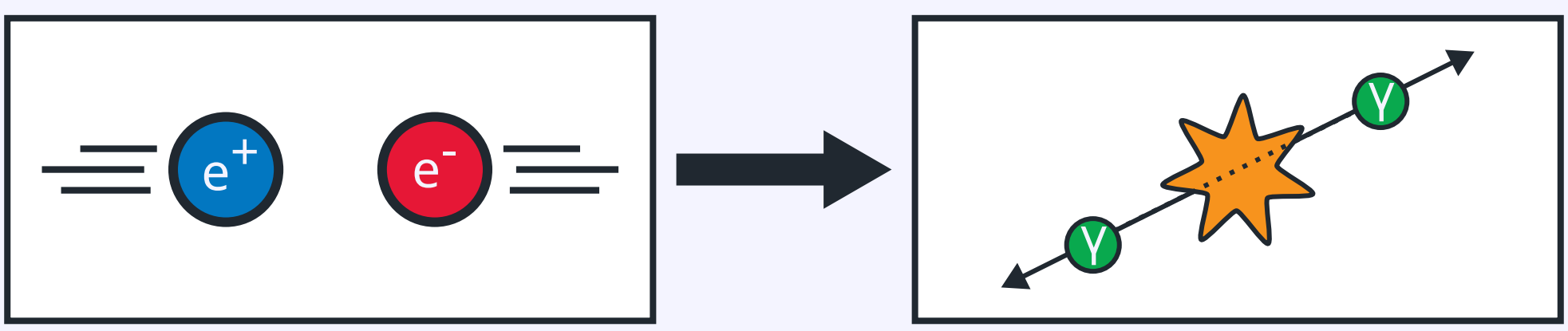
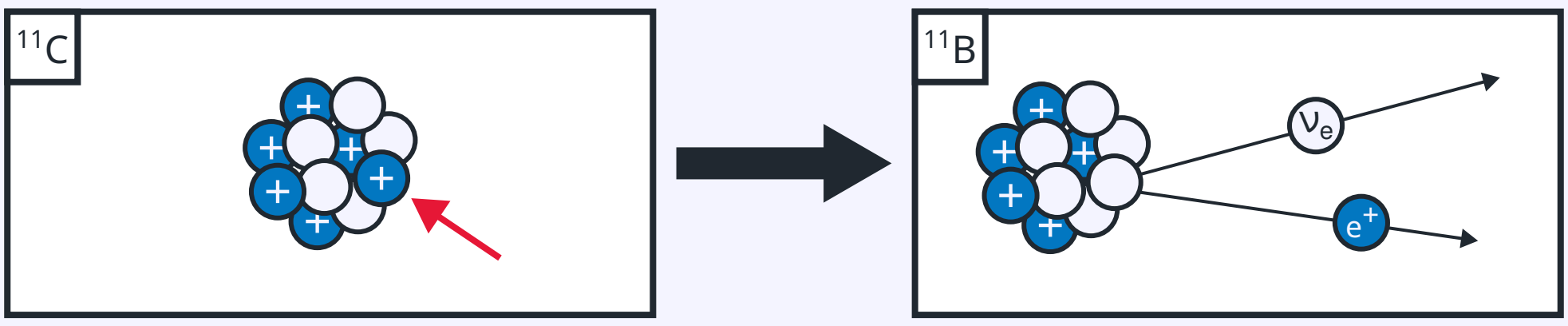
Positron

A positron (e^+) is the antimatter counterpart to an electron (e^-). This means that they have opposite charge, and if a positron and an electron collide, they will both be annihilated. Due to conservation of energy, two photons (γ) are produced by this annihilation, which travel in opposite directions away from the collision site. The energy of these photons is equal to the annihilated mass plus the kinetic energy of the particles at the time of collision ($E=mc^2$), which is roughly 511 keV per photon. Because these photons move in opposite directions, they effectively trace a line that passes through the point of collision. The energy signature and traceable path are crucial for PET to work.



Emission

Certain isotopes undergo beta decay, in which a proton is converted into a neutron, emitting a positron and an electron neutrino (ν_e). We ignore the electron neutrino for PET. Positrons from the radioactive material collide with electrons in the body, creating 511-keV photons within a couple millimeters of the material. Common isotopes used for PET include carbon-11 (^{11}C), oxygen-15 (^{15}O), and fluorine-18 (^{18}F).



Tomography

Before entering the PET scanner, radioactive material is first introduced to the body through injection, injestion, or inhalation. The PET scanner itself is a ring-shaped device designed to identify pairs of 511-keV photons hitting sensors on opposite sides of the scanner at almost exactly the same time. Each one of these signals is stored in a computer to backtrace the point of annihilation, thus identifying the location of the radioactive material in the body. This is repeated until a medical team can construct a two- or three-dimenstional heat map of the targeted area. The resulting image can show the medical team if the material is ending up where it's expected to go, potentially identifying health problems before symptoms appear.