ALPGEN:

an event generator for multi jet processes in hadronic collisions

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ALP: from "ALPHA", the recursive algorithm (numerical sol^{n} of Schwinger Dyson eq's) invented by Caravaglios & Moretti, used here for the evaluation of partonic ME's

KEY FEATURES

(P.L.)

- Parton-level, LO, exact Matrix Elements, with mass effects included.

- Ability to calculate processes of extreme complexity (most of the reactions in our code are calculated here for the first time)

- Event-by-event assignement of:
  - spins (allows factorised decay of unstable particles - W's, top, etc)
  - flavour
  - colour configuration

- Ability to use above information to process events with coherent parton shower MC's and then hadronise.

→ **Fully realistic final states, ready for detector simulation**

LIST of AVAILABLE PROCESSES

W/ $Q\bar{Q}$ + n-jets (light q's or g's)

- $W \to e\nu$ (spin correlations included)
  W-width effects "
- $Q = b, t$
- $n = 0, 1, \ldots, 4$
- Default generation-level cuts available:
  - p_T^{jets}, η^{jets}, ΔR_{jj} (= ΔR_{bj})
  - $p_T^{b,\bar{b}}$, $\eta^{b,\bar{b}}$, $\Delta R_{b\bar{b}}$
  - p_T^{ℓ}, η^{ℓ}, $\not{E}_T$, $\Delta R_{\ell j}$ (= $\Delta R_{\ell b}$)
  - No cuts on the top quarks
  - top → Wb decays w. spin corr^{n} in a forthcoming update.

Z/γ* $Q\bar{Q}$ + n-jets same features as $WQ\bar{Q}$, but:

- $Z/\gamma^* \to e^+e^-$ or $Z \to \nu\bar{\nu}$
- cuts on e^+e^- inv. mass
  - specify (m^{DY}_{min}, m^{DY}_{max})

W + n-jets , Z/γ* + n-jets

- Similar features to $VQ\bar{Q}$ proc's, but no final-state HVQ's.
- Up to 2 light-quark pairs
  → missing 3 light-q pair subprocs in $V + \geq 4$jets & 4 light-q in V+ 6jets :

  e.g. $u\bar{d} \to W^+ s\bar{s}\, u\bar{u}$
  $u\bar{d} \to W^+ u\bar{u}\, d\bar{d}\, s\bar{s}\, d\bar{d}$

  → 3 light-q pairs procs @ Tevatron are $\leq 2\%$ of total

$Q\bar{Q}$ + n-jets ← light q's or g's

- $Q = b, t$
- n-jets ≤ 6
- up to 2 light-q pairs
  (e.g. missing $u\bar{u} \to Q\bar{Q}\, d\bar{d}\, d\bar{d}$)

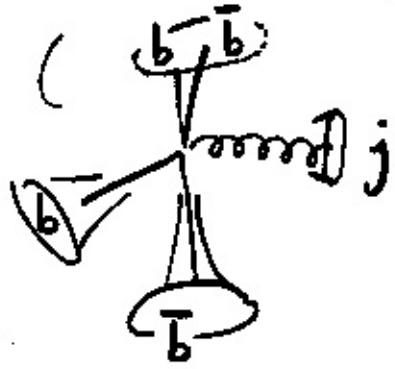
Example $b\bar{b}$ + 4 jets : bg to hadronic $t\bar{t}$ decays

$Q\bar{Q}\ Q'\bar{Q}'$ + n-jets

- $Q, Q' = \{b, t\}$
- n-jets ≤ 4 (up to 1 light-q pair)
- for $n_j = 2$, include $Q\bar{Q}Q'\bar{Q}'\ b\bar{b}$

Examples

- $b\bar{b}\ b\bar{b}$: bg to $b\bar{b}\ H_{\hookrightarrow b\bar{b}}$
- $b\bar{b}\ b\bar{b}\ j$: bg to ≤ 3 b tags in $b\bar{b}\ H_{\hookrightarrow b\bar{b}}$



- $t\bar{t}\ b\bar{b}$: bg to $t\bar{t}\ H_{\hookrightarrow b\bar{b}}$

$Q\bar{Q}\ H$ + n-jets

- Yukawa-induced H production
- n-jets ≤ 4 (all processes up to $n_j \leq 3$, missing 3 light-q pairs for $n_j = 4$)
- includes $Q\bar{Q}\ H\ b\bar{b}$ (bg to $Q\bar{Q}HH$ prod.)

$n\,W + m\,Z + k\,H + \ell$ jets

- $n+m+k+\ell \leq 8$
- $\ell \leq 3$
- Includes the full SM set of couplings:
  - boson production via VB fusion
  - EW couplings of jets
  - Virtual boson interm. states

Examples

- $W^\pm W^\pm W^\mp$ (includes resonant/non-resonant $H^* \to W^+W^-$ proc's)
- $W^\pm H^0$, $Z H^0$
- $q(\bar{q}) W^+ W^-$, $q\bar{q} H$ (includes VB fusion)
- $q(\bar{q}) W^+ W^-$ jet : allows PT study of rap-gap survival probability (keep two fwd/bwd jets, third central)
- $q\bar{q} H$ jet ↗
- Decays of weak bosons, including spin correlations will be implemented in next update.

Still missing

- Real photons
  - γ + jets
  - γ $Q\bar{Q}$ + jets
  - γ W/Z + jets
  - $\gamma\gamma$ + ...
- Light-parton multijets, w.
  $N_j > 4$ ($N_j \leq 4$ is a trivial limit of $Q\bar{Q}$ + N jets)

⇒ Will be part of future updates

RUNNING STRATEGY (ies)

A. Stand-alone calculation of P.L.

X sect's & distributions :

- default generation cuts available
  - ⇒ link, assign cut values, run
- user's access available to personalised analysis module.

B. Generation of unwgt^d events

Phase I:

- same as A. but weighted events are stored for later unweighting - Wgt distributions plotted to optimize unwgt^{ng} efficiency

Store : wgt, random seed, x_i for sanity check

Phase II:

- scan evt file for unwgt^s, write full evt info to file

one executable for A & B

hard process: same executable

C. Shower & hadronization

Phase III:

- Run HERWIG or PYTHIA on these events

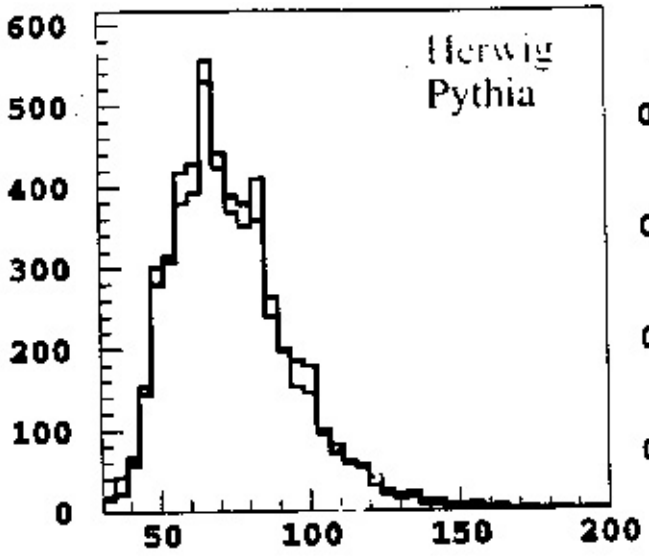
one executable for all processes

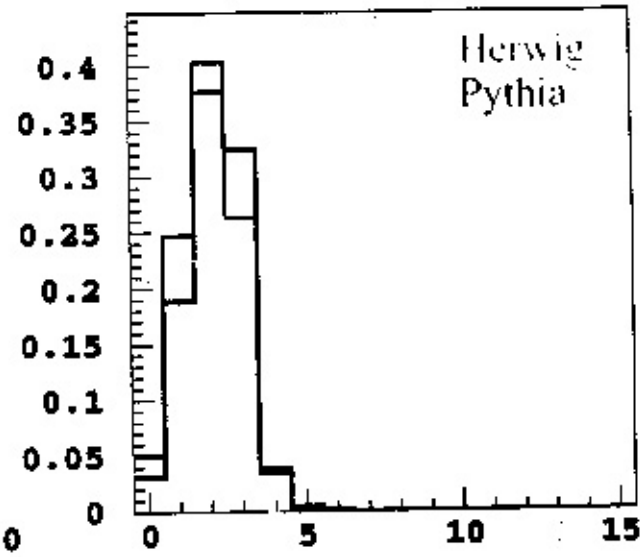
$Wb\bar{b}$ (ALPGEN) + HERWIG PYTHIA

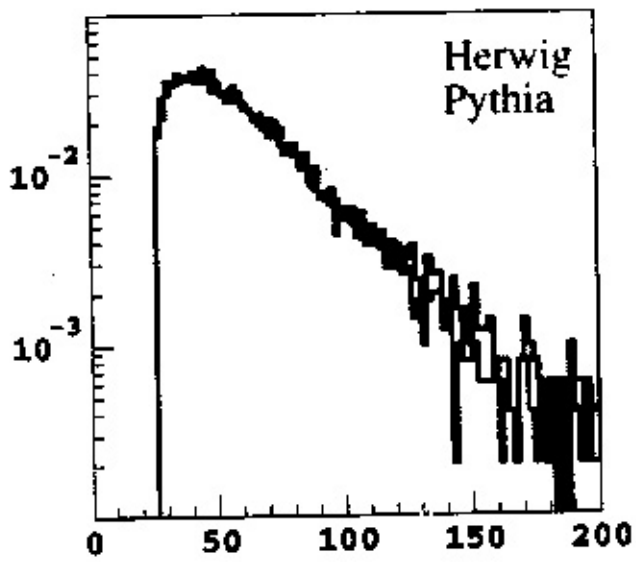
generation cuts
$P_T(b) > 20$ GeV
$|\eta(b)| < 2.5$
$\Delta R_{b\bar{b}} > 0.4$

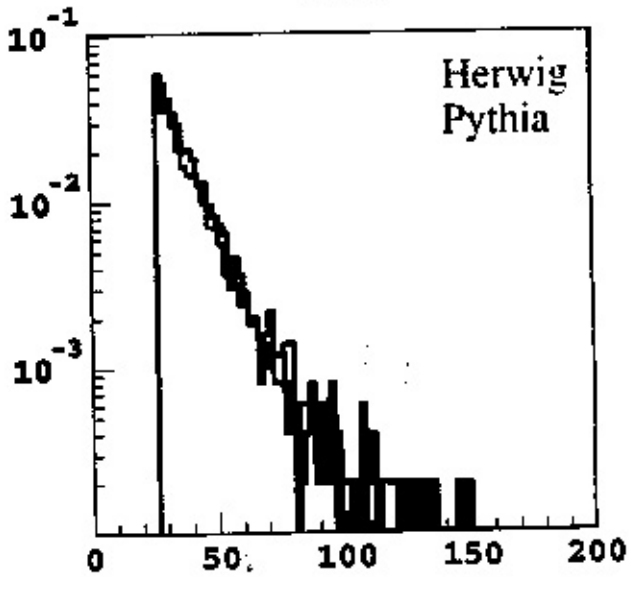
π^0, B stable

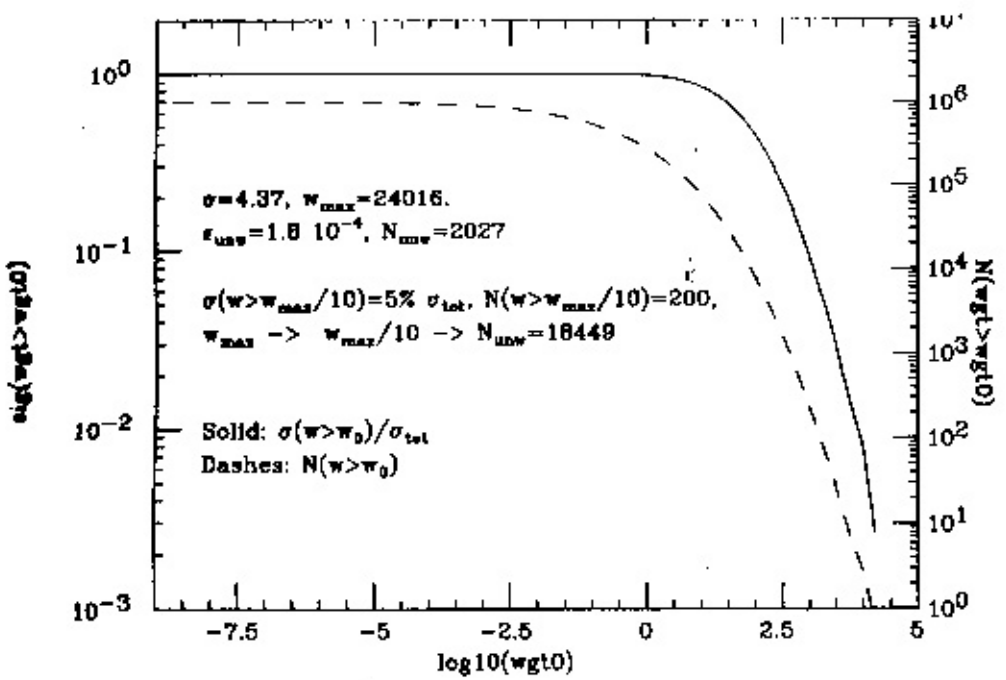
Andrea Messina
(Roma 1)

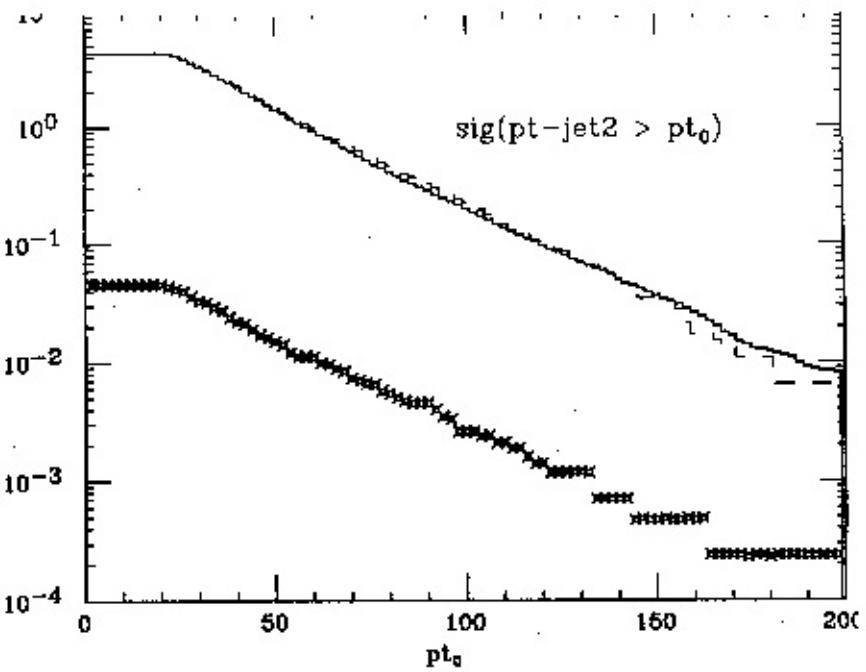


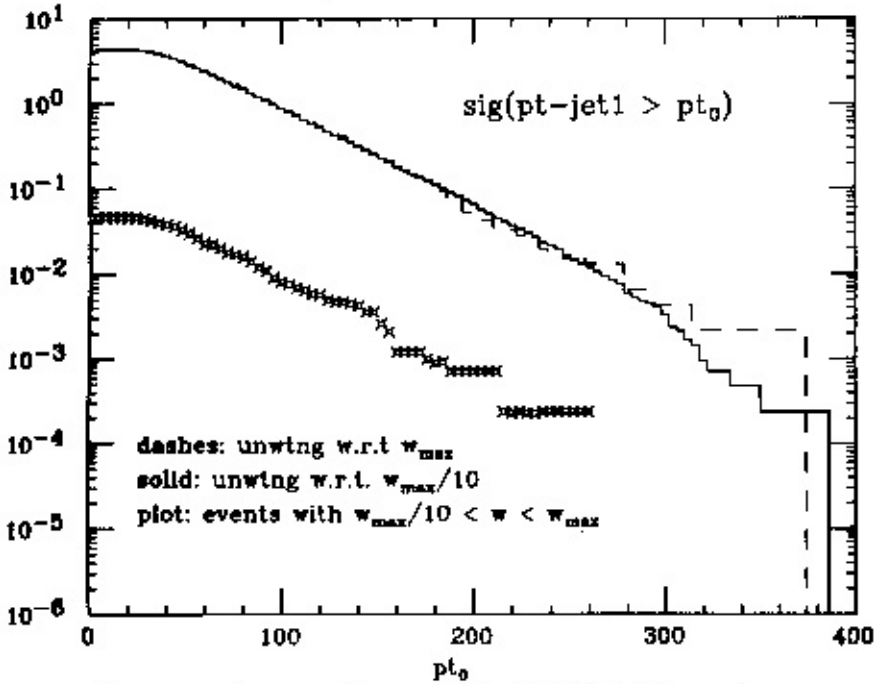


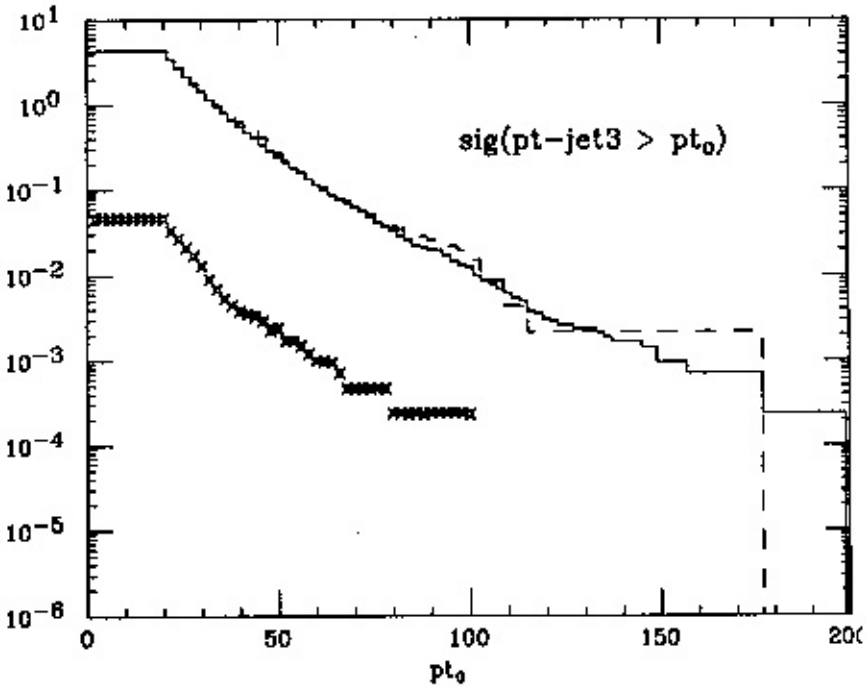












Example of optimization of unweighting, in W+3jet events.
Reduce wmax by factor of 10 : unbiased distributions, large gain in efficiency.