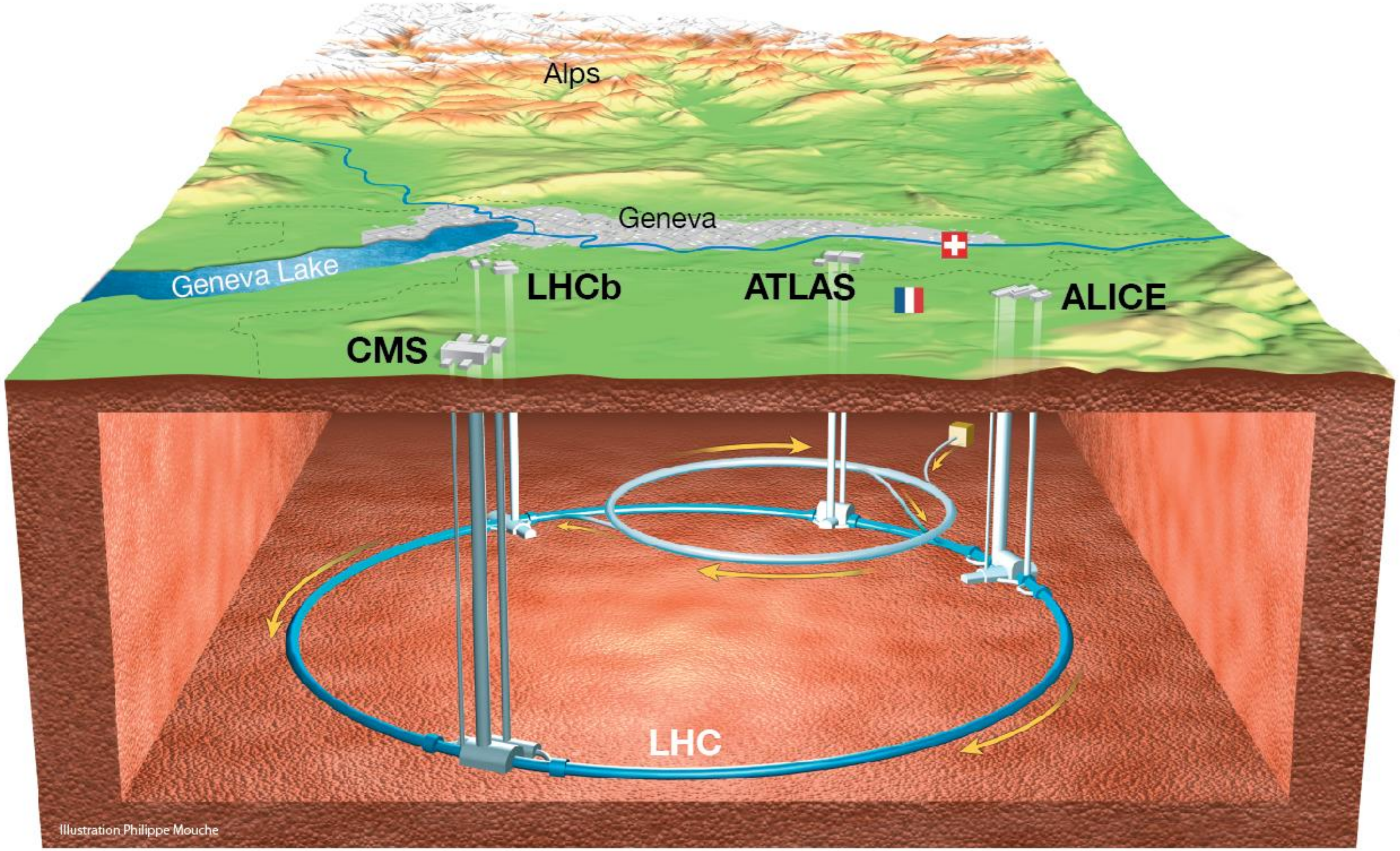
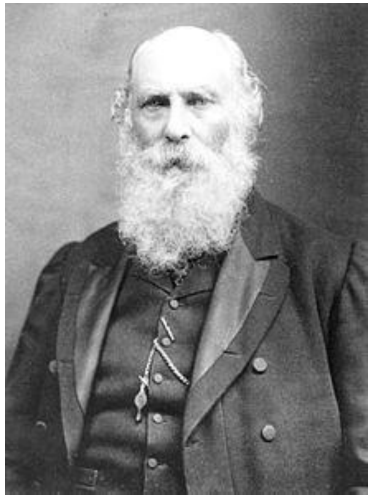
Accelerators and Detectors – Working Scientifically

Amanda Poole
Jenny Watson
Jackie Flaherty



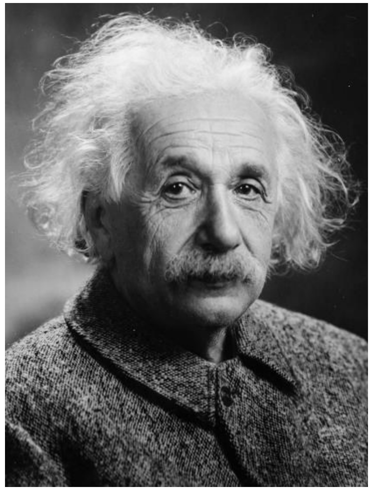
Changing Scientific Ideas Over Time

Democritus
460 -370 BC

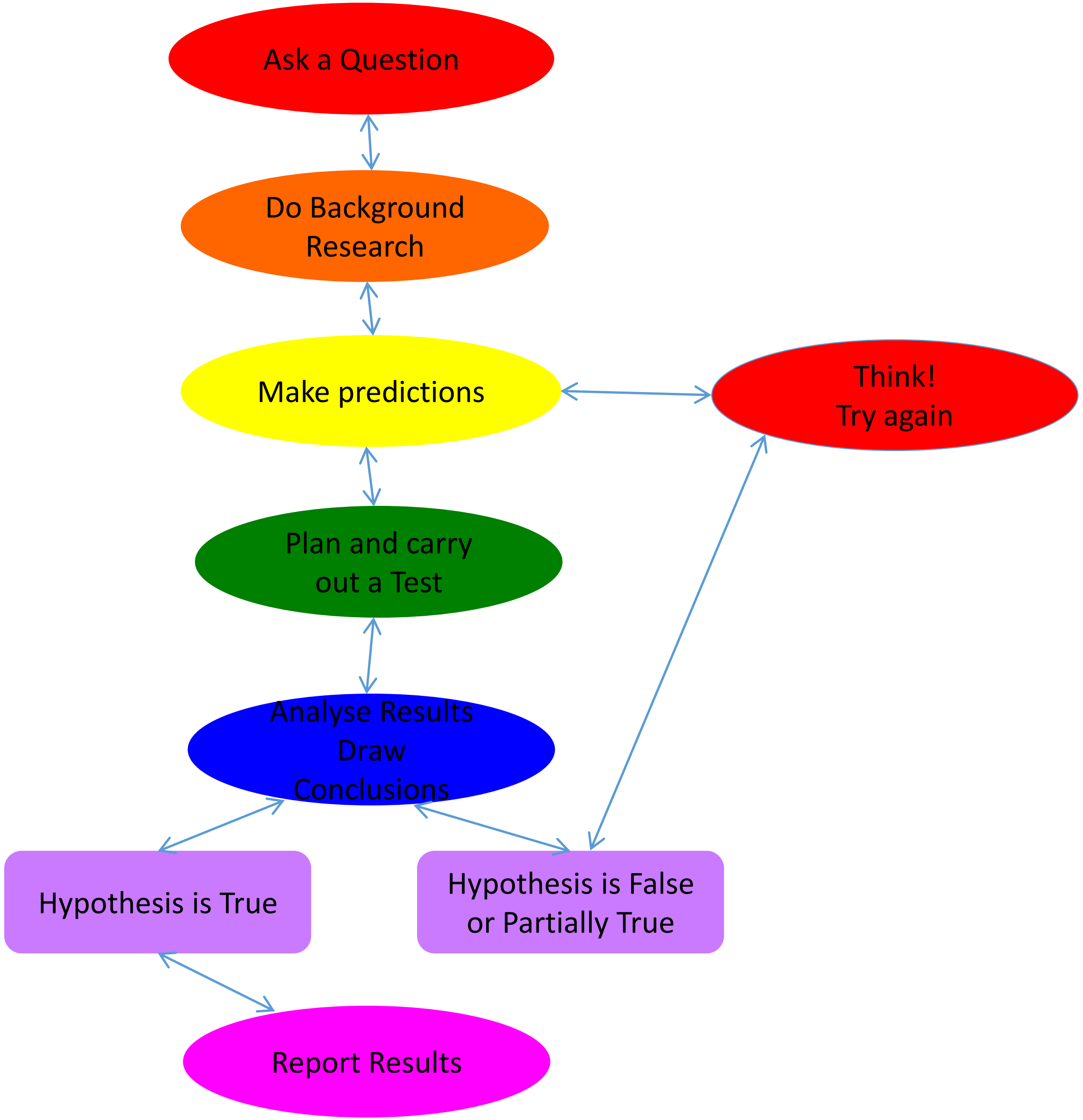


George Stoney
1874

J J Thomson
1898

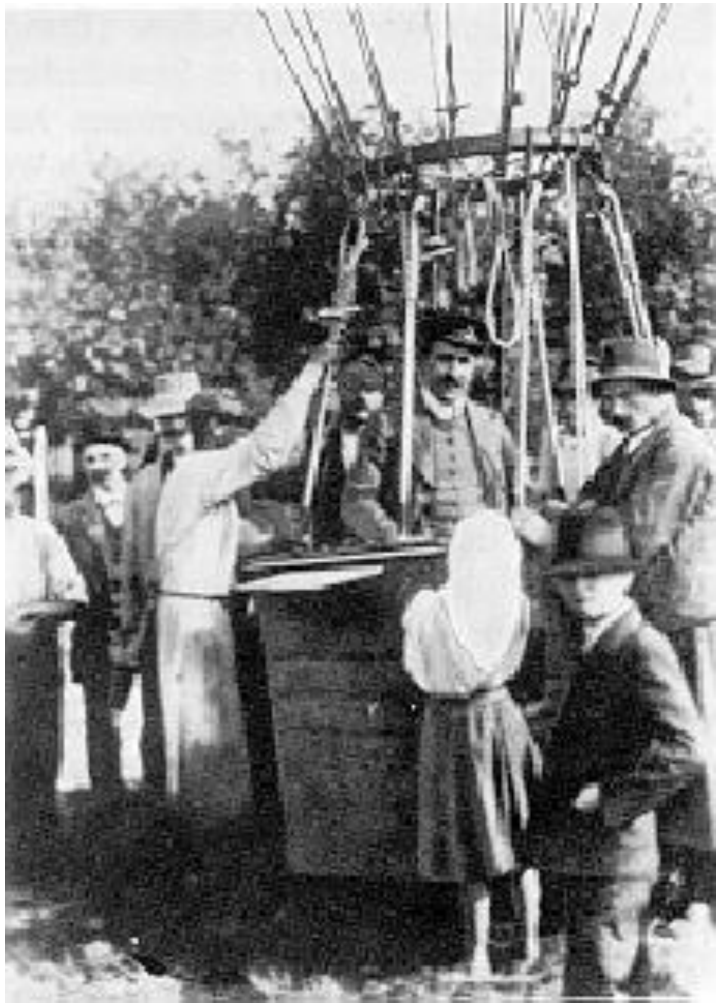


Albert Einstein
1905

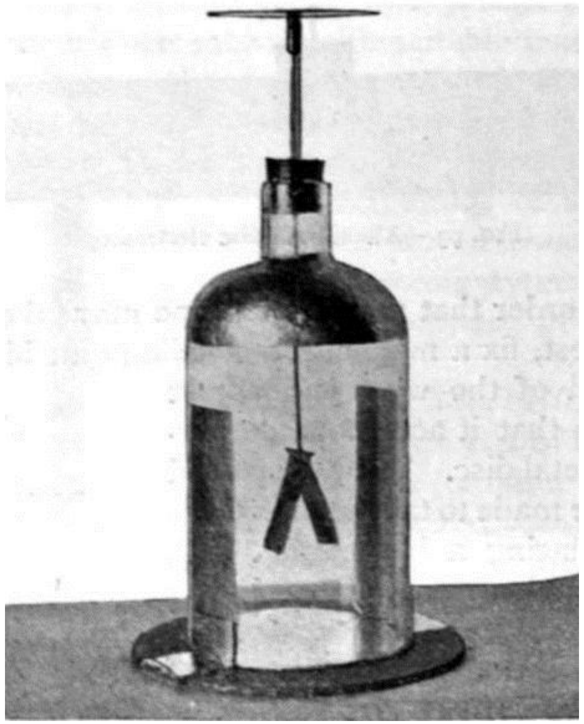


The Discovery of Cosmic Radiation

Early Detectors



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



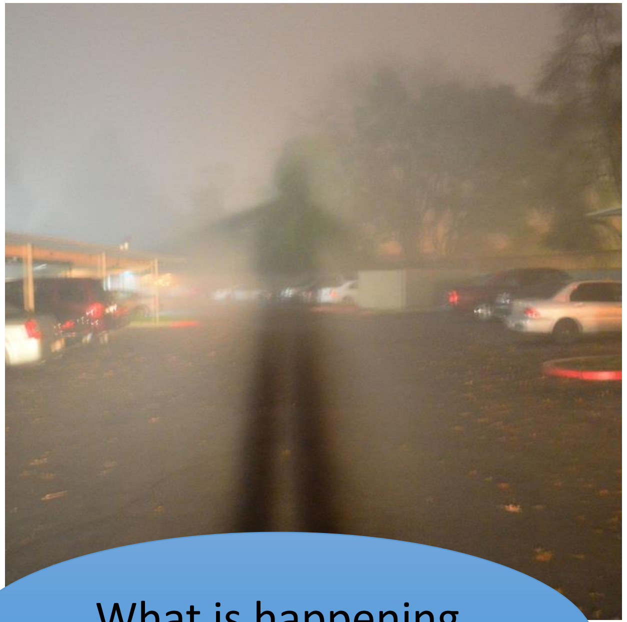
Does this strange radiation really get weaker at higher altitudes?

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

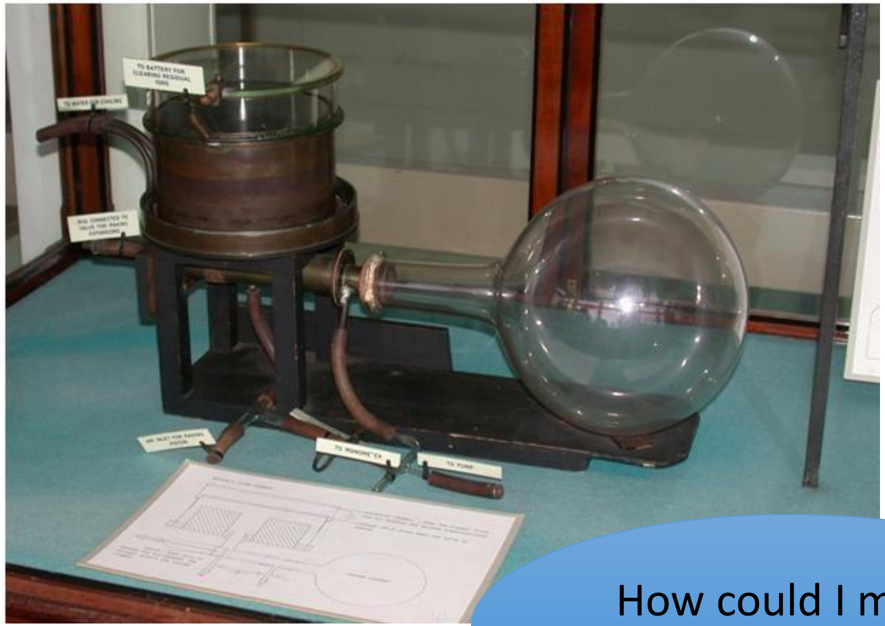
Invention of the Cloud Chamber

Early Detectors

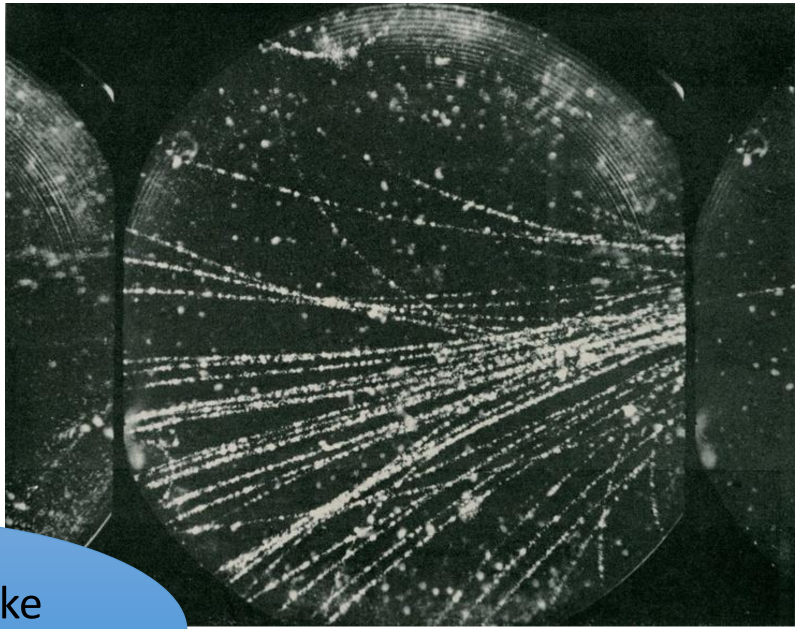
Charles Wilson, 1894 was inspired by sightings of the Brocken spectre (large foggy shadows) seen while working on the summit of Ben Nevis.



What is happening here?



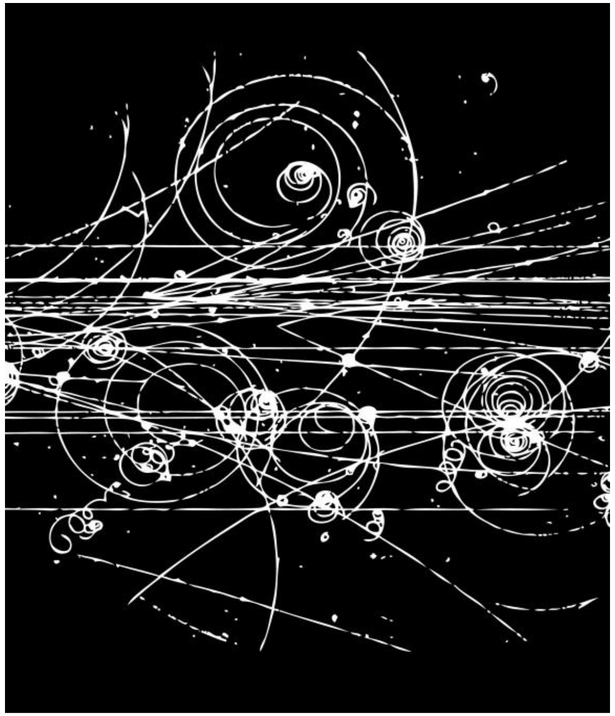
How could I make use of this?



What has beer got to do with elementary particles?

Invention of the Bubble Chamber

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

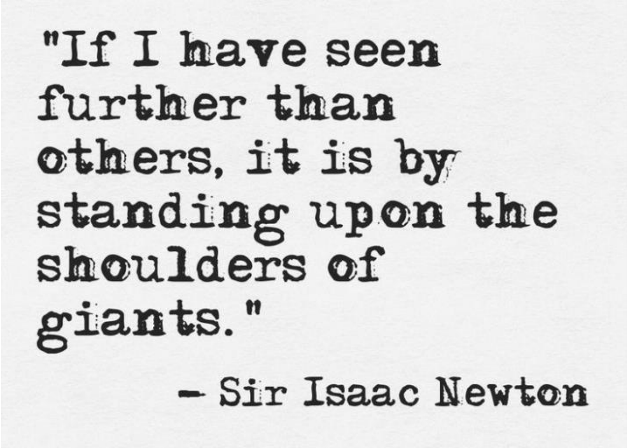


How do superheated liquids behave?

How could this be useful when learning about elementary particles?

Early Detectors

Discovery



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?

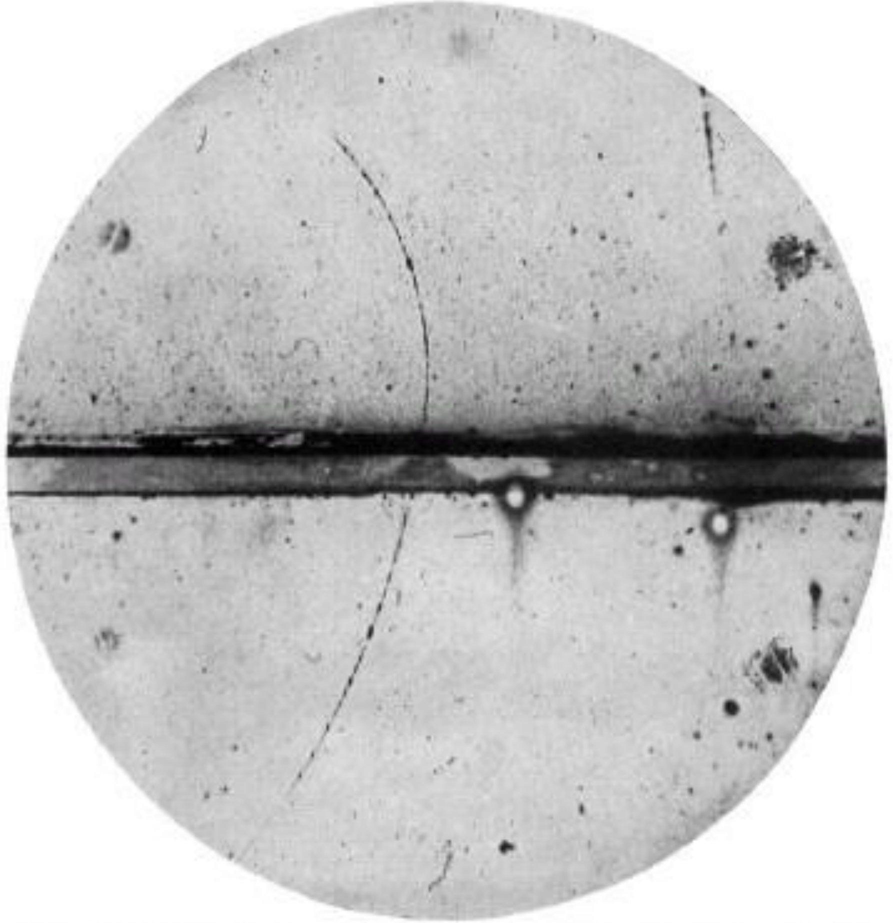
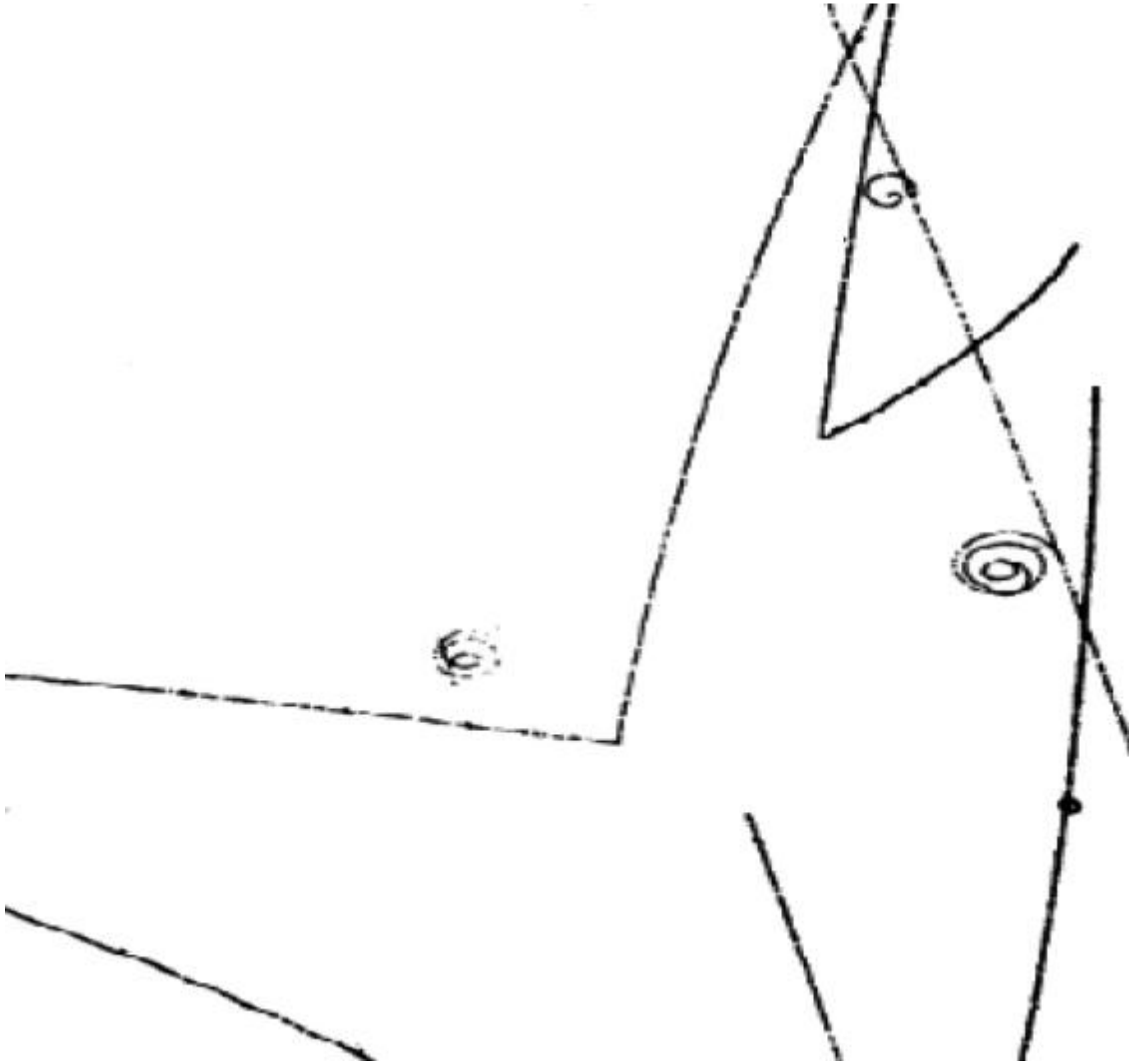


FIG. 1. A 63 million volt positron ($H\rho = 2.1 \times 10^5$ gauss-cm) passing through a 6 mm lead plate and emerging as a 23 million volt positron ($H\rho = 7.5 \times 10^4$ gauss-cm). The length of this latter path is at least ten times greater than the possible length of a proton path of this curvature.

How do we identify elementary particles?

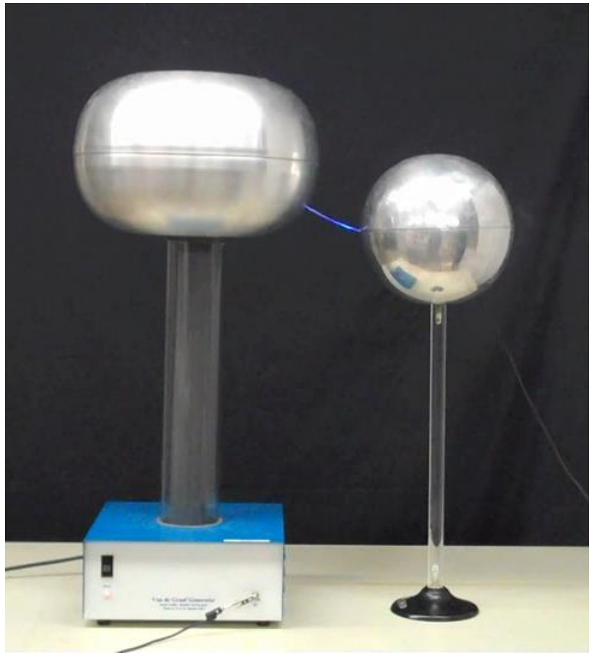


By their:
- charge
- mass
- lifetime
- decay modes
  (what they change into)

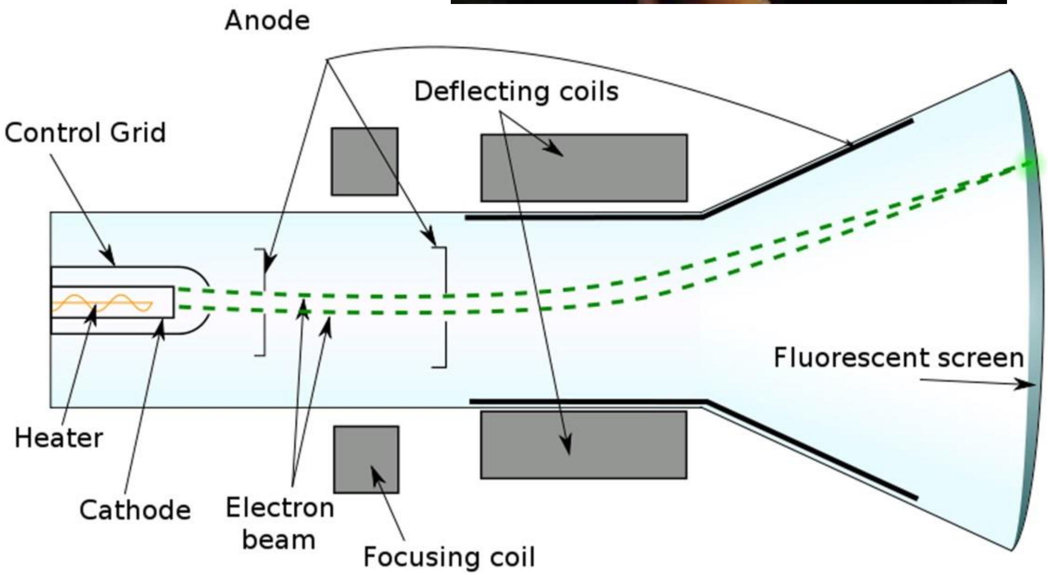
Magnetic simulation

Particle Accelerators

Van de Graaffs



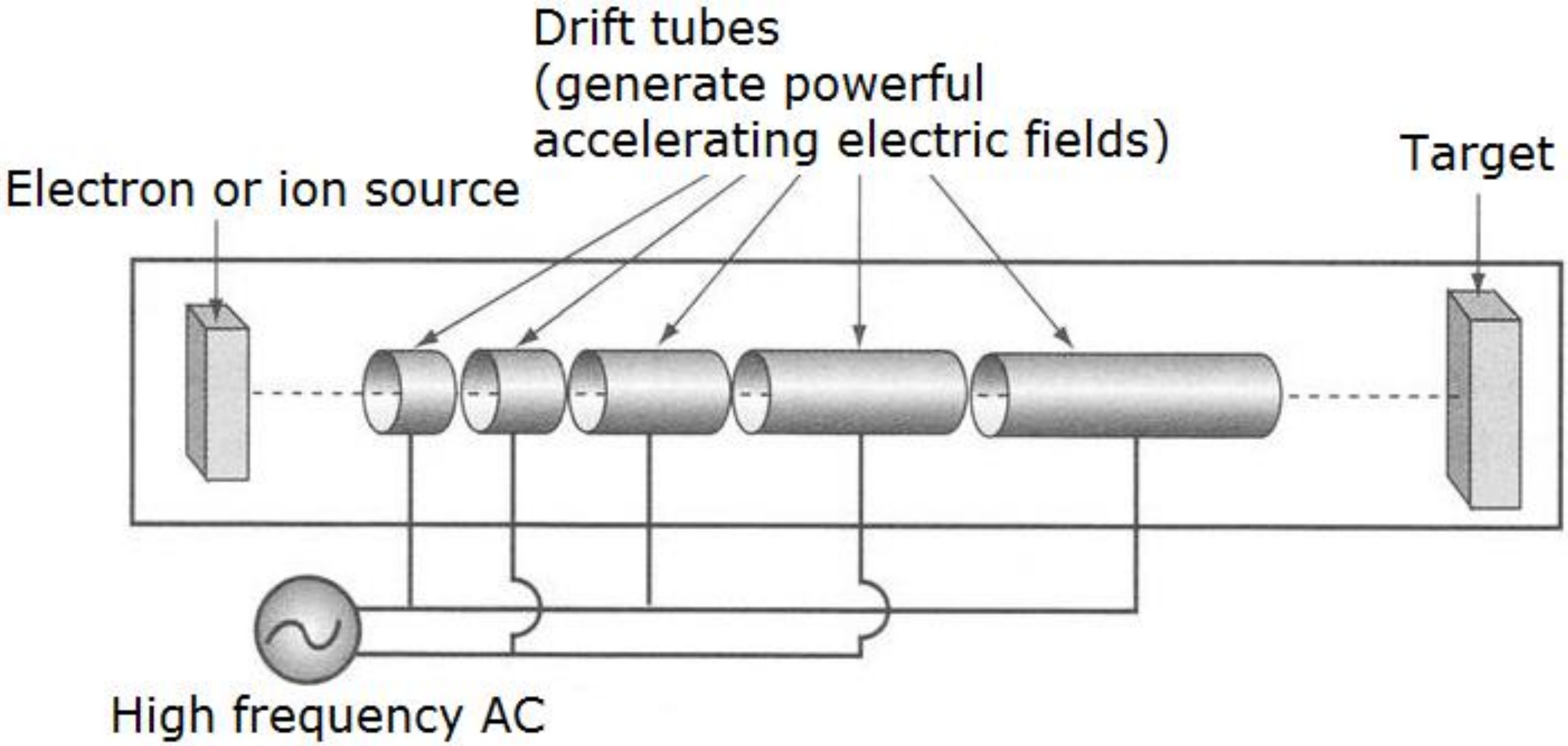
CRT TVs



Electron microscopes

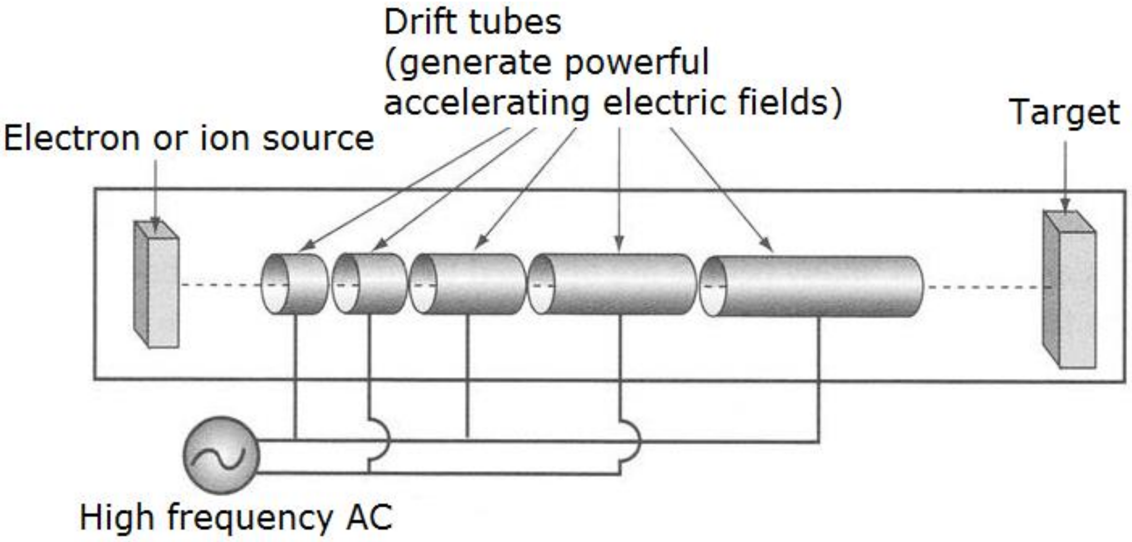
Balloon & ES demo

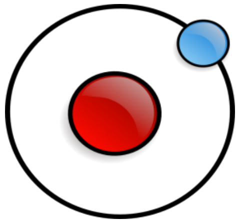
Linear Accelerators



Beachball accelerator: Oxford sheet
gauss gun

Particle Accelerators



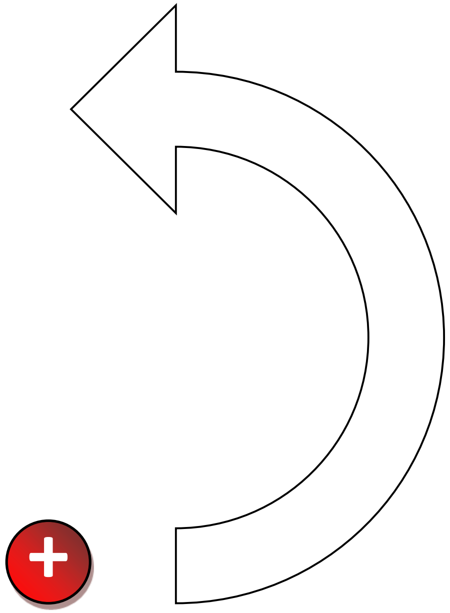


1. A **Hydrogen Atom** is **ionised** i.e. has its electron removed, leaving a charged **proton**.

Introduce Pizza box LHC: Labels 1-5 on inside lid

Circular Accelerators

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

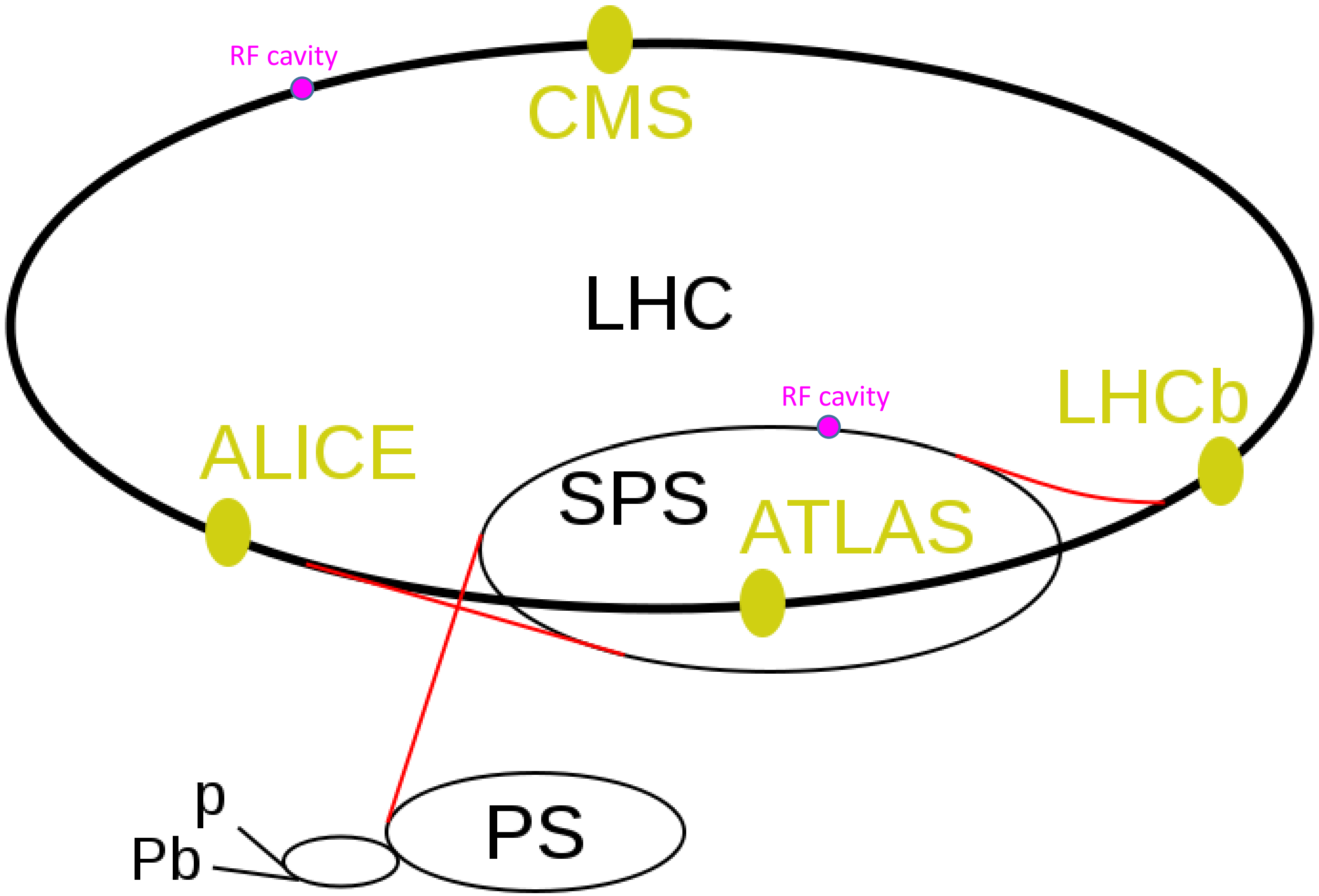


Direction – marble on slope & label 6

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**.



Labels 7, 8, draw 12cm rad LHC, 5cm SPS & 0.8cm PS circles & label 9

SPS Beam Pipes & Magnets

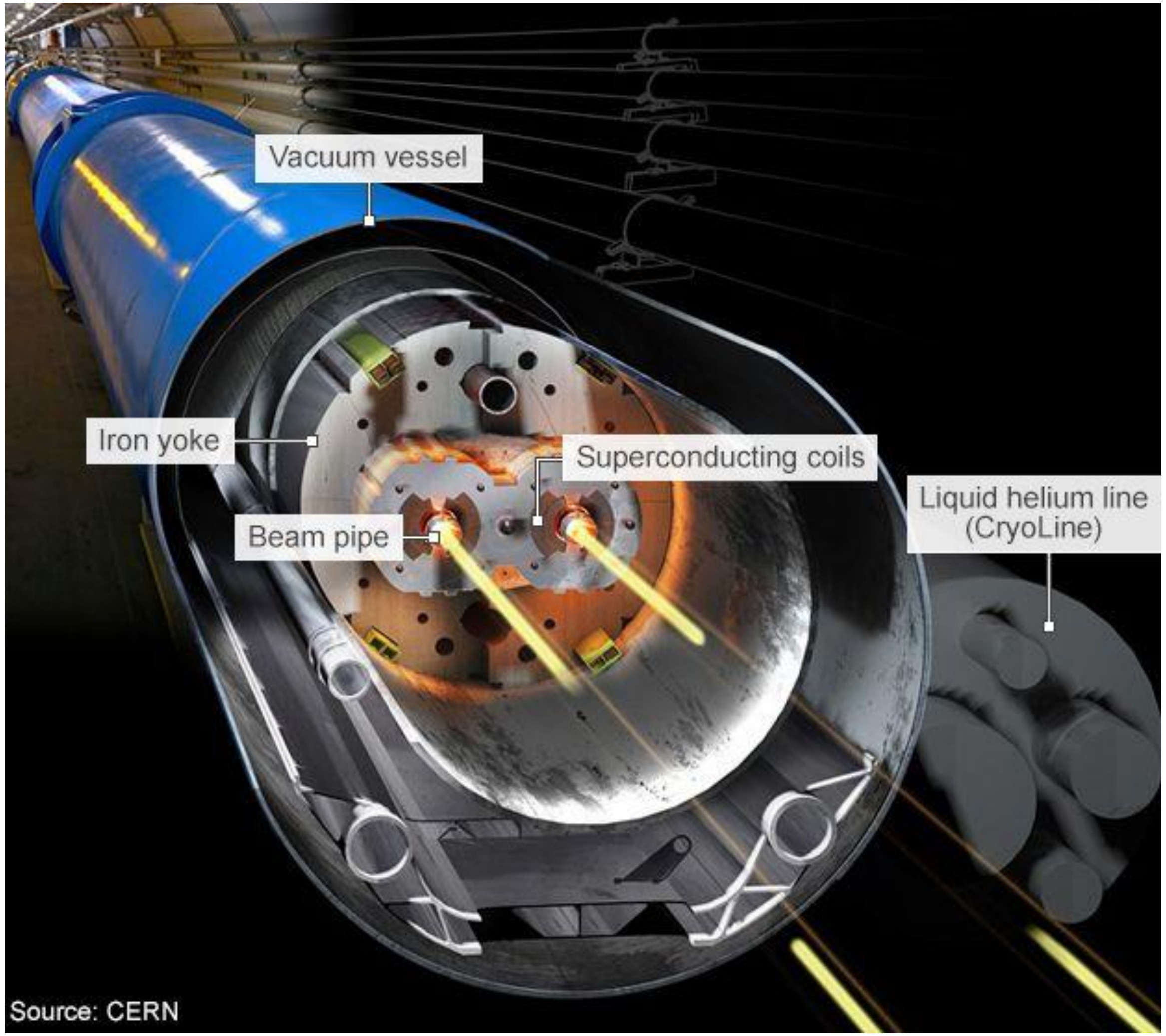
7. The LHC protons have to travel in a **vacuum** (very empty space) to stop them hitting things and changing direction.

Label 10, 11, 12. Make & place SPS magnets & RF cavity

LHC Beam pipes & Superconducting magnets

8. The LHC uses 1,600 (<u>very</u> cold) **superconducting magnets** spaced around the ring to make the protons travel in a circle. These work at a temperature of -271°C (1.9K), i.e. just above **absolute zero**.

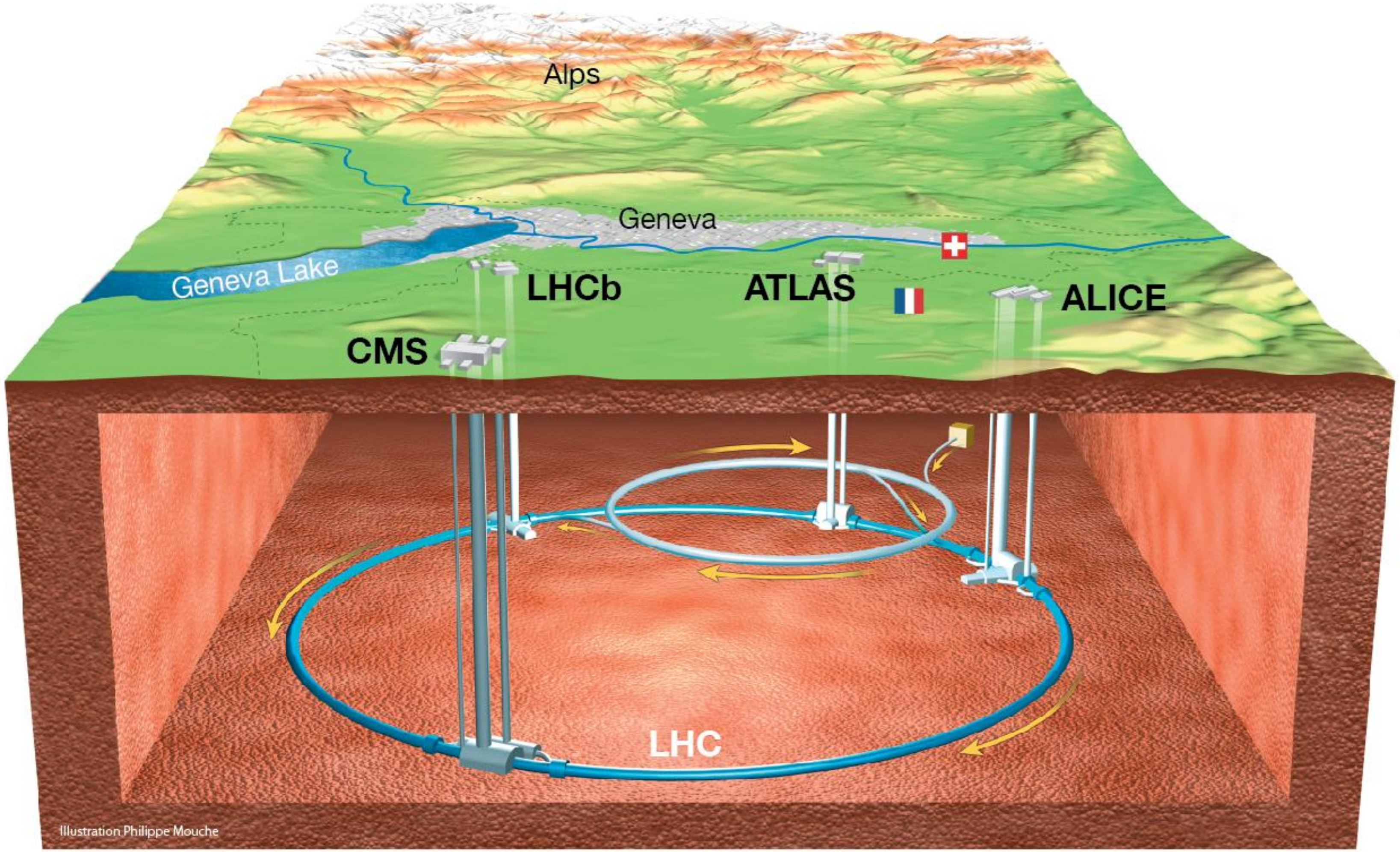
9. The LHC has **two vacuum tubes** in which protons travel - one for a ‘clockwise’ and another for an ‘anticlockwise’ beam, so that the **protons can collide** head-on!

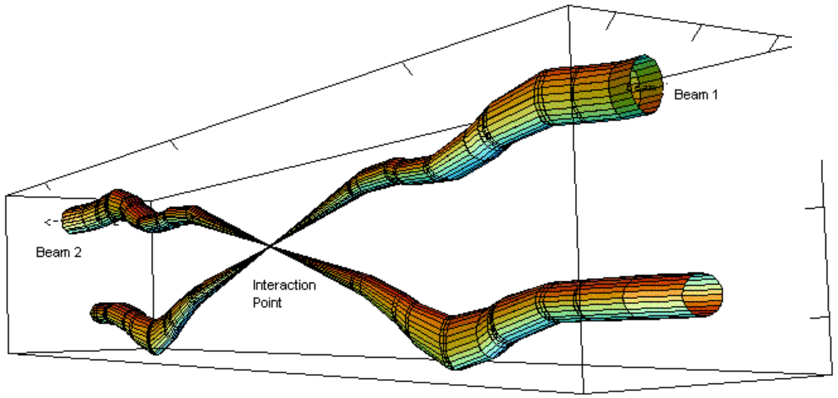


Label 13, 14, 15 & 16
Make LHC magnets/beam pipes & place these

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.

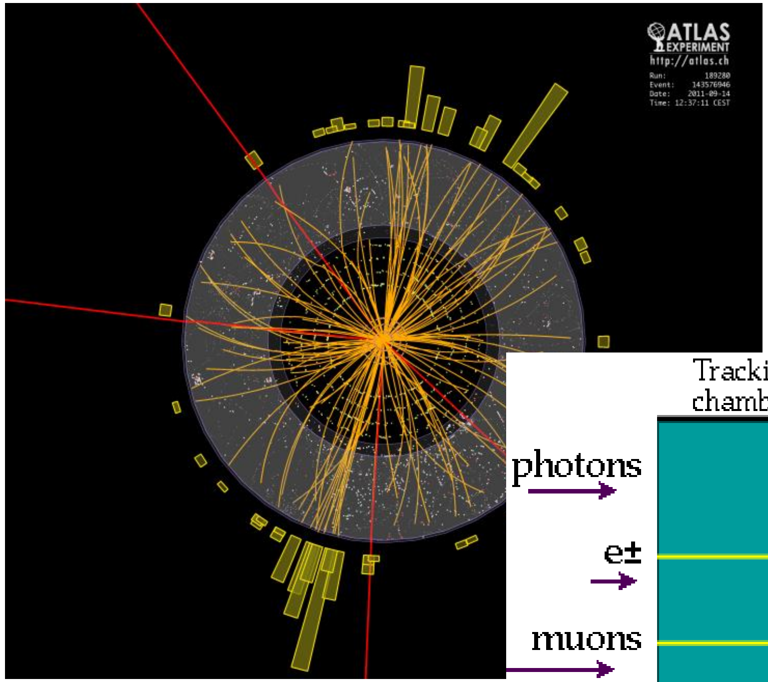


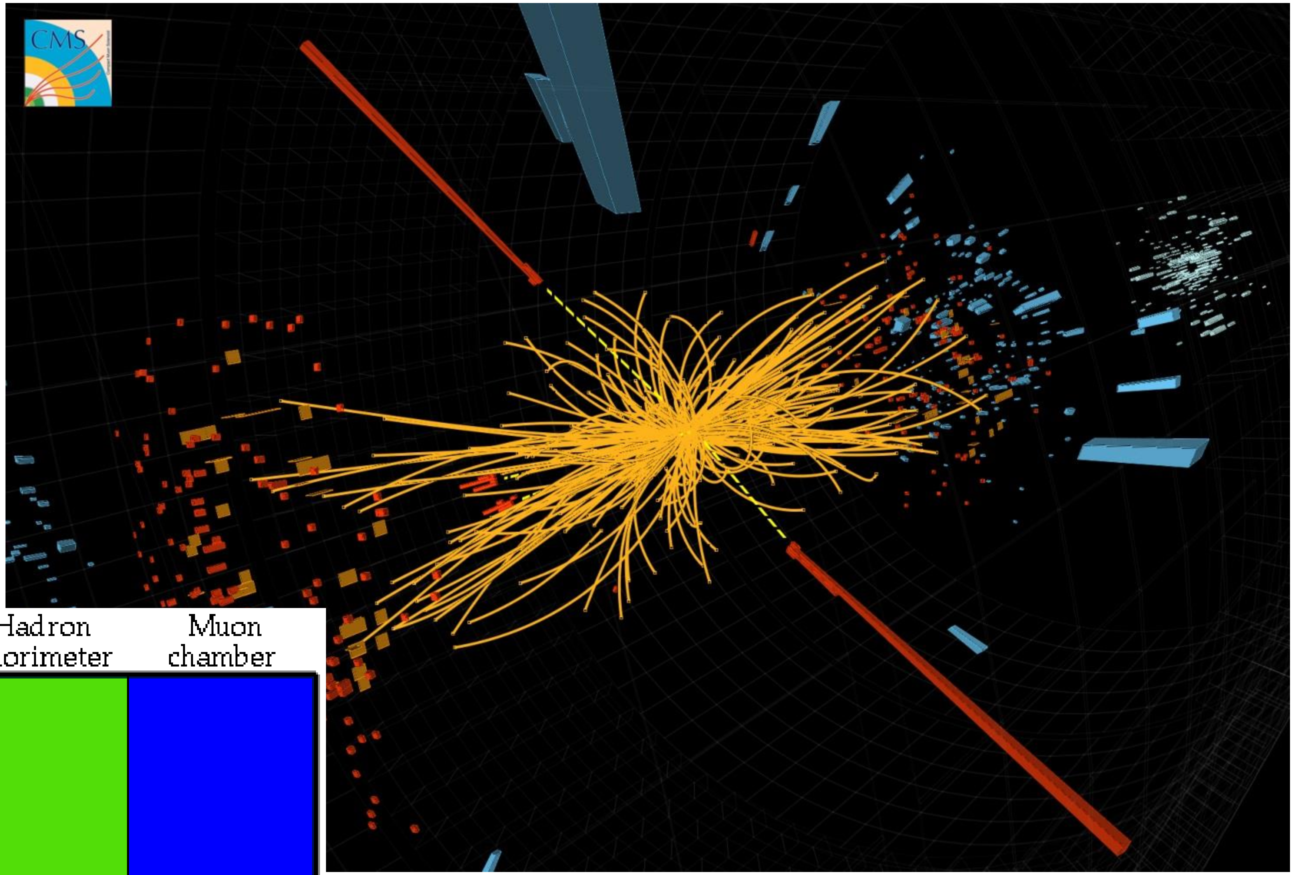


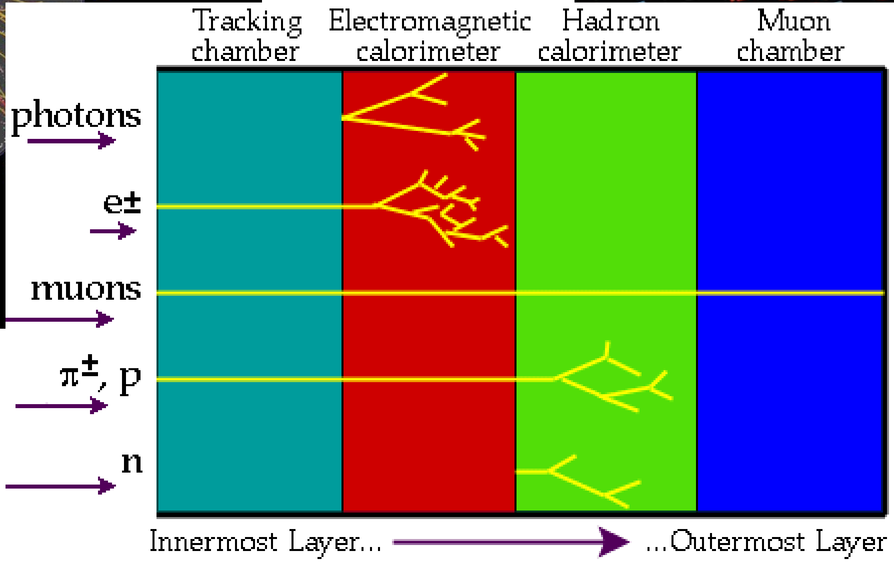
Relative beam sizes around IP1 (Atlas) in collision

New Particles….

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



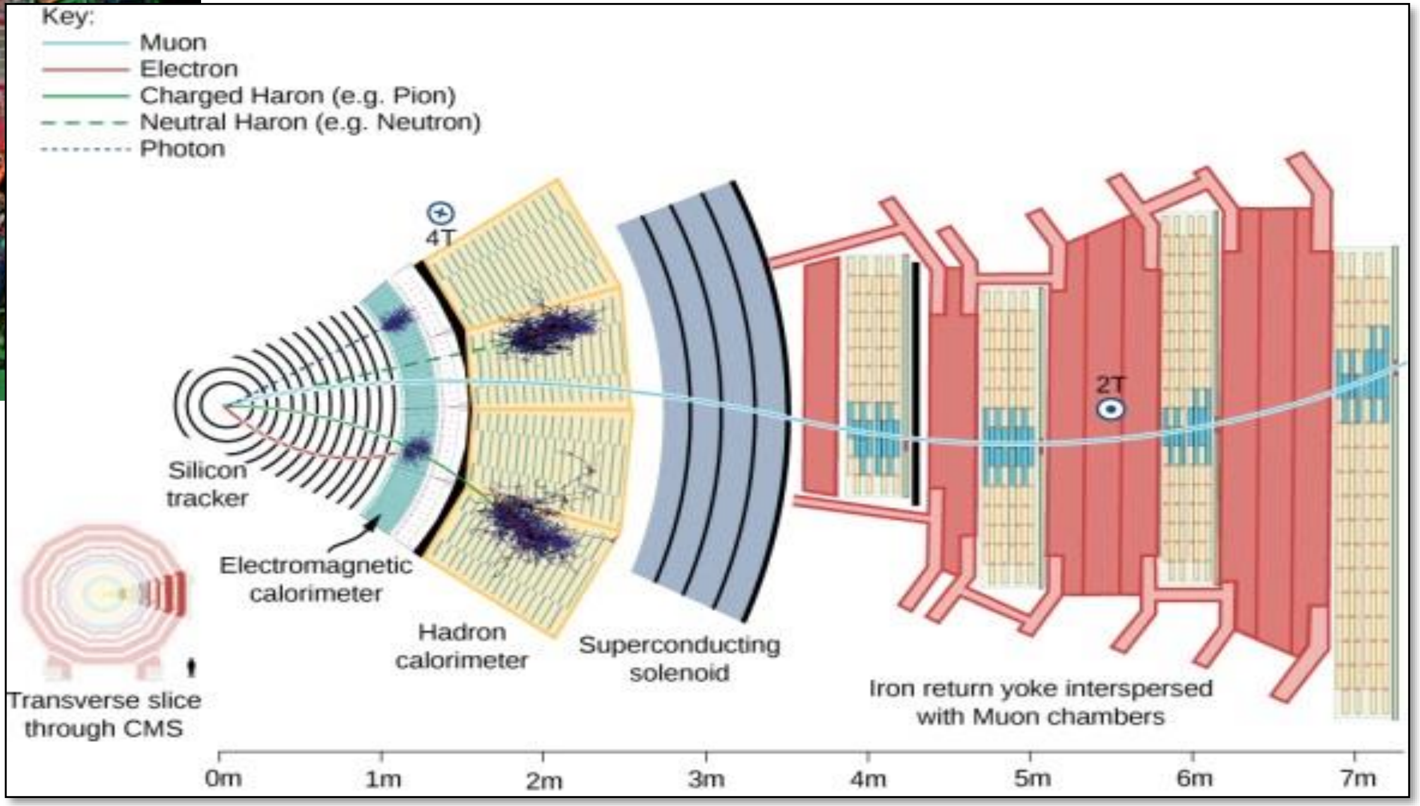




Labels 17 & 18 or 19

Demo splash-balls colliding: Oxford sheet

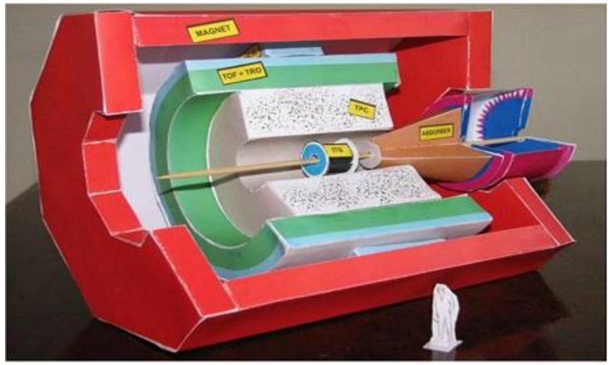
Modern detectors – working scientifically

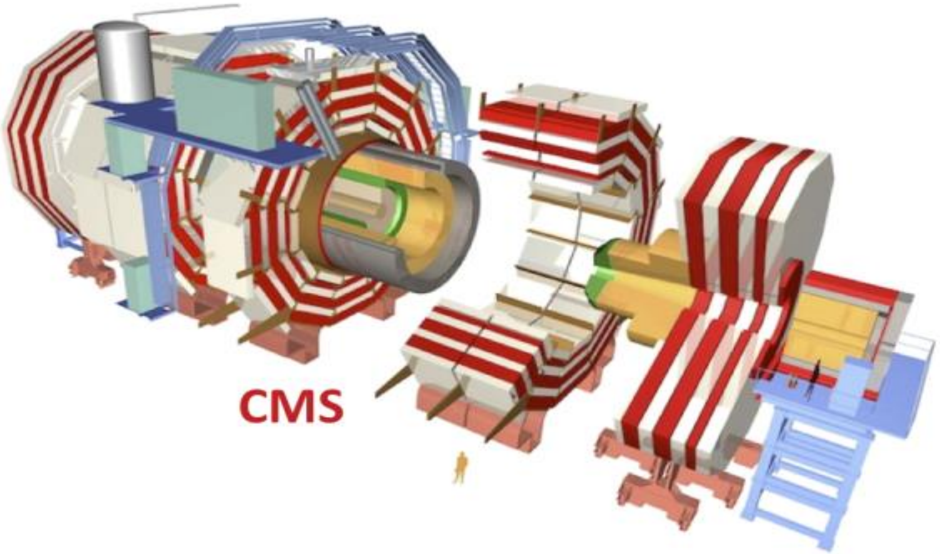


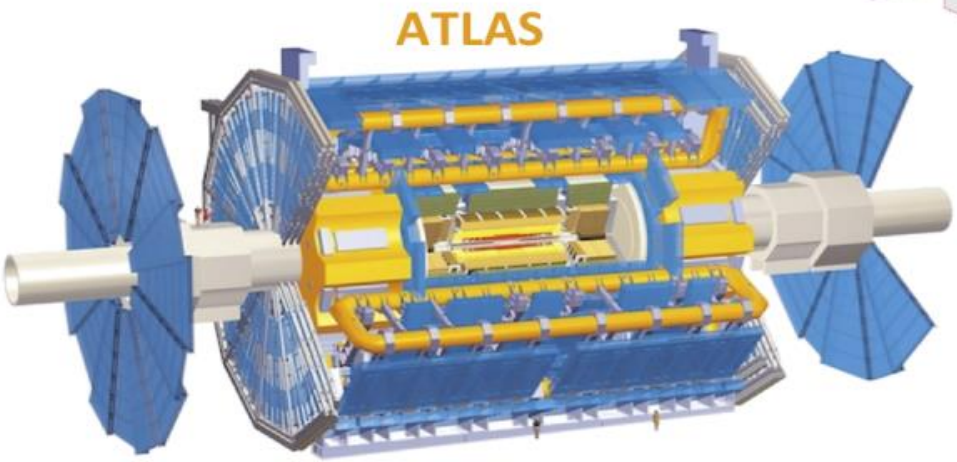
Modern detectors have **several layers** of different types of detector – for example using **semiconductors**, **charge-sensing wires** and **calorimeters** (which absorb energy).

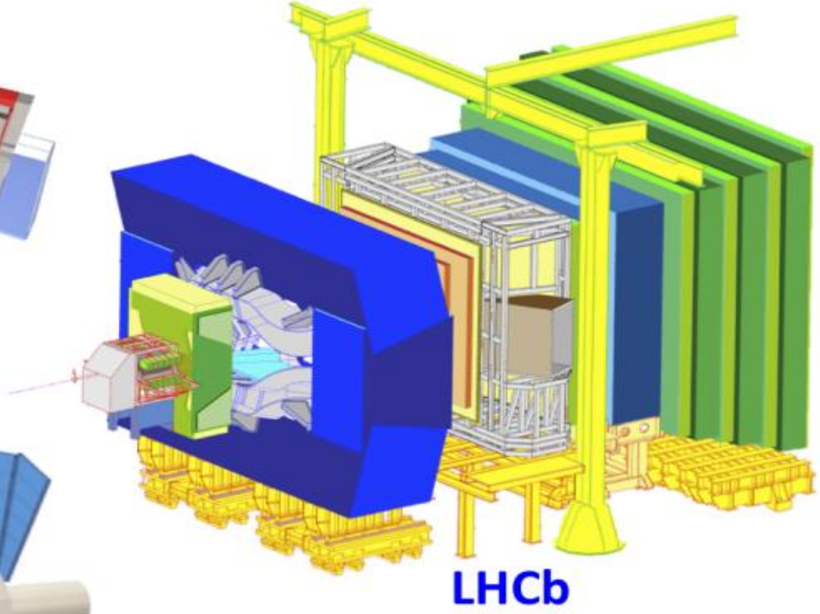
LHC Particle detectors

ALICE



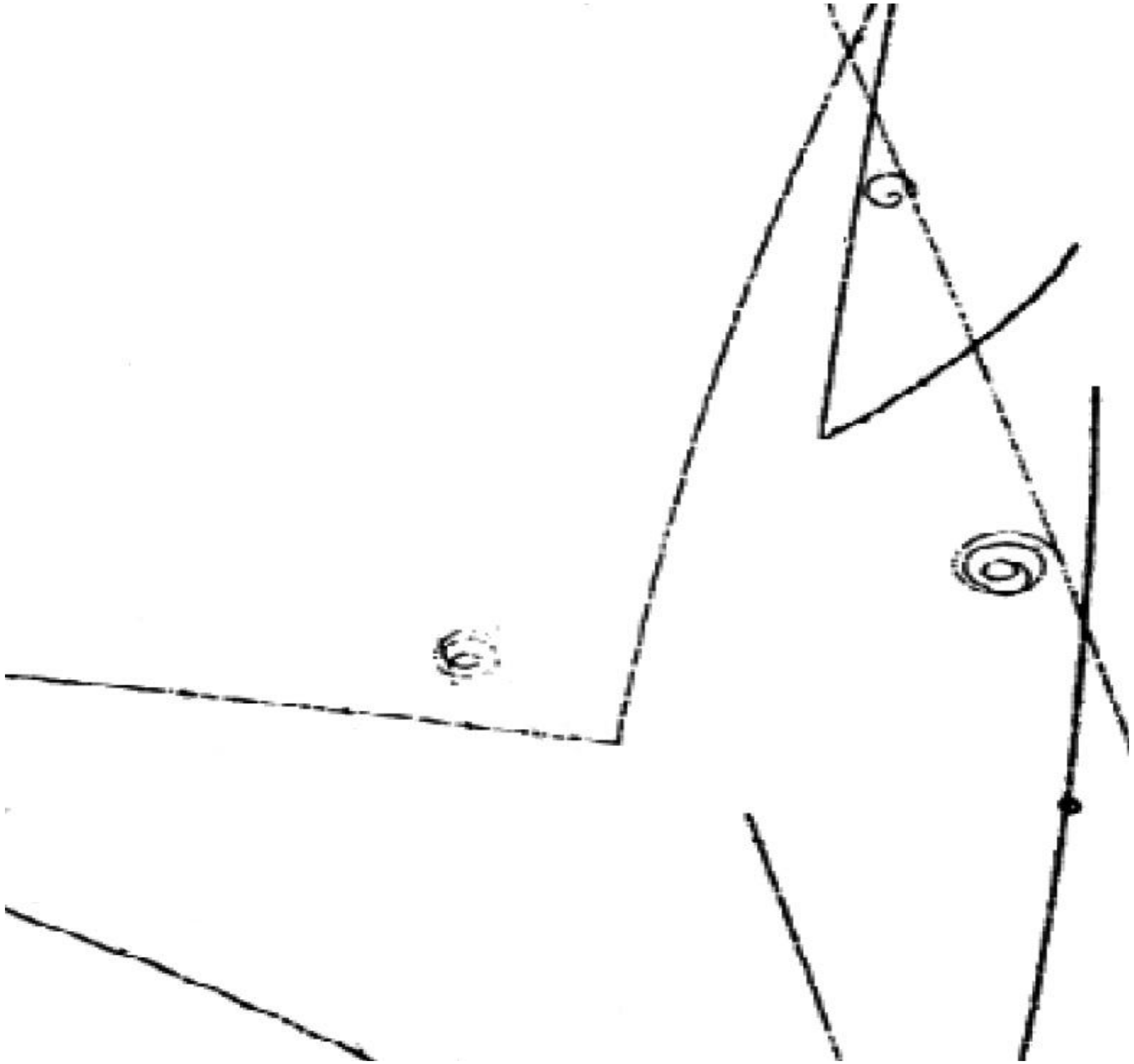






Make detectors & glue into Pizza box

How do we identify elementary particles?



By their:

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

Classifying activity, time permitting

Accelerators and Detectors

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