The HypHI project at GSI and FAIR: Genfit package for track fitting in the hypernuclei event reconstruction analysis

C.Rappold*[1,2], S. Bianchin[1], O. Borodina[1,3], V. Bozkurt[1], B. Göküzüm[1], M. Kavatsyuk[4], E. Kim[1], F. Maas[1,3], S. Minami[1], D. Nakajima[1,5,6], B. Özel-Tashenov[1], T.R. Saito[1,3], and W. Trautmann[1]

[1]GSI, Darmstadt, Germany; [2]Université de Strasbourg, Strasbourg, France; [3]Mainz University, Mainz, Germany; [4]KVI, Groningen, The Netherlands; [5]KEK, Tsukuba, Japan; [6]Tokyo University, Tokyo, Japan

The HypHI project aims to study hypernuclei by means of collisions of stable heavy ion and RI beams on stable target materials. As the first step (Phase 0), the feasibility of hypernuclear spectroscopy with heavy ion beams will be demonstrated with a ^{6}Li beam at 2 A GeV impinged on a ^{12}C target by identifying $^{3}_{\Lambda}$H, $^{4}_{\Lambda}$H and $^{5}_{\Lambda}$He hypernuclei from their mesonic decay modes. The Phase 0 experiment was performed in August and October 2009 [2].

A dedicated event reconstruction analysis has been developed in order to reconstruct hypernucleus event from the obtained data. The four-momentum of each particle is calculated by finding and fitting each possible tracks from hits collected by the tracker system [3, 4] and PID system [5]. The invariant mass method and vertex reconstruction of interested hypernuclei is performed from their respective daughter particles. Each daughter candidate is selected from the goodness of the track fitting.

A new step has been included in the track reconstruction after the satisfied implementation of track finding [6]. Possible track found by the Hough transform across the full setup is fitted with a Kalman Filter algorithm. The implementation of the algorithm has been initially based on the Genfit package provided in the PandaROOT framework. Several modifications have done to handle experimental data and the specificity of the setup of Phase 0 experiment. One of the main change includes a new propagation algorithm : a track propagation in non-homogeneous magnetic field by a analytic formula for track extrapolation [7].The new implementation of the full reconstruction analysis with the track fitting algorithm gives us the opportunity to select the goodness of the tracking within a high confidence level.

The reconstruction of hypernuclei from Monte Carlo simulations has been studied with the full event reconstruction analysis. Monte Carlo simulations have been based on a UrQMD event generator and the GEANT4 framework. 20000 $^{3}_{\Lambda}$H, $^{4}_{\Lambda}$H and $^{5}_{\Lambda}$He hypernucleus with their associated background particles from the production reaction have been used. For the background, firstly 20 million background events representing primary reaction which does not lead to any strangeness production have been used to simulate the primary reaction. This background represents $\sim$1b reaction cross section, from which all other simulation results have been scaled. Secondly, the background associating free Λ production with other possible Z=2 projectile fragments is the most crucial background since those events behave like hydrogen hypernuclei if the proton from the free Λ decay is missing.

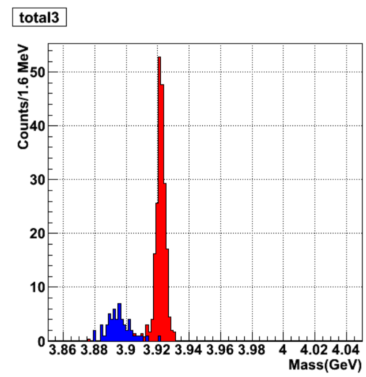

Figure 1: Invariant mass of $^{4}_{\Lambda}$H within 95 % CL. In blue : the background contribution while in red the $^{4}_{\Lambda}$H signal.

Those three different inputs have been analyzed and the resulting invariant mass of $^{4}_{\Lambda}$H from all input has been scaled to each other to match the expected cross section difference. The figure 1 is showing this scaled invariant mass spectrum, with two color codes separating the background from the signal. It shows a clear separation between background (in blue) and the hypernuclei signal (in red). The full background from primary reactions is completely rejected thanks to a secondary vertex selection. Only the free Λ background is contributing to the background shown in blue. The invariant mass resolution obtained in this way is 2.07 MeV for $^{4}_{\Lambda}$H. All other interested hypernuclei, $^{3}_{\Lambda}$H and $^{5}_{\Lambda}$He have been also studied in the same procedure.

* c.rappold@gsi.de

References

[1] Proposal of the HypHI Phase 0 experiment, the HypHI collaboration.

[2] T.R. Saito *et. al.*, in these Scientific Reports.

[3] D. Nakajima *et. al.*, in these Scientific Reports.

[4] E .Kim *et. al.*, in these Scientific Reports.

[5] S. Bianchin *et. al.*, in these Scientific Reports.

[6] C. Rappold *et. al.*, GSI Scientific Report 2008, GSI, Darmstadt, 2008, p. 53.

[7] S. Gorbunov, I. Kisel, *Analytic formula for track extrapolation in non-homogeneous magnetic field*. Nucl. Instr. Meth. A 559 (2006) 148-152