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Deciphering SASE X-ray Pulse Characteristics with β-Variational Autoencoder Networks

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Free electron lasers (FEL) play an important role across diverse scientific disciplines. Many experiments can benefit from a non-destructive online photon diagnostic of provided X-ray pulses. One method to obtain information about the pulse profile involves analyzing not the X-ray photons directly, but rather the energy distribution of the electrons downstream of a Self-Amplified Spontaneous Emission (SASE) undulator.
In recent times, neural networks have gained widespread recognition as potent analytical tools spanning various scientific domains. Among these, β Variational Autoencoder (β-VAE) networks stand out for their ability to discern key parameters within unlabeled datasets, even when these parameters are unknown beforehand. This study showcases the application of β-VAEs in characterizing SASE X-ray pulses generated by the free electron laser FLASH in Hamburg. Leveraging data from a Transverse Deflecting Structure (TDS), we demonstrate the β-VAE's capacity to identify the SASE strength, a critical parameter, within real-world data from FLASH. This discovery holds promise in improving the accuracy of lasing off references and therefore enhancing the reconstruction of XUV power profiles.

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