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Snowmass Process Advanced Accelerator Concepts (AF6) Perspective

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Snowmass Accelerator Frontier topical group \# 6, Advanced Accelerator Concepts (<https://doi.org/10.48550/arXiv.2208.13279>), covered new R&D concepts for particle acceleration, generation, and focusing at ultra high acceleration gradients (GeV/m and beyond). Leveraging these to efficiently harness the interaction of charged particles with extremely high electromagnetic fields at very high frequencies has the potential to enable future $e+e-$ and $\gamma - \gamma$ colliders to and beyond 15 TeV energies. In addition to proven high gradient and ultra-bright beam generation, these systems have the potential to increase luminosity per unit beam power via short beams, for practical energy recovery to extend the reach of high energy physics, and for fast cooling. They hence have potential to reduce the dimensions, CO₂ footprint, and costs of future colliders, with added potential to reduce power consumption. Techniques range from laser and beam driven plasma and advanced structure accelerators to advanced phase space manipulations and generation of beams with extreme parameters. The last decade has seen tremendous progress including the demonstration of multi-GeV acceleration in a single stage, positron acceleration, efficient loading of the structure, the first staging of plasma accelerators, demonstration of beam shaping to improve efficiency in plasmas and structures, high gradient structures and greatly improved beam quality which recently culminated in the spectacular first demonstrations of laser-driven and beam-driven plasma based FELs. At the same time, solutions for potential collider issues have been identified. Conceptual parameter sets for colliders have been developed for $e+e-$ and $\gamma\gamma$ colliders at a range of energies, which present potentially competitive options with prospects for future cost reduction. In addition to a strengthened ongoing R&D program, continuing to advance collider concepts in interaction with the collider and high energy physics communities, starting with an integrated set of parameters, is important as is development of technologies through nearer-term applications.

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