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Interface to JETSET7.3

Keisuke Fujii

JLC Physics Group
KEK, Tsukuba 305, Japan

Abstract

A simple interface to JETSET7.3 is now available. It can be used to hadronize partons in Spring:Parton_List and store the resultant particles in Generator:Particle_List. This version allows parton-showering of color-non-singlet systems such as a b-W^+ pair as occuring in a top decay. Primary taus decay with their spin polarization information preserved using TAUOLA, when their helicities are specified in Spring:Parton_List. In this short note, we summarize the philosophy and usage of the hadronizer.

Chapter 1

Introduction

LUND6.3 has been the default hadronizer of the JLC physics group. This is partly because the current standard interface between the event generators which generate partons and the hadronization package is a software module called LUHADR based on LUND6.3. The LUHADR program is a module defined in the FULL analysis system and thus can be easily used together with the detector simulator to generate Monte Carlo events. In order to preserve this nice feature, while upgrading to JETSET7.3, the best way is to rewrite LUHADR to accomodate with JETSET7.3. Because of the incompatibility between JETSET6.3 and JETSET7.3, this revision requires a substantial change in the program. In addition, there had been no immediate necessity for JETSET7.3 until recently. These are the two main reasons that delayed the modification.

The situation has changed recently in the course of SUSY studies requiring correct polarization treatments of tau decays. There is a general tau decay program in the market. This program called TAUOLA, however, includes some unstable particles which are supported only in JETSET7.3 or later. Moreover, the implementation of TAUOLA implies a substantial change in the hadronization module anyway. We thus decided to upgrade the LUHADR module in order to implement TAUOLA and JETSET7.3.

Another important point in this upgrade is the treatment of parton-showering of color-non-singlet system, which is important in decays of heavy colored objects. In a top quark decay, for instance, the parton-showering takes place in the b-W^+ system: the way gluons are emitted is controlled by the acceleration that the b-quark receives when the top decays and the 4-momentum adjustment should be carried out between the b-quark and the W boson. The 4-momentum of the W boson thus changes after the gluon emissions and the W's daughters momenta also change accordingly. This effect is consistently taken into account in the upgrade.

Chapter 2

Stand-Alone TAUOLA

In order to implement TAUOLA in the JLC simulator environment, TAUOLA, in which pair production is implicit, has to be encapsulated to work with a single tau decay. The so prepared stand-alone TAUOLA package is in

```
/home/fujiik/work/korale_exp/tauola/fujiik_lib/
```

and can be used as follows.

2.1 Usage

Before entering in the event loop,

```
CALL TAUINT(INUT,IOUT,JAK1,JAK2,ITDKRC,KEYA1,XK0DEC)
```

to initialize TAUOLA, where

```
INUT   = input unit (dummy)
IOUT   = output unit for job summary
JAK1   = tau+ decay mode ID (0 for all modes)
JAK2   = tau- decay mode ID (0 for all modes)
ITDKRC = (0,1) = (decay RC off, on)
KEYA1  = switch for a1 decay treatment (1 for constant widths)
XK0DEC = soft/hard photon phase space separator (0.001 usually)
```

are input parameters to be provided by the user.

Then, in the event loop,

```
CALL TAUDEC(KTO,NPNT,POL,P4TAU)
```

for each tau to decay, where

```
KTO        = (1,2) = (tau+,tau-)
NPNT       = location in /HEPEVT/ to store this tau
POL        = helicity (+/-1.)
P4TAU(1-4) = (Px,Py,Pz,E) of the tau
```

are all inputs, while outputs (decay daughters) are stored in the common /HEPEVT/. Notice that π^0's or η's do not decay in TAUOLA. If you want to use JETSET to decay them, you may

```
CALL LUHEPC(2)
```

to store the contents of /HEPEVT/ in /LUJETS/ so that LUEXEC can take care of the rest.

After the event loop, you are recommended to

```
CALL TAUTRM
```

to print out a TAUOLA summary of tau decays.

2.2 Example

An example of the TAUOLA outputs is shown in Fig.2.1 which compares the distributions of momentum fraction of daughter particles for left-handed and right-handed τ^-'s.

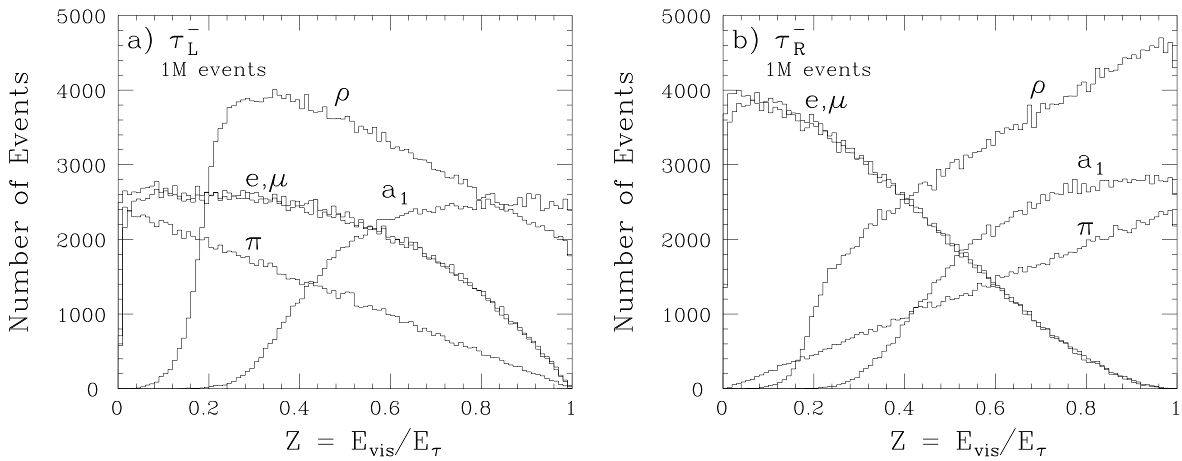

Figure 2.1: Momentum fraction distributions of daughter particles from τ^- decays: (a) for left-handed and (b) for right-handed τ^-'s.

2.3 Important Notice

Tau decay branching ratios are initialized in INITDK which is called in TAUINT. The default INITDK in the standard TAUOLA distribution assumes equal branching to all the implemented decay modes. The branching ratios has thus to be adjusted by users according to PDG data or to the results from high statistics TAUOLA runs: the TAUOLA run summary contains the estimated branching ratio to each of the implemented decay modes. The INITDK routine in the current stand-alone version has a reasonably accurate branching ratios for major decay modes but as for rare decay modes the accuracies are questionable. If such rare decay modes are important to your application, you have to rewrite the INITDK routine accordingly.

The currently used branching ratios are summarized the table below where you can identify the decay mode corresponding to each JAK values.

JAK	Decay Mode	BR/BR(1)
1	TAU- --> ELECTRON	1.0000
2	TAU- --> MUON	0.9696
3	TAU- --> PION	0.6058
4	TAU- --> RHO (->2PI)	1.3274
5	TAU- --> A1 (->3PI)	0.7194
6	TAU- --> KAON	0.0398
7	TAU- --> K*	0.0702
8	TAU- --> 2PI-, PI0, PI+	0.0840
9	TAU- --> 3PI0, PI-	0.0172
10	TAU- --> 2PI-, PI+, 2PI0	0.0634
11	TAU- --> 3PI-, 2PI+,	0.0289
12	TAU- --> 3PI-, 2PI+, PI0	0.0042
13	TAU- --> 2PI-, PI+, 3PI0	0.0042
14	TAU- --> K-, PI-, K+	0.0061
15	TAU- --> K0, PI-, K0B	0.0056
16	TAU- --> K-, K0, PI0	0.0005
17	TAU- --> PI0, PI0, K-	0.0061
18	TAU- --> K-, PI-, PI+	0.0315
19	TAU- --> PI-, K0B, PI0	0.0319
20	TAU- --> ETA, PI-, PI0	0.0109
21	TAU- --> PI-, PI0, GAM	0.0032
22	TAU- --> K-, K0	0.0181

Chapter 3

The LUHADR Hadronization Module

The new LUHADR module is in

```
/home/fujiik/work/lu_genlib/
```

which should be used together with the stand-alone TAUOLA package.

3.1 How to Use LUHADR

The LUHADR module has been completely rewritten except for its basic structure that LUHADR passes each color singlet system in the final state to LUFRAG to hadronize is preserved. As for the user interface, however, the new LUHADR module differs from the previous one only in the FT05 input stream. Nevertheless, we will show how to use LUHADR below from the beginning.

In FLANLI, invoke the description program for the LUHADR hadronizer

```
CALL DSLHAD
```

after the event read or the SPRING section.

The FT05 input stream for the LUHADR module is for instance

```
@!
@!**************************************************
@! Input section for Lund hadronizer.
@!**************************************************
@!
LUND_FRAG
   MDCY 23 1 0  ! MDCY(23,1) switches off Z decay
   MDCY 24 1 0  ! MDCY(24,1) switches off W decay
   MDCY 33 1 0  ! MDCY(33,1) switches off Z" (used for LSP) decay
   JAK1      0  ! JAK1 (0 for all tau+ decay modes)
```

```
   JAK2       0  ! JAK2 (0 for all tau- decay modes)
   ITDKRC     1  ! ITDKRC (1 for decay RC on)
   KEYA1      1  ! switch for a1 decay treatment (1 for constant widths)
   IHLON      1  ! tau polarization: IHLON = (0,1) = (off,on)
   XK0DEC 0.001  ! soft/hard photon phase space separator
EXIT
```

where the MDCY setting should not be modified unless you know exactly what you are doing. When Spring:Parton_List contains W's or Z's together with their daughters, never modify it. The particle code 33 for Z" is internally used for the LSP whose particle code is 220000 in the JLC convention: set particle ID code to 220000 in Spring:Parton_List, when you store the LSP.

The remaining inputs are related to TAUOLA as explained in the previous chapter and can be modified: the decay mode selection capability and the polarization switch will be particularly useful.

These are all to use the new LUHADR program, if you need no new features such as polarized tau decays or parton-showering of color-non-singlet system. Those who want these new feature have to prepare Spring:Parton_List accordingly.

3.2 How to Prepare Spring:Parton_List

Three entries in Spring:Parton_List, RBUF(17), (18), and (19), have different meanings from the previous ones.

Helicities of the primary partons should be stored in

```
RBUF(17) = IHEL
```

when necessary as with tau leptons: IHEL=-1 for left-handed and +1 for right-handed $\tau^{\pm}$'s. Notice that, when this entry is zero, taus decay as they are unpolarized.

Color singlet groups are distinguished by

```
RBUF(18) = ICF
```

where ICF must have different values for different color singlet groups. This entry is meaningful only when RBUF(19) is nonzero. Notice also that the ICF's are not necessarily contiguous.

The parton showering is handled level by level, since showers from parent parton pairs might modify the momenta of their daughter partons. The level is defined by

```
RBUF(19) = ISLEV*100 + ISPAIR
```

where partons with the same ISLEV are passed to LUFRAG at one time (that means they comprise a set of color singlet states and that there is no parent-daughter relation among the set) and partons with the same ISPAIR are paired in LUSHOW calls in LUFRAG. The ISPAIR's of the same ISLEV must be contiguous and must start from 1. On the other hand, the ISLEV itself is not necessarily contiguous, though it must be less than or equal to 10. Lepton pairs are required to have ISLEV = 0 and NDAU = 0 for proper polarization handling when the pair contains a tau. If you are satisfied with the default tau decay treatment, you do not have to distinguish leptons from quarks in the decay daughters from W or Z, etc.

Fig.3.1 shows an example of the color-singlet ID and showering-level setting (RBUF(18) and RBUF(19)) for $e^+e^- \to t\bar{t}$.

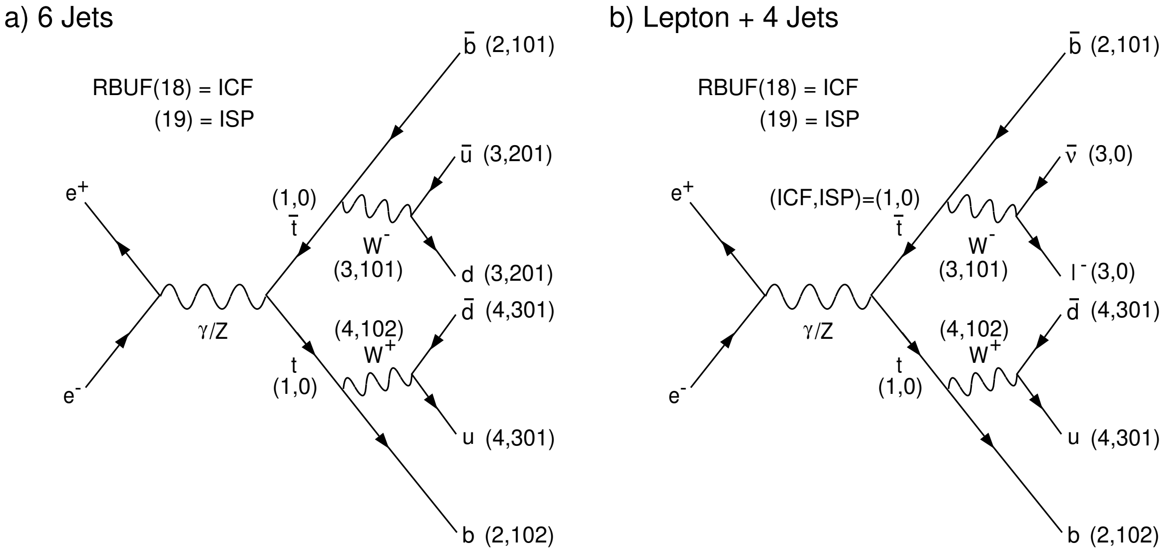

Figure 3.1: An example of the color-singlet ID and showering level setting in the case of $e^+e^- \to t\bar{t}$: (a) for 6jet and (b) for lepton+4jet modes.

Notice that the $W^\pm$ bosons have nonzero showering level flags so as to be paired with the b or $\bar{b}$ in the parton-showering. When W momenta change after the parton-showering, the momenta of their daughter partons get modified, regardless of whether they are leptons or quarks. The daughter partons with the modified momenta are then passed to LUFRAG to process the parton-showering or fragmentation in the next level.