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Fine-tuning objective functions for Bayesian optimization of LWFA-accelerated electrons in nanostructured CNT targets

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Nanostructured materials composed of alternating layers of two-dimensional carbon structures and empty or low-density regions have emerged as promising targets for compact, ultra-high gradient electron acceleration via LWFA. As an intense laser pulse propagates through these gaps, the carbon atoms at their boundaries are ionized, filling the voids with high-density electron plasmas capable of sustaining accelerating gradients on the order of TeV/m. Consequently, few-micrometer-long targets can generate electron bunches carrying charges of hundreds of pico-coulombs and energies of several tens of MeV. The performance of such accelerators – in terms of beam energy, charge, and quality – depends sensitively on multiple parameters, including laser intensity, pulse duration, and target geometry. In this work, Bayesian optimization is applied to particle-in-cell simulations of concentric cylindrical-shell targets separated by vacuum gaps, aiming to identify configurations that favor edge and bubble-like self-injection of electrons for LWFA acceleration. The simulations are conducted with the FBPIC code, and Optimas is employed as the Bayesian optimization framework. Different formulations of multi-objective functions are evaluated and compared, and preliminary results reveal how these formulations affect the acceleration process and the resulting beam properties.

Presenter: Prof. BONATTO, Alexandre (Universidade Federal de Ciências da Saúde de Porto Alegre)