RICH Spherical Mirror Acceptance Tests

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Two of the ten spherical mirrors of Hall B's Ring Imaging Cherenkov (RICH) detector were acceptance tested. This note presents the tests and their results.

Cherenkov light of charged particles entering the RICH detector at an angle θ with respect to the beam axis, z, where $\theta \in [12°, 35°]$, are focussed by carbon-fiber-reinforced polymer spherical mirrors onto multi-anode photo-multiplier tubes, Fig 1.

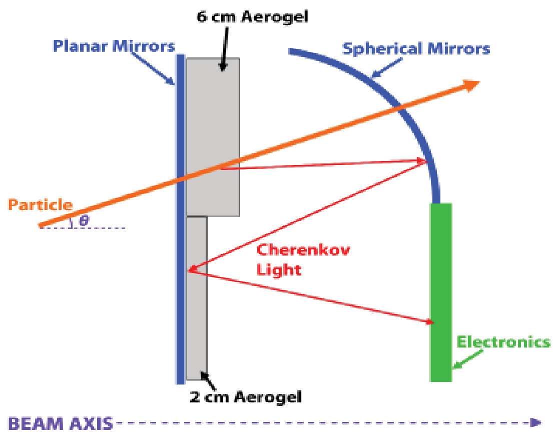

FIG. 1. Schematic of the RICH detector.

The detector's ten spherical mirrors must have a reflectivity R greater than or equal to 90%, per specification. After the final coating of the mirrors, two of the mirrors, M3 and M4, were acceptance tested at Jefferson Lab in June, 2017.

Visual inspection of M3 and M4, Figs. 3 and 4, showed good areas—circled in green, and bad smudged/scratched areas—circled in red. The faint white rings are a side effect of photographing the mirror with flash.

FIG. 3. Photo of M3.

FIG. 4. Photo of M4.

The test stand to measure R of M3 and M4 surfaces consisted of a monochromator, which output light in 10 nm steps of wavelength λ, where $\lambda \in$ [430 nm, 650 nm], a beam splitter that split the test beam into a control and an experimental beam, and two photodiodes, which measured the intensity of the control and experimental beams, Fig. 5.

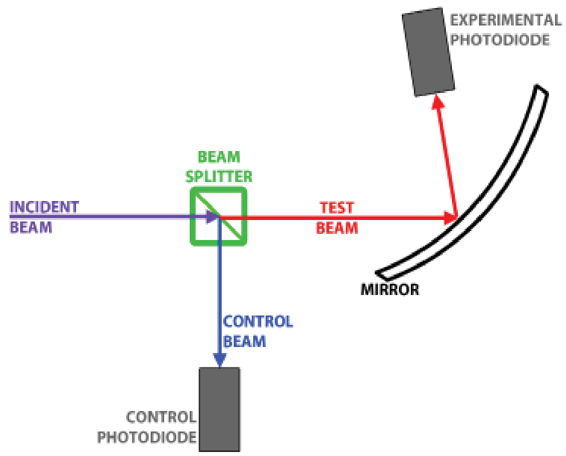

FIG. 5. System diagram for reflectivity test station.

For M3, R for five good areas and eight bad areas was measured. For M4, R for four good areas and seven bad areas was measured. Plots of $R(\lambda)$ generated in Python for M4 areas 4 and 7 are shown in Figs. 6 and 7. Table I lists $R(<\lambda>)$.

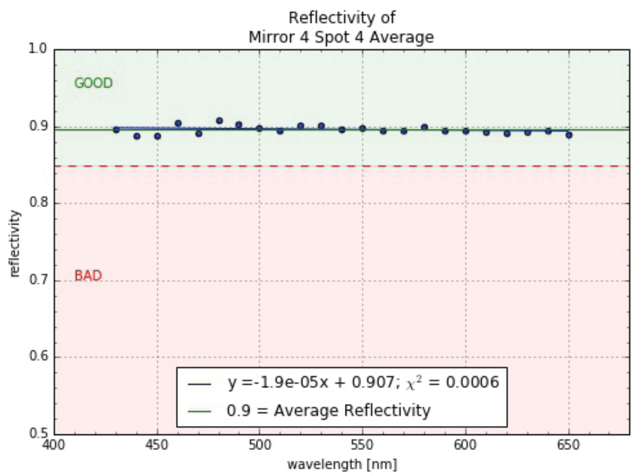

FIG. 6. Reflectivity at a visually identified good area.

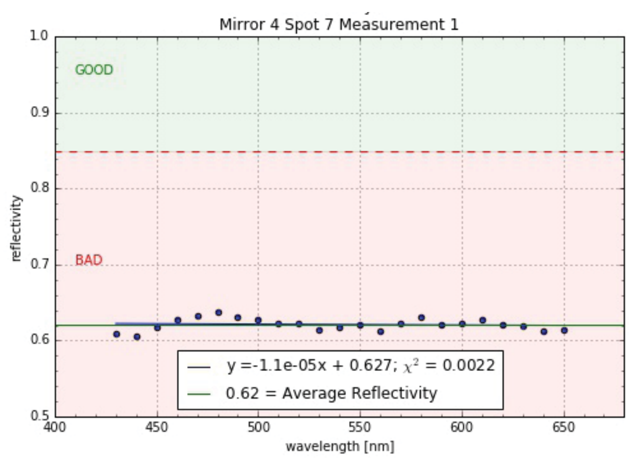

FIG. 7. Reflectivity at a visually identified smudged/scratched area.

Area #	Observed area quality/R [%]	
	M3	M4
1	good/89	good/88
2	good/87	good/80
3	good/89	bad/81
4	good/87	good/90
5	good/89	good/89
6	bad/83	bad/77
7	bad/82	bad/62
8	bad/73	bad/67
9	bad/84	bad/67
10	bad/77	bad/87
11	bad/84	bad/76
12	bad/86	n/a
13	bad/84	n/a

Table I. Results of inspection and measurements.

Table I shows that good areas had $R \approx 90\%$, bad areas had $R \leq 85\%$. Lower R for good areas and higher R for bad areas could be due to the inherent error in the reflectivity test station's alignment (measured to be ~6%).

In conclusion, reflectivity measurements showed that mirrors M3 and M4 had areas with $R \leq 85\%$. Discussions with Composite Mirrors Applications, Inc., the mirrors' fabricator, revealed that the poor surface quality was due to an issue in the fabrication process. Therefore, all ten spherical mirrors were reworked to meet reflectivity specification. The detector was assembled in November, 2017 and installed in the beam line in January, 2018. The RICH detector has been acquiring quality data since then.