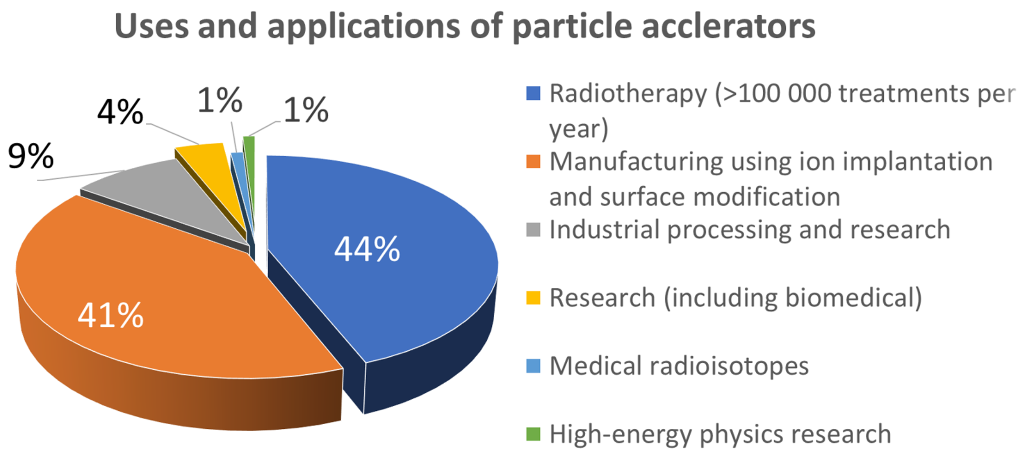
Accelerators are everywhere, perhaps closer than you think…

Accelerator applications

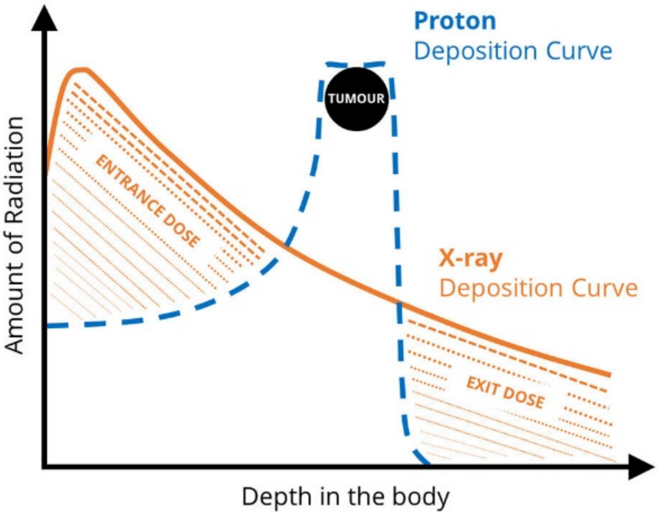


1. **Cancer therapy centres**

   These particle accelerators generate beams of photons, protons, or ions to irradiate tumours.

   Photon (X-ray) therapy centres are the most common, with hundreds in hospitals all over the world. They were first used on a patient in 1953 in London, UK, and they use linear accelerators to generate X-rays.

   Proton therapy uses both cyclotrons and synchrotrons to generate proton beams. There are more than 50 proton cancer therapy centres in hospitals globally, with many more under construction. The ones in Europe are listed on publicly available data sources and so are included on the map.



Radiation delivered by high-energy X-rays has a large entrance and exit dose, damaging healthy tissue. In contrast, the place where protons stop inside the body can be controlled by changing their energy.
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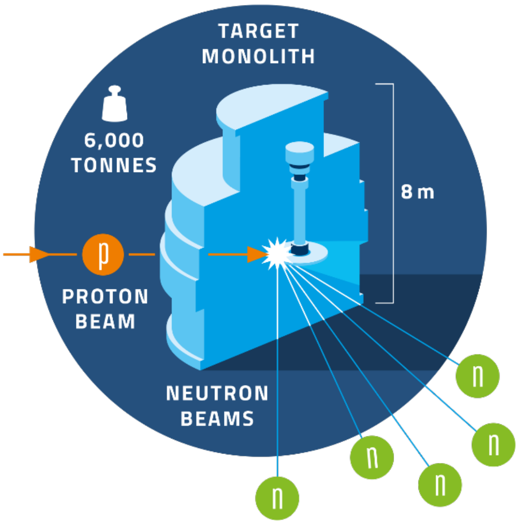
2. **Light sources**

   A synchrotron light source is a special kind of electron accelerator aimed at producing strong, intense light, which can be used to study matter and address many scientific questions in biology, chemistry, and materials science. Like with a giant microscope, the photon beams (X-rays) generated are scattered by the sample atoms and then detected/observed. To find answers to these questions, we need to investigate and look at things closer and, for that, we need light – very bright, X-ray light.

3. **Neutron sources**

   To look even closer at a sample, instead of synchrotron light, we can use a neutron beam. When they are moving very fast, neutrons act a little like light, and we can detect the way they bounce or scatter off a sample to find out about that sample’s structure. But neutrons are bound in the nucleus of the atom, so a lot of energy is required to get them out. We can extract neutrons from atoms like uranium using nuclear fission, in a nuclear reactor, such as at the Institut Laue Langevin (ILL) in Grenoble, France.

   Another method to obtain a larger and more controllable flux of neutrons is to use the technique of spallation: neutrons of a heavy atom, like mercury or tungsten, are struck with high-energy protons that have been accelerated to almost the speed of the light. This is how the new European Spallation Source (ESS) ERIC in Sweden will work, just like some existing spallation sources, such as the Spallation Neutron Source in Oak Ridge, USA; the J-PARC in Japan; the ISIS Neutron and Muon Source in the UK; or the Chinese Spallation Neutron Source (C-SNS).



The accelerator at ESS generates high-energy protons, which hit the tungsten target, releasing a high flux of neutrons for scientists to use.
©ESS

4. High-energy physics

Some particle accelerators are used to understand the very nature of particles. Often this uses a type of accelerator called a collider. Here, particles are typically accelerated in opposite directions towards one another until they collide and the particles themselves break apart, revealing what is inside. This helps particle physicists to understand the basic building blocks of the universe – the fundamental particles – and they have used this knowledge to build and test the standard model of fundamental particles.

The largest and most famous machine is the Large Hadron Collider (LHC) at CERN on the border of France and Switzerland. This is a circular accelerator, a synchrotron, with a perimeter of 27 km!