STRAWb: Minispectrometer module

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The MINI-Spectrometer module

1. THE SCIENCTIFIC GOAL

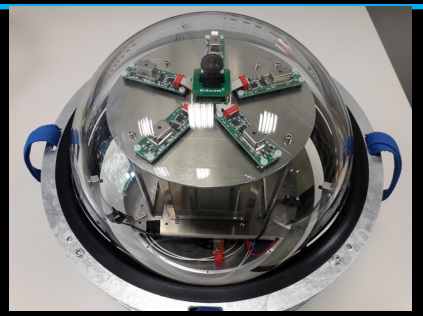
- STRAW: long-term information about background and bioluminescence *emission rates*.
- STRAWb: in-situ bioluminescence emission spectra.

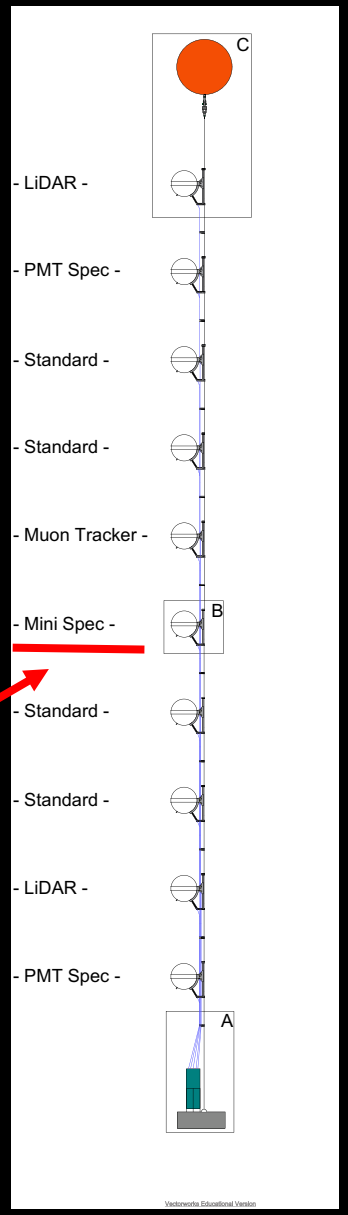
2. MEASUREMENT TO ACHIEVE

- STRAWb: 3 dedicated modules for bioluminescence emission spectra measurement
- 2 PMT-spectrometers (very low light detection) and 1 MINIspectrometer (high burst detection)

3. THE LIGHT SENSORS

- The module is built on a combination of commercial devices:
  - 5 Hamamatsu C12880MA spectrometers
  - 1 low light camera
- Advantages: high reliability devices (commercial standard), factory calibration available



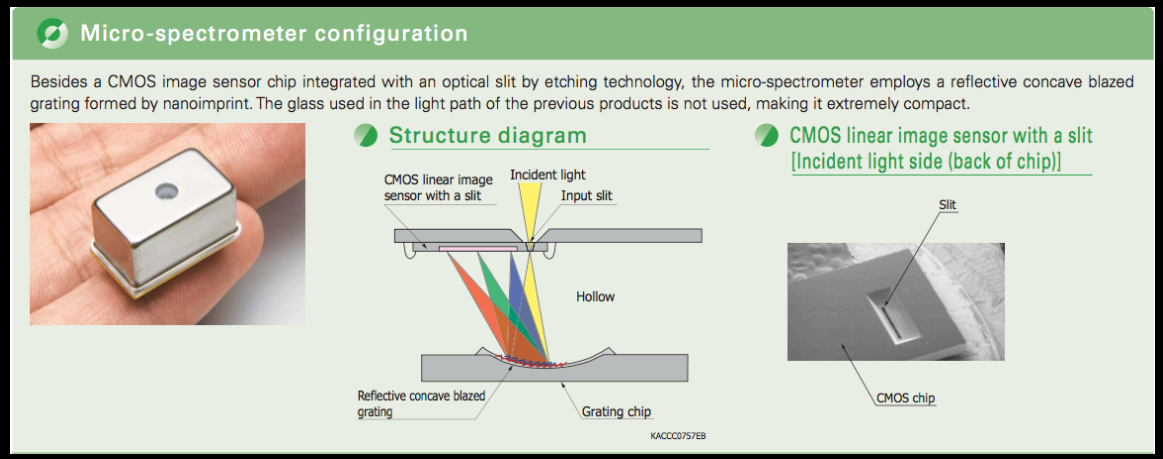


position: 264 m from the seabed

The minispectrometer device

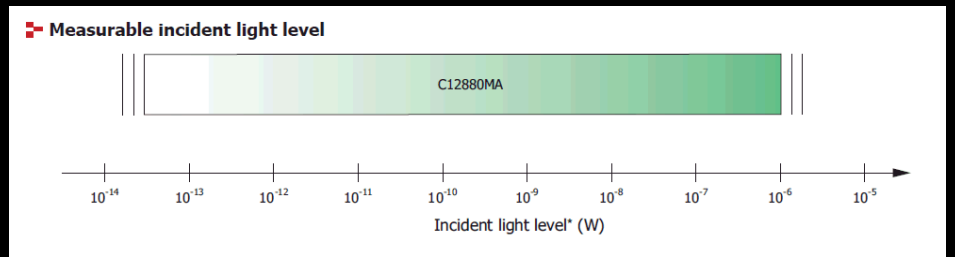
The Hamamatsu mini-spectrometer C12880MA

- C12880MA uses a linear image sensor (vector-like 288 pixels)
- Conversion factors for converting the image sensor pixel number into a wavelength are available for every sensor
- Slit 50 x 500 μm
- Spectral resolution 15 nm
- One minispectrometer price: 170 euro
- Sensitivity: minimum detection few tens of photons (PMT sensitivity single photon over several cm photocathode area)
  Constraint: dimension of the slit



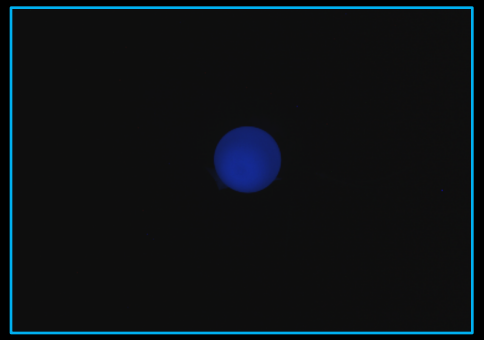
Parameter	Micro-spectrometer	
	C12666MA	C12880MA
Photo		
Type	Spectrometer head / Wide dynamic range	Spectrometer head / High sensitivity
Spectral response range	340 to 780	340 to 850
Spectral resolution (FWHM)*1	15 max.	
Wavelength reproducibility*2	-0.5 to +0.5	
Wavelength temperature dependence	-0.1 to +0.1	
Spectral stray light*1 *3	-25 max.	
Dimensions (W × D × H)	20.1 × 12.5 × 10.1	
Weight	5	
Image sensor	CMOS linear image sensor	High-sensitivity CMOS linear image sensor
Number of pixels	256	288
Slit (H × V)*4	50 × 750	50 × 500
NA*5	0.22	
Operating temperature*6	+5 to +50	
Storage temperature*6	-20 to +70	
Trigger compatible	-	
Evaluation circuit (sold separately)	C14465-10	C13016

Note: We also provide the C12880MA-10, which is identical to the C12880MA except that it has an SMA connector.



Last functional tests before shipment

Before the shipment, the entire module has been subjected to a functional test of all the elements: camera and minispecs



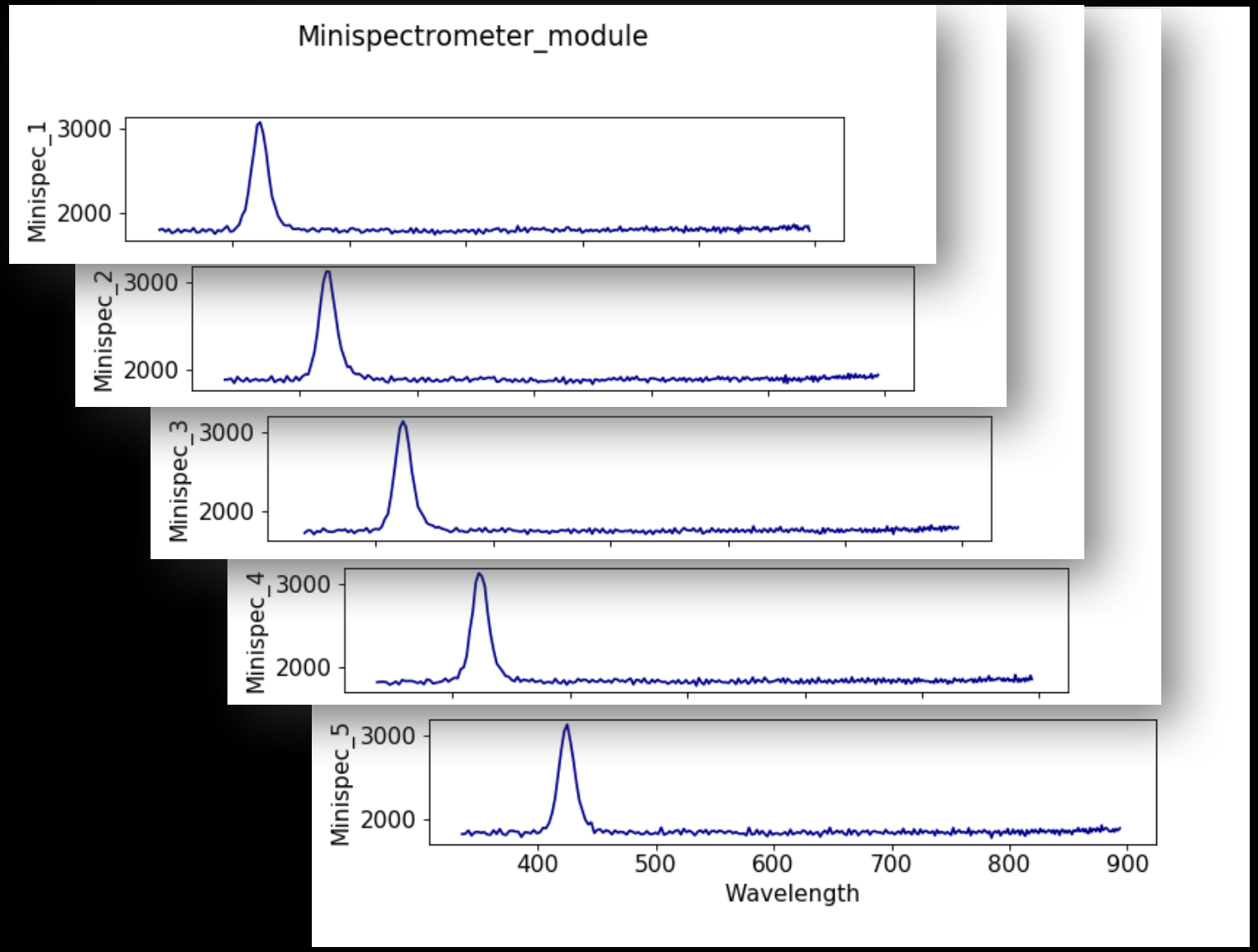
TEST of the camera using a POCAM integrating sphere

Last functional tests before shipment

TEST of the minispectrometers using a POCAM integrating sphere.

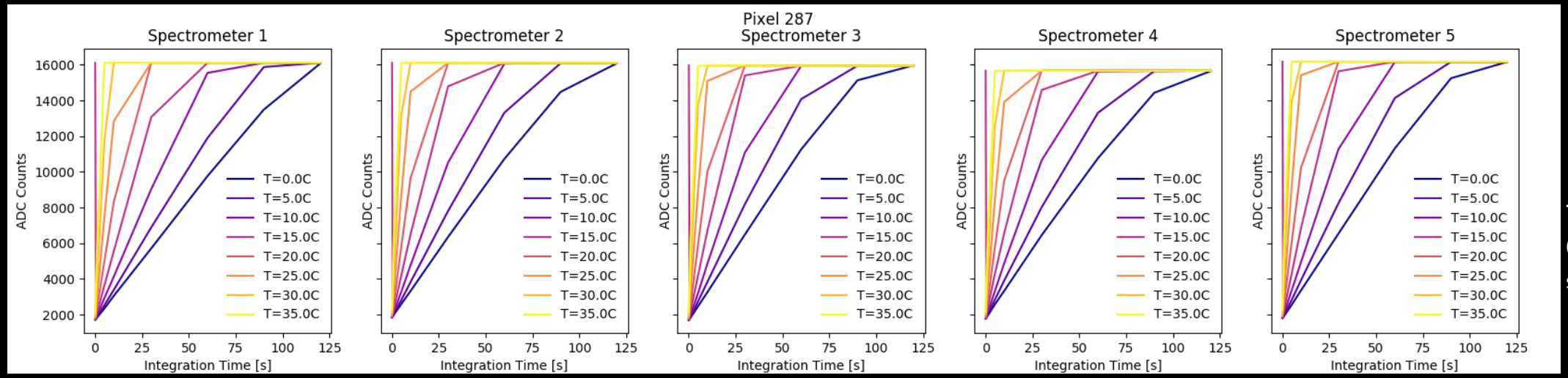
The LEDs used for the test have been:

365 ± 8 nm
405 ± 8 nm (in the example)
465 ± 7 nm
605 ± 6 nm



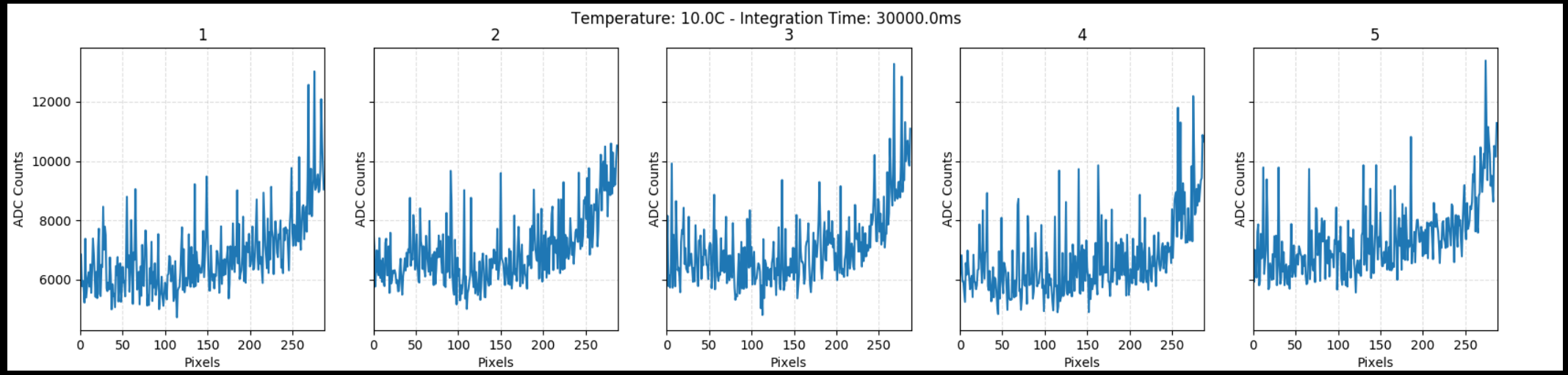
Calibration tests for dark subtraction

Before the deployment, the entire module has been tested in the dark controlled temperature chamber to collect the wide range of data that now turn out to be helpful in the data analysis



Temperature tested:
0 ℃ to 35 ℃,
step 5 ℃

For each temperature, the following integration time has been used:
0.1 s, 0.5 s, 1 s , 5 s, 10 s, 30 s, 60 s, 90 s, 120 s



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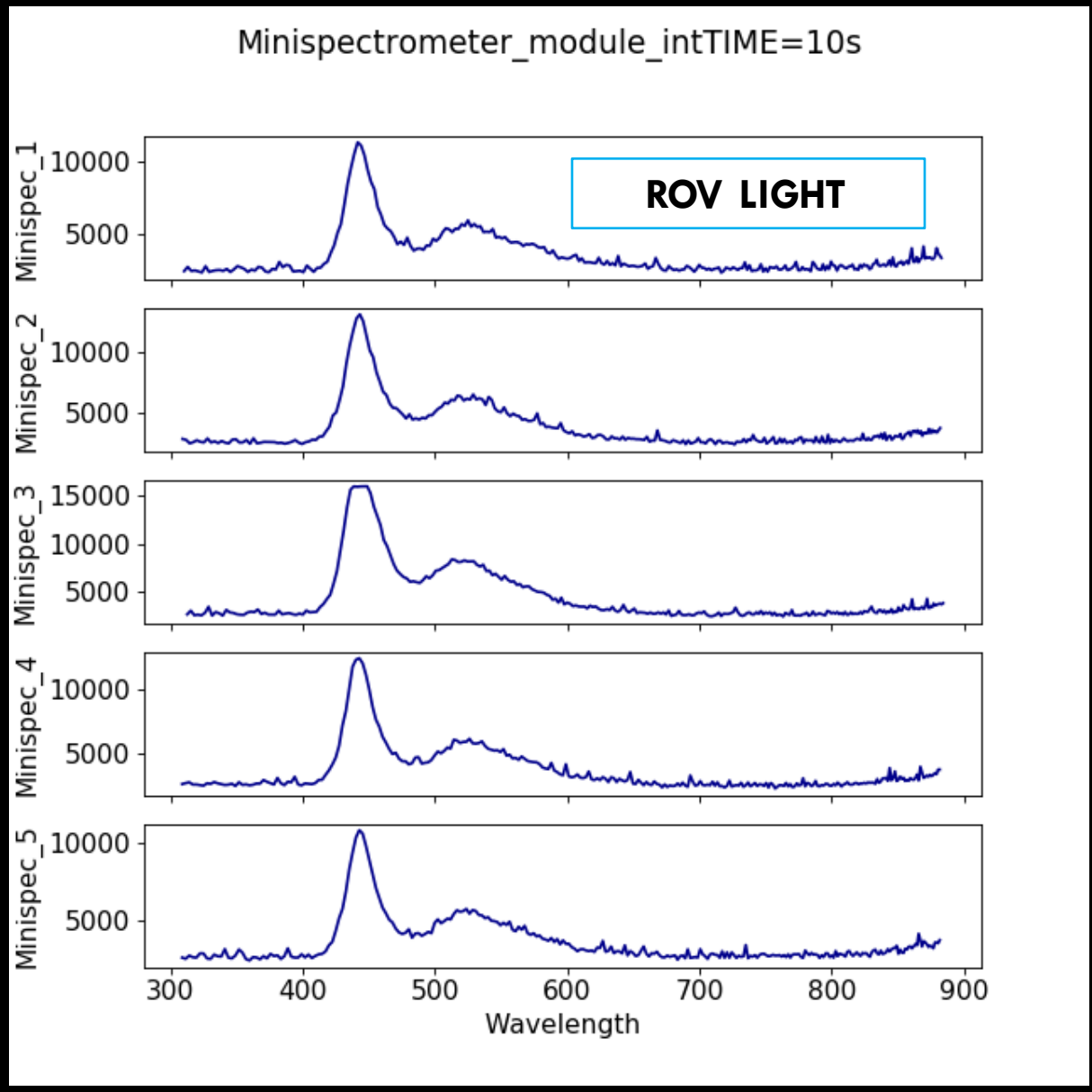
Successfully deployed



Measurement strategy: dark subtraction

- Choose the calibration data file with the closest to deep-sea environmental temperature for the minispec devices and with the closest integration time.

- Each minispec device has its own temperature sensor

Example:

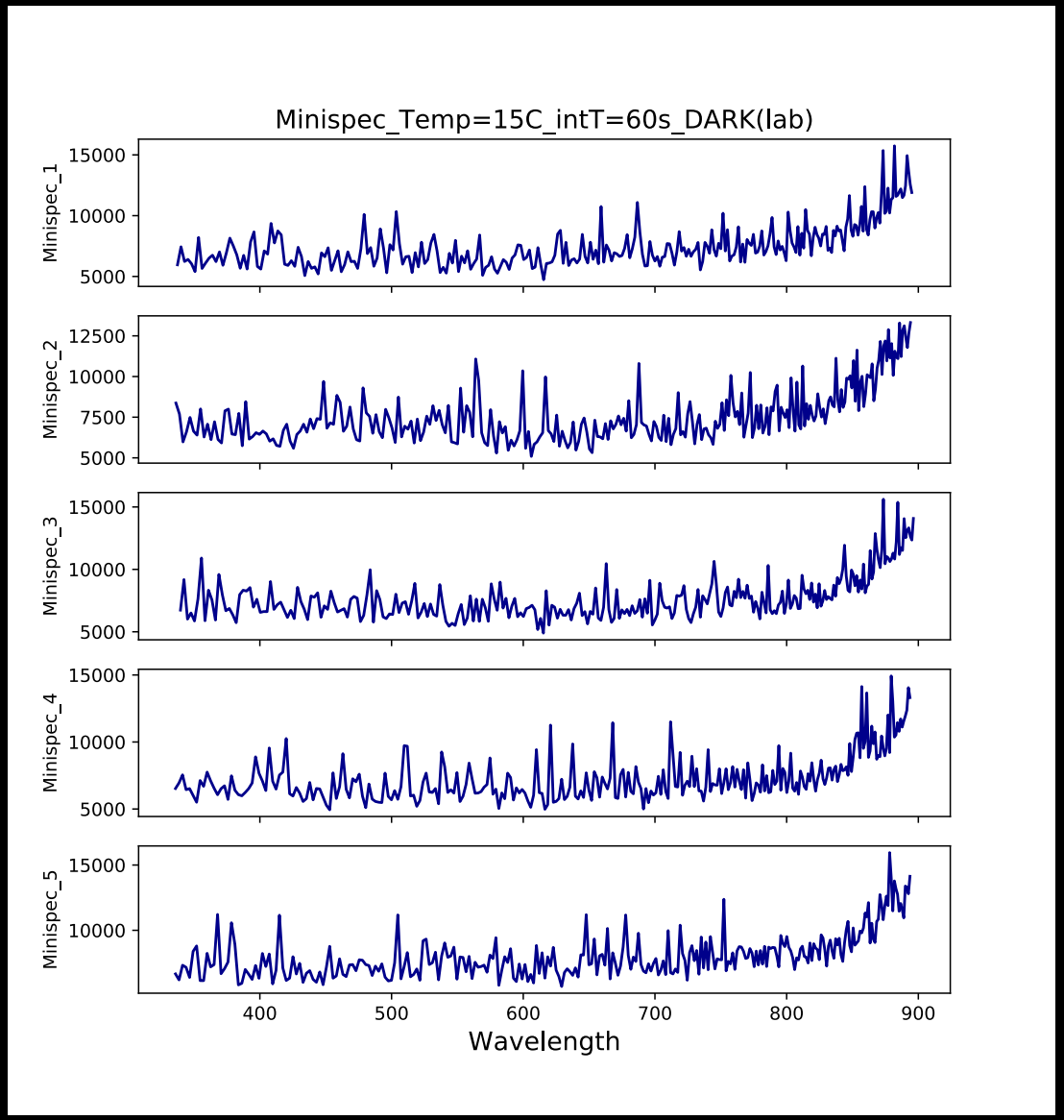
DARK FILE:

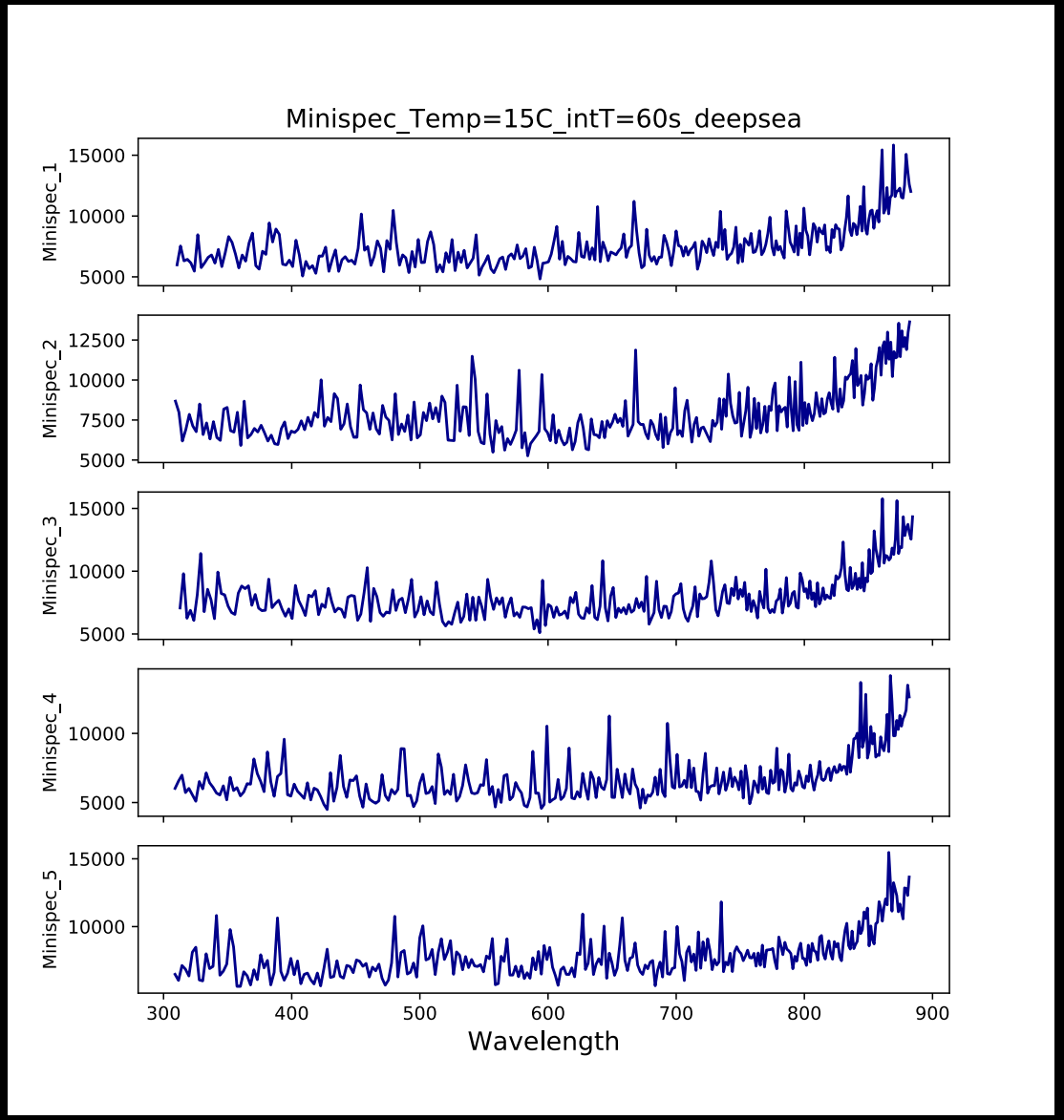
temp1 14.3125 [C]
temp2 13.875 [C]
temp3 14.1875 [C]
temp4 15.0 [C]
temp5 15.0 [C]
integration_time 60000000 [us]

DEEP-SEA MEASURE:

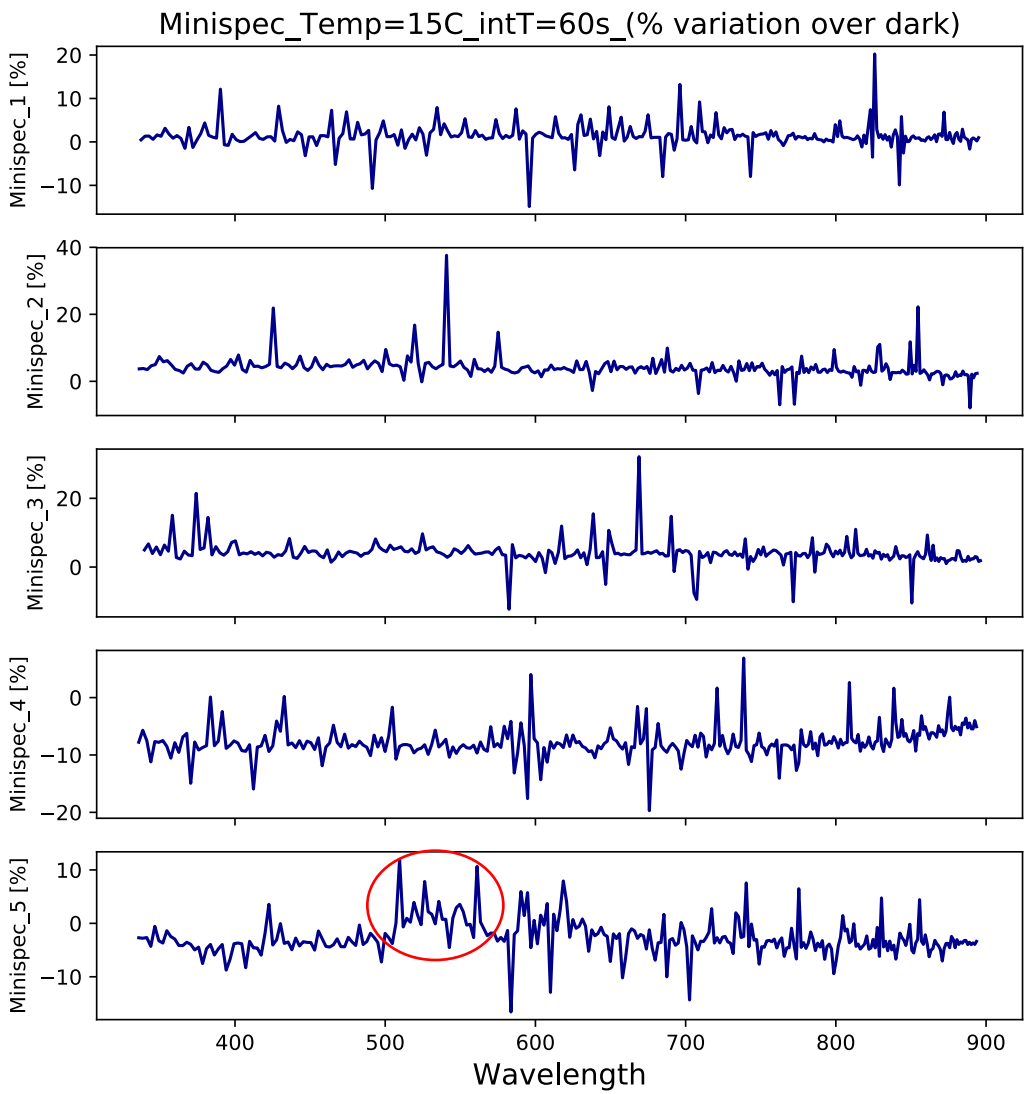
temp1 14.0625 [C]
temp2 13.8125 [C]
temp3 14.25 [C]
temp4 13.8125 [C]
temp5 14.1875 [C]
integration_time 60000000 [us]

Measurement strategy: dark subtraction





Measurement strategy: dark subtraction



- Studying the variation of the signal over the calibrated dark, single pixel variation (±) can be around 10%
- This variations are both belonging to the nature of the sensor and to the differences in the temperature at which the dark calibration happened

DARK FILE:	DEEP-SEA MEASURE:
temp1 14.3125 [C]	temp1 14.0625 [C]
temp2 13.875 [C]	temp2 13.8125 [C]
temp3 14.1875 [C]	temp3 14.25 [C]
temp4 15.0 [C]	temp4 13.8125 [C]
temp5 15.0 [C]	temp5 14.1875 [C]
integration_time 60000000 [us]	integration_time 60000000 [us]

- In the Minispec 5, in the region around 550 nm, several consecutive pixels showed a 10% variation over dark.
  It is unlikely that this is only a dark variation.
  It could be a very faint event: more study is needed! And more data should be taken!

It's a Long Way to the Top

Still several steps to stabilize the data-taking:

- Dark subtraction fine tuning
- Debugging run autoscheduling
- Improve the offline analysis software
- Implement autocalibration procedure (Muon-Tracker LED) – serving also biofouling/sedimentation monitoring purposes

(If You Wanna Rock 'N' Roll)