

# Hybrid-BLond: Efficient Scale-Out of Beam Longitudinal Dynamics Simulations

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Excessive studies and simulations are required to plan for the upcoming upgrades of the world's largest particle accelerators as well as for the design of future machines with tight budgetary margins. The Beam Longitudinal Dynamics (BLond) simulator suite incorporates the most detailed and complex physics phenomena in the field of longitudinal beam dynamics, required for extremely accurate predictions. Those predictions are invaluable to operate the existing accelerators for cost efficiency, plan the upcoming upgrades and design future machines. In this paper, we implement and evaluate a hybrid version of the code BLond, that efficiently combines horizontal and vertical scaling. We propose and evaluate a series of techniques that minimize the inter-node communication overhead and improve scalability. Firstly, we exploit task parallelism opportunities. Secondly, we discuss and implement two approximate computing techniques. Finally, we build a dynamic load balancer to bring everything together. We evaluate Hybrid-BLond in an HPC cluster built with cutting-edge Intel servers and Infiniband interconnection network. Our implementation demonstrates an average 6.4-fold speedup over the previous state-of-the-art simulator and 79.7% scalability efficiency on average across three realistic test-cases.

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