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End-to-end differentiable digital twin for the IOTA/FAST facility- 15'+5'

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As the design complexity of modern accelerators grows, there is more interest in using controllable-fidelity simulations that have fast execution time or yield additional insights as compared to standard codes. One notable example of additional information are gradients of physical observables with respect to design parameters produced by differentiable simulations. The IOTA/FAST facility has recently begun a program to implement and experimentally validate an end-to-end digital twin to serve as a virtual accelerator test stand, allowing for rapid prototyping of new software and experiments with minimal beam time costs. In this contribution we will discuss our plans and progress. Specifically, we will cover the selection and benchmarking of both physics and ML codes for linac and ring simulation, the development of generic interfaces between surrogate and physics-based sections, and presenting the control interface as either a deterministic event loop or a fully asynchronous EPICS soft IOC. We will also discuss challenges in model calibration and uncertainty quantification, as well as future plans to extend modelling to larger machines like PIP-II and Booster.

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