Survey of interesting or useful switches and parameters

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Here we will only scratch the surface;
450 pp of manual gives the full story!
Utilities

MSTP(125) = 2: retain complete parton-shower history.
MSTP(125) = 1: retain short summary of the hard process story plus ultimate string/particle configuration.
MSTP(125) = 0: only retain ultimate string/particle configuration.
CALL PYEDIT(1) : only keep final-state particles.
CALL PYEDIT(3) : only keep charged final-state particles.

MSTP(128): different mother pointer choices in resonance decays.

CALL PYGIVE(‘variable = value’) : set common block variable.

CALL PYLIST(1) : list event in 80-column format (incomplete).
CALL PYLIST(2) : list event in 132-column format, no vertices.
CALL PYLIST(3) : list event in 132-column format, with vertices.

CALL PYCELL(NJET) : simple UA1-inspired cone jet finder.
CALL PYCLUS(NJET) : e^+e^- -type jet finder (Lund, JADE, Durham).

CALL PYBOOK(ID,TITLE,NXBIN,XLOWER,XUPPER) : book simple histogram.
CALL PYFILL(ID,X,WEIGHT) : fill simple histogram.
CALL PYHIST : print (and reset) all simple histograms.
Hard processes — basics

MSEL = 0: pick your wanted set of processes I by MSUB(I) = 1;

MSEL = 1, CKIN(3) > ~10 : QCD jet production with $p_\perp > CKIN(3)$; $p_\perp \to 0$ divergence $\Rightarrow$ inconsistencies for small CKIN(3).

MSEL = 1, (CKIN(3) = 0.): “minimum bias”, including unitarized jets but excluding elastic/diffractive;

MSEL = 2, (CKIN(3) = 0.): “minimum bias”, including elastic/diffractive.

For $s$-channel resonances, like $q\bar{q} \to \gamma^* / Z^0 \to \ell^+ \ell^-$,
$CKIN(1) < \hat{m} < CKIN(2)$.

For $2 \to 2$ processes, like $qg \to \bar{q}g$, $CKIN(3) < \hat{p}_\perp < CKIN(4)$. Note: $p_\perp$ changed by showers, so important smearing effects.
The same is true for many other CKIN variables.

Irrespective of smearing, it is consistent to split cross section into a set of consecutive non-overlapping $\hat{p}_\perp$ (or $\hat{m}$) bins.
Hard processes — specialized

**MSTP(33) = 1**: multiply all (perturbative) cross sections by a “$K$ factor” **PARP(31)**.

**MSTP(142) = 2**: define your own event-by-event “$K$ factor” in **PYEVWT** routine.

There is an “infinity” of switches specific to the hard process selected.

**MSTP(43)**: allow pure $\gamma^*$, pure $Z^0$ or full $\gamma^*/Z^0$ interference.

**MSTP(25)**: allow mixed CP-even and CP-odd Higgs in

$$h^0 \rightarrow W^+ W^- / Z^0 Z^0 \rightarrow f_1 \bar{f}_2 f_3 \bar{f}_4.$$ 

**IMSS(1)**: master switch SuperSymmetry scenario, default 0 = off.

**RMSS(5)**: $\tan \beta$ if SUSY on.

**PARU(141)**: $\tan \beta$ if SUSY off; else overwritten by **RMSS(5)**.

**ITCM(1)**: number of TechniColors.
Parton densities and Scales

\( \text{MSTP}(51) = 7: \) CTEQ 5L parton densities.

\( \text{MSTP}(51) = 8: \) CTEQ 5M1 parton densities (NLO!).

\( \text{MSTP}(51) = 4: \) GRV 94L parton densities.

\( \text{MSTP}(52) = 2: \) link to PDFLIB with \( \text{MSTP}(51) = 1000 \times \text{NGROUP} + \text{NSET} \);
requires that dummy PDFSET and STRUCTM routines not linked;
can also be used as interface to LHAPDF

\( \text{MSTP}(3) = 2: \) set \( \Lambda_{QCD} \) value according to the choice of PDF set,
defined for 4 flavours, except FSR showers in resonances (\( \approx \) LEP).

\( \text{MSTP}(3) = 1: \) set \( \Lambda_{QCD} \) value by hand separately for
(a) hard interactions, (b) ISR, (c) FSR except resonances,
(d) FSR in resonances, defined for 5 flavours.

\( \text{PARP}(1) : \) \( \Lambda_{QCD} \) for hard interaction.

\( \text{MSTP}(32) = 8: \) the \( 2 \rightarrow 2 \) hard interaction process scale
\[ Q^2 = (m_{13}^2 + m_{14}^2)/2 = p_\perp^2 + (m_3^2 + m_4^2)/2. \]

\( \text{MSTP}(32) = 4: \) \( Q^2 = \hat{s} \) instead.
Resonances

“Resonance” = massive unstable, i.e. $Z^0$, $W^\pm$, $t$, $h^0$, SUSY, Technicolor, ...., but not hadrons like $\rho^0$ and not $\mu^\pm$, $\tau^\pm$.

CALL PYSTAT(2) : print resonance info (after PYINIT call).

MSTP(41) = 0/1/2: perform resonance decays, no/yes/conditional, in latter case set individually in MDCY(KC,1) after PYINIT call.

MSTP(42) = 0/1: pick resonance mass at nominal value or according to Breit-Wigner; does not work for single s-channel resonance.

MSTP(47) = 0/1: decays isotropic or according to proper matrix elements (where implemented).

MSTP(110) > 0: multiply width of resonance $KF = MSTP(110)$ by a factor PARP(110).

MWID(KC) = 0 : not resonance; fixed width.
MWID(KC) = 1 : resonance, dynamically calculated width(s).
MWID(KC) = 2 : resonance, (almost) fixed tabulated width(s).
Final-state showers

**MSTP(71) = 0/1**: master switch off/on.

FSR in resonance decay

- $u \to bg$ in top decay partly constrained by $Z^0 \to b\bar{b}g$
- $W^± \to q\bar{q}' = Z^0 \to q\bar{q}$ to high accuracy

**PARJ(81) = 0.29**: $\Lambda_{QCD}$ for resonance FSR, for 5 flavours, extreme range would be 0.2 – 0.4.

**PARJ(82) = 1.0**: lower invariant-mass cutoff $m_{\text{min}}$ for shower evolution.

**PARP(72)**: $\Lambda_{QCD}$ for non-resonance FSR (e.g. off top *before* decay), cf. MSTP(3), extreme range would be 0.1 – 0.5.

**PARP(71) = 4.**: $Q^2_{\text{shower, max}} = \text{PARP}(71) \times Q^2_{\text{hard interaction}}$;
- $p_{\perp}^2 \approx z(1 - z)m^2 < m^2/4$ motivates default, extreme range 1. – 16.
Initial-state showers (+ interference)

\[ \text{MSTP}(61) = 0/1 : \text{master switch off/on.} \]

\[ \text{MSTP}(67) = 0 \]
\[ \text{MSTJ}(50) = 0 \]

\[ \text{switch off} \]
\[ \text{destructive interference} \]
\[ \text{ISR/FSR} \]

\[ \text{PARP}(61) : \Lambda_{QCD} \text{ for ISR, cf. MSTP(3), extreme range } 0.1 - 0.5. \]

\[ \text{PARP}(62) = 1.0 : \text{lower cutoff } Q_{\text{min}} \text{ for shower evolution.} \]

\[ \text{PARP}(64) = 1.0 : \alpha_s \text{ and PDF scale } Q^2 = \text{PARP}(64) \times p^2_\perp. \]

\[ \text{PARP}(67) = 4. : Q^2_{\text{shower, max}} = \text{PARP}(67) \times Q^2_{\text{hard interaction}}; \]
\[ p^2_\perp \approx (1 - z)m^2 \text{ motivates default } > 1, \text{ extreme range } 1. - 8. \]

\[ \text{MSTP}(68) = 1 : \text{put } Q^2_{\text{shower, max}} = s \text{ for single-resonance production with ME matching } (\gamma^*/Z^0, W^\pm, h^0, \ldots) \]
Beam remnants and Multiple interactions

**PARP(91) = 2.0**: width of Gaussian primordial $k_\perp$ distribution; uncomfortably high, but seems required by data.

MI range well represented by parameters of Rick Field’s tunes:

**MSTP(81) = 0/1**: master switch off/on.

**PARP(82) = 2.0**: $p_{\perp 0}$ regularization of the divergent cross section in the $p_\perp \to 0$ limit, vary in range $1.8 - 2.2$

**PARP(89) = 1800., PARP(90) = 0.25**: rescale $p_{\perp 0}$ with CM energy like $(E_{cm}/\text{PARP}(89))^{\text{PARP}(90)}$.

**MSTP(82) = 4**: assume a double Gaussian matter profile for the incoming hadrons,

**PARP(83) = 0.5**: with half of the matter in a central core,

**PARP(84) = 0.4**: of radius 40% of that of the rest.

**PARP(85) = 0.9, PARP(86) = 0.95**: assume 90% of the additional interactions are of the $gg \to gg$ type, with colour connections so as to minimize the additional string length from multiple interactions.
Hadronization

Tuned to LEP; if “jet universality” then minor issue.

MSTP(111) = 0/1 : master switch off/on.

PARJ(1) = 0.1 : diquark/quark production ratio.
PARJ(2) = 0.3 : s quark to u or d quark production ratio.
PARJ(11) = 0.5, PARJ(12) = 0.6 , PARJ(13) = 0.75, : vector meson fraction of primary mesons for light, strange, and charm+bottom

PARJ(41) = 0.3, PARJ(42) = 0.58 : parameters $a$ and $b$ of Lund-Bowler symmetric fragmentation function $f(z) = z^a \exp(-bm^2) / z^{1+bm^2}$

MSTJ(11) = 3 : switch to alternative forms for heavy quarks,
e.g. with Peterson $\epsilon_c = -$PARJ(54) and $\epsilon_d = -$PARJ(55)
not really required, but fundamentalist religious dogma

PARJ(21) = 0.36 : width of Gaussian fragmentation $p_\perp$ distribution
Particle data and Decays

**KF**: particle identity code, PDG standard.

**KC**: compressed code, in range 1 – 500, used as entry to data tables,

\[KC = PYCOMP(KF)\].

**CALL PYLIST(12)**: list particle and decay data defined in program.

**PMAS(KC,1)**: particle mass.

**PMAS(KC,2)**: particle width.

**PMAS(KC,3)**: maximum deviation from nominal mass.

**PMAS(KC,4)**: particle lifetime \(ct\) (in mm).

**PARF(94)** = 1.23, **PARF(95)** = 4.17: starting values for running \(c\) and \(b\) masses, especially for Higgs couplings.

**MDCY(KC,1)** = 0/1: decay of particle is off/on.

**MDCY(KC,2)**, **MDCY(KC,3)**: decay channels IDC are stored in range from **MDCY(KC,2)** to **MDCY(KC,2)** + **MDCY(KC,3)** − 1.

**MDME(IDC,1)** = 0/1/−1: individual decay channel IDC is off/on/nonexisting; off reduces cross section for resonance production; nonexisting not, further options allow separate particle/antiparticle choices.

**BRAT(IDC)**: branching ratio for decay channel IDC.