PHGN 326
Experiment 2:

Gamma ray attenuation

Purpose:

The purpose of this experiment is to measure experimentally the mass attenuation coefficient in lead and aluminum for 662 keV gamma rays. Gammas interact in matter primarily by photoelectric, Compton or pair-production interactions. The total mass attenuation coefficient can be easily measured with a gamma ray spectrometer. In this experiment we will measure the number of gammas that are removed from the photopeak by photoelectric or Compton interactions that occur in a lead (or aluminum) absorber placed between the source and the detector. From Lambert's law the decrease of the intensity of radiation as it passes through the absorber is given by:

$I = I_0 e^{-\mu x}$

Where:

I = intensity after the absorber
I_0 = intensity before the absorber
μ = total mass attenuation coefficient in cm^2/g
x = density thickness in g/cm^2

The density thickness is the product of the density in g/cm3 times the thickness in cm.
Densities:
Pb: 11.434 g/cm^3
Al: 2.702 g/cm^3

The half-value layer (HVL) is defined as the density thickness of the absorbing material that will reduce the original intensity (the value is dependent on the photon energy) by a factor 2.
Using

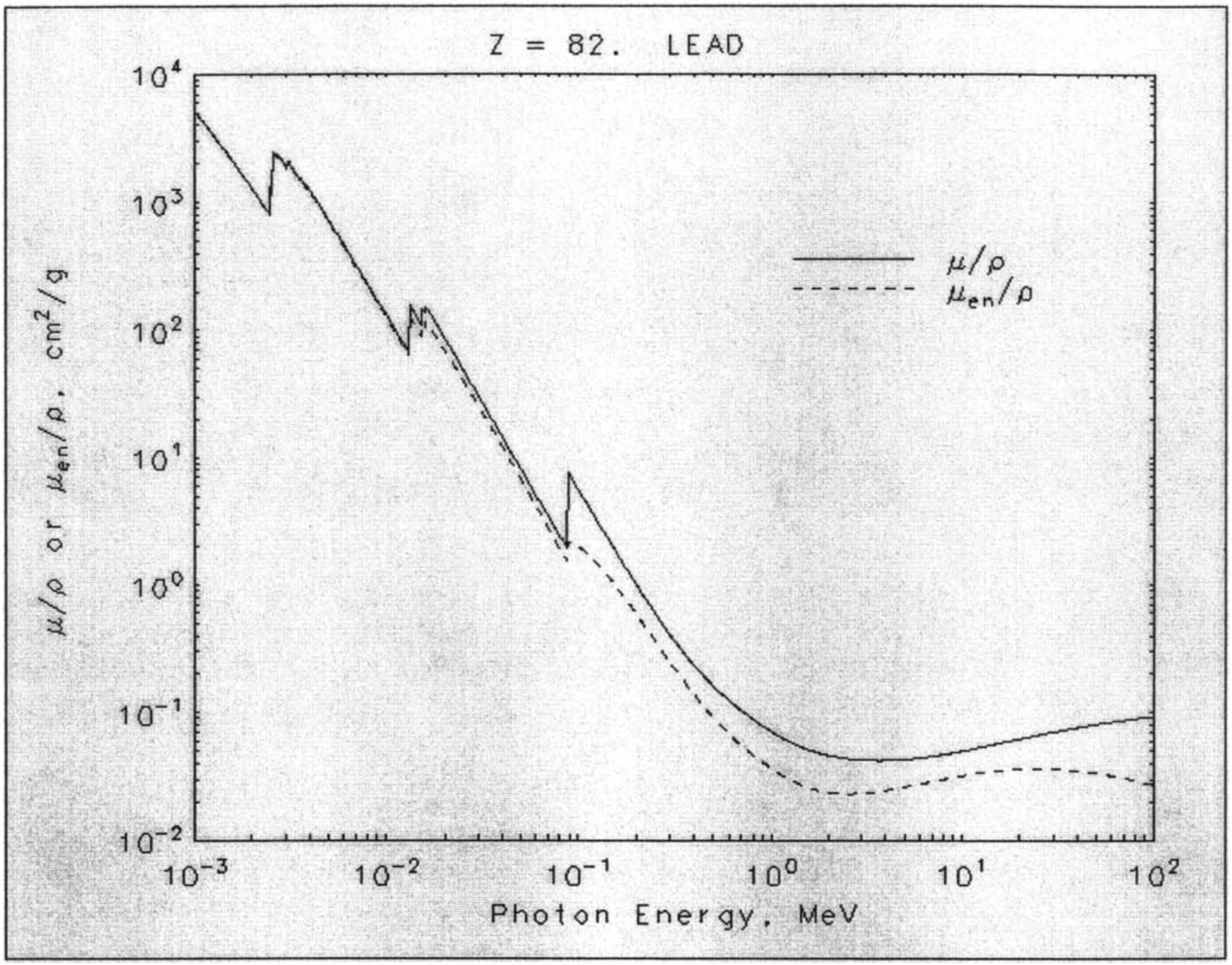
$\ln I/I_0 = -\mu x$; with $I/I_0 = 0.5$ and x = HVL

We assume at: HVL = $0.693/\mu$.
In this experiment we will measure μ and HVL in lead and aluminum for the 0.662 MeV gammas from a 137-Cs source.

Procedure:

1. Mount the NaI(T1) detector and the 137-Cs source with a distance of app. 30 cm. The center of the source should be on the same height as the center of the detector crystal. Connect the photomultiplier base (base) to the photomultiplier (PM) connector.
2. Connect the high voltage (HV) input of the PM base to the HV output of the HV power supply.
3. Connect the anode output of the PM base to the oscilloscope. Signals visible?
4. Turn on the HV power supply (screw/switch on the back side should be on positive). Try if you see signals turning up the voltage in +100 V steps. Maximum **+** 1000 Volts!!!
5. Take notes of the results and sketch the signals on the oscilloscope at **+** 1000 V. Risetime, falltime, noise?
6. Using the same HV, have a look at the dynode signal and sketch it. Why different polarity?
7. Return to the anode signal and connect it to the spectroscopy amplifier input. Turn on the power of the NIM bin and check the input signal polarity.
8. Connect the oscilloscope to the amplifier output (unipolar). Sketch the signal.
9. Connect the unipolar output with the ADC input and start a measurement. Adjust amplification so that you can clearly see the photopeak in the spectrum. Sketch the spectrum. Check the signal again on the oscilloscope. Voltage of photopeak?
10. Determine the count rate (net) in the photopeak region at your given distance without absorber foils (zero measurement).
11. Determine the count rate in the photo peak region with **3** absorber foils of aluminum and lead each. Take 3 measurements with each foil. To recognize inadvertent changes in the detector/source alignment, perform a zero measurement between each foil change.
12. Calculate the attenuation coefficient and half-value layer for lead and aluminum for 662 keV photons.

Table of Contents Back to table 3



Lead
$Z = 82$

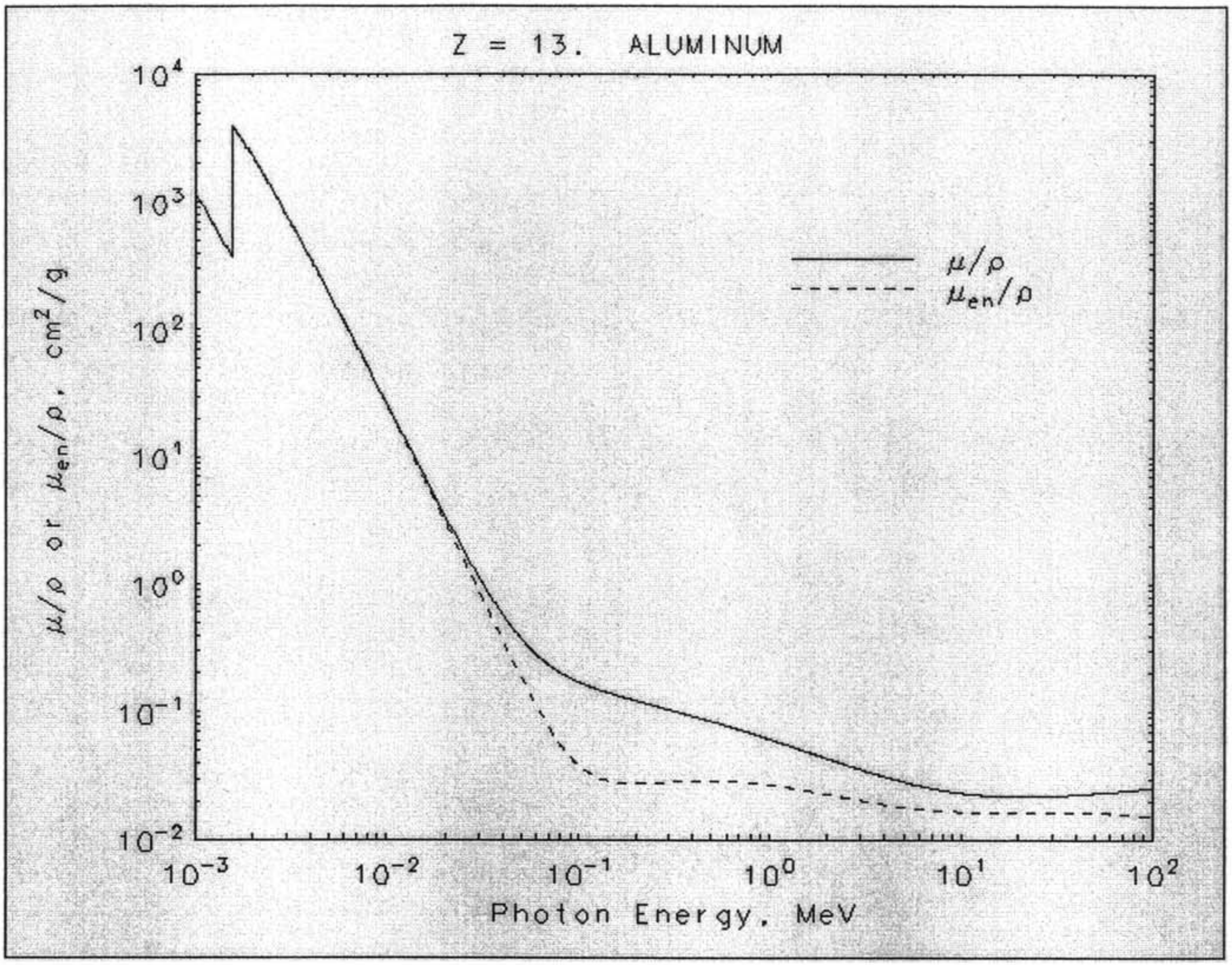
	Energy (MeV)	μ/ρ (cm^2/g)	μ_{en}/ρ (cm^2/g)
	1.00000E-03	5.210E+03	5.197E+03
	1.50000E-03	2.356E+03	2.344E+03
	2.00000E-03	1.285E+03	1.274E+03
	2.48400E-03	8.006E+02	7.895E+02
M5	2.48400E-03	1.397E+03	1.366E+03
	2.53429E-03	1.726E+03	1.682E+03
	2.58560E-03	1.944E+03	1.895E+03
M4	2.58560E-03	2.458E+03	2.390E+03
	3.00000E-03	1.965E+03	1.913E+03
	3.06640E-03	1.857E+03	1.808E+03
M3	3.06640E-03	2.146E+03	2.090E+03
	3.30130E-03	1.796E+03	1.748E+03
	3.55420E-03	1.496E+03	1.459E+03

M2	3.55420E-03	1.585E+03	1.546E+03
	3.69948E-03	1.442E+03	1.405E+03
	3.85070E-03	1.311E+03	1.279E+03
M1	3.85070E-03	1.368E+03	1.335E+03
	4.00000E-03	1.251E+03	1.221E+03
	5.00000E-03	7.304E+02	7.124E+02
	6.00000E-03	4.672E+02	4.546E+02
	8.00000E-03	2.287E+02	2.207E+02
	1.00000E-02	1.306E+02	1.247E+02
	1.30352E-02	6.701E+01	6.270E+01
L3	1.30352E-02	1.621E+02	1.291E+02
	1.50000E-02	1.116E+02	9.100E+01
	1.52000E-02	1.078E+02	8.807E+01
L2	1.52000E-02	1.485E+02	1.131E+02
	1.55269E-02	1.416E+02	1.083E+02
	1.58608E-02	1.344E+02	1.032E+02
L1	1.58608E-02	1.548E+02	1.180E+02
	2.00000E-02	8.636E+01	6.899E+01
	3.00000E-02	3.032E+01	2.536E+01
	4.00000E-02	1.436E+01	1.211E+01
	5.00000E-02	8.041E+00	6.740E+00
	6.00000E-02	5.021E+00	4.149E+00
	8.00000E-02	2.419E+00	1.916E+00
	8.80045E-02	1.910E+00	1.482E+00
K	8.80045E-02	7.683E+00	2.160E+00
	1.00000E-01	5.549E+00	1.976E+00
	1.50000E-01	2.014E+00	1.056E+00
	2.00000E-01	9.985E-01	5.870E-01
	3.00000E-01	4.031E-01	2.455E-01
	4.00000E-01	2.323E-01	1.370E-01
	5.00000E-01	1.614E-01	9.128E-02
	6.00000E-01	1.248E-01	6.819E-02
	8.00000E-01	8.870E-02	4.644E-02
	1.00000E+00	7.102E-02	3.654E-02
	1.25000E+00	5.876E-02	2.988E-02
	1.50000E+00	5.222E-02	2.640E-02
	2.00000E+00	4.606E-02	2.360E-02
	3.00000E+00	4.234E-02	2.322E-02
	4.00000E+00	4.197E-02	2.449E-02
	5.00000E+00	4.272E-02	2.600E-02
	6.00000E+00	4.391E-02	2.744E-02
	8.00000E+00	4.675E-02	2.989E-02
	1.00000E+01	4.972E-02	3.181E-02
	1.50000E+01	5.658E-02	3.478E-02
	2.00000E+01	6.206E-02	3.595E-02

Back to table 3

Table of Contents

Table of Contents Back to table 3



Aluminum
***Z* = 13**

	Energy (MeV)	μ/ρ (cm^2/g)	μ_{en}/ρ (cm^2/g)
	1.00000E-03	1.185E+03	1.183E+03
	1.50000E-03	4.022E+02	4.001E+02
	1.55960E-03	3.621E+02	3.600E+02
K	1.55960E-03	3.957E+03	3.829E+03
	2.00000E-03	2.263E+03	2.204E+03
	3.00000E-03	7.880E+02	7.732E+02
	4.00000E-03	3.605E+02	3.545E+02
	5.00000E-03	1.934E+02	1.902E+02
	6.00000E-03	1.153E+02	1.133E+02
	8.00000E-03	5.033E+01	4.918E+01
	1.00000E-02	2.623E+01	2.543E+01
	1.50000E-02	7.955E+00	7.487E+00
	2.00000E-02	3.441E+00	3.094E+00

3.00000E-02	1.128E+00	8.778E-01
4.00000E-02	5.685E-01	3.601E-01
5.00000E-02	3.681E-01	1.840E-01
6.00000E-02	2.778E-01	1.099E-01
8.00000E-02	2.018E-01	5.511E-02
1.00000E-01	1.704E-01	3.794E-02
1.50000E-01	1.378E-01	2.827E-02
2.00000E-01	1.223E-01	2.745E-02
3.00000E-01	1.042E-01	2.816E-02
4.00000E-01	9.276E-02	2.862E-02
5.00000E-01	8.445E-02	2.868E-02
6.00000E-01	7.802E-02	2.851E-02
8.00000E-01	6.841E-02	2.778E-02
1.00000E+00	6.146E-02	2.686E-02
1.25000E+00	5.496E-02	2.565E-02
1.50000E+00	5.006E-02	2.451E-02
2.00000E+00	4.324E-02	2.266E-02
3.00000E+00	3.541E-02	2.024E-02
4.00000E+00	3.106E-02	1.882E-02
5.00000E+00	2.836E-02	1.795E-02
6.00000E+00	2.655E-02	1.739E-02
8.00000E+00	2.437E-02	1.678E-02
1.00000E+01	2.318E-02	1.650E-02
1.50000E+01	2.195E-02	1.631E-02
2.00000E+01	2.168E-02	1.633E-02

Back to table 3

Table of Contents