

## Investigation of the contrast ratio from the 9mm preamplifiers

M. Galimberti, J. S. Green, R. Heathcote, C. Hernandez-Gomez, A. K. Kidd, K. L. Lancaster, I. O. Musgrave and W. Shaikh

Central Laser Facility, STFC, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, OX11 0QX, UK

Main contact email address

M.Galimberti@rl.ac.uk

### Introduction

After the rearrangement of the 9mm preamplifier<sup>[1]</sup> to increase the alignment stability for TAW and TAE reconfigurations in 2005, a degradation of the performance of the laser was reported by the user community. Despite the pulse energy and duration remaining as before.

The main effect reported was the degradation of the proton generation in TAW from metal targets, suggesting a reduction of the contrast ratio. Several tests were performed to look at the nanosecond contrast using a fast photodiode. However, no appreciable degradation was observed.

During an experiment in March 07 in TAP, a test shot on a 25  $\mu\text{m}$  Ni target using the 9mm preamplifiers was performed. The interferometry results were very interesting and indicated that further investigation was required. After this experiment there was a four-week maintenance period so it was possible to reuse the existing experimental setup in TAP.

To further investigate this problem and to try to improve the contrast some test shots on thin foil metal targets were performed. The main diagnostics used to investigate any pre-pulse was interferometry at 90° able to see any preplasma formation on the picosecond timescale.

An unusual laser configuration is required in order to be able to use the 9mm preamplifiers to fire a shot to TAP. Instead of using the OPCPA front-end and the silicate chain, the stretched pulse is directed into the 9mm preamplifiers and then to the phosphate amplifiers, as it is shown in fig. 1.

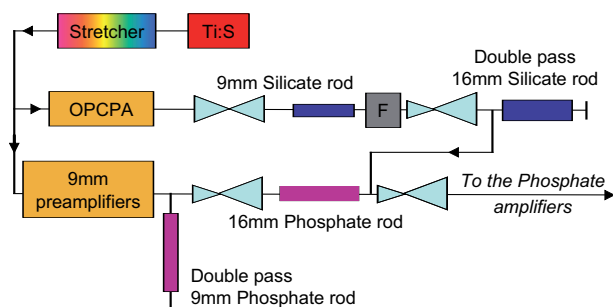


Figure 1. Used laser configuration.

### Preliminary shot

As explained in the introduction, during an experiment in TAP, a shot on a 25  $\mu\text{m}$  Ni target with the 9mm preamplifiers was performed. In this shot an interferogram at the nominal 0ps of delay (precision  $\pm 10\text{ps}$ ) was obtained. As shown in fig. 2. The interferogram shows a bubble-like preplasma in front of the target and a

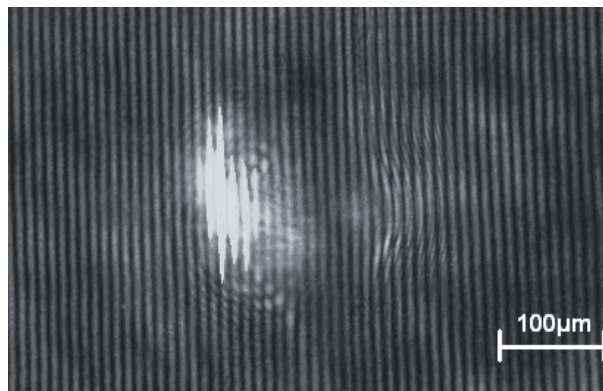


Figure 2. Interferogram from 25  $\mu\text{m}$  Ni target at 0 ps. The laser pulse comes from the left.

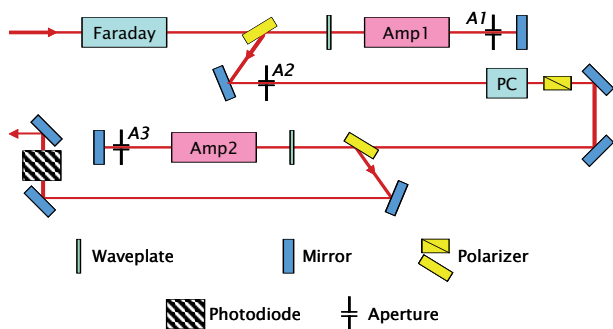
perturbation on the back. This suggests that the preplasma is generated by a short pulse creating a shock into the target that propagates to the back surface, and a shock on the front of the target, creating the bubble. Assuming a preplasma size of 70  $\mu\text{m}$  and an expansion speed of  $\sim 400\mu\text{m/ns}$ , the distance between the pre-pulse and the main pulse is of the order of 200ps, a pre-pulse in this timescale would be quite hard to detect with a photodiode.

This shot also provided information about the Front End configuration in TAW, because we used another oscillator and stretcher instead of the SAM oscillator and TAW stretcher. This confirmed that the pre-pulse was generated after the TAW stretcher. However, contrast for the normal TAP configuration is well characterized and it is free of picosecond pre-pulses<sup>[2,3]</sup>. So any source of pre-pulse must be before the injection of the silicate chain into the outer track. These observations reduce the area that must be investigated to the 9mm preamplifiers and the 9mm and 16mm phosphate amplifiers on the outer track.

In fact, before the reconfiguration there was no pre-pulse problem so the 9mm preamplifiers were the main area to be investigated.

### Reconfiguration of the 9mm preamplifiers

On the initial 9mm preamplifier setup, shown in fig. 3, all the distances between the optical components are larger than 10cm, except for two cases. On the table there are three apertures, they are closed such they clip slightly the beam. These are necessary to avoid the self-lasing of the two amplifiers. In particular, the first (A1) and the third (A3) apertures are in proximity to two zero degree mirrors, with a distance of the order of 1-2 cm. This suggests that potentially the scattered light from these apertures is collected by the amplifiers, creating a pre-pulse, replica of the main pulse, earlier in time.



**Figure 3. Initial 9 mm preamplifiers setup.**

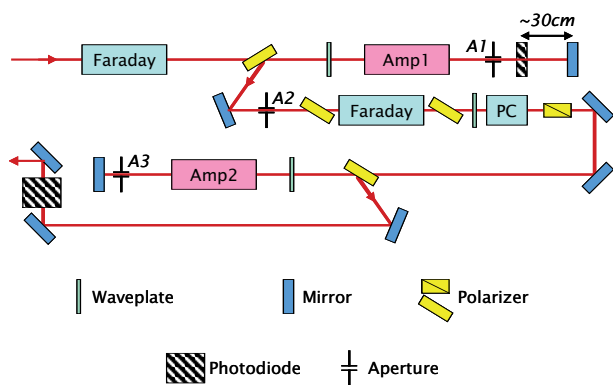
In order to remove these pre-pulses, the plan was:

1. To add a Faraday rotator between the two amplifiers, to stop the pre-lasing with the apertures fully opened;
2. To increase the distance between A1 and the mirror, to move any eventually pulse replica even earlier in time.

Before implementing any changes to the preamplifier, another four shots on 10  $\mu\text{m}$  and 25  $\mu\text{m}$  Au target were taken, at -10ps of delay, as references. On some of these shots, it was observed that the target was completely destroyed before the main pulse, suggesting a strong nanosecond pre-pulse.

In order to monitor the self-emission from the preamplifier during the reconfiguration of the layout, a fast photodiode (70ps rise time) was placed on the beam after the second amplifier. The signal was observed with a 1GHz digital oscilloscope.

The final setup of the 9mm preamplifier is shown in fig. 4.



**Figure 4. Final 9 mm preamplifier setup.**

With the Faraday rotator between the two amplifiers, no self lasing was observed, even if all apertures were fully opened. The photodiode was also positioned after the diffraction limited pinhole of the first spatial filter, between the last 9mm preamplifier and the 16mm phosphate amplifier of the rod chain. The target was to try to estimate the contrast ratio between stretched pulse and ASE.

During these tests, self-lasing of the 9mm double pass amplifier in the outer track was observed. This self-lasing was generated by the spurious cavity between the zero degree mirror and the waveplate. The net result of this pre-

lasing was a degradation of the nanosecond pre-pulse, responsible for the destruction of the target on the first four shots.

Adding a tilt to the second one, this effect was eliminated.

Using a series of calibrated filters, the contrast ratio between stretched pulse and ASE was measured and it was as expected at this point of the laser.

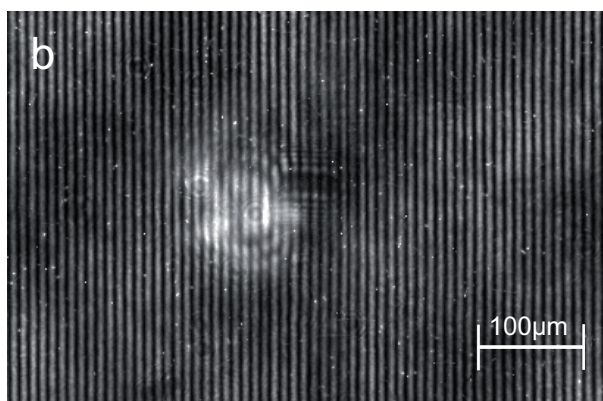
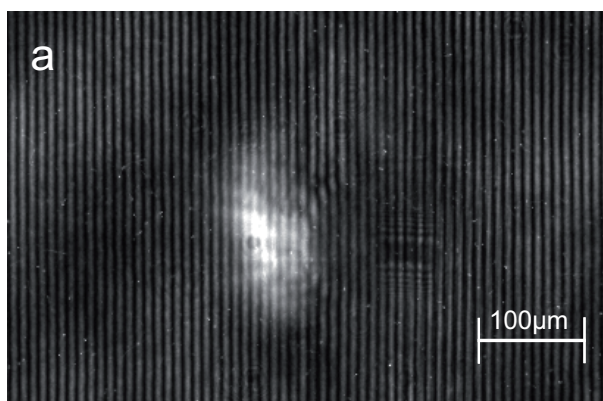
### TAP tests shot

A final series of three shots were performed, using 25 $\mu\text{m}$  Au target, changing the apertures size of A1 and A3 on the 9mm preamplifier. The second aperture A2 was always left closed, because it cannot generate any pre-pulse.

The size of the first aperture (A1) did not have any relevant influence on the interaction while the third one (A3), if closed, had the consequences to create a shock in front of the target (see fig. 5). In all the case, only a small preplasma was observed, excluding the presence of a strong nanosecond pre-pulse.

Because when closing the A3 aperture, a shock was created, it suggests that the scattered light from this aperture generates a pulse replica of the main pulse.

No perturbation on the back surface was observed, but this could be due to the different material of the target material with respect to the first test.



**Figure 5. Interferogram from 25 $\mu\text{m}$  Au target at -20 ps with: a) A1 and A3 fully opened; b) A1 and A3 closed. The laser comes from the left.**

## Conclusions

These tests suggest that the contrast issue on the 9mm preamplifier was a pulse replica of the main pulse. The source of this pre-pulse was the scattered light from the apertures A1 and A3 inserted into the 9mm preamplifier during the first reconfiguration to avoid self lasing.

Two possible sources of this kind of pre-pulse were eliminated, adding a Faraday rotator between the two amplifiers, moving a mirror and opening an aperture.

A prelasing issue on another amplifier was discovered and removed, that could be degraded the nanosecond contrast ratio. However, this prelasing was not observed before, so the misalignment of the waveplate probably occurred during the realignment after the new air conditioning servicing, occurred on the first two week of the maintenance period.

Some tests shot show an improvement of the contrast ratio and the absence of perturbation of the back surface of the target, that can degrade the efficiency of the proton generation.

Future tests will be performed to verify the proton generation and try to characterize better the contrast ratio.

## References

1. S. J. Hawkes *et al.*, *Reconfiguration of the Vulcan pre-amplifiers*. CLF Annual Report 2003-2004.
2. I. O. Musgrave *et al.*, *Nanosecond contrast measurements of the Vulcan Petawatt facility*. CLF Annual Report 2004-2005.
3. C. Hernandez-Gomez *et al.*, *Picosecond contrast measurement of the Vulcan Petawatt facility*. CLF Annual Report 2004-2005.