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Porting and optimizing the performance of LArTPC Detector Simulations with C++ standard parallelism

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There is a significant expansion in the variety of hardware architectures these years, including different GPUs and other specialized computing accelerators. For better performance portability, various programming models are developed across those computing systems, including Kokkos, SYCL, OpenMP, and others. Among these programming models, the C++ standard parallelism (std::par) has gained considerable attention within the community. Its inclusion as a part of the C++ standard library underscores its significance and potential impact, and it is also supported on AMD and Intel GPU recently.

As part of the High Energy Physics Center for Computational Excellence (HEP-CCE) project, we investigate if and how std::par may be suitable for experimental HEP workflows with some representative use cases. One of such use cases is the Liquid Argon Time Projection Chamber (LArTPC) simulation which is essential for LArTPC detector design, validation and data analysis. Following our earlier work of using Kokkos, OpenMP, and SYCL to port LArTPC simulations module, we are going to present the following topics: 1). How std::par is currently supported on different architectures and compiler, and comparison with other programming models; 2). Lesson learned from optimizing kernels with std::par; 3). Advantages and disadvantages of using std::par in porting LArTPC simulation and other HEP programs.

Significance

In this presentation, we intend to show the feasibility of porting HEP applications using C++ standard parallelism. As part of the C++ standard, we believe this will greatly interest the broader HEP community.

std::par was previously only supported by limited types of GPU architecture and compiler. However, recently, std::par has been supported on AMD GPU by llvm and intel GPU by onedpl. Because of that we would like to present how it performs on a wider range of architecture and the experience we learned to improve the performance using std::par.

References

[1] Yu, Haiwang; Dong, Zhihua; Knoepfel, Kyle; Lin, Meifeng; Viren, Brett; Yu, Kwangmin; Evaluation of Portable Acceleration Solutions for LArTPC Simulation Using Wire-Cell Toolkit,EPJ Web of Conferences,251,03032,2021,EDP Sciences

[2] Dong, Zhihua; Knoepfel, Kyle; Lin, Meifeng; Viren, Brett; Yu, Haiwang; Evaluation of Portable Programming Models to Accelerate LArTPC Detector Simulations, arXiv preprint arXiv:2203.02479,2022

[3] M Lin; Z Dong; T Wang; M Atif; M Battacharya; K Knoepfel; C Leggett; B Viren; H Yu; Portable Programming Model Exploration for LArTPC Simulation in a Heterogeneous Computing Environment: OpenMP vs. SYCL, arXiv preprint arXiv:2304.01841,2023

Experiment context, if any

The Liquid Argon Time Projection Chamber (LArTPC) technology is widely used in high energy physics experiments, including the upcoming Deep Underground Neutrino Experiment (DUNE).

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