# An overview of the Target Area West short pulse upgrade

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## Introduction

Target Area West (TAW) has traditionally delivered 100 TW (100 J in 1 ps) in its short pulse configuration reaching focused intensities of $10^{20}$ Wcm$^{-2}$. In addition to the main CPA beam line there is a secondary short pulse beam line that is configured as a low energy probe, and six long pulse beams that can deliver energies up to 1.8 KJ.

This project is concerned with the upgrade of the short pulse capabilities in TAW. Whilst we will maintain the 100 J and 1 ps beam, a second CPA beam delivering 500 J in 10 ps will be now available in TAW. This beam line can also operate a 1 ps pulse length and 100 J of energy. This new configuration is scheduled to be on line to users by September 2008. The focused intensity for the short pulse beams will remain at ~$10^{20}$ Wcm$^{-2}$.

New experiments looking at the physics relevant to fast ignition inertial confinement fusion could be performed using this new configuration, taking advantage of the existing 6 long pulse beams. In recent years TAW has also used a dual CPA scheme [1] by which two short pulses were generated by spatially splitting a single short pulse beam, this limited the energy to 50 J per beam. With this new configuration experiments requiring 2 short pulse beams will be more easily accessible.

## Methodology

The aim of this upgrade was to provide two short pulse beams to TAW as well as enhancing the energy in one of the beams. It was decided that this could be achieved best by the use of a pair dielectric gratings for the additional short pulse beam, whilst maintaining the gold gratings for the existing short pulse beam.

A pair of 47 × 43 cm dielectric gratings with 1740 l/mm were supplied by LLNL for the upgrade in order to achieve the 500 J energy requirement for the 10 ps beam. Dielectric gratings have a higher damage threshold than gold coated gratings at 10 ps. At this pulse length the damage threshold is 2.7 J/cm$^2$ normal to the beam, and the operating fluence will be 1.2 J/cm$^2$, the efficiency of the grating is 98% which is also higher than for gold gratings.

To meet the final specification of the additional short pulse beam of 500 J in 10 ps some of the laser parameters have been changed. The main driver for these changes was the B-integral which limits the maximum energy. Calculations of the B-integral showed that a 1 ns stretched pulse could be amplified to 500 J whilst keeping the B-integral less than 3. Therefore the Chirp Pulse Amplification configuration was redefined to obtain a longer pulse with the same bandwidth. The new parameters for the short pulse beams are summarized below:

**Inverted geometry (61° input angle rather than 73°)**
**3.5 m grating separation (same separation)**
**1.0 ns stretched pulse (rather than 300 ps)**
**2.5 nm bandwidth**
**Beam size is ~200 mm × 200 mm square for both beams**

Several parts of the facility have been modified to meet this new specification: Stretcher [2], rod chain, beam propagation in Laser area 3, compressor chamber and interaction chamber. Figure 1 shows a schematic of the short pulse beams delivered to TAW.

The stretched pulse needs to be >1ns for B-integral reasons. The stretcher for TAW has been modified using existing gratings and components as mentioned above. The operation angle for the short pulse configuration is with an input angle for the stretcher and compressor of 61° rather than 72, the 12° angle between input and output angles is maintained. The bandwidth is limited in the stretcher with current components to ~10 nm rather than 16 nm in the former geometry [3]. The stretch imposed by the stretcher is 400 ps/nm.

The stretched pulse is then directed to the main Vulcan hall for amplification. The beam will first be directed to the 9 mm preamplifiers, although there are plans to build a new OPCPA preamplifier like the one used for Pettawatt beam [4] to replace the 9 mm amplifier in the near future. The amplifier chain for TAW only has 108 and 150 disk amplifiers available. In order to deliver 500 J on the 10 ps beam an extra 45 rod amplifier is required as well as a different energy distribution at the end of the rod chain. The beam is now split into beams 7 and 8 using a combination of waveplates and polarisers rather than a using a fixed 50/50 beam splitter. The new 45 mm amplifier has been added to beam 8 only for the TAW 500 J-10 ps configuration.

After the last disc amplifiers, beams 7 and 8 are expanded prior to the injection into TAW. Beam seven is expanded to a 200 mm × 200 mm square beam instead of 190 mm × 110 mm. Beam 8 is expanded to a 205 mm circular beam for the 10 ps option and apodised to be 200 mm × 200 mm square for the 1 ps option.

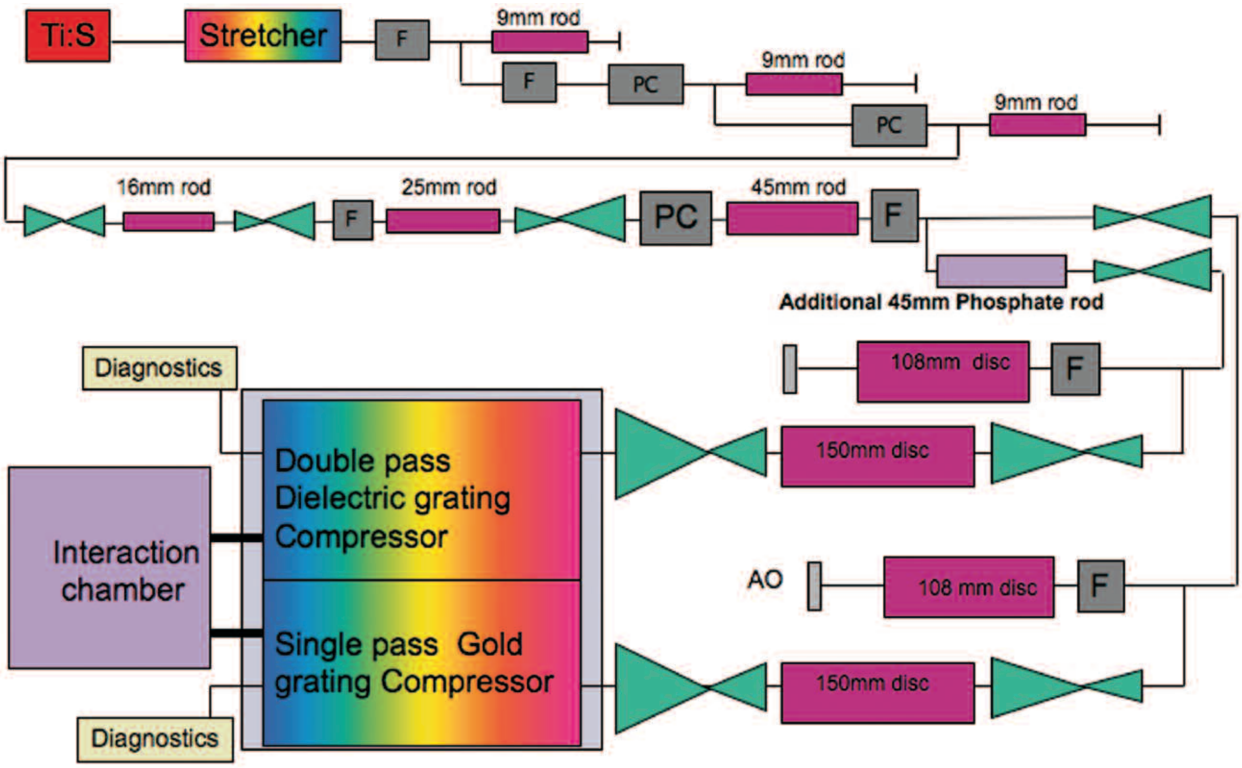


**Figure 1. Schematic of the TAW short pulse configuration.**

The beams are then are directed to the new compressor chamber though a new timing slide system in TAW. Figure 2 shows a 3D beam layout of the new short pulse configuration for TAW. The compressor chamber has two decks, the upper level houses the double pass dielectric-grating compressor whilst the lower deck houses the existing single pass gold grating compressor. The lower compressor has been folded using a mirror between the gratings so that the length of the compressor chamber size is kept to a minimum. Figure 3 shows an inside view of the compressor chamber with both compressors. The 1 ps beam in the lower deck is then directed to the interaction chamber by a high reflecting mirror. The leakage of this last turning mirror is used for the laser diagnostics. The 10 ps beam is directed to the lower deck via a periscope and the leakage of this mirror is used to diagnose this beam, then from the lower deck the beam will be sent to the new interaction chamber extension. The diagnostics beams are directed to the diagnostic suit located in a double layer table. The beams are de-magnified down to ~20 mm, the first de-magnifying lens for the diagnostics is in the compressor chamber immediately after the mirrors used to generate the leakage. The energy management necessary for the shot diagnostics is also done outside the chamber in the diagnostics suit.

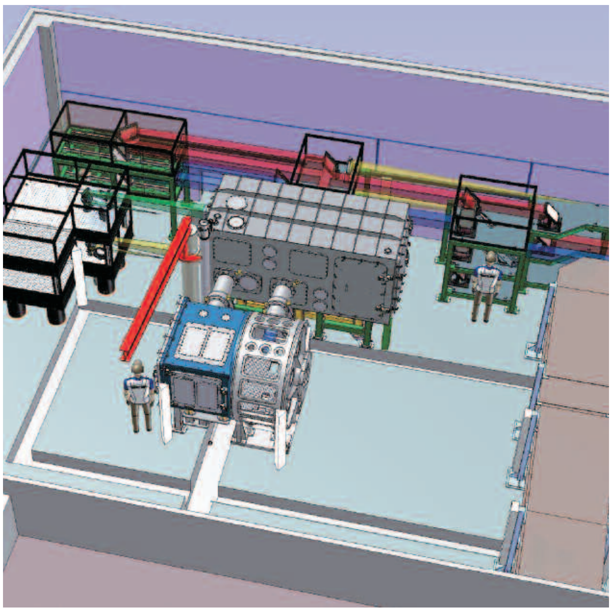

**Figure 2. 3D beam layout of the short pulse configuration.**

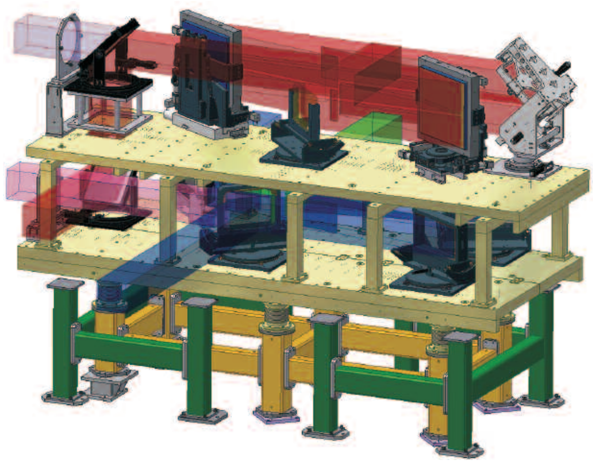

**Figure 3. TAW 3-d Compressor view.**

## Implementation

The project implementation phase started in January with the decommissioning of the old short pulse compressor followed by the installation of the new compressor chamber and interaction chamber installation. The Vulcan laser will be shut down for an eight-week period to conduct the laser modifications. Following this there will be a final system commissioning in August prior to the first scheduled experiment in September 2008.

## References


1. S. Hawkes, CLF Annual Report, 183, (2001-2002).
2. C. Burton *et al*., CLF Annual Report, (2007-2008).
3. J. Collier *et al*., CLF Annual Report, 188-189, (1996-1997).
4. C. Hernandez-Gomez *et al*., CLF Annual Report, 175-176, (2001-2002).