

# Les Houches and Monte Carlos

- Much of the time during meeting was spent developing a generic process interface from matrix element to Monte Carlo programs

- This interface allows:

- ◆ arbitrary hard subprocesses to be plugged into shower/hadronization generators.

CompHEP

Grace

MadGraph -->

VecBos

Wbbgen

Herwig

Isajet

Pythia

- ◆ ->Les Houches accord (#1)

“Les Houches” User Process  
Interface  
for Event Generators

hep-ph/0109068

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- Possible because one or more authors from each of these programs was present at Les Houches

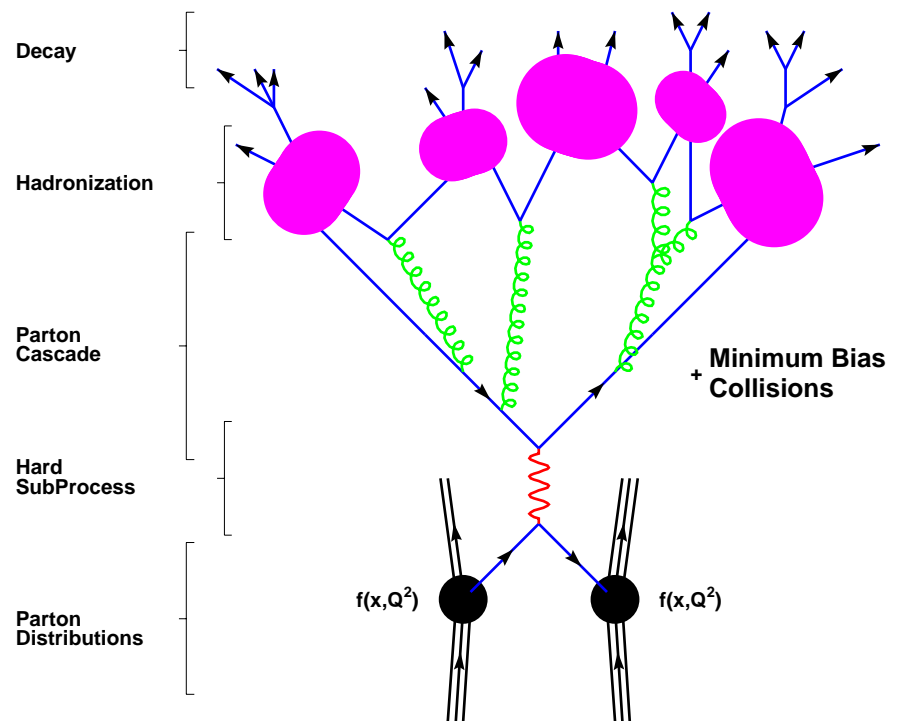
- ◆ Matt Dobbs has been the front man for coordinating the disputes/discussions
- ◆ literally hundreds of email exchanges

Les Houches accords  
J. Huston

# Universal Interface

- This interface will allow for a more complete predictability for ME programs
  - ◆ parton showering (additional jets)
  - ◆ hadronization
  - ◆ detector simulation
- Some specialized interfaces already exist
  - ◆ VECBOS->Herwig (HERPRT)
  - ◆ Wbbgen->Herwig
  - ◆ CompHep->Pythia
- This interface should supercede them.

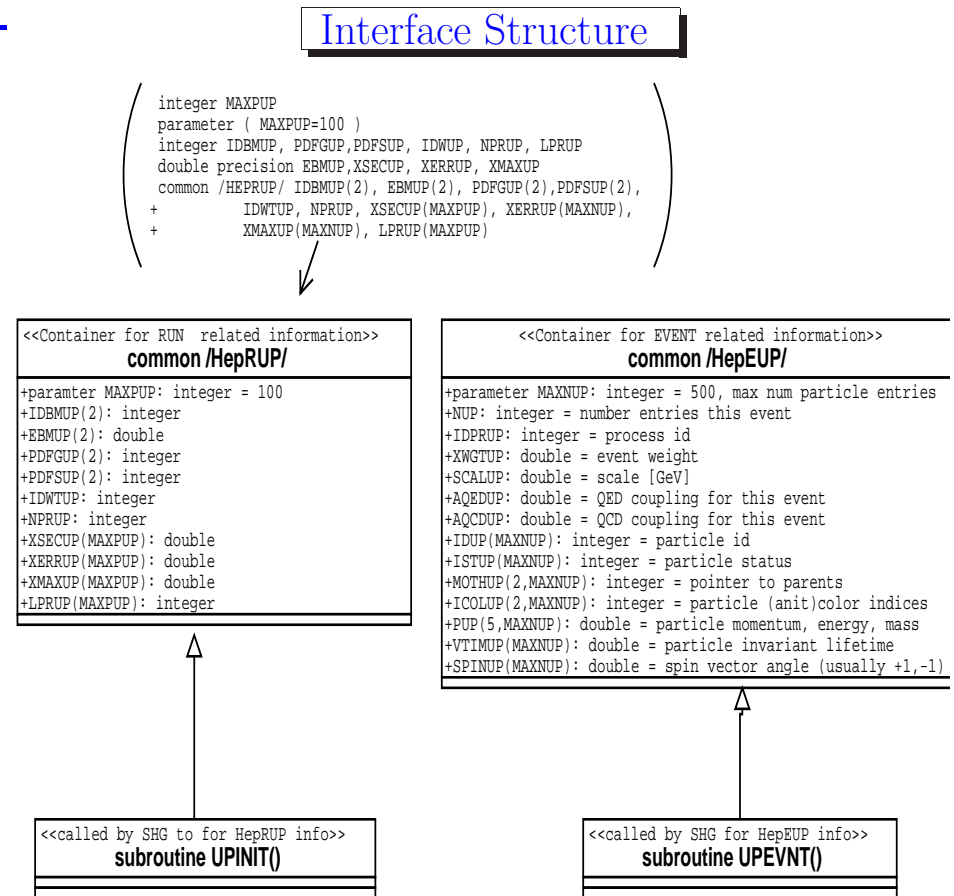
Specialize in the 'generic' parts of the event.



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# Interface

- Provides information on parton 4-vectors, mother-daughter relationships, spins/helicities and color flow
  - ◆ also points to intermediate particles whose mass should be preserved in the parton showering
- Not intended as a replacement for HEPEVT
  - ◆ addresses communication between event generators only, not between event generators and the outside world
- Partonic information is in 2 Fortran common blocks
  - ◆ run info
  - ◆ specific event info

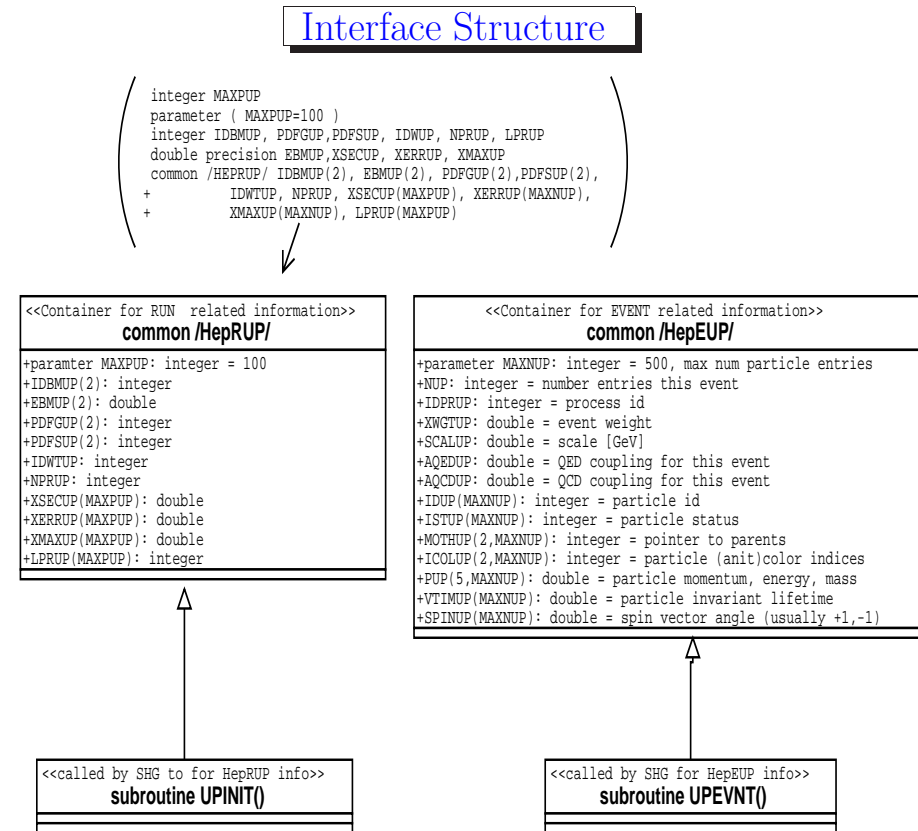


(Specialized for each matrix element)

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# Subroutines

- Each stage (run and event) associated with own subroutine, called from the shower generator, where information is placed in the respective common block, based on output from the matrix element generator
- Subroutine names (in Pythia 6.2) are:
  - ◆ **UPINIT**
  - ◆ **UPEVNT**
  - ◆ note no PY prefixes
- Other authors should use the same convention



(Specialized for each matrix element)

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- Shower generator can unweight events from matrix element generator, mix different subprocesses from matrix element generator, or just read events straight from a file
  - ◆ if unweighting/mixing is needed then shower generator needs info about subprocess cross sections and/or maximum weights
- If extra information is needed for specific user implementation, then implementation-specific common block has to be created
- Note that a lot of the technicalities are intended for ME/MC authors, not for users; in most cases, these details will be invisible to the casual user

## Interface Structure

```

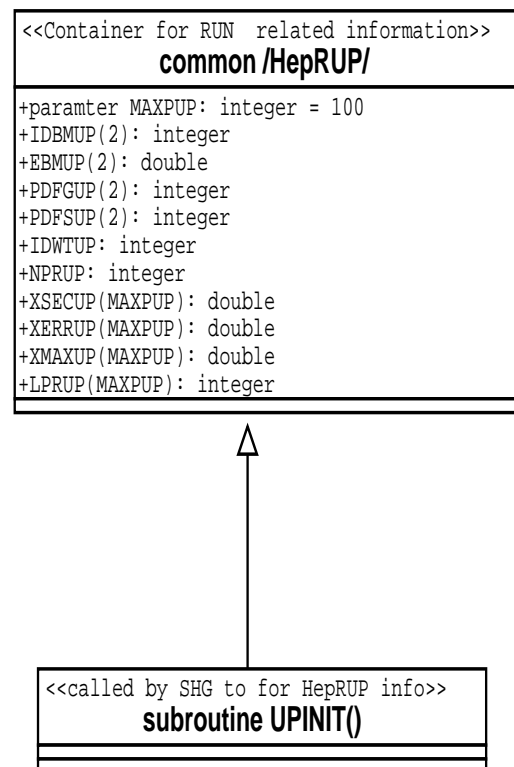
integer MAXPUP
parameter ( MAXPUP=100 )
integer IDBMUP, PDFGUP,PDFSUP, IDWUP, NPRUP, LPRUP
double precision EBMUP,XSECUP, XERRUP, XMAXUP
common /HEPRUP/ IDBMUP(2), EBMUP(2), PDFGUP(2),PDFSUP(2),
+             IDWTUP, NPRUP, XSECUP(MAXPUP), XERRUP(MAXNUP),
+             XMAXUP(MAXNUP), LPRUP(MAXPUP)

```

MAXUP: maximum number of different processes to be interfaced at one time

# Run related information

- Each stage (run and event associated with own subroutine)
- Run subroutine
  - ◆ **IDWTUP**: master switch indicating how the event weights (XWGTUP) are interpreted (some examples below)
    - ▲ +1: events are weighted on input and SHG is asked to produce events with weight +1 on output
    - ▲ -1: same as above but event weights may be either positive or negative; SHG will produce events with weights +1 or -1 on output
    - ▲ +3: events are unweighted on input so SHG only asks for next event
    - ▲ -3: same as above but event weights may be either +1 or -1

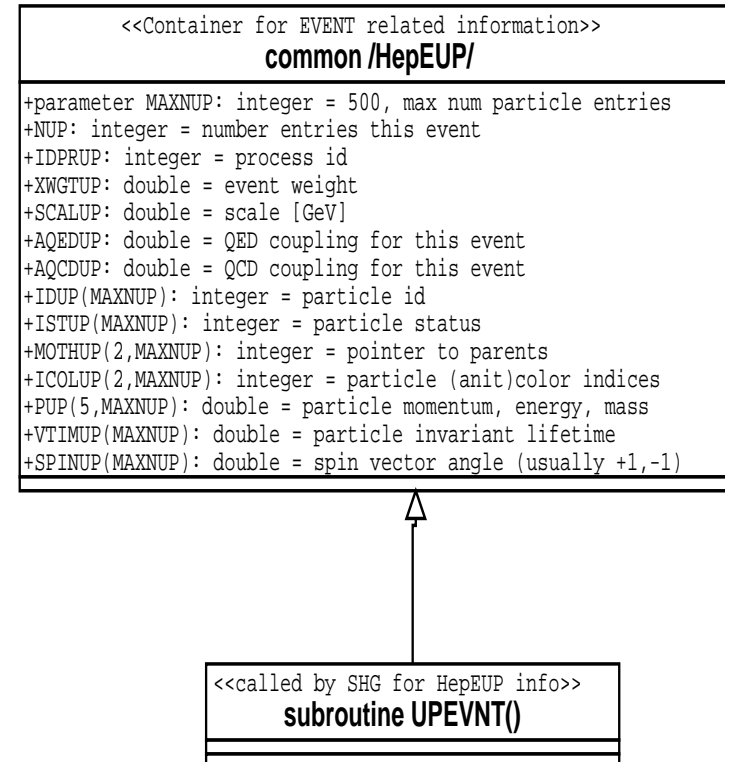


(Specialized for

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# Event related information

- NUP: number of particle entries for this event
- IDPRUP: ID of the process for this event
- XWGTUP: event weight
- IDUP: particle ID (non-physical particles assigned IDUP=0)
- ISTUP: status code
  - ◆ -1: incoming particle
  - ◆ +1: outgoing particle
  - ◆ -2: intermediate space-like propagator defining an  $x$  and  $Q^2$  which should be preserved (DIS-specific)
  - ◆ +2: intermediate resonance, mass should be preserved
    - ▲ recoil from parton shower needs to be absorbed by particles in the event
  - ◆ +3: intermediate resonance, for documentation only
  - ◆ -9: incoming beam particles

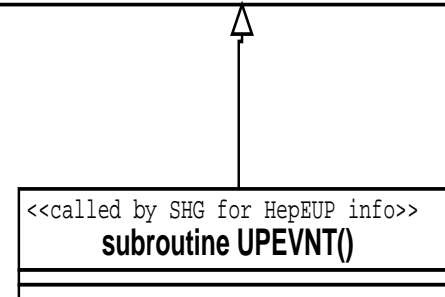
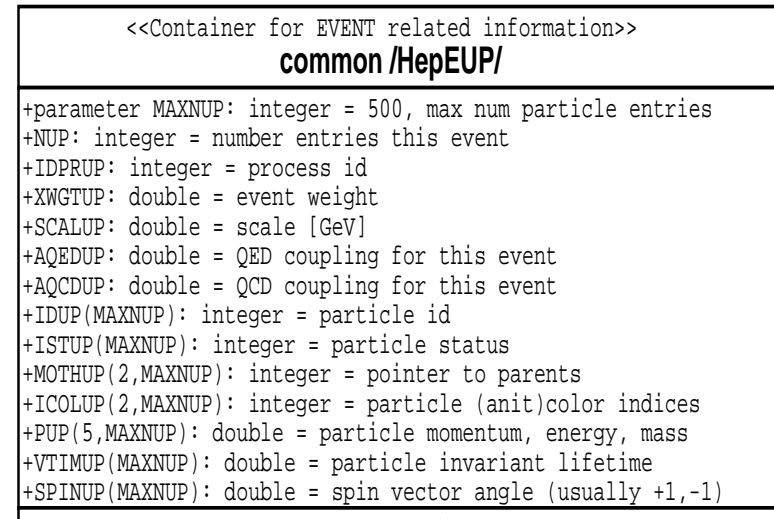


each matrix element)

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# Event info

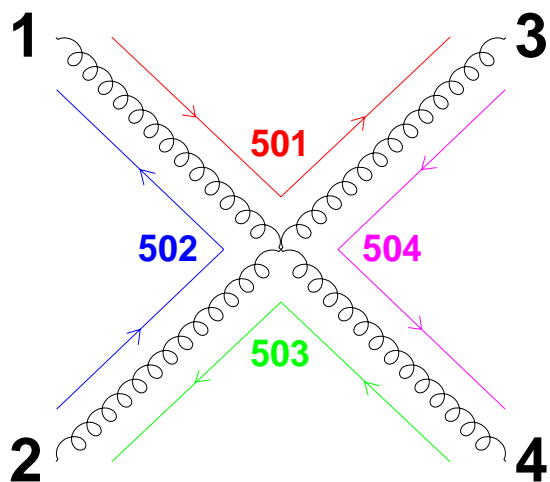
- **MOTHUP(2,I): index of first and last mother**
  - ◆ For decays, daughter particles will only have 1 mother
  - ◆ For 2->n, daughter particles will have 2 mothers
- **Color flow: specific choice of color flow for a particular event is often unphysical, due to interference effects, but SHGs require specific color state from which to begin shower**
  - ◆ **ICOLUP(1,I): integer tag for color flow line passing through color of the particle**
  - ◆ **Integer tag fro color flow line passing through anti-color of tag**



each matrix element)

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# Example (gg->gg)

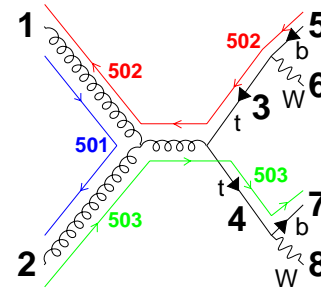


I	ISTUP(I)	IDUP(I)	MOTHUP(1,I)	MOTHUP(2,I)	ICOLUP(1,I)	ICOLUP(2,I)
1	-1	21 (g)			501	502
2	-1	21 (g)			502	503
3	+1	21 (g)	1	2	501	504
4	+1	21 (g)	1	2	504	503

# Consider $t\bar{t}b\bar{b}$ production

- $t$  and  $t\bar{b}$  given  $ISTUP=+2$ , which informs SHG to preserve their invariant masses when showering and hadronizing the event
- Intermediate s-channel gluon has been drawn, but no entry because cannot be distinguished from t-channel
- Definition of color or anti-color line depends on orientation of graph
  - ◆ define color and anti-color according to physical time order
  - ◆ quark will always have color tag  $ICOLUP(1,I)$  filled, but never its anti-color tag  $ICOLUP(2,I)$ ; reverse for anti-quark; gluon has info in both tags

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



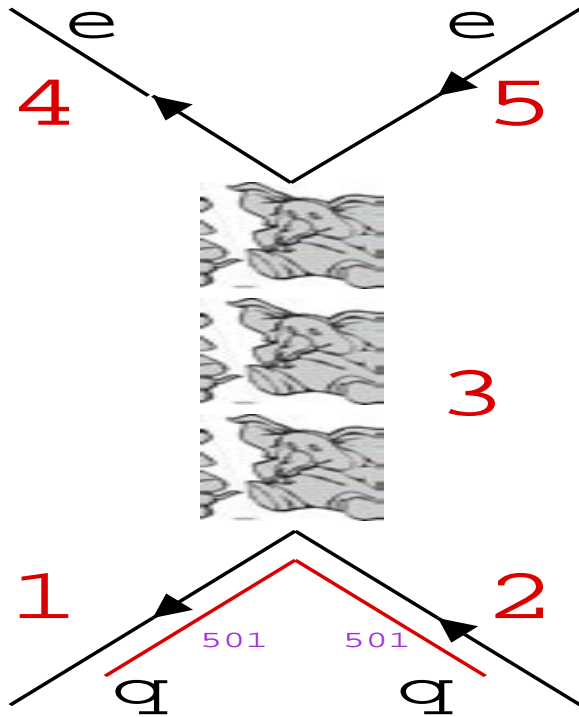
I	ISTUP(I)	IDUP(I)	MOTHUP(1,I)	MOTHUP(2,I)	ICOLUP(1,I)	ICOLUP(2,I)
1	-1	21 ( $g$ )	0	0	501	502
2	-1	21 ( $g$ )	0	0	503	501
3	+2	-6 ( $\bar{t}$ )	1	2	0	502
4	+2	6 ( $t$ )	1	2	503	0
5	+1	-5 ( $\bar{b}$ )	3	3	0	502
6	+1	-24 ( $W^-$ )	3	3	0	0
7	+1	5 ( $b$ )	4	4	503	0
8	+1	24 ( $W^+$ )	4	4	0	0

The  $t$  and  $\bar{t}$  are given  $ISTUP=+2$ , which informs the SHG to preserve their invariant masses when showering and hadronizing the event. An intermediate s-channel gluon has been drawn in the diagram, but since this graph cannot be usefully distinguished from the one with a t-channel top exchange, an entry has not been included for it in the event record.

The definition of a line as 'color' or 'anti-color' depends on the orientation of the graph. This ambiguity is resolved by defining color and anti-color according to the physical time order. A quark will always have its color tag  $ICOLUP(1,I)$  filled, but never its anti-color tag  $ICOLUP(2,I)$ . The reverse is true for an anti-quark, and a gluon will always have information in both  $ICOLUP(1,I)$  and  $ICOLUP(2,I)$  tags.

Note the difference in the treatment by the parton shower of the above example, and an identical final state, where the intermediate particles are not specified:

# Another example: little pink elephant exchange



I	ISTUP(I)	IDUP(I)	MOTHUP(1,I)	MOTHUP(2,I)	ICOLUP(1,I)	ICOLUP(2,I)
1	-1	-2 ( $\bar{u}$ )	0	0	0	501
2	-1	2 ( $u$ )	0	0	501	0
3	+2	0 (pink elephant)	1	2	0	0
4	+1	11 ( $e^-$ )	3	3	0	0
5	+1	-11 ( $e^+$ )	3	3	0	0