Studies of radiation from 10 keV e-lens

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I. Introduction

Here, we investigate the possible (x-ray) radiation from the electron beam at (maximum energy of) 10 keV in the e-lens device at a current of 1A. Simulations were done using MCNPX[1] to find possible doses.

II. Production

The author has looked at how much x-ray can be generated with electrons hitting a piece of copper. Apparently, the maximum amount of x-ray (photons) can be obtained if the copper is thin. When the copper is thick, the electrons and photons are absorbed by the copper. For example, electron hitting a copper of 0.001 cm, the dose at one foot in the forward direction can be 2.8×10^{5} rem/hour. This thickness is used for the x-ray generation in the simulation. It can be considered as an overestimation (as there may not be thin wire as such in this device).

III. Shielding

Various thicknesses of stainless steel are placed behind the copper and various doses at one foot are found from simulation. The results are shown in Figure 1. With a thickness of 0.05 cm of steel, the dose is only ~9.5×10^{-12} rem/hour. The e-lens device is wrapped by at least 1/8 of

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

inches (~0.3175 cm) of stainless steel and then there is even a second layer of stainless steel (the second layer has at least a thickness of 0.065 inches, ~0.1651 cm, of steel which are for some vertical pipes). The author cannot find a non-zero dose in simulation even after 2 billions of events at a thickness of 0.1651 cm.

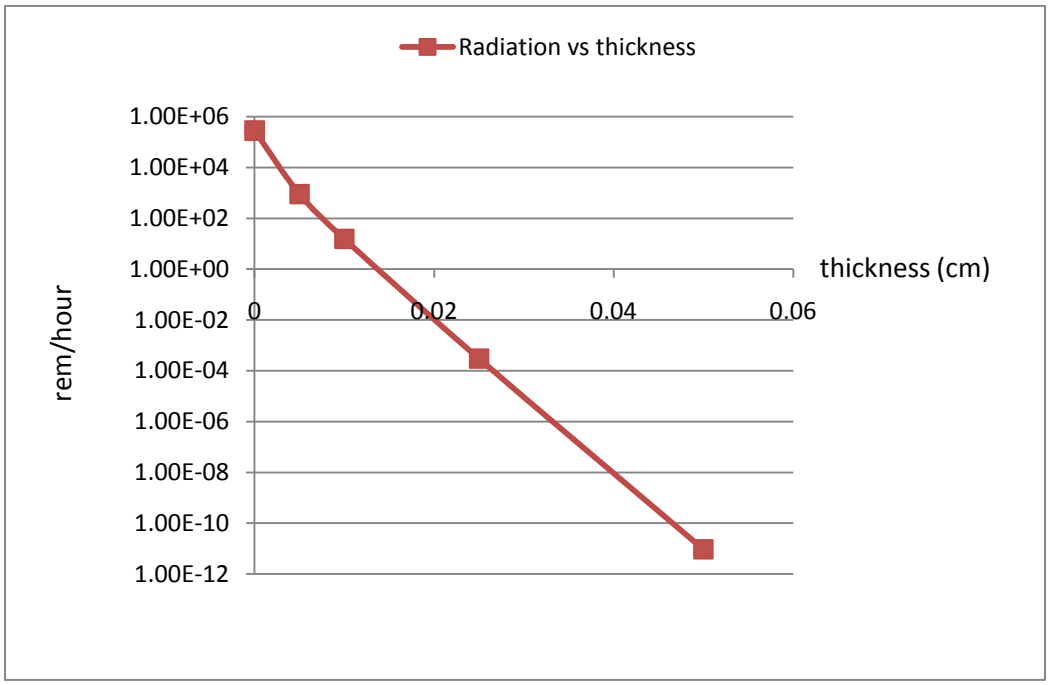

Figure 1: Doses (in rem/hour) behind various thicknesses of stainless steel are shown here.

From the above, the requirement of <5 mrem/hour (Controlled Area) or even 50 μrem/hour is readily satisfied by all the available stainless steel (in design).

IV. Appendix

The MCNPX input file is as follows :

```
Electron Copper --- Energy Distribution
c
c base walls
c
  1 1 -8.96 -1  imp:n,p,e=1
c
c detector
c
  2 0 -10  imp:n,p,e=1
c
  3 3 -7.8 -2  imp:n,p,e=1
c
c inside the room
c
  900 0 -900 1 2 10 imp:n,p,e=1
c
c outside
c
  901 0 900 imp:n,p,e=0
c
c
c ===================================================================
c ===================================================================
c the center of the beam is at 50 inches above ground and x = 0 and y = 0
c
c Surfaces  q
c
c Copper
c
c   1 rpp   -0.75  0.75   -0.75  0.75    0.0 1.5
    1 rpp   -0.01  0.01   -0.01  0.01    0.0 0.001 c
c
c made up a plate of 0.065 inch steel
c
c  2 rpp    -6. 6. -6. 6.  1.0 1.1651
  2 rpp    -6. 6. -6. 6.  1.0 1.01
```

```
c
c detector
c
c   10 sph   0. 0. 31. 1.0
c   10 rpp   -5. 5. -5. 5.  30.5 35.0
    10 rpp   -5. 5. -5. 5.  31.0 35.0
c
c
   900 rpp    -6.0  6.0  -6.0  6.0  -1.0  35.0
c
c ============================================================

c
c
c Materials
c
c Copper
c
m1  29063  0.6917  29065 0.3083
c
c
c
c steel
m3 6000 -0.0003                  $ 0.0003 carbon
     7014 -0.0009963
     7015 -0.0000037             $ 0.001 nitrogen
     14000 -0.0075               $ 0.0075 silicon
     15031 -0.00045              $ 0.00045 phosphorus
     16032 -0.0003               $ 0.0003 sulfur
     24050 -0.00862
     24052 -0.16752
     24053 -0.0191
     24054 -0.00476              $ 0.20 chromium
     25055 -0.02                 $ 0.02 manganese
     26054 -0.03785619
     26056 -0.5962025
     26057 -0.01424486
     26058 -0.002146485          $ 0.65045 iron
     28058 -0.0814176
     28060 -0.0314736
     28061 -0.0014256
     28062 -0.0043896
     28064 -0.0012936            $ 0.12 nickel
mx3:h 6012 j j 14028 16j
mx3:p 6012 j j 14028 16j
c
```

```
SDEF erg = 0.01 par=3  dir=1  vec = 0 0 1  x=0. y=0. z=-0.9  wgt=1
c
c ---------------------------------------------------------------------
c
c
DBCN   997383
c
c biased photonuclear treatment to gain statistics quicker
c
phys:p 0.011  2j 1
phys:e 0.011
phys:n 0.011
c
cut:p 0.
cut:e 0.
c
c
c
mode n p e
c
c
c ------------------------------- Doses ----------------------
c
F5:p    0.   0. 31.  0.
F15:p   1.  0. 31.  0.
F25:p   0.  -1. 31.  0.
c
F4:p  2
c
c ---------------------------------------------------------------------
c
c nps 25000000
c nps 2500000
nps 1500000000
c
c prdmp    50000 j j 10 j
c
print
c
c Energy Bins (upper limits)
e0 1.0e-7 1.0e-5 1.0e-3 .01 .1 1. 2. 20.  100. 200.
c
c converted to dose  (1/3600 because the original unit is rem/hour)
c
df0 iu=1 fac=2.77777777778E-4  log ic=10
```