Tuning Priorities for PYTHIA 8

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Key ordering:

I) e^+e^- annihilation

II) $pp/\overline{p}p$

III) ep tuning almost irrelevant for LHC physics!!

Depends too much on extra parameters for photon!

Hard pill to swallow: HERA/DESY allegiance, HZTOOL origins!

Of course still: PDF's, diffractive lessons, . . .

$\mathrm{e}^{+}\mathrm{e}^{-}$ annihilation

Flavour composition

What: particle composition, mainly at the Z^0

Where: table in the Review of Particle Physics, already averaged over experiments.

Why: tune flavour parameters (almost decouples in PYTHIA).

Topological properties

What: charged particle multiplicity distribution, sphericity, thrust, n-jet rates, inclusive particle spectra (longitudinal, in and out of event plane), and so on.

Where: LEP (ALEPH, DELPHI, and OPAL) at Z^0 and maybe higher, Mark II at 29 GeV, JADE reanalyses at several energies.

Why: non-flavour hadronization parameters (a, b, σ) and the FSR shower (α_s, cutoff). Should work at all energies.

Heavy-flavour spectra

What: charm and bottom x spectra, preferably primaries only.

Where: LEP/SLC.

Why: finetuning of Lund–Bowler fragmentation shapes.

Secondary c/b production

What: total rate, if possible differential distributions.

Where: LEP/SLC.

Why: check handling of $\mathrm{g} \to \mathrm{Q}\overline{\mathrm{Q}}$ in FSR.

Light-flavour spectra

What: $\pi/\mathrm{K}/\mathrm{p}$ x spectra and ratios.

Where: LEP/SLC.

Why: tune/check baryon production model.

Correlations

What: charge correlations, baryon-antibaryon pair correlations.

Where: LEP/SLC.

Why: check fragmentation parameters, tune/check baryon production model.

Hadron colliders

$\gamma^*/\mathbf{Z}^0$ $p_\perp$ spectra

What: the $p_\perp$ spectrum for Drell-Yan pairs in specific mass intervals.

Where: Z^0 at the Tevatron and $\mathrm{Sp\overline{p}S}$, lower masses also at fixed target/ISR.

Why: tune the ISR shower (α_s, cutoff) and the primordial $k_\perp$.

Inclusive jet rates

What: the single-inclusive reasonably-hard jet rate ($p_\perp = 20 - 100$ GeV, say, so little multiple interactions), as a function of $p_\perp$ and rapidity.

Where: Tevatron, RHIC pp for energy (in)dependence.

Why: tune/test QCD processes, specifically K factor.

Multi-jets

What: rates and relative distributions (angles and $p_\perp$'s) for arbitrary n-jet events, both for QCD processes, $\mathrm{Z}^0/\mathrm{W}^\pm$ production and photon pairs.

Where: Tevatron.

Why: check the upper range/matching of the ISR and FSR algorithms.

Jet shapes

What: the differential flow of particles and energy around a jet direction (hardest jet, second hardest, third hardest separately?)
Where: Tevatron.
Why: at large separations it checks especially that FSR is correctly matched on to the ISR showers (including coherence phenomena), at small separations that FSR/hadronization jet universality matching works.

Minimum-bias event properties

What: charged multiplicity distribution, forward-backwards correlations (charged multiplicity in two $\Delta y = 1$ bins with varying central gap).
Where: UA5 at 200 and 900 GeV (and intermediate), E735 at 1800 GeV (and lower; note disagreement with UA5), RHIC at 200 GeV (crosscheck).
Why: tune multiple-interactions parameters.

Transverse momenta

What: $\langle p_\perp \rangle (n_{\mathrm{charged}})$.
Where: Tevatron, $\mathrm{Sp\overline{p}S}$, RHIC pp.
Why: is very sensitive to the way colours are hooked up between the multiple interactions. Energy dependence very useful.

Minijet rates

What: the probability distribution in the number of jets per event, for varying cone sizes and $p_{\perp \mathrm{min}}$ values, extending very far down in $p_{\perp \mathrm{min}}$. Even if not ”proper” jets, these gauge the ”lumpiness” of the energy flow.

Where: Tevatron, RHIC pp, UA1.

Why: tune multiple-interactions parameters.

Jet pedestal

What: underlying activity as function of jet trigger $p_{\perp}$.

Where: Tevatron, $\mathrm{Sp\overline{p}S}$, RHIC pp.

Why: tune multiple-interactions, especially impact-parameter profile.

Medium-rare processes

What: production of c and b, J/ψ and prompt photons.

Where: Tevatron, RHIC pp.

Why: these processes ought to be part of the multiple-interactions description of mimimum-bias physics. Therefore useful to checks whether one can indeed obtain a sensible description in this context.

HERA and hadronic collisions

Beam remnants

What: beam-jet properties, such as spectra of leading particles.

Where: HERA, fixed-target (many old, Compass still running).

Why: the structure of remnants (including or not interplay with multiple interactions).

Charm

What: asymmetries between charm and anticharm hadrons.

Where: fixed target.

Why: constrains collapse of a charm quark with valence quarks, and more generally treatment of low-mass string systems.

Diffractive physics

What: integrated and differential (scattering angle and mass) cross sections for elastic and diffractive events. Rapidity gap rates.

Where: Tevatron, RHIC pp, HERA.

Why: tune PYTHIA elastic/diffractive parameters. Currently PYTHIA does not handle hard diffractive physics, so only "damage control" there.