

Introduction to Phenomenology and Experiment
of Particle Physics (PEPP)
Cycle 5
Minimum bias

The Underlying Event

Any measurement of jets at a hadron collider, such as the Tevatron, will necessarily be affected by the so-called underlying event. There are several definitions of what exactly an underlying event is. On the theoretical side the most common definition is to regard anything that is not directly related to the primary sub-process under study. E.g. if we are studying the production of a W in association with a jet, the particles stemming from the W and from the incoming and outgoing partons, including perturbative bremsstrahlung, are considered to belong to the primary event, while particles from additional interactions between the hadron remnants and from soft collisions between other hadrons in the same bunch crossing, belong to the underlying event.

Experimentally, a standard procedure is to measure some average activity away from the jets which are to be measured. This is then an estimate of how much transverse energy the underlying event would contribute to a given jet-cone, and this value is then subtracted from the jets under study, before they are compared to theoretical predictions.

The main objections to this experimental procedure is that it ignores fluctuations in the underlying event, and that it also may include some perturbative bremsstrahlung from the primary process into the average transverse energy being subtracted from the jets. Also, it does not always take into account that the activity in the underlying event may be correlated with the primary process.

Literature

A good introduction to this area is the CERN School 2007 lecture notes

T. Sjöstrand, *Monte Carlo Generators*, [hep-ph/0611247](#).

A fairly recent overview of the subject is given in

C. Buttar, et al., *The underlying event*, in the proceedings of the *HERA and the LHC* workshop, [hep-ph/0601012](#).

Also the manual for the Pythia program contains useful input, especially relevant for completing the exercises:

T. Sjöstrand et al., *PYTHIA 6.4 Physics and Manual*, [hep-ph/0603175](#).

Goals

- Remnant-remnant interactions
- Eikonalization of the partonic cross section
- Multiple collision/interactions/scattering
- Minimum bias
- Underlying events

Exercises

All the following simulations should be done with Pythia version 6.4 <http://projects.hepforge.org/pythia6/>, using both the default and the *Tune-A* parameter setting, both at the Tevatron and the LHC.

1. Simulate *minimum bias* events and plot the distribution in number of scatterings per event.
2. Apply the PYCELL cone algorithm to find a trigger (highest $E_{\perp}$) jet in an event. Then, select only charged particles in the central unit of rapidity which are transverse to the trigger jet in the sense that they are more than 60° and less than 120° away in azimuth angle. Plot the average number of these particles as a function of the transverse energy of the trigger jet. Also plot the average (scalar) sum of the transverse momentum of these particles as a function of the transverse energy of the trigger jet.
3. Simulate W -production events, and plot the distribution in number of scatterings per event.