**COMPTON SCATTERING EXPERIMENT – SAMPLE RAW DATA (March 2020)**

The following is a set of raw data obtained using the experimental set-up described in the handouts. **Please make sure you mention the use of these data at the start of your report.** For the second part of the experiment, based on the paper by Jolivette and Rouze (1994), please note that you are only expected to carry out the analysis described in section II of the paper (i.e. Monte Carlo simulations described in part III are not done!). A document is attached explaining the basis of gamma detection using a NaI detector, and the different components of the observed gamma spectrum.

**Part 1 – Compton scattering formula and differential cross section**

The requirements for this experiment are described in detail in the handout provided (Compton scattering Experiment). Essentially, gamma rays from a Cs-137 source are scattered by the electrons in an aluminium rod (scattering rod) and the energy of the scattered gamma rays measured against the angle of scattering to verify Compton scattering formula. The acquired spectrum for a particular angle is analysed and measurements taken of the net area under the so-called photopeak, which is proportional to the number of gamma rays arriving to the detector at that angle.

|  |  |  |  |
| --- | --- | --- | --- |
| **Angle (θ)** | **Counting time (s)** | **Energy of scattered gamma ray, E’γ (keV)** | **Net area under photopeak** |
| 20 | 158.56 | 597 ± 56 | 12616 ± 343 |
| 25 | 221.78 | 573 ± 65 | 15240 ± 430 |
| 30 | 290.38 | 549 ± 55 | 17925 ± 456 |
| 35 | 208 .42 | 518 ± 50 | 10484 ± 368 |
| 40 | 318.50 | 487 ± 54 | 15680 ± 467 |
| 45 | 307.54 | 470 ± 55 | 13043 ± 437 |
| 50 | 390.84 | 439 ± 54 | 14791 ± 499 |
| 55 | 706.66 | 416 ± 52 | 24188 ± 598 |
| 60 | 446.52 | 390 ± 49 | 14105 ± 474 |
| 65 | 466.00 | 371 ± 44 | 14757 ± 460 |
| 70 | 359.30 | 348 ± 41 | 10067 ± 393 |
| 75 | 713.38 | 332 ± 38 | 19027 ± 470 |
| 80 | 467.74 | 316 ± 37 | 11828 ± 383 |
| 85 | 420.62 | 300 ± 35 | 10227 ± 347 |
| 90 | 3029.70 | 284 ± 35 | 73551 ± 1082 |

For the calculation of the differential cross section, you will need the following additional data:

**(1) Intrinsic peak efficiency of NaI detector:**

To determine the intrinsic peak efficiency of the detector, use the formula:

0.1522 x (E’γ)–1.1325

where the energy of the scattered gamma ray is expressed in MeV.

**(2) Intensity of the Cs-137 source:**

To calculate the intensity of the source, use the following formula:

I = 1.013 x 106 e–*t*/43.48 cm–2 s–1

where *t* is the time (in years) elapsed since the source was purchased in August 1977 and March 2020.

**(3) Solid angle subtended by detector:**

To calculate the solid angle subtended by the detector, you will need the area of the entrance window for the detector, which is a circular aperture of radius *r*, and the distance from the detector to the scattering rod (*Rd*)

Radius of detector *r* = 1 cm

Distance from detector to scattering rod *Rd* = 26 cm

**(4) Number of electrons in the scattering rod:**

To calculate the number of electrons in the scattering rod, which is made of aluminium, you will need the mass *m* of the rod

Mass *m* = 79.3 g

*[Note: The order of magnitude of the experimental cross-section and its shape should be ok, but do not worry if its appears to be a factor of ~7 times lower than the predictions of the Klein-Nishima formula]*

**Part 2 – Compton scattering, electron mass and relativity**

In this second part, a high-purity germanium detector (HPGe) is used to measure the photopeaks and Compton edges for a number of gamma-emitting sources. The analysis allows to examine some relativistic relations and to determine the rest mass of the electron. Use is made of a HPGe detector because of its higher resolution compared with the NaI detector used in the first part. The following is a set of raw data obtained by counting different sources in the detector:

|  |  |  |
| --- | --- | --- |
| **Source** | **Photopeak Eγ**  **(keV)** | **Compton edge T (keV)** |
| Na-22 | 510 ± 2 | 338 ± 6 |
| Na-22 | 1275 ± 2 | 1062 ± 10 |
| K-40 | 1457 ± 2 | 1240 ± 7 |
| Mn-54 | 833 ± 2 | 637 ± 4 |
| Co-56 | 1236 ± 2 | 1025 ± 5 |
| Co-57 | 123 ± 2 | 39 ± 3 |
| Co-60 | 1173 ± 2 | 963 ± 5 |
| Co-60 | 1332 ± 2 | 1118 ± 4 |
| In-116 | 417 ± 2 | 263 ± 6 |
| In-116 | 1098 ± 2 | 890 ± 10 |
| In-116 | 1293 ± 2 | 1076 ± 5 |
| Ba-133 | 355 ± 2 | 204 ± 4 |
| Cs-137 | 662 ± 2 | 474 ± 10 |
| Bi-207 | 570 ± 2 | 390 ± 2 |
| Bi-207 | 1063 ± 3 | 857 ± 8 |
| Tl-208 | 2613 ± 3 | 2379 ± 4 |