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TEST SETUP FOR REGISTRATION OF COINSIDENT SIGNALS FROM REACTIONS WITH THE EMISSION OF CHARGED PARTICLES AND NEUTRONS ON THE RADEX CHANNEL

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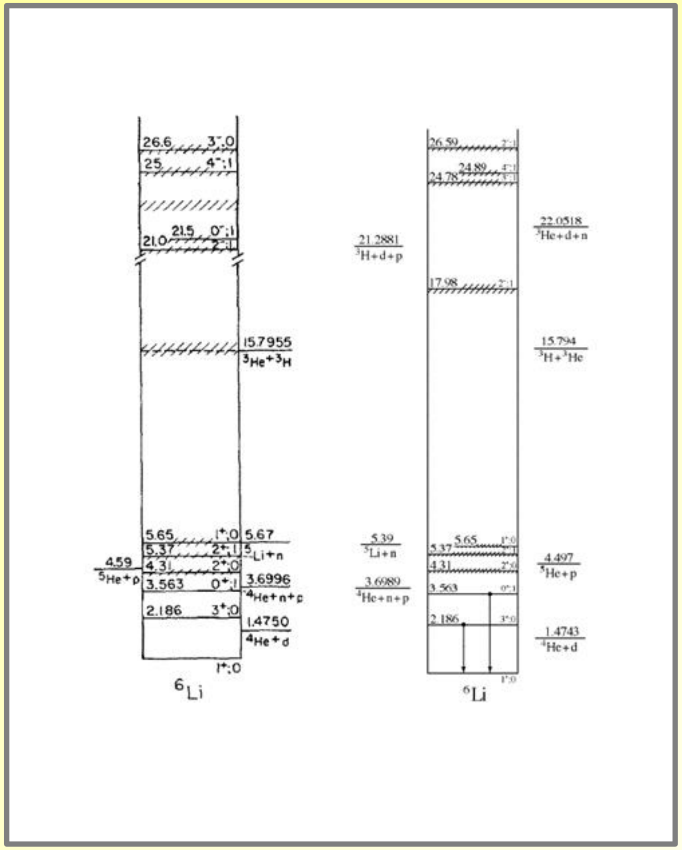
INR RAS 2021

Energy levels of ^{6}Li nuclei



Energy levels of ^{6}Li as compiled by Ajzenberg-Selove (left) and Tilley (right)

Spectroscopic information on the lower levels of the ^{6}Li nucleus is known with sufficient accuracy, while the data on the structure of excited states, especially the data on the structure, energies, and widths of highly excited states, are still rather contradictory.

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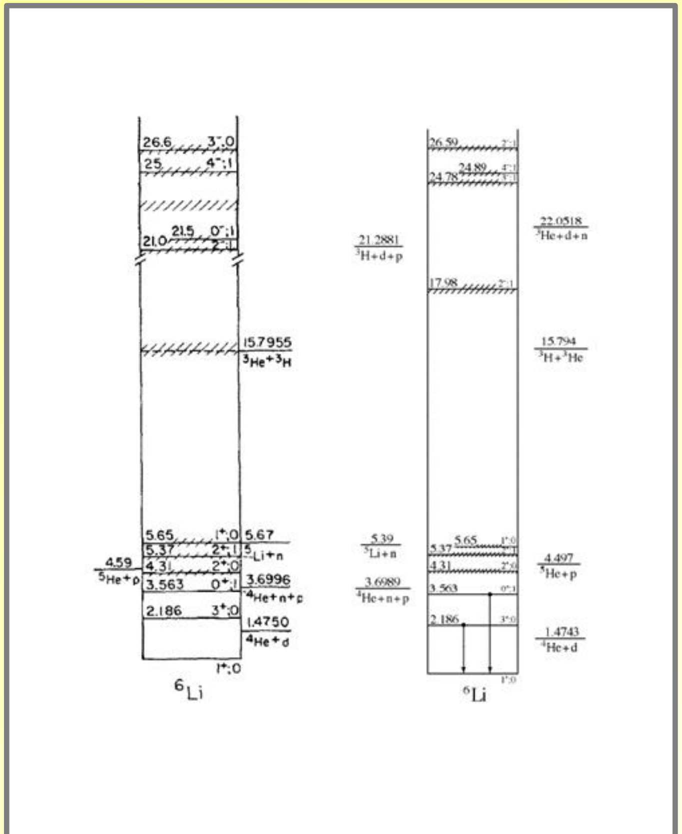

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Further study of the structure of excited states of ^{6}Li in various reactions and using various methods is required.

Possible variants of the cluster structure of the ^{6}Li excited states

Cluster structure:	Reactions:
$\alpha + d$ (breakup energy -1.4743 MeV)	$n + {}^6\text{Li} \rightarrow n' + {}^6\text{Li}^* \rightarrow n' + \alpha + d$
$\alpha + n + p$ (breakup energy -3.6989 MeV)	$n + {}^6\text{Li} \rightarrow n' + {}^6\text{Li}^* \rightarrow n' + \alpha + n + p$
^{5}He + p (breakup energy -4.497 MeV)	$n + {}^6\text{Li} \rightarrow n' + {}^6\text{Li}^* \rightarrow n' + {}^5\text{He} + p \rightarrow n' + \alpha + n + p$
^{5}Li + n (breakup energy -5.39 MeV)	$n + {}^6\text{Li} \rightarrow n' + {}^6\text{Li}^* \rightarrow n' + {}^5\text{Li} + n \rightarrow n' + \alpha + p + n$
$t + \tau$ (breakup energy -15.7947 MeV)	$n + {}^6\text{Li} \rightarrow n' + {}^6\text{Li}^* \rightarrow n' + t + \tau$

The main idea:

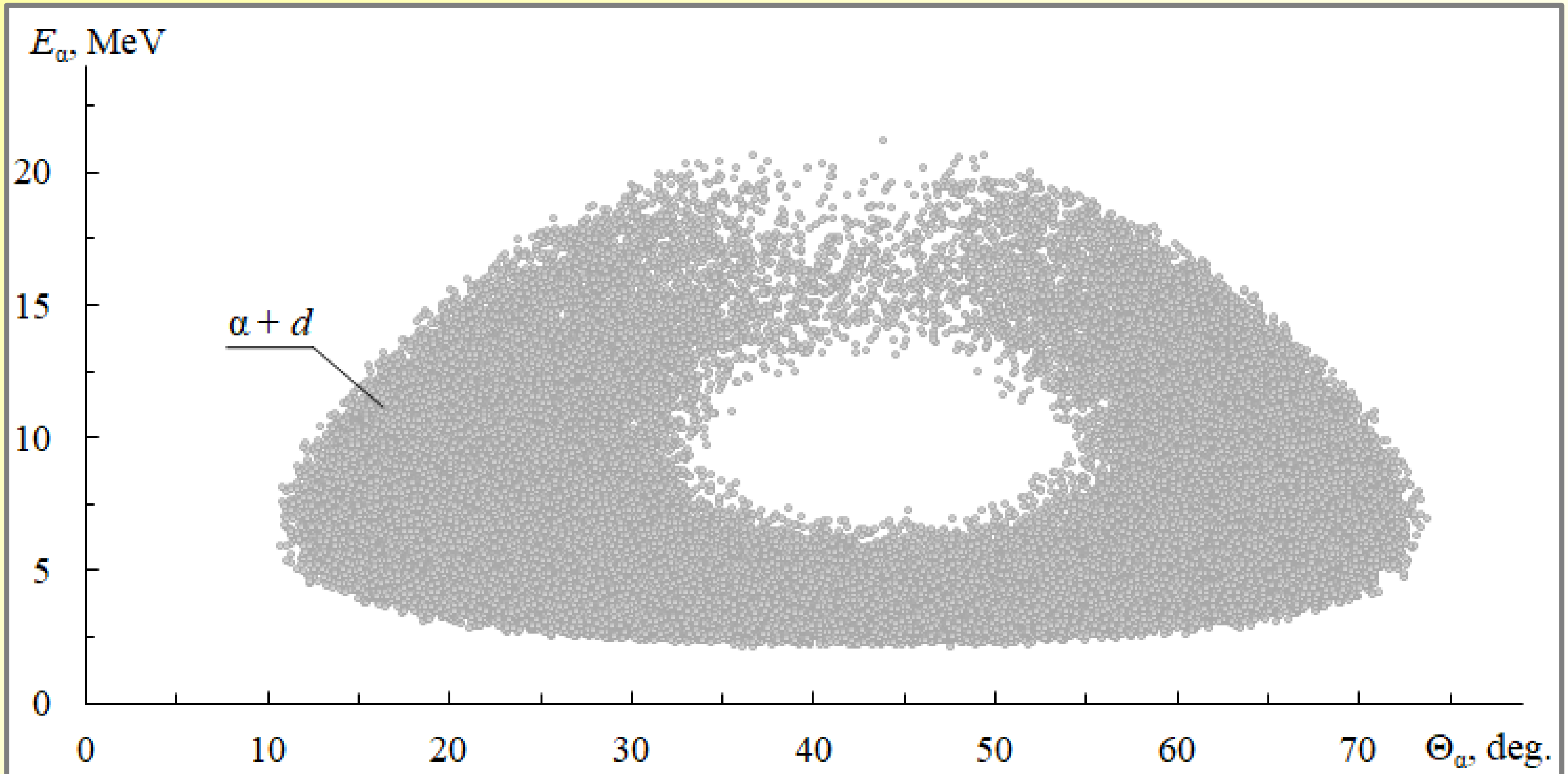
1). First, the neutron is inelastically scattered on the ^{6}Li nucleus, the ^{6}Li nucleus is excited, and then its subsequent breakup occurs.

2). By registering inelastically scattered neutrons on ^{6}Li nuclei in the coincidence with particles from the breakup of the excited state, we can distinguish kinematic areas of secondary particles corresponding to a certain breakup channel.

The simulation of the $n + {}^{6}\text{Li} \rightarrow n' + {}^{6}\text{Li}^{*}$ (5.65 MeV). Diagram E_α–Θ_α for breakup alpha-particles

Parameters:

$E_n = 60 \pm 1$ MeV; $\Theta_{n'} = 80° \pm 1°$; $\Theta_{n'} = 40.06 \pm 2.14$ MeV.



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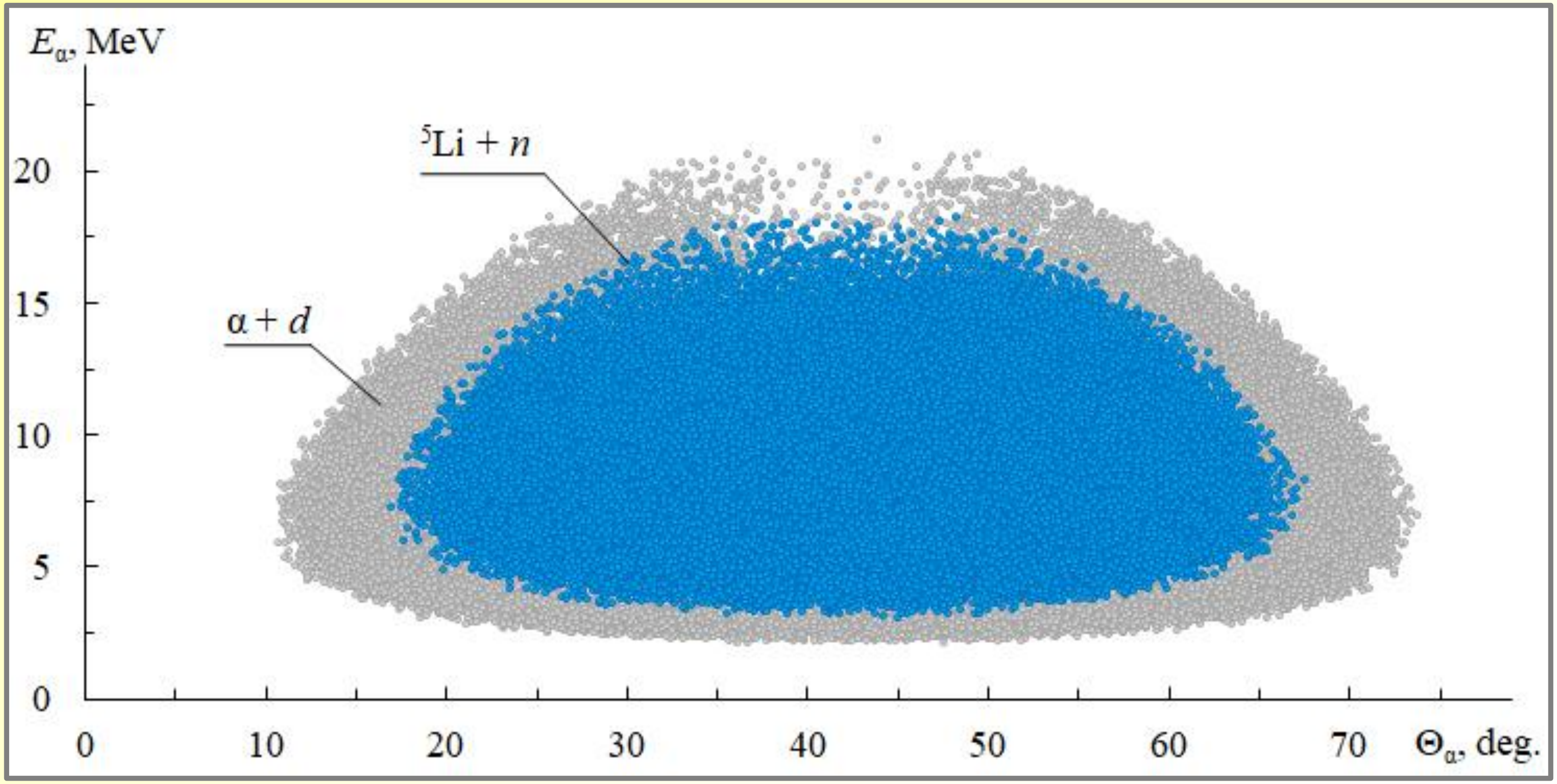

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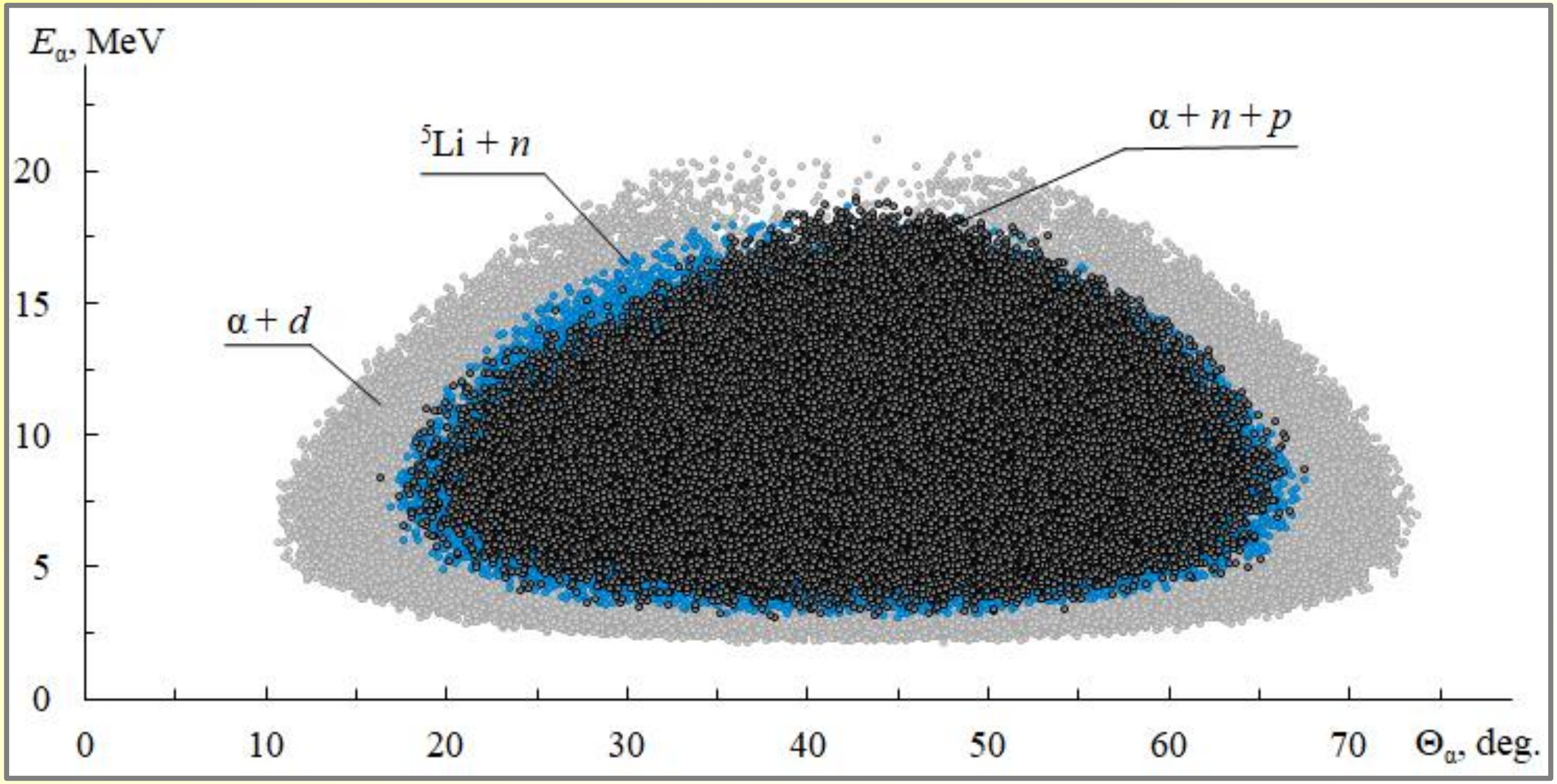

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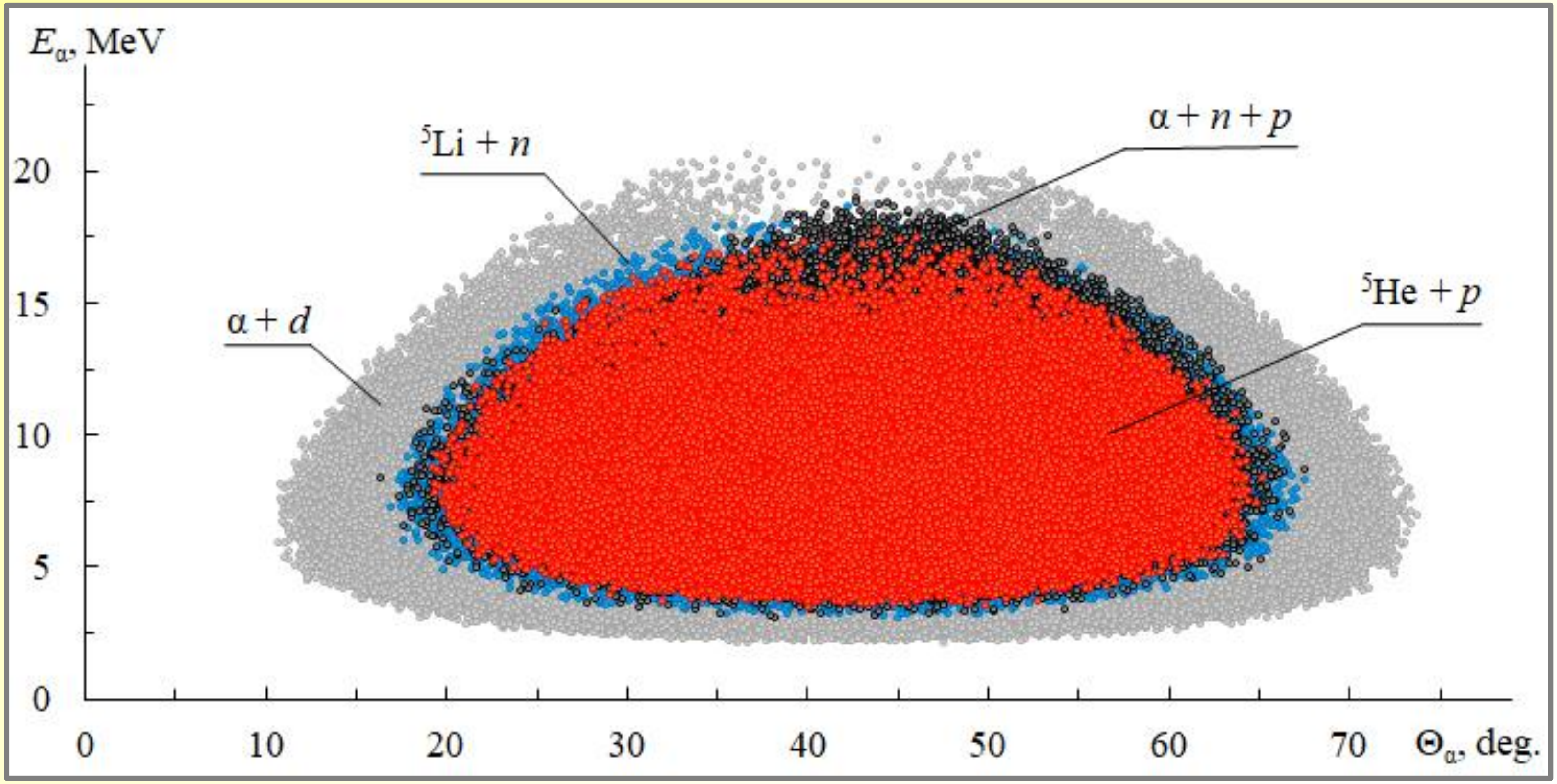
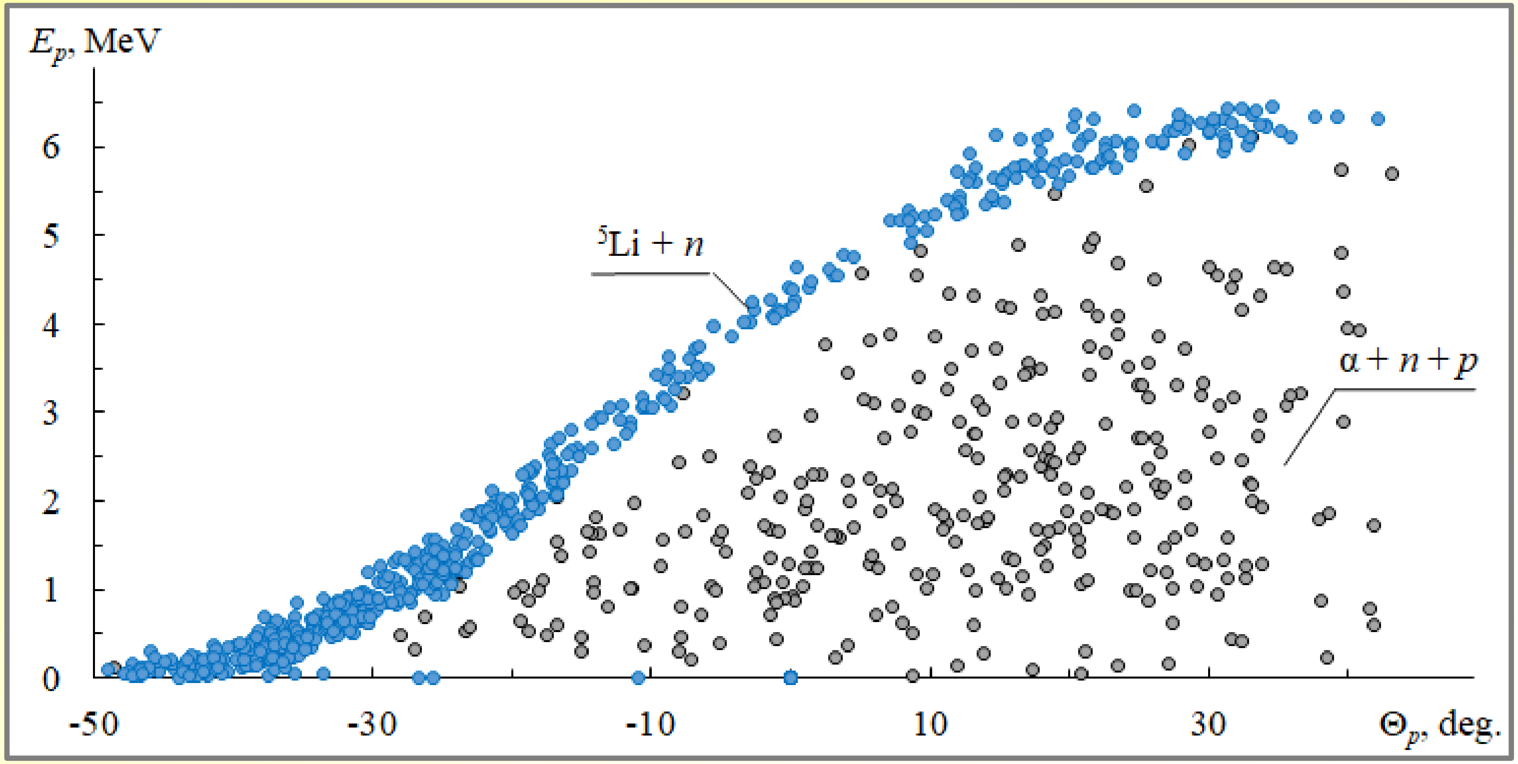


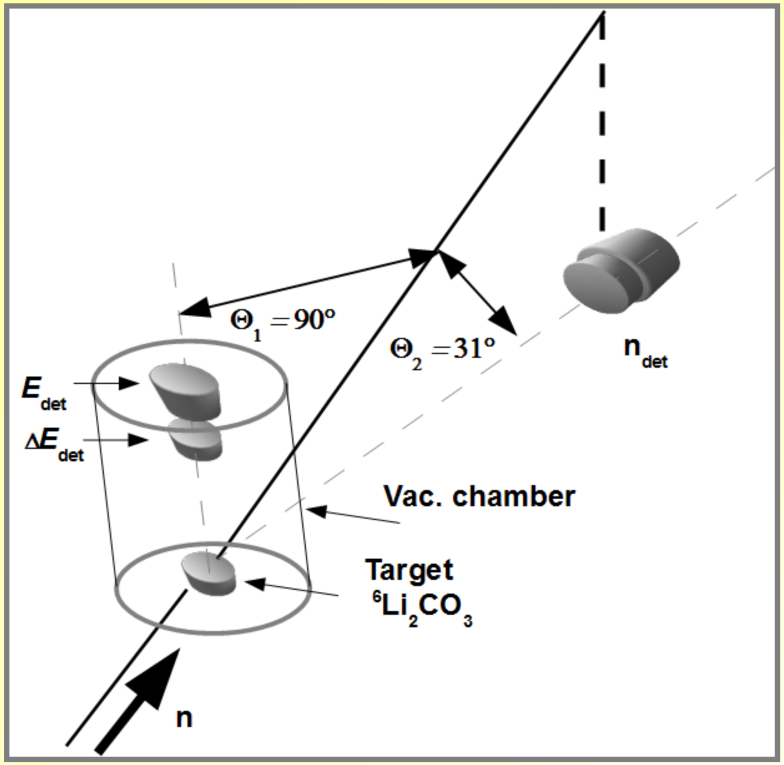
The simulation of the $n + {}^6\text{Li} \rightarrow n' + {}^6\text{Li}^*$ (5.65 MeV). Diagram E_p–Θ_p for breakup protons

Parameters:

$E_n = 60 \pm 1$ MeV; $\Theta_{n'} = 80° \pm 1°$; $\Theta_{n'} = 40.06 \pm 2.14$ MeV;
$\Theta_\alpha = -45° \pm 2°$; $\Theta_n = -55° \pm 2°$; $E_n > 8$ MeV.



Test setup for registration of coincident signals from the $n + {}^6\text{Li} \rightarrow n + \alpha + d$ reaction



Difficult conditions of the RADEX channel:

1) wide energy spectrum of RADEX channel neutrons incident on the target;

2) wide neutron beam with a diameter of ~50 mm;

3) presence of a large γ-background;

4) limitations in the operation of silicon detectors when irradiated with neutrons.

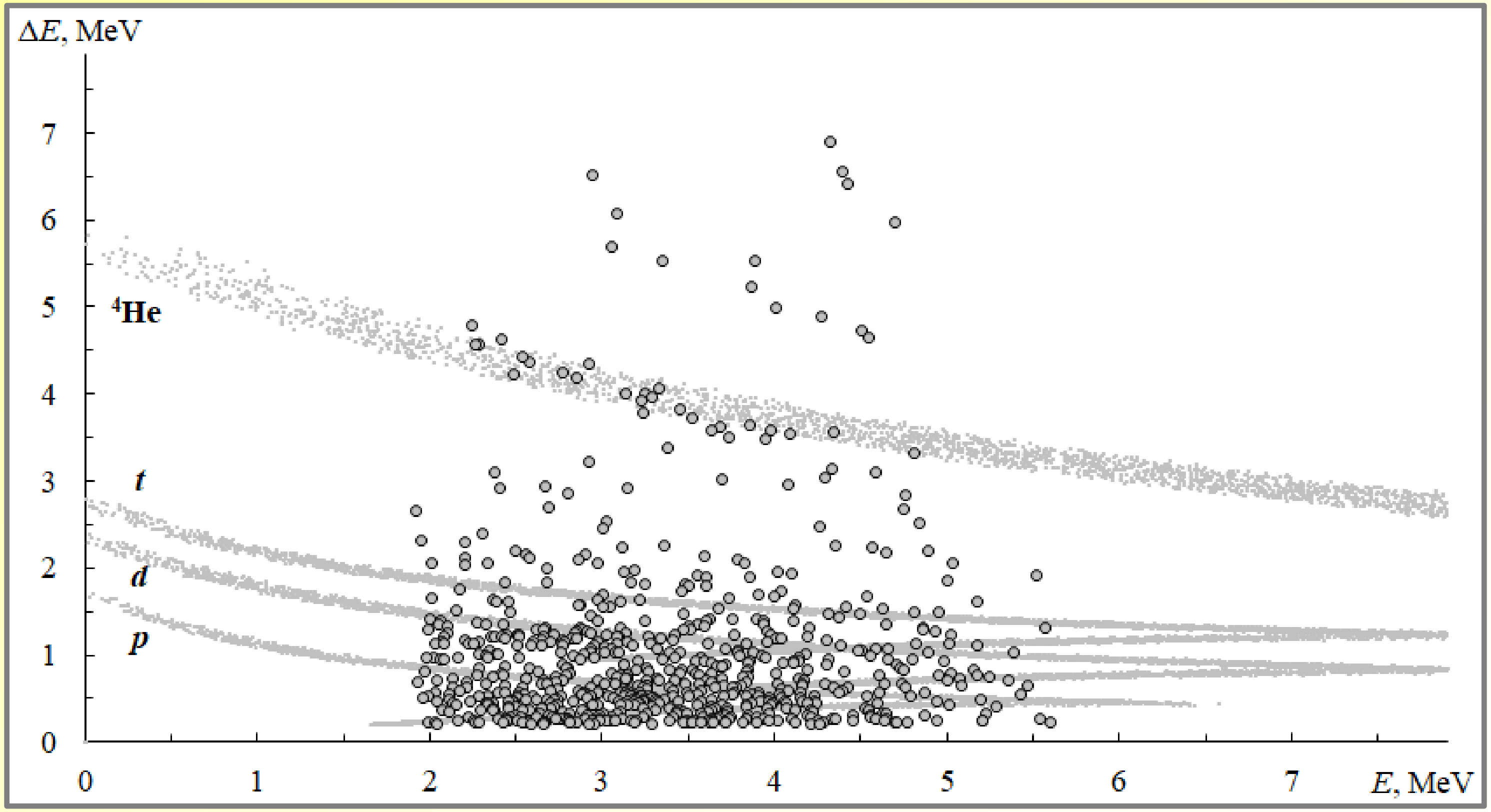
Main purpose of measurements:

1) registration in the coincident of neutrons and charged particles (α-particles);

2) the presence of peaks in the energy spectrum of α-particles corresponding to the breakup of the ground and excited states of the ^{6}Li nucleus

Experimental ΔE-E diagram.
Coincidence of signals from ΔE-, E- and neutron detectors

The diagram shows the calculated loci corresponding to *p*, *d*, *t* and ^{4}He.



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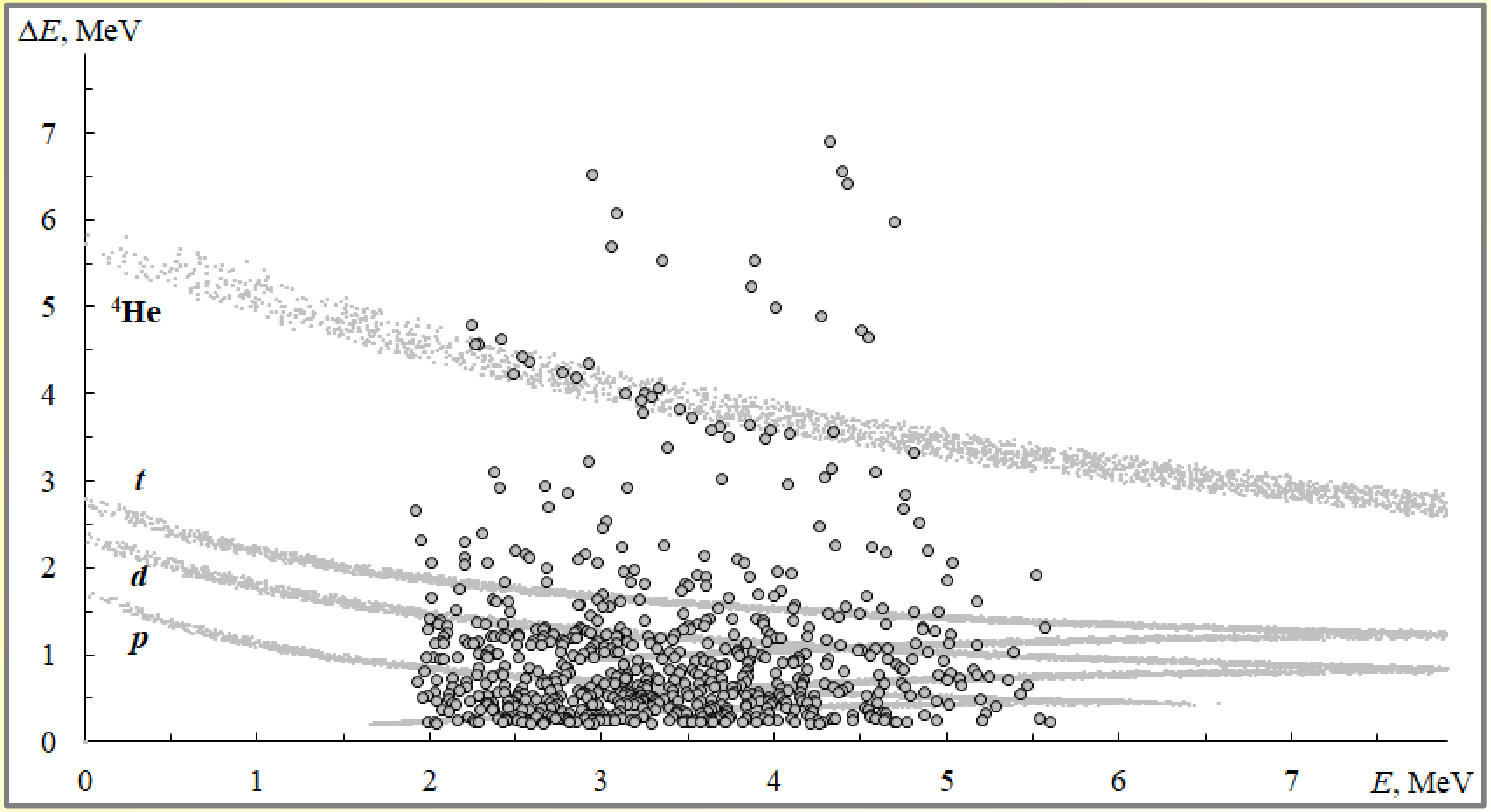

Test measurements were carried out for 30 min at a neutron flux of $\sim 10^7$ $cm^{-2} \cdot s^{-1}$.
At solid angles of charged particles and neutrons of $\sim 6 \cdot 10^{-3}$ sr and $\sim 2 \cdot 10^{-3}$ sr, respectively, the number of "useful" events was $\sim 1.8 \cdot 10^{-2} \cdot s^{-1}$.

Summary and conclusions

- a prototype of experimental setup for testing the registration possibility in the coincidence of charged particles and neutrons on the RADEX neutron channel of INR RAS is described;
- the setup includes a small vacuum scattering chamber (with installed $^{6}Li_2CO_3$ target and an ΔE-E telescope of silicon) and a neutron detector based on an organic scintillator;
- test measurements of the $n + {}^{6}Li \rightarrow \alpha + d + n$ reaction were carried out;
- the registration possibility in the coincidence of charged particles and neutrons, as well as the identification possibility of the charged particle type was shown;
- it is assumed that the use of the second arm for the registration of charged particles and a thin target will make it possible to significantly expand the program of the studied few-nucleon reactions on the neutron beam of the RADEX channel and to begin the study of the cluster structure of excited states of light nuclei, with the reconstruction their complete kinematics, with the separation of background and investigated reactions.

Thank you!