ALPGEN update

http://mlm.home.cern.ch/mlm/alpgen

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- Ready-to-use exact LO matrix element calculations for multiparton final states in hadronic collisions
- Parton-level event generation (weighted/unweighted)
  - mass terms and finite width effects
  - spin correlations, also in decays like $t \to bW(\to ff')$
  - cross section exact to all orders in $1/N_c$, colour structure to $O(1/N^2)$
  - EW/QCD interferences available for key processes
- Evolution of the parton level final state through parton shower and hadronization phases, using Herwig or Pythia
- Code available in F77, as well as in a version with some F90 routines (transparent to the user, preferred for CPU performance if compiler available)

Features of the new version, v2

- More processes (single top, gg->H, W gamma, etc)
- Option of CKKW scale-setting procedure
- Matching/merging prescription hard-wired
- Optimized unweighting hard-wired
- Improved structure for passing inputs (cuts, options, parameters,etc) to the executable
- Improved output-file management
- Few, minor, bugs fixed

Available processes

- **WQQ**+N jets, **Z/γ+QQ**+N jets (Q=c,b,t), N≤4
- **W**+ N jets, **Z/γ**+ N jets, N≤6
- **W+c**+ N jets, N≤5
- **QQ** + N jets (Q=c,b,t), N≤6
- **QQQ'Q'** + N jets (Q,Q'=b,t), N≤4 **In V2.0: Q,Q'=b,t,c**
- N jets, N≤6
- QQ+**Higgs**+ N jets (Q=b,t), N≤4
- n**W** + m**Z** + p**Higgs** + N jets, N < n+m+p+N ≤8, N≤3
- n **γ** + N jets, N< n+N≤6

In V2.0:

- single top production: t+q, t+bbar, t+W, t+bbar+W
- Higgs plus multijets, via the ggH vertex

Input-cards structure

All parameters relevant for a given process have a preset default.

The list of parameters of a given process, their labels and preset value can be automatically displayed (or printed) running the code with imode=3,4

```
~/alpha/v20/wjetwork> ./wjetgen
 input generation mode:
 0: generate weighted events, no evt dumps to file
 1: generate wgtd events, write to file for later unweighting
 2: read events from file for unweighting or processing
 3: print parameter options and defaults, then stop
 4: write to par.list parameter options and defaults, then stop
3
 ------
 hard process code (not to be changed):
 ihrd = 3
 ------
 Select pp (1) or ppbar (-1) collisions:
 ih2= -1
 ------
 beam energy in CM frame (e.g. 7000 for LHC):
 ebeam=  980.
 ------
 parton density set:
 ndns= 5
```

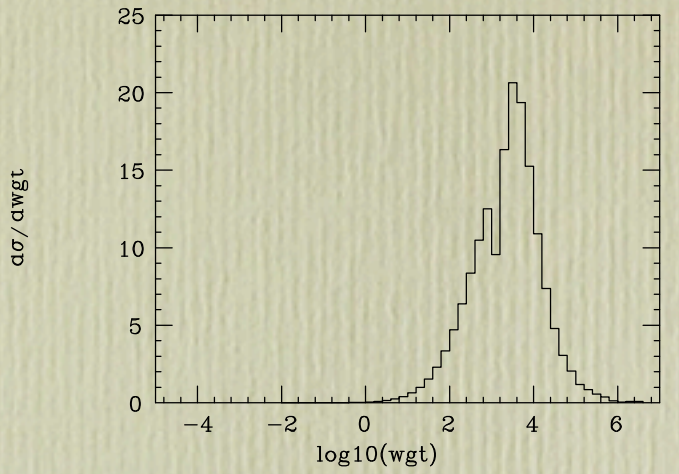
Each parameter is labeled by a string (e.g. “njets”, “ptjmin”), to be used to reset the parameters before a run

Input file, common structure for all processes

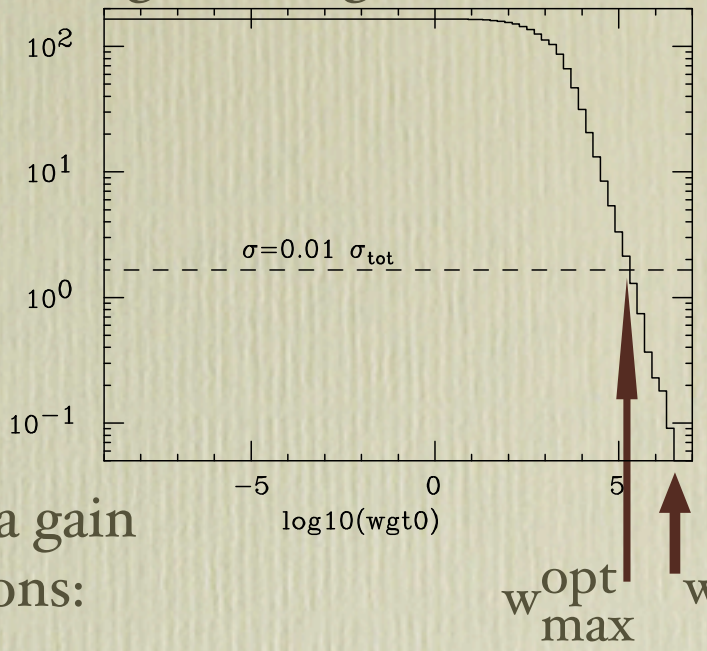
```
1                ! imode
w2j              ! label for files
0 ! start with: 0=new grid, 1=previous warmup grid, 2=previous generation grid
10000 2          ! Nevents/iteration,  N(warm-up iterations)
100000           ! Nevents generated after warm-up
*** The above 5 lines provide mandatory inputs for all processes
*** The lines below modify existing defaults for the hard process under study
print 1          !  display list of parameters and default values
ickkw 1          !  reset parameter "ickkw"
njets 2          !  reset parameter "njets"
ptjmin 20        !  reset parameter "ptjmin"
print 1          !  redisplay list, to make sure its all OK
eoi 1            !  end sequence of inputs
```

Optimized unweighting: example W+3 jet events

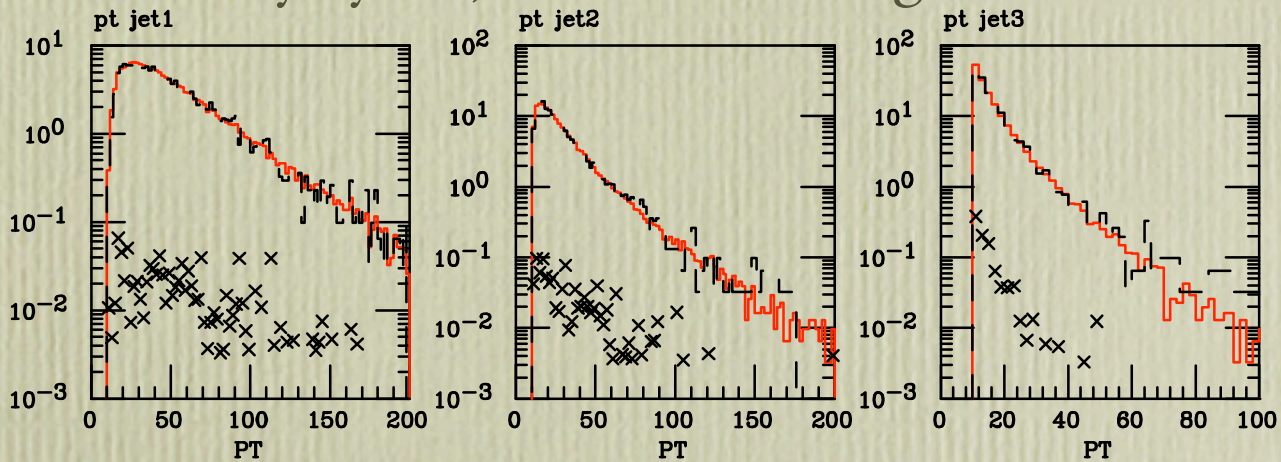
Weight distribution:

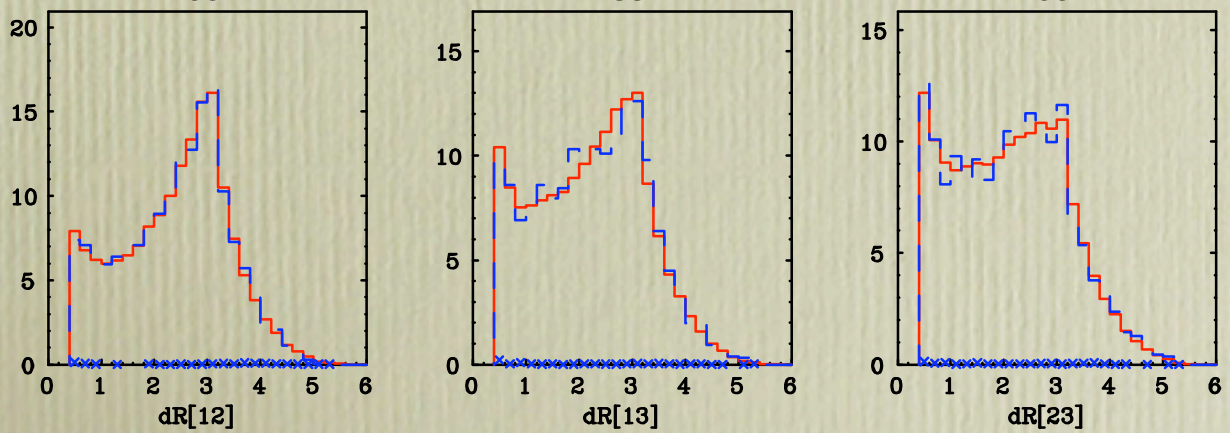


Weights integral distribution:



Unweighting w.r.t. the optimal max weight leads to a gain in efficiency by ~10, without affecting the distributions:





Red histo: optimal unweighting

Dark histo: w_{max} unweighting

x: distribution of events with $w>w_{max}$

No discernible bias!

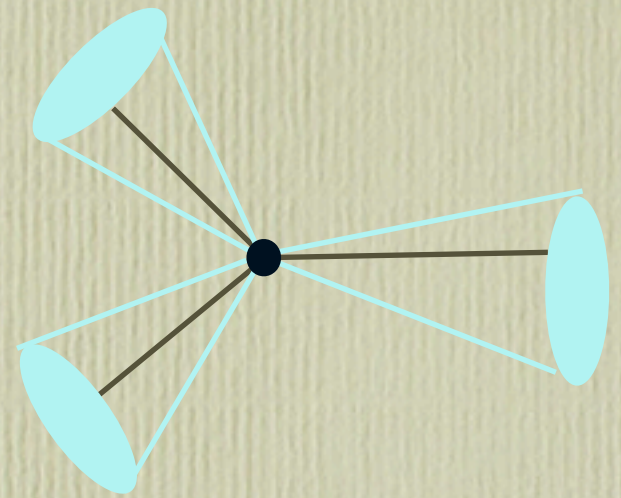
In v20 the optimized unweighting is hard wired, with a threshold of 5% of the total cross-section

Outline of the matching/merging prescription

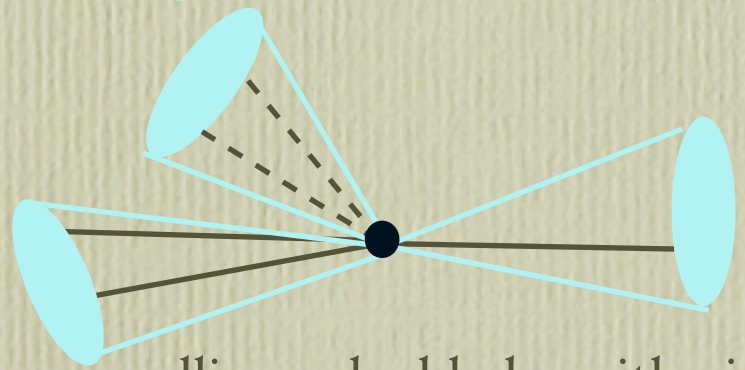
- **Generate parton-level configurations** for a given hard-parton multiplicity N_{part}, with partons constrained by
  - $p_T > p_{T\,min}$ $\quad \Delta R_{jj} > R_{min}$
- **Perform the jet showering**, using the default Herwig/Pythia algorithms
- Process the showered event (**before hadronization**) with a **cone jet algorithm,** defined by
  - $E_{T\,min}$ **and** R_{jet}
- **Match partons and jets:**
  - for each hard parton, select the jet with min $\Delta R_{j\text{-}parton}$
  - if $\Delta R_{j\text{-}parton} < R_{jet}$ the parton is "matched"
  - a jet can only be matched to a single parton
  - **if all partons are matched, keep the event, else discard it**
- This prescription defines an **inclusive sample** of $N_{jet}=N_{part}$ **jets**
- Define an **exclusive N-jet** sample by requiring that the number of reconstructed showered jets N_{jet} be equal to N_{part}
- After matching, combine the exclusive event samples to obtain an **inclusive sample containing events with all multiplicities**

Few examples of matching: ——— hard parton

- - - - - parton emitted by the shower



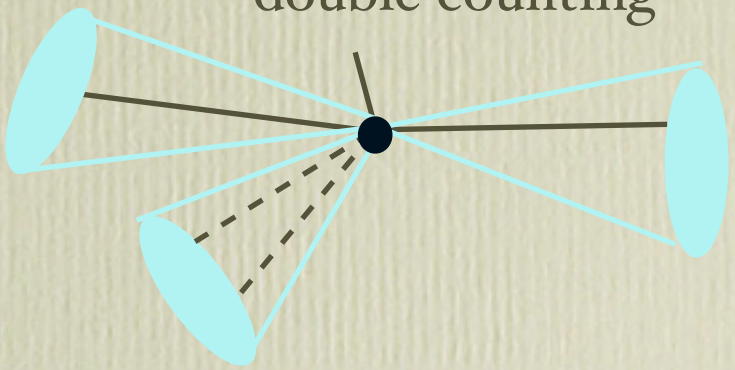
Event matched, $N_{jet}=N_{part}=3$, keep

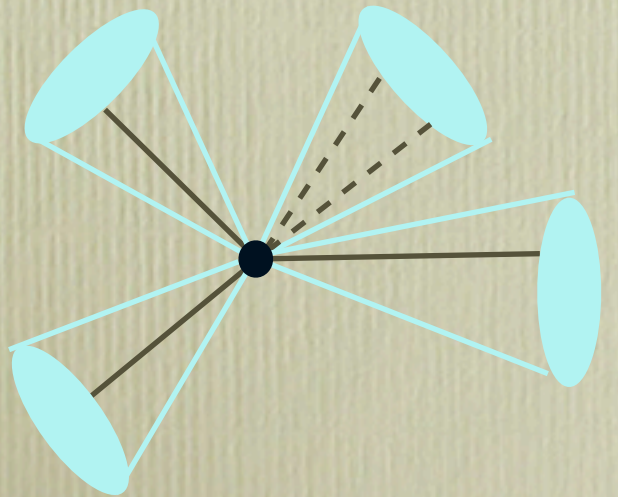


collinear double-logarithmic
double counting

NOT matched,
$N_{jet}=N_{part}=3$,
but $N_{match}=2$
Throw away

soft single-logarithmic
double counting





Event matched, $N_{jet}>N_{part}$, keep for inclusive sample, but throw away for exclusive samples.

Matching implementation, status

CKKW scale setting implemented in the Alpgen parton-level generation for:

W/Z+jets
N jets
ttbar + jets

(turned on by parameter ICKKW=1)

Factorization scale: selected by the user
Renormalization scale: CKKW prescription

In progress for:

W/Z+ b bbar + jets
b bbar + jets

In this case
only the light jets are matched

Jet-parton matching implemented for the above procs using cone jets:

* ET(cluster)= 0.75 * ptjmin
* R(cluster)=dRjmin
* ΔR(parton-jet)>1.5 R(cluster)

Events not passing the matching are thrown away, and counted as "inefficiency", in other words they reduce the cross-section of the sample.

The matching is transparent to the user (if an event doesn't match, the code goes directly to the next event; a matched event carries no special flag)

Processes not in the above list behave as before

Future plans

Immediate future:

complete v2.0 for release:

* overall validation (e.g. against v1.33)
* freezing of the input/output changes (with input form users interfacing pre-release versions in cdf/d0/atlas/cms)
* documentation

v2.1:

Add new processes:

* t tbar gamma gamma
* W/Z + gamma (possibly with anomalous couplings)

Implement matching for other processes:

* vbjets
* gamma + jets