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Non-invasive bunch length reconstruction in linacs

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The bunch length in linacs is an important parameter to characterize the beam as well as to tune and optimize the final accelerator performances. In linear machines this observable is typically determined from the bunch imaged on a screen located downstream of a Transverse Deflecting Structure (TDS) used to impinge a time dependent kick along the longitudinal coordinate of the beam. This kind of measurement is typically performed during the machine setup and only sporadically to check the beam duration, but it cannot be continuously repeated, because time consuming and invasive. A non-invasive method to determine the electron bunch length was already presented in the past [1]. This method is based on the analysis of the synchrotron radiation light spot emitted by the bunch passing through a magnetic chicane provided that the energy chirp impinged on the bunch by the upstream radiofrequency structures is known. In order to overcome a systematic discrepancy affecting the SRM based results compared to the absolute TDS based ones, we implemented and optimized a Machine Learning (ML) approach to predict the bunch length downstream of the two SwissFEL compression stages - from about 10 fs up to about 2 ps - as well as the beam longitudinal profile at the first one.

[1] G.L. Orlandi, R. Xue, H. Brands, F. Frei, Z. Geng, V. Thominet, and S. Bettoni, Bunch length and energy measurements in the bunch compressor of a free-electron laser, *Phys. Rev. Accel. Beams* 22, 072803 (2019).

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Footnotes

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