ASML
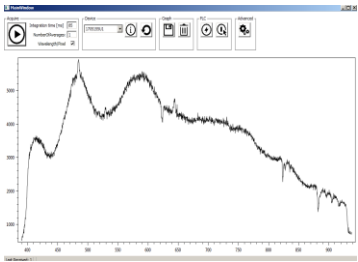
KTD CLM Spectrometer Tasks
#604 IlluminationSpectrometerDCOffsetCalibration
#623 IlluminationSpectrometerDCOffsetPerformance

Tina

wk1840
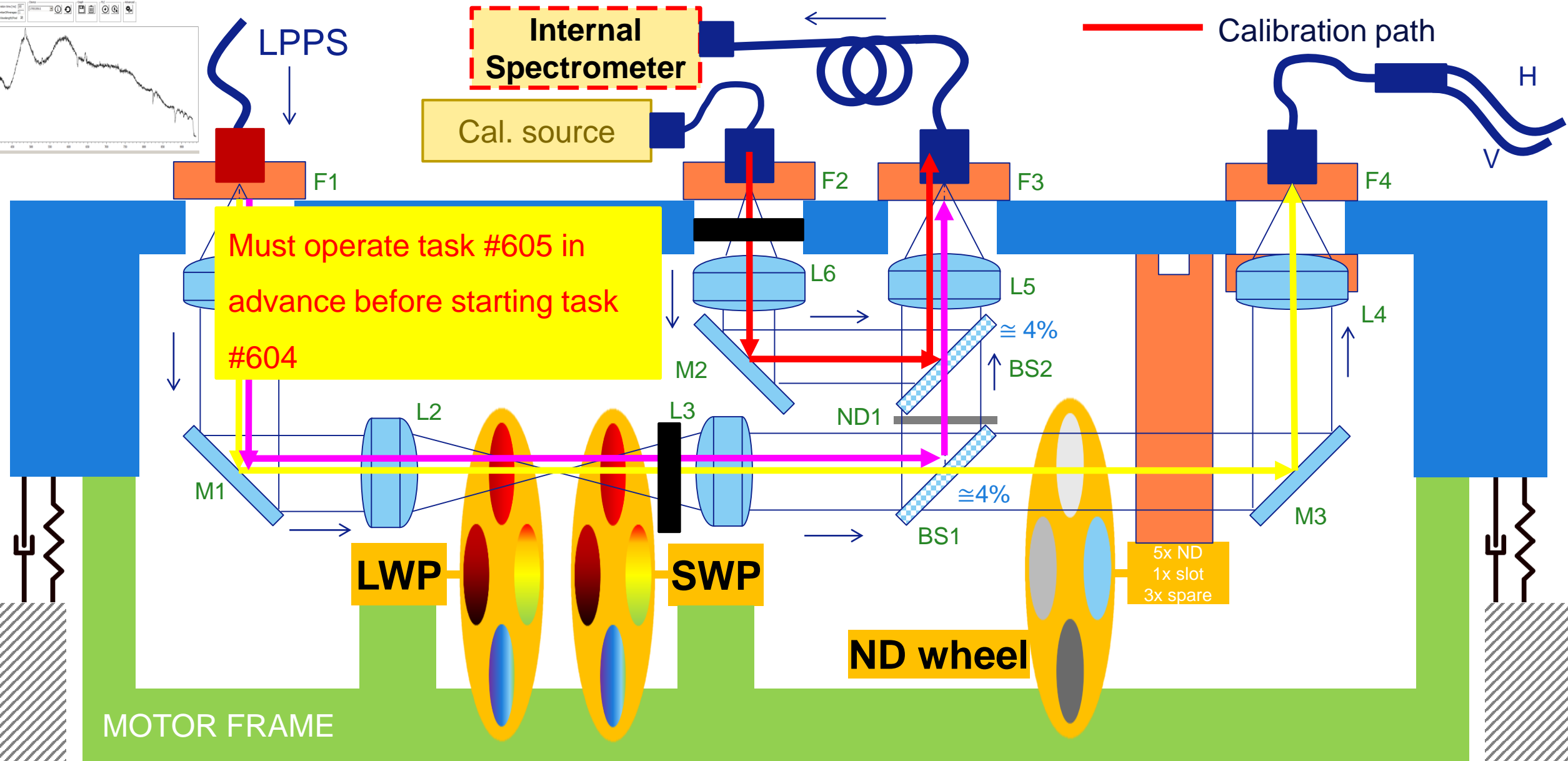
The DC offset origin

The dark current offset has DC and AC components:

DC
1. Electronic offset such as programmed DC offset
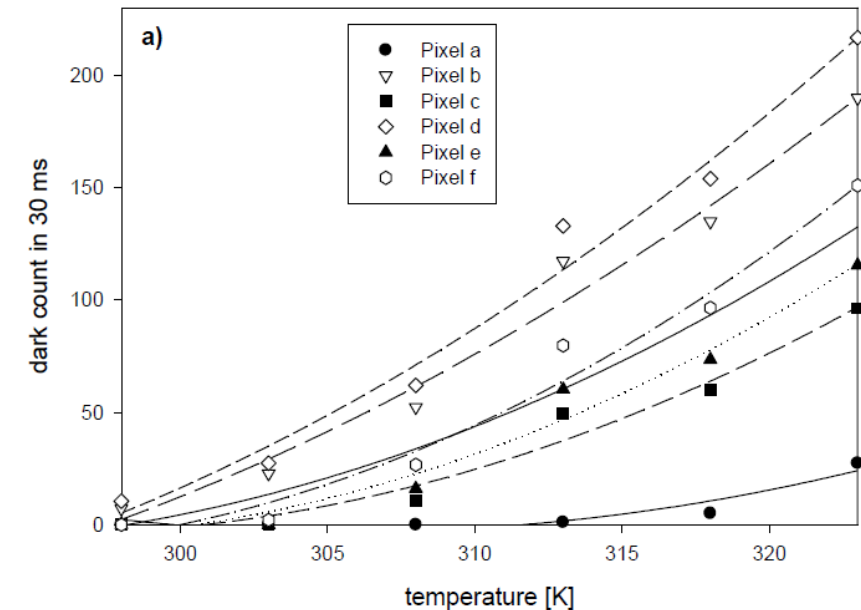2. Integrated dark photodiode current.

AC
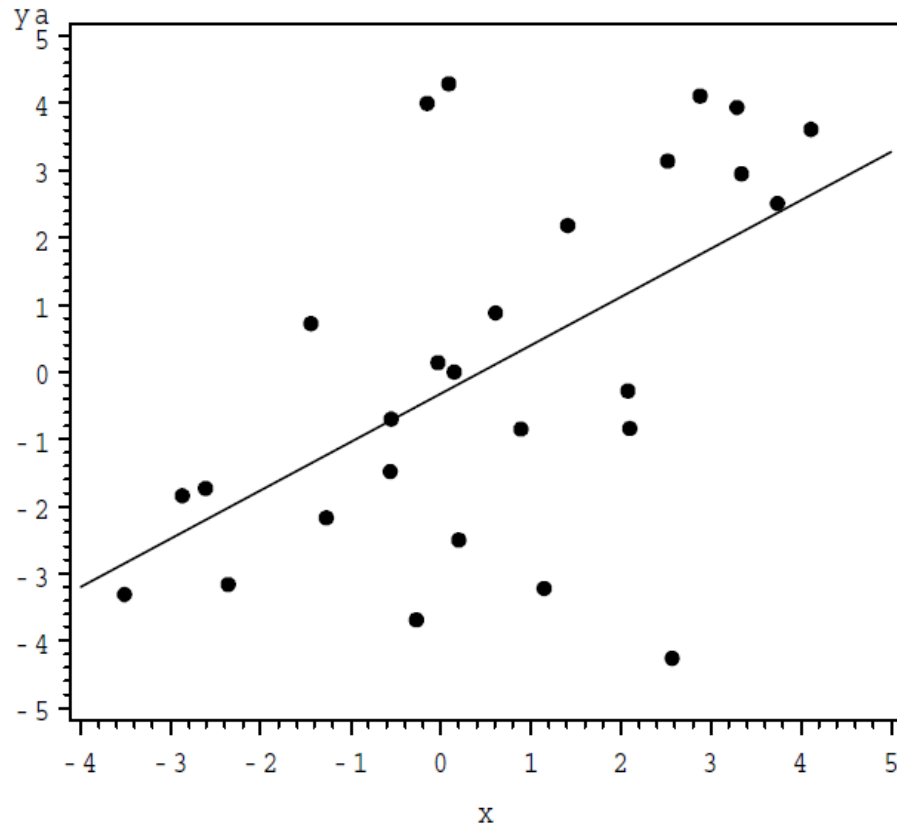1. Dark current shot noise
2. Read-noise

⬇

Position   **Integration time**   **Temperature**

Dark current would increase as the temperature increases

Linear regression

The fitted equation

$$\hat{y}_i = b_0 + b_1 \text{x}$$

Minimize the error sum of squares (SSE)

$$SSE = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2 = \sum_{i=1}^{n}(y_i - (b_0 + b_1\text{x}))^2$$

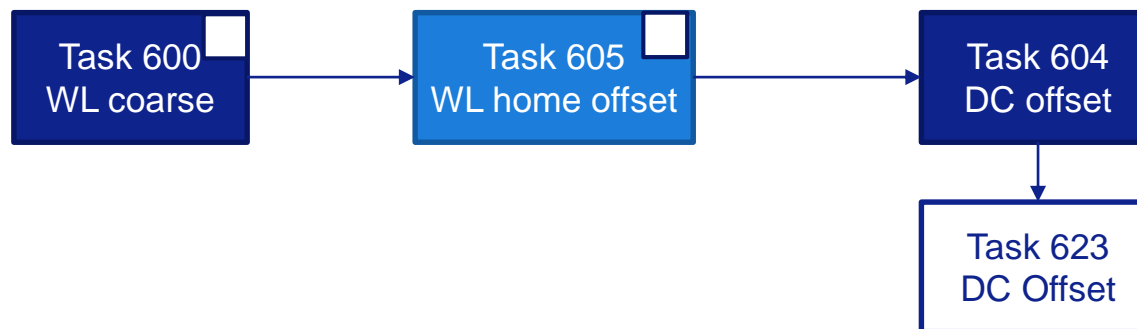Through some calculation, obtain the coefficients b0, b1,

$$b_1 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x}_i)^2}$$

$$b_0 = \bar{y} - b_1\bar{x}$$

Spectrometer DC Offset Calibration In Task #604

- Dark current offset is an offset of the spectrum in dark conditions.

```
Task 600          Task 605              Task 604
WL coarse    →    WL home offset   →    DC offset
                                              ↓
                                        Task 623
                                        DC Offset
```

Sensing	Time [s] to wait to ensure ShutterS-Ctrl command has been executed	0.015
Focus	Time [s] to wait to ensure WaveLength-Ctrl command has been executed	0.01
Simulation	**Spectrometer**	
SoftwareLayout	Additional delay between spectrometer acquirememts [s]	0
UserInterface	Default Integration Time For Spectrometer	0.0025
WaferHandler	Queued spectrometer acuisition mode enabled	False
	Spectrometer corrections	**SpectrometerCorrections**
	Apply spectrometer Central Wavelength Bandwidth correction	**True**
	Apply spectrometer DC-offset correction	**True**
	Apply spectrometer Irradiance correction	**False**
	Apply spectrometer Non-linearity correction	**False**
	Spectrometer DC Offset	**Spectrometer DC Offset**
	Elbow integration time [ms]	**0.25**
	Spectrometer DC Offset file name	**SpectrometerDCOffset_DCOffset_20180327_044111.csv**
	Spectrometer Irradiance calibrated values	**Spectrometer Irradiance**
	Spectrometer mapping of Pixel to corresponding Wavelength	
	Spectrometer Non-Linearity calibrated values	**0 | 0 |**
	Spectrometer wavelength range	**925 | 350**
	Spot Homogeneity Images	
	Spot Homogeneity Detection calibration images	(Collection)
	Spot Homogeneity Illumination calibration images	(Collection)
	Spot Size Selector	
	Spot size selector encoder positions	EncoderPositionPSpotEntry[] Array
	Switch Mirror Selector	

For a specific pixel
100 acquisitions for each integration time

Blue→uncorrected
Red→corrected

τ_{min} τ_{elbow} τ_{max}
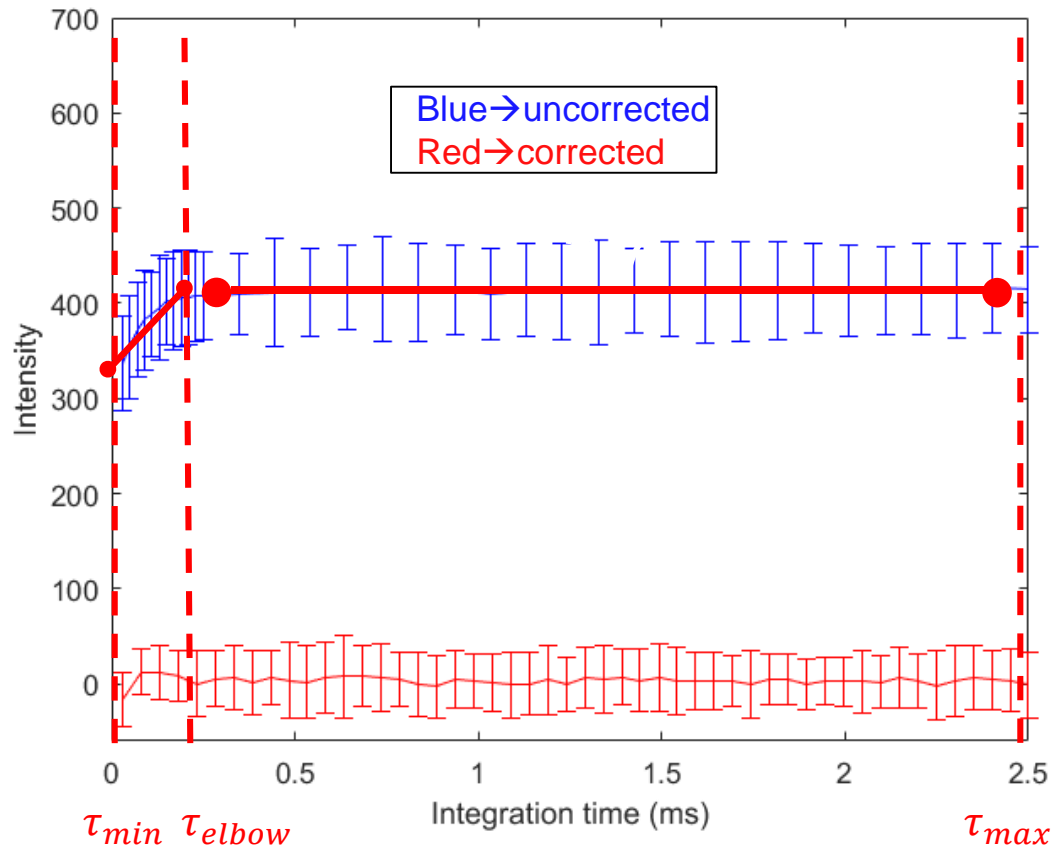
1. Apply linear regression to obtain the coefficients, C and S, of the fitting line.

$$I = C + S\,\tau$$

2. Calculate the slope scaling factor(using the last 12 dark pixels)

$$f = \frac{\sum_{i=N-11}^{N} I_i - C_i}{\sum_{i=N-11}^{N} S_i \cdot t},$$

3. Subtract the fitted spectra from the measured spectra to get the corrected spectra I'

$$I' = I - C - f\,S\,t.$$

How to perform task #604

ASML

1. Equipment constant → Sensing → Spectrometer

Measuring	Time [s] to wait to ensure WaveLength-Ctrl command has been executed — 0.01
NumberCruncher	**Spectrometer**
Positioning	Additional delay between spectrometer acquirememts [s] — 0
Sensing	Default Integration Time For Spectrometer — 0.0025
Focus	Queued spectrometer acuisition mode enabled — False
Simulation	Spectrometer corrections — **SpectrometerCorrections**
SoftwareLayout	Apply spectrometer Central Wavelength Bandwidth correction — **True**
UserInterface	Apply spectrometer DC-offset correction — **False** → Make True
WaferHandler	Apply spectrometer Irradiance correction — **False**
	Apply spectrometer Non-linearity correction — **False**
	Spectrometer DC Offset — **Spectrometer DC Offset**
	Elbow integration time [ms] — **0.25**
	Spectrometer DC Offset file name — **SpectrometerDCOffset_DCOffset_20180327_062207.csv**
	Spectrometer Irradiance calibrated values — **Spectrometer Irradiance**

2. Select task #604, check the default input setting and commit ECs if there is no problem

Default input setting	
Minimal integration time[ms]	0.03
Elbow integration time [ms]	0.25
Maximal integration time [ms]	2.5
Number of points [min, elbow]	12
Number of point(elbow, max)	23
Duration for calibration [s]	120

How to verify task #604

1. Select task #623, check input setting, run the task.
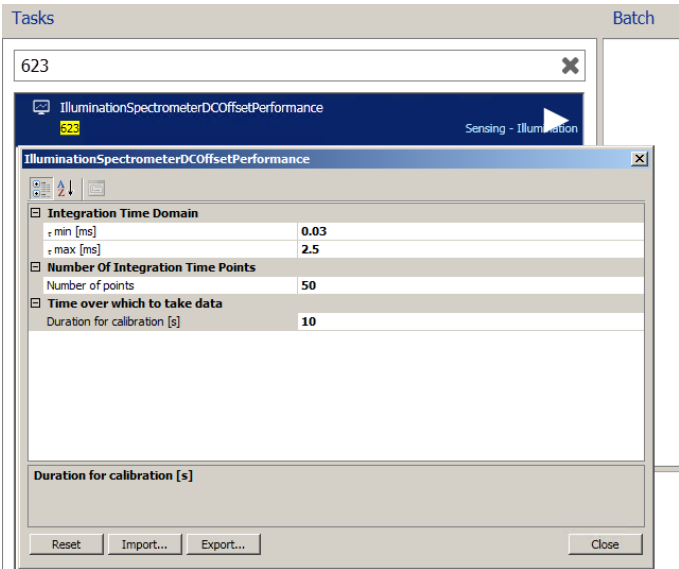
Input setting of task #623	
Minimal integration time[ms]	0.03
Maximal integration time [ms]	2.5
Number of points	50
Duration for calibration [s]	10

2. Check the following specification:
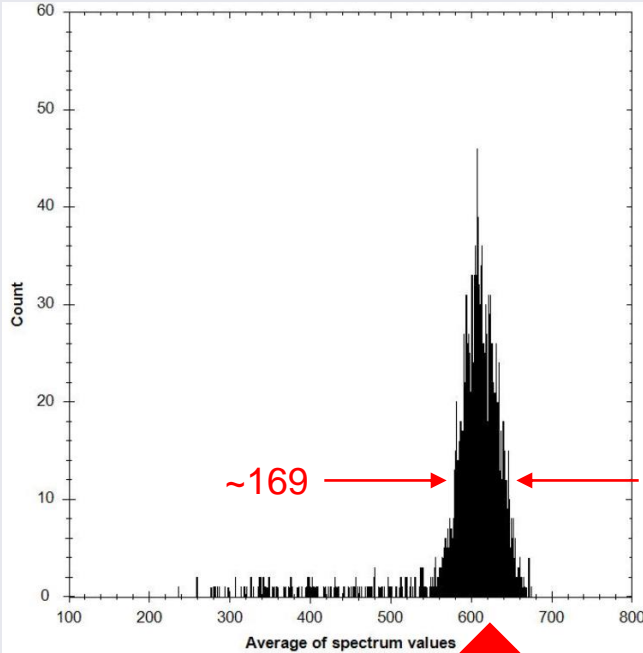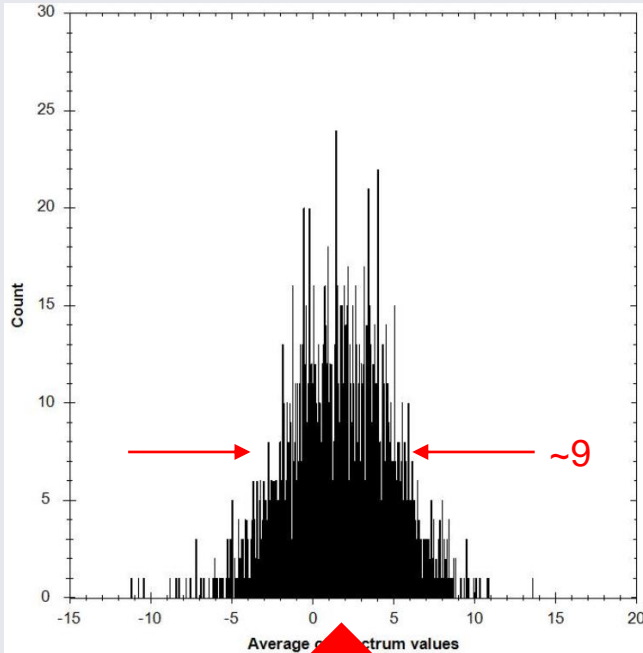
Uniformity of pixels across each acquisition at given integration time

Maximal Offset Level Noise (3Σ) [DN16] 20.652 **< 50.**
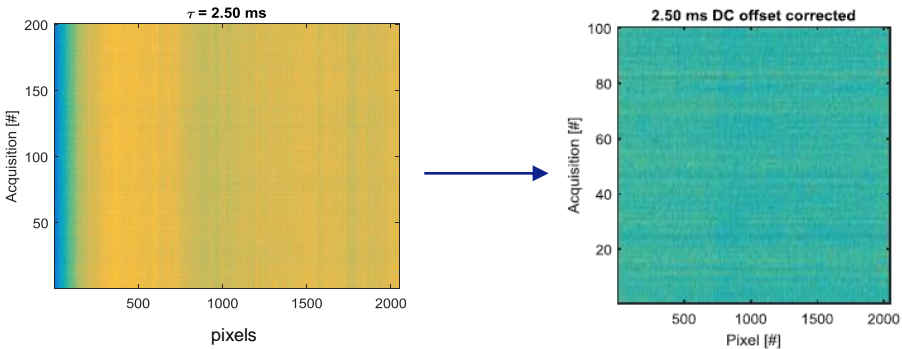
Spectrometer DC Offset Calibration Validation

2.5 ms int. time	Before cal.	After cal.
Reports	<table><tr><td></td><td>Maximal integration time</td></tr><tr><td rowspan="3">Average DCOffset [DN16]</td></tr></table> Average DCOffset [DN16] — Min: 236.019, Mean: 597.893, Max: 678.794; Spatial Noise [DN16]: 169.838	Average DCOffset [DN16] — Min: -11.227, Mean: 1.603, Max: 13.624; Spatial Noise [DN16]: 9.598

Before cal.

		Maximal integration time
Average DCOffset [DN16]	Min	236.019
	Mean	597.893
	Max	678.794
Spatial Noise [DN16]		169.838

After cal.

		Maximal integration time
Average DCOffset [DN16]	Min	-11.227
	Mean	1.603
	Max	13.624
Spatial Noise [DN16]		9.598

Average Spectrum Histogram

OCAP

SPEC: Maximal offset level noise (3∑) < 50

No OCAP for current version

Potential Problems	Possible Causes	Solutions
• Pixel noise too high • Frame-to-frame noise too high	1. Increased temperature 2. Presence of stray light 3. Spectrometer HW issue	1. Check CL module spectrometer temperature, ensure temp as close to 35˚C. 2. Ensure spectrometer shielded properly from stray light during calibration. 3. Check noise histogram to see if an increase in hot-pixels due to aging might have occurred. In such a case, the spectrometer might be defective.