GammaCell Project

Interim Report

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TABLE OF CONTENTS

INTRODUCTION

Working with irradiation chambers, one often needs exposure rate information about a sample placed at a particular location in the chamber. More often, one would also like to know the distribution of the radiation within the sample itself. Direct measurements of these distributions are tedious and impractical thus leading to the development of computer programs to simulate and calculate dose information. In the past, programs such as Rumjana Chakarova's FORTRAN program have been able to calculate dose information with limitations such as a fixed source fixture shape. These limitations have led to the desire for programs with additional features, flexibility, and user friendliness.

ACCOMPLISHMENTS

With user friendliness in mind, it was felt that a new program should be written replacing the textual user interface with a graphical one that also increases the possibilities of flexibility. Writing the foundation for the graphical user interface in Java was one major task accomplished. It allows users to interact with the program in a way familiar to Windows and Macintosh users. Screen shots of the program can be found in the Appendix on page 3.

To allow for program flexibility, much of the program design time was spent developing data structures to encapsulate data and functions used to simulate irradiation dosing. By using an object-oriented programming language such as Java, the project was broken down into many parts with functions associated with their data. This allows easy expansion of the program as the need arises in the future.

Computational functions written for the program involved the use of common formulas such as radioactive decay and point source exposure and also adaptations of functions used in the FORTRAN program such as calculation of the radiation penetration distance.

PROBLEMS

Problems encountered during development were of two main types. The first pertains to user interface problems consisting of data input and output issues and the other pertains to computational ones.

For input, a lot of error checking was put into place to prevent the user from inputting invalid data such as negative quantities of objects. For output, speed was an issue where the user had to wait about the same amount of time for the output to display as it did to calculate the results. With simplifications of the output and calculation progress display, this was resolved.

Regarding computational problems, initial tests comparing the FORTRAN program with the new Java program showed great deviation of about 20%. Comparing the models used by the two programs, it was found that one difference was that the old program had used 18 point sources to approximate one source pencil while the new program uses only 12. Varying the number of point sources for approximation in the new program did not change results significantly (less than 0.02%). Another difference between the programs was that the new program did not account for shielding of radiation by the source fixture or the sample. After accounting for the shielding effect of the pencils, the programs showed great correlation within 2% in cases like the one shown in Sample 1 on page 2, but in other cases such as in Sample 2 and 3, results deviated about 20% higher than the old program. These results are somewhat surprising, and needs to be investigated further.

FUTURE WORK

Additional work required on this project involves resolution of the discrepancy between the two programs by more extensive testing to find the source of the error. In addition, results need to be compared with actual experimental measurements to ensure validity. After comparison with measured data using simple configurations of source fixtures, more complicated configurations should be examined to see if the current modeling system can be extended to provide accurate results. Besides allowing for more complicated configurations of source fixtures, the program can further be extended to produce contour maps of the exposure rate distribution within the sample. These program extensions can be easily added once the validity of the results has been established. Future work should focus on getting accurate results from the program in comparison to measured data and then on additional program features.

APPENDIX

Sample Output

Sample 1

FORTRAN Program

```
GCELL1 - PROGRAM


 one source pencil activity (Ci)    192.5739
 source rack diameter (inches)      2.0000
 number of the source pencils    6
 Dose rate - for water equivalent detector
 Exposure rate - for ionisation chamber
 x,y,z (inch) of the material center   10.0000      .0000      .0000
Material lenght,width,height (inch),density(g/cm3)
       3.000       3.000       6.000        .000
x(inches)= 10.00  y=  0.00  z=   .00  dose rate (krad/h) =      20.42
x(inches)= 11.50  y=  0.00  z=   .00  dose rate (krad/h) =      15.54
x(inches)= 10.00  y=  1.50  z=   .00  dose rate (krad/h) =      20.95
x(inches)= 10.00  y= -1.50  z=   .00  dose rate (krad/h) =      20.92
x(inches)=  8.50  y=  0.00  z=   .00  dose rate (krad/h) =      27.96
x(inches)= 10.00  y=  0.00  z=  3.00  dose rate (krad/h) =      18.95
x(inches)=  8.50  y=  1.50  z=  3.00  dose rate (krad/h) =      25.95
x(inches)= 11.50  y= -1.50  z=  3.00  dose rate (krad/h) =      15.13
x(inches)= 11.50  y=  1.50  z=  3.00  dose rate (krad/h) =      15.13
x(inches)=  8.50  y= -1.50  z=  3.00  dose rate (krad/h) =      25.95
x(inches)= 10.00  y=  1.50  z=  3.00  dose rate (krad/h) =      19.50
x(inches)= 10.00  y= -1.50  z=  3.00  dose rate (krad/h) =      19.48
x(inches)= 11.50  y=  0.00  z=  3.00  dose rate (krad/h) =      14.65
x(inches)=  8.50  y=  0.00  z=  3.00  dose rate (krad/h) =      25.39
 The point of the maximum is    8.5    0.0     .0  Dmax=      27.96 krad/h
 The point of the minimum is   11.5    0.0    3.0  Dmin=      14.65 krad/h
 non-uniformity index=  1.91
```

Java Program

```
Calculation date: 05/14/1998
Fixture Annular: Center (0.0, 0.0, 0.0) Radius 1.0 Pencils 6
Target Rectangular Parallelepiped: Center (10.0, 0.0, 0.0) Height 6.0 Width
3.0 Length 3.0

      Coordinate (Inches)         Dose (Rads/hour)
        (8.5, -1.5, -3.0)                 25646.6
       (10.0, -1.5, -3.0)                 19041.3
       (11.5, -1.5, -3.0)                 14808.6
        (8.5, 0.0, -3.0)                  25720.6
       (10.0, 0.0, -3.0)                  19187.7
       (11.5, 0.0, -3.0)                  14834.2
        (8.5, 1.5, -3.0)                  25419.3
       (10.0, 1.5, -3.0)                  19119.3
       (11.5, 1.5, -3.0)                  14861.5
        (8.5, -1.5, 0.0)                  28143.0
       (10.0, -1.5, 0.0)                  20480.9
       (11.5, -1.5, 0.0)                  15694.0
         (8.5, 0.0, 0.0)                  28320.4
        (10.0, 0.0, 0.0)                  20678.9
        (11.5, 0.0, 0.0)                  15742.7
         (8.5, 1.5, 0.0)                  27906.3
        (10.0, 1.5, 0.0)                  20564.6
        (11.5, 1.5, 0.0)                  15750.0
        (8.5, -1.5, 3.0)                  25646.6
       (10.0, -1.5, 3.0)                  19041.3
       (11.5, -1.5, 3.0)                  14808.6
         (8.5, 0.0, 3.0)                  25720.6
        (10.0, 0.0, 3.0)                  19187.7
        (11.5, 0.0, 3.0)                  14834.2
         (8.5, 1.5, 3.0)                  25419.3
        (10.0, 1.5, 3.0)                  19119.3
        (11.5, 1.5, 3.0)                  14861.5

Calculation time: 1.54 s
```

Sample 2

FORTRAN Program

```
GCELL1 - PROGRAM


 one source pencil activity (Ci)     70.9215
 source rack diameter (inches)       5.0000
 number of the source pencils   12
 Dose rate - for water equivalent detector
 Exposure rate - for ionisation chamber
 x,y,z (inch) of the material center    7.5000      .0000      .0000
 material diameter,depth(inch),density(g/cm3)
         2.0000        10.0000          .0000
x(inches)=  7.50  y=  0.00  z=   .00  dose rate (krad/h) =      26.20
x(inches)=  8.50  y=  0.00  z=   .00  dose rate (krad/h) =      20.32
x(inches)=  7.50  y=  1.00  z=   .00  dose rate (krad/h) =      26.05
x(inches)=  7.50  y= -1.00  z=   .00  dose rate (krad/h) =      25.99
x(inches)=  6.50  y=  0.00  z=   .00  dose rate (krad/h) =      35.21
x(inches)=  7.50  y=  0.00  z=  5.00  dose rate (krad/h) =      18.28
x(inches)=  7.50  y=  1.00  z=  5.00  dose rate (krad/h) =      18.28
x(inches)=  7.50  y= -1.00  z=  5.00  dose rate (krad/h) =      18.26
x(inches)=  8.50  y=  0.00  z=  5.00  dose rate (krad/h) =      15.14
x(inches)=  6.50  y=  0.00  z=  5.00  dose rate (krad/h) =      22.53
 The point of the maximum is    6.5    0.0     .0  Dmax=      35.21 krad/h
 The point of the minimum is    8.5    0.0    5.0  Dmin=      15.14 krad/h
 non-uniformity index=  2.33
```

Java Program

```
Calculation date: 05/14/1998
Fixture Annular: Center (0.0, 0.0, 0.0) Radius 2.5 Pencils 12
Target Cylinder: Center (7.5, 0.0, 0.0) Height 10.0 Radius 1.0

      Coordinate (Inches)         Dose (Rads/hour)
        (7.5, -1.0, -5.0)                 21299.9
         (6.5, 0.0, -5.0)                 26297.1
         (7.5, 0.0, -5.0)                 21331.5
         (8.5, 0.0, -5.0)                 17436.6
         (7.5, 1.0, -5.0)                 21158.9
         (7.5, -1.0, 0.0)                 29735.0
         (6.5, 0.0, 0.0)                  40001.3
         (7.5, 0.0, 0.0)                  29941.2
         (8.5, 0.0, 0.0)                  23051.5
         (7.5, 1.0, 0.0)                  29542.7
        (7.5, -1.0, 5.0)                  21299.9
         (6.5, 0.0, 5.0)                  26297.1
         (7.5, 0.0, 5.0)                  21331.5
         (8.5, 0.0, 5.0)                  17436.6
         (7.5, 1.0, 5.0)                  21158.9

Calculation time: 1.54 s
```

Sample 3

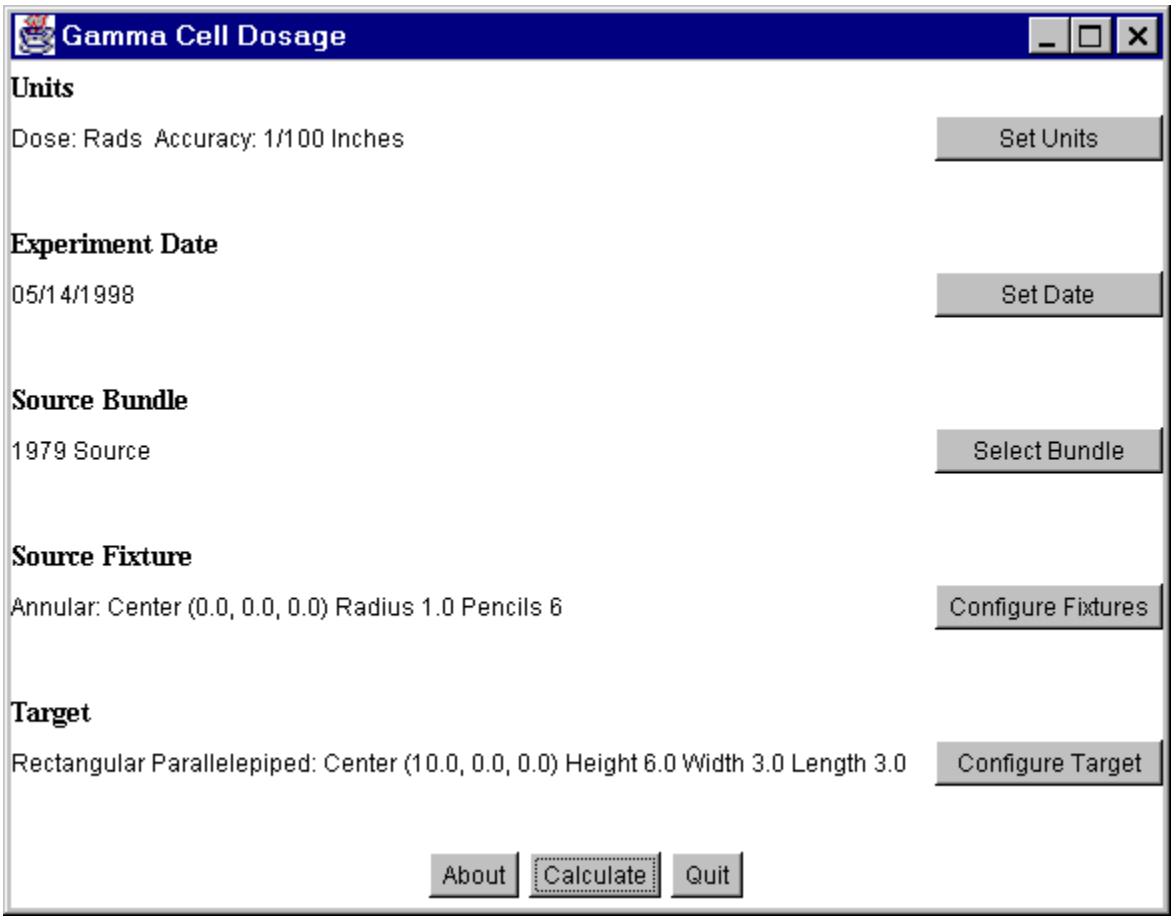
FORTRAN Program

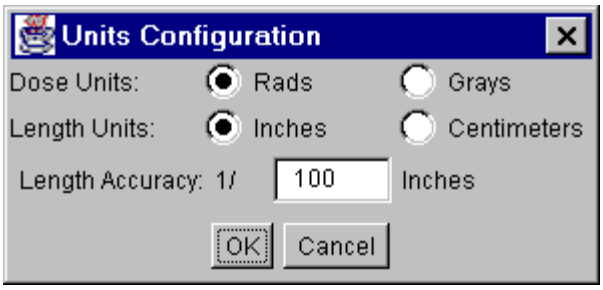
```
GCELL1 - PROGRAM


  one source pencil activity (Ci)     70.9215
  source rack diameter (inches)       5.0000
  number of the source pencils   12
  Dose rate - for water equivalent detector
  Exposure rate - for ionisation chamber
  x,y,z (inch) of the material center    7.5000      .0000     2.0000
  material diameter,depth(inch),density(g/cm3)
           2.0000        10.0000           .0000
x(inches)=  7.50  y=  0.00  z=  2.00  dose rate (krad/h) =      24.62
x(inches)=  8.50  y=  0.00  z=  2.00  dose rate (krad/h) =      19.30
x(inches)=  7.50  y=  1.00  z=  2.00  dose rate (krad/h) =      24.51
x(inches)=  7.50  y= -1.00  z=  2.00  dose rate (krad/h) =      24.46
x(inches)=  6.50  y=  0.00  z=  2.00  dose rate (krad/h) =      32.65
x(inches)=  7.50  y=  0.00  z=  7.00  dose rate (krad/h) =      13.89
x(inches)=  7.50  y=  1.00  z=  7.00  dose rate (krad/h) =      13.93
x(inches)=  7.50  y= -1.00  z=  7.00  dose rate (krad/h) =      13.91
x(inches)=  8.50  y=  0.00  z=  7.00  dose rate (krad/h) =      12.01
x(inches)=  6.50  y=  0.00  z=  7.00  dose rate (krad/h) =      16.16
x(inches)=  7.50  y=  0.00  z= -3.00  dose rate (krad/h) =      22.80
x(inches)=  7.50  y=  1.00  z= -3.00  dose rate (krad/h) =      22.73
x(inches)=  7.50  y= -1.00  z= -3.00  dose rate (krad/h) =      22.69
x(inches)=  8.50  y=  0.00  z= -3.00  dose rate (krad/h) =      18.13
x(inches)=  6.50  y=  0.00  z= -3.00  dose rate (krad/h) =      29.69
 The point of the maximum is    6.5    0.0    2.0  Dmax=       32.65 krad/h
 The point of the minimum is    8.5    0.0    7.0  Dmin=       12.01 krad/h
 non-uniformity index=  2.72
```

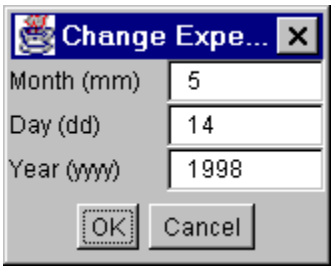
Java Program

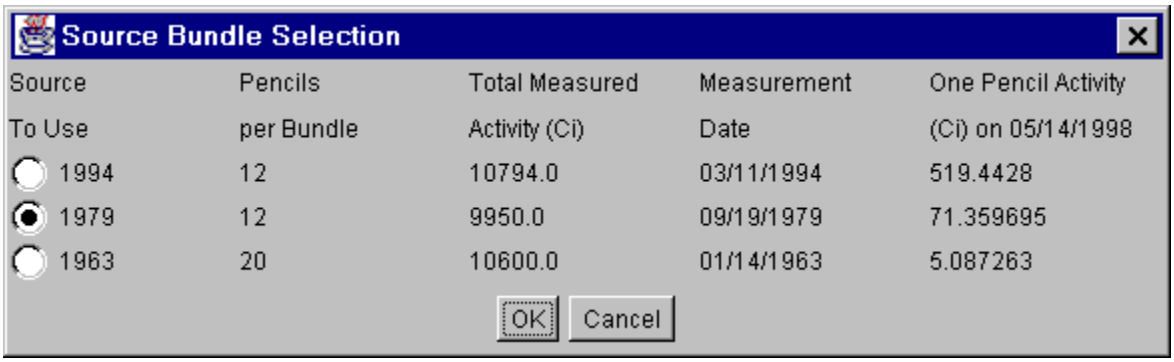
```
Calculation date: 05/14/1998
Fixture Annular: Center (0.0, 0.0, 0.0) Radius 2.5 Pencils 12
Target Cylinder: Center (7.5, 0.0, 2.0) Height 10.0 Radius 1.0

      Coordinate (Inches)         Dose (Rads/hour)
        (7.5, -1.0, -3.0)                 26189.7
         (6.5, 0.0, -3.0)                 34159.6
         (7.5, 0.0, -3.0)                 26317.0
         (8.5, 0.0, -3.0)                 20722.9
         (7.5, 1.0, -3.0)                 26018.5
         (7.5, -1.0, 2.0)                 28086.1
          (6.5, 0.0, 2.0)                 37292.8
          (7.5, 0.0, 2.0)                 28255.5
          (8.5, 0.0, 2.0)                 21970.8
          (7.5, 1.0, 2.0)                 27903.7
         (7.5, -1.0, 7.0)                 16436.9
          (6.5, 0.0, 7.0)                 19159.3
          (7.5, 0.0, 7.0)                 16410.2
          (8.5, 0.0, 7.0)                 13973.0
          (7.5, 1.0, 7.0)                 16325.9

Calculation time: 1.54 s
```

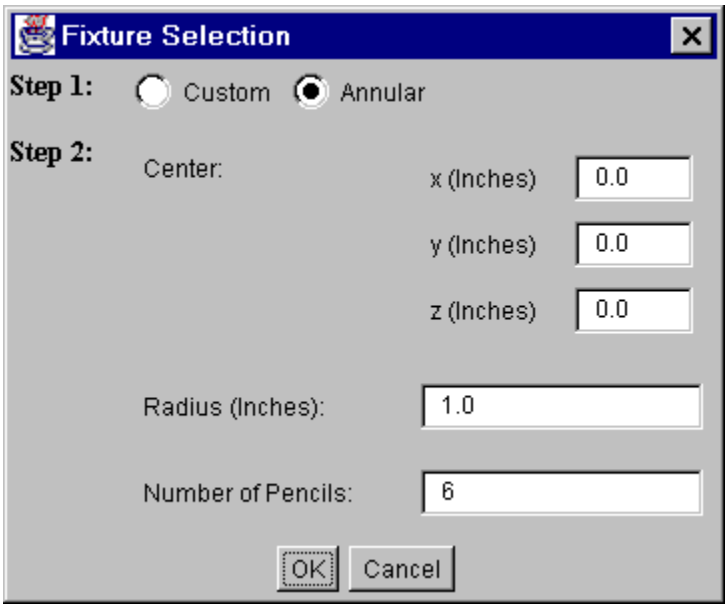
Screen Shots

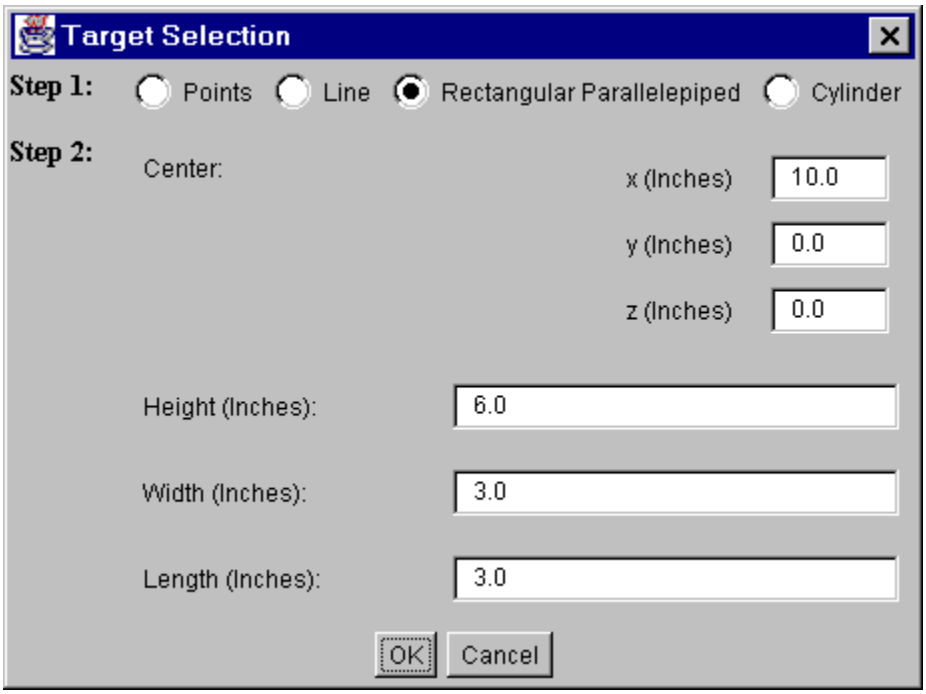


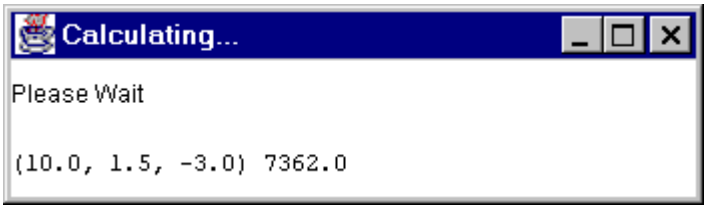

Units Configuration
Dose Units:
Rads
Grays
Length Units:
Inches
Centimeters
Length Accuracy: 1/
100
Inches
OK
Cancel

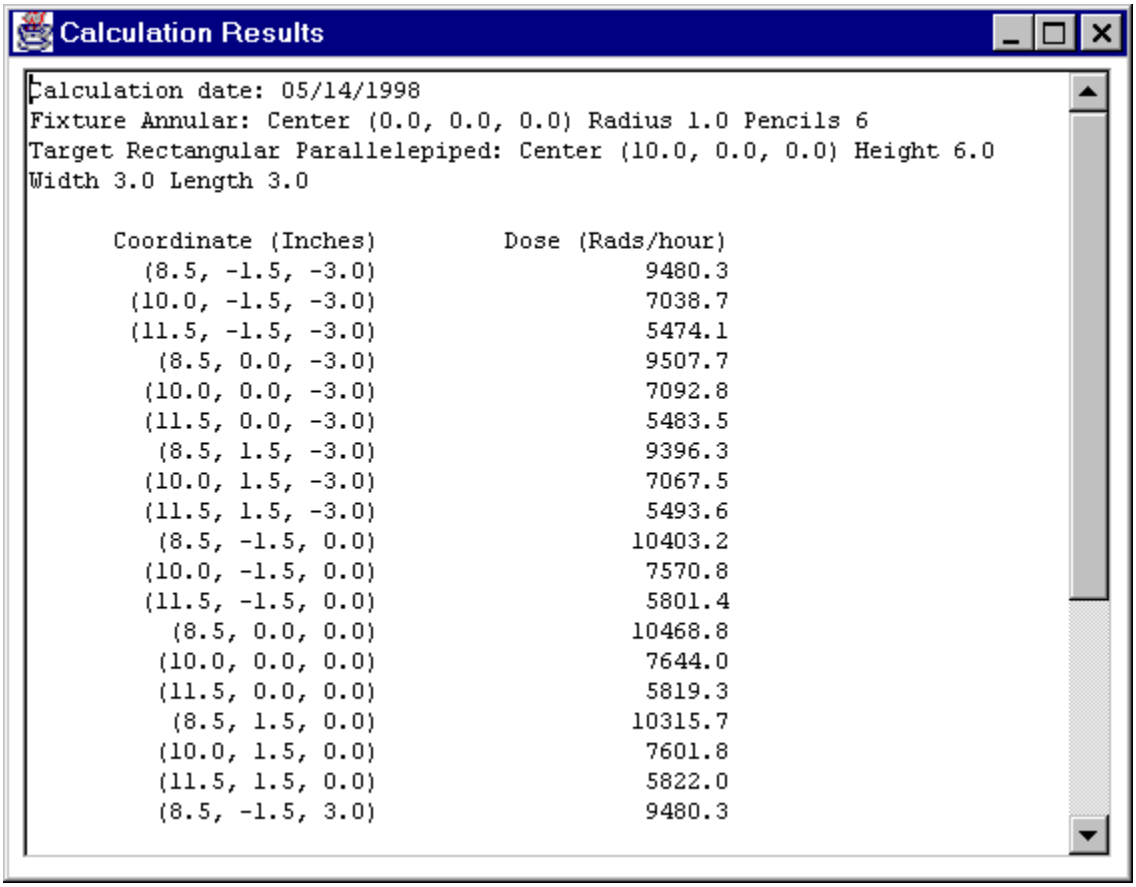

Change Expe...
Month (mm)
5
Day (dd)
14
Year (yyyy)
1998
OK
Cancel


Source Bundle Selection
Source To Use
Pencils per Bundle
Total Measured Activity (Ci)
Measurement Date
One Pencil Activity (Ci) on 05/14/1998
1994
12
10794.0
03/11/1994
519.4428
1979
12
9950.0
09/19/1979
71.359695
1963
20
10600.0
01/14/1963
5.087263
OK
Cancel


Fixture Selection
Step 1:
Custom
Annular
Step 2:
Center:
x (Inches)
0.0
y (Inches)
0.0
z (Inches)
0.0
Radius (Inches):
1.0
Number of Pencils:
6
OK
Cancel


Target Selection
Step 1:
Points
Line
Rectangular Parallelepiped
Cylinder
Step 2:
Center:
x (Inches)
10.0
y (Inches)
0.0
z (Inches)
0.0
Height (Inches):
6.0
Width (Inches):
3.0
Length (Inches):
3.0
OK
Cancel


Calculating...
Please Wait
(10.0, 1.5, -3.0) 7362.0


Calculation Results
Calculation date: 05/14/1998
Fixture Annular: Center (0.0, 0.0, 0.0) Radius 1.0 Pencils 6
Target Rectangular Parallelepiped: Center (10.0, 0.0, 0.0) Height 6.0
Width 3.0 Length 3.0
Coordinate (Inches) Dose (Rads/hour)
(8.5, -1.5, -3.0) 9480.3
(10.0, -1.5, -3.0) 7038.7
(11.5, -1.5, -3.0) 5474.1
(8.5, 0.0, -3.0) 9507.7
(10.0, 0.0, -3.0) 7092.8
(11.5, 0.0, -3.0) 5483.5
(8.5, 1.5, -3.0) 9396.3
(10.0, 1.5, -3.0) 7067.5
(11.5, 1.5, -3.0) 5493.6
(8.5, -1.5, 0.0) 10403.2
(10.0, -1.5, 0.0) 7570.8
(11.5, -1.5, 0.0) 5801.4
(8.5, 0.0, 0.0) 10468.8
(10.0, 0.0, 0.0) 7644.0
(11.5, 0.0, 0.0) 5819.3
(8.5, 1.5, 0.0) 10315.7
(10.0, 1.5, 0.0) 7601.8
(11.5, 1.5, 0.0) 5822.0
(8.5, -1.5, 3.0) 9480.3