



U.S. DEPARTMENT OF
ENERGY



New Reflectivity Test Station

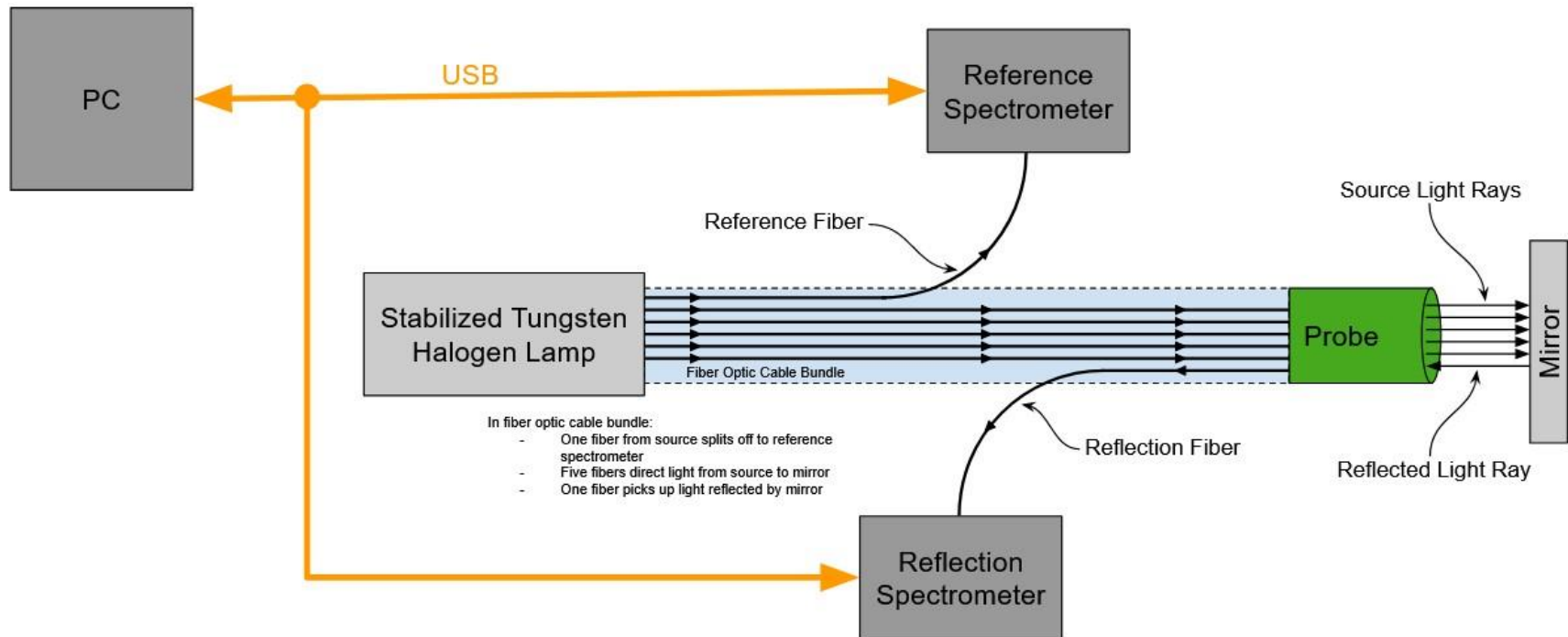
Tyler Lemon
Detector Support Group
April 22, 2022

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New Test Station

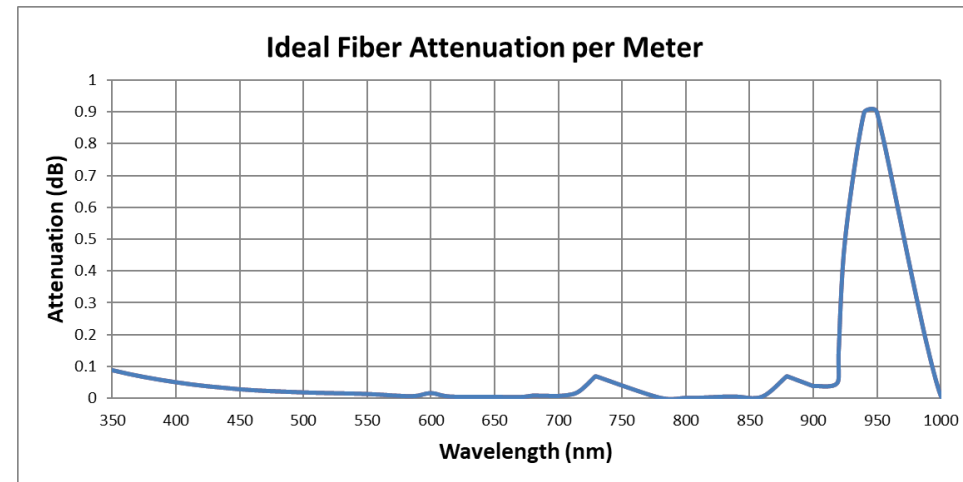
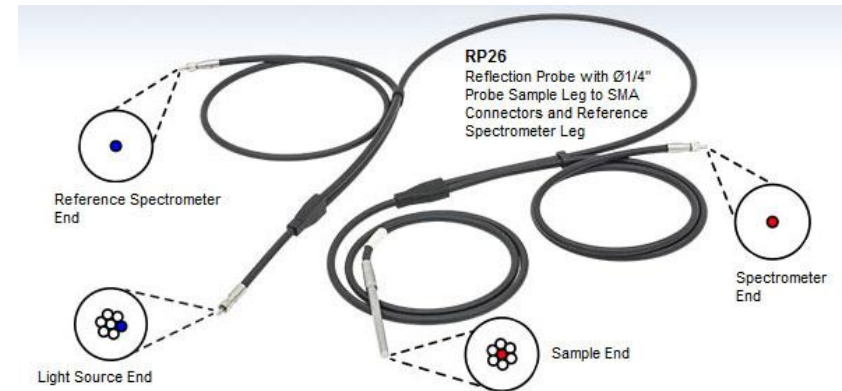
- Uses fiber optic reflection probe, compact spectrometers, and stabilized source for measurements



New Components

Fiber Optic Reflection Probe

- Thorlabs item # RP26
- **Flexible fiber optic cable eliminates need to align reference light with detector**
 - Only alignment needed is probe with mirror
- To account for attenuation of fiber, a one-time calibration was done with light source and spectrometers to determine a correction factor



New Components

Compact CCD Spectrometer (CCS)

- Thorlabs part # CCS200
 - Two required
- Measures power across full spectrum of input light
- Includes DAQ program and full suite of LabVIEW drivers



Specification	Value
Wavelength Range	200 - 1000 nm
Spectral Accuracy	<2 nm FWHM @ 633 nm
Slit (W x H)	20 μ m x 2 mm
Grating	600 Lines/mm, 800 nm Blaze
Fiber Connector	SMA 905
Detector Range (CCD Chip)	200 - 1100 nm
CCD Pixel Size	8 μ m x 200 μ m (8 μ m pitch)
CCD Sensitivity	160 V / (lx \cdot s)
CCD Pixel Number	3648
Resolution	4 px/nm
Integration Time	10 μ s - 60 s
Scan Rate Internal Trigger	Max 200 Scans/s
S/N Ratio	\leq 2000 : 1
Interface	USB 2.0
Dimensions (L x W x H)	122 mm x 79 mm x 29.5 mm

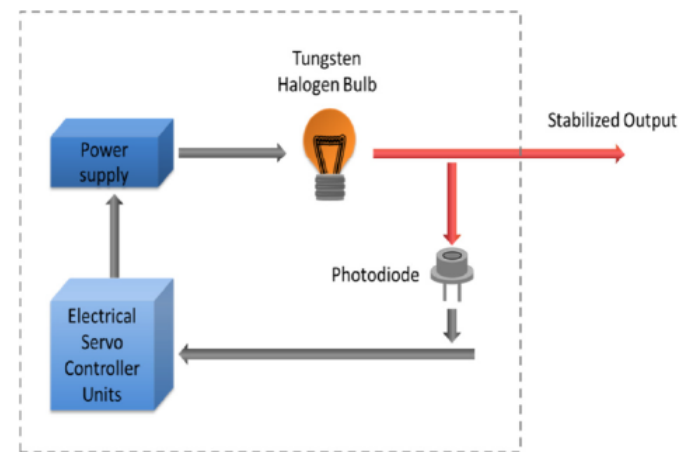
New Components

Stabilized Tungsten-Halogen Broadband Source

- Thorlabs part # SLS201L
- Has built-in output stabilization circuit that ensures output power is steady



Spec	Value
Wavelength Range	360 - 2600 nm
Peak Wavelength	1000 nm
Bulb Electrical Power	9 W
Output Coupling	Fiber Coupled (SMA) and Free Space
Fiber-Coupled Optical Power	10 mW
Free-Space Optical Power	500 mW
Beam Divergence without Fiber Coupler	8.2°
Output Power Stability	<0.05%
Optical Power Drift per Hour	0.01% (Typical)
Optical Power Drift per °C	0.1% (Typical)
Color Temperature	2796 K
Color Temperature Stability	±15 K
Lifespan	10 000 Hours (Avg.)
Dimensions (L × W × H)	8.52" × 2.17" × 2.26"

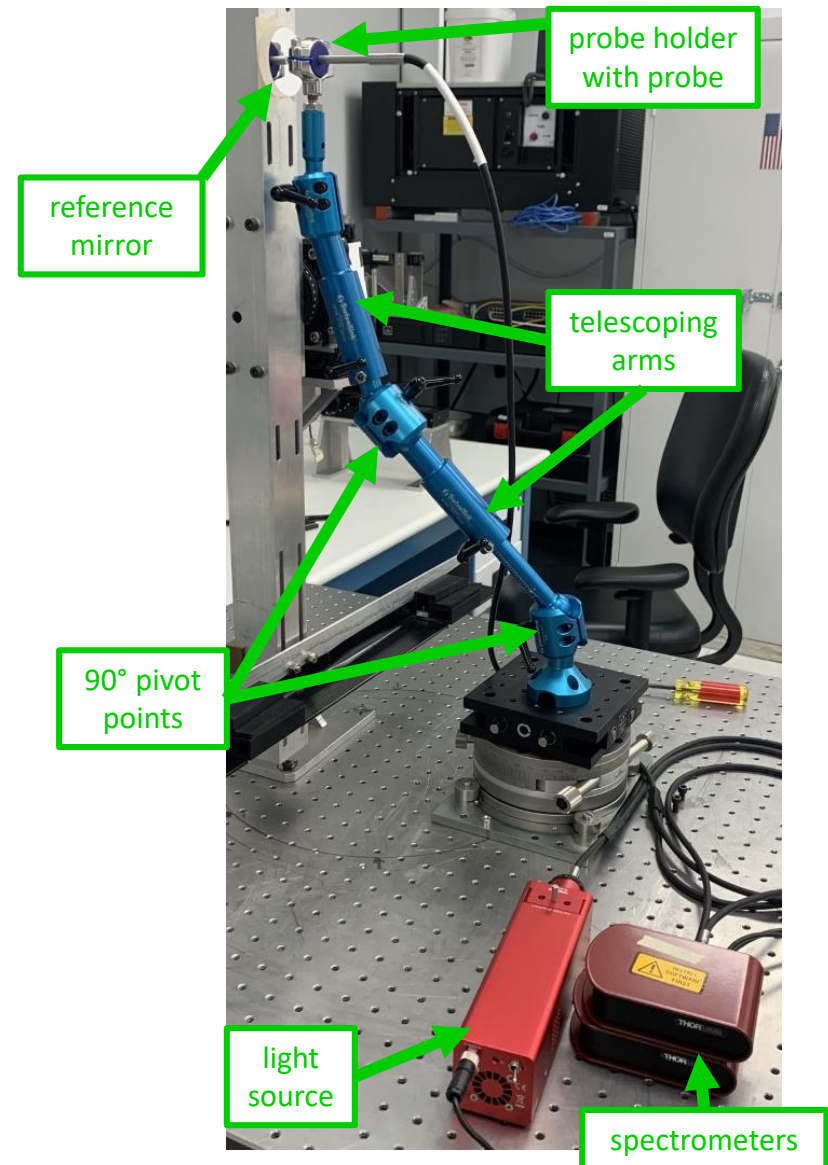


Output stabilization circuit

New Components

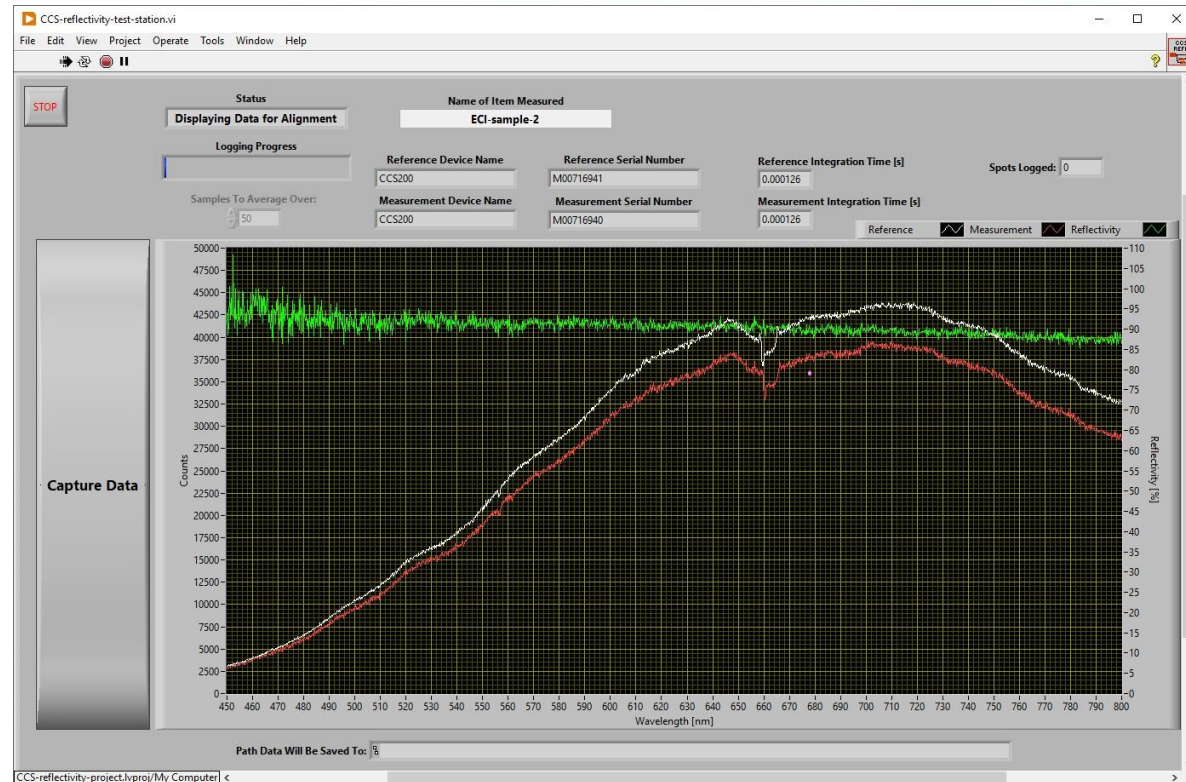
Probe Support Arm

- McMaster-Carr heavy duty, ball grip, positioning arm
- Arm is bolted to 1" grid on optical table
- Two 90° pivot points
 - Can also swivel 360°
- Two telescoping arms
 - Extends from 6.75" to 10.75"



New Test Station Program

- Live feed from both spectrometers and reflectivity calculation for alignment
- Data capture and logging
 - Captures user-set number of samples from both CCSs and calculates reflectivity
 - Averages over all samples
 - Logs all data
- Creates summary file with average results for each spot

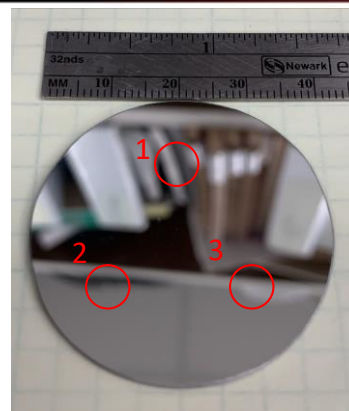


Procedure

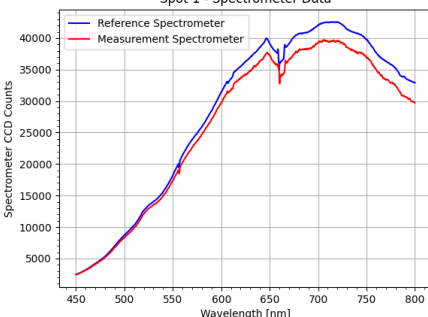
1. Run DAQ program
2. Align probe with mirror using live feed from DAQ program
3. Click “Capture Data” button
4. Wait until done (a few seconds)
5. Repeat steps 2-4 until all desired areas are measured

RICH-1 Mirror Sample #23

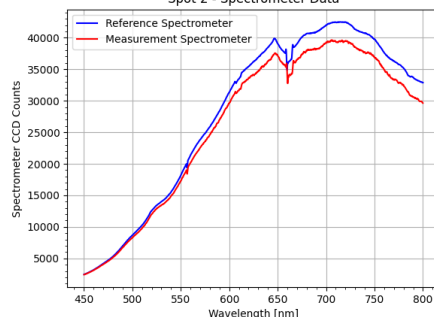
- Three spots measured
 - All at visually good areas



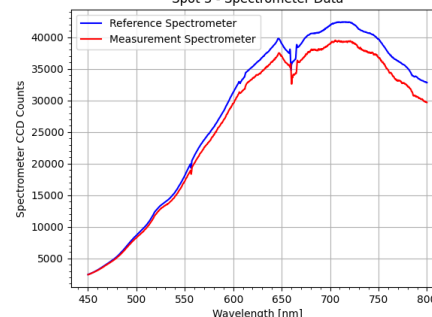
Spot 1 - Spectrometer Data



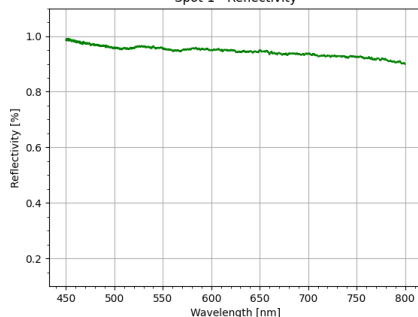
Spot 2 - Spectrometer Data



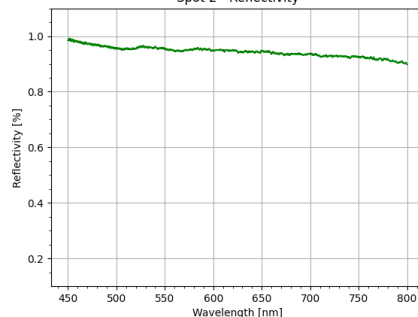
Spot 3 - Spectrometer Data



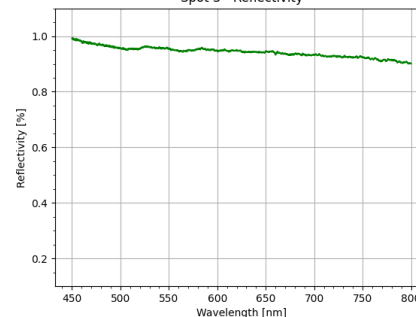
Spot 1 - Reflectivity



Spot 2 - Reflectivity



Spot 3 - Reflectivity



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RICH-1-leftover-23

Reference CCD

Name: CCS200

Serial Number: M00716941

Integration Time [s]: 0.000100

Measurement CCD

Name: CCS200

Serial Number: M00716940

Integration Time [s]: 0.000100

Number of spots measured: 3

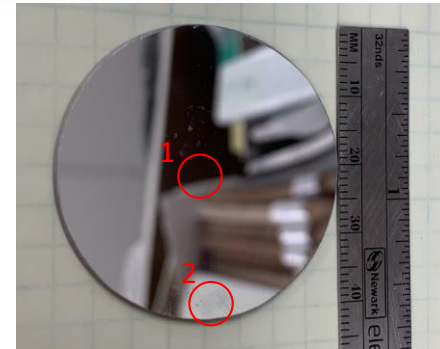
Samples Averaged Over: 1000

Overall reflectivity averages:

Spot #	Average Reflectivity [%]
Spot 1	0.94
Spot 2	0.94
Spot 3	0.94

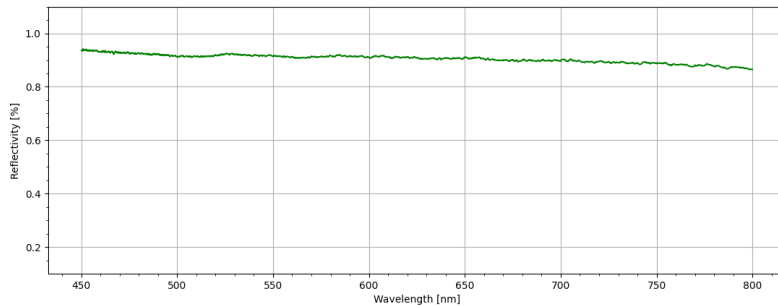
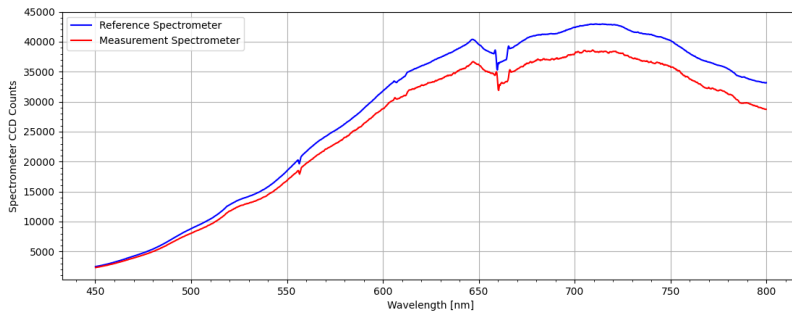
RICH-1 Mirror Sample #24

- Two spots measured
 - One at a visually good area
 - One at purposefully smudged, visually bad area



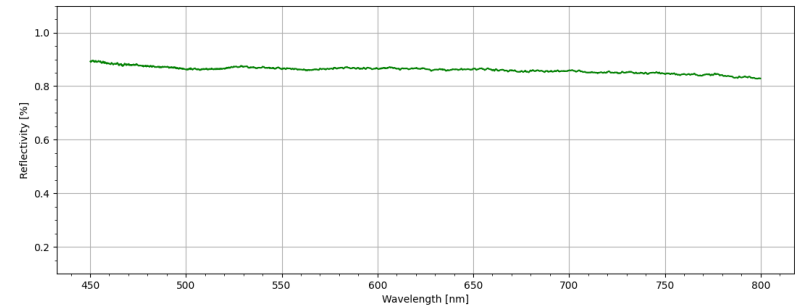
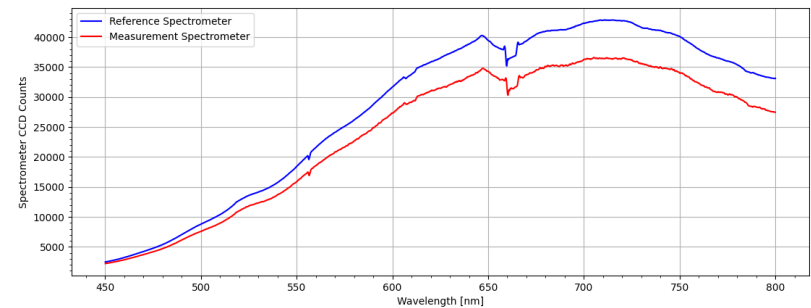
Spot 1: Good Area

Overall Average Reflectivity: 91 %



Spot 2: Bad Area

Overall Average Reflectivity: 86 %



Conclusion

- New test station uses two compact CCD spectrometers to measure light reflected off of a mirror
 - Light directed using fiber optic cable
 - Light source is stabilized with consistent power
- New components greatly improve alignment procedure
- Samples from RICH-1 measured and confirmed to have reflectivity of $> \sim 90\%$ in visually good locations
 - One visually bad area had reflectivity of $\sim 84\%$