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Intelligent experiments through real-time AI: Fast Data Processing and Autonomous Detector Control for sPHENIX and future EIC detectors

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A collaboration of scientists from LANL, MIT, FNAL, NJIT, ORNL, and GIT, supported by the DOE Office of Science Nuclear Physics AI Machine Learning initiative, is exploring advanced AI technologies to tackle data processing challenges at RHIC and the future EIC. The main objective is to develop a demonstrator for real-time processing of high-rate data streams from sPHENIX experiment tracking detectors to identify rare heavy-flavor events in proton-proton (p+p) collisions. Our innovative approach integrates streaming readout with an intelligent control system, utilizing FPGA hardware to accelerate AI inference. This improves the efficiency of collecting rare heavy-flavor events in high-rate p+p collisions (˜1 MHz), optimizing the use of limited DAQ bandwidth (˜15 kHz). We employ Graph Neural Network-trigger algorithms, trained on sPHENIX p+p collision simulation data, and use the hls4ml package to convert AI models into firmware. These real-time AI technologies are deployed on FELIX-712 boards equipped with Xilinx Kintex Ultrascale FPGAs. Our approach is also adaptable to other fields requiring high-throughput data streams and real-time detector control, including future EIC experiments. This talk will highlight AI-driven heavy-flavor triggering for sPHENIX and the development of DIS electron tagger algorithms for the EIC, showcasing the transformative potential of AI and FPGA technologies in real-time data processing for high-energy nuclear and particle experiments.

Category

Experiment

Collaboration

sPHENIX

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