The difference between the development and shape of a particle shower as a result of a beam of electrons or a beam of positrons perforating graphite

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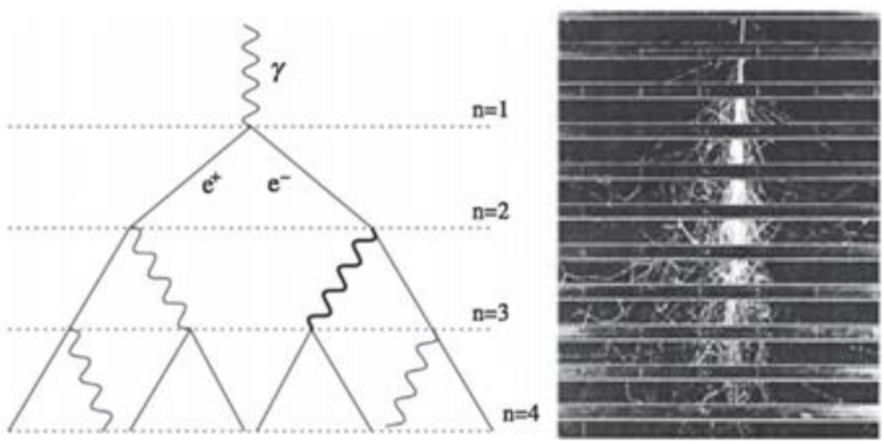
We are a group of six high-school students, between 15-17 years old. We are interested in science and especially physics. At the start of this project, regardless of our enthusiasm for physics, particle physics was a section of physics we barely had any experience with; it is not taught to us yet. For us, this was just an incentive to participate in Beamline for Schools.

Theoretical background

All types of matter particles have antiparticles. All our modern-day physics models are based on the idea that they behave in the same way, although not all their properties are similar. They have the same mass and spin, but all their other properties are exactly the opposite. For example, antimatter has an opposite charge.

The antiparticle of an electron is a positron. We want to research if there is a difference between them that is not discovered yet. Researching if there is a difference between matter and antimatter is of great importance, since there have been a lot of assumptions based on the concept that matter and antimatter behave indistinguishably. We want to focus on electrons and positrons, by testing if their particle showers difference.

The phenomenon of the particle shower is the main concept of our proposal. This shower occurs when a high energy photon splits itself in an electron and positron, both with the exact same energy. Thereafter, the electrons and positrons emit photons and these lower-energy photons again split up in an electron and its antiparticle. This sequence continues until the energy levels are too low for the photon to generate electrons and positrons and for the latter to emit photons.



Left: systematic drawing of a particle shower; right: a particle shower

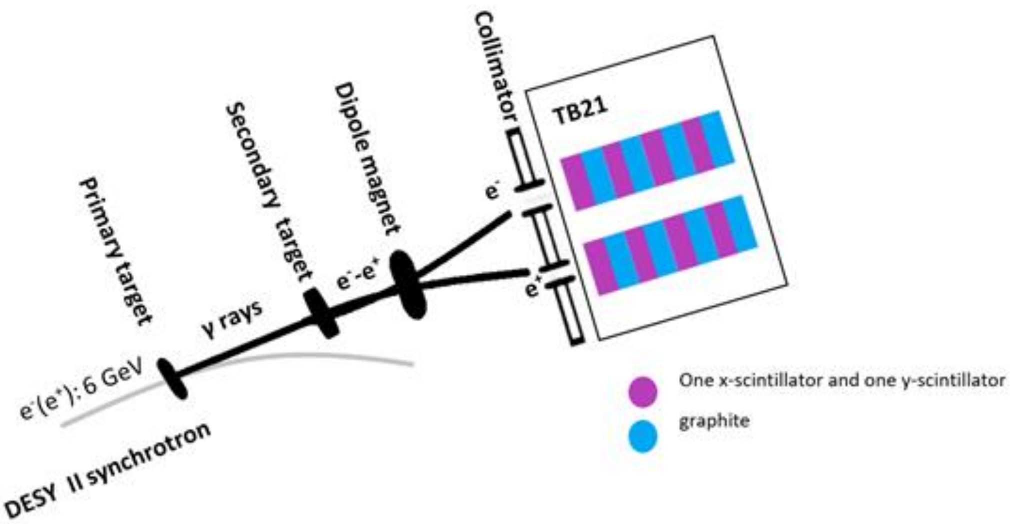
Research question

In our experiment, we want to research what the difference is between the development and shape of a particle shower as a result of a beam of electrons and a beam of positrons, which are both flown out from the same photons?

Hypothesis

Our expectancy is that the particle showers will look similar, considering the general believe that electrons and positrons behave the same[1] and because there will emerge new positrons and electrons out of the photons. Thus, if you start with positrons there will be electrons after two steps since positrons will split up in a photon and a positron and the photon will split up in an electron and positron. This is the same with electrons.

Method



A systematic drawing of our set-up

We want to test their particle shower difference by shooting beams of both electrons and positrons through layers of graphite. Between those layers of graphite, we put x- and y-scintillators. This will make it possible to compare the shapes of the showers and not only the amount of particles. We will start with a beam of electrons in the DESY II Synchrotron with an energy of 6 GeV. Half of the energy of the electron beam will convert to γ rays, which will bend towards our set-up.

The γ rays will split up in electron and positron beams with again equally divided energy. These will be separated by a dipole magnet and will form two separate beams. The beams will both go through the layers of graphite and scintillators. This will continue for a certain amount of time. To limit inaccuracy in the results, for example, because of a small deviation in the scintillators, we will change the positive side of the dipole magnet into the negative side and vice versa. This way the electron beam will be in the place of the positron beam and will go through the scintillators where the positron beam went through the first time. The same change happens with the positron beam. The graphite needs to be changed because it is already used. This will continue for the same length of time as the first time. Afterwards, we will compare the results given by the scintillators.

[1] Centre for Antimatter-Matter Studies (Australian Research Council Centre of Excellence)

Limitations

There are some points we need to pay attention to. For example, the amount of time we measure the electrons and positrons. This time should be long enough to make sure we measure all the different energies since not all particles have the same energies. Thus, we have the most accurate results.

Another limitation we might get in touch with is energy loss of the particle beams due to the scintillators. If there is energy lost, this probably is not a big concern; after all, the loss of the electron beam is the same as the loss of the positron beam, if the scintillators are exactly the same.

We also need to note that we cannot use the same piece of graphite twice. Therefore there might be a small difference in the properties of the graphite that we will use. This will possibly affect the outcomes. We will try to minimize this by using graphite that is as similar as possible.

What we hope to take away

The aim of our experiment is to contribute to the scientific knowledge about the electromagnetic showers of positron and electron beams.

Besides that, we hope for an unforgettable experience and encouragement to continue working and researching in the field of physics. Friends of us were wondering about the meaning of ''electromagnetic showers'' and ''scintillators'' while listening to our discussions, so we explained it to them and tried to get them thrilled for particle physics too. With the right motivation and drive, people will not stop being curious.

Acknowledgments

We want to thank Ad van den Berg for giving us an insight into particle physics and leading us through the project. Because of him, our enthusiasm for electrons grew positively.

Sources and other helpful literature

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