Contribution ID: **1738** Contribution code: **THPL014** Type: **Poster Presentation**

Accurate prediction of mega-electron-volt electron beam properties from UED using machine learning

Thursday 11 May 2023 16:30 (2 hours)

To harness the full potential of the ultrafast electron diffraction (UED) and microscopy (UEM), we need to know accurately the electron beam properties, such as emittance, energy spread, spatial-pointing jitter, and shot-to-shot energy fluctuation. Owing to the inherent fluctuations in UED/UEM instruments, obtaining such detailed knowledge requires real-time characterization of the beam properties for each electron bunch. While diagnostics of these properties exist, they are often invasive, and many of them cannot operate at a high repetition rate. Here, we present a technique to overcome such limitations. Employing a machine learning (ML) strategy by training a model on a small set of fully diagnosed bunches, we can accurately predict electron beam properties for every shot using only parameters that are easily recorded at high repetition rate by the detector while the experiments are ongoing. Applying ML as real-time non-invasive diagnostics could enable some new capabilities, such as online optimization of the long-term stability and fine single-shot quality of the electron beam, filtering the events and making online corrections of the data for time-resolved UED, fully realizing the potential of high repetition rate UED and UEM for life science and condensed matter physics applications.

Funding Agency

Footnotes

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Yes

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Session Classification: Thursday Poster Session

Track Classification: MC6: Beam Instrumentation, Controls, Feedback and Operational Aspects: MC6.A27: Machine Learning and Digital Twin Modelling