Poltava State Medical University,
Department of oncology and radiology
with radiation medicine
ssistan Nestulia K.I.

Lecture topic

Types of radiology departments. Features of the device of radiological and radiological departments.

2.History

- **The discovery of radioactivity was due to the development of physics and chemistry. The impetus for this discovery was the detection of X-rays. Scientists in many countries have studied one of the properties of X-rays to cause fluorescence. The French physicist Henri Becquerel in 1896, experimenting with the double uric acid salt of uranium-potassium, discovered that this salt emits a ray similar to X-rays. It is called the Becquerel ray.**

3 Medical radiology is the science of using ionizing radiation to recognize and treat human diseases.

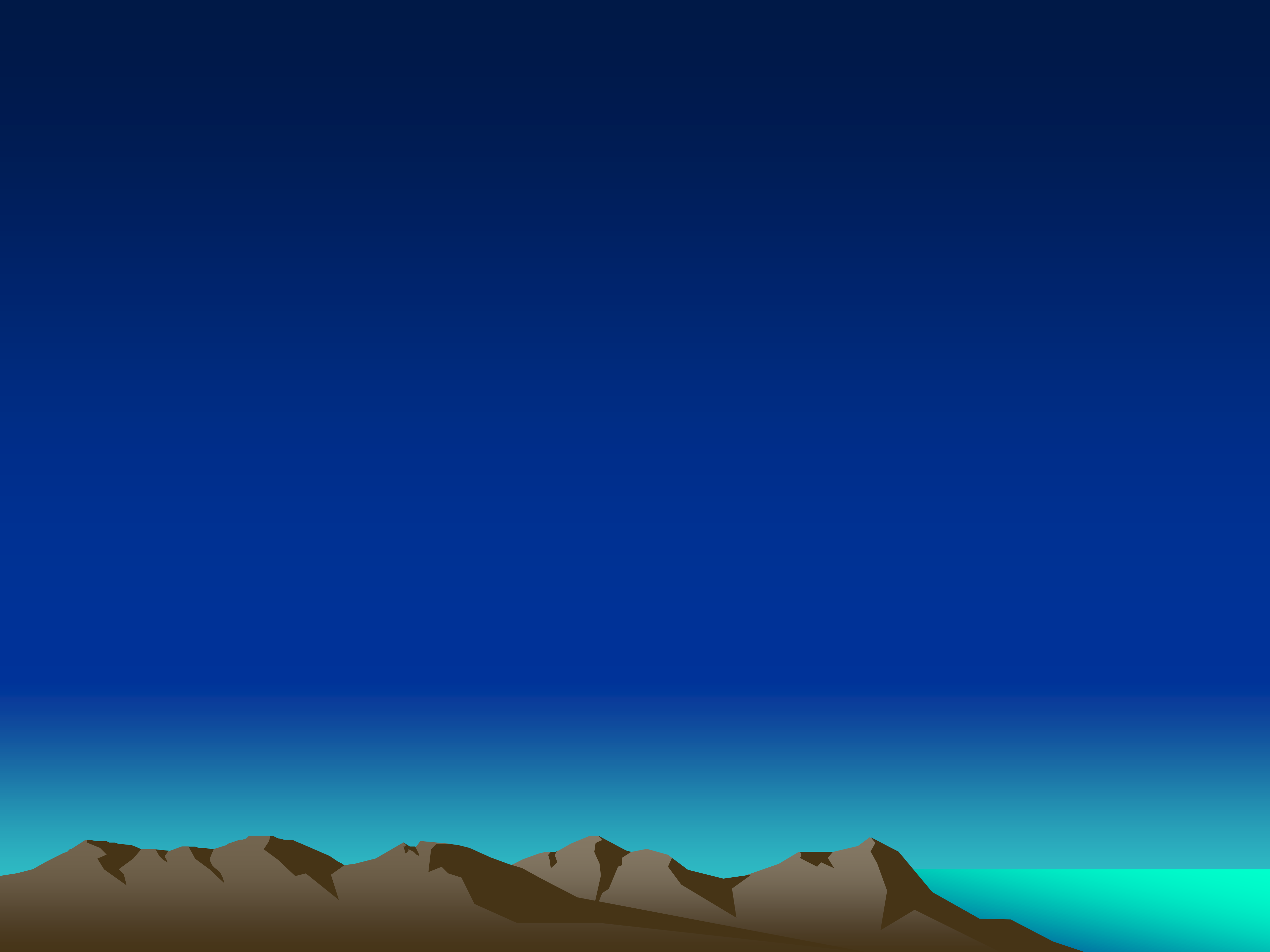
- Accordingly, these two main tasks divide medical radiology into diagnostic and therapeutic radiology. The components of medical radiology are: radioisotope diagnostics, radiation therapy, radiation hygiene, radiobiology.
- Medical radiology is closely related to other scientific disciplines and, above all, to physics, mathematics and technology.

. Types of radiology departments:

- Based on the tasks of medical radiology and the specifics of working with the source, there are six types of radiology departments:
- And - X-ray - diagnostic;
- II - remote radiation therapy;
- III - therapeutic use of sealed radioactive substances;
- IV - radiation therapy with open radioactive substances;
- V - diagnostic use of open radioactive substances;
- VI - mixed, or complex departments.

5. Radionuclides as potential sources of internal radiation are divided according to the degree of radiation hazard into four groups depending on the minimum significan activit :

- group A - radionuclides with a minimum significant activity of 103 Bq. Radionuclides with particularly high radiotoxicity, not used in radionuclide diagnostics 235 U 92;
- group B - radionuclides with minimally significant activity of 104 and 105 Bq, radionuclides with high radiotoxicity, 125J; 129J; 131J; 90Sr; 203Hg.
- group B - radionuclides with minimally significant activity of 106 and 107 Bq, radionuclides with average radiotoxicity, 24Na; 32P; 42K; 57Co; 59Fe; 75Se; 90Y; 132J; 198Au.
- group D - radionuclides with a minimum significant activity of 108 Bq and more, radionuclides with low radiotoxicity, 51Cr; 67Ga; 64Cu.
- Radiotoxicity is primarily determined by T1 / 2, as well as the routes of entry of radioactive substances into the body, their distribution in organs and systems, the time of radionuclides in the body.
- Radionuclides as potential sources of internal radiation are divided according to the degree of radiation hazard into five groups of works from the least significant activity:



7 The structure of the atom

- The atom is neutral, consisting of a positively charged nucleus and negatively charged electrons orbiting it. This is a planetary model of the Rutherford-Bohr atom

- The orbits of only seven K.L. M. N. O. P. Q. The number of electrons in the orbit is N = 2n2, where N is the maximum of electrons, n is the number of the orbit.
- Electrons placed in stationary orbits do not emit energy.
- When energy is absorbed, the electron goes into outer orbit (with more energy).
- When energy is emitted in the form of a photon, the electron passes into the inner orbit (with less energy).
- The size of the hydrogen atom d = 0.5 x 10-15 m, and the mass is 1.67 x 10-27 kg.
-
- The chemical properties of atoms are determined by the number of electrons in outer orbit. Their binding energy to the atom was low.

9. The structure of the atomic nucleus

- The nucleus consists of protons and neutrons, which is not strictly limited by the wave properties of the particles that make it up; its diameter is from 1 to 10 trusses. 1 farm = 10-15m. And the diameter of the hydrogen atom = 0.5 • 10-15 m
- In the free state, the neutron can decay into:
- 1n0 → 0e-1 + 1p + 1 + v (antineutrino).
- In the nucleus constantly at a speed of 10-23 seconds. transformation is taking place:
- neutron per proton 1n0 → 1p + 1 + π-
- and a proton on a neutron 1P + 1 → 1n0 + π +.
- π ± are pi mesons called nuclear field quanta. For this reason, protons and neutrons are considered two states of one nuclear part and combine them under the name of nucleons.

10.Theories of the structure of the atomic nucleus. There are two models of the structure of the atomic nucleus: droplet and shell.

- Drip model.
- The nucleus is like a droplet, in which the function of the intermolecular forces of the compound is performed by nuclear forces. According to the drip model, in order for the nucleus to be stable, the ratio between the number of protons and the atomic weight must be strictly defined and equal to:
- N = ______ A _____
- 1.98 + 0.015 A2 \ 3
- N is the number of protons. A - atomic weight.
- When the ratio between neutrons and protons changes, the nucleus becomes unstable, either due to an increase in the number of neutrons or due to a decrease in their number.
- As the number of protons increases, the binding energy of the nucleons in the nucleus decreases due to the increase in the Coulomb repulsive forces, and the nucleus begins to decay.
-
- As the number of neutrons in the nucleus increases, the nucleus decays because the additional neutrons that appeared in the nucleus did not bring with them an additional portion of π ±, ie the nuclear forces that hold the nucleons together, and therefore the nucleus begins to decay..

11 drip model of the structure of the nucleus of the extension atom

- For light elements, the ratio between 1n0 \ 1p + 1 is 1, and then - with increasing atomic mass, the ratio between protons and neutrons increases to 1.5 and when reaching 1.6 (in the elements of the last row) there is a decay. 208,98Bi83 and 209Po84
- As in a droplet, the surface of the nucleus can oscillate, and as the amplitude of oscillations increases, the nucleus can divide with the emission of particles and quanta.
- It was observed that excited nuclei, like atoms, emit electromagnetic radiation in the form of gamma quanta.
- In addition, it was noted that similarly to chemical stability with increasing atomic mass, the increased stability of nuclei is periodically repeated. Particularly stable and widespread in nature atoms, where protons 2, 8, 20, 50, 82 and neutrons 2, 8, 20, 50, 82, 126. These are No, O, Ca, Rb.

2.Shel model.

- *According to the shell model:*
- *Nucleons are at energy levels, where there can be no more than one proton and one neutron.*
- *Groups of close levels form a shell.*
- *The shells are filled on the principle of minimum energy.*
- *Upon excitation of the nucleus, the nucleons can move to a higher energy level, their return to the previous level is accompanied by the release of energy in the form of gamma-ray. When the quantum transition is difficult, the nucleus can more or less remain excited - a metastable isomer.*
- *To reconcile the mutually exclusive positions of the droplet and shell models, a superflow model was proposed.*
- *Types of radiation: electromagnetic and corpuscular.*
- *Properties of radiation: penetrating property, ionizing, photochemical action, light-exciting action, property to change the electrical conductivity of semiconductors, biological action.*

Radioactivity -

- it is a property of the spontaneous transformation of the nuclei of one element into the nuclei of another with the emission of energy in the form of rays, including ionizing ones. There are natural and artificial radioactivity. The nucleus is stable (according to drip theory), because neutrons and protons are kept close to each other by nuclear forces.
- Properties of nuclear forces:
- These are the strongest known in nature, so nothing can break the stable core.
- They are charge independent (combining protons and neutrons).
- They act only at very short distances, as the nature of these forces is quantum and involves the exchange of nucleons by π ± mesons, which form a thin cloud around protons and neutrons. Exchange of π ± -mesons is possible only at a distance of not more than 10-15 m, so they act only in the nucleus.
- Nuclear forces can be saturated, as each nucleon can interact only with a limited number of nucleons close to it. The decay of nuclei is accompanied by the emission of energy in the form of alpha, beta, gamma radiation and others.
- There are three radioactive families: 238U92 uranium,
- 238Th90 thorium, 222Ac89 sea anemone.
- All of them decompose into different isotopes of lead through 4α + 2 decay.

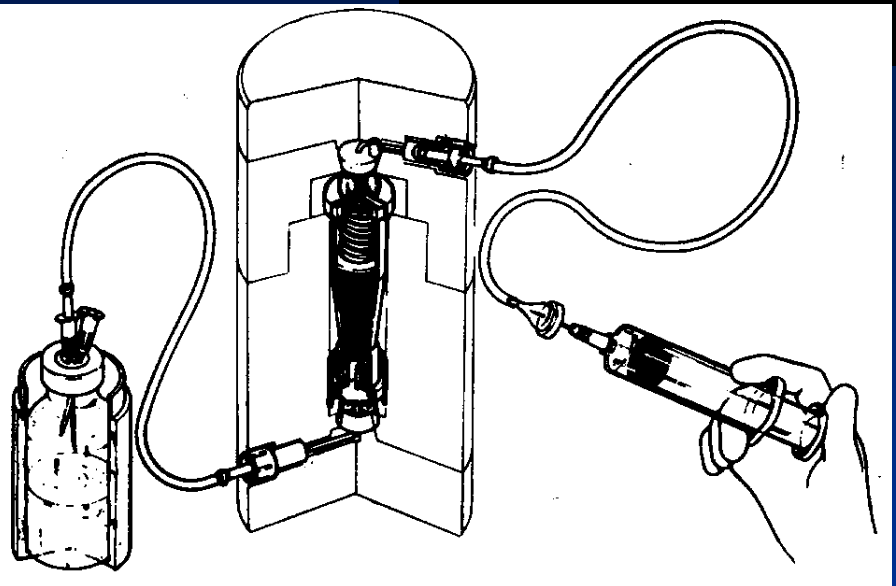
1 Types of decays:

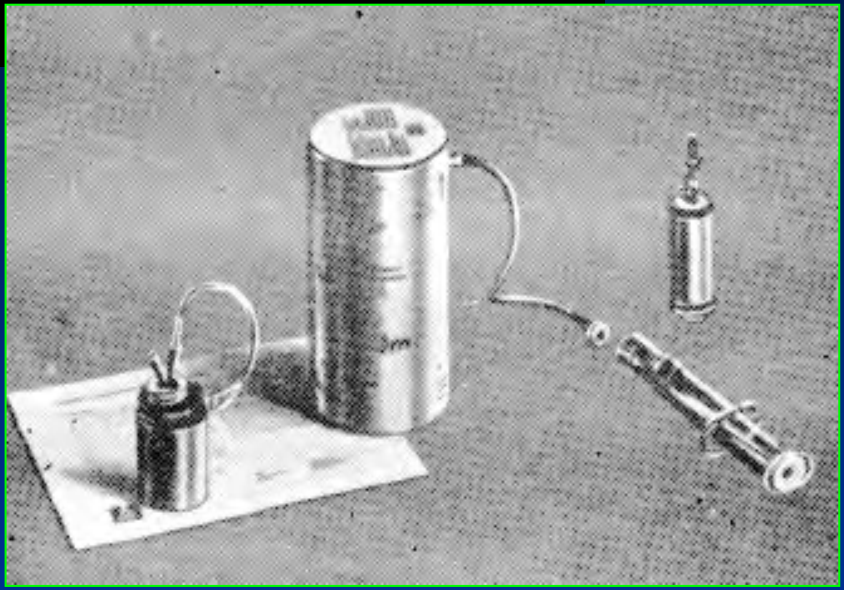
- A ;X; Z.
- A is the atomic mass consisting of the sum of protons and neutrons,
- Z is the ordinal number of the element, which is equal to the number of protons,
- X is the symbol of the element.
- $\sum n = A-Z$
- Alpha decay AXz → 4α + 2 + A- 4yz-2 + Y - the nucleus of an atom with an excess of protons and neutrons decays with the release of alpha particles. The nucleus of a new atom formed during the decay of the primary nucleus of an atom is in an excited state, since after the decay of the nucleus a nucleon in it passes to a higher energy level. Going back, it emits a gamma quantum.
- Beta decay - A X z → 0e-1 + AUZ + 1 + Y when with an excess of neutrons, the latter turns into a proton. This is accompanied by the radiation of a negatively charged electron 1n0 → 1p + 1 + 0e-1
- Positron decay - AXZ → 0e + 1 + AyZ-1 + v (neutrino) - few neutrons, the proton is converted into a neutron, emitting a positron. 1P + 1 → 1n0 + 0e + 1.
- Electronic capture - AXZ + 0e-1 → AUZ-1 + Y when there are few neutrons in the nucleus.
- 1P + 1 + 0e-1 → 1n0 + Y

Isomeric transition

- During beta and alpha decay, the formed new nucleus is in an excited state, which is accompanied (according to the shell model) by Y-ray radiation. Such nuclei emit only Y-quanta. This phenomenon is used in Technetium and India generators, which are used to label various compounds in radioisotope diagnostics.
- 113Sn50 + 0e-1 → 133m In49 → hv → 113 In49, T 1 \ 2 = 100 min.
- 99Mo42 - 0e-1 → 99m Tc43 → hv → 99 Tc43, T 1 \ 2 = 6 hours.
- These are examples of an isomeric transition.

6 99mTc generator





- After the decay of the nucleus, a nucleon in it moves to a higher energy level. Going back, this nucleon emits a gamma quantum. If it knocks an electron out of the nucleus along the way, this is an example of another type of decay called internal conversion.

. *Decay of nuclei of heavy radioactive elements.*

235U92 + 1n0 → 236U92 → 90Kr36 + 141Ba56 + 5 1n0 (202.5 MeV)

90Kr36 → 90Rb37 → 90Sr38 → 90I39 → 90 Zr40- one of 14 possible decay options

Nuclear synthesis:

2H1 + 3H1 → 4He2 + 1n0 + E (~ 17 MEB)

6Li3 + 2H1 → 4He2 + 4He2 + E (26 MEB)

And although one helium atom here heat is 7.5 times less than one uranium atom during the fission of its nucleus, but the mass of the helium atom is 59 times less than the mass of the uranium atom. Therefore, the "caloric content" of hydrogen "fuel" in terms of kilograms of substance is almost 8 times higher than uranium.

19 Nuclear fission:

- ***The law of constancy of radioactive decay - for the same period of time the same parts of unstable atoms decay is presented by the formula.***
- ***Nt = N0 • e-λ t, where Nt is the desired activity, N0 is the initial activity, e is the basis of the natural logarithm, λ is the decay constant, which is determined by the number of atoms decaying per unit time, t is the decay time.***
- ***λ = 0.693***
- ***T 1 \ 2 where 0,693 = ln 2***
- ***T 1 \ 2 - the time during which half of the initial number of atoms decays. The relationship between the decay constant and the half-life is inverse. The greater the decay constant, the shorter the half-life of the isotope.***

20 Activity

- Activity is a measure of the number of decays per unit time. It is measured in BC and Curie. 1 Bq = 1 decay in 1 sec. 1 Curie = 3.7 1010 decays in 1 sec. one gram of radium. Specific activity - the activity per unit mass and volume of the substance BC \ Kg.
- Activity at any time is calculated by the formula
- At = A0 • e - 0.693__t__
- T 1 \ 2
- Where At-activity is sought, Ao is the initial activity, e is the basis of the natural logarithm in the degree of 0.693. T 1 \ 2 - half-life, t - time after which the activity is determined. Determination of radioactivity residue is found from the ratio At = Ao
- K
- K-factor, found in the table of amendments
- NO. Verkhovskaya as a coefficient equal to K = _t_
- T 1 \ 2

- **Example. Find the specific activity of J 131 on May 20, if on May 6 the initial activity was 200 MBq / ml. The half-life of J 131 is 8.1 days**
- **Decision:**
- **1. __t___ = 14 = 1.73**
- **T 1 \ 2 8.1**
- **2. In the table (NI Verkhovskaya, Manual of Nuclear Medicine, 1991) the number 1.73 corresponds to a correction factor K = 3.31**
- **3. Hence A = 200 = 60.4 MBq \ Ml**
- **3.31**
- **Calculation of the activity of one drop: in one ml. saline solution 20 drops.**

2 Dose

- Dose - the energy transmitted by ionizing radiation to the elemental volume or mass of the irradiated substance. There are absorbed and exposed doses.
- Absorbed dose - the amount of energy absorbed per unit mass of irradiated substance.
- In SI units, 1 Gy = 1 J \ kg is measured in gray, ie it is equal to the dose of ionizing radiation at which a substance of mass 1 kg transmits energy in 1 J.
- In non-system units of RAD (Radiation Absorbed Dose). 1 RAD = 100 erg \ g and is equal to the dose when the mass is 1 kg. transmitted 0.01 J.
- Exposure dose - X - the dose absorbed in the air, introduced for the quantitative characterization of quantum radiation. In SI units it is measured in pendants \ kg.1 pendant \ kg. equal to the exposure dose of X-ray or gamma radiation, at which the conjugate corpuscular emission of 1 kg. dry air produces ions that carry an electric charge of each sign equal to 1 k.

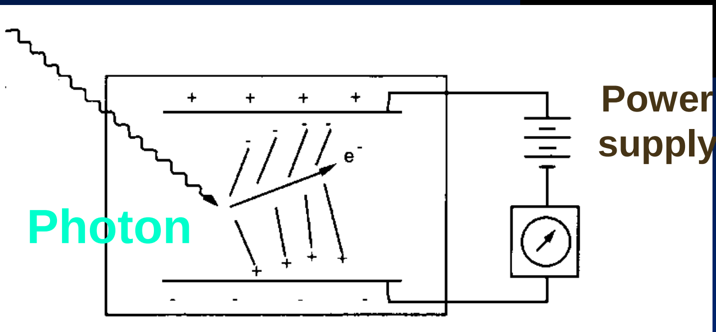
23.

- Extrasystem unit - 1 X-ray equal to the radiation dose at which the conjugate emission with X-ray or gamma radiation forms a corpuscular emission of 0.001293
- (1 cm3) of air, ions that carry a charge in one electrostatic unit of the amount of electricity of each sign.
- D = f x, where the coefficient of proportionality for X-ray f = 0,873. D is the absorption dose, x is the exposure dose.
- Dose rate Gr \ s. for the absorbed dose, and A \ kg. for exposition.
- Equivalent dose. Different types of ionizing radiation act on tissues differently, depending on the density of ionization and the ability to transmit energy to the surrounding particles.
- The equivalent radiation dose is the absorbed dose of any radiation, which when irradiated causes the same bioeffect as 1 Gy. absorbed x-ray or gamma radiation.
- The equivalent dose is the product of the absorbed dose by the quality factor, which shows how many times this type of irradiation has a stronger biodiversity than the quantum at the same absorbed dose of energy in units of mass of matter.
- Measured in the SI system in Sieverts: 1 Sv = 1 Gy = 1 J \ kg
- K K
- in non-system units in Ber: 1 Ber = 1 RAD = 0.01 J \ kg
- K K

26 Dosimeters.

- Devices for measuring the dose or dose rate of ionizing radiation are called dosimeters or X-ray meters. The device is used to measure the dose or dose rate, evaluate the effectiveness of protective devices of controlled objects or areas, to measure individual radiation doses of personnel or the public. Information on the dose can be obtained by:
- individual dosimetry of the body surface;
- dose measurement in groups of people who are in the same conditions (military dosimetry);
- dose measurement in air;
- calculations based on data on the length of stay of people in the area of radioactive radiation;
- biological dosimetry (for example, the number of lymphocytes on the third day after irradiation);
- the fact of neutron irradiation is established by determining the induced radioactivity in the human body and objects around it.

27 Dosimeters.



Individual dosimeters of ionizing radiation: a and b - directly indicating portable dosimeters; in - the individual thermoluminescent detector.

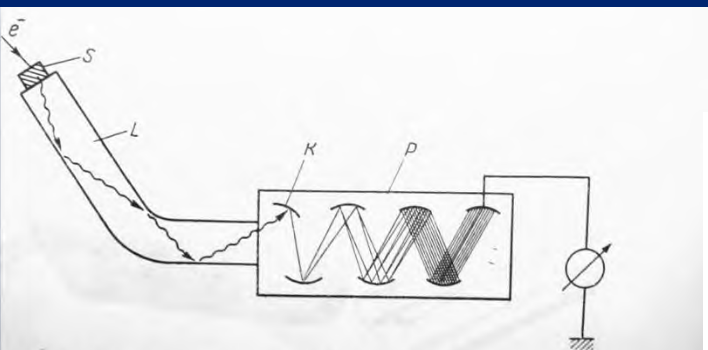


Рис. 10. Схема сцинтилляционного счетчика.
S — сцинтиллятор; L — светопровод; K — фотокатод; P — фотоумножитель; e — заряд.

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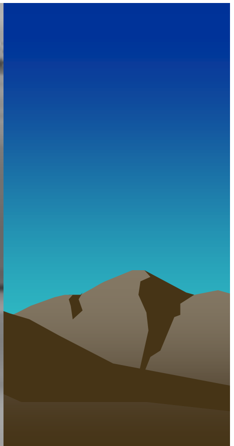
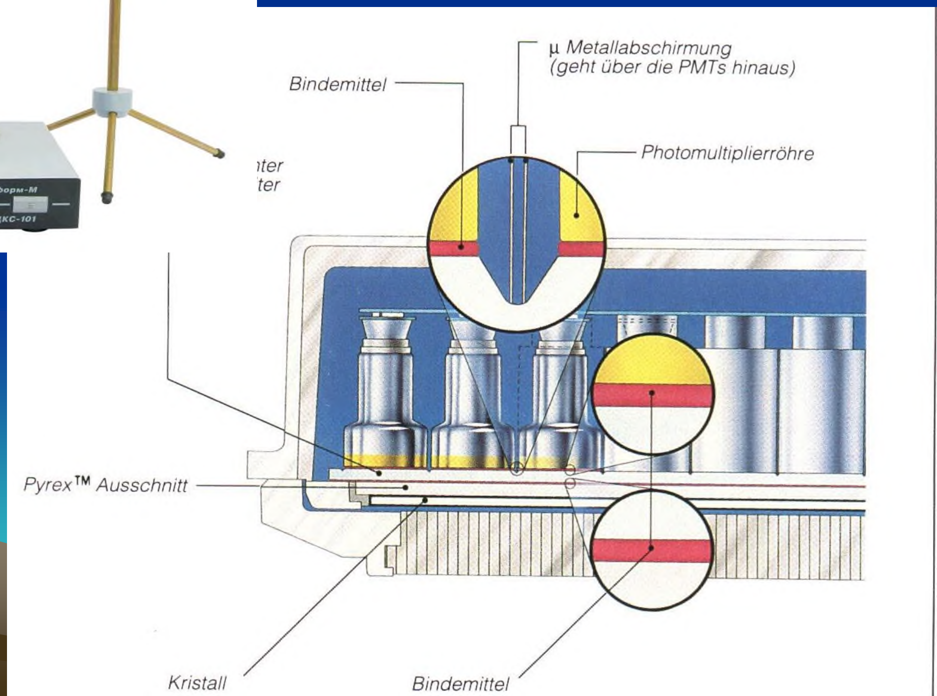
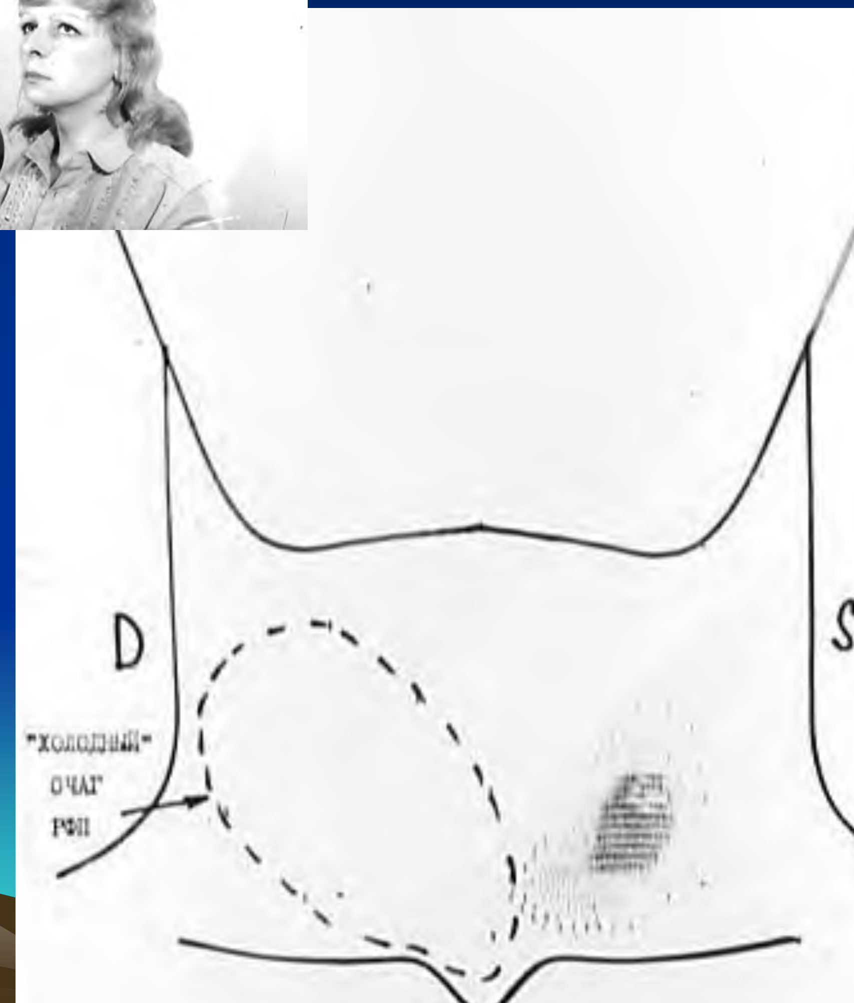




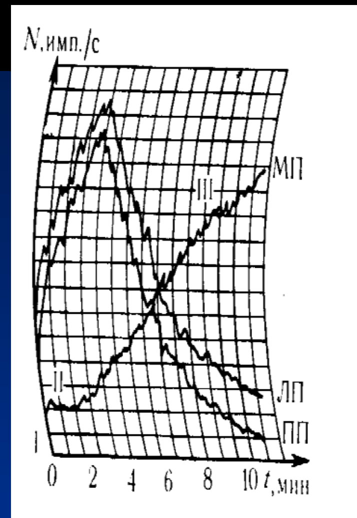
2

30 In vitro laboratory radiometry

Medical radiometers



2. Medical radiometers



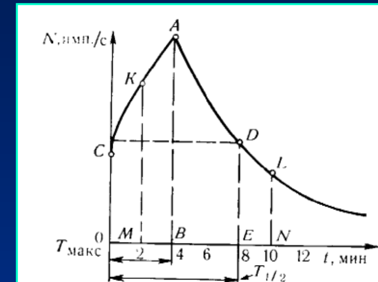
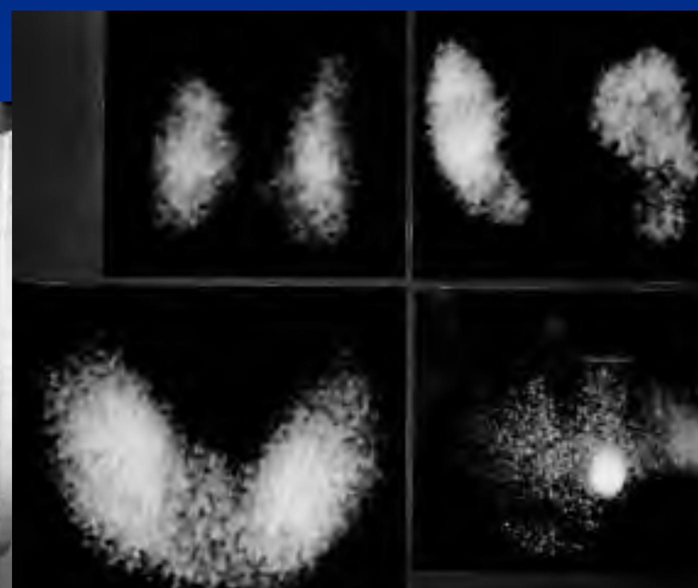


Рис. 106. Принцип расчета амплитудно-временных показателей ренограммы:



34.Spectrometers.

- Sources of nuclear radiation usually generate monoenergetic particles, or quanta. The distribution of radiation by energy is called the energy spectrum of nuclear radiation.
- Instruments that measure radiation spectra are called spectrometers. With the help of spectrometers determine the energy of gamma rays and on this basis -element that this gamma ray emits.
- The basis of the spectrometer (single-channel pulse analyzer) is a differential discriminator (limiter). By consistently shifting the discrimination thresholds, it is possible to measure the entire range of amplitudes and obtain the energy spectrum of radiation of a radioactive drug.

35 Protection against ionizing radiation.

- Means of protection:
- Maximum reduction (exclusion) of direct contact with a radioactive substance.
- Prevention of radioactive substance entering the air of working premises, premises.
- Prevention of contamination of clothes, body, work surfaces.
- Specific principles of protection: sealing of premises, equipment, planning measures, use of sanitary devices.
- Principles of protection (general):
- Reducing the dose rate to a minimum.
- Reduction of hours of work with the source. (protection of time).
- Increasing the distance from the source to the worker (distance protection).
- Shielding of the radiation source with materials that absorb ionizing radiation (screen protection).

6. Radiation safety standards (NRB - 97) provide the following basic principles of radiation safety:

– not exceeding the basic dose limit;

– exclusion of any unreasonable exposure;

– reducing the radiation dose to the lowest possible level (reducing the risk of stochastic effects).

- *NRB - 97 is the category of irradiated people:*
- *A - (staff) - persons who permanently or temporarily work directly with sources of ionizing radiation (radiologist, radiologist).*
- *B - (personnel) - persons who are not directly involved in working with sources of ionizing radiation, but due to the location of workplaces in the premises and on the industrial sites of facilities with radiation and nuclear technology may receive additional radiation.*
- *In - the whole population.*
- *NRB - 97 is three groups of critical organs:*
- *lens;*
- *skin;*
- *hands and feet.*

38 Irradiation dose limits Sv / RIK

	Category of persons exposed to radiation		
	А	Б	В
LDe (effective dose limit)	0,02	0,002	0,001
The effective equivalent dose is the dose evenly absorbed by the whole body, which creates the same risk of damage to health from individual stochastic effects as the actual doses absorbed in individual organs or tissues.			
Limits of equivalent dose of external irradiation Sv / RIK			
Annual equivalent dose for the lens of the eye	0,15	0,015	0,015
Annual equivalent dose for the skin	0,5	0,05	0,05
Annual equivalent dose for hands and feet	0,5	0,05	
An equivalent radiation dose is an absorbed dose of any radiation that, when irradiated, produces the same biological effect as 1 Gy of an absorbed dose of X-ray or gamma radiation.			

THANK YOU!