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Multi-TeV colliders based on advanced accelerator concepts for the Energy Frontier

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As discussed at Snowmass, there is great interest in a lepton collider in the energy range of 10 TeV and beyond, where colliding elementary particles are anticipated to offer powerful signatures for discovery science. Ultrahigh-gradient Advanced Accelerator Concepts (AAC) offer an attractive path to enable such future colliders by significantly shrinking their size and enhancing their energy reach and efficiency while reducing their environmental impact. AAC technologies include large amplitude wakefields excited in plasmas or structures driven by intense laser pulses or particle beams. These generate acceleration fields in the range 1-100 GV/m, far greater than those achievable with conventional RF-based technologies. This implies that an AAC-based collider can be more compact, and less expensive. At the same time, their short beams and high gradients offer paths to greater efficiency than conventional approaches. Significant R&D is still required to realize any collider at this scale, and AAC research programs are making strong progress in the US and around the world. In the US, the General Accelerator R&D program-funded Beam Test Facilities have recently demonstrated milestones including staging of two modules and single stages of 8 GeV in 20 cm at LBNL's BELLA for laser-plasma accelerators; efficient wake energy transfer and positron acceleration at SLAC's FACET and now FACET II for particle-beam-driven plasma accelerators; high gradient structures and other attributes at AWA at ANL for beam driven structures; and ATF at BNL for beam-driven and CO2 laser-driven accelerators, together with strong University Programs. This active research area world-wide attracts many early career scientists and hundreds of papers are published each year reflecting rapid progress in AAC topics. Large investments are being made overseas in the potential of these technologies, which also threatens US leadership. It is timely to leverage recent progress and investment to move forward with collider options realizing these groundbreaking technologies. This includes: funding research at a vigorous level, together with upgrades to the Beam Test Facilities to ensure international competitiveness, enhanced R&D on high average power drive beams, and initiation of an integrated design study of an AAC collider, and exploration of an intermediate AAC collider facility.

For those that are here at LBNL for this townhall, you are invited to tour the BELLA PW laser facility and learn more about our laser-plasma accelerator activities.

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