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ФИАН

Fast and thermal neutron scattering and absorption by structural materials of neutron detectors

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Introduction

It is important to choose structural materials for its parts when creating a neutron detector. Gaseous detectors have advantages over detectors based on scintillation detectors because of they have low sensitivity to photons. Usually tube counters filled by ^{3}He or $^{10}BF_3$ gas are used. Scintillation detector contains ^{6}Li isotope as converting material. A gaseous detector efficiency is significantly grater than scintillation one because of the cross section of the interaction of neutrons with ^{3}He and ^{10}B nuclei is higher than the cross section for ^{6}Li.

Scintillation detector also causes a large scattering of neutrons due to the large density of the substance. Scattering of neutrons distorts the measured neutron field and reduces flux from the source. The activation of structural material nuclei leads to an excitation of the detector in the absence of neutrons. The neutron absorption reduce the flux. Gas-filled detectors are being replaced by detectors based on a 10B solid layer and gaseous chamber.

S. Potashev, A. Drachev, Yu. Burmistrov, S. Karaevsky et al. Hybrid boron-10 gaseous detector for slow and fast neutron simultaneous detection. EPJ Web of Conf. V.231, P.05010 (2020).

Substances for converting neutrons

The following table lists the parameters of the most commonly used nuclei for converting neutrons to charged nuclei.

Nucleus	Content, %	Thermal cross section, b	Outgoing nuclei	Reaction energy, MeV
^{3}He	0,0137	5730	^{1}H, ^{3}H	0,78376
^{6}Li	7,5	739	^{3}H, ^{4}He	4,78
^{10}B	19,97	3839	^{4}He, ^{7}Li	2,79

^{3}He in detectors is used in a gas mixture with CF_4 at a pressure from 3 to 8 bar. Thermal neutron efficiency reaches 70%. The ^{6}Li nucleus in scintillation detectors is introduced as LiF into the scintillator no more than 6% to keep transparency. The efficiency is about 30%. ^{10}B is used as $^{10}BF_3$ gas at a pressure of 0.24 bar. The efficiency does not exceed 10%. Also ^{10}B can be as a solid layer and proportional chamber. Efficiency 2 - 3% can be increased due to the large number of detector layers.

Constructive substances

The following table lists the parameters of constructive substance.

	%	погл ощ	расс еив	кг\.куб.м.
C 12	98,89	3,8	4,8	1,98
N 14	99,63	1,88	10	
O 16	99,76	0,000 2	4,2	
Al 27	100	241	1,4	2,7
Si 28	92,27	0,16	1,7	2,42
Ar 40	99,6	0,61	1,5	
F 19	100	0,01	3,9	
Fe 56	91,68	2,7	11	7,87
Cr 52	83,76	3,1	3	7,19
Ni 58	67,76	4,6	17,5	8,7
Cu 63	69,1	3,85	7,2	8,93

Reduction by constructive substances

Nucleus	H , cm	Reduction %
Si(SiO2)	0,19	1,82
O(SiO2)	0,19	13,53
Si	0,035	0,34
Al	0,3	2,50
Ar	0,4	0,05
F(LiF)	0,3	3,65
Ni(NiCrAl)	0,1	18,09

It can be seen from the table that the content of O, Ni and F leads to a large scattering of neutrons making the background. At the same time, the preferred materials are gases, Si and Al. Ni is contained in the walls of stainless steel tube gaseous counters.

Summary and conclusions

Oxigen, Nickel and Fluorine leads to a large scattering of neutrons making the background.

Preferred materials are gases, Silicium and Aluminum