

## **K1DM3 Design Note**

### **Vignetting with K1DM3 assuming a masked M3.**

**Drew Phillips -- 29 Sep, 2015 (v1.1)**

#### **I. The Nasmyth Focus**

##### **Introduction:**

The clear aperture needed for a 5.0' FOV is an ellipse 881.1 x 623.0 mm. We have allotted 10mm additional mirror surface beyond the clear aperture of M3 for a full size 901.1 x 643.0mm. Zygo has informed us that the outer 15mm at the edge of the mirror may have substandard surface and therefore we may need to mask this. The question is what degree of vignetting results from such masking.

We undertook a ZEMAX study to determine the amount of vignetting at 2.5' radius caused by a mask of inner size 871.1 x 613.0mm, and how large the unvignetted field of view would be.

The results are that the unvignetted field is 4.7x5.0', and the amount of vignetting at 2.5' is only 0 to 0.1%. Given that less than ~0.1% of the PSF is affected anywhere within the 5.0' FOV (and none within 4.7'), it is proposed that we ignore this and dispense with the mask. This also removes the risk associated with aligning the mask.

##### **Methodology:**

A ZEMAX model ("Small\_mirror.ZMX") was constructed of the telescope and deployed K1DM3 illuminating the Nasmyth focus – this will represent either side or the bent Cassegrain foci. The segmented shape outline of the primary was created with a User Define Aperture (UDA) file. We used the footprint diagram at M3 which calculates the vignetting, or (through trial-and-error) found the maximum field angle where vignetting starts to occur.

Unvignetted throughput is 76.81% (a combination of the secondary shadow and the missing parts of the segmented outline). Note that this is a very slight overestimate, as the M2 structure shadow is somewhat larger than M2 itself; this will have no significant effects on the results.

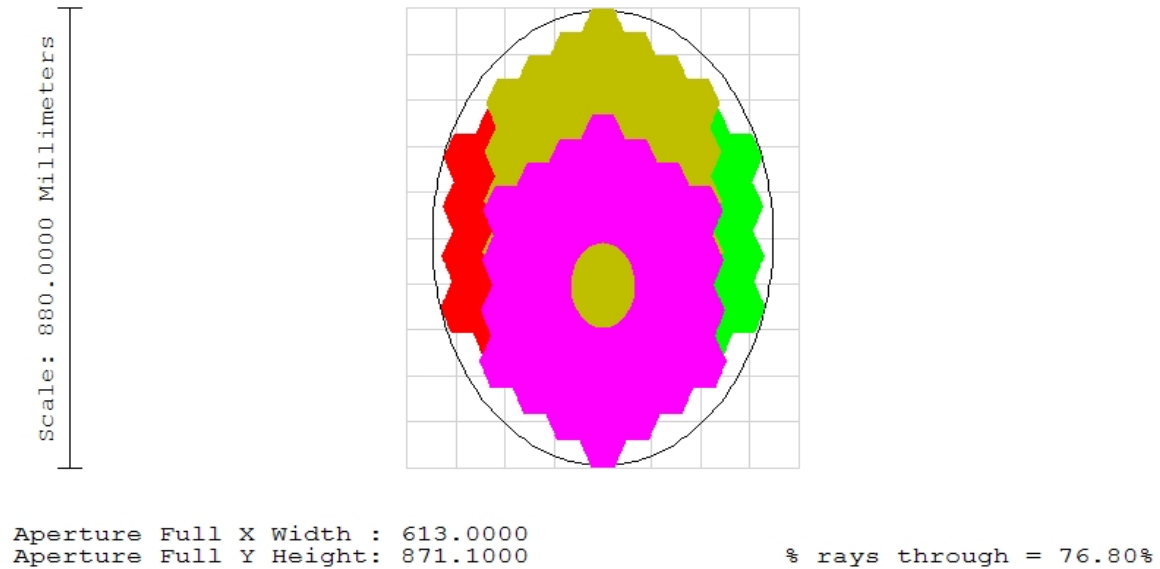
We then imposed a 435.55 x 306.5 mm elliptical mask onto M3. We find that at 2.5' field radius (that is, the radius of the 5.0' FOV), there is no vignetting on the minor axis, and only 0.10% on the major axis.

The masked M3 has a 4.739' unvignetted field on the major axis, and 5.0' unvignetted field on the minor axis.

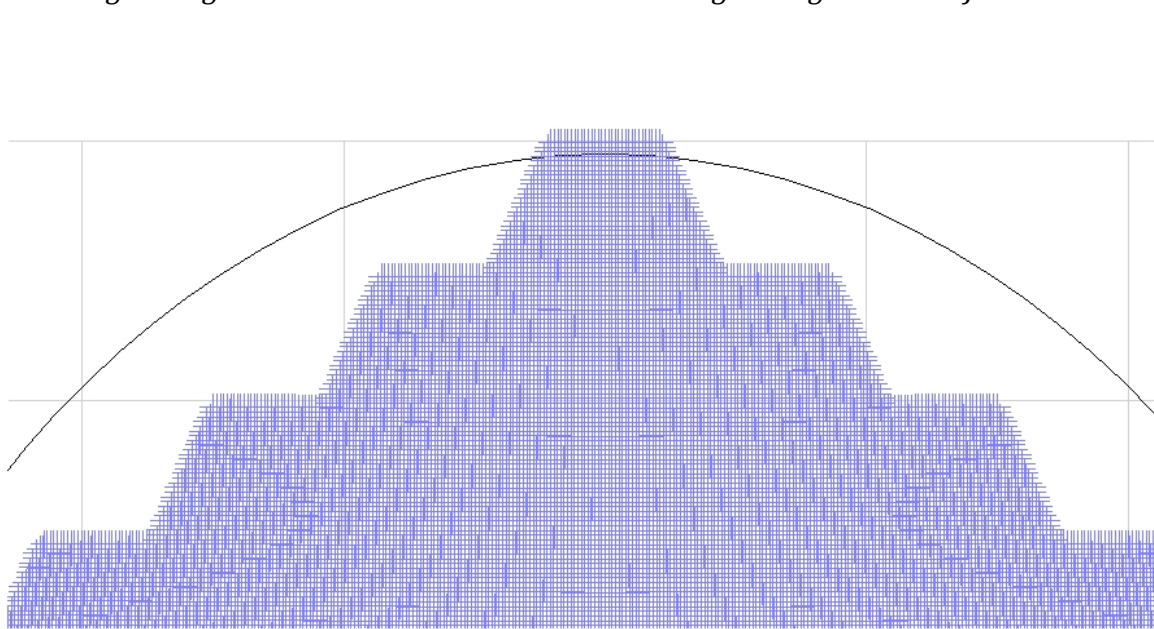
The new displacement of the tiled M3 from the optical axis (in the plane of the mirror) is 13.71mm (was 13.76mm).

### Discussion and Conclusion:

The amount of vignetting is negligible. Similarly, the image quality at the edge will be degraded but not terrible, and only 0-to-0.1% of the light is affected; it is not worth masking M3 from an image quality point of view. Furthermore, masking M3 would require us to very carefully align the mask to avoid unwanted vignetting.



*Figure 1: The footprint of the 4 cardinal field points at 2.5' radius. The ellipse represents the masked aperture. The shape of the primary is critical for the lack of vignetting on the minor axis and the minimal vignetting on the major axis.*



*Figure 2: Detail of the vignetting at 2.5' on the major axis. Just the top of one segment is clipped.*