DataRay Inc.

BladeCam series CMOS
WinCamD series CMOS
TaperCamD series CMOS

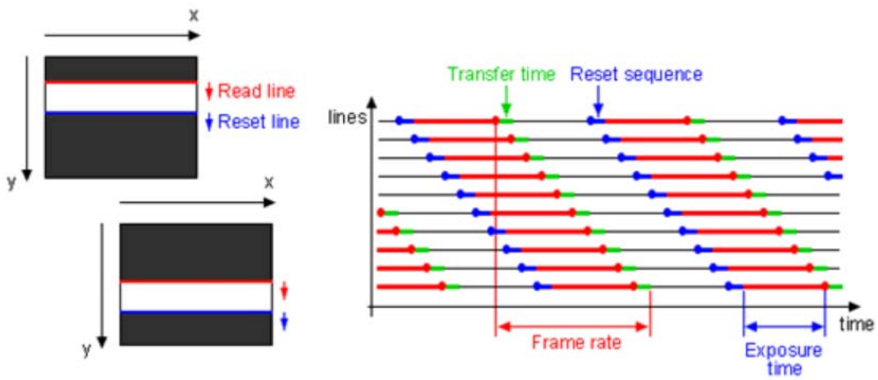
CMOS Rolling Shutter with Pulsed Lasers

Applies to: All *current* BladeCam, WinCamD & TaperCamD series products with CMOS sensors.

Issue addressed: Can I capture pulsed lasers with rolling shutter CMOS?

To capture a pulse on all pixels simultaneously, normally requires a synchronous shutter which opens and closes on all pixels simultaneously, and which is preferably triggered to coincide with the laser pulse.

With a rolling shutter sensor - almost all CMOS sensors - each line in the frame opens at a different time, stays open for the duration of the exposure and then closes - see diagram below. The white block in the two frames on the left illustrates this open period of the electronic shutter 'rolling' down the frame.



Pulse capture ***may*** be achieved with a rolling shutter CMOS camera if:

- **You are lucky**. The size of beam and the duration of the **Exposure**, the **PRR** (Pulse Repetition Rate), the pulsewidth (**pw**) and the pulse timing all come together and the world is evolving as it should and your personal stars are aligned in the heavens.
- **Pulse averaging**. The exposure time adequately averages a number of pulses, most commonly true at high PRR.

1) You are lucky

The cycle time for DataRay cameras is the serial addition of:

- The exposure time, 0.040 to 1024 ms.
- The ~50 ms transfer time across the USB 2.0 interface, limited by the USB 2.0 standard and the Capture Block size.
- The *highly PC and processor dependent* processing time for analysis and display, 50 to 500 ms.

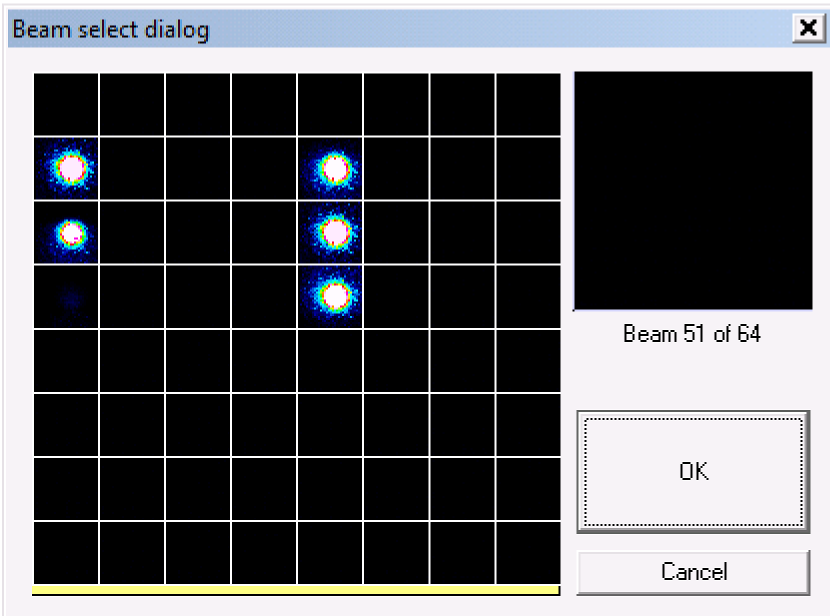
Even at the shortest exposure time of 0.040 ms, this cycle time is 100 to 300 ms, so the highest **Pulse Capture Rate** is going to be **3 to 10 Hz**.

If: a) The laser fires off during the exposure time

and: b) The pulse sits completely within the open frame

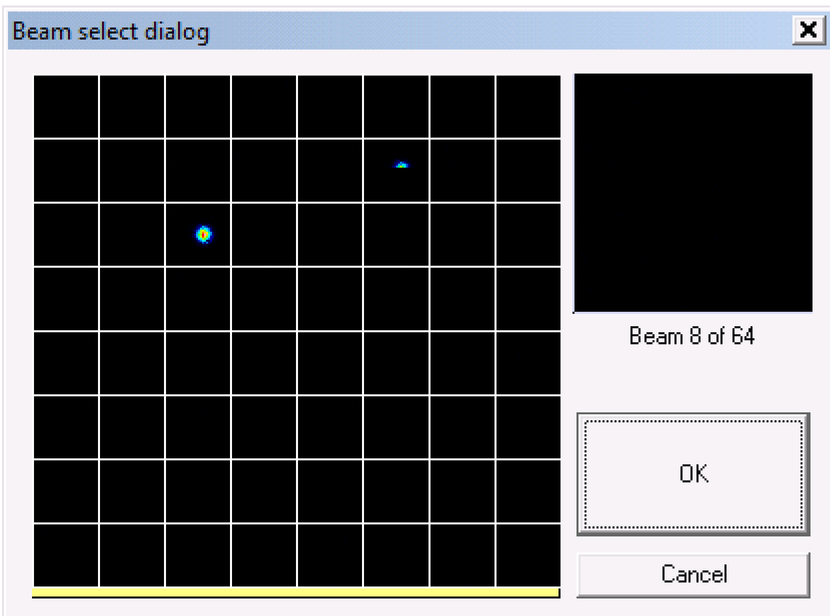
Then: ... you may occasionally capture a full pulse image. The first Image Buffer sequence below, with a 2 Hz PRR and auto-exposure, shows 5 captures out of 64 but they are overexposed. This is because most frames have no images so the auto-exposure auto-adjusts to 100 ms, over-exposing the pulses that are captured.

2 Hz PRR, 100 ms pw, Auto-exposure



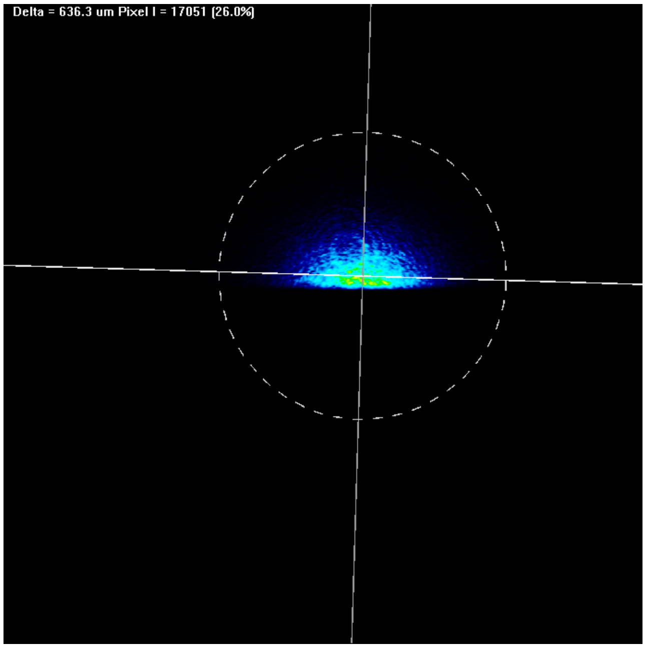
Since these pulses were long (10's ms) reducing the exposure time and taking it off auto-exposure can capture pulses, as shown below at an exposure of 1.3 ms, but the capture rate can be very poor, in this instance 1 complete image in 64 frames. There is also one chopped image.

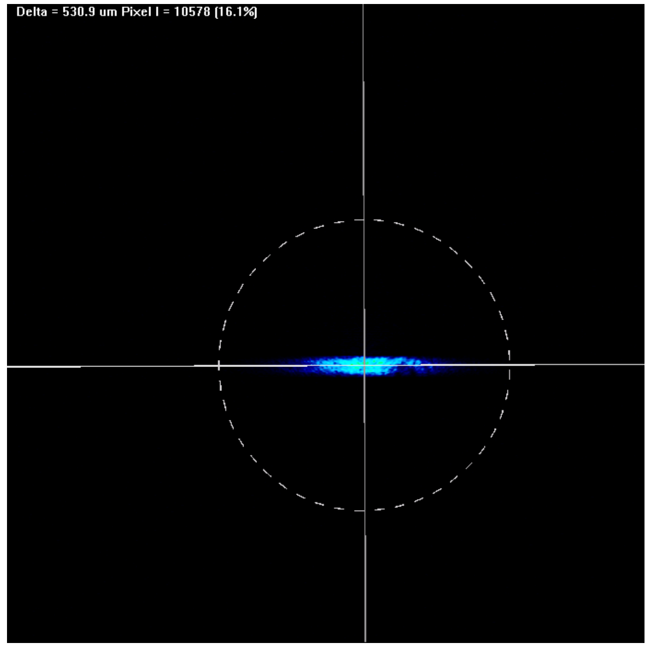
2 Hz PRR, 100 ms pw @ fixed 1.3 ms exp.



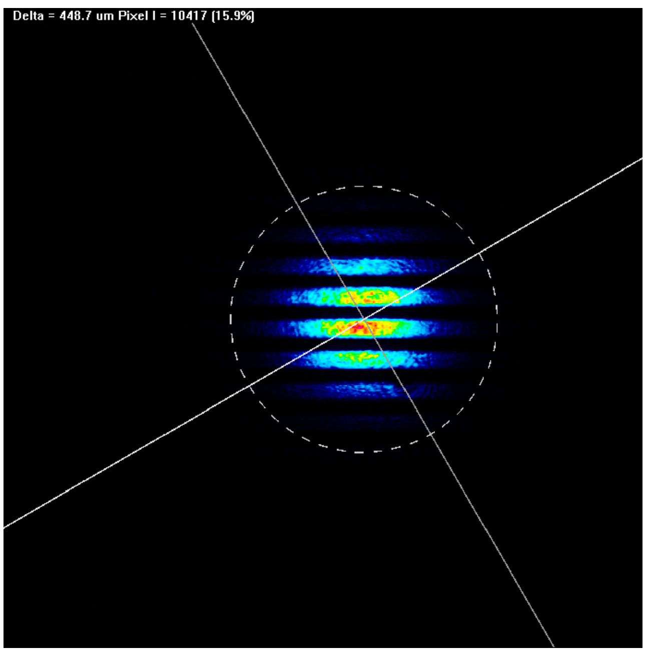
The two images below show examples of two 'chopped images due to the rolling shutter.

Both were taken at **5 Hz PRR, 1 ms pw @ 1.3 ms exp**.





Increasing the PRR to **500 Hz PRR, 1 ms pw @ 1.2 ms exp**. gives a more complete, but still chopped image.

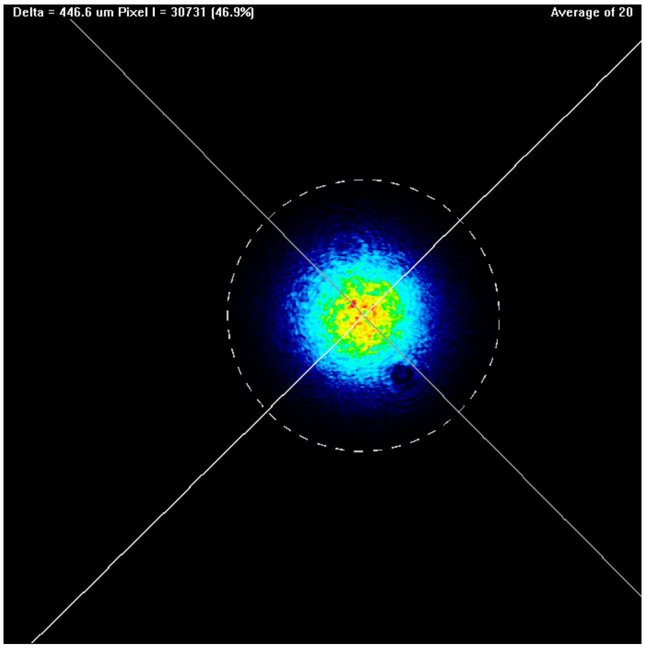


2) Pulse averaging

If your rep rate is high and you do not need to capture individual pulses, then averaging can make a big difference. When you are averaging, the potential pulse profile errors are the inverse of the number of pulses which you have averaged. E.g., If you average 100 pulses, potential errors are ~1 %. If you average 10 pulses, potential errors are ~10 %.

a) Average using exposure time and Averaging function.

1 kHz PRR, 0.1 ms pw @ 10 ms exp., Ave 20 Effectively an average of 200 pulses.



b) Average using exposure time only.

10 kHz PRR, 0.01 ms pw @ 11.5 ms exp., No Ave. Effectively an average of 115 pulses.