



*Russian Federal Nuclear Center – Zababakhin
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ПРЕДПРИЯТИЕ ГОСКОРПОРАЦИИ «РОСАТОМ»

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System for identification of devices containing fissile and explosive materials

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The system provides measurement of the following characteristics

- Presence of plutonium;
- Confirmation of weapon grade of plutonium by the ratio of isotopes $^{240}\text{Pu}/^{239}\text{Pu}$;
- Presence of plutonium with mass exceeding threshold value (while testing the system, threshold value was determined to be 500g);
- Presence of uranium;
- Degrees of uranium enrichment by uranium-235;
- Presence of highly enriched uranium with mass exceeding threshold value (while testing the system, threshold value was determined to be 500g);
- Presence of HE with mass exceeding 1 kg.

Measuring system

External computer

Electronic unit

Model assembly

Neutron detector

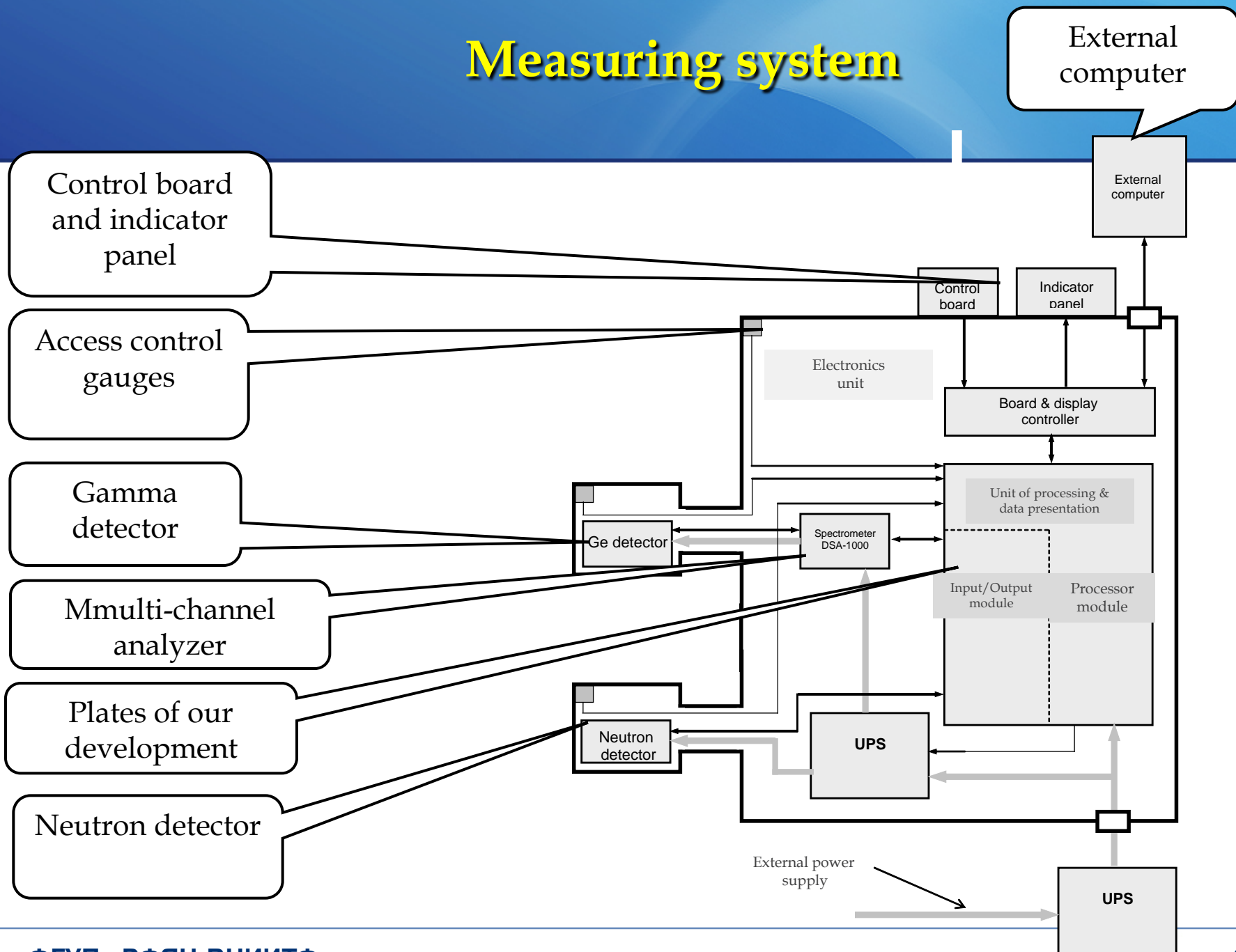
Measuring bench

Neutron generator control block

High-purity Ge detector

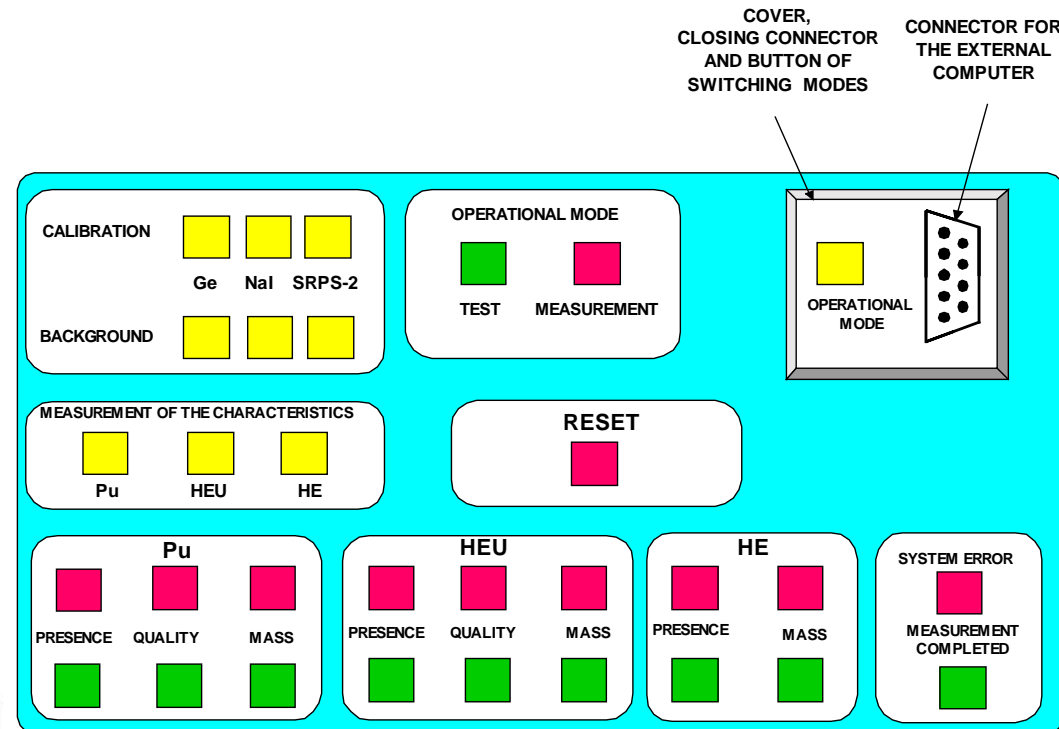
Neutron generator

Measuring system



Control board and indicator panel

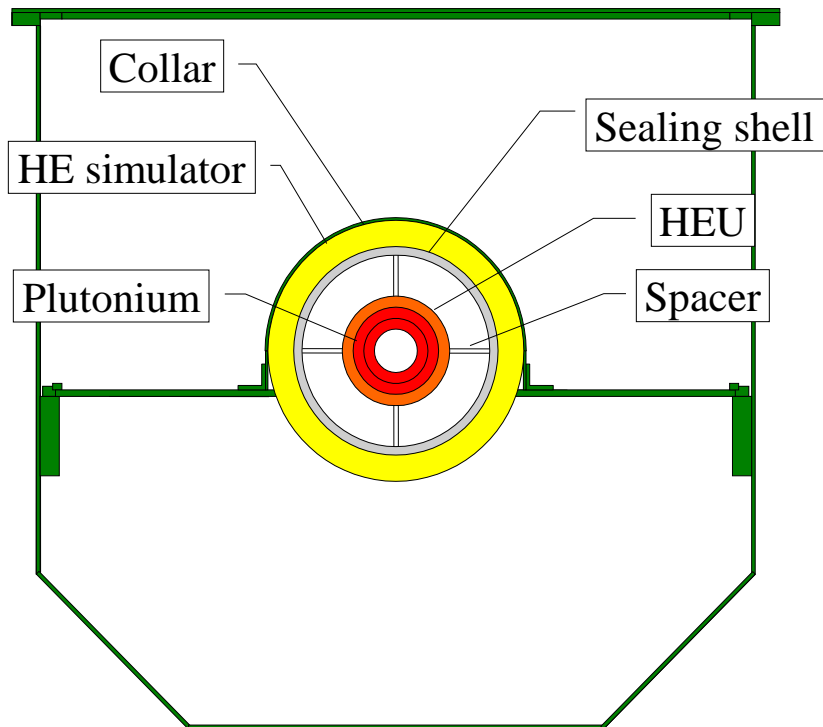
Control board and indicator panel are aligned with the top panel of electronics unit



All measured characteristics are divided into three groups: plutonium, uranium, HE. The procedures of measuring the characteristics of each material are initiated by pressing corresponding button.

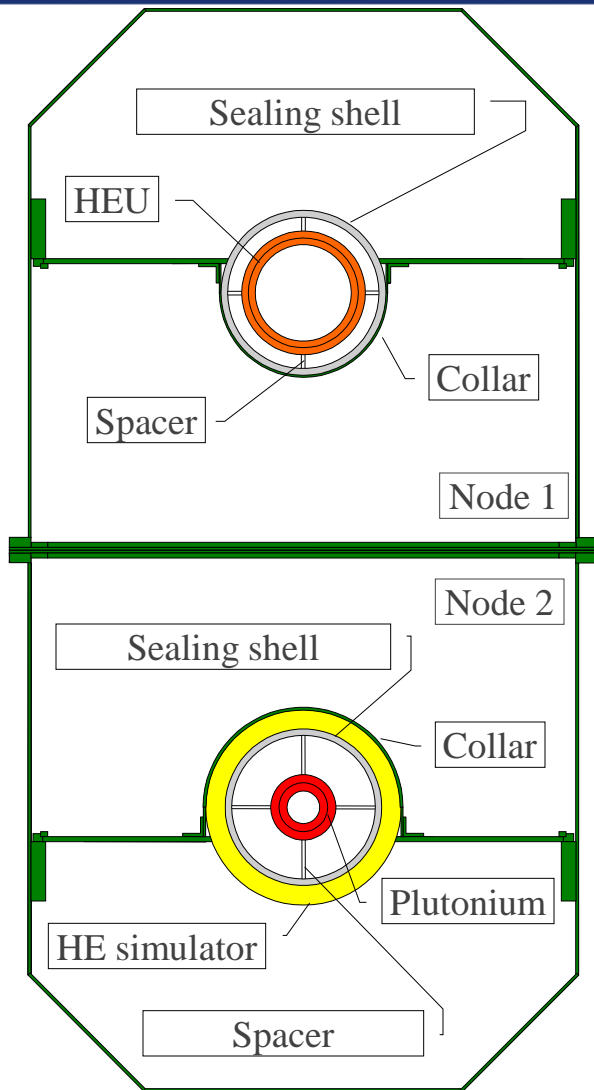
Model assembly for conducting measurements

Scheme of model assembly containing plutonium, HEU and HE simulator



External view of model assembly

Model assembly for conducting measurements with two nodes



External view of model assembly

Measurement of plutonium characteristics

- Presence of Pu was determined by γ -lines in the range 630...670 keV,
- Confirmation of Pu grade was made by measuring isotope ratio $^{240}\text{Pu}/^{239}\text{Pu}$.

Measured instrumental spectra were processed by program Pu600. Program Pu600 permits to determine the presence of plutonium and isotope ratio $^{240}\text{Pu}/^{239}\text{Pu}$.

- Confirmation of Pu mass was performed by measuring the total neutron yield from the sample.

Measurement of plutonium characteristics

The results of measurements of neutron yield for assemblies with plutonium with different mass and processing of measured instrumental spectra by program Pu600

Assembly#	Pu mass, g	Pu600	Neutron counting rate, 1/s
		$^{240}\text{Pu}/^{239}\text{Pu}$	SRPS-2
1	113	0.099	33.6
2	930	0.102	344.9
3	1682	0.096	574.4
4	3200	0.089	1226.4

According to the results of measurements, dependence was built of speed of counting by neutron detector SRPS-2 on ^{240}Pu mass in plutonium sample. The dependence of neutron counting rate on ^{240}Pu mass has linear character and weakly depends on the design of concrete assembly.

Obtained dependence is used for evaluation of plutonium mass in measured sample.

Measurement of uranium characteristics

- Confirmation of uranium presence was determined by γ -lines ($E_\gamma=186, 1001\text{keV}$).
- Uranium enrichment was determined by the presence of line 2614 keV in gamma radiation spectrum. The program determines the area of the peak 2614 keV and on the basis of comparison of this peak area with background value draws a conclusion about HEU presence.

The results of processing of measured instrumental spectra by the programs determining uranium presence and uranium enrichment

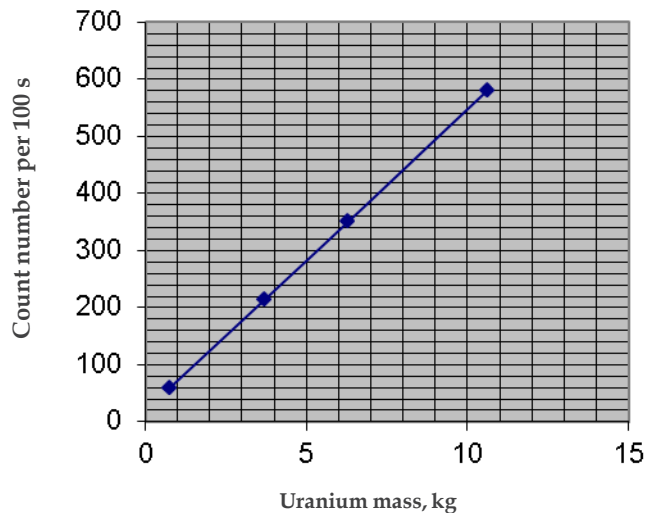
Assembly #	Uranium mass, kg	Counting rate in a peak, count/s		
		186 keV	1001 keV	2614 keV
1	~0.76	212.4	1.47	8.9
2	~3.7	217.5	1.5	8
3	~6.3	214	1.4	7.3

For all assemblies, uranium lines 186 keV, 1001 keV, 2614 keV in gamma radiation spectrum, and counting rate in peaks of corresponding lines exceeds background rate by a factor of 20 and more.

Measurement of uranium characteristics

- Uranium mass was evaluated by registration of delayed fission neutrons that appear in HEU sample after its irradiation by neutron generator ING-07D. Counting is performed within 100 s after irradiation extinction. In order to increase the portion of thermal neutrons in neutron spectrum, polyethylene chamber was used.

Dependence of counting rate of neutron detector on uranium mass



The results of measuring delayed fission neutron

Assembly #	Uranium mass, kg	The number of counts in each measurement with duration 10 sec									
		1	2	3	4	5	6	7	8	9	10
1	~0.76	36	27	29	14	23	17	16	24	14	20
2	~3.7	90	63	50	37	27	31	18	16	24	18
3	~6.3	146	86	49	45	37	26	32	44	28	18
4	~10.6	215	120	85	65	61	58	40	34	35	27

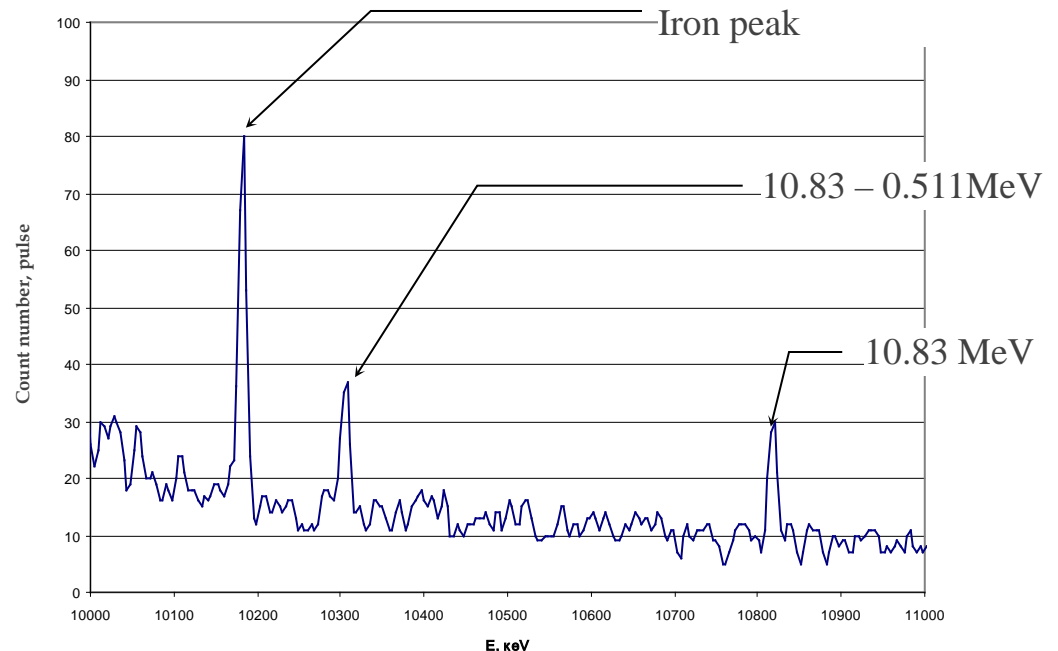
Measurement of HE characteristics

- Detection of HE with minimum mass by γ -radiation of nitrogen ($E_\gamma=10.83$) under the impact of neutrons from neutron generator. Time of measurements - 1 hour.

The results of measurements by HE detection

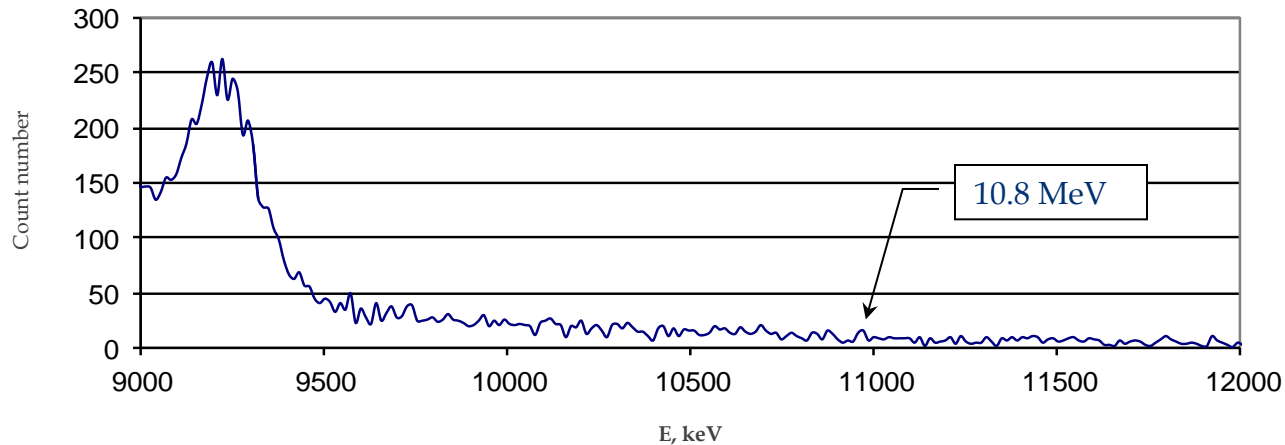
Assembly #	Mass of HE simulator, kg	Pulses with energy 10.8MeV, pulse
1	~0.43	-
2	~1.0	32
3	~2.0	38
4	~2.9	43

Instrumental gamma spectrum in 1- MeV region for assembly # 3 (2 kg of HE) that was obtained by detector out of high-purity germanium



Measurement of HE characteristics

Instrumental spectrum of gamma radiation in 10 MeV region for assembly # 4 (2.9 kg of HE). Spectrum was measured by NaI(Tl)-based detector with size 150x100 mm.



Detection of HE in the content of model assembly can be made by high-purity Ge detector.

Required time of measurements for getting acceptable statistics makes 1...2 hour with HE mass not more than 1 kg.

Conclusion

1 The results of testing experimental sample showed that complete control of model assembly containing uranium, plutonium and HE takes about 2 hours, sufficient time will be necessary for measuring HE characteristics. Measuring uranium characteristics will take about 30 minutes. For determining plutonium characteristics will take about 15 minutes.

2 The system permitted to realize evaluation of HEU mass. It is possible to evaluate mass of HEU samples, beginning from 500 g.

3 The system does not permit to measure uranium mass for uranium-plutonium groups. The problem of measuring uranium mass in uranium-plutonium systems is very complicated and requires further studies for searching new methods.

4 Using neutron generator permits to completely computerize the process of measurement conducting.

5 Polyethylene chamber for increasing thermal neutron flow does not permit to sufficiently decrease the time of HE detection. It is not reasonable to use it in measuring system.

Thank you for
your
attention!