Line Laser Profiling System

Introduction

The Line Laser Profiling System (LLPS) is a complete solution for analyzing line lasers up to 200 mm in length and up to 8mm in width. This application note will provide instruction for the setup and use of the LLPS, as well as provide descriptions of the measurements offered by the LLPS software.
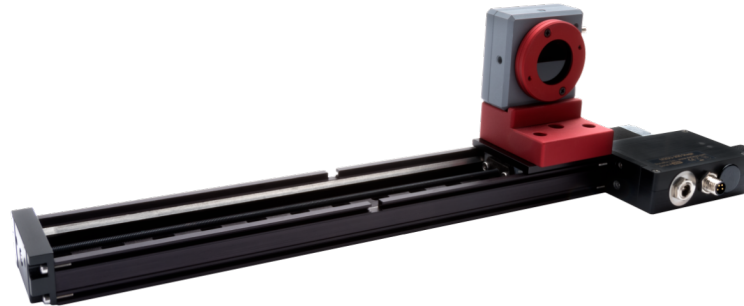

Figure 1: Line laser profiling system

Overview

DataRay's flagship WinCamD-LCM beam profiling camera is used to scan across the length of a line laser using our 50mm or 200 mm linear stage. The full-featured free software will display a full image of the line laser intensity distribution along with a vertical centroid plot, line width plot, summed intensity plot, peak intensity plot and several other useful metrics.

System Setup

Software Setup

Install as administrator the latest version of DataRay software that supports line laser measurements. The software for the WinCamD-LCM is freely available on the DataRay website.

Hardware Setup

The following parts will be included with the LLPS. Follow the assembly steps to mount the LCM camera on the M2DU stage as shown in Figure 1 for use with the line laser software.

Parts List

- (1) M2DU-50 or M2DU-200 Stage
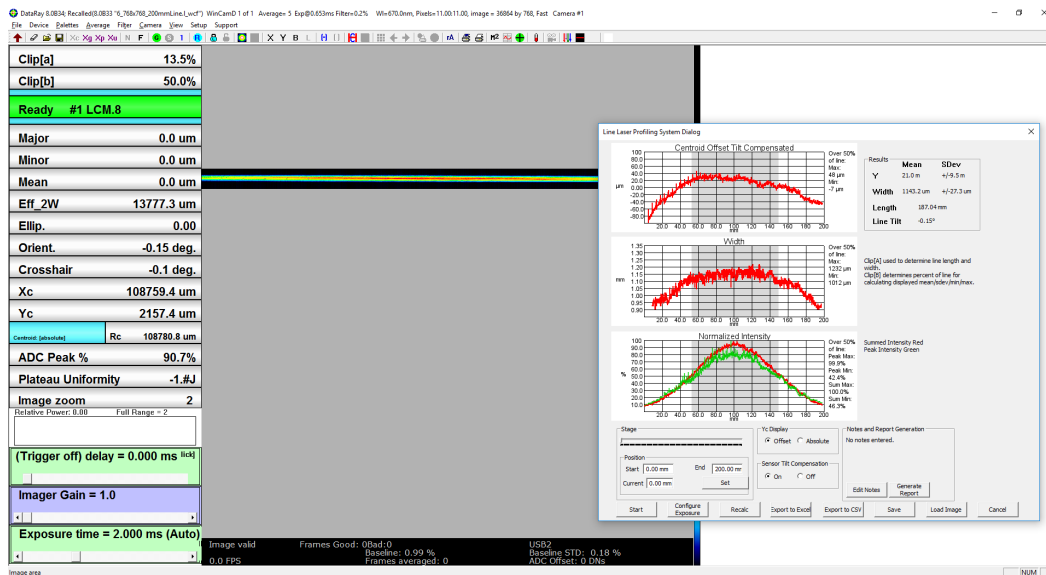   - (2) Adapter plate to attach stage to optical table

Figure 2: A 200 mm line laser displayed with a 2x zoom

- (8) M3 screws
- (8) M6X1 screws
- (1) WinCamD-LCM Camera System (Includes ND-1, ND-2, and ND-4 filters)
  - (1) #8-32 screw to attach camera to mounting block
- (1) M2DU mounting block for WinCamD
  - (2) M3X0.5 screws to attach mounting block to stage
- (1) USB 3.0 Type A to Micro-B cable
- (1) M2DU Power Supply
- (1) M2DU USB 2.0 Data Cable

Assembly

1. Attach the M2DU stage to an optical breadboard using the included adapter plates. Four M6 screws will attach each plate to the optical table, and four M3 screws will attach each plate to the stage.

2. Attach the WinCamD-LCM camera to the red M2DU mounting block using a #8-32 screw through the bottom of the mount to the bottom of the camera as shown in Figure 3.

3. Attach the mounting block with attached camera to the stage using two M3X0.5 screws down through the front of the mounting block to the front two holes of the stage parallel to the stage movement as shown in Figure 1.

4. Attach the power supply cable to the stage control box.

5. Attach the stage to the computer's USB port.

6. Attach the LCM to the computer's USB 3.0 port.

7. Ensure the camera's travel range is clear of obstacles, and ensure the USB 3.0 cable is positioned such that the camera can move freely across the entire stage.

(a)

(b)

Figure 3: (a) The WinCamD-LCM is placed on the mounting block as shown. (b) A #8-32 screw fastens the WinCamD-LCM to the mounting block.

Quick Start

DataRay's latest software (8.0C30 or later) supports the analysis of line laser width, absolute vertical centroids, the deviation of vertical centroids from a linear regression line, normalized summed intensity of columns, and normalized peak intensity of columns. The following steps will introduce how to perform a line laser measurement.

1. Follow the System Setup section above to install and attach all hardware.

2. Orient the line laser horizontally such that the camera, as it moves across the stage, can scan across the laser.

3. Start the DataRay software.

4. Open the Capture Setup Dialog box from the main menu bar (Setup→Capture Setup Dialog) and choose an appropriate capture block such that the laser will be within the capture block along the entire movement of the stage. You may move the stage using the physical knob on the stage. Then press OK in the Capture Setup Dialog to save the capture block.

    (a) A smaller-width capture block may produce better results, but the scan will take longer. In some cases a smaller-width capture block is necessary because the ND-filter on the camera will block light from the laser at either end of the stage. A custom capture block with a small width, but large height is recommended.

5. Open the line laser dialog by pressing the line laser icon ▬ located in the toolbar.

6. Press Configure Exposure in the Line Laser Dialog. The camera will move across the stage and find the appropriate exposure time for a full scan. Wait for this to complete.

7. Press Start to begin a full line laser scan. The camera will automatically move across the stage and stitch images together to create a full line laser profile. The exposure time remains constant throughout the scan.

8. Review the results and optionally:

    - Save the data
    - Change between absolute Y-centroid measurements or offset from linear
    - Enable or Disable Residual Sensor Tilt Compensation
    - Add notes (up to 512 characters)
    - Export as Excel or CSV
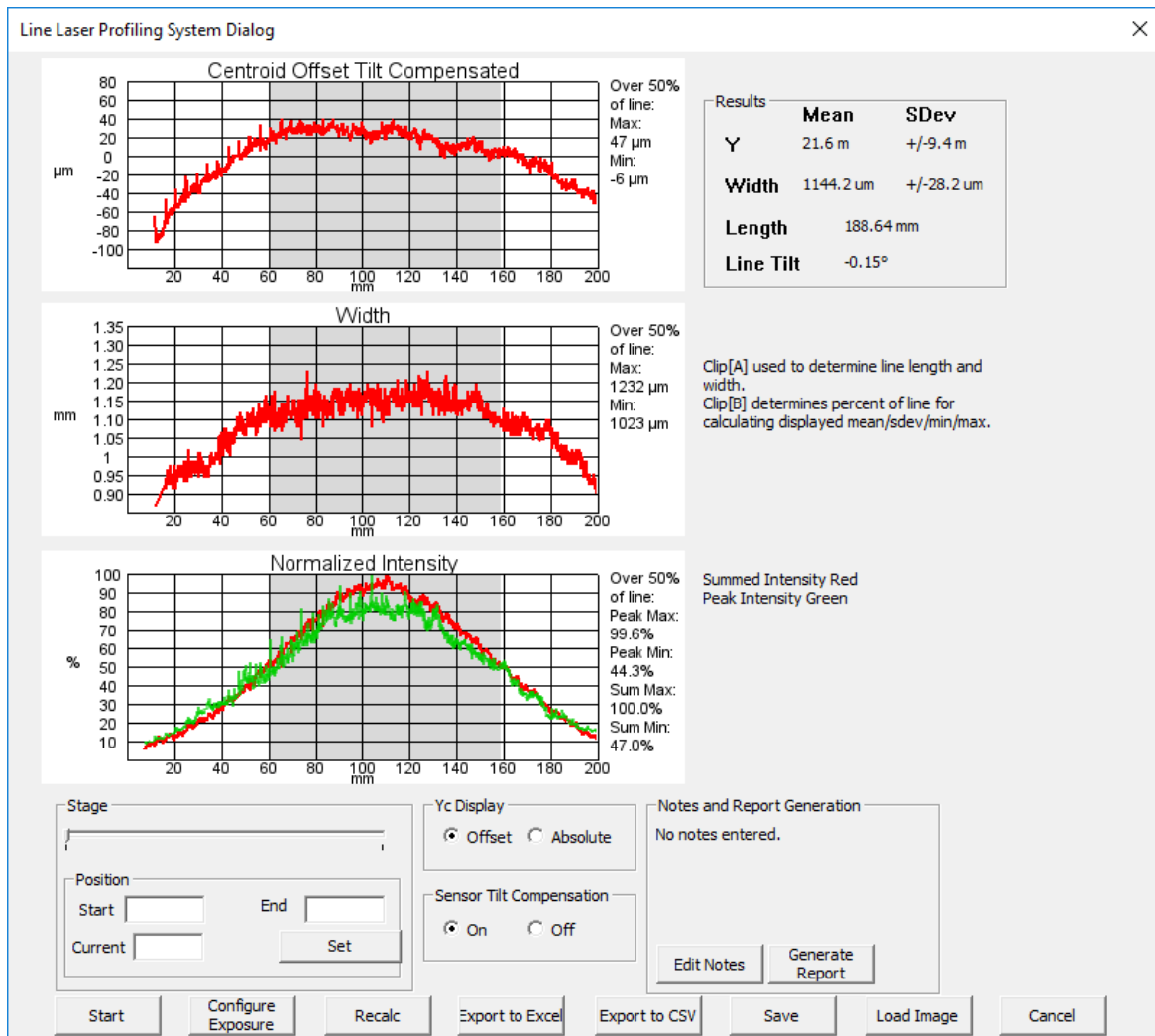   - Generate PDF Report

Line Laser Dialog

Figure 4: The line laser dialog provides the controls and results for the analysis

Controls

- **Start & Stop** will start and stop line laser imaging

- **Configure Exposure** will find the appropriate uniform exposure time by scanning across the length of travel

- **Recalc** will recalculate results, this can be useful so that a new scan is not necessary after changing a parameter such as clip level

- **Export to Excel** will export the absolute and offset Y_c values with and without Residual Sensor Tilt Compensation, the widths, the normalized summed intensity data and the normalized peak intensity data to an Excel document

- **Export to CSV** will export the absolute and offset Y_c values with and without Residual Sensor Tilt Compensation, the widths, the normalized summed intensity data and the normalized peak intensity data to a CSV text file

- **Generate Report** will generate a PDF report with a summary of the measured data.

- **Save** will save the current data into a .l _wcf file

- **Load Image** will load the data from a .l _wcf file.

- **Set** will set the current, start and end points for the stage depending on the manually entered values in the **Start**, **End** and **Current** entry boxes. After clicking **Set**, the stage will move immediately to the value entered in the **Current** entry box. You may also control the stage position with the slide control. The value in the **Current** indicator box, will update to display the current position of the stage with respect to its home position after each movement.

- Y_c **display mode**

  1. **Offset** displays the difference between centroids and a linear regression of the centroids $y = mx + b$

  $$m = \frac{n * \sum_{c=1}^{n}(x * y) - (\sum_{c=1}^{n} x * \sum_{c=1}^{n} y)}{n * \sum_{c=1}^{n}(x^2) - (\sum_{c=1}^{n} x)^2} \tag{1}$$

  $$b = \frac{\sum_{c=1}^{n} y - m * \sum_{c=1}^{n} x}{n} \tag{2}$$

  2. **Absolute** displays the absolute centroids

- **Residual Sensor Tilt Compensation** is enabled by default, but may be disabled if desired. See the Additional Notes section for more information.

- **Clip[a]** is used as a clip level to determine the line length and width.

- **Clip[b]** defines the percent of the line over which the mean/sdev/min/max is calculated.

Results

- **Y centroid plot**: Finds the Y-position centroid for each column and plots against X-position. May be displayed as Absolute data or as an offset from linear fit.

- **Width plot**: Plots the width of the line laser along the axis of movement, measured in the vertical direction according to the chosen Clip[a] width calculation method in the Clip Level Entry dialog (accessed by clicking on the Clip[a] box). 13.5% clip level is default.

- **Normalized intensity plot**: Plots the normalized sum and peak of the pixel intensities in each column against X-position.

- Plot Features

  - **Zoom:** The plots dynamically zoom using the mouse wheel or trackpad.
  - **Measure:** X and Y distance can be measured directly on a plot by left-clicking in two locations.
  - **Export:** Right-click on a plot for options to export to paint or as a bitmap.
  - Statistics are calculated within the shaded region which is defined by Clip[b] as a percent of the total line length. Max/min are displayed on the plots. Mean and standard deviation are displayed in the Results box.

- Results box

  - **Y**: Mean and standard deviation of Y centroids (Mean is 0 when Yc display is set to Offset)
  - **Width**: Mean and standard deviation of the width measurements taken for each column. (The "width" of the line laser is measured vertically for a horizontal line)
  - **Length**: Length of the line; see Additional Notes for an explanation of how this is calculated
  - **Line tilt**: Angle of a linear fit. Measured in degrees from the axis of movement, in the plane of measurement.

Additional Notes

Residual Sensor Tilt Compensation

- This is to correct the "zigzag" effect caused by the possibility of slight roll of the sensor along the optical axis (even a few mrad of rotation can cause the effect). Due to manufacturing limitations, it is not always possible to completely avoid this effect. An exaggerated diagram demonstrating the effect as the sensor moves across the stage is shown in Figure 5.
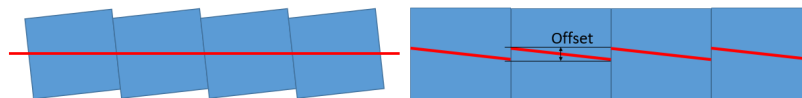

Figure 5: The left shows four captures from the camera, the right shows the image of these four captures that the computer will display. Slight rotation of the sensor will result is a "zigzag" effect since the computer assumes the sensor is perfectly aligned.

- The software can correct this effect by calculating the average slope for each frame of the offset from linear data, and reprocessing the data to correct for this slope.

- Note that many sensors will not have a significant "zigzag" problem, especially with smaller-width capture blocks. So the correction factor should have little effect in most cases, and can be disabled if desired.

Line Length Calculation

- The length of the line laser depends on the Clip[a] clip level (accessed by clicking on the Clip[a] box) and the highest intensity pixel value. The edges of the line laser will be located at the vertical column of pixels on either end of the line just before the column that does not contain a pixel with a value above the Clip[a] clip level percent of the peak pixel value across the entire scan.

Centroid Calculation

- The vertical centroid of each column of pixels is determined according to the chosen Clip[a] width calculation method in the Clip Level Entry dialog (accessed by clicking on the Clip[a] box). 13.5% clip level is default.

- Each column's centroid provides a Y-position which is plotted in the Y centroid plot against its X-position on the line.

- If **Offset** is chosen in the Yc Display box, then the offset of Y-centroid values to a linear fit will be plotted.

- If **Absolute** is chosen in the Yc Display box, then the absolute Y-centroids will be plotted so any line tilt will then be apparent on the plot.

Stage Position

The position of the stage read out by the software is relative to the stage's home position at the far side of the rail. At the home position the reading will be 0.00 mm. The position of the capture area with regard to a physical reference point on the stage will depend on the capture block location.

Beam Position

Users who place beams at the top/bottom edges of the sensor, especially the four corners, will negatively impact their results. The four, nominally 'dark', corners of the image are used to calculate the baseline whose value is displayed below the 2D image. In most cases, a baseline below 4% and a baseline standard deviation below 0.40% are ideal.

Please send any questions, requests, or comments to support@dataray.com