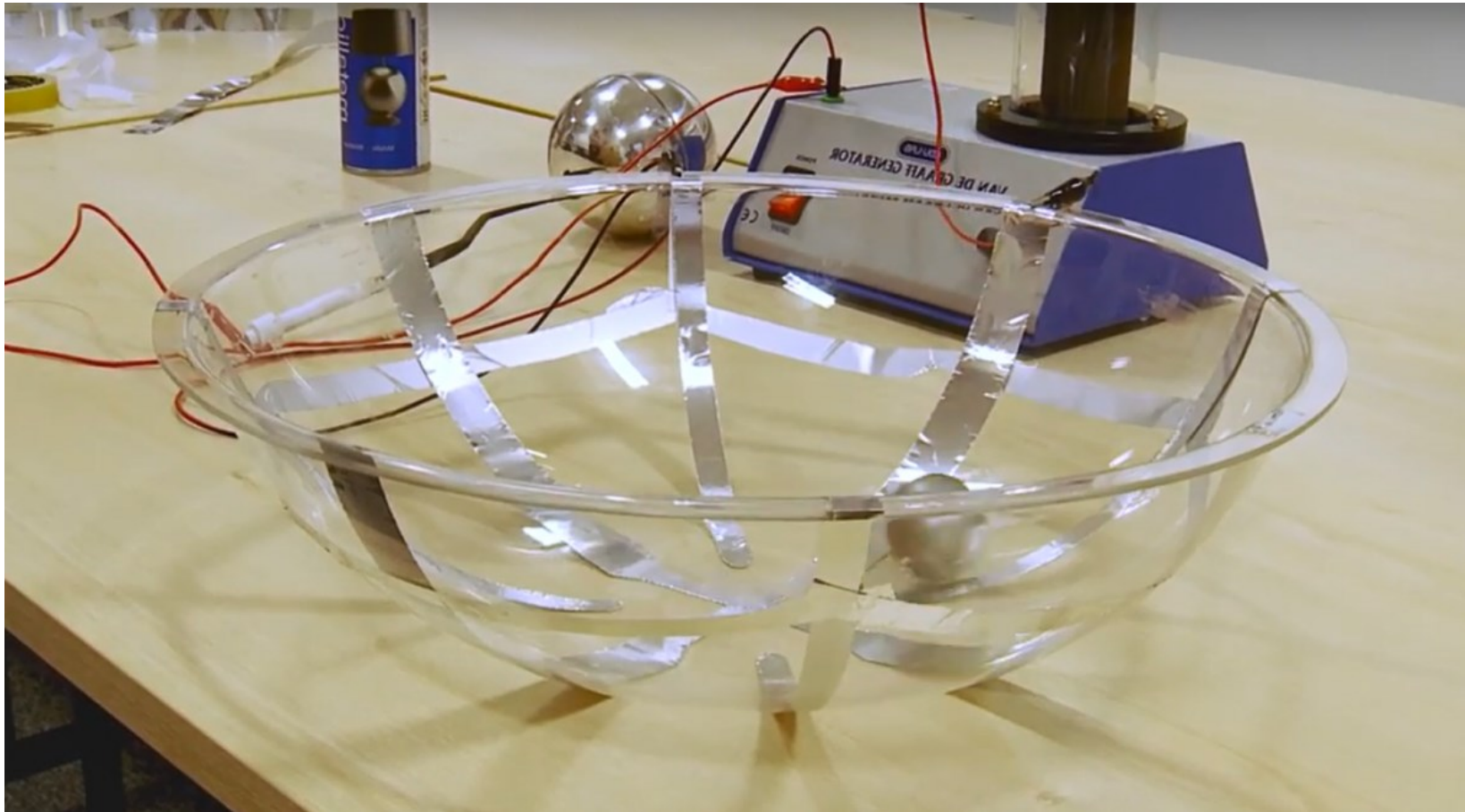


The Salad Bowl Particle Accelerator



<https://www.scienceinschool.org/article/2017/particle-accelerator-your-salad-bowl/>

A particle accelerator in your salad bowl

Create a particle accelerator using a Van de Graaff generator, a ping-pong ball and a salad bowl to understand how it is used to study matter at the smallest scale.

Two protons collide in the LHC producing a Higgs boson, which quickly decays into four muons (yellow tracks).

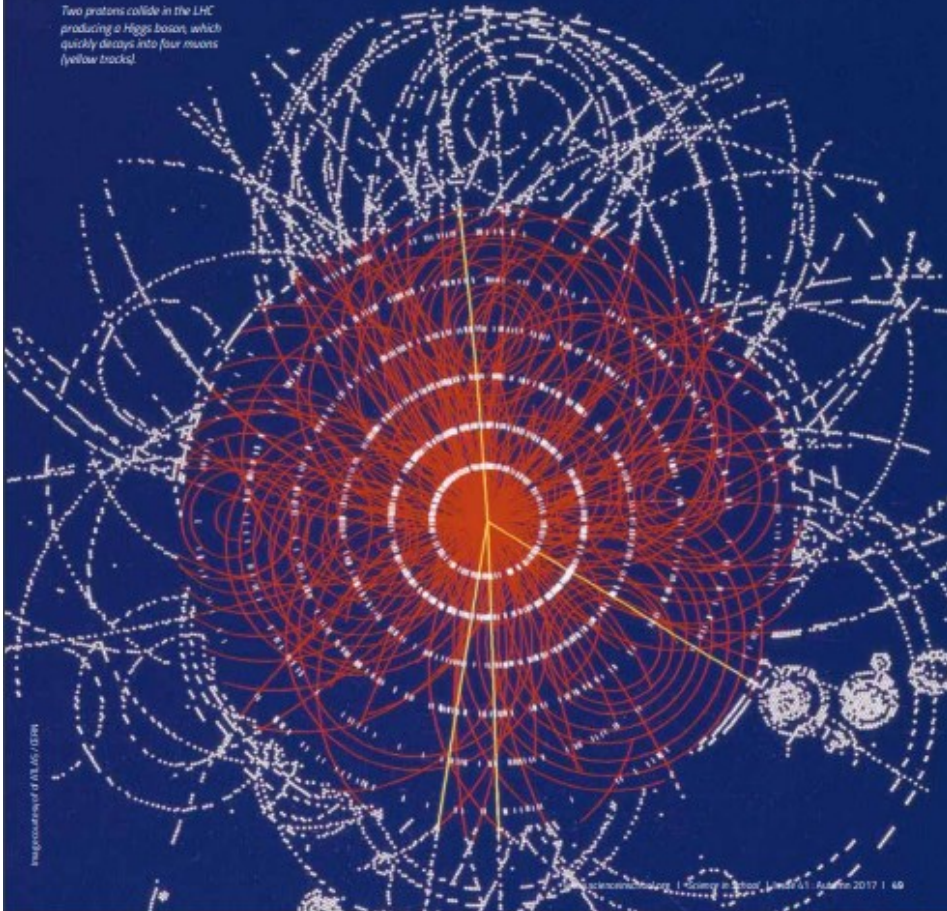


Image courtesy of ATLAS/CERN

Science Learning Centre, University of Lincoln, Lincoln, UK. 2017 | 48

By Ricardo Torres

Scientists are always on the hunt to find the smallest building blocks in the Universe. The atom, once believed to be indivisible, was the smallest fundamental particle until it was split to reveal electrons, protons and neutrons. More powerful particle accelerators revealed that protons and neutrons could be divided even further: each contains three quarks. The latest of these discoveries is a particle called the Higgs boson, observed in 2012 by the world's largest particle accelerator – the Large Hadron Collider (LHC) at CERN.

Particle accelerators, which accelerate charged particles (such as protons or electrons) close to the speed of light, are used to study matter on the smallest scale. This enables scientists to better understand the properties of elementary particles, see how they interact and ultimately fathom how the Universe works. The theory that best describes particles and their interactions (all except gravity) is known as the Standard Model of particle physics. Since the model was finalised in the 1970s, it has successfully explained countless experimental results.

The quest is not over, though. It is known that the Standard Model describes only 4% of the Universe. Therefore, more experiments and more powerful tools are needed to explain the remaining 96%, including the enigmatic 'dark matter'. The accelerators that are used to perform these experiments are huge, but you can show their basic operation in your classroom.

Creating a salad bowl accelerator

You may have experienced a shock from static electricity caused by friction, or perhaps seen how a Van de Graaff generator can make your hair stand on end. This device is used to charge a large metal sphere to high voltage. It was invented to supply the high energy required to propel charged particles in early particle accelerators, and the same



- ✓ Physics
- ✓ Static electricity
- ✓ Magnetism
- ✓ Ages 14–19

REVIEW

This article models the operation of a synchrotron particle accelerator. It's great fun to build and even more exciting to operate and watch. A brief history of the use and operation of particle accelerators is included. This would be the perfect way to prepare for a trip to Diamond Light Source in the UK or CERN in Switzerland.

Comprehension questions could include:

- What are fundamental particles?
- Why are particle accelerators important to scientific research?
- Can the cost of particle accelerators be justified?
- Why can the building and operation of a particle accelerator be classed as multidisciplinary?

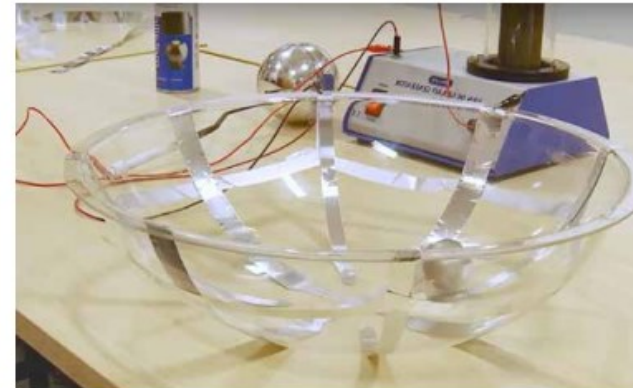
Robert Woodman, head of science, Ysgol Bro Gwaun, UK

principle is still used in electrostatic particle accelerators today.

Most modern large-scale accelerators, however, use changing electromagnetic fields: electric fields accelerate the particles to incredibly high speeds and magnetic fields control the beam of particles and its trajectory. This process can be demonstrated using a small Van

de Graaff generator, a metal-coated ping-pong ball and a salad bowl. Students can construct the accelerator themselves, or the teacher can prepare it in advance of the lesson. A video outlining how to build a salad bowl accelerator (following the method below), and a paper cup accelerator, is available on YouTube¹.

Image courtesy of Cockcroft Institute



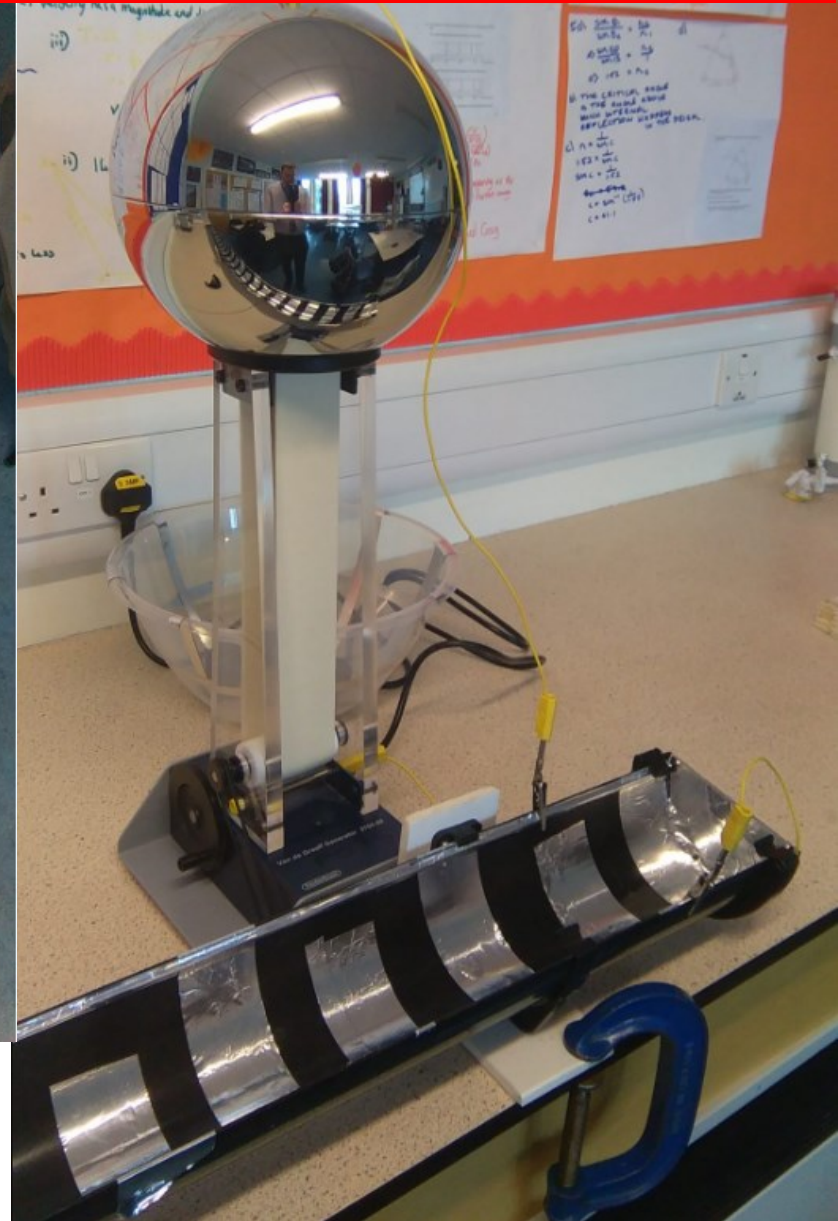
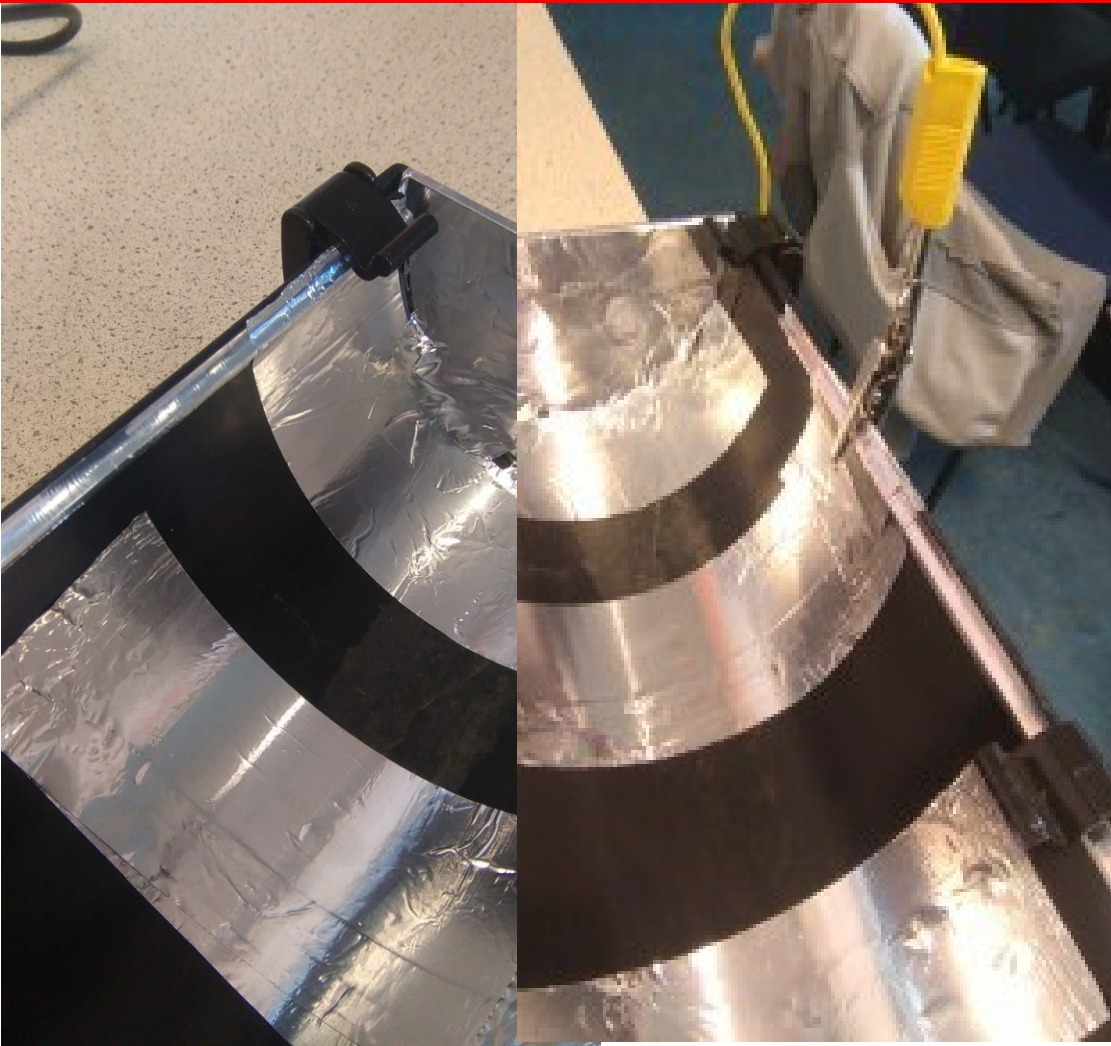
The salad bowl accelerator

https://www.scienceinschool.org/wp-content/uploads/2017/09/issue41_salad.pdf



SCAN ME

Drew's LINAC



The Linear “Guttering” Accelerator
(thanks to Drew Burrett for this and the photographs)

<https://www.stuckwithphysics.co.uk/2016/03/model-linear-accelerator/>

Youtube! But no Wimshurst Machines

The LHC

- https://www.youtube.com/watch?v=G6mmlzRz_f8

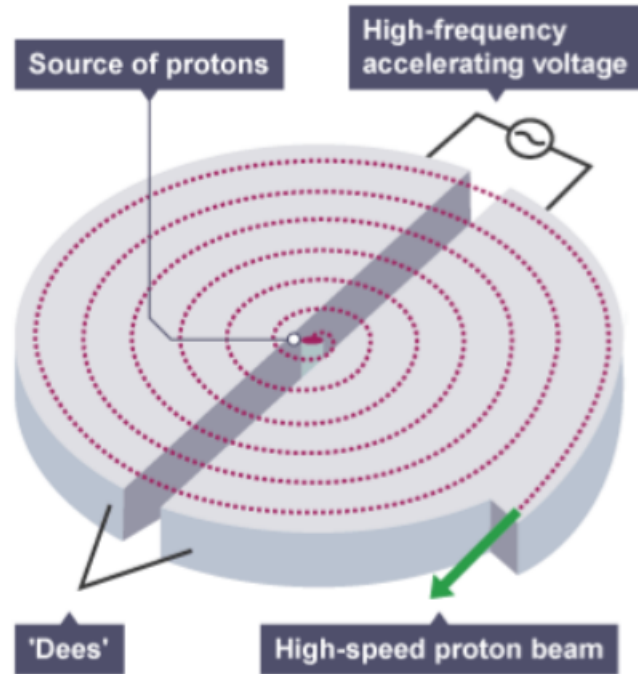
The Salad Bowl Cyclotron

- <https://www.youtube.com/watch?v=ste3iijdOh8>
- <https://www.youtube.com/watch?v=1x5hupUifBk>
- <https://www.youtube.com/watch?v=rvk5Rem1708>
- <https://www.youtube.com/watch?v=Vy8SzgwgfsfA>
- The LINAC
- <https://www.youtube.com/watch?v=UYzGzt0oJTs>

Particle accelerators

Cyclotron

A cyclotron has two D-shaped chambers (known as 'dees') which are in a strong vertical magnetic field.



1. The protons are injected into the centre and are accelerated by the voltage between the dees.
2. The protons move in a semicircular path due to the magnetic field round one dee until they cross the gap again and are accelerated by high voltage again. This time the polarity of voltage has been reversed to accelerate the protons in the opposite direction.

3. As the protons travel faster, their radius around the dees increases until finally they are ejected as a high speed proton beam.

A cyclotron can be used to make short-lived radioisotopes (radioactive atoms) that can be used for medical imaging and research.

Other particle accelerators which involve the use of fields on charges include synchrotrons and linear accelerators.

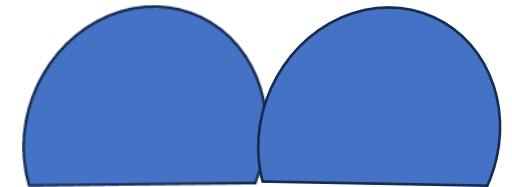
All particle accelerators have the following in common:

1. **Electric Fields** are usually used to **increase the speed** of the particles. The force is constant in a uniform electric field so the particles are accelerated in a straight line.
2. **Magnetic Fields** are used to control the direction of particle beams. The force when cutting a magnetic field acts perpendicular to the direction of travel of the particle and therefore changes as the particle travels in a circular path.
3. Very fast and therefore high-energy particles then collide with a stationary target or other moving particles to disintegrate and reveal their internal composition.



D

Double D



<https://www.bbc.co.uk/bitesize/guides/zyfyrd/revision/6>

Our Model v the real thing

Electric Field

Accelerates the particles

Charged strips accelerate

Charge/discharge \equiv a.c.

Magnetic Field

alters the direction of the particles

curve of the bowl

The balls represent the particles size represents the mass

Risk Assessment – 1 for make, 1 for use

Risk assessment Salad Bowl Particle Accelerator- make and test!

Company name: IOP Coaches

Assessment carried out by: 06/02/24

Date of next review: 06/02/27

Date assessment was carried out: 06/02/24

What are the hazards?	Who might be harmed and how?	What are you already doing to control the risks?	What further action do you need to take to control the risks?
scissor	Sharp objects can cause cuts, could poke someone's eye out	Warn of the participants of the dangers of scissor	Ensure scissors are only as sharp as required and in a good state of repair
Electrical Appliances	Users of the VdG	<p>All electrical equipment must be PAT tested and testing must be kept up to date as indicated by a council sticker on the appliance, unless under 1 year old.</p> <p>Adequate reporting procedures must be set in place with regard to electrical hazards.</p> <p>Staff should visually inspect all pieces of electrical equipment for any sign of defects including:</p> <p>Wear on cables, exposed cables, scorch marks on the plug and damaged plugs and sockets.</p> <p>Arrangements should be made to ensure that equipment is repaired or disposed of as necessary.</p> <p>Members of staff without the relevant competences must not interfere with or attempt to make repairs to electrical equipment.</p> <p>Where practical, electrical equipment should be low voltage (110V or battery operated).</p> <p>All mains supplies must be protected with residual current devices (RCD).</p> <p>RCDs must be tested on a regular basis.</p> <p>Leave equipment on for the minimum amount of time</p>	Check Bridge has RCDs in the room being used

Risk Assessment – 1 for make, 1 for use

- USE

- Visually inspects electrics
- Usual VdG risks **not for use with**: epilepsy, coronary heart disease e.g. angina, history of heart attack, cardiac rhythm disorders. intra-cardiac conduction pathway anomalies, presence of an implanted cardiac pacemaker, high blood pressure
- VdG diameter well below the max recommended
- Could use with EHT but **must** do a risk assessment, are they current limited. Never use an HT
- **Absolutely No Wimshurst Machine**
- **Discharge between use**
- **Watch adding the balls, drop don't touch**

Some theory- for those who don't know

- $E_w = E_k$
- $QV = \frac{1}{2}mv^2$

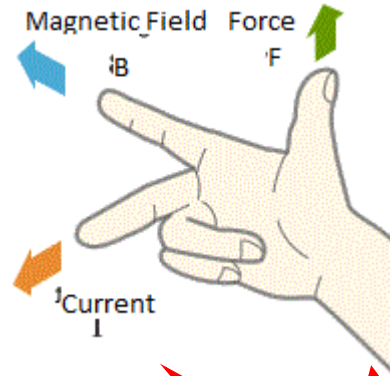
Where:

First Finger is the magnetic **F**ield

se**C**ond Finger is the **C**urrent (ele**C**tron flow)

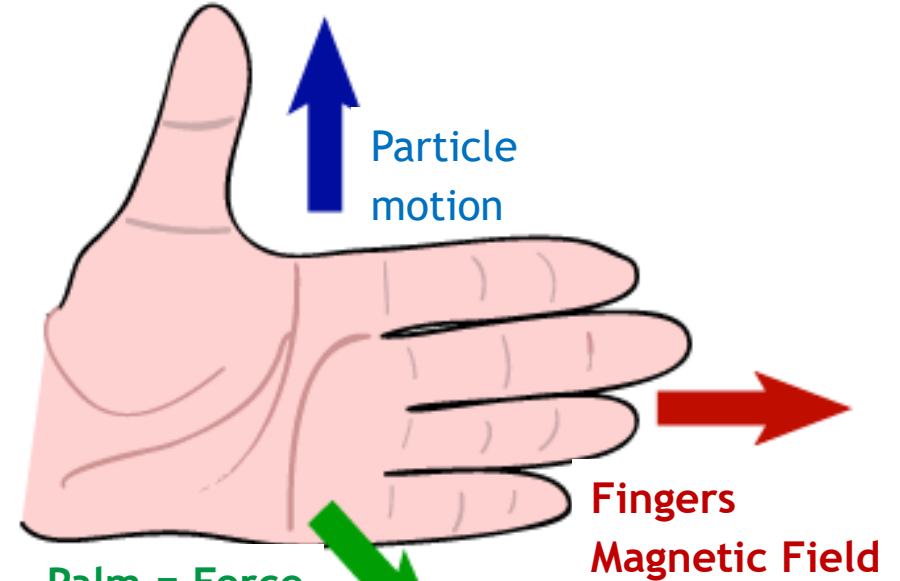
Thu**M**b is the **M**otion

Right Hand Motor Rule



The new method I will use is the Stewart K, Hargreaves R (2016) method

Let's do the Fool Proof System of Remembering with LEFT HAND

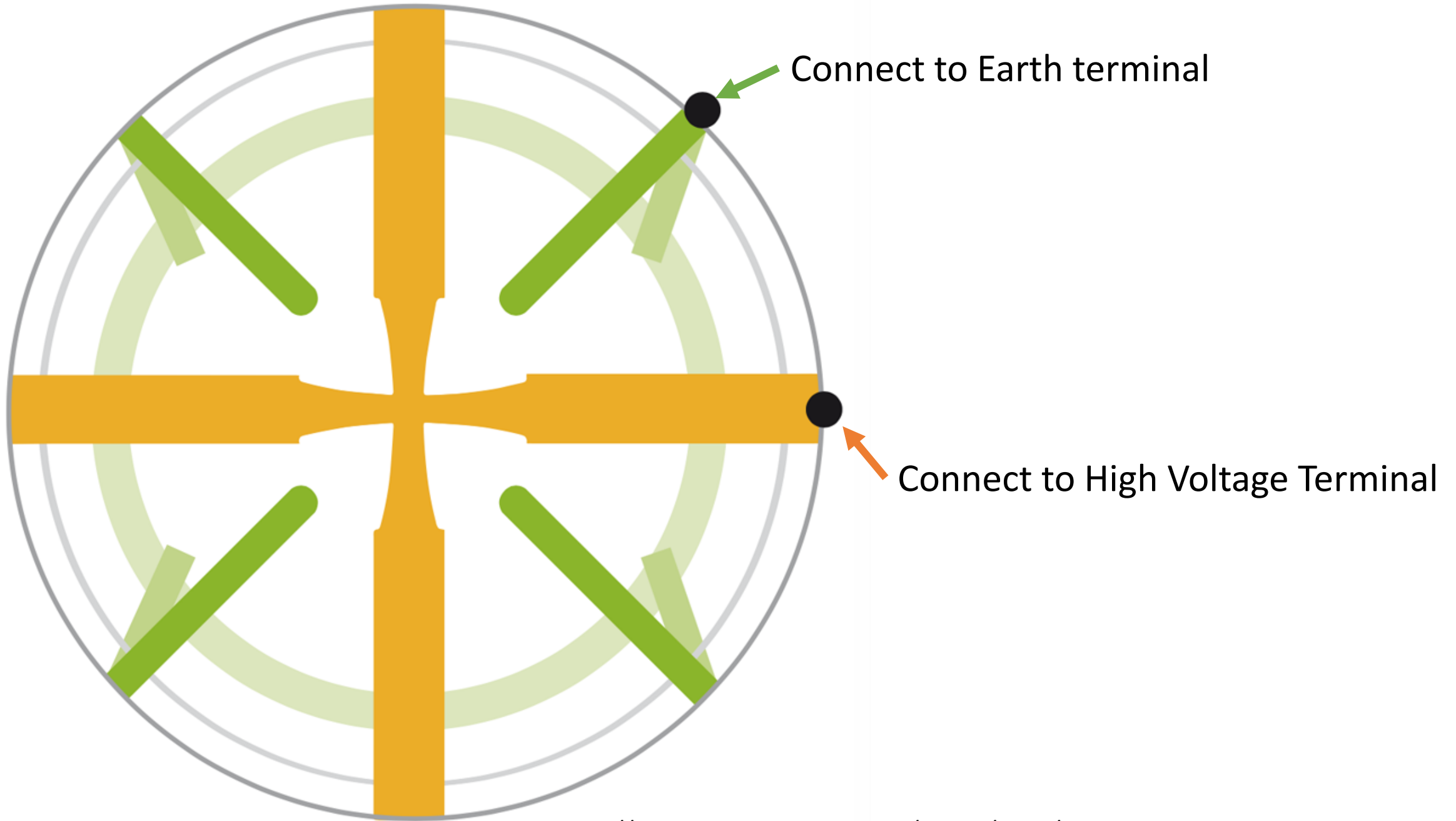


Palm gives the force on a negative particle.
Backhand gives the force on a positive particle, and it's more Painful on the backhand

Secret sign
Of a
Physicist

Amy ought to have drawn a dot to represent the force as it is out of the page. She drew this before we'd finished talking about dots and crosses.





Where to order for your class set!

- Everything was either purchased from **RAPIDONLINE** or obtained from - **Wickes**
- Graphite Kontakt Spray Paint: 87-0695
- Ultratape Aluminium foil tape: 87-1900
- Rapid Plastic Mixing Bowl 30cm: 52-9351
- Rapid Foam Balls 25mm Diameter - Pack of 20: 06-7582
- Major Brushes Polystyrene Balls 35mm Pack of 10: 06-9329
- Eisco Van De Graaff Generator - Motor Or Hand Driven: 52-3416 (£155)

IOP Scotland Teacher Network

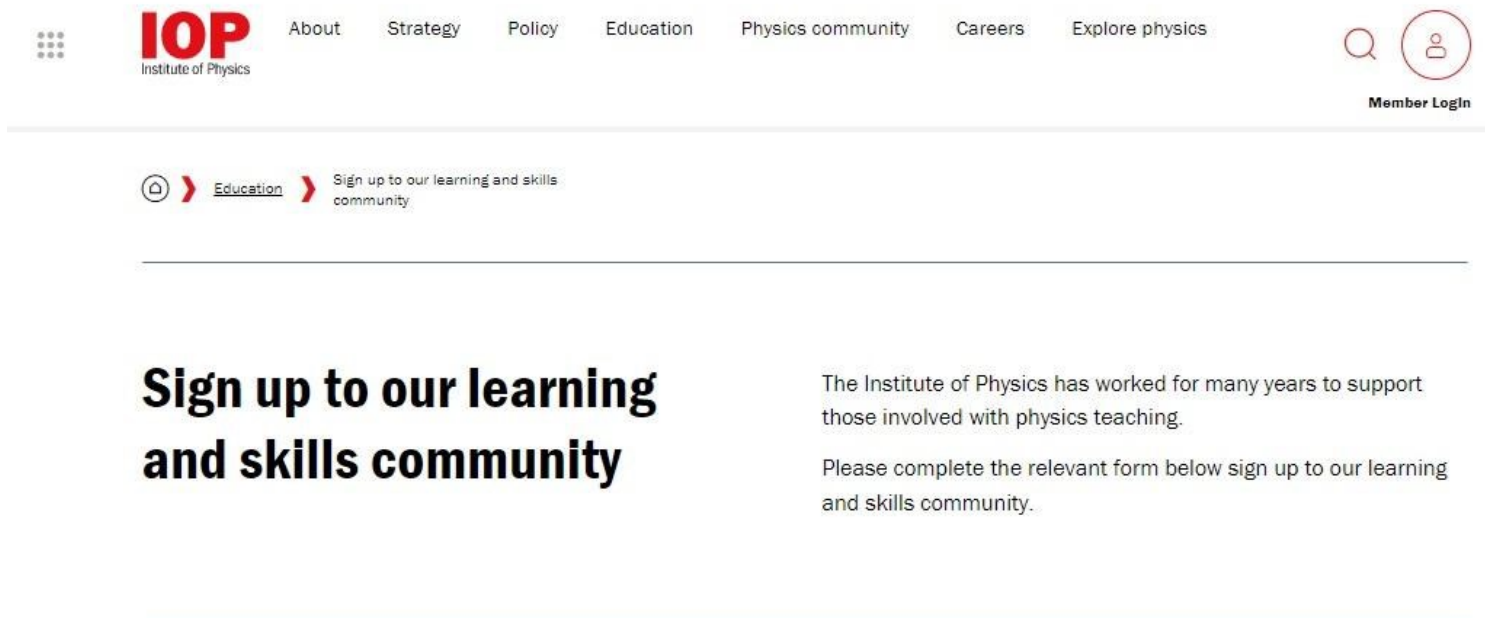
Please complete this short evaluation form:

Completing this evaluation is important to help ensure continued support for IOP activities and to ensure they meet your needs.

IOP New Contact List

Register for our new email list:

www.iop.org/education/sign-up-learning-skills-community



The screenshot shows the IOP website header with navigation links: About, Strategy, Policy, Education, Physics community, Careers, and Explore physics. A search icon and a Member Login button are also visible. Below the header, a breadcrumb trail shows 'Education' and 'Sign up to our learning and skills community'. The main content area features the heading 'Sign up to our learning and skills community' and a paragraph: 'The Institute of Physics has worked for many years to support those involved with physics teaching. Please complete the relevant form below sign up to our learning and skills community.'



49th Stirling Physics Teachers Meeting

23 May 2024

Stirling Court Hotel, Stirling, Scotland



Lascells Cloud Chamber

- One in every Scottish local authority.
- Great alternative to dry ice variant
- No dry ice or water required
- Integrated power supply
- Teachers guide available for this





<https://www.youtube.com/watch?v=zKyvZ0ZrV00>