Determining Reflectivity Test Station's Capabilities for UV Wavelengths

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Components – Measurement Device and Light Source

Measurement Device

- Thorlabs compact CCD spectrometer (CCS)
  - Part number CCS200
- Measures power across full spectrum of input light

Specification	Value
Wavelength Range	200 - 1000 nm
Spectral Accuracy	<2 nm FWHM @ 633 nm
Grating	600 Lines/mm, 800 nm Blaze
Detector Range (CCD Chip)	200 - 1100 nm
CCD Pixel Size	8 µm x 200 µm (8 µm pitch)
Resolution	4 px/nm
Integration Time	10 µs - 60 s
S/N Ratio	≤2000 : 1
Interface	USB 2.0
Dimensions (L x W x H)	122 mm x 79 mm x 29.5 mm

Light Source

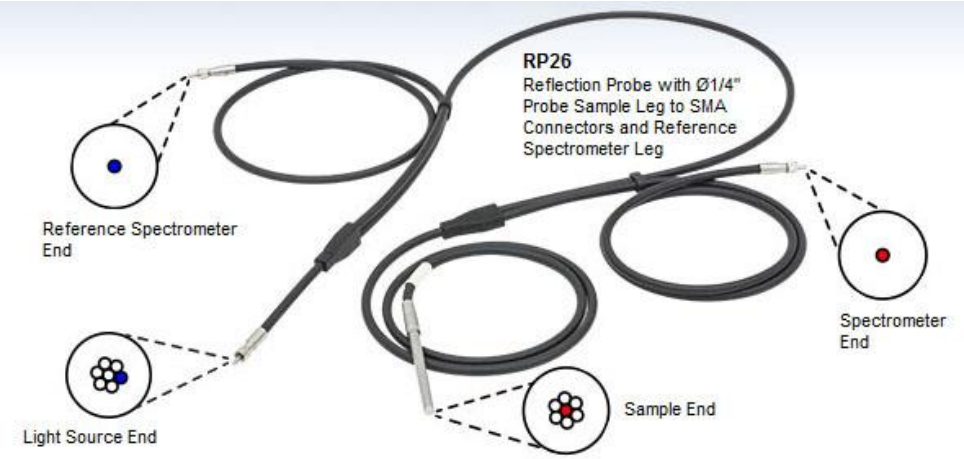
- Thorlabs stabilized Quartz-Tungsten Halogen (QTH) broadband source
  - Part number SLS201L
- Has built-in output stabilization circuit to keep changes in output power to < 0.05%

Specification	Value
Wavelength Range	360 - 2600 nm
Peak Wavelength	1000 nm
Bulb Electrical Power	9 W
Output Coupling	Fiber Coupled (SMA) and Free Space
Output Power Stability	<0.05%
Dimensions (L × W × H)	8.52" × 2.17" x 2.26"

Components – Fiber Optic Probe

Fiber Optic Probe

- Thorlabs reflection probe with reference leg
  - Part number RP26
- Fiber optic bundle for routing test light to sample and devices



Specification	Value
Wavelength Range	250 - 1200 nm
Overall Length	2 m
Number of Legs	4 (source, reference, sample, measurement)
Sample Leg Termination	1/4-inch OD probe

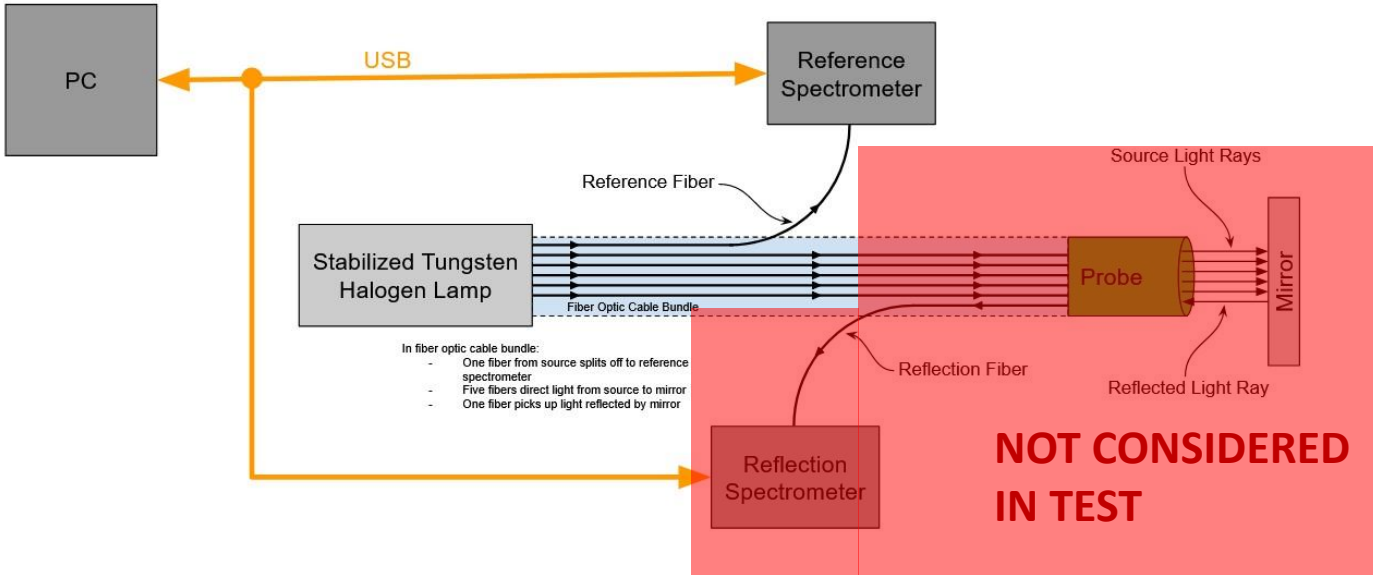
Components – Summary & Comments

- Only CCS is rated for wavelengths down to 200 nm
  - Lower limits:
    - CCS – 200 nm
    - Probe – 250 nm
    - Source – 360 nm

- Probe should not be used for long term measurements less than 250 nm
  - Okay to use briefly for one or two tests
  - Optical fibers in probe's cable may be damaged by UV, or become solarized, making the fibers more optically opaque over time
  - Can get custom probe with solarization-resistant optical fibers
    - Information requested from Thorlabs on lead time and cost of custom probe; waiting for reply

On-Hand Components Test

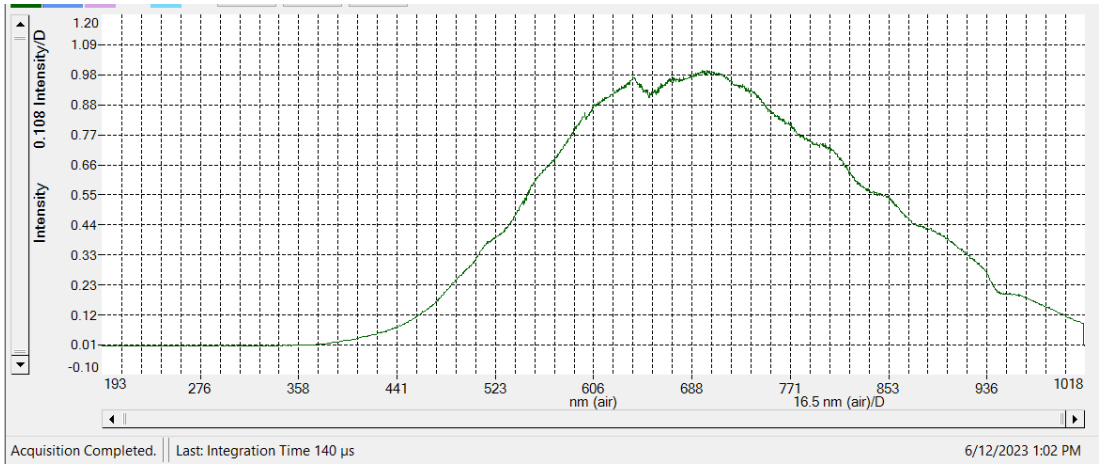
- Reference leg of set up tested to see its response for low-wavelength light



System diagram of test set up.
For test, only the reference leg of the fiber-optic cable and the reference spectrometer (CCS) was used.

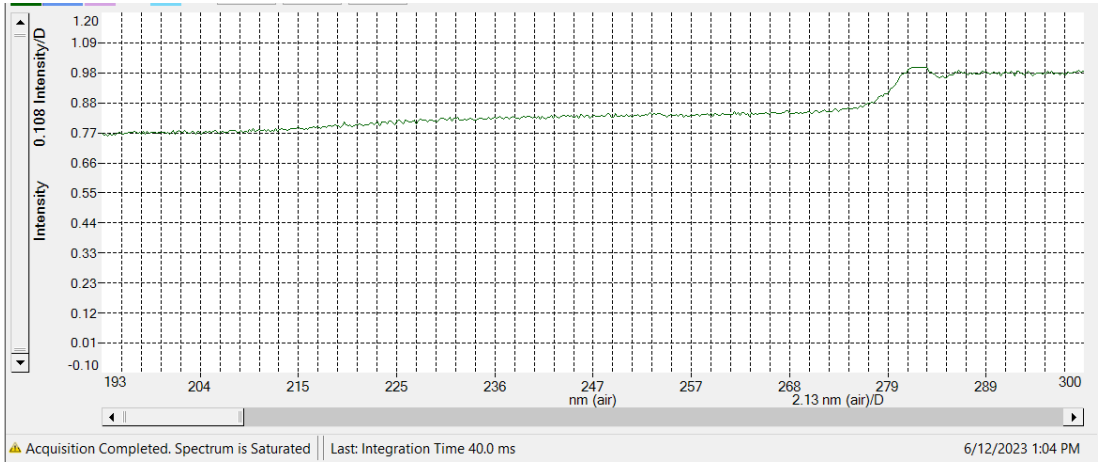
On-Hand Components Test Results

- CCS can read down to ~193 nm
- QTH lamp's output is mainly in visible spectrum
  - Need ~250 times longer CCS integration time to get equivalent measurement results for 200-nm wavelengths
- Do not recommend using QTH lamp for EIC RICH tests



Above: CCS measurement of QTH lamp full spectrum with 0.14-ms integration time.

Below: CCS measurement of QTH lamp, focusing on wavelengths ~190 – 300 nm with 40-ms integration time.



Deuterium Lamp Test

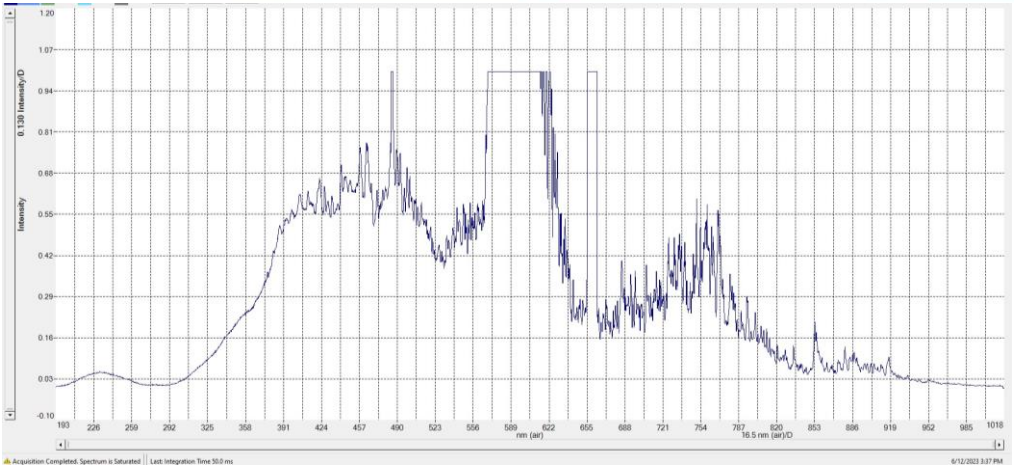
- From CLAS12 HTCC tests, we have a 30-W Deuterium lamp whose output is rated for 200 – 400 nm

- Fiber coupler and output cap used to create adapter for lamp to connect fiber optic cable

Deuterium Lamp Test Results

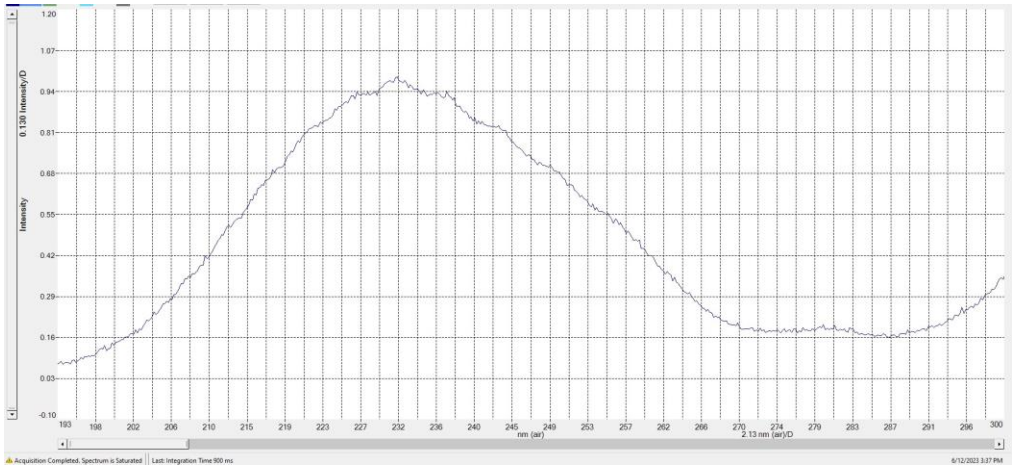
- Results show a better defined spectrum for lower wavelengths
- Requires much longer integration times
  - 900 ms for Deuterium lamp vs 40 ms for QTH lamp

- Results are better for ~190 nm – 300 nm wavelengths
  - Spectral curve present as opposed to a flatter curve



Above: CCS measurement of Deuterium lamp full spectrum with 50-ms integration time.

Below: CCS measurement of Deuterium lamp, focusing on wavelengths ~190 – 300 nm with 900-ms integration time.



Recommendations

- If CCS measurement spectrum with the Deuterium lamp is okay:
  - Recommend procurement of a custom fiber bundle that is solarization-resistant

- If CCS measurement spectrum with Deuterium lamp is not okay:
  - Recommend investigating a monochromator-photodiode set up
    - Monochromator lets a specific output wavelength to be set
    - Light induces a current response in the photodiode that proportional to the light's power
    - Photodiode current read by an ADC (multimeter, benchtop meter, peripheral device, etc.)

- Recommendations, regardless of set up:
  - New, more stable, UV light source
    - Power of on-hand UV source is known to vary over time and alignment can be tricky
  - Investigate optical fiber switcher so reference and measurement beams can be read by same CCS
    - Helps remove effects from any CCS calibration differences
  - Develop a full automation of alignment and DAQ

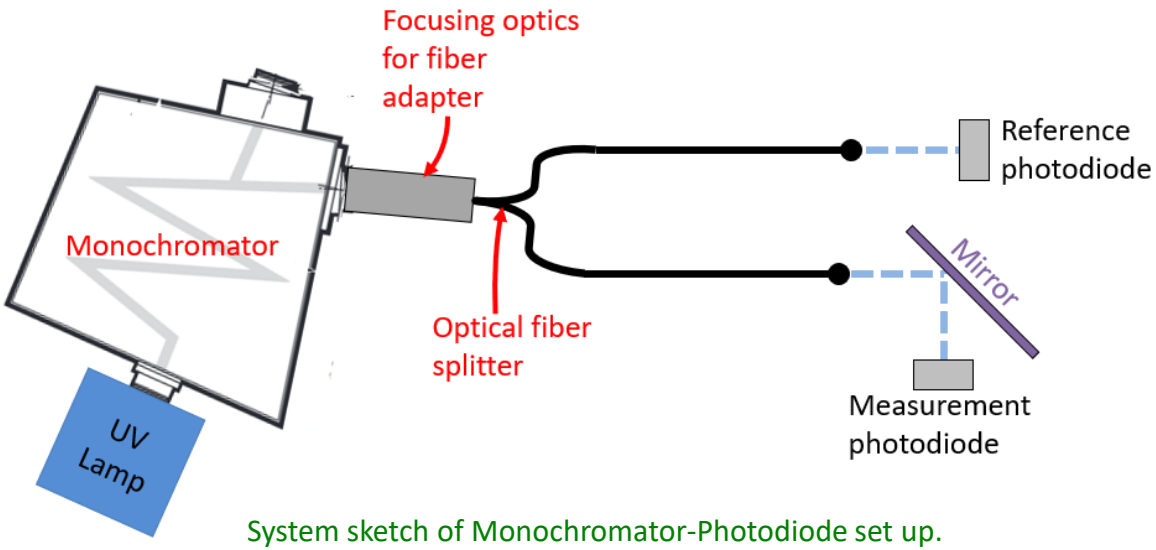
Conclusion

- ~200-nm is the lowest rated wavelength for measurement equipment we have on hand
  - CCSs do not provide data for wavelengths under ~193 nm
- CCSs could be used with a UV source, but the lower wavelengths introduce risk of solarizing fiber optic bundle
  - Risk could be mitigated with custom, solarization-resistant fiber bundle
- If better responsivity is needed with wavelengths around 200 nm, recommend using a monochromator-photodiode set up

Thank You

Backup – Monochromator-Photodiode Set Up

- Newport CS260 monochromator
  - DSG has one on hand
  - Newport has focusing optics to allow output of monochromator to be directed through an optical fiber
  - Could output the lower ~200 nm wavelengths, but a better source lamp is recommended
- Photodiodes
  - DSG has two Newport 818-UV-L photodiodes on hand
  - Each has calibration data down to 200-nm
  - Would need a photodiode readout device or circuit
    - Expect photodiode responsivity at 200-nm to be ~60 mA/W



System sketch of Monochromator-Photodiode set up.