A Basic Monte Carlo Course (Electron Gamma Shower)

Speaker: Dr. Joel Y.C Cheung
Date: 24th Jan 2015
Venue: Queen Elizabeth Hospital, HK

1

Monte Carlo – A Statistical Calculation, problem solving

2

Probability of drawing 6 ?

1) Perform an actual experiment !

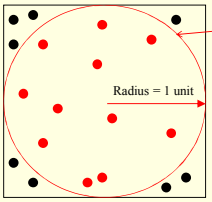
2) Using the Monte Carlo technique!

3

Monte Carlo - π Calculation

4

Calculation of π using the Monte Carlo method



$x^2 + y^2 = 1$

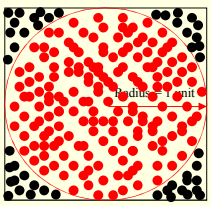
History run = 19

π = Area of the square x $\frac{\text{no: of } \bullet}{\text{no: of } \bullet\bullet}$

= 4 x $\frac{11}{19}$ = 2.32

5

Calculation of π using the Monte Carlo method – cont.



History run = ~200

π = Area of the square x $\frac{\text{no: of } \bullet}{\text{no: of } \bullet\bullet}$

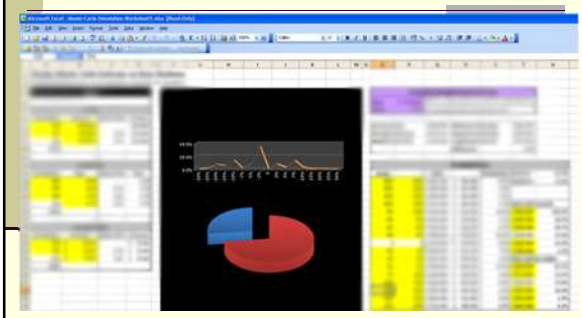
= 4 x $\frac{150}{200}$ = 3.0

6

Monte Carlo – Sales Forecast

7

Sales Forecast Monte Carlo Simulation



8

Monte Carlo in Radiation Physics

9

Monte Carlo in Radiation Physics

- Monte Carlo modeling of particle transport problems in medical and radiation physics gives more advantages than other techniques. Experiments can be done without setting up the physical situation, and results of some “impossible” experiments can be obtained.
- e.g. scoring the numbers of created particles or calculating the relative OPFs of narrow beams.

10

Determine by Random Numbers ?

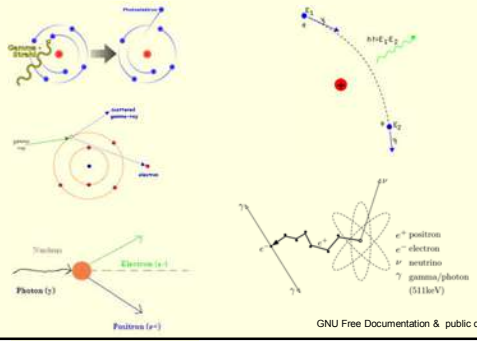
Photon or Charge Particle

Before Interaction
Position ? (X,Y,Z)
Moving Direction ? (U,V,W)
Energy ? (E)

After Interaction / Next Step
Position ? (X,Y,Z)
Moving Direction ? (U,V,W)
Energy ? (E)
Energy Deposition (EDEP)

11

Radiation Interactions



12

GNU Free Documentation & public domain

Monte Carlo Packages

13

Monte Carlo packages

The availability of standardized Monte Carlo packages such as:

- EGSNRC
- BEAM
- EGS
- ETRAN/ITS
- PENELOPE
- MCNP
- GEANT

along with the development of more powerful and inexpensive computers has allowed more widespread use of the technique.

14

EGS4 – Electron Gamma Shower

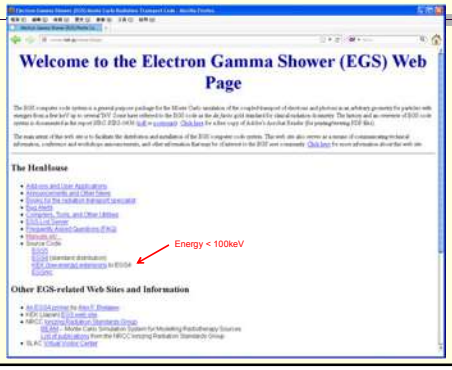
15

EGS4 (Electron Gamma Shower) code

Standford Linear Accelerator Center
- by Nelson, Harayama and Rogers.

16

http://rcwww.kek.jp/research/egs/



17

http://rcwww.kek.jp/research/egs/epub.html

18

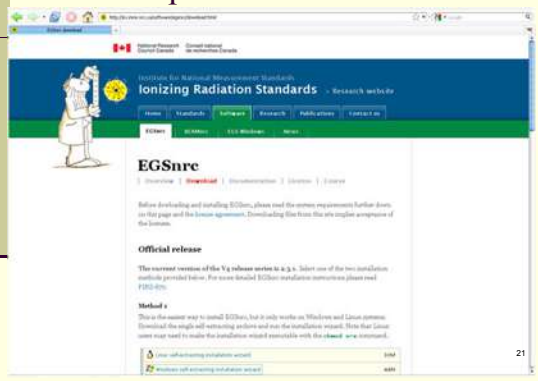
http://rcwww.kek.jp/research/egs/egs5.html

19

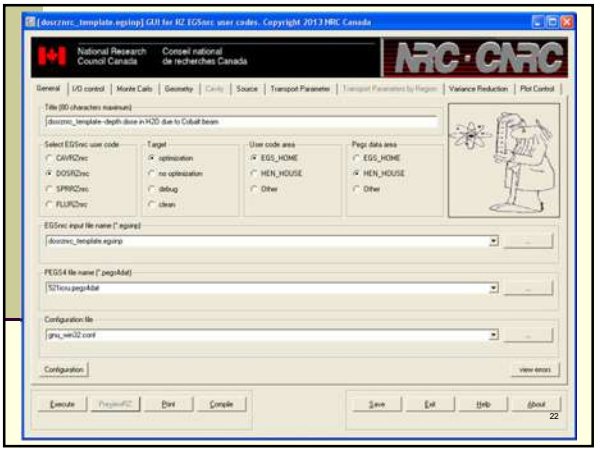
EGSnrc Code

20

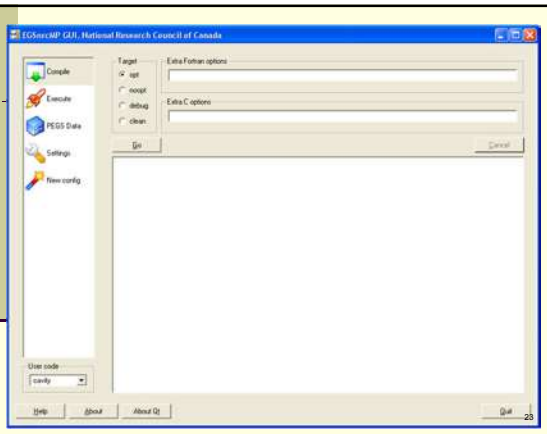
http://irs.inms.nrc.ca/



21



22



23

Fortran Compilers

24

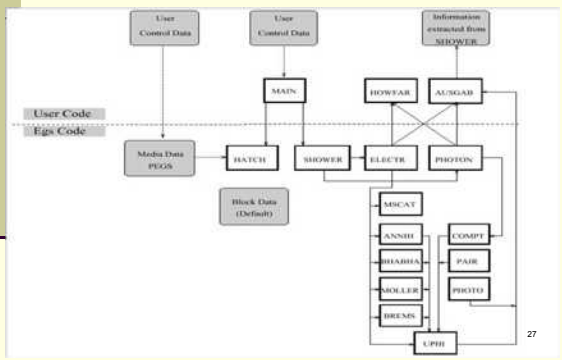
Fortran Compilers

25

EGS4 Code

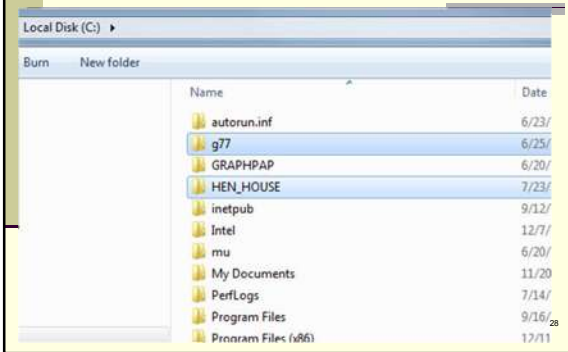
26

EGS4 Structure



27

EGS4 Distribution / Fortran Compiler



28

EGS4 folders on PC

- EGS4 ← Main folder
- MORTRAN3 ← Converting code into Fortran
- PEGS4 ← Creating material file(s) for radiation interaction
- $DATTIM.EXE
- $DATTIM.FOR
- BATCH.BAT
- COMPILER.TXT
- DIR.LST
- FORTRAN.TXT
- READEGS.DOC
- READMEOR.DIE
- STEPS.TXT

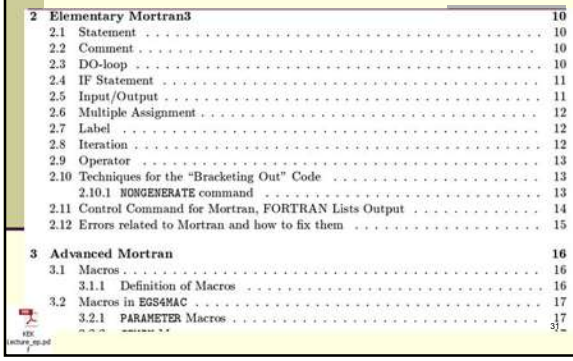
29

EGS4 - Main Folder

APPENDIX	ECNSV1.MOR	MF.BAT	RANMAR.REA
BENCHMRK	EDGSET.MOR	NRCC4MAC.MOR	Srcrz.mor
DOSRZ	EGS4.MOR	NRCCAUX.MOR	SRCSPH.MOR
ESPECT	EGS4BLOK.MOR	NRCCAUXP.MOR	STDCONF.BAT
EXAMIN	EGS4ENV.BAT	NTALLY.MOR	TRACEMAC.MOR
EXAMPLES	EGS4MAC.MOR	PLANES.MOR	
INHOM	EGSINTER.BAT	PRESTA.MAC	
INHOMP	EMF_MACS.MOR	Presta.mor	
TUTOR	ENSRC.MOR	PRNTER.MOR	
CHECK77.EXE	EPSFX85.MOR	RANMAR.INI	
CHECK77.MOR	EX.BAT	RANMAR.MAC	
CYLNDR.MOR	GEOMAUX.MOR	RANMAR.MIN	
E_X_FIX.MAC	MACHINE.MAC	RANMAR.MS	

30

Mortran or Fortran



User Code: Tutor1.mor

32

User Code: CALL SHOWER

```
DO J=1,1000000 [

CALL SHOWER
   (IQIN,EIN,XIN,YIN,ZIN,UIN,VIN,WIN,IRIN,WTIN)
   ;
]
```

33

User Code: HOWFAR

```
SUBROUTINE HOWFAR;
COMIN/EPCONT,PLADTA,STACK/;

IRL=IR(NP);  "SET LOCAL VARIABLE"

IF(IRL.NE.2) [IDISC=1; "TERMINATE THIS HISTORY"]
ELSE [
$PLAN2P(IRL,IRL+1,1,IRL-1,IRL-1,-1);
]

RETURN;
END;" END OF SUBROUTINE HOWFAR
```

34

User Code: AUSGAB

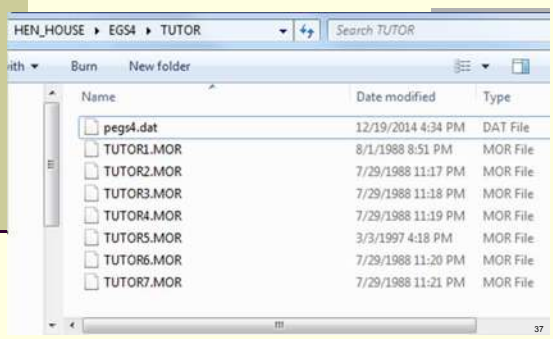
```
SUBROUTINE AUSGAB(IARG);
COMIN/EPCONT,SCORE,STACK,GEOM/;

IF (IARG.LE.3) [
ESCORE(ITEMP1)=ESCORE(ITEMP1)+EDEP;]
]

RETURN;END;"END OF AUSGAB"
```

35

Compiling a Tutor Code

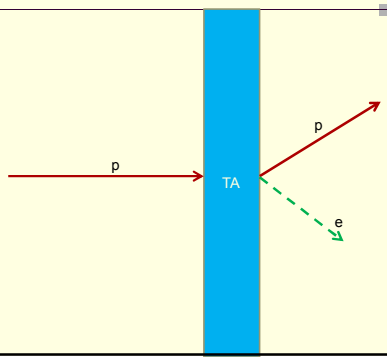
36

Folder Content



37

HOWFAR (Tutor1)



38

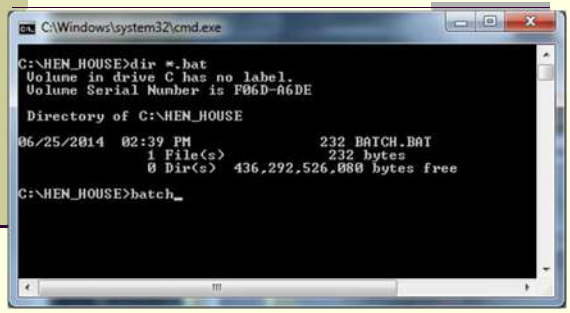
User Code: Tutor1.mor

39

Open a DOS prompt

40

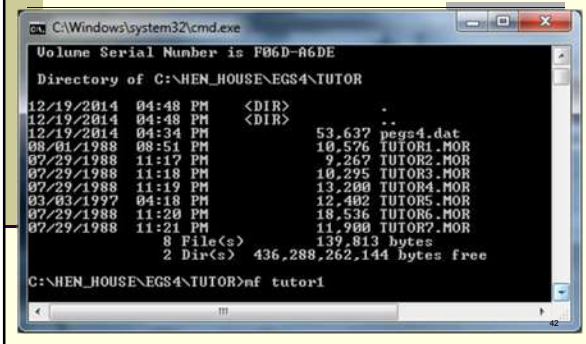
Setup Enviroment



C:\cd hen_house

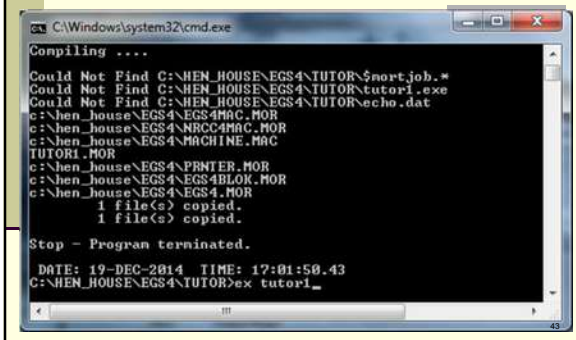
41

Mortran to Fortran and Compile

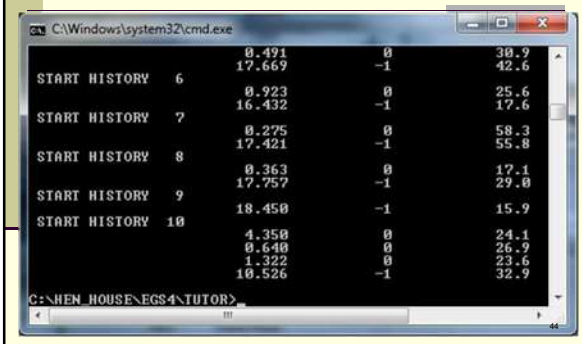


42

Execute Tutor1



Results of Tutor1

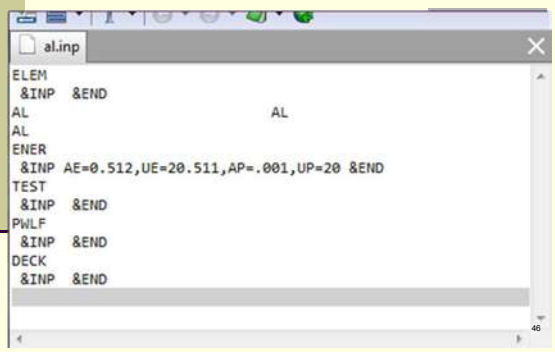


Assignment #1: Al attenuation coefficient

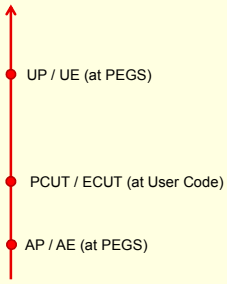
- Change Tutor1 target thickness
- Change Tutor1 target material to Al

45

Assignment #1: al.inp

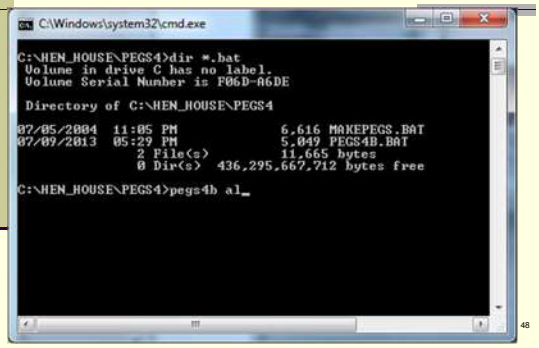


Assignment #1: Energy Cut Off

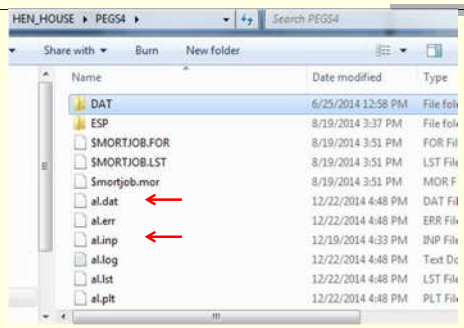


47

Assignment #1: aluminum data file



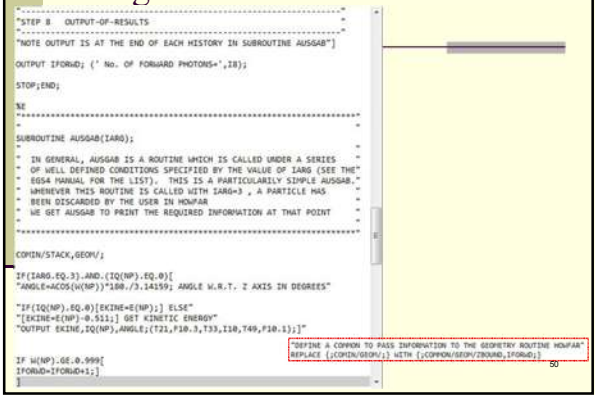
Assignment #1: al.dat



>copy al.dat pegs4.dat

49

Assignment #1: t1al-u.mor



50

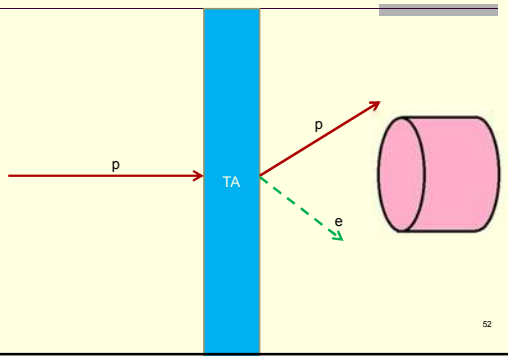
Assignment #1: Result

$$\ln\left(\frac{I_o}{I}\right) = \mu t$$

I_0=1000000
I=438007
t=5cm
μ=0.165104 cm^{-1} (ref 0.165942 cm^{-1})

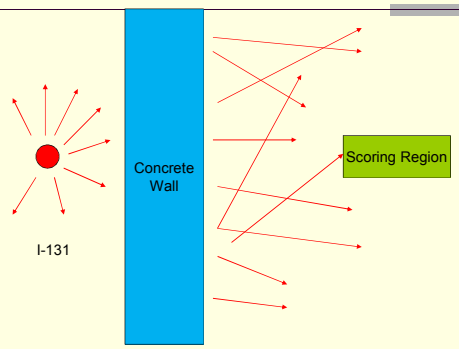
51

A complicated HOWFAR



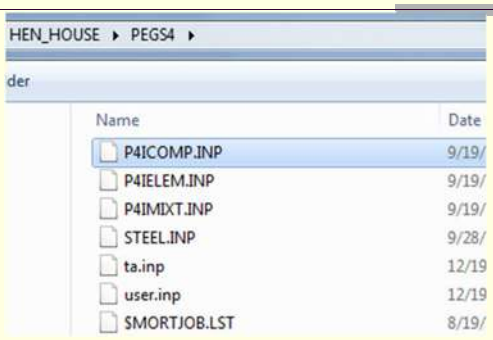
52

Application: w/ detector



53

PEGS4 - Template



54

Mixture / Compound

P4IMXT.INP

```
MIXT
 &INP NE=7,RHO=2.26,RHOZ=49.83,1.71,4.56,31.58,1.92,8.26,1.22 &END
CONCRETE
O  NA AL SI K  CA FE
ENER
 &INP AE=1.5,UE=100000,AP=.1,UP=100000 &END
TEST
 &INP  &END
PWLF
 &INP  &END
DECK
 &INP  &END
```

P4ICOMP.INP

```
COMP
 &INP NE=2,RHO=1.0,PZ=2,1 &END
WATER                          H2O
H  O
ENER
 &INP AE=1.5,UE=100000,AP=.1,UP=100000 &END
TEST
 &INP  &END
PWLF
 &INP  &END
DECK
 &INP  &END
```

55

Steel

STEEL.INP

```
MIXT
 &INP NE=2,RHO=7.7796,RHOZ=12.0,88.0 &END
STEEL
CR FE
ENER
 &INP AE=0.515,UE=1.411,AP=.005,UP=0.900 &END
TEST
 &INP  &END
PWLF
 &INP  &END
DECK
 &INP  &END
```

56

Simplified HOWFAR: Tutor7

```
;COMIN/BOUNDS,MEDIA,MISC,PLADTA,THRESH/


"-------------------------------------------------------------------"
"STEP 4  INITIALIZATION-FOR-HOWFAR                "
"-------------------------------------------------------------------"
"FIRST PLANE:"
PCOORD(1,1)=0.0; PCOORD(2,1)=0.0; PCOORD(3,1)=0.0;      "COORDINATES"
PNORM(1,1) =0.0; PNORM(2,1) =0.0; PNORM(3,1)= 1.0;      "NORMAL VECTORS"

"SECOND PLANE    (NOTE: SLAB IS 1 MM THICK STILL)"
PCOORD(1,2)=0.0; PCOORD(2,2)=0.0; PCOORD(3,2)=0.1;      "COORDINATES"
PNORM(1,2) =0.0; PNORM(2,2) =0.0; PNORM(3,2)= 1.0;      "NORMAL VECTORS"
```

57

Simplified HOWFAR cont.: Tutor7

```
SUBROUTINE HOWFAR;

COMIN/EPCONT,PLADTA,STACK/;

IRL=IR(NP);  "SET LOCAL VARIABLE"

IF(IRL.NE.2) [IDISC=1;]
ELSE [  $PLAN2P(IRL,IRL+1,1,IRL-1,IRL-1,-1); ]
RETURN;
END;" END OF SUBROUTINE HOWFAR
```

58

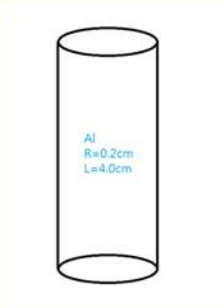
Table 1 Lists of geometry SUBROUTINEs and macros

SUBROUTINE	Function	MACRO
PLANE1	Determines if the particle trajectory strikes a plane surface. Returns trajectory distance (TPLN).	$PLANE1
CYLNDR	Determines if the particle trajectory strikes a cylindrical surface. Returns trajectory distance (TCYL).	$CYLNDR
CONE	Determines if the particle trajectory strikes a conical surface. Returns trajectory distance (TCONE).	$CONE
SPHERE	Determines if the particle trajectory strikes a spherical surface. Returns trajectory distance (TSPH).	$SPHRE
CHGTR	Change USTEP and IRNEW whenever USTEP is larger than the trajectory distance (TPLN, TCYL, TCONE, TSPH).	$CHGTR
FINVAL	Determines the coordinates of the particle trajectory at the point of an intersection with a given surface.	$FINVAL
PLAN2P	Determines the intersection point for two parallel planes by calling PLANE1 twice (when necessary) and CHGTR if a plane is hit.	$PLAN2P
PLAN2X	Determines the intersection point for two crossing planes by calling PLANE1 twice (always) and CHGTR if a plane is hit.	$PLAN2X
CYL2	Similar to PLAN2P, but for concentric cylinders.	$CYL2
SPH2	Similar to PLAN2P, but for concentric spheres	$SPH2
CON2	Similar to PLAN2P, but for concentric cone.	$CON2

59

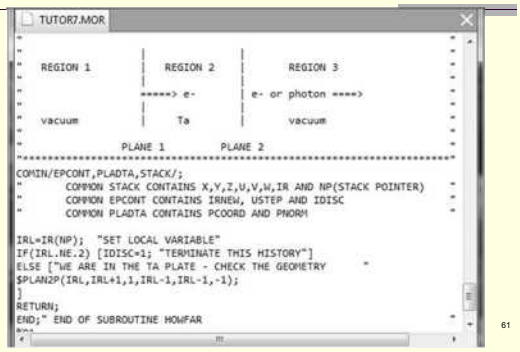
KEK Lecture_ep.pdf

Assignment # 2: Wire Source



60

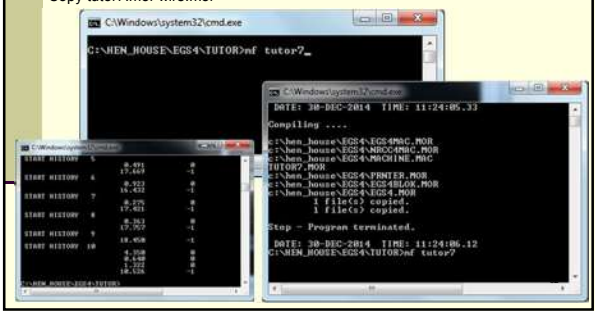
Assignment # 2: modify tutor7.mor



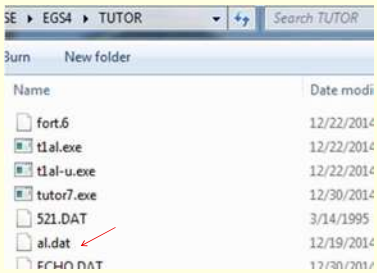
61

Assignment # 2: test tutor7 OK?

Test tutor7 OK?
Copy tutor7.mor wire.mor



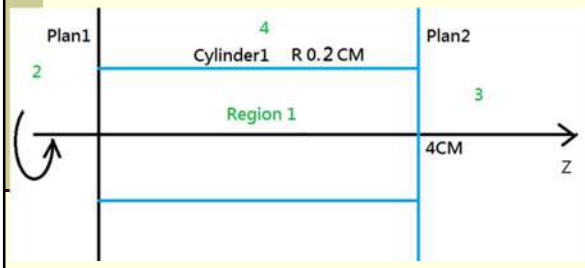
Assignment # 2: make pegs4.dat



>copy al.dat pegs4.dat

63

Assignment # 2: Geometry



64

Assignment # 2: Macro $CYLNDR

4 The $CYLNDR and $CYL2 Macros

The $CYLNDR macro treats a cylinder which has the Z-axis as symmetry axis is:

```
$CYLNDR(ICYL,ISIDE,IHIT,ZCYL);
    ICYL: ID number of cylinder to be checked.
   ISIDE: 1 means particle is inside cylinder.
          0 means particle is outside cylinder.
    IHIT: 1 means particle intersects surface.
          0 means particle misses surface.
    ZCYL: distance to surface if IHIT=1.
```

CYRAD(I) and CYRAD2(I) must be defined to use $CYLNDR or $CYL2. CYRAD is the radius of the cylinder and CYRAD2 is its square. They are included in COMMON/CYLDTA/.

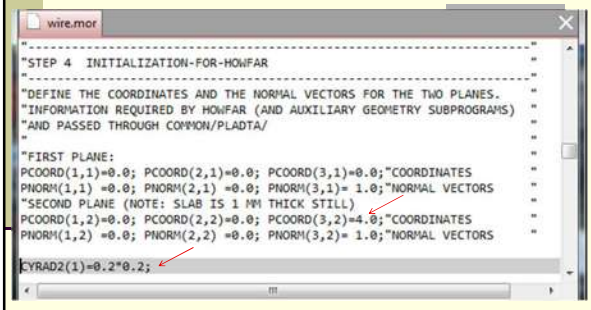
The macro corresponding to $PLAN2P for the plane is $CYL2, which treats particles between two cylinders.

```
$CYL2(NCY1,NRG1,NCY2,NRG2);
    NCY1: ID number of first cylinder to be checked.
          particle must be outside the first cylinder.
    NRG1: region to go into if first cylinder is intersected by particle.
    NCY2: ID number of second cylinder to be checked.
          particle must be inside the second cylinder.
    NRG2: region to go into if second cylinder is intersected by particle.
```

The $CYL2 macro is written to check the cylinder inside the particle first, and then to check the cylinder outside the particle.

65

Assignment # 2: Dimensions



66

Assignment # 2: COMIN CYLDTA

wire.mor

```
;COMIN/BOUNDS,MEDIA,MISC,PLADTA,THRESH,CYLDTA,RANDOM/;
"       THE ABOVE EXPANDS INTO A SERIES OF COMMON STATEMENTS
"       BOUNDS CONTAINS ECUT AND PCUT
"       PLADTA PASSES COORDINATE AND NORMAL VECTOR DATA OF EACH
"          PLANE INTO HOWFAR AND THE AUXILIARY GEOMETRY SUBPROGRAMS
"       MEDIA CONTAINS THE ARRAY MEDIA
"       MISC CONTAINS MED
"       THRESH CONTAINS AE AND AP
"
"STEP 2 PRE-HATCH-CALL-INITIALIZATION
```

67

Assignment # 2: HOWFAR

wire.mor

```
"                PLANE 1          PLANE 2
COMIN/EPCONT,PLADTA,STACK,CYLDTA/;
"       COMMON STACK CONTAINS X,Y,Z,U,V,W,IR AND NP(STACK POINTER)
"       COMMON EPCONT CONTAINS IRNEW, USTEP AND IDISC
"       COMMON PLADTA CONTAINS PCOORD AND PNORM

IRL=IR(NP);  "SET LOCAL VARIABLE"
IF(IRL.NE.1) [IDISC=1; "TERMINATE THIS HISTORY"]
ELSE [
$CYLNDR(1,1,IHIT,TCYL); IF (IHIT.EQ.1) [$CHGTR(TCYL,4);]
$PLAN2P(2,3,1,1,2,-1);
]
RETURN;
END;" END OF SUBROUTINE HOWFAR
```

68

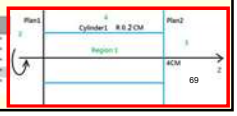
Assignment # 2: Medium

wire.mor

```
"STEP 2 PRE-HATCH-CALL-INITIALIZATION
$TYPE MEDARR(24) /$5'AC',22*' '/; "PLACE MEDIUM NAME IN AN ARRAY
"                  $5 IS A MORTRAN MACRO TO EXPAND STRINGS
"                  $TYPE IS INTEGER(F4) OR CHARACTER*4 (F77)"
"                  DEPENDING ON THE EGS4 VERSION BEING USED
"                  IN ORDER TO MATCH THE TYPE OF MEDIA
DO I=1,24[MEDIA(I,1)=MEDARR(I);]"THIS IS TO AVOID A DATA STATEMENT FOR"
"                        A VARIABLE IN COMMON
"NMED AND DUNIT DEFAULT TO 1, I.E. ONE MEDIUM AND WE WORK IN CM
/MED(2),MED(3),MED(4)/=0;MED(1)=1;
```

wire.mor

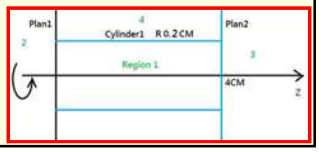
```
"STEP 1:  USER-OVERRIDE-OF-EGS4-MACROS
REPLACE ($NMED) WITH (1)    "ONLY 1 MEDIUM IN THE PROBLEM(DEFAULT 10)"
REPLACE ($NREG) WITH (4)    "ONLY 3 GEOMETRIC REGIONS (DEFAULT 2000) "
REPLACE ($MXSTACK) WITH (15) "LESS THAN 15 PARTICLES ON STACK AT ONCE "
```



69

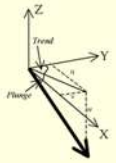
Assignment # 2:
Initial Position: (XIN, YIN, ZIN)

```
"-------------------------------------------------------------------------------"
"STEP 6   DETERMINATION-OF-INCIDENT-PARTICLE-PARAMETERS
"-------------------------------------------------------------------------------"
.......

LOOP[ $RANDOMSET XIN;XIN=(2.0*XIN-1.0)*0.2;
    $RANDOMSET YIN;YIN=(2.0*YIN-1.0)*0.2;
    R2=XIN**2+YIN**2;]
UNTIL (R2.LE.0.2);
$RANDOMSET ZIN;ZIN=ZIN*4.0;
```



Assignment # 2:
Direction Cosines of a Line from Azimuth and Plunge

```
"-------------------------------------------------------------------------------"
"STEP 6   DETERMINATION-OF-INCIDENT-PARTICLE-
PARAMETERS"
"-------------------------------------------------------------------------------"
.......
$RANDOMSET COSTHE; COSTHE=2.*COSTHE-1;
SINTHE=SQRT(1.0-COSTHE**2);
$RANDOMSET PHI;PHI=2*3.14*PHI;

UIN=SINTHE*COS(PHI);
VIN=SINTHE*SIN(PHI);
WIN=COSTHE;
```



71

Assignment # 2: Modify Step 6

wire.mor

```
"STEP 5  INITIALIZATION-FOR-AUSGAB
"-------------------------------------------------------------------------------"
"-------------------------------------------------------------------------------"
"STEP 6   DETERMINATION-OF-INCIDENT-PARTICLE-PARAMETERS
"-------------------------------------------------------------------------------"
IQIN=0;
EIN=1.0;

DO I=1,10[OUTPUT I;(' START HISTORY',I4);

LOOP[ $RANDOMSET XIN;XIN=(2.0*XIN-1.0)*0.2;
     $RANDOMSET YIN;YIN=(2.0*YIN-1.0)*0.2;
     R2=XIN**2+YIN**2;]
UNTIL (R2.LE.0.2);
$RANDOMSET ZIN;ZIN=ZIN*4.0;

$RANDOMSET COSTHE; COSTHE=2.*COSTHE-1;
SINTHE=SQRT(1.0-COSTHE**2);
$RANDOMSET PHI;PHI=2*3.14*PHI;
UIN=SINTHE*COS(PHI);
VIN=SINTHE*SIN(PHI);
WIN=COSTHE;

IRIN=1;"              STARTS IN REGION 2, COULD BE 1
WTIN=1.0;"            WEIGHT = 1 SINCE NO VARIANCE REDUCTION USED
```

useless

move from step7

72

Assignment # 2: Check Parameters before the Shower Call

```
"FOR DEBUGGING:"
"OUTPUT EIN;(' EIN=',F8.4);"
"OUTPUT XIN,YIN,ZIN;(' XIN=',F8.4,' YIN=',F8.4,' ZIN=',F8.4);"
"OUTPUT UIN,VIN,WIN;(' UIN=',F8.4,' VIN=',F8.4,' WIN=',F8.4);"
"OUTPUT IRIN,WTIN,IQIN;(' IRIN=',I4,' WTIN=',F8.4,' IQIN=',I4/);"
```

73

Assignment # 2: DEBUGGING

wire.mor

```
"-------------------------------------------------------------"
"STEP 7   SHOWER-CALL                                        "
"-------------------------------------------------------------"
"FOR DEBUGGING:"
OUTPUT EIN;(' EIN=',F8.4);
OUTPUT XIN,YIN,ZIN;(' XIN=',F8.4,' YIN=',F8.4,' ZIN=',F8.4);
OUTPUT UIN,VIN,WIN;(' UIN=',F8.4,' VIN=',F8.4,' WIN=',F8.4);
OUTPUT IRIN,WTIN,IQIN;(' IRIN=',I4,' WTIN=',F8.4,' IQIN=',I4/);

CALL SHOWER(IQIN,EIN,XIN,YIN,ZIN,UIN,VIN,WIN,IRIN,WTIN);

"-------------------------------------------------------------"
"STEP 8   OUTPUT-OF-RESULTS                                  "
"-------------------------------------------------------------"
"NOTE OUTPUT IS AT THE END OF EACH HISTORY IN SUBROUTINE AUSGAB   "
]
STOP;END;
```

74

Assignment # 2:AUSGAB

wire.mor

```
"*************************************************************"
"                                                             "
SUBROUTINE AUSGAB(IARG);
"                                                             "
"  IN GENERAL, AUSGAB IS A ROUTINE WHICH IS CALLED UNDER A SERIES     "
"  OF WELL DEFINED CONDITIONS SPECIFIED BY THE VALUE OF IARG (SEE THE "
"  EGS4 MANUAL FOR THE LIST).  THIS IS A PARTICULARILY SIMPLE AUSGAB. "
"  WHENEVER THIS ROUTINE IS CALLED WITH IARG=3 , A PARTICLE HAS       "
"  BEEN DISCARDED BY THE USER IN HOWFAR                               "
"  WE GET AUSGAB TO PRINT THE REQUIRED INFORMATION AT THAT POINT      "
"                                                             "
"*************************************************************"

COMIN/STACK,EPCONT/;

IF(IARG.LE.2.OR.IARG.EQ.4 )[
TENERGY=TENERGY+EDEP;
]
RETURN;END;" END OF AUSGAB                                    "
```

75

Assignment # 2: Energy Deposition

Table 1(a) Value for IARG and corresponding situation.

IARG	IAUSFL	Situation
0	1	A particle is going to be transported by distance TVSTEP.
1	2	A particle is going to discarded because its energy is below the cutoff ECUT (for charged particles) or PCUT (for photons)—but its energy is larger than the corresponding PEGS cutoff AE or AP, respectively.
2	3	A particle is going to be discarded because its energy is below both ECUT and AE (or PCUT and AP).
3	4	A particle is going to be discarded because a user requested it (in HOWFAR usually).
4	5	A photoelectric interaction has occurred and either: a) the energy of the incident photon was below the K-edge binding energy and it is going to be discarded, or b) a (fluorescent) photon is going to be discarded with the K-edge binding energy.

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76

Assignment # 2: Other IARG situations

Table 1(b) Value for IARG and corresponding situation.

IARG	IAUSFL	Situation
5	6	A particle has been transported by distance TVSTEP.
6	7	A bremsstrahlung interaction is to occur and a call to BREMS is about to be made in ELECTR.
7	8	Return to ELECTR after a call to BREMS was made.
8	9	A Moller interaction is to occur and a call to MOLLER is about to be made in ELECTR.
9	10	Return to ELECTR after a call to MOLLER was made.
10	11	A Bhabha interaction is to occur and a call to BHABHA is about to be made in ELECTR.
11	12	Return to ELECTR after a call to BHABHA was made.
12	13	An in-flight annihilation of positron is to occur and a call to ANIHI is about to be made in ELECTR.
13	14	Return to ELECTR after a call to ANIHI was made.
14	15	A positron has annihilated at rest.
15	16	An pair production interaction is to occur and a call to PAIR is about to be made in PHOTON.
16	17	Return to PHOTON after a call to PAIR was made.
17	18	A Compton interaction is to occur and a call to COMPT is about to be made in PHOTON.
18	19	Return to PHOTON after a call to COMPT was made.
19	20	A photoelectric interaction is to occur and a call to PHOTO is about to be made in PHOTON.
20	21	Return to PHOTON after a call to PHOTO was made (assuming NP is non-zero).
21	22	Subroutine UPHI was just entered.
22	23	Subroutine UPHI was just exited.
23	24	A coherent (Rayleigh) interaction is about to occur.
24	25	A coherent (Rayleigh) interaction has just occurred.

77

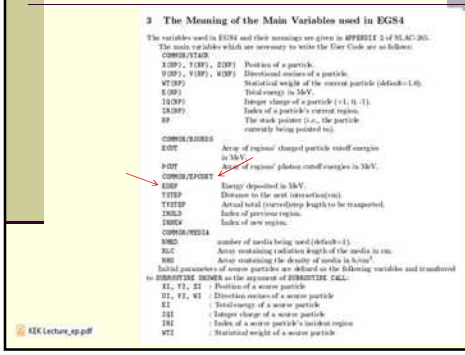
User Code: Tutor5.mor

TUTOR5.MOR

```
"-------------------------------------------------------------"
"STEP 5  INITIALIZATION-FOR-AUSGAB                           "
"-------------------------------------------------------------"
DO I=1,3 [ COUNT(I)=0.0;ENTOT(I)=0.0;]"ZERO SCORING ARRAY AT START"

"  WE WANT TO SET FLAGS IN AUSGAB EVERY TIME A RAYLEIGH SCATTERING   "
"  OR COMPTON SCATTERING OCCURS. SET THE FLAGS IN IAUSFL(COMIN       "
"  EPCONT) TO SIGNAL THE  EGS SYSTEM TO MAKE THE APPROPRIATE CALLS   "
/IAUSFL(18),IAUSFL(24)/=1;

"-------------------------------------------------------------"
"STEP 6  DETERMINATION-OF-INCIDENT-PARTICLE-PARAMETERS       "
"-------------------------------------------------------------"
"DEFINE INITIAL VARIABLES FOR 20 MEV BEAM OF ELECTRONS  INCIDENT"
"PERPENDICULAR TO THE SLAB"

IQIN=0;"              INCIDENT PHOTONS"
EIN=0.050;"           50 KEV"
/XIN,YIN,ZIN/=0.0;"   INCIDENT AT ORIGIN"
/UIN,VIN/=0.0;WIN=1.0;" MOVING ALONG Z AXIS"
IRIN=2;"              STARTS IN REGION 2, COULD BE 1"
WTIN=1.0;"            WEIGHT = 1 SINCE NO VARIANCE REDUCTION USED"
LATCHI=0;"            LATCH SET TO ZERO AT START OF EACH HISTORY"
```

78

Assignment # 2: EDEP



3 The Meaning of the Main Variables used in EGS4

The variables used in EGS4 and their meanings are given in APPENDIX 2 of SLAC-265. The main variables which are necessary to write the User Code are as follows:

COMMON/STACK
X(NP), Y(NP), Z(NP) Position of a particle.
U(NP), V(NP), W(NP) Directional cosines of a particle.
WT(NP) Statistical weight of the current particle (default=1.0).
E(NP) Total energy in MeV.
IQ(NP) Integer charge of a particle (+1, 0, -1).
IR(NP) Index of a particle's current region.
NP The stack pointer (i.e., the particle currently being pointed to).

COMMON/BOUNDS
EXTT Array of regions' charged particle cutoff energies in MeV.
PCUT Array of regions' photon cutoff energies in MeV.
COMMON/EPCONT
EDEP Energy deposited in MeV.
USTEP Distance to the next interaction(cm).
TVSTEP Actual total (curved)step length to be transported.
IRNEW Index of previous region.
INDEN Index of new region.
COMMON/MEDIA
NMED number of media being used (default=1).
RLC Array containing radiation length of the media in cm.
RHO Array containing the density of media in g/cm^3.

Initial parameters of source particles are defined as the following variables and transferred to SUBROUTINE HOWFAR as the argument of SUBROUTINE CALL:
X, Y, Z : Position of a source particle
U, V, W : Direction cosines of a source particle
E : Total energy of a source particle
IQ : Integer charge of a source particle
IR : Index of a source particle's incident region
WT : Statistical weight of a source particle

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79

Assignment # 2: Output the Result

wire.mor

```
"-------------------------------------------------------------"
"STEP 8   OUTPUT-OF-RESULTS                                   "
"-------------------------------------------------------------"
"NOTE OUTPUT IS AT THE END OF EACH HISTORY IN SUBROUTINE AUSGAB   "
]

OUTPUT TENERGY;(' Total Energy Deposition=',E12.6)

STOP;END;
```

80

Assignment # 2: Zero??

C:\Windows\system32\cmd.exe

```
0KNOCK-ON ELECTRONS CAN BE CREATED AND ANY ELECTRON FOLLOWED
                                        0.001 MeV KINETIC
 BREM PHOTONS CAN BE CREATED AND ANY PHOTON FOLLOWED DOWN TO
                                        0.001 MeV

 START HISTORY   1
 START HISTORY   2
 START HISTORY   3
 START HISTORY   4
 START HISTORY   5
 START HISTORY   6
 START HISTORY   7
 START HISTORY   8
 START HISTORY   9
 START HISTORY  10
 Total Energy Deposition=0.000000E+00

C:\HEN_HOUSE\EGS4\TUTOR>
```

81

Assignment # 2: Pass Variable

wire.mor

```
"-------------------------------------------------------------"
"STEP 1:  USER-OVERRIDE-OF-EGS4-MACROS                        "
"-------------------------------------------------------------"
REPLACE {$MXMED} WITH {1}    "ONLY 1 MEDIUM IN THE PROBLEM(DEFAULT 10)"
REPLACE {$MXREG} WITH {4}    "ONLY 3 GEOMETRIC REGIONS (DEFAULT 2000) "
REPLACE {$MXSTACK} WITH {15} "LESS THAN 15 PARTICLES ON STACK AT ONCE "

REPLACE {;COMIN/SCORE/;} WITH {;COMMON/SCORE/TENERGY;}

"  THE FOLOWING RANDOM NUMBER GENERATOR NEEDS TO BE USED ON A VAX     "
"  REMOVE THIS MACRO DEFINITION ON AN IBM MACHINE SINCE THE EGS4      "
"  DEFAULT WORKS THERE                                                "
REPLACE {;COMIN/RANDOM/;} WITH {;COMMON/RANDOM/IXX;}
REPLACE {$RANDOMSET#;} WITH
{IXX=IXX*663608941;{P1}=0.5 + IXX*0.23283064E-09;}

;COMIN/BOUNDS,MEDIA,MISC,PLADTA,THRESH,CYLDTA,RANDOM,SCORE/;
```

82

Assignment # 2: Pass Variable

wire.mor

```
"
SUBROUTINE AUSGAB(IARG);
"
"  IN GENERAL, AUSGAB IS A ROUTINE WHICH IS CALLED UNDER A SERIES     "
"  OF WELL DEFINED CONDITIONS SPECIFIED BY THE VALUE OF IARG (SEE THE "
"  EGS4 MANUAL FOR THE LIST).  THIS IS A PARTICULARILY SIMPLE AUSGAB. "
"  WHENEVER THIS ROUTINE IS CALLED WITH IARG=3 , A PARTICLE HAS       "
"  BEEN DISCARDED BY THE USER IN HOWFAR                               "
"  WE GET AUSGAB TO PRINT THE REQUIRED INFORMATION AT THAT POINT      "
"                                                                     "
"*********************************************************************"

COMIN/STACK,EPCONT,SCORE/;

IF(IARG.LE.2.OR.IARG.EQ.4 )[
TENERGY=TENERGY+EDEP;
]
RETURN;END;" END OF AUSGAB
```

83

Assignment # 2: Increase History

wire.mor

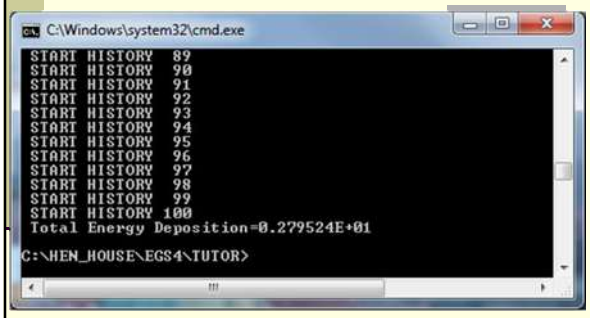
```
"-------------------------------------------------------------"
"STEP 6   DETERMINATION-OF-INCIDENT-PARTICLE-PARAMETERS       "
"-------------------------------------------------------------"
IQIN=0;
EIN=1.0;

DO I=1,100[OUTPUT I;(' START HISTORY',I4);

LOOP[ $RANDOMSET XIN;XIN=(2.0*XIN-1.0)*0.2;
      $RANDOMSET YIN;YIN=(2.0*YIN-1.0)*0.2;
```

84

Assignment # 2: Done



85

Thank You!

86