

Vulcan Petawatt-Operation and Development

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Petawatt capability on the Vulcan laser facility has been available to the international plasma physics community for over two years. This has enabled novel experiments to be carried out and new regimes of physics to be investigated. During that time, there have been 10 successful user experiments with more than 89% of shots delivered within the requested energy limits. In the autumn of 2004, pulses with powers of more than a petawatt (10^{15} Watts) were delivered to target. This was achieved by generating pulses that have energies greater than 400J and pulsewidths shorter than 400 femtoseconds (10^{-15}) on target.

The generation of short pulses requires the amplification process to maintain as broad a spectral bandwidth as possible. The methods used to maintain the pulse bandwidth on Vulcan include the use of an optical parametric pre-amplifier to amplify the pulses to the millijoule level followed by a series of mixed glass amplifiers taking the pulse energies to the hundreds of joules level. A large aperture adaptive optic is used to ensure a high quality wave front for optimal compression.

In parallel to the development of ultra-high intensity pulses is a programme to enhance Vulcan's long pulse capabilities. Control over the temporal profile of the amplified pulse has become fundamental to the success of recent experiments. During amplification, the effects of gain saturation distort the temporal profile of the pulse. Depending on the required pulse duration, several methods to combat these effects on the temporal shape of the pulse during amplification have been used. These include:

- For pulses of 1ns a pulse shaper technique, using a Pockell's cell to modify the leading edge of the input pulse.
- For pulses between 4 and 8ns the leading edge of an initially near Gaussian pulse has been injected into the amplifier system.

Greater flexibility and control will be provided by using modulators developed for telecommunications combined with arbitrary waveform generators to create a pulse with programmable characteristics.

The generation of 'Top-Hat' beams is also necessary for the next phase of the Vulcan Petawatt upgrade. This phase of the upgrade introduces long pulse beams into TAP allowing experiments that are more complex. The planned operational parameters of these beams will be in the kilojoule and nanosecond regimes.

This paper will present an overview of the current capabilities of the Vulcan Petawatt facility, discuss some of the recent technological advances that have enabled the generation of petawatt pulses and introduce various developments to the system that are in progress.