ENERGETICALLY INVESTIGATING AND BIOLOGICAL EFFECTS OF ALPHA RAYS IN HUMAN BODY

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ABSTRACT

This study examines the impact of ionizing radiation, particularly alpha particles, on human cells and molecules, with a focus on DNA damage. Alpha particles, although unable to penetrate the skin, pose significant health risks when inhaled, swallowed, or entered the body through a cut, causing severe damage to sensitive living tissue. The experiment involved measuring alpha particle interactions with human cells, revealing that even low doses of radiation can cause significant biological changes, including mutations that may lead to cancer in the current or future generations. According to the comparison of the energy of radio-active radiation, alpha rays cannot pass through ordinary paper. Accordingly, in our experimental procedure and method, we first record alpha particles without radio-active nucleus, and then we use radio-active nucleus that emit alpha rays. has taken into consideration. According to the relevant data, we have drawn graphs and obtained alpha ray energy in air $E_{\propto max} = 3.407\ Mev$ and distance $R_0 = 1{,}99mm$.The results indicated that alpha particles induce DNA double-strand breaks (DSBs) in the nuclei of peripheral blood mononuclear cells (PBMCs), underscoring the necessity for stringent radiation protection measures. This study highlights the critical need for understanding radiation-induced damage mechanisms to develop effective prevention and treatment strategies for radiation-related health issues.

Keywords: Alpha Particles, Radiation Effects, dose energy of radiation, biological effects; determination of length path and energy of α particles.

Introduction

The emission of ionizing radiation from any source such as X-rays, radioactive nucleus, Antiproton beam, Neutron(n) and Meson ($\pi^{\pm}$), causes ionization and excitation of electrons in the atom, resulting in the transfer of energy to tissues Fig. 1. The given energy can easily cause the molecule to change. As a result, the change of molecules in the body becomes the cause of dangerous events. The human body has a very closed and complex structure including many organs, each of which is made up of one or more closed tissues. There are many elements in the same tissues and cells, and these elements include, for example, oxygen, hydrogen, sulfur, phosphorus, carbon, and water, and radiation has a specific effect on each element [1].

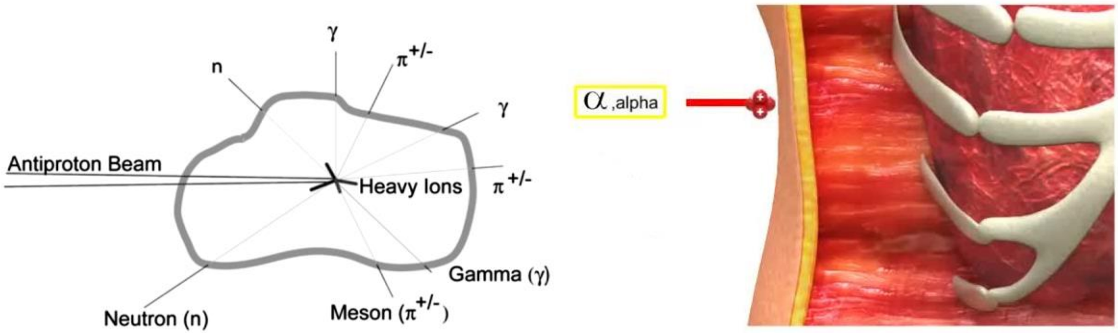


Fig. 1. Interaction Antiproton and Alpha ray with human body.

The relationship indicates that if the dose level of radiation energy increases, then as a result, the biological, clinical, and physical effects of radiation in the whole body or each part of the body are caused in two ways [2].

1. Random effects: For example, there is a possibility that a very low energy dose with a value of zero to two hundred millisieverts $(0 - 200msv)$ can cause a biological and pathological change in the tissues in the future and bring up the following effects.

- At a very low energy dose, 0-200msv, that is, in the limit of $0\ to\ 200$ millisieverts, there is a high probability of this radiation damage.
- There is no specific limit (attack) for radiation energy dose, but it can induce mutations in DNA. Because of this, defective cells of the body or defective cells of the gene are formed, as a result, cancer can occur in the current generation or the next generation.
- The damage occurs suddenly and therefore cannot be predicted.
- The degree of damage is not subject to the radiation energy dose, but the probability and frequency of occurrence are directly related to the energy dose.
- The last stochastic loss of body cells is blood cancer (Leukemia), which has a high rate of occurrence after eight years, and other cancers such as lung, thyroid, and breast cancer, etc., which have a high rate of occurrence. It occurs after about 20 to 30 years.
- The final harm of genetic stochasticity, which results from mutation, is hereditary disease such as the birth of disabled children (Malformatiol) or other diseases [2,3].

2. Non-random or deterministic effects: The non-random or deterministic effects of radiation is not a statistical phenomenon, it can occur when the energy dose exceeds a certain limit, then after this stage as a result of the pathological effects, the severity of the disease increases according to the energy dose, for example, for the skin, this level has been revealed at a little six grams $(6Gy)$. An example of this effect is:

- Erythem
- Cataract

If an energy dose of less than six grams $(6Gy)$ reaches the skin of $10cm^2$of the body at one time, no clinical adverse effect appears, but when the energy dose level is equal to or higher than six grams, the skin color first appears. In this stage, it becomes red (Erythem) and if it exceeds this value, then the skin burns and causes the skin to die or necrosis (Necrosis) [3].

Effects of radiation on body molecules

The human body is made up of molecules and atoms, these molecules and atoms interact with radiation and the atomic composition of the body determines the degree of interaction. Proteins, fats, sugars, and nucleic acids are very large molecules, some of which are composed of hundreds of atoms. One of these molecules inside the nucleus is DNA, which is the most basic molecule and the most critical molecule due to the effects of radiation Fig. 2. Another molecule that is most included in the vital substance is nucleic acid with metabolic value, DNA, RNA. RNA is mainly divided into two types, mRNA and tRNA, in the cytoplasm of the cell, each of which has different biochemical characteristics and different roles. The diagram below shows the structure of DNA, RNA, and the expression of its components.

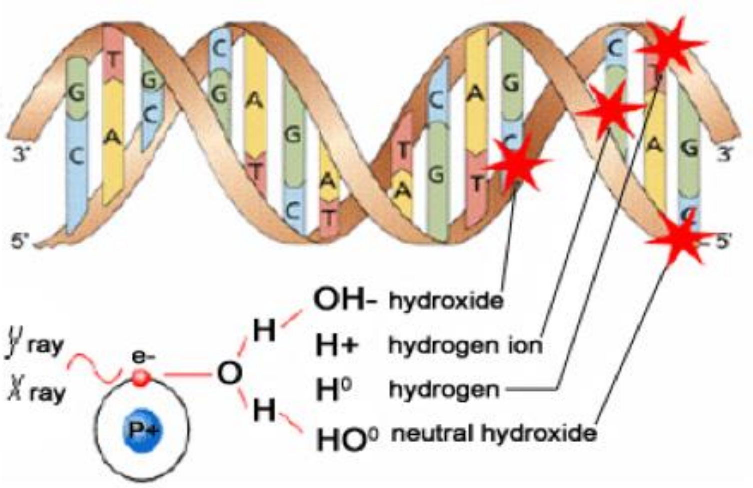


Fig. 2. Interaction of molecules inside the nucleus is DNA.

DNA is made up of different types of sugars and phosphates, and each sugar molecule has one of four nitrogen-containing special bases, which are adenine, guanine, thymine, and cytosine. On the type of spring, it is complicated as in the above form. It should be noted that when biological macromolecules come under radiation bombardment in an external living environment, approximately $10kGY$ radiation can cause physical changes in it, while these molecules are alive. A cell bombarded with only about 50 mGy of radiation can produce measurable biological reactions. The nucleus is more sensitive than the cytoplasm. A dose of $1Gy$ radiation is required to kill the nucleus of a cell. Meanwhile, $10GY$ radiation can do the same thing on the cytoplasm [4].

Effects of radiation on cells

In females, the sex cells include the Oogonium. In males is Spermatogonium. The remaining cells of the human body are somatic. Body cells range from 3 to 100 microns in diameter and each cell are made up of approximately 10^{14}atoms. At the time of birth, the body cells are approximately 3.10^{12}, so when it reaches adulthood, the number of cells in all tissues reaches 4.10^{3}. It creates members and then members create the system. Such as the nervous system, digestive system, endocrine system, reproductive system, and so on.

All organs of the body have different sensitivities to radiation. These sensitivities are related to the function and growth of organs, and exposure to cells and organs is also related to personal sensitivity. In 1906, two French scientists named Bergonie and Tribondeau explained that the sensitivity of visible tissues to radiation is subject to metabolic activity and consequently described the sensitivity of living tissue to radiation as follows [1].

- The immature cell is more sensitive to radiation than the mature cell.
- Young tissues and organs are very sensitive to radiation.
- The higher the metabolic rate, the higher the sensitivity.
- The more the amount of cell reproduction and tissue growth increases, the more sensitive it is to radiation.

The adverse biological effects of radiation on a cell are as follows

- Chromosomal aberration.
- Induction of cancer.
- Induction of somatic mutation in body cells.
- Birth of disabled children.
- Induction of cell killing.
- Weakening of the body's immune system.
- Sudden impacts occur below about 250 milliseconds $< 250msv$.
- Non-accidental effects such as radiation sickness are most likely to occur when the radiation level exceeds 250 millisieverts $> 250msv$ [1-3].

DNA (Deoxyribonucleic acid) and radiation response

There are forty-six chromosomes in every single cell of the human body, in which all the genetic material and hereditary information are safely stored. One of the most important parts of chromosomes is the Deoxy ribonucleic acid molecule. Deoxy rib nucleotide is made up of a double helix. It consists of nitrogen (base), sugar or sugar, and phosphate group from Uracil (U=Uracil). The bases of DNA molecules such as adenine, guanine, cytosine, thymine, and uracil are connected with the help of hydrogen bonds. Human DNA is two meters long and two nanometers (one billionth of a meter) wide. In 2001, the human genetic code was published and it was revealed that there are about 30,000 30,000 embryos. The response of ionizing radiation to the cells of the body is very bad when it hits the DNA of the chromosomes because all the genetic information of a cell's life is kept safe in the DNA molecule Fig. 3.

- The breaking number of a twisted wire of this NA is proportional to the square of the radiation dose.
- The number of breaks in both DNA strands is directly proportional to the radiation dose.
- The chemical bonds that bind the strands of each protein and DNA molecule to each other are destroyed.

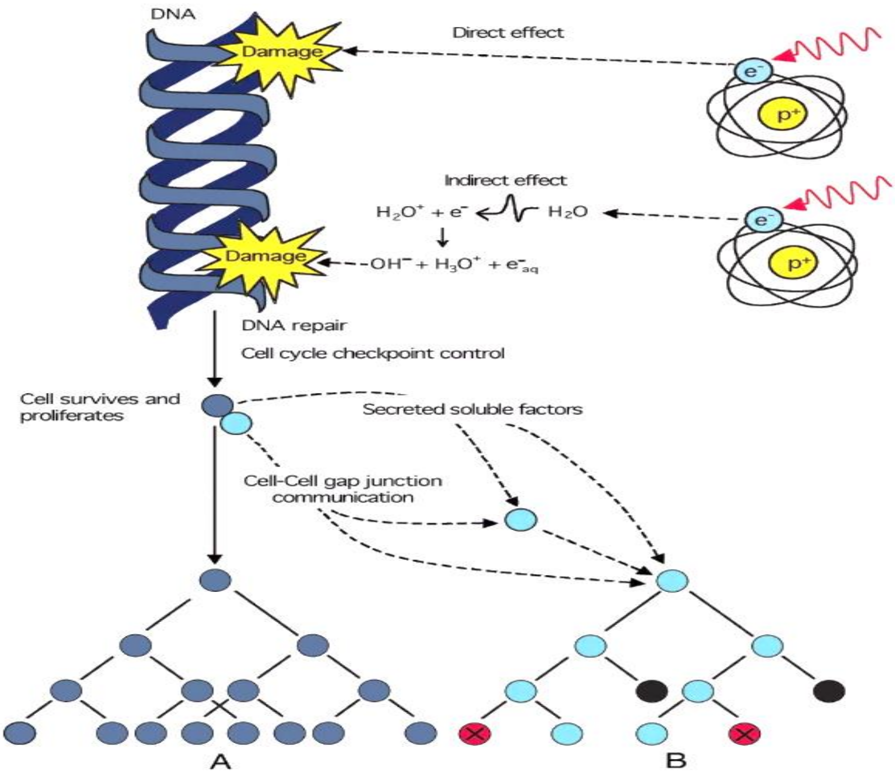


Fig. 3. Direct and indirect effect with DNA.

Today, scientists at the international level have presented two types of models that indicate the harmful effects of ionizing radiation on DNA [5].

The first model: when an ionizing particle hits DNA, it loses some of its energy during the passage, which causes the DNA to cut both strands at once. strand breaks DOUBLE) In this model, the DNA number (N) of the broken DNA is directly proportional to the radiation energy dose D.

The second model: When two ionizing particles that have nothing to do with each other and specifically hit the DNA, each of them can transfer enough energy to the helix, resulting in this model, the DNA number N of the DNA of the tumor is directly proportional to the square D of the radiation energy dose. The average number of DNA fragments N in a cell, which occurs as a result of the radiation energy dose D response, can be obtained from the following equation. Radiation is related to the chemical radicals in the environment of the cell and the way the absorbed energy is dissipated there. Tests have shown that if the ionizing radiation hits the DAN molecule of the healthy cells of the body and cuts the double helix, it can most likely lead to the emergence of cancer cells Fig. 4 [1].

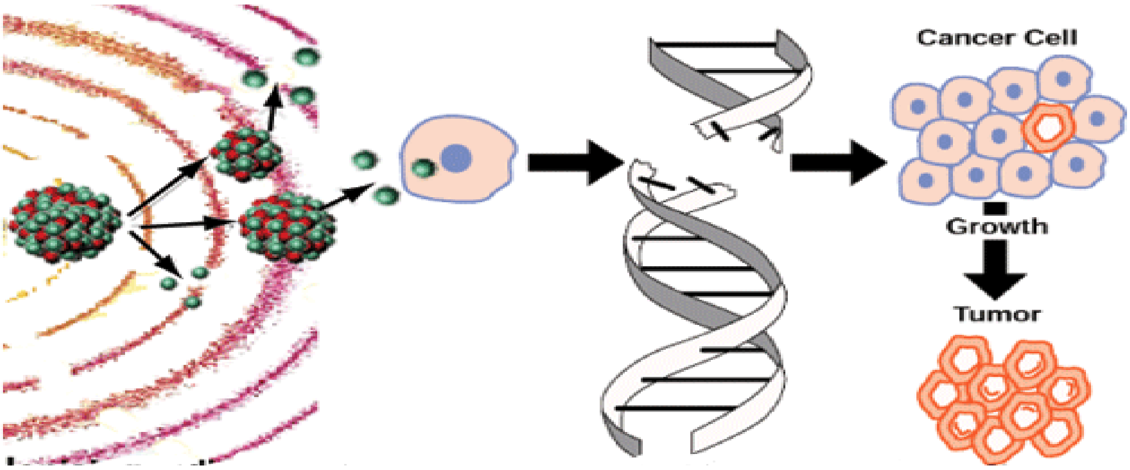


Fig. 4. Increases cancer cells during interaction Alpha ray with DNA.

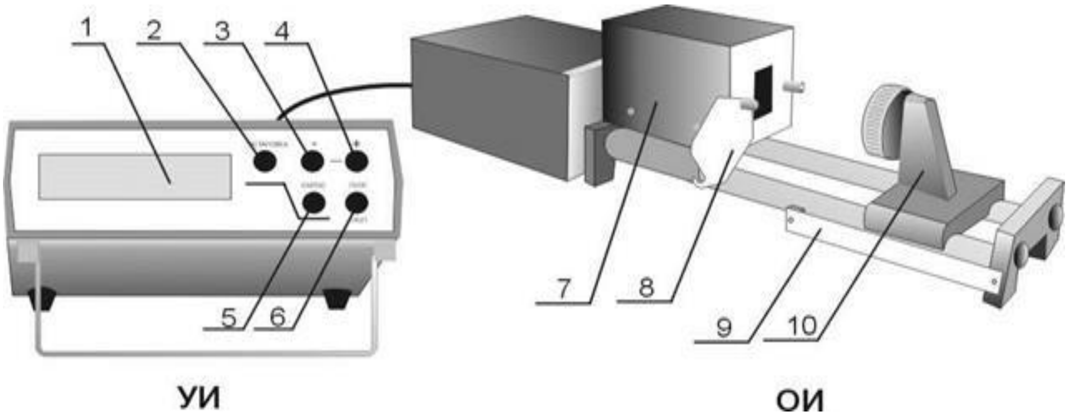
Experiment

To obtain the total number of particles, it is necessary to divide the registered number of particles by the correction, let's take this from Table 1.

$x/r0$	0.1	0.2	0.4	0.5	0.6	0.8	1.0	1.25	1.5
Correction	0,286	0,253	0,197	0,175	0,158	0,127	0,102	0,080	0,062

Table.1

Where x is the distance between the detector window and α −preparation, r_0 is the radius of the detector window [5]. Experimental was carried out on the installation, a schematic view is shown in $Fig.5$.



$Fig.5$. Schematic diagram of the installation. 1- Indicator, 2- Button "Setting", 3 and 4- buttons (+, -), 5-reset, 6-start and stop, 7- Counter block, 8- Curtain, 9-line with a scale, 10-source Alpha particle [3].

To determine the path length of Alpha particles, we obtained the average Background ($\overline{N}$), with a time sweep of $t = 300\ Sec$.

$$\overline{N} = \frac{57+57+65}{3} = 66$$

Here, each time we increase the distance between the source and the detector by $1mm$, remember that here the distance between the source and the detector is $1mm$, and the distance inside the detector itself is $5mm$, $Fig.5$, it turns out to be $7mm$. with a time-base $t = 1\ mim, 2min, 3min$ etc. we multiply the distances by 5, $5/_2$, $5/_3$etc. We got a $table.2$.

Time(t)	Distance (x)	Number of particles (N)	Particles – average Background x Time	Result
60Sec	7+0=7 mm	2376	2376-66x5=11550	11550
60 Sec	7+1=8mm	2081	2081-66x5=10075	10075
60 Sec	7+2 =9mm	1710	1710-66x5=8220	8220
60 Sec	7+3 =10mm	1229	1229-66x5=5815	5815
60 Sec	7+4=11mm	762	762-66x5=3480	3480
120 Sec	7+4=11mm	1644	1644-66x2,5=3945	3945
120 Sec	7+5=12 mm	1028	1028-66x2,5= 2405	2405
120 Sec	7+6=13 mm	637	637-66x2,5=1427,5	1427,5
180 Sec	7+6=13 mm	942	942-66x1,666=1459	1459
240 Sec	7+6=13 mm	1298	1298-66x1,25=1540	1540
240 Sec	7+7=14 mm	947	947-66x1,25=1101	1101
300 Sec	7+7=14 mm	1206	1206-66x1=1140	1140
300 Sec	7+8=15 mm	721	721-66x1=655	655
300 Sec	7+9=16 mm	452	452-66x1=386	386
300 Sec	7+10=17 mm	280	280-66x1=214	214
300 Sec	11mm+7mm=18mm	185	185-66x1=185-66	119
300 Sec	12mm+7mm=19mm	146	146-66x1=146-66	80
300 Sec	13mm+7mm=20mm	93	93-66x1=93-66	27
300 Sec	14mm+7mm=21mm	85	85-66x1=85-66	19
300 Sec	15mm+7mm=22mm	98	98-66x1=98-66	32
300 Sec	16mm+7mm=23mm	82	82-66x1=82-66	16
300 Sec	17mm+7mm=24mm	79	79-66x1=79-66	13
300 Sec	18mm+7mm=25mm	85	85-66x1=85-66	19

Table.2

We need to get the real particle number and we need to get r_0 and the correction from the equation.

$$r_0 = \sqrt{\frac{S}{\pi}} = \sqrt{\frac{a.b}{\pi}} = \sqrt{\frac{30mm.18mm}{3,14}} = 13,11mm = 1,311cm$$

$$\text{Correction } (y) = 0.1002(x/r_0)^2 - 0.3139(x/r_0) + 0.3116$$

x/r_0	Correction (**y**)	**Number of particles (N)** ÷ Correction (**y**)	Result
7÷ **13,11** ≅0,533	0,173	11550÷ 0,173	66763
8÷ **13,11** ≅0,610	0,158	10075÷ 0,158	63765
9÷ **13,11** ≅0,686	0,144	8220÷ 0,144	57083
10÷ **13,11** ≅0,763	0,131	5815÷ 0,131	44389
11÷ **13,11** ≅0,839	0,120	3480÷ 0,120	29000
11÷ **13,11** ≅0,839	0,120	3945÷ 0,120	32875

12÷ **13, 11** ≅0,915	0,083	2405÷ 0,083	28975
13÷ **13, 11** ≅0,991	0,100	1427,5÷ 0,100	14275
13÷ **13, 11** ≅ **0, 991**	0,100	1459÷ 0,100	14590
13÷ **13, 11** ≅0,991	0,100	1540÷ 0,100	15400
14÷ **13, 11** ≅1,0678	0,093	1101÷ 0,093	11838
14÷ **13, 11** ≅1,0678	0,093	1140÷ 0,093	12258
15÷ **13, 11** ≅1,144	0,086	655÷ 0,086	7616
16÷ **13, 11** ≅1,220	0,080	386÷ 0,080	4825
17÷ **13, 11** ≅1,296	0,076	214÷ 0,076	2815
18÷ **13, 11** ≅1,372	0,0729	119÷ 0,0729	1632
19÷ **13, 11** ≅1,449	0,055	80÷ 0,055	1454
20 ÷ **13, 11** ≅1,525	0,069	27÷ 0,069	391
21÷ **13, 11** ≅ **1, 601**	0,070	19÷ 0,070	27
22÷ **13, 11** ≅1,678	0,071	32÷ 0,071	450
23÷ **13, 11** ≅1,754	0,073	16÷ 0,073	219
24÷ **13, 11** ≅1,830	0,077	13÷ 0,077	168
25÷ **13, 11** ≅1,906	0,082	19÷ 0,082	231

Table.3

Results

To correct, the error of which is received by the detector, we use the correction in Table 1. In this experiment, the results were obtained in Table 3, and from this, the results plotted the correction in Fig. 6.

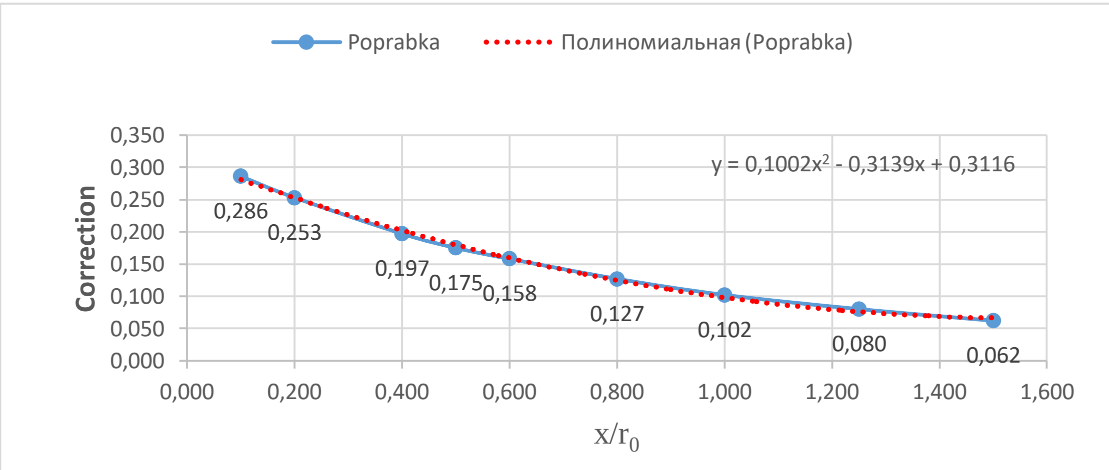


Fig. 6 Correction

Now the number of received particles for correction and built the following graph Fig. 7. d. There is no correction in this chart either. With corrected values, it is necessary to obtain $dN/dx$to the transmission curve of α - particles in Fig.7. e.

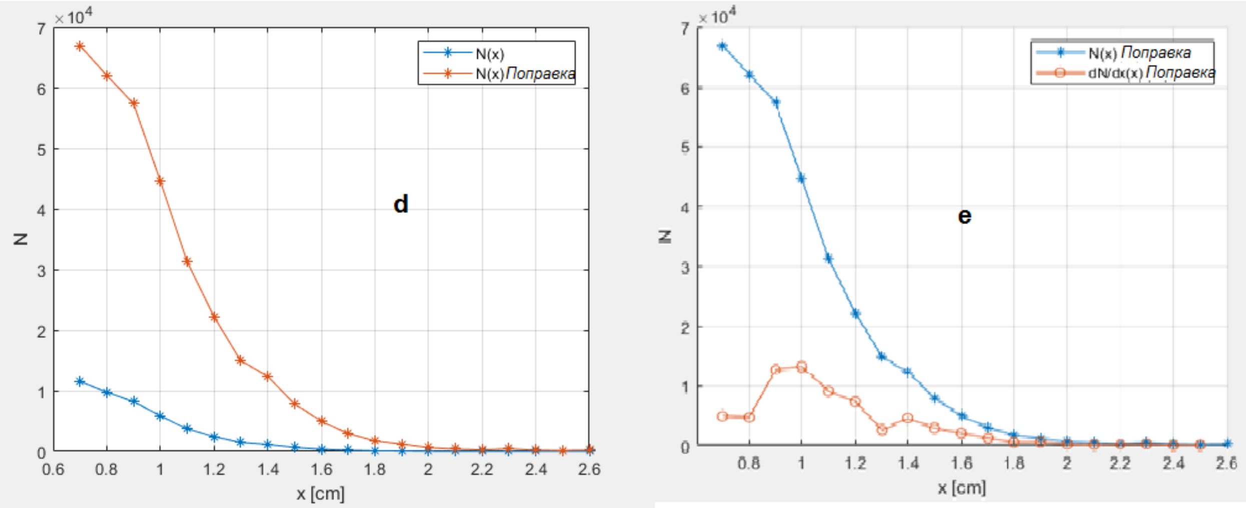


Fig.7. d) Graph of the number of particles received with correction, e) Graph of the passage of Alpha particles through the air without correction.

The values for obtaining energy are maximum at $x = 2$ and minimum at $x = 1$ are shown in Fig.7.e and we obtain the energy of alpha particles from these equations.

$$E_{\propto min} = \left(\frac{R_{min}}{0.318}\right)^{2/3} = \left(\frac{1}{0.318}\right)^{2/3} = 2.146\ Mev$$

$$E_{\propto max} = \left(\frac{R_{max}}{0.318}\right)^{2/3} = \left(\frac{2}{0.318}\right)^{2/3} = 3.407\ Mev$$

Since the energy is less than 4 MeV, we use Fig.7. e. It can be seen that at $x = 1$ the energy is 2.146 MeV, and at $x = 2$ the energy is 3.407 MeV.

DISCUSSION AND CONCLUSIONS

Alpha radiation has bad effects, it breaks the DNA strand and therefore the cell is destroyed or it survives and sustains its sleep, but its defect is wrong like mutation. remains Although these cells are regenerated by some specific enzymes, the small number that remain incorrect are likely to turn into cancer cells in the long run [3].

For example, within four hours, 97% of the 2,000 broken helix strands of DNA can be repaired. Mutated cells, which cause cancer, cause these cells to forget the other properties of the cell and the genetic code program set during survival and continue the process of mitosis on their own. Normally, in normal cells, the process of division or mitosis is done under a certain program and control according to the work and need of that organ. On the other hand, the body's immune system can recognize any defective cell as a tumor, so it destroys it with the help of certain cells such as macrophages [2].

If a strand of a chromosome is cut by radiation, the body has mechanisms, such as repair enzymes and certain proteins, to copy the broken DNA from one strand of DNA and replace it with the broken strand. connect and with the help of such a genetic technology, this defect can be eliminated again, but when both lines of chromosomes are cut once due to any reason, the probability of complete restoration is very low and it may be after many years. This cell turns into a cancer cell. If we assume that this damage reaches the sex cells of the body in the form of mutation, then this defect can occur in every single cell of the body of the children of the next generation. It means that if a person has been exposed to a very low level of nuclear radiation, for example, around a few millimeters of radiation, there is still a possibility that his children will be born with disabilities and diseases, for example. Absence of eyes, trisomy 11, increased water in the skull or (Hydrocephalus), lack of organs blood cancer, and other diseases. The cutting edge is directly related to the equivalent energy line [1-5].

We have obtained the curve of the passage of $\alpha - particles$ through the air Fig. 4.e, determined the length of the mean path $R_0 = 1{,}99mm$ and the energy of $\alpha - particles\ E_{\propto max} = 3.407\ Mev$. Consequently, the α-particles induce DNA double-strand breaks (DSBs) in the nuclei of the hit peripheral blood mononuclear cell (PBMC) [7, 8, 9].

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