AbstractID: 10557 Title: Acceleration of protons by high-contrast ultra-intense laser pulses

Purpose: To increase the proton energy generated in a laser-plasma accelerator by pulse contrast improvement and minimization of phase distortions.

Method and Materials: In a redesigned experiment the laser chain has been upgraded to a 150TW level and the pulse contrast has been improved by the implementation of double chirped pulse amplification (DCPA) and a cross-polarized wave (XPW) modulation technique. This novel method of prepulse reduction has been shown to generate contrast levels of the order of 10^{-10}-10^{-11}. In our new laser system stable XPW is achieved in two-pass geometry on a single BBO crystal, making the setup compact and versatile. The laser pulse is subsequently stretched and amplified in an additional 4-pass amplifier. High-dynamic range third-harmonic autocorrelator is used for pulse contrast evaluation. The wavefront distortions in the laser pulse are monitored by a 2D micro-lens array detector. The accelerated protons are registered on a CR-39 nuclear track detector behind a range filter (for energy measurement).

Results: The implementation of the XPW technique led to an improvement of the prepulse contrast from $2x10^{-5}$ to $5x10^{-9}$. The "cleaner" laser pulse allowed us to use thinner targets (<10 μm) and observe more energetic protons (>3.5 MeV). The wavefront distortions due to thermal effects in the amplifier crystals and astigmatism in our imaging systems are monitored and minimized (phase distortion <λ/3) in order to achieve optimum conditions for tight focusing.

Conclusion: Proton acceleration in excess of 3.5 MeV has been experimentally demonstrated using a more powerful laser source with better control over the laser pulse parameters. Further experiments to optimize target parameters for higher proton energies are underway using our 150TW laser as a proof that upward scaling of the laser power in a controlled fashion can bring us into the range of therapeutically useful protons.