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.numOfFractions = 30;
pln.propOpt.bioOptimization = 'none';
pln.propStf.gantryAngles    = [0];
pln.propStf.couchAngles     = [0];
```

```
pln.propStf.bixelWidth      = 10;
pln.propStf.numOfBeams      = numel(pln.propStf.gantryAngles);
pln.propStf.isoCenter       = ones(pln.propStf.numOfBeams,1) *
 matRad_getIsoCenter(cst,ct,0);
pln.propOpt.runSequencing   = 0;
pln.propOpt.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: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\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 = (-26,22.5,22.5)
============================================================
================================================================
              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: 3.385 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: 3.416 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: 0.016  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.11  500  500
+++finished batch 2 cpu time: 0.062  500  500
+++finished batch 2 cpu time: 0.203  500  500
+++finished batch 3 cpu time: 0.156  500  500
+++finished batch 3 cpu time: 0.281  500  500
+++finished batch 4 cpu time: 0.234  500  500
+++finished batch 4 cpu time: 0.359  500  500
+++finished batch 5 cpu time: 0.328  500  500
+++finished batch 6 cpu time: 0.359  500  500
+++finished batch 5 cpu time: 0.453  500  500
+++finished batch 7 cpu time: 0.452  500  500
+++finished batch 6 cpu time: 0.578  500  500
+++finished batch 8 cpu time: 0.53  500  500
+++finished batch 7 cpu time: 0.64  500  500
+++finished batch 9 cpu time: 0.624  500  500
+++finished batch 8 cpu time: 0.718  500  500
+++finished batch 10 cpu time: 0.702  500  500
finished simulation, cpu time = 0.718 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: 0.812  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.718
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.89  500  500
finished simulation, cpu time = 0.89 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: 0.89
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0345088 in region 1880046
    max dose is 0.0343228 in region 1803246
 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: 4.243 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: 0.015  500  500
+++finished batch 2 cpu time: 0.062  500  500
+++finished batch 3 cpu time: 0.093  500  500
+++finished batch 4 cpu time: 0.125  500  500
+++finished batch 5 cpu time: 0.156  500  500
+++finished batch 6 cpu time: 0.203  500  500
+++finished batch 7 cpu time: 0.234  500  500
+++finished batch 8 cpu time: 0.265  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 = (-26,22.5,23.5)
```

```
============================================================
============================================================
              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: 5.101 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 9 cpu time: 0.296  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.031  500  500
+++finished batch 10 cpu time: 0.343  500  500
finished simulation, cpu time = 0.343 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 2 cpu time: 0.078  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.343
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 3 cpu time: 0.109  500  500
+++finished batch 4 cpu time: 0.156  500  500
    max dose is 0.0343312 in region 2033647
+++finished batch 5 cpu time: 0.203  500  500
+++finished batch 6 cpu time: 0.234  500  500
+++finished batch 7 cpu time: 0.281  500  500
+++finished batch 8 cpu time: 0.327  500  500
+++finished batch 9 cpu time: 0.359  500  500
+++finished batch 10 cpu time: 0.405  500  500
finished simulation, cpu time = 0.421 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: 0.421
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0342552 in region 1956847
    ICRU-2K efficiency: 1178.48 1/s
```

```
+++ total
    max dose is 0.0345088 in region 1880046
    ICRU-2K efficiency: 1178.48 1/s
================================================
    ICRU-2K efficiency: 2354.74 1/s
+++ total
    max dose is 0.0343312 in region 2033647
    ICRU-2K efficiency: 2354.74 1/s
================================================
    ICRU-2K efficiency: 918.692 1/s
+++ total
    max dose is 0.0343228 in region 1803246
    ICRU-2K efficiency: 918.692 1/s
================================================
    ICRU-2K efficiency: 1981.51 1/s
+++ total
    max dose is 0.0342552 in region 1956847
    ICRU-2K efficiency: 1981.51 1/s
================================================
Completed 4 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_4.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 ... 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
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
 OK
Initializing cross sections ...
 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 = (-26,22.5,25)
============================================================
================================================================
              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: 1.872 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: 0.031  500  500
+++finished batch 2 cpu time: 0.078  500  500
+++finished batch 3 cpu time: 0.109  500  500
+++finished batch 4 cpu time: 0.156  500  500
+++finished batch 5 cpu time: 0.249  500  500
+++finished batch 6 cpu time: 0.312  500  500
+++finished batch 7 cpu time: 0.358  500  500
+++finished batch 8 cpu time: 0.39  500  500
+++finished batch 9 cpu time: 0.436  500  500
+++finished batch 10 cpu time: 0.468  500  500
finished simulation, cpu time = 0.468 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: 0.468
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0341063 in region 2187246
 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 = (-26,22.5,25.5)
============================================================
================================================================
              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: 2.558 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: 0.062  500  500
+++finished batch 2 cpu time: 0.094  500  500
+++finished batch 3 cpu time: 0.187  500  500
+++finished batch 4 cpu time: 0.265  500  500
+++finished batch 5 cpu time: 0.328  500  500
+++finished batch 6 cpu time: 0.421  500  500
+++finished batch 7 cpu time: 0.452  500  500
+++finished batch 8 cpu time: 0.53  500  500
+++finished batch 9 cpu time: 0.608  500  500
+++finished batch 10 cpu time: 0.64  500  500
finished simulation, cpu time = 0.702 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: 0.702
 number of histories: 5000
```

```
 number of batches: 10
+++ beamlet 0
    max dose is 0.0345979 in region 2264047
 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: 3.744 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: 0.031  500  500
+++finished batch 2 cpu time: 0.062  500  500
+++finished batch 3 cpu time: 0.093  500  500
+++finished batch 4 cpu time: 0.14  500  500
+++finished batch 5 cpu time: 0.171  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: 3.525 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 6 cpu time: 0.202  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.031  500  500
+++finished batch 7 cpu time: 0.234  500  500
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 8 cpu time: 0.265  500  500
+++finished batch 3 cpu time: 0.094  500  500
+++finished batch 9 cpu time: 0.296  500  500
+++finished batch 4 cpu time: 0.141  500  500
+++finished batch 10 cpu time: 0.343  500  500
finished simulation, cpu time = 0.343 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: 0.343
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 5 cpu time: 0.172  500  500
+++finished batch 6 cpu time: 0.203  500  500
+++finished batch 7 cpu time: 0.25  500  500
    max dose is 0.0346184 in region 2110447
+++finished batch 8 cpu time: 0.281  500  500
+++finished batch 9 cpu time: 0.312  500  500
+++finished batch 10 cpu time: 0.359  500  500
finished simulation, cpu time = 0.359 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: 0.359
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0338019 in region 1803726
    ICRU-2K efficiency: 1198.23 1/s
+++ total
    max dose is 0.0345979 in region 2264047
    ICRU-2K efficiency: 1198.23 1/s
================================================
    ICRU-2K efficiency: 2469.1 1/s
+++ total
    max dose is 0.0346184 in region 2110447
    ICRU-2K efficiency: 2469.1 1/s
```

```
==================================================
    ICRU-2K efficiency: 1748.44 1/s
+++ total
    max dose is 0.0341063 in region 2187246
    ICRU-2K efficiency: 1748.44 1/s
==================================================
    ICRU-2K efficiency: 2236.03 1/s
+++ total
    max dose is 0.0338019 in region 1803726
    ICRU-2K efficiency: 2236.03 1/s
==================================================
Completed 8 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_4.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\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
============================================================
                  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: 2.059 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: 0.031  500  500
 OK
Initializing cross sections ... +++finished batch 2 cpu time: 0.093
 500  500
+++finished batch 3 cpu time: 0.171  500  500
+++finished batch 4 cpu time: 0.203  500  500
+++finished batch 5 cpu time: 0.281  500  500
+++finished batch 6 cpu time: 0.374  500  500
+++finished batch 7 cpu time: 0.452  500  500
+++finished batch 8 cpu time: 0.483  500  500
+++finished batch 9 cpu time: 0.561  500  500
+++finished batch 10 cpu time: 0.639  500  500
finished simulation, cpu time = 0.655 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: 0.655
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
```

```
   max dose is 0.0340826 in region 1957327
 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: 2.917 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: 0.062  500  500
+++finished batch 2 cpu time: 0.156  500  500
+++finished batch 3 cpu time: 0.187  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 = (-26,23,23)
============================================================
================================================================
              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: 3.291 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: 0.016  500  500
+++finished batch 4 cpu time: 0.265  500  500
+++finished batch 2 cpu time: 0.094  500  500
+++finished batch 5 cpu time: 0.343  500  500
+++finished batch 6 cpu time: 0.374  500  500
+++finished batch 3 cpu time: 0.187  500  500
+++finished batch 7 cpu time: 0.452  500  500
+++finished batch 4 cpu time: 0.265  500  500
+++finished batch 5 cpu time: 0.297  500  500
+++finished batch 8 cpu time: 0.53  500  500
+++finished batch 6 cpu time: 0.359  500  500
+++finished batch 9 cpu time: 0.608  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 = (-26,23,24.5)
============================================================
================================================================
              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: 3.603 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: 0.016  500  500
+++finished batch 7 cpu time: 0.437  500  500
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 10 cpu time: 0.702  500  500
finished simulation, cpu time = 0.702 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: 0.484  500  500
+++finished batch 3 cpu time: 0.094  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.702
```

```
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 4 cpu time: 0.141  500  500
+++finished batch 9 cpu time: 0.562  500  500
+++finished batch 5 cpu time: 0.172  500  500
+++finished batch 10 cpu time: 0.593  500  500
+++finished batch 6 cpu time: 0.203  500  500
+++finished batch 7 cpu time: 0.25  500  500
finished simulation, cpu time = 0.655 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
    max dose is 0.0344097 in region 2034127
+++finished batch 8 cpu time: 0.281  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.655
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.312  500  500
+++finished batch 10 cpu time: 0.359  500  500
finished simulation, cpu time = 0.359 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: 0.359
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0342145 in region 1880527
    max dose is 0.0342117 in region 2110926
    ICRU-2K efficiency: 1235.21 1/s
+++ total
    max dose is 0.0342145 in region 1880527
    ICRU-2K efficiency: 1308.85 1/s
+++ total
    max dose is 0.0340826 in region 1957327
    ICRU-2K efficiency: 1235.21 1/s
================================================
    ICRU-2K efficiency: 1308.85 1/s
================================================
    ICRU-2K efficiency: 1166.83 1/s
+++ total
    max dose is 0.0344097 in region 2034127
    ICRU-2K efficiency: 1166.83 1/s
================================================
    ICRU-2K efficiency: 2347.74 1/s
+++ total
```

```
    max dose is 0.0342117 in region 2110926
    ICRU-2K efficiency: 2347.74 1/s
==================================================
Completed 12 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\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
DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
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
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
 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 = (-26,23,25.5)
============================================================
================================================================
              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: 2.433 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: 0.078  500  500
+++finished batch 2 cpu time: 0.156  500  500
+++finished batch 3 cpu time: 0.187  500  500
+++finished batch 4 cpu time: 0.281  500  500
+++finished batch 5 cpu time: 0.359  500  500
+++finished batch 6 cpu time: 0.437  500  500
+++finished batch 7 cpu time: 0.468  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)
============================================================
================================================================
             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: 2.979 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 8 cpu time: 0.546  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.016  500  500
+++finished batch 9 cpu time: 0.64  500  500
+++finished batch 2 cpu time: 0.109  500  500
+++finished batch 10 cpu time: 0.702  500  500
finished simulation, cpu time = 0.718 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 3 cpu time: 0.187  500  500
============ DE_ScoreDose::analyze ====================
 geometry: CT
 cpu time: 0.718
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 4 cpu time: 0.265  500  500
+++finished batch 5 cpu time: 0.297  500  500
+++finished batch 6 cpu time: 0.375  500  500
    max dose is 0.0343579 in region 2264526
+++finished batch 7 cpu time: 0.453  500  500
+++finished batch 8 cpu time: 0.531  500  500
+++finished batch 9 cpu time: 0.562  500  500
+++finished batch 10 cpu time: 0.64  500  500
finished simulation, cpu time = 0.64 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
 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: 3.525 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: 3.634 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: 0.031  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.016  500  500
+++finished batch 2 cpu time: 0.063  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.64
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 3 cpu time: 0.109  500  500
+++finished batch 2 cpu time: 0.078  500  500
+++finished batch 4 cpu time: 0.141  500  500
+++finished batch 3 cpu time: 0.11  500  500
+++finished batch 5 cpu time: 0.172  500  500
+++finished batch 6 cpu time: 0.219  500  500
+++finished batch 4 cpu time: 0.203  500  500
+++finished batch 7 cpu time: 0.25  500  500
    max dose is 0.0343928 in region 2187726
+++finished batch 8 cpu time: 0.281  500  500
+++finished batch 5 cpu time: 0.281  500  500
+++finished batch 9 cpu time: 0.312  500  500
+++finished batch 10 cpu time: 0.359  500  500
finished simulation, cpu time = 0.359 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 6 cpu time: 0.344  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.359
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 7 cpu time: 0.375  500  500
+++finished batch 8 cpu time: 0.422  500  500
    max dose is 0.0340248 in region 1881006
+++finished batch 9 cpu time: 0.453  500  500
+++finished batch 10 cpu time: 0.484  500  500
finished simulation, cpu time = 0.484 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: 0.484
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.03426 in region 1804207
    ICRU-2K efficiency: 1319.99 1/s
+++ total
    max dose is 0.0343928 in region 2187726
    ICRU-2K efficiency: 1319.99 1/s
================================================
    ICRU-2K efficiency: 1158.22 1/s
+++ total
    max dose is 0.0343579 in region 2264526
    ICRU-2K efficiency: 1158.22 1/s
================================================
    ICRU-2K efficiency: 1770.96 1/s
+++ total
    max dose is 0.03426 in region 1804207
    ICRU-2K efficiency: 2321.96 1/s
+++ total
    max dose is 0.0340248 in region 1881006
    ICRU-2K efficiency: 1770.96 1/s
================================================
    ICRU-2K efficiency: 2321.96 1/s
================================================
Completed 16 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc
```

```
Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\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
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
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
 OK
Initializing cross sections ...
 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
============================================================
                   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: 2.215 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: 2.293 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: 0.109  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.078  500  500
+++finished batch 2 cpu time: 0.14  500  500
+++finished batch 2 cpu time: 0.109  500  500
+++finished batch 3 cpu time: 0.218  500  500
+++finished batch 3 cpu time: 0.203  500  500
+++finished batch 4 cpu time: 0.296  500  500
+++finished batch 4 cpu time: 0.281  500  500
+++finished batch 5 cpu time: 0.39  500  500
+++finished batch 5 cpu time: 0.359  500  500
+++finished batch 6 cpu time: 0.452  500  500
+++finished batch 6 cpu time: 0.437  500  500
```

```
+++finished batch 7 cpu time: 0.468  500  500
+++finished batch 7 cpu time: 0.53  500  500
+++finished batch 8 cpu time: 0.624  500  500
+++finished batch 8 cpu time: 0.577  500  500
+++finished batch 9 cpu time: 0.655  500  500
+++finished batch 10 cpu time: 0.717  500  500
finished simulation, cpu time = 0.733 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: 0.671  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.733
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.764  500  500
finished simulation, cpu time = 0.764 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: 0.764
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0349114 in region 2034607
    max dose is 0.0347457 in region 1957807
 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: 3.447 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: 0.031  500  500
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 3 cpu time: 0.094  500  500
+++finished batch 4 cpu time: 0.141  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 = (-26,23.5,24.5)
============================================================
================================================================
              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: 3.588 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 5 cpu time: 0.172  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.031  500  500
+++finished batch 2 cpu time: 0.062  500  500
+++finished batch 6 cpu time: 0.203  500  500
+++finished batch 3 cpu time: 0.093  500  500
+++finished batch 7 cpu time: 0.234  500  500
+++finished batch 4 cpu time: 0.14  500  500
+++finished batch 8 cpu time: 0.281  500  500
+++finished batch 9 cpu time: 0.312  500  500
+++finished batch 5 cpu time: 0.171  500  500
+++finished batch 10 cpu time: 0.343  500  500
+++finished batch 6 cpu time: 0.202  500  500
finished simulation, cpu time = 0.359 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: 0.359
```

```
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 7 cpu time: 0.249  500  500
+++finished batch 8 cpu time: 0.28  500  500
+++finished batch 9 cpu time: 0.327  500  500
+++finished batch 10 cpu time: 0.358  500  500
finished simulation, cpu time = 0.358 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
    max dose is 0.0344827 in region 2188206
============ DE_ScoreDose::analyze ====================
 geometry: CT
 cpu time: 0.358
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0346036 in region 2111407
    ICRU-2K efficiency: 1179.96 1/s
+++ total
    max dose is 0.0349114 in region 2034607
    ICRU-2K efficiency: 1179.96 1/s
================================================
    ICRU-2K efficiency: 2439.96 1/s
+++ total
    max dose is 0.0344827 in region 2188206
    ICRU-2K efficiency: 2439.96 1/s
================================================
    ICRU-2K efficiency: 1119.14 1/s
+++ total
    max dose is 0.0347457 in region 1957807
    ICRU-2K efficiency: 2420.28 1/s
+++ total
    max dose is 0.0346036 in region 2111407
    ICRU-2K efficiency: 1119.14 1/s
================================================
    ICRU-2K efficiency: 2420.28 1/s
================================================
Completed 20 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc
```

```
Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\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)
============================================================
============================================================
              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: 2.932 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: 3.213 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: 0.11  500  500
+++finished batch 2 cpu time: 0.141  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.078  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 = (-26,24,22.5)
============================================================
================================================================
              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: 3.276 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: 0.109  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 = (-26,24,23.5)
============================================================
================================================================
              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
================================================================

+++finished batch 3 cpu time: 0.234  500  500
 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: 3.198 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: 0.015  500  500
+++finished batch 4 cpu time: 0.297  500  500
+++finished batch 3 cpu time: 0.156  500  500
+++finished batch 2 cpu time: 0.062  500  500
+++finished batch 4 cpu time: 0.265  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.046  500  500
+++finished batch 5 cpu time: 0.375  500  500
+++finished batch 2 cpu time: 0.234  500  500
+++finished batch 3 cpu time: 0.14  500  500
+++finished batch 5 cpu time: 0.343  500  500
+++finished batch 6 cpu time: 0.468  500  500
+++finished batch 3 cpu time: 0.312  500  500
+++finished batch 4 cpu time: 0.234  500  500
+++finished batch 6 cpu time: 0.437  500  500
+++finished batch 5 cpu time: 0.265  500  500
+++finished batch 7 cpu time: 0.546  500  500
+++finished batch 4 cpu time: 0.405  500  500
+++finished batch 7 cpu time: 0.499  500  500
```

```
+++finished batch 6 cpu time: 0.343  500  500
+++finished batch 8 cpu time: 0.531  500  500
+++finished batch 8 cpu time: 0.624  500  500
+++finished batch 5 cpu time: 0.483  500  500
+++finished batch 6 cpu time: 0.514  500  500
+++finished batch 7 cpu time: 0.436  500  500
+++finished batch 9 cpu time: 0.624  500  500
+++finished batch 9 cpu time: 0.718  500  500
+++finished batch 10 cpu time: 0.749  500  500
finished simulation, cpu time = 0.749 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 7 cpu time: 0.608  500  500
+++finished batch 8 cpu time: 0.514  500  500
+++finished batch 10 cpu time: 0.702  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.749
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.546  500  500
+++finished batch 8 cpu time: 0.686  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
+++finished batch 10 cpu time: 0.639  500  500
finished simulation, cpu time = 0.639 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: 0.764  500  500
    max dose is 0.0343559 in region 1881486
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.639
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.842  500  500
finished simulation, cpu time = 0.858 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
```

```
total number of particles: 5000
average sampled energy: 6 +/- 0
    max dose is 0.0344111 in region 2265006
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.858
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0343987 in region 1958286
    max dose is 0.0339486 in region 1804686
    ICRU-2K efficiency: 1155.14 1/s
+++ total
    max dose is 0.0343559 in region 1881486
    ICRU-2K efficiency: 1155.14 1/s
================================================
    ICRU-2K efficiency: 1139.12 1/s
+++ total
    max dose is 0.0344111 in region 2265006
    ICRU-2K efficiency: 1139.12 1/s
================================================
    ICRU-2K efficiency: 1347.55 1/s
+++ total
    max dose is 0.0343987 in region 1958286
    ICRU-2K efficiency: 1347.55 1/s
================================================
    ICRU-2K efficiency: 1004.96 1/s
+++ total
    max dose is 0.0339486 in region 1804686
    ICRU-2K efficiency: 1004.96 1/s
================================================
Completed 24 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\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 = (-26,24,24)
============================================================
============================================================
              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: 2.324 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: 0.062  500  500
+++finished batch 2 cpu time: 0.14  500  500
```

```
+++finished batch 3 cpu time: 0.218  500  500
+++finished batch 4 cpu time: 0.25  500  500
+++finished batch 5 cpu time: 0.328  500  500
+++finished batch 6 cpu time: 0.421  500  500
+++finished batch 7 cpu time: 0.499  500  500
+++finished batch 8 cpu time: 0.53  500  500
+++finished batch 9 cpu time: 0.608  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 = (-26,24,25.5)
============================================================
================================================================
              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: 2.808 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 10 cpu time: 0.686  500  500
finished simulation, cpu time = 0.686 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.078  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.686
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 2 cpu time: 0.14  500  500
+++finished batch 3 cpu time: 0.171  500  500
+++finished batch 4 cpu time: 0.249  500  500
    max dose is 0.034533 in region 2035086
+++finished batch 5 cpu time: 0.343  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 = (-26,24,24.5)
============================================================
================================================================
              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: 3.338 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
+++finished batch 6 cpu time: 0.421  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.062  500  500
+++finished batch 2 cpu time: 0.094  500  500
+++finished batch 7 cpu time: 0.499  500  500
+++finished batch 8 cpu time: 0.53  500  500
+++finished batch 3 cpu time: 0.172  500  500
+++finished batch 9 cpu time: 0.608  500  500
+++finished batch 4 cpu time: 0.25  500  500
+++finished batch 5 cpu time: 0.281  500  500
+++finished batch 10 cpu time: 0.686  500  500
finished simulation, cpu time = 0.702 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 6 cpu time: 0.343  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.702
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 7 cpu time: 0.39  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 = (-26,24,25)
============================================================
============================================================
              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: 3.681 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: 0.016  500  500
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 8 cpu time: 0.468  500  500
+++finished batch 3 cpu time: 0.094  500  500
    max dose is 0.0347752 in region 2265486
+++finished batch 4 cpu time: 0.141  500  500
+++finished batch 9 cpu time: 0.546  500  500
+++finished batch 5 cpu time: 0.172  500  500
+++finished batch 10 cpu time: 0.577  500  500
+++finished batch 6 cpu time: 0.203  500  500
finished simulation, cpu time = 0.624 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 7 cpu time: 0.25  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.624
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 8 cpu time: 0.297  500  500
+++finished batch 9 cpu time: 0.328  500  500
    max dose is 0.0344639 in region 2111887
+++finished batch 10 cpu time: 0.359  500  500
finished simulation, cpu time = 0.375 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: 0.375
 number of histories: 5000
 number of batches: 10
```

```
+++ beamlet 0
    max dose is 0.0347516 in region 2188686
    ICRU-2K efficiency: 1232.81 1/s
+++ total
    max dose is 0.0347752 in region 2265486
    ICRU-2K efficiency: 1232.81 1/s
==================================================
    ICRU-2K efficiency: 1375.99 1/s
+++ total
    max dose is 0.0344639 in region 2111887
    ICRU-2K efficiency: 1230 1/s
+++ total
    max dose is 0.034533 in region 2035086
    ICRU-2K efficiency: 1375.99 1/s
==================================================
    ICRU-2K efficiency: 1230 1/s
==================================================
    ICRU-2K efficiency: 2331.82 1/s
+++ total
    max dose is 0.0347516 in region 2188686
    ICRU-2K efficiency: 2331.82 1/s
==================================================
Completed 28 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\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 = (-26,24.5,23.5)
============================================================
================================================================
              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: 2.62 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: 0.063  500  500
+++finished batch 2 cpu time: 0.141  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 = (-26,24.5,24)
```

```
============================================================
============================================================
              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: 2.823 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 3 cpu time: 0.234  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.078  500  500
+++finished batch 4 cpu time: 0.312  500  500
+++finished batch 5 cpu time: 0.344  500  500
+++finished batch 2 cpu time: 0.156  500  500
+++finished batch 3 cpu time: 0.187  500  500
+++finished batch 6 cpu time: 0.422  500  500
+++finished batch 4 cpu time: 0.265  500  500
+++finished batch 7 cpu time: 0.5  500  500
+++finished batch 8 cpu time: 0.531  500  500
+++finished batch 5 cpu time: 0.359  500  500
+++finished batch 9 cpu time: 0.609  500  500
+++finished batch 6 cpu time: 0.437  500  500
+++finished batch 7 cpu time: 0.468  500  500
+++finished batch 10 cpu time: 0.687  500  500
finished simulation, cpu time = 0.687 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
 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: 3.479 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: 3.556 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: 0.031  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.016  500  500
+++finished batch 2 cpu time: 0.109  500  500
============ DE_ScoreDose::analyze ===================
 geometry: CT
 cpu time: 0.687
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 8 cpu time: 0.531  500  500
+++finished batch 3 cpu time: 0.187  500  500
+++finished batch 9 cpu time: 0.687  500  500
+++finished batch 3 cpu time: 0.141  500  500
+++finished batch 4 cpu time: 0.281  500  500
+++finished batch 10 cpu time: 0.765  500  500
finished simulation, cpu time = 0.78 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 4 cpu time: 0.219  500  500
    max dose is 0.0346977 in region 1958767
+++finished batch 5 cpu time: 0.25  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.78
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 5 cpu time: 0.359  500  500
+++finished batch 6 cpu time: 0.39  500  500
+++finished batch 6 cpu time: 0.344  500  500
+++finished batch 7 cpu time: 0.421  500  500
+++finished batch 8 cpu time: 0.468  500  500
+++finished batch 7 cpu time: 0.422  500  500
+++finished batch 9 cpu time: 0.499  500  500
    max dose is 0.0343716 in region 2035566
+++finished batch 10 cpu time: 0.53  500  500
finished simulation, cpu time = 0.546 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: 0.468  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.546
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.515  500  500
+++finished batch 10 cpu time: 0.546  500  500
finished simulation, cpu time = 0.562 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: 0.562
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0341074 in region 1805166
    max dose is 0.0341867 in region 1881967
    ICRU-2K efficiency: 1322.04 1/s
+++ total
    max dose is 0.0346977 in region 1958767
    ICRU-2K efficiency: 1322.04 1/s
================================================
    ICRU-2K efficiency: 1534.86 1/s
+++ total
```

```
    max dose is 0.0341074 in region 1805166
    ICRU-2K efficiency: 1534.86 1/s
==================================================
    ICRU-2K efficiency: 1063.83 1/s
+++ total
    max dose is 0.0343716 in region 2035566
    ICRU-2K efficiency: 1063.83 1/s
==================================================
    ICRU-2K efficiency: 1552.55 1/s
+++ total
    max dose is 0.0341867 in region 1881967
    ICRU-2K efficiency: 1552.55 1/s
==================================================
Completed 32 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



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

```
 OK
Initializing cross sections ...
 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
============================================================
                   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: 2.246 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: 0.109  500  500
+++finished batch 2 cpu time: 0.14  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 = (-26,24.5,24.5)
============================================================
================================================================
              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: 2.62 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: 0.016  500  500
+++finished batch 3 cpu time: 0.234  500  500
+++finished batch 2 cpu time: 0.094  500  500
+++finished batch 4 cpu time: 0.312  500  500
+++finished batch 3 cpu time: 0.188  500  500
+++finished batch 5 cpu time: 0.39  500  500
+++finished batch 4 cpu time: 0.219  500  500
+++finished batch 6 cpu time: 0.484  500  500
+++finished batch 5 cpu time: 0.297  500  500
+++finished batch 7 cpu time: 0.515  500  500
+++finished batch 6 cpu time: 0.375  500  500
+++finished batch 8 cpu time: 0.608  500  500
+++finished batch 7 cpu time: 0.468  500  500
+++finished batch 9 cpu time: 0.686  500  500
+++finished batch 8 cpu time: 0.5  500  500
+++finished batch 10 cpu time: 0.78  500  500
+++finished batch 9 cpu time: 0.593  500  500
finished simulation, cpu time = 0.78 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: 0.78
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 10 cpu time: 0.671  500  500
finished simulation, cpu time = 0.671 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: 0.671
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0337888 in region 1805646
    max dose is 0.0344799 in region 2112366
 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: 3.697 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: 0.015  500  500
+++finished batch 2 cpu time: 0.047  500  500
+++finished batch 3 cpu time: 0.093  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 = (-26,24.5,25.5)
============================================================
================================================================
              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: 3.681 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 4 cpu time: 0.125  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.031  500  500
```

```
+++finished batch 5 cpu time: 0.171  500  500
+++finished batch 2 cpu time: 0.078  500  500
+++finished batch 6 cpu time: 0.203  500  500
+++finished batch 3 cpu time: 0.109  500  500
+++finished batch 7 cpu time: 0.249  500  500
+++finished batch 4 cpu time: 0.156  500  500
+++finished batch 8 cpu time: 0.281  500  500
+++finished batch 5 cpu time: 0.187  500  500
+++finished batch 9 cpu time: 0.327  500  500
+++finished batch 6 cpu time: 0.234  500  500
+++finished batch 10 cpu time: 0.359  500  500
+++finished batch 7 cpu time: 0.265  500  500
finished simulation, cpu time = 0.374 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: 0.374
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 8 cpu time: 0.312  500  500
+++finished batch 9 cpu time: 0.359  500  500
+++finished batch 10 cpu time: 0.39  500  500
finished simulation, cpu time = 0.406 seconds
total particle fluence from the source: 20000
total number of particle sets: 5000
total number of particles: 5000
average sampled energy: 6 +/- 0
    max dose is 0.0347981 in region 2189167
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.406
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0342375 in region 2265967
    ICRU-2K efficiency: 1016.25 1/s
+++ total
    max dose is 0.0337888 in region 1805646
    ICRU-2K efficiency: 1016.25 1/s
================================================
    ICRU-2K efficiency: 1268.04 1/s
+++ total
    max dose is 0.0344799 in region 2112366
    ICRU-2K efficiency: 1268.04 1/s
================================================
    ICRU-2K efficiency: 2318.2 1/s
+++ total
    max dose is 0.0347981 in region 2189167
    ICRU-2K efficiency: 2318.2 1/s
================================================
```

```
    ICRU-2K efficiency: 2082.46 1/s
+++ total
    max dose is 0.0342375 in region 2265967
    ICRU-2K efficiency: 2082.46 1/s
================================================
Completed 36 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_4.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
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
 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 = (-26,25,24.5)
============================================================
================================================================
              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   : 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: 1.872 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: 0.062  500  500
+++finished batch 2 cpu time: 0.14  500  500
+++finished batch 3 cpu time: 0.234  500  500
+++finished batch 4 cpu time: 0.312  500  500
+++finished batch 5 cpu time: 0.343  500  500
+++finished batch 6 cpu time: 0.436  500  500
+++finished batch 7 cpu time: 0.514  500  500
+++finished batch 8 cpu time: 0.592  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 = (-26,25,23)
============================================================
============================================================
              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: 2.808 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: 0.031  500  500
+++finished batch 9 cpu time: 0.624  500  500
+++finished batch 2 cpu time: 0.109  500  500
+++finished batch 10 cpu time: 0.702  500  500
finished simulation, cpu time = 0.764 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 3 cpu time: 0.202  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.764
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 4 cpu time: 0.28  500  500
+++finished batch 5 cpu time: 0.312  500  500
+++finished batch 6 cpu time: 0.39  500  500
    max dose is 0.0343678 in region 2112847
+++finished batch 7 cpu time: 0.468  500  500
+++finished batch 8 cpu time: 0.499  500  500
+++finished batch 9 cpu time: 0.639  500  500
+++finished batch 10 cpu time: 0.67  500  500
finished simulation, cpu time = 0.67 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: 0.67
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
 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: 3.385 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: 0.031  500  500
    max dose is 0.0340882 in region 1882447
+++finished batch 2 cpu time: 0.093  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 = (-26,25,23.5)
============================================================
================================================================
              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: 3.759 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 3 cpu time: 0.14  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.016  500  500
+++finished batch 4 cpu time: 0.171  500  500
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 5 cpu time: 0.203  500  500
+++finished batch 3 cpu time: 0.094  500  500
+++finished batch 6 cpu time: 0.249  500  500
+++finished batch 4 cpu time: 0.125  500  500
+++finished batch 7 cpu time: 0.281  500  500
+++finished batch 5 cpu time: 0.172  500  500
+++finished batch 8 cpu time: 0.312  500  500
+++finished batch 6 cpu time: 0.203  500  500
```

```
+++finished batch 9 cpu time: 0.359  500  500
+++finished batch 7 cpu time: 0.234  500  500
+++finished batch 10 cpu time: 0.39  500  500
finished simulation, cpu time = 0.405 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: 0.281  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.405
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.328  500  500
+++finished batch 10 cpu time: 0.359  500  500
finished simulation, cpu time = 0.375 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: 0.375
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0342205 in region 2036047
    max dose is 0.0343793 in region 1959246
    ICRU-2K efficiency: 1101.87 1/s
+++ total
    max dose is 0.0343678 in region 2112847
    ICRU-2K efficiency: 1101.87 1/s
================================================
    ICRU-2K efficiency: 1249.65 1/s
+++ total
    max dose is 0.0340882 in region 1882447
    ICRU-2K efficiency: 1249.65 1/s
================================================
    ICRU-2K efficiency: 2079.38 1/s
+++ total
    max dose is 0.0342205 in region 2036047
    ICRU-2K efficiency: 2079.38 1/s
================================================
    ICRU-2K efficiency: 2432.49 1/s
+++ total
    max dose is 0.0343793 in region 1959246
    ICRU-2K efficiency: 2432.49 1/s
================================================
Completed 40 of 49 beamlets...
```

```
Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc
Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1



Input file is: \\Mac\Home\Documents\Heidelberg\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
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 ... Reading MS data ...  OK
Parsing input file ... construct_mmc_geometry: urs = 1
 OK
Initializing cross sections ...  OK
Initializing cross sections ...
 DE_GeometryFactory::get_region_size():
get_region_size: urs = 1 ignore = 1
region size: 0.3
 geometry 1 region size: 0.3
 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
     dose scans:


CPU time so far: 2.043 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: 0.031  500  500
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 3 cpu time: 0.109  500  500
+++finished batch 4 cpu time: 0.141  500  500
+++finished batch 5 cpu time: 0.172  500  500
+++finished batch 6 cpu time: 0.203  500  500
+++finished batch 7 cpu time: 0.234  500  500
+++finished batch 8 cpu time: 0.281  500  500
+++finished batch 9 cpu time: 0.312  500  500
+++finished batch 10 cpu time: 0.343  500  500
finished simulation, cpu time = 0.343 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: 0.343
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0340721 in region 2189646
 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
  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   : 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: 2.823 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: 0.078  500  500
+++finished batch 2 cpu time: 0.156  500  500
+++finished batch 3 cpu time: 0.234  500  500
+++finished batch 4 cpu time: 0.265  500  500
+++finished batch 5 cpu time: 0.343  500  500
    ICRU-2K efficiency: 2335.88 1/s
+++ total
    max dose is 0.0340721 in region 2189646
+++finished batch 6 cpu time: 0.437  500  500
    ICRU-2K efficiency: 2335.88 1/s
=====================================================
+++finished batch 7 cpu time: 0.515  500  500
+++finished batch 8 cpu time: 0.546  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 = (-26,25,25.5)
============================================================
================================================================
              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: 3.494 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 9 cpu time: 0.64  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.094  500  500
+++finished batch 10 cpu time: 0.733  500  500
finished simulation, cpu time = 0.733 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: 0.733
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 2 cpu time: 0.172  500  500
+++finished batch 3 cpu time: 0.218  500  500
+++finished batch 4 cpu time: 0.25  500  500
    max dose is 0.033951 in region 1806126
+++finished batch 5 cpu time: 0.296  500  500
+++finished batch 6 cpu time: 0.328  500  500
+++finished batch 7 cpu time: 0.359  500  500
+++finished batch 8 cpu time: 0.406  500  500
+++finished batch 9 cpu time: 0.452  500  500
+++finished batch 10 cpu time: 0.515  500  500
finished simulation, cpu time = 0.53 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: 0.53
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
 OK
Initializing cross sections ...     max dose is 0.0350693 in region
 2266446
    ICRU-2K efficiency: 1149.48 1/s
+++ total
    max dose is 0.033951 in region 1806126
    ICRU-2K efficiency: 1149.48 1/s
=====================================================
 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: 4.929 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: 0.031  500  500
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 3 cpu time: 0.109  500  500
    ICRU-2K efficiency: 1654.18 1/s
+++ total
    max dose is 0.0350693 in region 2266446
    ICRU-2K efficiency: 1654.18 1/s
================================================
+++finished batch 4 cpu time: 0.141  500  500
+++finished batch 5 cpu time: 0.203  500  500
+++finished batch 6 cpu time: 0.25  500  500
+++finished batch 7 cpu time: 0.297  500  500
+++finished batch 8 cpu time: 0.328  500  500
+++finished batch 9 cpu time: 0.359  500  500
+++finished batch 10 cpu time: 0.406  500  500
finished simulation, cpu time = 0.406 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: 0.406
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.0342376 in region 1882926
    ICRU-2K efficiency: 2062.88 1/s
+++ total
    max dose is 0.0342376 in region 1882926
    ICRU-2K efficiency: 2062.88 1/s
================================================
Completed 44 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_1.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_2.vmc
```

```
Input file is: \\Mac\Home\Documents\Heidelberg\matRad\vmc++\runs/
MCpencilbeam_temp_3.vmc



Input file is: \\Mac\Home\Documents\Heidelberg\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 = (-26,25.5,24.5)
============================================================
============================================================
              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: 2.73 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: 0.062  500  500
+++finished batch 2 cpu time: 0.14  500  500
+++finished batch 3 cpu time: 0.234  500  500
+++finished batch 4 cpu time: 0.265  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 = (-26,25.5,25)
============================================================
================================================================
              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: 2.839 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 5 cpu time: 0.327  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.078  500  500
+++finished batch 6 cpu time: 0.405  500  500
+++finished batch 2 cpu time: 0.156  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 = (-26,25.5,24)
============================================================
```

```
============================================================
              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: 3.276 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: 0.031  500  500
+++finished batch 7 cpu time: 0.499  500  500
+++finished batch 3 cpu time: 0.234  500  500
+++finished batch 8 cpu time: 0.53  500  500
+++finished batch 2 cpu time: 0.109  500  500
+++finished batch 4 cpu time: 0.281  500  500
+++finished batch 9 cpu time: 0.624  500  500
+++finished batch 5 cpu time: 0.359  500  500
+++finished batch 3 cpu time: 0.202  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 = (-26,25.5,23.5)
============================================================
================================================================
              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   : 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: 3.51 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 10 cpu time: 0.702  500  500
+++finished batch 6 cpu time: 0.437  500  500
finished simulation, cpu time = 0.717 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 4 cpu time: 0.265  500  500
Running part 1 of 1 ...
+++finished batch 1 cpu time: 0.062  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.717
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 7 cpu time: 0.53  500  500
+++finished batch 5 cpu time: 0.358  500  500
+++finished batch 2 cpu time: 0.156  500  500
+++finished batch 6 cpu time: 0.39  500  500
+++finished batch 8 cpu time: 0.608  500  500
+++finished batch 3 cpu time: 0.234  500  500
+++finished batch 7 cpu time: 0.468  500  500
+++finished batch 9 cpu time: 0.671  500  500
+++finished batch 4 cpu time: 0.265  500  500
    max dose is 0.0342907 in region 2113326
+++finished batch 10 cpu time: 0.702  500  500
+++finished batch 8 cpu time: 0.546  500  500
finished simulation, cpu time = 0.749 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 5 cpu time: 0.358  500  500
+++finished batch 9 cpu time: 0.592  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.749
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 6 cpu time: 0.39  500  500
+++finished batch 7 cpu time: 0.436  500  500
+++finished batch 10 cpu time: 0.655  500  500
finished simulation, cpu time = 0.67 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: 0.468  500  500
============ DE_ScoreDose::analyze ==================
 geometry: CT
 cpu time: 0.67
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
+++finished batch 9 cpu time: 0.514  500  500
+++finished batch 10 cpu time: 0.546  500  500
```

```
finished simulation, cpu time = 0.561 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: 0.561
 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 0.0339002 in region 1959726
    ICRU-2K efficiency: 1112.57 1/s
+++ total
    max dose is 0.0343218 in region 2190126
    ICRU-2K efficiency: 1112.57 1/s
=====================================================
    ICRU-2K efficiency: 1557.55 1/s
+++ total
    max dose is 0.0339002 in region 1959726
    ICRU-2K efficiency: 1557.55 1/s
=====================================================
    ICRU-2K efficiency: 1243.61 1/s
+++ total
    max dose is 0.0342907 in region 2113326
    ICRU-2K efficiency: 1243.61 1/s
=====================================================
    ICRU-2K efficiency: 1259.86 1/s
+++ total
    max dose is 0.0341925 in region 2036526
    ICRU-2K efficiency: 1259.86 1/s
=====================================================
Completed 48 of 49 beamlets...



Input file is: \\Mac\Home\Documents\Heidelberg\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
```

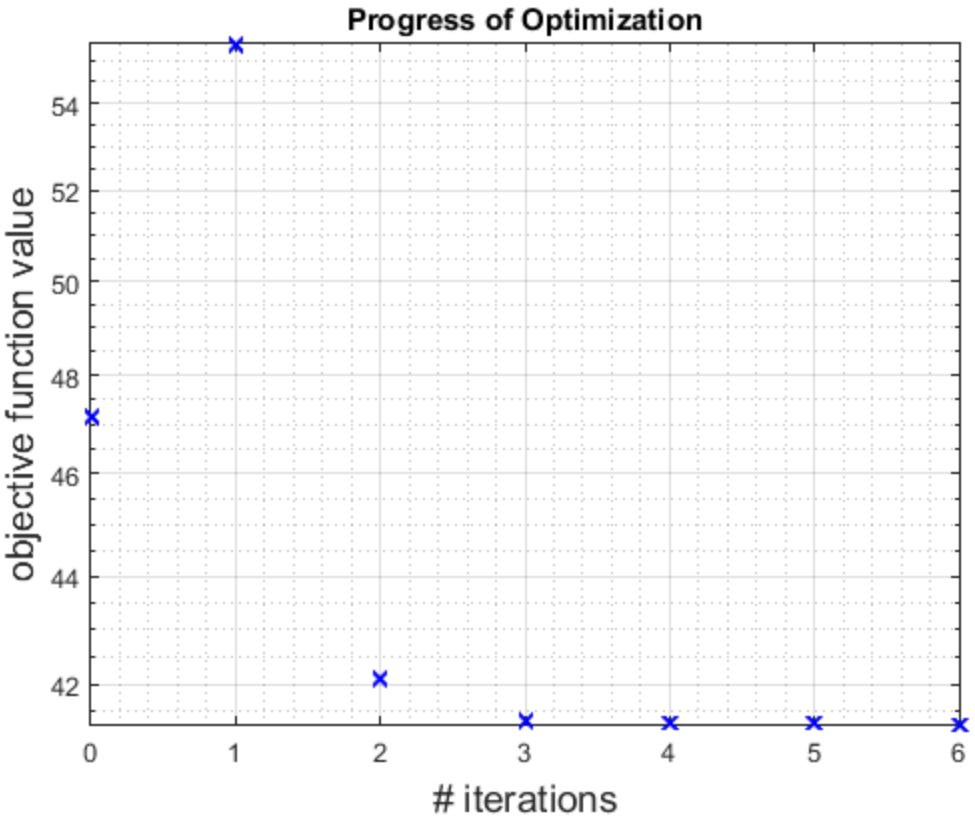
```
================================================================
================================================================
                  Scoring and output options
================================================================
  number of dose scoring objects: 1
  dose output options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


CPU time so far: 1.606 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: 0.032  500  500
+++finished batch 2 cpu time: 0.063  500  500
+++finished batch 3 cpu time: 0.11  500  500
+++finished batch 4 cpu time: 0.141  500  500
+++finished batch 5 cpu time: 0.172  500  500
+++finished batch 6 cpu time: 0.219  500  500
+++finished batch 7 cpu time: 0.25  500  500
+++finished batch 8 cpu time: 0.281  500  500
+++finished batch 9 cpu time: 0.312  500  500
+++finished batch 10 cpu time: 0.344  500  500
finished simulation, cpu time = 0.359 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: 0.359
 number of histories: 5000
 number of batches: 10
+++ beamlet 0
    max dose is 0.034158 in region 2266926
    ICRU-2K efficiency: 2306.14 1/s
+++ total
    max dose is 0.034158 in region 2266926
    ICRU-2K efficiency: 2306.14 1/s
================================================
Completed 49 of 49 beamlets...
```

Inverse Optimization for IMRT

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

```
******************************************************************************
This program contains Ipopt, a library for large-scale nonlinear
 optimization.
 Ipopt is released as open source code under the Eclipse Public
 License (EPL).
         For more information visit http://projects.coin-or.org/Ipopt
******************************************************************************

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
```

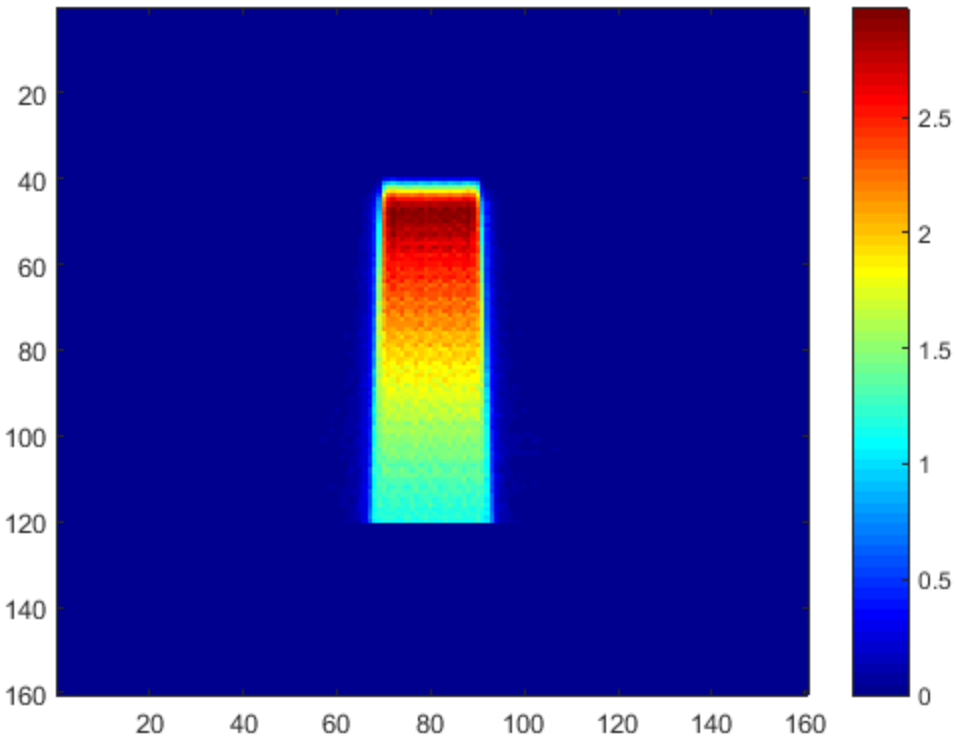
```
Number of objective function evaluations             = 15
Number of objective gradient evaluations             = 7
Number of equality constraint evaluations            = 0
Number of inequality constraint evaluations          = 0
Number of equality constraint Jacobian evaluations   = 0
Number of inequality constraint Jacobian evaluations = 0
Number of Lagrangian Hessian evaluations             = 0
Total CPU secs in IPOPT (w/o function evaluations)   =      0.891
Total CPU secs in NLP function evaluations           =      1.449

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



Plot the Resulting Dose Slice

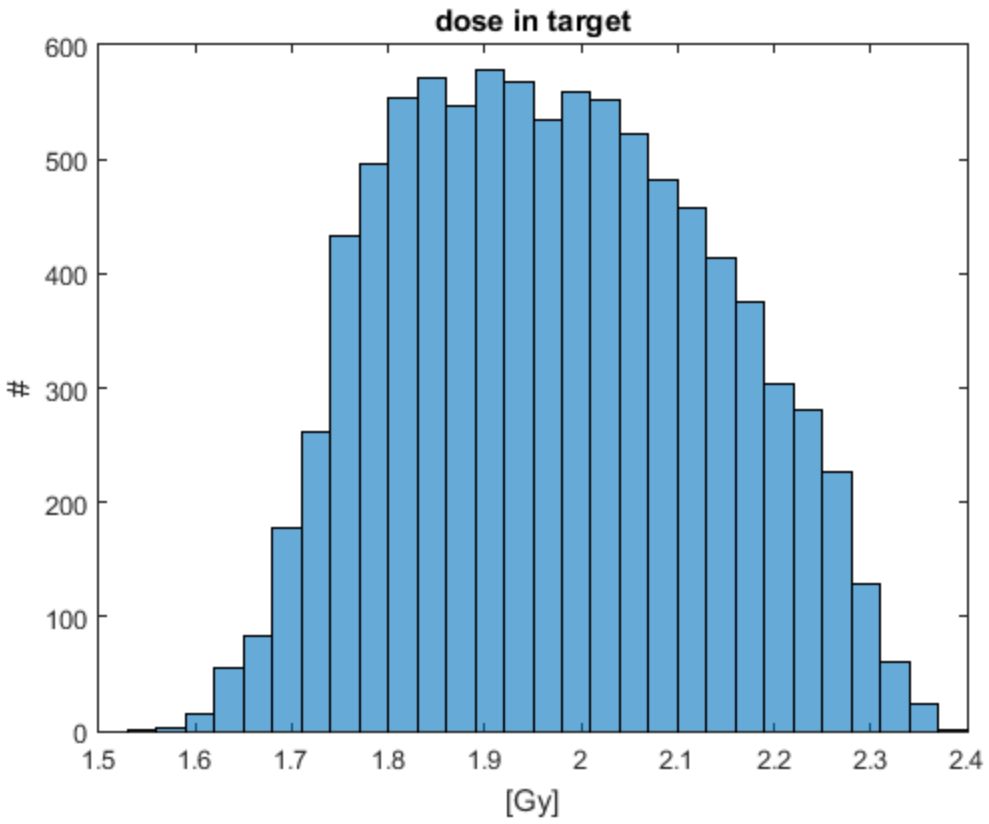
Just let's plot the transversal iso-center dose slice

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



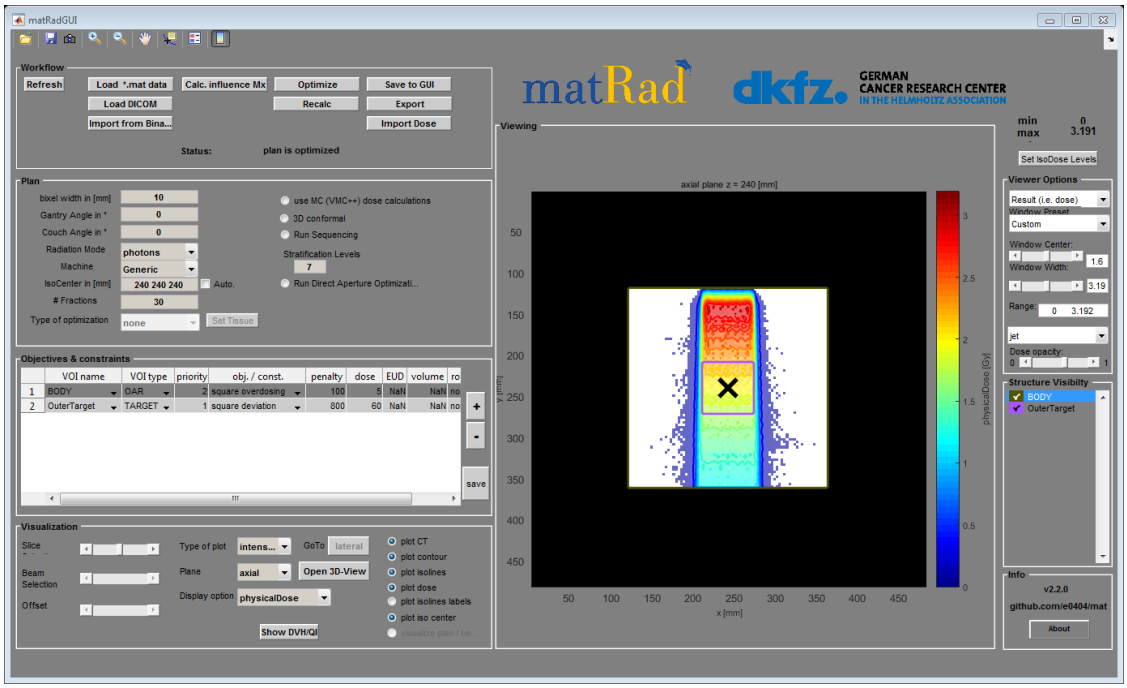
Exemplary, we show how to obtain the dose in the target and plot the histogram

```
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
```



Published with MATLAB® R2015a