

# String hadronization

We explain the content of `expl1.optns` found in `examples/`.

## Simulation configuration

First we consider a kinky string, defined by the ids and momenta of the endpartons and the internal gluons. We take a  $u - g - \bar{u}$  string, which can be defined in the input file, for example like:

```
! Decay of a kinky string
!-----
!-----
! Define run
!-----
application kinky ! decay of kinky string
kinks
1 0 0 50 ! id,px,py,pz of upper string
9 7 0 0 ! id,px,py,pz of intermediate gluon (kink)
-1 0 0 -50 ! id,px,py,pz of lower string
endkinks
nodecays 110 end ! do not decay pi0
set nevent 3000 ! number of events
set modsho 100 ! output message after modsho events
!-----
! Printout particle list
!-----
print * 2 ! to get list in z-expl1.check in ${CHK} directory
```

We first define an application of type kinky (**application kinky**), which corresponds to a simulation of kinky string decays. We then describe the string with an upper string end, a kink and the lower string end. The four numbers in each line following the key word **kinks** represent the parton id and the 3 momentum components  $p_x, p_y, p_z$  for each parton.

The parton ids are 1-6 for the quarks (1=u, 2=d, 3=s, 4=c, 5=b, 6=t), the corresponding negative numbers for the anti-quarks, and 9 for gluons. So in the example, we consider a  $u - g - \bar{u}$  string, where the  $u$  carries a longitudinal momentum of 50 GeV, the  $\bar{u}$  a longitudinal momentum of -50 GeV, and the gluon a transverse momentum of 7 GeV (and no longitudinal momentum).

We choose to block the decay of the particle  $\pi^0$  whose EPOS identifier is 110 (**nodecays 110 end**): the EPOS particle identifiers are described in the file `src/KWt/idt.dt`.

The number of simulated events is set to 3000 (**set nevent 3000**). A message will be displayed in the standart output every 100 events (**set modsho 100**).

The print command (**print \* 2**) writes the particule list in a file. The output filename is created from the optns file name: `${CHK}z-expl1.check`

## Results

One can check, on the standard output, the display of a message, every 100 events, with the total number of simulated events and the seeds values for `seedj` and `seedf`.

```
nrevent: 100 seedj: 111111111 seedf: 0.84023000D+05
...
nrevent: 3000 seedj: 111111111 seedf: 0.24942720D+07
```

In `${CHK}z-expl1.check`, one finds several lists of partices (including their parent-children relations), at different stages of the simulation. The structure of the file is as follows

```
##### start event number 1 #####
.....
##### list before fragmentation #####
...
##### list after fragmentation #####
...
##### final decay #####
...
##### list after bjinta #####
...
##### start event number 2 #####
.....
```

where “...” refers to the particle list at that stage. A particle list contains the particles with one line per particle, with several columns, representing particle properties and parent children relations, a detailed discussion can be found in “Check File Structure”.

For simplicity we only show the first 9 columns, corresponding to: ior, jor, i, ifr1, ifr2, id, ist, ity, and pt (see Check File Structure).

The first table (before fragmentation) shows the initial particles, the three lines ( $i = 1, 2, 3$ ) refer to the 3 input partons, having  $id=1$  (u quark),  $id=9$  (gluon), and  $id=-1$  (anti u quark).

```
#####
##### list before fragmentation #####
#####
ior jor i ifr1 ifr2 id ist ity pt
-----
0 0 1 0 0 1 20 0 0.000E+00
0 0 2 0 0 9 20 0 0.700E+01
0 0 3 0 0 -1 20 0 0.000E+00
```

Next we look at the list after fragmentation. In our example, the chain of 3 partons  $u - g - \bar{u}$  represents a kinky string, which decays into hadrons. In the list, one first maps the chain of partons to a string, with  $i=4$ , and with status  $ist=29$  (=string). The string entry is only for bookkeeping, the properties of the string are known via the parent indices ior and jor, which allow to trace back to the partons which constitute the string. We consider this string as “child” of the three partons, the partons being the “parents” of the string.

```
#####
##### list after fragmentation #####
#####
ior jor i ifr1 ifr2 id ist ity pt
-----
1 3 4 5 26 810001000 29 0 0.700E+01
4 0 5 0 0 120 0 0 0.571E+00
4 0 6 0 0 110 0 0 0.599E+00
4 0 7 0 0 110 0 0 0.183E+00
4 0 8 0 0 -120 0 0 0.110E+00
4 0 9 0 0 130 0 0 0.141E+00
4 0 10 0 0 -230 0 0 0.292E+00
4 0 11 0 0 1220 0 0 0.489E+00
4 0 12 0 0 -1120 0 0 0.104E+01
4 0 13 0 0 121 0 0 0.464E+00
4 0 14 0 0 -121 0 0 0.418E+00
4 0 15 0 0 121 0 0 0.191E+01
4 0 16 0 0 -120 0 0 0.145E+01
4 0 17 0 0 120 0 0 0.547E+00
4 0 18 0 0 221 0 0 0.529E+00
4 0 19 0 0 110 0 0 0.456E+00
4 0 20 0 0 110 0 0 0.308E+00
4 0 21 0 0 3123 0 0 0.131E+00
4 0 22 0 0 -1132 0 0 0.971E-01
4 0 23 0 0 120 0 0 0.419E+00
4 0 24 0 0 110 0 0 0.247E+00
4 0 25 0 0 221 0 0 0.679E+00
4 0 26 0 0 -120 0 0 0.605E+00
```

Directly following the string `stry i=4`, we see the string decay products, with `i` from 5 to 26. All these particles have mother index 4 (the string) and status 0, because they are (at this moment) last generation. The resonances did not decay yet. Looking at `ifr1, ifr2`, we see that the string  $i = 4$  has children with indices ( $i$ ) from 5 to 26.

In the list, we see several resonances, which will finally decay:

```
i=10, id=-230, name=K0
i=13, id=121, name=rho+
i=14, id=-121, name=rho-
i=15, id=121, name=rho+
i=18, id=221, name=omega
i=21, id=3123, name=Sigma(1775)0
i=22, id=-1132, name=Sigma(1660)-
i=25, id=221, name=omega
```

The decay products will be seen in the following list, where the father index `ior` (the leftmost number) allows to identify the decaying particle.

```
#####
##### final decay #####
#####
10  0  27  0  0    20    0  0  0.292E+00
13  0  28  0  0   120    0  0  0.105E+00
13  0  29  0  0   110    0  0  0.397E+00
14  0  30  0  0  -120    0  0  0.199E+00
14  0  31  0  0   110    0  0  0.326E+00
15  0  32  0  0   120    0  0  0.863E+00
15  0  33  0  0   110    0  0  0.107E+01
18  0  34  0  0  -120    0  0  0.287E+00
18  0  35  0  0   110    0  0  0.329E+00
18  0  36  0  0   120    0  0  0.118E+00
21  0  37  0  0  -130    0  0  0.401E+00
21  0  38  0  0  1120    0  0  0.426E+00
22  0  39  0  0 -1130    0  0  0.270E+00
22  0  40  0  0   110    0  0  0.360E+00
25  0  41  0  0  -120    0  0  0.588E+00
25  0  42  0  0   110    0  0  0.195E+00
25  0  43  0  0   120    0  0  0.956E-01
27  0  44  0  0   120    0  0  0.185E+00
27  0  45  0  0  -120    0  0  0.314E+00
39  0  46  0  0  1120    0  0  0.177E+00
39  0  47  0  0   110    0  0  0.216E+00
```

We also see decays of decay products: particles 44 and 45 are decay products of 27, particles 46 and 47 are decay products of 39. In principle we are done, particle production is finished, but it is nevertheless useful to consider one more list, namely the full list at the end with the complete parent-children relations for all particles. This is provided in the following list.

```
#####
##### list after bjinta #####
#####
ior jor i ifr1 ifr2 id ist ity pt
-----
0  0  1  4  0    1   21  0  0.000E+00
0  0  2  4  0    9   21  0  0.700E+01
0  0  3  4  0   -1   21  0  0.000E+00
1  3  4  5  26 810001000 29  0  0.700E+01
4  0  5  0  0   120  0  0  0.571E+00
4  0  6  0  0   110  0  0  0.599E+00
4  0  7  0  0   110  0  0  0.183E+00
4  0  8  0  0  -120  0  0  0.110E+00
4  0  9  0  0   130  0  0  0.141E+00
4  0 10  27  27 -230  1  0  0.292E+00
4  0 11  0  0  1220  0  0  0.489E+00
```

4	0	12	0	0	-1120	0	0	0.104E+01
4	0	13	28	29	121	1	0	0.464E+00
4	0	14	30	31	-121	1	0	0.418E+00
4	0	15	32	33	121	1	0	0.191E+01
4	0	16	0	0	-120	0	0	0.145E+01
4	0	17	0	0	120	0	0	0.547E+00
4	0	18	34	36	221	1	0	0.529E+00
4	0	19	0	0	110	0	0	0.456E+00
4	0	20	0	0	110	0	0	0.308E+00
4	0	21	37	38	3123	1	0	0.131E+00
4	0	22	39	40	-1132	1	0	0.971E-01
4	0	23	0	0	120	0	0	0.419E+00
4	0	24	0	0	110	0	0	0.247E+00
4	0	25	41	43	221	1	0	0.679E+00
4	0	26	0	0	-120	0	0	0.605E+00
10	0	27	44	45	20	1	0	0.292E+00
13	0	28	0	0	120	0	0	0.105E+00
13	0	29	0	0	110	0	0	0.397E+00
14	0	30	0	0	-120	0	0	0.199E+00
14	0	31	0	0	110	0	0	0.326E+00
15	0	32	0	0	120	0	0	0.863E+00
15	0	33	0	0	110	0	0	0.107E+01
18	0	34	0	0	-120	0	0	0.287E+00
18	0	35	0	0	110	0	0	0.329E+00
18	0	36	0	0	120	0	0	0.118E+00
21	0	37	0	0	-130	0	0	0.401E+00
21	0	38	0	0	1120	0	0	0.426E+00
22	0	39	46	47	-1130	1	0	0.270E+00
22	0	40	0	0	110	0	0	0.360E+00
25	0	41	0	0	-120	0	0	0.588E+00
25	0	42	0	0	110	0	0	0.195E+00
25	0	43	0	0	120	0	0	0.956E-01
27	0	44	0	0	120	0	0	0.185E+00
27	0	45	0	0	-120	0	0	0.314E+00
39	0	46	0	0	-1120	0	0	0.177E+00
39	0	47	0	0	110	0	0	0.216E+00

Many different hadron species can be seen, the complete list of particle ids can be found in the EPOS package, see `src/KWt/idt.dt`. We observe two kinds of hadrons, those with `ist=0`, which are last generation hadrons, and those with `ist=1`. The latter ones are resonances, which decay. With `ior`, `ifr1`, `ifr2` we can completely follow the decay chains.