AbstractID: 8705 Title: Laser-to-proton energy transfer efficiency in laser-plasma interactions

Purpose: In recent years there has been an explosion of research work concerning the topic of charged ion acceleration using high-power lasers. The maximum particle energy and the shape of the distribution function are the two main parameters influencing the potential utilization of the new technology in radiation therapy. Low energy transfer efficiency from the laser pulse to protons (~ 5%) is one of the detrimental factors limiting the production of particle beams in the therapeutic energy range. In this study we show that the energy transfer efficiency can be significantly increased through a process of splitting the single interaction stage (conventional interaction design) into multiple sub-stages.

Method and Materials: 2D Particle in Cell simulation code and 3D theoretical model were used to simulate interaction of laser sub-pulses with multiple targets in a sequential manner. The thin layer of protons is initially located only at the back surface of the first target. The remaining targets are devoid of any contaminant hydrogen-rich materials.

Results: It was shown that in a three-stage setting, there is ~ 60% increase in the energy efficiency of the laser accelerator as compared to a single interaction scheme. At the same time according to the results of our 3D model, it should be possible to increase the energy efficiency by more than 100% for a six-stage interaction setting without using more powerful lasers.

Conclusions: The splitting of a single interaction site into multiple stages is an effective way of reducing an irreversible component in the energy exchange process between the laser and protons. As a result more laser energy is transformed into proton kinetic energy, thus increasing effectiveness of the “pump”.