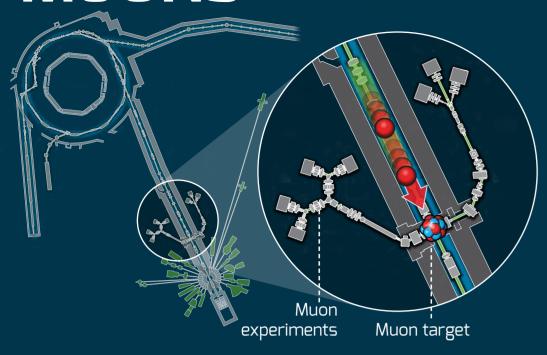
# HOW ISIS MAKES MUONS

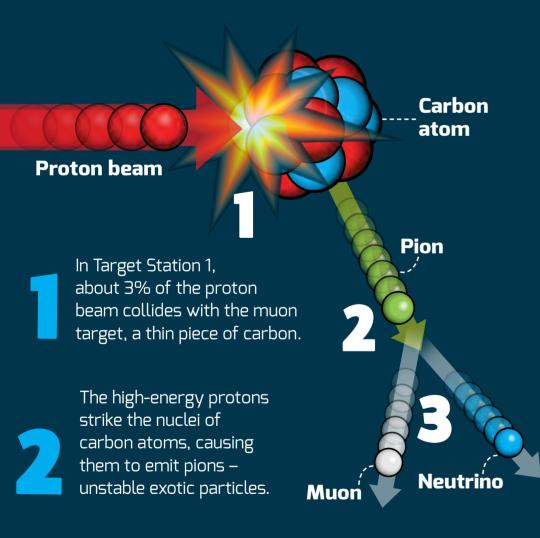


### What is a Muon?

Muons are exotic relatives of electrons, but with more mass. They are unstable particles that quickly decay into an electron, or positron, and two neutrinos, but they live long enough to be used in experiments.

## Why use muons?

Muons carry an electric charge and have a property called 'spin' that makes them very sensitive to magnetic fields. They can be used to study magnetic materials, battery materials and superconductors. They can also be used to study the composition of archaeological and historical artefacts.



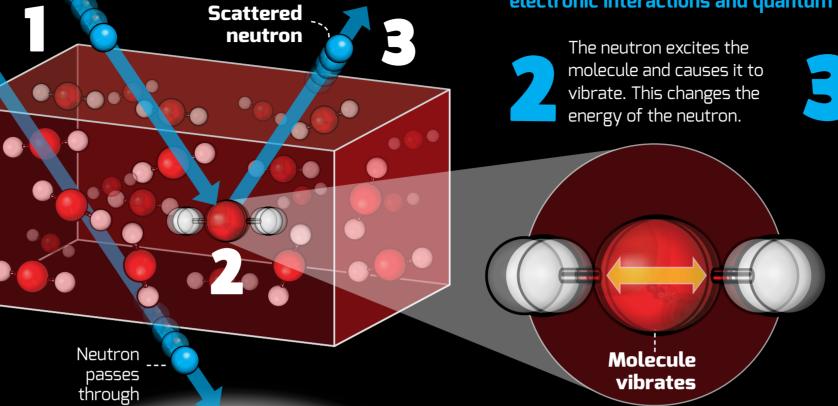
Pions are so unstable that, within a few nanoseconds, they decay into neutrinos (particles with no electric charge and almost no mass) and muons.

The muons are then directed to the muon experimental areas.

Muons only live for **2** millionths of a second before they decay into lighter particles.

# How neutrons probe matter

#### **NEUTRON SPECTROSCOPY** Neutron spectroscopy measures the change in energy of a neutron when it scatters off a sample. This allows A neutron beam is fired at the us to understand how atoms and molecules in the sample. Most neutrons pass straight sample are moving and the forces acting between through, but some collide with atoms them. It can be used to explore diverse materials and or molecules within the sample. Neutron processes, from molecular vibrations and rotations to beam electronic interactions and quantum tunnelling. Scattered neutron The neutron excites the When the molecule and causes it to vibrate. This changes the



When the scattered neutron exits the sample, it has a different energy than when it entered. From the change in energy scientists can study the chemical and physical properties of the molecule it scattered from.

# NEUTRON DIFFRACTION It can be used to in

Neutron diffraction reveals the locations of atoms in materials and can be used to explore atomic, molecular and magnetic structure.

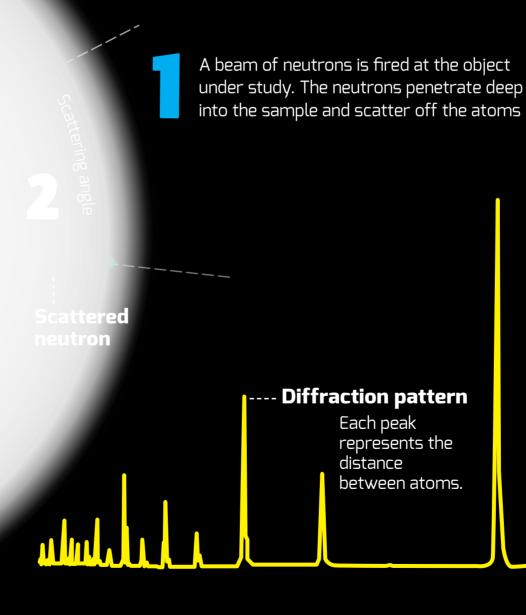
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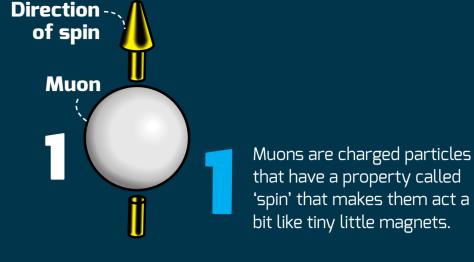
Technology Facilities Council It can be used to investigate a wide range of materials and how they work, such as battery materials in mobile phones, magnetic materials in computer hard drives, molecules in cell membranes or soaps in cleaning products.

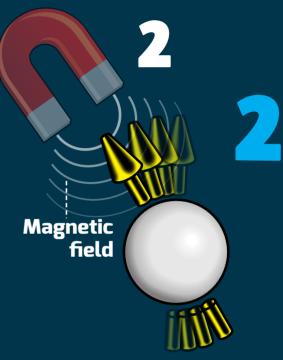


The scattered neutrons exit the sample towards an array of detectors. By recording the angles at which the neutrons scatter, scientists can create a diffraction pattern that solves the sample's structure by revealing the position of its atoms.

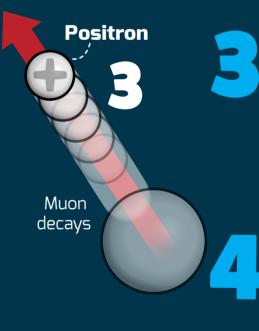
# How muons probe matter

# **MUON SPECTROSCOPY**



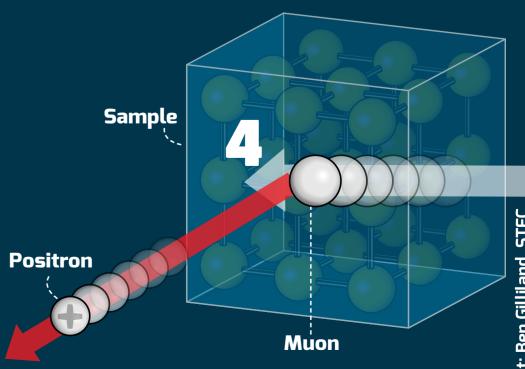


When muons are placed within a sample, their spin direction will be affected by any magnetic field they encounter.



Muons decay very quickly and emit a positron (positively-charged electron). The direction the positron leaves the sample tells scientists which way the muon spin was pointing when it decayed.

By recording millions of muon decays, scientists can determine the magnetic properties of the sample.



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