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## Research on Ultra-short Bunch Length Measurements with Femtosecond Resolution for EuPRAXIA

While plasma-based concepts and experiments offer increasingly high acceleration gradients with every new advancement, there is a growing need to develop and implement suitable beam diagnostics. Longitudinal diagnostics are significantly challenging when the bunch length is in the few femtoseconds scale, which is the case for ultra-short electron bunches produced on Plasma Wakefield Accelerators.

Previous research has found that coherent radiation emitted by the beam in different conditions depends on bunch length. More specifically, at the University of Liverpool, a THz-based imaging system has already been developed to image the source distribution of coherent transition and diffraction radiation, for which theory and simulations have already shown their dependence on bunch length.

This research project focuses on using broadband imaging of coherent radiation to develop a bunch-length monitor with femtosecond resolution, which will also be integrated into a virtual diagnostics suite for EuPRAXIA that works online on a non-invasive and single-shot basis.

Until now, the research activities have been focused on studying the use of coherent radiation for bunch-length measurements, reviewing cases of implementation of virtual diagnostics for several accelerator experiments around the globe, and training in machine learning tools.

The research activities are now ready to focus on (a) identifying the specific EuPRAXIA parameters and requirements for the monitor's design and optimization in close collaboration with the company D-Beam and (b) planning a future secondment for testing and integration at INFN.

**Autore principale:** GUIAO BETANCUR, Ana Maria (University of Liverpool)

**Coautore:** WOLFENDEN, Joseph (University of Liverpool); WELSCH, Carsten Peter

**Relatore:** GUIAO BETANCUR, Ana Maria (University of Liverpool)