UK Outreach Topics

Rachel Montgomery on behalf of UK institutes

Funding Opportunities

- Spark award from UKRI STFC (up to ~$20k)
  - https://www.ukri.org/what-we-do/public-engagement/public-engagement-stfc/our-support-for-public-engagement-stfc/funding-for-public-engagement/
  - Used this for outreach at INPC2019 conference
  - Plus other larger awards eg outreach fellowship type awards

- Most Uni's in UK have internal funds to pay "salary" for Summer students
  - (e.g. we had Summer students in Glasgow work on timepix or physics topics)
  - Would be welcome to external students - if funds could be sought elsewhere for living costs and travel

Binding Blocks in UK

- Nuclear physics outreach collaboration in UK led and coordinated by University of York
- Run yearly online nuclear physics masterclasses for high school students
- In addition to curriculum related material, masterclasses are research-led, they involve researchers and research topics
    - e.g. webinars, research-led modules (eg “particle physics meets nuclear physics” module)
- Would be great to get EIC embedded in these masterclasses
- Binding Blocks have STFC funding. Can help support people getting involved (eg materials production, travel)
- In the past (from Glasgow personal experience) we partook in masterclasses via development of “particle physics meets nuclear physics” module, live webinars about our research, and creating pre-recorded videos with PhD students discussing their research in Mainz and JLab or on strong force topics
    - e.g. PhD student videos (https://www.youtube.com/watch?v=KfB-eU9HUjg and https://www.youtube.com/watch?v=nf_sZVCnugI)

Binding Blocks in UK

Join the **Binding Blocks** team to explore cutting-edge research in nuclear physics.

Format of post-16 masterclass

- 6 week programme with 3-5 hours content per week.
- Work at your own pace, in the classroom or at home.
- Weekly live webinars with leading experts from around the world.
- Get help and find out more through an online question forum.
- Complete all activities to receive a Certificate of Participation, awarded by the **University of York.**

This programme is suitable for students aged 16-19 studying Physics (AS or A Levels, IB, Highers or Advanced Highers, or equivalent).

Module 1: Energy and Decay

Explore the Nuclear Chart, showing all the isotopes discovered so far. Refresh your understanding of the different decay types, follow nuclear decay chains, explore the concept and applications of binding energy, and investigate half-lives. This first module will give you all the building blocks you need to explore Nuclear Physics in more detail.

Module 2: Experimental Nuclear Physics

From historic experiments that revealed the structure of the atom, to cutting-edge detectors and particle accelerators, in this module you'll explore how discoveries in Nuclear Physics have been made, and get a glimpse of some of the exciting research that's currently being undertaken around the world. Take part in virtual tours of National Laboratories, find out about underground research facilities, and investigate detector science through online simulations.

Module 3: Nuclear Astrophysics

Investigate the life cycle of stars - from fusion taking place in main sequence stars, to the nuclear reactions happening during stellar explosions. Discover the origins of the elements and find out about the roles of different isotopes in these processes. Investigate a model of the nucleus using an interactive simulation, and use this to explore the size and density of neutron stars.

Module 4: Fusion Technology

In this module we bring nuclear fusion, the process that powers the stars, down to Earth. Find out about this potential method of power generation that could solve the energy crisis. From tokamaks to laser-driven fusion, discover the interface between nuclear and plasma physics and explore the devices being used to create temperatures more than ten times hotter than the centre of the Sun.

Module 5: Medical Physics

Explore Nuclear Medicine - from imaging techniques to treatment of diseases such as cancer. Discover what medical physicists do; find out how PET scanners work, and how quantum entanglement can make these more effective; and use computer modelling to investigate proton-beam therapy and optimise treatment.

Module 6: Particle Physics meets Nuclear Physics

This is an opportunity to delve inside the nucleus. Protons and neutrons are both examples of hadrons - particles that are composed of quarks and therefore feel the strong force. In this module, discover some of the more exotic quark combinations and newly discovered particles that may give us the answer to questions such as 'What is dark matter?'.

It would be great to get EIC embedded within this module

- Online masterclasses:
- Pre-16 masterclass https://isaacscience.org/events/2503_pre16_bindingblocks
- Post-16 masterclass https://isaacscience.org/events/2503_post16_bindingblocks
- Students get certificate from University of York after completion

Binding Blocks in UK - Loan Kits

- Teacher loan kits: https://sites.google.com/york.ac.uk/bindingblocks/teachers/loan-kit
- We developed a couple of kits in Glasgow (particle scattering kit and cloud chamber) and there are others available too
- Schools can request kits to be sent to them, teachers can also attend teacher training events if they want to - but kits are all self explanatory with accompanying video content explaining how to use them
- Only in England currently - would be nice to expand to other countries/remote places far form Universities (eg highlands and islands)

A **free*** loan kit is available for UK schools and colleges to use in Key Stage 4 and 5 physics lessons (GCSE and A-level or equivalent) for up to a term. Each item of the kit is accompanied by online resources including video content and activities, as well as instructions for use.

* Please note that shipping for independent schools is charged at £160.

Request a loan kit

Binding Blocks in UK - Loan Kits

Particle Zoo

You can use the particle zoo to demonstrate beta-decay. The neutron turns inside out into a proton, emitting an electron and an anti-neutrino, (this process can also be done in reverse).

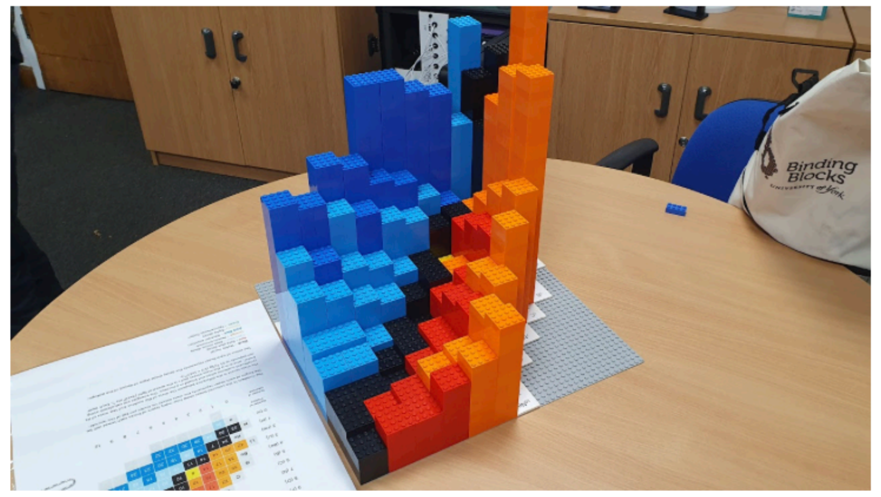
LEGO Physics

Queen Mary's University London have put together a suite of resources for using LEGO bricks to explore how our universe was created, fusion and fission, and particle physics.

Hot CNO Cycle

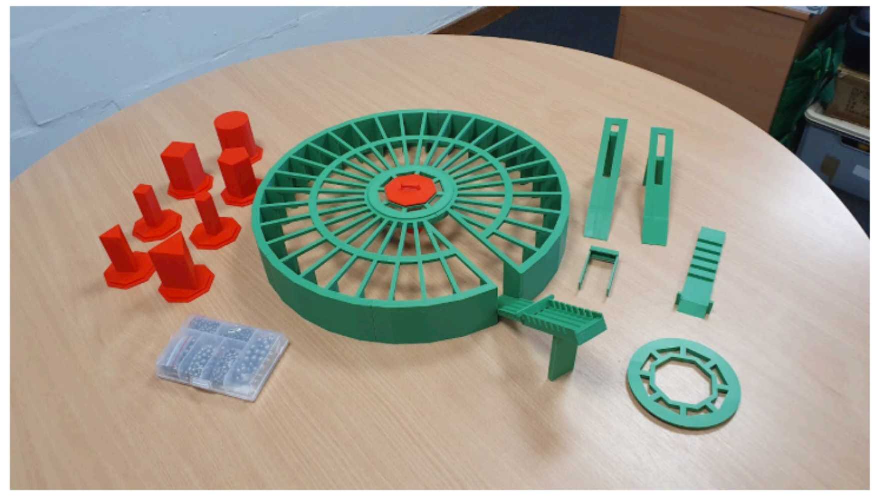
The Hot CNO cycle is a sequence of reactions that provides most of the energy radiated by stars hotter than our Sun. Have your class play the game to learn about radioactive decays.

LEGO Chart



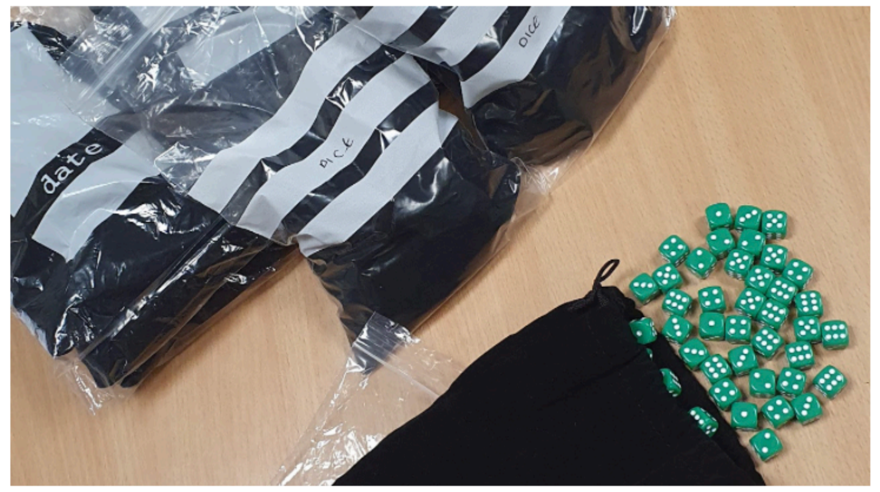
Use LEGO bricks to construct the first ten elements in the nuclide chart. The colour shows the decay mode and the height represents the binding energy.

Scatterer



This simplified model of a particle scatterer can be used to visualise famous experiments, such as Rutherford's experiment to determine the structure of the atom.

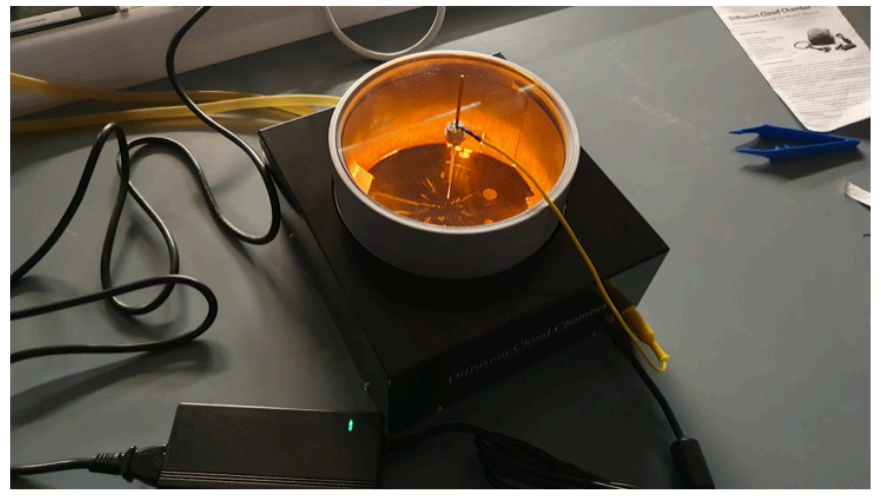
Dice



1,500 dice (100 each of 15 different colours) can be used to model radioactive decay and calculate half lives.

VR Headsets

Cloud Chamber



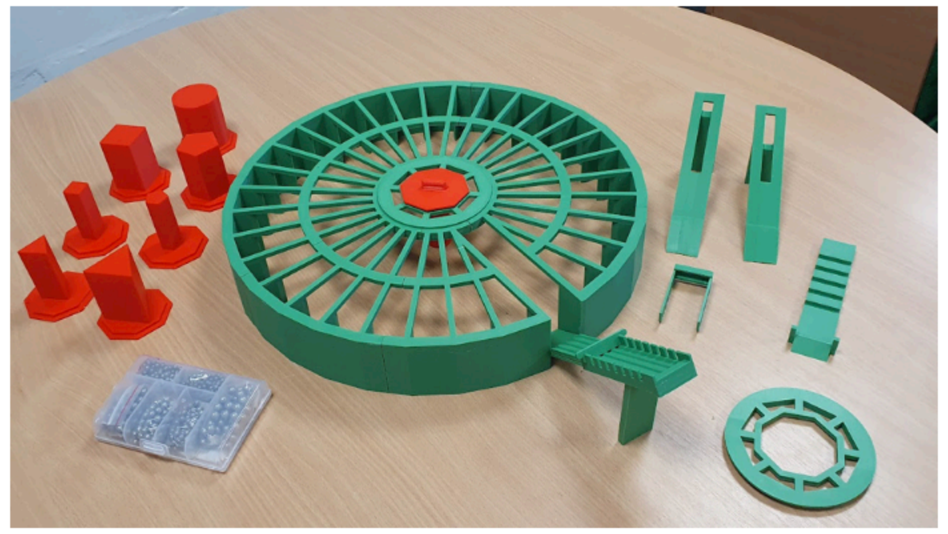
Geiger Counter

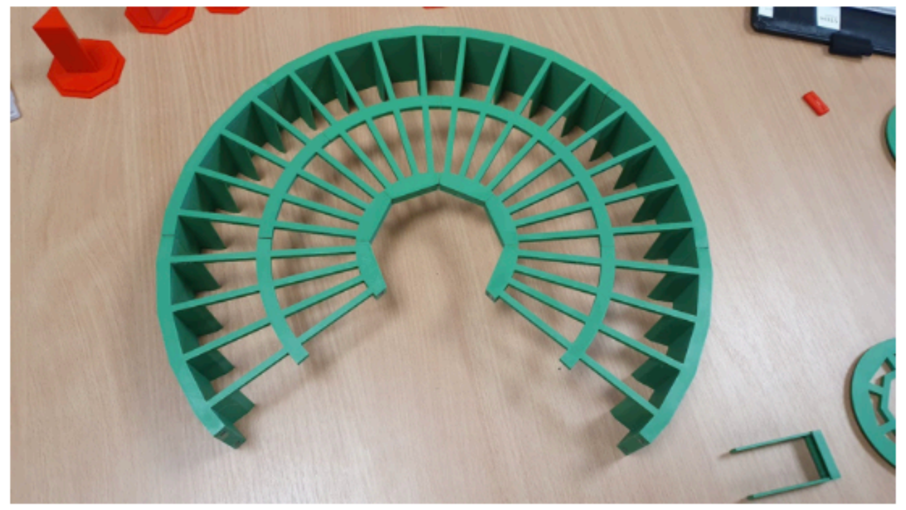
D3S Detector

Scatterer

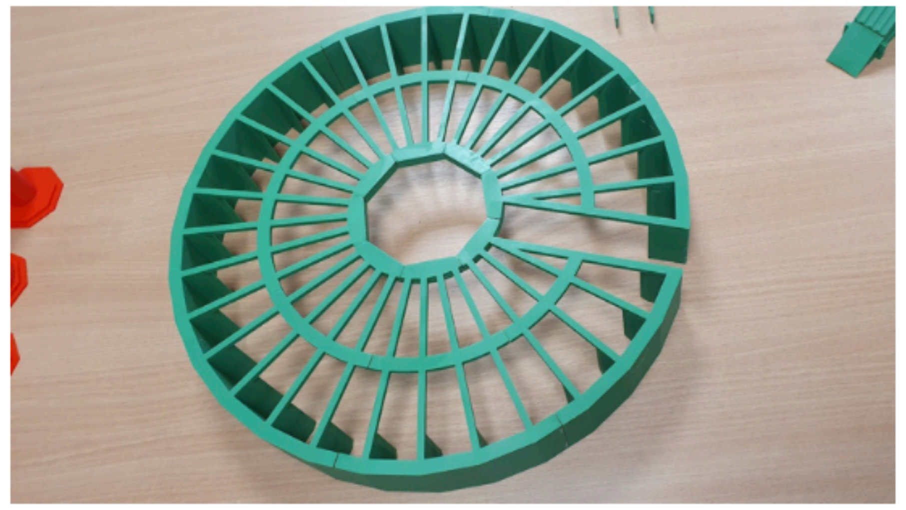
The loan kit contains the 3D printed parts to construct a simplified model of a particle scatterer:

- Scatterer Structure Edges x8
- Targets x8
- Target slots x2
- Ramps x3
- Ridged Track x1
- Ramp Holder x1
- Ball Bearing Holders x2
- Stopper x1
- Ball Bearings x1 pack

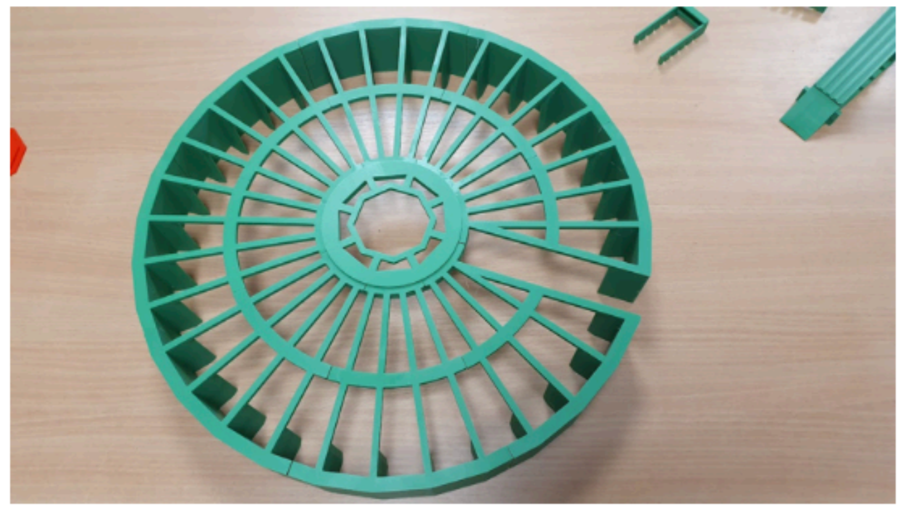




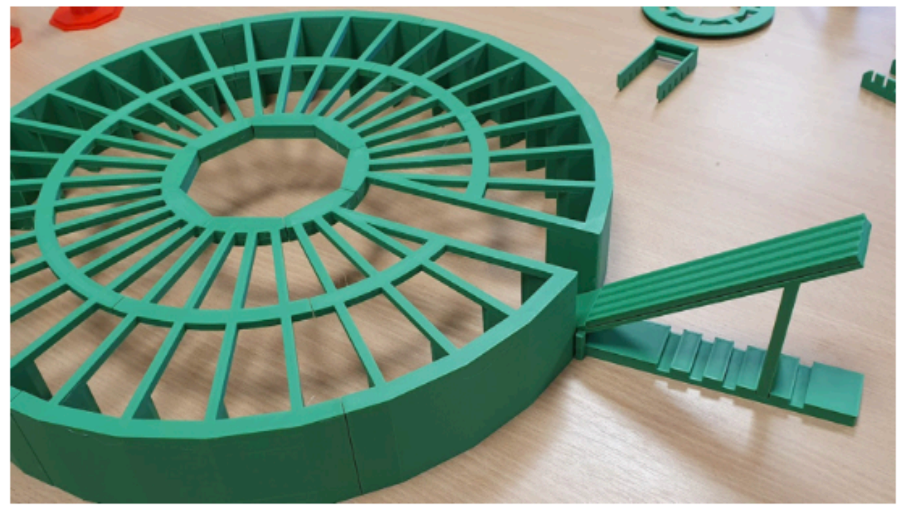
You want to start by putting together the outer edges of the scatterer. There are six identical pieces, and then two pieces that form a gap, (for where the ball bearings are loaded).



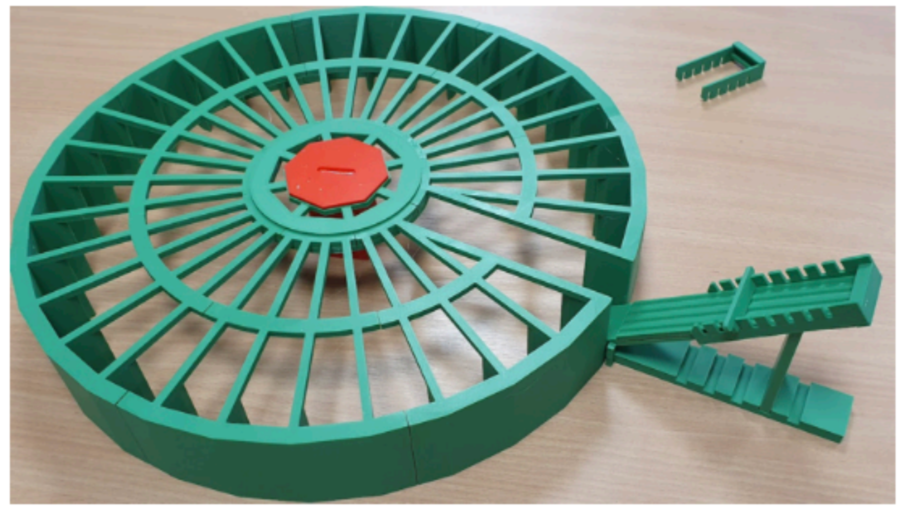
Each "bin" of the scatterer is labelled 0 through to 31, so connect the pieces together such that these are in order. The magnets will easily clip each piece together.



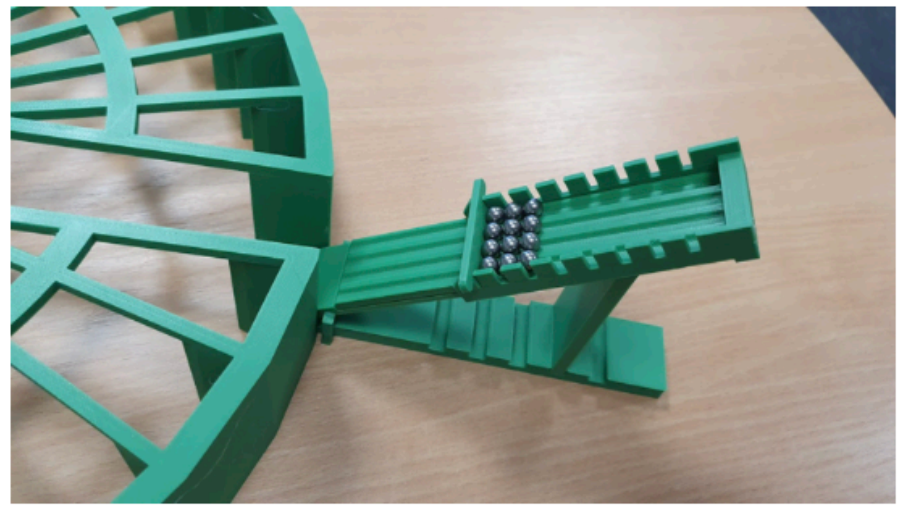
Next, in the hexagonal ring in the centre, place of the target slots - the ring that holds the target, (this allows for a consistent placing of the angle of the target). The structure of the scatterer is now set up.



We have a segmented piece that holds the ramp in a consistent location. You also have three different heights of ramps, which affects the speed of the ball bearings.



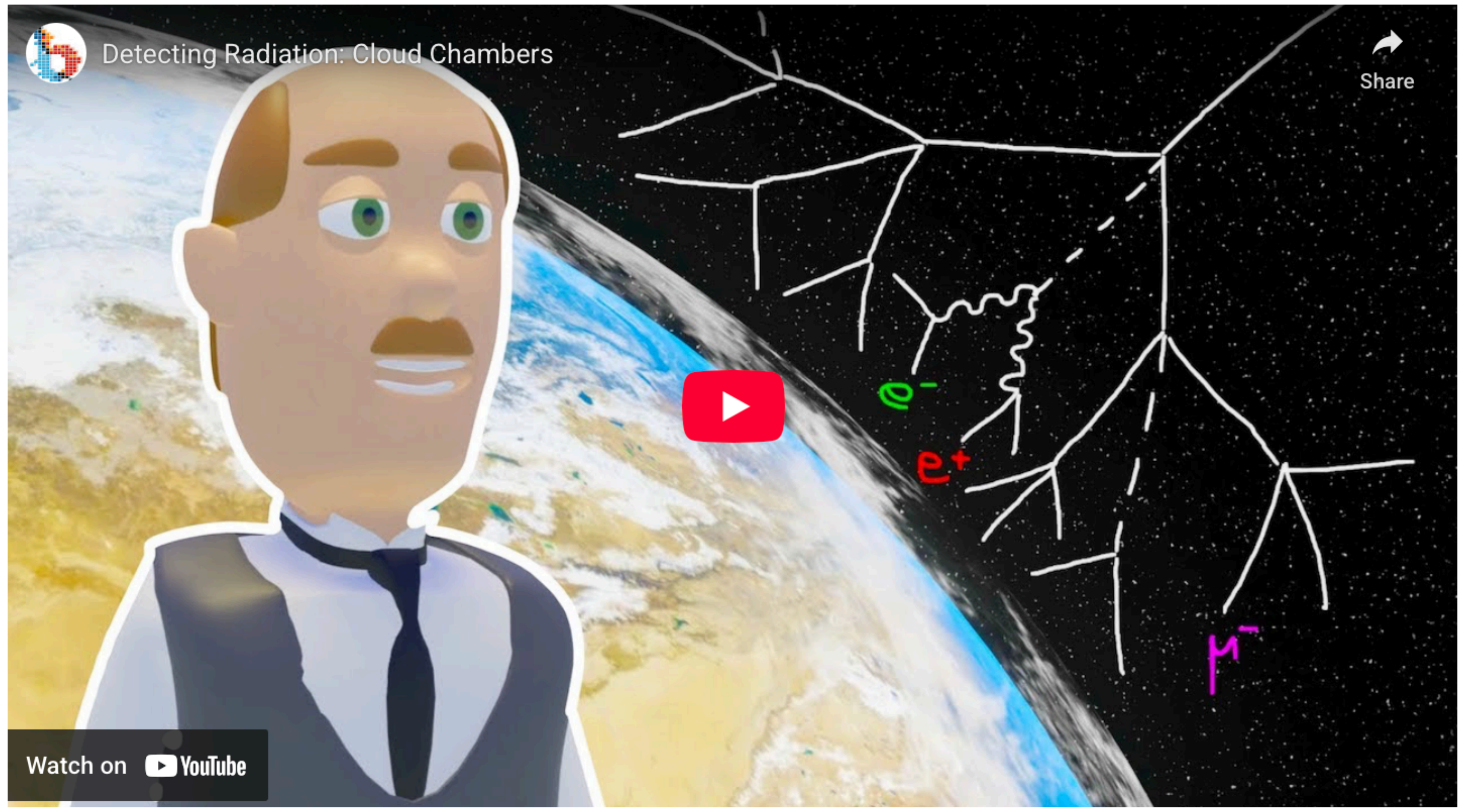
The final part of setting up our "experiment" is selecting the shape and size of the target we wish to investigate. Choose one of the eight targets and place it in the central slot.



We now need to prepare the "energetic particles" - the ball bearings. There is a serrated piece that fits onto the end of the ramp and a small piece that acts as a stopper. Load the ball bearings, release, and tabulate the data!

- https://sites.google.com/york.ac.uk/bindingblocks/teachers/loan-kit/scatterer#h.rrkn5x1d8wo5
- Designed for fixed target experiments
- Different target shapes
- Reconstruct diameters of targets
- Comes with worksheets and excel sheet to analyze results
- Explicitly linked to schools curriculum
- Can provide 3d printing files to anyone who wants it

Cloud Chamber

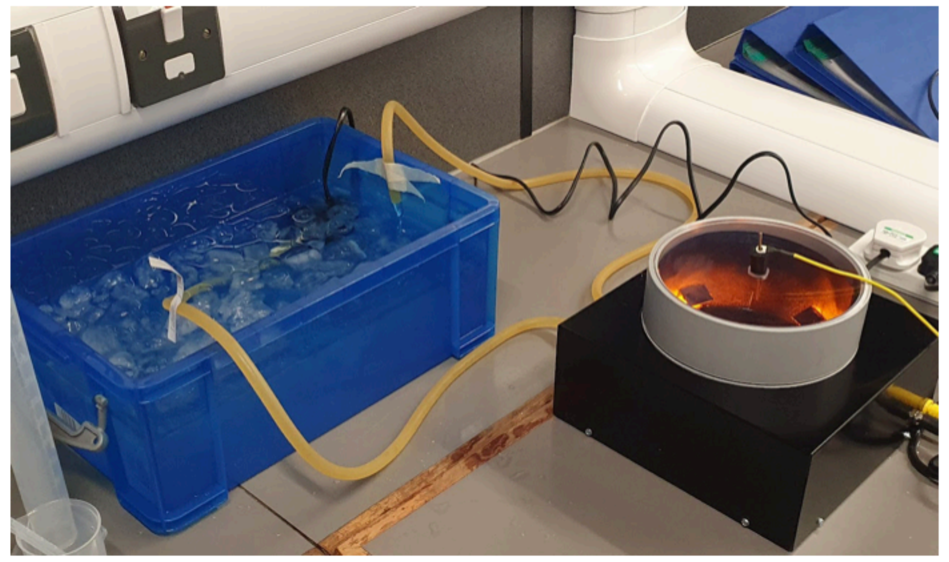


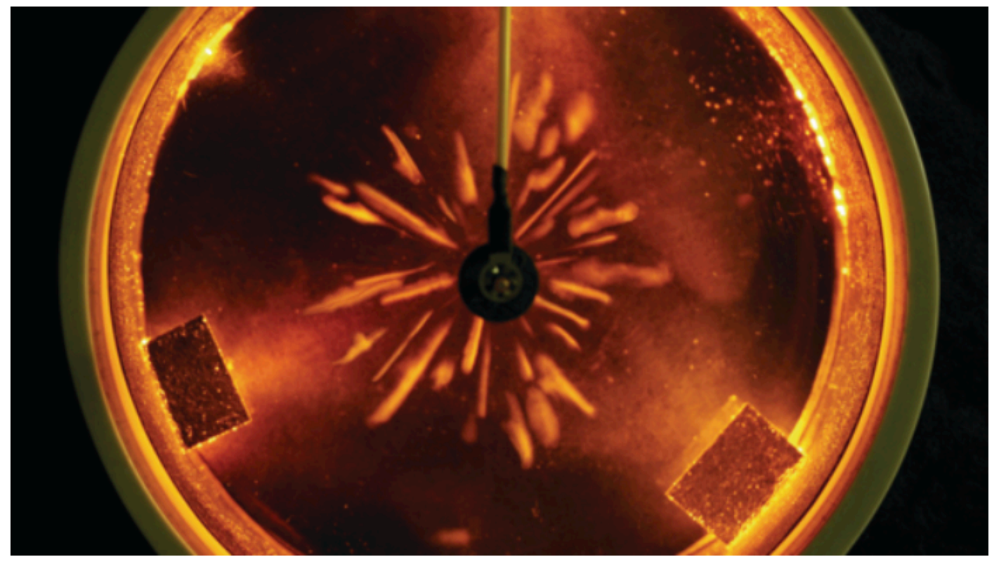
- https://sites.google.com/york.ac.uk/bindingblocks/teachers/loan-kit/cloud-chamber
- Cloud chamber which only needs normal ice cubes and alcohol, not dry ice
- Comes with worksheets
- Linked to school curriculum explicitly

How It Works

At the bottom of the chamber is a metal plate cooled by circulating ice water through the base and further cooling it to -35°C. You can see a thin film of liquid alcohol on top of it. At the top of the chamber is a glass plate with fine heating wires. Alcohol is evaporated from this plate at a temperature of about 50°C. The isopropyl alcohol placed in the chamber wicks up the inside chamber lining, where it evaporates in the warmer region of the chamber and diffuses downward. The alcohol vapour is then cooled near the chamber bottom, becoming super saturated.

As energetic alpha and beta particles from a radioactive source pass through the alcohol vapour, the vapour condenses, forming droplets that appear as tracks in the strong chamber cross-lighting - the small droplets of alcohol show where the particle has passed through. It's a bit like the vapour trails you see when a jet aircraft flies through the high, cold atmosphere.





The loan kit contains a diffusion cloud chamber that **does not require any dry ice**. A cloud chamber is a good way to show up the radiation produced by radioactive sources, as well as the radiation present in our environment, known as background radiation.

The cloud chamber was invented by Charles Thomson Rees Wilson. He used his understanding of how clouds in the air are formed, from water vapour condensing onto ions, to create a device that allows us to see the tracks of subatomic particles, smaller than an ion, with our bare eyes.

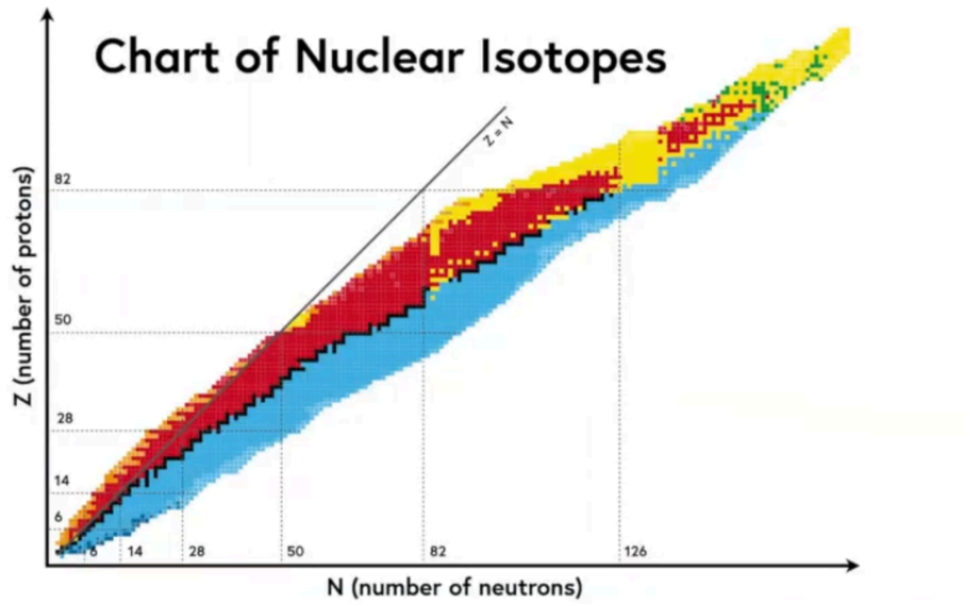
Lego Chart of Nuclides (University of York)

What is the Nuclear Chart?

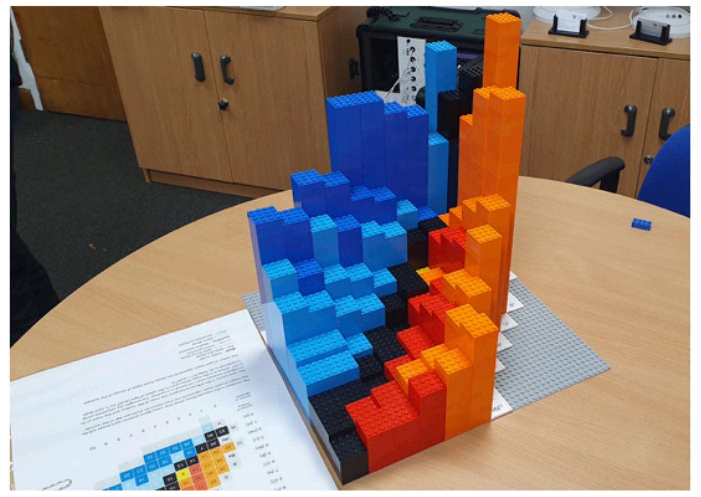
Just like the periodic table for every known element, we similarly have a chart of all the 3,000 known nuclear isotopes. This is referred to as the nuclide chart.

The *x*-axis indicates the number of neutrons, *N*, and the *y*-axis the number of protons, *Z*. The colour of each square for a particular isotope links to its decay mode, as described below:

- **Black** – Stable nuclei
- **Red** – Beta plus decay
- **Light blue** – Beta minus decay
- **Orange** – Proton emission
- **Dark Blue** – Neutron emission
- **Yellow** – Alpha decay
- **Green** – Spontaneous fission



Nuclide chart. You can also explore this through the Colourful Nuclear Chart. You can match our colour scheme by selecting 'Force Binding Blocks decay mode colours' in the menu.

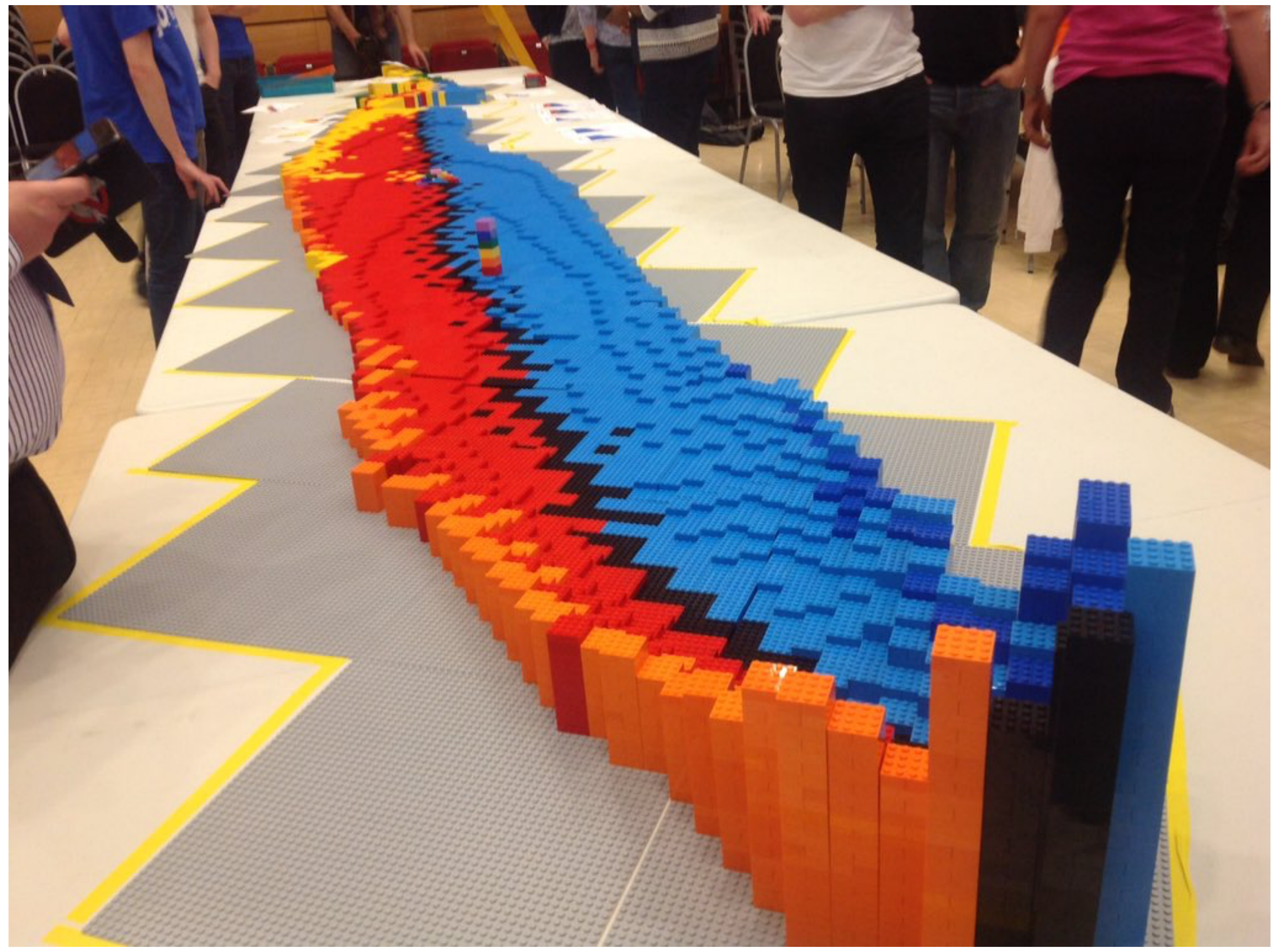


LEGO version of the first ten elements in the nuclide chart.

To help visualise this chart better, we can look at a 3D version built from LEGO® ! Each LEGO tower represents a different isotope. The full nuclear chart contains over 29,000 pieces of LEGO!

In the loan kit, we provide you with the LEGO bricks to build the first plate of the full chart. This covers isotopes of the elements from hydrogen to neon. You can see what the plate looks like on the left.

Find out more about the nuclear chart, and this LEGO version, with nuclear physicist Dr Christian Diget:



- https://sites.google.com/york.ac.uk/bindingblocks/teachers/loan-kit/lego-chart
- 3D chart of nuclear isotopes, height indicative of binding energy
- Comes with worksheets
- Linked to curriculum explicitly
- Can borrow small kits up to iron
- Or big kit for all 3k isotopes available for bigger events

Caveat

- This has been biased towards nuclear physics community in UK
- Particle physics community in UK also run masterclasses, eg analyzing CERN data etc - perhaps we should reach out to them too