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Nano-Engineered Xtal (Crystal) Technology for Accelerator Revolution (NEXTAR) - Feasibility Study of TeV/m Nano-Crystal Acceleration

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The development of high gradient acceleration and tight phase-space control of high power beams is a key element for future lepton and hadron colliders since the increasing demands for higher energy and luminosity significantly raise costs of modern HEP facilities. Atomic channels in crystals are known to consist of 10 −100 V/Å potential barriers capable of guiding and collimating a high energy beam and continuously focused acceleration with exceptionally high gradients (TeV/m). However, channels in natural crystals are only angstrom-size and physically vulnerable to high energy interactions and these factors have prevented crystals from being applied to high power accelerators. Synthetically manipulated nano-crystals (in particular those based on carbon composites, such as carbon-nanotube (CNT) and graphene) have a large degree of dimensional flexibility and thermomechanical strength. Such features could be suitable for high gradient acceleration and high intensity beam control. Nano-channels of the synthetic crystals can accept a few orders of magnitude larger phase-space volume of channeled particles with much higher thermal tolerance than natural crystals. Our preliminary simulations identified an energy gain and focusing effect of plasma wakefields in an effective nano-channel model. However, it is important to experimentally identify a wakefield generated in a quasi-ionized crystalline solid, when it is optically or electronically pumped by a high energy source (x-ray laser or particle-beam), and to examine the properties such as amplitude, phase-velocity, de-phasing length and so on. The experimental verification is a prerequisite before the idea is further explored. This report will present simulation results and discuss our plan on feasible experiments to test the nanostructured crystals at a high energy physics (HEP) facility (e.g. Fermilab Accelerator Science and Technology (FAST)) and possible collaborations on the opportunity.

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