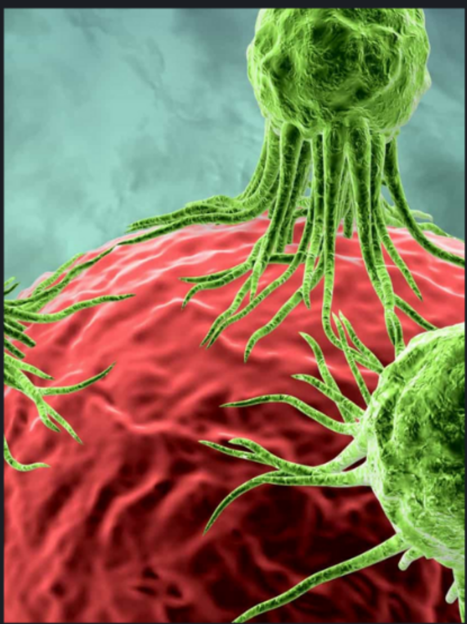
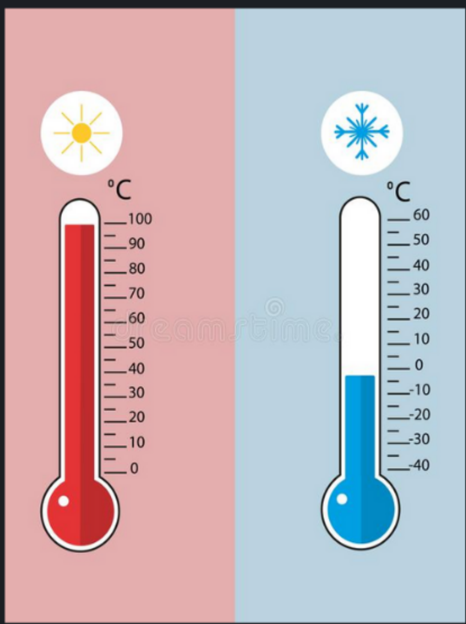
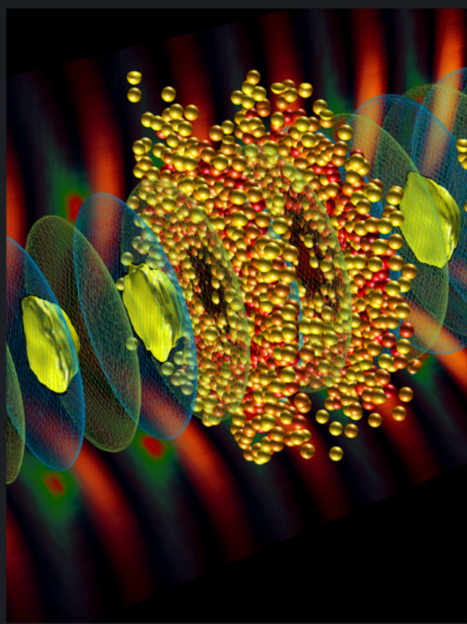
TURN ON THE TEMPERATURE OFF THE CANCER

BY TEAM **SPECTech**

EFFECT OF TEMPERATURE VARIATIONS, ON THE TRAJECTORY, SPEED, AND ENERGY OF PROTONS







BEAMLINE FOR SCHOOLS

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1. Abstract

BL4S (Beamline for schools) is a competition that invites high school teams to propose a scientific experiment that they wish to carry out on a particle accelerator. It is organized by CERN, however, due to unique circumstances it will be held at DESY (Deutsches Elektronen-Synchrotron, German electron synchrotron). Our experience consists of studying the influence of temperature on the trajectory, speed, and energy of the protons. For this purpose, we will use several materials listed and described below. We decided that this experiment would focus on one of the methods to fight cancer: proto therapy. Currently, cancer has a huge incidence rate. For example, in 2018, according to the World Health Organization (WHO), there were 18 million new cases worldwide and 10 million deaths. Moved by these numbers, we decided to propose a solution that can help to revert these statistics.

2. Why we want to go to Desy

Last year our school applied for the first time to the Beamline for schools contest, ending up reaching the shortlist. In order to continue the work of our colleagues, even though through a totally different experience, we signed up. In addition, the possibility of a trip to Desy, combined with the interaction with highly qualified scientists, represents an opportunity of a lifetime.

3. Introduction

The word cancer shows up almost everyday in our lives and in the lives of those around us. Despite the burden that is given to it, the advanced studies of science increases the belief in an effective cure. When this project was proposed to us, we saw a possibility of actually intervening, although in a simple way, in this problem that affects a considerable part of the population. With the help of several laboratories and universities, we intend to improve one of the treatments for the disease, proton therapy, which has been growing exponentially in the fight against cancer.

4. Aim

Observe the effect of temperature variations, at relatively extreme levels, on the trajectory, speed, and energy of protons to study the influence that these results may have in medical applications.

5. Theory

5.1 Different ways to treat cancer and the benefits of proton therapy

Currently, the three most common ways to treat cancer are surgery, radiation, and chemotherapy. It is known that proton therapy, a cancer-fighting treatment that has been developed, uses proton beams (particles with a positive charge) in the elimination of cancerous cells. This technique has advantages over traditional methods, as it has greater precision and is less toxic to the organism. Traditional methods use photons and electrons, instead of proton beams. The photon beams have higher energy than proton beams and that is the reason, not only the tumor is reached but is also pierced resulting in damaged tissues and organs, and that is why we are using protons. On the other hand, electrotherapy, which uses electron beams, is a procedure that, despite being advantageous, has a range of only 3 cm, which means that this treatment can only be used in skin cancers.

We then consider it advantageous to use a proton beam since its physical properties allow us to administer a greater dose of treatment, safeguarding the organs closest to the tumor, which makes it possible to minimize the side effects resulting from radiotherapy. The proton beam technology allows the effective treatment of many types of cancer and because it is more accurate, it minimizes the damage to healthy tissues surrounding the tumors. So far, there has been a higher success rate in pediatric cases and tumors located in the brain, spine, and close to vital organs, such as the heart and lungs. This technique is more common in the United States of America and in Europe.

5.2 Particle Physics in our experience

Particle Physics is extremely present in our day-to-day lives. It served and continues to serve as the basis for several studies and experiences, and ours is no exception. It is defined as a branch of physics that studies the elementary constituents of matter and radiation, as well as the interaction between them. Since our experience uses electron beams, which result in proton beams, we consider it relevant to focus on these two particles. Also, relating photons to protons is a topic of high relevance, since they are used in some cancer treatments.

Electron: fundamental particle of the atom with a negative charge and mass 1840 times lower than that of the proton (or neutron);

Proton: fundamental particle of the atom with a positive charge and a mass approximately equal to the neutron;

Photon: elementary particle mediating the electromagnetic force. It is also the quantum of electromagnetic radiation.

By relating the beams of protons with the beams of photons, and considering the physical characteristics of these two particles, it can be said that photons can be somehow disadvantageous, as they release part of their energy in the path taken until they reach the tumor, while the protons reserve their energy, releasing it only when they reach the tumor.

5.3 Thermodynamics

Knowing that part of our experience consists of temperature variations to relatively extreme levels, in order to study the effects that it may have on the effectiveness of proton therapy, it is extremely important to briefly address the concept of thermodynamics. This is defined as the branch of Physics that studies the causes and effects of changes in temperature, pressure, and volume. Therefore, thermodynamics studies the movement of energy and how energy creates movement. It is therefore important for the experiment to reinforce that the lower the temperature, the less the particles will be agitated and vice versa.

6. Materials

6.1. Calorimeter: Detector that measures the energy of particles. As a particle collides with the calorimeter it produces an Electromagnetic Shower, an avalanche of particles created from the interaction between the calorimeter material and a high-energy particle. All energy from the Electromagnetic Shower is deposited in the calorimeter, thus allowing an accurate measurement of that energy. Consequently, from the deposited energy, we are able to determine the energy of the particle under study.

6.2. Scintillator: Material that, when excited by ionizing radiation, produces light, a luminescence property. When struck by an electrically charged particle, luminescent materials absorb part of the particle's energy and emit light. This material can be used to measure the time that a particle takes to travel from one scintillator to the other.

6.3. Delay Wire Chamber / Tracker (DWC): Provides tracking information, through a cable network that can identify the coordinates of the particles that pass through the detector.

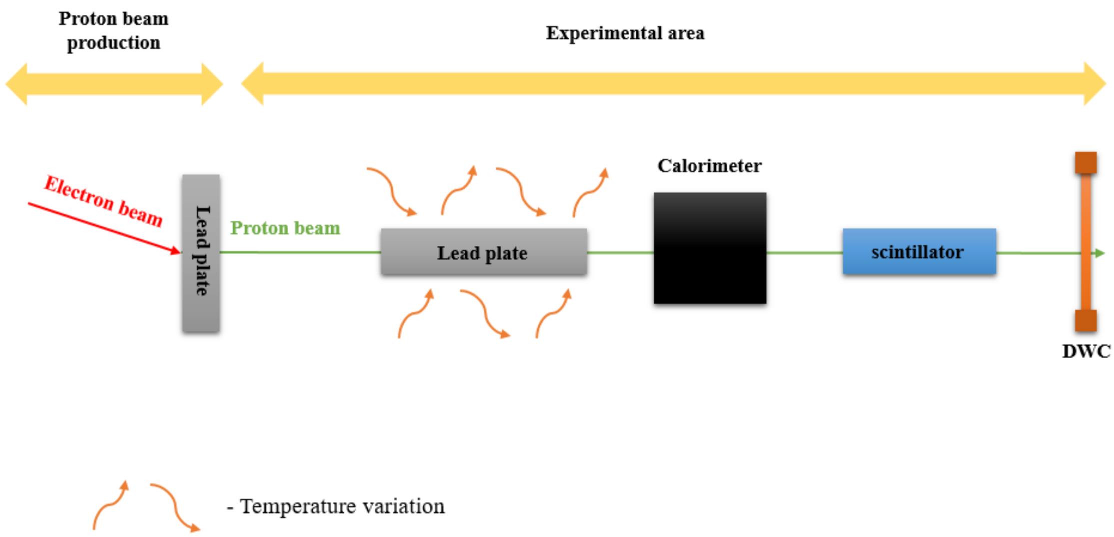
6.4. Electron beam: Nuclear particles with a negative charge.

6.5. Lead Plate: Lead (from the Latin *plumbum*) is a chemical element with the symbol Pb, atomic number 82, that is, it has 82 protons and 82 electrons, with an atomic mass equal to 207.2 u the belonging to group 14 and period 6 of the periodic table of chemical elements. At room temperature, lead is in a solid-state.

7. Method

1. Use a beam of electrons, causing it to collide with a lead plate that will subsequently release a beam of protons due to the collision that occurred.
2. In the second segment of this course, already with protons in place, the temperature will be maintained through the lead plate in order to vary the temperature of the neighborhood and, consequently, the proton beam.
3. Measure the energy of the proton beam, using the calorimeter, which will be positioned after the lead plate.
4. Measure the speed of the proton beam, through the scintillator, which will be positioned after the calorimeter.
5. Observe the trajectory of the proton beam, through the DWC, which will be positioned after the scintillator.

8. Experimental set up



9. What we hope to take away

As we have already shown, the experience to be carried out is based on facts and concepts, which means we are not sure what can happen at the time of its realization, since there are several variables to consider. On the one hand, it is expected to be able to vary the accuracy of the beam, since with a higher temperature it may have a larger area of incidence, which would be beneficial in cancers of high dimensions. On the other hand, it is expected that a lower temperature will cause a reduction in the area of incidence of the proton beam, which may be beneficial in tumors of small dimensions and in tumors located in the vicinity of vital organs, whose preservation is essential.

10. Purposes of the experiment

As already mentioned, our work will focus on innovative cancer treatment, proton therapy. We will evaluate the influence of temperature on the trajectory, speed, and energy of the proton beam and the consequences that this variation may have on this treatment. Based on research already done, it was found that currently there are several successful treatments, even if not for cancer, that use temperatures different from the average temperature of the human body. Based on these facts, we intend to observe whether a decrease, as well as an increase in temperature, can modify the way the beam behaves, and which of these variations will be more beneficial, taking into account the patients and their type of cancer.

11. Final considerations

If expectations are met and the experience becomes achievable, it will be possible to vary the temperature, adapting the proton beam to the needs of each patient and their type of cancer. Therefore, it will be possible to expand the limits of proton therapy, thus contributing to the advancement of the treatment of this disease.

12. Acknowledgments

The development of this project allowed the group to obtain an in-depth knowledge of DESY (Deutsches Elektronen-Synchrotron, German electron synchrotron) and the BL4S (Beamline for schools) contest and the role they play in the evolution of Physics. In addition, it promoted a personal evolution of each member of the group, since elaborating an experience from scratch, communicating with university professors and with departments of several universities enriches our capacities both in terms of communication and science. Therefore we would like to thank our school, Escola Secundária Sebastião e Silva, and to our Physics teacher, Cristina Pinho, for helping us and providing us this opportunity