International High School Teacher Programme 2018

WORK GROUP:7- PARTICLE DETECTORS

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Particle Detectors in School Education

Introduction:

The introduction to particle physics and the basic concepts of particle detectors are introduced in the high school that generally comprises of age group of 16-18 years, in some countries introduction of particles is given to the primary students as well, age group ranging between 8-13 years. Another interesting educational level we can introduce particle detectors is to the university students.

This report is written focusing on students of high school and does not introduce topics beyond the scope of fundamental principle of particle detectors and its types. Engineering, technical details data collection and analysis have not been included.

Most high school physics curriculum across the world teach atomic model with an introduction to subatomic particles and properties, nuclear physics, radioactivity with alpha, Beta and Gama decay. Prior knowledge of these topics is a prerequisite for the students to study particle physics, through these topics can be introduced to the students through different activities. Introduction of Lorentz force and its application in determining the trajectories of charged particle with mathematical formula and calculations is also introduced. Use of this information can be used to teach trajectories of charge particles in a particle detector.

Curriculum & classroom connections:

- **Atomic model (Thompson, Rutherford, Bohr):**
  Particle physics in general and particle detector in general is a difficult concept in for the students of high school. Thus before introducing particle physics, students require certain basic in Physics. Student also needs to understand the real meaning of term MODEL, so that they should understand that a given set of information is only valid that Model only and may or may not be applicable to other Model(s). With this view students should be taught about the historical development of the model of an atom.
- **Meaning of elementary particle and identifications in terms of its properties(mass, charge, quantum and spin) :**
  Names and meaning of elementary particles is important t for making connections and understanding for further studies. This can be very effectively taught to the students in a fun way by several online games freely available on CERN and other websites. (Some of the links are being provided in the resource segment)

- **Describing particles Photoelectric effect (Einstein's equation):**
  General description of photo electric effect explains students about the particle nature of Photon. Depending upon age group, curriculum and level of students' basic idea of wave particle duality, mathematical equations and graphical explanations can also be introduced.

- **Radioactivity (alpha, beta, gamma) decays and provoked nuclear reactions(fission and fusion):**
  Particle physics deals with the study of matter and radiations, thus inclusion of radioactivity and alpha beta and Gama decay provides students with an idea as to how, when a particle disintegrate it give rise to other particles and energy, which can be stable or can further disintegrate into other particles or energy. This provides students with a launch pad to venture into the territory of particle Physics.

- **Standard model :**
  After achieving above level understanding and skills, students are now ready to take up further challenges in particle physics. Students can now be introduced to fundamental interactions and explanations in terms of exchange particles. Experimental evidence for the standard model and introduction to antiparticles. Writing equations of particle decay following various conservation laws and representation using Feynman diagrams.
  Now the students are prepared to understand the concepts of applied physics in Particle accelerators and detectors. Here students can be introduced with the key concepts of classical physics like Magnetic and electric field, Lorentz force, Circular motion, energy momentum conservation, semiconductor physics (to name a few) and these concepts now can be linked with the working and construction of particle accelerators and detectors. Still looking at the age group of the students engineering and technical details of the particle detector should just be introductory. Detectors like Geiger - Miller counter, Cloud chambers and how these detector works should be introduced make student understand the basics principles of detection.

Key Ideas:

Based on above curriculum connections following key ideas can be adopted-

- **Identification of observable properties**- This will help student identify the particle in a detector.
- **Interaction of particles with materials and fields**- How particles interact with materials and the field is an important key concept used in particle detection and should be introduced to the students.
- **Application of conservation principles**- Conservation of energy and momentum plays a very vital role in particle detection thus the students should know basic skills required for its application.
- **Data collection and measurement-** Though a very important aspect of particle detection, but should be kept at introductory level looking at the complexities involved in the process.
- **Filtration and Analysis**.- Skills required for the same, are very complex , thus should be left for higher studies or should be for selective set of students.

Helpful material and resources:

Apart from the regular printed material (books, paper and journals) and on line study materials following online games will be a good tool for student learning and understanding-

Virtual Atom Smasher

An interactive game that lets students become virtual scientists at CERN! Presented with real data and tools that scientists use students are guided step-by-step through the exciting world of particle physics!
http://test4theory.cern.ch/about/

Particle Clicker

A game that teaches players the history of high energy particle physics
https://particle-clicker.web.cern.ch/particle-clicker/

Quark poker

Playing cards to discover the elementary particles and their interactions. Suitable for all audiences.
http://ippog.org/resources/2012/quark-poker

Potential Student (Mis) conceptions and Challenges:

- Choosing a relevant model for scientific explanation
- Making connection between conservation laws as applied to particle physics.
- Confusion between mass-energy equivalence.
- Diagrammatic representation of particle interaction(Feynman Diagram)
- Lack of understanding of detection principles (like application of semiconductor physics.)
- Lack of experimental facilities and equipment(Lot of theoretical information)
- Teacher misconception and lack of experience.

Best practice examples

- Alpha particle track in magnetic field and calculation of the radius of a charge particle using Lorentz force using TI-Nspire application.
- One of the group member has presented an encouraging idea of introducing particle physics to the primary students, which could be implemented in the following manner-

Key idea

CERN and particle detectors at CMS, ATLAS, ALICE are a stimulus for students and could : Help students understand and follow the scientific method

Potential students' conceptions and challenges

They believe that:

- Science and scientific ideas are absolute.
- Science and its methods can answer all questions

Be a Physicist "

- 9-12 year old students
- Offers teachers and their pupils the opportunity to work like real scientists

The kit includes the necessary tools to carry out the project.

- A booklet setting out the theory and containing practical information
- Mystery boxes- Physicists at CERN search for invisible elementary particles
- Control boxes- Pupils conduct investigations to identity the contents of mystery boxes they cannot open.

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