BNL-105883-2014-TECH

EP&S No. 168;BNL-105883-2014-IR

Simulation of soil activation of gold-ions hitting a tungsten target at J7 of AGS

K. Yip

December 2010

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Experimental Support and Facilities Division
Collider-Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Upton, New York 11973-5000

ES&F Division Technical Note # 168

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I. Introduction

This time, the concern is the soil activation due to gold beam hitting a tungsten target of at J7. Simulations with MCNPX[i] with the gold ions of kinetic energy of 8.8648684×197 GeV or 1746379.07480 GeV[ii] have been used to find the fluxes so that one may estimate the soil activation.

II. Setup

Figure 1 shows the cross-section of the geometry setup (perpendicular to the beam direction which is also the z-axis) in the MCNPX simulation. In the simulation, y-axis is pointing towards the sky and x-axis is the remaining lateral dimension. The red area indicates the concrete wall which is of 1 foot thick. Outside the concrete wall, it's the soil (blue). In the simulation, I measure the fluxes of neutrons and protons inside the volume where x is between 10 cm and 20 cm (ie. a thickness of 10 cm) behind the concrete wall (which is my typical way in soil activiation problems).

The tungsten target is 1 inch x 1 inch with a thickness of 0.001 inches (or 2.54 × 2.54 × 0.00254 cm^3) and the front face of the tungsten has the origin of the setup (0, 0, 0), which is also where the pencil beam of gold ions hit.

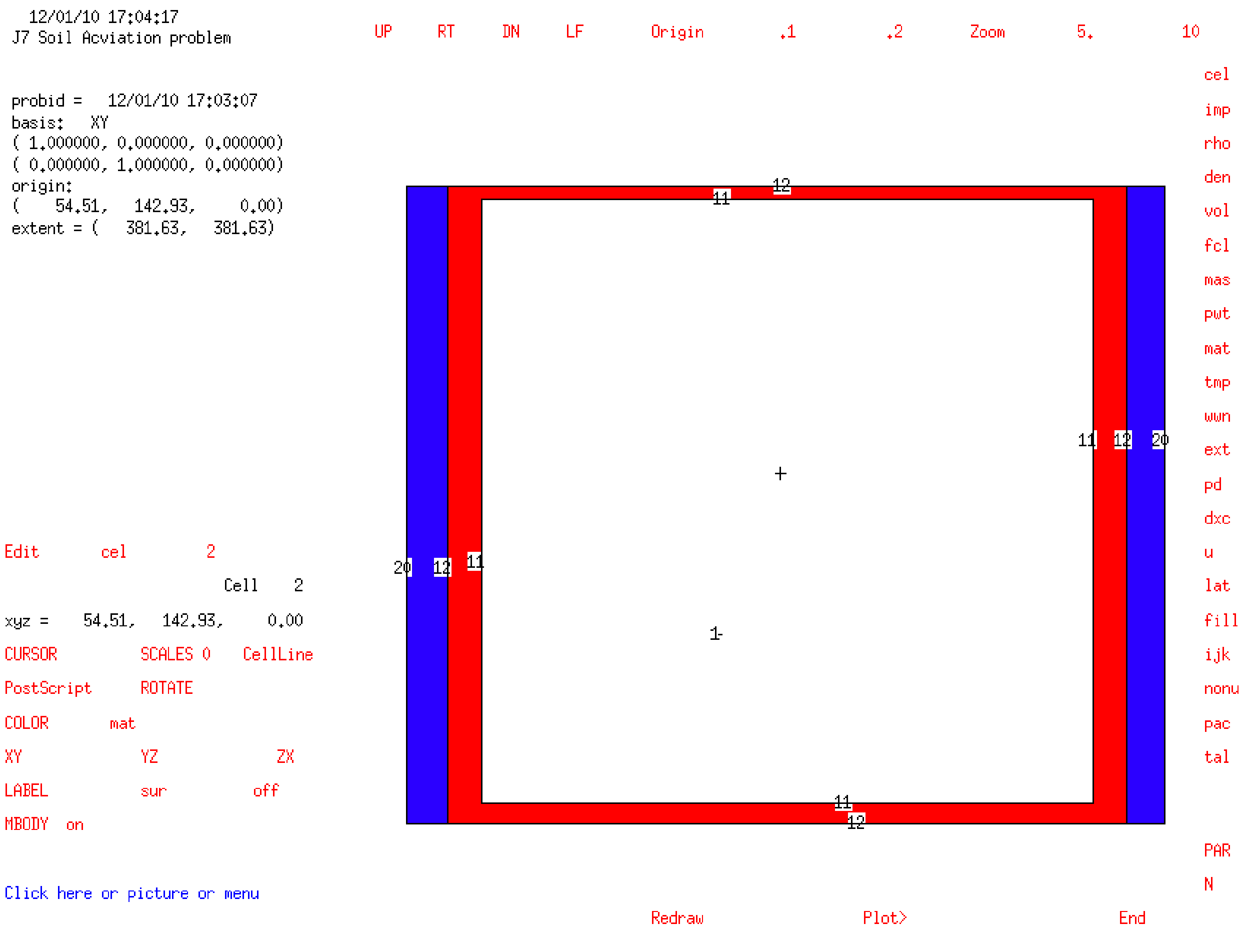

Figure 1: A picture of the MCNPX geometry used in the simulation. The blue area indicates the soil and the red area indicates the concrete wall. The place with the mark of "1" is where the tungsten target is.

III. Results

Figure 2 shows the neutron fluxes integrated over x from 10 cm to 20 cm in the y-z plane in soil. After running over 130000000 events, the maximum neutron flux is 7.5181×10^{-8} (statistical error of ±3.86%) cm^{-2} per incident gold ion and the maximum proton flux is 1.8334×10^{-8} (statistical error of ±7.92%) cm^{-2} per incident gold. As they may not peak in the same place but conservatively, their sum gives a maximum flux is ~9.351510^{-8} cm^{-2} per incident gold.

Assuming that the interaction length of 34 cm and the above flux, using the soil activation webpage calculators that I have written at http://www.c-ad.bnl.gov/kinyip/Radiation/Calculators.html, it would take about 9.2×10^{16} gold ions to get to 1000 pCi/L of Tritium (which is 5% of the drinking water standard).

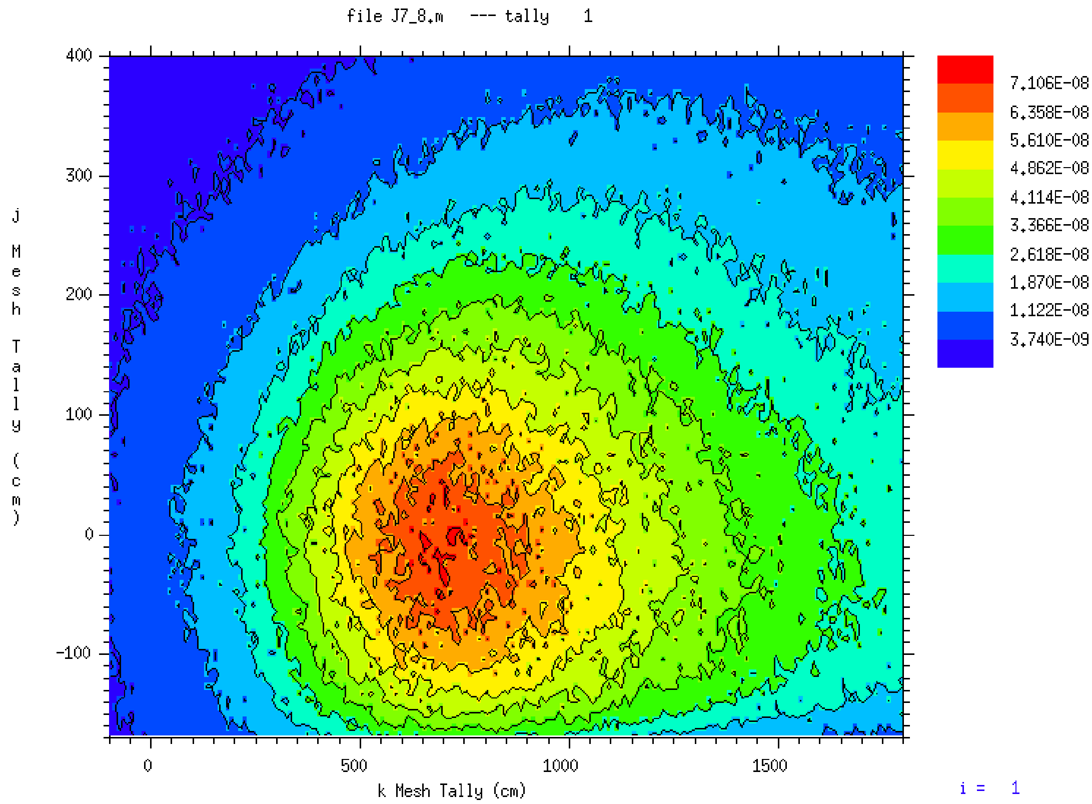

Figure 2: shows the neutron fluxes (cm^{-2} per incident gold ion) in the y-z plane in the soil of x from 10 cm to 20 cm behind the wall closer to the target.

IV. Appendix

The MCNPX input file is as follows :

```
Soil Acviation problem
c
c --- (0, 0, 0) is the center of the Tungsten target
c
c Tungsten target of inch/1000 thick
c
  1  3 -19.30  -1       imp:e,n,p,h,#,d,t,s,a=1
c
c vacuum inside tunnel
c
  2 0 1 -11        imp:e,n,p,h,#,d,t,s,a=1
c
c concrete wall
c
  3 4 -2.35 11 -12     imp:e,n,p,h,#,d,t,s,a=1
c
c the soil
c
  4 2 -1.9  12 -20      imp:e,n,p,h,#,d,t,s,a=1
c
c
c -- don't care area
  991 0  12 20        imp:e,n,p,h,#,d,t,s,a=0
c ===============================================
c ===============================================
c
c Tungsten target of inch/1000 thick
c
  1 rpp    -1.27  1.27  -1.27  1.27  0.  0.00254
c
c
c inner wall
c horizontal (7+11 feet)
c floor to ceiling 17' 9" (target 5' from floor)
c
  11 rpp   -213.36   335.28   -152.4  388.62  -100.  1900.
c
c outer wall (including all concretes at the side but only a small portion on floor and ceiling)
c
  12 rpp   -243.84   365.76   -170.0  400.0   -100.  1900.
```

```
c
c
c Soil
c
  20 rpp   -280.     400.     -170.   400.    -100.  1900.
c
c
c ==============================================================
c ==============================================================
c
c Materials
c
c
c
c Soil
c
m2   1001 .084 8016 .611 14028 .28130  14029 .01424 14030 .00946
c
c Tungsten
m3  74182 0.26530  74183 0.14331  74184 0.30679  74186 0.28460
c
c
c concrete
m4 1001 0.1686 8016 0.5762 13027 0.0219 14028 0.1935 14029 0.0098 14030 0.0065
    20000 0.0191 26056 0.0044
mx4:h j j j j j j 20040 j
mx4:p j j j j j j 20040 j
sdef  erg=1746379.07480  par=79197  dir=1 vec=0 0 1 pos = 0.0 0.0 -0.01
     axs 0 0 1 wgt=1
c
DBCN   623487
c
c
phys:e 100000.
phys:n 1747000. 5j 1
phys:h 1747000. 5j 1
phys:d 1747000. 5j 1
phys:t 1747000. 5j 1
phys:a 1747000. 5j 1
phys:s 1747000. 5j 1
phys:# 1747000.
phys:p 1747000. 2j 1
cut:n j 20.0
cut:h j 20.0
c
c mode n h
```

```
c
mode  e n p h # d t s a
c
c
c
nps   50000000
print
c
c
prdmp  2j 1
c
tmesh
rmesh1:n flux
CORA1  -263.84    -253.84
CORB1  -170.   99i  400.
CORC1  -100.   189i  1800.
rmesh11:h flux
CORA11  -263.84    -253.84
CORB11  -170.   99i  400.
CORC11  -100.   189i  1800.
rmesh21:n flux
CORA21  375.76    385.76
CORB21  -170.   99i  400.
CORC21  -100.   189i  1800.
rmesh31:h flux
CORA31  375.76    385.76
CORB31  -170.   99i  400.
CORC31  -100.   189i  1800.
endmd
```

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[i] MCNPX, version 2.7.c, http://mcnpx.lanl.gov .

[ii] The total and kinetic energies can be found in Section 7 on page 9 of the document written by Kip Gardner: http://www.cadops.bnl.gov/AGS/Operations/GardnerNotes/RhicRunParameters/barp10.pdf