Group 3 - Particle Detectors

Team Teacherino

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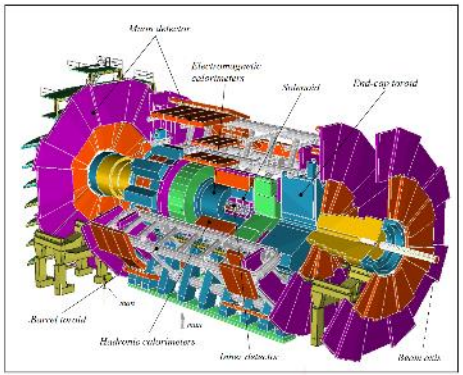
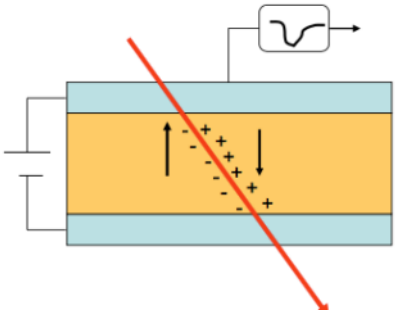
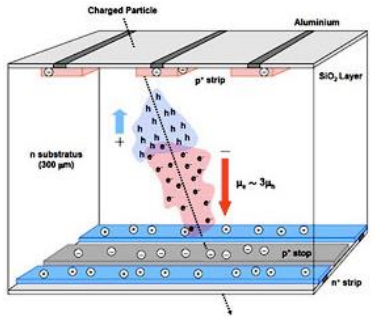


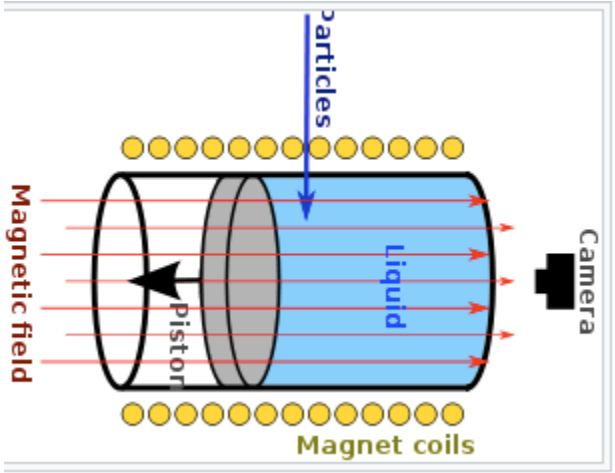
Key Ideas and Curriculum & Classroom connections.

Key Idea:
The interaction between a particle and a known medium under controlled conditions in terms of the energy transferred make possible the detection and identification of the particle. INDIRECT MEASSUREMENT.





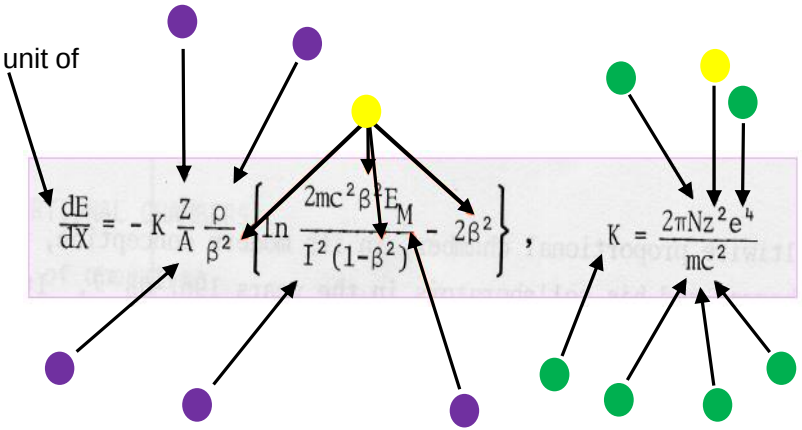
Curriculum and classroom connections:
Principle of conservation of Energy.
Ionization.
Thermal Physics and states of the matter.
Electricity and Magnetism.



Curriculum and classroom connections (Extensions)

Bethe-Bloch equation

Energy lost per unit of length.



$$-\frac{dE}{dX} = K\frac{Z}{A}\frac{\rho}{\beta^2}\left\{\ln\frac{2mc^2\beta^2 E_M}{I^2(1-\beta^2)} - 2\beta^2\right\}, \qquad K = \frac{2\pi N z^2 e^4}{mc^2}$$

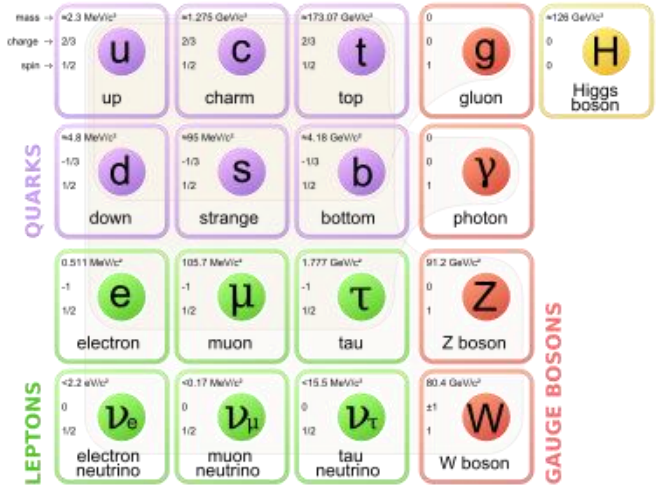
- **Medium**
- **Particle**
- **Constants**

$$E_K = \frac{1}{2}mv^2 \qquad p = mv$$

$$E_K = \frac{p^2}{2m}$$

“Guess μ”

- Based on the game “Guess Who?”
- Revision/Diagnostic tool
- **Misconceptions which are addressed**
  - Invisible object
  - Properties can be detected
  - Identifying by select characteristics
  - Inferral of information
- **Misconceptions which are not addressed**
  - Not all properties can be detected
  - Properties are revealed by interactions, not direct measurement
  - Particles are identified by their decay chain

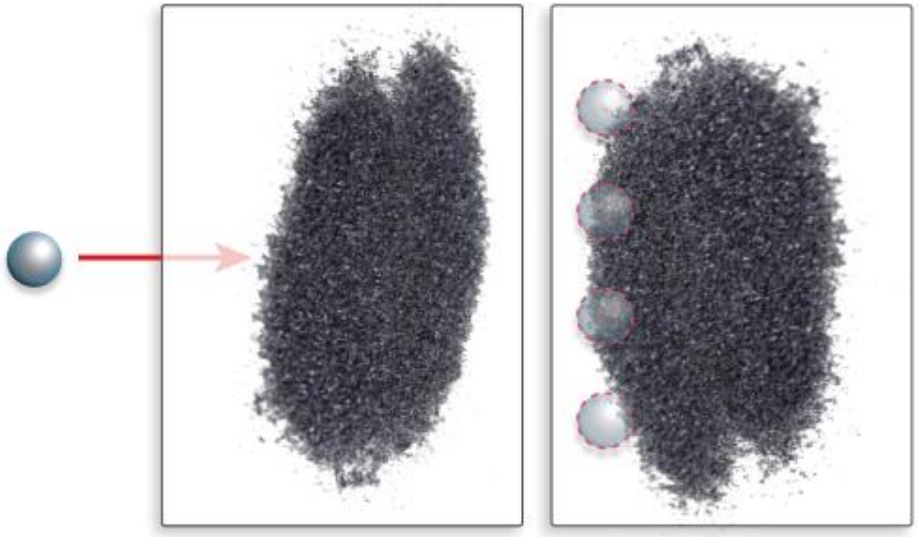


Measuring the unseen - marble activities

Rutherford scattering experiment. *University of Rochester PARTICLE Program*

- Conceptual experience with indirect measurement, exploiting interactions between particles and media
- Potential misconceptions
  - Only one interaction mode
  - Particles are independent of each other

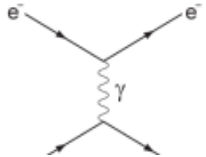
Measuring the unseen - marble activities



Tracking unseen particles experiment. *Contemporary Physics Education Project*

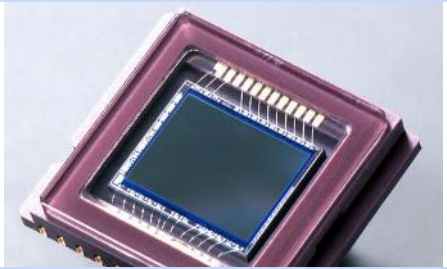
- Models decay
- Allows for detection of “neutral” particles
- Potential misconceptions
    - Reason for magnetic interaction in actual particles
    - Decay definition

Concept 3 - Cloud Chamber

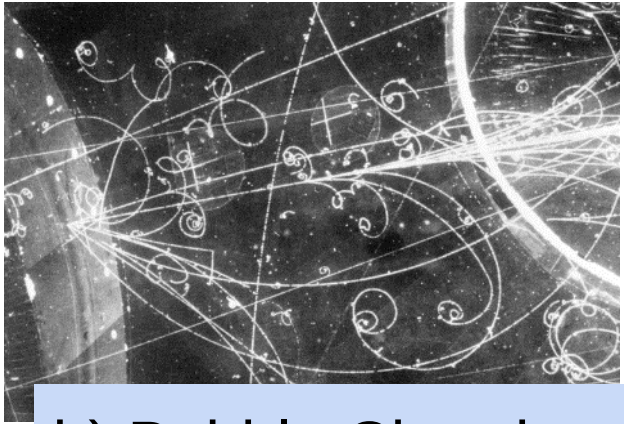
Pictures © Karlsruher Institut für Technologie (KIT)	Particle
	muon or anti-muon
	electron or positron
	α particle system
	electron 

Which is the odd one out?

a) Cloud chamber

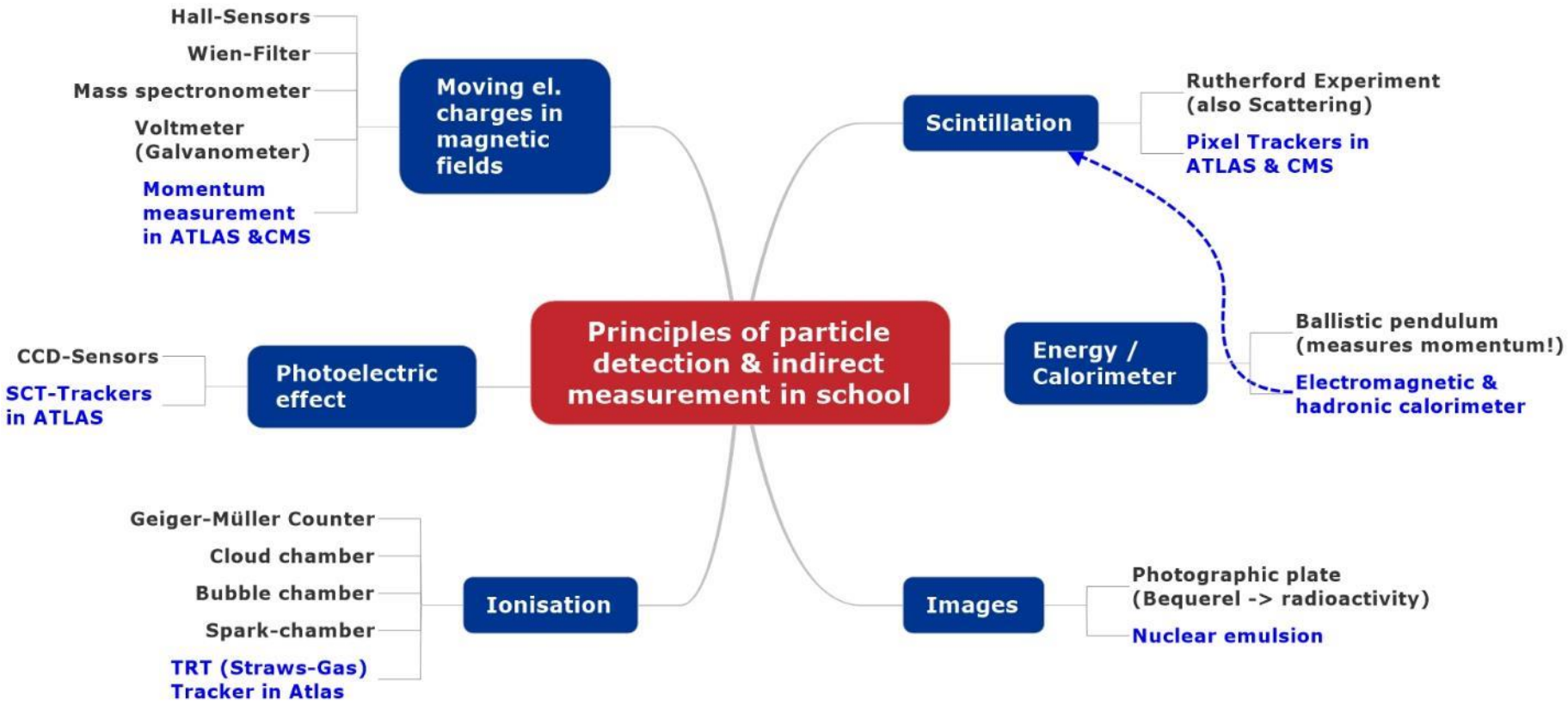


c) CCD



b) Bubble Chamber

d) Cheese Fondue


Principles of particle detection & indirect measurement in school
Moving el. charges in magnetic fields
Hall-Sensors
Wien-Filter
Mass spectronometer
Voltmeter (Galvanometer)
Momentum measurement in ATLAS &CMS
Scintillation
Rutherford Experiment (also Scattering)
Pixel Trackers in ATLAS & CMS
Energy / Calorimeter
Ballistic pendulum (measures momentum!)
Electromagnetic & hadronic calorimeter
Photoelectric effect
CCD-Sensors
SCT-Trackers in ATLAS
Ionisation
Geiger-Müller Counter
Cloud chamber
Bubble chamber
Spark-chamber
TRT (Straws-Gas) Tracker in Atlas
Images
Photographic plate (Bequerel -> radioactivity)
Nuclear emulsion

Hall-Sensors

Wien-Filter

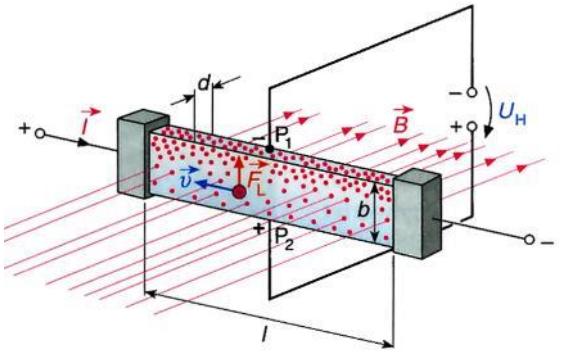
Mass spectronometer

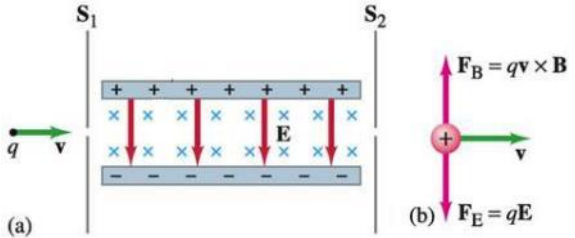
Voltmeter (Galvanometer)

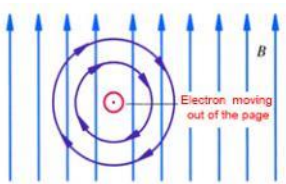
Momentum measurement in ATLAS &CMS

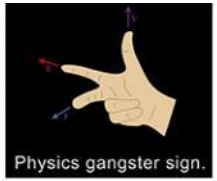
Moving el. charges in magnetic fields

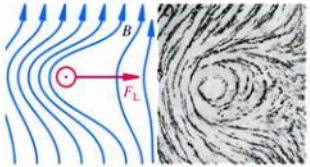
Principles of particle detection & indirect measurement in school

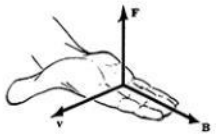


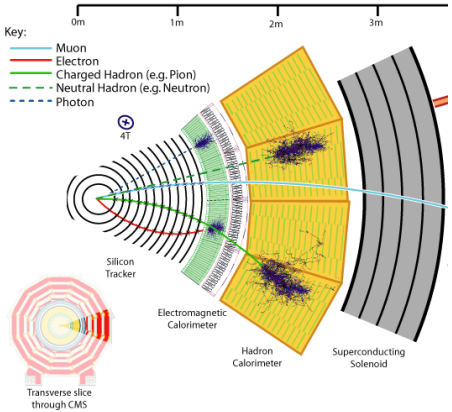


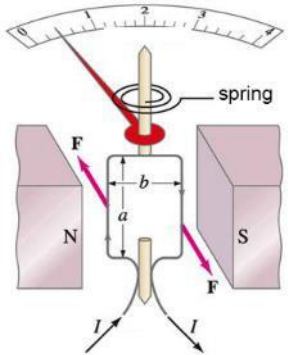


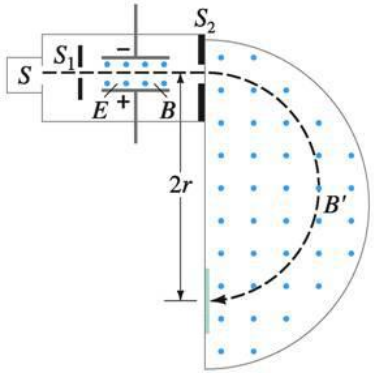












Summarization of the Key principles students should understand:

1. Particles have several **observable properties**

2. We observe these properties by making **indirect measurements**,

3. We detect & identify particles by **designing systems** that utilize their **interactions with various media**

Any Questions?

Suggested (mandatory) questions:

Why did Erwin Schrödinger, Paul Dirac and Wolfgang Pauli work in very small garages?

What is an English physicist's favourite food?

How much will the “Guess μ” game cost?

Where does bad light end up?

Any Questions?

Suggested (mandatory) questions:

Why did Erwin Schrödinger, Paul Dirac and Wolfgang Pauli work in very small garages?

They’re both quantum mechanics

What is an English physicist's favourite food?

Fission chips

How much will the “Guess μ” game cost?

The first edition of the game will involve neutral particles only, so there’s no charge.

Where does bad light end up?

In prism