



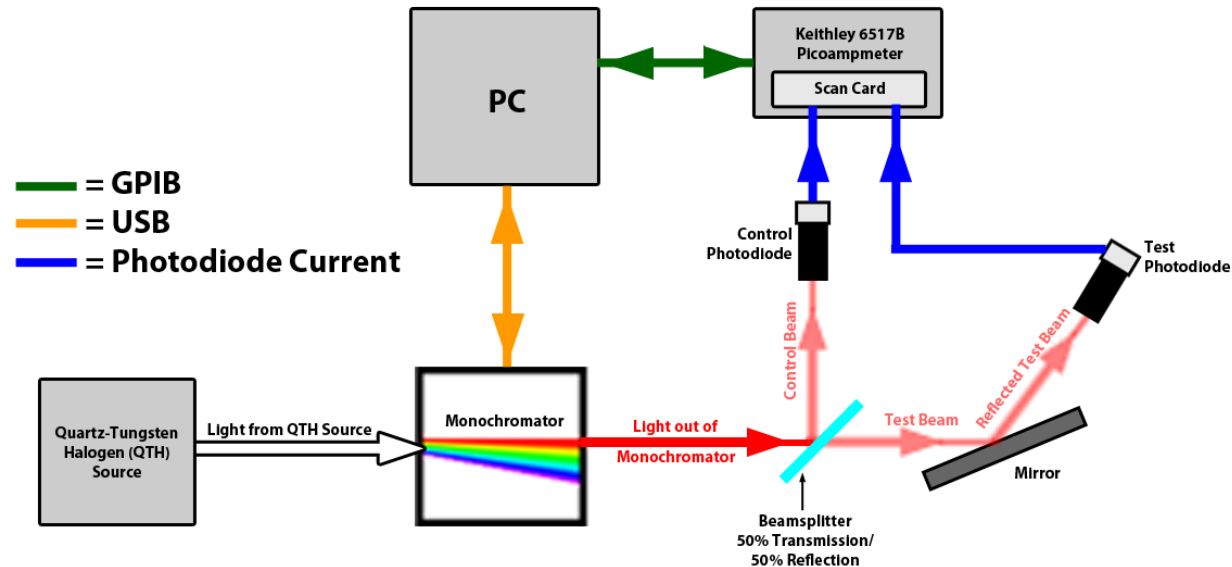
Mirror Reflectivity Upgrade Proposal

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Present Mirror Reflectivity Test Station



- Monochromator provides light of a specified wavelength
- Light is split into control beam and test beam using beamsplitter
- Test beam is reflected off mirror
 - For calibrations, test beam directly hits test photodiode
- Control beam and reflected test beam's power are measured by separate photodiodes
- Photodiode current response measured by Keithley picoampmeter

Present Test Station Procedure – Calibration

1. Move test photodiode and its mount to calibration rail in test station
2. Remove test photodiode from its mount
3. Attach collimators to both ends of tube on mount
4. Place alignment laser on monochromator and turn on
5. Align test photodiode so light from laser passes through both collimators
6. Turn off alignment laser, remove it from monochromator, and replace monochromator lid
7. Re-install test photodiode on its mount
8. Run program in calibration mode

Highlighted items are steps with largest potential to cause error in measurement

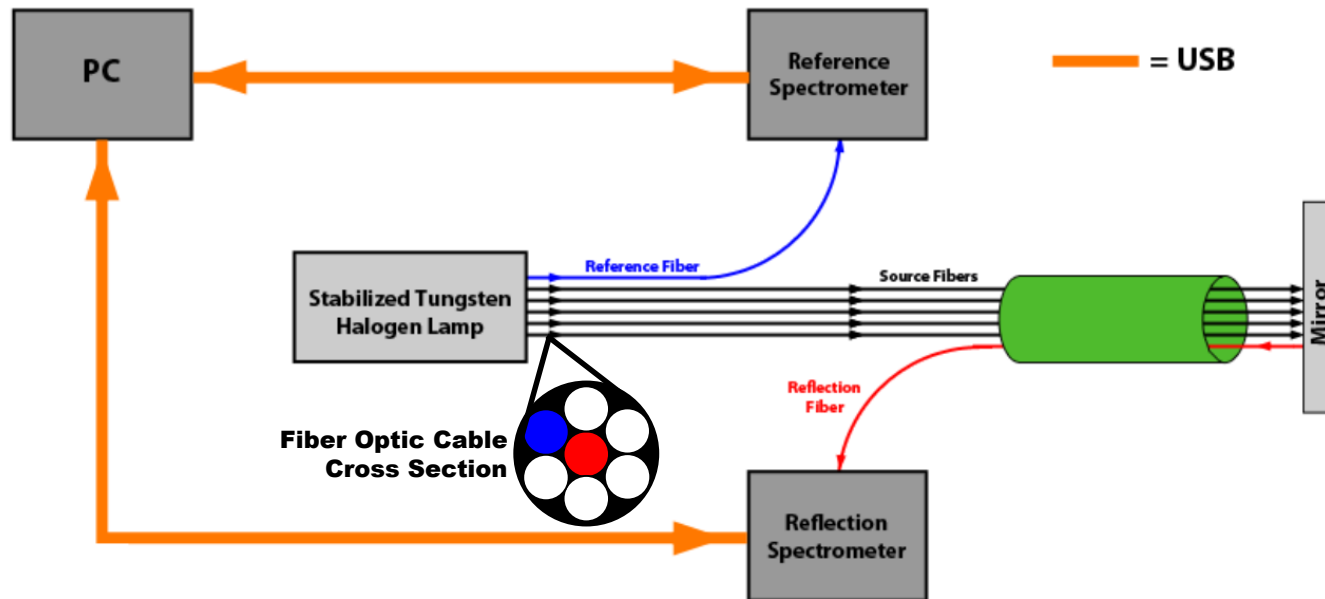
Present Test Station Procedure - Measurement

1. Move test photodiode and its mount to measurement rail in test station
2. Remove test photodiode from its mount
3. Attach collimators to both ends of tube on mount
4. Place alignment laser on monochromator and turn on
5. Align mirror to be tested so alignment laser reflects off of mirror and to test photodiode mount
6. Align test photodiode so reflected beam from laser passes through both collimators
 - A. If beam is not parallel to table, mirror must be adjusted until beam is parallel to table
7. Turn off alignment laser, remove it from monochromator, and replace monochromator lid
8. Re-install test photodiode on its mount
9. Run program in measurement mode

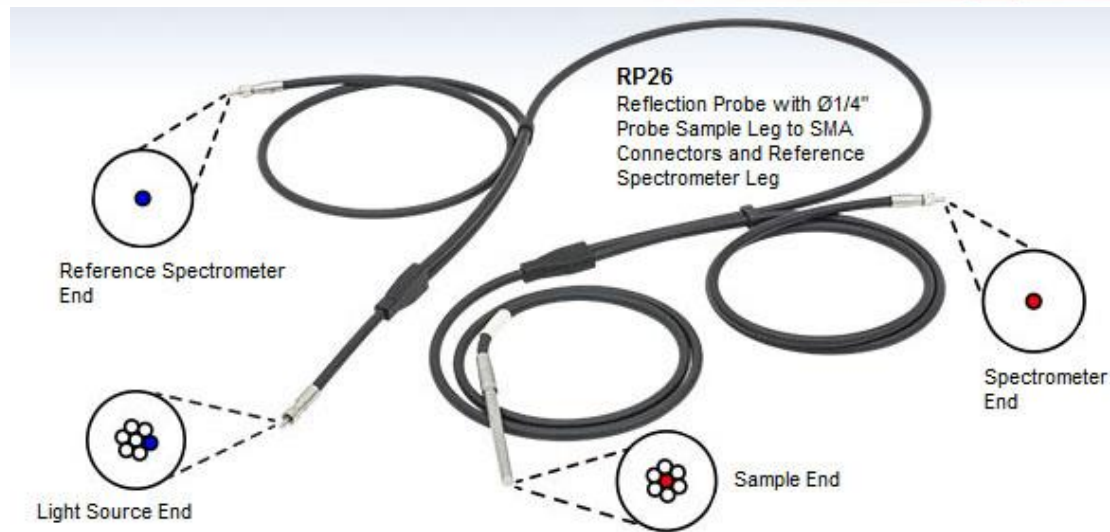
Highlighted items are steps with largest potential to cause error in measurement

Proposed New Test Station

- Use fiber optic reflection probe, compact spectrometers, and stabilized source for measurements
- Limits alignments required



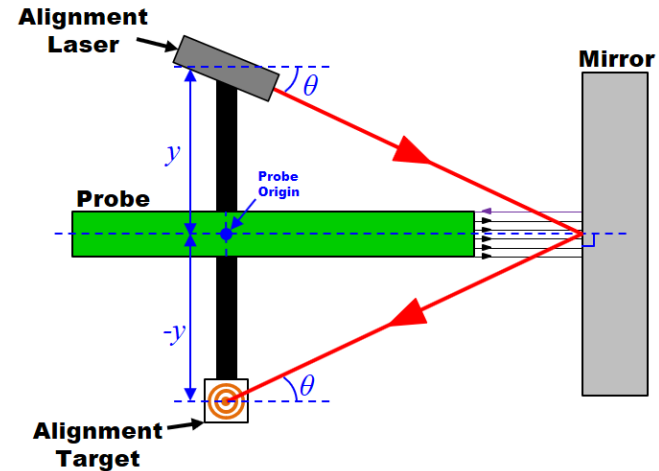
Fiber Optic Reflection Probe



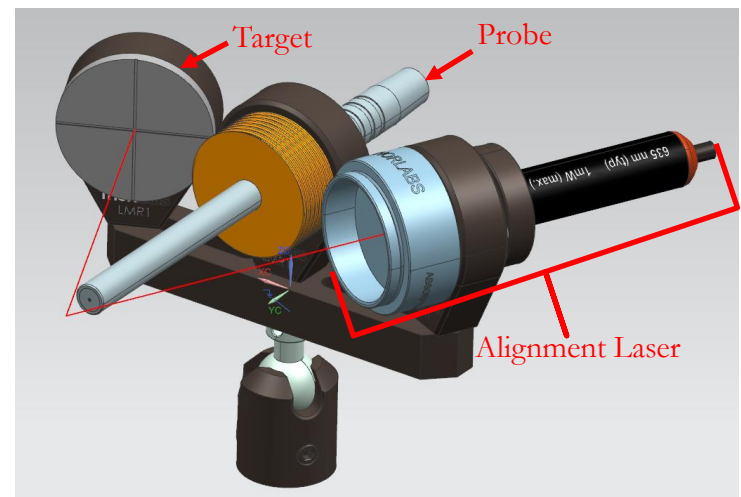
- Thorlabs item # RP26
- Seven-fiber fiber optic cable bundle
- Sample end has a 0.25" diameter probe
- Source, reference, and measurement ends have SMA connectors
- Flexible fiber optic cable eliminates need to align reference light with detector
- Only alignment needed is to align probe with mirror

Fiber Optic Probe Alignment

- For best results, probe should be perpendicular to mirror
- Alignment laser procured in January 2020 will be used to ensure perpendicularity
 - Laser at distance y from probe origin and tilted towards mirror and $y = 0$ at an angle θ
 - Target at distance $-y$ from probe origin
 - If probe is perpendicular to mirror, laser will hit target.



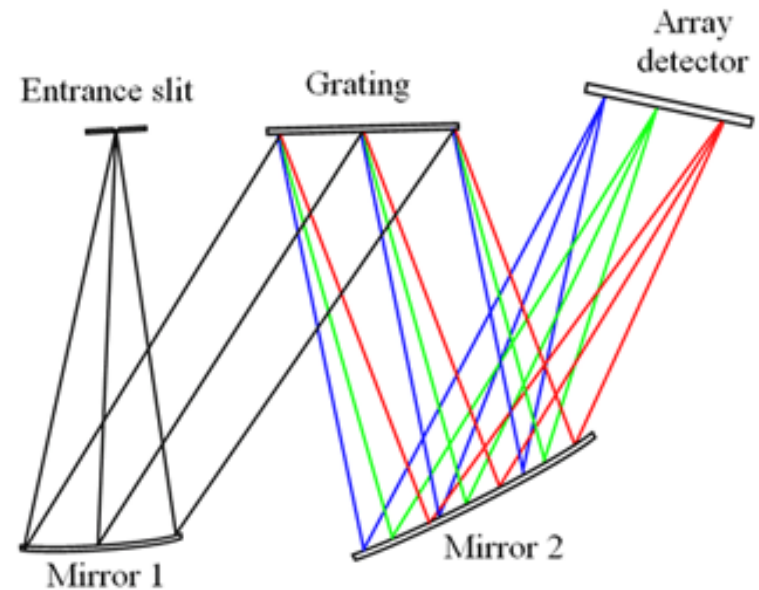
Probe alignment diagram



Probe alignment model

Compact USB Spectrometer

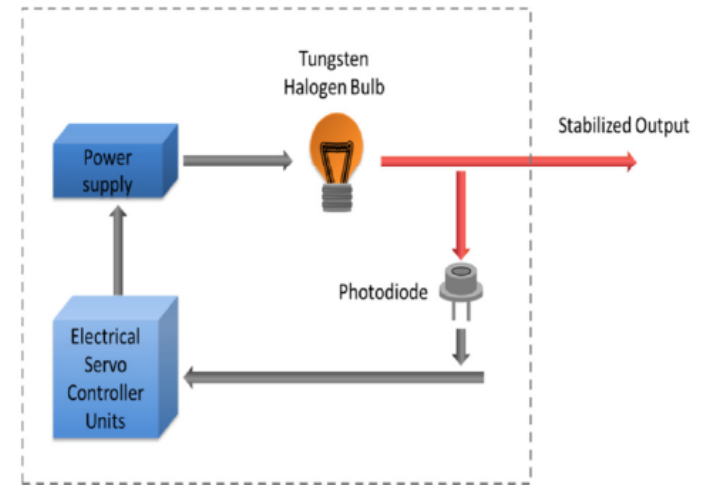
- Thorlabs part # CCS200
 - Two needed for test station
- Czerny-Turner optics
- Measures power across full spectrum of input light
 - Analyzes all wavelengths at once
- Includes DAQ program and full suite of LabVIEW drivers
- Specs
 - 200 nm – 1000 nm analysis range
 - 2 nm spectral accuracy



Czerny-Turner optics diagram

Stabilized Tungsten-Halogen Broadband Source

- Thorlabs part # SLS201L
- Output: 360 nm – 2600 nm
“white light”
- Has built-in output stabilization circuit that ensures output power is steady



Output stabilization circuit

Full Automation

- Move equipment in a way where program can test entire mirror surface without user input beyond clicking start
- Requires:
 - Motorized linear stages
 - Three on hand
 - Motorized rotation mounts
 - Because mirrors are spherical, probe needs to rotate in two axes to follow mirror surface
 - Alignment readback device
 - CCD or other sensor to verify with alignment laser that probe is in correct position
 - Interlock system to ensure probe does not hit mirror

Benefits of Proposed Test Station

- Faster set up
- Fewer steps that could introduce error
- Faster results
 - No stepping through wavelengths
- Adding a second UV light source expands test station to UV spectrum
- Test station could be modified with additional fiber optic cables and lenses for use as transmittance test station and for aerogel





Estimated Cost List

Fiber Optic Probe

Item	Image	Part Number	Ship Date	Qty	Price	Subtotal	Remove
1		W8S038 - (WEIGHT (Total)):0.07 lbs #8 Washer, M4 Compatible, Stainless Steel, 100 Pack	Today	<input type="text" value="1"/>	\$3.59* \$3.52	\$3.52	<input type="checkbox"/>
2		PJ301 - (WEIGHT (Total)):0.05 lbs Centered Mounting Post Joist, 8-32 Mounting Hardware	Today	<input type="text" value="1"/>	\$18.29* \$17.92	\$17.92	<input type="checkbox"/>
3		RP26 - (WEIGHT (Total)):3.48 lbs Reflection Probe with Reference Leg, Ø200 µm, High-OH (250 - 1200 nm), SMA to Ø1/4" Probe, 2 m Long	Today	<input type="text" value="1"/>	\$679.57* \$665.98	\$665.98	<input type="checkbox"/>
4		LMR1 - (WEIGHT (Total)):0.04 lbs Lens Mount with Retaining Ring for Ø1" Optics, 8-32 Tap	Today	<input type="text" value="2"/>	\$15.69* \$15.38	\$30.76	<input type="checkbox"/>
6		SH8S050 - (WEIGHT (Total)):0.20 lbs 8-32 Stainless Steel Cap Screw, 1/2" Long, 50 Pack	Today	<input type="text" value="1"/>	\$7.19* \$7.05	\$7.05	<input type="checkbox"/>
7		SM1A7 - (WEIGHT (Total)):0.01 lbs SM1 Series Alignment Disk	Today	<input type="text" value="1"/>	\$26.25* \$25.73	\$25.73	<input type="checkbox"/>
8		SL S201L - (WEIGHT (Total)):4.42 lbs Stabilized Fiber-Coupled Light Source w/ Universal Power Adapter, 360 - 2600 nm, 1/4"-20 Taps	5-8 Days	<input type="text" value="1"/>	\$1,092.94* \$1,071.08	\$1,071.08	<input type="checkbox"/>
9		CCS200 - (WEIGHT (Total)):4.79 lbs Compact Spectrometer, Extended Range: 200 - 1000 nm	Today	<input type="text" value="2"/>	\$3,042.92* \$2,982.06	\$5,964.12	<input type="checkbox"/>
* For Thorlabs Price and Discount Policy please see Thorlabs Price Policy . WEIGHT (Total): 13.07 lbs						TOTAL:	\$7,786.16

Fiber Optic Probe and Spectrometers Cost Estimate: ~\$8k

Automation

Item	Image	Part Number	Ship Date	Qty	Price	Subtotal	Remove
2		PRM1SP2 - (WEIGHT (Total)):0.22 lbs Horizontal Mounting Plate (Imperial and Metric)	Today	<input type="text" value="1"/>	\$54.65	\$54.65	<input type="checkbox"/>
3		KPRM1E - (WEIGHT (Total)):4.41 lbs Ø1" Motorized Precision Rotation Stage (Imperial) Bundled with DC Servo Motor Driver and Power Supply	Today	<input type="text" value="2"/>	\$1,483.58	\$2,967.16	<input type="checkbox"/>
4		PRM1SP1 - (WEIGHT (Total)):0.16 lbs Grooved Adapter Plate	Today	<input type="text" value="2"/>	\$47.88	\$95.76	<input type="checkbox"/>
5		KCH301 - (WEIGHT (Total)):3.75 lbs USB Controller Hub and Power Supply for Three K-Cubes or T-Cubes	Today	<input type="text" value="1"/>	\$524.83	\$524.83	<input type="checkbox"/>
WEIGHT (Total): 8.54 lbs						TOTAL:	\$3,642.40

Automation Cost Estimate: ~\$4k

Conclusion

- Improved, fully automated reflectivity test station can be developed
 - fiber optic cable
 - compact USB spectrometers
 - motorized stages
- New test station advantages
 - Expedite testing
 - Decrease sources of errors
 - Allow for testing more areas on mirror

Thank You