shows the calculated spectral shape and illustrates how this shape evolves into a smooth top-hat spectrum with increasing gain.

We succeeded in compressing these spectrally shaped, amplified pulses with 66 % efficiency to 900 fs with 200 mJ. In a Treacy type grating compressor [16] with 6 m grating separation, gratings with the same grating period as in the stretcher are utilized. As shown in Fig. 1 we use a reverse configuration, meaning that the incident beam has a smaller angle to the grating normal than the diffracted one. The grating angles were optimized for shortest pulses and the implemented Dazzler enables us to correct for higher order phases.

The compressed pulse duration is measured by a home-built single-shot second-order autocorrelator with a tuning window of 6 ps and a pixel resolution of 22 fs. This device is designed to measure 700 fs pulses with 6 % accuracy. For 1000 shots the autocorrelation traces are measured the mean width is 1.21 ps with a standard deviation of 0.04ps. The measured autocorrelation trace is shown in Fig. 5.

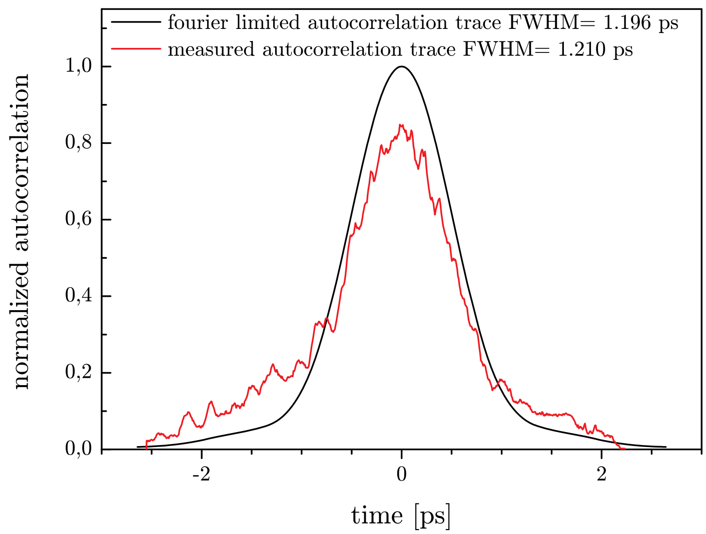

Fig. 5. Calculated autocorrelation trace for the Fourier-limited pulse (black) and measured autocorrelation trace (red). The latter one is normalized to to enclose the same area as the calculated autocorrelation trace. The corresponding pulse length is 884 fs and 895 ps, respectively.

The fourier limited pulse shape and the corresponding autocorrelation trace are calculated from the measured spectrum. From this we have inferred a deconvolution factor between the pulse duration and the width of the autocorrelation trace of 1.3518 for this particular case. Using this factor we can obtain a realistic estimate for our compressed pulse duration which turns out to be 895 fs (transform limit 884 fs) with a measurement uncertainty of 40 fs. As can be seen in Fig. 5 the autocorrelation trace is slightly asymmetric, which is most likely caused by an imperfect beam profile in the autocorrelator. Although the main pulse is close to fourier limited FWHM, there are large side wings which could be explained by uncompensated higher order dispersion. Another possibility could be spatio-temporal coupling caused by B-integral issues when the compressed pulse propagates in several meters air after the last grating. This problem will be solved by a vacuum chamber for the compressor, which is currently under construction.

In a 5 mm type 2 DKDP crystal frequency doubling with 40% conversion efficiency is achieved so far. We therefore have 80 mJ pulse energy in the green, which is sufficient for pumping the first two to three OPA stages. The beam profile of the frequency doubled beam at

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the position of the first OPA stage is shown in Fig. 2(c).

Another important aspect for short pulse pumped OPCPA is the timing jitter between pump and seed pulses. In our case the pulse length is 1ps and therefore a timing jitter at least 100 fs is desired for reliable operation of the OPCPA process. We measured the timing jitter in a single-shot cross-correlation experiment between the 30 fs, 800 nm pulse (representing the timing of the OPCPA seed) and the compressed pulses (1030 nm) in a 1 mm BBO crystal. The relative position of the correlation traces on the camera can be converted to a relative timing between the pulses. On a 10 s timescale, a jitter of 273 fs standard deviation was measured. We believe, these timing fluctuations mainly originate from air turbulences, and the mechanical instability of different optical components in the pump laser chain. A more extensive analysis of the jitter is under way in order to find out where exactly this jitter originates from. Preliminary results show, that active stabilization allows for a timing jitter of less than 100fs.

4. Summary

In summary we showed amplification in Yb:YAG up to 300 mJ pulse energy at 10 Hz repetition rate with an unprecedented spectral bandwidth of 3.5 nm. This was realized by spectral amplitude shaping using a SLM to counteract gain narrowing. In our system we demonstrated the operation of a sub-ps CPA laser system based on Yb:YAG at an energy level of up to 200 mJ for the first time. We have therefore demonstrated, to our knowledge, the highest-peakpower pulses ($\approx$160GW) generated in a Yb:YAG laser to date. From a gain-narrowing point-of-view, these results can be scaled to the 50 J-level, as predicted by our simulations. In order to obtain the best possible efficiency for the frequency doubling stage and therefore the highest possible pulse energy in the green, some additional optimization will have to be performed. The laser system described in this manuscript fulfills the requirements and is currently being used to drive the next important step in the PFS-project, namely the development of the first OPA-stage.

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