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Corrector Plate with an Annulus Shape

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Abstract

In this note we want to show another version of a corrector plate design. It consists in an annulus (ring) of corrector plate with inside diameter 1.7m and outside diameter 2.0m. The (uncorrected) diaphragm opening would be inside the ring. The corrector ring would allow us to greatly increase the collecting area without degrading the spot size or enlarging the mirror.

1 Introduction

We were asked to see if it were possible to use an annulus of corrector plate, instead of using an entire corrector plate. This idea came from Paul Sommers.

In order to be possible to use a corrector ring instead of using a corrector plate it is necessary to have the focal distance of the corrector ring equal to the focal distance of the opened diaphragm inside the corrector ring. However looking at fig.1, which gives the relation between the cluster radius[1] and diaphragm radius using and without using

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[1]Focal distance is equal to the difference between the mirror radius and cluster radius, $f = R_{mirror} - R_{cluster}$, $R_{mirror} = 3.4m$

corrector plate, we see that for a diaphragm opening of 0.85m without corrector plate we need a cluster with 1.743m of curvature radius and for a diaphragm opening of 1m with corrector plate type I and II we need a cluster with 1.71m and 1.76m of curvature radius respectively. So it is necessary to change some parameters of the optical system in order to design a corrector ring ($R_{inner} = 0.85m$ and $R_{exterior} = 1m$) with same focal distance as the inner diaphragm ($f = 3.4m - 1.743m$).

Looking at the thickness functions of corrector plates I (eq.1) and II (eq.2),

$$T(r) - T(0) = \frac{r^4}{32(n-1)f^3} \quad , \tag{1}$$

$$T(r) - T(0) = \frac{r^4 - Ar^2}{32(n-1)f^3} \quad , \tag{2}$$

we notice that the function of the corrector plate I is just the function of corrector plate II, with the parameter $A = 0$. The parameter $A = \frac{3}{2}{R_{dia}}^2$ adopted for corrector plate II is in order to reduce to chromatic aberration (see footnote in [2]). We also notice looking at figure 1, that the value of the focal distance needed for a diaphragm with $0.85m$ of radius without using any corrector plate is between the corresponding values needed for a diaphragm with $1m$ of radius when using corrector plate I and II. So the value of the parameter A for a corrector ring with same focal distance to the inside opened region should be between 0 and $\frac{3}{2}{R_{dia}}^2$. After some simulations we find that A should be $0.91965 \times {R_{dia}}^2$.

We simulate the optical system using the designed corrector ring. In fig. 2 we show the spot size for rays with incidence angles of 0^o and 20^o. The concentrated spot at the core is due to the corrector ring. Notice that it is smaller than the spot due to the opening diaphragm.

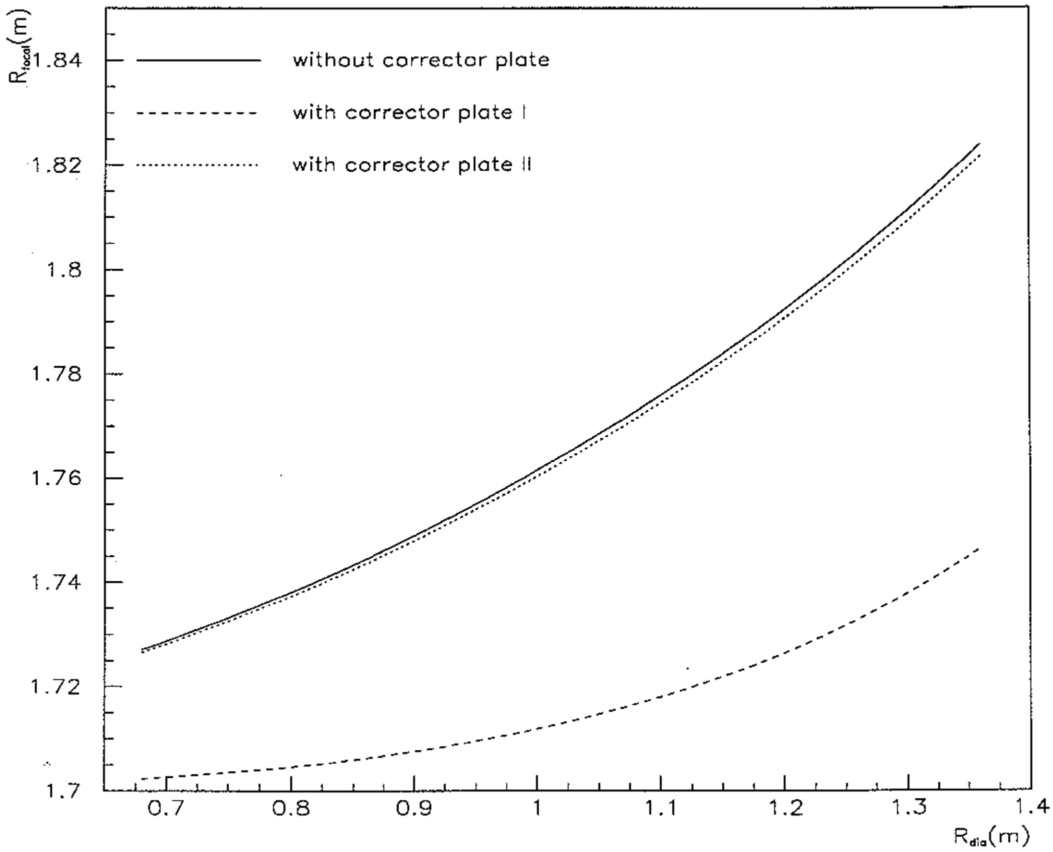

Figure 1: Cluster curvature radius as a function of the diaphragm aperture radius.

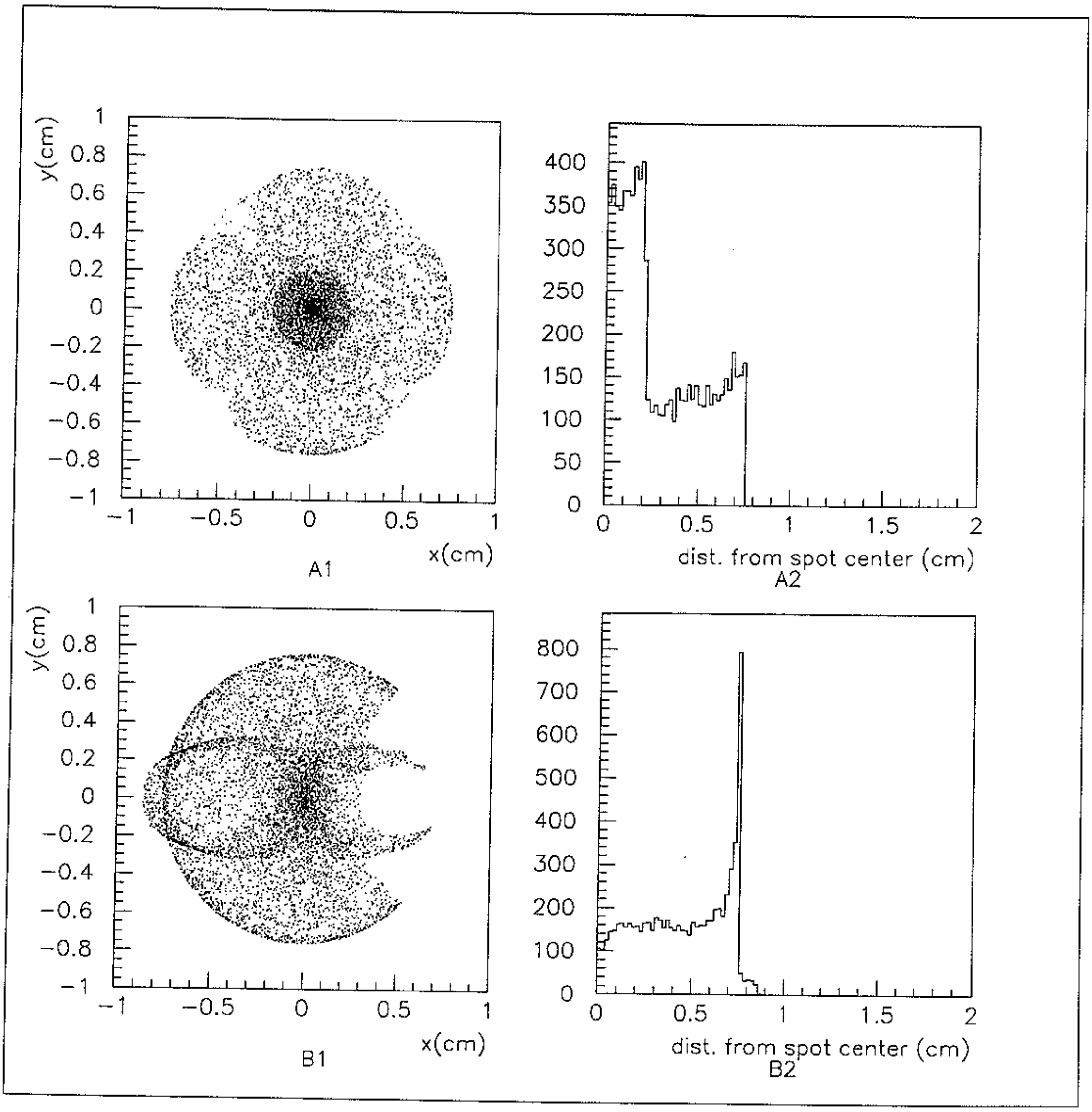

Figure 2: Spot size using corrector ring for incidence angles of 0^o (A1) and 20^o (B1). Figures A2 and B2 are the corresponding radial distribution of the spot size.

2 Conclusions

It is possible to use a corrector ring without degrading the spot size instead of using an entire corrector plate. It is appropriate to call attention to a disadvantages of the annulus configuration:

- The figure formed at the pixel by the light passing through the annulus overlaps with light coming through the open diaphragm, generating an irregular distribution of the spot (fig.2). This irregular distribution should be attenuated when imperfections of the optical elements are considered [1].

One advantage of the annulus is to increase the effective light collecting area ($\sqrt{A_{eff}} \propto S/N$). In the case here studied this represents an increase in S/N of about 25%. The final decision of using a corrector plate or a corrector ring will depend on the cost of fabrication and the associated difficulties in installation and maintenance of the annulus.

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[2] M. Born and E. Wolf, *Principles of Optics*, Sec. 6.4.