

# Overview of a new OPCPA beamline in Vulcan TAP

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## Introduction

In this contribution we outline our plans for an auxiliary beamline into Vulcan Target Area Petawatt (TAP). The new beamline will be based on Optical Parametric Chirped Pulse Amplification (OPCPA) [1,2] it will ultimately deliver 30J in 30fs onto target with a centre wavelength of 880nm. The new beamline will be able to be operated both in conjunction and independently of the existing petawatt beamline. As part of this project we will be exploring the prospect of an increased long pulse energy beam into the area. We will therefore, be able to offer a unique set of beams to the user community who will be able to conduct novel pump-probe type experiments. Target Area East (TAE) of Vulcan will be converted into a new laser area which will house the seed generation scheme and initial power amplification. One of the existing laser areas (LA4) of the Vulcan laser will be modified to include a power amplifier stage. A new compressor and focusing chambers will be installed in TAP. A simple flow diagram of the new beamline is shown in figure 1. The pulse starts in the front-end section where it is amplified to the Joule level before being amplified further in stage B1. The pump for stage B1 is provided by the output of a flash-lamp pumped rod amplifier chain. The front-end and stage B1 will be housed in the refurbished TAE. Following B1 there is stage B2 which is housed in LA4 and pumped by one of the existing Vulcan long pulse beamlines. After amplification the pulses enter TAP and are compressed and directed to the interaction chamber. In the following sections we further detail our plans and progress to deliver this beamline.

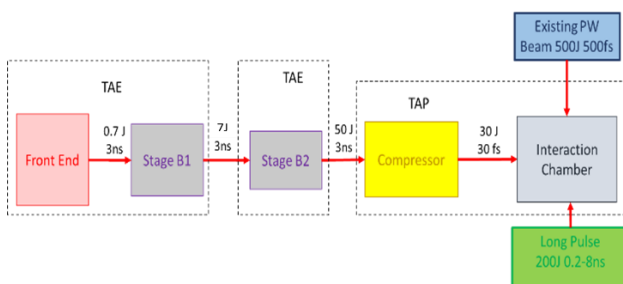


Figure 1. Flow diagram of the sub-systems making up the new beamline and the rooms that the sub-systems will occupy.

## Front End

A new front-end generating the seed source has been established off-line. It is currently capable of generating a millijoule source with sufficient bandwidth to support a sub 30fs pulse. This is achieved using 4 stages of picosecond time domain OPCPA as shown in figure 2. For these smaller stages of amplification BBO could be used as the non-linear crystal. Whilst it does have a larger non-linear coefficient enabling shorter crystals than LBO we have decided to use LBO to confirm the modelling for the later stages. In figure 2 the output from the Venteon (Laser Quantum [3]) seed oscillator is stretched by passing through 2 glass blocks to ~3ps. Once it has been stretched it is relayed to the first OPCPA stage. The first

two stages are pumped by the frequency doubled output from a S-PULSE (Amplitude Laser Systems [4]). After these 2 stages the beam passes through an acousto-optic programmable dispersive filter {DAZZLER (Fastlite [5])} to enable spectral phase control and then goes onto stages 3 and 4. The pump for these stages is provided by the frequency doubled output from a MAGMA-25 (Amplitude Laser Systems [4]). A test compressor is available to check the performance of this section of the system.

The seed source oscillator can be synchronised to an external radio-frequency source. This will enable the new beamline to be synchronised to the seed oscillator of the existing Vulcan beamlines. It is anticipated that this will initially enable synchronisation on the picosecond timescale. To improve the level of synchronisation optical synchronisation will be required. This might be achieved by directly seeding the Vulcan PW beam from the additional output of the Venteon oscillator at 1053nm. This option would require additional pre-amplification and further work is required to understand the impact on the contrast of the PW beam.

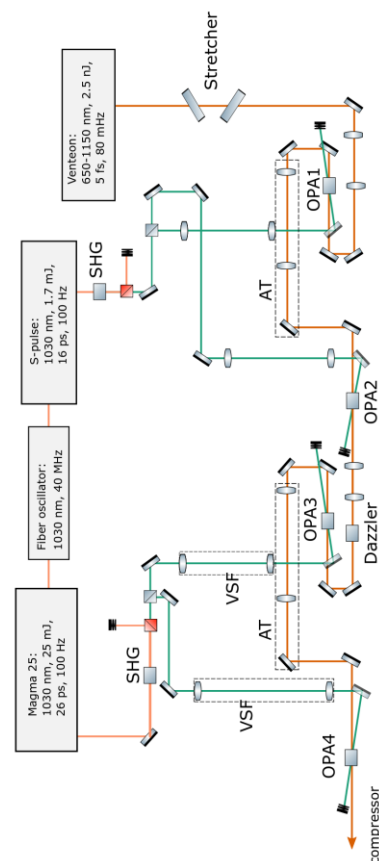


Figure 2. Schematic of the 4 stages of the picosecond OPCPA. The seed source is to the right of the image. VSF Vacuum spatial filter, OPA optical parametric amplifier, SHG second harmonic generation crystal, AT achromatic telescope.

After the mJ system, the pulse will be stretched to the nanosecond regime, the stretcher to achieve this is currently being designed. Following the stretcher, there will then be 3 stages of further amplification taking the beam energy to the Joule level.

### Stage B1

After the front end there will be a stage that is pumped by the output from a dedicated rod-amplifier stage [6]. This rod amplifier system has been developed off-line and demonstrated 30J of infra-red energy which has successfully been frequency doubled to 17J and used to test the impact of the deuteration level on the bandwidth performance of DKDP previously [7]. At this energy level there are two possible nonlinear crystals that could be used, LBO or DKDP, to meet the pulse duration specification. For this project we have chosen to use LBO rather than DKDP due to its higher nonlinear coefficient and lower walk-off angle. In addition to the lasers a small control area will be created in TAE to enable local control of the new beamline.

### Stage B2

A final stage of amplification is pumped by the output from a Vulcan long pulse beam. This is shown in figure 3. The long pulse pump beam derived from the output from one of the main 6 beams is relayed into LA4 where it is frequency doubled and used to pump the final OPCPA stage. It is anticipated that there should be >100J of pump available and that >50J should be delivered after this stage. Also shown in this image is an alternative arrangement to enable the output from the existing 208 amplifiers to be injected into the long-pulse beamline to TAP for experimental purposes.

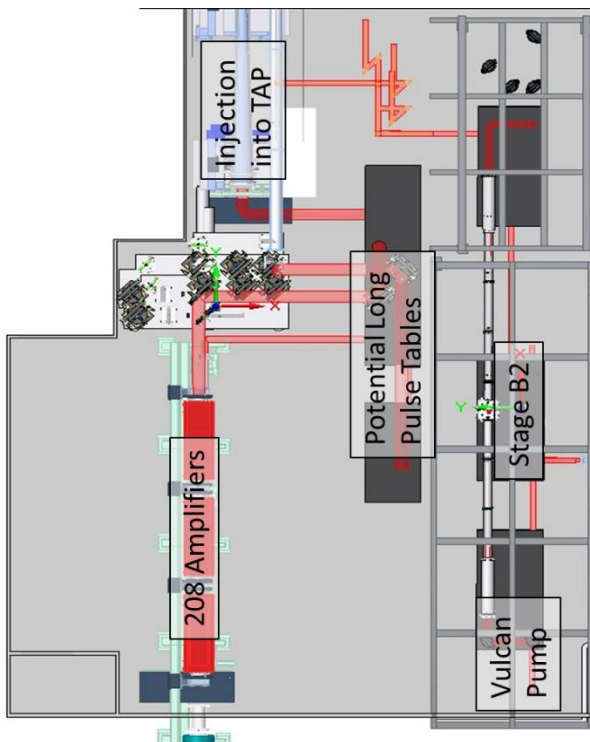


Figure 3. Planned layout in LA4 to accommodate the final amplification stage and to enable a higher energy long pulse beam for TAP.

### Compression and Focusing

After amplification the beam will be relayed into a compressor chamber in TAP. Where it will be compressed to 30J. After the compressor the beam is passed to a focusing chamber from which it is focused into the existing interaction chamber. It is envisioned that there will be the opportunity to conduct interactions between the 2 short pulse beams in a variety of geometries such as orthogonal, counter and co-propagating. To achieve some of these geometries the use of plasma mirrors might be required to re-direct one or more of the beams.

### Conclusion

In this contribution we have laid out our plans for an upgrade to the Vulcan facility through the provision of a new OPCPA beamline. An artist's impression of how the new beamline might look in the existing facility is shown in figure 4. This new beamline will enable new science to be conducted in the Vulcan laser facility. It is scheduled to be online to users at the beginning of 2022.

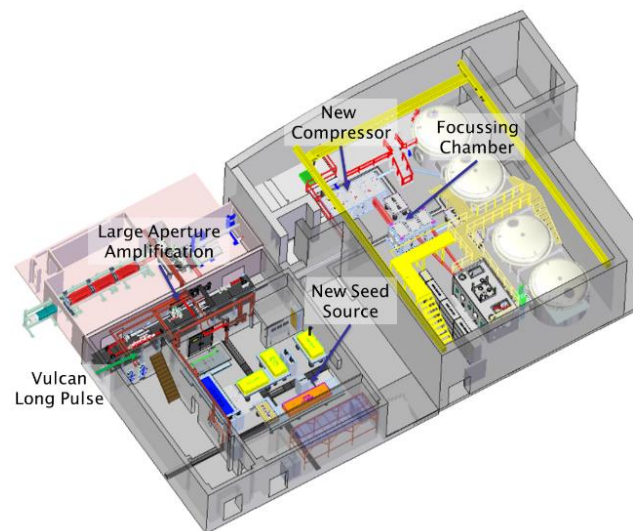


Figure 4 Artist's impression of the new beamline in the existing facility.

### References

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