Herwig++

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Abstract
I briefly review the status of the Herwig++ event generator. Current achievements are highlighted and a brief summary of future plans is given.

1 Introduction

Herwig++ [1] is a new Monte Carlo event generator for simulating collider physics, written in the object oriented programming language C++. The idea is to rewrite the well-established multi–purpose event generator HERWIG [2] and to improve it where necessary [3]. The Lund event generators PYTHIA [4] and ARIADNE [5] are also being rewritten at the moment. Herwig++ and ARIADNE will both be based on a common event generation framework, called ThePEG [6] which will make it possible to exchange single modules of the event generation and allows us to have a common, or at least a very similar user interface. PYTHIA8, the rewrite of PYTHIA (6.3) will be written independently of this project but may become integrated into the structure later [7]. A further object oriented event generator, SHERPA [8], is established as an independent project.

2 Event Generation

In its present version (1.0) Herwig++ is capable of simulating e^+e^- annihilation events. The physics simulation consists of several steps, going from small (perturbative) to large (non–perturbative) distance scales. First, the effective CM energy of the annihilating e^+e^- pair is selected according to some model structure function of the electron, thereby radiating photons that carry some fraction of the original energy. Next, we set up the $q\bar{q}$ final state and a hard matrix element correction is applied [9]. In the next step, parton showers are radiated from the coloured final state particles. These effectively resum large soft and collinear logarithms. The parton shower is modelled in terms of new evolution variables with respect to the FORTRAN program [10]. This, and the use of splitting functions for massive particles allow us to simulate the suppression of soft and collinear radiation from heavy particles dynamically (dead cone effect) which has previously only been modelled in a crude way. Parton showers from initial state particles in a hard scattering and from decays of heavy particles (particularly t–quarks) have been formulated for various situations in [10]. The next stage of the simulation is the hadronization of the outgoing coloured particles. First, remaining gluons are split into non–perturbative $q\bar{q}$–pairs. Colour connected particles are paired into colourless clusters. The invariant mass spectrum of these clusters contains a long high–mass tail that still contains a large scale. These heavy clusters are further split into pairs of lighter clusters. Once all clusters are below a certain mass threshold they decay into pairs of hadrons. The hadron species are selected only according to a handful of parameters. It is this stage where it has been observed in previous versions of the FORTRAN program that the meson/baryon number ratio in e^+e^- annihilation events was difficult to obtain when a large number of highly excited mesons is available in the program [11]. In the current version the hadron selection is reorganised and we obtain more stable results. Finally, the produced hadrons decay into stable hadrons according to some models. In version 1.0 the hadronic decays were modelled similarly to the decays in the FORTRAN version.

We have tested the simulation of e^+e^- annihilation events in very great detail [1]. We considered event shape variables, jet rates, hadron yields and many more observables. One observable of special interest has been the b–quark fragmentation function that we found to be well–described on the basis of the parton shower only. This is a result of the new shower algorithm for heavy quarks. The overall result was that we are capable of simulating e^+e^- events at least as well good as with the FORTRAN version.

3 Current and Future Developments

Many new features are currently being implemented for the event simulation at hadron colliders. The list of hard matrix elements will be slightly extended in the next version in order to cover some basic processes. In principle we can also rely on parton level event generators and read in event files that follow the Les Houches Accord [12]. The parton shower will include initial state radiation and gluon radiation in the perturbative decay of heavy particles. Some related aspects of estimating uncertainties from initial state parton showers were addressed in [13]. A large effort went into remodelling and updating the secondary hadronic decays. A future version should also be able to simulate hard jets in deep inelastic scattering. Exhaustive tests of our generator output against current data from the experiments at HERA and the Tevatron will be made in order to validate and understand our program. In the long–term we plan to include a larger number of simple processes, mainly $2 \to 2$ and some $2 \to 3$, both Standard Model processes and some BSM processes as well. The modelling of the underlying event will at first only be on the basis of the simple so–called UA5 model that is also available in the FORTRAN version. A refinement towards a more sophisticated multiple interaction model [14, 15] is planned.

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