MATTER AND TECHNOLOGIES

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Towards a Data-driven Digital Twin of a Free Electron Laser

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Sources of soft X-rays are highly appealing in research as they allow to image atomic- and molecule- scaled structures, however high requirements to technical equipment complicate application of such systems. Free electron laser is one of famous sources of ultra-intense coherent X-ray beams. Convenient kilometer-scale electron accelerators make these facilities expensive and difficult to maintain, while laser-driven electron accelerators might significantly reduce size of free-electron lasers. In order to control such a source of X-rays there are required time consuming numerical and experimental research. A rising demand on statistical and mathematical methods for inversion of the system state, comprehension of measurement data and quantification of data stability can only be met by a comprehensive machine learning based digital twin for Free Electron Laser. The digital twin potentially accelerates theoretical comprehension of the system, novel means for design space exploration and promises reliable in-situ analysis of experimental diagnostics and parameters which leads to democratization of laser-driven FELs accelerating fundamental science in research field MATTER by collaborative efforts in Matter and Technologies. Digital twin is comprising of multiple surrogate models for electron acceleration processes by virtue of that one could unveil beam dynamics on the scope of collected diagnostic. This formulation allows us to derive observables within the beamline promising physics-informed inversion of the beamline meaning that we are able to explain observations guided by our theoretical understanding.

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