2. PYTHIA VERSION 4.1

(version 4.1, June 1985)

The Lund Monte Carlo for QCD High-$p_\perp$ Scattering

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2.1 Introduction

PYTHIA is a program intended for the study of high-pt physics in hadronic interactions. In its present form it includes hard scattering matrix elements, structure functions and initial and final state parton showers. Fragmentation is done using the ordinary Lund fragmentation model, JETSET version 6.2, but an important task for PYTHIA is to set up the correct string configuration, particularly nontrivial for the low-pt target remnants.

The program presented here, PYTHIA version 4.1, deviates from previous versions by the inclusion of initial and final state radiation, as well as the production of intermediate W and Z bosons. This has necessitated a complete restructuring of commonblocks, as outlined below, whereas the user subroutine calls are essentially unchanged. The program descriptions

H.-U. Bengtsson, Computer Phys. Comm. 31 (1984) 323
H.-U. Bengtsson, G. Ingelman, Computer Phys. Comm. 34 (1985) 251 (somewhat modified version of LUTP 84-3 and Ref.TH.3820-CERN)

are of limited use for programming purposes, but contain useful information about physics assumptions. In particular, the description below is very sketchy for details that are unchanged from these publications. The initial state radiation algorithm is described in

T. Sjöstrand, Phys. Lett 157B (1985) 321

Fragmentation is performed using JETSET version 6.2; because of common block lengths etc. no earlier version will work. The published description of JETSET T. Sjöstrand, Computer Phys. Comm. 27 (1982) 243 accurately reflects the basic programming filosophy, but for details of the present program users are referred to a companion file, available on request (together with the program itself).

The program is written completely in Fortran 77. Two non-standard functions are required. One is RLU, which is to give a random number between 0 and 1; a dummy function with this name is available in JETSET 6.2, with some examples how it can be linked to existing random number generators. The other is the ordinary Γ function, called as GAMMA(X), which e.g. may be available in FORTRAN 77.

2.2 Routines to be called by the user

The two main routines that a user encounters are PYINIT, which initializes the event generation, and PYTHIA, which generates one event of the required type for each subsequent call. In addition, PYSTAT may be used to print out cross section statistics, PYFRAM to boost event between CM and lab frame and PYKCUT to introduce kinematical cuts on the hard scattering.

SUBROUTINE PYINIT(FRAME,BEAM,TARGET,WIN,QTMIN)
Purpose: to initialize the generation procedure. Note that capital letters are used for the character arguments below; this may make a difference on some machines.
FRAME : a character variable used to specify the frame of the experiment.
= 'FIXT' : fixed target experiment, with beam particle momentum pointing in +z direction.
= 'CMS' : colliding beam experiment in CM frame, with beam momentum in +z direction and target momentum in -z direction.
= 'USER' : full freedom to specify frame by giving beam momentum in P(1,1), P(1,2) and P(1,3) and target momentum in P(2,1), P(2,2) and P(2,3) in commonblock LUJETS.
BEAM, TARGET : character variables to specify beam and target particles.
= 'P' : proton.
= 'PBAR' : antiproton.
= 'N' : neutron.
= 'NBAR' : antineutron.
= 'PI+' : positive pion.
= 'PI-' : negative pion.
WIN : related to energy of system, exact meaning depends on FRAME.
FRAME='FIXT' : momentum of beam particle.
FRAME='CMS' : total energy of system (sqrt(s)).
FRAME='USER' : dummy.
QTMIN : minimum transverse momentum of the central hard parton-parton scattering. Since the QCD cross sections are divergent at small qt, it is recommended that this value never be put smaller than 2 GeV, unless only W and/or Z production is studied. Because of initial and final state radiation and mass effects, the actual qt distribution of jets will not cut off sharply at QTMIN.

SUBROUTINE PYTHIA
Purpose: to generate one event of the type specified by the PYINIT call. (This is the main routine, which calls a number of other routines for specific tasks.)

SUBROUTINE PYSTAT
Purpose: to print out a table of how many events have been generated of the different kinds and give the corresponding cross sections. All figures already include the effects of cuts required by the user in PYKCUT. PYSTAT may be called at any time, e.g. at the end of the run, or not at all.

SUBROUTINE PYFRAM(IFRAME)

Purpose: to transform event between different frames, if so desired.

IFRAME : specification of frame the event is to be boosted to.

= 1 : frame specified by user in the PYINIT call.

= 2 : CM frame of incoming particles.

SUBROUTINE PYKCUT(X1,X2,SHAT,THAT,QT,Q2,ICUT)

Purpose: to enable a user to reject a given set of kinematic variables at an early stage of the generation procedure, so as not to spend unnecessary time on the generation of events that are not wanted. A dummy routine PYKCUT is included in the program file.

X1,X2 : Feynman-x values for the two incoming partons at the hard scattering.

SHAT : invariant mass-square of incoming partons.

THAT : momentum transfer of hard scattering.

QT : transverse momentum of the two outgoing partons in frame where incoming partons are back-to-back.

Q2 : scale of hard interaction, as used e.g. for α_s.

ICUT : flag giving the decision of the user.

= 0 : event is to be retained and generated in full.

= 1 : event is to be rejected and a new one generated.

2.3 Common blocks

COMMON /PYPARA/ IPY(40),PYPAR(40),PYVAR(40)
Purpose: to give access to status code and parameters which regulate the performance of the program. If the default values, below denoted by (D = ...), are not satisfactory, they must be changed before the PYINIT call.

IPY(1) : (D = 0) calculation of differential cross section maximum for QCD, W and/or Z production.
- = 0 : not known, to be calculated at initialization.
- = 1 : known, stored in PYVAR(1) - PYVAR(3) by user before initialization.

IPY(2) : (D = 0) possibility to have events with weights; used to increase the number of events with a high qt (defined for the hard scattering) at the expense of giving the events smaller weights at higher qt. For obvious reasons, nonzero IPY(2) can not be used if QTMIN = 0. in PYINIT, as is otherwise allowed for W and/or Z production.
- = 0 : all events have weight 1, i.e. the user need not bother about weights.
- = 1 : events have an associated weight (qtmin/qt)**2, stored in PYVAR(19), meaning that the relative probability to have an event at qt has been increased by a factor qt**2.
- = 2 : events have an associated weight (qtmin/qt)**4, stored in PYVAR(19), meaning that the relative probability to have an event at qt has been increased by a factor qt**4.
- = 3 : events have an associated weight (qtmin/qt)**6, stored in PYVAR(19), meaning that the relative probability to have an event at qt has been increased by a factor qt**6.

IPY(3) : (D = 1) calculation of α_s in hard scattering
- = 0 : fixed α_s given by PYPAR(3)
- = 1 : first order running α_s

IPY(4) : (D = 1) Q2 definition in hard scattering for QCD processes; for W and Z production it is always chosen to be M**2/4.
- = 1 : Q2 = 2*SHAT*THAT*UHAT/(SHAT**2 + THAT**2 + UHAT**2)
- = 2 : Q2 = THAT*UHAT/SHAT = pt2 (of hard scattering)
- = 3 : Q2 = −THAT
- = 4 : Q2 = min(−THAT, −UHAT)

IPY(5) : (D = 5) max number of active flavours in α_s of hard scattering

IPY(6) : not used

IPY(7) : (D = 1) choice of structure functions
- = 0 : simple scaling functions
- = 1 : EHLQ set 1 for p, Owens set 1 for π
- = 2 : EHLQ set 2 for p, Owens set 2 for π
- = 3 : Duke-Owens set 1 for p, Owens set 1 for π
- = 4 : Duke-Owens set 2 for p, Owens set 2 for π
- = 5 : Gluck-Hoffman-Reya for p, Owens set 2 for π

IPY(8) : (D = 5) maximum number of quark flavours in structure
functions, and thereby also for initial state spacelike showers

IPY(9) : not used

IPY(10) : (D = 1) use of interference term in matrix elements
= 1 : excluded (i.e. string-inspired matrix elements)
= 2 : included (i.e. conventional QCD matrix elements)

IPY(11) : (D = 5) maximum outgoing flavour allowed, both for hard
scattering and subsequent timelike showers (see MSTE(15)).
At the hard scattering, the production of new flavours
also depend on the INNEW flags, see below.

IPY(12) : not used

IPY(13) : (D = 1) final state timelike parton showers
= 0 : not included
= 1 : included

IPY(14) : (D = 2) initial state spacelike parton showers
= 0 : not included
= 1 : included, associated timelike partons put on mass shell
= 2 : included, associated timelike partons may shower

IPY(15) : (D = 1) treatment of soft gluon emission in spacelike
parton shower evolution.
= 0 : soft gluons are entirely neglected.
= 1 : soft gluon emission is resummed and included together
with the hard radiation as an effective z shift.

IPY(16) : (D = 1) primordial kt distribution
= 0 : none
= 1 : Gaussian, width given in PYPAR(7)
= 2 : exponential, width given in PYPAR(8).

IPY(17) : (D = 1) energy partitioning in hadron remnant. The energy
fraction χ taken by one of the two objects, with conventions
as described for PYPAR(13) - PYPAR(16), is parametrized as
$(k+1)(1-\chi)^k$, i.e. with mean value $1/(k+2)$.
= 1 : k = 0 for meson, k = 1 for baryon, i.e. simple counting rules.
= 2 : k as given in PYPAR(13) - PYPAR(16).

IPY(18) : not used

IPY(19) : (D = 1) cuts on partonic events
= 0 : no cuts (can be used only with independent fragmentation)
= 1 : string cuts (as normally required for fragmentation)

IPY(20) : (D = 1) switch for fragmentation.
= 0 : fragmentation not performed.
= 1 : fragmentation performed.
= −1 : only choose kinematical variables for hard scattering
(X(2,1), X(2,2), SHAT(2), THAT, Q2, KFL(2,1), KFL(2,2) and KTY
in commonblock PYPROC), i.e. no jets are defined. This is useful
e.g. to calculate cross sections (by Monte Carlo integration)
without wanting to simulate events; information in XSEC as
printed in PYSTAT will be correct.

IPY(21) : not used
IPY(22) : (D = 1) initialization and differential cross section maximization printout
- = 0 : none
- = 1 : short message
- = 2 : detailed message, including full maximization

IPY(23) : (D = 2) reaction to violation of maximum differential cross section
- = 0 : stop generation, print message
- = 1 : continue generation, print message for each subsequently larger violation
- = 2 : as 1, but also increase value of maximum

IPY(24) : (D = 1) frame event is presented in
- = 1 : as specified in PYINIT
- = 2 : CM frame of incoming particles

IPY(25) : (D = 1) documentation of partonic process
- = 0 : only list ultimate string/particle configuration
- = 1 : additionally list incoming particles (positions 1 and 2), initial partons before spacelike shower (3 and 4), incoming partons at hard scattering (5 and 6) and outgoing partons/leptons/photon after hard scattering (7 and 8). Also, K(I,1) of the ultimate string/particle configuration will point to 3 or 4 for beam/target remnants, to 5 or 6 for partons from initial state shower and to 7 and 8 for final state shower.
- = 2 : list complete documentation of intermediate steps of showers, with lines having K(I,1) > 70000 interspersed containing colour flow information (for connoisseurs only), This e.g. means that incoming partons are in positions 5 and 7 and outgoing in 9 and 11.

IPY(26) - IPY(30) : not used
IPY(31) : internal flag for current frame of event, cf. IPY(24)
IPY(32) : internal flag for events failing cuts
IPY(33) : internal flag that (some) QCD processes are included.
IPY(34) : internal flag that (some) W production graphs are included.
IPY(35) : internal flag that (some) Z production graphs are included.
IPY(36) - IPY(40) : not used
PYPAR(1) : not used.
PYPAR(2) : (D = 0.0073) alpha-electromagnetic
PYPAR(3) : (D = 0.2) constant α_s vaule used for IPY(3) = 0
PYPAR(4) : (D = 0.25 GeV) Λ_{QCD} used in running α_s for hard scattering
PYPAR(5) : (D = 4 GeV2) mimimum Q2 value in α_s for hard scattering, below which α_s is frozen
PYPAR(6) : (D = 1.) k-factor for cross section for flavour annihilation graphs, including W and Z production.
PYPAR(7) : (D = 0.44 GeV) width of Gaussian primordial kt distribution for IPY(16) = 1.
PYPAR(8) : (D = 0.44 GeV) width of exponential primordial kt distribution

for IPY(16) = 2.
PYPAR(9) - PYPAR(10) : not used.
PYPAR(11) : (D = 2 GeV) upper cutoff for primordial kt distribution
PYPAR(12) : (D = 2 GeV) used to define the minimum invariant mass of the remnant hadronic system (i.e. when interacting partons have been taken away), together with original hadron masses and extra parton masses.
PYPAR(13) : (D = 0.) for IPY(17) = 2 it gives the value of the parameter k for the case when a pion remnant is split into two fragments (which is which is chosen at random).
PYPAR(14) : (D = 0.) for IPY(17) = 2 it gives the value of the parameter k for the case when a pion remnant is split into a meson and a spectator fragment jet, with χgiving the energy fraction taken by the meson.
PYPAR(15) : (D = 1.) for IPY(17) = 2 it gives the value of the parameter k for the case when a nucleon remnant is split into a diquark and a quark fragment, with χgiving the energy fraction taken by the quark jet.
PYPAR(16) : (D = 1.) for IPY(17) = 2 it gives the value of the parameter k for the case when a nucleon remnant is split into a baryon and a quark jet or a meson and a diquark jet, with χgiving the energy fraction taken by the quark jet or meson, respectively.
PYPAR(17) - PYPAR(20) : not used.
PYPAR(21) : (D = 0.25 GeV) Lambda-QCD value used in spacelike parton shower.
PYPAR(22) : (D = 4. GeV2) effective cutoff Q2 value, below which spacelike parton showers are not evolved.
PYPAR(23) : (D = 2. GeV) effective minimum energy (in CM frame) of timelike or on-shell parton emitted in spacelike shower, see also PYPAR(26).
PYPAR(24) : (D = 4.) multiplies Q2 in the definition of maximum parton virtuality allowed in timelike showers.
PYPAR(25) : (D = 4.) multiplies Q2 in the definition of maximum parton virtuality allowed in spacelike showers.
PYPAR(26) : (D = 0.001) effective lower cutoff on 1-z in spacelike showers, in addition to the cut implied by PYPAR(23).
PYPAR(27) - PYPAR(29) : not used.
PYPAR(30) : (D = 0.217) sin2(θ_W), weak mixing angle in QFD.
PYPAR(31) : (D = 84. GeV) W mass.
PYPAR(32) : (D = 2.8 GeV) W full width.
PYPAR(33) : (D = 94. GeV) Z^0 mass.
PYPAR(34) : (D = 2.8 GeV) Z^0 full width.
PYPAR(35) : (D = 50. GeV) minimum required mass for a W or Z.
PYPAR(36) : (D = 0.05) sin2(θ_C), sine-squared of Cabibbo mixing angle. This value (in combination with the incoming structure functions and the production matrix element) is used to define the cross section for W production from different initial parton states (e.g. $u\bar{d}$ versus $u\bar{s}$), assuming only two generations, whereas so far no Cabibbo mixing has been implemented for the decay of a W.
PYPAR(37) - PYPAR(40) : not used.
PYVAR(1) : maximum value of differential cross section for QCD processes,

must be given by user for IPY(1) = 1.
PYVAR(2) : maximum value of differential cross section for W production, must be given by user for IPY(1) = 1.
PYVAR(3) : maximum value of differential cross section for Z production, must be given by user for IPY(1) = 1.
PYVAR(4) : latest value for α_S in hard scattering.
PYVAR(5) : ECM, center of mass energy
PYVAR(6) : s (=ECM**2) mass-square of complete system
PYVAR(7) : qt − min as given in PYINIT
PYVAR(8) : qt − min**2
PYVAR(9) : τ⁻min = 4*qt − min**2/s for hard scattering
PYVAR(10) : −ln(τ⁻min)
PYVAR(11) : sum of phase space suppression factors, in some cases multiplied by coupling constants, for the production of new quark-antiquark flavours in QCD, W or Z processes.
PYVAR(12) : cos-th$\eta$for hard scattering angle in the CM frame of the hard scattering.
PYVAR(13) : relative preliminary probability for W production.
PYVAR(14) : relative preliminary probability for Z production.
PYVAR(15) : Λ_{QCD} value used in last structure function call.
PYVAR(16) : THATL value obtained in PYTHAT call.
PYVAR(17) : THATU value obtained in PYTHAT call.
PYVAR(18) : not used.
PYVAR(19) : weight associated to event for IPY(2) > 0, is = 1 for IPY(2) = 0.
PYVAR(20) : sum of PYVAR(19) weights for the events generated (i.e. the number of events for IPY(2) = 0). At the end of a run, the conversion from events with relative weights PYVAR(19) to absolute cross sections (in mb) is obtained by multiplying by a factor XSEC(0)/PYVAR(20).
PYVAR(21) - PYVAR(25) : theta, ϕ and β for rotation and boost between user-specified frame and CM frame
PYVAR(26) - PYVAR(40) : not used.

COMMON /PYPROC/ KFL(3,2),KTY,KCF,X(2,2),SHAT(2),THAT,Q2,XSEC(0:11)

Purpose: to provide user with event information on parton level

KFL : gives flavour of partons/leptons/photon participating in event
    using the KF flavour codes (500 = g, 501 = u, − 501 = $\bar{u}$, etc.).
    KFL(1,j) : original partons before initial state parton shower,
        j = 1 for beam side and j = 2 for target side.
    KFL(2,j) : incoming partons to hard scattering,
        j = 1 for beam side and j = 2 for target side
    KFL(3,j) : outgoing partons/leptons/photon from hard scattering,
        j = 1 and j = 2 arbitrary

KTY : specifies (together with KFL(2,1) and KFL(2,2)) the hard
    scattering that took place; the codes are the same as for the
    third (K) argument in the INCLU matrix, see below.

KCF : specifies the general type of subprocess that has occured,
    1 - 11, with ordering as for the ISUBPR array (see below).

X : gives the momentum fraction taken by partons as used in
    structure functions (with exact kinematic meaning uncertain)
    X(1,j) : original partons before initial state parton shower,
        j = 1 for beam side and j = 2 for target side
    X(2,j) : incoming partons to hard scattering,
        j = 1 for beam side and j = 2 for target side

SHAT : invariant mass-squared of reacting subsystem
    SHAT(1) : for original partons before initial state parton showers
    SHAT(2) : for hard scattering partons

THAT : momentum transfer of hard scattering

Q2 : the Q2 scale used for the hard scattering, cf. IPY(4)

XSEC : calculated cross sections within given cuts in mb, based
    on all events up till the last generated one
    XSEC(0) : estimate for total cross section
    XSEC(1) - XSEC(11) : estimate for the various subprocesses (ordering as for ISUBPR below).

COMMON /PYSUBS/ ISELEC,ISUBPR(11),INCLU(-5:5,-5:5,6),INNEW(10)
Purpose: to allow the user to run the program with any desired subset of high-pt processes. For details on the different colour configurations mentioned below, see Computer Phys. Comm. 34 (1985) 251.

ISELEC (D=0) a switch to select between preprogramming and full user control.
- = 0 : all high-pt subprocesses are included.
- = 1 : allows the user to choose between different preprogrammed subsets of high-pt processes by setting the corresponding entries of ISUBPR to 1.
- = 2 : gives the user full freedom to include desired subprocesses by setting the corresponding entries of INCLU to 1.

ISUBPR : (D=11*0) array to be set when ISELEC=1 (for ISELEC=0 all are set 1 at PYINIT call). For ISUBPR(KCF)=1 the corresponding processes are included, for =0 they are excluded.
- KCF = 1 : $q(i)q(j) \rightarrow q(i)q(j)$, $q(i)\bar{q}(j) \rightarrow q(i)\bar{q}(j)$.
- KCF = 2 : $q(i)\bar{q}(i) \rightarrow q(j)\bar{q}(j)$.
- KCF = 3 : $q(i)\bar{q}(i) \rightarrow gg$.
- KCF = 4 : $q(i)g \rightarrow q(i)g$.
- KCF = 5 : $gg \rightarrow q(i)\bar{q}(i)$.
- KCF = 6 : $gg \rightarrow gg$ (colour configurations A and B)
- KCF = 7 : $gg \rightarrow gg$ (colour configurations C).
- KCF = 8 : $q(i)\bar{q}(i) \rightarrow g\gamma$.
- KCF = 9 : $q(i)g \rightarrow q(i)\gamma$.
- KCF = 10 : $q(i)\bar{q}(j) \rightarrow W^+$ or W^-.
- KCF = 11 : $q(i)\bar{q}(i) \rightarrow Z^0$.

INCLU : (D=726*0) array to be set when ISELEC=2 (for ISELEC=0 and 1 relevant entries are set at the PYINIT call). For INCLU(I,J,K)=1 the corresponding subprocess is included, for =0 it is excluded. The first two arguments I and J give flavour of the two incoming partons (from beam and target particle respectively) at the hard scattering according to standard IFL code (0=g, 1=u, 2=d, 3=s, 4=c, 5=b, − for antiquarks), the last argument numbers the possible subprocesses for this choice. Depending on the I and J values, the various final states associated with different K values are listed below.

I * J > 0, I and J not equal : nonidentical quarks or antiquarks.
- K = 1 : q(I)q(J).

I * J > 0, I = J : identical quarks or antiquarks.
- K = 1 : q(I)q(J) (colour configuration A).
- K = 2 : q(I)q(J) (colour configuration B).

I * J < 0, I and −J not equal : nonidentical quark-antiquark pair.
- K = 1 : q(I)q(J).
- K = 2 : W^+ or W^- (if possible).

I * J < 0, I = −J : identical quark-antiquark pair.
- K = 1 : q(I)q(J) (i.e. old flavour retained).
- K = 2 : q(L)q(−L) (i.e. annihilation to new flavour).

K = 3 : gg (colour configuration A).
K = 4 : gg (colour configuration B).
K = 5 : g+γ.
K = 6 : Z^0.
I * J = 0, I and J not equal : quark or antiquark plus gluon.
K = 1 : qg (colour configuration A).
K = 2 : qg (colour configuration B).
K = 3 : q+γ.
I = J = 0 : gluon- gluon.
K = 1 : q(L)q(−L) (colour configuration A).
K = 2 : q(L)q(−L) (colour configuration B).
K = 3 : gg (colour configurations A).
K = 4 : gg (colour configurations B).
K = 5 : gg (colour configurations C).

INNEW : (D=5*1,5*0) array that can be set to regulate the production of new flavours, mainly via an intermediate W or Z, but the first six entries also for strong production of a new $q\bar{q}$ pair (here with the upper limit given in IPY(11) still valid, however). For INNEW(I)=1 the corresponding channel is open, for =0 it is closed. Can be used for all ISELEC values. The default values corresponds to having the standard jet channels open, i.e. excluding top and lepton production.
I = 1 : $u\bar{u}$ for QCD and Z.
I = 2 : $d\bar{d}$ for QCD and Z, $u\bar{d}$ or $d\bar{u}$ for W.
I = 3 : $s\bar{s}$ for QCD and Z.
I = 4 : $c\bar{c}$ for QCD and Z, $c\bar{s}$ or $s\bar{c}$ for W.
I = 5 : $b\bar{b}$ for QCD and Z.
I = 6 : $t\bar{t}$ for QCD and Z, $t\bar{b}$ or $b\bar{t}$ for W.
I = 7 : e^+e^- for Z, e^{+-} and ν for W.
I = 8 : $\mu^+\mu^-$ for Z, μ^{+-} and ν for W.
I = 9 : $\tau^+\tau^-$ for Z, τ^{+-} and ν for W.
I = 10 : $\nu\bar{\nu}$ (e, μ or τ) for Z.

COMMON /PYCROS/ NGEN(3,0:11),XPRI(0:11),VMAX
Purpose: to store information necessary for cross section calculation and differential cross section maximum violation. Should not be touched by any user.

COMMON /PYINTE/
KI(2,2),PI(2,5),XQ(2,−5:5),DSIG(−5:5,−5:5,6),
KPRO(−5:5,−5:5),NMAX(6),ICOL(20,4,2),CHARGE(−5:10)
Purpose: to store information on initial hadrons, structure functions, subprocess cross sections, number of subprocesses, colour flow indices and charges. Should not be touched by any user.

2.4 Example on how to use the program

The program is built as a slave system, i.e. the user supplies the main program, which calls on the PYTHIA and JETSET routines to perform specific tasks and then resumes control.

A typical program for analysis of collider events at 540 GeV CM energy with a minimum pt of 10 GeV at the hard scattering (because of initial state radiation, fragmentation effects, etc., the actual pt-cutoff will be smeared around this value) might look like

```
      COMMON /LUJETS/ N,K(2000,2),P(2000,5)
      COMMON /PYPARA/ IPY(40),PYPAR(40),PYVAR(40)
      COMMON /PYPROC/ KFL(3,2),KTY,KCF,X(2,2),SHAT(2),THAT,Q2,XSEC(0:11)
      COMMON /PYSUBS/ ISELEC,ISUBPR(11),INCLU(-5:5,-5:5,6),INNEW(10)
      ...                          set all commonblock variables that
      ...                          did not have desired default values
      CALL PYINIT('CMS','P','PBAR',540.,10.)  initialize
      ...                          initialize analysis statistics
      DO 100 IEVENT=1,1000         loop over events
      CALL PYTHIA                  generate event
      IF(IEVENT.EQ.1) CALL LULIST(11)  list first event
      ...                          insert desired analysis chain for
      ...                          each event
  100 CONTINUE
      CALL PYSTAT                  print cross sections
      ...                          user output
      END
```