PET (positron emission tomography) involves the introduction of radioactive substances ("tracers") into the brain.

The amount of tracer present in neurons corresponds to neuronal rate of glucose metabolism, which reflects changes in local synaptic activity.

18 (e.g. F-labelled fluorodeoxyglucose)

Local change in cerebral blood flow (CBF) is linearly related to glucose metabolism.

15 (e.g. O-labelled water)

Tracers are created in a cyclotron (required for on-site PET imaging) by bombarding the nuclei of nitrogen, oxygen, carbon, and fluorine atoms, which usually contain protons and neutrons in equal numbers.

Introducing additional protons creates unstable isotopes with half-lives ranging from just minutes to a few hours.

15 Typically, O is used in water molecules for language imaging studies (half-life of two minutes).

When a proton decays, the resultant particles are:

1) a neutron
   remains in the nucleus, because a nucleus can contain extra neutrons

2) a positron
   travels away from the nucleus at the speed of light, eventually collides with an electron, mutually annihilating both, and resulting in two gamma rays (photons) traveling at 180° from each other.

What the scanner detects is the annihilation site:

the distance between the nucleus of origin and the annihilation site 15 (which can be several millimeters -- 3 millimeters for O ) limits the spatial resolution of PET (which is between 5 and 8 millimeters).

The scanner contains gamma ray detectors (crystals and photomultipliers) surrounding the subject’s head.
The annihilation site of a positron/electron pair is detected by gamma ray detectors (photomultipliers) located diagonally from each other.

One emission occurs in a plane; multiple emissions are recorded and reconstructed to localize the annihilation site in three dimensions.

Energy is consumed by both excitatory and inhibitory synapses, so activation and deactivation of cerebral energy consumption should not be confused with neural excitation and inhibition.

"Because MR images are sharp, PET and other functional techniques are often done concomitantly with MRI to take advantage of MRI's ability to locate within the brain the site of the isotope signal detected by PET scanning."