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EGS4 Shower Display System, EGS4PICT(2), Windows Version

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Abstract

A three-dimensional electro-magnetic shower display system on a personal computer was developed and is described. Data concerning particle trajectories are produced by using the EGS4 Monte Carlo code. A sample user code to produce trajectory data is presented together with the way of handling the display system on a personal computer. The display system runs under the Microsoft Windows system.

1 Introduction

The EGS4 Shower Display system (EGS4PICT) is a system used to display three-dimensional particle trajectories of electrons, positrons and photons on a personal computer (PC). The data of particles' trajectories are calculated by using the EGS4 Code System.[1)]

This system is similar to the EGS4_Windows system,[2)] which runs on the UNIX workstation by using the graphic system PHIGS. Although the EGS4_Windows system is a very useful tool for understanding an electro-magnetic shower, it needs a workstation and PHIGS. The EGS4PICT is constructed to display shower picture more easily on a PC, which is cheap and can be used at the many locations.

We have already reported on a version[3)] which runs under MS-DOS. It can be used only on a Japanese PC (PC-98). This version runs under the Microsoft Windows system, and, therefore, can be used on various PCs.

An outline of the system, the structures of the data produced by using EGS4, a sample user code of EGS4 to obtain the trajectory data and the display system, itself, are presented.

2 Outline of EGS4PICT

The EGS4PICT is a system used to display the trajectory of electrons, positrons and photons, which were calculated by using the EGS4 Monte Carlo code, on a PC.

It has the following functions:

- Expands the designated area
- Rotates around the X-, Y-, and Z-axis
- Changes the color and type of line for each particle
- Selects the history number or the history range to be displayed
- Displays the title and scale
- Displays the geometry
- Outputs the the picture to the printer

The system works on the PC with the Microsoft Windows 3.1.

3 Structures of the Trajectory Data

To reduce the data size of the trajectory, the position and the energy of each particle are expressed by number comprising five figures.

One record is composed from '$abbbbbccccdddddefghi$'. The meaning of each character is as follows:

a: variable to indicate the type of the record
- 0 $\Longrightarrow$ start of the new history
- 1 $\Longrightarrow$ data of photon
- 2 $\Longrightarrow$ data of electron
- 3 $\Longrightarrow$ data of positron
- 9 $\Longrightarrow$ end of the history

If a=0, *bbbbb* follows after a.
bbbbb:the history number
If a=1, 2 or 3, *'bbbbbccccdddddefghi'* follows.
bbbbb:X-coordinate
ccccc:Y-coordinate
ddddd:Z-coordinate
efghi:kinetic energy of the particle
If a=9, no character follows.

The X-, Y-, and Z-coordinates are expressed as integers in order to reduce the data size. To express a wide range of data depending on each problem, the coordinate is normalized with FNORM by the following equation:

$$bbbbb = INT(X/FNORM * 10000) + 50000. \quad (1)$$

Inside the display program, *'bbbbb'* is converted to a real coordinate by

$$x = (bbbbb - 50000)/10000 * FNORM. \quad (2)$$

The *efghi* is converted to kinetic energy in MeV by

$$E(MeV) = efgh \times 10^{i-3}. \quad (3)$$

In this way, it is possible to express the energy from 1 keV to 9.9999×10^9 MeV using numbers with five figures to the same precision.

4 EGS4 User Code for EGS4PICT

For drawing the trajectories of the particles, it is necessary to obtain a series of data, which include the type of particle as well as its position and energy. These data must be outputted as a group for the type of particle and the associated position. In the EGS4 calculation, a particle having a smaller kinetic energy is followed first after the interaction. When the type of particle followed is different from that of the incident particle, the group of data must be written on the output file.

`SUBROUTINE PLOTXYZ` was developed by modifying `SUBROUTINE PLOTXZ`,[4] which was developed at SLAC for a 2-dimensional shower display using the Unified Graphics System. The coordinates and the energy of particle are transferred into a number having five figures, as described at the previous section. These procedures are also included in this `SUBROUTINE`.

`SUBROUTINE GEOMOUT` was newly developed. The cylinder-plane and the plane geometry are currently included in this `SUBROUTINE`. Other geometries may be added in the future.

The EGS4 user code to obtain data concerning the particle trajectories for EGS4PICT is explained below using ucpict4.mor, which is the user code used to obtain shower display data of ucsampl4.mor, lists of it are given in Appendix.

4.1 Main Program

The statements that are necessary for the EGS4PICT have a comment "PICT" at the right side. In the main program, the following statements must be added.

(1) `COMMON/NFAC/FNORM,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX;`
The FNORM is the maximum size of the range to be displayed between X-, Y- and Z-coordinate. XMIN, YMIN and ZMIN are the minimum values in the X-, Y- and Z-coordinate, respectively. XMAX, YMAX and ZMAX is the maximum one.

(2) `OPEN(9,file=mortjob.9out,status=unknown);`
Define the file name to which the data for the shower display are written.

(3) `XMIN=-5.0; XMAX=5.0; YMIN=-5.0; YMAX=5.0; ZMIN=0.0; ZMAX=ZTHICK;`
Define the region that you want to display at each coordinate.

(4) `CALL GEOMOUT(NCYL,NPLAN);`
Call the SUBROUTINE GEOMOUT to output the geometry data. NCYL is the number of cylinders and NPLAN the number of planes. If the geometry is constructed by the plane only, like in this example, NCYL is set to 0.

As data of cylinders or planes, CYRAD2 or PNORM and PCOORD, which are used in the EGS4 geometry subroutines or macros, are used. For this purpose, the 7 statements above this are added.

If both NCYL and NPLAN are 0, the geometry data are not outputted.

(5) `FNORM=AMAX1(XMAX-XMIN,YMAX-YMIN,ZMAX-ZMIN);`
Calculate the maximum size to be displayed in the X-, Y- and Z-coordinate.

(6) `WRITE(9,:FMT90:) XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX,FNORM;`
`:FMT90:FORMAT(7F10.2);`
Output the region to be displayed at each coordinate and the normalization factor.

(7) `WRITE(9,:FMT91:) I; :FMT91:FORMAT('0',I5);`
Output the '0' which indicate the start of the history and the history number.

(8) `WRITE(9,:FMT92:); :FMT92:FORMAT('9');`
Output the '9' which indicate the end of the history.

If you want to display shower pictures produced by several incident particles, make the NBATCH LOOP outside the SHOWER-CALL LOOP and put the above two statements before and after the SHOWER-CALL LOOP, respectively.

```
DO J=1,NBATCH [
WRITE(9,:FMT91:) J; :FMT91:FORMAT('0',I5);
DO I=1,NCASES [
.....................................
.....................................
"END OF SHOWER-CALL LOOP"]
WRITE(9,:FMT91:);:FMT91:FORMAT('9');
"END OF NBATCH LOOP"]
```

(9) `CALL PLOTXYZ(99,0,0,0.,0.,0.,0.,0.);`
Tell to the SUBROUTINE PLOTXYZ that all of the histories are finished. If the first argument is 99, all of the data that are not written on the output file are outputted.

4.2 SUBROUTINE AUSGAB

Each time when the SUBROUTINE AUSGAB is called, IARG, the stack number (NP), the type of particle (IQ(NP)), the position of the particle (X(NP), Y(NP), Z(NP)) and the energy of the particle (E(NP)) are transferred to the SUBROUTINE PLOTXYZ by the following statement.

```
CALL PLOTXYZ(IARG,NP,IQ(NP),X(NP),Y(NP),Z(NP),E(NP));
```

4.3 SUBROUTINE PLOTXYZ

SUBROUTINE PLOTXYZ was written based on SUBROUTINE PLOTXZ developed at SLAC for the 2-dimensional display of a shower picture.

To express the coordinates and energy of a particle using a number having five figures, the following statements are inserted.

```
IF(X/FNORM.GT.4.999.OR.X/FNORM.LT.-4.999) [RETURN;]
IF(Y/FNORM.GT.4.999.OR.Y/FNORM.LT.-4.999) [RETURN;]
IF(Z/FNORM.GT.4.999.OR.Z/FNORM.LT.-4.999) [RETURN;]
.............................
IXPT(NPT(NP),NP)=X/FNORM*10000+50000;
IYPT(NPT(NP),NP)=Y/FNORM*10000+50000;
IZPT(NPT(NP),NP)=Z/FNORM*10000+50000;
IF(IQ.EQ.0) [EEE=ENP*1000;]
ELSE [EEE=(ENP-RM)*1000;]
IF(EEE.LT.10000.0) [
IEPT(NPT(NP),NP)=INT(EEE)*10;]
ELSE [
IFF=ALOG10(EEE)-3;
IEE=EEE/10**IFF;
IEPT(NPT(NP),NP)=IEF*10+IEF;]
```

SUBROUTINE PLOTXYZ stores the coordinates, the energy and the type of particle at each NP with the number from 1 to 100. When the type of the particle changes in the same NP or the stored number become 100, the stored data are written in the output file. The last stored data are set to the data of number 1. These procedures are those developed in SUBROUTINE PLOTXZ.

4.4 SUBROUTINE GEOMOUT

The current version treats only cylinder-slab geometry and plane geometry. If NCYLP is not 0, the cylinder-slab geometry is selected. If NCYLP is zero and NSLAB is not zero, the plane geometry is selected. If both NCYL and NPLAN are 0, geometry data are not produced.

a) the cylinder-slab geometry
The following data are written.

```
GSTA
CYLS
NCYLG,NZP          <-- NCYLG:number of cylinders,
                       NZP:number of Z-axis planes
CYL(I),I=1,NCYLG   <-- radius of the cylinder
ZBIN(I),I=1,NZP    <-- coordinate of Z-axis planes
GEND
```

b) the plane geometry
The following data are written.

```
GSTA
SLAB
NXP,NYP,NZP       <-- number of X-, Y- and Z-axis planes, respectively
XBIN(I),I=1,NXP   <-- coordinate of X-axis planes
YBIN(I),I=1,NYP   <-- coordinate of Y-axis planes
ZBIN(I),I=1,NZP   <-- coordinate of Z-axis planes
GEND
```

c) Other case

```
GSTA
GEND
```

5 EGS4PICT system

5.1 Hardware Requirewment

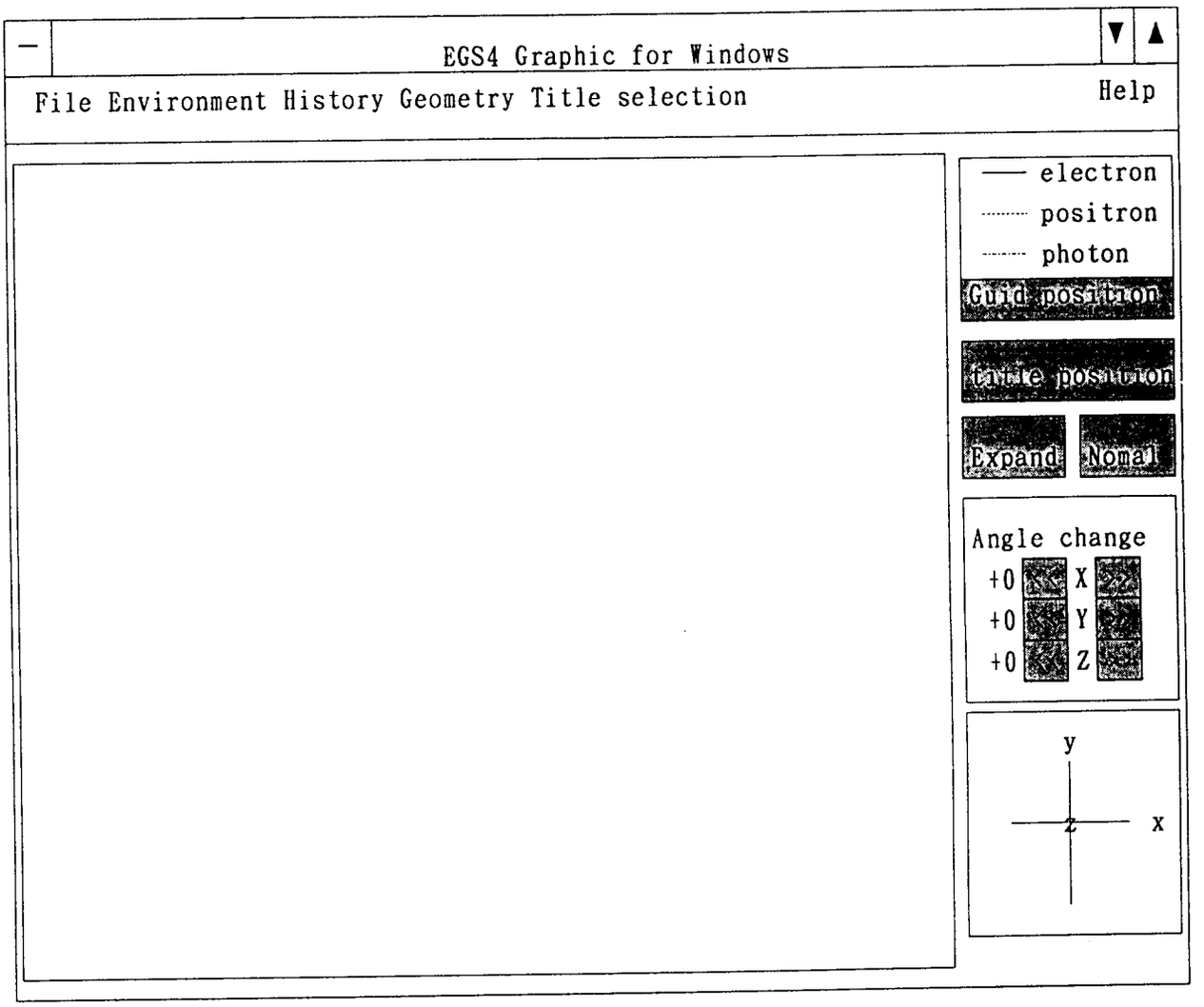
The EGS4PICT system runs under the following hardwares situation:

- Personal Computer (PC) – Operating with the Microsoft Windows 3.1
- Memory – minimum 4MB
- Hard disk – 1 $\sim$ 2 MB for this system

Although you can use the EGS4PICT system with the same resolution that you used on your PC, (640 x 400, 640 x 480, 800 x 600, or 1,024 x 768 dots), the font must be **16**.

5.2 Main Display

When you run the EGS4PICT, the following display appears first.



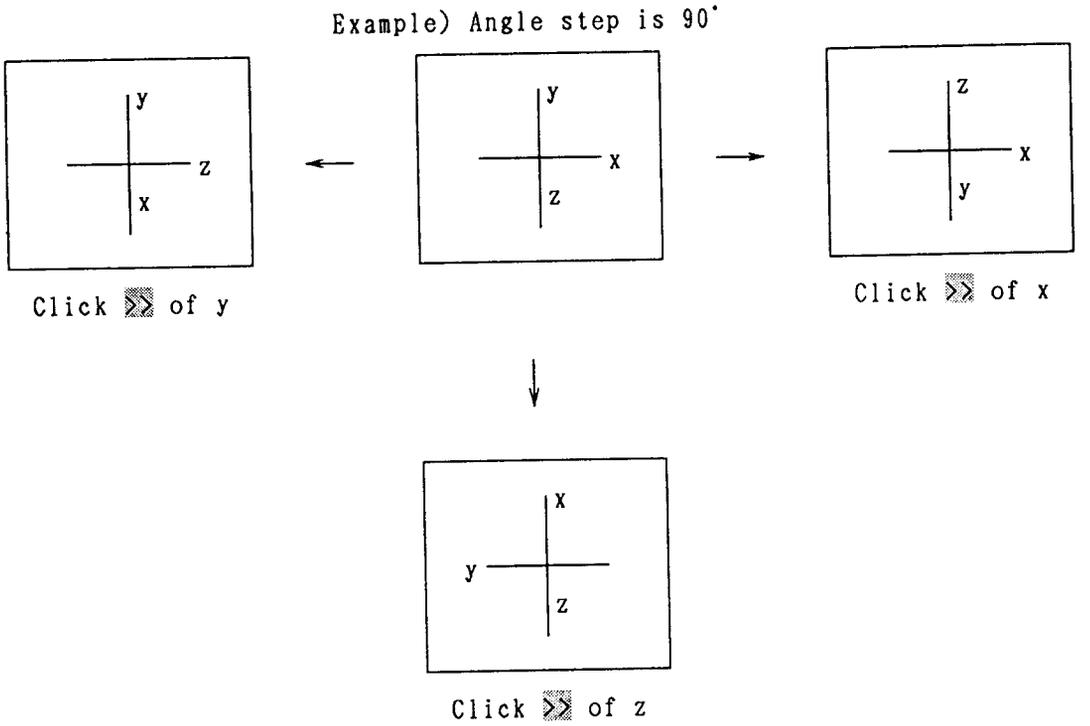
Main display

5.2.1 Angle Change

The angle change is a function used to change the view angle of each coordinate with the angle step value determined at "Angle step" in the environment.

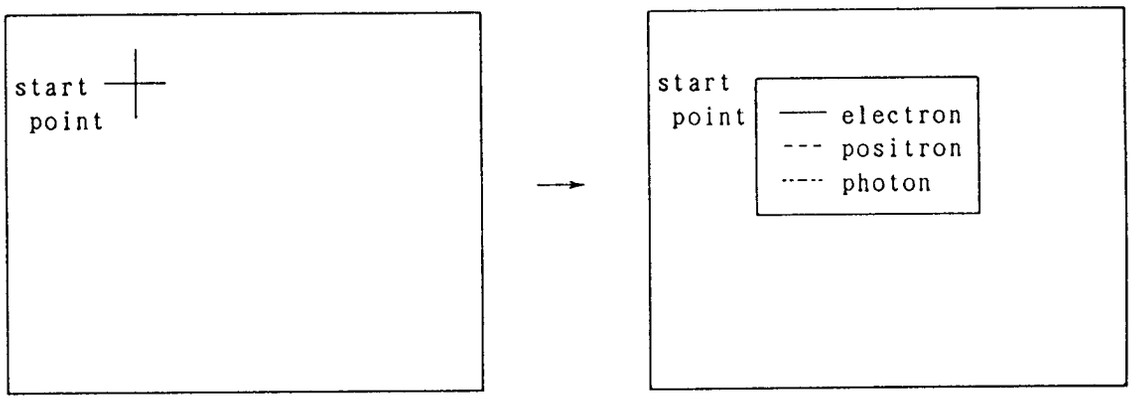
If the + button or the - one of x is clicked by the mouse , the x-axis rotates counter-clockwise or clockwise, respectively. The situation of the coordinate is shown at the box below that of the angle change.

The following figure shows an example of the rotation when the angle step is 90°.



5.2.2 Guide Position

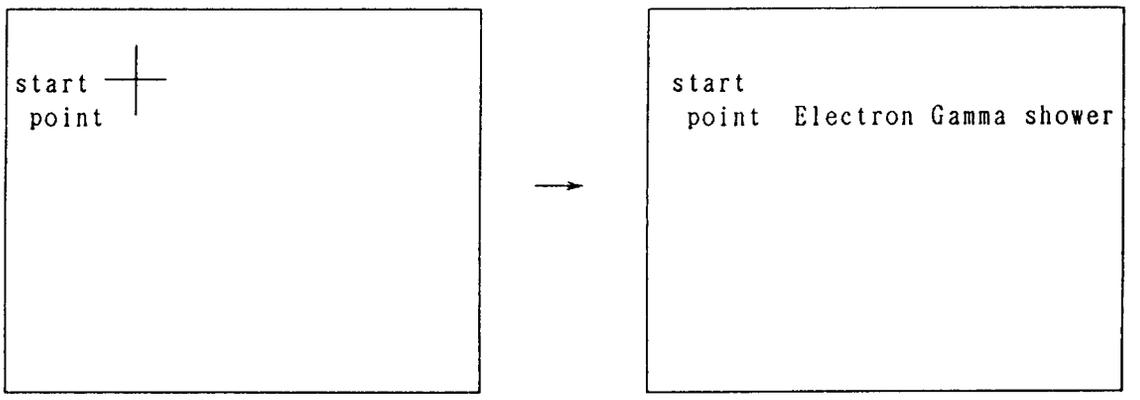
Guidance to show the color and the line type of each particle can be included inside the display window by clicking the guide position. You can display this guide box at any place by the clicking at the position that you want to display. The ESC-key cancels this procedure.



Click mouse at the start point Dsplay on the screen

5.2.3 Title Position

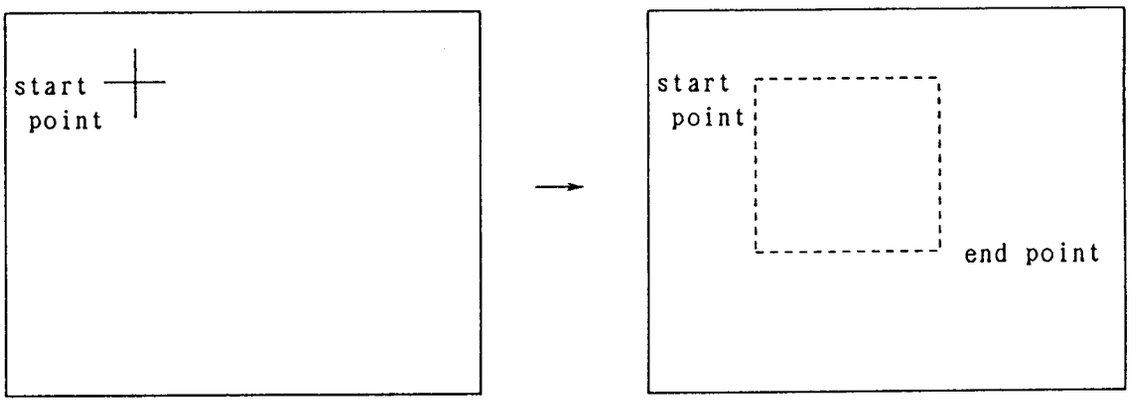
The title of the shower picture written by 'title' can be included inside the display window by clicking the title position. You can display the title at any place by clicking at the position that you want to display. The ESC-key cancels this procedure.



Click mouse at the start point Dsplay on the screen

5.2.4 Expand

Any part of the shower picture can be expanded by clicking at the Expand box. Push the left button of the mouse at the start point (the upper left) and drag until the end point (the lower right). It is possible to expand any part of the expanded picture by using the same procedure. The ESC-key cancels this procedure.



Push the left button of the mouse at the start point and drag till to the end point

If the Normal box is clicked, the expand display is canceled and the original display appears.

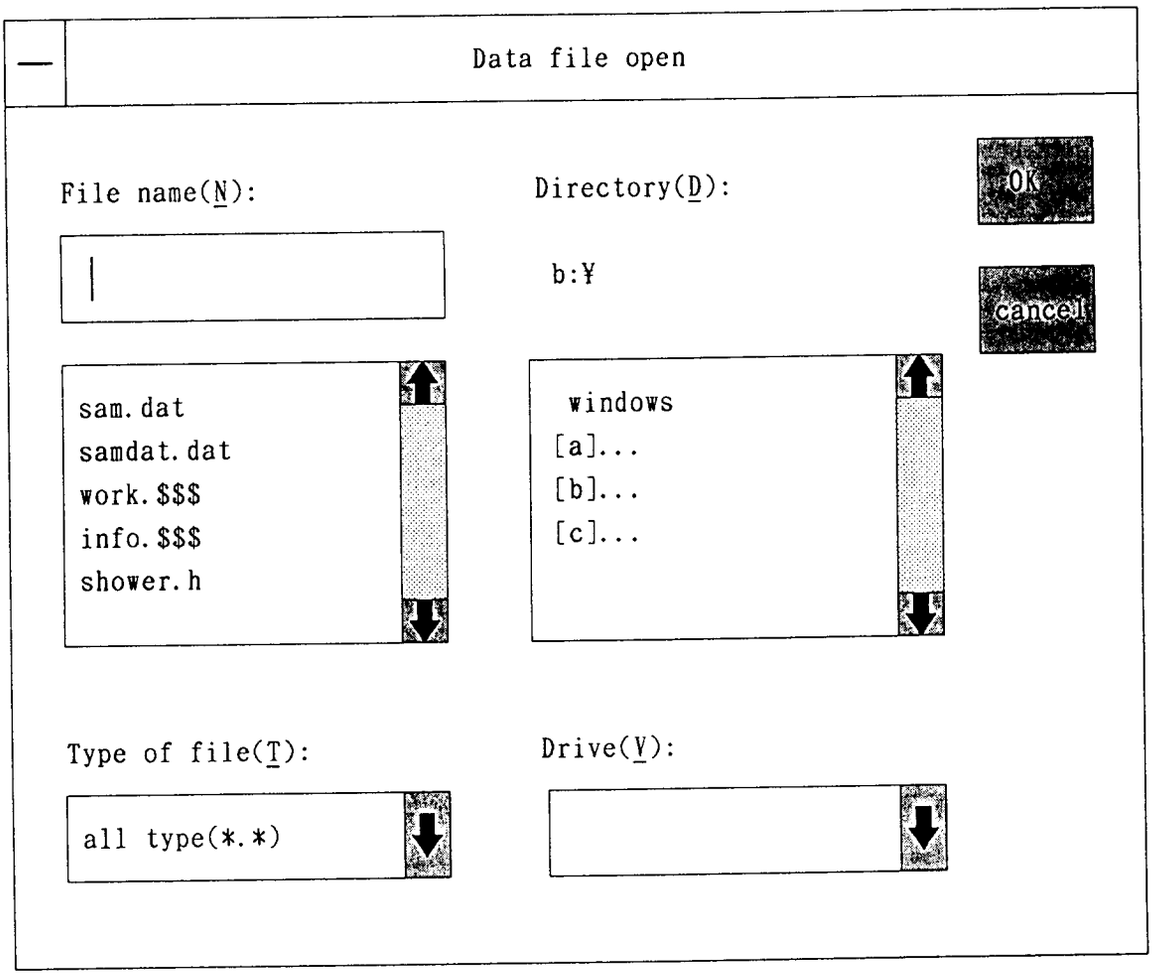
5.3 File

The file has the following pull-down menu.

Data file open	
Print	
Printer setup...	
Exit	GRPH+f4

5.3.1 Data file open

If data file open is selected, the following data file window appears. The file name calculated by using EGS4 for EGS4PICT must be defined with the full path by selecting the directory and file by clicking the mouse. After defining the file, the system starts reading the trajectory data and drawing the shower picture by clicking the OK box. Clicking of the Cancel box or ESC-key cancels the procedure.



Data file Window

5.3.2 Print

Print out the shower picture displayed on the screen to the printer. The printer is selected using the "Printer setup" menu.

5.3.3 Printer setup

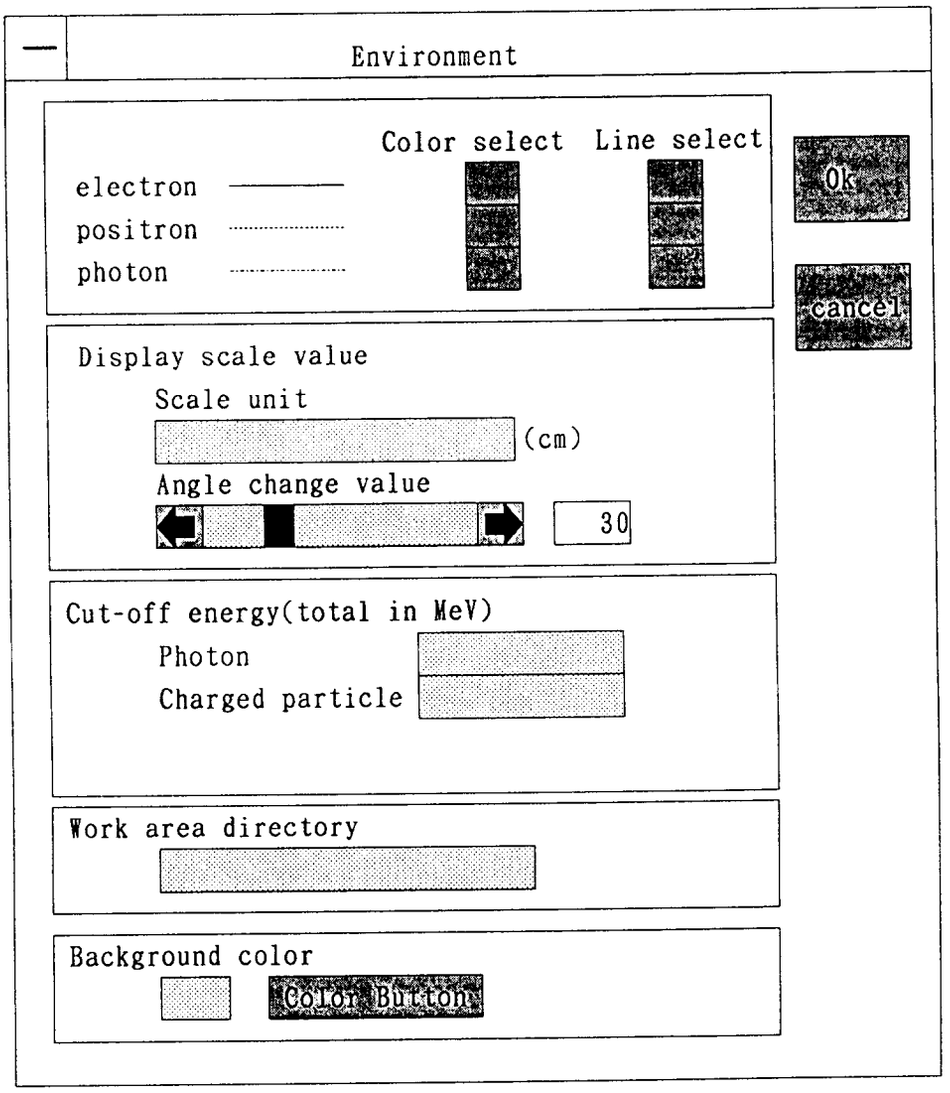
Select the printer and change the established items. The selection and the established items depend on Windows 3.1.

5.3.4 Exit

Exit the EGS4PICT system. After finishing the system, the established conditions are stored in the information file (info.$$$).

5.4 Environment

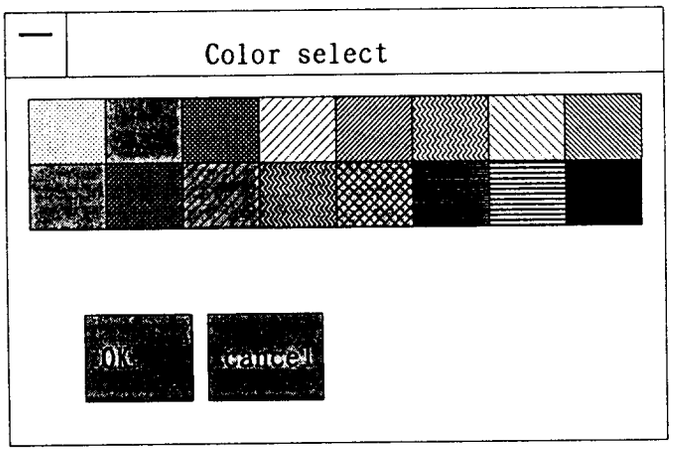
Establish the drawing environment on the following display.



Environment Window

5.4.1 Color select

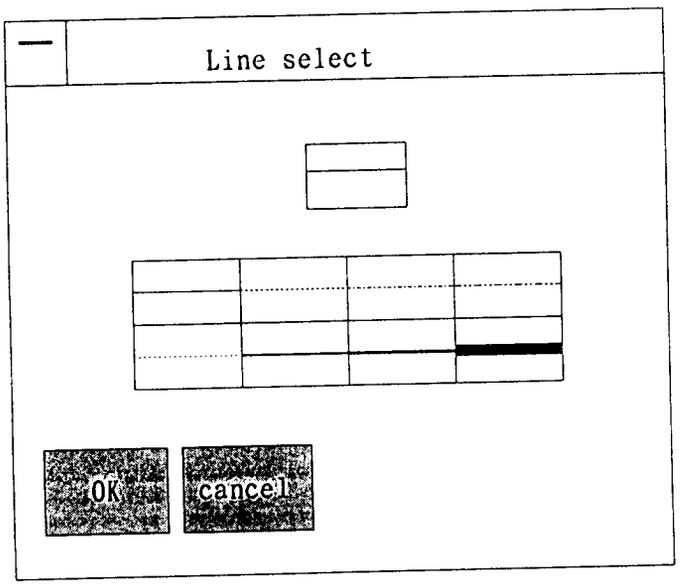
The color of the electron, positron or photon is selected from the following color-selection window.



Color select Window

5.4.2 Line select

The line type of the electron, positron or photon is selected from the following line-type selection window.



Line select Window

5.4.3 Scale unit

Define the unit of the scale in cm. The default value is 0.1.

5.4.4 Angle step

Define any change in the view angle of each axis with one mouse click.

5.4.5 Cut-off energy

Define the cut-off energy in the total energy below that energy the trajectory is not drawn. A charged particle corresponds to electrons and positrons.

5.4.6 Work area directory

Define the directory to make a workfile.

5.4.7 Background color

Change the background color. If 'Color Button' is clicked, the color-select window appears and the background color can be selected from a pallet.

5.5 History

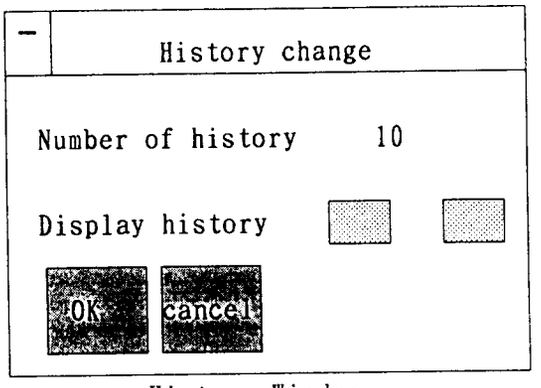
Define the history region to be displayed in the following window. If the start number is left blank, the start history is set to 1. If the end history is set to blank, the end history is set to the number of history including the data file.

[ ] ~ [ ] - draw all histories

[2] ~ [ ] - draw histories from 2 to last

[ ] ~ [4] - draw histories from first to 4

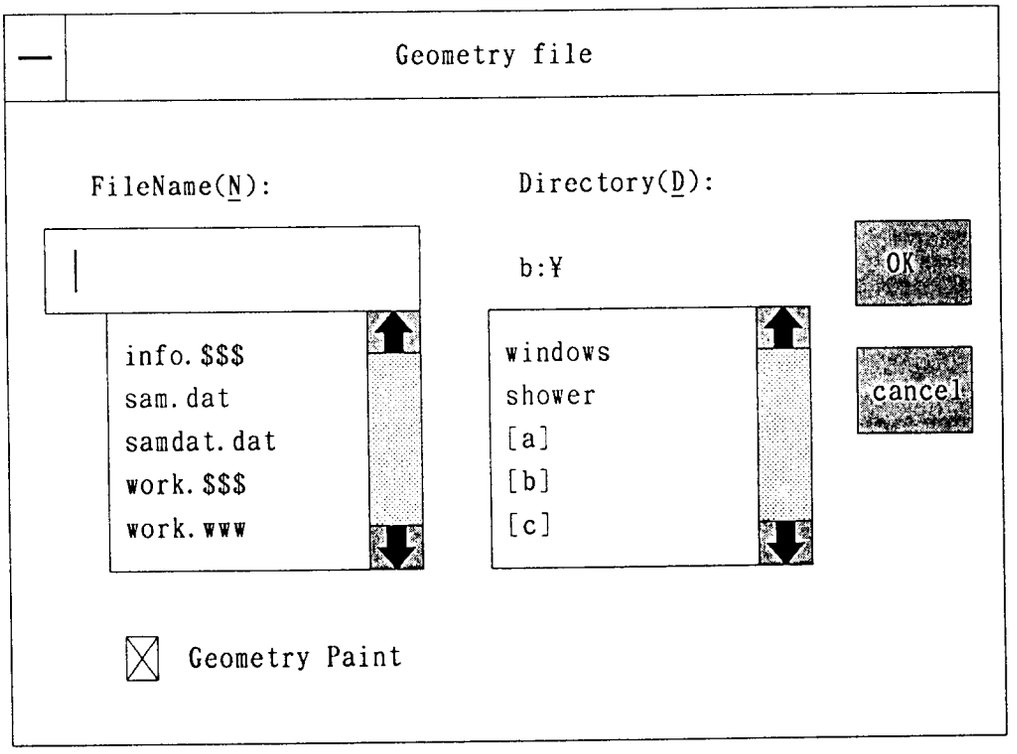
[1] ~ [3] - draw histories from first to 3



History Window

5.6 Geometry

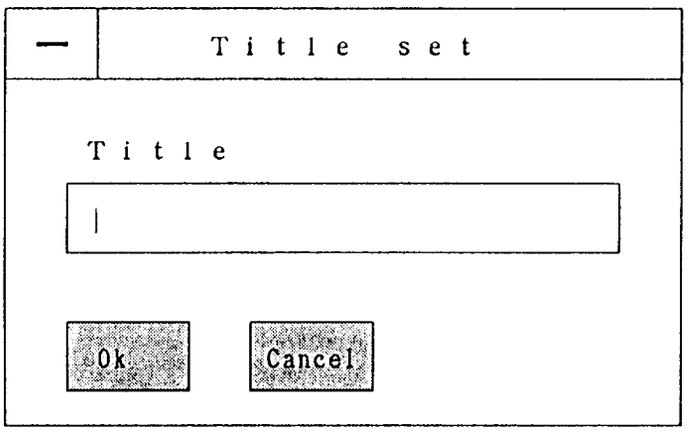
Define the geometry file. This may be used for the future development of drawing complex geometry. The geometry Paint box is used to on/off the geometry drawing.



Geometry file Window

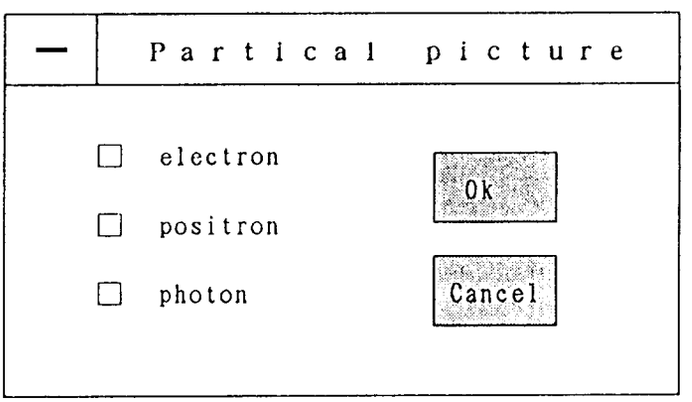
5.7 Title

Write the title of the picture in the following window.



5.8 Particle picture

On/off the drawing of each type of particle.



6 How to get EGS4PICT System

You can obtain the EGS4PICT system from kekrc3.kek.jp (IP address 130.87.45.3) via an anonymous ftp. The system is put at the directory of `~ftp/pub/pictwin`. Obtain 3 files, README, egspict.tar.Z and pictwin.exe, in the binary mode.

The egspict.tar.Z includes the sample user code for the EGS4PICT, ucpict4.mor and ucbubble.mor. The ucpict4.mor is the same one as that given in this paper as the appendix. The ucbubble.mor is the user code for the EGS4PICT used to simulate a bubble chamber. The sampl4.dat and bubble.dat are the material data used in these user codes and the sample4.pic and bubble.pic are the trajectory data calculated by these user codes.

After obtaining pictwin.exe, execute pictwin. You can obtain shower.exe and shower.hlp. By executing shower.exe, the EGS4PICT system runs. You can see the shower pictures by using the sample data, sample4.pic or bubble.pic, as the data file.

References

[1] W.R. Nelson, H. Hirayama and D.W.O. Rogers, "The EGS4 Code System", Stanford Linear Accelerator Center Report SLAC-265 (Stanford Calif) (1985).

[2] A.F. Bielajew and P.E. Weibe, "EGS-Windows - A Graphical Interface to EGS," NRCC Report: PIRS-0274 (1991).

[3] H. Hirayama, Y. Namito, S. Ban and R. Ikeda, "EGS Shower Display System (1) MS-DOS Version," KEK Report: KEK Internal 94-6 (1994).

[4] W.R. Nelson, private communication (1984).

Appendix List of ucpict4.mor

```
!INDENT C6;
!INDENT M3;
!INDENT F2;
"*************************************************************************"
"***************************     KEK National Laboratory for High  "
"***   U C P I C T 4 *******     Energy Physics                    "
"***************************     EGS4 USER CODE -- 30 JUL 1994/1600"
"*************************************************************************"
"                                                                         "
"************"
"*** MAIN ***"
"************"

"STEP 1.  USER-OVER-RIDE-OF-EGS-MACROS"

" THE FOLOWING RANDOM NUMBER GENERATOR CAN BE USED ON A VAX.  IT IS
 COMMENTED OUT BELOW BECAUSE THE DEFAULT ONE PROVIDED WITH THE EGS4"
" MACROS (IBM COMPATIBLE) WAS THE ONE ACTUALLY USED IN THIS EXAMPLE."
REPLACE {;COMIN/RANDOM/;} WITH {;COMMON/RANDOM/IXX;}
REPLACE {$RANDOMSET#;} WITH
{IXX=IXX*663608941;{P1}=IXX*0.23283064E-09;IF(IXX.LT.0){P1}={P1}+1.0;}
REPLACE{$MXREG} WITH {20} "OVER-RIDE MAXIMUM NO. OF REGIONS"
;COMIN/BOUNDS,DEBUG,MEDIA,MISC,PLADTA,USEFUL/;   "COMMONS NEEDED"
COMMON/PASSIT/ZTHICK; "SLAB THICKNESS....NEEDED IN HOWFAR"
COMMON/LINES/NLINES,NWRITE; "TO KEEP TRACK OF LINES-PRINTED"
COMMON/TOTALS/ESUM($MXREG);  "FOR ENERGY CONSERVATION CHECK"
COMMON/NFAC/FNORM,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX;                    "PICT"
"$ENERGY PRECISION EI,ESUM,EKIN,TOTKE,ETOT; DOUBLE PRECISION"
$ENERGY PRECISION ESUM,EKIN,TOTKE,ETOT; "DOUBLE PRECISION KLUDGE"
" Y.NAMITO & H.HIRAYAMA"
"CREATE A TEMPORARY ARRAY AND DEFINE THE MEDIA, NEXT"
$TYPE TEMP(24,2)/$S'FE',22*' ',$S'AIR AT NTP',14*' '/;
COMIN/RANDOM/;  "LOCATED HERE TO AVOID FORTRAN 77 DIAGNOSTIC"

"STEP 2.  PRE-HATCH-CALL-INITIALIZATION"
OPEN(6,FILE='mortjob.out');
OPEN(8,FILE='mortjob.dummy');
OPEN(9,file='mortjob.9out',status='unknown');     "PICT"
OPEN(12,FILE='mortjob.xsec',status='old');

"THE NUMBER OF REGIONS---A LOCAL VARIABLE ONLY"
NREG=3;

NMED=2;   "TWO MEDIA WILL BE USED"
DO J=1,NMED [DO I=1,24 [MEDIA(I,J)=TEMP(I,J);]]

MED(1)=0;  "REGION 1 IS VACUUM"
MED(2)=1;  "REGION 2 IS IRON"
MED(3)=2;  "REGION 3 IS AIR AT NTP"

"SET ENERGY CUTOFFS FOR EACH REGION NEXT"
DO I=1,NREG [ECUT(I)=1.511;]

"STEP 3.  HATCH-CALL"

CALL HATCH;

"STEP 4.  INITIALIZATION-FOR-HOWFAR"

ZTHICK=5.0;  "SLAB THICKNESS IN CENTIMETERS"

"STEP 5.  INITIALIZATION-FOR-AUSGAB"

DO I=1,$MXREG [ESUM(I)=0.D0;] "ZERO THE ENERGY BALANCE ARRAY"
```

```
NLINES=0;  "INITIALIZE THE NLINES-COUNTER"
NWRITE=15; "THE NUMBER OF LINES TO PRINT OUT"

"STEP 6.  DETERMINATION-OF-INCIDENT-PARTICLE-PROPERTIES"

IQI=-1;  "INCIDENT PARTICLE IS AN ELECTRON"
EI=1000.E0; "INCIDENT ENERGY (TOTAL) IN MEV  "
EKIN=EI-PRM;  "K.E. OF ELECTRON---PRM IS THE REST MASS"
XI=0.0; YI=0.0; ZI=0.0;  "COORDINATES OF INCIDENT PARTICLE"
UI=0.0; VI=0.0; WI=1.0;  "DIRECTION COSINES---ALONG Z=AXIS"
IRI=2;  "INCIDENT PARTICLE STARTS OUT IN REGION 2---IRON"
WTI=1.0;  "WEIGHT FACTOR---NOT USED IN CALCULATION, BUT"
"          IS A PARAMETER IN SUBROUTINE SHOWER; HENCE DEFINE"
"          AS UNITY"
IXX=987654321;  "RANDOM NUMBER GENERATOR SEED"
NCASES=5;  "NUMBER OF HISTORIES (CASES) TO RUN"
ICODE=-1;  "AN OUTPUTING PARAMETER, INVENTED TO MARK THE"
"           INCIDENT PARTICLES"

"STEP 7.  SHOWER-CALL"

OUTPUT;  (1H1/,' SHOWER RESULTS:',///,7X,'E',14X,
  'Z',14X,'W',10X,'IQ',3X,'IR',2X,'IARG',/);

" Parameter to define graphic size. It is better that the    **PICT**"
" width of each axis is nearly same.                         **PICT**"
XMIN=-5; XMAX=5.0; YMIN=-5.0; YMAX=5.0; ZMIN=0.0; ZMAX=ZTHICK; "PICT"

NPLAN=6;
/PNORM(3,1),PNORM(3,2)/=1.0;
PCOORD(3,1)=0.0; PCOORD(3,2)=ZMAX;
/PNORM(2,3),PNORM(2,4)/=1.0;
PCOORD(2,3)=-5.0; PCOORD(2,4)=5.0;
/PNORM(1,5),PNORM(1,6)/=1.0;
PCOORD(1,5)=-5.0; PCOORD(1,6)=5.0;

CALL GEOMOUT(0,NPLAN);                                          "PICT"

FNORM=AMAX1(XMAX-XMIN,YMAX-YMIN,ZMAX-ZMIN);                     "PICT"
WRITE(9,:FMT90:) XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX,FNORM;           "PICT"
:FMT90:FORMAT(7F10.2);                                          "PICT"

DO I=1,NCASES [

WRITE(9,:FMT91:) I; :FMT91:FORMAT('0',I5);                      "PICT"

  IF (NLINES.LT.NWRITE) [
    OUTPUT EI,ZI,WI,IQI,IRI,ICODE;
    (3G15.7,3I5);
    NLINES=NLINES+1;]

  CALL SHOWER(IQI,EI,XI,YI,ZI,UI,VI,WI,IRI,WTI);

WRITE(9,:FMT92:); :FMT92:FORMAT('9');                           "PICT"

"END OF SHOWER-CALL LOOP"]

CALL PLOTXYZ(99,0,0,0.,0.,0.,0.,0.);                            "PICT"

"STEP 8.  OUTPUT-OF-RESULTS"

TOTKE=NCASES*EKIN;  "TOTAL K.E. INVOLVED IN RUN"

OUTPUT EI,ZTHICK,NCASES,IXX;
(//,' INCIDENT TOTAL ENERGY OF ELECTRON=',F12.1,' MEV',/,
  ' IRON SLAB THICKNESS=',F6.3,' CM',/,
  ' NUMBER OF CASES IN RUN=',I3,/,' LAST RANDOM NUMBER=',
```

```
  I12,//,' ENERGY DEPOSITION SUMMARY:',//);

"CALCULATE AND PRINT OUT THE FRACTION OF ENERGY"
"DEPOSITED IN EACH REGION"

ETOT=0.D0;
DO I=1,NREG [
  ETOT=ETOT+ESUM(I);
  ESUM(I)=ESUM(I)/TOTKE;  "FRACTION IN EACH REGION"

  OUTPUT I, ESUM(I);  (' FRACTION IN REGION',I3,'=',F10.7);
]

ETOT=ETOT/TOTKE;  "THE TOTAL FRACTION OF ENERGY IN RUN"

OUTPUT ETOT;  (//,' TOTAL ENERGY FRACTION IN RUN=',G15.7,/,
  '   WHICH SHOULD BE CLOSE TO UNITY');

STOP;
END;  "LAST STATEMENT OF MAIN"

SUBROUTINE AUSGAB(IARG);
COMIN/EPCONT,STACK/; "COMMONS NEEDED IN AUSGAB"
COMMON/LINES/NLINES,NWRITE; "TO KEEP TRACK OF LINES-PRINTED"
COMMON/TOTALS/ESUM($MXREG);  "FOR ENERGY CONSERVATION CHECK"
$ENERGY PRECISION ESUM;  "DOUBLE PRECISION"

"KEEP A RUNNING SUM OF THE ENERGY DEPOSITED IN EACH REGION"
ESUM(IR(NP))=ESUM(IR(NP)) + EDEP;

"PRINT OUT THE FIRST NLINES OF STACK INFORMATION, ETC."
"BUT, ONLY FOR PHOTONS THAT ARE DISCARDED IN REGION 3"

CALL PLOTXYZ(IARG,NP,IQ(NP),X(NP),Y(NP),Z(NP),E(NP));   "PICT"

IF (NLINES.LT.NWRITE) [
    OUTPUT E(NP),Z(NP),W(NP),
    IQ(NP),IR(NP),IARG; (3G15.7,3I5);

    NLINES=NLINES+1; ]

RETURN;
END;  "LAST STATEMENT OF SUBROUTINE AUSGAB"

SUBROUTINE HOWFAR;
COMIN/DEBUG,EPCONT,STACK/;  "COMMON NEEDED IN HOWFAR"
COMMON/PASSIT/ZTHICK; "SLAB THICKNESS DEFINED IN MAIN"

IF (IR(NP).NE.2) [IDISC=1; RETURN;]

"MIGHT AS WELL SET DNEAR NEXT"
DNEAR(NP)=AMIN1(Z(NP),ZTHICK-Z(NP));

IF (W(NP).EQ.0.0) [RETURN; "PARTICLE GOING PARALLEL TO PLANES"]

"CHECK FORWARD PLANE FIRST SINCE SHOWER HEADING THAT WAY"
"MOST OF THE TIME"
IF (W(NP).GT.0.0) [DELTAZ=(ZTHICK-Z(NP))/W(NP); IRNXT=3;]
"OTHERWISE, PARTICLE MUST BE HEADING IN BACKWARDS DIRECTION"
ELSE [DELTAZ=-Z(NP)/W(NP); IRNXT=1;]
"NOW CHECK WITH USTEP AND RESET THINGS IF NECESSARY"
IF (DELTAZ.LE.USTEP) [USTEP=DELTAZ; IRNEW=IRNXT;]

RETURN;

"LAST STATEMENT OF EGS4 USER CODE UCSAMPL4" END;

%E
```

```
"*****************************************************************"
"                    KEK,National Laboratory for High Energy Physics"
SUBROUTINE PLOTXYZ(IARG,NP,IQ,X,Y,Z,ENP);
"                                  EGS4 SUBPROGRAM - 03 MAR 1994/1515"
"*****************************************************************"
"Output X,Y,Z,IQ,E for 3 dimensional graphic display on PC.         "
"This subroutine based on PLOTXZ developped at SLAC for 2           "
"dimensional display with UG.                                       "
"                                  H. Hirayama                      "
"*****************************************************************"
COMIN/DEBUG/;
COMMON/NFAC/FNORM,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX;
DIMENSION IXPT(100,40),IYPT(100,40),IZPT(100,40),IEPT(100,40),
          NPT(40),IQTOLD(40);
$ENERGYPRECISION ENP;
DATA NPT/40*0/;
IF(IARG.EQ.99) [

DO I=1,40 [
IF(NPT(I).LE.1) NEXT;
IF(IQTOLD(I).EQ.0) [IIQ=1;]
ELSEIF(IQTOLD(I).EQ.-1) [IIQ=2;]
ELSE [IIQ=3;]
DO INP=1,NPT(I) [
WRITE(9,:FMT90:) IIQ,IXPT(INP,I),IYPT(INP,I),IZPT(INP,I),IEPT(INP,I);
:FMT90:FORMAT(I1,4I5);
IF(INP.EQ.NPT(I)) [
WRITE(9,:FMT91:);
:FMT91:FORMAT('-1');
]
]
NPT(I)=0;
]

"END OF IARG EQ 99 LOOP"]

ELSE ["IARG NE 99"
IF(X/FNORM.GT.4.999.OR.X/FNORM.LT.-4.999) [RETURN;]
IF(Y/FNORM.GT.4.999.OR.Y/FNORM.LT.-4.999) [RETURN;]
IF(Z/FNORM.GT.4.999.OR.Z/FNORM.LT.-4.999) [RETURN;]
JARG=IARG;
NPT(NP)=NPT(NP) + 1;
IF(NPT(NP).EQ.1) IQTOLD(NP)=IQ;
IXPT(NPT(NP),NP)=X/FNORM*10000+50000;
IYPT(NPT(NP),NP)=Y/FNORM*10000+50000;
IZPT(NPT(NP),NP)=Z/FNORM*10000+50000;
IF(IQ.EQ.0) [EEE=ENP*1000.;]
ELSE [EEE=(ENP-0.511)*1000.]
IF(EEE.LT.10000.0) [
IEPT(NPT(NP),NP)=INT(EEE)*10;]
ELSE [
IFF=ALOG10(EEE)-3;
IEF=EEE/10**IFF;
IEPT(NPT(NP),NP)=IEF*10+IFF;]

IF(IQ.NE.IQTOLD(NP)) JARG=-1;

IF(NPT(NP).GE.100.OR.JARG.NE.0) [
IF(IQTOLD(NP).EQ.0) [IIQ=1;]
ELSEIF(IQTOLD(NP).EQ.-1) [IIQ=2;]
ELSE [IIQ=3;]
IF(NPT(NP).GT.1) [
DO INP=1,NPT(NP) [
WRITE(9,:FMT90:) IIQ,IXPT(INP,NP),IYPT(INP,NP),IZPT(INP,NP),IEPT(INP,NP);
IF(INP.EQ.NPT(NP)) [WRITE(9,:FMT91:);]
]]

IF(JARG.GT.0.OR.IARG.GT.0) [NPT(NP)=0;]
```

```
ELSEIF(JARG.EQ.-1) [
IXPT(1,NP)=IXPT(NPT(NP),NP);
IYPT(1,NP)=IYPT(NPT(NP),NP);
IZPT(1,NP)=IZPT(NPT(NP),NP);
IEPT(1,NP)=IEPT(NPT(NP),NP);
NPT(NP)=1;
IQTOLD(NP)=IQ;
]

ELSE [
NPT(NP)=1;
IXPT(1,NP)=IXPT(100,NP);
IYPT(1,NP)=IYPT(100,NP);
IZPT(1,NP)=IZPT(100,NP);
IEPT(1,NP)=IEPT(100,NP);
]

]
ELSE [IQTOLD(NP)=IQ;]

"END OF IARG NE 99 LOOP"]

RETURN;
END;  "END OF SUBROUTINE PLOTXYZ"

%E
"*****************************************************************"
"                    KEK,National Laboratory for High Energy Physics"
SUBROUTINE GEOMOUT(NCYLG,NPLANG);
"                                 EGS4 SUBPROGRAM - 03 MAR 1994/1515"
"*****************************************************************"
"Output geometry data for cylinder-slab or slab geometry.          "
"                                  H. Hirayama                     "
"*****************************************************************"
COMIN/DEBUG,PLADTA,CYLDTA/;
COMMON/NFAC/FNORM,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX;
DIMENSION CYL($MXCYLS),ZBIN($MXPLNS),YBIN($MXPLNS),XBIN($MXPLNS);
IF(NCYLG.NE.0) ["Cylinder slab geometry"
WRITE(9,:FMT90:);
:FMT90:FORMAT('GSTA');
WRITE(9,:FMT91:);
:FMT91:FORMAT('CYLS');
WRITE(9,:FMT92:) NCYLG,NPLANG;
:FMT92:FORMAT(3I6);
DO I=1,NCYLG [
CYL(I)=SQRT(CYRAD2(I));
]
WRITE(9,:FMT93:) (CYL(I),I=1,NCYLG);
:FMT93:FORMAT(8E10.3);
NZP=0;
DO I=1,NPLANG [
IF(PNORM(3,I).EQ.1.AND.(PCOORD(3,I).GE.ZMIN.AND.PCOORD(3,I).LE.ZMAX)) [
NZP=NZP+1;
ZBIN(NZP)=PCOORD(3,I);]
]
IF(NZP.EQ.0) [
NZP=2;
ZBIN(1)=ZMIN; ZBIN(2)=ZMAX;
]
WRITE(9,:FMT93:) (ZBIN(I),I=1,NZP);
WRITE(9,:FMT94:);
:FMT94:FORMAT('GEND');
]  "End of Cylinder slab geometry"

ELSEIF(NPLANG.NE.0) ["Plane geometry"
WRITE(9,:FMT90:);
WRITE(9,:FMT95:);
```

```
:FMT95:FORMAT('SLAB');

/NZP,NYP,NXP/=0;
DO I=1,NPLANG [
IF(PNORM(1,I).EQ.1) [
IF(PCOORD(1,I).GE.XMIN.AND.PCOORD(1,I).LE.XMAX) [
NXP=NXP+1;
XBIN(NXP)=PCOORD(1,I);]]
ELSEIF(PNORM(2,I).EQ.1) [
IF(PCOORD(2,I).GE.YMIN.AND.PCOORD(2,I).LE.YMAX) [
NYP=NYP+1;
YBIN(NYP)=PCOORD(2,I);]]
ELSE [
IF(PCOORD(3,I).GE.ZMIN.AND.PCOORD(3,I).LE.ZMAX) [
NZP=NZP+1;
ZBIN(NZP)=PCOORD(3,I);]]
]
ZWID=ABS(XMAX-ZMIN);
IF(NXP.EQ.0) [NXP=2;
XBIN(1)=-ZWID/2.0;
XBIN(2)=ZWID/2.0;]
IF(NYP.EQ.0) [NYP=2;
YBIN(1)=-ZWID/2.0;
YBIN(2)=ZWID/2.0;]
OUTPUT (PNORM(1,I),PNORM(2,I),PNORM(3,I),I=1,NPLANG);
(' PNORM(1)    PNORM(2)      PNORM(3)'/(3G15.5));
WRITE(9,:FMT92:) NXP,NYP,NZP;
WRITE(9,:FMT93:) (XBIN(I),I=1,NXP);
WRITE(9,:FMT93:) (YBIN(I),I=1,NYP);
WRITE(9,:FMT93:) (ZBIN(I),I=1,NZP);
WRITE(9,:FMT94:);
]

ELSE [" Do not produce geometry data"
WRITE(9,:FMT90:);
WRITE(9,:FMT94:);
STOP;]

RETURN;
END;  "END OF SUBROUTINE GEOMOUT"
"************************************************************"
"******************** End of ucpict4.mor ********************"
"************************************************************"
```