AbstractID: 5515 Title: High-Energy Proton Acceleration Driven by Ultra-Intense Ultra-Clean Laser Pulses

Purpose: To improve the contrast ratio of the multi-terawatt Chirped-Pulse Amplification (CPA) Ti:Sapphire laser to 10^{11} to allow Coulomb explosion regime of ion acceleration in the interaction of ultra-short high-intensity laser pulses with ultra-thin (< 1 micron) foils.

Method and Materials: The cross-polarized wave generation (XPW) technique in BaF_2 crystals was implemented. This technique improves contrast by rejecting the low-intensity amplified spontaneous emission (ASE) preceding the main laser pulse. Particle-in-cell (PIC) simulations were conducted under the anticipated experimental conditions: 225 TW in a 6.75 J, 30 fs laser pulse with no prepulse, focused to a spot size of 2.4 microns (FWHM) on thin foils of varying thickness.

Results: Implementation of the cross-polarized wave generation technique resulted in a contrast improvement of three orders of magnitude to approximately 10^{11}. The performed PIC simulations show that for a 0.2 μm thick hydrogen foil, protons with energy of about 200 MeV can be generated. In the case of the two-layer aluminum-hydrogen foil the maximum energy of accelerated protons is about 150 MeV, but the proton spectrum has a flatter distribution, which may be more advantageous for therapy applications.

Conclusion: We demonstrated that pulse cleaning based on cross-polarized wave generation (XPW) using two BaF_2 crystals yields a 10^{11} contrast ratio for a 50 TW laser system. Such contrast may be sufficient for a preplasma-free interaction of sub-Petawatt laser pulses with a sub-micron thickness foils at intensity of ~10^{22} W/cm^2. Modeling of this interaction with PIC simulations demonstrated proton energies that are of interest for the radiation therapy.

This study was supported by the National Science Foundation through the Frontiers in Optical and Coherent Ultrafast Science Center at the University of Michigan and the National Institute of Health.