PHY 411 VLab 3: Estimation of linear and mass attenuation factor

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Aim: To estimate the linear and mass attenuation factor of

Data taken:

1.For lead as absorber:

- Density = 11.29 gm/cc

Source: Cs-137

Gamma E = 0.66 MeV

Thickness (in cm)	Counts
0	23335
0.2	16699
0.4	14046
0.6	9105
0.8	7110
1	5553
1.5	3087
2	1618
2.5	840
3	421
3.5	243
4	115
4.5	58
5	36
5.5	18
6	8
6.5	4
7	300
7.5	1
8	0

Source: Co-60

Gamma E = 1.25 MeV

Thickness (in cm)	Counts
0	20344
0.2	17395
0.4	17992
0.6	13619
0.8	13528
1	11983
1.5	7767
2	6162
2.5	1874
3	2723
3.5	2023
4	1531
4.5	1105
5	846
5.5	564
6	366
6.5	291
7	300
7.5	146
8	112

Source: Na-24

Gamma E = 2.75 MeV

Thickness (in cm)	Counts
0	21197
0.2	20079
0.4	16474
0.6	14759
0.8	15207
1	13860
1.5	9690
2	7771
2.5	6414
3	4638
3.5	3635

4	2946
4.5	2152
5	1864
5.5	1505
6	1033
6.5	843
7	35
7.5	558
8	434

2.For Source Na-22:

- Gamma E = 0.51 MeV

Absorber: Silicon

Density = 2.33 gm/cc

Thickness (in cm)	Counts
0	22789
0.2	18595
0.4	19208
0.6	18941
0.8	16901
1	17621
1.5	14878
2	15013
2.5	12937
3	11657
3.5	10964
4	9267
4.5	9331
5	8474
5.5	7274
6	6162
6.5	5872
7	35
7.5	4243
8	3866

Absorber: Lead

Density = 11.29 gm/cc

Thickness (in cm)	Counts
0	20817
0.2	13793
0.4	9915
0.6	6764
0.8	5505
1	3347
1.5	1548
2	562
2.5	225
3	100
3.5	43
4	16
4.5	7
5	1
5.5	1
6	0
6.5	0
7	35
7.5	0
8	0

Absorber: Iron

Density = 7.87 gm/cc

Thickness (in cm)	Counts
0	19370
0.2	17276
0.4	15892
0.6	14705
0.8	11409
1	11384
1.5	8445
2	5557
2.5	3775
3	2692
3.5	2263
4	1617
4.5	1071
5	777

5.5	604
6	397
6.5	322
7	35
7.5	159
8	100

Absorber: Copper

Density = 8.96 gm/cc

Thickness (in cm)	Counts
0	21336
0.2	20092
0.4	16618
0.6	13769
0.8	11131
1	9739
1.5	7359
2	5262
2.5	3385
3	2082
3.5	1551
4	1077
4.5	700
5	544
5.5	340
6	263
6.5	172
7	35
7.5	79
8	60

Absorber: Water

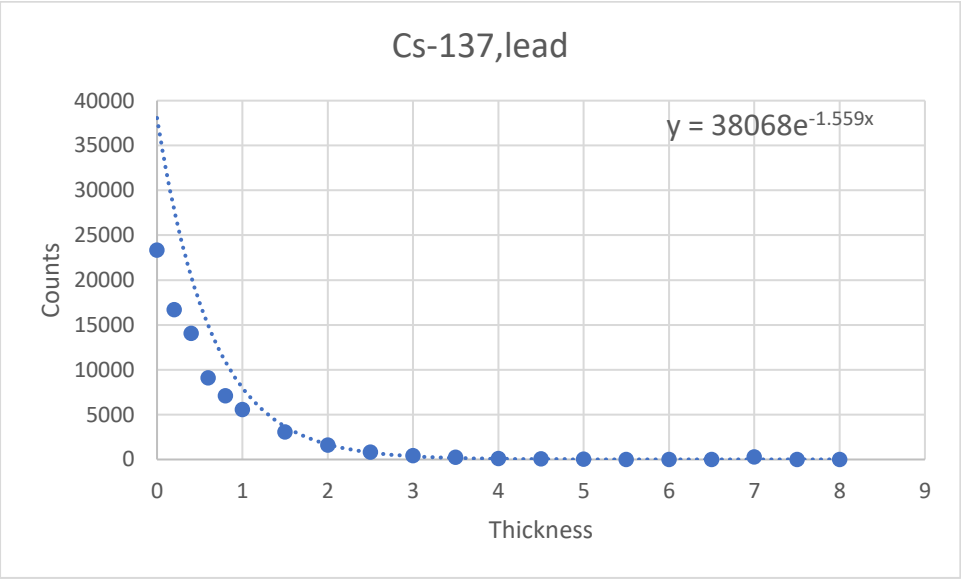
Density = 1.09 gm/cc

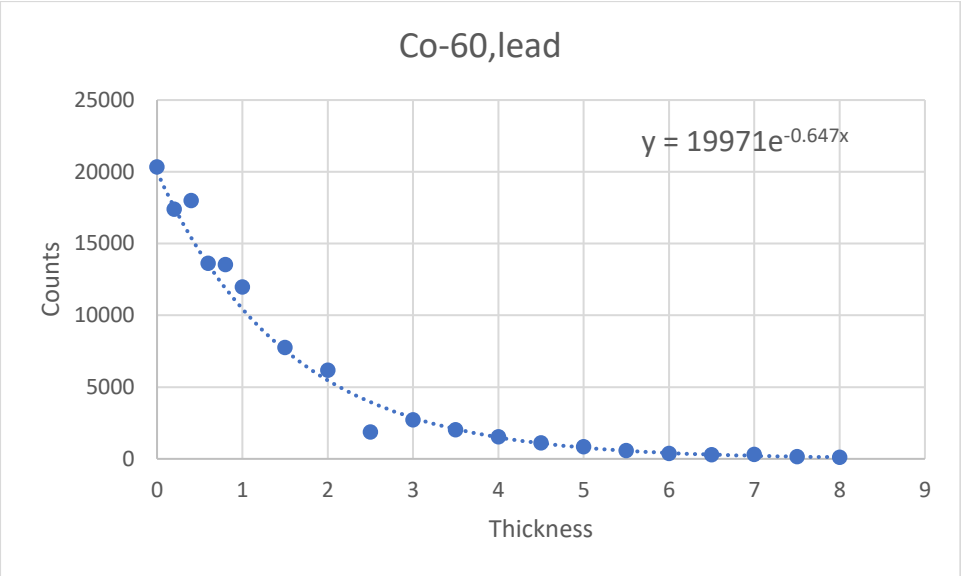
Thickness (in cm)	Counts
0	21336
0.2	20092
0.4	16618
0.6	13769
0.8	11131

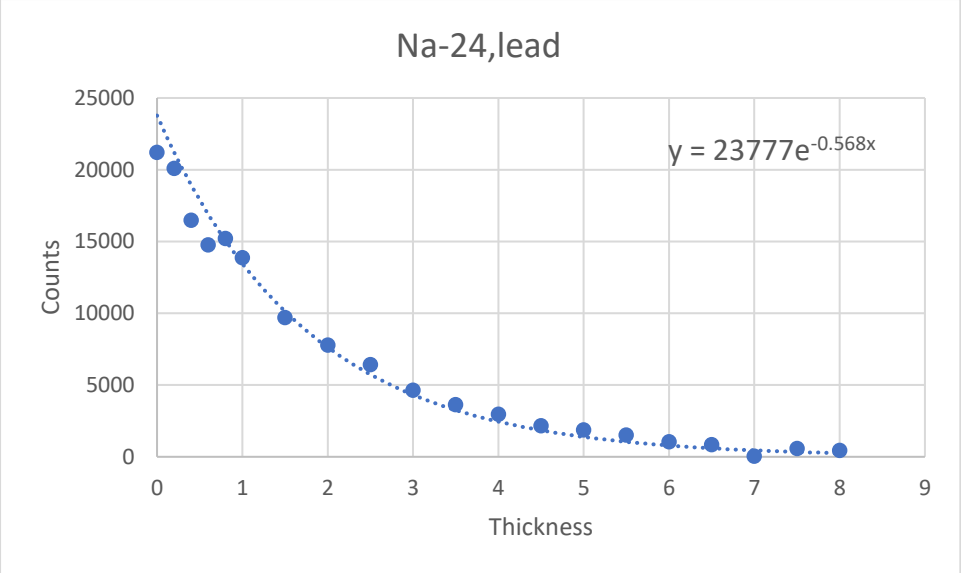
1	9739
1.5	7359
2	5262
2.5	3385
3	2082
3.5	1551
4	1077
4.5	700
5	544
5.5	340
6	263
6.5	172
7	35
7.5	79
8	60

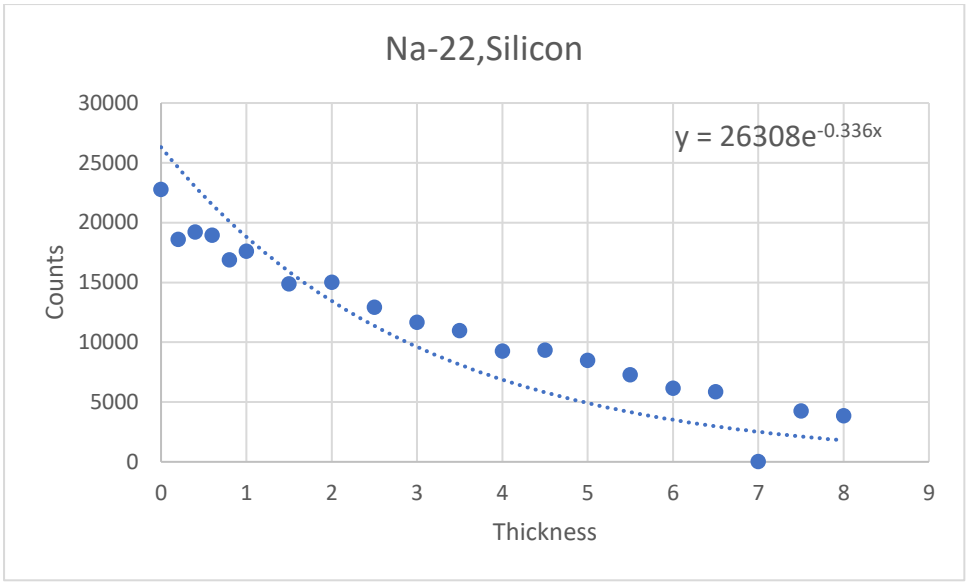
Observations and Calculations

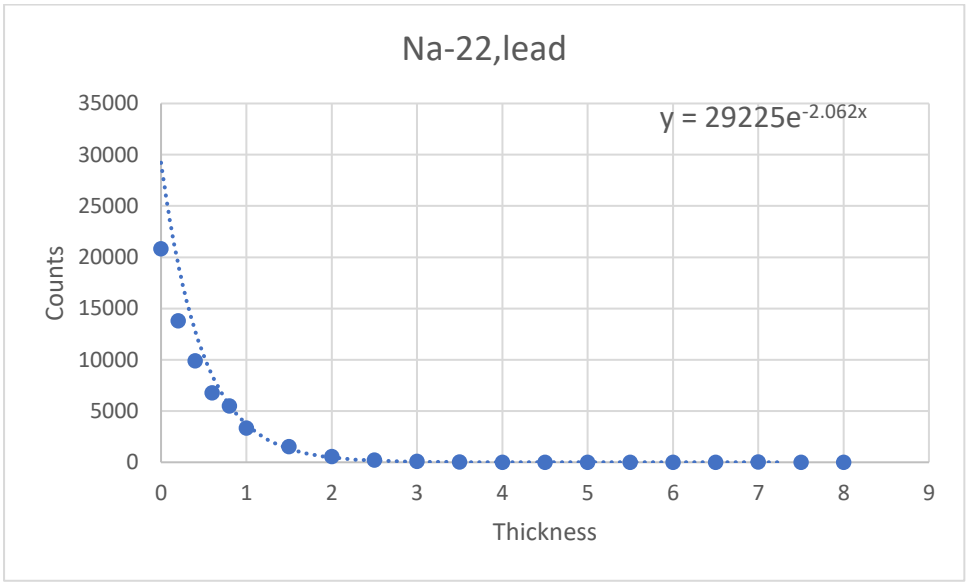
The Counts vs Absorber thickness plots obtained for the above source-absorber pairs are given below. The first element in the plots represent the source, while the second element is the absorber.

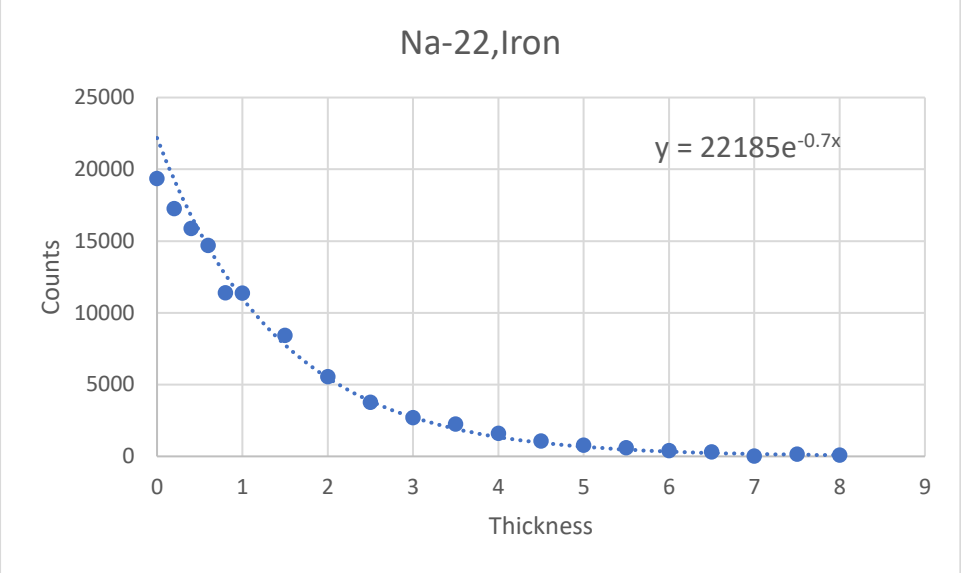


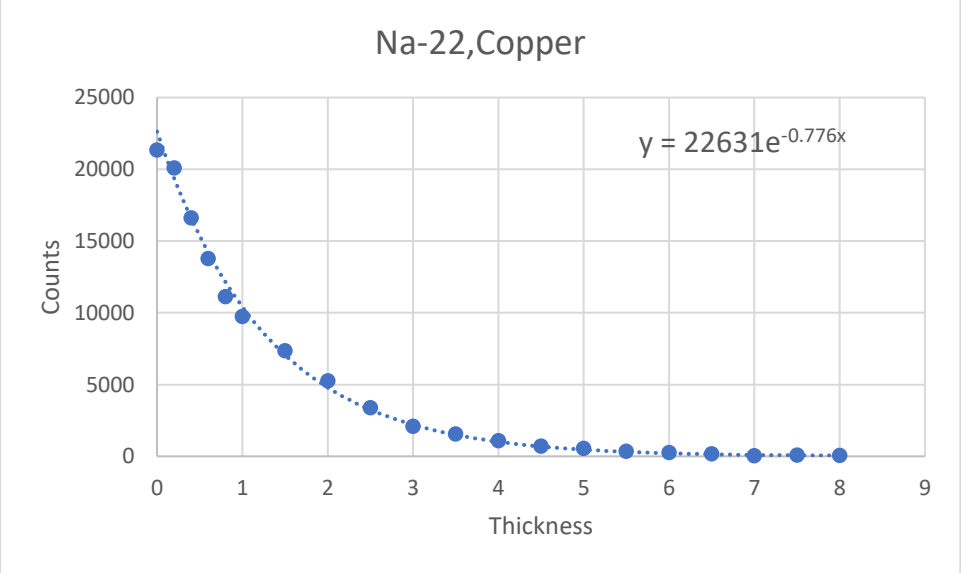

Co-60,lead
y = 19971e-0.647x
Counts
Thickness
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
8
9

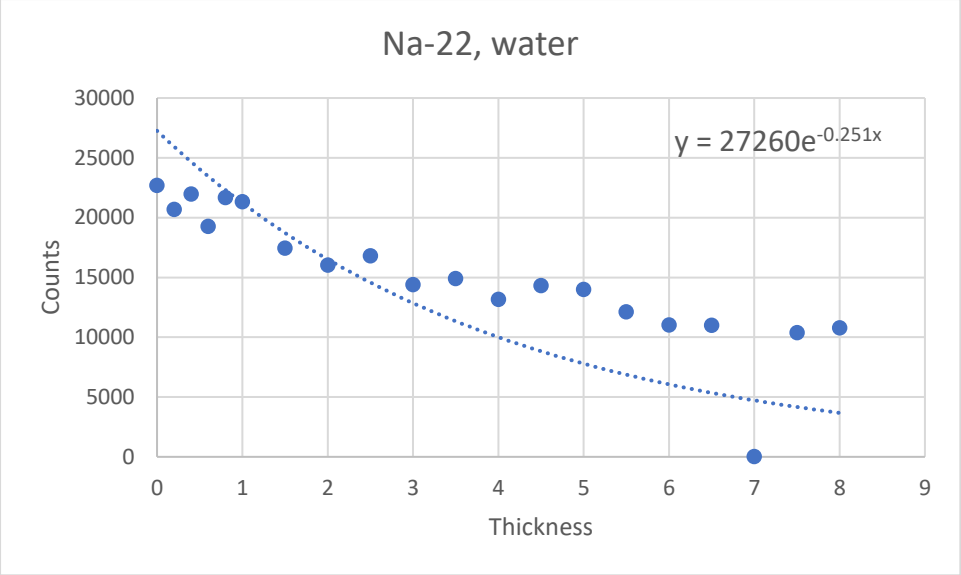

Na-24,lead
y = 23777e-0.568x
Counts
Thickness
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
8
9


Na-22,Silicon
y = 26308e-0.336x
Counts
Thickness
30000
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
8
9


Na-22,lead
y = 29225e-2.062x
Counts
Thickness
35000
30000
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
8
9


Na-22,Iron
y = 22185e-0.7x
Counts
Thickness
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
8
9


Na-22,Copper
y = 22631e-0.776x
Counts
Thickness
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
8
9



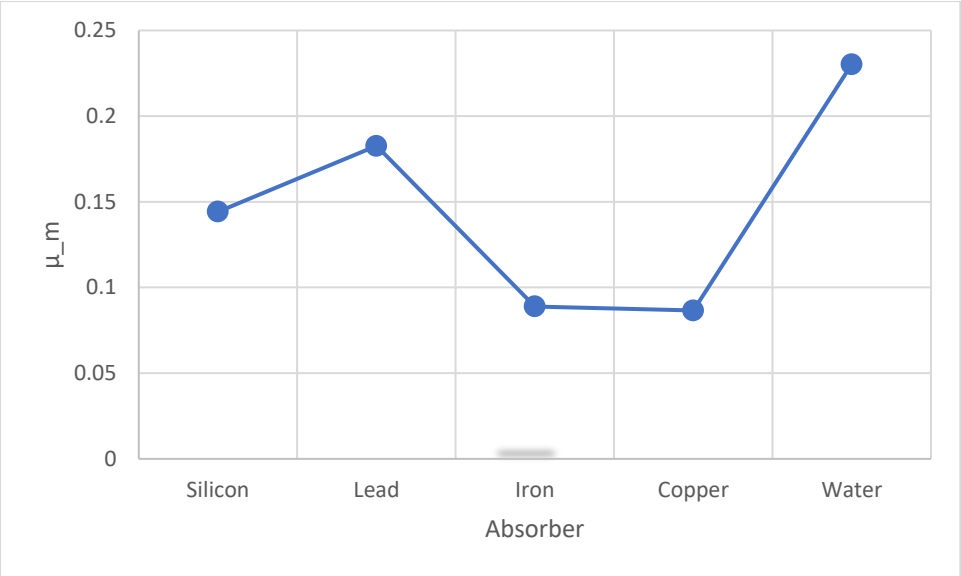
From the plots, the linear attenuation factor, μ is obtained from an exponential fit to the data points. The thickness of the material is denoted by r, and the mass attenuation factor, $\mu_m = \frac{\mu}{r}$

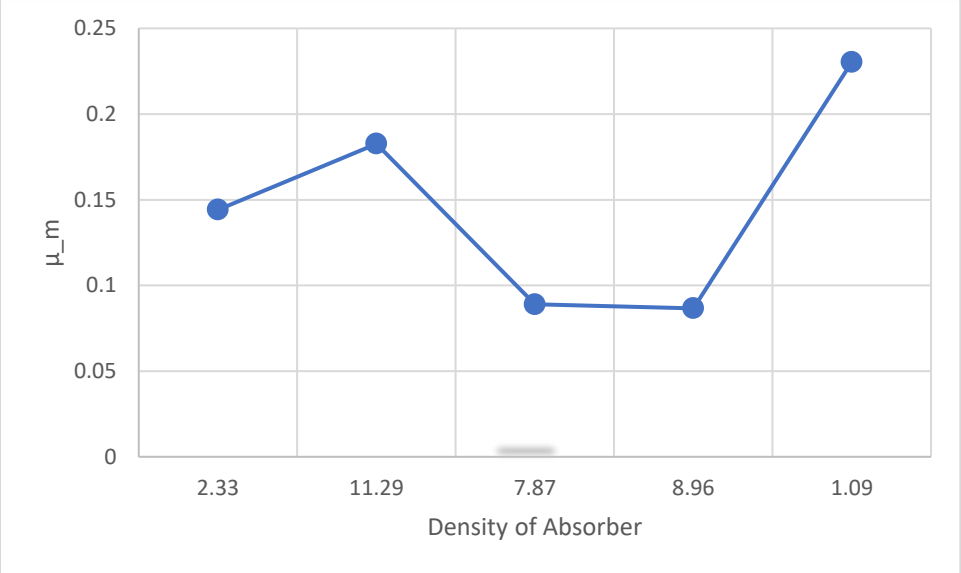
The values obtained for μ and μ_m are given below.

Source	Absorber	μ	r	$\mu_m = \frac{\mu}{r}$
CS-137	lead	2	11.29	0.138087
Co-69	lead	0.647	11.29	0.057307
Na-24	lead	0.568	11.29	0.05031
Na-22	Silicon	0.336	2.33	0.144206
Na-22	Lead	2.062	11.29	0.18264
Na-22	Iron	0.7	7.87	0.088945
Na-22	Copper	0.776	8.96	0.086607
Na-22	Water	0.251	1.09	0.230275

μ_m vs Absorber plot

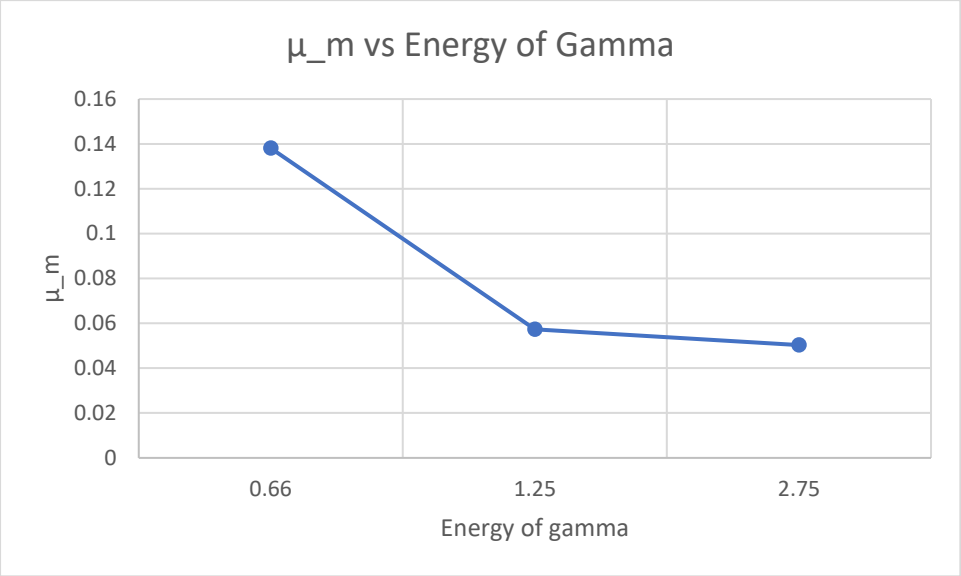
Source: Na-22





μ_m vs Energy of gamma plot

Absorber: Lead



Error Analysis

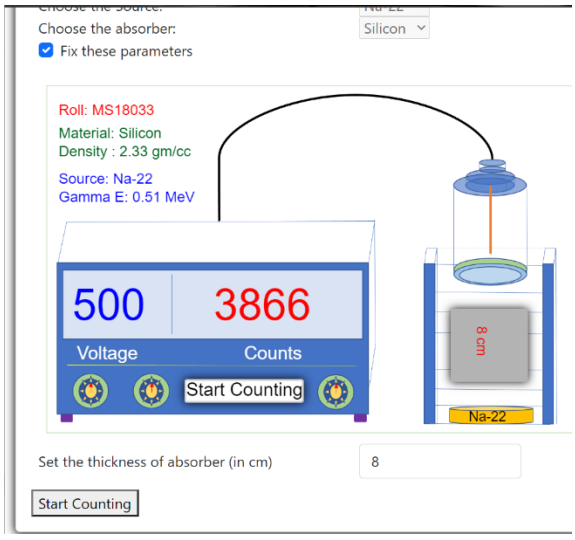
The error as a function of thickness is estimated by taking 5 different readings if count at each thickness.

- Source: Cs-137
- Absorber: Lead
- Density = 11.29 gm/cc
- E = 0.66 MeV

Thickness (in cm)	Counts	Counts	Counts	Counts	Counts	Mean	Std dev	Error %
0	19532	21112	23506	19560	19480	20638	1560.537	7.561476
0.2	17753	16126	18071	16731	15046	16745.4	1099.481	6.565871
0.4	12232	12604	13844	12385	11838	12580.6	679.4061	5.400427
0.6	10351	9059	9725	9501	10312	9789.6	491.7949	5.023647
0.8	8236	8117	7066	7811	7523	7750.6	422.8449	5.455641
1	5957	6346	5525	5684	5528	5808	311.6119	5.365219

1.5	3055	3061	3145	2873	2956	3018	94.03829	3.115914
2	1661	1598	1604	1525	1556	1588.8	46.20563	2.908209
2.5	810	922	903	803	894	866.4	49.78594	5.7463
3	474	490	493	449	412	463.6	30.15029	6.503514
3.5	221	248	237	255	245	241.2	11.63443	4.823562
4	130	134	136	113	131	128.8	8.182909	6.35319
4.5	67	64	68	69	67	67	1.67332	2.497493
5	35	34	31	32	32	32.8	1.469694	4.480774
5.5	17	19	18	19	18	18.2	0.748331	4.111711
6	9	8	9	8	8	8.4	0.489898	5.832118
6.5	3	4	4	3	4	3.6	0.489898	13.60828
7	300	300	300	300	300	300	0	0
7.5	1	1	1	1	1	1	0	0
8	0	0	0	0	0	0	0	0

Snapshot of data collected



Results

Counts were obtained as a function of thickness for different sources and absorbers, and the linear attenuation factors were obtained. Error Analysis was also done for error as a function of absorber thickness.