Perspective on SVJ parameter choices

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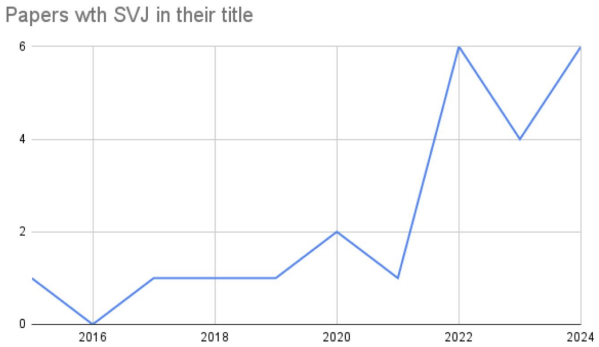
ATLAS *t*-channel parameter choices

- As a first search, the focus was on generating the topology
- This was pre-snowmass (it takes a while to generate fully simulated samples in experimental collaborations)
- The legacy of the search will be the “model independent” limit calculated, data yield in the specific signal region, which was chosen to be fairly inclusive.



However, with a larger community, broader search programme, it will be helpful to have HV benchmarks …

Focussing on two parameters: $N_{Flavour}$ and R_{inv}

$N_{Flavour}$

- Universal agreement on $N_{Flavour} > 1$
- $N_{Flavour} = 3$ seems more QCD-like, but $N_{Flavour} = 2$ does not have a strong drawback?
- This ties strongly to …

R_{inv}

- In Pythia8 HV, $N_{Flavour} > 1$ implies 4900211/3 are also produced with status codes 83 and 84 (primary hadrons produced directly from hadronisation) as opposed to only with status code 91 (decay products). They do not decay by default in either case.
- So keeping the simple decay(*) means a higher effective *output* Rinv.

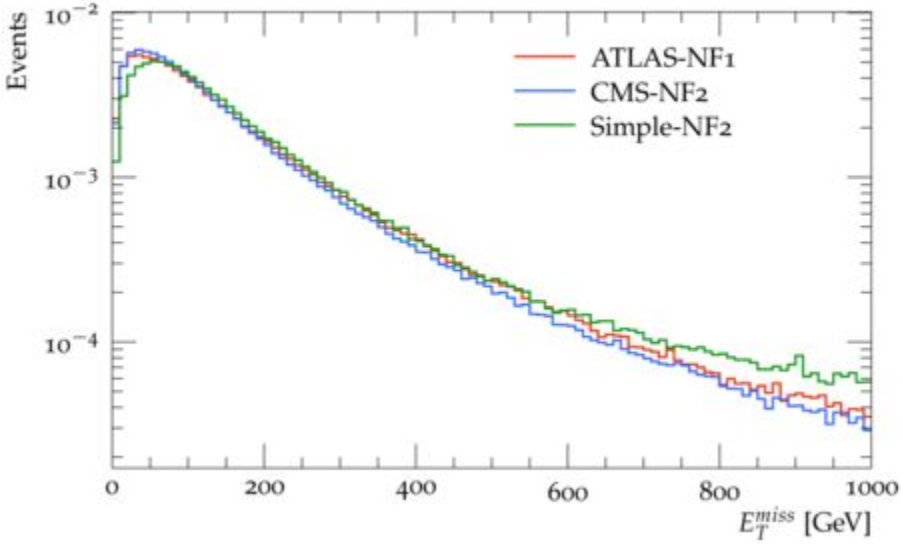
R_{inv}

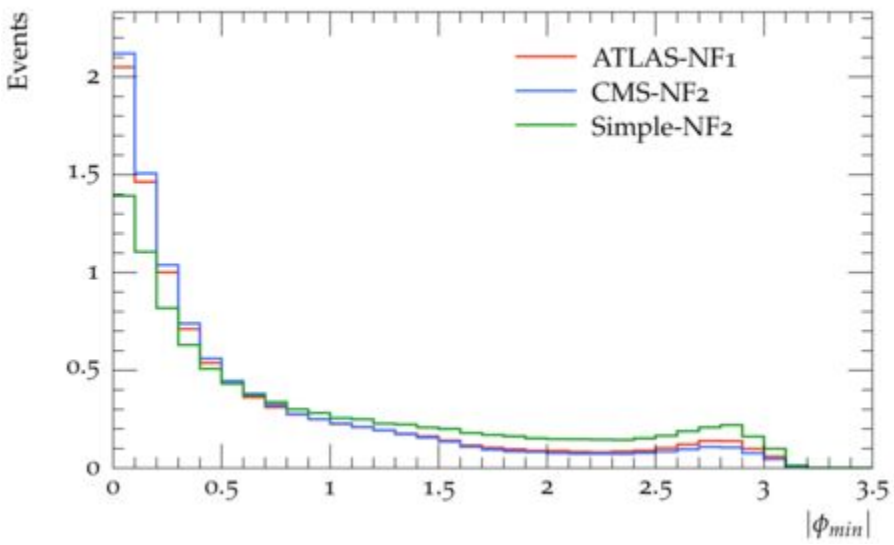
```
* Decay (example Rinv = 0.3):
4900111:onechannel = 1  0.7  91 -3 3                    # 1 + to_st(1.0-inv) + 91 -3 3
4900111:addchannel = 1  0.3  0 4900211 -4900211         # 1 + to_st(inv) + 0 4900211 -4900211
4900113:onechannel = 1  0.14 91 -1 1                    # 1 + to_st((1-inv)/5.) + 91 -1 1
4900113:addchannel = 1  0.14 91 -2 2                    # 1  + to_st((1-inv)/5.)  + 91 -2 2
4900113:addchannel = 1  0.14 91 -3 3                    # 1 + to_st((1-inv)/5.) + 91 -3 3
4900113:addchannel = 1  0.14 91 -4 4                    # 1 + to_st((1-inv)/5.) + 91 -4 4
4900113:addchannel = 1  0.14 91 -5 5                    # 1+ to_st((1-inv)/5.) +  91 -5 5
4900113:addchannel = 1  0.3  0 4900213 -4900213         # 1 + to_st(inv) + 0 4900213 -4900213
```

R_{inv}

- In Pythia8 HV, $N_{Flavour} > 1$ implies 4900211/3 are also produced with status codes 83 and 84 (primary hadrons produced directly from hadronisation) as opposed to only with status code 91 (decay products). They do not decay by default in either case.
- So keeping the simple decay(*) means a higher effective *output* Rinv.
- Is this a problem?

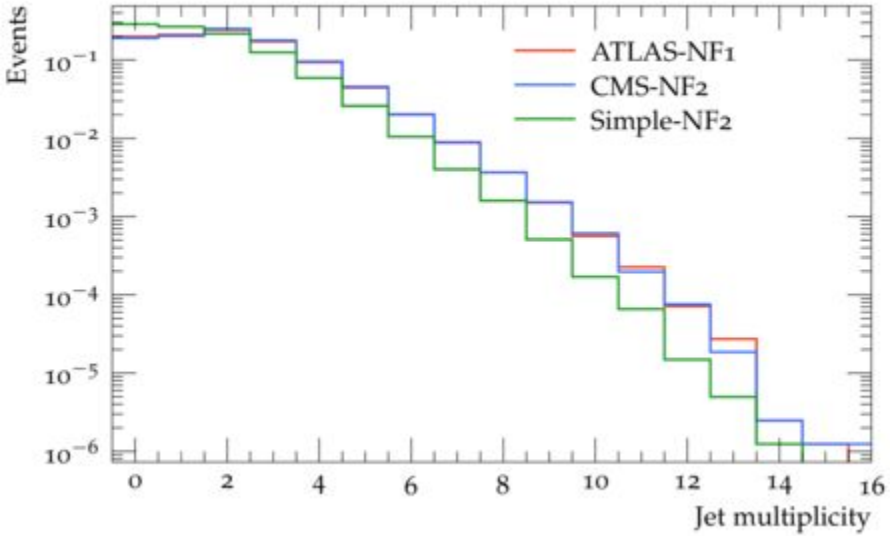
Let's have a look …

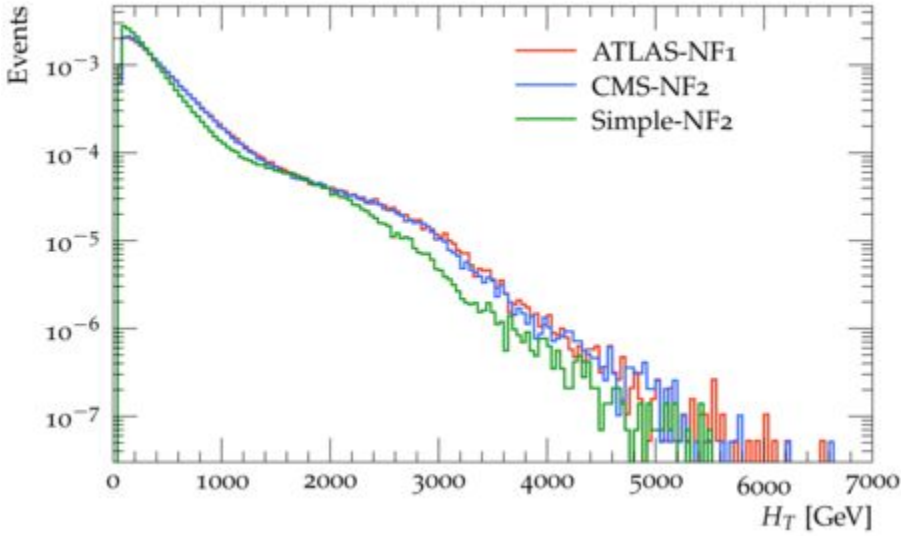




Pythia HV does not support decaying off-diagonal 4900211/3 back to SM!
Simple: keep the same decay chain!

Let’s have a look …





Not identical kinematics …

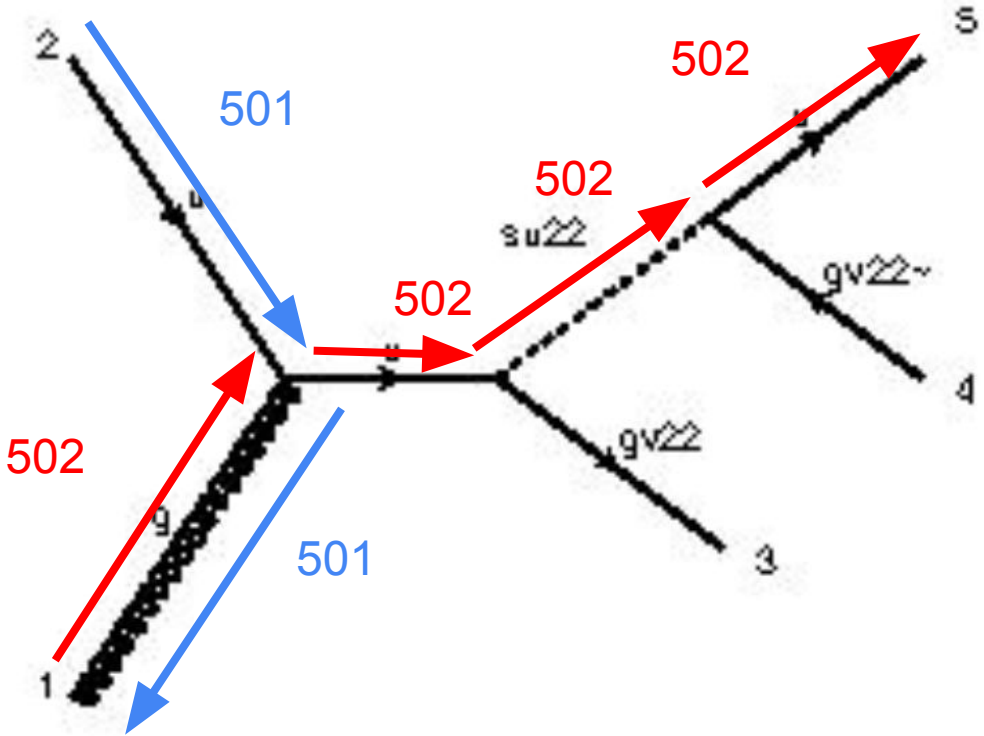
Discussion Points

- Output R_{inv} is not a physically well defined observable (for a proxy, see: arXiv:2409.04741v3)
- So how concerned are we about “conserving it”, i.e expecting mapping input R_{inv} to an output observable?
- There are other options, generate a continuous R_{inv} distribution without setting it explicitly as input, as implemented in Herwig (well it is not a uniform distribution..). Same can be done in Pythia.
- This is a general discussion beyond vanilla SVJ!

Additional comments: following from Clarisse’s talk yesterday, CONTUR (and friends) can exclude some bits of parameter space. In fact in ATLAS, Louie Corpe implemented Autocontur, which automatically runs Contur over new signal requests. Should be a parallel exercise along with benchmarking?

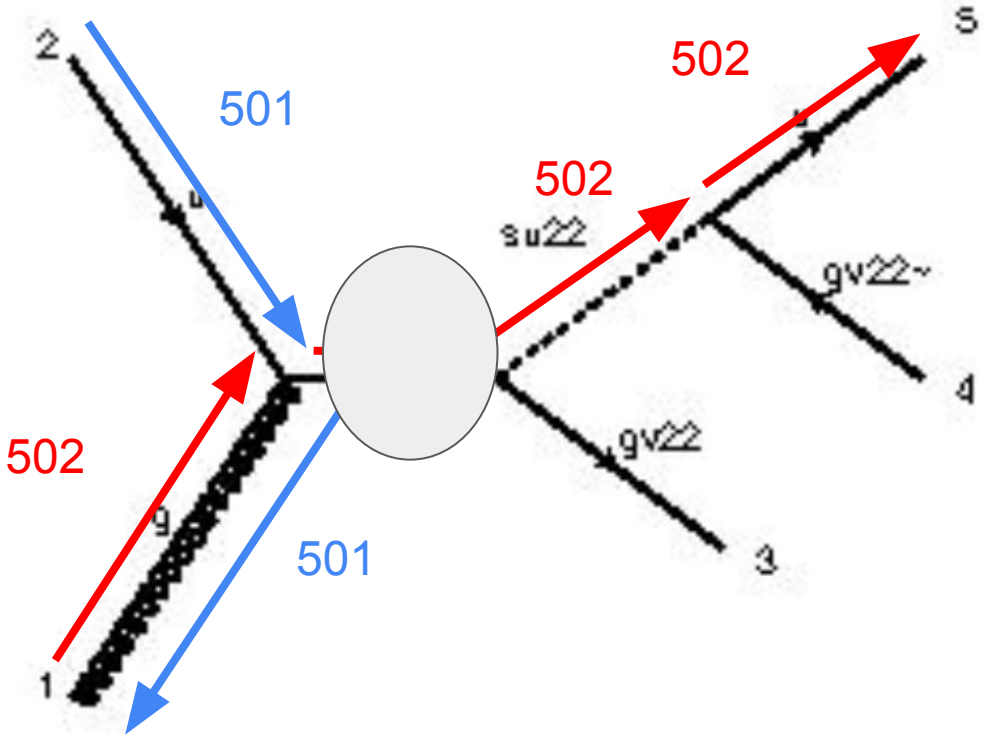
Bonus: Pythia HV breaks after 8306 for external LHEs with extra partons:

From 8308(?) HV colour counting was enabled. Which is great, but since in the original approach, we did a PID substitution to HV particles, we have an issue…



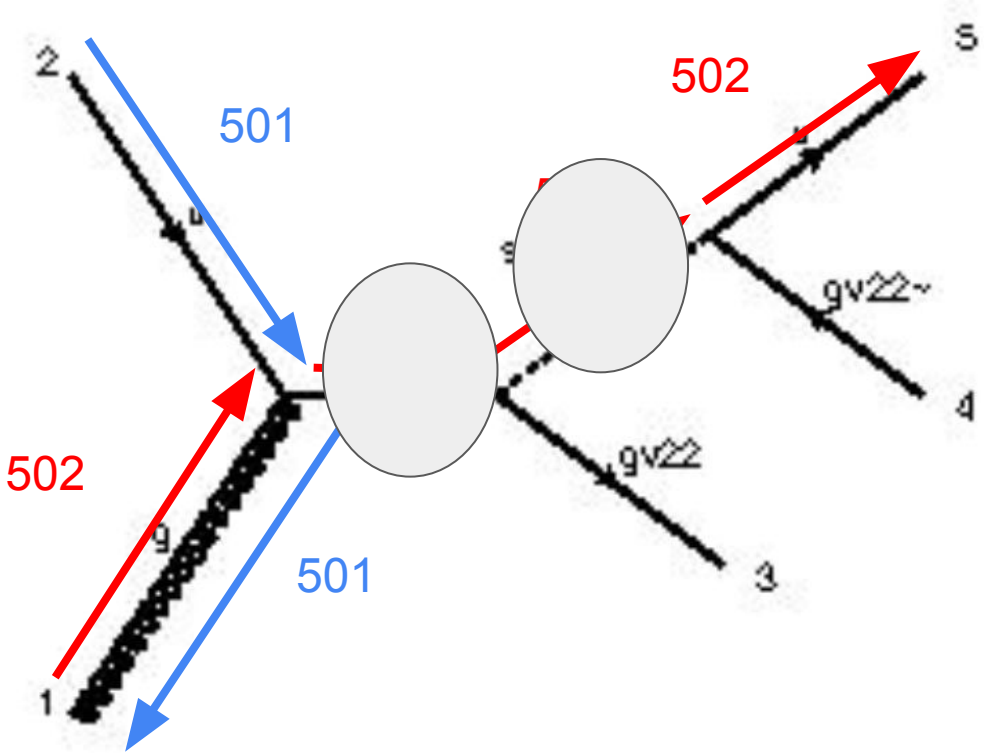
An example event, ignore the quark flavour

21	-1	0	0	501	502	+0.0000000000e+00	+0.0000000000e+00	+5.7001894904e+02	5.7001894904e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00
-3	-1	0	0	0	501	-0.0000000000e+00	-0.0000000000e+00	-7.8851896653e+02	7.8851896653e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00
-9000012	2	1	2	0	502	-1.2522200808e+02	-1.9357906157e+02	+7.0782039724e+01	9.8848722578e+02	9.5861540463e+02	0.0000e+00	0.0000e+00
4900101	1	3	3	0	0	-4.0228012535e+02	-3.8469860521e+01	-2.9773133199e+02	5.0204897716e+02	1.0000000000e+01	0.0000e+00	-1.0000e+00
-4900101	1	1	2	0	0	+1.2522200808e+02	+1.9357906157e+02	-2.8928205722e+02	3.7005068979e+02	1.0000000000e+01	0.0000e+00	1.0000e+00
-3	1	3	3	0	502	+2.7705811727e+02	-1.5510920105e+02	+3.6851337171e+02	4.8643824862e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00



Presumably this is how Pythia sees the event…

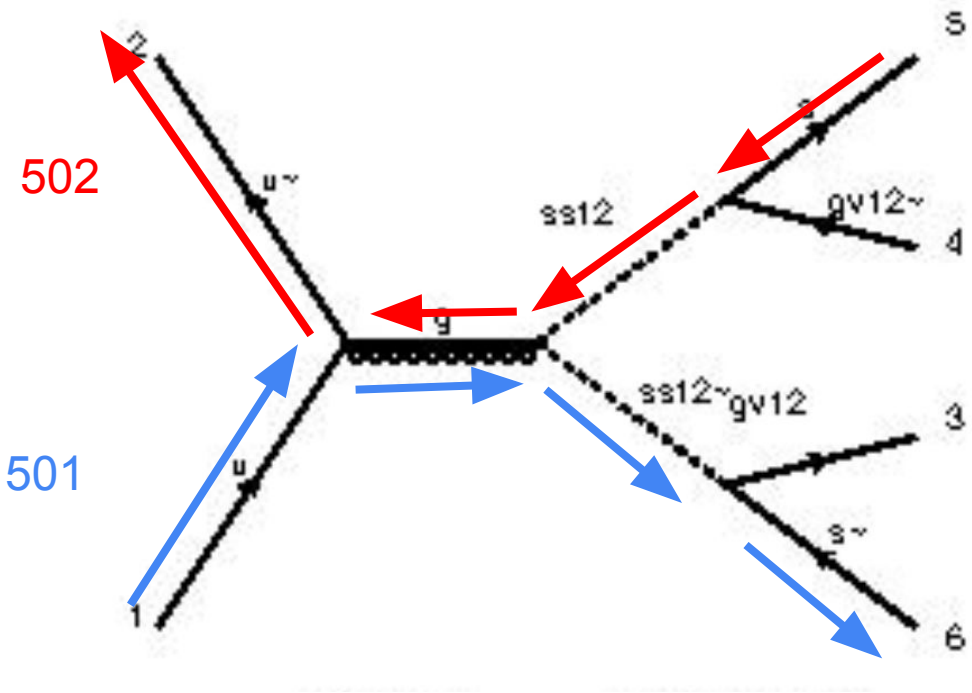
21	-1	0	0	501	502	+0.0000000000e+00	+0.0000000000e+00	+5.7001894904e+02	5.7001894904e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00
-3	-1	0	0	0	501	-0.0000000000e+00	-0.0000000000e+00	-7.8851896653e+02	7.8851896653e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00
-9000012	2	1	2	0	502	-1.2522200808e+02	-1.9357906157e+02	+7.0782039724e+01	9.8848722578e+02	9.5861540463e+02	0.0000e+00	0.0000e+00
4900101	1	3	3	0	0	-4.0228012535e+02	-3.8469860521e+01	-2.9773133199e+02	5.0204897716e+02	1.0000000000e+01	0.0000e+00	-1.0000e+00
-4900101	1	1	2	0	0	+1.2522200808e+02	+1.9357906157e+02	-2.8928205722e+02	3.7005068979e+02	1.0000000000e+01	0.0000e+00	1.0000e+00
-3	1	3	3	0	502	+2.7705811727e+02	-1.5510920105e+02	+3.6851337171e+02	4.8643824862e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00



Removing the mediator means we are doing 2->3 process, and messing up the mother/daughter labels

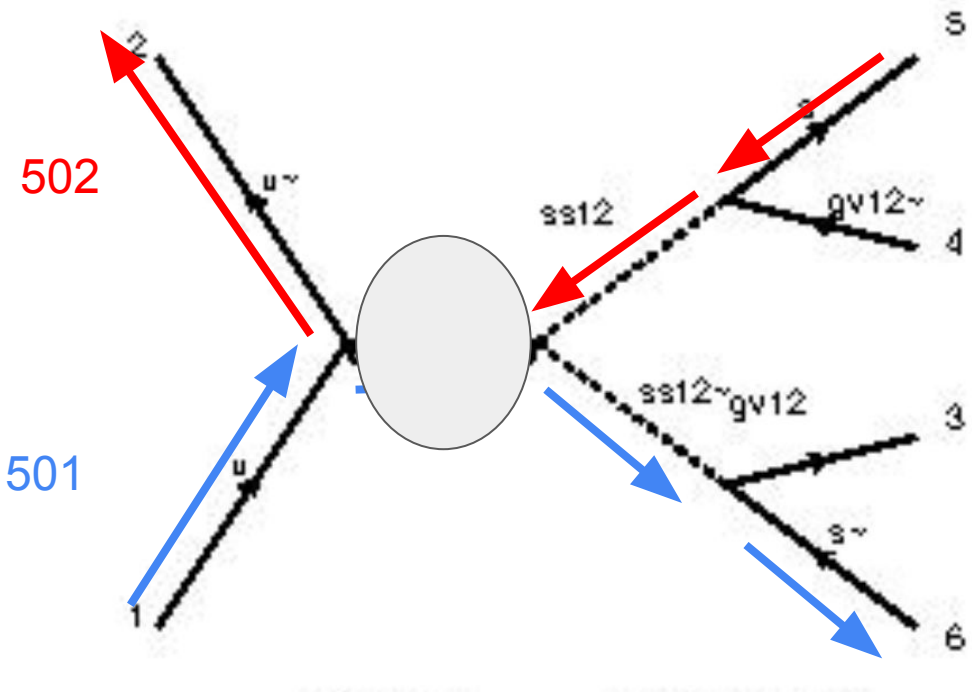
```
    21 -1   0    0  501  502 +0.0000000000e+00 +0.0000000000e+00 +5.7001894904e+02 5.7001894904e+02 0.0000000000e+00 0.0000e+00 -1.0000e+00
    -3 -1   0    0    0  501 -0.0000000000e+00 -0.0000000000e+00 -7.8851896653e+02 7.8851896653e+02 0.0000000000e+00 0.0000e+00 -1.0000e+00

4900101  1   3    3    0    0 -4.0228012535e+02 -3.8469860521e+01 -2.9773133199e+02 5.0204897716e+02 1.0000000000e+01 0.0000e+00 -1.0000e+00
-4900101  1   1    2    0    0 +1.2522200808e+02 +1.9357906157e+02 -2.8928205722e+02 3.7005068979e+02 1.0000000000e+01 0.0000e+00 1.0000e+00
    -3  1   3    3    0  502 +2.7705811727e+02 -1.5510920105e+02 +3.6851337171e+02 4.8643824862e+02 0.0000000000e+00 0.0000e+00 -1.0000e+00
```



An example event, ignore the quark flavour

-1	-1	0	0	0	501	-0.0000000000e+00	+0.0000000000e+00	+7.2048883440e+02	7.2048883440e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00
1	-1	0	0	502	0	+0.0000000000e+00	-0.0000000000e+00	-2.5147676835e+03	2.5147676835e+03	0.0000000000e+00	0.0000e+00	1.0000e+00
9000024	2	1	2	502	0	-4.2379615736e+02	+2.7192412741e+01	-1.8525760820e+03	2.1481339766e+03	1.0010488658e+03	0.0000e+00	0.0000e+00
-9000024	2	1	2	0	501	+4.2379615736e+02	-2.7192412741e+01	+5.8297232865e+01	1.0871225413e+03	9.9904666661e+02	0.0000e+00	0.0000e+00
4900101	1	4	4	0	0	+5.8671023489e+02	-2.8860473555e+02	+2.7615117181e+02	7.0984580213e+02	1.0000000000e+01	0.0000e+00	-1.0000e+00
-4900101	1	3	3	0	0	+3.1903662457e+02	+1.0699342519e+02	-6.5919869259e+02	7.4018570451e+02	1.0000000000e+01	0.0000e+00	1.0000e+00
4	1	3	3	502	0	-7.4283278193e+02	-7.9801012445e+01	-1.1933773894e+03	1.4079482721e+03	0.0000000000e+00	0.0000e+00	1.0000e+00
-4	1	4	4	0	501	-1.6291407753e+02	+2.6141232281e+02	-2.1785393895e+02	3.7727673914e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00



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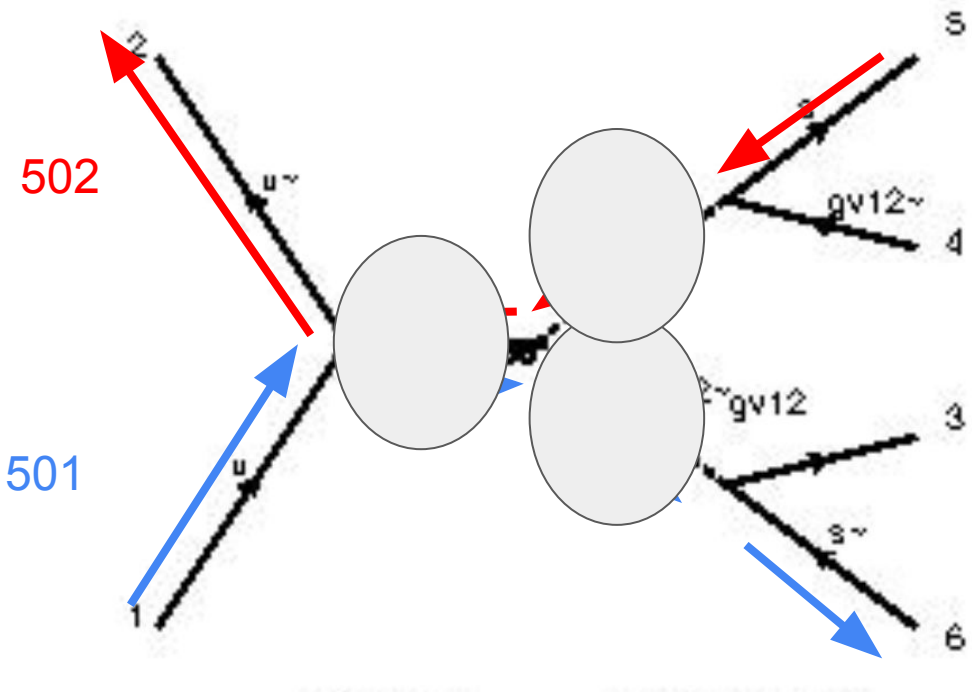
1	-1	0	0	502	0	+0.0000000000e+00	-0.0000000000e+00	-2.5147676835e+03	2.5147676835e+03	0.0000000000e+00	0.0000e+00	1.0000e+00
9000024	2	1	2	502	0	-4.2379615736e+02	+2.7192412741e+01	-1.8525760820e+03	2.1481339766e+03	1.0010488658e+03	0.0000e+00	0.0000e+00
-9000024	2	1	2	0	501	+4.2379615736e+02	-2.7192412741e+01	+5.8297232865e+01	1.0871225413e+03	9.9904666661e+02	0.0000e+00	0.0000e+00
4900101	1	4	4	0	0	+5.8671023489e+02	-2.8860473555e+02	+2.7615117181e+02	7.0984580213e+02	1.0000000000e+01	0.0000e+00	-1.0000e+00
-4900101	1	3	3	0	0	+3.1903662457e+02	+1.0699342519e+02	-6.5919869259e+02	7.4018570451e+02	1.0000000000e+01	0.0000e+00	1.0000e+00
4	1	3	3	502	0	-7.4283278193e+02	-7.9801012445e+01	-1.1933773894e+03	1.4079482721e+03	0.0000000000e+00	0.0000e+00	1.0000e+00
-4	1	4	4	0	501	-1.6291407753e+02	+2.6141232281e+02	-2.1785393895e+02	3.7727673914e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00



Removing the mediator means we are doing 2->4 process, and messing up the mother/daughter labels

```
-1 -1   0   0   0  501 -0.0000000000e+00 +0.0000000000e+00 +7.2048883440e+02 7.2048883440e+02 0.0000000000e+00 0.0000e+00 -1.0000e+00
 1 -1   0   0 502    0 +0.0000000000e+00 -0.0000000000e+00 -2.5147676835e+03 2.5147676835e+03 0.0000000000e+00 0.0000e+00 1.0000e+00

4900101  1   4   4   0   0 +5.8671023489e+02 -2.8860473555e+02 +2.7615117181e+02 7.0984580213e+02 1.0000000000e+01 0.0000e+00 -1.0000e+00
-4900101  1   3   3   0   0 +3.1903662457e+02 +1.0699342519e+02 -6.5919869259e+02 7.4018570451e+02 1.0000000000e+01 0.0000e+00 1.0000e+00
   4  1   3   3 502   0 -7.4283278193e+02 -7.9801012445e+01 -1.1933773894e+03 1.4079482721e+03 0.0000000000e+00 0.0000e+00 1.0000e+00
  -4  1   4   4   0 501 -1.6291407753e+02 +2.6141232281e+02 -2.1785393895e+02 3.7727673914e+02 0.0000000000e+00 0.0000e+00 -1.0000e+00
```