Long pulse beamline to TAP

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Introduction

The Vulcan Petawatt Facility currently delivers a single Chirped Pulse Amplification (CPA)[1] beamline with energies up to 500 J in pulse lengths as short as 400 fs. On target intensities >10^{21} Wcm^{-2} are produced in Target Area Petawatt (TAP)[2].

Despite the higher intensity available in TAP, thus far it has lacked the versatility imparted to the other Vulcan target areas by their multiple beamlines. In order to expand the range of experimental configurations possible, Vulcan has been enhanced to deliver a long (nanosecond) pulse to target in TAP.

Improved Capabilities

The long pulse beamline has the capability to deliver energies up to 200 J in a 1 ns pulse length. The pulse length can be varied from 0.5 to 4 ns, and the modulator system for temporal pulse shaping is currently in the final testing phase[3]. It could also be used to provide an uncompressed CPA pulse perfectly synchronised to the short pulse by splitting the beam before injection into the rod amplifier chains. However due to the difference in path lengths between the short and long pulses, this would require a delay mechanism to be implemented.

It will increase the capabilities of the Petawatt Facility by enabling pre-heating of targets before interaction with the high power pulse, and production of x-rays for target backlighting. The upgrade will also facilitate investigations which are not currently possible in TAP, such as pump-probe type experiments.

Implementation of the Beamline

The Vulcan Laser system consists of two rod amplifier chains, one of which is directed into the six 108 mm diameter beamlines (beams 1-6) and the other into the two 150mm diameter amplifier beamlines (7 and 8). Although designed for versatility to deliver different pulse lengths on different beamlines, Vulcan has traditionally run short pulse beams using the CPA technique on the 150 beams and longer pulses on the 108 beams.

Figure 1. The beamline in LA4, the VSF for the long pulse beamline can be seen below the 208 mm diameter disc amplifiers.

To create the new beamline, the beam is diverted from the end of the beam 6 amplifier chain in laser area 3 (LA3). It is directed into laser area 4 (LA4) where it enters a Vacuum Spatial filter (VSF) located below the 208 amplifiers for the short pulse beamline. This has the benefit of minimising the extra floor space occupied by the new hardware. The spatial profile of the 108 mm diameter

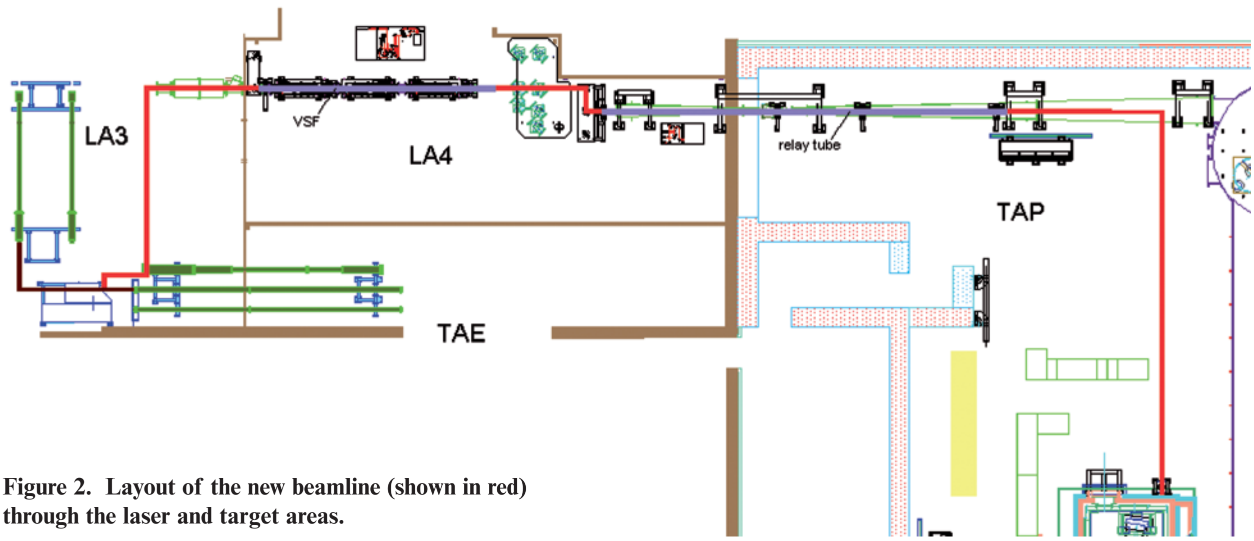

Figure 2. Layout of the new beamline (shown in red) through the laser and target areas.

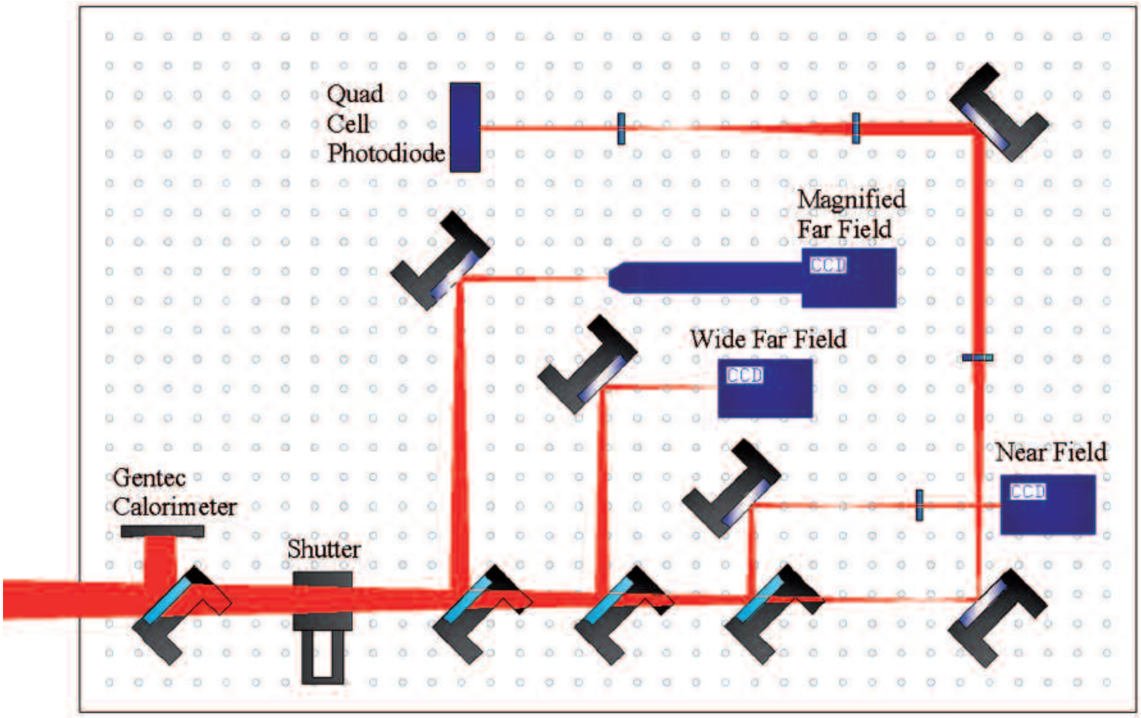

Figure 3. Diagnostics layout.

beam is cleaned in the 7 m long VSF and exits at the same size as the input. The VSF (shown in figure 1) is of the new design used for the CPA beamline in LA3[4].

The beam then goes through a dog leg before being image relayed by a 12 m long telescope into TAP. The relay tube is located beneath the VSF for the CPA beamline, again saving space. Once in TAP the beam is directed across the target area, and raised by a periscope to enter the chamber at high level. The beam path inside the chamber is entirely flexible to facilitate the experimental teams' requirements on a case by case basis. The complete path from LA3 to TAP is shown in Figure 2.

New Alignment Laser

The operational model of having an independent alignment laser and associated diagnostics sited in LA4 has proven itself to be a successful one for the CPA beamline into TAP. LA4 is independent of the main Laser Area, allowing TAP to carry out beam alignment simultaneously with operations to the other target areas. A local alignment laser also avoids the reduction in intensity resulting from losses through the long optical path length from the CW alignment laser located at the start of the rod chain in Vulcan. For these reasons, this scheme has been replicated for the long pulse beamline.

The laser used is a small 500 mW diode pumped crystal laser[5]. The beam is expanded up through a 4 times diffraction limited spatial filter and recollimated at a beam diameter of 108 mm. It is then steered by further 169 mm mirrors prior to being injected co-linearly into the beamline immediately before the VSF.

Diagnostics

The diagnostics channel is formed by the leakage through the second mirror in the dogleg between the VSF and the vacuum relay tube. A 2.4 m focal length lens focuses the beam down into the diagnostics, which are mounted on an optical breadboard located below the diagnostics for the CPA beamline.

The diagnostics suite consists of; a calorimeter[6] for energy measurement, a wide angle far field for monitoring pointing, a magnified far field to look at focal spot quality and a near field which images the output of the VSF. A quadrant cell photodiode is in place and will be configured for automatic alignment in the future. The layout is shown below in figure 3.

Conclusion

A 108 mm diameter long pulse beamline has been installed and commissioned through to the Petawatt Target Area to extend the operational capability and enable a new range of experimental set ups.

References

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