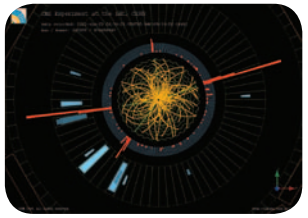
PARTICLES

What is the most famous particle accelerator?

The Large Hadron Collider (LHC) is a gigantic particle accelerator at CERN, near Geneva, where it spans the border between Switzerland and France, about 100 m underground. Here physicists study the smallest known particles – the fundamental building blocks of all things.

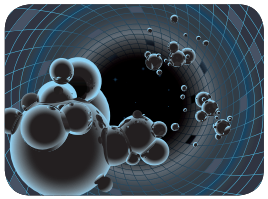


CERN

In the LHC two beams of sub-atomic particles called "hadrons" – either protons or heavy (lead) ions – will travel in opposite directions inside the circular accelerator, gaining energy with every lap, before being collided together head-on at very high energy.

Teams of physicists from around the world will analyse the particles created in the collisions using different detectors.

Some of the questions the LHC is trying to answer:



- What creates mass; is it the Higgs Boson?
- Does dark matter exist?
- Why is there no more antimatter in the universe?
- What was it like at the Big Bang and the very start of the universe?
- Do extra dimensions of space and time exist?

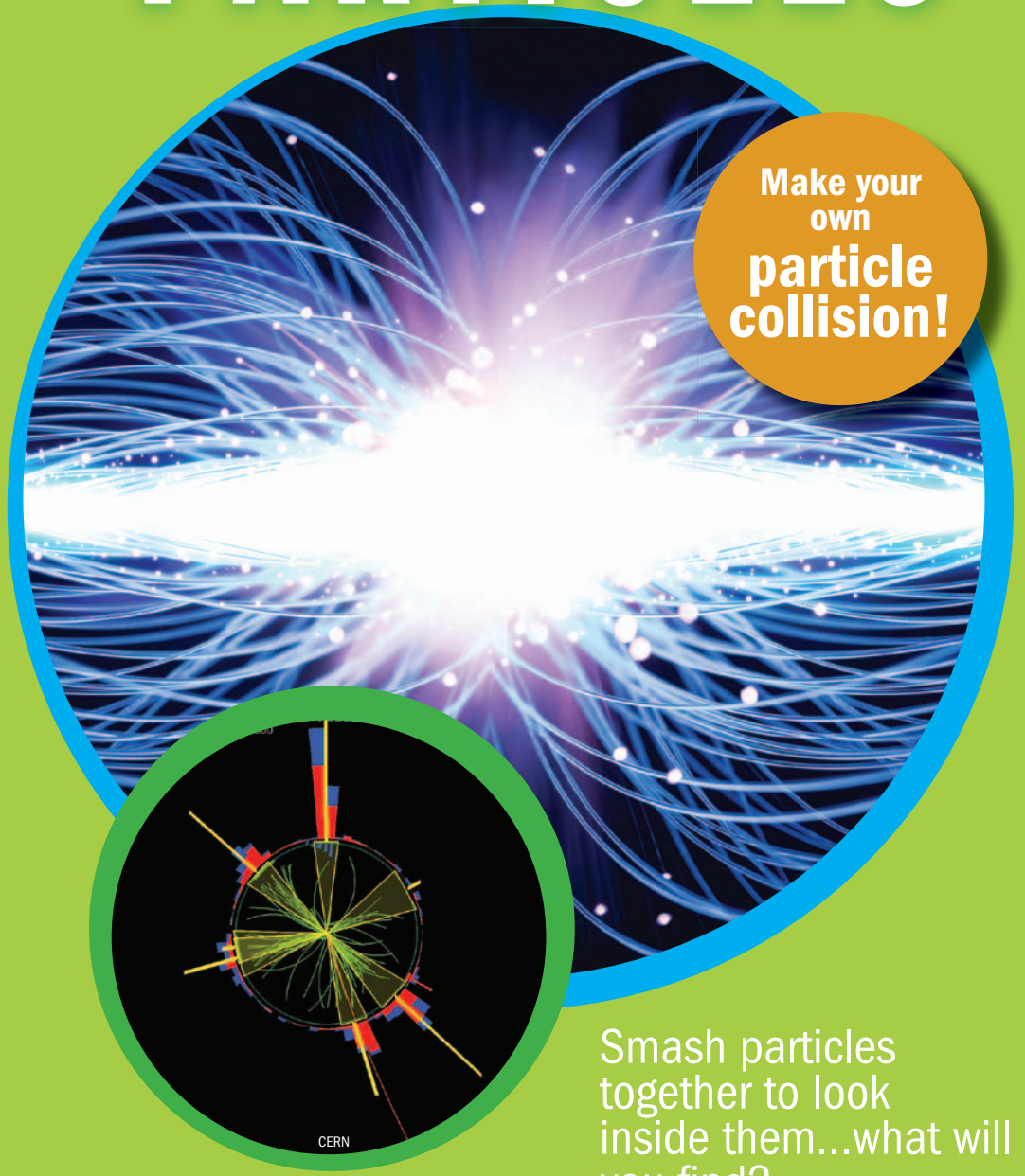
Find out more…

Particle Detectives **www.lhc.ac.uk/The+Particle+Detectives/LHC_project.html**
Try the LHC experiment simulator for yourself.

CERNLand **project-cernland.web.cern.ch**
Find out about CERN and the LHC and the science behind it – for younger children.

Particle Adventure **www.particleadventure.org**
Interactive tour of the fundamentals of force and matter – for older students.

CMS Education website **cmsinfo.web.cern.ch/cmsinfo/Education/index.html**
Educational and teaching resources based on LHC physics topics.

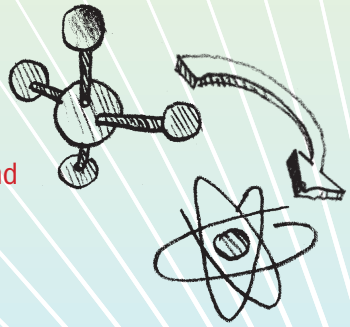


Smash particles together to look inside them…what will you find?

IOP Institute of Physics

Particles are all around us...

Everything we see around us is made up of tiny particles called **atoms**



Atoms have a **nucleus** at the centre surrounded by a cloud of **electrons**

The nucleus contains **protons** and **neutrons**

2 up + 1 down quarks = proton

Inside each proton or neutron are 3 **quarks up + down**

1 up + 2 down quarks = neutron

○ Many particles have an antimatter sibling too ~ kind of a mirror image

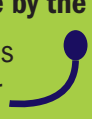
Many particles have an antimatter sibling too ~ kind of a mirror image ●

How do we find out what particles are made of?

- Protons or atoms are accelerated to very high speeds and smashed together.
- The resulting debris is analysed to see what new particles have been produced.
- We see the tracks that the different particles leave as they pass through the detector.

We can tell what particles are by the shape of their tracks

Charged particle tracks **curve** as they move through the detector



Particles with less energy follow **spiral** paths

Neutral (uncharged) particles go in **straight** lines

Particles with more energy have **longer** tracks

Make your own particle explosion mobile

- Choose two particles (beads) to collide.
- Tie them tightly together with some elastic thread.

  ...Now decide...

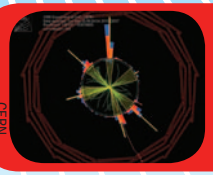
  → How big will your collision be – how many pipe cleaners?

  → Will the particles be charged – straight, curved or spiral?

  → How much energy will they have – how long and bent are they?
- Push the pipe cleaners through the elastic loop and secure by twisting them together. Then shape them!
- If you want particles on the ends, ask a demonstrator to stick some pom-poms on with the glue gun.

What particles have you made?

Straight, long tracks	Photon	*Pure energy*
Straight, short tracks	Neutrino or anti-neutrino	*Tiny & light*
Curved, short tracks	Electron or positron	*Small & charged*
Curved, long tracks	Muon or anti-muon	*The electron's big brother*
Spiral tracks	Pion	*An up & down quark pair*
Jets (several tracks starting together and spraying out)	Quark pairs & gluons	*Gluons stick quarks together*
	Z-bosons W-bosons	*Heavy particles that carry force*



Have you found the Higgs boson? This is the particle that physicists think might carry **mass**, which is what makes us heavy. They are looking for it in particle accelerators all over the world.