Commissioning Progress of the New Petawatt Beamline in Vulcan

Contact: samuel.buck@stfc.ac.uk

S. Buck, V. Aleksandrov, P. Oliveira, M. Tobiasiewicz, T. Winstone, M. Woodward and M. Galimberti

Central Laser Facility, Rutherford Appleton Laboratory, OX11 0QX, United Kingdom

Abstract

A new short pulse petawatt beamline was successfully installed into R1 to accompany the Vulcan laser. The layout and progress is discussed with the various commissioning challenges and accomplishments.

1 Introduction

The Vulcan OPcpa PEtawatt Laser (VOPPEL) has recently been moved from the R2 10 PW FE/Component Test Lab and reassembled, then expanded, into the new Laser Area 5 (LA5) - originally Target Area East. This report documents some of the overall progress of the project, aimed at providing a short pulse (30 fs) petawatt pulse to the Vulcan Target Area Petawatt (TAP), amplified entirely by OPA, using Lithium Triborate (LBO) crystals. The laser system began as a development project aimed at testing ultrabroadband amplification for technologies in high intensity laser systems. The possibility of redirecting one of the main 6 (>200 J) long pulse beams from Vulcan as a pump source sparked the idea for a cost-efficient, ultrashort, petawatt pulse for use as a high-intensity probe beam in TAP. This will allow unique experimental capabilities to users internationally.

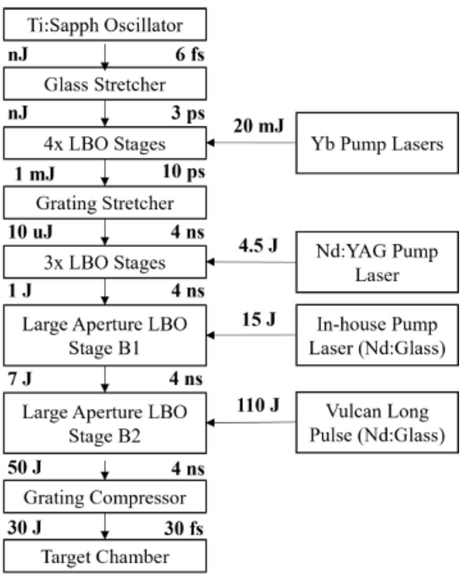

Figure 1: Schematic layout of the main components in the VOPPEL beamline.

A schematic of the planned beamline is given in Figure 1; a commercial broadband oscillator is amplified 9 times by increasing energy LBO OPA stages to reach 50 J, pre-compressor, 30 J on target.

2 Front End

The VOPPEL front end (FE) consists of: 4 picosecond OPA stages pumped by commercial pump lasers; a stretcher; and 3 nanosecond OPA stages pumped by a 4.5 J Continuum laser. All tables, optomechanics and optics are installed in LA5, with operating stations throughout.

The first 4 amplification stages were previously shown to be operational in R2 [1], [2]. These were redesigned to allow more robust diagnostics, easier maintenance and a more viable layout. The picosecond front end was recently able to reach similar levels of energy and compressed pulse duration compared to before moving the laser.

Figure 1 shows the complete picosecond FE, as built

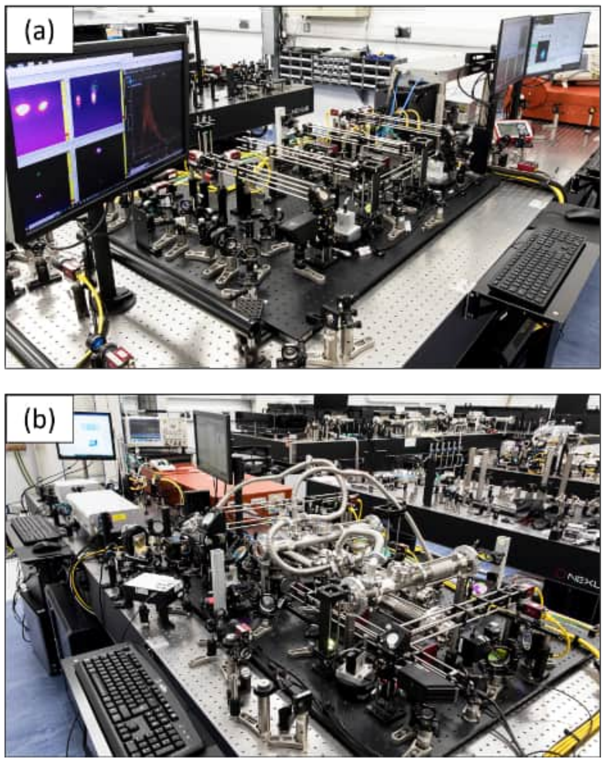

Figure 2: Picosecond front end of the VOPPEL beamline. (a) Stages 1 & 2, (b) Stages 3 & 4.

in LA5. Final output is capable of delivering over 1 mJ, 100 Hz, 180 nm bandwidth to the stretcher.

3 High Energy Stages

The final 2 stages of amplification will be large-aperture LBO. The B1 amplifier (50 mm LBO) will be pumped by an in-house Nd:Glass laser to around 7 J. This will then travel to LA4 to the B2 amplifier (90 mm LBO), where the frequency-doubled Vulcan long pulse will allow for up to 50 J broadband signal.

Figure 3 shows the B2 amplification stage for the VOPPEL system, situated in LA4, alongside the main 'long pulse' petawatt beamline. The 3-tier table was designed to route, amplify and deliver the VOPPEL pulse towards TAP. The 90 mm LBO crystal has been ordered, but is still in manufacturing. Remaining in LA4 is a beam delivery and diagnostics corner housing alignment lasers for the compressor and pre compressor diagnostics.

Figure 3: 3-tier table installed in LA4. A large-aperture (90 mm) LBO OPA stage on the bottom level will be pumped by a frequency-converted Vulcan long pulse beam, delivered from the top level.

4 Compression & Beam Delivery

With limited space in TAP, a new compact compressor was designed based on the Gemini double-pass grating layout and installed, as shown in Figure 4. This is capable of compressing the 180 nm bandwidth down to sub 20 fs (limited only by the grating size). The beam will then be sent through a turning chamber and focused into the existing TAP target chamber.

To evaluate the delivered pulse, a post-compressor diagnostics setup has been designed to monitor pulse quality and duration. This will have the option of viewing a full beam pulse replica (through a turning mirror), and a pickoff section of the main beam simultaneously. The turning mirror is removable (motorised) to allow the full beam to propagate to the diagnostics for calibration.

Figure 4: CLF's Simon Spurdle beside the new 'compact' VOPPEL compressor chamber based on the Gemini double-pass design, aimed at compressing the large bandwidth pulse to 20-25 fs with $\sim$ 67% efficiency.

5 Conclusion

The VOPPEL system has been substantially improved and established in LA5. All major components have been purchased, with most delivered and installed, such as: the front end, high energy beam delivery and amplification stages, and the compressor chamber. Alignment has begun on the front end, with the aim to send light to TAP in the new year.

References

[1] G. Archipovaite, M. Galletti, P. Oliveira, M. Galimberti, A. Frackiewicz, I. Musgrave, and C. Hernandez-Gomez, "880 nm, 22 fs, 1 mJ pulses at 100 Hz as an OPCPA front end for Vulcan laser facility", Optics Communications 474, 126072, ISSN 0030-4018 (2020).

[2] M. Galletti, P. Oliveira, M. Galimberti, M. Ahmad, G. Archipovaite, N. Booth, E. Dilworth, A. Frackiewicz, T. Winstone, I. Musgrave, and C. Hernandez-Gomez, "Ultra-broadband all-OPCPA petawatt facility fully based on LBO", High Pow Laser Sci Eng 8, (2020)