A compact dual vacuum compressor for the Target Area West

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Introduction

The aim of the upgrade of Target Area West was to provide two high energy CPA pulses for experiments. With the added capabilityy that one of those beams should be capable of reaching up to 500 J of energy for pulses longer than 10 ps [1].

In the previous short pulse configuration in TAW there was a single gold grating compressor. The gratings limited the energy to up to 120 J at the input and a minimum pulse length of 1 ps. The first grating was under air and only the second grating was under vacuum. In addition to this beam line there was a second small aperture compressor operating under air and delivering up to 20 J. The aim of the upgrade was to provide two short pulse beams: one with energy up to 100 J before compression and pulse length down to 1 ps; the other with energy up to 100 J in 1 ps or up to 500 J for pulses in 10 ps or longer, with an independent control of the pulse length.

Target Area layout

A sketch of the layout of TAW is shown in figure 1. As it is shown, both CPA beams are confined close to the West wall. To make best use of space, the two short pulse beams beams are propagated at two different levels.

There is a single vacuum chamber that houses two compressors; the two compressors are arranged in two decks at the same level as the beam propagation in the area.

Optical layout and optics

The requirement on the energy of one beam imposed a change to the geometry of the existing compressor. To reduce the B-integral inside the laser to a reasonable value (maximum of 1.3), it was necessary to increase the pulse length of the stretched pulse. A relatively easy way to achieve this was to change the input angle of the gratings and move to the reverse geometry [1,2], retaining the same distance between the gratings.

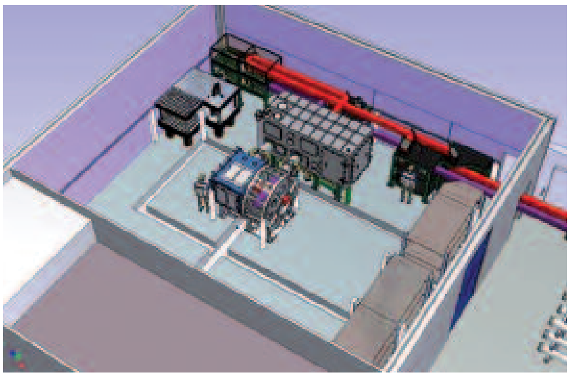

Figure 1. TAW layout.

To allow full control of the pulse length on both beams, the double pass compressor was designed so that the distances between the gratings could be altered in order to tune it without touching the stretcher.

In order to meet the high energy requirement dielectric gratings have been used in a double pass configuration due to the limited space available. These gratings are able to withstand higher energy compared to the gold gratings. At 10 ps, the damage threshold is up to 5 times greater than gold ones.

For the second compressor it was decided to have a similar configuration to the previous one, i.e. single pass with the existing gold gratings.

The double pass compressor was designed to be on the top level while the single pass is on the lower level.

The layout used for the double pass compressor is shown in figure 2. The input beam as shown in the figure is coming from the bottom. Using a mirror (UM1) the beam is directed to the first and the second gratings (UG1 and UG2). After the first pass, the beam is sent back at a higher level using the retro mirror assembly (UR). The beam from the second pass pass over the UM1 up to the first periscope mirror (UPM), to send down the beam at the same level of the interaction chamber.

The transmission from that mirror is collected by a lens and it is directed to the diagnostic suite.

The beam coming down reaches the second periscope mirror (LPM) (see fig. 3), that it turns its polarization of 90 degree. This because the dielectric gratings require a s-polarized beam whilst the experiments require a p-polarized beam.

Moving to the other compressor, shown in figure 3, the beam is coming from the bottom and is redirected with mirror (LM1) to the first gratings (LG1). After that grating it reaches a folding mirror (LM2). In this way it was possible to reduce the overall size of the vacuum chamber. Then the beam arrives to the second gratings and the final mirror (LM3) redirects it to the interaction chamber.

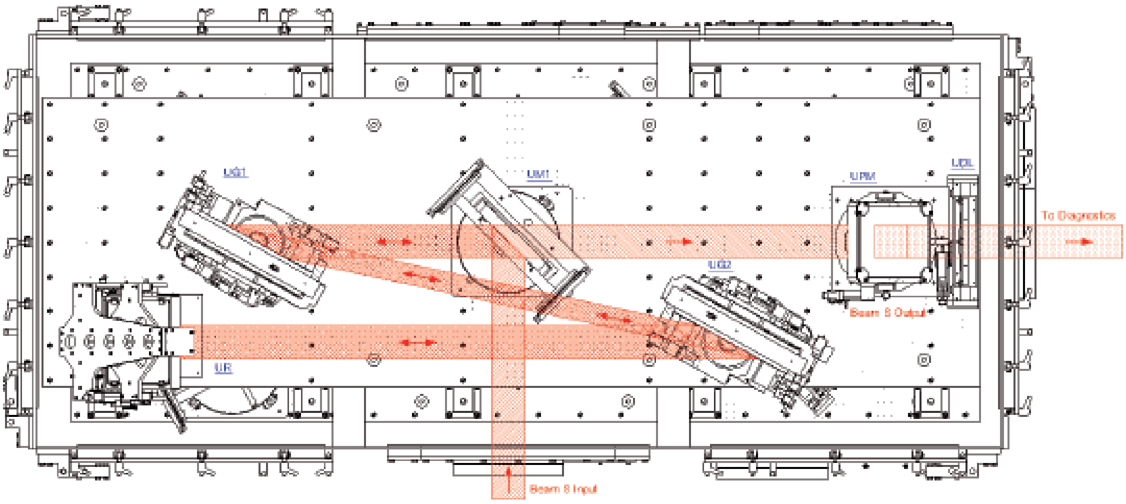

Figure 2. Double pass compressor. Upper layer.

The transmission from the LM3 is collected by a lens (LDL) and it is sent to the diagnostics.

The entire mirror and the gratings mount were motorized to allow remote control.

The second grating on the upper compressor was mounted on a translation stage of 30 cm, in order to be able to change the pulse length on the upper compressor without having to make any changes in the stretcher.

Alignment procedure

The alignment of the compressors was performed in four stages:

1. Alignment with CW in air;
2. Alignment with CW under vacuum;
3. Stretcher tuning on the lower compressor;
4. Compressor tuning for the upper one.

The CW beam alignment checks the parallelism of the gratings. The standard procedure requires two CW lasers, perfectly aligned, operating at two different wavelengths. It also requires the beam to be retro-reflected using an auxiliary mirror and the far field observed of the two lasers coming back. When the gratings are parallel, there is no mismatch in the far fields, if the mismatch is horizontal, the two gratings are not parallel horizontally (tilt) while if it was vertically the grooves were not parallel (rotation).

However, for the double pass compression, this procedure is not suitable. Whilst for the horizontal parallelism it works well, the double pass configuration used induced a cancellation on the pointing mismatch in case of grooves being anti-parallel.

So, we proceeded to retro only one pass to the check groove and grating parallelism, and this was only possible in air. We tested the stability of the alignment pumping down the auxiliary mirror with good results.

The vacuum alignments were just a double check. No further alignments were required thanks to the stability of all the mounts and the structure.

The preliminary stretcher tuning was performed using a streak camera. After that, a single shot autocorrelator was used. The result is shown in figure 4. The minimum pulse length obtained for the single pass compressor was around 900 fs.

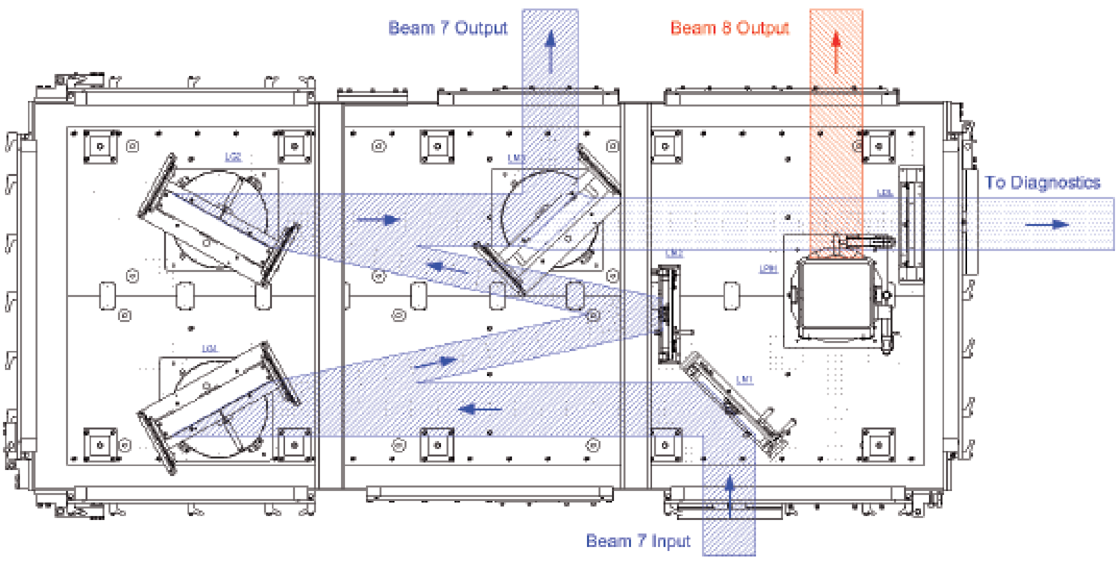

Figure 3. Single pass compressor. Lower layer.

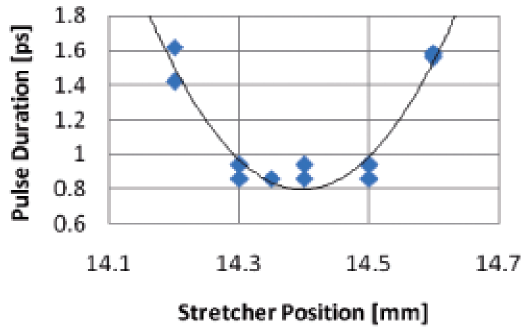

Figure 4. Stretcher tuning for beam 7.

The tuning of the double pass compressor was performed primarily with a streak camera, with the requested pulse length too long for our single shot autocorrelator. Only one experiment up to now required 3 ps and the autocorrelator has been therefore used.

Grating conditioning and efficiency

The dielectric gratings are characterized by high damage threshold. However, they are sensitive to the cleanness of the vacuum and, in general, to the dust. To avoid contaminants, we decided to use an oil free vacuum system.

Also, to condition the gratings, a number of low power shots where performed. The overall efficiency of both compressors where measured using a calorimeter. The Calorimeter was placed in both cases after the off-axis parabola in the interaction chamber.

The efficiency through the compressor up to the target on beam 7 (single pass compressor) is around 53%, with the existing parabola (dia. 20 cm).

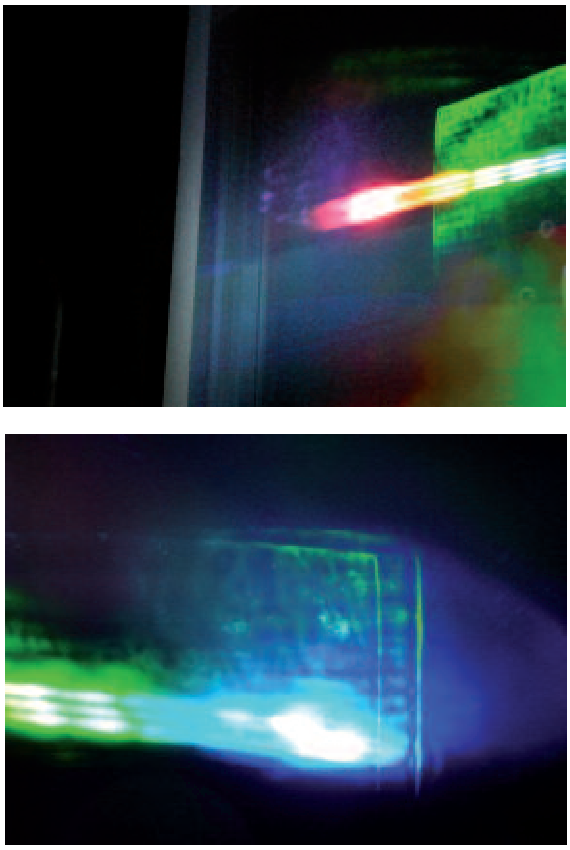

Figure 5. Damages on the first grating of the double pass compressor.

Also for beam 8 (double pass compressor) is around 54%.

Current status of TAW

We have performed four experiments, limiting the maximum energy on beam 8 at 300 J for pulses longer that 10 ps. In the middle and at the end of that period, we inspected the gratings and the mirrors the check any possible damages.

Both gold gratings showed few small damages. They appeared after the first shot, even though it was a relatively low energy shot. However they look stable and they have substantial no influence on the beam.

On the upper compressor, the second dielectric grating showed no damage. However, the first grating had some damages on the upper part, i.e. where the pulse is short. That damages started to appear around an artifact, a square visible only by eye and not on the beam. But afterwards some damage also appeared in different places (fig.5).

The mirrors did not show any laser damage. However, some strange features on the retro mirror (UR) were visible by eye but do not seem to affect their efficiency (fig. 6).

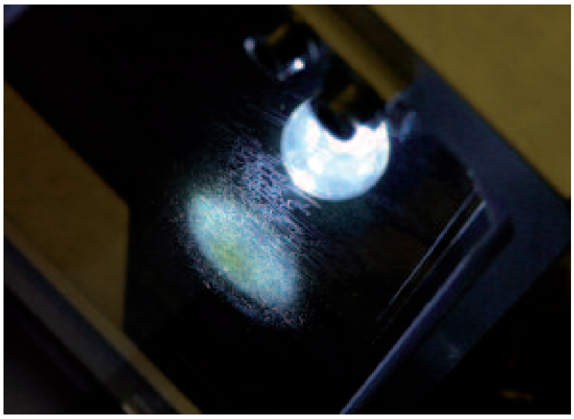

Figure 6. Strange features on the retro mirror.

Conclusions

A new double vacuum compressor has been commissioned in TAW. It is able to allow two high power CPA pulses on target with different pulse lengths. Thanks to the dielectric gratings on one of the two compressor four experiments have already been conducted with up to 300 J in 10 ps on one beam, and 100 J 1 ps on the other.

After these experiments some damage has been observed on the gratings and also some strange features on one mirror. These are currently being monitored and under investigation.

References

1. *"An overview of the Target Area West short pulse upgrade"*, C. Hernandez–Gomez *et al.*, CLF Annual Report 260-261 (2007-2008).
2. *"TAW Pulse stretcher upgrade"*, C. S. Burton *et al.*, CLF Annual Report 263-264 (2007-2008).