Intelligent control of Lasers for Accelerators

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For optimal operation, accelerators and FELs require precise control of their control parameters. Lasers are of critical importance for photocathode, FEL seeding, and probe lasers. We will show our current results and plans to optimize the performance (pulse parameters, fast set-point tuning, stability) of our photocathode and pump-probe lasers using AI methods.

In an accelerator, the laser driving the electron generation in the photocathode is of critical importance. The X-ray FEL research infrastructures in Hamburg (FLASH [1], European XFEL) operate in "burst mode" where a train of high repetition rate X-ray pules is generated every 100ms. This operation mode is very challenging for laser systems since they are not in thermal equilibrium. For example, the pulse energies, pulse shape, the beam pointing, and beam size of the output beam can vary along with the burst. We have developed a feed-forward method to enable control of each of the pulses in the burst. To further improve the FEL pulses the charge profile – especially the emittance – has to be optimized. This can be achieved by shaping of the individual laser pulses. Here the challenge is the large parameter space when shaping the laser pulse as well as the time-consuming simulation of the photocathode. The flow of this shaping procedure is shown in Fig.1. To address these challenges, we are going to use a neural network to speed up calculations.

For the pump-probe lasers used to acquire a snapshot of a chemical reaction with femtosecond resolution, high laser stability is required. During the 100ms gap between X-ray and laser bursts, no laser parameters can be measured and therefore active feedback is of limited use. However, using a deep learning model presents the opportunity to anticipate some of the changes and react in advance. This concept was evaluated on static data and about 30% of timing fluctuations can be predicted in this way.

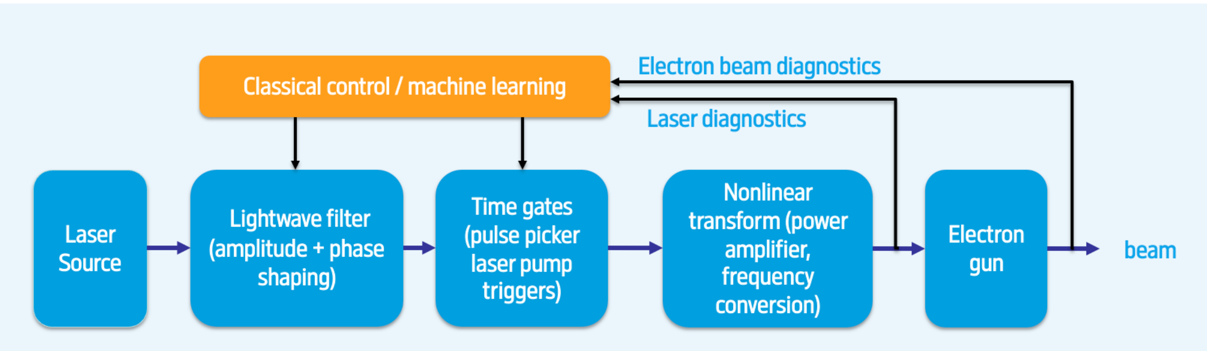

Fig. 1 Flow of the pulse shaping procedure

References

[1] M. Beye, "FLASH2020+: Making FLASH brighter, faster and more flexible : Conceptual Design Report," Verlag Deutsches Elektronen-Synchrotron, Hamburg, 2020. doi: 10.3204/PUBDB-2020-00465.