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EASTERN TIME [GMT-4]

Compact Production of a Low Energy Laser Wakefield Accelerated Electron Beam for Medical Applications

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Purpose: To produce a low energy, keV to MeV, electron beam via laser wakefield acceleration (LWFA) that can be used for medical applications.

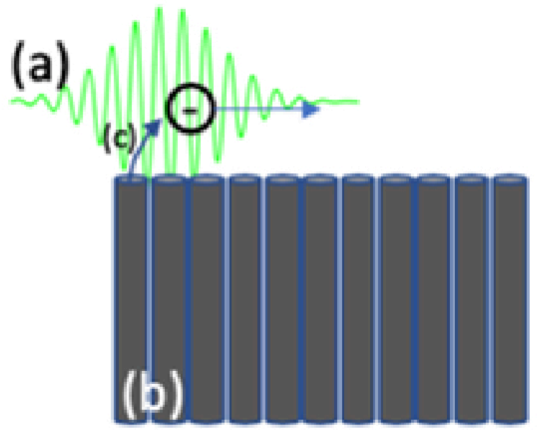
Methods: Low energy LWFA electron beams can be produced by a laser irradiating high density nanomaterials or plasma. This process was considered theoretically and simulated using the particle-in-cell (PIC) code EPOCH where a laser in vacuum enters a uniform high density plasma of electrons and protons. In this regime, the electron density is 0.1~1 times critical density.

Results: Calculations indicate that, for a laser beam intensity of 10^{16} W/cm^2, a stream of low energy electrons can be ejected from the laser-matter interaction site. These electrons can have energies from 100 keV to 1 MeV and the electron fluence can be increased by increasing the laser pulse length.

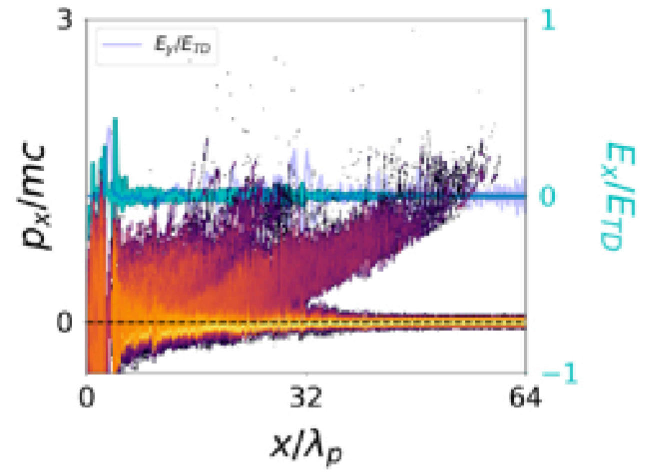
Conclusions: LWFA in a high density matter can result in a compact device of low energy electrons. The electron energy range could have useful applications in radiotherapy like treatment of superficial lesions, interstitial insertion, endoscopic treatment, and/or brachytherapy.

Innovation/Impact: The innovation factor is the used of LWFA to produce a tunable low energy electron beam that can be emitted from the tip of a micron thick fiberoptic cable. This could be a noteworthy technological advancement in Brachytherapy (superficial, interstitial, endoscopic, intravascular) since it may reduce its dependence on a high-activity radioactive source as well as reducing shielding costs.

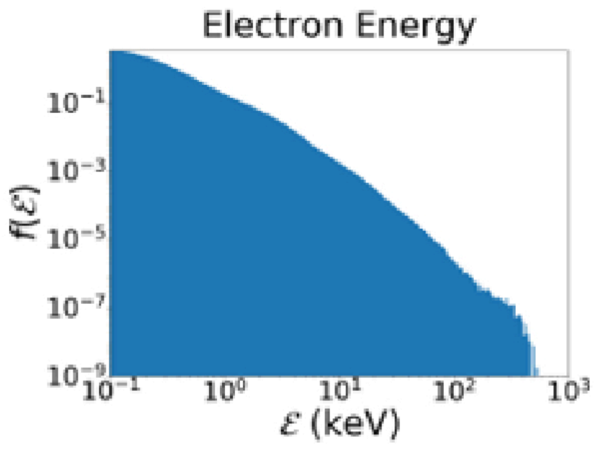
Key Results:



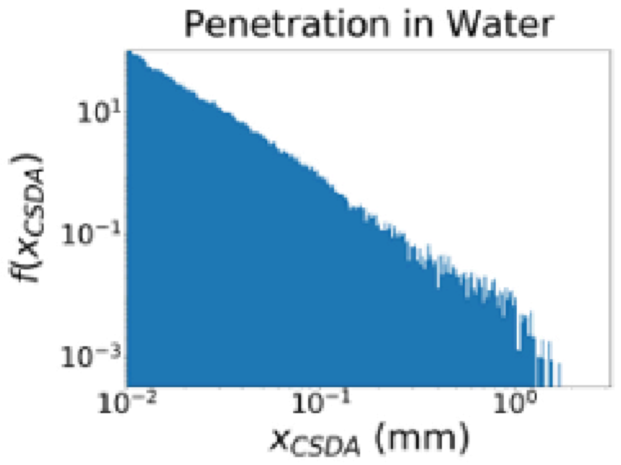
Schematic of the proposed electron beam generation. Laser (a) is injected into a "forest" of CNTs*. In the first half of a cycle (b), electrons are pulled out (c) by a transverse laser E-field and accelerated forward by $v \times B$ force.



A snapshot of the electron phase space near peak mode activity overlaid with the electrostatic field normalized to the Tajima-Dawson saturation.



Normalized electron energy spectrum.



Combining the electron energy spectrum with a stopping power in water we obtain the electron penetration in tissue.

*CNT: Carbon nanotubes

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