Outline of Talk

- Study the “underlying event” as defined by the leading “charged particle jet” and compare with the Run I analysis.

- Study the “underlying event” as defined by the leading “calorimeter jet” and compare with the “charged particle jet” analysis.

- Study the relationship between “charged particle jets” and “calorimeter jets”.
Outline of Talk

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JetClu $R = 0.7$
The “Underlying Event” in Run 2 at CDF

Outline of Talk

- Study the “underlying event” as defined by the leading “charged particle jet” and compare with the Run I analysis.

- Study the “underlying event” as defined by the leading “calorimeter jet” and compare with the “charged particle jet” analysis.

- Study the relationship between “charged particle jets” and “calorimeter jets”.

Compare the data with PYTHIA Tune A which was tuned to fit the Run 1 “underlying event”.

Extrapolate to the LHC!
“Underlying Event”
as defined by “Charged particle Jets”

Charged Particle $\Delta \phi$ Correlations
$P_T > 0.5$ GeV/c $|\eta| < 1$

- Define $|\Delta \phi| < 60^\circ$ as “Toward”, $60^\circ < |\Delta \phi| < 120^\circ$ as “Transverse”, and $|\Delta \phi| > 120^\circ$ as “Away”.
- All three regions have the same size in $\eta$-$\phi$ space, $\Delta \eta \times \Delta \phi = 2 \times 120^\circ = 4\pi/3$.

Look at the charged particle density in the “transverse” region!
CDF Run 1 “Min-Bias” Data
Charged Particle Density

CDF Published

Charged Particle Pseudo-Rapidity Distribution: $dN/d\eta$

- CDF Min-Bias 1.8 TeV
- CDF Min-Bias 630 GeV
- all PT

CDF Published

Charged Particle Density: $dN/d\eta d\phi$

- CDF Min-Bias 630 GeV
- CDF Min-Bias 1.8 TeV
- all PT

<$$dN_{chg}/d\eta$$> = 4.2

“Min-Bias” data on the number of charged particles per unit pseudo-rapidity at 630 and 1,800 GeV. There are about 4.2 charged particles per unit $\eta$ in “Min-Bias” collisions at 1.8 TeV ($|\eta| < 1$, all $P_T$).

Convert to charged particle density, $dN_{chg}/d\eta d\phi$, by dividing by $2\pi$.

There are about 0.67 charged particles per unit $\eta$-$\phi$ in “Min-Bias” collisions at 1.8 TeV ($|\eta| < 1$, all $P_T$).
CDF Run 1 “Min-Bias” Data
Charged Particle Density

F “Min-Bias” data on the number of charged particles per unit pseudo-rapidity at 630 and 1,800 GeV. There are about 4.2 charged particles per unit \( \eta \) in “Min-Bias” collisions at 1.8 TeV (|\( \eta \)| < 1, all PT).

- Convert to charged particle density, \( \frac{dN_{\text{chg}}}{d\eta d\phi} \), by dividing by \( 2\pi \). There are about 0.67 charged particles per unit \( \eta - \phi \) in “Min-Bias” collisions at 1.8 TeV (|\( \eta \)| < 1, all \( P_T \)).
- There are about 0.25 charged particles per unit \( \eta - \phi \) in “Min-Bias” collisions at 1.8 TeV (|\( \eta \)| < 1, \( P_T > 0.5 \) GeV/c).

\[ \langle \frac{dN_{\text{chg}}}{d\eta} \rangle = 4.2 \]

\[ \langle \frac{dN_{\text{chg}}}{d\eta d\phi} \rangle = 0.67 \]
Compares the average “transverse” charge particle density with the average “Min-Bias” charge particle density (|\(\eta\)|<1, \(P_T\)>0.5 GeV). Shows how the “transverse” charge particle density and the Min-Bias charge particle density is distributed in \(P_T\).
Run 1 Charged Particle Density

“Transverse” $P_T$ Distribution

Compares the average “transverse” charge particle density with the average “Min-Bias” charge particle density ($|\eta|<1, P_T>0.5$ GeV). Shows how the “transverse” charge particle density and the Min-Bias charge particle density is distributed in $P_T$. 

$P_T$(charged jet#1) $> 30$ GeV/c
“Transverse” $<dN_{chg}/d\eta d\phi> = 0.56$

CDF Run 1 Min-Bias data
$<dN_{chg}/d\eta d\phi> = 0.25$

Factor of 2!
Pythia uses multiple parton interactions to enhance the underlying event.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSTP(81)</td>
<td>0</td>
<td>Multiple-Parton Scattering off</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Multiple-Parton Scattering on</td>
</tr>
<tr>
<td>MSTP(82)</td>
<td>1</td>
<td>Multiple interactions assuming the same probability, with an abrupt cut-off $P_{T_{\text{min}}}=\text{PARP}(81)$</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Multiple interactions assuming a varying impact parameter and a hadronic matter overlap consistent with a single Gaussian matter distribution, with a smooth turn-off $P_{T_{0}}=\text{PARP}(82)$</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Multiple interactions assuming a varying impact parameter and a hadronic matter overlap consistent with a double Gaussian matter distribution (governed by PARP(83) and PARP(84)), with a smooth turn-off $P_{T_{0}}=\text{PARP}(82)$</td>
</tr>
</tbody>
</table>
PYTHIA uses multiple parton interactions to enhance the underlying event. Pythia uses multiple parton interactions to enhance the underlying event.

Pythia uses multiple parton interactions to enhance the underlying event. Pythia uses multiple parton interactions to enhance the underlying event.

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### PYTHIA: Multiple Parton Interaction Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARP(83)</td>
<td>0.5</td>
<td>Double-Gaussian: Fraction of total hadronic matter within PARP(84)</td>
</tr>
<tr>
<td>PARP(84)</td>
<td>0.2</td>
<td>Double-Gaussian: Fraction of the overall hadron radius containing the fraction PARP(83) of the total hadronic matter.</td>
</tr>
<tr>
<td>PARP(85)</td>
<td>0.33</td>
<td>Probability that the MPI produces two gluons with color connections to the “nearest neighbors.”</td>
</tr>
<tr>
<td>PARP(86)</td>
<td>0.66</td>
<td>Probability that the MPI produces two gluons either as described by PARP(85) or as a closed gluon loop. The remaining fraction consists of quark-antiquark pairs.</td>
</tr>
<tr>
<td>PARP(89)</td>
<td>1 TeV</td>
<td>Determines the reference energy ( E_0 ).</td>
</tr>
<tr>
<td>PARP(90)</td>
<td>0.16</td>
<td>Determines the energy dependence of the cut-off ( P_{T0} ) as follows ( P_{T0}(E_{cm}) = P_{T0}(E_{cm}/E_0)^\varepsilon ) with ( \varepsilon = \text{PARP}(90) ).</td>
</tr>
<tr>
<td>PARP(67)</td>
<td>1.0</td>
<td>A scale factor that determines the maximum parton virtuality for space-like showers. The larger the value of PARP(67) the more initial-state radiation.</td>
</tr>
</tbody>
</table>

- **Hard Core**
- **Multiple Parton Interaction**
- **Color String**

Reference point at 1.8 TeV

Take \( E_0 = 1.8 \) TeV

Determine by comparing with 630 GeV data
Tuned PYTHIA 6.206

**Parameter** | **Tune B** | **Tune A**
---|---|---
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(67) | 1.0 | 4.0

Plot shows the “Transverse” charged particle density versus $P_T(chgjet#1)$ compared to the QCD hard scattering predictions of two tuned versions of PYTHIA 6.206 (CTEQ5L, Set B (PARP(67)=1) and Set A (PARP(67)=4)).
Compared the average "transverse" charge particle density ($|\eta|<1$, $P_T>0.5$ GeV) versus $P_T$(charged jet#1) and the $P_T$ distribution of the "transverse" density, $dN_{chg}/d\eta d\phi dP_T$ with the QCD Monte-Carlo predictions of two tuned versions of PYTHIA 6.206 ($P_T$(hard) > 0, CTEQ5L, Set B (PARP(67)=1) and Set A (PARP(67)=4)).

Can we distinguish between PARP(67)=1 and PARP(67)=4? No way! Right!
Tuned PYTHIA 6.206
“Transverse” $P_T$ Distribution

Compares the average “transverse” charge particle density ($|\eta|<1$, $P_T>0.5$ GeV) versus $P_T$(charged jet#1) and the $P_T$ distribution of the “transverse” density, $dN_{chg}/d\eta d\phi dP_T$ with the QCD Monte-Carlo predictions of two tuned versions of PYTHIA 6.206 ($P_T$(hard) > 0, CTEQ5L, Set B (PARP(67)=1) and Set A (PARP(67)=4)).
Compared the average “transverse” charge particle density (|η|<1, P_T>0.5 GeV) versus P_T(charged jet#1) and the P_T distribution of the “transverse” and “Min-Bias” densities with the QCD Monte-Carlo predictions of a tuned version of PYTHIA 6.206 (P_T(hard) > 0, CTEQ5L, Set A). Describes “Min-Bias” collisions! Describes the “underlying event”!
“Transverse” Charged Particle Density

“Transverse” region as defined by the leading “charged particle jet”

Charged Particle Jet #1 Direction

Delta Phi

“Toward”

“Transverse”

“Transverse”

“Away”

"Transverse" Charged Particle Density: dN/dηdφ

![Graph showing the data on the average “transverse” charge particle density (|η|<1, PT>0.5 GeV) as a function of the transverse momentum of the leading charged particle jet from Run 1.](image)

shows the data on the average “transverse” charge particle density (|η|<1, PT>0.5 GeV) as a function of the transverse momentum of the leading charged particle jet from Run 1.
“Transverse” Charged Particle Density

![Graph showing charged particle density as a function of transverse momentum.](image)

- Shows the "transverse" charge particle density ($|\eta|<1$, $P_T>0.5$ GeV) as a function of the transverse momentum of the leading charged particle jet from Run 1.

- Compares the Run 2 data (Min-Bias, JET20, JET50, JET70, JET100) with Run 1. The errors on the (uncorrected) Run 2 data include both statistical and correlated systematic uncertainties.

**Fermilab MC Workshop**

**April 30, 2003**

**Rick Field - Florida/CDF**
“Transverse” Charged Particle Density

- Shows the prediction of PYTHIA Tune A at 1.96 TeV after detector simulation (i.e. after CDFSIM).
- Compares the Run 2 data (Min-Bias, JET20, JET50, JET70, JET100) with Run 1.
  The errors on the (uncorrected) Run 2 data include both statistical and correlated systematic uncertainties.
- Shows excellent agreement between Run 1 and 2!
- PYTHIA Tune A was tuned to fit the “underlying event” in Run 1!
Shows the data on the average “transverse” charged PTsum density ($|\eta|<1, P_T>0.5$ GeV) as a function of the transverse momentum of the leading charged particle jet from Run 1.
"Transverse" Charged PTsum Density

- Shows the "transverse" charged PTsum density ($|\eta|<1, P_T>0.5 \text{ GeV}$) as a function of the transverse momentum of the leading charged particle jet from Run 1.

- Compares the Run 2 data (Min-Bias, JET20, JET50, JET70, JET100) with Run 1. The errors on the (uncorrected) Run 2 data include both statistical and correlated systematic uncertainties.
Shows the averaged "transverse" charged PTsum density (|\(\eta\)|<1, \(P_T>0.5\) GeV) as a function of the transverse momentum of the leading charged particle jet from Run 1.

Compared the Run 2 data (Min-Bias, JET20, JET50, JET70, JET100) with Run 1. The errors on the (uncorrected) Run 2 data include both statistical and correlated systematic uncertainties.

Shows the prediction of PYTHIA Tune A at 1.96 TeV after detector simulation (i.e. after CDFSIM).

PYTHIA Tune A was tuned to fit the "underlying event" in Run 1!
Compares the average “transverse” charge particle density (|\eta|<1, P_T>0.5 GeV) versus P_T(charged jet#1) with the P_T distribution of the “transverse” density, dN_{chg}/d\eta d\phi dP_T. Shows how the “transverse” charge particle density is distributed in P_T.
Charged Particle Density

“Transverse” $P_T$ Distribution

- Compares the average “transverse” charge particle density ($|\eta|<1$, $P_T>0.5$ GeV) versus $P_T$ (charged jet#1) with the $P_T$ distribution of the “transverse” density, $dN_{\text{chg}}/d\eta d\phi dP_T$. Shows how the “transverse” charge particle density is distributed in $P_T$.

- Excellent agreement between Run 1 and 2!

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- Shows the prediction of PYTHIA Tune A at 1.96 TeV after detector simulation (i.e. after CDFSIM).

Fermilab MC Workshop

April 30, 2003
Relationship Between
“Calorimeter” and “Charged Particle” Jets

- Shows the “matched” JetClu jet $E_T$ versus the transverse momentum of the leading “charged particle jet” (closest jet within $R = 0.7$ of the leading chgjet).

- Shows the EM fraction of the “matched” JetClu jet and the EM fraction of a typical JetClu jet.

- Shows the ratio of $P_T(chgjet#1)$ to the “matched” JetClu jet $E_T$ versus $P_T(chgjet#1)$.
Relationship Between
“Calorimeter” and “Charged Particle” Jets

- Shows the “matched” JetClu jet $E_T$ versus the transverse momentum of the leading “charged particle jet” (closest jet within $R = 0.7$ of the leading chgjet).

- Shows the “matched” JetClu jet ET versus the transverse momentum of the leading “charged particle jet” (closest jet within $R = 0.7$ of the leading chgjet).

The leading chgjet comes from a JetClu jet that is, on the average, about 90% charged!
Look at charged particle correlations in the azimuthal angle $\Delta \phi$ relative to the leading JetClu jet.

- Define $|\Delta \phi| < 60^\circ$ as “Toward”, $60^\circ < |\Delta \phi| < 120^\circ$ as “Transverse”, and $|\Delta \phi| > 120^\circ$ as “Away”.

- All three regions have the same size in $\eta$-$\phi$ space, $\Delta \eta \times \Delta \phi = 2 \times 120^\circ = 4\pi/3$. 
"Transverse" Charged Particle Density

shows the data on the average "transverse" charge particle density ($|\eta|<1$, $P_T>0.5$ GeV) as a function of the transverse energy of the leading JetClu jet ($R=0.7$, $|\eta(jet)|<2$) from Run 2, compared with PYTHIA Tune A after CDFSIM.
Shows the data on the average “transverse” charge particle density (|η|<1, PT>0.5 GeV) as a function of the transverse energy of the leading JetClu jet (R = 0.7, |η(jet)| < 2) from Run 2, compared with PYTHIA Tune A after CDFSIM.

Compares the “transverse” region of the leading “charged particle jet”, chgjet#1, with the “transverse” region of the leading “calorimeter jet” (JetClu R = 0.7), jet#1.
Shows the data on the average “transverse” charged PTsum density ($|\eta|<1$, PT>0.5 GeV) as a function of the transverse energy of the leading JetClu jet (R = 0.7, $|\eta(jet)| < 2$) from Run 2, compared with PYTHIA Tune A after CDFSIM.
Shows the data on the average “transverse” charged PTsum density ($|\eta|<1$, PT>0.5 GeV) as a function of the transverse energy of the leading JetClu jet (R = 0.7, $|\eta(jet)| < 2$) from Run 2, compared with PYTHIA Tune A after CDFSIM.

Compares the “transverse” region of the leading “charged particle jet”, chgjet#1, with the “transverse” region of the leading “calorimeter jet” (JetClu R = 0.7), jet#1.
Charged Particle Density

“Transverse” $P_T$ Distribution

- Compares the average “transverse” charge particle density ($|\eta|<1, P_T>0.5$ GeV) versus $E_T$ (jet#1) with the $P_T$ distribution of the “transverse” density, $dN_{chg}/d\eta d\phi dP_T$.

- Shows the prediction of PYTHIA Tune A at 1.96 TeV after detector simulation (i.e. after CDFSIM).

CDF Preliminary

30 < $E_T$ (jet#1) < 70 GeV/c

95 < $E_T$ (jet#1) < 130 GeV

$dN_{chg}/d\eta d\phi$ = 0.61

$dN_{chg}/d\eta d\phi$ = 0.65
Charged Particle Density

“Transverse” $P_T$ Distribution

- Compares the average “transverse” as defined by “calorimeter jets” (JetClu R = 0.7) with the “transverse” region defined by “charged particle jets”.

- Shows the prediction of PYTHIA Tune A at 1.96 TeV after detector simulation (i.e. after CDFSIM).

CDF Preliminary

Charged Particles ($|\eta|<1.0, PT>0.5$ GeV/c)

ChgJet#1 R = 0.7

JetClu Jet#1 (R = 0.7, |$\eta$(jet)|<2)

PYTHIA Tune A 1.96 TeV

30 < $P_T$(charged jet#1) < 50 GeV/c

“Transverse” $<dN_{chg}/d\eta d\phi> = 0.59$

30 < $E_T$(jet#1) < 70 GeV/c

“Transverse” $<dN_{chg}/d\eta d\phi> = 0.61$
Tuned PYTHIA (Set A)
LHC Predictions

Show the average “transverse” charge particle and PT\textsubscript{sum} density (|\eta|<1, P\textsubscript{T}>0) versus P\textsubscript{T}(charged jet#1) predicted by HERWIG 6.4 (P\textsubscript{T}(hard) > 3 GeV/c, CTEQ5L), and a tuned versions of PYTHIA 6.206 (P\textsubscript{T}(hard) > 0, CTEQ5L, Set A) at 1.8 TeV and 14 TeV.

At 14 TeV tuned PYTHIA (Set A) predicts roughly 2.3 charged particles per unit \eta-\phi (P\textsubscript{T} > 0) in the “transverse” region (14 charged particles per unit \eta) which is larger than the HERWIG prediction.

At 14 TeV tuned PYTHIA (Set A) predicts roughly 2 GeV/c charged PT\textsubscript{sum} per unit \eta-\phi (P\textsubscript{T} > 0) in the “transverse” region at P\textsubscript{T}(chgjet#1) = 40 GeV/c which is a factor of 2 larger than at 1.8 TeV and much larger than the HERWIG prediction.
Tuned PYTHIA (Set A)
LHC Predictions

- Shows the average “transverse” charge particle and PT\textsubscript{sum} density (|\eta|<1, P\textsubscript{T}>0) versus P\textsubscript{T}(charged jet#1) predicted by HERWIG 6.4 (P\textsubscript{T}(hard) > 3 GeV/c, CTEQ5L), and a tuned versions of PYTHIA 6.206 (P\textsubscript{T}(hard) > 0, CTEQ5L, Set A) at 1.8 TeV and 14 TeV. Also shown is the 14 TeV prediction of PYTHIA 6.206 with the default value \varepsilon = 0.16.

- Tuned PYTHIA (Set A) predicts roughly 2.3 charged particles per unit \eta-\phi (P\textsubscript{T} > 0) in the “transverse” region (14 charged particles per unit \eta) which is larger than the HERWIG prediction and much less than the PYTHIA default prediction.
Tuned PYTHIA (Set A)
LHC Predictions

Shows the average “transverse” charge particle and PT\textsubscript{sum} density (|\eta|<1, P\textsubscript{T}>0) versus P\textsubscript{T}(charged jet\#1) predicted by HERWIG 6.4 (P\textsubscript{T}(hard) > 3 GeV/c, CTEQ5L), and a tuned versions of PYTHIA 6.206 (P\textsubscript{T}(hard) > 0, CTEQ5L, Set A) at 1.8 TeV and 14 TeV. Also shown is the 14 TeV prediction of PYTHIA 6.206 with the default value \varepsilon = 0.16.

Tuned PYTHIA (Set A) predicts roughly 2.5 GeV/c per unit \eta-\phi (P\textsubscript{T} > 0) from charged particles in the “transverse” region for P\textsubscript{T}(chgjet\#1) = 100 GeV/c. Note, however, that the “transverse” charged PT\textsubscript{sum} density increases as P\textsubscript{T}(chgjet\#1) increases.
Tuned PYTHIA (Set A) LHC Predictions

Show the center-of-mass energy dependence of the charged particle density, \( \frac{dN_{\text{chg}}}{d\eta d\phi} \), for “Min-Bias” collisions compared with the a tuned version of PYTHIA 6.206 (Set A) with \( P_T(\text{hard}) > 0 \).

PYTHIA was tuned to fit the “underlying event” in hard-scattering processes at 1.8 TeV and 630 GeV.

PYTHIA (Set A) predicts a 42% rise in \( \frac{dN_{\text{chg}}}{d\eta d\phi} \) at \( \eta = 0 \) in going from the Tevatron (1.8 TeV) to the LHC (14 TeV).
Shows the center-of-mass energy dependence of the charged particle density, $dN_{\text{chg}}/d\eta d\phi dP_T$, for “Min-Bias” collisions compared with the a tuned version of PYTHIA 6.206 (Set A) with $P_T(\text{hard}) > 0$.

This PYTHIA fit predicts that 1% of all “Min-Bias” events at 1.8 TeV are a result of a hard 2-to-2 parton-parton scattering with $P_T(\text{hard}) > 10$ GeV/c which increases to 12% at 14 TeV!
There is excellent agreement between the Run 1 and the Run 2. The "underlying event" is the same in Run 2 as in Run 1 but now we can study the evolution out to much higher energies!

PYTHIA Tune A does a good job of describing the "underlying event" in the Run 2 data as defined by "charged particle jets" and as defined by "calorimeter jets". HERWIG Run 2 comparisons will be coming soon!

Lots more CDF Run 2 data to come including MAX/MIN "transverse" and MAX/MIN "cones".
Both HERWIG and the tuned PYTHIA (Set A) predict a 40-45% rise in $dN_{ch}/d\eta d\phi$ at $\eta = 0$ in going from the Tevatron (1.8 TeV) to the LHC (14 TeV). 4 charged particles per unit $\eta$ at the Tevatron becomes 6 per unit $\eta$ at the LHC.

The tuned PYTHIA (Set A) predicts that 1% of all “Min-Bias” events at the Tevatron (1.8 TeV) are the result of a hard 2-to-2 parton-parton scattering with $P_T(\text{hard}) > 10$ GeV/c which increases to 12% at LHC (14 TeV)!

For the “underlying event” in hard scattering processes the predictions of HERWIG and the tuned PYTHIA (Set A) differ greatly (factor of 2!). HERWIG predicts a smaller increase in the activity of the “underlying event” in going from the Tevatron to the LHC.

The tuned PYTHIA (Set A) predicts about a factor of two increase at the LHC in the charged $P_T^{\text{sum}}$ density of the “underlying event” at the same $P_T(\text{jet#1})$ (the “transverse” charged $P_T^{\text{sum}}$ density increases rapidly as $P_T(\text{jet#1})$ increases).
Both HERWIG and the tuned PYTHIA (Set A) predict a 40-45% rise in \( \frac{dN_{ch}}{d\eta} \) at \( \eta = 0 \) in going from the Tevatron (1.8 TeV) to the LHC (14 TeV). 4 charged particles per unit \( \eta \) at the Tevatron becomes 6 per unit \( \eta \) at the LHC.

The tuned PYTHIA (Set A) predicts that 1% of all “Min-Bias” events at the Tevatron (1.8 TeV) are the result of a hard 2-to-2 parton-parton scattering with \( P_T(\text{hard}) > 10 \) GeV/c which increases to 12% at LHC (14 TeV)!

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The tuned PYTHIA (Set A) predicts about a factor of two increase at the LHC in the charged \( P_T^{\text{sum}} \) density of the “underlying event” at the same \( P_T(\text{jet#1}) \) (the “transverse” charged \( P_T^{\text{sum}} \) density increases rapidly as \( P_T(\text{jet#1}) \) increases).
LHC Predictions

Summary & Conclusions

Both HERWIG and the tuned PYTHIA (Set A) predict a 40-45% rise in $dN_{\text{ch}}/d\eta$ at $\eta = 0$ in going from the Tevatron (1.8 TeV) to the LHC (14 TeV). 4 charged particles per unit $\eta$ at the Tevatron becomes 6 per unit $\eta$ at the LHC.

The tuned PYTHIA (Set A) predicts that 1% of all “Min-Bias” events at the Tevatron (1.8 TeV) are the result of a hard 2-to-2 parton-parton scattering with $P_{T(\text{hard})} > 10$ GeV/c which increases to 12% at LHC (14 TeV).

For the “underlying event” in hard scattering processes the predictions of HERWIG and the tuned PYTHIA (Set A) differ greatly (factor of 2!). HERWIG predicts a smaller increase in the activity of the “underlying event” in going from the Tevatron to the LHC.

The tuned PYTHIA (Set A) predicts about a factor of two increase at the LHC in the charged $P_{T\text{sum}}$ density of the “underlying event” at the same $P_{T(\text{jet#1})}$ (the “transverse” charged $P_{T\text{sum}}$ density increases rapidly as $P_{T(\text{jet#1})}$ increases).

“Min-Bias” at the LHC contains much more hard collisions than at the Tevatron! At the Tevatron the “underlying event” is a factor of 2 more active than “Tevatron Min-Bias”. At the LHC the “underlying event” will be at least a factor of 2 more active than “LHC Min-Bias”!

12 times more likely to find a 10 GeV “jet” in “Min-Bias” at the LHC!

Twice as much activity in the “underlying event” at the LHC!