 GeV	2.0 GeV
PARP(83)	0.5	0.5
PARP(84)	0.4	0.4
PARP(85)	1.0	0.9
PARP(86)	1.0	0.95
PARP(89)	1.8 TeV	1.8 TeV
PARP(90)	0.25	0.25
PARP(62)	1.25	1.25
PARP(64)	0.2	0.2
PARP(67)	2.5	4.0
MSTP(91)	1	1
PARP(91)	2.1	2.1
PARP(93)	15.0	0

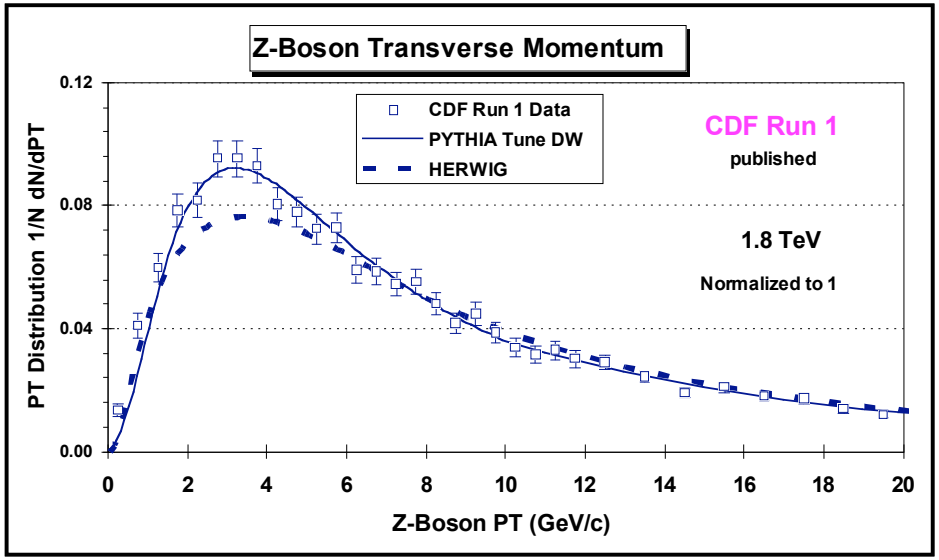
UE Parameters

ISR Parameters

Intrinsic KT

Tune DW has a lower value of PARP(67) and slightly more MPI!

Tune DW uses D0's preferred value of PARP(67)!



➡ Shows the Run 1 Z-boson p_T distribution ($\langle p_T(Z)\rangle \approx 11.5$ GeV/c) compared with PYTHIA Tune DW, and HERWIG.

Discussion

Underlying Event (cont.)

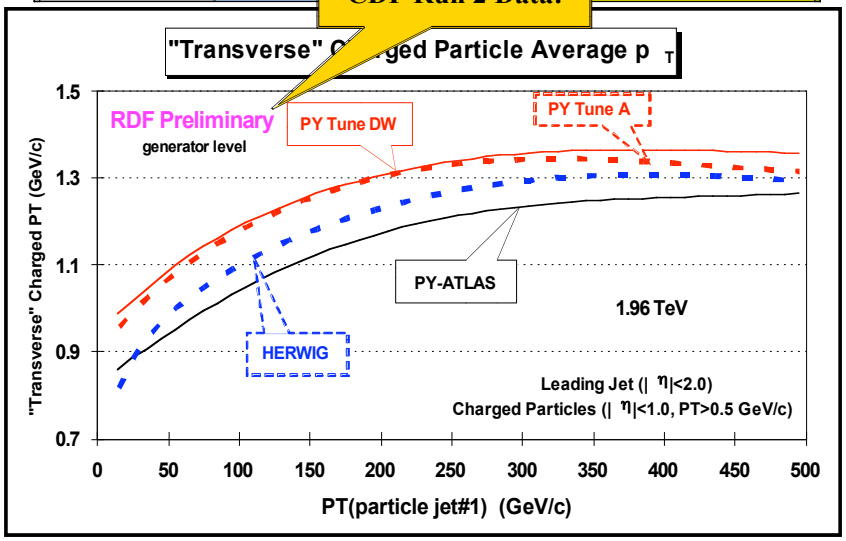
PYTHIA 6.2 CTEQ5L

Parameter	Tune A	Tune DW	Tune DWT	ATLAS
MSTP(81)	1	1	1	1
MSTP(82)	4	4	4	4
PARP(82)	2.0 GeV	1.9 GeV	1.9409 GeV	1.8 GeV
PARP(83)	0.5	0.5	0.5	0.5
PARP(84)	0.4	0.4	0.4	0.5
PARP(85)	0.9	1.0	1.0	0.33
PARP(86)	0.95	1.0	1.0	0.66
PARP(89)	1.8 TeV	1.8 TeV	1.96 TeV	1.0 TeV
PARP(90)	0.25	0.25	0.16	0.16
PARP(62)	1.0	1.25	1.25	1.0
PARP(64)	1.0	0.2	0.2	1.0
PARP(67)	4.0	2.5	2.5	1.0
MSTP(91)	1	1	1	1
PARP(91)	1.0	2.1	2.1	1.0
PARP(93)	5.0	15	15.0	5.0

Identical to DW at 1.96 TeV but uses ATLAS extrapolation to the LHC!

	σ(MPI) at 1.96 TeV	σ(MPI) at 14 TeV
Tune A	309.7 mb	484.0 mb
Tune DW	351.7 mb	549.2 mb
Tune DWT	351.7 mb	829.1 mb
ATLAS	3	768.0 mb

CDF Run 2 Data!



➡ **Shows the "transverse" charged average p_T, versus P_T(jet#1) for "leading jet" events at 1.96 TeV for Tune A, DW, ATLAS, and HERWIG (without MPI).**