Nuclear Physics Detector Design Using A.I.

Thomas Jefferson National Accelerator Facility, University of Massachusetts, Amherst

Detector design optimization using A.I. maximizes impact of future measurement of charged π polarizability

Innovation

Sophisticated particle beam experiments carried out at Jefferson Lab often combine multiple detector technologies to measure different properties of the particles produced in subatomic reactions. Combining the information from multiple detectors has always been a challenge and one primarily faced after the experimental data has already been gathered. Using A.I. we were able to determine the design of a detector prior to the experiment that will be optimal for meshing its data with other existing detectors.

Physicists from Jefferson Lab collaborated with scientists at UMass, Amherst to design the muon chambers for the Charged Pion Polarizability (CPP) experiment[1]. The experiment will leverage already existing detectors in conjunction with a new detector to measure and identify π and μ particles. A.I. was used to perform the complex analysis that combined the information from the very different detector types. This allowed the parameters of the new detector to be optimized to give maximum signal purity.

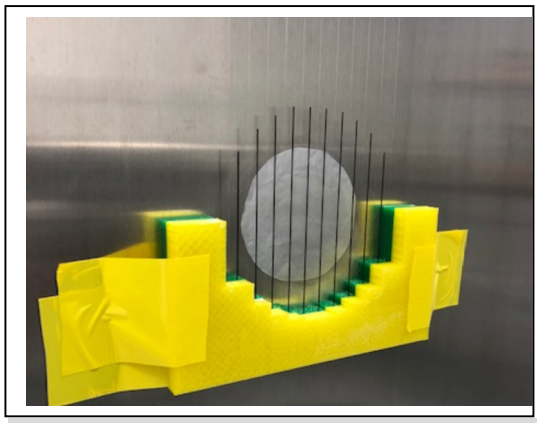
Outcomes

Technology Advancement

The CPP experiment requires distinguishing the very similar π and μ particles to a contamination level of 0.5% or less. The use of A.I. performing a multi-variate analysis was able to show this would be possible with addition of a supplemental detector. The A.I. technology was further employed to optimize the design of the supplemental detector so that the overall goal of 0.6% statistical uncertainty can be achieved in the beam time allotted to the experiment.

Impact

Jefferson Lab's Continuous Electron Beam Accelerator Facility is the world's most advanced particle accelerator for investigating the quark structure of matter. As a DOE user facility, it provides electron beams for research carried out by more than 1,600 nuclear physicists across the nation and around the world. Use of the facility is in very high demand. Using A.I. to aid in the design of detectors helps make efficient use of this valuable resource allowing more experiments to be done while improving their precision.



Carbon fiber tubes used to deaden drift chamber wires in beam region. The size and shape of the dead region as well as other design parameters were optimized using A.I.

"A.I. has allowed us to save valuable accelerator beam time and simultaneously achieve unprecedented precision in our experiments"

David Lawrence Ph.D.
Staff Scientist, Jefferson Lab

Timeline

2017-2021: Detector optimization using A.I. was done in 2017. Detector construction in 2017-2020. The experiment is expected to run in 2021 or 2022.

[1] A. AlekSejevs et al. *Measuring the Charged Pion Polarizability in the γγ -> $\pi^+\pi$ Reaction (A proposal to the 40th Jefferson Lab Program Advisory Committee.* https://www.jlab.org/exp_prog/proposals/13/PR12-13-008.pdf