Experimental Setup for hypernuclear study at the Super-FRS

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The first experiment of the HypHI collaboration aimed to demonstrate the feasibility of the hypernuclear spectroscopy by means of heavy ion beam induced reactions. The final results show that the experimental method is viable for the study of hypernuclei [1, 2, 3].

The study of exotic hypernuclei which can not be produced in typical missing mass experiments involved at JPARC or JLab and MamiC is the topic of the future phases of the project[4]. The use of rare-isotope beams is mandatory to the study of exotic hypernuclei toward the proton- and neutron-drip line. The Super-FRS is crucial to the future phases of the HypHI project at FAIR, a feasibility study of the Super-FRS capability toward high energy of several GeV had to be achieved. A dedicated apparatus for exclusive measurement can be set up within the fragment separator Super-FRS, as an alternative to the experimental apparatus devoted to inclusive measurement as it was performed during the first experiments of the HypHI project. A detection apparatus consisting of an additional set magnetic optics could be install in order to separate the π^- meson of the mesonic weak decay of produced hypernuclei, while the second part of the Super-FRS is used as a fragment spectrometer to determine precisely the momentum of the fragment of hypernucleus of interest. Two different strategies have been investigated. The first strategy is to use a couple of dipole magnets in order to deflect the π^- meson from the positively charged particles and fragments with a first dipole magnet. The induced deflection to the fragments is then compensated with the second magnet in order to allow them to enter appropriately the second part of the Super-FRS. The second approach consists of using a solenoid magnet in order to analyze the momentum of the π^- meson while the fragments is to enter the second part of the Super-FRS as in the case of first approach. The detection apparatus is then to be considered to allow the vertex reconstruction of the hypernuclear decay. In the first case, detectors already developed and used in the first experiment of the HypHI project such as the fiber detectors can used in a similar way to track charged particles around the decay volume and in the upstream of the dipole magnets. π^- meson are then detected with a set of a hodoscope wall and drift chambers already available from the first HypHI experiment in order to complete the information needed for the track reconstruction. In solenoid magnet approach, a dedicated detection apparatus has to be developed in order to perform the position and energy-loss measurements within the solenoid magnet and the solenoid end-cap.

In both case, Monte Carlo simulations of the experimental apparatus has been carried out in the case of the study of the d+π^- final state of the ${}^{3}_{\Lambda}$n that was reported to be found by the HypHI collaboration [3]. In those case studies, dedicated detection apparatus as described above was designed. The main purpose of those first Monte Carlo simulations was to estimate the possible improvement that the use of the Super-FRS as spectrometer could provide. The invariant mass distributions of d+π^- final state of the event reconstruction of the simulated data is shown figure 1. On the left panel, the invariant mass was calculated exclusively with the track reconstruction involving the simulated data from the detection apparatus, without including the Super-FRS momentum measurement of the deuteron fragment, while on the right panel, the distribution include the expected momentum measurement of the deuteron with the momentum reconstruction of the π^- within the detection apparatus. An improvement on the mass resolution of a factor 4.5 is expected when the momentum resolution $\delta p/p$ of deuteron is about 10^{-3}. It demonstrates the gain of performing a exclusive measurement of hypernuclear matter with the Super-FRS.

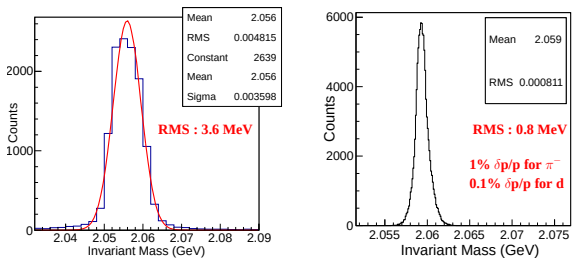

Figure 1: The invariant mass distribution of simulated d+π^- final state of ${}^{3}_{\Lambda}$n, without (left panel) and with (right panel) the expected momentum measurement of the deuteron fragment by Super-FRS as a spectrometer.

References

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