Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 **Published:29/12/2025** **Accepted: 18/01/2026**

Backscattering Behavior of Beta Particles as a Function of Material Properties: Effects of Atomic Number and Material Thickness

Zineb Muftah Elswayeb
Department of physics Education faculty, Misurata University, Misurata, Libya
Zineeee1@gmail.com

Abstract

The aim of the research is to measure the relationship between the backscatter of beta particles and the atomic number and thickness of the scattering material. To accomplish this, we experimented with different materials in kind and thickness including aluminum (Al), iron (Fe), and lead (Pb) and thickness of 5 mm, 10 mm, and 15 mm. Beta particles when interacting with the surface of a substance are scattered at a wide angle. When the angle of scattering is 180 degrees, it is known as backscattering. The measured backscattering coefficient according to the findings is positively correlated with the atomic number of the target material, and increases with the atomic number of the target material and the atomic number of the material, and with the thickness of the material. The increase was not however linear. Rather, the coefficient rose sharply with the increase of the thickness to a saturation level at which the backscatter was not strongly influenced by the increasing thickness anymore. This was realized in the samples of the aluminum of varying thicknesses whereby the value of the backscattering coefficient increased with the thickness of the material approaching to the saturation value of the material. This is saturated in the saturation thickness which is approximately 2. 0 cm thick (5. 4 g/cm ^{2}).

This nonlinear increase is necessary in the study of the use of different materials in radiation physics. As an example, the atomic number of lead is greater; hence it backscatters much more than aluminum and other materials with a lower atomic number. Also, the findings of the study show that there is an optimal thickness of each substance and beyond that thickness there is no substantial increase in backscatter.

Key words: Beta Backscattering, Backscattering coefficient, Dependence on Atomic Number, Dispersion, Saturation Thickness and Thickness-meter.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

سلوك التشتت الخلفي لجسيمات بيتا كدالة لخصائص المادة: تأثير العدد الذري وسُمك المادة

زينب مفتاح السويب

قسم الفيزياء، كلية التربية، جامعة مصراتة، مصراتة ،ليبيا.

ملخص البحث

هدف البحث هو قياس العلاقة بين التشتت الخلفي لجسيمات بيتا والعدد الذري والسُمك للمادة المشتتة. لتحقيق ذلك، أجرينا تجارب باستخدام مواد مختلفة من حيث النوع والسُمك، بما في ذلك الألمنيوم(Al) ، والحديد(Fe) ، والرصاص (Pb)، وبسماكات 5 مم، 10 مم، و15 مم. عندما تتفاعل جسيمات بيتا مع سطح مادة ما، فإنها تتشتت بزاوية واسعة. وعندما تكون زاوية التشتت 180 درجة، يُعرف ذلك بالتشتت الخلفي. ووفقًا للنتائج، فإن معامل التشتت الخلفي المقاس يرتبط ارتباطًا إيجابيًا بالعدد الذري للمادة الهدف، ويزداد مع العدد الذري للمادة الهدف، وكذلك مع سُمك المادة، ومع ذلك لم يكن هذا الازدياد خطيًا؛ بل ارتفع المعامل بشكل حاد مع زيادة السُمك حتى مستوى التشبع، حيث لم يعد التشتت الخلفي يتأثر بشكل كبير بزيادة السُمك. وقد تحقق ذلك في عينات الألمنيوم ذات السماكات المختلفة، حيث زادت قيمة معامل التشتت الخلفي مع زيادة سُمك المادة مقتربة من قيمة التشبع للمادة. ويحدث هذا التشبع عند سُمك تشبع يقارب 2.0 سم (5.4 جم/سم^2).

هذه الزيادة الغير خطية ضرورية في دراسة استخدام المواد المختلفة في فيزياء الإشعاع. على سبيل المثال، العدد الذري للرصاص أكبر؛ وبالتالي فإنه يعكس الإشعاع للخلف أكثر بكثير من الألمنيوم والمواد الأخرى ذات العدد الذري الأقل. كما تظهر نتائج الدراسة أن هناك سُمكاً مثالياً لكل مادة، وما بعد هذا السُمك لا يوجد زيادة كبيرة في الانعكاس الخلفي.

الكلمات المفتاحية:

التشتت الخلفي لبيتا، معامل التشتت الخلفي، الاعتماد على العدد الذري، التشتت، سُمك التشبع، سُمك المادة .

1. Introduction

The identification of the relationship between the material thickness and the backscattering of the beta particles is the step forward in the sphere of radiation physics. The given research does not only perfect theoretical constructs but also improves the practical uses, as it gives a more in-depth understanding of the backscattering mechanisms. The implications are very wide-reaching which includes better calibration of radiation detectors, design of more efficient shielding and proper radiation dosimetry. The work will not only add to the academic literature but it will also provide students and researchers in nuclear and medical

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

physics with useful information, which will result in better and more efficient use of radiation in any field.

Beta particles are high-energy electrons or positrons emitted during the radioactive decay process and can react with matter through the inelastic collisions and scattering. Backscattering, which is defined as the deflection of the beta particles at angles greater than 90 degrees with regard to the incident trajectory, is of vital importance in the radiation detection, shielding design, and dosimetric services. The degree of backscattering is proportional to a number of variables, among which the atomic number (Z) of the material used and its thickness. This dependence is of great importance both in theoretical modelling of radiation- matter interactions and in practical applications in medical physics, nuclear industries and radiation safety. The β particles have several processes of interaction with matter. Their dispersion may be due to a collision with atomic nuclei or with the surrounding electrons of the scattering material or a combination of both. The greatest interaction is that which takes place with atomic nuclei. In the course of more than 100 years ago, the English physicist Ernest Rutherford found out that scattering was the effect of the electrostatic forces between negatively charged β particles, and positively charged nuclei of atoms. This is an elastic interaction, that is, no kinetic energy is lost and hence the β particle does not change its speed, however, because of the relatively low mass of the β particle, its course is deflected significantly (Süvegh, & Homonnay,).

2. The research Problem

Despite the fact that a substantial literature has been published on the topic of beta-particle interactions with matter, little quantitative information has been provided that defines the simultaneous effect of atomic number and material thickness on backscattering intensity. Such shortage of narrow data makes precise predictions of patterns of energy deposition and detector responses difficult, particularly in environments that need strict quantification of radiation. Based on this, systematic research is justified in order to clarify the extent of such dependencies.

3. Aim of the Study

This study aims to investigate the dependence of beta particle backscattering on two key variables:

1. The atomic number of the scattering material.
2. The thickness of the scattering material.

By quantifying this relationship, the study will contribute to refining theoretical models and improving practical applications in radiation physics.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

4. Significance of the Study

Scientific Contribution: Provides a clearer understanding of the mechanisms governing beta particle backscattering.

Practical Applications: Improves calibration of radiation detectors, enhances shielding design, and supports accurate radiation dosimetry.

Educational Value: Offers experimental and theoretical insights valuable for students and researchers in nuclear physics and medical physics.

5. Previous Studies

The interaction of beta particles with matter has been a subject of extensive research, particularly concerning the backscattering phenomena that depend on the atomic number (Z) and thickness of the scattering material. Early studies, such as those by McKinley and Feshbach (1948), established foundational theories regarding the scattering of charged particles, providing a framework for understanding how beta particles interact with various materials. Their work highlighted the importance of both material composition and geometry in determining scattering outcomes.

Subsequent research expanded on these principles, with notable contributions from Kahn (1956), who investigated the energy loss of beta particles in different materials, emphasizing the role of atomic number in influencing scattering behavior. Kahn's findings indicated that higher atomic number materials tend to exhibit greater backscattering due to increased interaction cross-sections, a concept further elaborated by Haff and Haff (1971) in their exploration of beta particle backscattering as a function of material thickness.

Recent studies have employed advanced computational methods to model the backscattering of beta particles. For instance, the work by Ranjit et al. (2019) utilized Monte Carlo simulations to analyze the dependence of backscattering on varying atomic numbers and material thicknesses, yielding results that corroborate earlier theoretical predictions while providing new insights into the intricacies of particle interactions at different energy levels.

Moreover, the investigation of backscattering effects has implications for radiation protection and medical applications, as discussed by Beddar et al. (2014). Their research underscores the necessity of understanding backscattering in the design of shielding materials and in optimizing therapeutic protocols in radiation oncology.

Recent advances in the field have been on improved modeling methods and experimental methods to accurately describe the backscattering coefficient as a function of atomic number and thickness. An example of a generalized Monte Carlo is a model of electron backscattering behavior of normally incident beam up to 30 keV on thin film targets, which explicitly

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

includes the atomic number as well as the thickness, and can be used to determine the critical thickness at which the thin films participate in the same backscattering as semi-infinite solids. The model has been demonstrated to be in great agreement with experimental and theoretical data, with a powerful tool to assess the surface property of thin films (Betka, Bentabet et al., 2022). Multilayer detector structures have also been investigated more recently, where it is shown that by placing an additional 100200um thick metal film (Cu or Pb) under the sensitive volume of a CdTe detector, the fraction of reflected electrons is further enhanced, particularly at low energy (100200 keV), and that the dependence of the thickness of a backscattering coefficient of a thin film is saturated at thicknesses greater than the electron ranges themselves due to the large-angle scattering (Akbari, Shvydka et al., 2022). Moreover, low-Z top layers that are used in realistic thicknesses (tens of micrometers) have been demonstrated to partially recombine electrons with the semiconductor layer, increasing the signal intensity of thin-film detectors (Akbari, Shvydka et al., 2022).

Recent theoretical modeling developments have incorporated the utilization of current Monte Carlo simulations and relativistic dielectric functional techniques to calculate electron inelastic cross sections, in which the datasets of optical energy loss functions (ELF) have a significant impact on the derived backscattering coefficient (Imtiaz, Khan et al., 2024). These investigations point to the significance of clean surfaces or sound theoretical computations with correct optical constants since contamination may bring up considerable systematic errors in experimental data (Imtiaz, Khan et al., 2024).

Also, there has been a mathematical model established to correlate detector signal intensity with the effective atomic number of alloys that has been confirmed by experimental data of twelve materials, and that predicts alloy atomic number within one unit of its ELO intensity (Gardfjell, Reith et al., 2023). All these new results and methods contribute to the accuracy and usefulness of measurements and modeling of the backscattering coefficient in thin films and multilayer designs, which directly relate to radiation detector development and the characterization of materials.

In summary, the literature indicates a clear correlation between the atomic number and thickness of scattering materials and the extent of beta particle backscattering. Continued exploration in this domain is essential for advancing both theoretical models and practical applications in radiation science.

6. Beta Particles Backscattering.

Beta particle striking the coating layer would be interacting in the orbital electrons and due to equal mass one can transfer a large percentage of its kinetic energy in a single collision.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

The absorbance of the beta particles in a restricted area is exponentially dependent on the thickness of the thin layer (Katz, & Penfold, 1952).

The beta emitter strontium-90 is a directionless emitter as shown in Figure1. A Geiger counter has the ability to detect some of the emitted particles and a backscattering material can be used to increase the number of particles that are detected by placing it behind the source to scatter some of the initially emitted particles towards a direction not facing the counter.

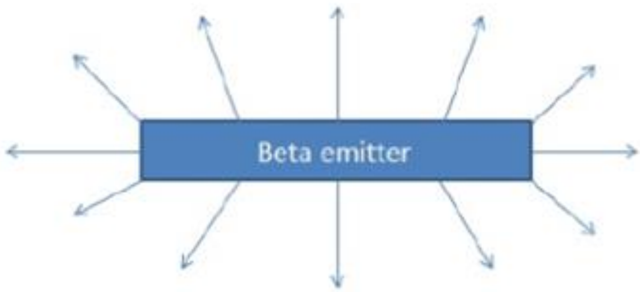

Figure1: The beta emitter emits beta particles in all directions.

7. Backscattering Theory.

When the beta particle is penetrating the material, it may be deflected by hitting the nuclei of the material in the material. These deflections highly rely on the initial energy of the incident beta particle and in most cases the beta particle is deflected is positioned appropriately with regard to the nucleus and thus the particle can be deflected at an approximate of 180 degrees (Galloway, 1994). The probability of the backscattering of the beta particles is mainly influenced by the density of electron, which was directly proportional to: (a) the atomic number and (b) the mass density of the target matter. It has been experimentally demonstrated that the strength of the backscattered radiation is determined by the thickness of the coating layer and saturation value is dependent on the atomic number of the coating component (Arjhangmehr, et al., 2014).

8. Saturation thickness.

In the case that the beta particles (electrons or positrons) are sent to a material like aluminum, the heavier the thickness of the material, the higher the probability of some particles being reflected, scattered or absorbed. However, after a certain thickness, extra increase does not have a significant effect on the amount of backscattering or reflection, that is, a backscattering saturation effect is attained. This thickness which practically gives the approximate maximum of the backscattering coefficient is known as the saturation thickness (L'vova, & Bochkarev, 1965).

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

9. Methodology and Procedures

The experimentation design of this work is illustrated in Figure2. In a position where the absorbent material is facing the most radioactive side of the radioactive element (Sr^{90}). Geiger-Muller counter is adjusted to 60sec. The radioactive element of beta is put without an absorbent material to determine the quantity of radiations. Back count (n_0) is called in this case.

During the initial section of the measurements, a number of elements of the same thickness

were chosen (Pb, Fe, Al). The thickness (5, 10 and 15 mm) of each slide was used in our measurement. Next a counter reading is made and denoted in this instance by the back count rate with absorbent material (n_b) and the remaining process continued with the remainder of the metal segments and each thickness.

In the second section of the measurements, we used Aluminum slides of thickness (0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4 and 4.5cm) and repeated the steps followed during the first part.

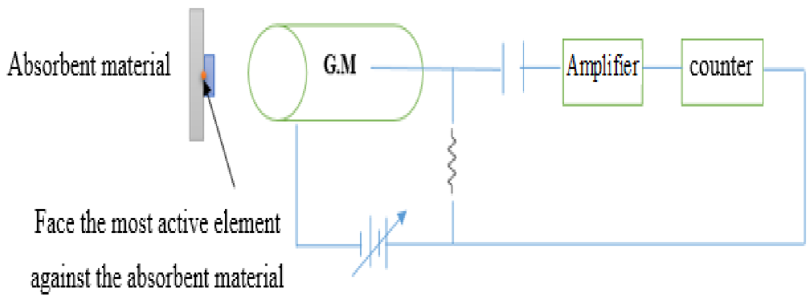

Figure 2: Measurement System Model.

10. Results and Discussion

The findings made in the current research are useful information concerning how the thickness of the backscattering material affects the counting rates and backscattering elements of different nuclides. The systematic analysis of three types of thickness (5 mm, 10 mm, and 15 mm) shows significant differences in the rates of counting corrections and factors of backscattering on aluminum (Al), iron (Fe) and lead (Pb) that are important to have in the area of radiation detection and measurement. The computation of the backscattering coefficient is done by each time of taking the counter reading using:

$$f_b = \frac{n_b}{n_0} \quad (1)$$

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

Table 1 depicts the back count, which is the count of the backscattering without the absorbing material, the rate of the count of different materials with the atomic number (13, 26 and 82) at the thickness (5, 10, 15 mm).

Table 1: Exhibits beta scattering ratio among the various materials in type and thickness.

Backscattering material thickness (Δx =5mm)				
Nuclide IPL	Atomic number	Background counting(n_o) (count/min)	Correction counting rate (n_b)	Backscattering Factor
Al	13	0.378	0.083	0.219
Fe	26		0.155	0.410
Pb	82		0.361	0.953
Backscattering material thickness (Δx =10mm)				
Nuclide IPL	Atomic number	Background counting(n_o) (count/min)	Correction counting rate (n_b)	Backscattering Factor
Al	13	0.378	0.099	0.263
Fe	26		0.194	0.512
Pb	82		0.411	1.085
Backscattering material thickness (Δx =15mm)				
Nuclide IPL	Atomic number	Background counting(n_o) (count/min)	Correction counting rate (n_b)	Backscattering Factor
Al	13	0.378	0.105	0.278
Fe	26		0.211	0.557
Pb	82		0.449	1.188

Plotting the relationship between the backscattering coefficient of beta particles and the atomic number of the materials used at the specified thickness, as illustrated in Figure 3, and applying a linear fit to the data, gives us the following equation to compute the backscattering coefficient as a function of the atomic number at the specified thickness:

$$f_b = a\,Z + b \qquad (2)$$

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

Where: f_b is the experimentally measured backscattering coefficient and (a, b) is constants of any given atomic number at the same thickness as shown in Table 2.

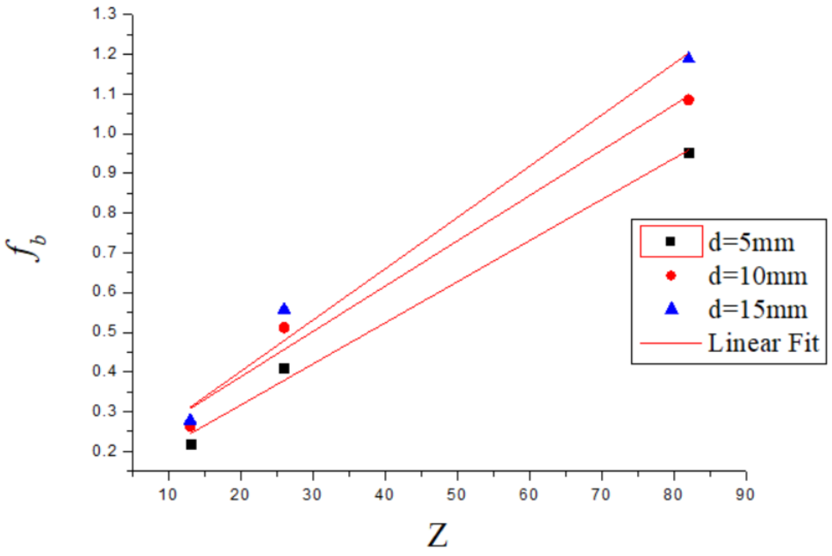

Figure 3: Shows the correlation between the backscattering coefficient of beta particle and the atomic number of slides (Al, Fe, Pb) versus the thickness (5, 10, 15 mm).

Table 2: Values of constants (a, b) according to atomic number and thickness.

Z	Δ*x(mm)*	a	b
13			
26	5	0.0104	0.1096
82			
13			
26	10	0.0114	0.1597
82			
13			
26	15	0.0129	0.1432
82			

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

Using Equation 2 and the constant values (a) and (b) from Table 2, the backscattering coefficient for beta particles can be calculated for any atomic number at thicknesses of 5, 10, and 15 mm, as shown in Figure 4.

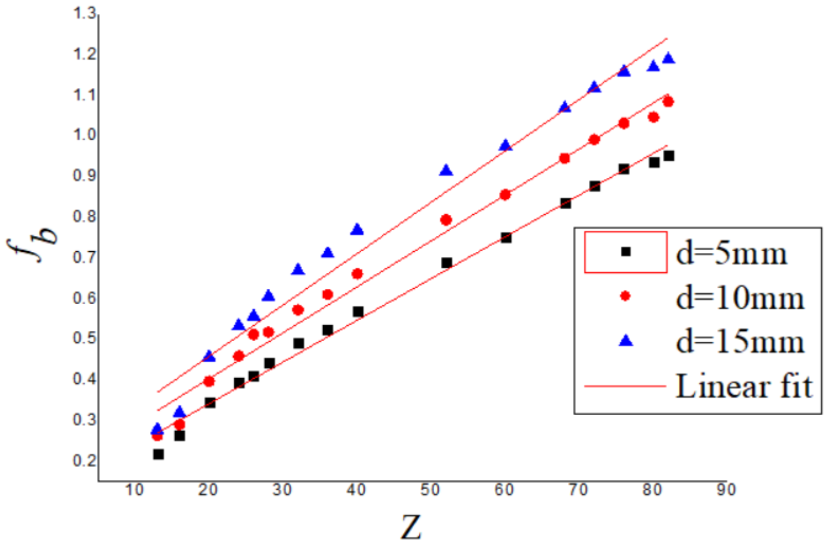

Figure 4: shows the relationship between the calculated and measured values of the backscatter coefficient with changes in the atomic number according to variations in material thickness.

The data shows that there is a steady trend in all the materials examined in that the backscattering material thickness is directly related to the increase in the backscattering factor as in Figure 3. This is very noticeable in the example of lead with the backscattering factor increasing from 0.953 at 5 mm to 1.188 at 15 mm. This high atomic number and high density enable the lead to greatly increase the backscattering factor of this material, which is able to reflect the incident radiation that is directed to a detector. The effect of this phenomenon highlights the significance of the material composition and thickness in terms of the detection efficiency.

By contrast aluminum, which has a lower atomic number is less boastful of its increase in the backscattering factor, between 0.219 at 5 mm and 0.278 at 15 mm. This implies that although aluminum is a contributor of backscattering, it is much less effective as compared to the heavier metals such as lead. The results emphasize the importance of careful choice of materials depending on their atomic characteristics when developing a system used to detect radiations, more so in cases where the measurements have to be very precise.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

The same tendency can be observed in the behavior of iron, whose atomic number is intermediate, but the values of the backscattering factors are rising between 0.410 at 5 mm and 0.557 at 15 mm. Iron results also help to highlight this point which is that the atomic number is related to the backscattering efficiency and so an increase in the atomic number implies an increase in the ability of the material to backscatter radiation.

On plotting the dependence between the relationship of the backscattering coefficient of beta particles and material thickness in terms of the atomic number (Z), we get Figure 5. On doing an exponential fit to this data we derive an empirical formula through which we can compute the backscattering coefficient of beta particles as follows:

$$f_b = a(z)e^{b(z)\Delta x} \tag{3}$$

Where a (z) and b (z) are constants for a given atomic number, Δ x is the thickness of the material as shown in Table 3.

The values of the constant a (z) change linearly with the atomic number, while the constant b (z) changes markedly as shown in Figure 6.

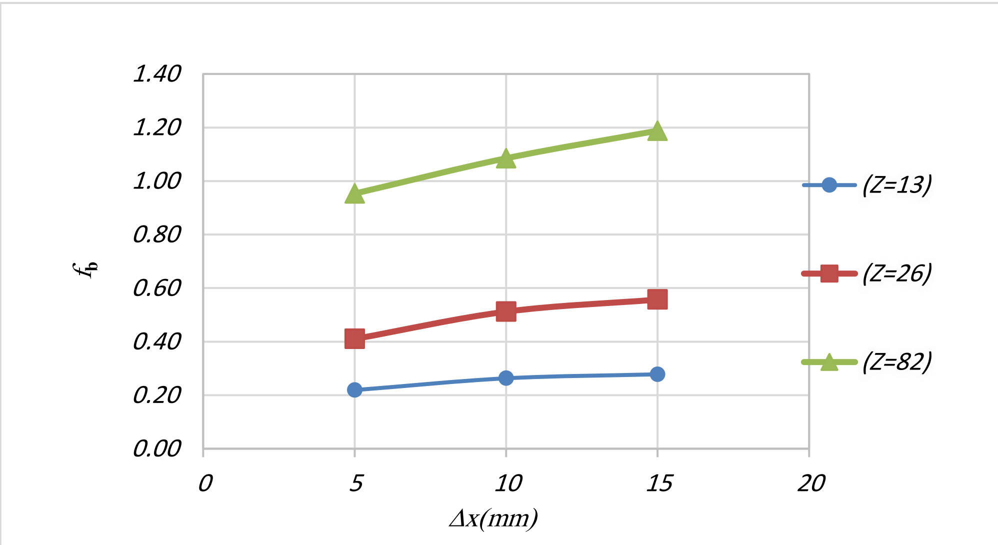

Figure5: Represents the change in backscattering coefficient of beta particle with the thickness of the material.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 **Published:29/12/2025** **Accepted: 18/01/2026**

Table 3**:** Values of constants (*a*, *b*) according to atomic number.

Δx(mm)	Z	a	b
5	13	0.1986	2.3855
10			
15			
5	26	0.3599	3.0641
10			
15			
5	82	0.8591	2.2041
10			
15			

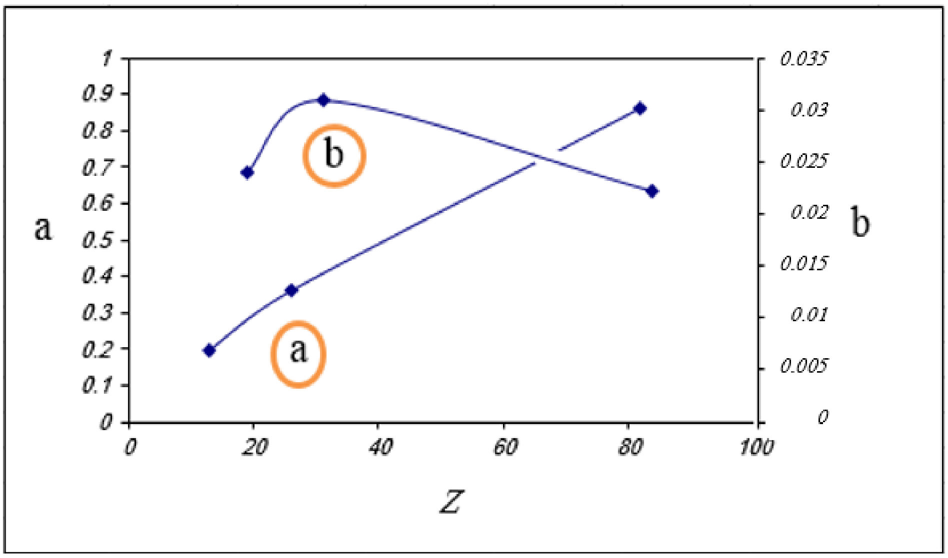

Figure 6: represents the change in constant values (a) and (b) with the atomic number.

Based on Figure 6, we get the values of the constants (a) and (b) of any atomic number, as indicated in Tables 4,5 and 6. Based on these data, one can readily compute the backscattering coefficient of beta particles at any thickness and also at any atomic number by use of the Equation (3) shown in Figure 7.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

Table 4: Calculated values of the backscattering coefficient of beta particles at each atomic number are indicated at 5 mm thickness.

Δx =5mm			
Atomic number	a	b	Backscattering Factor ($f_b = a(z)e^{b(z)\Delta x}$)
16	0.240	0.026	0.273
20	0.3	0.03	0.349
24	0.34	0.031	0.397
28	0.38	0.031	0.444
32	0.42	0.03	0.488
36	0.45	0.03	0.523
40	0.49	0.029	0.566
52	0.6	0.027	0.687
60	0.66	0.026	0.752
68	0.74	0.024	0.834
72	0.78	0.024	0.879
76	0.82	0.023	0.919
80	0.84	0.022	0.938

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

Table 5: Calculated values of the backscattering coefficient of beta particles at each atomic number are indicated at 10 mm thickness.

Δx =10mm			
Atomic number	a	b	Backscattering Factor ($f_b = a(z)e^{b(z)\Delta x}$)
16	0.240	0.026	0.311
20	0.3	0.03	0.405
24	0.34	0.031	0.464
28	0.38	0.031	0.518
32	0.42	0.03	0.567
36	0.45	0.03	0.607
40	0.49	0.029	0.655
52	0.6	0.027	0.786
60	0.66	0.026	0.856
68	0.74	0.024	0.941
72	0.78	0.024	0.992
76	0.82	0.023	1.032
80	0.84	0.022	1.047

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

Table 6: Calculated values of the backscattering coefficient of beta particles at each atomic number are indicated at 15 mm thickness.

Δx =15mm			
Atomic number	a	b	Backscattering Factor ($f_b = a(z)e^{b(z)\Delta x}$)
16	0.240	0.026	0.354
20	0.3	0.03	0.470
24	0.34	0.031	0.541
28	0.38	0.031	0.605
32	0.42	0.03	0.659
36	0.45	0.03	0.706
40	0.49	0.029	0.757
52	0.6	0.027	0.899
60	0.66	0.026	0.975
68	0.74	0.024	1.061
72	0.78	0.024	1.118
76	0.82	0.023	1.158
80	0.84	0.022	1.168

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

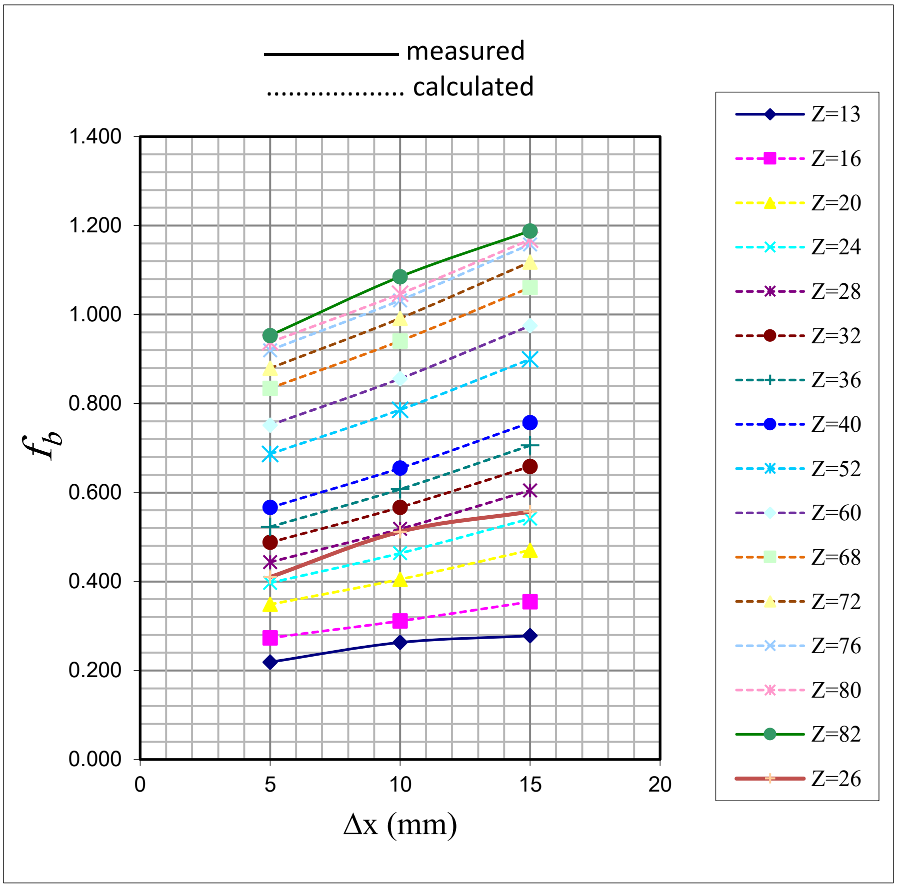

Figure 7: shows the relationship between calculated and measured backscattering coefficient values with the change in the thickness of the material according to the change in atomic number.

The results presented in the table 7 concerning the backscatter coefficient of beta particles in relation to the areal thickness of aluminum foils provide significant insights into the interaction of beta radiation with matter. The data indicates a clear trend in the backscattering factor as a function of the aluminum foil thickness, revealing important implications for radiation shielding and detection applications.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

Table 7: Determination of Backscattering Factor of beta rays using aluminum sheets of different thicknesses. Where the mass of matter (ρ) =2.70 gm/cm^3

material thickness (cm)	Background counting(n_o) (count/sec)	Correction counting rate (n_b)	Backscattering Factor	Area thickness (d_m= ρ. Δx) gm/cm^2
0.5	0.378	0.083	0.219	1.35
1		0.099	0.263	2.7
1.5		0.105	0.278	4.05
2		0.133	0.351	5.4
2.5		0.105	0.278	6.75
3		0.116	0.307	8.1
3.5		0.100	0.264	9.45
4		0.100	0.264	10.8
4.5		0.089	0.264	12.15

The illustrations of the results in Figure 8 that reveal the relationship between the beta backscattering factor and the thickness of the aluminum foils, indicate that the backscattering factor rises slowly with the increase in the thickness until it reaches a peak value with the thickness of about 2.0 cm, which corresponds to the areal thickness of 5.4 g/cm ^{2}. At a further point, the point of backscattering is almost constant with values in the range of 0.26 -0.28 which means that the aluminum has reached its saturation thickness.

Physically, this behavior can be attributed to noting that at small thicknesses, there is a few scattering interactions between beta particles in the material with the majority of particles going through without much energy loss. The thickness becomes larger the more likely are the scattering events to occur owing to more atomic collisions, and the number of particles reflected backwards increases. But with further increase in thickness, then extra layers do not add much to the process of backscattering as most of the beta particles exhaust their kinetic energy prior to returning to the surface. The scattering therefore increases up to a saturation point at which point no additional increase is perceived.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

Thus, the thickness of aluminum, which is saturated by the beta particles in this research is experimentally defined as approximately 2.0 cm (5.4 g/cm ^{2}), beyond which the intensity of the radiation reflected back is nearly the same.

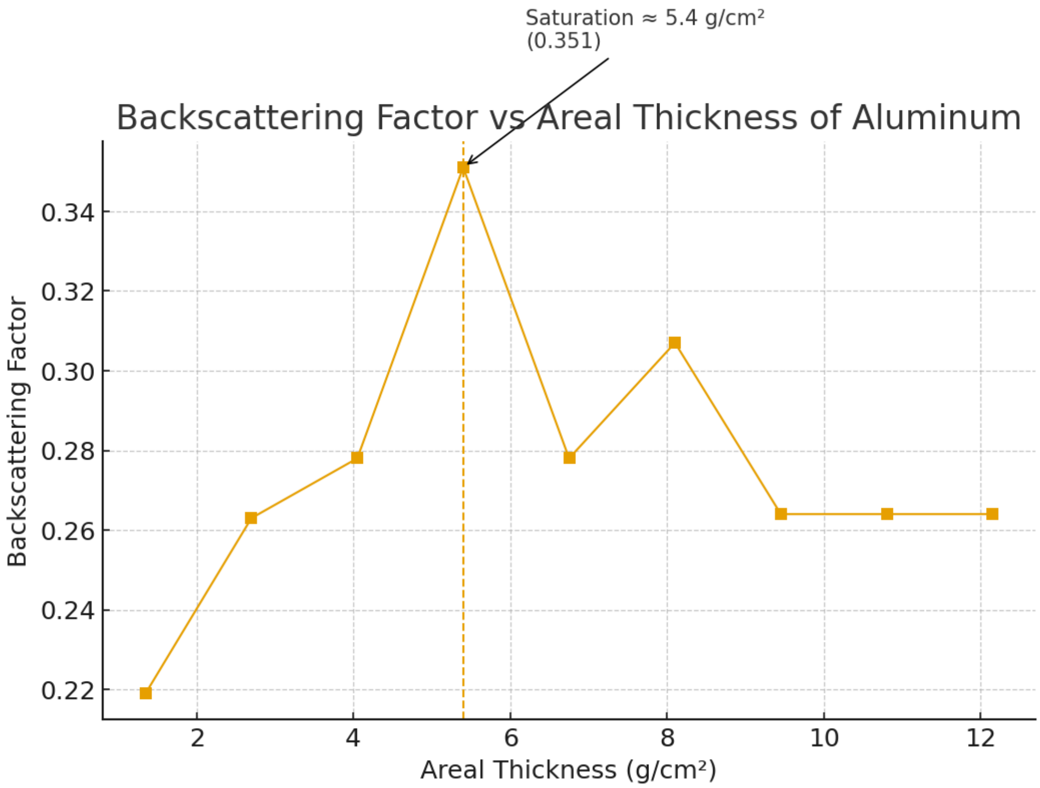

Figure8: Variation of Backscattering Factor with Areal Thickness of Aluminum.

11. Conclusion

1. Lead has the greatest value of backscattering coefficient then iron and finally aluminum. This shows that the backscattering is directly proportional to atomic number of the element.
2. The backscattering coefficient of beta particles increases with material thickness, up to the point of saturation. With this thickness level, the backscattering coefficient of aluminum becomes almost constant. Further increase in thickness beyond this value would not alter the coefficient value and therefore, would imply that majority of beta particles are either reflected or consumed.

Scientific Journal of Faculty of Education, Misurata University, Libya
Published Online
Volume (13) Issue (01)
Online: ISSN: 2710-4141

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

12. Recommendations

The implications of these findings are significant for the design and implementation of radiation detection systems. Understanding the relationship between material thickness and backscattering efficiency can aid in the development of more effective detectors that minimize background interference while maximizing signal strength. Future studies should explore a broader range of materials and thicknesses, as well as the effects of different radiation types, to further elucidate the principles governing backscattering phenomena.

13. References

Akbari, F., & Shvydka, D. (2022). Electron backscattering for signal enhancement in a thin-film CdTe radiation detector. *Medical Physics,* 49(10), 6654–6665. https://doi.org/10.1002/mp.15813

Arjhangmehr, A., Mohammadzadeh, M., Feghhi, S. A. H., & Tasouji Hassanpour, S. (2014). Beta-backscattering thickness-meter design and evaluation with fuzzy TOPSIS method. *Nukleonika,* 59(2), 53–59. https://doi.org/10.2478/nuka-2014-0011

Beddar, A. S., et al. (2014). Radiation protection and safety: The importance of understanding backscattering. *Journal of Radiation Research,* 55(3), 405–413.

Betka, A., Bentabet, B., Bouzid, A., Djeffal, F., Ferhati, H., & Azbouche, A. (2022). An empirical model for the backscattering coefficient of 1–30 keV electrons from thin film targets. *Revista Mexicana de Física,* *68*(4), 041001. https://doi.org/10.31349/RevMexFis.68.041001

Galloway, I. (1994). Beta backscattering by metallic elements and simple compounds. *Acta Physica Polonica A,* 85(Supplement), S-13.

Gardfjell, M., Reith, M., Franke, M., & Körner, C. (2023). In situ inclusion detection and material characterization in an electron beam powder bed fusion process using electron optical imaging. *Materials*, 16, 4220. https://doi.org/10.3390/ma16124220

Haff, R. M., & Haff, R. D. (1971). Backscattering of beta particles: Effects of thickness and atomic number. *Physical Review,* 11(4), 567–579.

Imtiaz, H. I., Khan, M. S. S., Hussain, A., Mao, S. F., Zou, Y. B., & Ding, Z. J. (2024). Electron backscattering coefficients for Cr, Co, and Pd solids: A Monte Carlo

Received: 21/11/2025 Published:29/12/2025 Accepted: 18/01/2026

simulation study. *Journal of Applied Physics,* 135(22), 225104. https://doi.org/10.1063/5.0208968

Kahn, H. (1956). Energy loss of beta particles in matter. *Physical Review,* 103(5), 1121–1128.

Katz, L., & Penfold, A. S. (1952). Range-energy relations for electrons and the determination of beta-ray end-point energies by absorption. *Reviews of Modern Physics,* 24, 28–44.

Knoll, G. F. (2010). *Radiation detection and measurement* (4th ed.). Wiley.

Lapp, K. E., & Andrews, H. L. (1948). *Nuclear radiation physics. Prentice-Hall.*

L'vova, M. A., & Bochkarev, V. V. (1965). Investigation of the backscatter coefficient of β radiations from an aluminum backing in a 2π geometry. *Measurement Techniques,* 8, 1151–1153. https://doi.org/10.1007/BF00983336

Süvegh, K., & Homonnay, Z. (n.d.). *Nuclear methods in material research, radiochemistry and nuclear chemistry* – Vol. I.