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CCD-S3600-D(-UV) APPLICATION EXAMPLE

Long-Term Frequency Stability Analysis of a Pulsed Laser

In this example, the frequency stability and the longitudinal mode content of a single-frequency diode-pumped Q-switched laser was conveniently monitored and analyzed by means of a combination of a Fabry-Perot interferometer and the CCD-S3600-D line camera. The laser used in this experiment was the PULSELAS-P-1064-100-SF (manufactured by ALPHALAS GmbH) delivering 1 mJ pulses with 3 ns pulse duration (FWHM) in single-frequency mode and operating at a repetition rate of 100 Hz.

The laser output was frequency-doubled to 532 nm, not only for the convenience to work with visible light, but also to allow high-sensitivity detection of weaker additional longitudinal modes [1]. The Fabry-Perot interferometer (FPI) had a free spectral range of 50 GHz (~ 47 pm at 532 nm).

The experimental setup is shown in Figure 1.

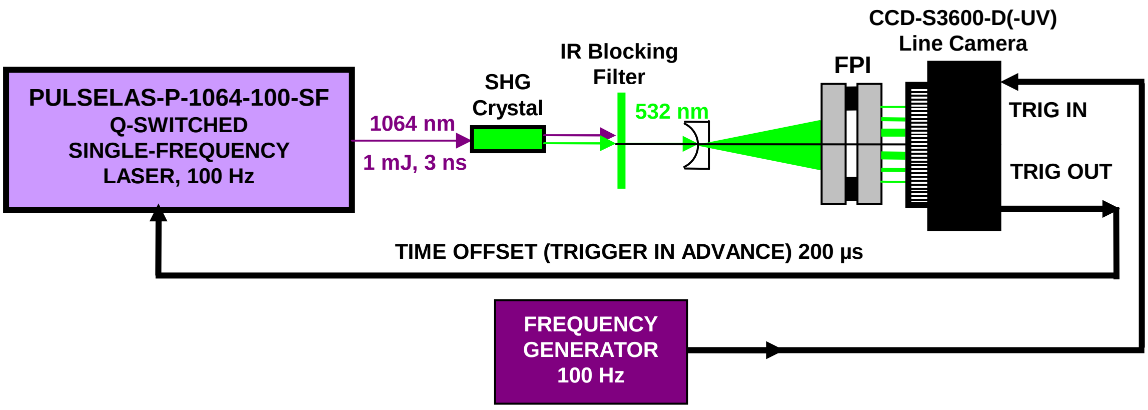

Figure 1: Experimental Setup for Long-Term Frequency Stability Analysis of a Pulsed Laser

The CCD camera was set to “single-shot” operating mode. It was triggered from a frequency generator at 100 Hz. Its trigger output in turn was used to trigger the pulsed laser. This resulted in the same repetition rate of 100 Hz, but the laser could be triggered always exactly at the moment when integration begins in the CCD. Thus, the shortest possible integration times could be used and noise was reduced to a minimum.

Because this particular laser fires with a delay of approximately 200 µs after having received a trigger signal, another unique feature of the CCD-S3600-D line camera to generate trigger in advance was also used.

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In addition, because a jitter of about 30 µs was typical for this particular laser, a slightly increased integration time of 50 µs was set. Thus, the shots could be captured in spite of the jitter. Without jitter, one could have set the shortest possible integration time of 10 µs.

The following CCD camera settings were used:

- **CCD operating mode**: "**Single-shot, clean & ready with external hardware trigger**"
- **Integration Time**: 50 µs (because of the jitter specific for that laser)
- **Trig Out before Integration**: 200 µs (this is the pre-integration start offset for the trigger output to trigger the laser in advance, also specific for that laser)
- **Scans per Acquisition**: 3024 (this is the number of captured frames required by the user). It is worth mentioning that CCD-S3600-D(-UV) line cameras allow to capture up to 4599 shots in standard onboard data storage mode. In the advanced streaming mode, the number of captured frames can be much higher and is only limited by the capacity of the hard drive of the user's computer.

The line camera was able to capture the Fabry-Perot interference pattern for each laser shot. In Figure 2 below, 3024 shots were recorded. Clearly visible is the transition feature at the beginning of the recording after turning on the laser, where the laser frequency is still unstable. All recorded data was captured and conveniently visualized in a LabVIEW 3-D plot. Please refer to the LabVIEW example applications included with the CCD camera.

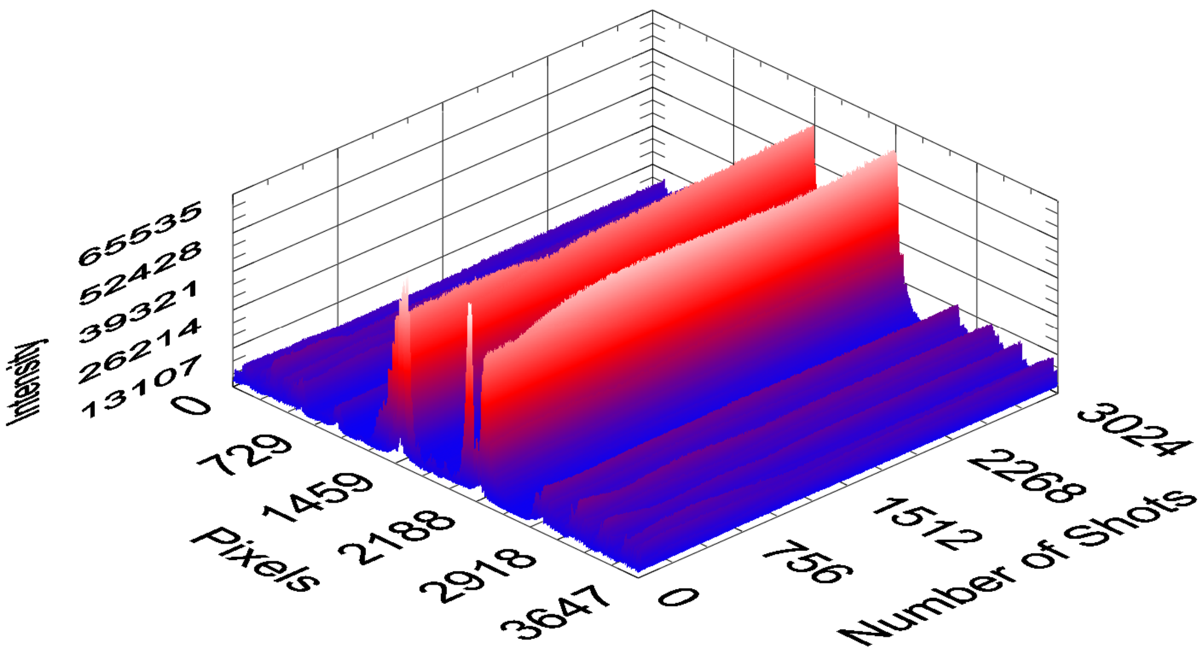

Figure 2: Record of the Fabry-Perot Interference Pattern Evolution

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Another recorded data set is shown in a second run that clearly demonstrates the slight change of the laser frequency (best visible through the spacing change for the most inner maxima of the interference pattern) during the warm-up stage (see Figure 3).

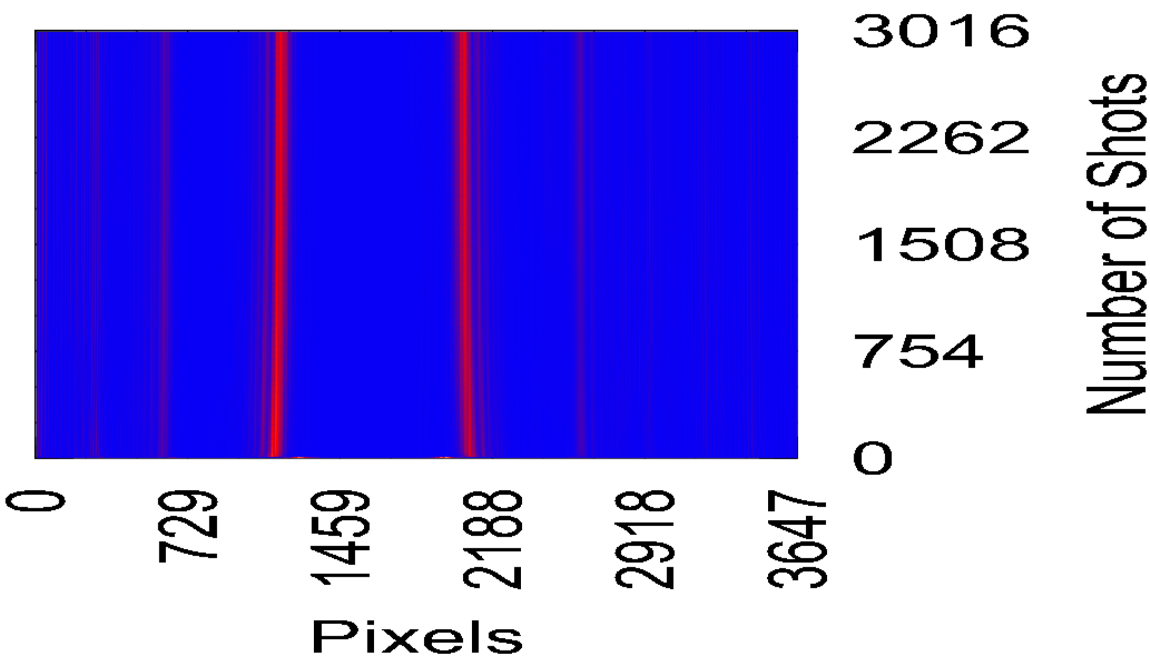

Figure 3: Laser Frequency Drift as Function of Time (Number of Shots)

Reference:

[1]. K. A. Stankov and I.Y.Milev, **Use of a vacuum-planar photodiode to drive an electro-optic Q-switch directly**, APPLIED OPTICS, Vol. 30, No. 36 , (1991) p. 5250

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