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APOLLO: a facility-scale differentiable virtual accelerator at Fermilab FAST/IOTA

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As the design complexity of modern accelerators grows, there is more interest in using advanced simulations that have fast execution time or yield additional insights like gradients. The FAST/IOTA facility has been working on implementing and experimentally validating an end-to-end digital twin that is both fast and gradient-aware, allowing for rapid prototyping of new software and experiments with minimal beam time costs. Our framework integrates physics and ML codes for linac and ring simulation through a set of generic interfaces between surrogate and physics-based sections. To reproduce device inputs and outputs, system state is exposed as a deterministic event loop in a specialized discrete event simulator architecture. Because Fermilab is undergoing control system transition, several APIs were implemented as final user interfaces - a fully asynchronous EPICS soft IOC, a gRPC-based Data Pool Manager (DPM), and legacy ACNET protocols. We discuss implementation details as well as challenges handling live data assimilation and future plans to extend modelling to main complex proton accelerators like PIPII and Booster.

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Footnotes

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