NERS544: (Introduction to) Monte Carlo Methods

Assignment 6: **Reflection** 2-week assignment, weight = 2 Fall 2016

Revision: November 9, 2016
Alex Bielajew, 2927 Cooley, `bielajew@umich.edu`
Due: November 17, 2016 before class

This assignment will involve surface with mirror-reflection properties (See section 10.7 in the book), as well as totally absorbing surfaces.

Consider a two dimensional square box centered at the origin with sides $2L$ in length. Also centered at the origin is a circle of radius R. For this assignment you should show results for $L = 1$ and $R = 0.2$, although your code should be generalizable to run for any L and R. (This may be useful when you are debugging your code as well.)

You will consider two source types, a "volume source" that emits particles uniformly and isotropically throughout the square, and a "surface source" that emits particles uniformly and isotropically from the "surface" of the square. Those generated within the absorbing circle are "absorbed on the spot", at their point of creation. Otherwise they are transported inside the box until they reflect from one of its sides, or gets absorbed on the surface of the circle. (Graphical output helps a lot with debugging the code.) In addition, if a particle is about to take a step larger than $100L$, its transport is halted. (This is a great time saver.)

Tally the total pathlength each particle history accumulates following the example output attached to this description.

For the graphs given, the tally mesh is described by:

```
M = 256; % Mesh size of the distribution tally
if     (surfaceSource) pathlog = logspace(log10(L-R),2,M); % L-R is the minimum
elseif (volumeSource)  pathlog = logspace(-1,2,M); % Minimum can be zero
end
```

As well, your code must visually display the particle tracks for the first 100 histories. This will be demonstrated in class.

Submit your code by email.

Discussion. This is "food for thought" only.

- The connection of this problem to reactor physics should be apparent. The construction of this problem is over-simplified for this application, yet it contains features that are common, in particular the periodic boundary conditions (infinite. At this point in your Monte Carlo development, it should be clear how to add different absorption or scattering constants for the "fuel bundle" (the circle) and the moderator (everything else).
- Pathlength distributions are very important for nuclear and radiological applications because the ability for a particle to interact with the medium it is being transported in, is proportional to the number of atoms or nuclei it encounters along its path.
- It is a mathematically interesting problem, one that is challenging to express mathematically, but easy to describe, and the limits if its behavior, easy to figure out. Hence, it is an ideal candidate for numerical study. For example, once could ask:
  - What happens as the ratio R/L is varies. The limits are easy to express. For example, when R/L approaches $\sqrt{2}$, there is no space left for particles to be transported. As R/L approaches 0 the

pathlengths become infinite. What exactly do the distributions look like, for different R/L.

– One could provide the pathlength distributions for the 0 walls struck, 1 wall struck and so on. The 0-wall and 1-wall might be doable analytically. More than that may be prohibitive.
– How would the distributions change if the transport medium was weakly absorbing, or the walls only partially mirrored? Leakage could be modeled!
– How about 3D and more-D behaviors?

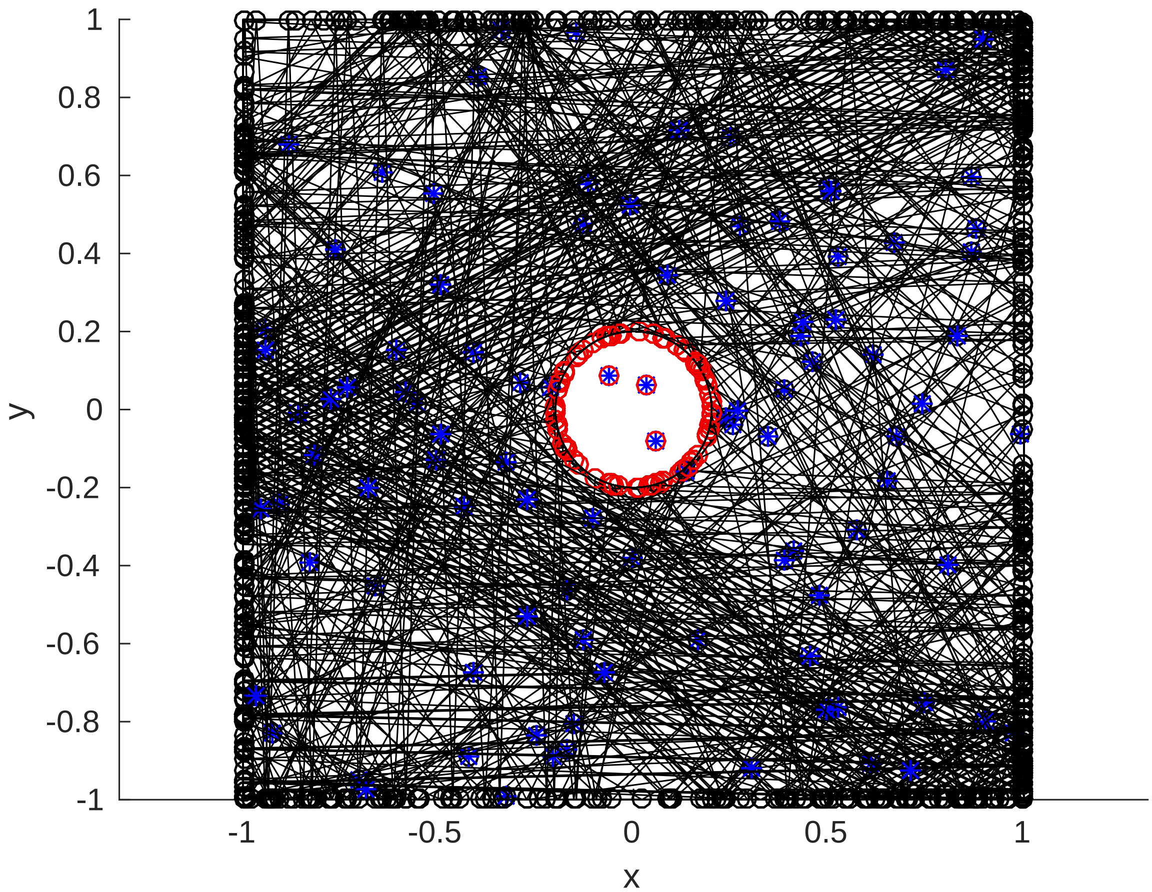

Figure 1: Volume source, 2×2 box, absorber $R = 0.2$, tracks of 100 histories. A particle's starting location is represented with a blue asterisk, its final location by a red circle. Note the particles that started and ended immediately in the interior of the absorber.

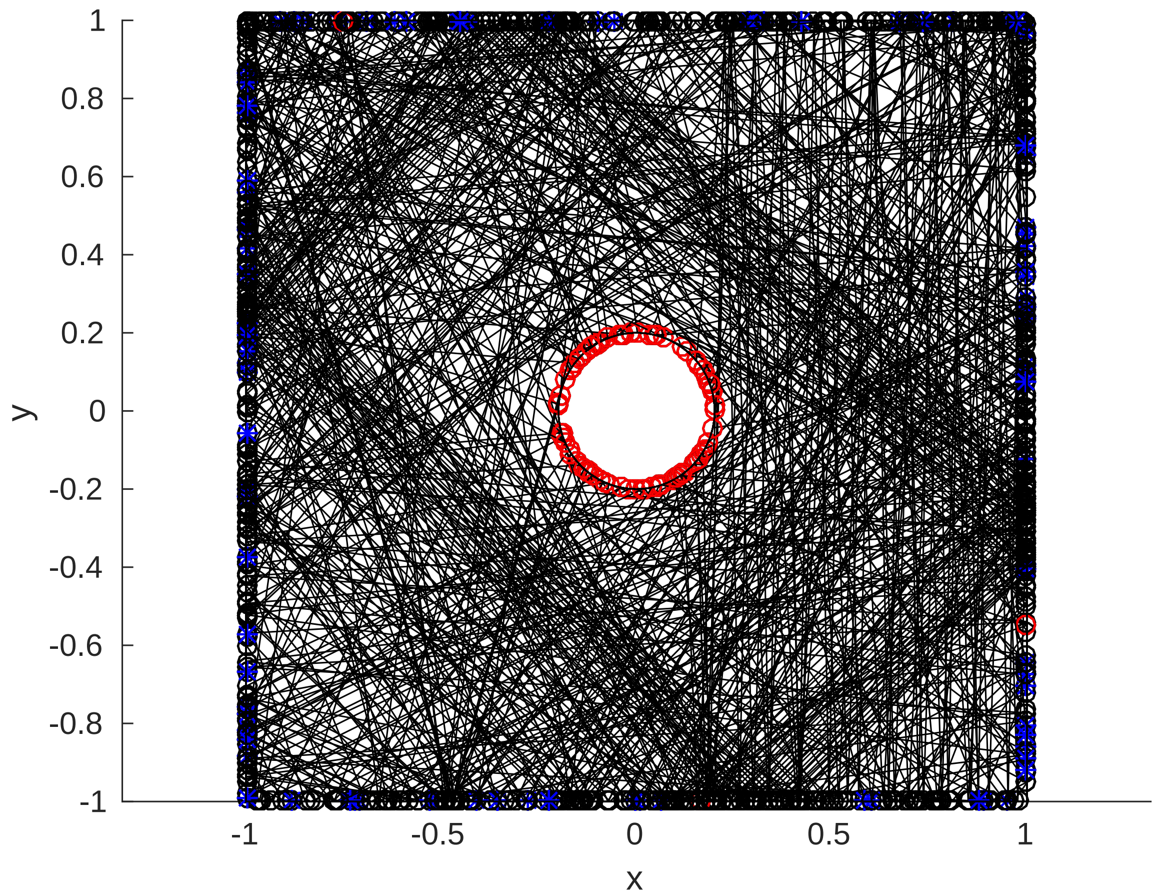

Figure 2: Surface source, 2×2 box, absorber $R = 0.2$, tracks of 100 histories. A particle's starting location is represented with a blue asterisk, its final location by a red circle. Note that two of the particles ended at the edge of the box due to the pathlength restriction.

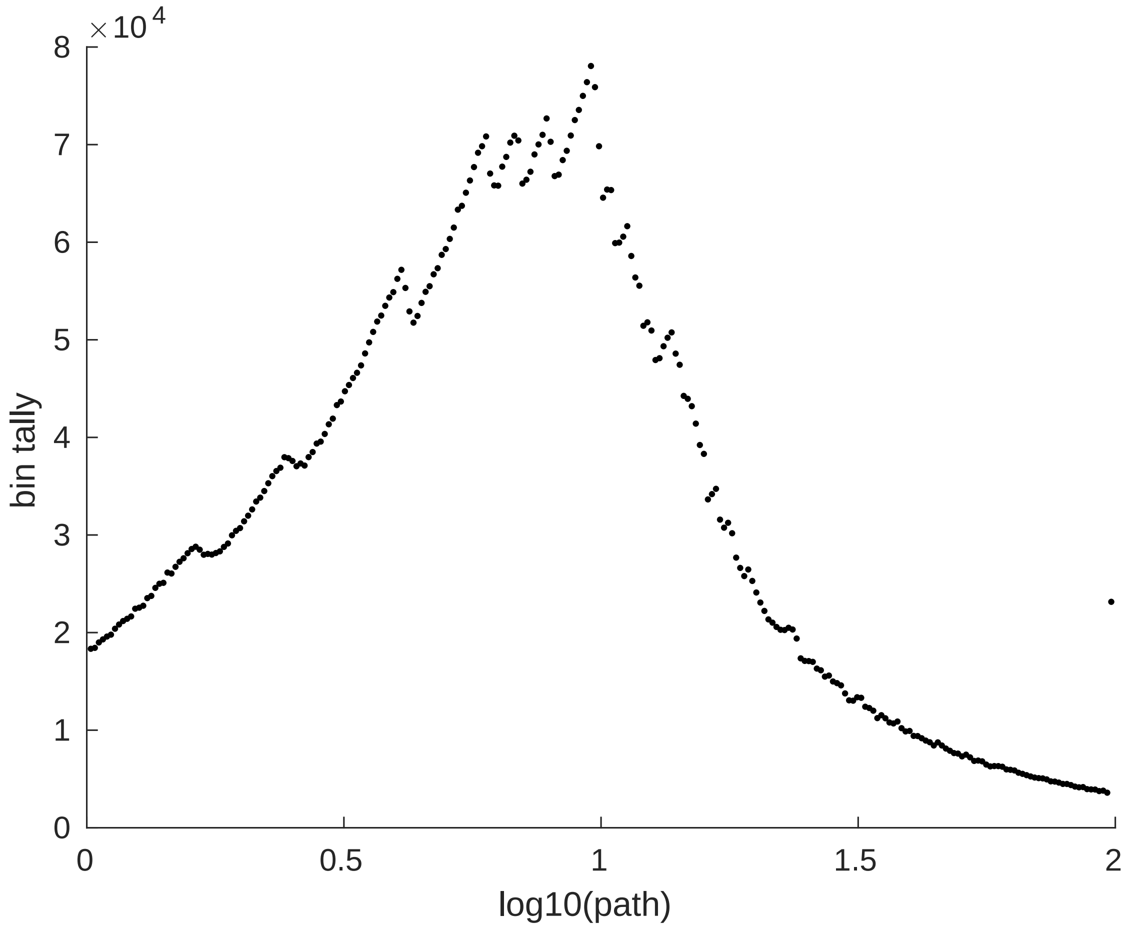

Figure 3: Volume source, 2×2 box, absorber $R = 0.2$, 10^7 histories.

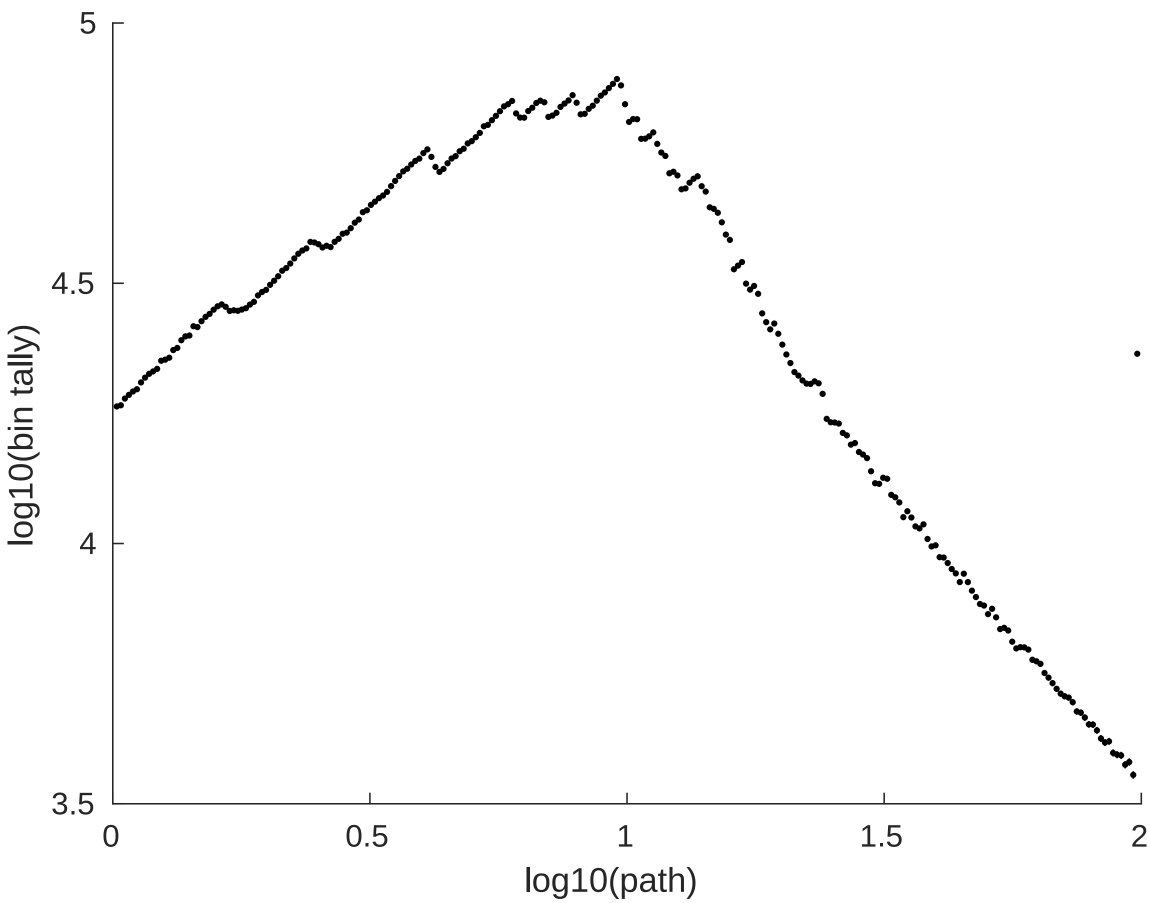

Figure 4: Same as before Figure 3, but with a logarithmic ordinate axis.

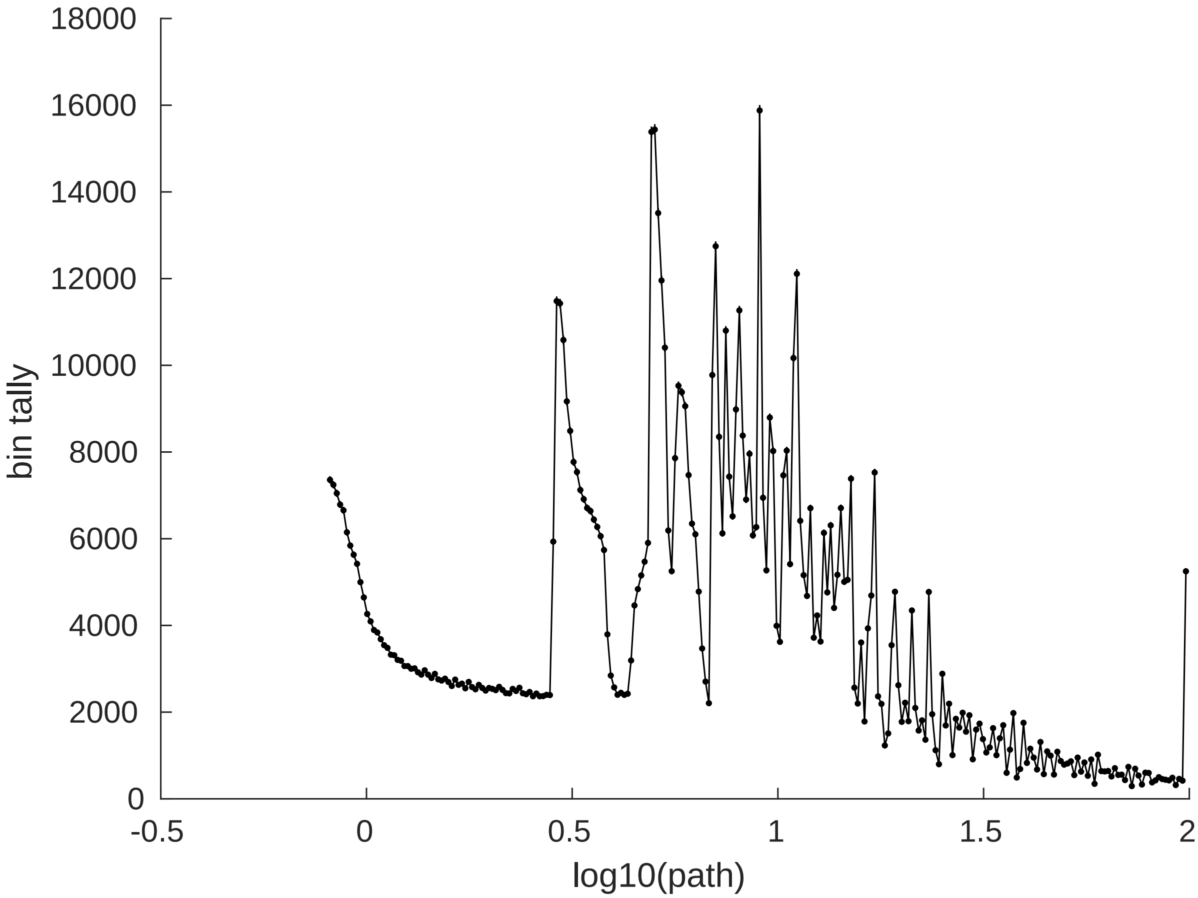

Figure 5: Surface source, 2×2 box, absorber $R = 0.2$, 10^6 histories.

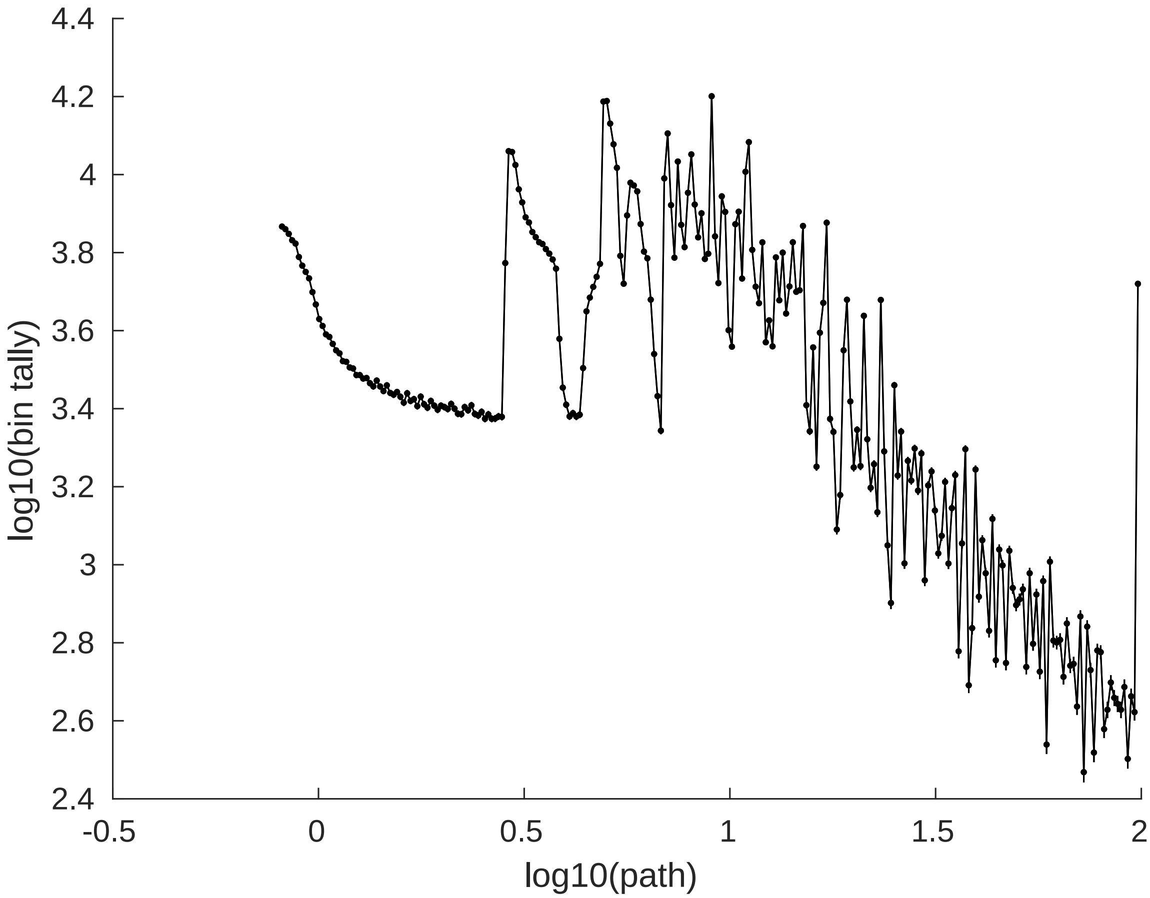

Figure 6: Same as before Figure 5, but with a logarithmic ordinate axis.