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Exploring Dark Matter with Dielectric Laser Acceleration

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This study presents a Dielectric Laser Accelerator (DLA) tailored for single-electron acceleration, optimised for particle survival and minimal beam energy spread. Leveraging a genetic algorithm, we strategically design the dielectric structure to achieve efficiency in both computational runtime and structure performance.
The study focuses on three key aspects: the selection of a suitable electron source with the right emittance, beam dynamics for sub-relativistic and relativistic electrons, and the alignment of beam properties with the requirements for indirect dark matter search. Our findings establish DLA as a promising tool for advancing dark matter research.
Indirect dark matter exploration necessitates a high repetition rate of single electrons in the GeV energy range. The DLA's potential to operate at GHz rates makes it an ideal candidate for designing a compact accelerator for dark matter search. To achieve high repetition rates, a suitable laser and electron source are essential. Hence, we introduce RF-based electron microscope type-sources for our design, as they can operate at 3GHz or higher.
A segmented optimization approach is employed to the structure accelerating particles from 10 MeV to 1GeV. Instead of conducting global optimization for the entire DLA structure length, we will employ a localized optimization strategy, optimizing each 10mm-long segment independently while iteratively adjusting the input beam conditions for subsequent segments. Through this iterative process, the DLA structure can be optimized in an efficient runtime. The output beam parameters like energy spread and survival rate will be compared to the parameters required for indirect search of dark matter.

Working group

WG4 : Novel structure acceleration

Primary author: DADASHI MOTLAGH, Raziyeh

Co-authors: FERRO-LUZZI, Massimiliano (CERN); ISCHEBECK, Rasmus (Paul Scherrer Institut (PSI)); JACOBSSON, Richard (CERN); KRASNY, Mieczyslaw Witold (Sorbonne University); LATYCHEVSKAIA, Tatiana (Paul Scherrer Institut); NIEDERMAYER, Uwe (Technische Universität Darmstadt); ZIMMERMANN, Frank (CERN); SEIDEL, Mike (PSI)

Presenter: DADASHI MOTLAGH, Raziyeh

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