Issue 67 – April 2024

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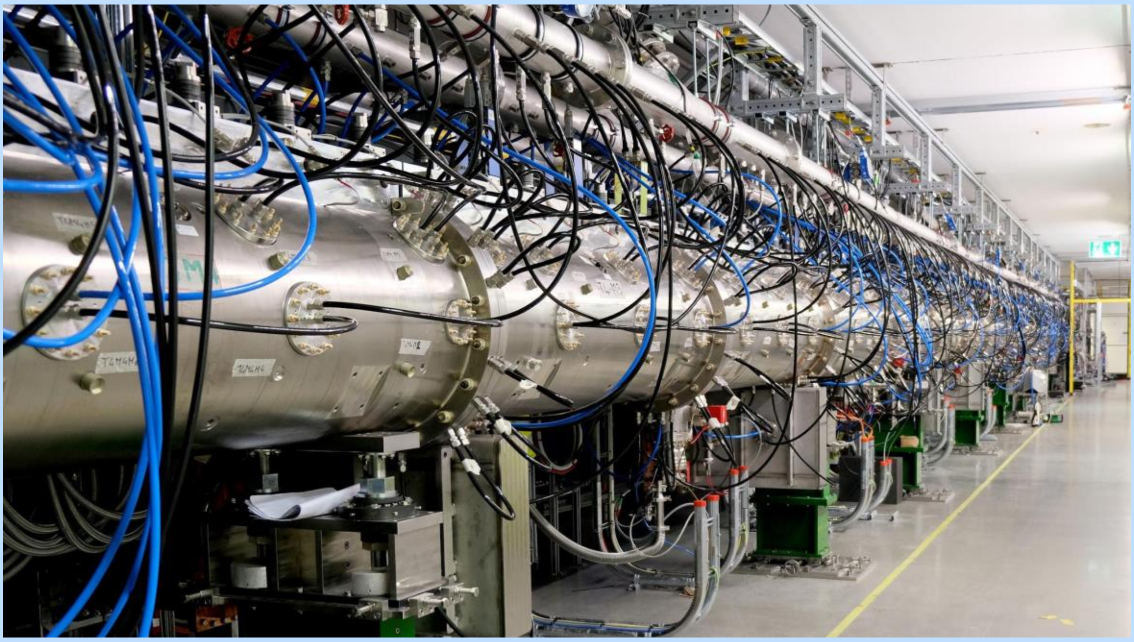
Build a linear accelerator model

Activity instructions

European Spallation Source (ESS)



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ESS can be described as a neutron factory. Neutrons are a powerful research tool, as they have certain useful properties. They travel deep into materials and straight through metals. At the energies used, neutrons have wavelengths similar to atomic distances, and thus, provide the right resolution to look at structures at the atomic level. They have a high sensitivity to light elements, like hydrogen, which is dominant in biological systems, and lithium, which is present in rechargeable batteries. Neutrons are nondestructive and, therefore, particularly suitable for studying fragile samples. All these properties, and more, make neutron science a powerful tool for research and can be used to advance our knowledge in medicine, chemistry, transportation, energy, and more. In addition, research with neutrons is complementary to other techniques, so researchers will often use a neutron source to add more data to the experiments they may carry out at, for example, synchrotron-light-source facilities.

An important part of ESS is a linear particle accelerator, where protons will be accelerated up to very high speeds. Acceleration is achieved using strong electric fields.

A particle accelerator that can enable such high speeds will, of course, be difficult to build at school, but here is an experimental model of a linear accelerator: the Gauss cannon.

In a Gauss cannon, a series of strong magnets are placed evenly on a track and steel balls are placed such that releasing one at the start leads ultimately to the last ball leaving the track with an increased speed and energy.

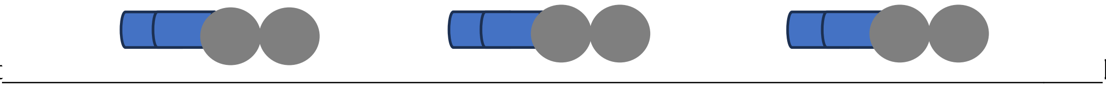
If a bunch of small balls are then placed at the end of the accelerator, these balls – or ‘neutrons’ – will be scattered in many directions, demonstrating the spallation process, when the protons hit the neutron-rich target.

Materials

- Six neodymium magnets
- At least seven steel balls (approx. 1 cm in diameter)
- Track that can guide the balls in a straight line
- Tape or sticky gum to fix the magnets to the track
- Box, bag, or tray to catch the balls at the end of the track

Setup

1. Use sticky gum or tape to fix magnets in pairs along the track with around 10–15 cm between each pair.
2. Place two steel balls next to each pair of magnets, and repeat with each pair of magnets. Each set should have two magnets and then two steel balls.

Start  **End**

3. Place your box, bag, or tray at the end of the track closest to the wall, such that the balls coming off the end will land in the ‘target’. Fix it firmly in place.
4. Prepare to gently push a ball from the start of the track towards the first pair of magnets.