

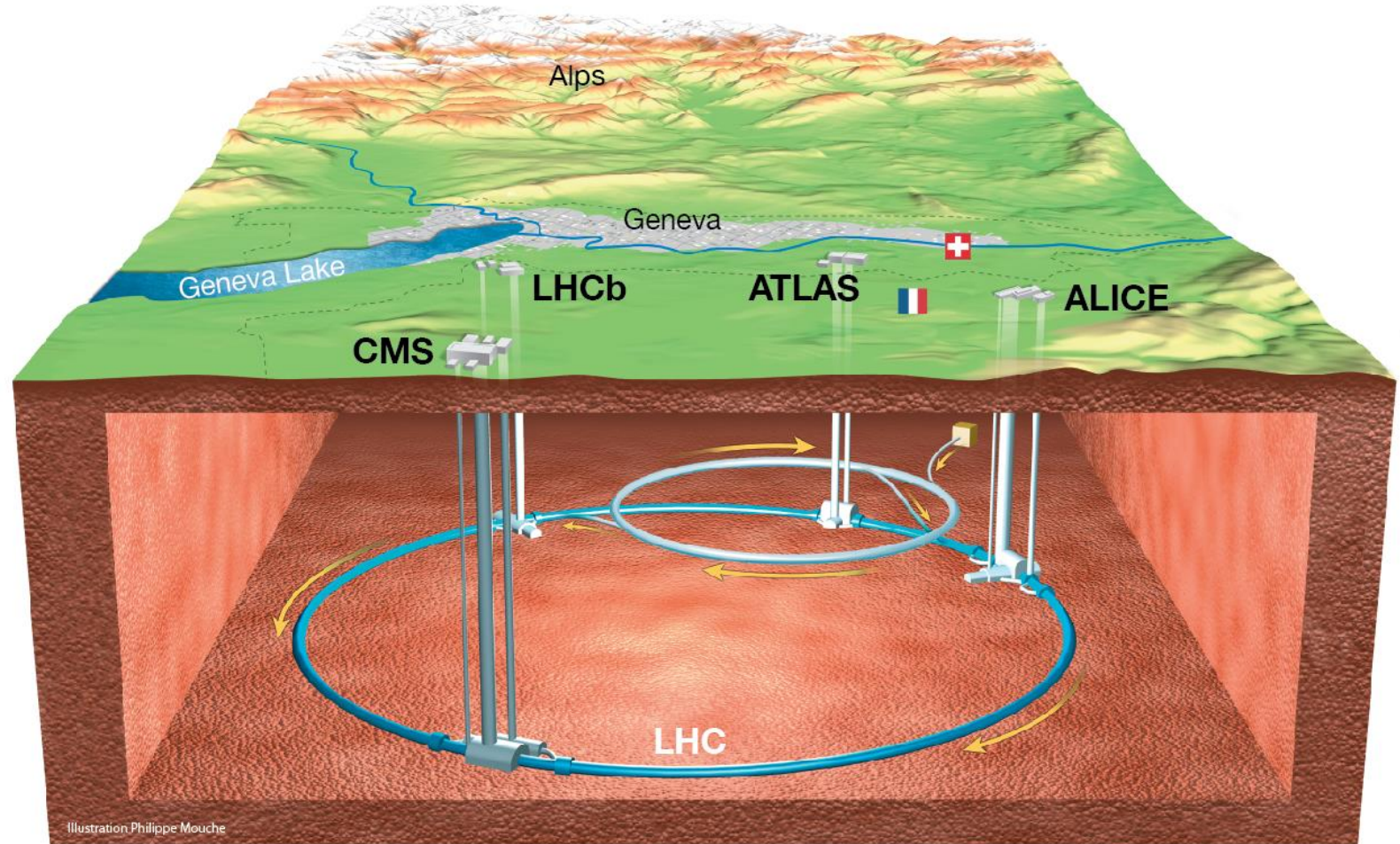


making physics matter

# Accelerators and Detectors – Working Scientifically



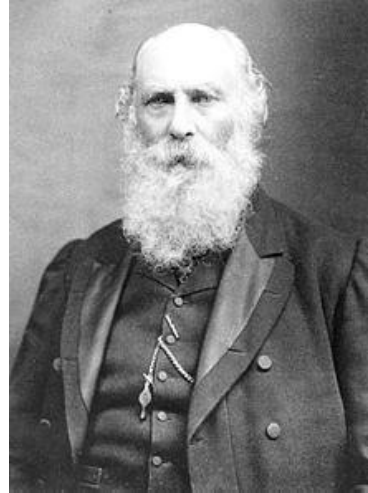
Amanda Poole  
Jenny Watson  
Jackie Flaherty



# Changing Scientific Ideas Over Time



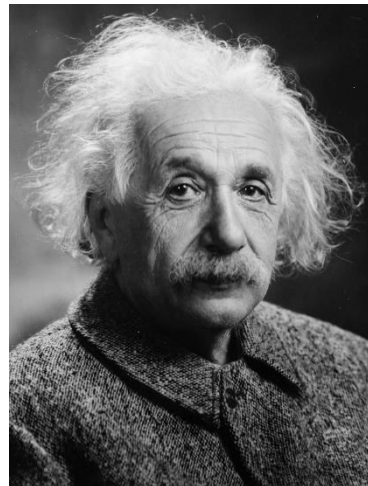
Democritus  
460 -370 BC



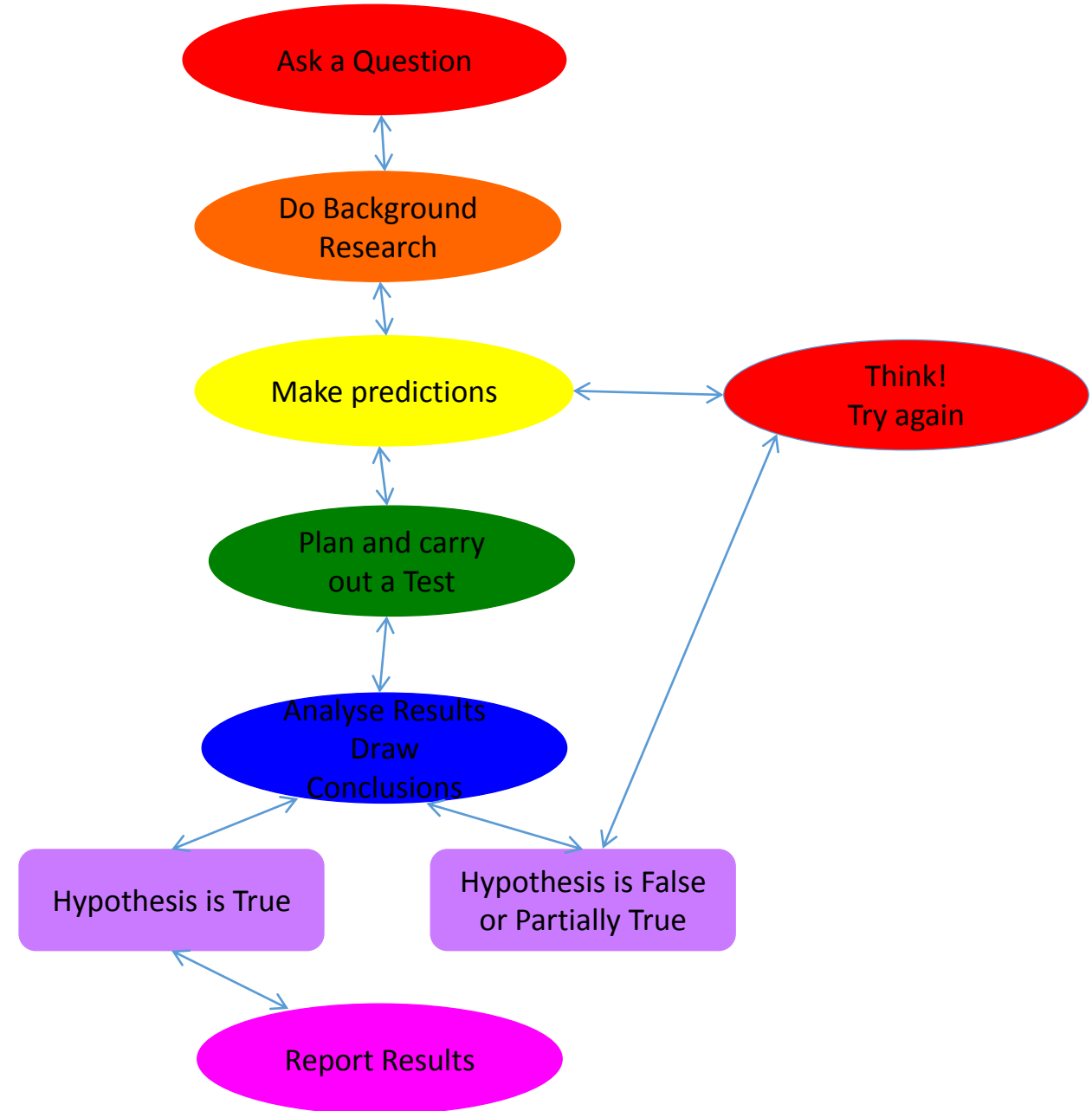
George Stoney  
1874



J J Thomson  
1898



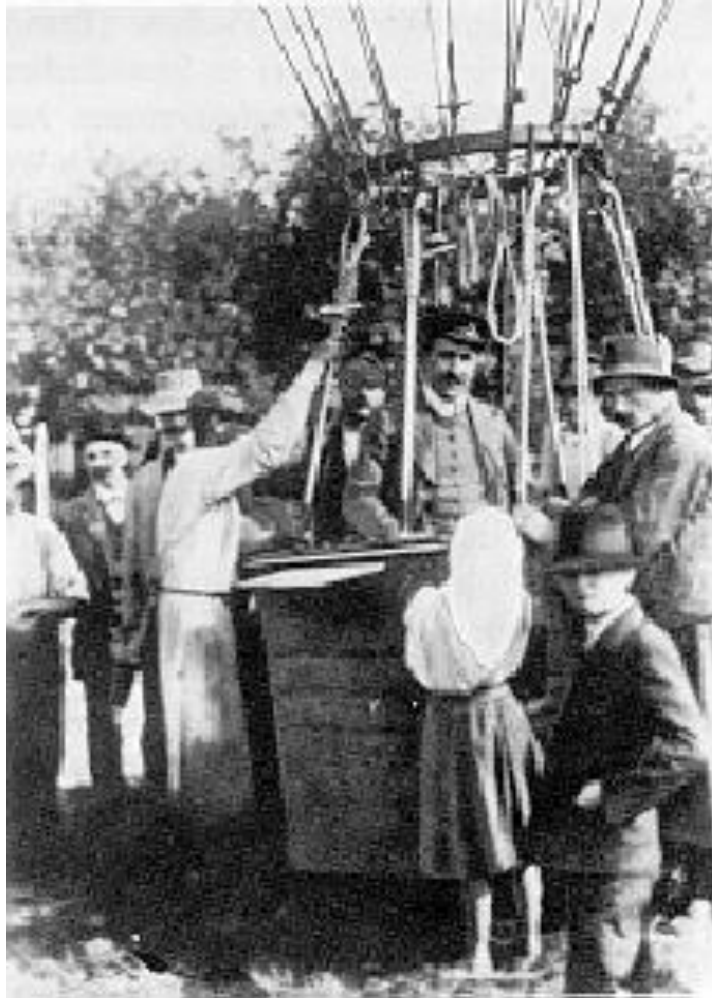
Albert Einstein  
1905



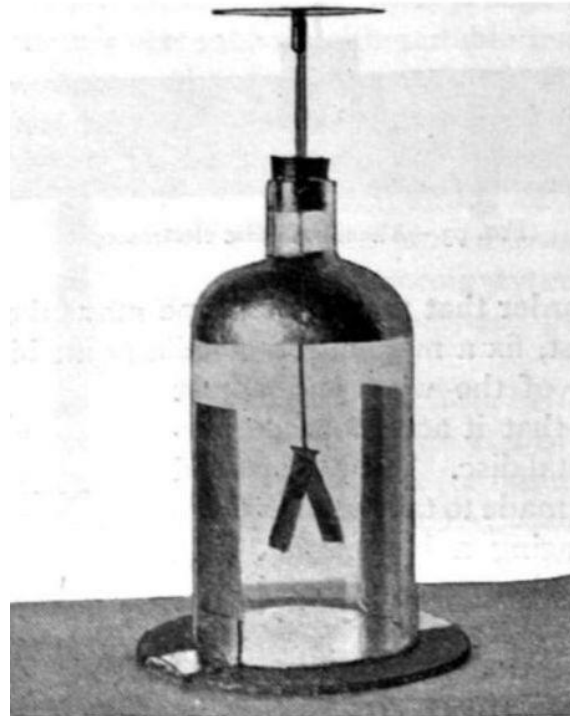


# The Discovery of Cosmic Radiation

Early Detectors



Victor Hess, 1912 took charge-measuring equipment up in a hot air balloon.



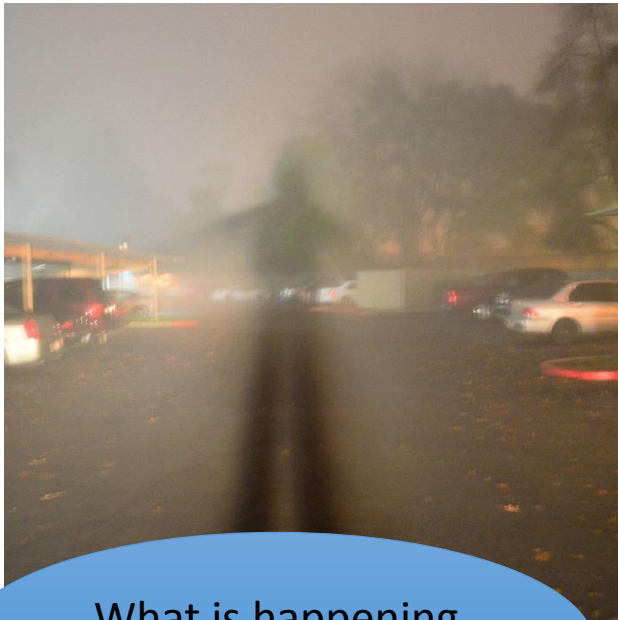
Does this strange radiation really get weaker at higher altitudes?

What would happen to the electrostatic detector if I could take it to higher altitudes?

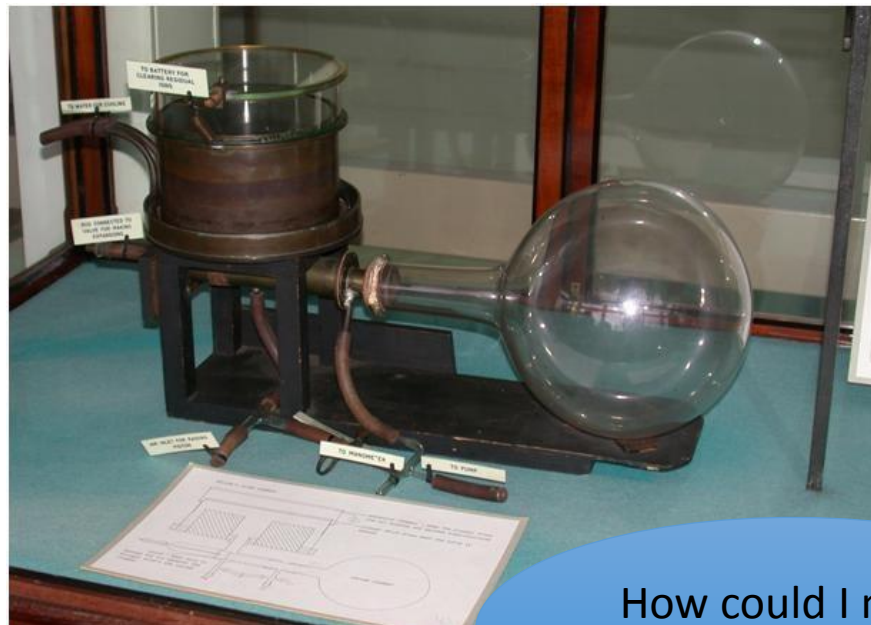
# Invention of the Cloud Chamber

Early Detectors

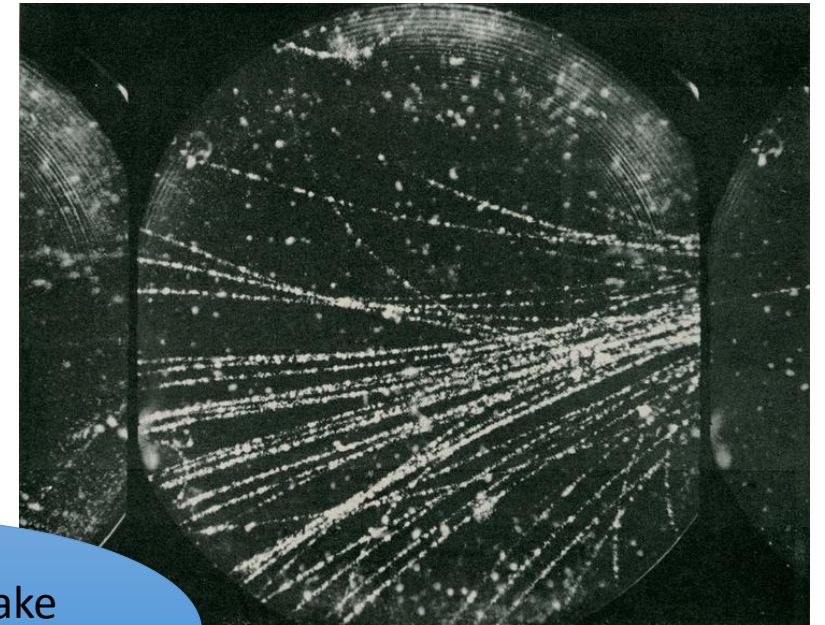
Charles Wilson, 1894 was inspired by sightings of the Brocken spectre (large foggy shadows) seen while working on the summit of Ben Nevis.



What is happening here?



How could I make use of this?





What has beer got to do with elementary particles?

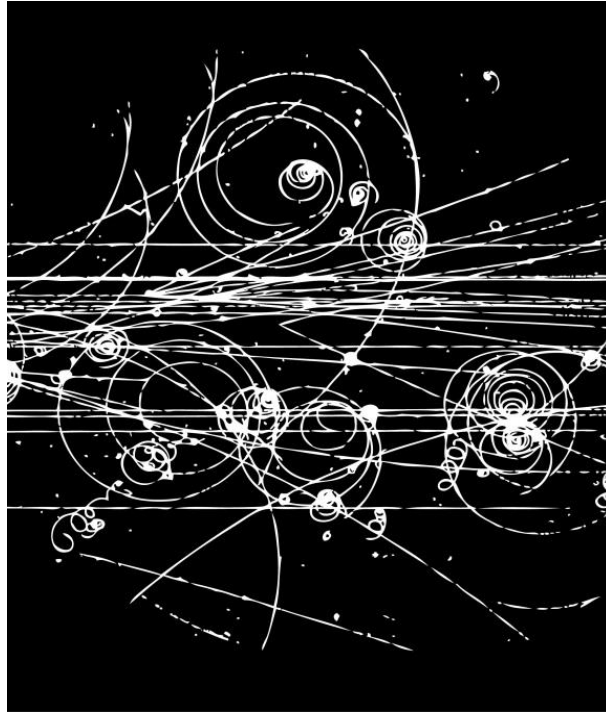


Photo source: [www.tapsong.net](http://www.tapsong.net)



# Invention of the Bubble Chamber

Donald Glaser, 1952 used beer in some of his early bubble chamber prototypes.



How do superheated liquids behave?

How could this be useful when learning about elementary particles?



Early Detectors



"If I have seen further than others, it is by standing upon the shoulders of giants."

- Sir Isaac Newton

Dmitri Skobeltsyn, 1929, observed electron-like particles which curved the 'wrong' way in a magnetic field.



What is going on here?

Why is this happening?

Discovery

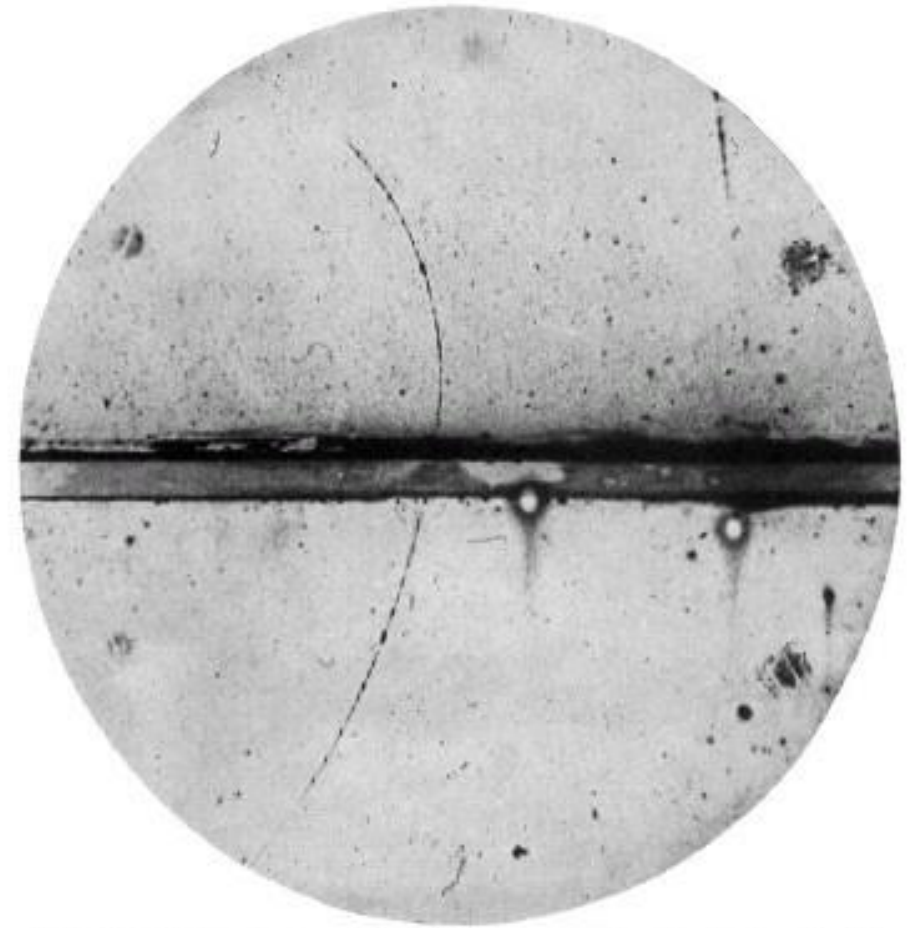
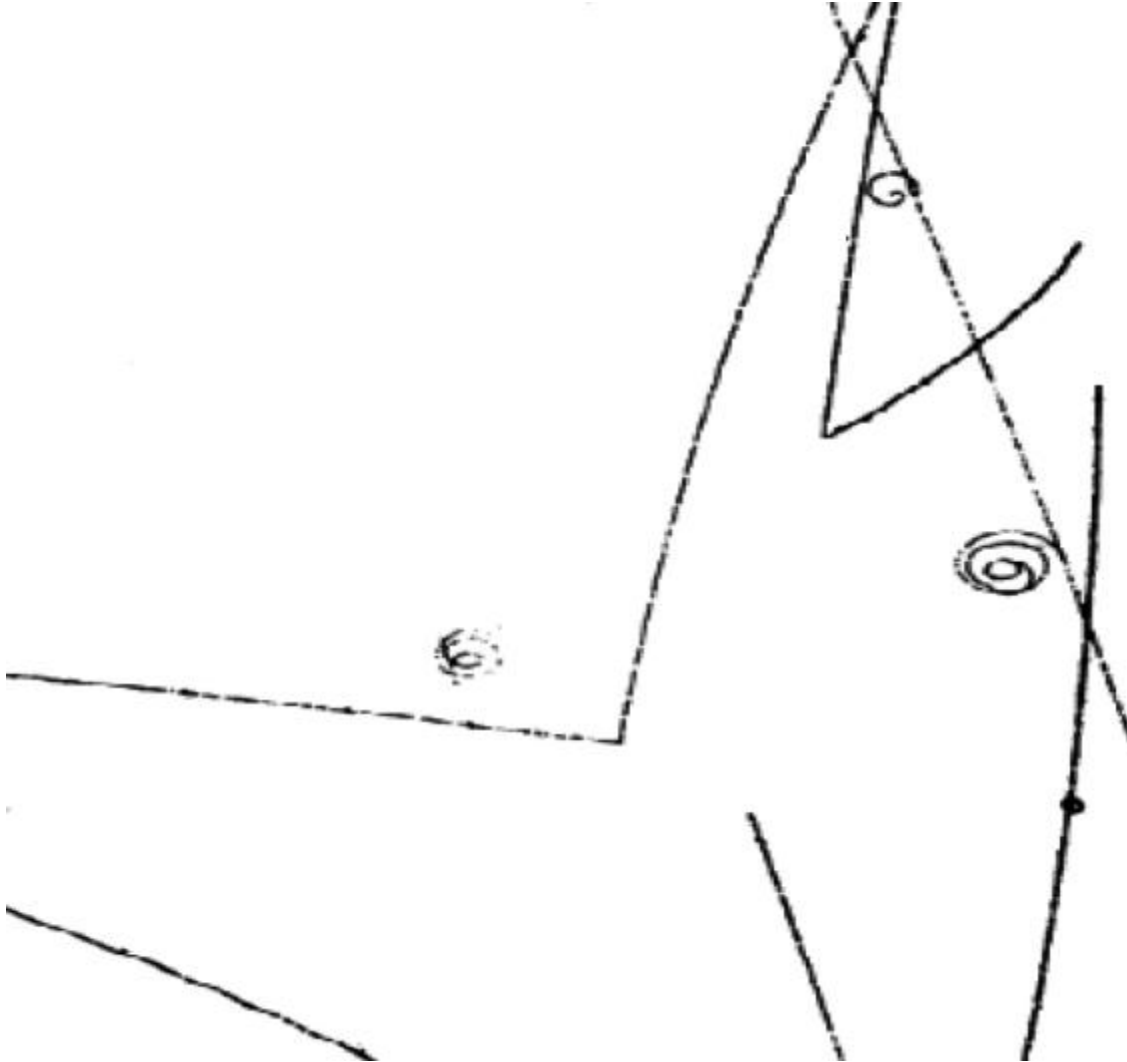


FIG. 1. A 63 million volt positron ( $H\rho = 2.1 \times 10^6$  gauss-cm) passing through a 6 mm lead plate and emerging as a 23 million volt positron ( $H\rho = 7.5 \times 10^4$  gauss-cm). The length of this latter path is at least ten times greater than the possible length of a proton path of this curvature.

# How do we identify elementary particles?

By their:

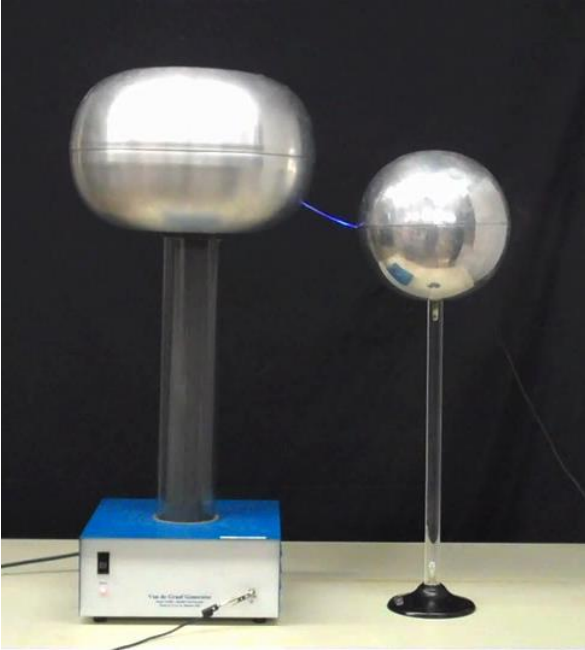
- charge
- mass
- lifetime
- decay modes  
(what they change into)



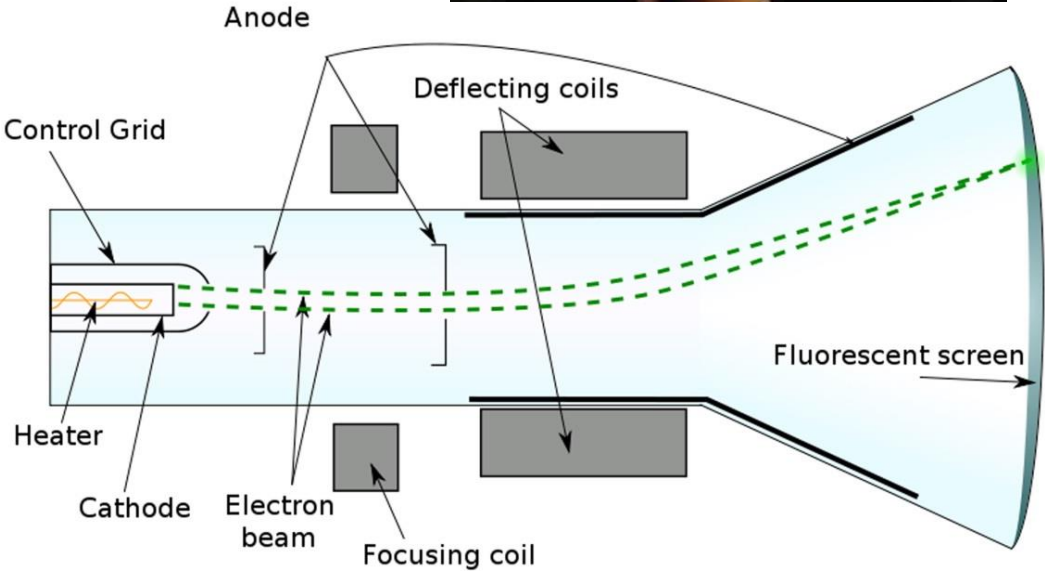


# Particle Accelerators

Van de Graaffs

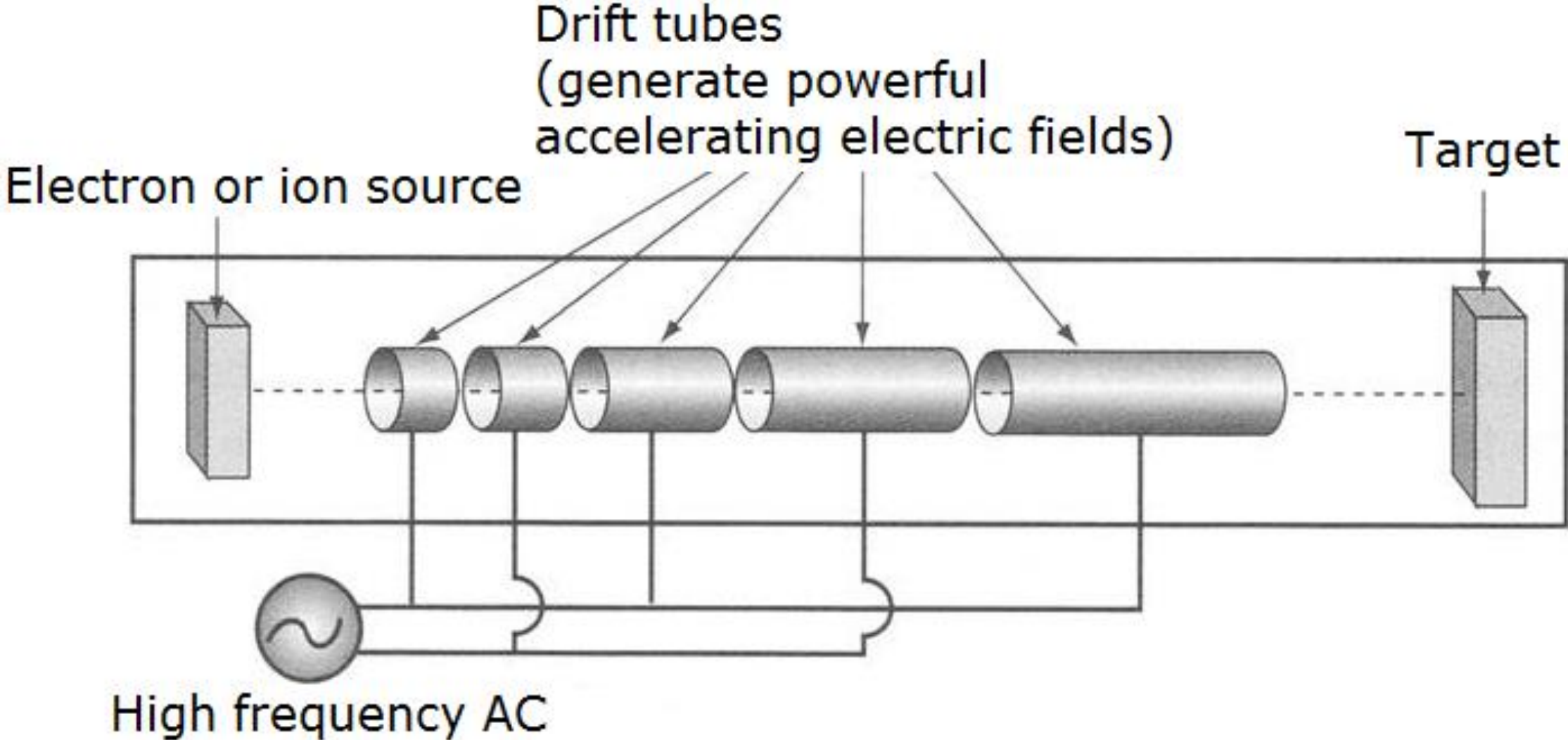


CRT TVs



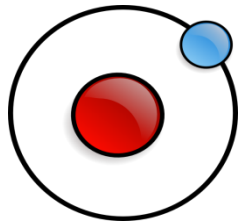
Electron microscopes

# Linear Accelerators

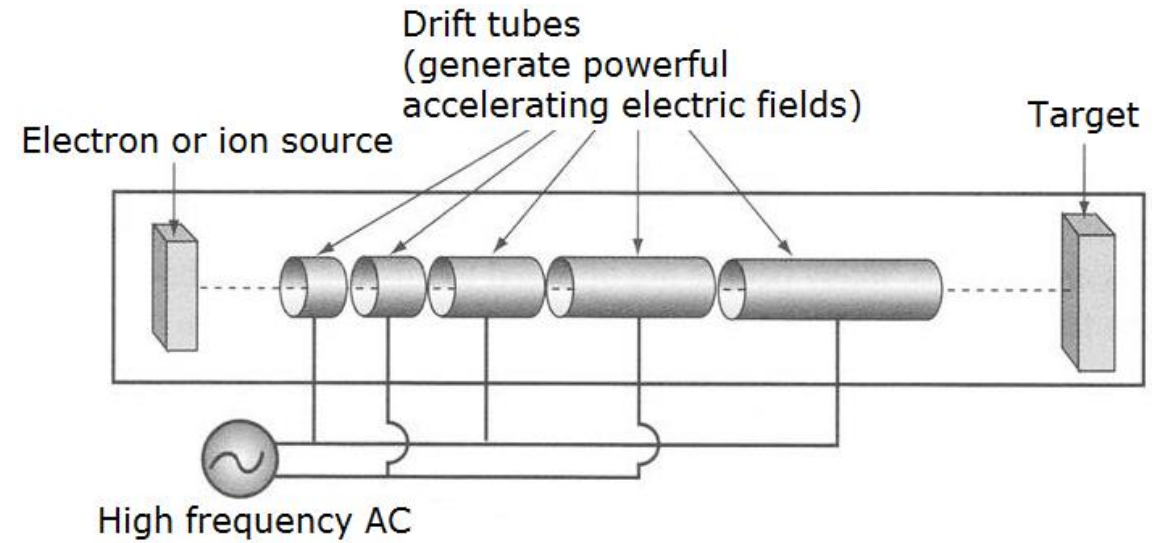




# Particle Accelerators

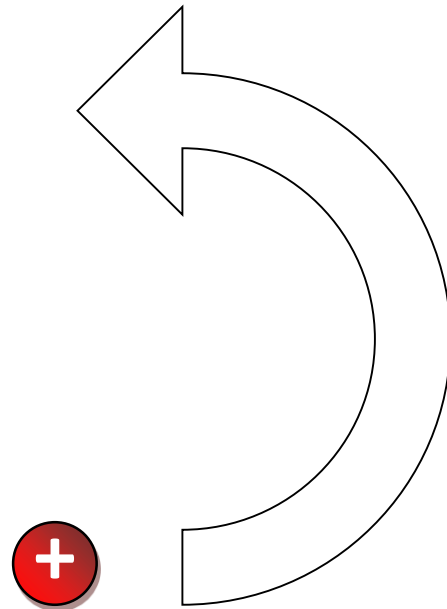


1. A **Hydrogen Atom** is **ionised** i.e. has its electron removed, leaving a charged **proton**.



# Circular Accelerators

4. To keep the protons contained, **magnets** are used, which **make charged particles move in curved paths** - round in circles!

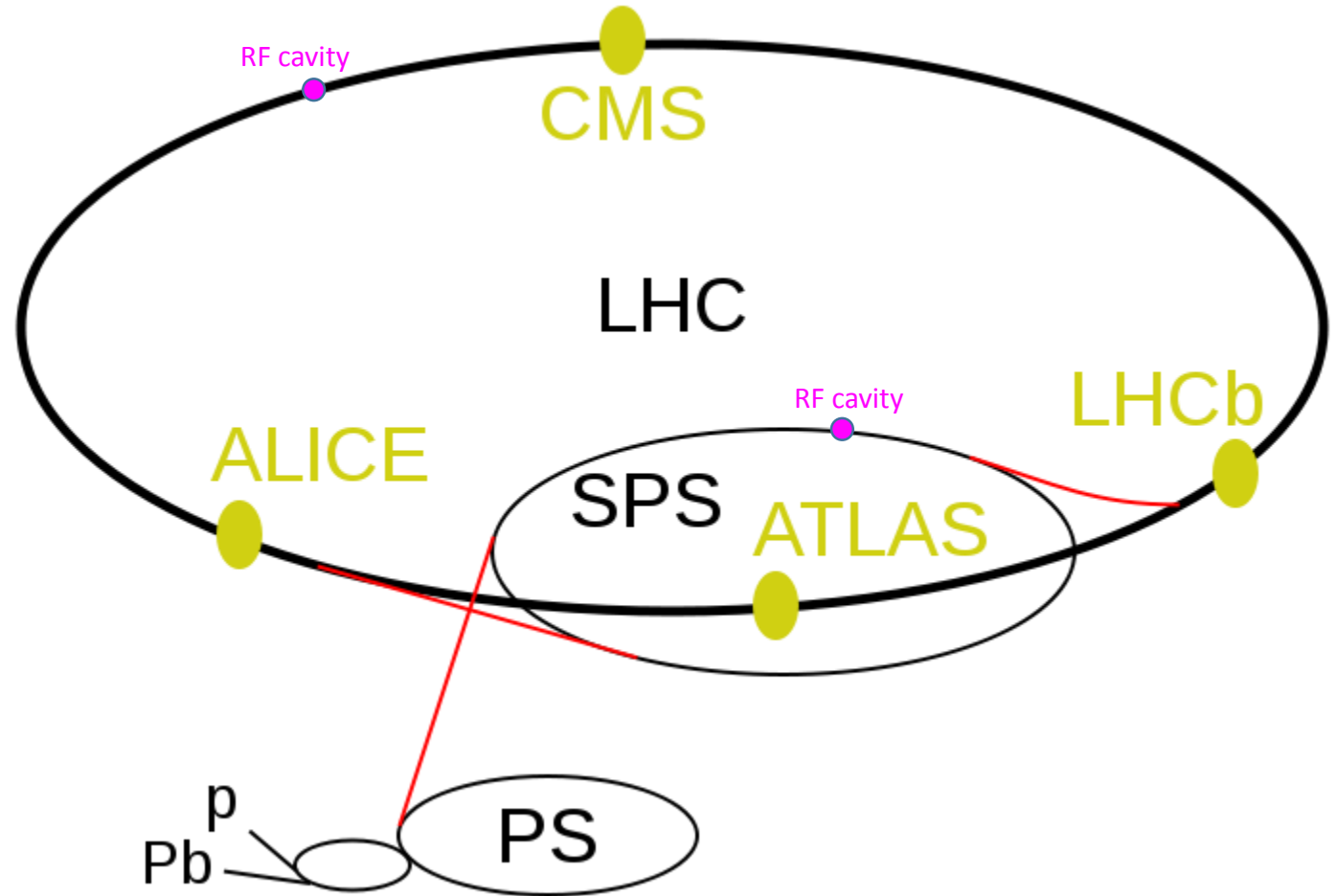




# Larger rings mean you can reach higher energies

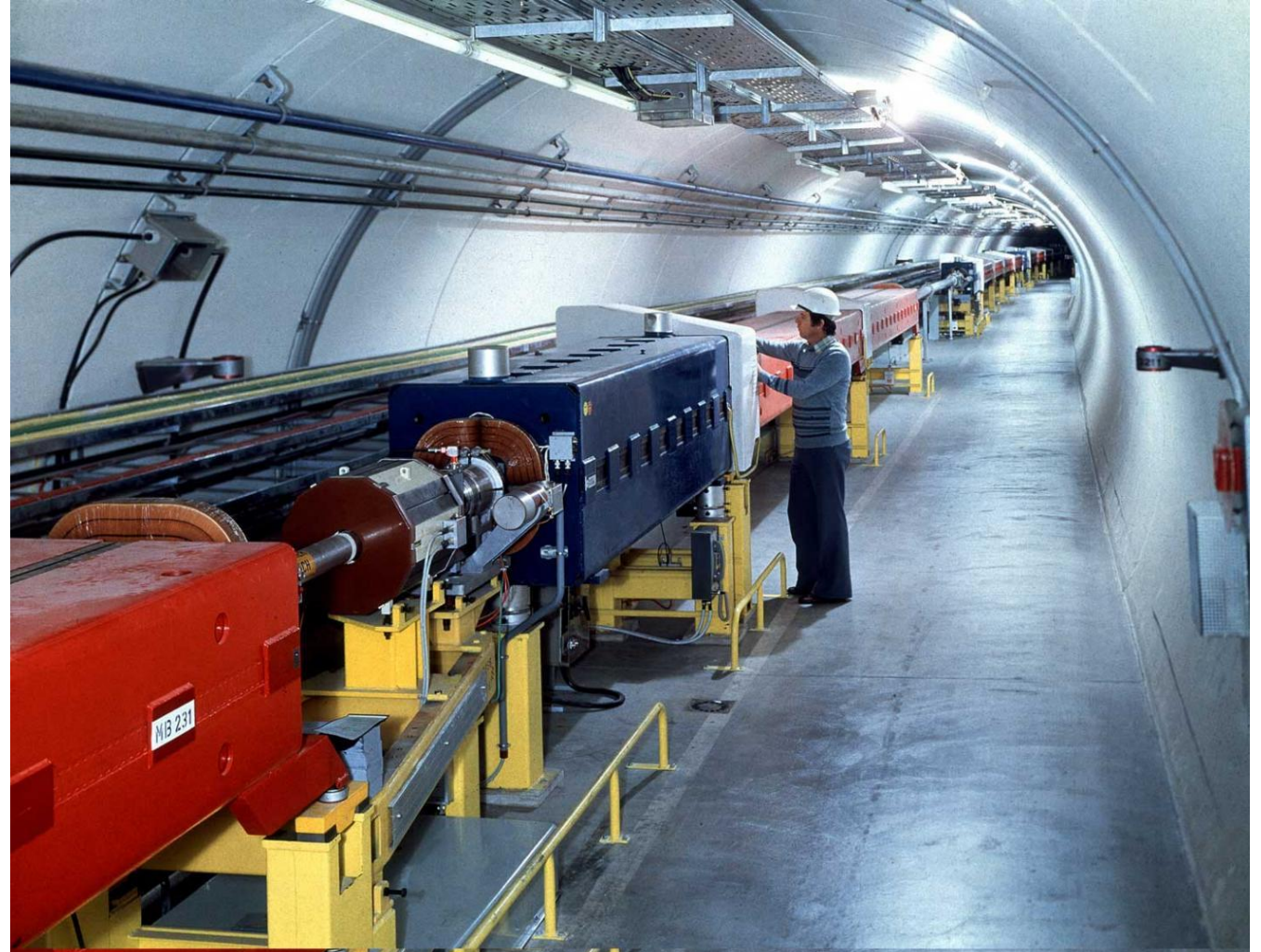
5. These very fast protons are then injected from one ring into another larger ring. **Bigger accelerators mean higher energies.**

6. Protons in the **SPS** have energies of **450GeV**, and travel at **99.9998% of the speed of light**. They are then injected into the **LHC ring** which works at **6.5TeV** and **99.9999991% of the speed of light**.



# SPS Beam Pipes & Magnets

7. The LHC protons have to travel in a **vacuum** (very empty space) to stop them hitting things and changing direction.

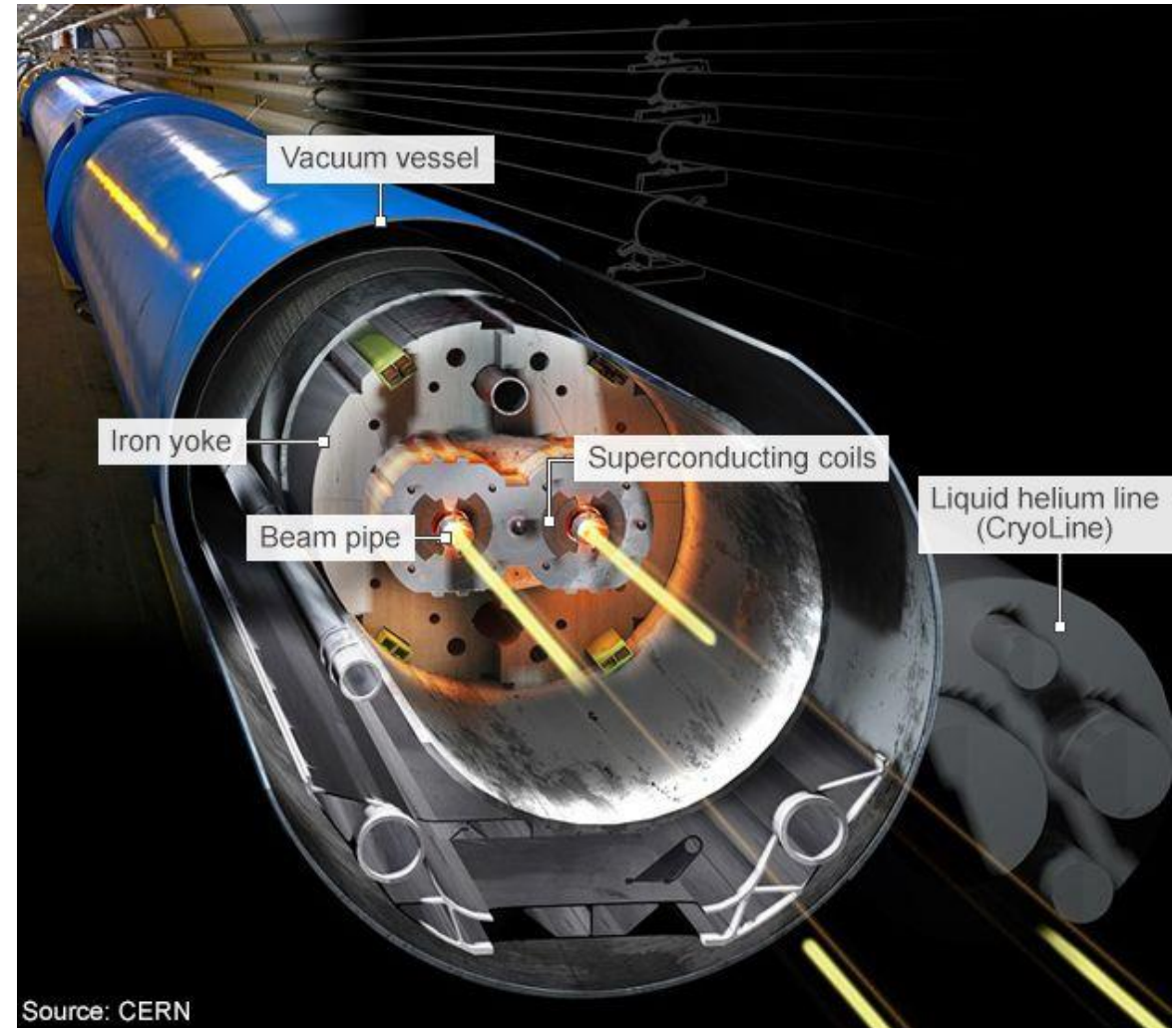




# LHC Beam pipes & Superconducting magnets

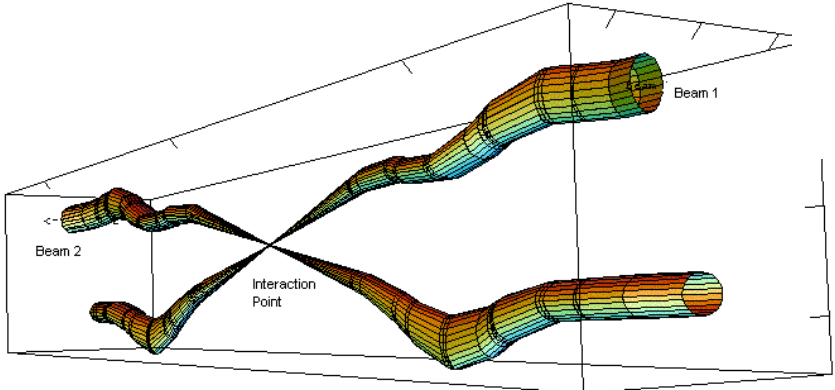
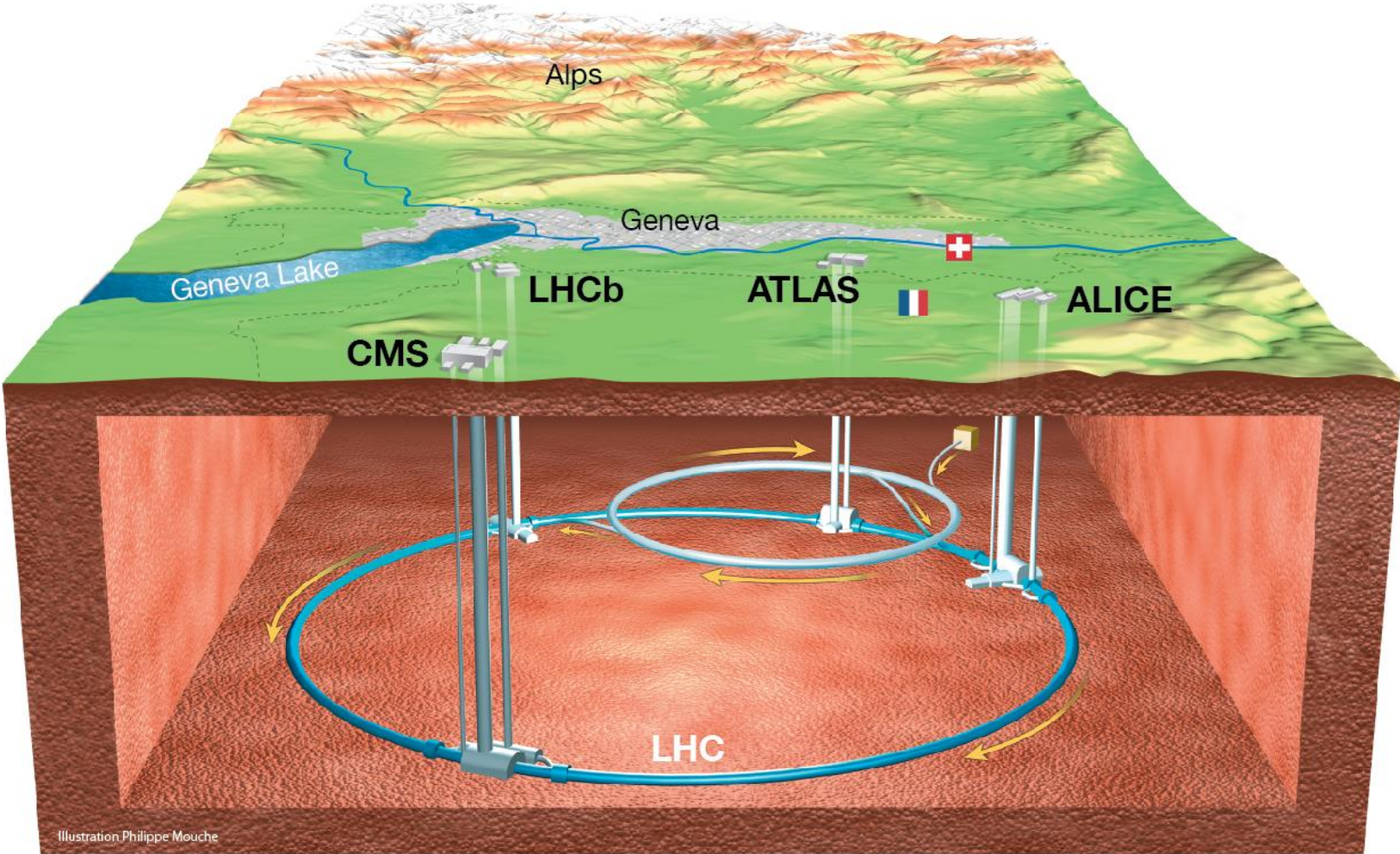
8. The LHC uses 1,600 (very cold) **superconducting magnets** spaced around the ring to make the protons travel in a circle. These work at a temperature of  $-271^{\circ}\text{C}$  (1.9K), i.e. just above **absolute zero**.

9. The LHC has **two vacuum tubes** in which protons travel - one for a 'clockwise' and another for an 'anticlockwise' beam, so that the **protons can collide head-on!**



# LHC Detectors

**10.** The two proton beams are brought together at a few ‘crossing points’ in the LHC ring – which is where the main experiments take place – at the **CMS, ATLAS, ALICE** and **LHCb** detectors.

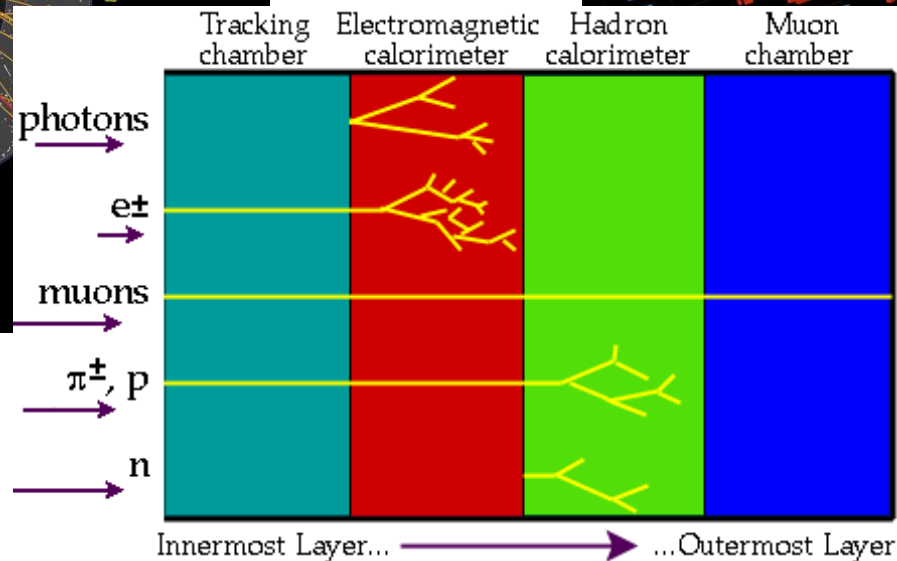
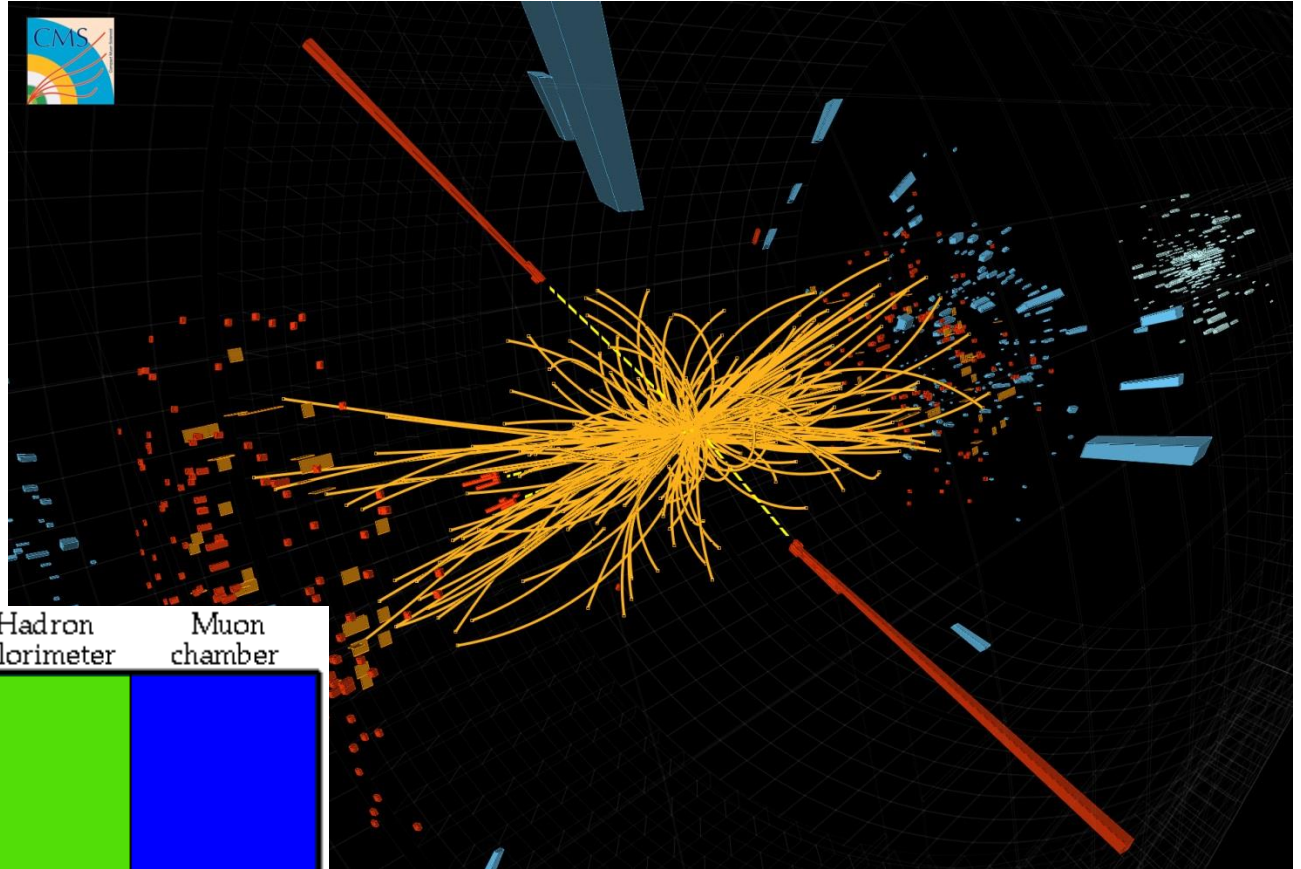
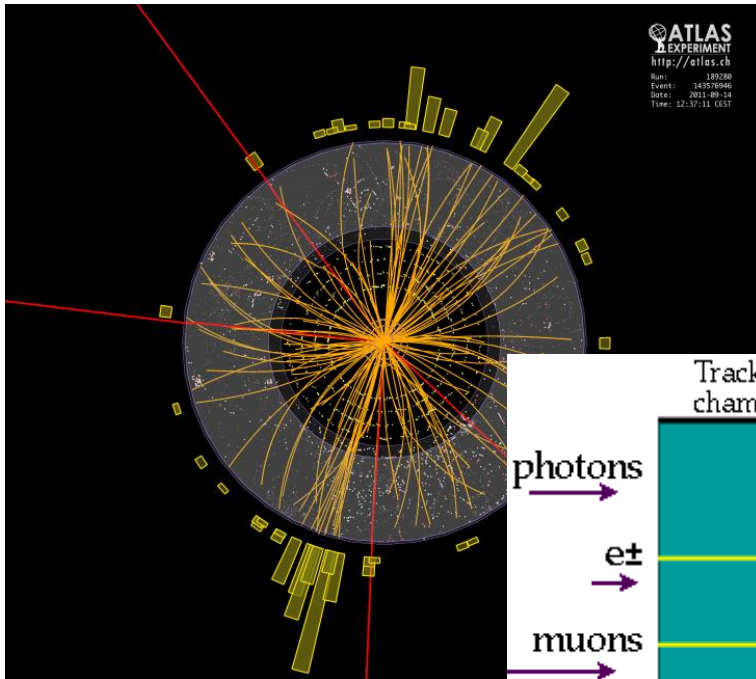


Relative beam sizes around IP1 (Atlas) in collision



# New Particles....

11. When the protons collide, new particles are formed with distinctive tracks in the detector sub-systems.

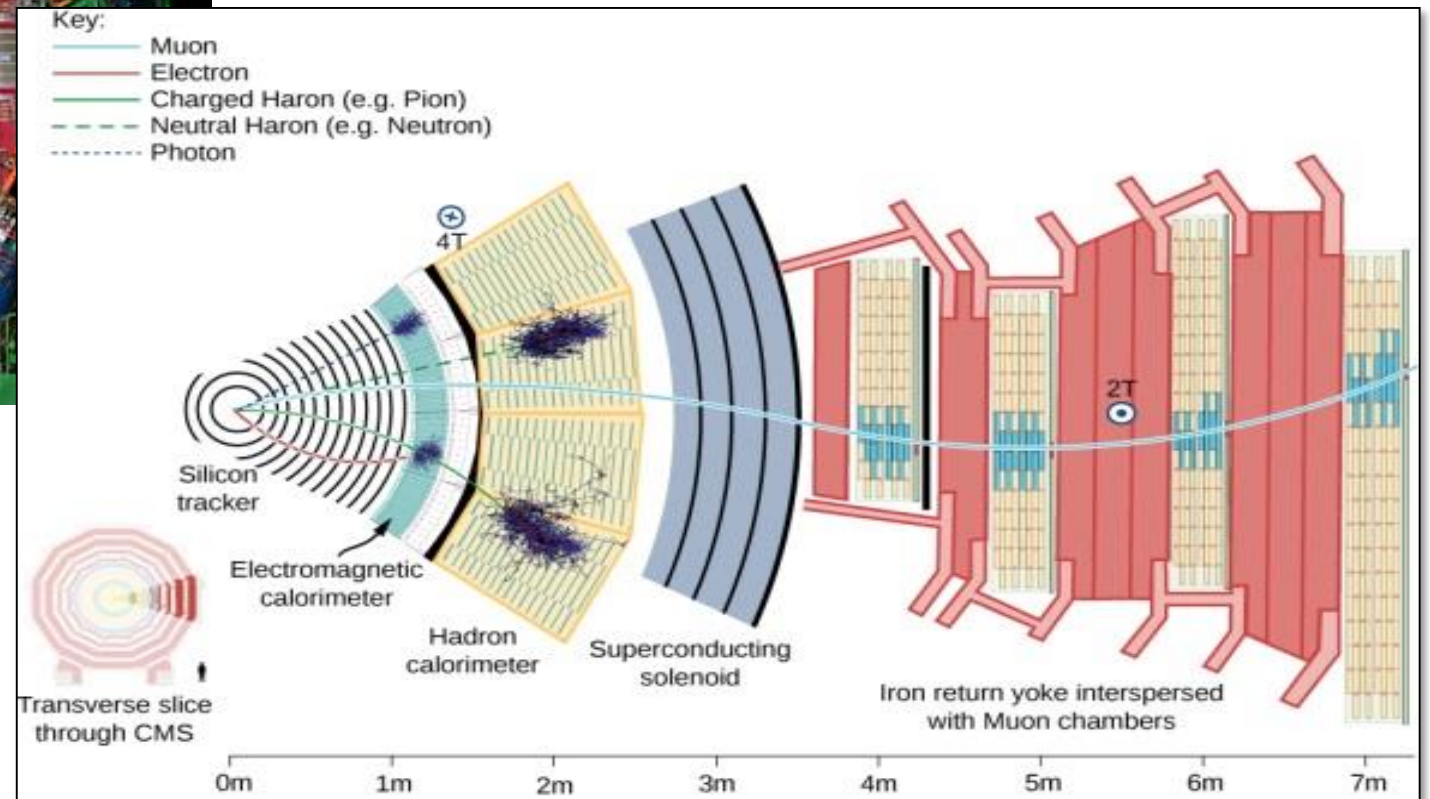




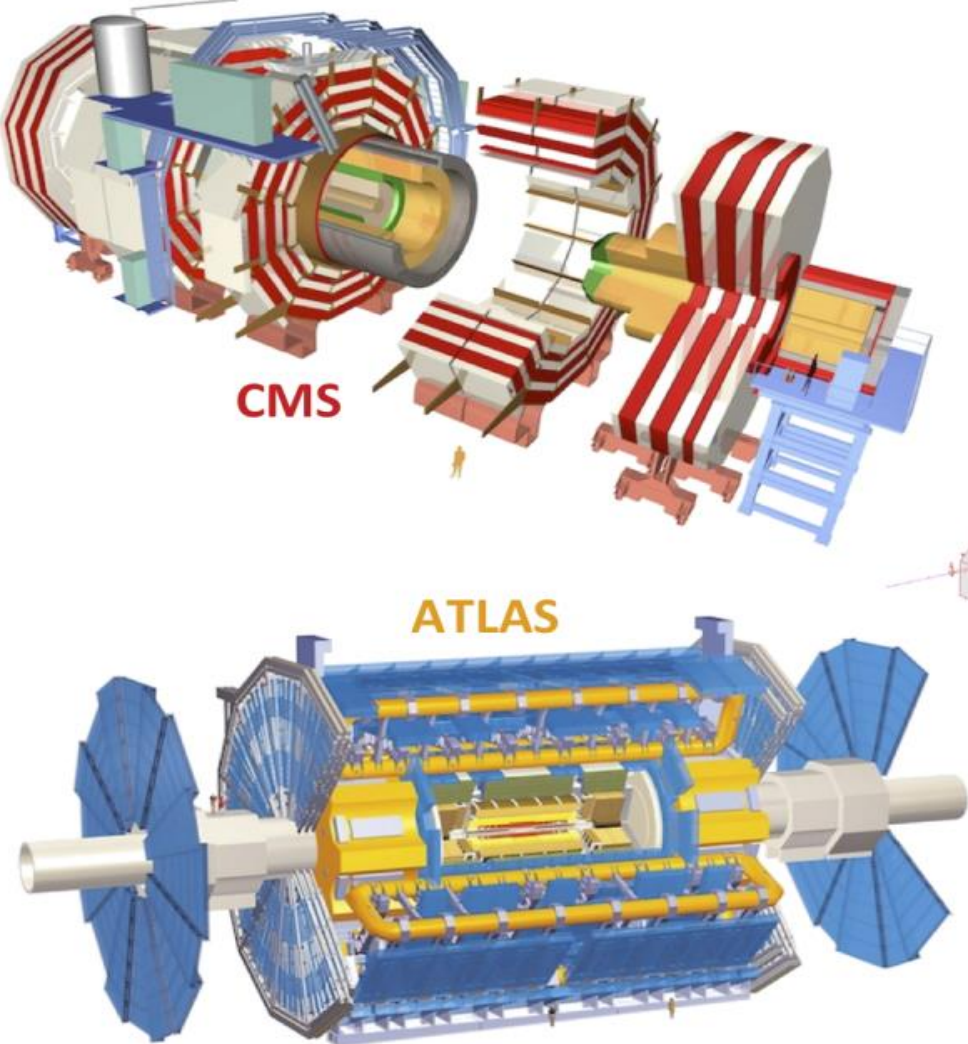
# Modern detectors – working scientifically



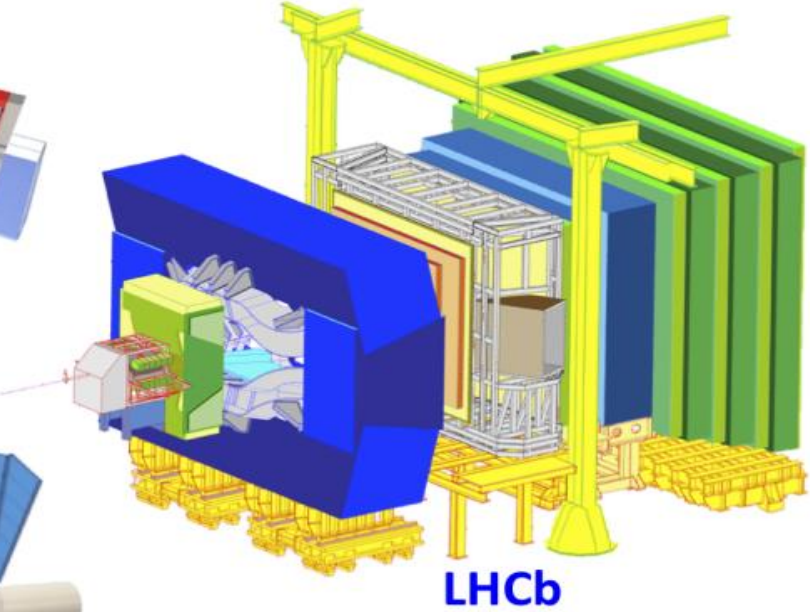
Modern detectors have **several layers** of different types of detector – for example using **semiconductors**, **charge-sensing wires** and **calorimeters** (which absorb energy).



# LHC Particle detectors

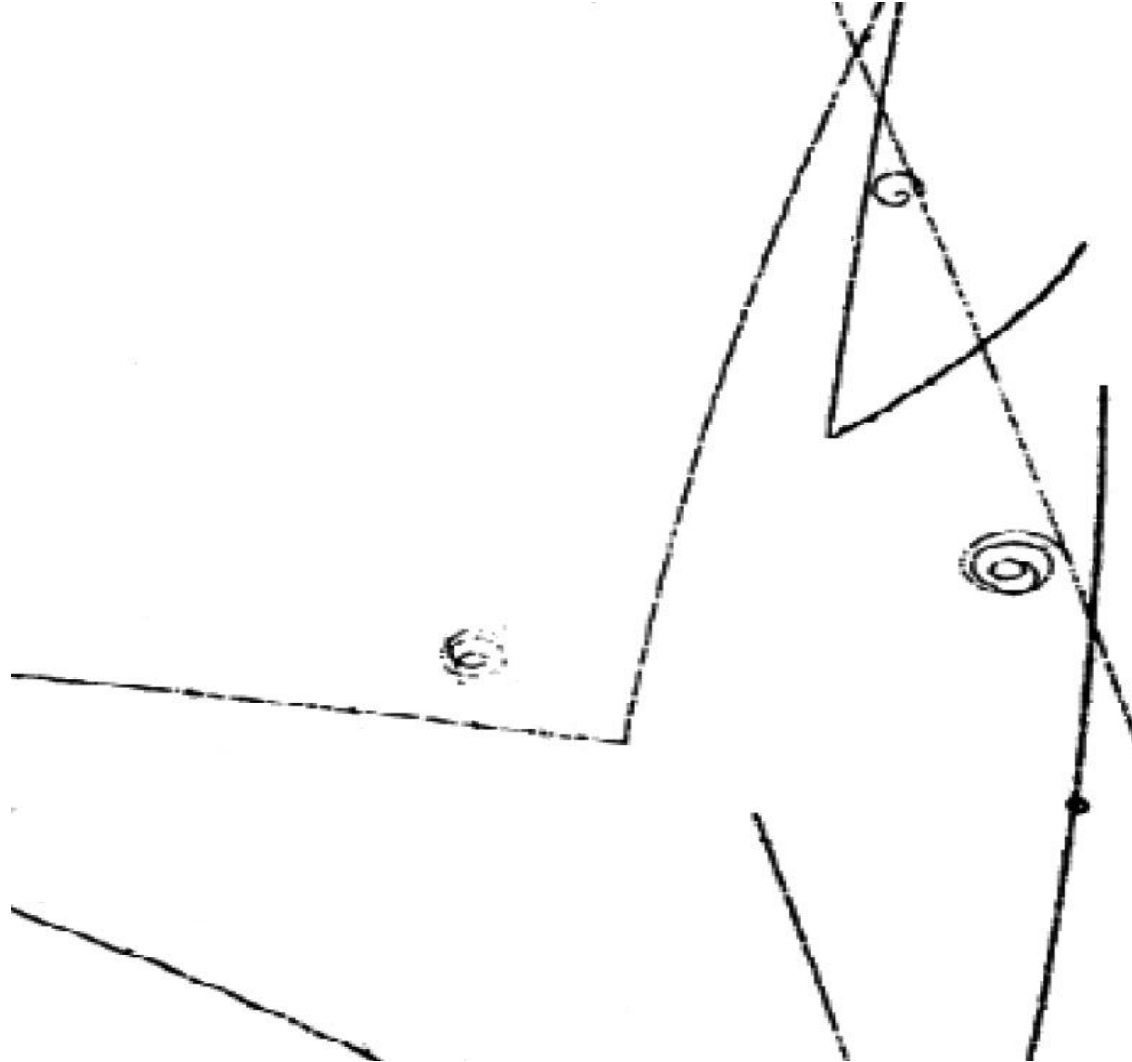


ALICE





# How do we identify elementary particles?



By their:

- charge
- mass
- lifetime
- decay modes  
(what they change into)





making physics matter

# Accelerators and Detectors



Amanda Poole  
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