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Progress on AI-Assisted Detector Design for the EIC (AID(2)E)

Artificial Intelligence is set to play a transformative role in designing large and complex detectors, such as the ePIC detector at the upcoming Electron-Ion Collider (EIC). The ePIC setup features a central detector and additional systems positioned in the far forward and far backward regions. Designing this system involves balancing many factors—performance, physics goals, and cost—while also meeting strict mechanical and geometric constraints.

This project introduces a scalable, distributed AI-assisted framework for detector design, known as AID(2)E. It uses advanced multi-objective optimization methods to tackle the complexities of the detector configuration. The framework is built on the ePIC software stack and relies on GEANT4 simulations. It supports clear parameter definitions and integrates AI techniques to improve and speed up the design process.

The workflow is powered by the PanDA and iDDS systems, which are widely used in major experiments like ATLAS at CERN, the Rubin Observatory, and sPHENIX at RHIC. These systems help manage the heavy computing needs of ePIC simulations. Modifications made to PanDA in this project aim to improve usability, scalability, automation, and monitoring.

The main goal is to build a strong design capability for the ePIC detector using a distributed AI-assisted workflow. This approach will also be extended to support the development of the EIC's second detector (Detector-2), as well as tasks like calibration and alignment. In parallel, we are creating new data science tools to better understand and manage the complex trade-offs revealed during the optimization.

We will present recent updates to the AID(2)E framework, with a focus on new features that support scalable and efficient detector design. Specifically, we will show how distributed optimization is integrated into the ePIC software stack and demonstrate its use in large-scale simulation and design optimization efforts.

Significance

The work demonstrates how AI-driven, distributed optimization can significantly streamline and enhance the complex design process of large-scale particle detectors like ePIC, paving the way for more efficient, scalable, and data-informed experimental infrastructure at the Electron-Ion Collider.

References

https://arxiv.org/abs/2405.16279

Experiment context, if any

EIC, ePIC

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