Minimum Reflected Spot Size Measurements for Hall B's Second Ring Imaging Cherenkov Detector

Tyler Lemon and Mindy Leffel, Mary Ann Antonioli, Peter Bonneau, Aaron Brown, Pablo Campero, Brian Eng, George Jacobs, Marc McMullen, and Amrit Yegneswaran
Physics Division, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606
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Measurement results of the minimum reflected spot size, *d0*, of spherical mirrors for Hall B's second Ring Imaging Cherenkov (RICH II) are discussed in this note.

The RICH detector's array of ten spherical mirrors, Fig. 1, focus Cherenkov light generated by charged particles with incident angles between 12° and 35° with respect to the beamline onto the photomultiplier tubes; mirror specifications are listed in Table I.

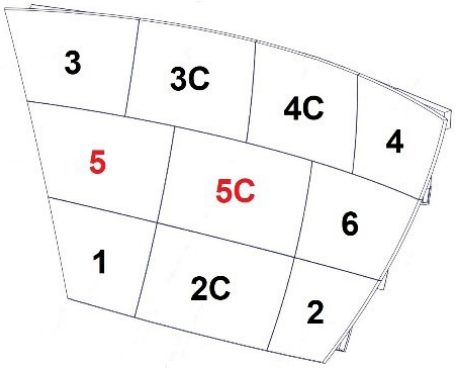

FIG. 1. RICH spherical mirror array, consisting of ten mirrors. Tested mirrors 5 and 5C are labeled in red.

Parameter	Specification [mm]
Radius of curvature	2700
d0	2.5

Table I. Specifications for RICH II spherical mirrors.

To determine whether mirrors made by Composite Mirror Associates, using a new fabrication mold, meet specifications, the minimum reflected spot size *d0* of mirrors 5 and 5C was measured [1] in the horizontal and in the vertical positions. Results are shown in Table II.

Mirror	Position	Lowest *d0* observed [mm]	Fit *d0* [mm]	Fit mirror radius of curvature [mm]
5	horizontal	1.950	1.98	2710.21
	vertical	2.291	2.29	2702.53
5C	horizontal	2.248	2.26	2708.40
	vertical	3.430	3.31	2700.78

Table II. Results for first set of *d0* measurements.

Figure 2 shows the test station setup. After taking into account the distance D between the charge-coupled device (CCD) stand and the mirror stand and the offset values, the radius of curvature R is given by the equation R [mm] = 2803.276 [mm] - z [mm]; where z is the z position of the CCD on the z-linear stage.

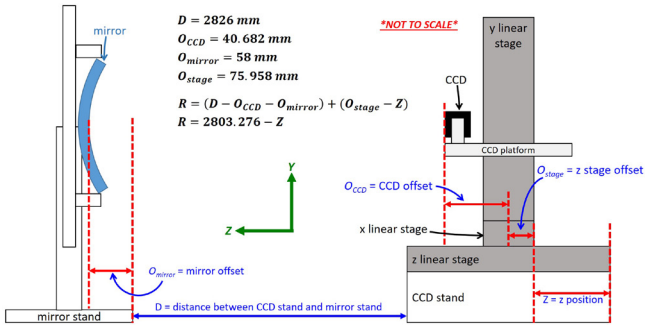

FIG. 2. Test station.

Figures 3 and 4 show the *d0* vs z plots and their fits for mirrors 5 and 5C, respectively. The red line on each plot is a parabolic fit of data around the minimum.

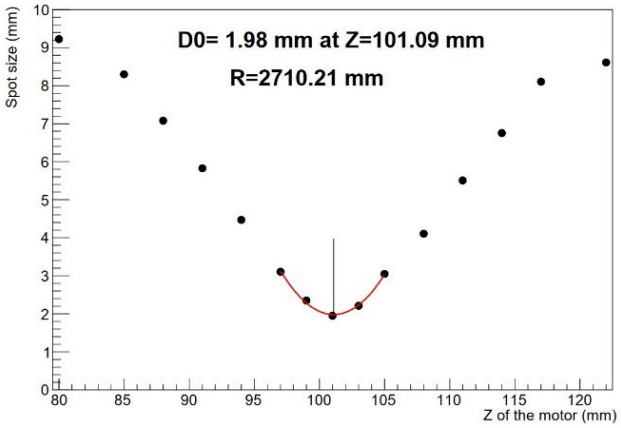

FIG. 3. *d0*-vs-z data and fit for mirror 5.

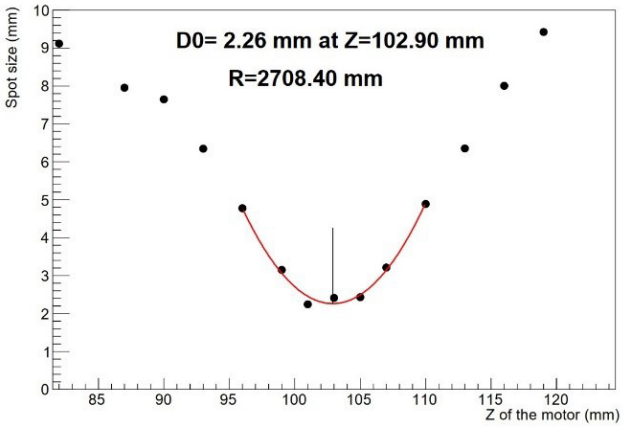

FIG. 4. *d0*-vs-z data and fit for mirror 5C.

The *d0* measurements for RICH II mirrors show that these new mirrors do not have the same quality as the RICH I mirrors. For mirror 5C of RICH I, the image of the reflected source light looks like a circular spot, Fig. 5, whereas for mirror 5C of RICH II, the image is distorted—not a circular spot, Fig. 6.

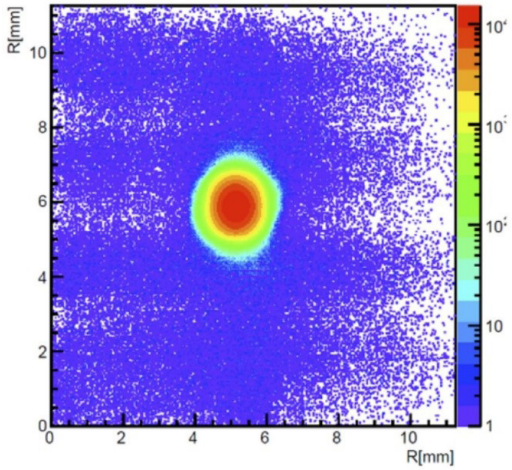

FIG. 5. Image of *d0* for RICH I mirror 5C. Image is like a circle.

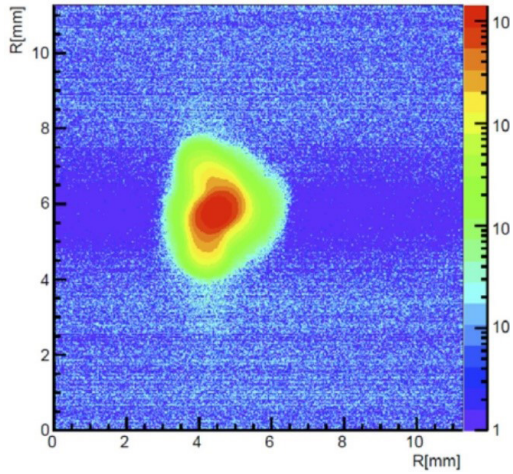

FIG. 6. Image of *d0* for RICH II mirror 5C. Image is not like a circle.

When the CCD stage is moved ~4 mm closer to the mirror, for mirror 5C of RICH I, the CCD image of the reflected light source has the same general shape as the mirror, Fig. 7, whereas with mirror 5C of RICH II, the image is distorted, Fig. 8.

To test whether these differences are due to the mirrors or due to the test equipment, the following checks were done.

1. The ambient light was reduced in the cleanroom. The results, Table III, were similar to the first set of measurements, Table I; thus, the darkening of the cleanroom had no effect on the *d0* measurements.

2. The CCD stand and mirror stand of the test station were realigned using a laser-collimator set up to ensure that the CCD *z*-axis is parallel and aligned to the *z*-axis of the mirror stand. The only change after realignment was that the image on the CCD stayed in the same location rather than moving on the CCD as *z* changed.

3. The intensity of the fiber-optic source used to direct light towards the mirror was increased as much as possible. This change resulted in a lower CCD exposure time being required to get the desired CCD count levels, but the overall results were not affected.

4. The fiber used to direct light toward the mirrors was cut and polished; again there was no effect.

Since none of the changes improved the results, it appears that RICH II mirrors 5 and 5C are of poorer quality than the mirrors 5 and 5C of RICH I.

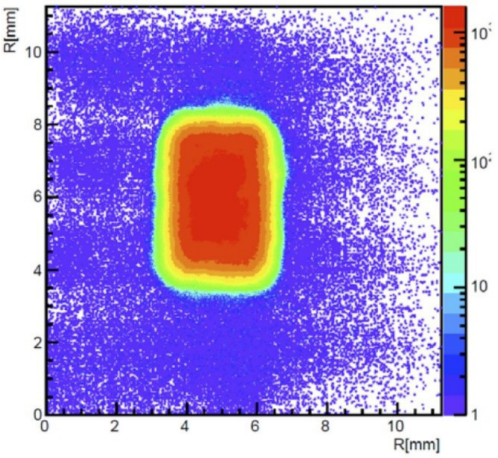

FIG 7. Image of reflected light source for RICH I mirror 5C when CCD is closer to mirror than *d0* location. Image is in general shape of mirror.

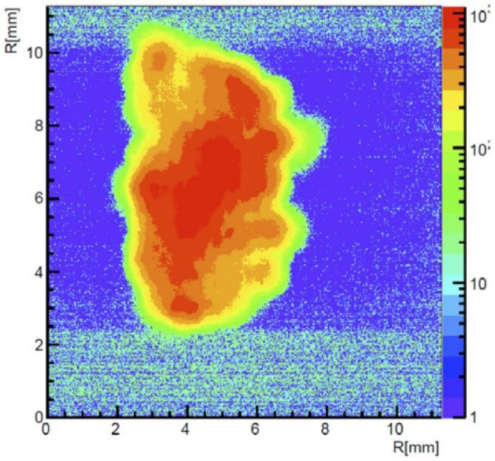

FIG. 8. Image of reflected light source for RICH II mirror 5C when CCD is closer to mirror than *d0* location. Image is distorted.

Mirror	Position	Lowest *d0* observed [mm]	Fit *d0* [mm]	Fit mirror radius of curvature [mm]
5	horizontal	2.468	2.81	2709.8
	vertical	2.670	2.69	2704.26
5C	horizontal	2.008	2.16	2708.23
	vertical	2.989	3.01	2702.15

Table III. Results for *d0* measurements after darkening cleanroom.

[1] Tyler Lemon, et al., *RICH Spherical Mirror Optical Tests*, DSG Note 2018-01, 2018.