APR20-2020-020178

Abstract for an Invited Paper
for the APR20 Meeting of
the American Physical Society

FACET-II: Unprecedented Beam Properties

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It is widely recognized that current designs for energy frontier colliders are pushing the envelope of affordability. They are expensive to construct and operate due to the high beam power necessary to achieve the required luminosity. Reduction in beam power without sacrificing luminosity and physics potential is only possible through tighter focusing of the colliding beams. In current designs, beamstrahlung radiation prevents further tightening of the beam focus in lepton colliders. Beamstrahlung is the fundamental process of synchrotron radiation as particles bend in the electromagnetic fields of the opposing colliding bunch. Beamstrahlung radiation both smears out the energy spectrum and produces an unwanted background source for the physics detectors. Both of these effects significantly degrade the quality of physics measurements possible. These effects become more of a challenge with higher collision energies. This obstacle can be effectively mitigated by longitudinally compressing the bunches to the extent that the radiation probability becomes small. The bunch length range to achieve this is of the order of 100nm depending on colliding beam energy [[i],[ii]]. Suppressed beamstrahlung enables a reduction of the horizontal beam size by a factor of 100 compared to existing designs and corresponding reduction in beam power, while maintaining luminosity. Further, this strategy prevents degradation of the energy spectrum, so a greater fraction of this luminosity is close to the peak collision energy a key factor for lepton collision physics. The expected performance of the FACET-II facility at SLAC National Accelerator Laboratory allows us to study beam compression within a factor of four of the aforementioned goal at higher than required bunch charge. [i] V. Yakimenko et.al. Phys. Rev. Lett. 122, 190404, 2019. [ii] G. White and V. Yakimenko, Ultra-Short-Z Linear Collider Parameters, Workshop on Future Linear Colliders (LCWS2018), Arlington, Texas, 22-26 October 2018. arXiv:1811.11782v1