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Experimental results for machine learning based diagnostics and optimization at FACET-II

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This contribution addresses recent progress in machine learning based diagnostics and optimization at the FACET-II facility at SLAC National Accelerator Laboratory. We focus the discussion around three examples: longitudinal phase space diagnostics [1-2], new algorithms for 20x speedup in optimization of beam emittance, and automated sextupole tuning to reduce minimum spot sizes in the FACET experimental area. We also present results describing the application of machine learning based characterization methods to efficiently explore high-dimensional parameter spaces [3], as compared to traditional parameter scans, in the context of emittance optimization of the FACET-II photoinjector. We will show results obtained during the last experimental run and discuss plans for deployment of these tools in future runs, along with their potential to aid in beam setup for experimental configurations, reduce tuning time, and improve beam stability. While we focus on applications at FACET-II, most of these tools can be readily used at other facilities through our open-source software packages (e.g. see [4,5]); we will briefly highlight the current capabilities of these software packages.

[1] C. Emma and A. Edelen, M.J. Hogan, B. O'Shea, G. White, and V. Yakimenko , Phys. Rev. Accel. Beams 21, 112802 (2018)

[2] C. Emma, A. Edelen, A. Hanuka, B. O'Shea, A. Scheinker, Information 2021, 12(2), 61; https://doi.org/10.3390/info12020061

[3] Ryan Roussel, Juan Pablo Gonzalez-Aguilera, Young-Kee Kim, Eric Wisniewski, Wanming Liu, Philippe Piot, John Power, Adi Hanuka & Auralee Edelen Nature Communications volume 12, Article number: 5612 (2021)

[4] C. Mayes, R. Roussel, H. Slepicka, Xopt. 10.5281/zenodo.6991160

[5] C. E. Mayes and P. H. Fuoss and J. R. Garrahan and H. Slepicka and A. Halavanau and J. Krzywinski and A. L. Edelen and F. Ji, W. Lou and N. R. Neveu and A. Huebl and R. Lehe and L. Gupta and C. M. Gulliford and D. C. Sagan and J. C. E and C. Fortmann-Grote, IPAC'21, THPAB217.

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