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A MONTE CARLO PROGRAM FOR CALCULATING CHARGED PARTICLE TRANSMISSION THROUGH SPECTROMETERS AND BEAM LINES

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CONTENTS

1. INTRODUCTION

REVMOC is a Monte Carlo computer program, written in FORTRAN IV, for the design and analysis of magnetic spectrometers and beam transport systems. In tracing charged particles through a system of magnets, first order theory is used by the program, that is, in a Taylor's series expansion about the principal trajectory, second and higher order terms are neglected. The program attempts to simulate the physical processes, such as decay, multiple scattering, nuclear scattering absorption, and calculates corrections for any loss or gain of particles from these causes. The program will also give distributions of particles accepted by the system as a function of a variety of variables, if this is desired.

2. DESCRIPTION OF PROGRAM

The program calculates the probability that a particle, in traversing a given experimental system, will be lost from that system by means of decay, scattering, absorption or energy loss in material in the particle path.

To simulate a given experimental system, a series of regions is specified. Regions which may be specified are:

1) drift region
2) quadrupole magnet
3) uniform field bending magnet
4) double focusing spectrometer magnet

(3 and 4: bending in the horizontal plane)

Any number of regions in any order may be specified, provided the total number is not more than fifty. The first region is the experimental target. Parameters, such as magnetic fields, lengths, densities, atomic species, etc., are specified for each element on data cards. The program traces particles through the system using 'first order' theory to calculate displacements and deviations caused by magnetic fields.

Initial parameters for each particle are determined by the program from uniform random distributions within specified limits on the momentum range Δp, position in the target, and initial displacements ΔX_T, ΔY_T and deviations $\Delta X_T'$, $\Delta Y_T'$ in the horizontal and vertical planes. The particle is then traced through the system. At the end of each drift region a test is applied to see if the particle displacement lies within specified limits, given by counter and slit sizes in the actual experimental system. If a particle satisfies all the tests, then this particle will be counted in the system in the absence of decay, scattering, etc. The particle, with the same initial parameters, is then traced through a second time, this time being allowed to decay, scatter, etc., with appropriate probabilities. The same tests are applied at the end of each drift region to determine whether the particle remains in the experimental system. The whole process is repeated for a large number of particles, each particle being traced through twice, once without 'physical processes' such as decay, scattering, etc., and once with these processes. Should, however, incorporation of these 'physical processes' not be required in a run, the second trace for each particle is *not* done.

3. PHYSICAL INTERACTIONS

3.1 Decay

The decay length Λd of the particles is calculated from the lifetime and momentum by means of the relation

$$\Lambda d = 30\,\tau\,(p_0/mc) \quad \text{cm}$$

where τ = lifetime in nsec

p_0 = central value of momentum in GeV/c

m = rest mass of particle in GeV/c^2.

The value of Λd obtained is therefore only correct when the momentum of the particle is equal to its central value. This should not lead to large errors provided $\Lambda p/p_0$ is not too large.

A two-body final state is assumed to result from particle decay. The decay angle is chosen randomly from a uniform distribution in the centre of mass of the decaying particle. This procedure is correct only if the final state has orbital angular momentum of zero, such as:

$$\pi^{\pm} \rightarrow \mu^{\pm} + \nu$$

$$K^{\pm} \rightarrow \pi^{\pm} + \pi^{\circ}$$

$$K^{\pm} \rightarrow \mu^{\pm} + \nu$$

$$K^{\circ} \rightarrow \pi^{+}\pi^{-}$$

$$K^{\circ} \rightarrow \pi^{\circ}\pi^{\circ}$$

The energies of the decay products are then determined from their masses, which are specified as input data. One of the decay products is traced through the rest of the system, which one being determined by the input data. It is assumed that this decay product undergoes no absorption, nuclear scattering, energy loss or decay in traversing the rest of the system. Multiple scattering, however, is allowed to occur. Up to two different two-body decay modes may be specified. The branching ratios and masses of the products are given as input data. The program randomly chooses via which decay mode a given particle decays, with probabilities given by the branching ratios. If the sum of the two branching ratios is less than unity, the remainder of the decays are assumed to be into three or more body final states, and are lost to the system immediately.

In order to obtain better statistics in cases where the probability for decay in the system is small, a scale factor, SCALE, may be specified. This multiplies the particle lifetime by SCALE. Thus, if SCALE = 0.1, ten times as many particles will undergo decay in the system. Appropriate corrections are made so that the number of undecayed particles at the beginning of each region is equivalent to the number which would be there if SCALE = 1.0. The results are normalized to what would be obtained if SCALE = 1. The only result is to increase the statistical accuracy of the distributions of decay products. If the value of SCALE is not specified, it is assumed to be unity.

3.2 Nuclear Absorption

For each region in the system, a nuclear absorption length Λa is calculated as follows. The absorption cross section per nucleon σ_a for the particle is specified as input data. For each atomic species, the absorption cross section per nucleus is calculated from an empirical formula by Williams[1]

$$\sigma = 44\ A^{0.69} \left(1 + 0.039\ A^{-\frac{1}{3}} (\sigma_a - 33) - 0.0009\ A^{-\frac{1}{3}} (\sigma_a - 33)^2\right) \text{mb}$$

where A = atomic weight of nucleus

σ_a = absorption cross section per nucleus in mb.

This formula is expected to be accurate to about 5% for strongly interacting particles with energies greater than 1 GeV. For the best value of σ_a to use, the reader is referred to Williams' paper.

From the density of material in the region and the proportions by weight of each atomic species, which are specified as input data, the absorption length Λa is calculated. Up to three different atomic species may be specified for each region.

3.3 Nuclear Elastic Scattering

The nuclear scattering length Λe is obtained from the nuclear absorption length Λa by means of the relation

$$\Lambda e = (\sigma_a/\sigma_e)\ \Lambda a$$

where σ_e = nuclear scattering cross section per nucleon and is specified in millibarns as input data.

The angular distribution of the elastically scattered particles is assumed to be a forward diffraction peak of the form

$$\frac{d\sigma}{d\Omega_{1ab}} = \alpha e^{-(\theta_{1ab}/\theta_0)^2}$$

where $\theta_0{}^2 = \frac{1}{3} A^{\frac{2}{3}} (p_0/m_\pi c)^2$

m_π = mass of pion

A = atomic weight of nucleus.

This distribution is in reasonably good agreement with experimental data in the GeV energy range.[2] The distribution function is calculated for each atomic species in the region. When a particle is being traced through the system and a nuclear scattering occurs, the atomic species on which the scattering takes place is determined with probabilities given by the proportion by weight and total elastic cross section for each species. The scattering angle is randomly chosen from the above distribution, and the particle is assumed to lose no energy in the scatter. The scattered particle is then traced through the rest of the system, in which further interactions such as decay, absorption, scattering or energy loss may occur.

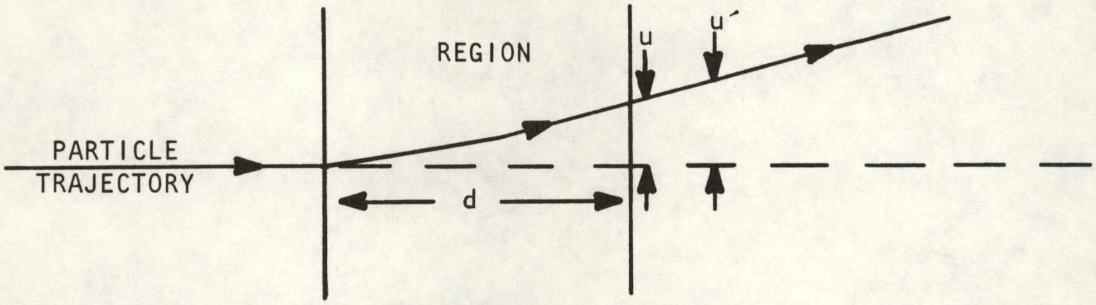
For each region of the system a total interaction length Λ is defined by the relation

$$\frac{1}{\Lambda} = \frac{1}{\Lambda d} + \frac{1}{\Lambda a} + \frac{1}{\Lambda e}.$$

As a particle is traced through the system, the distance ℓ to the next interaction is determined at the beginning of each region by the usual Monte Carlo technique, from the distribution $e^{-\ell/\Lambda}$. If ℓ is greater than the length of the region, then no interaction (decay, absorption or nuclear scattering) is assumed to occur, and the particle is traced straight through to the beginning of the next region. If ℓ is less than the length of the region, then the particle is traced up to ℓ, when an interaction is assumed to occur. The type of interaction is decided with probabilities determined by the relative magnitudes of Λd, Λa and Λe.

3.4 Multiple Scattering

The program assumes that multiple scattering will occur in any region in which the density of material is non-zero. Both scattering angles (u') and displacements (u) are calculated in the horizontal and vertical planes, and are chosen randomly from distributions deduced by Molière.[3]



In order to calculate these distributions the program assumes that the particle travels a distance d through the material, and that the particle energy is constant and equal to its value half-way through the region. In order that these assumptions may not lead to large errors, it may be necessary to split regions (e.g. range counters), in which the multiple scattering and energy loss are large, into a series of smaller regions. Since up to three atomic species may be specified in each region, the program calculates average Molière distributions in a suitable way.[4] Calculations are carried out up to and including the second correction term in the Molière distribution, higher order corrections being ignored.

If a particle undergoes a 'physical interaction' inside a region, the multiple scattering is calculated up to the point where the 'interaction' occurs, and then for the rest of the region after the new angles or energy resulting from the 'interaction' have been calculated.

3.5 Energy Loss

Ionization energy loss

Charged particles traversing matter lose energy through inelastic collisions with the atomic electrons of the material. Because of the statistical nature of the ionization process, the energy lost ε will have a spread $\Delta\varepsilon$ about the most probable energy loss ε_{prob}. Suppose W_{max} is the maximum energy transfer (determined by kinematics) to an atomic electron in a single collision. Then if $\Delta\varepsilon \ll W_{max}$, the distribution of energy losses is Gaussian, and ε_{prob} is equal to the average energy loss of the particles.[5] If $\Delta\varepsilon << W_{max}$ however, the distribution of energy losses is that calculated by Landau.[6] This distribution is asymmetric, with a long tail on the side of high energy losses which falls off as ε^{-2}.

The program decides which type of distribution is applicable for each region in turn. If $\Delta\varepsilon \sim W_{max}$, and neither distribution is applicable, a message is printed. The value of ε_{prob} is calculated from the expression[7]

$$\varepsilon_{prob} = \frac{At}{\beta^2}\left(B + 1.06 + 2\ell n\frac{p}{Mc} + \ell n\frac{At}{\beta^2} - \beta^2 - \delta - U\right)$$

$$= \frac{At}{\beta^2}\left(34.92 + 2\ell n\frac{p}{Mc} - 2\ell n I + \ell n\frac{At}{\beta^2} - \beta^2 - \delta - U\right)$$

where p = momentum of particle of mass M, velocity βc

I = ionization potential of material in eV

t = thickness of material in g/cm^2

$A = 0.1536\left(\frac{Z}{A}\right) \times 10^{-3}$ for t_{prob} in GeV

$B = \ell n\left(\frac{M_e c^2 \times 10^6}{I^2}\right)$.

The density effect correction δ is calculated from formulae due to Sternheimer:[8]

$$\delta = 0 \qquad X < X_0$$
$$\delta = 4.606\,X + C + a(X_1 - X)^m \qquad X_0 \le X \le X_1$$
$$\delta = 4.606\,X + C \qquad X_0 > X_1$$
$$X = \log_{10}\,(p/Mc)$$

and a, C, m, X_0, and X_1 are constants depending on the material. It is assumed that the shell correction term U is negligible. This assumption is good when the velocity of the particle is much greater than the velocities of the atomic electrons. The expression for ε_{prob} is valid for both electrons and heavy particles. The program also calculates the width of the distribution, which is typically about 20% of ε_{prob}. Where necessary, ε_{prob} and $\Delta\varepsilon$ are averaged over the atomic species in the region, using Bragg's Law.

As particles are traced through the system, the ionization energy loss ε for each region is selected randomly from the relevant distribution, using the values of ε_{prob} and $\Delta\varepsilon$ previously calculated for that region. Since the distribution is obtained from a table, linear interpolation is used to obtain values intermediate between those given in the table, except where the value of $\varepsilon > 8\,\Delta\varepsilon$, when the distribution is assumed to go as ε^{-2} for the Landau curve.

Radiative energy loss

For all particles except electrons, the radiative energy loss is assumed to be negligible. This is true except at very high energies. If electrons are to be traced through the system, the thickness L in radiation lengths of each region is calculated using a formula due to Rossi.[9] Let $W(E_0,E,L)dE$ be the probability that an electron with initial energy E_0 has energy between E and E + dE after traversing the region. Bethe and Heitler[10] give an expression for $W(E_0,E,L)$ of the form

$$W(E_0,E,L)dE = \frac{dE}{E_0}\,\frac{[\ln(E_0/E)]^{(L/\ln 2\,-\,1)}}{\Gamma(L/\ln 2)}\,.$$

The program calculates and stores a table of the integral

$$W(E_0,E,L) = \int_{E_0}^{E} W(E_0,E,L)dE$$

at 5% intervals in $(E_0 - E)/E_0$ for each region.

When an electron is traced through the system its radiative energy loss is chosen randomly in each region, using the stored distribution tables of $W(E_0,E,L)$. Interpolation between the calculated values of $W(E_0,E,L)$ is done as follows:

a) For energy losses <5% of E_0, it is assumed that

$$W(E_0,E,L) \sim (\ln E_0/E)^{L/\ln 2}.$$

b) For energy losses >5% of E_0, interpolation is carried out using a general quadratic fit to the three nearest values of $W(E_0,E,L)$.

Any photons or secondary electrons which might be emitted in the radiative energy loss process are neglected.

Note that since ε_{prob} and W are calculated using the central momentum p_0 of the particles, errors may arise if the momentum spread of the particles is too large. The program does not attempt to calculate any energy loss for decay products traversing the system.

4. DATA INPUT

4.1 General

The first data card *must* contain NEL, the number of different regions in the experimental system being considered. The target counts as one region. The total number of regions must be 50 or less.

This card has FORMAT(I2).

The following cards specify the elements, i.e. the different regions and initial conditions for the system. Each element is specified by an input card of the form

ELMENT,IC,I1,INDEX,(DUM(I),I=1,6), where

ELMENT is a type code which determines the kind of element.

IC is a code used for changing elements, with the following meanings:

IC=0 means the element is being specified for the first time, or is being changed. In the latter case the parameter values on the remainder of the card are substituted for those already in memory.

I1 gives the number of the element being changed. Elements are numbered sequentially, with values of I1 increasing by unity, on first being read.

IC=1 causes the region specified by I1 to be deleted and the old value of I1 for each following element to be decreased by unity.

IC=2 causes an extra region, with the parameters specified on the card, to be inserted between the old $I1^{th}$ and $(I1+1)^{th}$ regions. The old value of I1 for each succeeding region is increased by unity.

INDEX is a code determining whether the region is or is not vacuum.

INDEX=0 means the region contains no appreciable material which could cause scattering, energy loss, absorption, etc.

INDEX=1 means the region does contain appreciable material which could cause scattering, energy loss, etc.

(DUM(I),I=1,6) are the parameter values (to be described in the following sections) for the element.

The card has FORMAT(5A1,I1,2I2,6F10.0).

If INDEX=1, the following two cards specify the material in the region. The first following card contains the parameters FRAC and RHO, where

FRAC = fraction of cross sectional area of aperture covered by material. Normally FRAC = 1.0, except for spark chambers, where the wires cover only some fraction of the aperture.

RHO = density of material in the region, in g/cm^3.

This card has FORMAT(10X,2F10.0).

The second following card contains the parameters (PROP(J),Z(J),J=1,3) where

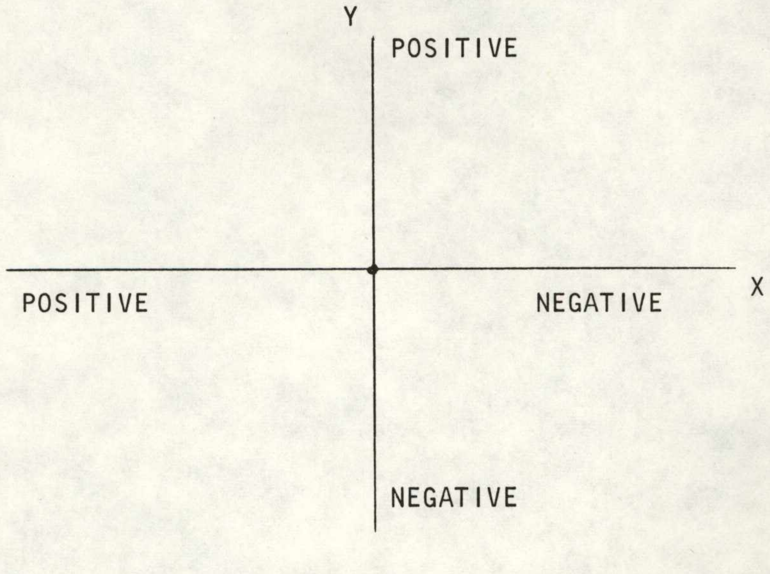
PROP(J)= proportion by weight of material with atomic number Z(J). Up to three different atomic species may be specified for any one region.

This card has FORMAT (10X,6F10.0).

Note that with the format F10.0, the decimal point may be placed anywhere inside the field.

4.2 Sign Conventions

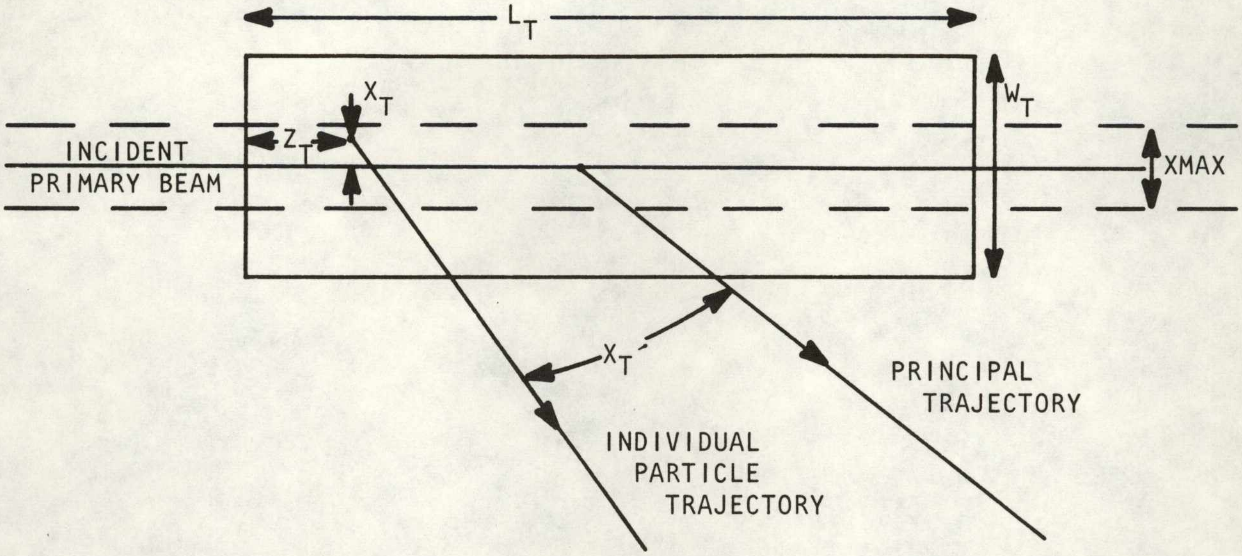
When facing along the direction of travel of the particle, X is negative to the right, positive to the left, and Y is positive up, negative down. The values of X′ and Y′ are positive when the particle displacement is increasing, and negative when it is decreasing.



Particle going into paper.

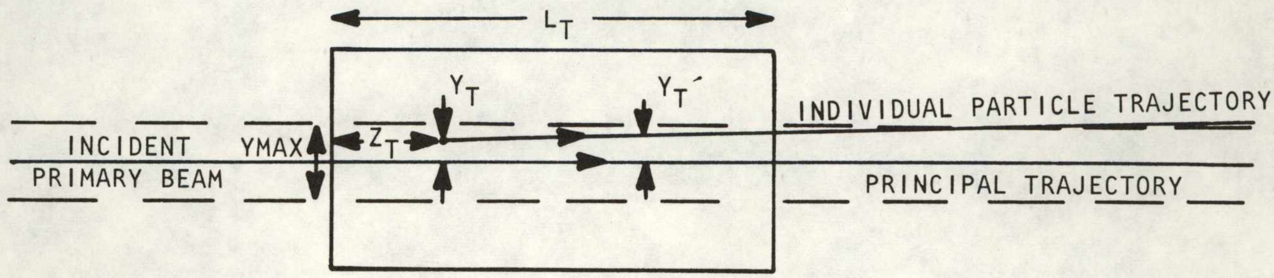
4.3 Target Geometry

Horizontal Plane



The starting co-ordinates X_T, X_T' and Z_T are chosen from uniform distributions of width XMAX, DXMAX and L_T, respectively (see Section 4.8). The distance travelled by the particle through the target (d) is then calculated, and the effects of multiple and nuclear scattering, absorption, energy loss and decay in the target material are also calculated. The target walls must be put in as a separate region if they have a significant effect. If L_T or θ_T are sufficiently small that particles leave the target via its downstream face, this is correctly calculated by the program.

Vertical Plane



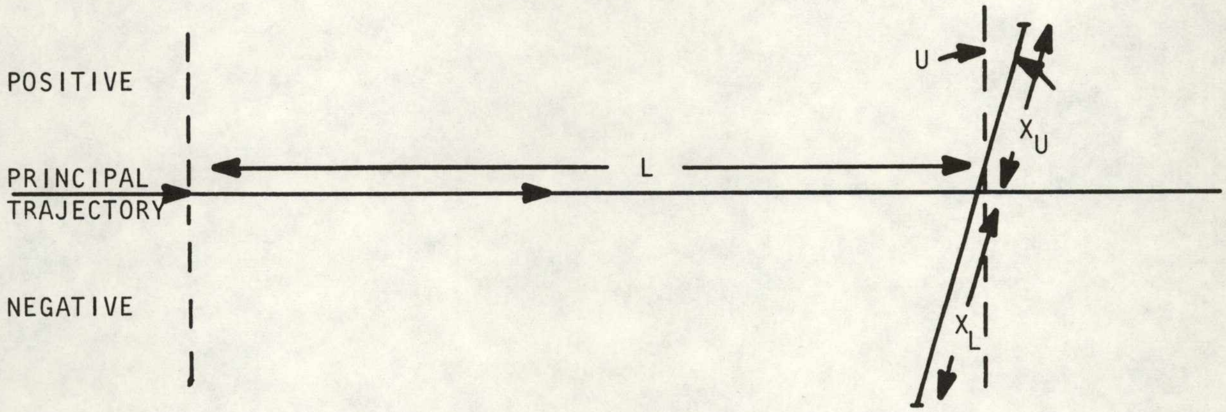
The starting co-ordinates in the vertical plane, Y_T, Y_T' are chosen from uniform distributions of width YMAX and DYMAX, respectively (see Section 4.8). The effect of Y_T', the initial angle in the vertical plane on the distance d travelled through the target, is small, and is ignored in this calculation.

The values of L_T and X_T are specified on the input data card as follows:

1. Type code = TARGƀ
2. I1,INDEX (see Section 4.1, Data Input - General)
3. DUM(1) = Length of target L_T, in cm
4. DUM(2) = Horizontal width of target X_T, in cm
5. DUM(3) to DUM(5) are blank
6. DUM(6) = Horizontal angle θ_T between incident primary beam and principal trajectory, in deg

This card is FORMAT(5A1,ƀ,2I2,6F10.0).

4.4 Drift Region



The co-ordinates at the end of the drift region are obtained from

$$\begin{pmatrix} x \\ x' \\ y \\ y' \end{pmatrix} = \begin{pmatrix} 1 & L & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & L \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_0 \\ x_0' \\ y_0 \\ y_0' \end{pmatrix}.$$

At the end of each drift space the co-ordinates are tested to see if they are within limits specified as input to the program. The limits can be thought of as a defining slit or counter at the end of each drift region. The counter can be set at an angle U to the normal to the beam, in the horizontal plane. As shown above, U is positive.

The parameters are specified as an input data card of the following type:

1. Type code = DRIFT
2. IC,I1,INDEX (see Section 4.1, Data Input - General)
3. DUM(1) = Length of region L in cm
4. DUM(2) = Upper limit on x at end of region X_U, in cm
5. DUM(3) = Lower limit on x at end of region X_L, in cm (normally negative)
6. DUM(4) = Upper limit on y at end of region Y_U, in cm
7. DUM(5) = Lower limit on y at end of region Y_L, in cm (normally negative)
8. DUM(6) = Angle U between limiting aperture and normal to principal trajectory, in deg

The magnitudes of X_U, X_L, Y_U, Y_L must be less than 10 m

The card is FORMAT(5A1,I1,I2,I2,6F10.0).

4.5 Quadrupole Magnet

The program calculates the particle co-ordinates relative to the principal trajectory from the equation

$$\begin{pmatrix} x \\ x' \\ y \\ y' \end{pmatrix} = M \begin{pmatrix} x_0 \\ x_0' \\ y_0 \\ y_0' \end{pmatrix}$$

where

$$M = \begin{pmatrix} \cos kL & \frac{\sin kL}{k} & 0 & 0 \\ -k \sin kL & \cos kL & 0 & 0 \\ 0 & 0 & \cosh kL & \frac{\sinh kL}{k} \\ 0 & 0 & k \sinh kL & \cosh kL \end{pmatrix}$$

where $k = \frac{1}{3000p} \left| \frac{\partial By}{\partial x} \right|$

L = effective length of quadrupole.

This is for a quadrupole which focuses in the horizontal plane, which is signified on the data cards by a positive value of the field gradient.

A negative value of the field gradient means a vertically focusing quadrupole, in which case the two partial matrices above are interchanged.

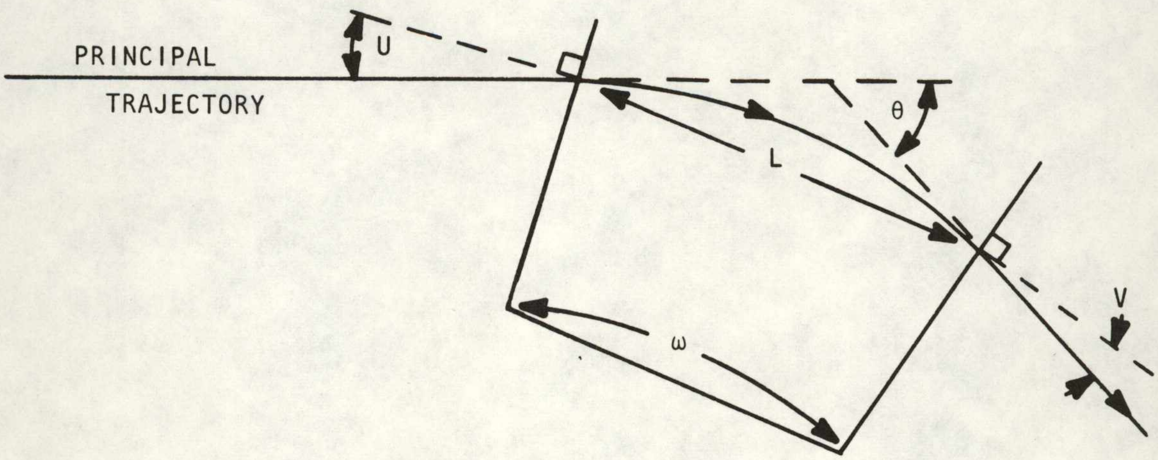
The principal trajectory must enter the quadrupole normal to the magnetic field. The parameters are specified on an input data card as follows:

1. Type code = QUADƀ
2. IC,I1,INDEX (see Section 4.1, Data Input - General)
3. DUM(1) = Effective length of quadrupole L, in cm
4. DUM(2) = Field gradient in, kG/cm
5. DUM(3) to DUM(4) are blank
6. DUM(5) = Difference T between path length of principal trajectory in quadrupole, and effective length L, in cm
7. DUM(6) is blank

The card is FORMAT(5A1,I1,2I2,6F10.0).

Here and for bending magnets the difference T (6, above) must be specified if physical processes such as decay scattering or absorption occur in the region since the probability of these occurring is proportional to the distance the particle travels in the region. Normally T will be small in comparison with L, and need only be crudely estimated. If the region is vacuum and the particle cannot decay, T may be left zero.

4.6 Uniform Field Bending Magnet



The bending magnet bends in the horizontal plane, a positive value of the magnetic field bending to the right if one travels with the particles. The angle U is positive as shown. The angle V is negative.

The co-ordinates of the particle after the magnet is in the horizontal plane relative to the principal trajectory are calculated assuming that the particle follows a circular path in the magnetic field, the radius of curvature being

$$\rho = 3335.6\ p/B \text{ with } \rho_0 = 3335.6\ \frac{p_0/B}{\Lambda}\ \text{cm}$$

for the principal trajectory.

The vertical co-ordinates after the magnet are obtained from the equation

$$\begin{pmatrix} y \\ y' \end{pmatrix} = M \begin{pmatrix} y_0 \\ y_0' \end{pmatrix}$$

where

$$M = \begin{pmatrix} 1 & 0 \\ \frac{+\tan V}{\rho} & 1 \end{pmatrix} \begin{pmatrix} 1 & \rho\theta \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \frac{-\tan U}{\rho} & 1 \end{pmatrix}$$

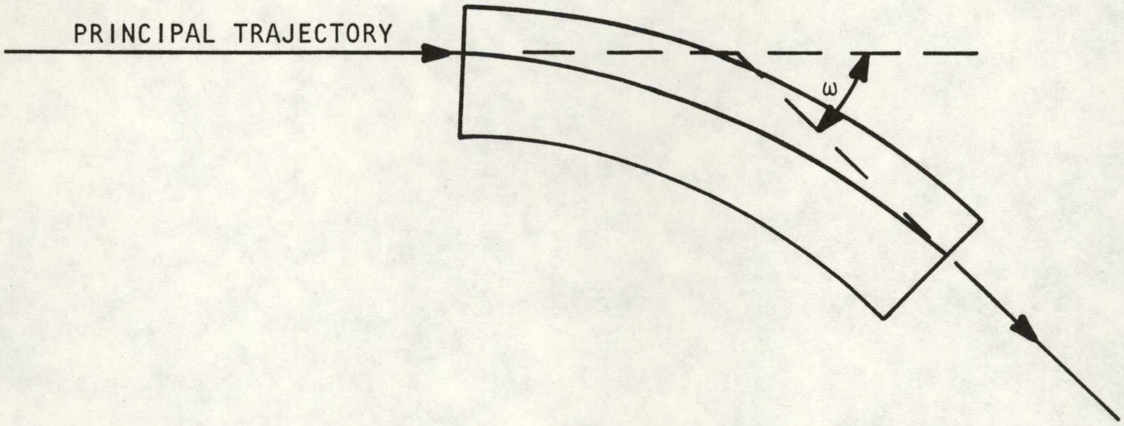
where θ is angle through which the particle is bent by the magnet.

The parameters are specified on an input data card as follows:

1. Type code = BENDƁ
2. IC,I1,INDEX (see Section 4.1, Data Input - General)
3. DUM(1) = Effective length L of magnetic field, in cm
4. DUM(2) = Magnetic field strength B, in kG
5. DUM(3) = Angle ω between entrance and exit face of magnet, in deg
6. DUM(4) is blank
7. DUM(5) = Difference T between path length if principal trajectory through magnet, and effective length L, in cm
8. DUM(6) = Entrance angle U between principal trajectory and normal to magnet face, in deg

For more information on T (7 above), see the remarks at the end of Section 4.5.

4.7 Double Focusing Magnet



The program calculates the particle co-ordinates relative to the principal trajectory from the equation

$$\begin{pmatrix} x \\ x' \\ y \\ y' \end{pmatrix} = M \begin{pmatrix} x_0 \\ x_0' \\ y_0 \\ y_0' \end{pmatrix}$$

where

$$M = \begin{pmatrix} \cos\sqrt{1-n}\,\omega & \rho\,\dfrac{\sin\sqrt{1-n}\,\omega}{\sqrt{1-n}} & 0 & 0 \\ -1-n\,\dfrac{\sin\sqrt{1-n}\,\omega}{\rho} & \cos\sqrt{1-n} & 0 & 0 \\ 0 & 0 & \cos\sqrt{n}\,\omega & \rho\sin\sqrt{n}\,\omega \\ 0 & 0 & -\sqrt{n}\,\dfrac{\sin\sqrt{n}\,\omega}{\rho} & \cos\sqrt{n}\,\omega \end{pmatrix}$$

where

$n = \frac{1}{2}$

ω = angle of bend

ρ = radius of curvature

The principal trajectory is assumed to enter and exit the magnet normally.

The parameters are specified on an input data card as follows:

1. Type code = SPECT
2. IC,I1,INDEX (see Section 4.1, Data Input - General)
3. DUM(1) = Effective length L of magnetic field between entrance and exit of principal trajectory, in cm
4. DUM(2) = ɓ
5. DUM(3) = Angle ω through which principal trajectory is bent, in deg
6. DUM(4) to DUM(6) are blank

The card is FORMAT (5A1,I1,2I2,6F10.0).

4.8 Beam Spot Parameters

Each input deck of data cards must contain two cards specifying the beam spot and angular range in which particles are produced. These cards are of the following kind:

First Card

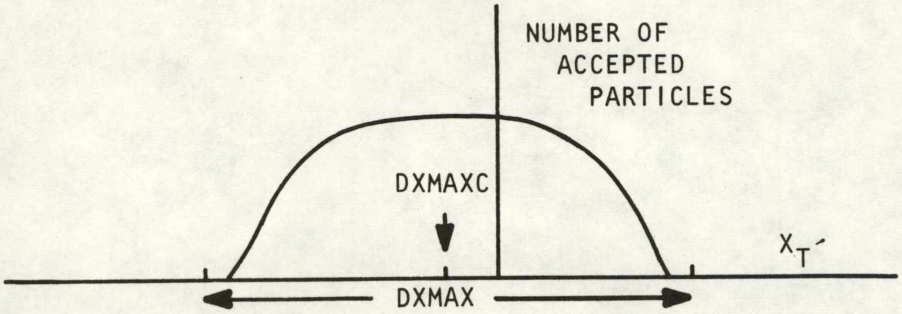
1. Type code = XSIZE
2. IC,I1 (see Section 4.1, Data Input - General)
3. DUM(1) = Horizontal full width, XMAX, of beam spot on target, in cm
4. DUM(2) = Full width, DXMAX, of uniform initial distribution in horizontal angle X_T', in mrad
5. DUM(3) = Central value x_c of beam spot on target in horizontal direction, in cm
6. DUM(4) = Central value, DXMAXC, of uniform initial distribution in horizontal direction X_T', in mrad
7. DUM(5) and DUM(6) are blank

Second Card

1. Type code = YSIZE
2. IC,I1
3 - 6. Same as first card, replacing horizontal by vertical parameters

These cards are FORMAT (5A1,I1,I2,2X,6F10.0).

The values of DXMAX and DYMAX should be chosen large enough to fill the aperture of the apparatus, i.e. a plot of accepted events versus initial angle should go to zero at the ends.



Making DXMAX or DYMAX too large merely reduced the efficiency of the program, since then a large number of particles have no chance of being accepted by the system.

4.9 Interchange of Axes

At any point in the system the horizontal and vertical axes may be interchanged. This is used, for example, when a bending magnet bends the beam in the vertical direction, or when the vertical distribution of particles at the end of some drift region is desired. A single input data card is needed each time the axes are interchanged

1. Type code = ROTAT
2. IC,I1 (see Section 4.1, Data Input-General)
3. DUM(1) to DUM(6) are blank

The card is FORMAT (5A1,I1,I2,2X,6F10.0).

4.10 Particle Momentum Parameters

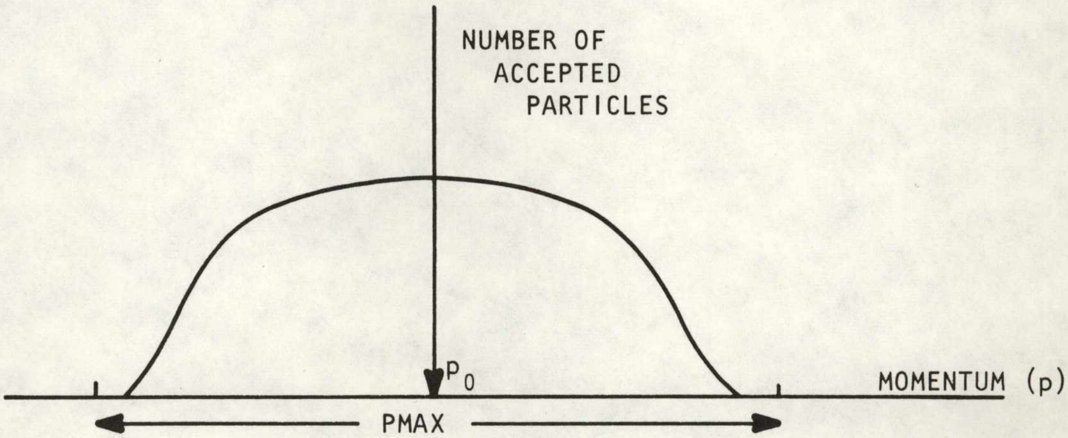
Each input deck of data cards must contain a card specifying the particle momentum parameters. This card is of the following kind:

1. Type code = P0bbb (0 = alphabetic)
2. IC,I1 (see Section 4.1, Data Input - General)
3. DUM(1) = Central momentum p_0, of uniform initial momentum distribution, in GeV/c
4. DUM(2) = Full width PMAX of uniform initial momentum distribution, in GeV/c
5. DUM(3) = Momentum of principal trajectory p_c, in GeV/c. This trajectory is the reference trajectory with respect to which all displacements are measured. If p_c is left blank, the program automatically puts $p_c = p_0$.

6. DUM(4) = Threshold energy TTHR, below which particles are assumed to be lost to the system, in GeV.
7. DUM(5) and DUM(6) are blank

The card is FORMAT (5A1,I1,I2,2X,6F10.0).

The value of PMAX should be greater than the momentum acceptance of the system, i.e. so that a plot of accepted events versus initial momentum goes to zero at the extremities:



Making PMAX too large reduces the efficiency of the program, since then a large number of particles have no chance of being accepted by the system.

4.11 Particle Mass and Other Parameters

Every input deck of data cards must contain a card giving information about the particles being traced through the system. This card is of the following kind:

1. Type code = MASSɓ
2. IC,I1,INDEX (see Section 4.1, Data Input-General for IC,I1) Here, if INDEX ≠ 0, this means that the particle can decay, and a following card is needed to specify the decay products.
3. DUM(1) = Particle mass, in GeV/c^2
4. DUM(2) = Absorption cross section σ_a of the particle on a nucleon, in mb
5. DUM(3) = Nuclear scattering cross section σ_e of the particle on a nucleon, in mb

6. DUM(4) = Lifetime of particle τ in nsec
7. DUM(5) = Scale factor, SCALE (see section 3.1, Decay)
8. DUM(6) is blank

The card is FORMAT (5A1,I1,2I2,6F10.0).

If INDEX ≠ 0, the following card must contain the parameters:

1. 10b̸
2. DUM(1) = Branching ratio $\alpha(1)$ into first two-body final state decay mode
3. DUM(2) = Mass of decay product of first two-body decay mode, in GeV/c^2, which is to be traced on through the system after decay
4. DUM(3) = Mass of other decay product of first two-body decay mode, in GeV/c^2
5. DUM(4) = Branching ratio $\alpha(2)$ into second two-body final state decay mode
6. DUM(5) = Mass of decay product of second two-body decay mode, in GeV/c^2, which is to be traced on through the system after decay
7. DUM(6) = Mass of other decay product of second two-body decay mode, in GeV/c^2

The card is FORMAT (10X,6F10.0).

4.12 Initialization of Random Number Generator

Each input deck of data cards must contain a card to initialize the random number generator. The random number generator operates by multiplying an integer by 65539 to form a new integer. The least significant part of the new integer is then normalized to be between 0 and 1 to give the required random number. The new integer is used to form the next random number, and so on. A total of 2^{29} random numbers is obtained before the sequence starts to repeat.

The starting integer is specified on a data card as follows:

1. Type code - INITb̸
2. IC,I1 (see Section 4.1, Data Input - General)
3. DUM(1) = RANDOM NUMBER INITIALIZER, any odd number $\leq$ 9 digits in length

4. DUM(2) to DUM(6) are blank

The card is FORMAT(5A1,I1,I2,2X,F10.0).

When changes are made to a system, and it is desired to see the effect, the random number initializer should be reset to the value used in the first run. This reduces statistical fluctuations.

4.13 Number of Trials

Each input deck of data cards must contain a card specifying the number of particles to be traced through the system. This card is of the following kind:

1. Type code - GROUP
2. IC,I1
3. DUM(1) = Number of blocks, NSET, of particles to be traced through the system
4. DUM(2) = Number of thousand particles, NT, in each block
5. DUM(3) = A parameter NORM
6. DUM(4) to DUM(6) are blank

The program prints out the cumulative results up to that point after each block of particles. A total of NSET x NT x 1000 particles is traced in a single run. If the final results are to be normalized to the final number of particles accepted by the system, then the value of NORM should be greater than zero; otherwise the non-normalized results will be printed.

This card is FORMAT(5A1,I1,I2,2X,6F10.0).

4.14 Distributions

Particles accepted by the system may be classified into "bins" to give distributions in a variety of ways. Thus, for instance, the program will give the number of accepted events in 'bins' corresponding to the initial momenta of the particles, i.e. a distribution of accepted events as a function of initial momentum may be obtained. In this case the 'space' consists of just one 'dimension', initial momentum. More complicated distributions may be calculated, for instance the number of accepted events as a function of both initial momentum of the particles and horizontal position at the end of some specified drift region. In this case the 'space' has two 'dimensions'. Distributions in 'spaces' of up to twenty 'dimensions' may be obtained, with a maximum of 999 'bins' in any 'dimension'. In any one run up to seven 'spaces' may be defined, provided the total number of 'bins' in all 'dimensions' is less than 15,000. The total number of 'bins', N_B, in all 'dimensions' is given by:

$$N_B = \sum_{\text{spaces}} \; \underset{\substack{\text{dimensions} \\ \text{in each space}}}{\text{PRODUCT}} \; \left(\begin{array}{l}\text{no. of bins in} \\ \text{each dimension}\end{array}\right)$$

Distributions in all 'spaces' specified are printed out at the end of the run. Any of the following 'dimensions' may be specified:

a) Initial momentum of the particles
b) Starting position along the length of the target
c) Initial displacement or deviation in the horizontal plane
d) Initial displacement or deviation in the vertical plane
e) Momentum at the end of some specified drift region in the system
f) Horizontal displacement or deviation at the end of some specified drift region in the system

The feature enabling interchange of vertical and horizontal axes may be used to obtain distributions as a function of vertical displacement or deviation at the end of any drift region.

Distributions may be obtained for the following:

g) Particles initially accepted by the system, in the absence of decay, scattering, absorption or energy loss
h) Particles finally accepted by the system, in the presence of decay, scattering, absorption and energy loss
i) Decay products only

The necessary parameters are specified on data input cards of the following type:

First card

1. Type code = NSPAC
2. IC,I1 (see Section 4.1, Data Input - General)
3. DUM(1) = Number of 'spaces', NSPACE = 0, in which distributions are required. If NSPACE = 0, no multidimensional analysis is done.

4. DUM(2) = A code parameter NW, for which

   NW = 0 gives distributions of particles initially accepted by the system (g above)

   NW = 1 gives distributions of particles finally accepted by the system (h above)

   NW = 2 gives distributions for decay products only (i above)

5. DUM(3) to DUM(6) are blank

This card is FORMAT (5A1,I1,I2,2X,6F10.0).

Second card

1. 10b̸
2. DUM(1) = Number of 'dimensions' in first 'space'
3. DUM(2) = Number of 'dimensions' in second 'space'

   ⋮ ⋮

   Up to N S P A C E

This card has FORMAT (10X,7F10.0)

Up to seven 'spaces' may be specified in one run.

A single card now follows for each 'dimension' in each 'space'. Each card contains the following parameters:

1. The type of 'dimension' J
   a) = b̸P = momentum
   b) = b̸X = displacement in horizontal plane
   c) = DX = deviation in horizontal plane
   d) = b̸Y = displacement in vertical plane
   e) = DY = deviation in vertical plane
   f) = b̸T = starting position along length of target
2. DUM(1) = Region number I where distribution of this 'dimension' is required
3. DUM(2) = Number of bins required in this dimension
4. DUM(3) = Full width S of dimension J, in appropriate units (GeV/c)
5. DUM(4) = Central value C of dimension J, in appropriate units (GeV/c, cm or mrad)
6. DUM(5) to DUM(6) are blank

This card is FORMAT (A2,8X,6F10.0).

Distributions of type d), e) or f) above may only be obtained for I = 1, i.e. at the target. If vertical distributions are required elsewhere, interchange of horizontal and vertical axes can be used.

4.15 End of Case and End of Data

The program will do up to ten cases or runs with one block of data cards. After all the data cards for one case have been read in, a card of the type

1. Type code = ENDɓɓ

causes the program to begin calculations on that case.

Changes may be made in the parameters for particular elements for the next case using the code (IC) as specified in Section 4.1, Data Input - General. After all the changes have been made, a card with type code = END will cause the case to be run. When all cases have been run, the program is terminated by means of a card of the type

1. Type code = FINIɓ.

5. ERROR MESSAGES

On encountering certain input errors, error message are printed out and execution of further calculation is stopped. Most of these messages are self explanatory. Calculation is stopped for the following reasons:

1) Invalid ELMENT code parameter - The entire input card and its position in the data deck is printed out. Execution is terminated.

2) Incorrect number of transport elements - If the number of transport elements read is less than or greater than NEL, the appropriate message is printed and execution terminated.

3) IC > 2 - A change parameter not one of 0, 1 or 2 is meaningless, and execution is terminated with appropriate message.

4) Invalid region parameter (I1) - If in the second and subsequent runs a region number is undefined, the offending card input is printed and execution terminated. It should again be stressed that if an element has been deleted (inserted) all region numbers are decremented (incremented) by unity immediately upon deletion (insertion).

5) Normal run termination - When FINI has been read a message is printed out and execution terminated.

6. EXAMPLES

6.1 Example 1

A quadrupole spectrometer using time of flight

The spectrometer consists of a quadrupole triplet focusing protons onto a detector ten metres from the target. The required field gradients in the quadrupoles were first calculated using the program TRANSPORT.[11] The present program was then used to calculate the solid angle and momentum acceptances of the spectrometer. The data cards used are shown on page 28. Note the following points:

1) The target length was assumed to be negligible. Hence θ_T is not important and was put equal to zero.
2) Cards 3 and 5 define the entrance and exit apertures of the first quadrupole, which are assumed to be 4" x 4" squares. Cards 6, 8 and 9, 11 do the same thing for the other two quadrupoles.
3) Card 13 defines the aperture of the detector, 2 x 2 cm^2.
4) The target spot size was 0.5 x 0.5 cm^2 and the central momentum was 200 MeV/c.
5) The system was assumed to be vacuum throughout.

The following pages give the output from the program. The program first prints out the input parameters, with some minor changes. These are:

1) angles are in radians
2) the lifetime is in seconds

The program then prints out the results of its calculations. Most of this is self explanatory except for the following:

1) The most important result of the calculation is

   SOLIDANGLE*MOM.RES = 0.291937E-4 STERAD-BeV/c

   The quoted error is the statistical error arising from the number of particles traced through the system. If the values of PMAX, DXMAX or DYMAX were too small, however, unknown systematic errors would arise.
2) The correction factor gives the ratio of PARTICLES ACCEPTED INITIALLY/ PARTICLES ACCEPTED FINALLY. The same considerations about the quoted error apply here. In this particular case, since no physical interactions such as decay, scattering, etc., take place, the correction factor is identically equal to 1.0.

3) In the distribution of particles as a function of initial conditions, the columns headed FINAL.NOT(INITIAL) give the number of particles finally accepted which were initially rejected, as a function of the various parameters. Here initially means with no scattering, decay or energy loss, and finally means with scattering, decay and energy loss. In this particular spectrometer, since there is vacuum throughout, and no particles decay, these columns are always zero.

13

TARG	0.0				
DRIFT	150.0	+5.08	-5.08	+5.08	-5.08
DRIFT	10.0	+5.08	-5.08	+5.08	-5.08
QUAD	24.765	-0.2922			
DRIFT	0.001	+5.08	-5.08	+5.08	-5.08
DRIFT	20.000	+5.08	-5.08	+5.08	-5.08
QUAD	24.765	+0.5186			
DRIFT	0.001	+5.08	-5.08	+5.08	-5.08
DRIFT	20.000	+5.08	-5.08	+5.08	-5.08
QUAD	24.765	-0.2922			
DRIFT	0.001	+5.08	-5.08	+5.08	-5.08
DRIFT	10.0	+5.08	-5.08	+5.08	-5.08
DRIFT	715.0	+1.0	-1.0	+1.0	-1.0
INIT	123456789.				
NSPAC					
GROUP	1.0	2.0			
XSIZE	0.5	75.0			
YSIZE	0.5	100.0			
PO	0.2	0.15			
MASS	0.938				
END					
FINI					

```
      MONTE CARLO CALCULATION FOR COUNTER EXPERIMENTS  ----- BEGIN CALCULATION NUMBER 1

   SYSTEM PARAMETERS DERIVED FROM INPUT -- (L(K)) -- 1 1 1 2 1 1 2 1 1 2 1 1 1


*TARG * ---------- SETTING UP REGION  1 ----- IDENTIFIER =  1

   DATA(  1 , J ) =      0.0          0.0         0.0         0.0         0.0
   U(  1 )        =       0.0

   VACUUM IN THIS ELEMENT


*DRIFT* ---------- SETTING UP REGION  2 ----- IDENTIFIER =  2

   DATA(  2 , J ) =   150.00000     5.08000    -5.08000     5.08000    -5.08000
   U(  2 )        =       0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    2

*DRIFT* ---------- SETTING UP REGION  3 ----- IDENTIFIER =  3

   DATA(  3 , J ) =    10.00000     5.08000    -5.08000     5.08000    -5.08000
   U(  3 )        =       0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    3

*QUAD * ---------- SETTING UP REGION  4 ----- IDENTIFIER =  4

   DATA(  4 , J ) =    24.76500    -0.29220     0.0         0.0         0.0
   U(  4 )        =       0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    4

*DRIFT* ---------- SETTING UP REGION  5 ----- IDENTIFIER =  5

   DATA(  5 , J ) =     0.00100     5.08000    -5.08000     5.08000    -5.08000
   U(  5 )        =       0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    5
```

```
*DRIFT* ---------- SETTING UP REGION  6 ----- IDENTIFIER =  6

   DATA(  6 , J ) =     20.00000      5.08000     -5.08000      5.08000     -5.08000
   U(  6 )        =      0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   6


*QUAD * ---------- SETTING UP REGION  7 ----- IDENTIFIER =  7

   DATA(  7 , J ) =     24.76500      0.51860      0.0          0.0           0.0
   U(  7 )        =      0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   7


*DRIFT* ---------- SETTING UP REGION  8 ----- IDENTIFIER =  8

   DATA(  8 , J ) =      0.00100      5.08000     -5.08000      5.08000     -5.08000
   U(  8 )        =      0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   8


*DRIFT* ---------- SETTING UP REGION  9 ----- IDENTIFIER =  9

   DATA(  9 , J ) =     20.00000      5.08000     -5.08000      5.08000     -5.08000
   U(  9 )        =      0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   9


*QUAD * ---------- SETTING UP REGION 10 ----- IDENTIFIER = 10

   DATA( 10 , J ) =     24.76500     -0.29220      0.0          0.0           0.0
   U( 10 )        =      0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION  10


*DRIFT* ---------- SETTING UP REGION 11 ----- IDENTIFIER = 11
```

```
DATA( 11 , J ) =      0.00100      5.08000     -5.08000      5.08000     -5.08000
U( 11 )        =        0.0

VACUUM IN THIS ELEMENT

 TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION  11


*DRIFT* ---------- SETTING UP REGION 12 ----- IDENTIFIER = 12

DATA( 12 , J ) =     10.00000      5.08000     -5.08000      5.08000     -5.08000
U( 12 )        =        0.0

VACUUM IN THIS ELEMENT

 TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION  12


*DRIFT* ---------- SETTING UP REGION 13 ----- IDENTIFIER = 13

DATA( 13 , J ) =    715.00000      1.00000     -1.00000      1.00000     -1.00000
U( 13 )        =        0.0

VACUUM IN THIS ELEMENT

 TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION  13


*INIT * ---------- SETTING UP REGION 14 ----- IDENTIFIER = 14

RANDOM NUMBER INITIALIZER = 123456789


*NSFAC* ---------- SETTING UP REGION 15 ----- IDENTIFIER = 15

NSFACE =     0      NW     =    0


*GROUP* ---------- SETTING UP REGION 16 ----- IDENTIFIER = 16

CALCULATIONS FOR  1 BLOCKS OF  2 THOUSAND EACH
NORMALIZATION FACTOR =     0


*XSIZE* ---------- SETTING UP REGION 17 ----- IDENTIFIER = 17

XMAX     =      0.50000      DXMAX  =      0.07500
XC       =      0.0          DXMAXC =      0.0
```

```
*YSIZE* ---------- SETTING UP REGION 18 ----- IDENTIFIER = 18

   YMAX   =      C.5CCOC      DYMAX  =      0.10000
   YC     =      0.0          DYMAXC =      0.0


*PU    * ---------- SETTING UP REGION 19 ----- IDENTIFIER = 19

   PC    =     0.2C000     PMAX =      0.15000     PC    =     C.20000
   TTHR  =     0.0


*MASS * ---------- SETTING UP REGION 20 ----- IDENTIFIER = 20

   MASS  =     0.53800     SIGA  =     0.0       SIGE  =     0.0
   TAUO  =   0.0           SCALE =     1.CC000

   DECAY MODES : ALF(1) =  0.0      A3(1)  =          0.0        A4(1)  =          0.0
                 ALF(2) =  0.0      A3(2)  =          0.0        A4(2)  =          0.0
```

```
IN THE FOLLOWING TABULATION OF RESULTS
INITIAL OR INITIALLY MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH NO DECAY,SCATTERING,ABSORPTION OR ENERGY LOSS
  FINAL OR FINALLY   MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH    DECAY,SCATTERING,ABSORPTION AND ENERGY LOSS
TOTAL NUMBER OF TRIAL PARTICLES TRACED THROUGH SYSTEM=  2000
              NUMBER OF PARTICLES ACCEPTED INITIALLY=     46
                NUMBER OF PARTICLES ACCEPTED FINALLY=     46.00


     PARTICLES INITIALLY REJECTED FROM TOTAL TRIALS
          OUTSIDE HORIZONTAL LIMITS     OUTSIDE VERTICAL LIMITS
AT  1  TARG        0.0                       0.0
AT  2  DRIFT         207.000                   618.000
AT  3  DRIFT          76.0000                   76.0000
AT  4  QUAD        0.0                       0.0
AT  5  DRIFT         215.000                    21.0000
AT  6  DRIFT         169.000                 0.0
AT  7  QUAD        0.0                       0.0
AT  8  DRIFT          11.0000                   12.0000
AT  9  DRIFT       0.0                         104.000
AT 10  QUAD        0.0                       0.0
AT 11  DRIFT       0.0                          49.0000
AT 12  DRIFT       0.0                           1.00000
AT 13  DRIFT         357.000                    38.0000


SOLID ANGLE*MOM.RES.= 0.258750E-04 STERAD-BEV/C   FRACTIONAL ERROR= 0.147442E 00
TOTAL CORRECTION FACTOR= 0.100000E 01   FRACTIONAL ERROR= 0.208514E 00
```

DISTRIBUTIONS OF ACCEPTED PARTICLES AS A FUNCTION OF STARTING CONDITIONS OF PARTICLE AT TARGET

MOMENTUM(GEV/C)				POSITION ALONG TARGET(CM)			
GEV/C	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)	CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
0.128750	0.0	0.0	0.0	0.0	46.0000	46.0000	0.0
0.136250	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.143750	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.151250	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.158750	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.166250	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.173750	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.181250	1.00000	1.00000	0.0	0.0	0.0	0.0	0.0
0.188750	6.00000	6.00000	0.0	0.0	0.0	0.0	0.0
0.196250	12.0000	12.0000	0.0	0.0	0.0	0.0	0.0
0.203750	13.0000	13.0000	0.0	0.0	0.0	0.0	0.0
0.211250	6.00000	6.00000	0.0	0.0	0.0	0.0	0.0
0.218750	4.00000	4.00000	0.0	0.0	0.0	0.0	0.0
0.226250	1.00000	1.00000	0.0	0.0	0.0	0.0	0.0
0.233750	2.00000	2.00000	0.0	0.0	0.0	0.0	0.0
0.241250	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.248750	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.256250	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.263750	1.00000	1.00000	0.0	0.0	0.0	0.0	0.0
0.271250	0.0	0.0	0.0	0.0	0.0	0.0	0.0

POSITION IN HORIZONTAL PLANE(CM)				ANGLE IN HORIZONTAL PLANE(MR)			
CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)	MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.237500	2.00000	2.00000	0.0	-35.6250	0.0	0.0	0.0
-0.212500	1.00000	1.00000	0.0	-31.8750	0.0	0.0	0.0
-0.187500	2.00000	2.00000	0.0	-28.1250	0.0	0.0	0.0
-0.162500	3.00000	3.00000	0.0	-24.3750	0.0	0.0	0.0
-0.137500	3.00000	3.00000	0.0	-20.6250	0.0	0.0	0.0
-0.112500	4.00000	4.00000	0.0	-16.8750	2.00000	2.00000	0.0
-0.875000E-01	2.00000	2.00000	0.0	-13.1250	3.00000	3.00000	0.0
-0.625000E-01	0.0	0.0	0.0	-9.37500	1.00000	1.00000	0.0
-0.375000E-01	4.00000	4.00000	0.0	-5.62500	7.00000	7.00000	0.0
-0.125000E-01	1.00000	1.00000	0.0	-1.87500	9.00000	9.00000	0.0
0.125000E-01	2.00000	2.00000	0.0	1.87500	11.0000	11.0000	0.0
0.375000E-01	1.00000	1.00000	0.0	5.62499	6.00000	6.00000	0.0
0.625000E-01	3.00000	3.00000	0.0	9.37499	2.00000	2.00000	0.0
0.875000E-01	2.00000	2.00000	0.0	13.1250	2.00000	2.00000	0.0
0.112500	1.00000	1.00000	0.0	16.8750	2.00000	2.00000	0.0
0.137500	3.00000	3.00000	0.0	20.6250	1.00000	1.00000	0.0
0.162500	6.00000	6.00000	0.0	24.3750	0.0	0.0	0.0
0.187500	1.00000	1.00000	0.0	28.1250	0.0	0.0	0.0
0.212500	3.00000	3.00000	0.0	31.8750	0.0	0.0	0.0
0.237500	2.00000	2.00000	0.0	35.6250	0.0	0.0	0.0

CM	POSITION IN VERTICAL PLANE(CM) INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.237500	1.00000	1.00000	0.0
-0.212500	4.00000	4.00000	0.0
-0.187500	2.00000	2.00000	0.0
-0.162500	4.00000	4.00000	0.0
-0.137500	6.00000	6.00000	0.0
-0.112500	3.00000	3.00000	0.0
-0.875000E-01	3.00000	3.00000	0.0
-0.625000E-01	2.00000	2.00000	0.0
-0.375000E-01	2.00000	2.00000	0.0
-0.125000E-01	6.00000	6.00000	0.0
0.125000E-01	0.0	0.0	0.0
0.375000E-01	3.00000	3.00000	0.0
0.625000E-01	2.00000	2.00000	0.0
0.875000E-01	1.00000	1.00000	0.0
0.112500	1.00000	1.00000	0.0
0.137500	1.00000	1.00000	0.0
0.162500	0.0	0.0	0.0
0.187500	4.00000	4.00000	0.0
0.212500	1.00000	1.00000	0.0
0.237500	0.0	0.0	0.0

MR	ANGLE IN VERTICAL PLANE(MR) INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-47.5000	0.0	0.0	0.0
-42.5000	0.0	0.0	0.0
-37.5000	0.0	0.0	0.0
-32.5000	0.0	0.0	0.0
-27.5000	0.0	0.0	0.0
-22.5000	2.00000	2.00000	0.0
-17.5000	1.00000	1.00000	0.0
-12.5000	8.00000	8.00000	0.0
-7.50000	7.00000	7.00000	0.0
-2.50000	9.00000	9.00000	0.0
2.50000	7.00000	7.00000	0.0
7.49999	4.00000	4.00000	0.0
12.5000	3.00000	3.00000	0.0
17.5000	4.00000	4.00000	0.0
22.5000	1.00000	1.00000	0.0
27.5000	0.0	0.0	0.0
32.5000	0.0	0.0	0.0
37.5000	0.0	0.0	0.0
42.5000	0.0	0.0	0.0
47.5000	0.0	0.0	0.0

CENTRAL VALUES AND WIDTHS OF DISTRIBUTIONS IN STARTING MOMENTA AND ANGLES
(THESE RESULTS ARE ROUGH ESTIMATES ONLY-FOR ACCURATE VALUES THE DISTRIBUTIONS SHOULD BE PLOTTED)

	INITIAL BEAM CENTRE	INITIAL BEAM WIDTH	FINAL BEAM CENTRE	FINAL BEAM WIDTH
MOMENTUM(GEV/C)	0.205	0.285E-01	0.205	0.285E-01
HORIZONTAL ANGLE(MR)	0.326	17.0	0.326	17.0
VERTICAL ANGLE(MR)	-1.30	27.0	-1.30	27.0

END OF FILE ENCOUNTERED FOLLOWING CALCULATION NUMBER 1 . STOP .

STOP 0
EXECUTION TERMINATED

6.2 Example 2

A single bending magnet spectrometer

This spectrometer consists of a single bending magnet, with an angle of bend of 27 deg, and with spark planes on either end of the magnet and 200 cm for the exit of the magnet. A scintillation counter for triggering purposes is placed just in front of the magnet. The program calculated two cases in this run:

1) The solid angle and momentum acceptance of the total system

   It is also desired to know the number of particles with a given initial momentum as a function of position in the final spark plane. This is accomplished by cards 12, 13, 14 and 15, which specify a 'space' of two dimensions, P at the target and X in the final spark plane. The system is assumed to be vacuum throughout except for the scintillation counter (cards 4, 5 and 6).

2) The momentum resolution, assuming wire spacings of 0.10, 0.14 and 0.24 cm in the first, second and third wire planes, respectively

   Since the angular acceptance of the single wire spacings is very small in the horizontal direction, the value of DXMAX is reduced as well as PMAX, to keep a reasonable efficiency. This example illustrates how elements are changed and how distributions as a function of desired variables are obtained using NSPAC.

One point in the output deserves mention. In the 'DISTRIBUTION OF PARTICLES FINALLY ACCEPTED' is given the number of particles as a function of P (target) and X (at region 6). The final number for each value of X (6) is the total, summed over all momenta, counted at that position. This is the single number which appears every second line.

```
6
TARG          0.0001   1.0                                        45.0
DRIFT          200.0   10.0    -10.0     7.5      -7.5
DRIFT     1     0.16   50.0    -50.0    +50.0    -50.0
                 1.0   1.03
              0.9157   6.0     0.0843    1.0
BEND            80.0   14.0                                       13.88
DRIFT            1.0   14.0    -14.0     7.5      -7.5
DRIFT          200.0   24.0    -24.0     15.0     -15.0
INIT      111111111.
GROUP            1.0   15.
NSPAC            1.0    1.0
                 2.0
 P            1.0     10.0      0.6      0.7
 X            6.0     10.0     48.0      0.0
XSIZE            0.2   150.0
YSIZE            0.5    70.0
PO               0.7     0.6
MASS           0.938
END
DRIFT  6     200.0    +0.12    -0.12    +15.0    -15.0
PO    12       0.7     0.004
DRIFT  5       1.0    +0.07    -0.07     +7.5     -7.5
DRIFT  2     200.0    +0.05    -0.05     +7.5     -7.5
INIT   7  111111111.
NSPAC  9
XSIZE 10       0.2     1.5
END
FINI
```

```
      MONTE CARLO CALCULATION FOR COUNTER EXPERIMENTS  ----- BEGIN CALCULATION NUMBER 1

   SYSTEM PARAMETERS DERIVED FROM INPUT -- (L(K)) -- 1 1 1 3 1 1


*TARG * ---------- SETTING UP REGION  1 ----- IDENTIFIER =  1

   DATA(  1 , J ) =      0.00010     1.00000     0.0         0.0          0.0
   U(  1 )        =        0.78540

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   1


*DRIFT* ---------- SETTING UP REGION  2 ----- IDENTIFIER =  2

   DATA(  2 , J ) =    200.00000    10.00000   -10.00000     7.50000    -7.50000
   U(  2 )        =        0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   2


*DRIFT* ---------- SETTING UP REGION  3 ----- IDENTIFIER =  3

   DATA(  3 , J ) =      0.16000    50.00000   -50.00000    50.00000   -50.00000
   U(  3 )        =        0.0

    100.0000 % OF APERATURE COVERED BY MATERIAL WITH DENSITY 1.0300 GM / CC
   COMPOSITION OF MATERIAL FOLLOWS :

      Z       PROP OF MATERIAL
              WITH ATOMIC NO Z
     6.0        0.915700
     1.0        0.084300
     0.0        0.0


   1/E SCATT.ANGLE=0.1664E-02   1/E DISPLACEMENT=0.1380E-03 THICKNESS IN RADIATION LENGTHS=0.3607E-02

   IONISATION ENERGY LOSS DISTRIBUTION IS OF LANDAU TYPE,AVERAGE=0.5967E-03 WIDTH=0.1643E-03 GEV

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   3


*BEND * ---------- SETTING UP REGION  4 ----- IDENTIFIER =  4

   DATA(  4 , J ) =     80.00000    14.00000     0.0         0.0          0.0
```

```
U(  4 )          =        0.24225

  PARAMETERS FOR CENTRAL TRAJECTORY THROUGH BENDING MAGNET
  RADIUS OF CURVATURE=   166.8      CMS,INPUT ANGLE=   13.8300 ANGLE OF BEND=   27.7538 OUTPUT ANGLE=  -13.8738 DEGREES
  VACUUM IN THIS ELEMENT

   TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   4


*DRIFT* ---------- SETTING UP REGION  5 ----- IDENTIFIER =  5

   DATA(  5 , J ) =       1.00000     14.00000    -14.00000     7.50000    -7.50000
   U(  5 )        =       0.0

   VACUUM IN THIS ELEMENT

   TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   5


*DRIFT* ---------- SETTING UP REGION  6 ----- IDENTIFIER =  6

   DATA(  6 , J ) =   200.00000    24.00000    -24.00000    15.00000   -15.00000
   U(  6 )        =       0.0

   VACUUM IN THIS ELEMENT

   TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   6


*INIT * ---------- SETTING UP REGION  7 ----- IDENTIFIER =  7

   RANDOM NUMBER INITIALIZER = 111111111


*GROUP* ---------- SETTING UP REGION  8 ----- IDENTIFIER =  8

   CALCULATIONS FOR  1 BLOCKS OF 15 THOUSAND EACH
   NORMALIZATION FACTOR =    0


*NSPAC* ---------- SETTING UP REGION  9 ----- IDENTIFIER =  9

   NSPACE =    1     NW    =    1
MULTI-DIMENSIONAL ANALYSIS,NUMBER OF SPACES=   1
NUMBER OF DIMENSIONS IN EACH SPACE=   2
  P 1  10      0.6000      0.7000      X 6  10    48.0000      0.0


*XSIZE* ---------- SETTING UP REGION 10 ----- IDENTIFIER = 10
```

0.

```
 XMAX   =       C.20000       DXMAX  =       C.150CC
 XC     =       C.0           DXMAXC =       C.0


*YSIZE* ---------- SETTING UP REGICN 11 ----- IDENTIFIER = 11

 YMAX   =       C.5CCCC       DYMAX  =       C.C7000
 YC     =       0.0           DYMAXC =       0.0


*PC    * ---------- SETTING UP REGICN 12 ----- IDENTIFIER = 12

 PC     =     C.7C0CC     PMAX =      0.60CCC     PC    =      0.70000
 TTHR =       C.C


*MASS * ---------- SETTING UP REGION 13 ----- IDENTIFIER = 13

 MASS  =      C.53E0C     SIGA  =      0.C           SIGE   =     0.0
 TAUC  =  C.0             SCALE =      1.00000

 DECAY MODES : ALF(1) =  0.C        A3(1)   =        0.0        A4(1)    =       0.0
               ALF(2) =  0.0        A3(2)   =        0.0        A4(2)    =       0.0
```

```
IN THE FOLLOWING TABULATION OF RESULTS
INITIAL OR INITIALLY MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH NO DECAY,SCATTERING,ABSORPTION OR ENERGY LOSS
  FINAL OR FINALLY   MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH    DECAY,SCATTERING,ABSORPTION AND ENERGY LOSS
TOTAL NUMBER OF TRIAL PARTICLES TRACED THROUGH SYSTEM= 15000
           NUMBER OF PARTICLES ACCEPTED INITIALLY=  3928
           NUMBER OF PARTICLES ACCEPTED FINALLY=     3882.
```

PARTICLES INITIALLY REJECTED FROM TOTAL TRIALS

	OUTSIDE HORIZONTAL LIMITS	OUTSIDE VERTICAL LIMITS
AT 1 TARG	0.0	0.0
AT 2 DRIFT	4928.00	0.0
AT 3 DRIFT	0.0	0.0
AT 4 BEND	0.0	0.0
AT 5 DRIFT	1632.00	1399.00
AT 6 DRIFT	3113.00	0.0

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED

	ENERGY TOO LOW	MULTIPLY SCATTERED OUT	ABSORBED	3-BODY DECAYS	TOTAL NUMBER REJECTED
AT 1 TARG	0.0	0.0	0.0	0.0	0.0
AT 2 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 3 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 4 BEND	0.0	0.0	0.0	0.0	0.0
AT 5 DRIFT	0.0	58.0000	0.0	0.0	58.0000
AT 6 DRIFT	0.0	57.0000	0.0	0.0	57.0000

PARTICLES FINALLY ACCEPTED FROM THOSE INITIALLY REJECTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE

	SCATTERING FROM NUCLEUS 1	SCATTERING FROM NUCLEUS 2	SCATTERING FROM NUCLEUS 3	DECAY-MODE 1	DECAY-MODE 2
OCCURING IN 1 TARG	0.0	0.0	0.0	0.0	0.0
OCCURING IN 2 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 3 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 4 BEND	0.0	0.0	0.0	0.0	0.0
OCCURING IN 5 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 6 DRIFT	0.0	0.0	0.0	0.0	0.0

TOTAL EXTRA PARTICLES PUT INTO BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.690000E 02 NUC.SCATT= 0.0 DECAY MODE 1= 0.0 DECAY MODE 2= 0.0 TOTAL= 0.690000E 02

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE

	SCATTERING FROM NUCLEUS 1	SCATTERING FROM NUCLEUS 2	SCATTERING FROM NUCLEUS 3	DECAY-MODE 1	DECAY-MODE 2
OCCURING IN 1 TARG	0.0	0.0	0.0	0.0	0.0
OCCURING IN 2 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 3 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 4 BEND	0.0	0.0	0.0	0.0	0.0
OCCURING IN 5 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 6 DRIFT	0.0	0.0	0.0	0.0	0.0

TOTAL PARTICLES REMOVED FROM BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.115000E 03 NUC.SCATT= 0.0 DECAY MODE 1= 0.0 DECAY MODE 2= 0.0
3-BODY DECAY= 0.0 ABSORPTION= 0.0 TOTAL= 0.115000E 03

SOLID ANGLE*MOM.RES.= 0.164976E-02 STERAD-BEV/C FRACTIONAL ERROR= 0.159556E-01
TOTAL CORRECTION FACTOR= 0.101185E 01 FRACTIONAL ERROR= 0.226314E-01

DISTRIBUTIONS OF ACCEPTED PARTICLES AS A FUNCTION OF STARTING CONDITIONS OF PARTICLE AT TARGET

MOMENTUM(GEV/C)

GEV/C	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
0.415000	0.0	0.0	0.0
0.445000	0.0	0.0	0.0
0.475000	0.0	0.0	0.0
0.505000	18.0000	16.0000	3.00000
0.535000	100.000	97.0000	4.00000
0.565000	179.000	172.000	3.00000
0.595000	230.000	225.000	5.00000
0.625000	296.000	288.000	5.00000
0.655000	331.000	323.000	2.00000
0.685000	399.000	389.000	4.00000
0.715000	395.000	394.000	7.00000
0.745000	371.000	368.000	7.00000
0.775000	318.000	315.000	3.00000
0.805000	277.000	273.000	4.00000
0.835000	247.000	245.000	1.00000
0.865000	193.000	194.000	5.00000
0.895000	169.000	173.000	6.00000
0.925000	156.000	155.000	2.00000
0.955000	130.000	130.000	2.00000
0.985000	119.000	125.000	6.00000

POSITION ALONG TARGET(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.475000E-04	197.000	198.000	3.00000
-0.425000E-04	162.000	161.000	2.00000
-0.375000E-04	195.000	191.000	3.00000
-0.325000E-04	197.000	194.000	2.00000
-0.275000E-04	177.000	170.000	1.00000
-0.225000E-04	195.000	191.000	3.00000
-0.175000E-04	179.000	181.000	5.00000
-0.125000E-04	195.000	193.000	6.00000
-0.750000E-05	189.000	186.000	4.00000
-0.250000E-05	191.000	186.000	3.00000
0.250000E-05	209.000	204.000	4.00000
0.750000E-05	187.000	189.000	6.00000
0.125000E-04	220.000	221.000	5.00000
0.175000E-04	208.000	205.000	4.00000
0.225000E-04	191.000	190.000	5.00000
0.275000E-04	219.000	216.000	3.00000
0.325000E-04	199.000	194.000	1.00000
0.375000E-04	207.000	204.000	0.0
0.425000E-04	209.000	209.000	4.00000
0.475000E-04	202.000	199.000	5.00000

POSITION IN HORIZONTAL PLANE(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.950000E-01	192.000	189.000	2.00000
-0.850000E-01	204.000	201.000	2.00000
-0.750000E-01	187.000	185.000	7.00000
-0.649999E-01	189.000	184.000	4.00000
-0.550000E-01	179.000	177.000	5.00000
-0.450000E-01	210.000	211.000	5.00000
-0.350000E-01	189.000	184.000	1.00000
-0.250000E-01	205.000	204.000	4.00000
-0.150000E-01	187.000	184.000	3.00000
-0.500001E-02	183.000	180.000	4.00000
0.499999E-02	215.000	210.000	2.00000
0.150000E-01	185.000	184.000	4.00000
0.250000E-01	196.000	194.000	4.00000
0.350000E-01	213.000	211.000	5.00000
0.450000E-01	180.000	181.000	3.00000
0.550000E-01	195.000	193.000	2.00000
0.649999E-01	220.000	216.000	2.00000
0.749999E-01	208.000	205.000	3.00000
0.850000E-01	194.000	196.000	5.00000
0.950000E-01	197.000	193.000	2.00000

ANGLE IN HORIZONTAL PLANE(MR)

MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
714.148	0.0	0.0	0.0
721.648	0.0	0.0	0.0
729.148	0.0	0.0	0.0
736.648	218.000	214.000	1.00000
744.148	338.000	331.000	3.00000
751.648	323.000	325.000	7.00000
759.148	357.000	350.000	1.00000
766.648	366.000	358.000	7.00000
774.148	351.000	346.000	7.00000
781.648	306.000	302.000	8.00000
789.148	292.000	239.000	5.00000
796.648	271.000	268.000	4.00000
804.148	267.000	268.000	7.00000
811.648	261.000	258.000	6.00000
819.148	229.000	227.000	3.00000
826.648	203.000	205.000	6.00000
834.148	146.000	141.000	4.00000
841.648	0.0	0.0	0.0
849.148	0.0	0.0	0.0
856.648	0.0	0.0	0.0

	POSITION IN VERTICAL PLANE(CM)			ANGLE IN VERTICAL PLANE(MR)			
CM	INITIAL EEAM	FINAL BEAM	FINAL.NOT(INITIAL)	MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.237500	174.000	166.000	1.00000	-33.2500	0.0	3.00000	3.00000
-0.212500	180.000	177.000	3.C0000	-29.7500	79.0000	82.0000	16.0000
-0.187500	184.000	177.000	1.00000	-26.2500	220.000	206.000	0.0
-0.1625CC	209.000	206.0CC	4.00000	-22.7500	236.000	232.000	3.00000
-0.137500	218.000	213.000	4.C0000	-19.2500	240.000	236.000	1.00000
-0.112500	178.000	178.000	5.00000	-15.7500	252.000	249.000	1.00000
-0.875000E-01	196.000	196.000	3.00000	-12.2500	258.000	257.000	2.00000
-0.625000E-01	195.000	198.000	5.C0000	-8.75000	221.000	217.000	1.00000
-0.3750CCE-01	229.000	229.000	6.00000	-5.25000	251.000	251.000	5.00000
-0.125000E-01	176.CC0	179.000	6.C0C00	-1.75000	270.000	267.000	1.00000
0.1250C0E-01	183.000	182.000	3.CC000	1.75000	215.000	217.000	2.00000
0.3750C0E-01	214.000	210.000	1.00000	5.25000	241.000	239.000	3.00000
0.625000E-01	181.000	173.000	2.C0000	8.74999	232.000	228.000	1.00000
0.875000E-01	199.000	202.000	8.00000	12.2500	232.000	233.000	3.00000
0.112500	215.C00	215.00C	4.00000	15.7500	236.000	236.000	4.00000
0.137500	184.000	180.000	2.00000	19.2500	221.000	221.000	3.00000
0.162500	222.000	219.000	2.00000	22.7500	220.000	222.000	5.00000
0.187500	203.000	197.00C	4.C0000	26.2500	227.000	216.000	1.00000
0.212500	206.000	204.000	1.00000	29.7500	77.0000	68.0000	12.0000
0.2375C0	182.000	181.000	4.00000	33.2500	0.0	2.00000	2.00000

CENTRAL VALUFS AND WIDTHS CF DISTRIBUTIONS IN STARTING MUMENTA AND ANGLES
(THESE RESULTS ARE ROUGH ESTIMATES CNLY-FCR ACCURATE VALUES THE DISTRIBUTIONS SHOULD BE PLOTTED)

	INITIAL BEAM		FINAL BEAM	
	CENTRE	WIDTH	CENTRE	WIDTH
MCMENTUM(GEV/C)	0.742	0.315	0.744	0.315
HCRIZCNTAL ANGLE(MR)	781.	94.9	781.	95.2
VERTICAL ANGLE(MR)	-0.313	55.8	-0.324	55.1

DISTRIBUTICN CF FARTICLES FINALLY ACCEPTED
SPACE 1

X 6 F 1	0.430	0.490	0.550	0.610	0.670	0.730	0.790	0.850	0.910	0.970	
-21.6	0.0	16.0	95.0	89.0	70.0	23.0	0.0	0.0	0.0	0.0	293.
-16.8	0.0	0.0	72.0	85.0	79.0	67.0	0.0	0.0	0.0	0.0	303.
-12.0	0.0	0.0	56.0	85.0	76.0	75.0	37.0	0.0	0.0	0.0	329.
-7.20	0.0	0.0	41.0	84.0	89.0	94.0	68.0	2.00	0.0	0.0	378.
-2.40	0.0	0.0	5.00	70.0	80.0	79.0	83.0	50.0	0.0	0.0	367.
2.40	0.0	0.0	0.0	54.0	92.0	84.0	85.0	76.0	39.0	0.0	430.
7.20	0.0	0.0	0.0	38.0	71.0	93.0	91.0	70.0	64.0	16.0	443.
12.0	0.0	0.0	0.0	8.00	83.0	77.0	77.0	92.0	79.0	91.0	507.
16.8	0.0	0.0	0.0	0.0	56.0	85.0	75.0	73.0	69.0	69.0	427.
21.6	0.0	0.0	0.0	0.0	16.0	85.0	72.0	76.0	77.0	79.0	405.

SUMS CF CCLUMNS ARE

0.0	16.0	269.	513.	712.	762.	588.	439.	328.	255.

```
      MONTE CARLO CALCULATION FOR COUNTER EXPERIMENTS   ----- BEGIN CALCULATION NUMBER 2

   SYSTEM PARAMETERS DERIVED FROM INPUT -- (L(K)) -- 1 1 1 3 1 1


*TARG * ---------- SETTING UP REGION  1 ----- IDENTIFIER =  1

   DATA(  1 , J ) =      0.00010      1.00000      0.0          0.0          0.0
   U(  1 )        =       0.78540

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    1


*DRIFT* ---------- SETTING UP REGION  2 ----- IDENTIFIER =  2

   DATA(  2 , J ) =    200.00000      0.05000     -0.05000      7.50000     -7.50000
   U(  2 )        =       0.0

   VACUUM IN THIS ELEMENT

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    2


*DRIFT* ---------- SETTING UP REGION  3 ----- IDENTIFIER =  3

   DATA(  3 , J ) =      0.16000     50.00000    -50.00000     50.00000    -50.00000
   U(  3 )        =       0.0

    100.0000 % OF APERATURE COVERED BY MATERIAL WITH DENSITY 1.0300 GM / CC
   COMPOSITION OF MATERIAL FOLLOWS :

        Z      PROP OF MATERIAL
               WITH ATOMIC NO Z
       6.0       0.915700
       1.0       0.084300
       0.0       0.0


   1/E SCATT.ANGLE=0.1664E-02   1/E DISPLACEMENT=0.1380E-03 THICKNESS IN RADIATION LENGTHS=0.3607E-02

   IONISATION ENERGY LOSS DISTRIBUTION IS OF LANDAU TYPE,AVERAGE=0.5967E-03 WIDTH=0.1643E-03 GEV

    TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    3


*BEND * ---------- SETTING UP REGION  4 ----- IDENTIFIER =  4

   DATA(  4 , J ) =     80.00000     14.00000      0.0          0.0          0.0
```

```
U(  4 )          =       0.24225

PARAMETERS FOR CENTRAL TRAJECTORY THROUGH BENDING MAGNET
RADIUS OF CURVATURE=   166.8     CMS.INPUT ANGLE=   13.8800 ANGLE OF BEND=   27.7538 OUTPUT ANGLE=  -13.8738 DEGREES
VACUUM IN THIS ELEMENT

 TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0         3-BODY DECAY PROBABILITY=0.0         REGION   4


*DRIFT* ---------- SETTING UP REGION  5 ----- IDENTIFIER =  5

DATA(  5 , J ) =      1.00000      0.07000     -0.07000      7.50000     -7.50000
U(  5 )        =       0.0

VACUUM IN THIS ELEMENT

 TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0         3-BODY DECAY PROBABILITY=0.0         REGION   5


*DRIFT* ---------- SETTING UP REGION  6 ----- IDENTIFIER =  6

DATA(  6 , J ) =    200.00000      0.12000     -0.12000     15.00000    -15.00000
U(  6 )        =       0.0

VACUUM IN THIS ELEMENT
 TOTAL INTERACTION LENGTH=0.1000E 31 ABS PROBABILITY=0.0         3-BODY DECAY PROBABILITY=0.0         REGION   6


*INIT * ---------- SETTING UP REGION  7 ----- IDENTIFIER =  7

RANDCM NUMBER INITIALIZER = 111111111


*GROUF* ---------- SETTING UP REGION  8 ----- IDENTIFIER =  8

CALCULATIONS FOR  1 BLOCKS OF 15 THOUSAND EACH
NORMALIZATION FACTOR =     0


*NSPAC* ---------- SETTING UP REGION  9 ----- IDENTIFIER =  9

NSPACE =     0     NW      =     0


*XSIZE* ---------- SETTING UP REGION 10 ----- IDENTIFIER = 10

XMAX    =     0.20000     DXMAX  =      0.00150
```

```
 XC      =      0.0        DXMAXC =      0.0


*YSIZE* ---------- SETTING UP REGION 11 ----- IDENTIFIER = 11

 YMAX    =      C.50000    DYMAX  =      0.07000
 YC      =      0.0        DYMAXC =      0.0


*PO    * ---------- SETTING UP REGION 12 ----- IDENTIFIER = 12

 FC    =     0.70000     PMAX =      0.00400     PC    =      0.70000
 TTHR  =     0.0


*MASS * ---------- SETTING UP REGION 13 ----- IDENTIFIER = 13

 MASS  =      0.93800     SIGA  =      0.0          SIGE  =      0.0
 TAU0  =  0.0             SCALE =      1.00000
 DECAY MODES : ALF(1) = 0.0       A3(1)  =        0.0        A4(1)  =        0.0
               ALF(2) = 0.0       A3(2)  =        0.0        A4(2)  =        0.0
```

```
IN THE FOLLOWING TABULATION OF RESULTS
INITIAL OR INITIALLY MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH NO DECAY,SCATTERING,ABSORPTION OR ENERGY LOSS
  FINAL OR FINALLY   MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH    DECAY,SCATTERING,ABSORPTION AND ENERGY LOSS
TOTAL NUMBER OF TRIAL PARTICLES TRACED THROUGH SYSTEM= 15000
           NUMBER OF PARTICLES ACCEPTED INITIALLY= 1465
             NUMBER OF PARTICLES ACCEPTED FINALLY=    719.0
```

PARTICLES INITIALLY REJECTED FROM TOTAL TRIALS

	OUTSIDE HORIZONTAL LIMITS	OUTSIDE VERTICAL LIMITS
AT 1 TARG	0.0	0.0
AT 2 DRIFT	10010.0	0.0
AT 3 DRIFT	0.0	0.0
AT 4 BEND	0.0	0.0
AT 5 DRIFT	1088.00	697.000
AT 6 DRIFT	1740.00	0.0

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED

	ENERGY TOO LOW	MULTIPLY SCATTERED OUT	ABSORBED	3-BODY DECAYS	TOTAL NUMBER REJECTED
AT 1 TARG	0.0	0.0	0.0	0.0	0.0
AT 2 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 3 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 4 BEND	0.0	0.0	0.0	0.0	0.0
AT 5 DRIFT	0.0	856.000	0.0	0.0	856.000
AT 6 DRIFT	0.0	280.000	0.0	0.0	280.000

```
    PARTICLES FINALLY ACCEPTED FROM THOSE INITIALLY REJECTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE
            SCATTERING FROM NUCLEUS 1 SCATTERING FROM NUCLEUS 2 SCATTERING FROM NUCLEUS 3    DECAY-MODE 1    DECAY-MODE 2
OCCURING IN  1  TARG     0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  2  DRIFT    0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  3  DRIFT    0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  4  BEND     0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  5  DRIFT    0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  6  DRIFT    0.0                      0.0                        0.0               0.0              0.0

TOTAL EXTRA PARTICLES PUT INTO BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.390000E 03   NUC.SCATT= 0.0           DECAY MODE 1= 0.0            DECAY MODE 2= 0.0             TOTAL= 0.390000E 03

    PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE
            SCATTERING FROM NUCLEUS 1 SCATTERING FROM NUCLEUS 2 SCATTERING FROM NUCLEUS 3    DECAY-MODE 1    DECAY-MODE 2
OCCURING IN  1  TARG     0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  2  DRIFT    0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  3  DRIFT    0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  4  BEND     0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  5  DRIFT    0.0                      0.0                        0.0               0.0              0.0
OCCURING IN  6  DRIFT    0.0                      0.0                        0.0               0.0              0.0

TOTAL PARTICLES REMOVED FROM  BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.113600E 04   NUC.SCATT= 0.0           DECAY MODE 1= 0.0            DECAY MODE 2= 0.0
  3-BODY DECAY= 0.0              ABSORPTION= 0.0          TOTAL= 0.113600E 04

SOLID ANGLE*MOM.RES.= 0.410199E-07 STERAD-BEV/C   FRACTIONAL ERROR= 0.261265E-01
TOTAL CORRECTION FACTOR= 0.203755E 01   FRACTIONAL ERROR= 0.455348E-01
```

DISTRIBUTIONS OF ACCEPTED PARTICLES AS A FUNCTION OF STARTING CONDITIONS OF PARTICLE AT TARGET

MOMENTUM(GEV/C)

GEV/C	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
0.698100	0.0	9.00000	9.00000
0.698300	9.00000	11.0000	10.0000
0.698500	15.0000	14.0000	11.0000
0.698700	22.0000	18.0000	13.0000
0.698900	45.0000	26.0000	19.0000
0.699100	93.0000	41.0000	21.0000
0.699300	101.000	35.0000	12.0000
0.699500	122.000	37.0000	10.0000
0.699700	164.000	38.0000	10.0000
0.699900	170.000	51.0000	9.00000
0.700100	167.000	51.0000	7.00000
0.700300	154.000	36.0000	11.0000
0.700500	119.000	52.0000	22.0000
0.700700	101.000	59.0000	29.0000
0.700900	86.0000	49.0000	24.0000
0.701100	43.0000	44.0000	35.0000
0.701300	31.0000	45.0000	38.0000
0.701500	13.0000	36.0000	34.0000
0.701700	7.00000	37.0000	36.0000
0.701900	3.00000	30.0000	30.0000

POSITION ALONG TARGET(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.475000E-04	71.0000	26.0000	18.0000
-0.425000E-04	76.0000	37.0000	14.0000
-0.375000E-04	77.0000	36.0000	22.0000
-0.325000E-04	65.0000	35.0000	21.0000
-0.275000E-04	67.0000	29.0000	14.0000
-0.225000E-04	61.0000	33.0000	19.0000
-0.175000E-04	83.0000	34.0000	16.0000
-0.125000E-04	72.0000	38.0000	22.0000
-0.750000E-05	79.0000	32.0000	16.0000
-0.250000E-05	73.0000	38.0000	21.0000
0.250000E-05	76.0000	37.0000	18.0000
0.750000E-05	64.0000	43.0000	26.0000
0.125000E-04	84.0000	34.0000	17.0000
0.175000E-04	65.0000	40.0000	20.0000
0.225000E-04	74.0000	31.0000	17.0000
0.275000E-04	71.0000	37.0000	23.0000
0.325000E-04	70.0000	36.0000	18.0000
0.375000E-04	69.0000	40.0000	21.0000
0.425000E-04	85.0000	47.0000	26.0000
0.475000E-04	83.0000	36.0000	21.0000

POSITION IN HORIZONTAL PLANE(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.950000E-01	64.0000	42.0000	25.0000
-0.850000E-01	71.0000	33.0000	16.0000
-0.750000E-01	72.0000	35.0000	14.0000
-0.649999E-01	73.0000	43.0000	25.0000
-0.550000E-01	77.0000	45.0000	27.0000
-0.450000E-01	51.0000	27.0000	15.0000
-0.350000E-01	72.0000	37.0000	26.0000
-0.250000E-01	79.0000	29.0000	15.0000
-0.150000E-01	84.0000	38.0000	22.0000
-0.500001E-02	65.0000	31.0000	18.0000
0.499999E-02	81.0000	43.0000	25.0000
0.150000E-01	72.0000	34.0000	16.0000
0.250000E-01	80.0000	34.0000	17.0000
0.350000E-01	67.0000	39.0000	25.0000
0.450000E-01	65.0000	34.0000	16.0000
0.550000E-01	76.0000	32.0000	16.0000
0.649999E-01	76.0000	39.0000	19.0000
0.749999E-01	76.0000	25.0000	11.0000
0.850000E-01	73.0000	33.0000	19.0000
0.950000E-01	91.0000	46.0000	23.0000

ANGLE IN HORIZONTAL PLANE(MR)

MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
784.685	0.0	0.0	0.0
784.760	0.0	0.0	0.0
784.835	18.0000	7.00000	4.00000
784.910	29.0000	13.0000	7.00000
784.985	65.0000	29.0000	13.0000
785.060	93.0000	42.0000	19.0000
785.135	97.0000	44.0000	22.0000
785.210	124.000	61.0000	31.0000
785.285	173.000	60.0000	29.0000
785.360	147.000	74.0000	49.0000
785.435	155.000	93.0000	56.0000
785.510	149.000	78.0000	40.0000
785.585	135.000	62.0000	34.0000
785.660	94.0000	40.0000	18.0000
785.735	89.0000	55.0000	29.0000
785.810	58.0000	36.0000	23.0000
785.885	30.0000	17.0000	11.0000
785.960	9.00000	8.00000	5.00000
786.035	0.0	0.0	0.0
786.110	0.0	0.0	0.0

POSITION IN VERTICAL PLANE(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.237500	77.0000	37.0000	19.0000
-0.212500	64.0000	32.0000	22.0000
-0.187500	80.0000	40.0000	18.0000
-0.162500	83.0000	36.0000	20.0000
-0.137500	86.0000	42.0000	21.0000
-0.112500	77.0000	34.0000	21.0000
-0.875000E-01	67.0000	32.0000	20.0000
-0.625000E-01	71.0000	40.0000	22.0000
-0.375000E-01	65.0000	38.0000	19.0000
-0.125000E-01	57.0000	25.0000	16.0000
0.125000E-01	75.0000	27.0000	13.0000
0.375000E-01	56.0000	41.0000	26.0000
0.625000E-01	74.0000	31.0000	19.0000
0.875000E-01	77.0000	37.0000	17.0000
0.112500	82.0000	46.0000	25.0000
0.137500	73.0000	38.0000	24.0000
0.162500	78.0000	43.0000	19.0000
0.187500	68.0000	35.0000	17.0000
0.212500	82.0000	27.0000	18.0000
0.237500	73.0000	38.0000	14.0000

ANGLE IN VERTICAL PLANE(MR)

MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-33.2500	0.0	0.0	0.0
-29.7500	20.0000	16.0000	12.0000
-26.2500	85.0000	42.0000	22.0000
-22.7500	98.0000	44.0000	30.0000
-19.2500	72.0000	32.0000	22.0000
-15.7500	89.0000	42.0000	22.0000
-12.2500	103.000	40.0000	12.0000
-8.75000	95.0000	53.0000	28.0000
-5.25000	83.0000	48.0000	28.0000
-1.75000	92.0000	44.0000	23.0000
1.75000	86.0000	44.0000	23.0000
5.25000	81.0000	46.0000	28.0000
8.74999	86.0000	38.0000	17.0000
12.2500	81.0000	39.0000	23.0000
15.7500	84.0000	45.0000	28.0000
19.2500	87.0000	41.0000	22.0000
22.7500	96.0000	48.0000	24.0000
26.2500	90.0000	44.0000	19.0000
29.7500	37.0000	12.0000	6.00000
33.2500	0.0	1.00000	1.00000

CENTRAL VALUES AND WIDTHS OF DISTRIBUTIONS IN STARTING MOMENTA AND ANGLES
(THESE RESULTS ARE ROUGH ESTIMATES ONLY-FOR ACCURATE VALUES THE DISTRIBUTIONS SHOULD BE PLOTTED)

	INITIAL BEAM		FINAL BEAM	
	CENTRE	WIDTH	CENTRE	WIDTH
MOMENTUM(GEV/C)	0.700	0.174E-02	0.700	0.385E-02
HORIZONTAL ANGLE(MR)	785.	0.731	785.	0.616
VERTICAL ANGLE(MR)	0.295	57.9	0.173	57.2

END OF FILE ENCOUNTERED FOLLOWING CALCULATION NUMBER 2 . STOP .

STOP 0
EXECUTION TERMINATED

6.3 Example 3

A spectrometer consisting of a quadrupole pair and two bending magnets

This spectrometer consists of a quadrupole pair focusing the particles through two vertical 45 deg bends onto a spark chamber plane. Parallel to point focusing horizontally and point to point focusing vertically is used, the required quadrupole fields being obtained using TRANSPORT.[11] A scintillation counter is located just after the second bend. Since the bends are in the vertical plane, the element ROTAT is used just before the first bending magnet. The particles traversing the system are assumed to be pions, which decay in flight, with a lifetime of 26.08 nsec. Absorption and nuclear scattering can also occur. This leads to fractional numbers of particles occurring in the output, since whenever an interaction occurs in the scintillation counter, a calculated fraction is assumed to be absorbed.

```
15
TARG          0.01      0.317
DRIFT        100.0      7.62     -7.62      7.62     -7.62
QUAD         40.64     0.3646
DRIFT         0.01      7.62     -7.62      7.62     -7.62
DRIFT        23.02      7.62     -7.62      7.62     -7.62
QUAD         40.64    -0.3193
DRIFT         0.01      7.62     -7.62      7.62     -7.62
DRIFT        30.48     15.24    -15.24      7.62     -7.62
ROTAT
BEND         173.9      16.0      45.0
DRIFT         0.01      7.62     -7.62     15.24    -15.24
DRIFT         50.0      7.62     -7.62     15.24    -15.24
BEND         173.9      16.0      45.0
DRIFT    1    0.16      7.62     -7.62     15.24    -15.24
               1.0      1.03
            0.9157       6.0    0.0843       1.0
DRIFT        150.0      7.62     -7.62     15.24    -15.24
INIT     73662497.
GROUP          3.0       2.0
NSPAC
XSIZE        0.144      40.0
YSIZE        0.084      80.0
PO            1.09      0.06
MASS     1  0.1396      30.0      20.0     26.08
               1.0    0.1055       0.0
END
FINI
```

```
       MONTE CARLO CALCULATION FOR COUNTER EXPERIMENTS  ----- BEGIN CALCULATION NUMBER 1

    SYSTEM PARAMETERS DERIVED FROM INPUT -- (L(K)) -- 1 1 2 1 1 2 1 1 6 3 1 1 3 1 1
 (1-BETA)CMS= 0.8101E-02   GAMMA-CMS= 0.7872E 01   P-CMS= 0.6980E-01   T3-CMS= 0.6980E-01   T4-CMS= 0.6980E-01
  DECAY LENGTH= 0.6109E 04    0.1637E-03    0.0            0.0


 *TARG * ---------- SETTING UP REGION  1 ----- IDENTIFIER =  1

    DATA(  1 , J ) =      0.01000     0.31700     0.0        0.0        0.0
    U(  1 )        =       0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE    1
DEC.PROBABILITY=0.0          MODE    2
     TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    1


 *DRIFT* ---------- SETTING UP REGION  2 ----- IDENTIFIER =  2

    DATA(  2 , J ) =    100.00000     7.62000    -7.62000     7.62000    -7.62000
    U(  2 )        =       0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE    1
DEC.PROBABILITY=0.0          MODE    2
     TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    2


 *QUAD * ---------- SETTING UP REGION  3 ----- IDENTIFIER =  3

    DATA(  3 , J ) =     40.64000     0.36460     0.0        0.0        0.0
    U(  3 )        =       0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE    1
DEC.PROBABILITY=0.0          MODE    2
     TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    3


 *DRIFT* ---------- SETTING UP REGION  4 ----- IDENTIFIER =  4

    DATA(  4 , J ) =      0.01000     7.62000    -7.62000     7.62000    -7.62000
    U(  4 )        =       0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE    1
DEC.PROBABILITY=0.0          MODE    2
     TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION    4
```

```
*DRIFT* ---------- SETTING UP REGION  5 ----- IDENTIFIER =  5

    DATA(  5 , J ) =    23.01999     7.62000    -7.62000     7.62000    -7.62000
    U(  5 )        =     0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE   1
DEC.PROBABILITY=0.0        MODE   2
  TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   5


*QUAD * ---------- SETTING UP REGION  6 ----- IDENTIFIER =  6

    DATA(  6 , J ) =    40.64000    -0.31930     0.0          0.0          0.0
    U(  6 )        =     0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE   1
DEC.PROBABILITY=0.0        MODE   2
  TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   6


*DRIFT* ---------- SETTING UP REGION  7 ----- IDENTIFIER =  7

    DATA(  7 , J ) =     0.01000     7.62000    -7.62000     7.62000    -7.62000
    U(  7 )        =     0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE   1
DEC.PROBABILITY=0.0        MODE   2
  TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   7


*DRIFT* ---------- SETTING UP REGION  8 ----- IDENTIFIER =  8

    DATA(  8 , J ) =    30.48000    15.24000   -15.24000     7.62000    -7.62000
    U(  8 )        =     0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE   1
DEC.PROBABILITY=0.0        MODE   2
  TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION   8


*ROTAT* ---------- SETTING UP REGION  9 ----- IDENTIFIER =  9

    DATA(  9 , J ) =     0.0         0.0         0.0          0.0          0.0
    U(  9 )        =     0.0
```

```
    VACUUM IN THIS ELEMENT


 *BEND * ---------- SETTING UP REGION 10 ----- IDENTIFIER = 10

    DATA( 10 , J ) =    173.89999     16.00000     45.00000       0.0             0.0
    U( 10 )        =          0.0

    PARAMETERS FOR CENTRAL TRAJECTORY THROUGH BENDING MAGNET
    RADIUS OF CURVATURE=    227.2       CMS,INPUT ANGLE=      0.0      ANGLE OF BEND=    45.0026 OUTPUT ANGLE=    -0.0026 DEGREES
    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE     1
DEC.PROBABILITY=0.0        MODE     2
     TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION  10


 *DRIFT* ---------- SETTING UP REGION 11 ----- IDENTIFIER = 11

    DATA( 11 , J ) =        0.01000      7.62000     -7.62000     15.24000    -15.24000
    U( 11 )        =          0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE     1
DEC.PROBABILITY=0.0        MODE     2
     TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION  11


 *DRIFT* ---------- SETTING UP REGION 12 ----- IDENTIFIER = 12

    DATA( 12 , J ) =       50.00000      7.62000     -7.62000     15.24000    -15.24000
    U( 12 )        =          0.0

    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE     1
DEC.PROBABILITY=0.0        MODE     2
     TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION  12


 *BEND * ---------- SETTING UP REGION 13 ----- IDENTIFIER = 13

    DATA( 13 , J ) =    173.89999     16.00000     45.00000       0.0             0.0
    U( 13 )        =          0.0

    PARAMETERS FOR CENTRAL TRAJECTORY THROUGH BENDING MAGNET
    RADIUS OF CURVATURE=    227.2       CMS,INPUT ANGLE=      0.0      ANGLE OF BEND=    45.0026 OUTPUT ANGLE=    -0.0026 DEGREES
    VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE     1
DEC.PROBABILITY=0.0        MODE     2
     TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0          REGION  13
```

```
*DRIFT* ---------- SETTING UP REGION 14 ----- IDENTIFIER = 14

   DATA( 14 , J ) =      0.16000     7.62000    -7.62000    15.24000   -15.24000
   U( 14 )        =      0.0

    100.0000 % OF APERATURE COVERED BY MATERIAL WITH DENSITY 1.0300 GM / CC
   COMPOSITION OF MATERIAL FOLLOWS :

       Z      PROP OF MATERIAL
              WITH ATOMIC NO Z
     6.0        0.915700
     1.0        0.084300
     0.0        0.0

   1/E SCATT.ANGLE=0.6442E-03   1/E DISPLACEMENT=0.5345E-04 THICKNESS IN RADIATION LENGTHS=0.3607E-02

   IONISATION ENERGY LOSS DISTRIBUTION IS OF LANDAU TYPE,AVERAGE=0.2823E-03 WIDTH=0.5975E-04 GEV

INT.PROBABILITY=0.8290E 00 ON ATOM    1   RMS ANGLE=0.9647E-01
INT.PROBABILITY=0.1524E 00 ON ATOM    2   RMS ANGLE=0.2212E 00
INT.PROBABILITY=0.0        ON ATOM    3   RMS ANGLE=0.0
DEC.PROBABILITY=0.1860E-01 MODE    1
DEC.PROBABILITY=0.0        MODE    2
    TOTAL INTERACTION LENGTH=0.4597E 02 ABS PROBABILITY=0.5955E 00  3-BODY DECAY PROBABILITY=0.0        REGION  14


*DRIFT* ---------- SETTING UP REGION 15 ----- IDENTIFIER = 15

   DATA( 15 , J ) =   150.00000     7.62000    -7.62000    15.24000   -15.24000
   U( 15 )        =      0.0

   VACUUM IN THIS ELEMENT

DEC.PROBABILITY=0.1000E 01 MODE    1
DEC.PROBABILITY=0.0        MODE    2
    TOTAL INTERACTION LENGTH=0.6109E 04 ABS PROBABILITY=0.0          3-BODY DECAY PROBABILITY=0.0        REGION  15


*INIT * ---------- SETTING UP REGION 16 ----- IDENTIFIER = 16

   RANDOM NUMBER INITIALIZER =  73662497


*GROUP* ---------- SETTING UP REGION 17 ----- IDENTIFIER = 17

   CALCULATIONS FOR  3 BLOCKS OF  2 THOUSAND EACH
   NORMALIZATION FACTOR =     0
```

```
*NSFAC* ---------- SETTING UP REGION 18 ----- IDENTIFIER = 18

   NSPACE =     C      NW      =     0


*XSIZE* ---------- SETTING UP REGION 19 ----- IDENTIFIER = 19

   XMAX    =       0.14400      DXMAX  =       C.04000
   XC      =       0.0          DXMAXC =       0.0


*YSIZE* ---------- SETTING UP REGION 20 ----- IDENTIFIER = 20

   YMAX    =       C.C8400      DYMAX  =       0.08000
   YC      =       0.0          DYMAXC =       C.0


*PC    * ---------- SETTING UP REGION 21 ----- IDENTIFIER = 21

   PC     =     1.09000      PMAX =       0.06000      FC    =      1.09000
   TTHR =       0.0


*MASS * ---------- SETTING UP REGION 22 ----- IDENTIFIER = 22

   MASS   =      0.13960      SIGA   =     30.00000      SIGE   =     20.00000
   TAU0   =   0.2608E-07      SCALE  =      1.00000

   DECAY MODES : ALF(1) =  1.00      A3(1)   =           0.1055      A4(1)   =           0.0
                 ALF(2) =  0.C       A3(2)   =           0.0         A4(2)   =           0.0
```

IN THE FOLLOWING TABULATION OF RESULTS
INITIAL OR INITIALLY MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH NO DECAY,SCATTERING,ABSORPTION OR ENERGY LOSS
FINAL OR FINALLY MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH DECAY,SCATTERING,ABSORPTION AND ENERGY LOSS
TOTAL NUMBER OF TRIAL PARTICLES TRACED THROUGH SYSTEM= 2000
NUMBER OF PARTICLES ACCEPTED INITIALLY= 579
NUMBER OF PARTICLES ACCEPTED FINALLY= 528.0

PARTICLES INITIALLY REJECTED FROM TOTAL TRIALS

	OUTSIDE HORIZONTAL LIMITS	OUTSIDE VERTICAL LIMITS
AT 1 TARG	0.0	0.0
AT 2 DRIFT	0.0	0.0
AT 3 QUAD	0.0	0.0
AT 4 DRIFT	0.0	0.0
AT 5 DRIFT	0.0	0.0
AT 6 QUAD	0.0	0.0
AT 7 DRIFT	0.0	350.000
AT 8 DRIFT	0.0	150.000
AT 9 ROTAT	0.0	0.0
AT 10 BEND	0.0	0.0
AT 11 DRIFT	469.000	0.0
AT 12 DRIFT	66.0000	0.0
AT 13 BEND	0.0	0.0
AT 14 DRIFT	213.000	0.0
AT 15 DRIFT	131.000	42.0000

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED

	ENERGY TOO LOW	MULTIPLY SCATTERED OUT	ABSORBED	3-BODY DECAYS	TOTAL NUMBER REJECTED
AT 1 TARG	0.0	0.0	0.0	0.0	0.0
AT 2 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 3 QUAD	0.0	0.0	0.0	0.0	0.0
AT 4 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 5 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 6 QUAD	0.0	0.0	0.0	0.0	0.0
AT 7 DRIFT	0.0	0.0	0.0	0.0	1.00000
AT 8 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 9 ROTAT	0.0	0.0	0.0	0.0	0.0
AT 10 BEND	0.0	0.0	0.0	0.0	0.0
AT 11 DRIFT	0.0	0.0	0.0	0.0	22.0000
AT 12 DRIFT	0.0	0.0	0.0	0.0	4.00000
AT 13 BEND	0.0	0.0	0.0	0.0	0.0
AT 14 DRIFT	0.0	0.0	1.19097	0.0	12.0000
AT 15 DRIFT	0.0	6.00000	0.0	0.0	15.8090

PARTICLES FINALLY ACCEPTED FROM THOSE INITIALLY REJECTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE

	SCATTERING FROM NUCLEUS 1	SCATTERING FROM NUCLEUS 2	SCATTERING FROM NUCLEUS 3	DECAY-MODE 1	DECAY-MODE 2
OCCURING IN 1 TARG	0.0	0.0	0.0	0.0	0.0
OCCURING IN 2 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 3 QUAD	0.0	0.0	0.0	0.0	0.0
OCCURING IN 4 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 5 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 6 QUAD	0.0	0.0	0.0	0.0	0.0
OCCURING IN 7 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 8 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 9 ROTAT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 10 BEND	0.0	0.0	0.0	0.0	0.0
OCCURING IN 11 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 12 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 13 BEND	0.0	0.0	0.0	0.0	0.0
OCCURING IN 14 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 15 DRIFT	0.0	0.0	0.0	1.00000	0.0

TOTAL EXTRA PARTICLES PUT INTO BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.400000E 01 NUC.SCATT= 0.0 DECAY MODE 1= 0.100000E 01 DECAY MODE 2= 0.0 TOTAL= 0.500000E 01

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE

	SCATTERING FROM NUCLEUS 1	SCATTERING FROM NUCLEUS 2	SCATTERING FROM NUCLEUS 3	DECAY-MODE 1	DECAY-MODE 2
OCCURING IN 1 TARG	0.0	0.0	0.0	0.0	0.0
OCCURING IN 2 DRIFT	0.0	0.0	0.0	9.00000	0.0
OCCURING IN 3 QUAD	0.0	0.0	0.0	5.00000	0.0
OCCURING IN 4 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 5 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 6 QUAD	0.0	0.0	0.0	1.00000	0.0
OCCURING IN 7 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 8 DRIFT	0.0	0.0	0.0	4.00000	0.0
OCCURING IN 9 ROTAT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 10 BEND	0.0	0.0	0.0	15.0000	0.0
OCCURING IN 11 DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 12 DRIFT	0.0	0.0	0.0	4.00000	0.0
OCCURING IN 13 BEND	0.0	0.0	0.0	9.00000	0.0
OCCURING IN 14 DRIFT	0.809030	0.0	0.0	0.0	0.0
OCCURING IN 15 DRIFT	0.0	0.0	0.0	1.00000	0.0

TOTAL PARTICLES REMOVED FROM BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.600000E 01 NUC.SCATT= 0.809030E 00 DECAY MODE 1= 0.480000E 02 DECAY MODE 2= 0.0
3-BODY DECAY= 0.0 ABSORPTION= 0.119097E 01 TOTAL= 0.560000E 02

TOTAL NUMBER OF DECAY PRODUCTS FINALLY ACCEPTED FROM DECAYS

OCCURING IN 1 TARG	0.0
OCCURING IN 2 DRIFT	0.0
OCCURING IN 3 QUAD	0.0
OCCURING IN 4 DRIFT	0.0
OCCURING IN 5 DRIFT	0.0
OCCURING IN 6 QUAD	0.0
OCCURING IN 7 DRIFT	0.0

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OCCURING IN  8  DRIFT    0.0
OCCURING IN  9  ROTAT    0.0
OCCURING IN 10  BEND      1.00000
OCCURING IN 11  DRIFT    0.0
OCCURING IN 12  DRIFT    0.0
OCCURING IN 13  BEND      4.00000
OCCURING IN 14  DRIFT    0.0
OCCURING IN 15  DRIFT     13.0000

SOLID ANGLE*MOM.RES.= 0.555840E-04 STERAD-BEV/C   FRACTIONAL ERROR= 0.415586E-01
TOTAL CORRECTION FACTOR= 0.109659E 01   FRACTIONAL ERROR= 0.601752E-01
```

DISTRIBUTIONS OF ACCEPTED PARTICLES AS A FUNCTION OF STARTING CONDITIONS OF PARTICLE AT TARGET

MOMENTUM(GEV/C)

GEV/C	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
1.06150	21.0000	19.0000	0.0
1.06450	16.0000	14.0000	0.0
1.06750	27.0000	24.0000	1.00000
1.07050	23.0000	20.0000	0.0
1.07350	34.0000	28.0000	0.0
1.07650	31.0000	26.0000	0.0
1.07950	35.0000	31.0000	0.0
1.08250	40.0000	38.0000	0.0
1.08550	33.0000	31.0000	0.0
1.08850	29.0000	27.0000	1.00000
1.09150	39.0000	40.0000	1.00000
1.09450	38.0000	35.0000	0.0
1.09750	33.0000	33.0000	1.00000
1.10050	36.0000	35.0000	0.0
1.10350	29.0000	25.0000	0.0
1.10650	23.0000	23.0000	0.0
1.10950	33.0000	30.0000	0.0
1.11250	20.0000	16.0000	0.0
1.11550	22.0000	20.0000	1.00000
1.11850	17.0000	13.0000	0.0

POSITION ALONG TARGET(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.475000E-02	26.0000	20.0000	0.0
-0.425000E-02	32.0000	29.0000	1.00000
-0.375000E-02	26.0000	23.0000	0.0
-0.325000E-02	28.0000	29.0000	1.00000
-0.275000E-02	29.0000	29.0000	0.0
-0.225000E-02	35.0000	30.0000	0.0
-0.175000E-02	25.0000	25.0000	0.0
-0.125000E-02	23.0000	18.0000	0.0
-0.750000E-03	25.0000	24.0000	0.0
-0.250000E-03	25.0000	23.0000	0.0
0.250000E-03	25.0000	20.0000	1.00000
0.750000E-03	32.0000	30.0000	0.0
0.125000E-02	38.0000	37.0000	0.0
0.175000E-02	31.0000	28.0000	0.0
0.225000E-02	36.0000	31.0000	0.0
0.275000E-02	26.0000	22.0000	0.0
0.325000E-02	24.0000	24.0000	1.00000
0.375000E-02	34.0000	31.0000	0.0
0.425000E-02	26.0000	25.0000	1.00000
0.475000E-02	33.0000	30.0000	0.0

POSITION IN HORIZONTAL PLANE(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.684000E-01	23.0000	20.0000	0.0
-0.612000E-01	38.0000	33.0000	1.00000
-0.540000E-01	22.0000	20.0000	0.0
-0.468000E-01	39.0000	38.0000	0.0
-0.396000E-01	26.0000	23.0000	0.0
-0.324000E-01	26.0000	21.0000	0.0
-0.252000E-01	30.0000	26.0000	1.00000
-0.180000E-01	34.0000	32.0000	2.00000
-0.108000E-01	28.0000	29.0000	1.00000
-0.360000E-02	33.0000	30.0000	0.0
0.360000E-02	34.0000	33.0000	0.0
0.108000E-01	27.0000	25.0000	0.0
0.180000E-01	26.0000	24.0000	0.0
0.252000E-01	25.0000	22.0000	0.0
0.324000E-01	32.0000	31.0000	0.0
0.396000E-01	30.0000	28.0000	0.0
0.468000E-01	34.0000	31.0000	0.0
0.540000E-01	21.0000	18.0000	0.0
0.612000E-01	28.0000	27.0000	0.0
0.684000E-01	23.0000	17.0000	0.0

ANGLE IN HORIZONTAL PLANE(MR)

MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-19.0000	11.0000	7.00000	0.0
-17.0000	38.0000	33.0000	0.0
-15.0000	24.0000	23.0000	0.0
-13.0000	32.0000	29.0000	0.0
-11.0000	36.0000	33.0000	0.0
-9.00000	23.0000	23.0000	0.0
-7.00000	27.0000	25.0000	0.0
-5.00000	33.0000	30.0000	0.0
-3.00000	33.0000	30.0000	0.0
-1.00000	24.0000	21.0000	0.0
0.999999	23.0000	23.0000	1.00000
3.00000	39.0000	38.0000	0.0
5.00000	26.0000	25.0000	1.00000
7.00000	29.0000	25.0000	0.0
9.00000	29.0000	24.0000	0.0
11.0000	40.0000	38.0000	0.0
13.0000	34.0000	30.0000	0.0
15.0000	38.0000	34.0000	0.0
17.0000	30.0000	28.0000	1.00000
19.0000	10.0000	9.00000	2.00000

	POSITION IN VERTICAL PLANE(CM)				ANGLE IN VERTICAL PLANE(MR)		
CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)	MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.399000E-01	32.0000	28.0000	0.0	-38.0000	0.0	0.0	0.0
-0.357000E-01	35.0000	32.0000	0.0	-34.0000	0.0	0.0	0.0
-0.315000E-01	23.0000	22.0000	0.0	-30.0000	0.0	0.0	0.0
-0.273000E-01	27.0000	27.0000	0.0	-26.0000	2.00000	1.00000	0.0
-0.231000E-01	28.0000	27.0000	0.0	-22.0000	21.0000	17.0000	0.0
-0.189000E-01	25.0000	22.0000	0.0	-18.0000	48.0000	47.0000	1.00000
-0.147000E-01	28.0000	29.0000	2.00000	-14.0000	51.0000	48.0000	2.00000
-0.105000E-01	17.0000	16.0000	0.0	-10.0000	41.0000	39.0000	0.0
-0.630000E-02	32.0000	30.0000	1.00000	-6.00000	64.0000	58.0000	0.0
-0.210000E-02	28.0000	24.0000	1.00000	-2.00000	66.0000	60.0000	0.0
0.210000E-02	28.0000	27.0000	1.00000	2.00000	56.0000	53.0000	1.00000
0.629999E-02	33.0000	26.0000	0.0	6.00000	58.0000	49.0000	0.0
0.105000E-01	29.0000	25.0000	0.0	9.99999	51.0000	46.0000	0.0
0.147000E-01	35.0000	33.0000	0.0	14.0000	53.0000	49.0000	1.00000
0.189000E-01	24.0000	18.0000	0.0	18.0000	38.0000	36.0000	0.0
0.231000E-01	27.0000	25.0000	0.0	22.0000	25.0000	20.0000	0.0
0.273000E-01	32.0000	30.0000	0.0	26.0000	5.00000	5.00000	0.0
0.315000E-01	37.0000	34.0000	0.0	30.0000	0.0	0.0	0.0
0.357000E-01	31.0000	30.0000	0.0	34.0000	0.0	0.0	0.0
0.399000E-01	28.0000	23.0000	0.0	38.0000	0.0	0.0	0.0

CENTRAL VALUES AND WIDTHS OF DISTRIBUTIONS IN STARTING MOMENTA AND ANGLES
(THESE RESULTS ARE ROUGH ESTIMATES ONLY-FOR ACCURATE VALUES THE DISTRIBUTIONS SHOULD BE PLOTTED)

	INITIAL BEAM		FINAL BEAM	
	CENTRE	WIDTH	CENTRE	WIDTH
MOMENTUM(GEV/C)	1.09	0.522E-01	1.09	0.479E-01
HORIZONTAL ANGLE(MR)	0.302	49.6	0.371	47.2
VERTICAL ANGLE(MR)	0.100	38.1	-0.227E-01	37.4

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IN THE FOLLOWING TABULATION OF RESULTS
INITIAL OR INITIALLY MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH NO DECAY,SCATTERING,ABSORPTION OR ENERGY LOSS
  FINAL OR FINALLY   MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH    DECAY,SCATTERING,ABSORPTION AND ENERGY LOSS
TOTAL NUMBER OF TRIAL PARTICLES TRACED THROUGH SYSTEM=  4000
            NUMBER OF PARTICLES ACCEPTED INITIALLY=  1140
              NUMBER OF PARTICLES ACCEPTED FINALLY=     1036.
```

PARTICLES INITIALLY REJECTED FROM TOTAL TRIALS

		OUTSIDE HORIZONTAL LIMITS	OUTSIDE VERTICAL LIMITS
AT 1	TARG	0.0	0.0
AT 2	DRIFT	0.0	0.0
AT 3	QUAD	0.0	0.0
AT 4	DRIFT	0.0	0.0
AT 5	DRIFT	0.0	0.0
AT 6	QUAD	0.0	0.0
AT 7	DRIFT	0.0	709.000
AT 8	DRIFT	0.0	311.000
AT 9	ROTAT	0.0	0.0
AT 10	BEND	0.0	0.0
AT 11	DRIFT	943.000	0.0
AT 12	DRIFT	127.000	0.0
AT 13	BEND	0.0	0.0
AT 14	DRIFT	423.000	0.0
AT 15	DRIFT	272.000	75.0000

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED

		ENERGY TOO LOW	MULTIPLY SCATTERED CUT	ABSORBED	3-BODY DECAYS	TOTAL NUMBER REJECTED
AT 1	TARG	0.0	0.0	0.0	0.0	0.0
AT 2	DRIFT	0.0	0.0	0.0	0.0	0.0
AT 3	QUAD	0.0	0.0	0.0	0.0	0.0
AT 4	DRIFT	0.0	0.0	0.0	0.0	0.0
AT 5	DRIFT	0.0	0.0	0.0	0.0	0.0
AT 6	QUAD	0.0	0.0	0.0	0.0	0.0
AT 7	DRIFT	0.0	0.0	0.0	0.0	2.00000
AT 8	DRIFT	0.0	0.0	0.0	0.0	2.00000
AT 9	ROTAT	0.0	0.0	0.0	0.0	0.0
AT 10	BEND	0.0	0.0	0.0	0.0	0.0
AT 11	DRIFT	0.0	0.0	0.0	0.0	39.0000
AT 12	DRIFT	0.0	0.0	0.0	0.0	9.00000
AT 13	BEND	0.0	0.0	0.0	0.0	0.0
AT 14	DRIFT	0.0	0.0	1.78645	0.0	26.0000
AT 15	DRIFT	0.0	12.0000	0.0	0.0	33.2135

PARTICLES FINALLY ACCEPTED FROM THOSE INITIALLY REJECTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE

		SCATTERING FROM NUCLEUS 1	SCATTERING FROM NUCLEUS 2	SCATTERING FROM NUCLEUS 3	DECAY-MODE 1	DECAY-MODE 2
OCCURING IN 1	TARG	0.0	0.0	0.0	0.0	0.0
OCCURING IN 2	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 3	QUAD	0.0	0.0	0.0	0.0	0.0
OCCURING IN 4	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 5	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 6	QUAD	0.0	0.0	0.0	0.0	0.0
OCCURING IN 7	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 8	DRIFT	0.0	0.0	0.0	1.00000	0.0
OCCURING IN 9	ROTAT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 10	BEND	0.0	0.0	0.0	0.0	0.0
OCCURING IN 11	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 12	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 13	BEND	0.0	0.0	0.0	0.0	0.0
OCCURING IN 14	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 15	DRIFT	0.0	0.0	0.0	2.00000	0.0

TOTAL EXTRA PARTICLES PUT INTO BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.600000E 01 NUC.SCATT= 0.0 DECAY MODE 1= 0.300000E 01 DECAY MODE 2= 0.0 TOTAL= 0.900000E 01

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE

		SCATTERING FROM NUCLEUS 1	SCATTERING FROM NUCLEUS 2	SCATTERING FROM NUCLEUS 3	DECAY-MODE 1	DECAY-MODE 2
OCCURING IN 1	TARG	0.0	0.0	0.0	0.0	0.0
OCCURING IN 2	DRIFT	0.0	0.0	0.0	20.0000	0.0
OCCURING IN 3	QUAD	0.0	0.0	0.0	10.0000	0.0
OCCURING IN 4	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 5	DRIFT	0.0	0.0	0.0	2.00000	0.0
OCCURING IN 6	QUAD	0.0	0.0	0.0	2.00000	0.0
OCCURING IN 7	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 8	DRIFT	0.0	0.0	0.0	9.00000	0.0
OCCURING IN 9	ROTAT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 10	BEND	0.0	0.0	0.0	25.0000	0.0
OCCURING IN 11	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN 12	DRIFT	0.0	0.0	0.0	9.00000	0.0
OCCURING IN 13	BEND	0.0	0.0	0.0	19.0000	0.0
OCCURING IN 14	DRIFT	1.21354	0.0	0.0	0.0	0.0
OCCURING IN 15	DRIFT	0.0	0.0	0.0	2.00000	0.0

TOTAL PARTICLES REMOVED FROM BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.120000E 02 NUC.SCATT= 0.121354E 01 DECAY MODE 1= 0.980000E 02 DECAY MODE 2= 0.0
3-BODY DECAY= 0.0 ABSORPTION= 0.178645E 01 TOTAL= 0.113000E 03

TOTAL NUMBER OF DECAY PRODUCTS FINALLY ACCEPTED FROM DECAYS

OCCURING IN 1	TARG	0.0
OCCURING IN 2	DRIFT	2.00000
OCCURING IN 3	QUAD	0.0
OCCURING IN 4	DRIFT	0.0
OCCURING IN 5	DRIFT	0.0
OCCURING IN 6	QUAD	0.0
OCCURING IN 7	DRIFT	0.0

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OCCURING IN  8  DRIFT      1.00000
OCCURING IN  9  ROTAT    0.0
OCCURING IN 10  EEND       1.00000
OCCURING IN 11  DRIFT    0.0
OCCURING IN 12  DRIFT    0.0
OCCURING IN 13  EEND       8.00000
OCCURING IN 14  DRIFT    0.0
OCCURING IN 15  DRIFT      25.0000


SOLID ANGLE*MOM.RES.= 0.547199E-04 STERAD-BEV/C   FRACTIONAL ERROR= 0.296174E-01
TOTAL CORRECTION FACTOR= 0.110039E 01   FRACTIONAL ERROR= 0.429237E-01
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DISTRIBUTIONS OF ACCEPTED PARTICLES AS A FUNCTION OF STARTING CONDITIONS OF PARTICLE AT TARGET

MOMENTUM(GEV/C)

GEV/C	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
1.06150	37.0000	30.0000	0.0
1.06450	37.0000	32.0000	0.0
1.06750	43.0000	38.0000	1.00000
1.07050	33.0000	29.0000	0.0
1.07350	59.0000	51.0000	0.0
1.07650	66.0000	58.0000	0.0
1.07950	63.0000	58.0000	0.0
1.08250	80.0000	72.0000	0.0
1.08550	64.0000	57.0000	0.0
1.08850	53.0000	49.0000	1.00000
1.09150	79.0000	76.0000	2.00000
1.09450	71.0000	65.0000	0.0
1.09750	75.0000	70.0000	1.00000
1.10050	67.0000	62.0000	1.00000
1.10350	57.0000	52.0000	0.0
1.10650	59.0000	58.0000	0.0
1.10950	63.0000	55.0000	0.0
1.11250	44.0000	40.0000	0.0
1.11550	53.0000	51.0000	3.00000
1.11850	37.0000	33.0000	0.0

POSITION ALONG TARGET(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.475000E-02	55.0000	45.0000	0.0
-0.425000E-02	61.0000	54.0000	2.00000
-0.375000E-02	63.0000	57.0000	0.0
-0.325000E-02	49.0000	50.0000	1.00000
-0.275000E-02	62.0000	59.0000	0.0
-0.225000E-02	57.0000	52.0000	1.00000
-0.175000E-02	55.0000	53.0000	0.0
-0.125000E-02	49.0000	41.0000	1.00000
-0.750000E-03	59.0000	51.0000	0.0
-0.250000E-03	49.0000	45.0000	0.0
0.250000E-03	55.0000	48.0000	1.00000
0.750000E-03	58.0000	55.0000	1.00000
0.125000E-02	65.0000	59.0000	0.0
0.175000E-02	53.0000	49.0000	0.0
0.225000E-02	57.0000	49.0000	0.0
0.275000E-02	65.0000	55.0000	0.0
0.325000E-02	49.0000	47.0000	1.00000
0.375000E-02	63.0000	59.0000	0.0
0.425000E-02	57.0000	54.0000	1.00000
0.475000E-02	59.0000	54.0000	0.0

POSITION IN HORIZONTAL PLANE(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.684000E-01	51.0000	45.0000	0.0
-0.612000E-01	64.0000	54.0000	1.00000
-0.540000E-01	47.0000	44.0000	0.0
-0.468000E-01	72.0000	69.0000	0.0
-0.396000E-01	53.0000	48.0000	0.0
-0.324000E-01	52.0000	46.0000	0.0
-0.252000E-01	51.0000	46.0000	1.00000
-0.180000E-01	66.0000	64.0000	2.00000
-0.108000E-01	55.0000	52.0000	2.00000
-0.360000E-02	74.0000	67.0000	0.0
0.360000E-02	66.0000	61.0000	0.0
0.108000E-01	55.0000	50.0000	1.00000
0.180000E-01	47.0000	43.0000	0.0
0.252000E-01	51.0000	45.0000	0.0
0.324000E-01	52.0000	49.0000	0.0
0.396000E-01	69.0000	63.0000	1.00000
0.468000E-01	61.0000	56.0000	0.0
0.540000E-01	54.0000	49.0000	1.00000
0.612000E-01	45.0000	43.0000	0.0
0.684000E-01	55.0000	42.0000	0.0

ANGLE IN HORIZONTAL PLANE(MR)

MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-19.0000	20.0000	13.0000	0.0
-17.0000	70.0000	61.0000	0.0
-15.0000	52.0000	46.0000	0.0
-13.0000	64.0000	57.0000	0.0
-11.0000	71.0000	67.0000	1.00000
-9.00000	51.0000	48.0000	1.00000
-7.00000	51.0000	46.0000	0.0
-5.00000	60.0000	53.0000	0.0
-3.00000	61.0000	55.0000	0.0
-1.00000	59.0000	54.0000	0.0
0.999999	50.0000	48.0000	1.00000
3.00000	73.0000	70.0000	0.0
5.00000	54.0000	52.0000	1.00000
7.00000	62.0000	59.0000	1.00000
9.00000	59.0000	51.0000	0.0
11.0000	69.0000	66.0000	0.0
13.0000	64.0000	58.0000	0.0
15.0000	70.0000	60.0000	0.0
17.0000	64.0000	58.0000	2.00000
19.0000	16.0000	14.0000	2.00000

POSITION IN VERTICAL PLANE(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.399000E-01	71.0000	61.0000	0.0
-0.357000E-01	64.0000	58.0000	0.0
-0.315000E-01	43.0000	42.0000	1.00000
-0.273000E-01	57.0000	54.0000	0.0
-0.231000E-01	65.0000	61.0000	0.0
-0.189000E-01	57.0000	51.0000	0.0
-0.147000E-01	49.0000	48.0000	2.00000
-0.105000E-01	41.0000	39.0000	1.00000
-0.630000E-02	61.0000	54.0000	1.00000
-0.210000E-02	50.0000	39.0000	1.00000
0.210000E-02	55.0000	55.0000	2.00000
0.629999E-02	58.0000	49.0000	0.0
0.105000E-01	65.0000	56.0000	0.0
0.147000E-01	66.0000	61.0000	0.0
0.189000E-01	51.0000	43.0000	0.0
0.231000E-01	60.0000	57.0000	0.0
0.273000E-01	59.0000	54.0000	0.0
0.315000E-01	52.0000	47.0000	0.0
0.357000E-01	56.0000	55.0000	1.00000
0.399000E-01	60.0000	52.0000	0.0

ANGLE IN VERTICAL PLANE(MR)

MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-38.0000	0.0	0.0	0.0
-34.0000	0.0	0.0	0.0
-30.0000	0.0	0.0	0.0
-26.0000	5.00000	4.00000	0.0
-22.0000	54.0000	48.0000	0.0
-18.0000	85.0000	78.0000	1.00000
-14.0000	97.0000	91.0000	3.00000
-10.0000	97.0000	90.0000	0.0
-6.00000	128.000	118.000	2.00000
-2.00000	130.000	119.000	0.0
2.00000	110.000	101.000	1.00000
6.00000	99.0000	86.0000	0.0
9.99999	111.000	100.000	1.00000
14.0000	92.0000	83.0000	1.00000
18.0000	82.0000	77.0000	0.0
22.0000	45.0000	36.0000	0.0
26.0000	5.00000	5.00000	0.0
30.0000	0.0	0.0	0.0
34.0000	0.0	0.0	0.0
38.0000	0.0	0.0	0.0

CENTRAL VALUES AND WIDTHS OF DISTRIBUTIONS IN STARTING MOMENTA AND ANGLES
(THESE RESULTS ARE ROUGH ESTIMATES ONLY-FOR ACCURATE VALUES THE DISTRIBUTIONS SHOULD BE PLOTTED)

	INITIAL BEAM		FINAL BEAM	
	CENTRE	WIDTH	CENTRE	WIDTH
MOMENTUM(GEV/C)	1.09	0.465E-01	1.09	0.422E-01
HORIZONTAL ANGLE(MR)	0.189	42.5	0.320	41.4
VERTICAL ANGLE(MR)	-0.347	37.5	-0.479	36.9

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IN THE FOLLOWING TABULATION OF RESULTS
INITIAL OR INITIALLY MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH NO DECAY,SCATTERING,ABSORPTION OR ENERGY LOSS
  FINAL OR FINALLY   MEANS PARTICLES WERE TRACED THROUGH SYSTEM WITH    DECAY,SCATTERING,ABSORPTION AND ENERGY LOSS
TOTAL NUMBER OF TRIAL PARTICLES TRACED THROUGH SYSTEM=  6000
              NUMBER OF PARTICLES ACCEPTED INITIALLY=  1714
                NUMBER OF PARTICLES ACCEPTED FINALLY=    1554.
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PARTICLES INITIALLY REJECTED FROM TOTAL TRIALS

	OUTSIDE HORIZONTAL LIMITS	OUTSIDE VERTICAL LIMITS
AT 1 TARG	0.0	0.0
AT 2 DRIFT	0.0	0.0
AT 3 QUAD	0.0	0.0
AT 4 DRIFT	0.0	0.0
AT 5 DRIFT	0.0	0.0
AT 6 QUAD	0.0	0.0
AT 7 DRIFT	0.0	1042.00
AT 8 DRIFT	0.0	468.000
AT 9 ROTAT	0.0	0.0
AT 10 BEND	0.0	0.0
AT 11 DRIFT	1429.00	0.0
AT 12 DRIFT	202.000	0.0
AT 13 BEND	0.0	0.0
AT 14 DRIFT	636.000	0.0
AT 15 DRIFT	398.000	111.000

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED

	ENERGY TOO LOW	MULTIPLY SCATTERED OUT	ABSORBED	3-BODY DECAYS	TOTAL NUMBER REJECTED
AT 1 TARG	0.0	0.0	0.0	0.0	0.0
AT 2 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 3 QUAD	0.0	0.0	0.0	0.0	0.0
AT 4 DRIFT	0.0	0.0	0.0	0.0	0.0
AT 5 DRIFT	0.0	0.0	0.0	0.0	1.00000
AT 6 QUAD	0.0	0.0	0.0	0.0	0.0
AT 7 DRIFT	0.0	0.0	0.0	0.0	2.00000
AT 8 DRIFT	0.0	0.0	0.0	0.0	5.00000
AT 9 ROTAT	0.0	0.0	0.0	0.0	0.0
AT 10 BEND	0.0	0.0	0.0	0.0	0.0
AT 11 DRIFT	0.0	0.0	0.0	0.0	55.0000
AT 12 DRIFT	0.0	0.0	0.0	0.0	11.0000
AT 13 BEND	0.0	0.0	0.0	0.0	0.0
AT 14 DRIFT	0.0	0.0	1.78645	0.0	42.0000
AT 15 DRIFT	0.0	19.0000	0.0	0.0	55.2135

PARTICLES FINALLY ACCEPTED FROM THOSE INITIALLY REJECTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE

			SCATTERING FROM NUCLEUS 1	SCATTERING FROM NUCLEUS 2	SCATTERING FROM NUCLEUS 3	DECAY-MODE 1	DECAY-MODE 2
OCCURING IN	1	TARG	0.0	0.0	0.0	0.0	0.0
OCCURING IN	2	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	3	QUAD	0.0	0.0	0.0	0.0	0.0
OCCURING IN	4	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	5	DRIFT	0.0	0.0	0.0	1.00000	0.0
OCCURING IN	6	QUAD	0.0	0.0	0.0	0.0	0.0
OCCURING IN	7	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	8	DRIFT	0.0	0.0	0.0	1.00000	0.0
OCCURING IN	9	ROTAT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	10	BEND	0.0	0.0	0.0	0.0	0.0
OCCURING IN	11	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	12	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	13	BEND	0.0	0.0	0.0	1.00000	0.0
OCCURING IN	14	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	15	DRIFT	0.0	0.0	0.0	2.00000	0.0

TOTAL EXTRA PARTICLES PUT INTO BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.800000E 01 NUC.SCATT= 0.0 DECAY MODE 1= 0.500000E 01 DECAY MODE 2= 0.0 TOTAL= 0.130000E 02

PARTICLES FINALLY REJECTED FROM THOSE INITIALLY ACCEPTED BECAUSE OF INTERACTIONS OF THE FOLLOWING TYPE

			SCATTERING FROM NUCLEUS 1	SCATTERING FROM NUCLEUS 2	SCATTERING FROM NUCLEUS 3	DECAY-MODE 1	DECAY-MODE 2
OCCURING IN	1	TARG	0.0	0.0	0.0	0.0	0.0
OCCURING IN	2	DRIFT	0.0	0.0	0.0	30.0000	0.0
OCCURING IN	3	QUAD	0.0	0.0	0.0	14.0000	0.0
OCCURING IN	4	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	5	DRIFT	0.0	0.0	0.0	3.00000	0.0
OCCURING IN	6	QUAD	0.0	0.0	0.0	5.00000	0.0
OCCURING IN	7	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	8	DRIFT	0.0	0.0	0.0	11.0000	0.0
OCCURING IN	9	ROTAT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	10	BEND	0.0	0.0	0.0	36.0000	0.0
OCCURING IN	11	DRIFT	0.0	0.0	0.0	0.0	0.0
OCCURING IN	12	DRIFT	0.0	0.0	0.0	18.0000	0.0
OCCURING IN	13	BEND	0.0	0.0	0.0	29.0000	0.0
OCCURING IN	14	DRIFT	1.21354	0.0	0.0	0.0	0.0
OCCURING IN	15	DRIFT	0.0	0.0	0.0	5.00000	0.0

TOTAL PARTICLES REMOVED FROM BEAM(SUMMED OVER ALL REGIONS)
MULT.SCATT.= 0.190000E 02 NUC.SCATT= 0.121354E 01 DECAY MODE 1= 0.151000E 03 DECAY MODE 2= 0.0
3-BODY DECAY= 0.0 ABSORPTION= 0.178645E 01 TOTAL= 0.173000E 03

TOTAL NUMBER OF DECAY PRODUCTS FINALLY ACCEPTED FROM DECAYS

OCCURING IN	1	TARG	0.0
OCCURING IN	2	DRIFT	2.00000
OCCURING IN	3	QUAD	0.0
OCCURING IN	4	DRIFT	0.0
OCCURING IN	5	DRIFT	1.00000
OCCURING IN	6	QUAD	0.0
OCCURING IN	7	DRIFT	0.0

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OCCURING IN  8  DRIFT     1.00000
OCCURING IN  9  ROTAT    0.0
OCCURING IN 10  BEND      2.00000
OCCURING IN 11  DRIFT    0.0
OCCURING IN 12  DRIFT    0.0
OCCURING IN 13  BEND      12.0000
OCCURING IN 14  DRIFT    0.0
OCCURING IN 15  DRIFT     35.0000

SOLID ANGLE*MOM.RES.= 0.548480E-04 STERAD-BEV/C   FRACTIONAL ERROR= 0.241543E-01
TOTAL CORRECTION FACTOR= 0.110296E 01   FRACTIONAL ERROR= 0.350276E-01
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DISTRIBUTIONS OF ACCEPTED PARTICLES AS A FUNCTION OF STARTING CONDITIONS OF PARTICLE AT TARGET

MOMENTUM(GEV/C)

GEV/C	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
1.06150	61.0000	52.0000	0.0
1.06450	55.0000	49.0000	0.0
1.06750	64.0000	57.0000	1.00000
1.07050	61.0000	55.0000	0.0
1.07350	92.0000	83.0000	0.0
1.07650	98.0000	87.0000	0.0
1.07950	95.0000	84.0000	0.0
1.08250	113.000	101.000	0.0
1.08550	100.000	86.0000	0.0
1.08850	85.0000	80.0000	2.00000
1.09150	106.000	98.0000	2.00000
1.09450	111.000	101.000	0.0
1.09750	119.000	111.000	1.00000
1.10050	104.000	97.0000	2.00000
1.10350	82.0000	75.0000	0.0
1.10650	91.0000	89.0000	2.00000
1.10950	88.0000	76.0000	0.0
1.11250	63.0000	58.0000	0.0
1.11550	69.0000	65.0000	3.00000
1.11850	57.0000	50.0000	0.0

POSITION ALONG TARGET(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.475000E-02	78.0000	65.0000	0.0
-0.425000E-02	94.0000	86.0000	3.00000
-0.375000E-02	91.0000	81.0000	0.0
-0.325000E-02	84.0000	80.0000	1.00000
-0.275000E-02	88.0000	83.0000	0.0
-0.225000E-02	78.0000	70.0000	1.00000
-0.175000E-02	78.0000	73.0000	0.0
-0.125000E-02	86.0000	73.0000	1.00000
-0.750000E-03	98.0000	86.0000	0.0
-0.250000E-03	83.0000	75.0000	0.0
0.250000E-03	79.0000	70.0000	2.00000
0.750000E-03	88.0000	82.0000	1.00000
0.125000E-02	95.0000	86.0000	1.00000
0.175000E-02	77.0000	70.0000	0.0
0.225000E-02	82.0000	72.0000	0.0
0.275000E-02	97.0000	81.0000	0.0
0.325000E-02	79.0000	77.0000	1.00000
0.375000E-02	86.0000	80.0000	0.0
0.425000E-02	85.0000	82.0000	2.00000
0.475000E-02	88.0000	82.0000	0.0

POSITION IN HORIZONTAL PLANE(CM)

CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.684000E-01	79.0000	69.0000	0.0
-0.612000E-01	93.0000	80.0000	1.00000
-0.540000E-01	74.0000	69.0000	0.0
-0.468000E-01	98.0000	90.0000	1.00000
-0.396000E-01	93.0000	83.0000	0.0
-0.324000E-01	77.0000	70.0000	0.0
-0.252000E-01	85.0000	77.0000	1.00000
-0.180000E-01	96.0000	92.0000	2.00000
-0.108000E-01	85.0000	82.0000	3.00000
-0.360000E-02	91.0000	84.0000	0.0
0.360000E-02	93.0000	87.0000	1.00000
0.108000E-01	80.0000	73.0000	1.00000
0.180000E-01	77.0000	69.0000	0.0
0.252000E-01	90.0000	79.0000	0.0
0.324000E-01	85.0000	79.0000	0.0
0.396000E-01	87.0000	80.0000	1.00000
0.468000E-01	93.0000	85.0000	0.0
0.540000E-01	77.0000	69.0000	2.00000
0.612000E-01	73.0000	68.0000	0.0
0.684000E-01	88.0000	69.0000	0.0

ANGLE IN HORIZONTAL PLANE(MR)

MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-19.0000	28.0000	20.0000	0.0
-17.0000	92.0000	83.0000	0.0
-15.0000	77.0000	68.0000	0.0
-13.0000	94.0000	87.0000	0.0
-11.0000	106.000	96.0000	1.00000
-9.00000	88.0000	83.0000	1.00000
-7.00000	82.0000	75.0000	0.0
-5.00000	87.0000	73.0000	0.0
-3.00000	80.0000	73.0000	0.0
-1.00000	87.0000	81.0000	1.00000
0.999999	82.0000	75.0000	1.00000
3.00000	102.000	94.0000	0.0
5.00000	89.0000	87.0000	2.00000
7.00000	99.0000	92.0000	2.00000
9.00000	84.0000	74.0000	0.0
11.0000	102.000	95.0000	0.0
13.0000	100.000	90.0000	0.0
15.0000	100.000	88.0000	0.0
17.0000	101.000	92.0000	2.00000
19.0000	34.0000	28.0000	3.00000

	POSITION IN VERTICAL PLANE(CM)				ANGLE IN VERTICAL PLANE(MR)		
CM	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)	MR	INITIAL BEAM	FINAL BEAM	FINAL.NOT(INITIAL)
-0.399000E-01	102.000	89.0000	0.0	-38.0000	0.0	0.0	0.0
-0.357000E-01	98.0000	88.0000	0.0	-34.0000	0.0	0.0	0.0
-0.315000E-01	77.0000	75.0000	1.00000	-30.0000	0.0	0.0	0.0
-0.273000E-01	78.0000	74.0000	1.00000	-26.0000	8.00000	5.00000	0.0
-0.231000E-01	90.0000	84.0000	0.0	-22.0000	84.0000	77.0000	0.0
-0.189000E-01	81.0000	72.0000	0.0	-18.0000	121.000	111.000	1.00000
-0.147000E-01	76.0000	71.0000	3.00000	-14.0000	150.000	136.000	3.00000
-0.105000E-01	66.0000	62.0000	2.00000	-10.0000	143.000	133.000	0.0
-0.630000E-02	87.0000	76.0000	1.00000	-6.00000	183.000	163.000	2.00000
-0.210000E-02	79.0000	64.0000	1.00000	-2.00000	189.000	171.000	0.0
0.210000E-02	96.0000	93.0000	2.00000	2.00000	170.000	155.000	2.00000
0.629999E-02	86.0000	76.0000	0.0	6.00000	160.000	140.000	1.00000
0.105000E-01	101.000	86.0000	0.0	9.99999	167.000	151.000	2.00000
0.147000E-01	94.0000	88.0000	0.0	14.0000	133.000	123.000	2.00000
0.189000E-01	78.0000	68.0000	1.00000	18.0000	123.000	117.000	0.0
0.231000E-01	88.0000	83.0000	0.0	22.0000	77.0000	66.0000	0.0
0.273000E-01	90.0000	83.0000	0.0	26.0000	6.00000	6.00000	0.0
0.315000E-01	82.0000	73.0000	0.0	30.0000	0.0	0.0	0.0
0.357000E-01	83.0000	78.0000	1.00000	34.0000	0.0	0.0	0.0
0.399000E-01	82.0000	71.0000	0.0	38.0000	0.0	0.0	0.0

CENTRAL VALUES AND WIDTHS OF DISTRIBUTIONS IN STARTING MOMENTA AND ANGLES
(THESE RESULTS ARE ROUGH ESTIMATES ONLY-FOR ACCURATE VALUES THE DISTRIBUTIONS SHOULD BE PLOTTED)

	INITIAL BEAM		FINAL BEAM	
	CENTRE	WIDTH	CENTRE	WIDTH
MOMENTUM(GEV/C)	1.09	0.522E-01	1.09	0.501E-01
HORIZONTAL ANGLE(MR)	0.467	41.1	0.514	40.6
VERTICAL ANGLE(MR)	-0.201	38.0	-0.180	38.0

END OF FILE ENCOUNTERED FOLLOWING CALCULATION NUMBER 1 . STOP .

STOP 0
EXECUTION TERMINATED

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