AbstractID: 6637 Title: Chain acceleration of protons using high-power laser pulses

Purpose: To study the temporal evolution of the target's charge and its effect on the acceleration of protons. To optimize the proton energy by designing new target geometry, in which the protons experience the full acceleration potential created by the laser pulse.

Method and Materials: The process of proton acceleration is studied by means of fully relativistic two-dimensional PIC simulations (2D3V PIC) with initial conditions similar to a realistic experimental situation, where a relativistically intense (I_0=1.92x10^{21}W/cm^2, a=30) ultrashort (~40fs) infrared (λ = 800nm) laser pulse interacts with a Cu target of thickness 400~nm at normal incidence.

Results: Protons at rest on the back surface of the target were initially studied and their dynamics was analyzed. It was determined, that in this geometry the protons experience acceleration in only 25% of the peak of the electric field. The conditions were subsequently optimized by assuming a moving proton bunch incident on the target. A novel two-stage acceleration scheme was proposed (chain acceleration) and a total energy gain of 50% was estimated under optimum conditions. The implications for proton therapy are discussed.

Conclusion: It is shown, that in a conventional proton acceleration geometry using lasers, the acceleration conditions are far from optimum due to the fact that the protons are expelled from the target before the maximum charge build up is reached and as a result experience reduced acceleration potential. We proposed and analyzed a new acceleration scheme employing a double target, in which the protons accelerated in the first stage are properly timed with the laser pulse that ionizes the second target. Under such conditions the energy gain is substantial, opening up the way for proton acceleration above 100MeV using the today’s state of laser technology.