The underlying event in hadron hadron collisions

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Outline of the talk:
- The underlying event in jet events and motivation
- Measure of the underlying event at CDF
- Results
- Jet events
- Minimum bias events
- Conclusions
The underlying event in jet events and motivation:

- beam–beam remnants
- Initial state radiation
- final state radiation
- multiple parton interactions

- The underlying event (UE) contribution must be subtracted from jet’s energy (CDF dominant error at low \( E_t \))
- Subtraction is based on the energy found in a random cone in active minimum bias events (triggered by a coincidence in scintillators placed along the beam)

sensitive to UE and NLO pert corrections to hard scattering

MAX / MIN cones

sensitive to UE only
Measure of the underlying event in jet events at 1800 GeV:

- Tracks are reconstructed by CTC and corrected for track finding efficiency
- Estimated systematic errors ~10%

At low energy, tracks are less sensitive to detector calibration/simulation than calorimeter cells

Pythia has been tuned:
- CTEQ4L
- Varying impact parameters
- $p_{T0} = 2.0$ GeV/c
- QFL: fast CDF detector simulation

The MAX cone increases with increasing $E_t$ of the leading jet.
- The MIN cone stays flat.
- In the MAX-MIN cone Pythia+QFL and Herwig+QFL differ by about 300-500 MeV.
The tuned Pythia reproduces the $p_t$ distribution well
Herwig does not generate tracks with $p_t > 5$ GeV/c, indicating a lack of hard physics description in minimum bias model.
$\sim20\%$ less $p_t$ than in MIN cone in jet events (according on selection criteria)

630 GeV:
At 630 GeV, the two Monte Carlo reproduce the data in jet events (similar behavior as at 1800 GeV)
In Pythia, $p_{t0}$ has been set to 1.4 GeV/c
Conclusions:

**Tevatron:**
- Jet events are more *active* than minimum bias events
- **Herwig**
  - in jet events, describes well the underlying event at both 1800 and 630 GeV
  - in minimum bias events, generated tracks are too soft
- **Pythia**
  - at 1800 GeV can be tuned to reproduce both jet and minimum bias events. The regularization scale of the transverse momentum spectrum for multiple interactions ($p_{t0}$) varies with the center of mass energy
  - Reproduces better than Herwig the slope of the $p_t$ distribution in the transition region ($4 < p_{t\text{Lead Jet}} < 20$ GeV/c)

**LHC:**
- At LHC about 23 minimum bias events superimpose to the hard scattering corresponding to about 7/12 GeV/c in a jet cone due to soft interactions (m.b.+MIN cone) according to Herwig/Pythia's simulation
- $p_t$ in the MIN cone is about 70% larger than in a random cone in m.b. events