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EFFICIENCY AND ENERGY RESOLUTION CALCULATION UNDER DEVELOPING OF FAST NEUTRON DETECTOR WITH BORON-10 CONVERTER

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Operational neutron detector with ^{10}B converter

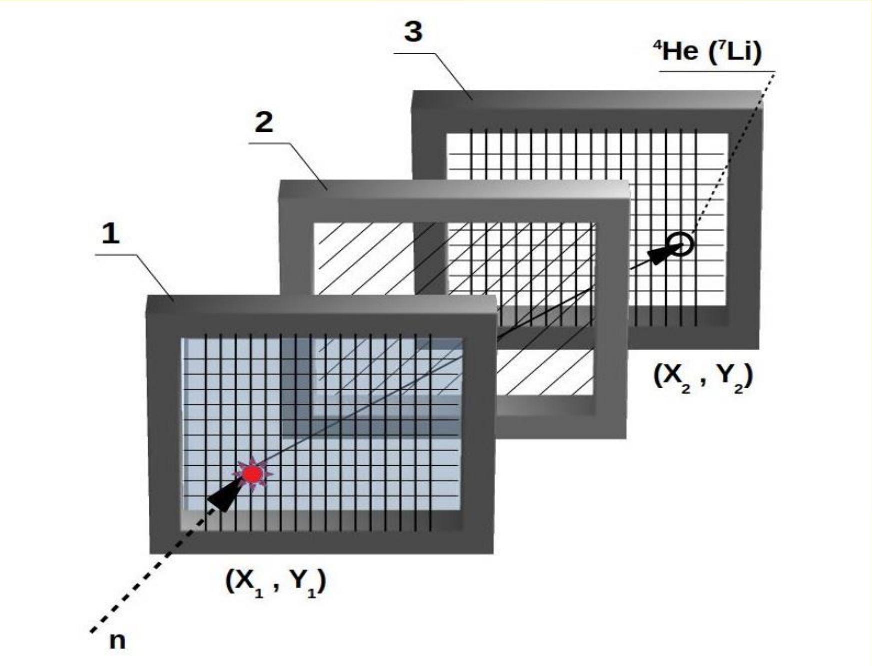
S. Potashev, A. Drachev, Yu. Burmistrov, S. Karaevsky, A. Kasparov, V. Ponomarev, and G, Solodukhov. Hybrid boron-10 gaseous detector for slow and fast neutron simultaneous detection. EPJ Web of Conferences 231, 05010 (2020) UCANS-8

Advantages:

1. Extremely low sensitivity to photons (gamma and X-ray quanta)
2. Almost does not distort the measured neutron field
3. Sensitivity to fast neutrons in the energy range of several MeV
4. High sensitivity to a directed neutron flux
5. Can operate at high fluxes of fast neutrons

It's impossible to determine the initial neutron energy due to the uncertainty in the angle of emission of a ^{4}He or ^{7}Li nucleus from a nuclear reaction

Fast neutron detector under development with ^{10}B converter



1. Surface with a ^{10}B layer and a wire cathode for measuring the coordinates of the starting point of the nucleus track
2. Anode
3. Wire cathode for measuring the coordinates of the finishing point of a nucleus track

Reaction: $n + {}^{10}B \rightarrow {}^{4}He + {}^{7}Li$

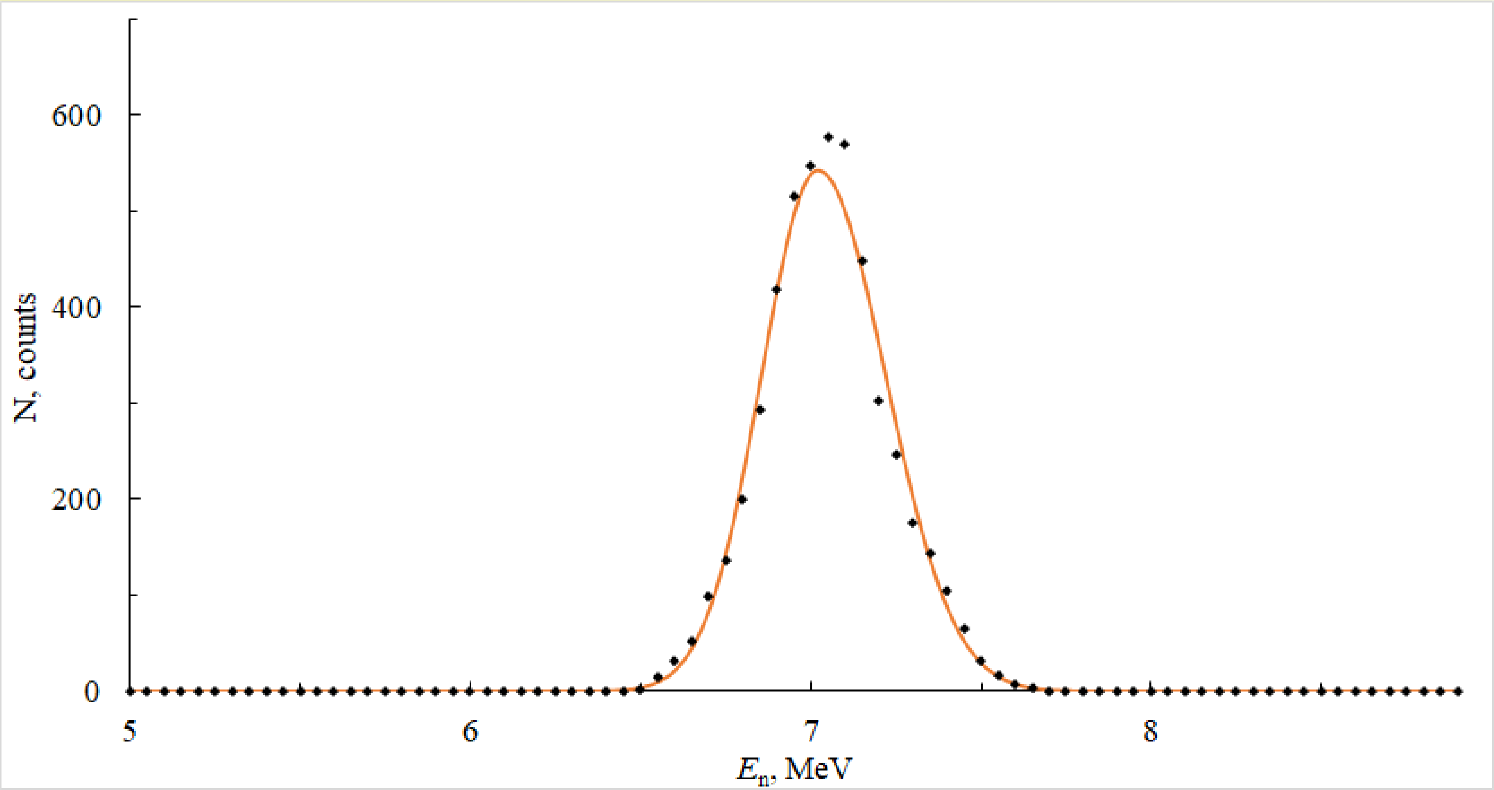
The error in determining the emission angle is ~ 5.7°

The simulation results of $n + {}^{10}B \rightarrow {}^{4}He + {}^{7}Li$ reaction

E_n, MeV	Cross-section, barn	^{10}B thickness, cm	Reaction efficiency	^{4}He particle efficiency	^{7}Li particle efficiency	^{4}He registration efficiency	^{7}Li registration efficiency
0.5	0.886	0.0003	$4.35 \cdot 10^{-6}$	0	0	0	0
1	0.1797	0.0003	$4.35 \cdot 10^{-6}$	0.003135	0	$2.36 \cdot 10^{-8}$	0
2	0.4513	0.0003	$1.89 \cdot 10^{-5}$	0.05646	0	$1.07 \cdot 10^{-6}$	0
3	0.3675	0.0003	$1.54 \cdot 10^{-5}$	0.15912	0	$2.45 \cdot 10^{-6}$	0
4	0.2959	0.0003	$1.24 \cdot 10^{-5}$	0.282535	0	$3.51 \cdot 10^{-6}$	0
5	0.10369	0.0003	$4.35 \cdot 10^{-6}$	0.36597	0.00004	$1.59 \cdot 10^{-6}$	$1.74 \cdot 10^{-10}$
6	0.1257	0.0003	$5.27 \cdot 10^{-6}$	0.40674	0.001635	$2.14 \cdot 10^{-6}$	$8.62 \cdot 10^{-9}$
7	0.11405	0.0003	$4.78 \cdot 10^{-6}$	0.43189	0.00543	$2.07 \cdot 10^{-6}$	$2.59 \cdot 10^{-8}$
8	0.079	0.0003	$3.31 \cdot 10^{-6}$	0.447845	0.012345	$1.48 \cdot 10^{-6}$	$4.09 \cdot 10^{-8}$
9	0.051	0.0003	$2.14 \cdot 10^{-6}$	0.458705	0.021275	$9.81 \cdot 10^{-7}$	$4.55 \cdot 10^{-8}$

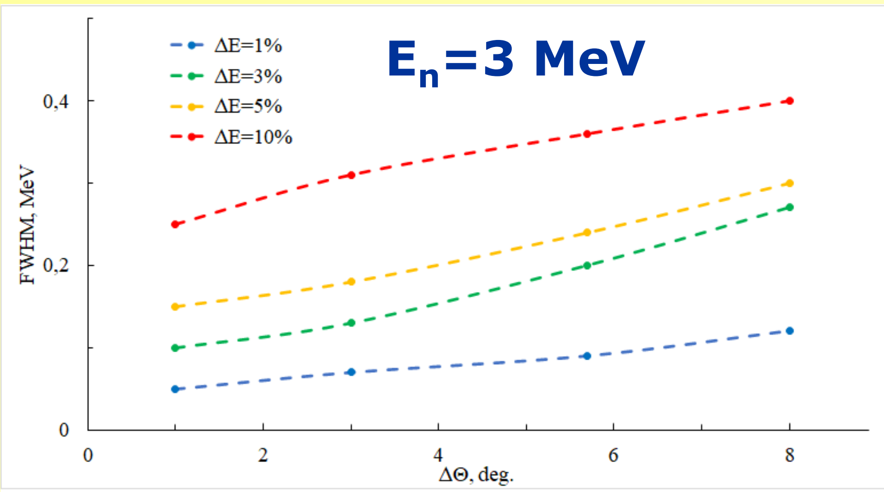
Low registration efficiency of ^{4}He particles ($\sim 10^{-6}$) and ^{7}Li particles ($\sim 10^{-8}$) will be useful for registration high fluxes $>10^{7}$ neutrons/($cm^{2} \cdot s$)

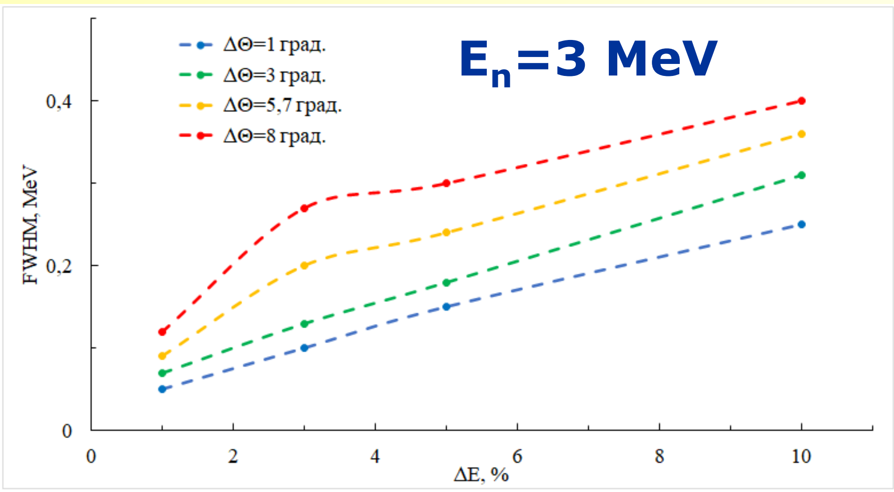
Recovery of neutron energy

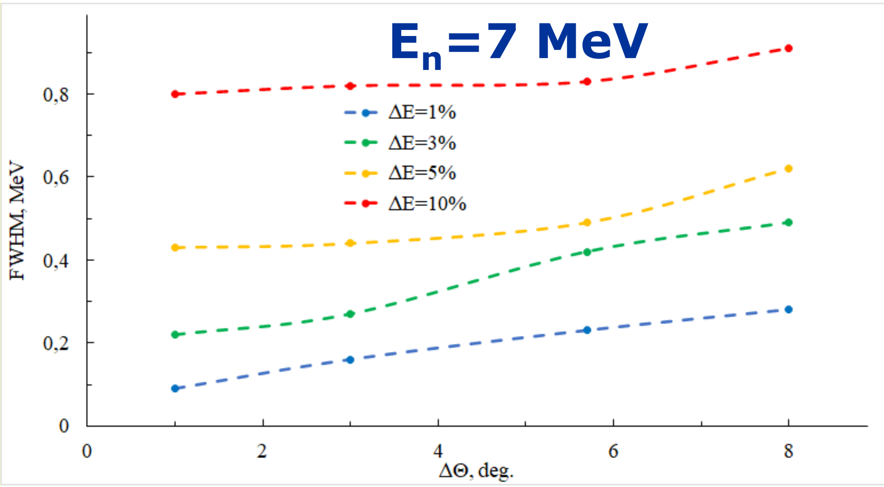


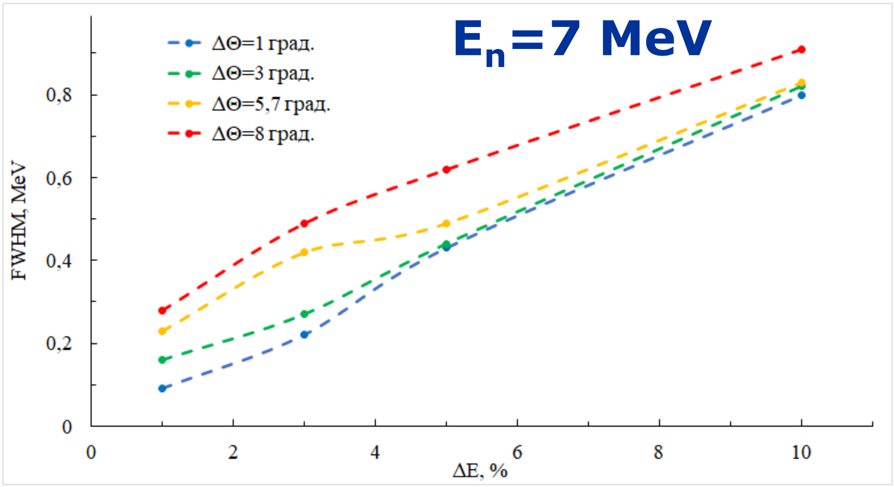
Simulation parameters: E_n=7 MeV; ΔΘ=5.7º; ΔE=3%
FWHM ~ 0.42 MeV

Dependence of FWHM on angular and energy resolution of the detector

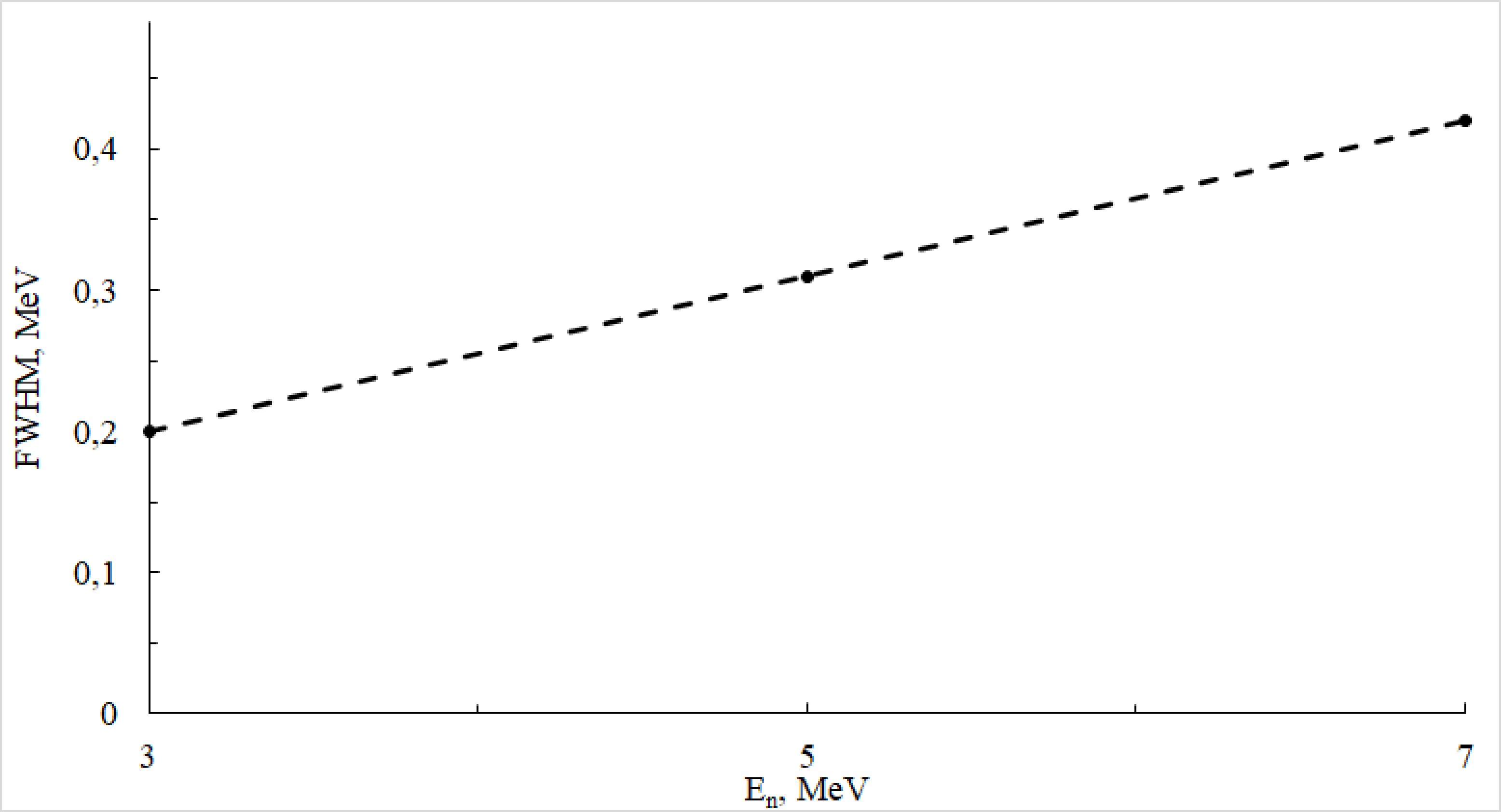








Dependence of FWHM on the incident neutron energy



The energy resolution is about 6% for each of the three energies

Summary and conclusions

- Fast neutron detector (>1 MeV)
- Detector with low detection efficiency of secondary ^{4}He and ^{7}Li nuclei
- Detector for registration high fluxes >10^{7} neutrons / ($cm^{2}\cdot s$)
- The energy resolution of the detector in terms of neutron energy is estimated to be ~ 6% and weakly depends on the neutron energy (in the energy range 1 - 9 MeV)
- Multi-channel position-sensitive detector (it's possible to watch the two-dimensional distribution of neutrons at the energy of interest
- Depending on the type of detected particle, it's possible to recover the energy of an incident neutron in two ranges, in the region of different ranges (>1 MeV for ^{4}He; >5 MeV for ^{7}Li)

Thank you!