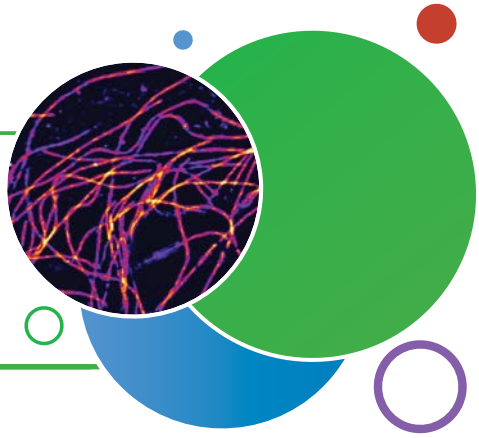
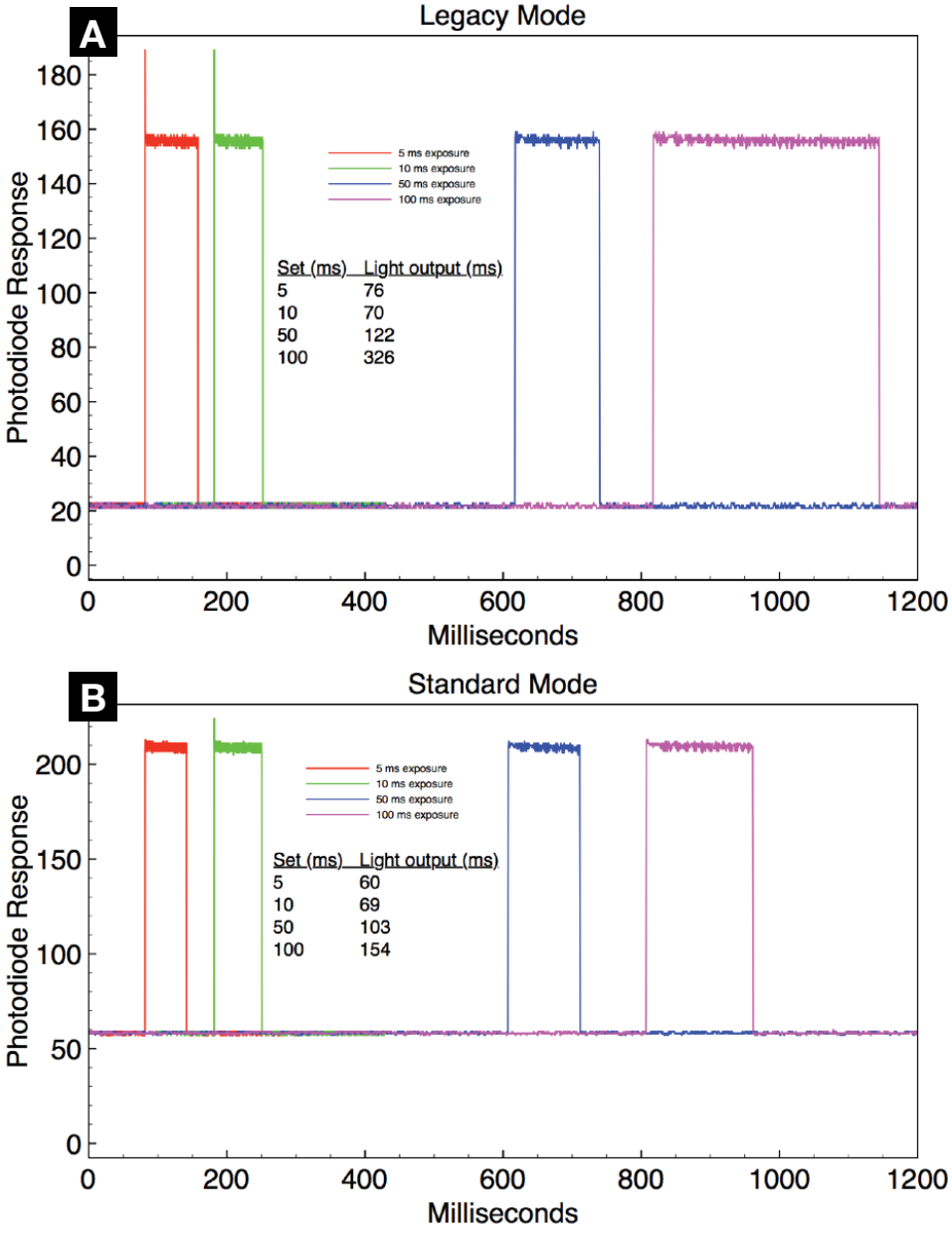


USB Control Latency and How to Avoid It

Control latency limits the response time of all USB-connected microscope accessories, including cameras, stage controllers, filter wheels and Lumencor light engines. Latency originates from the fact that the supervising PC operating system (usually Microsoft Windows) must allocate time to many competing tasks. As shown in the adjacent data plots, the impact on the user is that the duration of light output on the specimen is longer, and sometimes much longer, than the exposure time set in the acquisition software.



Duration of light output produced by a CELESTA light engine, and detected by an external analog photodiode, in response to various exposure times set for a Hamamatsu ORCAFlash 4.0 camera controlled by MicroManager (v1.4.23) image acquisition software. Note that the discrepancies between set exposure time and light output duration are not specific (except in minor details) to any particular image acquisition software or light engine or camera model. **Panel A** shows data for light engine control via LEGACY mode USB communication. **Panel B** shows the same nominal exposure sequence controlled via STANDARD mode USB communication.

Two scenarios are shown, one using LEGACY mode USB communication (as implemented on the SPECTRA X and SOLA SE light engines), and the other using STANDARD mode communication (as implemented on the AURA III, SPECTRA III and CELESTA light engines). Because the USB data transmission rate in STANDARD mode is faster than that of LEGACY mode (115,200 vs 9,600 baud), it provides a significant reduction of latency for exposure times on the order of 100 ms (and above). However at short exposure times (5–10 ms), the impact of the faster communication speed in STANDARD mode diminishes, as the response is dominated by the software processing speed.

To obtain light output durations less than about 50 ms, timing must be derived from a hardware controller instead of the PC operating system. The hardware controller supplies TTL timing signals to the light engine via a breakout cable **(Table 1)**. Examples of millisecond-duration light pulses generated in this way can be found in the Performance section of our website. At the present time, the capacity to acquire time-lapse sequences of short duration exposures is limited by the camera (modern sCMOS cameras typically have a maximum frame rate of around 100/second), rather than by the light source.

TABLE 1

Manufacturer	Hardware timing controller**	Lumencor breakout cable (connector)
Nikon	National Instruments breakout box (NI-BB)	29-10156 (BNC)
Olympus	U-RTCE real-time controller	29-10216 (SMB)
Zeiss	Trigger board and signal distribution box	29-10156 (BNC)
Leica	Synapse real-time controller	29-10216 (SMB)

**These devices are controlled by the manufacturer's image aquisition software packages – Nikon NIS Elements, Olympus cellSens, Zeiss Zen and Leica LASX respectively