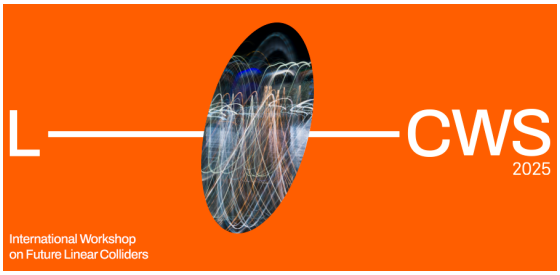

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Wakefield Mitigation and beam based alignment studies for the High-Energy EuPRAXIA@SPARC_LAB X-Band Linac

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EuPRAXIA@SPARC_LAB will be the first European research infrastructure designed to demonstrate plasma-based acceleration, combining a high-brightness GeV-class electron beam with a state-of-the-art X-band linac and a 0.5 PW-class laser system. The success of this facility critically depends on the preservation of beam quality during acceleration, as wakefields and structural misalignments in the linac can lead to significant transverse emittance growth and compromise the efficiency of plasma injection. To address these challenges, advanced beam-based alignment (BBA) and correction techniques are required. In particular, Dispersion-Free Steering (DFS) and Wakefield-Free Steering (WFS) have been developed to minimize trajectory deviations and mitigate the impact of short-range wakefields, which represent one of the main limitations in high-gradient linacs. In this work, we present a detailed study of emittance preservation along the EuPRAXIA@SPARC_LAB X-band linac. Dedicated RF-Track simulations are performed to evaluate the effectiveness of DFS and WFS in compensating for wakefield-induced distortions and alignment errors. The results aim to demonstrate that both techniques significantly reduce emittance dilution, ensuring the beam quality required for efficient plasma injection. These findings highlight the crucial role of correction algorithms in the realization of next-generation plasma accelerator facilities.

Author: SILVI, Gilles Jacopo (Istituto Nazionale di Fisica Nucleare)

Co-authors: LATINA, Andrea (CERN); GIRIBONO, Anna (INFN-LNF); VACCAREZZA, Cristina (INFN-LNF); FERRARIO, Massimo

Presenter: SILVI, Gilles Jacopo (Istituto Nazionale di Fisica Nucleare)

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