Л.Н. Гумилев атындағы Еуразия ұлттық университетінің ХАБАРШЫСЫ.
ISSN: 2616-6836. eISSN: 2663-1296

ФИЗИКА СЕРИЯСЫ/ PHYSICS SERIES / СЕРИЯ ФИЗИКА

IRSTI 29.15.35
https://doi.org/10.32523/2616-6836-2026-154-1-137-153
Review Article

# Lithium borohydride ($LiBH_4$) as a promising material for neutron–gamma radiation shielding

**K. Nalibay*, N. Amangeldi**

*L.N. Gumilyov Eurasian National University, Astana, Kazakhstan*

*(E-mail: kanatbekati@gmail.com, nur19792@mail.ru)*

**Abstract.** This review discusses recent progress in neutron–gamma radiation shielding, with a focus on composite materials containing lithium borohydride ($LiBH_4$). The work is mainly based on the study by Lotfalian et al. (2024), where Monte Carlo neutron-transport simulations using the MCNPX code were applied to assess the performance of $LiBH_4$ incorporated into high-performance concrete (HPC). Instead of presenting new experimental or numerical results, this article aims to summarize and interpret existing data, explain the key physical mechanisms involved, and critically assess the assumptions and limitations of the reported approaches.

Special attention is given to the role of $LiBH_4$ as a multifunctional component that combines neutron moderation and absorption within a single material system. The review highlights its effectiveness in reducing fast-neutron flux, which remains a major challenge for conventional concrete-based shielding materials. In addition, the potential benefits related to shield compactness, thickness reduction, and long-term stability are discussed. At the same time, unresolved issues such as the lack of experimental validation and practical concerns related to material behavior under realistic conditions are addressed. Overall, this review provides a balanced perspective on the potential of $LiBH_4$-based shielding materials and outlines key directions for future research and practical implementation.

**Keywords:** radiation shielding, lithium borohydride, fast neutrons, high performance concrete, Monte Carlo simulation

## Introduction

Radiation shielding plays a fundamental role in ensuring the safe operation of nuclear reactors, particle accelerators, medical radiation facilities, and spacecraft. The primary difficulty in shielding design lies in the simultaneous attenuation of neutrons and gamma rays, particularly for hard neutron spectra typical of fast reactors.

Conventional materials such as concrete, lead, and polyethylene are widely used; however, they suffer from large required thicknesses, high mass, or limited effectiveness against fast neutrons. As a result, modern research increasingly focuses on composite materials incorporating neutron absorbers and moderators.

Received 15.01.2026. Revised 06.02.2026. Accepted 06.02.2026. Available online 30.03.2026.

*the corresponding author

Among light elements, boron and lithium possess exceptionally high neutron absorption cross-sections, while hydrogen is an efficient neutron moderator. Lithium borohydride ($LiBH_4$), consisting solely of these elements, represents a unique candidate for radiation shielding. Its application as a shielding component was systematically investigated in the recent work by Lotfalian et al. [1], which forms the main subject of the present review. The present article does not present new numerical simulations. Instead, it provides a critical synthesis of recent Monte Carlo–based studies, with particular emphasis on the physical mechanisms, performance metrics, and practical limitations of $LiBH_4$-containing shielding materials. While the numerical data are taken from published sources (primarily Ref. [1]), the comparative analysis, interpretation of trends, and practical conclusions are provided by the authors.

**Methodology**

*Physical principles of neutron and gamma shielding*

*Neutron interactions*

Neutron attenuation in matter is governed by elastic scattering, inelastic scattering, and absorption. For a homogeneous material, the macroscopic cross section for a given interaction channel can be written as:

$$\sum = \sum_i N_i \sigma_i$$

where Ni is the atomic number density of nuclide i and σi is its microscopic cross section.

In shielding practice, neutron attenuation is often characterized using an effective removal cross section (especially for fast neutrons), which serves as an engineering parameter for comparing materials rather than a strict exponential-law constant for all energies. Physically, the effective removal cross section represents the probability that a fast neutron is removed from the primary neutron beam through a combination of scattering and absorption processes.

Hydrogen-rich components effectively slow down fast neutrons via elastic scattering, while isotopes such as $^{10}B$ and $^{6}Li$ capture thermalized neutrons through reactions such as $^{10}B(n, \alpha)\,^{7}Li$ and $^{6}Li(n, \alpha)\,^{3}H$. These reactions convert neutron energy into charged particles that are readily stopped within the shielding medium [2].

*Gamma-ray attenuation*

Gamma-ray attenuation in matter is commonly approximated by the exponential attenuation law:

$$I = I_0 e^{-\mu x}$$

where $I_0$ and $I$ are the incident and transmitted intensities, μ is the linear attenuation coefficient, and x is the material thickness. In general, gamma shielding improves with increasing material density and effective atomic number Z, due to enhanced photoelectric absorption, Compton scattering, and (at high energies) pair production.

*High-performance concrete as a shielding matrix*

High-performance concrete (HPC) has attracted increasing interest as a structural and functional matrix for radiation shielding. Compared with ordinary concrete, HPC typically exhibits higher strength, reduced porosity, and improved durability, enabling thinner shielding structures without sacrificing mechanical integrity [3].

From a radiation-protection perspective, concrete shields are often optimized by incorporating functional fillers. Adding boron carbide to concrete improves neutron shielding, especially for low-energy neutrons [3]. Metal-oxide fillers (e.g., $WO_3$) are frequently investigated to enhance gamma attenuation, including micro- and nano-sized additives [5]. Heavy aggregates such as magnetite and limonite can also increase photon attenuation compared with conventional mixes.

Overall, HPC provides a flexible host matrix for combining such additives. When space is limited, HPC-based composites can be attractive because they offer improved structural performance while supporting tailored neutron and gamma attenuation through appropriate filler selection [4].

The use of HPC as a matrix is particularly relevant for hydrogen- and boron-containing fillers, such as $LiBH_4$, because its reduced porosity and improved mechanical stability may mitigate some of the compatibility and durability concerns associated with reactive or hygroscopic additives.

*Lithium borohydride (LiBH4) in radiation shielding*

Lithium borohydride ($LiBH_4$) is a lightweight compound composed of elements with favorable nuclear properties for neutron shielding. Hydrogen provides efficient moderation of fast neutrons via elastic scattering, while boron and lithium isotopes contribute to neutron absorption after thermalization.

Unlike conventional absorbers such as boron carbide, LiBH4 can act as both a moderator and an absorber in a single compound, enabling a single-layer shielding concept and potentially reducing the need for separate moderating and absorbing layers [1]. Lithium- and boron-containing systems have also been investigated in other material classes (e.g., borate glasses), supporting the broader motivation for combining these elements in shielding design [5].

The study by Lotfalian et al. [1] is among the first systematic evaluations of $LiBH_4$ as a shielding additive in concrete-based composites and is therefore a useful focal point for the present review.

*Key conceptual advantages of $LiBH_4$-based shielding systems*

- simultaneous moderation and absorption;
- effectiveness for intermediate-energy neutrons (100 keV–1 MeV);
- potential reduction of multilayer shielding concepts;
- low predicted absorber depletion under fast-reactor irradiation.

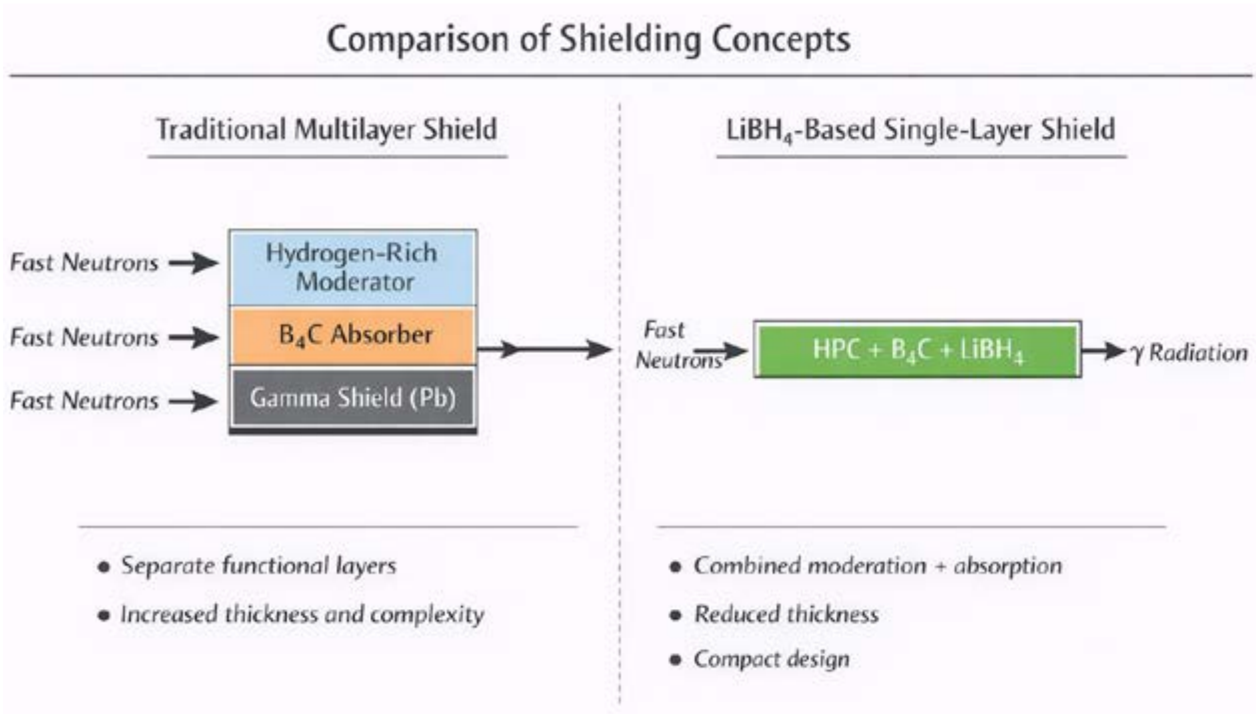


**Figure 1. Schematic comparison of conventional multilayer neutron–gamma shielding concepts and $LiBH_4$-based single-layer composite shields**

In traditional designs, moderation, absorption, and gamma attenuation are achieved using separate layers, resulting in increased thickness and structural complexity. In contrast, $LiBH_4$-containing HPC composites enable combined moderation and absorption within a single material layer, allowing more compact shielding configurations.

*Monte Carlo modeling and benchmarking*

In the reviewed study [1], Monte Carlo simulations were carried out using the MCNPX 2.7E radiation transport code originally developed at Los Alamos National Laboratory. It should be emphasized that the simulations discussed in this review were performed by the original authors; no independent MCNPX calculations were conducted in the present work.

The neutron-gamma source in Ref. [1] was the MET-1000 sodium-cooled fast reactor benchmark. Core layout and compositions were taken from established benchmark specifications [6].

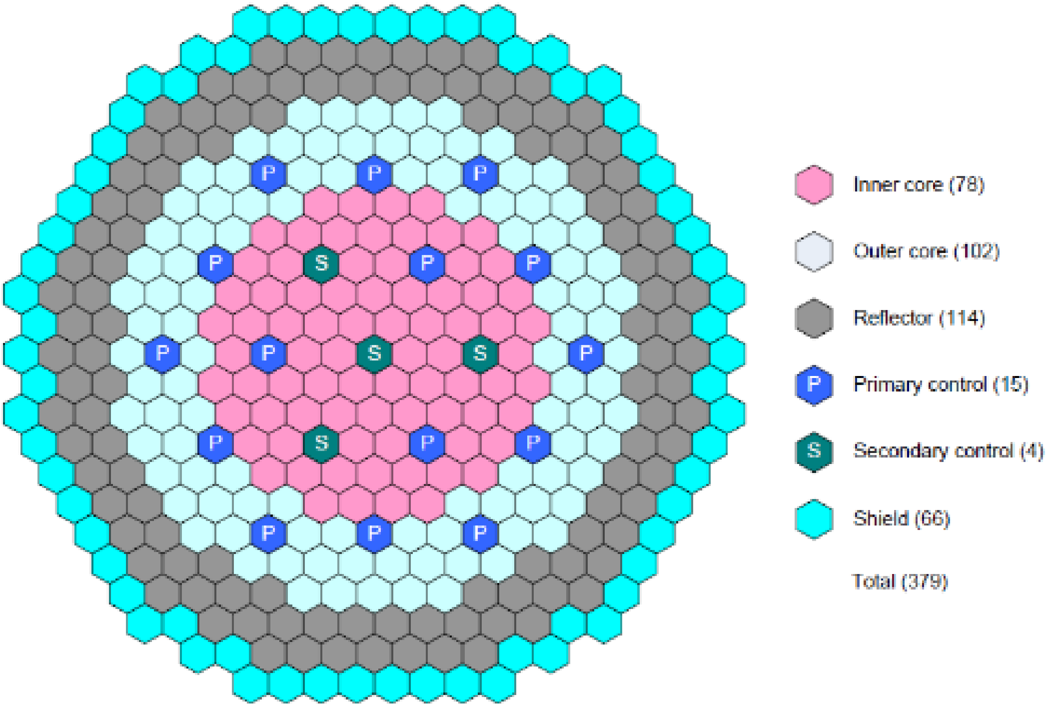


**Figure 2. Radial layout of the MET-1000 core (as reported in Ref. [1])**

Benchmark calculations reported in Ref. [1] yielded an effective multiplication factor (Keff) of approximately 1.02, which is consistent with published reference data and supports the validity of the computational model [6,7].

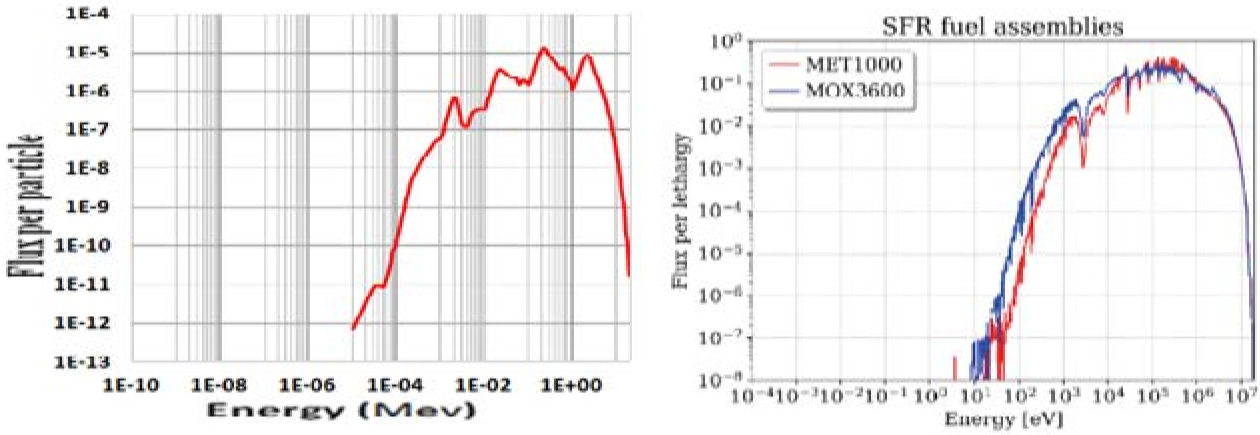


**Figure 3. Comparison of neutron flux behind various shielding materials (5 cm thickness; data from Ref. [1])**

*Shielding performance and thickness optimization*

*Neutron attenuation*

The reviewed study reports that high-performance concrete (HPC) containing 10 wt.% $B_4C$ and 5 wt.% $LiBH_4$ significantly reduces neutron flux over a broad energy range [1]. In the broader shielding literature, boron-carbide additives are primarily associated with enhanced absorption of low-energy neutrons due to their high capture cross sections [3], whereas hydrogen-rich components are widely employed to improve the moderation of fast neutrons [8].

The results indicate that $LiBH_4$-containing composites provide improved attenuation in the intermediate neutron energy range, particularly between 100 keV and 1 MeV, complementing the low-energy effectiveness typically attributed to boron-based absorbers [7].

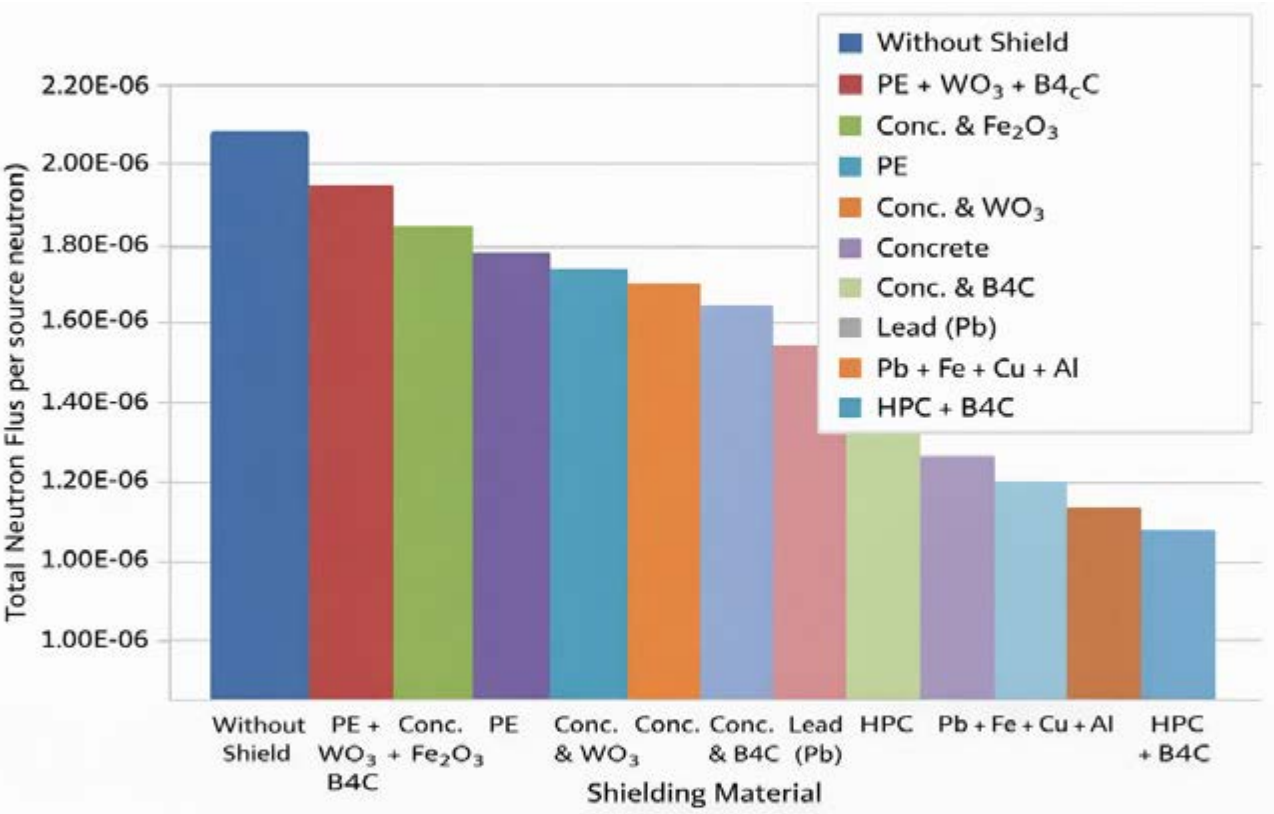


**Figure 4. Total neutron flux after different types of shields with a thickness of 5 cm (Ref. [1])**

Conventional concrete provides limited reduction, whereas boron-containing systems show improved suppression due to enhanced capture of moderated neutrons. Lead exhibits poor neutron shielding, consistent with its low effectiveness for neutron moderation and absorption. Overall, the reported trends support the advantage of boron- and hydrogen-containing composites for neutron attenuation.

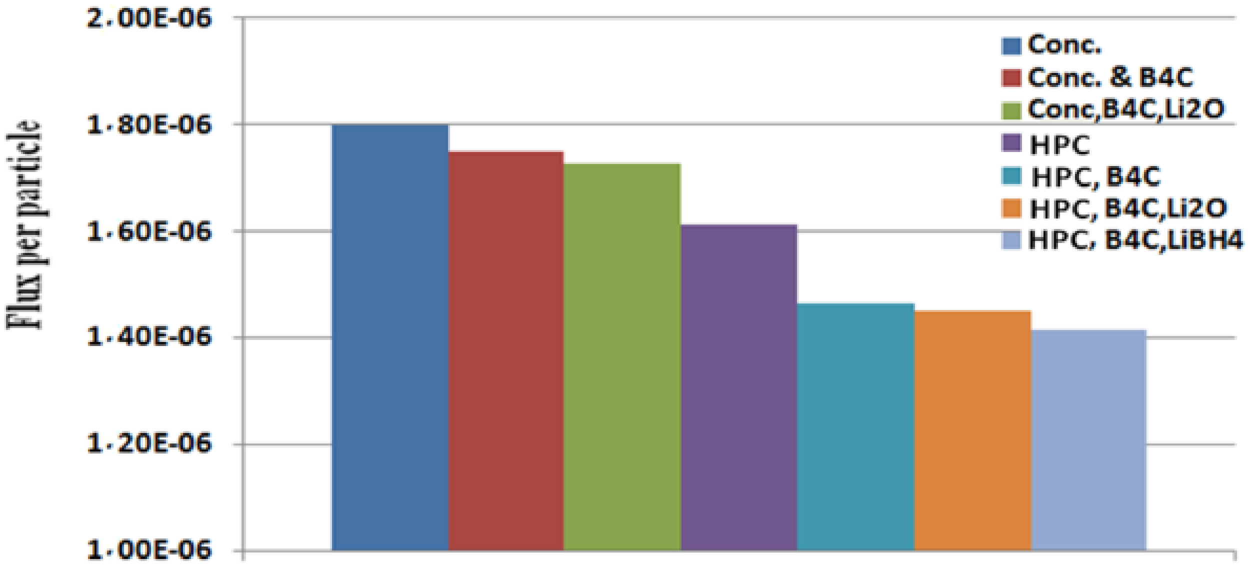


**Figure 5. Total neutron flux through new and conventional shields (5 cm) (Ref. [1])**

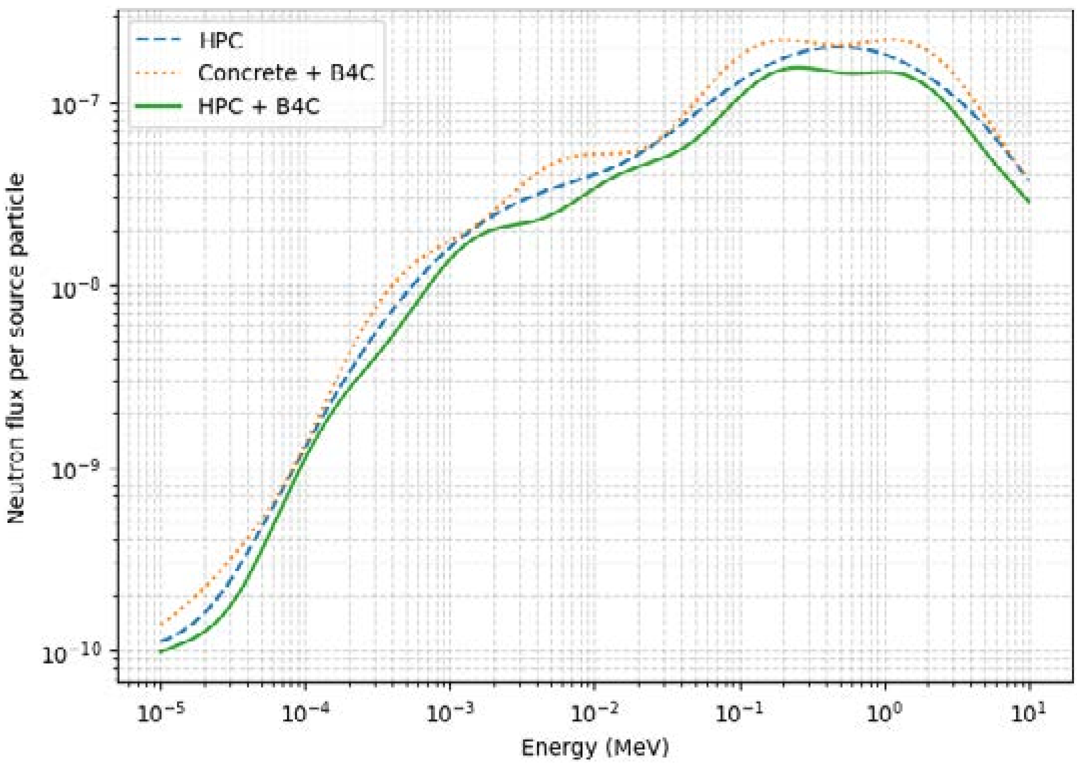


**Figure 6. Schematic comparison of neutron energy spectra after shielding with HPC, concrete + $B_4C$, and HPC + $B_4C$. The figure illustrates qualitative trends reported in Ref. [1]**

The neutron spectra in Figure 6 indicate that boron-containing shields reduce the low-energy part of the spectrum more effectively than plain HPC, consistent with enhanced thermal-neutron capture. At the same time, moderation shifts the spectrum toward lower energies, and the combined moderator–absorber concepts provide a more balanced suppression across energy regions. These qualitative trends are consistent with the role of hydrogen for moderation and boron for absorption.

From an engineering perspective, these results indicate that $LiBH_4$-containing composites are particularly attractive for shielding systems exposed to fast and intermediate-energy neutron spectra, where simultaneous moderation and absorption are required within limited thickness.

**Gamma attenuation**

Although lithium borohydride is introduced primarily to enhance neutron shielding, the reviewed results indicate that HPC-based composites can also provide acceptable attenuation of gamma radiation when sufficient thickness is used [1]. In general, gamma-ray shielding is dominated by material density and effective atomic number, with high-Z materials (e.g., lead) typically exhibiting stronger photon attenuation, while cementitious matrices provide moderate attenuation that increases with thickness.

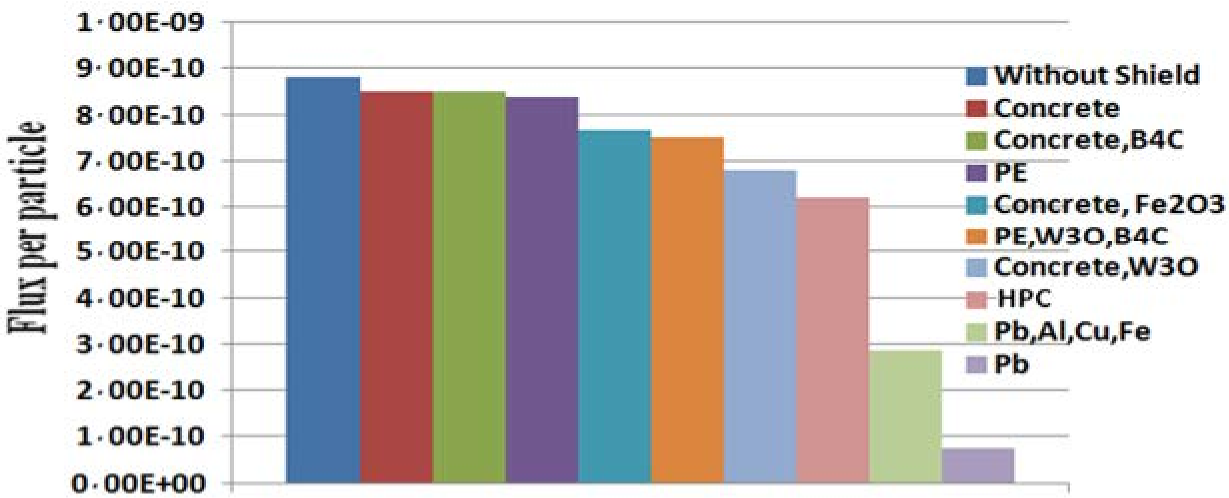


**Figure 7. Total transmitted gamma flux behind different shields (5 cm thickness; reproduced from Ref. [1])**

The observed ranking is consistent with the established understanding that heavy-metal shields (e.g., Pb) are highly effective for gamma rays, whereas polymer-based or low-Z hydrogenous materials are comparatively less efficient for photon attenuation. Concrete-based systems generally occupy an intermediate position due to their moderate density, while the use of high-Z fillers (such as tungsten-containing additives) is associated with improved gamma attenuation trends reported in shielding literature.

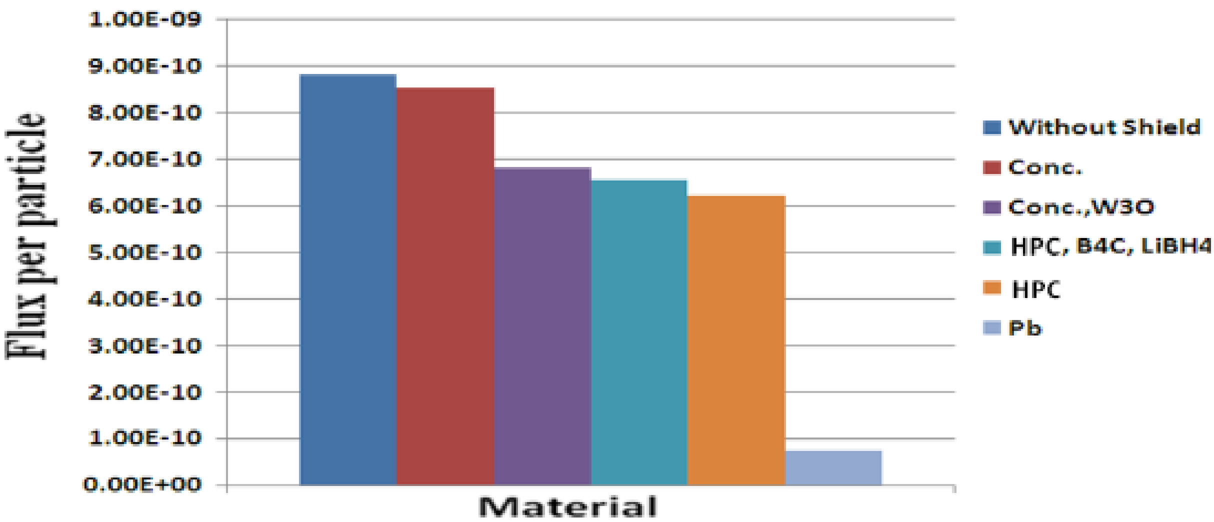


**Figure 8. Comparison of gamma flux behind the $LiBH_4$-based "new" shield and selected conventional shields (5 cm; reproduced from Ref. [1])**

Figure 8 further contrasts the gamma flux behind the $LiBH_4$-containing "new" composite shield with selected conventional shielding options at the same thickness (Ref. [1]). The comparison suggests that the principal benefit of $LiBH_4$-based composites lies in neutron performance, whereas gamma attenuation remains largely governed by the bulk properties of the composite (matrix density and composition) rather than by $LiBH_4$ itself. Consequently, when gamma shielding requirements are stringent, the reviewed results support the common design approach of combining neutron-optimized materials with high-Z components or dense concrete formulations to achieve balanced neutron–gamma protection.

In practical applications, this suggests that $LiBH_4$-based composites should be combined with sufficiently dense matrices or high-Z additives when stringent gamma-shielding requirements are imposed.

*Thickness optimization and compactness*

In shielding design, the half-value layer (HVL) is frequently used as a comparative engineering metric to assess material effectiveness, rather than as a strict exponential attenuation parameter for neutron fields. The HVL is defined as the material thickness required to reduce the incident radiation intensity by 50% and is widely employed for engineering comparison of shielding materials. For the optimized HPC–$B_4C$–$LiBH_4$ composite discussed in Ref. [1], the reported neutron HVL is approximately 3.3 cm, compared with about 4.5 cm for conventional boron-doped concrete.

Thickness-dependent analyses further indicate that a shield thickness of approximately 30 cm provides effective attenuation of both neutrons and gamma rays, achieving strong suppression of the neutron flux while maintaining acceptable gamma shielding performance. From a practical standpoint, this behavior corresponds to an estimated volume reduction of roughly 40% relative to conventional concrete-based shielding concepts. Such compactness represents a key advantage of $LiBH_4$-containing composites in applications where space and mass constraints are critical in nuclear, accelerator-based, and compact radiation facilities.

*Shielding performance summary*

**Table 1. Shield materials and functional roles (synthesized from Ref. [1])**

| Shield concept | Main neutron function | Main gamma function | Notes |
|---|---|---|---|
| Ordinary concrete (Conc.) | Limited moderation (low H fraction) | Moderate attenuation | Baseline cementitious shield |
| Concrete + 10 wt.% $B_4C$ | Strong absorption of low-energy neutrons | Similar to concrete | Reported as the best conventional option in Ref. [1] |
| High-performance concrete (HPC) | Similar moderation; improved mechanical properties | Typically improved vs. ordinary concrete | Useful when space is limited |
| HPC + 10 wt.% $B_4C$ | Absorption is enhanced at low neutron energies | Comparable to HPC | Improves thermal-neutron suppression |
| HPC + 10 wt.% $B_4C$ + 5 wt.% $LiBH_4$ | Moderation + absorption across wider energies | Acceptable at sufficient thickness | best among the configurations tested in Ref. [1] |
| Lead (Pb) | Inefficient for neutrons | Excellent gamma attenuation | Often used as a secondary layer |

Table 1 summarizes the functional roles of the investigated shielding concepts, highlighting the complementary contributions of moderation, absorption, and gamma attenuation. Among the reviewed materials, the HPC + $B_4C$ + $LiBH_4$ composite exhibits the most balanced performance across neutron energy ranges while maintaining acceptable gamma-ray shielding at sufficient thickness.

Key quantitative shielding performance indicators reported in Ref. [1] are compiled in Table 2. Collectively, these metrics support the conclusion that $LiBH_4$-containing HPC composites offer a compact and multifunctional shielding solution compared with conventional boron-doped concrete systems.

**Table 2. Summary of key quantitative shielding parameters reported in Ref.** [1]

| Metric (reported in Ref. [1]) | Value |
|---|---|
| Neutron energy range where $LiBH_4$ is more effective | 100 keV – 1 MeV |
| Recommended shield thickness | 30 cm |
| Neutron attenuation at 30 cm | ~95% reduction |
| Gamma attenuation at 30 cm | ~92% reduction |
| Relative thickness/volume reduction vs. Conc. + $B_4C$ | ~40% |
| Neutron HVL (half-value layer) | 3.32 cm |
| Gamma HVL (half-value layer) | 2.47 cm |

For the engineering context, Table 3 provides a qualitative comparison of $LiBH_4$-containing composites with alternative modern shielding material classes.

**Table 3. Qualitative comparison of $LiBH_4$-containing cementitious composites with alternative shielding material classes**

| Material class | Neutron shielding effectiveness | Gamma shielding effectiveness | Cost & availability | Technological feasibility | Long-term durability |
|---|---|---|---|---|---|
| $LiBH_4$-containing HPC composites | High (balanced moderation + absorption; compactness) | Medium (matrix-governed; can be improved with dense/ high-Z components) | Medium–High (specialty additive; may be offset by volume reduction) | High (concrete technology mature; requires handling/ compatibility measures) | Medium (depends on moisture control; chemical compatibility) |
| Hydrogenous polymer composites (PE/rubber-based) | Medium–High (good moderation; absorber loading needed) | Low–Medium (low-Z → weaker photon attenuation unless high-Z fillers used) | Medium (often scalable) | High (molding/ modularity) | Medium (aging, temperature/ radiation effects vary) |
| Glassy Li–B systems (lithium borate glasses) | Medium–High (capture + composition tuning) | Medium (composition-dependent; can be enhanced) | Medium (process-dependent) | Medium (high-T processing; size limitations) | High chemical stability / Medium mechanical (brittleness risk) |

*Long-term stability and isotope depletion*

Long-term performance is a critical requirement for shielding materials exposed to sustained neutron fields, as absorber depletion and radiation-induced material changes may reduce shielding effectiveness over time.

In Ref. [1], time-dependent burnup calculations were performed to estimate the consumption of key neutron absorbers, namely 10B and 6Li. After 180 days of continuous reactor operation, the reported depletion remained low (approximately 0.32% for 10B and 0.05% for 6Li), indicating that the neutron attenuation capability of the proposed shielding material should remain largely stable over the considered time window.

Beyond nuclear depletion effects, the long-term chemical and structural stability of $LiBH_4$-containing composites remains an open question. Lithium borohydride is known to be hygroscopic and chemically reactive, and potential issues such as moisture uptake, hydrogen release, and radiation-induced microstructural changes have not yet been experimentally assessed. These factors may influence both the mechanical integrity and the long-term shielding performance of cementitious composites incorporating $LiBH_4$ and therefore require dedicated experimental investigation.

Related studies on boron- and lithium-containing shielding systems, such as lithium borate glasses, suggest that carefully designed compositions can maintain effective neutron attenuation over extended periods, provided that chemical stability and matrix compatibility are adequately addressed [9].

**Results and discussions**

The reviewed results collectively indicate that lithium borohydride enables a shift from traditional multilayer shielding strategies toward more compact single-layer concepts. By combining neutron moderation and absorption within a single compound, $LiBH_4$-based composites address a key challenge in shielding fast-neutron spectra — simultaneous suppression of high-energy and thermalized neutrons without excessive thickness. Fast-neutron spectra in the MeV energy range pose a particular challenge for shielding design, since purely absorbing materials become less effective at high neutron energies. In particular, the reported effectiveness in the intermediate energy range complements the well-established low-energy performance of boron-based absorbers, yielding a more balanced attenuation profile.

At the same time, the reviewed evidence remains primarily simulation-based and should be interpreted accordingly. The conclusions in Ref. [1] rely on Monte Carlo transport modeling without experimental benchmarking, and practical material issues—such as the hygroscopic and reactive nature of $LiBH_4$ and its long-term compatibility with cementitious matrices—have not yet been systematically validated under realistic environmental and irradiation conditions. Therefore, targeted neutron–gamma attenuation measurements on representative $LiBH_4$-containing composite specimens under well-characterized sources are a key next step to validate the reported trends. In addition, existing experimental analogs for lithium–boron shielding systems (e.g., lithium borate glasses investigated experimentally and by Monte Carlo methods) provide contextual support for the feasibility of Li–B-based shielding concepts [10].

**Conclusions**

This review highlights $LiBH_4$ as a promising additive for compact neutron–gamma shielding composites, particularly when combined with HPC and $B_4C$. The reviewed Monte Carlo results reported in Ref. [1] suggest improved fast-neutron attenuation and reduced shielding thickness compared with conventional concrete-based concepts. Overall, $LiBH_4$-based composites represent a strong conceptual direction for compact shielding design.

Implications, Limitations, and Research Outlook

From an application perspective, $LiBH_4$-containing composites appear most relevant for fast reactors, accelerator-driven systems, and compact radiation facilities where space constraints limit the practicality of thick conventional shields. To move the concept from simulation to implementation, future research should prioritize the following directions:

1. Experimental benchmarking: fabricate representative HPC–$B_4C$–$LiBH_4$ specimens and measure neutron–gamma attenuation under well-characterized sources to validate simulation trends.
2. Environmental and chemical stability: assess moisture uptake, possible hydrogen release, and microstructural changes during thermal cycling and irradiation-relevant heating.
3. Mechanical compatibility: quantify how $LiBH_4$ affects compressive strength, cracking behavior, and long-term integrity of cementitious matrices.
4. Multi-code verification: reproduce key transport results using alternative Monte Carlo toolchains (e.g., Geant4 or comparable codes) to reduce code-dependent uncertainties.
5. System-level assessment: evaluate practical deployment constraints (fabrication route, encapsulation/barrier strategies, safety handling, and lifecycle performance).

Overall, while $LiBH_4$-based composites are not yet a mature shielding technology, the reviewed findings provide a solid foundation for targeted experimental and engineering development.

**The contribution of the authors**

Nalibay K. – conceived the review framework; performed the literature search and selection; carried out the critical analysis and synthesis of the reviewed study; prepared all tables/figures; wrote the original draft; revised and finalized the manuscript.

Amangeldi N. – provided scientific supervision; reviewed the manuscript and contributed to editing; approved the final version.

Statement on the use of generative AI and AI-enabled technologies in the manuscript preparation process

During the preparation of this paper, the authors used Chat GPT for language editing and text style improvement, as well as for clarity of wording. After using this service, the authors have checked and edited the content as needed and are fully responsible for the content of the published article.

**References**

1. Lotfalian M., Athari Allaf M., Mansouri M. Lithium Borohydride (LiBH4): An Innovative Material for Neutron Radiation Shielding (2024). arXiv:2406.03640
2. F. Bostelmann, A.M. Holcomb, J.B. Clarity, W.J. Marshall, V. Sobes, B.T. Rearden, Nuclear data performance assessments for advanced reactors, Oak Ridge National Laboratory (2019), DOI: https://doi.org/10.2172/1506806
3. Salimi M., Ghal-Eh N., Asadi Amirabadi E. Characterization of a new shielding rubber for use in neutron–gamma mixed fields, Nuclear Science and Techniques, Vol. 29 (2018). https://doi.org/10.1007/s41365-018-0371-7
4. Reda S.M. Gamma ray shielding by a new combination of aluminum, iron, copper and lead using MCNP5, Arab Journal of Nuclear Science and Applications (2016).
5. Yıldız Yorgun N., Kavaz E., Tekin H.O., Sayyed M.I., Özdemir Ö.F. Borax effect on gamma and neutron shielding features of lithium borate glasses: experimental and Monte Carlo studies, Materials Research Express (2019). https://doi.org/10.1088/2053-1591/ab4fcc
6. Stankovic S.J., Ilic R., Jankovic K., Loncar B. Gamma radiation absorption characteristics of concrete with components of different type materials, Acta Physica Polonica A, Vol. 117 (2010). https://doi.org/10.12693/aphyspola.117.812
7. Han Y., Zhou T. Performance analysis of high-performance concrete materials in civil construction, Materials (2023). https://doi.org/10.3390/ma16165711
8. Mokhtari K., Kheradmand Saadi M., Panahi H.A., Jahanfarnia G. Shielding properties of ordinary concrete reinforced with nano polymer particles containing PbO–H3BO3 for dual protection against gamma and neutron radiations, Radiation Physics and Chemistry, Vol. 189 (2021). https://doi.org/10.1016/j.radphyschem.2021.109711
9. Cai Y., Hu H., Pan Z., Sun W., Yan M. Metaheuristic optimization in shielding design for neutrons and gamma rays reducing dose equivalent as much as possible, Annals of Nuclear Energy, Vol. 120 (2018). https://doi.org/10.1016/j.anucene.2018.05.038
10. Tekin H.O., Singh V.P., Manici T. Effects of micro-sized and nano sized WO3 on mass attenuation coefficients of concrete by using MCNPX code, Applied Radiation and Isotopes, Vol. 121 (2017). https://doi.org/10.1016/j.apradiso.2016.12.040

**Қ. Нәлібай*, Н. Амангелді**

*Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан*

*(E-mail: kanatbekati@gmail.com, nur19792@mail.ru)*

## Литий боргидриді ($LiBH_4$) нейтрон-гамма сәулеленуден қорғайтын экрандау үшін перспективті материал

**Аннотация.** Бұл шолуда литий борогидридін ($LiBH_4$) қамтитын композиттік материалдарға баса назар аудара отырып, нейтронды-гамма сәулеленуден қорғау саласындағы соңғы жетістіктер талқыланады. Жұмыс негізінен Лотфалиан және т.б. (2024) зерттеуіне негізделген, онда жоғары өнімді бетонға (HPC) енгізілген $LiBH_4$ өнімділігін бағалау үшін MCNPX кодын қолдана отырып, Монте-Карло нейтрон тасымалдау модельдеулері қолданылған. Жаңа эксперименттік немесе сандық нәтижелерді ұсынудың орнына, бұл мақалада бар деректерді қорытындылау және түсіндіру, негізгі физикалық механизмдерді түсіндіру және хабарланған тәсілдердің болжамдары мен шектеулерін сыни бағалау мақсат етіледі.

$LiBH_4$-тің бір материалдық жүйеде нейтронды модерациялау мен сіңіруді біріктіретін көпфункционалды компонент ретіндегі рөліне ерекше назар аударылады. Шолуда оның жылдам нейтронды ағынды азайтудағы тиімділігі атап өтіледі, бұл дәстүрлі бетон негізіндегі қорғаныс материалдары үшін үлкен қиындық болып қала береді. Сонымен қатар, қалқанның тығыздығы, қалыңдығының азаюы және ұзақ мерзімді тұрақтылыққа байланысты әлеуетті артықшылықтар талқыланады. Сонымен қатар, эксперименттік валидацияның болмауы және нақты жағдайларда материалдың мінез-құлқына қатысты практикалық мәселелер сияқты шешілмеген мәселелер қарастырылады. Жалпы алғанда, бұл шолу $LiBH_4$ негізіндегі экрандау материалдарының әлеуетіне теңгерімді көзқарас береді және болашақ зерттеулер мен практикалық енгізудің негізгі бағыттарын белгілейді.

**Түйін сөздер:** радиациялық қорғаныс, литий боргидриді, жылдам нейтрондар, жоғары өнімді бетон, Монте-Карло әдісімен модельдеу

**Қ. Нәлібай*, Н. Амангелді**

*Евразийский национальный университет имени Л.Н. Гумилева,*
*Астана, Казахстан*
*(E-mail: kanatbekati@gmail.com, nur19792@mail.ru)*

## Боргидрид лития ($LiBH_4$) как перспективный материал для нейтронно-гамма радиационного экранирования

**Аннотация.** В данном обзоре рассматриваются последние достижения в области защиты от нейтронно-гамма-излучения с акцентом на композитные материалы, содержащие борогидрид лития ($LiBH_4$). Работа в основном основана на исследовании Лотфалиана и др. (2024), где моделирование переноса нейтронов методом Монте-Карло с использованием кода MCNPX применялось для оценки эффективности $LiBH_4$, включенного в высокопрочный бетон (ВБ). Вместо представления новых экспериментальных или численных результатов, данная статья направлена на обобщение и интерпретацию существующих данных, объяснение ключевых физических механизмов и критическую оценку допущений и ограничений представленных подходов.

Особое внимание уделяется роли $LiBH_4$ как многофункционального компонента, сочетающего замедление и поглощение нейтронов в рамках одной материальной системы. В обзоре подчеркивается его эффективность в снижении потока быстрых нейтронов, что остается серьезной проблемой для традиционных экранирующих материалов на основе бетона. Кроме того, обсуждаются потенциальные преимущества, связанные с компактностью экрана, уменьшением толщины и долговременной стабильностью. В то же время рассматриваются нерешенные вопросы, такие как отсутствие экспериментальной проверки и практические

проблемы, связанные с поведением материалов в реальных условиях. В целом, этот обзор дает сбалансированное представление о потенциале экранирующих материалов на основе $LiBH_4$ и определяет ключевые направления будущих исследований и практического применения.

**Ключевые слова:** радиационная защита, боргидрид лития, быстрые нейтроны, высокопрочный бетон, моделирование методом Монте-Карло.

**References**

1. Lotfalian M., Athari Allaf M., Mansouri M. Lithium Borohydride (LiBH4): An Innovative Material for Neutron Radiation Shielding (2024). arXiv:2406.03640
2. F. Bostelmann, A.M. Holcomb, J.B. Clarity, W.J. Marshall, V. Sobes, B.T. Rearden, Nuclear data performance assessments for advanced reactors, Oak Ridge National Laboratory (2019), DOI: https://doi.org/10.2172/1506806
3. Salimi M., Ghal-Eh N., Asadi Amirabadi E. Characterization of a new shielding rubber for use in neutron–gamma mixed fields, Nuclear Science and Techniques, Vol. 29 (2018). https://doi.org/10.1007/s41365-018-0371-7
4. Reda S.M. Gamma ray shielding by a new combination of aluminum, iron, copper and lead using MCNP5, Arab Journal of Nuclear Science and Applications (2016).
5. Yıldız Yorgun N., Kavaz E., Tekin H.O., Sayyed M.I., Özdemir Ö.F. Borax effect on gamma and neutron shielding features of lithium borate glasses: experimental and Monte Carlo studies, Materials Research Express (2019). https://doi.org/10.1088/2053-1591/ab4fcc
6. Stankovic S.J., Ilic R., Jankovic K., Loncar B. Gamma radiation absorption characteristics of concrete with components of different type materials, Acta Physica Polonica A, Vol. 117 (2010). https://doi.org/10.12693/aphyspola.117.812
7. Han Y., Zhou T. Performance analysis of high-performance concrete materials in civil construction, Materials (2023). https://doi.org/10.3390/ma16165711
8. Mokhtari K., Kheradmand Saadi M., Panahi H.A., Jahanfarnia G. Shielding properties of ordinary concrete reinforced with nano polymer particles containing PbO–H3BO3 for dual protection against gamma and neutron radiations, Radiation Physics and Chemistry, Vol. 189 (2021). https://doi.org/10.1016/j.radphyschem.2021.109711
9. Cai Y., Hu H., Pan Z., Sun W., Yan M. Metaheuristic optimization in shielding design for neutrons and gamma rays reducing dose equivalent as much as possible, Annals of Nuclear Energy, Vol. 120 (2018). https://doi.org/10.1016/j.anucene.2018.05.038
10. Tekin H.O., Singh V.P., Manici T. Effects of micro-sized and nano sized WO3 on mass attenuation coefficients of concrete by using MCNPX code, Applied Radiation and Isotopes, Vol. 121 (2017). https://doi.org/10.1016/j.apradiso.2016.12.040

**Information about the authors**

**Nalibay K.** – the corresponding author, 2nd year doctoral student, specialty «Nuclear Physics», L.N. Gumilyov Eurasian National University, Satbayev str., 2, Astana, Republic of Kazakhstan.

**Amangeldi N.** – PhD, Associate Professor, Institute of Nuclear Physics, L.N. Gumilyov Eurasian National University, Satbayev street, 2, Astana, Republic of Kazakhstan.

**Нәлібай Қ.** – хат-хабар авторы, «Ядролық физика» мамандығы бойынша 2 курс докторанты, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Сәтбаев көшесі, 2, Астана, Қазақстан Республикасы.

**Амангелді Н.** – PhD, доцент, ядролық физика институты, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Сәтбаев көшесі, 2, Астана, Қазақстан Республикасы.

**Нәлібай Қ.** – автор для корреспонденции, докторант 2 курса по специальности «Ядерная физика», Евразийский национальный университет имени Л. Н. Гумилева, ул. Сатбаева, 2, Астана, Республика Казахстан.

**Амангелді Н.** – PhD, доцент, Институт ядерной физики, Евразийский национальный университет имени Л.Н.Гумилева, ул. Сатбаева, 2, Астана, Республика Казахстан.