

TAW Long Pulse Facility Upgrades

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Introduction

Target Area West (TAW) is an eight beam facility able to deliver 2 beams in CPA short pulse (1-10ps) and 6 beams in long pulse mode at 1053nm or 527nm (1ω and 2ω respectively) for a variety of high power laser interactions¹.

This facility has recently undergone two major beamline delivery upgrades to improve its versatility and operability. The two upgrades took place over the 2 month period August - September 2013. Firstly improvements to the cluster of 6 $\phi 110$ mm beams which aimed to enable a faster and more streamlined turn around between experiments. Secondly implementation of a new capability to deliver high energy (500J) long pulses to target on the other two traditionally short pulse beamlines.

These upgrades came in response to feedback from community users and facility staff about future versatility requirements and efficiency improvements for experiments. This article reports on the details of both upgrades.

Six Beam Cluster

A number of new infrastructure items are now present in TAW to facilitate easier delivery of the main 6 cluster of beams. New lens mounts attached to the interaction chamber with encoded stepper drives have now been installed, they include the ability to be both manually and electrically adjusted. A new pillar mounting system independent of the interaction chamber has also been installed to hold the final beam turning mirrors. Fig 1 shows the new system.

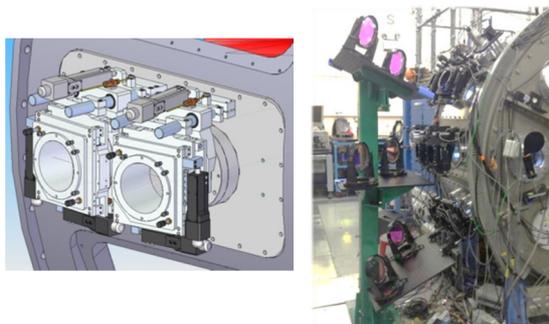


Fig. 1 a) new lens mount assembly and b) turning mirror infrastructure for the main 6 cluster

This combined change should improve alignment and stability of focus position between conditions when the interaction chamber is at air and it being pumped out. The lenses will

move with the interaction chamber and the mirror mounts are isolated from it so the beams won't move on pump down as they have previously. There is a pillar either side of the interaction chamber able to deliver up to 6 beams on the East and West sides, facilitating an array of cluster arrangements.

In order to make beam delivery around the room more flexible, straightforward and systematic to implement a new 3-tiered optical bench has been added as an extension to the existing bench. This addition enables easier configuration changes of beams to either side of the interaction chamber, or other parts of the lab, for experiments. Crystals for 2ω generation, when required, are installed in the beam line at the entry point to the extension. The arrangement for detecting 2ω energy has also been made more straightforward with calorimeters now being located out of the main beam (rather than in the beam as they were historically) taking a 5% leakage for calorimetry data to be recorded. This reduces the losses connected with taking calorimetry data from within the main beam and makes alignment of the whole system much easier. Fig 2 shows the new layout.

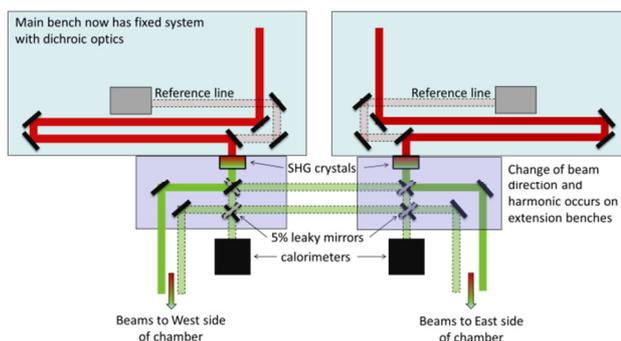


Fig. 2 Schematic of the new main 6 beam layout – everything up to extension bench is permanent set-up, with reference line. Anything after can be adjusted for direction and harmonic used.

This new arrangement makes installation and alignment of both 1ω and 2ω beam configuration more straightforward by making the referenced section of all the beams permanently installed and separate from any part that may need to be adjusted. Dichroic mirrors have been installed in the permanent section to allow alignment beams of both harmonics to be easily utilised in addition to propagation of the main high power IR beams. Transportation of 1ω , or generation and use of 2ω , now occurs after this permanent section of beamline ensuring that alterations in harmonic or beam directions between experiments

cannot interfere with aligned, referenced sections of beam path that need to remain permanently aligned. Fig 3 shows the new infrastructure that has been added to the existing arrangement.

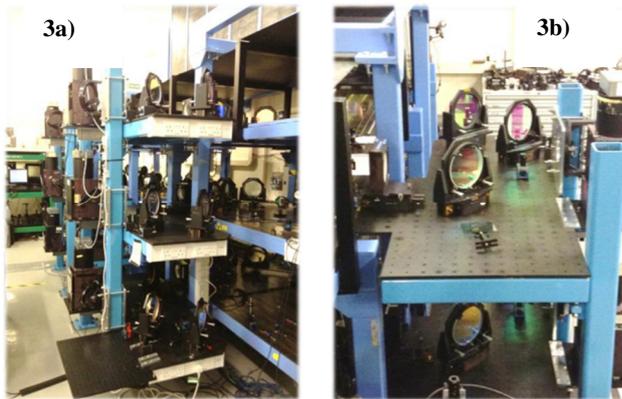


Fig. 3 a) new 3-tier extension benches added to the existing hardware b) view of top platform showing optics arrangement

In addition to this new infrastructure a considerable effort has been made to quantify and correct the collimation differences between all the beams delivered from Vulcan into TAW. Measurements taken and matched against optics ray-tracing modelling have allowed precise adjustments to be made to ensure that all of the main 6 are divergence matched. The internal alignment beams - both in the IR and Green - have also gone through this process. This will remove the requirement to check offsets between Vulcan beam foci positions and those of the internal alignment system which was previously essential to experiment setup. TAW's independent operation of Vulcan for alignment purposes and overall experiment set-up time should be hugely improved as a result of all of these improvements.

Compressor By-pass

To enable additional high energy long pulses beams to be delivered to target new infrastructure has been installed in the CPA beamlines of TAW. These beamlines usually deliver high energy short pulses in beam size of either 200mm circular or square beam profile - 100J Beam 7, 60J Beam 8 at 1ps, with the option for 250J at 10ps on beam 8.

The provision of long pulses to target (200ps up to 8ns) is now possible due to a new beam path that by-passes the compressor system. To enable this, additional framework has been designed and installed. Additional 250mm x 360mm mirrors and new mirror mounts optimised for prevention of effects from vibration have also been implemented. This new beam path flexibly delivers beams to the interaction chamber without passing through the compressor. Fig's 4 & 5 show the 3D and plan views of the new infrastructure respectively.

The first mirrors in the new paths for beam 7 & 8 intercept each beam in front of the respective compressor input windows.

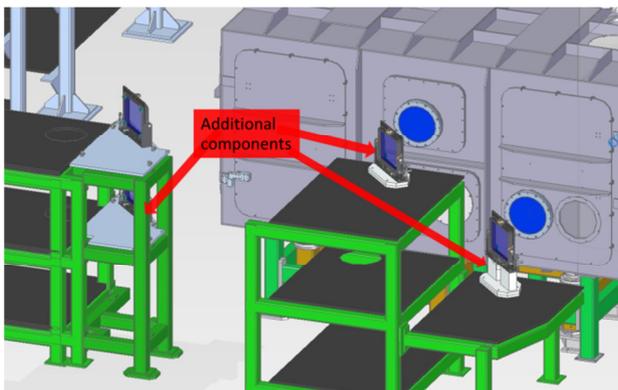


Fig. 4 3D view of new infrastructure enabling beams 7 and 8 to bypass the compressor

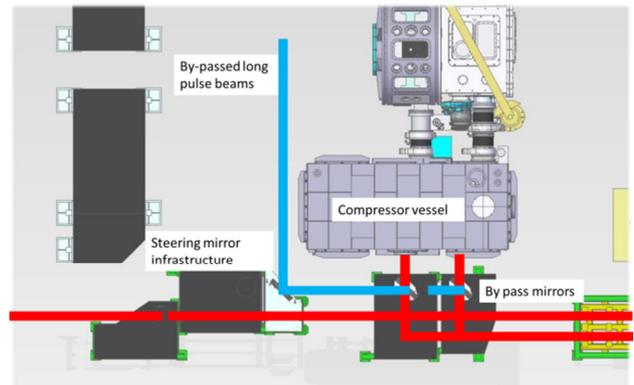


Fig. 5 plan view showing the new beam layout (in blue) by-passing the compressor

They are kinematically located enabling installation for long pulse experiments and removal for short pulse experiments to be straightforward and reliable. The beams from this point are directed towards a further set of turning mirrors that are permanently located on the new installed framework. These steer the beams into the rest of the room. From this point they can be directed towards the interaction chamber for a variety of experiment geometries. A periscope is available to enable the top beam (Beam 8) to be brought down to the standard beam height for in plane interaction, if and when required.

These beamlines can now use the functionality of either the shaped long pulse (SLP)² or SLM oscillators in order to be utilised at long pulse lengths (>200ps up to 8ns) and at energies up to 500J.

Conclusions

A much wider choice is now available for beam configurations that may require long pulses on all 8 beams available in TAW. The re-design of the bank of 6 long-pulse beamlines, with permanent and adjustable sections being separated, enables easier configuration to either side of the laboratory, in either 1 ω or 2 ω . This shortens turn around between, and set-up activities in, experiments by up to 1 week per experiment. These improvements will reduce the chances of errors being introduced due to a combination of some activities not being needed anymore (such as checking the focus offset between Vulcan and TAW internal alignment beams) and other activities being more straightforward to achieve. Redirecting beams to the interaction chamber, checking and setting co-linearity and calibrating 2 ω calorimetry are all examples of these.

Additional option of either 1 or 2 higher energy, long pulse beams (0.2 - 8ns, 500J per beam) makes TAW a much more versatile laboratory. Shaped pulses are deliverable on those experiments demanding this requirement on either the main 6 cluster (as previously) or now on the 2 additional higher energy beams. This fulfils some of the demand from the User community for additional long pulse capability and enables experiments which require higher energy to be realised.

References

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2. W. Shaikh "Development, commissioning and experimental delivery of full energy chosen shaped long pulse laser pulses at Vulcan" Annual report 2008/2009 p283