GENERAL INFORMATION ABOUT PARTICLE ACCELERATORS USING THE "BLITZ-POLL" METHOD

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Abstract. The pack contains valuable information about charged particle accelerators, what they are, what types of accelerators exist today in the world and where they are used. You can get answers to all these kinds of questions using the interactive Blitz survey method, which also saves time for assessing knowledge or checking students' homework.

Keywords: interactive methods, Blitz survey", charged particle accelerators, cathode ray tubes, x-ray generation, collimated beam, injector.

Introduction. "Blitz-survey" (English "blitz" - quick, instant) method is a method that requires short, clear and concise answers to the given questions. In educational institutions, questions according to this method are mainly asked by the teacher. The answers to the given questions can be returned collectively, in groups, in pairs or individually. The form of feedback is determined according to the type of training, the complexity of the studied topic, and the inclusion of pupils (students).

The application of the method in training is as follows:

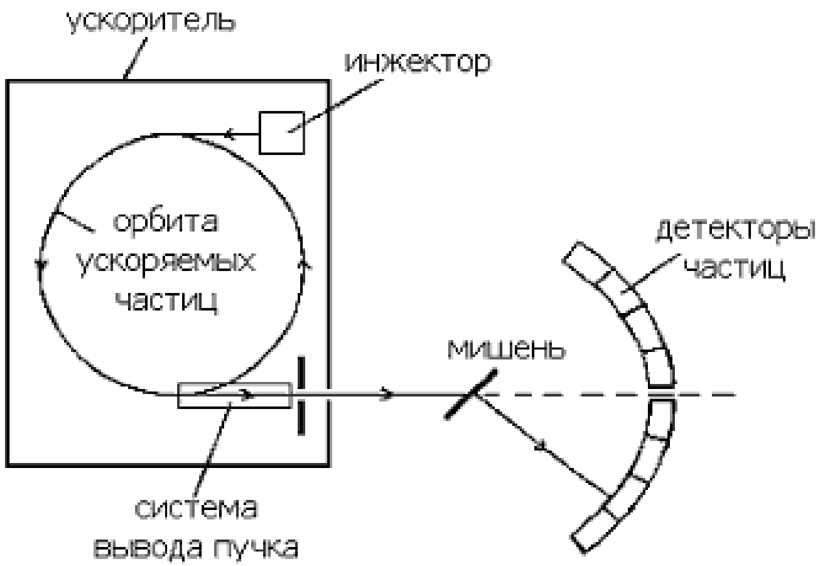
- The teacher prepares questions that require the disclosure of the essence of the studied topic and specific components and brings it to the attention of the students (but before asking the question, either he asks a question from the previous topic or after briefly explaining the new topic, etc.);
- Pupils (students) answer the given question clearly and concisely in a short period of time;

- When working in a group (pair), one student answers the given question (his relatives fill in the answer (however, thoughts should not be repeated).

In the application of the method, the basic concepts of the topic, the essence of the main ideas can be explained by students (students) verbally, in writing or in the form of images (tables, diagrams).

Main part. First, there is a review of a new topic: "Charged particle accelerators", these are installations for accelerating charged particles to energies at which they can be used for physical research, in industry and medicine. At relatively low energies, accelerated particles are used, for example, to obtain an image on a TV screen or an electron microscope, to generate X-rays (cathode ray tubes), to destroy cancer cells, and to kill bacteria. When accelerating charged particles to energies exceeding 1 megaelectronvolt (MeV), they are used to study the structure of micro-objects (for example, atomic nuclei) and the nature of fundamental forces. In this case, charged particle accelerators act as sources of test particles probing the object under study.

The role of the accelerator in the modern physical experiment is illustrated by the figure. A collimated beam of test particles from the accelerator is directed to a thin target under study, containing, for example, the nuclei of some chemical element, and the test particles scattered by the target or other products of their interaction with the target nuclei are recorded by a detector or a system of detectors. An analysis of the experimental results provides information about the nature of the interaction and the structure of the object under study.



Picture 1. The place of the accelerator in a physical experiment.

The need to use accelerators to study such micro-objects as atomic nuclei and elementary particles is due to the following. First, atomic nuclei and elementary particles occupy small regions of space (R< 10^{-12} cm), and penetration into these regions requires a high resolution (and hence energy) of the probing beam, which ensures the interaction of a separate test particle with a separate micro-object. Secondly, the smaller the micro-object, the stronger it is, and carrying out experiments with the restructuring or destruction of the internal structure of such an object also requires more and more energy.

Knowing the dimensions of the object under study, it is easy to estimate the energy of test particles required for its study. Particles have wave properties. The wavelength of a particle depends on its momentum p and is given by the de Broglie formula:

$$\lambda = \frac{h}{p} \approx \frac{2\pi\hbar}{E} \approx \frac{2\pi \cdot 200\ MeV \cdot Fm}{E\ (MeV)}$$

here *h* - is Planck's constant, and 1 $F_m = 10^{-13}$ cm. The above formula also gives the relationship between the wavelength of a relativistic particle and its kinetic energy E in megaelectronvolts.

In a scattering experiment, the structure of an object becomes “visible” (through, for example, diffraction of de Broglie waves) if the de Broglie wavelength is comparable to or less than the size (radius) of the object R, i.e. at $\lambda<R$. When electrons are used as probing particles, one can “look” into the nucleus if the electron energy exceeds 100 MeV. To observe the structure of a nucleon, the energy of an electron must already be calculated in gigaelectronvolts (1 GeV = 10^9 eV).

Accelerators differ in the type of accelerated particles, beam characteristics (energy, intensity, etc.), and design. Electron and proton accelerators are the most common, since beams of these particles are the easiest to prepare. In modern accelerators designed to study elementary particles, antiparticles (positrons, antiprotons) can be accelerated, and in order to increase the efficiency of using particle energy, their beams in a number of facilities called colliders collide (counter beams) after the completion of the accelerating cycle.

Any accelerator structurally consists of three parts - a system where accelerated particles are “manufactured” (an injector), an accelerator system where low-energy particles from an injector (usually formed in the form of bunches localized in space) increase the energy in high vacuum to the design one, and a transportation system (output) of the beam to the experimental setup.

Conventionally, from the point of view of the trajectory along which particles move during acceleration, accelerators can be divided into two classes - linear (and direct action) and cyclic. In linear accelerators, particles move in a straight line during acceleration, and in cyclic ones, they either follow the same closed trajectory, repeatedly passing through the same accelerating gaps (synchrotrons), or along a trajectory resembling an unwinding spiral (cyclotrons, microtrons, phasotrons).

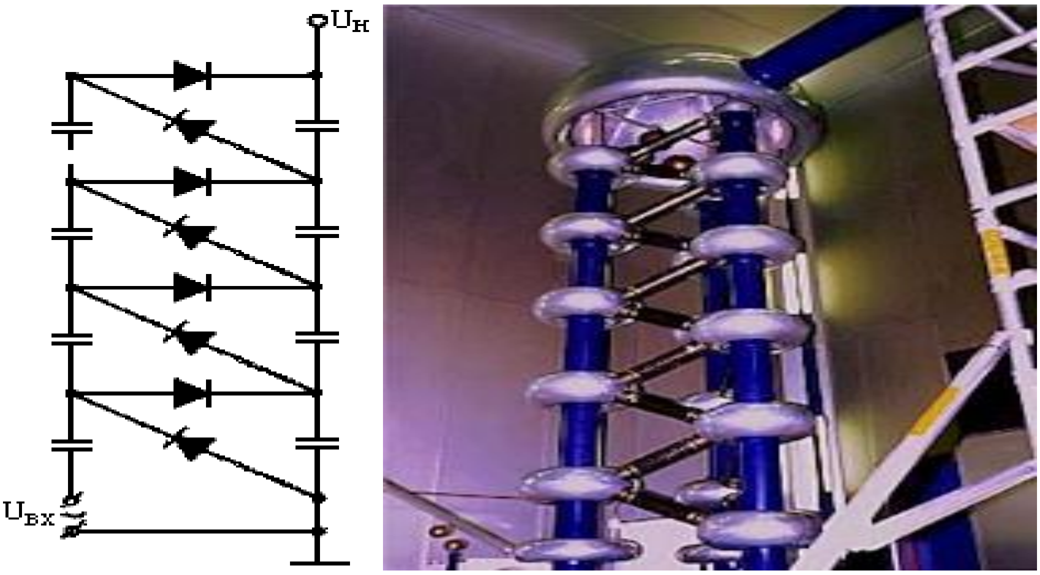
The main sources of test particles in subatomic experiments are accelerators. The need to use accelerators to study the structure of the microworld is obvious. First, atomic nuclei and elementary particles occupy very small regions of space, and penetration into these regions requires a high resolution of the probing beam, which ensures the interaction of an individual test particle with an individual micro-object. Secondly, the smaller the micro-object, the stronger it is, and carrying out experiments with the restructuring or destruction of the internal structure of such an object also requires more energy.

Cascade generator

The cascade generator is a direct action accelerator, i.e. the particles in it are accelerated directly by passing through a high potential difference. In cascade generators, a high DC voltage is obtained from a low AC voltage using voltage multipliers, also called cascade generators.

The first 700 keV cascade generator (accelerator) was created in 1931 in England by J. Cockcroft and E. Walton.

On picture 2a shows the voltage multiplier circuit used by Cockcroft and Walton*. When the input has a negative AC half-wave, the first diode is open and the lower left capacitor is charged to the peak value of the input voltage. When the polarity is reversed, the first diode closes, and the second opens, and the left capacitor is charged to double the voltage. With each change in the polarity of the input voltage, the charges of the capacitances are sequentially summed up. Thus, the output voltage is twice the product of the input voltage and the number of stages.



a b

Picture. 2. a - voltage multiplier circuit, b - photograph of a cascade generator

And now you can move on to blitz questions, the answers of which should be given immediately clearly and clearly.

1. What are charged particle accelerators?

2. What accelerators are called linear? What are cyclic?

3. What is a collimated beam?

4. What other types of accelerators are used in industry, medicine and agriculture?

6. On what physical parameters does the wavelength of a particle depend on the de Broglie formula?

7. What is the reason for the need to use accelerators to study such micro-objects as atomic nuclei and elementary particles?

8. List similar properties and differences between cyclotron, microtron and phasotron.

9. Tell us the principle of operation of a cascade generator?

10. What was the energy of the first cascade generator (accelerator), created in 1931 in England by J. Cockcroft and E. Walton? etc.

Results and discussions. The “Blitz survey” method outlined above is understandable to everyone, with a lack of knowledge, you can immediately read it easily and get to know it better. Approbation of the work was successful among bachelor students of the Department of Nuclear Physics of the Faculty of Physics of the National University of Uzbekistan. The Blitz survey method is unique in that, along with it, you can simultaneously use other methods to conduct an unconventional lesson.

Conclusion. Based on the foregoing, we can say that modern charged particle accelerators are used today everywhere: in industry, in medicine, in the electric power industry, in nuclear energy, in pharmaceuticals, etc. But the most important big plus is that the demand for training accelerators is growing higher and higher over time.

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