Efficiency of the neutron detector measurement (w/o PMT holders).

A. Understanding of BKG nature.

Run 3412. U(NaI(Tl)) = -1050 V, CFD thresh(NaI(Tl)) = -14 mV, U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -5 mV. DAQ trigger rate = 17.82 Hz. BKG measurement run. NaI(Tl) was out of the shielding on the lower shelf. There was 2" of lead above on the upper shelf. Big plastic detector was shielded with 2" of lead in front.

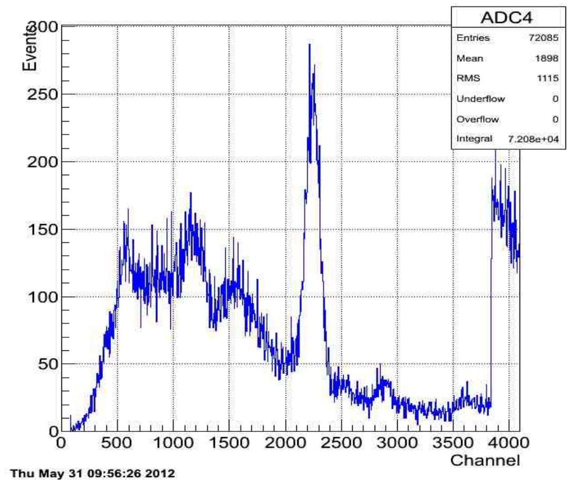

Fig. 1. ADC spectrum of the dark room BKG.

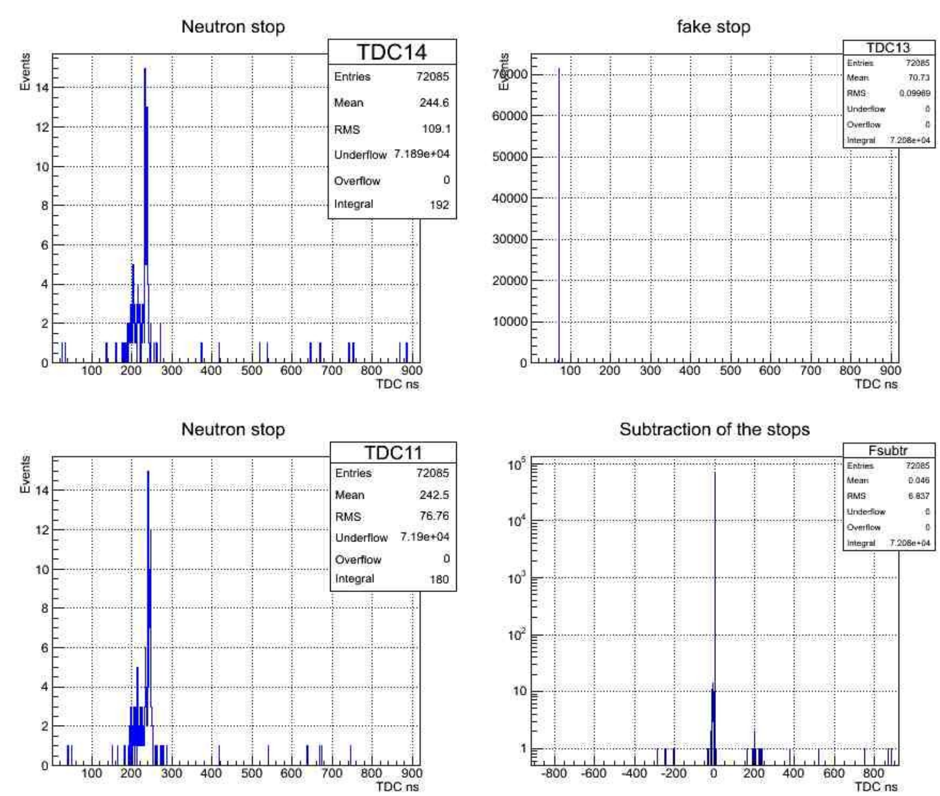

Fig. 2. TDC spectrum of BKG. Unzoomed.

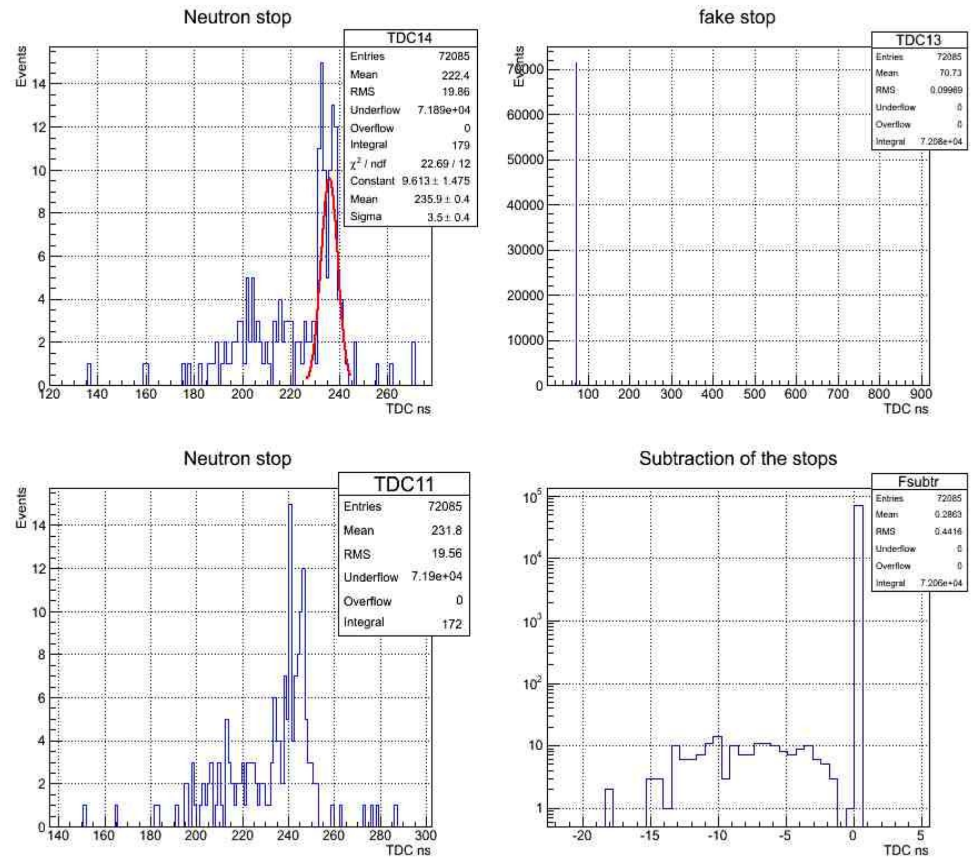

Fig. 2a. TDC spectrum of BKG. Zoomed.

Ir can be seen that there is clear correlation between NaI and neutron detector signals. In the next couple of runs we will try to destroy the correlation by placing NaI detector in a different places and under different shielding. Duration of the run was 4045.17 seconds.

Run 3413. U(NaI(Tl)) = -1050 V, CFD thresh(NaI(Tl)) = -14 mV, U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -5 mV. DAQ trigger rate = 50.6 Hz. BKG measurement run. NaI(Tl) was out of the shielding ~ 2m aside from big plastic detector (right behind the sink). There should be no correlation between the NaI and big plastic scintillator. NaI is covered with 2" of polyethylene on the top and on the sides.

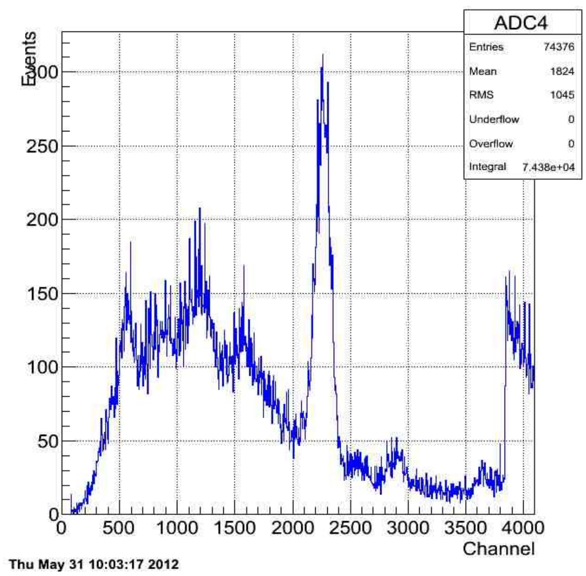

Fig. 3. ADC spectrum of the dark room BKG.

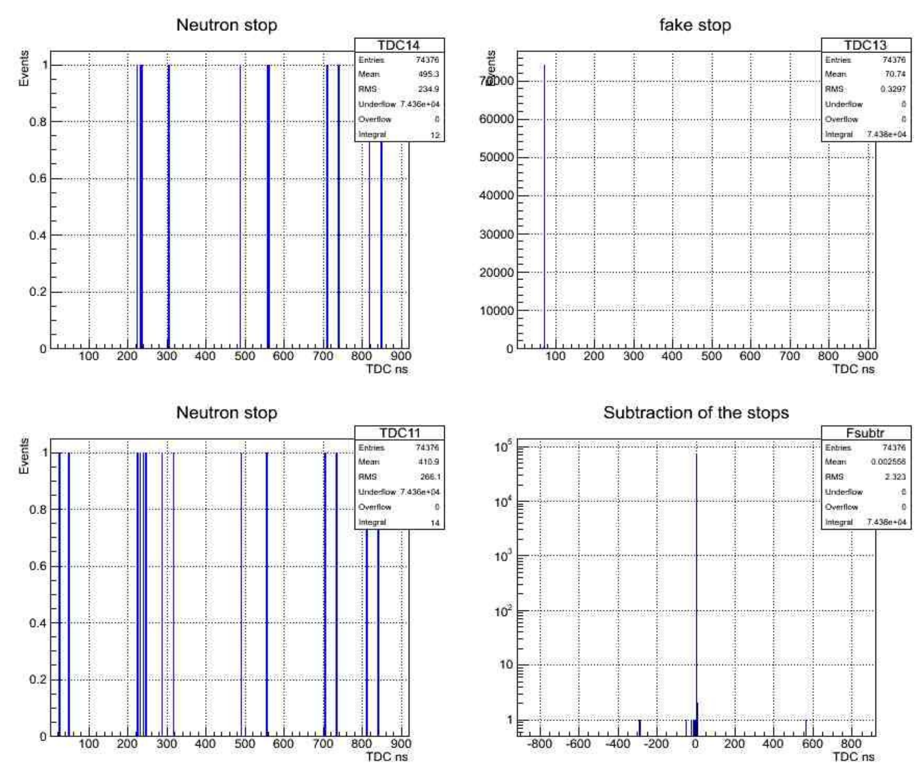

Fig. 4. TDC spectrum of BKG. Unzoomed.

The start rate was 50.6 Hz and at this rate there is no correlation between NaI and neutron detector. In the next run we will place NaI in side a better shielding to bring the start rate to the rate when NaI was on the lower shelf of the table under 2 " of lead, i.e. We will try to reproduce run# 3412 but NaI moved away from the neutron detector.

Run 3415. U(NaI(Tl)) = -1050 V, CFD thresh(NaI(Tl)) = -14 mV, U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -5 mV. DAQ trigger rate = 15.23 Hz. BKG measurement run. NaI(Tl) was out of the shielding ~ 2m aside from big plastic detector (room floor level). There should be no correlation between the NaI and big plastic scintillator. NaI is covered with 2" of lead on the sides + 4" of lead on the top + 2" of polyethylene on the top and on the sides.

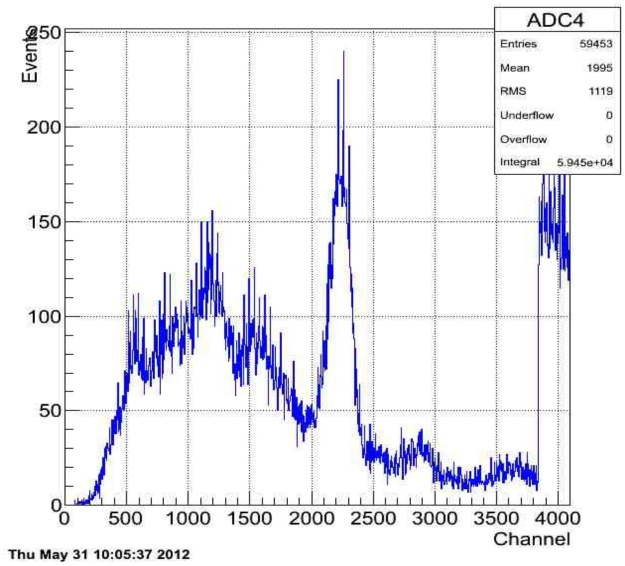

Fig. 5. ADC spectrum of the dark room BKG.

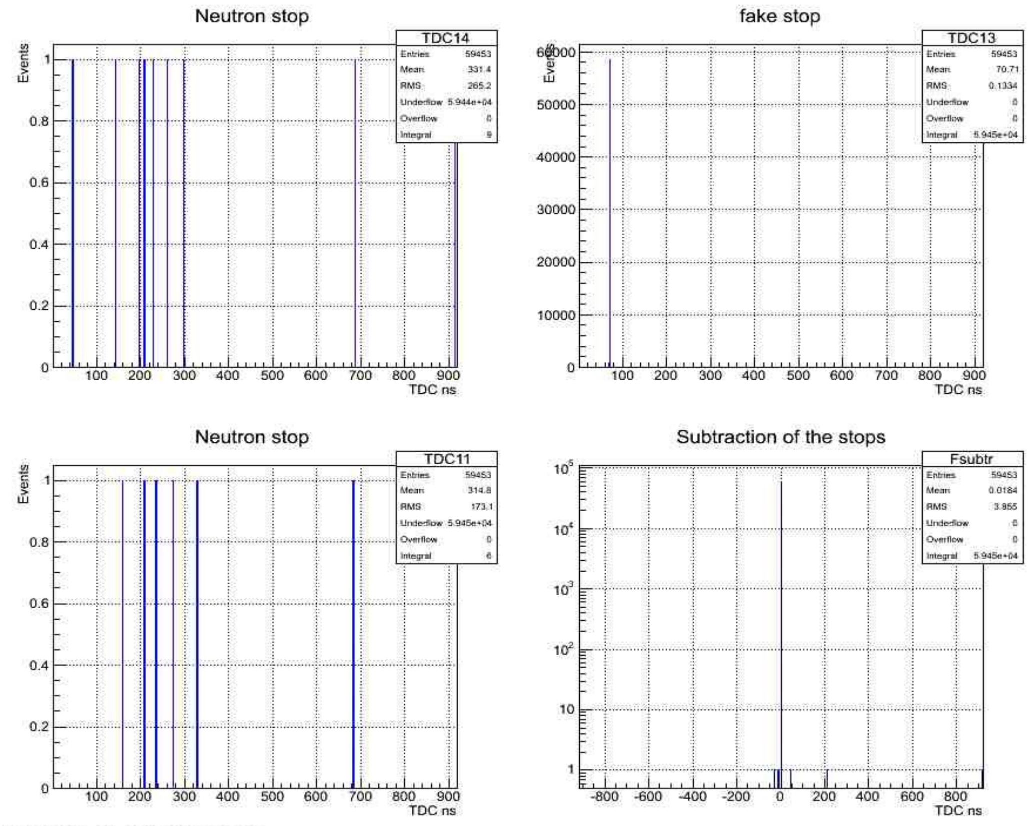

Fig. 6. TDC spectrum of BKG. Unzoomed.

Duration of this run (3903.67 seconds) is comparable to the duration of the run# 3412 (4045.17 seconds), however, if one compares Fig. 6 and Fig. 2a it is clear that in this run the correlation was destroyed.

So, for now it can be concluded that there is a source of radiation in the area where the main experiment is being carried out and the two detectors are facing each other.

B. Zero time calibration and BKG study contd.

Run 3417. U(NaI(Tl)) = -1050 V, CFD thresh(NaI(Tl)) = -14 mV, U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -5 mV. DAQ trigger rate = 48.87 Hz. Zero time measurement run. NaI is under 2" of lead shield. Lead shield removed from the front part of the plastic scintillator (just two bricks in the middle part). The distance between NaI and plastic scintillator was ~20 cm. Na-22 source was placed in between.

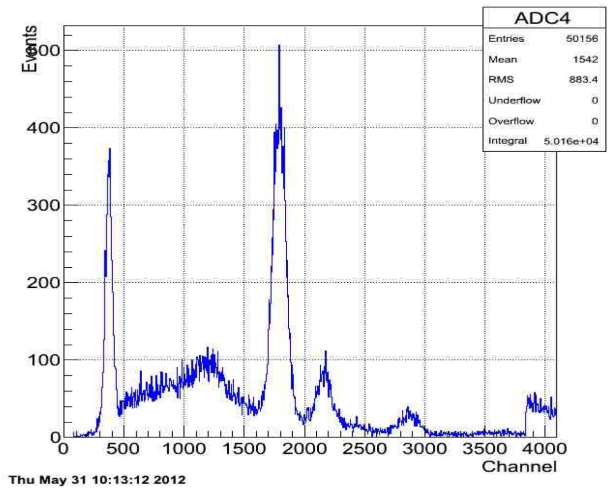

Fig. 7. ADC spectrum of Na-22.

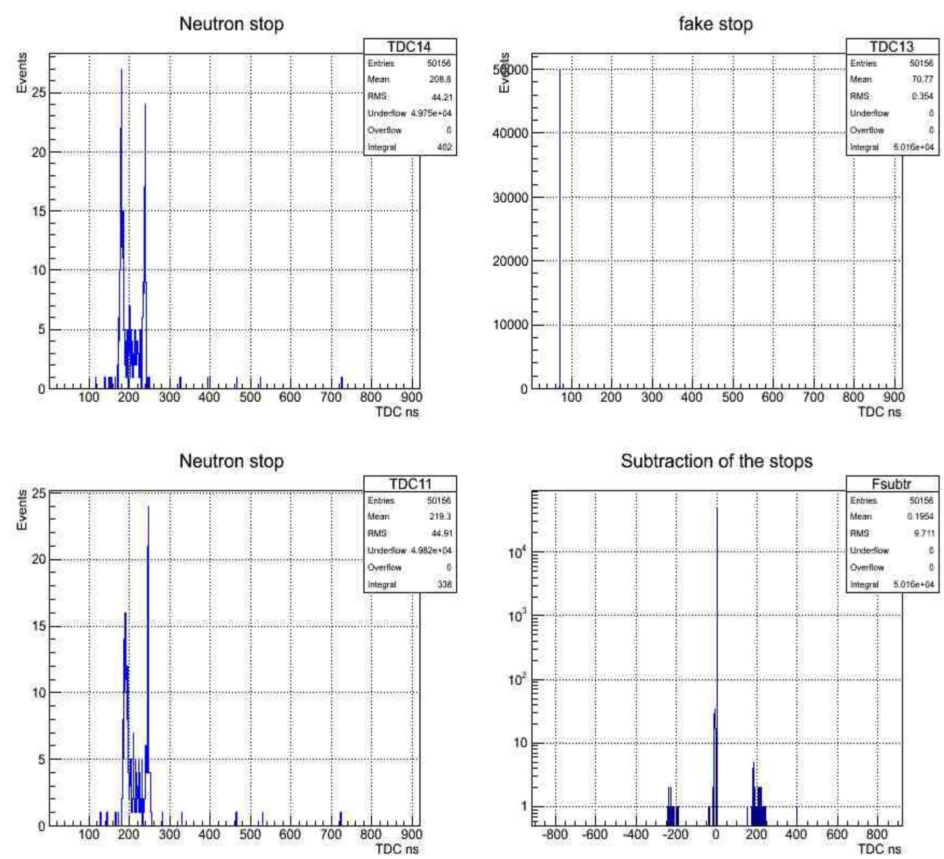

Fig. 8. TDC spectrum. Unzoomed.

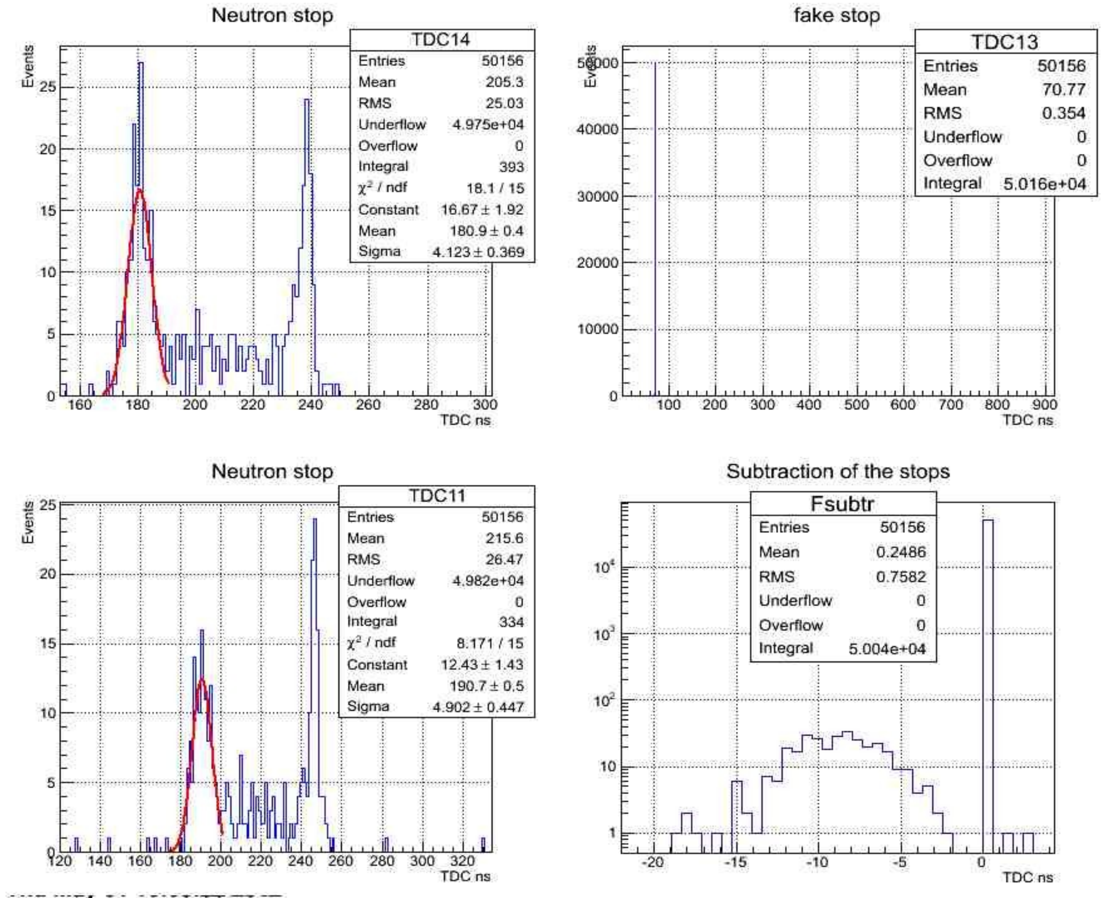

Fig. 8a. TDC spectrum. Zoomed.

In Fig. 8a in can be clearly seen the presence of Na-22 (fitted w/ Gaussian). It was assumed that the zero time for TDC14 is 180 ns and neutron spectrum starts at 190 ns. The zero time for TDC11 is 190 ns and neutron spectrum starts at 200 ns.

The time region where neutrons will be counted for TDC14 was set to 190 - 320 ns.

The time region where neutrons will be counted for TDC11 was set to 200 - 330 ns.

B.a. Lead shielding influence on the BKG correlation.

Run 3419. U(NaI(Tl)) = -1050 V, CFD thresh(NaI(Tl)) = -14 mV, U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -5 mV. DAQ trigger rate = 18.9 Hz. NaI is under 2" of lead shield. Lead shield removed from the front part of the plastic scintillator (just two bricks in the middle part). The distance between NaI and plastic scintillator was ~20 cm. BKG run, Na-22 source was removed.

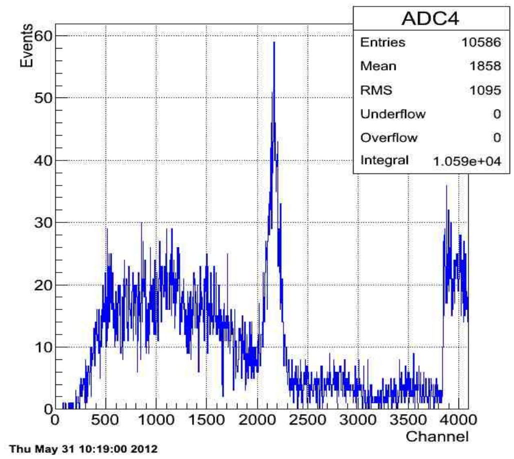

Fig. 9. ADC spectrum of BKG.

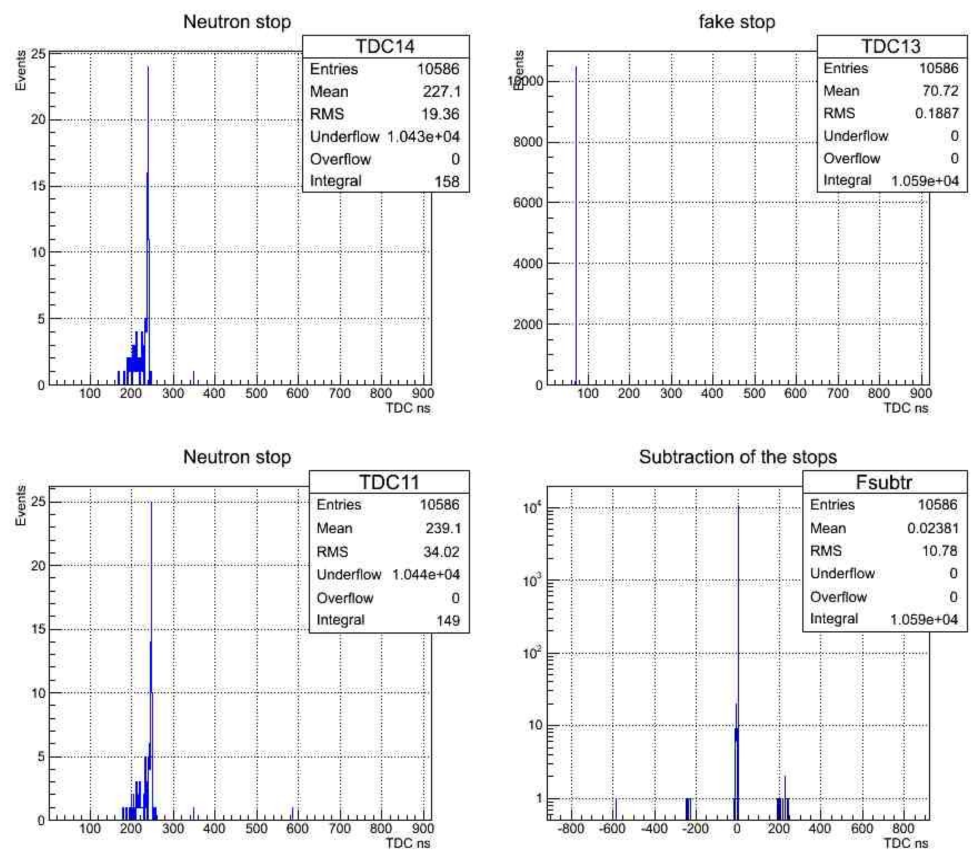

Fig. 10. TDC spectrum. Unzoomed.

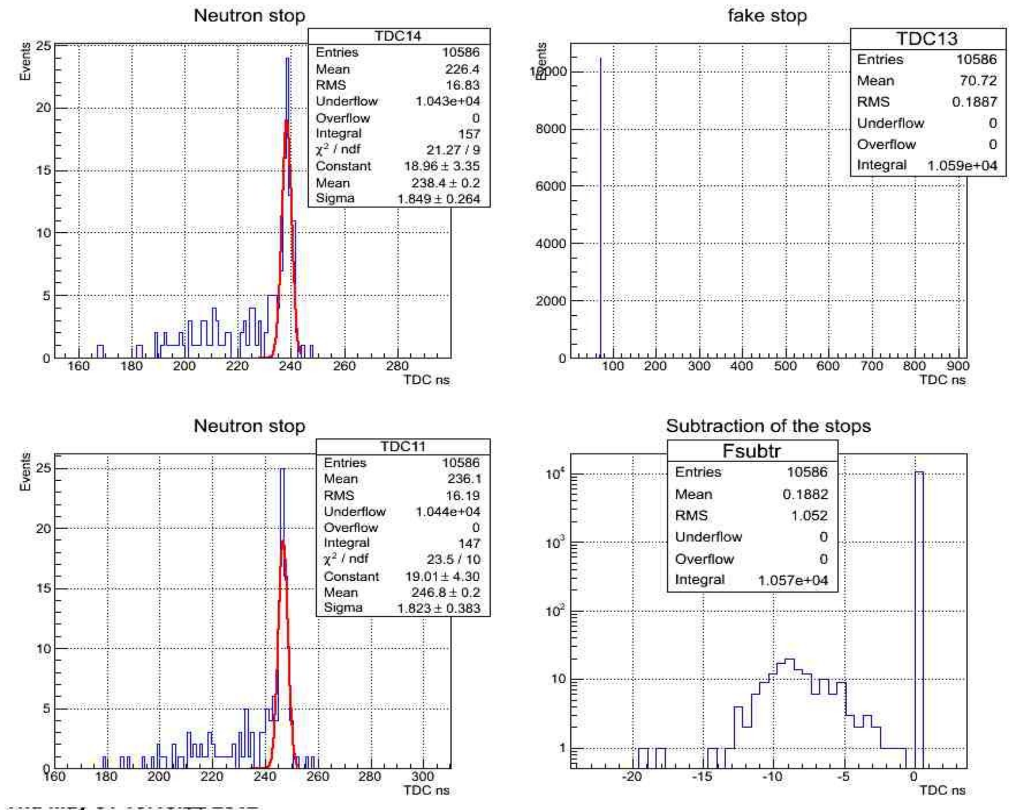

Fig. 10a. TDC spectrum. Zoomed.

BKG counting rate was for TDC14 = 0.28 Hz, peak at 238.4 ns; for TDC11 = 0.26 Hz, peak at 246.1 ns.

Run 3420. U(NaI(Tl)) = -1050 V, CFD thresh(NaI(Tl)) = -14 mV, U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -5 mV. DAQ trigger rate = 14.64 Hz. NaI is under 2" of lead shield. Lead shield restored to the full 2" of lead in the front part of the plastic scintillator. The distance between NaI and plastic scintillator was ~20 cm. BKG run.

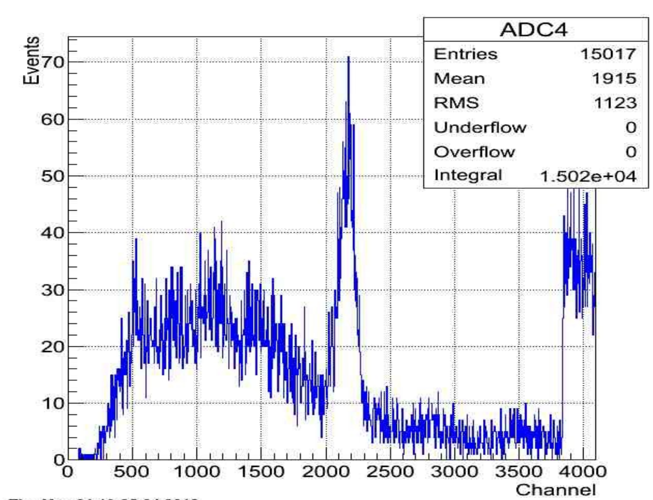

Fig. 11. ADC spectrum of BKG.

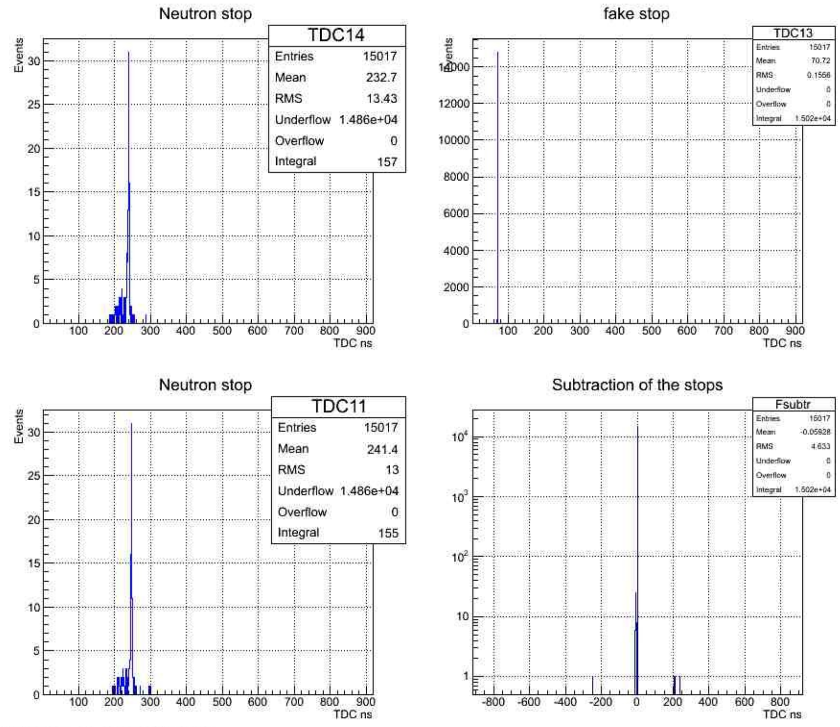

Fig. 12. TDC spectrum. Unzoomed.

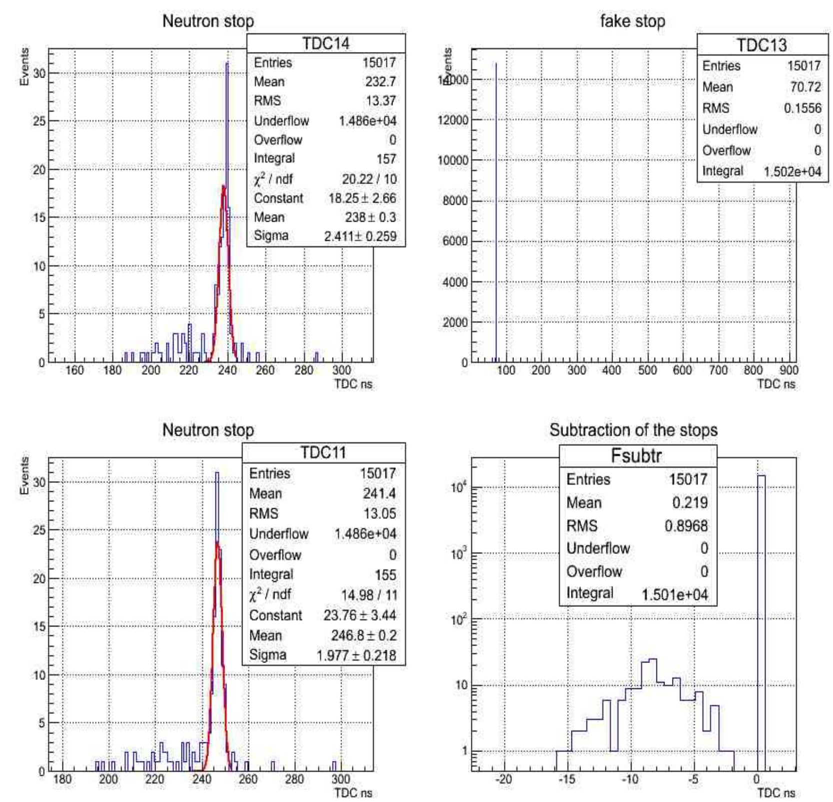

Fig. 12a. TDC spectrum. Zoomed.

BKG counting rate was reduced: for TDC14 = 0.15 Hz, peak at 238 ns; for TDC11 = 0.15 Hz, peak at 246.8 ns. Peak position didn't change.

B.b. Distance influence on the BKG correlation in time.

Run 3421. U(NaI(Tl)) = -1050 V, CFD thresh(NaI(Tl)) = -14 mV, U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -5 mV. DAQ trigger rate = 17.0 Hz. Zero time measurement run. NaI is under 2" of lead shield. Lead shield restored to the full 2" of lead in the front part of the plastic scintillator. The distance between NaI and plastic scintillator was ~54 cm. BKG run.

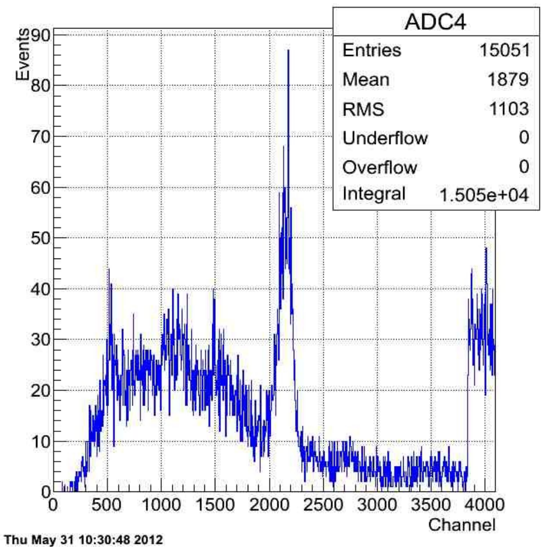

Fig. 13. ADC spectrum of BKG.

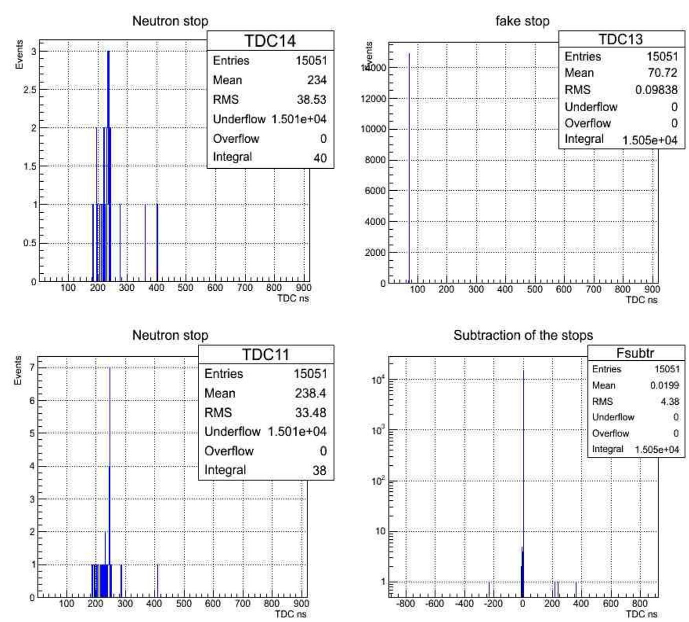

Fig. 14. TDC spectrum. Unzoomed.

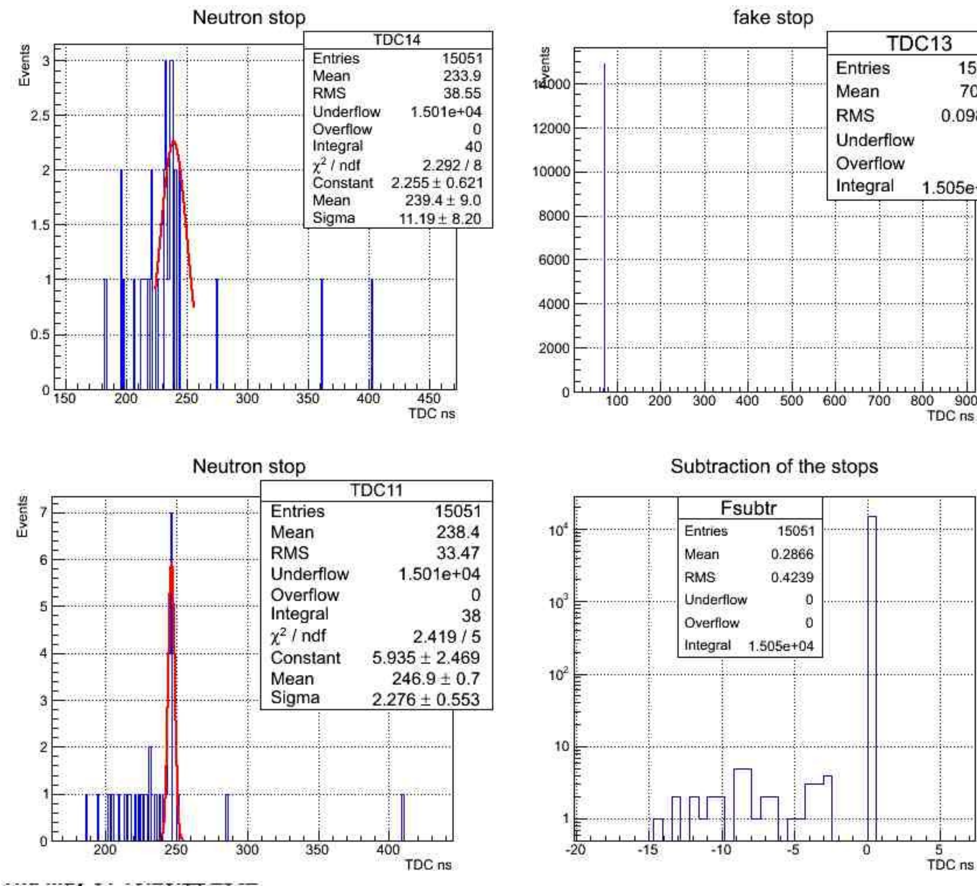

Fig. 14a. TDC spectrum. Zoomed.

After NaI detector was moved twice far away from the neutron detector the time position didn't change much: for TDC14 peak is at ~239 ns; for TDC11 peak is at 246.9 ns (low statistics though).

We can conclude that the BKG correlation intensity is related to the NaI detector shielding.

C. Efficiency measurement.

C.a. BKG measurement.

Run 3422. U(NaI(Tl)) = -1020 V, CFD thresh(NaI(Tl)) = -50 mV, 50 Ohm signal splitter is in NaI signal channel. U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -1 mV. DAQ trigger rate = 1.0063 Hz. BKG measurement run. NaI(Tl) was inside of the shielding on the lower shelf. From the side where the source is suppose to be was 2" of borated polyethylene. There was 2" of lead above on the upper shelf. Big plastic detector was shielded with 2" of lead in front. Both veto detectors in DAQ

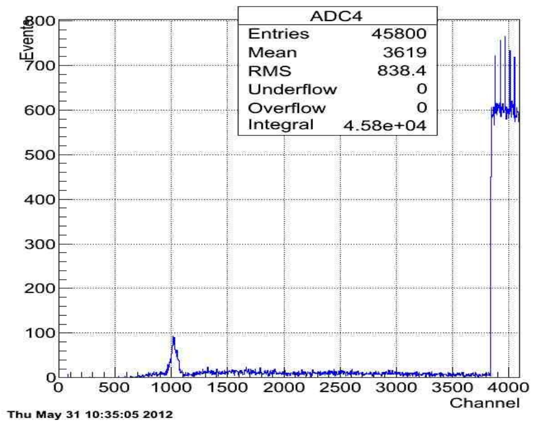

Fig. 15. ADC BKG spectrum.

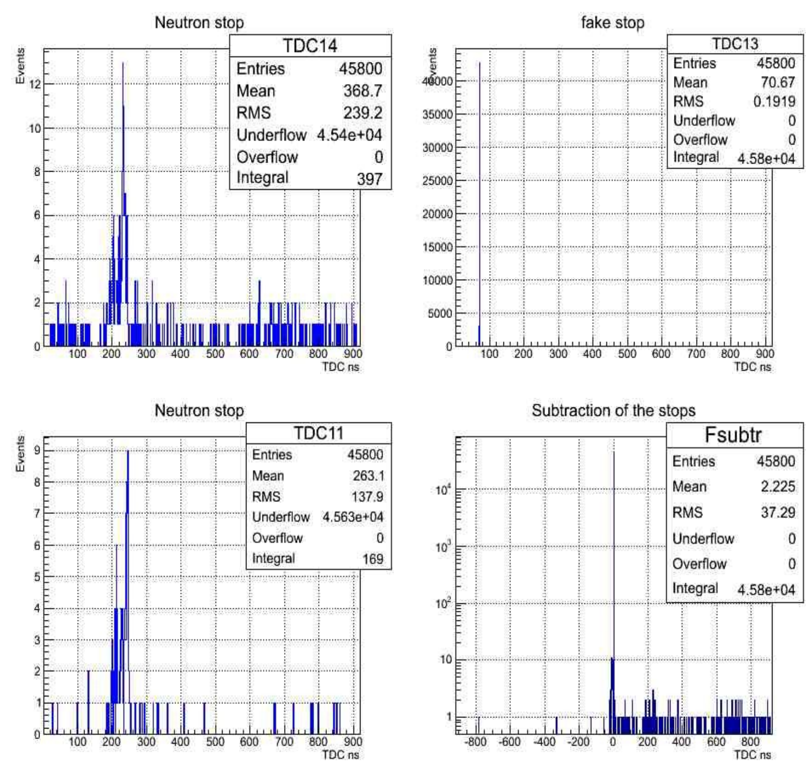

Fig. 16. TDC spectrum. Unzoomed.

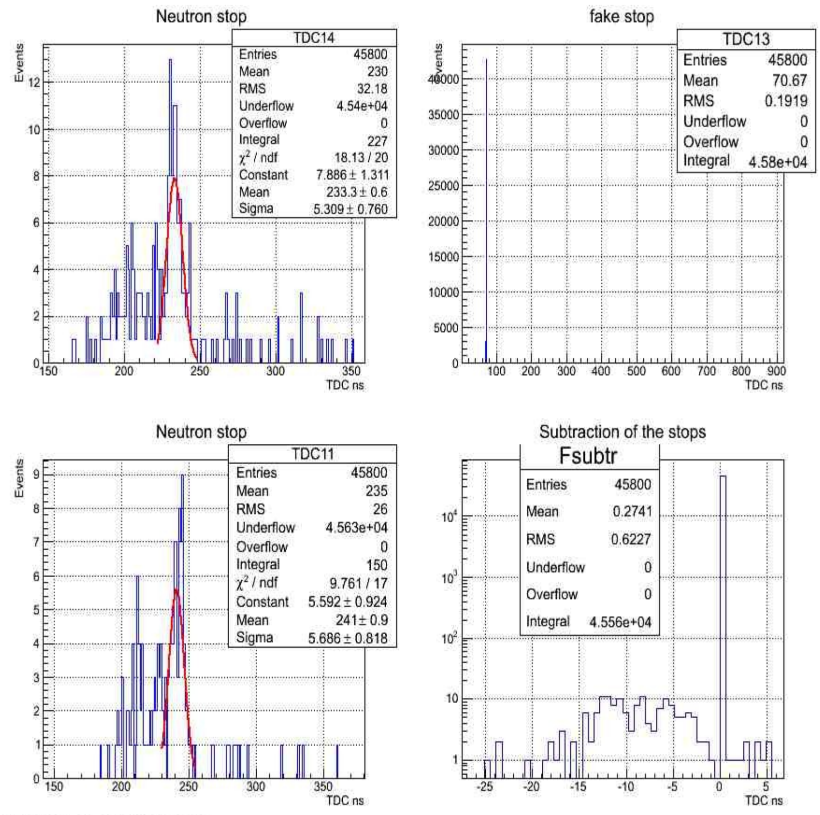

Fig. 16a. TDC spectrum. Zoomed.

The BKG counting rate for TDC14 is ~227/45513=0.005 Hz. The BKG counting rate for TDC11 is ~150/45513=0.003 Hz. It was the worst case when CFD threshold = - 1 mV.

Cb. Efficiency measurement using Cf-252 source.

Run 3423. U(NaI(Tl)) = -1020 V, CFD thresh(NaI(Tl)) = -50 mV, 50 Ohm signal splitter is in NaI signal channel. U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -1 mV. DAQ trigger rate = 45.9 Hz. Cf-252 source in. NaI(Tl) was inside of the shielding on the lower shelf. From the side where the source is suppose to be was 2" of borated polyethylene. There was 2" of lead above on the upper shelf. Big plastic detector was shielded with 2" of lead in front. Both veto detectors in DAQ.

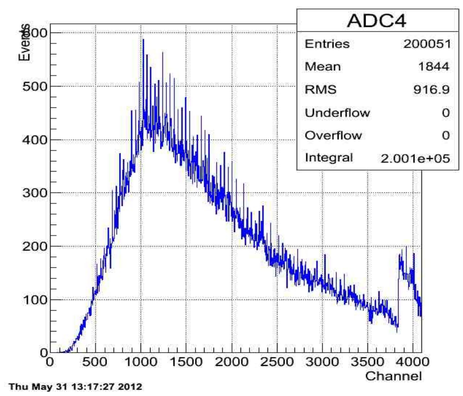

Fig. 17. ADC Cf-252 spectrum.

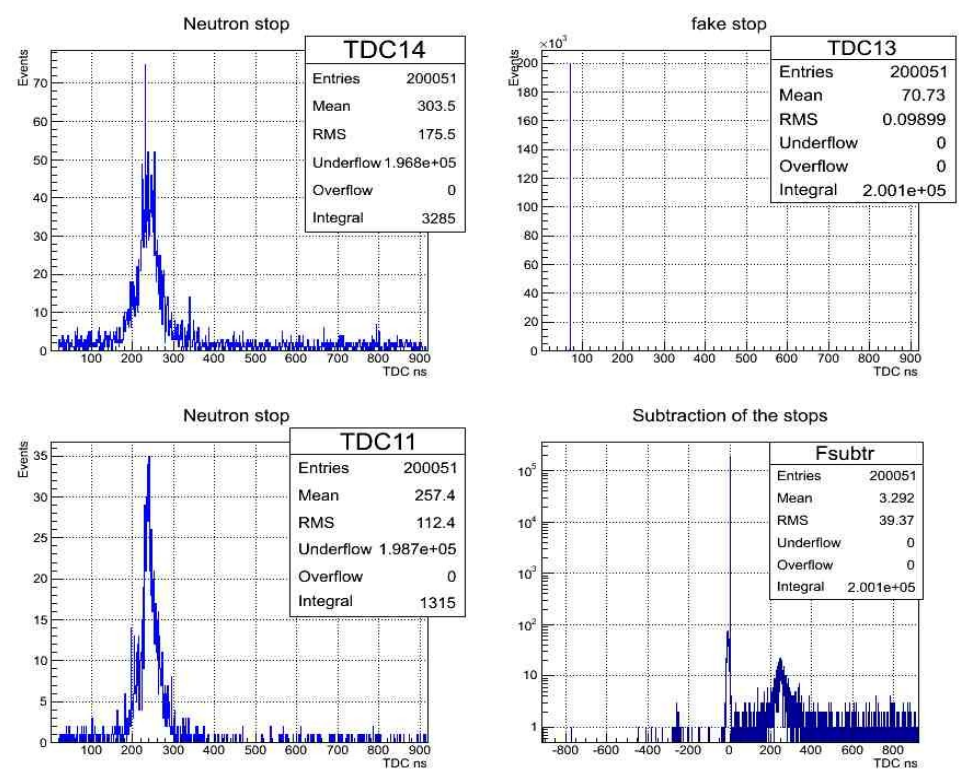

Fig. 18. TDC spectrum. Unzoomed.

In Fig. 18 on the “Subtraction of the stops” it can be seen the TDC distribution around 200 ns. This are the events that didn't find a corresponding events in the opposite channel of the neutron detector.

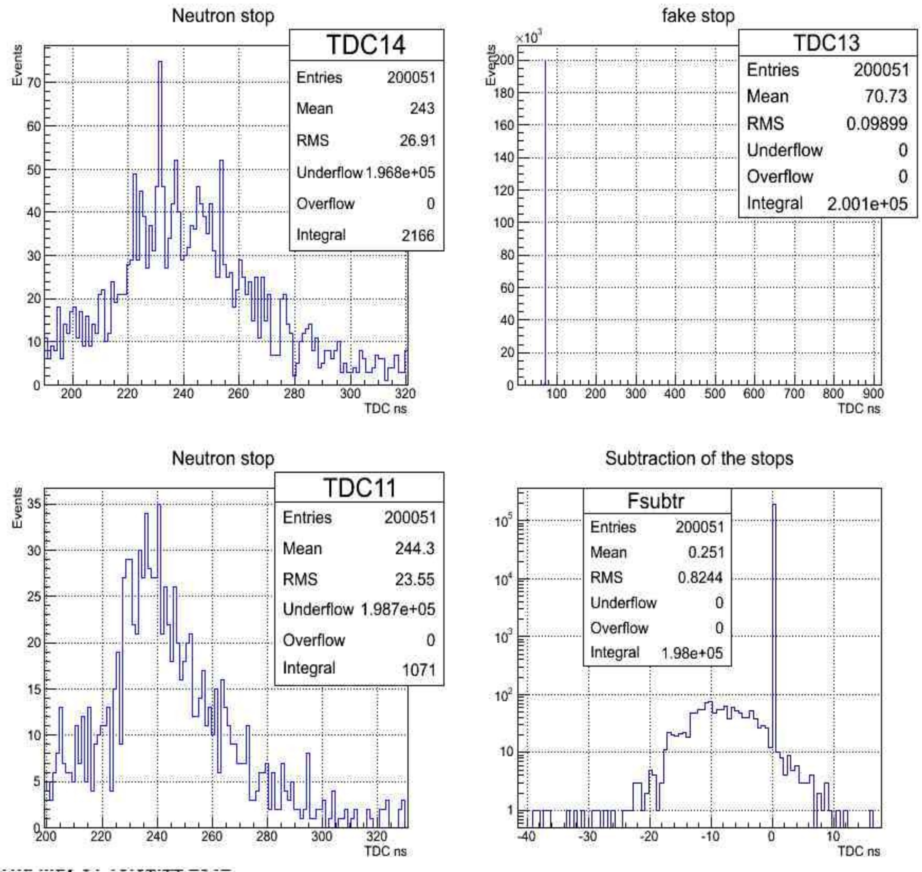

Fig. 18a. TDC spectrum. Zoomed.

According to Fig. 18A, TDC14 got 2166 neutrons (21 of those were BKG) in the time region 190-320 ns and TDC11 got 1071 neutrons (13 of those were BKG) in the time region 200-330 ns.

Below the plots of ADC and TDC distributions for runs with different CFD thresholds are presented.

All the data are presented in the table at the end of the paper.

Run 3427. U(NaI(Tl)) = -1020 V, CFD thresh(NaI(Tl)) = -50 mV, 50 Ohm signal splitter is in NaI signal channel. U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -2 mV. DAQ trigger rate = 44.5 Hz. Cf-252 source in. NaI(Tl) was inside of the shielding on the lower shelf. From the side where the source is suppose to be was 2" of borated polyethylene. There was 2" of lead above on the upper shelf. Big plastic detector was shielded with 2" of lead in front. Both veto detectors in DAQ.

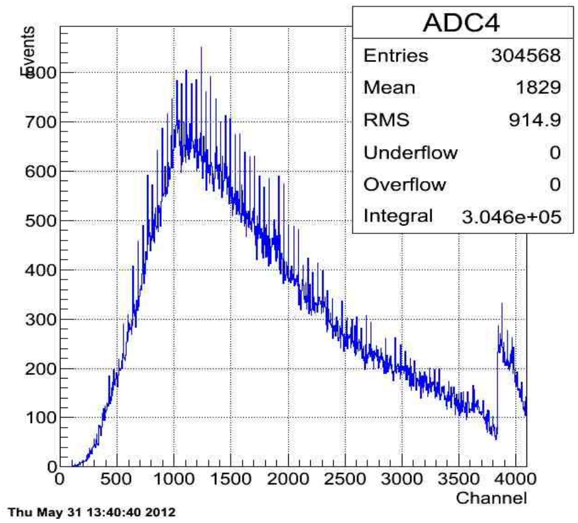

Fig. 19. ADC Cf-252 spectrum.

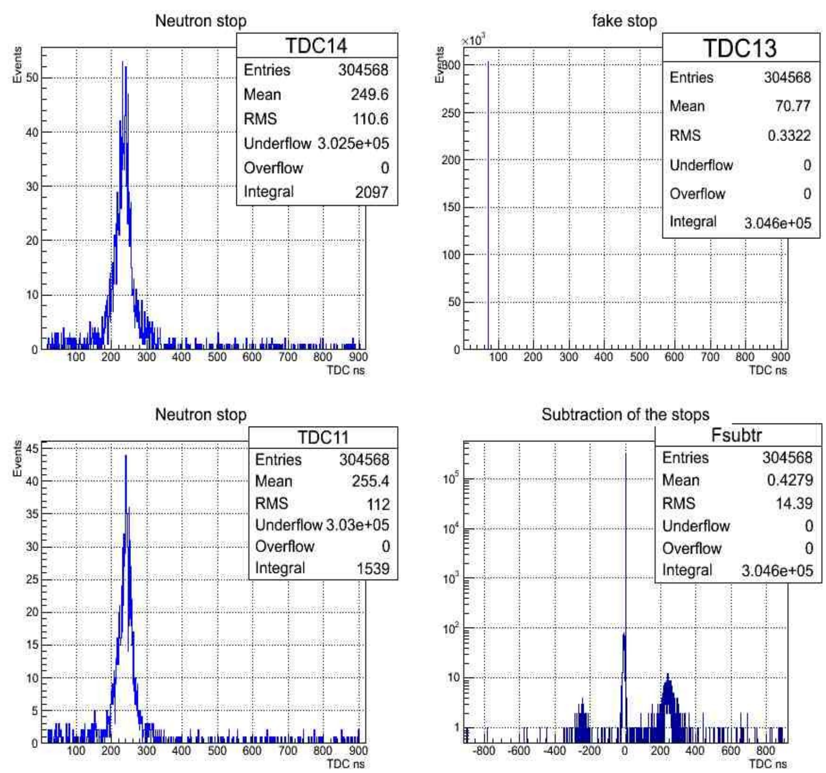

Fig. 20. TDC spectrum. Unzoomed.

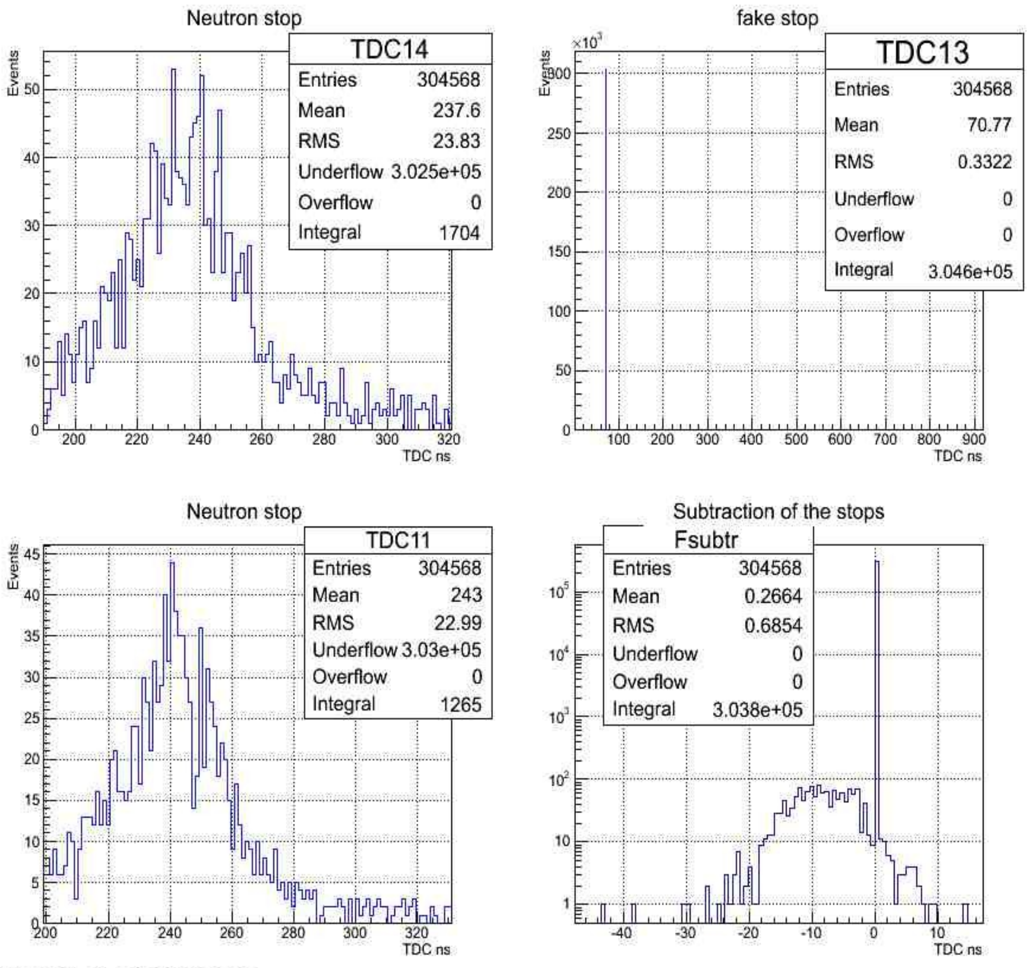

Fig. 20a. TDC spectrum. Zoomed.

Run 3428. U(NaI(Tl)) = -1020 V, CFD thresh(NaI(Tl)) = -50 mV, 50 Ohm signal splitter is in NaI signal channel. U(E1,E2) = -1250 V, CFD thresh(E1,E2) = -3 mV. DAQ trigger rate = 44.5 Hz. Cf-252 source in. NaI(Tl) was inside of the shielding on the lower shelf. From the side where the source is suppose to be was 2" of borated polyethylene. There was 2" of lead above on the upper shelf. Big plastic detector was shielded with 2" of lead in front. Both veto detectors in DAQ.

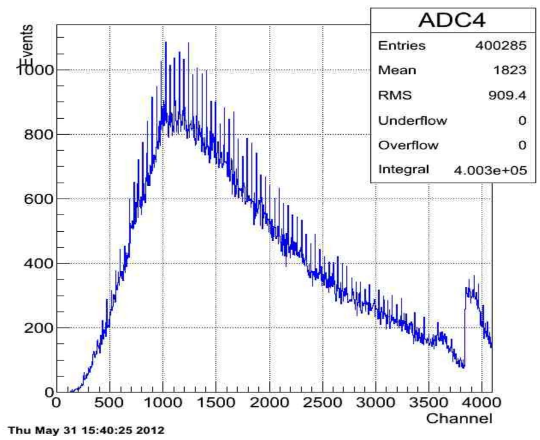

Fig. 21. ADC Cf-252 spectrum.

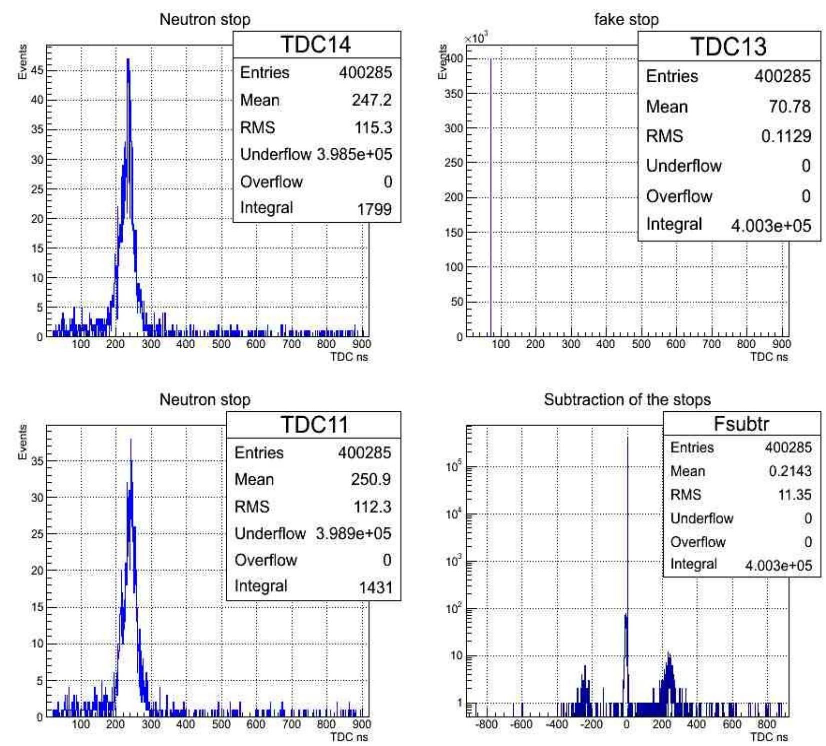

Fig. 22. TDC spectrum. Unzoomed.

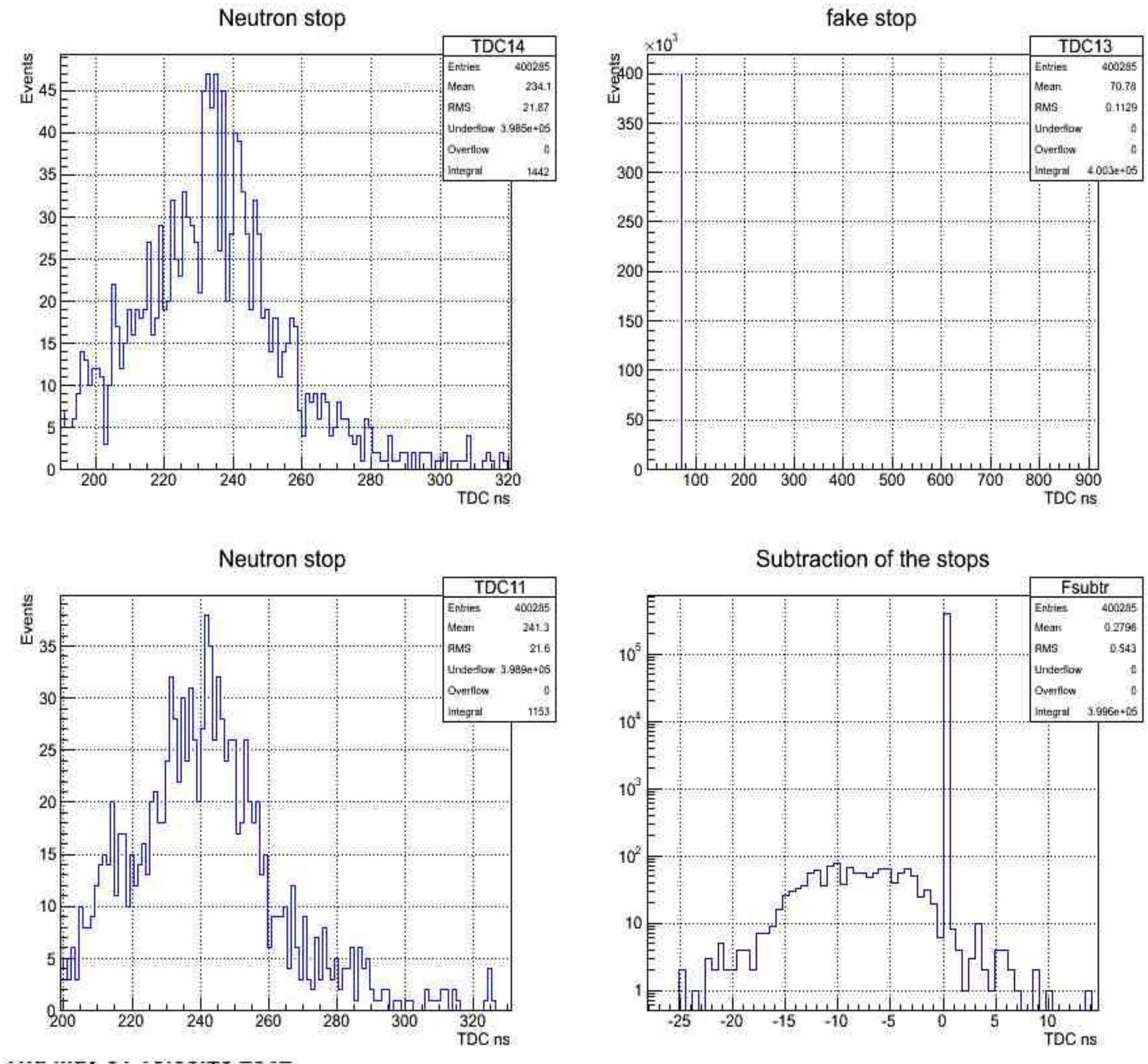

Fig. 22a. TDC spectrum. Zoomed.

Summary Table:

run#	Channel	CFD th, mV	N_trig	N_n (#BKG evt)	Run time, sec	Eff, %	delta_Eff,%
3423/3429	TDC14 (190ns-320ns)	-1	200051/ 200116	2166(21.7)/ 1960(22.6)	4358.4/ 4537.7	16.85/15.24	0.023/0.022
	TDC11 (200ns-330ns)			1071(13.07)/ 1145(13.61)		8.33/8.9	0.0164/0.017
3427	TDC14 (190ns-320ns)	-2	304568	1704(34.2)	6844.22	8.7	0.01
	TDC11 (200ns-330ns)			1265(20.53)		6.46	0.012
3428	TDC14 (190ns-320ns)	-3	400285	1441(44.9)	8995.16	5.6	0.01
	TDC11 (200ns-330ns)			1153(26.98)		4.48	0.0085
3430	TDC14 (190ns-320ns)	-4	835526	1948(95.86)	19172.23	3.63	0.0053
	TDC11 (200ns-330ns)			1690 (57.51)		3.15	0.0049
3435	TDC14 (190ns-320ns)	-6	580055	717(61.68)	12336.34	1.92	0.0046
	TDC11 (200ns-330ns)			682(37.01)		1.83	0.0045