Preliminary results of a 20 nm high efficiency picosecond OPA system for a Petawatt dual OPCPA scheme

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Introduction

The delivery of high intensity petawatt laser systems over the last few years has inevitably rasied questions on the contrast that can be achieved on such systems. The development of this PS OPA system is to primarily address the issue of the ASE pedestal that arises from noise in the amplifier chain [1]. For CPA schemes the limitation on the duration of this ASE pedestal is governed by the stretched pulse duration. For systems with an OPCPA pre-amplifier where the pump pulse duration is matched to the stretched seed pulse duration then the pump pulse duration is the limiting factor [2]. This has been demonstrated by recent experiments on the Vulcan Petawatt facility [3]. For the Petawatt facility, the ASE pedestal is ~2 ns long. In this report we discuss a scheme to inject clean microjoule pulses (in comparison to the current nanojoule pulses) into the existing Vulcan Amplifier chain to improve the contrast on these timescales. These microjoule pulses can be delivered by developing a piosecond OPCPA.

Our picosecond OPCPA shown in Figure 1 uses a 527 nm 10 ps pump pulse in a near collinear degenerate scheme. The pump pulse operates at 10 Hz and is locked to the output of the modelocked ~80 MHz short pulse oscillator – both providing near gaussian spatial and temporal profiles.

Picosecond Gaussian pump

For a 10 ps pulse with a Gaussian Temporal Profile Figure 2(a), a simple SSG gain analysis using the experimental intensities of 1 mJ in a 1.3 mm diameter pump beam provides a temporal dependent gain similar to that shown in Figure 2(b). The gain coefficient dependence on the square root of the pump intensity effectively narrows the available 'time window' during which relatively uniform gain can be achieved – because the seed pulse is stretched to optimise gain extraction from the OPA, this thereby determines the optimum duration of the stretched pulse duration to enable broad bandwidth seed amplification.

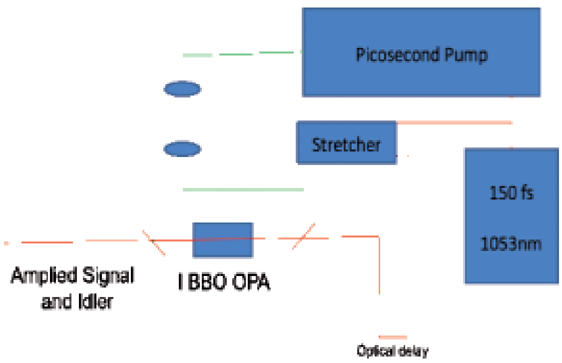

Figure 1. Schematic of picosecond OPCPA arrangement.

A picoseond stretcher based on a 4 F folded single lens and single grating

To achieve the required picosecond seed signal duration, a 1500 l/mm grating used near littrow in a double pass refective 4 f design was chosen as shown in Figure 3 enabling 'automatic' parallel alignment for the gratings to eliminate spectral sheer. This also provided the convenient ability to provide pulse durations of arbitrary chosen duration by adjustment of the position of the mirror and lens position, both located on a common translation stage, while simultaneously keeping the input and output stretched beam position constant. The effective grating

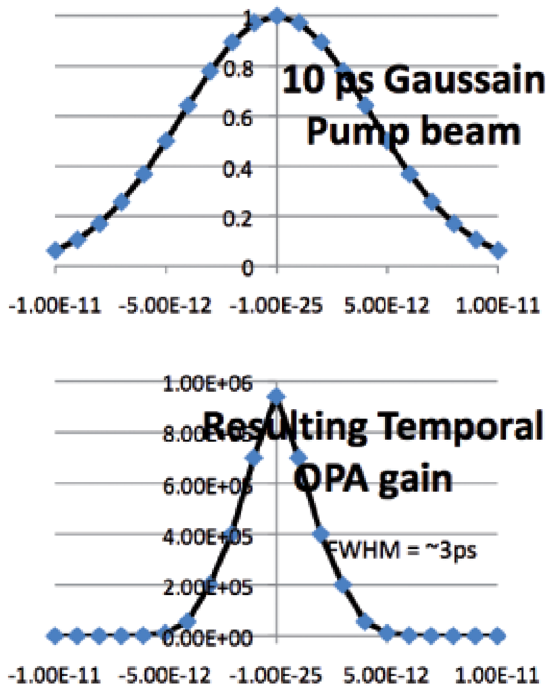

Figure 2 (a) and (b). Effective spectral narrowing of the seed bandwidth due to the gaussian pump pulse temporal profile.

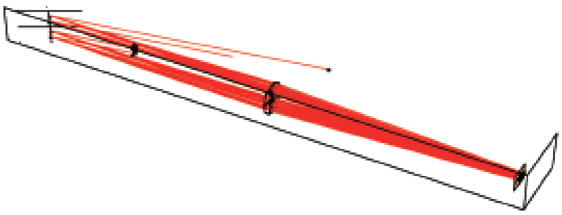

Figure 3. Single grating 4f stretcher used to provide the optimum seed pulse duration.

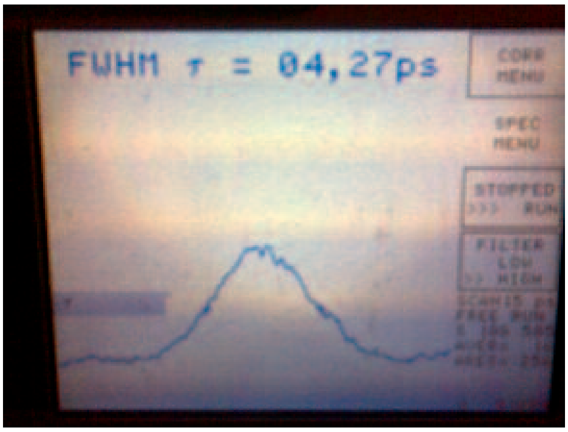

Figure 5. Stretcher pulse duration set using a scanning autocorrelator.

separation for a positive chirp is given by 4× (focal length of lens – grating to lens distance), ensuring the grating is located at a distance shorter than the lens focal length to the lens. Chromatic aberration in the lens leading to pulse front distortion was calculated to be less than 50 fs and was supported by the minimum pulse width obtained by the stretcher. This could be removed using a achromatic lens [4]. The stretcher was set up to provide a pulse duration of ~3 ps using a scanning autocorrelator (Figure 5) as required by the modeling in Figure 2.

Optimisation of OPCPA energy and bandwidth for Vulcan

The OPA pump intensity in the BBO was adjusted to prevent significant OPG generation using the telescope in Figure 1. Using matched signal seed beam and pump beams of ~1.3 mm diameter, the generated output was optimized and approximately calibrated using ND filters – gains in excess of 10^6 were measured – final seed and idler outputs were measured to be in excess of 150 µJ providing up to 40% conversion from pump to signal and idler. These outputs were measured to be stable to the 5% level and were collimated to match the beam diameter of the usual Ti-sapphire seed that propagates through the TAP stretcher to enable nanosecond amplification and injection into Vulcan.. The amplified bandwidth obtained on the amplified idler is shown in figure 7 – it extends well into the wings of the seed spectrum suggesting heavy saturation and can be optimized for optimum central wavelength by adjusting the timing between the seed and pump – this is done by small changes in the mechanical optical delay indicated in figure 1.

Figure 6 shows the spectral content obtained from the oscillator. Of the total available output, 4.2 mW was diverted into the stretcher resulting in~ 2.1 mW before the OPA.

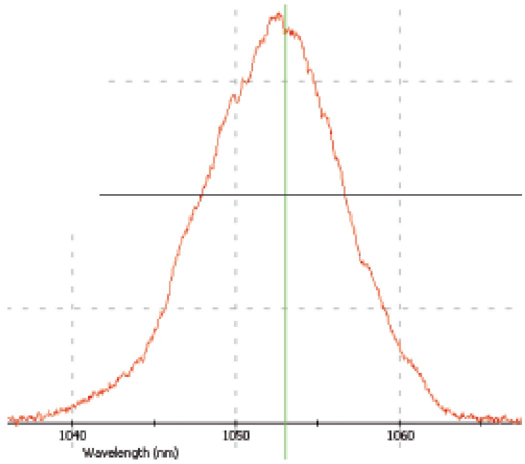

Figure 6. Bandwidth of seed spectrum from oscillator.

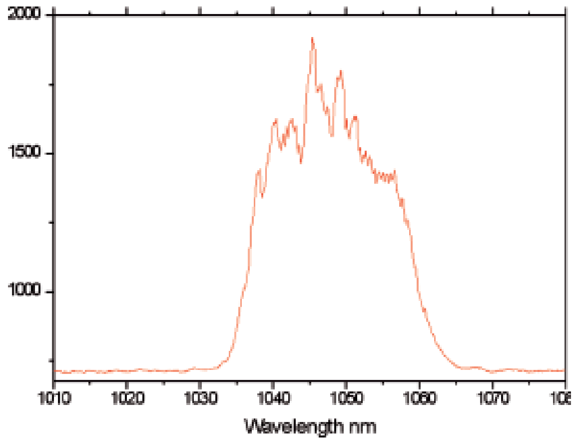

Figure 7. OPCPA spectral output extending over 20 nm.

References

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