Self lasing effect on proton beam production in Target Area West

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Introduction

A series of actions have been performed [1] to investigate and address the degradation of the proton generation in TAW, after the rearrangement of the 9 mm's preamplifier [2]. In order to prove definitively the effectiveness of the new setup on the 9 mm's preamplifier and investigate in greater detail what was the cause, an experimental campaign has been performed during August in TAW prior to the TAW upgrade described in this volume. The plan was to test the proton generation using the short pulse beam 100 J in 1 ps on thin gold targets (thickness of 10 μm and 25 μm) using different setup for the laser, primarily on the 9 mm's preamplifier.

The 9 mm preamplifier

As was described in [2], the 9 mm preamplifier was modified to avoid self-lasing. An additional faraday isolator was inserted between the two amplifiers. The waveplates required for the double pass of the amplifiers were tilted and the mirror after the first amplifier was moved further from it by about 30 cm (figure 1).

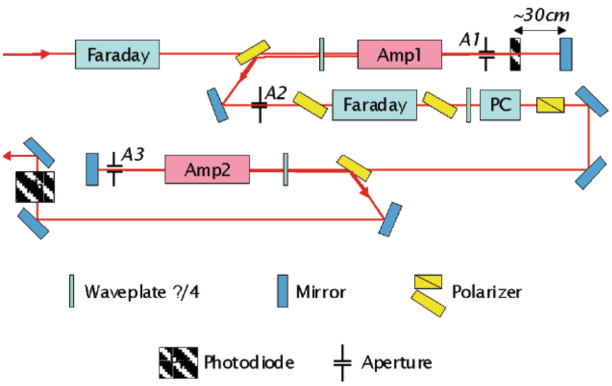

Figure 1. The 9 mm preamplifier layout.

The self emission from these amplifiers was monitored by putting a photodiode in the beam. No self lasing was observed with this new layout.

During this self lasing testing, spurious self lasing of the double pass 9 mm rod amplifier on the outer track was observed. This was removed by tilting the waveplate that is used to generate the double pass.

Experimental setup

The 100 J 1 ps laser beam in TAW was focused using an f/3 off axis parabola on a thin gold foil. The thicknesses of the targets used were 10 μm and 25 μm. The choice of the target material and thickness was chosen to reproduce a 'standard' proton generation experiment. In order to investigate any possible prepulse and/or contrast issue from the laser, a Nomarsky interferometer was setup at 90º in respect to the normal of the target surface. The second short pulse beam available in TAW, 20 J in approx. 2 ps at 1 μm, was frequency doubled and used as a probe (figure 2).

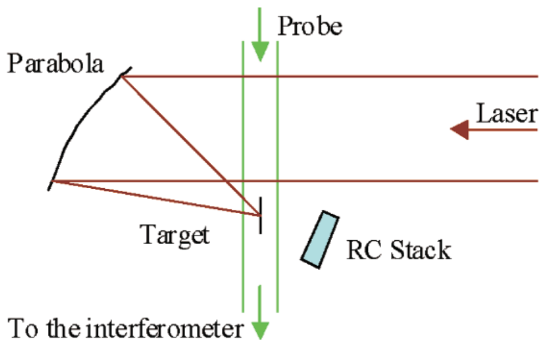

Figure 2. Experimental setup.

The proton beam was observed using a stack of radiochromic films type HD810, interleaved with mylar sheets. A layer of Al, 10 μm thick, was used to protect the stack from any residual laser light.

Results

During the experimental campaign, 36 shots in different configurations were performed. Using the new laser arrangement the proton beam generated was quite stable. The maximum observed proton energy was 36 MeV, as is shown on figure 3. The transversal beam profile shows some structure, but the divergence remains in the range that has previously been observed in TAW.

In this condition, no appreciable preplasma was observed with the interferometry and changing the target thickness did not significantly affect the generated proton beam.

In order to investigate more precisely what was the issue, all the changes were removed from the laser step by step.

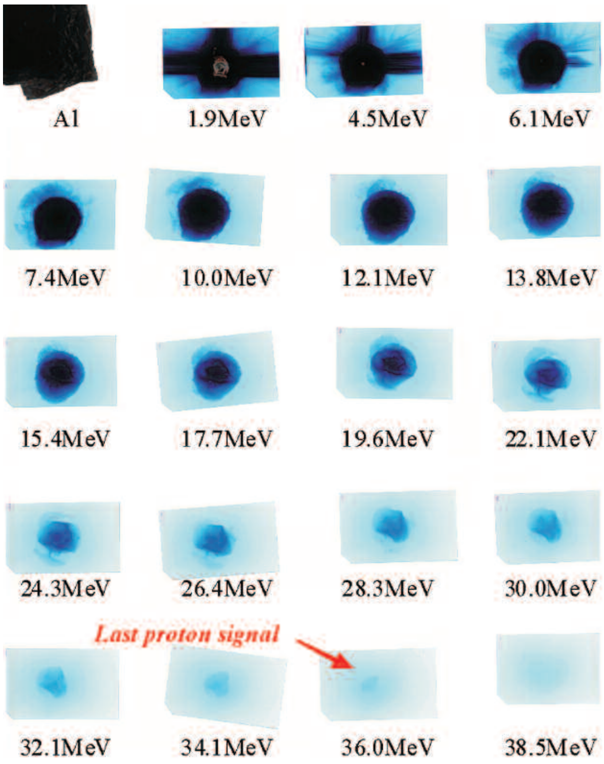

Figure 3. Proton beam with the new layout.

Reusing the old setup for 9 mm preamplifier the proton generation was only marginally affected, the maximum proton energy reduced to 24.3 MeV, and no appreciable preplasma on the interferometer.

However, reintroducing the self lasing on the 9mm rod amplifier on the outer track depleted the proton beam, reducing the maximum proton energy down to 17.7 MeV, as is shown in figure 4.

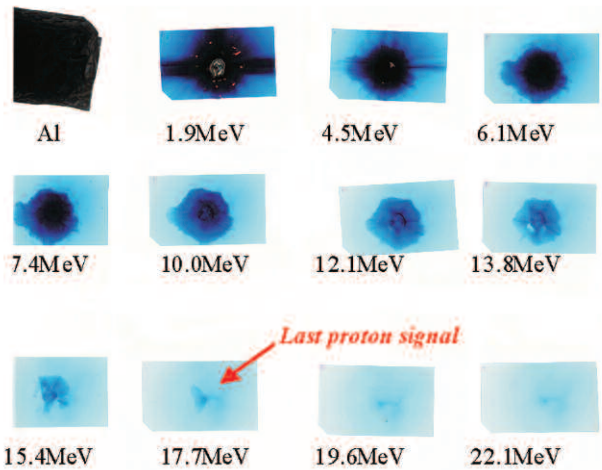

Figure 4. Proton beam with the old setup.

However, the transversal proton beam profile did not change dramatically. In this case the interferometry shows a series of week shock in the front of the target (figure 5), but no deformation on the back or a big preplasma.

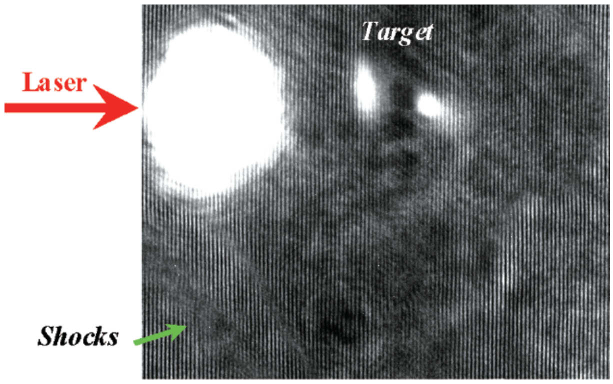

Figure 5. Interferometer of the shot with self lasing.

Returning to the best laser layout, some other shots at full energy were performed to test the stability of the laser system. Finally some more shots were taken at lower energy (20 J) with the setup for the dual cpa beam.

In some experiments performed in the past [4], the main short pulse beam has been divided into two to allow to make proton radiography experiments. Some shots were performed with this setup, to check the capabilities of the target area to perform again this kind of experiments.

Both pulses were checked, and the proton beams generated by the two beams demonstrated the same characteristics. One of the radiochromic stacks is show in figure 6.

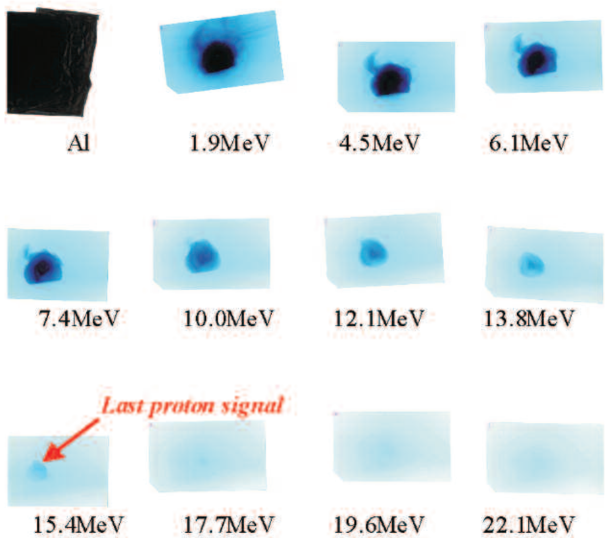

Figure 6. Proton beam with the dual cpa setup.

Conclusions

A series of shots were performed to investigate the proton generation in TAW. Using the new laser configuration, the proton generation from thin target was improved to previous performance, with a maximum proton energy of 36 MeV and nice proton beam quality. During these tests it was discovered that the main cause was the self lasing of the 9 mm rod amplifier on the outer track. Self lasing on the 9 mm preamplifier has an effect on the proton generation but less significantly.

Because the position of the 9 mm amplifier in the laser, the generated prepulse is not enough to destroy the target and/or create a preplasma. However it is enough to reduce the proton generation, perhaps cleaning the target.

The absence of a big preplasma suggests that the prepulse level was bellow the plasma threshold on gold, i.e. around 10^9 W/cm^2 for ns pulses, and this can explain why was not possible to observe in the past with a fast photodiode. [3]

References

1. M. Galimberti *et al*., *Investigation of the contrast ratio from the 9mm preamplifiers.* CLF Annual Report 2006-2007.
2. S. J. Hawkes *et al*., *Reconfiguration of the Vulcan pre-ampliers*. CLF Annual Report 2003-2004.
3. I. O. Musgrave *et al*., *Nanosecond contrast measurements of the Vulcan Petawatt facility*. CLF Annual Report 2004-2005.
4. S. Hawkes, *Beam splitter implementation for proton radiography*, CLF Annual Report 2001-2002.