Automatic tuning for high gain, low energy spread, and low variance PWFA

E-325 FY22 Progress and Plans for FY23

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Adaptive ML-based longitudinal phase space control & predictions at FACET-II

SYAG spectrum measurements

TCAV

P1: L1 phase [deg], P2: L1 voltage offset [dV/V], P3: L2 phase [deg], P4: L2 voltage offset [dV/V], P5: x-offset, P6: y-offset

Non-invasive phase space diagnostics-based adaptive tuning of the longitudinal phase space distribution of the FACET-II beam. Automatic current profile tuning.


FY21: Natural Machine Variance

LI11 KLYS 11

phase [deg]

amp [%]
FY21: Solenoid + X,Y Correctors Scan

SOLN:IN10:121

QUAD:IN10:121

XCOR:IN10:121

YCOR:IN10:121

FY21: Solenoid + X,Y Correctors Scan

PR14803 \( \sigma_x \) [mm]

PR14803 \( \sigma_y \) [mm]

PMON \( \sigma_x \) [mm]

PMON \( \sigma_y \) [mm]

PRDMP \( \sigma_x \) [mm]

PRDMP \( \sigma_y \) [mm]
Physics-Informed Adaptive ML for 6D phase space diagnostics. Observational biases introduced directly through data that embody the underlying physics to learn functions that reflect the physical structure of the data. Encoder-decoder CNN for nonlinear data compression: Low-dimensional latent space tuning.


Adaptive Latent Space Tuning

BC20

IP
FY22: Robust Adaptive Latent Space Tuning
Adaptive ML Robustness test: Moving far beyond the span of the training data to a unseen input beam distribution, higher solenoid strength, and larger charge.

**Change:** % difference of the 15 projections relative to initial input and parameter settings as the beam changes.

**CNN:** % difference of the 15 projections if the input beam and parameter settings are known. The error remains small within the span of the training set and then the CNN catastrophically fails as the training set is left behind (it is actually worse than doing nothing), as expected.

**AML:** % error of the 15 projections if the input beam and parameter settings are unknown, but adaptive ML is used for active feedback based on \((z,E)\) measurements, resulting in higher accuracy tracking and no catastrophic failure with this robust approach.
FY22: Simultaneous recording of PR10571, PR11375, SYAG, and S20 TCAV

With help from: Henrik Ekerfelt & Sebastian Turkewitz
FY22: Simultaneous recording of PR10571, PR11375, SYAG, and S20 TCAV, xy-scan

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FY22: Simultaneous recording of PR10571, PR11375, SYAG, and S20 TCAV

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Next Steps for FY23

1. SYAG + Profile Monitors to TCAV mapping.
2. Adaptive ML-based tuning for custom current profile control.
3. Adaptive ML-based tuning for custom 2D LPS profile control.