**POSITRON EMISSION DETECTOR & TOMOGRAPHY**

Positron-emission tomography (PET) is a nuclear medicine [functional imaging](https://en.wikipedia.org/wiki/Functional_imaging) technique that is used to observe metabolic processes in the body. The system detects pairs of [gamma rays](https://en.wikipedia.org/wiki/Gamma_ray) emitted indirectly by a [positron](https://en.wikipedia.org/wiki/Positron)-emitting [radionuclide](https://en.wikipedia.org/wiki/Radionuclide) ([tracer](https://en.wikipedia.org/wiki/Radioactive_tracer)), which is introduced into the body on a biologically active molecule. Three-dimensional images of tracer concentration within the body are then constructed by computer analysis. [1] PET detectors consists a ring of detectors placed around the object that detects photon pairs which are generated as a result of the annihilation of a positron emitted by the radio-pharmaceutical. To record the detectors typically used in PET have an extremely finite time resolution of a few nanoseconds (ns) allowing for detection of photon events within a predefined time window. A PET scanner consists of a set of detectors that surround the object to be imaged and are designed to convert these high-energy gamma quanta into an electrical signal that can be fed to subsequent electronics.

Usually, one or more detector rings surround the patient wherein two opposite detector segments rotate around the patient covering 360◦. The line passing through the annihilation point and connecting two opposite detector channels is called Line of Response (LOR). The PET scanner is made up of a circular arrangement of detectors. These detectors pick up the pattern of radioactivity from the radiopharmaceutical in the body. A computer analyzes the patterns and creates 3-dimensional color images of the area being scanned. Different colors or degrees of brightness on a PET image represent different levels of tissue or organ function.

**POSITRON AND ITS EMISSION**

Positrons are thepositively charged [subatomic particle](https://www.britannica.com/science/subatomic-particle) having the same mass and magnitude of [charge](https://www.britannica.com/science/electric-charge) as the [electron](https://www.britannica.com/science/electron) and [constituting](https://www.merriam-webster.com/dictionary/constituting) the [antiparticle](https://www.britannica.com/science/antiparticle) of a negative electron. Positrons are emitted in the positive beta decay of proton-rich (neutron-deficient) radioactive nuclei and are formed in pair production, in which the energy of a gamma ray in the field of a nucleus is converted into an electron-positron pair. Positron emission or beta plus decay is a subtype of radioactive decay called beta decay, in which a proton inside a radionuclide nucleus is converted into a neutron while releasing a positron (+) and an electron neutrino (-). [2] Positron emission increases the number of neutrons and decreases the number of protons. Positron emission occurs when a proton in a radioactive nucleus changes into a neutron and releases a positron and an electron neutrino. The bio-molecule is chosen such that it will preferentially accumulate in the area of interest resulting in high radio-tracer concentration in this region. A PET acquisition is based on the coincident detection of many pairs of simultaneous anti-parallel photons following the annihilation of the positron emitted by the radio-tracer. Acquisition from detector pairs at various angular views (tomographic acquisition) followed by appropriate reconstruction algorithms allows for estimation of the tracer bio-distribution within the imaged object with a finite spatial resolution and sensitivity.

**NUCLEAR MEDICINE**

Nuclear medicine is a branch of medical imaging that uses small amounts of [radioactive](https://www.radiologyinfo.org/en/glossary/glossary.cfm?gid=605) material to diagnose and determine the severity of or treat a variety of diseases, including many types of cancers, heart disease, gastrointestinal, endocrine, neurological disorders and other abnormalities within the body. [3] Because nuclear medicine procedures are able to pinpoint molecular activity within the body, they offer the potential to identify disease in its earliest stages. Nuclear medicine imaging procedure is noninvasive and is usually painless medical tests that help physicians diagnose and evaluate medical conditions. These imaging scans use radioactive materials called [radiopharmaceuticals](https://www.radiologyinfo.org/en/glossary/glossary.cfm?gid=606) or [radiotracers](https://www.radiologyinfo.org/en/glossary/glossary.cfm?gid=607).

Depending on the type of nuclear medicine exam, the radiotracer is either introduced into the body, and eventually accumulates in the organ or area of the body being examined. Radioactive emissions from the radiotracer are detected by a special camera or imaging device that produces pictures and provides molecular information. This makes the body slightly radioactive for a short time. A special camera detects the radiation, which is emitted (released) from the body, and takes images or pictures of how the inside of the body is working. Many different organs can be imaged depending on the type of radioactive medication used. [Nuclear medicine](javascript:;)uses radioactive tracers to assess bodily functions and to diagnose and treat disease. The radioactive tracer shows the activity and function of the tissues or organs.

**NUCLEAR MEDICINE AS OPPOSED TO PET**

[4] Positron emission tomography is a nuclear medicine exam that produces a 3D image of functional processes in the body to show difference between healthy and diseased issue ; Nuclear medicine uses a small amount of a radioactive substance to produce two or three-dimensional images of body anatomy and function. Another difference between PET scan and Nuclear Medicine is that the PET scan reveals the cellular level metabolic changes occurring in an organ or tissue while nuclear imaging techniques show the physiological function of the tissue or organ under investigation. Only a very small amount of radiopharmaceutical is given to keep the radiation dose to a minimum. Nuclear medicine imaging uses safe, painless, and cost effective techniques to image the body and treat disease.

**ACCELERATION OF H+ IONS TO PRODUCE ENERGY FOR RADIOTRACER**

In a cyclotron, ions of hydrogen, deuterium, or helium are accelerated in a vacuum chamber by an electric field, while their path of movement is controlled by a magnetic field. [5] Cyclotrons accelerate charged particles using a high-frequency alternating voltage. A perpendicular magnetic field causes the particles to spiral in a circular path so that they re-encounter the accelerating voltage many times. Very high current cyclotrons will typically accelerator negative hydrogen ions so that beam extraction can be efficiently obtained to enable the highest currents. Ions of a light particle such as hydrogen or helium are injected into the center of the cyclotron where they are accelerated by the electrically charged particles. The magnet forces the charged particles to move in a circular path. As the particle gains energy the circular path increases in radius until it reaches the energy desired whereupon it is extracted and directed to a target material where a nuclear reaction forms the radionuclide of choice. [6] With an external ion source, maintenance can be performed without opening the cyclotron or breaking vacuum. The simplicity of the design for proton-only cyclotrons resulted in cyclotrons which accelerate H− ions capable of two or more simultaneous beams of varying energies and intensities. The modern cyclotron is completely controlled by a computer and is capable of running for many days with minimal attention.

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