

Upgrading the kHz pump laser for the Gemini front-end

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Introduction

The Gemini laser facility has been in great demand for high-profile scientific experiments, such as electron and proton acceleration and secondary source radio-tomography applications. As the starting point of the entire laser chain, the preamplifier in the front-end plays an important role in providing reliable and stable operation of the facility to the users. The existing pump laser of our FemtoPower Compact Pro preamplifier, the Thales Jade 2, was in need of fundamental maintenance, service, and an upgrade to the obsolete control software after many years of operations.

The current line of FemtoPower systems is fitted with the more modern Ascend line of diode-pumped solid-state Q-switched laser, following the company's merger with Spectra-Physics. To maintain reliable and stable operation of the front-end, to futureproof the system to deliver the best service and to make maintenance easier, we upgraded the pump laser for our front-end to an Ascend system.



Figure 1 – The Ascend pump laser.

Installation of the new front-end pump laser

The Ascend 40 is an industrial diode-pumped solid-state Q-switched laser, manufactured by Spectra-Physics. This laser is capable of delivering more than 25 W of average output power at the wavelength of 527 nm and a repetition rate of 1 kHz, similar to that of the Jade 2 pump laser. The Ascend 40 is a robust and easy-to-operate laser with an up-to-date control console, delivering industry-leading output power and energy reliability and beam quality. This laser has been designated by the manufacturer as the preferred replacement for the Jade 2 laser as the pump for the FemtoPower amplifier, delivering an optimal performance.

In March 2020, the Jade 2 was removed from the optical table and replaced with the Ascend 40. As the beam waist of the Ascend differs slightly from that of the Jade, the beam transport from the Ascend to the multi-pass amplifier was partially redesigned to deliver the same spot size at the Ti:sapphire crystal of the multi-pass amplifier. As was the case with the Jade 2, the pump beam is fully enclosed from the output of the laser to input into the preamplifier, for safety reasons.

The replacement of the pump laser was accompanied by a thorough service and optimisation of the multi-pass amplifier, after which the FemtoPower preamplifier performance was greatly improved, as discussed below.

Performance improvements

The output of the preamplifier is monitored using a fast photodiode and recorded onto the eCAT data handling system. Fig. 2 shows an output stability measurement with photodiode voltages recorded every 1.3 s over a period of 30 minutes.

There is a significant improvement in three key aspects: the average output was increased from 0.43 mV to 0.94 mV; the shot-to-shot stability was greatly improved; and finally a high-amplitude slow drift with a period of ~200 s is no longer present. Overall, the RMS stability of the system was greatly improved from 19 % to 0.9%.

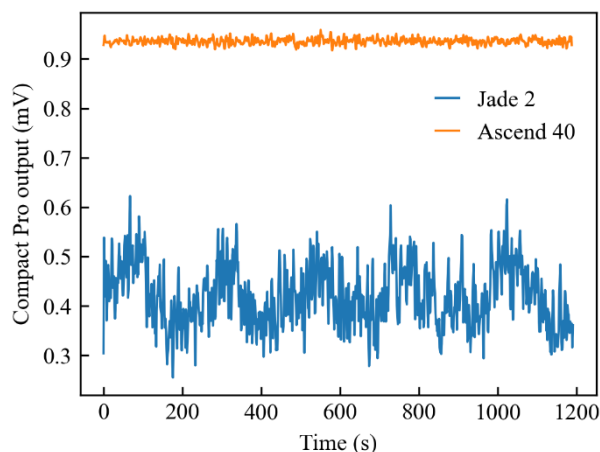


Figure 2 – Stability measurement of the FemtoPower Compact Pro output before (blue) and after (orange) the pump laser upgrade and system maintenance.

Although the subsequent amplification stages used to mitigate the effects of the instabilities and the slow drift, because they operate in the gain saturation regime, there was nevertheless a noticeable improvement in system performance. The increased output stability of the front-end led to an increased energy stability throughout the Astra system, and the increase in output reduced the pump energy required in the first amplification stage of the Astra amplifier chain.

Conclusions

The Gemini front-end pump laser upgrade was performed successfully, resulting in significant improvements to the energy and stability of the front-end. Since its installation one year ago, the Ascend has proved to be a reliable laser, with no faults or operational disruptions to report.