

The Les Houches Accord

Les Houches accord May 2001 \Rightarrow E Boos et al., hep-ph/0109068
or PYTHIA manual section 9.9

The LHA introduces two steps in a run, where a user can intervene:

1) at initialization, e.g. from inside PYINIT, do a

CALL UPINIT

where the user will define the character of a run by setting info in

COMMON/HEPRUP/

2) for each new event, e.g. from inside PYEVNT, do a

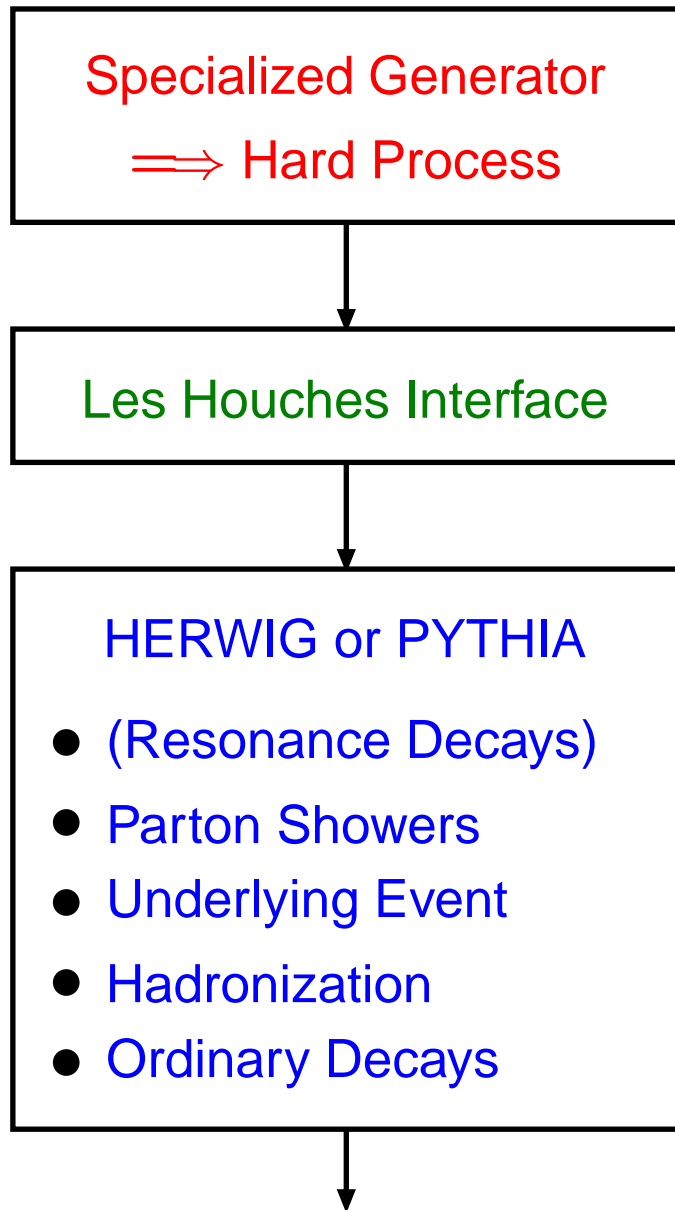
CALL UPEVNT

where the user will define the next event by setting info in

COMMON/HEPEUP/

PYTHIA facility enabled by CALL PYINIT('USER', ' ', ' ', 0D0)

The Context



Some Specialized Generators:

- AcerMC: $t\bar{t}b\bar{b}$, ...
- ALPGEN: $W/Z + \leq 6j$,
 $nW + mZ + kH + \leq 3j$, ...
- AMEGIC++: generic LO
- CompHEP: generic LO
- GRACE+Bases/Spring:
generic LO+ some NLO loops
- GR@PPA: $b\bar{b}b\bar{b}$
- MadCUP: $W/Z + \leq 3j$, $t\bar{t}b\bar{b}$
- MadGraph+HELAS: generic LO
- MCFM: NLO $W/Z + \leq 2j$,
 $WZ, WH, H + \leq 1j$
- O'Mega+WHIZARD: generic LO
- VECBOS: $W/Z + \leq 4j$

Apologies for all unlisted programs

Initialization

```
INTEGER MAXPUP
PARAMETER (MAXPUP=100)
INTEGER IDBMUP,PDFGUP,PDFSUP, IDWTUP, NPRUP, LPRUP
DOUBLE PRECISION EBMUP, XSECUP, XERRUP, XMAXUP
COMMON/HEPRUP/IDBMUP(2), EBMUP(2), PDFGUP(2), PDFSUP(2), IDWTUP,
&NPRUP, XSECUP(MAXPUP), XERRUP(MAXPUP), XMAXUP(MAXPUP), LPRUP(MAXPUP)
```

IDBMUP: incoming beam particles (PDG codes, $p = 2212$, $\bar{p} = -2212$)

EBMUP: incoming beam energies (GeV)

PDFGUP, PDFSUP: PDFLIB parton distributions (not used by PYTHIA)

IDWTUP: weighting strategy

- = 1: PYTHIA mixes and unweights events, according to known $d\sigma_{\max}$
- = 2: PYTHIA mixes and unweights events, according to known σ_{tot}
- = 3: unit-weight events, given by user, always to be kept
- = 4: weighted events, given by user, always to be kept
- = -1, -2, -3, -4: also allow negative $d\sigma$

NPRUP: number of separate user processes

XSECUP(i): σ_{tot} for each user process

XERRUP(i): error on σ_{tot} for each user process

XMAXUP(i): $d\sigma_{\max}$ for each user process

LPRUP(i): integer identifier for each user process

Example of UPINIT routine (from PYTHIA 6.3)

```
SUBROUTINE UPINIT
```

```
C...Precision and commonblocks (omitted here).
```

```
C...Read info from file (you must have opened file MSTP(161)).
```

```
IF(MSTP(161).GT.0) THEN
```

```
    READ(MSTP(161),*,END=110,ERR=110) IDBMUP(1),IDBMUP(2),EBMUP(1),  
& EBMUP(2),PDFGUP(1),PDFGUP(2),PDFSUP(1),PDFSUP(2),IDWTUP,NPRUP  
    DO 100 IPR=1,NPRUP
```

```
        READ(MSTP(161),*,END=110,ERR=110) XSECUP(IPR),XERRUP(IPR),  
& XMAXUP(IPR),LPRUP(IPR)
```

```
100 CONTINUE
```

```
RETURN
```

```
C...Error or prematurely reached end of file.
```

```
110 WRITE(MSTU(11),5000)
```

```
STOP
```

```
C...Else not implemented.
```

```
ELSE
```

```
WRITE(MSTU(11),5100)
```

```
STOP
```

```
ENDIF
```

```
C...Formats for error printout (omitted here).
```

```
RETURN
```

```
END
```

The event

```
INTEGER MAXNUP
PARAMETER (MAXNUP=500)
INTEGER NUP, IDPRUP, IDUP, ISTUP, MOTHUP, ICOLUP
DOUBLE PRECISION XWGTUP, SCALUP, AQEDUP, AQCDUP, PUP, VTIMUP, SPINUP
COMMON/HEPEUP/NUP, IDPRUP, XWGTUP, SCALUP, AQEDUP, AQCDUP,
&IDUP(MAXNUP), ISTUP(MAXNUP), MOTHUP(2, MAXNUP), ICOLUP(2, MAXNUP),
&PUP(5, MAXNUP), VTIMUP(MAXNUP), SPINUP(MAXNUP)
```

IDPRUP: identity of current process

XWGTUP: event weight (meaning depends on IDWTUP weighting strategy)

SCALUP: scale Q of parton distributions etc.

AQEDUP: α_{em} used in event

AQCDUP: α_S used in event

NUP: number of particles in event

IDUP(i): PDG identity code for particle i

ISTUP(i): status code (-1 = incoming parton, 1 = final-state parton,
 2 = intermediate resonance with preserved m)

MOTHUP(j, i): position of one or two mothers

PUP(j, i): (p_x, p_y, p_z, E, m)

VTIMUP(i): invariant lifetime $c\tau$

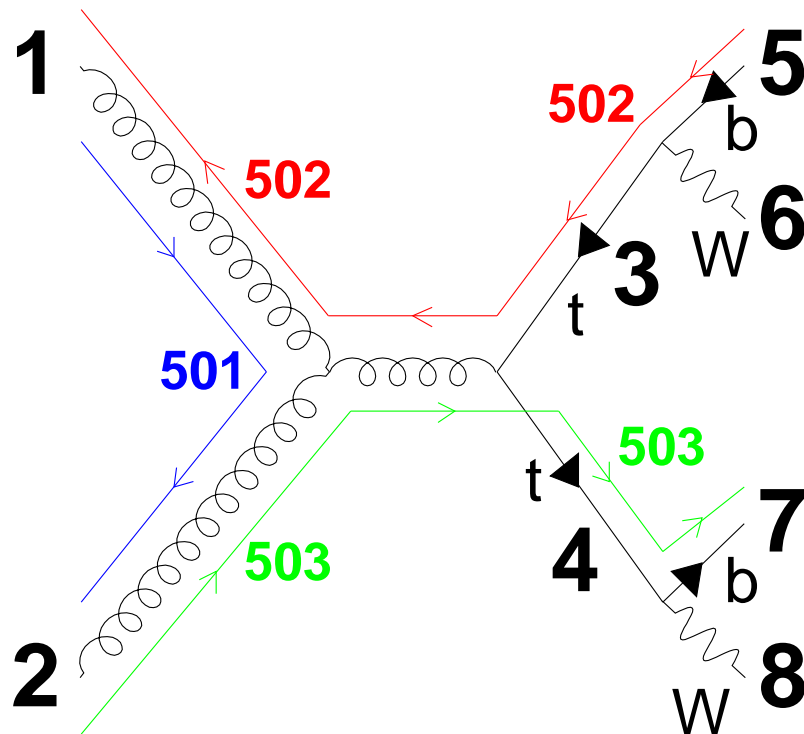
SPINUP(i): spin (helicity) information

Examples of colour flows and indices

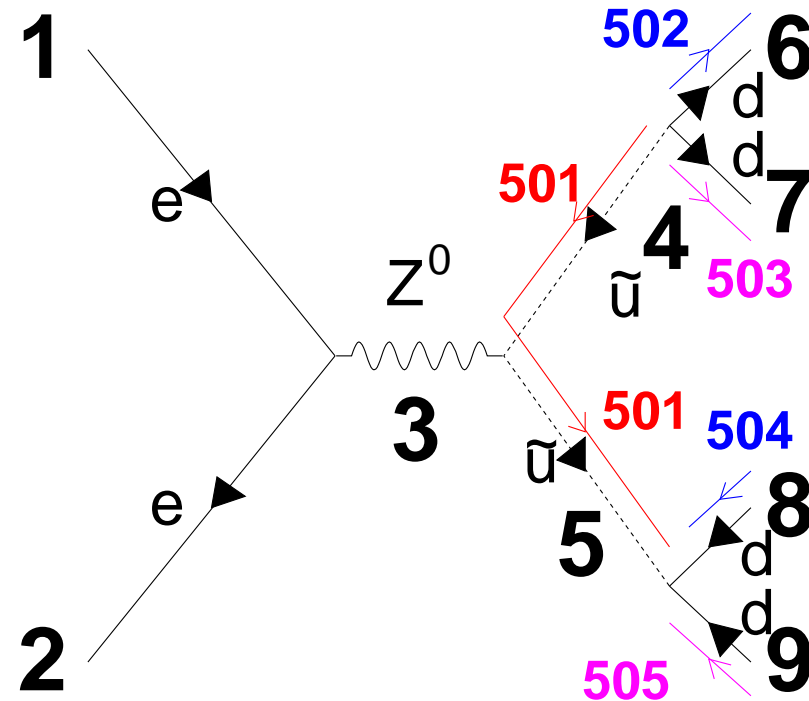
ICOLUP(j, i): colour and anticolour indices

= colour line tags, in the $N_C \rightarrow \infty$ limit, starting e.g. with number 501.

Example 1: hadronic $t\bar{t}$ production



Example 2: baryon number violation



user-process BNV not (yet) implemented in PYTHIA
(but part of internal PYTHIA SUSY machinery)

Example of UPEVNT routine (from PYTHIA 6.3)

```
SUBROUTINE UPEVNT
```

C...Precision and commonblocks (omitted here).

C...Read info from file (you must have opened file MSTP(162)).

```
IF(MSTP(162).GT.0) THEN
```

```
    READ(MSTP(162),*,END=110,ERR=110) NUP, IDPRUP, XWGTUP, SCALUP,  
    & AQEDUP, AQCDUP
```

```
    DO 100 I=1, NUP
```

```
        READ(MSTP(162),*,END=110,ERR=110) IDUP(I), ISTUP(I),
```

```
        & MOTHUP(1,I), MOTHUP(2,I), ICOLUP(1,I), ICOLUP(2,I),
```

```
        & (PUP(J,I), J=1,5), VTIMUP(I), SPINUP(I)
```

```
100    CONTINUE
```

```
    RETURN
```

C...Special when reached end of file or other error.

```
110    NUP=0
```

C...Else not implemented.

```
ELSE
```

```
    WRITE(MSTU(11),5000)
```

```
    STOP
```

```
ENDIF
```

C...Format for error printout (omitted here).

```
RETURN
```

```
END
```

Skeleton main program

```
C...Precision and commonblocks (omitted here).

C...Files for input (specific to PYTHIA UPINIT/UPEVNT routines).
  MSTP(161)=21
  OPEN(21,FILE='sample.init',STATUS='unknown')
  MSTP(162)=22
  OPEN(22,FILE='sample.evnt',STATUS='unknown')

C...Initialize with external process.
  CALL PYINIT('USER',' ',' ',0D0)

C...Event loop; generate event; check it was obtained or quit.
  DO 130 IEV=1,NEV
    CALL PYEVNT
    IF(MSTI(51).EQ.1) GOTO 140

C...List first few events: Les Houches input and PYTHIA generated.
  IF(IEV.LE.3) CALL PYLIST(7)
  IF(IEV.LE.3) CALL PYLIST(2)

C...Insert event analysis here.

C...End of event loop. Final statistics. Done.
  130 CONTINUE
  140 CALL PYSTAT(1)
  END
```


Example of PYLIST(7) output

Event listing of user process at input (simplified)

I	IST	ID	Mothers	Colours	p_x	p_y	p_z	E	m		
1	-1	21	0	0	101	102	0.000	0.000	37.808	37.808	0.000
2	-1	2	0	0	102	0	0.000	0.000	-191.351	191.351	0.000
3	2	23	1	2	0	0	1.320	-27.987	-171.365	195.951	90.806
4	1	2	1	2	101	0	-1.320	27.987	17.823	33.208	0.330
5	1	1	3	0	103	0	1.584	-55.632	-62.765	83.886	0.330
6	1	-1	3	0	0	103	-0.264	27.645	-108.601	112.065	0.330

Event listing of user process at input (simplified)

I	IST	ID	Mothers	Colours	p_x	p_y	p_z	E	m		
1	-1	2	0	0	101	0	0.000	0.000	265.515	265.515	0.000
2	-1	-2	0	0	0	102	0.000	0.000	-139.629	139.629	0.000
3	2	6	1	2	101	0	60.993	15.214	111.242	217.597	176.131
4	2	-6	1	2	0	102	-60.993	-15.214	14.644	187.547	176.090
5	1	5	3	0	101	0	-17.822	-35.670	79.802	89.323	4.500
6	2	24	3	0	0	0	78.815	50.884	31.440	128.274	81.638
7	1	-5	4	0	0	102	39.830	-0.176	37.926	55.182	4.500
8	2	-24	4	0	0	0	-100.824	-15.038	-23.282	132.364	81.158
9	1	2	6	0	103	0	86.769	55.002	7.840	103.032	0.000
10	1	-1	6	0	0	103	-7.954	-4.118	23.600	25.242	0.000
11	1	-2	8	0	0	104	6.270	10.530	-18.457	22.155	0.000
12	1	1	8	0	104	0	-107.093	-25.568	-4.824	110.209	0.000

Backup: PDG Particle Codes

A. Fundamental objects

1	d	11	e^-	21	g						add – sign for antiparticle, where appropriate
2	u	12	ν_e	22	γ	32	Z'^0				
3	s	13	μ^-	23	Z^0	33	Z''^0				
4	c	14	ν_μ	24	W^+	34	W'^+				
5	b	15	τ^-	25	h^0	35	H^0	37	H^+	+ diquarks, SUSY,	
6	t	16	ν_τ			36	A^0	39	Graviton	technicolor, ...	

B. Mesons

$100 |q_1| + 10 |q_2| + (2s + 1)$ with $|q_1| \geq |q_2|$
 particle if heaviest quark u, \bar{s} , c, \bar{b} ; else antiparticle

111	π^0	311	K^0	130	K_L^0	221	η^0	411	D^+	431	D_s^+
211	π^+	321	K^+	310	K_S^0	331	η'^0	421	D^0	443	J/ψ

C. Baryons

$1000 q_1 + 100 q_2 + 10 q_3 + (2s + 1)$
 with $q_1 \geq q_2 \geq q_3$, or Λ -like $q_1 \geq q_3 \geq q_2$

2112	n	3122	Λ^0	2224	Δ^{++}	3214	Σ^{*0}
2212	p	3212	Σ^0	1114	Δ^-	3334	Ω^-

Backup: The HEPEVT Event Record

Standard output of the *final* event.

```
PARAMETER (NMXHEP=4000)
COMMON/HEPEVT/NEVHEP , NHEP , ISTHEP (NMXHEP) , IDHEP (NMXHEP) ,
&JMOHEP (2 , NMXHEP) , JDAHEP (2 , NMXHEP) , PHEP (5 , NMXHEP) ,
&VHEP (4 , NMXHEP)
DOUBLE PRECISION PHEP , VHEP
```

NMXHEP = maximum number of entries

NEVHEP = event number

NHEP = number of entries in current event

ISTHEP = status code of entry (0 = null entry, 1 = existing entry,
2 = fragmented/decayed entry, 3 = documentation entry)

IDHEP = PDG particle identity (+ some internal, e.g. 92 = string)

JMOHEP = mother position(s)

JDAHEP = first and last daughter position

PHEP = momentum (p_x, p_y, p_z, E, m) in GeV

VHEP = production vertex (x, y, z, t) in mm