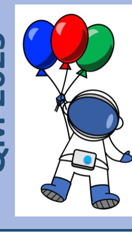
Directed Flow of Λ, ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ in Au+Au collisions at $\sqrt{s_{NN}}$ = 3.2, 3.5, and 3.9 GeV at RHIC

Junyi Han(jyhan@mails.ccnu.edu.cn), for the STAR Collaboration
Central China Normal University

QM 2023

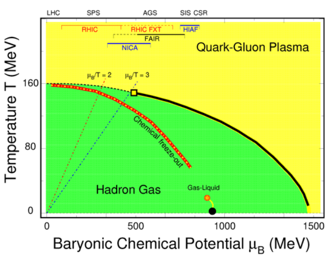


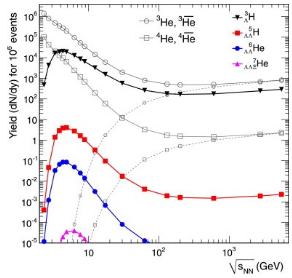
Abstract

Studying hyper-nuclei production and their collectivity can shed light on their production mechanism as well as the hyperon-nucleon interactions under finite density and pressure. This is a unique opportunity for heavy-ion collisions at high baryon density region where the hyper-nuclei production rate increases.

In this poster, we will present v_1 of the hyper-nuclei(Λ, ${}^{3}_{\Lambda}H$, ${}^{4}_{\Lambda}H$) from mid-central Au+Au collisions at $\sqrt{s_{NN}}$ = 3.2, 3.5, and 3.9 GeV, collected by the STAR experiment with the fixed-target mode during the second phase of the RHIC beam energy scan program. The rapidity dependence of the hyper-nuclei directed flow(v_1) is studied in mid-central collisions. The extracted v_1 slopes of the hyper-nuclei are positive and decrease gradually as the collision energy increases. The results will be compared with models using the framework of hadronic transport and a coalescence after-burner.

Motivation

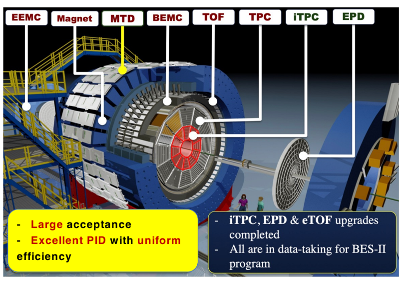


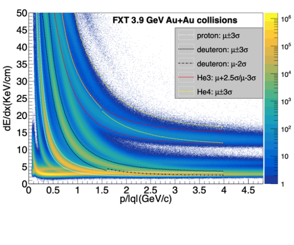


- Hyper-Nuclei are abundantly produced at high baryon density region.
- The study of Hyper-Nuclei provides the opportunity to study the hyperon-nucleon(Y-N) interaction at high baryon density and temperature.

X.Luo, S. Shi, N. Xu, and Y. Zhang, Particles 3(2), 278-307 (2020)
A.Andronic *et al.* Phys.Lett.B 697, 203 (2011)

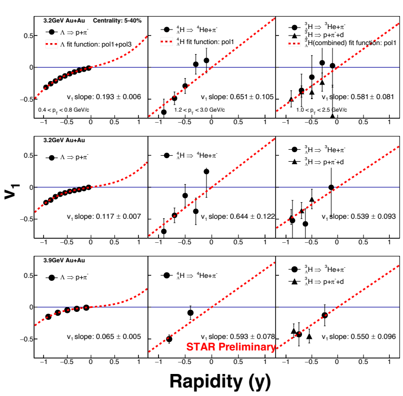
The STAR Detector

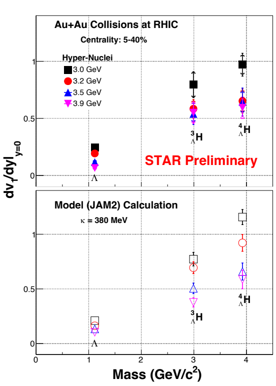




- The data is projected onto the x-axis and y-axis separately, and then fit using a multiple Gaussian function
- The extracted mean(μ) and width(σ) of these Gaussians are used to select intervals for the identification of protons, deuterons, He3 and He4.

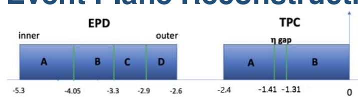
Λ, ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ v_1 Results





- Directed flow of Λ and hyper-nuclei show rapidity dependence in the mid-central collisions.
- At given energy, for hyper-nuclei, it seems that the slopes of mid-rapidity v_1 are scaled with atomic mass number A or/and particle mass.

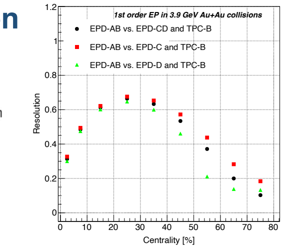
Event Plane Reconstruction



- Three-sub-event method:

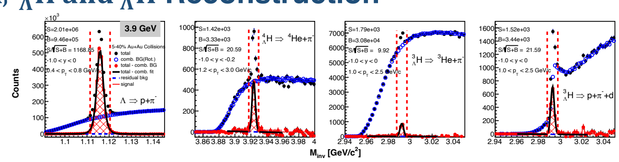
$$R_1 = \sqrt{\frac{\langle\cos(\psi_{AB}^{EPD} - \psi_{C}^{EPD})\rangle\langle\cos(\psi_{AB}^{EPD} - \psi_{B}^{TPC})\rangle}{\langle\cos(\psi_{C}^{EPD} - \psi_{B}^{TPC})\rangle}}$$

- Recentering and shift corrections were done.



A. M. Poskanzer and S. A. Voloshin, Phys. Rev. C 58, 1671 (1998)

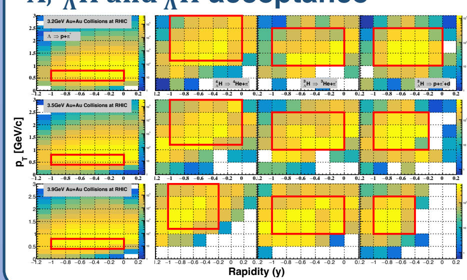
Λ, ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ Reconstruction



- KF Particle finder is used to reconstruct Λ, ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ to improve signal significance.
- Combinatorial backgrounds are reconstructed using a rotation technique, where a daughter track in a single event is rotated by a random angle in transverse plane multiple times.
- After subtraction of combinatorial backgrounds, the resultant distribution is fitted by student_t (Λ) or Gaussian (${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$) function for the signal and a polynomial function for residual background.
- Signal counts are extracted within a 3σ mass window width by a bin counting method.

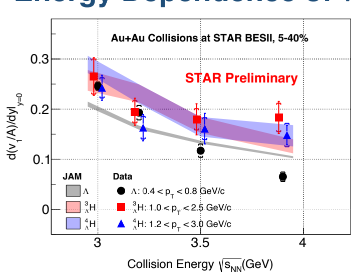
KF Particle Finder: M. Zyzak, Dissertation thesis, Goethe University of Frankfurt, 2016.

Λ, ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ acceptance



- The p_T-y regions in the red boxes are the regions of acceptance used in the directed flow analysis.
- Acceptance $\otimes$ reconstruction efficiency are corrected.

Energy Dependence of v_1 slope



- As the collision energy increases, the v_1 slopes of both Λ and hyper-nuclei decrease.
- Hadronic transport model (JAM2 mean field + Coalescence) calculations provide a good description of the v_1 slope of hyper-nuclei.

Summary

- Directed flow (v_1) of Λ, ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ is measured in Au+Au collisions at 3.2, 3.5 and 3.9 GeV using the Event Plane Method.
- The mass and energy dependence of the v_1 slope of Λ, ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ was measured.

Supported in part by the U.S. DEPARTMENT OF ENERGY Office of Science
NSFC
National Natural Science Foundation of China , and Fundamental Research Funds for the Central Universities

The STAR Collaboration
https://drupal.star.bnl.gov/STAR/presentations