Plasma accelerators for high energy physics

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The long-term sustainability particle accelerators requires novel accelerator techniques that can be more cost effective, with smaller environmental footprints, and more compact. Plasma-based accelerators are in a unique position in this regard as recent experiments demonstrated the generation of 10 GeV electron bunches with percent-level energy spreads in a 30 cm long plasma. Furthermore, with a 0.5% relative energy spread, (comparable with that presented on the CLIC conceptual design report), GeV class electron bunches from plasma accelerator experiments, met the conditions to obtain lasing in free-electron lasers.

Europe is leading high-profile projects and initiatives to consolidateestablish the maturity of this technology. This includes the ESFRI roadmap EuPRAXIA project, which is currently in the preparatory phase (GoLP leads two work-packages of EuPRAXIA), a new Higgs factor concept (Hybrid Asymmetric Linear Higgs Factory-HALHF), and the community-based effort Advanced LinEar collider study GROup (ALEGRO), which complements a similar effort that is taking place in the US, and whose 2024 edition was organised at IST by GoLP researchers.
As a result of formidable progress in terms of stability, reproducibility and electron beam quality, plasma accelerators were included as a high research priority initiative in the previous European Particle Physics Update. An expert panel, of which GoLP researchers were members, designed a roadmap for future developments in this area. A design study, based on computer simulations, that demonstrates that plasma accelerators can preserve the emittance and energy spread at the levels required for HEP applications, is a critical missing step towards a plasma electron-positron linear collider beyond the energy frontier, and one that needs endorsement and support from the global HEP landscape and community.