Important notes on using Pythia 6.3 (v. 6.324+)

P. Skands, September '05

PYTHIA 6.3 contains 3 major features not present in PYTHIA 6.2:

- A new model for the underlying event in hadron–hadron collisions. It is available either by calling the routine `PYEVNW` directly to generate events, or by using `MSTP(81)>20` with `PYEVNT`. A brief overview of the new features is given below.

- New $p_\perp$–ordered parton showers (both FSR and ISR). For events generated with the new multiple interactions framework, these showers are default, while the old mass–ordered showers are the default when using the old multiple interactions framework, see the update notes [1] for details.

- An interface to SUSY Les Houches Accord format SUSY spectra and decay tables [2]. See the PYTHIA 6.3 manual [3] and update notes [1] for details.

For example main programs using these features and more, see the PYTHIA 6.3 homepage: `http://www.thep.lu.se/~torbjorn/Pythia.html`

Important notes on the underlying event

The default parameters for the underlying event model in PYTHIA 6.3 were chosen to reproduce only a few Tevatron distributions approximately, and so should *not* be taken as the word of the gospel. To produce the most reliable underlying event simulation for physics studies, it is therefore still recommended to use the old underlying event framework, with the parameters of Rick Field's Tune A [4] or similar [5].

The new model *is* more sophisticated in many respects but has not been tuned to the same extent and is still in a development stage, so that its usefulness for ordinary users is at present limited to "playing around with the parameters", e.g. to gauge the impact of possible variations of the physics model.

There are also a few potential pitfalls that any user should be aware of, as follows:

- Baryon number violating SUSY decays *should not* be switched on together with the new underlying event model, as this would lead to unpredictable behaviour at the fragmentation stage.
- So far, we have concentrated almost exclusively on proton beams, although provision has been made for handling meson beams as well. Photon beams are not handled.
- Heavy quark decays (with showers) *after* hadronisation may lead to problems.

Parameters controlling the underlying event

Here, we just give a brief comment describing the meaning of each of the relevant parameters. The possible values that can be assigned etc. are described in detail in the update notes [1], which may serve as a convenient reference, with more elaborate explanations in the manual [3] and detailed physics descriptions (and studies) in two recent publications [6].

Switches:

MSTP(61)	Master switch for initial–state radiation. Default is on.
MSTP(70)	Selects regularization scheme for ISR when $p_\perp \to 0$. Default is sharp cutoff at the regularization scale used for MI.
MSTP(71)	Master switch for final–state radiation. Default is on.
MSTP(72)	Selects maximum scale for radiation off FSR dipoles stretched between ISR partons. Default is $p_\perp$ scale of radiating parton.
MSTP(81)	Selects the basic multiple interactions and beam remnant framework. Interpretation depends on whether PYEVNT or PYEVNW is called.
MSTP(82)	Selects which functional form to assume for the impact-parameter dependence of the matter overlap between two beam particles. Default is a gaussian ansatz for the matter distribution inside a beam particle.
MSTP(84)	Selects whether initial–state radiation is turned on or off for subsequent interactions (i.e. interactions after the main one). Default is on. (MSTP(61) off takes precedence and will override this.)
MSTP(85)	Selects whether final–state radiation is turned on or off for subsequent interactions (i.e. interactions after the main one). Default is on. (MSTP(71) off takes precedence and will override this.)
MSTP(86)	Selects whether the multiple interactions are required to be softer than the main process. Default is to allow harder multiple interactions when the main process is not itself of the QCD jets type.
MSTP(87)	Controls the large-x behaviour of the parton distributions used for "companion quarks" (partners of knocked–out sea quarks).
MSTP(88)	Controls if and how composite objects are formed in the beam remnant.
MSTP(89)	Controls how initial–state parton shower initiators are colour–connected to each other. Default is to assume a rapidity ordering.
MSTP(90)	Controls the sharing of "primordial $k_\perp$" recoils.
MSTP(91:94)	Not used in the new model.
MSTP(95)	Switch for colour reconnections. Default is on.
MSTP(96)	Selects shape of primordial $k_\perp$ distribution. Default is gaussian.

Parameters:

PARP(78)	Controls the amount of colour reconnection in the final state.
PARP(79)	Enhancement factor for x values of composite systems (e.g. diquarks) in the beam remnant.
PARP(80)	Suppression factor for initial–state colour connections that would break up the beam remnant.
PARP(82)	Regularization scale, $p_{\perp 0}$, for multiple interactions, at reference energy PARP(89). Default is 2 GeV.
PARP(83:84)	Shape parameters, controlling the assumed matter distribution or overlap profile, as applicable (i.e. depending on MSTP(82)).
PARP(85:86)	Not used in the new model.
PARP(89)	Reference energy for energy rescaling of $p_{\perp 0}$ cutoff, i.e. the energy scale at which $p_{\perp 0}$ is equal to PARP(82). Default is 1800 GeV.
PARP(90)	Power of energy rescaling used to determine the value of $p_{\perp 0}$ at scales different from the reference scale PARP(89).
PARP(91:92)	Not used in the new model.
PARP(93)	Upper cutoff for primordial $k_\perp$. Default is 5 GeV.

References

[1] Pythia 6.3 update notes,
www.thep.lu.se/∼torbjorn/pythia/pythia6324.update

[2] P. Skands *et al.*, SUSY Les Houches accord: Interfacing SUSY spectrum calculators, decay packages, and event generators, JHEP **0407** (2004) 036 [hep-ph/0311123].
See also: www.thep.lu.se/∼zeiler/slha/

[3] T. Sjöstrand *et al.*, PYTHIA 6.3 physics and manual, hep-ph/0308153

[4] R.D. Field, arXiv:hep-ph/0201192 CDF Note 6403; further recent talks available from webpage http://www.phys.ufl.edu/∼rfield/cdf/

[5] For ATLAS, see e.g. work and talks by A. Moraes. For CMS, P. Bartalini.

[6] T. Sjöstrand and P. Skands, Transverse-momentum-ordered showers and interleaved multiple interactions, EPJ **C39** (2005) 129;
T. Sjöstrand and P. Skands, Multiple interactions and the structure of beam remnants, JHEP **0403** (2004) 053.