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Measurement of Charge Symmetry Breaking in A = 4 hypernuclei in 3GeV Au+Au collisions at RHIC

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The Λ binding energy difference, which is called the charge symmetry breaking in the ground states of a pair of A = 4 hypernuclei, ^{4}H and ^{4}He, was measured to be $\Delta B_\Lambda^4(0^+_{g.s.}) \approx 350$ keV in nuclear emulsion experiments in the 1970s. In the 2015 and 2016 experiments from J-PARC and A1 collaboration, the binding energy difference in excited states was found to be much smaller than that in the ground states. These results are difficult to reproduce in existing theoretical models. The full understanding of the charge symmetry breaking in A = 4 hypernuclei still remains an open question.

As a part of the STAR fixed target program, the STAR detector collected data in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV. The high production yield of hypernuclei provides an opportunity to measure the Λ binding energies of both A = 4 hypernuclei in ground states in the same experiment to address this charge symmetry breaking puzzle. In 2022, STAR published the measurements of the Λ binding energies of ^{4}H and ^{4}He with the data taken in 2018. The result showed that $\Delta B_\Lambda^4(1^+_{exc}) = -\Delta B_\Lambda^4(0^+_{g.s.}) = -0.16 \pm 0.14(\text{stat.}) \pm 0.12(\text{syst.})$ MeV. However the statistical uncertainties were large. STAR has taken about 2 billion events in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV in the run 2021, which allows us to improve this measurement.

In this talk, we will present the improved measurement of the charge symmetry breaking in A = 4 hypernuclei in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV with 2021 data. The signal reconstructions and binding energy measurements of ^{4}H and ^{4}He, including corrections and systematic uncertainty evaluations, will be discussed. The new results show about factor of 3 reduction in statistical uncertainties. These results will be compared to previous measurements and theoretical models.

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