22.S902 IAP 2015 (DIY Geiger Counters), Problem Set 3

Due January 9th in class

January 5, 2015

1   (15 points) Watch Out, Radioactive Man!

Assuming that your eye is a point detector, and assuming a spherical mushroom cloud from a far-off atomic explosion, derive a relationship between the size and the distance of the resulting mushroom cloud that your thumb would completely cover with your arm extended. You may use your actual body measurements in your answer.

2   (25 points) Economical Terrorism

You are trying to smuggle a fresh, $1,000\,\mathrm{Ci}$ source of Cs-137 through the port of Singapore, inside a standard-sized shipping container. In order for it to slip by unnoticed, the activity measured on a perfectly efficient, $0.01\,m^2$ radiation detector must be within 2x of the local natural background levels.

1. Design a shielding system to fit inside the shipping container, that will hide the source from the detector. Disregard cost, and try to minimize the volume of the shielding.

2. Revisit your design in Problem 2.1, but take cost into account. Which materials would you switch to, assuming you may fill the entire shipping container if you so desire?

3   (60 points) Pre-Lab Calculations

Using actual data from your Geiger counter (tube materials, gases, plastic thickness), determine an experiment to measure the *efficiency* of your SMB-20 Geiger tube using our Co-60 source. In other words, how many gamma rays do you expect to *interact with* (not just enter) the gases in your Geiger tube, compared to the actual number of counts that you measure? You will want to use your answers in Problem Set 1 concerning actual source activity and uncertainty, and use/make measurements of your own Geiger counter. Look at slide 19 of today's lecture notes for inspiration, though your experiment may not look exactly like this...

Be creative! You don't necessarily have to use the Geiger counter in exactly the way it was meant to be used... also, do account for things like dead time, true source activity uncertainty, and other sources of dead time in the experiment from Problem Set 2.

Your answer should be an expression for the efficiency of your GM tube as a function of other known and measurable parameters in an experiment. You will actually perform this experiment on Thursday.

You may find this online database most useful: http://www.nist.gov/pml/data/xraycoef/

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