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DEVELOPMENT OF Si-PIN DIODES DETECTION UNIT FOR NOBLE SYSTEMS GAS ARIX

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Abstract

New detecting unit was made in new geometry of 11- pieces Si-PIN diodes, disposed in an aluminum cylinder of height 35 mm and diameter 18 mm (~8cm^3 volume) . Si - detectors with a thickness of ~0.5 mm and an active area of ~1 cm^2 were used. The parameters of the created detection unit was tested using gas that contains ^{131m}Xe. All 11 flat silicon p-i-n detectors are connected to a single preamplifier. New development of detection unit allowed to obtain the energy resolution for conversion electrons ^{131m}Xe equal 15 keV. The ratio of the counting rate of KX-quanta of ^{131m}Xe in the β-γ coincidence mode with the conversion electrons to the counting rate without coincidence was equal to 30 %. This ratio was used as an indicator of the efficiency of electron registration by the tested assembly. The test results are compared with the parameters of the scintillation electron detector, which is currently used in ARIX installations, and with the parameters of detecting unit consisting of 5 Si-PIN diodes.

NaI (Tl) – Si-PIN detector will be used for Noble gas system ARIX-4 for the IMS radionuclide station RUX-55 in Norilsk (Russia) and mobile system of high productivity RINGA-F.

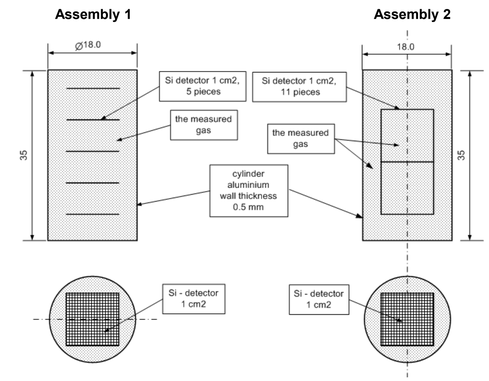
1. Introduction

In recent years, the possibility of using β-γ coincidence spectrometers with an electron detecting unit based on Si-PIN diode detectors has been considered for measuring xenon radionuclides in noble gas systems. High resolution Si detectors facilitates the selection in the histogram of beta-gamma coincidences regions of ^{131m}Xe and ^{133m}Xe and reduces the background under their lines in the spectrum. At the Radium Institute, two detecting assemblies designed to register electrons in beta-gamma coincidence spectrometer were developed and tested. Assemblies include respectively 5 and 11 flat Si PIN detectors that are connected to a single preamplifier. In the test used a gas containing ^{131m}Xe, obtained from the ^{131}I. The energy resolution for the energy of 129 keV and the ratio of the counting rate of KX-quanta of ^{131m}Xe in the β-γ coincidence mode with the conversion electrons to the counting rate without coincidence mode were measured. This ratio was used as an indicator of the efficiency of electron registration by the tested assembly. The test results are compared with the parameters of the scintillation detector, which is currently used in ARIX system.

2. Some History

- Dr. Nikolay Kazarinov et all (KRI) developed β-γ coincidence spectrometer with Si-pin detectors in 2011.
- ARIX-03F mobile installation with NaI(Tl) and Si-pin diodes in well was tested in Ussuriisk (RUX58) in August 2012.
- In cooperation with the Institute “VNIIA” (Moscow) we reported on the development of an improved detecting unit (CTBTO: SnT 2015 Conference, June,22-26).

3. The placement of the silicon detectors



4. Design

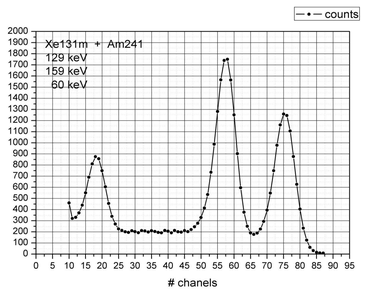
5. Features of assemblies

--- Using square silicon detectors with an area of 1 cm2.
--- Construction:
- "whatnot" of the 5 detectors with a thickness of 0.45 mm (assembly 1);
- Two cubes having 1 common face, collected from 11 detectors with a thickness of 0.5 mm (assembly 2).

Limiting parameters are: the total electrical capacitance of the detectors , the permissible scattering of electrons in the thickness of the gas containing Xe, the volume of the gas sample, the availability of the items assembly.
--- The connection of all the detectors of the assembly to the entrance of one charge sensitive preamplifier. The use of thick (0.45 and 0.5 mm) detectors allows to reduce the capacitive noise of the preamplifier.
--- The operation of detectors in the full depletion mode. The detectors are preliminarily selected according to the full depletion voltage, which in our case does not exceed 40 V.
--- Registration of electrons by two sides of a Si plate.
--- Placing the assembly in a thin-walled aluminum cylinder, the dimensions of which is determined by the volume of the measured gas mixture and the dimensions of the well of the NaI (Tl) gamma-ray detector.

6. The conversion electron spectra of ^{131m}Xe

The figure shows the electron spectrum obtained by filling the assembly 2 with a gas containing ^{131m}Xe. The coincidence mode is turned off. Next to the assembly was located ^{241}Am. The left peak corresponds to registration of gamma-ray 59.4 keV (^{241}Am) by a beta detector. The other two peak formed by the electron conversion ^{131m}Xe. Left peak corresponds to the energy of 129 keV. Right peak is formed by electrons with energies of 159, 163.0, 163.8 keV. In the mode of beta-gamma coincidences (in ARIX system) right peak is absent as the energy LX,MX,NX quanta less than 5 keV (below the registration threshold of gamma channel).



6. Comparison of results

Technical parameter	Scintillation detector	Silicon assembly - 1	Silicon assembly - 2
The number of Si plates with area of 1 cm^2	Plastic glass	5	11
Number of preamps used	1	1	1
Filled with gas the volume of the measuring chamber	6,63 cm^3	7,15 cm^3	7,85 cm^3
Energy resolution for conversion electrons 129 keV	37 keV	12 keV	15 keV
The efficiency of coincidences with the KX quanta of ^{131m}Xe (≈30 keV)	85 %	18 %	30 %

7. Conclusion

- The assembly of 11 silicon PIN detectors (S = 1 cm^2 each, thickness 0.45 mm), made in the form of two cubes with a common face, has a registration efficiency of ^{131m}Xe conversion electrons of about 30% (in the chamber filled with gas 7 cm^3).
- The energy resolution of the assembly is 15 keV when all 11 detectors are connected to the input of a one charge-sensitive preamplifier.
- Thus, confirmed the possibility of creating a detector of electrons having satisfactory characteristics (for registration systems of Xe radionuclides by the method of beta-gamma coincidences) without the use of multichannel recording electronics.
- In the near future it is supposed to begin the design development of the silicon detector and its placement in the well NaI (Tl), the modernization of electronics, lead protection, and software.
- As a result of this work we hope to create a detection unit with energy resolution 15 keV and with detection efficiency of conversion electrons ^{131m}Xe of at least 30%.
- We expect to equip ARIX installation, intended for the station RUX55 (Norilsk) by spectrometer with a Si-PIN detectors.