PARTICLE ACCELERATORS

HST2026 Study Group 6

Curriculum & Classroom Connections

Scientists apply the Lorentz force equation to beam control in CERN particle accelerators.

- Electric
- Magneti
  around

Bhutan National School Curriculum

3.1 Magnetic Fields

e on a current carrying conductor in a magnetic field,

raight current carrying conductor).

ational Curriculum

t and Magnetism

sm

ment.

nt carrying circular loop.

itely long straight wire. Straight solenoid (only

arge in uniform magnetic and electric fields.

al Curriculum:

rged objects by a magnetic field.

on a charged object moving within that field, with

nd on the cross-product of the charge's velocity and the

magnetic field. Relevant equation:

$$F_B = q(\vec{v} \times \vec{B})$$

- In a region containing both a magnetic field and an electric field, a moving charged object will experience independent forces from each field.

The Lorentz F

- The motion of a charged

Slide: Marlene Tu

USA AP Physics C

12.

In a region containing both a magnetic field and an electric field, a moving charged object will experience independent forces from each field

Key Ideas

*A **particle accelerator** uses electric fields to add energy and speed to charged particles, and magnetic fields to steer and focus them.*

***Radiofrequency cavities** provide repeated energy boosts, enabling particles to reach extremely high energies.*

***Linear accelerators (linacs)** accelerate particles along a straight path, whereas **circular accelerators (cyclotrons/synchrotrons)** reuse the same accelerating gap over and over.*

*Simon introduced particle accelerators by showing that their basic principles are already present in familiar devices such as **cathode-ray tubes (CRTs)** in old televisions and **magnetrons** in microwave ovens.*

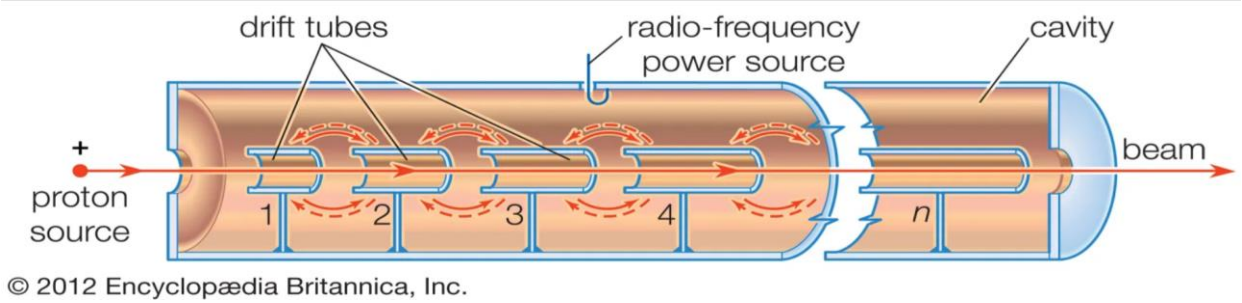
***Accelerators are everywhere!** (not just particle physics research)*

*They range from small devices, such as **microwave ovens**, to huge facilities like the **Large Hadron Collider (LHC).***

*Almost **47,000** particle accelerators in operation around the world:*

➢ ***only 6% for research** (0.5% particle physics)*

➢ ***94% for medicine and industry***



Potential Students' Conceptions & Challenges

Common misconceptions:

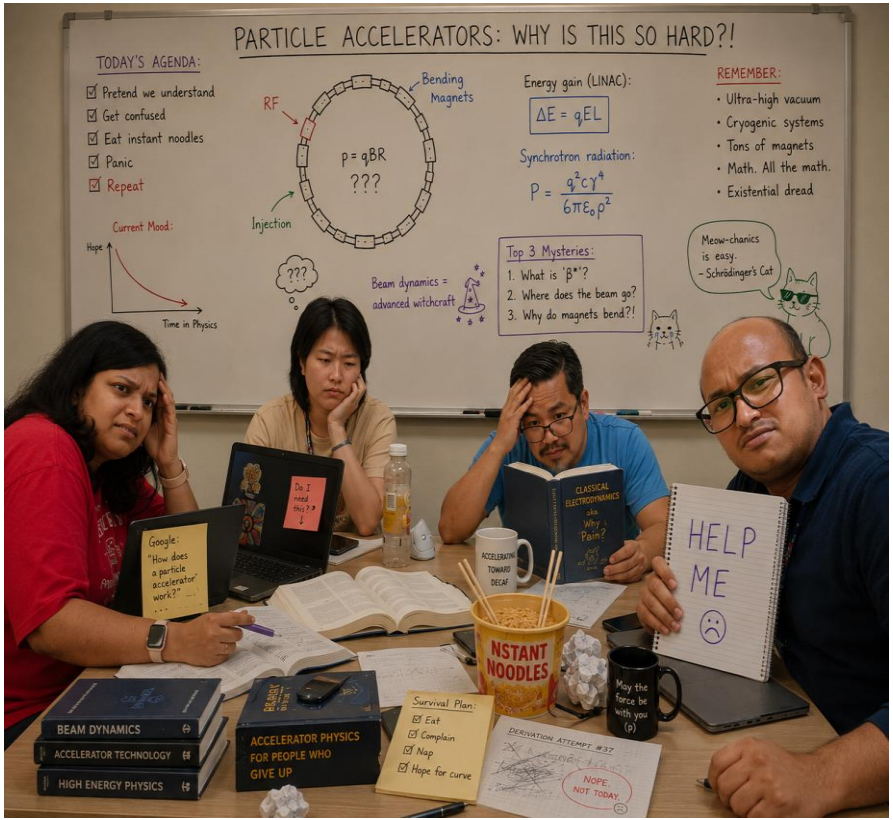
– acceleration means going faster → in fact, at near light speed, the speed of the particle barely changes.

– particle accelerates around the LHC → in fact, the proton is accelerated at one point in the LHC (RF cavity)

– the acceleration is due to both electric and magnetic field → in fact the magnetic field is used only to bend and squeeze the beam

– the beam is a continuous stream of protons → in fact, the "beam" is made up of stacks or bundles of protons

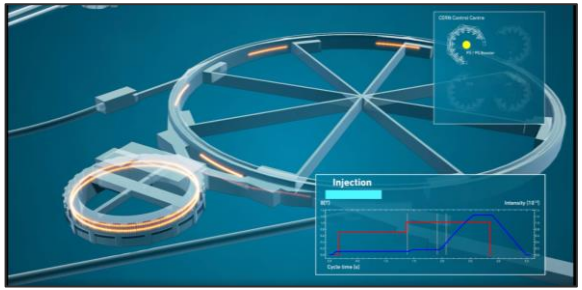
We agreed that the biggest challenge is making the "scale" of particle physics relatable to our students, i.e. **one proton bunch has energy equivalent to a house fly, but the entire beam is a jet!**



Useful Material & Resources

1. CERN control center animations of accelerations
2. Group research and discussion activity (Quarknet)
3. Accelerators are everywhere activity (European Journal for Science Teachers)
    - Map of accelerators around the world
4. Youtube Playlist of accelerator-driven research scientists personal career stories (European Spallation Source)
5. Use of Lego to make your own model of the LHC

1.



2.

3.

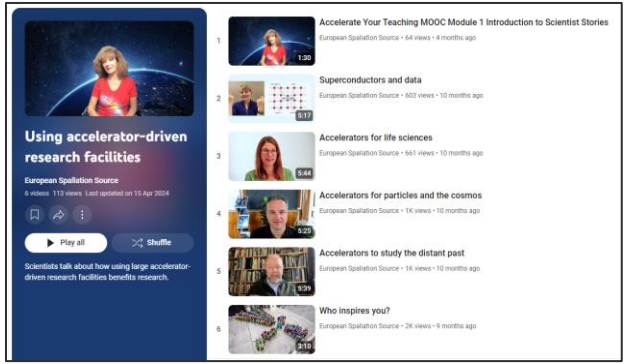
Divide into 3 groups. Each group should answer the Foundation Question plus one of the three Group questions. Each group should prepare to present to the other groups what they have learned.

Foundation Question for all 3 groups: What is a particle accelerator?

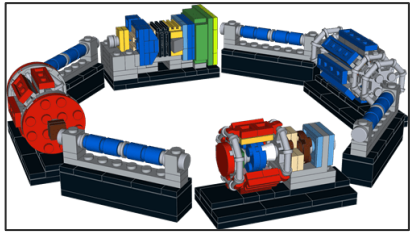
Group questions (one per group):

1. What are 3-5 major milestones in the development of particle accelerators? Describe them.
2. How are particles accelerated and how are they steered?
3. Describe 2-4 modern particle accelerator facilities. Include the LHC. Describe them. How do they compare?

4.

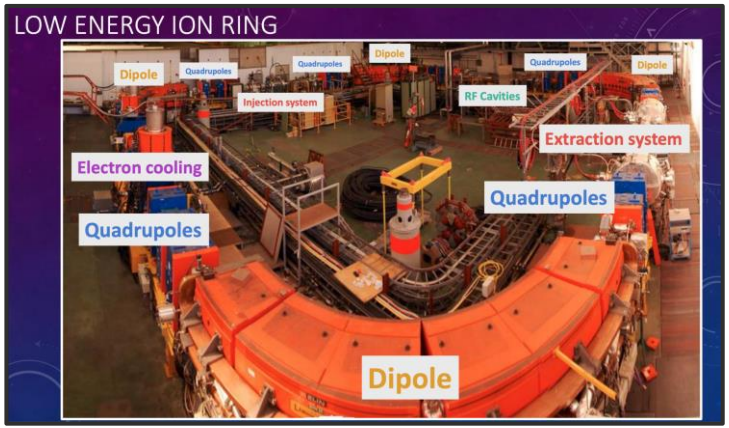


5.

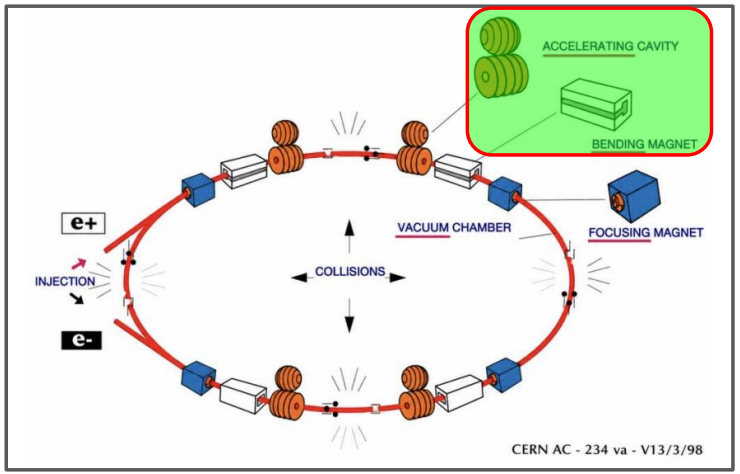


Best Practice Example

- In your curriculum where you **already discuss** E&M, use **particle accelerators** as **motivation** for why we learn about the **Lorentz Force**.



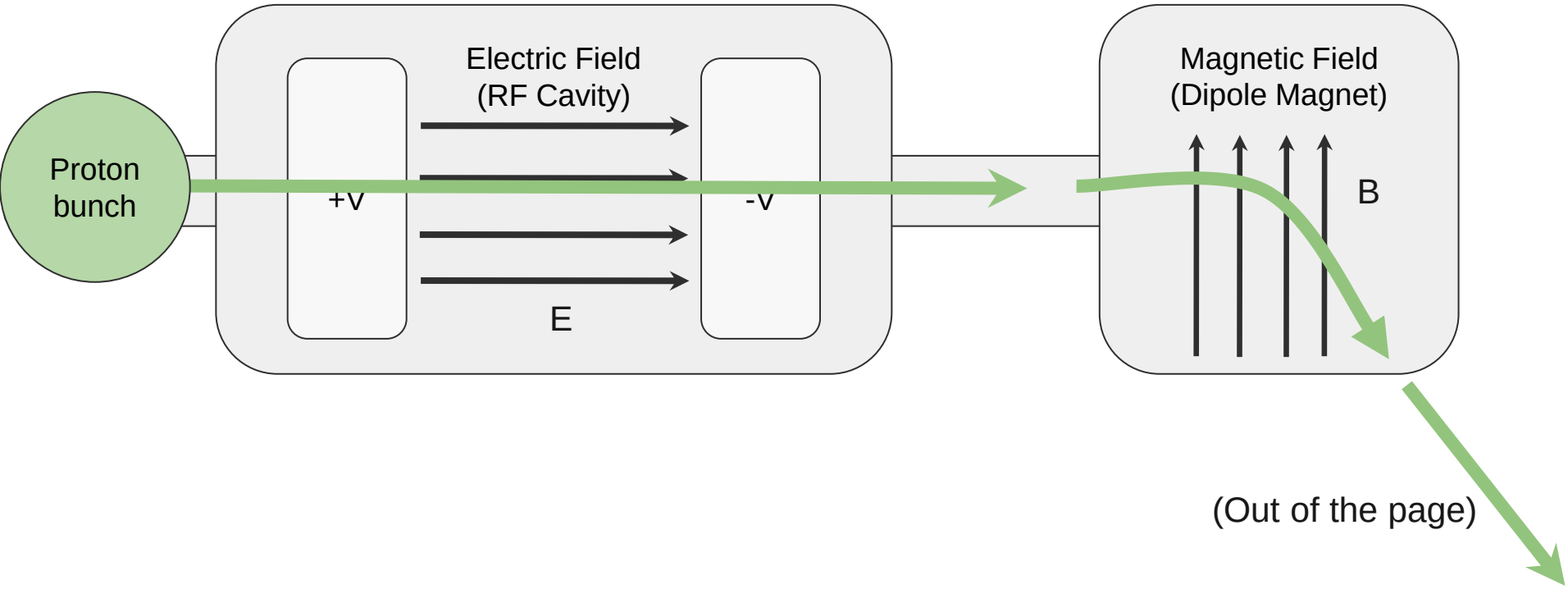
Slide: Simon Albright (CERN, Particle Accelerator lecture)



Slide: Marlene Turner (CERN, Plasma Wakefield lecture)

Slide: Simon Albright (CERN, Particle Accelerator lecture)

Best Practice Example

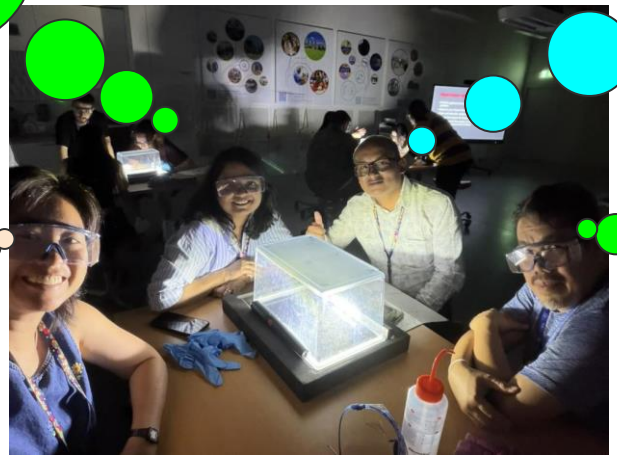


HST2026 Study Group 6

Chandra Bahadur Pradhan (Bhutan), Lauren Kwee (USA), Sunita Singh (India), Ian Ceasar Vicente (Philippines/UAE)

One of the most valuable takeaways was the realization that many of the world's most significant scientific discoveries are rooted in the fundamental science concepts taught in schools.

From the Himalayas to the Heart of Particle Physics — “thank you CERN for accelerating our curiosity and transforming us into ambassadors of CERN”. The journey continues beyond the tunnel!



To understand science, students must learn how “All models are wrong, but some are useful!”

I am bringing with me not just fond memories of friendships that were made but new ideas on how to inspire my students in class.