Videos and Animations

Accelerators for Humanity. A series of films exploring the varied applications of particle accelerators as well as the human stories of particle accelerator researchers working in STFC-funded facilities.
www.richannel.org/collections/2016/particle-accelerators-for-humanity

In Search of Giants. Fifteen short films starring Professor Brian Cox. These episodes begin by looking at the history of particle and nuclear physics – they go on to describe the physics principles important to these fields of research – and finish by looking at the work being done at CERN.
www.youtube.com/playlist?list=PL322304BDE289D607

Colliding Particles. A series of films following just one of the teams of physicists involved in the research at the LHC. The project documents their work at the frontiers of particle physics, exploring the human stories behind the research and investigating the workings of the scientific process itself.
http://www.collidingparticles.com/

The Basics of the Higgs. Two CERN scientists discuss just what the Higgs Boson is and explain the exciting implications of its discovery.
http://ed.ted.com/lessons/the-basics-of-boson-dave-barney-and-steve-goldfarb

Just how small is an atom? This TED-Ed lesson uses spectacular metaphors (imagine a blueberry the size of a football stadium!) to explore the questions: Just how small are atoms? And what's inside them?
http://ed.ted.com/lessons/just-how-small-is-an-atom

Radioactivity: Expect the unexpected. This animation nicely explains radioactivity and how it can be both dangerous and useful.
http://ed.ted.com/lessons/radioactivity-expect-the-unexpected-steve-weatherall

Other websites

www.stfc.ac.uk/InsidetheAtom
Make this your first stop for an overview of particle and nuclear physics in the UK. This page has links to all the resources mentioned in this document and to other relevant sites including:

http://education.web.cern.ch/education
The CERN education website offers information about visiting CERN, teacher programmes and educational resources. For more advice about visiting CERN go to *www.stfc.ac.uk/VisitCERN*.

http://ippog.web.cern.ch
The international particle physics outreach group (IPPOG) is a network of scientists and educators who produce particle physics resources, events and masterclasses. To see where your nearest particle physics masterclass is being held go to *www.stfc.ac.uk/pp-masterclasses*.

Teaching STEM through 'Inside the Atom'

This document details a collection of teaching resources available from STFC and partner organisations that use particle and nuclear physics as an inspirational context for STEM learning.

Particle and nuclear physicists study the building blocks of the Universe and the forces of nature that influence them. Their research is fundamental to our understanding of the physical world around us. Unfortunately no instrument allows us to see inside the atom directly, so scientists have to observe the hidden world inside atoms indirectly using accelerators.

The world's largest particle accelerator is the Large Hadron Collider (LHC) at CERN on the French-Swiss border. The LHC is 27km long, 100m underground and accelerates particles to 99.999999% the speed of light!

To learn why particle physicists are recreating the conditions just after the Big Bang at the LHC, or to find out why nuclear physicists study supernova to explain how almost all the elements in your body were made in stars go to *www.stfc.ac.uk/InsideTheAtom*.

Inside the Atom and STEM learning

Using particle and nuclear physics as a context for STEM teaching might spark some immediate questions:

- Just how small is an atom?
- How many fundamental particles are there – and are we likely to find any more?
- What is radiation? How dangerous is it and how can it be useful?
- What is antimatter and can it be used to power spaceships?
- Is nuclear energy safe?
- Just what is the Higgs Boson?

Physicists look inside the atom and study the hidden world of tiny particles to help explain what happens on the largest scales of the Universe. While exotic topics like antimatter might seem far removed from everyday life, applications from particle and nuclear physics do have a real impact on our lives. Here are some examples of inspirational contexts from inside the atom science to aid STEM learning:

How the very small impacts the very big

- Nuclear processes are involved at every stage of a star's life: from birth, when hydrogen fusion begins in its core – to death, when the nuclear fuel in its core runs out and much more dramatic nuclear reactions can occur to produce the elements needed for life.
- Dark matter effects how galaxies evolve and influences the large scale structure of the Universe. Astronomers use big telescopes to watch the effects of dark matter, while particle and nuclear physicists use huge accelerators and detectors to try to identify what it is.
- In the first moments after the Big Bang the Universe consisted of a hot soup of fundamental particles. The LHC simulates these conditions to help us understand how the Universe evolved into what we observe today.

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Inside the Atom – Inside everyday lives

- Everyone will know someone who has benefitted from a medical procedure based on the applications of particle and nuclear physics. Whether they have had a routine X-ray, PET scan or undergone radiotherapy to treat cancer.
- Nuclear power stations generate about 18% of the UK's electricity and are a vital part of the UK's energy plan – to keep our lights on – while keeping our greenhouse gas emissions down.
- The most common domestic smoke alarms use a radioactive source to detect smoke. When smoke interrupts the current caused by low a level of ionising radiation – the alarm sounds.

Physics

- *Particle model of matter:* Starting with the atom and the discovery of the atomic nucleus, then delving deeper into the fundamental particles and forces – the standard model, not only teaches students about the nature of matter, but also the nature of science. How methods and theories develop as earlier explanations are modified to take into account new evidence and ideas.
- *Radioactivity and ionising radiation:* These topics provide great opportunities for practical physics – exploring the types and range of ionising radiation, as well as mathematical studies of probability and statistics through the random nature of radioactive decay. Examining half-lives can also lead to interesting discussions on the environmental impact of long lived radioactive waste and applications in radioactive dating

Chemistry and Biology

- *Periodic table:* How the discovery of the structure of the atom – a nucleus surrounded by shells of electrons – led to the explanation of the chemical properties of the elements in the periodic table.
- *Chemical vs nuclear reactions:* Chemical reactions involve a change in the electrons surrounding the nucleus, while nuclear reactions involve a change in the atomic nucleus itself. Nuclear reactions release a lot more energy than chemical reactions due to the differences in nuclear and electron binding energies.
- *Ionising radiation, negatives:* Radiation is all around us – as a background to the natural world, but increased exposure can have damaging effects on the human body and our DNA. DNA damage can lead to replication errors, cell death and mutations.
- *Ionising radiation, positives:* The damaging nature of radiation can be used in radiotherapy to kill cancer cells. Radioactive elements are also used in medicine as tracers for imaging and mapping the functions of organs.

Engineering

- *Running an accelerator:* There are ten times more engineers and technicians than scientists employed by CERN because of the challenges associated with running the world's largest machine, 100m underground, at temperatures colder than Pluto, with a vacuum emptier than outer space!

Inside the Atom Resources

This is a collection of resources freely available for use by students and teachers in the classroom.

Publications

Big questions, big experiment. A full-colour A5 leaflet that opens out into an A2 double-sided wall poster describing the "big questions" about our Universe that scientists are trying to answer and how the amazing LHC will help them do so.

Inside the atom: nuclear activity in the UK. A full-colour A5 leaflet that opens out into an A2 double-sided wall poster describing the activity of the nuclear physics community and how their work impacts our lives.

A tunnel to the beginning of time. A spectacular full-colour A1 poster showing the famous view through the middle of the ATLAS detector, looking down the centre of the LHC tunnel.

The little book of the big bang. A cartoon booklet that introduces particle physics, particle accelerators and the LHC. This clear, concise and entertaining booklet explains what a particle accelerator such as the LHC is and the questions it is trying to answer.

What is next for the LHC? A full-colour leaflet describing what the LHC is, what is still to come, what the UK has already gained thanks to the LHC, how it will inspire the next generation of scientists, and the engineering and technology successes.

All these publications can be printed directly from the STFC website or ordered online and sent to a UK postal address: *www.stfc.ac.uk/pub-order-form*

Classroom Activities

Get involved in CERN science. Through the Institute for Research in Schools (IRIS) you can participate in the exciting research at CERN:

CERN@school: You can borrow a CERN detector, through the CERN@school project. This free programme gives you a chance to use state of the art technology for radiation lessons and further investigation – all the teacher resources are on the IRIS website and there is online training too.

CERN data: There are school data analysis projects using CERN@school detectors at CERN, in space, at sea and at the South Pole! The Higgs Hunting project also gives you access to real ATLAS data to analyse and find decay products from the Higgs.

www.researchinschools.org

www.higgshunters.org

Teaching Radioactivity. A number of teaching resources developed by the Institute of Physics to support the teaching of radioactivity and to give students a more authentic and engaging experience of ionising radiations and sub-atomic particles.

www.iop.org/education/teacher/resources/radioactivity/page_41558.html

Physics kits. Resources developed at Queen Mary University of London using LEGO® to illustrate physics concepts such as fission, fusion and the structure of nuclei. The lesson plans, activity sheets and booklets cover curriculum linked topics in particle and nuclear physics.

www.ph.qmul.ac.uk/engagement/physics-kits

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