# Particle Detectors

**ITW2024 Study Group 2**

# Curriculum & Classroom Connections (Ilaria)

*Image 1: footprints in the snow*

None of our curricula include *particle detectors*.
**Strategy** → let's **sneak it in** the classroom finding connections with other topics!

An example: **the cloud chamber**

- Supersaturation
- Phase transitions
- The water cycle

Suitable for chemistry, science and physics classes!

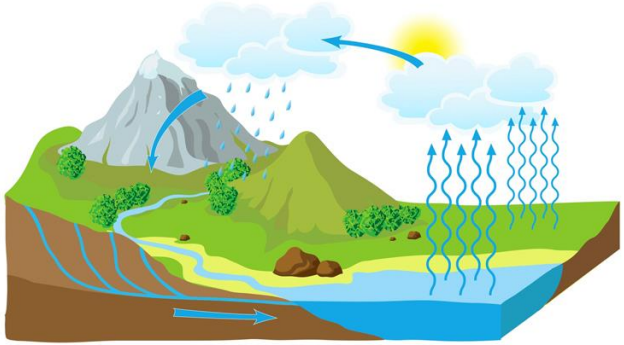


*Image 2: the water cycle*

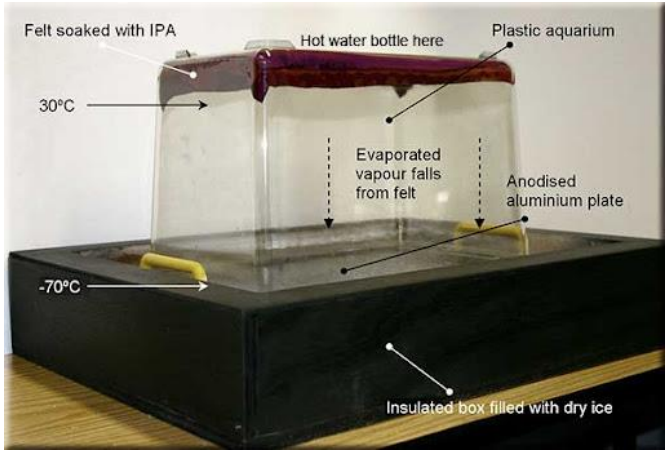
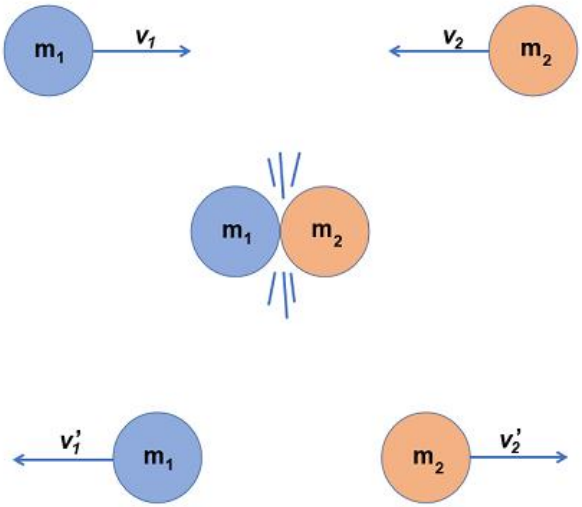



*Image 3: cloud chamber*

# Curriculum & Classroom Connections (Ilaria)

Another example: **newtonian mechanics**

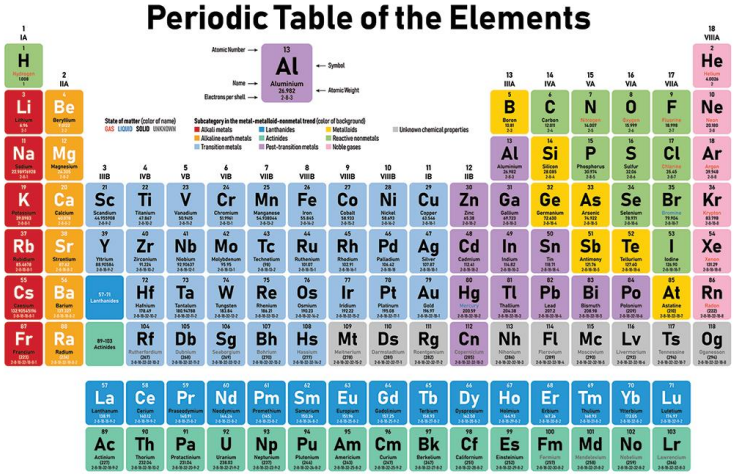
- Momentum and collisions: particle detectors measure the *momentum of particles* resulting from high-energy collisions, and use the conservation of momentum to analyze the outcomes

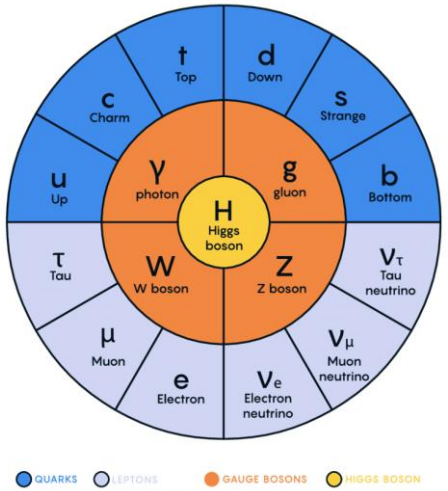



**Learning via gamification:** the Newton's cradle

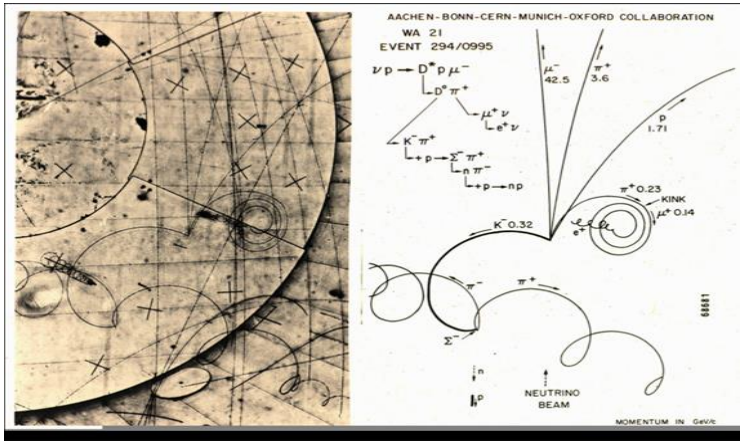
# Curriculum & Classroom Connections (Ilaria)

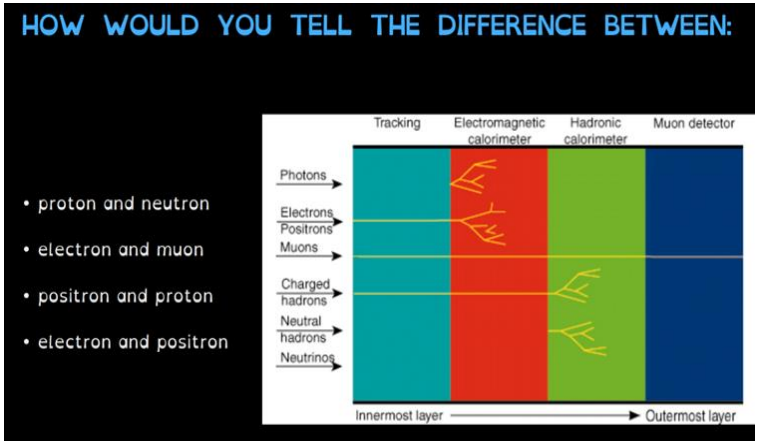
Collisions → Smashing things together and studying the outcomes → “Transitioning” from the periodic table to the Standard Model!



# Key Ideas (Sam)



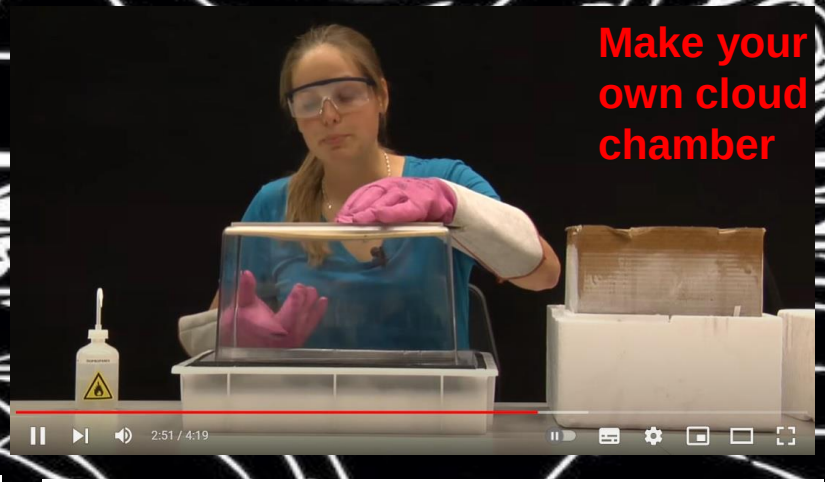

- We detect particles by their interactions with other particles and the matter of the detector.
- Particle detectors make use of different types of sensors at various locations to track particles because of each particle's unique interactions and properties.
- Electromagnetic calorimeters let us see paths made by photons, electrons, and positrons
- Hadronic calorimeters let us see the paths of charged and neutral hadrons
- Magnetic fields allow us to see where muons travel in the muon detector
- CMS and other large detectors essentially take pictures of the signal path the particle makes as it moves through the detector grid.
- Piecing together the particle's path through each detector region can tell us what the particle is.

# Potential Students' Conceptions & Challenges (Zohre)

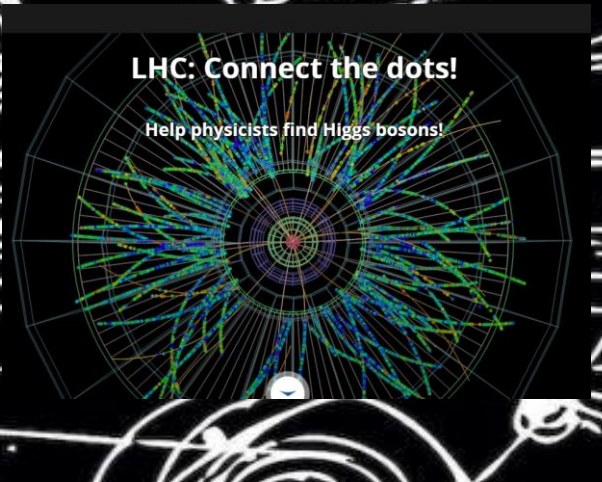
- Complexity: understanding the principles and technologies behind particle detectors can be difficult for students → break down the knowledge to basic physics concepts
- Accessibility: limited access to detectors or simulation tools might hinder hands-on learning → provide low-cost workshops and hands-on experiments
- Curricular fit: this topic has not been discussed much in the curriculum → find possible connections with topics included in the curriculum
- Real-world relevance: students might struggle to see the connection between particle detectors and their lives or other disciplines → collaborate with your colleagues

# Useful Material & Resources (Martin)

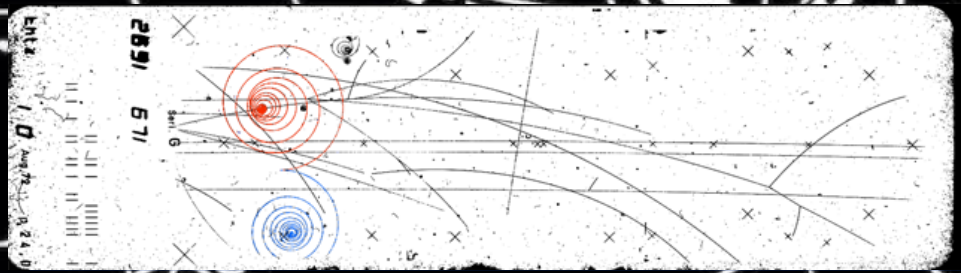

https://scoollab.web.cern.ch/diy-particle-detector




https://home.cern/news/news/experiments/how-make-your-own-cloud-chamber

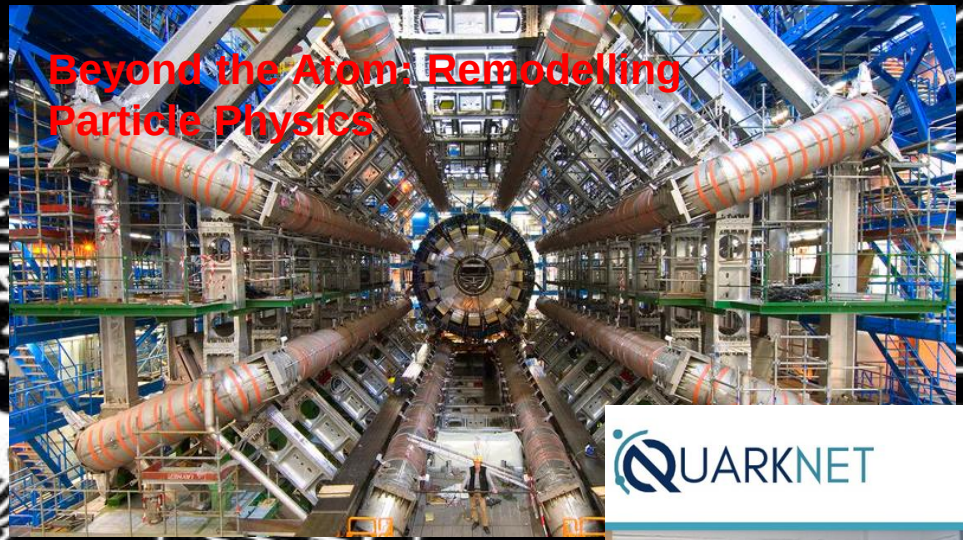



https://connectdots.web.cern.ch/



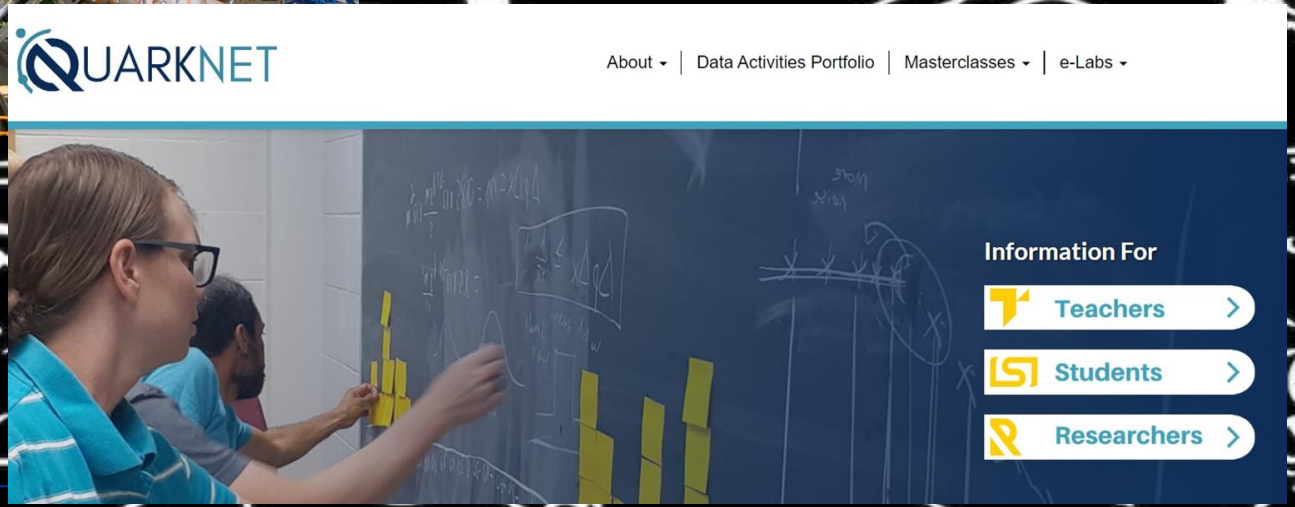
https://scoollab.web.cern.ch/bubble-chamber-pictures-classroom

# Useful Material & Resources (Martin)



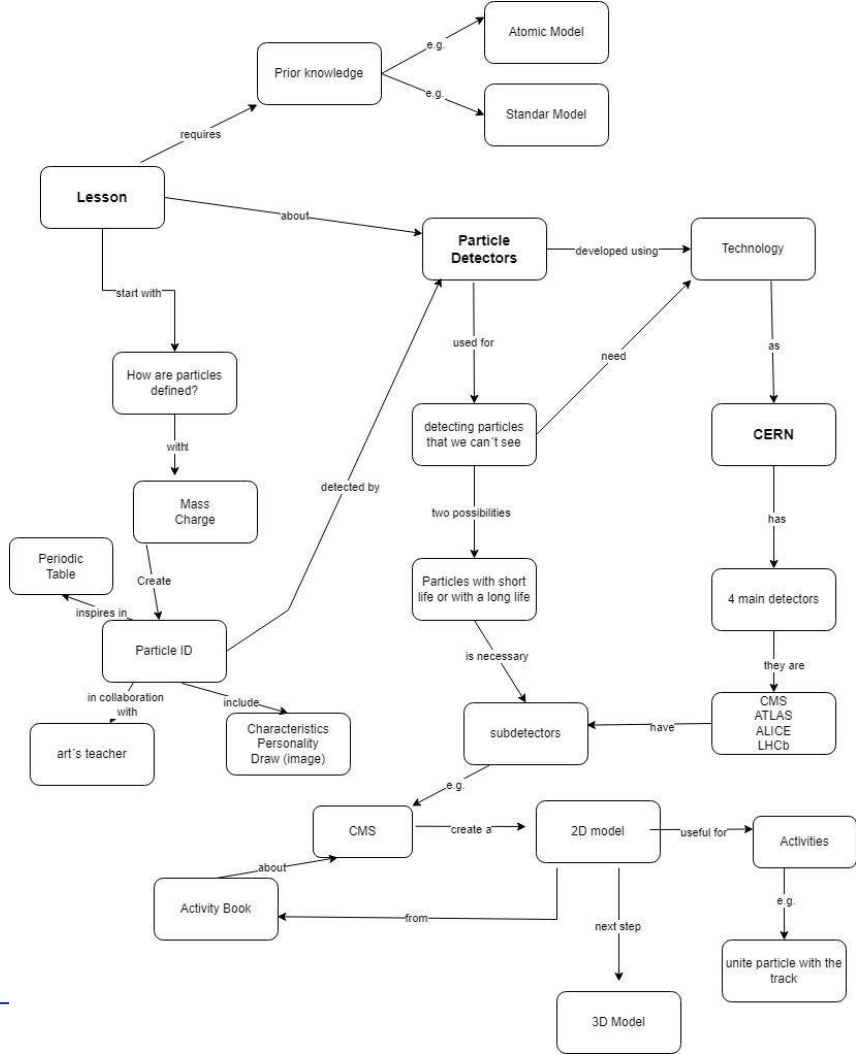

https://resources.perimeterinstitute.ca/products/beyond-the-atom-remodelling-particle-physics

https://quarknet.org/



# Best Practice Example (Cinthia)

An idea to introduce the topic of Particle Detectors to our students



Now you are ready to build your CMS detector.
Paint these detector components. Then cut and glue them on page 9.

**Tracker:**
The CMS tracker records the paths taken by charged particles by finding their positions on very sensitive layers.

**The Electromagnetic Calorimeter (ECAL):**
It measures the energy of electrons and photons by stopping them completely. The photon is the particle of light.

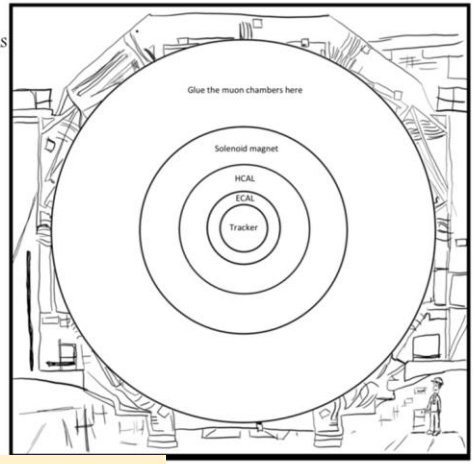
**The Hadron Calorimeter (HCAL):**
It measures the energy of "hadrons", particles made of quarks and gluons (for example protons, neutrons).

**The Solenoid Magnet:**
The CMS magnet produces a magnetic field that is 100,000 times stronger than the Earth's. Its job is to bend the paths of the particles emerging from high-energy collisions at the CERN LHC.





Build your CMS detector here



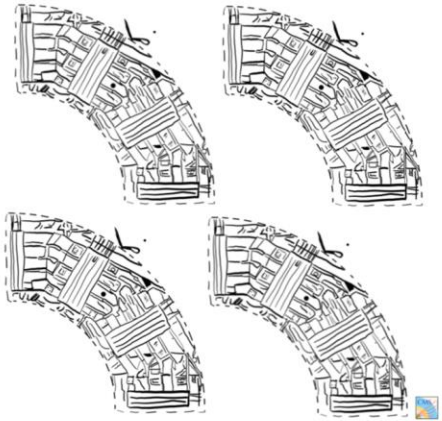





Paint these detector components. Then cut and glue them on next page.

**The Muon Chambers:**
detecting muons is one of the most important tasks of CMS. Muons are like heavy electrons and one of the clearest "signatures" of the Higgs Boson.

Muons are not stopped by any of CMS's calorimeters and can penetrate several meters of iron without interacting. Therefore, muons chambers are placed at the very edge of CMS where muons are the only particles likely to register a signal.

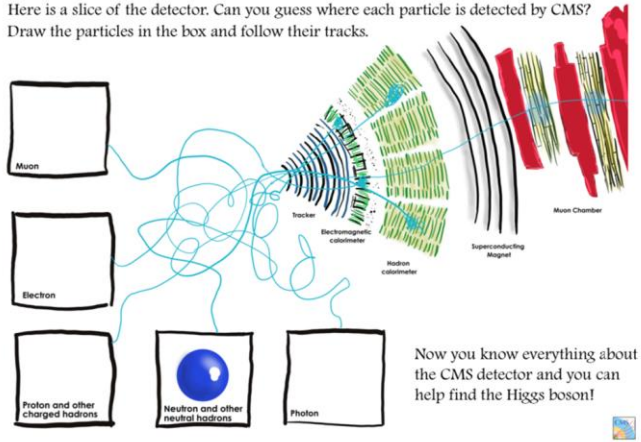




https://cds.cern.ch/record/2714290?ln=es



Here is a slice of the detector. Can you guess where each particle is detected by CMS?
Draw the particles in the box and follow their tracks.




Now you know everything about the CMS detector and you can help find the Higgs boson!

# ITW2024 Study Group 2

Martin (Slovakia), Ilaria (Italy), Cinthia (Uruguay), Zohre (Iran), Sam (USA)

## One way in which our thinking has changed…

- You don’t necessarily need to dedicate a specific modulus in your class to particle detectors; finding **connections** with other topics is the key!
- You don’t need to be the physics teacher to **include** particle physics in your classes
- You can make this topic **accessible** to younger students

## Highlights, snapshots, final words…

- **Frontal classes** are necessary, but they are not the only option!
- Implement your classes with Q&A sessions, **lab experiences** and workshops!
- **Gamification** is the key, try to involve every student individually