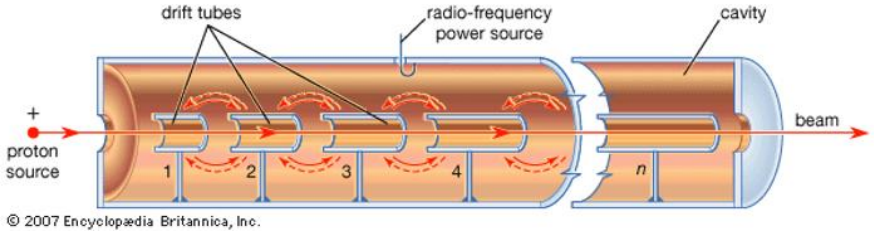
Potential Students' Conceptions & Challenges

Illustrate elements of the topic that might obstruct a successful introduction in the classroom



Potential questions

1. **How many particles are in there?**
2. **How do we know that particles are there if you can't see them?**
3. **Why does the LHC have to be circular? Why not just have a linear one?**
4. **What is the difference between linear and circular accelerators? Why do we need both?**
5. **How are particles trapped inside the accelerators? Why don't they just come out?**
6. **What is a drift tube and why do they get bigger?**
7. **How do you make the magnetic field stronger?**
8. **Why are the electric fields changing direction?**
9. **What is a particle?**

Particle Accelerators

HST2024 Study Group 3 - Haromdheensum

Meeting with Gunther Rens, Department of Education

Monday, September 9, 2024

Agenda

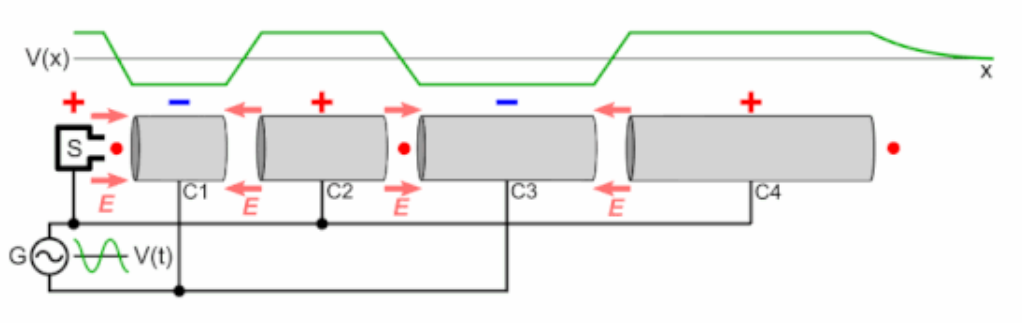
1. Curriculum Connections
    - Acceleration
    - Electric fields
    - Magnetic fields
    - Uniform circular motion
    - Electromagnetic interaction
    - Conservation of Energy and momentum

1. Particle Accelerators and Teaching Practices
    - Providing examples in kinematics including charged particles
    - Linking Newton’s second law to accelerated particles
    - Work done on a charged particle in an electric field transformed into kinetic energy
    - Force experienced by a charged particle in a magnetic field and calculations of radius of motion

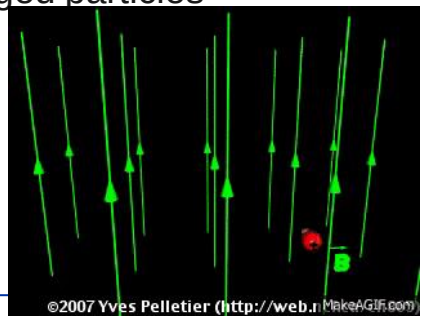
Lesson - Particle Accelerators

Thursday, September 12, 2024

- Why do we use them?
  - Used to make particles travel close to *c*
  - Collide with other particles where data is analyzed by detectors



- How do they work?
  - Electric fields are used to tangentially accelerate charged particles
  - Magnetic fields are used to both centripetally accelerate and focus charged particles
  - Two types - linear and circular



- What is their purpose?
  - Fundamental research
  - Attempting to answer big questions about the universe

What is  article?

Best Practice Examples

Making connections

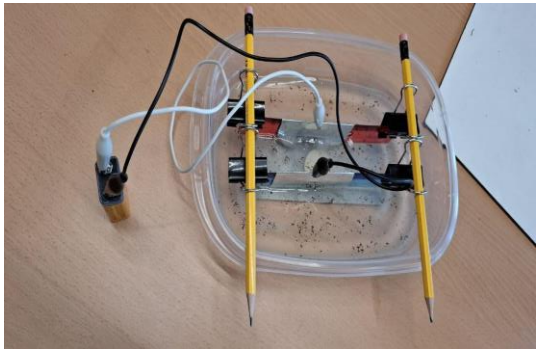
- Use particle accelerators as an example under kinematics, dynamics, work and energy, circular motion and/or electric fields in order to provide some foundational knowledge, develop idea over time

Consolidation

- Connecting magnetic fields and electric fields using observations, inferences and predictions in terms of movement of a charged particle
- Include particle accelerator data in problem solving = real life

Design Challenge

- How to make a particle accelerate faster - Perimeter Institute



Useful Material & Resources

Charged particles in Electric Fields:

- Simulation: https://ophysics.com/em6.html
- Simulation: https://phet.colorado.edu/en/simulations/charges-and-fields
- Simulation: https://phet.colorado.edu/en/simulations/electric-hockey

Charged particles in Magnetic Fields:

- Simulation: https://ophysics.com/em8.html
- https://www.geogebra.org/m/xpRMzPgc

Uniform Circular Motion

- Simulation: https://ophysics.com/w0.html

Build your own! https://www.scienceinschool.org/article/2014/accelerator/

Free textbook which covers particle accelerators:
https://openstax.org/details/books/university-physics-volume-3

Citations

Resources

Science in School. (2022, December 16). *Build your own particle accelerator – Science in School*. https://www.scienceinschool.org/article/2014/accelerator/

OPhysics. (n.d.). https://ophysics.com/

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Frederick

Woithe, J., Wiener, G. J., & Van Der Veken, F. F. (2017). Let's have a coffee with the Standard Model of particle physics! *Physics Education*, *52*(3), 034001. https://doi.org/10.1088/1361-6552/aa5b25

HST2024 Study Group 3 - Haromdheensum

Joe (USA), Noor (Pakistan), Amanda (Canada), Sobit (Bhutan), Károly (Hungary)

One way in which our thinking has changed…

➔ Linguistic accuracy - use of models have limitations and we need to carefully choose our words to not feed students' misconceptions or create them LOL= laugh out loud

Free flow, highlights, snapshots…

★ Collaboration
★ Organization
★ Passion
★ Innovation
★ Inventors
★ Creativity