Liang Liu

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Education

Sep. 2018 – Ongoing

University of Science and Technology of China
PhD in Particle Physics
Supervisor: Haiping Peng
Granted: Outstanding Student International Exchange Funding Program, 50 000 yuan.
Visiting student in Uppsala University, Sweden, 2021 – 2022.

Sep. 2014 – Jun. 2018

University of Science and Technology of China
BS in Physics
Outstanding Student Scholarship, Grade 3 (33%; Both in 2015 and 2016)

Research experience

Nov. 2022 – Ongoing

Probing the nucleus structure with the anti-neutron source at BESIII
The structure of nuclei is a quantum many-body problem. The equations of quantum chromodynamics (QCD) that describe the interaction between quarks and gluons (the constituents of nucleons) cannot be solved directly. Nucleons, proton, anti-proton, and neutron beams were widely used as probes to study the interaction and structure of nuclei. Anti-neutron beams were hardly used before because they are very difficult to produce and store. However, anti-neutron beams would be a good probe due to the large cross section between nuclei and anti-neutron. It is found that anti-neutron will interact with nuclei of materials of beam pipe and MDC inner wall, which are beryllium, gold, carbon and oxgen. in the study of the reaction of $e^+e^- \to J/\psi \to p\bar{n}\pi^-$, using 10 billion J/ψ events collected at BESIII. With a careful analysis of the background events in the reaction $e^+e^- \to J/\psi \to p\bar{n}\pi^-$, two exclusive nucleus-nucleon reactions $\bar{n} + A \to \bar{p} + p + X$ and $\bar{n} + A \to \bar{p} + 2p + X'$ are found and reconstructed with high resolution. We can extract the intensity of the reactions between nuclei and anti-neutron and nucleon-nucleon correlations inside the nuclei. GEANT4 doesn't include this two reactions yet. I'm developing a DIY GEANT4 physics process to simulate the interaction between anti-neutron and nuclei to study the efficiency of reconstruction.

Nov. 2021 – Ongoing

Measurement of decay parameters and test of $\Delta I = 1/2$ rule by investigating Ξ^- neutral sequential decay in the process $J/\psi \to \Xi^-\bar{\Xi}^+$

Charge conjugation and parity (CP) symmetry violation in baryon sector is one of three essential conditions to understand baryogenesis. The mechanisms of CP violation predicted by the standard model are too small to explain the observed matter-antimatter asymmetry of the Universe. Physics beyond the standard model is expected in the CP violation of baryon weak decays. This project is one of the most precise measurement of the decay asymmetry parameters of hyperons $\Xi^- \to \Lambda\pi^- + c.c$ and $\Lambda \to p\pi^- + c.c.$ or $\Lambda \to n\pi^0 + c.c.$. Four hyperon CP asymmetry observables are constructed from decay asymmetry parameters, $A_{CP}^{\Xi} = \frac{\alpha_{\Xi^-} + \alpha_{\bar{\Xi}^+}}{\alpha_{\Xi^-} - \alpha_{\bar{\Xi}^+}}$, $\phi_{CP}^{\Xi} = \frac{\phi_{\Xi^-} + \phi_{\bar{\Xi}^+}}{2}$, $A_{CP}^{-} = \frac{\alpha_- + \alpha_+}{\alpha_- - \alpha_+}$, and $A_{CP}^{0} = \frac{\alpha_0 + \bar{\alpha}_0}{\alpha_0 - \bar{\alpha}_0}$. The isospin amplitudes of $\Delta I = 1/2$ and $\Delta I = 3/2$ transitions in Λ non-leptonic decay are determined. We combined the A_{CP}^{-} and A_{CP}^{0} under the limit of the first order of $\Delta I = 3/2$ to obtain a more accurate CP test for Λ decay $A_{CP}^{\Lambda} = \frac{2A_{CP}^{-} + A_{CP}^{0}}{3}$. In order to discriminate the signal photons from other showers, I apply a boost decision tree on them based on the the measured variables. I measure the decay asymmetry parameters by adopting a maximum likelihood fit with a joint-angular amplitude derived based on helicity frame. I designed a GPU-based CUDA package to speed up the fit program more than 20 times. This project will result in doctoral thesis and a publication. Draft is under collaboration inner review.

Sep. 2018 – Ongoing

First Measurement of $J/\psi \to \Sigma^-\bar{\Sigma}^+$ at BESIII

The project aims to measure the branching fraction and production parameters of $J/\psi \to \Sigma^-\bar{\Sigma}^+$. The decay processes $\psi \to B\bar{B}$ pairs, where ψ denotes both the J/ψ and $\psi(2S)$ charmonium states and B denotes SU(3)-flavor-octet baryon, serve as a good laboratory for understanding perturbative QCD (pQCD) in a transition region between perturbative and non-perturbative regimes. Under the hypothesis of flavor-SU(3) symmetry and neglected the electromagnetic contribution, the amplitude of $\psi \to B\bar{B}$ pairs should be the same. The consistency between measurement and theoretical value in $J/\psi \to \Sigma^-\bar{\Sigma}^+$ will be a crucial evidence to verify the effective Lagrangian theory. A simple effective, data-driven method are developed to improve the modeling of anti-neutron signatures in the BESIII EMC to study the reaction $\bar{\Sigma}^+ \to \bar{n}\pi^+$. This project will result in a physics publication (preparing draft).

Sep. 2018 – 2021

Development of a data-driven method to simulate the detector response of anti-neutron at BESIII

The neutron is one of the primary building blocks of atomic matter in the visible universe. A rich physics program involve neutron in the final state, such as $\Lambda \to n\pi^0$, $e^+e^- \to n\bar{n}$, $\Lambda_c^+ \to n + X$, $\Sigma^- \to n\pi^-$. Usually, the anti-particles to neutrons, namely anti-neutrons, are used in the reconstruction instead of neutrons due to their large cross section with materials. Due to the lack of the knowledge of the hadronic interaction for a hadron passing through or depositing in material, the energy deposited, the secondary particles produced, and the shower shape when the antineutron interacts with the calorimeter cannot be simulated acceptably under the current GEANT4-based model. Though many models have been implemented in Geant4 to describe hadron– nucleon interactions, such as quark–gluon string model (QGS), the Fritiof parton model (FTF) or the Bertini and Precompound models, none of them gives a satisfactory result for the simulation of antineutrons. We developed a data-driven method to simulate the detector response of the anti-neutron at BESIII. Both the detection efficiency and various observables of anti-neutrons are sampled from data, which is independent from the Geant4 simulation. Up to now, five projects involving anti-neutron adopt the data-driven method and three have been published.

Publications

First author

1. **Liu, L.**, Zhou, X. & Peng, H. Development of a data-driven method to simulate the detector response of anti-neutron at BESIII. *Nucl. Instrum. Meth. A* **1033,** 166672 (2022).
2. **Liu, L.** CP symmetry tests in hyperon weak decays at BESIII. *PoS* **ICHEP2022,** 951 (2022).

Main author

3. Ablikim, M. *et al.* Measurement of the Absolute Branching Fraction and Decay Asymmetry of $\Lambda \to n\gamma$. *Phys. Rev. Lett.* **129,** 212002 (2022).
4. Ablikim, M. *et al.* Observation of the decay $\psi(3686) \to \Sigma^- \overline{\Sigma}^+$ and measurement of its angular distribution. *JHEP* **12,** 016 (2022).

Status : submitted

5. Ablikim, M. *et al.* Measurement of the absolute branching fraction of the inclusive decay $\bar{\Lambda}_c^- \to \bar{n} + X$. arXiv: 2210.09561 [hep-ex] (Oct. 2022).

*(*note: According to the policy of BESIII Collaboration, the authors of the papers are sorted alphabetically. I have published 3 collaboration papers at BESIII as the main author.)*

Co-author

Status : submitted

6. Zhang, J.-Y., Fu, C.-D., Li, H.-B., **Liu, L.** & Zhou, X.-R. Measurement of CP violation of neutral kaon system in J/ψ decay at the Super Tau-Charm Facility. arXiv: 2209.12551 [hep-ex] (Sept. 2022).

Conference

2022 | *CP symmetry tests in hyperon weak decays at BESIII*
Volume 414 - 41st International Conference on High Energy physics (ICHEP2022) - Poster Session

Teaching assistant

2018 | **Electromagnetism**
Tutoring; holding office hours; invigilating tests or exams; discussion sessions.

2017 | **Complex analysis**
Tutoring; holding office hours; invigilating tests or exams; discussion sessions.

BESIII Referee Committee

2022 | **First measurement of the Lambda-p inelastic scattering at e^+e^- collider**
Reanalysis of $D_s^+ \to \tau^+\nu_\tau$ via $\tau^+ \to \pi^+\bar{\nu}_\tau$ with data between 4.178 and 4.226 GeV

2021 | **Upper limit for $e^+e^- \to \bar{p}\bar{p}\pi^+ d$ + $c.c.$ above 4 GeV**