Simulation Study of the Production of Exotic Hypernuclei 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 Phase 0 experiment was performed with a ^{6}Li beam at 2AGeV impinged on a stable ^{12}C target material. The main goal of the experiment was to produce, reconstruct and identify decay vertexes of Λ particle and ${}^{3}_{\Lambda}$H, ${}^{4}_{\Lambda}$H and ${}^{5}_{\Lambda}$He hypernuclei [1]. With the finalized data analysis of Phase 0 experiment, the final results show that the experimental method is viable for the study of hypernuclei. The future phases of the project focus on the study of exotic hypernuclei which can not be produced in typical missing mass experiments involved at JPARC or JLab and MamiC [2]. The study of exotic hypernuclei toward the proton- and neutron-drip line necessarily involves the use of rare-isotope beams. One of the main goals of the HypHI project is to extend the hypernuclear chart to the proton drip line up to ΛSi hypernuclei and neutron drip line up to ΛLi hypernuclei. A larger charge symmetric breaking effect may be expected in very proton/neutron rich hypernuclei. It may cause a change in the difference between Λ-proton and Λ-neutron interactions which may induce a shift of the drip-line positions.

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. This study was to determine which couple of primary beam and target isotopes have to be chosen to obtain the exotic beam of interest at 2 A GeV for the study of the subsequent exotic hypernuclei produced in the induced reaction of this secondary beam and the production target. A systematic study using EPAX [3] have performed to determine the production cross section of secondary beam isotopes between a large couple of beam and target isotopes (all combination up to ^{40}Ca + ^{40}Ca). Then MOCADI Monte Carlo simulations [4] was employed for calculating the transmittance of the secondary beam of interest and the possible other contaminating isotopes, also produced at the same time, up to the last stage of the High Energy Branch (HEB) of the SuperFRS. Once again a systematic study of all the possible couple of (Beam,Target) with several target thicknesses was performed in order to find the best possible parameters to obtain the highest intensity of the secondary beam of interest at the last stage of the HEB of the SuperFRS. Fig. 1 shows a summary of case study of ^{9}C secondary beam in which only the most predominant couple (Beam,Target) is represented. The calculation shows the reaction between (C,N) beam isotopes and (Li,Be,B,C) target isotopes gives the highest ^{9}C beam intensity up to $\sim 3 \cdot 10^{6}$ beam per second. More intensive simulations which aim to minimized the contamination of the other isotopes is on-going.

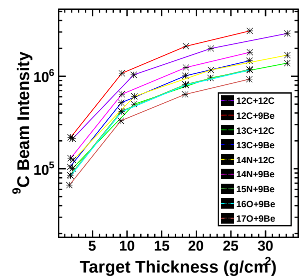

Figure 1: Intensity of secondary beam ^{9}C at the exit of the HEB of the SuperFRS as function of the target density, the primary beam and target isotope, which were used as variable inputs in MOCADI simulations. The intensity of the primary beam was set to 10^{10} per second which should be available at the SuperFRS.

The study of the production of the exotic hypernuclei with the secondary beam of interest is achieved thanks to the following theoretical model [5]. This is an hybrid model between the transport model "Dubna cascade model" (DCM), which simulates the collision between the beam and the target, and a statistical approach for the Fermi break up model to describe the deexictation of spectators. The first estimation of production cross section of some unknown proton-rich hypernuclei is listed in the table below. Further investigations are on-going about a future experimental setup.

${}^{4}_{\Lambda}$He	${}^{5}_{\Lambda}$Li	${}^{5}_{\Lambda}$Be	${}^{6}_{\Lambda}$Be	${}^{8}_{\Lambda}$B	${}^{8}_{\Lambda}$C
3.6 μb	1.2 μb	0.4 μb	1.6 μb	0.6 μb	0.2 μb

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