Example: Photon Treatment Plan using VMC++ dose calculation

Table of Contents

In this example we will show (i) how to load patient data into matRad (ii) how to setup a photon dose calculation based on the VMC++ Monte Carlo algorithm (iii) how to inversely optimize the beamlet intensities directly from command window in MATLAB. (iv) how to visualize the result

Patient Data Import

Let's begin with a clear Matlab environment and import the boxphantom into your workspace.

```
clc,clear,close all;
load('BOXPHANTOM.mat');
```

Treatment Plan

The next step is to define your treatment plan labeled as 'pln'. This structure requires input from the treatment planner and defines the most important cornerstones of your treatment plan.

```
pln.radiationMode = 'photons';
pln.machine       = 'Generic';
pln.bioOptimization = 'none';
pln.gantryAngles    = [0];
pln.couchAngles     = [0];
pln.bixelWidth      = 10;
```

```
pln.numOfFractions  = 30;
pln.numOfBeams      = numel(pln.gantryAngles);
pln.numOfVoxels     = prod(ct.cubeDim);
pln.voxelDimensions = ct.cubeDim;
pln.isoCenter       = ones(pln.numOfBeams,1) *
 matRad_getIsoCenter(cst,ct,0);
pln.runSequencing   = 0;
pln.runDAO          = 0;
```

Generate Beam Geometry STF

```
stf = matRad_generateStf(ct,cst,pln);
```

```
matRad: Generating stf struct... Progress: 100.00 %
```

Dose Calculation

Calculate dose influence matrix for unit pencil beam intensities using the VMC++ monte carlo algorithm. We define the number of photons simulated per beamlet to be 700. You can find compatible VMC++ files at http://www.cerr.info/download.php which have to located in matRadrootDirectory\vmc++.

```
dij = matRad_calcPhotonDoseVmc(ct,stf,pln,cst);
```

```
Warning: Number of photons simulated per bixel (nCasePerBixel) and
 number
of parallel MC simulations (numOfParallelMCSimulations) not specified
 by
user. Use default settings with nCasePerBixel = 5000 and
numOfParallelMCSimulations = 4 in vmc++ calculations.
matRad: VMC++ photon dose calculation...


Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
```

```
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,22.5,23.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                    Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
```

```
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 18971  2927
================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.179 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
==========================================================
                   Beamlet Source
==========================================================
       charge = 0
```

```
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,22.5,22.5)
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                   Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 24442  27174
================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
```

```
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.24 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,22.5,24)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
```

```
 Fano calculation                  :   0
 Exact Compton                     :   0
 Electron transport mode           :   VMC++

============================================================
============================================
               MC_Control
============================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 8355  16407
============================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                  Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.338 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,22.5,23)
```

```
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                   Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 3810  27402
================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================
```

```
                Scoring and output options
=====================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.458 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.043  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.045  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.045  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.045  500  500
+++finished batch 2 cpu time: 0.307  500  500
+++finished batch 2 cpu time: 0.364  500  500
+++finished batch 2 cpu time: 0.204  500  500
+++finished batch 2 cpu time: 0.144  500  500
+++finished batch 3 cpu time: 0.383  500  500
+++finished batch 3 cpu time: 0.44  500  500
+++finished batch 3 cpu time: 0.311  500  500
+++finished batch 3 cpu time: 0.215  500  500
+++finished batch 4 cpu time: 0.504  500  500
+++finished batch 4 cpu time: 0.449  500  500
+++finished batch 4 cpu time: 0.371  500  500
+++finished batch 4 cpu time: 0.285  500  500
+++finished batch 5 cpu time: 0.58  500  500
+++finished batch 5 cpu time: 0.533  500  500
+++finished batch 5 cpu time: 0.46  500  500
+++finished batch 6 cpu time: 0.655  500  500
+++finished batch 5 cpu time: 0.398  500  500
+++finished batch 6 cpu time: 0.619  500  500
+++finished batch 6 cpu time: 0.528  500  500
+++finished batch 7 cpu time: 0.718  500  500
+++finished batch 7 cpu time: 0.68  500  500
+++finished batch 6 cpu time: 0.473  500  500
+++finished batch 7 cpu time: 0.589  500  500
+++finished batch 8 cpu time: 0.784  500  500
+++finished batch 8 cpu time: 0.767  500  500
+++finished batch 7 cpu time: 0.569  500  500
+++finished batch 8 cpu time: 0.686  500  500
+++finished batch 9 cpu time: 0.877  500  500
+++finished batch 8 cpu time: 0.641  500  500
+++finished batch 9 cpu time: 0.861  500  500
```

```
+++finished batch 9 cpu time: 0.763  500  500
+++finished batch 10 cpu time: 0.955  500  500
finished simulation, cpu time = 0.982 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.982
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.939  500  500
finished simulation, cpu time = 0.952 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.952
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.856  500  500
+++finished batch 9 cpu time: 0.746  500  500
finished simulation, cpu time = 0.871 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.871
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.843  500  500
finished simulation, cpu time = 0.857 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.857
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0342552 in region 1956847
    max dose is 0.0343312 in region 2033647
    max dose is 0.0343228 in region 1803246
    max dose is 0.0345088 in region 1880046
```

```
    ICRU-2K efficiency: 849.507 1/s
+++ total
    max dose is 0.0342552 in region 1956847
    ICRU-2K efficiency: 849.507 1/s
==================================================
    ICRU-2K efficiency: 858.861 1/s
+++ total
    max dose is 0.0343228 in region 1803246
    ICRU-2K efficiency: 858.861 1/s
==================================================
    ICRU-2K efficiency: 927.296 1/s
+++ total
    max dose is 0.0343312 in region 2033647
    ICRU-2K efficiency: 987.342 1/s
+++ total
    max dose is 0.0345088 in region 1880046
    ICRU-2K efficiency: 927.296 1/s
==================================================
    ICRU-2K efficiency: 987.342 1/s
==================================================
Completed 4 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
```

```
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,22.5,25)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
====================================================================
                   Monte Carlo Parameter
====================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
```

```
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 4729  29118
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================================
                  Scoring and output options
================================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.371 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.052  500  500
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23,22.5)
============================================================
============================================================
              XYZ Geometry
```

```
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                  Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 24009  4257
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
================================================================
                Scoring and output options
================================================================
  number of dose scoring objects: 1
```

```
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.45 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,22.5,24.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
====================================================================
                   Monte Carlo Parameter
====================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

====================================================================
================================================
               MC_Control
```

```
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 28726  28947
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================================
                 Scoring and output options
================================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.571 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,22.5,25.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
```

```
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 28716  14562
================================================
================================================================
                  Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                  Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
====================================================================
                Scoring and output options
====================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:
```

```
CPU time so far: 2.584 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
+++finished batch 2 cpu time: 0.13  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.069  500  500
+++finished batch 3 cpu time: 0.305  500  500
+++finished batch 2 cpu time: 0.109  500  500
+++finished batch 2 cpu time: 0.226  500  500
+++finished batch 2 cpu time: 0.137  500  500
+++finished batch 4 cpu time: 0.375  500  500
+++finished batch 3 cpu time: 0.175  500  500
+++finished batch 3 cpu time: 0.305  500  500
+++finished batch 3 cpu time: 0.203  500  500
+++finished batch 5 cpu time: 0.444  500  500
+++finished batch 4 cpu time: 0.238  500  500
+++finished batch 4 cpu time: 0.374  500  500
+++finished batch 4 cpu time: 0.269  500  500
+++finished batch 5 cpu time: 0.301  500  500
+++finished batch 6 cpu time: 0.512  500  500
+++finished batch 5 cpu time: 0.439  500  500
+++finished batch 5 cpu time: 0.353  500  500
+++finished batch 7 cpu time: 0.578  500  500
+++finished batch 6 cpu time: 0.384  500  500
+++finished batch 6 cpu time: 0.514  500  500
+++finished batch 6 cpu time: 0.419  500  500
+++finished batch 8 cpu time: 0.642  500  500
+++finished batch 7 cpu time: 0.448  500  500
+++finished batch 7 cpu time: 0.595  500  500
+++finished batch 7 cpu time: 0.482  500  500
+++finished batch 9 cpu time: 0.704  500  500
+++finished batch 8 cpu time: 0.51  500  500
+++finished batch 8 cpu time: 0.665  500  500
+++finished batch 8 cpu time: 0.552  500  500
+++finished batch 10 cpu time: 0.769  500  500
finished simulation, cpu time = 0.787 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.787
 number of histories: 5000
```

```
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.586  500  500
+++finished batch 9 cpu time: 0.615  500  500
+++finished batch 9 cpu time: 0.74  500  500
+++finished batch 10 cpu time: 0.648  500  500
finished simulation, cpu time = 0.662 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.662
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.8  500  500
+++finished batch 10 cpu time: 0.684  500  500
finished simulation, cpu time = 0.697 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.697
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.834 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.834
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0341063 in region 2187246
    max dose is 0.0346184 in region 2110447
    max dose is 0.0345979 in region 2264047
    max dose is 0.0338019 in region 1803726
    ICRU-2K efficiency: 1039.73 1/s
+++ total
    max dose is 0.0341063 in region 2187246
    ICRU-2K efficiency: 1039.73 1/s
================================================
    ICRU-2K efficiency: 1279.31 1/s
+++ total
    max dose is 0.0346184 in region 2110447
    ICRU-2K efficiency: 1279.31 1/s
```

```
==================================================
    ICRU-2K efficiency: 962.513 1/s
+++ total
    max dose is 0.0338019 in region 1803726
    ICRU-2K efficiency: 962.513 1/s
==================================================
    ICRU-2K efficiency: 1206.82 1/s
+++ total
    max dose is 0.0345979 in region 2264047
    ICRU-2K efficiency: 1206.82 1/s
==================================================
Completed 8 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
```

```
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23,23.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 23767  28785
================================================
```

```
================================================================
                    Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                    Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                  Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.277 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23,24.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                    Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
```

```
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 25474  28020
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
========================================================================
                 Scoring and output options
========================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.353 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source
```

```
Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23,23)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 12653  27473
================================================
================================================================
                   Variance Reduction
================================================================
```

```
 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.475 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23,24)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
```

```
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 19673  1072
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.548 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.059  500  500
```

```
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.043  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.043  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.045  500  500
+++finished batch 2 cpu time: 0.293  500  500
+++finished batch 2 cpu time: 0.195  500  500
+++finished batch 2 cpu time: 0.39  500  500
+++finished batch 2 cpu time: 0.135  500  500
+++finished batch 3 cpu time: 0.367  500  500
+++finished batch 3 cpu time: 0.264  500  500
+++finished batch 3 cpu time: 0.471  500  500
+++finished batch 3 cpu time: 0.197  500  500
+++finished batch 4 cpu time: 0.339  500  500
+++finished batch 4 cpu time: 0.452  500  500
+++finished batch 4 cpu time: 0.542  500  500
+++finished batch 4 cpu time: 0.273  500  500
+++finished batch 5 cpu time: 0.516  500  500
+++finished batch 5 cpu time: 0.41  500  500
+++finished batch 5 cpu time: 0.605  500  500
+++finished batch 5 cpu time: 0.343  500  500
+++finished batch 6 cpu time: 0.579  500  500
+++finished batch 6 cpu time: 0.673  500  500
+++finished batch 6 cpu time: 0.485  500  500
+++finished batch 6 cpu time: 0.415  500  500
+++finished batch 7 cpu time: 0.654  500  500
+++finished batch 7 cpu time: 0.565  500  500
+++finished batch 7 cpu time: 0.779  500  500
+++finished batch 7 cpu time: 0.486  500  500
+++finished batch 8 cpu time: 0.75  500  500
+++finished batch 8 cpu time: 0.649  500  500
+++finished batch 8 cpu time: 0.862  500  500
+++finished batch 8 cpu time: 0.577  500  500
+++finished batch 9 cpu time: 0.817  500  500
+++finished batch 9 cpu time: 0.743  500  500
+++finished batch 9 cpu time: 0.947  500  500
+++finished batch 9 cpu time: 0.677  500  500
+++finished batch 10 cpu time: 0.895  500  500
finished simulation, cpu time = 0.911 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.911
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.822  500  500
finished simulation, cpu time = 0.836 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
```

```
total number of particles: 5000
average sampled energy: 6 +/- 0
+++finished batch 10 cpu time: 1.03  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.836
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 1.046 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 1.046
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.751  500  500
finished simulation, cpu time = 0.765 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.765
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0342117 in region 2110926
    max dose is 0.0342145 in region 1880527
    max dose is 0.0340826 in region 1957327
    max dose is 0.0344097 in region 2034127
    ICRU-2K efficiency: 967.774 1/s
+++ total
    max dose is 0.0342145 in region 1880527
    ICRU-2K efficiency: 967.774 1/s
================================================
    ICRU-2K efficiency: 819.593 1/s
+++ total
    max dose is 0.0340826 in region 1957327
    ICRU-2K efficiency: 819.593 1/s
================================================
    ICRU-2K efficiency: 925.181 1/s
+++ total
    max dose is 0.0342117 in region 2110926
    ICRU-2K efficiency: 1070.74 1/s
+++ total
    max dose is 0.0344097 in region 2034127
    ICRU-2K efficiency: 925.181 1/s
================================================
```

```
    ICRU-2K efficiency: 1070.74 1/s
==================================================
Completed 12 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
==========================================================
                   Beamlet Source
```

```
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23.5,23)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 21182  955
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
```

```
                    Quasi Random Numbers
============================================================
 number of generators: 1
                   1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================
                  Scoring and output options
============================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.487 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23.5,22.5)
============================================================
============================================================
               XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                    Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
```

```
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
============================================
               MC_Control
============================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 19665  5136
============================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                 Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.557 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
```

```
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23,25)
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================================
                    Monte Carlo Parameter
============================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================================
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 20363  22733
================================================
============================================================================
                    Variance Reduction
============================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================================
============================================================================
                    Quasi Random Numbers
============================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
```

```
================================================================
================================================================
                  Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.583 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.049  500  500
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23,25.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
```

```
 Fano calculation                  :   0
 Exact Compton                     :   0
 Electron transport mode           :   VMC++

============================================================
==================================================
               MC_Control
==================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 22294  11767
==================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                 Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.669 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.041  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.046  500  500
+++finished batch 2 cpu time: 0.145  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.043  500  500
+++finished batch 2 cpu time: 0.179  500  500
+++finished batch 2 cpu time: 0.186  500  500
```

```
+++finished batch 3 cpu time: 0.278  500  500
+++finished batch 2 cpu time: 0.111  500  500
+++finished batch 3 cpu time: 0.249  500  500
+++finished batch 3 cpu time: 0.255  500  500
+++finished batch 4 cpu time: 0.35  500  500
+++finished batch 3 cpu time: 0.169  500  500
+++finished batch 4 cpu time: 0.315  500  500
+++finished batch 4 cpu time: 0.317  500  500
+++finished batch 5 cpu time: 0.408  500  500
+++finished batch 4 cpu time: 0.237  500  500
+++finished batch 5 cpu time: 0.378  500  500
+++finished batch 5 cpu time: 0.381  500  500
+++finished batch 6 cpu time: 0.472  500  500
+++finished batch 5 cpu time: 0.299  500  500
+++finished batch 6 cpu time: 0.441  500  500
+++finished batch 7 cpu time: 0.536  500  500
+++finished batch 6 cpu time: 0.451  500  500
+++finished batch 6 cpu time: 0.381  500  500
+++finished batch 7 cpu time: 0.511  500  500
+++finished batch 7 cpu time: 0.513  500  500
+++finished batch 8 cpu time: 0.606  500  500
+++finished batch 7 cpu time: 0.448  500  500
+++finished batch 8 cpu time: 0.572  500  500
+++finished batch 9 cpu time: 0.668  500  500
+++finished batch 8 cpu time: 0.583  500  500
+++finished batch 8 cpu time: 0.515  500  500
+++finished batch 9 cpu time: 0.634  500  500
+++finished batch 10 cpu time: 0.725  500  500
+++finished batch 9 cpu time: 0.642  500  500
finished simulation, cpu time = 0.742 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.742
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.577  500  500
+++finished batch 10 cpu time: 0.699  500  500
+++finished batch 10 cpu time: 0.702  500  500
finished simulation, cpu time = 0.716 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.716
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
```

```
finished simulation, cpu time = 0.719 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.719
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.65  500  500
finished simulation, cpu time = 0.663 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.663
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0340248 in region 1881006
    max dose is 0.0343928 in region 2187726
    max dose is 0.03426 in region 1804207
    max dose is 0.0343579 in region 2264526
    ICRU-2K efficiency: 1123.43 1/s
+++ total
    max dose is 0.0340248 in region 1881006
    ICRU-2K efficiency: 1123.43 1/s
================================================
    ICRU-2K efficiency: 1192.13 1/s
+++ total
    max dose is 0.03426 in region 1804207
    ICRU-2K efficiency: 1192.13 1/s
================================================
    ICRU-2K efficiency: 1179.88 1/s
+++ total
    max dose is 0.0343928 in region 2187726
    ICRU-2K efficiency: 1179.88 1/s
================================================
    ICRU-2K efficiency: 1254.3 1/s
+++ total
    max dose is 0.0343579 in region 2264526
    ICRU-2K efficiency: 1254.3 1/s
================================================
Completed 16 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc
```

```
Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23.5,25)
============================================================
============================================================
              XYZ Geometry
```

```
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                  Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 28507  1034
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================
                Scoring and output options
============================================================
  number of dose scoring objects: 1
```

```
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.295 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23.5,23.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
====================================================================
                   Monte Carlo Parameter
====================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

====================================================================
================================================
               MC_Control
```

```
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 8308  1386
================================================
=====================================================================
                    Variance Reduction
=====================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
=====================================================================
=====================================================================
                    Quasi Random Numbers
=====================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
=====================================================================
=====================================================================
                 Scoring and output options
=====================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.363 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23.5,24.5)
============================================================
=============================================================
              XYZ Geometry
=============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
```

```
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 20845  9513
================================================
================================================================
                  Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                  Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
====================================================================
                Scoring and output options
====================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:
```

```
CPU time so far: 2.466 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23.5,24)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
```

```
  total histories     : 5000
  initial rng seeds   : 2914  24704
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.577 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.058  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.041  500  500
+++finished batch 2 cpu time: 0.33  500  500
+++finished batch 2 cpu time: 0.31  500  500
+++finished batch 2 cpu time: 0.203  500  500
+++finished batch 2 cpu time: 0.136  500  500
+++finished batch 3 cpu time: 0.405  500  500
+++finished batch 3 cpu time: 0.376  500  500
+++finished batch 3 cpu time: 0.29  500  500
+++finished batch 3 cpu time: 0.203  500  500
+++finished batch 4 cpu time: 0.472  500  500
+++finished batch 4 cpu time: 0.45  500  500
+++finished batch 4 cpu time: 0.347  500  500
+++finished batch 4 cpu time: 0.269  500  500
```

```
+++finished batch 5 cpu time: 0.536  500  500
+++finished batch 5 cpu time: 0.511  500  500
+++finished batch 5 cpu time: 0.408  500  500
+++finished batch 5 cpu time: 0.327  500  500
+++finished batch 6 cpu time: 0.608  500  500
+++finished batch 6 cpu time: 0.584  500  500
+++finished batch 6 cpu time: 0.499  500  500
+++finished batch 6 cpu time: 0.392  500  500
+++finished batch 7 cpu time: 0.68  500  500
+++finished batch 7 cpu time: 0.652  500  500
+++finished batch 7 cpu time: 0.57  500  500
+++finished batch 7 cpu time: 0.47  500  500
+++finished batch 8 cpu time: 0.767  500  500
+++finished batch 8 cpu time: 0.739  500  500
+++finished batch 8 cpu time: 0.648  500  500
+++finished batch 8 cpu time: 0.545  500  500
+++finished batch 9 cpu time: 0.828  500  500
+++finished batch 9 cpu time: 0.811  500  500
+++finished batch 9 cpu time: 0.712  500  500
+++finished batch 9 cpu time: 0.615  500  500
+++finished batch 10 cpu time: 0.875  500  500
+++finished batch 10 cpu time: 0.915  500  500
+++finished batch 10 cpu time: 0.777  500  500
+++finished batch 10 cpu time: 0.677  500  500
finished simulation, cpu time = 0.899 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.899
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.796 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
finished simulation, cpu time = 0.937 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.796
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.937
```

```
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.694 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.694
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0347457 in region 1957807
    max dose is 0.0344827 in region 2188206
    max dose is 0.0349114 in region 2034607
    max dose is 0.0346036 in region 2111407
    ICRU-2K efficiency: 951.083 1/s
+++ total
    max dose is 0.0347457 in region 1957807
    ICRU-2K efficiency: 951.083 1/s
==================================================
    ICRU-2K efficiency: 934.841 1/s
+++ total
    max dose is 0.0344827 in region 2188206
    ICRU-2K efficiency: 1088.52 1/s
+++ total
    max dose is 0.0346036 in region 2111407
    ICRU-2K efficiency: 1246.27 1/s
+++ total
    max dose is 0.0349114 in region 2034607
    ICRU-2K efficiency: 934.841 1/s
==================================================
    ICRU-2K efficiency: 1088.52 1/s
==================================================
    ICRU-2K efficiency: 1246.27 1/s
==================================================
Completed 20 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc
```

```
Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24,23.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================
```

```
 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 13368  19390
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.273 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
```

```
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24,23)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 5607  14693
================================================
================================================================
                  Variance Reduction
```

```
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                  Quasi Random Numbers
================================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.36 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,23.5,25.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
```

```
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
============================================
                MC_Control
============================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 13163  11447
============================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                 Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.48 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
```

```
 OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24,22.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
====================================================================
                    Monte Carlo Parameter
====================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

====================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 22966  23856
================================================
====================================================================
                    Variance Reduction
====================================================================

 f_repeat           = 0.251
 split photons      = 1
```

```
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.583 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.043  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.045  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.043  500  500
+++finished batch 2 cpu time: 0.289  500  500
+++finished batch 2 cpu time: 0.181  500  500
+++finished batch 2 cpu time: 0.368  500  500
+++finished batch 2 cpu time: 0.117  500  500
+++finished batch 3 cpu time: 0.356  500  500
+++finished batch 3 cpu time: 0.432  500  500
+++finished batch 3 cpu time: 0.249  500  500
+++finished batch 3 cpu time: 0.182  500  500
+++finished batch 4 cpu time: 0.496  500  500
+++finished batch 4 cpu time: 0.426  500  500
+++finished batch 4 cpu time: 0.336  500  500
+++finished batch 4 cpu time: 0.244  500  500
+++finished batch 5 cpu time: 0.56  500  500
+++finished batch 5 cpu time: 0.492  500  500
+++finished batch 5 cpu time: 0.401  500  500
+++finished batch 5 cpu time: 0.31  500  500
+++finished batch 6 cpu time: 0.628  500  500
+++finished batch 6 cpu time: 0.559  500  500
+++finished batch 6 cpu time: 0.465  500  500
+++finished batch 6 cpu time: 0.386  500  500
+++finished batch 7 cpu time: 0.704  500  500
```

```
+++finished batch 7 cpu time: 0.526  500  500
+++finished batch 7 cpu time: 0.644  500  500
+++finished batch 7 cpu time: 0.454  500  500
+++finished batch 8 cpu time: 0.785  500  500
+++finished batch 8 cpu time: 0.721  500  500
+++finished batch 8 cpu time: 0.61  500  500
+++finished batch 8 cpu time: 0.537  500  500
+++finished batch 9 cpu time: 0.853  500  500
+++finished batch 9 cpu time: 0.676  500  500
+++finished batch 9 cpu time: 0.795  500  500
+++finished batch 9 cpu time: 0.606  500  500
+++finished batch 10 cpu time: 0.928  500  500
+++finished batch 10 cpu time: 0.746  500  500
finished simulation, cpu time = 0.942 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.942
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.871  500  500
finished simulation, cpu time = 0.772 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.772
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.885 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.885
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.674  500  500
finished simulation, cpu time = 0.689 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
```

```
 geometry: CT
 cpu time: 0.689
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0343987 in region 1958286
    max dose is 0.0344111 in region 2265006
    max dose is 0.0339486 in region 1804686
    max dose is 0.0343559 in region 1881486
    ICRU-2K efficiency: 914.102 1/s
+++ total
    max dose is 0.0343987 in region 1958286
    ICRU-2K efficiency: 914.102 1/s
================================================
    ICRU-2K efficiency: 1128.79 1/s
+++ total
    max dose is 0.0344111 in region 2265006
    ICRU-2K efficiency: 1251.46 1/s
+++ total
    max dose is 0.0339486 in region 1804686
    ICRU-2K efficiency: 977.628 1/s
+++ total
    max dose is 0.0343559 in region 1881486
    ICRU-2K efficiency: 1251.46 1/s
================================================
    ICRU-2K efficiency: 1128.79 1/s
================================================
    ICRU-2K efficiency: 977.628 1/s
================================================
Completed 24 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
```

```
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24,25.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                    Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
```

```
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 3570  14951
================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
========================================================================
                  Scoring and output options
========================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.223 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
```

```
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24,24.5)
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3   Number of
 y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                   Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 8281  20392
================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
```

```
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.231 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24,24)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
```

```
 Fano calculation                  :   0
 Exact Compton                     :   0
 Electron transport mode           :   VMC++

============================================================
=================================================
               MC_Control
=================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 21281  22641
=================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                  Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.359 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24,25)
```

```
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                   Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 19653  4879
================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================
```

```
                Scoring and output options
=====================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.345 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.053  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.04  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.041  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.052  500  500
+++finished batch 2 cpu time: 0.223  500  500
+++finished batch 2 cpu time: 0.21  500  500
+++finished batch 2 cpu time: 0.108  500  500
+++finished batch 2 cpu time: 0.147  500  500
+++finished batch 3 cpu time: 0.297  500  500
+++finished batch 3 cpu time: 0.189  500  500
+++finished batch 3 cpu time: 0.3  500  500
+++finished batch 3 cpu time: 0.21  500  500
+++finished batch 4 cpu time: 0.384  500  500
+++finished batch 4 cpu time: 0.263  500  500
+++finished batch 4 cpu time: 0.389  500  500
+++finished batch 4 cpu time: 0.296  500  500
+++finished batch 5 cpu time: 0.444  500  500
+++finished batch 5 cpu time: 0.332  500  500
+++finished batch 5 cpu time: 0.453  500  500
+++finished batch 6 cpu time: 0.509  500  500
+++finished batch 5 cpu time: 0.385  500  500
+++finished batch 6 cpu time: 0.413  500  500
+++finished batch 6 cpu time: 0.528  500  500
+++finished batch 7 cpu time: 0.586  500  500
+++finished batch 6 cpu time: 0.453  500  500
+++finished batch 7 cpu time: 0.487  500  500
+++finished batch 7 cpu time: 0.607  500  500
+++finished batch 7 cpu time: 0.521  500  500
+++finished batch 8 cpu time: 0.675  500  500
+++finished batch 8 cpu time: 0.567  500  500
+++finished batch 8 cpu time: 0.684  500  500
+++finished batch 9 cpu time: 0.734  500  500
+++finished batch 8 cpu time: 0.6  500  500
+++finished batch 9 cpu time: 0.631  500  500
```

```
+++finished batch 9 cpu time: 0.764  500  500
+++finished batch 9 cpu time: 0.666  500  500
+++finished batch 10 cpu time: 0.81  500  500
finished simulation, cpu time = 0.824 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.824
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.714  500  500
+++finished batch 10 cpu time: 0.835  500  500
finished simulation, cpu time = 0.727 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.727
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.725  500  500
finished simulation, cpu time = 0.85 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.85
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.748 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.748
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0347752 in region 2265486
    max dose is 0.034533 in region 2035086
    max dose is 0.0344639 in region 2111887
    max dose is 0.0347516 in region 2188686
```

```
    ICRU-2K efficiency: 1050.29 1/s
+++ total
    max dose is 0.0347752 in region 2265486
    ICRU-2K efficiency: 1050.29 1/s
==================================================
    ICRU-2K efficiency: 1160.63 1/s
+++ total
    max dose is 0.034533 in region 2035086
    ICRU-2K efficiency: 1010.14 1/s
+++ total
    max dose is 0.0344639 in region 2111887
    ICRU-2K efficiency: 1160.63 1/s
==================================================
    ICRU-2K efficiency: 1169.03 1/s
+++ total
    max dose is 0.0347516 in region 2188686
    ICRU-2K efficiency: 1010.14 1/s
==================================================
    ICRU-2K efficiency: 1169.03 1/s
==================================================
Completed 28 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
```

```
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24.5,24)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
====================================================================
                   Monte Carlo Parameter
====================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
```

```
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 15179  20973
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================================
                 Scoring and output options
================================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.38 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24.5,22.5)
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
```

```
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                    Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
                 MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 28793  10212
================================================
================================================================
                    Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                    Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
====================================================================
                  Scoring and output options
====================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
```

```
     dose scans:


CPU time so far: 2.475 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24.5,23)
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                  Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
```

```
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 17559  6715
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
=========================================================================
                 Scoring and output options
=========================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.471 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.045  500  500
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24.5,23.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
```

```
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 22539  7653
================================================
================================================================
                  Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                  Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
========================================================================
                Scoring and output options
========================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:
```

```
CPU time so far: 2.54 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.041  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.06  500  500
+++finished batch 2 cpu time: 0.161  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.045  500  500
+++finished batch 2 cpu time: 0.179  500  500
+++finished batch 2 cpu time: 0.181  500  500
+++finished batch 3 cpu time: 0.293  500  500
+++finished batch 2 cpu time: 0.124  500  500
+++finished batch 3 cpu time: 0.249  500  500
+++finished batch 3 cpu time: 0.266  500  500
+++finished batch 4 cpu time: 0.362  500  500
+++finished batch 3 cpu time: 0.187  500  500
+++finished batch 4 cpu time: 0.343  500  500
+++finished batch 4 cpu time: 0.347  500  500
+++finished batch 5 cpu time: 0.424  500  500
+++finished batch 4 cpu time: 0.277  500  500
+++finished batch 5 cpu time: 0.424  500  500
+++finished batch 5 cpu time: 0.418  500  500
+++finished batch 6 cpu time: 0.518  500  500
+++finished batch 5 cpu time: 0.374  500  500
+++finished batch 6 cpu time: 0.498  500  500
+++finished batch 6 cpu time: 0.503  500  500
+++finished batch 7 cpu time: 0.588  500  500
+++finished batch 6 cpu time: 0.433  500  500
+++finished batch 7 cpu time: 0.586  500  500
+++finished batch 8 cpu time: 0.671  500  500
+++finished batch 7 cpu time: 0.609  500  500
+++finished batch 7 cpu time: 0.523  500  500
+++finished batch 9 cpu time: 0.757  500  500
+++finished batch 8 cpu time: 0.688  500  500
+++finished batch 8 cpu time: 0.71  500  500
+++finished batch 8 cpu time: 0.619  500  500
+++finished batch 10 cpu time: 0.838  500  500
+++finished batch 9 cpu time: 0.767  500  500
finished simulation, cpu time = 0.851 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
+++finished batch 9 cpu time: 0.683  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
```

```
 cpu time: 0.851
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.794  500  500
+++finished batch 10 cpu time: 0.833  500  500
finished simulation, cpu time = 0.848 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
+++finished batch 10 cpu time: 0.864  500  500
+++finished batch 10 cpu time: 0.77  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.848
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.88 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.88
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.8 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.8
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0343716 in region 2035566
    max dose is 0.0341074 in region 1805166
    max dose is 0.0341867 in region 1881967
    max dose is 0.0346977 in region 1958767
    ICRU-2K efficiency: 975.077 1/s
+++ total
    max dose is 0.0343716 in region 2035566
    ICRU-2K efficiency: 975.077 1/s
=================================================
    ICRU-2K efficiency: 988.245 1/s
+++ total
    max dose is 0.0341074 in region 1805166
    ICRU-2K efficiency: 988.245 1/s
```

```
==================================================
    ICRU-2K efficiency: 991.515 1/s
+++ total
    max dose is 0.0341867 in region 1881967
    ICRU-2K efficiency: 1135.3 1/s
+++ total
    max dose is 0.0346977 in region 1958767
    ICRU-2K efficiency: 991.515 1/s
==================================================
    ICRU-2K efficiency: 1135.3 1/s
==================================================
Completed 32 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
```

```
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24.5,24.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 26728  28779
================================================
```

```
================================================================
                    Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                    Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                  Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.411 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24.5,25.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                    Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
```

```
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 4479  7726
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
========================================================================
                Scoring and output options
========================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.47 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source
```

```
Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.065  500  500
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25,22.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 25222  7629
================================================
================================================================
                  Variance Reduction
```

```
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                  Quasi Random Numbers
================================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.571 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,24.5,25)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
```

```
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 16417  4159
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                 Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.674 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
```

```
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
+++finished batch 2 cpu time: 0.135  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.039  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.045  500  500
+++finished batch 2 cpu time: 0.287  500  500
+++finished batch 3 cpu time: 0.35  500  500
+++finished batch 2 cpu time: 0.181  500  500
+++finished batch 2 cpu time: 0.11  500  500
+++finished batch 4 cpu time: 0.413  500  500
+++finished batch 3 cpu time: 0.246  500  500
+++finished batch 3 cpu time: 0.374  500  500
+++finished batch 3 cpu time: 0.175  500  500
+++finished batch 5 cpu time: 0.474  500  500
+++finished batch 4 cpu time: 0.311  500  500
+++finished batch 4 cpu time: 0.443  500  500
+++finished batch 4 cpu time: 0.237  500  500
+++finished batch 6 cpu time: 0.534  500  500
+++finished batch 5 cpu time: 0.37  500  500
+++finished batch 5 cpu time: 0.507  500  500
+++finished batch 7 cpu time: 0.591  500  500
+++finished batch 6 cpu time: 0.429  500  500
+++finished batch 5 cpu time: 0.318  500  500
+++finished batch 6 cpu time: 0.573  500  500
+++finished batch 8 cpu time: 0.657  500  500
+++finished batch 7 cpu time: 0.492  500  500
+++finished batch 7 cpu time: 0.63  500  500
+++finished batch 6 cpu time: 0.411  500  500
+++finished batch 9 cpu time: 0.721  500  500
+++finished batch 8 cpu time: 0.574  500  500
+++finished batch 8 cpu time: 0.707  500  500
+++finished batch 7 cpu time: 0.486  500  500
+++finished batch 10 cpu time: 0.801  500  500
+++finished batch 9 cpu time: 0.64  500  500
finished simulation, cpu time = 0.815 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.815
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.777  500  500
+++finished batch 8 cpu time: 0.557  500  500
+++finished batch 10 cpu time: 0.699  500  500
finished simulation, cpu time = 0.713 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
```

```
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.713
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.832  500  500
+++finished batch 9 cpu time: 0.618  500  500
finished simulation, cpu time = 0.85 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.85
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.683  500  500
    max dose is 0.0344799 in region 2112366
finished simulation, cpu time = 0.697 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.697
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0337888 in region 1805646
    max dose is 0.0342375 in region 2265967
    max dose is 0.0347981 in region 2189167
    ICRU-2K efficiency: 1043.99 1/s
+++ total
    max dose is 0.0344799 in region 2112366
    ICRU-2K efficiency: 1043.99 1/s
================================================
    ICRU-2K efficiency: 1111.75 1/s
+++ total
    max dose is 0.0337888 in region 1805646
    ICRU-2K efficiency: 994.682 1/s
+++ total
    max dose is 0.0342375 in region 2265967
    ICRU-2K efficiency: 994.682 1/s
================================================
    ICRU-2K efficiency: 1111.75 1/s
================================================
    ICRU-2K efficiency: 1243.91 1/s
+++ total
    max dose is 0.0347981 in region 2189167
```

```
    ICRU-2K efficiency: 1243.91 1/s
==================================================
Completed 36 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
==========================================================
                   Beamlet Source
```

```
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25,23)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 24429  7306
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
```

```
                  Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.186 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.055  500  500
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25,24)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
```

```
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 5898  7533
================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
========================================================================
                 Scoring and output options
========================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.234 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
```

```
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25,23.5)
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                   Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 27878  10500
================================================
============================================================
                   Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                   Quasi Random Numbers
============================================================
```

```
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.351 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25,24.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.043  500  500
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
```

```
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 18482  14199
================================================
================================================================
                  Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                  Quasi Random Numbers
================================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.456 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
+++finished batch 2 cpu time: 0.147  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
+++finished batch 2 cpu time: 0.181  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
+++finished batch 3 cpu time: 0.354  500  500
```

```
+++finished batch 2 cpu time: 0.188  500  500
+++finished batch 3 cpu time: 0.326  500  500
+++finished batch 2 cpu time: 0.119  500  500
+++finished batch 4 cpu time: 0.44  500  500
+++finished batch 3 cpu time: 0.283  500  500
+++finished batch 4 cpu time: 0.413  500  500
+++finished batch 3 cpu time: 0.196  500  500
+++finished batch 4 cpu time: 0.354  500  500
+++finished batch 5 cpu time: 0.541  500  500
+++finished batch 5 cpu time: 0.493  500  500
+++finished batch 4 cpu time: 0.276  500  500
+++finished batch 5 cpu time: 0.422  500  500
+++finished batch 6 cpu time: 0.561  500  500
+++finished batch 6 cpu time: 0.627  500  500
+++finished batch 5 cpu time: 0.358  500  500
+++finished batch 6 cpu time: 0.517  500  500
+++finished batch 7 cpu time: 0.696  500  500
+++finished batch 7 cpu time: 0.656  500  500
+++finished batch 6 cpu time: 0.449  500  500
+++finished batch 7 cpu time: 0.582  500  500
+++finished batch 8 cpu time: 0.78  500  500
+++finished batch 7 cpu time: 0.515  500  500
+++finished batch 8 cpu time: 0.74  500  500
+++finished batch 8 cpu time: 0.659  500  500
+++finished batch 9 cpu time: 0.856  500  500
+++finished batch 8 cpu time: 0.589  500  500
+++finished batch 9 cpu time: 0.823  500  500
+++finished batch 9 cpu time: 0.733  500  500
+++finished batch 10 cpu time: 0.925  500  500
+++finished batch 10 cpu time: 0.891  500  500
finished simulation, cpu time = 0.954 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.954
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.674  500  500
finished simulation, cpu time = 0.92 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
+++finished batch 10 cpu time: 0.815  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.92
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
```

```
finished simulation, cpu time = 0.835 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.835
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.734  500  500
finished simulation, cpu time = 0.758 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.758
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0340882 in region 1882447
    max dose is 0.0342205 in region 2036047
    max dose is 0.0343793 in region 1959246
    max dose is 0.0343678 in region 2112847
    ICRU-2K efficiency: 915.378 1/s
+++ total
    max dose is 0.0342205 in region 2036047
    ICRU-2K efficiency: 877.636 1/s
+++ total
    max dose is 0.0340882 in region 1882447
    ICRU-2K efficiency: 915.378 1/s
================================================
    ICRU-2K efficiency: 877.636 1/s
================================================
    ICRU-2K efficiency: 1092.44 1/s
+++ total
    max dose is 0.0343793 in region 1959246
    ICRU-2K efficiency: 1110.6 1/s
+++ total
    max dose is 0.0343678 in region 2112847
    ICRU-2K efficiency: 1092.44 1/s
================================================
    ICRU-2K efficiency: 1110.6 1/s
================================================
Completed 40 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc
```

```
Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25.5,23)
============================================================
============================================================
              XYZ Geometry
```

```
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                  Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 22717  22612
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================
                Scoring and output options
============================================================
  number of dose scoring objects: 1
```

```
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.459 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25,25)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
====================================================================
                   Monte Carlo Parameter
====================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

====================================================================
================================================
               MC_Control
```

```
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 10550  24925
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================================
                 Scoring and output options
================================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
 OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25.5,22.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
     dose scans:


CPU time so far: 2.566 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
```

```
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.048  500  500
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 27516  8576
================================================
================================================================
                  Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                  Quasi Random Numbers
================================================================
 number of generators: 1
                1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
========================================================================
                Scoring and output options
========================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
```

```
     dose scans:


CPU time so far: 2.671 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25,25.5)
============================================================
============================================================
              XYZ Geometry
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                  Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
```

```
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 17558  16492
================================================
================================================================
                   Variance Reduction
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.654 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.042  500  500
+++finished batch 2 cpu time: 0.157  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.04  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.048  500  500
+++finished batch 2 cpu time: 0.165  500  500
+++finished batch 3 cpu time: 0.277  500  500
+++finished batch 2 cpu time: 0.105  500  500
+++finished batch 2 cpu time: 0.126  500  500
+++finished batch 3 cpu time: 0.238  500  500
+++finished batch 4 cpu time: 0.358  500  500
+++finished batch 3 cpu time: 0.173  500  500
+++finished batch 4 cpu time: 0.304  500  500
+++finished batch 3 cpu time: 0.2  500  500
+++finished batch 5 cpu time: 0.429  500  500
+++finished batch 4 cpu time: 0.242  500  500
```

```
+++finished batch 5 cpu time: 0.364  500  500
+++finished batch 4 cpu time: 0.27  500  500
+++finished batch 6 cpu time: 0.487  500  500
+++finished batch 5 cpu time: 0.301  500  500
+++finished batch 6 cpu time: 0.423  500  500
+++finished batch 5 cpu time: 0.337  500  500
+++finished batch 7 cpu time: 0.547  500  500
+++finished batch 6 cpu time: 0.361  500  500
+++finished batch 7 cpu time: 0.511  500  500
+++finished batch 8 cpu time: 0.624  500  500
+++finished batch 6 cpu time: 0.419  500  500
+++finished batch 7 cpu time: 0.435  500  500
+++finished batch 8 cpu time: 0.59  500  500
+++finished batch 9 cpu time: 0.696  500  500
+++finished batch 7 cpu time: 0.493  500  500
+++finished batch 8 cpu time: 0.506  500  500
+++finished batch 9 cpu time: 0.652  500  500
+++finished batch 10 cpu time: 0.758  500  500
finished simulation, cpu time = 0.775 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
+++finished batch 8 cpu time: 0.565  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.775
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.575  500  500
+++finished batch 10 cpu time: 0.728  500  500
+++finished batch 10 cpu time: 0.635  500  500
+++finished batch 9 cpu time: 0.635  500  500
finished simulation, cpu time = 0.746 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.746
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.653 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.653
 number of histories: 5000
```

```
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.731  500  500
    max dose is 0.0342376 in region 1882926
finished simulation, cpu time = 0.744 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.744
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0340721 in region 2189646
    max dose is 0.033951 in region 1806126
    max dose is 0.0350693 in region 2266446
    ICRU-2K efficiency: 1080.68 1/s
+++ total
    max dose is 0.0342376 in region 1882926
    ICRU-2K efficiency: 1080.68 1/s
==================================================
    ICRU-2K efficiency: 1074.01 1/s
+++ total
    max dose is 0.0340721 in region 2189646
    ICRU-2K efficiency: 1290.31 1/s
+++ total
    max dose is 0.033951 in region 1806126
    ICRU-2K efficiency: 1074.01 1/s
==================================================
    ICRU-2K efficiency: 1290.31 1/s
==================================================
    ICRU-2K efficiency: 1178.38 1/s
+++ total
    max dose is 0.0350693 in region 2266446
    ICRU-2K efficiency: 1178.38 1/s
==================================================
Completed 44 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc
```

```
Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
Initializing cross sections ...  OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25.5,25)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                   Monte Carlo Parameter
================================================================
```

```
 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 28021  3898
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================================
                Scoring and output options
============================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.206 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
```

```
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25.5,24.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

================================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 15924  23376
================================================
================================================================
                  Variance Reduction
```

```
================================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                  Quasi Random Numbers
================================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.242 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
 OK
============================================================
                  Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25.5,24)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
================================================================
                  Monte Carlo Parameter
================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
```

```
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 2276  1619
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================
                Scoring and output options
============================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.359 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
```

```
 OK
============================================================
                    Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25.5,23.5)
============================================================
================================================================
              XYZ Geometry
================================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
====================================================================
                    Monte Carlo Parameter
====================================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

====================================================================
================================================
                MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.057  500  500
  initial rng seeds   : 11414  17035
================================================
================================================================
                    Variance Reduction
================================================================
```

```
 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
================================================================
================================================================
                   Quasi Random Numbers
================================================================
 number of generators: 1
                  1st:  base = 2 dimensions = 60 warm-up = 1
================================================================
================================================================
                 Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 2.364 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.041  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.041  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.058  500  500
+++finished batch 2 cpu time: 0.235  500  500
+++finished batch 2 cpu time: 0.224  500  500
+++finished batch 2 cpu time: 0.123  500  500
+++finished batch 2 cpu time: 0.155  500  500
+++finished batch 3 cpu time: 0.322  500  500
+++finished batch 3 cpu time: 0.195  500  500
+++finished batch 3 cpu time: 0.324  500  500
+++finished batch 3 cpu time: 0.223  500  500
+++finished batch 4 cpu time: 0.411  500  500
+++finished batch 4 cpu time: 0.281  500  500
+++finished batch 4 cpu time: 0.395  500  500
+++finished batch 4 cpu time: 0.308  500  500
+++finished batch 5 cpu time: 0.491  500  500
+++finished batch 5 cpu time: 0.355  500  500
+++finished batch 5 cpu time: 0.469  500  500
+++finished batch 5 cpu time: 0.397  500  500
+++finished batch 6 cpu time: 0.563  500  500
+++finished batch 6 cpu time: 0.422  500  500
+++finished batch 6 cpu time: 0.554  500  500
+++finished batch 6 cpu time: 0.471  500  500
+++finished batch 7 cpu time: 0.626  500  500
```

```
+++finished batch 7 cpu time: 0.623  500  500
+++finished batch 7 cpu time: 0.514  500  500
+++finished batch 7 cpu time: 0.55  500  500
+++finished batch 8 cpu time: 0.71  500  500
+++finished batch 8 cpu time: 0.588  500  500
+++finished batch 8 cpu time: 0.712  500  500
+++finished batch 8 cpu time: 0.625  500  500
+++finished batch 9 cpu time: 0.79  500  500
+++finished batch 9 cpu time: 0.783  500  500
+++finished batch 9 cpu time: 0.678  500  500
+++finished batch 9 cpu time: 0.716  500  500
+++finished batch 10 cpu time: 0.868  500  500
finished simulation, cpu time = 0.895 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
+++finished batch 10 cpu time: 0.863  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.895
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.756  500  500
finished simulation, cpu time = 0.783 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.783
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
finished simulation, cpu time = 0.897 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.897
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.797  500  500
finished simulation, cpu time = 0.829 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
```

```
 geometry: CT
 cpu time: 0.829
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0343218 in region 2190126
    max dose is 0.0341925 in region 2036526
    max dose is 0.0342907 in region 2113326
    max dose is 0.0339002 in region 1959726
    ICRU-2K efficiency: 931.074 1/s
+++ total
    max dose is 0.0343218 in region 2190126
    ICRU-2K efficiency: 931.074 1/s
==================================================
    ICRU-2K efficiency: 1078.04 1/s
+++ total
    max dose is 0.0341925 in region 2036526
    ICRU-2K efficiency: 1078.04 1/s
==================================================
    ICRU-2K efficiency: 1054.03 1/s
+++ total
    max dose is 0.0339002 in region 1959726
    ICRU-2K efficiency: 994.057 1/s
+++ total
    max dose is 0.0342907 in region 2113326
    ICRU-2K efficiency: 1054.03 1/s
==================================================
    ICRU-2K efficiency: 994.057 1/s
==================================================
Completed 48 of 49 beamlets...



Input file is: C:\Home\Bangertm\Git\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 OK
Initializing cross sections ...  OK
============================================================
                   Beamlet Source
============================================================
       charge = 0
 virtual source position = (-76,24,24)
       Energy = 6 MeV
 number of beamlets = 1
 beamlet 1: size = 0.5x0.5 cm**2 midpoint = (-26,25.5,25.5)
============================================================
============================================================
              XYZ Geometry
```

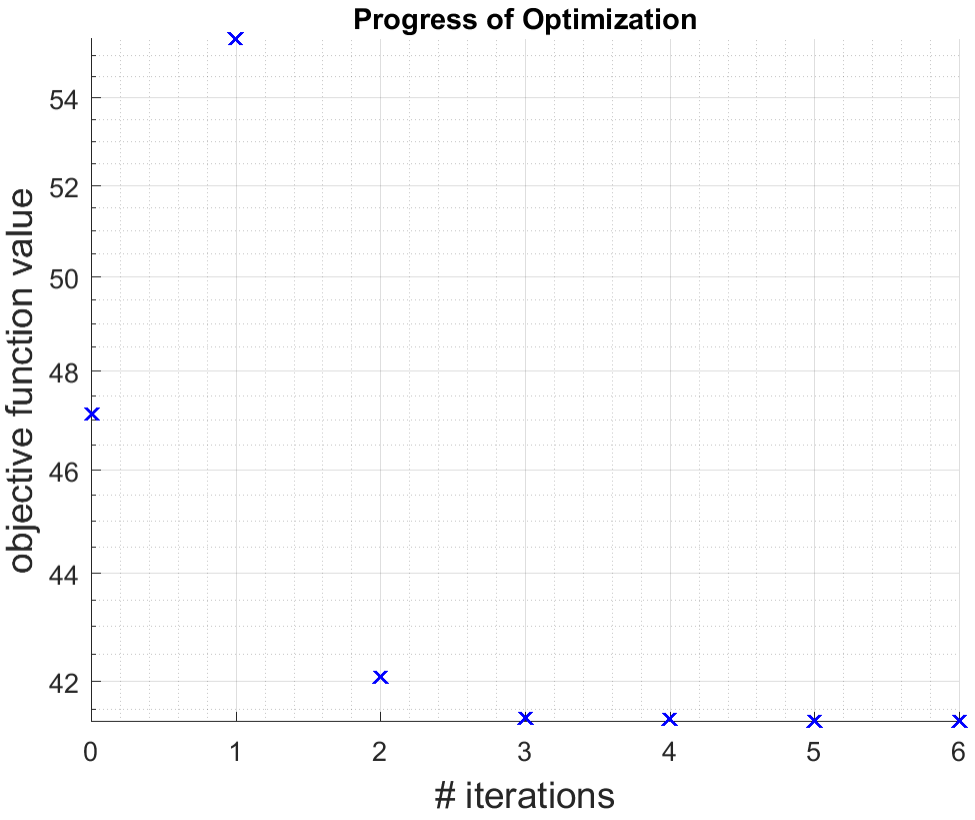
```
============================================================
   name: CT  id: 0
   global smax: 1e+030
  Number of x-planes: 160  uniform with Xo = 0.15 Dx = 0.3
  Number of y-planes: 160  uniform with Yo = 0.15 Dx = 0.3
  Number of z-planes: 160  uniform with Zo = 0.15 Dx = 0.3
============================================================
                  Monte Carlo Parameter
============================================================

 Delta particle production threshold:   0.447479 MeV
 Bremsstrahlung production threshold:   0.05 MeV
 Min. electron transport energy     :   0.447479 MeV
 Min. photon transport energy       :   0.05 MeV
 Local track-end energy deposition  :   0
 Cut-off energy for KERMA approx.   :   1.10239 MeV
 Bremsstrahlung transport mode      :   1
 CSDA approximation                 :   0
 Fractional energy loss/step at Ep  :   10%
 Max. 1st elastic moment per step   :   0.5
 Max. acceptable energy loss/step   :   0.6 MeV
 alpha and beta                     :   0.0298764  0.420741
 Fano calculation                   :   0
 Exact Compton                      :   0
 Electron transport mode            :   VMC++

============================================================
================================================
               MC_Control
================================================
  will use fixed number of histories
  number of batches   : 10
  histories per batch : 500
  total histories     : 5000
  initial rng seeds   : 17065  14082
================================================
============================================================
                  Variance Reduction
============================================================

 f_repeat            = 0.251
 split photons       = 1
 photon split factor = -40
============================================================
============================================================
                  Quasi Random Numbers
============================================================
 number of generators: 1
                 1st:  base = 2 dimensions = 60 warm-up = 1
============================================================
============================================================
                Scoring and output options
============================================================
  number of dose scoring objects: 1
```

```
  dose output options for geometry CT
     dump dose: 2
     dose scans:


CPU time so far: 1.745 seconds

Will run approximately 5000 particle sets
   with 1 particles per set on average
will use 2 quasi numbers to sample the source


Starting MC simulation
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.036  500  500
+++finished batch 2 cpu time: 0.086  500  500
+++finished batch 3 cpu time: 0.139  500  500
+++finished batch 4 cpu time: 0.191  500  500
+++finished batch 5 cpu time: 0.245  500  500
+++finished batch 6 cpu time: 0.303  500  500
+++finished batch 7 cpu time: 0.364  500  500
+++finished batch 8 cpu time: 0.408  500  500
+++finished batch 9 cpu time: 0.457  500  500
+++finished batch 10 cpu time: 0.507  500  500
finished simulation, cpu time = 0.522 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.522
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.034158 in region 2266926
    ICRU-2K efficiency: 1586.02 1/s
+++ total
    max dose is 0.034158 in region 2266926
    ICRU-2K efficiency: 1586.02 1/s
================================================
Completed 49 of 49 beamlets...
```

Inverse Optimization for IMRT

```
resultGUI = matRad_fluenceOptimization(dij,cst,pln);

This is Ipopt version 3.11.8, running with linear solver ma57.

Number of nonzeros in equality constraint Jacobian...:        0
Number of nonzeros in inequality constraint Jacobian.:        0
Number of nonzeros in Lagrangian Hessian.............:        0
```

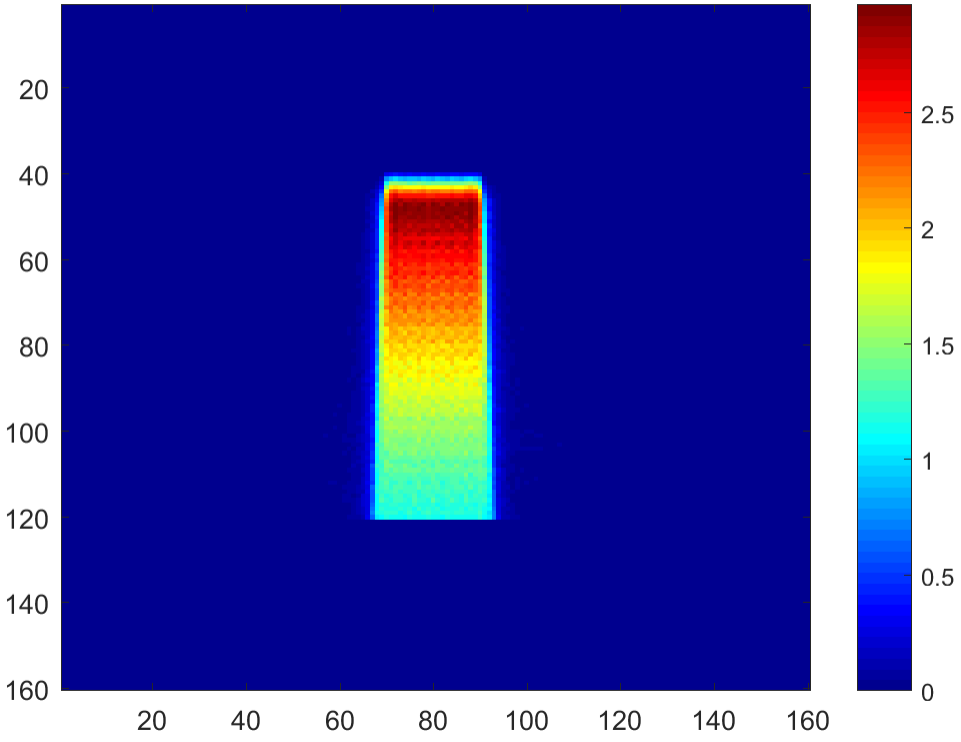
```
Total number of variables.............................:       49
                     variables with only lower bounds:       49
                variables with lower and upper bounds:        0
                     variables with only upper bounds:        0
Total number of equality constraints.................:        0
Total number of inequality constraints...............:        0
        inequality constraints with only lower bounds:        0
   inequality constraints with lower and upper bounds:        0
        inequality constraints with only upper bounds:        0

iter    objective    inf_pr   inf_du lg(mu)  ||d||  lg(rg) alpha_du
 alpha_pr  ls
   0 4.7141751e+001 0.00e+000 1.40e+001   0.0 0.00e+000    -  0.00e
+000 0.00e+000   0
   1 5.5399399e+001 0.00e+000 1.99e+001   0.7 6.17e+000    -
 4.91e-001 1.76e-002f  5
   2 4.2089461e+001 0.00e+000 1.05e+001   0.2 5.45e-002    -  1.00e
+000 1.00e+000f  1
   3 4.1347678e+001 0.00e+000 1.35e+000  -1.1 1.99e-002    -
 9.99e-001 1.00e+000f  1
   4 4.1316763e+001 0.00e+000 9.35e-001  -2.8 4.59e-003    -
 9.99e-001 1.00e+000f  1
   5 4.1284000e+001 0.00e+000 2.40e-001  -4.5 1.22e-002    -  1.00e
+000 1.00e+000f  1
   6 4.1281126e+001 0.00e+000 3.16e-001  -6.1 3.71e-003    -  1.00e
+000 1.00e+000f  1

Number of Iterations....: 6

                                   (scaled)                 (unscaled)
Objective...............:  4.1281126121699344e+001
 4.1281126121699344e+001
Dual infeasibility......:  3.1588500984810963e-001
 3.1588500984810963e-001
Constraint violation....:  0.0000000000000000e+000
 0.0000000000000000e+000
Complementarity.........:  8.5126569666667240e-007
 8.5126569666667240e-007
Overall NLP error.......:  3.1588500984810963e-001
 3.1588500984810963e-001


Number of objective function evaluations             = 15
Number of objective gradient evaluations             = 7
Number of equality constraint evaluations            = 0
Number of inequality constraint evaluations          = 0
Number of equality constraint Jacobian evaluations   = 0
Number of inequality constraint Jacobian evaluations = 0
Number of Lagrangian Hessian evaluations             = 0
Total CPU secs in IPOPT (w/o function evaluations)   =      0.463
Total CPU secs in NLP function evaluations           =      0.810

EXIT: Solved To Acceptable Level.
Calculating final cubes...
```



Plot the Resulting Dose Slice

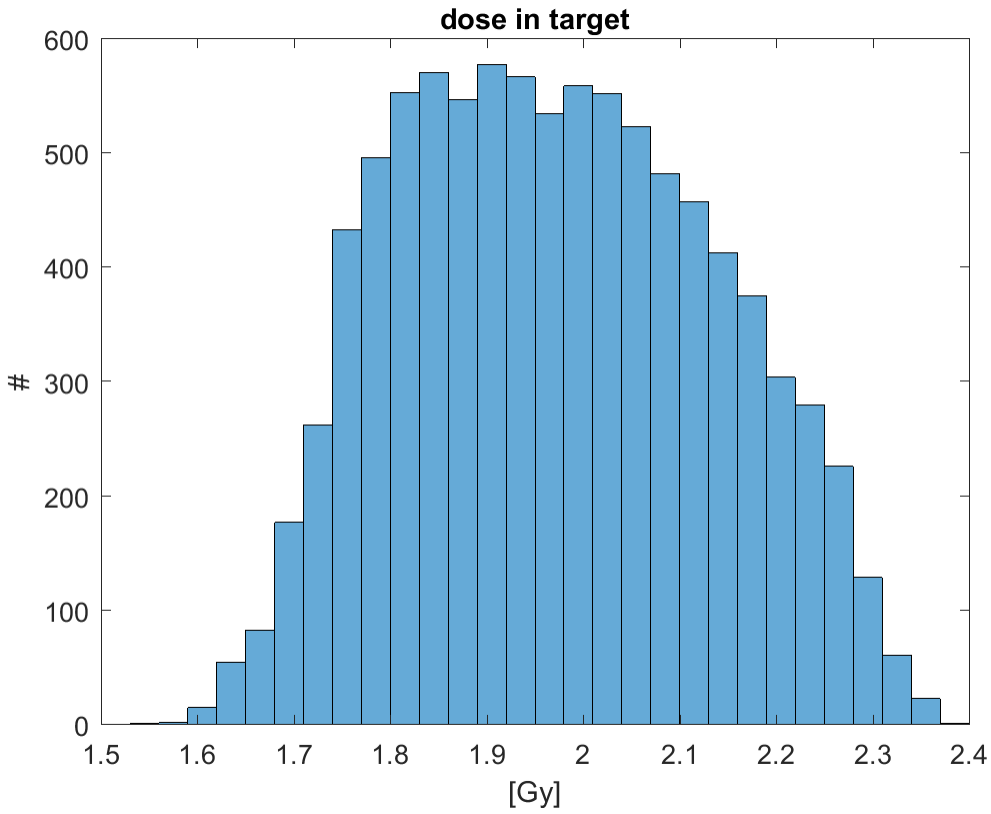
Just let's plot the transversal iso-center dose slice

```
slice = round(pln.isoCenter(1,3)./ct.resolution.z);
figure,
imagesc(resultGUI.physicalDose(:,:,slice)),colorbar, colormap(jet)
```



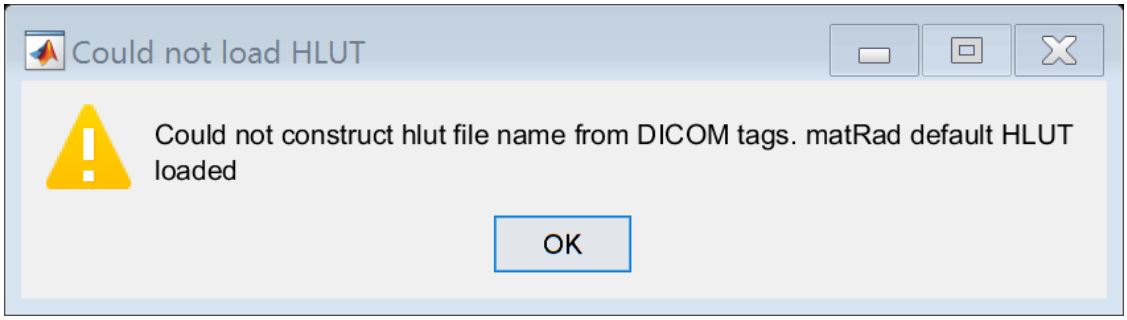
Exemplary, we show how to obtain the dose in the target and plot the histogram

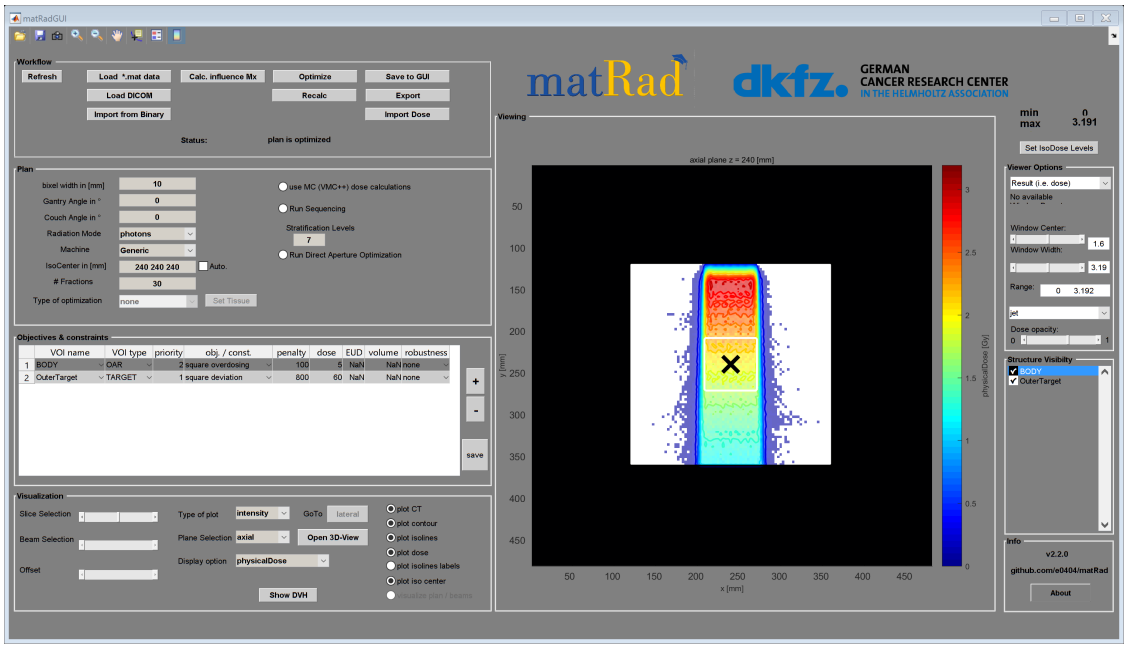
```
ixTarget     = cst{2,4}{1};
doseInTarget = resultGUI.physicalDose(ixTarget);
figure
histogram(doseInTarget);
title('dose in target'),xlabel('[Gy]'),ylabel('#');
```



Start the GUI for Visualization

```
matRadGUI

Warning: matRad default HLUT loaded
Reconversion of HU values could not be done because HLUT is not
 bijective.
Warning: 'popupmenu' control requires that 'Value' be an integer
 within
String range
Control will not be rendered until all of its parameter values are
 valid
```





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