Investigation of hypernuclei with Nuclotron beams

To cite this article: A. Korotkova and 2016 J. Phys.: Conf. Ser. 668 012108

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Abstract. At the Laboratory of High Energy Physics (JINR, Dubna) a unique approach was elaborated with hypernuclei produced by the excitation of the accelerator beam nuclei and decay observed at a distance of tens of cm behind the production target. While the very first experiments were carried out in the Synchrophasotron beams, a more extensive hypernuclei research programme is planned for the Nuclotron accelerator and the new spectrometer created by the authors (Hypernuclei and NIS experiments). An investigation of hydrogen hypernuclei isotopes is in the first line of the experimental research plans. Namely, lifetimes and cross sections of $\Lambda^4$H and $\Lambda^3$H together with the search for $\Lambda^6$H are among the tasks. The next experiment can be the investigation of $\Lambda^6$He.

1. Introduction
The experimental program of the HyperNIS project initially was aimed to investigate the role which strangeness plays in nuclei. Hypernuclear research programme was proposed for the Nuclotron accelerator with a new HyperNIS spectrometer [1].

2. Physics motivation
Recently, evidence from Frascati for three $\Lambda^6$H hypernuclei was reported [2, 3]. In the concluding remarks at the closing of the 11th International Conference on Hypernuclei and Strange Particle Physics (held in 2012 in Barcelona), the first observation of $\Lambda^6$H was mentioned by T.Nagae [4] as one of the four main achievements in hypernuclear physics reached during the last years. On the other hand, the E10 collaboration at J-PARC experiment in 2013 did not observe the missing mass peak corresponding to $\Lambda^6$H production [5]. However, A.Gal at the Barcelona conference noted, that there will be a low probability to see signal from $\Lambda^6$H at J-PARC experiment due to high transferred momentum and, consequently, high momentum of produced hypernuclei. Theoretical predictions are strongly model dependent and are controversial as well. For example, E.Hiyama and others have calculated [6] that $\Lambda^6$H is not a stable nucleus and should decay into $\Lambda^4$H+n+n, if one takes into account the parameters of $^3$H resonance measured up to now. At the same time, there are estimates [7, 8] showing that the binding energy for $\Lambda^6$H should be about a few MeV. So, it is necessary to carry out an experiment, which can test $\Lambda^6$H hypernucleus without doubt.

3. Method to produce relativistic hypernuclei
A unique approach suggested in the Laboratory of High Energy Physics (JINR, Dubna) will be used. In this approach the hypernuclei under study are being produced by the excitation of the beam nuclei, and the hypernuclei decay is being observed at a distance of tens of centimetres behind the production
target. Thus, passage of the hypernuclei “beam” through vacuum or a matter can be investigated in order to obtain experimental estimation of the lifetimes, production cross sections and binding energy of the lightest neutron-rich hypernuclei. It should be noted that the approach is adequate for hypernuclei lifetime measurements because of minimal background in case of hypernuclei decay in the vacuum.

4. Present status and results

An extracted deuteron beam with typical kinetic energy of 3 GeV/nucleon and intensity of \((10^4 \pm 10^5)\) s\(^{-1}\) was used in the test runs. In the Nuclotron run (June 2014), a \(^7\)Li beam was used as well. Data for proportional chambers alignment were taken in test runs and trigger tuned. A few alignment program codes were developed and investigated, all necessary calculations and fits were carried out. The trigger of the HyperNIS spectrometer works perfectly. Now, installing and commissioning of the new FEE are carried out.

References