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http://www.teledynedalsa.com/Genie-Nano

G3-AN0005-Laser Line Profiler Application Note

Genie Nano: Laser Line Profiler Firmware

For Nano models with P/N: G3-GM10-M0640/M0800/M1280/M1930/M2590

Overview

Genie Nano custom firmware that supports line profile data output is available for camera models equipped with monochrome On-Semi Python P1 sensors (0.3M to 5M).

Line profiles are calculated from 2D images and results are output as a single line buffer with each profile point represented by a 64-bit value.

The following table lists the required Genie Nano firmware and software to support line profile output.

Genie Nano Firmware Design	Software SDK
Custom Design with Laser Profiler	Sapera LT 8.32 or higher

Sapera LT SDK (full version), the image acquisition and control SDK for Teledyne DALSA cameras is available for download from the Teledyne DALSA website:

http://teledynedalsa.com/imaging/support/downloads/sdks/

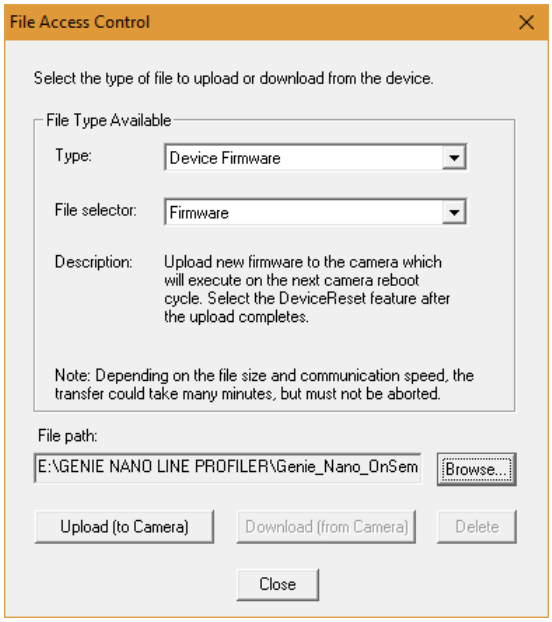
If the required version is not available, contact your Teledyne DALSA representative.

Sapera LT includes the CamExpert application, which provides a graphical user interface to access camera features for configuration and setup.

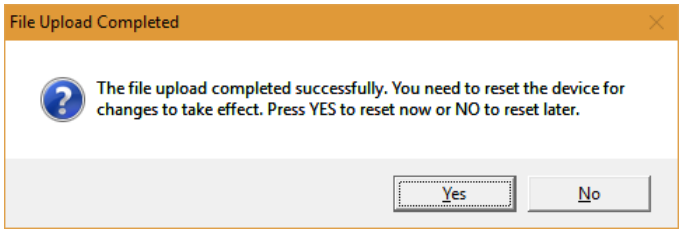
The Custom Design with Laser Profiler firmware is also available for download from the Teledyne DALSA ftp site:
ftp://ftp.dalsa.com/Private/p_ProductSupport/Genie/Genie_Nano_Firmware/GenieNano_On-Semi_Python-0.3_to_5M_Laser_Profiler_Firmware.zip

Camera Setup and Calibration

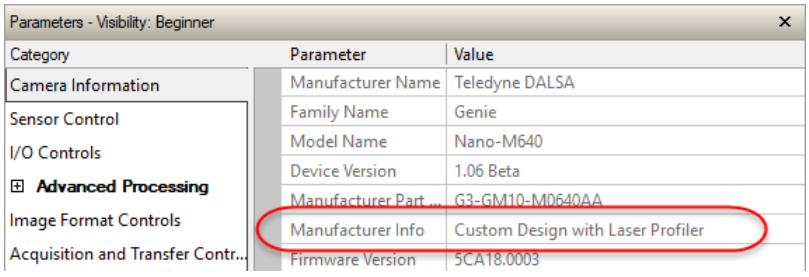
The Custom Design with Laser Profiler firmware can be loaded to the camera using the File Access Control features. CamExpert provides a dialog interface to perform the firmware update; select the required firmware file and click **Upload (to Camera)**.



When the file upload is completed, a prompt appears to reset the camera.

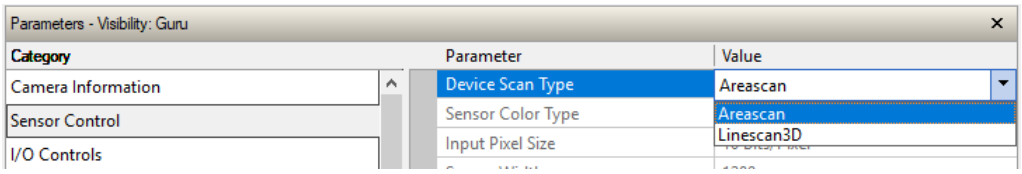


When the custom firmware is loaded, the *DeviceManufacturerInfo* feature (in the Camera Information category) reads "Custom Design with Laser Profiler".



The *DeviceScanType* feature (available in the Sensor Control or Image Format Controls category) determines whether the camera outputs 2D 8-bit monochrome images (*Areascan* mode) or 64-bit 1D line profile data (*Linescan3D* mode).

To display the camera sensor output as a 2D 8-bit monochrome image for camera setup and calibration (exposure, frame rate, and so forth), set the *DeviceScanType* feature to *Areascan* mode.



The *Areascan* mode also allows an ROI to be set for image capture using the *OffsetX*, *OffsetY*, *Height* and *Width* features. The image height for the ROI to capture profiles is limited between 16 and 512 rows, in increments of 1. The *Width* feature is limited by the maximum supported by the sensor, and can be set to smaller values in supported increments, depending on the camera model.

Profile Data Output

To output profile data, set the *DeviceScanType* feature to *Linescan3D*. Each profile point is formatted as a 64-bit value that contains the following information:

- **Antiscatter**: Maximum intensity of the peak (8-bit integer). The maximum intensity does not include any threshold subtraction.
- **Scatter**: Number of pixels composing the peak (8-bit integer).

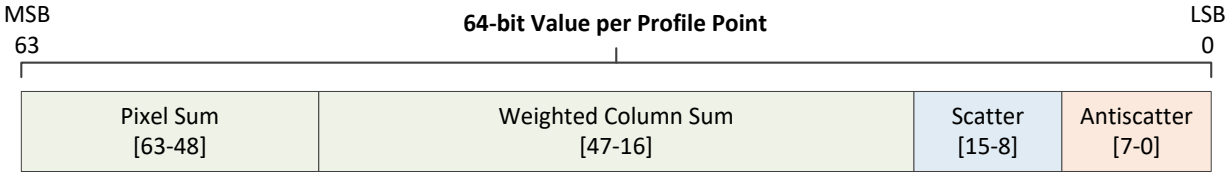
Peak Position Calculation:

- **Weighted Column Sum:** Sum of weighted pixel values (Y position * pixel value) composing the peak. Limited by max search radius, threshold and image border (32-bit integer).
- **Pixel Sum:** Sum of pixel values composing the peak. Limited by max search radius, threshold and image border (16-bit integer).

The calculation of the peak position is performed on the host PC using the following calculation:

$$Peak\ Position = Weighted\ Column\ Sum \div Pixel\ Sum$$

The 64-bit value for each profile point is ordered as follows:



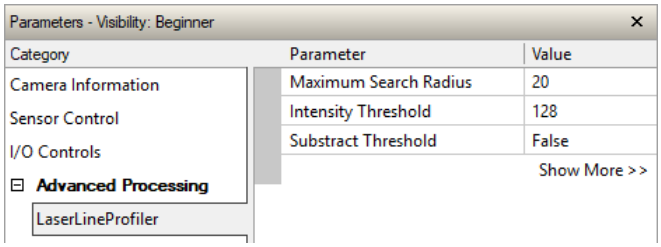
The 64-bit value for each profile position in X is determined by analyzing the pixels in the corresponding Y column.

	For columns where the max value is lower or equal to the minimum programmable intensity threshold, the 64-bit value for the Antiscatter, Scatter, Weighted Column Sum and Pixel Sum is 0. That is, if the 64-bit value is 0, no peak is detected at that profile position.

	To ensure compatibility with third-party software that do not support 64-bit profile output, the Pixel Format feature may be set to *Monochrome 8-bit* (Mono8) in Linescan3D mode. In this setting, each profile point value consists of a combination of 8 x 8-bit values. The Width feature will indicate 8 times the sensor width.

Profile Peak Detection

The profile peak detection features are available in the LaserLineProfiler sub-category of the Advanced Processing category.

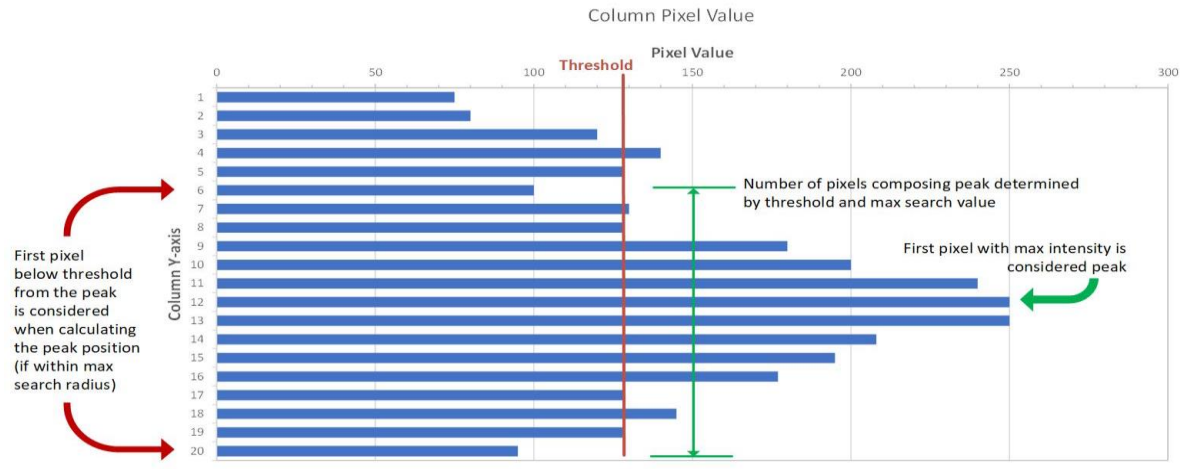


The *maxSearchRadius* feature sets the maximum number of pixels on each side of the peak to consider when calculating the peak position. The maximum search radius value is limited to the smallest value of either 127 or (Height -1) / 2. The search radius can be limited by the image border, depending on the peak position.

The *intensityThreshold* feature determines the minimum pixel intensity that can be considered as a valid peak. To calculate the peak position, the first pixel below the threshold on each side of the peak and within the max search radius is used.

The *subtractThreshold* feature, when enabled, subtracts the *intensityThreshold* value from the pixel (negative values are replaced with 0) before calculating the pixel sum and weighted column sum.

The following figure shows an example column (Y-axis) of intensity values for a single X position.



With a threshold intensity of 128, the pixels composing the peak (scatter) range from Y = 6 to 20 (assuming a sufficient max search radius). The peak position calculation using the weighted column sum and pixel sum is:

Y position	Value	Weighted Value
6	100	6 x 100 = 600
7	130	7 x 130 = 910
8	128	8 x 128 = 1024
9	180	9 x 180 = 1620
10	200	10 x 200 = 2000
11	240	11 x 240 = 2640
12	250	12 x 250 = 3000
13	250	13 x 250 = 3250
14	208	14 x 208 = 2912
15	195	15 x 195 = 2925
16	177	16 x 177 = 2832
17	128	17 x 128 = 2176
18	145	18 x 145 = 2610
19	128	19 x 128 = 2432
20	95	20 x 95 = 1900
	Pixel Sum = 2554	**Weighted Column Sum** = 32 831
	Peak Position: 32 831 / 2554 = 12.855	

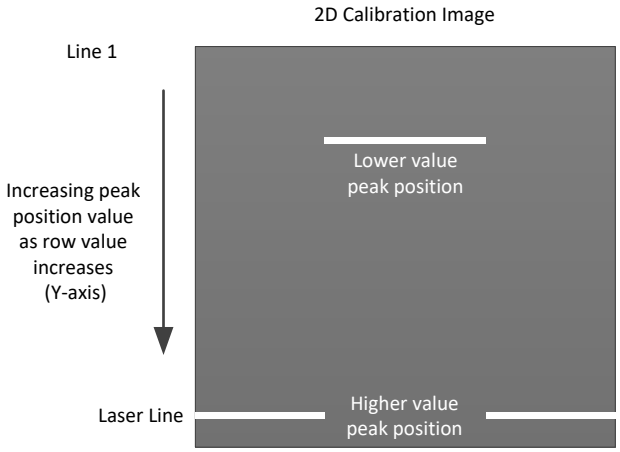
If *subtractThreshold* is enabled, the corresponding example values, with intensityThreshold = 128, are:

Y position	Value	Weighted Value
6	100 – 128 = 0	6 x 0 = 0
7	130 – 128 = 2	7 x 2 = 14
8	128 – 128 = 0	8 x 0 = 0
9	180 – 128 = 52	9 x 52 = 468
10	200 – 128 = 72	10 x 72 = 720
11	240 – 128 = 112	11 x 112 = 1232
12	250 – 128 = 122	12 x 122 = 1464
13	250 – 128 = 122	13 x 122 = 1586
14	208 – 128 = 80	14 x 80 = 1120
15	195 – 128 = 67	15 x 67 = 1005
16	177 – 128 = 49	16 x 49 = 784
17	128 – 128 = 0	17 x 0 = 0
18	145 – 128 = 17	18 x 17 = 306
19	128 – 128 = 0	19 x 0 = 0
20	95 – 128 = 0	20 x 0 = 0
	Pixel Sum = 695	**Weighted Column Sum** = 8699
	Peak Position: 8699 / 695 = 12.517	

Peak Position and Height Value Considerations

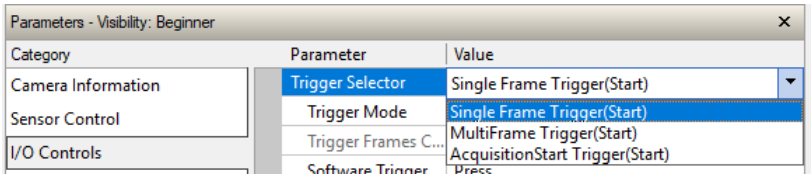
When the *DeviceScanType = Linescan3d* mode, the peak position calculation (*peak position = weighted column sum / pixel sum*) has a range that corresponds to the image height in 2D.

For example, with an image height of 512, a valid *peak position* can range from 1-511 (the value 0 represents a profile position where no peak was detected), where 1 always represents the highest point in the field of view and the lowest point corresponds to the image height -1 (in this case, 511).

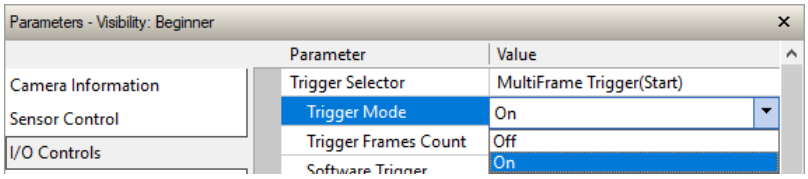


Using Triggers to Acquire Line Profiles

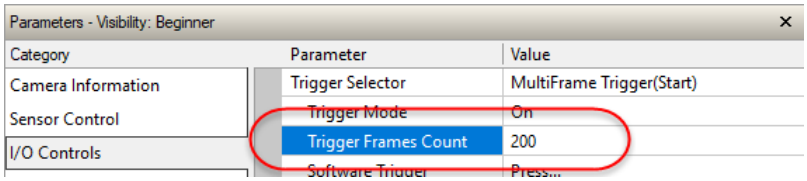
Trigger related features are grouped in the I/O Controls category. The *TriggerSelector* feature determines the type of trigger (*FrameStart*, *FrameBurstStart* or *AcquisitionStart)*.



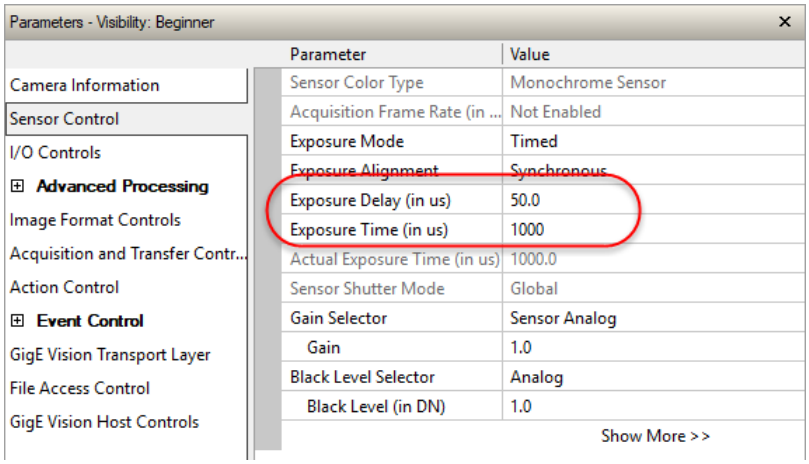
To use an acquisition trigger the *TriggerMode* feature must be enabled.



When using a MultiFrame Tirgger (*FrameBurstStart*), the *triggerFrameCount* sets how many line profiles are aquired with each trigger.



The *ExposureTime* and *exposureDelay* features (available in the Sensor category) control the acquisition frame rate when acquiring multiple frames with a trigger. The delay is introduced before the exposure is started.



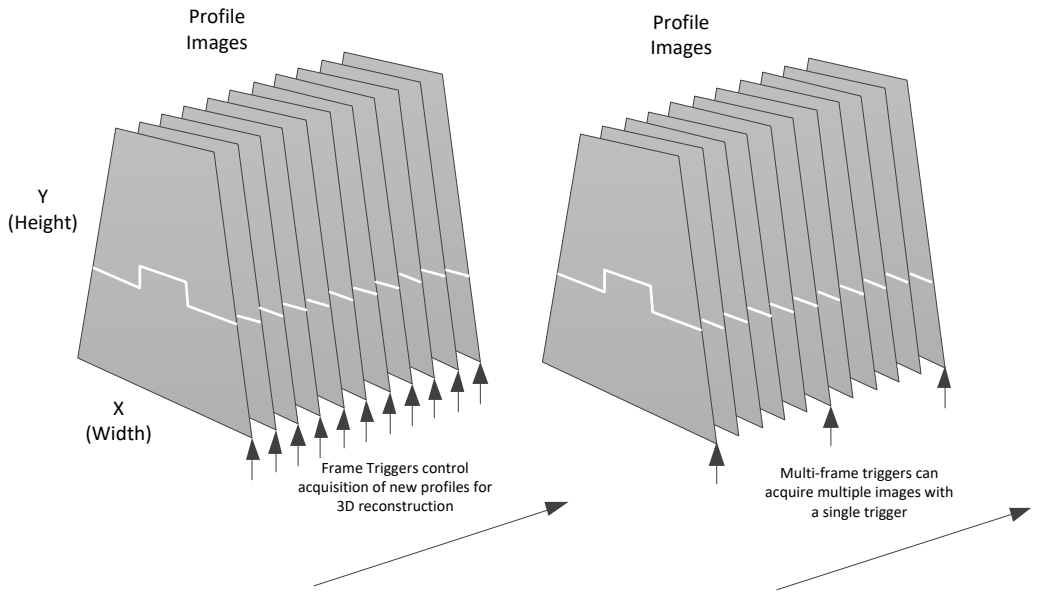
The maximum frame rate is calculated using the following equation (refer to Genie Nano user manual for more information):

$$Maximum\ Frame\ Rate = \frac{1}{exposureDelay\ + Exposure\ Time + Sensor\ Readout\ Time}$$

Adjusting the *exposureDelay* time allows you to slow the frame rate in multi-frame trigger mode.

3D Image Reconstruction

Profile image acquisition can be free-running or controlled using a hardware trigger (for example, a shaft encoder). When acquiring in *Linescan3D* mode, the profile output does not provide any specific information to group profiles into a 3D image. The expected spacing between triggers can be used for 3D image construction, along with the acquisition timestamp.

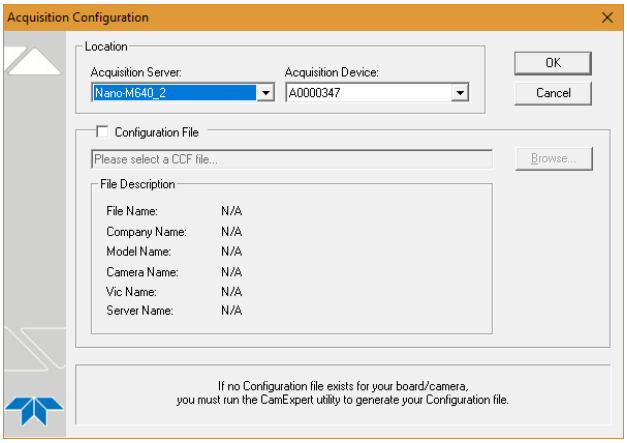


Genie Line Profile Output Demo

The Genie Line Profile Output Demo application demonstrates the line profile output capabilities using a live acquisition and includes source code.

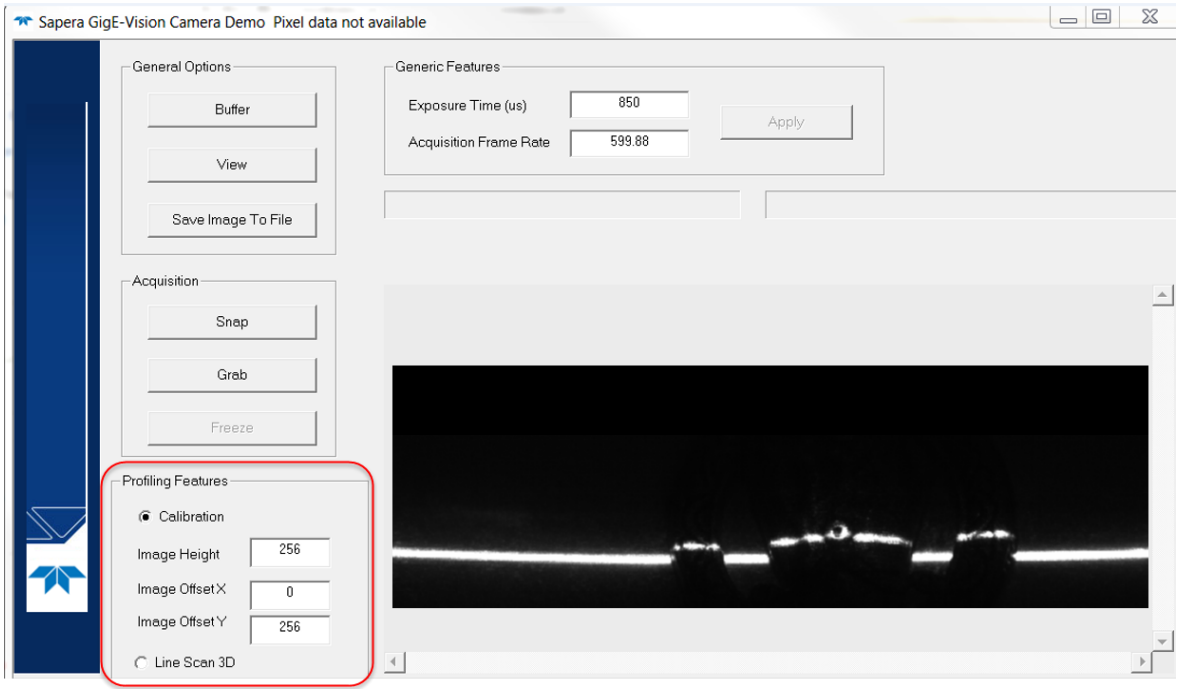
The demo is available for download at from the Teledyne DALSA ftp site:
ftp://ftp.dalsa.com/Private/p_ProductSupport/Genie/Demo/LaserLineProfilerDemo.zip

When the application is launched, the Acquisition Configuration dialog appears to select the required camera (a configuration file is optional and not required).

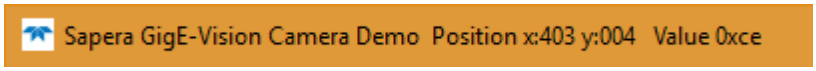


When the application is launched, the Acquisition Configuration dialog allows selection of the required camera (a configuration file is optional and not required).

The Profiling Features section allows selection of the scan type using the Calibration (area scan output) or Line Scan 3D (profile output) radio buttons.

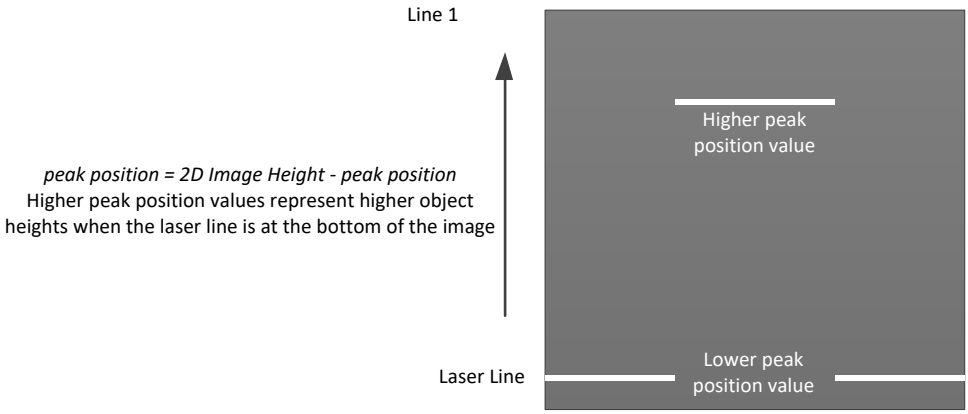


In both modes, the mouse position in the image display area updates the pixel position and Z value in the status bar at the top of the application.



For display purposes, to maintain the same orientation in 2D or 3D output when the laser is at the bottom of the image, the demo uses the following equation to calculate the peak position, such that higher values in peak positions represent greater object height (0 represents a blind spot where no peak position can be measured).

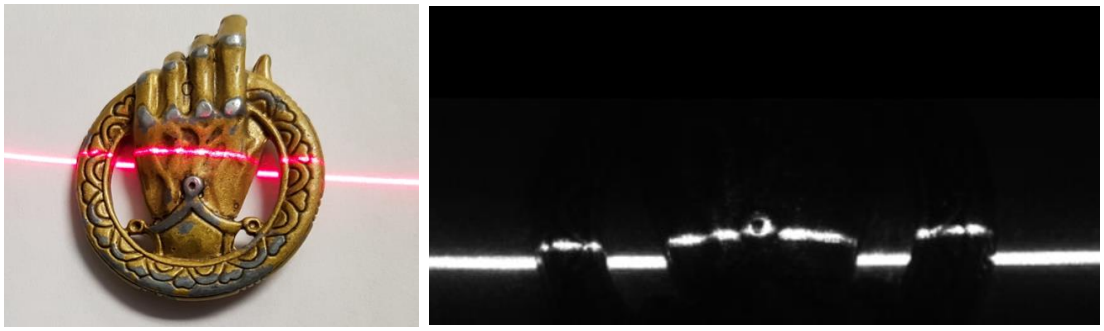
$$Peak\ Position = (2D\ Image\ Height - Peak\ Position)$$



Calibration Image Output

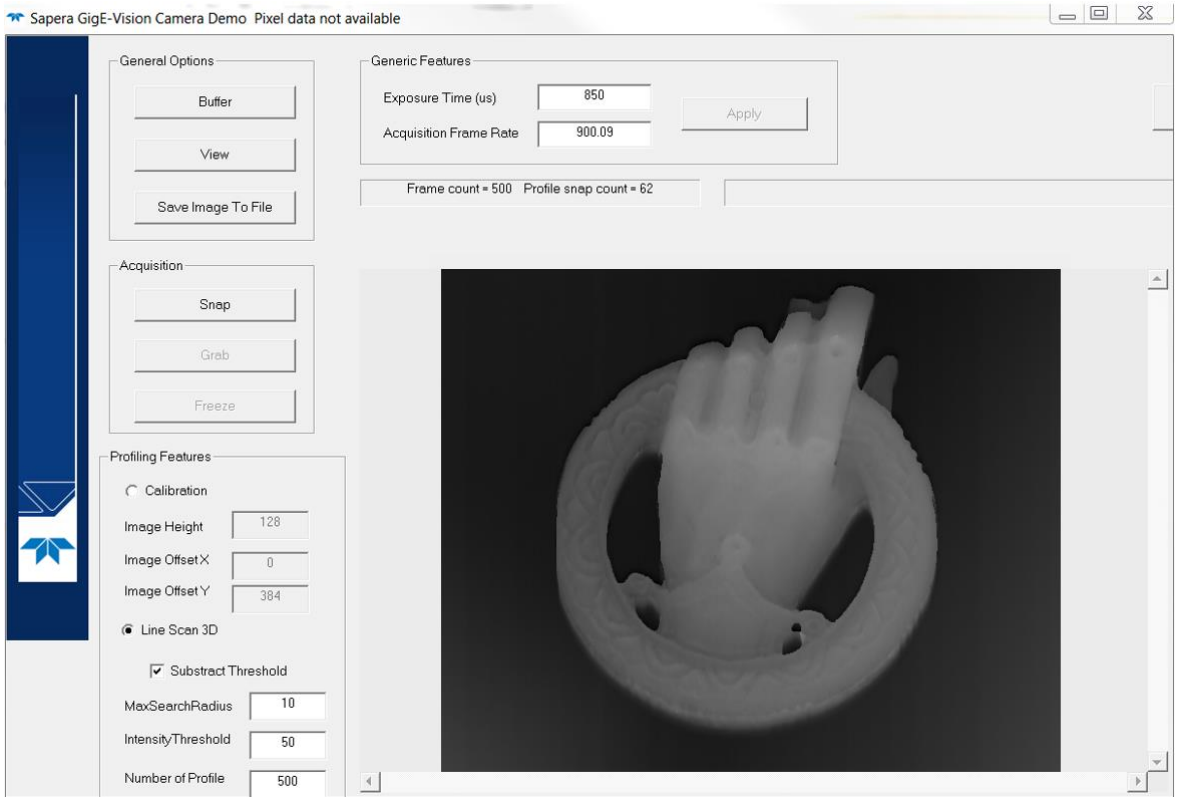
The demo Calibration mode raw image output (*DeviceScanType* feature = *Areascan*) is used to validate the hardware setup, such as adjusting the lens (for example focus, aperture), camera gain and exposure, as well as the image height and vertical offset. The image format is monochrome 8-bit.

For example, the following object (a small decorative pin) generates the line profile shown as part of the scan.



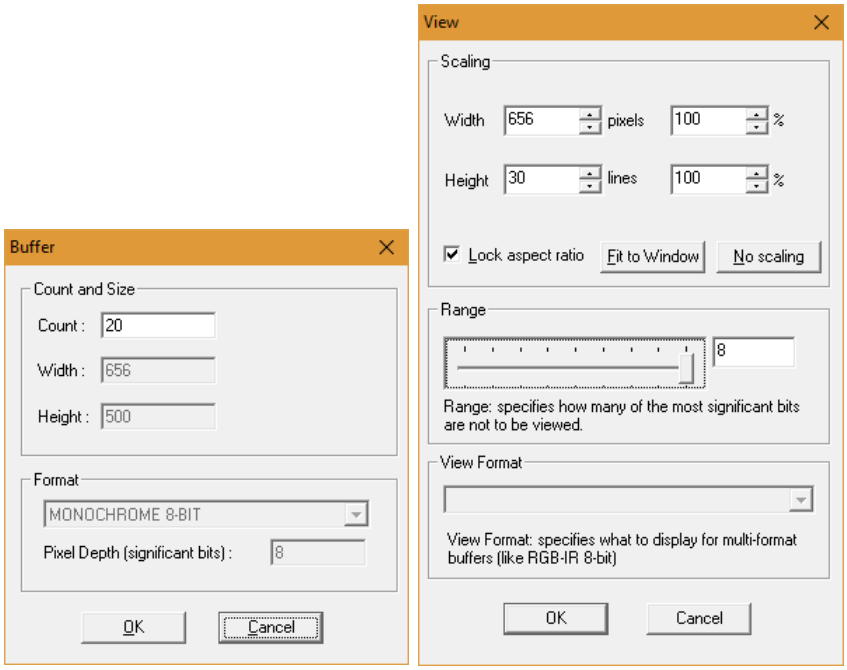
Line Scan 3D Mode

In Line Scan 3D mode, the acquisition is performed as a snap of a number of profiles; this allows the image peak position data to be extracted and displayed as a 16-bit monochrome image (peak positions used as pixel values for display can be greater than 8-bits, depending on the 2D image height). Each profile is single line in X; each successive profile is added to the image as a new row in Y (use the *Number of Profile* field to set the how many profiles to grab with each acquisition snap).



Features such as the *maxSearchRadius, intensityThreshold*, and *subractThreshold* can be set. The Frame count and Profile snap count are also displayed.

The General Options section provides access to buffer and view properties, as well as the option to save images to file.



In the View dialog, the Range setting specifies how many of the most significant bits are display (for example, when displaying line profile output as a 16 bit image).