# The Use of Accelerators

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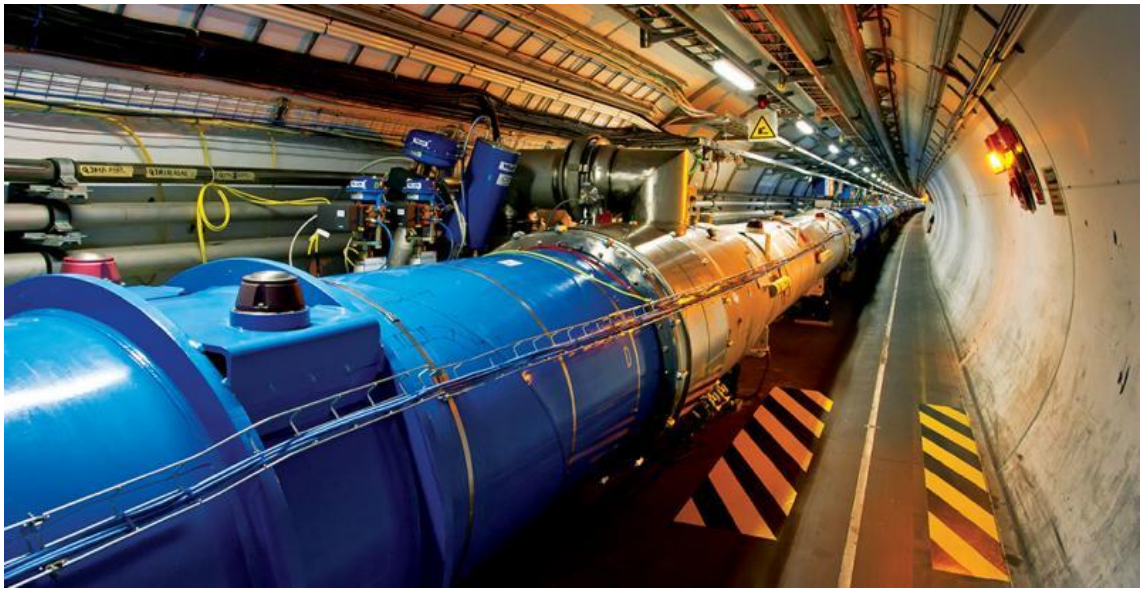

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Do you know “particle accelerator”? The role of particle accelerators is literally just to accelerate particles. (Occasionally, accelerators that have the function of colliding are also called "accelerator".) Despite simple role, the methods of accelerators have evolved over more than a century and have a wide range of applications in our lives. I would like to write a story about such a particle accelerator.

First, I want to introduce about the history of the development of accelerators. Particle accelerators were originally created in the field of nuclear and particle physics to find the answer to the question that "What is the world made of?". The field called "accelerator science" began in the first quarter of the 20th century. At that time, it had just been discovered that atoms (elements), which had been thought to be fundamental components of matter, contained electrons, so that atoms could be divided into smaller pieces. At

around the same time, it was discovered that "something" was emitted from unstable elements called radioactive elements. They are particles with some velocities, and they could be classified into two types. They were called alpha and beta particles. In the 1910s, an experiment group including Rutherford discovered that the existence of atomic nuclei by irradiating atoms with alpha particles emitted from radioactive elements, and that the nuclei can decay by bombarding with alpha particles.

Although the experiments by Rutherford and his teams were with naturally emitted particles by radioactive materials, not with artificially accelerated particles, they have great means that we can investigate about small fragments of the atoms by colliding the particles with matters. In the 1920s, the first accelerator in the world was created, and in 1932, an experiment using an accelerator succeeded in disintegrating the nucleus of lithium.

By the way, how are particles accelerated? You might seem that accelerating particles is a very difficult task because the particles are small. The method used in the first accelerators and still in use today is electromagnetic force. As we learn in electromagnetics, when a charged particle (e.g., an electron) is placed in electric fields, it receives an electromagnetic force and accelerated. Theoretically, if you apply a high voltage, you can accelerate the particles as far as you can. the accelerator used in the 1932 experiment described above accelerated using a voltage of 800 kV.

However, if you try to accelerate it further, it requires a huge amount of voltage, and there are technical limits such as financial and durability. Therefore, the next idea was to change the electric field over time so that the region where particles exist always becomes the acceleration zone. In addition, in order to reduce the size of the accelerator, the

circulator accelerator was invented. In the circulator accelerator, particles can pass through the same acceleration zone many times. A circular accelerator is called a cyclotron, and a linear accelerator is called a LINAC.

Since then, further improvements have been made using vacuum and super-electric technologies, etc., and even now it continues to improve for the discovery of new particles and new reactions. Now, improving has two main directions. One is "high energy", that is, it aims to accelerate faster. To generate heavy elementary particles (you may have heard the name of Higgs boson in the news), we have to collide the particles which have enormous energy. The other is "high current", which aims to accelerate many particles in addition to high energy. By increasing the number of collisions and generated particles, it is possible to investigate rare reactions and the particles generated by them.

For example, in the experiment which I join now, called “T2K Experiment”, we shoot neutrino beam made by accelerator to Super-Kamiokande which is large detector located at 295km downstream from accelerator. Neutrino rarely interact with other particles, so the number of neutrinos in the beam, which is just the magnitude of “current” of beam, is very important.

Lastly, I want to write about accelerator which is active beyond physics. Accelerators are applied not only in the field of physics but also in fields such as medicine. To know how accelerators are used in medicine, we need to know about radiology. Radiology, like accelerator science, has its roots in the discovery of radioactive materials, and is an academic field that explores the possibility of applying radiation such as α-rays and β-rays emitted from radioactive materials to understanding and treatment of the human body. In the development of radiology, to put it simply, an examination method was proposed

to examine the state of the body by taking in this radioactive material and detecting the emitted radiation. Accelerators are used to generate this radioactive material (Those are also called radiopharmaceuticals in the context of medicine). There is a limit to the amounts of radioactive substances that can be produced in nature, and they may contain dangerous impurities. Therefore, it is useful that we can make radiopharmaceuticals by an accelerator. Since there is technology to disintegrate atomic nuclei using accelerators, it is possible to create atoms that are convenient for inspection but have few reserves in nature.

Another possible use is for treatment use. In addition to α particles and β particles, there is another type called γ rays emitted from radioactive substances. This has a strong penetrating power, and when it hits the human body, it causes damage at the atomic level where it passes. Therefore, even if it is pierced, basically no visible scratches remain. Irradiating people with radiation is generally dangerous, but if we devise the intensity and direction carefully, in other words, the focus is concentrated on the lesion from various directions, we can damage foci with the burden on the body less than that of surgery. Accelerators can also be used to generate these gamma rays. It is essential to use an accelerator in order to adjust the direction and intensity.

Accelerators are still cutting-edge tools for finding answers to the ultimate question, "What is the world made of?", simultaneously, they are also useful tools that support our lives in some fields including medicine.

I used Grammarly to check grammar and spell.