HZTool

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Abstract
HZTOOL is a library of Fortran routines used for tuning and validating of Monte Carlo and analytical models of high energy particle collisions. The library includes an extensive collection of routines reproducing ep, γp, $p\bar{p}$ and $\gamma\gamma$ data published by the HEP experiments, as well as calculations as they were performed in the experimental data analyses. During this workshop the library was further developed to include HERA and TeVatron results relevant for the studies at the LHC.

1 Introduction

Data from high-energy physics experiments have seen the triumph of the Standard Model both in precision electroweak measurements and in the verification of QCD to a reasonable degree of precision. However, a number of aspects of high energy collisions remain poorly understood due to technical difficulties in the calculation. This is particularly the case for measurements of the hadronic final state in high energy collisions, where the specific event shapes variables, jet algorithms and kinematic cuts may be rather complex.

Accurate models of the final state are often needed to design new experiments and to interpret the data from them. Simulation programs employing fits to existing data address these problems. However, consistent tuning of the parameters of these programs, and examination of the physics assumptions they contain, is non-trivial due to the wide variety of colliding beams, regions of phase space, and complex observables. Comparing a new calculation to a sensible set of relevant data is in practice extremely time consuming and prone to error.

HZTOOL [1] is created to improve this situation. It is a library of Fortran routines allowing reproduction of the experimental distributions and easy access to the published data. Basically, each subroutine corresponds to a published paper. If supplied with the final states of a set of simulated collisions, these routines will perform the analysis of the final state exactly as it was performed in the paper, providing simulated data points which may be compared to the measurement. HZTOOL currently contains measurements from ep, γp, $\gamma\gamma$ and $p\bar{p}$ collisions. Others may easily be added.

While it is designed to be used as simply as possible as a standalone library, HZTOOL is also a key component of JETWEB [2]. JETWEB is a Web-based facility for tuning and validating Monte Carlo models. A relational database of reaction data and predictions from different models is accessed via the Web, enabling a user to find out how well a given model agrees with a range of data and to request predictions using parameter sets that are not yet in the database.

HZTOOL can also be used together with RUNMC [3], which is an object-oriented frond-end for Monte Carlo programs incorporating a sophisticated graphical user interface.

The library was initially developed within the workshop "Future Physics at HERA" [4] but has since expanded to become a more general toolkit. The package was managed by *T. Carli* for quite some time and many people have contributed routines and general development to HZTOOL since it first appeared. Nowadays, HZTOOL and JETWEB are further developed within the CEDAR project [5]. The

current maintainers are *J. Butterworth*, *H. Jung*, *E. Nurse* and *B. Waugh*[1]. It is planned to design a C++ equivalent, in order to provide a native interface to the new C++ Monte Carlo programs, to enable a straightforward implementation of new HEP data analyses performed in C++.[2]

2 HZTOOL Usage

Each analysis subroutine books, fills and outputs two sets of histograms: one reproducing the published data and another one filled by the chosen simulation program. The routine names relate to the publication. The preferred convention is:

`HZHyymmnnn` where yymmnnn is the arXiv:hep–ex preprint number.

Alternative naming schemes, used for older routines or when a hep–ex number is not available, are:

`HZDyynnn` where yynnn is the DESY preprint number.
`HZCyynnn` where yynnn is the CERN preprint number.
`HZFyynnnE` where yynnn is the FNAL preprint number.
`HZyynnn` where yynnn is the DESY preprint number[3].

If none of the above number schemes exist, the routine name is generally derived from the journal publication (e.g. `HZPRT154247`). Occasionally a single publication contains results taken under more than one set of beam conditions, in which case there will be a routine for each beam condition, distinguished by appending a letter to the expected name (e.g. `HZC88172A`, `HZC88172B`).

HZTOOL is a library, and the main program, which is usually a Monte Carlo event generator, must be provided by the user. The code of HZTOOL routines is basically independent of the program used to simulate the collisions. The Monte Carlo generators currently supported are: ARIADNE [6], CASCADE [7], HERWIG [8] (including JIMMY [9]), LEPTO [10], PYTHIA [11], PHOJET [12], QCDINS [13], RAPGAP [14], RIDI [15], and DJANGOH [19]. The production versions of these programs are all currently written in Fortran. The library can also be accessed within the NLOLIB framework for running NLO QCD programs [16]. Besides the HZTOOL library it is also necessary to link in the CERNLIB library routines and possibly PDFLIB [17] or LHAPDF [18]. Examples of the main programs can be found in the HZSTEER package [20] which provides the executable programs for JETWEB to submit from its backend.

To ease the implementation of the analysis code, HZTOOL provides the relevant jet finders (the cluster and cone algorithms with various options), as well as a number of utilities to calculate event shape variables, to perform Lorentz boosts etc.

3 Recent Developments

Within this workshop, an effort was made to include all results from HERA and other HEP experiments which can be helpful for tuning of MC models used for event simulations at the LHC. In particular, the models for multiple interactions and for heavy flavour production were considered.

The publications which may be relevant for the tuning of multiple interaction models and which are available in HZTOOL are listed in [21]. The names for the corresponding HZTOOL subroutines are also specified. From this list, the newly written routines are: `HZH9505001` (*J. M. Butterworth*, *B. M. Waugh*), `HZH9810020` (*S. Lausberg*, *V. Lendermann*), `HZH0006017` (*D. Beneckenstein*, *V. Lendermann*) and `HZH0302034` (*K. Lohwasser*, *V. Lendermann*). The routine `HZ95219` was extended by *A. Buniatian* to include the results from the corresponding H1 paper which are especially sensitive to underlying events in the photoproduction of jets. The models of multiple interactions and efforts of their tuning are reviewed in [22].

[1] The maintainers can be contacted at `hztool@cedar.ac.uk`. To receive announcements of new releases, send an e-mail to `majordomo@cedar.ac.uk` with `subscribe hztool-announce` in the body of the e-mail.

[2] More details may be found at `http://hepforge.cedar.ac.uk/rivet`.

[3] This naming should not be used for new routines; the HZD prefix is preferred.

As for heavy flavour production, a number of HERA measurements of open charm and beauty production are included in the library [23]. From those, the newly written routines are: HZH0108047 (*P. D. Thompson*), HZH0312057 (*O. Gutsche*), HZH0408149 (*A. W. Jung*). New publications [24] are to be implemented. The following routines for the TeVatron results [25] were also recently provided: HZH9905024 (*O. Gutsche*), HZH0307080 (*H. Jung*), HZH0412071 (*H. Jung*, *K. Peters*). Furthermore a set of *Benchmark* cross sections have been defined for easy comparison of different calculations: HZDISCC, HZDISBB for charm and beauty production in DIS, HZHERAC, HZHERAB for photoproduction of charm and beauty and HZLHCC, HZLHCBB for charm and beauty production at the LHC [26].

References

[1] HZTOOL package, manual and tutorial can be downloaded from
http://hepforge.cedar.ac.uk/hztool/

[2] J. M. Butterworth and S. Butterworth, Comput. Phys. Commun. **153**, 164 (2003);
http://jetweb.cedar.ac.uk

[3] S. Chekanov, these proceedings, working group 5; http://hepforge.cedar.ac.uk/runmc/

[4] J. Bromley *et al.*, Proceedings of the Workshop "Future physics at HERA", Hamburg 1995/96, vol. 1, 611-612.

[5] J. M. Butterworth, S. Butterworth, B. M. Waugh, W. J. Stirling and M. R. Whalley, hep–ph/0412139;
A. Buckley *et al.*, these proceedings, working group 5; http://www.cedar.ac.uk/

[6] L. Lönnblad, Comput. Phys. Commun. **71**, 15 (1992);
http://www.thep.lu.se/~leif/ariadne/

[7] H. Jung, G. Salam, Eur. Phys. J. C **19**, 351 (2001);
H. Jung, Comput. Phys. Commun. **143**, 100 (2002); http://www.desy.de/~jung/cascade/

[8] G. Corcella, I. G. Knowles, G. Marchesini, S. Moretti, K. Odagiri, P. Richardson, M. H. Seymour and B. R. Webber, JHEP **0101**, 010 (2001);
http://hepwww.rl.ac.uk/theory/seymour/herwig

[9] J. M. Butterworth, J. R. Forshaw and M. H. Seymour, Z. Phys. C **72**, 637 (1996);
http://hepforge.cedar.ac.uk/jimmy

[10] G. Ingelman, A. Edin and J. Rathsman, Comput. Phys. Commun. **101**, 108 (1997);
http://www3.tsl.uu.se/thep/lepto/

[11] T. Sjöstrand, P. Eden, C. Friberg, L. Lönnblad, G. Miu, S. Mrenna and E. Norrbin, Comput. Phys. Commun. **135**, 238 (2001); http://thep.lu.se/tf2/staff/torbjorn/

[12] R. Engel, Z. Phys. C **66**, 203 (1995); http://www.physik.uni-leipzig.de/~engel

[13] A. Ringwald and F. Schrempp, Comput. Phys. Commun. **132**, 267 (2000);
http://www.desy.de/~t00fri/qcdins/qcdins.html

[14] H. Jung, Comput. Phys. Commun. **86**, 147 (1995); http://www.desy.de/~jung/rapgap/

[15] M. G. Ryskin and A. Solano, http://www-zeus.desy.de/~solano/RIDI2.0/

[16] K. Rabbertz and T. Schörner-Sadenius, these proceedings, working group 5;
http://www.desy.de/~nlolib/

[17] H. Plothow-Besch, Comput. Phys. Commun. **75**, 396 (1993).

[18] W. Giele *et al.*, Proceedings of Workshop on Physics at TeV Colliders, Les Houches, France, 2001, [hep–ph/0204316];
M. Whalley, D. Bourilkov and R. C. Group, these proceedings, working group 5;
http://hepforge.cedar.ac.uk/lhapdf/

[19] G. A. Schuler and H. Spiesberger,
http://wwwthep.physik.uni-mainz.de/~hspiesb/djangoh/djangoh.html

[20] HZSTEER package can be downloaded from
http://hepforge.cedar.ac.uk/hzsteer/

[21] M. Derrick *et al.* [ZEUS Collaboration], Phys. Lett. B **342**, 417 (1995), HZ94176;
M. Derrick *et al.* [ZEUS Collaboration], Phys. Lett. B **348**, 665 (1995), HZ95033;
M. Derrick *et al.* [ZEUS Collaboration.], Phys. Lett. B **354**, 163 (1995), HZH9505001;
M. Derrick *et al.* [ZEUS Collaboration], Phys. Lett. B **369**, 55 (1996), HZ95194;
S. Aid *et al.* [H1 Collaboration], Z. Phys. C **70**, 17 (1996), HZ95219;
M. Derrick *et al.* [ZEUS Collaboration], Phys. Lett. B **384**, 401 (1996), HZ96094;
K. Ackerstaff *et al.* [OPAL Collaboration], Z. Phys. C **73**, 433 (1997), HZC96132;
C. Adloff *et al.* [H1 Collaboration], Eur. Phys. J. C **1**, 97 (1998), HZ97164;
J. Breitweg *et al.* [ZEUS Collaboration], Eur. Phys. J. C **2**, 61 (1998), HZ97191;
J. Breitweg *et al.* [ZEUS Collaboration], Eur. Phys. J. C **1**, 109 (1998), HZ97196;
J. Breitweg *et al.* [ZEUS Collaboration], Eur. Phys. J. C **4**, 591 (1998), HZ98018;
J. Breitweg *et al.* [ZEUS Collaboration], Eur. Phys. J. C **6**, 67 (1999), HZ98085;
J. Breitweg *et al.* [ZEUS Collaboration], Phys. Lett. B **443**, 394 (1998), HZ98162;
C. Adloff *et al.* [H1 Collaboration], Eur. Phys. J. C **10**, 363 (1999), HZH9810020;
G. Abbiendi *et al.* [OPAL Collaboration], Eur. Phys. J. C **10**, 547 (1999), HZC98113;
J. Breitweg *et al.* [ZEUS Collaboration], Eur. Phys. J. C **11**, 35 (1999), HZ99057;
C. Adloff *et al.* [H1 Collaboration], Phys. Lett. B **483**, 36 (2000), HZ00035;
C. Adloff *et al.* [H1 Collaboration], Eur. Phys. J. C **18**, 293 (2000) HZH0006017;
S. Chekanov *et al.* [ZEUS Collaboration], Eur. Phys. J. C **23**, 615 (2002), HZ01220;
C. Adloff *et al.* [H1 Collaboration], Eur. Phys. J. C **25**, 13 (2002), HZ01225;
T. Affolder *et al.* [CDF Collaboration], Phys. Rev. D **65**, 092002 (2002), HZF01211E;
C. Adloff *et al.* [H1 Collaboration], Eur. Phys. J. C **29**, 497 (2003), HZH0302034;
S. Chekanov *et al.* [ZEUS Collaboration], Eur. Phys. J. C **35**, 487 (2004), HZH0404033.

[22] C. Buttar *et al.*, *Underlying events*, these proceedings, working group 2.

[23] C. Adloff *et al.* [H1 Collaboration], Z. Phys. C **72**, 593 (1996), HZ96138;
J. Breitweg *et al.* [ZEUS Collaboration], Eur. Phys. J. C **6**, 67 (1999), HZ98085, HZ98085p;
C. Adloff *et al.* [H1 Collaboration], Nucl. Phys. B **545**, 21 (1999), HZ98204;
C. Adloff *et al.* [H1 Collaboration], Phys. Lett. B **467**, 156 (1999)
[Erratum-ibid. B **518**, 331 (2001)], HZ99126;
J. Breitweg *et al.* [ZEUS Collaboration], Eur. Phys. J. C **18**, 625 (2001), HZ00166;
C. Adloff *et al.* [H1 Collaboration], Phys. Lett. B **528**, 199 (2002), HZ01100;
C. Adloff *et al.* [H1 Collaboration], Phys. Lett. B **520**, 191 (2001), HZH0108047;
S. Chekanov *et al.* [ZEUS Collaboration], Phys. Lett. B **565**, 87 (2003), HZ03015;
S. Chekanov *et al.* [ZEUS Collaboration], Nucl. Phys. B **672**, 3 (2003), HZ03094;
S. Chekanov *et al.* [ZEUS Collaboration], hep–ex/0312057, HZH0312057;
A. Aktas *et al.* [H1 Collaboration], Eur. Phys. J. C **38**, 447 (2005), HZH0408149.

[24] S. Chekanov *et al.* [ZEUS Collaboration], Phys. Rev. D **69**, 012004 (2004);
S. Chekanov *et al.* [ZEUS Collaboration], Phys. Lett. B **599**, 173 (2004);
A. Aktas *et al.* [H1 Collaboration], Eur. Phys. J. C **40**, 349 (2005);
A. Aktas *et al.* [H1 Collaboration], Eur. Phys. J. C **41**, 453 (2005);
A. Aktas *et al.* [H1 Collaboration], Phys. Lett. B **621**, 56 (2005);
A. Aktas *et al.* [H1 Collaboration], Submitted to Eur. Phys. J. C , hep–ex/0507081;
S. Chekanov *et al.* [ZEUS Collaboration], hep–ex/0508019.

[25] B. Abbott *et al.* [D0 Collaboration], Phys. Lett. B **487**, 264 (2000), HZH9905024;
D. Acosta *et al.* [CDF Collaboration], Phys. Rev. Lett. **91**, 241804 (2003), HZH0307080;
D. Acosta *et al.* [CDF Collaboration], Phys. Rev. D **71**, 032001 (2005), HZH0412071.

[26] O. Behnke, M. Cacciari, M. Corradi, A. Dainese, H. Jung, E. Laenen, I. Schienbein and H. Spiesberger, these proceedings, working group 3.