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An Integrated Research Infrastructure framework for digital twins of laser-plasma acceleration experiments- 10'+5'

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Laser-plasma acceleration is a promising acceleration technology for a number of applications due to the large accelerating gradient and unique beam properties that it produces. This technology is in active development, and experimental campaigns typically dedicate significant time to exploring the parameter space in real time, adjusting laser properties, target configuration, and other factors to find the optimal setup. Therefore, having AI/ML-driven digital twins capable of providing real-time optimization guidance, by learning from both experimental and simulation data, would be highly beneficial.

We present progress towards an Integrated Research Infrastructure framework that can run multi-GPU simulations during experimental campaigns, and combine the results with ongoing measurements to provide real-time guidance. The framework is primarily intended for use at LBNL's BELLA Center and leverages several open-source tools, including WarpX and LASX for simulations, lume-model for the AI/ML digital twin, NERSC's superfacility API for submitting multi-GPU simulations in real time and the Prefect platform for overall workflow orchestration. Additionally, we will discuss challenges in building ML models that must learn from distinct and potentially mismatched data sources.

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