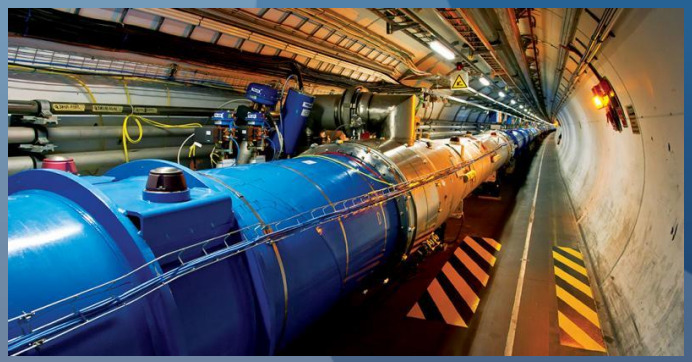
International Teacher Programme 2017

6/8/2017-19/8/2017

Study group 2 - Particle accelerators

Speakers:
Bronislav Zachrdla (Czech Republic)
Diego Albarracin (Spain)
Khalid Siddique (Pakistan)
Maria Rosa Di Marco (Italy)
Ram Saadon (Israel)



Curriculum

Mechanics :

Motion and circular motion.

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2$$

$$v = v_0 + at$$

$$a_R = \frac{v^2}{R} \qquad \omega = \frac{\Delta\theta}{\Delta t}$$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

Kinetic energy.

$$E_k = \frac{1}{2} m v^2$$

Momentum.

$$\vec{p} = m\vec{v}$$

Electromagnetism:

Atom structure and ionization.

Electric field and electric force .

$$\vec{E} = \frac{\vec{F}}{q}$$

Magnetic field and force.

$$\vec{F} = q\vec{v} \times \vec{B}$$

Modern Physics :

equivalent between mass and energy.

$$\Delta E = \Delta m c^2$$

Key Ideas

Some basic concepts about electromagnetism:

1- Electric field (acceleration purposes).

2- Magnetic field (bending trajectories). Motion of charged Particles: cyclotron frequency, radius,...

3- Electrical current.

4- Electromagnetical radiation.

Some basic concepts about kinematics and dynamics:

1- Acceleration.
2- Circular motion.

Some basic concepts about relativity:

1- Acceleration?
2- Energy.

Some other physics concepts:

1- Atom structure.

2- Ionization.

3- Sequential acceleration array at CERN: LINAC, PS, SPS, LHC

Potential student conceptions & challenges

Following topics will <u>obstruct</u> a successful introduction

1. How mass and energy can be converted into each other.

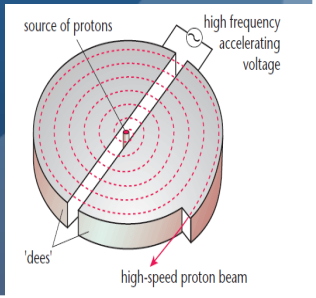
$$E = mc^2$$

2. Although atom is neutral then from where we get a charge particle to accelerate?

3. How does a charge particle get accelerated?

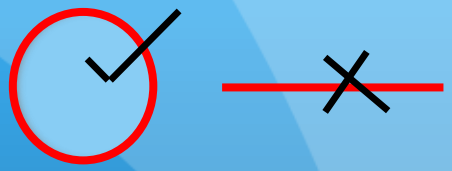
4. Can a neutral particle get accelerated?

5. Construction of cyclotron. It is difficult for the students to understand it only with the help of ray diagram.



Potential student conceptions & challenges

Cont….

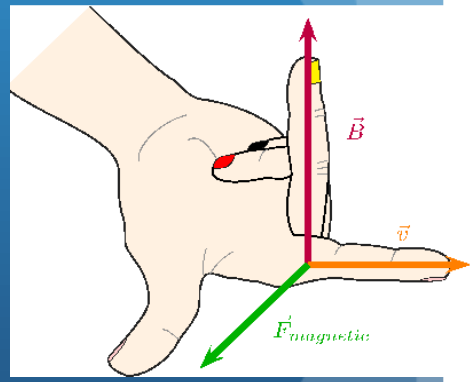


6. In a cyclotron, why does a particle move in circle but not in a straight line?

7. Which force bend charged particle in a field?

E.F
Or
M.F

8. Understanding of direction of magnetic force on charged particle in magnetic field.



9. What is the meaning of cyclotron frequency?

10. Results of special theory of relativity

Helpful material and resources

Presentations:

- rudi.home.cern.ch/rudi/.../Kapitel1-Introduction.pptx
- https://www.scientificofoligno.it/documenti/Area_Scientifica/as_2015_2016/PHYSICS%20CLIL%20PROJECT.pdf (Activity CLIL)
- http://www.aps.org/units/dpb/upload/accel_beams_2013.pdf
- http://uspas.fnal.gov/materials/09UNM/Unit_1_Lecture_1_Motivation.pdf

Helpful material and resources

Material on the websites:

- https://home.cern/about/accelerators
  http://www.accelerators-for-society.org/

Videos on Youtube:

- https://www.youtube.com/watch?v=328pw5Taeg0
  (Inside The World's Largest Particle Accelerator)
- *https://www.youtube.com/watch?v=esnqn_vutH4*
  (Principle and Working of Cyclotron)

Helpful material and resources

Exercises:

- https://particlephysicsassessments.wikispaces.com/Particle+Detectors+and+Accelerators
- PARTICLE ACCELERATORS AND DETECTORS-short Answers Latest.ppt

Masterclasses in particle physics:

- https://home.cern/students-educators/updates/2014/03/masterclasses-particle-physics

Laboratory activity:

- http://www.scienceinschool.org/2014/issue30/accelerator

Best practice example

In teaching accelerators, focus on these aspects :

1. Why do we need to accelerate the particles ?
   a tool to investigate the structure of the atomic nucleus and particles. If we observe smaller objects, we need them "shine" waves of wavelength less than or comparable to the size of the object.
2. You can only accelerate charged particles - electrons, protons, antiparticles and ions !
   Electric force only acts on charged particles. A magnetic force acting on charged particles by Lorenz's force that curves the trajectory of the particle
3. The basic principles of the accelerators
   Repeat : Electric field end force, magnetic field and Lorentz force, circular motion, relativity - change in weight, the conversion of mass into energy, units $1eV=1,602.10^{-19}$ J, $1TeV=1,602.10^{-7}$ J

4. How an accelerator works

two main groups : linear accelerators, circular accelerators

The main components of an accelerator :

a) Radiofrequency (RF) cavities and electric fields – these provide acceleration to a beam of particles.

b) Magnets – various types of magnets are used to serve different functions. Dipole magnets are usually used to bend the path of a beam of particles and quadrupole magnets are used to focus a beam.

c) Vacuum chamber – this is a metal pipe inside which a beam of particles travels.

5. Use of accelerators and new technology in practice

for example in medicine – radiotherapy, in art history: particle beams are used for non-destructive analysis of works of art and ancient relics and in the industry in order to produce smaller and smaller devices

6. For a better understanding of the topic

the students need to indicate examples of everyday life, enjoy the videos, animations, applets, and also solve (calculating) simple tasks to understand the relationships and patterns between variables and parameters. It is necessary to use activating methods and forms of teaching (dialogue, discussion, problem solving, group work, searching for information on the Internet and in books, papers)

THANK YOU FOR YOUR ATTENTION!!!

Thanks for your attention and patience