Particle Detectors

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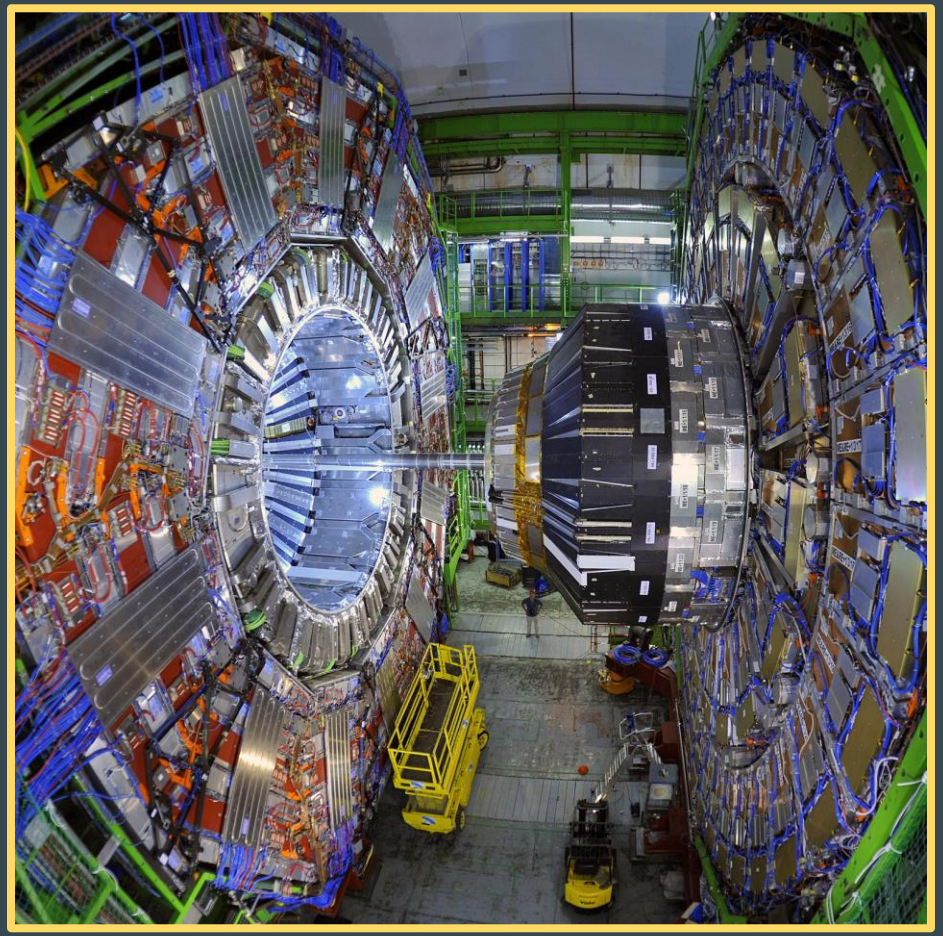
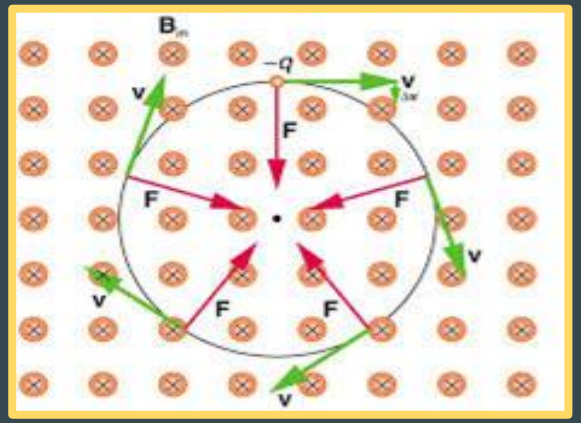
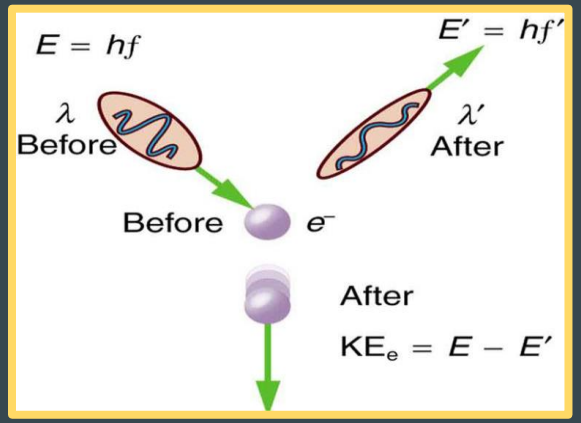


Detectors are fascinating for they
MAKE VISIBLE the INVISIBLE
- *Focus Group 8*

Curriculum & classroom connections

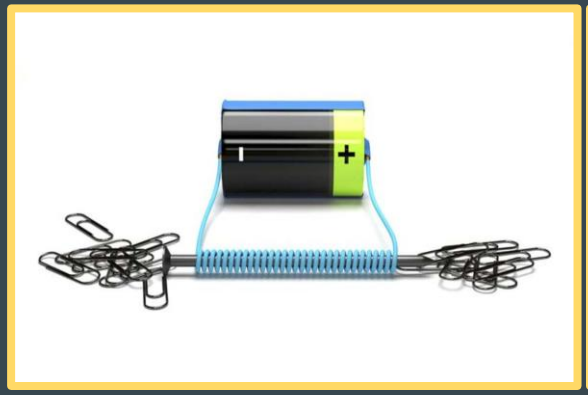
Magnetic Forces





Momentum & Energy

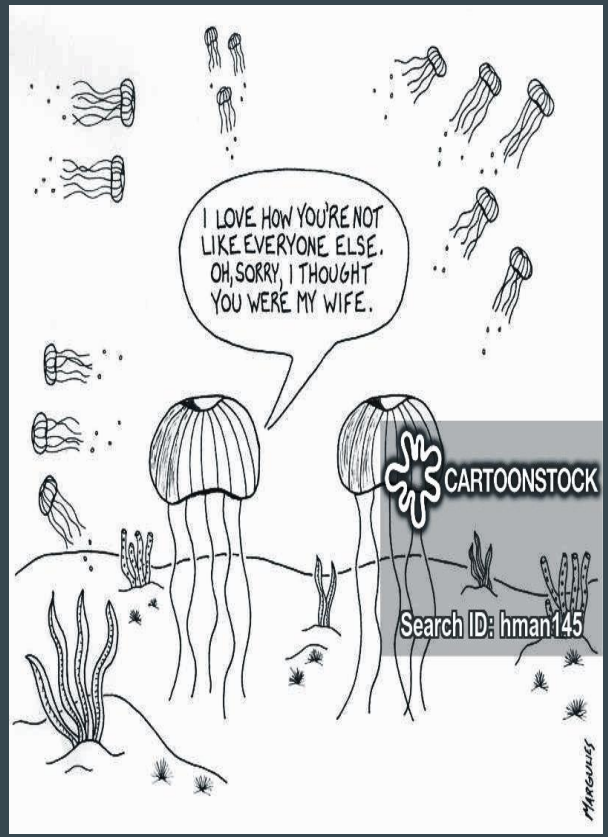
Electro-magnet



Technology

Students need to understand in before:

- electromagnetic fields
- the right-hand rule of forces
- what is a “particle”
- fundamentals concerning particles such as
    1 the invisibility
    2 their structure
- trajectories of particles
- how Energy is deposited
- momenta, energy values of particles and how it is measured



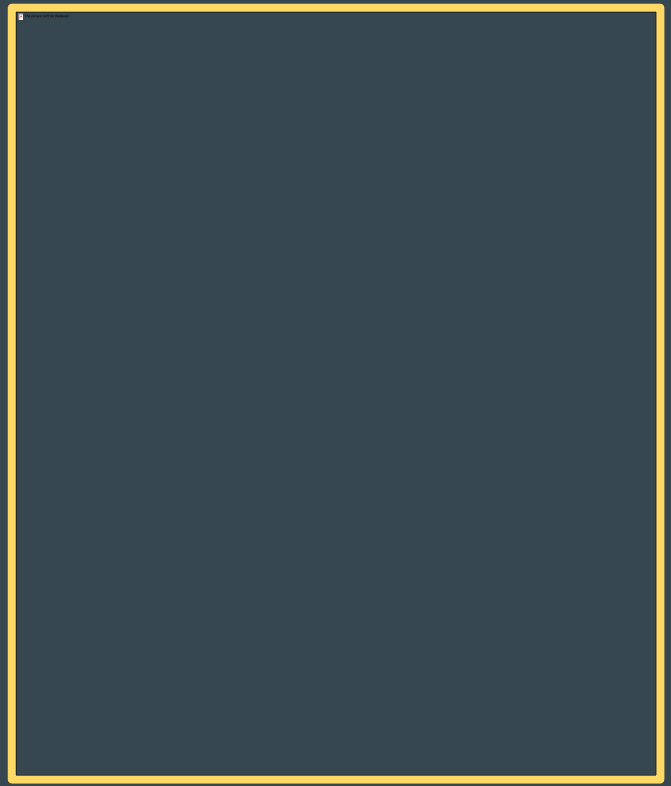
Students should be able to understand:

- the concept of detecting particles
- principles and differences between Cloud Chamber & Bubble Chamber
- capture the function of particle accelerators
- the principles of particle detectors
- working of detectors like silicon detectors; EM calorimeter

https://tonkanews.com/wp-content/uploads/2018/02/ScanDoc.jpg

Potential students' conceptions & challenges

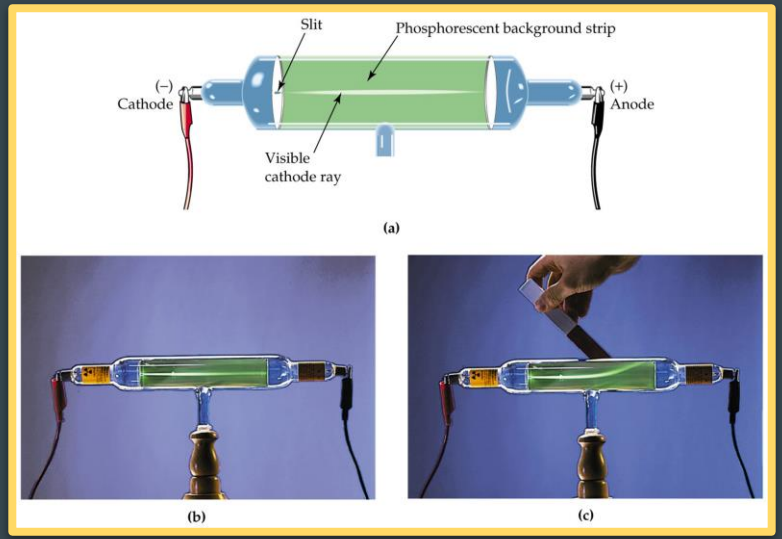
- Particles can only be seen when they interact with matter
- Think only 1 proton against 1 proton is being collided in LHC
- When particles collide, they don't just decay, they form secondary particles
- Difficult and frustrating to use data containing momenta and energy values



https://www.behance.net/gallery/32330695/Particle-physics-collision

How we can SEE the particles?

- Cathode ray tube with fluorescent screen ⇒ also to measure momentum
  - Real time experiment in classroom



https://d2jmvrsizmvf4x.cloudfront.net/Ett0gAotTFyOvz7Fmzbf_FG02_03.JPG

How we can SEE the particles?

- Cathode ray tube with fluorescent screen ⇒ also to measure momentum
  - Real time experiment in classroom
  - Watch documentary, for instance,

    "The Discovery of the Electron" with Brian Cox
- Building a Cloud Chamber
  - Interaction is needed

https://ak5.picdn.net/shutterstock/videos/24304025/thumb/1.jpg

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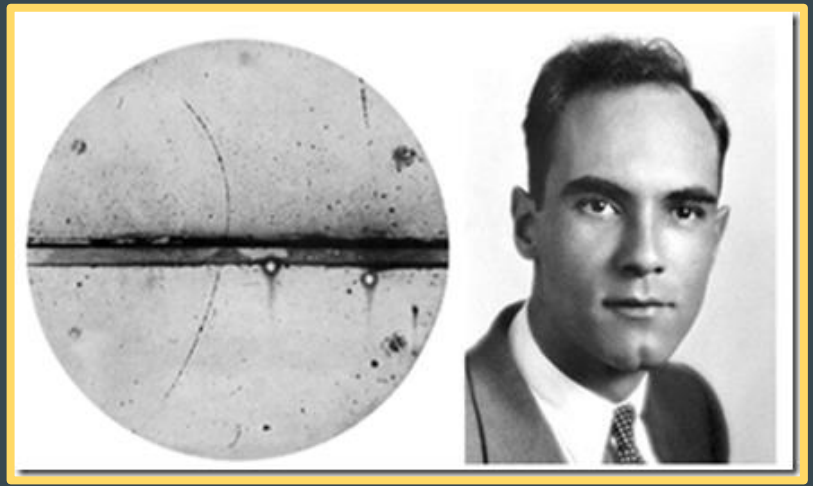
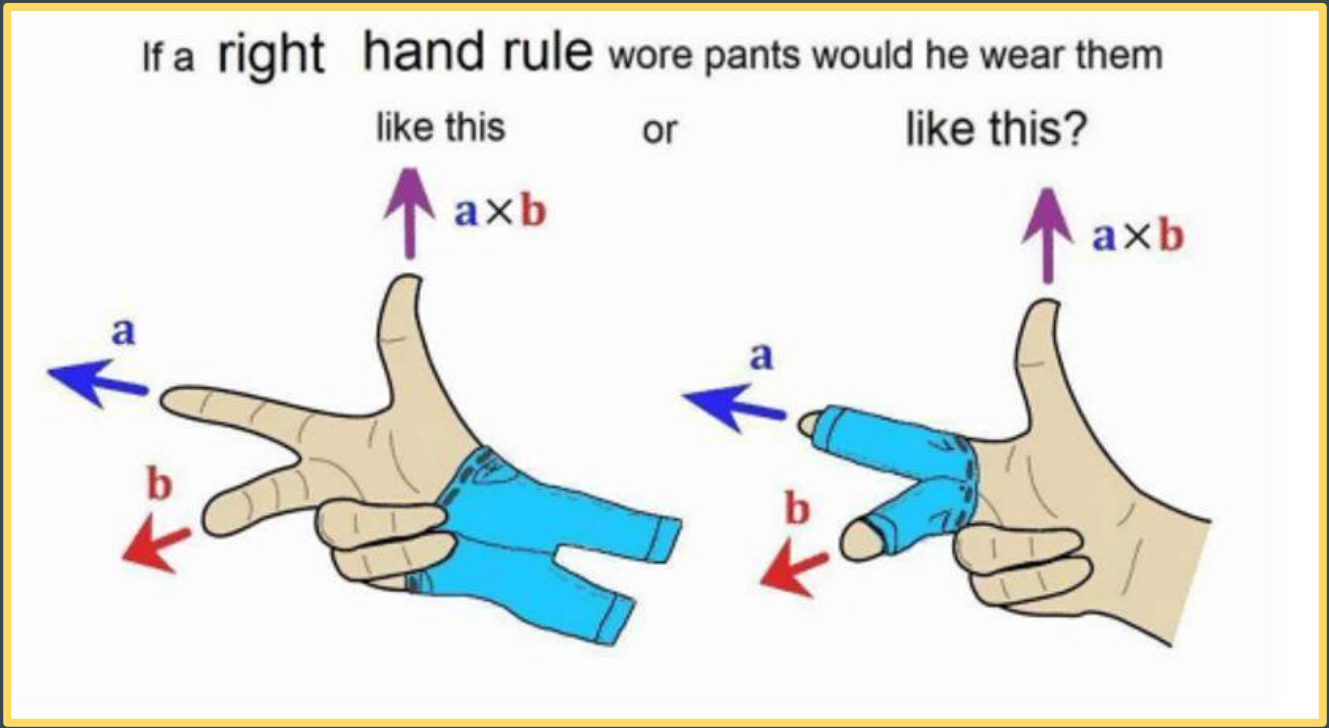
- Building a Cloud Chamber
  - Interaction is needed
  - Discovery of the positron



https://thescientificodyssey.typepad.com/.a/6a01b8d0788cce970c01b7c79e566f970b-pi

Right hand rule

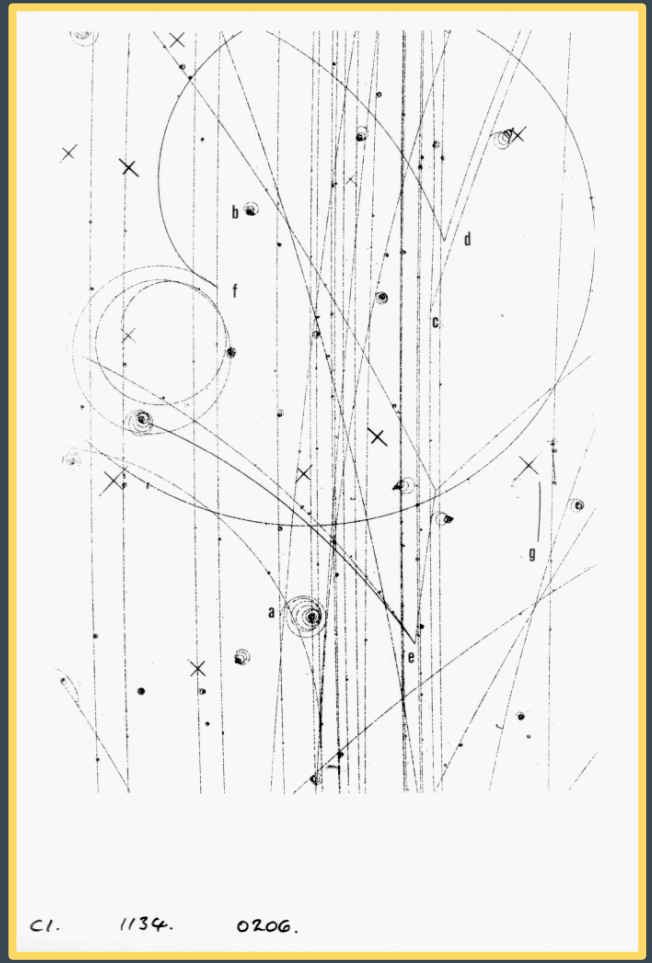


https://i.redd.it/5ln8o96s60v11.jpg

Right hand rule

Analyzing pictures of bubble chamber:

- Peter Watkins "Seeing Particles"
  ⇒ also to teach fundamental interactions
- Science in School
  ⇒ see fundamental interaction (pair production, Compton effect)



http://epweb2.ph.bham.ac.uk/user/watkins/seeweb/photo206.gif

Some other helpful materials

- ATLAS virtual lab
- Exercises and information in German
- CERN Open Data
- Charged particle tracking in 2D
- Deep Learn Physics Open Data
- Teachers TV video collection - Secondary Science - KS3 & KS4 Classroom Resources - Physics

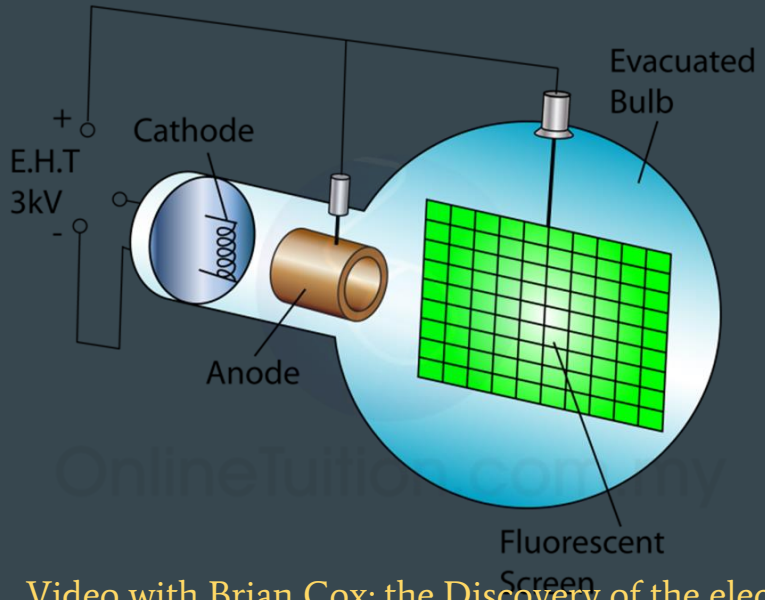
Best practice example : Seeing and measuring particles

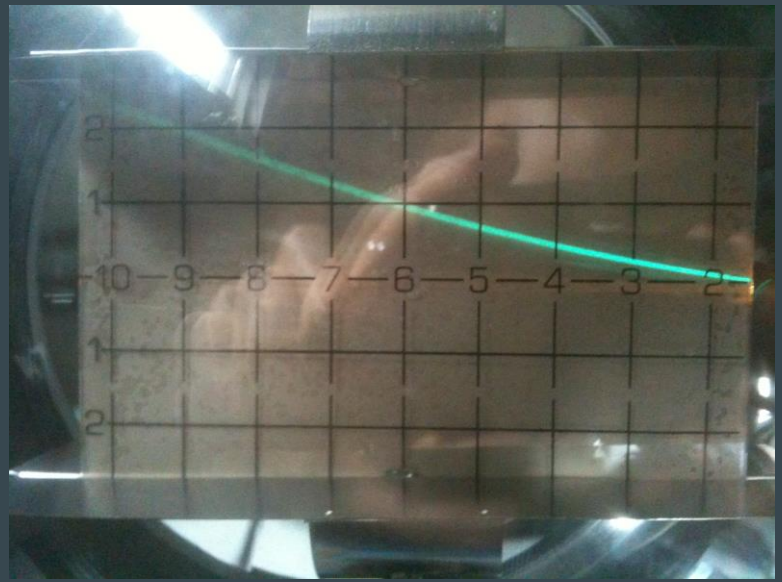
Need interaction with medium :
particles deposit energy in medium
to affect it along their track
⇒ Make their track visible

Activity 1: Build cloud chamber
or show video

Best practice example : Seeing and measuring particles

Activity 2: Use cathode ray tube with fluorescent screen; A part of the electron energy excite the fluorescent coating along the track but electrons cannot be seen outside the screen.

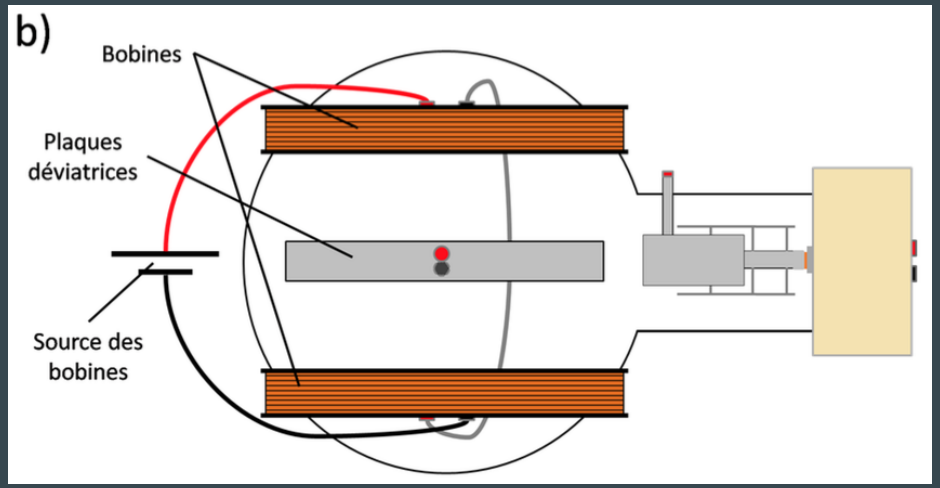


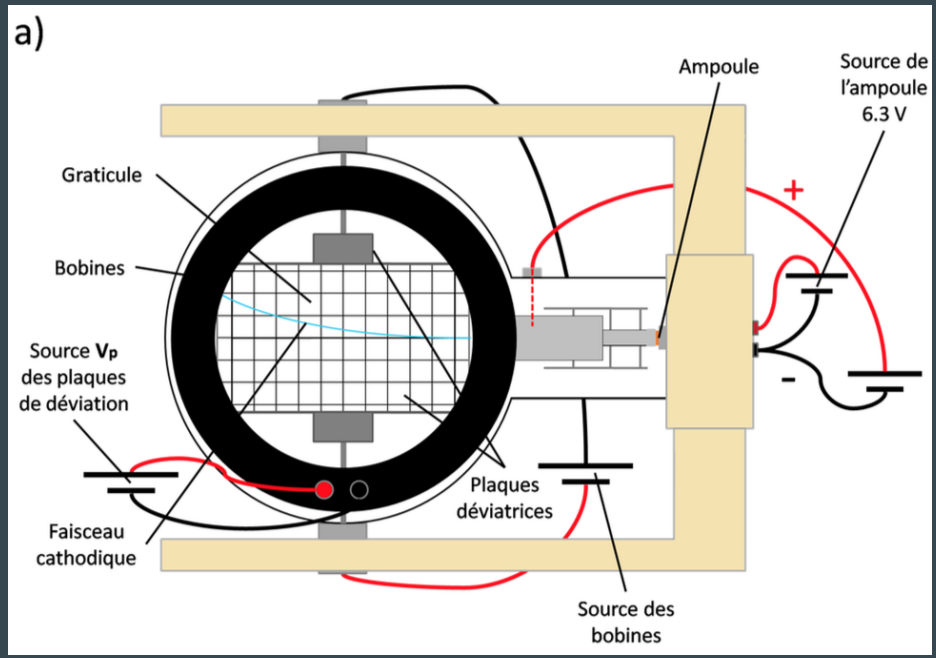


Video with Brian Cox: the Discovery of the electron

Best practice example : Seeing and measuring particles

Activity 2: How to measure momentum with uniform magnetic field and CRT
When discovering the first elementary particle, JJ Thomson used the same technique as in modern particle detectors!





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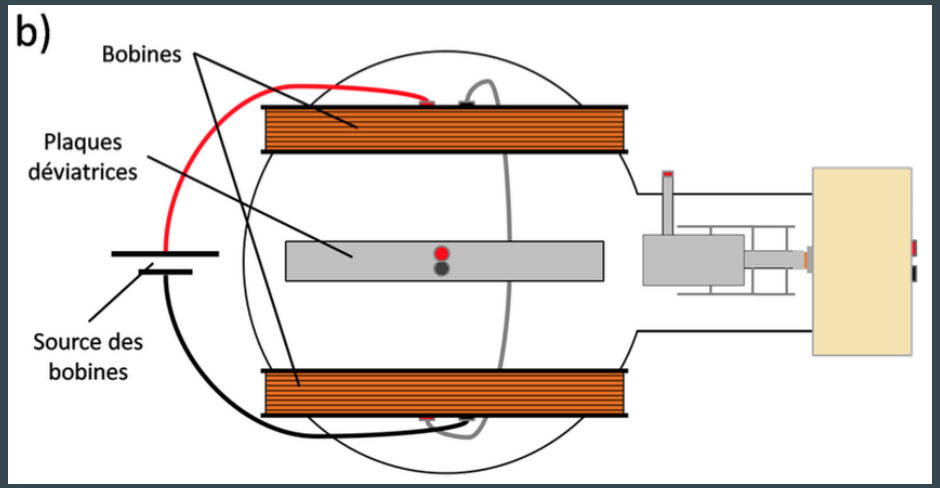

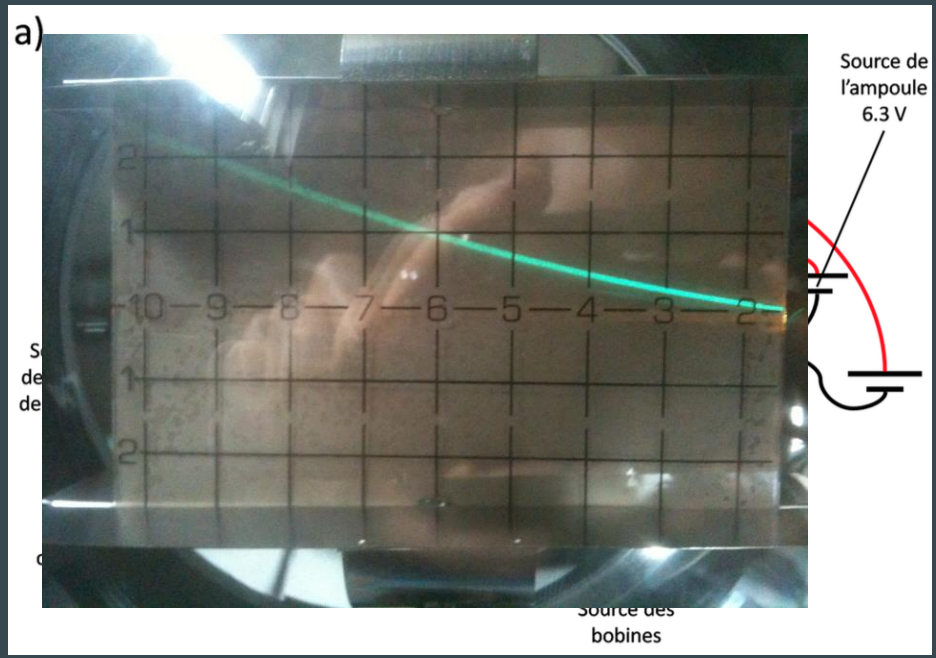

Best practice example : Seeing and measuring particles

Activity 4: Use momentum values of tracks in ATLAS online simulator

https://hypatia-app.iasa.gr/Hypatia_Vaadin-1.0/?lang=en&layout=medium

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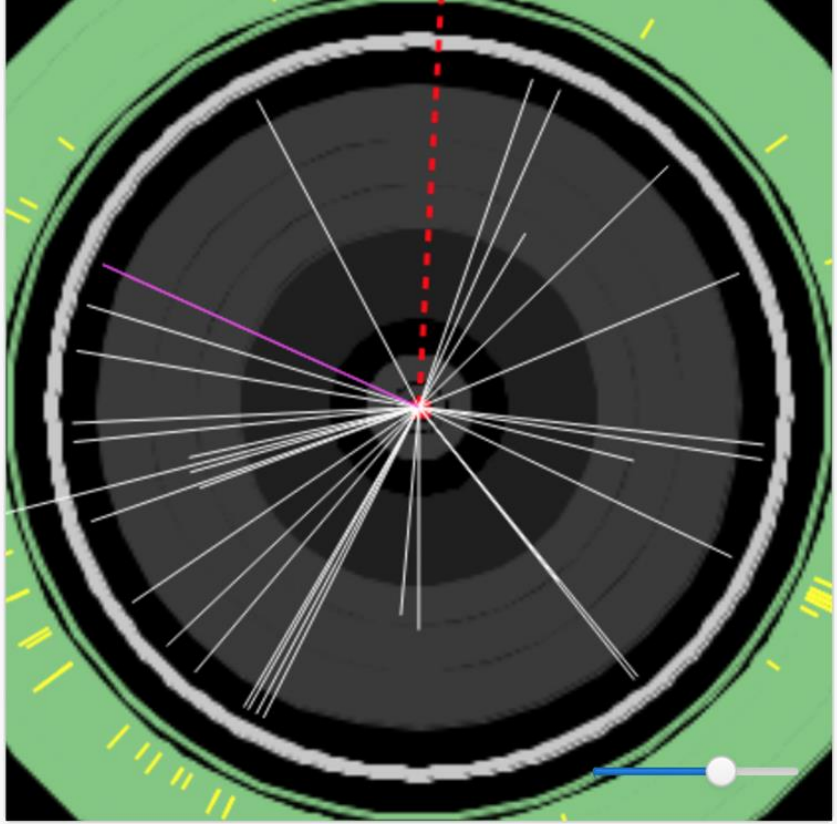
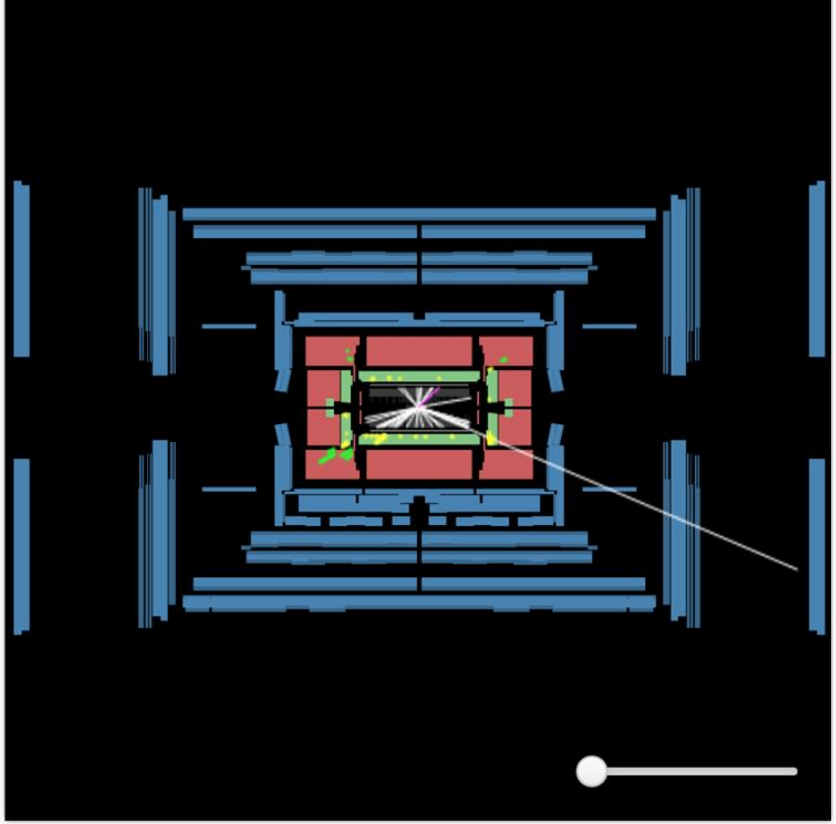




Previous Event | Next Event | Insert Electron | Insert Muon | Delete Track

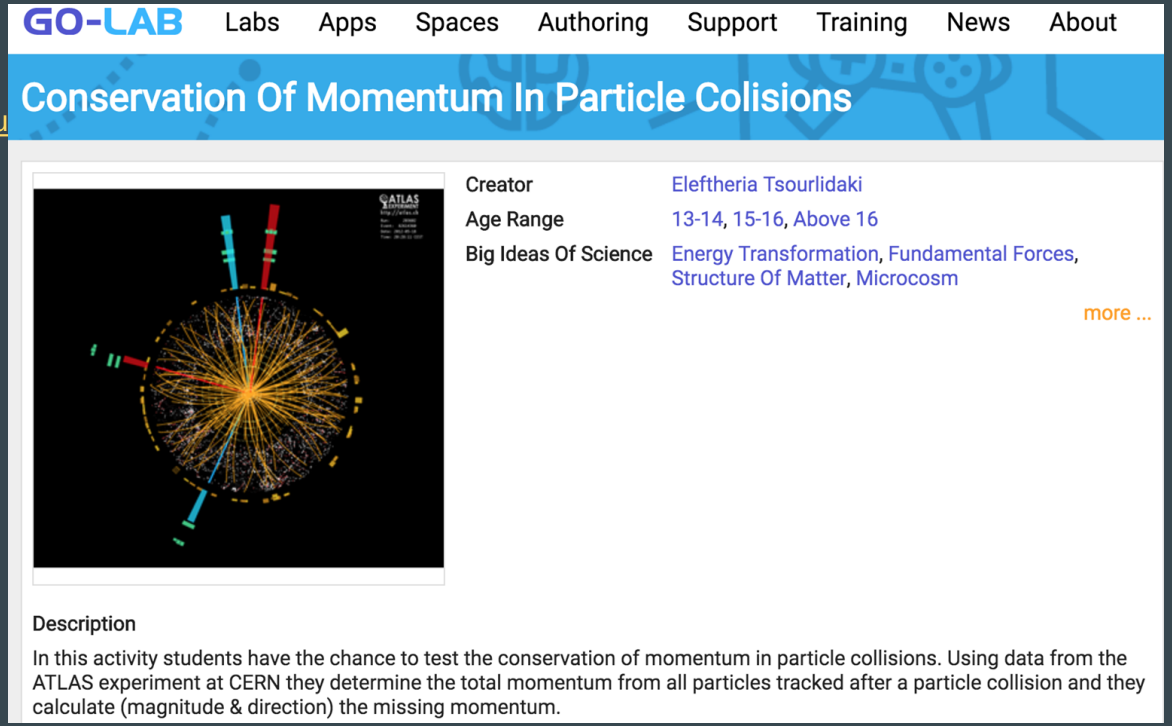
ETMiss: 43.33 GeV ϕ: 1.52 rad p_T 1 GeV B_Field JiveXML_5... Start ≡

Track	+/-	p [GeV]	p_T [GeV]	ϕ [rad]	θ [rad]
Tracks_0	+	1.205	0.819	2.718	0.747

Best practice example : Seeing and measuring particles

Step 5: Use momentum values of tracks in ATLAS to test conservation of momentum

https://www.golabz.eu/ils/conservation-of-momentu



Any questions?