KTD CLM Spectrometer Task

#619 IlluminationSpectrometerWavelengthFineCalibration

#626 IlluminationSpectrometerWavelengthFinePerformance/

YANN

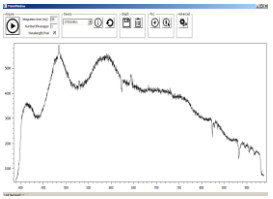
WK1840

Why Task 619/626

- Task 619 is in principle the same as task 600 (EPROM ECs).
- However, ASML repeats the calibration for the following reasons:
  - Task 600 provides a calibrated ECs at room temperature.
  - ASML applications require a higher accuracy than the supplier provides.
  - Task 600 Uses the supplier calibration as a coarse calibration, task 619 Uses the calibration lamp installed in the CL module to perform a fine calibration.

YS(1)375 Source Architecture

Task**#619#626**: pixel to wavelength calibration/performance



Task #619 Pixel to Wavelength Fine Calibration

CL Module Tasks Dependencies Wrt 619 Flow

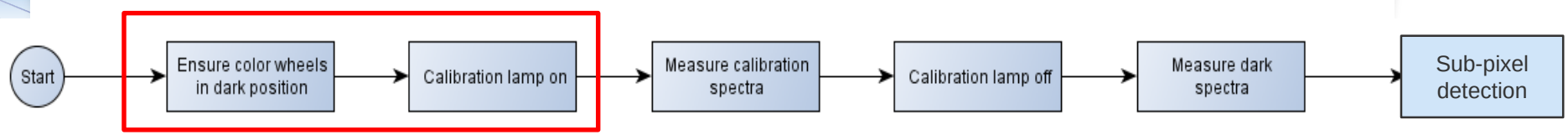


Fig. Task 619 measurement flow

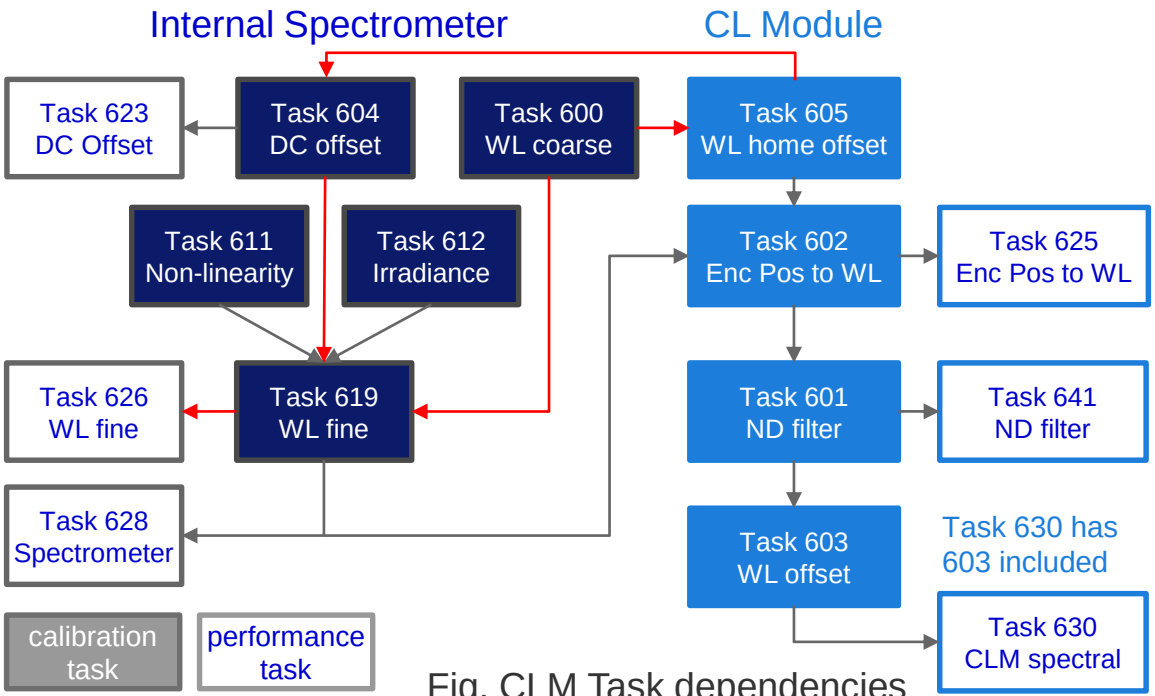


Fig. CLM Task dependencies

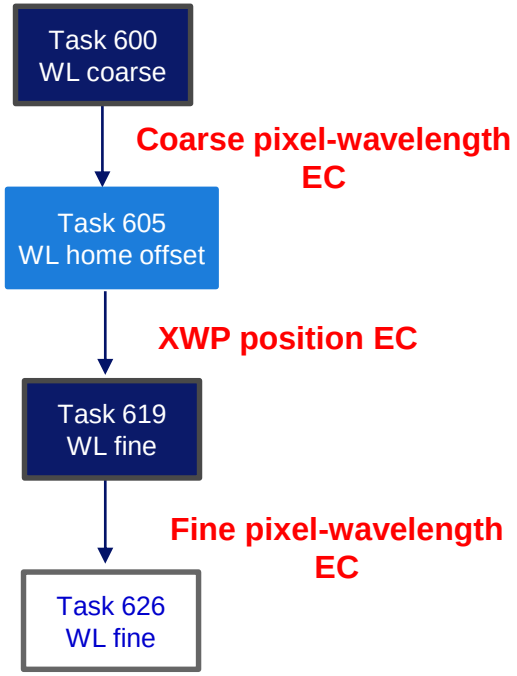


Fig. Task dependencies

CLM Calibration Light Source

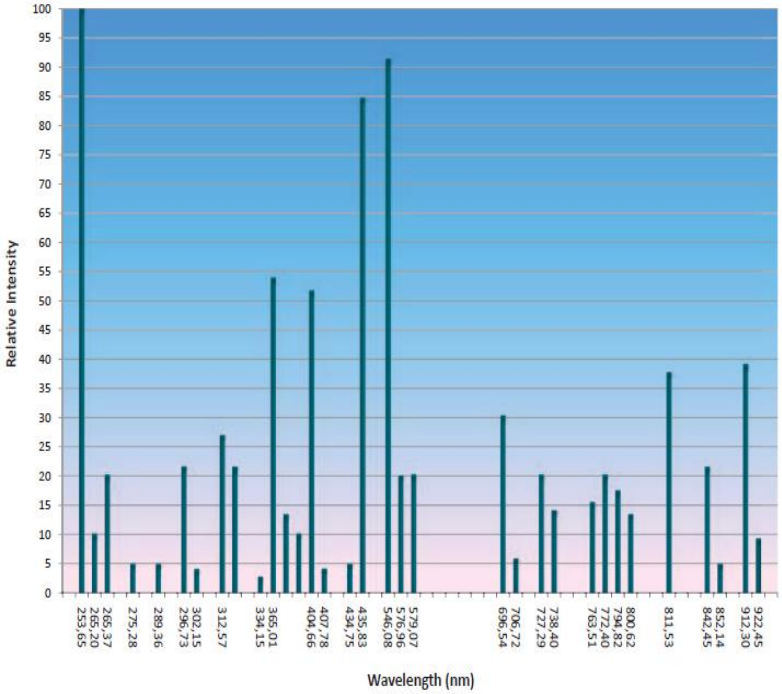


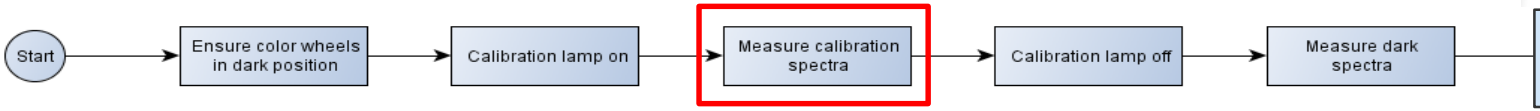
Fig. Spectrum of the AvaLight CAL calibration lamp

Wavelength	Regime	Atom
253.652	0	Hg
296.728	0	Hg
302.150	0	Hg
313.155	0	Hg
334.148	0	Hg
365.015	0	Hg
404.656	2	Hg
407.783	0	Hg
435.833	3	Hg
546.074	3	Hg
576.960	2	Hg
579.066	2	Hg
696.543	2	Ar
706.722	1	Ar
714.704	0	Ar
727.294	1	Ar
738.398	1	Ar
750.387	0	Ar
763.511	3	Ar
772.376	0	Ar
794.818	1	Ar
800.616	0	Ar
811.531	0	Ar
826.452	2	Ar
842.465	0	Ar
852.144	1	Ar
866.794	0	Ar
912.297	2	Ar
922.450	1	Ar

Totally 15 peaks will be used!

- Emits the spectral lines of Hg and Ar.
- Three intensity regimes defined
  - 0. Will not be used
  - 1. Low intensity
  - 2. Medium intensity
  - 3. High intensity
- Life time: 7 years.

Spectra Band Build-up for Regime 1



IT: 150ms

Magnify the intensity by increasing IT

IT: 3000ms

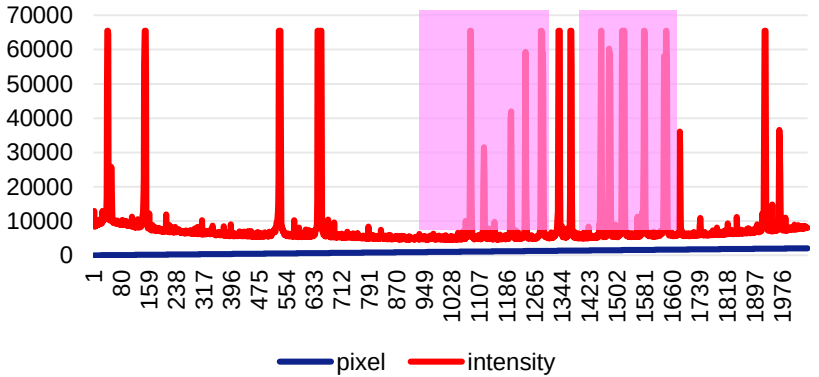


Fig. Calibration light source measured from M6445

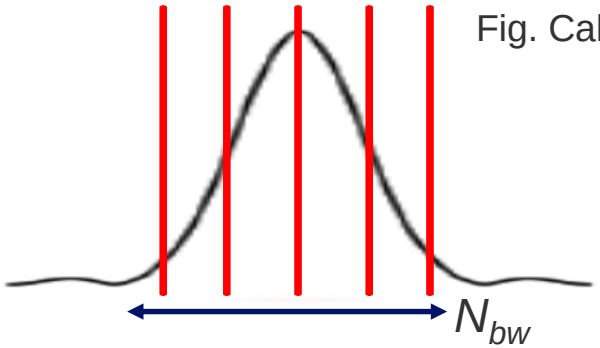
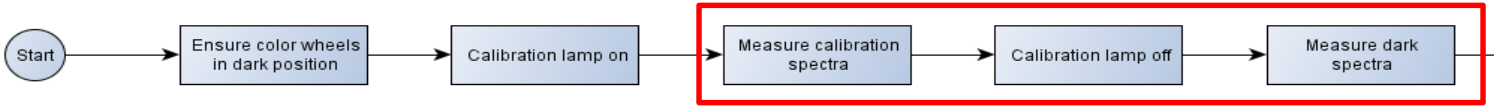


Fig. Pixel range expend

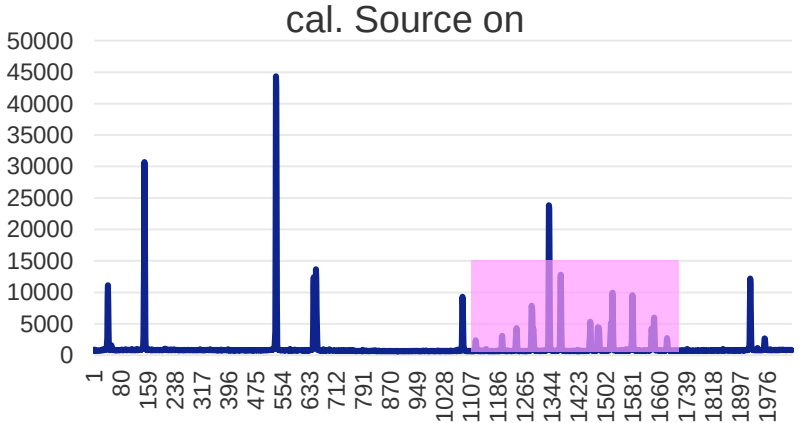
- Inverse lookup on the coarse pixel-wavelength EC, find the coarse central pixel.
- Expend the range by N_{bw} pixels centered around.

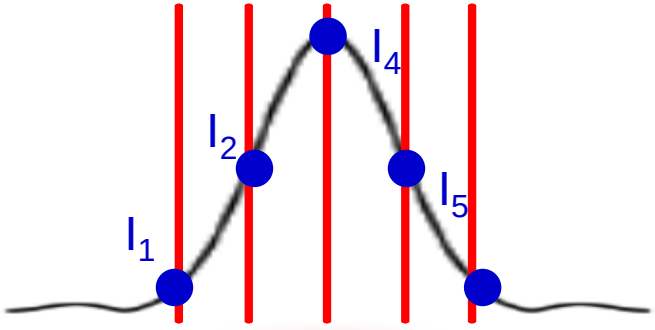
Integration Time Calibration



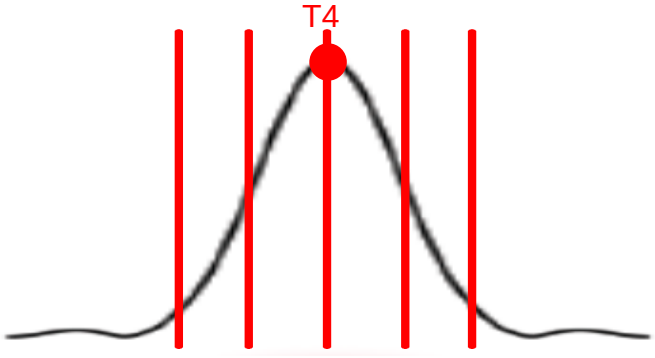
Integration time calibration:

- Take spectrums from T_{min} to T_{max} to aim for target intensity.
- Stare the optimized integration time for 1 regime.
- Repeat for regime 2 and regime 3.



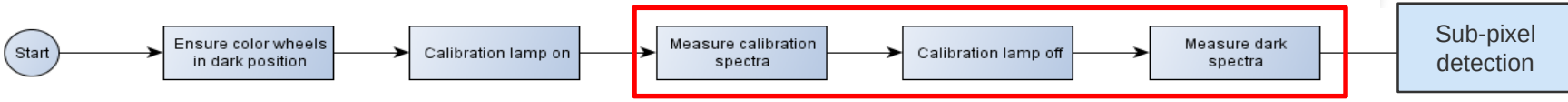


Get intensities within same regime



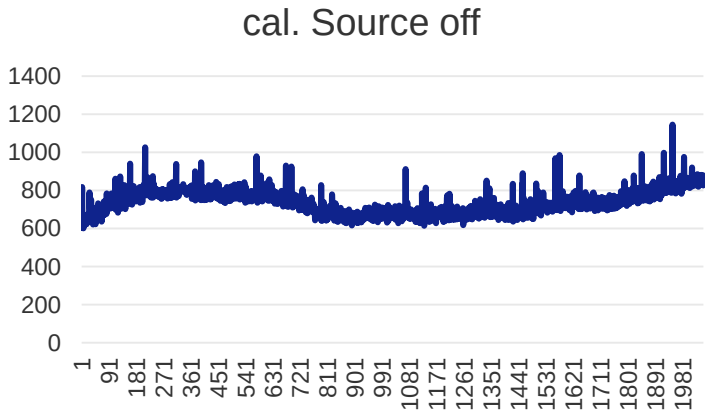
Find 1 optimized integration time

Spectrum Acquisition

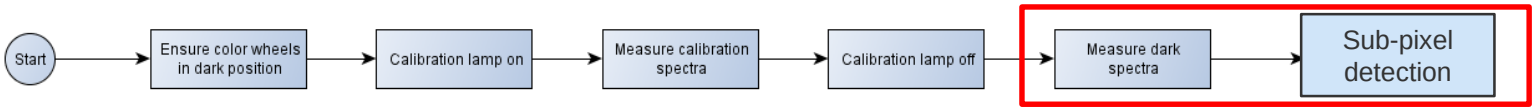


Spectrum acquisition:

- Acquire raw spectrums at each of the three integration times.
- Calibration source off and Repeat above acquisitions.



Average, Dark-off, Non-linearity, Irradiance



1. Average the dark spectrums.
2. Subtract above dark spectrum from each light spectrum.
3. Perform non-linearity correction for each spectrum
4. Perform irradiance correction for each spectrum.
5. Take average of the resulting spectrum.

Then, we have one spectrum per integration time !

Fine Wavelength Calibration - Sub-Pixel Detection

$$X_j = m - \frac{1}{2}\left(\frac{\ln(I_{j,m+1}) - \ln(I_{j,m-1})}{\ln(I_{j,m-1}) + \ln(I_{j,m+1}) - 2\ln(I_{j,m})}\right),$$

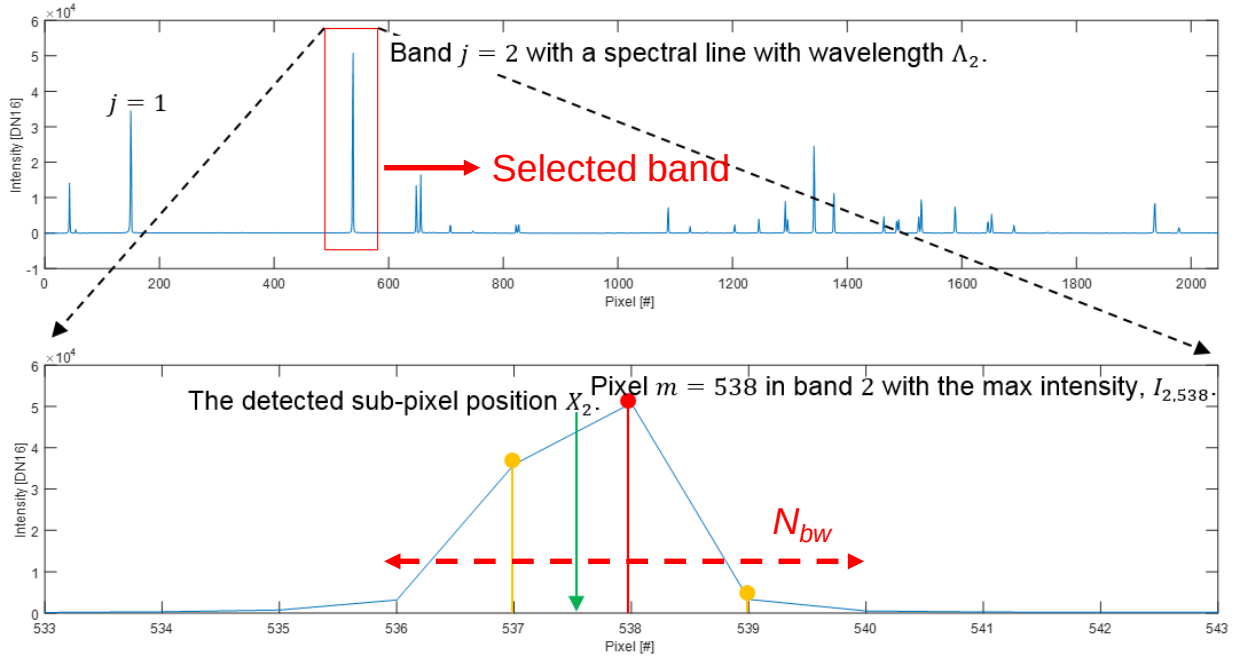


Fig. Sub-pixel detection algorithm

- Three-point Gaussian approximation to find the real center.
- The detected sub-pixel center, X_j, should correspond to certain wavelength.
- These pixels will be recorded.

Fine Wavelength Calibration – Full Wavelength Table

$$\lambda_i = \sum_{k=0}^{4} C_k i^k = C_0 + C_1 i + C_2 i^2 + C_3 i^3 + C_4 i^4,$$

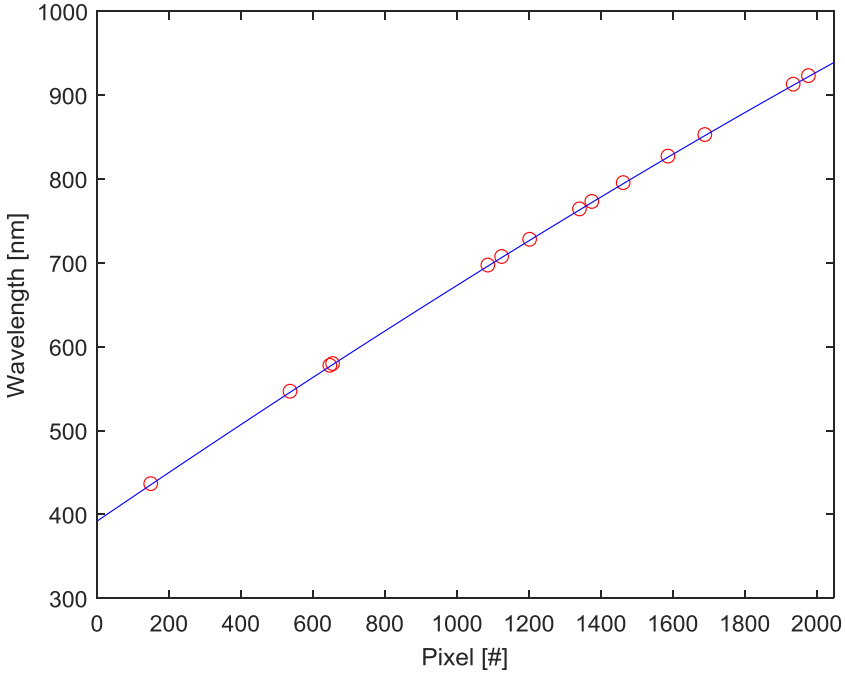


Fig. 4th order polynomial fit

- After running sub-pixel peak detection algorithm, we have 15 points (red circle) in terms of wavelength vs. pixel.
- 4th order polynomial fit, this yields:
  - Full wavelength vs pixel table.
  - Coefficients C_k with k = 0 ~ 4.

This yields an array of 2048 rows contains calibrated wavelengths!

How To Perform Task #619

1. Equipment constant → Sensing → Spectrometer

Spectrometer	
Additional delay between spectrometer acquirements [s]	0
Default Integration Time For Spectrometer	0.0025
Queued spectrometer acuisition mode enabled	False
Spectrometer Calibration Lamp burn time [min]	0.00
Spectrometer Calibration Lamp warm up time [s]	600
Spectrometer coarse mapping of Pixel to corresponding Wavelength	
Spectrometer Pixel to wavelength data file name	**SpectrometerPixelToWavelength_ClModule_20180424_110745.csv**
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
Apply spectrometer Pixel To WaveLength correction type	Coarse
Spectrometer fine mapping of Pixel to corresponding Wavelength	
Spectrometer Pixel to wavelength data file name	
Spectrometer Irradiance calibrated values	**Spectrometer Irradiance**
Spectrometer Irradiance Calibrated Integration Time	**0**
Spectrometer Irradiance data file name	
Spectrometer Non-Linearity calibrated values	**0 | 0 |**
Spectrometer Non-linearity correction coefficients	
Spectrometer Non-linearity high boundary	**0**
Spectrometer Non-linearity low boundary	**0**
Spectrometer wavelength range	**925 | 350**

Coarse: task #600 EC

Make fine

Empty (#619 EC)

How To Perform Task #619

3. Edit inputs.

IlluminationSpectrometerWavelengthFineCalibration

Input Values	
List of Wavelengths and corresponding Intensity Regimes	(Collection)
Number of acquirements for every regime [#]	50
Number of points around spectral lines [#]	10
Integration Time	
Spectrometer integration time parameters High Regime [s]	
Max IntegrationTime Coarse [s]	0.2
Number coarse acquirements [#]	15
Number fine acquirements [#]	5
Saturation intensity level [0-1]	0.9
Target intensity level [0-1]	0.8
Spectrometer integration time parameters Low Regime [s]	
Max IntegrationTime Coarse [s]	2
Number coarse acquirements [#]	15
Number fine acquirements [#]	5
Saturation intensity level [0-1]	0.9
Target intensity level [0-1]	0.8
Spectrometer integration time parameters Medium Regime [s]	
Max IntegrationTime Coarse [s]	0.8
Number coarse acquirements [#]	15
Number fine acquirements [#]	5
Saturation intensity level [0-1]	0.9
Target intensity level [0-1]	0.8

Spectrometer integration time parameters Medium Regime [s]

Reset | Import... | Export... | Close

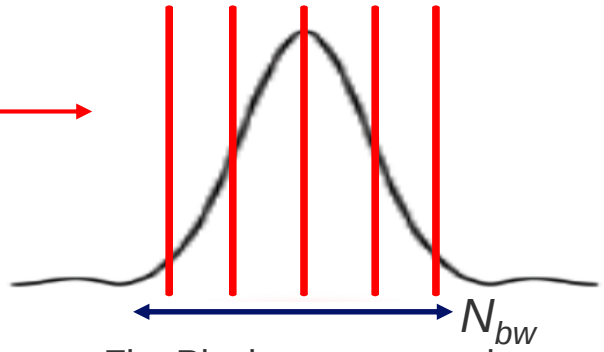
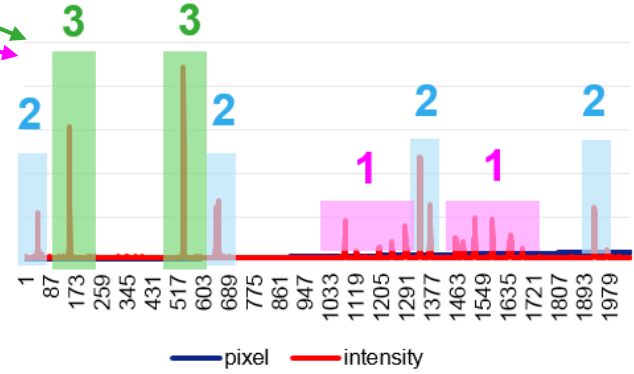


Fig. Pixel range expend



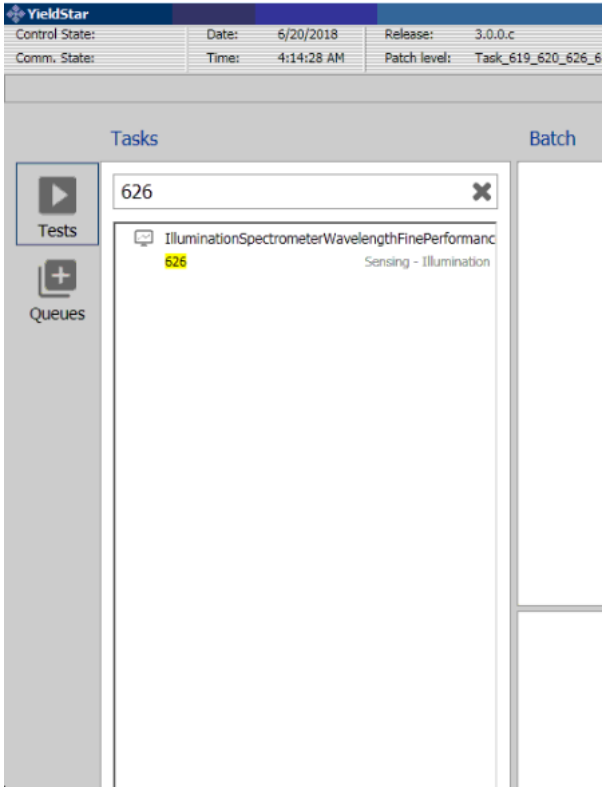
3 intensity regimes

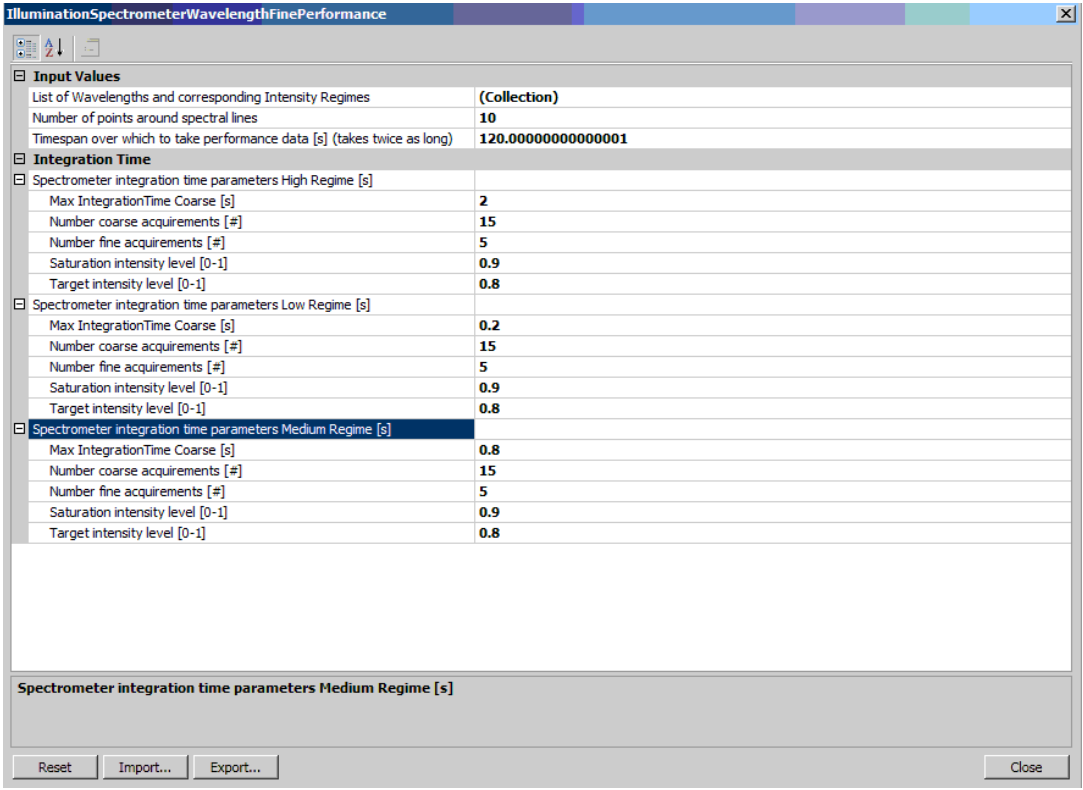
EC After Running #619

Spectrometer	
Additional delay between spectrometer acquirements [s]	0
Default Integration Time For Spectrometer	0.0025
Queued spectrometer acuisition mode enabled	False
Spectrometer Calibration Lamp burn time [min]	**34.98**
Spectrometer Calibration Lamp warm up time [s]	600
Spectrometer coarse mapping of Pixel to corresponding Wavelength	
Spectrometer Pixel to wavelength data file name	**SpectrometerPixelToWavelength_ClModule_20180424_110745.csv**
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
Apply spectrometer Pixel To WaveLength correction type	**Fine**
Spectrometer fine mapping of Pixel to corresponding Wavelength	
Spectrometer Pixel to wavelength data file name	**SpectrometerPixelToWavelengthFine_ClModuleFine_20180706_035221.csv**
Spectrometer Irradiance calibrated values	**Spectrometer Irradiance**
Spectrometer Irradiance Calibrated Integration Time	**0**
Spectrometer Irradiance data file name	
Spectrometer Non-Linearity calibrated values	**0 | 0 |**
Spectrometer Non-linearity correction coefficients	
Spectrometer Non-linearity high boundary	**0**
Spectrometer Non-linearity low boundary	**0**
Spectrometer wavelength range	**925 | 350**
Highest spectrometer wavelength [nm]	**925**
Lowest spectrometer wavelength [nm]	**350**
Spot Size Selector	
Spot size selector encoder positions	**EncoderPositionPSpotEntry[] Array**
Switch Mirror Selector	
Default Switch Mirror Darkfield position [m]	**0.0026104**
Default Switch Mirror Pupil position [m]	**0.013885**
Switch Mirror Darkfield position [m]	**0.0026104**
Switch Mirror Pupil position [m]	**0.013885**

How to Verify Task #619

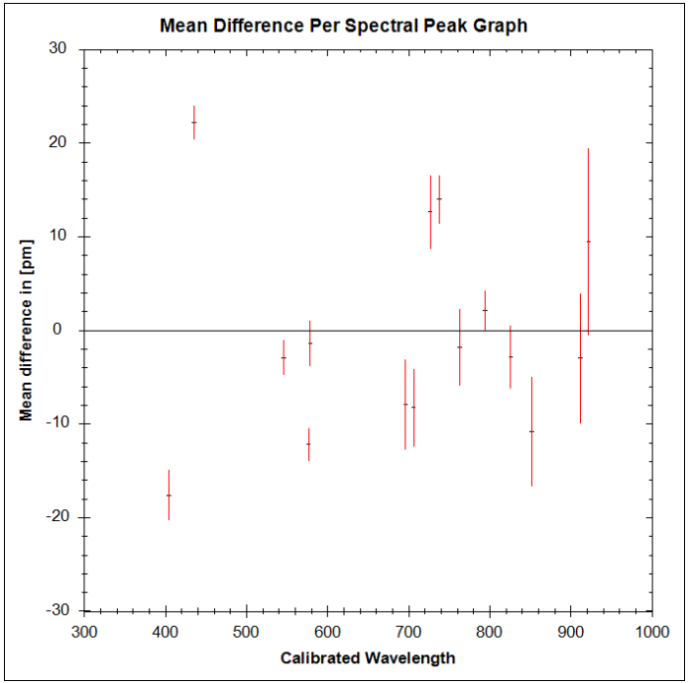
1. Select task #626, check input setting, run the task.





How to Verify Task #619

2. Check the following specification in #626 report:



Mean Difference All Spectra *[nm]*	-1.3020560618315358E-05
Three Sigma of found peak positions *[pm]*	55.04428864209379

< 0.05nm

3std of the performance measurement and calibration data < 0.05nm

ASML

Q & A