Underlying Event in Herwig++ - Status report

Manuel Bähr

University of Karlsruhe

January 8, 2008
UE in Herwig++
based on [Butterworth, Forshaw, Seymour ’96]

- fully working model included in Herwig++ 2.1
- Based on the eikonalization of the cross section $pp \rightarrow jj$ with $p_T > p_T^{\text{min}} (\sigma^{\text{inc}})$.

\[
\sigma_{\text{inel}} = \int d^2b \sum_{m=1}^{\infty} \frac{(A(b)\sigma^{\text{inc}})^m}{m!} e^{-A(b)\sigma^{\text{inc}}} = \int d^2b (1 - e^{-A(b)\sigma^{\text{inc}}})
\]

- $A(b)$ is the overlap function of the two colliding particles.

\[
A(b = |b|) = \int d^2b' G_{h_1}(b') G_{h_2}(b - b')
\]

\[
G_{\bar{p}}(b) = G_p(b) = \int \frac{d^2k}{2\pi} \frac{e^{k \cdot b}}{(1 + k^2/\mu^2)^2}
\]
Exp. analysis
R. Field’s TVT analysis; PRD65,092002

- non standard jet algorithm used to reconstruct jet with largest scalar ptsum: leading jet
- define 3 regions with respect to $\phi$ of the leading jet: towards, transverse, away
- plot $\langle N^{chg} \rangle$ and $\langle p_{T,sum}^{chg} \rangle$ for each of these regions
- use $\chi^2$ of describing the data as benchmark
Parameter Scan
all regions
Parameter Scan
only transverse region
Best fit: $N_{\text{transv}}^{\text{chg}}$

$p_T^{\text{min}} = 3.2$ GeV, $\mu^2 = 1.75$ GeV$^2$

---

**CDF data, uncorrected**
**Best fit:** $p_{T, \text{sum}}^{\text{transv}}$

$p_{T}^{\text{min}} = 3.2 \text{ GeV}, \mu^2 = 1.75 \text{ GeV}^2$
Best fit: \( N_{\text{tow}}^{\text{chg}} \)

\[ p_T^{\text{min}} = 3.2 \text{ GeV}, \mu^2 = 1.75 \text{ GeV}^2 \]
Best fit: $p_{T,\text{sum}}^{\text{tow}}$

$p_{T}^{\text{min}} = 3.2 \text{ GeV}, \mu^2 = 1.75 \text{ GeV}^2$
double parton scattering

Occurance of several signal processes in one collision. The assumption of the independence of additional scatters leads to $(p_n(x) = \frac{x^n}{n!} e^{-x})$:

$$\sigma_{n,m}(\sigma_a, \sigma_b) = \int d^2 b \ p_n(A(b)\sigma_a) \ p_m(A(b)\sigma_b)$$

In the case of small cross sections and one interaction each, this leads to

$$\sigma_{1,1}(\sigma_a, \sigma_b) = \int d^2 b \ A^2(b)\sigma_a\sigma_b$$

$$= \sigma_a\sigma_b \ \underbrace{\int d^2 b \ A^2(b)}_{1/\sigma_{eff}}$$
$\sigma_{\text{eff}}$ measured in [CDF coll. PRD 56, 3811 (1997)]

$\sigma_{\text{eff}} = 14.5 \pm 1.7^{+1.7}_{-2.3} \text{ mb}$
Occurrence of several signal processes in one collision and low pt jet events:

$$\sigma_{n,m,k}(\sigma_a, \sigma_b, \sigma_{soft}) = \int d^2 b \ p_n(A(b)\sigma_a) \ p_m(A(b)\sigma_b) \ p_k(A(b)\sigma_{soft})$$

Probability of $k$ soft jet events

$$P_k = \frac{\sigma_{n,m,k}}{\sum_{\ell=0}^{\infty} \sigma_{n,m,\ell}} = \frac{\int d^2 b \ p_n \ p_m \ p_k}{\int d^2 b \ p_n \ p_m}$$

The double parton scattering cross section from the slides before would be

$$\sigma_{DP} = \sum_{\ell=0}^{\infty} \sigma_{1,1,\ell}$$
Next Steps

- Double/multiple parton scattering + low $p_T$ jets
- Modeling of the soft part below $p_T^{\text{min}}$