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Guide to the Lund Monte Carlo

JETSET Version 4.1 (prel)

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Abstract:
We present a preliminary version of the planned successor to the LUTP 80-3 version of the Lund Monte Carlo. There exists no explicit backwards compatibility, but the basic structure is similar. New features include multijet fragmentation, baryon pair production, diquark jet fragmentation, a fourth generation of quarks and leptons and heavy particle decays into jets.

Contents

1. Introduction

This is a very informal report, rather in the form of a "private communication" to some interested parties. As such it presents a program that has not yet reached its final form, neither in programming nor in physics content. This means that feedback from users is welcome. In particular, if any errors should be found, I would appreciate being informed.

We will refer to the theoretical framework underlying this program as the Lund model, to the program in a general sense as the Lund Monte Carlo (although it also includes variations not in accordance with the Lund model, to allow comparisons to be made) and to the actual "deck of cards" as JETSET. The latter then exists in several versions. The presently available official one is the one presented in the Lund preprint LUTP 80-3, with some errata corrected. In this paper the planned successor is presented. Although there are very large similarities with the LUTP 80-3 version, there exists no direct backwards compatibility. We will take LUTP 80-3 as a starting point in this description. In particular, the physics discussion there is still relevant. Below, new physics introduced will be outlined very briefly. The main part of this report will be a manual on the use of the program.

2. New Physics

2.1. Large Jet Systems

A specific feature of the Lund model is that the jets in the final state of a hard collision do not fragment independently of each other. This is described thoroughly in LUTP 80-3 for two- and three-jet systems. In this program systems containing up to ten jets may be considered at a time. The colour flux lines can have two configurations, either stretched from a quark via an arbitrary number of gluons to an antiquark or in a closed loop consisting of an arbitrary number of gluons. So far, we have however not included any routines for e+e- which require more than three-jet configurations.

2.2. Baryon Pair Production

In LUTP 81-3 (B. Andersson, G. Gustafson, T. S., March 1981) an extension of the Lund model is made to baryon production in e+e- (or other) events. The mechanism is the inclusion of diquark-antidiquark production in the field in addition to the ordinary quark-antiquark one. The overall production rate has been normalized to data. Baryon pair production in jet fragmentation is automatically included unless otherwise specified.

2.3. Baryon Jets

In e.g. leptoproduction, one quark is kicked out of the target proton, leaving two quarks which give a baryon in the target fragmentation region. This then is similar to the situation in low-pt physics described by B. Andersson, G. Gustafson, I. Holgersson and O. Månsson (Nucl. Phys. B178, 242) except that we have no I quark to consider but rather a fast quark giving rise to the current jet. The program presented here only contains a simplified version of the full low-pt reaction Monte Carlo, i.e. the bits relevant for hard primary collisions such as leptoproduction, Drell-Yan and high-pt physics.

We emphasize that the jet containing the two left-over quarks, which we sometimes loosely will call a diquark jet, is not equivalent to a jet with a diquark according to the previous section at the tip. The exact structure is explained in the paper above, the main result from our point of view is that these two quarks will only end up in the same hadron 50%-60% of the time, compared to 100% if they really were treated as a diquark. A simplification occurs in that these two quarks may be treated symmetrically, since the current quark is so far away that its interaction with the two target quarks should be about the same.

If a given quark has been kicked out, the configuration of the remaining two quarks may be found from SU(6) factors. For future reference we note that the proton consists of 1/2 ud0, 1/6 ud1 and 1/3 uu1.

2.4. A Fourth Generation of Fermions

An important task at LEP will certainly be the search for heavy leptons and quarks, top and beyond, irrespectively of whether current theories at that time would like to put a stop after the third generation or not. Without taking any stand in this question, we include a fourth generation to allow the study of such scenarios. The quarks are called h (high, charge +2/3) and l (low, charge -1/3), the lepton chi. They are assumed to decay sequentially in the standard manner h -> l -> t -> b -> c -> s.

2.5. Particle Decays into Jets

Heavy particle decays (top and beyond) will give a jet structure of its own. We therefore in this program allow them to decay into a number of jets, with two jets sometimes collapsing to one particle if the invariant mass is low. Jet systems are then allowed to fragment as usual.

This part of the program has yet to reach a more definitive form.

3. The Program Components

Below we describe the set of subprograms for jet fragmentation and associated tasks which collectively is known as JETSET. In any actual run, a main program has to be supplied by the user. Here he may
1. change default parameter values if desired;
2. specify an initial jet and/or particle configuration;
3. demand that a resulting jet fragmentation and particle decay chain be simulated;
4. study the event obtained.

The routines are sufficiently general to allow the simulation of a wide variety of jet phenomena. Different tasks may be combined at will.

Applications of the program to specific physical processes are here represented by e^+e^- annihilation into two- or three-jet events and by heavy "onia" decays into three gluon jets. In LUTP 80-12 (G. Ingelman, T. S., Oct. 1980) we presented a program for leptoproduction events based on LUTP 80-3, which rather easily can be modified to run in conjunction with the present program. A program for Drell-Yan processes is in preparation (H.-U. Bengtsson).

The program is written in FORTRAN 77. The only nonstandard feature is our use of a random number generator RANF giving numbers R with uniform probability distribution in the interval $0 < R < 1$. If a random number generator is available under another name, a function RANF calling this generator should be created. For LIST we assume a standard output file with logical file number 6.

3.1. The JETS Commonblock

Via the commonblock JETS the complete history of an event may be studied. For each jet or particle a row is filled in the matrices K and P. With an entry we will mean such a row, giving information about which jet/particle it is, where it comes from and its momentum, energy and mass. The first few entries contain the original jet/particle configuration, defined by the user, followed by a list of all subsequent fragmentation and decay products. For colour singlet jet systems, the entries are arranged in the order in which the colour lines go (a gluon loop goes on from the last jet to the first one). The format of the commonblock is

COMMON /JETS/ N,K(250,2),P(250,5)

N : is the number of entries for the event, these being stored in the N first rows of the K and P matrices. N is continuously updated as definition of the original configuration and fragmentation and decays proceed.

K(I,1) : contains three pieces of information about the I:th entry. The sign is positive for a particle and negative for a jet. The absolute value gives the row number where the immediate precursor in the fragmentation/decay chain can be found. For the original configuration, this is chosen to be the jet/particle itself. (Note that in the Lund model the relevant objects for fragmentation are not the partons but the strings between the partons, meaning that the assignment of a particle to a jet is ambiguous. The actual number used corresponds to the jet on the side of the string on which the particle was generated, and may be of little practical use.) Finally, when defining a jet configuration, we add a further -1000 for a single jet, -2000 for the non-final jets of a (colour singlet) system and -3000 for the final jet of a system. (These numbers are removed when the actual fragmentation is performed.)

K(I,2) : contains either the jet or the particle code, depending on the sign of K(I,1). The jet (flavour) code is given in Appendix 1. The full list of particle codes can be obtained with LIST, a summary is given in Appendix 1. An antijet or antiparticle will have the negative code number. Obviously, for mesons the particle-antiparticle definition is arbitrary.

P(I,1), P(I,2), P(I,3) : the jet/particle momentum vector (px,py,pz) in GeV/c.

P(I,4) : the jet/particle energy in GeV.

P(I,5) : the jet/particle mass in GeV/c2 (the masses listed for partons, roughly constituent quark masses, are not critical).

3.2. The Filling Subroutines

Using the conventions described above, it is possible to specify any initial jet/particle configuration. This may be a rather lengthy task, so we provide subroutines which fill the relevant information for a few standard situations, at the same time updating the N value. In case the desired initial configuration can be described by a single such call, it is also possible to have the whole subsequent event chain generated at the same time. The possibilities available are

CALL FIENT(IP,K1,K2,E,THE,PHI,AM)
Purpose : to fill one single entry.
IP : row number for the jet/particle. If IP=0, row 1 is used, followed by a call to JETGEN.
K1, K2 : see K(I,1), K(I,2), sect. 3.1.
E : jet/particle energy.
THE, PHI : polar angles for outgoing jet/particle.
AM : jet/particle mass.

CALL FPART(IP,K2)
Purpose : to fill a particle at rest.
IP : row number for the particle. If IP=0, row 1 is used, followed by a call to JETGEN.
K2 : particle code.

CALL F1JET(IP,IFL,EJET)
Purpose : to fill a single jet (not part of a jet system).
IP : row number for the jet. If IP=0, row 1 is used, followed by a call to JETGEN.
IFL : jet code.
EJET : jet energy.
Remarks : the jet is taken to be going out in the +z direction, but particles with $pz < 0$ are also kept (see also IST(5) and PAR(1)).

CALL F2JET(IP,IFL1,IFL2,ECM)
Purpose : to fill a two-jet system.
IP : row number for first jet, second in IP+1. If IP=0, rows 1 and 2 are used, followed by a call to JETGEN.
IFL1, IFL2 : jet codes for the two jets.
ECM : the energy of the system.
Remark : the system is given in the CM frame, with the first jet going out in the +z direction.

CALL F3JET(IP,IFL1,IFL3,ECM,X1,X3)
Purpose : to fill a three-jet system.
IP : row number for first jet, second in IP+1, third in IP+2. If IP=0, rows 1, 2 and 3 are used, followed by a call to JETGEN.
IFL1, IFL3 : jet codes for the first and the third jet (the middle one must be a gluon).
ECM : the energy of the system.
X1, X3 : twice the energy fractions taken by the first and the third jet.
Remark : the system is given in the CM frame, in the xz-plane, with the first jet going out in the +z direction and the third one having $px > 0$.

CALL F4JET(IP,IFL1,IFL2,IFL3,IFL4,ECM,X1,X2,X3,X12,X13)
Purpose : to fill a four-jet system.

IP : row number for the first jet, second in IP+1, third in IP+2, fourth in IP+3. If IP=0, rows 1, 2, 3 and 4 are used, followed by a call to JETGEN.
IFL1, IFL2, IFL3, IFL4 : jet codes for the four jets.
ECM : the energy of the system.
X1, X2, X3 : twice the energy fractions taken by the first, second and third jet.
X12, X13 : XIJ is twice the four-vector product of the momenta for jets I and J, divided by ECM**2.
Remark : the system is given in the CM frame, with the first jet going out in the +z direction, the second is in the xz-plane with px > 0 and the third has py > 0.

We note that essentially the same functions as in LUTP 80-3 can be obtained by the substitutions

```
                CALL DECGEN(K2) -> CALL FPART(0,K2)
           CALL QJET(IFL,EJET) -> CALL F1JET(0,IFL,EJET)
              CALL GJET(EJET) -> CALL F1JET(0,0,EJET)
         CALL QQJET(IFL,ECM) -> CALL F2JET(0,IFL,-IFL,ECM)
   CALL QQGJET(IFL,ECM,X1,X3) -> CALL F3JET(0,IFL,-IFL,ECM,X1,X3)
       CALL GGGJET(ECM,X1,X3) -> CALL F3JET(0,0,0,ECM,X1,X3)
```

3.3. The Service Subroutines

Here we collect a few routines which sometimes are useful, for rotating and boosting an event, for throwing away unwanted particles, for listing an event or the particle data used. The routines are

CALL ROTBST(THETA,PHI,BETAX,BETAY,BETAZ)
Purpose : to perform rotations and Lorentz boosts (in that order, if both in the same call).
THETA, PHI : standard polar angles, corresponding to the final direction of a jet/particle initially along the +z axis.
BETAX, BETAY, BETAZ : gives the direction and size of a Lorentz boost beta, such that a jet/particle initially at rest will have p/E=beta afterwards.
Remark : all entries 1 through N are affected by the transformations, unless lower and upper bounds are explicitly given by IST(1) and IST(2). May be used in combination with the filling routines for defining the initial configuration or be applied after the event has been generated.

CALL EDIT(IEDIT)
Purpose : to exclude unstable or undetectable particles from the table stored in JETS.
IEDIT : tells which entries to be thrown away. If 1, jets and unstable particles are thrown away. If 2, also neutrinos (and heavy particles with particle code > 100, which have been declared stable using IDB) are thrown away. If 3, all remaining neutral particles (gamma, KOL, n, etc.) are thrown away, leaving only charged, stable particles.
Remark : the particles kept are compressed in the beginning of JETS, and the value of N is updated accordingly. In an EDIT call, the event history is lost, all particles will have K(I,1)=999 afterwards.

CALL LIST(ILIST)

Purpose : to list an event or list particle data.
ILIST : if 0, a list of all jets/particles in the present event will be given, including their origin (if no EDIT call has been made), momentum, energy and mass. If 1, a list of all particle data used in the program will be printed out: codes, names, masses, decay data.
Remarks : the output will be written on logical file number 6. Jet/particle names are 8 characters long. For particles, positions 1-4 contain a particle name (for charm and beyond, these names often are only the quark content of the particle, with spin information 0, 1, 1, 0 and * corresponding to ISP=0-4, see IDB), positions 5-7 contain a 'B' for an antiparticle, and the charge (particles which are their own antiparticles do not get any charge sign, where ambiguities may exist a 0 is included in the particle name) and position 8 is 'S' for stable particles (i.e. stable according to IDB). For jets, positions 1-3 give quark content, followed by an 'A' for antiquarks and antidiquarks, position 4 gives the spin for diquarks and positions 5-8 are 'JET '. 'Q+QA' corresponds to 599 and 'REMN' to 600 for KDP codes.

3.4. The Physics Routines

The physics subroutines and functions form a closely interrelated group. The only direct contact the user should have with these is

CALL JETGEN
Purpose : to generate a complete event from a given initial jet/particle configuration (stored in JETS).
Remark : this call can only be made once for each event (including calls made in the filling routines when IP=0).

The JETGEN routine only administrates the fragmentation and decay chain. The actual work is done in the following routines

ONEJET : generates the fragmentation of one single jet (quark, gluon, diquark), i.e. a jet not considered part of a system. This is of course never the case, but it is sometimes used as an approximation, or used to represent independent jet fragmentation in jet systems (to contrast with the Lund model).
SYSJET : generates the fragmentation of a colour singlet jet system consisting of up to ten jets, according to the Lund model. This subroutine is very powerful, the only limitation is that two adjacent jets (I and J) along the colour chain must have a certain minimum invariant mass M(I,J), roughly
M(I,J) > M(I) + M(J) + 2 GeV
where M(I) and M(J) are parton masses (important for charm and beyond) and only half the momentum should be counted for gluon jets (since the momentum of a gluon is shared between two systems).
DECAY : performs a particle decay, essentially in one of three ways, according to particle tables for ordinary hadrons, according to a phase space model for charm and bottom hadrons and into new jet systems for heavier hadrons.
IFLDIS : generates a quark or diquark flavour in jet fragmentation or phase space decay, with appropriate SU(6) weighting for diquarks.
K2DIST : generates a particle from a quark-antiquark or quark-diquark pair.

PTDIST : generates pt for a quark-antiquark or diquark-antidiquark pair formed in the field.

ZDIST : generates z, the longitudinal scaling variable describing the fraction of E+pz (for a jet along the +z axis) that a particle takes.

IFLAV : gives the quark content and spin for a particle with code > 100.

CNAME : returns the name (a character string) for particles or jets.

AMAS : gives the mass for particles or jets.

ALPHAS : gives the strong coupling constant in QCD.

ANGLE : calculates the angle from x and y coordinates.

3.5. Routines for e+e- Physics

In this program we include two routines for direct application to e+e- annihilation physics. They are

CALL EVTGEN(IFL,ECM)

Purpose : to generate a quark-antiquark or quark-gluon-antiquark jet system according to the matrix element given by QCD for e+e- annihilation.

IFL : the flavour of the initial quark in the event. If 0, a QED mixture of u, d, s, c and b quarks is assumed (see also IST(12) and IST(13)).

ECM : the energy of the system.

Remarks : putting IST(9)=0 only two-jet events will be generated, putting IST(10)=0 the event will have the standard orientations for F2JET and F3JET, respectively. Polarized incoming beams can also be simulated. No radiative corrections, weak effects or higher order QCD effects have been included.

CALL GGGGEN(ICH,ECM)

Purpose : to generate a three-gluon or gluon-gluon-photon system according to the matrix elements given by QCD for 1-- "onium" resonance decays.

ICH : the charge of the quark giving the resonance, 1 for -1/3 quarks and 2 for +2/3 quarks (this determines the probability for gluon-gluon-photon events, by choosing ICH=0 it is possible to generate three-gluon events only).

ECM : the energy of the system.

Remarks : this routine is not intended for upsilon physics, since the jet energies there are so low that with the cuts implied for SYSJET all events collapse to two-gluon systems. Putting IST(10)=0 the event will have the standard orientation for F3JET.

3.6. The DATA Commonblocks

The three commonblocks DATA1, DATA2 and DATA3 contain a wealth of parameter and particle data. All are given sensible default values in BLOCK DATA, below indicated by (D=...). These values may be changed by the user to modify the behaviour of the program. In some cases several parameters are interrelated, making their use somewhat more tricky. The information stored in the different commonblocks is

COMMON /DATA1/ IST(20),PAR(20),FPAR(20),QMAS(20),PMAS(100)

Purpose : DATA1 contains most parameters and also mass data.

IST(1), IST(2) : (D=0,0, i.e. inactive) can be used to override the ordinary lower and upper limits (1 and N) for the action of ROTBST calls, the lower limit for EDIT calls and the lower and upper limit for LIST particle data calls. Note that these parameters are also used internally, so that they must be reset to 0 before the next JETGEN call.

IST(3) : used internally for IFLDIS and ZDIST calls in connection with diquark jets.

IST(4) : (D=2) choice of longitudinal fragmentation scheme, 1 is an extended Field-Feynman parametrization (can e.g. be used in conjunction with ONEJET to obtain jets precisely according to the original Field-Feynman prescription) and 2 is the Lund model prescription.

IST(5) : (D=2) 0 means that all jet fragmentation is inhibited, 1 means that jets fragment independently of each other (jets with the right initial energy are generated along the +z axis using ONEJET, primaries with pz < 0 are not kept, afterwards the jet is rotated to the correct orientation), 2 gives the Lund model for jet systems.

IST(6) : (D=1) 0 means that particle decays are inhibited, 1 that they are allowed (see also IDB).

IST(7), IST(8) : presently unused.

IST(9) : (D=1) 0 means lowest order QCD matrix element in e+e- annihilation (EVTGEN), 1 means first order QCD, also including the possibility of one gluon being emitted.

IST(10) : (D=1) 0 means that events in e+e- annihilation (EVTGEN, GGGGEN) are left in the standard orientation for F2JET and F3JET, 1 that angular orientation is simulated according to QED+QCD.

IST(11) : presently unused.

IST(12), IST(13) : (D=1,5) minimum and maximum values used when generating event flavour in e+e- annihilation (EVTGEN), the latter also being used when calculating the strong coupling constant.

IST(14) - IST(20) : presently unused.

PAR(1) : (D=0.065) is P(qq)/P(q), the suppression of diquark-antidiquark pair production in the field compared to quark-antiquark production.

PAR(2) : (D=0.3) is P(s)/P(u), the suppression of s quark pair production in the field compared to u or d pair production.

PAR(3) : (D=0.2) is (P(us)/P(ud))/(P(s)/P(d)), the extra suppression of strange diquark production compared to the normal suppression of strange quarks.

PAR(4) : (D=0.35) is (1/3)P(ud1)/P(ud0), the suppression of spin 1 diquarks compared to spin 0 (excluding the factor 3 coming from spin counting).

PAR(5) : (D=0.5) is the probability that a meson has spin 1 (1-PAR(5) is probability for spin 0).

PAR(6) : (D=1.) is the suppression of spin 3/2 baryons compared to the SU(6) spin 3/2:1/2 ratio (in addition to what is implied by PAR(2), PAR(3) and PAR(4)).

PAR(7) : (D=0.44 GeV/c) corresponds to the width in the Gaussian px and py distributions for primary hadrons.

PAR(8) : (D=1.) corresponds to a string constant a factor PAR(8) higher for breakups closest to a heavy quark (charm and beyond), influencing the rate of s quark and baryon production and the mean pt.

PAR(9) : (D=0.0073) is the electromagnetic coupling constant 1/137.

PAR(10) : (D=0.4 GeV) is the lambda value used in the strong coupling constant.

PAR(11) : (D=1. GeV) represents an average (transverse) hadron mass used in various matrix element cuts.
PAR(12) : presently unused.
PAR(13), PAR(14) : (D=0.,0.) represents transverse and longitudinal polarizations for the incoming e+e- beams, used for angular orientation in EVTGEN and GGGGEN.
PAR(15), PAR(16) : (D=1., 0. GeV) give optional maximum quark thrust and minimum gluon energy cuts, respectively, for three-jet events in EVTGEN.
PAR(17) - PAR(20) : presently unused.
FPAR(1) : (D=0.1 GeV) gives the remaining W, below which the generation scheme in ONEJET is stopped.
FPAR(2) : (D=0.5) for a diquark jet of flavour 10*q1+q2, the probability that the q2 quark becomes the leading one.
FPAR(3) : presently unused.
FPAR(4) : (D=1. GeV) is, with quark masses added, used to define the minimum allowable energy for a quark-antiquark jet system or subsystem.
FPAR(5), FPAR(6) : (D=3.5, 2. GeV) are used to define the stopping point in quark-antiquark system fragmentation for Field-Feynman and Lund fragmentation functions, respectively.
FPAR(7), FPAR(8) : (D=0.39, 0.30) give the probability for "reverse" relative rapidity ordering of the final two hadrons for the same two cases as above.
FPAR(9) : (D=0.9) represents the maximum cuts allowed for the z range in quark-antiquark system generation.
FPAR(10) : (D=0.5) represents the softening of the z spectrum from soft gluon effects expected in the Lund model, giving the shape (1+beta)*(1-z)**beta, where beta=FPAR(10) for a u or d quark fragmenting and beta is smaller for heavier quarks.
FPAR(11) - FPAR(18) : (D=3*0.77,5*0.) gives the shape of the scaling function in the Field-Feynman scheme for the different quark flavours IFL so that, with c=FPAR(10+IFL), f(z)=1-c+3*c*(1-z)**2 if 0 < c < 1 and f(z)=(1-c)*z**(-c) if c < 0.
FPAR(19), FPAR(20) : presently unused.
QMAS(1) - QMAS(8) : (D=0.3,0.3,0.5,1.6,5.,20.,40.,80. GeV/c2) give constituent quark masses used for u, d, s, c, b, t, l and h quarks.
QMAS(9) : (D=0.275 GeV/c2) is subtracted from the values above to represent current algebra quark masses.
QMAS(10) : presently unused.
QMAS(11) - QMAS(15) : is used in calculating mas splittings due to spin for heavy hadrons.
QMAS(16) - QMAS(20) : presently unused.
PMAS(1) - PMAS(100) : particle masses for particles 1 - 100, for other heavier hadrons constituent quark masses are used to build up the mass.

COMMON /DATA2/ KFL(64),CMIX(12),CHA1(40),CHA2(100),ITYP(100)
Purpose : DATA2 contains data for flavour handling, character variables and some particle information, which the user normally will not have to bother about.
KFL(1) - KFL(64) : is used to construct particle numbers from flavour codes and spin.
CMIX(1) - CMIX(12) : gives a parametrization of diagonal flavour mixing for pseudoscalar and vector mesons.
CHA1(1) - CHA1(40) : contain various character strings used in building up jet/particle names.

CHA2(1) - CHA2(100) : contain particle names (without charge etc.).
ITYP(1) - ITYP(100) : give particle type, 0 for neutral particle its own antiparticle, 1 for negative particle, 2 for neutral particle not its own antiparticle, 3 for positive particle, 4 for doubly positive particle.

COMMON /DATA3/ DPAR(20),IDB(120),CBR(300),KDP(1200)
Purpose : DATA3 contains all particle decay data and parameters.
DPAR(1) - DPAR(10) : give corrective factors to the weight calculations for multiparticle decay (1-8 for 3-10-particle decay, 9 for omega and phi decay to three pions, 10 for semileptonic decays).
DPAR(11) - DPAR(13) : give the primary multiplicity distribution in particle decays according to
<n> = const. + DPAR(11) * ln((M-m(quarks)) / DPAR(12))
(+ DPAR(13) for multigluon decays).
DPAR(14) : minimum kinetic energy in phase space decays.
DPAR(15) : related to minimum invariant mass below which two jets are assumed to collapse into a particle.
DPAR(16) - DPAR(20) : presently unused.
IDB(1) - IDB(120) : give the entry points into the particle decay data table, components up to 100 for individual particles, values 76+5*IFL+ISP above 100 lumped into groups where IFL is the flavour of the heaviest quark (>4) and ISP relates to spin (0=pseudoscalar meson, 1=vector meson, 2=spin 1/2 baryon with lightest two or equal two quarks in spin triplet (sigma0-like), 3=ditto in spin singlet (lambda-like), 4=spin 3/2 baryons). For stable particles IDB=0, giving a possibility to selectively inhibit particle decays (e.g. for K0-short or lambda).
CBR(1) - CBR(300) : give cumulative branching ratios for the different decay channels IDC.
KDP(1) - KDP(1200) : contain the decay products in the different channels, with four numbers 4*IDC-3 to 4*IDC for each channel, 0 corresponds to no jet/particle, numbers with absolute value below 400 to particle codes, with absolute value between 500 and 588 to jet codes (with +500 added for flavours and -500 for antiflavours), 599 to a colour triplet-antitriplet pair (generated according to the probabilities given by PAR(1)-PAR(4),PAR(6)) and 600 to the remaining quarks of a hadron (code > 100) after the heaviest quark has been removed. In KDP(4*IDC-3) a term 1000*IMAT is added (or subtracted, for negative KDP) where IMAT give extra matrix element treatment if nonzero, 1=omega and phi decays into three pions, 2=generate particles according to phase space from initial quark configuration, 3=semileptonic decay for charm or bottom, 4= heavier quark decay into jets.

Appendix 1 : Jet and Particle Codes

Jet (flavour) codes

0	g					33	ss1
1	u	5	b	11	uu1	13	us0
2	d	6	t	22	dd1	31	us1
3	s	7	l	12	ud0	23	ds0
4	c	8	h	21	ud1	32	ds1

All diquarks have not been included. For a diquark q1q2 where q1>q2, 10*q1+q2 is the code for the spin 1 diquark and 10*q2+q1 the code for the spin 0 diquark, if q1=q2 we always have a spin 1 diquark 10*q1+q2. Antiquarks and antidiquarks are given with a negative sign.

Particle codes

1	F	gamma	26	M	eta-c	51	B	csu1	76	B	css*
2	F	Z0	27	M	rho+	52	B	csd1	77	B	ccu*
3	F	W+	28	M	K*+	53	B	css1	78	B	ccd*
4	F	higgs0	29	M	K*0	54	B	ccu1	79	B	ccs*
5			30	M	D*0	55	B	ccd1	80	B	ccc*
6			31	M	D*+	56	B	ccs1	81		
7	L	e-	32	M	F*+	57	B	lambda	82		
8	L	nu-e	33	M	rho0	58	B	lambda-c++	83	M	eta-b
9	L	mu-	34	M	omega	59	B	csu0	84	M	eta-t
10	L	nu-mu	35	M	phi	60	B	csd0	85	M	eta-l
11	L	tau-	36	M	J/psi	61	B	delta++	86	M	eta-h
12	L	nu-tau	37	M	K0-short	62	B	delta+	87	M	upsilon
13	L	chi-	38	M	K0-long	63	B	delta0	88	M	phi-t
14	L	nu-chi	39			64	B	delta-	89	M	phi-l
15			40			65	B	sigma*+	90	M	phi-h
16			41	B	p	66	B	sigma*0	91		
17	M	pi+	42	B	n	67	B	sigma*-	92		
18	M	K+	43	B	sigma+	68	B	xi*0	93		
19	M	K0	44	B	sigma0	69	B	xi*-	94		
20	M	D0	45	B	sigma-	70	B	omega-	95		
21	M	D+	46	B	xi0	71	B	sigma-c*++	96		
22	M	F+	47	B	xi-	72	B	sigma-c*+	97		
23	M	pi0	48	B	sigma-c++	73	B	sigma-c*0	98		
24	M	eta	49	B	sigma-c+	74	B	csu*	99		
25	M	eta-prime	50	B	sigma-c0	75	B	csd*	100		special use

101 - 122 M heavy pseudoscalar mesons
123 - 144 M heavy vector mesons
145 - 240 B heavy spin 1/2 baryons
(spin triplet diquark like sigma0)
241 - 292 B heavy spin 1/2 baryons
(spin singlet diquark like lambda)
293 - 392 B heavy spin 3/2 baryons

F=field quanta, L=leptons, M=mesons, B=baryons.
Antiparticles are given with a negative sign.

Appendix 2 : Summary of Program Elements

```
CALL FIENT(IP,K1,K2,E,THE,PHI,AM)
CALL FPART(IP,K2)
CALL F1JET(IP,IFL,EJET)
CALL F2JET(IP,IFL1,IFL2,ECM)
CALL F3JET(IP,IFL1,IFL3,ECM,X1,X3)
CALL F4JET(IP,IFL1,IFL2,IFL3,IFL4,ECM,X1,X2,X3,X12,X13)

CALL ROTBST(THETA,PHI,BETAX,BETAY,BETAZ)
CALL EDIT(IEDIT)
CALL LIST(ILIST)

CALL JETGEN

CALL EVTGEN(IFL,ECM)
CALL GGGGEN(ICH,ECM)
```

COMMON /JETS/ N,K(250,2),P(250,5)
N : number of entries
K(I,1) : jet or particle + origin + (for jets) position in system
K(I,2) : jet or particle code
P(I,1), P(I,2), P(I,3) : momentum vector
P(I,4), P(I,5) : energy, mass

COMMON /DATA1/ IST(20),PAR(20),FPAR(20),QMAS(20),PMAS(100)
IST(1), IST(2) : optional lower and upper limits in ROTBST calls
IST(4) : fragmentation scheme, extended Field-Feynman or Lund
IST(5) : jet systems, independent jets or Lund
IST(9) : lowest or first order QCD matrix elements in e+e-
IST(10) : orientation of e+e- events
IST(12), IST(13) : minimum and maximum flavour in e+e-
PAR(1) : suppression of diquarks
PAR(2) : suppression of s quarks
PAR(3) : extra suppression of strange diquarks
PAR(4) : suppression of spin 1 diquarks
PAR(5) : fraction of spin 1 primary mesons
PAR(6) : suppression of spin 3/2 primary baryons
PAR(7) : width of Gaussian px and py distributions
PAR(10) : lambda in strong coupling constant
FPAR(1) : W stopping point in single jet generation
FPAR(10) : soft gluon effects on Lund fragmentation scheme
FPAR(11) - FPAR(18) : extended Field-Feynman fragmentation functions

COMMON /DATA2/ KFL(64),CMIX(12),CHA1(40),CHA2(100),ITYP(100)

COMMON /DATA3/ DPAR(20),IDB(120),CBR(300),KDP(1200)
IDB(1) - IDB(120) : if 0 particle is stable