MMTO Internal Technical Memorandum #03-1

MMT Observatory

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MMT F/5 Baffles and Double Reflections

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January 2003

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Recently, some problems with imaging on the MMT using the minicam at F/9 were found. The symptoms were an increased level in the background, with in-focus images of dust shadows formed on the detector. The dust was probably the dust on the dewar window or filter. Diffraction rings were also noticed around the dust images (which were dark). The problem images occured when data was being taken near a very bright astronomical object, in this case, Saturn. After a little bit of analysis, it was determined that light could make two passes through the telescope optics and reach the focal plane. In so doing, the light is no longer an f/9 beam, but is more nearly collimated, thus leading to the nearly in-focus images of dust. See figure 1.

This situation occurs at a specific and narrow range of angles off-axis, around 0.45 to 0.49 degrees for the f/9 focus (and would be 0.79 to 1.43 degrees for the f/5 focus). Thus the problem is noticed only when a bright object is in that range of angle. However, sky light does make that pass at all times, and does add about 1% to the overall background level.

The reason this happens with the f/9 system is that the baffling for the f/9 focus is not a complete system. The baffling is in two parts: a primary cylindrical baffle which extends to about 1m above the primary vertex, and a secondary conical baffle. The primary baffle length was restricted to 1m because of the mirror cover height, which needs to roll over the baffle. The design thus considered what was needed to baffle the focal plane from direct skylight (that which doesn't hit any mirrors), taking into account the 1m restriction. Once the diameter of the primary baffle was set, the diameter and length of the secondary baffle could also be designed. Thus the design was not a critical baffle design as described in the MMT document #370. The primary baffle built was about half its critical length.

It wasn't realized at the time that a critical baffle also by design cuts out light that makes two reflections off of each mirror. If we had realized this, a fairly simple addition would have been made to the f/9 secondary baffle, which would be an occluding central disk (say attached by guy wires to the secondary baffle), which would block the offending light before it hits the secondary for the second time, without loss of the wanted light.

The f/5 system is a complete, critical baffle, even though the same 1m restriction applies to the primary baffle here as well. The mid-baffle does the work of cutting out the off-axis light trying to make a second pass through the telescope. Figure 2 shows the rays that can make the double pass in the f/5 system.

The third figure shows the extreme rays of Fig 2 in a drawing of the f/5 baffle design. Rays originating near the edge of the primary will hit the top of the mid-baffle rings after

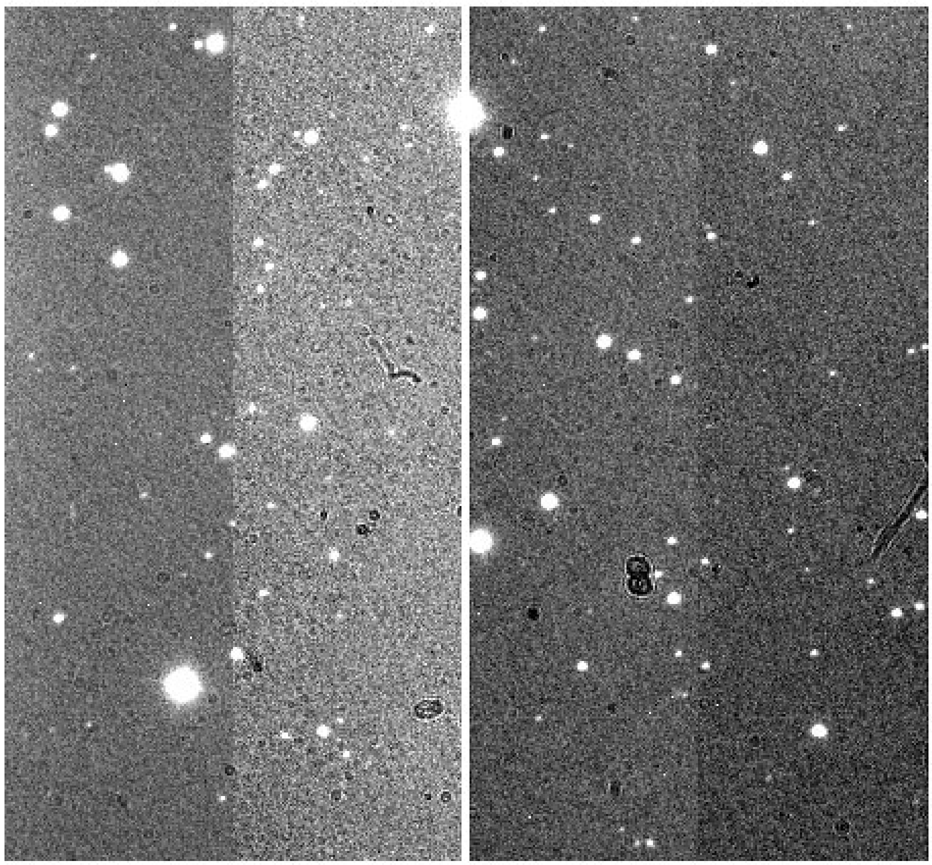

Fig. 1.— Minicam image taken Dec 13, 2002, that shows the stray light problem.

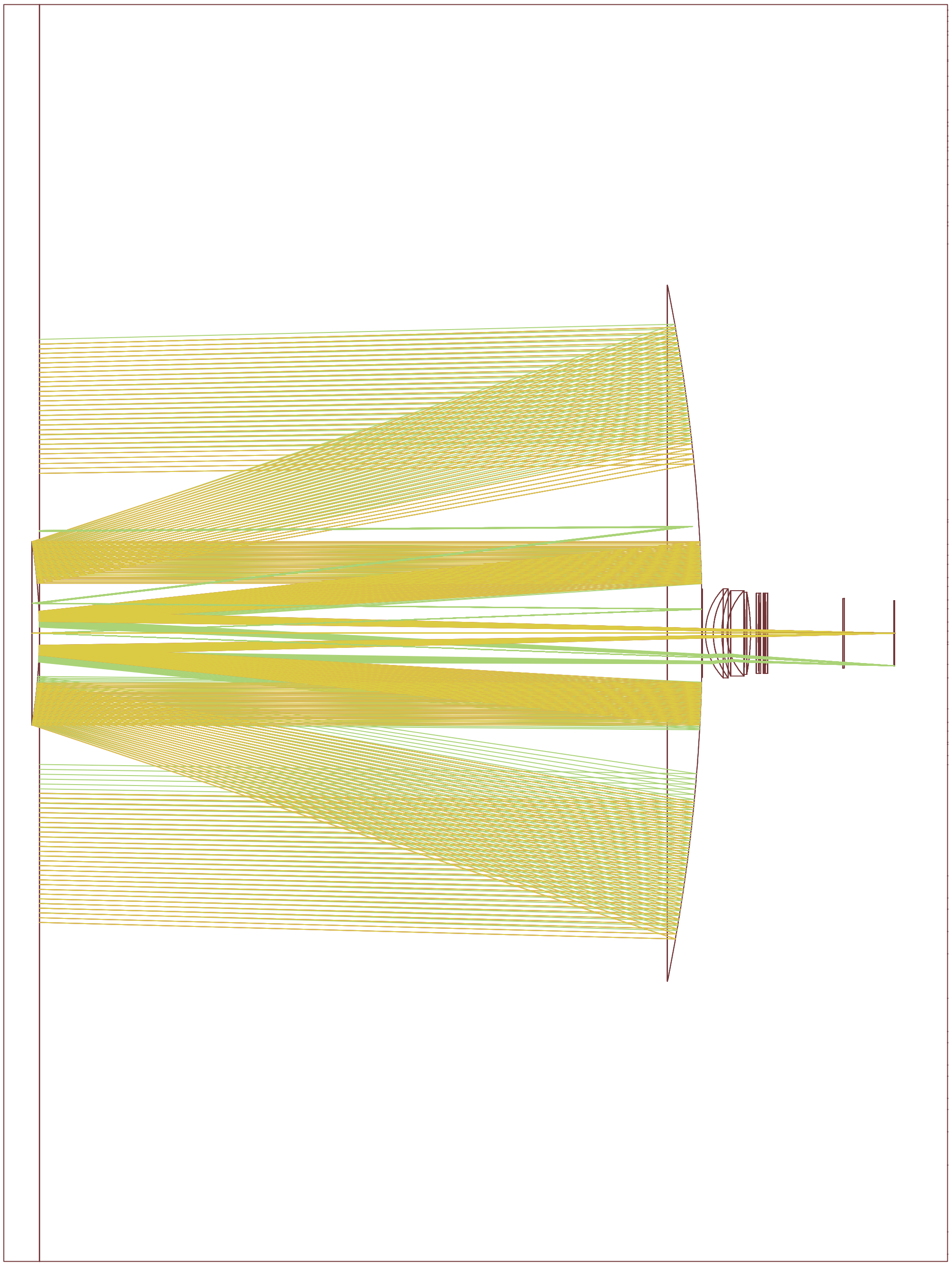

Fig. 2.— Zemax ray trace showing the rays, on and off axis that can make a double pass onto the focal plane

hitting the secondary for the first time. Rays originating closer to the primary hole will pass through the mid baffle, but will be intercepted by the inside of the primary baffle. So in conclusion, we don't expect the double reflection problem to occur with the f/5 setup.

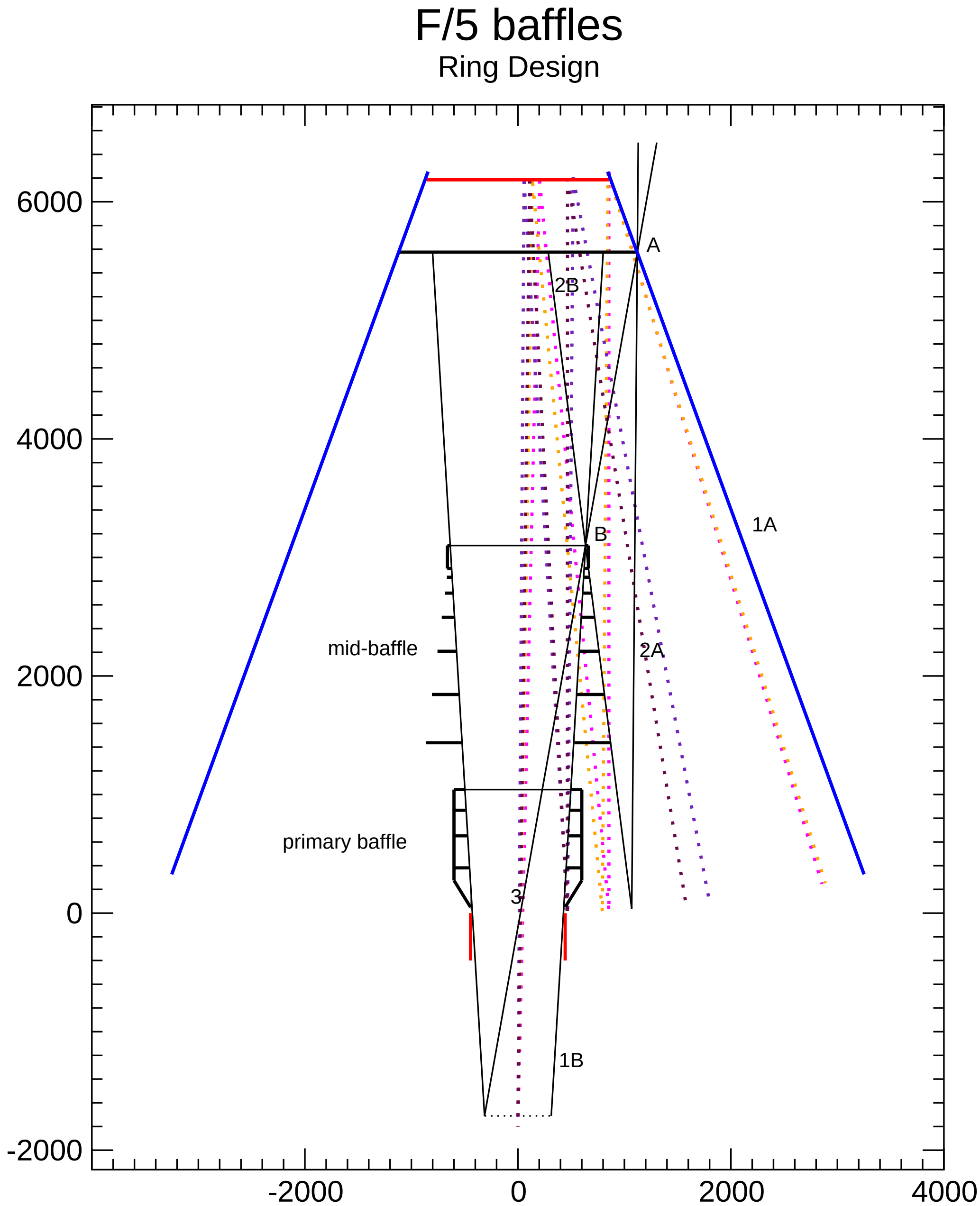

Fig. 3.— Thick black lines show the baffles. Thin black lines show critical rays that determine the design. Rays that would make a double pass are shown as dotted. Follow lines of the same color. 4 are shown, 2 originating near the edge of the primary but at different angles, and 2 originating around r=2000. (The rays hitting the primary the first time are omitted for clarity). Rays in between are of course also a problem. To see why the f/9 baffle has a problem, imagine the mid-baffle here being absent. Dimensions are in millimeters.